MANITOBA

DEPARTMENT OF ENERGY AND MINES

MINERAL RESOURCES DIVISION
GEOLOGICAL REPORT GR 82-2

SYSTEMATICS AND PALEOECOLOGY OF UPPER ORDOVICIAN TRILOBITES FROM THE SELKIRK MEMBER OF THE RED RIVER FORMATION, SOUTHERN MANITOBA

by
S.R. Westrop and R. Ludvigsen
Department of Geology
University of Toronto
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FOREWORD

The Selkirk Member of the Red River Formation comprises one of the best known lithologies or rock types in Canada. It is the source of Manitoba's "Tyndall Stone", the decorative building stone that is widely used throughout Canada. This stone is not only an attractively mottled building stone, but contains a suite of exceptionally large and well preserved fossils, well shown in many buildings throughout the Province, most notably the Legislative Building. The trilobites form a small but elegant portion of this fossil community, and the following report presents all known data concerning this trilobite fauna. Although much of the material is technical, the layman can nevertheless come to appreciate one of the most interesting and complex fossil types found in Manitoba.

On the technical level, this report provides a comprehensive study of all available trilobite material from the Selkirk Member. This will help to establish a more detailed bio-stratigraphic correlation of the Manitoba outcrop section with equivalent Ordovician strata throughout North America and the world. Of considerable importance is the fact that the stratigraphic position of the Selkirk Member within the Red River Formation is indicated correctly – as occurring near the middle of the Red River Formation, below the Fort Garry Member and above the Cat Head Member. Some previous studies had incorrectly placed the Selkirk Member (and its contained fauna) at the top of the Red River succession, approximately 75 m stratigraphically above its true position.

W.D. McRitchie
Director, Geological Services Branch

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ABSTRACT

The Selkirk Member of the Red River Formation exposed at Garson and other localities in southern Manitoba contains a diverse trilobite association of the illaenid-cheirurid type consisting of twenty genera. The thickly-bedded, dolomite-mottled lime wackestones of the Selkirk Member record deposition in a shallow, subtidal, level-bottom, environment with firm substrates. The trilobites are minor components of a paleocommunity which consists of two types of deposit feeder burrows, mound stromatoporoids, tabulate and rugose corals, receptaculitids, cephalopods, and gastropods (the "Arctic Ordovician" fauna). This paleocommunity is similar to those of the Black River Group in New York State, but it differs markedly from coeval paleocommunities in the Trenton Group of New York State.

The Selkirk trilobite association is composed of *Bumastoides* (28%), *Illaenus* (11%), *Ceraurinus* (10%) *Amphilichas (9%), Sphaerocoryphe* (8%), *Failleana* (6%) *Stenopareia* (4%), and *Nahannia* (3%). *Borealaspis, Calyptaulax, Ectenaspis, Encrinuroides, Flexicalymene, Isotelus, Hypodicranotus, Eobronteus, Dolichoharpes, Ceraurus, Acanthoparypha?,* and *Hemiarges* are represented by a few specimens each. The morphology of *Bumastoides* and other similar trilobites suggests an infaunal existence. The distribution of the illaenid-cheirurid community type is controlled by the availability of firm, cohesive substrates – necessary for the maintenance of burrows.
nance of burrows.

The Selkirk trilobite association correlates with those from the Kimmswick Limestone of Missouri and Illinois, the Cobourg Formation of southern Ontario, and the Cape Calhoun Formation of northern Greenland; suggesting an Edenian and, possibly, early Maysvillian (Late Ordovician) age for the Selkirk Member.

Twenty-three species of trilobites are described. Of these, *Stenopareia garsonensis* is new. The isoteline *Ectenaspis* is revised and its type species, *E. beckeri,* is redescribed.

INTRODUCTION

The fossiliferous limestones exposed on the western shore of Lake Winnipeg and in the Red River Valley of Manitoba have been known since the early 1800's. They were initially described by Sir John Richardson in 1819 and 1825-27 in his capacity as naturalist to the first and second Franklin Expeditions. Richardson noted that the limestones lay above the "New Red Sandstone"; presumably the Winnipeg Formation. Nautiloids, corals, and brachiopods were collected by both the Franklin Expeditions and by Captain Back's Expedition in 1833 from limestones exposed on the shore of Lake Winnipeg. Robert Jameson of the University of Edinburgh, who examined some of the rocks and fossils collected by Richardson, declared that these strata belonged to the Mountain Limestone (that is, Carboniferous). By 1851, Richardson had suggested that these rocks represented the Black River Limestones and, in his survey of the Lake Superior region, D. Dale Owen (1852) had stated that the mottled limestones exposed at Lower Fort Garry contained fossils that were identical to those of the Upper Magnesian limestones of Wisconsin and Iowa (that is, the Galena Formation) and the "Lower Silurian" of Europe. Thus, by the mid-nineteenth century the correct stratigraphic position and approximate age of the strata now assigned to the Red River Formation had been determined (see Whiteaves, 1897, p. 129-136 for a more complete historiography).

Although the dolomite-mottled limestones of the Selkirk Member of the Red River Formation in Manitoba are clearly dominated by large specimens of nautiloids, receptaculitids, tabulate corals, stromatoporoids, gastropods, rugose corals, and brachiopods – the characteristic faunal elements of the "Arctic Ordovician" fauna of Nelson (1959) – the presence of other less conspicuous fossil groups in this stratigraphic interval was noted by a number of authors. Owen (1852) first reported the presence of trilobites in rocks exposed at Lower Fort Garry; that is, *Calymene senaria, Asaphus iowensis,* and *Illaenus crassicauda.* Whiteaves (1897, p. 231-237) listed ten genera and thirteen species of trilobites as occurring in the Red River Formation, and Baillie (1952, p. 31) reported nine genera and thirteen species of trilobites from the same interval.

Middle and Upper Ordovician trilobites are poorly known from localities in western Canada. Only from the District of Mackenzie have extensive trilobite faunas of these ages been described (Chatterton and Ludvigsen, 1976; Ludvigsen, 1979c), but these faunas belong to platform margin, open shelf paleocommunities that are notably different from the platform centre, somewhat restricted shelf paleocommunities of the Red River Formation.

The availability of a number of trilobites from the Selkirk Member of the Red River Formation exposed at Garson-Tyndall and East Selkirk in the collections of the Manitoba Museum of Man and Nature, Winnipeg; the Geological Survey of Canada, Ottawa; the University of Alberta, Edmonton; and in collections accumulated over many years by Prof. E.I. Leith of the University of Manitoba prompted us to undertake a systematic study of these fossils. Field work by Westrop in the Garson area for two months in 1978 augmented the trilobite collections and provided critical data on carbonate sedimentology and paleoecology.

The number of trilobites in the combined collections is not great. The 151 specimens available for study from the Selkirk Member at Garson, however, include representatives of twenty genera and, at least, twenty-three species of trilobites. More than half of these specimens belong to only four genera – *Bumastoides, Illaenus, Ceraurinus,* and *Amphilichas.* Thus, the Garson assemblage shows close similarities to those Ordovician trilobite assemblages that have been termed the illaenid-cheirurid type by Fortey (1975).

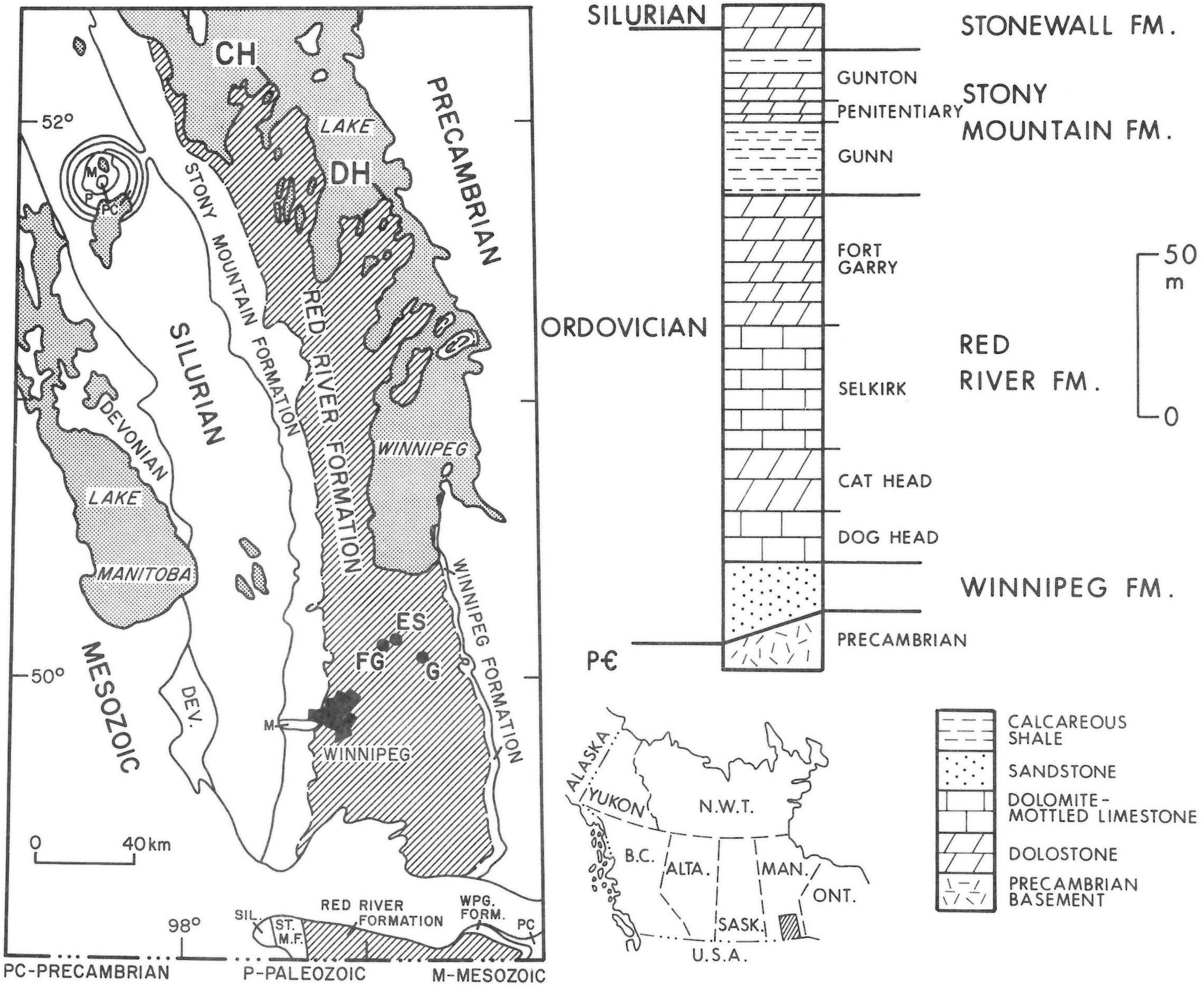

FIGURE 1: Generalized geologic map showing outcrop pattern of Ordovician formations in southern Manitoba and a schematic lithologic column. Localities that yielded Red River trilobites are indicated: Cat Head (CH), Dog Head (DH), East Selkirk (ES), Garson (G), and Fort Garry (FG).

ACKNOWLEDGEMENTS

This study could not have been completed without the assistance of a number of individuals and institutions who loaned us their entire collections of Red River trilobites. We are particularly indebted to Prof. E.I. Leith of the University of Manitoba who made available a large collection of trilobites from Garson. Smaller collections were loaned by George Lammers of the Manitoba Museum of Man and Nature, Winnipeg; T.E. Bolton of the Geological Survey of Canada, Ottawa; R.J. Elias of the University of Manitoba; and B.D.E. Chatterton of the University of Alberta, Edmonton. H.R. McCabe of the Geological Services Branch, Manitoba Department of Energy and Mines provided helpful stratigraphic data.

We are grateful to Mr. F.J. Gillis of Gillis Quarries Ltd. for granting permisssion to collect at the Garson quarries and to the quarry superintendent and staff for co-operation during the period of field work.

The photography is by Brian O'Donovan and the drafting by Subhash Shanbhag, both of the Department of Geology, University of Toronto.

STRATIGRAPHY OF THE RED RIVER FORMATION

The Red River Formation is a carbonate unit that overlies sandstones and shales of the Winnipeg Formation and underlies calcareous shales, limestones, and dolostones of the Stony Mountain Formation. The outcrop belt of the Red River Formation averages 65 km in width and trends roughly north-south between the United States border and Dog Head on Lake Winnipeg. North of Dog Head, the Ordovician outcrop belt curves to trend roughly north-northwest (Fig. 1).

The first detailed description of the Red River Formation in southern Manitoba was provided by Dowling (1900), who recognized three divisions. In descending order:

(3) Upper Mottled Limestone
(2) Cat Head Limestone
(1) Lower Mottled Limestone

Dowling considered the Red River to be equivalent to the "Trenton" of Minnesota (that is, the Galena Group). Foerste (1928) formally named the remaining divisions of Dowling's stratigraphic classification:

(3) Selkirk limestone
(2) Cat Head limestone
(1) Dog Head limestone

The Dog Head and Selkirk Members were thought to be synonymous by Sinclair (1959) who concluded that the Red River Formation in southern Manitoba consists of an upper Cat Head Member of aphanitic limestone and dolostone with chert, and a lower Dog Head Member of fragmental limestone with dolomite mottling.

McCabe and Bannatyne (1970) and McCabe (1971) have shown that Sinclair erred in equating the Dog Head and Selkirk, and maintain that these members are discrete mappable units that are, in most areas, separated by the Cat Head Member. (McCabe, pers. comm.). McCabe and Bannatyne (1970) recognized a post-Selkirk and pre-Stony Mountain unit and proposed a four-fold division of the Red River Formation. In descending order (thickness information for Garson area is from McCabe, pers. comm.)

(4) Fort Garry Member (35 m of mainly dolostones)
(3) Selkirk Member (50 m of dolomite-mottled limestones)
(2) Cat Head Member (15 m of calcitic and cherty dolostones)
(1) Dog Head Member (45 m of dolomite-mottled limestones)

Sinclair's (1959) interpretation of Red River stratigraphy was followed by McGregor et al. (1971) who placed their Cat Head fossil assemblages of palynomorphs, cephalopods, and sponges above the Selkirk Member in the upper part of the Red River Formation. These assemblages, however, occur below the Selkirk Member according to the correlations of McCabe and Bannatyne (1970).

The Red River Formation of southern Manitoba thickens southwards towards the depocentre of the Williston Basin. Porter and Fuller (1959) recognized an Upper Red River and a Lower Red River in the subsurface of the Williston Basin. McCabe (1971) correlated the former with the Fort Garry Member and the latter with the Selkirk, Cat Head, and Dog Head Members. Recently, Kendall (1976) elevated the Upper and Lower Red River in the Williston Basin to formational status and named them the Herald and Yeoman Formations, respectively.

The Selkirk Member is poorly exposed over the outcrop belt (Baillie 1952). However, the "Tyndall Stone interval" of the Member provides an attractive building stone which has been exploited in quarries in the Garson-Tyndall and East Selkirk districts, about 40 km north-east of Winnipeg (Fig. 1). The majority of quarries are now inactive and most are partly flooded. The best sections available are in two excavations owned by Gillis Quarries Ltd., at Garson, where the stone is cut from the quarry face using large circular saws. The resultant cut surfaces are excellent for making detailed abundance counts of the macrofauna. A composite section of nearly 6 m is available for examination.

Using data from the Manitoba Mines Branch shallow cores, Kendall (1977) has shown that the Garson exposure lies within the lower third of the Selkirk Member. Dip of the bedding is less than one degree and, therefore, negligible.

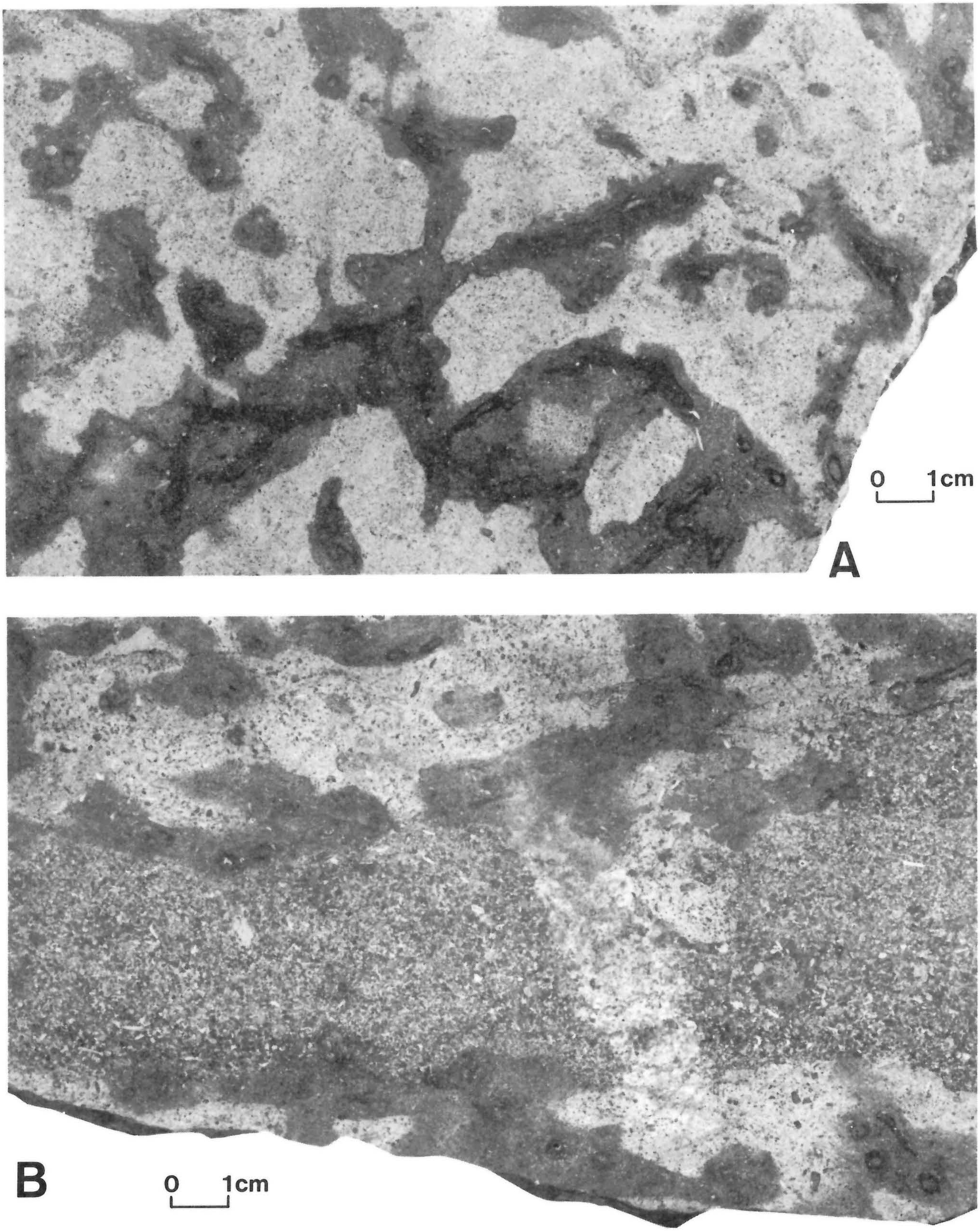

FIGURE 2: A. Dolomite-mottled wackestone to packstone biomicrite showing small meniscus-fill burrows reworking larger *"Spongeliomorpha paradoxica"* burrows. Polished slab cut parallel to bedding, Selkirk Member at Garson. B. Grainstone biosparite storm sheet overlain by burrow mottled wackestone to packstone biomicrite. Polished slab cut perpendicular to bedding, Selkirk Member at Garson.

ENVIRONMENTAL SEDIMENTOLOGY OF THE SELKIRK MEMBER

The sedimentology of the 5.6 m sampled interval of the Selkirk Member at Gillis Quarries, Garson, was studied to provide a paleoenvironmental framework within which the paleoecology of the fauna may be considered. General observations were made on the diagenesis, but a detailed study of the complex syn- and post-sedimentary changes is beyond the scope of this paper (see Kendall, 1977).

The entire section consists of dolomite-mottled wackestone to packstone biomicrites (Fig. 2A and Kendall 1977, fig. 3), with scattered two to three centimeter thick calcarenite stringers composed of packstone biomicrite to grainstone biosparite (Fig. 2B). Echinoderm debris, especially pelmatozoan columnals, are the dominant bioclasts.

As has already been noted by Kendall (1977), the dolomitic mottles are composed of microcrystalline to microsucrosic dolomite (Fig. 2A and Kendall 1977, fig. 3B). Calcitic echinoderm debris, present within the mottles, is commonly slightly corroded at the edges by dolomite. Kendall has argued that these mottles are probably burrows. A burrow origin is supported by the observation that bioclasts at the margins of the mottles are not truncated, although they may be slightly corroded by dolomite. This indicates that the mottles do not represent voids produced by erosion of lithified limestone; for example, during karstic weathering. Kendall (1977) also demonstrated that the mottles are preferentially reworked by smaller, dolomitized meniscus-fill burrows. Undolomitized versions of these smaller burrows may also be seen in the "normal" limestone surrounding the large mottles, although they are very much reduced in numbers.

Pressure solution has been extensive within the section, and all the sedimentary contacts have been stylolitized.

The abundance of wackestone biomicrites suggests that quiet water conditions prevailed during the deposition of most of the studied interval. Although wackestone is the most commonly encountered lithology, patches of packstone are generally present in any slab examined. This inhomogeneity may be the result of bioturbation.

The calcarenities are composed of abraded clasts and, in some cases, display vague crosslamination. They are best interpreted as the result of occasional storm activity. Calcarenite stringers usually cannot be traced laterally for more than a few metres. This feature seems to be best ascribed to the effects of bioturbation. Bioclasts present in the calcarenites represent organisms from the autochthonous paleocommunity present in the section at Garson. No "exotic" taxa are present. Therefore, transportation of material by storms seems to have been negligible.

It would appear that the limestones present at Garson were deposited under quiet, fairly shallow, subtidal conditions, which were occasionally interrupted by storm generated currents. Shaw (1964) has suggested that elevated water temperatures and salinities are likely to have occurred locally in epeiric seas. However, the composition of the Selkirk paleocommunity suggests that salinity did not depart too far from that of normal sea water during the deposition of the interval considered herein.

An environmental parameter which is of particular interest to the ecology of benthic organisms such as trilobites is the nature of the substrate, which is often an important limiting factor (Craig and Jones 1966; Rhoads and Young 1970). Consideration of the state of preservation of biogenic structures may give some indication of the stability and mass properties of the substrate (Rhoads 1970).

The outlines of the large dolomite burrow-mottles are sharp, with roughly circular cross-section (Fig. 2A); deformation at the burrow margins appears to have been slight. These features indicate the presence of a firm substrate (Rhoads 1970; Goldring and Kazmierczac 1974). The burrows were probably open tubes, by comparison with recent crustacean burrows described by Shinn (1968). Such an open network would require a firm substrate to avoid collapse. This indicates the existance of a firm substrate during the deposition of the Selkirk Member exposed at Garson.

The Selkirk Member at Garson has undergone a complex history of syn- and post-sedimentary changes. Kendall (1976, 1977) has proposed a model for the early diagenesis of this and other Ordovician dolomite-mottled limestone units. This model involves synsedimentary submarine lithification in a thin layer close to the sediment-water interface; the cement is thought to have been high magnesium calcite. Farther down, some distance below the surface but still within the zone of influence of the burrows, was a zone of aragonite dissolution. Mollusc skeletons were dissolved at this level. Sediment infiltrated into the shell molds via the burrow systems and was reworked by meniscus-fill deposit feeder burrows. Dolomitization was not synsedimentary, but occurred at a later post-sedimentary stage. In the case of dolomite-mottled limestones, only a single dolomitization event is involved.

There seems to be little doubt that aragonite dissolution in the Selkirk Member is synsedimentary, but the extent to which synsedimentary lithification occurred is debatable. Kendall (1977) felt that early cementation of the host sediment was implied by the lack of deformation of the shell molds and the large burrow mottles, even though the fills of both had been reworked later by the small meniscus-fill burrows.

The large burrow systems closely resemble the *"Spongeliomorpha paradoxica"* burrow systems which characterize synsedimentary hardgrounds in the Chalk (Upper Cretaceous) of Great Britain (Kendall 1977). Kendall also noted that the reworking of the fills of the large burrow-mottles by the smaller meniscus-fill burrows is reminiscent of the pre- and post-omission suites of trace fossils observed in Chalk hardgrounds by Bromley (1975). *"Spongeliomorpha paradoxica"* appears to be a deformed version of the ichnogenus *Thalassinoides* (Kennedy 1975). Its irregular appearance is attributed to its having been constructed in a substrate which was undergoing cementation (see Bromley 1975 and Kennedy 1975 for details). However, in the case of the Selkirk burrow-mottles, it is by no means certain that such an explanation may be used to account for their somewhat irregular form. "Normal", regular versions of the burrows are not known and the identity of the producers is, at best, speculative.

Studies of modern crustacean burrows by Shinn (1968) and Pemberton *et al.* (1976) are also relevant to the question of the extent of synsedimentary lithification of the Selkirk Member. Shinn (1968) has documented open callianassid burrows down to two and a half metres in recent carbonate sediments of Florida. He estimated that some burrows had remained open for at least 1000 years. It seems reasonable to suggest that the large burrow-mottles may have been able to survive compaction without early cementation being involved. Also, the fills would have been protected from extensive compaction. Work by Pemberton *et al.* (1976) on large shrimp burrows in sediments off the coast of Nova Scotia has shown that a significant water content difference may exist between burrow fills and surrounding sediment. The fills contain more water and, in some cases, are thixotropic. Accordingly, a significant contrast in coherency (and porosity) may exist between burrow fills and surrounding sediment without lithification being involved. The preferential reworking of the large burrow-mottle and shell mold fills by the smaller burrows in the Selkirk Member may simply reflect differences in water content between fills and host sediment.

There are considerable differences in the preservation of the shell molds illustrated by Kendall (1977: figs. 6-8). In many cases (eg. fig. 6B) the outer margin of the shell mold has been obliterated by bioturbation. While this may be due to the merging of the shell mold with burrows which predate aragonite dissolution, the exact timing of the burrows is by no means clear in each case. Common preservation of undeformed shell molds could occur in firm and cohesive, but unlithified sediment. Cases in which the outer margin of the shell mold is largely obliterated could equally well be explained by burrows which post-date aragonite dissolution abutting more or less completely cemented steinkerns. Synsedimentary, submarine lithification of steinkerns is well documented in the literature. Seilacher (1971) has described early lithification of steinkerns of ceratitid ammonoids from the Middle Triassic of Germany which did not involve lithification of the surrounding calcilutites. Taylor and Illing (1969: 79-80) have documented the cementation of sediment within skeletal cavities in recent intertidal and offshore sediments of the Persian Gulf. It is clear that early lithification may proceed in sheltered microenvironments, such as the interiors of shells, without cementation of the surrounding sediments taking place.

The evidence presented to date for the pervasive synsedimentary cementation of the Selkirk Member at Garson is somewhat equivocal. More work will be required to resolve this problem.

SYNECOLOGY OF THE SELKIRK MEMBER

A number of studies have demonstrated that the distribution of marine paleocommunities can be related to paleoenvironmental parameters. Among the recently published examples are the studies of the Middle Ordovician Black River Group and the Devonian Manlius Formation of New York State by Laporte (1967, 1969), Walker (1972b, c) and Walker and Laporte (1970). Examination of the paleocommunity present in the Selkirk Member at Garson may, therefore, allow refinement of the paleoenvironmental interpretation made on the basis of lithology. Owing to the relatively small stratigraphic extent of the sections available for study, it is not certain whether the generalizations proposed here are valid for the entire Selkirk Member.

Two quarries at Garson, located four hundred metres apart, provide a stratigraphic section that was examined in detail. Owing to the well-cemented nature of the limestones, "crack-out" methods of fossil extraction could not be used to obtain a sufficiently large sample for analysis. However, quarrying activities had produced vertical cut surfaces, which are amenable to study by the use of quadrats. All macrofossils within each quadrat above a certain size (one centimetre) were counted. For each of nine beds, fifteen quadrat samples were taken at a horizontal interval of two metres. A standard area of 0.6 m^2 was arbitrarily selected as a convenient sample size.

Extensive pressure solution has resulted in numerous, horizontal stylolitized surfaces and, apart from a few well defined (? bedding) surfaces, it proved impossible to correlate stylolite seams between quarries. It may be that some quadrats crossed bedding planes, but since there are no lithologic changes in either section, this does not greatly reduce the value of the data.

A number of problems exist in estimating the standing crop of trace fossils. Within a given bed, not all of the burrows would have been occupied at the same time. In addition, a single burrow may intersect a two-dimensional plane more than once (Walker 1972a). The extremely high densities of burrows throughout the section examined indicated that burrowing organisms were important contributors of biomass to the original community (Fig. 2A shows typical density of burrows on a slab cut parallel to bedding).

Because of the difficulties in determining the absolute abundance of burrowing organisms, the importance of each taxon within the paleocommunity will be expressed in terms of rank abundance (Walker and Bambach 1974a). The large burrow-mottles and meniscus-fill burrows are considered to have occupied first and second rank positions, respectively, within the paleocommunity. The rank abundance positions for the body fossils present in the paleocommunity were determined from the quadrat counts referred to above. Numerical abundance values were size-weighted to allow for the different sizes of the taxa present (the method of calculation of size-weighted abundances is outlined in Westrop, 1979).

The faunal assemblage present in the studied interval of the Selkirk Member may be regarded as the preservable remnants of an autochthonous paleocommunity. Several lines of evidence can be presented in support of this conclusion:

1) Over 80% of the body fossils, in terms of size-weighted abundance, occur in presumed position of life.

2) Fossils are unabraded except in thin calcarenite storm sheets. The calcarenite bioclasts consist solely of fragments of taxa occurring within the "normal" dolomite-mottled wackestones.

3) Apart from the storm sheets, there is no evidence for extensive current activity, and deposition occurred under quiet, subtidal conditions.

The position of pelmatozoans within the paleocommunity is uncertain. They are the dominant bioclast in both the wackestone and calcarenite stringers. Complete calyces and holdfasts are absent. The hydrodynamic properties of echinoderm debris result in extensive transportation (Ager 1963, p. 132), For these reasons, the pelmatozoan debris is considered to be largely transported and is therefore excluded from the paleocommunity. Similar conclusions were reached by Walker (1972b) in his consideration of the Black River Group subtidal level-bottom paleocommunity.

Study of the paleocommunity is hindered by the lack of knowledge of the zoological affinities of many of the important taxa; in particular, *Receptaculites* and the producer of the large burrow-mottles.

Stearn (1972) has demonstrated similarities between stromatoporoids and sclerosponges and has suggested that the former be regarded as a subphylum of Porifera; in which case they would be classified as filter feeders. Walker and Laporte (1970) also suggested a filter feeding mode of life for stromatoporoids.

The large burrow-mottles are similar to the Mesozoic ichnospecies *Spongeliomorpha paradoxica*, a trace considered to have produced by decapod crustaceans (Kendall 1977; Palmer 1978). Decapods are unknown in the Paleozoic and the name *"S. paradoxica"* type burrow is applied in the sense of Palmer (1978); that is, without implication of a crustacean origin. The largely horizontally directed, meandering nature of the *"S. paradoxica"* type burrows suggests deposit feeder activity (Walker and Laporte 1970) and, by comparison to modern callianassid burrows (see Shinn 1968), it is probable that they also functioned as dwelling structures.

The biological affinity of receptaculitids is controversial at present. Certain lines of evidence strongly suggest that they were a group of calcareous algae (Byrnes 1968; Campbell *et al.* 1974; Gould and Katz 1975) and this interpretation is followed here. Some workers, however, prefer to regard them as sponges (Foster 1973).

Laboratory examination of the body fossils revealed that many are infested with microborings. These borings have not been included in the abundance table (Table 1), but they must have been an important element within the paleocommunity. *Trypanities* is the boring most commonly encountered, especially in stromatoporoid colonies. These borings are generally infilled with sediment, which is usually non-dolomitized. Composite borings, produced by the coalescence of adjacent borings, are not uncommon. Elias (1980) has recently discussed the taxonomy of *Trypanities* and other borings from the Selkirk Member and used the distribution of borings to infer a "reclined" life orientation for the solitary rugose corals present in the Selkirk Member.

Walker and Bambach (1974b) have suggested trophic terminology for benthic invertebrates and this will be used herein. Under their system, corals are classified as passive predators. Both passive predators and suspension feeders are dependent upon organic matter suspended in the overlying water mass as a food source. Their responses to many environmental factors, such as water turbidity, would have been similar.

The autecologies and the rank abundances of the components of the paleocommunity are summarized in Table 1. Owing to difficulties in their recognition on two-dimensional cut surfaces, small fossils such as trilobites and brachiopods are probably under-represented.

Five of the first ten rank positions are occupied by organisms utilizing suspended organic matter (that is, stromatoporoids and corals), suggesting that suspended organic matter was fairly abundant. The different sizes of the various organisms exploiting suspended organic

TABLE 1: Components of paleocommunity present in the Selkirk Member at Garson

TAXON AND RANK ABUNDANCE	BIOLOGICAL AFFINITY	PRESERVATION	FEEDING TYPE AND POSITION	SIZE WEIGHTED ABUNDANCE OF BODY FOSSILS
1. "SPONGELIOMORPHA? PARADOXICA" type burrow	?Arthropod burrow	Dolomitized burrow fills	Infaunal deposit feeder	
2. Meniscus-fill burrow	Indet. "worm"	Dolomitized burrow fills, usually reworks "S. PARADOXICA"	Infaunal deposit feeder	
3. Mound stromatoporoid	?Porifera	Mounds in presumed life position	Epifaunal medium level suspension feeder	47.1%
4. PALAEOFAVOSITES	Tabulate coral	As for mound stromatoporoid	Epifaunal medium level predator	18.0%
5. RECEPTACULITES	Calcareous alga	Low level mounds, convex side up	Primary producer	15.3%
6. Nautiloids	Cephalopods	Dolomitized molds, up to 50 cm long	Nekto-benthic predator/scavenger	8.0%
7. "GREWINGKIA"	Solitary rugose coral	Long axis parallel to bedding	Epifaunal low level predator	7.0%
8. CATENIPORA	Tabulate coral	Low mounds	Epifaunal low level predator	2.0%
9. MACLURITES	Archeogastropod	Large molds, dolomitized	Epifaunal browser	1.5%
10. RAFINESQUINA	Strophomenid brachiopod	Articulated shells	Epifaunal low level suspension feeder	1.5%
11. CALAPOECIA	Tabulate coral	Low mounds attached to dead shells	Epifaunal low level predator	less than 1.0%
12. PROTROCHISCOLITHUS	Tabulate coral	As for CALAPOECIA	Epifaunal low level predator	less than 1.0%
13. Ectoprocts	Bryozoans	Small mounds or fenestellid colonies	Epifaunal low level suspension feeder	less than 1.0%
14. Trilobites	Arthropods	Disarticulated	Varied	less than 1.0%
15. FUSISPIRA and HORMOTOMA	Archeogastropods	Dolomitized molds	Epifaunal browsers	less than 1.0%

matter suggest that competition may have been avoided by stratification of feeding heights (Walker 1972a). In addition, the rugose corals could probably exploit particles such as larger zooplankton that were not available to the stromatoporoid and smaller tabulates, so that some partitioning may have occurred in this way. However, it may not be necessary to invoke partitioning of food supplies to explain the abundance of passive predators and suspension feeders in the paleocommunity. Levinton (1972, 1974) has suggested that owing to the low predictability of supplies of suspended organic matter, there is unlikely to be competition for food between organisms using this resource, but competition may have existed for other niche dimensions, such as space.

Although probable deposit feeders occupy the first two positions in the paleocommunity, competitive trophic interactions appear to have been minimal. The smaller burrower seems to have preferentially reworked the fills of the *"S. paradoxica"* type burrow.

The subtidal, level-bottom paleocommunity described by Walker and Laporte (1970) and Walker (1972b) from the Black River Group of New York State is close in composition to that of the Selkirk Member and is the only comparable Ordovician benthic "community" which has been described to date. Corals and stromatoporoids are very important elements in both. There are, however, some differences which may be seen by comparing the Selkirk abundances tabulated in Table 1 with the rank abundance data published by Walker (1972b; table 7). Ectoprocts are ranked third in the Black River paleocommunity, but are rare elements in the Selkirk Member. Benthic calcareous algae are a major group (ranked second) in the Black River level-bottom environment, whereas in the Selkirk calcareous algae *(Receptaculites)* are ranked fifth. There are general similarities in terms of lithology – the Black River level-bottom community occurs in burrow-mottled bioclastic muds (Walker and Laporte 1970; Walker 1972b), as does the Selkirk paleocommunity.

The Black River level-bottom paleocommunity (and its congruent paleocommunity in the Devonian Manlius Formation) was interpreted as having existed under somewhat restricted, shallow subtidal conditions (Walker and Laporte 1970: 940). Anderson (1971) has demonstrated the general correlation between Paleozoic "community" types and paleoenvironmental setting, and Walker and Laporte (1970) have suggested that paleocommunities in shallow marine carbonate environments underwent little structural evolution between the Middle Ordovician and the Lower Devonian. Therefore, from a consideration of the paleoecological data, a fairly shallow, somewhat restricted environment is inferred for the paleocommunity from the Selkirk Member. Berry (1974) has also suggested that Middle and Upper Ordovician paleocommunities of this type ("Nautiloid-archaeogastropod-tabulate coral-receptaculitid faunas") occupied shallow subtidal environments on the carbonate platform.

The great difference between the Selkirk paleocommunity and the open marine shallow and deep shelf paleocommunities *(Encrinurus* and *Trematis* communities, respectively) described by Titus and Cameron (1976) from the Lower Trenton Group of New York State appear to support the environmental interpretation adopted herein for the Selkirk Member. The Trenton paleocommunities are dominated by brachiopods, ectoprocts and crinoids; deposit feeder burrows are of lesser importance, corals are rare, and both stromatoporoids and receptaculitids are absent. None of the five paleocommunities recognized in the Trenton are comparable to the one described here.

In conclusion, it is considered that the compositions of the paleocommunities from the interval of the Selkirk Member examined at Garson and from the subtidal, level-bottom environment in the Black River Group are broadly comparable and that these similarities probably reflect comparable paleoenvironmental settings.

PALEOECOLOGY OF THE SELKIRK TRILOBITE ASSEMBLAGE

The trilobite assemblage from Garson is dominated in terms of simple numerical abundance by the families Illaenidae (49%), Cheiruridae (23%) and Lichidae (11%); Isotelinae (7.3%) is also fairly common (see Table 2 for further details). It is therefore an example of the illaenid-cheirurid trilobite "community" type (Fortey 1975). Although many of the trilobites were obtained from collections at the Manitoba Museum of Man and Nature and the University of Manitoba, field work at the Garson site during July and August 1978 has shown that the dominance of illaenids, cheirurids and lichids is not due to sampling bias. The small vertical extent of the Garson exposure, together with the constancy of lithology, sedimentary environment and associated fauna, indicate that the collection considered herein is drawn from a single trilobite association. There is little evidence for abrasion of the trilobite material except in thin storm sheets, and large articulated specimens, for example *Bumastoides*, have been found. These features, together with the quiet, subtidal conditions which prevailed during the deposition of the studied portion of the Selkirk Member, indicate that the Garson trilobite assemblage is autochthonous.

The trilobites in the Selkirk association are considered to have been benthic. None of the trilobites shows the morphological adaptations of pelagic forms (Fortey, 1974).

The broad, low convexity exoskeletons of *Amphilichas* and *Eobronteus* suggest that these genera may have been epifaunal crawlers and a similar mode of life is inferred for *Failleana*. Unlike genera such as *Bumastoides*, the palpebral lobes of *Failleana* (and therefore the visual field) are horizonal when the exoskeleton is in a horizontally extended position. This lends further support to the notion that this genus was epifaunal.

In the case of cheirurine genera such as *Ceraurinus* and *Ceraurus* an epifaunal existence again seems probable. It is difficult to draw any conclusions as to exact details of their life habits. From a consideration of appendage morphology of *Ceraurus* and *Phacops*, Bergström (1969) suggested that these genera were carnivores. Enditic jaws appear to be present in the latter genus (Bergström 1973; Stürmer and Bergström 1973). A predatory existence is thus possible for cheirurine genera, although scavenging and/or filtering are equally as likely.

Holloway and Campbell (1974) have developed a model for the life habits of the deiphonine *Onycopyge* which involves epifaunal deposit feeding. This seems reasonable and a similar existence may be inferred for *Sphaerocoryphe*.

Illaenine trilobites such as *Bumastoides*, *Stenopareia* and *Illaenus* and panderines such as *Panderia* share a strongly convex, effaced morphology. Bergström (1973) concluded that this morphotype represented an adaptation for an infaunal life. Similar morphologies occur in certain bumastines *(Bumastus)* and asaphids *(Anataphrus* and *Nahannia)*. Stitt (1976) has discussed the functional morphology of effaced,

TABLE 2: Composition and abundance of trilobites in collections from the Selkirk Member at Garson

SPECIES NAME	COMPLETE INDIVIDUALS	CEPHALA/ CRANIDIA	PYGIDIA	TOTAL INDIVIDUALS
BUMASTOIDES TENUIRUGOSUS	3	29	16	32
ILLAENUS AMERICANUS		13	9	13
CERAURINUS cf. ICARUS	1	11	3	12
AMPHILICHAS cf. CUCULLUS		10	4	10
SPHAEROCORYPHE ROBUSTUS	1	8		9
FAILLEANA INDETERMINATA	2	3	5	7
STENOPAREIA GARSONENSIS		4		4
NAHANNIA GRATIOSA	2	1	1	3
BOREALASPIS WHITTAKERENSIS		3		3
CALYPTAULAX cf. SCHMIDTI		3		3
ECTENASPIS sp.	1	1		2
ENCRINUROIDES sp.		1	2	2
FLEXICALYMENE cf. SENARIA	1	1		2
CALYPTAULAX spp.			2	2
ISOTELUS cf. GIGAS			2	2
ISOTELUS sp.		1		1
HYPODICRANOTUS sp.		1		1
EOBRONTEUS cf. SLOCOMI			1	1
DOLICHOHARPES DENTONI		1		1
CERAURUS cf. TUBEROSUS		1		1
ACANTHOPARYPHA sp.		1		1
HEMIARGES cf. TUBERCULATUS		1		1
AMPHILICHAS cf. CLERMONTENSIS		1		1
	11	95	45	114

strongly convex representatives of the Upper Cambrian family Plethopeltidae *(Stenopilus* and *Plethometopus)* and has proposed that they also adopted an infaunal mode of life. Finally, Owens (1978) has noted morphological similarities between the unique Ordovician proetid *Isbergia* (Aulacopleuridae) and *Panderia,* and has suggested that they shared the same life habits.

It is probable that the occurrence of convergent morphologies in a number of unrelated families is due to the adoption of infaunal habits by some of their members. Occupation of the infaunal niche had taken place by, at least, the Late Cambrian with the appearance of the plethopeltids. Representatives of the Illaeninae, Panderinae, Asaphidae and Aulacopleuridae filled this niche during the Ordovician, and the record of infaunal trilobites was extended into the Silurian by some bumastines *(Bumastus)* and illaenines *(Stenopareia).* Certain effaced, convex Devonian scutelluids *(Paralejurus)* may also have been infaunal.

Convex, effaced trilobites are numerically dominant members of the illaenid-cheirurid trilobite "community" type of Fortey (1975). This recurrent association of trilobites has been recognized from shelf-edge mud mound (Antelope Valley Limestone of Nevada, see Ross 1972; Fortey 1975), on-shelf patch reef (Chazy Group of New York State, see Shaw 1968; Fortey 1975) and shallow subtidal carbonate (this paper) environments. Published examples of illaenid-cheirurid associations occur in environments which may be demonstrated or inferred to have had relatively firm, cohesive substrates. This distribution pattern may be related to the requirements of an infaunal existence – illaenid burrows could be maintained most easily in firm substrates.

AGE AND CORRELATION OF THE RED RIVER FORMATION

The faunas of the Red River Formation in southern Manitoba are central to the longstanding controversy about the age and correlation of the "Arctic Ordovician" fauna in western North America. W.H. Twenhofel and G.M. Kay presented two opposing viewpoints about the age of the Red River (in Twenhofel et al., 1954, p. 281, 282). Twenhofel considered the Red River to be Late Ordovician (Richmondian) in age and correlative to the "English Head Formation" (equivalent to part of the Vaureal Formation; Bolton, 1972) of Anticosti Island while Kay supported a Middle Ordovician (Trentonian) age and suggested that the Red River, Cape Calhoun, Bighorn and similar carbonate units in western and northern North America are correlative to the Trenton Group of New York, Ontario and Quebec. Twenhofel's view prevailed, and on the correlation chart (Twenhofel et al., 1954, pl. 1) the Winnipeg, Red River, and Stony Mountain Formations are shown as Richmondian and above a pronounced Edenian and Maysvillian regional unconformity.

Recent biostratigraphic work on conodonts from the type Cincinnatian and the Trenton Group in New York State (Sweet and Bergström, 1971, 1976) has indicated that the age discrepancy of the Red River Formation is not as great as previously supposed. Sweet and Bergström demonstrated that there is considerable overlap of the Cincinnatian and the Trentonian and that the top of the Trenton Group in New York State is as young as mid-Maysvillian.

The trilobite fauna from the Selkirk Member of the Red River Formation in southern Manitoba is similar to faunas from both the Cobourg Formation of southern Ontario (Ludvigsen, 1978) and the Kimmswick Limestone of Missouri and Illinois (Bradley, 1930). The following Red River species are close to, or identical with, Cobourg or Kimmswick species: *Isotelus* cf. *gigas, Illaenus americanus, Flexicalymene* cf. *senaria, Failleana indeterminata, Dolichoharpes dentoni, Amphilichas* cf. *cucullus, Eobronteus* cf. *slocomi,* and *Sphaerocoryphe robustus.*

A few species are shared with the Cape Calhoun Formation of northern Greenland but, unfortunately, reliable stratigraphic data do not exist for this unit. Troelsen (1950) suggested that the fossils described by Troedsson (1928) came from at least two separate stratigraphic horizons. The following Red River species are close to, or identical with, Cape Calhoun species: *Bumastoides tenuirugosus, Nahannia gratiosa, Ceraurus* cf. *tuberosus,* and *Hemiarges* cf. *tuberculatus.*

With the exception of *Borealaspis whittakerensis* and *Sphaerocoryphe robustus,* there is not much in common between the illaenid-dominated fauna of the Red River and the cheirurid-dominated fauna of the lower Whittaker Formation in the District of Mackenzie (Ludvigsen, 1979c). The two species occur in the *Ceraurus mackenziensis* Zone which was assigned a late Middle Ordovician age. In view of the strong similarity of the trilobites of the *C. mackenziensis* Zone and those of the Hanson Creek Formation in Nevada (which occur in strata that are well-dated as Maysvillian and Richmondian; Ross et al., 1980), it is likely that the ages of the *C. mackenziensis* Zone and the overlying *Whittakerites planatus* Zone in the District of Mackenzie should be revised upward.

Some species from the Red River Formation have affinity for Richmondian species in eastern North America; among them, *Ceraurinus* cf. *icarus, Ectenaspis* sp., and *Amphilichas* cf. *clermontensis.* This similarity is probably attributable to eastward migration of some trilobites of the "Arctic Ordovician" fauna during the mid-Late Ordovician. Many brachiopods display the same distribution pattern (Macomber, 1970).

The trilobites of the Selkirk Member at Garson are minor components of the "Arctic Ordovician" fauna; a paleocommunity that developed on firm substrates in shallow, subtidal, level-bottom settings in the interior and western parts of North America. In being dominated

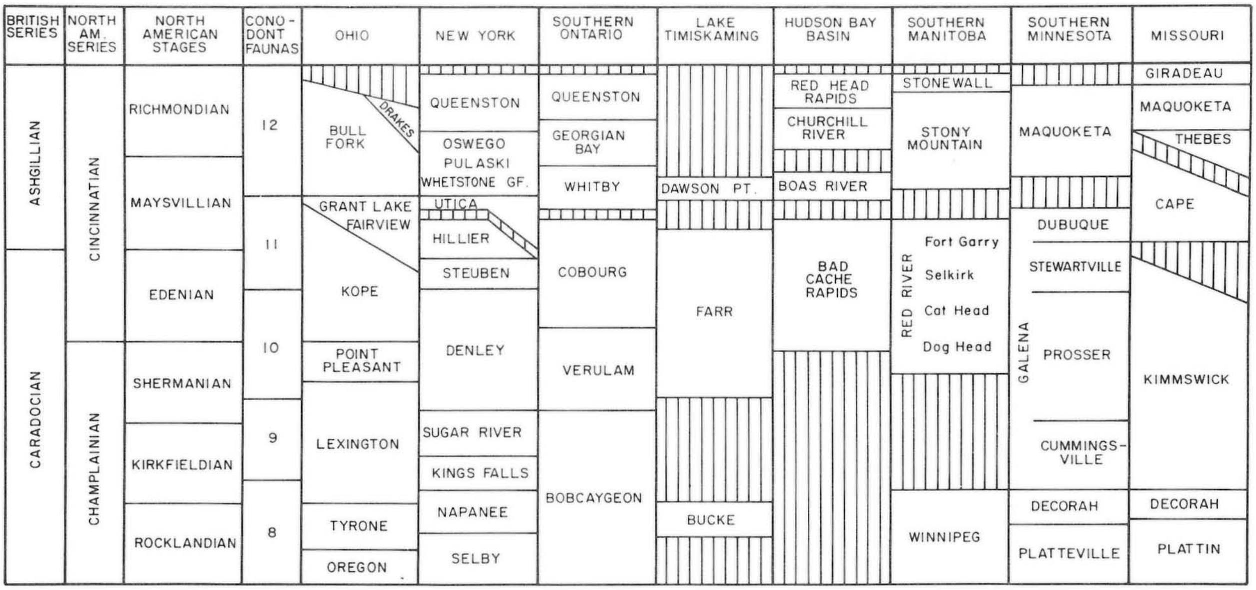

FIGURE 3: Correlation chart of upper Middle and Upper Ordovician formations in central and eastern North America (based largely on Sweet and Bergström, 1976 and Barnes *et al.,* 1976).

by large illaenids, cheirurids, and lichids (*Bumastoides, Illaenus, Ceraurinus, Amphilichas;* Table 2), the Selkirk trilobite fauna differs markedly from other late Middle and Late Ordovician trilobite assemblages in North America, most of which are dominated by asaphids, cheirurids, and pterygometopids (in particular, *Isotelus, Ceraurus,* and *Calyptaulax).*

The biofacies difference between the Selkirk Member and potential correlative units in eastern North America prevents any more than general correlations of the trilobite assemblages. The fauna from the Selkirk is most similar to those from the Kimmswick Limestone, Cobourg Formation, and Cape Calhoun Formation and, therefore, implies an Edenian and, possibly, early Maysvillian age for the Selkirk Member (Fig. 3).

These correlations receive general support from conodont biostratigraphy. Conodont Fauna 8 (Rocklandian/Kirkfieldian) occurs in the upper Winnipeg Formation (Oberg, 1966; Sweet and Bergström, 1976). Fauna 9 (Kirkfieldian/Shermanian) has not been recovered from either the Winnipeg or the Red River Formations. Vigrass (1971) suggested that a hiatus occurs between these units. Faunas 10 and 11 (Shermanian to Maysvillian) occur in the Red River Formation (Barnes and Munro, 1973; Barnes *et al.,* 1976). Fauna 12 (Maysvillian/Richmondian) occurs in the Stony Mountain and lower Stonewall Formations (Sweet and Bergström, 1976; Barnes et al., 1976).

SYSTEMATIC PALEONTOLOGY

Terminology used in descriptions follows the Treatise (Moore, 1959). The occipital ring is not included in the glabella, except for cases in which the occipital ring and occipital furrow are obsolete. Lateral glabellar furrows are numbered 1s, 2s, etc. from the rear. Lateral glabellar lobes are numbered 1p, 2p, etc. in the same direction.

The material is housed with the Geological Survey of Canada, Ottawa (GSC prefix), the University of Manitoba, Winnipeg (UM prefix), the University of Alberta (UA prefix), the Royal Ontario Museum, Toronto (ROM prefix), the Field Museum of Natural History, Chicago (FM prefix), and the Manitoba Museum of Man and Nature, Winnipeg (MM prefix).

Order Ptychopariida Swinnerton, 1915
Superfamily Remopleuridacea Hawle and Corda, 1847
Family Remopleurididae Hawle and Corda, 1847
Subfamily Remopleuridinae Hawle and Corda, 1847

Genus *Hypodicranotus* Whittington, 1952

Type species. Remopleurides striatulus Walcott, 1875 from the Middle Ordovician of New York State (by original designation).

Hypodicranotus sp.
Pl. 1, fig. 8.

Material. An incomplete external mold of a free cheek (GSC 64075) from the Selkirk Member at Garson.

Discussion. The specimen shows the basal part of a marginal cephalic spine and is therefore assigned to *Hypodicranotus* Whittington instead of to *Remopleurides* Portlock. The material does not allow an identification to be made at the species level.

Suborder Asaphina Salter, 1864
Superfamily Asaphacea Burmeister, 1843
Family Asaphidae Burmeister, 1843
Subfamily Isotelinae Angelin, 1854

Genus *Isotelus* DeKay, 1824

Type species. Isotelus gigas DeKay, 1824 from the Trenton Group, Trenton Falls, New York State (by original designation).

Isotelus cf. *gigas* DeKay, 1824
Pl. 1, fig. 1, Pl. 2, fig. 2, 3, 6.

Material: A complete exoskeleton (MMI129) from the Red River Formation (Cat Head Member?) at Lake Winnipeg. A complete exoskeleton (GSC 1799) and a nearly complete exoskeleton (GSC 1798) from the Cat Head Member, Inmost Island, Lake Winnipeg; an external mold (GSC 7173d) from the Cat Head Member, Cat Head, Lake Winnipeg; and about ten additional specimens from the Cat Head Member, Manitoba. An incomplete thorax and pygidium (GSC 64076) and a pygidium from the Selkirk Member at Garson are also assigned to this species.

Description. Cephalon of low convexity, subtriangular in outline, length (sag.) somewhat less than three-quarters of maximum width (tr.), and comprises one-third of length (sag.) of exoskeleton. Glabella indistinct and of low convexity. Axial furrows very shallow and converge forward to a point opposite anterior tips of eyes; forward from this point, furrows barely perceptible and parallel course of facial sutures. Anterior portion of cephalon slopes down to flattened border. Cranidium wide (tr.), width between palpebral lobes three-quarters of cephalic width (tr.). Palpebral lobes semicircular in outline and elevated above adjacent parts of cranidium; palpebral furrows very weak. Eyes crescentic in outline, with steeply inclined visual surfaces, and situated posteriorward of mid-length, close to lateral cephalic margin. Anterior branches of facial suture diverge initially forward to a point close to anterolateral cephalic margin; from here, converge abruptly forward, running parallel with, and close to, margin, to join a short distance from "apex" of cephalon and on sagittal line. Anteriorward of this point median suture runs along sagittal line to margin. Posterior branches diverge abruptly backwards in a curve, convex to lateral cephalic margin, to cut posterior margin midway between axial furrow and genal angle. Occipital ring and furrow obsolete and genal angles rounded.

Thorax of low convexity, with eight segments and comprises one-third of length (sag.) of exoskeleton. Axis wide (tr.) and weakly to moderately convex. Pleurae initially flat, but then curve downward and backward away from axis. Each pleura has shallow pleural furrow directed posterolaterally away from axis; pleural ends rounded.

Pygidium subtriangular in outline, length (sag.) a little more than three-quarters of width (tr.) and accounts for one-third of exoskeleton length (sag.). Axis very poorly defined and narrows backward. Articulating facet present at anterolateral corner of pygidium. One interpleural furrow present at anterior end of pygidium, remainder of pleural fields smooth; axis also smooth. Border well-defined, broad, length (sag.) one-sixth of pygidial length (sag.) and concave. Entire dorsal surface of exoskeleton ornamented with fine granules.

Discussion. The material from the Cat Head Member differs from *Isotelus gigas* DeKay, 1824 by the possession of a weakly convex thoracic axis that is raised only slightly above the adjacent parts of the pleural fields. However, these specimens show evidence of compaction, so that the true convexity of the axial lobe is difficult to determine. A single, uncompacted thorax and pygidium from the Selkirk Member, assigned to *I.* cf. *gigas* (Pl. 2, fig. 6) resembles *I. gigas* much more closely.

Isotelus sp.
(Pl. 2, fig. 1)

Material. An incomplete free cheek (GSC 64077) from the Selkirk Member at Garson.

Discussion. The free cheek assigned to *Isotelus* sp. carries a genal spine which tapers to a fine point, and thus differs from *I.* cf. *gigas*. Several species of *Isotelus* display genal spines in adult forms, including *I. iowensis* Locke, 1838 and *I. maximus* (Owen, 1852).

Genus *Ectenaspis* Raymond, 1920

Type species. Megalaspis beckeri Slocom, 1913 from the Maquoketa Formation at Clermont, Iowa (by original designation).

Diagnosis. (modified from Jaanusson, 1959b) Isoteline trilobite with anterior part of cephalon extended into an acutely-angled process; glabella only outlined at posterior end, behind level of eye stalks; distinct cephalic border and border furrow are not present; eyes are located on long stalks which slope forward and outward; genal angles bear long, stout genal spines. Hypostome is unknown. Thoracic axis is well defined, broader than pleurae. Pygidium is triangular in outline;

pygidial border is wide at posterior, behind axis; pygidial axial furrows are shallow but well-defined, and converge gently backward.

Occurrences. Maquoketa Formation of Iowa; Selkirk Member of the Red River Formation at Garson, Manitoba; unnamed Upper Ordovician strata, Akpatok Island, Ungava Bay.

Discussion. The genus *Ectenaspis* was established by Raymond (1920) to accomodate *Megalaspis beckeri* Slocom, 1913 from the Maquoketa Formation of Iowa. The most recent diagnosis of the genus (Jaanusson, 1959b, p. 341) states that the genal angles are rounded. However, examination of the type specimen of *E. beckeri* (UC 41151) reveals that an external mold of a long genal spine is evident on the right side of this specimen. The diagnosis of *Ectenaspis* must therefore be modified.

Trigonocercella Hintze, 1952 from the Upper Canadian (Zone J) of Nevada and Utah, appears to be the most similar North American genus to *Ectenaspis* (see Hintze, 1952, pl. 9, figs. 1-5). Like *Ectenaspis,* the glabella of *Trigonocercella* is poorly defined, and the pygidium is relatively smooth. It differs from *Ectenaspis* in that the cephalon, although somewhat extended anteriorly so that it is subtriangular in outline, lacks the anterior cephalic prolongation (the "snout" of Bohlin, 1960); the eye stalks are shorter; the pygidium bears a terminal spine; the genal spines are relatively more slender, and much shorter. The hypostome of *Trigonocercella* is of typical isoteline outline; that of *Ectenaspis* is unknown.

Ectenaspis is also superficially similar to the Scandinavian subgenus *Megistaspis (Megistaspidella)* Jaanusson, 1956 which has both long genal spines and an anterior cephalic prolongation. The illustrations presented by Bohlin (1960, pl. 8-12) show the following differences with *Ectenaspis:* cephalic axial furrows are more clearly defined and glabella is more strongly inflated; eyes are raised only slightly above adjacent parts of free cheeks; course of the facial suture differs – in *M. (Megistaspidella),* the anterior branches of the suture diverge initially in front of the eyes before converging forward, while the anterior branches of *Ectenaspis* converge gently forward; genal spines are slender; the interpleural and axial ring furrows of the pygidium are more clearly defined in *M. (Megistaspidella)* (see Bohlin, 1960, pl. 8, fig. 4, pl. 9, fig. 4).

Raymond (1920, 1925) also assigned *Isoteloides homolonotoides* Walcott, 1879 to *Ectenaspis.* The best illustration of the pygidium assigned to this species (Raymond, 1913, pl. 4, fig. 1) shows that it is similar to that of *E. beckeri,* but it differs in possessing a wider, concave border which is of uniform width (tr.) along the entire lateral pygidial margin. However, Raymond's illustration (1925, pl. 4, fig. 10) of the cephalon of Walcott's type of *I. homalonotoides* shows that its assignment to *Ectenaspis* cannot be justified. The glabella is well-defined, extending beyond the eyes, and has two pairs of lateral glabellar furrows. It is clearly different from that of *Ectenaspis.* The cephalon and pygidium illustrated by Raymond may represent two different trilobites.

Cox (1933) described two pygidia from Upper Ordovician strata on Akapatok Island that he identified as *Megalaspis beckeri.* Although the illustrations are poor (pl. 20, fig. 18), his description suggests that these pygidia may be placed in *Ectenaspis.* However, Cox stated that the pygidium is "slightly produced anteriorly"; in which case it may be closer to *Ectenaspis* sp. from the Selkirk Member of the Red River Formation than to *E. beckeri.*

The discovery of long stout genal spines on a species of *Ectenaspis* from the Selkirk Member at Garson led us to investigate the type material of *E. beckeri* from the Upper Ordovician of Iowa. A description of the type species and illustrations of the holotype are included to substantiate the presence of long genal species in *Ectenaspis* and to correct the erroneous depiction of the eye stalks by Jaanusson (1959, fig. 252).

Ectenaspis beckeri (Slocom, 1913)
Pl. 1, figs. 2, 4, 10, Fig. 4

1913 *Megalaspis beckeri* Slocom, p. 50, pl. 14, fig. 5
1916 *Megalaspis beckeri* Slocom, p. 196, pl. 14, fig. 5
1920 *Ectenaspis beckeri,* Raymond p. 292
1924 *Ectenaspis beckeri,* Walter, p. 201, pl. 13, figs. 8, 9, pl. 27, fig. 22.
1925 *Ectenaspis beckeri,* Raymond p. 101, pl. 9, fig. 7.
1959b *Ectenaspis beckeri,* Jaanusson, p. 0341, fig. 252, 4.

Material. One nearly complete specimen (Holotype, UC 41151) from the Lower Maquoketa Formation, Clermont, Iowa; a partial cranidium (FM P16998) from the Lower Maquoketa Formation at Potsville Junction, Iowa.

Description. Cephalon acutely triangular in outline and accounts for more than one-third of exoskeletal length (sag.). Anterior half of cephalon in form of elongate, tongue-like prolongation. Cephalon most elevated at posterior end and slopes down anteriorly to base of prolongation; prolongation is directed upward at an angle of about fifteen degrees. Glabella clearly defined only at posterior end of cranidium, and is moderately convex. Axial furrows faint, subparallel and extend as far forward as the posterior end of the base of the eye stalk. Lateral glabellar furrows, occipital ring and occipital furrow not evident. Eyes located at tips of long stalks, directed upward, outward and slightly forward. Base of each stalk subtriangular in outline, width (tr.) slightly more than one-third width (tr.) of cephalon at posterior end, and outlined on anterior and posterior side by shallow furrows. Posterior furrow extends posterolaterally almost as far as genal angle and serves to define short (exsag.) posterior border. Posterior branches of facial suture diverge gently backward, to cut posterior cephalic margin about midway between axial furrows and genal angle. Anterior branches converge gently forward, running parallel with cephalic margin, to join at anterior end of cephalic prolongation. Cranidium broad, width (tr.) at posterior almost three-quarters of cephalic width (tr.). Posterolateral corners of cephalon extended into long (exsag.), stout, faintly carinate genal spines.

Thorax has eight segments. Axis broad, width (tr.) a little less than one-half of thoracic width (tr.) and moderately convex. Axial furrows shallow, but well-defined, and converge very gently backward. Pleural fields horizontal near axis, but distally dip steeply downward. Each pleura bears shallow pleural furrow, running posterolaterally away from axis for about one-half pleural width (tr.). Broad (exsag.) articulating facet present on distal end of each pleura.

Pygidium triangular in outline, width (tr.) a little more than length (sag.) and moderately convex. Anterolateral corners with articulating facet and one deep interpleural furrow. Axis broad, width at anterior one-third of pygidial width, and raised above adjacent parts of pleural fields; terminates a short distance from posterior tip of pygidium. Axial furrows shallow but clearly defined; axial ring furrows barely perceptible. Pleural fields initially horizontal, then dip downward away from axis; interpleural furrows very faint. Pygidial border present posteriorly, behind level of posterior tip of axis.

Ectenaspis sp.
Pl. 1, figs. 3, 5-7, 9

Material. One individual showing a complete thorax, a nearly complete pygidium and a partial cephalon (GSC 64083) and an external mold of a genal spine (GSC 64084), both from the Selkirk Member at Garson.

Discussion. Although the anterior cephalic prolongation is not preserved in *Ectenaspis* sp., the genal spines and the location of the eye stalks seem to be identical to those of *E. beckeri.* There is no significant difference between the thoraces of the two. The pygidium of *Ectenaspis* sp. appears to be extended at the posterior end, so that the border behind the tip of the axis is longer (exsag.) than that of *E. beckeri.* However, since the Garson specimens are incomplete, it is best to defer a decision on its specific identity until more material can be examined.

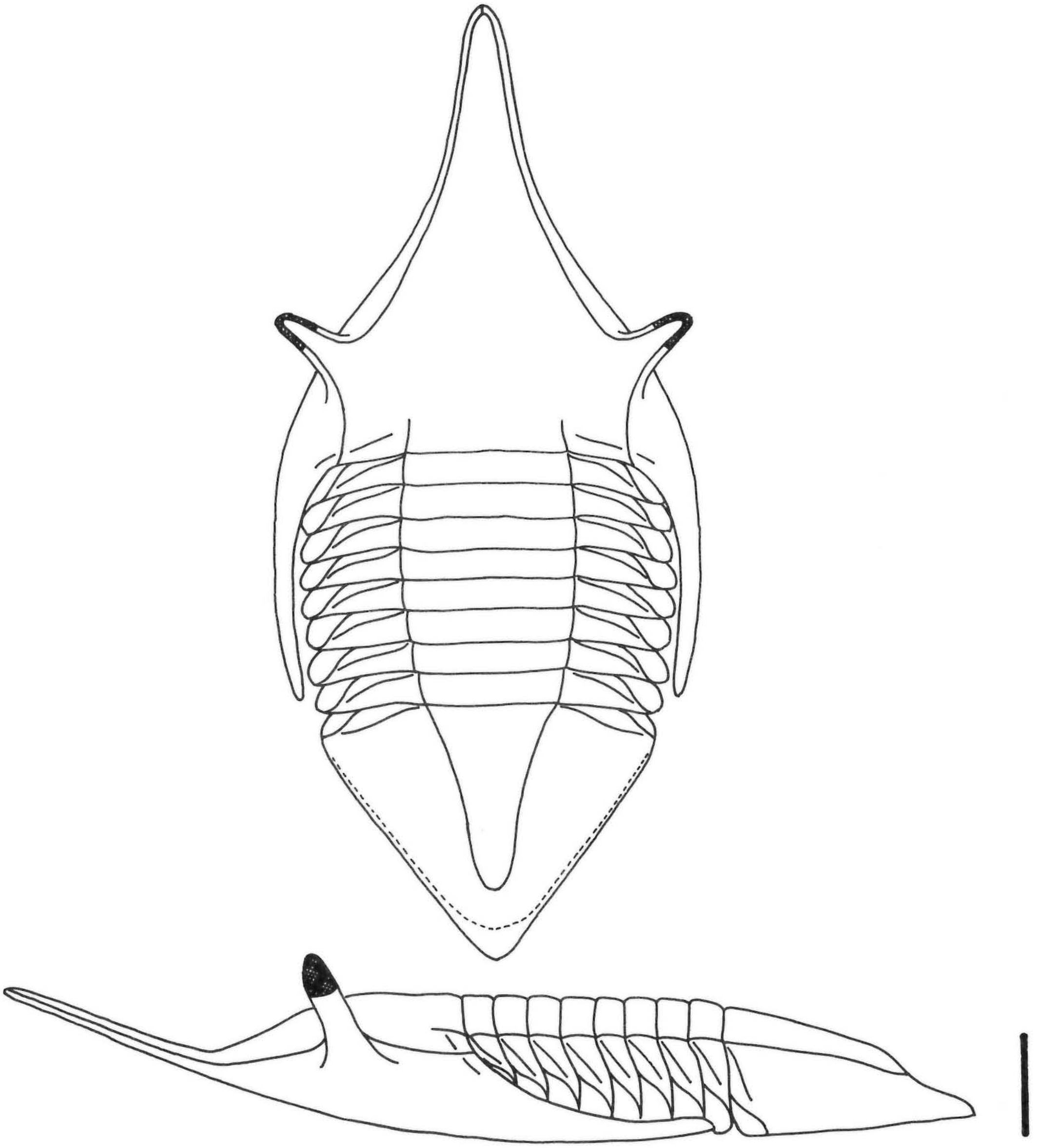

FIGURE 4: Reconstruction of holotype of *Ectenaspis beckeri* (Slocom) from the lower Maquoketa Formation, Clermont, Iowa; dorsal and lateral views, UC 41151. Bar represents 1 cm.

Genus *Nahannia* Chatterton and Ludvigsen, 1976

Type species. Nahannia humilisulcata Chatterton and Ludvigsen, 1976 from the Esbataottine Formation, Sunblood Range, southern District of Mackenzie (by original designation).

Discussion: Nahannia was established by Chatterton and Ludvigsen (1976) for a group of North American isoteline trilobites that appears to differ from *Brachyaspis* Salter, 1866 in possessing a median connective suture, among other features. In keeping with the diagnoses presented by both Jaanusson (1959b) and Poulsen (1959), Chatterton and Ludvigsen suggested that *Brachyaspis* belonged in the family Nileidae. However, more recent work has shown that members of other isotelines, such as *Pseudogygites* Kobayashi, lack median connective sutures and that the presence of median sutures is not, in itself, sufficient to separate the Asaphidae from the Nileidae (Ludvigsen, 1979d).

The specimens of *Nahannia* from the Selkirk Member possess clearly defined median connective sutures. However, examination of a species of *Nahannia* from the Bad Cache Rapids Formation, Melville Peninsula, recently illustrated by Bolton (1977, pl. 17, figs. 2-4) as an "asaphid n. gen.?", shows that is differs from *N. gratiosa* in lacking a median connective suture and in possessing a more strongly vaulted cephalon.

Ludvigsen (1979d) has suggested that *Brachyaspis* can be separated from *Nahannia* by its shorter palpebral lobes and more clearly defined pygidial axis.

Presbynileus ibexensis (Hintze, 1952) from the Upper Canadian of Nevada and Utah is close to both *Nahannia* and *Brachyaspis.* It can be distinguished from *Nahannia* by the less deeply notched posterior margin on the hypostome and by the palpebral lobes, which are located further forward on the cranidium (see Hintze, 1952, pl. 12, figs. 6-12). *Presbynileus* differs from *Brachyaspis* in possessing weak pygidial axial furrows and somewhat larger palpebral lobes that are located further forward on the cranidium.

The deeply notched hypostomes of both *Nahannia* and *Presbynileus* indicate that they belong to the subfamily Isotelinae; the hypostome of *Brachyaspis* is unknown and a confident familial assignment of this genus cannot be made at the present time.

Nahannia gratiosa (Raymond, 1920)

Pl. 3, figs. 1, 7, 8, 9-11

1897 *Asaphus (Isotelus) susae* Whitfield; Whiteaves, p. 231.
1912 *Onchometopus susae,* Raymond, pl. 2, figs. 1, 2.
1920 *Homotelus gratiosus,* Raymond, p. 291
1924 Non *Homotelus gratiosus,* Walter, p. 209, pl. 17, figs. 6, 7. [figs. 6 = *Nileoides perkinsi* (Raymond); fig. 7 = *Vogdesia? obtusus* (Hall)]
1925 *Homotelus gratiosus,* Raymond, p. 94, pl. 6, figs. 1, 2
1928 *Homotelus gratiosus,* Troedsson, p. 32, pl. 12, fig. 13, pl. 13, figs. 1, 2.
1976 *Nahannia gratiosa,* Chatterton and Ludvigsen, p. 25.

Holotype. A complete individual from the Maquoketa Formation, Patterson's Spring, near Brainerd, Iowa, described by Raymond (1920).

Material. Two complete enrolled specimens (GSC 7170 from the Selkirk Member at East Selkirk and MM 1227 from the Selkirk Member at Garson); one poorly preserved, but nearly complete individual (GSC 7171) from the Selkirk Member at Lower Fort Garry; one thorax (UM 375), two pygidia (UM 402 and GSC 64082) and one hypostome (GSC 64094), all from the Selkirk Member at Garson.

Description. Cephalon roughly semicircular in outline, width (tr.) at posterior end slightly more than twice length (sag.), moderately convex, and comprises somewhat more than one-quarter of length of exoskeleton. Posterior margin of cephalon bowed very gently forward. Glabella weakly inflated; axial furrows absent except for ill-defined sub-parallel grooves behind, and just in front of, eyes. Occipital ring and furrow obsolete. Anterior branches of facial suture diverge initially forward, but curve sharply inward a short distance from posterolateral margin to join at anterior margin, on sagittal line. Median suture continues across cephalic margin and onto ventral surface. Posterior branches diverge abruptly backward to a point close to posterior margin; from here become subparallel, continuing backward to cut posterior margin at one-third of distance from axial furrow to genal angle, and nearer axial furrow. Eyes large, crescentic in outline, well raised above adjacent parts of free cheeks, and with visual surfaces steeply inclined; located just posterior of midlength. Palpebral lobes semicircular in outline and elevated above adjacent parts of the cranidium; palpebral furrows barely perceptible. Genal angles rounded. Articulating socket, identical to those on thoracic axis, present in axial furrow at posterior cephalic margin.

Hypostome subquadrate in outline, but posterior margin deeply indented. Lateral margin with antennal notch located close to anterolateral corner and bounded posteriorly by rounded shoulder. Anterior margin curves backward medially, but anterolateral corners bowed forward. Lateral margins curve very gently posteriorly and extended to form broad (tr.), long prolongations. Median body consists of shallow depression, roughly circular in outline; border furrows weak. Pair of oval maculae, longer (exsag.) than wide (tr.), located opposite antennal notch.

Thorax of eight segments accounts for somewhat less than half of length (sag.) of exoskeleton. Axis moderately convex, raised above adjacent parts of pleural fields, and wide, width (tr.) a little less than half of thoracic width (tr.). Axial furrows shallow, but well-defined, and axial segments bowed very gently forward. Axial furrows with deep articulating sockets at the posterior end of each segment. Pleura broad (exsag.), curved downward, and bears broad articulating facet, width (tr.) half of pleural width (tr.); pleural ends bluntly rounded.

Pygidium roughly equal in size to cephalon, length (sag.) a little less than one-third exoskeleton length (sag.) and semicircular in outline. Anterolateral corner has broad (exsag.) articulating facet. Axis poorly defined, raised only slightly above adjacent parts of pleural fields and axial furrows very faint. Posteriorly, axis unbounded by axial furrow. Interpleural furrows appear obsolete, axial ring furrows very faint. Doublure broad, width (tr.) one-fifth of pygidial width at anterior margin, and ornamented with terrace ridges.

Discussion. The complete enrolled specimen from the Selkirk Member (GSC 7170) was assigned to *Onchometopus susae* (Whitfield, 1882) by Raymond (1912, pl. 2, figs. 1, 2). Raymond (1920) later transferred GSC 7170 to a new species and genus, *Homotelus gratiosus,* which was established for material from the Maquoketa Formation of Iowa. The type specimen of *Asaphus susae* Whitfield, 1882 was assigned to *Homotelus susae* by Raymond in 1925 and apparently differs from *H. gratiosus* in that the central part of the cranidium, between the palpebral lobes, is raised above eye level. The pygidium of the former has weak border furrows which the latter lacks. The specimen of *Isotelus susae* described by Clarke (1892) was placed in *Homotelus florencevillensis* (Calvin, 1903) by Raymond (1925). However, both Clarke's figures and description are poor and it is difficult to reach any decision regarding its correct specific assignment. The validity of the genus *Homotelus* has been commented upon by a number of authors (Whittington, 1950). The type species does not agree with the diagnosis presented by Raymond (1920) and the general consensus is that *Homotelus* should be restricted to the type species, *H. ulrichi.*

The specimens described herein, and those described by Whitfield and Clarke, possess a number of features considered diagnostic of the genus *Nahannia* Chatterton and Ludvigsen, 1976 (semicircular cephalon and pygidium with weak axial furrows; large eyes located towards the back of the cephalon and fairly well-defined thoracic axis). Chatterton and Ludvigsen (1976) assigned *Homotelus gratiosus* to *Nahannia.*

The material described by Whitfield is best assigned to *N. susae*, while the specific identity of Clarke's specimen remains uncertain.

Walter (1924) repeated Raymond's (1920, p. 291) description of *Homotelus gratiosus* and apparently intended to reproduce the photographs of GSC 7170 published by Raymond (1912, pl. 2, figs. 1, 2). Unfortunately, Walter's illustrations of *H. gratiosus* are, in fact, reproductions of plate 3, figures 1 and 2 from Raymond's (1912) paper [*Nileoides perkinsi* (Raymond) and *Vogdesia? obtusus* (Hall), respectively].

Suborder Illaenina Jaanusson, 1959
Superfamily Illaenacea Hawle and Corda, 1847
Family Illaenidae Hawle and Corda, 1847
Subfamily Illaeninae Hawle and Corda, 1847

Discussion. Diagnoses of both the Illaeninae and Bumastinae have been revised recently by Ludvigsen and Chatterton (1980); these will be followed herein.

Genus *Illaenus* Dalman, 1827

Type species. Entomostracites crassicaudata Wahlenberg, 1821 from the Lower Ordovician Crassicaudata Limestone of Sweden (subsequent designation by Miller, 1889).

Discussion. The problem of distinguishing *Thaleops* from *Nanillaenus* on one hand and *Illaenus* from *Nanillaenus* on the other has been discussed by Shaw (1968) and Chatterton and Ludvigsen (1976). The possibility that all three may eventually be regarded as synonymous cannot be disregarded (Chatterton and Ludvigsen, 1976). However, until this group of genera have been adequately revised, it is best that the diagnoses of Jaanusson (1959a) be adhered to.

Nanillaenus is restricted to forms having eight thoracic segments and a pygidial axis whose sagittal length is more than half of pygidial length (Jaanusson, 1959a). The pygidial axial length of the specimens from the Selkirk Member is slightly less than half of pygidial length. A complete thorax is not available, but the specimens described here are considered to be conspecific with *Illaenus americanus* Billings, 1859; a species with ten thoracic segments (Billings, 1859; Wilson, 1947). The Selkirk material is therefore assigned to *Illaenus* rather than *Nanillaenus*.

Thaleops differs from both *Illaenus* and *Nanillaenus* in possessing deeply incised axial furrows and elevated eyes.

Illaenus americanus Billings, 1859
Pl. 3, figs. 2, 4-6.

1859 *Illaenus americanus* Billings, p. 371
1894 *Illaenus americanus,* Clarke, p. 714, figs. 20-23.
1908 *Illaenus americanus,* Raymond and Narraway, pl. 60, figs. 1-4
1947 *Illaenus americanus,* Wilson, p. 31, pl. 7, figs, 3, 4.
1979a *Nanillaenus americanus,* Ludvigsen, p. 37

Type. The type lot of *Illaenus americanus* has been lost (see Wilson (1947) and Bolton (1966)).

Material. One nearly complete exfoliated cephalon (GSC 64085); five exfoliated cranidia (UM 364, 378, 383, 409); a complete pygidium (GSC 64086) and about six additional cranidia and pygidia. All material is from the Selkirk Member at Garson.

Description. Cephalon subrectangular in outline, length (sag.) half of width (tr.) and strongly convex, with anterior and anterolateral portions dipping almost vertically downward. Axial furrows well-defined, moderately deep, proceeding forward and slightly inward almost as far as mid-length. Glabella of low convexity, raised only slightly above adjacent parts of cranidium and recognizable only in posterior half of cephalon. Glabellar width (tr.) at posterior end somewhat less than half of cephalic width (tr.). Eyes poorly preserved but appear to have been small and located close to posterior cephalic margin. Palpebral lobes also small and semicircular in outline; palpebral furrows very weak. Anterior branches of facial suture converge forward in smooth curve to join rostral suture roughly midway between sagittal line and anterolateral corner of cephalon. Cranidium semicircular in outline. Exact course of posterior branches uncertain. Connecting sutures run backward and slightly inward; rostral suture forwardly convex. Rostral plate subtrapezoidal in outline, length (sag.) one-fifth of width (tr.); weakly convex, raised very slightly above adjacent parts of doublure and ornamented with terrace ridges. Rostral flange cannot be seen. Doublure short (sag.) and decreases in length (exsag.) towards anterolateral corner of cephalon.

Pygidium semielliptical in outline, length (sag.) somewhat less than half of width (tr.) and of low convexity. Posterior margin regularly rounded; anterior margin interrupted by axis, which extends forward beyond the level of adjacent pleural regions. Axis short, length (sag.) slightly less than half of pygidial length (sag.); weakly convex, barely raised above adjacent parts of pleural fields. Axial furrows shallow. Median ridge on doublure runs along sagittal line from posterior end of axis and terminates close to posterior margin of pygidium. Pygidial surface smooth.

Discussion: The Selkirk material is very similar to the specimens of *Illaenus americanus* from the Cobourg Formation of Ontario, illustrated by Wilson (1947, pl. 7, figs. 3, 4). Wilson's "cephalon" (pl. 7, fig. 3) is probably a cranidium. Billings' original description of *I. americanus* states that the cephalon is "oblong or suboval" in outline; Wilson's specimen is semicircular in outline.

Illaenus americanus differs from *Nanillaenus conradi* Chatterton and Ludvigsen, 1976 from the Esbataottine Formation, District of Mackenzie, in possessing a subrectangular, rather than semielliptical, cephalon and a shorter pygidial axis.

Illaenus latiaxiatus Raymond and Narraway (1908) from the Black River Group of the Ottawa district (Ludvigsen, 1979a, fig. 20E) has a pygidium with a more angular lateral margin and a broader axis than *I. americanus*.

Genus *Bumastoides* Whittington, 1954

Type species. Illaenus milleri Billings, 1859 from the Trenton Group of Ontario (by original designation).

Discussion. Ludvigsen and Chatterton (1980) have recently elevated *Bumastoides* to full generic status and transferred this genus to the subfamily Illaeninae.

Bumastoides tenuirugosus (Troedsson, 1928)
Pl. 4, figs. 1, 2, 5, 7, 8, Pl. 5, figs. 1-6

1928 *Bumastus tenuirugosus* Troedsson, p. 43, pl. 15, figs. 1-10.
1954 *Bumastus (Bumastoides) tenuirugosus,* Whittington, p. 139.

Holotype. A cranidium and thorax from the Cape Calhoun Formation. Cape Calhoun, Northern Greenland illustrated by Troedsson (1928, pl. 15, fig. 1).

Material. Three nearly complete individuals (MM I148 and I220, GSC 64090) a complete cephalon (GSC 64091), two cranidia (ROM 475T and GSC 64092), two pygidia showing doublure (GSC 64093, 64095) and about thirty-five additional cranidia and pygidia. All material is from the Selkirk Member at Garson.

Description. Cephalon semielliptical in outline, length (sag.) less than half of width (tr.), and strongly convex. Axial furrows barely perceptible, subparallel and extending forward for a little over one-third of cephalic length (sag.); terminate at elliptical lunettes. Eyes small, crescentic in outline, raised slightly above adjacent parts of cranidium, and situated close to posterior margin. Palpebral lobes also small and crescentic in outline; palpebral furrows very weak. Posterior branches of facial suture directed straight back, cutting posterior margin at one-seventh of distance from sagittal line to genal angle. Anterior branches converge gently forward, running in a smooth curve, and join rostral suture directly in front of lunettes. Connecting sutures directed backward and slightly inward. Rostral plate subtrapezoidal in outline and moderately convex, raised well above adjacent parts of doublure. Rostral flange subtrapezoidal in outline, length (sag.) a little more than half of length of rostral plate, and forwardly turned. Entire dorsal surface ornamented with coarse terrace ridges. Exfoliated individuals show small median tubercle located between palpebral lobes.

Thorax has ten segments and accounts for somewhat more than one-third of total length (sag.) of exoskeleton. Axis wide (tr.), comprising a little more than two-thirds of thoracic width, and of low convexity. Axial furrows very faint and bowed very slightly outward. Pleurae narrow (tr.), width a little less than one-eighth of thoracic width (tr.), and terminate at blunt spines. Each pleura bears a well-defined articulating facet.

Pygidium roughly elliptical in outline, length (sag.); slightly less two-thirds width (tr.), and moderately convex. Dorsal surface smooth. Doublure long (sag.), length half of pygidial length (sag.); carries ridge along sagittal line. Anterior margin scalloped, with two short (exsag.) triangular projections lying symmetrically about, and a short distance from, sagittal line. Ventral surface of doublure ornamented with terrace ridges.

Discussion. Some of the smaller cranidia of *Bumastoides tenuirugosus* (Troedsson) in the Garson collection differ slightly from larger examples. In particular, the lunettes are less clearly defined and the length/width ratios vary somewhat – the larger cranidia tend to be broader (tr.) and less rounded than the smaller. Cranidia vary considerably in the quality of preservation and are not suitable for tracing changes in holaspid morphology. Until more data become available, it is probably best to include both large and small specimens in a single species.

The specimens of *Bumastoides tenuirugosus* (Troedsson, 1928) from the Cape Calhoun Formation of northern Greenland are very close to the Selkirk specimens and show a similar range of morphological variation (see Troedsson, 1928, pl. 15, figs. 1-10). They are considered to be conspecific.

The type specimen of *Bumastoides billingsi* (Raymond and Narraway, 1908), illustrated by Ludvigsen (1979a, fig. 28, c, d), is similar to the Selkirk material. The only major difference is the presence of distinct axial furrows behind the lunettes in the former. *B. bellevillensis* (Raymond and Narraway, 1908) possesses only eight thoracic segments while *B. milleri* (Billings, 1859) differs from the material described here in having nine thoracic segments. *B. porrectus* (Raymond, 1925) and *B. beckeri* (Slocom, 1913) possess semicircular cranidia and, in addition, the latter is more strongly vaulted than *B. tenuirugosus*. *B. lenzi* Chatterton and Ludvigsen, 1976 is similar to the specimens described herein, but has fainter lunettes which are located closer together and nearer to the posterior margin. Also, the cranidium is more elongate longitudinally.

Bumastoides tenuirugosus is the most common trilobite in the Selkirk Member at Garson and also the largest (Table 2).

Genus *Stenopareia* Holm, 1886

Type species. Illaenus linnarssoni Holm, 1882 from the Upper Ordovician Boda Limestone, Dalarne, Sweden (by original designation).

Discussion. A holotype was not designated for *Stenopareia linnarssoni*, but specimens from the type area at Dalarne, Sweden have been illustrated by Warburg (1925, pl. 2, figs. 14-18) and by Dean (1978a, text-fig. 5). From these figures, it is clear that the axial furrows are well-defined on the cephalon and thorax. Cephalic axial furrows are subparallel and particularly well incised on exfoliated individuals. Axial furrows widen anteriorly to produce a lunette. The cephalic axis is broad at the posterior end of the cranidium, accounting for more than half cranidial width (tr.).

Stenopareia differs from *Bumastoides* Whittington in possessing more strongly incised axial furrows, a more convex (tr.) glabella and a pygidium with a transverse, rather than rounded, anterior margin. *Thaleops* Conrad can readily be separated from *Stenopareia* by its more strongly incised axial furrows and longer (sag.), more convex cephalic and pygidial axes. *Illaenus* Dalman and *Nanillaenus* Jaanusson both possess pygidia with longer (sag.), more convex axes than those found in *Stenopareia*. Separation of isolated cranidia is more difficult. Both *Illaenus* and *Nanillaenus* have relatively narrow (tr.) glabellae (glabellar width is half, or less, of cranidial width). The glabella of *Stenopareia* is relatively broad, with transverse width at the posterior end more than half of cranidial width.

Shaw (1968) described *Bumastoides aplatus* (Raymond), and *Bumastoides gardenensis* Shaw from the Chazy Group of New York State. These species possess well incised cephalic axial furrows and transverse anterior pygidial margins similar to those of *S.linnarssoni*. Whittington (1954) did not include the former species in *Bumastoides* and both *B. aplatus* and *B. gardenensis* are best assigned to *Stenopareia*, as was suggested by Chatterton and Ludvigsen (1976).

Illaenus globosus Billings (1859) from the Chazyan of New York and Quebec was assigned to *Bumastus* by Shaw (1968, p. 45, pl. 17, figs. 15-24, pl. 18, figs. 4, 7, 13, 17). This species has well incised axial furrows, a strongly convex thoracic axis, and a scalloped anterior margin of the pygidial doublure with anteriorly directed angular prolongations. These features ally *I. globusus* with the illaenines and this species probably belongs to *Stenopareia*.

Based on the deeply incised (on exfoliated specimens) subparallel cephalic axial furrows and wide cephalic axis, the Selkirk material is assigned to *Stenopareia*. Without a thorax and pygidium to support the decision, this assignment may be open to criticism. However, the width of the glabella appears to be a potentially useful criterion for assisting in identification of isolated illaenine cranidia. Two cranidia illustrated by Troedsson (1928) can be assigned to *Stenopareia* on the same basis.

Stenopareia garsonensis sp. nov.
Pl. 4, figs. 3, 4, 6

Derivation of name. From the village of Garson, Manitoba; the location of the quarries from which most of the trilobites were obtained.

Diagnosis. A species of *Stenopareia* with a cranidium that is semielliptical in outline, and with subparallel cephalic axial furrows which proceed as far forward as midlength. On exfoliated individuals, an elliptical, raised boss is present at the anterior end of each furrow.

Holotype. A nearly complete, exfoliated cranidium (GSC 64087) from the Selkirk Member at Garson.

Other material. A nearly complete cranidium (GSC 64088) from the Selkirk Member at Garson, a cranidium (GSC 7180) from the Selkirk Member at East Selkirk and two poorly preserved cranidia from the Selkirk Member at Garson.

Description. Cranidium semielliptical in outline, length (sag.) two-thirds of width (tr.) and strongly convex. Axial furrows deep, subparallel, well defined (on exfoliated individuals); extending forward as far as midlength. Anterior end of furrow has, on abaxial side, a small elliptical boss. Glabella moderately convex, raised above adjacent parts of cheeks and only recognizable on posterior half of cranidium. Palpebral lobes small, semielliptical, located well back on cephalon. Exact course of facial suture uncertain. Free cheeks, doublure and rostral plate unknown.

Discussion. Stenopareia garsonensis sp. nov. differs from *S. linnarssoni* (Holm, 1882) from the Boda Limestone of Sweden in having a cranidium which is semielliptical rather than semicircular in outline and a raised boss, instead of a depressed lunette, at the anterior ends of exfoliated axial furrows.

Stenopareia aplatus (Raymond, 1925), *S. gardenensis* (Shaw, 1968), and *S. globosus* (Billings, 1859) from the Chazy Group of New York State, all have cranidia which are roughly semicircular in outline and all possess axial furrows which converge more abruptly than those of *S. garsonensis*. Internal molds of cranidia of *S. globosus* show a faint, raised boss at the anterior end of each axial furrow, similar to those present in the Selkirk material. The course of this furrow around the boss leads to slight divergence of the anterior furrow terminations.

Two cranidia illustrated by Troedsson (1928) as *Illaenus* sp. indet. 2 and *Illaenus* sp. indet. 3 (pl. 14, figs. 6a-d and 7a, b, respectively) from the Cape Calhoun Formation of northern Greenland closely resemble the Selkirk specimens. *Illaenus* sp. indet. 2 appears to lack the raised bosses at the anterior ends of the axial furrows, which extend forward beyond midlength. The other specimen also lacks the bosses and its axial furrows terminate in front of midlength. Both of these species should be assigned to *Stenopareia*.

Subfamily Bumastinae Raymond, 1916

Genus *Failleana* Chatterton and Ludvigsen, 1976

Type species. *Failleana calva* Chatterton and Ludvigsen, 1976 from the lower Esbataottine Formation, Sunblood Range, southern District of Mackenzie (by original designation).

Failleana indeterminata (Walcott, 1877)

Pl. 6, figs. 1-4, 6, 7

1877 *Illaenus indeterminatus*, Walcott, p. 19
1879 *Illaenus indeterminatus*, Walcott, p. 70
1908 *Bumastus indeterminatus*, Raymond and Narraway, p. 253, pl. 62, figs. 8, 9.
1913 *Bumastus indeterminatus*, Raymond, pl. 3, fig. 12.
1916 *Bumastus indeterminatus*, Raymond, p. 22, pl. 2.
1947 *Bumastus indeterminatus*, Wilson, p. 34, pl. 7, fig. 12.
1947 *Bumastus billingsi*; Raymond and Narraway; Wilson, p. 34, pl. 7, fig. 13.
1974 *Platillaenus* cf. *P. limbatus* (Raymond); Shaw, p. 17, pl. 3, fig. 9.
1976 *Failleana indeterminata*, Chatterton and Ludvigsen, p. 38
1978 *Failleana indeterminata*, Ludvigsen, pl. 2, figs. 21, 22.
1979a *Failleana indeterminata*, Ludvigsen, p. 39, figs. 23, A, B.

Holotype. An incomplete exoskeleton from the Leray-Black River at Newport, New York illustrated by Raymond (1916, pl. 2).

Material. A partial exfoliated cephalon and anteriormost portion of thorax (UA Or93) from the Selkirk Member at Tyndall; exfoliated cranidia (GSC 64095, 64096) from the Selkirk Member at Garson; an exfoliated cranidium (GSC 7201) from the Selkirk Member at Lower Fort Garry; and incomplete exfoliated exoskeleton (MM I95) and a poorly preserved, nearly complete exoskeleton (UM 356) from the Selkirk Member at Garson; and three pygidia from the Selkirk Member at Garson.

Description. Cephalon of slight convexity, semielliptical in outline, length (sag.) two-thirds width (tr.) and comprising somewhat less than one-third length of exoskeleton (sag.). Glabella raised only very slightly above surrounding parts of fixed cheeks; hourglass shaped in outline, minimum glabellar width (tr.) is slightly more than one-third cephalic width (tr.) and occurs level with anterior tip of eye. Axial furrows shallow, but fairly well-defined on exfoliated specimens. Behind eye, axial furrows run along course parallel to posterior cephalic margin, then converge gradually forward to reach minimum separation (tr.) at a point opposite anterior end of eye. Forward from this point they diverge and each branch terminates a short distance from anterior margin, in conspicious circular pit. Exfoliated specimens have shallow, elliptical lunette on each axial furrow, located at point where latter diverge forward. Eyes not preserved but appear to have been of moderate size and located close to posterior margin of cephalon. Base of eye marked by deep furrow. Posterior branches of facial suture diverge backward to cut posterior cephalic margin close to axial furrow. Anterior branches diverge forward to a point close to anterolateral margin of cephalon; from here converge abruptly forward to cut anterior cephalic margin opposite anterior termination of axial furrows. Connecting sutures not preserved, so that details of rostral plate and doublure are uncertain. Occipital ring and furrow obsolete. Articulating furrow present at posterior end of cephalon, extending between facial suture and axial furrow, and merging with latter. Cephalic surface smooth except for short (sag.) band of terrace ridges running parallel with margin along entire width of anterior cephalic margin. Terrace ridges also present on doublure and rostral plate. Exfoliated examples show a very small median tubercle, located close to posterior cephalic margin.

Both specimens showing the thorax are poorly or incompletely preserved and their condition allows only a brief general description. Thorax has at least nine segments and accounts for one-quarter exoskeleton length (sag.). Width of axis (tr.) more than two-thirds thoracic width (tr.); axial furrows very shallow. Pleural fields narrow (tr.) and curved downward; pleurae curved gently backward and with rounded terminations.

Pygidium semielliptical in outline, width (tr.) a little greater than length (sag.) and more convex than cephalon. Axis and axial furrows effaced. Border narrow, and deliniated by very shallow concave border furrow. Short (tr.) articulating facet present at anterolateral corner. Entire dorsal surface appears to be smooth. Doublure moderately wide, equal to one-fifth width (sag.) of pygidium and carries well-defined terrace ridges.

Discussion. Species of *Failleana* possess basically similar cephalic features – general low convexity, "hourglass" shaped glabella and eyes placed far back on the cephalon. Consequently, their separation is difficult. However, the depth and point of forward divergence of cephalic axial furrows and the cephalic length/width ratios may be used as criteria for species identification, provided that similar sized individuals are compared.

The material described herein is very close to *Failleana indeterminata* (Walcott, 1877) illustrated by Raymond and Narraway (1908), Raymond (1916), and Ludvigsen (1978). Locations of the points of forward divergence of the axial furrows are identical and cranidial length/width ratios are very close. The Selkirk specimens are therefore assigned to *F. indeterminata*. This species ranges from Blackriveran to Edenian (Ludvigsen, 1978).

The species described by Troedsson (1928) from the Cape Calhoun Formation of Greenland, *Failleana fronto*, possesses cephalic axial furrows that are subparallel posteriorly and that diverge forward well in front of the eyes. In addition, the cephalon seems to be longer (sag.) than that of the specimens described herein, so that its outline is semicircular, and the pygidium has steeper flanks. These features are sufficient to separate it from *F. indeterminata*. *F. calva* Chatterton and Ludvigsen, 1976 from the lower Esbataottine Formation, District of Mackenzie, differs from the species considered here in possessing cephalic axial furrows which diverge at a point further back on the cephalon. Also, both the cephalon and pygidium are semicircular in outline. *F. limbata* (Raymond, 1905) from the Chazy Group of New York State has axial furrows which begin diverging well in front of the eyes; cranidial length/width ratio is lower in the specimens described herein. *F. orbicaudata* (Billings, 1859) from the Upper Ordovician of Anticosti Island (Billings, 1866, fig. 10) has a longer cephalon than *F. indeterminata*.

Shaw (1974) identified a specimen from the upper Bromide Formation of Oklahoma as *Platillaenus* cf. *P. limbatus* (Raymond). This cranidium closely resembles the species considered here. Axial furrows begin diverging forward at approximately the same point, and cranidial length/width ratios are similar. The only difference is that the minimum glabellar width of Shaw's specimen is slightly less than that of the Selkirk material. However, the Oklahoma cranidium is much smaller than any of the examples described herein. It cannot be regarded as being conspecific with *F. limbata* and is here assigned to *F. indeterminata*.

The specimen described by Clarke (1894) as *Illaenus* cf. *I. indeterminata* Walcott appears to have cephalic axial furrows which converge forward to a point well in front of the eyes; the point of forward divergence is not shown in Clarke's illustration. This appears to indicate a closer affinity to *F. fronto* or *F. limbata* than to *F. indeterminata*. Foerste (1920) described *F. rowleyi* from the Kimmswick Limestone of Missouri. This species appears to be closely related to *F. indeterminata*, but differs in that the eyes are somewhat shorter (exsag.) and are placed farther forward on the head.

Family Scutelluidae Richter and Richter, 1955

Genus *Eobronteus* Reed, 1928

Type species. Entomostracites laticaudata Wahlenberg, 1821 from the Upper Ordovician Boda Limestone of Sweden (by original designation).

Eobronteus cf. *slocomi* (Bradley, 1930)

Pl. 3 fig. 3

1930 *Goldius slocomi* Bradley, p. 257, pl. 29, figs. 30-32.
1949 *Eobronteus slocomi,* Sinclair, p. 40, pl. 12, figs. 1-4, 7-11.

Material. A single pygidium (GSC 64098) from the Selkirk Member at Garson.

Description. Pygidium semicircular in outline and of slight convexity. Axis short, length (sag.) somewhat less than one-quarter of pygidial length (sag.) and moderately convex, raised well above adjacent parts of pleural fields. Axial furrows weak. Axis with two rings of unequal size; anteriormost short, length (sag.) one-third of posterior. Axial ring furrow very shallow. Pleural field initially horizontal but declines distally decreasing in slope near margin. Six pairs of pleural ribs present, fanning out from axis. Doublure broad (sig.), extending to tip of axis and ornamented with scalloped terrace ridges that are subparallel with margin.

Discussion. Identification of *Eobronteus* to the species level is difficult without well preserved cranidia. Of the ten species of *Eobronteus* described and illustrated by Sinclair (1949), the small and poorly preserved pygidium from the Selkirk Member is most similar to those of *E. slocomi* (Bradley, 1930) from the Kimmswick Limestone of Missouri; in particular, the small exfoliated pygidium (pl. 12, fig. 8).

As Sinclair (1949, p. 55) noted, the incomplete cranidium of *Illaenus* sp. indet. I. (Troedsson, 1928, pl. 14, fig. 5) establishes the presence of *Eobronteus* in the Cape Calhoun Formation of northern Greenland.

Suborder Harpina Whittington, 1959

Family Harpidae Hawle and Corda, 1847

Genus *Dolichoharpes* Whittington, 1949

Type species. Harpes dentoni Billings, 1863 from the upper Trenton Group of Ontario (by original desgination).

Dolichoharpes dentoni (Billings, 1863)

Pl. 2 figs. 4, 5

1863 *Harpes dentoni,* Billings, p. 63
1865 *Harpes dentoni,* Billings, p. 183, fig. 166
1913 *Eoharpes dentoni,* Raymond, p. 33, pl. 3, fig. 5
1921 *Eoharpes dentoni,* Raymond, p. 30, pl. 9, fig. 6
1925 *Eoharpes uniserialis* Raymond, p. 15, pl. 1, figs. 8, 9
1930 *Eoharpes uniserialis,* Bradley, p. 244, pl. 28, figs. 8-10
1947 *Eoharpes dentoni,* Wilson, p. 11, pl. 1, figs. 7, 8
1949 *Dolichoharpes uniserialis,* Whittington, p. 278, pl. 1, figs. 1, 3-5
1959 *Dolichoharpes uniserialis,* Whittington, p. 0417, fig. 320, 1a, b
1963 *Dolichoharpes uniserialis,* DeMott, p. 123
1978 *Dolichoharpes dentoni,* Ludvigsen, pl. 4, fig. 36
1979a *Dolichoharpes dentoni,* Ludvigsen, p. 49, fig. 30B

Neotype. A nearly complete exoskeleton from the Trenton Group of Ottawa selected by Wilson (1947) and illustrated by Ludvigsen (1979a, fig. 30B).

Material. A single cephalon (MM 135) from the Selkirk Member at Garson.

Description. Cephalon elliptical in outline, length (sag.) somewhat less than half of width (tr.) and strongly convex, height one-third of width (tr.). Genal prolongations long, length (exsag.) a little more than cephalic width (tr.) and narrow. Glabella bell-shaped in outline, narrowing forward so that width (tr.) at anterior end somewhat less than half of width at posterior; moderately convex, raised well above surrounding parts of genae, and bounded by deep axial furrows. Glabellar surface badly weathered so that only 1s furrow recognisable. 1s furrow moderately deep, directed posteromedially, width (tr.) one-quarter of glabellar width. 1p lobe subcircular in outline, length (sag.) three-eighths of glabellar length. Preglabellar field short (sag.), length slightly more than one-eighth of glabellar length. Alae semicircular in outline, length (sag.) somewhat more than 1p lobe, and depressed a little below adjacent parts of genae; extend laterally as far as level of eyes. Alar furrows deep, semicircular in outline but modified at anterior end, near axial furrow by short, anteromedially directed extension. Occipital ring and furrow poorly preserved. Eyes small, located at anterolateral corners of genae, just posterior of anterior end of glabella and roughly opposite lateral edges of alae. Eye ridges prominent and nearly transversely directed. Genal roll high, comprising almost one-third of total cephalic height, and is gently convex forward. Brim narrow, gently concave and barely depressed below low external rim. Anterior portion of fringe not preserved. Brim prolongation also weakly concave, narrow (tr.), decreasing in width towards anterior; has low external rim. Genal roll prolongations high and slope almost vertically downward. Internal rim badly weathered, but appears to have been low and slopes down posteriorward. Upper lamella of fringe, apart from smooth external and internal rims, bears a reticulate pattern of ornament. Lower lamella, beneath genal roll and genal roll prolongation, appears to have been tuberculate. Genae and glabella too badly weathered to allow identification of ornament.

Discussion. The original specimen of *Harpes dentoni* from which Billings described the species has been lost but a neotype (GSC 1764) was designated by Wilson (1947). The neotype has been reillustrated recently by Ludvigsen (1978, pl. 4, fig. 6; 1979a, fig. 30B).

Raymond (1925) established *Eoharpes uniserialis* for specimens from the Kimmswick Limestone of Missouri. He claimed that this species differs from *E. dentoni* by possessing a smooth glabella. However, Whittington (1949) has demonstrated the presence of glabellar ornament in *Dolichoharpes uniserialis,* so this species and *D. dentoni* may be regarded as synonyms, as suggested by DeMott (1963).

Dolichoharpes reticularis Whittington, 1949 from the Edinburg Formation of Virginia is close to *D. dentoni,* but differs in details of the fringe. For example, the internal rim of *D. reticularis* is more prominent and runs back horizontally. *D.* aff. *reticularis* from the Esbataottine Formation, District of Mackenzie (Chatterton and Ludvigsen, 1976) also differs in these respects and has shorter (tr.) alae.

Order Phacopida Salter, 1864
Suborder Cheirurina Harrington and Leanza, 1957
Family Cheiruridae Hawle and Corda, 1847
Subfamily Cheirurinae Hawle and Corda, 1847

Genus *Ceraurinus* Barton, 1913

Type species. Ceraurinus marginatus Barton, 1913 from Upper Ordovician rocks of Ontario (by original designation).

Discussion. The discovery that *Ceraurinus marginatus* Barton bears carinate first pygidial spines led Ludvigsen (1977) to suggest that *Remipyga* Whittington, 1954 is a junior subjective synonym of *Ceraurinus*.

Ceraurinus cf. *icarus* (Billings, 1860)

Pl. 7, figs. 1-4, 6, 8, 11

1977 *Ceraurinus icarus* (Billings, 1860), Ludvigsen, 1977, p. 966, pl. 2, figs. 3-10, text-fig. 2B (see for synonymy).

Material. A nearly complete individual (MM I228) from the Selkirk Member at Garson, a partial cephalon with an incomplete external mold of a hypostome (GSC 64099), a complete cranidium (GSC 64100), and about twelve additional cranidia and pygidia from the Selkirk Member at Garson. Four cranidia from the Selkirk Member at East Selkirk and Lower Fort Garry.

Description. Cephalon subtrapezoidal in outline, length (sag.) half of width (tr.) and accounts for one-quarter of length of exoskeleton. Glabella subrectangular in outline, width (tr.) four-fifths of length (sag.) and comprises slightly more than one-third of cephalic width (tr.). Axial furrows well-defined and deep. Glabella has three pairs of lateral glabellar furrows. 1s furrow deep, proceeding very slightly posteromedially for somewhat less than one-third glabellar width, then directed straight back to join occipital ring; 1p lobe moderately inflated, subrectangular in outline, width (tr.) a little more than length (exsag.). 2s furrow deep, transverse, and as wide (tr.) as 1s furrow; 2p lobe rectangular in outline, length (exsag.) five-sevenths of width (tr.). 3s furrow curves slightly posteromedially and is a little shorter than 1s furrow; 3p lobe rectangular in outline, equal in size to 2p lobe. Frontal lobe long, length (sag.) somewhat more than one-third of glabellar length. Preglabellar furrow well-defined. Lateral border flat and rather broad. Occipital ring bowed forward and a little narrower than glabella. Occipital furrow also bowed forward, shallow at sagittal line but deeper behind 1p lobe. Posterior border furrow well defined, deep; posterior border short (exsag.) near axis but longer at genal angle. Eyes moderate in size, raised slightly above cheeks, situated opposite 3p lobe, midway between axial furrows and lateral cephalic margin. Palpebral lobes crescentic in outline; palpebral furrows faint. Anterior branches of facial suture converge forward in an arc to cut cephalic margin between axial furrow and sagittal line. Posterior branches run in a forwardly convex curve to cut lateral margin opposite 2p lobe. Fixed cheeks bear long, carinate genal spines which taper to fine points and extend back as far as third thoracic pleura.

Hypostome pentagonal in outline. Median body moderately inflated, ellipitical in outline, length (sag.) a little more than width (tr.); divided into two lobes by faint median furrow. Anterior lobe subcircular in outline and convex. Posterior lobe crescentic in outline, almost flat and much shorter (sag.) than anterior lobe, accounting for only one-third of length (sag.) of median body. Maculae elliptical in outline and slightly deeper than median furrow. Anterior border furrow shallow. Lateral border convex, widest (tr.) at anterior end and narrowing posteriorly. Lateral border furrow well defined and somewhat deeper than anterior border furrow. Posterior border long (sag.). Anterior wing broad (exsag.), curved upward and slightly backward. Posterior wing low, triangular in outline. Shoulder poorly defined, weakly convex. Hypostome surface ornamented with fine granules.

Thorax of eleven segments. Axis comprises somewhat less than one-third of thoracic width (tr.) at anterior and narrows slightly towards posterior; strongly convex, well raised above pleural regions. Axial furrows well defined and moderately deep. Pleurae horizontal near axis, but curve distally downward and slightly backward; terminate at blunt spines. Each pleura bears short (tr.), deep, posterolaterally directed pleural furrow.

Pygidium small, length (sag.) one-eight of length of exoskeleton and semiellipitical in outline. Axis narrows posteriorly, accounting for one quarter of pygidial width (tr.) and has three axial rings. Axial ring furrows well incised, shallowest at sagittal line and deeper laterally. Two posteriormost furrows terminate in circular pits. Pleurae decrease in size towards rear and terminate as blunt spines. First pair curves out and back, extending almost as far as tips of third pair; degree of outward curvature lower in second pair, while third pair proceed directly backward. Anteriormost pair carinate, slightly expanded (tr.) and bear short pleural furrows identical to those of thoracic pleurae. Other pairs faintly carinate and unfurrowed.

Discussion. Ceraurinus icarus (Billings) is a widespread species that occurs in Maysvillian and Richmondian strata of Iowa, Indiana, Anticosti Island, Gaspé Peninsula, Manitoulin Island, and Nevada (Ludvigsen, 1977; Ross et al., 1980). The species from the Selkirk Member of southern Manitoba differs from *C. icarus* in possessing longer and more pointed genal spines and posterior pygidial spines that bear somewhat fainter carinae. The outline of the pygidium of *C.* cf. *icarus* from Garson (Pl. 7, fig. 4) is identical to that of the lectotype of *C. icarus* from the Vaureal Formation, Anticosti Island (Ludvigsen, 1977, pl. 2, fig. 6).

Genus *Ceraurus* Green, 1832

Type species. Ceraurus pleurexanthemus Green, 1832 from the Middle Trenton Group of New York State (by original designation).

Ceraurus cf. *tuberosus* Troedsson, 1928

Pl. 8, figs. 1-3

1928 *Ceraurus tuberosus* Troedsson, p. 71, pl. 18, figs. 1-9 (not pl. 17, fig. 13).
1979c *Ceraurus tuberosus*, Ludvigsen, p. 34, pl. 17, figs. 36-41.

Material. An incomplete cranidium (MM I192c) from the Selkirk Member at Garson; an incomplete cranidium and anterior portion of thorax (GSC 7208) from the Selkirk Member at St. Andrews, Manitoba.

Description. Glabella moderately inflated and expands abruptly forward, so that length (sag.) equals maximum width (tr.). Three pairs of deep and narrow (tr.) lateral glabellar furrows oriented perpendicular to axial furrows. 1p lobe short, isolated, subcircular in outline. 2p lobe longer (exsag.) than 1p lobe, 3p lobe slightly longer than 2p lobe. Frontal lobe long (sag.), comprising slightly more than one-third of glabellar length. Glabella has scattered fine and coarse tubercles. Occipital ring long (sag.), equal to about one-sixth of glabellar length; moderately arched, transverse behind central portion of glabella but curved gently backward behind 1p lobe. Occipital furrow deep and straight (tr.). Axial furrows converge very gently forward as far as 1s; from here diverge abruptly, reaching maximum separation at posterior end of frontal lobe; forward of this point they converge gradually. Fixed cheeks strongly inflated (tr. and exsag.) and ornamented with fine tubercles. Posterior border slightly shorter (exsag.) than occipital ring; posterior border furrow well-defined and deep. Genal spines long (exsag.), at least as long as glabella, and curved outward and backward. Palpebral lobe located opposite 2s furrow or 3p lobe and raised above surrounding parts of cheeks. Facial sutures converge gently forward and diverge markedly outwards. Free cheeks unknown.

Only four thoracic segments preserved. Axis narrow, width (tr.) one-quarter of thoracic width (tr.), and strongly arched above pleural fields. Axial furrows well-defined, moderately deep,and subparallel. Each pleura bears a short (tr.), anteromedially directed pleural furrow; pleurae terminate as blunt spines.

Discussion. Ceraurus tuberosus occurs in both the Cape Calhoun Formation of northern Greenland (Troedsson, 1928) and in the Whittaker Formation of the District of Mackenzie (Ludvigsen, 1979c). The Selkirk material, assigned to *C.* cf. *tuberosus,* differs in having a slightly more inflated glabella with a greater forward expansion. Closely similar species of *Ceraurus* occur in the Upper Ordovician part of the Hanson Creek Formation of Nevada (Ross et al., 1980, fig. 4 a-p).

Genus *Borealaspis* Ludvigsen, 1976

Type species. Borealaspis whittakerensis Ludvigsen, 1976 from the lower Whittaker Formation, District of Mackenzie (by original designation).

Borealaspis whittakerensis Ludvigsen, 1976

Pl. 6, fig. 5, Pl. 9, figs. 7, 9, 10

1975 *"Ceraurus"* cf. *numitor* (Billings), Ludvigsen, pl. 5, fig. 11.
1976 *Borealaspis whittakerensis* Ludvigsen, p. 953, pl. 2, figs. 1-7.
1979 *Borealaspis whittakerensis,* Ludvigsen, p. 39, pl. 17, figs. 1-21.

Holotype. A cranidium from the lower Whittaker Formation, District of Mackenzie illustrated by Ludvigsen (1976, pl. 2, figs. 1-3).

Material. An incomplete cranidium (UA Ty 130) from the Selkirk Member at Tyndall; and an incomplete cranidium (GSC 64102), an incomplete external mold of a cranidium (GSC 64103), and an incomplete fixed cheek (GSC 64112), all from the Selkirk Member at Garson.

Description Glabella bulb-shaped in outline, moderately inflated, well raised above free cheeks and reaching maximum width (tr.) at 3p lobe. Glabellar length (sag.) equal to maximum glabellar width (tr.). Three pairs of lateral glabellar furrows. 1s furrow transversely directed, short (exsag.) at axial furrow but expanding inwardly. 2s furrow curved very slightly backward, shorter (exsag. and tr.) and shallower than 1s furrow. 3s furrow directed obliquely inwards and slightly deeper than 2s furrow. 1p lobe somewhat shorter (exsag.) than 2 or 3p, which are roughly equal in size. Frontal lobe slightly longer. Glabella bears long, stout spine, directed upward and backward, located between 1p lobes. Diameter of spine base somewhat more than one-quarter of glabellar length (sag.). Anterior portion of glabella bears scattered, paired, coarse tubercles which appear to be present no further back than 1s furrow. Glabella separated from narrow (sag.) anterior border by sharply incised, preglabellar furrow. Occipital furrow obsolete in region of sagittal line but deep, lateral 0s furrows are present behind 1p lobe. Occipital ring bowed very gently backward; length slightly less than one-fifth of glabellar length (sag.). Axial furrows deep and bowed outward. Palpebral lobes elevated, located far out on cheek, opposite 3p lobe. Long (tr.) palpebral ridge nearly transverse across cheek, joins axial furrow at 3s furrow. Anterior branch of facial suture curves inwards just in front of palpebral ridge. Fixed cheeks moderately convex (exsag.) and ornamented by scattered fine tubercles. Posterior border moderately long (exsag.), length somewhat less than one-tenth of glabellar length (sag.). Posterior border furrow deep.

Discussion. The incomplete cranidium from the Selkirk Member at Garson (Pl. 9, fig. 9) is, by far, the largest specimen of *Borealaspis* recovered to date. It is three times as long (sag.) as the neotype cranidium of *B. numitor* (Billings) from the Vaureal Formation, Anticosti Island and nearly ten times as long as the holotype cranidium of *B. whittakerensis* Ludvigsen from the Whittaker Formation, District of Mackenzie (Ludvigsen, 1976, pl. 1, fig. 16, pl. 2, fig. 1). The Selkirk cranidium shows the following features: The palpebral lobes are located opposite 3p lobes, the median glabellar spine is located between 1p lobes, the glabella has moderate convexity, and the glabellar tubercles appear to be paired. These characters are shared with *B. whittakerensis* and the Selkirk material is assigned to that species. By contrast, in *B. numitor* the palpebral lobes are located opposite 2s furrows, the median glabellar spine is located between 0s furrow, the glabella is strongly inflated, and the glabellar tubercles are distributed without apparent pattern.

Cheirurine indet.

Pl. 9, figs. 5, 8

Material. Two complete cranidia (GSC 64105, 64106) from the Selkirk Member at Garson.

Description. Glabella moderately convex, length (sag.) somewhat less than maximum width (tr.) and subtrapezoidal in outline. Axial furrows diverge gradually forward to maximum separation at frontal lobe. Three pairs of deep lateral glabellar furrows. Exact details of frontal lobe uncertain. Two large circular-shaped protuberances located on glabella opposite 3s furrow and extending onto frontal lobe. Other parts of glabellar surface bear scattered coarse tubercles. Occipital furrow shallow, transverse behind central part of glabella but curves gently back behind 1s. Occipital ring long, length (sag.) a little less than one-quarter of cranidial length but becomes shorter (exsag.) towards the axial furrows.

Discussion. The glabella appears to continue expanding forward beyond the level of the 3p glabellar lobe, so that these cranidia cannot be accomodated in *Borealaspis* Ludvigsen. They may well belong to *Ceraurus;* a genus which includes a number of late Middle and Late Ordovician species with a pair of anterior swellings on the glabella (for example, *Ceraurus bispinosus* Raymond and Barton, *C. binodosus* Cooper and Kindle, *C. bituberculatus* Troedsson, and *C. maewestoides* Ludvigsen; see Ludvigsen, 1979c, p. 37).

Subfamily Acanthoparyphinae Whittington and Evitt, 1954

Genus *Acanthoparypha* Whittington and Evitt, 1954

Type species. Acanthoparypha perforata Whittington and Evitt, 1954 from the Edinburg Limestone of Virginia (by original designation).

Acanthoparypha? sp.

Pl. 7, fig. 5

Material. A single incomplete cranidium (GSC 64107) from the Selkirk Member at Garson.

Discussion. Post-Chazyan species of *Acanthoparypha* are poorly known in North America. The incomplete cranidium from the Selkirk Member is similar to both *A. subcircularis* (Bradley, 1930) from the Kimmswick Limestone of Missouri and Illinois and *A. goniopyga* Ludvigsen, 1979c from the Whittaker Formation of the District of Mackenzie.

Subfamily Deiphoninae Raymond, 1913

Genus *Sphaerocoryphe* Angelin, 1854

Type species. Sphaerocoryphe dentata Angelin, 1854 from the Upper Ordovician of Sweden.

Sphaerocoryphe robustus Walcott, 1875

Pl. 8, figs. 4, 6, 10

1875 *Sphaerocoryphe robustus* Walcott, p. 273, figs. 18a, b.
1897 *Staurocephalus* sp., Whiteaves, p. 236
1947 *Sphaerocoryphe robustus,* Wilson, p. 52, pl. 10, figs. 1, 2a.
1968 *Sphaerocoryphe robustus,* Shaw, pl. 14, fig. 1
1975 *Sphaerocoryphe* sp., Ludvigsen, pl. 5, figs. 12, 13
1978 *Sphaerocoryphe robustus,* Ludvigsen, pl. 4, fig. 41
1979a *Sphaerocoryphe robustus,* Ludvigsen, fig. 32D
1979b *Sphaerocoryphe robustus,* Ludvigsen, pl. 3, fig. 31
1979c *Sphaerocoryphe robustus,* Ludvigsen, p. 44, pl. 18, figs. 33-53

Material. An incomplete external mold (GSC 64108); an incomplete cranidium (GSC 64109) and about eight glabella from the Selkirk Member at Garson, a glabella (MM I192C) from the Selkirk Member at East Selkirk.

Description. Cephalon, excluding anterior glabellar lobe, roughly semielliptical in outline and strongly convex. Anterior portion of glabella strongly inflated, spherical in outline, length (sag.) slightly less than width (tr.); accounts for two-thirds of cephalic length (sag.). Posterior portion of glabella less convex and subrectangular in outline. 1p lobes represented by small, subtriangular nodes and separated from swollen anterior lobe by broad (sag.) transglabellar furrow. Axial furrows diverge gently forward, becoming wider (tr.) and deeper beyond 1p; shallower at anterior border, where they merge with preglabellar furrow. Occipital furrow bowed forward, weakly incised medially but deepens laterally towards axial furrows. Occipital ring short (sag.), bowed gently forward and convex, raised well above adjacent parts of glabella. Palpebral lobes located just in front of 1p lobes. Posterior border furrow broad (exsag.) and fairly shallow. Posterior border narrower (exsag.) than border furrow and merges with genal spine. Anterior border strongly convex, raised well above adjacent portions of cheeks and also merges with genal spine; widest (exsag.) at genal spine and narrows laterally towards axial furrow. Genal angles bear slender spines of uncertain length. Short fixigenal spine located on lateral cephalic margin, at base of genal spine. Anterior branches of facial suture converge forward to cut anterior cephalic margin at axial furrows. Posterior branches run in forwardly convex curve to cut lateral margin just in front of fixigenal spine. Surface of anterior glabellar lobe covered with coarse granules.

Only eight thoracic segments preserved. Axis convex, narrow, width (tr.) somewhat less than one-third of thoracic width. Axial furrows weakly impressed and subparallel. Axial ring furrows well incised and bowed forward. Pleurae flat for most of width (tr.) but distal ends flexed sharply downward; terminate at blunt spines. Each pleura bears shallow pleural furrow; initiated at axial furrow and extending laterally as far as down-turned portion of pleura.

Pygidium poorly preserved, incomplete; has pair of long, tapered spines directed outward and backward.

Discussion. The Selkirk material is very similar to the type specimen of *Sphaerocoryphe robustus* Walcott, 1875 (Shaw, 1968, pl. 14, fig. 1; Ludvigsen, 1979a, fig. 32D). The main differences are a slightly shorter posterior portion of the glabella and shorter posterior border furrows in the type. There is some variability in the shape and ornament of the anterior glabellar lobe in the Manitoba specimens. Smaller examples are roughly spherical in outline while some larger specimens are slightly flattened, so that they are in the form of oblate spheroids. Also, some specimens have fewer tubercles on the anterior and ventral portions of this lobe.

According to Bradley (1930), a flattened anterior glabellar lobe with sparse tubercles is characteristic of *S. arachniformis* from the Kimmswick Limestone of Missouri. Unfortunately, this species is poorly illustrated so that comparison is difficult. Bradley (1930, p. 285) claimed that a smooth posterior border was characteristic of this species. It is difficult to evaluate the significance of this feature. The eyes of *S. arachniformis* are supposed to be farther forward on the cephalon than those of other species (Bradley, 1930, p. 285). However, from Bradley's description, their location ("situated opposite the anterior border of the posterior glabellar lobes") does not seem significantly different from the position of the eyes in *S. robustus*. Despite minor differences, the specimens described herein are assigned to *S. robustus* instead of *S. arachniformis*. Bradley's species may well prove to be a junior synonym of *S. robustus*.

Sphaerocoryphe maquoketensis Slocom, 1913 from the Maquoketa Formation of Iowa differs from other North American species in possessing ill-defined 1p lobes. *S. pemphis* Lane, 1971 from the Caradoc of the Girvan district of Scotland has palpebral lobes that are located farther forward, opposite the posterior end of the anterior glabellar lobe, and the posterior portion of the glabella is shorter than in *Sphaerocoryphe robustus*.

Family Encrinuridae Angelin, 1854
Subfamily Encrinurinae Angelin, 1854

Genus *Encrinuroides* Reed, 1931

Type species. Cybele sexacostatus Salter, 1848 from the Ashgill of Wales (by original designation).

Encrinuroides sp.
Pl. 8, figs. 11, 12, 14

Material. Two pygidia (MM I192c and GSC 64113) and an incomplete external mold of a cranidium (MM I192a) from the Selkirk Member at Garson.

Description. Glabella elliptical in outline, maximum width (tr.) slightly less than length (sag.) and moderately inflated. Glabella carries very coarse tubercles; coarseness of tubercles makes recognition of lateral glabellar furrows difficult. 1s furrow short (tr.) and directed very slightly anteromedially; 1p lobe very small, poorly defined. 2s furrow similar in size and orientation to 1s furrow; 2p lobe somewhat longer (tr. and exsag.) than 1p lobe. Size and position of 3s furrow uncertain. Occipital ring smooth, moderately long (sag.). Occipital furrow narrow (sag.) and bowed slightly forwards. Axial furrow moderately deep and curved gently outward. Fixed cheeks barely inflated, standing well below level of glabella and ornamented with coarse tubercles. Posterior border smooth; posterior border furrow prominent, deep and slightly shorter (exsag.) than posterior border. Exact course of facial sutures uncertain.

Pygidium subtriangular in outline, length (sag.) slightly more than two-thirds of width (tr.) and moderately convex (tr. and sag.). Axis convex, raised above pleural fields, width (tr.) at anterior a little less than one-third of pygidial width (tr.); narrows posteriorly, terminating a short distance from posterior tip of pygidium. Axial rings poorly preserved, but at least seventeen present. Axial ring furrows deep at anterior, becoming shallower posteriorly. Pleural fields curved sharply downward. Seven pairs of pleural ribs, decreasing in length towards rear, and separated by wide (tr.) pleural furrows. First four pairs curve out and back, degree of outward curvature decreasing towards rear; last three pairs directed almost straight back. Tips of ribs extend back no farther than pygidial margin and are slightly inflated to produce small, roughly circular shaped bosses.

Discussion. The description of *Encrinuroides pernodosus* (Slocom, 1913) from the Maquoketa Formation of Iowa is very similar to the specimens considered herein. The glabellar outline and degree of inflation seem to be very close and, in both, the lateral glabellar furrows are indistinct. Unfortunately, Slocom's illustrations are poor (pl. 16, figs. 5-7) and do not allow a direct comparison to be made. Walter (1928) reproduced Slocom's photographs and description.

E. rarus (Walcott, 1877), *E. sexocostata* (Salter, 1848) and *E. capitonis* Fredrickson, 1964 can be distinguished from the material described herein by their abruptly expanding glabellae. *E. capitonis* also differs in having 9 pairs of pleural ribs in the pygidium, while *E. rarus* shows fusion of the posterior-most pair of pleural ribs to produce a postaxial piece. This latter feature can also be seen in *E. insularis* Shaw, 1968 and in the species established by Evitt and Tripp (1977), *E. uncatus* and *E. tholeus*. *E. insularis* also differs in possessing prominent eye tubercles on the fixed cheeks while the latter two species have more strongly expanded glabellae than those of the Selkirk specimen.

E. nodosarius (Raymond, 1925) and *E. neuter* Evitt and Tripp, 1977 differ from the material described herein in possessing eight pairs of pleural ribs on the pygidium, while *E. vigilans* Hall (1847) and its synonyms *E. trentonensis* (Walcott) and *E. cybeleformis* (Raymond) (see Ludvigsen, 1979a) have ten pairs of pleural ribs. *E. spicatus* (Tripp, 1974) and *Encrinuroides* sp. (Tripp, 1974) from the Galena Formation of Wisconsin and Iowa also differ in the number of pygidial ribs; the former has six while the latter has eight.

Suborder Calymenina Swinnerton, 1915
Family Calymenidae Milne-Edwards, 1840
Subfamily Flexicalymeninae Siveter, 1977

Discussion. The subfamily Flexicalymeninae was erected by Siveter (1977) to accomodate calymenids which lack buttresses extending from fixed cheeks to lateral glabellar lobes.

Genus *Flexicalymene* Shirley, 1936

Type species. Calymene blumenbachi var. *caratacti* Salter, 1865 from the Caradoc of Shropshire (by original designation).

Flexicalymene cf. *senaria* (Conrad, 1841)
Pl. 8, figs. 5, 7-9

1841 *Calymene senaria* Conrad, p. 38
1842 *Calymene senaria,* Emmons, p. 380, fig. 2.
1941 *Flexicalymene senaria,* Whittington, p. 493, pl. 72, figs. 1-27, 31-34, 38-40, 42-47, text – fig. 1.
1947 *Flexicalymene senaria,* Wilson, p. 48, pl. 10, figs. 11a, b, 12.
1958 *Flexicalymene senaria,* Stumm and Kauffman, p. 949, pl. 123, figs. 1-11.
1967 *Flexicalymene senaria,* Ross, p. B14, pl. 4, figs. 1-6.
1978 *Flexicalymene senaria,* Ludvigsen, pl. 3, figs. 31-32.
1979a *Flexicalymene senaria,* Ludvigsen, p. 46, figs. 29 a-d.

Material. An incomplete, exfoliated exoskeleton (GSC 7168) from the Selkirk Member at Lower Fort Garry, Manitoba and an exfoliated glabella (GSC 64115) from the Selkirk Member at Garson.

Description. Cranidium subtrapezoidal in outline, length (sag.) roughly half width (tr.) at posterior end, and moderately convex. Glabella broad, moderately convex, well raised above cheeks, parabolic in outline, narrowing forward so that width (tr.) at anterior is three-fifths of width at posterior. Axial furrows well incised, converging forward in a smooth curve, and becoming deeper in front of 3s furrows. Three pairs of lateral glabellar furrows. 1s furrow curved posteromedially, and deep. 1p lobe subcircular in outline and inflated. 2s furrow also directed posteromedially, shorter and shallower than 1s. 2p lobe subcircular in outline and inflated; length (exsag.) a little more than half of that of 1p. 3s furrows weak, directed slightly posterolaterally. 3p lobe subcircular in outline, length (exsag.) about one-third that of 1p. Frontal lobe subrectangular in outline and accounts for slightly more than one-quarter of glabellar length (sag.). Occipital ring incomplete but apparently bowed forward. Occipital furrow bowed gently forward, shallow at sagittal line but deeper behind 1p lobe. Posterior border short (exsag.) at axial furrows but becomes broader towards genal angle. Posterior border furrow moderately deep and long (exsag.). Preglabellar furrow well incised and long (sag.). In front of glabella, anterior border in form of low, upturned rim. Lateral border not preserved. Exact course of facial sutures and location of palpebral lobes uncertain; free cheeks not preserved.

Thorax incomplete and poorly preserved. Only six thoracic segments preserved. Axis broad (tr.), width a little more than one-third of thoracic width (tr.) and convex, well raised above pleural fields. Axial furrows shallow, and subparallel. Pleurae poorly preserved; shallow pleural furrows present.

Pygidium subtriangular in outline, length (sag.) equals maximum width (tr.) and strongly convex. Axis broad, width (tr.) at anterior end almost half of maximum pygidial width (tr.); tapers backward to terminate well in front of posterior margin; posterior end of axis rounded. Axis strongly convex, well raised above adjacent portions of pleural fields. Axial furrows shallow and converge backward; posterior termination of axis bounded by faint furrow. At least four axial rings present. Pleural fields dip steeply down and away from axis. Six pairs of pleural ribs separated by shallow interpleural furrows. Anterior pair curves outward and backward; degree of backward curvature gradually increases in successively posterior pairs, so that posteriormost are directed almost straight back.

Discussion. Flexicalymene senaria (Conrad, 1841) from the Trenton Group of Ontario and New York State is very similar to the Selkirk specimens in terms of cephalic morphology. The only major differences between the two appear to be the somewhat longer (sag.) pygidium and less convex pygidial axis of *F. senaria.*

F. meeki (Foerste, 1910) from the Upper Ordovician of the Cincinnati region also differs from the Selkirk material in these respects. In addition, the glabella of the former is somewhat longer (sag.) and the anterior cephalic border is more steeply inclined.

The broader pygidium and higher, more steeply inclined anterior cephalic border separates *F. griphus* Ross, 1967 from the Upper Ordovician of Kentucky from the specimens described here. *F. gracilis* (Slocom, 1913) from the Maquoketa Formation of Iowa possesses both a strongly convex pygidium and pygidial axis which is similar to that of *F.* cf. *senaria.* However, it differs in having a shorter (sag.) glabella and longer (sag.) preglabellar furrow; in addition there is, apparently, a node on each of the cheeks, opposite the frontal glabellar lobe (see Slocom, 1913, pl. 18, fig. 9). *F. fayettensis* (Slocom, 1913), also from the Maquoketa Formation of Iowa, differs from the specimens considered here in possessing pleural furrows on the pygidium. In addition, the anterior cephalic border is more steeply inclined.

The Selkirk material is closest to *F. senaria.* It is possible, however, that it represents a new species of *Flexicalymene* characterised by a relatively short, strongly convex pygidium with a strongly convex axis; a moderately long glabella and a gently inclined anterior cephalic border. More material is necessary in order to confirm this possibility.

Suborder Phacopina Struve, 1959
Superfamily Dalmanitacea Vogdes, 1890
Family Pterygometopidae Reed, 1905
Subfamily Pterygometopinae Reed, 1905

Genus *Calyptaulax* Cooper, 1930

Type species. Calyptaulax glabella Cooper, 1930 from the Whitehead Formation (Ashgill) of Gaspé, Quebec (by original designation).

Calyptaulax cf. *schmidti* (Clarke, 1894)
Pl. 7, fig. 9, Pl. 8, figs. 13, 15

1894 *Pterygometopus schmidti* Clarke, p. 729, fig. 50.
1940 *Calliops schmidti,* Delo, p. 99, pl. 12, figs. 6, 7.
1977 *Calliops* sp., Bolton, pl. 10, fig. 12, pl. 17, fig. 8.

Material. An incomplete cephalon (GSC 64116), a small cephalon (GSC 64117), an incomplete glabella (UM 399), and one eye and palpebral lobe (UM 425). All from the Selkirk Member at Garson.

Description. Cephalon broad (tr.), length (sag.) half of width (tr.), subtrapezoidal in outline but modified anteromedially by an upturned, triangular prow. Lateral cephalic margin bowed outward. Glabella comprises one-third of cephalic width (tr.) and is moderately inflated; expands anteriorly to maximum at frontal lobe although is only slightly narrower (tr.) at 3p lobe. Three pairs of lateral glabellar lobes present. 1s furrow deep, short, curved gently forward; 1p lobe isolated near axial furrow. 2s furrow shallower, curves slightly backwards. 2p lobe subrectangular in outline, width (tr.) twice length (exsag.). 3s furrow deep and wide (tr.), and directed posteromedially, proceeding inward for about one-third of glabellar width (tr.). 3p lobe subtriangular in outline and slightly inflated. Frontal lobe long (sag.), accounting for a little less than half of maximum glabellar length (sag.). Occipital ring is bowed gently backward, length (sag.) one-third width. Occipital furrow as deep as 1s furrow and nearly straight. Axial furrows well defined; converge gradually as far as 1s and diverge in even curve in front of 1s. Glabellar surface bears numerous medium sized tubercles. Posterior border moderately inflated, narrow (exsag.) near axial furrow but widens towards genal angle. Lateral border wide (tr.), narrows in front of eyes and, in front of glabella, anterior border expands into triangular prow. Genal angles have moderately long, slender, slightly curved genal spines which terminate as fine points. Eyes large, elevated well above level of adjacent parts of cheeks. In dorsal view, visual surface curves through an arc of about 170°. Surface consists of 187 dome shaped lenses, each being about half a millimetre in diameter; sclera between lenses thin and depressed. Lenses are arranged in 26 vertical files, central files have eight lenses. Palpebral lobes narrow, crescentic in outline and raised well above adjacent parts of genae. Palpebral furrows deep, also crescentic in outline. Course of facial sutures uncertain.

Discussion. The triangular anterior prow, the board lateral cephalic borders below the eye, the large eyes with numerous lenses, and the slender curved genal spines of the two cephala from the Selkirk Member at Garson indicate close affinity to the cephala of *Calyptaulax schmidti* (Clarke) from the Galena Formation of Minnesota and Wisconsin (Clarke, 1894, fig. 50; Delo. 1940, pl. 12, fig. 7). Some of these features are also shared with the cephalon of *Calliops* sp. from the Bad Cache Rapids Formation of Melville Peninsula, District of Franklin (Bolton, 1977, p. 10, fig. 12, pl. 17, fig. 8). A decision as to whether the Minnesota, Wisconsin, Manitoba, and Melville Peninsula material is conspecific must await redescription of the type material of *Calyptaulax schmidti* and recovery of other exoskeletal elements.

Calyptaulax sp. A
Pl. 7, fig. 7

Material. A small pygidium (GSC 64118) from the Selkirk Member at Garson and an incomplete internal mold (GSC 7205) from the Selkirk Member at Lower Fort Garry.

Description. Pygidium moderately inflated and subtriangular in outline, width (tr.) slightly greater than length (sag.). Axial furrows deep and coverge backwards. Axis convex, narrow, terminates just in front of posterior margin. At least eight axial rings present. Axial ring furrows bowed backwards and decrease in depth towards the rear. Pleural fields initially flat but then curve downward at an angle of about 45 degrees; terminate at narrow, smooth border. Six pairs of interpleural furrows terminate a short distance from pygidial margin. Each pleura bears a well-defined pleural furrow, running roughly parallel to interpleural furrow; initiated close to axis and becoming deeper and wider (exsag.) and terminates at border.

Discussion. There are two types of pygidia in the collection and it is not certain which belongs to *Calyptaulax* cf. *schmidti.*

Calyptaulax sp. B
Pl. 7, fig. 8

Material. an incomplete pygidium (MM I192b) from the Selkirk Member at Garson and a pygidium (GSC 7204a) from the Selkirk Member at East Selkirk.

Discussion. The single pygidium of *Calyptaulax* sp. B is narrower (tr.) and possesses a longer axis than that of *Calyptaulax* sp. A. In these respects, *Calyptaulax* sp. B is somewhat similar to the pygidia of *"Calyptaulax" lincolnensis* (Branson) – a species that occurs widely in Blackriveran to Edenian strata of North America (Ludvigsen, 1978, fig. 3).

Order Lichida Moore, 1959
Family Lichidae Hawle and Corda, 1847
Subfamily Tetralichinae Phleger, 1936

Genus *Amphilichas* Raymond, 1905

Type species. Platymetopus lineatus Angelin, 1854 from the Boda Limestone (Upper Ordovician) of Sweden (by original designation).

Amphilichas cf. *cucullus* (Meek and Worthen, 1865)
Pl. 9, figs. 1, 6, Pl. 10, figs. 1-7

1865 *Lichas cucullus* Meek and Worthen, p. 266
1894 *Platymetopus cucullus,* Clarke, p. 746, figs. 66, 67.
1897 *Lichas (Platymetopus) cucullus,* Whiteaves, p. 236.
1920b *Acrolichas cucullus,* Foerste, p. 30, pl. 1, figs. c, d, f, g; [not figs. a, b, e, = *Amphilichas ottawaensis* (Foerste)].
1930 *Acrolichas cucullus,* Bradley, p. 264, pl. 29, figs. 1-9.
1944 *Acrolichas cucullus,* Shimer and Shrock, p. 649, pl. 270, figs. 19-22.
1957 *Amphilichas cucullus,* Tripp, text-fig. 4, q.
1959 *Amphilichas cucullus,* Tripp, p. 0498, fig. 395, 1c.

Material. Three large incomplete cranidia (UM 394, MM I34, GSC 64123), a small cranidium (GSC 64124) and 3 other cranidia from the Selkirk Member at Garson, Manitoba; a small nearly complete cranidium (GSC 7214a) from the Selkirk Member at East Selkirk, Manitoba; a large, incomplete pygidium (GSC 64126) and a small complete pygidium (MM I33) from the Selkirk Member at Garson, Manitoba; a small incomplete pygidium (GSC 64127) from the Selkirk Member at St. Andrews, Manitoba; a large thoracic pleura (MM I35) from the Selkirk Member at Garson.

Description. Cranidium subtriangular in outline, length (sag.) two-thirds width, and strongly convex so that anterior half is extended into conical protuberance. Glabella comprises three lobes. Central glabellar lobe expands forward so that width (tr.) at anterior termination of longitudinal glabellar furrows is somewhat more than twice width (tr.) at occipital ring; extends well beyond the anterior ends of lateral glabellar lobes and narrows to bluntly rounded apex. Longitudinal glabellar furrows well incised, subparallel behind level of eyes and diverge forward and downward anteriorly to join preglabellar furrow. Lateral glabellar lobes subtrapezoidal in outline, length (exsag.) roughly twice width (tr.); gently inflated at posterior but depressed well below central lobe anteriorly. Axial furrows strongly incised, initially diverge very gradually forward to a point just in front of posterior end of palpebral lobe; from here, converge forward and downward to join preglabellar furrow at its intersection with longitudinal glabellar furrow. Occipital furrow also well incised, transverse behind central glabellar lobe but deflected backwards behind lateral lobes. Occipital ring longest (sag.) behind central glabellar lobe and narrows towards axial furrows. Posterior border furrow clearly defined, directed anterolaterally away from axis; posterior border very short. Fixed cheeks arcuate in outline. Palpebral lobes semicircular in outline and depressed very slightly below adjacent parts of fixigenae; palpebral furrows weak. Anterior branches of facial suture directed downward in smooth curve. Posterior branches diverge abruptly backward in forwardly convex curve. Entire cranidium is densely covered with medium sized tubercles and a few larger tubercles that are paired.

Only one thoracic pleura known. Pleura bowed backward, flat near axis, but curved gently downward distally; termination not preserved. Shallow, oblique pleural furrow directed anteromedially. Surface bears medium sized tubercles and terrace ridges near distal termination. Axial furrows shallow, but well-defined; axial lobe appears to have been moderately convex, width (tr.) unknown.

Pygidium suboval in outline, weakly convex, and has three pairs of pleurae. Axis of low convexity with two short (sag.) axial rings at anterior end. First axial ring furrow bowed gently forward; posterior ring furrow bowed backward. Axial furrows shallow, but well defined, converging backwards to meet at posterior end of pygidium. Two first pleurae curve backward to terminate at short, bluntly rounded spines and bear short (tr.) pleural furrows close to axial furrow. Third pair proceeds straight back, terminating at short, bluntly rounded spines which are somewhat wider (tr.) than those of anterior pairs. Doublure broad (sag.) and bears terrace ridges. Entire dorsal surface covered by medium sized tubercles.

Discussion. Smaller cranidia of *Amphilichas* cf. *cucullus* (Meek and Worthen) from the Selkirk Member (Pl. 9, fig. 6, Pl. 10, figs. 5, 7) appear identical to those of *A. cucullus* from the Kimmswick Limestone of Missouri (Shimer and Shrock, 1944, Pl. 270, figs. 19-22) and the "Galena Limestone" of Minnesota (Clarke, 1894, figs. 66, 67). The development of a large blunt and conical protuberance results in a triangular outline to each large cranidium (Pl. 10, fig. 1). Similar swellings are known in both *A. cucullus* and *A. ottawaensis* (Foerste), but in these species the swellings are dorsally directed. In *A.* cf. *cucullus* it is anteriorly directed (Pl. 10, fig. 2); essentially a shorter, blunter and broader-based version of the "proboscis" seen in *Amphilichas (Probolichas)* as illustrated by Clarke (1894, figs. 68, 69) and Evitt (1951, fig. 9a-d).

Amphilichas cf. *clermontensis* Slocom, 1913

Pl. 9, fig. 2

1913 *Amphilichas clermontensis,* Slocom, p. 59, pl. 15, fig. 7.
1916 *Amphilichas clermontensis,* Slocom, p. 207, pl. 16, fig. 7.
1920b *Acrolichas clermontensis,* Foerste, p. 31, pl. 2, figs. 7.
1924 *Amphilichas clermontensis,* Walter; p. 227, pl. 18, fig. 9.
1944 *Tetralichas clermontensis,* Shimer and Shrock, p. 654, pl. 270, fig. 6.

Material. A nearly complete cranidium (GSC 64121) from the Selkirk Member at Garson.

Description. Cranidium subcircular in outline, length (sag.) slightly more than half width (tr.) and strongly convex. Glabella comprises three lobes. Central glabellar lobe expands forward, so that width (tr.) at anterior is nearly three times that at occipital ring. Anterior portion of lobe regularly rounded and projects only slightly beyond anterior ends of lateral lobes. Longitudinal glabellar furrows well incised, subparallel from occipital ring to a point just in front of posterior end of palpebral lobes; forward of this point they diverge abruptly forward and downward. Lateral glabellar lobes subtrapezoidal in outline, length (exsag.) twice width (tr.) at posterior end, and depressed slightly below central lobe. Occipital furrow well incised, transverse behind central glabellar lobe, but deflected back behind lateral lobes. Occipital ring wide (tr.) and short (sag.). Between occipital ring and anterior end of palpebral lobe, axial furrows proceed forward in a curve, gently convex towards sagittal line; from end of palpebral lobes, converge abruptly forward and downward to join longitudinal glabellar furrow. Fixed cheeks arcuate in outline, shorter (exsag.) than lateral glabellar lobes, and dip gently backwards. Palpebral lobes semicircular in outline and raised slightly above adjacent parts of fixed cheeks; palpebral furrows very weak. Posterior branches of facial suture diverge backwards in a faintly sigmoidal curve. Exact course of anterior branches uncertain but apparently converge forward and downward in a smooth curve. Entire dorsal surface of cranidium covered by fine tubercles.

Discussion. The specimen described here appears to be close to *Amphilichas clermontensis* Slocom, 1913 from the Maquoketa Formation of Iowa. The only difference between the two is the more abruptly divergent longitudinal glabellar furrows and somewhat shorter (sag.) occipital ring in the latter. Published illustrations of *A. clermontensis* (Slocom, 1913, pl. 15, fig. 7) are poor, so that a definite decision regarding the correct assignment of the Selkirk material cannot be made at the present time.

Amphilichas minganensis (Billings, 1865) differs from the Selkirk specimen in possessing longitudinal glabellar furrows that diverge more gradually, being subparallel between the occipital ring and the anterior end of the palpebral lobes. *A. cucullus* (Meek and Worthen, 1865), *A. ottawaensis* (Foerste, 1920), *A. aspratilis* (Bradley, 1930), and *A. subpunctatus* Esker, 1964 all differ from *A.* cf. *clermontensis* in possessing median glabellar lobes that are narrower (tr.) and less regularly rounded anteriorly, and that extend further forward beyond the anterior ends of the lateral glabellar lobes.

Subfamily Ceratarginae Tripp, 1957

Genus *Hemiarges* Gürich, 1901

Type species. Lichas wesenbergensis Schmidt, 1885 from the Rakvere Limestone (Middle Ordovician) of Estonia (subsequent designation by Reed, 1902).

Hemiarges cf. *tuberculatus* (Weller, 1903)

PL. 9, figs. 3, 4

1903 *Arges tuberculatus* Weller, p. 199, pl. 15, figs. 11-13.
1927 *Hemiarges paulianus* (Clarke), Troedsson, p. 53, pl. 15, figs. 15a-c.
1958 *Hemiarges tuberculatus,* Tripp, p. 577.

Material. A cranidium (GSC 64122) from the Selkirk Member at Garson.

Discussion. Three separate species groups of *Hemiarges* are found in Kirkfieldian to Edenian strata in North America:

(1) A group typified by *H. paulianus* (Clarke, 1894) (senior synonym of *H. bartoni* Raymond and *H. aeolus* Sinclair) which is characterized by an evenly and coarsely tuberculate glabella with a moderately inflated central glabellar lobe that expands forward. This group occurs widely in Shermanian and Edenian strata of eastern North America (Ludvigsen, 1978) and is clearly similar to both the type species. *H. wesenbergensis* (Schmidt), from Estonia and *H. turneri* Chatterton and Ludvigsen, 1976 from the Chazyan of the District of Mackenzie and New York State.

(2) A group typified by *H. leviculus* Bradley, 1930 which is characterized by a granulate glabella with a weakly inflated central glabellar lobe that expands markedly forwards, and a broad, flat anterior border. This group occurs in Missouri and Illinois and in the District of Mackenzie (Ludvigsen, 1979b, pl. 2, fig. 16).

(3) A group typified by *H. tuberculatus* (Weller, 1903) which is characterized by a transverse cranidium with a narrow (tr.) and highly inflated central glabellar lobe that expands only slightly forward. A pair of very large tubercles are situated on a transverse line on the central glabellar lobe and a similar tubercle surmounts each of the lateral glabellar lobes. This group occurs in eastern North America, northern Greenland (Troedsson, 1928), and the District of Mackenzie (Ludvigsen, unpublished).

The single cranidium from the Selkirk Member at Garson clearly belongs in the third group of *Hemiarges*. This cranidium is wider than long and the central glabellar lobe is strongly inflated and raised above the lateral lobes. Three prominent tubercles are arranged in a posteriorly-pointing triangle on the central glabellar lobe and one each on the lateral glabellar lobes.

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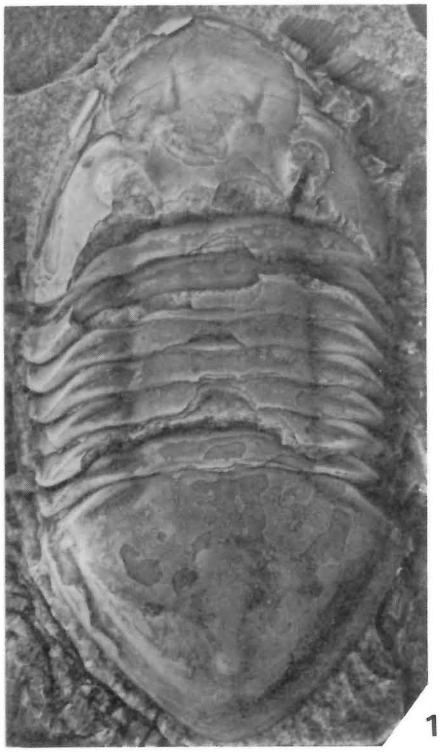
PLATE 1:

Isotelus cf. *gigas* DeKay
1. Nearly complete exfoliated exoskeleton, dorsal view, X 1, GSC 1799. Cat Head Member, Inmost Island, Lake Winnipeg.

Ectenaspis beckeri (Slocom)
2, 4. Nearly complete partially exfoliated exoskeleton, lateral and dorsal views, X 1, holotype, FM 41151. Maquoketa Formation, Clermont, Iowa.
10. Incomplete exfoliated cranidium, dorsal view, X 1.5, FM 16998. Maquoketa Formation, Potsville Junction, Iowa. Note eye stalk on right side.

Ectenaspis sp.
6, 7, 9. Incomplete partially exfoliated exoskeleton, dorsal and lateral views, X 2.2, GSC 64083. Selkirk Member, Garson.
3, 5. Incomplete free cheek, latex impression, lateral and dorsal views, X 1.2, GSC 64084. Selkirk Member, Garson.

Hypodicranotus sp.
8. Incomplete free cheek, latex impression, lateral view, X 2.5, GSC 64075. Selkirk Member, Garson.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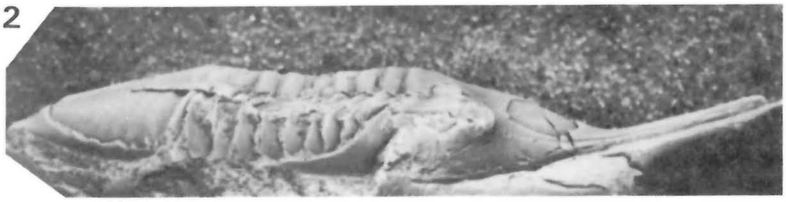
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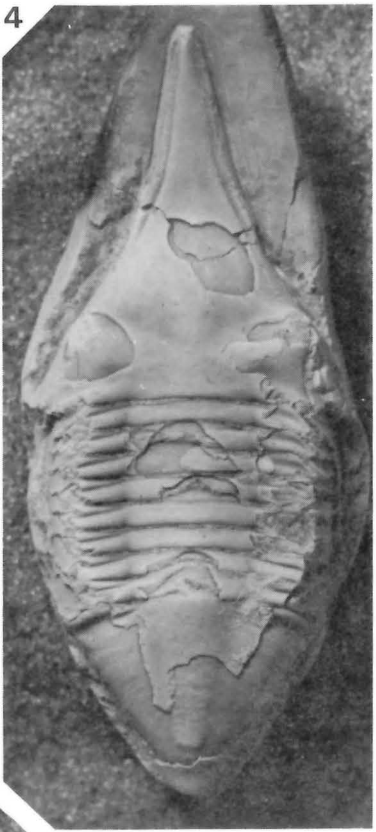
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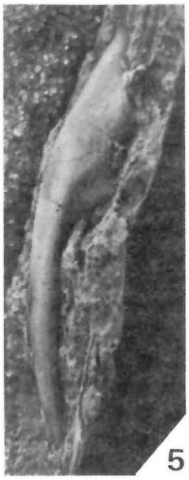
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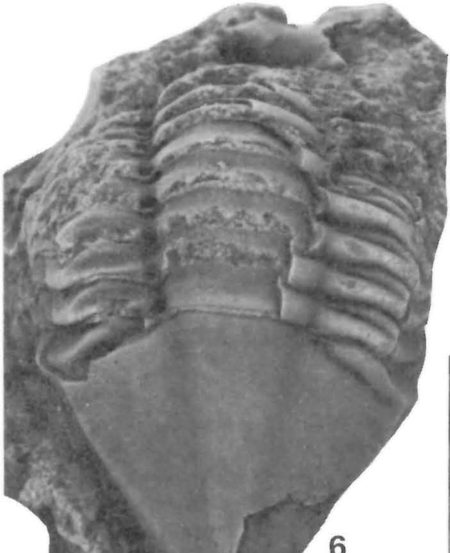
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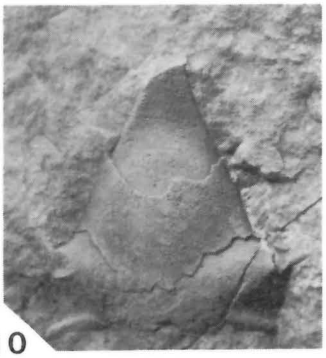
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PLATE 1

PLATE 2:

Isotelus sp.

1. External mold of free cheek, ventral view, X 2, GSC 64077. Selkirk Member, Garson.

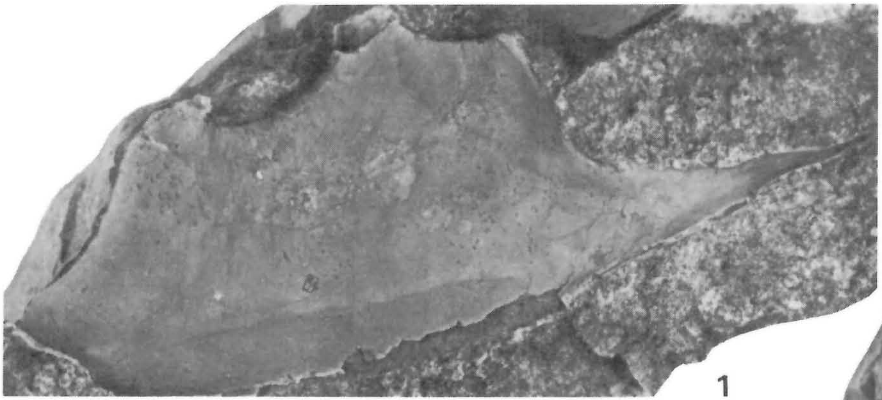
Isotelus cf. *gigas* DeKay

2, 3. Partially exfoliated exoskeleton, dorsal and lateral views, X 1.1, MM I129. Cat Head Member, Cat Head, Lake Winnipeg.

6. Exfoliated thorax and incomplete pygidium, dorsal view, X 1.3, GSC 64076. Selkirk Member, Garson.

Dolichoharpes dentoni (Billings)

4, 5. Incomplete and largely exfoliated cephalon, lateral and dorsal views, X 3, MM I35. Selkirk Member, Garson.



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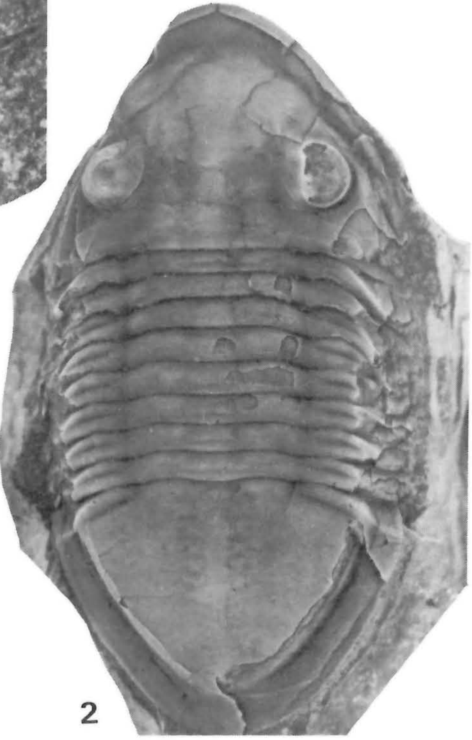

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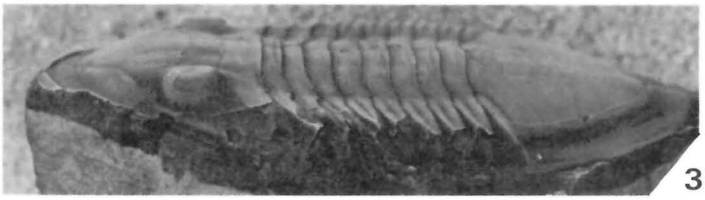

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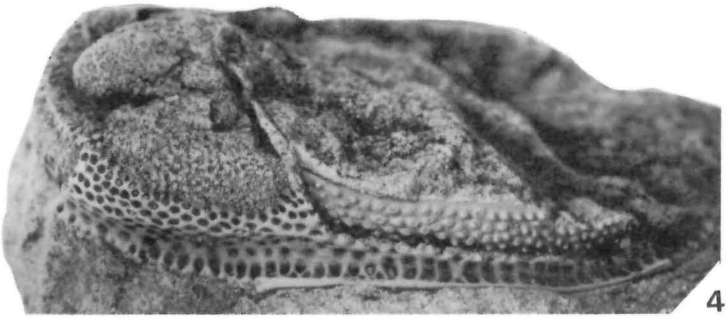

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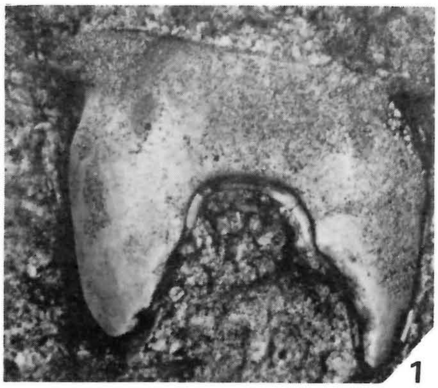
PLATE 2

PLATE 3:

Nahannia gratiosa (Raymond)
1. Exfoliated hypostome, ventral view, X 2.1, GSC 64094. Selkirk Member, Garson.
7, 8. Enrolled exfoliated exoskeleton anterior and dorsal views, X 1.5, MM I227. Selkirk Member, Garson.
9, 10, 11. Partly enrolled exfoliated exoskeleton, lateral and dorsal views, X 1.4, GSC 7170. Selkirk Member, East Selkirk.

Eobronteus cf. *slocomi* (Bradley)
3. Internal mold of pygidium, dorsal view, X 2.5, GSC 64098. Selkirk Member, Garson.

Illaenus americanus Billings
2, 5, 6. Incomplete exfoliated cephalon, lateral, dorsal, and ventral views, X 2, GSC 64085. Selkirk Member, Garson.
4. Partly exfoliated pygidium, dorsal view, X 2, GSC 64086. Selkirk Member, Garson.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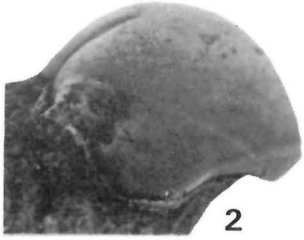
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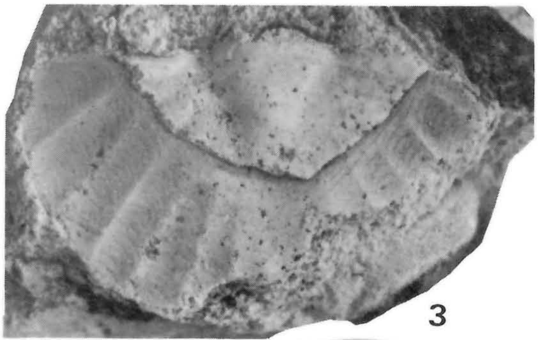
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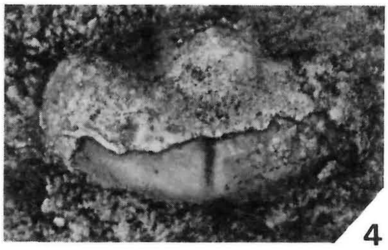
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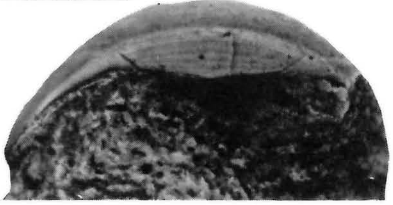
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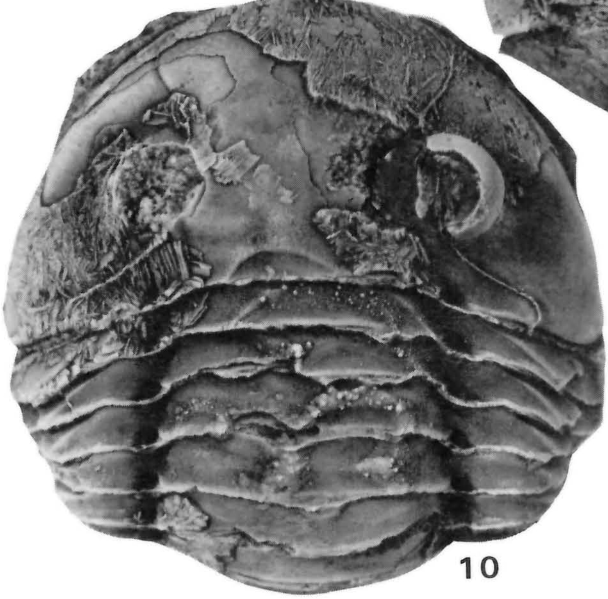
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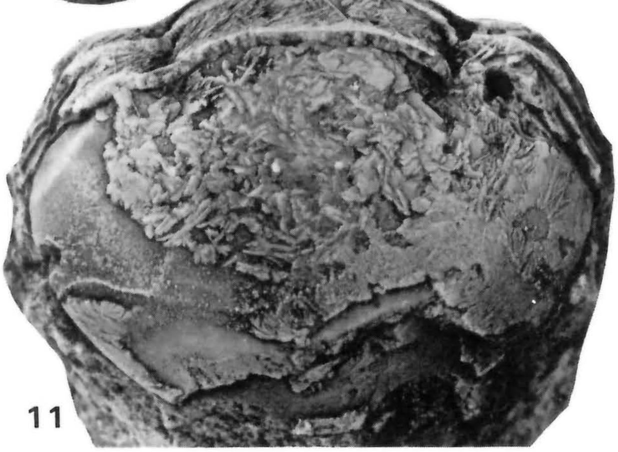
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PLATE 3

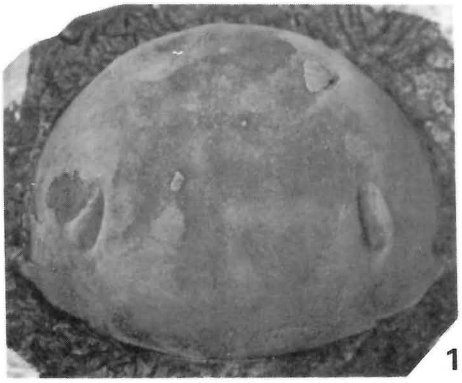
PLATE 4:

Stenopareia garsonensis sp. nov.

3, 6.	Incomplete exfoliated cranidium, lateral and dorsal views, X 2.3, holotype, GSC 64087. Selkirk Member, Garson.
4.	Incomplete exfoliated cranidium, dorsal view, X 1.5, GSC 64088. Selkirk Member, Garson.

Bumastoides tenuirugosus (Troedsson)

1.	Exfoliated cranidium, dorsal view, X 1, GSC 64092. Selkirk Member, Garson.
2.	Exfoliated pygidium showing doublure, dorsal view, X 1.5, GSC 64093. Selkirk Member, Garson.
5, 8.	Nearly complete exoskeleton, oblique lateral and dorsal views, X 2, GSC 64090. Selkirk Member, Garson.
7.	Partly exfoliated cranidium, dorsal view, X 1.4, ROM 475T. Selkirk Member, Garson.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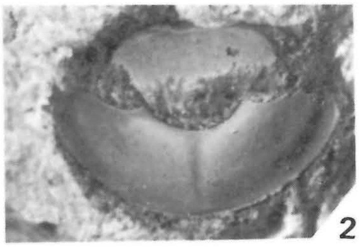
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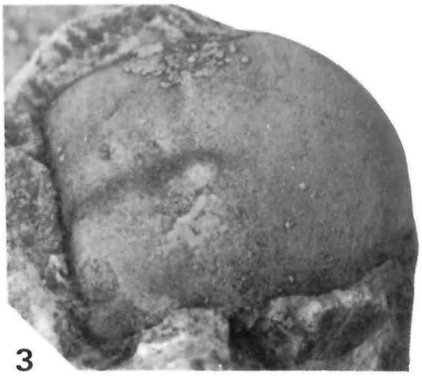
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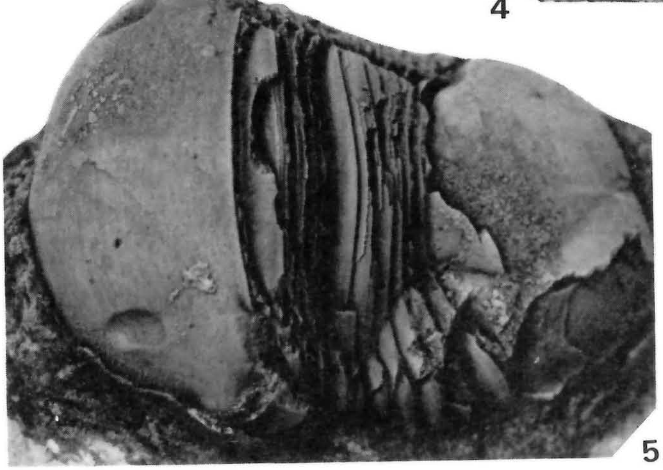
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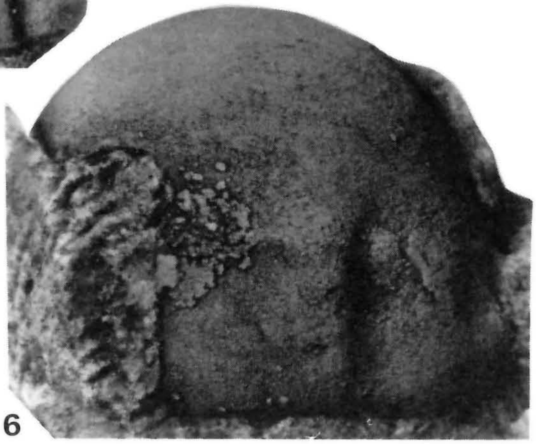
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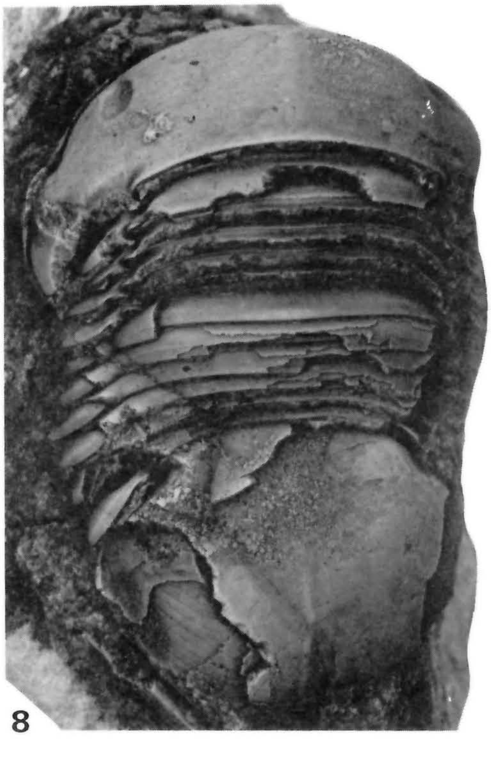
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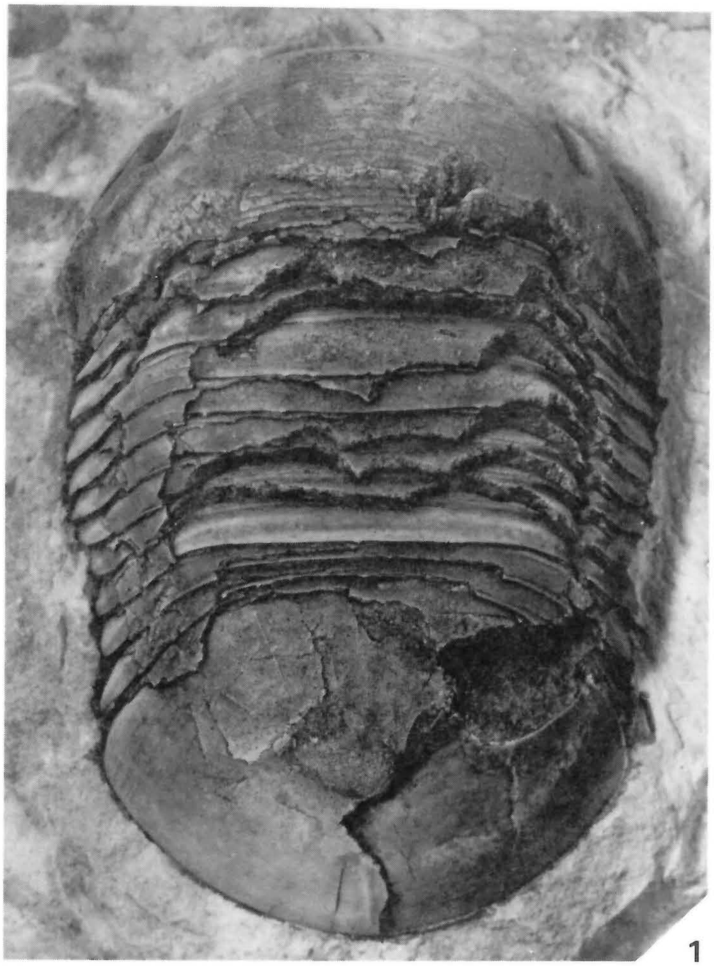
PLATE 4

PLATE 5:

Bumastoides tenuirugosus (Troedsson)
1, 6. Exfoliated exoskeleton, dorsal and lateral views, X 1.1, MM I220. Selkirk Member, Garson.
2. Incomplete thorax and pygidium, latex impression of external mold, ventral view, X 2, MM I149. Selkirk Member, Lockport, Manitoba.
3. Exfoliated pygidium showing doublure, dorsal view, X 1.2, GSC 64095. Selkirk Member, Garson.
4, 5. Exfoliated cephalon, postero-ventral view showing rostral flange and ventral view, X 3 and X 1.3, GSC 64091. Selkirk Member, Garson.



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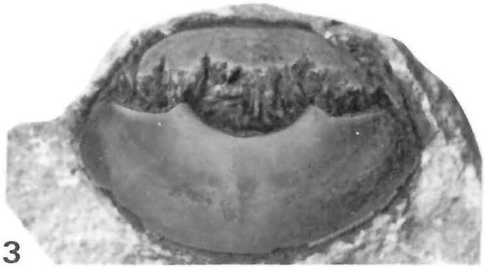

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PLATE 5

PLATE 6:

Failleana indeterminata (Walcott)

1, 3. Exfoliated cephalon and two thoracic segments, lateral and dorsal views, X 1.2, UA Or 93. Selkirk Member, Tyndall.

2. Partly exfoliated pygidium, dorsal view, X 0.9, GSC 64096. Selkirk Member, Garson.

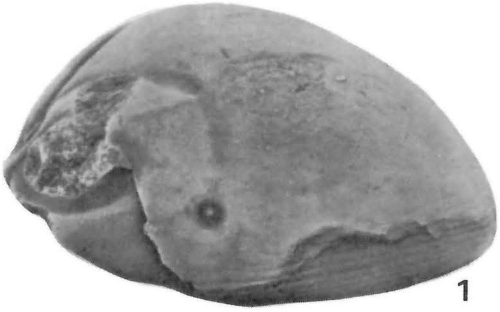
4. Incomplete exfoliated cranidium, dorsal view, X 2.3, GSC 7201. Selkirk Member, Lower Fort Garry.

6. Exfoliated cranidium, dorsal view, X 1.4, GSC 64095. Selkirk Member, Garson.

7. Incomplete exfoliated exoskeleton, dorsal view, X 1, MM I95. Selkirk Member, Garson.

Borealaspis whittakerensis Ludvigsen

5. Incomplete exfoliated fixed cheek, dorsal view, X 1.7, GSC 64112. Selkirk Member, Garson.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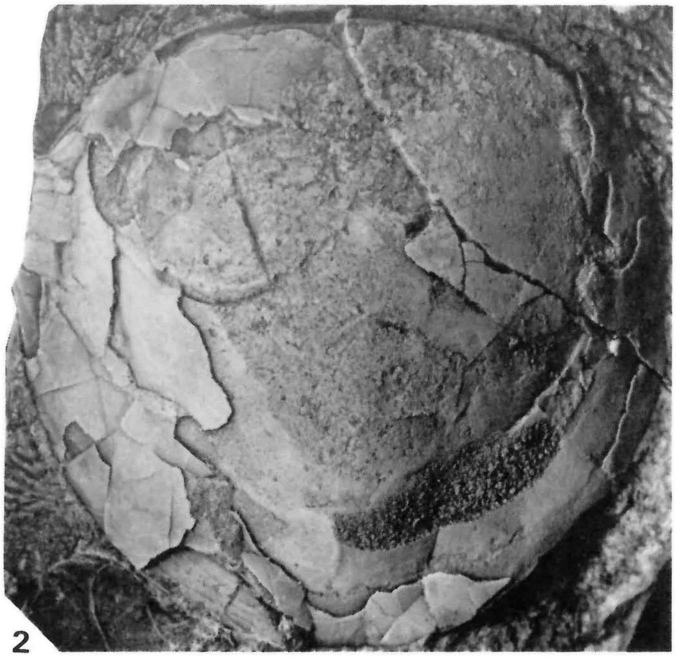
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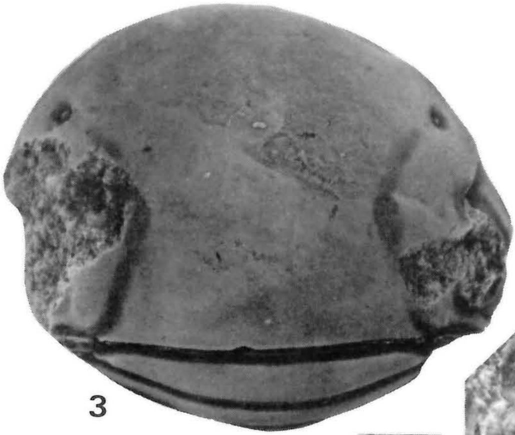
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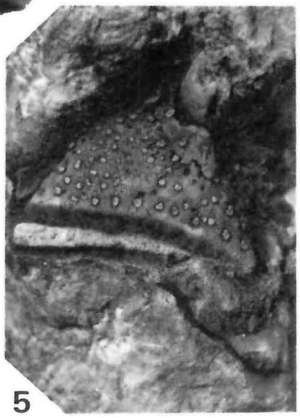
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PLATE 6

PLATE 7:

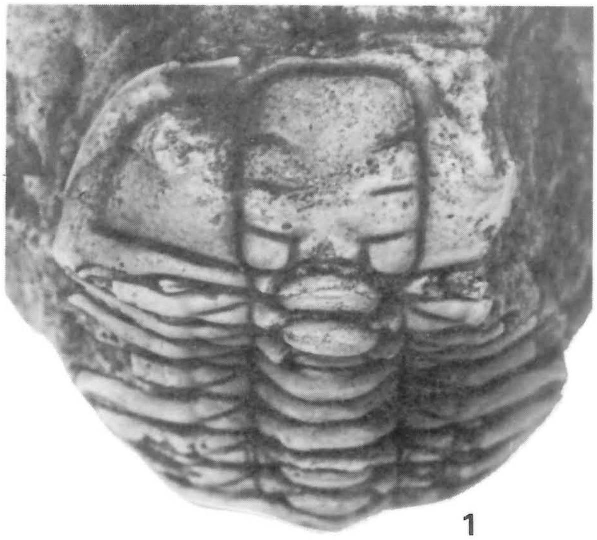
Ceraurinus cf. *icarus* (Billings)
1, 4. Exfoliated exoskeleton, dorsal view of cephalon and dorsal view of pygidium, X 3.5, MM I228. Selkirk Member, Garson.
2. Exfoliated cephalon, dorsal view, X 2, GSC 7211. Selkirk Member, Lower Fort Garry.
3. Largely exfoliated cranidium, dorsal view, X 2.3, GSC 64100. Selkirk Member, Garson.
6. Exfoliated cephalon and thorax, dorsal view, X 2, MM I426. Selkirk Member, Garson.
8, 11. Incomplete hypostome, latex impression, ventral and lateral views, X 3.5, GSC 64099. Selkirk Member, Garson.

Acanthoparypha ? sp.
5. Exfoliated glabella, dorsal view, X 4, GSC 64107. Selkirk Member, Garson.

Calyptaulax cf. *schmidti* (Clarke)
9. Exfoliated cephalon, dorsal view, X 3, GSC 64117. Selkirk Member, Garson.

Calyptaulax sp. A
7. Exfoliated pygidium, dorsal view, X 5, GSC 64118, Selkirk Member, Garson.

Calyptaulax sp. B
10. Exfoliated pygidium, dorsal view, X 3, MM I192b, Selkirk Member, Garson.



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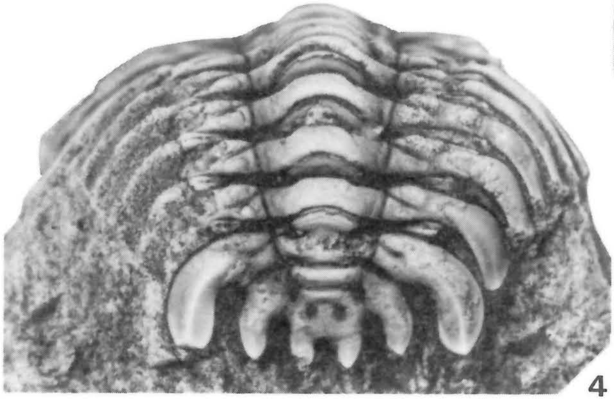

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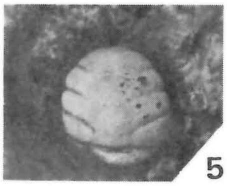

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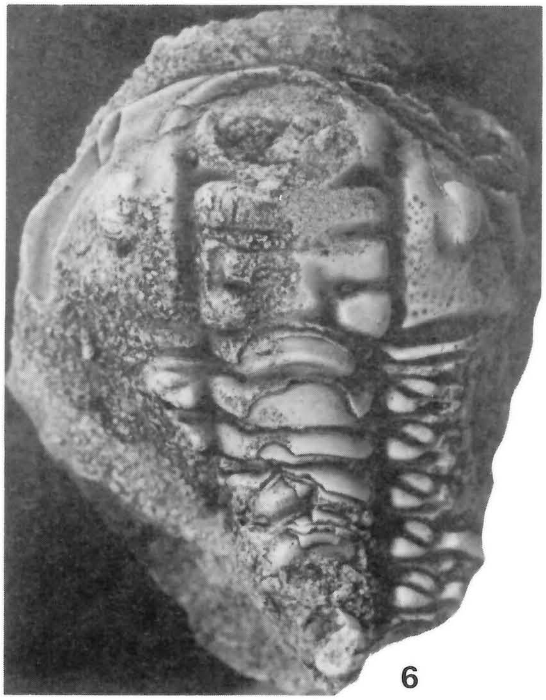

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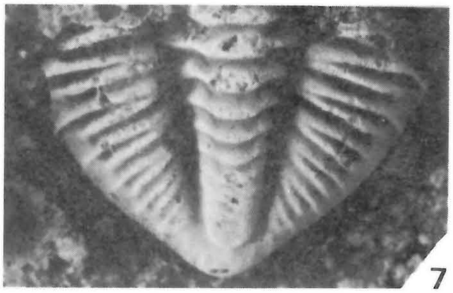

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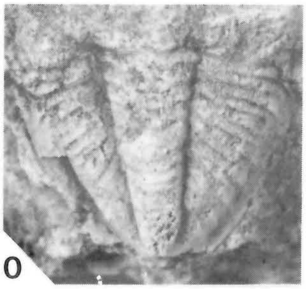

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PLATE 7

PLATE 8:

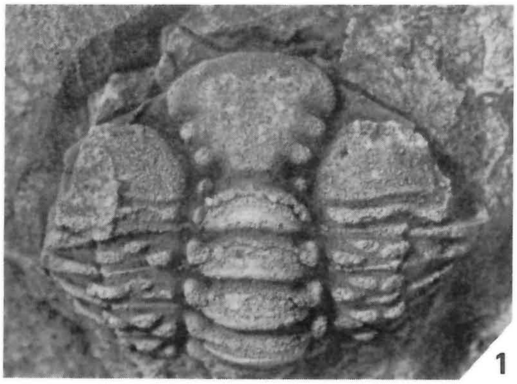
Ceraurus cf. *tuberosus* Troedsson
1. Exfoliated cephalon and incomplete thorax, dorsal view, X 2.5, GSC 7208. Selkirk Member, St. Andrews, Manitoba.
2, 3. Incomplete exfoliated cranidium, dorsal and lateral views, X 4, MM I192c. Selkirk Member, Garson.

Sphaerocorphe robustus Walcott
4. Nearly complete external mold of exoskeleton, ventral view, X 4, GSC 64108. Selkirk Member, Garson.
6. Incomplete cranidium, latex impression, dorsal view, X 4.5, GSC 64109. Selkirk Member, Garson.
10. Incomplete cranidium, latex impression, dorsal view, X 5, MM I192c. Selkirk Member, Garson.

Flexicalymene cf. *senaria* (Conrad)
5. Exfoliated cranidium, dorsal view, X 4, GSC 64115. Selkirk Member, Garson.
7, 8, 9. Partially enrolled exoskeleton, dorsal and lateral views of cephalon, dorsal view of pygidium, X 3.5, GSC 7168. Selkirk Member, Lower Fort Garry.

Encrinuroides sp.
11. Incomplete cranidium, latex impression, dorsal view, X 3.5, MM I192a. Selkirk Member, Garson.
12. Pygidium, dorsal view, X 4, MM I192c. Selkirk Member, Garson.
14. Pygidium, latex impression, dorsal view, X 3, GSC 64113. Selkirk Member, Garson.

Calyptaulax cf. *schmidti* (Clarke)
13, 15. Incomplete cephalon, anterolateral and dorsal views, X 3, GSC 64116. Selkirk Member, Garson.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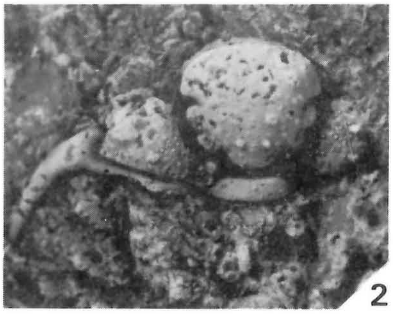
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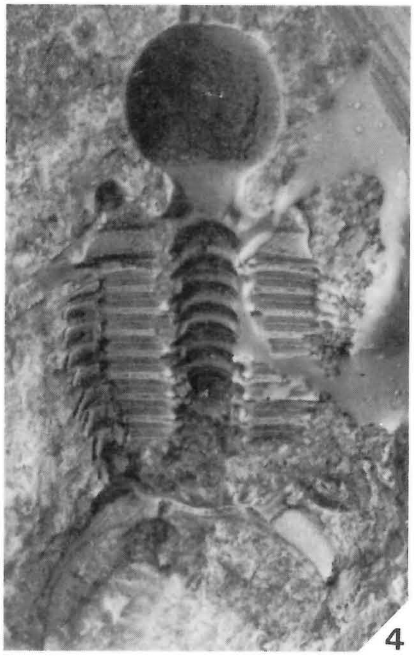
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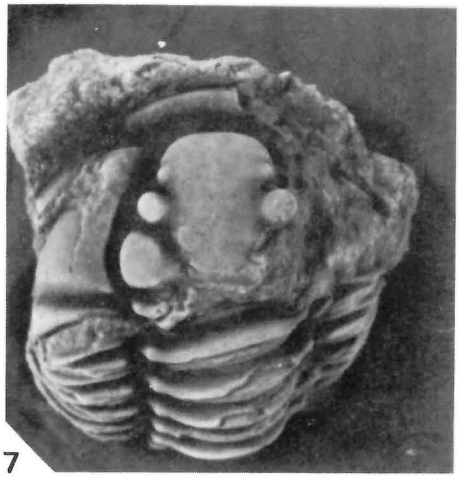
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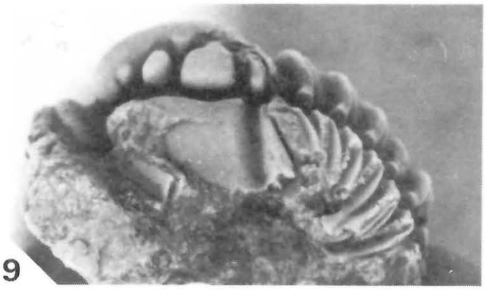
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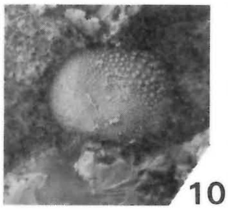
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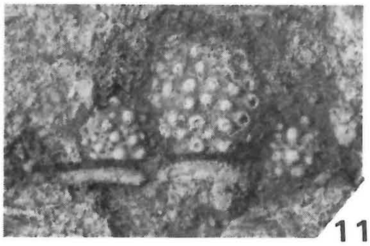
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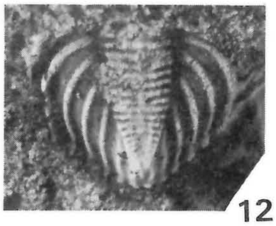
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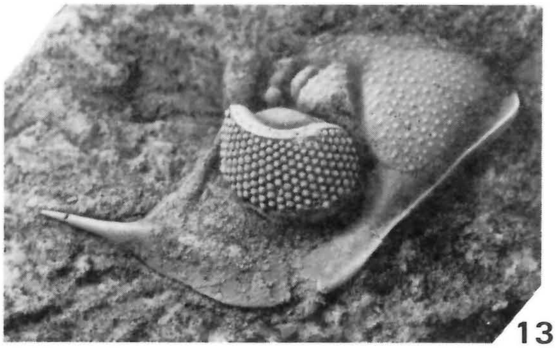
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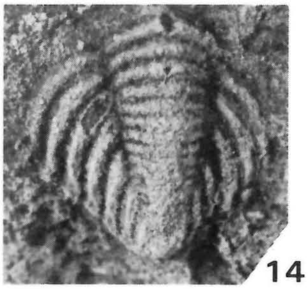
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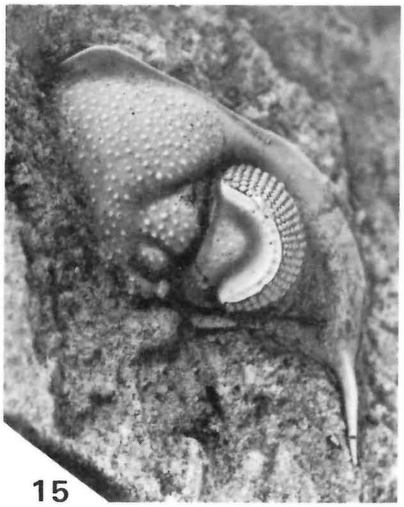
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PLATE 8

PLATE 9:

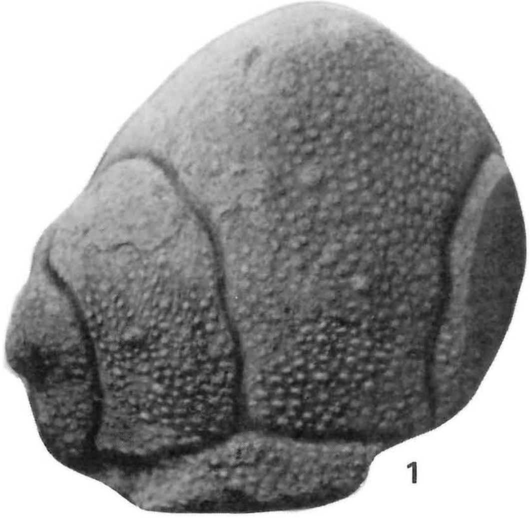
Amphilichas cf. *cucullus* (Meek and Worthen)
1. Incomplete cranidium, dorsal view, X 1.2 GSC 64123. Selkirk Member, Garson.
6. Small cranidium, dorsal view, X 2, GSC 7214a. Selkirk Member, East Selkirk.

Amphilichas cf. *clermontensis* Slocom
2. Incomplete cranidium, dorsal view, X 1.7, GSC 64121. Selkirk Member, Garson.

Hemiarges cf. *tuberculatus* (Weller)
3, 4. Exfoliated cranidium, dorsal and anterior views, X 3, GSC 64122. Selkirk Member, Garson.

Cheirurine indet.
5. Incomplete cranidium, dorsal view, X 1.5, GSC 64105. Selkirk Member, Garson.
8. Incomplete cranidium, dorsal view, X 1.5, GSC 64106. Selkirk Member, Garson.

Borealaspis whittakerensis Ludvigsen
7, 10. Incomplete cranidium, latex impression, dorsal and lateral views, X 3, GSC 64102. Selkirk Member, Garson.
9. Incomplete exfoliated cranidium, dorsal view, X 2, GSC 64103. Selkirk Member, Garson.



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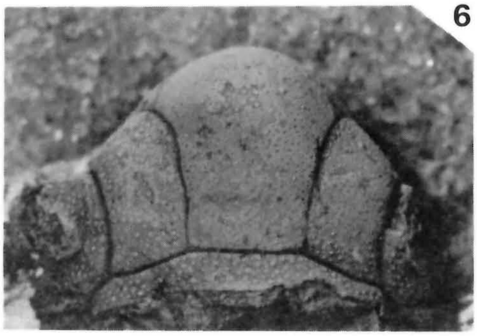

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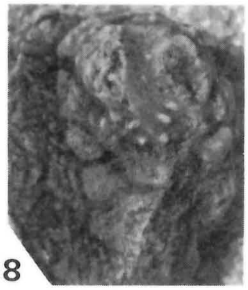

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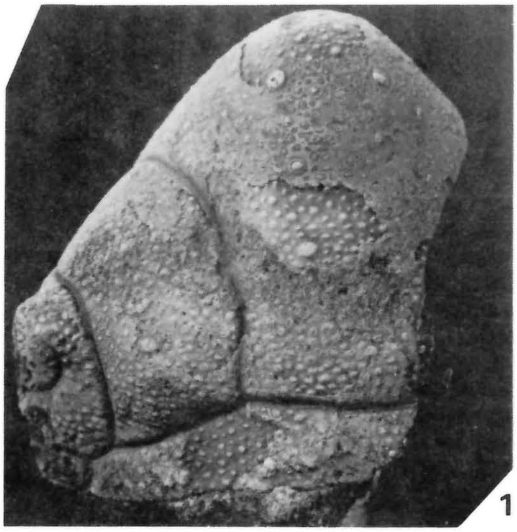
PLATE 9

PLATE 10:

Amphilichas cf. *cucullus* (Meek and Worthen)

1, 2.	Cranidium, dorsal and lateral views, X 1.3, MM I34. Selkirk Member, Garson.
3.	Pygidium, dorsal view, X 1.7, MM I33. Selkirk Member, Garson.
4.	Incomplete thoracic segment, dorsal view, X 2, MM I35. Selkirk Member, Garson.
5, 7.	Small cranidium, dorsal and lateral views, X 1.3, GSC 64124. Selkirk Member, Garson.
6.	Large pygidium, dorsal view, X 1.2, GSC 64126. Selkirk Member, Garson.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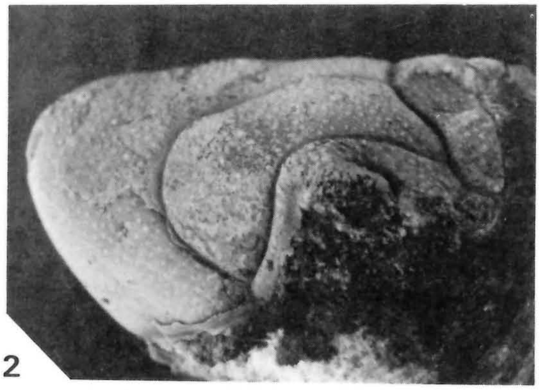
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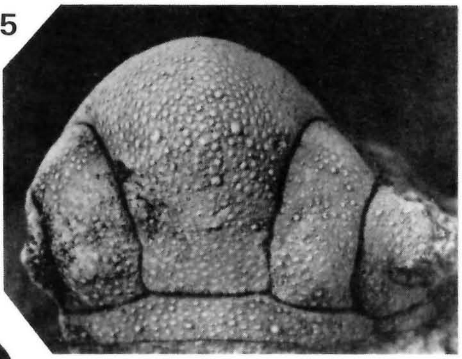
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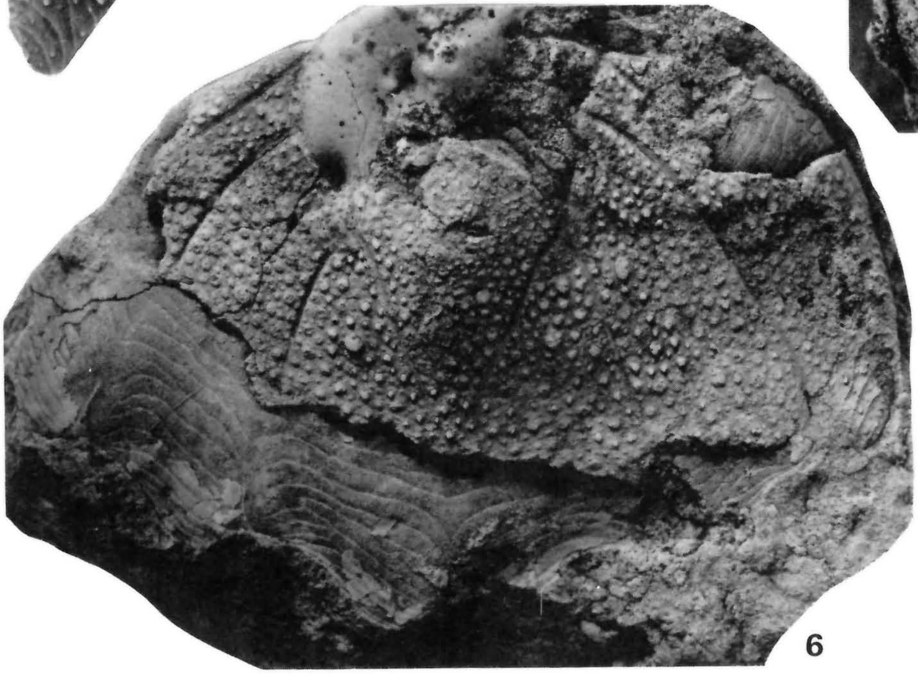
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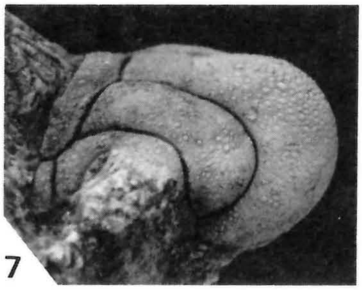
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PLATE 10