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CAMBRIAN [MARJUMAN] TRILOBITES (ARTHROPODA) OF THE
COW HEAD, WESTERN NEWFOUNDLAND

A Dissertation

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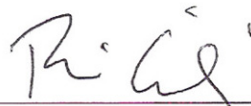
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MARJUMAN PTYCHOPARIIDA OF THE COW HEAD,
WESTERN NEWFOUNDLAND

A Dissertation APPROVED FOR THE
DEPARTMENT OF ZOOLOGY

BY



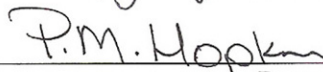
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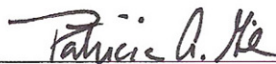
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Abstract

Conglomerates consisting of shelf-derived limestone boulders in debris flows form the fossiliferous strata of the Cow Head Group on the west coast of Newfoundland. These conglomerates have yielded in excess of 20,000 trilobites dated from mid-Cambrian into Ordovician. This study examines 1500 specimens of those trilobites in the order Ptychopariida from the earliest Upper Cambrian, the Marjuman. The Upper and Lower Marjuman are distinctly different, with only 3 genera appearing in both. Each boulder comprises a separate collection and the faunas of most are unique.

Ptychoparioid trilobites are found in 15 boulders of the Upper Marjuman and 54 in the Lower. The Upper Marjuman has yielded 21 genera and 37 species, the Lower Marjuman 18 genera and 35 species. Of those, 1 family, 2 genera and 14 species in the Lower are new: the Dineidae fam. nov., *Dinea* and *Rogeraspis* gen. nov., and *Brassicacephalus rhakion*, *Bynumia demissa*, *Dinea bovicephala*, *D. extremis*, *Eldoradia batilla*, *Holmdalia stenis*, *Kingstonioides delgada*, *K. grandilabra*, *Matania brachys*, *M. catherinae*, *M. hueva*, *M. liamae*, *Prolonchocephalus orcinus* and *Rogeraspis burkhalter*, sp. nov. In the Upper Marjuman, 1 genus, *Kindleia* gen. nov., and 9 species are new: *Cedaria curta*, *C. fedora*, *C. superficialis*, *Deiracephalus genior*, *D. intersectus*, *D. ornatus*, *Kindleia*

williamae, *Lecanopleura habros*, and *Matania kindlensis*. Fifty-three plates document these and other taxa. Correlation is obtained by comparison with fauna lists reported by Lochman, Palmer and others. Westrop, Ludvigsen and Kindle established an excellent base with their analysis of Agnostoids of the Cow Head upon which this correlation is built. Others are working on the brachiopods. The project will be finalized when the remaining order, the Corynexochida, are documented and incorporated into the correlations.

Chapter One
The History and Significance of Newfoundland's
Cow Head Trilobites

Introduction to This Study

As described below, a number of fossils, primarily trilobites and brachiopods, have been recovered from material collected on the west coast of Newfoundland in the vicinity of the peninsula called Cow Head. The collections pertinent to this study come from conglomerates about five hundred million years old, a unit of time called the Marjuman and designated as the earliest stage of the Upper Cambrian (Ludvigsen and Westrop 1985). In earlier literature that stage is referred to as the Dresbachian in part (e.g. Harrington et. Al. 1959) or the Marjumiid biomere (the concept of biomerics was established by Palmer, (1965) and supported by Stitt (1977), who first applied the term Marjuman Biomere to this time frame.

Although the material also contains agnostoids and trilobites of the order Corynexochida, only the libriformate trilobites (Fortey 1990) are considered in this work.

This study establishes the systematics of the collections and describes new species occurring in eastern Laurentia. It correlates and fine-tunes the temporal relationships of previously described species with collections from other areas. It assists in assigning to more specific zones the boulders of the Lévis and Métis Formations of Quebec, which are Cambrian collections in Ordovician conglomerates, thus disassociated from their source material and therefore difficult to place with confidence in established zones. Too, it redefines and expands taxa at the family level.

These fossils in the Cow Head collections record not just a unique fauna but also a previously undescribed major faunal turnover between the Lower and Upper Marjuman. Whether that turnover was local or widespread, genuine or an artifact of incomplete sampling, it is recognized nowhere else, in part because it has not been sampled in the few other exposures where Marjuman faunas have been studied.

Finally, this study is needed to complete a greater study of the Cambrian. To quote from Westrop, Ludvigsen and Kindle (1996, p. 805), “Complete biostratigraphic analysis of the Marjuman faunas of the Shallow Bay Formation must await description of the diverse corynexochoid and libristomate trilobites that occur with the agnostoids.” The specimens of this study are the libristomates to which that statement refers. Data on the distribution of species among Cow Head boulders provide the opportunity to evaluate previous assessments of age and correlation of the Cow Head Group based on the agnostoids of the 1996 paper cited above. Assessment

of the Corynexochida will follow shortly. From that full body of work, agnostoids, corynexochoids and libristomates, the greater picture can be drawn.

Until the systematics are completely worked out, however, so that one might know exactly which species occurs where, none of the above correlations and comparative dating can happen. The bulk of this study therefore is to provide reliable systematics of both Lower and Upper Marjuman Ptychopariina as a solid base for workers, myself included, to progress in this field.

Background on the Cow Head Study Material

During the Cambrian and early Ordovician of what is now the west coast of Newfoundland, shelf-derived limestone boulders accumulated as debris flows in deep water (James and Stevens 1986; Westrop, Ludvigsen and Kindle 1996). Later, in the Ordovician, collision of the Laurentian plate with what was probably an island arc drove an overthrust, the Humber Arm Allochthon, up onto the craton, obliterating everything on the shelf (Williams 1975; Williams and Hatcher 1982; Chow and James 1987; James et.al. 1989).

Later, the Taconic orogeny buckled the sea floor as it raised the mountains nearby, bringing the debris aprons, lithified as conglomerates, to sea level. The conglomerates of those debris aprons, of which the Cow Head Group on Newfoundland's west coast is one of several units, are now our lone window into that particular place and time, for the only evidence of the Cambrian and early Ordovician

communities in the shelf environments of eastern Laurentia survives in the boulders of the debris flows.

In fact, very little of any of the Laurentian Middle Cambrian Stage is preserved. Because of a marine low stand during the Middle and early Upper Cambrian, the Laurentian craton provided minimal shelf environments suitable for shallow-marine life. Figures 1 and 2 (Lochman and Wilson 1958; Lochman-Balk 1971) show how little marine edge was available to shelf organisms during the time span of this study. Figures 3 and 4, depicting habitats later in the Upper Marjuman, present a picture that had changed radically. Sea level had risen and more of the continental shelf flooded, providing extensive shallow marine environments. Although the problem of limited shelf margins remain to some extent, more is known of the Upper Marjuman than of the Lower simply because its habitats were more widespread and therefore more widely available for discovery and sampling. Thus the Cow Head material, as a part of the Middle and very early Upper Cambrian debris-flow conglomerates, provides important new information, not available elsewhere, on the Lower Marjuman, the time preceding more extensive deposition.

Recent Work

Over a span of nearly thirty years in the middle of the last century, geologist Cecil Kindle extracted boulders from the conglomerates that form the Cow Head Group, each boulder numbered and constituting a separate collection. Harry Whittington, an eminent trilobite specialist, accompanied him on some of these

collecting forays, as did Kindle's family and friends. These collections eventually amassed between 20- and 25,000 specimens.

Kindle (1982) prepared most of the specimens, identified many to genus and named a few new species (Kindle 1948). The bulk of the collections remained undescribed and unpublished at the species level. Following Kindle's retirement, the Geologic Survey of Canada purchased his private collection. Rolf Ludvigsen and Stephen Westrop began detailed study of the material in the 1980s (Ludvigsen et al 1989; Westrop et al 1996; Westrop and Adrain 1998; Westrop and Ludvigsen 2000). At the University of Oklahoma, Westrop is overseeing systematic study and publication of the remainder of the Cow Head material (Eoff 2002).

Other workers have dealt with the western Newfoundland and the Cow Head faunas (Kindle 1948; Kindle and Whittington 1958 and 1959; Kindle 1982; James and Stevens 1986; Harris and Fettes 1988; Hatcher 1988; Tracy et al. 1988; Stillman 1988; Ludvigsen, Westrop and Kindle 1989; Young and Ludvigsen 1989; Westrop, Ludvigsen and Kindle 1996; Westrop and Ludvigsen 2000). Still others have studied nearby faunas of approximately coeval age, such as those from extreme northern Greenland (Palmer 1981; Robison *in* Peel 1988; Babcock 1994), the St. Lawrence Valley and the Gaspé Peninsula (Rasetti 1946, 1955, 1963; Fritz, Kindle and Lesperance 1970). More remote locations in which similar but nowise identical faunas occur include Pennsylvania (Tasch 1951), New Jersey (Howell 1945), New York (Rasetti 1967), Vermont (Raymond 1924, 1937; Shaw 1952, 1956, 1956b), the Appalachians (Resser 1938; Wilson 1951; Rasetti 1961; Taylor, Loch and Perfetta

1999) , Great Basin/Utah and Nevada (Palmer 1960; Robison 1964, 1964b, 1971; Fritz 1966; Palmer and Halley 1979, Sundberg 1994; Sundberg and McCollum 2000), Missouri (Lochman 1936, 1940), Texas (Palmer 1954; Wilson 1954, 1956), Montana (Lochman 1944), Wyoming (Miller 1936; Lochman 1960, 1961, 1962), South Dakota (Stitt 1998; Stitt and Perfetta 2000), Alaska (Palmer 1968), extreme western and northwestern Canada (Kobayashi 1936; Rasetti 1951; Fritz 1991; Pratt 1992; Melzak and Westrop 1994).

Chapter Two

Materials and methods

Materials

The material under study consists of boulders derived from the exposed conglomerates of the Cow Head Group. Each was individually numbered when extracted (Kindle and Whittington 1958). Although the Cow Head Group provides fossil sequences from the mid-Cambrian into Ordovician, only those associated with the earliest Upper Cambrian, the Marjuman Stage, are included in this study. The Marjuman material is exposed on the peninsular headland, on Stearing Island and the White Rock Islets just offshore, as well as on Broom Point South in the immediate vicinity (Figure 5). In these exposures a clear chronological succession is apparent, as will be discussed below.

The Marjuman Stage divides clearly into Upper and Lower, containing two disparate suites of libristomates. The Order Corynexochida, common in the Lower Marjuman, is entirely absent from the Upper. Only three genera occur in both, and no species is shared by both.

Boulders 3 through 48 (identified as CH#), recovered from the extreme northwest coast of Cow Head proper, represent the Upper Marjuman and contain few genera found in the Lower Marjuman collections (Appendix C). The Broom Point South collections (BPS), the 400s series, contain Lower Marjuman material that is both older and younger than that of the White Rock Islets (Appendix A). Boulders

numbered in the 600s (with the prefix WRI), from the White Rock Islets just offshore from the Cow Head, contain Lower Marjuman specimens. Faunas preserved under circumstances similar to those of the Cow Head Group, namely, shelf-derived boulders occurring in deeper-water debris-flow conglomerates, occur in Alaska (Palmer 1968) and Quebec (Kindle 1948; Rasetti 1946, 1955, 1963, 1963b; Fritz 1970, Westrop 1992). A few boulders (specifically 272, 273 and BPS 402, 410, 413, 414, 417, 418, 420, 421, 434) belong to the older Topazan, which was defined recently by Sundberg (2005).

The Cow Head specimens, of unsilicified carbonate, are preserved in limestone from a shallow-water shelf environment and were extensively reworked before final deposition. The bulk of the specimens consists of isolated cranidia, with lesser quantities of pygidia, free cheeks and thoracic sclerites. Fewer than a dozen specimens possess articulated thoracic segments or free cheeks. No specimen is complete. Some collections contain large quantities of the broken, unidentifiable sclerites of larger specimens, particularly in the Upper Marjuman. Nearly all of the identifiable material consists of sclerites from small species and small individuals of larger species.

Most fossil assemblages are composed of skeletal material concentrated into pockets by waves and currents. Because of this, size and/or shape sorting, in which currents or wave action secondarily gather remains of differing hydrodynamic properties into different groupings, must be accepted as the null model (Westrop 1986). Since specimens can be drawn from different environments or water depths

and assembled into new groupings by hydrodynamic action, genera and species co-occurring *post-mortem* cannot be assumed to have co-occurred in life. Indeed, individual sclerites might not have been contemporaneous. Size sorting is a factor in these study collections. Several boulders, 3 from the Cow Head proper as a prime example, yield only very small cranidia—either small species such as *Nasocephalus flabellatus* and *Hysteropleura macgerriglei*, or small individuals of larger genera like *Cedaria*. The abundances of sclerites found in such conditions probably do not reflect the original abundances of the living animals.

Differential sorting exists in other ways as well. Specimens from the White Rock Islets' WRI 616, for instance, contains few cranidia and many pygidia. Most of the boulders from the White Rock Islets are poorly fossiliferous, particularly the dolomite boulders in the south part. Others, such as limestone boulders from the more northerly strata, may be rich.

Methods

As per standard practice, the numbered boulders recovered from the sites by Kindle and others were broken open and the pieces further split, with fossils being revealed along the break-planes. The boulder numbers, representing collection numbers, were maintained on each piece. Kindle himself prepared perhaps 90 percent of the cranidia, as well as a few pygidia or free cheeks, at least enough to allow identification. At the Sam Noble Oklahoma Museum of Natural History's invertebrate paleontology laboratory, we used air-scribes, needles and dental tools to

trim additional matrix from those specimens that had been only partially prepared, and to prepare additional sclerites, especially free cheeks and pygidia, that had not been previously treated.

Thus prepared, each specimen was gently cleaned just prior to being photographed, covered in a thin coat of black dye (Perfect Liquid Opaque[®], Retouch Methods Company Inc. Chatham NJ), then dusted with a very thin coat of heat-sublimated ammonium chloride. The resulting temporary blue-grey film reveals the surface architecture in remarkable detail. Figures of the specimen were then made using a digital camera with either a 120 mm or 80 mm lens and, when appropriate, extension tubes. Adobe Photoshop[®] 7 was employed to sharpen photos and build plates. All plates are reproduced here at a resolution of 450 dpi.

Specimens used in plates will receive Geologic Survey of Canada (GSC) accession numbers. Specimens not used in plates are accessioned in bulk by boulder number.

Chapter Three

Stratigraphy of the Cow Head Study Area

The Facies

James and Stevens (1986) divided the Cow Head Group into two formations. The Green Bay Formation, primarily of dark shales, represents the distal margins of the debris apron. The Shallow Bay Formation, a coarse-grained sequence containing carbonate conglomerates interbedded with shales and lime mudstones, is interpreted as the proximal portion. The most productive boulders are of light brown or light grey coarse grainstones and packstones, probably derived from shelf-margin sand shoals. A few, as for example WRI 619 from the White Rock Islets, are of dark grey, brown or umber wackestones and may derive from deeper slope regimes.

The conglomerates—boulders with carbonate interclasts—and their interbedded shales are consistently of the same age. Of the four members of the Shallow Bay Formation, the Downes Point Member is the lowest, identified as the Marjuman Stage.

The boulders from which the Upper Marjuman material comes were recovered by Kindle from facies he identified as Zone 5, specifically from beds 1, 3 and 4 (Kindle 1982) on the north shore of the Cow Head Peninsula along Beachy Cove (Kindle and Whittington 1958; Kindle 1958; Kindle 1959) (Kindle claimed that bed 2, also of Zone 5, yields no fossils) . Figure 6 from Westrop, Ludvigsen and Kindle

(1996) shows the stratigraphy of the Cow Head Peninsula and the immediate area from which the boulders were obtained.

Lower Marjuman collections derive from the White Rock Islets and the south of Broom Point. Figures 7 and 8, also from Westrop, Ludvigsen and Kindle (1996), illustrate those in stratigraphic section. For a more extensive discussion of the geology and stratigraphy of the area, consult Kindle and Whittington (1958), Kindle (1982), James and Stevens (1986), Ludvigsen, Westrop and Kindle (1989), and Westrop, Ludvigsen and Kindle (1996).

Biostratigraphic Methods and Generalisations

When Kindle and Whittington (1958, p. 319) described the stratigraphy of the Cow Head area, they prepared a preliminary correlation of the faunas found at Broom Point, the White Rock Islets and Cow Head. That is, they arranged the fossils they found there in temporal order based on known occurrences in stratigraphic successions elsewhere in North America, a column with the presumed oldest at the bottom. For the most part, that first basic correlation is still valid. The Late Topazan and Marjuman faunas described herein fall into Kindle's (1982) Zones 2 through 5. In 1996, Westrop Ludvigsen and Kindle performed extensive cladistic analyses of the Marjuman agnostoid faunas of the Cow Head Group, laying a foundation of solid taxonomy. They then used the agnostoids to revise the correlation of Kindle's zones (Figure 6 in Westrop, Ludvigsen and Kindle 1996) with well-documented faunas from the Great Basin (Robison 1964, 1976, 1984) and northern Canada (Pratt 1992).

In this study I build on Westrop et. al.'s work by incorporating new data from the libristomate trilobites. Agnostoids do not occur in all lithofacies (Robison 1976, *e.g.*), and the libristomates provide an opportunity to extend correlation into those collections where agnostoids are rare or absent. Further refinement will be possible when work on the Order Corynexochida is completed.

Figures 9, 10 and 11 list the informative species in the Marjuman Cow Head material and indicate their presence in other formations. It is assumed that, within very rough parameters, a species will be more or less coeval (that is, in the same temporal biostratigraphic zone) throughout its geographic range. Species occurring in two different locations are thus presumed to exist at the same general geologic interval, although not necessarily at the same geologic horizon. As example, *Deiracephalus unicornis* was described from the Conosauga Formation of Alabama and reported from the Rabbitkettle Formation of northwestern Canada. Assuming the species' identification and taxonomy are correct, its occurrence in boulders from Cow Head links the three geographically separate sites to the same general, and roughly correlative, *Cedaria* Zone.

This picture is complicated by the fact that faunas or their fossil remains may be passively transported far beyond their original geographic range by means of tectonic plate movement. Case in point, Avalonian—i.e. present European—faunas occur in southeast Newfoundland, accreted to the Laurentian craton as foreign terranes. A further complication is that the Cow Head represents, in many ways, a unique fauna, with numerous species not described elsewhere. Of course, these new

species are appropriate for within-zone comparisons but cannot be used for correlation with faunas in other formations.

Figures 13 and 14 correlate zones on other cratons according to Ludvigsen and Westrop (1985) when they established the Marjuman, Steptean and Sunwaptan Stages. Figures 15 and 16 show Pratt's correlation in which he subdivides the *Cedaria* Zone further, based on *C. spp.* from the Mackenzie Mountains.

Materials from the Métis and Lévis Formations deserve special mention. Like the boulders of the Cow Head Group, boulders from the Métis and Lévis Formations are shelf-derived clasts recovered from deeper-water deposits. However, they represent Cambrian shelf facies in Ordovician deep-water apron sequences and are thus completely distanced from coeval facies. The Cow Head species can therefore date some Métis and Lévis material that could not otherwise be assigned. Accordingly, in Figures 9-11, the boulders in which correlative species are found are identified by number in the Métis, Lévis and Grosses Roches columns.

Numbers found in the initial columns of Figures 9-11 are the quantity of Cow Head Group collections containing the given species but not the numbers of specimens in the collections. Their presence in collections found elsewhere is marked simply with X.

Kindle's Biostratigraphic Zones

The five zones Kindle identified in 1958 (page 319) for the Cow Head material, with modest modification, still hold true today. Westrop, Ludvigsen and

Kindle (1996) used them as the framework for establishing a stratigraphy for the Cow Head based upon agnostoids. Their modified Kindle zonation is used here.

Kindle Zone 2

Westrop, Ludvigsen and Kindle (1996) assigned *Baltagnostus robustus* Öpik 1979, *Ptychagnostus seminula* (Whitehouse 1939), *Ptychagnostus fissus* (Lundgren 1879) and *Peronopsis segmenta* Robison 1964 to Kindle's Zone 2. The authors could then with confidence place collections 402, 410, 413, 414, 421 and 434 in Zone 2.

That zone is depauperate in libristomate fossils, with only two species.

Onchocephalites punctatus (Rasetti 1963) occurs nearly as frequently as does the commonest agnostoid, *B. robustus*. *Onchocephalites punctatus* establishes BPS 417, 418 and 420 as Zone 2, despite that the collections contain no agnostoids. *Spencella spinosa* (Rasetti 1963) appears in WRI 434, which allows correlation of boulders 272 and 273 (Young and Ludvigsen 1989) with BPS 434.

The type of *Spencella spinosa* Rasetti 1963 was recovered from boulder M-24 of the Métis Formation, and from G-38, Grosses Roches in the eastern Gaspé, which enables those boulders' assignment to Kindle's Zone 2, and by extension the *Ptychagnostus gibbus* and *Bathyriscus-Elrathina* Zones of the Utah sites, which are now Topazan rather than Marjuman. Similarly, *Onchocephalites punctatus* occurs in M-13, M-24, G-22 and G-39, identifying those boulders as being of the aforementioned zones.

The Zone 2 collections: 272, 273, 402, 410, 413, 414, 417, 418, 420, 421, 434.

Species other than agnostoids occurring in Zone 2 are: *Onchocephalites punctatus* and *Spencella spinosa*. Both are confined to Zone 2.

Kindle Zone 3

Hypagnostus parvifrons (Linnarsson 1869) and *Kormagnostus copelandi* (Westrop, Ludvigsen and Kindle 1996) mark this zone along with *Ptychagnostus fissus* (Lundgren 1879), *Ptychagnostus hybridus* (Brögger 1878) and *Ptychagnostus atavus* (Tullberg 1880). Among non-agnostoid species, *Catillicephalites liami* sp. nov. is commonest, occurring in six of the nineteen boulders containing identifiable libristomates. *Catillicephalites brachys* sp. nov. appears in five. These two species enable the placing of BPS 605 and 620, which have no agnostoids, in Zone 3. *Holmdalia punctata* (Rasetti 1967), found only in this zone, allows assignment of BPS 471 in Zone 3.

In the original paper defining *Holmdalia* (i.e. *Modocia*) *punctata*, Rasetti (1967) reported finding fragmentary libristomate material that perhaps suggested a late Middle Cambrian or early Late Cambrian stage. *Hypagnostus parvifrons* formed part of the faunule at Nutten Hook from the Taconic sequence in New York (coll. cs-22), where he found *H. punctata*, and he referred that faunule to the possible late Middle Cambrian. The Cow Head material puts the Nutten Hook collection into Kindle's Zone 3, within the *Ptychagnostus atavus* Zone that sets the base of the Marjuman, and links it to correlative collections in Utah.

Bolaspidella cf *B. contracta* Robison 1964 in WRI 614, 617 and 632 further support these collections' membership in the *Bolaspidella contracta* faunas of Utah (Robison 1964, 1971)—Kindle's upper Zone 3.

Of interest is *Meneviella venulosa* (Salter 1865), found in BPS 448. Walcott (1884) considered *Conocoryphe* (Salteria) *bailieyi* equivalent to *Conocoryphe* (*Meneviella*) *venulosa* for all practical purposes (p. 12). Elsewhere, *M. venulosa* is considered Avalonian and in limited contexts occurs on other cratons. It definitely occurs in eastern Newfoundland with *P. fissus*. It is reported from the Saint John formation of New Brunswick (southeast) (Walcott 1884) and (*fide* Walcott) Bohemia, Wales and Sweden. Its appearance here links the St. John Formation Avalonian faunas in North America into Kindle's Zone 3 and by extension to the *Bolaspidella* Zone of the southern Great Plains. Painted with a sufficiently wide brush, this picture still pertains.

Zone 3 collections: 431, 448, 450, 451, 452, 471, 601, 602, 603, 605, 606, 607, 608, 609, 611, 613, 614, 615, 616, 617, 619, 620, 621, 622, 623, 624, 625, 627, 630, 631, 632, 633, 634, 640, 641.

Libristomate species found in Zone 3 are *Bolaspidella contracta*, *Catillicephalites brachys* sp. nov., *Catillicephalites liami* sp. nov., *Conocoryphe* sp. indet., *Dinea bovicephalus* sp. nov., *Eldoradia batilla* sp. nov., *Holmdalia punctata*, *Hysteropleura schucherti* (Raymond 1937), *Kingstonioides delgada* sp. nov. and *Kingstonioides grandilabra* sp. nov. Also found are undetermined species of *Hysteropleura*, *Metisaspis*, *Metisella*, *Mexicella* and *Syspecheilus*.

Kindle Zone 4

Analysis of the Cow Head librostomate material assignable to Zone 4 must be approached with caution because sample size is an issue; species appear in comfortable quantity only in BPS 467 and 468 (twenty and eight species, respectively). Four boulders contain only one or two species each, rendering analysis difficult.

The agnostoid species *Peronopsis scutalis* (Hicks 1872), *Ptychagnostus aculeatus* (Angelin 1851), *Kormagnostus seclusus* (Westrop, Ludbigesen and Kindle 1996) and *Megagnostus glandiformis* (Angelin 1851) identify BPS 458, 460, 467 and 468 as Zone 4 collections.

Holmdalia stenis sp. nov. occurs in 458, 467 and 468 with the above agnostoids and also in 462 and 469, which identifies 462 and 469 as Zone 4 faunas, equivalent to the *Lejopyge laevigata* Zone of northern Greenland (identified as *H. punctata* by Robison, 1988). Pratt (1992) claims *H. punctata* from the Rabbitkettle Formation in the Mackenzie Mountains of northern Canada. However, he misidentified it. The Rabbitkettle species is actually *H. stenis*, which extends the geographical range of the species into the Mackenzie Mountains and suggests that its facies there is the equivalent of Kindle's Zone 4.

Catillicephalites marginatus Rasetti 1963 and *Kingstonioides grandilabra* sp. nov. in BPS 467 occur with *K. seclusus*, a Zone 4 indicator, and also in Boulder 98, placing Boulder 98 with BPS 467.

Rasetti's type of *C. marginatus* is found in boulder M-22 from the Métis Conglomerate of Quebec. He was uncertain whether M-22, a disassociated clast, should be assigned to the *Bathyuriscus-Elrathina* Zone (Kindle's Zone 2) or the later *Bolaspidella* Zone (Kindle's Zone 3). His *C. marginatus* and therefore everything occurring in the Métis Conglomerate boulder M-22 fits best in Zone 4, the *Lejopyge laevigata* Zone and thereby in all other areas correlated with *Lejopyge laevigata*.

Arapahoia raymondi Lochman 1938 occurs only in BPS 470, which was collected, as it were, on the cusp between Zone 3 (471) and Zone 4 (467, 468, 469). Without definite indicators, I suggest it be tentatively assigned to Zone 4 on the basis that Westrop (1992) reports it in the Big Cove Member of the Petit Jardin Formation, equivalent to the *L. laevigata* Zone of Greenland where *K. seclusus* also is found.

The only species of either agnostoid or libristomate in BPS 464 is *Dinea extremis* sp. nov. and this is the only collection in which it is found. A direct correlation cannot therefore be made. BPS 464 sits amid a series of Zone 4 collections—460, 462, 467, 468 and 469. The collections when made were numbered in sequence and with caution, so *Dinea extremis* may perhaps, with caution, be assigned to Zone 4.

Zone 4 collections: 98, BPS 458, 460, 462, 467, 468, 469, ?470.

Libristomate species found exclusively in Zone 4 include *Arapahoia raymondi*, *Brachyaspidion spinosum* Rasetti 1946, *Brassicicephalus rhakionus* sp. nov., *Bynumia demissa* sp. nov., *Catillicephalites catherinae* sp. nov., *Catillicephalites marginatus*, *Holmdalia stenis* sp. nov., *Hysteropleura adraini*

Westrop and Ludvigsen 2000, *H. edgecombei* Westrop and Ludvigsen 2000, *H. ramskoldi* Westrop and Ludvigsen 2000, *Matania hueva* sp. nov., *M. ovata* Rasetti 1946, *Prolonchocephalus orcinus* sp. nov., *Rogeraspis burkhalteris* sp. nov. and possibly *Dinea extremis* sp. nov. Species found in both Zone 3 and Zone 4 are *Catillicephalites liami* and *Kingstonioides grandilabra*.

Kindle Zone 5

Agnostoids, notably *Pseudagnostina douvillei* (Bergeron 1899), *Kormagnostus boltoni* (Westrop, Ludvigsen and Kindle 1996), *Nahannagnostus logani* Pratt 1992, *Acmarhacis typicalis* Resser 1938 and *Connagnostus fritzi* Pratt 1992 occur in only five of the fifteen Zone 5 boulders containing librismates, but the librismates in them correlate the other ten. For example, *Catillicephala fowleri* Shaw 1952 occurs in CH3 and 11, both assigned to Zone 5 by virtue of their agnostoids. *Catillicephala fowleri*, also found in CH 20, 26, 33 and 39, identifies those collections as Zone 5 also. Similarly, *Deiracephalus ornatus* sp. nov., *Kingstonia vagrans* Lochman 1938, and others establish CH 9; *Meteoraspis borealis* Lochman 1938 and *Tricrepicephalus johnsoni* Kindle 1948 place CH 22; *Kingstonia vagrans* CH 21; and *Talbotina degreasensis* Lochman 1938, *Hardyoides minor* Kobayashi 1938 and *Deiracephalus genior* sp. nov. CH 36.

Blountia terranovica Lochman 1938 occurs in none of the collections defined by agnostoids, but the collections in which it is found, CH 9, 21, 33 and 39 are placed

in Zone 5 by matches described above. CH 48 can then be placed in Zone 5 secondarily by the presence of *B. terranovica*.

CH 3 produces two species—*Lecanopleura habros* sp. nov. and *Nasocephalus flabellatus* Wilson 1954—found nowhere else in the Cow Head. All are tiny. The other species in the boulder are all small specimens of larger species. In short, size sorting is a major factor in the makeup of this collection. *Nasocephalus flabellatus* correlates CH 3 with the *Cedaria selwyni* Zone of Pratt (1992; see also Figures 15 and 16), placing the species in the Rabbitkettle Formation as well as the Marathon Uplift (Wilson 1954).

Zone 5 provides enough collections with six or more species that some observations can be made. I have no explanations for these observations. I find them interesting and offer them, thinking that myself or others may at some time find patterns discernible in broader contexts. *Catillicephala* spp. and *Kingstonia* spp. are commonly found in immediate association; usually the grouping is *C. fowleri* Shaw 1953, *C. impressa* (Rasetti 1946), *K. vagrans* Lochman 1938 and *K. walcotti* Resser 1938. *Hysteropleura macgerriglei* (Raymond 1937) does not occur in collections where *Hardyoides* spp. do not also appear. This all may merely be coincidence or a sampling artifact. Perhaps, on the other hand, there are cogent reasons.

Zone 5 collections: CH 3, 9, 11, 12, 20, 21, 22, 26, 28, 33, 34, 35, 36, 39, 48.

The species of Zone 5 are *Blountia terranovica*, *Catillicephala impressa*, *C. fowleri*, *Cedaria curta* sp. nov., *C. fedora* sp. nov., *C. gaspensis* Rasetti 1946, *C. superficialis* sp. nov., *Crepicephalus rivus* Kindle 1948, *Deiracephalus genior* sp.

nov., *D. intersectus* sp. nov., *D. ornatus* sp. nov., *D. unicornis* Palmer 1962 ,
Hardyoides katherina Lochman 1938, *H. minor* Kobayashi 1938, *H. tenerus* (Walcott
1916), *H. tunda* (Lochman 1940), *Hysteropleura macgerriglei* Raymond 1937,
Kindleia mutica (Rasetti 1961), *K. unicornis* (Kindle 1948), *K. Williami* sp. nov.,
Kingstonia vagrans Lochman 1938, *K. walcotti* Resser 1938, *Lecanopleura habros*
sp. nov., *Matania kindlei* sp. nov., *Meteoraspis borealis*, *Nasocephalus flabellatus*,
Talbotina degreasensis, *Tricrepicephalus johnsoni*, *T. rusticus* Kindle 1948 and *T.*
tripunctata (Whitefield 1876). All these species are confined to Zone 5. Identified to
genus only are *Avonina*, *Cheilocephalus*, *Coosia*, *Coosina* *Holmdalia* and
Menomonie spp. indet.

Remaining collections

Three collections, BPS 464 and 470 and WRI 618, have neither agnostoids
nor species shared with other boulders. WRI 618 contains what is possibly
Hysteropleura schucherti, but the determination cannot be made with any degree of
confidence. BPS 464 with *Dinea extremis* sp. nov. is discussed above.

BPS 470 yielded *Hysteropleura ramskoldi* Westrop and Ludvigsen 2000, a
species unique to that collection and therefore of no value in correlation, but it also
produced *Arapahoia raymondi*, which in Lochman's March Point material (Lochman
1938 p. 462) occurs with *Talbotina degreasensis* Lochman 1938, and *T. degreasensis* in
these collections is part of the Zone 5 fauna. As described above, however, according
to Westrop (1992), a better fit is Zone 4 and I suggest it belongs there.

Other formations

The indicator genera in other formations (Bonneterre of Missouri, Lochman 1940, for example), such as *Bolaspidella*, *Cedaria* and *Crepicephalus* accompany the same suites of genera as do the indicator genera in these collections, and in the same general order. Figure 12 from Westrop et. al. (1996) shows local correlations, fully supported by these collections. Figures 13 and 14, from Ludvigsen and Westrop (1985) and Figures 15 and 16 (Pratt 1992) fit the cow Head material into the greater picture, both in Laurentia and also in other cratons separate from Laurentia during the Cambrian—Queensland/Australia, Kazkahstan, Siberia, North China and Baltica. Avalon is represented directly by *Meneviella* in its terrane attached to Newfoundland.

Chapter Four

What the Cow Head Libristomates Tell us

The Advantage of Analysing a Large Number of Collections

Each of the 52 libristomate-containing boulders in the Cow Head is an individual and independent collection. It may or may not be associated chronostratigraphically with any of the others in a particular conglomerate, although there is a generalized upward succession of boulder ages from early to late. They can be roughly arrayed in time by comparison of their faunas with faunas of known provenance elsewhere, but direct, detailed stratigraphic comparison is usually not possible as it is, for example, in the Marjuman-Steptoean of the Rabbitkettle Formation of northern Canada, where strata can be measured to the centimeter (Pratt 1992).

However, 52 separate collections from one very small area, sampling a wide range of eras and environments, has an important advantage. A far broader picture of change and constancy results, something that more limited sampling cannot offer. This is particularly important when considering possible relationships among major groups of libristomates, or of agnostoids, for that matter. One can see trends and variation of speciation across a broad spectrum.

The Differences Between Lower and Upper Marjuman

The most obvious and noteworthy character of the Marjuman is that it consists of two nearly discrete suites of organisms. The order Corynexochida, the primary group of trilobites of the Middle Cambrian preceding the Marjuman, is still common in the Lower Marjuman. By the Upper, it is gone (unpublished material). The genus lists in appendices A1 and A2 also demonstrate the difference between Lower and Upper. Only the genera *Matania*, *Hysteropleura* and *Holmdalia* reside on both lists, each with several species in the Lower and only one in the Upper. No one species appears in both Upper and Lower Marjuman.

Ludvigsen and Westrop (1985) defined the base of the Marjuman Stage as the base of the *Ptychagnostus atavus* Zone, the first appearance of *P. atavus*. When this present work was begun in 2000, Palmer (1998) had extended the Marjuman downward to the top of the *Glossopleura* Zone, where he believed that a better break, a stronger signal of faunal turnover, existed between biomes (Palmer 1965, 1984), although that position was never fully accepted elsewhere. He posited that the extinction of *Glossopleura* and first appearance of *Proehmaniella basilica* Sundberg 1994 marked a faunal changeover that could be recognized across North America. However, *Proehmaniella basilica* occurs only in the Great Basin, the Weeks Formation of Nevada and Utah, whereas *Ptychagnostus atavus* is much more widely distributed. This signifies because the precise boundaries for the Middle and Upper Cambrian of Laurentia differ from Cambrian boundaries set on other cratons (Palmer

1998; Sundberg 2005), and a more nearly cosmopolitan species provides a more helpful indicator.

Recently, Frederick Sundberg (2005) proposed the Topazan, a new stage on the division between Middle and Upper Cambrian, below the Marjuman and above the Delamaran, formerly the highest stage of the Middle Cambrian. Its lower boundary is the first appearance of *Proehmaniella basilica*, corroborated by the disappearance of the corynexochid *Glossopleura* sp. In Sundberg's stages, the lower boundary of the Marjuman, and therefore by default the upper boundary of the Topazan, is the first appearance of *Ptychagnostus atavus*—in short, just where Ludvigsen and Westrop had originally set the lower boundary of the Marjuman. The boundary of Ludvigsen and Westrop is followed in this study.

The discrete faunas of Lower and Upper Marjuman in these Cow Head collections do not represent the break between Sundberg's new Topazan and the classic Marjuman. They indeed mark a nearly complete turnover of genera and a complete turnover of species; however, the boundary between the Lower and Upper Marjuman as defined by agnostoids occurring across a number of collections in this and other geographic areas is well defined, and all three series of collections still lie above the Topazan. These collections appear to sit on the cusp of a major faunal shift, but that shift has not heretofore been mentioned in the literature or examined. According to the Agnostoid occurrences in these collections, it is not *that* cusp dividing the Topazan and Marjuman.

Topazan material does, however, appear at the bottom of the stratigraphic column for the Cow Head, Kindle's Zone 2. *Ptychagnostus atavus* does not occur until Kindle's Zone 3, where it is a common component.

There is not, at present, a good way to evaluate the break between Lower and Upper Marjuman, if indeed it exists and is not merely a sampling artifact caused by a paucity of intervening boulders. It could occur by one of several means, none mutually exclusive. In a major marine transgression, the sea level might rise too rapidly for offshore reef communities to expand landward up the continental ramp, keeping ahead of the sea rise, as it were. The offshore communities, then, effectively "drown", for the water has become too deep for survival. In a major marine regression, the sea level falls. Offshore slope habitats shrink in size, and marine shallow-water populations lose habitable space. If the regression is rapid, again, the communities cannot shift fast enough to avoid stranding (we are speaking in terms of geologic time here). In either situation, extirpation and extinction clear the way for rapid expansion and diversification when sea levels return to average depths, but the colonizing species will likely be novel (Eldredge and Gould, 1972; Gould and Eldredge 1977).

Tectonic and seismic events can reshape coastlines, producing major habitat changes, and with those changes radical shifts in communities. Climate change may play a role, but climate change usually is not so rapid as to extinguish communities. If the shoreline rises or is buckled upward tectonically, deposition may cease for an

indefinite time. When conditions for deposition recommence, the faunas have changed, perhaps several times over.

All this is abetted by a rapid rate of trilobite speciation. Steven Stanley reports that trilobite species turnover equals that of mammals, trilobites being the only cold-blooded group to do so (Stanley 1996; Westrop 1996).

Last and least, a bit of fancy

Certain boulders contain a jumble of fragments of larger trilobites—bits and pieces of cranidia and pygidia, primarily—that perhaps were swept and swirled by errant water currents into one sheltered place. Such differential sorting is common, as was shown earlier, and is seen in modern reefs as well. Among these middens occur certain tiny cranidia. The simplest explanation is that the hydrodynamics of both the small cranidia and the much larger fragments are such that they all were carried to the same place. But that does not satisfactorily explain that only a certain few species of tiny trilobites are represented among the fragments. The imagination suggests that these tiny forms, but apparently not any of the other tiny species in that area at that time, made their living amid the organic-rich detritus of larger genera, in quite the same manner that cockroaches dwell among us today.

Chapter Five

Systematic Paleontology

Descriptive terminology follows Whittington et. Al. (1997). The terms *long* and *short* refer to sagittal (lengthwise) dimensions. *Wide, broad, narrow* etc. describe transverse dimensions. *Broad* and *narrow* in reference to furrows, however, means broad or narrow in any dimension. Abbreviations used are as follows:

- BPS Broom Point South (collections in the 400 series)
CH Cow Head (collections in single- and double-digit series)
WRI White Rock Islets (collections in the 600 series)

Repositories include:

- LU Laval University
GSC Geologic Survey of Canada, Ottawa
NMC National Museum of Canada
ROM Royal Ontario Museum, Toronto
USNM United States National Museum
YPM Yale Peabody Museum

Order PTYCHOPARIIDA Swinnerton 1915

Suborder Ptychopariina Richter 1933

Family MARJUMIIDAE Kobayashi 1935

Remarks: Pratt (1992) reviewed the family and based differentiation of *Marjumi* Walcott 1916 and *Modocia* Walcott 1924 on the presence of spines on the pygidia. In general, I accept Pratt's analysis. However, he suggests that the use of pygidial spines is an artificial distinction and I would go farther, subsuming *Modocia* spp. into *Marjumi* (excepting *Modocia punctata* Rasetti 1967, which has been assigned to *Holmdalia* Robison 1988) as per Melzak and Westrop (1994). In the absence of defining pygidia, the cranidia are virtually indistinguishable in form and detail. Too, some members of the family Marjumiidae have been assigned spined pygidia and others spineless.

Marjumi sp. indet.

Plate 43, figs. 1-4, 9, 10

Occurrence: Collection CH 28, Upper Marjuman of western Newfoundland

Remarks: Traces of facial sutures on this specimen, which is complete save for the pygidial area, are nearly parallel. The preglabellar field is one and a half times the length of the anterior border.

Genus *Holmdalia* Robison 1988

Type species: Modocia punctata Rasetti 1967 from the Taconic sequence, New York

Diagnosis: Small (cranidia <3 mm) Marjumiids with a unique suite of characters that includes unfurrowed, tapered, rounded glabella, strongly punctate prosopon and often an indentation that appears medially in the preglabellar furrow, sometimes accompanied by a small indentation or depression in the preglabellar field just above it.

Remarks: Following Pratt (1992, p. 61), *Holmdalia* is assigned to the Marjumiidae. Robison (1988) erected this new genus to accept *M. punctata* Rasetti 1967 from the Taconic sequence of New York's Columbia County and specimens from the Holmdal in northern Greenland. By examining specimens from Greenland with thoracic segments, he determined that this form has a pygidium atypical of *Marjumi* Walcott 1916. He opined that the uniformly small specimens he gathered were not, as Rasetti (1967) had suggested, merely meraspides of larger forms but rather, were holaspides of a distinct genus. Comparing his illustrations of *Holmdalia punctata* in (Robison 1988 figures 27.1-5) with figures of the type material of *Modocia punctata* (Rasetti 1967, plate 12, figs. 24-28), small discrepancies appear. Both forms possess punctation, a pit in the preglabellar furrow and an attendant indentation in the preglabellar field. However, the length of the palpebral lobes on Robison's 1988 species are one fifth the glabellar length (inclusive of the occipital ring) and their

shape almost hemispherical. The palpebral lobes of Rasetti's 1967 forms are elongate—nearly one third the glabellar length, yet no wider than Robison's. Moreover, the anterior border of Robison's species is wider, its curve tighter and more pronounced than is the case of Rasetti's.

In the present collections, specimens meeting the exact criteria of Rasetti's species and also specimens accurately reflecting Robison's forms both occur. In short, Robison's *Holmdalia* sp. is not *Holmdalia punctata*. However, *Holmdalia punctata* is in fact present in the Cow Head Group, as discussed below.

Holmdalia punctata (Rasetti 1967)

Plate 1, Figs. 11, 16; Plate 2, Figs. 1-18

1967 *Modocia punctata* Rasetti, p. 99, pl. 12, figs. 24-28

Diagnosis: A species of *Holmdalia* Robison 1988 with a subovate glabella and closely pitted surface. Palpebral lobes elongate and one third glabellar length; width of the posterior fixed cheeks is less than that of the glabella at its widest.

Occurrence: Collections BPS 471 and WRI 603, 607, 611, 616 and 627, Lower Marjuman of western Newfoundland; Nutten Hook, Taconic Sequence, New York

Description: Cranidial outline subrectangular, nearly square. Anterior border almost flat in anterior aspect, modestly curved in dorsal aspect, carrying terrace lines on the

leading edge; length is one half to two thirds the length of preglabellar field. Anterior border furrow narrow and deep; preglabellar field tumid, convex, strongly downsloping; glabella inflated, virtually effaced, tapered, evenly rounded; S1 glabellar furrows sometimes barely visible on large individuals; axial furrows extremely deep, slightly outwardly curved; preglabellar furrow deep, narrow, possessing a small, median indentation or pit; an indentation in the preglabellar field immediately adjacent accompanies the pit; fixed cheeks narrow, one third glabellar width at midpoint, convex, nearly horizontal; ocular ridge obsolete, the fixed cheeks and preglabellar field contiguous; palpebral lobes long, nearly one half glabellar length exclusive of occipital ring, one half width of fixed cheek, situated just anterior to glabellar midpoint; posterior fixed cheeks blunt, triangular, their width less than the glabellar width at its widest; posterior furrow shallow proximally, broadening and disappearing distally; occipital furrow shallow and broad mesially, deep and narrow laterally; occipital ring crescentic, simple; anterior facial sutures short, parallel; posterior facial sutures nearly horizontal as they leave the palpebral lobes, then curving down around to shape the posterior fixed cheeks.

Ornamentation consists of terracing on the anterior border and punctae elsewhere. Punctae on the glabella are evenly spaced, clustered in the center and reduced or absent along the edges; punctae on the preglabellar field and fixed cheeks, although strong in the central areas, disappear as they approach the axial and preglabellar furrows. Occipital ring evenly pitted, posterior fixed cheeks pitted on anterior member only. Palpebral lobes not pitted.

Remarks: This species shares with *H. stenisp. nov.* the presence of punctation in similarly placed patches (gathered centrally, absent peripherally), the abutting indentations in the preglabellar furrow and preglabellar field, the outline of the cranidium, the shape and nature of the occipital furrow, and the virtually identical lateral view (e.g. Plate 1 Fig. 7 and Plate 2 Fig. 15). *H. punctata* differs from *H. stenisp.* in its shorter and straighter anterior border, the narrower fixed cheeks, and shorter posterior fixed cheeks. The glabella is rounder in dorsal aspect, lacking the straight sides of *H. stenisp.* The punctae themselves are comparatively finer and seem not to expand into the huge honeycomb-like pits of some *H. stenisp.* specimens.

Holmdalia stenisp. (Robison 1988)

Plate 1, Figs. 1-10, 12-15

1988 *Holmdalia punctata* Robison, p. 96, figs. 27:1-5

1992 *Holmdalia punctata*, Pratt, p. 61, pl. 20, figs. 7-10

Diagnosis: A species of *Holmdalia* with a deeply punctate prosopon and width of posterior fixed cheeks exceeding the width of the glabella. Punctuation variably broad. Glabella tapered, with fairly straight sides. Palpebral lobe small, globose, equal to 20% or less of the glabellar length.

Type: A cranidium from BPS 467, Plate 1, Figure 12

Name: Greek, *stenis* meaning narrow, the glabella being narrower in this species than in *H. punctata*.

Occurrence: Collections BPS 458, 462, 467, 468 and 469, Lower Marjuman of western Newfoundland; Holm Dal Formation, Greenland; Rabbitkettle Formation, Mackenzie Mountains.

Description: Anterior border almost flat in anterior aspect, strongly curved in dorsal aspect, arcing back so acutely that a transverse line drawn from tip to tip touches the leading edge of the glabella; terrace lines on the leading edge; length is one half to two thirds the length of preglabellar field. Anterior border furrow narrow and deep; preglabellar field tumid, convex, downsloping; glabella inflated, virtually effaced, tapered, straight-sided; glabellar furrows fully effaced; axial furrows deep, straight; preglabellar furrow deep, possessing a small, median indentation or pit; an indentation in the preglabellar field immediately adjacent accompanies the pit; fixed cheeks narrow, one third glabellar width at midpoint, convex, nearly horizontal; ocular ridge obsolete, the fixed cheeks and preglabellar field contiguous; palpebral lobes short, one fifth the glabellar length (including occipital ring), situated just anterior to glabellar midpoint; posterior fixed cheeks blunt, triangular, their width that of the glabella; posterior furrow well expressed; occipital furrow shallow and broad;

occipital ring crescentic; anterior facial sutures short, parallel in dorsal aspect; posterior facial sutures angling obliquely at $-38-40^{\circ}$ from horizontal.

Ornamentation consists of terracing on the anterior border and punctae elsewhere. Punctae on the glabella are evenly spaced, clustered in the center and reduced or absent along the edges; punctae on the prelabellar field and fixed cheeks, although strong in the central areas, disappear as they approach the axial and prelabellar furrows. Occipital ring evenly pitted, posterior fixed cheeks pitted on anterior member only. Palpebral lobes not pitted.

Remarks: Similarities to *H. punctata* (Rasetti 1967) are discussed above.

The deep, evenly spaced pits are large in all but seem disproportionately larger in some individuals than in others. This variation appears randomized; it does not grade from collection to collection or according to size. The occasional pit enlargement is not observed in *H. punctata*.

Holmdalia noensis sp. nov.

Plate 49, Figs. 8, 9, 13, 14

Diagnosis: A species of *Holmdalia* lacking the pit in the prelabellar furrow and the adjacent dent in the prelabellar field possessed by *H. punctata* and *H. stenis*, although some specimens offer the barest suggestion of one. The pitting in this species is shallower and finer.

Holotype: A cranidium from CH 11 (Plate 49, Fig. 8)

Name: For grandson Noah, sunshine in a grey world

Occurrence: Collection CH 11, Upper Marjuman of the Cow Head

Description: Anterior border mildly arched, almost flat, carrying terrace lines on the leading edge. A line drawn from end to end of the anterior border passes in front of the anterior edge of the glabella. Preglabellar field one and one third the length of the anterior border at midpoint, convex; Glabella effaced, subtriangular, anterior end evenly rounded, axial furrows straight, deep; preglabellar furrow deep; fixed cheeks two thirds the width of the glabella at midpoint in dorsal view, ocular ridges marked by lack of punctation, palpebral lobes short and narrow, one fifth glabellar length including occipital ring; occipital furrow broad, narrowest mesially, the distal fourths of the furrow longest and deepest; occipital ring mildly crescentic; posterior fixed cheeks triangular, convex, blunt-tipped, equal in width to maximum glabellar width; posterior furrow well defined, deep, horizontal. Anterior facial sutures parallel; posterior facial sutures slightly convex, angling back from the palpebral lobes at -68° . Punctae of prosopon thickly and evenly distributed, coarser in small individuals than in larger ones.

Remarks: *Holmdalia noensis* resembles *H. punctata* in the narrow, slightly arched anterior border. It resembles *H. stenisin* the short palpebral lobes and wide, triangular posterior fixed cheeks. The prosopon is more finely pitted than is that of either of the other species.

Family TRICREPICEPHALIDAE, Palmer 1954

Remarks: Palmer (1954) pulled *Tricrepicephalus* (Hawle and Corda 1857) and *Meteoraspis* Resser 1935 out of the Crepicephalidae Kobayashi 1935 where Kobayashi (1935, p 278), citing the pygidial morphology (backwardly-directed spines on the posterior corners of the pygidial pleurae), had placed them. Palmer claimed that the paired pygidial spines which the two genera share with *Crepicephalus* Owen 1851 probably arose under different circumstances and did not necessarily indicate common ancestry. He offered no argument or substantiation to support his opinion. The presence of two or three pits in the anterior border furrow, however, do indeed appear to be apomorphic, setting the family apart from the Crepicephalidae, and the Tricrepicephalidae can stand on that basis.

Genus *Tricrepicephalus* Kobayashi 1935

Type species: *Arionellus (Bathyrus) texanus* Shumard, 1861, Riley Formation, Texas

Diagnosis: Cranidium with prominent anterior border furrow marked by three pits. Pygidium massive, nearly square, with two long spines extending out from pleural field on each side above the posterior margin.

Remarks: Resser (1938) described 23 species, 20 of them new, from the southern Appalachians. Palmer (1954) cited the degree and location of cranidial surface ornamentation as important determining factors and sorted the genus into three species: *T. texanus* (Shumard 1861), possessing unevenly distributed tubercles and a smooth, granular or finely tubercular glabella, *T. coria* (Walcott 1916), identified by evenly, thickly distributed tubercles on the glabella and elsewhere, and *T. tripunctatus* (Whitfield 1876), with moderately distributed tubercles and an occipital spine, which the others lack.

Pratt (1992, p. 62) argued against this sorting by ornament, referring to a high degree of variation in pustulation and tuberculation in otherwise very similar co-occurring animals. He synonymized five superficially differing species as *T. texanus*. Eight years after Pratt's analysis, Stitt and Perfetta (2000) examined numbers of collections and claimed that Palmer's concept of species identification was valid after all.

All of this disregards the problem that the ornamentation tends to fade with growth; large specimens lose tuberculation. *T. coria* is primarily the pattern found in smaller specimens and *T. texanus* in larger ones. In these Cow Head collections, large specimens that are strongly tuberculate do not occur and small specimens devoid of

glabellar tuberculation do not occur. It is probable, therefore, that ontogeny plays a key role in ornamentation and that ornamentation should not be used at all as a character to separate species. Moreover, the pygidia assigned to *T. coria* and *T. texanus* differ in that the terminal pieces of *T. coria* pygidia usually reach the posterior edge whereas those of *T. texanus* usually fail to.

Another point pertains. From the Cow Head, Kindle (1948) named three species, *T. johnsoni*, *T. rusticus* and *T. murphyi*. His types are figured in Plates 4 and 5 (and well illustrated in the original paper). Ornament is limited to the preglabellar field in the larger *T. johnsoni* Kindle 1948 and prominent all over the cranidium in the smaller *T. rusticus* Kindle 1948. The relative proportions of *T. johnsoni* and *T. rusticus* differ in subtle ways—the anterior border of *T. rusticus*, for example, is more crescentic and a little longer in proportion to the glabella (one third glabellar length as opposed to one fourth glabellar length) and the shape of the glabella differs (the glabella of *T. johnsoni* is as wide as long, the glabella of *T. rusticus* wider than long). *Tricrepicephalus johnsoni* specimens are consistently much larger than those of *T. rusticus*. Is this another case in which the smaller individuals of a single species are more richly ornamented than are the large individuals, and they are thus simply ontogenetic variants of the same species? If there are two species here, the tendency of ornamentation to be partially dependent upon size prevails between species as well as within. Possibly the morphological variation described above is developmental and these two forms will prove to be ontogenetic variants of one species. Until specimens of intermediate size are found, I prefer to maintain the two as distinct species based

upon the differences in proportions cited above, disregarding ornamentation, and cautioning that the separation may be artificial after all.

In the 1954 paper, Palmer identified as a single species, *T. coria*, specimens that vary widely, some possessing a long, triangular anterior border while another does not (Palmer 1954, pl. 81, figs. 1-4, 6). He then synonymized all three of Kindle's species as variants of *T. texanus*. Although Palmer based his synonymy on surface sculpture, there are clear differences in other characters, such as the length of the anterior border (Palmer 1954, pl. 81, figs. 2 and 9), and shape and maximum cranidium width. Neither species has been adequately evaluated in its respective type area, and until this is done I prefer to apply Kindle's species names to the Cow Head material.

Tricrepicephalus cf. *T. tripunctatus* (Whitfield 1876)

Plate 5, Figs. 3-5, 7, 8

1876 *Arionellus tripunctatus* Whitfield p. 141, pl. 1, figs. 3-5

1916 *Crepicephalus tripunctatus*, Walcott, p. 215, pl. 33, fig. 1

1942 *Tricrepicephalus tripunctatus*, Resser, pl. 14, fig. 1

1946 *Tricrepicephalus* sp. indet. Rasetti, p. 461, pl. 70, figs. 1, 2

1954 *Tricrepicephalus tripunctatus*, Palmer, p. 755

2000 *Tricrepicephalus tripunctatus*, Stitt and Perfetta, p. 212, figs. 10.1-7

Occurrence: Collection CH 35; Riley Formation, central Texas; Deadwood Formation, South Dakota

Remarks: The occipital spine distinguishes *T. tripunctatus* from all other members of the genus. If a spine is broken off, the shape of the occipital ring—flattened in lateral view, triangular in posterior view and tipped to nearly 85° from horizontal—may still be a species indicator, provided it is not broken back to the floor of the occipital furrow. Occipital rings of other species are evenly curved in lateral and posterior views.

Tricrepicephalus rusticus Kindle 1948

Plate 4, Figs. 10-17, types; Plate 5, Figs. 13-18, Plate 6, Figs. 5, 6, 8, 9, 12

1948 *Tricrepicephalus rusticus* Kindle, p. 447, pl. 1, figs. 4-7

1954 *Tricrepicephalus rusticus* Palmer p. 755

Diagnosis: A *Tricrepicephalus* with an anterior border length one third glabellar length; leading edge follows line of curve of the anterior border furrow. Glabella subtriangular, wider than long, occipital ring with a shallow node.

Occurrence: Collections CH 11, 35, 36, Upper Marjuman of Cow Head

Remarks: The rounded occipital ring with a node but no spine quickly separates this species from the only other small *Tricrepicephalus* in the collections, *T. tripunctatus*. The axial furrows, curved slightly, make the glabella of *T. tripunctatus* appear rounder than the glabella of *T. rusticus* with its straighter sides. Other members of the genus lack the occipital node.

Tricrepicephalus johnsoni Kindle 1948

Plate 4, Figs. 1-9, types; Plate 5, Figs. 6, 9-12, 19,

Plate 6, Figs. 1-4, 7, 10, 11, 13-20

1948 *Tricrepicephalus johnsoni* Kindle, p. 449, pl. 2, figs. 5, 6, 12, 13

1954 *Tricrepicephalus johnsoni*, Palmer p. 755

Diagnosis: a moderately convex tricrepicephalid with a relatively wide preglabellar field that, in length, is twice glabellar length exclusive of occipital ring.

Holotype: Princeton 57904 from the Cow Head

Occurrence: Collections CH 11, 12, 21, 35, Upper Marjuman of Cow Head

Remarks: *T. johnsoni* most resembles *T. texanus* in the length and curvature of the anterior border, but the fixed cheeks in *T. johnsoni* are narrower and the preglabellar

field in lateral view a bit longer; no occipital node or spine. Both the types and the local specimens are devoid of ornamentation save on the prelabellar field, but as discussed above, I consider that ornamentation offers no more than corroboration and do not use it as a primary criterion.

Genus *Meteoraspis* Resser 1936

Type species: Ptychoparia metra, Walcott 1890

Diagnosis: A genus of Tricrepicephalidae with two pits, or slots, in the anterior border furrow; suite of other characters includes narrow prelabellar field, small, flat anterior border with pronounced anterior border furrow, narrow fixed cheeks and large eyes.

Pygidia with spines, usually the length of the pygidium or less, extending from the outer posterior angles of the pleurae.

Remarks: The defining feature of *Meteoraspis*, the pair of pits (more properly, slits) in the anterior border furrow is easily discernible even in internal moulds. Too, *Meteoraspis* differs from *Tricrepicephalus* in having narrower fixed cheeks. It differs from *Kindleia* gen. nov., specifically, *K. mutica*, in the nature of the anterior border furrow slits; in *Meteoraspis* they are discrete; in *Kindleia* they begin at either side of the medial area and extend nearly to the distal ends of the furrow.

Shaw (1952) described a tiny form, *M. minuta* (Raymond's *Greylockia minuta* Raymond 1937), as a separate species, and indeed, some very small *M. borealis* come from boulders in which tiny specimens of other genera are also found. As mentioned previously, this strongly suggests that size sorting is at work. I suggest that *M. minuta* is most likely an early meraspis rather than a separate species. This opinion is strengthened by the fact that sizes grade smoothly from tiny (± 1 mm) to small (2 or 3 mm) to fairly large for the genus (4 mm or more).

Meteoraspis borealis Lochman 1938

Plate 7, Figs. 1-17; Plate 8, Figs. 1-14

1938 *Meteoraspis borealis* Lochman, p. 472, pl. 56, figs. 1-5

1948 *Meteoraspis borealis*, Kindle, p. 446, pl. 2, figs. 7-11

Diagnosis: A species of *Meteoraspis* with a convex, conical, effaced glabella; anterior border length approximately equaling length of preglabellar field; The glabella may have a slight median longitudinal ridge; ornamentation granulate. Pygidium with posterior spines; nearly square, the pleurae effaced and finely pitted. The broad axis, raised well above the pleural plane and deeply furrowed, is not pitted.

Type: Cranidium YPM 15849 from Cow Head, western Newfoundland, figured in Plate 8, Figs. 4, 14

Occurrence: Collections CH 9, 12, 21, 22, 26, 28, 34, 35, 36 and 39, Upper Marjuman of Cow Head

Remarks: All of the *Meteoraspis* cranidia in this collection conform well to Lochman's holotype (figured in Plate 8, Figs. 4, 14) and Kindle's specimens, which he claimed as hypotypes, (Plate 7, Figs. 1-17). The uniformity in the cranidia is not echoed in pygidia. Comparing Plate 7, Fig. 9 with examples such as Palmer's (1954) plate 82, figs. 1, 2 or this work, Plate 8, Fig. 12 and Plate 7, Fig. 13, I believe that Kindle erred in his assignment of pygidium 9460 to *Meteoraspis borealis*. The left posterior spine is not reducing in size quickly enough, and the axis is disproportionately small. Rather it is here referred to *Crepicephalus*.

Genus *Kindleia* gen. nov.

Type species: *Kindleia williamae*, Upper Marjuman of Cow Head

Diagnosis: Tricrepicephalids with tumid anterior border, smooth or finely granular surface, narrow fixed cheeks and two or three pits in the anterior border furrow; occipital ring crescentic, with or without a spine. Pygidium robust with narrow pleurae as in *Tricrepicephalus* but lacking posterior spines.

Name: For Cecil Kindle, who collected this Cow Head material

Remarks: This genus differs from the others in the family in the shape and tumidity of the anterior border, the nature of the anterior border furrow pits, and the narrow fixed cheeks. Two of the three species carry an occipital spine; occipital spines are rare or absent in the other genera. *Meteoraspis* and *Tricrepicephalus* are readily differentiated, both in genus and in species determination, by the shape nature of their respective pygidial spines and the relationship of the terminal piece to the posterior border (either falling short of it, touching it or extending beyond it). If the assignment of a pygidium to *Kindleia* (see below) is correct, the genus possesses a pygidium similar in stricture to that of other tricrepicephalids save without posterior spines.

Worthy of comment is the degree to which the cranidium of this genus lies intermediate between *Meteoraspis* and *Tricrepicephalus*. Ornamentation is that of *Meteoraspis*; *gestalt* is that of *Tricrepicephalus*: the anterior border pits are those of either, and the presence of a spine echoes *Tricrepicephalus tripunctatus*, but the respective spines are unlike.

Palmer (Palmer 1965) claimed to find occasional third medial pits, very shallow, in *Meteoraspis* specimens he examined. He neither elaborated nor commented further, so it is unknown as to whether he was, perhaps, looking at *Kindleia*.

Kindleia williamae gen. nov., sp. nov.

Plate 10, Figs. 1-11, Plate 11, Figs. 5, 14

Diagnosis: A species of *Kindleia* with an inflated anterior border, anterior border furrow with three pits, and an occipital ring expanded medially into a short, blunt spine.

Type: A cranidium from CH 11, Plate 10, Figures 1-4

Name: For William Dengler, husband of the author

Occurrence: Collection CH 11, Upper Marjuman of Cow Head

Description: Glabella effaced, subtriangular, evenly rounded, its length exclusive of occipital ring equaling its maximum width; anterior border crescentic, strongly tumid, with terrace lines tracing the leading edge; anterior border furrow well incised, possessing three closely spaced pits, the lateral pits expressed as slits and the median pit round; all three fall within the median third of the furrow. Axial and preglabellar furrows deep, narrow; preglabellar field tumid, downsloping, shorter than anterior border; fixed cheeks convex, one fifth glabellar width at its widest; palpebral lobes nearly as wide as the fixed cheeks, their length a bit less than one third glabellar length exclusive of occipital ring, situated opposite glabellar midpoint; palpebral furrow shallow; ocular ridges effaced but sometimes discernible as a change in slope;

posterior fixed cheeks narrow, one half glabellar width, short, with strong, round-edged posterior border furrow that curves forward distally; Occipital furrow broad, shallow medially and deep laterally; occipital ring flattened, tilted back and upward at 60-65°, expanding smoothly into a blunt, stubby spine. Anterior facial sutures curve out, then converge to meet the narrow anterior border. Posterior sutures trace a nearly transverse course. Surface very finely granular, internal mould finely pitted.

Remarks: The species differs from *K. unicornis* (Kindle 1948) in the shape of the occipital spine, which in *K. unicornis* is long and thin, untapered; in the shape of the glabella, which in *K. unicornis* is longer and narrower; and in the shape of the anterior border, which in *K. unicornis* is less tumid and more triangular. *Kindleia williamae* differs from *K. mutica* in the number of anterior border furrow pits, three instead of two, and the blunt spine.

Kindleia cf. *mutica* (Rasetti) 1961

Plate 11, Figs. 1-4, 6-12

1961 *Meteoraspis mutica* Rasetti, p. 116, pl. 21, figs. 25-29

1965 *Meteoraspis mutica* Rasetti, p. 54, pl. 6, figs. 13, 14

Diagnosis: A*Kindleia* with tumid anterior border, two pits in anterior border furrow expressed as broad slits beginning within the mesial fourth and deepening laterally, and unornamented, crescentic occipital ring.

Type: a cranidium from CH 11, Upper Marjuman of western Newfoundland

Occurrence: Collections CH 3, 11, 12, 21, and 39, Upper Marjuman of western Newfoundland.; Conococheague Formation, Virginia; Nolichucky Formation, Tennessee; possibly Pilgrim Formation, Montana (see below)

Description: Glabella subtriangular, effaced, evenly rounded, longer than wide, not noticeably inflated; anterior border crescentic, only mildly tumid, possessing terrace lines; anterior border tends to tip upward in lateral view; anterior border furrow shallow, with two lateral pits expressed as deep slits extending from the median fourth of the furrow to the distal edges; Preglabellar field shorter than anterior border, convex and downsloping; fixed cheeks narrow, one third glabellar maximum width, convex and horizontal; ocular ridges obsolete; palpebral lobes one fourth glabellar length (including occipital ring), narrow, separated by shallow palpebral furrow, situated opposite glabellar midpoint; posterior fixed cheeks short, equal in width to one half greatest glabellar width, posterior marginal furrows strong; occipital furrow shallow mesially, deep laterally, almost straight; occipital ring plain, crescentic, lacking spine or node. Anterior facial sutures curve out before converging to meet the anterior border; posterior facial sutures angle down and out immediately. Exterior surface granular, the ornament appearing almost smooth except at high magnification.

Remarks: *Kindleia mutica* differs from *K. williamae* in the longer glabella, narrower fixed cheeks, the nature of the anterior border furrow, and lack of an occipital spine. It differs from *K. unicornis* in the lack of a thin occipital spine. No *K. mutica* specimens the size of *K. unicornis* have been recovered as yet. The tumid anterior border and unusual pit arrangement in the anterior border furrow separate it from *Meteoraspis*.

Figures of *Meteoraspis keeganensis* Duncan 1944 in Lochman and Duncan 1944 (p. 99, pl. 9, figs. 1-3, 29) suggest that *M. keeganensis* is also a *Kindleia*, but the type material should be examined before making a decision.

Kindleia unicornis (Kindle 1948)

Plate 9, Figs. 1-6

1948 *Tricrepicephalus unicornis* Kindle, p. 448, pl. 2, figs. 1, 2

Diagnosis: a species of *Kindleia* with three closely spaced pits in the anterior border furrow, subtriangular glabella that is longer than wide, a tumid, crescentic anterior border, and a short, untapered occipital spine. Tentatively assigned pygidium roughly trapezoidal; the axis, with two rings plus terminal piece, is broader than the pleurae; pleurae with strong anterior border furrow and three faint pleural furrows; pygidial border one third the length of the axis, thick, possessing terrace lines along the outer edge. Posterior edge slightly embayed.

Holotype: A cranidium (Princeton 57901) from the Cow Head Group, western Newfoundland

Occurrence: Collection CH 11, Upper Marjuman of western Newfoundland.; type from “Cow Head”

Description: Cranidium longer than wide. Glabella length one fifth longer than greatest width. Glabella sub triangular, evenly rounded anteriorly; anterior border flat in anterior view, tumid in lateral view, crescentic in dorsal view, one fourth glabellar length exclusive of occipital ring. Preglabellar field shorter than anterior border and strongly downsloping; anterior border furrow broad and shallow, marked by three small, short pits within the central third of its total width; fixed cheeks convex, horizontal, less than one third maximum glabellar width; faint ocular ridges slope back to meet palpebral lobes that are one fourth glabellar length exclusive of occipital ring, with widths one-half their palpebral length. Width of posterior fixed cheeks approximately three fourths glabellar width, almost straplike; occipital ring crescentic, tilted up and back at 64° to 75° from horizontal; median occipital spine arises abruptly from the occipital ring as a thin, brad-like spike the length of the occipital ring. Anterior facial sutures slightly convergent; posterior facial sutures angle out from the palpebral lobes at close to -25° from horizontal.

Tentatively assigned pygidium is similar in shape to *Crepicephalus* pygidia, in dorsal view broadly subtrapezoidal with rounded corners. Axis broad, blunt, squared off, with one furrow plus anterior furrow; terminal piece downsloping. Pleurae four fifths axis width, carrying two furrows plus the anterior border furrows, strongly convex and downsloping; posterior border embayed, and posterior lateral borders with terrace lines.

Remarks: The exact source of Kindle's single type specimen is not recorded. But its matrix matches in colour and texture the matrix of CH 11 and to a lesser extent that of CH 39.

Size considerations aside because they cannot be evaluated (large individuals of the other species may have existed; that they have not been found means nothing), *Kindleia unicornis* differs from *K. williamae*, the other spinous species, in the nature of the spine. In *K. williamae* it is blunt, tapering, and resting at a very low angle; in *K. unicornis* it is straight-sided, nail-like and steeply atilt. The cranidium and glabella are more elongate in *K. unicornis* than in the other species, the anterior border less tumid and more triangular. *K. williamae* differs from *K. mutica* in the number of anterior border furrow pits, three instead of two, and the blunt spine.

Family CREPICEPHALIDAE Kobayashi 1935

Remarks: This is a part of a larger marjumioid group of diverse characters. Both *Tricrepicephalus* and *Meteoraspis* (above) were removed from this family and given a family of their own, the Tricrepicephalidae. The remaining genera of the Crepicephalidae, *Crepicephalus* Owen 1852, *Bonneterrina* Lochman 1936, *Uncaspis* Kobayashi 1935, *Coosella* Lochman 1936, *Coosia* Walcott 1911 and *Coosina* Rasetti 1956 span the classic Dresbachian Stage.

Genus *Crepicephalus* Owen 1852

Type species: *Dikelocephalus iowensis* Owen 1852

Remarks: The species are sorted based on the width of the fixed cheeks, the length of the preglabellar field, and the shape of the occipital ring. Where pygidia can be assigned, the length of the posterior spines and the angles at which they leave the posterior border help distinguish species.

Crepicephalus rivus Kindle 1948

Plate 12, Figs. 1-3 (paratype), 4-12

1938 *Crepicephalus columbiensis* Kobayashi, p 187, pl 15, figs. 24-28

1948 *Crepicephalus rivus* Kindle p 446, pl 1, figs. 14-18

1992 *Crepicephalus columbiensis*, Pratt, p 63, pl 21, figs. 8-20, text-fig. 30 pygidia

Type: Cranidium NMC 9468, from British Columbia

Occurrence: Collections CH 3 and 35, Upper Marjuman of western Newfoundland

Remarks: Kindle's (1948) *C. rivus* from the Gaspé (paratype figured in Plate 12, Figs. 1-3), synonymized by Pratt (1992) with *C. columbiensis* Kobayashi 1938, varies slightly from *C. columbiensis*. I suggest that *C. rivus* differs sufficiently to remain an entity and am restoring it as a valid species. The glabella of *C. rivus* is more tapered and more sharply rounded anteriorly, the preglabellar field more convex, and the fixed cheeks a little wider, proportionately, at palpebral level than is the case with *C. columbiensis*. Moreover, the anterior border is longer and the preglabellar field shorter than those of *C. snowiensis* Lochman 1944, the anterior border more curved in dorsal aspect than that of *C. rectus* Resser 1938, *C. buttsi* Resser 1938 or *C. explicatus* Resser 1938, and the prosopon smoother than the granulate prosopon of *C. iowensis* (Owen 1852) Walcott 1916.

The terminal piece of the pygidium assigned to *C. rivus* by Kindle (Plate 12, Figure 12) stops short of the posterior border, the axis comprising three fourths of the total pygidial length at midpoint. The posterior spines are broken back, but enough stub remains to ascertain that they leave the pygidial border at an angle of about 80°.

Genus *Nasocephalus* Wilson 1954

Type species: Nasocephalus nasutus cranidium CW-257, Cedaria Zone, Marathon Uplift, Texas.

Diagnosis: A genus of Crepicephalidae in which the tapered, rounded glabella is prominent and well defined but not highly arched, and with three pairs of faint glabellar furrows, S1 slightly arcuate. The anterior border is extended into a triangular process, separated from the fixed cheeks and short preglabellar field by a lightly expressed anterior furrow; large, prominent palpebral lobes posterior to the glabellar midpoint (not as in Moore 1959, p 308, fig. 229). Short posterior fixed cheeks. Occipital ring expands medially; occipital node or spine may be present.

Remarks: Wilson (1954 p. 268) placed the genus provisionally in the Crepicephalidae on the strength of narrow fixed cheeks and the wide anterior border. Pratt (1992, p. 89) left the genus unassigned. Jell *in* Jell and Adrain (2003) placed it in the Marjumiidae without comment. I submit that the suite of characters, namely narrow fixed cheeks, relatively straight anterior border furrow, tapered yet somewhat truncated glabella, and truncated crescentic pygidium, all shared with some members of Crepicephalidae (*C. australis* Palmer 1954 and *C. iowensis* (Owen 1852), *C. columbiensis* Kobayashi 1938 to some extent) but not Marjumiidae, place it in the Crepicephalidae. The pygidium of *Nasocephalus* assigned by Pratt (1992, p. 89), however, bears more resemblance to the Marjumiidae than to the Crepicephalidae, in

that it lacks the posterior spines of most crepicephalids and possesses wide pleurae such as found in *M. transversa* Palmer 1968.

Refer to Wilson (1954) and Pratt (1992) for a recapitulation of Wilson's and Westergard's interchange regarding the relationship between *Nasocephalus* and *Agraulos*.

Nasocephalus flabellatus Wilson 1954

Plate 13, Figs. 6, 7, 10-13

1954 *Nasocephalus flabellatus* Wilson p. 269, pl. 24, figs. 3 and 22

1992 *Nasocephalus flabellatus*, Pratt p. 89, pl. 18, figs. 11-20, text fig. 34

Holotype: A cranium, CW-261 from SS-31, from Woods Hollow Shale, Marathon Uplift, Texas

Occurrence: Collection CH 3, Upper Marjuman of western Newfoundland; Marathon Uplift, Texas; Rabbitkettle Formation, Mackenzie Mountains, Canada

Remarks: Pratt's (1992) specimens of *N. flabellatus* differ from Wilson's and from each other in the presence of an occipital node and in the length of the frontal border. The CH 3 specimens seem to fall near the middle of Wilson's and Pratt's two extremes; one Cow Head specimen possesses an occipital node; the other does not.

The shape rather than the length of the anterior border, however, is diagnostic for *N. flabellatus*.

Genus *Syspacheilus* Resser 1938

Type species: Syspacheilus typicalis Resser 1938 from the Nolichucky south of Rome, Georgia

Remarks: When he erected the genus, Resser (1938) claimed of the type species, *S. typicalis*, “The illustrations, together with the generic diagnosis, present the characteristics of the species.” They do no such thing. The figures are totally inadequate (and if the Lochman and Hu (1961) interpretation be followed, inaccurate also) and the diagnosis describes any number of libristomate genera.

Three different kinds of pygidia were assigned to the disarticulated cranidia by Resser (1938) (an alate, flat pygidium with six short marginal spines), Palmer (1955) and Lochman and Hu (1961). Robison (1988) opines that the Lochman and Hu interpretation best fits the collections from northern Greenland and follows that emended diagnosis, as shall this work.

Syspacheilus sp. indet.

Plate 48, Fig. 5

Occurrence: Collections BPS 467 and WRI 613, Lower Marjuman, western Newfoundland

Remarks: The figures of *Syspacheilus* (*Blountia*) in Miller 1936 lack resolution sufficient for interpretation. Figures in Lochman and Duncan (1944) and Lochman and Hu (1961) differ in detail. The 1961 paper offers a number of cranidia and some pygidia designated by the authors as plesiotypes. They identify variants which they consider to be subspecific (p. 135) to *Syspacheilus dunoirensis*, underlining the difficulty of assigning species status to members of this genus with any confidence. The *Syspacheilus* sp. indet. in these collections occur in boulders interpreted as Lower Marjuman, yet Lochman assigns the genus to the *Cedaria* Zone. This casts doubt on both the range limits and the identification of the Cow Head specimen.

Genus *Coosina* Rasetti 1956

Type species: *Maryvillia ariston* Walcott 1916 from the Nolichucky Formation, Tennessee

Remarks: The combination of a largely effaced cranidium with a very shallow, weakly arched glabella identify this genus.

Westrop (1992) reports an unusual, perhaps unique, hypostome for *Coosina*. The borders, broad and flat, completely encompass the median body, whereas others

possess borders that terminate just anterior to the midpoint of the main body. No such hypostomes were recovered from these collections.

Coosina sp. indet.

Plate 13, Figs. 1-5

Occurrence: Collections CH 9 and 34, Upper Marjuman of western Newfoundland.

Remarks: The material in these collections is much too limited to assign with confidence.

Genus *Coosia* Walcott 1911

Type species: *Coosia superba* Walcott 1911

Remarks: Anterior border of most species longer than prelabellar field, anterior border furrow very shallow, broad. Occipital furrow narrow, shallow, straight; occipital ring flat.

Coosia sp. indet.

Plate 13, Figs. 8, 9

Occurrence: Collections CH 11 and 34, western Newfoundland.

Remarks: The anterior field, accompanied by the partially effaced prelabellar and axial furrows, is diagnostic of the genus, but not enough material occurs to be able to assign a species with confidence.

Family ALOKISTOCARIDAE Resser 1939

Genus *Mexicella* Lochman 1948

Type species: *Mexicella mexicana* Lochman 1948 from the Carerra Formation, Caborca, Mexico

Remarks: Additional species in this genus were described from the Pioche Shale of extreme eastern Nevada, which Sundberg and McCollum (2000) date at the lower-middle Cambrian boundary interval. This poses an interesting prospect. Apparently nowhere is the genus common, but it seems to be quite wide-ranging. However, as discussed later, at least a few of Sundberg and McCollum's specimens appear to be *Onchocephalites* Rasetti 1957 spp., so the actual range of this genus is in question.

Mexicella sp. *indet.*

Plate 48, Figs. 11-13

Occurrence: Collections BPS 458 and WRI 602, 603 and 624, Lower Marjuman of western Newfoundland

Remarks: A species of *Mexicella* Lochman 1948 with narrow fixed cheeks and anterior facial sutures that, although they bow out slightly, are nearly parallel. The anterior border and preglabellar field are downsloping.

As mentioned above, the genera and species listed by Sundberg and McCollum (2000) as *Mexicella* Lochman 1948 (p. 622, figs. 13. 1-10) strongly resemble *Onchocephalites* Rasetti 1957, e.g. in the glabella, which is sharply truncated *a la* *Onchocephalites*, not triangular as in *Mexicella*. Palmer and Halley (1979) figure *Mexicella mexicana* from the Pioche Shales (p. 109, pl. 13, figs. 13-21) with subtriangular glabella. Their new species *M. grandoculus* (p. 109, pl. 13, figs. 5, 9, 10) has a slightly truncated glabella. I recommend that the genus be reserved for those species with a long preglabellar area, obsolete anterior border furrow and subtriangular, non-truncated glabella.

Family ASAPHISCIDAE Raymond 1924

Genus *Kingstonioides* Rasetti 1963

Type species: Kingstonioides laevigatus Rasetti 1963 from the Métis Formation of the Lower St. Lawrence Valley

Remarks: Though sharing a limited number of characters with *Kingstonia*, *Kingstonioides* lacks the occipital ring and occipital furrow typical of the Kingstoniidae. The occipital ring is flat and follows the curve of the glabella. Whereas the straight axial furrows of *Kingstonia* are clearly discernible only on the interior mould where they are strongly impressed, the equally straight axial furrows in *Kingstonioides* are visible but partially effaced and also strongly impressed in the internal mould. However, the posterior fixed cheeks carry posterior border furrows, which *Kingstonia* does not, and are considerably narrower than in most kingstoniids. *Kingstonioides* therefore possesses characters better reflecting Asaphiscidae than Kingstoniidae.

Rasetti established *K. laevigatus* (Rasetti 1963, p. 583, pl 68, figs. 26-30) from the lower St. Lawrence Valley. In their analysis of Rasetti's genus, Fritz, Kindle and Lesperance (1970) claimed there were two or three species of *Kingstonioides* from the White Rock Islets (p. 53) but described only *K. primicaudus* (Fritz, Kindle and Lesperance, 1970, p 53, figs. 3-10) from the eastern Gaspé, and that inadequately. The specimens in this present collection fit neither of the two described species, the most distinctive differences lying in the shape and positioning of the anterior border and of the occipital ring and its furrow.

Pygidium short and broad, terminal piece of axis short, broad (nearly one third maximum pygidial width), stopping just short of the posterior border.

Kingstonioides delgada sp. nov.

Plate 15, Figs. 1-8

Diagnosis: A species of *Kingstonioides* with a nearly effaced occipital furrow and short occipital ring fitted tightly against the posterior edge of the glabella. Anterior border prominent, thin and shallow, nearly horizontal in lateral aspect.

Type: A cranidium from WRI 606, White Rock Islets, Plate 15, Figs. 1, 2

Name: From the Spanish, meaning lean or lanky and referring to the longer-than-wide glabella, unusual in the genus, and flat, thin anterior border

Occurrence: Collections WRI 606, 615, 627 and 634, lower Marjuman of western Newfoundland.

Description: Cranidium oval save for the posterior fixed cheeks, strongly arched. Glabella a longer-than-wide ovoid, evenly rounded anteriorly, more broadly rounded posteriorly, fully effaced; axial and preglabellar furrows almost completely effaced, the glabella defined more by the change of slope of the fixed cheeks than by its

furrows; posterior corners of the glabella bulge slightly as they meet the occipital furrow. Anterior border evenly rounded in dorsal aspect, a bit longer than the preglabellar field in dorsal aspect, equal in length to preglabellar field in lateral aspect; anterior border thin, carrying prominent terrace lines, visible dorsally, on the leading edge; preglabellar field downsloping, following the curve of the glabella; fixed cheeks slightly downsloping, a bit less than one third glabellar width at midpoint; ocular ridges obsolete; palpebral lobes narrow, short, one fourth glabellar length, set at the glabellar midpoint. Posterior fixed cheeks short, a little less than half the glabellar width, the posterior furrow partially effaced; occipital furrow curved following the line of the glabella, of uniform depth in internal mould, almost fully effaced on exterior test; occipital ring narrower than glabella, comprising one ninth glabellar length, mildly crescentic. Test smooth. Anterior facial sutures slightly convergent, slightly curved. Posterior facial sutures angle obliquely at 55-60° from horizontal. Following edge of posterior fixed cheeks approximately horizontal.

Remarks: Rasetti's type species, *K. laevigatus*, possesses an anterior border that is quite thick, with a leading edge nearly as deep as the anterior border is long. The occipital ring of *K. laevigatus* is crescentic, the occipital furrow deeply impressed in the exterior test. The other features of the cranidia, however, compare well. *K. primicaudus*, so much as can be discerned from the type (Fritz, Kindle and Lespérance 1970, pl. 9, figs. 3-10) is rounder in glabellar and in general outline, and the anterior border appears to be thick. See also *K. grandilabra* below.

Kingstonioides grandilabra sp. nov.

Plate 16, Figs. 1-16

Diagnosis: A species of *Kingstonioides* with a broad anterior border that has tipped up against the preglabellar field and an occipital furrow that is almost fully effaced exteriorly.

Type: Cranidium [570-4] from WRI 603, White Rock Islets, Plate 16, Figs. 8, 9, 14, 15

Name: Latin, “large lips,” referring to the anterior border; the author vigorously resists any pun on fossils, hard rock and Mick Jagger

Occurrence: Collections CH 98, BPS 467 and WRI 603 and 615 of Lower Marjuman, western Newfoundland.

Description: Cranidium squared anteriorly, rounded posteriorly, convex both sagittally and transversely; glabella effaced, low, sides slightly convex, broadly curved at front; preglabellar and axial furrows almost fully effaced both externally and on interior mould. Anterior border thick, marked with five or six prominent terrace lines, and pressed back against the preglabellar field; the exposed, terraced

face of the anterior border in anterior or lateral view (*i.e.* its full length) is close to one fourth total cranidial length measured in dorsal view. The anterior border angles back so far, lying on the preglabellar field, that its terrace lines are fully visible in dorsal view. Exposed preglabellar field length one half anterior border length; fixed cheeks downsloping, a little less than one third glabellar width at midpoint; ocular ridges obsolete; palpebral area one fourth of glabella at base, palpebral lobes narrow, one fourth glabellar length, situated just behind the glabellar midpoint. Occipital furrow nearly effaced, following the posterior curve of the glabella; occipital ring curved, very mildly crescentic, pressed against the posterior glabella. Posterior fixed cheeks short, less than one half glabella width, bluntly triangular; posterior furrow partially effaced. Anterior facial sutures nearly parallel; posterior facial sutures angle back obliquely at 25–30° from horizontal.

Pygidium sub triangular, one third wider than long, almost fully effaced, with rounded edges; axis slightly wider than pleurae, bluntly rounded, three fourths total pygidial length, with one axial furrow barely visible. No terrace lines.

Remarks: The closest species to *K. grandilabra* is probably *K. primacaudus*.

However, the axial furrows in *K. primacaudus* appear less effaced and the anterior border not so firmly pressed to the preglabellar field. The occipital area of *K. primacaudus* is damaged beyond interpretation. The anterior borders of *K. laevigatus* and *K. delgada* differ greatly as discussed above.

Genus *Asaphiscus* Raymond 1924

Type species: Asaphiscus wheeleri Meek 1873

Remarks: Axial, prelabellar and occipital furrows shallow; the axial furrows fade from posterior to anterior, meeting the partially effaced prelabellar furrow to form a tapered, effaced glabella; glabella does not rise far above the fixed cheeks. Occipital furrow similarly shallow, partially effaced. These furrows, though partially effaced, are still effective on the outer test. This separates the genus from genera such as *Kingstonioides* in which the effacement masks a much broader, partially inflated glabella, smaller fixed cheeks, and obsolete prelabellar field.

Pygidia of *Asaphiscus* spp. possess clearly defined axes and discernible pleural furrows. Pygidial axes of *Kingstonioides* spp. are so subdued as to be virtually undiscernible, and pleural furrows are effaced.

Asaphiscus cf. *A. wheeleri* Meek 1873

Plate 48, Figs. 3, 4, 10, 14

1873 *Asaphiscus wheeleri* Meek, p. 485

1877 *Asaphiscus wheeleri*, White, p. 43, pl. 2, fig. 1

1886 *Asaphiscus wheeleri*, Walcott, p. 220, pl. 25, fig. 9 and pl. 31, fig. 3

1916 *Asaphiscus wheeleri*, Walcott, p. 390, pl. 58, fig. 1

1954 *Asaphiscus wheeleri*, Palmer, p. 74, pl. 16, fig. 7

1964 *Asaphiscus wheeleri*, Robison, p. 544, pl. 86, figs. 1-3

Type: Type material fragmentary; Palmer (1954b), feeling the lack, suggested that his USNM 15460, collected from the same area as the holotype, the Wheeler Formation of the House Range, was an adequate substitute and called it a topotype.

Occurrence: Collections BPS 467 and WRI 603, 611, 614, 616, 617, 630 and 633, Lower Marjuman of western Newfoundland; Wheeler Formation, Western Utah

Remarks: A species of *Asaphiscus* with faint axial and occipital furrows, a strong anterior border furrow and broad anterior border. The axial furrows are convex, making the glabella appear rounded and separating it from highly similar marjumiids. The type figures are virtually impossible to interpret. Palmer re-evaluated the species with new specimens from the same strata, but he figured only one of them.

Genus *Lecanopleura* Raymond 1937

Type species: *Lecanopleura interrupta* Raymond 1937 from northwestern Vermont

Remarks: In his original description, Raymond (1937) erected this genus because the

eyes are set closer to the glabella than are those of what he considered the most nearly similar genus, Walcott's *Blountia* Walcott 1916, and placed it in the Asaphiscidae. *Jell in* Jell and Adrain (2003) listed it with the Marjumiidae but, probably because the format did not provide a venue, made no comment as to why. I consider the Asaphiscidae the best place for it considering these characters: The eyes of marjumiids are generally large with well defined palpebral lobes; eyes of *Lecanopleura* are relatively small with modest palpebral lobes; the occipital furrow is deep and evenly incised in marjumiids, whereas in *Lecanopleura*, as in Asaphiscidae in general, it is shallow, sometimes shallowing further mesially; axial and preglabellar furrows are deeply incised in marjumiids, less so in this genus; the posterior furrows and posterior fixed cheeks angle posterior-ward in *Lecanopleura*, particularly in *L. interrupta*, and are horizontal in marjumiids. In shape, the pygidia of *Lecanopleura* resemble those of asaphiscids, though their axial and pleural furrows are much less pronounced.

The diagnoses and figures of both species Raymond established lack clarity.

As much as can be ascertained from those diagnoses and figures, the specimens of *Lecanopleura* recovered from CH 3 fit the genus but fully satisfy neither the figures nor the descriptions at species level.

Lecanopleura habros sp. nov.

Plate 3, Figs. 1-5, 8-11, 15-19, 22-26

Diagnosis: A species of *Lecanopleura* in which the occipital furrow connects with the

intramarginal furrows of the posterior fixed cheeks and the long, convex anterior border possesses a slight plectrum. Pygidium with small, tapered axis one fourth the total pygidial width, the terminal piece fading into the posterior border at about the two-thirds point.

Type: A cranidium from CH 3

Name: Greek *habros* meaning pretty, graceful, dainty

Occurrence: Collection CH 3, Upper Marjuman, western Newfoundland

Description: Cranidium subrectangular, flat in anterior view, convex in dorsal aspect. Anterior border curved in dorsal aspect, inflated, one fourth total cranidial length, its width two times glabellar width, sometimes widening medially in a slight plectrum. Anterior border furrow nearly obsolete, the demarcation between anterior border and preglabellar field clearly expressed as an abrupt change of slope; preglabellar field convex and short, half the length of the anterior border; glabella tapered and evenly rounded, somewhat inflated, nearly effaced, although a straight, backsloping S1 appears in a few individuals; preglabellar and axial furrows shallow but clearly incised; occipital furrow straight, shallow, its edges rounded; fixed cheeks narrow, one third mesial glabellar width; ocular ridges straight, faint, angling slightly from the preglabellar furrow to the palpebral lobes; palpebral lobes narrow, less than one

fourth glabellar length situated at or just ahead of glabellar midline; posterior fixed cheeks short, less than one glabellar width at its widest; broadly subtriangular with a long base and blunt, backswept distal corners; posterior furrow similar in depth to occipital furrow, its edges rounded; occipital ring rounded, upturned at 40-45°, crescentic, its length half its width, without node or ornament. Anterior facial sutures diverge, meeting curved anterior border at approximately right angles; posterior facial sutures angled sharply back at – 60° from palpebral lobes. Prosopon very finely granulate, appearing smooth except at high magnification.

Pygidium semicircular; axis tapered, its width a bit less than one third total pygidial width, its length two thirds pygidial length; axial furrows well expressed, axis and pleurae effaced; posterior of terminal piece indistinct, fading into the pleural field. Borders and edges softly rounded.

Remarks: The short preglabellar field and broad anterior border differ from those of *L. inflecta* (Raymond 1937, p. 1111, pl. 3, fig. 2) and *L. interrupta* (Raymond 1937, p. 1111, pl. 3, fig. 1), the only other species in the genus (see below). The glabella is more ovate than in those two and the occipital ring longer. *Lecanopleura habros* is part of a collection composed almost exclusively of very small species, and like others of them occurs only in that collection.

Rasetti's types of *Lecanopleura? tuberculata* Rasetti 1946 and *Lecanopleura? punctata* Rasetti 1946 are illustrated herein, Plates 3 (*L?. tuberculata*, Figs. 14, 16-21) and 19 (*L?. punctata*, Figs. 6, 7, 12-14, 20, 21, 28-31). I submit that the question

mark is justified. These are not *Lecanopleura* but rather a genus with cedariform posterior facial sutures and pits in the anterior border furrow. They are therefore members of the Cedariidae. They do not compare to any other members of the Cedariidae and I have erected the genus *Alderia* described below under the family Cedariidae, to receive them.

Family CHEILOCEPHALIDAE Shaw 1956

Remarks: Pratt (1992, p 69) sees similarities of the Cheilocephalidae with the Catillicephalidae Raymond 1937. Westrop (1986, p. 68) suggests a closer relationship with the Leiostegiacea Bradley 1925. The material in this collection is too fragmentary to make any firm judgments in the matter. The fact that it is present at all extends the range of *Cheilocephalus* sp. from the Steptoean down into the Upper Marjuman.

Genus *Cheilocephalus* Berkey 1898

Type species: *Cheilocephalus st. croixensis* Berkey 1898

Remarks: Although adult glabellae taper forward, small juveniles' glabellae expand anteriorly. Rasetti (1954b) in his discussion of the Catillicephalidae noted that some genera retain what he called a corynexochid structure to the cranidium—*i.e.* the

glabella is enlarged anteriorly—during early instars. Such a juvenile is present in the collection, as is a well preserved holaspide pygidium.

Cheilocephalus sp. indet.

Plate 41, Figs. 7, 9

Occurrence: Collections WRI 617, Lower Marjuman and CH 11, 20 and 35, Upper Marjuman of western Newfoundland

Remarks: The distinctive proportions of the short anterior border relative to the equally distinct convex, subtrapezoidal, tumid glabella material in these two collections is fragmentary at best but the meraspis is definitely *Cheilocephalus*.

Family CATILLICEPHALIDAE Raymond 1938

Remarks: Rasetti (1954b) cited a nearly unbroken series of intermediate characters providing a continuum from *Lonchocephalus* Owen 1852 and *Welleraspis* Kobayashi 1935 to the extremes of the catillicephalids, suggesting common ancestry. The Lonchocephalidae Hupé and Catillicephalidae are clearly sister taxa, sharing details of glabella shape, occipital ring structure and other features.

Genus *Catillicephala* Raymond 1938

Type species: Cephalocoelia ovoides Raymond 1937

Remarks: Raymond called *Catillicephala* proparian. Rasetti used the words “supposedly proparian” for the genus. He pointed out that the specimen used to arrive at the conclusion “proparian” was damaged and could not be interpreted. He pointed out the occasional confusion of the genus with *Ucebia* (actually *Kingstonia*) and that Raymond did not consider it proparian. Shaw (1952) claimed that he observed both proparian and opisthoparian specimens of *Catillicephala lata* and therefore proposed the descriptor “amphiparian,” a term no longer used. Incidentally, Rasetti in 1946 apparently was unaware that Raymond changed the genus name, coined in 1937, in 1938, for Rasetti identified four species, *C. simplex*, *C. lata*, *C. impressa* and *C. rotunda* as *Cephalocoelia*.

The rostral plate cannot always be discerned even in type specimens.

As an aside, Cooper (1990) uses *Catillicephala* sp. to illustrate tectonic distortion in Antarctic strata; cranidia less than 4 mm long are skewed.

On page 287 of his Skeels Corners paper, Shaw (1966) reversed his prior decision (1952) to lump species of *Catillicephala* together and provided a key, based upon glabella shape, for sorting through species. To wit:

A. Sides straight

1. Glabella plus occipital ring longer than wide – *C. lata* (Raymond 1937)
2. Glabella plus occipital ring wider than long – *C. fowleri* Shaw 1952

B. Sides curved

1. Length=width of glabella without occipital ring – *C. rotunda* (Rasetti 1946)

2. Glabella without occipital ring wider than long

a. occipital furrow evenly impressed – *C. ovoides* Raymond 1937

b. occipital furrow shallow mesially – *C. impressa* Rasetti 1946

Those criteria, I posit, profit from modification. The key does not mention *C. simplex*, the only species of Catillicephalidae so far known to have an occipital spine, and *C. fowleri* does not fall out well. In fact, the types of *C. fowleri* are highly ambiguous *in re* these criteria. I would emend the key as follows (all glabellar lengths are exclusive of occipital ring):

A Sides straight

1. Leading edge of glabella in dorsal view gently curved, glabella usually longer than wide – *C. lata*

2. Leading edge of glabella in dorsal view flattened, glabella usually wider than long – *C. fowleri*

B Sides curved

1. Length = width of glabella without occipital ring – *C. rotunda*

2. Glabella without occipital ring wider than long

a. occipital furrow somewhat more evenly impressed – *C. ovoides*

b. occipital furrow very shallow mesially – *C. impressa*

Catillicephala fowleri Shaw 1952

Plate 28, Figs. 1-16

1952 *Catillicephala fowleri* Shaw, p. 464, pl. 57, figs. 6, 7

Holotype A cranidium, YPM 18633 from the Rockledge Formation at Skeels Corners, northwest Vermont

Occurrence: Collections CH 26, 33, 39; Rockledge conglomerate near St Albans

Remarks: This species of *Catillicephala* possesses a glabella that is wider than long in dorsal view, the anterior outline appears somewhat flattened, and the occipital furrow is so shallow mesially as to be nearly effaced in its median third.

Shaw considered this species to be closest to *C. impressa* Rasetti 1946 in the width of the glabella. However, it resembles *C. lata* very closely, with specimens such as cranidium [33g 818], (Plate 28 Fig. 11), partially intergrading between *C. lata* and *C. fowleri* (Compare with specimens attributed by Rasetti to *C. lata*, 1946 (Plate 26). The figures of Shaw's types are nearly useless in assaying the differences. I am keeping *C. fowleri* as a separate species with the caveat that distinguishing it from *C. lata* may be difficult.

Catillicephala lata (Raymond) 1937

Plate 26, Figs. 1-10

- 1937 *Ucebia lata* Raymond p. 1103, pl. 2, figs. 2-4
- 1938 *Catillicephala lata* Raymond p. xv
- 1946 *Cephalocoelia lata*, Rasetti p. 450 pl. 68, figs. 9-17
- 1951 *Catillocephala lata*, Wilson p. 627
- 1952 *Catillicephala lata*, Shaw p. 463, pl. 57, figs. 1-5
- 1954 *Catillicephala lata*, Rasetti p. 604
- 1966 *Catillicephala lata*, Shaw p. 287, pl. 34, figs. 18-23

Holotype: YPM 14721, Rockledge Conglomerate of Vermont

Occurrence: Western Gaspé, Canada; *Cedaria* Zone, Rockledge conglomerate
Vermont

Remarks: *Catillicephala fowleri* and *C. lata* are similar in that the axial furrows are fairly straight in both (compare, Plate 26). They differ in that *C. fowleri* is distinguished by the a broader glabella, proportionally narrower occipital ring and flattened anterior edge as seen in dorsal aspect. Only *C. fowleri* occurs in these collections.

Catillicephala impressa (Rasetti) 1946

Plate 27, Figs. 1-10, types; Plate 28, Figs. 8, 17-19

1946 *Cephalocoelia impressa* Rasetti p. 450, pl. 68, fig. 1-8

ate A cranidium, LU 1014 a, from the eastern Gaspé, illustrated herein Pl. 27, Figs. 1-10

Occurrence: Collection CH 20, Upper Marjuman of western Newfoundland; western Gaspé, Canada

Remarks: Comparisons are discussed re *C. fowleri* and *C. lata* above. Examples of *C. lata* as defined by Rasetti (1946) (Plate 26, Figs. 1-10), *C. impressa* (Plate 27, Figs. 1-10) and *C. simplex* (*Cephalocoelia? simplex* (Raymond) Rasetti 1946) (Plate 25, Figs. 1, 2, 5-7, 11-15) are figured herein.

Genus *Catillicephalites* Rasetti 1963

Type species: *Catillicephalites marginatus* Rasetti 1963 from Métis conglomerate, Quebec

Diagnosis: A genus with broadly inflated glabella, well impressed anterior border furrow and wirelike anterior border.

Remarks: At first approximation, *Matania* Rasetti 1946 and *Catillicephalites* Rasetti 1963 share similar anterior borders, short preglabellar fields, narrow fixed cheeks, and inflated glabellae. They differ in that *Catillicephalites* spp. possess visible arcuate S1 glabellar furrows and the typical catillicephalid posterior third of the cranidium: that is, an occipital furrow that is shallow mesially and deep laterally, widened into definite slits in the lateral thirds. The posterior aspect of the glabella in *Matania* is always evenly rounded—not squared off with enlarged posterior corners, so to speak—and the occipital furrow is evenly incised. The anterior border of *Catillicephala* spp. is sharply attenuated and attached directly to the glabella, the anterior border of *Catillicephalites* discrete.

Catillicephalites marginatus Rasetti 1963

Plate 29, Figs. 6, 11, 17

1963 *Catillicephalites marginatus* Rasetti 1963, p. 580, pl. 70, figs. 1-5

Holotype: USNM 140255 from M-22, Métis Conglomerate of Quebec

Occurrence: Collection WRI 467, western Newfoundland; Métis conglomerate of Quebec

Remarks: Rasetti reported over a dozen *C. marginatus* from the Métis conglomerates of Quebec, from which he chose his types. From the Cow Head only two specimens were recovered, although three new species are described in the genus.

Catillicephalites catherinae sp. nov.

Plate 30, Figs. 1-17

Diagnosis: A species of *Catillicephalites* with a glabella longer than wide and an unadorned occipital ring without a spine

Holotype: Cranidium[1447], BPS 467 Lower Marjuman of western Newfoundland (Plate 30, Figs. 2-4)

Name: For Catherine Demarais, a strong and determined young woman

Occurrence: Collection BPS 467, lower Marjuman of western Newfoundland

Description: Cranidium elongate, ovoid. Anterior border very short, less than one twelfth glabellar length exclusive of occipital ring, curved strongly in dorsal view, flat in anterior aspect. The anterior border curves back in such manner that a transverse line drawn between the distal ends of the anterior border would cut off the anterior fifth of the glabella. Preglabellar field obsolete. Glabella egg-shaped, moderately

inflated, somewhat squared off posteriorly as it meets the occipital ring, narrowing and curving evenly anteriorly; depth of inflation one half glabella length exclusive of occipital ring; glabella curves sagittally arching forward in lateral aspect, slightly overhanging its furrows on all sides; deeply-incised, narrow axial and preglabellar furrows, the axial furrows almost straight at midpoint; glabellar furrows very faint, S1 arcuate, angled posterior-ward and S 2 rarely visible; Fixed cheeks narrow, less than one fourth glabellar width at midpoint; ocular ridges faint, backsloping in parallel with lateral ends of anterior border, meeting the narrow palpebral lobes that are situated at midpoint; palpebral lobes one sixth glabellar length including occipital ring; medial third of occipital furrow shallow, the lateral thirds deeper and broader; posterior corners of glabella bulge out and slightly overhang the furrow. Crescentic occipital ring completes the oval shape of the glabella, sometimes possessing a small node on larger individuals. Anterior facial sutures short, nearly parallel; posterior facial sutures curve posterior-ward and outward to define narrow, triangular posterior fixed cheeks with deep intramarginal furrows, their width one half the glabellar width at its widest. Surface smooth to finely granulate.

Pygidium semicircular, the axis broad and tapering. Axis almost reaches the posterior edge, its length the pygidial length and its width one third total width; one clear axial ring plus the anterior ring, very faint furrows marking six additional rings. Anterior pleural furrow and 6 shallower furrows mark the pleurae. Posterior border short, flat.

Remarks: The elongate glabella separates this species from all others in the genus. Although *Matania* spp such as *M. ovata* share the oval form of the glabella, in *C. catherinae*, the posterior of the glabella is somewhat flattened transversely in dorsal aspect, the occipital ring is clearly crescentic and the occipital furrow possesses lateral expanded slits, whereas *Matania ovata* possesses a fully rounded, oval posterior glabella that partially covers the occipital ring and furrow.

Catillicephalites brachys sp. nov.

Plate 31, Figs. 1, 15

Diagnosis: A species of *Catillicephalites* whose glabella is globular and nearly as wide as long. Occipital ring crescentic to subtriangular, with a median node.

Holotype: A cranidium in WRI 620, White Rock Islets (Plate 31, Figs. 2-4)

Name: Greek *brachys* meaning short, in reference to the short, broad glabella and cranidium

Occurrence: Collections WRI 603, 613, 614, 615, 620, 621 and 627, Lower Marjuman of western Newfoundland

Description: Cranidium almost round except for the posterior fixed cheeks. Anterior

border narrow, rounded, tipped slightly up; curve very shallow in dorsal aspect; preglabellar field obsolete; Glabella as long as wide, evenly rounded anteriorly; preglabellar and axial furrows deeply incised, curved; dorsal furrow S1 faint and arcuate, S2 *et al* obsolete. Fixed cheeks narrow, one fifth median glabellar width, the ocular ridges backsloping at an angle steeper than that of the anterior border furrow. Palpebral lobes small, narrow, one fifth glabellar length or slightly less, situated anterior to glabellar midpoint; posterior fixed cheeks narrow-based, short—one half maximum glabellar width—bluntly triangular, with deep intramarginal furrows; median third of occipital furrow quite shallow, the lateral thirds deep and wider; posterior corners of glabella bulge out over the furrow slightly. Occipital ring narrowly triangular, carrying a shallow median node. Anterior facial sutures parallel, posterior facial sutures angle out and back at 45°. Prosopon very finely granulate.

Remarks: The subcircular aspect of the glabella and cranidium in general separates this species from *C. marginatus*, whose cranidium and glabella are wider than long; it differs from *C. liamae* in the absence of an occipital spine and from *C. catherinae* by the shorter glabella.

Catillicephalites liamae sp. nov.

Plate 32, Figs. 1-14

Diagnosis: A species of *Catillicephalites* with ovoid glabella, occipital ring drawn out

into a blunt spine, and narrow, short, anterior border tapered laterally.

Holotype: Cranidium WRI 611[611c 1337-40], from White Rock Islets, (Plate 32, Figs. 1-4)

Name: For the youngest grandson, who enjoys anything paleontological

Occurrence: Collections WRI 603, 605, 607, 611, 614, 615 and 631, Lower Marjuman of western Newfoundland

Description: Cranidium elongate, ovoid. Anterior border short, less than one twelfth glabellar length exclusive of occipital ring, curved very little in dorsal view, flat in anterior aspect. Preglabellar field obsolete. Anterior border furrow shallow, the line marked primarily by the change in slope. Glabella sub-spherical, moderately inflated, somewhat squared off posteriorly as it meets the occipital ring; depth of inflation three fifths glabella length exclusive of occipital ring; glabella curves sagittally, arching forward in lateral aspect, the greatest inflation occurring posteriorly, slightly overhanging its furrows on all sides; deeply-incised, narrow axial and preglabellar furrows, the axial furrows curved gently at midpoint; Fixed cheeks narrow, less than one fourth glabellar width at midpoint, convex, horizontal; ocular ridges faint, curved backward to the narrow palpebral lobes, which are situated at midpoint; palpebral lobes one fourth glabellar length exclusive of occipital ring, one half width of fixed cheeks, separated by a shallow palpebral furrow; medial third of occipital furrow very

shallow, the distal thirds deep and broad; posterior corners of glabella bulge out and slightly overhang the furrow. Sub-triangular occipital ring extends evenly into a broad blunt spine one half glabella length exclusive of occipital ring. Anterior facial sutures short, convergent; posterior facial sutures curve posterior-ward and outward to define downsloping, triangular posterior fixed cheeks with deep intramarginal furrows, their width approximately three fourths the glabellar width at its widest. Surface smooth to granulate, but see remarks below.

Assignment of pygidium tentative. Posterior of pygidium semicircular, anterior borders angled back, the axis broad and tapering, its width equal to pleura width. Axis reaches to the posterior border; one clear axial ring plus the anterior ring, very faint furrows marking six additional rings. Pleurae marked by an anterior pleural furrow and three shallower furrows.

Remarks: *C. liamae* differs from other *Catillicephalites* spp. in the presence of the blunt occipital spine. It differs from *C. marginatus*, which also bears an occipital spine, in that the axial furrows are straighter, the glabella longer relative to width, and the occipital ring with spine broader and longer (one third total glabellar length as opposed to one fourth total glabellar length in *C. marginatus*; Compare Plate 29, Figs. 6, 11 with Plate 32, Figs. 1-14).

The type and paratype specimens were chosen to illustrate the slight differences within this species with the blunt occipital spine, namely the shape and

degree of curvature of the anterior border, which I attribute to intraspecific variation, the degree of difference being insufficient basis to mount a new species.

However, the type specimen differs in one other highly significant way. Of the 85 specimens of *Catillicephalites* spp. recovered from these collections, only one individual shows surface ornamentation other than fine granulation, the one designated here as the type of *C. liamae*. This anomaly is the presence of paired tubercles—four pairs evenly spaced on the glabella and four mirror-image pairs on the proximal areas of the fixed cheeks, however small and faint they may be.

Genus *Matania* Rasetti 1946

Type species: Matania ovata Rasetti, 1946, western Gaspé, Canada

Remarks: Rasetti (1946) first described *Cryptoderaspis* Rasetti 1946, *Matania* and *Onchonotopsis* Rasetti 1946 in his article on the systematics of trilobites from the Gaspé. The genera are confined, so far as is known, to northwestern Laurentia—Greenland (Robison 1988), Quebec (Rasetti 1946) and western Newfoundland (the present work). *Onchonotopsis* (type species *O. pergibba* Rasetti 1946) is a genus with a highly inflated glabella which may overhang the occipital ring to some extent. The preglabellar field is short, the anterior border usually equal in length to the preglabellar field and moderately arched. The palpebral lobes are short and indistinct, the fixed cheeks narrow and the narrow occipital ring may or may not possess a

median spine. The genus includes *O. pergibba* Rasetti 1946 and *O. physala* Robison 1988.

The above diagnosis applies equally to *Matania*. In fact, the diagnoses in the 1946 article agree nearly word for word and are virtually interchangeable, the only real differences being the length of the short prelabellar field viewed in lateral aspect and degree of inflation of the glabella. The shape of the prelabellar area in dorsal view, the fixed cheeks and the position of the eyes remain the same. In short, the two genera appear to all practical purposes identical (Compare Rasetti, [1946] plate 70, figs. 11-14 and figs. 23-26; Robison [1988] p. 84, fig. 23, and p. 88, fig. 24; *Matania ovata* Rasetti 1946 types [Plate 33, Figs. 1-11] with the types of *Onchonotopsis pergibba* [Plate 34, Figs. 1-14]).

On the basis of this extreme similarity, therefore, glabellar inflation being highly variable and the small differences in prelabellar field length trivial, I am suppressing the genus *Onchonotopsis*. Because Rasetti described the libristomate genera of the Gaspé in alphabetical order, *Matania* prevails.

A noteworthy aspect of this genus is that it crossed the chasm between lower and upper Marjuman, one of few genera to do so. Robison (1988, p 85) did not know for certain of anyspecies of *Matania* above the *Lejopyge laevigata* Zone, *i.e.* occurring in the *Cedaria* zones. *Matania kindlensis* sp. nov. in the CH 11 and CH 36 collections does so.

Matania ovata Rasetti 1946

Plate 33, Figs. 1-11, 19

1946 *Matania ovata* Rasetti, p. 458, pl. 70, figs. 11-14

Holotype: Laval Univ. 1030 a-e, from Grosses Roches, block G-18, western Gaspé

Occurrence: Collection BPS 462, western Newfoundland; Grosses Roches, western Gaspé

Remarks: *Matania ovata* and *M. quadrata* Robison 1988 share a posterior glabellar outline that is fully oval, rounded as is the anterior end. *M. quadrata*'s glabellar outline is less evenly rounded than is *M. ovata*'s. *Matania occidentalis* (*Onchonotopsis occidentalis* Palmer 1968, p. 92, pl 6, figs. 11, 12) has a longer preglabellar field and slightly broader fixed cheeks.

Rasetti's holotype and paratypes of *M. ovata* are figured herein (Plate 33, Figs. 1-11). Rasetti called the surface smooth, but it is actually very finely granulate. It will be noted that the glabellae of the paratypes are less inflated than is that of the holotype.

Matania hueva sp. nov.

Plate 35, Figs. 1-3, 6-10, 12-15

1988 *Onchonotopsis pergibba*, Robison, p. 87, fig. 24.9-12

Diagnosis: A species of *Matania* with very short preglabellar field, moderately inflated glabella that is egg-shaped in dorsal aspect, unadorned occipital ring, and moderately inflated glabella.

Holotype: A cranidium from White Rock Islets, WRI 467 (Plate 35, Figs. 1, 2)

Name: Spanish *huevo*, egg; the glabella is egg-shaped in dorsal aspect, evenly rounded and narrower anteriorly than posteriorly

Occurrence: Collections BPS 462 and 467, Lower Marjuman of western Newfoundland; Holm Dal Formation, north Greenland

Description: Cranidial outline in dorsal aspect oval save for the posterior fixed cheeks. Anterior border length less than one eighth glabellar length, slightly downsloping, evenly arched in dorsal aspect; preglabellar field less than the width of the anterior border, downsloping, separated from the anterior border by a shallow anterior border furrow, possessing faint terrace lines on its leading edge; glabella evenly ovate, highly inflated, effaced, set off by deep preglabellar and axial furrows; glabellar outline smoothly and evenly rounded posteriorly in lateral aspect; fixed cheeks narrow, one fifth glabellar width at its widest, horizontal at the palpebral lobes; palpebral lobes very narrow, less than one fourth glabellar length, lacking

palpebral furrows; ocular ridges effaced; posterior fixed cheeks one third glabellar width at its widest, narrowly triangular, somewhat backsloping; posterior furrows shallow, wide; occipital ring a flat lip following the posterior curve of the glabella, plain, tilted upward at 25-30°. Anterior facial sutures nearly parallel; posterior facial sutures angle back from the palpebral lobes at close to 65°. Surface smooth or very finely granulate.

Remarks: *Matania hueva* differs from *M. pergibba* (Rasetti) 1946 in the considerably less pronounced inflation of the glabella, as well as its shape; the glabella of *M. pergibba* is more drawn out and pointed posteriorly. The occipital ring of *M. hueva* tilts upward more sharply than does that of the *M. pergibba*, and the preglabellar field is even shorter. *Onchonotopsis occidentalis* Palmer 1968 (p. 92, pl 6, figs. 11, 12) possesses a longer preglabellar field and less acutely angled occipital ring.

The specimens from the Holm Dal that Robison assigned to *Onchonotopsis pergibba* (Robison 1988, p. 87, fig. 24.9-12), differ from Rasetti's types, (Plate 34, Figs. 1-14), the glabellae of the types being more extremely drawn out and rounded posteriorly and the preglabellar fields shorter; the glabellae do not overhang the occipital rings. The Holm Dal specimens are identical in every detail with *M. hueva* and I therefore refer them to this species.

The width of the anterior border and the degree to which it curves differ slightly from specimen to specimen (*e.g.* cranidia Plate 35, Figs. 1 and 6). Because

such specimens occur in the same collection, I attribute the differences to intraspecific variation.

Matania kindlensis sp. nov.

Plate 33, Figs. 13-18

Diagnosis: A species of *Matania* possessing granulate prosopon, an effaced anterior border furrow and a thin, needle-like occipital spine.

Type: Cranidium [1461], CH 36

Name: Cecil Kindle, who collected and prepared the type specimen

Occurrence: Collections CH 11 and 36, Upper Marjuman of western Newfoundland

Description: Cranidium longer than wide excluding the spine; anterior border short, one sixth glabellar length excluding occipital ring, terrace lines sometimes visible though a rostrum cannot be discerned, anterior border gently curved in both anterior and dorsal views; anterior border furrow nearly effaced, although a trace can be seen in small individuals (compare 33 fig. 13, a presumed holaspis, with fig. 16); preglabellar field extremely short, its length less than that of the anterior border, axial and preglabellar furrows deeply incised. Glabella inflated to a depth of one third

glabella length exclusive of the occipital ring, arched sagittally, nearly effaced, its posterior outline swelling out over the occipital furrow slightly, the occipital ring still visible in dorsal aspect; posterior aspect of glabella evenly rounded; S1 shifted posteriorly, faint, angled backward. Fixed cheeks very narrow, one seventh maximum glabellar width, convex, slightly downsloping; eyes small, palpebral lobes virtually nonexistent, situated just ahead of the glabellar midline; Ocular ridge weak or absent. Broad-based triangular posterior fixed cheeks; posterior furrow narrow, deep, transverse or angled slightly forward, distal tips of posterior fixed cheeks angled sharply back. Occipital furrow deep and narrow, shallowest across the median third; subtriangular occipital ring tips up and back, lengthens and expands medially, culminating abruptly in a narrow spine tilted slightly upward. Anterior facial sutures curved, convergent; posterior facial sutures diverge evenly, angling back at approximately 70°. Surface finely granulate.

Remarks: The occipital spine differentiates this species from any others of *Matania* known to date. It is the only member of *Matania*, a genus common and widespread in the Lower Marjuman, to appear in the Upper Marjuman.

Genus *Prolonchocephalus* Palmer 1981

Type species: *Prolonchocephalus spinosus* Palmer 1981

Remarks: Palmer assigned this genus to the Lonchocephalidae. I submit that it does not belong there. It possess no hint of glabellar furrows, which lead the description of the family (Rasetti 1954b). He also (p. 600) mentions a prominent anterior border furrow and distinct ocular ridges as signifying at family level and this genus has neither. However, it shares with *Matania* a short anterior border and preglabellar field, well rounded posterior portion of the glabella, full glabellar effacement, and the flattened occipital ring. I am therefore assigning it to the Catillicephalidae.

Prolonchocephalus orcinus sp. nov.

Plate 21, Figs. 1-3, 7-9, 13-15

Diagnosis: A species of *Prolonchocephalus* with broad posterior fixed cheeks and coarsely granular prosopon.

Holotype: A cranidium from BPS 467 (Plate 21, Figs. 1, 2)

Name: The genus of killer whales because of an imagined fancy, the visual effect in anterior view of the short, broad posterior fixed cheeks and long, upright spine—an orca headed right at you

Occurrence: Collections BPS 458 and 467, Lower Marjuman of western Newfoundland

Description: Cranidium rounded, subtrapezoidal save for the extended posterior fixed cheeks, well arched sagittally, relatively flat transversely. Anterior border curved only slightly in dorsal aspect, virtually flat in anterior aspect, possessing terrace lines on the leading edge; length one fifth glabellar length exclusive of occipital ring, width one and one third maximum glabellar width. Preglabellar field extremely short, one half length of anterior border, strongly downsloping; anterior border furrow obsolete. Glabellar footprint subtrapezoidal, well defined by strong axial and preglabellar furrows; glabella highly inflated, its height from its base two thirds its maximum width, its maximum height achieved near posterior terminus, the dorsal outline sloping down toward anterior terminus; subtriangular in anterior or posterior view; fixed cheeks horizontal, strongly convex, short—one half glabellar midpoint width; ocular ridge arising from behind junction of preglabellar and axial furrows, angling back to the short, narrow palpebral lobes located at glabellar midpoint. Palpebral lobes a bit more than one fourth glabellar length exclusive of occipital ring. Posterior fixed cheeks convex, arching with the fixed cheeks before curving down at an angle of nearly -55° from the horizontal; width of posterior fixed cheeks slightly exceeds maximum glabellar width, length of their bases a bit less than one third glabellar length exclusive of occipital ring; posterior furrow strong, round-edged. Occipital furrow wide, nearly obsolete mesially, well impressed laterally, curved convexly following the base of the glabella. Lateral ends of occipital ring fused with posterior

borders, the ring shape triangular, expanding into a narrow spine perhaps as long as maximum glabellar width (no spine in the collection is unbroken).

Anterior facial sutures short, convergent; posterior facial sutures angle out and down -30° before curving more steeply down around the ends of the posterior fixed cheeks. Surfaces of fixed cheeks and glabella sparsely granular. Surfaces of palpebral lobes, ocular ridges, anterior border and occipital ring very finely granulate or smooth.

Remarks: Superficially, this species resembles Palmer's *P. spinosus* (Palmer in Palmer and Peel, 1981, p 26, pl 1, figs. 5-7, 9, 10). However, the anterior border of *P. orcinus* is shorter, narrower and straighter, the glabella shorter and less tapered, the posterior border more nearly horizontal. The specimen that Pratt described as *Onchonotopsis? kobluki* (Pratt 1992, p 74, pl 27, figs. 1-6) is most probably a *Prolonchocephalus*, differing from *P. orcinus* in that its anterior border is more strongly curved, the anterior facial sutures more convergent, the posterior facial sutures angling obliquely at -45° or more, making the posterior fixed cheeks narrower and their bases longer, and the occipital spine is broader-based.

In his original description, Palmer stated that the degree of ornamentation varies widely from specimen to specimen, from marked to scarcely present, but offered no illustration of this. In these collections it is present as close pebbled granules, and in Pratt's and Palmer's, fine granulation or none.

Family LONCHOCEPHALIDAE Hupé 1953

Remarks: Pratt (1992) provides a clear discussion of the family, particularly as regards the rostral plate present in some Catillicephalidae Raymond 1938. He suggests, in summary, that the Lonchocephalidae are distinguished primarily by the glabellar outline, rectangular and tapered rather than spherical, and that the similarities between Lonchocephalidae and Catillicephalidae could unite them as a single family. He did not take that step. I suggest such a step would be inappropriate in that glabellar outline is a good indicator of lineage, making Catillicephalidae and Lonchocephalidae sister groups but certainly not identical twins.

Genus *Brachyaspidion* Miller 1936

Type species: *Brachyaspidion (Brachyaspis) rhynchinum* Miller 1936 from the Deadwood Formation, Wyoming

Remarks: Miller and others (*e.g.* Rasetti 1946, Jell *in* Jell and Adrain 2003) placed this genus in the Kingstoniidae Kobayashi 1933. *Brachyaspidion* does not belong in the Kingstoniidae. Like kingstoniids, the genus is effaced and its relatively straight axial furrows are best seen on the interior mould. But kingstoniids lack occipital nodes and spines on the exterior test. Even if Rasetti (1946) were justified when describing his *B?* *spinosum* to question the genus designation, the presence of the spine does not greatly alter the situation; the type of *B. rhynchinum* (Miller 1936, p.

28, pl. 8, fig. 8) carries a node on the exterior test, not common to kingstoniids (Plate 22, Figs. 1-8). Unlike the case in *Brachyaspidion*, occipital rings of kingstoniids are reduced, the fixed cheeks relatively narrow compared to the effaced glabella, and the posterior fixed cheeks, often alate and frequently backswept, lack furrows. Rather, I suggest that the characters of the Catillicephalidae and Lonchocephalidae—particularly the broad posterior fixed cheeks, the occipital ring and its furrow, and shallow or absent glabellar furrows—more clearly reflect what is seen in *Brachyaspidion* and therefore assign *Brachyaspidion* to the Lonchocephalidae. Too, the trapezoidal glabella is found in some lonchocephalids but not kingstoniids.

Moreover there is the matter of the highly similar genus *Onchocephalites* Rasetti 1957. The differences between the genera *Onchocephalites* and *Brachyaspidion* appear trivial. The tendency of the posterior corners of the glabella to impinge on the occipital furrow, the well developed occipital ring, posterior fixed cheeks, anterior border, presence of a convex preglabellar field, fairly straight axial furrows expressed primarily on the interior mould, glabellar furrows visible on the interior mould, and a well defined posterior furrow unite them. However, the shape of the cranium as defined by the anterior facial sutures distinguishes them. The anterior facial sutures of *Onchocephalites* are convexly curved in dorsal view and the anterior facial sutures of *Brachyaspidion* are straight as they converge on a less curved anterior border. This gives the cranium of *Onchocephalites* an evenly rounded, filled-out outline in dorsal aspect and the anterior portion of *Brachyaspidion*'s cranium a truncate or dished appearance in dorsal aspect.

The foregoing similarities and differences are seen clearly in Plate 22, Figs. 1-8 illustrating Rasetti's types of *Brachyaspidion? spinosum*, compared with Plate 24, Figs. 1-8 figuring *Onchocephalites punctatus*.

Brachyaspidion? spinosum Rasetti 1946

Plate 22, Figs. 1-8

1946 *Brachyaspidion? spinosum* Rasetti p. 447, pl. 67, figs. 21, 22

Diagnosis: This species, which I am definitely assigning to *Brachyaspidion* on the basis that it meets all the descriptive requirements for the genus, possesses anterior facial sutures that converge to a reduced anterior border and a pronounced occipital spine at least one third glabellar length.

Holotype: Cranidium LU 1008 a, Métis Conglomerate of the lower St. Lawrence Valley, Quebec

Occurrence: St Lawrence Valley of Quebec

Remarks: *B. spinosum* differs from *Onchocephalites punctatus* as well as *B. rhynchina* Miller 1936 (p. 417, pl. 8, fig. 7), *O. laevis* Rasetti 1957 (p. 962, pl. 121, figs. 5-9), *O. versilis* Palmer 1968 (p. 91, pl. 4, figs. 1-5), and *O. redpathi* Rasetti

1963 (p. 588, pl. 67, figs. 11-14) in the presence of the spine. The very finely granulate prosopon and cranidial outline, discussed above, separates it from *O. punctatus*. Too, *O. spinulosus* possesses a node or, at the very most, a short, narrow spine, the occipital ring plus spine equaling one fourth total cranidial length; the length of the occipital ring plus its spine equals one third the total cranidial length in *B. spinosum*.

Brachyaspidion henriensis sp. nov.

Plate 23, Figs. 1-8

Diagnosis: A species of *Brachyaspidion* with a stubby spine, elongate cranidium and relatively narrow posterior fixed cheeks

Holotype: A cranidium [1584], BPS 467 from Broom Point south (Plate 23, Figs. 1, 2)

Name: For a budding paleontologist who will make his own name one day

Occurrence: Collection BPS 467, Lower Marjuman of western Newfoundland

Description: Cranidial outline subelliptical. Anterior border with tapered ends, slightly convex, its length twice that of prelabellar field, its width a bit less than the

maximum glabellar width; preglabellar field mildly downsloping, following the line of the glabella and the downsloping anterior border in lateral view; anterior border furrow effaced, the interface of the curved anterior border and preglabellar field indicated by slight differences of slope and convexity; glabella subtrapezoidal, length equal to maximum width, anterior edge straight, posterior edge slightly embayed because of swollen posterior glabella corners; arcuate S1 glabellar furrow discernible on interior mould only; glabella minimally inflated, its height in lateral view equal to the height of the convex fixed cheeks; axial furrows convergent, shallow, preglabellar furrow even shallower, more deeply expressed in interior mould; fixed cheeks less than one half glabellar width at palpebral line, convex, slightly downsloping; ocular ridges obsolete; palpebral lobes very narrow, short, one fourth glabellar length exclusive of occipital ring, situated at the glabellar midpoint; posterior fixed cheeks short, narrow, three fifths maximum glabellar width, the posterior furrows rounded, angling up and out, the posterior members sharply angled in some specimens, rounded in others; anterior members convex; occipital ring triangular, drawing back into a stubby, tapering spine, the total length of spine and occipital ring one half glabellar length in dorsal aspect; occipital furrow nearly horizontal, shallow mesially, deep laterally, expanding into slits distally; anterior facial sutures converge as nearly straight lines to meet the anterior border; posterior facial sutures trace a slightly curved line nearly straight back to include the posterior members of the fixed cheeks, but the visual line melds with the anterior members of the posterior fixed cheeks. Surface very finely granulate.

Remarks: The anterior facial sutures of *B. henriensis* and *B. spinosum* are nearly identical, but the spine of *B. henriensis* is shorter, wider and more evenly tapered, and the posterior fixed cheeks are not as broad. Excepting the cranidial outline, this species resembles *O. redpathi* in the long, relatively narrow glabella.

Genus *Onchocephalites* Rasetti 1957

Type species: *Onchocephalites laevis* Rasetti 1957

Remarks: The differences between the genera *Onchocephalites* and *Brachyaspidion* are discussed immediately above.

Onchocephalites punctatus Rasetti 1963

Plate 23, Figs. 5, 8-11; Plate 24, Figs. 1-8

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

1989 *Onchocephalites punctatus*, Young and Ludvigsen, p. 25, pl. 10, figs. 12-15

Holotype: USNM 140290 from the Métis Conglomerates, Lower St. Lawrence Valley

Occurrence: Collections BPS 402, 413, 417, 418, 420, 421, 434 and 467, Lower Marjuman of Downes Point Member, western Newfoundland; St Lawrence Valley

Remarks: *Onchocephalites punctatus* is readily distinguished by the lack of an occipital spine and the evenly spaced pits covering the exterior test. The even blanket of pits in the exterior test plus the subsemicircular outline in dorsal aspect separate this species from all others, including the type species *O. laevis* Rasetti 1957 (p. 962, plate 121, figs. 5-9). Its unremarkable occipital ring, sometimes bearing a node, differs from the occipital ring of *O. spinulosus* (Rasetti 1963), which is drawn into a more nearly triangular shape.

Genus *Talbotina* Lochman 1938

Plate 37, Figs. 12, 13

Type species: *Talbotina degreasensis* Lochman 1938

Remarks: Two families share the backward-slanting or arcuate S1 glabellar furrows, Catillicephalidae and Lonchocephalidae. *Talbotina* with its arcuate S1 glabellar furrows can be quickly differentiated from similar-looking basal families, such as the Marjumiidae, by means of this feature.

Talbotina cf. *T. degreasensis* Lochman 1938

Plate 37, Figs. 12, 13

1938 *Talbotina degreasensis* Lochman, p. 467, pl. 56, figs. 12-15

1992 *Talbotina degreasensis*, Westrop, p. 250, figs. 15.15-15.21

Holotype: A cranidium, YPM 15829, from the Upper Marjuman of the Cow Head

Occurrence: Collections CH 3 and 36, Upper Marjuman; Petit Jardin Formation, western Newfoundland

Remarks: *Talbotina degreasensis* from western Newfoundland is well figured and discussed by Westrop (1992). The species in CH 3 and 36 differ from the type (Lochman 1938, p. 467, pl. 56, figs. 12-15) and other specimens from the Port au Port group in slight detail of inflation.

Genus *Spencella* Rasetti 1963

Type species: *Spencella montanensis* Rasetti 1963

Diagnosis: Small, compact lonchocephalids with tumid glabella, anterior border and fixed cheek, giving a “puffy” look to the cranidium. Occipital ring expanded medially; node or spine may or may not be present.

Pygidium known from two complete specimens; width twice length, posterior edge semicircular, axis slightly more than one third the pygidial width; terminal piece fades into the pygidial border near the posterior edge.

Remarks: I am suppressing Robison's *Trymataspis* (1964) and making it a junior synonym of *Spencella* (Rasetti 1963) according to the following reasoning. In both genera, the shapes of the glabellae, occipital ring, fixed cheeks, ocular ridges and posterior fixed cheeks are virtually identical. The anterior facial sutures converge at the same angles and the anterior borders are not only the same widths relative to glabellar width (allowing for species differences) but also the same lengths and shapes. Rasetti (1963) when erecting the genus considered it to be a solenopleuroid, apparently because Resser (1938) originally assigned this form to *Solenopleurella*. Robison put his *Trymataspis* spp. in the Lonchocephalidae. I suggest that is a much better assignment, based on the nature of the preglabellar field and the positioning and structure of the fixed cheeks.

The Cow Head contains several previously undescribed species, but too little material has been recovered to adequately document them.

The presence and degree of inflation in the plectra of Rasetti's type species *S. montanensis* vary within the holotype and paratype (Rasetti 1963, plate 68, figs. 1-11). Similarly, the holotype of Robison's *T. pristina* does not possess a plectrum but the other specimens attributed to the species do (Robison 1964, plate 86 figs. 7-9); *i.e.* both genera show intraspecific variation in the same manner regarding the same

feature. The occipital spines of *T. spp.* and *S. spinosus*, when present, are identical. In short, detailed comparison of *Spencella* with *Trymataspis* supports the contention that they are the same genus.

Spencella spinosa Rasetti 1963

Plate 51, Fig. 6

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

Holotype: USNM 140309, Métis Conglomerates of lower St. Lawrence Valley, Quebec

Occurrence: Collection BPS 434, Lower Marjuman western Newfoundland; St Lawrence Valley, Quebec

Remarks: *Spencella spinosa* differs from other *Spencellas* and the former *Trymetaspis* species *Spencella pristina*, *S. lomaleie* and *S. depressa* in the shape of the anterior border combined with the shape of the spine. The spine in *S. spinosa* is small and relatively untapered, in contrast to the spines in other species. Also, the anterior border is longer, more tumid, and carrying a plectrum.

Spencella spp. is more numerous in the Cow Head material than this study would indicate, but the specimens are so damaged as to prevent determination with confidence.

Family CEDARIIDAE Raymond 1937

Remarks: The cedariform posterior suture pattern is a good indicator of the family in my opinion should be emphasized. So too is the broad anterior area and row of pits in the anterior border furrow that usually, but not always, set this family immediately apart from others. The tapered, evenly rounded, effaced glabella, while present in several families, is a good corroborating feature when considered in conjunction with the aforementioned characters.

Genus *Cedaria* Walcott 1924

Type species: *Cedaria prolifica* Walcott 1924, Conasauga Formation, Alabama

Cedaria gaspensis Rasetti 1946

Plate 44, Figs. 1-13, Plate 45, Figs. 1-17

1946 *Cedaria gaspensis* Rasetti, p. 449, pl. 67, figs. 26-29

Holotype: Cranidium 1011a, from boulder G-30, Grosses Roches, Gaspé, Quebec

Occurrence: Collections CH 28 and 34, western Newfoundland; Grosses Roches, Quebec

Remarks: Rasetti (1946) did not figure the paratypes of *C. gaspensis*, and his illustration of the holotype is quite small. His types are illustrated herein (Plate 43, Figs. 1-13). The preglabellar field of *C. gaspensis* is one and a half times the anterior border length, the preglabellar area twice the width of the glabella at its widest, and the occipital ring carries a small node. *Cedaria gaspensis* most closely resembles *C. buttsi* Resser 1838 (p. 68, pl. 11, fig. 8), in that the occipital rings of both species bear a node, and in both the pits in the anterior border are very poorly impressed, barely discernible. However, the angle of divergence of the anterior facial sutures in *C. buttsi* is less acute, resulting in a narrower preglabellar area. The posterior fixed cheeks are narrower in *C. buttsi* than in *C. gaspensis*. *Cedaria gaspensis* differs from the type species, *C. prolifica* Walcott 1924 (p. 55, pl. 10 fig. 6) in the faintness of the anterior border pits.

Cedaria fedora sp. nov.

Plate 46, Figs. 1-13

Diagnosis: a species of *Cedaria* with exceptionally long preglabellar field and anterior border, equaling at least two thirds the length of the glabella; puncta in anterior border furrow fine, closely spaced.

Holotype: A cranidium from CH 34, Upper Marjuman of Cow Head (Plate 46, Figs. 1, 2)

Name: The name reflects the broad brim of a man's hat worn in the first half of the twentieth century, referring to the ample preglabellar area

Occurrence: Collections CH 3, 28 and 34, Upper Marjuman of western Newfoundland

Description: Anterior border curved in dorsal aspect, crescentic, flat, three fourths the length of the preglabellar field; straight-line distance from side to side one and a half times the length of the glabella; anterior border furrow poorly incised, carrying a row of very fine punctae visible only under high magnification. Preglabellar field convex, nearly half the length of the glabella. Glabella effaced, slightly tapered and bluntly rounded, axial furrows slightly convex, giving the glabella an egg shape; axial and preglabellar furrows narrow and shallow; fixed cheeks flat and very narrow, approximately one fourth glabellar width at midpoint; ocular ridge nearly effaced; palpebral lobes prominent and crescentic, their length equal to their width, one third glabella width at its midpoint, more or less, the palpebral furrow obsolete; short, wide posterior fixed cheeks possess strong posterior furrows that round upward distally as per the genus; occipital furrow narrow, shallow, nearly effaced; occipital ring short,

slightly crescentic, bearing a tiny median node. Anterior facial sutures straight, strongly divergent, meeting the anterior border at a bit less than 90°.

Free cheek with broad outer rim; genal spine present but of unknown length.

Pygidium semicircular, partially effaced; axis narrow, tapered, the terminal piece ending short of the posterior border by one half axis length; only the first two or three axial furrows visible; pleural fields each two times the maximum axial width, with three widely spaced pleural furrows plus the anterior border furrow; pygidial border quite thin and flat in lateral aspect.

Remarks: Lack of clear punctation in the anterior border sets this species off immediately from others with broad anterior borders, such as *C. prolifica* (e.g. Robison 1988, p. 59, figs. 14.8-14, 26.3), *C. gaspensis*, *C. major* (Robison 1988, p. 57, fig. 14.1-7) and *C. buttsi*. The long frontal region separates it from other species with nearly effaced occipital furrows such as *C. superficialis* (below) and *C. buttsi* (Resser 1938, p. 68, pl. 11, fig. 8).

Cedaria superficialis sp. nov.

Plate 47, Figs. 1-9

Diagnosis: A species of *Cedaria* with anterior border furrows, occipital and prelabellar furrows all nearly effaced; anterior border pits visible only under high magnification; posterior and axial furrows also very lightly impressed. Pygidium

semicircular, largely effaced, with only the first two plural furrows normally visible; pygidial border wide; axis tapered, narrow, axial furrows effaced, terminal piece ends just short of border.

Holotype: A cranidium from CH 39, Upper Marjuman of the Cow Head (Plate 47, Figs. 1, 2)

Name: From the shallow, indistinct furrows that help set it apart

Occurrence: Collections CH 28, 34 and 39, Upper Marjuman of western Newfoundland

Description: Cranidium subtrapezoidal, convex sagittally. Anterior border flat in anterior view, curved in dorsal view, the same length as the preglabellar field, one fourth glabellar length; anterior border furrow lightly impressed, possessing pits visible under high magnification; preglabellar field mildly convex, downsloping, extending the curve of the downsloping glabella; glabella ovoid, convex, effaced; axial furrows shallow, preglabellar furrow even moreso; fixed cheeks less than one third glabellar width; palpebral lobes one third glabellar length, lacking palpebral furrows; ocular ridges effaced; posterior fixed cheeks short and wide, each the width of the glabella, their posterior furrows broad and shallow; length at base one third glabellar length; occipital ring plain, of uniform width, composing one fifth total

glabellar length, bearing a median swelling too small and shallow to be called a node; occipital furrow virtually obsolete. Anterior facial sutures diverge at 65-68° from horizontal, cutting an anterior border that is twice the width of the glabella. Posterior sutures leave the palpebral lobes along a nearly horizontal line.

Pygidium semicircular; axis tapered, rounded, axis width a bit less than one fourth total pygidial width; axis effaced, bearing traces of four axial furrows; pleurae partially effaced, with three faint pleural furrows plus the anterior border furrow; pygidial border wide, one third total pygidial length; no postaxial ridge.

Remarks: the anterior facial sutures of *C. superficialis* do not diverge at angles as acute as do those of species such as *C. prolifica* Walcott 1924 (p. 55, pl. 10 fig. 6), *C. minor* (Walcott 1916) and *C. buttsi*. *Cedaria superficialis* most closely resembles *C. major* Robison 1988 (p. 57, fig. 14.1-7), in that the furrows of both species are shallow and partially effaced. However, the anterior border pits of *C. major* are more easily discernible, the anterior border is less than two thirds the length of the preglabellar field, and the pygidium possesses a postaxial ridge. The furrows of *C. gaspensis*, whose anterior border pits are also faint, are better impressed than are those of *C. superficialis*.

Cedaria curta sp. nov.

Plate 43, Figs. 5-8, 11-13

Diagnosis: A species of *Cedaria* with a short preglabellar field and long anterior border. Pits in the anterior border furrow are large.

Holotype: Cranidium [39e 1117] from CH 39, Upper Marjuman of Cow Head (Plate 43, Figs. 6-8, 11)

Name: Latin *curtus*, short or cut short, referring to the preglabellar field

Occurrence: Collection CH 39, Upper Marjuman of western Newfoundland

Description: Anterior border slightly convex in anterior view, smoothly curved in dorsal view, tapering laterally, total straight-line width from end to end close to two times glabellar width, its length at midpoint one fifth glabellar length; preglabellar field less than one half length of anterior border, convex and downsloping; anterior border furrow well impressed, its pits large, prominent and well spaced; glabella very slightly tapered, well rounded anteriorly, effaced; its length exclusive of occipital ring equals glabellar width; axial and preglabellar furrows clearly impressed. Fixed cheeks one fourth glabellar width, slightly upsloping; ocular ridges obsolete; palpebral lobes situated just ahead of glabellar midpoint, almost one third as long as glabella (occipital ring included) and as wide as long, separated by well expressed palpebral furrows; posterior fixed cheeks as broad as occipital ring, the length of the occipital ring at narrowest. Posterior furrow shallow.

Anterior facial sutures diverge at 30° to 35° from horizontal, bowing out slightly before reaching the anterior border; posterior facial sutures leave the palpebral furrow horizontally, curving anterior-ward smoothly to join posterior fixed cheeks that are longest mesially..

Pygidium with three nearly effaced axial furrows and three faint pleural furrows, both the tapered axis and its furrows becoming indistinct posteriorly, the terminal piece ending at the pygidial border. Width of axis two thirds pleural width, length of posterior border one fifth total pygidial length; no postaxial ridge.

Remarks: Palmer described *C. brevifrons* (1962, p. 26, pl. 31, figs. 1-6) as a *Cedaria* with a very short preglabellar field and other features as in *C. prolifica*. Palmer's figure shows a cranidium with a glabella that is less tapered than that of *C. prolifica*. The *Cedaria brevifrons* of Pratt (1992 p. 81, plate 31, figs. 1-6) fails in several details to conform to Palmer's type. Pratt's cranidia possess very large anterior border furrow pits—Palmer's does not—and their preglabellar fields are longer than that of Palmer. That is, Pratt's species most probably is not actually *C. brevifrons sensu strictu*.

Compared to *C. curta*, Pratt's specimens possess anterior border furrow pits that are even larger and more sparsely placed. Pits in *C. curta*, in turn, are larger than those of species such as *C. prolifica* and are more widely spaced. The anterior border of *C. curta* is longer than those of both the type material of *C. brevifrons* (Palmer

1962, pl. 3, figs. 8-11, 13) and the specimens illustrated by Pratt. The preglabellar field of *C. curta* is shorter than those of all species other than the aforementioned.

The pygidium of Pratt's *Cedaria* has well-impressed furrows.

Genus *Alderia* gen. nov.

Type species: Lecanopleura? tuberculata (Rasetti) 1946 from the western Gaspé, Quebec

Diagnosis: a genus of the Cedariidae with effaced subtriangular or ovoid glabella, anterior border width less than one and a half glabellar width end to end, triangular rather than straplike posterior fixed cheeks, and a row of coarse pits in the anterior border furrow.

Remarks: Straight, strongly divergent anterior facial sutures limning a broad anterior field that will span double the glabellar width or more in (straightline measurement transversely from side to side) separate *Cedaria* from *Alderia*, which also possesses pits in the anterior border furrow and cedariform posterior facial sutures; anterior facial sutures in *Alderia*, however, are much more modestly divergent.

No other genus in the Cedariidae combines a relatively narrow anterior border with large glabella and short, triangular posterior fixed cheeks. The shape and

punctuation resemble those of the genus *Cedaria* but the narrower anterior border distinguishes *Alderia*.

Alderia punctata (Rasetti) 1946

Plate 19, Figs. 14, 16-21

1946 *Lecanopleura? punctata* Rasetti, p. 456, pl. 69, figs. 35, 36

Diagnosis: A species of *Alderia* with coarse granulation, a glabella one and one fourth times as long as wide with slightly curved axial furrows, flat anterior border and fine pits in the anterior border furrow.

Holotype: Cranidium LU 1026 from Grosses Roches, western Gaspé (Plate 19, Figs. 14, 17, 18, 21)

Occurrence: G-28, Grosses Roches, western Gaspé

Description: Glabella convex, tapered, effaced, subtriangular, evenly rounded; preglabellar and axial furrows deeply incised, mildly convex. Anterior border thin, convex in anterior view, one sixth total glabellar length; anterior border width tip to tip, measured straightline, one and a half times glabellar width; preglabellar field two thirds length of anterior border; anterior border furrow with a row of fine, closely

spaced pits. Fixed cheeks narrow, a bit more than one third glabellar width, horizontal; ocular ridges barely discernible, palpebral lobes very narrow, short—one fourth glabellar length—situated at glabellar midpoint. Posterior fixed cheeks triangular, blunt-tipped, two thirds glabellar width, slightly backswept; occipital furrow deeply incised, the occipital ring plain, tumid, following the posterior line of the glabella in lateral view and not angled upward. Posterior furrows deep, curling up distally in the cedariform manner. Prosopon coarsely granulate. No trace of paired tuberculae.

Remarks: This species differs from *Alderia (Leconpleura?) tuberculata* primarily in the ornamentation, with the granulation being coarser in *L. tuberculata*. The anterior border of *L. tuberculata* is tumid, more crescentic and marked with faint terracing on the leading edge. However, there is a small amount of variation, particularly in ornamentation, between Rasetti's holotype, the paratype, and his *L. tuberculata*. When more material is recovered, these two species may eventually prove to be but one exhibiting wide intraspecific variation.

Alderia tuberculata sp. nov.

Plate 3, figs. 14, 16-21

1946 *Lecanopleura? tuberculata* Rasetti, p. 457, pl. 69, figs. 37, 38

Diagnosis: A species of *Alderia* with small tubercles rather than granulation and a glabella one and a half times as long as wide.

Holotype: Cranidium LU 1027 a from the Métis Conglomerates of the western Gaspé, Quebec (Plate 3, figs. 6, 7, 13, 14)

Occurrence: M-17, Métis conglomerate, western Gaspé

Description: Glabella convex, effaced, its axial furrows nearly parallel, anterior evenly rounded; preglabellar and axial furrows deeply incised, almost straight posteriorly. Anterior border tumid, convex in anterior view, carrying terrace lines on leading edge, a mere one seventh total glabellar length; anterior border width tip to tip, measured straightline, one and a half times glabellar width; preglabellar field three fourths length of anterior border; anterior border furrow with a row of coarse pits. Fixed cheeks narrow, one third glabellar width, horizontal; ocular ridges discernible only as a slight change of slope, palpebral lobes very narrow, short—one fourth glabellar length—situated at glabellar midpoint. Posterior fixed cheeks triangular, blunt-tipped, two thirds glabellar width, their trailing edges roughly horizontal; posterior furrows curl distally in the cedariform manner; deep, narrow occipital furrow is nearly straight, the occipital ring plain, tumid, following the posterior line of the glabella in lateral view, the posterior edge angled upward in lateral view. Prosopon finely and evenly tuberculate. No trace of paired tuberculae.

Remarks: That this species and *A. punctata* may prove to be subspecific variants has been remarked upon above. Apart from *A. punctata*, no other species combines cedariform sutures and pitted anterior border furrow with a fairly narrow anterior border.

Family LLANOASPIDIDAE Lochman *in* Lochman and Duncan 1944

Remarks: Pratt (1992) split the family into two subfamilies, the Llanoaspidinae (*Llanoaspis* Lochman 1938, *Genevievella* Lochman 1936) and the Nahannicephalinae, which includes *Nahannicephalus* Pratt 1992 and *Deiracephalus* Resser 1935.

Subfamily NAHANNICEPHALINAE Pratt 1992

Genus *Deiracephalus* Resser 1935

Type species: *Acrocephalites? aster* Walcott 1916, “Upper Cambrian, Alabama and Tennessee,” by original designation

Remarks: In recent literature (*e.g.* Pratt 1992, p 87) two species were assumed, *D. unicornis* and *D. aster*. The latter possesses an occipital spine and the former a

median “occipital” spine that originates on the posterior margin of the glabella. The uniqueness of *D. unicornis*’s posterior spine sets it apart.

However, *D. aster* requires re-examination. When Resser in 1935 described the genus, he designated two similar but distinct species, not one—*D. aster* and *D. buttsi*. He refigured the 1935 holotypes in his 1938 monograph, indicating that the median ridge of *D. aster* forms nearly straight right angles with the anterior border, and that of *D. buttsi* possesses curved Y connections at either end. The type material was crushed and not fully informative, the figures small and inadequate. The type is reproduced herein (Plate 51, Figs. 11, 12]. Pygidia of the two species can be separated by virtue of the fact that terminal piece of the pygidium of *D. buttsi* tends to descend into the pygidial border, whereas that of *D. aster* does not. In the intervening years, however, the two species were conflated and figured indiscriminately as *D. aster*. Too, the original material is inadequate for close analysis, as the above cited figure attests. I am therefore restricting both species, *D. aster* and *D. buttsi*, to type.

Deiracephalus unicornis Palmer 1962

Plate 50, Figs. 13-18; Plate 51, Figs. 8, 13-17

1962 *Deiracephalus unicornis* Palmer, p. 30, pl. 6, figs. 1-4

1982 *Deiracephalus unicornis*, Kindle, pl. 1.3, fig. 11

1992 *Deiracephalus unicornis* Pratt, p. 88, pl. 33, fig. 14-22

Holotype: A cranidium from the Conasauga Formation, Alabama

Occurrence: Collections CH 11, 34 and 39, Upper Marjuman of western Newfoundland; Conasauga Formation, Alabama; *Cedaria brevifrons* Zone of Rabbitkettle Formation, Mackenzie Mountains, Canada

Remarks: *D. unicornis* differs from all other species in the genus in the position of the posterior spine. Pratt (1992, p 88) noted that among the Rabbitkettle specimens, the median occipital spine in *D. unicornis* arose variously from the occipital ring and in some specimens from the very posterior of the glabella. The occipital spine of one specimen of this collection rises from the occipital furrow (Plate 51, Fig. 17) but none from the occipital ring.

Deiracaphalus ornatus sp. nov.

Plate 49, Figs. 1-7, 10-12

Diagnosis: A species of *Deirocephalus* with elaborate ornamentation, particularly on the fixed cheeks, length of median ridge equal to mean length of anterior border, and a prelabellar field only mildly convex.

Holotype: A cranidium from CH 3, Upper Marjuman of Cow Head (Plate 49, Figs. 1, 2, 5)

Name: From the ornamentation of both exterior test and interior mould

Occurrence: Collections CHG 3, 9 and 11 of Upper Marjuman, western Newfoundland

Description: Cranidium rectangular, nearly square; glabella subtriangular; S1 glabellar furrows vaguely apparent as dimples or arcuate indentations, axial furrows deep; median ridge expands anteriorly into a broad Y as it meets the anterior border and possesses a short, narrow prefrontal band at the preglabellar furrow; median ridge short, subequal in length to the length of the anterior border. Ocular ridge prominent, palpebral lobes short, situated at glabellar midpoint but almost always broken away; fixed cheeks convex, downsloping; anterior border furrow curves around posteriorly following the median ridge and its expansion, giving the two parts of the divided preglabellar field a rounded outline; anterior facial sutures curve out, then in to meet the anterior border, further adding to the softly curved outline of the preglabellar field; posterior facial sutures nearly horizontal, defining short, narrow posterior fixed cheeks with deep posterior furrows. Occipital furrow shallowest medially; occipital ring crescentic, possessing an upwardly-directed median spine with oval base. Fixed cheeks anterior to ocular ridges ornamented with sagittally oriented reticulations and large, scattered tubercles; fixed cheeks posterior to ocular ridges granulate with scattered large tubercles; glabella surface granular with scattered small tubercles. The

ubiquitous pattern of four matched pairs of tubercles on the glabella and eight paired tubercles on the fixed cheeks is apparent within the scattering of ornament.

The free cheek possesses in addition to a genal spine of unknown length a second spine proceeding from the posterior border. Ornamentation on the free cheek reflects that of the preglabellar field and fixed cheek, with venation and tubercles on the anterior slope and granulation posteriorly.

Pygidium with broad axis carrying three major furrows and tapering to a blunt terminal piece that just meets the pygidial margin; three prominent pleural furrows and a flat, narrow pygidial margin strongly set off by the change of slope from convex pleurae.

Remarks: The Y shape of the anterior and posterior points of contact with anterior border and prefrontal band, plus the reduced convexity of the preglabellar field, separate it from the similar *D. genior* sp. nov. The Y aspect of the termini of the median ridge separate it from *D. intersectus* sp. nov. and *D. aster*.

Deiracephalus genior sp. nov.

Plate 50, Figs. 1-12

Diagnosis: A species of *Deiracephalus* with inflated cheeks, prosopon limited to fine granulation and a few scattered tubercles, and a median ridge usually longer than the length of the anterior border.

Holotype: A cranidium from CH 36, Upper Marjuman of Cow Head (Plate 50, Figs. 4, 9-11)

Name: From the Latin *gena*, cheek, with the comparative ending, *id.est.* “cheekier”

Occurrence: Collections CH 26, 28, 36 and 39 of Upper Marjuman, western Newfoundland

Description: Cranidium rectangular, glabella subtriangular, anterior border narrow, rolled; median ridge on preglabellar field more than twice the length of the anterior border, expanding into a very broad Y with curving arms as it meets the anterior border and into a short, narrow prefrontal band at the posterior end that follows the curve of the preglabellar furrow; the curve of the anterior border furrow as it follows the median ridge with its expansions traces a broad, long oval, giving the divided preglabellar fields a jowly, inflated appearance; the course of the anterior facial sutures as they curve out, then in to meet the anterior border furrows adds to the effect. Fixed cheeks narrow, one half glabellar width; ocular ridges faint, straight, backsloping; palpebral lobes small, narrow, one fourth glabellar length, situated at or just posterior to the glabellar midpoint; axial and occipital furrows deep; occipital ring crescentic, carrying a node or spine; posterior facial suture nearly transverse. Ornamentation similar to that of *D. ornatus* with granular surfaces, reticulation on the

preglabellar fields, and tubercles much reduced inside on glabella, but tubercles on prelabellar fields and fixed cheeks are one third more numerous; sagittal reticulations prominent in interior mould, less obvious on exterior test.

Remarks: The broad, sweeping Y shape of the anterior and posterior points of contact with the anterior border and prelabellar ridge contrast with those species meeting the anterior border and prefrontal band more abruptly, particularly *D. intersectus* sp. nov. and *D. aster* Resser 1935. *Deiracephalus ornatus* resembles most closely *D. genior* sp. nov. but lacks the extreme convexity in the prelabellar field and the bowed-out anterior facial sutures of *D. genior*. *Deiracephalus genior* differs from *G. ornatus* and in the greater length of the median ridge on the prelabellar field and the number of prominent tubercles. It differs from all others in the broad, prominent anterior expansion of the median ridge, the median ridges of *D. ornatus*, *D. intersectus* and *D. unicornis* meeting their anterior borders at sharper angles, and the convex curves of the anterior facial sutures, intensifying the effect of a “bulging” prelabellar field.

Deiracephalus intersectus sp. nov.

Plate 51, Figs. 1-7, 9, 10

Diagnosis: A species of *Deiracephalus* in which a short median sagittal ridge meets the straight, heavily built anterior border without expanding significantly anteriorly.

Holotype: Cranidium [1021-4], CH 11 of the Upper Marjuman, Cow Head (Plate 51, Figs. 1, 2)

Name: For the squared-off intersection of the median ridge with the anterior border

Occurrence: Collections CH 11, 36, 39

Description: Cranidium subrectangular, wider than long; anterior border rolled, nearly straight, possessing terrace lines on its leading edge, the ends tapering very little laterally. Median ridge, measured from preglabellar furrow to anterior border furrow, the length of the anterior border; expansion minimal anteriorly, expanding into a narrow small, Y-shaped preglabellar ridge posteriorly. Divided preglabellar fields convex, downsloping, marked with faint venation and scattered tubercles. Glabella sub triangular, evenly rounded anteriorly, effaced save for a shallow, oblique indentation marking the S1 furrow. Fixed cheeks each two third glabellar width, mildly upsloping, rising from deep axial furrows. Ornamentation consists of faint, dense venation with scattered tubercles anterior to the ocular ridges, granulation and scattered tubercles posterior to the ocular ridges. The pattern of four sets of paired tubercles on glabella and on fixed cheeks is apparent within the scatter arrangement of tubercles. Ocular ridges straight, distinct, angling back slightly to meet the palpebral lobes, devoid of ornamentation; palpebral lobes narrow, less than one fourth glabella length, devoid of ornamentation, separated by a palpebral furrow. Posterior fixed cheeks short and broad, equal in width to the glabella, one third glabella length

at the base, tapering to a blunt point distally. Posterior furrow deep, extending virtually the full length of the posterior fixed cheek. Occipital ring flat, angled up and back at 65 to 70° from horizontal, drawing out into a spine of unknown length. Occipital furrow well impressed.

Remarks: The median ridge of *D. intersectus* is half the length of the median ridge in the type of *D. aster* (Plate 51, Figs. 11, 12) although the median ridge in the type may have been artificially lengthened taphonomically; the part/counterpart are distorted. The lack of anterior expansion in the median ridge separates this species from others in the Cow Head collections. The prelabellar fields are less developed and less elaborately ornamented than in *D. genior* and *D. ornatus*.

The expansive Y shape of both the anterior and posterior points of contact with anterior border and prelabellar ridge contrast with those species meeting the cross pieces abruptly, particularly *D. intersectus* sp. nov. and *D. aster* Resser 1935. *Deiracephalus ornatus* resembles most closely *D. genior* sp. nov. but lacks the extreme convexity in the prelabellar field and the bowed-out anterior facial sutures of *D. genior*.

Family KINGSTONIIDAE Kobayashi 1933

Remarks: Pygidia as well as cranidia of kingstoniids are effaced, triangular in dorsal outline, with prominent, raised axes. Westrop (1992) provides a detailed analysis of

features of the Kingstoniidae and its members. In summary, he describes a short, straplike band, fused or depressed below the abutting glabella, as the occipital ring of *Kingstonia*. He then explores the prospect that this occipital ring structure may be synapomorphic. *Blountia* Walcott 1916 and *Maryvillia* Walcott 1916 (but see synonymy in Pratt 1992) , for reason that their occipital rings are similar, are thus drawn out of the Asaphiscidae, where they originally resided, and into the Kingstoniidae.

Genus *Blountia* Walcott 1916

Type species: Blountia mimula Walcott 1916, Maryville Formation, Tennessee

Remarks: Stitt and Perfetta (2000) reject placing *Blountia* in the Kingstoniidae on the basis that the frontal area is not like that of a kingstoniid. I suggest that Stitt and Perfetta overlooked several important points. *Blountia* shares with Kingstoniidae a reasonably similar pygidium, and with both the kingstoniids (whose anterior border is greatly reduced) and genera such as *Matania*, *e.g.* (whose anterior border is well developed) pointed posterior fixed cheeks which often extend backward beyond the occipit, a reduced and sometimes fused occipital ring, reduced axial and preglabellar furrows, effaced glabella, and a characteristically arching sagittal curvature to the cranium. Ergo, this ties them in with groups both possessing and lacking a prominent anterior border, reducing the importance of the nature of the anterior

border as a criterion. Inclusion of *Blountia* in the Kingstoniidae is thus justified by their shared characters.

Remarks: *Blountia*, found in these collections, and *Maryvillia*, which does not occur, appear quite similar. Palmer (1954) showed that *Blountia* has pointed rather than rounded posterior fixed cheeks (As an aside, Palmer also found the true *Maryvillia* to be a good and reliable indicator of the level just below *Aphelaspis* Resser 1935). He then (1962) separated *Blountia* from *Maryvillia* by the convexity of the cranidium; *Blountia*'s cranidium is moderately to strongly convex sagittally rather than flat or gently convex as in *Maryvillia*. Pratt (1992) later synonymized *Blountia* and *Maryvillia*. Jell in Jell and Adrain (2003) treat *Blountia* and *Maryvillia* separately and place both in the Kingstoniidae. This study adopts that opinion.

***Blountia terranovica* Resser 1942**

Plate 14, figs. 1-16

- 1938 *Maryvillia arion* (Walcott), Lochman, p. 469, pl. 57, fig. 4
- 1942 *Blountia terranovica* Resser, p. 8
- 1944 *Blountia beltensis* Duncan in Lochman and Duncan, p. 87, p. 11; figs. 20-27
- 1946 *Blountia gaspensis* [Rasetti, p. 446, pl. 67, figs. 7-10]
- 1983 *Blountia* sp., Stouge and Boyce, pl. 11, figs. 7 and 8
- 1992 *Blountia terranovica*, Westrop, p. 246, figs. 14.16, 14.17, 18.1, 18.2 and 18.5

1992 *Blountia beltensis*, Pratt, p. 66, pl. 24, figs. 7-12

Type: Cranidium YPM 15821 from the Petit Jardin Formation on the south shore of Cape St. George, western Newfoundland

Occurrence: Collections CH 9, 21, 33, 39 and 48, Upper Marjuman of western Newfoundland; *Cedaria selwyni* Zone of Rabbitkettle Formation, Mackenzie Mountains, Canada; Nolichucky Formation, Tennessee; upper *Crepicephalus* Zone of Maryville Formation, Tennessee; upper *Cedaria* and lower *Crepicephalus* Zones in Utah.

Remarks: Large bits and pieces that could represent *Blountia* have accumulated in some boulders of these collections. I am cautiously referring the partial cranidia from the Cow Head to *B. terranovica*. They do not closely resemble *B. montanensis* Duncan in Lochman and Duncan 1944. Rasetti's types of *B. terranovica* (formerly *B. gaspensis*) are illustrated herein (Plate 14, Figs. 1- 8, 10, 12) for comparison.

Cranidia in the Cow Head material differ in minor detail from those of the Gaspé or Port au Port collections—for example, the anterior borders are a bit longer. But the differences are trivial enough that, I suggest, this species can still be used for correlation.

Genus *Kingstonia* Walcott 1924

Type species: Kingstonia apion Walcott 1924

Remarks: When the outer test of Walcott's (1924) *Kingstonia* (p. 58, pl. 14, fig. 2, holotype specimen SMC 75 #2) is broken away, his *Ucebia* (p. 60, pl. 14, fig. 4, holotype SMC 75 #3) lies beneath, an internal mould. Thus he inadvertently confused the issue until partially exfoliated specimens demonstrated that *Ucebia* and *Kingstonia* are one and the same. *Kingstonia* prevails by page priority.

Kingstonia walcotti Resser 1938

Plate 17, Figs. 1-11, Plate 25, Figs. 3, 8, 9, 10

- 1938 *Kingstonia walcotti* Resser, p. 83, pl. 12, figs. 3, 4
- 1940 *Kingstonia walcotti*, Lochman p. 35, pl. 4, figs. 13-16
- 1944 *Kingstonia walcotti*, Lochman in Lochman and Duncan p. 113, pl. 14 figs. 21-26
- 1946 *Kingstonia walcotti*, Rasetti p. 455, pl. 69, figs. 23, 24
- 1951 *Kingstonia walcotti*, Tasch, p. 298, pl. 44, figs. 6, 16, 17
- 1960 *Kingstonia walcotti*, Robison, p. 15, pl. 1, figs. 14, 17, 18
- 1992 *Kingstonia walcotti*, Pratt, p. 67, pl. 25, figs 1-11
- 2000 *Kingstonia walcotti*, Stitt, p. 213. fig. 10.13-10.18

Lectotype: A cranidium (USNM 94937) from the Nolichucky Formation, Tennessee

Occurrence: Collections CH 9, 20, 21, 26, 33, 35 and 39, Upper Marjuman; *Cedaria minor* and *Cedaria prolifica* Zones of Rabbitkettle Formation, Mackenzie Mountains, Canada; Nolichucky Formation, Tennessee; *Cedaria* Zone of Bonnetterre Dolomite, Missouri; *Cedaria* to *Crepicephalus* Zones in part of Pilgrim Formation, Montana; Upper Cambrian clasts in Lower Ordovician conglomerate, Quebec; *Crepicephalus* Zone of Warrior Formation, Pennsylvania; Orr Formation, Utah.

Remarks: *Kingstonia walcotti*'s cranidium is so convex that it is nearly semicircular in dorsal outline. The anterior border consists of three clear terrace lines on the leading edge; the posterior fixed cheeks slope sharply downward at 60° to 75° from horizontal. *Kingstonia vagrans* Lochman 1938, also in these collections, is far less convex, spreading wide, as it were. The posterior edge of the cranidium of *K. vagrans*, viewed in dorsal aspect, describes what could be called, almost, a shallow V. The posterior line of *K. Walcotti*, in comparison, is a smoothly circular arc.

The subtriangular pygidium is effaced exteriorly, showing seven to nine rings on the prominent axis when exfoliated; pleurae same width as axis. The distal anterior corners are rounded.

Rasetti (1946) illustrated only two sclerites. His remaining specimens are figured herein (Plate 17, Figs. 1-11).

Kingstonia vagrans Lochman 1938

Plate 18, Figs. 1-17, Plate 25, Figs. 4, 16, 17

1938 *Kingstonia vagrans* Lochman, p. 471, pl. 56, figs. 2-24

1946 *Kingstonia quebecensis* Rasetti, p. 455, pl. 69, figs 25-31

Holotype: Cranidium YPM 15841 from “Cow Head breccia” (Plate 18, Figs. 3, 4)

Occurrence: Collections CH 3, 9, 20, 21, 26, 33, 35, 36 and 39, Upper Marjuman;
Grosses Roches, Quebec

Remarks: Rasetti (1946, p. 455) defined *K. quebecensis* in part by the nature of the axial furrows on the internal moulds. Lochman’s types of *K. vagrans*, illustrated herein (Plate 18, Figs. 1-4 and 11), are in fact interior moulds, and the axial furrows fade anterior-ward. Rasetti (1946, p. 456), pointed out that his *K. quebecensis* most closely resembled *K. vagrans*, including highly similar pygidia, but cited differences in longitudinal convexity of the cranidium. However, in the present collections, I have found quite a bit of variation in convexity. I do not believe Rasetti’s criteria are valid and therefore suppress *K. quebecensis* as a synonym of *K. vagrans*.

Genus *Bynumia* Walcott 1924

Type species: Bynumia eumus Walcott 1924 from the Upper Cambrian, British Columbia

Remarks: Westrop (1992) noted the wide variation found within the genus *Bynumia*. This (in his words) dramatic variation in cranidia extends to the other sclerites as well. He recommends that membership in the genus be limited to those forms with roughly subtriangular outlines, *B. eumus*, *B. lata* Lochman and Hu 1962, and *B. metisensis* Rasetti 1964. I suggest that even this criterion may not serve the number of species actually in the genus. Rounding of the anterior dorsal profile in *Bynumia* appears to occur frequently elsewhere and is present in these collections. I suggest that these criteria—extended, sloping preglabellar field and anterior border that echoes the slope of the anterior glabella; shallow axial and preglabellar furrows; shallow, arched “hump-backed” glabella; and posterior fixed cheeks that sweep back to some extent, at times even beyond the occipital ring—define the genus adequately.

Bynumia metisensis Rasetti 1946

Plate 19, Figs. 1-13, 15, 16

1946 *Bynumia metisensis* Rasetti, p. 448, pl. 67, figs. 23-25

1988 Not*Bynumia metisensis* Robison p. 65, figs. 17.1-10

Remarks: These types are included to illustrate both holotype and paratypes of Rasetti's species from the Métis conglomerate of the western Gaspé. By virtue of the length of the anterior border, *B. metisensis* bears a better resemblance to the undetermined species figured in Westrop (1992, p. 245, fig. 1) than does *B. demissa* sp. nov.

Robison (1988 p. 65, figs. 17.1-10) figured seven cranidia attributed to *B. metisensis*. The average length-to-width ratio of glabellae in the *B. metisensis* types is 0.80 with no outliers below 0.77. The average length-to-width ratio of *B. demissa* glabellae is 0.66 with no outliers above 0.72. The length-to-width ratios of the glabellae of Robison's specimens vary from 0.72 to 0.86. In his figures, the lengths of the frontal areas expressed as a percent of total length vary from 18% to 30%. In short, it appears that Robison figured more than one species, an observation borne out by consideration of the shapes of the specimens, varying from sharply triangulate to nearly oval. The backswept posterior fixed cheeks of Robison's specimens reach a transverse line drawn at the posterior margin of the glabella but none goes beyond it. That plus the outline in dorsal view suggests that none is *B. demissa*. The posterior fixed cheeks of *B. metisensis* do not reach a transverse line tangent to the posterior edge of the glabella. Therefore, Robison's species are most likely not *B. metisensis* either. Again, the cranidial outlines bear this out, for the anterior fields of Rasetti's types represent from 30% to 33% of the total lengths. At least one of Robison's several species resembles *B. eumus* Walcott 1924 (from Alberta) or *B. lata* Lochman 1944 (from Montana). The actual identity of his specimens remains open.

Bynumia demissa sp. nov.

Plate 20, figs. 1-16

Type: A cranidium from BPS 467, Broom Point south in the Cow Head Group, (Pl. 20, Figs. 5-7, 9)

Name: Latin *demissa*, drooping, for the backward “drooping” nature of the posterior free cheeks

Occurrence: Collections BPS 467 and 468, lower Marjuman of w. Newf.

Description: Cranidial outline sub-triangular, with long, posteriorly extending posterior fixed cheeks; anterior leading edge sharply rounded. Anterior border tumid, evenly rounded in both dorsal and lateral views, flat in anterior view, sometimes with very faint terracing on the leading edge. Anterior border furrow obsolete, the anterior border melding almost imperceptibly with preglabellar field, but see Plate 20, Figs. 4-7, illustrating a paratype specimen in which the dividing line is discernible. Preglabellar field downsloping. Axial and preglabellar furrows shallow and broad; glabella effaced, sub-rectangular, parallel-sided and rounded at both ends, convex, arched both longitudinally and sagittally in lateral view; the crest of the glabella may form a slight longitudinal ridge; In lateral view, the preglabellar area follows the

arched line of the glabella. occipital furrow very shallow and often fully effaced; fixed cheeks narrow, one third glabellar width, slightly convex, contiguous with preglabellar field; palpebral lobes quite small, one sixth glabellar length, narrow, situated just ahead of the glabellar midpoint; ocular ridges wide but shallow and vaguely defined, angling back to the palpebral lobes from a point one third of the way from the glabella's leading edge; posterior fixed cheeks bluntly triangular, broadly based, tumid, their edges smoothly rounded, the fixed cheeks extending backwards beyond the occipital ring; terrace lines appear along the trailing edge in larger specimens; intramarginal furrows fully effaced except in smallest specimens; on small specimens, occipital ring discernible as a simple, narrow, tumid strap following the curve of the glabella; on larger specimens, occipital furrow is fully effaced, the occipital ring and glabella melding into one. Anterior facial sutures parallel as they start forward from the palpebral lobes, then at the point of the glabella's anterior edge curve inward to meet the anterior border; posterior facial sutures angle outward from the palpebral lobes at approximately 40 degrees, then curve back to form the posterior lobe extensions. Prosopon smooth or very finely granulate.

Remarks: *Bynumia demissa* differs from the type in the much more rounded anterior border, the anterior border of *B. eumus* being triangular in dorsal aspect. The species most closely similar to *B. demissa*, *B. metisensis* Rasetti 1946 (Plate 19, Figs. 1-13, 15, 16) possesses posterior fixed cheeks that do not sweep back beyond the occipital ring. The anterior border of *B. lata* (Lochman in Lochman and Duncan 1944, p. 112,

plate 16, figs. 14-20) is also far more triangular in dorsal aspect. *Bynumia* sp. indet. figured by Westrop (1992 p. 245 fig. 1) is incomplete but appears to have a longer preglabellar area, particularly medially, than does *B. demissa*.

Genus *Rogeraspis* gen. nov.

Type species: Rogeraspis burkhalterensis sp. nov.

Diagnosis: a very small libristomate with unfurrowed, inflated, elongate glabella, expanded posterior fixed cheeks, and a flat, shelf-like occipital ring that follows the posterior curve of the glabella and merges with the posterior fixed cheeks.

Remarks: At first approximation, this unusual species fits no family diagnosis well. *Rogeraspis* carries to obvious excess the suite of characters that might be identified with the Kingstoniidae: that is, a short, flat anterior border with short or obsolete preglabellar field, broad-based triangular importantly, a narrow, straplike occipital ring that follows the curve of the posterior aspect of the glabella around, both sagittally and transversely.

It is enough like the Kingstoniidae therefore to be assigned to that family, however distantly its relationships tie it to the more typical kingstoniids.

Rogeraspis burkhalter sp. nov.

Plate 52, figs. 1-16

Diagnosis: As for the genus, above.

Holotype: A cranium from Broom Point south, BPS 467, Lower Marjuman of the Cow Head Group (Plate 52, Figs. 12-15)

Name: For Roger Burkhalter, a colleague whose aid was instrumental in completing this project.

Occurrence: Collections BPS 467 and 468, Lower Marjuman of western Newfoundland

Description: Cranial outline a rough parallelogram or diamond shape. Anterior border a narrow roll tilted upward, arcing a bit convexly in anterior view, curving evenly in dorsal view, carrying terrace lines on leading edge, ending laterally just short of the palpebral lobes; short prelabellar field half the length of the anterior border, separated by a change of plane rather than an anterior border furrow as such; glabella straight-sided and rounded symmetrically at both ends, unfurrowed except for traces of an arcuate S1, tumid, sub-triangular in anterior aspect, its maximum elevation two thirds glabellar width; prelabellar, axial and occipital furrows broad and pronounced, though of medium depth; fixed cheeks one half glabellar width,

convex, slightly downsloping; ocular ridges faint, angled only slightly, coursing from the anterior ends of the axial furrows to the palpebral lobes; palpebral lobes short, narrow, situated opposite the front third of the glabella, angled slightly so that the anterior corner is closest the glabella; posterior fixed cheeks bluntly, broadly triangular, with deep intramarginal furrows; occipital ring, a flat strap that follows the posterior curve of the glabella, tilts up a few degrees. The posterior fixed cheeks and occipital ring meet in an unusual way: the anterior member of the posterior fixed cheek joins seamlessly with the distal edge of the occipital ring; the posterior member of the posterior fixed cheek then dips under the anterior member midway between the distal tip of the posterior fixed cheek and the beginning of the occipital ring and fuses to the underside at the posterior terminus of the axial furrow. The doublure on the underside of the occipital ring ends just short of contact with the underside of the occipital furrow. The cranium appears smooth, its fine granulation visible only under high magnification.

Remarks: The anterior border and short preglabellar field, fixed cheeks and occipital ring form a dish or halo around the long-ovate glabella and echo its anterior and posterior curves. Small specimens appear to have narrower posterior fixed cheeks than do holaspides, but their posterior fixed cheeks are proportionally the same as larger specimens', close to a glabellar width, the glabella in their case being proportionally narrower.

Family DINEIDAE, fam. nov.

Diagnosis: This family is erected to receive *Dinea* and *Cryptoderaspis*, genera with a long, convex, downsloping frontal area, narrow, downsloping fixed cheeks, a flat occipital ring with or without a spine, and an ovoid glabella that is inflated, often highly so, and may overhang the occipital ring. The glabella in anterior view is usually subtriangular.

Remarks: The combination of flat, straplike occipital ring, strongly downsloping preglabellar field and fixed cheeks and the highly inflated, unfurrowed glabella sets this family apart from all others in the Marjuman.

Genus *Dinea*, gen. nov.

Type species: *Dinea extremis* sp. nov.

Diagnosis: A genus of Dineidae with strongly inflated glabella, long, tumid preglabellar field, and flat anterior border usually nearly equal in length to the preglabellar field. Posterior fixed cheeks narrow and somewhat backsloping. Axial and preglabellar furrows clearly impressed but shallow, occipital furrow shallow or partially effaced. The occipital ring may partially adhere to the posterior surface of the inflated glabella (e.g. plate 36, fig. 11).

Remarks: This genus shares with *Matania* Rasetti 1946 spp. the shape of the glabella, particularly its footprint, which is to say the line of union joining the glabella with the preglabellar field and fixed cheeks. It differs from *Matania* in the nature of the anterior border, which is flat in *Dinea* and convex in *Matania*, in the length of the preglabellar field, which is quite short in *Matania*, in the absence of ocular ridges, and in shallow preglabellar, axial and occipital furrows, which are deep and narrow in *Matania*. In *Cryptoderaspis* Rasetti 1946, which shares the strongly downsloping preglabellar field and fixed cheeks, the anterior border and border furrow are not visibly present. Terracing on the leading edge of the preglabellar field suggests that at least a remnant of an anterior border persists.

Dinea extremis sp. nov

Plate 36, Figs. 1-14

Diagnosis: A species of *Dinea* with flat anterior border, long preglabellar field, and an extremely inflated glabella that draws to a point posteriorly.

Type: A cranidium from BPS 464, Lower Marjuman of western Newfoundland (Plate 36, Figs. 1, 2, 6, 11)

Name: Reflecting the opinion that a glabella ought not get much more extreme than this

Occurrence: Collection BPS 464, Lower Marjuman of western Newfoundland

Description: Cranidium subrectangular in dorsal aspect with the front margin curved and the inflated glabella extending beyond posterior margin. Length of anterior border one third the length of the preglabellar field. Preglabellar field tumid, strongly downsloping, length one third glabellar length, meeting anterior border at a deep anterior border furrow. Glabella effaced, highly inflated, its greatest height more than equalling its greatest width. Approximately one third of the posterior part of the glabella extends beyond the occipital ring, drawing out into a blunt point, softened in some individuals, extreme in others. Axial furrows deeper than preglabellar furrow, bowed out to give the glabella an oval base. Fixed cheeks narrow, one fourth glabellar width at midpoint, slightly downsloping, blending smoothly into the preglabellar field; ocular ridges obsolete; palpebral lobes very narrow, less than one fourth the glabellar length; palpebral furrows barely noticeable; anterior facial sutures diverge, bow outward slightly; posterior facial sutures angle transversely to form the blunt, subtriangular posterior fixed cheeks, their width slightly more than half glabellar width at its widest; intramarginal furrows well expressed. The occipital ring appears partially fused to the overhanging ventrum of glabella, the occipital furrow shallow distally and effaced medially. Surface smooth.

Remarks: This species differs from *Dinea bovicephala* sp. nov. in the relative lengths of the prelabellar field and anterior border, the shape and degree of inflation of the glabella, and the lack of an occipital spine, which is present in *D. bovicephala*. It differs from *Cryptoderaspis*, Rasetti 1946, in the presence of a discernible anterior border and shallow anterior border furrow. Although the occipital furrow is still visible, the occipital ring appears to adhere to the glabella in part, the occipital furrow in effect wrapping down each side. This is not the case in *Cryptoderaspis*, wherein the occipital ring is reduced and downsloping (a situation unusual and perhaps even unique among libristomates).

Dinea bovicephala sp. nov.

Plate 37, Figs. 1-6, 8-9

Diagnosis: A species of *Dinea* with a long, tumid, downsloping prelabellar field, flat anterior border, occipital spine and subtriangular lateral silhouette.

Type: Cranidium WRI 627 from White Rock Islets (Plate 37, Figs. 1-4)

Name: Latin *bos-bovis* cow, and *cephalus* head, for the Cow Head of Newfoundland

Occurrence: Collections WRI 616 and 627, Lower Marjuman of western Newfoundland

Description: Cranidial dorsal outline a deep arch. Anterior border flat, curved in dorsal aspect, mildly arched in anterior aspect, equal in length to the preglabellar field, approximately one third glabellar length; preglabellar field strongly downsloping, nearly vertical in lateral aspect, tumid; anterior border furrow well incised. Glabella arched, greatly inflated, effaced, subtriangular in both aspects: anteriorly, an approximately equilateral triangle, laterally a nearly right triangle; axial furrows bow out slightly before converging; anterior evenly rounded; posterior drops abruptly to meet the shallow, nearly straight (transv.) occipital furrow. Width of fixed cheeks 0.4 glabellar width at midpoint; fixed cheeks tumid, downsloping; ocular ridges obsolete. Palpebral lobes a bit over one fourth glabellar length, narrow, situated at the glabellar midpoint; Occipital furrow narrow and shallow, nearly straight; occipital ring flat, tilted upward at 72 to 75°, expanding into a broad-based spine of unknown length. Anterior facial sutures curve out and forward to meet the anterior border. Posterior facial sutures diverge and angle backward to define blunt, broad-based, subtriangular posterior fixed cheeks; posterior fixed cheek width two thirds glabellar width at its widest; posterior edges of posterior fixed cheeks angle back at -10° (in dorsal aspect). Posterior furrow shallow and soft-edged. Surface smooth.

Remarks: This species differs from the type species, *D. extremis*, in the shortened, vertical aspect of the posterior part of the glabella, and in the occipital spine. The triangulated shape of the inflated glabella differs from the posteriorly extended glabella of *D. extremis* and the rounded glabella of *Cryptoderaspis*. The presence of an occipital spine separates this species from *Cryptoderaspis* and other named species in the Dineidae.

Dinea atyphos sp. nov.

Plate 38, Figs. 4-10

Diagnosis: A species of *Dinea* with a preglabellar field exceeding the anterior border in length by nearly a third, a very small, minimally expressed preglabellar ridge, and a glabella that is only modestly inflated. The occipital ring is a plain crescent without spine or node.

Type: A cranidium, WRI 614, from White Rock Islets, western Newfoundland (Plate 38, Figs. 7-10)

Name: Greek *atyphos*, “not puffed up,” in reference to the modest glabellar inflation; it can also mean “modest,” “unremarkable.” Both pertain.

Occurrence: Collections WRI 614, Lower Marjuman of western Newfoundland

Description: Cranidium mildly convex in anterior and lateral views. Glabella only moderately inflated, half the total cranidial height in lateral view, ovoid, very slightly triangular in anterior aspect, rounded rather than pointed posteriorly in lateral aspect; preglabellar, axial and occipital furrows shallow, lightly expressed; anterior border slightly convex, modestly curved, its width one and one third maximum glabellar width; anterior border furrow shallow but distinct; preglabellar field twice the length of the anterior border, continuing the curve of the glabella in lateral aspect; preglabellar furrow shallow. A small (less than one half maximum glabellar width) preglabellar ridge, also shallow but distinct, sits anterior to the preglabellar furrow. Fixed cheeks downsloping, one fourth glabellar width; palpebral lobes narrow, one fourth glabellar length including occipital ring; posterior fixed cheeks narrow, short, subtriangular; occipital ring one fifth total glabellar length, crescentic; anterior facial sutures nearly parallel; posterior facial sutures not available. Prosopon finely granulate.

Remarks: *Dinea atyphos* differs from *D. bovicephala* and *Dinea* spp. indet. by the lack of an occipital spine. It differs from *D. extremis* in the modest glabellar inflation. It differs from *Matania* spp., some of which display similar glabellar shape and inflation, by the long preglabellar field, shallow furrows, and the downslope of the fixed cheeks. The small prefrontal band has so far not been seen in any other species of either *Matania* or *Dinea*.

Dinea sp. indet. #1

Plate 37, Figs. 7, 10, 11

Occurrence: Collections WRI 616, Lower Marjuman of western Newfoundland

Remarks: The degree and angle of inflation of the glabella separates this specimen from both *Dinea extremis* and *Dinea bovicephala*. Also, the occipital ring extends up the posterior surface of the glabella farther than do those of the named species.

Dinea sp. indet. #2

Plate 38, Figs. 1-3

Remarks: The anterior border is nearly equal in length to the preglabellar field and the occipital ring is a smooth crescent without spine or node. This separates this species from *Dinea* sp. indet. #1 and *D. bovicephala*, which have an occipital spine. The modest inflation separates it from *D. extremis*. The smooth surface and shorter preglabellar field separate it from *D. atyphos*.

Genus *Cryptoderaspis* Rasetti 1946

Type species: Cryptoderaspis metisensis Rasetti 1946 from the Métis conglomerate of the western Gaspé

Occurrence: The Métis Conglomerates of the western Gaspé, Quebec. Not found in the Cow Head so far

Diagnosis: A genus of the Dineidae with ovate, effaced glabella that is highly tumid, partially overhanging the occipital ring. Preglabellar field long, convex and downsloping; Anterior border furrow obsolete. Terrace lines mark the leading edge of the cranidium. Fixed cheeks convex and downsloping. Occipital ring downsloping.

Remarks: *Cryptoderaspis metisensis* Rasetti (1946, Holotype LU 1018, Plate 29, Figs. 1-3, 7-10, 12-16), possesses a highly inflated glabella, the posterior portion of which is drawn back and upward and overhangs a small, flattened occipital ring. The fixed cheeks and long frontal area and even the occipital ring are downsloping. The anterior border and anterior border furrow are effaced, although terrace lines mark the narrow leading edge of the cranidium's anterior. Eyes are small, situated just anterior to the glabellar midline; faint, straight ocular ridges angle back to narrow palpebral lobes less than one fourth the glabellar length.

Robison (1988) assigned *Cryptoderaspis* to the Onchonotopsidae Shaw 1952 (which I have suppressed, placing the other genera in the Catillicephalidae) because of its short palpebral lobes, the ovate and inflated glabella and downsloping cheeks.

He then added that the cheeks are downsloping more so in *Cryptoderaspis* than in “*Onchonotopsis*” (= *Matania* herein). The exclusion of *Cryptoderaspis* from the Catillicephalidae is remarked upon above, under discussion of *Matania*.

This genus and *Dinea* gen. nov. share a suite of similar characters discussed above. Exceptions are the ocular ridges, which are barely visible in *Cryptoderaspis* and absent in *Dinea*, and more importantly the nature of the anterior border. In *Dinea* the anterior border furrow is well impressed, the anterior border present and conspicuous with its altered slope. The flat occipital ring is more prominent, sometimes impinging on and limiting the backward extension of the posterior portion of the glabella. I propose that the similarities, however, easily outweigh the differences. The tall, highly inflated glabella, combined with the reduced, flat occipital ring and strongly downsloping frontal area and cheeks, a suite of characters not found in other groups, suggest relationship.

Cryptoderaspis metisensis Rasetti 1946

Plate 29, Figs. 1-3, 7-10, 12-16

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

1981 *Cryptoderaspis metisensis*, Palmer in Palmer and Peel, p 36, pl 6 figs. 9, 12

1988 Not *Cryptoderaspis metisensis*, Robison, p 83, Figs. 23.1-4

Occurrence: Métis conglomerate, Gaspé, Quebec; Cass Fjord Formation of Greenland

Remarks: Robison (1988, p. 83) commented upon the wide variation in the shape of the glabella in specimens he identified “provisionally” (his word) as *C. metisensis* Rasetti 1946. Individuals in his figure 23.1-4 indeed vary widely and none closely resembles Rasetti’s types (Plate 29). In side view, the glabellar outlines of Robison’s specimens do not match that of the types. Too, the footprints, so to speak, of the Robison glabellae—*i.e.* the line along which they attach to the cheeks and preglabellar field—differ drastically. I submit that Robison illustrated at least one new species of *Cryptoderaspis*, and none of those figured is *C. metisensis*.

Family NORWOODIIDAE Walcott 1916

Remarks: Resser (1938) erected the genus *Holcacephalus* Resser 1938 in the Norwoodiidae to contain a distinctive group of small trilobites with subrectangular glabellae and, usually, genal spines extending back from the ends of the posterior fixed cheeks. Lochman (1940) coined *Norwoodina* to receive three species, *N. appalachia* (Resser 1938), *N. tunda* Lochman 1940 and *N. tenera* (Walcott 1916) and Resser’s *Holcacephalus granulatus*. Chaos then descended. For a complete description of the machinations regarding these genera, refer to Palmer (1965, p. 53),

who devoted a full page and a little more to a discussion of the names and relationships for *Holcacephalus*.

Pratt (1992, p. 76) considers all of the species group to be genuine norwoodiids and transfers nearly all into *Hardyoides* Kobayashi 1938. His diagnostic reasoning makes this treatment both simple and acceptable. Here I follow his diagnosis, which is based upon a combination of broad fixed cheeks, bullet-shaped glabella and curved, halo-like anterior field.

Genus *Hardyoides* Kobayashi 1938

Type species: Hardyoides minor Kobayashi 1938, McKay Group, British Columbia.

Remarks: Despite work on the genus such as Pratt's (1992), the systematics of *Hardyoides* and *Norwoodia* need clarification. Additional problems lie in the type material of several species such as *H. katherina* Lochman 1938 and *H. tunda* Lochman 1940, which are poorly preserved and difficult or impossible to interpret clearly.

Hardyoides cf *H. tenerus* (Walcott 1916)

Plate 39, Figs. 14, 17-21

1916 *Norwoodia tenera* Walcott, p. 172, pl. 28, fig. 2

- 1938 *Norwoodia tenera*, Lochman, p. 83, pl. 18, figs. 11-13
- 1938 *Norwoodia katherina* Lochman, p. 473, pl. 56, figs. 19-21
- 1940 *Norwoodina tenera* Lochman, p. 50, pl. 5, figs. 12-14
- 1940 *Norwoodia tunda* Lochman, p. 50, pl. 5, figs. 8-11
- 1940 *Norwoodia tenera cuneifera* Lochman, p. 51, pl. 5, figs. 15, 16
- 1944 *Holcacephalus tenerus*, Lochman and Duncan, p. 137, pl. 13, figs. 15-17
- 1946 *Holcacephalus tener*, Rasetti p. 454, pl. 69, fig. 16
- 1954 *Holcacephalus tenerus*, Palmer, p. 742, pl. 84, fig. 3
- 1960 *Holcacephalus tenerus*, Lochman and Hu, p. 823, pl. 98, figs. 1-52
- 1960 *Holcacephalus tenerus*, Robison, p. 27, pl. 2, fig. 2
- 1971 *Holcacephalus tenerus*, Hu and Li, p. 176, pl. 3, figs. 1-32
- 1978 *Holcacephalus tenerus*, Hu, p. 355, pl. 48, figs. 12-22
- 1985 *Holcacephalus tenerus*, Thomas and Fortey in Murray, pl. 9.5 .34, 35
- 1992 *Hardyoides tenerus*, Pratt, p. 76, pl. 28, figs. 22-29
- 1998 *Hardyoides tenerus*, Stitt, p. 1039, figs. 7.11-7.13

Lectotype: (USNM 61617) Weeks Formation, Utah (Walcott 1916, pl. 28, fig. 2) as designated by Pratt (1992)

Occurrence: Collection CH 11, Upper Marjuman; widespread in Laurentian North America

Remarks: *H. tenerus* seems to be a catch-all rather than a discrete species. In fact, the nearly cosmopolitan distribution of this species raises some questions. Did this species really spread so far and wide? In the Cow Head collections, a variety of forms that answer the diagnosis nonetheless vary among themselves in the degree and coarseness of surface sculpture and in details of proportions, particularly the length of the extended genal spine tips. Too, half possess baculae on the fixed cheeks at the posterior ends of the axial furrows. This is another species in need of detailed study.

Hardyoides minor Kobayashi 1938

Plate 39, Figs. 11-13, 15, 16

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

1962 *Hardyoides minor*, Palmer, p. 94, pl. 19, figs. 20-25

1965 *Hardyoides minor*, Palmer, p. 54, pl. 7, figs. 3-5, 9-11

1992 *Hardyoides minor*, Pratt, p. 77, pl. 28, figs. 30, 31

Holotype: Cranidium NMC 11941 from the McKay Group, British Columbia

Occurrence: Collections CH 11 and 36, Upper Marjuman of western Newfoundland; McKay Group, British Columbia; Rabbitkettle Formation, Mackenzie Mountains; Dunderberg Formation, Utah and Nevada.

Remarks: The anterior border and preglabellar area together comprise less than one third the length of the glabella excluding the occipital ring; in contrast, the preglabellar field and anterior border of *H. tenerus* well over one third glabellar length. The short preglabellar field also differentiates *H. minor* not just from *H. tenerus* but *H. katherina* Lochman 1938 and *H. tunda* Lochman 1940. The occipital ring bears a shallow node rather than a spine, and at times the node is obsolete.

Hardyoides cf *H. katherina* Lochman 1938

Plate 39, Figs. 1-5, 15, 16

1938 *Norwoodia katherina* Lochman, p. 83, pl. 18, figs. 11-13

1940 *Norwoodina tenera* Lochman, p. 50, pl. 5, figs. 12-14

1992 *Hardyoides tenerus*, Pratt, p 76, pl 28, figs. 22-29

Diagnosis: A species of *Hardyoides* with subequal anterior border and preglabellar field and genal spines one third the glabellar width.

Holotype: Cranidium YPM1582 from "Cow Head," western Newfoundland, by original designation

Occurrence: Collections CH 11, 35 and 36, Upper Marjuman of western Newfoundland

Remarks: Lochman (1940) suppressed her *N. katherina* in favour of *N. tenera*. I submit that the two forms differ sufficiently that *H. katherina* merits separate species status. Assuming that her pygidium assignment is correct (YPM 14834), the pygidia of the two forms differ in that the pygidium of *H. tenerus* is narrower. Too, the length of the genal spines in *H. katherina* is one third glabellar width, whereas those of *H. tenerus* are longer, usually one half. The posterior fixed cheeks of *H. katherina* do not curve rearward in the same manner as do those of *H. tenerus* and the percent of total cranidial length represented by the glabella of *H. katherina* is a little greater than that of *H. tenerus*. An occipital spine separates it from *H. minor* and the anterior border, flat and wide, differs from the narrow wirelike anterior border of *H. tunda*.

Hardyoides cf. *H. tunda* Lochman 1940

Plate 39, Figs. 7-10

1940 *Norwoodina tunda* Lochman, p. 50, pl. 5, figs. 8-11

1951 *Holcacephalus tunda atypicala* Tasch, p. 294, pl. 44, figs. 25, 26

1965 *Hardyoides tunda*, Palmer, discussion p. 53

Holotype: Cranidium USNM 98782, Bonneterra Dolomite of southeastern Missouri

Occurrence: Collection CH 39, Upper Marjuman of western Newfoundland; *Cedaria* Zone, Bonnetterre Dolomite, Missouri

Remarks: The narrow, wire-like anterior border, convex preglabellar field and granular surface distinguish *H. tunda* from other species of *Hardyoides* in these collections.

Family MENOMONIIDAE Walcott 1916

Remarks: Pratt (1992, p 77) offers a lengthy and detailed analysis of the genera comprising, and no longer comprising, the family. He discussed in particular differences between *Menomonina* Walcott 1916 and *Densonella* Shaw 1952.

Densonella has not been found in these collections, and *Menomonina* occurs only as one or two poorly preserved specimens, so no comment is appropriate here.

Westrop and Ludvigsen (2000) performed a rigorous and detailed study of the genus *Hysteropleura* Raymond 1937 as it occurs in the Cow Head Group. Their phylogenetic work clarifies the relationships of *Verditerrina* Robison 1988, *Tavsenia* Robison 1988 and *Knechtelia* Lochman 1950 to *Hysteropleura*, using *Bolaspidella housei* Resser 1937 as the outgroup. *Verditerrina* falls out nicely as a subgenus of *Hysteropleura*. They were also able to track and clarify ontogenetic changes, particularly relative length and shape of the anterior border.

Genus *Hysteropleura* Raymond 1937

Type species: Hysteropleura macgerriglei Raymond 1937, Rockledge conglomerate, Vermont

Remarks: The rough chronological order of the pertinent collections covered here is: White Rock Islets (600 series), Broom Point in part (400 series, both very early and very late, bracketing the White Rock Islets) and the Upper Marjuman Cow Head (single and double digits). The chronology and correlation, based on agnostoids, is provided in detail in Westrop, Ludvigsen and Kindle (1996). *H. schucherti* appears earliest, with numerous cranidia of *H. adraini* in the Broom Point material. Only *H. macgerriglei*, presumably closely related to *H. schucherti*, represents the line in the Upper Marjuman as an identifiable form. *H. sp. indet. #1* in CH 11 can be placed neither as *H. schucherti* nor *H. macgerriglei*.

Hysteropleura (Verditerrina) adraini Westrop and Ludvigsen 2000

Plate 41, Figs. 1, 2, 5, 7, 8

2000 *Hysteropleura (Verditerrina) adraini* Westrop and Ludvigsen, p. 1026, figs.

6.3-6.6, 7

Holotype: Cranidium GSC 118724 from BPS 468, Downes Point Member

Occurrence: Collection BPS 458, 460, 467 and 468, Lower Marjuman; Downes Point Member, Shallow Bay Formation, *Lejopyge laevigata* Zone, western Newfoundland.

Remarks: Westrop and Ludvigsen (2000) describe the ontogenetic changes in the anterior border of *H. adraini*, the projection becoming longer and more pronounced with growth. In BPS 468, one specimen with a clearly meraspid anterior border configuration—that is, limited projection—(Plate 40, Fig. 8) occurs with seven specimens of *H. adraini* displaying holaspid proportions (the anterior border is broken away on another small specimen, presumably a meraspid). Another specimen from boulder 468 retains the palpebral lobe, which is almost enough elevated to be called a socle.

Hysteropleura (Verditerrina) edgecombei Westrop and Ludvigsen 2000

Plate 41 Figs. 6, 10, 11, 14, 15

2000 *Hysteropleura edgecombei* Westrop and Ludvigsen, p. 1029, figs. 8.1-8.10

Holotype: Cranidium GSC 118730 from BPS 469, Downes Point Member, Shallow Bay Formation, western Newfoundland

Occurrence: Collection BPS 469, Lower Marjuman of western Newfoundland

Remarks: *H. edgecombei* combines the features of a smooth test with long, heavy occipital spine, elevated fixed cheeks and palpebral lobes with an anterior border that is subsemicircular in anterior aspect. This separates it from *H. adraini*, which possesses a long, spine-like anterior border in holaspids, and from *H. ramskoldi*, which displays an anterior border that does not exceed the length of the preglabellar field. *H. edgecombei* differs from all other known *Hysteropleura* spp. in the smooth versus tuberculate prosopon.

Hysteropleura (Verditerrina) ramskoldi Westrop and Ludvigsen 2000

Plate 41, Figs. 3, 4, 9, 12, 13

2000 *Hysteropleura ramskoldi* Westrop and Ludvigsen, p. 1029, figs. 8.11-8.19

Holotype: Cranidium GSC 118738 from BPS 470, Downes Point Member

Occurrence: Collection BPS 470, Lower Marjuman of western Newfoundland

Remarks: For comparisons, see *H. edgecombei* above. The three smooth-surfaced *Hysteropleura* spp. from the Broom Point/Downes Point series of boulders form a

continuum of anterior border development, from this species with little development through *H. edgecombei* to the extreme of *H. adraini*.

Hysteropleura cf. *H. macgerriglei* Raymond 1937

Plate 42, Figs. 1, 2, 6

- 1937 *Hysteropleura macgerriglei* Raymond p. 1094, pl. 1, Fig. 22
1952 *Bolaspidella macgerriglei*, Shaw p. 478, pl. 57, fig. 44
1956 *Bolaspidella macgerriglei*, Wilson p. 1343, pl. 146, fig. 8
1966 *Hysteropleura macgerriglei*, Shaw p. 291, pl. 34, fig. 7
1992 *Hysteropleura macgerriglei*, Pratt p. 79, pl. 29, figs. 22-27
2000 *Hysteropleura macgerriglei*, Westrop and Ludvigsen p. 1025, figs. 9.1, 9.2

Holotype: Cranidium YPM 14761, from the Rockledge conglomerate, Vermont

Occurrence: Collections CH 3, 11, 35, 36 and 39, Upper Marjuman, western Newfoundland; *Cedaria prolifica* Zone of Rabbitkettle Formation, Mackenzie Mountains, Canada; Rockledge Conglomerate and Skeels Corners Formation, Vermont.

Remarks: *Hysteropleura macgerriglei* differs from other species of *Hysteropleura* in the length preglabellar field, which is one half the glabellar length exclusive of occipital ring. Compare Plate 41, Fig. 1 with same, Fig. 13.

This is the only representative of the genus to enter the Upper Marjuman (Kindle's Zone 5) of the Cow Head.

Hysteropleura cf *H. schucherti* (Raymond 1937)

Plate 39, Figs. 1, 2, 6; Plate 42, Figs. 2, 4, 5, 10, 12-17

1937 *Antagmus schucherti* Raymond p.1107, pl. 4, figs. 10-13

1966 *Hysteropleura schucherti*, Shaw p. 290 pl. 34, figs. 1-6

1992 *Hysteropleura schucherti*, Pratt p. 79, pl. 29, figs. 17-21

Occurrence: Collections WRI 607, 611, 615, 617, 618, 630, 631 and 632, Lower Marjuman of western Newfoundland; *Cedaria minor* Zone of Rabbitkettle Formation, Mackenzie Mountains, Canada; Skeels Corner Formation, Rockledge Conglomerates of Vermont; *Lejopyge laevigata* Zone of Holm Dal Formation, Greenland

Remarks: The length of the preglabellar field, equal to that of the anterior border or a bit less, separates this species from similar forms such as *H. macgerriglei* with its longer preglabellar field. Robison (1988 p. 79, figs. 22.2, 3) erected *Bolaspidella stymacantha* Robison, which Pratt (1992) synonymized into *H. schucherti*. I suggest

that the synonymy may be inappropriate, in that although *H. schucherti* may have a median swelling on the preglabellar field, it does not have a plectrum, as appears in Robison's holotype. Moreover Robison's paratype lacks the plectrum, narrow glabella and broader fixed cheeks of his holotype. *Bolaspidella stymacantha* itself may represent more than one species.

Hysteropleura sp. 1

Plate 40, Figs. 6, 7

Occurrence: Collections WRI 615, 616, Lower Marjuman of western Newfoundland

Remarks: The subtriangular anterior border, truncated, slightly tapered glabella with lateral glabellar furrows, large palpebral lobes and occipital ring drawn up into a nearly vertical spine do not compare precisely with any other species.

Genus *Menomonion* Walcott 1916

Type species: *Conocephalites calymenoides* Whitfield 1878 from Wisconsin

Menomonion sp. indet.

Description: Partial cranidium semicircular in dorsal aspect, with stubby glabella, sparse tuberculation, prelabellar field approximately equal to anterior border, and highly inflated fixed cheeks.

Occurrence: Collections CH 28, 36 and 39, Upper Marjuman of western Newfoundland

Remarks: On all the specimens from this collection, the fixed cheeks have been badly broken away and the tubercles are worn, faint or missing. They are among those species that are found mixed into a coarse lag of broken trilobite and brachiopod pieces (see *Hardyoides* for discussion).

Genus *Bolaspidella* Resser 1937

Type species: *Ptychoparia housensis* (Walcott) 1886, House Range, Utah

Remarks: Robison (1964) observed that the prelabellar field was shortest (sagittally) in the smallest, presumably immature meraspids and lengthened in larger specimens. Some of this material, one suspects, could vary ontogenetically, but it is nearly impossible to interpret which would relate directly to whom.

The anterior border of *Hysteropleura* is not much wider than the occipital ring. In *Bolaspidella*, the anterior border width comfortably exceeds that of the

occipital ring. That modest distinction aside, the proportions of fixed cheeks, glabellae, posterior fixed cheeks and occipital rings are similar in the two genera. Underscoring the similarity, Shaw (1952) transferred *Bolaspidella macgerriglei* to *Hysteropleura macgerriglei*, an opinion I follow here. Too, Lochman (1953) claimed that *Bolaspidella* was “ancestral” (her term) to *Hysteropleura*, *Menomonina* Walcott 1916 and *Dresbachia* Walcott 1916.

Bolaspidella cf. *B. contracta* Robison 1964

Plate 40, Figs. 8-10, 14

1964 *Bolaspidella contracta* Robison, p. 554, pl. 89, figs. 14-17

Holotype: A cranium, USNM 141281, from the House Range, western Utah

Occurrence: Collections WRI 614, 617 and 632, Lower Marjuman of western Newfoundland; Marjum Formation, House Range of western Utah

Remarks: Robison’s (1964, pl. 89, figs. 14-17) material displays some variation—for example, his figure 17 shows a glabella that is more tapered and evenly rounded than are the truncate, less tapered glabellae of figures 14 and 15, though ostensibly all are *B. contracta*. Robison noted the variation without going into detail and minimized its

importance based on the fact that variation did not occur consistently in the collections.

Material from the Cow Head Formation resembles Robison's figures 14 and 15 in the relative length of preglabellar field and anterior border, the shape of the fixed cheeks and width of the posterior fixed cheeks, as well as the size and position of the palpebral lobes. However, the shape of the glabella in mine as well as Robison's varies somewhat. The cranidia come from boulders of about the same age as the sources of *B. contracta*. If the specimens in WRI 614, 617 and 632 are indeed *B. contracta*, correlation is afforded between the Lower Marjuman White Rock Islets and Robison's collections from the House Range.

Bolaspidella sp. 1

Plate 40, figs. 11-13

Occurrence: Collection WRI 611, Lower Marjuman of western Newfoundland

Remarks: Some of the scattered tubercles on the cranidium include four paired sets on the glabella and four mirror-image, paired sets on the proximal surfaces of the fixed cheeks. The anterior border is tapered, the fixed cheeks elevated, the palpebral lobes prominent, and the occipital ring drawn out into a tapered spine that angles back and up. The preglabellar field is longer than that of *B. contracta*, the glabella more truncate.

Genus *Eldoradia* Resser 1935

Type species: Ptychoparia? linnarssoni Walcott 1884 from the Eureka district (Nevada) by original designation

Remarks: The type specimens of *E. linnarssoni* (Walcott 1884, p. 47, pl. 9, figs. 18, 18a) and *E. prospectensis* (Walcott 1884, p. 36), poorly preserved in shale, were figured by Palmer (1954b, pl. 16, figs. 9, 10) . He synonymized *E. lata* with *E. linnarssoni*. Lochman provided somewhat better material than what Walcott could find to support *E. dunbari* (Lochman 1938 p. 465, pl. 56, figs. 36-43). Palmer however (pp. 76, 77) opined that *E. dunbari*, lacking a boss on the short prefrontal area, was not a true representative of the genus. Clearly, the genus needs work.

Eldoradia batilla sp. nov.

Plate 40, Figs. 1-4

Diagnosis: A species of *Eldoradia* with a total preglabellar area nearly as long as the glabella exclusive of the occipital ring

Holotype: A cranidium in WRI 603, White Rock Islets of western Newfoundland (Plate 40, Fig. 4)

Name: Latin for shovel, fire pan or chafing dish, referring to the long preglabellar field

Occurrence: Collections WRI 603 and 631, White Rock Islets, Lower Marjuman of western Newfoundland

Description: Cranium nearly square except for the posterior fixed cheeks. Glabella 20% longer than wide exclusive of occipital ring, slightly tapered, truncated; glabellar furrows expressed laterally, straight, slightly backsloping; anterior border crescentic, tapered at the ends; anterior border furrow partially effaced; preglabellar field long, 80 to 85% of the glabellar length exclusive of the occipital ring; median circular swelling rises evenly, filling space between preglabellar furrow and anterior furrow, impinging on the preglabellar furrow; posterior preglabellar furrow shallow and slightly concave, the effect of the median swelling in the preglabellar field. Fixed cheeks broad and upsloping, their width equalling glabellar width; ocular ridges prominent, straight, angled slightly back; palpebral lobes a bit less than one fourth glabellar length; posterior fixed cheeks one and two thirds glabellar width, tapered, straplike; posterior furrow deep, posterior border approximately horizontal (transv.) in dorsal view. Occipital furrow shallow, straight; occipital ring triangular, drawing up and back into a spine of unknown length. Anterior facial sutures converge slightly; posterior facial sutures leave the palpebral lobes at roughly -20° . surface of

preglabellar field very finely and faintly veined, cranium dotted with scattered tubercles, glabella and fixed cheeks each display the pattern of four pairs of tubercles.

Pygidium not known.

Remarks: This species differs from all others, particularly *E. dunbari*, in the length of the prelabellar field, nearly twice that of *E. dunbari* proportionally. The prelabellar furrow is much more obvious than are the prelabellar furrows of *E. linnarssoni* and *E. prospectensis*, and the glabella less tapered.

Eldoradia cf. *E. batilla* sp. nov.

Plate 40, Fig. 5

Occurrence: Collections WRI 606, Lower Marjuman of western Newfoundland

Remarks: This specimen varies slightly from the holotype in that the anterior border is narrower and the median swelling larger. Whether this is intraspecific variation is arguable.

Family PTYCHOPARIIDAE Matthew 1887

Genus *Metisella* Rasetti 1963

Type species: Metisella microphthalmia Rasetti 1963

Metisella sp. indet.

Plate 15, Figs. 9-11

Occurrence: Collections WRI 615, Lower Marjuman of western Newfoundland

Remarks: The specimen from WRI 615A in most regards fits the genus description except that the prelabellar field is little longer and wider. It does not agree in detail with the type species Rasetti (1963 p. 586, pl. 69, figs. 31-35).

Family CONOCORYPHIDAE Angelin 1878

Remarks: When Resser (1936) examined this family, phylogenetics methods were unavailable. Recently Cotton (2001) reorganized the blind libristomates using two distinct cladistic analyses, one of the assigned genera in Conocoryphidae proper and also a more inclusive study of the blind Cambrian genera including the Conocoryphidae and a clade of corynexochids. The two genera of blind libristomates in this collection, *Conocoryphe* Hawle and Corda 1847 and *Meneviella* (Salter) 1872, fall into different families under Cotton's new classification.

Babcock (1994) noted that occurrences of Avalonian or Baltic taxa in Laurentia are always in deep water facies. The appearance of rare specimens of *Conocoryphe* and *Meneviella* in the Cow Head Group is consistent with this pattern.

Genus *Conocoryphe* Corda 1847

Type: Trilobites sulzeri (Schlotheim) 1823

Conocoryphe Hawle and Corda 1847, sp. indet.

Plate 21, Figs. 4-6, 10-12, 16, 17

Occurrence: Collections BPS 448 and 467 and WRI 632, Lower Marjuman of western Newfoundland

Remarks: This species of *Conocoryphe* differs from others, such as *C. artagena* Howell 1937 and particularly *C. terranovica* Resser 1937 in the surface ornamentation, which is granulate rather than tuberculate, as well as a narrow glabella and a median occipital node.

Family HOLOCEPHALIDAE Hupé 1953

Remarks: Cotton (2001) in his thorough revision of the taxonomy of blind trilobites transferred *Meneviella* from the Conocoryphidae to this family. See Cotton (2001, p. 190) for a complete emended diagnosis.

Genus *Meneviella* Stubblefield 1951

Type species: *Meneviella venulosa* (Salter 1865)

Remarks: The relative size of glabella to fixed cheeks, the extremely wide fixed cheeks and the prominent caecal network separate this family from Conocoryphidae above, as well as separating *Meneviella* from *Conocoryphe*. Convexity also helps differentiate them, the glabella convex and raised well above the tumid fixed cheeks.

For so unique a genus, this animal has had its naming ups and downs. Hicks (1866) named it *Erinnys*, but it was transferred to *Conocoryphe* because Agassiz had already taken the name. Lake erected the genus *Menevia* for it, but Schaus had preoccupied that name. Undaunted, Stubblefield in 1951 coined *Meneviella*.

Meneviella cf. *M. venulosa* (Salter) 1865

Plate 20, Figs. 17-19

1865 *Erinnys venulosa* Salter, p. 285

1884 *Conocoryphe (Salteria) venulosa*, Walcott, p. 31

- 1899 *Erinnys breviceps*, Matthew, p. 91, pl. 4, fig 9
1938 *Menevia venulosa*, Lake, p. 270, pl. 39, figs. 4-9
1951 *Meneviella venulosa*, Stubblefield, p. 213
1962 *Meneviella venulosa*, Hutchinson, p. 108, pl. XVI, figs. 2-7

Holotype: GSC 12047 from 21810

Occurrence: Collection BPS 448, Lower Marjuman of western Newfoundland; Avalonian Newfoundland; rare but widespread elsewhere. Indicative of deep-water regimes in Laurentia, shallow environments on more northerly cratons—*i.e.* a coldwater species.

Family INCERTIS

Genus *Brassicicephalus* Lochman 1940

Remarks: The genus *Brassicicephalus* Lochman 1940 fails to fall comfortably into any family. Jell (2003) placed the genus in the Plethopeltidae Raymond 1925 despite that the axial and prelabellar furrows of *Brassicicephalus* are quite well defined and a feature of the Plethopeltidae is ill-defined furrows. There appears to be a cedariform posterior facial suture, but the posterior fixed cheeks are not broad and straplike as in most cedariids and, most of all, there is no good anterior border furrow, let alone

punctae anywhere in the prelabellar area. I suggest that, until more material or other closely allied genera are recovered, that it remain without a family assignment.

Genus *Brassicicephalus* Lochman 1940

Type species: Brassicicephalus pulchellus Lochman 1940, from the Bonnetterre, Missouri

Remarks: Robison (1988) suppressed *Brassicicephalus* as a synonym of *Exigua* Howell 1937 on the basis that the differences were too trivial to merit genus consideration. No one seems to have paid attention to this, although Jell (2003) acknowledges Robison's opinion. I reject that synonymy for several reasons. For one, the anterior border furrow is expressed distally in *Brassicicephalus* and not in *Exigua*. They are thus easily separable. More importantly, however, the posterior facial sutures of *Brassicicephalus*, apparently wrapping around the ends of the posterior fixed cheeks, are not at all like the opisthoparian sutures of *Exigua*. Despite the superficial similarities, therefore, I am leaving *Brassicicephalus* as its own entity.

Interestingly, Cooper (1990, p 60, fig. 6 and text-fig. 5, line drawings with proportions restored) reports this genus (sp. indet.) from Reilly Ridge in Antarctica. The posterior fixed cheeks do not adhere to type well, but his material is laterally distorted, so the path of the posterior facial suture is difficult to interpret and therefore calling the determination into serious question.

Brassicicephalus quebecensis Rasetti 1946

Plate 53, Figs. 5-11

1946 *Brassicicephalus quebecensis* Rasetti p. 448, pl. 67, figs. 19, 20

Diagnosis: A species of *Brassicicephalus* with a finely granulate test and terrace lines on the leading edge of the anterior border

Occurrence: None in these collections. Métis conglomerate, Quebec

Remarks: Rasetti described a smooth test. His types, illustrated here, actually have very finely granulate tests. He also neglected to mention the terrace lines on the leading edge of the anterior border, visible at magnification. Photographing the holotype (Plate 53, Figs. 5-11) reveals the new information.

Brassicicephalus rhakionus sp. nov.

Plate 33, Figs. 1-4, 12-19

Diagnosis: A species of *Brassicicephalus* with relatively long, narrow glabella and wide fixed cheeks. Clusters of closely-spaced, blister-like granules form large patches on the glabella and fixed cheeks.

Holotype: A cranidium from BPS 468, Shallow Bay formation, western Newfoundland

Name: Greek *rhakion* means ragged or patchy and secondarily, also, skin disease, referring to the unusual spotty pattern of granulation.

Occurrence: Collections BP 467 and 468, Lower Marjuman of western Newfoundland

Description: Cephalon rounded, arched, tumid. Anterior border flat, tumid and evenly rounded, possessing terrace lines on the leading edge, visible in dorsal aspect. Anterior border furrow effaced, evidenced as soft indentations on the lateral edges of the cranidium. Preglabellar field tumid, almost obsolete, contiguous with the anterior border. Anterior border area *en toto* close to 20% of total glabellar length. Glabellar width slightly less than half glabellar length; glabella tumid, straight-sided, arched sagittally, its anterior evenly rounded. Preglabellar and axial furrows narrow and deep. Fixed cheeks narrow, half the glabellar width at midpoint; ocular ridges effaced proximally, faint distally as they angle down from the juncture of axial and preglabellar furrows. Palpebral lobes narrow, short, one fifth glabellar length, separated by a shallow palpebral furrow. Occipital ring deep, narrow, the occipital furrow slightly convex, bowed toward the posterior. Posterior fixed cheeks subtriangular and long-based, blunt and broad, slightly exceeding glabellar width.

Posterior border furrow deep, arising not from the occipital furrow but from the sides of the occipital ring. Posterior border angles back. Occipital ring simple, crescentic. Anterior facial sutures short, curving outward slightly but otherwise parallel, short. Posterior facial sutures angle back at from 35 to 38° from the long axis.

Surface ornamented with closely spaced, blister-like granules arranged in patches. A patch covers the central area of the glabella but not the edges. Others cover the central areas of the fixed cheeks and anterior members of the posterior fixed cheeks.

Remarks: The glabella is less tumid, the preglabellar area wider than in *B. pulchellus*. The patches of clustered granules also separate this species from *B. pulchella* and *B. quebecensis*, which are described as having smooth tests, neither are terrace lines mentioned.

Genus *Arapahoia* Miller 1936

Remarks: The genus *Arapahoia* Miller 1936 lacks good indicators of either suborder or family. Miller (1936) and others suggest the Plethopeltidae Raymond 1925, citing similarities in the cranidium between *Arapahoia* and *Plethemotopus* Ulrich 1930. Westrop (1992, p. 251) reviews the situation and proposes that, because the features held in common with *Arapahoia* and plethopeltids also occur in *Norwoodella* Resser 1938, and the pygidia of *Arapahoia* and *Norwoodella* are broadly comparable,

Arapahoia might be an effaced norwoodiid. I point out that the axial furrows of Norwoodiids commonly run parallel or nearly so, and what can be seen of the axial furrows in *Arapahoia* converge, the glabella shape almost approaching that of *Onchocephalites*. However, with no clear signal to argue for, I demur.

Arapahoia raymondi Lochman 1938

Plate 53, Fig. 20

1938 *Arapahoia raymondi* Lochman, p. 446, pl. 57, figs. 17-25

1965 *Arapahoia* sp., Kindle and Whittington (*per* Westrop 1992), pl. 1, figs. 3, 4,

1983 *Arapahoia*, Boyce in Stouge and Boyce, pl. 11, figs. 5, 6

1992 *Arapahoia raymondi*, Westrop, p. 251, figs. 17.3-11

Holotype: A cranidium, YPM 15863, from the Petit Jardin Formation, by original designation

Occurrence: Collection BPS 470; Petit Jardin of western Newfoundland

Remarks: This genus is difficult to evaluate because of effacement and a lack of key identifying features. The comparisons of *A. raymondi* with other species, including the type, *A. typa* Miller 1936, are discussed in Westrop (1992, p. 251).

The present material consists of a nearly complete cranidium (Plate 52, Fig. 20) and several partial cranidia from the same collection.

Genus *Avonina* Lochman 1936

Type species: Avonina bizarria Lochman 1936 from the Bonnetterre, Missouri

Avonina sp. indet.

Plate 46, figs. 10-13

Occurrence: Collection CH 11, Upper Marjuman of western Newfoundland

Remarks: The long and backswept posterior fixed cheeks of *A. bizarria* are shorter and broader in this species. The Cow Head specimen possesses terrace lines on the leading edge of the anterior border. Although Lochman's description fails to mention terrace lines, the narrative is too terse to be able to say that the type specimens had none. The type and this specimen agree in other regards.

I suggest that Robison's *Exigua quebecensis* Rasetti 1946 (1988) illustrated in fig. 15. 12-14 agrees in detail with the Cow Head specimen and is also an *Avonina*.

Figures

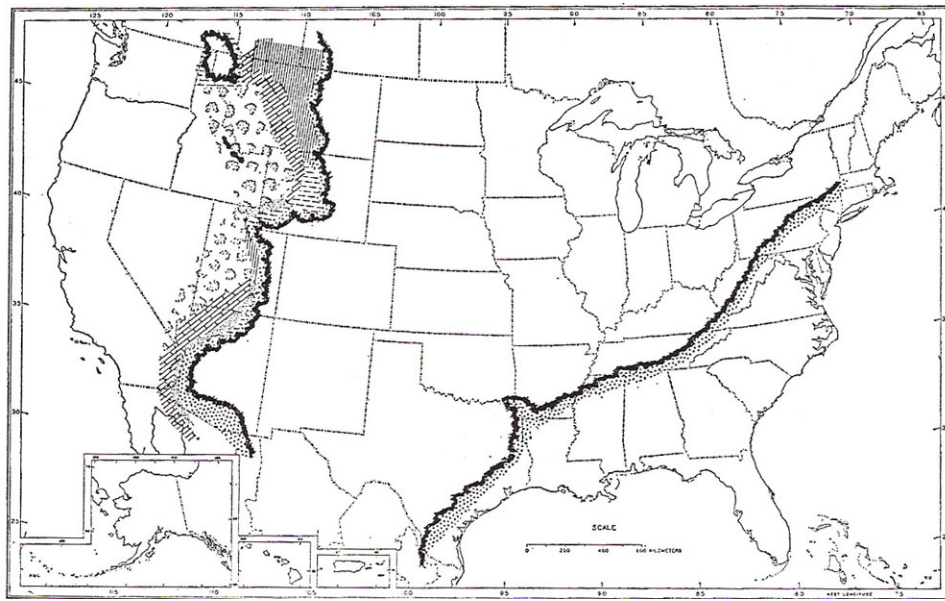


Figure 1. *Bathyriscus-Elrathina* Zone of the Middle Cambrian. Heavy black is shoreline. Stipples etc. indicate habitable shelf environments. Diagonal lines indicate algal reefs. This zone includes some of Broom Point South and the White Rock Islets material of the Cow Head. (Lochman-Balk 1971)

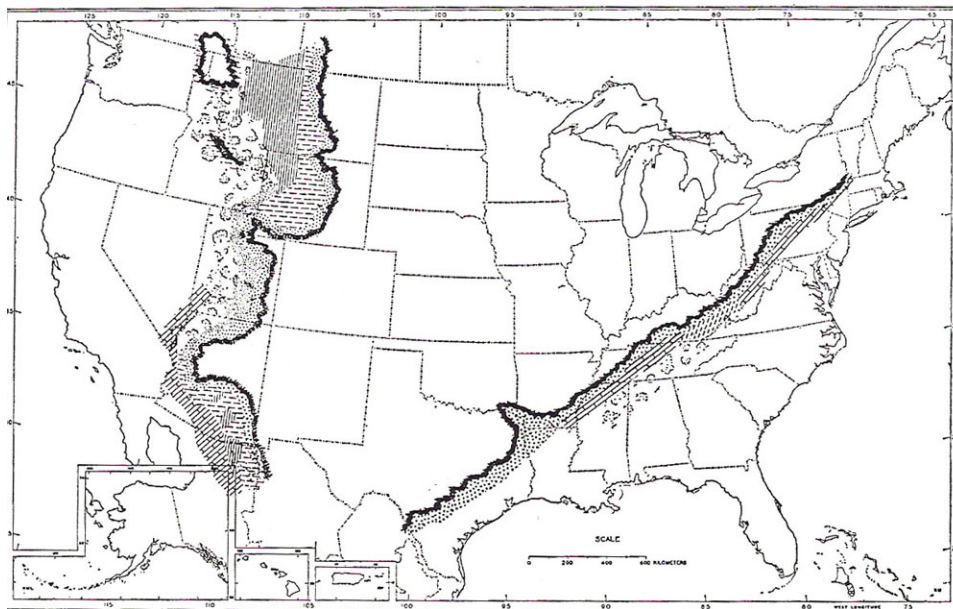


Figure 2. *Bolaspidella* Zone, Middle Cambrian, encompassing the rest of the Broom Point South and White Rock Islets material from the Cow Head. Lines and stippling indicate shelf environments. (Lochman-Balk 1971)

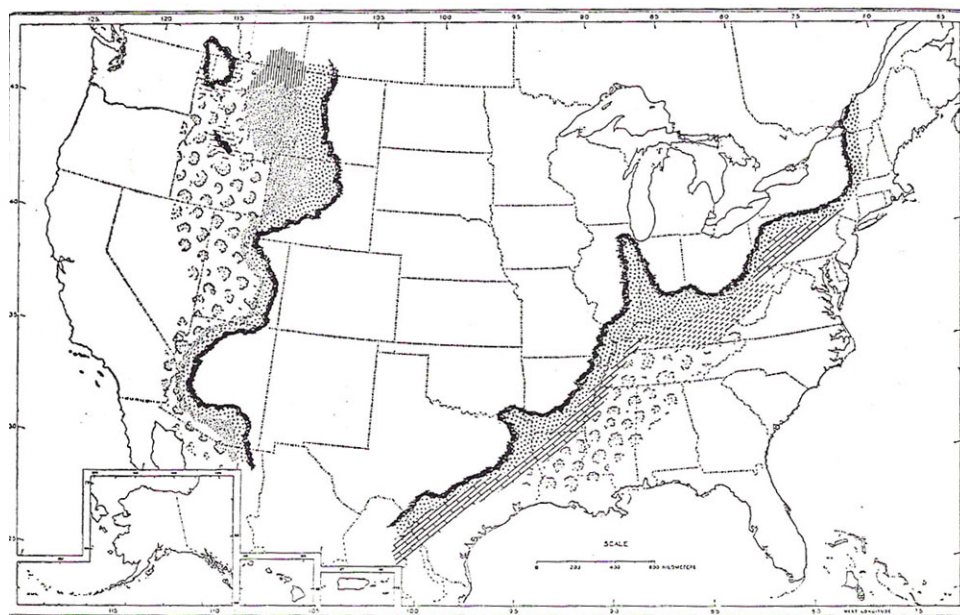


Figure 3. Upper Cambrian early *Cedaria* Zone shelf habitats, such as found on Cow Head proper. Note that shallow environments are expanding as the shelf is flooded by rising sea level.
(Lochman-Balk 1971)

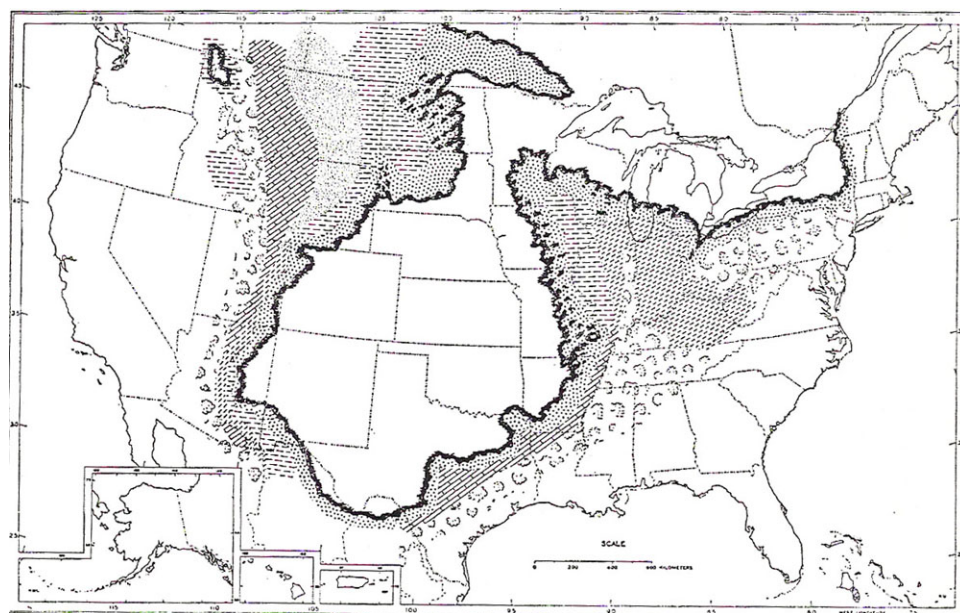


Figure 4. Late *Cedaria* Zone of the Upper Cambrian with extensive shallow-water habitat on the craton.
(Lochman-Balk 1971)

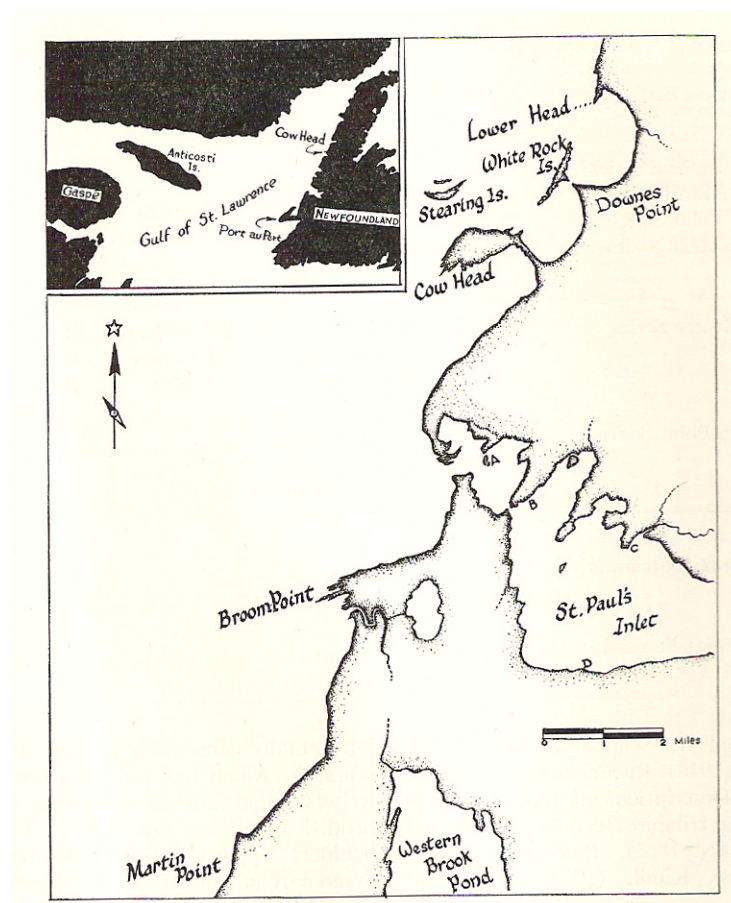


Figure 5. Map of the Cow Head region showing study areas including the White Rock Islets (WRI) and Broom Point South (BPS). Marjuman Cow Head material (CH) was recovered from the north shore of the peninsula proper. (Kindle 1958)

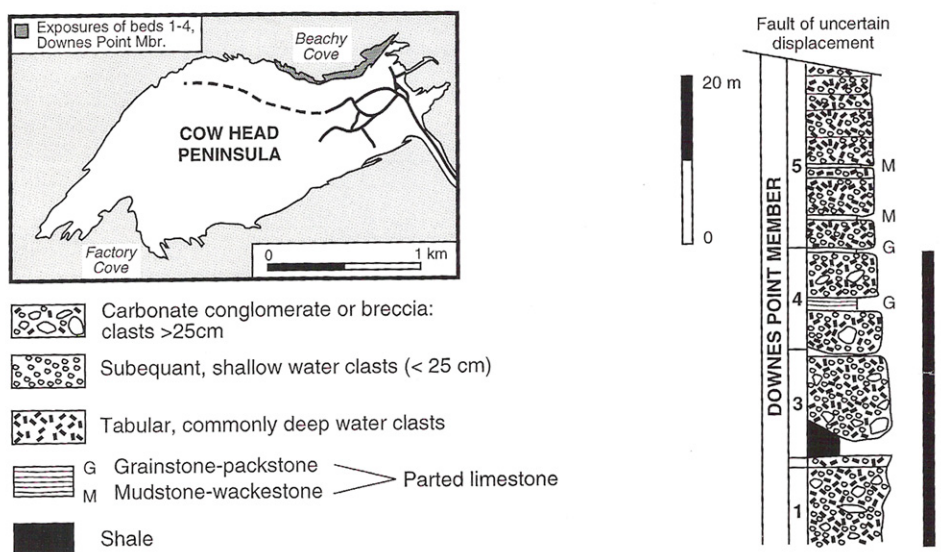


Figure 6. Stratigraphy of Cow Head Peninsula. Material for this study comes from exposures in the Beachy Cove area on the Cow Head proper.

Westrop et al 1996 p. 806

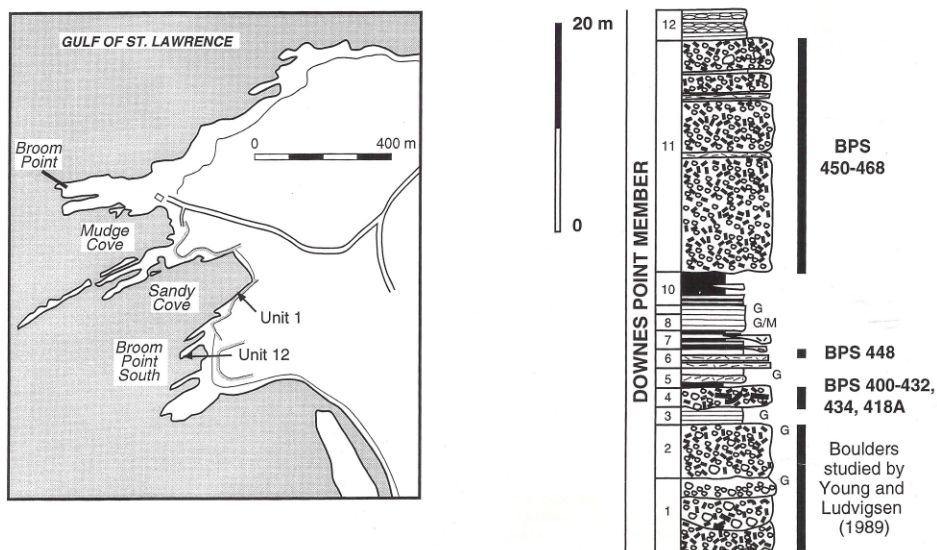


Figure 7. Stratigraphy of Broom Point. Materials examined in this study were collected at Broom Point South. Key as in Figure 6. Westrop et. al. 1996, p 806

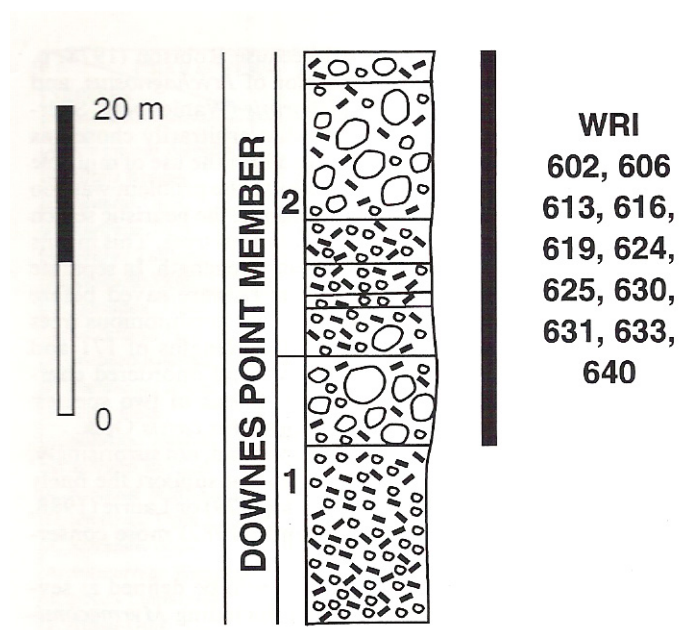


Figure 8. Stratigraphy of the White Rock Islets, just offshore to the northeast of Cow Head. Key as in Figure 6.

Westrop et. al. 1996, p. 807

species	Z 2	Z 3	Z 4	Z 5	March Pt	Pet Jard	Levis/Metis
<i>Araphahoia raymondi</i>			1		X		
<i>Asaphiscus wheeleri</i>		6					
<i>Bolaspidella contracta</i>			2				
<i>Catillicephala fowleri</i>				7			
<i>Catillicephala impressa</i>				2			
<i>Catillicephalites marginatus</i>			2				M-22
<i>Cedaria gaspensis</i>				2			
<i>Crepicephalus rivus</i>				2		X	
<i>Deiracephalus unicornis</i>				2			
<i>Hardyoides katherina</i>				3		X	
<i>Hardyoides minor</i>				2			
<i>Hardyoides tenerus</i>				1			
<i>Hardyoides tunda</i>				1			
<i>Holmdalia punctata</i>		6					
<i>Holmdalia stenis</i>			5				
<i>Hysteropleura macgerriglei</i>				5			
<i>Kindleia mutica</i>				4			
<i>Kingstonia vagrans</i>				9			M-1
<i>Kingstonia walcotti</i>				7			
<i>Matania hueva</i>			1				
<i>Matania ovata</i>			1				
<i>Meneviella venulosa</i>		1					
<i>Nasocephalus flabellatus</i>				1			
<i>Onchocephalites punctatus</i>	7		1				M-13, 24
<i>Spencella spinosa</i>	3						M-24
<i>Talbotina degreasensis</i>				2		X	

Figure 9. Correlation of local species with collections elsewhere. Numbers indicate number of collections in which the species is found in the given zone. *March Pt.* is March Point Formation (Middle Cambrian); *Pet Jard* is elsewhere in the Petit Jardin Formation; *Levis/Metis* are collections from the Lévis and Métis Conglomerates of eastern Quebec. Incidence in Lévis and Métis is recorded by boulder numbers.

species	Gro. Roch.	Gaspé St L	Holm Dal	VT	NY	TN-VA	MO
<i>Araphahoia raymondi</i>							
<i>Asaphiscus wheeleri</i>							
<i>Bolaspidella contracta</i>							
<i>Catillicephala fowleri</i>				X			
<i>Catillicephala impressa</i>	G-18,29,40						
<i>Catillicephalites marginatus</i>							
<i>Cedaria gaspensis</i>	G-29,30						
<i>Crepicephalus rivus</i>							
<i>Deiracephalus unicornis</i>							
<i>Hardyoides katherina</i>							
<i>Hardyoides minor</i>							
<i>Hardyoides tenerus</i>	G-18,30					X	
<i>Hardyoides tunda</i>							X
<i>Holmdalia punctata</i>					X		
<i>Holmdalia stenis</i>			X				
<i>Hysteropleura macgerriglei</i>				X			
<i>Kindleia mutica</i>						X	
<i>Kingstonia vagrans</i>	G-29,40						
<i>Kingstonia walcotti</i>	G-28					X	X
<i>Matania hueva</i>							
<i>Matania ovata</i>	G-18,29,40		X				
<i>Meneviella venulosa</i>							
<i>Nasocephalus flabellatus</i>							
<i>Onchocephalites punctatus</i>							
<i>Spencella spinosa</i>	G-22, 39						
<i>Talbotina degreasensis</i>	G-38						

Figure 10. Continuation of the correlation chart for the study material. *Gro. Roch.* is the Grosses Roches conglomerates of Quebec and incidence is recorded by boulder number; *Gaspé* is the Gaspé Peninsula; *Holm Dal* is the Holm Dal Formation in the extreme north of Greenland; VT is Rockledge and Skeels Corners collections of Vermont; NY is the Taconic Sequence of New York state; TN-VA encompasses collections in the mid- and southern Appalachians of Tennessee into Virginia; MO is the Bonneterre Formation of Missouri.

species	TX Ril	TX Mara	UT/NV	MT	PA	WY	Rabb	SD
<i>Araphahoia raymondi</i>								
<i>Asaphiscus wheeleri</i>			X					
<i>Bolaspidella contracta</i>			X					
<i>Catillicephala fowleri</i>								
<i>Catillicephala impressa</i>								
<i>Catillicephalites marginatus</i>								
<i>Cedaria gaspensis</i>								
<i>Crepicephalus rivus</i>								
<i>Deiracephalus unicornis</i>			X				C brv	
<i>Hardyoides katherina</i>								
<i>Hardyoides minor</i>			X				X	
<i>Hardyoides tenerus</i>	X		X	X	X	X	X	X
<i>Hardyoides tunda</i>					X			
<i>Holmdalia punctata</i>								
<i>Holmdalia stenis</i>							C selw	
<i>Hysteropleura macgerriglei</i>							X	
<i>Kindleia mutica</i>				?			C min	
<i>Kingstonia vagrans</i>								
<i>Kingstonia walcotti</i>			X	X	X		C min	
<i>Matania hueva</i>								
<i>Matania ovata</i>								
<i>Meneviella venulosa</i>								
<i>Nasocephalus flabellatus</i>		X					X	
<i>Onchocephalites punctatus</i>								
<i>Spencella spinosa</i>								
<i>Talbotina degrasensis</i>								

Figure 11. Continuation of correlation chart. *TX Riley* is Riley Formation of Texas; *TX Mara* is Marathon Uplift of west Texas; UT/NV is House Range and Wheeler Formation of Utah and Nevada; MT is Pilgrim Formation, Montana; PA is Warrior Formation of Pennsylvania; WY is Wind River of Wyoming; *Rabb* is Rabbitkettle Formation, Mackenzie Mountains of northwest Canada; SD is Deadwood Formation of South Dakota. *C min* indicates the *Cedaria minor* Zone, *C. selw* the *C. selwyni* Zone and *C. brv.* the *Cedaria brevis* Zone (Pratt 1992).

MACKENZIE MOUNTAINS		UTAH		NFLD
MARJUMAN	<i>Cedaria brevifrons</i>	<i>"Crepicephalus"</i>		ZONE 5
	<i>C. prolifera</i>			
	<i>C. selwyni</i>	----- <i>"Cedaria"</i>		?
	<i>C. minor</i>			
	Zonation not established	<i>L. calva</i>	<i>Lejopyge laevigata</i>	ZONE 4
		<i>Bolaspidea</i> <i>Bolaspidea contracta</i>	<i>P. punctuosus</i>	ZONE 3
			<i>P. atavus</i>	
		<i>"Bathyriscus- Elrathina"</i>	<i>P. gibbus</i>	ZONE 2
				ZONE 1

Figure 12. Local correlation of the Cow Head material based on coeval material from the Rabbitkettle (Canada) and Wheeler Formations. The question mark indicates that no material has been found from that interval. (Westrop et. al. 1996)

LAURENTIA		AUSTRALIA		NORTH CHINA		KAZAKHSTAN		BALTICA	
IBEXIAN	Mississquoia	DAYSONIAN	Cordylodus proavus	WAN- WAN	Mississquoia	MALYKARATA- UIAN	Paraceratopyge / Euloma	TREM- DOC	Dictyonema flabelliform
	apopsis		Michosaukia perplexa		Michosaukia orientalis				Acerocare
SUNWAPTAN	Sautia	JIN- YUAN	quasibilobus / nomas	PENGSHANIAN	Changia		Micragnostus mutabilis	DOIGELLIAN	scarabaeic
	Illoenurus		Sinosaukia impages maximus / papilio		Sinoeremoceras				Peltura minor
	Ellipsocephaloides		bifax / denticulatus prolatus / sectatrix		Quadrati-cephalus		tristulus		praecursor
	S. oweni		pahulus / squamosa	CHANGSHANIAN	Kaolishania		scrobicularis		Leptaplastus
STEPTOZAN	Taenicephalus	IDAMEAN	tertia / quarta		Changshania	SACKIAN	quadrati-formis	MAENTWEGIAN	Parabolina
	major		secunda / glabella		Chuangia		ovaliformis		spinula
	Elvinia		iata / apsis				kazakhstanicus		scanicus / angu-
	Dunderbergia		Irvingella tropica	KUSHENIAN	Drepanura		pseudangustilobus		dentatus
MARJUMAN	Prehausia	MINDVALLAN	Strigmatia diloma		Blackwelderia	AUSOCKA- NIAN	ivshini		attenuatus
	Dicanthopyge		Erivanium sentum	CHANGHIAN	Damesella		curtare		Olenus wahlenber-
	Aphelaspis		Proceratopyge cryptica		Taitzia		longiformis		truncatus
			Glyptagnostus reticulatus		Amphoton		Glyptagnostus reticulatus		gibbosus
	Crepicephalus	TEMPLE- TONIAN	Glyptagnostus stolidotus	HSÜCHUAN- GIAN	Lioparia	AMGINIAN	Glyptagnostus stolidotus	SOLVAN	Agnostus pisiform
	Cedaria		quasivespa eretes		Bailiella		simplex		
	L. laevigata		L. laevigata		Pariagranelus		L. laevigata		L. laevigata
	Punctuosus		nathorsti		Sunaspis		L. armata		brachymetopa
	Bolaspis	FLO- UND- TONIAN	nathorsti				nathorsti	MENEVIAN	lundgreni / natho-
	P. punctuosus		nathorsti				P. punctuosus		P. punctuosus
	P. atavus		optimus				P. parvifrons		P. parvifrons
	P. gibbus		P. atavus				P. atavus		P. atavus
	Orycto- cephalus		P. gibbus				P. intermedius		P. gibbus
	P. praecurrens		longinqua				ultrimus		pinus

Figure 13. Correlation of local material with other locations on the craton. Zonations shown in Figure 12 are in the lower left hand corner.

(Ludvigsen and Westrop 1985)

		SOUTHERN ALBERTA	EASTERN NEVADA	WESTERN UTAH	OKLAHOMA	WISCONSIN
MARJUMAN	IBEXIAN	<i>Missisquoi</i> <i>apopsis</i>		<i>Missisquoi</i> <i>apopsis</i>	<i>Missisquoi</i> <i>apopsis</i>	ONEOTA
	SUNWAPTAN	<i>Saukia</i>		<i>Saukia</i>	<i>Saukia</i>	JORDAN
	STEPTOEAN	<i>Iliaenurus</i>	WINDFALL			ST. LAWRENCE
		<i>Ellipsocephaloides</i> <i>S. oweni</i>				LONE
		<i>Taenicephalus</i> <i>major</i> <i>Elvinia</i>	<i>major</i> <i>Elvinia</i>	<i>Taenicephalus</i> <i>major</i> <i>Elvinia</i>	<i>Taenicephalus</i> <i>major</i> <i>Elvinia</i>	ROCK
MARJUMAN			<i>Dunderbergia</i>	<i>Dunderbergia</i>		WONEWOC
			<i>Prehousia</i>	<i>Prehousia</i>		
			<i>Dicanthopyge</i>	<i>Dicanthopyge</i>		
		<i>Aphelaspis</i>	<i>Aphelaspis</i>	<i>Aphelaspis</i>		<i>Aphelaspis</i>
		<i>Crepicephalus</i>	<i>Crepicephalus</i>	<i>Crepicephalus</i>		<i>Crepicephalus</i>
		<i>Cedaria</i>	<i>Cedaria</i>	<i>Cedaria</i>		<i>Cedaria</i>
		<i>Bolospidella</i>	<i>P. punctuosus</i>	<i>P. punctuosus</i>		
		<i>Oryctocephalus</i>	<i>P. gibbus</i>	<i>P. gibbus</i>		
			<i>Oryctocephalus</i>	<i>Oryctocephalus</i>		

Figure 14. Continuation of correlation chart in Figure 13.
(Ludvigsen and Westrop 1985)

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Appendices

Appendix A

Kindle Zone	4	2a	2a	2	2	2	2a	2a	3a	4a		4a
	98	402	413	417	418	420	421	434	448	458	459	460
Arapahoia raymondi												
Bolaspidella contracta												
Brachyaspidion spinosus												
Brassicacephalus rhakionus												
Bynumia demissa												
Catillicephalites brachys												
Catillicephalites catherinae												
Catillicephalites liami												
Catillicephalites marginatus	X											
Conocoryphe sp indet												
Dinea bovicephalus												
Dinea extremis												
Eldoradia batilla												
Holmdalia punctata												
Holmdalia stenis										X		
Hysteropleura adraini										X		X
Hysteropleura edgecombei												
Hysteropleura ramskoldi												
Hysteropleura schucherti												
Hysteropleura sp.												
Kingstonioides delgado												
Kingstonioides grandilabrum	X											
Matania hueva												
Matania ovata												
Meneviella venulosa									X			
Metisaspis sp indet												
Metisella sp indet												
Mexicella canadensis										X		
Onchocephalites punctatus		X	X	X	X	X	X	X				
Prolonchocephalus orcinus										X		
Rogeraspis burkholderi												
Spencella spinosa								X				
Syspecheilus sp.												
Kindle Zone	4	2a	2a	2	2	2	2a	2a	3a	4a		4a
	98	402	413	417	418	420	421	434	448	458	459	460

Species occurrence in numbered boulders from the 400 series (Broom Point South), plus collection 98. Letter “a” with a Kindle Zone designation indicates that that collection is assigned to the zone using agnostoids (Westrop 1996).

Appendix A

Kindle Zone	4	4?	4a	4a	4	4	3	3	3	3a	3a	3
	462	464	467	468	469	470	471	603	605	606	607	611
Arapahoia raymondi						X						
Bolaspidella contracta												
Brachyaspidion spinosus			X									
Brassicacephalus rhakionus			X	X								
Bynumia demissa			X	X								
Catillicephalites brachys								X				
Catillicephalites catherinae			X									
Catillicephalites liami			X	X				X	X		X	X
Catillicephalites marginatus			X									
Conocoryphe sp indet												
Dinea bovicephalus												
Dinea extremis		X										
Eldoradia batilla								X		X		
Holmdalia punctata							X	X			X	X
Holmdalia stenis	X		X	X	X							
Hysteropleura adraini			X	X								
Hysteropleura edgecombei					X							
Hysteropleura ramskoldi						X						
Hysteropleura schucherti											X	X
Hysteropleura sp.												
Kingstonioides delgado										X		
Kingstonioides grandilabrum			X					X				
Matania hueva	X		X									
Matania ovata	X											
Meneviella venulosa												
Metisaspis sp indet				X				X				
Metisella sp indet												
Mexicella canadensis								X				
Onchocephalites punctatus			X									
Prolonchocephalus orcinus			X									
Rogeraspis burkholderi			X	X								
Spencella spinosa												
Syspecheilus sp.			X									
	4	4?	4a	4a	4	4	3	3	3	3a	3a	3
	462	464	467	468	469	470	471	603	605	606	607	611

Continuation, species occurrence in numbered boulders from the 400 series (Broom Point South) and 600 series (White Rock Islets). Letter “a” with a Kindle Zone designation indicates that that collection is assigned to the zone using agnostoids (Westrop 1996).

Appendix A

Kindle Zone	3a	3a	3a	3a	3a	3	3	3a	3a	3a	3a	3a	3
	613	614	615	616	617	618	620	621	627	630	631	632	634
Arapahoia raymondi													
Bolaspidella contracta		X			X							X	
Brachyaspidion spinosus													
Brass'ephalus rhakionus													
Bynumia demissa													
Catillicephalites brachys	X	X	X				X	X	X				
Cat'ites catherinae													
Catillicephalites liami		X	X								X		
Cat'ites marginatus													
Conocoryphe sp indet												X	
Dinea bovicephalus				X					X				
Dinea extremis													
Eldoradia batilla											X		
Holmdalia punctata				X					X				
Holmdalia stenis													
Hysteropleura adraini		?											
Hyst'aura edgecombei													
Hysteropleura ramskoldi													
Hysteropleura schucherti			X		X	X				X	X	X	
Hysteropleura sp.			X	X									
Kingstonioides delgado			X						X				X
King'oides grandilabrum			X										
Matania hueva													
Matania ovata													
Meneviella venulosa													
Metisaspis sp indet													
Metisella sp indet			X										
Mexicella sp. indet.													
Onch'ites punctatus													
Prolonch'us orcinus													
Rogeraspis burkholderi													
Spencella spinosa													
Syspecheilus sp.	X												
	3a	3a	3a	3a	3a	3	3	3a	3a	3a	3a	3a	3
	613	614	615	616	617	618	620	621	627	630	631	632	634

Species occurrence in numbered boulders from the 600 series (White rock Islets). Letter “a” with a Kindle Zone designation indicates that that collection is assigned to the zone using agnostoids (Westrop 1996).

Appendix B

Kindle Zone collection	5a 3	5 9	5a 11	5a 12	5 20	5 21	5 22	5 26	5 28	5 33	5a 34
Avonina sp indet			X								
Blountia terranovica		X				X				X	
Catillicephala impressa					X			X			
Catillicephala fowleri	X		X		X			X		X	
Cedaria curta											
Cedaria fedora	X								X		X
Cedaria gaspensis									X		X
Cedaria superficialis									X		X
Cheilocephalus sp. indet			X								
Coosia sp			X								X
Coosina sp		X									X
Crepicephalus rivus	X										
Deiracephalus genior								X	X		
Deiracephalus intersectus			X								
Deiracephalus ornatus	X	X	X								
Deiracephalus unicornis			X								X
Hardyoides katherina											
Hardyoides minor			X								
Hardyoides tenerus			X								
Hardyoides tunda											
Holmdalia noensis			X								
Hysteropleura macgerriglei	X		X								
Kindleia mutica	X		X	X		X					
Kindleia unicornis			X								
Kindleia willamae			X								
Kingstonia vagrans	X	X			X	X		X		X	
Kingstonia walcotti		X			X	X		X		X	
Lecanopleura habros	X										
Matania kindlensis			X								
Menomonina sp.									X		
Meteoraspis borealis		X		X		X	X	X	X		X
Nasocephalus flabellatus	X										
Talbotina degrasensis	X										
Tricrepicephalus johnsoni			X	X		X					
Tricrepicephalus rusticus			X								
Tricrepicephalus tripunctata											
	3	9	11	12	20	21	22	26	28	33	34

Species from the Upper Marjuman, Zone 5. Collections assigned by means of agnostoids are designated with “a”.

Appendix B

Kindle Zone	5a	5	5	5
collection	35	36	39	48
Avonina sp indet				
Blountia terranovica			X	X
Catillocephala impressa			X	
Catillocephala fowleri			X	
Cedaria curta			X	
Cedaria fedora				
Cedaria gaspensis				
Cedaria superficialis			X	
Cheilocephalus sp. indet	X			
Coosia sp				
Coosina sp				
Crepicephalus rivus	X			
Deiracephalus genior		X	X	
Deiracephalus intersectus		X	X	
Deiracephalus ornatus				
Deiracephalus unicornis			X	
Hardyoides katherina	X	X		
Hardyoides minor		X		
Hardyoides tenerus				
Hardyoides tunda			X	
Holmdalia noensis				
Hysteropleura macgerriglei	X	X	X	
Kindleia mutica			X	
Kindleia unicornis				
Kindleia williamae				
Kingstonia vagrans	X	X	X	
Kingstonia walcotti	X		X	
Lecanopleura habros				
Matania kindlensis		X		
Menomonie sp.		X	X	
Meteoraspis borealis	X	X	X	
Nasocephalus flabellatus				
Talbotina degreasensis		X		
Tricrepicephalus johnsoni	X			
Tricrepicephalus rusticus	X	X		
Tricrepicephalus tripunctata	X			
	35	36	39	48

Continuation of Upper Marjuman data, species from Zone 5. Collection 35 is assigned by means of agnostoids.

PLATES

Marjuman (Cambrian) Trilobites (Arthropoda) of
The Cow Head Group, Western Newfoundland

Plate 1

Holmdalia stenis sp. nov.; *Holmdalia punctata* Robison 1988

Figs. 1-10, 12-15. *Holmdalia stenis* sp. nov. All x12.

Fig. 1: Cranidium [1162], BPS 469

Fig. 2, 7, 8: Cranidium [1158], BPS 467

Fig. 3: Cranidium [1175], BPS 458

Fig. 4: Cranidium [784, 468i], BPS 468

Fig. 5: Cranidium [1164], BPS 469

Fig. 6: Cranidium [1167 468c], BPS 468

Figs. 9, 10: Cranidium [1168, 1169 468a], BPS 468

Fig. 12: Holotype cranidium [1174], BPS 468

Figs. 13, 14: Cranidium [1170, 1171], BPS 462

Fig. 15: Cranidium [1173], BPS 458

Figs. 11, 16. *Holmdalia punctata* Robison 1988, x12

Fig. 11: Cranidium [1163 607e], WRI 607, x12

Fig. 16: Cranidium [1161 607a], WRI 607, x12

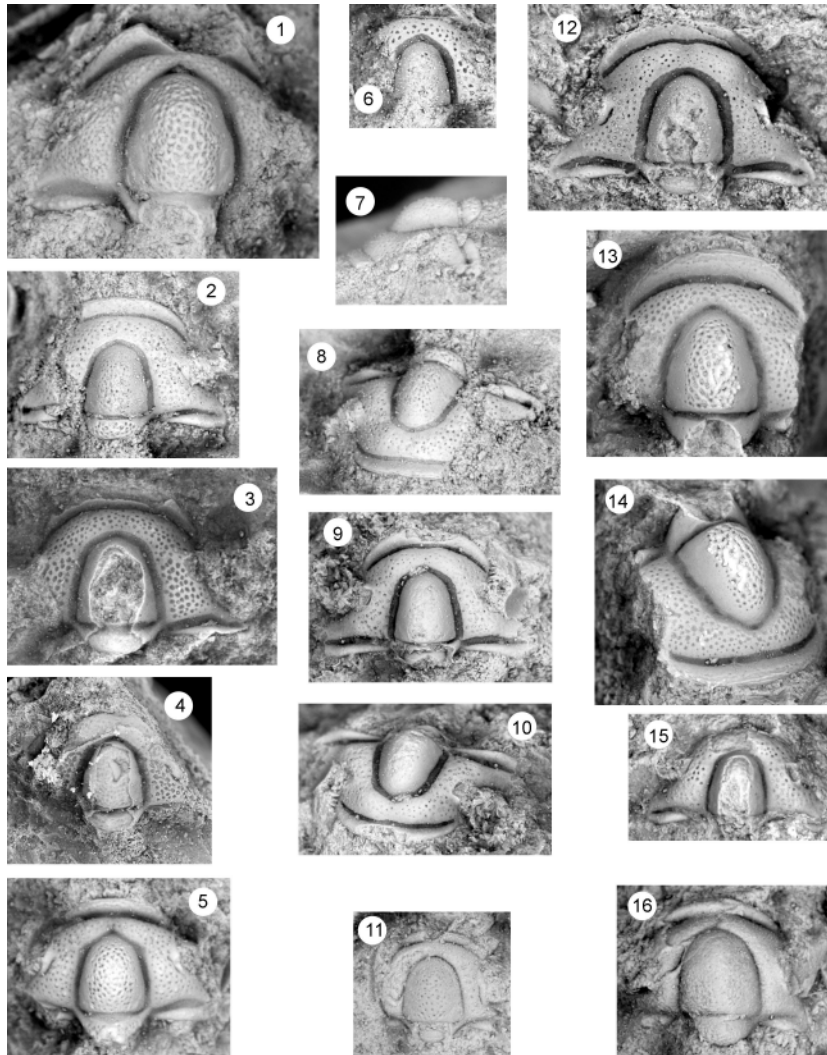


Plate 1

Plate 2

Holmdalia punctata (Rasetti 1967)

Figs. 1-18. *Holmdalia punctata* (Rasetti 1967), All x12

Figs. 1-3: Cranidium [1185-7], WRI 611

Fig. 4: Cranidium [1195], WRI 607

Fig. 5: Cranidium [1190 607c], WRI 607

Fig. 6: Cranidium [1191], WRI 616

Fig. 7: Cranidium [1194 607d], WRI 607

Fig. 8: Cranidium [1183], BPS 471

Fig. 9: Cranidium [1176], 601

Fig. 10. Cranidium [1192], WRI 627

Fig. 11. Paratype cranidium [1172], WRI 603

Fig. 12. Cranidium [1189 607b], WRI 607

Figs. 13-16: Holotype cranidium [1177-1180], WRI 603

Figs. 17, 18: Cranidium [1181, 1182 607b], WRI 607

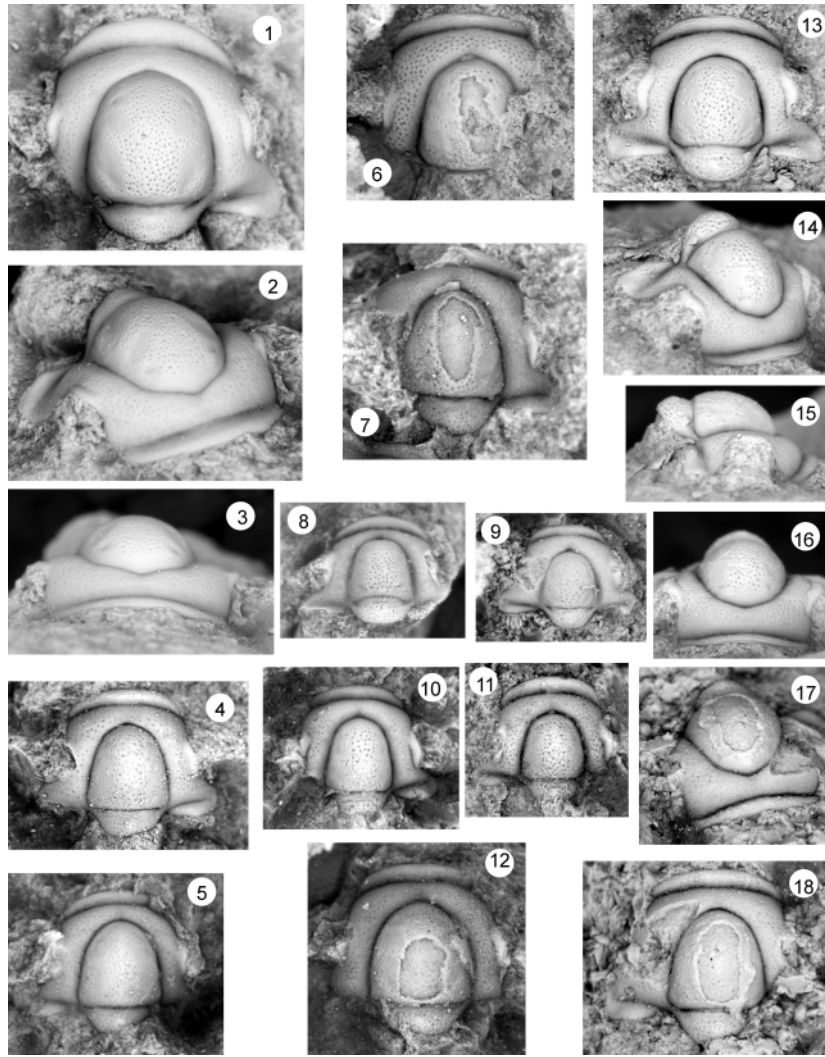


Plate 2

Plate 3

Lecanopleura habros sp. nov., *Alderia tuberculata* (Rasetti) 1946

Figs. 1-5, 8-11, 15-19, 22-26. *Lecanopleura habros*. All x6, all from CH 3, western Newfoundland

Figs. 1-3: Holotype cranidium [3b, 980-982]

Figs. 4, 5: Cranidium [3c 976, 977]

Figs. 8, 9: Cranidium [3e, 970, 971]

Figs. 10, 11: Cranidium [3d 983, 984]

Fig. 15, 17, 25: Cranidium [3a, 965, 966, 968]

Figs. 16, 23: Cranidium [3c, 973, 974]

Fig. 18: Cranidium [3, 986]

Fig. 19: Pygidium [3x, 978]

Figs. 22, 24: Cranidium [3h, 988, 989]

Fig. 26: Cranidium [3g 987]

Figs. 14, 16-21. *Alderia tuberculata* (Rasetti) 1946; all x6, all from M-17, Métis conglomerate, Quebec

Figs. 6, 7, 13, 14: Holotype cranidium 1027a [a, 995-998]

Figs. 28-31: Paratype cranidium 1027b [b 990-993]

Figs. 12, 20, 21, 31: Paratype cranidium [c 1000-1003]

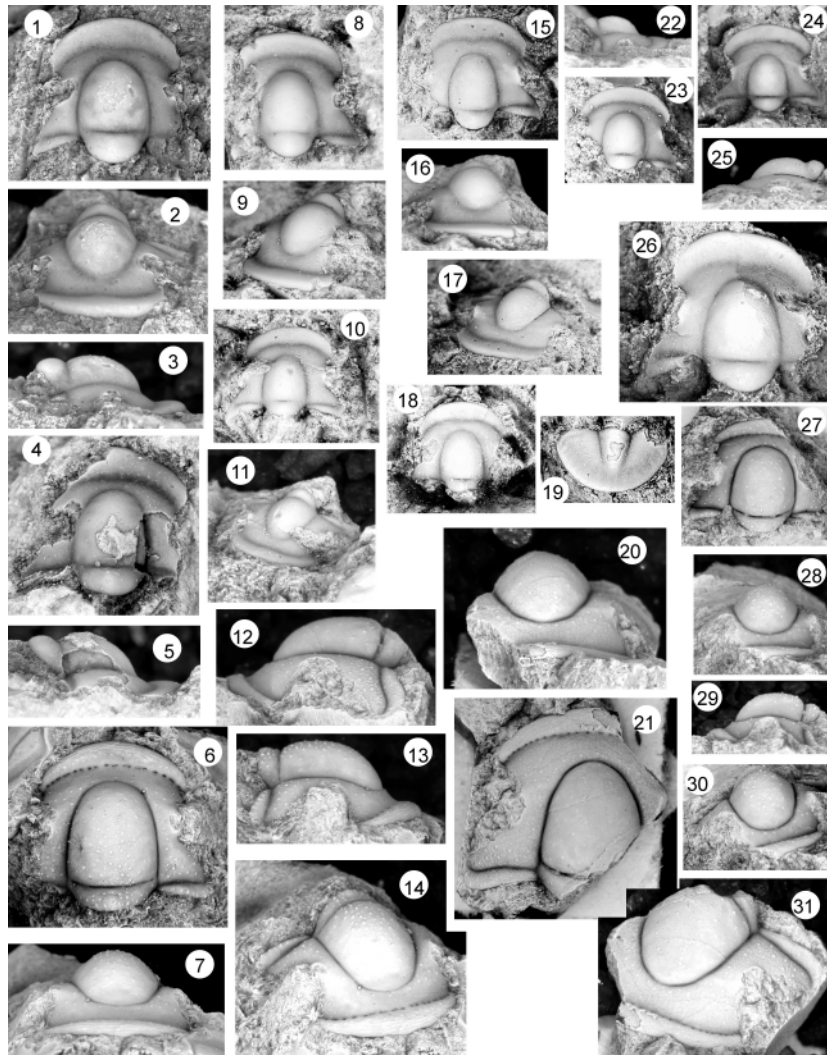


Plate 3

Plate 4

Tricrepicephalus johnsoni Kindle 1948 types, *Tricrepicephalus*
rusticus Kindle 1948 types

Figs. 1-9: *Tricrepicephalus johnsoni* types Kindle 1948

Figs. 1-4: Holotype cranidium UPM 57904 [254-7] x2

Fig. 5: Pygidium UPM 57909 [427] x2

Figs. 6-9: Paratype cranidium UPM 57903 [408-11] x2

Figs. 10-17: *Tricrepicephalus rusticus* types Kindle 1948

Fig. 10: Pygidium [412] x3

Fig. 11: Pygidium UPM 9459 [405] x3

Figs. 12-14: Cranidium [413-5] x5

Figs. 15-17: Cranidium [429-31] x5

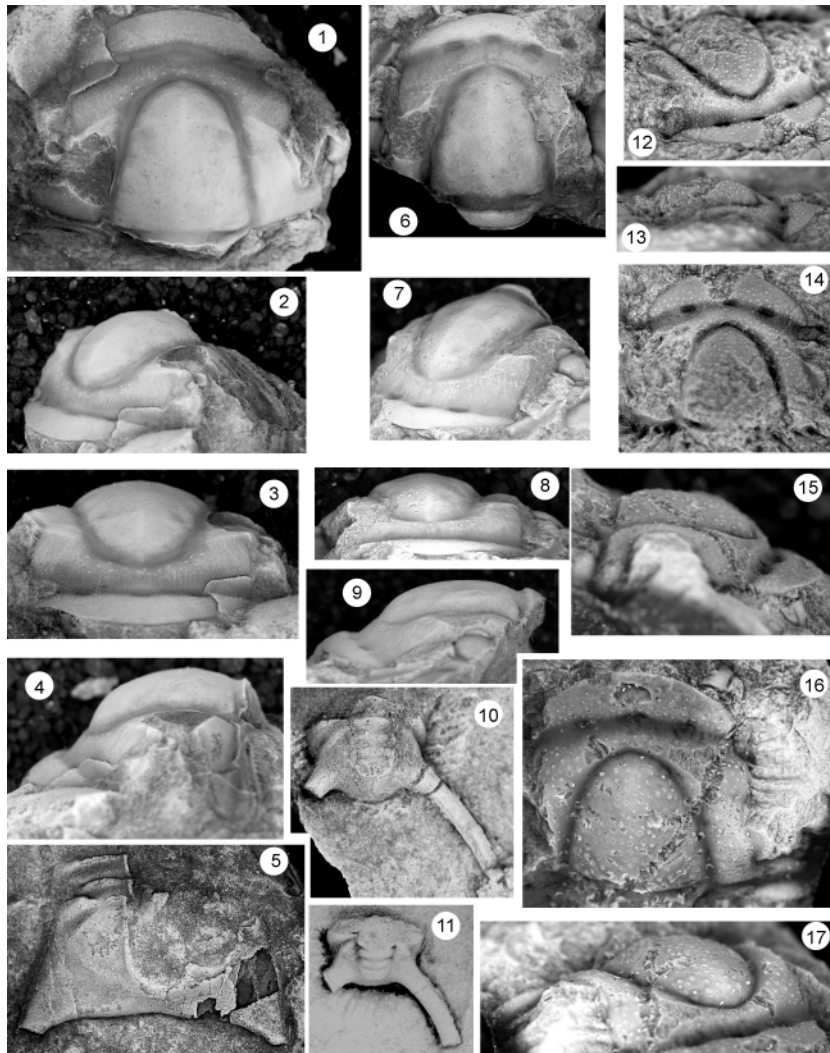


Plate 4

Plate 5

Tricrepicephalus murphyi Kindle 1948 types, *Tricrepicephalus rusticus* Kindle 1948,
Tricrepicephalus johnsoni Kindle 1948, *Tricrepicephalus tripunctata* (Whitfield)

1876

Figs. 1, 2: *Tricrepicephalus murphyi* Kindle 1948

Fig. 1: Holotype cranidium UPM 9456 [407] x2

Fig. 2: Pygidium UPM 9457 [395] x2

Figs. 3-5, 7, 8: *Tricrepicephalus* cf *T. tripunctata* (Whitfield) 1876

Figs. 3-5: Cranidium [35m 269], CH 35 x5

Figs. 7, 8: Cranidium [310, 313], CH 35 x5

Figs. 6, 9-12, 19 : *Tricrepicephalus johnsoni* Kindle 1948

Fig. 6: Pygidium [660], CH 11 x2

Figs. 9-12: Pygidium [35n 657-660], CH 35 x2

Fig. 19: Pygidium [12c 291], CH 12 x2

Figs. 13-18: *Tricrepicephalus rusticus* Kindle 1948

Fig. 13: Cranidium [11o 653] CH 11 x5

Figs. 14, 15: Pygidium [307], CH 36 x5

Figs. 16-18: Cranidium [35L 314-7], CH 35 x5

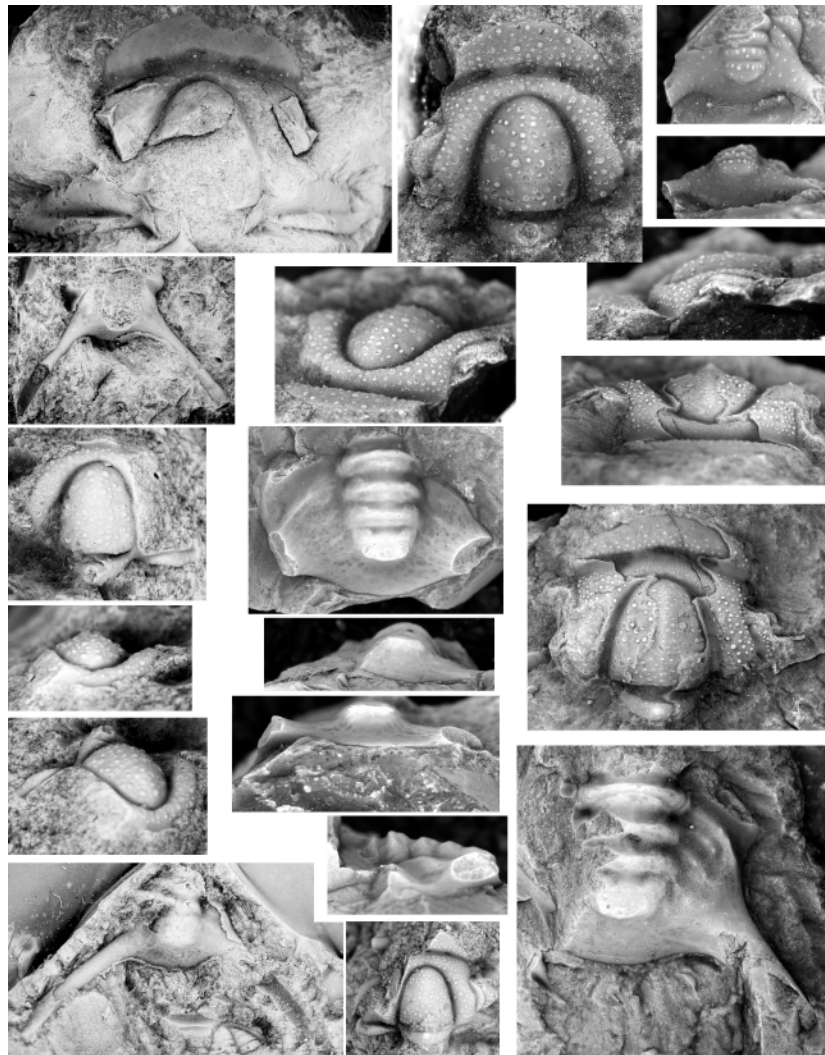


Plate 5

Plate 6

Tricrepicephalus johnsoni Kindle 1948, *Tricrepicephalus rusticus*

Kindle 1948

Figs. 1-4, 7, 10, 11, 13, 18, 19, 20: *Tricrepicephalus johnsoni* Kindle 1948

Figs. 1-4: Cranidium [21c 265-8], CH 21 x2

Figs. 7, 13, 14: Cranidium [21b 261-4], CH 21 x2

Figs. 10, 11: Cranidium [12a 294], CH 12 x2

Figs. 15-18: Cranidium [12b 283-6], CH 12 x2

Figs. 19, 20: Cranidium [35d 298-301], CH 35 x2

Figs. 5, 6, 8, 9, 12: *Tricrepicephalus rusticus* Kindle 1948

Figs. 5, 6, 12: Cranidium [11a 650-2], CH 11 x5

Figs. 8, 9: Cranidium [35n 657-8], CH 35 x5

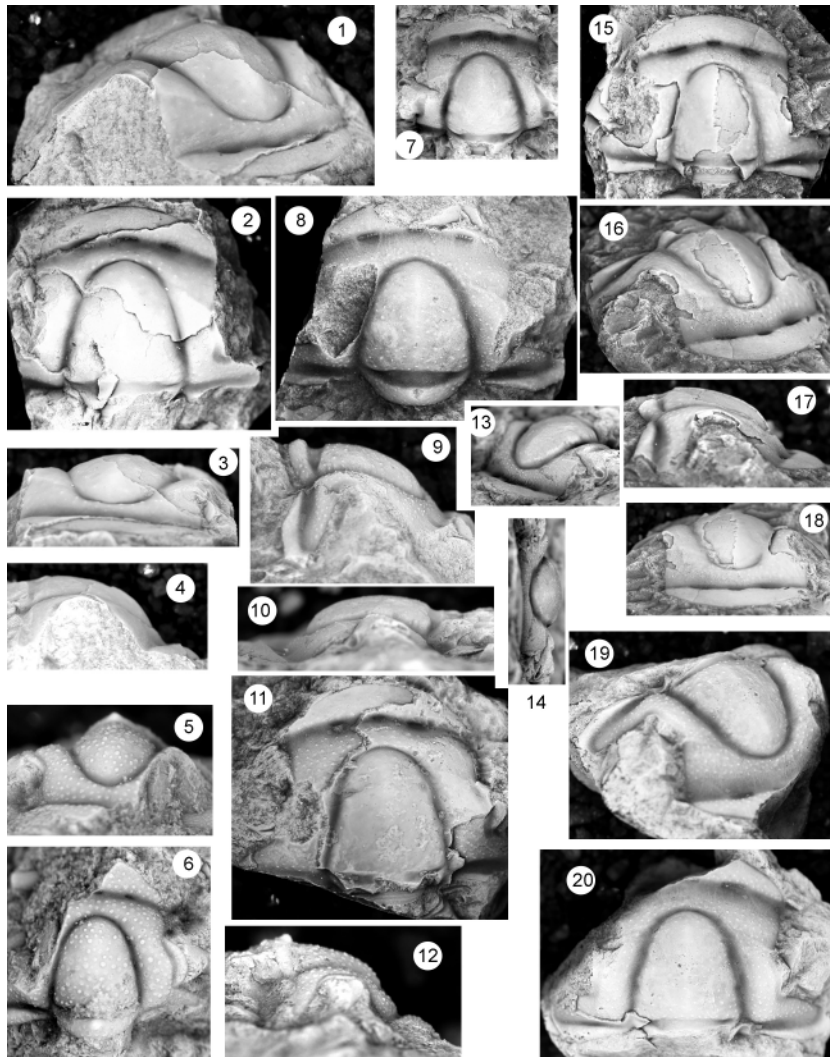


Plate 6

Plate 7

Meteoraspis borealis Lochman 1938

Figs. 1-17: *Meteoraspis borealis* Lochman 1938, figured previously by C Kindle (1948)

Figs. 1-4: Cranidium [389-392] x4

Figs. 5, 6: Pygidium 9412 [433-4] x6

Figs. 7, 8, 10, 11: Cranidium [420-3] x4

Fig. 9: Pygidium 9460 [432] x6

Fig. 12: Pygidium [406] x4

Figs. 13-16: Cranidium [397-400] x4

Fig. 17: Free cheek [424] x4

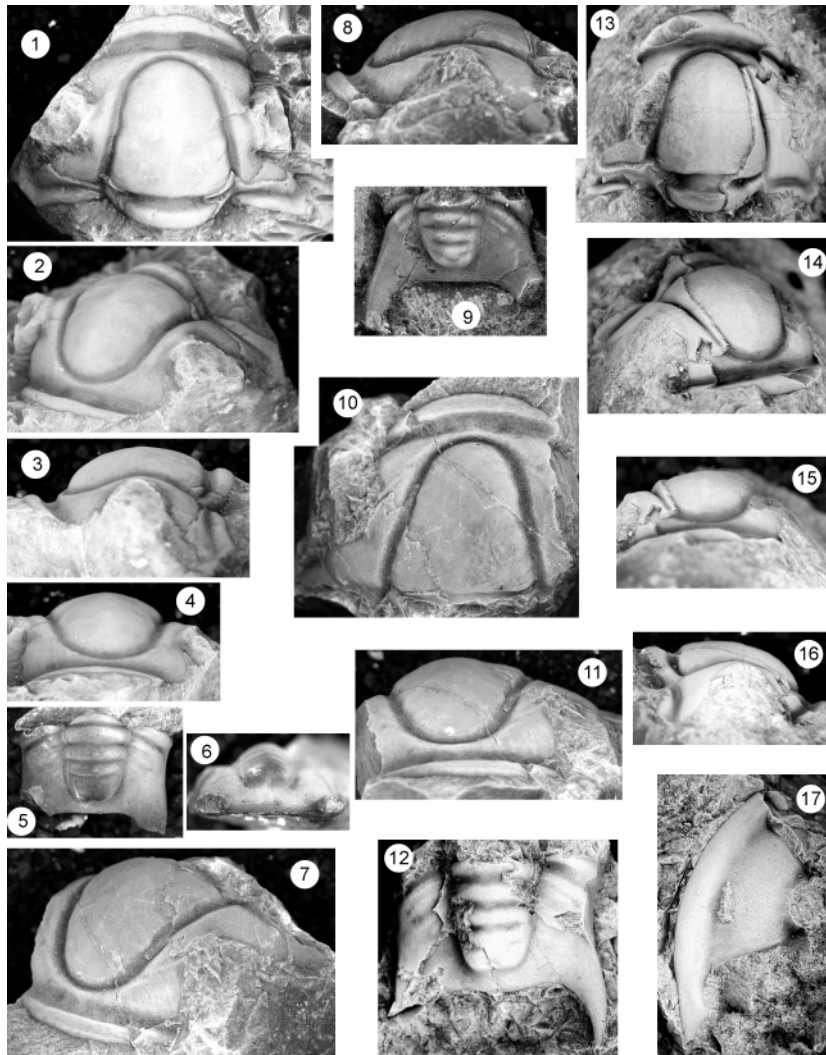


Plate 7

Plate 8

Meteoraspis borealis Lochman 1938

Figs. 4, 14: *Meteoraspis borealis* holotype YPM 15849 x4

Figs. 1-3, 5-13: *Meteoraspis borealis* Lochman 1938

Figs. 1, 2: Cranidium [22m 634-5] , CH 22 x3

Fig. 3: Cranidium [272], CH 9 x3

Fig 5: Cranidium [3a 238], CH 3 x6

Figs. 6-8: Cranidium [22c 249, 251, 252], CH 22 x3

Fig. 9: Cranidium [22e 637], CH 22 x3

Figs. 10-12: Cranidium [22g 242, 243, 245], CH 22 x3

Fig. 13: Pygidium [22m 659], CH 22 x3

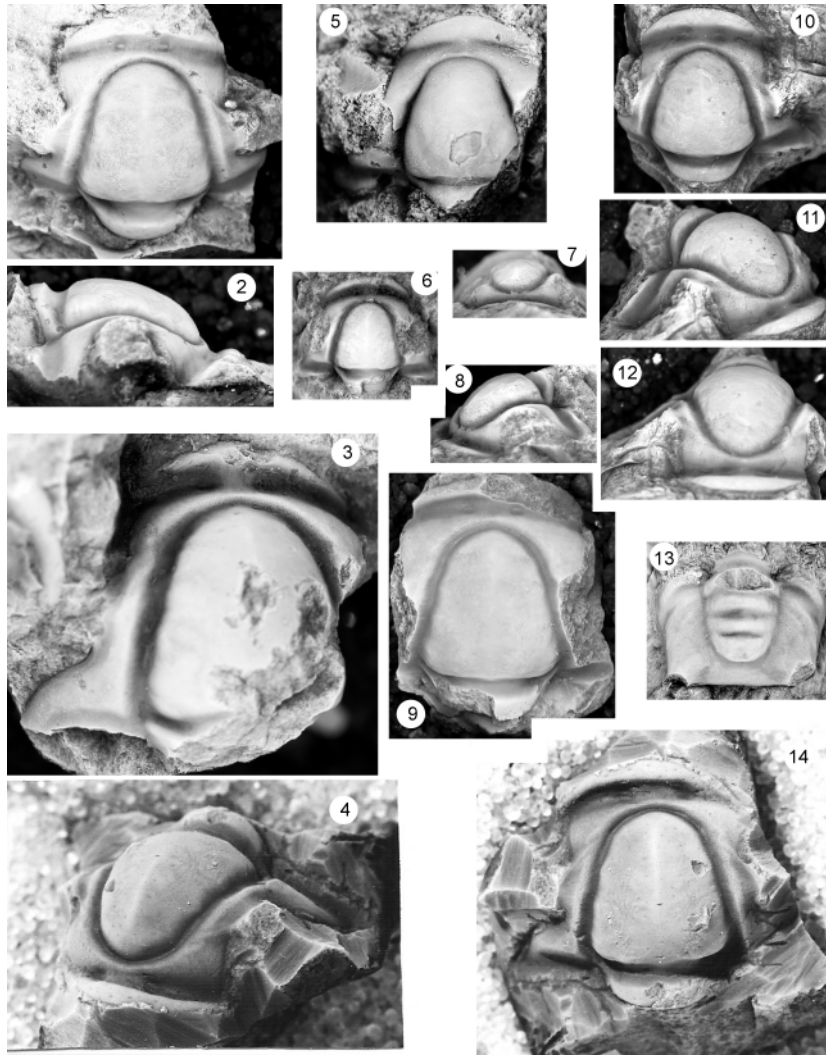


Plate 8

Plate 9

Kindleia unicornis (Kindle) 1948

Figs. 1-6: *Kindleia unicornis* (Kindle) 1948, Cow Head

Figs. 1-3: Holotype cranidium Princeton 57901 [230-234] x4

Figs. 4, 5: Pygidium [380, 1715], CH 11 x10

Fig. 6: Cranidium [11p 1734], CH 11 x10

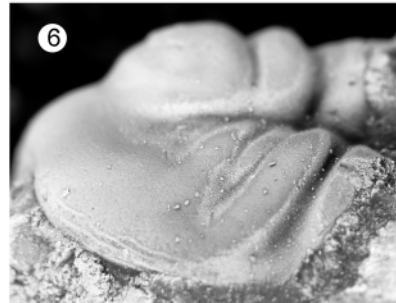
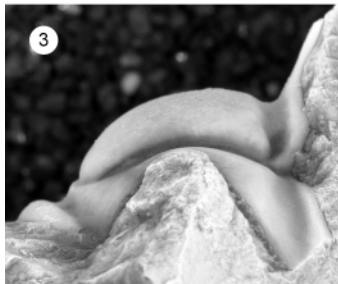
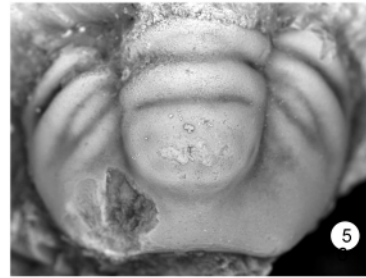
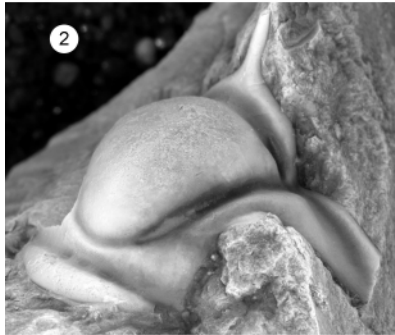


Plate 9

Plate 10

Kindleia williamae gen. nov. sp. nov.

Figs. 1-11: *Kindleia williamae* gen. nov. sp. nov. all x10

Figs. 1-4: Holotype cranidium [11L c 1740-43], CH 11

Figs. 5-8: Paratype cranidium [11o 1719-22], CH 11

Fig. 9: Cranidium [12f 1744], CH 12

Fig. 10: Cranidium [11t 1728], CH 11

Fig. 11: Cranidium [11c 1717], CH 11

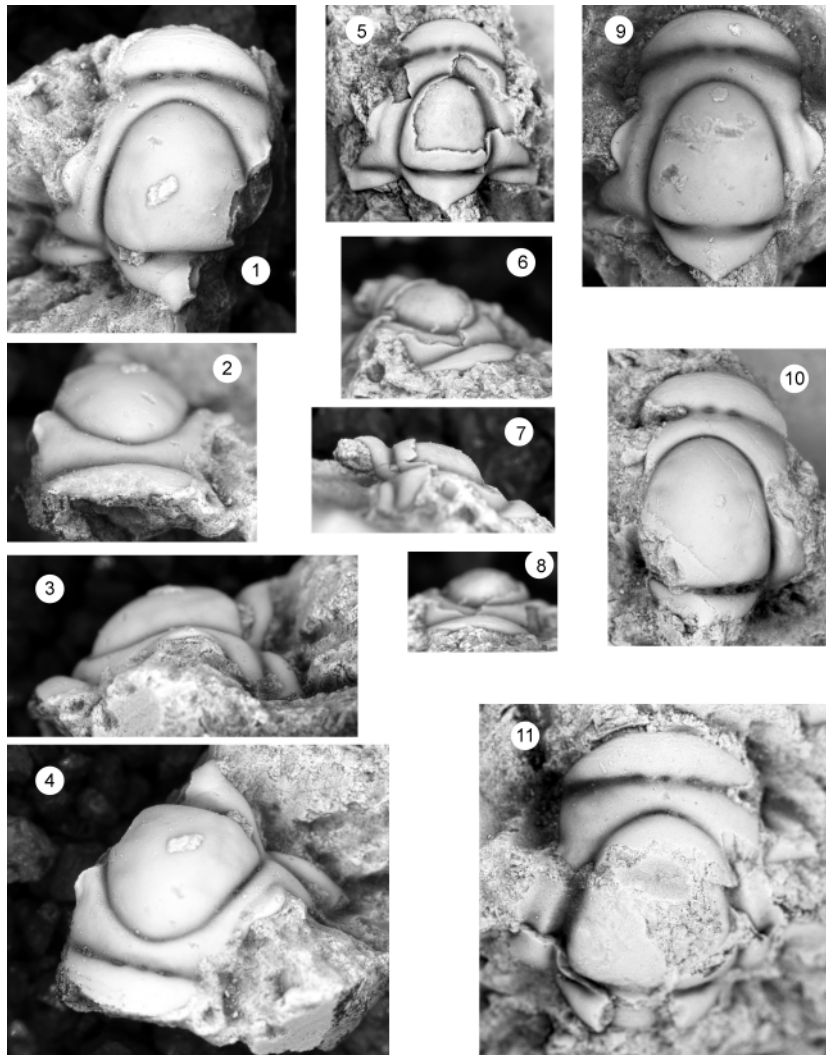


Plate 10

Plate 11

Kindleia mutica (Rasetti) 1961, *K. williamae* sp. nov.

Figs. 1-4, 6-13: *Kindleia mutica* (Rasetti) 1961

Figs. 1, 3: Cranidium [21b 641-2], CH 21 x3

Figs. 3, 4: Cranidium [648-9], CH 39 x8

Figs. 6-8: Cranidium [11a 1725, 342-3], CH 11 x16

Fig. 9, 10: Cranidium [11k 731, 372], CH 11 x10

Fig. 11: Cranidium [1735], CH 3 x10

Fig. 12: Exfoliated cranidium [12f 1744], CH 12 x10

Fig. 13: Exfoliated cranidium [11b 1733], CH 11 x10

Fig. 5, 14: *Kindleia williami* sp. nov.

Fig. 5: Cranidium [11o 1719], CH 11 x10

Fig. 14: cranidium amid debris typical of CH 11 [11t 1730] x10

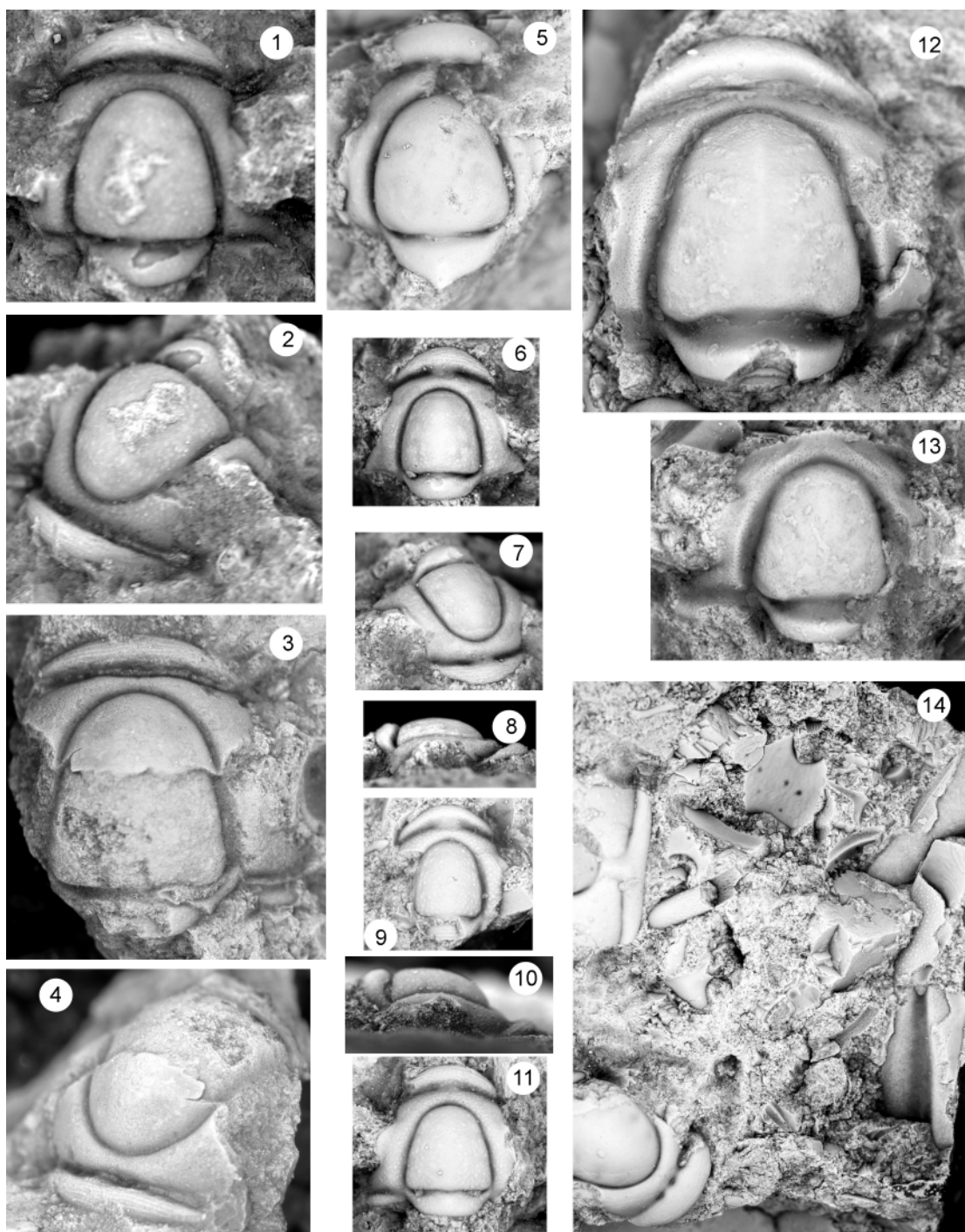


Plate 11

Plate 12

Crepicephalus rivus Kindle 1948, figs. 1-3 (paratype), figs. 4-12

Figs. 1-3: *Crepicephalus rivus* Kindle 1948, x3

Figs. 1-3: Paratype cranidium NMC 9468 [402-404]

Figs. 4-12: *Crepicephalus rivus* Kindle 1948

Figs. 4, 5: Cranidium [35d 690-1], CH 35 x6

Figs. 6: Cranidium [K], CH 35 x6

Fig. 7: Cranidium, CH 35 x6

Figs. 8, 12: Pygidium [35 687-8], CH 35 x6

Figs. 9: Cranidium [K], CH 35 x6

Figs. 10, 11: Cranidium [K], CH 35 x6

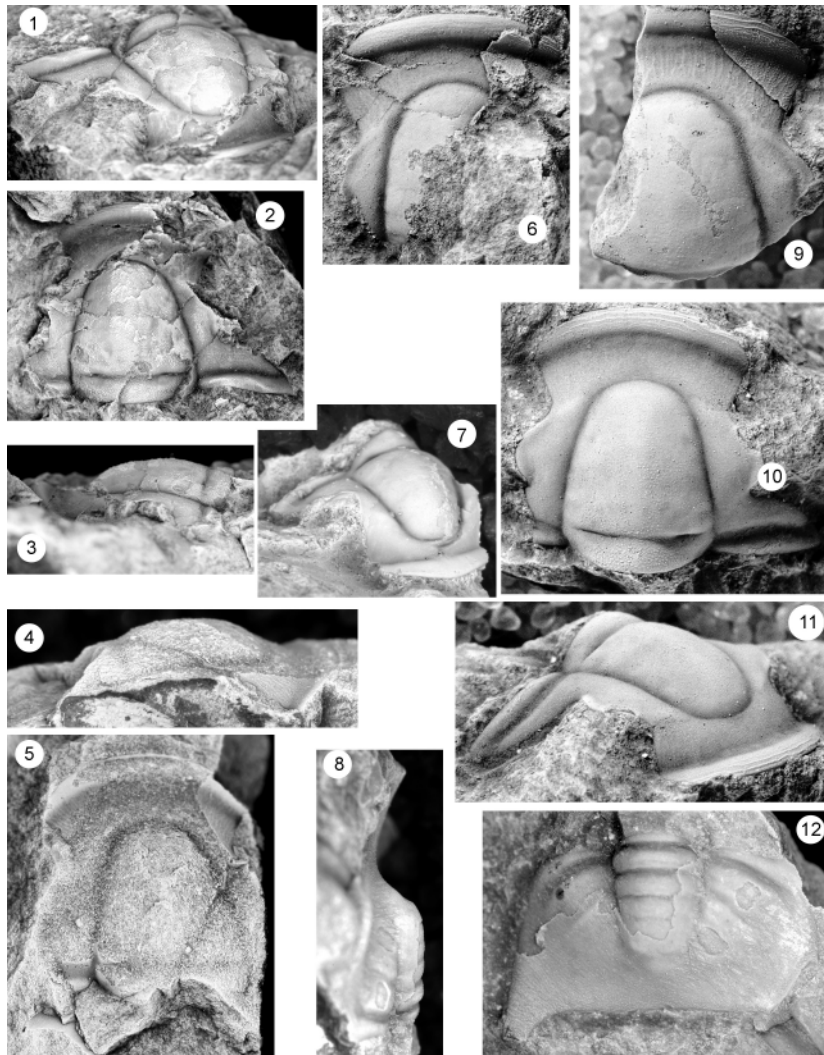


Plate 12

Plate 13

Nasocephalus flabellatus Wilson 1954, *Coosina* sp. indet., *Coosia* sp. indet.

Figs. 1-5: *Coosina* sp. indet.

Fig. 1: Cranidium [9 1250], CH 9 x4

Fig. 2: Pygidium [34 1248], CH 34 x4

Figs. 3-5: Cranidium [1253 1255], CH 9 x4

Figs. 6, 7, 10-13: *Nasocephalus flabellatus* Wilson 1954, all CH 3 x13

Figs. 6, 7, 11: Cranidium [493-495]

Figs. 10, 12: Pygidium [497, 499]

Fig. 13: Cranidium [400]

Figs. 8, 9: *Coosia* sp. indet.

Figs. 8, 9: Partial cranidium [11 34 1245-6], CH 11 x4

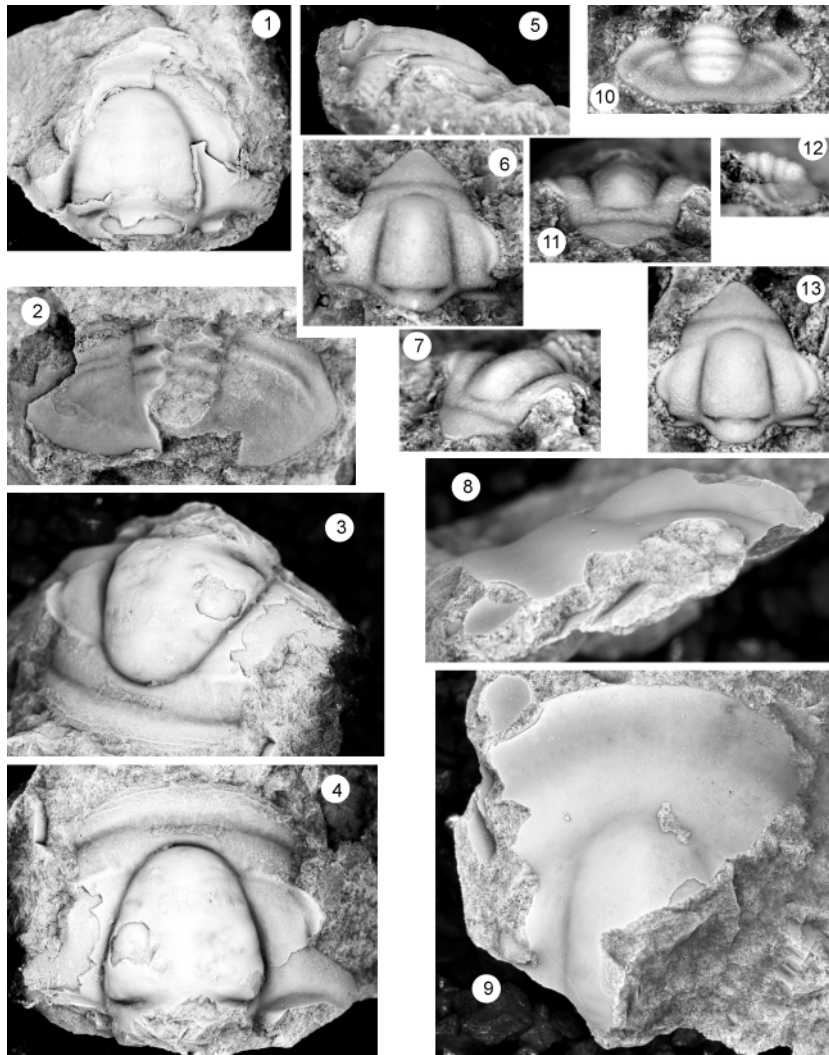


Plate 13

Plate 14

Blountia cf. *B. terranovica* Lochman 1938

Figs. 1-8, 11, 16: *Blountia terranovica*, Block G-28, Grosses Roches, w Gaspé. All x 5; described as *Blountia gaspensis* Rasetti 1946

Figs. 1, 2: Paratype cranidium 1004d [1706-7]

Figs. 3, 4, 6, 7: Holotype cranidium 1004a [1710-3]

Fig. 5: Paratype pygidium 1004c [1708]

Fig. 8: Paratype pygidium 1004 b [1709]

Fig. 11: Pygidium 1004f [1705]

Fig. 16: Pygidium 1004e [1714]

Figs. 9, 10, 12-15: *Blountia terranovica* Lochman 1938. All x7

Fig. 9, 14-15: Cranidium [624-6], CH 39

Fig. 10: Pygidium [11q 630], CH 11

Fig. 12, 13: Cranidium [627-8], CH 21

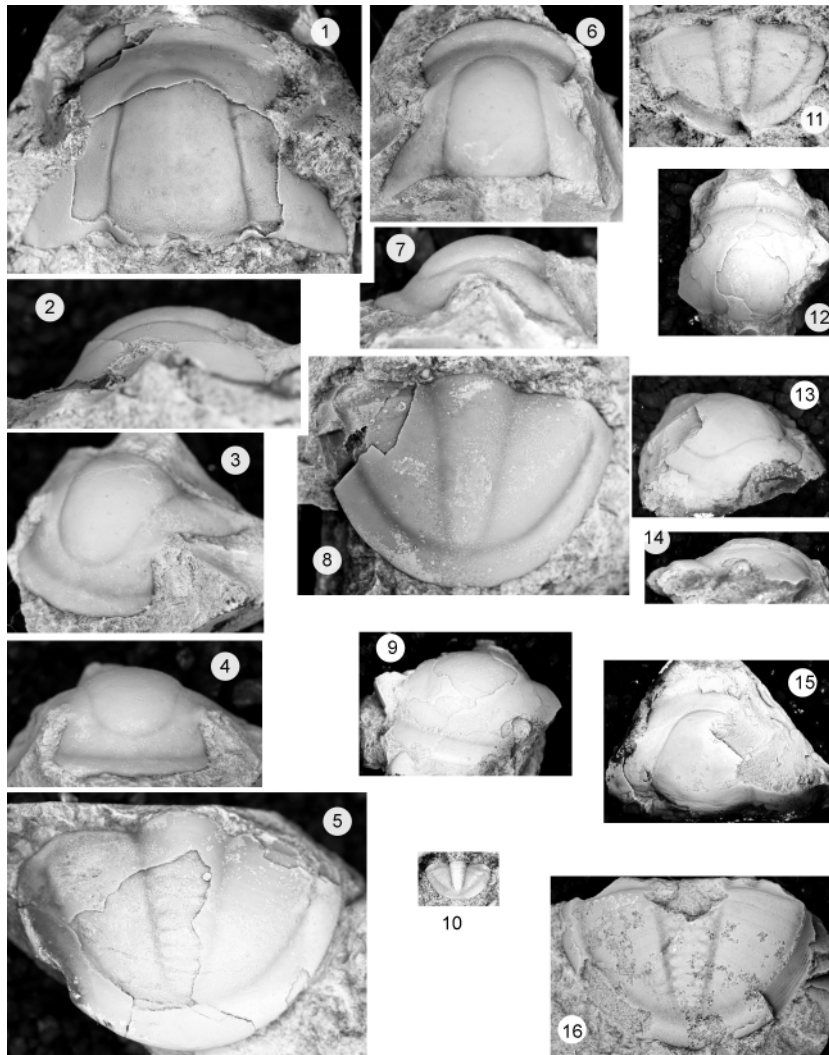


Plate 14

Plate 15

Kingstonioides delgada Rasetti 1963, *Metisella* sp. indet.,

Metisaspis sp. indet.

Figs. 1-8: *Kingstonioides delgada* Rasetti 1963, all x7

Figs. 1, 2: Holotype cranidium [620-1], WRI 606

Figs. 3, 4: Cranidium [579, 581], WRI 627

Figs. 5, 6: Cranidium [600, 602], WRI 627

Fig. 7: Cranidium [588], WRI 634

Fig. 8: Cranidium [471], WRI 615

Figs. 9-11: *Metisella* sp. indet., x6

Figs. 9-11: Cranidium [615a 1455-7], WRI 615

Figs. 12-14: *Metisaspis* sp. indet. x6

Figs. 12, 13: Cranidium [1466, 1467], WRI 603

Fig. 14: Cranidium [1465], BPS 468

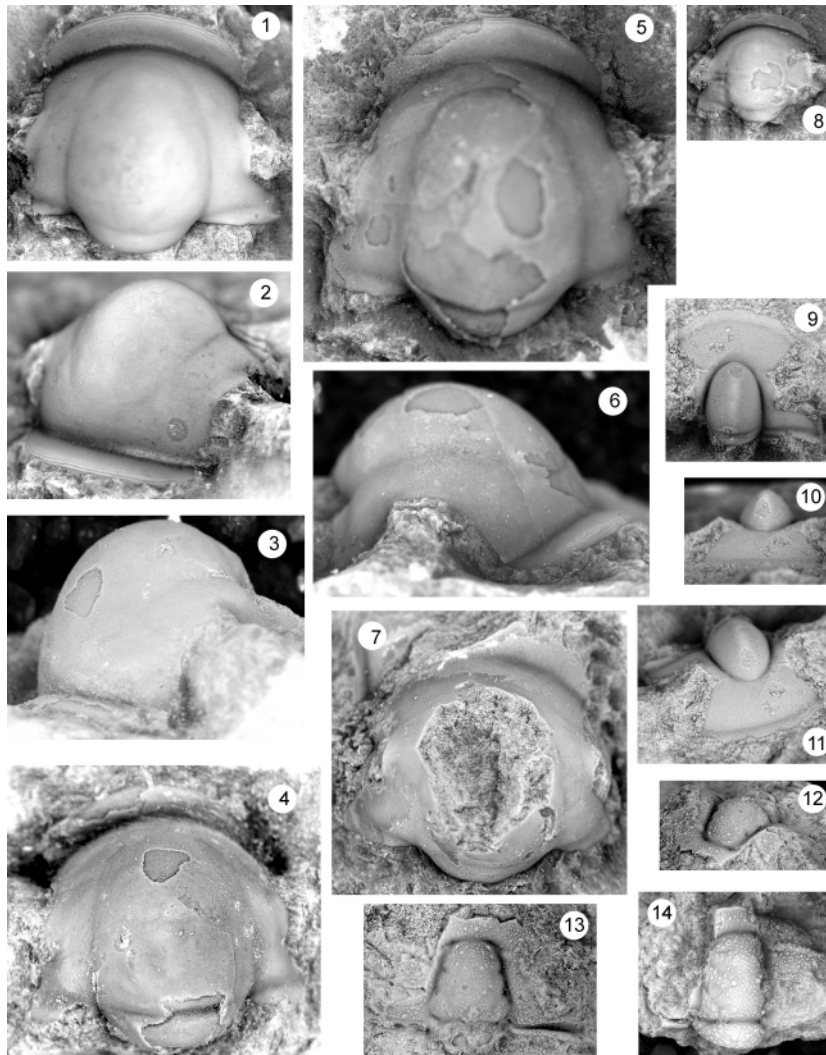


Plate 15

Plate 16

Kingstonioides grandilabra sp. nov.

Figs. 1-16. *Kingstonioides grandilabra* Fritz 1970, all x7

Figs. 1, 2: Cranidium [615a 550, 553], WRI 615

Fig. 3: Cranidium [615a 568], WRI 615

Fig. 4: Cranidium [576], WRI 603

Figs. 5-7, 10: Cranidium [615a 557-560], WRI 615

figs. 11-12: Pygidium [615a 554-5], WRI 615

Figs. 8, 9, 14, 15: Holotype cranidium [570-1, 573-4], WRI 603

Fig. 13: Cranidium [561], WRI 603

Fig. 16: Pygidium [615Ab 547], WRI 615

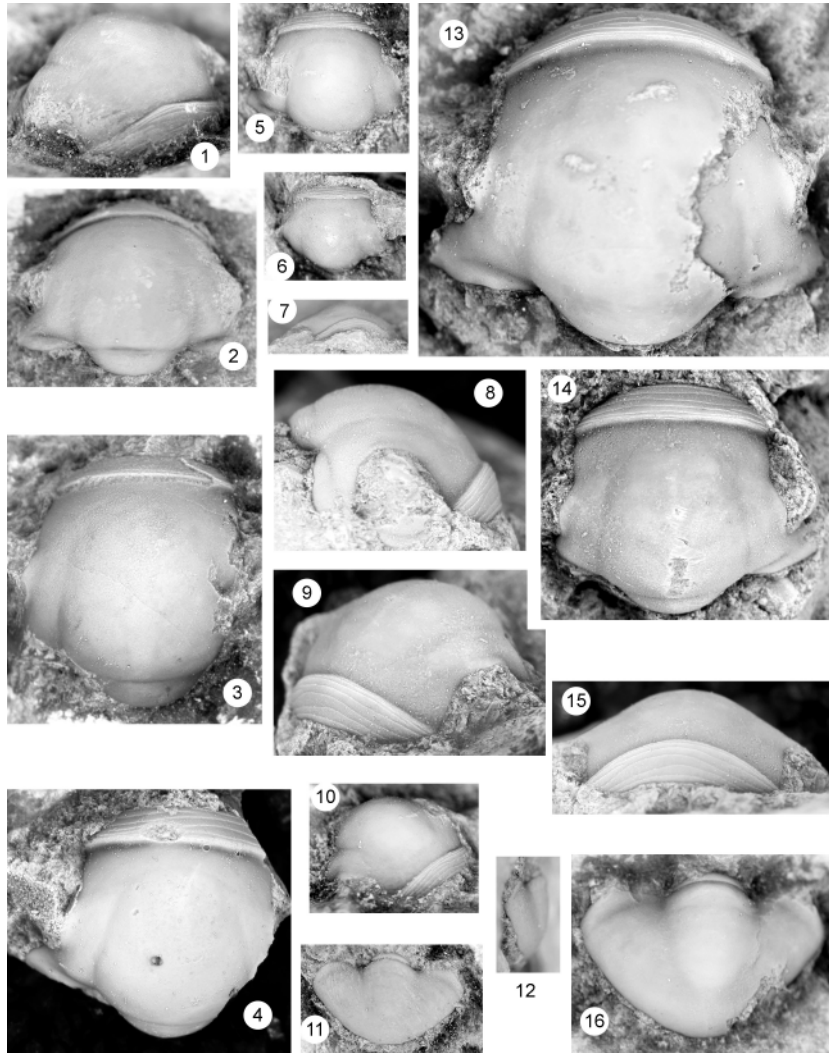


Plate 16

Plate 17

Kingstonia walcotti Resser 1938

Figs. 1-11: *Kingstonia walcotti* Resser 1938, all x9, chosen by Rasetti (1946) but not figured.

Figs 1-4: Cranidium 1024 c [1659-62]

Figs. 5, 9: Cranidium 1024 d [1671-2]

Figs. 6, 10: Pygidium 1024 j [1667-8]

Figs. 7, 8: Cranidium 1024 e [1667, 1669]

Fig. 11: Cranidium 1024 g [1665]

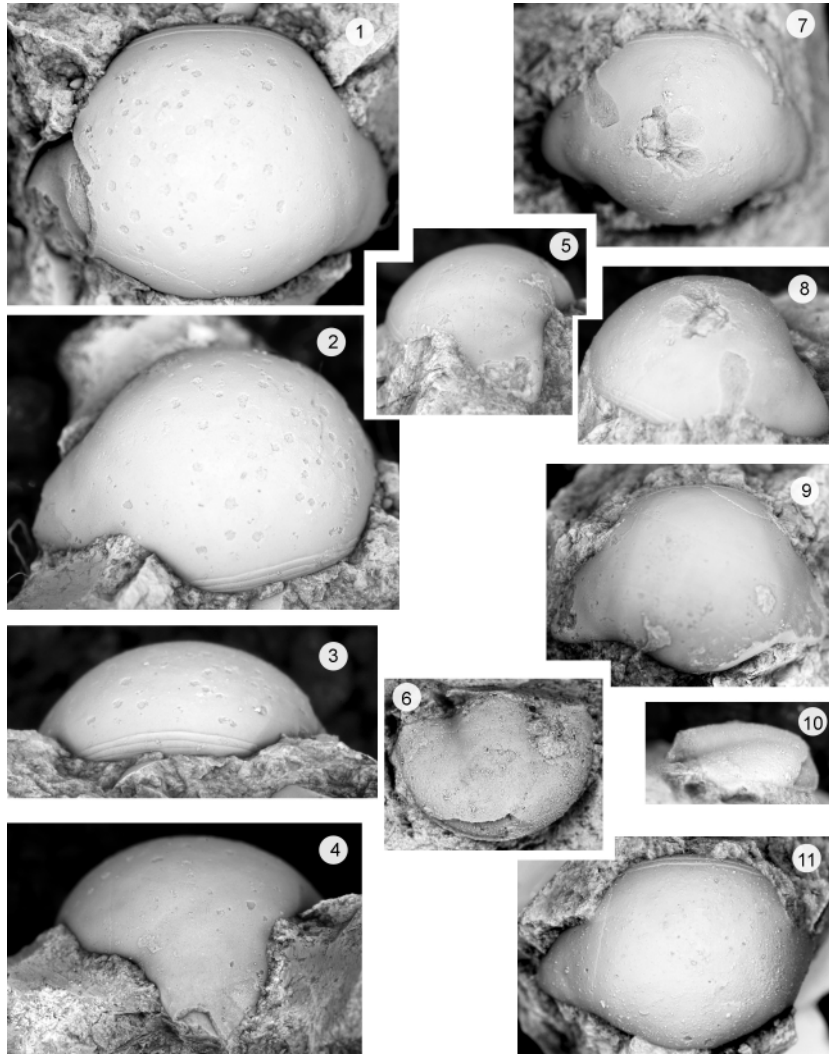


Plate 17

Kingstonia vagrans, Lochman 1938, types, described as

K. (quebecensis Rasetti 1946)

Figs. 1-4, 11: *Kingstonia vagrans*, holotype and paratypes

Figs. 1, 2: Paratype cranidium YPM 15495 [K35-11, 12], x12

Figs. 3, 4: Holotype cranidium YPM 15841 [K35-09, 10], x15

Fig. 11: Paratype pygidium YPM 15842 [K36-02], x9

Figs. 5-10, 12-17. *Kingstonia vagrans* paratypes. All x9

Figs. 5, 17: Paratype cranidium 1025e [1686-7]

Figs. 6, 14: Paratype cranidium 1025 i [1680-1]

Fig 7: Paratype cranidium 1025 h [1683]

Figs. 8, 13: Paratype cranidium 1025 j [1684-5]

Fig. 9: Paratype cranidium 1025 f [1676]

Fig. 10: Paratype pygidium p [1679]

Fig. 12: Paratype pygidium 1025 q [1688]

Figs. 15, 16: Paratype cranidium 1025 g [1677-8]

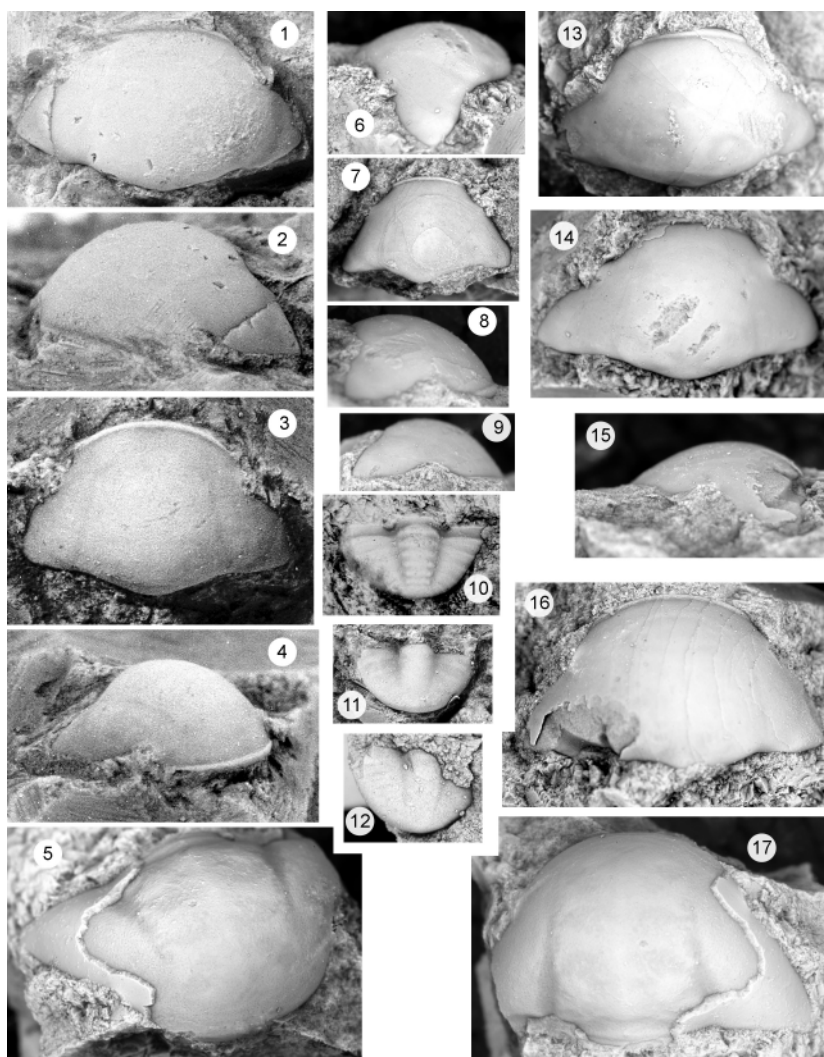


Plate 18

Plate 19

Bynumia metisensis Rasetti 1946, *Alderia punctata* (Rasetti) 1946

Figs. 1-13, 15, 16. *Bynumia metisensis* Rasetti 1946, all from M-17, Métis Cglmte, Quebec

Figs. 5-7, 9: Holotype cranidium 1010a [a 746-749] x4

Figs. 8, 10, 12, 15: Paratype cranidium 1010b [b 751-753] x4

Figs. 1-4: Paratype cranidium 1010f [f 762-765] x6

Fig. 11: Paratype cranidium 1010e [e 756] x8

Fig. 13: Paratype cranidium 1010 d [d 745] x4

Figs. 14, 16-21. *Alderia punctata* (Rasetti) 1946. All x5, all from G-28, Gross Roches, Quebec

Figs. 14, 17, 18, 21: Holotype cranidium 1026a [a 861-864]

Figs. 16, 18, 19, 20: Paratype cranidium 1026 b, c. [857, 859, 860, 864]

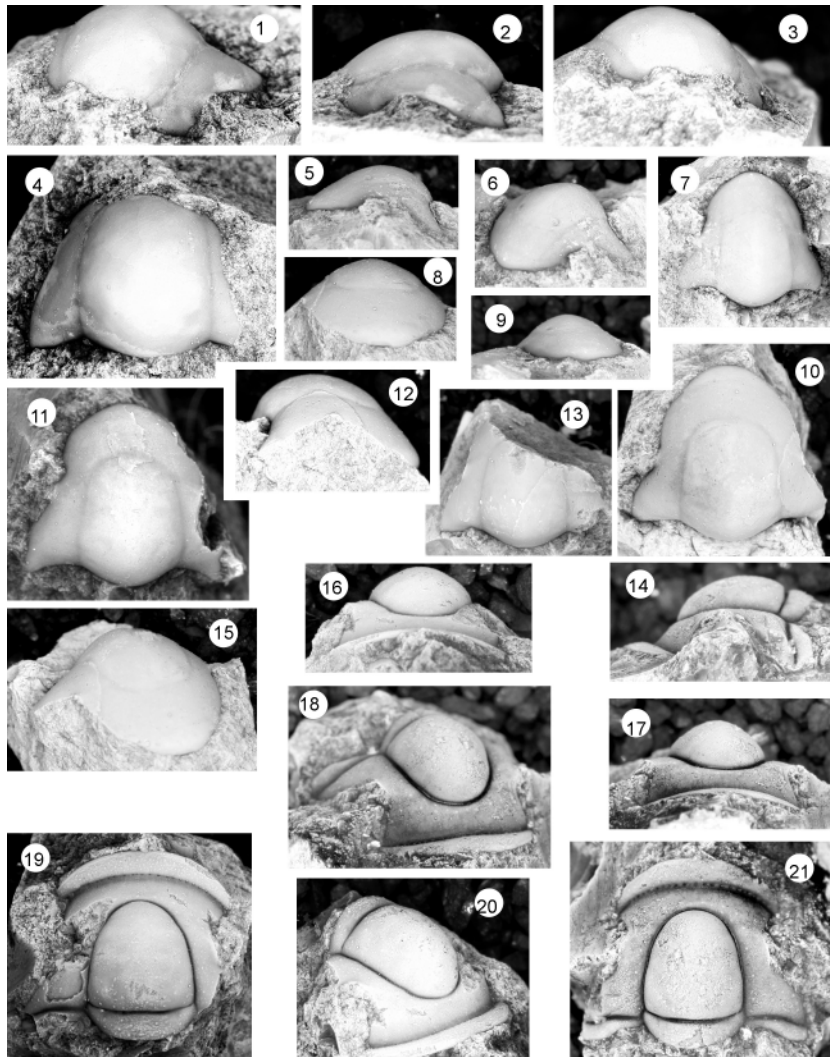


Plate 19

Plate 20

Bynumia demissa sp. nov. and *Meneviella* cf. *M. venulosa* (Salter) 1986

Figs. 1-16. *Bynumia demissa* sp. nov., all x10 except fig. 12

Figs. 1-3: Paratype cranidium [47-49 468c], BPS 468

Figs. 4-7: Paratype cranidium [54-57], BPS 468

Figs. 8-11: Paratype cranidium [58-61 467d], BPS 467

Fig. 12: Cranidium [606 468e], BPS 468 x6

Figs. 13-16: Holotype cranidium [50-52], BPS 468

Figs. 17-19. *Meneviella* cf. *M. venulosa* (Salter) 1865, x10, BPS 448, western
Newfoundland

Figs. 17-19: Cranidium [6, 7, 9]

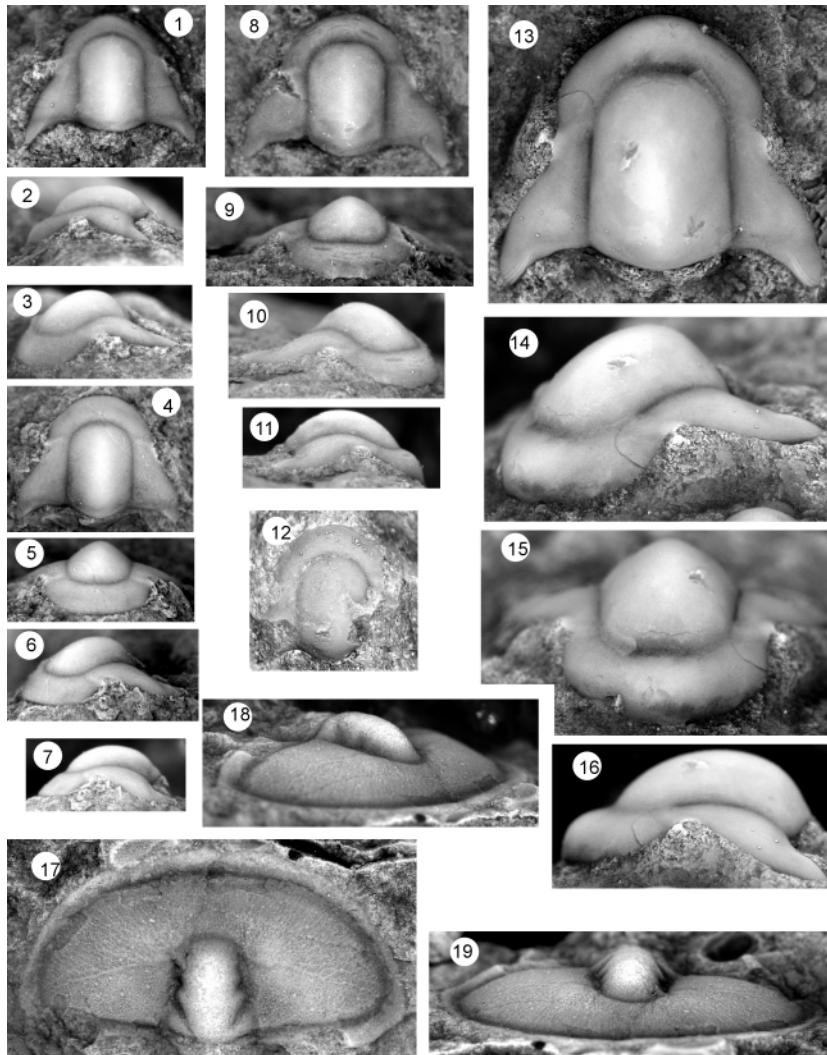


Plate 20

Plate 21

Prolonchocephalus orcinus sp. nov., *Conocoryphe* sp. indet.

Figs. 1-3, 7-9, 13-15: *Prolonchocephalus orcinus* sp. nov. All x9

Figs. 1, 2: Holotype cranidium [1328], BPS 467

Figs. 3, 8, 15: Cranidium [1324-7], BPS 467

Figs. 7, 13, 14: Cranidium [1331-2], BPS 458

Fig. 9: Cranidium [467f 1424], BPS 467

Figs. 4-6, 10-12, 16, 17: *Conocoryphe* sp. nov., all WRI 632, x10

Figs. 4-6, 10: Holotype cranidium [632b 13-16]

Fig. 11: Cranidium [632c 10]

Figs. 12, 16, 17: Paratype cranidium [632a 2, 5]

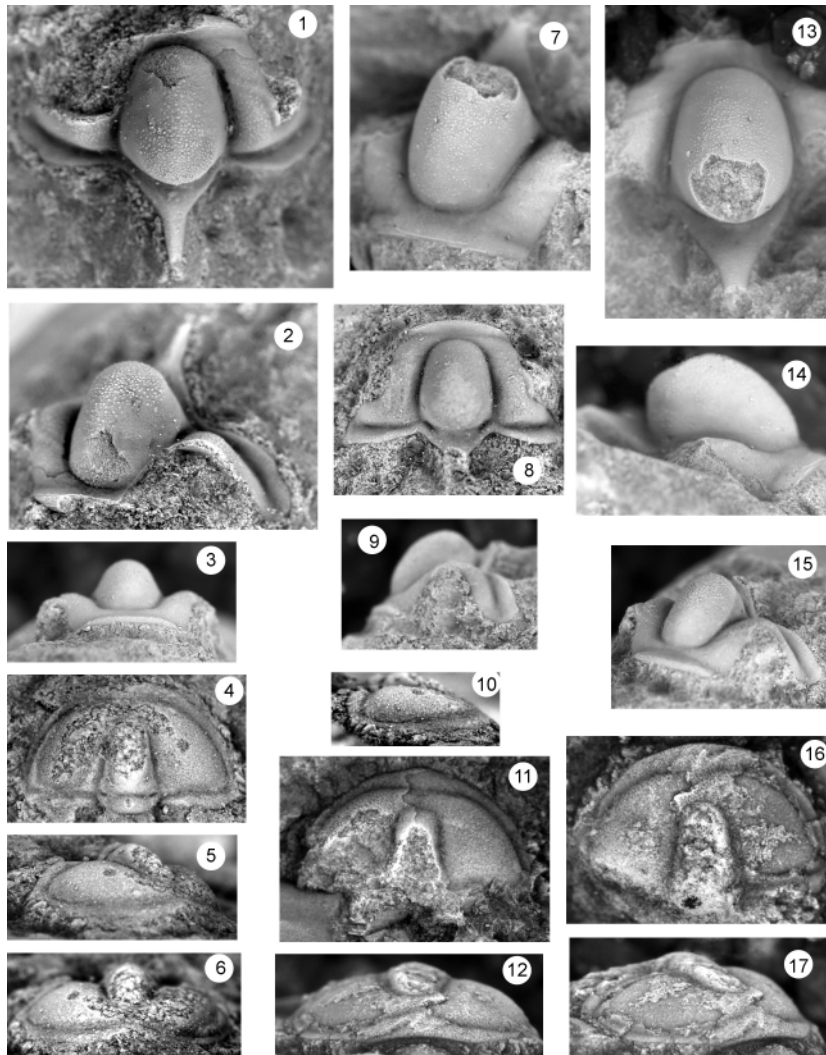


Plate 21

Plate 22

Brachyaspidion spinosum Rasetti 1964, Holotype and paratype

Figs. 1-8: *Brachyaspidion spinosum* Rasetti 1964

Figs. 1, 2, 5, 6: Holotype cranidium LU 1008a [1745-1748]

Figs. 3, 4, 7, 8: Paratype cranidium LU 1008b [1749-52]

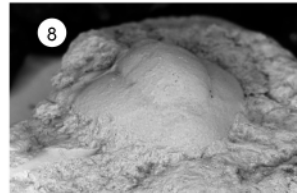
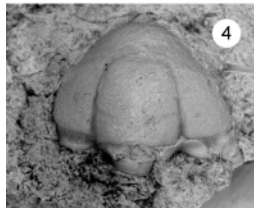
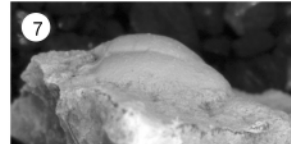
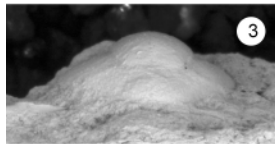
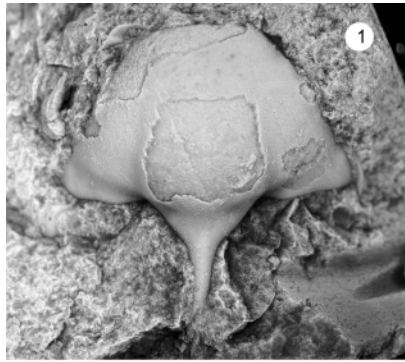


Plate 22

Plate 23

Brachyaspidion henriensis sp. nov.

Onchocephalites punctatus (Rasetti) 1963

Figs. 1-8: *Brachyaspidion henriensis* sp. nov., all BPS 467, all x7

Figs. 1, 2: Holotype cranidium [1587-8]

Fig. 3: Cranidium [467bb 1568]

Fig. 4: Cranidium [1589]

Figs. 5, 8: Cranidium [467e 1582-3]

Figs. 6, 7: Cranidium [1584]

Figs. 9-11: *Onchocephalites punctatus* (Rasetti) 1963, x7

Figs. 9, 10: Cranidium [418 1600-1601], BPS 418

Fig. 11: Cranidium [417 1605], BPS 417

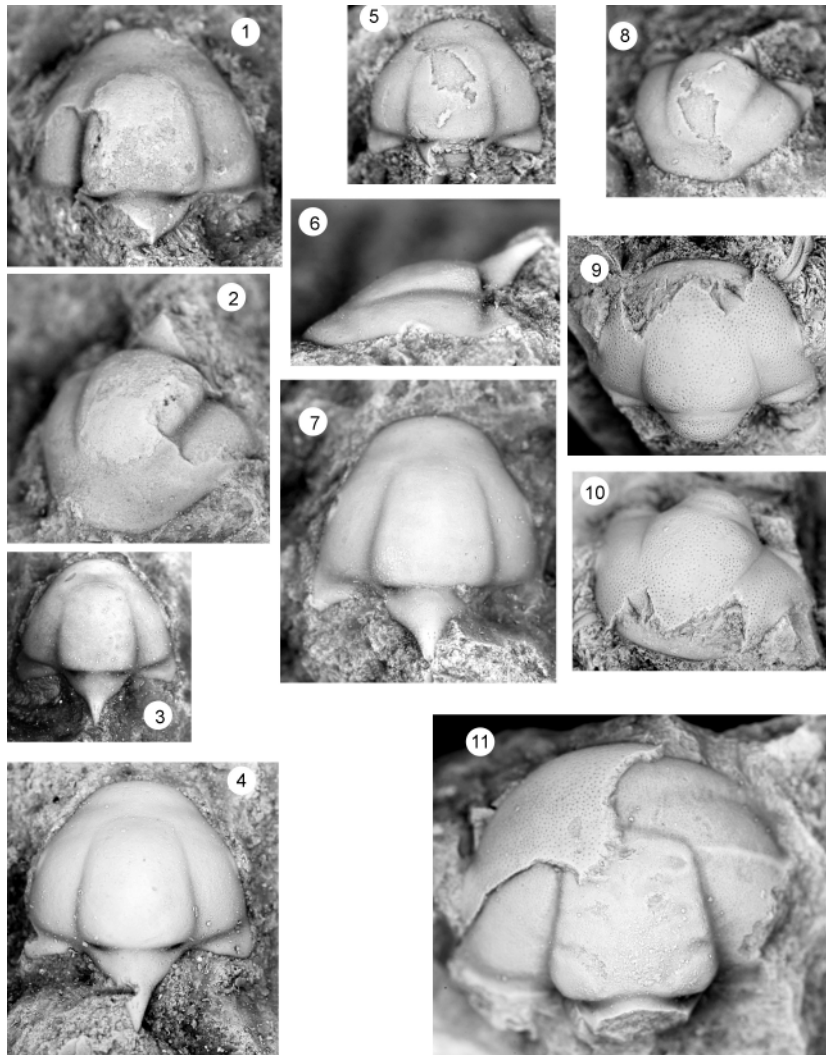


Plate 23

Plate 24

Onchocephalites punctatus (Rasetti) 1963

Figs. 1-8: *Onchocephalites punctatus* Rasetti 1963, all x7

Figs. 1, 2: Cranidium [1602-3], BPS 413

Fig. 3: Exfoliated cranidium [1604], BPS 421

Fig. 4: Partially exfoliated cranidium [1607], BPS 402

Fig. 5: Exfoliated cranidium [1618], BPS 412

Fig. 6: Complete cranidium [1608], BPS 413

Fig. 7: Exfoliated cranidium [1617], BPS 420

Fig. 8: Partially exfoliated cranidium [1616], BPS 434

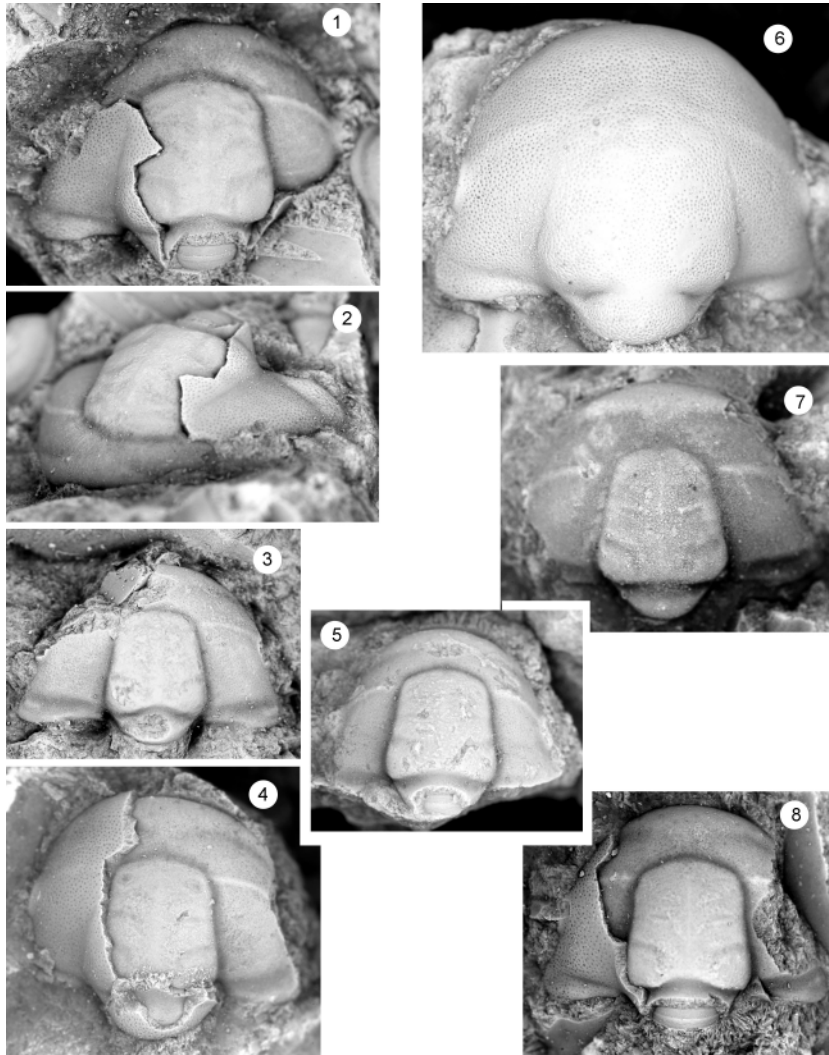


Plate 24

Plate 25

Catillicephala simplex (Resser 1938)

Kingstonia walcotti Resser 1938, *Kingstonia vagrans* Lochman 1938

Figs. 1, 2, 5-7, 11-15: *Catillicephala simplex* (Resser 1938) chosen by Rasetti from

G-18, G-40 Grosses Roches, Quebec, all x7

Figs. 1, 2, 5, 6: Cranidium 1015a [510-513]

Figs. 7, 15: Cranidium 1015b [514, 522]

Figs. 11-14: Cranidium 1015c [515-8]

Figs. 3, 8, 9, 10: *Kingstonia walcotti* Resser 1938, all x 12

Fig. 3: Cranidium [1553], CH 9

Fig. 8: Cranidium [33c 807], CH 33

Fig. 9: Cranidium [29r 1648], CH 20

Fig. 10: Cranidium [1656], CH 36

Figs. 4, 16, 17: *Kingstonia vagrans* Lochman 1938, all x12

Fig. 4: Cranidium [K35-09], CH 39

Fig. 16: Cranidium [3d 1555], CH 3

Fig. 17: Cranidium [33y 1641], CH 33

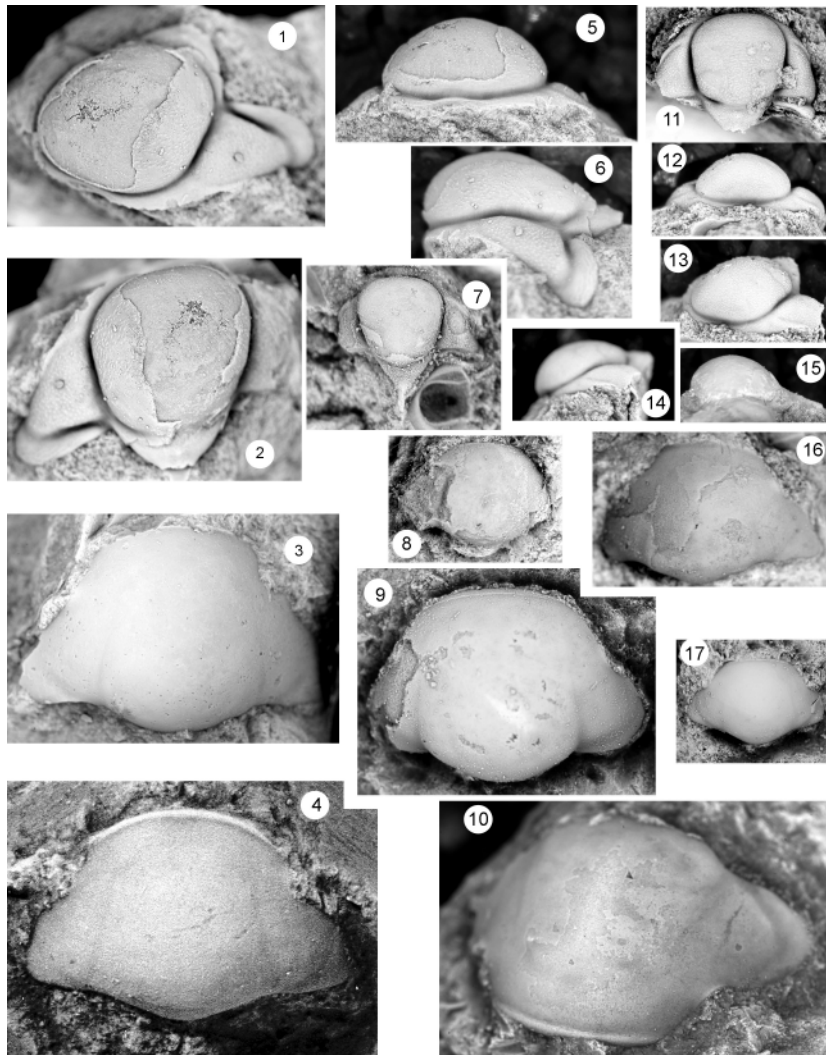


Plate 25

Plate 26

Catillicephalia lata (Raymond) (Rasetti) 1946

Figs. 1-10: *Catillicephalia lata* (Raymond), (Rasetti) 1946, all x17

Figs. 1-3: Cranidium 1012 a [469-71]

Figs. 4, 5, 7, 10: Cranidium 1012 b [444-6]

Fig. 6: Cranidium 1012g [456]

Figs. 8, 9: Cranidium 1012 h [448-50]

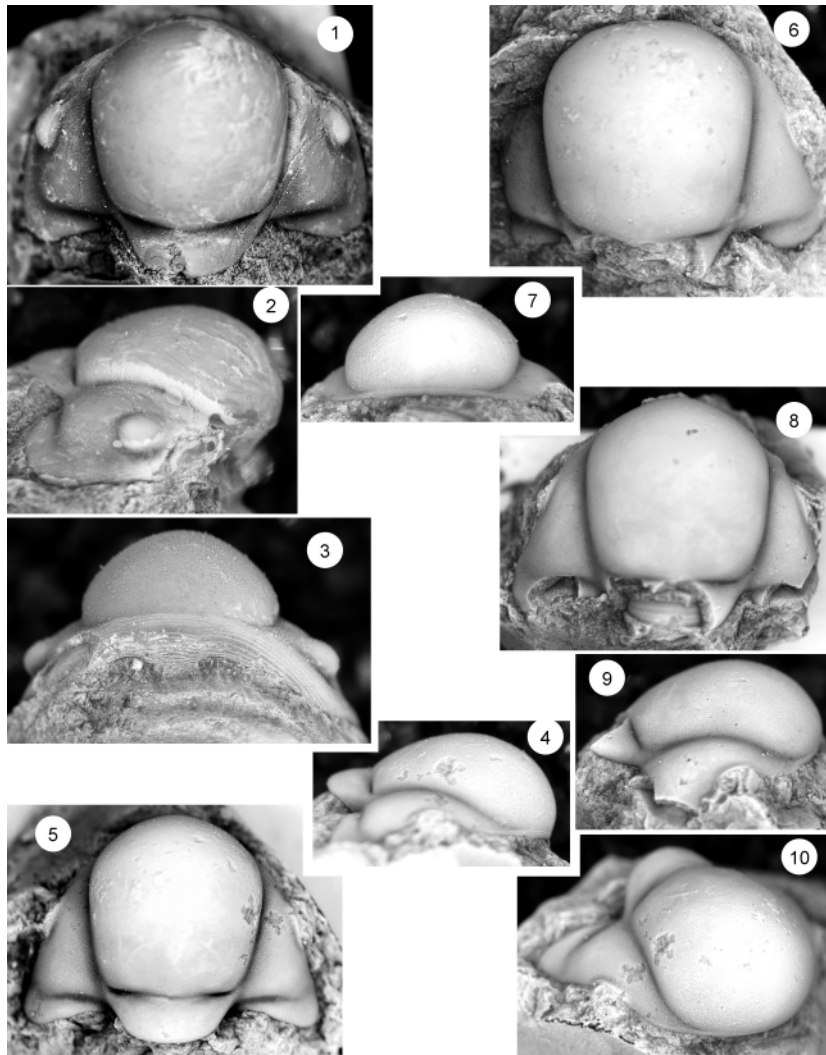


Plate 26

Plate 27

Catillicephala impressa (Rasetti) 1946

Figs. 1-10: *Catillicephala impressa* (Rasetti) 1946, all x17

Figs. 1, 6, 7: Cranidium 1014f [458-461]; rostral plate difficult to discern

Figs. 2, 3: Cranidium 1014b [470-1] ; rostral plate nicely expressed

Figs. 5, 8-10: Cranidium 1014a [472-4]; rostral plate clearly evident

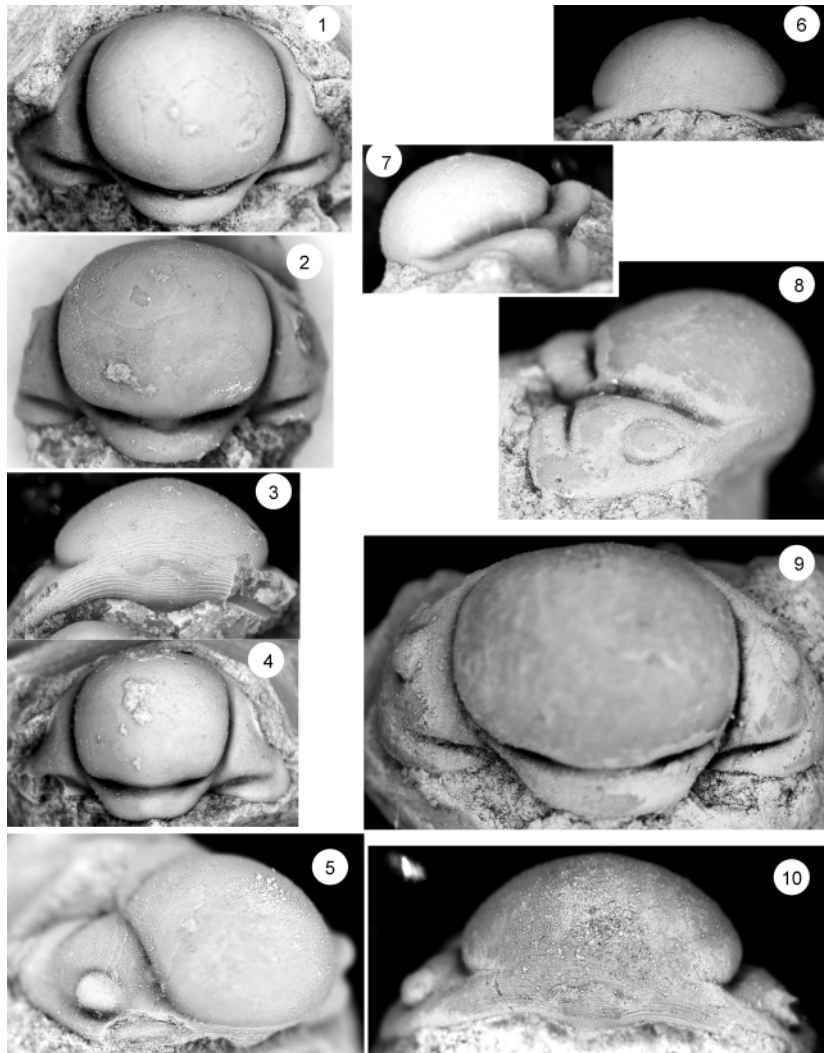


Plate 27

Plate 28

Catillicephala fowleri, *Catillicephala impressa*

Figs. 1, 2, 5, 6 *Catillicephala impressa* Rasetti 1946, all x10

Figs. 1, 2: Cranidium [20c 825-6], CH 20

Figs. 5, 6: Cranidium [20L] 827-8], CH 20

Figs. 3, 4, 7-19: *Catillicephala fowleri* Shaw 1952, all x6

Fig. 3: Cranidium [824], CH 39

Fig. 4: Cranidium [26e 813], CH 26

Fig. 7: Pygidium [20t 831], CH 20

Fig. 8: Cranidium [33h 816], CH 33

Fig. 9: Pygidium [26a 829], CH 26

Fig. 10: Pygidium [33y 815], CH 33

Figs. 11-13, 19: Cranidium [33g 818-821], CH 33

Figs. 14, 15: Cranidium [822-3], CH 26

Figs. 16, 17: Cranidium [811, 816], CH 33

Fig. 18: Cranidium [812], CH 33

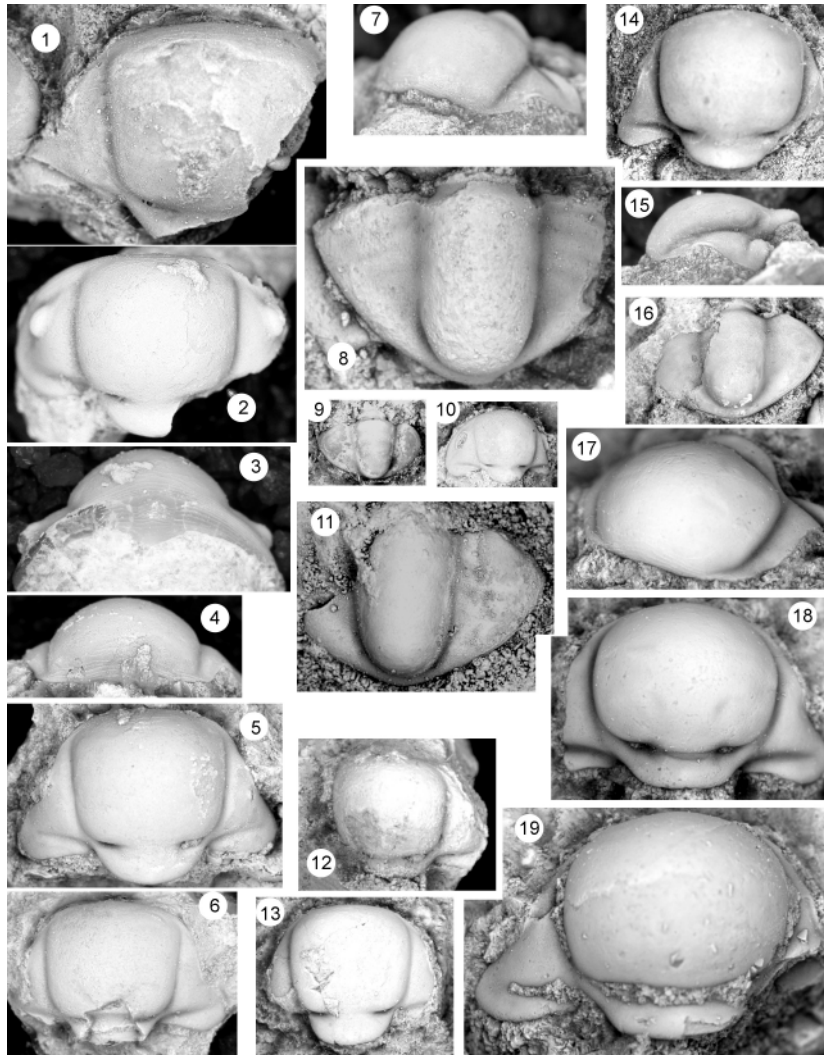


Plate 28

Plate 29

Cryptoderaspis metisensis Rasetti 1946, *Catillicephalites marginatus* Rasetti 1963

Figs. 1-3, 7-10, 12-16: *Cryptoderaspis metisensis*; All from block M-7, Métis

cnglmte, Quebec. All x12

Figs. 1-3: Holotype cranidium LU 1018a [503-5]

Figs. 7-10: Paratype cranidium LU 1018b [524-7]

Fig. 12: Paratype cranidium LU 1018c [528]

Figs. 13-16: Paratype cranidium LU 1018d [529-32]

Figs. 4-6: *Catillicephalites marginatus* Rasetti 1963 All BPS 467. All x7

Figs. 4, 5: Pygidium [467b 866, 867], BPS 467

Fig. 6: Cranidium [98 35], CH 98

Fig. 11: Cranidium [98 876], CH 98

Fig. 17: Pygidium [467 872], BPS 467

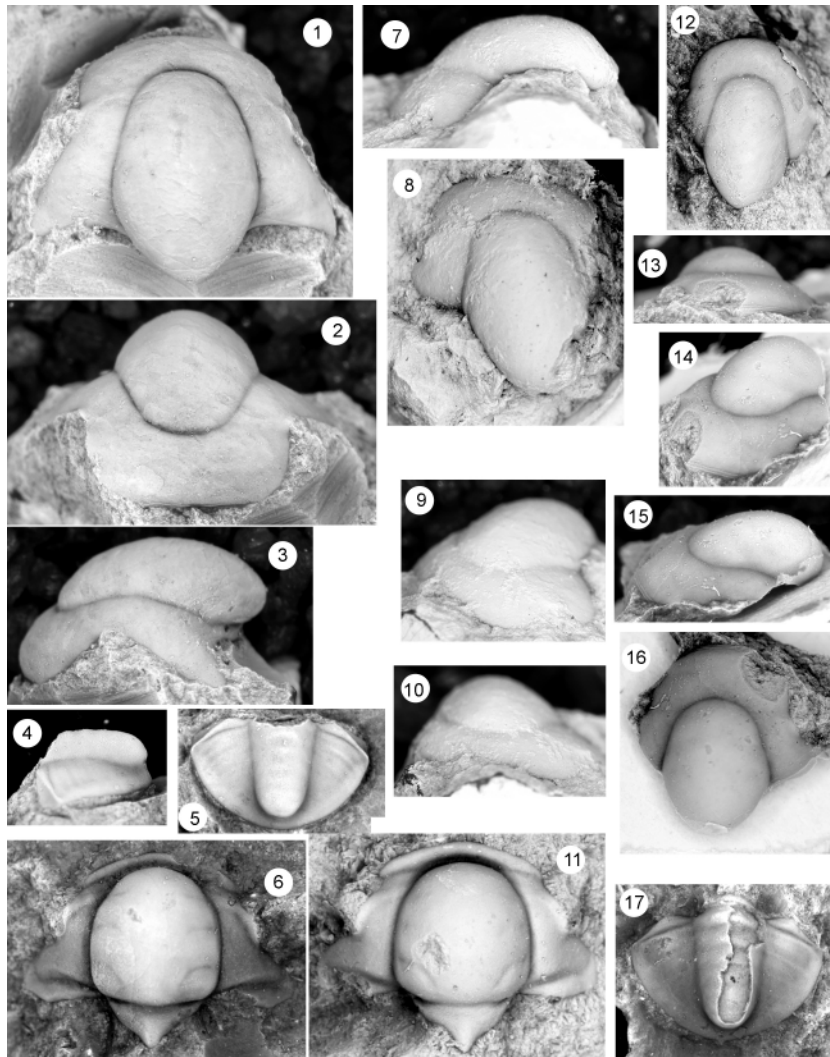


Plate 29

Plate 30

Catillicephalites catherinae sp. nov.

Figs. 1-17: *Catillicephalites catherinae*, sp. nov. All from BPS 467, all x12

Fig. 1: Cranidium [1450]

Figs. 2-4: Holotype cranidium [467o 1447-9]

Fig. 5: Cranidium [1460]

Fig. 6: Cranidium [467e 1400]

Fig. 7: Cranidium [467e 1429]

Fig. 8: Cranidium [467a 1437]

Fig. 9: Free cheek [467b 1346]

Figs. 10: Pygidium [467bb 1347]

Fig. 11: Cranidium [467a 1435]

Fig. 12: Cranidium [467g 1401]

Figs. 13, 14: Cranidium [467g 1402-3]

Fig. 15: Cranidium [467d 1441]

Fig. 16, 17: Pygidium [467d 1405-6]

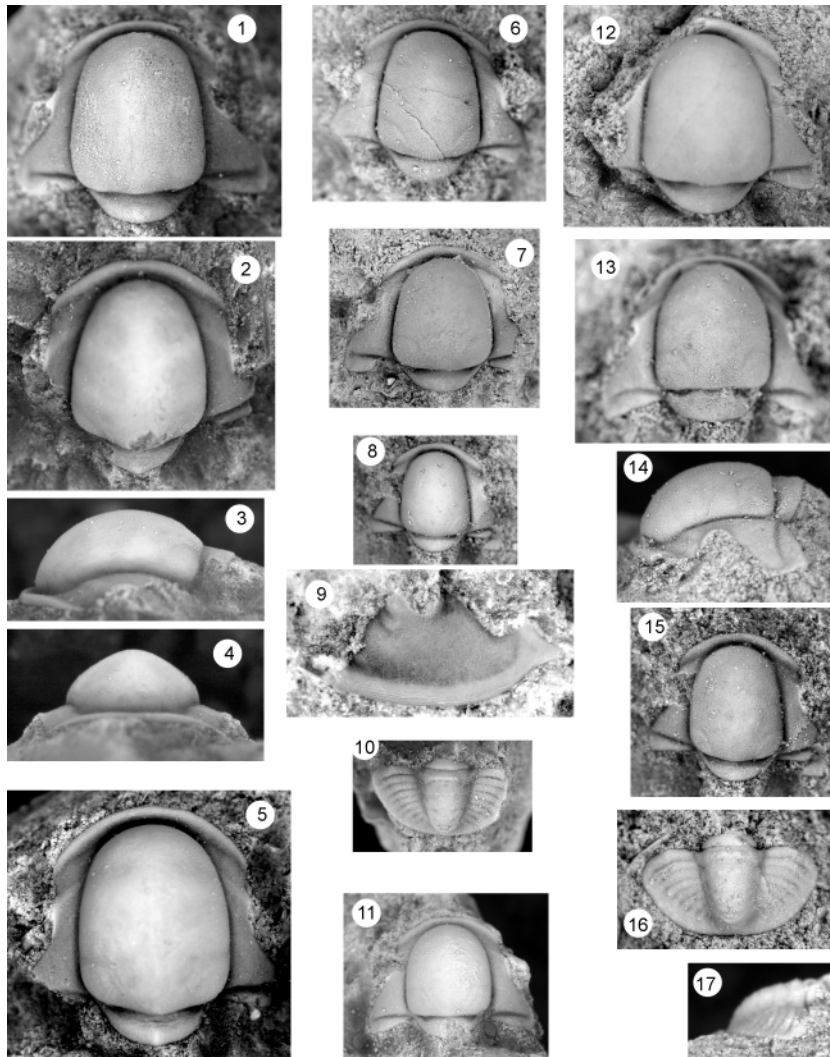


Plate 30

Plate 31

Catillicephalites brachys sp. nov.

Figs. 1-15: *Catillicephalites brachys* sp. nov., all x12

Fig. 1: Paratype cranidium [620b 1408], WRI 620

Figs. 2-4: Holotype cranidium [1485-7 -9], WRI 620

Fig. 5: Cranidium [613b 1373], WRI 613

Fig. 6: Cranidium [1407], WRI 614

Fig. 7: Cranidium [603c 1342], WRI 603

Figs. 8, 9: Cranidium [1481-2], WRI 627

Fig. 10: Cranidium [1488], WRI 621

Figs. 11, 12: Cranidium [615d 1483-4], WRI 615

Fig. 12: Cranidium [1488], WRI 621

Fig. 13: Cranidium [1496], WRI 621

Figs. 14, 15: Cranidium [603d 1490-1], WRI 603

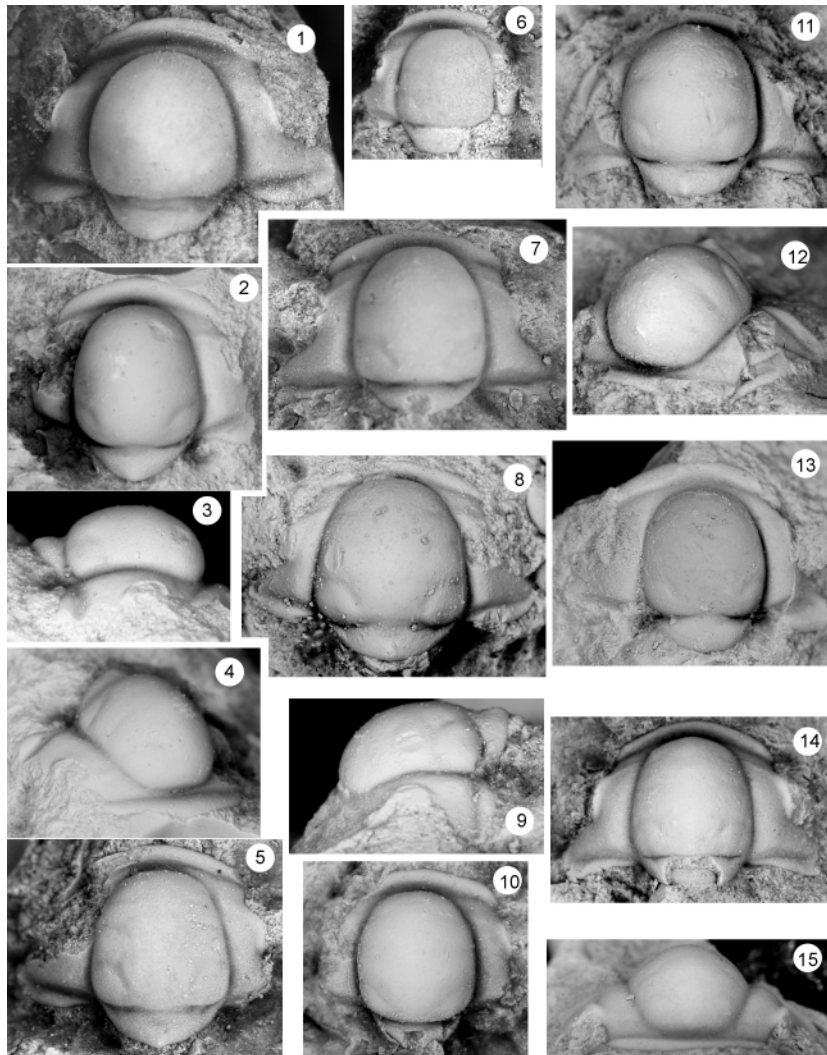


Plate 31

Plate32

Catillicephalites liamae sp. nov.

Figs. 1-14: *Catillicephalites liamae* sp. nov., all x12

Figs. 1-4: Holotype cranidium [611c 1337-40], WRI 611

Figs. 5: Pygidium [611b 1341], WRI 611

Fig. 6: Cranidium [1343], WRI 605

Fig. 7: Cranidium [615c 1374], WRI 615

Fig. 8, 13: Cranidium [615a 1376-7], WRI 615

Fig. 9: Cranidium [603e 1370], WRI 603

Fig. 10: Cranidium [1372], WRI 631

Fig. 11: Cranidium [615c 1375], WRI 615

Fig. 12: Pygidium [611a 1369], WRI 611

Fig. 14: Cranidium [1381], WRI 605

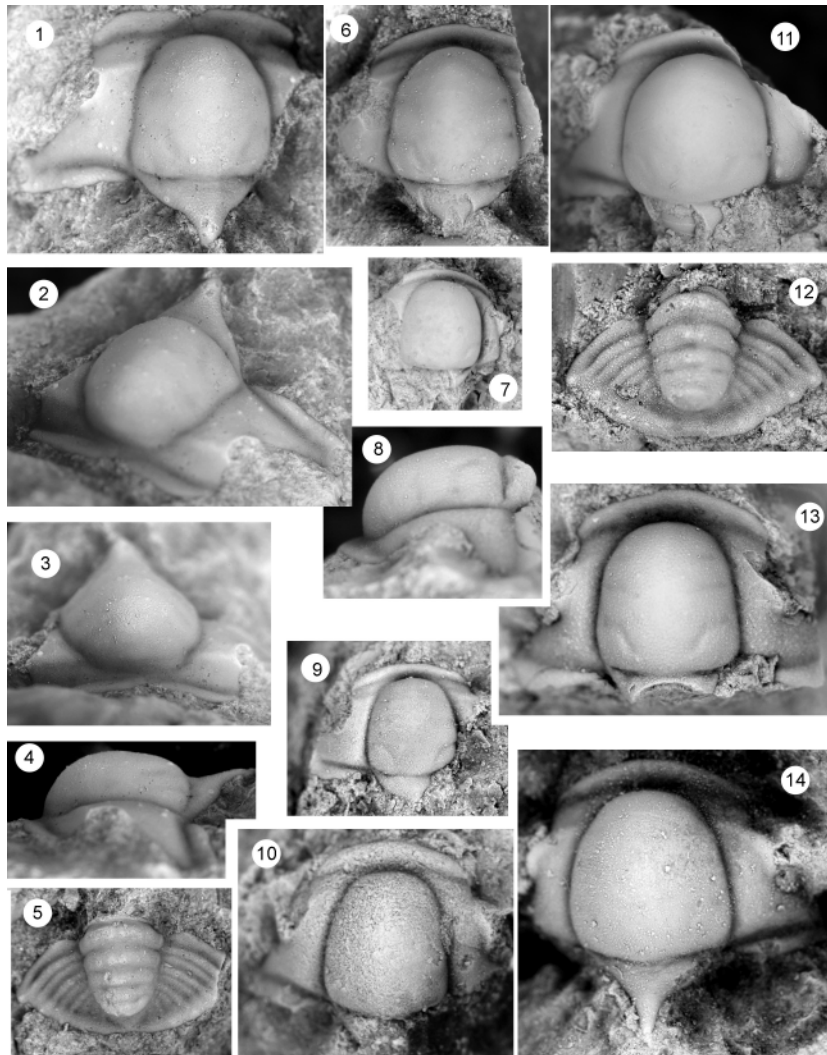


Plate 32

Plate 33

Matania ovata Rasetti 1946, *Matania kindlensis* sp. nov.

Figs. 1-11: *Matania ovata* Rasetti 1946, holotype and paratypes, all x12

Fig 1, 2: Paratype 1030 c [678-681]

Figs. 3, 4: Paratype 1030 d [680 681]

Figs. 5, 6: Holotype 1030 a [676 677]

Figs. 7-9: Paratype b [672-4]

Figs. 10, 11: Paratype e [683 –4]

Figs. 12-18: *Matania kindlensis* sp. nov. all x12

Fig. 12: Cranidium [36a 1647], CH 36

Figs. 13, 14: Cranidium [11a 1451-2], CH 11

Figs. 15,16: Holotype cranidium [36c 1461-2], CH 36

Fig. 17: Paratype cranidium [36b 1453], CH 36

Fig. 18: Cranidium [36d 1444], CH 36

Fig. 19: *Matania ovata* Rasetti 1946, x12

Fig. 19: Cranidium [1330], BPS 462

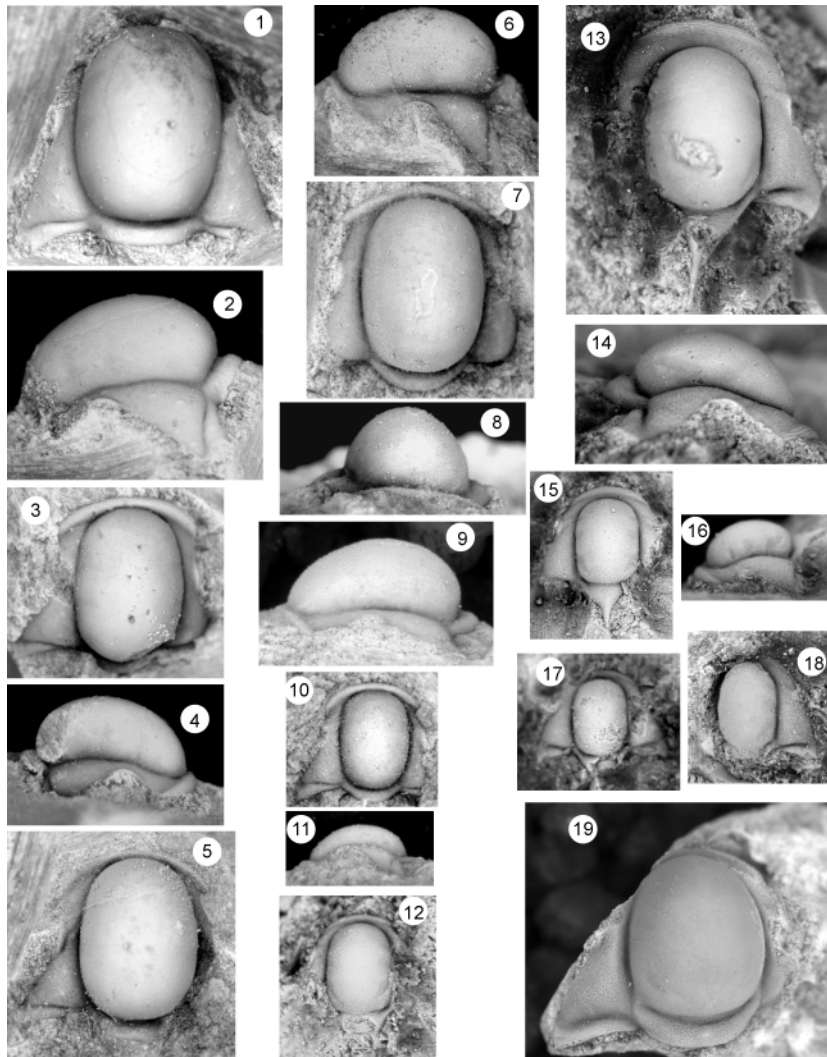


Plate 33

Plate 34

Matania pergibba (Rasetti) 1946

Figs. 1-14. *Matania* (*Onchonotopsis*) *pergibba* genotype, block M-17, Métis cglte.

Quebec. All x12

Figs. 1-4: Holotype cranidium 1036a [882-6]

Figs. 5-7: Paratype cranidium 1036b [887-890]

Fig. 8: Paratype cranidium 1036f [902]

Fig. 9: Paratype cranidium 1036d [896]

Figs. 10-12: Paratype cranidium 1036c [891-5]

Figs. 13, 14: Paratype cranidium 1036g [906, 907]

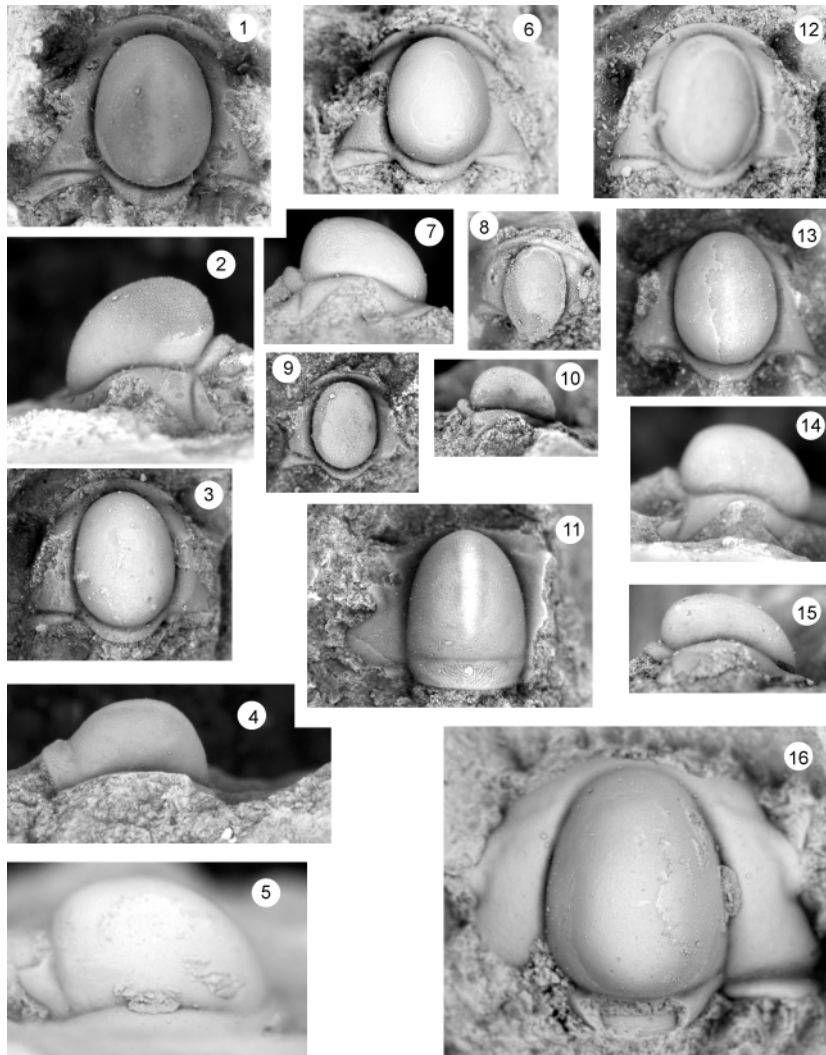


Plate 34

Plate 35

Matania hueva, 2 sp. indet.

Figs. 1-3, 6-10, 12-15: *Matania hueva*, sp. nov. all x12

Figs. 1, 2: Holotype cranidium [1580, 1581], BPS 462

Figs. 3, 15: Cranidium [467b 1570, 1571], BPS 467

Figs. 6, 7: Cranidium [467a 1574, 1575], BPS 467

Fig. 8: Cranidium [467a 1579], BPS 467

Figs. 9, 10: Cranidium [467bb 1576, 1577], BPS 467

Fig. 12: Cranidium [467b 1567], BPS 467

Figs. 13, 14: Cranidium [1572, 1573], BPS 467

Figs. 4, 11: sp. indet.

Figs. 4, 11: Cranidium [1425, 1426], WRI 603

Figs. 5, 16: sp. indet.

Figs. 5, 16: Cranidium [1609, 1610], WRI 601

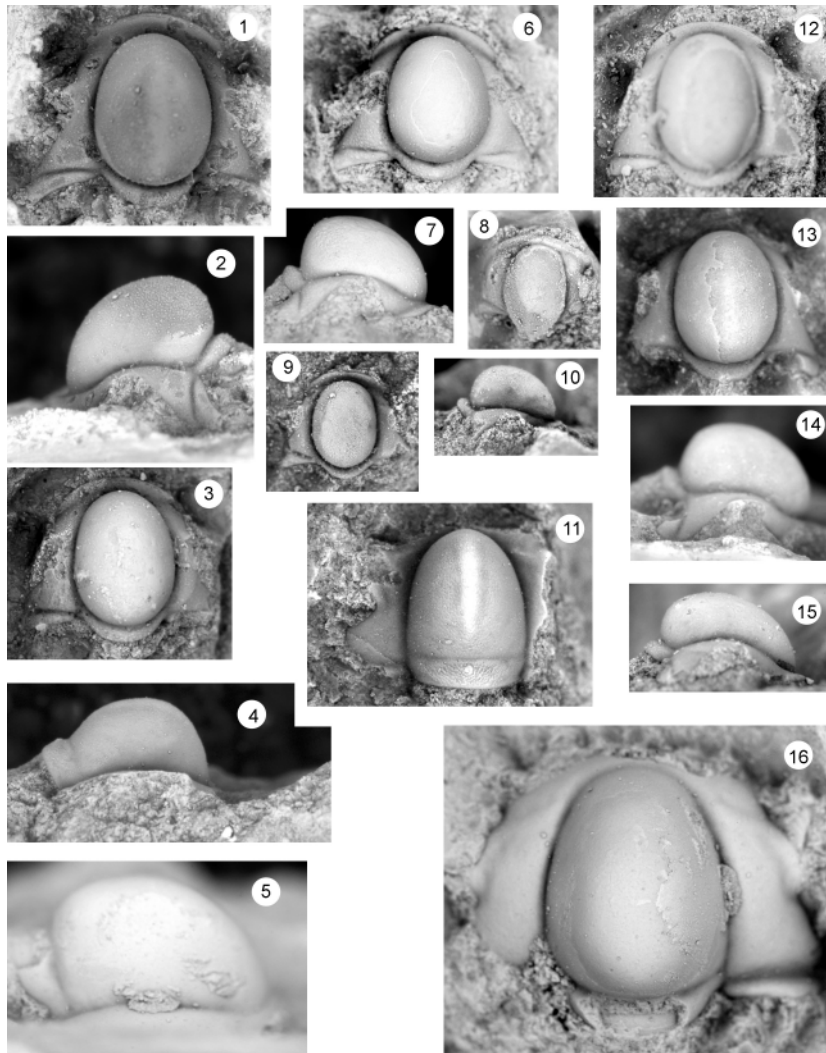


Plate 35

Plate 36

Dinea extremis, sp. nov.

Figs. 1-14: *Dinea extremis*, sp. nov. All BPS 464. All x12

Figs. 1, 2, 6, 11: Holotype cranidium [126-9]

Figs. 3, 4, 5, 10: Cranidium [122-125]

Figs. 7-9: Cranidium [175-177]

Figs. 12-14: Cranidium [133, 134]

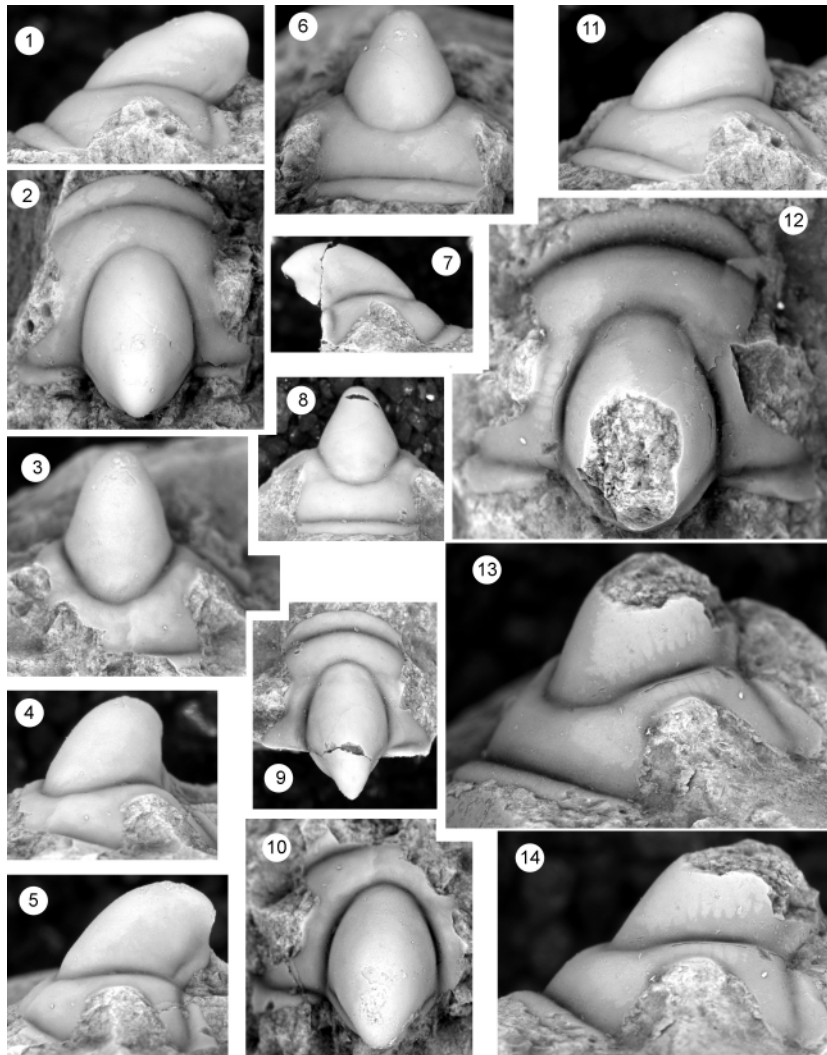


Plate 36

Plate 37

Dinea bovicephala sp. nov., *Dinea* sp. indet. #1;

Talbotina cf *T. degراسensis* Lochman 1938

Figs. 1-6, 8, 9: *Dinea bovicephala* sp. nov. All x8

Figs. 1-3, 10: Cranidium [627a, 1591-5], WRI 627

Figs. 4, 6: Cranidium [627b, 1622-3], WRI 627

Fig. 5: Pygidium [601 1623], WRI 601

Fig. 8, 9: Cranidium [1609-10], WRI 601

Figs. 7, 10, 11: *Dinea* sp. indet. #1, x8

Figs. 7, 11, 12: Cranidium [1597-9], WRI 616

Figs. 12, 13: *Talbotina* cf *T. degراسensis* Lochman 1938, x8

Figs. 13, 14: Cranidium [k18-01, 02], CH 3

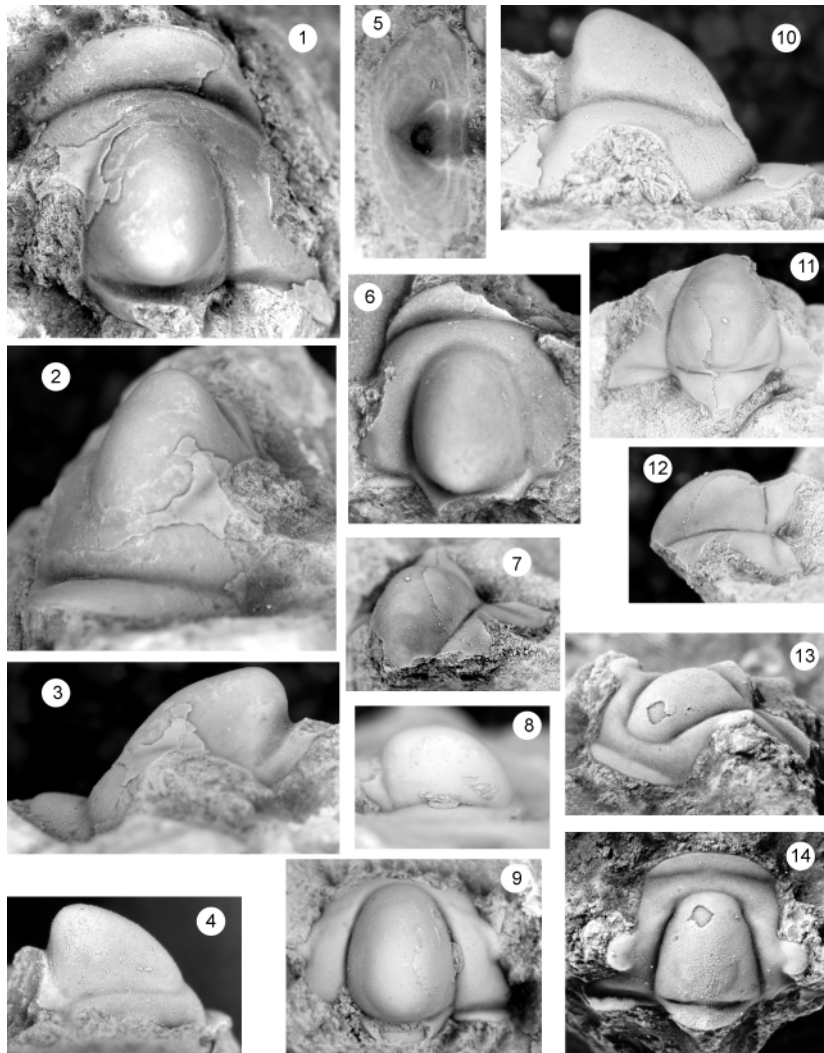


Plate 37

Plate 38

Dinea atyphos sp. nov.; *Dinea* sp. indet

Figs. 1-3: *Dinea* sp. indet. #2

Figs. 1-3: Cranidium [1417-9], WRI 620

Figs. 4-10: *Dinea atyphos* sp. nov.

Fig. 4: Cranidium [614c 1624], WRI 614

Figs. 5, 6: Cranidium [614c 1422-3], WRI 614

Figs. 7-10: Holotype cranidium [615b 1430-3], WRI 614

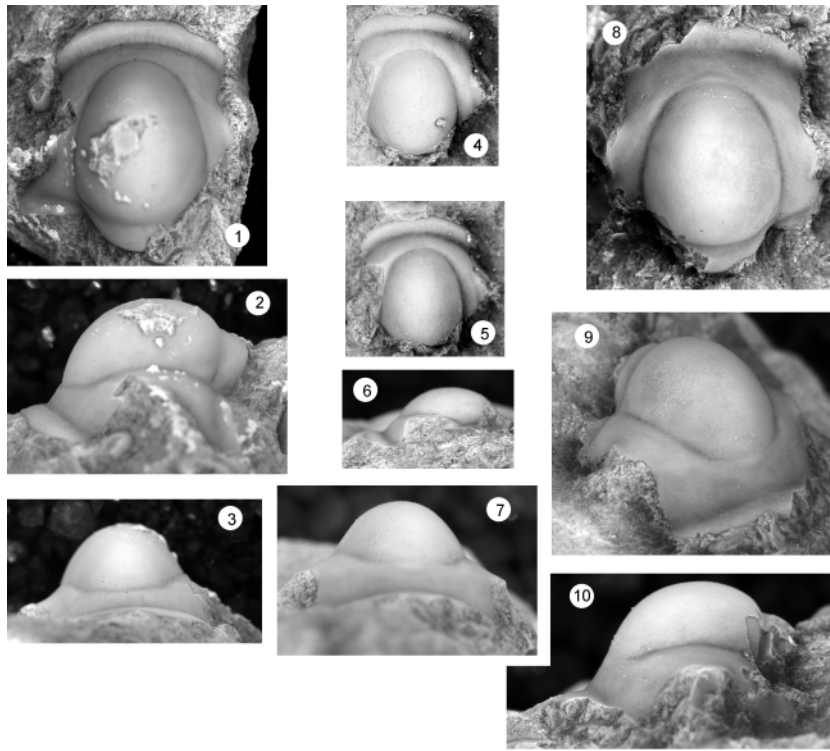


Plate 38

Plate 39

Hardyoides tunda (Lochman) 1940 , *Hardyoides tenerus*, (Walcott) 1916,
Hardyoides minor Kobayashi 1938, *Hardyoides katherina* Lochman 1938

Figs. 1-5: *Hardyoides katherina* Lochman 1938 all x12

Fig. 1: Cranidium [36h 1290], CH 36

Fig. 2: Cranidium [11e 1282], CH 11

Fig. 3: Cranidium [11f 1268], CH 11

Fig. 4: Cranidium [11e 1263], CH 11

Fig. 5: Cranidium [35g 1298], CH 35

Figs. 6-10: *Hardyoides tunda* (Lochman) 1940, all CH 39, all x12

Fig. 6: Cranidium [39a 1296]

Figs. 7-9: Cranidium [39b 1287]

Fig. 10: Cranidium [1295]

Figs. 11-13: *Hardyoides minor* Kobayashi 1938, all x12

Fig. 11: Cranidium [11k 1732], CH 11

Fig. 12: Cranidium [36a 1293], CH 36

Fig. 13: Cranidium [11ab 1280], CH 11

Fig. 15: Pygidium [11f 1270], CH 11

Fig. 16: Pygidium [11f 1286], CH 11

Figs. 17-21: *Hardyoides tenerus* (Walcott) 1916, all CH 11, all x12

Fig. 14: Pygidium [11e 1266]

Fig. 17: Cranidium [11j 1272]

Fig. 18: Cranidium [11j 1273]

Fig. 19: Cranidium [11f 1269]

Fig. 20: Cranidium [11e 1285]

Fig. 21: Cranidium 11e 1264]

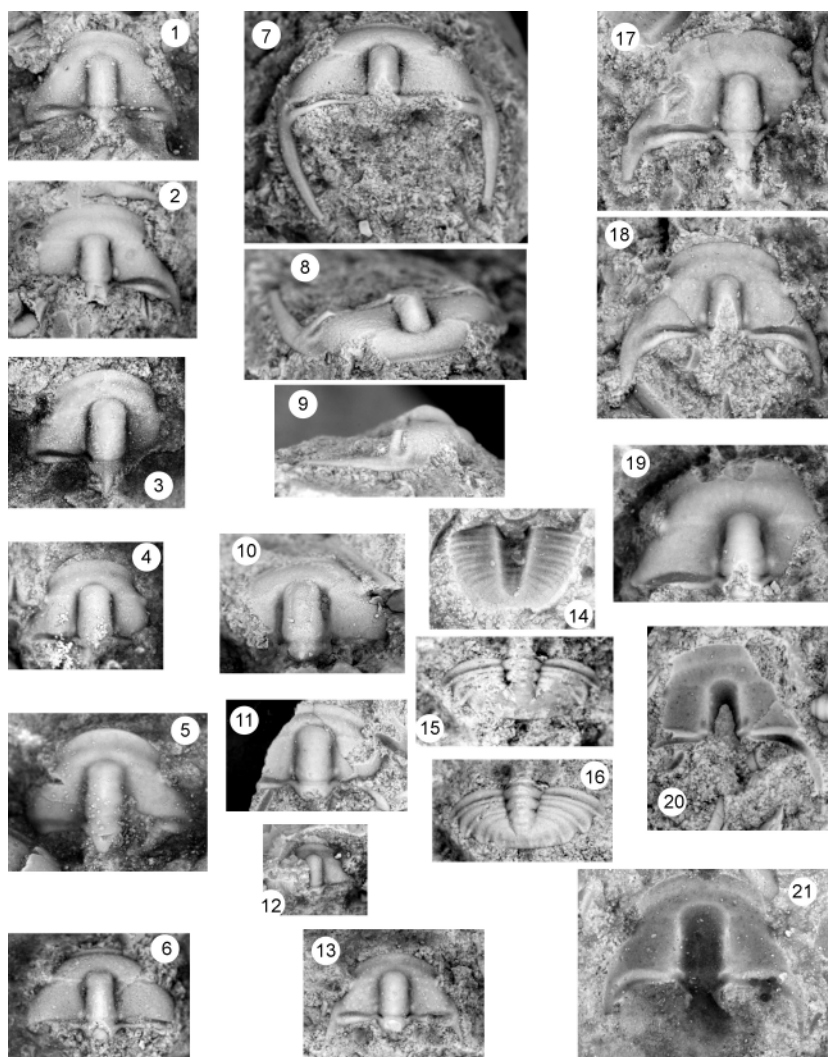


Plate 39

Plate 40

Bolaspidella cf. *B. contracta* Robison 1964, *Bolaspidella* sp. indet.,

Hysteropleura sp., *Eldoradia batilla* sp. nov.

Figs. 1-4: *Eldoradia batilla* sp. nov. all x8

Fig. 1: Cranidium [631c 197], WRI 631

Fig. 2: Cranidium [603 44], WRI 603

Fig. 3: Cranidium [603b 194], WRI 603

Fig. 4: Cranidium [603a 218], WRI 603

Fig. 5: *Eldoradia* cf. *E. batilla* x8

Fig. 5: Cranidium [606Aa 44], WRI 606

Figs. 6, 7: *Hysteropleura* sp. 1, x8

Fig. 6: Cranidium [616 201], WRI 616

Fig. 7: Cranidium [615 918], WRI 615

Figs. 8-10, 15: *Bolaspidella* cf. *B. contracta* Robison 1964, all x8

Fig. 8: Cranidium [632f 182], WRI 632

Fig. 9: Cranidium [117], WRI 614

Fig. 10: Cranidium [617a 67], WRI 617

Fig. 14: Cranidium [632b 156], WRI 632

Figs. 11-13: *Bolaspidella* sp. 1

Fig. 11, 12: Cranidium [611b 205-7], WRI 611, 12

Fig. 13: Cranidium [110], WRI 611, x15

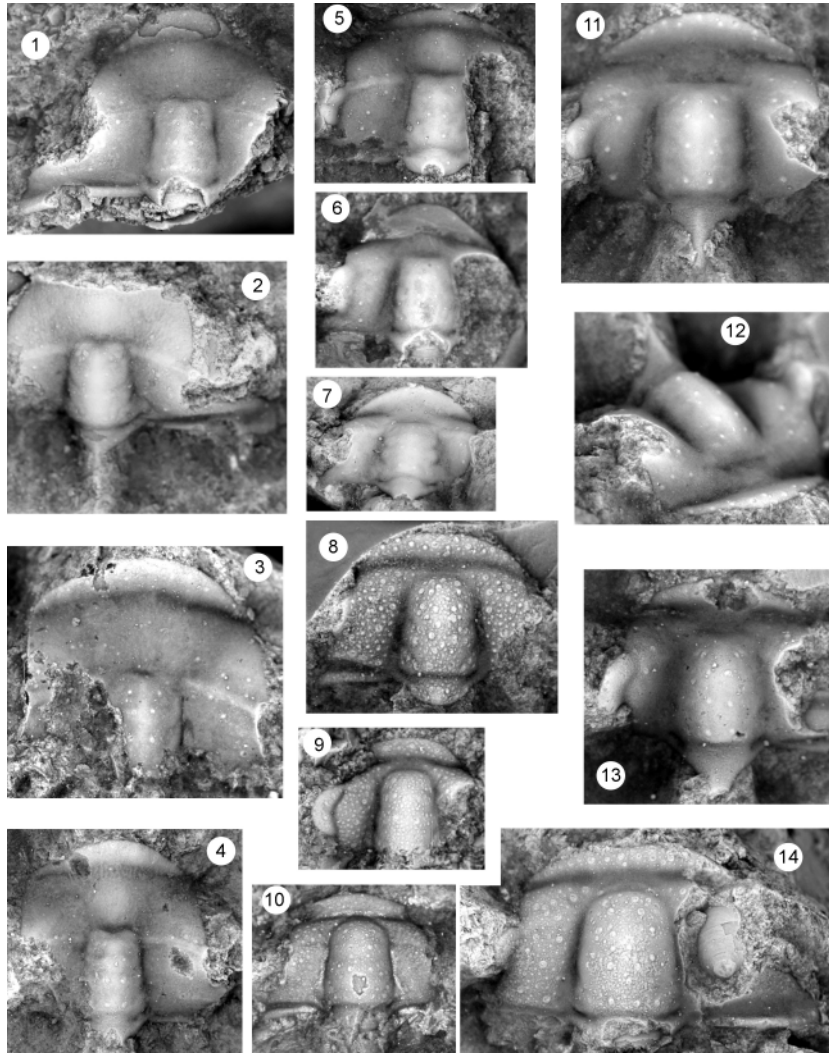


Plate 40