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BULLETIN 187

CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

(nine papers)

By

M. J. Copeland, Thomas E. Bolton, W. H. Fritz,
C. H. Kindle, P. J. Lespérance, M. A. Fritz,
C. R. Barnes, M. F. Tuke, and T. T. Uyeno

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PREFACE

In eastern Canada fossiliferous sedimentary rocks of Paleozoic age comprise the thick sequences of economically important strata in the Atlantic, St. Lawrence, and Hudson Bay areas. Their contained fossils are widely distributed and chronologically significant.

The nine papers that form this Bulletin describe ostracods, trilobites, echinoderms, bryozoans, and conodonts from several localities in eastern Canada. These systematic studies are fundamental to the paleontological correlation of the strata in which the fossils occur.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, April 15, 1969

BULLETIN 187 — Beiträge zur kanadischen Paläontologie

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Von M. J. Copeland

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TWO NEW GENERA OF BEYRICHIID OSTRACODA FROM THE NIAGARAN (MIDDLE SILURIAN) OF EASTERN CANADA

by M. J. Copeland

Abstract

The new ostracod genera *Zygocosta* and *Zygobursa* (Beyrichiidae, Zygobolbinae) are described from the early Middle Silurian Dyer Bay and Wingfield Formations of southern Ontario and Becscie Formation of Anticosti Island, Quebec. The relationship of these genera with previously described zygobolbids is discussed.

Résumé

Les nouveaux genres d'ostracodes, *Zygocosta* et *Zygobursa* (Beyrichiidae, Zygobolbinae) décrits proviennent des formations de Dyer Bay et Wingfield (Silurien moyen) du sud de l'Ontario, et de la formation de Becscie de l'île d'Anticosti, au Québec. L'auteur étudie les rapports entre ces genres et les zygobolbidés décrits auparavant.

Cruminal (brood pouch) morphology has become an increasingly important criterion for the distinction of beyrichiid ostracods. Kesling (1957) and Kesling and Rogers (1957) stressed certain beyrichiid characteristics based on frill and brood pouch features. With the description by Martinsson (1962) of the stratigraphic and morphologic sequence of beyrichiid faunas so well developed on Gotland, the significance of these ventral structures became more evident. Martinsson's studies were greatly facilitated by the exceptional preservation of these Gotland fossils and the relative ease with which they could be extracted from the enclosing marl.

Few detailed taxonomic studies of North America beyrichiid ostracods have been possible because of their restricted occurrence primarily in the Appalachian region, and their presence in limestone or altered argillaceous rock which does not permit their easy extraction (Swartz and Whitmore, 1956; Copeland, 1964). Most specimens from that region have been altered by pressure to impressions or steinkerns. The occurrence of excellently preserved silicified beyrichiid remains (Martinsson, 1960) from Devon

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Island, Canadian Arctic, has been duplicated by the present author in collections from Prince of Wales Island. Silicification, in this area, has not been sufficiently extensive, however, to preserve more than a partial stratigraphic sequence of beyrichiids.

To be truly effective as North American stratigraphic indicators it is desirable that, initially, sequences of beyrichiid ostracods be determined in the Appalachian region in relative proximity to the typical reference sections of Silurian and Devonian ages. This was attempted by Ulrich and Bassler (1923) who proved conclusively that such a stratigraphic succession of Silurian beyrichiids occurs. Their conclusions, however, were based on imperfectly preserved specimens and, apart possibly from those of Maryland and Pennsylvania, incomplete collections. Modern taxonomic revision and augmentation of this beyrichiid succession, following Martinsson, can be effected only by examination of better preserved specimens, presumably from exposed strata similar in lithology to those which have proved so favourable on Gotland. Such strata, lying adjacent to the Appalachian belt but not altered by Appalachian tectonic activity, are found in Canada on Anticosti Island, Quebec, and along the Niagara Escarpment, southern Ontario.

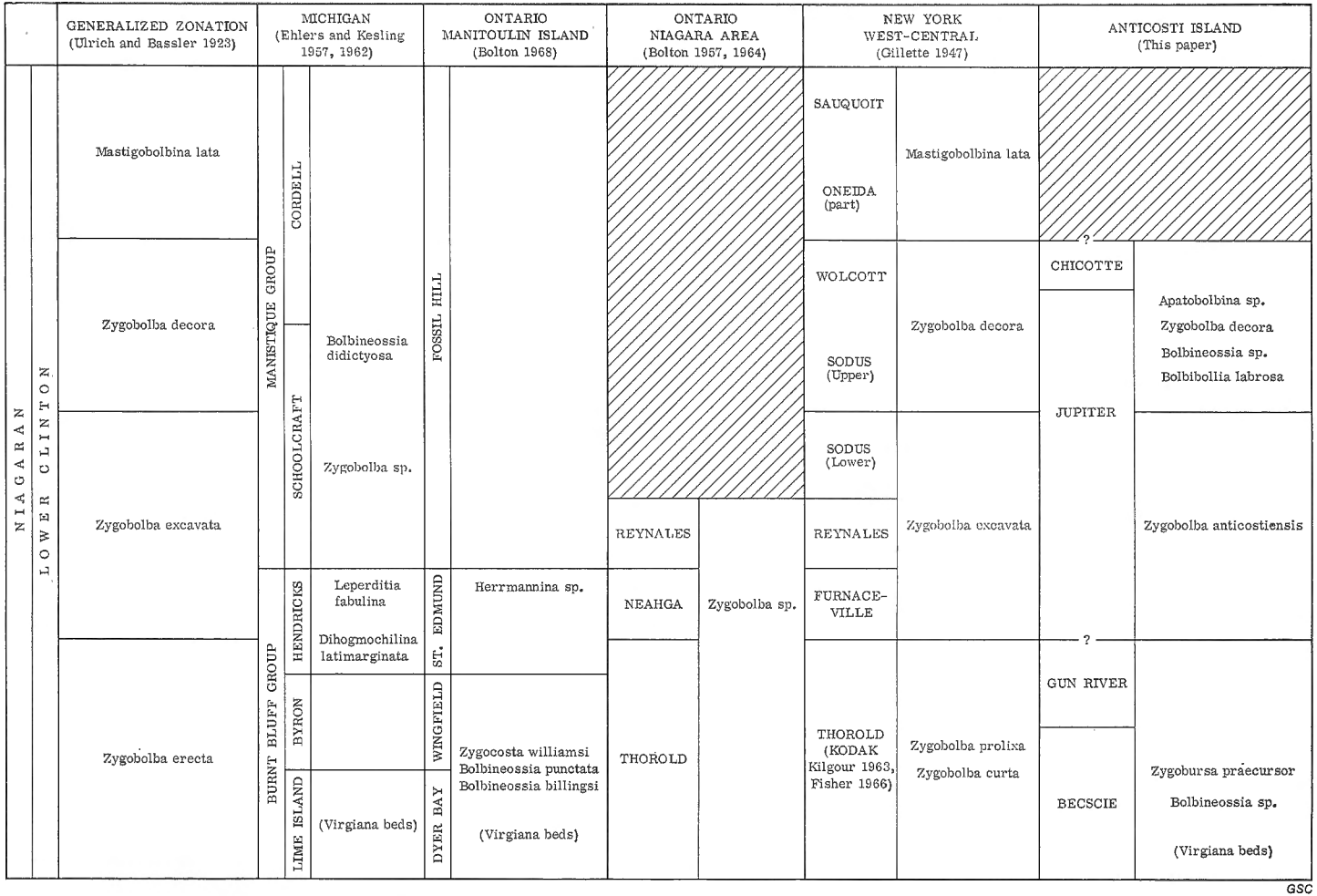
Buttressed by the southern flank of the Canadian Shield, Anticosti Island lies north of the area of major Appalachian deformation. Undeformed marine sedimentary rocks of Upper Ordovician to Middle Silurian ages occur in an exposed sequence more than 2,300 feet thick. Ostracods are present throughout, the Silurian strata providing the most complete succession of well preserved beyrichiids in eastern Canada (Fig. 1).

The Niagara Escarpment, comprised primarily of Lower and Middle Silurian strata, extends from northern New York, through southwestern Ontario and the northern peninsula of Michigan. Strata in the western part have yielded few beyrichiids but their correlatives in central and eastern New York (Fig. 1) bear faunas contained in the zonal sequence established by Ulrich and Bassler (1923) and revised by Gillette (1947).

Billings (1866), Ulrich and Bassler (1923), and Bassler (*in* Twenhofel, 1928) described ostracod faunas containing beyrichiids from these strata. Their observations were based on specimens preserved on slabs with other fossils, poorly exposed, and usually exhibiting only lateral surfaces. It is understandable, therefore, that little information is available on which to base descriptions of the ventral and cruminal structures of these beyrichiids. The use of well established techniques to disintegrate clay and siltstone has resulted in the extraction from these rocks of many beyrichiids rivalling those from Gotland in preservation. These beyrichiids and other ostracods from Anticosti Island and elsewhere in eastern Canada are the subject of continuing investigations by the present author; two new genera are discussed in this paper.

Systematic Paleontology

The most typical Middle Silurian zone ostracods in eastern North America are Beyrichiidae of the subfamily Zygobolbinae. Martinsson (1962, pp. 257–258) included eight genera within this subfamily. In ventral view their relationship is shown by the dolonoid scar on the ventral part of the crumina which (p. 258) "consists of a fissure or fold breaking through the margin." This scar has been observed on species of *Zygobolba, Noviportia, Slependia* (?), *Plethobolbina* (?), *Zygocosta* gen. nov., and *Zygobursa* gen. nov. In lateral view, North American zygobolbids (except *Plethobolbina*) possess a distinct U-shaped ridge ventrally limiting S2. This does not occur on species of the referred European genera (*Slependia, Noviportia*).



GSC

FIGURE 1. Zonation and stratigraphic occurrence of some Niagaran Ostracoda in eastern North America.

Three zygobolbid genera possess adventral structures which originate or encroach on the crumina of the female dimorph. *Slependia* has the "Crumina with a spur, inflating the anteroventral part of the velar flange and adjoining parts of the valve" (Martinsson, 1962, p. 263). This cruminal spur may not be connected with the interrupted velar ridge (Kesling and Rogers, 1957). *Zygocosta* gen. nov. has the velar ridge encroaching on the posteroventral part of the crumina and a distinct supracruminal ridge expanded posteriorly. *Zygobursa* gen. nov. has a complete velar structure which passes uninterruptedly across the dorsomedian part of the crumina.

Martinsson considered the lobation of *Slependia armata* (Henningsmoen) to be derived from primitive beyrichiid lobation, and the cruminal spur to be in the position of the calcarine spine. This cruminal spur apparently has no counterpart on male specimens of *S. armata* as it does in certain genera of Craspedobolbininae. If this spur is a velar structure it could be considered to represent a later stage in the disintegration of the zygobursid complete supracruminal velum (*see* Kesling, 1957, p. 64; Martinsson, 1962, pp. 107, 117). But, what of the supracruminal ridge of *Zygocosta*? Neither *Slependia* nor *Zygobursa* possesses a velar ridge encroaching on the posteroventral cruminal surface similar to that of *Zygocosta.* The supracruminal ridge of *Zygocosta* is distinct from the undeflected velar ridge and extends in a posterior direction to the position of the cruminal spur of *Slependia.* The cruminal ridge of *Zygocosta* can, therefore, only be supravelar and the cruminal spur of *Slependia* probably has a similar position.

The complete supracruminal velar ridge of *Zygobursa* has no counterpart in the Zygobolbinae. This structure is typical of some advanced beyrichiids (Martinsson, 1962, p. 107; Kesling, 1957, p. 70), generally of Upper Silurian or Lower Devonian ages. Martinsson (1962, p. 117) does not believe that this represents a phylogenetic trend, rather he explains this feature "as depending on the varying part taken by the velum in the inflation of the crumina in different forms." No relative stratigraphic significance may be attached to velar structures of this type if this hypothesis is valid.

Family BEYRICHIIDAE Matthew, 1886
Subfamily ZYGOBOLBINAE Ulrich and Bassler, 1923

Zygocosta gen. nov.

Type species. *Zygocosta williamsi* (Ulrich and Bassler)

Referred species. Zygobolba williamsi Ulrich and Bassler

Diagnosis. Zygobolbinae with broad adductoral sulcus (S2) limited by a prominent U-shaped ridge. Lobes with pronounced dorsal cristae. Flange-like velum extending onto antero- and posteroventral surface of crumina, discontinuous. Dolonoid scar a fissure or fold interrupting the ventral margin. Dorsal part of crumina with prominent, isolated costa.

Zygocosta williamsi (Ulrich and Bassler)
Plate I, figures 12–22; Figure 2A

Zygobolba williamsi Ulrich and Bassler 1923, p. 550, pl. 41, figs. 1–9; authors.

Description. Carapace subovate, quadrilobate; L1 low, indistinct, separated from L2 by shallow S1; S2 deep, wide, bordered by distinct U-shaped ridge lying on low L2 and L3; separation of L3 and L4 indistinct. L1 and L4 pustulose, with dorsal cristae.

Velar ridge broad, flattened on male. Crumina sausage-shaped, longitudinally striated, in anteroventral part of female, with velum encroaching, undeflected, onto its posteroventral surface. Supracruminal ridge, widest posteriorly, crossing the crumina diagonally, dying out anteriorly. Dolonoid scar extending from velar to marginal ridges (Fig. 2A), intersecting the margin ventral of the crumina.

Remarks. Ulrich and Bassler (1923, p. 550) separated this species into three unnamed varieties based on lateral shape (i.e., typical, low-elongate, large-short). Variation in size and shape occurs, but is not considered to be of taxonomic importance.

A distinctive feature of this species is the prominent U-shaped ridge bordering S2. This comma-shaped ridge is expanded over L2 and its anterior branch does not extend to the dorsal margin. Its posterior branch is thin and straight, extending vertically to the dorsal margin and anteriorly limiting the crista of L4.

Occurrence. Middle Silurian, Dyer Bay and lower shale of Wingfield Formations, Bruce Peninsula and Manitoulin Island, Ontario.

Types. Hypotypes, GSC Nos. 24397–24407.

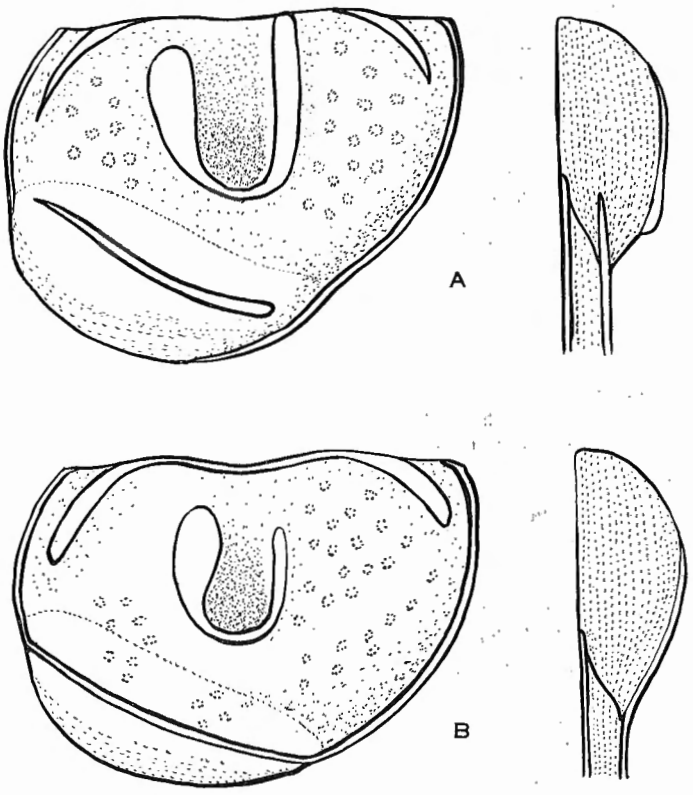


FIGURE 2. Diagrammatic representations of left lateral and anteroventral views of (A) *Zygocosta williamsi* (Ulrich and Bassler), and (B) *Zygobursa praecursor* n. sp. showing the relationship on female dimorphs of the velum and supracruminal ridges.

Zygobursa gen. nov.

Type species. *Zygobursa praecursor* n. sp.

Referred species. Zygobursa praecursor n. sp.

Diagnosis. Zygobolbinae with broad adductoral sulcus (S2) limited by a prominent U-shaped ridge. Lobes with pronounced dorsal plica. Flange-like velum extending as a ridge across the dorsal part of the crumina. Dolonoid scar a fissure or fold interrupting the ventral margin.

Zygobursa praecursor n. sp.

Plate I, figures 1–11; Figure 2B

Description. Carapace subovate, quadrilobate; L1 low, indistinct, separated from L2 by shallow S1; S2 deep, wide, bordered by distinct U-shaped ridge lying on low L2 and L3; separation of L3 and L4 indistinct. L1 and L4 pustulose with pronounced dorsal plica.

Velar flange broad, flattened on male. Crumina sausage-shaped, pustulose in dorsal part, longitudinally striated, in anteroventral part of female, with velar ridge crossing its lateral surface uninterruptedly and continuing as a flange to the cardinal angles. Dolonoid scar extending from velar to marginal ridges (Fig. 2B) intersecting the margin ventral of the crumina.

Remarks. Neither branch of the prominent U-shaped ridge surrounding S2 extends to the dorsal margin and thus does not intersect the dorsal plica. The pustulose ornamentation of L1 and L4 overlies the much finer surface reticulation of this species. This reticulation is best observed on the lateral surface ventral of S2 and in a nontuberculate area on L4 in the position of the syllobial groove of Martinsson.

Occurrence. Middle Silurian, Becscie Formation, 80 to 100 feet below the top of the formation, Anticosti Island, Quebec.

Types. Holotype, GSC No. 24386; paratypes, GSC Nos. 24387–24396.

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REDESCRIPTION OF THE MIDDLE SILURIAN LEPERDITICOPID OSTRACOD *DIHOGMOCHILINA LATIMARGINATA* (JONES)

by M. J. Copeland

Abstract

The type species of *Dihogmochilina* Teichert 1937, *Isochilina grandis latimarginata* Jones 1891, is an acknowledged Middle Silurian zone fossil from Manitoba, northern Michigan, and Hudson Bay Lowland. Its great size, "fish-tailed" sulcus, and broad, marginal border serve to distinguish it from all other leperditiids found in those areas. The phylogenetic position of this species within the Leperditicopida, based on musculature, has, however, not previously been known.

Résumé

L'espèce type *Dihogmochilina* Teichert 1937, *Isochilina grandis latimarginata* Jones 1891 est un fossile du Silurien moyen du Manitoba, du nord du Michigan et des Basses-Terres de la baie d'Hudson. Sa grande dimension, sa sulcature en forme de queue de poisson et sa large bordure marginale le distinguent de tous les autres léperditiidés de ces régions. La position phylogénétique de l'espèce parmi les léperditicopidés, selon la musculature, n'était cependant pas connue auparavant.

Abushik (1960) has drawn attention to the importance of the size and form of muscular attachments in any systematic grouping of leperditicopid ostracods. Her classification of the muscle scar areas of these ostracods (adductoral, chevron, preocular, and anterodorsal) points to the growing complexity of morphological terminology necessary to adequately understand and describe them. Of prime importance are the shape and tubercular structure of the two largest and most prominent muscular areas, the adductor and chevron. Undoubtedly, with advances in optical and photographic techniques and the discovery of better preserved specimens, all muscular areas will prove of taxonomic significance.

Observation of muscular scars on leperditicopid ostracods is dependent, particularly, on a combination of specimen size and preservation. In general, larger specimens (adults of a species) have greater shell thickness and larger muscular areas. The imprints

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are slightly elevated on the interior surface of the valve and become visible in interior view when coated with ammonium chloride (Pl. II, figs. 15, 17, 19, 20). If viewed through the shell (Pl. III, fig. 8), immersed in liquid, the tubercular imprints usually appear less distinctly as lighter coloured, opaque spots in a denser background. This may result from the preferred orientation of shell material exterior to the tubercular scars which permits light to reflect more readily.

The adductor muscle scar, the largest and most posteroventrally situated, is ovate to tear-shaped, and composed of numerous randomly oriented, angular tubercular impressions. Abushik believes that these tubercular impressions tend to be smaller and more numerous in stratigraphically younger appearing genera. This trend, thought to result from progressive division of original thicker muscular fibres, is, in Siberia, concurrent with increase in specimen size. It becomes apparent with the introduction in middle Llandoverian time of species of *Sibiritia* Abushik 1958. Isolated examples, possibly supporting such a hypothesis, have been found but no such morphological sequence has been verified from Canada.

The chevron muscle scar, so-named for its usual V-shape, lies anterior of the adductor scar and ventral of the "eye" tubercle. In its typical development, this triangular area bears numerous semi-oriented muscular tubercles such as those displayed by *Moelleritia canadensis* Copeland 1962. Atypically this muscular area may form as a narrow band of uniform (*Gibberella lenaica* Abushik) or variable sized (*Hogmochilina ovata* Abushik) tubercles. This atypical chevron development is also exemplified by *Dihogmochilina latimarginata* (Jones) and is known only from these three genera of the Family Isochilinidae.

Dihogmochilina Teichert, 1937

Type species. *Isochilina grandis* var. *latimarginata* Jones, 1891

Teichert's original description of this genus is: "... Leperditiidae that are similar to *Isochilina* but have a forked sulcus behind the eye-spot. The muscle-spot is located between the two forks of the sulcus." (p. 153).

Swartz (1949, p. 326) gave a redescription of the genus, adding to it information based on *Dihogmochilina straightcreekensis* Swartz, a species designated by Swain (1956, p. 1374) as the type of *Swartzochilina* Swain. Swain (loc. cit.) applied Swartz's description of *Dihogmochilina* to *Swartzochilina* and later (1957, p. 555, Pl. 61, figs. 4a, b) used the binomen *Isochilina latimarginata* (Jones), apparently considering *Dihogmochilina* a junior synonym of *Isochilina*. This has not been followed by subsequent workers.

Based on examination of the typical specimens of *Dihogmochilina latimarginata* (Jones) and additional specimens from Tyrrell's original collection it is possible to emend Teichert's description of this genus as follows:

> Subequivalved leperditicopid ostracods with entire, flattened, free marginal border, without marginal nodes or prongs. Sulcus (S2) strong, posterior of eye tubercle, divided into two ventrally. Adductor scar oval to tear-shaped, situated between the ventral parts of S2. Chevron scar forming narrow band along entire anterior edge of adductor.

This description clearly indicates the position of *Dihogmochilina* within the Family Isochilinidae, and its relationship with *Gibberella* and *Hogmochilina* as described by Abushik (1960). Until the muscle scar patterns for all species of these genera have been described it is not certain that a subfamilial designation for these genera is warranted.

Dihogmochilina latimarginata (Jones)

Plate II; Plate III, figures 8–15

Leperditia marginata? Keyserling, Jones, 1856, p. 94, pl. 7, figs. 14a-d.
Isochilina grandis (Schrenck), Jones, 1881, p. 347.
Isochilina grandis Jones, 1882, p. 171; Jones, 1884, p. 344; Jones, 1903, p. 303.
Isochilina grandis var. *latimarginata* Jones, 1891, p. 78, pl. 10, figs. 1–4; Bassler, 1915, p. 673; Savage and Van Tuyl, 1919, pp. 360, 363, 365, 366.
Isochilina latimarginata (Jones), Bassler and Kellett, 1934, p. 340; Swain, 1957, p. 555, pl. 61, figs. 4a, b.
Dihogmochilina latimarginata (Jones), Teichert, 1937, p. 153, pl. 22, figs. 1, 2; Swartz, 1949, p. 326; Stearn, 1956, pp. 35, 36, 44–46, 126, pl. 12, fig. 5; Ehlers and Kesling, 1957, pp. 15, 17, pl. 6, figs. 9–14; Ehlers and Kesling, 1962, pp. 3, 9, 13.

Description. Valves large, oval, 11 to 31 mm in greatest oblique length, 7 to 20 mm high perpendicular to the straight hingeline. L/H ratios of twenty-five specimens averaging 1.59. Hingeline straight, two thirds greatest oblique length, making obtuse angle at anterior corner and slightly projecting at posterior end, making a right or slightly acute angle with the posterior margin. Marginal border entire, without nodes or prongs, broadest anteriorly and posteroventrally. Greatest valve width slightly anterior of median, decreasing abruptly to ventral border, more gradually to dorsum.

Dorsal margin also with border, widest at extremities, with deep sulcus (S2) .33 to .40 of hinge length posterior of anterior corner. Sulcus divided ventrally into two prongs, delimiting the dorsal half of the adductor scar, posterior prong generally longer. "Eye" tubercle prominent, conical, anterior to widest part of S2. Dorsal part of posterior half of valve also prominent, slightly overhanging dorsal border in some specimens.

Adductor area large, tear-shaped, lying between ventral prongs of S2, comprised of numerous (80 to 100 estimated) angular muscle tubercles. Tubercles of large size except along ventral margin of area where they occur as two irregular rows of smaller paired scars or are elongate and constricted medially.

Chevron area a narrow band anterior of the adductor, extending from anteroventrally of adductor (Pl. II, fig. 19) to base of "eye" tubercle (Pl. III, fig. 12). Muscle tubercles usually large and angular but may be slightly smaller near mid-length of the chevron band.

Remarks. Based on development of the chevron scar, *Dihogmochilina latimarginata* is allied with upper Llandovery species of *Gibberella* and *Hogmochilina* described by Abushik (1960), and combines features of both. The chevron scar of *Gibberella lenaica* is comprised of uniform-sized tubercles of large size, that of *Hogmochilina ovata* is comprised of larger tubercles only in its dorsal part, the tubercles becoming progressively smaller ventrally. If, as is suspected, *D. latimarginata* possesses larger chevron tubercles dorsally and ventrally with some smaller tubercles medially, it may show an intermediate stage of development.

Also, as supposed by Abushik, if adductor scar development beginning with middle Llandoverian species of *Sibiritia* shows progressive muscular division, *D. latimarginata*

may show supporting evidence. Paired or dumbbell-shaped adductoral muscle tubercles occur on several specimens of *D. latimarginata* (Pl. II, figs. 19, 20; Pl. III, figs. 8, 15) only along the ventral edge of this area. This may indicate, in Middle Silurian strata of North America, one of the initial stages of a similar muscular development to that indicated from Siberia.

Occurrence. Specimens from the upper part of the Interlake (East Arm dolomite, Cedar Lake Formation) and Burnt Bluff (Hendricks dolomite) Groups of Manitoba and Michigan respectively, Severn River limestone on Harricanaw River, Quebec (GSC loc. 78698), a block of limestone found loose near Churchill, Manitoba (GSC loc. 77705), and unnamed strata at Kûk, Southampton Island are referred to *D. latimarginata.* This species has not been found in southern Ontario in stratigraphically equivalent strata (St. Edmund Formation of Manitoulin Island and Wabi Formation of Lake Timiskaming) or identified during the present study from elsewhere in the Hudson Bay Lowland, but its presence, especially in the latter area, is considered highly probable.

Age. Ehlers and Kesling (1962, p. 9) have designated a zone of *Camarotoechia winiskensis - Dihogmochilina latimarginata* for fauna of the Hendricks dolomite of northern Michigan. It typically contains: *Camarotoechia winiskensis* Whiteaves, *Dihogmochilina latimarginata* (Jones), *Plectatrypa lowi* (Whiteaves), *Leperditia fabulina* Jones, *Multisolenia tortuosa* Fritz, *Trimerella ekwanensis* Whiteaves, and *Scutellum magnificum* Teichert.

This fauna lies between the older *Virgiana decussata* and younger *Pentamerus* (*P. "oblongus"*) zones—both of lower Niagaran age and widespread throughout central North America. A similar age is indicated for this fauna in the Hudson Bay area.

Types. No type specimen was originally designated for this species by Jones. Stearn (1956) elected GSC No. 6055a as holotype of this species. In this report GSC No. 6055 (and No. 6055a, its plaster cast) is designated as the lectotype.

Lectotype, GSC No. 6055; paralectotypes, GSC Nos. 6055b, d, f, g, h, i, 6057a; plaster casts, GSC Nos. 6055a, c, e; hypotypes, GSC Nos. 17089, 20619, 23968–72, 23979–81.

Dihogmochilina boothia n. sp.

Plate III, figures 1–7

Description. Valves large, oval, 14 to 27 mm in greatest oblique length, 11.5 to 19 mm high perpendicular to the straight hingeline. L/H ratios of three complete specimens averaging 1.33. Hingeline straight, about two thirds greatest oblique length, making obtuse angles at anterior and posterior corners. Marginal border entire, without nodes or prongs, broadest anteriorly and posteroventrally. Greatest valve width near median, rounding evenly to dorsum and venter.

Dorsal margin also with border, widest at extremities, with broad sulcus (S2) .35 to .45 of hinge length posterior of anterior corner. Sulcus divided ventrally into two prongs, delimiting the dorsal half of the adductor scar, posterior prong generally more pronounced. "Eye" tubercle prominent, conical, anterior to widest part S2. Dorsal part of posterior half of valve also prominent, not overhanging dorsal border.

Adductor area large, tear-shaped, lying between ventral prongs of S2, comprised of numerous equal-sized angular muscle tubercles. Chevron area a narrow triangular

band anterior of the adductor, extending ventrally from the base of the "eye" tubercle and dying out below mid-height of adductor scar. Muscle tubercles few, angular, irregular in size, becoming smaller ventrally.

Remarks. This species differs from *D. latimarginata* (Jones) in its greater valve width, semicircular outline, and irregular elongate chevron scar. It is somewhat similar to specimens of *Gibberella lenaica* but is easily distinguished by the presence of the bifurcate sulcus (S2) delimiting the dorsal half of the adductor scar.

Occurrence. Northeastern Boothia Peninsula, Northwest Territories (71°31′N, 94°12′W), GSC loc. 50731.

Age. Middle Silurian?

Types. Holotype, GSC No. 23973; paratypes, GSC Nos. 23974–78.

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OSTRACODA FROM THE VAURÉAL FORMATION (UPPER ORDOVICIAN) OF ANTICOSTI ISLAND, QUEBEC

by M. J. Copeland

Abstract

The lower, exposed 400-foot-thick member of Vauréal strata on Anticosti Island has yielded a sparse microfauna of Ostracoda and a species of foraminifer. This fauna belongs to the North American geological province and is correlated with Upper Ordovician faunas of the central mid-continent area.

Résumé

Les couches inférieures exposées de la formation de Vauréal, d'une puissance de 400 pieds, dans l'île d'Anticosti ont livré une microfaune éparse formée d'ostracodes et d'une espèce de foraminifère. Cette faune appartient à la province géologique de l'Amérique du Nord et correspond aux faunes de l'Ordovicien supérieur du centre du continent.

Strata of the Vauréal Formation are exposed for more than 100 miles along the north shore of Anticosti Island from West Point to east of Salmon River. They are about 1,000 feet thick and were included by Twenhofel (1928) in the English Head and Vauréal Formations.

Bolton (1961, 1965) has shown stratigraphically that rocks of the type English Head Formation lie within the upper 600 feet of the Vauréal sequence. This upper member consists mainly of brown weathering, grey limestone with minor argillaceous partings and much intraformational conglomerate. The fauna of these beds includes *Palaeophyllum vaurealensis* Twenhofel, *Catenipora* sp., *Deiracorallium*? *angulatum* (Billings), *Beatricea* spp., and favositids. The lower 400-foot member consists, in the upper part, of blue-grey, fine-grained to dense limestone with interbedded grey shale, the latter increasing in thickness in the middle and lower parts. This is the north shore argillaceous "English Head" strata of Twenhofel. These beds contain *Billingsites canadensis* (Billings), *Cyrtodonta anticostiensis* (Billings), *Rhytimya emma* (Billings), *Dendrocrinus minutus* Springer, and most of the microfauna described in this paper. An easily accessible, nearly complete section of this member is exposed along Rivière à l'huile for about 3 miles above its mouth (Bolton, 1961). Lower exposures occur along the north shore of the island from Wreck Point east to Carleton Point.

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Subsurface investigations by Lowlands Exploration Limited have revealed several hundred feet of beds of Vauréal lithology underlying the lowest exposed strata on the island. These are termed "English Head Formation" by Roliff (1968), following the terminology of Twenhofel, and are shown as conformably overlying black bituminous shale of the Macasty Formation. The probable Edenian age of the Macasty fauna predicates the younger Upper Ordovician age of these subsurface and surface Vauréal strata. The age and arthropod fauna of these subsurface strata are being studied (Bolton and Copeland, *in preparation*).

Stratigraphy and Age Relationships

Most of the microfauna described herein was obtained from blue-grey clay shale beds distributed randomly throughout the lower exposed member of the Vauréal Formation. Exact equivalence among the shallowly dipping (±2°SW) strata along the rivers and shore cliffs of the northern part of the island is not possible; however, relative stratigraphic relationships may be based on distance north of the Vauréal and overlying Ellis Bay Formation contact and the general N75°W strike of the beds. No surface structural discordance has been found in the area occupied by these strata and the low, quaquaversal dips observed over thin biohermal (?) accumulations of beatriceids and corals in the upper Vauréal member do not seriously affect stratigraphic measurement.

Figure 3 shows the known occurrence of Ostracoda and a foraminifer from Vauréal strata of Anticosti Island. Five similar species are reported by Carter (1957) from the St. Hilaire–Pontgravé Formations of southern Quebec, five from the Maquoketa Formation of Iowa, four each from the Stony Mountain Formation of Manitoba and the undivided Richmond of Indiana, and the widespread species *"Bythocypris" cylindrica* (Hall) and *Ulrichia nodosa* (Ulrich) from Eden, Maysville, and Fulton strata of the mid-continental United States.

There is little diagnostic evidence on which to base the age of this Vauréal microfauna. The Stony Mountain, Maquoketa, and Vauréal ostracod faunas are very possibly equivalent, but their reputed Richmondian age needs verification. There is little similarity between these ostracod faunas and that reported from type Richmond strata of Indiana. Several ostracod species from the overlying Ellis Bay Formation on Anticosti appear to be of Late Ordovician age; few of them also occur in Vauréal strata. It appears probable that these formations, with a combined thickness of more than 1,200 feet, may represent a time span encompassing the Richmondian and at least part of the Maysvillian.

Systematic Paleontology

Platyrhomboides? *subcylindrica* (Jones)

Plate IV, figure 1

Macrocypris? *subcylindrica* Jones, 1890, p. 549, pl. 21, figs. 5a, b.
Macrocypris subcylindrica (Jones), Bassler *in* Twenhofel, 1928, p. 350.

Description. Valves subtriangular in lateral and end views, greatest length near ventral margin, greatest height in anterior third, greatest width at ventral edge. Left valve overlapping right dorsally and ventrally, overreaching right at hingeline. Hinge sunken,

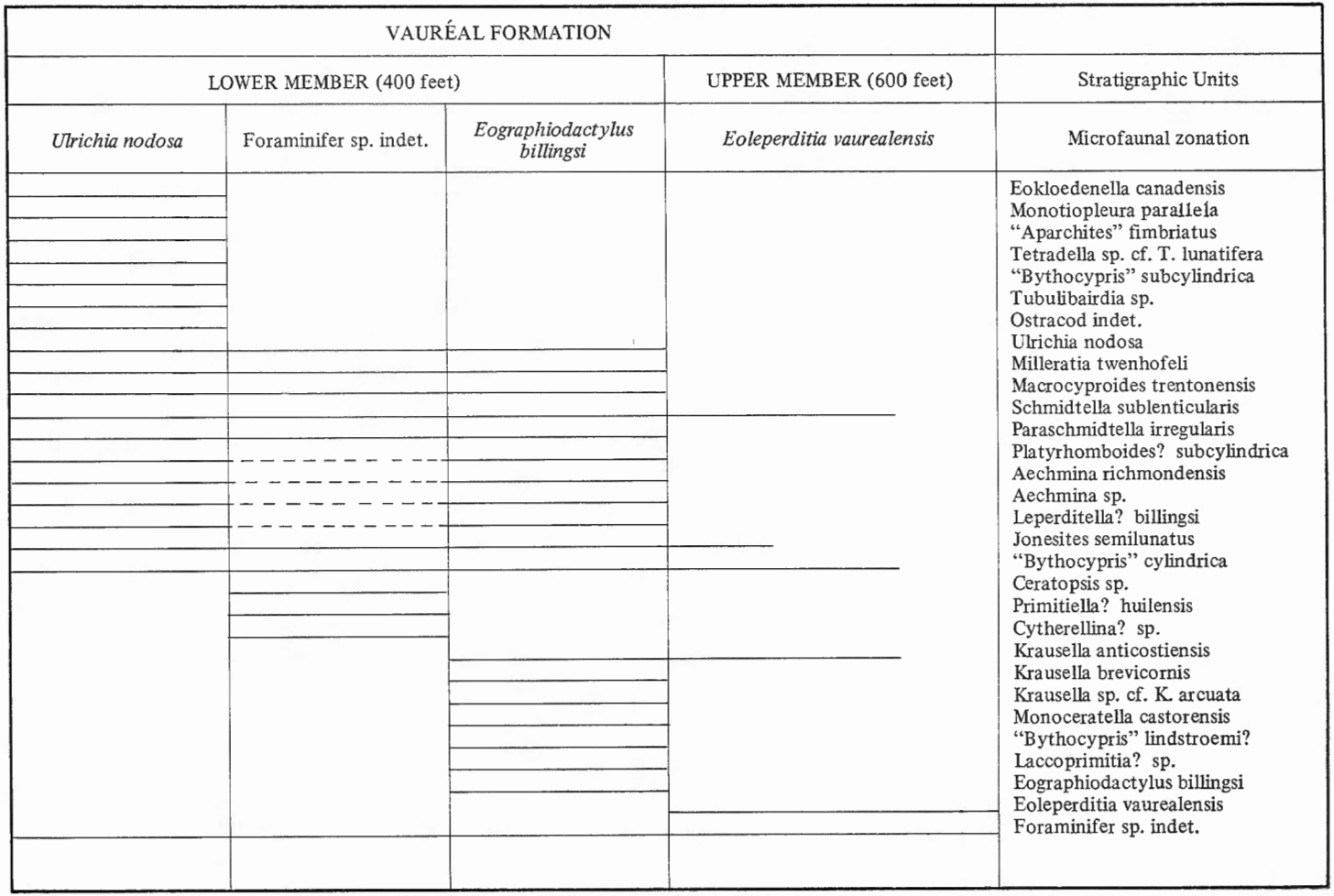

FIGURE 3. Stratigraphic occurrence of microfauna in surface members of the Vauréal Formation, Anticosti Island, Quebec.

occupying entire straight, posteriorly inclined, middle half of valve. Extremities of valves with narrow, ventral flattened areas. Ventral surface of valves broad, flat to slightly sunken near free edge. No ventral marginal ridge.

Remarks. The posterior curvature of the figured specimen does not agree with that of the left valve shown by Jones. This may be due to matrix obscuring the marginal areas of the original specimen.

Occurrence. Vauréal Formation, lower and upper zones of lower surface member. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC locs. 66808, 76151.

Type. Hypotype, GSC No. 23982.

Paraschmidtella irregularis Keenan

Plate IV, figure 2; Plate V, figures 4, 8

Paraschmidtella n. sp. Keenan, *in* Branson, 1944, pl. 15, figs. 32–34.
Paraschmidtella irregularis Keenan, 1951, p. 562, pl. 78, figs. 32–34.

Remarks. The Anticosti Island specimens are similar to the type specimens in having approximately twenty-five pits on the lateral surface of each valve, most pits with a small projection extending from the wall, and a smooth marginal area. The central area, over the point of adductoral attachment, is smooth, outlined by an irregular circle of pits.

Occurrence. Vauréal Formation, lower surface member. Figured specimens (Pl. IV, fig. 2) from Rivière à l'huile, a mile above its mouth, GSC loc. 76143; (Pl. V, fig. 4) from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132; (Pl. V. fig. 8) from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Types. Hypotypes, GSC Nos. 23983, 24141, 24145.

Ulrichia nodosa (Ulrich)

Plate IV, figures 3, 4

Primitia nodosa Ulrich, 1890, p. 134, pl. 10, figs. 11, 12.
Ulrichia nodosa (Ulrich), Ulrich, 1891, p. 203.
Warthinia nodosa (Ulrich), Spivey, 1939, p. 167, pl. 21, figs. 3–6.

Remarks. The specimens figured here are typical and show, better than most other figures, the ventral node characteristic of the species.

Occurrence. Vauréal Formation, lower surface member. Figured specimens from cliff at side of Beaver Cove road where it descends to the shore on the north coast of Anticosti Island.

Types. Hypotypes, GSC Nos. 23984, 23985.

Monotiopleura parallela (Ulrich)

Plate IV, figure 5

Primitia? (?*Beyrichia*) *parallela* Ulrich, 1889, p. 51, pl. 9, figs. 7, 7a.
Beyrichia parallela (Ulrich), Bassler *in* Twenhofel, 1928, p. 343.
Monotiopleura parallela (Ulrich), Guber and Jaanusson, 1964, pp. 13, 17.

Remarks. This species has been described by Guber and Jaanusson (1964) in their discussion of *Monotiopleura auriculata.* Differentiation between these species apparently is based on the bisulcate nature of *M. parallela* and the trisulcate nature of *M. auriculata.* The holotype and other identified primary specimens of *Primitia*? (*?Beyrichia*) *parallela* from Manitoba are poorly preserved but, like the better preserved technomorph figured here from Anticosti, bear no or little indication of S1.

Occurrence. Vauréal Formation, lower zone of lower surface member. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 23986.

Eographiodactylus billingsi n. sp.
Plate IV, figures 6–9, 15, 19

Description. Carapace subquadrate in lateral view, somewhat preplete; dorsum long, four fifths greatest length, straight to slightly convex; venter slightly convex; anterior rounded; posterior slightly curved. Valves nearly equal, right may extend beyond left along venter. Cardinal angles distinct, anterior approximately 120 degrees, posterior 90 degrees, forming a blunt spine.

Narrow, complete velar ridge on both valves, broadest anteriorly (figs. 6, 9) and supporting a small spine at the posteroventral angle of the valves. Marginal ridge on both valves, that of the right larger (fig. 7).

Hinge short, slightly sunken, mostly in posterior half of valve. Surface smooth, with slight dorsomedian depression.

Remarks. Eographiodactylus eos Kraft, the type species, differs from *E. billingsi* in having pronounced anterior and posteroventral spines and apparently in lacking a marginal ridge on either valve. The velar ridge of *E. billingsi* is complete, extending to the cardinal angles whereas in *E. eos* it is reported to extend only from the mid anterior to the posteroventral angle.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimens from Beaver Cove road at west end of bridge over Beaver Cove River, GSC loc. 66771.

Types. Holotype, GSC No. 23987; paratypes, GSC Nos. 23988–23991, 23997.

Jonesites semilunatus (Jones)
Plate IV, figure 10; Plate V, figure 14

Bollia semilunata Jones, 1890, p. 548, pl. 21, figs. 9a, b.
Bollia semilunata Jones, Bassler, *in* Twenhofel, 1928, p. 346.

Description. Valves ovate in lateral view, postplete, dorsum lowly arched. Marginal structures consisting of submarginal ridge along valve contact, channelled marginal field, and abruptly elevated, thick marginal ridge or rim along entire free edge of valve. Marginal ridge in contact near obtuse cardinal angles with thick, U-shaped ridge comprising bulbous L2 and ridge-like L3. Contact between marginal ridge and L2 broad, that between marginal ridge and L3 narrow, ridge-like. Broad marginal ridge continuing dorsal of S2, elevated above the sunken hinge.

Valve surface with U-shaped L2-L3 outlining, ventrally, the prominent, deep, pit-like, reverse comma-shaped S2. Lateral surface of valves enclosed by continuous smooth marginal and U-shaped L2-L3 ridges; a deeply depressed, crescentic area extending higher posteriorly on the valve surface than anteriorly. Floor of this depressed area may be reticulate.

Remarks. This species is most similar to *Jonesites inornatus* (Ulrich) and *Jonesites marginatus* (Ulrich) from Cincinnatian strata at Covington, Kentucky and Cincinnati, Ohio, respectively. *J. semilunatus* is not as symmetrical as *J. marginatus* and has the marginal ridge overhanging and obscuring, in lateral view, the anteroventral valve contact. *J. inornatus* apparently lacks a defined, channelled, marginal field and submarginal ridge.

Occurrence. Vauréal Formation, widespread in lower and upper members.

Types. Hypotypes, GSC Nos. 23992, 24151.

Aechmina sp.

Plate IV, figures 11, 12

Description. Carapace subovate in lateral view, truncated dorsally by straight hinge, preplete. Free margin with thin marginal border and small, discrete, marginal tubercles. Dorsal spine slightly anterior of median, base broad, distal end unknown.

Remarks. These specimens are most similar to *A. cuspidata* Jones and Holl but lack the more numerous marginal tubercles of that species. The extremely long distal part of the spine of *A. cuspidata* is unknown for the present specimens.

Occurrence. Vauréal Formation, lower and upper zones of the lower surface member. Figured specimens (fig. 11) from Beaver Cove road at west end of bridge over Beaver Cove River, GSC loc. 66771; (fig. 12) from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Types. Figured specimens, GSC Nos. 23993, 23994.

Eokloedenella canadensis (Bassler)

Plate IV, figures 13, 14; Plate V, figure 1

?*Aparchites unicornis* var. Ulrich, 1889, p. 50, pl. 9, fig. 11.
?*Primitiella canadensis* Bassler, *in* Twenhofel, 1928, p. 345.

Description. Valves oval in lateral view, dorsum curved, highest posteriorly; anterior and posterior margins evenly rounded; venter straight to slightly sinuate. Left valve overlapping right anteriorly and posteriorly. Contact margin of both valves with fine marginal ridge. Hingeline curved, left valve overlapping right anteriorly, with a narrow, indistinct stragular process, hinge sunken in posterior half.

Valves unisculate, S2 pit-like, deeply incised, in dorsal half and near mid-length of valve, reverse comma-shaped, concave anteriorly. Valve surface abruptly terminated posteriorly, overhanging as a ridge or projecting flap the depressed posterior margin. Posterior projection curved almost parallel with posterior margin, nearly indistinguishable in lateral view.

Dimorphism may be evidenced by posterior width of specimens, hypotype 23995, a presumed heteromorph, being wider posteriorly than hypotype 23996, a presumed technomorph.

Remarks. Guber and Jaanusson (1964) have erected a family, Monotiopleuridae, for Kloedenellacea of Ordovician age, primarily species of the genera *Monotiopleura, Primitiella,* and *?Haploprimitia.* The genus *Eokloedenella* was restricted from this grouping because of valve outline, lack of kloedenellid dimorphism, and possession of a posterior groove. The present specimens of *E. canadensis* are thought to show posterior dimorphism of kloedenellid type, and the posterior groove of *E. canadensis,* lying posterior to the overhanging valve surface or projecting flap, is reminiscent of the groove limiting the posterior side of the posteriorly overturned L4 of *Monotiopleura auriculata* Guber and Jaanusson. If these apparent similarities are valid, *Eokloedenella* might lie between the non-sulcate *Primitiella* and bi- to tri-sulcate *Monotiopleura.* Valve shape is, however, an unexplained feature.

E. canadensis is smaller than the genotype, *E. posterodepressa* Kraft, and does not bear, on its dorsoposterior surface, numerous small pits and intervening low ridges.

Occurrence. Vauréal Formation, lower zone of lower surface member. Figured specimens from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Types. Hypotypes, GSC Nos. 23995, 23996, 24138.

Cytherellina? sp.

Plate IV, figure 18

Description. Carapace ovate in lateral view, somewhat tumid in end view. Left valve overreaching right on all margins, overlapping right along free margin. Hinge short, in posterior half of dorsum. Surface with fine, obscure punctae.

Remarks. The only specimen obtained is not well enough preserved for more detailed description. The surface of the valves is slightly etched and roughened. It is not thought that the slightly greater rounding of the posterior margin, in lateral view, warrants consideration of its inclusion in the genus *Cyrtocypris.* It is possible that the specimen figured by Jones (1890, p. 549, pl. 21, figs. 4a, b) as *Bythocypris*? *obtusa* Jones may represent the right valve of this species.

Occurrence. Vauréal Formation, middle zone of lower surface member. Figured specimen from logging road, a mile north of the bridge over Beaver Cove River.

Type. Figured specimen, GSC No. 24000.

Monoceratella castorensis n. sp.

Plate IV, figures 20–22

Description. Carapace semi-ovate in lateral view, preplete, greatest height median, greatest width ventral, greatest length along dorsal margin. Contact margin of each valve with tuberculate marginal ridge. Hingeline long, straight, anterior cardinal angle projecting, more than 90 degrees, with a blunt spine base; posterior cardinal angle 90 degrees. Lateral surface of valves smooth, slightly depressed dorsomedially, with a strong, laterally directed ventral spine.

Remarks. This differs from other monoceratellid species in possessing a tuberculate marginal ridge on each valve, and having the lateral spine more ventral in position.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimens from Beaver Cove road at west end of bridge over Beaver Cove River, GSC loc. 66771.

Types. Holotype, GSC No. 24001; paratypes, GSC Nos. 24002, 24003.

Schmidtella sublenticularis (Jones)

Plate IV, figure 23

Polycope sublenticularis Jones, 1890, p. 550, pl. 21, figs. 6a, b.
Schmidtella sublenticularis (Jones), Bassler *in* Twenhofel, 1928, p. 342.

Description. Valves subovate in lateral view, truncated dorsally. Valves meeting evenly along free margin, slightly postplete, more broadly rounded anteriorly. Cardinal angles obtuse, anterior angle greater than posterior. Hinge about one half greatest length of valve, sunken between dorsal elevations of valves. Surface smooth.

Remarks. This species is somewhat similar to specimens of *Schmidtella incompta* Ulrich described from Middle Ordovician strata of eastern North America. The dorsal margin of *S. sublenticularis* (Jones) is slightly curved and somewhat longer than is typical of *S. incompta.*

Occurrence. Vauréal Formation, throughout lower and upper surface members. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 24004.

Primitiella? *huilensis* n. sp.

Plate IV, figures 24, 27

Description. Carapace elongate, subrhomboidal. Dorsal margin straight; ventral margin nearly parallel with dorsum, slightly concave medially; ends smoothly curved, anterior less broadly. Cardinal angles obtuse. Valves equal, meeting evenly on all margins, anterior contact margin slightly extended, producing a faint furrow parallel with the anterior margin. Slight, near-median sulcal depression (S2) extending from dorsal margin to adductoral scar near mid-valve, posterior of low, indistinct L2. Surface of valve with numerous papillae, becoming linear near the free margins, and scattered punctae. Short, distinct, posteriorly directed, near marginal spine in posterior ventral quarter of each valve.

Remarks. Guber and Jaanusson (1964) have redescribed *Primitiella,* basing their discussion on *P. minima* (Harris). If their observations are valid for the type species, *P. constricta* Ulrich, most previously known *Primitiella* species, including the present one, belong elsewhere. Until this is clarified *P.*? *huilensis* will be assigned questionably to *Primitiella.*

This species appears most similar to *P.*? *unicornis* (Ulrich) but has a papillose surface (fig. 24) with scattered pores or punctae (fig. 27), bears the posterior spine in a more ventral position, and has a rhomboidal lateral outline.

Occurrence. Vauréal Formation, middle zone of lower surface member. Figured specimens (fig. 24) from Rivière à l'huile, a mile above its mouth, GSC loc. 76143; (fig. 27) from logging road, a mile north of the bridge over Beaver Cove River.

Types. Holotype, GSC No. 24005; paratype, GSC No. 24008.

"Bythocypris" cylindrica (Hall)

Plate IV, figure 25

Leperditia cylindrica Hall, 1871, p. 7, pl. 4, fig. 12.
Bythocypris cylindrica (Hall), Ulrich, 1889, p. 48, pl. 9, fig. 6.

Remarks. This widespread species is found in strata of Middle and Upper Ordovician age throughout eastern North America.

Occurrence. Vauréal Formation, lower and upper surface members. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 24006.

"Bythocypris" subcylindrica (Ulrich)

Plate IV, figure 26

Leperditia subcylindrica Ulrich, 1889, p. 49, pl. 9, figs. 4, a, b.

Occurrence. Vauréal Formation, lower zone of lower surface member. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 24007.

"Aparchites" fimbriatus (Ulrich)

Plate IV, figure 28

Leperditia fimbriata Ulrich, 1892, p. 268.
Aparchites fimbriatus (Ulrich), Ulrich, 1894, p. 645, pl. 45, figs. 10–12.

Remarks. This specimen agrees in all respects with *A. fimbriatus* (Ulrich). Examination of the holotype of *A. whiteavesi* Jones, however, indicates that *A. fimbriatus* probably does not belong within the genus *Aparchites.*

Occurrence. Vauréal Formation, lower zone of lower surface member. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 24009.

Krausella sp. cf. *K. arcuata* Ulrich

Plate IV, figure 29

Krausella arcuata Ulrich, 1894, p. 692, pl. 44, figs. 47–53; (authors).

Remarks. The crushed specimen figured here shows the strong posteroventral spine of the right valve, the straight ventral and arched dorsal margins, and anterodorsal slope typical of the species.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimen from the Beaver Cove road at west end of bridge over Beaver Cove River, GSC loc. 66771.

Type. Hypotype, GSC No. 24010.

Ceratopsis sp.

Plate IV, figure 30

Description. Carapace semi-ovate in lateral view, truncated dorsally by long straight hinge, preplete. Cardinal angles abrupt, anterior angle greater. Quadrilobate, L1 prominent (broken on figured specimen), extending at least to hingeline; L2 short, almost ventral to L1; L3 long, ridgelike, extending to dorsal margin; L4 broad, occupying posterior third of valve. S1 straight, deep; S2 deep, curved, concave anteriorly, extending to below mid-height of valve; S3 broad, shallow, in dorsal half of valve. Valves with prominent velar ridge along anterior and ventral surface, broad subvelar groove, and thin marginal ridge.

Remarks. Without knowing the exact configuration of the distal part of L1, it is impossible to assign a specific name for this specimen. The broad, low L4 may be similar to that of *C. oculifera* (Hall).

Occurrence. Vauréal Formation, middle zone of lower surface member. Figured specimen from Rivière à l'huile, a mile above its mouth, GSC loc. 76143.

Type. Figured specimen, GSC No. 24011.

Laccoprimitia? sp.

Plate V, figures 2, 3

Description. Valves ovate in lateral view, truncated dorsally, preplete. Hingeline three fourths greatest length. Greatest width in ventral third. Cardinal angles abrupt, obtuse. Surface of valves reticulate. S2 prominent, deepest ventrally; presulcate node low. Free margin depressed, with fine admarginal ridge.

Remarks. The generic position of these possibly immature specimens is difficult to determine. The marginal structure is poorly preserved on all specimens observed and may be only weakly developed. If, as is suspected, the figured specimens are steinkerns, better preserved material must be obtained before a detailed description is possible. *Primitia micula* Ulrich 1894 may be somewhat similar to the present specimens.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimens from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132.

Types. Figured specimens, GSC Nos. 24139, 24140.

Macrocyproides trentonensis (Ulrich)

Plate V, figures 5, 10, 15

Aparchites minutissimus trentonensis Ulrich, 1894, p. 646, pl. 43, figs. 18–20.
Aparchites trentonensis Ulrich, Kay, 1940, p. 244, pl. 29, fig. 33.
Macrocyproides trentonensis (Ulrich), Swain, Cornell, and Hansen, 1961, p. 371, pl. 48, fig. 11, pl. 50, figs. 5a, d, text-fig. 2-l.

Remarks. This widespread species is found in strata of Middle Ordovician age throughout eastern North America.

Occurrence. Vauréal Formation, lower surface member. Figured specimens (5) from Vauréal River a short distance upstream from the mouth; specimens (10, 15) from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Types. Hypotypes, GSC Nos. 24142, 24147, 24152.

Leperditella? *billingsi* n. sp.
Plate V, figures 6, 7, 11, 12

Description. Carapace truncate-oval in lateral view, greatest length median, greatest height and width in posterior half, somewhat postplete. Anterior margin evenly rounded, ventral margin nearly straight, posterior margin curved. Dorsum orthocline? in posterior half, hypocline in anterior half. Valves smooth, with faint sulcal depression near mid-length. Lateral surface of valves increasing slightly in width posteriorly. Fine admarginal ridge on both valves along anterior and posterior margins, reduced along venter. Left valve may slightly overreach right along part of the posterior and ventral margins on some specimens.

Remarks. The systematic position of this species is extremely difficult to ascertain. Only carapaces have been obtained, making it impossible to view the extent and shape of hingement.

Occurrence. Vauréal Formation, lower and upper zones of lower surface member. Figured specimen from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132.

Types. Holotype, GSC No. 24148; paratypes, GSC Nos. 24143, 24144, 24149.

Tubulibairdia sp.
Plate V, figure 9

Description. Carapace semitriangular in lateral view; ends somewhat flattened, thickened, equally rounded. Inequivalved, tumid left valve overreaching equally tumid right valve dorsolaterally and overlapping right along slight mid-ventral concavity. Right valve slightly overreaching left dorsally. Hinge in posterior half of dorsum, sunken between slightly angular dorsal shoulders of both valves. Both valves with a posteroventral slit-like angular depression parallel with and near their thickened free margins. Surface granular with some indication of punctae.

Remarks. This species is similar to *T. punctulata* (Ulrich) in end view but is more subtriangular than other tubulibairdiids in lateral view. A posteroventral depression in each valve near its free margin is reminiscent of the marginal structures found in some leperditiids. Whether these structures serve as closure devices is unknown.

Occurrence. Vauréal Formation, lower zone of lower surface member, Nid de Corbeau, north shore of Anticosti Island, a mile west of the mouth of MacDonald River.

Type. Figured specimen, GSC No. 24146.

Milleratia twenhofeli n. sp.
Plate V, figures 13, 16, 20

Description. Carapace subovate in lateral view, slightly postplete; dorsum straight; hinge long, two thirds greatest length. Anterior cardinal angle obtuse, larger than posterior angle. Valve surface with two lobes, separated by a deep, anteriorly concave, sulcus. Posterior lobe (L3) larger, extending to dorsum, joining anterior lobe (L2) ventral of S2. Anterior lobe low, node-like, not extending to dorsum. S2 less than one half greatest height of valve, deepest ventrally. Indistinct ridges on surface of valve, surrounding lobate area and parallel with free margin. Free margin with narrow, flattened border. Valves equal; surface smooth. Dimorphism unknown.

Remarks. This species is similar to but has greater height than *Milleratia cincinnatiensis* (Miller) as described by Ulrich (1890) and Ulrich and Bassler (1923). More recent descriptions of that species by Swartz (1936) and Levinson (1951) appear very different, L2 and L3 extending much above the hingeline and the ventral half of the valves being more expanded. In end view, *M. twenhofeli* is somewhat heart-shaped, the dorsal lobes, however, not extending above the hinge.

Occurrence. Vauréal Formation, lower surface member. Figured specimens (13, 16) from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132; (20) from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Types. Holotype, GSC No. 24157; paratypes, GSC Nos. 24150, 24153.

Aechmina richmondensis Ulrich and Bassler
Plate V, figures 18, 19

Aechmina richmondensis Ulrich and Bassler, 1923, p. 299, text-fig. 15, figs. 19–21.

Remarks. The smooth contact margin, and strong, blunt dorsal spine are typical of this species.

Occurrence. Vauréal Formation, lower and upper zones of the lower surface member. Figured specimens (fig. 18) from Rivière à la Patate, half a mile above its mouth; (fig. 19) from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132.

Types. Hypotypes, GSC Nos. 24155, 24156.

"Bythocypris" lindstroemi? Jones
Plate V, figure 21

Bythocypris? *Lindstroemii* Jones, 1890, p. 548, pl. 21, figs. 11a–c.

Remarks. This species should be considered a nomen dubium, in that the original description could pertain to any bythocyprid-type ostracod. The location of the type specimen is unknown; the present specimen is figured only to indicate that ostracods of the type referred to by Jones are in these strata.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimen from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132.

Type. Hypotype, GSC No. 24158.

Krausella anticostiensis (Jones)

Plate V, figures 22, 23

Bairdia anticostiensis Jones, 1890, p. 548, pl. 21, figs. 3a, b.
Krausella anticostiensis (Jones), Ulrich, 1894, pp. 691, 693.
Krausella anticostiensis (Jones), Bassler *in* Twenhofel, 1928, p. 349.

Description. Valves semi-ovate, highest anteriorly, left valve slightly overlapping right dorsally and ventrally; right valve projecting past left antero- and posteroventrally. Right valve with pronounced, apparently blunt ventral process low on the posterior margin. Valves flattened ventrally.

Remarks. This species differs from *K. arcuata* Ulrich in its blunt anterior margin and right valve anteroventral projection. The figure by Jones is not considered typical of the species in that the specimens viewed by him were much concealed by matrix and were probably individual valves. Also, the ventral view of a valve figured by Jones (3b) does not seem logical, unless reversed. Bassler's assumption (p. 350) that *Bythocypris obtusa* Jones "in all probability represents only the left valve" of *K. anticostiensis* is not thought to be valid because of the asymmetry of the left valve of the specimens of *K. anticostiensis* figured here.

Occurrence. Vauréal Formation, upper zone of lower surface member, and upper member. Figured specimens from Beaver Cove road at east end of bridge over Beaver Cove River, GSC loc. 76289.

Types. Hypotypes, GSC Nos. 24159, 24160.

Eoleperditia vaurealensis (Twenhofel)

Plate V, figures 24–27

Isochilina vaurealensis Twenhofel, 1928, p. 341, pl. 60, fig. 6.

Description. Valves oval in side view, flattened dorsally. Hingeline short, slightly more than one half greatest length, with slightly produced, obtuse cardinal angles. Greatest length, parallel with hinge, 7.6 mm; greatest height in posterior half, 5.7 mm; greatest width ventral of median, 3.8 mm (2 valves). Valves with smooth, submedian, conical swelling ventral of large, ovate adductoral scar. No chevron scar. Surface of valves with discrete, widely spaced pustules, except on submedian swelling. "Eye" spot low, indistinct. Right valve with a long, ventral row of internal tubercles parallel with the contact margin. Tubercles (ca. 23) visible only when immersed in liquid, largest ventrally, becoming smaller anteriorly and posteriorly.

Remarks. There is no indication that this species should be assigned to *Isochilina.* The presence of right valve tubercles, indistinct eye spot, large adductoral scar, and absence of a subocular chevron are typical features of *Eoleperditia* species.

Occurrence. Vauréal Formation, upper member. Figured specimen from a mile north of main road, on first tote road east of Chicoigne's 1966 camp.

Type. Hypotype, GSC No. 24161.

Krausella brevicornis (Keenan)

Plate V, figure 28

Rayella n. sp., Keenan *in* Branson, 1944, pl. 14, figs. 40, 41.
Rayella brevicornis Keenan, 1951, p. 567, pl. 79, figs. 40, 41.
Krausella brevicornis (Keenan), Copeland, 1965, p. 46, pl. 2, figs. 10–12 (synonymy).

Remarks. The specimen figured here has left valve overlap along the entire free margin and slight right valve overlap dorsally. The posterior spine on the right valve is minute, extending to, or only slightly past, the overlap of the left valve, is more ventral in position than that shown by Keenan for *K. brevicornis,* but is similar to specimens of a conspecific form, *Bythocypris*? *spinosa* Harris.

Occurrence. Vauréal Formation, upper zone of lower surface member. Figured specimen from main road, on west side of west branch of small creek flowing northward into Squaw Cove, GSC loc. 76132.

Type. Hypotype, GSC No. 24162.

Tetradella sp. cf. *T. lunatifera* (Ulrich)

Plate V, figure 29

Strepula lunatifera Ulrich, 1889, p. 56, pl. 9, figs. 14, a, b.
Tetradella lunatifera (Ulrich), Ulrich, 1890, p. 112; Bassler *in* Twenhofel, 1928, p. 342.

Remarks. Only fragmentary specimens have been obtained. The figured specimen shows the base of L2, divided L3, and simple L4 joined dorsally with L3.

Occurrence. Vauréal Formation, lower zone of lower surface member. Figured specimen from Pte à l'epinette, north shore of Anticosti Island, a mile east of the mouth of MacDonald River, GSC loc. 76151.

Type. Hypotype, GSC No. 24163.

Foraminifer sp. indet.

Plate IV, figures 16, 17

Description. Test free, circular to elliptical, discoidal, centrally compressed. Central cavity simple. Wall finely agglutinated, surface smooth without visible apertures or somewhat irregular with numerous, widely spaced, round pore-like openings. Greatest diameter of figured specimens 0.9 mm.

Remarks. The compressed, discoidal nature of the test of this species is comparable to that of the holotype of *Thuramminoides sphaeroidalis* Plummer, of Pennsylvanian age. *Thurammina,* a globular Silurian to Recent genus, is typified by having apertures commonly situated on mammillate protuberances.

Occurrence. Vauréal Formation, upper and lower surface members.

Types. Figured specimens, GSC Nos. 23998, 23999.

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SUBSURFACE ORDOVICIAN FAUNA, ANTICOSTI ISLAND, QUEBEC

by Thomas E. Bolton

Abstract

The grey shale at the base of the Vauréal Formation, as studied in three drill cores, contains a trilobite fauna consisting of *Primaspis evoluta canadiana* n. subsp., *Tretaspis ceriodes* (Angelin), *Cryptolithus* sp. aff. *C. bellulus* (Ulrich), *Lonchodomas* sp., and *Triarthrus huguesensis* Foerste; the last species is diagnostic of the Nicolet River Formation (Lorraine shales) of St. Lawrence Lowland. The underlying Macasty black shales are characterized by *Triarthrus spinosus* Billings, *Leptobolus insignis* Hall, *Geisonoceras* sp., and several graptolites. Various invertebrates associated with the trilobites are discussed and, in part, illustrated. A Middle Ordovician trilobite *Lonchodomas denova* n. sp. is described.

Résumé

Le schiste gris qui forme la base de la formation de Vauréal, selon l'étude de trois carottes, renferme une faune constituée principalement des tribolites suivants: *Primaspis evoluta canadiana*, nouv. sous-esp., *Tretaspis ceriodes* (Angelin), *Cryptolithus*, esp. aff. avec *C. bellulus* (Ulrich), l'esp. *Lonchodomas* et *Triarthrus huguesensis* Foerste; cette dernière espèce est typique de la formation de rivière Nicolet (schistes de Lorraine) des Basses-Terres du Saint-Laurent. Les schistes noirs de Macasty sous-jacents renferment *Triarthrus spinosus* Billings, *Leptobolus insignis* Hall, l'espèce *Geisonoceras* ainsi que plusieurs graptolites. L'auteur étudie divers invertébrés associés aux trilobites et décrit également la nouvelle espèce de trilobite de l'Ordovicien moyen, *Lonchodomas denova.*

Information derived from the systematic review of the Silurian and Ordovician faunas of Anticosti Island, Quebec, will form the basis of a series of notes rather than being withheld until completion of the stratigraphic and paleontologic studies. The first reports of this series (Copeland, this bulletin) dealt with the Ostracoda of the Ordovician Vauréal Formation and *Zygobursa praecursor* Copeland from the middle beds of the Silurian Becscie Formation. The present notes outline principally the

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Upper Ordovician fauna recognized in subsurface samples with particular emphasis on the Arthropoda. A new species of *Lonchodomas* is described from Middle Ordovician strata.

The exposed rocks of Anticosti Island are subdivided, in descending order, into the following formations (Bolton, 1961, 1965): the Silurian Chicotte crinoidal limestone, Jupiter limestone and shale, Gun River limestone, and Becscie limestone; the Ordovician Ellis Bay limestone and shale, and Vauréal limestone and shale. Limestone predominates in this sequence of rocks, with thin shale members characterizing definite horizons in the Jupiter and Ellis Bay Formations. The lower member of the Vauréal Formation exposed in the northern part of the island consists of shale with interbedded limestone.

In subsurface, the shale content increases with depth until a distinct grey shale member can be distinguished, overlying black limestone and shale assignable to the Macasty Formation. The grey shale unit is included herein within an expanded Vauréal Formation, rather than assigned to a new formation or, as adopted by Roliff (1968, p. 34), to the English Head, a facies within the upper member of the surface Vauréal only (Bolton, 1965, p. 113). The major subdivisions recognized by the writer within the Upper Ordovician in the Lowlands Gamache Carleton Point No. 1 well (*see* fig. 8, Roliff, 1968; originally logged by S. B. MacEachern) are:

Vauréal Formation—	0′–983′	Limestone and shale grading downward into shale with limestone interbeds.
	983′–1305′	Grey shale.
Macasty Formation—	1305′–1445′	Black limestone and shale.

A total thickness of 3,344 feet (556 to 3,900-foot interval) is assigned to the Vauréal Formation in New Associated Consolidated Paper Anticosti No. 1 well near 24-mile lodge on Jupiter River (underlain by 92 feet of Macasty Formation). Only 2,990 feet of Vauréal is present in Lowlands Gamache Princeton Lake No. 1 well (underlain by 283 feet of Macasty Formation).

A fairly complete core of the Upper Ordovician rocks obtained from the Carleton Point well was studied during the present investigation, and partial sections within the other two cores, through the courtesy of W. A. Roliff, Imperial Oil Limited, Toronto. G. W. Sinclair and M. J. Copeland undertook preliminary identification of the contained fossils. A report (GSC Fossil Report Misc. 4-1968) of the trilobites identified within a more complete sample from the New Associated Consolidated Paper well by P. J. Lespérance, University of Montreal, provided additional information.

Vauréal fauna. Most of the trilobites studied were from the grey shale unit at the base of the Vauréal Formation. Amongst the trilobites, specimens of the odontopleurid *Primaspis evoluta canadiana* n. subsp. and *Primaspis* sp. were abundant within the grey shale between 1,065–1,110 feet in the Carleton Point well. Specimens of the trinucleid *Tretaspis ceriodes* (Angelin) occurred in the same well at 1,008 and 1,033 feet and slightly higher stratigraphically in the New Associated Consolidated Paper well, within the interval 3,204 to 3,280 feet. In addition, *Cryptolithus* sp. aff. *C. bellulus*

(Ulrich) was found at 1,070 feet (fragments of trinucleids identified in the interval 939 to 1,075 feet) near the top of the shale unit in the Carleton Point well and near the base of the shale unit between 2,863 and 2,884 feet in the Princeton Lake well (fragments identified in the interval 1,952 to 2,984 feet). One specimen of the raphiophorid *Lonchodomas* sp. was identified within the upper part of the grey shale at a depth of 3,319.8 feet in the New Associated Consolidated Paper well; most of the raphiophorids (*Lonchodomas denova* n. sp.) were found in the Middle Ordovician of both the Carleton Point and Princeton Lake wells. The olenid *Triarthrus huguesensis* Foerste ranged in the Carleton Point well throughout the lower 226 feet of the Vauréal Formation.

Graptolites were distributed throughout the Vauréal of Princeton Lake well, i.e., *Didymograptus* sp., *Amplexograptus* sp. and/or *Diplograptus* sp. (Pl. VII, figs. 13, 14), *Climacograptus* sp., and *Dicellograptus* sp. (Pl. VII, fig. 2). *Diplograptus* sp. and *Climacograptus* sp. were abundant in the upper 778–1,033 foot and 1,136–1,272 foot intervals of the Carleton Point well. Other invertebrate fossils within the Vauréal of this well are the brachiopod *Lingula* sp. cf. *L. divulgata* Sinclair (Pl. VI, fig. 22); pelecypods *Byssonychia* sp. and *Ctenodonta* sp. (Pl. VI, fig. 23); and cephalopod *Geisonoceras* sp. (basal 235 feet). Ostracods (as identified by M. J. Copeland) *"Bythocypris" cylindrica* (Hall), *Pseudulrichia* sp., and *Jonesella* (?) sp. were recognized in both the Carleton Point and Princeton Lake wells; in the latter well *Aechmina* sp., *Parenthatia* n. sp., and *Primitia* sp. were additional ostracods present in the basal shales.

Chitinozoans recognized by Jansonius (1964, p. 908; pl. 1, figs. 7, 8) included *Tanuchitina* sp. A at 480 feet, *Hercochitina crickmayi* Jansonius at 690 feet, and *Belonechitina* sp. A at 1,100 feet in the Princeton Lake well. The acritarchous hystrichospheres described by Staplin, *et al.* (1965) from the Vauréal Formation (not Trenton as published) of New Associated Consolidated well consisted of *Poikilofusa striata* Staplin, Jansonius and Pocock at 2,945 feet, and *P. spinata* Staplin, Jansonius and Pocock, *Multiplicisphaeridium bifurcatum* Staplin, Jansonius and Pocock, and *M. irregulare* Staplin, Jansonius and Pocock at 3,005 feet. The only bryozoan identified during the present investigation, *Prasopora* sp. aff. *P. lenticularis* Ulrich (Pl. VII, figs. 10, 11, 15) was from this same well.

Macasty fauna. The olenid trilobite *Triarthrus spinosus* Billings (Pl. VI, fig. 7) was present 88 feet below the top of the Macasty Formation in the Carleton Point well, and *Triarthrus* sp. in the upper foot of the Macasty in the Princeton Lake well. Graptolites were very abundant in both wells. G. W. Sinclair reported *Diplograptus* sp., *Dicellograptus*(?) sp., *Climacograptus* sp., *Glossograptus* sp., and *Dicranograptus* sp. (Pl. VII, fig. 12). According to Riva (1968, p. 50), the Macasty black shales of Anticosti, time-equivalents of the 'Lorraine shales' of the St. Lawrence Lowland, bear a distinct graptolite assemblage, the *Climacograptus manitoulinensis* fauna. *Climacograptus typicalis* var. *magnificus* Twenhofel characterizes the typical Macasty shales, associated with *Triarthrus macastyensis* Twenhofel, *Leptobolus insignis* Hall, and *Geisonoceras* sp. In subsurface, both the brachiopod (Pl. VII, fig. 7) and cephalopod were abundant, with the latter identified to within 25 feet of the base of the Macasty in the Carleton Point well and to within 58 feet of its base in the Princeton Lake well.

Systematic Paleontology

TRILOBITA

Family ODONTOPLEURIDAE Burmeister, 1843

Genus ***Primaspis*** R. and E. Richter, 1917

Type species. *Odontopleura primordialis* Barrande, 1846

Primaspis evoluta (Törnquist, 1884) *canadiana* n. subsp.

Plate VII, figures 1, 3, 5, 6, 8

Description. Cranidium crescentic in outline, moderately convex, 8 mm wide (tr.) and 5 mm long (sag.). Surface tuberculate. Glabella convex, median lobe distinct, standing highest, with relatively constant width, frontal lobe sloping steeply down into narrow anterior border furrow with little lateral expansion; both preoccipital and middle lateral glabellar lobes well defined, but short anterior lobe weakly but distinctly developed; furrows deep with lateral furrows oblique to the sagittal line.

Occipital ring wide with low, distinct occipital lobes behind preoccipital lobes, and low mesial tubercle; occipital furrow deepest between occipital and glabellar lobes.

Inner fixed cheeks or cheek-roll medium width, triangulate, dying out anteriorly opposite middle lobe; narrow eye or ocular ridge, blending into surface opposite anterior lobe, outlined by a well developed furrow along the inner edge (Pl. VII, fig. 1); outer fixed cheek depressed concave, anterior facial suture curves forward and inwards from opposite the anterior tip of the preoccipital lobe (Pl. VII, fig. 1) to cross the anterior border opposite the anterior lobe; posterior facial suture curves outward and forward until parallel with posterior border furrow.

Associated free cheeks (Pl. VII, fig. 6) triangulate, strongly convex, granulate, with narrow flattened border bearing seventeen–eighteen short, backward curving spines; some swelling at base of tapering librigenal spine. Hypostome normal, slightly wider (tr.) than long, shield shape.

Isolated fragments of narrow (sag.) thoracic pleurae display slim principal pleural spines bent steeply backwards and stubby hooked anterior pleural spines; axis 1 mm width (tr.) in 6 mm total width; surfaces finely granulate.

Associated pygidia (Pl. VII, figs. 3, 5) 8.5 mm wide (tr.) and 3 mm long (sag.). Axis or rachis 1 mm at anterior end, tapering over a distance of 1 mm to a low terminal part that is fused with the broad, flat posterior border; two narrow rings separated by deep furrows; pleural ridge curved outward and backward from first ring to reach posterior margin at about one half pleural width, passing into two major spines, each at least 4 mm long; pleural area depressed. Four secondary spines posteriorly, unfused, and two pairs of spines anteriorly outside the major spines. Surface medium to finely granulate.

Discussion. The subspecies varies from *P. evoluta* from the Boda Limestone, Harju Series, Sweden (Burton, 1966, p. 4) in that: on the cranidia the S_2 lateral glabellar furrow is oblique rather than almost parallel to the longitudinal furrow and the anterior glabellar lobe is not as distinct; the free cheek of *canadiana* bears at least seventeen rather than eight spines; and the pygidia bear a total of ten border spines, unfused, compared with twelve and fused major spines. Pygidia of *P. semievoluta* (Reed) from

the Longvillian Stage, Caradoc Series, of Northern England, have five pairs of unfused marginal spines, but the pleural ridges and major spines are straight; in addition, the median glabellar lobe of *P. semievoluta* appears more expanding. Both *P. evoluta* and *P. semievoluta* recently have been assigned to the subgenus *Meadowtownella* (Přibyl and Vaněk, 1965, p. 282).

Types and occurrence. Holotype, GSC No. 24572; paratypes, GSC Nos. 24573, a-c (associated cranidium, free cheek, and two pygidia, obverse and reverse). Vauréal Formation, Upper Ordovician. Lowlands Gamache Carleton Point No. 1 well, depth 1,065 (holotype) and 1,110 (associated form *Triarthrus* sp. cranidium) feet; top of escarpment immediately west of mouth of Potatoe River, Anticosti Island, Quebec.

Primaspis sp.

Plate VII, figures 4, 9

Description. 1. Cranidium oval, 6 mm wide (tr.) and 5 mm long (sag.), characterized by a very narrow inner fixed cheek or cheek-roll, low eye ridge, and a wide outside area; vase-shaped median glabellar lobe widest opposite mid-point of posterior lobe; preoccipital or posterior glabellar lobe elongate; narrow anterior lobe well developed; frontal lobe gentle slope into shallow, broad anterior border furrow, with slight lateral expansion; anterior facial suture joins eye ridge in line with centre of preoccipital lobe.

In narrowness of cheek-roll and expanded median lobe, this specimen resembles *P. semievoluta* (Reed, 1910, pl. 17, fig. 1).

2. Pygidium at 1,075-foot depth much wider transversly (8 mm) than sagittally (2 mm); pleural ridge relatively straight, reaching the lateral margin close to the rachis or axis; two thin major spines, five pairs of outside border and two pairs of posterior spines, apparently unfused.

Another pygidium of similar proportions identified at 1,065.1-foot depth displays three pairs of posterior spines plus a smaller pair fused to the two major spines (hypotype, GSC No. 24576). The small incomplete glabella distinctly associated with this pygidium has narrow preoccipital glabellar lobes, quite unlike the lobes of *P. evoluta canadiana.* A very small pygidium (hypotype, GSC No. 24577), from the same horizon and of the same proportion as *P. evoluta canadiana,* displays two pairs of posterior spines plus one pair of short spines fused to the major spines.

Types and occurrence. Figured specimens, GSC Nos. 24574, 24575. Vauréal Formation, Upper Ordovician. Lowlands Gamache Carleton Point No. 1 well, depth 1,080 and 1,075 (associated forms *Cryptolithus*(?) sp.; *Lepidocoelus* sp.) feet; top of escarpment immediately west of mouth of Potatoe River, Anticosti Island, Quebec.

Family TRINUCLEIDAE Hawle and Corda, 1847

Genus ***Tretaspis*** M'Coy, 1849

Type species. *Asaphus seticornis* Hisinger, 1840

Tretaspis ceriodes (Angelin)

Plate VI, figures 12, 14, 15, 17–19

1930 *Tretaspis clarkei* Cooper *in* Schuchert and Cooper, p. 365, pl. 4, figs. 1–10.
1941 *T. cerioides* (Angelin), Whittington, p. 29, pl. 6, fig. 36.

Description. Cephalon length (sag.) to width (tr.) as 1:2; vase-like glabella bulbose anteriorly, narrowing posteriorly rapidly as in *Novaspis* with two relatively deep lateral glabellar furrows extending obliquely forward, anterior lobe opposite eye; occipital ring hood-like, rising out from a broad occipital furrow marked with apodemes (hypotype, GSC No. 24579).

Fixed cheek or genal roll trapezoid in outline, convex, highest dorsally; surface coarsely reticulate, particularly along posterior and inner axial furrow areas; tiny round eye tubercles offset towards axial furrow (Pl. VI, figs. 12, 17, 19); posterior border furrow deep. Fringe concave, characterized by two rows of pits external to girder, varying from offset to radially linear with each other, E_1 and E_2 fusing anteriorly and anterolaterally into one row; fourth row of pits, I_3, inserted in front of the glabellar frontal lobe with associated development of carinate ridges; laterally the rows of pits number four or five and are defined by non-carinate ridges; wide, convex lateral and posterior borders, doublure with terrace lines; hollow genal spine expands into free cheek.

Separate pygidium assigned to this species small, length (sag.) to width (tr.) as 1:3; stubby axis extending to posterior margin, with six narrow rings and three low pleural ridges. A pygidium with at least five bluntly pointed thoracic segments is preserved at 3,229 feet (hypotype, GSC No. 24583) beside an incomplete *Tretaspis* cephalon.

Discussion. T. ceriodes has been reported (as *T. clarkei*) from the Whitehead Formation of Gaspé (along with *T. granulata* (Wahlenberg) from the Lower or Middle Ashgill part according to Lespérance, 1968, p. 813). The type is from the upper part of the Upper Chasmops Limestone (Etage 4bγ) of southern Norway (Størmer, 1945). The specimens from Anticosti Island are larger and less convex than the Whitehead forms, and more angulate in the genal spine region apparently with extension posteriorly of fringe pits.

Types and occurrence. Hypotypes, GSC Nos. 24578 to 24583. Vauréal Formation, Upper Ordovician. New Associated Consolidated Paper Anticosti No. 1 well, depths between 3,208 and 3,269 feet; north side of Jupiter River at 24-mile lodge, Anticosti Island, Quebec. Fragments of *Tretaspis* were recognized in this well within the interval 3,204 to 3,280 feet, and two well preserved cephalons and a pygidium of *T. ceriodes* occur with *Climacograptus* sp. at 1,008 feet in Lowlands Gamache Carleton Point No. 1 well (hypotypes, GSC Nos. 24584, a, b). A very convex carinated fringe of *Tretaspis* was identified in the same well at 1,033 feet depth.

Genus *Cryptolithus* Green, 1832

Type species. *Cryptolithus tessellatus* Green, 1832

Cryptolithus sp. aff. *C. bellulus* (Ulrich)
Plate VI, figures 9, 10

Description. Fringe of one incomplete cephalon relatively flat; three to four rows of pits in the frontal glabellar lobe area, radially to alternately arranged, that continue posterolaterally with I_2 and I_3 pits equally small and I_1 and E_1 (at least 40) pits equally larger; I_4 pits minute, restricted posteriorly; additional pits at posterolateral edge of cheek lobe random spacing. In the other more elongate (tr.) specimen, row I_3 definitely

is interrupted in front of the anterior part of the cheek-roll, and I_3 and I_4 pits are of unequal size. Axial furrows of both specimens broad with anterior pits.

Types and occurrence. Hypotypes, GSC Nos. 24585, 24586. Vauréal Formation, Upper Ordovician. Lowlands Gamache Princeton Lake No. 1 well, depths 2,884 and 2,863 feet; southwest of south end of Princeton Lake, 9 miles northeast of Port Menier, Anticosti Island, Quebec. The highest *Cryptolithus* sp. recognized in this well was at 1,952 feet. A specimen similar to *C. bellulus* was found also in the Vauréal Formation of Lowlands Gamache Carleton Point No. 1 well at a depth of 1,070 feet.

Cryptolithus bellulus (Ulrich), in association with *C. recurvus* Ulrich, ranges throughout the Breault Member (*Cryptolithus* Zone) and into the lower 40 feet of the overlying Chambly Member (*Proetus* Zone), Nicolet River Formation, in the Yamaska-Aston area of the Eastern Townships, Quebec (Clark, 1964). The species was originally described from Eden shales of Covington, Kentucky, and is typical of the Eden of the adjacent Cincinnati, Ohio, area, the Martinsburg shale of Virginia and Pennsylvania, the Lorraine Group of eastern New York State (Whittington, 1968, p. 712), and the Blue Mountain or upper member of the Whitby Formation of southern Ontario (Liberty, 1964, p. 45).

Family RAPHIOPHORIDAE Angelin, 1854

Genus ***Lonchodomas*** Angelin, 1854

Type species. *Ampyx rostratus* Sars, 1835

Lonchodomas denova n. sp.

Plate VI, figures 16, 20, 21, 25

Description. Cephalon triangular in outline, relatively flat, 18 mm wide (tr.) and at least 10 mm long (sag.). Glabella widens steadily for half its length, gently convex, overhanging, bounded by broad, shallow axial furrows with anterior pits, carinate from occipital furrow forward, extending into a long, horizontally projected, grooved spine, quadrate and prismatic in cross-section; pair of low, distinct posterior glabellar lobes. Occipital furrow shallow, bearing posterior pair of muscle scars; occipital ring narrow, hood-like, extending laterally unbroken into posterior border of equal width; posterior border furrow medium depth, ending in a pit at suture line. Fixed cheek very gently convex; facial suture sigmoidal, extending underneath part of the overhanging glabella forward of axial furrow. Surface finely punctate.

Isolated pygidia length (sag.) to width (tr.) as 1:2, curved to slightly triangular in outline. Axial furrows very shallow; axis low, tip extending into well defined border, with fourteen to fifteen segmental divisions, outlined by two pairs of muscle areas; one well defined narrow pleural furrow curving outward and forward; doublure with terrace lines.

Discussion. The evenly curving sigmoidal facial suture and the wide (tr.) carinate glabella appear to separate the new species from most illustrated specimens of *Lonchodomas. L. longirostris* Cooper from the Whitehead Formation of Gaspé, Quebec (within the Lower or Middle Ashgill part according to Lespérance, 1968, p. 813), has the more typical shoulder development on the suture, a much narrower and pointed, non-carinate glabella, a spine circular (topotypic material prismatic grooved—Lespérance, pers. com.) in cross-section and more upwardly directed, and an ill-defined occipital furrow and ring. Cranidia of *L. pennatus* (La Touche) from the Actonian, Onnian, and Pusgillian

Stages of Northern England (Dean, 1960, p. 82) are similar to *L. denova* although they lack or only bear faint traces of a slight median ridge or carina on the glabella (Dean, 1962, p. 78). Pygidia of *L. denova* are of the *L. drummuckensis* (Reed) – *L. pennatus* – *L. rostratus* (Sars) type with only one pair of well defined, anteriorly located, pleural furrows which die out before reaching the axial furrows.

There is no evidence of the flat anterior cheek border characteristic of *L. normalis* (Billings) from the Table Head Formation of Newfoundland. The new species is closer to *L. clavulus* Whittington from the same beds which lacks the flat anterior cheek border, but it varies in extending farther forward over the anterior border. This last feature also distinguishes it from *L. carinatus* Cooper, *L. politus* Raymond, and from some figured cranidia of *L. mcgeheei* Decker.

Types and occurrence. Holotype, GSC No. 24587; paratypes, GSC Nos. 24588–24590. 'Trenton' Formation, Middle Ordovician. Lowlands Gamache Carleton Point No. 1 well, depth 1,900 feet (cranidia); top of escarpment immediately west of mouth of Potatoe River. Lowlands Gamache Princeton Lake No. 1 well, depths 3,431 and 3,468 feet; southwest of south end of Princeton Lake, 9 miles northeast of Port Menier, Anticosti Island, Quebec. *Isotelus* sp. is associated with all specimens (Pl. VI, fig. 11). A smooth pygidium of *Lonchodomas* sp. much like *L. denova* but with a low, broad axis and single pleural furrows, to which four thoracic segments are attached, is found at 1,992.7 feet depth, Lowlands Gamache Carleton Point No. 1 well (hypotype, GSC No. 24591).

Lonchodomas sp.
Plate VI, figure 13

Description. Isolated pygidium length (sag.) to width (tr.) as 1:2.7, semi-elliptical in outline. Axial furrows shallow; axis low, stubby extending to well defined border, with at least seven segmental divisions; single row of large muscle scars preserved; one well defined and three faint pleural furrows curving outward and forward; doublure with terrace lines.

Discussion. The illustrated form is similar to pygidia assigned to *L. carinatus* Cooper and *L. variable* Tripp.

Type and occurrence. Figured specimen, GSC No. 24592. Vauréal Formation, Upper Ordovician. New Associated Consolidated Paper Anticosti No. 1 well, depth 3,319.8 feet; north side of Jupiter River at 24-mile lodge, Anticosti Island, Quebec.

Family OLENIDAE Burmeister, 1843
Genus ***Triarthrus*** Green, 1832

Type species. *Triarthrus beckii* Green, 1832

Triarthrus huguesensis Foerste
Plate VI, figures 1–6, 24

Description. Cranidium length (sag.) to width (tr.) as 1:2. Maximum width of glabella at least half that of cranidium at posterior border; squarish glabella slightly wider than long, between 2.5 and 6 mm wide and 2.5 and 5.5 mm long, contracting anteriorly with rounded anterior corners and straight frontal lobe; two pairs of parallel, deep lateral glabella furrows curve posteriorly, preoccipital glabellar lobe slightly inflated; thin, light

brown layers of exoskeleton display dark coloured traces of two additional pairs of short furrows on the frontal lobe of the glabella—one pair very short, obliquely directed, located anterior to the inner ends of the second glabellar furrows, the second pair longer but normally not reaching axial furrows, horizontal, near the anterior end.

Axial furrows deep, continuous from posterior border into narrow preglabellar furrow; occipital furrow deep; occipital ring wide, equal width, curving forward distally, with a small mesial tubercle near the anterior margin.

Eye lobe narrow, sigmoidally curved, extending from opposite anterior furrow of the frontal lobe to opposite mid-point of preoccipital glabellar lobe, bounded by a strong palpebral furrow; anterior branch of facial suture curves outward slightly in the best preserved specimens (Pl. VI, figs. 2, 6); posterior branch of facial suture curves outward abruptly, producing stubby fixed cheeks. Surfaces of fixed cheek, anterior border, and glabella very finely punctate.

Isolated thorax of fourteen segments, with axis wider than pleural regions, tapering gently backward, particularly after the fifth segment; each pleura directed backward, deep diagonal pleural furrow.

Discussion. The types (GSC 6780b) of *Triarthrus huguesensis* Foerste are distorted; the glabella of the best preserved specimen has a maximum width of 4.5 mm and length of 3.6 mm. The species occurs throughout the upper 260 feet of the Breault Member (*Cryptolithus* Zone), Nicolet River Formation, in the Yamaska–Aston area of the Eastern Townships, Quebec (Clark, 1964). The Anticosti Island forms vary principally in their squarer glabella; one crushed specimen (Pl. VI, fig. 1) is very similar to the types. *T. huguesensis* and *T. spinosus rougensis* Parks (1928, fig. 25) appear similar in the length of their eye lobes, but the squarish glabella of *T. huguesensis* is more of the *T. glaber* Billings – *T. canadensis* Smith type (Parks, 1928, figs. 26, 27).

In *T. macastyensis* Twenhofel the axial sutures are curved, contracting at the occipital ring and the eyes appear shorter and more anteriorly located; outward curving of the anterior branch of the facial suture is similar in both species, but outward curving of the posterior branch of *T. huguesensis* is far more pronounced. The isolated thorax assigned to *T. huguesensis* is less pointed than *T. macastyensis* (Pl. VI, fig. 8) or *T. spinosus* Billings (Pl. VI, fig. 7) from the older Macasty Formation.

Types and ocurrence. Hypotypes, GSC Nos. 24593 – 24598 (cranidia), 24599 (thorax). Vauréal Formation, Upper Ordovician. Lowlands Gamache Carleton Point No. 1 well, variously from depths of 1,079 (associated with odontopleurid-spined free cheek), 1,110.6, 1,155, 1,157 (thorax), 1,163, and 1,165 feet; top of escarpment immediately west of mouth of Potatoe River, Anticosti Island, Quebec. The graptolite *Climacograptus* sp. occurs with *Triarthrus huguesensis* at 1,163 and 1,165 feet, and *Glossograptus* sp. at 1,157 feet. Additional specimens of the species have been identified in the Vauréal Formation of the Carleton Point No. 1 well at depths of 1,159, 1,160, and 1,241 feet.

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TRILOBITES AND STRATIGRAPHY OF THE MIDDLE CAMBRIAN CORNER-OF-THE-BEACH FORMATION, EASTERN GASPÉ PENINSULA, QUEBEC

by W. H. Fritz, C. H. Kindle, and P. J. Lespérance

Abstract

The upper 170 feet of the Corner-of-the-Beach Formation outcrops about 6 miles northwest of Percé, Quebec. This formation was previously assigned by Kindle to the late Lower(?) Cambrian. A study of recently collected trilobites indicates that the exposed, fossiliferous part of the formation belongs to the late Middle Cambrian *Bolaspidella* Zone, and that the upper, barren beds must belong to the same zone or to the early Upper Cambrian Dresbachian Stage. New species described are *Kingstonioides primicaudus, Modocia supera,* and *Spencella punctata.*

Résumé

La partie supérieure de la formation de Corner-of-the-Beach, d'une puissance d'environ 170 pieds, affleure à environ six milles au nord-ouest de Percé (Québec). Auparavant, C. H. Kindle l'avait classée à la fin du Cambrien inférieur (?). Une étude des trilobites recueillis dernièrement a révélé que la partie exposée et fossilifère de la formation appartient à la fin du Cambrien moyen, zone à *Bolaspidella,* et que les couches supérieures non fossilifères doivent appartenir à la même zone ou au début du Cambrien supérieur, stade Dresbachien. Les auteurs décrivent les nouvelles espèces suivantes: *Kingstonioides primicaudus, Modocia supera* et *Spencella punctata.*

A one-half by 5 mile area underlain by Cambrian rocks is reported to be centred 4 miles northwest of Percé, Quebec. Maps delineating this area have been shown by Kindle, 1936, maps B and C; Alcock, 1935, map 330A; McGerrigle, 1950, fig. 1; McGerrigle, 1953; and McGerrigle and Skidmore, 1967. None of these maps differentiates areas of Quaternary overburden from Cambrian outcrop, nor do they differentiate the individual Cambrian formations.

Within this area are two known outcrops of the Corner-of-the-Beach Formation. These are less than 3 miles from Corner-of-the-Beach Village (Fig. 4) and can be

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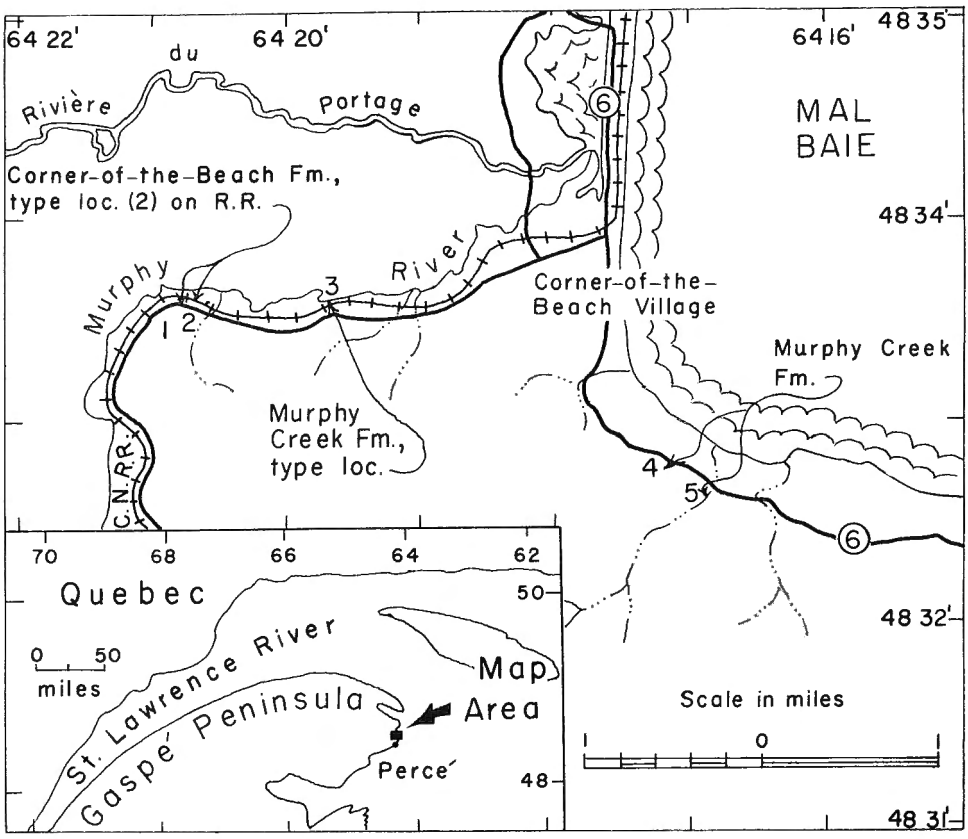

FIGURE 4. Index map of outcrops of the Corner-of-the-Beach Formation (1, 2) and Murphy Creek Formation (3 to 5).

reached by travelling westward on an unnumbered, paved road (locally called the Lemieux Road) that branches from highway 6 just north of the village.

Before reaching the Corner-of-the-Beach outcrops, and at a point 1.7 miles west of highway 6, the observer is close to the type locality of the Murphy Creek Formation. This type locality is about 200 yards north of the road and lies on the south bank of Murphy River. It is north of the western third of a sharp, elongate ridge that is near the road and parallels it to the south.

Continuing westward (past the sharp ridge), the road rises on the north flank of a hill, dips to cross a small stream, and rises a second time before curving southward. Near the top of the second rise, and 2.5 miles west of highway 6, is the first of the Corner-of-the-Beach outcrops. It is, in part, an east-west trending road cut that extends 150 feet along the south side of the road. The apparent dips at the cut suggest an anticline, and a short distance south of the road the beds dip steeply south. At this outcrop all the known stratigraphic units of the Corner-of-the-Beach Formation are exposed, but no fossils have been found. Also exposed is a 3-foot conglomerate bed at the base of the overlying Murphy Creek Formation and several tens of feet of greenish grey shale, the more typical Murphy Creek lithology.

The second outcrop, the type locality, is a short distance (100–200 yards) northeast of the first outcrop. It is exposed in a cut on the Canadian National railway. Here the strata strike N80°E and dip S65°. Equivalent beds are less deformed and better exposed at this locality than at the first.

In addition to these outcrops, two exposures of the overlying Murphy Creek Formation (Fig. 4, locs. 4 and 5) were examined and are discussed under *Stratigraphy*.

Previous Work

In 1930, Charles Schuchert discovered Middle Cambrian strata at what was to become the type locality of the Corner-of-the-Beach Formation, and made a small fossil collection. Later, Kindle made a collection from these strata, and Schuchert returned with P. E. Cloud, Jr. to collect again. In 1942 Kindle introduced the name Corner-of-the-Beach Formation, and provided the only illustrated description of its fauna. Even though he studied all three collections for his faunal description, the amount of the fossil material was small, and he questionably assigned it to the late Lower Cambrian.

Additional fossils were gathered by Lespérance in 1962 and by W. B. Skidmore in 1965. In 1968 Kindle and Fritz inspected Cambrian rocks in the area, and spent two days collecting at the type locality of the Corner-of-the-Beach Formation.

Acknowledgments

W. B. Skidmore guided us to a number of Cambrian outcrops and discussed with us his findings made while mapping for the Quebec Department of Natural Resources. Trilobites collected by Charles Schuchert, P. E. Cloud, Jr., and Skidmore were studied with our own material. Trilobite types described by Kindle (1942) were loaned by Mrs. M. D. Dasch of the Peabody Museum of Natural History. The manuscript was read by Skidmore and A. R. Palmer. To these we extend our appreciation and gratitude.

Stratigraphy

Description of the Corner-of-the-Beach Formation is mainly from observations at the type locality on the Canadian National railway (loc. 2); that of the contact between the Corner-of-the-Beach and the Murphy Creek Formation is from observations at locality 1. All descriptions of the strata are presented in ascending order unless otherwise indicated.

Corner-of-the-Beach Formation

Unit 1. The lowest visible strata consist of about 80 feet of poorly exposed, orange-yellow weathering, thin-bedded limestone. The beds undulate and have a shale or siltstone coating. Fresh surfaces are light brown and finely crystalline. Except for a few beds in unit 3, no other limestone in the region resembles that of unit 1, and therefore the fossiliferous, identical rock used as railway fill near the east end of the cut can be assumed to have come from unit 1 or 3. Parts of the fossil collections by Lespérance, and Skidmore came from the railway fill.

Unit 2. Resistant, medium grey weathering limestone makes this unit prominent, despite its thickness of only 3 feet. Fresh limestone is medium to dark grey, and finely crystalline. Although fossils are sparse, this unit yielded most of the trilobites figured in this paper.

Unit 3. Thicknesses within this 31-foot unit must be tentatively estimated because contacts at various lithologic changes are poorly exposed. The approximate thicknesses and lithology of its subunits are: (a) ±7 feet of light brown to light olive-brown weathering shale with some orange-yellow weathering limestone interbeds; (b) ±13 feet of light brown, oölitic limestone that weathers the same colour and is in beds averaging 8 inches thick; (c) ±11 feet of bright orange weathering, light to medium grey, finely crystalline limestone in thin, platy beds. No fossils were found in the Corner-of-the-Beach Formation above unit 3.

Unit 4. About 9 feet of nearly white weathering, very thick bedded, finely crystalline, white limestone constitutes unit 4.

Unit 5. Light grey, blocky weathering limestone in beds 4 to 8 inches thick comprises the uppermost unit exposed at the railway cut. The lower 25 feet is very light grey on both weathered and fresh surfaces, and the limestone is finely crystalline. Oölites are sparse near the base and increase in number upward. The uppermost 20 feet is very oölitic and light brownish grey. Correlation with the highway outcrop suggests that the highest oölite at the railway cut is not far below the top of the Corner-of-the-Beach Formation.

Murphy Creek Formation

The contact between the Corner-of-the-Beach Formation and the Murphy Creek Formation is hereby locally defined at the roadside outcrop (loc. 1) as the base of a 3½-foot limestone conglomerate bed. This bed is underlain by light grey, oölitic limestone and overlain by at least 20 feet of greenish grey shale. Limestone clasts within the conglomerate bed are various shades of grey or brown, up to a foot in diameter. No stratification is apparent within the conglomerate bed except for some local cross-bedding near the top. No discordance was noted between underlying strata and the conglomerate bed, but the roadside outcrop area is too limited to rule out low angle discordance.

At the other outcrops of the Murphy Creek Formation visited (Fig. 4, locs. 3–5), the predominant lithology is greenish grey shale. At the type locality (3) and locality 5, a subordinate amount of dark grey limestone is present in thin interbeds. At both localities the limestone contains an Upper Cambrian Dresbachian fauna. At localities 4 and 5, medium to thick interbeds of limestone conglomerate are found. These interbeds resemble the one seen at the roadside outcrop (1), but differ in that they contain "floating" grains of quartz. Localities 3–5 are surrounded by alluvium, and, therefore, do not provide data on the upper or lower contact of the Murphy Creek Formation.

Age and Correlation

Trilobites described by Kindle (1942) from locality 2 (Fig. 4) of the Corner-of-the-Beach Formation are listed below with our determinations of the same material:

Kindle, 1942	Present paper
Agnostus sp. undet.	*Baltagnostus* sp.
Chancia sp. undet.	*Alokistocare* sp.
Olenoides gaspensis sp. nov.	*Olenoides gaspensis* Kindle
Olenoides schucherti sp. nov.	*Olenoides schucherti* Kindle
Periomma cloudi sp. nov.	*Bolaspidella cloudi* (Kindle)

Prozacanthoides gaspensis sp. nov.
Ptychoparella(?) *gaspensis* sp. nov.
Ptychoparella(?) *murphyi* sp. nov.
Solenopleurella gaspensis sp. nov.
Zacanthopsis resseri sp. nov.

Zacanthoides gaspensis (Kindle)
Elrathia? *gaspensis* (Kindle)
Modocia? *murphyi* (Kindle)
Spencella gaspensis (Kindle)
Bathyuriscidella? *resseri* (Kindle)

Although the collecting horizons for these fossils are uncertain, the lithology of the enclosing limestone indicates that they are from unit 1 or unit 3 of the Corner-of-the-Beach Formation. Among the trilobites listed above, genera considered good indicators of the *Bolaspidella* Zone are *Baltagnostus, Bolaspidella, Bathyuriscidella*?, *Elrathia*?, and *Modocia*?. Both *Modocia* and *Bolaspidella* range into the next younger, *Cedaria* Zone.

Tribolites from unit 2 include *Americare*? sp., *Asaphiscus* sp., *Bathyuriscidella*? sp. 1, ?*Bathyuriscidella* sp. 2, *Kingstonioides primicaudus* sp. nov., *Modocia* cf. *M. brevispina* Robison, *Modocia supera* sp. nov., and *Spencella punctata* sp. nov. *Modocia* and *Spencella* are the only genera known to range beyond the limits of the *Bolaspidella* Zone, and therefore unit 2 is placed without question in this zone.

As the exposed part of unit 1 directly underlies unit 2 of definite *Bolaspidella* age, and as some of the diagnostic trilobites probably came from unit 1, the upper part of that unit can be tentatively placed in the *Bolaspidella* Zone.

One of Skidmore's collections (F-65-12) from locality 2 several feet above unit 2 contains *Bolaspidella gaspensis, Modocia* sp., and *Spencella gaspensis,* and therefore the *Bolaspidella* Zone can be said to extend at least this far up in the formation. It is obvious that the unfossiliferous upper part of the formation must belong to this or younger zones. These upper strata cannot be younger than early Upper Cambrian (Dresbachian), however, as a faunule of that age is contained in the overlying Murphy Creek Formation (Kindle, 1948).

Elsewhere, faunules belonging to the *Bolaspidella* Zone have been collected in southwestern Newfoundland from the autochthonous March Point Formation (Lochman, 1938) and from 60 miles to the northeast in the Cooks Brook Formation of the allochthonous Humber Arm Group (GSC locs. 82089–91 by R. K. Stevens). In west-central Newfoundland, boulders in the allochthonous Cow Head sequence contain *Bolaspidella* faunules at White Point in St. Paul's Inlet, Broom Point, and White Rock Islets (Kindle and Whittington, 1958, pp. 329, 333, 334; 1959, p. 17). Similar boulders containing *Bolaspidella* faunules were reported from Métis and Grosses Roches on the south shore of the lower St. Lawrence River (Rasetti, 1948; 1963).

About 40 miles northwest of the Corner-of-the-Beach outcrops, *Centropleura* was reported (Hutchinson, 1952) from shale on Dartmouth River. Although this genus is rare in the North American Faunal Province, its range there is probably within the time spanned by the *Bolaspidella* Zone. *Centropleura* also occurs in the allochthonous St. Albans Shale of northwestern Vermont (Howell, 1937; Shaw, 1966), and there the genus is intermixed with a *Bolaspidella* faunule. The upper part of the allochthonous Parker Slate in the same region of Vermont may also belong to the *Bolaspidella* Zone. Shaw (1954, 1957) assigned the upper part of this formation to the early Middle Cambrian, but Rasetti (*in* Theokritoff, 1968, p. 15) suggested that it may be younger. Indirectly, Robison's (1964, p. 541) reassignment of Shaw's species *Chancia rasettii* to *Elrathia rasettii* is another reason to suspect a younger age for the Parker Slate. Three other upper Parker specimens figured by Shaw (1957, Pl. 98, figs. 15–18, 19;

Pl. 99, figs. 19–21) as *Orriella* sp., *Athabaskia* sp., and *Peronopsis* sp. are considered by the present authors to belong to the genera *Bathyuriscus, Americare*? and *Baltagnostus,* respectively. The last two genera belong in the *Bolaspidella* Zone, and, although *Bathyuriscus* ranges through most of the Middle Cambrian, the *Bathyuriscus* pygidium illustrated by Shaw has a short axis and is therefore probably one of the younger species.

In east-central New York, the allochthonous Taconic sequence contains a *Bolaspidella* faunule (Rasetti, 1967, pp. 24–26) which is similar to that in the boulders at the White Rock Islets, Newfoundland. The New York occurrence is in bedded strata and is another locality where *Centropleura* is intermixed with a *Bolaspidella* faunule.

Paleontology

Morphological terms used here conform with those defined in the *Treatise of Invertebrate Paleontology* (Harrington and others, 1959) with one exception. In this paper the palpebral area does not include the palpebral lobe. Thus the width (tr.) of the area is measured from the axial furrow to the palpebral furrow. A deviation from a rather frequent informal usage is made by us when we refer to the slope of various parts of the cephalon and pygidium. If the part slopes towards the axis, we say that the slope is "inward" rather than "upward," and if the slope is reversed, we use "outward" rather than "downward."

Systematic assignments down to the generic level conform with those in the *Treatise* except for the genera *Americare, Kingstonioides,* and *Spencella,* which postdate that publication.

All specimens illustrated are in the type collection of the Geological Survey of Canada, Ottawa. Most of the remaining material is stored in the Geological Survey field collections (GSC locs. 82500, etc.) or at the Quebec Department of Natural Resources, Quebec City (F-65-12; 62-L-48, etc.). Some unnumbered material is in the Kindle collection.

All Geological Survey of Canada collections come from unit 2 at locality 2, which is a 3-foot limestone bed. Different collection numbers refer to lateral, closely spaced collections and not to vertical positions within unit 2.

The stratigraphic location of collections from the type section (loc. 2) belonging to Kindle and the Quebec Department of Natural Resources is stated under "Occurrence."

Systematic Descriptions

Family SPINAGNOSTIDAE Howell, 1935

Genus ***Baltagnostus*** Lochman, 1944

Type species. *Proagnostus*? *centerensis* Resser, 1938

Baltagnostus marginalis? (Rasetti), 1948

Plate VIII, figures 1–6

1942 *Agnostus* sp. undet. Kindle, p. 637, pl. 1, figs. 16, 17.
1948 *Peronopsis marginalis* Rasetti, p. 319, pl. 45, figs. 6, 7.
1964 *Baltagnostus*? *marginalis* (Rasetti), Robison, p. 526.

Material. One nearly complete, enrolled specimen 2 mm long and one pygidium 2 mm long.

Remarks. Rasetti has given an excellent description of this species and the present material adds no new information. He mentioned that the pygidium has a larger axis and a more swollen posterior border than do most species in *Peronopsis.* It is perhaps because of these features that Robison logically suggested that the species may belong in the genus *Baltagnostus.* The specific assignment of our material is questionable because of its poor preservation.

Occurrence. Unit 1 or 3, 62-L-48a; nearby railway fill, probably from unit 1 or 3, F-65-7b.

Types. Hypotypes, GSC Nos. 24609, 24610.

Family DOLICHOMETOPIDAE Walcott, 1916

Genus ***Bathyuriscidella*** Rasetti, 1948

Type species. *Bathyuriscidella socialis* Rasetti, 1948

Bathyuriscidella? sp. 1

Plate VIII, figures 8 and 9

Material. One pygidium 5 mm long.

Description. Pygidium of medium convexity, length–width ratio 5:7. Axis consisting of anterior ring with node, second ring, and terminal piece followed by postaxial ridge. Furrow between second axial ring and terminal piece having sinuous course. Pleural field marked by two sets of shallow pleural furrows of medium width; and two very shallow interpleural furrows, narrow near proximal end and expanding considerably over remainder of course, anterior set of interpleural furrows bordered by low ridge at posterior margin. Border furrow shallow and broad; border poorly defined from border furrow. Pygidium smooth except for venation on pleural field.

Remarks. In defining the genus *Bathyuriscidella,* Rasetti (1948, p. 322) included species with pleural furrows on the pygidium that are nearly transverse to moderately oblique and two species with pleural furrows that are inclined strongly backwards. Palmer (1968, pp. 43, 44) rightly returned one of these latter species, *Bathyuriscidella proba* (Walcott), to *Athabaskiella* and placed the second, *Bathyuriscidella longicauda* Rasetti, in *Athabaskiella* for the first time. Because of its transverse to moderately oblique pleural furrows, the present pygidium is placed in *Bathyuriscidella* rather than *Athabaskiella.* This pygidium, however, lacks the dorsally elevated terminal piece that is visible on other species of *Bathyuriscidella.*

Occurrence. Unit 2, GSC loc. 82503.

Type. Hypotype, GSC No. 24612.

?*Bathyuriscidella* sp. 2

Plate VIII, figure 7

Material. One partial pygidium 6 mm long.

Description. Pygidium with length–width ratio of 3:4. Axis of medium height, consisting of anterior ring with low node, second ring, and terminal piece followed by low posterior ridge. Pleural field marked by four sets of paired furrows and one broad (fused pair?) set. Anterior pair (two sets) consisting of nearly parallel, medium spaced

pleural and interpleural furrow; second pair consisting of parallel, closely spaced pleural and interpleural furrow. Border furrow very broad; border poorly defined from border furrow. Pygidium smooth.

Remarks. This pygidium resembles *Bathyuriscidella*? sp. 1, but differs in a number of features that cannot be properly evaluated in terms of interspecific variation. Although we have elected to describe the two separately, we recognize the need to review our decision when more material becomes available. The pygidium of ?*B.* sp. 2 differs from that of *B.*? sp. 1 in having interpleural furrows of uniform width (exsag.), no ridge at the posterior margin of the anterior set of interpleural furrows, a straight furrow between the second axial ring and the terminal piece, and no venation.

Occurrence. Unit 2, F-65-10.

Type. Hypotype, GSC No. 24611.

Family SOLENOPLEURIDAE Angelin, 1854

Genus ***Spencella*** Rasetti, 1963

Type species. *Spencella montanensis* Rasetti, 1963.

Rasetti's (1963, pp. 590–2) generic concept of *Spencella* is followed here. Two of the features that he attributes to *Spencella,* and not to the similar genus *Solenopleurella,* are given considerable weight in our assignment. These are a swollen antérior border and a strong posterior inclination of the posterior section of the facial suture.

Spencella punctata sp. nov.

Plate VIII, figures 10–17

Material. Seventeen cranidia 2 mm to 5 mm long.

Description. Cranidium moderately convex, length–width ratio 4:5. Glabella of medium height, sides straight to slightly convex and converging forward, front truncated. Three sets of shallow glabellar furrows, anterior set transverse and probably branching, second set transverse and branching with one limb inclined moderately forward and other strongly back, third set inclined back and branching with one limb directed moderately to strongly forward and other very strongly back. Palpebral area nearly half as wide (tr.) as glabella at base, moderately convex and outsloping. Palpebral lobes three eighths as long as glabella, centred somewhat ahead of glabellar midpoint. Facial suture converging moderately forward from palpebral lobes to anterior border, then strongly inward; posterior segment of suture inclined steeply back from palpebral lobe to posterior border furrow, then nearly straight back. Preglabellar field absent. Anterior border furrow deep and wide, very deep and wide on peeled specimens; anterior border convex in cross-section, widening in front of glabella, bowed upward in front view; anterior border on internal mould uniformly narrow (exsag.). Posterior area slightly wider (tr.) than half glabellar width at base, truncated at distal end. Posterior border furrow narrow at proximal end, becoming very broad (exsag.) distally. Occipital furrow of uniformly moderate width and depth. Occipital ring somewhat long (sag.) and bearing small node. External surface of cranidium marked by medium sized punctae, internal moulds by small punctae.

Remarks. This species differs from others in the genus *Spencella* in having a proportionately larger glabella and in being punctate. *Spencella gaspensis* (Kindle), 1942, from the same formation, has a narrower anterior border furrow on both internal and

external moulds, a swollen anterior border on internal moulds, wider (tr.) and more steeply outsloping palpebral areas, and longer palpebral lobes accompanied by shallower, narrower palpebral furrows.

Occurrence. Unit 2, GSC locs. 82500, 82501, 82502.

Types. Holotype, GSC No. 24613; paratypes, GSC Nos. 24614–24616.

Family ANOMOCARIDAE Poulson, 1927

Genus *Americare* Lochman, 1960

Type species. *Glyphaspis tetonensis* Resser, 1937

Lochman's (1960, p. 828) generic concept of *Americare* is followed in making our tentative assignment.

Americare? sp.

Plate VIII, figures 18–20

Material. One pygidium 4 mm long.

Description. Pygidium of medium convexity, length–width ratio slightly greater than 4:9. Axis tapering back at moderate rate, joined to border by short postaxial ridge; on internal mould four axial rings clearly defined, one poorly defined, one to three additional rings may be present but merger with terminal piece nearly complete. Pleural field marked by four sets of shallow pleural furrows of medium width, and three sets of narrow, shallow interpleural furrows; interpleural furrows indistinct on internal mould; all furrows extending onto border. Border furrow wide and shallow; border rather wide, grading into border furrow, narrowing behind axis where border is slightly recurved. Outer surface of pygidium smooth, internal mould punctate; anterior two axial rings marked by transverse ridges.

Remarks. Until more species have been assigned to this genus, it will not be fully understood. One of the diagnostic features on the pygidium may be the narrow anterior pleural bands that appear as ridges between closely spaced pleural and interpleural furrows. This feature is not well developed on our specimen which otherwise closely resembles the type species, *Americare tetonensis* (Resser). Since we have no additional material for further comparisons, our generic assignment is questioned.

Occurrence. Unit 2, GSC loc. 82502.

Type. Figured specimen, GSC No. 24617.

Family ASAPHISCIDAE Raymond, 1924

Genus *Asaphiscus* Meek, 1873

Type species. *Asaphiscus wheeleri* Meek, 1873

Asaphiscus sp.

Plate IX, figures 1 and 2

Material. One worn pygidium 12 mm long.

Description. Pygidium low, subsemicircular in outline, length–width ratio approximately 1:2. Axis straight sided, converging slightly in posterior direction, preservation incomplete, but probably consisting of six or seven axial rings and terminal piece, anterior

ring marked by transverse ridge. Pleural field with at least three sets of shallow pleural furrows and at least one set of very shallow interpleural furrows. Border flat, tilted slightly outward, width medium and fairly uniform. Ornamentation unknown.

Remarks. This pygidium closely resembles the pygidium of *Asaphiscus wheeleri* Meek, 1873 in all respects as figured by Palmer (1954, pl. 16, fig. 7), but it is too incomplete for specific identification.

Occurrence. Unit 2, F-65-14.

Type. Figured specimen, GSC No. 24618.

Genus *Kingstonioides* Rasetti, 1963

Type species. *Kingstonioides laevigatus* Rasetti, 1963.

This genus has been known only from Rasetti's (1963, p. 583) description of cephala of one species. Our concept is based on these cephala, the present material, and on available but undescribed species collected by Kindle from boulders from the Cow Head sequence in west-central Newfoundland. Our treatment of the genus will be confined to remarks; formal revision and expansion of Rasetti's concept can best be presented in another paper that contains illustrations and descriptions of the latter material.

The numbered boulders from Newfoundland containing *Kingstonioides* are from the White Rock Islets (601, 603, 606, and 618), Broom Point (459, 471), and White Point in St. Paul's Inlet (98, 97). In each of these boulders, *Kingstonioides* is associated with a fauna that can be definitely assigned to the *Bolaspidella* Zone. *Kingstonioides* is absent in numerous Cow Head boulders that contain faunas of younger and older zones.

At least three undescribed species of *Kingstonioides* are present in the Cow Head boulders. They resemble the type species in having cranidia that are small (average length of large specimens about 6 mm), rather smooth, and having palpebral lobes centred opposite the glabellar midpoint. All have short (sag.) preglabellar fields and narrow anterior borders. One species has a steep, forward sloping border with prominent terrace lines that is nearly identical to that on *K. laevigatus*. This is not considered a generic character, however, as a second species has a narrow border that tilts back as on *K. primicaudus* sp. nov., and a third has a very narrow, strap-like border. Glabellae of the Cow Head specimens approach the relative proportions of that on *K. primicaudus,* and thus are narrower and more strongly curved in front than on the type species, *K. laevigatus.*

Pygidia of the Cow Head specimens resemble that of *K. primicaudus* in being low, smooth, and possessing a wide border that slopes outward at approximately the same moderate rate as the pleural field. Two pygidia have a similar, semicircular outline (plan view) and one has a subtriangular outline. One species has an axis that is proportionately as long as that on *K. primicaudus,* and the other two have axes that are half or less than half the pygidial length.

We think that the Cow Head specimens lend ample support to our belief that the *Kingstonioides* cranidia and pygidia from the Corner-of-the-Beach Formation

have been properly matched, despite the small collection from the latter locality. Furthermore, the faunal associations within the Cow Head material suggest the range of *Kingstonioides* is locally within the *Bolaspidella* Zone and, elsewhere, provide reasonable grounds to question, although not to refute Rasetti's (1963, p. 584) assignment of *K. laevigatus* to the next older, *Bathyuriscus–Elrathina* Zone. The type species, known from two boulders collected near Métis, Quebec, is associated with other trilobites whose ranges are poorly understood.

Rasetti (1963, p. 583) has mentioned that *Kingstonioides* resembles *Kingstonia* and *Ankoura*. However, when both the cranidia and pygidia are considered, the greater similarity is with the genus *Blountia*. *Kingstonioides* differs from *Blountia* in having longer palpebral lobes located in a more posterior position, shorter (exsag.), narrower posterior areas that do not angle obliquely backwards, and a shorter pygidial axis. *Asaphiscus* also resembles *Kingstonioides* somewhat, but differs in being at least half again as large as *Kingstonioides*, and in having glabellar and pygidial axes with much more relief, palpebral lobes that are smaller, and much narrower pygidial border.

Kingstonioides primicaudus sp. nov.

Plate IX, figures 3–10

Material. Three cranidia 2 mm to ±12 mm long and seven pygidia 3 mm to ±13 mm long.

Description. Cranidium low, broadly convex in both directions, very lightly furrowed except for anterior border furrow of medium depth. Glabella very low, sides slightly convex and converging forward, broadly curved across front. No glabellar furrows visible. Palpebral area approximately one fourth as wide (tr.) as glabella at base. Palpebral lobes narrow, three tenths as long as glabella and centred opposite point three tenths glabellar length forward from occipital furrow; palpebral furrow of medium width on internal moulds. Preglabellar field short, width (exsag.) approximately equal to that of adjacent border. Facial sutures diverging forward from palpebral lobes to anterior border furrow, directed out and slightly back from posterior end of palpebral lobe. Anterior border flat and tilted towards rear.

Pygidium very lightly furrowed except for anterior border furrow of medium depth, low, length–width ratio slightly greater than 3:5, posterior margin smoothly curved, anterolateral margin marked by long (tr.) facet. Axis very low, axial rings poorly defined; exfoliated pygidia exhibit four faint rings, two very faint rings, and short (sag.) terminal piece. Pleural regions nearly smooth, very broadly curved (tr.), moderately outsloping, marked by anterior border furrows and four very faint sets of additional furrows. Border sloping moderately outward, width approximately equaling maximum width of pleural field. Surfaces of cranidium and pygidium smooth.

Remarks. In the foregoing it has been mentioned indirectly that *K. primicaudus* differs from the only previously described species in the genus, *K. laevigatus*, in having a border that tilts back and a narrower glabella. *K. primicaudus* differs from all *Kingstonioides* species known to us in having the palpebral lobes centred well back of the glabellar midpoint.

Occurrence. Unit 2, GSC locs. 82501, 82502, 82504; unit 2?, 62-L-48.

Types. Holotype, GSC No. 24620; paratypes GSC Nos. 24619, 24621, 24622, 24623.

Family MENOMONIIDAE Walcott, 1916

Genus ***Bolaspidella*** Resser, 1937

Type species. *Ptychoparia housensis* Walcott, 1886

Bolaspidella cloudi (Kindle), 1942

Plate IX, figures 11–15

Periomma cloudi Kindle, 1942, p. 638, pl. 2, figs. 1–3.

Material. Three cranidia 3 mm to 4 mm long.

Description. Cranidium with high relief, length–width ratio 2:3. Glabellar sides straight, converging rapidly forward, abruptly truncated in front. Two sets of glabellar furrows, anterior set consisting of shallow, short indentations at margin of glabella, posterior set of medium depth, inclined steeply back, and almost reaching occipital furrow. Axial furrow broad and of medium depth. Palpebral area half as wide (tr.) as glabella at base, flat, tilted moderately inward. Palpebral lobes very high, inclined steeply inward, centred slightly back of glabellar midpoint, and two thirds as long as glabella. Palpebral furrow shallow along posterior two thirds, anterior third obsolete as strong eye ridge attaching directly to palpebral lobes. Facial sutures directed nearly straight forward from palpebral lobes to anterior border furrow, posterior section directed nearly straight out from posterior margin of palpebral lobe for considerable distance before curving around distal end of posterior area. Anterior border furrow deep, of medium width (exsag.) near distal ends, widening in front of glabella with furrow totally displacing preglabellar field. Anterior border bowed strongly upward in front view, inclined steeply back in side view. Posterior area as wide (tr.) as glabella at base, marked by deep border furrow of uniformly moderate width. Distal one fourth of occipital furrow deep, narrow, and inclined back; middle half of medium depth, broader (exsag.), and having transverse course. Occipital ring long (sag.), triangular in plan view, directed up and back until considerably higher than glabella. Glabellar ornamentation consisting of granules of various sizes and sparse pustules.

Remarks. This species is removed from the genus *Periomma* as it lacks the swollen anterior border, deep axial furrows, medium to narrow (tr.) posterior areas, and palpebral lobes of medium size. The species does fit closely within the present concepts of *Bolaspidella* except for an unusually long occipital ring, which is significant at the specific but not at the generic level. Only one other species of *Bolaspidella, B. tuberculata* Rasetti, 1963, has the unusually long (sag.) occipital ring. *Bolaspidella tuberculata* differs from *B. cloudi* in having posterior glabellar lobes that expand into the axial furrow and in having an anterior border which is not strongly bowed upward.

Occurrence. Units 1 and/or 3, Kindle collection, unnumbered; lower part of unit 3, F-65-12.

Types. Hypotypes, GSC Nos. 24624, 24625, 24626.

Family MARJUMIIDAE Kobayashi, 1935

Genus ***Modocia*** Walcott, 1924

Type species. *Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden, 1861

Modocia sp. cf. *M. brevispina* Robison, 1964

Plate X, figures 1–9

Modocia brevispina Robison, 1964, p. 551, pl. 87, figs. 11–19.

Material. Fifteen cranidia 1 mm to ±8 mm long, two tentatively assigned pygidia 3 mm and 4 mm long, and one tentatively assigned librigena.

Description. Cranidium of medium convexity, length–width ratio of small (3 mm) cranidia 3:4. Glabella of medium to low height, sides nearly straight and converging moderately forward, front has medium curvature. Three sets of very shallow, broad glabellar furrows, all sets inclined towards rear, anterior set short and moderately inclined, second set moderately inclined, third set transverse near axial furrow and curving until strongly inclined towards rear. Axial furrow of medium depth and width throughout. Palpebral areas two sevenths as wide (tr.) as glabella at base, moderately convex (tr.), average slope horizontal. Palpebral lobes half as long as glabella and centred opposite glabellar midpoint. Preglabellar field slightly longer (sag.) to slightly shorter than anterior border. Facial suture straight and moderately diverging from palpebral lobes to anterior border furrow, then curving moderately inward. Anterior border furrow of medium width, moderately deep near ends, shallowing slightly in front of glabella. Anterior border somewhat convex in longitudinal profile, fairly uniform in width except for narrowing near ends, tilted moderately back. Posterior area on small (3 mm) cranidia three fourths as wide (tr.) as glabella at base. Posterior border furrow and occipital furrow of medium depth and width. Occipital ring marked by small node. Tentatively assigned librigena with short genal spine.

Tentatively assigned pygidium moderately convex, length–width ratio slightly less than 1:2, posterior and posterolateral margin broadly curved, distal ends terminating in posterolaterally directed points or spines (broken). Exfoliated axis consisting of two rings, small posterior ring obsolete near axial midline, and very short terminal piece. Pleural field marked near anterior end by pleural furrow of medium depth and width and by two (interpleural? and pleural?) small, closely spaced furrows. Border sloping steeply outward; width medium on external moulds, narrow on internal moulds. Ornamentation on cranidium and pygidium consisting of densely spaced, medium sized granules and of terrace lines at front of anterior border and along posterior margin of pygidium.

Remarks. A lack of material in the present collection negates the possibility of a full comparison with *M. brevispina.* Cranidia in this collection differ by having a more strongly curved anterior border furrow and facial sutures that do not angle strongly inward at the outer margin of the anterior border. The tentatively assigned librigena has a wider border near the genal angle. The tentatively assigned pygidia differ in having an abrupt bend on the anterior margin of the pleural field and a corresponding bend of the furrows on the pleural field. Pygidia have been tentatively assigned to this species and *Modocia supera* sp. nov. after matching ornamentation with that on the cranidia of the two species. Since the tests are not well preserved, there is a possibility that the natural association could have been reversed.

Occurrence. Unit 2, GSC locs. 82500, 82501, 82502, 82503.

Types. Hypotypes, GSC Nos. 24627–24633.

Modocia supera sp. nov.

Plate X, figures 10–19

Material. Six cranidia 3 mm to 9 mm long; all except smallest are exfoliated. Two tentatively assigned pygidia, both 3 mm long, one exfoliated and the other partly exfoliated.

Description. Cranidium very convex, length–width ratio 8:11. Glabella high, lateral margins broadly convex, converging moderately forward along posterior four fifths,

rapidly along anterior fifth, front strongly rounded. Three sets of very shallow glabellar furrows visible on exfoliated glabella; anterior set inclined moderately forward and branching with one limb directed forward and other back; second set inclined moderately back, broadening inward and probably branching; posterior set inclined moderately back and branching with one limb inclined moderately forward and other strongly back; short indentations at sides of glabella between posterior set of furrows and occipital furrow. Axial furrow of uniformly moderate depth and width throughout. Palpebral area convex (tr.), only one fifth as wide as glabella at base, average tilt is inward. Palpebral lobes centred opposite glabellar midpoint, tilted inward, three fifths as long as glabella. Facial sutures nearly straight and slightly diverging from palpebral lobes to anterior border furrow. Anterior border furrow of moderate to shallow depth and of uniform width (exsag.); anterior border slightly wider than adjacent furrow, broadly convex (exsag.), tilted slightly back. Posterior area somewhat narrower (tr.) than glabella at base. Posterior border furrow very deep and wide proximally, becoming very shallow distally. Posterior border very narrow at proximal end, widening distally. Occipital furrow of medium width and depth, widening near axial midline where front margin bows forward. Occipital ring (broken) probably rather short (sag.).

Tentatively assigned pygidium of medium convexity, length–width ratio 1:2, broadly and evenly curved along posterolateral and posterior margin, pointed at anterolateral ends. Axis consisting of three rings and short terminal piece; on exfoliated pygidium anterior ring of medium height, second ring low, posterior ring low and blending near axial midline with rest of axis. Pleural region marked by anterior pleural furrow of medium depth; exfoliated pygidium exhibiting two additional sets of weak pleural furrows. Ornamentation on exfoliated cranidium and pygidium consisting of medium sized punctae; outer surface of pygidium rough to finely granular.

Remarks. A very narrow (tr.) palpebral area, short (exsag.) posterior limb, and rather long (exsag.) anterior border differentiates cranidia of this species from most of the others in the genus. *Modocia nevadensis* Palmer, 1954 has a cranidium approaching these proportions, but has a wider palpebral area, a glabella with sides that converge more rapidly forward, and an occipital furrow that is bowed back. Cranidia of *Modocia metisensis* (Walcott), 1890 resemble those of *M. supera,* but have shorter palpebral lobes which are centred farther forward and a shorter (exsag.) anterior border. Although *Modocia compressa* Palmer, 1968 has narrow palpebral areas, both the glabella and cranidium as a whole are far more elongate than those of *M. supera.*

Occurrence. Unit 2, GSC locs. 82500, 82501, 82502, 82504.

Types. Holotype, GSC No. 24634; paratypes, GSC Nos. 24635–24638.

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ECHINODERMATA FROM THE ORDOVICIAN *(Pleurocystites, Cremacrinus)* AND SILURIAN *(Hemicystites, Protaxocrinus, Macnamaratylus)* OF LAKE TIMISKAMING REGION, ONTARIO AND QUEBEC

by Thomas E. Bolton

Abstract

The cystids *Pleurocystites squamosus* Billings and *P. distans* n. sp., in association with the crinoids *Cremacrinus* and *Cupulocrinus,* support a correlation of the Farr Formation, Liskeard Group, of the Lake Timiskaming area, with the Cobourg limestone of the Ottawa region, southeastern Ontario—formations within the Middle Ordovician late Barneveld Stage. The hemicystid *Hemicystites hawkesi* n. sp. and the crinoids *Protaxocrinus amii* n. sp. and *Macnamaratylus murrayi* n. sp. are Echinodermata characteristic of the Middle Silurian Wabi and Thornloe Formations.

Résumé

La présence des cystidés *Pleurocystites squamosus* Billings et *P. distans* (nouv. esp.) associés aux crinoides *Cremacrinus* et *Cupulocrinus* appuie la corrélation entre la formation de Farr, du groupe de Liskeard, de la région du lac Témiscamingue, et les grès de Cobourg, de la région d'Ottawa, dans le sud-ouest de l'Ontario; les deux formations appartiennent à la fin du stade Barneveld de l'Ordovicien moyen. L'hémicystidé *Hemicystites hawkesi* (nouv. esp.) et les crinoides *Protaxocrinus amii* (nouv. esp.) et *Macnamaratylus murrayi* (nouv. esp.) sont des échinodermes typiques des formations de Wabi et de Thornloe du Silurien moyen.

Paleozoic rocks in the Lake Timiskaming region are assigned to the following stratigraphic units, in ascending order (Hume, 1925; Sinclair, 1965; Thomson, 1965): Guigues, Bucke, Farr, and Dawson Point Formations (Ordovician Liskeard Group), Wabi and Thornloe Formations (Silurian). According to Sinclair (p. 4) the faunas suggest a Wilderness age for the Guigues and Bucke (Copeland, 1965, p. 4) Formations, a late Barneveld age for the Farr limestone, and an Edenian age for the Dawson Point

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shale. Both the Wabi and Thornloe faunas (Bolton, 1966, p. 5) are regarded as early Niagaran, with the Wabi equivalent to strata of northern Michigan and southern Ontario assigned to the *Virgiana decussata* and *Camarotoechia winiskensis – Dihogmochilina latimarginata* zones, and the Thornloe to strata within the *Pentamerus* and *Favosites favosus* zones (Ehlers and Kesling, 1962, pp. 9, 10; Bolton, 1968, pp. 39, 40).

Little has been detailed of the echinoderms found in the Wabi and Thornloe dolomites. Ami (*in* Barlow, 1899, pp. 128, 294) listed the crinoids *Thysanocrinus liliformis* Hall, *Dendrocrinus longidactylus* Hall, and *Taxocrinus* n. sp. (presumably the material herein described as *Protaxocrinus amii* n. sp.) from the Silurian [Thornloe] rocks exposed along the west shore of Mann Island, Lake Timiskaming, Quebec. Hume (1925, p. 32) recorded an edrioasteroid *Agelacrinites* sp. from the Wabi Formation exposed along the west shore of Lake Timiskaming, lot 11, con. V, Bucke tp. and the cystid *Pleurocystites squamosus* Billings from towards the base of the upper limestone member [Farr Formation] or *Macleurea* zone of the Liskeard Formation exposed at the 'Shipyards', lot 10, con. V, Bucke tp. (Hume, 1920, p. 302; 1925, p. 26). This same cystid species along with *P. filitextus* Billings and the crinoid *Cupulocrinus* sp. were recorded by Ollerenshaw and Macqueen (1960, p. 107). Sinclair (1965, p. 3) reported only *P. squamosus*. The present note illustrates specimens of *Pleurocystites, Cremacrinus,* and *Cupulocrinus* from the Ordovician Farr limestone, and new species of *Hemicystites* from the Silurian Wabi Formation and *Protaxocrinus* and *Macnamaratylus* from the Thornloe Formation.

Class CYSTOIDEA von Buch, 1846

Family PLEUROCYSTITIDAE Neumayr, 1889

Genus ***Pleurocystites*** Billings, 1854

Type species. *Pleurocystites squamosus* Billings, 1854

Pleurocystites squamosus Billings

Plate XI, figures 2, 4

Description. Theca compressed, 18 mm wide and 24 mm high, sides relatively parallel with well developed lateral shoulders. Three conjunct flat to slightly concave pore rhombs with raised borders, smallest part of each on L2 (11), L3 (10) and IL2 (5) plates; rhomb B2/IL2 (1/5) very small. R3 (15) plate long and narrow. Periproct plates minute and very numerous.

Discussion. Theca slightly less tapering than type specimens of *P. squamosus,* but in all other aspects the Lake Timiskaming specimens closely resemble the forms from the Cobourg limestone ("cystid beds") of the Ottawa area.

Types and occurrence. Hypotypes, GSC Nos. 24502, a–c (all on one slab). Farr Formation, Liskeard Group, Middle Ordovician. North-south road west of Farr quarry, lots 10, 11, con. III, Bucke tp., half a mile west of Haileybury, Ontario (GSC loc. 37150). Collector G. W. Sinclair, 1957. Other specimens (hypotypes GSC Nos. 24503–24505) of *Pleurocystites* cf. *squamosus* recently were collected from both the basal beds of the massive limestone unit (15 feet above the base of the Farr Formation) and the underlying rubbly limestones (*"Streptelasma corniculum* beds," associated with *Cremacrinus lucifer* n. sp. and *Cupulocrinus* sp.) exposed in the abandoned 'Shipyards' quarry, lot 10, con. V, Bucke tp. (GSC loc. 82541), and from a ridge exposure of Farr limestone, lots 8, 9, con. IV, Bucke tp. (GSC loc. 82543).

A reappraisal of the echinoderm fossils reported by Ollerenshaw and Macqueen (1960) from the rubbly beds of the Farr Formation exposed in the 'Shipyards' quarry was made possible through the courtesy of J. Monteith, Department of Invertebrate Palaeontology, Royal Ontario Museum, Toronto. Catalogue No. 27214 consists of two specimens: (1) the broadest, with rounded shoulders, assigned to *P. filitextus* Billings, is intermediate in outline between *P. squamosus* and *P. distans,* and retains several minute periproct plates; (2) a normal elongate form, assigned to *P. squamosus,* preserves the complete anal series of minute periproctals. Number 27211 consists of an incomplete calyx and stem, viewed to show the interior of antanal plates with brim plates on one side folded over onto the larger plates—assigned to *P. filitextus.* Number 27213, assigned to *Pleurocystites* sp., through erosion of antanal plates exposes many minute periproctals. None of the specimens displays the large anal plates characteristic of *P. filitextus*; rather the specimens by their minute anal plates are all best assigned to *P. squamosus.*

Pleurocystites distans n. sp.

Plate XI, figure 1

Description. Theca robust, 25 mm wide and 20 mm high. Three large conjunct pore rhombs; L3/L4 (10/14) rhomb largest extending full length of plates with triangulate major part on L4(14) plate; L1/L2(12/11) rhomb extending orally from junction of L1/IL plates three quarters of the way towards L/R plate intersection, with triangulate major part on L1(12) plate; B2/IL2(1/5) rhomb smallest, offset towards B3(4) plate, with triangulate major part on B2(1) plate.

Discussion. Pectinirhomb structures are similar to *P. filitextus* Billings, but the thecal size and shape are distinctive for the Farr specimen.

Type and occurrence. Holotype, GSC No. 24506. Farr Formation, 20± feet above base in measured limestone unit, Liskeard Group, Middle Ordovician. 'Shipyards' quarry, 50 feet southwest of Ontario Northland Railway tracks, lot 10, con. V, Bucke tp., between New Liskeard and Haileybury, Ontario. Collector Mrs. Janet Hawkes, 1961.

Class EDRIOASTEROIDEA Billings, 1858

Family HEMICYSTITIDAE Bassler, 1937

Genus ***Hemicystites*** Hall, 1852

Type species. *Hemicystites parasiticus* Hall, 1852

Hemicystites hawkesi n. sp.

Plate XII, figures 1-3, 5; Plate XIII, figures 7, 9, 11, 13

Description. Large circular hemicystid, holotype and paratype (Pl. XII, fig. 5) each 17 mm in diameter, remaining specimens range between 6 and 13 mm. Five narrow, tapered ambulacra, extending to the peripheral ring; ambulacral cover plates are biserial, narrow irregularly triangular in outline, tips of which frequently curve peristomialward. Three (A,B,E) ambulacra are straight or slightly curved counterclockwise (contrasolar), the right-posterior ambulacrum (C) curves clockwise (solar), and the left-posterior (D) curves strongly counterclockwise (contrasolar) producing a wide posterior interambulacrum.

Peristomial area generally squashed or fractured, principal posterior orotegminal plate appears large and angular (Pl. XII, fig. 5; Pl. XIII, fig. 9). Interambulacrals are large, smooth, scalelike, imbricating, increasing in size peripherally. Peripheral ring is wide (2.5–3 mm), composed of an inner zone of two or three large and an outer zone of minute, imbricating plates.

Periproct oval, much closer to the right-posterior than to the left-posterior ambulacrum, and even closer to the peripheral ring. The anal pyramid is composed of at least twelve large valvular plates and is irregularly bordered by small ambulacral or distal periproct plates.

Aboral view of specimen 6 mm in diameter (Pl. XIII, fig. 13) shows five straight, short ambulacra not extending to the submarginal ring, each floored by five or six simple, non-imbricating plates; terminal plate much smaller than the others. Submarginal ring wide and ridge radially striated, nodose (generally five nodes per plate preserved on the undersurfaces of the inner two rows of large plates). Aboral view of specimen 15 mm in diameter (Pl. XIII, fig. 7) shows five long ambulacra extending to the submarginal ring with the tips of ambulacra A and E curved contrasolar and ambulacrum C curved solar; nodose ridge with associated radial ridging on the submarginal ring of plates exposed in one area.

Discussion. The narrowness and curvature of the ambulacra, smaller oval periproct, and larger size distinguish the Wabi species from the type species of *Hemicystites, H. parasiticus* (Bassler, 1936, pl. 4, figs. 5, 6), found in the Niagaran Rochester shale of New York State. In aboral view, *H. hawkesi* is very similar to *H. pleiadae* Sinclair and Bolton (1965, p. 37) from the Upper Ordovician Vauréal Formation of Anticosti Island, Quebec.

Types and occurrence. Holotype, GSC No. 24507; paratypes, GSC Nos. 24508–24514, a–g, 24515, a–d. Wabi Formation, Middle Silurian, about 12 feet above *Zygocosta williamsi* (Ulrich and Bassler) beds and a foot below beds containing *Bolbineossia* sp. and *Stegerhynchus*(?) *winiskensis* (Whiteaves), 55 to 60 feet below base of the Thornloe Formation as delineated by Hume (1929, p. 29). Evanturel Creek, 1/2 to 1 mile south of road between Heaslip and Kap-Kig-Iwan Provincial Park, south of Englehart, Ontario (GSC loc. 82567). Collected 1967 and presented to the Survey by George J. Hawkes of Virginiatown, Ontario; additional specimens are in his private collection. Another slab, collected by Mrs. Hawkes about 200 feet north of the road, exhibits eight weathered specimens (paratypes, GSC Nos. 24516, a–g). Several other paratypes were collected in 1968.

The *Agelacrinites* sp. and associated forms *Stegerhynchus*(?) *winiskensis* and *Hormotoma* sp. reported by Hume (1925, p. 32) from limestones exposed along the west shore of Lake Timiskaming may be assigned to the same stratigraphic horizon within the Wabi Formation.

Class CRINOIDEA Miller, 1821

Family CALCEOCRINIDAE Meek and Worthen, 1869

Genus ***Cremacrinus*** Ulrich, 1886

Type species. *Cremacrinus punctatus* Ulrich, 1886

Cremacrinus lucifer n. sp.

Plate XIII, figures 2, 3

Description. A very large, monocyclic inadunate species, crown 420 mm high, calyx 65 mm high, maximum width of flattened calyx 136 mm. Basals not exposed and stem

position unknown, hinge base very wide and straight. Radial plates punctate; lateral or A- and D- radials (Moore, 1962a) large and undivided; median radial compound consisting of wider than usual, tall punctate inferradial bounded by gently concave sutures, and a wider than high superradial of E-ray; B- radial compound, small and rounded.

Arms stout, punctate, isotomous; median or E-ray branching on IBr_9 lateral or A- and D-rays isotomous branching on IBr_4, heterotomous branching on $IIBr_2$, $IIIBr_4$, $IVBr_4$, and (?) VBr_4 producing one arm of normal thickness and one thin unbranching ramule (Moore, 1962a, p. 15); first plate following branching consistently reduced in size; B-ray only exposed distally.

Discussion. In coarseness, *Cremacrinus lucifer* approaches *C. punctatus* from the Decorah Formation of Minnesota (i.e., Springer, 1926, pl. 28, fig. 19), and there is a similarity to *C. rugosus* Billings (i.e., Ringueberg, 1889, pl. 10, fig. 2) from the Trenton Formation of Belleville, Ontario (where associated with *Pleurocystites squamosus*—Billings, 1887, p. 53). *C. inaequalis* Billings, the most common form in the Cobourg Formation "cystid beds" of Ottawa, Ontario, is of smaller size; its unbranched E-ray is composed of smaller and different shaped superradial and IBr_1, and its lateral arms branch on IBr_1, $IIBr_2$, $IIIBr_2$ (high plate), and $IVBr_6$ with no reduction in size of main plates following branching.

Type and occurrence. Holotype, GSC No. 24517. Rubbly limestone unit at base of Farr Formation (associated with *Cupulocrinus* sp. [Hypotypes, GSC Nos. 24518, 24519; Pl. XIII, fig. 14—compare *C. jewetti* (Billings), Pl. XIII, fig. 12, associated with *Cyclocystoides* sp. cf. *C. halli* Billings, Pl. XIII, figs. 5, 8, of Verulam Formation of Liberty, 1968, p. 15] and *Pleurocystites* cf. *squamosus*), Liskeard Group, Middle Ordovician. Abandoned 'Shipyards' or Match Factory quarry 50 feet southwest of Ontario Northland Railway tracks, lot 10, con. V, Bucke tp. between New Liskeard and Haileybury, Ontario (GSC loc. 82541). Collector T. E. Bolton, 1968.

Family TAXOCRINIDAE Angelin, 1878 (?)

Genus ***Protaxocrinus*** Springer, 1906

Type species. *Taxocrinus ovalis* Angelin, 1878

Protaxocrinus amii n. sp.

Plate XI, figures 3, 5; Plate XII, figures 4, 6

Description. A large dicyclic species, crown 26 to 30 mm high, calyx to IBr 4 to 5 mm high, top of calyx at base of radials 6 mm wide. Infrabasals (IBB) are small, low and wide, forming part of the calyx wall, not much wider than connecting columnal rings. Basals are only slightly less high than the radials. Arm structure isotomous, branching three times, with two primibrachials essentially the same size as the radials, four to five secundibrachials, and terti- and quartibrachials that are smooth, long and slender, infolding and coiling at the ends.

Interradials are not exposed, area depressed. Radianal was not observed, but the anal series is slender, rising obliquely from the posterior basal plate (Pl. XI, fig. 5).

Column is round, the first 5 mm below the calyx composed of equally fine rings. The remainder of the stem is composed of coarse rings separated by four or five finer rings.

Discussion. The low infrabasals are comparable with those in the Silurian species *P. interbrachiatus* (Angelin) and *P. salteri* (Angelin), but the overall appearance of this new species from the Silurian of Lake Timiskaming is closer to Ordovician representatives. The Thornloe species differs from its closest ally *P. girardeau* Springer (1920, pl. 45, fig. 8) in its larger size and correspondingly coarser structures, and an arm composition of four to five rather than five to six secundibrachials.

Types and occurrence. Holotype, GSC No. 24520; paratypes, GSC Nos 24520a-e (all specimens grouped on surface of single slab), 24521, 24522. Thornloe Formation, Middle Silurian. Burnt or Mann Island, Lake Timiskaming, Quebec (GSC locs. 2148 and 82562). Collectors A. E. Barlow, 1894, and C. R. Barnes, 1968. Situated immediately below *Zygobolba*-bearing beds and above coral beds of the Thornloe, the associated fauna includes the trilobites *Cheirurus* and *Encrinurus* in addition to calymenids, brachiopods *'Atrypa' parva* Hume and *Pentamerus* sp., cephalopod *Discosorus humei* Foerste, and the crinoid *Dimerocrinus* sp. (Hypotype, GSC No. 24523).

Family MYELODACTYLIDAE Miller, 1883

Genus *Macnamaratylus* n. gen.

Type species. *Macnamaratylus murrayi* n. sp.

Diagnosis. Monocyclic inadunate with elongate crown, five-rayed; stem doubly recurved and coiled; columnals of three degrees, distal part longitudinally ridged, elliptical in cross-section, divided into five unequal parts surrounding a lens-shaped eccentrically located lumen, and irregularly bearing pairs of short, rounded cirrals, bead-like appearance.

Discussion. The five basals of *Macnamaratylus* relate this genus more to *Myelodactylus* than to the four basal-four rayed genus *Herpetocrinus*, but the beaded cirri are more characteristic of the latter. The elliptical shape and internally divided columnals find their closest counterpart in *Eomyelodactylus* from the Brassfield Formation of Ohio, but the type species *E. rotundatus* Foerste, a fragment of a column only, does not show reverse curvature in the proximal region, the equal sized, stout columnals are circular to elliptical in cross-section, and cirri are not apparent.

Macnamaratylus murrayi n. sp.

Plate XIII, figures 1, 4, 6, 10

Description. Crown is slender and elongate, at least 10 mm high; calyx 1.8 mm high and 2 mm wide, composed of five basals and five undivided radials. Arms branch heterotomously, brachials angulate; B(?)-ray (Moore, 1962b) composed of six brachials, plates semi-elliptical and apparently shallowly grooved along each edge to accommodate A- and C-rays.

Stem is serpent-like, coiled and doubly bent in proximal region. The cirri-free narrow proximal part is composed of at least 7 mm of wafer-thin, circular columnals (Pl. XIII, figs. 1, 10) succeeded by another 7 mm long unit composed of slightly thicker and less circular columnals with shallow grooves along each side (basilarids of Strimple, 1963, p. 15). The remainder of the stem consists of large, elliptical columnals bearing paired, short beaded cirrals of two sizes. These columnals are divided by eccentric lens-shaped lumen surrounded by pentameres of unequal size (Pl. XIII, fig. 4), and traces of the separating lines form five low longitudinal ridges on the outside which in turn are partitioned by other finer lines.

Discussion. Macnamaratylus murrayi is closely related to the type species *Herpetocrinus fletcheri* (Salter) from the Middle Silurian (Wenlockian) of Dudley, England, varying principally in the columnal cross-section and five rayed composition. It differs from the type species *Myelodactylus convolutus* Hall from the Rochester Formation of New York State and the Niagara Peninsula region of southern Ontario in its elliptical rather than crescentic-shaped columnals and beaded rather than long, slender cirri.

Types and occurrence. Holotype, GSC No. 24524; paratype, GSC No. 24525, and several columnal fragments. Thornloe Formation, Middle Silurian, 10 feet below the top of Macnamara Construction Company quarry, 6 miles south of Englehart River bridge, east side of highway 11, lot 6, con. VI, Armstrong tp., Ontario (GSC loc. 82563). Collector M. J. Copeland, 1968. The associated fauna include the trilobites *Encrinurus* and *Scutellum,* corals *Favosites* spp., brachiopods *'Atrypa' parva* Hume and *Dolerorthis* sp., and the cephalopod *Donacoceras arundineum* Foerste, situated directly below beds bearing numerous specimens of the ostracod *Zygobolba,* an early Niagaran, Lower Clinton Group, genus.

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PENNSYLVANIAN BRYOZOA (ECTOPROCTA) FROM THE TELLEVAK LIMESTONE, NORTHWESTERN ELLESMERE ISLAND, ARCTIC CANADA

by Madeleine A. Fritz

Abstract

One species of cyclostome and seven species of cryptostomes (six new) are described from the Tellevak Limestone, a back-reef, lagoonal deposit of Pennsylvanian age in northwestern Ellesmere Island, Arctic Canada. The fauna shows affinities with the Moscovian of the U.S.S.R. and the Atokan of the mid-continental United States.

Résumé

L'auteur décrit une espèce de cyclostome et sept espèces de cryptostomes (dont six sont nouvelles) provenant du calcaire de Tellevak, dépôt lagunaire du Pennsylvanien formant la partie interne d'un récif sis dans le secteur nord-ouest de l'île Ellesmere, dans l'Arctique canadien. La faune ressemble à la faune Moscovienne de l'URSS et à la faune Atokane du centre des États-Unis.

The Bryozoa described are from the Tellevak Limestone, a mound-like deposit of Pennsylvanian age, up to 1,700 feet thick, outcropping for about 8 miles along a fault scarp in the Blue Mountains on the south side of Hare Fiord, northwestern Ellesmere Island. This limestone, deposited in a back-reef, lagoonal environment, was described by G. F. Bonham-Carter (1966) who collected the material forming the subject of this paper. From the associated Foraminifera R. Thorsteinsson determined the age as Moscovian; W. Nassichuk matched the small collection of ammonites present with a similar fauna from the mid-continental Atokan of the United States. The Bryozoa show certain affinities with the U.S.S.R., but more particularly with the mid-continental region of the United States.

Bonham-Carter (1966, p. 13) states that the outcrop consists of a steep and crumbling cliff unsafe for climbing. Sampling traverses could only be made down a number of vertical gullies. The Bryozoa came from gullies BR and BK as indicated on a location map in Bonham-Carter (1967, fig. 2).

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Systematic Paleontology

Order CYCLOSTOMATA Busk 1852

Family FISTULIPORIDAE Ulrich 1882

Genus ***Eridopora*** Ulrich 1882

Type species. *Eridopora macrostoma* Ulrich 1882

Eridopora sp.

Plate XV, figures 3, 6

Description. Species recognized only in thin section, encrusting, less than 1 mm thick, on a longitudinal section of *Ascopora graemei* n. sp. Thin section, for the most part, longitudinal, but cut so that a few zooecia are seen tangentially; zooecia subtriangular to ovate, each with a sharply arched lunarium, thickest at the narrowest extremity of the zooecial aperture, the diameter of which is 0.25 mm. The shape of the zooecium and character of the lunarium typical of the genus.

In longitudinal section zooecia subprostrate at the base of the zoarium, becoming erect later and opening at right angles to the surface; three zooecia occur in 2 mm, their width being about 0.26 mm, walls slightly flexuous, diaphragms absent. Interzooecial tissue, from 0.13 to 0.19 mm wide, composed of crescentic to subquadrangular, vesicular to box-like elements, convex upward, occasionally imbricating; the individual elements conspicuously smaller than the zooecia.

Remarks. Insufficient data are provided by this single specimen to warrant specific determination. Affinities are with *Eridopora beilensis* Perkins, Perry, and Hattin (1962, pp. 12–14, pl. 3, figs. 1–4) from the Upper Pennsylvanian (Virgilian) of Kansas. Measurements for the Ellesmere Island form are of necessity limited, but they fall within the range recorded for *E. beilensis* rather than *E. macrostoma* Ulrich (1882, pl. 6, figs. 2, 2a).

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Figured specimen, GSC No. 24564.

Order CRYPTOSTOMATA Vine 1883

Family FENESTELLIDAE King 1850

Genus ***Fenestella*** Lonsdale 1839

Types species. *Fenestella antiqua* Lonsdale 1839

Fenestella carteri n. sp.

Plate XVI, figures 1, 2

Description. Known only from a concave fragment, 20 by 20 mm, of a zoarial expansion exposing the obverse side. Branches flexuous, radiating from a proximal point.

In tangential section branches 0.39 to 0.52 mm wide, broadest at the point of flexure. Dissepiments 0.13 to 0.28 mm wide, transversely striated, a little expanded where they meet a branch, 0.13 to 0.18 mm long. Fenestrules elongate-ovate, somewhat pointed, 1.43 to 1.56 mm long, 0.46 to 0.65 mm wide, surrounded by a collar

of concentrically banded tissue. Zooecia in two alternating rows, one on either side of a slightly elevated, somewhat zigzag medial carina, which bears one row of small nodes, one between each pair of alternating zooecia; zooecial apertures round, diameter 0.13 to 0.156 mm with peristome 0.013 mm wide, separated from each other by a little more than their diameter; basal chamber pentagonal to quadrangular; usually five zooecia, rarely six, to a fenestrule, which they slightly indent, giving the inner lateral margin a wavy appearance. Surface of the branches and dissepiments finely granulose.

Remarks. The flexuous nature of the branches is not common in the genus *Fenestella.* Two species thus characterized are *F. flexuosa* Ulrich (1890, pl. 51, figs. 4-4c) from the Chester Group (Upper Mississippian) of Kentucky and *F. tetratheca* Condra and Elias (1944, pp. 163-164, pl. 36, fig. 4) from the Des Moines Series (Middle Pennsylvanian) of Utah. The meshwork formula for *F. flexuosa* is not available. The branches, however, compare in width with *F. carteri,* the fenestrules are pointed, and have wavy intermargins, nodes are stronger, and zooecia are more numerous per 5 mm, i.e., 22 as against 14–16 in the present species, and 4 or 5 to a fenestrule rather than 5 or 6. The meshwork formulae of *F. carteri* and *F. tetratheca* are as follows:

Species	Branches per 10 mm	Fenestrules per 10 mm	Zooecia per 5 mm	Carinal nodes per 5 mm	Age
Fenestella tetratheca Condra and Elias	15 / 17	10 / 12	18 / 21	about 20	Middle Pennsylvanian, Utah
Fenestella carteri n. sp.	12 / 14	10 / 12	14 / 16	20?	Pennsylvanian, Ellesmere Island

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Holotype, GSC Nos. 24565, a.

Fenestella ellesmerensis n. sp.

Plate XVI, figure 3; Plate XVII, figures 1, 2

Description. Largest and best preserved fragment, exposing the obverse side of the median part of an undulating zoarial expansion, 18 by 20 mm. Branches straight, bifurcations at intervals of from 3 to 5 mm, diverging. Zooecia in two alternating rows, one on either side of a medial carina. Fenestrules ovate to subquadrangular; dissepiments short, expanded terminally.

In tangential section average width of branches just before bifurcation 0.325 mm, immediately above bifurcation 0.182 mm, the sides sloping down from a well defined medial carina on the crest of which is a row of relatively prominent nodes, three in

the length of a fenestrule, one between each pair of alternating zooecia. Fenestrules varying from 0.455 to 0.52 mm long and 0.325 mm wide; dissepiments striated transversely and slightly depressed below the surface of the branches, 0.286 to 0.325 mm wide and 0.065 to 0.091 mm long centrally, expanding at the junction with the branch to at least 0.156 mm. Zooecia round, 0.091 to 0.104 mm in diameter with peristome 0.013 mm wide, three to a fenestrule and, without exception, one zooecium located in a triangular area at the junction of a dissepiment and a branch, the third at mid-length of a fenestrule which it inflects slightly rendering the fenestrule semi-hourglass in shape; base of the zooecial chamber triangular.

Remarks. Features to be stressed include: stabilized disposition of the zooecia; fenestrules ovate to subquadrate but indented medially by a zooecium; basal chamber triangular; and one row of carinal nodes along a medial carina.

These features bring the species into Group XII of Elias and Condra (1957, p. 107) typified by *Fenestella spinulosa* Condra (1902, pp. 343-344, pl. 21, figs. 4–6) from the Coal Measures of Nebraska. Other related species are *F. pectinis* Moore (1929, pp. 18–19, pl. 2, figs. 8–10) from the Pennsylvanian of North Central Texas; *F. moorei* Sayre (1930, p. 89, pls. 2,3) from the Pennsylvanian of Kansas and Western Missouri; and *F. nikiforovae* Shulga-Nesterenko (1936, pp. 270–271, figs. 1–4; pl. 1, fig. 3) from the Lower Permian, Pechora Basin (*see* Elias and Condra, 1957, p. 113, pl. 17, fig. 1; pl. 20, fig. 6).

Meshwork formulae of the above species follows:

Species	Branches per 10 mm	Fenestrules per 10 mm	Zooecia per 5 mm	Carinal nodes per 5 mm	Age
Fenestella pectinis Moore	20 / 21	20 / 22	20 / 22	24	Upper Pennsylvanian, Northern Texas
Fenestella moorei Sayre	24 / 30	24	24	24	Upper Pennsylvanian, Kansas
Fenestella spinulosa Condra	19 / 20	19.5 / 21.5	19.5 / 21.5	21 / 25	Upper Pennsylvanian, Nebraska
Fenestella nikiforovae Shulga-Nesterenko	18 / 20	18 / 21	20 / 21	18 / 19	Lower Permian, Russia
Fenestella ellesmerensis n. sp.	17 / 20	17 / 18	17 / 18	17 / 20	Pennsylvanian, Ellesmere Island

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Holotype, GSC Nos. 24563, a-c.

Genus *Polypora* McCoy 1844

Type species. *Polypora dendroides* McCoy 1844

Polypora bonhami n. sp.

Plate XVII, figures 3, 4

Description. An eroded fragment, 20 by 25 mm, of an undulating zoarium exposing the obverse side of this species. Branches straight, fourteen to sixteen in 10 mm, width varying from 0.45 to 0.52 mm.

In tangential section, elongate, ovate fenestrules 0.65 to 0.85 mm long and 0.39 mm wide with a border of concentrically striated tissue; dissepiments 0.156 to 0.195 mm wide, transversely striated, slightly expanded terminally, a little longer than wide, and nearly even with the surface of the branches; surface of branches and dissepiments with minute granules. Zooecia normally in three (rarely two) alternating rows, apertures round, diameter 0.104 to 0.146 mm, peristome 0.013 mm wide; zooecia separated by a distance a little greater than their maximum diameter; usually three zooecia to length of a fenestrule which they indent rendering the fenestrules slightly trilobate. Between the rows of zooecia are linear, somewhat wavy ridges the width of which does not exceed 0.091 mm, typically the centre of the ridges clear with margins of denser tissue; on the ridges circular nodes, irregular in size, usually 2.5 to 4 in 1 mm.

Remarks. The species is closest to *P. michalevensis* Shulga-Nesterenko (1955, p. 128, pl. 22, fig. 4, text-figs. 29, 30) from the Coal Measures of the Russian Platform in general appearance, but differs widely in detail as indicated by the following mesh formulae:

Species	Branches per 10 mm	Fenestrules per 10 mm	Zooecia per 5 mm	Carinal nodes per 5 mm	Age
Polypora michalevensis Shulga-Nesterenko	12	8	13 / 14	?	Coal Measures, Russia
Polypora bonhami n.sp.	14 / 16	14 / 16	18 / 20	12 / 15	Pennsylvanian, Ellesmere Island

Regarding the carinal nodes in *P. michalevensis*, no indication is given as to their number in 5 mm. However, Shulga-Nesterenko (1955, p. 128) shows a similar arrangement to *P. bonhami*.

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Holotype, GSC Nos. 24562, a, b.

Family ACANTHOCLADIIDAE Zittel 1880
Genus *Septopora* Prout 1859

Type species. *Septopora cestriensis* Prout 1859

Septopora sp.
Plate XV, figures 2, 5

Description. Embedded in the matrix is a single specimen referable to this genus. Only one branch with a part of several dissepiments on either side is exposed; the form of the zoarium is not visible but the exposed part shows detail worthy of note.

Branch 20 mm long, 0.78 mm wide (maximum). Zooecia in two alternating rows, one on either side of a low, broadly rounded medial carina upon which one row of prominent nodes, 0.7 to 0.9 mm apart occur; tiny pores also present, but it is not possible to determine their distribution. Zooecial apertures round with diameter of 0.13 to 0.14 mm, peristome 0.013 mm wide, eighteen to twenty zooecia in 5 mm; accessory pores, much smaller than the typical zooecia, occur but measurements vary so much it is assumed that weathering destroyed their original size. Eleven dissepiments preserved on one side of the branch; on the opposite side seven or eight, indifferently preserved, occur alternating with their counterparts. Dissepiments straight, diverging regularly at an angle of 50 to 60 degrees, thus producing a pinnate appearance, about 0.286 mm wide. As on the branches two rows of alternating zooecia one on either side of a medial carina bearing one row of nodes as well as small pores, but neither their size nor occurrence can be accurately determined; zooecial apertures round, 0.078 to 0.091 mm in diameter, twenty-two to twenty-three per 5 mm, accessory pores between the zooecia only occasionally preserved.

Remarks. In many respects this species resembles the pinnate *Septopora alternata* Moore (1929, p. 129, pl. 16) from the Pennsylvanian of north-central Texas; the number of zooecia, however, per 5 mm is 15 to 15½ as opposed to 18 to 20 per 5 mm in the present form. *Septopora pinnata* Ulrich (1890, p. 633, pl. 64, fig. 7; pl. 65, figs. 1–1a) from the Pennsylvanian of Illinois is related, but differs in the distinctly narrower angle at which the dissepiments diverge and the smaller branches which are 0.5 to 0.7 mm wide as opposed to 0.7 to 0.9 mm in the present form. Because of the limited material the differences may not be too significant; affinities, however, are closer to American species than to any Russian forms known to the writer.

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Figured specimen, GSC No. 24566.

Family RHABDOMESIDAE Vine 1883
Genus *Ascopora* Trautscholde 1876

Type species. *Millepora rhombifera* Phillips 1836

Ascopora graemei n. sp.
Plate XIV, figures 3, 5

Description. Zoarium ramose, branches round, known only from embedded fragments 1.5 to 2 mm in diameter and not exceeding 6 mm long, surface not exposed, might be

confused with associated *Rhombopora* but for a central bundle of tubes, which show up in natural cross-sections.

In tangential section the zooecia elongate ovate, diagonally arranged, 6 to 6½ in 2 mm along the diagonal, 5 to 5½ parallel to the axis of the branch; apertural longitudinal diameter ranges from 0.234 to 0.325 mm, transverse diameter from 0.13 to 0.156 mm, wall 0.026 to 0.032 mm and concentrically banded; zooecia surrounded by a hyaline area; megacanthopores 0.039 to 0.091 mm in diameter, dense with a pinpoint lumen, normally one at the distal end of each zooecium; closely set micracanthopores 0.026 mm (or less) in diameter, dark in colour, each with a tiny lumen, encircling the zooecia.

In longitudinal section four to five tubes compose the central bundle, their walls straight to wavy; zooecia turn off at an angle of 20 to 25 degrees, walls remain thin for 0.221 mm; in the short mature zone, 0.264 mm long, walls thicken and are laminated as the zooecia turn in a gentle curve to the surface where they open slightly obliquely; a small hemiseptum at the base of the mature zone.

Remarks. A. graemei is readily distinguished from the associated *A. tellevakensis* by its smaller branches, shorter mature zone, wider turn off angle, and gentler curve of the zooecia to the surface.

Of the many species of *Ascopora*, of comparable age, described in the Russian literature, none is conspecific with *A. graemei*. A related species from the Coal Measures of the Russian Platform is *A. muromensis* Shulga-Nesterenko (1955, p. 160, pl. 26, figs. 4–8; pl. 29, fig. 5); a comparison of the two follows:

Species	Diameter Branch (mm)	Width of central bundle (mm)	Width of mature zone (mm)	Rows in bundle	Longitudinal apertures in 2 mm	Diagonal apertures in 2 mm	Age
A. muromensis Shulga-Nesterenko	1.5–2.5	0.5–1.0	0.264	4–5	5–5½	6–6½	Coal Measures, Russian Platform
A. graemei n. sp.	2–2.6	0.5–0.6	0.35–0.70	4–5	4–5	6–7(8)	Pennsylvanian, Ellesmere Island

Occurrence. Gullies BR, BK, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Type. Holotype, GSC Nos. 24560, a.

Ascopora tellevakensis n. sp.

Plate XIV, figures 1, 2, 4

Description. Zoarium ramose, branches round, diameter 3 to 4 mm, no fragment exceeding 6 mm long, surface not exposed.

In tangential section zooecia ovate, diagonally arranged, 6 to 6½ in 2 mm along the diagonal, 5 to 5½ in 2 mm measured parallel to the axis of the branch; apertural longitudinal diameter 0.156 to 0.234 mm, wall 0.032 to 0.39 mm wide and concentrically

banded; zooecia sunken in the hyaline zoarial tissue; megacanthopores prominent, ranging in diameter from 0.065 to 0.104 mm, concentrically banded, dense in centre but with a central lumen which may not show where the section is thick; micracanthopores, 0.013 to 0.026 mm, miniatures of the former, encircle the zooecia.

In longitudinal section tubes in axial bundle four to five, thin-walled, relatively straight with no internal structures; zooecia turn off at an angle of 18 to 20 degrees, are thin-walled in the immature zone, the length of which not exceeding 0.5 mm; they then turn out abruptly, almost at right angles to the axis; in this mature zone, 1 mm long, the walls thicken greatly and are laminated; at the base of the mature zone is a prominent, somewhat hook-shaped hemiseptum.

Remarks. This species differs from *A. graemei* in the stouter branches, smaller zooecia, more uniform size of megacanthopores, less pronounced diagonal arrangement of zooecia, and the longer mature zone. *A. duplicata* Shulga-Nesterenko from the Coal Measures of Russia (1955, p. 158, pl. 27, figs. 1–3) is closest to *A. tellevakensis.* A comparison of the two appears below.

Species	Diameter Branch (mm)	Width central bundle (mm)	Width mature zone (mm)	Rows in bundle	Apertures in 2 mm longitudinal	Apertures in 2 mm diagonal	Age
Ascopora duplicata Shulga-Nesterenko	3.3–4	0.55–0.65	1.0–1.4	4–5(6)	3½–4½	5–5½	Coal Measures, Russian Platform
Ascopora tellevakensis n. sp.	3–4	0.58	1	4–5	5½–6½	6–6½	Pennsylvanian, Ellesmere Island

Occurrence. Gully BK, Tellevak Limestone, Pennsylvania, northwestern Ellesmere Island, Arctic Canada.

Type. Holotype, GSC Nos. 24559, a.

Genus ***Rhombopora*** Meek 1872

Type species. *Rhombopora lepidodendroides* Meek 1872

Rhombopora cf. *R. lepidodendroides* Meek 1872

Plate XV, figures 1, 4

Description. Zoarium ramose, branches round, solid; embedded fragments 1.25 to 4 mm in diameter are common, the greatest observed length 10 mm; zooecial apertures ovate more or less aligned, with greatest diameter parallel to axis of branch; surface apparently without maculae or monticules.

In tangential section zooecial apertures ovate surrounded by a concentrically fibrous peristome 0.022 to 0.039 mm wide, usually five zooecia in 2 mm longitudinally, six diagonally, apertural length ranging from 0.22 to 0.26 mm, interapertural distance measured normal to long axes of contiguous zooecia from 0.09 to 0.19 mm; megacanthopores prominent, consisting of a small lumen surrounded by a dense tissue

becoming lighter in colour outward and made up of concentrically fibrous laminae; without exception each megacanthopore situated between two longitudinally aligned zooecia; micracanthopores eight or more times as numerous as the megacanthopores, dark in colour, each with a central lumen and forming an ornamental girdle round the zooecia.

In longitudinal section the zooecia are thin-walled, somewhat flexuous in the immature zone, turning out at an angle of about 20 degrees, then bending gently to the periphery where the walls are thick and laminate; the mature zone is 0.22 to 0.26 mm long; where the sections cut the interlaminar space the micracanthopores penetrate the tissue to a depth of at least 0.33 mm; diaphragms rare, not more than one or two observed.

Remarks. Perkins, Perry, and Hattin (1962, pp. 18-20, pl. 3) in their study of the Beil Limestone, upper Pennsylvanian of Kansas, state that this species is the most abundant in their fauna. They have been able to demonstrate, by exhaustive measurements, considerable range in the various microscopic structures. Measurements obtained from the present meagre material fall within the recorded ranges, not only of the above writers but of others who have encountered the species.

Rhombopora lepidodendroides has a wide stratigraphic range throughout the Pennsylvanian extending into the Lower Permian. In the United States it is common at various localities in Nebraska, Kansas, Missouri, Iowa, Illinois, and Ohio. The species is not mentioned in the Russian literature available to me, but in the Coal Measures of the Russian Platform, Shulga-Nesterenko (1955, pp. 147-149, pls. 22, 24) described three new species: *R. variaxis, R. riasanensis* and *R. diaphragmata,* and Morozova (1955, p. 59, pl. 2, figs. 2a, 2b) identified *R. diaphragmata* from the Coal Measures of the Don. None of these is conspecific with *R. lepidodendroides* as will be seen from the following table:

Species	Diameter Branch (mm)	Width mature zone (mm)	Apertures in 2 mm longitudinally	Apertures in 2 mm diagonally	Age
Rhombifera cf. *R. lepidodendroides* Meek	1.25–4	0.22–0.26	5	6	Pennsylvanian, Ellesmere Island
Rhombifera variaxis Shulga-Nesterenko	0.8	0.10	4½	—	Coal Measures, Russian Platform
Rhombifera riasanensis Shulga-Nesterenko	2–2.5	0.50–0.65	5–5½	5½–6½	Coal Measures, Russian Platform
Rhombifera diaphragmata Shulga-Nesterenko	2–3	0.50	5	6½	Coal Measures, Russian Platform

R. diaphragmata, furthermore, differs from *R. lepidodendroides* in that the zooecia are located within distinctly marked off polygonal areas, the megacanthopores are smaller and the micracanthopores are more numerous. In *R. riasanensis* the polygonal

areas are less marked than in the former species, the zooecia have a pronounced linear arrangement, and micracanthopores dominate.

Occurrence. Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island, Arctic Canada.

Types. Hypotypes, GSC Nos. 24561, a, b.

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CONODONTS FROM THE ST. GEORGE FORMATION (ORDOVICIAN), NORTHERN NEWFOUNDLAND

by C. R. Barnes and M. F. Tuke

Abstract

Samples of Lower and Middle Ordovician strata in northern Newfoundland yielded conodonts only from the St. George Formation. The formation is divided into units D to I; the productive samples were taken from the G–H interval and from bioclastic lenses within barren intertidal calcilutites and dololutites. The small fauna of twenty-one species representing ten genera is dominated by mid-continental faunal elements but contains some species characteristic of the Baltic area. Comparison within North America and with the Baltic region indicates that the fauna is of lower Arenig age.

Two new species, *Scolopodus emarginatus* and *Scolopodus multicostatus,* are described; a third, *Oepikodus* n. sp. A, is described but not named.

Résumé

Parmi les échantillons prélevés dans les couches de l'Ordovicien moyen et inférieur du nord de Terre-Neuve, seuls ceux en provenance de la formation de St. George ont livré des conodontes. Cette dernière se divise en unités, de D à I; les échantillons fossilifères proviennent de l'intervalle G-H et des amas lenticulaires bioclastiques à l'intérieur de calcilutites et de dololutites non fossilifères de la zone intertidale. Cette petite faune de 21 espèces réparties en dix genres se compose principalement d'éléments fauniques du centre du continent, mais renferme aussi certaines espèces typiques de la région baltique. La comparaison avec la faune nord-américaine et baltique semble indiquer que la faune est de l'Arenig inférieur.

Les auteurs décrivent deux nouvelle espèces, *Scolopodus emarginatus* et *Scolopodus multicostatus,* ainsi qu'une troisième *Oepikodus,* nouv. esp. A, non encore nommée.

The St. George Formation consists of Upper Cambrian and Lower Ordovician limestone and dolostone that outcrop in western Newfoundland.

The geology of the west coast was first studied by Richardson and his information was included in Logan's (1863) *Geology of Canada.* He divided the beds into seventeen

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units designated A to Q. Schuchert and Dunbar (1934) in their study gave names to groups of these units; D to I became the St. George Series now referred to as the St. George Formation. The fauna and correlation of the St. George Formation have recently been summarized by Whittington (1968, pp. 52, 53, Table 4-2).

The conodonts described in this paper came from the eastern shore of the Strait of Belle Isle, 2 to 3 miles southwest of Cape Norman in the northern part of the Great Northern Peninsula (Fig. 5). The rocks in this area were ascribed by Richardson (*in* Logan, p. 872) to his divisions G and H and the fossils he collected are recorded in Billings (1865). The conodonts here described were collected in 1964 by Tuke, who recently described the geology of the area (1968).

The St. George Formation consists of calcilutite and dololutite beds. In places these lithologies are interbedded as very thin laminae, commonly less than 5 mm thick, suggesting that the dolomite is primary or penecontemporary. Within the beds are lenses of intraformational breccia and calcilutite with abundant fossils. Stromatolites and desiccation cracks suggest the shallow water origin of the beds. The upper 50 metres of the St. George Formation is unfossiliferous, coarse-grained dolomite except at Cape Norman where silicified fossils can be found.

Although samples of all lithologies were processed, only two from the bioclastic lenses yielded conodonts. These samples, A and B (Fig. 5), were from about 70 and 85 metres respectively below the top of the St. George Formation. The faunal assemblage of these lenses is dominated by complete casts of *Ophileta* sp. and the thoraxes and pygidia (combined) of *Bathyurus timon* Billings. The absence of cephalons and of small fossil fragments in general suggests that the lenses are lag deposits, the conodonts though small, would remain because of their high specific gravity.

The following fossils were found by Tuke in the same outcrops as the conodonts: *Ophileta* sp., *Bathyurus timon* Billings, *Petigurus nero* (Billings), *Illaenus fraternus* Billings, and *Murchisonia simulatrix* Billings.

Richardson found several species of gastropods and one ostracod species (*in* Billings, 1865) about 30 metres stratigraphically above the upper conodont location.

Many limestone samples were collected north of Hare Bay in the hope of clarifying the stratigraphy; formations and localities that did not yield conodonts were Table Head Formation, at Cooks Point and on the west shore of Pistolet Bay; Northwest Arm Formation at Triangle Point; Maiden Point Formation at Griguet and on the west side of Four Ears Island.

Stratigraphic Significance of the Conodont Fauna

Lower Ordovician conodonts are relatively unknown from North America; in the eastern part only one small fauna has been illustrated (Sando, 1958). A fairly complete succession of conodont faunas of this age is, however, known from the Baltic area. As in the younger Ordovician, faunal provincialism is apparent in Lower Ordovician conodont faunas, for example, those described by Furnish (1938) from the upper Mississippi valley are very different from contemporaneous faunas in Europe. Although the St. George Formation has yielded a sparse conodont fauna, it is significant that both mid-continental (North American) and European elements are present.

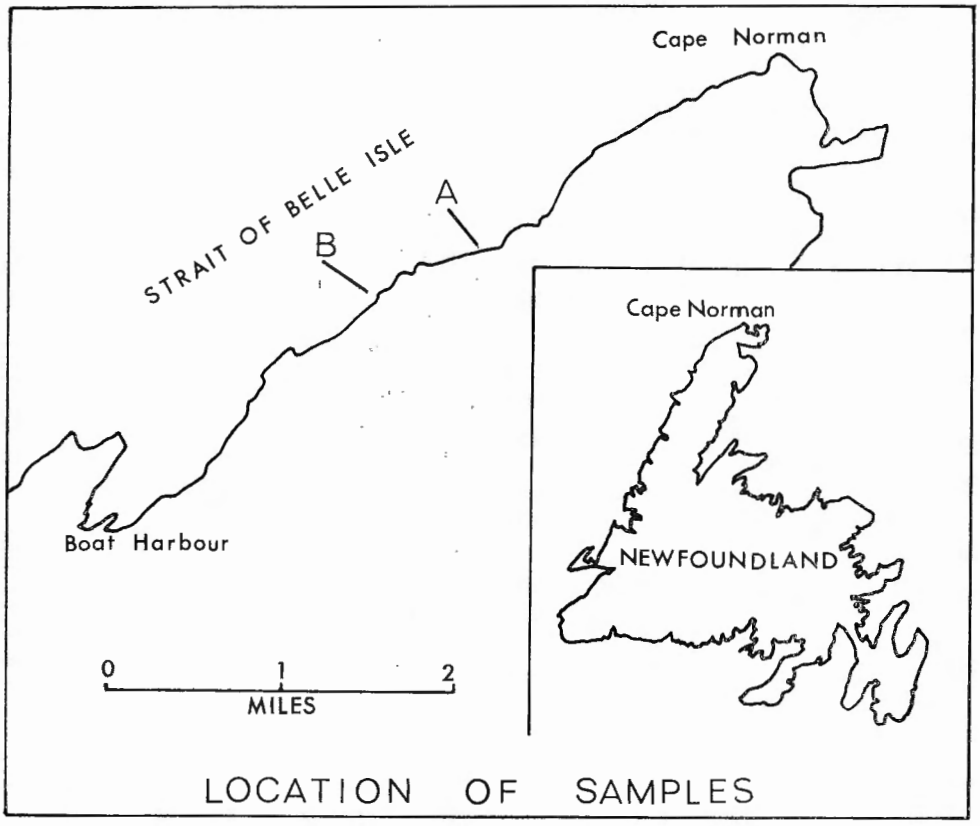

FIGURE 5. Index map of conodont localities, St. George Formation, northernmost Newfoundland.

Numerically, the fauna is dominated by species characteristic of the mid-continent (Table I) but because of the few collections described elsewhere in North America, faunal correlations within the continent are difficult. Fortunately, the presence of a few short-ranging European species allows the fauna to be dated in European terms.

Conodonts from the two samples are similar, and are treated as a single fauna. This is dominated by *Drepanodus simplex* Branson and Mehl, *Scolopodus quadraplicatus* Branson and Mehl, and the widespread Ordovician species *Drepanodus homocurvatus* Lindström.

Comparing this fauna with others in North America, similarity is apparent with those from the Prairie du Chien Group (Furnish, 1938) of the upper Mississippi valley and the upper Jefferson City "Formation" (Branson and Mehl, 1933) of central Missouri. The Prairie du Chien Group is divided, in ascending order, into the Oneota and Shakopee Formations. The conodont fauna from the latter is dominated by *D. simplex* (=*D. subarcuatus*) and *S. quadraplicatus*, and contains *Acontiodus staufferi* Furnish and *Ulrichodina prima* Furnish. The fauna of the Oneota Formation is less comparable, but *Loxodus bransoni* Furnish is present. The absence in the St. George collections of other genera found in the Oneota, especially *Acanthodus, Cordylodus*, and *Clavohamulus*, emphasizes its closer relationship with the Shakopee.

The Jefferson City "Formation" conodonts (Branson and Mehl, 1933; Mehl and Ryan, *in* Branson, 1944) are mostly simple cone types. The many species of *Scolopodus* and *Drepanodus* are also found in the St. George collection with *Ulrichodina* and *Oistodus inaequalis* Pander. Allowing for the geographic separation of the two faunas and the additional European elements in the St. George, a close specific comparison can be made.

The fauna from the middle El Paso Formation (Unit B1) of West Texas (Ethington and Clark, 1964) contains several species of *Drepanodus, Scolopodus,* and *Acontiodus* also present in the St. George. Specimens of *Oepikodus* from the El Paso Formation, however, represent well developed species in comparison to the simple undenticulate specimen described here from the St. George. Species of *Oistodus* are numerous in the El Paso; those from the St. George, however, are similar to species from strata of Lower Arenig age in the Baltic area. The St. George and middle El Paso faunas may be of similar age, or the former, possibly slightly older.

Tremadocian (units 17–30) and Arenigian (units 32–53) faunas were described from the Columbia Ice Fields section, Alberta, by Ethington and Clark (1965). Species comparable to those from the St. George collections were mostly found in their units 24 to 41.

In eastern North America, some Lower Ordovician conodonts were illustrated, but not described, by Sando (1958) from the Stonehenge Limestone and the Rockdale Run Formation (Beekmantown Group) of Pennsylvania. Of note, *S. quadraplicatus* is found only in the *Archaeoscyphia* and *Diparelasma* Zones. Sando (1957, Pl. 3) correlates the *Archaeoscyphia* Zone with the Rich Fountain Formation of the Jefferson City Group of the Ozarks, Unit B1 of the El Paso Formation of West Texas, and, possibly (1958, p. 842) a Shakopee equivalent in Minnesota. The latter correlation was based on the occurrence of *S. quadraplicatus.*

On the basis of conodont faunas, the beds sampled in the St. George Formation are correlated with the upper Jefferson City "Formation" of central Missouri, part of Unit B1 of the El Paso Formation of West Texas, with or slightly older than the Shakopee Formation of the upper Mississippi valley, and, tentatively, the *Archaeoscyphia* Zone of the Rockdale Run Formation of Pennsylvania. Ross (1951) tentatively correlated the Rich Fountain Formation with the upper part of Zone G of the Garden City Formation in Utah. Hintze, *et al.* (1968) stated that "Utah zone G contains conodonts of zone III which Lindström correlates with the British lower Arenigian *Didymograptus nitidus* subzone."

Some species in the St. George fauna occur in the Lower Ordovician Baltic faunas described by Lindström (1955, 1960) and Viira (1967). These are: *Distacodus rhombicus* Lindström, *Oistodus inaequalis* Pander, *O.* sp. cf. *O. parallelus* Pander, *O. "triangularis"* Lindström, *Oneotodus variabilis* Lindström, and *?Ozarkodina* sp. In Sweden, *Distacodus rhombicus* occurs in the Lower Planilimbata Limestone; *Distacodus* sp. is comparable to *D. stola* Lindström from the Upper Planilimbata Limestone (Lower Arenig); *Oistodus inaequalis* occurs in and below the Lower Planilimbata Limestone (Tremadocian); the Swedish specimens of *O. parallelus* most similar to the St. George form occur in the Upper Planilimbata Limestone; *O. "triangularis"* occurs almost exclusively in the Upper Planilimbata Limestone; *Oneotodus variabilis* is long-ranging within the Tremadocian; and blade elements referable to *Ozarkodina* first appear in the Upper Planilimbata Limestone. These forms indicate comparison with the Upper Planilimbata Limestone (Billingen Stage; Lower Arenig).

In a drill-core through Ordovician strata in Estonia (Viira, 1967), *O. "triangularis"*, *O. parallelus*, and early ozarkodinids (*Prioniodina*) are restricted to the very short interval of the Latorp (B_I) and lower part of the Volkhov Stages (B_{II}). They are of lower Arenig age.

In summary, the conodonts from the St. George Formation, northwest Newfoundland, are dominated by forms of mid-continental aspect that allow correlation with the Jefferson City interval (Twenhofel, *et al.*, 1954, Chart 2). The few species that are common to European faunas indicate a lower Arenig age. These also occur in faunas recovered in western North America and characterize Zone G of a Lower Ordovician reference section in Utah.

TABLE I | *St. George Conodont Species*

Genus and Species	Sample A (D/S)*	Sample B (D/S)*	Total
Acontiodus sp. cf. *A. iowensis* Furnish	1		1
A. staufferi Furnish	3	5	8
****Distacodus rhombicus*** Lindström	1		1
D. sp.	1		1
Drepanodus homocurvatus Lindström	28 (9/19)	18 (10/8)	46
D. pandus (Branson and Mehl)	2		2
D. simplex Branson and Mehl	36 (15/21)	15 (5/10)	51
D. toomeyi Ethington and Clark	3 (1/2)	6 (3/3)	9
Loxodus sp. aff. *L. bransoni* Furnish		2	2
****Oepikodus*** n. sp. A	1		1
****Oistodus*** sp. cf. *Oistodus inaequalis* Pander	3 (0/3)	7 (6/1)	10
****O. parallelus*** Pander	1 (0/1)		1
****O. "triangularis"*** Lindström	1 (0/1)	3 (2/1)	4
****Oneotodus variabilis*** Lindström	1		1
****?Ozarkodina*** sp.		2	2
Scolopodus cornutiformis Branson and Mehl	11	13	24
S. emarginatus n. sp.	5	13	18
S. gracilis Ethington and Clark		6	6
S. multicostatus n. sp.	6	5	11
S. quadraplicatus Branson and Mehl	68	47	115
Ulrichodina prima Furnish	2	7	9
Total identifiable St. George conodonts			323

*(D/S) indicates ratio of dextral:sinistral specimens
** indicates species regarded as having European provincial affinities

Systematic Paleontology

Genus *Acontiodus* Pander, 1856

Type species. *Acontiodus latus* Pander, 1856

Acontiodus sp. cf. *A. iowensis* Furnish

Plate XVIII, figure 10

?*Acontiodus iowensis* FURNISH, 1938, pp. 325, 326, pl. 42, figs. 16, 17; ETHINGTON and CLARK, 1964, p. 687, pl. 113, fig. 3.

Remarks. A single, poorly preserved, specimen is tentatively referred to this species. It is characterized by a narrow elliptical basal cavity and a posterior carina flanked by broad compressed lateral keels on the cusp.

Type. Figured specimen, GSC No. 24412.

Acontiodus staufferi Furnish

Plate XIX, figures 2, 3

Acontiodus staufferi FURNISH, 1938, p. 326, pl. 42, figs. 11, 12; ETHINGTON and CLARK, 1964, p. 687, pl. 113, figs. 4, 9; ETHINGTON and CLARK, 1965, pl. 2, fig. 14; MOUND, 1965, p. 12, pl. 1, fig. 22.

Remarks. In most specimens the posterior carina is divided by a prominent groove, deepening towards the base; in others the carina is simple and rounded. Both varieties were noted by Furnish (1938) in the type material from the Shakopee Dolomite of Wisconsin.

Types. Hypotypes, GSC Nos. 24413, 24414.

Genus *Distacodus* Hinde, 1879

Type species. *Machairodus incurvus* Pander, 1856

Distacodus rhombicus Lindström

Plate XIX, figures 1, 4; Figure 6H

Distacodus rhombicus LINDSTRÖM, 1955, p. 556, pl. 3, figs. 35, 36.

Remarks. A single specimen is referable to this species. The specimen is not laterally compressed and the two lateral costae and the anterior and posterior keels are sharp but not thin and extended. This appears to be one major difference between *D. rhombicus* and *D. stola stola* Lindström. However, one lateral costa is directed somewhat posteriorly and the other slightly anteriorly, producing an imperfect rhombic cross-section. Such variation was noted within *D. stola stola* by Ethington and Clark (1965, p. 189) but on the basis of the less prominent costae, and the greater curvature of the unit, the St. George specimen is referred to *D. rhombicus.*

The basal cavity is deep, conical, and extends to the point of greatest curvature.

Type. Hypotype, GSC No. 24415.

Distacodus sp.

Plate XIX, figure 5

Remarks. A single specimen belonging to *Distacodus* may represent a new species. The unit has a rounded shoulder at the anterior margin close to which is a sharp lateral costa. The posterior margin is sharply keeled and another lateral costa lies closer to the posterior than the anterior margin. The area between the anterior margin and the most posterior lateral costa is curved but the other three faces are flat. The unit is asymmetrical. A deep basal cavity extends up to the point of greatest curvature. The cusp is moderately recurved, the costae and keel prominent throughout its length, and there is some expansion of the cusp in the basal quarter of the length.

No closely comparable species of *Distacodus* have been previously described.

Type. Figured specimen, GSC No. 24416.

Genus *Drepanodus* Pander, 1856

Type species. *Drepanodus arcuatus* Pander, 1856

Drepanodus homocurvatus Lindström

Plate XIX, figures 14, 15

Oistodus curvatus BRANSON and MEHL, 1933, p. 110, pl. 9, figs. 4, 10, 12; FAY, 1952, p. 134.
Drepanodus homocurvatus LINDSTRÖM, 1955, p. 563, pl. 2, figs. 23, 24, 39, text-fig. 4d; BERGSTRÖM, 1964, p. 23; ETHINGTON and CLARK, 1964, p. 688, pl. 113, figs. 13, 16 (includes complete synonymy through 1963); HAMAR, 1964, p. 264, pl. 2, figs. 3, 4, text-fig. 6, No. 3b; SERPAGLI and GRECO, 1964, p. 200, pl. 35, fig. 2; BARNETT, 1965, p. 70, pl. 1, fig. 15, pl. 2, fig. 5; MOUND, 1965, p. 17, pl. 2, figs. 8, 10; BERGSTRÖM and SWEET, 1966, pp. 331–333, pl. 35, figs. 24, 25; FÄHRAEUS, 1966, p. 20, pl. 2, figs. 11a, 11b; OBERG, 1966, p. 137, pl. 16, fig. 13; SWEET and BERGSTRÖM, 1966, p. 152, pl. 18, fig. 10; ANDREWS, 1967, p. 889, pl. 113, fig. 16, pl. 114, figs. 8, 15.
Drepanodus sp. cf. *D. homocurvatus*, SCHOPF, 1966, p. 55, pl. 5, figs. 11, 14, 15.
?*Oistodus concavus* BRANSON and MEHL, 1933, p. 59, pl. 4, fig. 6; (authors).

Remarks. All the drepanodids not assigned to *D. pandus*, *D. simplex*, and *D. toomeyi*, have been placed in this species. The extensive synonymy attests to the ubiquitous nature of *D. homocurvatus* in Ordovician strata; there is considerable morphological variation within this species. The collection includes a few specimens that other writers would doubtless include in *D. concavus* (Branson and Mehl), but this latter species is tentatively considered to be synonymous with *D. homocurvatus*.

Types. Hypotypes, GSC Nos. 24417, 24418.

Drepanodus pandus (Branson and Mehl)

Plate XX, figures 18, 19

Oistodus pandus BRANSON and MEHL, 1933, p. 61, pl. 4, figs. 21, 22.
cf. *Oistodus* sp. A. SANDO, 1958, pl. 2, fig. 19.
non *Oistodus pandus*, FURNISH, 1938, p. 330, pl. 42, fig. 5; GRAVES and ELLISON, 1941, pl. 1, figs. 2, 31, 34, pl. 2, fig. 34.

Remarks. Several species of *Drepanodus*, including *D. amoenus* Lindström, *D. pandus* (Branson and Mehl), *D. proetus* Lindström, and *D. sculponea* Lindström possess similar characters but can be separated by consideration of the curvature, outline of the basal margin, character of the basal cavity, and the relative size of the basal region to that of the cusp.

The St. George specimens are identical to one of the cotypes (Branson and Mehl, 1933, fig. 21) and are characterized by the very prominent basal region, a strongly recurved cusp, a capacious basal cavity opening posteriorly rather than aborally and closing in a wedge pattern anteriorly, the upper margin of the base horizontal and parallel to the anterior half of the basal margin, and by the antero-posterior length of the base being approximately twice the height of the base. The overall shape of the base, viewed laterally, is almost rhombic.

Types. Hypotypes, GSC Nos. 24419, 24420.

Drepanodus simplex Branson and Mehl

Plate XIX, figures 8, 12, 13

Drepanodus arcuatus BRANSON and MEHL, 1933, p. 58, pl. 4, figs. 7, 8, 13, 16; FAY, 1952, p. 89; *non* PANDER, 1856, p. 20, pl. 1, figs. 2, 4, 5, 17, 30, 31.
Drepanodus parallelus BRANSON and MEHL, 1933, p. 59, pl. 4, fig. 17; SANNEMANN, 1955, pp. 26, 27, pl. 1, figs. 13, 15.
Drepanodus simplex BRANSON and MEHL, 1933, p. 58, pl. 4, fig. 2; MEHL and RYAN *in* BRANSON, 1944, pl. 7, figs. 9, 10; *non* BRANSON and MEHL, 1947, pp. 552, 553, pl. 81, figs 24–26, pl. 82, fig. 38.
?*Drepanodus simplex,* WOLSKA, 1961, p. 349, pl. 2, fig. 8.
Drepanodus subarcuatus FURNISH, 1938, pp. 328, 329, pl. 41, figs. 25–32, pl. 42, figs. 2, 3; FAY, 1952, p. 90; HASS, 1962, Treatise Invert. Paleont., pt. W, p. 43, fig. 22 (10a, b); ETHINGTON and CLARK, 1964, pl. 113, figs. 15, 20; MOUND, 1965, p. 19, pl. 2, figs. 14, 18, 19; LOCHMAN, 1966, p. 535, pl. 65, figs. 18, 20 (*non* figs. 17, 19).
Drepanodus cf. *D. subarcuatus,* LINDSTRÖM, 1955, p. 568, pl. 2, figs. 41, 44, 50; WOLSKA, 1961, p. 349, pl. 1, figs. 5, 7.
?*Drepanodus arcuatus,* MÜLLER, 1964, pp. 96, 97, pl. 13, figs. 5, 6; CARLSON, 1960, pl. 1, figs. 15, 16.
non *Drepanodus subarcuatus,* LOCHMAN, 1965, p. 484, pl. 63, fig. 13.

Remarks. The simple, relatively deep, basal cavity, terminating near the anterior margin is a constant feature in all the specimens. Variability occurs in the angle of recurvature with respect to the basal margin, ranging from a subparallel position to an angle of 30 degrees, but usually about 10 to 15 degrees. Specimens are all laterally flexed or twisted to some extent.

Ethington and Clark (1964, p. 689) and Mound (1965, p. 19) have noted the close similarity of *D. parallelus* with *D. subarcuatus.* Mound included both *D. parallelus* and *D. simplex* in synonymy with *D. subarcuatus.* The St. George specimens show complete gradation between the morphological extremes represented by the figured type specimens of *D. parallelus, D. simplex,* and *D. subarcuatus.* Of these three species *D. simplex* has priority and the others are grouped in synonymy.

Types. Hypotypes, GSC Nos. 24421–24423.

Drepanodus toomeyi Ethington and Clark

Plate XIX, figures 9–11; Figure 6I

Drepanodus toomeyi ETHINGTON and CLARK, 1964, p. 690, pl. 113, fig. 17, pl. 114, fig. 22; text-fig. 2 H.

Remarks. The few specimens at hand conform in all respects to the description of the type material, all the characteristics being evident in both large and small specimens.

Types. Hypotypes, GSC Nos. 24424, 24425.

Genus *Loxodus* Furnish, 1938

Type species. *Loxodus bransoni* Furnish, 1938.

Only Furnish (1938) has described forms belonging to *Loxodus*, all of which he included in the type species. Sando (1958, pl. 2, fig. 17), Ethington and Clark (1964, p. 686), and Longwell and Mound (1967, p. 409) have found, but not described, *Loxodus* from other Lower Ordovician strata. It is only known from North America. Although its existence appears to have been very brief, its ancestral development is not known.

Loxodus sp. aff. *L. bransoni* Furnish

Plate XX, figures 1, 4, 15–17

Remarks. The two specimens of *Loxodus* in the collection are similar to but possess certain characters not found in *L. bransoni* Furnish. The number and arrangement of denticles would conform to *L. bransoni* but the elements are asymmetrical having a prominent low rounded carina near the base of the most anterior denticle. This is developed only on one side and is seen as a V-shaped expansion of the basal margin. The anterior margin of the element is also directed inward near the base in the style of *Ulrichodina*. This inversion is not perfectly symmetrical and with adjacent carinal expansion produces a sinuous zone in the basal margin near the anterior tip. The basal cavity is shallower than the average width and is wedge-shaped, deepening slightly anteriorly. Each specimen contains five denticles and a posterior basal extension from which the denticles develop.

The infolding of the anterior end, the lateral carina, and the relatively shallow basal cavity aid to distinguish these forms from *L. bransoni*. The apparent reduction in the cavity depth may indicate a slightly younger age for the St. George specimens, this being a common trend with time in Ordovician conodonts.

Types. Figured specimens, GSC Nos. 24426, 24427.

Genus *Oepikodus* Lindström, 1955

Type species. *Oepikodus smithensis* Lindström, 1955

Oepikodus n. sp. A

Plate XX, figures 8–10; Figure 6A

Diagnosis. A single, small, fragile specimen possessing an anterior, posterior, and two lateral processes, all undenticulated, is assigned to *Oepikodus* n. sp. A.

Description. The cusp is moderately recurved and almost square in cross-section. Its anterior margin is sharp and developed aborally into a somewhat laterally flexed costa. The posterior process is undenticulated and continues up the posterior margin as a thin sharp costa. Two lateral processes are asymmetrically arranged. The larger, which is developed close to the anterior margin of the cusp at or slightly above the highest point of the basal cavity, flares outwards and follows the same curve pattern as the anterior costa. The smaller develops near mid-height of the cusp and extends as a prominent sharp wedge-shaped feature in a posterior direction to lie somewhat nearer the posterior than the anterior process. All four processes are joined by thin sheath-like

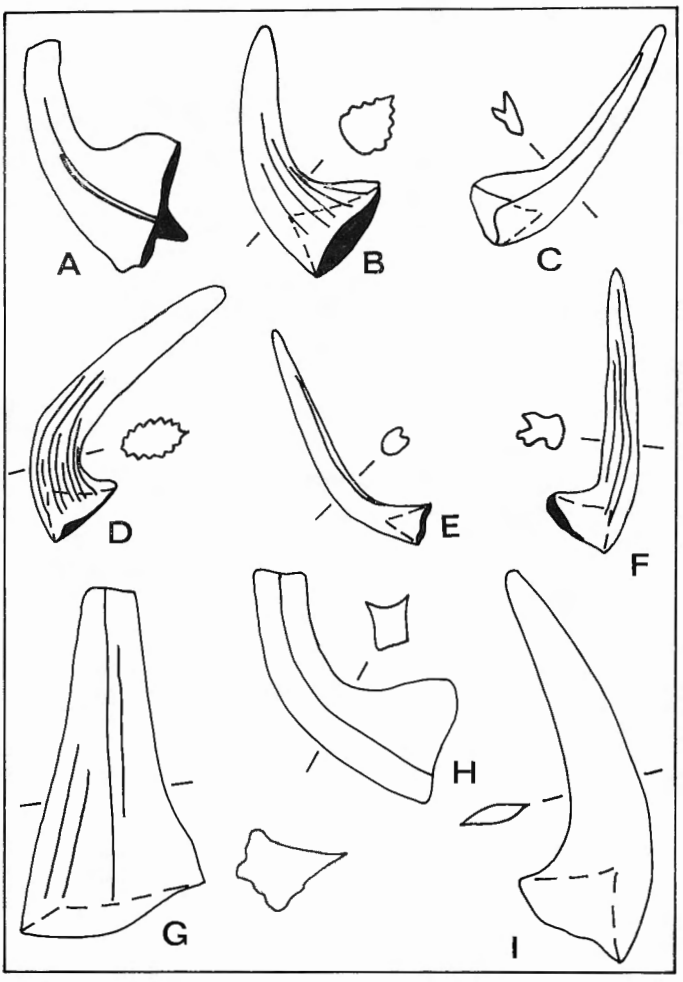

FIGURE 6. Conodonts from the St. George Formation, northernmost Newfoundland.

material producing a deep basal cavity. It is not known how far the processes extended beyond their present limits for, with the possible exception of the posterior one, they are broken terminally.

Remarks. This species differs from typical *Oepikodus* in lacking a denticulated posterior process and in having the lateral processes asymmetrically developed. However, the basic symmetry is that of *Oepikodus* and, as the genus first arises in the Arenigian, the absence of denticles on the posterior process of this species is not considered sufficiently important to restrict it from the genus. Few species of *Oepikodus* have been described and the present specimen differs from all of these. It is probably a primitive representative of the genus.

Type. Figured specimen, GSC No. 24428.

Genus ***Oistodus*** Pander, 1856

Type species. *Oistodus lanceolatus* Pander, 1856

Oistodus inaequalis Pander

Plate XX, figures 2, 3, 7

Oistodus inaequalis PANDER, 1856, p. 27, pl. 2, fig. 37; FAY, 1952, p. 125; LINDSTRÖM, 1955, pp. 576, 577, pl. 3, figs. 52–57; ETHINGTON and CLARK, 1965, p. 195, pl. 1, fig. 11.
Oistodus n. sp. MEHL and RYAN, *in* BRANSON, 1944, pl. 7, figs. 5, 6.

Remarks. The specimens conform to the description by Lindström (1955). The inwardly inclined cusps are markedly laterally compressed, the outer side being mildly convex and the inner side showing a weak rounded central carina. This latter feature was reported to be a "rather strong" feature in the Swedish forms. Relative to the cusp the basal region is prominent, and is laterally asymmetrical showing marked lateral flaring on the inner side.

Types. Hypotypes, GSC Nos. 24429, 24430.

Oistodus sp. cf. *O. parallelus* Pander

?*Oistodus parallelus* PANDER, 1856, p. 27, pl. 2, fig. 40; LINDSTRÖM, 1955, pp. 579, 580, pl. 4, figs. 26–31, 43, text-fig. 3N, O.

Remarks. A single specimen is tentatively referred to this species. Many previously described forms, especially from younger strata, have a truncated or rounded antero-aboral margin and an appreciably smaller basal region. In this specimen, the cusp is markedly depressed and lies directly on the posterior basal margin subparallel to the aboral margin. On the inner face, a large rounded carina is developed at the basal margin and swells out the cavity into a triangular shape, but does not extend along the cusp.

Type. Specimen lost.

Oistodus "triangularis" Lindström

Plate XX, figures 11, 13, 14

Oistodus triangularis LINDSTRÖM, 1955, p. 581, pl. 4, figs. 14–18; ETHINGTON and CLARK, 1964, p. 964, pl. 114, fig. 4.

Remarks. All specimens are small and fragile. The lateral costa is very strongly developed with delicate, thin walls between the three sharp edges. A simple, relatively deep, conical cavity is produced beneath a sharp-pointed, laterally compressed, slightly inclined cusp.

Furnish (1938, pp. 330, 331) gave the name *Oistodus*? *triangularis* to forms that certainly do not belong in *Oistodus*. Lindström (1964, pp. 82, 83) described a transition series of *O. lanceolatus, O. "triangularis"*, and *O. delta,* and inferred that *O. "triangularis"* could be grouped in with *O. lanceolatus*. Knowledge of North American Lower Ordovician faunas is so restricted at this time, that the specimens are referred to the more restricted taxon. Longwell and Mound (1967, p. 409) also record this species from the Lower Ordovician of Nevada.

Types. Hypotypes, GSC Nos. 24431, 24432.

Genus *Oneotodus* Lindström, 1955

Type species. *Distacodus*? *simplex* Furnish, 1938

Oneotodus variabilis Lindström

Plate XVIII, figure 3

Oneotodus variabilis LINDSTRÖM, 1955, p. 582, pl. 2, figs. 14–18, pl. 5, figs. 4, 5, text-fig. 6; ETHINGTON and CLARK, 1965, p. 197.

Remarks. A single specimen lies within the rather wide field of variation allowed by Lindström (1955) for this species. The basal area is relatively small and the cavity is not as deep as some of Lindström's specimens. The cusp is regularly curved, circular in cross-section and the unit is slightly twisted. There is no sign of longitudinal striations on the cusp.

Type. Hypotype, GSC No. 24433.

Genus ***Ozarkodina*** Branson and Mehl, 1933

Type species. *Ozarkodina typica* Branson and Mehl, 1933.

?*Ozarkodina* sp.

Plate XIX, figures 6, 7

Two broken specimens in the St. George collection are denticulate blade forms that are tentatively referred to *Ozarkodina.* The specimens are laterally compressed with a slightly inclined main cusp with one or two ill-defined confluent anterior denticles and on one specimen three or four ill-defined confluent posterior denticles. The basal cavity is small lying beneath the main cusp and with a slight flare to one side. The denticles all lie in one plane.

Lindström (1955; 1960, figs. 3 (10), 4 (12), 5 (1, 2); 1964, fig. 10, P) has described some early ozarkodinid elements from the Arenigian of Sweden. Middle Arenigian forms, *O. flabellum* (Lindström), have a single, rounded denticle in front of the cusp but in the higher part of the Arenigian more anterior denticles are added and become flattened. In North America, similar, but probably not conspecific, Lower Ordovician blade forms have been described by Graves and Ellison (1941, pl. 1, fig. 20: "indeterminable specimen") from the Marathon Formation of Texas and by Ethington and Clark (1965, pl. 2, fig. 8: *Prioniodina? inflata*) from the Columbia Ice Fields section of Alberta. Despite the fragmentary nature of the two St. George specimens, their presence as the only representatives of the blade conodonts is noteworthy.

Type. Figured specimen, GSC No. 24434.

Genus ***Scolopodus*** Pander, 1856

Type species. *Scolopodus sublaevis* Pander, 1856

Sweet and Bergström (1962, pp. 1246, 1247) have discussed some of the problems of definition for *Scolopodus*, especially the difficulties of adequately separating *Scolopodus* and *Paltodus*. Lindström (1955, p. 583) had earlier noted that "... no genus has been erected for simple, irregularly costate conodonts with sharp anterior and posterior edges, nor does this seem necessary at present." Lindström brought to *Scolopodus* simple conodonts that were symmetrical, multicostate, with or without posterior and anterior keels.

Sweet and Bergström (1962, p. 1246) advised that the definitions should not be rigidly applied. The scolopodids from the St. George Formation contain some species

that have been included in the rather loose interpretation of *Scolopodus*. Certain specimens within *S. emarginatus* n. sp., *S. multicostatus* n. sp., and *S. quadraplicatus* Branson and Mehl show slight asymmetry. *S. emarginatus* also is not strictly multicostate. Most of these nomenclatorial problems stem from the relatively little study given to Lower Ordovician conodonts.

Scolopodus cornutiformis Branson and Mehl

Plate XVIII, figures 1, 4; Figure 6B

Scolopodus cornutiformis BRANSON and MEHL, 1933, p. 62, pl. 4, fig. 23; ETHINGTON and CLARK, 1964, pp. 698, 699, pl. 114, figs. 16, 23; ETHINGTON and CLARK, 1965, p. 200, pl. 1, figs. 10, 12.
?*Scolopodus* n. sp. MEHL and RYAN, *in* BRANSON, 1944, pl. 6, figs. 41–43.

Remarks. The St. George specimens agree closely with previously described material. As in the El Paso material (Ethington and Clark, 1964) the costae are more numerous on the long slender forms, and fewer and coarser on the shorter robust specimens; costae arise just above the basal margin and the larger ones extend to the tip of the cusp.

The specimens are also characterized by having a colour pattern different from all other conodonts from the St. George Formation. The basal region (approximately the lower third) is dark amber to black whereas the distal two-thirds of the cusp is whitish; the colour change is sharp and the basal part becomes darker towards this level.

Types. Hypotypes, GSC Nos. 24435, 24436.

Scolopodus emarginatus n. sp.

Plate XVIII, figures 2, 6–8; Figure 6C

Paltodus n. sp., MEHL and RYAN, *in* BRANSON, 1944, pl. 7, figs. 17, 18.

Diagnosis. Suberect distacodontids with smooth lateral faces meeting at an acute angle to form a rounded anterior margin. A deep entrenched posterior groove is flanked by sharp posterior margins of the lateral faces. Commonly one side is slightly wider than the other producing a mildly asymmetrical unit. Basal cavity deep, conical, sharp-pointed, with the apex close to the anterior margin. Basal outline elliptical with a deep notch in the wider posterior end.

Description. Most of the simple cones are fairly robust and are suberect. Cusps terminate at a rather blunt point and are somewhat thickened in the basal region. The lateral sides widen at an angle of about 15 to 20 degrees from a rounded anterior margin. Sides are usually smooth but in some specimens a faint wide shallow groove runs along the narrowest side. Between the two faces posteriorly is a deep, relatively narrow groove or trench that increases in width and depth towards the basal margin. The junction of each lateral face and the side of the groove is sharp. The groove extends throughout the length of the unit. The basal cavity lying close to the anterior margin. The basal margin is elliptical to oval with a deep notch in the posterior end as the margin moves up into the groove. The growth axis extends in a straight line from the apex of the basal cavity to the tip of the cusp.

One lateral face is commonly slightly larger than the other, thereby producing minor asymmetry in the unit.

Remarks. These specimens are referred to *Scolopodus* with some hesitancy. Some are slightly asymmetrical and cannot be termed multicostate. If the asymmetry were more developed the elements would approach *Acodus* with one sharp posterior margin and one sharp lateral costa. However, *Scolopodus* currently does not have rigid morphological limits and for the present these forms are referred to this genus. Similar forms that possess relatively unornamented cusps but with a prominent posterior groove are referred to species such as *S. triangularis* Ethington and Clark and *S. gracilis* Ethington and Clark but they can readily be distinguished by study of their cross-section outlines: *S. triangularis* possesses a prominent keeled anterior margin and *S. gracilis* has essentially a round cusp, a less prominent groove and has a greater curvature of a much more slender cusp.

Types. Holotype, GSC No. 24438; paratypes, GSC Nos. 24437, 24439, 24440.

Scolopodus gracilis Ethington and Clark

Plate XVIII, figures 11, 12; Figure 6E

Scolopodus gracilis ETHINGTON and CLARK, 1964, p. 699, pl. 115, figs. 2, 3, 4, 8, 9, text-figs. 2D, G; ETHINGTON and CLARK, 1965, p. 200.
Scolopodus striolatus HARRIS and HARRIS, 1965, pp. 38, 39, pl. 1, figs. 6a–d.

Remarks. These slender slightly curved forms possess a circular to subcircular cross-section indented by a longitudinal posterior groove. The St. George forms differ slightly from those from the El Paso Formation (Ethington and Clark, 1964) in that the groove is deepest at the point of greatest curvature and proximally from this the groove widens but becomes shallow and in some specimens cannot be traced to the basal margin. The larger slender forms have fine striate surfaces. The basal cavity forms a simple cone, relatively deep, with the apex lying close to the anterior margin.

The fine striae on the surface was also reported on specimens by Ethington and Clark (1965) and this character would seem to be the only significant one separating *S. striolatus* Harris and Harris from *S. gracilis.* All other features, including the posterior groove, are present in *S. striolatus* which is here grouped in synonymy with *S. gracilis.*

Types. Hypotypes, GSC Nos. 24441, 24442.

Scolopodus multicostatus n. sp.

Plate XVIII, figures 5, 9, 15, 16; Figure 6D

Scolopodus n. sp. MEHL and RYAN, *in* BRANSON, 1944, pl. 6, figs. 27, 28, 46, 47.

Diagnosis. Robust, strongly recurved, multicostate, simple conodont elements with sharp anterior and posterior margins on the cusp and with entire unit possessing many fine longitudinal costae. Basal region only moderately expanded, possessing a relatively deep conical basal cavity.

Description. All specimens are robust or moderately robust and are recurved strongly so that the distal part of the cusp lies approximately parallel (within 10° either way) to the plane of the basal margin. The cusps are regularly curved and there is commonly an angle of 70 to 80 degrees between the anterior and basal margins; the angle between the posterior and basal margins is about 60 degrees. Smaller specimens appear to be the most erect. Distally from the point of greatest curvature, the cusps are laterally compressed and both anterior and posterior margins are sharp. The basal region itself

is only slightly compressed to produce a subcircular to elliptical or oval basal margin. Most specimens show slight asymmetry, the cusps being slightly twisted and the anterior margin being deflected to one side of the unit as it fades out towards the basal margin.

The lateral faces are ornamented by numerous sharp, fine costae which begin just above the basal margin and fade out in the tip of the cusp. The costae generally number about twenty on each face, but they are of variable size and the exact number is not critical. They cover the whole of the surface between the anterior and posterior margins.

The basal cavity is relatively deep being conical in shape with the apex lying close to the anterior margin of the cusp, similar to many other scolopodids. The basal region is slightly expanded posteriorly. The growth axis extends in a straight line from the tip of the basal cavity to that of the cusp, passing very close to the posterior margin at the point of greatest recurvature.

Remarks. Mehl and Ryan (*in* Branson, 1944) illustrated similar forms from the Lower Ordovician Jefferson City Formation of Missouri which appear to be conspecific with the St. George Formation specimens. Sweet and Bergström (1962, p. 1247) compared their new *S. giganteus* with *S.* n. sp. of Mehl and Ryan, but in the former species the fewer costae are much coarser and are not present on the anterior half of the cusp. Both *S. rex* Lindström and *S. striatus* Pander bear some resemblance to *S. multicostatus* but are less curved and do not show lateral compression; in these species also the costae do not extend up to the anterior margin.

Types. Holotype, GSC No. 24444; paratypes, GSC Nos. 24443, 24445–24447.

Scolopodus quadraplicatus Branson and Mehl

Plate XVIII, figures 13, 14, 17; Figure 6F

Scolopodus quadraplicatus BRANSON and MEHL, 1933, p. 63, pl. 4, figs. 14, 15; FURNISH, 1938, p. 332, pl. 41, figs. 1–12, text-fig. 1J; MEHL and RYAN, *in* BRANSON, 1944, pl. 6, figs. 31–37; SANDO, 1958, pl. 2, fig. 21; ETHINGTON and CLARK, 1964, pp. 699, 700, pl. 115, figs. 12, 25; MOUND, 1965, p. 35, pl. 4, figs. 26, 30; LOCHMAN, 1966, p. 535, pl. 65, fig. 22.
?*Scolopodus quadraplicatus,* GRAVES and ELLISON, 1941, pl. 1, fig. 10, pl. 3, figs. 2, 5.

Remarks. The wide variation within this species has been well illustrated by Furnish (1938) and by Mehl and Ryan (*in* Branson, 1944). All types are represented in the St. George material. Slight asymmetry is developed in some forms and varies from a flexing of the distal part of the cusp to slight asymmetry in the whole element. In the latter, the base is expanded slightly more to one side and on this side a deep lateral groove runs the length of the cusp; on the other lateral face the groove is shallower but an additional narrow groove divides the posterolateral carina.

Most of the typical specimens are slender with long cusps and a relatively small basal region. A second group of specimens are robust with relatively short stout cusps and a prominent, much expanded basal region (Pl. XVIII, fig. 17). On the cusp are two lateral and one posterior grooves which are shallow and broad, thus the cross-section is similar to typical *S. quadraplicatus* if more nearly square. These specimens also are sharply recurved at a point immediately above the basal region, at a lower point than typical *S. quadraplicatus.* These robust specimens do not appear to be just the mature forms of the species, but with the material at hand the morphological differences do not warrant a separate species designation.

Types. Hypotypes, GSC Nos. 24448 to 24451.

Genus *Ulrichodina* Furnish, 1938

Type species. *Ulrichodina prima* Furnish, 1938

Furnish (1938) included in *Ulrichodina* simple conodonts with bilaterally symmetrical cusps that were somewhat laterally compressed, anteriorly thickened, and posteriorly keeled. The cavity is a simple excavation and the anterobasal margin is characteristically infolded and slightly extended downwards to form the lowest point of the element. Many forms possess weak striations along the sides of the cusp.

Ulrichodina has been reported by Branson and Mehl (1933, p. 57) as *Acontiodus abnormalis*—later assigned to *Ulrichodina* by Mehl and Ryan, *in* Branson (1944), Furnish (1938), R. A. McTavish (*in* Lindström, 1964, p. 38), Harris and Harris (1965), and Longwell and Mound (1967). It is thus restricted to strata of Lower Ordovician age in North America and Australia. The specimen illustrated as *Ulrichodina* sp. by Graves and Ellison (1941, pl. 2, fig. 11) from the Fort Peña (Middle Ordovician) of southwestern Texas does not appear to belong to this genus.

Ulrichodina prima Furnish

Plate XX, figures 5, 6, 12; Figure 6G

Ulrichodina prima FURNISH, 1938, p. 335, pl. 41, figs. 21, 22, text-fig. 1A; FAY, 1952, p. 200; LONGWELL and MOUND, 1967, p. 410.

These simple specimens conform to the description of the type material. As in Furnish's specimens, the larger forms develop weak grooves along the anterolateral faces. Furnish described the anterior margin as "rounded or flattened;" in the St. George material the larger specimens develop a small, but sharp, anterior keel on the rounded or flattened margin. In this respect they resemble *U. cristata* Harris and Harris but in that species the anterior keel is extremely well developed, although Harris and Harris (1965, pp. 40, 41) give no data on the numbers and ontogeny of their specimens.

Types. Hypotypes, GSC Nos. 24452, 24453.

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CONODONTS FROM THE LÉVIS FORMATION (ZONE D1) (MIDDLE ORDOVICIAN), LÉVIS, QUEBEC

by T. T. Uyeno and C. R. Barnes

Abstract

Thirty-five species of conodonts representing twenty-one genera are described from the Lévis Formation (zone D1) at the Côte Fréchette section, Lévis, Quebec. Seven species are new, but are not formally named. The fauna is of North European provincial aspect, containing only a few species characteristic of the North American mid-continent. Comparisons with conodonts from the Baltic region indicate a lower Llanvirn age.

Résumé

L'auteur décrit trente-cinq espèces de conodontes représentant vingt et un genres en provenance de l'horizon D1 de la formation de Lévis, section de la côte Fréchette, Lévis (Québec). Sept espèces sont nouvelles mais n'ont pas encore été nommées officiellement. La faune ressemble à celle de la province géologique du nord de l'Europe et ne contient que quelques espèces caractéristiques du centre du continent nord-américain. La comparaison de ces conodontes avec ceux de la région baltique les place au Llanvirn inférieur.

The Lévis Formation was introduced by Sir William Logan in 1863. In 1861, however, he had established its type locality along the south shore of Ile d'Orléans. With its formal naming, Logan (1863) described the section in detail, and gave its thickness as 5,025 feet. The Lévis and Sillery Formations (with the latter then considered the younger unit) were placed in the Quebec Group and it, in turn, was correlated with the Chazy and Calciferous Formations of the Champlain Valley.

Since this initiation by Logan, various geological and paleontological aspects of the Lévis Formation have been studied extensively by others. Among the outstanding workers are Raymond (1913, 1914a, b), Clark (1924, 1926), Rasetti (1944, 1948a, b), Osborne (1956), and Osborne and Berry (1966). The reader is referred to Osborne's (1956) contribution for complete history of the investigation of the Lévis.

The Lévis Formation, briefly, consists of thin-bedded siltstone with lenticular limestone conglomerate beds. In places fine-grained, thin-bedded, nodular limestone and dolomite occur within the siltstone. As noted by Osborne (1956, p. 182): "The

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well known *Shumardia* limestone on Davidson Street [now called Côte Fréchette] in Lévis (Raymond, 1913b) [listed herein as 1913; the section is figured on page 37 of this reference] is an example of such a zone thicker than that ordinarily met with." It is this famous locality that was sampled and studied for its contained conodonts.

Within the town of Lévis, Raymond (1914b) measured the formation as 592 feet thick, with his units 1 through 20 exposed in the Begin's Hill section, and units 19 through 25 at the Davidson Street anticline. Raymond (ibid.) also grouped the Lévis fauna into four zones, A, B, C, and D. He noted (p. 528) that:

> D is the highest zone, characterized by *Diplograptus dentatus* and other Diplograptids. It may be subdivided into two zones, the lower one being that in which the strata are mostly limestone, and the upper in which the strata are shale. The total range of *D. dentatus* on Davidson Street is about 80 feet.
>
> D1 is the lower sub-zone with *Shumardia granulosa,* other trilobites, brachiopods, and a great abundance of *Dictyonema.*

The *Shumardia* limestone on Côte Fréchette is therefore assignable to Raymond's zone D1.

The Côte Fréchette section is 105 feet thick. Its gross lithic characteristics are shown in the columnar section in Table II. For finer definition, thin sections were made from a representative suite of rock samples collected in this section. The limestones collected are predominantly pelmicrites with some biopelsparites, and variable amounts of quartz sand. The limestone beds commonly show internal lamination. Samples were collected from the centre of the anticline uphill in a southerly direction and around the hair-pin turn. The section was channel-sampled at 5-foot intervals where limestone beds were encountered. Non-calcareous siltstone layers were not collected. Twelve samples were collected, and about 4 kilograms (Table II) of each sample were dissolved in acid solution. All samples except one (GSC locality 82741: 10 to 15-foot interval in Table II) yielded conodonts. The average number of conodonts obtained per kilogram per productive sample was fifteen. One exceptional sample from GSC locality 82750 (80- to 85-foot interval) yielded 331 specimens.

Boulders in the conglomerate beds within the Lévis Formation were also sampled for conodonts. The locality of these beds and the contained conodont fauna are discussed separately in the Appendix.

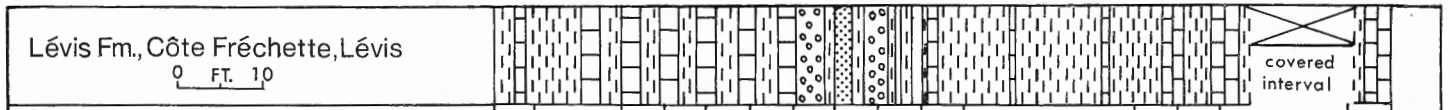
We are grateful to F. F. Osborne of Laval University for kindly showing us the various outcrops of the Lévis Formation.

Recent Correlations of the Upper Part of the Lévis Formation

The Lévis Formation contains several groups of fossils, but essentially only the graptolites and trilobites have been previously used for distant correlations. The more recent correlations of the upper part of the formation based on these fossils may be briefly summarized as follows.

Raymond's zone D1 was suggested to be of early Llanvirn age by Kindle and Whittington (1958), and was correlated with Ross-Hintze (Ross, 1951, 1964; Hintze, 1952) trilobite zone N of Utah and Nevada. It was further assigned to the *Isograptus caduceus* Zone which is Berry's (1960) zone 8. Berry assigned Raymond's zone D (undivided) to his zone 9, the *Hallograptus etheridgei* Zone (upper Whiterock, lower

TABLE II | *Distribution of conodonts in Lévis Formation (zone D1), Côte Fréchette section, Lévis, Quebec*



Productive 5-ft. sampling intervals with GSC Loc. Nos.	82740		82742	82743	82744	82745		82746	82747	82748		82749	82750		82751	Total
Sample weight (kg.)																
Conodonts	4.2		4.0	4.1	4.2	4.3		4.1	4.5	4.4		3.8	4.0		4.3	
Acontiodus robustus (Hadding)	26.		13.	4.	2.	1.		7.	3.	2.		5.	25.		1.	89
Acontiodus sp. 1	2.			2.	1.							1.	5.			11
Acontiodus sp. 2	1.								1.				1.			3
Acontiodus sp. 3	1.			1.									2.			4
Amorphognathus variabilis Sergeeva	1.		1.	1.									3.			6
Chosonodina n.sp. 1	1.															1
Cordylodus spinatus (Hadding)	5.		3.	1.	1.							1.	4.			15
Drepanodus homocurvatus Lindström	1.				2.								3.			6
Drepanodus suberectus (B. & M.)	3.				1.								12.			16
"Eoligonodina" sp.	1.															1
Falodus prodentatus (Graves & Ellison)	33.		5.	15.	5.			7.	5.	4.		9.	71.		1.	155
Falodus sp.	1.		2.													3
Hibbardella sp.	2.		1.	2.	4.	1.										10
Oistodus sp. cf. *O. abundans* B. & M.			1.													1
Oistodus inclinatus B. & M.			1.					1.					3.			5
Oistodus multicorrugatus Harris			1.													1
Oistodus venustus Stauffer	11.		5.		1.			1.		1.			24.		2.	45
Oistodus? sp.	1.															1
Paltodus sp.	1.		1.										2.			4
Panderodus n.sp. 1													5.			5
Periodon aculeatus Hadding	10.		6.	8.	3.	2.		4.	1.			5.	111.		2.	152
Periodon flabellum (Lindström)	7.		6.	5.								1.	12.			31
Polycaulodus sp.			1.													1
Prioniodina macrodentata (Graves & Ellison)	10.		4.	6.	3.			3.	3.	1.		1.	39.			70
Prioniodina? n.sp. 1				3.	8.											11
Prioniodus sp. aff. *P. evae* Lindström				5.	5.											10
Pygodus n.sp. 1													1.			1
Pygodus sp.													1.			1
Scandodus pipa Lindström	2.			1.		1.						1.	5.		1.	11
Scolopodus gracilis Ethington & Clark			1.					1.					1.			3
Scolopodus n.sp. 1	1.		1.	1.	1.					1.		1.				6
Scolopodus n.sp. 2				1.				1.				4.			1.	7
Spathognathodus sp.	1.		3.										1.			5
Trichonodella n.sp. 1	1.											1.			1.	3
Gen. et sp. indet	1.															1
Total	124		56	56	37	5		25	13	9		30	331		9	695

Marmor). Kay (1962, p. 1428) noted that "The uppermost Deepkill and Levis zone of *Diplograptus dentatus* . . . must be highest Arenigian and low Llanvirnian." Whittington and Kindle (1963) again correlated zone D with Ross-Hintze zone N; its age was given as upper Whiterock to lower Marmor, and as Llanvirn of the British classification. In addition to all the graptolite zones considered as correlative with the Canadian Series, Berry (1968) recorded Early through Middle Ordovician graptolites (zones 7, 9, 10, 11, and possibly 8) from the Lévis Formation.

Conodont Fauna

Raymond's zone D1 of the Lévis Formation yielded 695 identifiable conodont specimens which are referable to thirty-five species and twenty-one genera. Of these genera one is indeterminate. Both mid-continental (North American) and north European elements are present, but the whole aspect of this fauna is north European. Some specimens are fairly well preserved, but owing to the deformation of these rocks, presumably during the Taconic orogeny, most of these conodonts are generally friable, and dark amber to dark brown. Table II illustrates their distribution and abundance within the interval sampled.

Two species in our Lévis material exhibit widely variable forms. Transition series, similar to those described and illustrated by Lindström (1964, pp. 80, 83, figs. 27A–D, 28E–G) are present in specimens referable to *Periodon aculeatus* and *Cordylodus spinatus*. *P. aculeatus* exhibits a wide variation especially in its development of denticles on the anterior costa or process. Variations range from cordylodus- to ligonodina-like elements with a denticulate lateral process which is directed downwards and backwards. Only the hibbardella (roundya)-like elements are missing. Among specimens referable to *C. spinatus*, we have cordylodus- and ligonodina-like elements, and again only the hibbardella (roundya)-like elements are absent. The Lévis material, however, contains cladognathodus-like elements, a form not illustrated by Lindström (ibid.), but which would fit very well in the transition series between ligonodina- and hibbardella (roundya)-like stages. A similar, four-element transition series in *Periodon flabellum* was illustrated by Lindström (p. 83, figs. 28A–D).

On comparing the Lévis conodont fauna with those of similar age in North America, difficulty was encountered owing to faunal provincialism (*see* discussion by Barnes and Tuke, 1970). The Joins Formation of Oklahoma, which is considered to be in the Whiterock Stage by Cooper (1956) and Berry (1960), yielded a mid-continental (North American) conodont fauna (Harris, 1962; Mound, 1965a). Besides some ubiquitous species such as *Drepanodus homocurvatus* and *Falodus prodentatus*, the two faunas are quite different. Numerous "fibrous" forms present in the Joins fauna are extremely rare in the Lévis; only two such specimens were found, *"Eoligonodina"* sp. and *Polycaulodus* sp. The significance of "fibrous" forms is not yet certain (Sweet and Bergström, 1962; Bergström and Sweet, 1966).

One restricted mid-continental element that occurs in both the Lévis and the Joins, and which occurs almost throughout the latter, is *Oistodus multicorrugatus*. This species has also been found in the interval 2 to 4 feet below the top of the Outram Formation at the Nigel Peak Section (lat. 52°14′N, long. 117°13′W) in Alberta (GSC loc. 56047). B. S. Norford (pers. com., 1968) identified *Orthambonites marshalli* (Wilson) in the same sample, and also this species and *"Plectorthis" sinuatis*

Wilson in the interval 2 to 5 feet above the base of the Skoki Formation (which conformably overlies the Outram Formation) (GSC loc. 56048). Norford noted that "Both collections can be confidently assigned to the basal Whiterock *Orthidiella* Zone [Ross-Hintze zone L of the Utah-Nevada sequences]. The locality has also been called the Columbia Icefield Section (Rigby, 1965; Ethington and Clark, 1965), but the name Nigel Peak Section had been previously used in the literature."

Hintze, *et al.* (1967) recorded graptolite-conodont associations in some of the Ross-Hintze zones in the Pogonip Group of the Ibex area of Utah. Conodonts of Lindström's (1960) fauna V:2, with which we correlate the Lévis fauna, was not reported on, however. Consequently Raymond's zone D1 cannot be precisely correlated with the Utah section on the basis of conodonts at this time.

Another mid-continental element in the Lévis fauna is a new species of *Chosonodina*. The genus was previously known only from unnamed strata in South Korea (Müller, 1964) and from the West Spring Creek Limestone of Oklahoma (Harris and Harris, 1965). Both units are regarded as Lower Ordovician.

Berry (1960) correlated zone D of the Lévis, at least in part, with the Fort Peña Formation of the Marathon Basin of West Texas. Only a few mid-continental elements in the Fort Peña fauna (Graves and Ellison, 1941) are in common with the Lévis, and most of these are long ranging, and therefore of limited use for correlation. Among these are species of *Oistodus, Falodus prodentatus,* and *Prioniodina macrodentata*. The Texas specimen referred to as *Ulrichodina* by Graves and Ellison (1941) is probably misidentified (Barnes and Tuke, 1970). Bradshaw (1968) noted the abundance of simple cone forms in the Fort Peña. She (p. 42) further noted that "The Fort Peña conodonts are considered to be an example of the Ordovician conodont assemblage characteristic of the geosynclinal succession in the Appalachians." Lack of common elements in the two faunas is probably due to difference in age.

The only other well described early to medial Middle Ordovician North American conodont fauna is from the Pratt Ferry Formation of Alabama. Sweet and Bergström (1962) regarded it as early Porterfield, and noted its distinct north European aspect. But owing to wide age difference between this and the Lévis fauna, direct comparisons cannot be made.

On examining the north European elements in our fauna, we note that Lindström's (1960) *Spathognathodus* n. sp. 4 and *Falodus* n. sp. 2, from his fauna V:2, are also present in the Lévis. These were obtained from the Raniceps-Gigas limestones (Arenig-Llanvirn, but which are placed entirely within the lower Llanvirn by Whittington (1968)) and Platyurus limestone (Llanvirn), respectively, of the Isle of Öland in Sweden. Sergeeva (1963) reported *Amorphognathus variabilis* from the Kunda Stage of the Leningrad Oblast. Viira (1967) studied a succession of Ordovician conodonts obtained from the Ohesaare core on the island of Saaremaa in Estonia. In it *Spathognathodus* sp. was reported to occur within the upper half of the B_{III} (Kunda) Stage, and *A. variabilis* to range from the base of B_{III} to the lower part of the C_1b (Lasnamägi) Stage. With the entire Kunda Stage occurring in Estonia tentatively placed in early Llanvirn (Rõõmusoks, 1960), these ranges would be early Llanvirn, and early Llanvirn to early Llandeilo, respectively, in terms of the British classification.

Another European element in the Lévis fauna is a new species of *Pygodus* with two rows of denticles. It fits well into the evolutionary sequence of this genus. Species of lower Llandeilo age from Sweden exhibit three rows of denticles, and a fourth is added in still younger forms (Lindström, 1960; Sweet and Bergström, 1962).

In summary, Raymond's D1 zone of the Lévis Formation contains a conodont fauna that is, in aggregate, of north European aspect. Difficulty is therefore encountered on attempting to correlate it with other North American faunas of similar age, and of mid-continental aspect. Well described North American faunas of similar European aspect, such as the Pratt Ferry fauna, are dissimilar owing to age differences. Correlations with the Baltic–Scandinavian sequences, on the other hand, are more successful. The D1 zone is considered to belong to the upper part of the Kunda Stage ($B_{III}\beta$ and γ), and to Lindström's (1960) fauna V:2 which possibly corresponds to late Arenig to early Llanvirn age in terms of the British sequence.

Systematic Paleontology

Genus *Acontiodus* Pander, 1856

Type species. *Acontiodus latus* Pander, 1856

Acontiodus robustus (Hadding)

Plate XXI, figures 18, 19; Figure 7G

Drepanodus robustus HADDING 1913, p. 31, pl. 1, fig. 5.
Acontiodus robustus, LINDSTRÖM, 1955b, p. 108, pl. 22, figs. 1, 2, 4, 6; FÅHRAEUS, 1966, p. 16, pl. 2, figs. 5a, b, text-figs. 3E, F, G (includes synonymy through 1965).

Remarks. In the very large specimens a secondary pair of carinae occurs at the base and just inside the main postero-lateral carinae. This feature is observed only in large, and hence probably mature, specimens.

Types. Hypotypes, GSC Nos. 24715, 24716.

Acontiodus sp. 1

Plate XXI, figures 1, 2; Figure 7H

Description. Cusp inclined and asymmetrical in cross-section: inner side flat distally, sinuous near base, outer side slightly convex throughout. Anterior edge of cusp sharply keeled, posterior side with central carina flanked by postero-lateral carinae. Lip at the base of outer side upturned, resulting in a small indentation, whereas inner basal margin is even throughout. Junction of "oral edge" (of Lindström, 1964) and the posterior margin of the cusp geniculate, forming an angle of about 45 degrees.

Type. Hypotype, GSC No. 24717.

Acontiodus sp. 2

Plate XXI, figures 4, 5; Figure 7I

Description. Cusp erect and only slightly asymmetrical in cross-section. Both walls of cusp slightly convex. Anterior edge sharply keeled, posterior side with slightly offset central carina, flanked by postero-lateral carinae. Basal cavity shallow. Basal margin upturned at junction of anterior edge, but otherwise even. "Oral edge" slightly broken in the Lévis specimen.

Type. Hypotype, GSC No. 24718.

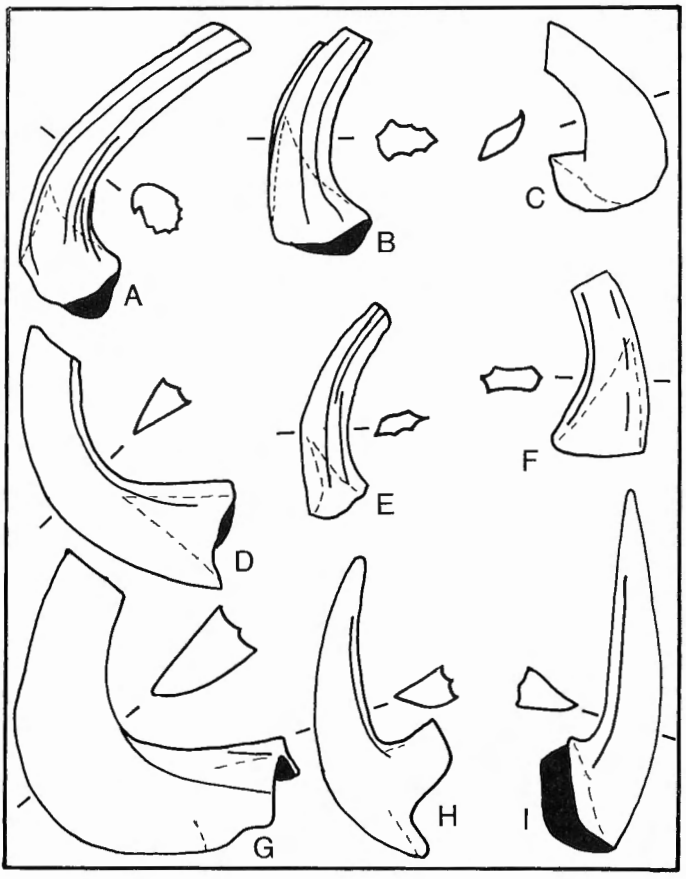


FIGURE 7. Lateral views and transverse sections of Lévis Formation (zone D1) conodonts.

Acontiodus sp. 3

Plate XXI, figures 10, 11; Figure 7D

Description. Cusp erect and symmetrical in cross-section. All carinae sharply edged. Posterior and postero-lateral carinae extending almost to the basal margin. "Oral edge" long, with basal margin at right angles to it. Basal cavity deep, reaching to the end of "oral edge", cone shaped in lateral outline. Basal margin sinuous.

Remarks. This species differs from *Acontiodus robustus* (Hadding) mainly in the outline of the basal margin; it is at right angles to the "oral edge", whereas in *A. robustus* the margin swings downward and anteriorly in a broad sinuous form.

Type. Hypotype, GSC No. 24719.

Genus ***Amorphognathus*** Branson and Mehl, 1933

Type species. *Amorphognathus ordovicica* Branson and Mehl, 1933

Amorphognathus variabilis Sergeeva

Plate XXIV, figures 5, 6

Amorphognathus variabilis SERGEEVA, 1963, pp. 106, 107, pl. 8, figs. 15–17, text-fig. 11; VIIRA, 1967, figs. 3(19a, b).

Remarks. The Lévis specimens exhibit a finely pustulate upper surface which becomes coarser in larger individuals. They also have a more deeply bifurcated lobe, separating the two posterior carinae (side D of Sergeeva, 1963), than those illustrated by Sergeeva from the Leningrad Oblast.

Type. Hypotype, GSC No. 24720.

Genus ***Chosonodina*** Müller, 1964

Type species. *Chosonodina herfurthi* Müller, 1964

Chosonodina has been described from Lower Ordovician strata from South Korea (Müller, 1964) and the West Spring Creek Limestone of Oklahoma (Harris and Harris, 1965). The genus includes palmate, multidenticulate forms with laterally compressed denticles and a narrow, distally widened basal cavity or slit that extends the length of the curved basal margin.

Chosonodina n. sp. 1

Plate XXIV, figures 15, 16

Diagnosis. A slightly asymmetrical, bowed, *Chosonodina* bearing single petaloid cusp above crescentic basal margin. Basal cavity slit-like, extending throughout margin, constricted at centre.

Description. Unit bowed (concavo-convex), laterally compressed and slightly asymmetrical. Single cusp large and petaloid with a central growth axis within thin, translucent, sheath material. Basal region with a crescentic margin extending distally to produce two denticle-like points flanking the base of the cusp. Basal cavity slit-like, running the length of the margin, slightly constricted at centre, widening distally and abruptly closing at the ends.

Remarks. Similar palmate conodonts have been referred to *Leptochirognathus* and *Rhipidognathus* and both Müller (1964) and Harris and Harris (1965) have noted the distinguishing characteristics.

Type. Hypotype, GSC No. 24721.

Cordylodus spinatus (Hadding)

Plate XXIV, figures 7–11

Polygnathus spinatus HADDING 1913, p. 32, pl. 1, fig. 8; FAY, 1952, p. 160.
Cordylodus spinatus, LINDSTRÖM, 1955b, pl. 22, figs. 5, 18, 27; SWEET and BERGSTRÖM, 1962, pp. 1225, 1226, pl. 170, fig. 12, pl. 171, fig. 13 (includes synonymy through 1961); LINDSTRÖM, 1964, p. 84, figs. 27A–D.

Remarks. The Lévis specimens possess widely spaced denticles posterior to the main cusp which has a limited basal extension. The denticles in some specimens are off-set and do not lie in one plane, a feature noted by Sweet and Bergström (1962, p. 1225)

in their Pratt Ferry Formation conodonts. Although most specimens are fragmentary, none possesses a pronounced anticusp, characteristic of *C. ramosus* Hadding. Lindström (1964, p. 84) regarded *C. spinatus* and *C. ramosus* as conspecific.

Lindström (ibid., figs. 27A–D) illustrated a transition series for *C. spinatus* in which cordylodus through ligonodina to hibbardella (roundya) elements are present. This series was found in specimens from the Winkston Limestone (Middle Ordovician) of Scotland. The Lévis specimens include representatives of the cordylodus and ligonodina stages (cf. Lindström, 1964, figs. 27A, B). The symmetrical hibbardella (roundya) stage is not represented but a form not illustrated by Lindström is present. In this, the specimens have a denticulate posterior bar with a lateral denticle posterior to the main cusp (ligonodina-type) and, in addition, one or two lateral denticles on the other side of the element. These are either immediately lateral to, or anterior to, the main cusp producing an asymmetrical unit of cladognathodus type. Thus, in *C. spinatus* there appear to be four rather than three main components of the transition series, comparable to the four within *Periodon flabellum* (Lindström) (*see* Lindström, 1964, figs. 28A–D and remarks below under *P. flabellum*).

Types. Hypotypes, GSC Nos. 24722–24726.

Genus *Drepanodus* Pander, 1856

Type species. *Drepanodus arcuatus* Pander, 1856

Drepanodus homocurvatus Lindström
Plate XXI, figure 9

Oistodus curvatus BRANSON and MEHL, 1933, pp. 110, 111, pl. 9, figs. 4, 10, 12; FAY, 1952, p. 134.
Drepanodus homocurvatus LINDSTRÖM, 1955a, p. 563, pl. 2, figs. 23, 24, 39, text-fig. 4d; BARNES and TUKE, 1970, p. 85, pl. XIX, figs. 14, 15 (includes synonymy through 1968).
Drepanodus sp. cf. *D. homocurvatus,* SCHOPF, 1966, p. 55, pl. 5, figs. 11, 14, 15.

Remarks. D. homocurvatus, a common species throughout the Ordovician, is rare in the Lévis material.

Type. Hypotype, GSC No. 24727.

Drepanodus suberectus (Branson and Mehl)
Plate XXI, figure 15

Oistodus suberectus BRANSON and MEHL, 1933, p. 111, pl. 9, fig. 7; FAY, 1952, p. 136.
Drepanodus suberectus, LINDSTRÖM, 1955a, p. 568, pl. 2, figs. 21, 22; SWEET and BERGSTRÖM, 1962, p. 1226, pl. 169, fig. 8 (includes synonymy through 1961); BERGSTRÖM, 1964, p. 24; ETHINGTON and CLARK, 1964, pp. 689, 690, pl. 113, fig. 18; BARNETT, 1965, p. 70, pl. 1, fig. 29, pl. 2, fig. 22; BERGSTRÖM and SWEET, 1966, pp. 330–333, pl. 35, figs. 22, 23; FÄHRAEUS, 1966, p. 23, pl. 2, fig. 10, text-fig. 2D; HAMAR, 1966, p. 58, pl. 1, figs. 8, 9; OBERG, 1966, pp. 137, 138, pl. 16, fig. 1; SCHOPF, 1966, pp. 54, 55, pl. 5, fig. 25; WEBERS, 1966, pp. 29, 30, pl. 6, fig. 9.

Remarks. Some specimens in the Lévis material show minor differences to typical *D. suberectus.* These forms do not have a flared basal rim, the whole unit being laterally compressed; they are also slightly wider towards the base.

Type. Hypotype, GSC No. 24728.

Genus *Eoligonodina* Branson, Mehl, and Branson, 1951

Type species. *Eoligonodina robusta* Branson, Mehl, and Branson, 1951

"Eoligonodina" sp.

Plate XXIV, figure 14

Remarks. A single "fibrous" conodont is a homeomorph of the genus *Eoligonodina*. The unit possesses a prominent cusp, a denticulate posterior process and a denticulate, downward-directed, lateral process that is an extension of the anterior margin of the main cusp. Sweet and Bergström (1962, Pl. 169, fig. 5) have also recorded a "fibrous" *"Eoligonodina."*

Type. Figured specimen, GSC No. 24770.

Genus *Falodus* Lindström, 1955

Type species. *Oistodus prodentatus* Graves and Ellison, 1941

Falodus prodentatus (Graves and Ellison)

Plate XXII, figures 8, 14, 18

Oistodus prodentatus GRAVES and ELLISON, 1941, pp. 13, 14, pl. 2, figs. 6, 22, 23, 28.
Falodus prodentatus, SWEET and BERGSTRÖM, 1962, pp. 1227–1229, pl. 170, figs. 2, 3, text-fig. 2B (includes synonymy through 1961); HAMAR, 1964, p. 265, pl. 4, fig. 10, text-fig. 4(18); ETHINGTON and CLARK, 1965, pp. 192, 193, pl. 1, fig. 16; HAMAR, 1966, p. 60, pl. 5, fig. 15, text-fig. 3(7b).

Remarks. Graves and Ellison (1941) included in their initial concept of this species two basically different forms: one with anterior denticle(s) developed on the main cusp, or crowded close to it (ibid., pl. 2, figs. 6, 23, 28), and the other with denticles on a posterior process developed as an extension of the base (ibid., pl. 2, fig. 22). The Lévis material contains both these forms, and are similarly considered herein as intraspecific variants.

Types. Hypotypes, GSC Nos. 24729–24731.

Falodus sp.

Plate XXII, figure 15

?*Falodus* n. sp. 2 LINDSTRÖM, 1960, fig. 5(17).

Description. Cusp reclined, slightly twisted inward, wide, laterally compressed, and with sharp posterior and anterior edges. Basal margin sinuous. Base widely flaring, widest near midpoint and tapering rapidly to either end. A small denticle at the base on the anterior edge of the cusp.

Remarks. This form differs from *Falodus prodentatus* (Graves and Ellison) in having a larger basal cavity with broadly and evenly flaring sides. It differs from *"F. prodentatus"* from the Upper (?) Ordovician Galena Formation of Iowa (Ethington, 1959) in possessing a basal margin that is sinuous, and not straight. A form that is most similar to the Lévis species was illustrated by Lindström (1960), from the Llanvirnian Platyurus limestone of Sweden.

Type. Figured specimen, GSC No. 24732.

Genus *Hibbardella* Bassler, 1925

Type species. *Prioniodus angulatus* Hinde, 1879

Hibbardella sp.
Plate XXII, figures 21, 22

Description. Symmetrical units comprising a prominent recurved cusp, one posterior and two lateral denticulate processes. Cusp with a broad, rounded anterior side, a keeled posterior margin, and two postero-lateral costae extending down into the lateral processes. Posterior process prominent, deep, bearing small, discrete denticles. Lateral processes are smaller than the posterior, but all specimens with incomplete processes. Basal cavity wide but relatively shallow.

Remarks. The postero-lateral costae, prominent posterior process, and small lateral processes characterize this group that has been assigned to *Hibbardella*. Huddle (1968, p. 13), following re-examination of *H. angulata,* regarded *Roundya* as an invalid generic name and that specimens with a symmetrical anterior arch, denticulated posterior bar, and large basal cavity should be brought to *Hibbardella*. The Lévis specimens appear to represent a new species but they are too incomplete for such assignment.

Types. Figured specimens, GSC Nos. 24733, 24734.

Genus *Oistodus* Pander, 1856

Type species. *Oistodus lanceolatus* Pander, 1856

Oistodus sp. cf. *O. abundans* Branson and Mehl
Plate XXII, figure 13

cf. *Oistodus abundans* BRANSON and MEHL, 1933, p. 109, pl. 9, figs. 11, 17.

Remarks. Schopf (1966, pp. 59, 60) included an extensive synonymy and discussion of *O. abundans*. The few Lévis specimens referred to this species are similar to *O. abundans* but generally have a shorter cusp, smaller basal cavity, and a smaller posterior extension of the base. But the inner lateral expansion of the base, the antero-basal angle of approximately 60 degrees, and the reclined cusp that typify *O. abundans* are all present. All the specimens are small.

Type. Figured specimen, GSC No. 24735.

Oistodus inclinatus Branson and Mehl
Plate XXI, figure 8

Oistodus inclinatus BRANSON and MEHL, 1933, p. 110, pl. 9, fig. 8; SCHOPF, 1966, pp. 60, 61, pl. 5, fig. 10 (includes synonymy through 1965); OBERG, 1966, p. 139, pl. 15, fig. 3.
?*Oistodus inclinatus,* FÄHRAEUS, p. 24, pl. 3, fig. 2, text-fig. 2G.
Oistodus excelsus Stauffer, OBERG, 1966, p. 139, pl. 15, fig. 2; HAMAR, 1966, p. 63, pl. 2, fig. 14, text-fig. 2(6).

Remarks. All Lévis specimens referred to *O. inclinatus* have broken cusps, but the characteristic basal part leaves no doubt as to their specific identity. We agree with Schopf (1966) that *O. inclinatus* and *O. excelsus* are conspecific.

Type. Hypotype, GSC No. 24736.

Oistodus multicorrugatus Harris

Plate XXI, figure 3

Oistodus multicorrugatus HARRIS, 1962, p. 204, pl. 1, figs. 2a–c; MOUND, 1965a, p. 29, pl. 3, figs. 31, 34, 35, pl. 4, fig. 2.

Remarks. Specimens belonging to *O. multicorrugatus* conform closest to those described by Mound (1965a) from the Joins Formation of Oklahoma; the sinuous basal margin is not present. Two specimens of similar form, without the corrugated surfaces, are present and resemble *O. pseudomulticorrugatus* Mound but they are fragmentary and are not included in the identifiable material.

Type. Hypotype, GSC No. 24737.

Oistodus venustus Stauffer

Plate XXI, figures 6, 7

Oistodus venustus STAUFFER, 1935, pp. 146, 159, pl. 12, fig. 12; BERGSTRÖM and SWEET, 1966, pp. 341, 342, pl. 35, figs. 20, 21 (includes synonymy through 1966).

Remarks. Most specimens of *O. venustus* are fragmentary, the cusp being commonly broken. In many, the anterior margin is more pointed (cf. Bergström and Sweet, 1966, pl. 35, figs. 20, 21) than the rather square form of the hypotypes illustrated. The latter variants are fairly close to *O. parallelus* Pander.

Types. Hypotypes, GSC Nos. 24738, 24739.

Oistodus? sp.

Plate XXII, figures 19, 20

Description. Simple cone with prominent reclined cusp. Cusp twisted, with sharp posterior and anterior margin, the latter slightly keeled. Both faces with two sharp, but low, costae near the centre, starting just above the basal region and extending the length of the cusp. Posterior margin curved in drepanodus form. Antero-basal margin also curved and basal cavity not extending anteriorly along the whole basal margin. Cavity widening markedly posteriorly, and relatively shallow with the apex lying near but below the point of maximum curvature of the posterior margin.

Cusp, in addition to being twisted, deflected inwards slightly. Costae on outer lateral face more pronounced than those on inner lateral face. Entire basal margin curved.

Remarks. The specimen grossly resembles *Oistodus*? n. sp. of Sweet and Bergström (1962) from the Pratt Ferry Formation of Alabama. The latter, however, exhibits smooth lateral faces, a more extended posterior portion of the base, and an antero-basal angle of 90 degrees. The Lévis specimen does not fit into any recognized conodont form-genus. The sharp and keeled posterior and anterior margins exclude the species from *Scolopodus*. Sweet and Bergström (1962, pp. 1232, 1233) noted that their specimens are transitional between *Drepanodus* and *Oistodus*. The presence of lateral costae is more common in *Oistodus* than *Drepanodus* and hence the Lévis specimen is referred, with question, to *Oistodus*.

Type. Figured specimen, GSC No. 24740.

Genus *Paltodus* Pander

Type species. *Paltodus subaequalis* Pander, 1856

Paltodus sp.

Plate XXI, figures 12, 13; Figure 7E

Description. Cusp asymmetrical, with inner side bearing three distinct costae, two extending to mid-height and one starting at mid-height, between lower two, and extending to tip of cusp. Outer side with a costa extending only to mid-height of cusp, and posterior one quarter flat, offset by a distinct costa extending the full cusp length.

Base indistinct. Basal margin at right angles to posterior and anterior margins. Basal cavity deep, conical, with sharp apex near anterior margin.

Type. Figured specimen, GSC No. 24741.

Genus *Panderodus* Ethington, 1959

Type species. *Paltodus unicostatus* Branson and Mehl, 1933

Panderodus n. sp. 1

Plate XXI, figures 14, 16; Figure 7F

Diagnosis. A *Panderodus* with sharp posterior and anterior margins, two rounded lateral carinae symmetrically placed behind anterior margin, and two lateral costae close to posterior margin. The latter two costae of unequal size and slightly asymmetrically placed with respect to posterior margin. Cusp relatively broad and compressed.

Description. Cusp gently recurved, relatively broad, showing slight lateral compression. Basal cavity conical, reaching to approximately mid-height, with apex of cavity lying close to anterior margin. Anterior margin sharp, with cusp thickening rapidly away from it to two rounded carinae symmetrically or slightly asymmetrically disposed to the margin. Cusp thin in central region forming a wide shallow trough. Cusp thickening again posteriorly forming two sharp costae, lying close to sharp posterior margin. These lateral costae slightly asymmetrically disposed about the posterior margin and one slightly larger and projecting a little farther posteriorly.

Remarks. Several specimens are assigned to this new species, but in all the tip is missing. The slender narrow form, the deep basal cavity, and the asymmetry of the lateral costae are typical of representatives of *Panderodus*. These specimens are more symmetrical than most of those referred to this genus, and although there are several ill-defined species within it, these specimens clearly belong to a new species.

Types. Hypotypes, GSC Nos. 24742, 24743.

Genus *Periodon* Hadding, 1913

Type species. *Periodon aculeatus* Hadding, 1913

Periodon aculeatus Hadding

Plate XXIII, figures 1–7

Periodon aculeatus HADDING, 1913, p. 33, pl. 1, fig. 14; SWEET and BERGSTRÖM, 1962, p. 1235, pl. 171, figs. 3, 9 (includes synonymy through 1961); HAMAR, 1964, p. 274, pl. 3, figs. 17, 21; LINDSTRÖM, 1964, fig. 28 E–G; ETHINGTON and CLARK, 1965, p. 198, pl. 2, fig. 10; SCHOPF, 1966, pp. 67, 68, pl. 3, figs. 10, 12–14, 16; WEBERS, 1966, pp. 57, 58, pl. 12, fig. 16.

Remarks. Lindström (1964, fig. 28) illustrated the transition series within *P. aculeatus* and *P. flabellum* (Lindström). These two species are closely comparable, the latter generally possessing a larger main cusp, fewer and larger denticles on the posterior process between the cusp and the largest denticle, and a deeper and wider basal cavity.

Within the Lévis specimens referable to *P. aculeatus* a wide variation exists, particularly with respect to the development of denticles on the anterior costa or process. Cordylodus-like elements are present with small "germ" denticles on the straight or slightly laterally flexed anterior margin or costa. In some forms, larger denticles emerge at right angles to the plane of the posterior process. This is transitional to the ligonodina-like group in which the denticles are developed on a distinct lateral process directed laterally and downwards. In a further group, this well developed denticulated lateral process is directed downwards and backwards. No hibbardella (roundya)-like specimens are present with two denticulated lateral processes.

The specimens commonly possess five to eight small denticles between the main cusp and the largest denticle on the posterior process. The posterior process is bowed, sinuous, or laterally flexed.

Types. Hypotypes, GSC Nos. 24744–24749.

Periodon flabellum (Lindström)

Plate XXIII, figures 10, 15

Trichonodella flabellum LINDSTRÖM, 1955a, pp. 599, 600, pl. 6, figs. 28–30; ETHINGTON and CLARK, 1965, p. 202, pl. 1, fig. 9; VIIRA, 1967, fig. 1(1a, b).
Prioniodina? *deflexa* LINDSTRÖM, 1955a, p. 586, pl. 6, figs. 31–35; LINDSTRÖM, 1960, fig. 2(5).
Periodon flabellum LINDSTRÖM, 1964, figs. 28A–D.
?*Prioniodina inflata* Lindström, VIIRA, 1967, figs. 1(2a, b).

Remarks. Most of the specimens referable to this species are of the cordylodus-like variety (Lindström, 1964, fig. 28A) and possess a large erect cusp.

Types. Hypotypes, GSC Nos. 24750, 24751.

Genus ***Polycaulodus*** Branson and Mehl, 1933

Type species. *Polycaulodus inclinatus* Branson and Mehl, 1933

Polycaulodus sp.

Plate XXI, figure 17

Description. Base flat, slightly arched, widest in the centre, and tapering towards the ends. Upper surface bearing five long slender denticles, round in cross-section with small, sharp, anterior and posterior keels. First four denticles progressively increasing in size posteriorly; the fifth broken but probably was smaller than the fourth denticle. All denticles rising erect from the base but terminally recurved laterally.

Remarks. Our single specimen, a "fibrous" form, does not have a markedly arched base and hence is excluded from *Curtognathus,* although the laterally curved denticles are not typical of *Polycaulodus.* The denticle pattern is similar to specimens of *Polycaulodus* found in the Wilderness Stage of mid-continental North America, these being a variant of *P. tridentatus* Branson and Mehl. However, in our specimen the denticles are much longer and are laterally recurved.

Type. Figured specimen, GSC No. 24771.

Genus *Prioniodina* Bassler, 1925

Type species. *Prioniodina subcurvata* Ulrich and Bassler, 1926

Prioniodina macrodentata (Graves and Ellison)

Plate XXIII, figures 12, 16

Ozarkodina macrodentata GRAVES and ELLISON, 1941, p. 14, pl. 2, figs. 33, 35, 36; FAY, 1952, p. 138.

Prioniodina macrodentata SWEET, *et al.*, 1959, p. 1060; SWEET and BERGSTRÖM, 1962, p. 1240, pl. 171, figs. 7, 8 (includes synonymy through 1961); HAMAR, 1964, p. 278, pl. 3, fig. 28, text-fig. 4(19); LINDSTRÖM, 1964, p. 85, fig. 30D; SCHOPF, 1966, pp. 70, 71, pl. 4, figs. 27, 28; SWEET and BERGSTRÖM, 1966, p. 152, pl. 18, fig. 9, text-figs. 1A, F.

Remarks. Specimens referred to *P. macrodentata* are fairly uniform in character. Minor variations exist in the relative size of the main cusp and in the degree of inward flexure of the anterior bar.

Types. Hypotypes, GSC Nos. 24752, 24753.

Prioniodina? n. sp.

Plate XXIII, figures 9, 11, 14

Diagnosis. Cusp large, recurved, sharply pointed, subcircular to lenticular in cross-section with sharp anterior and posterior keels. Cusp twisted, posterior margin running into denticulate posterior process and anterior margin passing into anterior to antero-lateral denticulate process.

Description. Cusp large, recurved, sharply pointed with subcircular cross-section near the base becoming more compressed distally. Both anterior and posterior margins of cusp sharp and keeled, especially the anterior, with both margins passing into the processes. Posterior process straight, bearing relatively small, discrete denticles. Anterior process with similar denticles, but not in the same plane as the posterior process owing to twisting of cusp. Conical basal cavity relatively deep, enclosed by sides extending to both processes.

Remarks. Several large, robust specimens, not apparently "fibrous" in nature, are questionably referred to a new species of *Prioniodina.*

In addition to the above features, one specimen (Pl. XXIII, fig. 14) bears four costae rising from the inner basal margin and extending part way up the cusp. Another specimen (Pl. XXIII, fig. 9) lacks a posterior process, but is similar in all other respects and may be part of a transition series within this group.

The large cusp and straight posterior process suggest that the specimens may belong in *Eoligonodina* but the angle between the two processes is too great. Mound

(1965b) described a new genus *Eoneoprioniodus* that superficially resembles the Lévis specimens. However, the latter do not have the flap-like downward extensions of the basal sheath, and most have two denticulated processes of similar size.

Types. Figured specimens, GSC Nos. 24754–24756.

Genus *Prioniodus* Pander, 1856

Types species. *Prioniodus elegans* Pander, 1856

Prioniodus sp. aff. *P. evae* Lindström

Plate XXIII, figures 8, 13; Plate XXIV, figure 18

aff. *Prioniodus evae* LINDSTRÖM, 1955a, pp. 589, 590, pl. 6, figs. 4–10.
cf. *Prioniodus evae,* MOUND, 1965a, pp. 32, 33, pl. 4, figs. 17, 18.

Description. Cusp large, erect to slightly recurved, with three sharp, well defined, keels passing into anterior, posterior, and lateral processes. All processes with relatively short, discrete denticles, those on the anterior process appreciably smaller than those on the other two processes. Anterior process a downward and slightly anterior extension of the main cusp. Basal cavity deep, extending into the initial portions of the processes, and defined by prominent sheath material.

Remarks. Mound (1965a) described similar specimens from the Joins Formation of Oklahoma, but they differ in having a biconvex, carinate cusp and poorly developed denticulation. Mound noted that the Joins specimens were most similar to the specimen in Plate 6, figure 7 of Lindström (1955a). Lindström's remaining illustrations of this species and those of Wolska (1961, pl. 5, figs. 1a, b) are significantly different and possess deep, well denticulated, blade-like processes. The Lévis material is probably a new species of *Prioniodus* similar to *P. evae* and perhaps conspecific with the Joins specimens.

Types. Figured specimens, GSC Nos. 24757–24759.

Genus *Pygodus* Lamont and Lindström, 1957

Type species. *Pygodus anserinus* Lamont and Lindström, 1957

Pygodus n. sp. 1

Plate XXIV, figures 1, 2

Diagnosis. A *Pygodus* with upper surface bearing two high ridges capped by indistinct nodes. Ridges running anteriorly from postero-lateral corners to merge at a point approximately two thirds distance to anterior tip; from that point a single ridge continuing toward cusp.

Description. Upper surface essentially flat with a roughly triangular shape, outer lateral margin being somewhat irregular. Upper surface with two prominent ridges, both terminating at postero-lateral corners and extending subparallel to lateral margins, to a junction approximately two thirds the distance to the anterior end. Angle formed at junction 50 degrees, with a single ridge extending from this point anteriorly. Ridges high, sharply crested, largely with a serrated edge but with distinct small

nodes appearing towards posterior extremities. Ridges far more prominent than those on all other described specimens of *Pygodus*. No evidence of transverse ridges observed, although upper surface partly obscured by quartz grains.

Under surface broadly excavated, enclosed by steep margins or sides of downward-directed upper surface. Height of these margins increasing anteriorly, with that of the inner lateral margin of greater size. Anterior tip, including cusp, missing on the damaged specimen, but anterior region more elongate and funnel-like than the V-shaped closure of *P. anserinus* Lamont and Lindström.

Remarks. Sweet and Bergström (1962, p. 1242) noted that the earliest *Pygodus* known was from the lower Llandeilian of Sweden. Within the lower Middle Ordovician, the earliest forms have only three denticle rows and a fourth row is added in younger forms (Lindström, 1960, p. 91; Sweet and Bergström, 1962, p. 1242). The Lévis *Pygodus* with two rows, from appreciably older (Llanvirnian) strata, thus fits well into the evolutionary sequence of this genus. In the Llandeilian, *Pygodus anserinus* is invariably found with *Haddingodus serra* and *Periodon aculeatus* (Lindström, 1964, p. 40) and it is noteworthy that although *Periodon aculeatus* is common in the Lévis fauna, no representatives of *Haddingodus* have been found.

Type. Hypotype, GSC No. 24760.

Pygodus sp.

Plate XXIV, figures 3, 4

Description. Unit triangular in outline with slightly outwardly bowed outer margin and straight inner margin. Upper surface gently domed and smooth, excepting for faint ridge along either margin where the surface directed downward. Under surface broadly excavated, deepest at the anterior end and along steep edge of outer margin. Cusp not well defined and may be broken at tip.

Remarks. A single, poorly preserved, specimen closely conforms to the general form of *P. anserinus* Lamont and Lindström but lacks the distinctive ornamentation of the upper surface.

Type. Figured specimen, GSC No. 24761.

Genus ***Scandodus*** Lindström, 1955

Type species. *Scandodus furnishi* Lindström, 1955

Scandodus pipa Lindström

Plate XXII, figures 6, 7; Figure 7C

Scandodus pipa LINDSTRÖM, 1955a, p. 593, pl. 4, figs. 38–42, text-fig. 3P; FÅHRAEUS, 1966, p. 30, pl. 3, fig. 13, text-fig. 2I.
?*Scandodus pipa,* ETHINGTON and CLARK, 1964, p. 698, pl. 114, fig. 8.

Remarks. The Lévis specimens exhibit a rounded antero-basal margin, similar to that illustrated by Lindström (1955a, pl. 4, fig. 38).

The El Paso specimen resembles *Drepanodus gracilis* (Branson and Mehl), excepting for the inner face of the cusp which has a median longitudinal carina, flanked by marginal linear concavities (Ethington and Clark, 1964, p. 698). An important generic characteristic of *Scandodus,* however, is the basal cavity that

opens slightly laterally (Lindström, 1964, p. 138). Consequently, it is perhaps better to retain such a form, as exemplified by the El Paso specimen, within the concept of *Drepanodus*.

Type. Hypotype, GSC No. 24762.

Genus *Scolopodus* Pander, 1856

Type species. *Scolopodus sublaevis* Pander, 1856

Scolopodus gracilis Ethington and Clark, 1964

Plate XXII, figures 9, 10

Scolopodus gracilis ETHINGTON and CLARK, 1964, p. 699, pl. 115, figs. 2–4, 8, 9, text-figs. 2D, G; BARNES AND TUKE, 1970, p. 92, pl. xviii, figs. 11, 12, text-fig. 6E (includes synonymy through 1968).

Remarks. The Lévis specimens differ slightly from those reported from the El Paso Formation by Ethington and Clark (1964) in exhibiting a more triangular shaped cross-section of the cusp at its mid-height. The specimen illustrated herein further exhibits a posterior groove which is deepest and widest near the midlength of the cone, becoming narrower and shallower near the distal end and also near the basal margin. The posterior side is slightly flattened and the anterior side gently pointed.

This species has been previously reported from older strata: the El Paso Formation of Texas, Mons and Sarbach Formations of the Columbia Ice Fields section of Alberta, St. George Formation of Newfoundland, and the West Spring Creek Limestone of Oklahoma. Although the drawing of any conclusion from only a few specimens is hazardous, the Lévis individuals may represent a later phylogenetic stage of this species.

Type. Hypotype, GSC No. 24763.

Scolopodus n. sp. 1

Plate XXII, figures 1, 2; Figure 7B

Description. Unit symmetrical with erect cusp. Cusp with six coarse, distinct costae extending the entire length of the unit. Posterior margin sharply keeled, and each lateral side with three costae, equally spaced and symmetrically arranged. Anterior margin weakly keeled. Basal part of the unit inflated, with greater expansion posteriorly. Basal outline circular.

Remarks. Because we have only a few specimens of this undescribed species, it is not formally named.

Type. Hypotype, GSC No. 24764.

Scolopodus n. sp. 2

Plate XXII, figures 3–5; Figure 7A

Diagnosis. An asymmetrical *Scolopodus* with base slightly bent laterally. Outer side of cusp with an extremely deep groove parallel and close to anterior edge. Cusp multicostate basally on posterior side, with several of the smaller lower costae disappearing distally. Anterior half of inner side smooth.

Description. Unit highly asymmetrical; base twisted, with basal cavity therefore opening slightly laterally. Outer side of cusp with an extremely deep groove parallel to and near the anterior edge. Posterior side of cusp rounded, multicostate basally, with many of the smaller, lower costae disappearing distally at midlength; near the apex only four or five coarse costae present. Anterior half of inner side of cusp gently convex. Anterior side of cusp bluntly rounded.

Upper margin of base forming a smooth curve with the posterior cusp margin. Cusp erect, at right angles to the basal upper margin. Antero-basal margin rounded.

Basal cavity relatively shallow and conical in shape.

Remarks. Following Sweet and Bergström (1962, pp. 1246, 1247), we are including some asymmetrical forms, such as the present species, in *Scolopodus*.

Types. Hypotypes, GSC Nos. 24765, 24766.

Genus *Spathognathodus* Branson and Mehl, 1941

Type species. *Spathodus primus* Branson and Mehl, 1933

Spathognathodus sp.

Plate XXIV, figures 12, 13

Spathognathodus n. sp. 4, LINDSTRÖM, 1960, fig. 5(3).

Description. Blade unarched but laterally twisted. Denticles fused excepting their apices; erect anteriorly, but the main cusp and those posterior to it slightly inclined; two or three small denticles at extreme anterior end, but the five or six between these and the main cusp of about equal size and height, and the four or five posterior to the main cusp progressively smaller to the terminus. Lateral sides of the blade slightly inflated, and marked by a sharp and distinct infolded flange at the base on either side. Basal flanges flat except for a small swelling, more accentuated on one side than the other, immediately anterior of the base of the main cusp, at the site of the basal cavity.

Remarks. The Lévis specimens bear close resemblance to an illustrated, but undescribed, form given by Lindström (1960). This form, designated as *Spathognathodus* n. sp. 4, was reported from the Arenigian(?) Obtusicauda-Gigas limestones of Sweden.

Ethington and Clark (1965) reported one specimen from the Skoki Formation of the Columbia Ice Fields section in Alberta, which they questionably compared with Lindström's (1960) form. Owing to the extremely fragmentary nature of the Alberta specimen, it is difficult to make direct comparisons with the Lévis individuals.

Type. Figured specimen, GSC No. 24767.

Genus *Trichonodella* Branson and Mehl, 1948

Type species. *Trichognathus primus* Branson and Mehl, 1933

Trichonodella n. sp. 1

Plate XXIV, figures 19, 20

Description. Cusp erect to midlength and only slightly curved distally. Basal part of the cusp highly inflated. Lateral and posterior processes high, sharply edged, and non-denticulate. Basal cavity wide and deep, with thin basal sheath. Unit shield-shaped in transverse section at base with rounded anterior margin.

Remarks. The Alberta specimen referred to as *Acontiodus* n. sp. by Ethington and Clark (1965, pp. 188, 189, pl. 1, fig. 14) has superficial resemblance to the Lévis individuals. However, the former exhibits triangular base in section, and has no distinct processes.

The present specimens are regarded as a *Trichonodella* with non-denticulate lateral processes rather than as an *Acontiodus*. The distinct processes rather than carinae, exhibited by one of the Lévis specimens, suggest this assignment.

Type. Hypotype, GSC No. 24768.

Conodont gen. et sp. indet.
Plate XXII, figures 11, 12

Description. Unit with an erect main cusp and three small denticles posterior to it surmounted on a large inflated basal region.

Basal cavity deep, with its upper surface horizontal and its apex lying close to the anterior margin. Anterior margin of unit directed downwards and posteriorly from a point just below the apex of basal cavity. One side of unit flat; on the other, the upper portion of basal margin swelled outward producing marked asymmetry and a rounded ridge on the upper posterior portion of the basal region.

Remarks. The main cusp is broken and the posterior denticles may have been part of a posterior process. The distinctive form cannot be assigned to any established taxon.

Type. Figured specimen, GSC No. 24769.

Appendix

Lévis Boulder Fauna

Within the Lévis Formation, there are many conglomeratic units, commonly of limited lateral extent. Fossils from some of the contained boulders are of Lower, Middle, and Upper Cambrian, and Lower Ordovician ages (Osborne, 1956, p. 184). Two thin conglomerate units are present in the Côte Fréchette section (Table II). These were not sampled. However, to determine what conodonts may be present in the zone D1 conglomerates, those exposed on Montcalm St., Lévis (locality S of Clark, 1924, 1926) were sampled. The few conglomeratic units exposed were each sampled with collections being from the boulders, not the matrix, although small amounts of matrix may have been incorporated. At this road-cut, shale is exposed above and below the conglomeratic interval and the four units have sharp contacts with one another. The following meagre conodont faunas were retrieved. Figures in brackets indicate number of specimens obtained.

First (lowest) conglomeratic unit; 0–12 ft.; GSC loc. 83353; large boulders; sample weight 2.5 kg.

Drepanodus suberectus (Branson and Mehl) (2)
Falodus prodentatus (Graves and Ellison) (1)

Second conglomeratic unit; 12–18 ft.; GSC loc. 83354; small, predominantly limestone, pebbles; samples weight 1.8 kg.

Drepanodus homocurvatus Lindström (1)
Falodus prodentatus (Graves and Ellison) (1)
Periodon aculeatus Hadding (3)
Conodont undet. (3)

P. aculeatus (Pl. XXIV, figs. 21, 22) includes symmetrical forms with undenticulate lateral processes or flanges directed posteriorly to form a broadly rounded anterior margin. These approximate to the hibbardella (roundya)-like elements in the *P. aculeatus* transition series as illustrated by Lindström (1964, fig. 28 G), but which was the only type absent from the Lévis collection. Conodont undet. (Pl. XXII, figs. 16, 17) is a simple cone with deep basal cavity which possesses a prominent lateral flange or keel developed at the anterior margin and producing an asymmetrical form.

Third conglomeratic unit; 18–23.5 ft.; GSC loc. 83355; large boulders; sample weight 2.4 kg.

Acodus sp. (3)
Falodus prodentatus (Graves and Ellison) (1)
Oistodus lanceolatus Pander (1)
Paltodus sp. (1)
Panderodus sp. (1)
Periodon aculeatus Hadding (6)
Prioniodina macrodentata (Graves and Ellison) (1)

New forms in this sample are *Acodus* sp. (Pl. XXIV, fig. 17), which is a robust form with a small basal cavity and triangular midheight cross-section, and *O. lanceolatus* (Pl. XXIV, figs. 23, 24).

Fourth (top) conglomeratic unit; 23.5–26.5 ft.; GSC loc. 83356; graded, mostly small pebbles; sample weight 2.4 kg.

Acontiodus robustus (Hadding) (1)
Falodus prodentatus (Graves and Ellison) (1)
Periodon aculeatus Hadding (4)
Scolopodus n. sp. 1 (1)

Clark (1926) showed that these conglomeratic units belong to zone D1 of Raymond, i.e., the same interval that includes the Côte Fréchette section. The fauna from the conglomerates is small, and most species are common to the Côte Fréchette collection. Additional species are *Acodus* sp., *Oistodus lanceolatus, Panderodus* sp., and conodont undet. *O. lanceolatus* is common in strata of Arenig age.

The data on sample weight and numbers of specimens presented in Table II indicate the relative paucity of conodonts in the Côte Fréchette section. Consequently, we doubt that the specimens above all came from the small amount of matrix that may have been attached to the boulders sampled. The faunas from the conglomerates at the Montcalm St. locality indicate that the boulders yielding conodonts are mostly of similar age to the bedded limestones of the same interval with perhaps some of Arenig age. Middle and Upper Cambrian limestone boulders sampled elsewhere in the Lévis Formation yielded no conodonts, hence the results do not exclude Cambrian boulders from being present.

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PLATES I to XXIV

PLATE I

Zygobursa praecursor n. sp. (PAGE 6)

Road cut, north bank of Jupiter River, Anticosti Island, Quebec, at Twenty-four Mile Lodge, GSC loc. 76279. Becscie Formation.

Figure 1. Left lateral view of a male carapace, x25. Holotype, GSC No. 24386.

Figure 2. Dorsal view of a male carapace, x25. Paratype, GSC No. 24387.

Figure 3. Ventral view of a male carapace, x20. Paratype, GSC No. 24388.

Figure 4. Right lateral view of a male carapace, x25. Paratype, GSC No. 24389.

Figure 5. Left lateral view of a female carapace, x26. Paratype, GSC No. 24390.

Figure 9. Left lateral view of a male carapace, x22. Paratype, GSC No. 24394.

Rivière-a-la-Loutre Road, a quarter of a mile north of the junction of Wilson Pool Road, Anticosti Island, Quebec, GSC loc. 62162. Becscie Formation.

Figure 6. Ventral view of a female carapace, x21. Paratype, GSC No. 24391.

Figure 7. Dorsal view of a female carapace, x19. Paratype, GSC No. 24392.

Figure 8. Right lateral view of a female valve, x20. Paratype, GSC No. 24393.

Figures 10, 11. Left lateral views of two female valves, x20. Paratypes, GSC Nos. 24395, 24396.

Zygocosta williamsi (Ulrich and Bassler) (PAGE 4)

North shore of bay west of Rocky Bay, Bruce Peninsula, Ontario. Dyer Bay Formation.

Figure 12. Left lateral view of a male valve, x20. Hypotype, GSC No. 24397.

Figure 14. Right lateral view of a male valve, x20. Hypotype, GSC No. 24399.

Figure 16. Ventral oblique view of a female right valve, showing crumina and dolonoid scar, x20. Hypotype, GSC No. 24401.

Figure 17. Ventral oblique view of a female left valve, showing crumina and dolonoid scar, x20. Hypotype, GSC No. 24402.

Figure 20. Ventral view of a female left valve, showing crumina with encroaching velar ridge and supracruminal ridge, x20. Hypotype, GSC No. 24405.

Rush Cove, road section, Bruce Peninsula, Ontario. Wingfield Formation.

Figure 13. Left lateral view of an immature valve, x20. Hypotype, GSC No. 24398.

Rocky Bay, Bruce Peninsula, Ontario. Dyer Bay Formation.

Figure 15. Right lateral view of a female valve, x20. Hypotype GSC No. 24400.

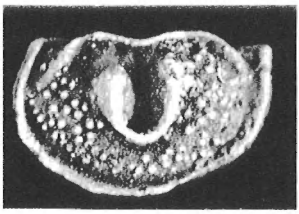
Figure 18. Left lateral view of a female valve, x20. Hypotype, GSC No. 24403.

Rocky Bay, Bruce Peninsula, Ontario. Wingfield Formation.

Figure 19. Left lateral view of a female valve, x20. Hypotype, GSC No. 24404.

Figure 21. Right lateral view of an immature valve, x20. Hypotype, GSC No. 24406.

Figure 22. Right lateral view of a female valve, x20. Hypotype, GSC No. 24407.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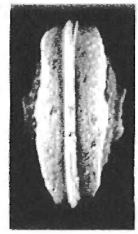
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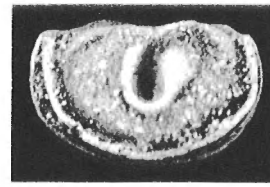
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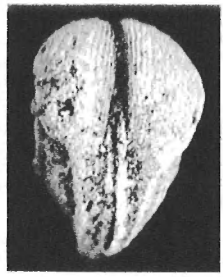
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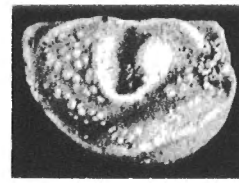
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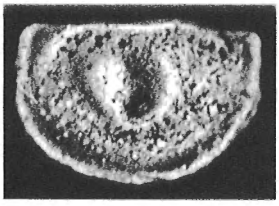
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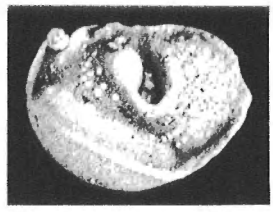
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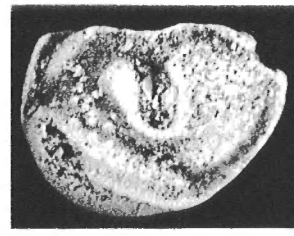
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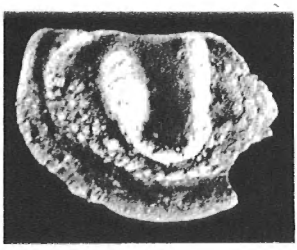
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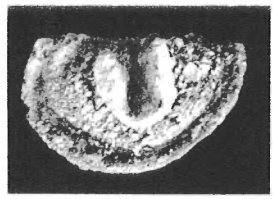
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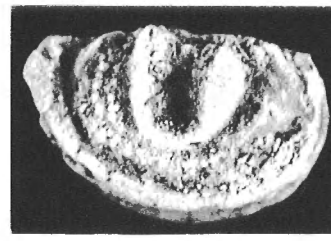
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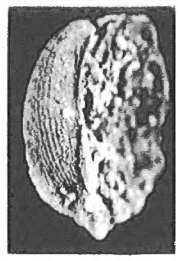
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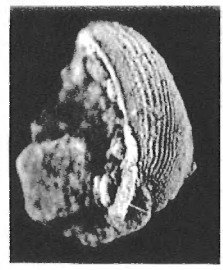
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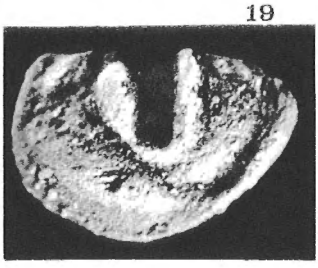

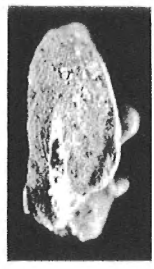
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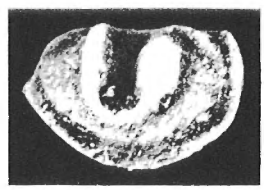

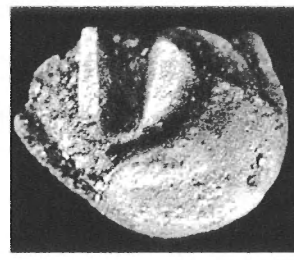
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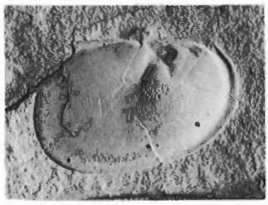
PLATE II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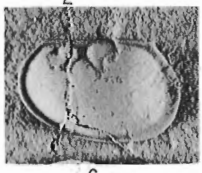
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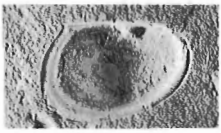
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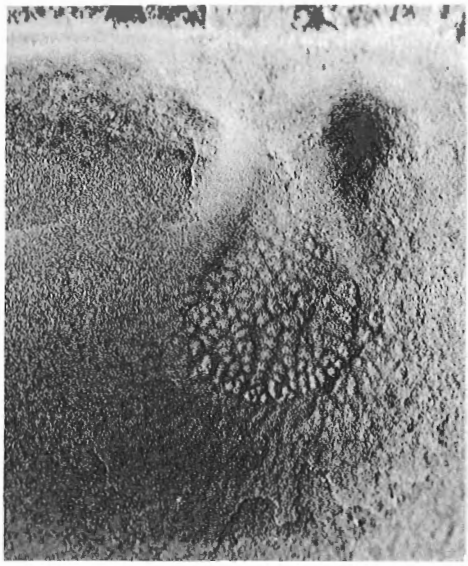
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PLATE II

(All figures x1 unless otherwise stated)

Dihogmochilina latimarginata (Jones) (PAGE 11)

Specimens from Manitoba, collected by J. B. Tyrrell, 1889, 1890.

Figures 1, 2. Interior of left valve and steinkern, paralectotype, GSC Nos. 6055f, 6055g. Lake Winnipegosis, east side.

Figures 3, 4. Cast and interior of right valve, lectotype, GSC Nos. 6055a, 6055. Lake Winnipegosis, east side.

Figures 5, 6. Interior of left valve and cast, paralectotype, GSC Nos. 6055b, 6055c. Lake Winnipegosis, east side.

Figure 7. Left valve, paralectotype, GSC No. 6055h. Lake Winnipegosis, east side.

Figures 8, 9. Cast and interior of right valve, paralectotype, GSC Nos. 6055e, 6055d. Lake Winnipegosis, east side.

Figure 10. Interior of left valve, hypotype, GSC No. 23968. Roche Rouge, Saskatchewan River.

Figure 11. Interior of left valve, paralectotype, GSC No. 6055i. Lake Winnipegosis, east side.

Figure 12. Left valve, hypotype, GSC No. 17089. Lake Winnipegosis, east side.

Figure 13. Right valve, paralectotype, GSC No. 6057. North end Mossy Portage, Cedar Lake.

Figures 14, 15. Interior of right valve, muscle scar area x6, hypotype, GSC No. 23969. Roche Rouge, Saskatchewan River.

Figures 16, 17. Interior of right valve, muscle scar area x6, hypotype, GSC No. 23970. Roche Rouge, Saskatchewan River.

Figures 18, 19. Interior of left valve, muscle scar area x6, hypotype, GSC No. 23971. Roche Rouge, Saskatchewan River.

Figure 20. Right valve muscle scar area x6, hypotype, GSC No. 23972. Roche Rouge, Saskatchewan River.

PLATE III

Dihogmochilina boothia n. sp. (PAGE 12)

Northeastern Boothia Peninsula. Northwest Territories (71°31'N, 94°12'W), collected by R. L. Christie, 1962.

Figure 1. Lateral view of left valve, x2. Holotype, GSC No. 23973.

Figure 2. Lateral view of right valve, x1. Paratype, GSC No. 23974.

Figure 3. Lateral view of left valve, x1. Paratype, GSC No. 23975.

Figure 4. Lateral view of left valve, x2. Paratype, GSC No. 23976.

Figure 5. Lateral view of right valve, x2. Paratype, GSC No. 23977.

Figures 6, 7. Lateral view of incomplete left valve, x2, and muscle scar area, x6. Paratype, GSC No. 23978.

Dihogmochilina latimarginata (Jones) (PAGE 11)

Harricanaw River, Quebec (50°41'N, 79°17.5'W), collected by B. S. Norford, 1967.

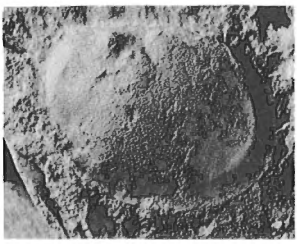
Figures 8, 9. Lateral view of slightly distorted right valve, x1, and muscle scar area photographed through the shell immersed in a liquid, x6. Hypotype, GSC No. 23979.

Hendricks Quarry, NW¼ sec. 6, T. 44N., R.8W., Mackinac County, Michigan, U.S.A.

Figures 10, 11. Lateral view of left valve with part of shell removed, muscle scar area, x6, specimen, x1. Hypotype, GSC No. 23980.

Figures 12, 13. Lateral view of left valve with part of shell removed, muscle scar area, x6, specimen, x1. Hypotype, GSC No. 20619.

Figures 14, 15. Lateral view of right valve with part of shell removed, specimen, x1, muscle scar area, x6. Hypotype, GSC No. 23981.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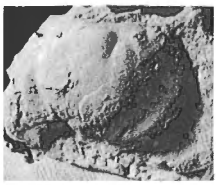
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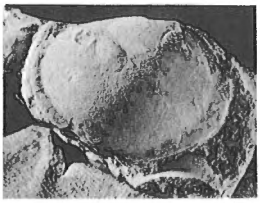
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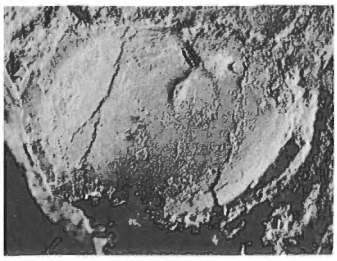
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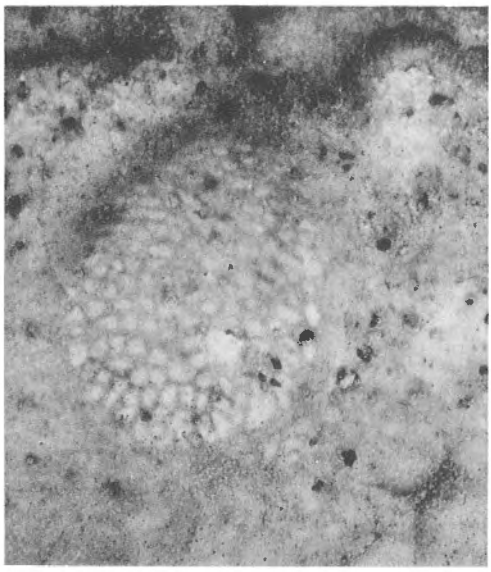
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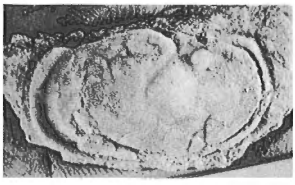
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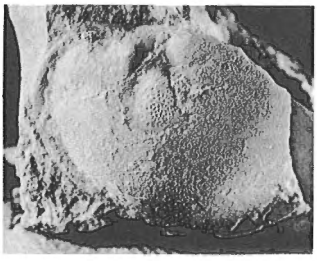
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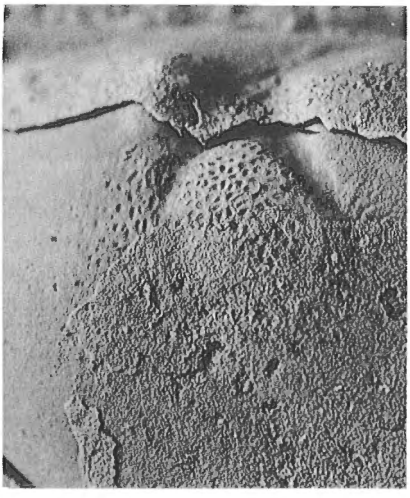


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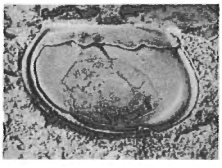
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PLATE IV


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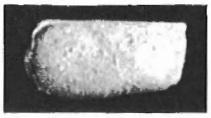
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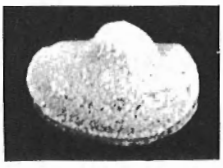
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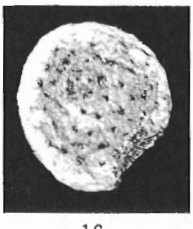
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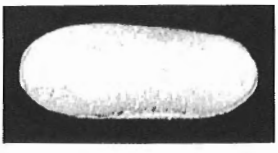
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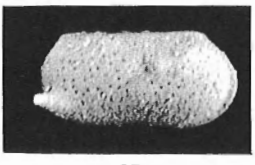
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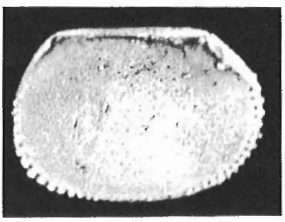
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PLATE IV

Figure 1. *Platyrhomboides*? *subcylindrica* (Jones) (PAGE 16)
Right lateral view of a carapace, x25. Hypotype, GSC No. 23982.

Figure 2. *Paraschmidtella irregularis* Keenan (PAGE 18)
Right? lateral view of a carapace, x20. Hypotype, GSC No. 23983.

Figures 3, 4. *Ulrichia nodosa* (Ulrich) (PAGE 18)
Right lateral views of two carapaces, x30. Hypotypes, GSC Nos. 23984, 23985.

Figure 5. *Monotiopleura parallela* (Ulrich) (PAGE 18)
Right lateral view of a carapace, x25. Hypotype, GSC No. 23986.

Figures 6–9. *Eographiodactylus billingsi* n. sp. (PAGE 19)
Left lateral, ventral, dorsal, and right lateral views of four carapaces, x30. Holotype, GSC No. 23987; paratypes, GSC Nos. 23988–23990.

Figure 10. *Jonesites semilunatus* (Jones) (PAGE 19)
Right lateral view of a carapace, x25; Pte à l'epinette, a mile east of the mouth of MacDonald River, GSC locality 76151. Hypotype, GSC No. 23992.

Figures 11, 12. *Aechmina* sp. (PAGE 20)
Right lateral views of two carapaces, x30, and x23. Figured specimens, GSC Nos. 23993, 23994.

Figures 13, 14. *Eokloedenella canadensis* (Bassler) (PAGE 20)
Dorsal and ventral views of two carapaces, x25. Hypotypes, GSC Nos. 23995, 23996.

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Figures 16, 17. Foraminifer sp. indet. (PAGE 28)
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Right lateral view of a carapace, x25. Figured specimen, GSC No. 24000.

Figures 20–22. *Monoceratella castorensis* n. sp. (PAGE 21)
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Figures 24, 27. *Primitiella*? *huilensis* n. sp. (PAGE 22)
Left and right lateral views of two carapaces, x23. Holotype, GSC No. 24005; paratype, GSC No. 24008.

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Left lateral view of a carapace, x18. Hypotype, GSC No. 24009.

Figure 29. *Krausella* sp. cf. *K. arcuata* Ulrich (PAGE 23)
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Figure 30. *Ceratopsis* sp. (PAGE 24)
Left lateral view of a carapace, x18. Figured specimen, GSC No. 24011.

PLATE V

Figure 1. *Eokloedenella canadensis* (Bassler) (PAGE 20)
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Figures 2, 3. *Laccoprimitia*? sp. (PAGE 24)
Right and left lateral views of two carapaces, x20. Figured specimens, GSC Nos. 24139, 24140.

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Left lateral views of three carapaces, x25. Paratypes, GSC No. 24150, 24153; holotype, GSC No. 24157.

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Figure 17. Ostracod indet.
Palaeocopid ostracod of unknown affinities, x23; Pte à l'epinette, a mile east of MacDonald River, GSC locality 76151. Figured specimen, GSC No. 24154.

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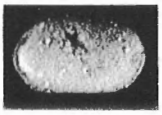
Figure 28. *Krausella brevicornis* (Keenan) (PAGE 28)
Right lateral view of a carapace, x18. Hypotype, GSC No. 24162.

Figure 29. *Tetradella* sp. cf. *T. lunatifera* (Ulrich) (PAGE 28)
Right lateral view of a broken specimen, x25. Hypotype, GSC No. 24163.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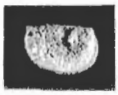
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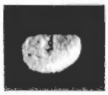
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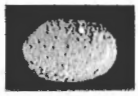
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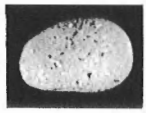
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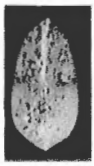
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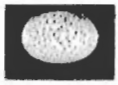
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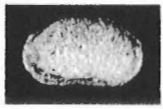
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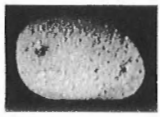
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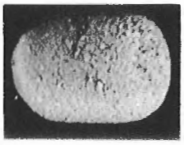
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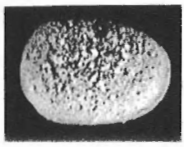
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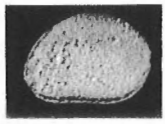
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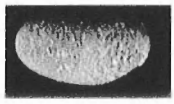
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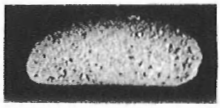
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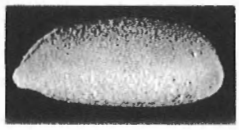
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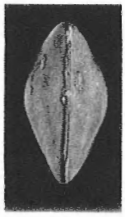
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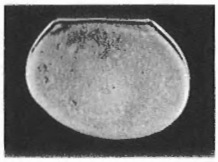
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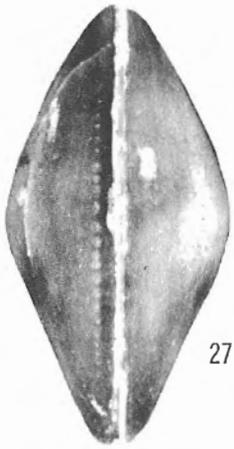
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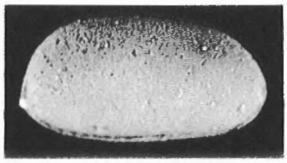
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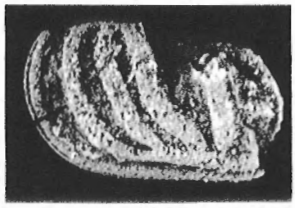
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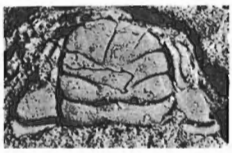
PLATE VI



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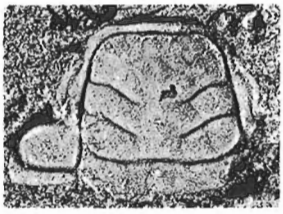

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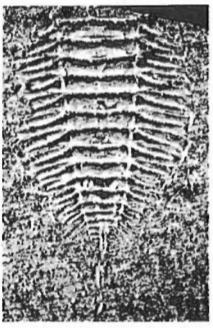

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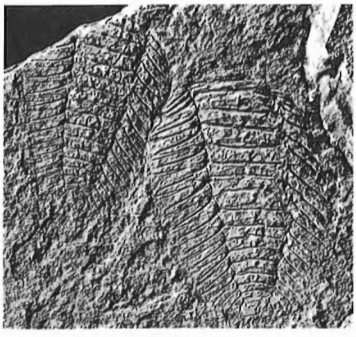

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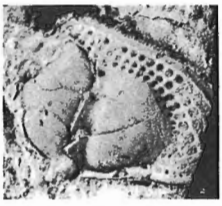

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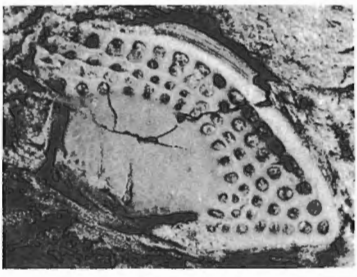

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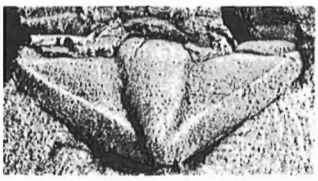

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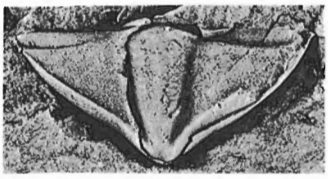

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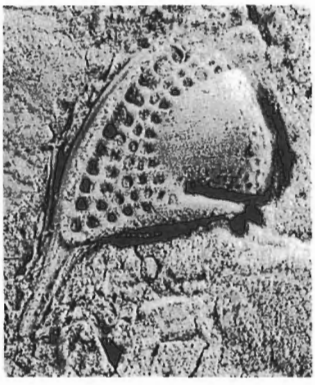

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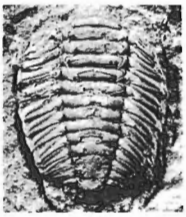

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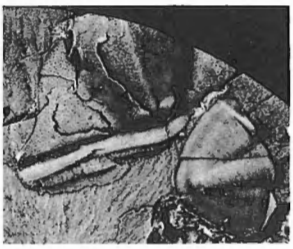

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PLATE VI

Figures 1–6, 24. *Triarthrus huguesensis* Foerste (PAGE 38)
Vauréal Formation, Upper Ordovician.
1, 4. Cranidia, squashed form very close to syntypes, x4; Carleton Point well, depth 1,163 feet. Hypotypes, GSC Nos. 24596, 24597.
2, 6. Cranidia showing outward curving anterior facial sutures and long, sigmoidal curving eye lobes, x2; Carleton Point well, depths 1,165 and 1,155 feet. Hypotypes, GSC Nos. 24598, 24595.
3. Incomplete cranidium with square glabella, x4; Carleton Point well, depth 1,079 feet. Hypotype, GSC No. 24593.
5. Incomplete cranidium, x4; Carleton Point well, depth 1,110.6 feet. Hypotype, GSC No. 24594.
24. Thorax, x2; Carleton Point well, depth 1,157 feet. Hypotype, GSC No. 24599.

Figure 7. *Triarthrus spinosus* Billings (PAGE 33)
Incomplete thorax of fourteen segments with axial spine and pygidium, x4. Macasty Formation, Upper Ordovician, Carleton Point well, depth 1,393 feet. Hypotype, GSC No. 24600.

Figure 8. *Triarthrus mccastyensis* Twenhofel (PAGE 33)
Incomplete thorax of sixteen segments with axial nodes, x2. Macasty Formation, Upper Ordovician, loose on shore where road meets beach, Grand Ruisseau (GSC loc. 36184). Hypotypes, GSC Nos. 24608, a.

Figures 9, 10. *Cryptolithus* sp. aff. *C. bellulus* (Ulrich). (PAGE 36)
Incomplete cranidia, dorsal views showing anterior pit and apodeme of posterior glabellar furrows, x2. Vauréal Formation, Upper Ordovician. Princeton Lake well, depths 2,884 and 2,863 feet. Hypotypes, GSC Nos. 24585, 24586.

Figure 11. *Isotelus* sp. (PAGE 33)
Glabella, x1. 'Trenton' Formation, Middle Ordovician. Princeton Lake well, depth 3,431 feet. Fig. spec., GSC No. 24607.

Figures 12, 14, 15, 17–19. *Tretaspis ceriodes* (Angelin) (PAGE 35)
Vauréal Formation, Upper Ordovician.
12, 17. Incomplete cranidia, dorsal views showing vase-like glabella, glabellar furrows, and eye tubercles, x4. New Associated well, depths 3,227 and 3,269 feet. Hypotypes, GSC Nos. 24578, 24579.
14. Pygidium, dorsal view, x4. New Associated well, depth 3,240 feet. Hypotype, GSC No. 24580.
15, 19. Incomplete cranidia, dorsal views showing carinate ridges of the fringe, reticulation of fixed cheek, eye tubercle, and genal spine, x4. New Associated well, depths 3,208 and 3,224 feet. Hypotypes, GSC Nos. 24581, 24582.
18. Pygidium and thoracic segments, dorsal view, x4. New Associated well, depth 3,229 feet. Hypotype, GSC No. 24583.

Figure 13. *Lonchodomas* sp. (PAGE 38)
Internal mould of pygidium, dorsal view, showing muscle scars, x4. Vauréal Formation, Upper Ordovician. New Associated well, depth 3,319.8 feet. Figured specimen, GSC No. 24592.

Figures 16, 20, 21, 25. *Lonchodomas denova* n. sp. (PAGE 37)
'Trenton' Formation, Middle Ordovician.
16. Pygidium and three thoraxial segments, dorsal view, x4. Princeton Lake well, depth 3,431 feet. Paratype, GSC No. 24588.
20. Partly exfoliated pygidium, dorsal view showing exoskeleton with terrace lines, and double pairs of axial muscle scars, x4. Princeton Lake well, depth 3,468 feet. Paratype, GSC No. 24589.
21. Partly exfoliated cranidium, dorsal view showing grooved glabella spine, x2. Carleton Point well, depth 1,900 feet. Holotype, GSC No. 24587.
25. Partly exfoliated cranidium, dorsal view showing lateral glabellar lobes and posterior muscle scars in occipital furrow, x2. *Isotelus* sp. pygidium associated. Carleton Point well, depth 1,900 feet. Paratype, GSC No. 24590.

Figure 22. *Lingula* sp. cf. *L. divulgata* Sinclair, x2 (PAGE 33)
Vauréal Formation, Upper Ordovician. Carleton Point well, depth 1,131 feet. Hypotype, GSC No. 24601.

Figure 23. *Ctenodonta* sp. (PAGE 33)
Left valve, x2. Vauréal Formation, Upper Ordovician. Carleton Point well, depth 1,135 feet. Figured specimen, GSC No. 24602.

PLATE VII

Figures 1, 3, 5, 6, 8. *Primaspis evoluta canadiana* n. subsp., x4 (PAGE 34)

Vauréal Formation, Upper Ordovician.

1. Incomplete cranidium with distinct anterior glabellar lobes and deep posterior border furrows, associated with left half of a pygidium. Carleton Point well, depth 1,065 feet. Holotype, GSC No. 24572.

3, 5, 6, 8. Dorsal views of two complete pygidia, each with a thoracic axial ring, a free cheek and associated hypostome, and an incomplete cranidium showing granulated surface and occipital lobes. Carleton Point well, depth 1,110 feet. Paratypes, GSC Nos. 24573, a–c.

Figure 2. *Dicellograptus* sp., x10 (PAGE 33)

Vauréal Formation, Upper Ordovician. Princeton Lake well, depth 2,844 feet. Figured specimen, GSC No. 24602.

Figures 4, 9. *Primaspis* sp. (PAGE 35)

Vauréal Formation, Upper Ordovician.

4. Pygidium with five outside border spines, x4. Carleton Point well, depth 1,075 feet. Figured specimen, GSC No. 24575.

9. Crushed cranidium with narrow cheek-roll and expanded median lobe, x2. Carleton Point well, depth 1,080 feet. Figured specimen, GSC No. 24574.

Figure 7. *Leptobolus insignis* Hall, x15 (PAGE 33)

Macasty Formation, Upper Ordovician. Princeton Lake well, depth 2,993 feet. Hypotype, GSC No. 24603.

Figures 10, 11, 15. *Prasopora* sp. aff. *P. lenticularis* Ulrich (PAGE 33)

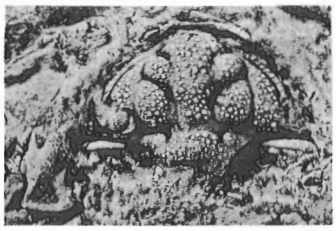
Longitudinal and tangential sections, x60 and x20. Vauréal Formation, Upper Ordovician. New Associated Consolidated Paper No. 1 well, depth 3,244 feet. Hypotype, GSC No. 24604.

Figure 12. *Dicranograptus* sp., x4 (PAGE 33)

Macasty Formation, Upper Ordovician. Princeton Lake well, depth 3,202 feet. Figured specimen, GSC No. 24605.

Figures 13, 14. *Diplograptus* sp., x6 (PAGE 33)

Vauréal Formation, Upper Ordovician. Princeton Lake well, depth 2,776 feet. Figured specimens, GSC Nos. 24606, a.



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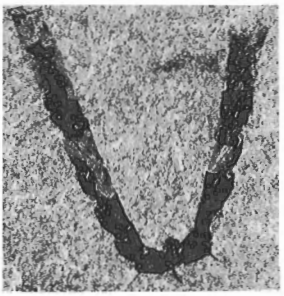

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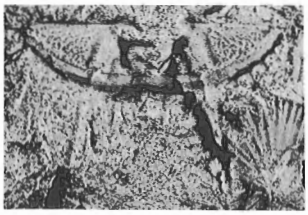

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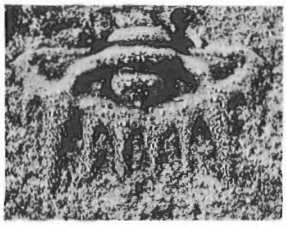

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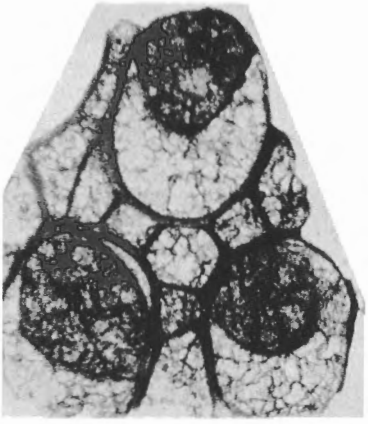

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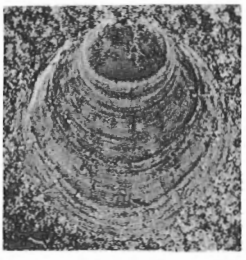

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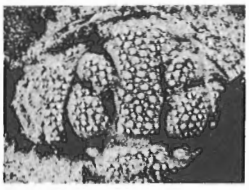

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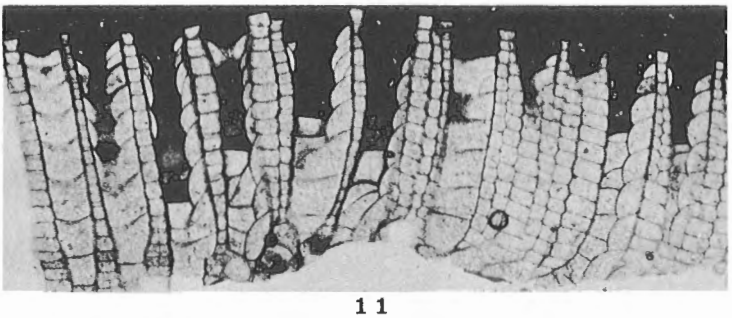

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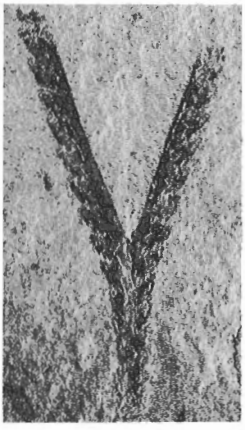

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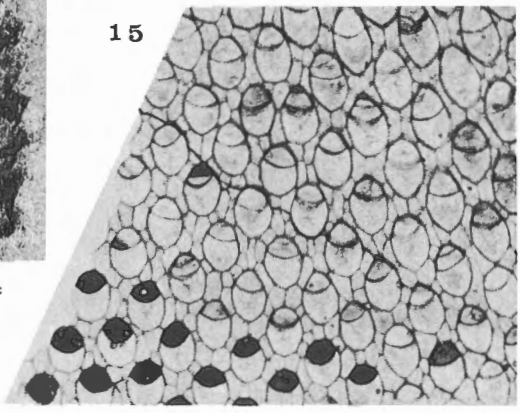

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PLATE VIII


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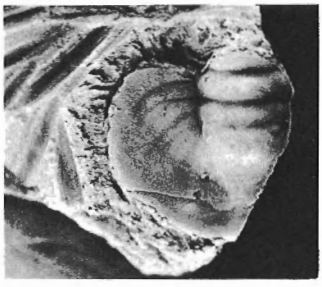
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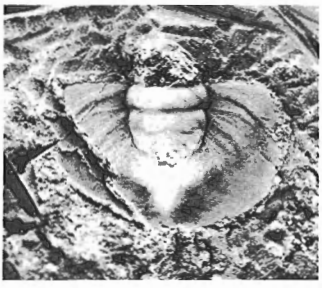
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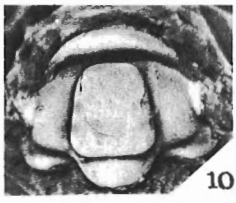
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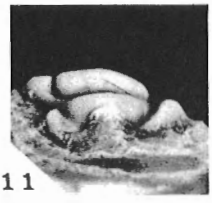
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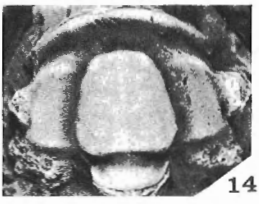
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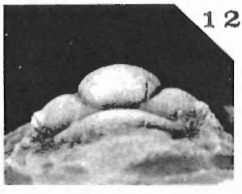
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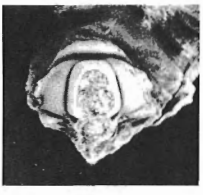
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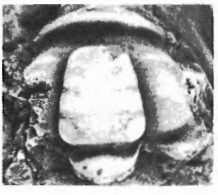
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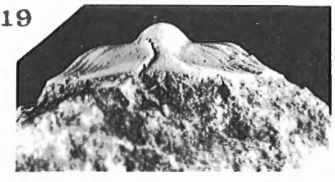
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PLATE VIII

Figures 1–6. *Baltagnostus marginalis*? (Rasetti) (PAGE 48)

1–4 Enrolled specimen, cephalic, end, pygidial, and side views; x14; railway fill, probably derived from unit 1 or 3; loc. F-65-7b; hypotype, GSC No. 24609.

5, 6 Pygidium, plan and side views; x14; unit 1 or 3; loc. 62-L-48a; hypotype, GSC No. 24610.

Figure 7 ?*Bathyuriscidella* sp. 2 (PAGE 49)

Pygidium, plan view; x5; unit 2; loc. F-65-10; hypotype, GSC No. 24611.

Figures 8, 9 *Bathyuriscidella*? sp. 1 (PAGE 49)

Pygidium, plan and side views; x4; unit 2; GSC loc. 82503; hypotype, GSC No. 24612.

Figures 10–17 *Spencella punctata* sp. nov. (PAGE 50)

10–12 Cranidium, plan, side, and front views; x6; unit 2; GSC loc. 82502; holotype, GSC No. 24613.

13 Small cranidium, plan view; x7; unit 2; GSC loc. 82501; paratype, GSC No. 24614.

14–16 Exfoliated cranidium, plan, side, and front views; x5; unit 2; GSC loc. 82501; paratype, GSC No. 24615.

17 Exfoliated cranidium, plan view; x5; unit 2; GSC loc. 82502; paratype, GSC No. 24616.

Figures 18–20 *Americare*? sp. (PAGE 51)

Half-exfoliated pygidium, plan, rear, and side views; x4; unit 2; GSC loc. 82502; figured specimen, GSC No. 24617.

PLATE IX

Figures 1, 2 *Asaphiscus* sp. (PAGE 51)

Pygidium, plan and rear views; x1.7; unit 2; loc. F-65-14; figured specimen, GSC No. 24618.

Figures 3–10 *Kingstonioides primicaudus* sp. nov. (PAGE 53)

3, 4 Half-exfoliated cranidium, plan and side views; x4; unit 2; GSC loc. 82502; paratype, GSC No. 24619.

5 Exfoliated pygidium, plan view; x4; unit 2; GSC loc. 82501; holotype, GSC No. 24620.

6 Small cranidium, plan view; x9; unit 2; GSC loc. 82501; paratype, GSC No. 24621.

7 Small pygidium, plan view; x6; unit 2; GSC loc. 82501; paratype, GSC No. 24622.

8–10 Large pygidium, partly exfoliated, rear, and plan views; x2; blow-up of plan view; x4; unit 2; GSC loc. 82504; paratype, GSC No. 24623.

Figures 11–15 *Bolaspidella cloudi* (Kindle) (PAGE 54)

11 Cranidium, plan view; x7; unit 1 or 3; Kindle collection; hypotype, GSC No. 24624.

12 Cranidium, plan view; x7; unit 2 or 3; Kindle collection; hypotype, GSC No. 24625.

13–15 Cranidium, plan, front, and oblique views; unit 1 or 3; Kindle collection; hypotype, GSC No. 24626.

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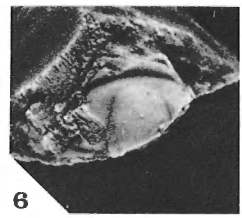

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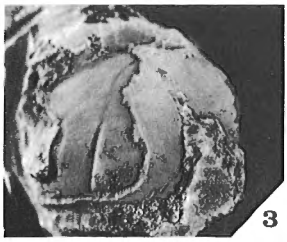

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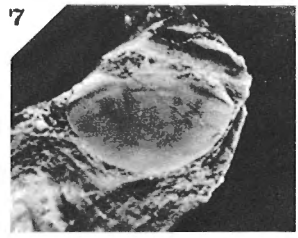

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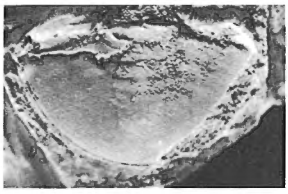

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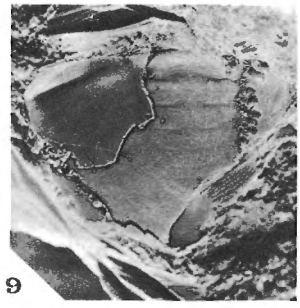

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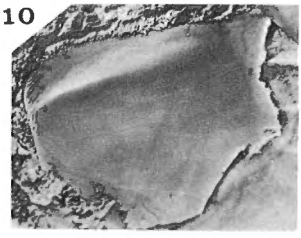

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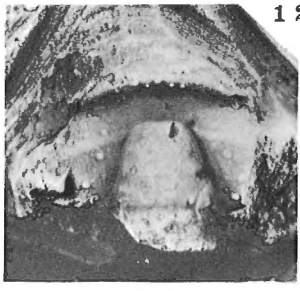

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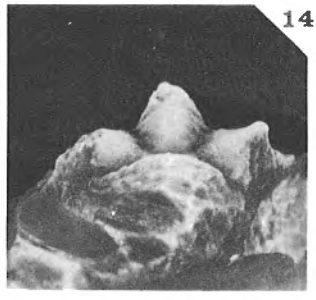

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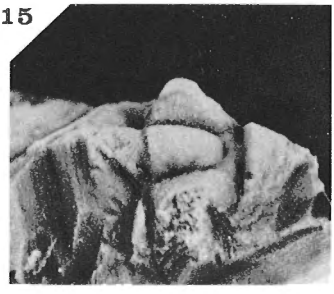

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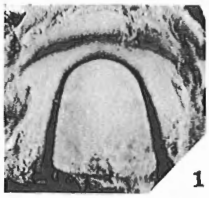
PLATE X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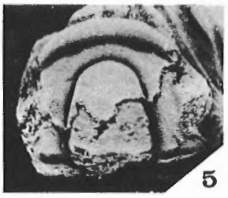
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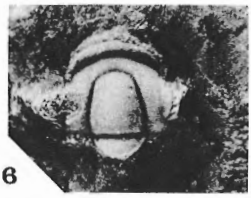
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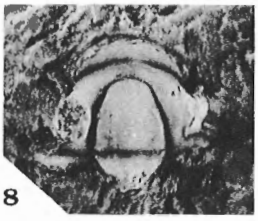
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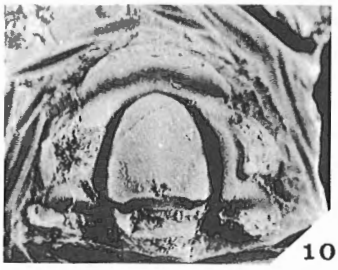
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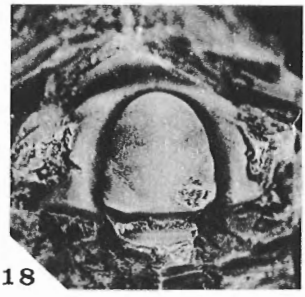
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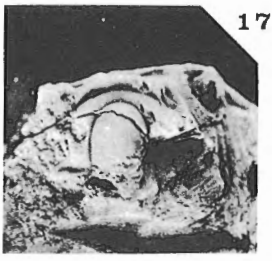
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PLATE X

Figures 1–9 *Modocia* sp. cf. *M. brevispina* Robison (PAGE 54)

1, 2 Cranidium, plan and side views; x4; unit 2; GSC loc. 82501; hypotype, GSC No. 24627.

3, 4 Tentatively assigned pygidium, plan and rear views; x4; unit 2; GSC loc. 82502; hypotype, GSC No. 24628.

5 Cranidium, plan view; x5; unit 2; GSC loc. 82502; hypotype, GSC No. 24629.

6 Small cranidium, plan view; x9; unit 2; GSC loc. 82503; hypotype, GSC No. 24630.

7 Exfoliated, tentatively assigned pygidium, plan view; x3; unit 2; GSC loc. 82501; hypotype, GSC No. 24631.

8 Cranidium, plan view; x6; unit 2; GSC loc. 82503; hypotype, GSC No. 24632.

9 Tentatively assigned librigena, plan view; x6; unit 2; GSC loc. 82503; hypotype, GSC No. 24633.

Figures 10–19 *Modocia supera* sp. nov. (PAGE 55)

10–12 Exfoliated cranidium, plan, side, and front views; x3; unit 2; GSC loc. 82501; holotype, GSC No. 24634.

13–16 Tentatively assigned, half-exfoliated pygidium, plan, rear, right side, and left side views; x5; unit 2; GSC loc. 82502; paratype, GSC No. 24635.

17 Small cranidium, plan view; x7; unit 2; GSC loc. 82500; paratype, GSC No. 24636.

18 Cranidium, plan view; x3; unit 2; GSC loc. 82501; paratype, GSC No. 24637.

19 Tentatively assigned, exfoliated pygidium, plan view; x5; unit 2; GSC loc. 82501; paratype, GSC No. 24638.

PLATE XI

Figure 1. *Pleurocystites distans* n. sp. (PAGE 61)

Antanal view x2. Farr Formation, Middle Ordovician, railroad quarry between Haileybury and New Liskeard, Ontario. Holotype, GSC No. 24506.

Figures 2, 4. *Pleurocystites squamosus* Billings, x2. (PAGE 60)

Farr Formation, Middle Ordovician, north-south road west of Farr quarry, Haileybury, Ontario. Hypotypes, GSC Nos. 24502, a–c.

2. Views from right to left: antanal, anal showing a few periproctals and interior of antanal plates with L1/L2 (12/11) and L3/L4 (10/14) rhombs, and anal with several minute periproct plates.

4. Incomplete theca, anal view showing a few periproctals and interior of antanal plates with L3/L4 (10/14) rhomb.

Figures 3, 5. *Protaxocrinus amii* n. sp. (PAGE 63)

Anterior showing isotomous arm structure and right posterior views showing anal series rising obliquely from posterior basal plate, x3. Thornloe Formation, Middle Silurian, Mann Island, Lake Timiskaming, Quebec. Paratypes, GSC Nos. 24520a, b.

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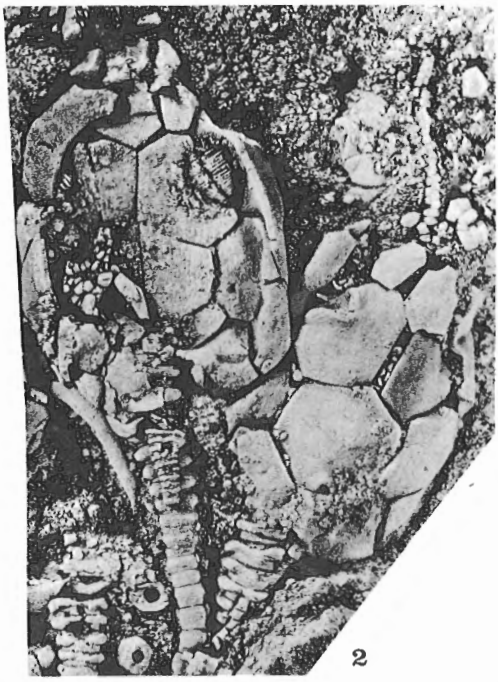

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PLATE XII

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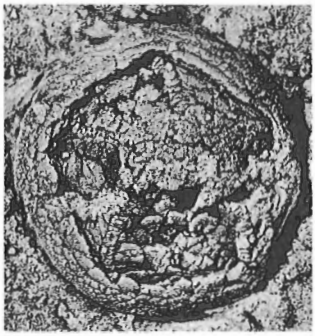

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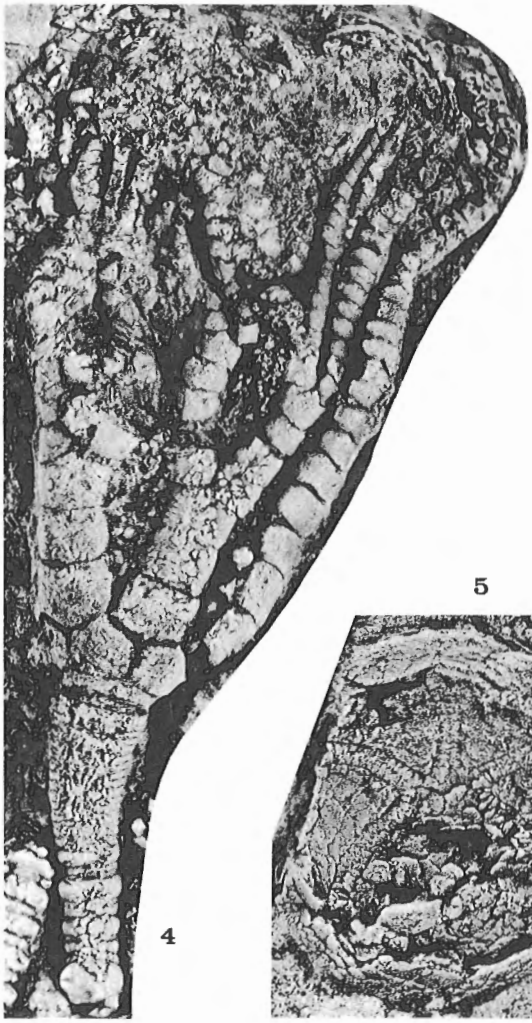

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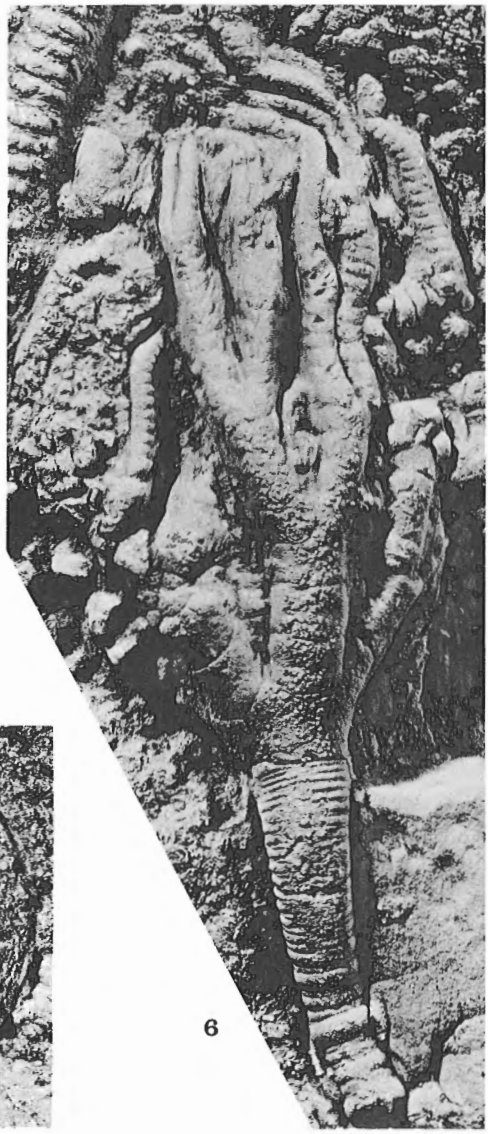

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PLATE XII

Figures 1–3, 5. *Hemicystites hawkesi* n. sp. (PAGE 61)

Adoral views—fig. 5 showing orotegminal plates of peristomial region with principal posterior plate split; second posterior and proximal cover plate of C ambulacrum both relatively large. Figs. 1, 3, 5—x3, fig. 2—x2. Wabi Formation, Middle Silurian, Evanturel Creek, south of Englehart, Ontario. Holotype, GSC No. 24507 (figs. 1, 2); paratypes, GSC Nos. 24508, 24509.

Figures 4, 6. *Protaxocrinus amii* n. sp. (PAGE 63)

Complete crowns showing infolding and coiling of arms, x3. Thornloe Formation, Middle Silurian, Mann Island, Lake Timiskaming, Quebec. Holotype, GSC No. 24520; paratype GSC No. 24521.

PLATE XIII

Figures 1, 4, 6, 10. *Macnamaratylus murrayi* n. sp. (PAGE 64)

Thornloe Formation, Middle Silurian, quarry lot 6, con. VI, Armstrong tp., Ontario.

1, 4. Coiled stem composed of basilarids and distal columnals and articular surface of elliptical columnal showing pentameres and lens-shaped lumen, x2 and x4. Paratype, GSC No. 24525.

6, 10. Well preserved specimen showing double-reverse coiled stem, crown along inner curve of stem in inverted position, and beaded cirrals, x2 and x4. Holotype, GSC No. 24524.

Figures 2, 3. *Cremacrinus lucifer* n. sp. (PAGE 62)

Median view and dorsal cup with punctate radial plates, x1. Farr Formation, Middle Ordovician, railroad quarry between Haileybury and New Liskeard, Ontario. Holotype, GSC No. 24517.

Figures 5, 8. *Cyclocystoides* sp. cf. *C. halli* Billings (PAGE 63)

Cross-section of plate showing paired ridges, x4; oral view showing oral side of ring of submarginal plates each with double facets (note one plate with single facet), and plates of aboral disc, x2. Verulam Formation, Middle Ordovician, east side of road-cut north end of Goat Island, Manitoulin Island area, Ontario. Hypotype, GSC No. 21099.

Figures 7, 9, 11, 13. *Hemicystites hawkesi* n. sp. (PAGE 61)

Wabi Formation, Middle Silurian, Evanturel Creek, south of Englehart, Ontario. Paratypes, GSC Nos. 24812, 24810, 24811.

7. Aboral view showing simple floor plates of strongly curved ambulacra, and nodose ridge and associated radial ridging of submarginal ring of plates, x3.

9. Adoral view of convex specimen showing orotegminal plates of peristomial region, x3.

11, 13. Aboral views showing simple floor plates of short, stubby ambulacra and five nodes per large plate on the inner two rows, x4 and x10.

Figure 12. *Cupulocrinus jewetti* (Billings), x2 (PAGE 63)

Verulam Formation, Middle Ordovician, west side of road-cut north end of Goat Island, Manitoulin Island area, Ontario. Hypotype, GSC No. 21100.

Figure 14. *Cupulocrinus* sp., x2 (PAGE 63)

Farr Formation, Middle Ordovician, railroad quarry between Haileybury and New Liskeard, Ontario. Figured specimen, GSC No. 24518.

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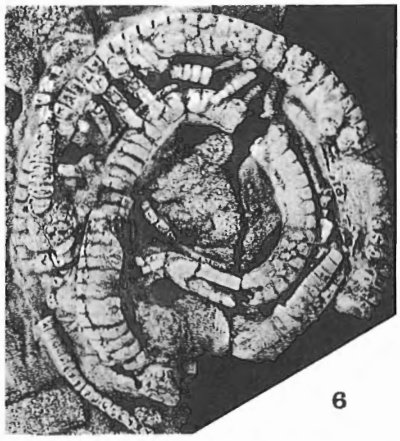

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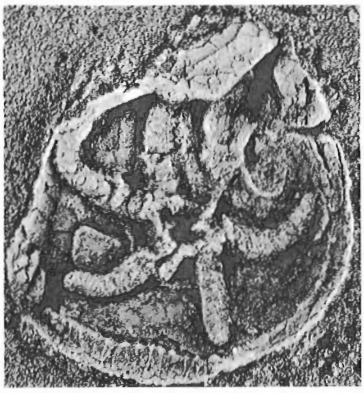

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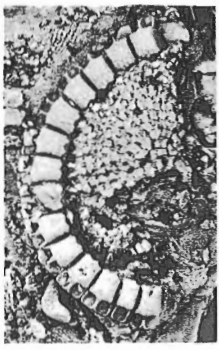

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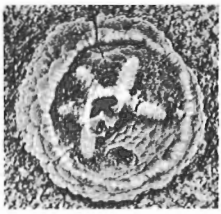

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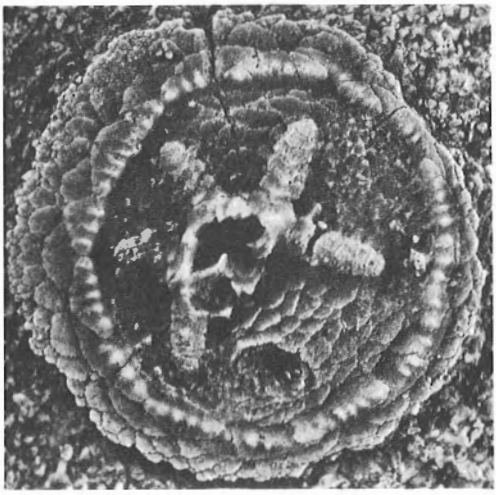

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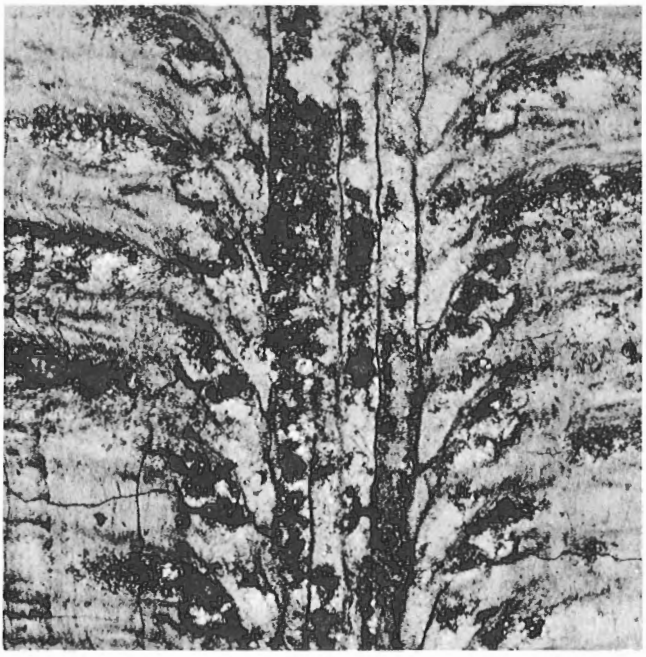
PLATE XIV



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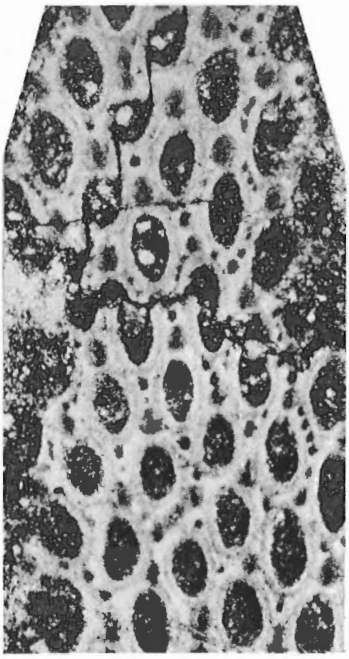

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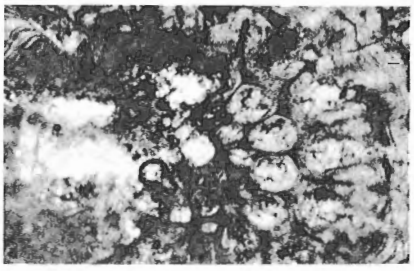

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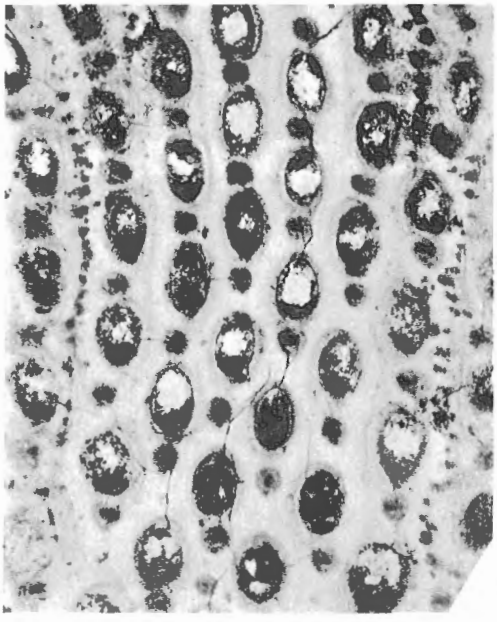

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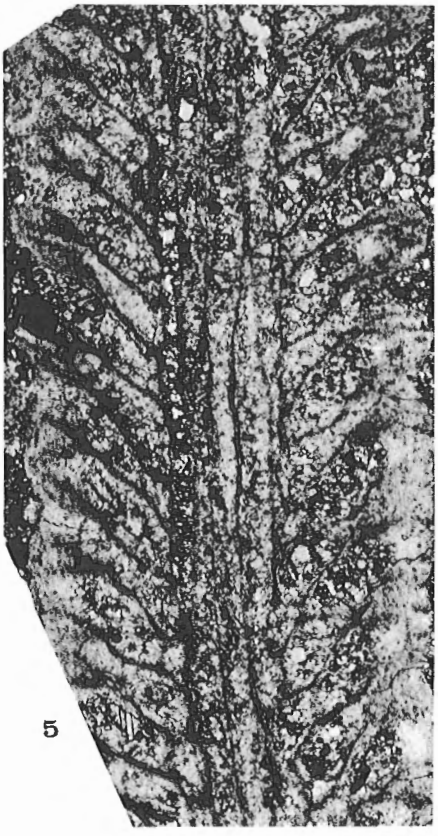

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PLATE XIV

Figures 1, 2, 4. *Ascopora tellevakensis* n.sp. (PAGE 73)
Longitudinal, transverse, and tangential sections, x30; Gully BK, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Holotype, GSC No. 24559.

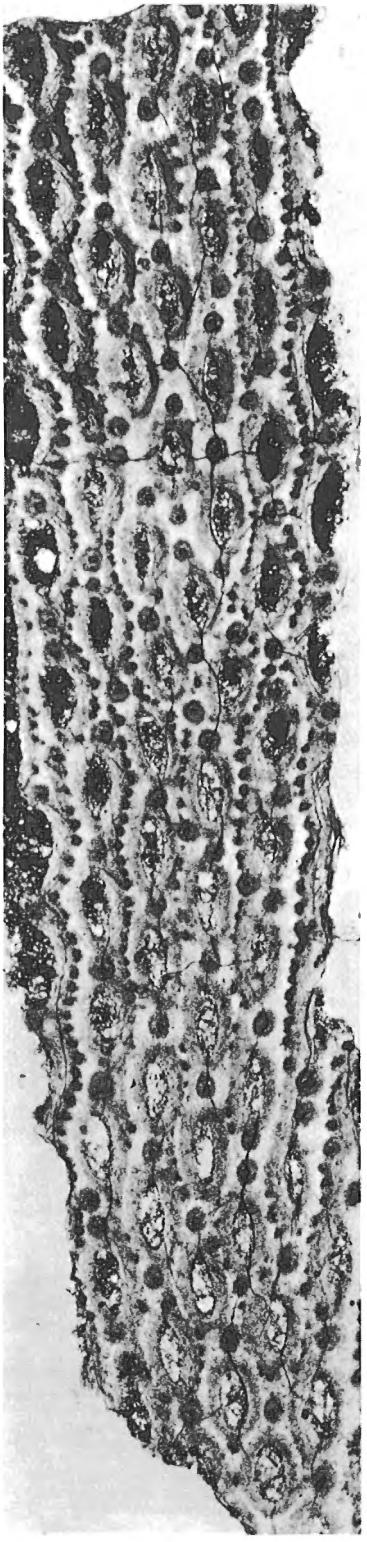
Figures 3, 5. *Ascopora graemei* n.sp. (PAGE 72)
Tangential and longitudinal sections, x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Holotype, GSC No. 24560.

PLATE XV

Figures 1, 4. *Rhombopora* cf. *R. lepidodendroides* Meek (PAGE 74)
Tangential and longitudinal sections, x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Hypotype, GSC No. 24561.

Figures 2, 5. *Septopora* sp. (PAGE 72)
Incomplete zoarium, x4 and x20; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Figured specimen, GSC No. 24566.

Figures 3, 6. *Eridopora* sp. (PAGE 68)
Tangential and longitudinal sections, x20 and x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Figured specimen, GSC No. 24564.



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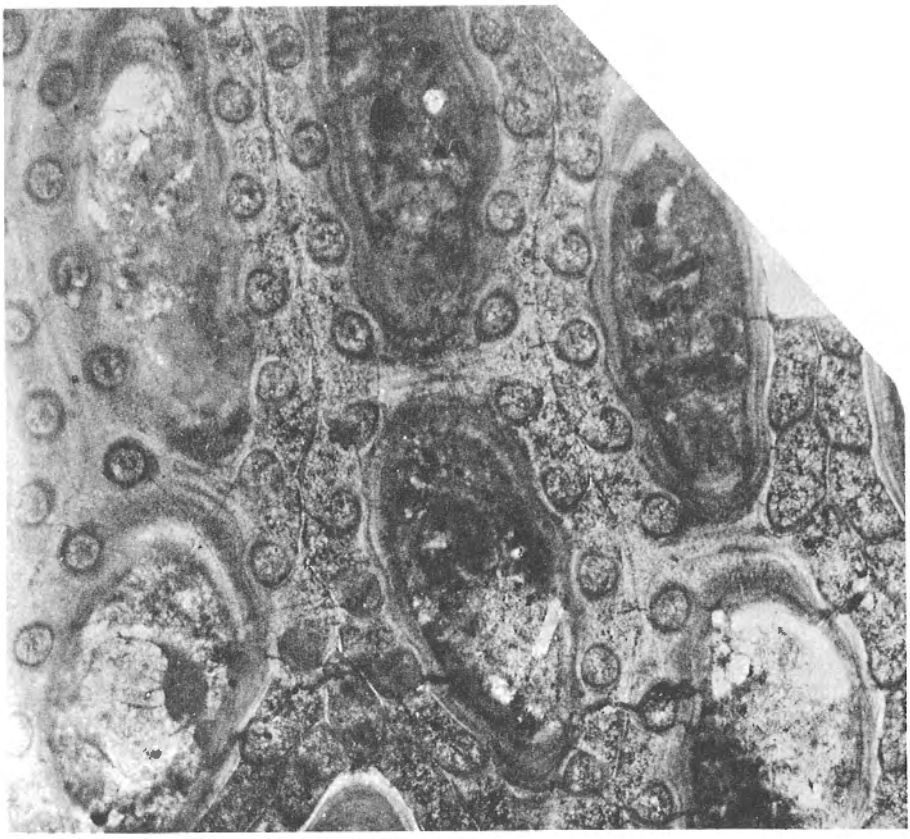

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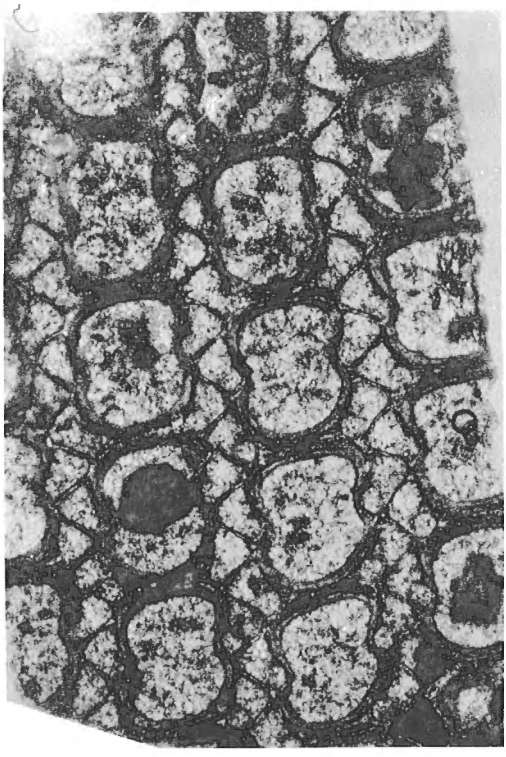


PLATE XVI

Figures 1, 2. *Fenestella carteri* n.sp. (PAGE 68)

Tangential section, x30; and portion of zoarium x20; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island Holotype, GSC No. 24565.

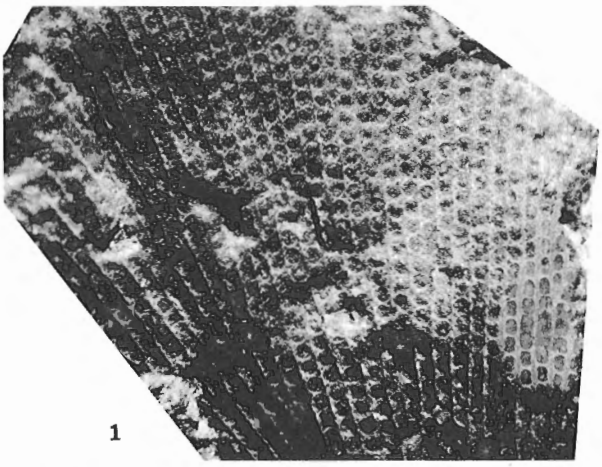
Figure 3. *Fenestella ellesmerensis* n.sp. (PAGE 69)

Tangential section, x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Holotype, GSC No. 24563.

PLATE XVII

Figures 1, 2. *Fenestella ellesmerensis* n.sp. (PAGE 69)
Portion of zoarium, x5 and surface, x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Holotype, GSC No. 24563.

Figures 3, 4. *Polypora bonhami* n.sp. (PAGE 71)
Tangential sections, x30; Gully BR, Tellevak Limestone, Pennsylvanian, northwestern Ellesmere Island. Holotype, GSC No. 24562.



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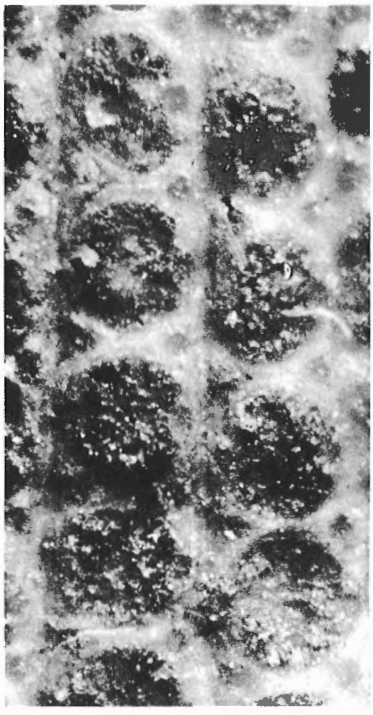

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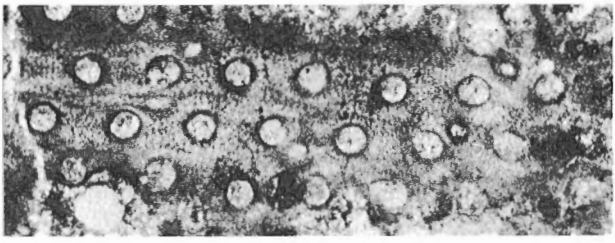

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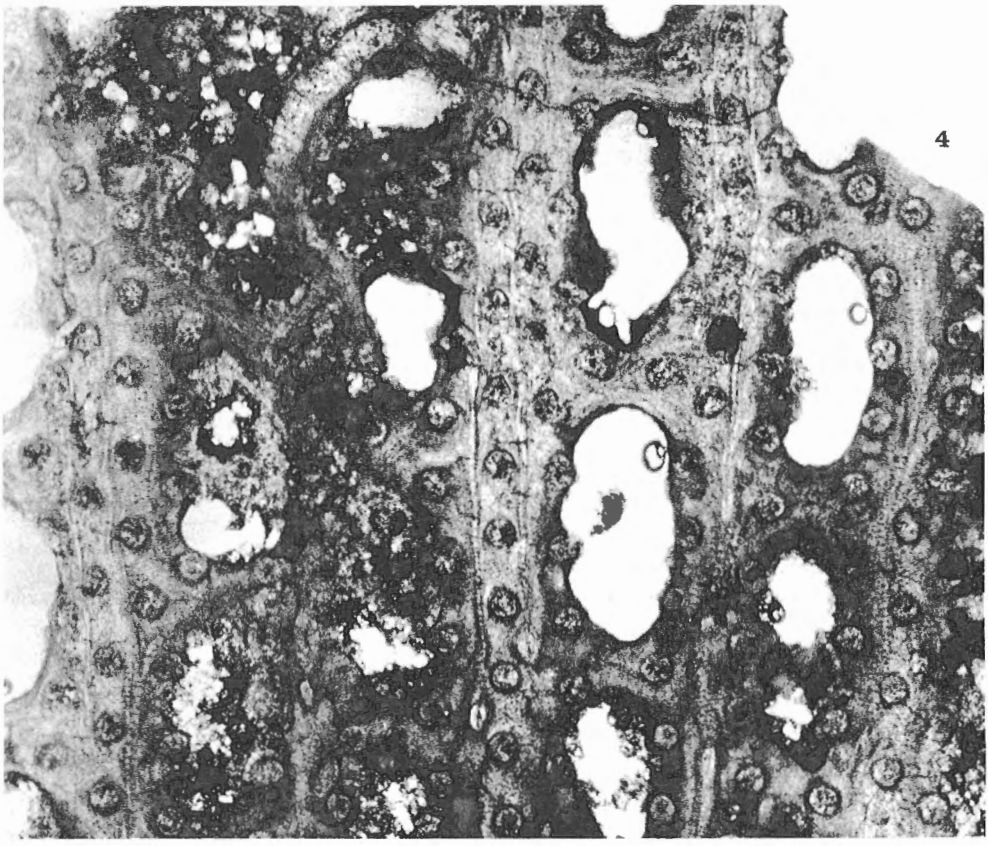

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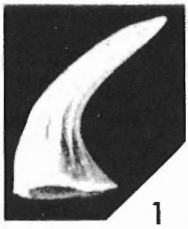
PLATE XVIII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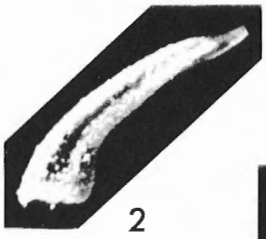
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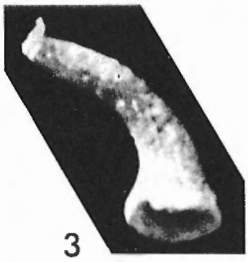
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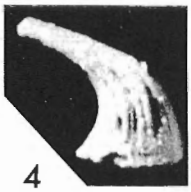
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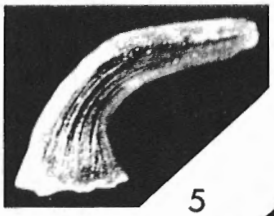
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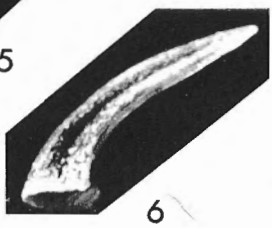
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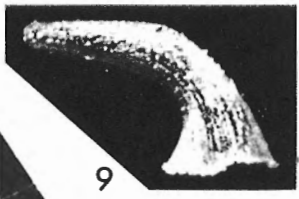
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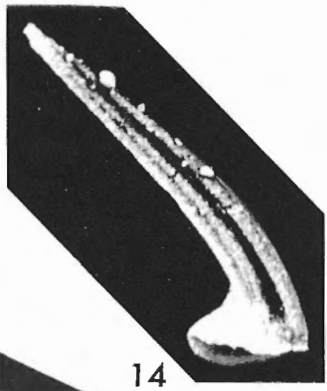
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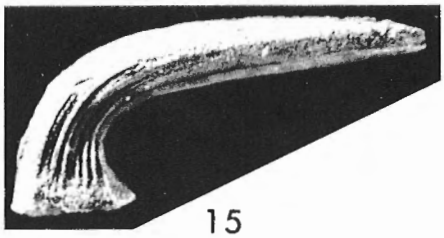
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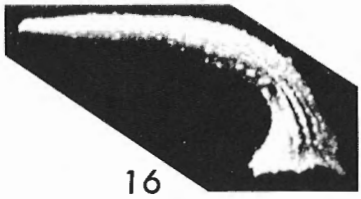
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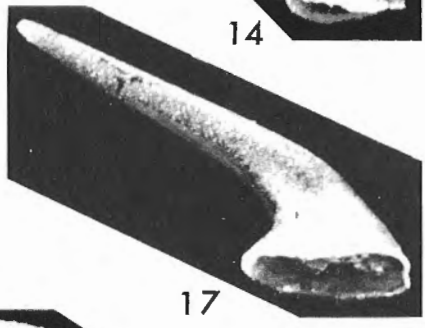
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PLATE XVIII

Conodonts from the St. George Formation, Newfoundland; specimens coated.

Figures 1, 4. *Scolopodus cornutiformis* Branson and Mehl (PAGE 91)
Lateral views, x40; sample A; hypotypes, GSC Nos. 24435, 24436.

Figures 2, 6–8. *Scolopodus emarginatus* n. sp. (PAGE 91)
Lateral views and aboral view (7), x40; sample B; paratype, GSC No. 24437, holotype, GSC No. 24438 (6, 7), paratype, GSC No. 24439.

Figure 3. *Oneotodus variabilis* Lindström (PAGE 90)
Lateral view, x60; sample A; hypotype, GSC No. 24433.

Figures 5, 9, 15, 16. *Scolopodus multicostatus* n. sp. (PAGE 92)
Lateral views, x40, (16) x 34; sample B; holotype, GSC No. 24444 (15), paratypes, GSC Nos. 24443 (5, 9), 24445.

Figure 10. *Acontiodus* sp. cf. *A. iowensis* Furnish (PAGE 84)
Posterior view, x60; sample B; figured specimen, GSC No. 24412.

Figures 11, 12. *Scolopodus gracilis* Ethington and Clark (PAGE 92)
Lateral views, x40; sample B; hypotypes, GSC Nos. 24441, 24442.

Figures 13, 14, 17. *Scolopodus quadraplicatus* Branson and Mehl (PAGE 93)
Lateral views and aboral view (13), 17 is view of robust variety, x40; sample B; hypotypes, GSC Nos. 24448 (13, 14), 24449.

PLATE XIX

Conodonts from the St. George Formation, Newfoundland; specimens coated except as noted.

Figures 1, 4. *Distacodus rhombicus* Lindström (PAGE 84)
Lateral views, x60; sample A; hypotype, GSC No. 24415.

Figures 2, 3. *Acontiodus staufferi* Furnish (PAGE 84)
Posterior views, x40; sample A; hypotypes, GSC Nos. 24413, 24414.

Figure 5. *Distacodus* sp. (PAGE 85)
Oral-lateral view, x40; sample A; figured specimen, GSC No. 24416.

Figures 6, 7. ?*Ozarkodina* sp. (PAGE 90)
Lateral views, x40; sample B; figured specimen, GSC No. 24434.

Figures 8, 12,13. *Drepanodus simplex* Branson and Mehl (PAGE 86)
Lateral views, x34; sample B; hypotypes, GSC Nos. 24421–24423.

Figures 9–11. *Drepanodus toomeyi* Ethington and Clark (PAGE 86)
Lateral views (10) uncoated; sample B; (10) x60, hypotype, GSC No. 24424 (9, 11) x34, hypotype, GSC No. 24425.

Figures 14, 15. *Drepanodus homocurvatus* Lindström (PAGE 85)
Lateral views (14) x34, (15) x50; sample B; hypotypes, GSC Nos. 24417, 24418.


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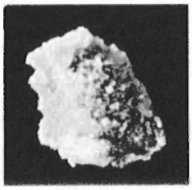
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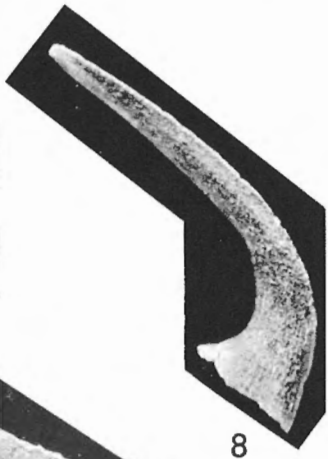
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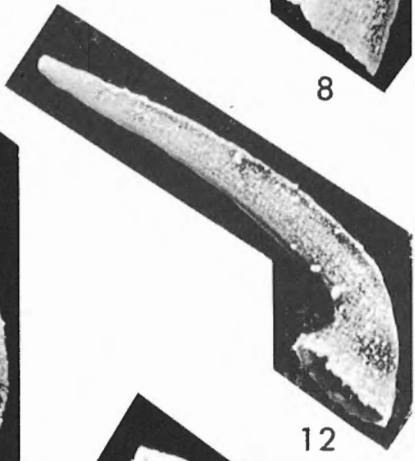
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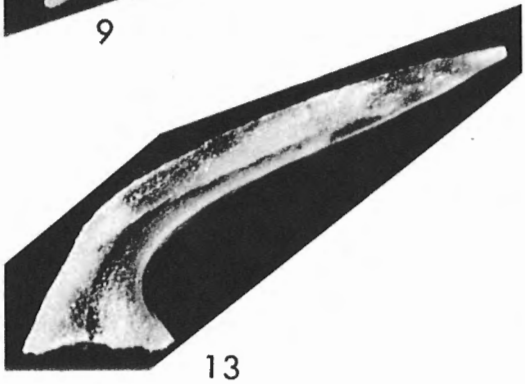
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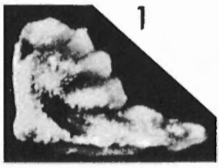
PLATE XX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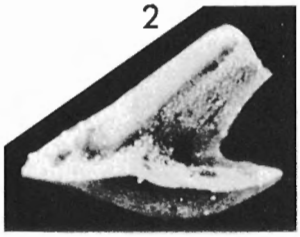
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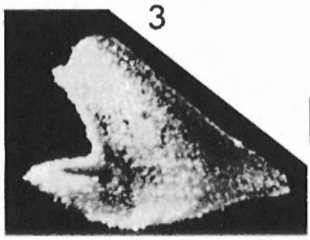
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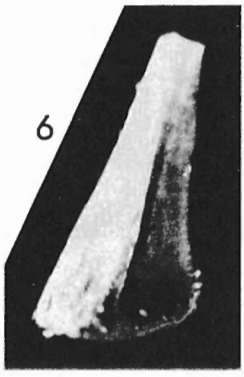
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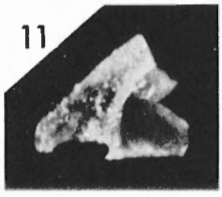
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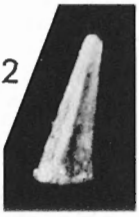
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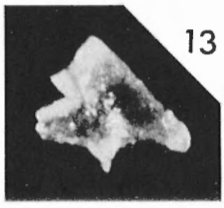
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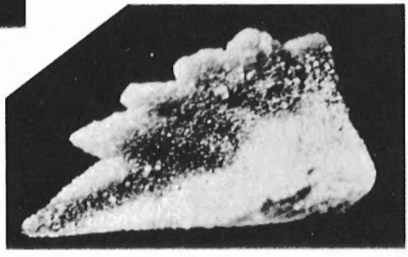
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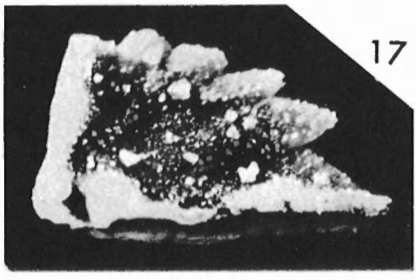
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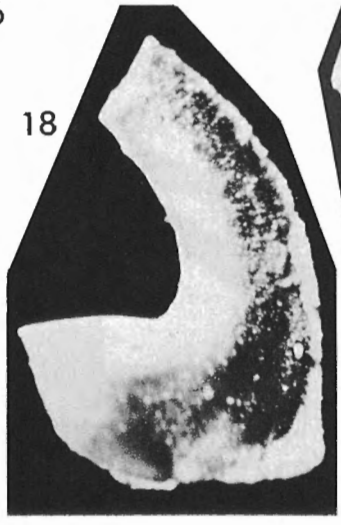
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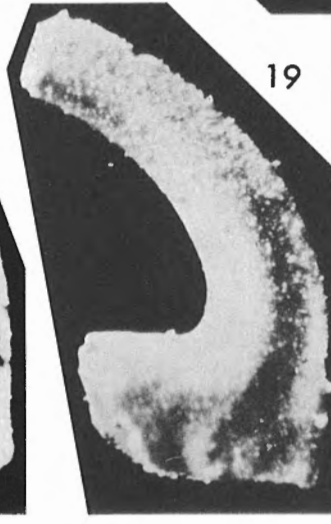
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PLATE XX

Conodonts from the St. George Formation, Newfoundland; specimens coated except as noted.

Figures 1, 4, 15–17. *Loxodus* sp. aff. *L. bransoni* Furnish (PAGE 87)
Lateral views and aboral view (15), x40; sample B; figured specimens, GSC Nos. 24426 (1, 4), 24427 (15, 16, 17).

Figures 2, 3, 7. *Oistodus inaequalis* Pander (PAGE 89)
Lateral views, x40; sample B; hypotypes, GSC Nos. 24429 (2, 3), 24430 (7).

Figures 5, 6, 12. *Ulrichodina prima* Furnish (PAGE 94)
Lateral views and aboral view (5), x40; sample B; hypotypes, GSC Nos. 24452 (5, 6), 24453 (12).

Figures 8–10. *Oepikodus* n. sp. A (PAGE 87),
Lateral views and posterior view (10), uncoated, x60; sample A; figured specimen GSC No. 24428.

Figures 11, 13, 14. *Oistodus "triangularis"* Lindström (PAGE 89)
Lateral views, uncoated, x60; sample B; hypotypes, GSC Nos. 24431 (11, 13), 24432 (14).

Figures 18, 19. *Drepanodus pandus* (Branson and Mehl) (PAGE 85)
Lateral views, x34; sample A; hypotypes, GSC Nos. 24419, 24420.

PLATE XXI

Unless otherwise indicated, all specimens from the Côte Fréchette section; refer to Table II for locality. Magnification as indicated.

Figures 1, 2. *Acontiodus* sp. 1 (PAGE 104)
Posterior and outer lateral views of hypotype, GSC No. 24717, x38; GSC loc. 82749.

Figure 3. *Oistodus multicorrugatus* Harris (PAGE 110)
Lateral view of hypotype, GSC No. 24737, x45; GSC loc. 82742.

Figures 4, 5. *Acontiodus* sp. 2 (PAGE 104)
Posterior and outer lateral views of hypotype, GSC No. 24718, x38; GSC loc. 82740.

Figures 6, 7. *Oistodus venustus* Stauffer (PAGE 110)
Inner lateral views of hypotypes, GSC Nos. 24738 and 24739, both x45; GSC locs. 82740 and 82742, respectively.

Figure 8. *Oistodus inclinatus* Branson and Mehl (PAGE 109)
Lateral view of hypotype, GSC No. 24736, x53; GSC loc. 82750.

Figure 9. *Drepanodus homocurvatus* Lindström (PAGE 107)
Lateral view of hypotype, GSC No. 24727, x30; GSC loc. 82744.

Figures 10, 11. *Acontiodus* sp. 3 (PAGE 105)
Lateral and posterior views of hypotype, GSC No. 24719, x38; GSC loc. 82750.

Figures 12, 13. *Paltodus* sp. (PAGE 111)
Inner and outer lateral views of figured specimen, GSC No. 24741, x45; GSC loc. 82742.

Figures 14, 16. *Panderodus* n. sp. 1 (PAGE 111)
Lateral views of hypotypes, GSC Nos. 24742 and 24743, both x53; GSC loc. 82750.

Figure 15. *Drepanodus suberectus* (Branson and Mehl) (PAGE 107)
Lateral view of hypotype, GSC No. 24728, x45; GSC loc. 82740.

Figure 17. *Polycaulodus* sp. (PAGE 112)
Inner lateral view of figured specimen, GSC No. 24771, x53; GSC loc. 82742.

Figures 18, 19. *Acontiodus robustus* (Hadding) (PAGE 104)
Lateral views of hypotypes, GSC Nos. 24716 and 24715, both x38; GSC loc. 82740.

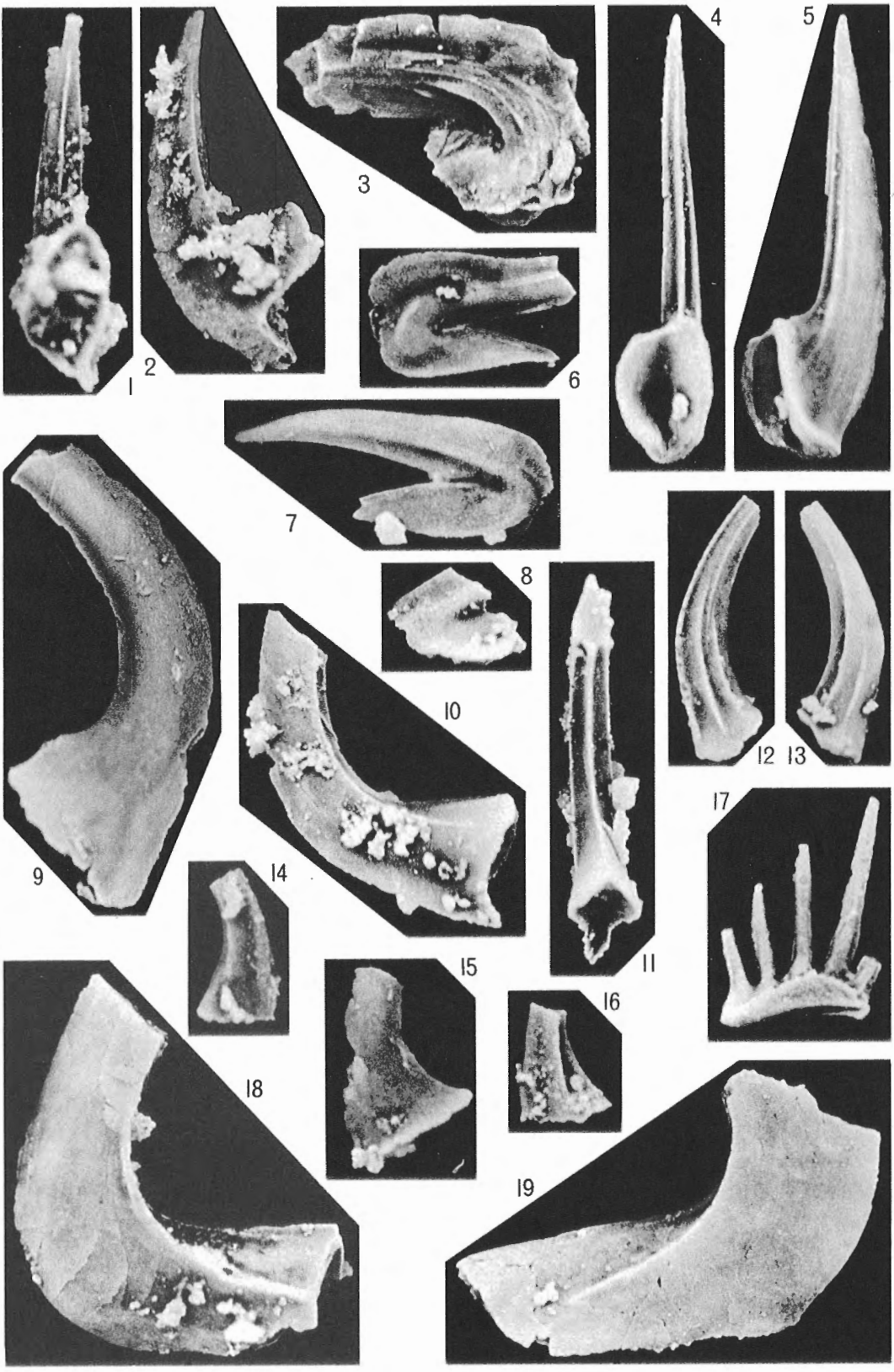
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PLATE XXII

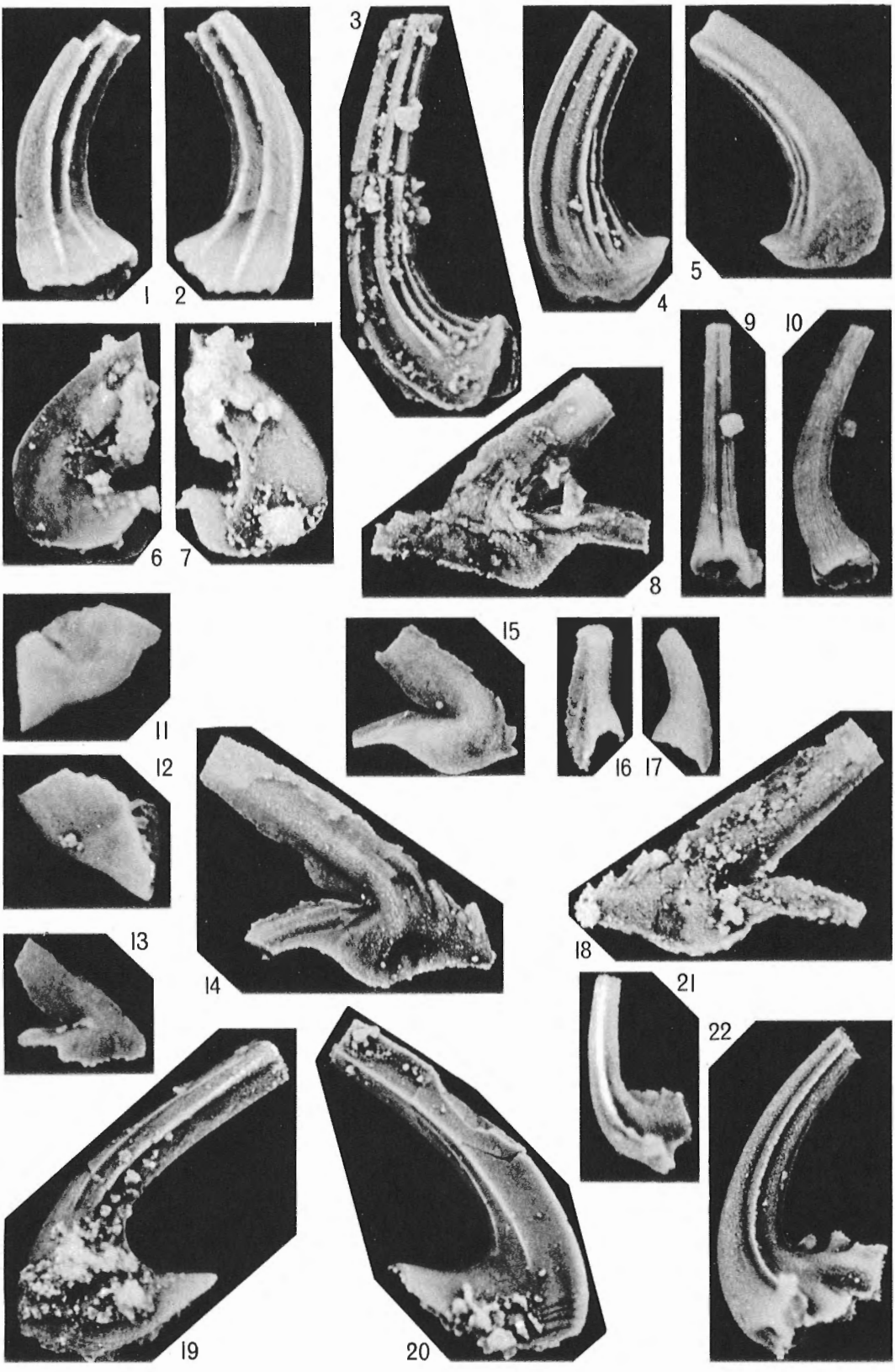

PLATE XXII

Unless otherwise indicated, all specimens from the Côte Fréchette section; refer to Table II for locality. Magnification as indicated.

Figures 1, 2. *Scolopodus* n. sp. 1 (PAGE 116)
Lateral views of hypotype, GSC No. 24764, x53; GSC loc. 82744.

Figures 3–5. *Scolopodus* n. sp. 2 (PAGE 116)
3. Inner lateral view of hypotype, GSC No. 24765, x45; GSC loc. 82749.
4, 5. Inner and outer lateral views of hypotype, GSC No. 24766, x45; GSC loc. 82743.

Figures 6, 7. *Scandodus pipa* Lindström (PAGE 115)
Inner and outer lateral views of hypotype, GSC No. 24762, x45; GSC loc. 82750.

Figures 8, 14, 18. *Falodus prodentatus* (Graves and Ellison) (PAGE 108)
8, 14. Inner lateral views of hypotypes, GSC Nos. 24729 and 24731, both x45; GSC locs. 82742 and 82744, respectively.
18. Outer lateral view of hypotype, GSC No. 24730, x45; GSC loc. 82749.

Figures 9, 10. *Scolopodus gracilis* Ethington and Clark (PAGE 116)
Posterior and lateral views of figured specimen, GSC No. 24763, x53; GSC loc. 82742.

Figures 11, 12. Conodont gen. et sp. indet. (PAGE 118)
Lateral views of figured specimen, GSC No. 24769, x53; GSC loc. 82740.

Figure 13. *Oistodus* sp. cf. *O. abundans* Branson and Mehl (PAGE 109)
Inner lateral view of figured specimen, GSC No. 24735, x53; GSC loc. 82742.

Figure 15. *Falodus* sp. (PAGE 108)
Inner lateral view of figured specimen, GSC No. 24732, x53; GSC loc. 82742.

Figures 16, 17. Conodont undet. (PAGE 119)
Posterior and outer lateral views of figured specimen, GSC No. 24775, x53; from the second conglomeratic unit on Montcalm St., GSC loc. 83354 (12 to 18 feet above base of outcrop).

Figures 19, 20. *Oistodus*? sp. (PAGE 110)
Outer and inner lateral views of figured specimen, GSC No. 24740, x45; GSC loc. 82740.

Figures 21, 22. *Hibbardella* sp. (PAGE 109)
21. Lateral view of figured specimen, GSC No. 24734, x53; GSC loc. 82740.
22. Lateral view of figured specimen, GSC No. 24733, x38; GSC loc. 82743.

PLATE XXIII

Unless otherwise indicated, all specimens from the Côte Fréchette section; refer to Table II for locality. Magnification as indicated.

Figures 1–7. *Periodon aculeatus* Hadding (PAGE 112)

1, 2, 4, 6. Inner lateral views of hypotypes, GSC Nos. 24748, 24744, 24747, and 24745, respectively, all x45; GSC loc. 82750.

3, 5. Inner and outer lateral views of hypotype, GSC No. 24749, x45; GSC loc. 82751.

7. Inner lateral views of hypotype, GSC No. 24746, x45; GSC loc. 82744.

Figures 8, 13. *Prioniodus* sp. aff. *P. evae* Lindström (PAGE 114)

Postero-lateral and antero-lateral views of figured specimens, GSC Nos. 24759 and 24758, both x38; GSC locs. 82743 and 82744, respectively.

Figures 9, 11, 14. *Prioniodina*? n. sp. (PAGE 113)

Inner lateral views of figured specimens, GSC Nos. 24754, 24755, and 24756, all x38; GSC locs. 82744, 82743, and 82744, respectively.

Figures 10, 15. *Periodon flabellum* (Lindström) (PAGE 112)

Inner lateral views of hypotypes, GSC Nos. 24751 and 24750, both x45; GSC loc. 82740.

Figures 12, 16. *Prioniodina macrodentata* (Graves and Ellison) (PAGE 113)

12. Inner lateral view of hypotype, GSC No. 24753, x45; GSC loc. 82740.

16. Inner lateral view of hypotype, GSC No. 24752, x53; GSC loc. 82740.

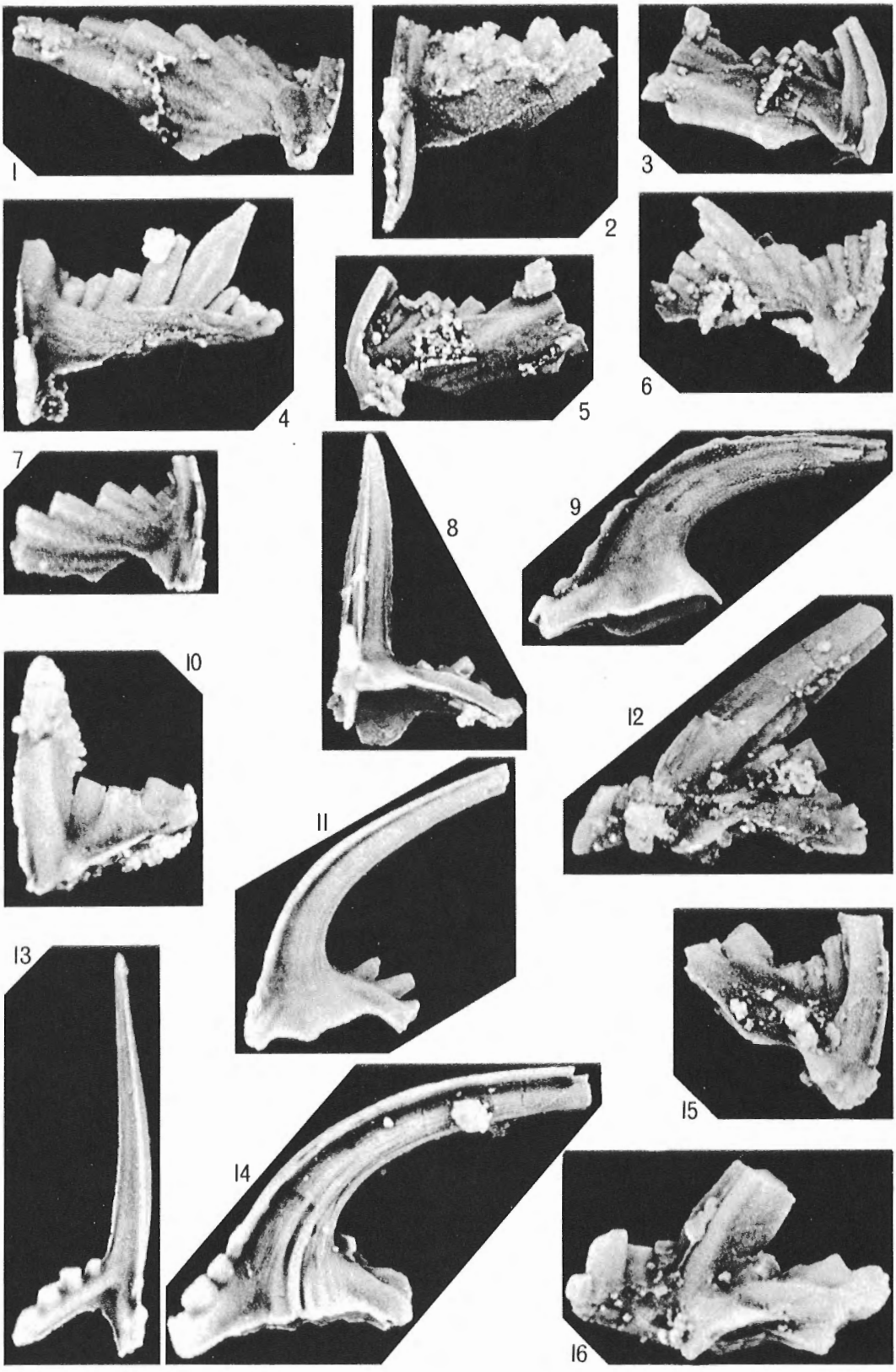
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PLATE XXIV

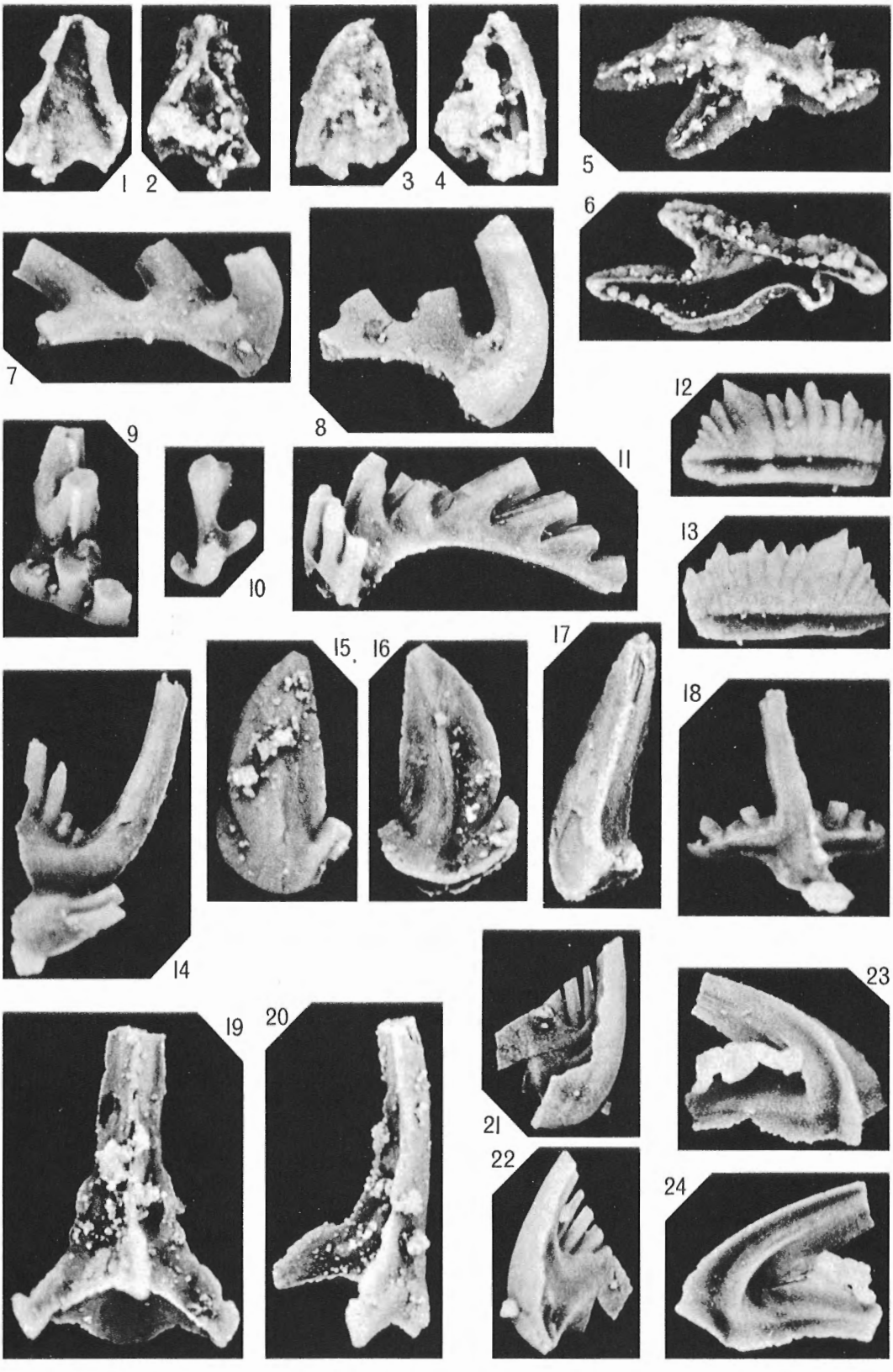

PLATE XXIV

Unless otherwise indicated, all specimens from the Côte Fréchette section; refer to Table II for locality. Magnification as indicated.

Figures 1, 2. *Pygodus* n. sp. 1 (PAGE 114)
Lower and upper views of hypotype, GSC No. 24760, x53; GSC loc. 82750.

Figures 3, 4. *Pygodus* sp. (PAGE 115)
Upper and lower views of figured specimen, GSC No. 24761, x53; GSC loc. 82750.

Figures 5, 6. *Amorphognathus variabilis* Sergeeva (PAGE 106)
Upper and lower views of hypotype, GSC No. 24720, x45; GSC loc. 82740.

Figures 7–11. *Cordylodus spinatus* (Hadding) (PAGE 106)
7, 8. Lateral views of hypotypes, GSC Nos. 24723 and 24722, respectively, both x45; GSC loc. 82740.
9. Upper view of hypotype, GSC No. 24725, x45; GSC loc. 82742.
10. Upper view of hypotype, GSC No. 24726, x53; GSC loc. 82742.
11. Lateral view of hypotype, GSC No. 24724, x38; GSC loc. 82744.

Figures 12, 13. *Spathognathodus* sp. (PAGE 117)
Lateral views of figured specimen, GSC No. 24767, x53; GSC loc. 82742.

Figure 14. "*Eoligonodina*" sp. (PAGE 108)
Lateral view of figured specimen, GSC No. 24770, x45; GSC loc. 82740.

Figures 15, 16. *Chosonodina* n. sp. 1 (PAGE 106)
Anterior and posterior views of hypotype, GSC No. 24721, x45; GSC loc. 82740.

Figure 17. *Acodus* sp. (PAGE 119)
Lateral view of figured specimen, GSC No. 24772, x45; from the third conglomeratic unit on Montcalm St., GSC loc. 83355 (18 to 23.5 feet above base of outcrop).

Figure 18. *Prioniodus* sp. aff. *P. evae* Lindström (PAGE 114)
Anterior view of figured specimen, GSC No. 24757, x45; GSC loc. 82744.

Figures 19, 20. *Trichonodella* n. sp. 1 (PAGE 117)
Posterior and lateral views of hypotype, GSC No. 24768, x45; GSC loc. 82740.

Figures 21, 22. *Periodon aculeatus* Hadding (PAGE 119)
Lateral views of hypotype, GSC No. 24774, x45; from the second conglomeratic unit on Montcalm St., GSC loc. 83354 (12 to 18 feet above base of outcrop).

Figures 23, 24. *Oistodus lanceolatus* Pander (PAGE 119)
Lateral views of hypotype, GSC No. 24773, x45; from the third conglomeratic unit on Montcalm St., GSC loc. 83355 (18 to 23.5 feet above base of outcrop).