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Biotic Recovery of Conodonts following the End-Ordovician Mass Extinction

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Appendix A: Systematic Palaeontology

A.1 Introduction

A.1.1 Descriptive terminology
A.1.2 Element notation
  A.1.2a Ramiform and pectiniform genera
  A.1.2b Coniform and rastrate genera
A.1.3 Synonymy lists

A.2 Ramiform and pectiniform taxa

Order Ozarkodinida Dzik, 1976
Order Prioniodinida Sweet, 1988
Order Prioniodontida Dzik, 1976

A.3 Coniform and rastrate taxa

Order Belodellida Sweet, 1988
Order Panderodontida Sweet, 1988
Order Panderodontida Sweet, 1988
Order Unknown

A.4 Plates

Appendix B: Abundance tables and percentages

B.1 Anticosti Island

Point Laframboise (AI 1) and Lac Wickenden Road sections (AI 17a)
Abundance Charts
Percentages
Cap a l’Aigle section (AI 2).
Abundance Charts
Percentages
Beescie, Merrimack and Gun River Formations at various localities.
Abundance Charts B5
Percentages B6
Gun River and Jupiter Formations at various localities. B7
Abundance Charts B7
Percentages B8
Upper Jupiter and Chicotte Formations at Brisants Jumpers (AI5) and other localities. B9
Abundance Charts B9
Percentages B10

B.2 Lake Timiskaming B11
Abundance Charts B11
Percentages B12

B.1 Prongs Creek B13
Transitional Limestone Unit. B13
Abundance Charts B13
Percentages B14
Road River Group. B15
Abundance Charts B15
Percentages B16

Appendix C: Localities and conodont samples C1

C.1 Introduction C1

C.2 Sampling areas C2

C.2.1 Anticosti Island (Québec) C2
C.2.1a Samples collected during field work C3
C.2.1b Samples collected during the Third International Brachiopod Congress Field Trip, Anticosti Island (Led by P. Copper & J. Jisuo) C7

C.2.2 Lake Timiskaming (Ontario) C10

C.2.3 Prongs Creek (northern Yukon Territories) C14

Appendix D: Sample preparation and collections studied D1
D.1.1 Sample Preparation at the University of Durham D1
D.1.2 Sample Preparation at the Geological Survey of Canada D1

D.2 Collections viewed D2

D.3 Samples On Loan D3
Appendix A

Systematic Palaeontology

A.1 Introduction

A.1.1 Descriptive terminology
A.1.2 Element notation
A.1.2a Ramiform and pectiniform genera
A.1.2b Coniform and rastrate genera
A.1.3 Synonymy lists

A.2 Ramiform and pectiniform taxa

Order Ozarkodinida Dzik, 1976
Order Prioniodinida Sweet, 1988
Order Prioniodontida Dzik, 1976

A.3 Coniform and rastrate taxa

Order Belodellida Sweet, 1988
Order Panderodontida Sweet, 1988
Order Panderodontida Sweet, 1988
Order Unknown

A.4 Plates
Appendix A

Systematic Palaeontology

A.1 Introduction

Conodonts can be divided into two informal groups, those with apparatuses largely composed of ramiform / pectiniform elements and those with coniform / rastrate elements. The systematic descriptions that follow have been divided into these two main groupings to enable the comparison of similar apparatuses.

Within the two main groupings, the conodont genera will be discussed within a suprageneric framework. The conodont suprageneric classification is currently unstable and is continually being revised. Major revisions have been undertaken by Sweet (1988), Dzik (1991) and most recently by Aldridge & Smith (1993).

A.1.1 Descriptive terminology

A standard scheme for the description of element morphology has been developed by Sweet (1981b, 1988) and has been utilised herein.

A.1.2 Element notation

A.1.2a Ramiform and Pectiniform genera

The notational scheme suggested by Sweet & Schönlaub (1975; modified by Cooper, 1975), relates element morphology to probable location within the apparatus. This scheme is widely used in Silurian conodont taxonomy and has been assumed herein. The addition of subscripts (e.g. Pa_1 and Pa_2) to this
notational scheme occur when multiple pairs of elements are present within an apparatus (suggested by Armstrong, 1990). The standard Sweet & Schönlaub (1975) scheme was extended by Aldridge et al. (1995) following the description of prioniodontid bedding plane assemblages. In wake of that study, the descriptions of prioniodontids herein will include Pc and Pd elements.

The element notation Sd has been previously used to describe asymmetrical quadriramate elements. However, in apparatus reconstructions from bedding plane assemblages an Sd position does not exist. In the Promissium reconstruction a four processed element occupies an Sb₂ position (Purnell & Donoghue, 1998). Therefore, herein the term Sd will not be used.

A.1.2b Coniform and Rastrate genera

Coniform genera have apparatuses consisting of conical elements lacking denticulated margins (exceptions include serrate elements of Panderodus). Rastrate genera are distinguished as consisting of conical elements, which have denticles on the concave posterior margin of the cone.

Barnes et al. (1979) described three morphotypes (p, q, r) within coniform apparatuses, based upon the degree of element curvature. This scheme was modified by Armstrong (1990), who subdivided the p and q categories based on variation in cusp cross section. These schemes were based on element morphology and were not compared to the locational scheme used for ramiform genera.

Sansom et al. (1995) proposed a locational and shape category scheme based upon the analysis of bedding planes and clusters of Panderodus. This scheme is preferred to the premature application of ramiform nomenclature to coniform taxa (see discussion in Sansom et al., 1995).
A notational scheme now exists for coniform and rastrate elements, which relates element morphology to probable location within the bauplan (see remarks in coniform and rastrate section).

A.1.3 Synonymy lists

The synonymy lists are abbreviated, containing only the original species designation, subsequent important taxonomic reviews and the most recent comprehensive synonymy list. The lists are annotated as advised by Matthews (1973, after Richter, 1948).
A.2 Ramiform and Pectiniform taxa

Phylum CHORDATA Bateson, 1886

Class CONODONTA Eichenberg, 1930

Remarks. Sweet (1988) regarded the ozarkodinid apparatus as comprising six or seven morphotypes, with carminate and angulate pectiniform (or platformed equivalents) elements in the P positions. The three dimensional apparatus plan of ozarkodinids has been studied by Schmidt (1934), Rhodes (1952), Nicoll (1985, 1987, 1995), Dzik (1991), Aldridge et al. (1987) and Purnell & Donoghue (1998). The most recent apparatus reconstruction consists of 15 elements, including paired Pa, Pb and M elements, a single symmetrical Sa element and four pairs of asymmetrical S elements (Sb₁, Sb₂, Sc₁, Sc₂), which differ in the degree of asymmetry. Multiple Sb and Sc elements have not been differentiated within any of the Ozarkodinida genera studied herein.

Figure A.1 The ozarkodinid apparatus redrawn from Aldridge et al. (1995).
Family Kockelellidae Klapper, 1981

Remarks. Sweet (1988) regarded Kockeella Walliser as the type genus of the Kockelellidae. The Kockeella apparatus is characterised by carminiscaphate to stelliscaphate Pa and angulate Pb elements. Within this family, Sweet (1988) also included the genus Ancoradella Walliser, which is thought to have descended from K. variabilis Walliser.

Aulacognathus Mostler included within the Pterospathodontidae Cooper by Sweet (1988), but subsequently placed in the Kockelellidae by Aldridge & Smith (1993). The Pa elements of Aulacognathus more closely resemble the corresponding elements of younger species of Kockeella, which have well-developed lateral processes. However, the M and S elements differ between the two genera, in Kockeella they commonly bear discrete denticles separated by wide, u-shaped gaps, whereas in Aulacognathus S elements commonly bear fused denticles, apart from A. aff. A. bullatus (see below).

Genus Aulacognathus Mostler, 1967

Type species. Aulacognathus kuehni Mostler, 1967.

Diagnosis. Refer to Armstrong (1990, p. 62)

Remarks. The Aulacognathus apparatus includes six morphotypes (Pa, Pb, M, Sa, Sb, Sc). This genus is characterised by a stelliscaphate Pa element, with a free anterior process, an inwardly bent posterior process and irregularly ornamented inner and outer-lateral processes (Armstrong, 1990). Species of Aulacognathus are traditionally differentiated by variation in the morphology and ornamentation of the Pa element.

Bischoff (1986) identified five previously unknown species of Aulacognathus in the Lower Silurian of New South Wales. He diagnosed these new species
based on variations in the ornamentation and morphology of the Pa element. Simpson (1995) suggested that *A. antiquus* Bischoff represents a juvenile or aberrant form of another species.

*Aulacognathus bullatus* (Nicoll & Rexroad, 1969)

Pl. 1, figs 1-7; Pl. 2, figs 1,2

* 1969  *Neospathognathodus bullatus* Nicoll & Rexroad, p. 44, pl. 1, figs 5-7.
1990  *Aulacognathus bullatus* (Nicoll & Rexroad); Armstrong, p. 63, pl. 6, figs 1-2, 4-7.

**Holotype.** *Neospathognathodus bullatus* Nicoll & Rexroad, 1969, pl. 1, fig. 5 Specimen from the Lee Creek Member of the Brassfield Limestone, Indiana, U. S. A.

**Diagnosis.** Refer to Armstrong (1990, p. 64)

**Description.** Refer to the description of *A. bullatus* in Armstrong (1990, p. 62-65)

**Remarks.** This is a species of *Aulacognathus* with a Pa element that has lateral processes, which are free distally, directed anteriorly and are densely ornamented with nodes. Nicoll & Rexroad (1969) observed that a posterior-outer-lateral process was sometimes developed. If the above characteristics are broadly taken as the diagnostic features of *A. bullatus*, then *A. angulatus* Bischoff, *A. antiquus* Bischoff, *A. bifurcatus* Bischoff and *A. liscombensis* Bischoff may represent ecophenotypic variations of *A. bullatus*. 
The Pa element was first described by Nicoll & Rexroad (1969) and the Pb element was associated with the Pa element by Uyeno & Barnes (1983). Armstrong (1990) reconstructed a full apparatus.

**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario; Jupiter (Pavillion Member) and Chicotte Formations, Anticosti Island, Québec; Road River Group, Prongs Creek, northern Yukon.

*Aulacognathus aff. A. bullatus.*

Pl. 1, figs 8-14

**Description.** Pa element. Stelliscaphate, with a free anterior process, an inwardly bent posterior process and anteriorly directed inner and outer-lateral processes. The outer lateral process is better developed than the inner and may bifurcate. Ornamentation on the lateral processes varies between rounded nodes and ridges. The carina bears at least six denticles on the posterior process and 11 on the anterior process. The prominent cusp is tall and broad. The proximal anterior denticles are also broad. Posterior denticles decrease in height distally, whereas the anterior denticles are irregular in height, but in general they decrease in height distally. The blade is thickened below the dentine row. The lower surface is shallowly excavated.

Pb element. Anguliscaphate, the posterior and anterior processes bear at least six and four denticles, respectively. The short inner-lateral process commonly bears only two denticles. The cusp is triangular with a wide base. The triangular denticles may be fused at the base or separated by v-shaped gaps. Some rare, possibly aberrant, specimens have wide u-shaped gaps between the denticles and an adenticulate lateral process. The blade is thickened below the dentine row. The entire lower surface is excavated.

M element. Modified tertiopedate, the inner-lateral process bears at least seven denticles, the outer is shorter and bears two denticles and is more steeply
inclined. The cusp is wide, tall and antero-posteriorly compressed with a posterior swelling at its base. The denticles on both processes are triangular and separated by narrow u-shaped gaps. The blade is thickened below the denticle row. The basal cavity is widest beneath the cusp and continues as tapering grooves along the lateral processes.

Sb element. Tertiopedate, with an inner-lateral process bearing four denticles and a shorter outer-lateral process bearing at least three denticles. There is a posterior swelling of the cusp. The denticles are upright, triangular and fused at the base. The blade is thickened below the denticle row.

Sc element. Bipennate, with a posterior and anterior process bearing at least five and three denticles, respectively. The posterior process is almost straight and the anterior process is downwardly directed. The denticles are triangular and separated by narrow u-shaped gaps. The blade is thickened below the denticle row.

**Remarks.** This is the oldest species of *Aulacognathus* ever recovered. *A. aff. A. bullatus* is likely to be the ancestor to the later species of *Aulacognathus*, which first appear within or just below the *celloni* CBZ. The Pa elements of *A. aff. A. bullatus* are similar to those of *A. bullatus* (Nicoll & Rexroad). The latter younger species differs in having fused denticles, rather than the discrete denticles seen in *A. aff. A. bullatus*

**Occurrence.** Transitional limestone, Prongs Creek, northern Yukon.

*Aulacognathus kuehni* Mostler, 1967

Pl. 2, figs 4,5

* 1967 *Aulacognathus kuehni* Mostler, p. 301, pl. 1, figs 12-15, 21, 24, 25.
1972 *Aulacognathus kuehni* Mostler; Aldridge, p. 167-168, pl. 2, fig. 6.
1977 *Aulacognathus kuehni* Mostler; Klapper, p. 61-62, pl. 1, figs 4, 7.
1986  *Aulacognathus kuehni* Mostler, Bischoff, p. 173, pl. 5, figs 10-16.

**Holotype.** *Aulacognathus kuehni* Mostler, 1967, p. 301, pl. 1. Specimen from the Kitzbuhl, Austria.

**Diagnosis.** Refer to Bischoff (1986, p. 173)

**Description.** Pa element. Refer to the description of *A. kuehni* in Aldridge (1972, p. 167).

Sc element. Bipennate with a straight posterior process and a downwardly directed anterior process. Both processes bear at least four badly broken denticles. The processes have a broad base.

**Remarks.** The Pa element of *A. kuehni* has an anteriorly directed outer-lateral lobe, and a trilobed inner platform. The Pa element depicted by Over & Chatterton (1987a, pi. 3, fig. 20) is atypical as it lacks three lobes on the inner platform.

The Pa element was described by Mostler (1967). Klapper (1977) suggested that *A. ceratoides* Nicoll & Rexroad represented the Pb of this apparatus and Bischoff (1986) emended the diagnosis to include this element. The Sc element herein, is the first to be described in association with *A. kuehni*. The denticles are thicker and the anterior process is less downwardly and inwardly directed than the Sc elements of *A. bullatus*.

**Occurrence.** Road River Group, Prongs Creek, northern Yukon.
Appendix A
Systematic Palaeontology

Aulacognathus sp. A
Pl. 2, figs 6-8

Remarks. The Pa element has a sub-circular, basal cavity flare, and lacks the lateral processes characteristic of Aulacognathus. This species has been classified within Aulacognathus, as the Sb and Sc elements associated with the Pa element are similar to those of species of Aulacognathus. The Sb and Sc elements bear slender denticles and have very broad bases. The cusp on the Sc element is much taller and the base thicker than the corresponding elements of A. bullatus herein. This species may represent an aberrant form of another species, such as A. bullatus.

Occurrence. Thomloe Formation, Lake Timiskaming, Ontario.

Genus Kockelella Walliser, 1964

Type species. Kockelella variabilis Walliser, 1957.

Diagnosis. Refer to Barrick & Klapper (1976, p. 72).

Remarks. The Pa element is characteristically carminiscaphate with an 'even-crested' anterior process and a shorter posterior process with smaller denticles, which decline in height distally (Sweet, 1988). The Pa element bears fused denticles, whereas the Pb, M and S elements bear discrete denticles, separated by wide, u-shaped gaps (Armstrong, 1990).

Species of Kockelella are differentiated by the morphology of the Pa element. In the early Llandovery, the posterior process is inwardly deflected (Armstrong, 1990), whereas in the upper Llandovery this process is reduced and the element has a large, circular basal cavity (Sweet, 1988).
Kockelella manitoulinensis (Pollock, Rexroad & Nicoll, 1970)

Pl. 3, figs 1,2


v 1981 Spathognathus manitoulinensis Pollock et al.; McCracken & Barnes, p. 90, pl. 7, fig. 19.

1990 Kockelella manitoulinensis Pollock et al.; Armstrong, p. 77, pl. 9, fig. 4-14.


Diagnosis. Refer to Armstrong (1990).

Description. Pa element. This element has been previously described by Armstrong (1990, p. 77). The posterior process is inwardly deflected at an angle of approximately 130° from the anterior process. The anterior process bears six to seven denticles; the most distal anterior denticle is smaller and lacks white matter. The posterior process bears up to six denticles. The denticles on both processes are sub-equal in height and width, and are fused almost to their tips. The processes are thickened beneath the denticle row. White matter distribution varies between specimens; in some samples, the denticles are completely filled with white matter and others are only partially filled.

Pb element. Refer to the description by Armstrong (1990, p. 77).

Remarks. A species of Kockelella in which the Pa element has an inwardly deflected posterior process (Armstrong, 1990) and no lateral processes. The Pa
elements were first described by Pollock et al. (1970). The multielement reconstruction was produced by Armstrong (1990).

McCracken & Barnes (1981) regarded the denticulation, cusp shape, and basal flare of the Pa elements of *K. manitoulinensis* and *O. oldhamensis* (Rexroad) as very similar. They recovered transitional forms between the two species, implying that *K. manitoulinensis* is a descendant of *O. oldhamensis*. However, the morphological similarity may be coincidental (Armstrong, 1990, p. 78). The Pa elements of *O. oldhamensis* from Prongs creek (northern Yukon) have thin, relatively long, posteriorly inclined, anterior denticles and an anterior upper margin, which is not even-crested. The above characteristics are all atypical of species of *Kockelella*.

Armstrong (1990) suggested that the process orientation, basal cavity morphology and white matter distribution of the Pa elements of *K. manitoulinensis* and *Ctenognathus pseudofissilis* Lindström were similar. However, the Pb elements of the two species differ in the fusion of the denticles (Armstrong, 1990). Aldridge & Smith (1993) tentatively placed *C. pseudofissilis* Lindström as the first known representative of the Kockellidae. The upper surface of the *C. pseudofissilis* elements figured by Lindström (1959) are even-crested and it, therefore, seems likely that *K. manitoulinensis* is a descendant of *C. pseudofissilis*.

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario; Ellis Bay (Laframboise Member) and Becscie Formations, Anticosti Island.

*Kockelella ranuliformis* (Walliser, 1964)

Pl. 3, figs 3-5

* 1964 *Spathognathodus ranuliformis* Walliser, p. 82, taf. 6, fig. 9, taf. 22, fig. 5-7.
Appendix A  

Systematic Palaeontology  

1976  
*Kockelella ranuliformis* (Walliser); Barrick & Klapper, p. 76, pl. 2, figs 1-11.

1995  
*Kockelella ranuliformis* (Walliser); Simpson & Talent, p. 135-137, pl. 6, figs 1-7.

**Holotype.** *Spaethognathodus ranuliformis* Walliser, 1964, taf. 22, fig. 5. Specimen Wa 744/10 from Bed 11 C, Cellon, Carnic Alps, Austria.

**Diagnosis.** Refer to Barrick & Klapper (1976, p. 76).

**Description.** Pa element. This carminiscaphate element has been previously described by Barrick & Klapper (1976, p. 76). Herein, the anterior portion of the blade bears nine or 10 denticles, whereas the shorter posterior portion bears three denticles. The most distal posterior denticle may be slightly inwardly offset from the carina. In lateral view, the basal margin is arched below the cusp, and straight beneath the anterior blade. White matter distribution varies between specimens, the denticles and cusp being completely or partially filled.

Pb element. Refer to the description in Barrick & Klapper (1976, p. 76).

**Remarks.** A species of *Kockelella* with a Pa element that has a round basal cavity, and lacks lateral processes (Barrick & Klapper, 1976). A full apparatus reconstruction of *K. ranuliformis* was developed by Barrick & Klapper (1976).

**Occurrence.** Jupiter (Pavillion Member) and Chicotte Formations, Anticosti Island, Québec.

*Kockelella* sp. A (Over & Chatterton, 1987a)  
Pl. 4, figs 1-7

1987a  
*Spaethognathus* sp. A s.f. Over & Chatterton, p. 27, pl. 6, figs 26-27.
Remarks. This species of *Kockelella* has an inwardly deflected posterior process and an outer-lateral process, which meet at an angle greater than 90°. The Pa element has been fully described by Over & Chatterton (1987a, p. 27). A partial apparatus has been recovered, including Pa, Pb, M, Sb and Sc elements. The Pb, M and S elements have fused denticles, which differs from the discrete denticles seen in the elements of *K.* sp. B

Pa elements were recovered from the *amorphognathoides* CBZ of Avalanche Lake (Mackenzie Mountains, Northwest Territories) by Over & Chatterton (1987a). They suggested that *K.* sp. A was a descendant of *K. manitoulinensis*.

Occurrence. Thornloe Formation, Lake Timiskaming, Ontario.

*Kockelella* sp B.

Pl. 3, figs 6-11

Description. Pa element. Pastiniscaphate, with a straight anterior process, an inwardly directed posterior process and an outer-lateral process. The anterior blade bears eight to 12 denticles, which are sub-equal in height. In upper view, the outer-lateral process and the posterior process meet at an angle of 90°. The posterior process is lower than the anterior process and bears up to six denticles, which decrease in height distally. The outer-lateral process is taller than the posterior process, but shorter than the anterior process. It bears at least six sub-equal denticles. In some specimens the anterior process is directed downwards. The cusp is a similar height and width to the anterior-proximal denticles. The denticles on all processes are fused and upright. The basal cavity is widest beneath the cusp. In rare specimens, there is a small sub-rounded basal flare. The basal cavity extends as grooves along the processes.

Pb element. Angulate, in which the anterior and posterior processes meet at an angle of approximately 120°. The posterior process bears up to six denticles, that are smaller and thinner than the anterior denticles, which number at least
four. The denticles on both processes are fused. The basal cavity is circular beneath the cusp and extends as tapering grooves along both processes, but does not reach to the tips of the processes. White matter entirely fills the cusp and denticles.

M element. Modified tertiopedate, with two lateral processes that meet at an angle of 120°. The long, lateral process is straight and bears five discrete denticles. The shorter, lateral process is downwardly directed and bears only two denticles. The denticles on both processes are divided by u-shaped gaps. There is a posterior swelling at the base of the cusp. White matter entirely fills the cusp and denticles.

Sa element. Alate, in which the two lateral processes meet at an angle of 115°. Both processes bear at least five denticles. The denticles are fused at the base. The basal cavity is circular beneath the cusp and extends as tapering grooves part way along both processes. White matter entirely fills the cusp and denticles.

Sb element. Tertiopedate, with at least six denticles on each lateral process. The denticles are fused at the base. The posterior edge of the basal cavity is upturned. The basal cavity is circular beneath the cusp and extends as tapering grooves along both processes, not reaching the tips of the processes. White matter entirely fills the cusp and denticles.

Sc element. Bipennate, with a straight posterior process and a downwardly directed anterior process. The processes bear at least three denticles. On the posterior process they are widely spaced whereas on the anterior process they are partially fused.

Remarks. The generic assignment may be questioned as the Pa elements do not have an even-crested lateral process. This species differs from K. sp. A (Over & Chatterton) in that the angle between the two lateral processes is less.
The denticulation is less regular on *K*. sp. B, whereas on the Pa of *K*. sp. A it is even crested. In addition, the M and S elements found associated with *K*. sp. A have fused denticles, whereas the M and S elements of *K*. sp. B bear discrete denticles.

**Occurrence.** Earlton Formation, Lake Timiskaming, Ontario.

**Family** Spathognathodontidae Hass, 1959

**Remarks.** Sweet (1988) considered spathognathodontids to have an apparatus containing six or seven morphotypes, with carminate and angulate elements in the P positions, dolabrate or bipennate M elements, and alate, digyrate and bipennate elements in the Sa, Sb and Sc positions.

**Genus** *Ozarkodina* Branson & Mehl, 1933

**Type Species.** *Ozarkodina typica* Branson & Mehl, 1933.

**Diagnosis.** Refer to Barrick & Klapper (1976, p. 78).

**Remarks.** Species of *Ozarkodina* are characterised by carminate and angulate P elements. They vary in the morphology of the P and M elements, but have similar S elements. The species recovered herein can be divided into 'types' by Pa and M element morphology:

Type I: Short Pa elements with an arched upper margin. Dolabrate M element, with a straight posterior process: *O. pirata*, *O. polinclina*.  

Type II: A long Pa element with an almost straight upper margin. Tertiopedate M element, with a downwardly directed inner-lateral process: *O. oldhamensis*, *O. hassi*, *O. masurensis*, *O. gulletensis*, *O. excavata sensu* Jeppsson.
Appendix A

Systematic Palaeontology

Type III: A long Pa element with an almost straight upper margin. A modified tertiopedate M element, with an almost straight inner-lateral process and a short, denticulate outer-lateral process: *O. aldridgei*.

Type IV: A Pa element with wide, sub-equal denticles. Modified tertiopedate M element, with an almost straight inner-lateral process and a short, denticulate outer-lateral process: *O. protoexcavata*.

Type II and Type III have similar Pa elements, but different M elements, whereas Type III and IV have similar M elements, but different Pa elements. The evolutionary relationships between the 'types' depends upon whether it is the M element morphology, Pa element morphology or denticulation pattern which is the common feature of a lineage.

Orchard (1980) suggested that the Ordovician species *C. pseudofissilis* was ancestral to the Silurian ozarkodinids. However, *C. pseudofissilis* is more likely to represent the ancestor of *Kockelella*.

*O. cf. O. hadra* of Armstrong (1990) occurs in the *celloni* CBZ in Greenland. *O. cf. O. hadra* lacks the even-crested upper margin of *Kockelella*, but has more features in common with *Kockelella* than *Ozarkodina*. The Pa of this species is similar to an element of *Kockelella* sp. A. from Lake Timiskaming (Ontario). The Sa and Sb elements are particularly similar to those of *K. sp. A.* and the M element of *O. cf. O. hadra* is atypical of *Ozarkodina*.

*Ozarkodina aldridgei* Uyeno & Barnes, 1983

Pl. 5, figs 1-4

1972 *Spathognathodus* n. sp. B, Aldridge, p. 216, pl. 4, fig. 5.

*v 1983 *Ozarkodina aldridgei* Uyeno & Barnes, p. 20, pl. 3, figs 16-24; pl. 8, fig. 20.
Appendix A

Systematic Palaeontology

1985  **Ozarkodina aldridgei** Uyeno & Barnes; Aldridge, p. 80, pl. 3.1, figs 24(a), 24 (b).

1995  **Ozarkodina aldridgei** Uyeno & Barnes; Simpson & Talent, p. 139-140, pl. 7, fig. 1.

**Holotype.** **Ozarkodina aldridgei** Uyeno & Barnes, 1983, pi. 3, fig. 17. Specimen GSC 64918 from the Jupiter Formation, Anticosti Island, Québec, Canada.

**Diagnosis.** Refer to Aldridge (1985, p. 80).

**Description.** Pa element. This element has been previously described as *Spathognathodus* sp. nov. B by Aldridge (1972, p. 216).

Pb element. Angulate, with a posterior process bearing four denticles and a slightly shorter, higher anterior process, which bears three to four denticles. The cusp is twice the height and width of the denticles and there is a u-shaped gap separating it from the first posterior denticle. The cusp and denticles are laterally compressed. The denticles are separated by u-shaped gaps on the posterior process and v-shaped gaps on the anterior process. The basal cavity is widest beneath the cusp due to an extension of the inner-lateral lip. The cavity continues as a narrow groove to the tips of the processes. White matter entirely fills the cusp and denticles.

M element. Refer to the description of *Neoprioniodus multiformis* Walliser in Aldridge (1972, p. 195).

Sb element. Tertiopedate, with a long, slender cusp, which may be ornamented with longitudinal striations. The denticles are very small proximally, but increase in height and width distally. They are upright and partially fused. The base of the element is very broad. There is a small basal cavity beneath the cusp extending as tapering grooves along the processes.
Sc element. Bipennate, with an inwardly bowed and downwardly directed, anterior process and a straight posterior process. The only example recovered bears at least four denticles on the anterior process and at least five on the anterior process. The cusp and denticles are laterally compressed and completely filled with white matter. The thin basal cavity extends beneath the processes and is only slightly wider beneath the cusp.

Remarks. The Pa element of *O. aldridgei* has a straight blade bearing sub-equal denticles, fused above the basal cavity. The basal-cavity lips extend to produce a wide, sub-circular basal-cavity flare. Uyeno & Barnes (1983) erected *O. aldridgei*, but did not write a diagnosis or describe the elements in detail. The multielement reconstruction figured by Uyeno & Barnes (1983) is followed herein.

Occurrence. Jupiter Formation (Ferrum Member), Anticosti Island, Québec.

*Ozarkodina excavata* (Branson & Mehl, 1933) *sensu* Jeppsson.

Pl. 5, figs 5-9

1933 *Ozarkodina simplex* Branson & Mehl, p. 52, pl. 3, figs 46, 47.
1933 *Prioniodus excavatus* Branson & Mehl, p. 45, pl. 3, figs 7, 8.
1971 *Neoprioniodus excavatus* Branson & Mehl; Rexroad & Craig, p. 692, pl. 80, figs 6-9.
1974 *Hindeodella excavata* Jeppsson, pl. 4, figs 1-17.
1976 *Ozarkodina excavata excavata* (Branson & Mehl); Barrick & Klapper, p. 78-79, pl. 4, figs 13-23, 26.
1985 *Ozarkodina excavata excavata* (Branson & Mehl); Savage, p. 722, fig. 14, A-L.
Neotype. *Neoprioniodus excavata* Branson & Mehl; Rexroad & Craig, 1971, pl. 80, fig. 7. Specimen from sample 2, Bainbridge Formation, Lithium, Missouri, U. S. A.

**Diagnosis.** Refer to Jeppsson (1974, p. 29).

**Description.** Refer to Jeppsson (1974, p. 29-).

**Remarks.** Jeppsson (1974) reconstructed the multielement apparatus of this species. The elements found herein are similar to those depicted by Barrick & Klapper (1976) and Savage (1985).

**Occurrence.** Chicotte Formation, Anticosti Island, Québec.

*Ozarkodina gulletensis* (Aldridge, 1972)

Pl. 6, figs 1-5

1965 *Spathognathodus cf. celloni* Walliser; Brooks & Druce, p. 377, pl. 12, figs 2, 3.

* 1972 *Spathognathodus gulletensis* Aldridge, p. 212-213, pl. 4, figs 9-12.

1975 *Ozarkodina gulletensis* (Aldridge), Aldridge, pl. 2, figs 7, 8.

1980 *Ozarkodina gulletensis* (Aldridge); Helfrich, p. 568, pl. 2, figs 21-24, 26-29.

v 1983 *Ozarkodina gulletensis* (Aldridge); Uyeno & Barnes, p. 21, pl. 4, figs 11-14, 16, 17, 19.

**Holotype.** *Spathognathodus gulletensis* Aldridge, 1972, pl. 4 fig. 9. Specimen X.577, from the Wych Formation, Gullet Quarry, Welsh Borderlands, Britain.

**Diagnosis.** The Pa element has been diagnosed by Aldridge (1972, p. 212).
Description. Pa element. This carminate element has been previously described as *Spathognathodus gulletensis* by Aldridge (1972, p. 212-213). The specimens herein bear five to eight denticles on the anterior process and four to eight posterior denticles; they decline in height and are inclined distally. In rare specimens the inner lip of the basal cavity is extended to produce a short inner-lateral process bearing one denticle. White matter distribution is variable. It may fill each denticle from the root to the tip, or only to mid-height. Submerged blocks of white matter are often seen especially adjacent to the cusp. The base of the white matter defines an upwardly inclined line, which is furthest from the basal margin at the distal tip of the anterior process.

Pb element. This angulate element has been described as *O. alisonae* by Aldridge (1972, p. 198-199). In the specimens herein, the processes meet at an angle of approximately 120-130°. In rare specimens, there is a central costa on the outer face of the cusp.

M element. Identification of the shape category of this element is problematic as only two poorly preserved specimens have been recovered. Both fragments have one lateral process and a slight posterior swelling at the base of the cusp. The lateral process is steeply inclined downwards and bears at least four erect, compressed denticles, which are fused to midheight. The cusp is tall, broad, and anterio-posteriorly compressed. White matter completely fills the denticles and cusp.

Sa element. Alate, with two lateral processes and a small posterior expansion of the basal margin. The lateral processes are directed downwards and are separated by an angle of approximately 90°. The lateral processes bear at least four denticles. The denticles are erect, compressed and fused to midheight. The cusp is at least four times taller than the denticles; it is compressed anterio-posteriorly, with central costae running down its lateral edges. Beneath the cusp, the basal cavity is oval in shape and the anterior edge is downwardly
extended. The cavity extends beneath the processes as a very narrow groove. White matter entirely fills the denticles and cusp.

Sb element. Modified tertiopedate, with two lateral processes and a posterior expansion of the basal cavity. The lateral processes are directed downward and meet at 90°. The cusp is compressed with costae running centrally down the lateral faces. The denticles are the same as those on the Sa and M elements. The basal cavity is more rounded than that of the Sa element. White matter entirely filling cusp and denticles.

Sc element. Bipennate, with an inwardly and downwardly deflected anterior process bearing at least five denticles; in all specimens the posterior process is broken. The denticles are the same as those on the other S elements. The cusp is very tall and a costa extends down both lateral faces. The basal cavity is very narrow and extends along the processes, as a groove. White matter completely fills the denticles and cusp.

Remarks. The posterior-distal end of the Pa element is lower than the anterior-distal end. The denticles are broad and the basal-cavity flare is sub-circular. The multielement reconstruction followed herein is that originally proposed by Helfrich (1980).

Uyeno & Barnes (1983) figured this species from Anticosti Island. The Sa and Sb elements figured by Uyeno & Barnes (1983) are not typical of Ozarkodina gulletensis and more closely resemble the Sa and Sb elements of Aulacognathus bullatus (see pl. 4, fig. 16 and 19). Uyeno & Barnes (1983) suggested that the Pb, Sa, Sb and Sc of O. gulletensis were shared with O. polinclinata. However, within this study Pb, Sa, Sb and Sc elements of O. polinclinata and O. gulletensis are morphologically distinct.

The elements of O. gulletensis recovered from Lake Timiskaming are much larger and more robust than those recovered from Anticosti Island.
**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario; Jupiter (Pavillion Member) and Chicotte Formations, Anticosti Island, Québec.

*Ozarkodina hassi* (Pollock, Rexroad & Nicoll, 1970)

Pl. 6, figs 6,7

* 1970 *Spathognathodus hassi*, p. 760-761, pl. 111, figs 8-12.
1975 *Ozarkodina hassi* (Pollock et al.); Aldridge, pl. 2, fig. 22.
1975 *Ozarkodina hassi* (Pollock et al.); Cooper, p. 1005, pl. 3, figs 7-12.
1990 *Ozarkodina hassi* (Pollock et al.); Armstrong, p. 92, pl. 13, figs 10-16.

**Holotype.** *Spathognathus hassi* Pollock, Rexroad & Nicoll, 1970, pl. 111, fig. 9. Sample 7-2 from the lower Llandovery of Manitoulin Island, Ontario, Canada.

**Diagnosis.** Refer to Armstrong (1990).

**Description.** Refer to McCracken & Barnes (1981, p. 83)

**Remarks.** The apparatus of *O. hassi* is morphologically similar to that of *O. oldhamensis*. The Pa element of *O. hassi* has larger, more discrete denticles, more unequal anterior denticles, a more prominent cusp and a less extensive basal-cavity flare, than that of *O. oldhamensis*. The Pb element of *O. hassi* has shorter processes, a wider cusp, and a less bowed aboral margin than the Pb element of *O. oldhamensis* (McCracken & Barnes, 1981). The S and M elements of *O. hassi* and *O. oldhamensis* appear to be indistinguishable based on known collections.
Occurrence. Evanturel Creek Formation, Lake Timiskaming, Ontario; Ellis Bay (Laframboise Member) and Becscie Formations, Anticosti Island, Québec; Transitional limestone, Prongs Creek, northern Yukon.

* 1986 Ozarkodina masurensis Bischoff, p. 141-144, pl. 22, figs 22-40; pl. 23, figs 1-20.

Holotype. Ozarkodina masurensis Bischoff, 1986, pl. 22, fig. 31. Specimen MU42273 from the Bagdad Formation (Bridge Creek Limestone Member), New South Wales, Australia.

Diagnosis. Refer to Bischoff (1986, p. 141).

Description. Refer to the description in Bischoff (1986, p. 141-145).

Remarks. The distinctive Pa element of O. masurensis has an angled, lower margin and a very small, proximal-posterior denticle, resulting in a v-shaped gap when the upper margin is viewed laterally (Bischoff, 1986).

This species has only been previously recorded by Bischoff (1986) from the late cyphus to early triangulatus GBZs in New South Wales, Australia. However, S. inclinatus (Rhodes) figured by Aldridge (1972, pl. 4, fig. 16) from the Welsh Borderlands, is similar to this species in that the proximal denticles are smaller than the cusp.

Occurrence. Transitional Limestone Unit and Road River Group, Prongs creek, northern Yukon.
Pl. 8, figs 10, 11

cf. 1986 Ozarkodina masurensis Bischoff, p. 141-144, pl. 22, figs 22-40; pl. 23, figs 1-20.


Remarks. The Pb element recovered herein matches the description of the corresponding element within O. masurensis by Bischoff (1986). However, in the absence of other elements it cannot be definitely identified. The elements recovered herein are also younger than the elements of O. masurensis recorded by Bischoff (1986). Uyeno & Barnes (1983, pl. 1, fig. 17) figured an element similar to this from the Jupiter Formation (Anticosti Island), which they classified as a Pb element of O. pirata.

The Pb element of O. broenlundi figured by Armstrong (1990, pl. 12, fig. 7) has the same general shape as the elements recovered herein, but differs in the thickness of the denticles.

Occurrence. Jupiter Formation (Ferrum Member), Anticosti Island, Québec.

Ozarkodina oldhamensis (Rexroad, 1967)
Pl. 6, figs 8-13

* 1967 Spathognathodus oldhamensis Rexroad, p. 49-50, pl. 3, figs 1-2.
1975 Ozarkodina oldhamensis (Rexroad); Aldridge, pl. 3, figs 16-17.
1975 Ozarkodina oldhamensis (Rexroad); Cooper, p. 1005-1006, pl. 3, figs 13-14.
1981 Ozarkodina oldhamensis (Rexroad); McCracken & Barnes, p. 111, pl. 7, figs 3, 5, 14-18.
Appendix A

**Holotype.** *Spathognathodus oldhamensis* Rexroad, pl. 3, fig. 2. Specimen 10068 from the Brassfield Formation, Cincinnati Arch, U. S. A.

**Diagnosis.** The Pa element has been diagnosed by Rexroad (1967, p. 49).

**Description.** Refer to McCracken & Barnes (1981, p. 84).

**Remarks.** The elements of *O. oldhamensis* are morphologically very similar to those of *O. hassi*. The differences between the Pa and Pb elements of *O. oldhamensis* and *O. hassi* are discussed under the remarks for *O. hassi*. The M and S elements of *O. oldhamensis* can not be distinguished from those of *O. hassi*.

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario; Ellis Bay (Laframboise Member), Becscie, Merrimack, and Jupiter (Base of Goeland Member) Formations, Anticosti Island, Québec; Transitional limestone, Prongs Creek, northern Yukon.

*Ozarkodina pirata* Uyeno & Barnes, 1983

Pl. 7, figs 5-11

1981 *Ozarkodina* n. sp. C Uyeno & Barnes, pl. 1, fig. 2.

*p 1983* *Ozarkodina pirata* Uyeno & Barnes, p. 21, pl. 1, figs 16, 21-25; pl. 2, figs 12-13, 19-28, *non* pl. 1, fig 17, *pl. 2, fig. 19.

? 1990 *Ozarkodina pirata* Uyeno & Barnes; Armstrong, p. 94, pl. 13, figs 20-23; pl. 14, figs 1-8.


**Holotype.** *Ozarkodina pirata* Uyeno & Barnes, 1983, pl. 2, fig. 12. Specimen G.S.C. 64831 from the Jupiter Formation, Anticosti Island, Québec, Canada.

**Diagnosis.** Refer to Uyeno & Barnes (1983, p.21).
Description. Pa element. A carminate element described previously by Uyeno & Barnes (1983, p. 21). On the specimens herein, the anterior process bears at least six denticles and the shorter posterior process bears three or four denticles. The anterior denticles are taller than those on the posterior process. The inner lip of the basal cavity is upturned. White matter fills the cusp and denticles. In lateral view, the trace of the lower edge of the white matter forms a downwardly-convex line.

Pb element. Refer to the description by Uyeno & Barnes (1983, p. 21). Angulate, with an anterior process bearing at least four denticles and the shorter posterior process bears one or two denticles. The denticles on each process decrease in height distally and are fused at the base. White matter fills the cusp and denticles.

M element. Refer to the description by Uyeno & Barnes (1983, p. 21). A dolabrurate element with a rounded antero-basal corner. There is a slight inner swelling of the basal cavity below the cusp and the inner lip of the basal cavity is upturned. White matter fills the cusp and denticles in individual blocks.

Sb element. Tertiopedate, the inner-lateral process bears four denticles and the longer outer-lateral processes bears at least five denticles. The outer-lateral process is more downwardly directed than the inner-lateral process. The denticles are fused only at the base. They are small adjacent to the cusp, but increase in width and height distally. The basal cavity is small and sub-circular beneath the cusp and extends along the processes as grooves. The posterior lip of the basal cavity is upturned, so that the basal cavity can be seen in posterior view.

Sc element. Bipennate, with a straight posterior process and an inwardly bowed and downwardly directed anterior process. The denticles are laterally compressed, fused at the base and inwardly bowed. The cusp is broad at the
base and tapers with height. It is at least twice the height of the denticles. The basal cavity is narrow, but slightly wider below the cusp, and extends as a narrow groove. White matter fills the cusp and denticles.

**Remarks.** Uyeno & Barnes (1983) diagnosed this as a species of *Ozarkodina* with a Pa element that has a straight lower margin, a convex upper margin, a restricted basal cavity and bears uneven denticles. They illustrated three dissimilar Pb elements, two M, two Sa, and two Sc elements within the apparatus of *O. pirata*. Some of these elements (pl. 2, fig. 20, 23, 26) are more likely to represent the elements of *Pseudolonchodina fluegeli*.

Armstrong (1990) emended the diagnosis of *O. pirata*. The original diagnosis is preferred as the P elements differ from those described by Armstrong (1990) in that the anterior denticles are larger than those on the posterior. The elements illustrated by Armstrong (1990) are more closely similar to *O. polinclinata*.

**Occurrence.** Becscie, Merrimack, Gun River (Sandtop Member) and Jupiter (Goéland and East Point Members) Formations, Anticosti Island, Québec.

*Ozarkodina polinclinata* (Nicoll & Rexroad, 1969)

Pl. 8, figs 1-5

* 1969  *Spathognathodus polinclinatus* Nicoll & Rexroad, p. 60, pl. 2, figs 19, 20.

1972  *Spathognathodus polinclinatus* Nicoll & Rexroad; Aldridge, p. 214-215, pl. 4, fig. 13.

1977  *Ozarkodina polinclinata* (Nicoll & Rexroad); Cooper, p. 1058-1062, pl. 1, figs 11, 13-15, 17, 28.

v 1983  *Ozarkodina polinclinata* (Nicoll & Rexroad); Uyeno & Barnes, p. 22, pl. 5, figs 11-16, 19.
Ozarkodina polinclinata (Nicoll & Rexroad); Simpson & Talent, p. 154-156, pl. 10, figs 8-9.

**Holotype.** *Spathognathodus polinclinatus*, Nicoll & Rexroad, 1969, pl. 2, fig. 19. Specimen 11427 from the Brassfield Formation, Jefferson County, Indiana, U. S. A.

**Diagnosis.** The Pa element has been diagnosed by Nicoll & Rexroad (1969 p. 60).

**Description.** Pa element. This has been previously described as *Spathognathodus polinclinatus* Nicoll & Rexroad by Aldridge (1972, p. 214-215). Carminate, with an anterior process bearing at least seven denticles and a shorter posterior process bearing only four denticles. The denticles on both processes increase in height proximally. The denticles on the posterior process are inclined posteriorly, whereas those on the anterior process are upright, but may become inclined anteriorly at the distal end of the process. The denticles can be squat, but more commonly are tall and completely fused. White matter fills the cusp and denticles.

Pb element. This element has been described by Aldridge (1972, p. 200-201) as *Ozarkodina hanoverensis* Nicoll & Rexroad. A carminate element with posteriorly inclined denticles, apart from the anterior-most denticle, which is upright. There are three denticles on the anterior and at least five on the posterior process. The denticles are fused almost to their tips. The anterior denticles are taller and wider than those on the posterior process. White matter fills the cusp and denticles.

M element. Dolabrate, bearing approximately five denticles on the posterior process. The denticles are inclined towards the posterior and are fused only at the bases. The cusp is wide and the antero-basal angle is rounded. White matter
fills the cusp. The basal cavity is widest beneath the cusp and tapers to the tip of the posterior process.

Sa element. This has been previously described by as *Trichonodella papilio* by Nicoll & Rexroad (1969, p. 65).

Sb element. This modified tertiopedate element has been previously described as *Trichonodella asymmetrica* Nicoll & Rexroad by Aldridge (1972, p. 217). The inner-lateral process bears at least six denticles, whereas the shorter and less steeply inclined outer-lateral process bears at least four denticles. The lower angle between the two processes is 90°. The denticles are discrete and separated by v-shaped gaps. The denticles on the inner-lateral process initially increase in height distally, but on the distal half of the process decrease in height distally. The cusp is slender and tall and the denticles are compressed and triangular in outline. There is a posterior inflation of the basal cavity beneath the cusp. White matter completely fills the cusp and denticles.

Sc element. A bipennate element that has been previously described by Cooper (1977, p. 1061). The very long posterior process, bearing at least 10 partially fused denticles, curves inwardly distally. The short anterior process bears only one discrete denticle. On the posterior process the proximal denticles are upright, but more distal denticles are inclined posteriorly. The denticles on the posterior process initially increase in height distally, but on the distal third of the process, decrease in height distally. There is thickening of the base below the line of denticles, which is more pronounced in the specimens from Anticosti Island. The basal cavity is a very narrow groove extending along the processes.

Remarks. The Pa element of *O. polinclinata* characteristically has a straight blade bearing slender, sub-equal denticles, and a small, narrow basal cavity. The other elements are all delicate. The S elements bear very long, slender
denticles. The elements recovered from Anticosti Island are more robust than those recovered from Lake Timiskaming.

The M element is dolabrate and is morphologically similar to that of *P. fluegeli*, but can be differentiated from that species by the more rounded nature of its antero-basal corner.

**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario; Jupiter (Pavillion and Chicotte Formations, Anticosti Island, Québec.

*Ozarkodina protoexcavata* Cooper, 1975

Pl. 8, figs 6-9

?-1970 *Ozarkodina* sp. n A Pollock et al., p. 757, pl. 113, figs 5-8.

1970 *Ozarkodina* sp. n. B Pollock et al., p. 757, pl. 113, figs 9-11.

?-1970 *Ligonodina? variablis* Nicoll & Rexroad; Pollock et al., p. 755, pl. 114, fig.12.

1975 *Ozarkodina protoexcavata* Cooper, p. 1006, pl. 3, figs 1-6.


**Holotype.** 1975 *Ozarkodina protoexcavata* Cooper, p. 1006, pl. 3, figs 1-6.

**Diagnosis.** Refer to Cooper (1975, p. 1006).

**Description.** The P and S elements have been described by Cooper (1975, p.1006). The M element fits the description of the M element of *O. excavata puskuensis* by Männik (1994, p. 188)

**Remarks.** Cooper (1975) erected this species and described the multielement apparatus. The M element figured by Cooper (1975, pl. 3, fig. 5) appears to be a broken Pb element.
Männik (1994) diagnosed and described *O. excavata puskuensis*, which has a very similar apparatus to *O. protoexcavata*. Männik (1994) regarded the main differences to be that *O. protoexcavata* elements are more compressed and have wider, more fused denticles than *O. e. puskuensis*. The elements herein have wider cusps and denticles than those figured by Männik (1994) and so have been placed within *O. protoexcavata*. It is possible that these taxa are ecophenotypes.

**Occurrence.** Becscie and Merrimack Formations, Anticosti Island, Québec.

*Ozarkodina* sp. A

Pl. 8, fig. 12

**Remarks.** The Pa element only has been recovered. It is carminate, with a posterior process bearing three broad denticles, which are posteriorly inclined. The anterior process bears eight thinner denticles, which are anteriorly inclined. The basal cavity is very distinctive. It forms a wide, deep groove running along the anterior process and the most proximal part of the posterior process.

**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario.


Pl. 7, figs 12,13


**Remarks.** The Pa element of this species is identical to that of *O. sp. C* Armstrong, but the other elements are different. Armstrong (1990) remarked that the apparatuses of *O. sp. C* and *O. excavata* are closely similar differing in the basal cavity and posterior process morphology of the Pa element. He
suggested that *O.* sp. C could be a stratigraphic or geographic variant of *O.* *excavata*.

The Pa element recovered herein, is similar to that of *O. excavata puskuensis*, but differs in that the cusp is less prominent and the anterior process is longer than that of *O. excavata puskuensis*. The Pb elements of the two species are disimilar.

In Greenland, *O.* sp. C has been recovered from the basal Aeronian, Silurian carbonate Formation 1 (Wulff Land) and the mid Aeronian, lower Odins Fjord Formation of Central Peary Land (Armstrong, 1990).

**Occurrence.** Earlton Formation, Lake Timiskaming, Ontario.
**Order** Prioniodinida Sweet, 1988

**Remarks.** Sweet (1988) regarded the prioniodinid apparatus as containing six or seven morphotypes, with a extensiform or breviform digyrate element in one or both of the P positions. The morphotypes are typically stout with discrete, peg-like denticles. The elements within an apparatus tend to be of a similar size, and are inter-gradational morphologically, which has led to confusion over the homology of elements between species (Sweet, 1988).

The determination of the prioniodinid apparatus architecture has been hampered by the lack of abundant bedding plane assemblages and clusters of prioniodinids (Purnell & Donoghue, 1998). Purnell (1993) recognised homologies between ozarkodinids and prioniodinids, and consequently the ozarkodinid plan is applied to prioniodinids (Purnell & Donoghue, 1998).

**Family** Prioniodinidae Bassler, 1925

**Remarks.** Sweet (1988, fig. 5.28) illustrated this family as consisting of Ordovician to Devonian genera, which evolved from the 'root stock', Oulodus. Aldridge & Smith (1993) included Pseudolonchodina within this family. Pseudolonchodina differs from Oulodus only in the compressed nature of its elements and the shape of the Pa element. The ancestry of Pseudolonchodina is currently unknown and needs to be elucidated before it can be confidently assigned within this Family. Multiple Sb and Sc elements have not been differentiated within any of the Prioniodinidae genera studied herein, apart from Pseudolonchodina.

**Genus** Oulodus Branson & Mehl, 1933

**Type species.** Cordylocus serratus Stauffer, 1930.

**Diagnosis.** Refer to Sweet & Schönlaub (1975, p. 45).
Remarks. Sweet & Schönlaub (1975) considered *Oulodus* as comprising species with six morphotypes, which bore 'stout, discrete, peg-like' denticles, separated by u-shaped gaps. Species of *Oulodus* are distinguished by the general morphology of the elements, but the Sc elements may show less interspecies variation.

McCracken & Barnes (1981) tentatively included *Oulodus*? *nathani* and *O.? kentuckyensis* within *Oulodus*, on the basis of the general shape of the elements, but considered the Pa elements to be sufficiently different to warrant distinction. These elements are more similar to those of *Ozarkodina* or *Kockeleva*.

Within this study, two sets of species currently classified within *Oulodus* have been identified:

Type I. *O. ulrichi*, *O. rohneri*, and *O. panuarensis*

Type II. *O. robustus*, *O.? nathani*, *O.? kentuckyensis*, and *O. petilus*

Type I species have dolabrate M elements and Sa elements with lateral processes meeting at an angle of less than 90°. Type II species have modified tertiopeate M elements and Sa elements with lateral processes separated by an angle greater than 90°. If the categories represent true evolutionary groups, it is conceivable that the Silurian species *O. panuarensis* evolved from an Upper Ordovician species of *Oulodus* such as *O. rohneri* or *O. ulrichi*, whereas, the Silurian species within Type II may have evolved from *O. robustus.*
Oulodus ? kentuckyensis (Branson & Branson, 1947)
Pl. 9, figs 10-15

* 1947 Ligonodina kentuckyensis Branson & Branson, p. 555, pl. 82, figs 28, 35.
p 1975 Oulodus sp. A Cooper, p. 997, pl. 2, figs 12, 16, 18, 19, 21.
v 1981 Oulodus ? kentuckyensis (Branson & Branson); McCracken & Barnes, p. 80, pl. 6, figs 1-20.

Holotype. Ligonodina kentuckyensis Branson & Branson, 1947, pl. 82, figs 28, 35. Specimen C674-5 from the Brassfield Formation, Kentucky, U. S. A.


Description. Refer to the description of modified oulodiform (= Pa), lonchodiniform (= Pb), euprioniodiniform (= M), trichonodelliform element (= Sa), zygognathiform (= Sb) and ligonodiniform (= Sc) in McCracken & Barnes (1981, p. 80-81).

Remarks. The elements of O.? kentuckyensis bear slightly compressed denticles, separated by u-shaped gaps. The Sc element was initially recovered by Branson & Branson (1947). Later, Cooper (1975) figured elements within the multielement reconstruction of Oulodus sp. A and Oulodus sp. B, which were assigned by McCracken & Barnes (1981) in their full reconstruction of O.? kentuckyensis.

O. angullongensis Bischoff ranges through the combinatus to pseudopedavis CBZs of New South Wales. The Pa, Sa and Sc elements of O. angullongensis Bischoff (1986, p. 69-72) are comparable to those of O.? kentuckyensis, but the Pb, M and Sb elements of the two species differ (Bischoff, 1986).
**Occurrence.** Becscie, Merrimack and Gun River (Sandtop Member) Formations, Anticosti Island, Québec; Transitional Limestone Unit, Prongs Creek, northern Yukon.

*Oulodus? nathani* McCracken & Barnes, 1981

Pl. 9, figs 8,9

*Oulodus? nathani* McCracken & Barnes, p. 81, pl. 6, figs 21-32.

**Holotype.** *Oulodus? nathani* McCracken & Barnes, 1981, pl. 6, fig 32. Specimen G.S.C. 60165 from the Becscie Formation, Anticosti Island, Québec, Canada.

**Diagnosis.** Refer to McCracken & Barnes (1981, p. 81).

**Description.** Refer to the description of blade (= Pa), lonchodiniform (= Pb), euprioniodiniform (= M), trichonodelliform element (= Sa), zygognathiform (= Sb) and ligonodiniform (= Sc) in McCracken & Barnes (1981, p. 82).

**Remarks.** The elements of *O.? nathani* bear compressed denticles, which are separated by v-shaped gaps. V-shaped gaps between denticles are atypical of the genus *Oulodus*.

**Occurrence.** Ellis Bay (Laframboise Member) and Becscie Formations, Anticosti Island, Québec; Transitional Limestone Unit, Prongs Creek, northern Yukon.

*Oulodus cf. O. panuarensis* Bischoff, 1986

Pl.10, figs 1-6

*Oulodus* sp. A Uyeno & Barnes, p. 19, pl. 1, figs 14, 15, 18-20.
**Description.** Pa element. Digyrate, with an inner-lateral process bearing at least four distally inclined denticles, and an outer-lateral process with at least three upright denticles. The denticles are separated by wide u-shaped gaps. The cusp is inclined to the posterior. There is a wide basal-cavity flare beneath the cusp, which is shallow and sub-rounded in outline. The basal cavity extends as tapering grooves beneath the lateral processes.

Pb element. This has previously been described as the Pa element of *O. panuarensis* by Bischoff (1986, p.76). Digyrate, with an anteriorly twisted inner-lateral process, and a long, straight outer-lateral process. The outer-lateral process bears six denticles and the inner-lateral process bears two. The denticles on both processes are compressed and are separated by wide, u-shaped gaps. Beneath the cusp and proximal part of the inner-lateral process, the basal cavity is wide and shallow. The cavity extends as tapering groove to the tips of the processes.

M element. Refer to the description in Bischoff (1986, p.76).

Sa element. Alate, with two lateral processes, which diverge at angle of approximately 70 to 80°. The cusp is very long and strongly curved to the posterior. The lateral processes bear at least four denticles, which are interspersed with wide, u-shaped gaps. The denticles are triangular, inwardly directed, and increase in height distally. The basal cavity is very deep below the cusp and extends as tapering grooves along the processes.

Sb element. Tertiopedate, with two lateral processes and a posterior projection of the base of the cusp. The angle between the lateral processes is approximately 60°. The lateral processes bear at least three denticles, which are separated by wide, u-shaped gaps. The basal cavity is deep beneath the cusp and extends as narrow grooves along the lateral processes.

Sc element. Refer to the description in Bischoff (1986, p.76-77).
Remarks. The Pb (== Pa of Bischoff), M and Sc elements of this species are indistinguishable from the corresponding elements in *O. panuarensis*, sensu Bischoff (1986, p. 76-77). However, the Pa, Sa, and Sb elements of this species contrast with the corresponding elements figured by Bischoff (1986).

An M element comparable to that of *O. cf. O. panuensis* has been described from the lower Silurian of the American midcontinent, as *Neoprioniodus planus* Walliser (Rexroad, 1967, pl. 3, fig. 11), *Neoprioniodus cf. N. excavatus* (Branson & Mehl) (Pollock et al., 1970, pl. 114, fig. 20), and *Oulodus* sp. B Cooper (1975, pl. 2, fig. 22). The Sa elements have been figured in Rexroad (1967, *Trichonodella cf. T. inconstans* Walliser, pl. 3, fig. 19) from the American midcontinent, and the M and Sb elements have been recorded from Greenland by Armstrong (1990, *Oulodus* spp. indet. group 8, pl. 12, figs 1-3).

Occurrence. Becscie, Merrimack, and Jupiter (Goeland and East Point Members) Formations, Anticosti island, Québec; Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

*Oulodus petilus* (Nicoll & Rexroad, 1969)

Pl. 10, figs 7-12

n 1991b *Aspelundia petila* (Nicoll & Rexroad); McCracken, p. 75. pl. 1, figs 1-4, 7-9, 11-12, 15-16, 18, 25, 28-30; pl. 2, figs 1-2, 5-6, 9, 12, 16, 26-28, 30-31.

Holotype. *Ligonodina petila* Nicoll & Rexroad, 1969, pl. 5, fig. 22. Specimen 11357 from the Brassfield Limestone, Indiana, U. S. A.
Appendix A

Systematic Palaeontology

**Diagnosis.** Refer to Barrick & Klapper (1976, p. 69).

**Description.** The Pa, Sa and Sb elements have been previously described by Sweet & Schönlaub (1975, p. 50). The Pb (= *Diadelognathus* n. sp. A and *Diadelognathus excertus* therein), M (= *Diadelognathus* n. sp. B therein) and Sc (=*Ligonodina petila* therein) elements have been described by Nicoll & Rexroad (1969).

**Remarks.** The diagnostic features of *O. petilus* are the widely spaced denticles on all elements, and the wide, posteriorly flared basal cavities of the Pb, M and Sb elements (Savage, 1985). Elements of this species were first recovered by Nicoll & Rexroad (1969) and partial apparatus reconstructions were discussed by Sweet & Schönlaub (1975), Barrick & Klapper (1976) and Uyeno & Barnes (1983).

Bischoff (1986) described a lineage of *Oulodus* with a similar apparatus to *O. petilus*, involving the evolution from *O. australis* (*pseudopedavis* to *celloni* CBZs) to *O. rectangulus* (*celloni* to *ranuliformis* CBZs), and subsequently *O. sinuosus* (*ranuliformis* CBZ). Savage (1985) reconstructed *Oulodus petilus pacificus* from the amorphognathoides and *ranuliformis* CBZs of Alaska, which he differentiated from *O. petilus jeannae*, as the M had a larger basal cavity and the S elements more-widely extended processes. Bischoff (1986, pl. 19, figs 8-12) figured Sa elements similar to those figured by Savage (1985, fig. 11, K-L), which he classified as *O. rectangulus* or *O. sinuosus*. It is possible that a similar evolutionary lineage to that observed by Bischoff (1986) can also be traced in the evolution of *O. petilus*.

**Occurrence.** Eventurel Creek, Earlton and Thornloe Formations, Lake Timiskaming, Ontario; Jupiter (Ferrum and Pavillion Members) and Chicotte Formations, Anticosti Island, Québec.
Appendix A

Systematic Palaeontology

Oulodus robustus (Branson, Mehl & Branson, 1951)
Pl. 9, figs 1-3

* 1951 Eoligonodina robusta Branson, Mehl & Branson, p. 15, pl. 4, figs 33, 35-37.
1968 Plectodina robusta (Branson, Mehl & Branson); Kohut & Sweet, p. 1471, pl. 185, figs 12, 14, 15, 17, 24.
1975 Oulodus robustus (Branson, Mehl & Branson); Sweet & Schönlaub, p. 48-49, pl. 2, figs 7-12.
v 1981 Oulodus robustus (Branson, Mehl & Branson); McCracken & Barnes, p. 79, pl. 4, figs 1-6.
1988 Oulodus robustus (Branson, Mehl & Branson); Barnes, pl. 2, figs 1-3, 6-8.

Holotype. Eoligonodina robusta Branson, Mehl & Branson, 1951, pl. 4, fig. 33. Specimen C756-2 from the Richmondian of Kentucky and Indiana, U. S. A.

Diagnosis. Refer to Sweet & Schönlaub (1975, p. 49).

Description. The elements have been described as Plectodina robusta by Kohut & Sweet (1968). The Pa has been described as the prioniodiform element of this apparatus by McCracken & Barnes (1981, p.79).

Remarks. O. robustus is characterised by comparatively large elements, which bear stout, discrete denticles, which are sub-circular in outline (Sweet & Schönlaub, 1975). Kohut & Sweet (1968) attempted a multielement reconstruction of O. robustus, which was later discussed by Sweet & Schönlaub (1975). McCracken & Barnes (1981) added the Pa (= prioniodiform therein) element to the apparatus.
Appendix A

Systematic Palaeontology

**Occurrence.** Ellis Bay Formation (Lousy Cove and Laframboise Members), Anticosti Island, Québec.

**Genus** *Pseudolonchodina* Zhou *et al.*, 1981

**Type Species.** *Pseudolonchodina irregularis* Zhou, Zhai & Xian, 1981.

**Diagnosis.** Refer to the generic diagnosis of *Aspelundia* by Armstrong (1990, p. 49)

**Remarks.** The elements of *Pseudolonchodina* are highly compressed. The apparatus comprises Pa, Pb, M, Sa, Sb and Sc elements. Multiple M and S elements have been identified within the apparatus. Zhou *et al.* (1981) erected *Pseudolonchodina* from specimens recovered from Chinese sections. Elements of species of *Pseudolonchodina* were later recovered by Savage (1985) and Armstrong (1990), but were assigned to a new genus, *Aspelundia*. *Pseudolonchodina* was not recognised as a senior synonym, due to the poor quality of the original illustrations, until a restudy of the Chinese material (Aldridge *pers. comm.*).

Armstrong (1990) was the first to recognise and differentiate two species: *P. fluegeli* (Walliser) and *P. expansa*. Armstrong (1990) regarded the main differences between the two species to be the morphology of the Pb and Sb elements and the extent of the basal cavity. McCracken (1991b) noted that corresponding elements in the two species differ in their denticulation, and that the morphology of the Sc elements differed. The c (Sa), f (Pa), and g (Pb) elements differ in the angle of process divergence between species. The apparatus reconstruction of the *Pseudolonchodina* apparatus differed between the studies of McCracken (1991b) and Armstrong (1990), in that McCracken (1991b) did not differentiate two Sb elements, and the morphology of the Pb elements differed.
Appendix A

Systematic Palaeontology

Pseudolonchodina capensis (Savage, 1985)

Pl. 11, figs 1-11

* 1964 ?Roundya trichondelloides Walliser, p. 72, pl. 6, fig. 2; pl. 31, figs 22-25.

? 1981 Pseudolonchodina irregularis; Zhou et al., p. 136-137, pl. 1, figs 45-47.

1985 Aspelundia capensis Savage, p. 725-726, fig. 19, A-T.

? 1985 Oulodus fluegeli (Walliser); Savage, p. 718-719, fig. 10, A-S.

1985 Pandorinellina plana (Walliser); Savage, p. 724-725, fig. 18, A-Y.

1986 Oulodus planus borenorensis Bischoff, p. 84-86, pl. 20, figs 8-16.

1987a Oulodus ? n. sp. 2 Over & Chatterton, pl. 5, figs 18-26.

? 1990 Aspelundia n. sp. 1 (Over & Chatterton), Armstrong, p. 55, pl. 3, fig. 10.

1991b Aspelundia capensis Savage?; McCracken, pl. 1, figs 18-20.

? 1993 Oulodus ? sp. nov. 2 Over & Chatterton; Xia, pl. II, figs 2-4, 6-12; pl. III, fig. 1.

1995 Pseudolonchodina borenorensis (Bischoff); Simpson & Talent, p. 110-111, pl. 1, fig. 2.

Holotype. ? Roundya trichondelloides Walliser, 1964, pl. 31, fig. 22. Specimen from the Llandovery of Cellon in the Carnic Alps.

Emended diagnosis. Refer to Bischoff (1986, p. 84).

Description. The elements have been previously described in the literature by Bischoff (1986) and Savage (1985).

Remarks. P. capensis has a diagnostic Sa element bearing three denticulate processes. Savage (1985) included elements of P. capensis within the apparatuses of Aspelundia capensis Savage, Pandorinellina plana (Walliser) and O. fluegeli (Walliser). Oulodus planus borenorensis Bischoff and Oulodus...
sp. 2 Over & Chatterton are multielement reconstructions of *P. capensis*. Simpson & Talent (1995) were the first to incorporate this species into the Genus *Pseudolonchodina* Zhou et al.

*P. capensis* evolved from *P. fluegeli* (Walliser) within the *celloni* CBZ. In the Prongs Creek section, rare Pb and Sa elements characteristic of *P. capensis* are found prior to the *celloni* CBZ. However, it is not until the *celloni* CBZ that *P. capensis* becomes the dominant species of *Pseudolonchodina*.

**Occurrence.** Road River Group, Prongs Creek, northern Yukon.

*Pseudolonchodina expansa* (Armstrong, 1990)

Pl. 12, figs 1-8

* 1990 *Aspelundia expansa* Armstrong, p. 50, pl. 3, figs 13-20.
1991b *Aspelundia petila* (Nicoll & Rexroad); McCracken, p. 75. pl. 1, figs 1-4, 7-9, 11-12, 15-16, 18, 25, 28-30, & pl. 2, figs 1-2, 5-6, 9, 12, 16, 26-28, 30-31.
1995 *Pseudolonchodina expansa* (Armstrong); Simpson & Talent, p. 111-112, pl. 1, fig. 3.

**Holotype.** *Aspelundia expansa* Armstrong, 1990, pl. 3, fig. 13. Specimen MGUH 17.687 from Cape Schuchert Formation, Kap Schuchert, Washington Land, Greenland.

**Diagnosis.** Refer to Armstrong (1990, p. 50).

**Description.** The Pa (*f*), Pb (*g*), M₁ (*e-1*), M₂ (*e-2*), Sa (*c*), Sc₁ (*a-1*) and Sc₂ (*a-2*) elements were fully described by McCracken (1991b, p. 76-77; *A. petila*). The Sb₁ and Sb₂ elements have been described by Armstrong (1990, p. 52).
**Remarks.** Armstrong (1990) characterised this species of *Pseudolonchodina* as having compressed, robust denticles and a modified angulate Pa element.

McCracken (1991b) incorrectly synonymised *Oulodus petilus* (Nicoll & Rexroad) with *Pseudolonchodina expansa* (Armstrong). The two species differ in the degree of compression and the general morphology of all of the elements. McCracken (1991b) included two dissimilar M elements (e-1 and e-2) within the apparatus of *P. expansa*. The less common M element (e-2) possesses a short, denticulate posterior process, and may have occupied a Sb₂ position. The samples processed herein failed to yield these elements.

**Occurrence.** Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

*Pseudolonchodina fluegeli* (Walliser, 1964)

![Pl. 12, figs 9-14](image)

* 1964 *Lonchodina fluegeli* Walliser, p. 44, pl. 6, fig. 4; pl. 32, fig. 24.


1981 *Pseudolonchodina irregularis* Zhou et al., 136-137, pl. 1, figs 45-47.

p 1990 *Aspelundia fluegeli* (Walliser); Armstrong, p. 53-55, pl. 3, figs 1-9, 11, 12.

1991b *Aspelundia fluegeli* (Walliser); McCracken, p. 73-75, pl. 1, figs 5, 6, 10, 13, 14, 17, 19-24, 26, 27, 31, 32; pl. 2, figs 3, 4, 7, 8, 10, 11, 13-15, 17-25, 29, 32.

1995 *Pseudolonchodina fluegeli* (Walliser); Simpson & Talent, p. 112-113, pl. 1, fig. 4.

**Holotype.** *Lonchodina fluegeli* Walliser, 1964, pl. 6, fig.4, pl. 32, fig. 24. Specimen from the Llandovery of Cellon, Carnic Alps, Austria.
Diagnosis. Refer to Armstrong (1990, p. 53).

Description. The Pa, Pb, M₁ (=M of Armstrong), M₂ (=Sd of Armstrong), Sa, Sb₁, (=Sb₂ of Armstrong) and Sc₁ elements have been described by Armstrong (1990, p. 53-54). The Sc₂ element differs from the Sc₁ element only in the downward deflection of the anterior process.

Remarks. Armstrong (1990) characterised this species of Pseudolonchodina as having a narrowly expanded basal cavity, compressed denticles and variably twisted and flexed processes.

Armstrong (1990) did not differentiate between elements of P. capensis and those of P. fluegeli (Walliser). A Sb₁ element included within the apparatus of P. fluegeli by Armstrong (1990), bearing a short, denticulate posterior process, may be alternatively assigned to P. capensis.

McCracken (1991b) identified three types of M element (e-1, e-2, and e-3) within the apparatus of P. fluegeli. The e-2 element was characterised by an expanded anterior cusp-edge, which bore two denticles. Similar elements were not identified during this study.

Occurrence. Jupiter Formation (Goéland Member), Anticosti Island, Québec; Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

Order Prioniodontida Dzik, 1976

Remarks. Sweet (1988) regarded the apparatus of prioniodontid conodonts as containing six or seven morphotypes, with one or two pastinate P elements (or a platform equivalent). Reconstructing the full apparatus at this time proved confusing as there appeared to be more morphotypes than would fit an
ozarkodinid apparatus; particularly elements attributable to P locations. This remained a problem until a prioniodontid animal *Promissium pulchrum* Kovács-Endrődy was discovered in the Ordovician Soom Shale (South Africa). Aldridge et al. (1995) reconstructed the apparatus comprising paired Pa, Pb, Pc, Pd, M, Sb₁, Sb₂, Sc, Sd and a single Sa element (Fig. A.2). Comparison with the ozarkodinid apparatus reconstruction led Purnell & Donoghue (1998) to suggest that the Sd and Sb₂ elements of *Promissium* are homologous with the Sb₂ and Sc₁ elements of the ozarkodinid apparatus, respectively.

![Figure A.2. Plan of the Promissium pulchrum apparatus from Aldridge et al. (1995).](image)

The Prioniodontida studied herein can be divided into two types (Type I and Type II) by their Pa element morphology, number of P elements and morphology of M elements.

Type I: The Type I apparatus consistently lacks a Pc element. The Pa element of Type I prioniodontids has an inner-lateral process situated to the posterior of the outer-lateral process. M elements are typically dolabrate. The Type I prioniodontids do not have the same number of morphotypes as the *Promissium* template. Examples of Type I include the Family
Distomodontidae, Family Icriodellidae and some members of the Family Balognathidae (e.g. Genus *Gamachignathus* McCracken *et al.*)

**Type II:** Type II prioniodontids have four P elements. The Pa element of the type two prioniodontids has an inner-lateral process situated to the anterior of the outer-lateral process. In *Pranognathus* Männik & Aldridge, the single process is situated anterior of the bifurcate lateral process. Examples of Type II include *Pterospathodus* Walliser, *Astropentagnathus* Mostler, *Pranognathus* Männik & Aldridge and *Apsidognathus* Walliser.

The general morphology and number of elements within the S array may vary between species within the same genus (e.g. *Astropentagnathus*) and so cannot be used in classification at the family level. *Apsidognathus* has at least four platform elements within its apparatus, and so is preliminary classified within Type II. Genera within the Family Cyrtoniodontidae do not fit into the above categories, as they only have two P elements within their apparatuses.

<table>
<thead>
<tr>
<th>Element</th>
<th>Morphology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pa</td>
<td>Pyramidal, pastiniscaphate with three primary processes and one secondary lateral process.</td>
</tr>
<tr>
<td>Pb</td>
<td>Similar to Pa, but processes may be slightly twisted and the secondary lateral process shorter.</td>
</tr>
<tr>
<td>Pc</td>
<td>Angulate with twisted processes.</td>
</tr>
<tr>
<td>Pd</td>
<td>Bipennate, symmetrically or subsymmetrically arched.</td>
</tr>
<tr>
<td>M</td>
<td>Curved, tertiopedate.</td>
</tr>
<tr>
<td>Sa</td>
<td>Alate.</td>
</tr>
<tr>
<td>Sb₁</td>
<td>Tertiopedate.</td>
</tr>
<tr>
<td>Sb₂</td>
<td>More asymmetrical than Sb₁.</td>
</tr>
<tr>
<td>Sd (Sc₁)</td>
<td>Asymmetrical, quadriramate</td>
</tr>
<tr>
<td>Sc (Sc₂)</td>
<td>Bipennate</td>
</tr>
</tbody>
</table>

**Figure A.3.** Elements within the *Promissium* apparatus, as described by Aldridge *et al.* (1995).
Family Balognathidae Hass, 1959

Remarks. Sweet (1988) included Baltoniodus and its descendant genera, which comprise Amorphognathus, Complexodus, Gamachignathus, Noixodontus, Rhodesognathus and Sagittodontina, in the Balognathidae. Sweet (1988) observed that Gamachignathus was closer morphologically to Prioniodus than Baltoniodus, but was closer stratigraphically to Baltoniodus, and so included Gamachignathus within the Balognathidae. Aldridge & Smith (1993) added Pygodus Lamont & Lindström, Polonodus Dzik and Promissium Kovács-Endrödy to this family.

The most recent multielement reconstruction of Amorphognathus by Armstrong et al. (1996) includes a Pc, and tentatively a Pd element. Thus, Amorphognathus can be classified within the Type II group of prioniodontids. Gamachignathus lacks a Pc element and has characteristics of the Type I prioniodontids.

Genus Amorphognathus Branson & Mehl, 1933

Type Species. Amorphognathus ordovicica Branson & Mehl, 1933.

Diagnosis. Refer to Bergström (1971, p. 131-134).

Remarks. Amorphognathus has a Type II apparatus comprising Pa, Pb, Pc, M, Sa, Sb1, Sb2 (= Sd of previous reconstructions) and Sc elements. Armstrong et al. (1996) tentatively included a small, pyramidal element in the Pd position, which has not yet been confirmed by other workers.

The Pa elements of Amorphognathus species have posterior, anterior, two outer-lateral processes and commonly two inner-lateral processes. The posterior process bears only one row of denticles, whereas the anterior process may be thicker, with two rows of denticles. The Pb elements are pyramidal
with an anterior, a posterior and an outer-lateral process. The M element is tertiiopedate and the apparatus has a full suite of S elements, including a quadriramate Sb₂ element. Species of *Amorphognathus* can be differentiated on differences in the rare M element (Orchard, 1980) and potentially the robustness and morphology of the Pb element (Savage & Bassett, 1985).

*Amorphognathus* cf. *A. ordovicicus* Branson & Mehl, 1933

Pl.13, fig.11.

**Description.** Only one broken fragment of a Pa element has been recovered in samples herein. Two processes are preserved, which are tentatively regarded as lateral processes. Each process is wide and bears two widely spaced nodes. The whole of the lower surface is excavated.

**Remarks.** The specific classification of this element has been hampered by its poor state and the absence of other more diagnostic elements, such as Pb and M elements. It has been compared to *A. ordovicicus* Branson & Mehl, as this is the only common species of *Amorphognathus* in the uppermost Ordovician.

**Occurrence.** Ellis Bay Formation (Laframboise Member), Anticosti Island, Québec.

**Genus Gamachignathus** McCracken, Nowlan & Barnes, 1980

**Type species.** *Gamachignathus ensifer* McCracken *et al.*, 1980.

**Diagnosis.** Refer to the original diagnosis in McCracken *et al.* (1980. p. 105).

**Remarks.** *Gamachignathus* has a Type I apparatus, comprising Pa, Pb, Pd (e-2 of McCracken & Barnes, 1981), M, Sa, Sb, Sc₁ and Sc₂ elements. The Pa element of the type species has a denticulate outer-lateral process, which is perpendicular to the blade, and an incipient inner-lateral process. Species of
Gamachignathus can be differentiated by the degree of lateral compression of the cusp and denticles.

Gamachignathus? macroexcavata (Zhou et al.) from the upper Llandovery (celloni CBZ) of China is the youngest species that has been classified within the genus Gamachignathus (Wang & Aldridge, 1996). The M and Pd elements of G.? macroexcavata are similar to the corresponding elements in G. ensifer. However, the element denticulation, Pa element morphology and Sc element morphology are atypical of Gamachignathus.

The prioinodontid genus, Birksfeldia, erected by Orchard (1980), has been regarded as closely similar to Gamachignathus. In fact, Savage & Bassett (1985) regarded Gamachignathus as a junior subjective synonym of Birksfeldia Orchard. However, McCracken (1987) argued that although the two genera are closely related they should remain separate genera, due to differences in their morphology and geographic distribution. He noted that the Pa elements of Gamachignathus and Birksfeldia differed in the length and denticulation of the lateral process, and the denticulation of the antero-lateral process. The debate is likely to continue until the criteria used for erecting conodont genera have been agreed upon. Armstrong et al. (1996) have recently reviewed this taxonomic problem.

Gamachignathus ensifer McCracken, Nowlan & Barnes, 1980
Pl. 13, figs 1-6

* 1980 Gamachignathus ensifer McCracken et al., pl. 10.1, figs 1-17.


v 1981 Gamachignathus ensifer McCracken et al.; McCracken & Barnes, p. 77, pl. 5, figs 1-27.

1987 Gamachignathus ensifer McCracken et al.; McCracken, p. 1460, pl. 1, fig. 25.
Appendix A

Systematic Palaeontology

Holotype. *Gamachignathus ensifer* McCracken et al., 1980, pl. 10.1, figs 9, 13. Specimen GSC 60063 from the Ellis Bay Formation, Anticosti Island, Québec, Canada.

Diagnosis. Refer to McCracken et al. (1980, p. 106)

Description. Elements of *G. ensifer* have been described fully in McCracken, Nowlan & Barnes (1980, p. 106-108).

Remarks. *G. ensifer* is distinguished from other species in the genus by the lateral compression of the cusp and denticles.

Occurrence. Ellis Bay Formation (Lousy Cove and Laframboise Members), Anticosti Island, Québec.

*Gamachignathus hastatus* McCracken, Nowlan & Barnes, 1980

Pl. 13, figs 7-10

* 1980  *Gamachignathus hastatus* McCracken et al., pl. 10.2, figs 1-16.


Holotype. *Gamachignathus hastatus* McCracken et al., 1980, pl. 10.2, fig. 12. Specimen GSC 60084 from the Ellis Bay Formation, Anticosti Island, Québec, Canada.

Diagnosis. Refer to McCracken et al. (1980, p. 110)

Description. Elements of *G. hastatus* have been described fully in McCracken, Nowlan & Barnes (1980, p. 110).
Remarks. *G. hastatus* can be distinguished from *G. ensifer* in having elements in which the cusp and denticles are long and slender with a sub-circular cross section.

Occurrence. Ellis Bay Formation (Lousy Cove and Laframboise Members), Anticosti Island, Québec.

Family Cyrtoniodontidae Hass, 1959

Remarks. Sweet (1988) placed *Phragmodus* Branson & Mehl and *Bryantodina* Stauffer within the Cyrtoniodontida. However, *Bryantodina* has carminate and angulate P elements, which are atypical of the Prioniodontida and more characteristic of the Ozarkodinida. The P elements of *Phragmodus* are pastinate, which is characteristic of the Prioniodontida, but lack a well-developed anterior process. Prior to a review of the suprageneric classification, *Phragmodus* is retained within the Family Cyrtoniodontidae, Order Prioniodontidae (Aldridge & Smith, 1993).

Genus *Phragmodus* Branson & Mehl, 1933

Type species. *Phragmodus primus* Branson & Mehl, 1933.

Diagnosis. Refer to Sweet (1981a, p. 245-246).

Remarks. The *Phragmodus* apparatus comprises two P elements, an M element and an S array (Leslie & Bergström, 1995). The Pa and Pb elements have a posterior process and an inner-antero-lateral process. The anterior margin of the cusp projects out of the plane of the blade and is adenticulate. They are not typical pastinate elements, as they lack well-developed anterior processes. The M element is dolabrate or coniform geniculate, and the S elements are alate, tertio pedate, and bipennate (Sweet, 1988).
**Phragmodus undatus** Branson & Mehl, 1933

Pl. 13, fig. 12.

1933 *Phragmodus primus* Branson & Mehl, p. 98-99, pl. 6, fig. 26.

* 1933 *Phragmodus undatus* Branson & Mehl, p. 115, pl. 8, figs 22-26.

1966 *Phragmodus undatus* Branson & Mehl; Bergström & Sweet.

1981a *Phragmodus undatus* Branson & Mehl; Sweet, p. 267-270, pl. 1, figs 8-14.


**Syntypes.** *Phragmodus undatus* Branson & Mehl, 1933, pl. 8, figs 22-26. Cotypes C105-4 and C103-3 from the Plattin Formation, Missouri, U. S. A.

**Diagnosis.** Refer to Sweet (1981a, p. 267).

**Description.** Sc element. Compressed, bipennate, with a denticulate posterior process and an anterior process reduced to a downward extension of the cusp. The posterior process bears at least five denticles. The proximal denticles are short and erect; distally, the denticles become taller and broader, and are inclined posteriorly. The basal margin of the posterior process is arched. The basal cavity is a narrow groove.

**Remarks.** Leslie & Bergström (1995) synonymised *P. primus* with *P. undatus*. Major reviews of this species include Bergström & Sweet (1966) and Sweet (1981a).

**Occurrence.** Ellis Bay Formation (Lousy Cove Member), Anticosti Island, Québec.
Family Distomodontidae Klapper, 1981

Remarks. Sweet (1988) defined the Distomodontidae as containing five or six morphotypes; stelliscaphate and pastinate P elements (or their reduced derivatives), and ramiform elements with short, weakly denticulate or adenticulate processes. He included Coryssognathus Link & Druce, Distomodus Branson & Branson and Rotundacodina Carls & Gandl.

Genus Coryssognathus Link & Druce 1972

Type species. Cordylodus ? dubius Rhodes, 1953.


Remarks. The apparatus of Coryssognathus consists of 16 elements, Pa, Pb, Pc, M, Sa / Sb, Sb and two pairs of Sc elements (Miller & Aldridge, 1993). Coniform elements found associated with Coryssognathus are thought to represent discrete denticles, which were added on to the elements during ontogeny (Miller & Aldridge, 1993).

Coryssognathus cf. C. dubius (Rhodes, 1953)

Pl. 15, figs 4,5

1990 Dentacodina aff. D. dubia (Rhodes); Armstrong, p. 72-73, pl. 20, figs 17-22.

Description. Pb? element. The elements recovered herein differ from those described by Armstrong (1990, p. 72) only in bearing one small denticle on the anterior edge of the platform.
**Remarks.** The elements were recovered from a sample, which also contained elements of *D. kentuckyensis*. This element may in fact represent the Pc element of *D. kentuckyensis* (Aldridge *pers. comm.*).

**Occurrence.** Transitional Limestone Unit, Prongs Creek, northern Yukon.

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Genus *Distomodus* Branson & Branson, 1947

**Type species.** *Distomodus kentuckyensis* Branson & Branson, 1947.

**Diagnosis.** Refer to Bischoff (1986, p. 94).

**Remarks.** Species of *Distomodus* have a Type I prioniodontid apparatus plan, characterised by Pa elements with multiple, wide processes, each ornamented with ridges and nodes. Species of *Distomodus* differ in the morphology of the Pa element. The ancestral *D. kentuckyensis* has a Pa element with 4 processes, whereas that of *D. staurognathoides* has 5 processes.

*Distomodus kentuckyensis* Branson & Branson, 1947

Pl. 14, figs 1-6

* 1947 *Distomodus kentuckyensis* Branson & Branson, p. 553, pl. 81, figs 21-23, 27, 29-33, 36-41.

1967 *Icriodina irregularis* Branson & Branson; Rexroad, p. 33-34, pl. 2, figs 18-21.

1975 *Distomodus kentuckyensis* Branson & Branson; Cooper, p. 998-999, pl. 2, figs 6, 8, 10, 11, 13, 14.

**Holotype.** *Distomodus kentuckyensis* Branson & Branson, 1947, pl. 81, figs 40, 41. Specimen C675-1, from the Brassfield Limestone, Kentucky, U. S. A.

**Diagnosis.** The Pa element has been diagnosed by Rexroad (1967, p. 33).
Description. The Pa, Sa and Sc elements were described by Rexroad (1967) and named *I. irregularis*, *T. brassfieldensis* and *Ligonodin? extrorsa*, respectively. Branson & Branson (1947, p. 552-553) originally described the Pb and M elements as *Drepanodus simplexus* and *Distomodus kentuckyensis*, respectively.

Remarks. *D. kentuckyensis* is characterised by a cruciform Pa element with four broad processes bearing irregular and coalescing nodes. The Pa element was originally discovered by Branson & Branson (1947). Aldridge & Mohammed (1982) figured adult and juvenile Pa elements.

Cooper (1975) reconstructed the multielement apparatus of *D. kentuckyensis* consisting of Pa, Pb, M, Sa, Sb and Sc elements. The M, and S elements of *D. kentuckyensis* and *D. staurognathoides* have often been classified and described together (e.g. Aldridge, 1972).

Bischoff (1986) erected a number of species with Pa elements bearing four processes. He differentiated them from *D. kentuckyensis* by the angles between the processes. Within this study, only rare Pa elements of *Distomodus* have been recovered and these all conform to the diagnosis of *D. kentuckyensis*.

Occurrence. Transitional Limestone Unit, Prongs Creek, northern Yukon.

*Distomodus staurognathoides* (Walliser, 1964)

Pl. 14, figs 7-13

* 1964 *Hadrognathus staurognathoides* Walliser, p. 35, pl. 5, fig. 2; pl. 13, figs 6-15.

1976 *Distomodus staurognathoides* (Walliser); Barrick & Klapper, p. 71-72, pl. 1, figs 20-28.
1977  *Hadrognathus staurognathoides* Walliser; Cooper, p. 1066-1967, pl.1, figs 1, 5-7, 12, 16.

1986  *Distomodus staurognathoides* (Walliser); Bischoff, p. 106, pl. 10, figs 13-36; pl. 11, figs 1-33; pl. 12, figs 1-28.

1987b  *Distomodus staurognathoides* (Walliser); Over & Chatterton, p. 581, fig. 1, 1-6.

1990  *Distomodus staurognathoides* (Walliser); Armstrong, p. 73-76, pl. 8, figs 6-10; pl. 9, figs 2-3.

**Holotype.** *Hadrognathus staurognathoides* Walliser, 1964, pl. 5, fig. 2; pl. 13, fig. 7. From sample 11c within the *P. celloni* CBZ, Carnic Alps, Austria.

**Diagnosis.** Refer to Bischoff (1986, p. 108).

**Description.** The Pa element has been described previously as *Hadrognathus staurognathoides* in Nicoll & Rexroad (1969, p. 36) and variations within the Pa element have been noted by Bischoff (1986, p. 110-118). The Pb element has been previously described as *Trichonodella ? expansa* in Nicoll & Rexroad (1969, p. 64). The M, Sa, Sb and Sc elements appear morphologically identical to those of *D. kentuckensis*.

**Remarks.** *D. staurognathoides* is characterised by a Pa element with five processes. The Pa element was recovered by Walliser (1964) and a multielement reconstruction was first proposed by Barrick & Klapper (1976). Over & Chatterton (1987b) included elements previously assigned to *Johnognathus huddlei* Mashkova considering them to represent the broken posterior process of an S element.

Bischoff (1986) identified four stages within the evolution of *D. staurognathoides*, which differed in the morphology and ornamentation of the Pa elements. The M and S elements are indistinguishable, but the Pb elements vary in the development of a platform ledge. Bischoff (1986) regarded the
alpha (*sedgwickii* to mid *crispus* GBZ), beta (upper *crispus* to *murchisoni* GBZ), gamma (*griestonensis* to *murchisoni* GBZ) and delta (upper *murchisoni* to *riccartonensis* GBZ) variations as stages within an evolving lineage.

**Occurrence.** Jupiter (Ferrum and Pavillion Members) and Chicotte Formations, Anticosti Island, Québec; Road River Group, Prongs Creek, northern Yukon.

*Distomodus?* sp. A

Pl. 15, figs 1-3

**Remarks.** The Pa element has a posterior blade and an anterior platform. The platform bears two rows of offset denticles, whereas the blade bears a single row of at least six denticles. The angle of deflection of the blade in relation to the platform is variable. There is an adenticulate, outer-lateral process and an inner, posterior basal-cavity flare. It has an irregular white matter distribution. This element can be distinguished from that found in species of *Icriodella* in the irregular nature of the denticles and white matter distribution. The Pb and M elements associated with the Pa element appear to be identical to those of *D. kentuckyensis*.

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario.

**Family** Icriodellidae Sweet, 1988

**Remarks.** Sweet (1988) defined this family as containing genera with a quinquimembrate apparatus, with a pastinate, pastiniscaphate, or stelliscaphate Pa element. The Pa element characteristically has one or more processes, which have two rows of denticles or nodes. He included *Icriodella, Pedavis* Klapper & Murphy, *Sannemannia* Al-Rawi and *Stepotaxis* Uyeno & Klapper. The latter three genera have subsequently transferred to the Icriodontidae (Aldridge & Smith, 1993).
Appendix A

Genus *Icriodella* Rhodes, 1953

**Type species.** *Icriodella superba* Rhodes, 1953.

**Diagnosis.** Refer to Cooper (1975, p. 1003).

**Remarks.** Species of *Icriodella* have a Type I prioniodontid apparatus, containing Pa, Pb, Pd, M, Sa, Sb and Sc elements. Species of *Icriodella* can be differentiated by the angle of deflection of the blade and denticulation of the Pa element.

*Icriodella deflecta* Aldridge, 1972

Pl. 16, figs 1-7

* 1972 *Icriodella deflecta* Aldridge, p. 183-184, pl. 1, figs 4-7.
* 1975 *Icriodella deflecta* Aldridge; Aldridge, pl. 1, fig. 16.
* 1975 *Icriodella deflecta* Aldridge; Cooper, p. 1003-1004, pl. 2, fig. 7.
* 1981 *Icriodella deflecta* Aldridge; McCracken & Barnes, p. 111, pl. 7, figs 40-42.

**Holotype.** *Icriodella deflecta* Aldridge, 1972, pl. 1, fig. 6. Specimen X.561 from the Venusbank Formation, Welsh Borderland, Britain.

**Diagnosis.** The Pa element has been diagnosed by Aldridge (1972, p. 183)

**Description.** Cooper (1975, p. 1003-1004) described all the elements of *I. deflecta*. The M elements recovered herein are very variable, but all have lenticular basal cavities. The S elements characteristically bear compressed cusps and denticles.

**Remarks.** This is a species of *Icriodella* with a Pa element in which the blade is deflected by approximately 45° from the axial plane of the platform. The M
and S elements of *I. deflecta* have been previously regarded as identical to the corresponding element of *I. discreta*. The M elements can be distinguished by the roundness of the basal cavity. The basal cavity of elements of *I. deflecta* is more lenticular than those of *I. discreta*. The S elements have been distinguished by the degree of compression of the cusp and denticles, the S elements of *I. deflecta* being more compressed than those of *I. discreta*. The Sb elements of *I. discreta* may have more twisted processes than the corresponding elements of *I. deflecta*.

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario; Becscie, Merrimack and Gun River Formations, Anticosti Island, Québec.

*Icriodella discreta* Pollock, Rexroad & Nicoll, 1970

Pl. 16, figs 8-14

1972 *Icriodella discreta* Pollock *et al.*; Aldridge, p. 184, pl. 1, figs 1-3.
1975 *Icriodella discreta* Pollock *et al.*; Aldridge, pl. 1, fig. 15.
1975 *Icriodella discreta* Pollock *et al.*; Cooper, p. 1004, pl. 2, figs 1-4.

**Holotype.** *Icriodella discreta* Pollock, Rexroad & Nicoll, 1970, pl. 111, figs 27a-b. Sample No. 16-6 (12536), from the Reynales Limestone, Niagara Falls, Ontario, Canada.

**Emended diagnosis.** A species of *Icriodella* with a Pa element in which the blade is deflected only a few degrees from the axial plane of the platform.

**Description.** The elements of *I. discreta* have been previously described by Cooper (1975, p. 1004). The M elements recovered herein are very variable,
but all have sub-circular basal cavities. The S elements have rounded cusps and denticles.

**Remarks.** The differences between the M and S elements of *I. deflecta* and *I. discreta* are discussed under the remarks for *I. deflecta.*

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario; Becscie, Merrimack and Gun River Formations, Anticosti Island, Québec.

*Icriodella* cf. *I. inconstans* Aldridge, 1972

Pl. 15, fig. 11

**Description.** Pa element. The element recovered herein is similar to that of *Icriodella inconstans* (Aldridge, 1972), but differs in lacking a well developed, outer-basal-cavity flare and bearing more rounded denticles.

**Remarks.** Uyeno & Barnes (1983) recovered Pa elements of *I. inconstans* from the Jupiter Formation (Anticosti Island), which also lacked a pronounced outer-lateral flange and bore rounded denticles in some specimens. Uyeno & Barnes (1983) used the first appearance of this species to identify the base of the *inconstans* CBZ ranging from the upper Jupiter to lower Chicotte Formations (Anticosti Island).

**Occurrence.** Jupiter Formation (Pavillon Member), Anticosti Island, Québec.

*Icriodella* sp. A

Pl. 15, fig. 10

**Remarks.** This species is known only from its Pa element, which appears to be intermediate between *I. discreta* and *I. deflecta*. There is little deflection of the platform from the blade, which is indicative of *I. discreta*. However, the blade and platform are long and the denticulation on the blade is typical of *I. deflecta.*
A similar element was figured by Aldridge & Mohammed (1982, pl. I, fig. 18) from the Oslo Graben.

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario.

**Family** Pterospathodontidae Cooper, 1977

**Remarks.** Sweet (1988) assigned this family to the Order Ozarkodinida, but Aldridge & Smith (1993) later transferred it to the Prioniodontida. Sweet (1988) originally included *Apsidognathus, Astropentagnathus, Aulacognathus, Carniodus, Johnognathus* and *Pterospathodus* within this family. However, Aldridge & Smith (1993) transferred *Carniodus* to Fam. nov. 6, *Johnognathus* to the Distomodontidae, *Aulacognathus* to the Kockelellidae and added the genus *Pranognathus*. The Aldridge & Smith (1993) reinterpretation is followed herein apart from the removal of *Carniodus*, which has been retained within this family.

Genera within Pterospathodontidae have a Type II prioniodontid apparatus, containing Pa, Pb, Pc, Pd, M, Sb, and Sc elements. The genera differ in the development of lateral processes on the Pa element.

**Genus** *Apsidognathus* Walliser, 1964

**Type species.** *Apsidognathus tuberculatus* Walliser, 1964.

**Diagnosis.** Refer to Armstrong (1990, p. 41).

**Remarks.** Seven elements have been identified within the *Apsidognathus* apparatus, which have proven difficult to homologise with other apparatus plans. This has led to the suggestion of a number of possible homologies (Fig. A.4.), the most recent, that of Armstrong (1990) will be followed herein.
**Appendix A**

**Systematic Palaeontology**


<table>
<thead>
<tr>
<th>Pa₁</th>
<th>Pa</th>
<th>Pa₁</th>
<th>Platform (Pa₁)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sa</td>
<td>Arched scaphate</td>
<td>S</td>
<td>Lyriform (Sa or Sb)</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb₂</td>
<td>Ambalodiform (Pb)</td>
<td>Arched anguliscaphate or pyramidal pastiniscaphate.</td>
</tr>
<tr>
<td>Pb</td>
<td>Stelliscaphate</td>
<td>Pb₁</td>
<td>Astrognathiform (Sa or Sd)</td>
</tr>
<tr>
<td><em>Pseudooneotodus</em> n. sp. of Cooper</td>
<td>Coniform</td>
<td>-</td>
<td>Coniform (M)</td>
</tr>
<tr>
<td>Pa₂</td>
<td>-</td>
<td>Pa₂</td>
<td>Lenticular (Pa₂)</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Compressed (Sc)</td>
</tr>
</tbody>
</table>

**Figure A.4.** Comparison of the terminology used to describe *Apsidognathus* elements.

The platform element is homologous to the Pa element of other prioniodontids. It has posterior, anterior, two inner-lateral processes and two outer-lateral processes, connected by an ornamented platform. This element differs from the Pa of *Astropentagnathus* in having two inner-lateral processes and a well-developed, inter-process platform, which is thick and ornamented. The general morphologies of the other elements are listed in Figure A.4.

**Apsidognathus tuberculatus** Walliser, 1964

Pl.17, figs 1-7

* 1964 *Apsidognathus tuberculatus*, p. 29, pl. 5, fig. 1; pl. 12, figs 16-22; pl. 13, figs 1-5.

1975 *Apsidognathus tuberculatus* Walliser; Aldridge, pl. 1, figs 1, 2.

1980 *Apsidognathus tuberculatus* Walliser; Helfrich, pl. 1, figs. 25, 29.
1983  *Apsidognathus tuberculatus* Walliser; Uyeno & Barnes, p. 14-15, pl. 6, figs 6-14.

1986  *Apsidognathus tuberculatus* Walliser; Bischoff, p. 150-156, pl. 1, figs 1-16, 17-28; pl. 2, figs 1-4.

1990  *Apsidognathus tuberculatus* Walliser; Armstrong, p. 41-47, pl. 1, figs 1-11, 12-16; pl. 2, figs 1-4.

**Holotype.** *Apsidognathus tuberculatus* Walliser, 1964, pl. 5, fig. 1; pl. 12, fig. 18. Specimen from Cellon, Carnic Alps, Austria.

**Diagnosis.** Refer to Armstrong (1990, p. 42).

**Description.** Platform and Lyriform elements identical to those found herein have been described by Uyeno & Barnes (1983, p. 14) as Pa and Sa elements respectively. The Coniform elements have previously been described as elements of *Pseudooneotodus* n. sp. of Cooper by Uyeno & Barnes (1983, p. 23-24). The Lenticular elements recovered herein conform to the description of the corresponding elements in *A*. n. sp. of Armstrong (1990, p. 48).

**Remarks.** The platform element was first recorded by Walliser (1964), the lyriform element by Aldridge (1975), the astrognathiform element by Helfrich (1980), the lenticular element by Uyeno & Barnes (1983), the ambalodiform and coniform elements by Bischoff (1986) and the compressed element by Armstrong (1990). *A. tuberculatus* was firstly diagnosed by Uyeno & Barnes (1983) and subsequently re-diagnosed by Bischoff (1986, p. 150) and Armstrong (1990, p.42), who both identified subspecies. Subspecies of *A. tuberculatus* have been differentiated by the general morphology and ornamentation of the platform and lyriform elements.

**Occurrence.** Jupiter (Pavillion Member) and Chicotte Formations, Anticosti Island, Québec.
Genus Astropentagnathus Mostler, 1967

Type species. Astropentagnathus irregularis Mostler, 1967.

Diagnosis. Refer to Armstrong (1990, p. 58).

Remarks. Species of Astropentagnathus differ in the presence or absence of an inter-process platform, which has well developed growth lines. The P and M elements of the Astropentagnathus species are similar in morphology, whereas the S elements are significantly different.

Astropentagnathus araneum McCracken, 1991c
Pl. 18 figs 12-16

1987a Astropentagnathus irregularis Mostler; Over & Chatterton, pl. 2, figs 2-9.
* 1991c Astropentagnathus araneum McCracken, p. 109-112, pl. 2, figs 1-10, text figs 5, 6.

Holotype. Astropentagnathus araneum McCracken (1991c), pl. 2, fig. 8. Specimen GSC 101208 from the Road River Group, Blackstone River, northern Yukon Territories, Canada.


Description. Pa element. Refer to the description of the g element of A. araneum by McCracken (1991c, p. 112, pl. 2, figs 8-10). Specimens from Prongs Creek differ from those described by McCracken (1991c) in that the inner and outer-lateral processes are not directly adjacent; the inner is offset to the anterior of the outer process. The processes are also shorter, the anterior has nine whereas the posterior bears, on average, seven denticles.
Pc element. Refer to the description of the $f$ element of *A. araneum* by McCracken (1991c, p. 110-112, pl. 2, figs 2, 6). The long, perpendicular inner-lateral process described by McCracken (1991c), is considered herein to be the outer-lateral process, with the inner-lateral process being poorly developed.


Sb$_2$ element. This element is similar to the description and figures of the $a$? element of *A. araneum* in McCracken (1991c, p. 109, pl. 2, fig. 5), but differs in that it has four processes (anterior, posterior, outer and inner-lateral processes) rather than the three described by McCracken (1991c).

Sc element. Bipennate, with anterior and posterior processes meeting at an angle of 45°. The anterior process is inwardly bowed, downwardly directed and bears at least eight denticles. The straight posterior process bears at least five denticles. On both processes the denticles are fused and elongate. The inter-process platform has well developed growth lines.

Remarks. This species is characterised by an inter-process platform on several of the elements. It also differs from other known species of *Astropentagnathus* in having a quadriramate Sb$_2$ element. McCracken (1991c) identified and reconstructed an apparatus for this species, which is followed herein. However, elements similar to the $e$ elements described by McCracken (1991c) have not been recovered during this study.

*A. araneum* has only previously been recorded by McCracken (1991c) from the northern Yukon. However, it is likely to have been previously identified as *A. irregularis*.

Occurrence. Road River Group, Prongs Creek, northern Yukon.
Astropentagnathus irregularis Mostler, 1967
Pl. 18, figs 1-11

* 1967 Astropentagnathus irregularis Mostler, p. 298, pl. 1, figs 1-11.
1986 Astropentagnathus irregularis Mostler; Bischoff, p. 158-162, pl. 2, figs 27-29; pl. 3, figs 1-14.
1990 Astropentagnathus irregularis irregularis Mostler; Armstrong, p. 59, pl. 5, figs 1-10.
1991c Astropentagnathus irregularis Mostler; McCracken, pl. 2, figs 11-19.

Holotype. Astropentagnathus irregularis Mostler, 1967, pl. 1, fig. 3.

Emended diagnosis. A species of Astropentagnathus with elements that lack an inter-process platform, which has widely spaced growth ridges and microreticulation.

Description. Pa element. This element has been fully described as the Pa₁ element of A. irregularis irregularis by Armstrong (1990, p. 59).

Pb element. Pyramidal, pastiniscaphate, with a posterior, anterior and outer-lateral process. The anterior and outer-lateral processes are more steeply directed downwards than the posterior process. An inter-process platform is present between all processes, which lacks the growth lines characteristically seen on elements of A. araneum. Denticulation on the processes is variable between specimens. The processes may be adenticulate, or denticulate with ill defined, upright denticles. The entire lower surface is excavated.

Pc element. The adult form of this element has been described as the Pa₂ element, and the juvenile form as the Pb element of A. irregularis irregularis by Armstrong (1990, p. 59).
M element. This element has been formerly described as the Sb element of *A. irregularis irregularis* by Armstrong (1990, p. 60). The specimens herein differ from those described by Armstrong (1990) in that the basal cavity is not restricted to beneath the cusp. The anterior tip of the basal cavity is not expanded and the posterior tip is expanded creating a short adenticulate process in adult forms. The basal cavity extends as tapering grooves to the tips of the processes.

Sb₁ element. Tertiopedate, with downwardly directed outer and inner-lateral processes. The angle between the processes is less than 90°. The lateral processes may be twisted. They bear at least eight denticles. The denticles are long, slender and completely fused. The basal cavity is sub-rounded and wide beneath the cusp. The cavity does not appear to continue along the lateral processes.

Sb₂? element. Tertiopedate element, which is similar to the Sb elements, but differs in having a more developed posterior process. The process is short and adenticulate.

Sc element. Bipennate, with downwardly directed posterior and anterior processes. The anterior process is more steeply downwardly directed. The anterior process bears at least five denticles and the posterior process bears at least three. Juvenile and adult forms can be distinguished.

Remarks. *A. irregularis* lacks the inter-process platform and quadriramate Sb₂ element seen in *A. araneum*. The Pa element of *A. irregularis* was first recovered by Mostler (1967). Klapper & Murphy (1975) regarded 'Rhyncognathus' n. sp. Schönlaub (1971) as the M (= Pb) element, and Armstrong (1990) included the ramiform elements figured by Schönlaub (1971) within this apparatus. Elements with the same morphology as the Sc element of *A. irregularis irregularis* in Armstrong (1990, p. 60) have not been recovered in this study.
**Occurrence.** Jupiter Formation (Pavillion Member), Anticosti Island, Québec; Road River Group, Prongs Creek, northern Yukon.

**Genus Pranognathus** Männik & Aldridge, 1989

**Type Species.** *Amorphognathus tenuis* Aldridge, 1972.

**Diagnosis.** Refer to Männik & Aldridge (1989, p. 904).

**Remarks.** The *Pranognathus* apparatus comprises Pa, Pb, Pc, Pd, M, Sb1, Sb2, and Sc elements. The inner-lateral process of the Pa and Pc elements is more developed than the outer-lateral process.

Pollock et al. (1970) identified a Pa element which they termed *Aphelognathus siluricus* Pollock et al. Later, Cooper (1977) added Pb (= Pc), M (= Pb?) and S (= Sb,) elements and placed this species in the new genus *Llandoverygnathus*. Uyeno & Barnes (1983) reassigned this species to *Pterospathodus*, and partially reconstructed the apparatus as consisting of Pa, Pb (= Pc), and M elements.

Aldridge (1972, pl. 2 fig. 3) figured the Pa element of *Amorphognathus tenuis*, an element with five processes (anterior, posterior, outer-lateral and two inner-lateral processes). Uyeno & Barnes (1983, p. 24-25) described a similar Pa element, which differed in having a reduced outer-lateral process. They erected a new species, *Pterospathodus posteritenuis* Uyeno & Barnes, which had an apparatus including Pa, Pb (?), M (= Pb?), Sa, Sb-Sa (?), Sb, Sc-Sb (?), Sc elements.

Männik & Aldridge (1989) regarded *P. tenuis* and *P. posteritenuis* as having comparable apparatus plans but differing in the development of lateral processes on the Pa element. They regarded the multielement apparatus of
Pranognathus tenuis as consisting of Pa, Pb (= Pc), Pc (= Pb), M, Sa, Sb, Sc₁ (= Pd) and Sc₂. Homology with the Promissium plan suggests that the element regarded as occupying the Pb position is more likely to have been in the Pc position and vice versa. The Sc₁ element (sensu Männik & Aldridge, 1989) is tentatively homologised with the Pd element.

Bischoff (1986 p. 190-194, pl. 28, figs 13-33) recovered a species of Pterospathomus, Pterospathomus cadiaensis, from the stauognathoides CBZ. The Pa element is blade-like with variable denticulation, lacks lateral processes and has a broad basal cavity. It is possible that this species is a geographic variation of Pranognathus, as it occurs at the same time interval and has similar S elements.

Pranognathus cf. P. tenuis (Aldridge, 1972)

Pl. 19, figs 1-6

* 1972 Amorphognathus tenuis Aldridge, p. 164, pl. 2, figs 3, 4.
1989 Pranognathus tenuis Aldridge; Männik & Aldridge, p. 904-905, text-fig. A-Z.

Description. Pc element. Refer to description of Ambalodus anapetus Pollock, Rexroad & Nicoll in Aldridge (1972)

Pd element. Bipennate, in which the posterior process is deflected downwards much less than the anterior process. The anterior and posterior processes bear at least three and two denticles respectively. The basal cavity is narrow.

M element. The inner-lateral process is longer and less downwardly directed than the outer-lateral process. The outer-lateral process is a denticulate, downward extension of the lateral edge of the cusp. The inner-lateral and outer-lateral processes bear at least four and three upright, fused, denticles,
respectively. There may be a posterior process, but this is broken in all specimens.

Sb\textsubscript{1} element. Tertiopedate, with inner and outer-lateral processes, which are steeply directed downwards and curve inwards distally. The posterior process is also steeply directed downwards, and in some more asymmetrical specimens curves towards the outer-lateral process. All processes are denticulate and bear at least five upright, fused denticles.

Sb\textsubscript{2} element. Tertiopedate elements, which are similar to the Sb\textsubscript{1} elements, but have an adenticulate inner-lateral process. A costa extends down the cusp to the tip of the inner-lateral process.

Sc element. Bipennate, with a posterior process, which is straight or slightly downwardly directed, and an anterior process which is steeply downwardly directed and inwardly inclined. The denticles are upright and partially fused. There are at least four on the anterior process and three on the posterior process. The basal cavity is narrow.

**Remarks.** *P. tenuis* is a species of *Pranognathus* which has a Pa element with well-developed, lateral processes. The elements recovered herein are very similar to those illustrated as *P. tenuis* in Männik & Aldridge (1989). However, the lack of a well preserved Pa element means that the elements herein can not be definitely assigned to *P. tenuis*.

**Occurrence.** Transitional Limestone Unit, Prongs Creek, northern Yukon.

**Genus** *Pterospathodus* Walliser, 1964

**Type Species.** *Pterospathodus amorphognathoides* Walliser, 1964.

**Diagnosis.** Refer to Barrick & Klapper (1976, p. 81).
Remarks. The *Pterospathodus* apparatus contains Pa, Pb, Pc, Pd, M, Sb1, Sb2, and Sc elements, but lacks a truly symmetrical, Sa element. The inner-lateral process of the Pa element is poorly developed and adenticulate. The outer-lateral process may bifurcate and if so the anterior secondary process is shorter than the posterior secondary process. The Pc element has poorly developed, adenticulate outer and inner-lateral processes. The species of *Pterospathodus* differ in the degree of development of a platform ledge.

Männik & Aldridge (1989) reviewed the taxonomy of *Pterospathodus* and documented gradual changes in morphology through the *celloni* and *amorphognathoides* CBZs. Within the *celloni* CBZ, dextral Pa elements developed pennate lateral processes. Männik & Aldridge (1989) considered pennate and non-pennate taxa to be conspecific and synonymised *P. celloni* (Walliser) with *P. pennatus* (Walliser) and *P. angulatus* (Walliser).

Jeppsson (1979) suggested the synonymy of *Carniodus* Walliser and *Pterospathodus*, but subsequent workers have maintained the separate genera. For example, Männik & Aldridge (1989) regarded *Carinodus* and *Pterospathodus* as separate genera due to the low abundance of *C. carnulus* Walliser in the *celloni* CBZ. However, in samples from Prongs Creek, elements of *C. carnulus* occur in abundance with *P. celloni*. *C. carnulus* has only been reported from the *celloni* and *amorphognathoides* CBZs (e.g. Armstrong, 1990; Bischoff, 1986; Over & Chatterton, 1987a) and commonly only occurs in samples that yield elements of *Pterospathodus* (e.g. Over & Chatterton, 1987a). Therefore, herein the apparatuses of *Carniodus* and *Pterospathodus* have been synonymised. This is in agreement with the independent work of Männik (1998).

The Männik & Aldridge (1989) reconstruction of *Pterospathodus* lacked a Sc element. Herein, an element that is traditionally assigned to *Carniodus carnulus* is regarded as the Sc element of *Pterospathodus*. Within the Prongs
Creek samples, elements similar to the Pd element of Pranognathus were found in samples containing Pterospathodus. This element was originally described as Carniodus carnus in Walliser (1964, pl. 28, fig. 5) and was later included as the Sb element of Carniodus carnulus by Barrick & Klapper (1976). Herein, it is regarded as a Pd element of Pterospathodus.

Pterospathodus celloni (Walliser, 1964)

Pl. 19, figs 7-13

1962 Spathognathodus n. sp. b Walliser, p. 282, fig. 1, no. 9.
1962 Ozarkodina n. sp. a Walliser, p. 282, fig. 1, no. 7.
* 1964 Spathognathodus celloni Walliser, p. 73-74, pl. 4, fig. 13; pl. 14, figs 3-16; text figs 1b, 7b-f.
1964 Carniodus carnulus Walliser, p. 32, pl. 6, figs 10; pl. 10, figs 20, 21; pl. 27, figs 27-38; pl. 1; text figs 4a-f.
1971 Spathognathodus celloni Walliser; Schönlaub, p. 44, pl. 2, fig 1-5.
1975 Pterospathodus celloni (Walliser); Klapper & Murphy, p. 27, pl. 2, figs 2-3.
1976 Carniodus carnulus Walliser; Barrick & Klapper, p. 68, pl. 1, figs 1, 2, 6-8, 12-14.
1976 Pterospathodus celloni (Walliser); Barrick & Klapper, p. 82, pl. 1, figs 2-3.
1985 Pterospathodus celloni (Walliser); Aldridge, p. 80, pl. 3.1, figs 25, 26.
1986 Pterospathodus celloni (Walliser); Bischoff, p. 194-197, pl. 28, figs 34-39; pl. 29, figs 1-8.
1989 Pterospathodus celloni (Walliser); Männik & Aldridge, text fig. 1 A-F.
1990 Pterospathodus celloni (Walliser); Armstrong, p. 118, pl. 19, figs 6-14.
1995 Pterospathodus celloni (Walliser); Simpson & Talent, p. 173-175, pl. 12, figs 7-8.
Holotype. *Spathognathodus celloni* Walliser 1964, pl. 14, fig. 5. Specimen Wa740/11 from the Cellon Mountains, Carnic Alps, Austria.

**Emended diagnosis.** A species of *Pterospathodus* in which the Pa element lacks a platform ledge surrounding the processes.

**Description.** Pa element. Elements that lack a well developed outer process have been fully described as *Neospathognathodus celloni* Walliser in Aldridge (1972, p. 197) and those with well developed outer-lateral processes as *Neospathognathodus pennisatius* Walliser in Aldridge (1972, p. 197).

Pb element. This element has been previously described as *Neoprioniodus costatus paucidentatus* Walliser in Aldridge (1972, p. 193-194). The convex inner-lateral face described by Aldridge (1972) is in fact the outer face, and *vice versa*.

Pc element. Refer to the description of *Ozarkodina adiutricis* Walliser in Aldridge (1972, p. 198). There is an incipient outer-lateral process beneath the cusp, and an inner expansion of the basal cavity to the posterior of the outer-lateral process.

Pd element. This element fits the description of *Carniodus carnus* Walliser in Aldridge (1972, p. 169-170), but the elements recovered herein commonly only bear four denticles on the posterior process.


Appendix A

Systematic Palaeontology

Sc element. Refer to the description of *Neoprionidus subcarnus* Walliser in Aldridge (1972, p. 195-196).

**Remarks.** The Schönlaub (1971) identified the Pb (= Pc) element and Barrick & Klapper (1976) described the M, and S (= Pb) elements. Jeppsson (1979) and Mabillard & Aldridge (1983) suggested that *Exochognathus brevialatus* (Walliser) may have occupied a Sa / Sb position. The S element of Barrick & Klapper (1976), was reinterpreted as a Pb / M intermediate by Aldridge (1985) and later as a Pc (=Pb) by Männik & Aldridge (1989). Herein, Pd, and Sc elements are added and the Pb and Pc elements of Männik & Aldridge (1989) are reversed.

**Occurrence.** Chicotte Formation, Anticosti Island, Québec; Road River Group, Prongs Creek, northern Yukon.

*Pterospathodus rhodesi* Savage, 1985

Pl. 19, figs 14, 15

* 1985 *Pterospathodus amorphognathoides rhodesi* Savage, p. 714, fig. 3 A-T.

1987a *Pterospathodus pennatus rhodesi* (Savage); Over & Chatterton, p. 21-22, pl. 4, figs 5, 6.

1990 *Pterospathodus pennatus rhodesi* (Savage); Armstrong, p. 120-122, pl. 20, figs 6-16

1991c *Pterospathodus rhodesi* Savage; McCracken, p. 109, pl. 5, figs 6-15.

**Holotype.** *Pterospathodus amorphognathoides rhodesi* Savage, 1985, fig. 3 A, B. Specimen number USNM 371651 from the Heceta Limestone, south-eastern Alaska.

**Diagnosis.** Refer to Savage (1985, p. 714).
Description. Pa element. Stelliscaphate, with a long carina, which curves inwardly in the anterior-most third. The outer-lateral process is posteriorly directed and bears seven denticles, which are fused to their tips. The inner-lateral process is an adenticulate inward expansion of the platform and basal cavity; this is situated posterior of the carina – outer-lateral process intersection. A wide platform surrounds the processes and is upturned at the edges. The basal cavity extends as tapering grooves, which do not reach the tips of the processes.

Pb element. Pastiniscaphate, with a posterior process which is longer and higher than the anterior process. The outer-lateral process is adenticulate, developed as a minor extension of a costa running down the cusp. The anterior process bears four denticles, whereas the posterior process bears five, larger denticles. The proximal posterior denticle is wider than the other denticles. The denticles on both processes decline in height distally and are fused to their tips. There is a narrow ridge below the line of denticles on the outer face of the anterior and posterior processes. The cusp is robust and sub-rounded in cross section. The basal cavity is obscured.

Remarks. A species of Pterospathodus in which the Pa element has a wide platform ledge surrounding the processes. It differs from Pterospathodus amorphognathoides Walliser in the thicker platform ledge and the lack of a bifurcating outer-lateral process. Savage (1985) reconstructed the apparatus of this species to include Pb (= Pc), M and S (=Pb) elements. Armstrong (1990) and McCracken (1991c) described the Sa and Sb elements.

Occurrence. Road River Group, Prongs Creek, northern Yukon.
Description. Pa element. Pastinate, with five to seven denticles on the posterior process and six to nine on the anterior process. There is a central, adenticulate, inner-lateral projection of the basal cavity. The denticles on the posterior process are wider, taller and inclined more steeply to the posterior than those on the anterior process; the denticles on the anterior process increase in width distally. The denticles on both processes are almost fused to their tips and generally decrease in height distally. The basal cavity is expanded on the outer side beneath the cusp or just posterior to the cusp, whereas on the inner side maximum expansion occurs further to the anterior. The basal cavity extends as tapering grooves to the tips of the processes. White matter fills the denticles and cusp.

Pb element. Pyramidal pastiniscaphate, with an anterior process bearing six denticles and posterior process bearing three denticles. On the outer-lateral face of the cusp, there is a central costa, which extends into a short outer-lateral process, bearing one small denticle. The cusp is tall, wide, and steeply inclined to the posterior. The cusp and denticles are laterally compressed. On the anterior process, the denticles increase in height distally, are fused at the base and separated by V-shaped gaps. The denticles on the posterior process are very small. The processes are joined from their tips by a downward extension of the basal cavity, creating a deep oval cavity beneath the cusp. White matter is restricted to the cusp.

M element. Dolabrate, with a very large, laterally compressed cusp, which is inclined posteriorly and curved inwardly. The anterio-basal corner of the cusp extends downwards in to an anticusp. The posterior basal extension of the cusp bears one small denticle. The basal cavity is deep and has a sub triangular outline beneath the cusp.
Sb element. Tertiopedate, with posterior, inner and outer-lateral costa that extend into denticulate processes. The processes in all specimens have been broken. There is a deep sub-circular basal cavity beneath the cusp.

Sc element. Dolabrate, with a keel along the anterior edge of the cusp that extends into an anticusp. The straight, posterior process bears only one small triangular, compressed denticle. The basal cavity is deep, forming an oval outline beneath the cusp and extends to the tip of the anticusp. The posterior process is broken in all specimens, so the extent of the basal cavity can not be determined.

**Remarks.** This species has been tentatively placed within *Pterospathodus*. However, the apparent lack of a Pc element and the tall cusp of the Pb element, are characteristics of *Gamachignathus*. *Pterospathodus* sp. A differs from species of *Gamachignathus* in that on the Pa element the outer-lateral process is situated to the posterior of the inner-lateral process. *Pterospathodus* sp. A. differs from *Gamachignathus? macroexcavata* in the Pa element denticulation and curvature of the basal margin.

**Occurrence.** Thomloee Formation, Lake Timiskaming, Ontario.
Appendix A

A.3 Coniform and Rastrate taxa

Phylum CHORDATA Bateson, 1886

Class CONODONTA Eichenberg, 1930
Sensu Clark, 1981

Order Belodellida Sweet, 1988

Remarks. Sweet (1988) defined this order as including conodont apparatuses with four to five morphotypes, characteristically coniform elements with thin walls, smooth faces, deep basal cavities and typically well developed keels or costae. He included the Belodellidae Khodalevich & Tschernich, Ansellidae Fähræus & Hunter and Dapsilodontidae Sweet. The Dapsilodontidae has subsequently been transferred to the Protopanderodontida by Aldridge & Smith (1993).

Figure A.5. Homology of the Panderodus plan with other coniforms (from Sansom et al. 1995).
Dzik (1991) combined the Bellodellida and Panderodontida Sweet, a step reversed by Aldridge & Smith (1993). Sansom et al. (1995) suggested homology between some elements in the apparatuses of Coelocerodontus Ethington and Belodella Ethington, and Panderodus. However, they suggested that a full architectural study of the bellodellid apparatus would be a prerequisite to placing the Belodellidae within the Panderodontida.

**Family** Belodellidae Khodalevich & Tschemich, 1973

**Remarks.** Sweet (1988) included Belodella, Coelocerodontus, Dvorakia Klapper & Barrick, Stolodus Lindström and Walliserodus Serpagli within this family. Goverdina Fähræus & Hunter was added by Aldridge & Smith (1993).

<table>
<thead>
<tr>
<th>Armstrong (1990)</th>
<th>McCracken (1991b)</th>
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<tr>
<td>Sp</td>
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**Figure A.6** Comparison of the notational schemes applied to *Walliserodus* elements.

**Genus** Walliserodus Serpagli, 1967

**Type species.** *Acodus curvatus* Branson & Branson, 1947, designated by Cooper (1975, p. 995).

**Diagnosis.** Refer to Cooper (1975, p. 995).

**Remarks.** The *Walliserodus* apparatus contains five morphotypes. The apparatus consists of broad, coniform elements which lack furrows, and are
commonly ornamented with costae. Species of *Walliserodus* are differentiated by the general morphology of the ae element and the nature of lateral costae.

*Walliserodus blackstonensis* McCracken, 1991b

Pl. 20, figs 1-7

1990 *Walliserodus bicostatus* (Branson & Mehl); Armstrong, p. 122, pl. 21, figs 1-5.

* 1991b *Walliserodus blackstonensis* McCracken, p. 80, pl. 3, figs 1-42.

**Holotype.** *Walliserodus blackstonensis* McCracken, 1991b, pl. 3, fig. 14. Specimen GSC 101111 from the Road River Group, Blackstone River, northern Yukon Territory, Canada.

**Diagnosis.** Refer to McCracken (1991b, p. 80).

**Description.** Refer to McCracken (1991b, p. 80-81).

**Remarks.** McCracken (1991b) synonymised *W. bicostatus sensu* Armstrong (1990) with *W. blackstonensis*. Armstrong (1990) considered the distinguishing feature of *W. blackstonensis* (*W. bicostatus* therein) to be the double lower-lateral costae exhibited by the aequaliform (sym. p) and graciliform (aq) elements. However, McCracken (1991b) alternatively diagnosed this species as including elements with wide bases, narrow recurved cusps, keeled margins and costate ornamentation, apart from on the tortiform (= *a* therein) element.

This species has only previously been described from Greenland (Armstrong, 1990) and the northern Yukon (McCracken, 1991b).

**Occurrence.** Road River Group, Prongs Creek, northern Yukon.
* 1947  *Acodus curvatus* Branson & Branson, p. 554, pl. 81, fig. 20.
1975  *Walliserodus curvatus* (Branson & Branson); Cooper, p. 995, pl. 1, figs 10, 11, 16-21.
1981  *Walliserodus curvatus* (Branson & Branson); McCracken & Barnes, p. 90-91, pl. 1, figs 26-30.
Pv 1983  *Walliserodus sancticlairei* Cooper; Uyeno & Barnes, p. 26, pl. 7, figs 1-3, 5, 6.
1990  *Walliserodus curvatus* (Branson & Branson); Armstrong, p. 124-126, pl. 21, figs 6-15.
1991b  *Walliserodus curvatus* (Branson & Branson); McCracken, p. 81, pl. 4, fig. 12.
1995  *Walliserodus curvatus* (Branson & Branson); Simpson & Talent, p. 127-128, pl. 4, figs 21-25.

Holotype. *Acodus curvatus* Branson & Branson, 1947, pl. 81, fig. 20. Specimen C672-4 from the Brassfield Formation, Kentucky, U.S.A.

Diagnosis. Refer to Armstrong (1990, p. 125).

Description. The elements have been fully described by Armstrong (1990, p. 125-126).

Remarks. *W. curvatus* has recurved graciliform (aq), falciform? (sq) and tortiform (r) elements, with keeled lower margins, and a graciliform (aq) element with one to three costae on the inner face (Armstrong, 1990).

Occurrence. Thomloe Formation, Lake Timiskaming, Ontario; Bescie, Jupiter and Chicotte Formations, Anticosti Island, Québec; Transitional Limestone Unit, Prongs Creek, northern Yukon.
Walliserodus sanctclairi Cooper, 1976
Pl. 20, figs 14-23


p 1977 Walliserodus sanctclairi Cooper; Barrick, p. 59, pl. 1, figs 11, 13-20.

pv 1983 Walliserodus sanctclairi Cooper; Uyeno & Barnes, p. 26, pl. 7, figs 1-3, 5, 6.


1991b Walliserodus sanctclairi Cooper; McCracken, p. 81-82, pl. 4, figs 3-10, 15.

1995 Walliserodus sanctclairi Cooper; Simpson & Talent, p. 128-129, pl. 4, figs 26-27.

**Holotype.** Walliserodus sanctclairi Cooper, 1976, pl. 1, figs 8, 12. Sample OSU 31164, from the St. Clair Limestone, Southern Illinois, U. S. A.

**Diagnosis.** Refer to diagnosis in Cooper (1976, p. 214)

**Description.** The elements have been previously described by Armstrong (1990, p. 126-127).

**Remarks.** W. sanctclairi differs from W. curvatus in the lack of costae on the inner face of the a (tortiform) element (McCracken, 1991b). The other elements of W. sanctclairi differ from the corresponding elements in W. curvatus in the presence and arrangement of costa (See McCracken, 1991b, p. 82).

**Occurrence.** Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.
**Order** Panderodontida Sweet, 1988

**Remarks.** Sweet (1988) regarded the longitudinal furrow as the diagnostic characteristic of this order. Sansom *et al.* (1995) regarded the furrow as diagnostic at the family level and proposed that the Panderodontida should include apparatuses comprising an anterior domain of qa, qg and qt elements, a posterior domain of pf and pt elements, and a symmetrical ae element.

**Family** Panderodontidae Lindström, 1970

**Remarks.** Sansom *et al.* (1995) suggested that the qt element may be unique to members of the Panderodontidae, as it has not yet been recorded in other apparatuses.

They tentatively included *Pseudobelodina* Sweet, *Parabelodina* Sweet, *Culumbodina* Moskalenko and *Plegagnathus* Ethington & Furnish within this family, on the grounds that their elements exhibit a furrow. *Pseudobelodella* Armstrong also bears a characteristic furrow and is included within this family.

**Genus** Panderodus Ethington, 1959

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

**Diagnosis.** Refer to Sweet (1979, p. 62).

**Remarks.** The elements of *Panderodus* are simple coniforms with a distinctive furrow on one face or both faces in aequaliform elements. The falciform element shows most interspecific variation.

The *Panderodus* plan was proposed by Sansom *et al.* (1995), using rare clusters and bedding-plane assemblages. The apparatus comprised six morphotypes: a pair of arcuatiform (qa) elements, four pairs of graciliform (qg)
elements, a pair of truncatiform (qt) elements, a pair of falciform (pf) elements, a pair of tortiform (pt) elements and a single aequaliform (ae) element (Figure A.7). This reconstruction is followed herein.

**Figure A.7** *Panderodus* plan from Sansom *et al.* (1995, text figure 6)

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**Figure A.8.** Comparison of notational schemes applied to *Panderodus* elements.
Panderodus acostatus (Branson & Branson)

Pl. 23, figs 1-8
Pl. 24, figs 7-15

* 1947 Paltodus acostatus Branson & Branson, p. 554, pl. 82, figs 1-5, 23-24.

1953 Paltodus equicostatus Rhodes, p. 297, pl. 21, figs 106-109.

1990 Panderodus aff. P. unicostatus (Branson & Mehl); Armstrong, p. 110, pl. 17, figs 8-13.

v 1995 Panderodus acostatus (Branson & Branson); Sansom et al., Text-Fig. 7.

Holotype. Paltodus acostatus Branson & Branson, 1947, pl. 82, figs 23-24. Specimen C676-4 from the Brassfield Formation, Kentucky, U. S. A.

Diagnosis. Refer to Rhodes (1953, p. 297).

Description. The elements of this species have been previously described by Armstrong (1990, p. 110). Additional, serrate arcuatiform elements have been previously described by Cooper (1975, p. 993).

Remarks. The elements of P. acostatus are morphologically similar to those of P. unicostatus (Branson & Mehl). The differences between the two are discussed under remarks for the latter species. Elements of P. acostatus have often been identified as elements of P. equicostatus (Rhodes) in the literature. However, P. equicostatus is a junior subjective synonym of P. acostatus (Sansom, 1992)

P. acostatus periodically develops serrations on the arcuatiform element. Serrate elements have traditionally been classified as a separate species, P. serratus, in form taxonomy. Serrate elements have also been observed in the P. unicostatus apparatus (e.g. Uyeno & Barnes, 1983). A detailed study is
needed to discern which species of *Panderodus* develop serrate elements, and the significance of their occurrence.

**Occurrence.** Eventurel Creek Formation, Lake Timiskaming, Ontario; Ellis Bay (Lousy Cove Member), Becscie, Merrimack, Gun River, Jupiter and Chicotte Formations, Anticosti Island, Quebec.

*Panderodus langkawiensis* (Igo & Koike, 1967)

Pl. 23, figs 9-17

* 1967 *Acodus langkawiensis* Igo & Koike, p. 12, pl. 1, figs 19-20.
  1977 *Panderodus spasovi* Drygant; Barrick, p. 56, pl. 3, figs 13-21.

v 1995 *Panderodus langkawiensis* (Igo & Koike); Sansom *et al*., Text-Fig. 7.

**Holotype.** *Acodus langkawiensis* Igo & Koike, 1967, pl. 1, fig. 19. Specimen from the Setul Limestone, Langkawi Island, Malaysia.

**Diagnosis.** Refer to the diagnosis of *P. spasovi* Drygant in Barrick (1977, p. 56).

**Description.** Previously described by Armstrong (1990, p. 107).

**Remarks.** The elements of *P. langkawiensis* are small, highly compressed, with a strongly recurved cusp. The cusp of graciliform elements may be at an angle of 90° to the base (Barrick, 1977). Elements of *P. panderi* (Stauffer) all also highly compressed, which led Armstrong (1990) to suggest that *P. langkawiensis* was a descendant of *P. panderi*.
Appendix A  Systematic Palaeontology

**Occurrence.** Chicotte Formation, Anticosti Island, Québec; Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

*Panderodus panderi* (Stauffer, 1940)
Pl. 24, figs 1-6

* 1940  *Paltodus panderi* Stauffer, p. 427, pl. 23, figs 219-220.
1953  *Paltodus recurvatus* Rhodes, p. 297, pl. 85, figs 8-9.
1959  *Panderodus panderi* (Stauffer); Stone & Furnish, p. 226, pl. 31, fig. 4.
1990  *Panderodus recurvatus* (Rhodes); Armstrong, p. 104-7, pl. 16, figs 1-11.
1995  *Panderodus panderi* (Stauffer); Sansom et al., Text-Fig. 7.
1995  *Panderodus recurvatus* (Rhodes); Simpson & Talent, p. 117-118, pl. 1, figs 21-27.

**Holotype.** *Paltodus panderi* Stauffer, 1940, pl. 60, fig. 8. Specimen from the shale overlying Cedar Valley Limestone, Austin, Minnesota, U.S.A.

**Diagnosis.** Refer to the diagnosis of *P. recurvatus* (Rhodes) in Armstrong (1990, p. 106).

**Description.** The elements have been previously described by Armstrong (1990, p. 106).

**Remarks.** *P. panderi* is characterised by laterally compressed and highly recurved elements. A curved heel is commonly present on the dorsal margin of the base.
**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario; Ellis Bay, Gun River, Jupiter and Chicotte Formations, Anticosti Island, Québec; Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

*Panderodus staufferi* (Branson, Mehl & Branson, 1951)

1951 *Paltodus staufferi* Branson, Mehl & Branson, p. 7-8, pl.1, figs 23-27.

1968 *Panderodus staufferi* (Branson, Mehl & Branson); Kohut & Sweet, p. 1470, pl. 186, figs 4-5.

1990 *Panderodus greenlandensis* Armstrong, p. 102-4, fig. 33, pl. 15, figs 1-8.

1994 *Panderodus staufferi* (Branson, Mehl & Branson); Sansom et al., Text-Fig. 7.

**Syntypes.** *Paltodus staufferi* Branson, Mehl & Branson, pl.1, figs 23-27. Four syntypes from the Whitewater Formation, east of Versailles, Ripley County, Indiana, U.S.A.

**Diagnosis.** Refer to the diagnosis of *P. greenlandensis* in Armstrong (1990, p. 102).

**Description.** The elements of this species have been fully described by Armstrong (1990, p. 102-104).

**Remarks.** The elements are all robust, broad, deeply furrowed with lateral costae. The basal wrinkle zone is well developed.

**Occurrence.** Thornloe Formation, Lake Timiskaming, Ontario; Jupiter and Chicotte Formations, Anticosti Island, Québec; Transitional Limestone Unit, Prongs Creek, northern Yukon.
*Panderodus unicostatus* (Branson & Mehl, 1933)

Pl. 25, figs 1-5

1933 *Paltodus unicostatus* Branson & Mehl, p. 42, pl. 3, fig. 3.

1977 *Panderodus unicostatus* (Branson & Mehl); Barrick, p. 56-57, pl. 3, figs 1, 2, 5, 6.

1994 *Panderodus unicostatus* (Branson & Mehl); Sansom *et al*., Text-Fig. 7.

1995 *Panderodus unicostatus* (Branson & Mehl); Simpson & Talent, p. 118-121, pl. 2, figs 1-32.

**Syntypes.** *Paltodus unicostatus* Branson & Mehl, 1933, pl. 3, fig. 3. Two elements from the Bainbridge Formation near Lithium, Missouri, U.S.A.

**Diagnosis.** Refer to the diagnosis of *P. unicostatus* in Barrick (1977, p. 56).

**Description.** The elements of *P. unicostatus* have been previously described by Cooper (1976, p. 213-214).

**Remarks.** The elements of *P. unicostatus* are gradually curving and tapering, slender cones (Barrick, 1977). This species is similar to *P. acostatus*, but can be differentiated by the more recurved nature of its falciform element. Serrate arcuatiform elements have been periodically observed within the apparatus of *P. unicostatus* (e.g. Uyeno & Barnes).

**Occurrence.** Earlton and Thornloe Formations, Lake Timiskaming, Ontario; Transitional Limestone Unit, Prongs Creek, northern Yukon.
Appendix A

Systematic Palaeontology

*Panderodus* sp. A
Pl. 25, figs 6-10

**Remarks.** A partial apparatus has been recovered. It is similar to that of *P. panderi*, but differs in that the falciform element is erect rather than recurved and has a more pronounced heel than the corresponding element of *P. panderi*. The falciform element is morphologically similar to that illustrated as *Panderodus* sp. A by Armstrong (1990, pl. 16, fig. 20).

**Occurrence.** Evanturel Creek Formation, Lake Timiskaming, Ontario.

*Panderodus* sp. B
Pl. 25, figs 11, 12

**Remarks.** Only two elements of this species have been recovered, a qt and an unidentifiable element. The tortiform element has a narrow base, which is slightly longer than the cusp. The erect cusp tapers and is entirely filled with white matter. The element has a prominent costa on the unfurrowed face. The other element is unidentifiable, as it has been crushed and fractured. The elements were recovered from a sample, which also contains *P. unicostatus*.

**Occurrence.** Earlton Formation, Lake Timiskaming, Ontario.

**Genus** *Pseudobelodella* Armstrong, 1990

**Type species.** *Pseudobelodella silurica* Armstrong, 1990.

**Diagnosis.** Refer to Armstrong (1990, p. 111)

**Remarks.** The elements of *Pseudobelodella* are rastrate and have a panderodontid furrow. Armstrong (1990) recognised four morphotypes within the apparatus. The element nomenclature of Armstrong (1990) has been
retained herein, as only one element of *Pseudobelodella* has been recovered, and so the apparatus can not be compared with that of *Panderodus*.

Armstrong (1990) differentiated *Pseudobelodella* from *Belodella*, as *Pseudobelodella* has an ap element and a morphologically different sym. p element. However, the elements of *Pseudobelodella* are significantly different from *Belodella* in that they possess a panderodontid furrow. This feature has been regarded as diagnostic at the family level (Sansom *et al.*, 1995).

Armstrong (1990) observed *Pseudobelodella* was restricted to deeper water in the upper *celloni* and *amorphognathoides* CBZs in Greenland. Elements of *Pseudobelodella* have only been recovered from the *celloni* CBZ of the deep water Prongs Creek section (northern Yukon).

**Pseudobelodella silurica** Armstrong, 1990

Pl. 26, figs 9, 10

1978 *Belodella* n. sp. A, Miller, p. 341, pl. 1, figs 19-23.
1987a *Belodella* n. sp. A, Over & Chatterton, pl. 6, figs 4, 8-11.
* 1990 *Pseudobelodella silurica* Armstrong, p. 111, pl. 18, figs 3-9.
1995 *Pseudobelodella silurica* Armstrong; Simpson & Talent p. 176, pl. 12, fig. 12.

**Holotype.** *Pseudobelodella silurica* Armstrong, 1990, pl. 18, fig. 4. Specimen MGUH 17-947 from the Lafayette Bugt Formation, at Kap Schuchert, Washington Land, Greenland.

**Diagnosis.** As for genus.

**Description.** Refer to the description of sym. p. element in Armstrong (1990, p. 111).
Remarks. Refer to generic remarks.

Occurrence. Road River Group, Prongs Creek, northern Yukon.

Order Protopanderodontida Sweet, 1988

Remarks. Sweet (1988) erected this order to include apparatuses with one or multiple morphotypes, which were unfurrowed coniform elements with longitudinal striae. He included the Protopanderodontidae Lindström, Clavohamulidae Lindström, Acanthodontidae Lindström and Drepanoistodontidae Fähræus & Nowlan. The Dapsilodontidae was originally classified within the Order Belodellida, but has been reclassified within the Order Protopanderodontida by Aldridge & Smith (1993). This new classification conforms with the study of apparatus structure by Sansom et al. (1995).

Family Dapsilodontidae Sweet, 1988

Remarks. Sweet (1988) included Besselodus Aldridge and Dapsilodus Cooper within this family, as their apparatuses comprised compressed, deeply excavated coniform elements, with characteristic oblique ornamentation along the anterior margins.

Genus Dapsilodus Cooper, 1976

Type species. Distacodus obliquicostatus Branson & Mehl, 1933.

Diagnosis. Refer to Armstrong (1990, p. 70).

Remarks. Serpagli (1970) and later Cooper (1976) identified three morphotypes within D. obliquicostatus. Barrick (1977) identified the same three morphotypes, and in addition two variants within the graciliform
elements. The two variants differed in the degree of torsion, but gradation between the two end members made separation of the two variants difficult (Barrick, 1977). Thus, later workers did not record this variation within the torsion of the graciliform elements (Armstrong, 1990; McCracken, 1991). Within this study, the graciliform elements vary in the development of a basal heel.

McCracken (1991b) identified a fourth morphotype (a element therein) within *D. obliquicostatus*, which has a subdued costa on one face, whilst the other face is acostate or bears a weak costa. This element may have been previously assigned within the graciliform morphotype. Herein, the apparatus of *Dapsilodus* is regarded as consisting of three main morphotype locations, one of which may be divided by the presence / absence of a basal heel. The a element of McCracken (1991b) is rare and may be a minor iterative or ecophenotypic variant.

Sansom et al. (1995) compared the *Dapsilodus* elements with those of *Panderodus* morphotypes and identified: a single aequaliform (ae), a suite of graciliform (qg) and a pair of arcuatiform (qa) elements within the *Dapsilodus* apparatus (Figure A.5). Cooper (1976) suggested that the ratio of elements within the apparatus was 1 arcuatiform: 2 graciliform + aequaliform, whereas work by Barrick (1977) suggested a ratio of 1 aequaliform: 10 graciliform: 5 arcuatiform. Herein, the ratio is 1 aequaliform: 12-8 graciliform: 3 arcuatiform. However, this ratio is suspect, as it is unlikely that the apparatus would contain an odd number of arcuatiform elements. The complete apparatus structure of *Dapsilodus* cannot be definitely determined until a bedding-plane assemblage or element clusters have been recovered and studied.

The upper Ordovician, *Besselodus* and *Paroistodus* Lindström have apparatuses similar to that of *Dapsilodus*. *Besselodus borealis*, as reconstructed by Nowlan & McCracken (in Nowlan et al., 1988) contains five major morphotypes, one of which can be subdivided. *Paroistodus* has four main
morphotypes, two of which can be subdivided. Nowlan et al. (1988) have suggested that either of these genera may have been the ancestral to the Silurian Dapsilodus. Besselodus and Paroistodus are abundant in deep-water sections during the upper Ordovician. Dapsilodus is most abundant in deeper-water sections in the Silurian and is only rarely recovered from shallow-water environments. Armstrong (1990) suggested loss of elements may have been a feature of the evolution of Dapsilodus.

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**Figure A.9.** Comparison of the notational schemes applied to Dapsilodus elements.

*Dapsilodus obliquicostatus* (Branson & Mehl, 1933)

Pl. 21, figs 1-5

* 1933 *Distacodus obliquicostatus* Branson & Mehl, p. 41, pl. 3, fig. 2.

1976 *Dapsilodus obliquicostatus* (Branson & Mehl); Cooper, p. 212, pl. 2, figs 10-13, 18-20.

1977 *Dapsilodus obliquicostatus* (Branson & Mehl); Barrick, p. 50, pl. 2, figs 6, 10, 13.

1990 *Dapsilodus obliquicostatus* (Branson & Mehl); Armstrong, p. 70, pl. 7, figs 7-12.

1991b *Dapsilodus obliquicostatus* (Branson & Mehl); McCracken, p. 78-79, pl. 4, figs 11, 13, 14, 16-28, 30-32, 35, 40.
Holotype. *Distacodus obliquicostatus* Branson & Mehl 1933, pl. 3, fig. 2. Specimen from the Bainbridge Formation, Lithium, Missouri, U. S. A.

Diagnosis. Refer to the generic diagnosis in Armstrong (1990, p. 70).

Description. Refer to descriptions in Armstrong (1990, p. 70)

Remarks. The number of morphotypes within this species is discussed under generic remarks. Elements similar to those described as a elements by McCracken (1991) do occur in the Prongs Creek samples, but are very rare.

Occurrence. Transitional Limestone Unit and Road River Group, Prongs Creek, northern Yukon.

*Dapsilodus?* sp. B McCracken (1991b)

Pl. 21, Figs 6-9

1991b *Dapsilodus?* sp. B, McCracken, p. 79, pl. 4, figs 29, 34, 36-38.

Description. Refer to McCracken (1991b, p. 79).

Remarks. The elements of *Dapsilodus?* sp. B have a distinctive bell shaped base. McCracken (1991b) regarded these elements as similar to elements of the Ordovician genera *Paroistodus?* and *Scabbardella* Orchard, but differing from *Paroistodus?* sp. A Nowlan & McCracken in having oblique and longitudinal striae. Oblique striae are a characteristic feature of *Dapsilodus* and so the elements of this species are more likely to belong within the Genus *Dapsilodus*. However, *Dapsilodus?* sp. B appears to lack an aequaliform element, as seen in other species of *Dapsilodus* (herein and McCracken, 1991b).
The discovery of a single oistodontiform element in association with *Dapsilodus*? sp. B led McCracken (1991b) to suggest that the elements in his study were a result of contamination. However, the discovery of similar elements in the samples herein indicates that contamination by laboratory techniques is unlikely.

McCracken (1991b) recovered elements of this species from the *gregarius* and *turriculatus* GBZs. Herein, *Dapsilodus*? sp. B occurs within the basal *celloni* CBZ.

**Occurrence.** Road River Group, Prongs Creek, northern Yukon.

**Family** Drepanoistodontidae Fahrasus & Nowlan, 1978


**Genus** Decoriconus Cooper, 1975

**Type species.** *Paltodus costulatus* Rexroad, 1967.

**Diagnosis.** Refer to Barrick (1977, p. 53).

**Remarks.** The elements of *Decoriconus* are small, twisted with striate ornamentation and a posterior longitudinal groove on both faces (Barrick, 1977). The apparatus of *Decoriconus* includes three morphotypes.

Barrick (1977) calculated the approximate ratio of the different morphotypes within *D. fragilis* (Branson & Mehl). His results suggested a ratio of one
arcuatiform element: four aequaliform and graciliform elements. Herein, the ratio is one aequaliform: approximately six graciliform and arcuatiform elements. However, the ratio varies considerably between samples and may not be a reliable indication of the number of elements in an individual apparatus.

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<td>Drepanodontiform</td>
<td>Sc</td>
<td>r</td>
<td>-</td>
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**Figure A.10** Comparison of the notational schemes applied to *Decoriconus* elements.

*Decoriconus costulatus* (Rexroad, 1967)

Pl. 21, figs 10-15.

* 1967 *Paltodus costulatus* Rexroad, p. 40-41, pl. 4, figs 26-29.
  1975 *Decoriconus costulatus* (Rexroad); Cooper, p. 992, pl. 1, figs 1, 12, 15, 22.
  v 1981 *Decoriconus costulatus* (Rexroad); McCracken & Barnes, p. 75, pl. 2, figs 24-27.

**Holotype.** *Paltodus costulatus* Rexroad, 1967, pl. 4, fig. 27. Specimen 10041, from the Brassfield Limestone, Cincinnati Arch, U. S. A.

**Diagnosis.** Refer to Rexroad (1967, p. 40)

**Description.** The elements have been previously described by Cooper (1975) and McCracken & Barnes (1981).

**Remarks.** Cooper (1976) suggested that *D. fragilis* differed from *D. costulatus* in three aspects. Firstly, *D. fragilis* had larger, more robust skeletal elements
than *D. costulatus*. Secondly, the apparatus of *D. fragilis* included an arcuatiform element, whereas the apparatus of *D. costulatus* lacked this element. Some elements of *D. fragilis* lacked ornamentation, which Cooper (1976) regarded as a key feature of the *D. costulatus* elements. Barrick (1977) clarified Cooper's suggestion by adding that 'all elements of *D. costulatus* are striate whereas the Sa (= aequaliform) element of *D. fragilis* is not'.

The evidence from this study does not concur with the first aspect, the difference in robustness. In the Prongs Creek section, the *Decoriconus* elements found at the base of the Silurian have pronounced striae and can be classified as *D. costulatus*. However, the elements are very robust, whereas the elements of *Decoriconus* found higher in the section are smaller and more compressed. Therefore, the evidence from this section does not suggest that *D. fragilis* is more robust than *D. costulatus*.

The second aspect, the lack of an arcuatiform element is erroneous. McCracken & Barnes (1981) included an arcuatiform element in their apparatus reconstruction of *D. costulatus*. The discovery of this element led them to suggest that *D. costulatus* and *D. fragilis* are conspecific. In the Prongs Creek section, arcuatiform elements are lacking only in samples that have yielded a low number of *Decoriconus* elements.

The current evidence for the lack of ornamentation on the aequaliform element is conflicting. Barrick (1977) declared that the aequaliform element of *D. fragilis* was not striate. However, Cooper (1976) had illustrated a striate aequaliform element of *D. fragilis*. Herein, the specimens are mainly affected by diagenetic mineralisation and so it is difficult to determine whether striations are present or not.

The general morphology of the elements of *D. costulatus* and *D. fragilis* seem to differ only in that the elements of *D. fragilis* are smoother. Herein, the two species have been retained. Elements described as *D. costulatus* have
pronounced striae and occur in the uppermost Ordovician to lowermost Silurian. Elements assigned to *D. fragilis* have generally less pronounced ornamentation and occur in the Llandovery.

**Occurrence.** Ellis Bay and Becscie Formations, Anticosti island, Québec; Transitional Limestone Unit, Prongs Creek, northern Yukon.

*Decoriconus fragilis* (Branson & Mehl 1933)

Pl. 21, figs 16-22

* 1933 *Paltodus fragilis* Branson & Mehl, p. 43, pl. 3, fig. 3.

1977 *Decoriconus fragilis* (Branson & Mehl); Barrick, p. 53, pl. 2, figs 15, 21-23.

1990 *Decoriconus fragilis* (Branson & Mehl); Armstrong, p. 71, pl. 7, figs 13-17.

1995 *Decoriconus fragilis* (Branson & Mehl); Simpson & Talent, p. 175-176, pl. 12, figs 10-11.

**Holotype.** *Paltodus fragilis* Branson & Mehl, 1933, pl. 3, fig. 6. Specimen from the Bainbridge Formation, Lithium, Missouri, U. S. A.

**Diagnosis.** Refer to Armstrong (1990, p. 71)

**Description.** The elements of *D. fragilis* have been fully described in the literature by Barrick (1977, p.) and Cooper (1976, p. 213).

**Remarks.** Refer to the remarks made for *D. costulatus* above.

**Occurrence.** Eventurel Creek Formation, Lake Timiskaming, Ontario; Jupiter (Ferrum Member) and Chicotte Formations, Anticosti Island, Québec; Road River Group, Prongs Creek, northern Yukon.
Family Protopanderodontidae Lindström, 1970

Remarks. Sweet (1988) considered members of this family to have an apparatus, which consisted of one or multiple morphotypes, commonly nongeniculate coniforms. The surfaces are commonly ornamented with fine striae, with longitudinal carinae, costae, or ridges variably developed. Sweet (1988) included 14 genera within this family, four of which were placed in the Oneotodontidae Miller and two (including Pseudooneotodus Drygant) transferred to other families, by Aldridge & Smith (1993). In addition, they included five new genera. The only genus recovered herein from the Protopanderodontidae is Staufferella Sweet, Thompson & Satterfield.

Genus Staufferella Sweet, Thompson & Satterfield, 1975

Type species. Distacodus falcatus Stauffer, 1935a.

Diagnosis. Refer to Sweet, Thompson & Satterfield (1975).

Remarks. This genus has been reviewed by McCracken & Barnes (1981, p. 90), Nowlan & Barnes (1981, p.24), and Nowlan et al. (1988, p. 38). Sweet et al. (1975) included cones formerly assigned to Distacodus Hinde and Acontiodus Pander, within Staufferella, and detailed three morphotypes termed symmetrical, slightly asymmetrical and markedly asymmetrical (Nowlan & Barnes, 1981). Apparatus reconstructions of Staufferella were attempted by Barnes et al. (1979), Sweet (1982) and Nowlan et al. (1988). Nowlan et al. (1988) identified six morphotypes within Staufferella divisa Sweet (c, a, b, e-1, e-2, e-3). Their symmetrical c element showed marked interspecific variation, whilst the other elements showed only subtle variations between species. The element nomenclature of Nowlan et al. (1988) has had to be retained herein, as only a few elements of Staufferella have been recovered and so the apparatus can not yet be compared with that of Panderodus.
Appendix A

Systematic Palaeontology

Staufferella cf. S. inaligera McCracken & Barnes, 1981
Pl. 23, fig. 19

cf.v1981 Staufferella inaligera McCracken & Barnes, p. 90, pl. 2, figs 22, 23.


Remarks. S. inaligera lacks the basal alae seen in most species of Staufferella. S. divisa also lacks this feature, but the c element of S. divisa differs from S. inaligera in the degree of compression of the element, pinching of the cusp, and the extent of lateral costae (Nowlan et al. 1988). The e elements also differ in the subtlety of the costae and the width of the cusp (Nowlan et al. 1988). The elements found herein have been compared with S. inaligera, as McCracken & Barnes (1981) have previously recovered this species from the upper Ordovician, Ellis Bay Formation on Anticosti Island.

Occurrence. Ellis Bay Formation (Lousy Cove and Laframboise Members), Anticosti Island, Quebec.

Order Unknown
Family Fam. Nov. 5

Remarks. The inclusion of Pseudooneotodus within the Conodonta has long been debated (for a review see Sansom, 1996). Currently, Pseudooneotodus is regarded as belonging within the Conodonta, but has proven difficult to place within with the suprageneric classification. It has been previously been placed within the Protopanderodontida (Sweet, 1988), the Panderodontida (Dzik, 1991), and most recently an Unknown Order (Aldridge & Smith, 1993). Sansom (1996) reviewed the current knowledge of Pseudooneotodus and presented a histological study of the elements.
Genus *Pseudooneotodus* Drygant, 1974

**Type species.** *Oneotodus ? beckmanni* Bischoff & Sannemann, 1958.

**Diagnosis.** Refer to Barrick (1977, p. 57)

**Remarks.** The elements of *Pseudooneotodus* are conical with thin walls and deep basal cavities. Barrick (1977) presented a trimembrate apparatus reconstruction for *P. bicornis* Drygant and *P. tricornis* Drygant, which was confirmed by Armstrong (1990).

*Pseudooneotodus beckmanni* (Bischoff & Sannemann, 1958)

Pl. 26, figs 1,2

* 1958 *Oneotodus ? beckmanni* Bischoff & Sannemann, p. 98, pl. 15, figs 22-25.

1977 *Pseudooneotodus beckmanni* (Bischoff & Sannemann); Cooper, p. 1068, pl. 2, figs 14, 17.

v 1981 *Pseudooneotodus beckmanni* (Bischoff & Sannemann); Nowlan & Barnes, p.23, pl. 2, figs 20, 21.

v 1981 *Pseudooneotodus beckmanni* (Bischoff & Sannemann); McCracken & Barnes, p. 89, pl. 2, figs 30, 31.

**Holotype.** *Oneotodus ? beckmanni* Bischoff & Sannemann, 1958, pl. 15, fig. 25. Specimen Bi Sa 1958 / 85, from the Lower Devonian of Frankenwald, south central Germany.

**Diagnosis.** Refer to Bischoff & Sannemann (1958, p. 98).

**Description.** Squat, conical elements with white matter concentrated at the apex. The apex is often slightly curved with only one tip. The basal outline is sub-circular, but variable.
Remarks. Cooper (1977) and McCracken & Barnes (1981) considered *P. beckmanni* as having a single morphotype, with elements only differing in basal outline.

Occurrence. Ellis Bay (Laframboise Member), Becscie and Jupiter Formations, Anticosti Island, Québec; Transitional Limestone Unit, Prongs Creek (northern Yukon).

*Pseudooneotodus tricornis* Drygant, 1974

Pl. 26, figs 5-7

* 1974 *Pseudooneotodus tricornis* Drygant, p. 67-68, pl. 2, figs 49, 50.
1977 *Pseudooneotodus tricornis* Drygant; Barrick, p. 59, pl. 2, fig. 18.
1977 *Pseudooneotodus tricornis* Drygant; Cooper, p. 1069, pl. 2, figs 15, 16.
1990 *Pseudooneotodus tricornis* Drygant; Armstrong, p. 114, pl. 18, figs 16-18.


Diagnosis. Refer to Barrick (1977, p. 58).

Description. The elements have been fully described by Barrick (1977, p. 58).

Remarks. Three morphotypes of *P. tricornis* have been described by Barrick (1977) and Armstrong (1990). The most diagnostic element is the squat conical element bearing three discrete denticles (Barrick, 1977). The other two morphotypes are unidenticulate squat and slender cones and are apparently identical to the corresponding elements of *P. bicornis*.

Occurrence. Chicotte Formation, Anticosti Island, Québec.
\textit{Pseudooneotodus sp. A}

Pl. 26, figs 3, 4

? 1983 \textit{Pseudooneotodus bicornis} Drygant; Uyeno & Barnes, p. 23, pl. 3, figs 25, 26, 27, 28.

\textbf{Remarks.} The elements are similar to those of \textit{P. beckmanni}, in having broad bases. The apical denticle can be curved or upright. Uyeno & Barnes (1983) recovered identical elements from the Jupiter and Chicotte Formations, which they assigned to \textit{P. bicornis}, as in three samples bidenticulate elements were also recovered. Herein, only unidenticulate elements have been found.

\textbf{Occurrence.} Jupiter Formation, Anticosti Island, Québec.
A.4 Plates

PLATE 1

Figs 1-7 *Aulacognathus bullatus* (Nicoll & Rexroad)
Specimens from Anticosti Island, x60.
1. Upper view of Pa element; D799-93 from sample AI 643.
2. Upper view of Pa element; D797-87 from sample AI 656.
3. View of Pb element; D798-88 from sample AI 656.
4. View of M element; D799-92 from sample AI 653.
5. Posterior view of Sa element; D798-89 from sample AI 643.
6. Posterior view of Sb element; D799-91 from sample AI 653.
7. Inner-lateral view of Sc element; D798-90 from sample AI 643.

Figs 8-14 *Aulacognathus* aff. *A. bullatus* (Nicoll & Rexroad).
All specimens from sample PC 552, Prongs Creek, x60.
8. Upper view of Pa element; D782-50.
9. Lateral view of Pb element; D787-63.
10. View of M element; D787-63.
11. Posterior view of Sa element; D783-51.
12. Posterior view of Sb element; D801-97.
13. Inner-lateral view of Sc element; D783-52.
Figs 1-3 *Aulacognathus bullatus* (Nicoll & Rexroad)
Specimens from Prongs Creek, x60.
1. Upper view of Pa element; D806-10 from sample PC 569.
2. Upper view of Pa element; D806-11 from sample PC 571.
3. Upper view of Pb element; D806-12 from sample PC 571.

Figs 4, 5 *Aulacognathus kuehni* Mostler
Specimens from sample PC 564, Prongs Creek, x60.
5. Inner-lateral view of Sc element; D759-27.

Figs 6-8 *Aulacognathus* sp. A
Specimens from sample LT 273, Thornloe Formation, Lake Timiskaming, x60.
6. Upper view of Pa element; D773-25.
7. Posterior lateral view of Sb element; D773-26.
8. Inner-lateral view of Sc element; D773-27.
Figs 1, 2 *Kockelella manitoulinensis* (Pollock, Rexroad & Nicoll)
Specimens from sample LT 262, Evanturel Creek Formation, Lake Timiskaming, All x60.
1. Inner-lateral view of Pa element; D833-78.
2. Inner-lateral view of Pb element; D726-27.

Figs 3-5 *Kockelella ranuliformis* (Walliser)
Specimens from the Chicotte Formation, Anticosti Island, x60.
3. Inner-lateral view of Pa element; D727-30 from sample AI 668.
4. Upper view of Pa element; D727-29 from sample AI 668.
5. Inner-lateral view of Pb element; D728-31 from sample AI 661.

Figs 6-11 *Kockelella* sp. B
Specimens from the Earlton Formation, Lake Timiskaming, x60.
6. Inner-lateral view of Pa element; D833-77 from sample LT 264.
7. Inner-lateral view of Pb element; D717-8 from sample LT 264.
8. View of M element; D719-13 from sample LT 265.
9. Posterior view of Sa element; D718-9 from sample LT 264.
10. Posterior view of Sb element; D866-75 from sample LT 264.
11. Inner-lateral view of Sc element; D719-12 from sample LT 265.
PLATE 4

Figs 1-7 *Kockelella* sp. A (Over & Chatterton)

Specimens from sample LT 278, Thornloe Formations, Lake Timiskaming, x60.

1. Upper view of Pa element; D752-77.
2. Inner-lateral view of Pb element; D752-78.
3. View of M element; D753-79.
4. Inner-lateral view of Sc element; D851-46.

Specimens from sample LT 279, Thornloe Formations, Lake Timiskaming, x60.

5. Upper view of Pa element; D721-16.
6. View of M element; D851-47.
PLATE 5

Figs 1-4  *Ozarkodina aldridgei* Uyeno & Barnes
All specimens from sample AI 670, Jupiter Formation (Ferrum Member), Anticosti Island. All x120.
1. Inner-lateral view of Pa element; D748-69.
2. Inner-lateral view of Pb element; D749-70.
4. Inner-lateral view of Sb element; D749-72.

Figs 5-9  *Ozarkodina excavata* (Branson & Mehl)
All specimens from sample AI 661, Chicotte Formation, Anticosti Island, x60.
5. Inner-lateral view of Pa element; D843-10.
7. Posterior view of Sa element; D843-12.
9. Inner-lateral view of Sc element; D844-14.
PLATE 6

Figs 1-5 Ozarkodina gulletensis (Aldridge)
All specimens x60.
1. Inner-lateral view of Pa element; D855-38 from sample 270, Lake Timiskaming.
2. View of M element; D855-39 from sample AI 653, Anticosti Island.
3. Posterior view of Sa element; D772-24 from sample 270, Lake Timiskaming.
4. Posterior view of Sb element; D849-40 from sample AI 653, Anticosti Island.
5. Inner-lateral view of Sc element; D849-41 from sample AI 653, Anticosti Island.

Figs 6, 7 Ozarkodina hassi (Pollock, Rexroad & Nicoll)
All specimens from sample PC 552, Prongs Creek, x60.
6. Inner-lateral view of Pa element; D861-64.
7. Inner-lateral view of Pb element; D862-65.

Figs 8-13 Ozarkodina oldhamensis (Rexroad)
All specimens from sample PC 552, Prongs Creek, x60.
8. Inner-lateral view of Pa element; D862-66.
10. View of M element; D863-68.
11. Posterior view of Sa element; D839-1.
12. Posterior view of Sb element; D839-2.
13. Inner-lateral view of Sc element; D840-3.
PLATE 7

Figs 1-4 *Ozarkodina masurensis* Bischoff
All specimens from sample PC 559, Prongs Creek, x60.
1. Inner-lateral view of Pa element; D732-39.
2. Inner-lateral view of Pb element; D733-40.
3. View of M element; D734-41.
4. Inner-lateral view of Sc element; D734-42.

Figs 5-11 *Ozarkodina pirata* Uyeno & Barnes
Specimens from the Jupiter Formation, Anticosti Island, x60.
5. Inner-lateral view of Pa element; D879-1A from sample AI 751.
6. Inner-lateral view of Pa element; D8791B from sample AI 751.
7. Inner-lateral view of Pa element; D713-21 from sample AI 647.
8. Inner-lateral view of Pb element; D713-22 from sample AI 647.
9. View of M element; D713-23 from sample AI 647.
10. Posterior view of Sb element; D714-24 from sample AI 647.
11. Inner-lateral view of Sc element; D879-2 from sample AI 751.

Figs 12-13 *Ozarkodina* cf. *O*. sp. C Armstrong
Specimens from Earlton Formation, Lake Timiskaming.
12. Inner-lateral view of Pa element from sample LT 266 x40; D741-55.
13. Inner-lateral view of Sc element from sample LT 264 x60; D742-57.
PLATE 8

Figs 1-5 Ozarkodina polinclinata (Nicoll & Rexroad)
Specimens from the Thomloe Formation, Lake Timiskaming. All x90.
1. Inner-lateral view of Pa element; D746-64 from sample LT 270.
2. Inner-lateral view of Pb element; D747-65 from sample LT 278.
3. View of M element; D747-66 from sample LT 278.
4. Posterior view of Sb element; D747-67 from sample LT 273.
5. Inner-lateral view of Sc element; D748-68 from sample LT 273.

Figs 6-9 Ozarkodina protoexcavata Cooper
Specimens from the uppermost Becscie Formation and Merrimack Formation, Anticosti Island, x60.
6. Inner-lateral view of Pa element; D844-15 from sample AI 673.
7. Inner-lateral view of Pb element; D845-16 from sample AI 673.
8. View of M element; D845-17 from sample AI 673.
9. Posterior view of Sb element; D878-7 from sample AI 675.

Figs 10, 11 Ozarkodina cf. O. masurensis
Specimens from sample AI 670, Jupiter Formation, Anticosti Island, x60.
10. Inner-lateral view of Pb element; D880-4.
11. Inner-lateral view of Sc element; D880-3.

Fig. 12 Ozarkodina sp. A
Specimens from sample LT 272, Thomloe Formation, Lake Timiskaming, x60.
12. Inner-lateral view of Pa element; D774-28.
PLATE 9

Figs 1-3  *Oulodus robustus* (Bramson, Mehl & Branson)
All specimens from Anticosti Island, x60.
1. Inner-lateral view of Pa element; D790-69 from sample AI 636.
2. View of Pb? Element; D790-70 from sample AI 636.
3. View of Sc element; D791-71 from sample AI 636.

Figs 4,5  *Oulodus* sp. A
Specimens from Anticosti Island, sample AI 638, x60.
5. Posterior view of M element; D808-16.

Figs 6,7, *Oulodus* sp. B
All specimens from Anticosti Island, sample AI 670, x60.
6. Posterior view of Sa element; D809-17.
7. Inner-lateral view of Sc element; D809-18.

Figs 8,9  *Oulodus* ? *nathani* McCracken & Barnes
All specimens from sample PC 552, Prongs Creek, x60.
8. View of Pa element; D817-37.

Figs 10-15  *Oulodus* ? *kentuckyensis* (Branson & Branson)
All specimens from sample PC 552, Prongs Creek, x60.
11. View of Pb element; D814-32.
12. View of M element; D815-33.
13. View of Sb element; D816-35.
14. View of Sb element; D816-36.
15. View of Sc element; D815-34.
PLATE 10

Figs 1-6 *Oulodus* cf. *O. panuarensis* Bischoff
Specimens from sample PC 552, Prongs Creek.
1. Inner-lateral view of Pa element, x60; D786-59.
2. Inner-lateral view of Pb element, x60; D786-60.
3. View of M element, x60; D734-43.
4. Posterior view of Sa element, x120; D735-44.
5. View of Sb element, x120; D735-45.
6. Inner-lateral view of Sc element, x120; D736-46.

Figs 7-12 *Oulodus petilus* (Nicoll & Rexroad)
All specimens from Lake Timiskaming.
7. Inner-lateral view of Pa element, x60; D831-74 from sample LT 262.
8. Inner-lateral view of Pb element, x60; D737-48 from sample LT 261.
9. View of M element, x60; D738-50 from sample LT 278.
10. Posterior view of Sa element, x40; D738-51 from sample LT 278.
11. View of Sb element, x60; D739-52 from sample LT 253.
12. Inner-lateral view of Sc element, x60; D740-54 from sample LT 264.
PLATE 11

Figs 1-11  *Pseudolonchodina capensis* (Savage)
Specimens from sample PC 570, Prongs Creek. All x60.
1. Inner-lateral view of Pa element; D777-36.
2. Inner-lateral view of Pb element; D781-47.
3. View of $M_1$ element; D778-38.
4. View of $M_2$ element; D778-39.
5. Lateral view of Sa element; D779-41.
6. View of Sa element; D778-40.
7. Upper view of Sa element; D779-42.
8. Posterior view of $S_b_1$ element; D781-46.
9. Posterior view of $S_b_2$ element; D780-45.
10. Inner-lateral view of $S_c_1$ element; D780-44.
11. Inner-lateral view of $S_c_2$ element; D779-43.
PLATE 12

Figs 1-8  *Pseudolonchodina expansa* (Armstrong)
All specimens from Prongs Creek. Sample PC 548, x60.
1. Inner-lateral view of Pa element; D818-40.
2. Inner-lateral view of Pb element; D821-49.
3. Inner-lateral view of M₁ element; D818-42.
4. Posterior view of Sa element; D819-43.
5. Posterior view of Sb₁ element; D820-46.
6. Inner-lateral view of Sc₂ element; D821-47.
7. Aboral view of Sa element; D819-44.
8. Posterior view of Sb₁ element; D820-45.

Figs 9-14 *Pseudolonchodina fluegeli* (Walliser)
Specimens from sample PC 561, Prongs Creek. All x 60.
10. Inner-lateral view of Pb element; D882-7.
11. Inner-lateral view of M₁ element; D882-8B.
12. Aboral view of Sa element; D882-8A.
13. Posterior view of Sb₁ element; D883-9B.
Fig. 11 *Amorphognathus* cf. *A. ordovicicus* Branson & Mehl
Specimen from sample AI 578, Ellis Bay Formation (Laframboise Member), Anticosti Island, x60.

Fig. 12 *Phragmodus undatus* Branson & Mehl
Specimen from sample AI 579, Ellis Bay Formation (Lousy Cove Member), Anticosti Island, x120.
12. Inner-lateral view of Sc element; D723-20.
PLATE 14

Figs 1-6  *Distomodus kentuckyensis* Branson & Branson
Specimens from the Prongs Creek. All x60.
1. Upper view of Pa element; D782-49 from sample PC 554.
2. Posterior view of Pb element; D802-98 from sample PC 552.
3. Inner-lateral view of M element; D875-1 from sample PC 547.
4. Posterior view of Sa element; D802-00 from sample PC 552.
5. Posterior view of Sb element; D802-99 from sample PC 552.
6. Inner-lateral view of Sc element; D803-02 from sample PC 552.

Figs 7-13  *Distomodus staurognathoides* (Walliser)
Specimens from the Jupiter and Chicotte Formations, Anticosti Island, x60.
7. Upper view of Pa element; D813-27 from sample AI 665.
8. Oblique view of Pb element; D814-30 from sample AI 656.
9. Inner-lateral view of M element; D877-6 from sample AI 652.
10. Posterior view of Sa element; D709-8 from sample AI 667.
11. Posterior view of Sb element; D709-9 from sample AI 667.
12. Inner-lateral view of Sc element; D813-28 from sample AI 656.
13. Inner-lateral view of Sc element; D813-29 from sample AI 665.
PLATE 15

Figs 1-3  *Distomodus* ? sp. A
Specimens from sample LT 267, Lake Timiskaming. All x60.
1. Lateral view of Pa element; D830-72.
2. Inner-lateral view of Pb element; D831-73.
3. Posterior view of M element; D881-5.

Figs 4, 5 *Coryssognathus* cf. *C. dubia* (Rhodes)
Specimens from sample PC 552, Prongs Creek, x60.
4. Inner view of Pb element; D800-95.
5. Outer view of Pb element; D800-94.

Figs 6-9 *Icriodella* (M elements)
All from Lake Timiskaming x60.

Fig. 10 *Icriodella* sp. A
Specimen from sample LT 261, Lake Timiskaming. x60.
10. Lateral view of Pa element; D830-71.

Fig. 11 *Icriodella* cf. *I. inconstans* Aldridge
Specimen from sample AI 653, Jupiter Formation (Pavillion Member),
Anticosti Island, x60.
11. Upper view of Pa element; D772-22.
PLATE 16

Figs 1-7 Icriodella deflecta Aldridge
Specimens recovered from sample LT 262, Evanturel Creek Formation, Lake Timiskaming, x60.
1. Upper view of Pa element; D825-57.
2. Inner-lateral view of Pb element; D825-58.
3. View of Pd(?) element; D825-59.
4. Posterior view of M element; D826-60.
5. Posterior view of Sa element; D826-61.
6. Posterior view of Sb element; D826-62.
7. Lateral view of Sc element; D826-63.

Figs 8-14 Icriodella discreta Pollock, Rexroad & Nicoll
Specimens recovered from the Evanturel Creek Formation, Lake Timiskaming. All x60.
8. Upper view of Pa element; D827-64 from sample LT 262.
9. View of Pb element; D827-65 from sample LT 262.
10. View of Pd element; D828-66 from sample LT 262.
11. View of M element; D829-67 from sample LT 262.
12. Posterior view of Sa element; D829-68 from sample LT 267.
13. Posterior view of Sb element; D829-69 from sample LT 267.
PLATE 17

Figs 1-7. *Apsidognathus tuberculatus* Walliser
Specimens from sample AI 644, Chicotte Formation, Anticosti Island.
1. Upper view of Platform element, x30; D803-3.
2. Upper view of Lyriform element, x30; D804-6.
3. Upper view of Ambalodiform element, x60; D852-30.
4. View of unknown element, x60; D804-4.
5. Upper view of Coniform element, x60; D805-8.
6. Upper view of Coniform element, x60; D805-7.
7. Upper view of Coniform element, x60; D805-9.

Specimens from sample LT 278, Thornloe Formation, Lake Timiskaming. All x60.
8. Lateral view of Pa element; D856-50.
10. View of Pb element; D856-51.
12. Outer view of Pa element; D856-49.
13. Posterior view of Sb element; D857-54.
14. Posterior view of Sb element; D858-56.
15. Inner-lateral view of Sc element; D859-57.
PLATE 18

Figs 1-11. *Astropentagnathus irregularis* Mostler
Specimens from sample PC 562, Prongs Creek, x60.
1. Upper view of Pa element; D836-85.
2. Upper view of Pc element; D836-86.
3. View of Pb element; D715-1.
4. Inner-lateral view of Pc element; D837-87.
5. Inner-lateral view of Pc element; D715-00.
6. Posterior view of M element; D837-88A.
7. Posterior view of Sb$_1$ element; D715-2.
8. Posterior view of Sb$_2$ element; D837-88B.
9. Posterior view of Sb$_2$ element; D837-89A.
10. Inner-lateral view of Sc$_1$ element; D838-90.
11. Inner-lateral view of Sc$_2$ element; D837-89B.

Figs 12-16. *Astropentagnathus araneum* McCracken
Recovered from sample PC 561, Road River Group, Prongs Creek, x60.
12. Upper view of Pa element; D853-34.
14. Posterior view of Sb$_1$ element; D853-35.
15. Inner-lateral view of Sb$_2$ element; D854-36.
PLATE 19

Figs 1-6. *Pranognathus* cf. *P. tenuis* (Aldridge)
All specimens from sample PC 559, Prongs Creek, x60.
1. Inner-lateral view of Pa element; D840-4.
2. Inner-lateral view of Pc element; D731-36.
3. Inner-lateral view of Pd element; D731-37.
4. Posterior view of M element; D841-7A.
5. Posterior view of Sb1 element; D731-35.
6. Inner-lateral view of Sc element; D842-8.

Figs 7-13. *Pterospathodus celloni* (Walliser)
All specimens from sample PC 561, Prongs Creek, x60.
7. Upper view of Pa element; D833-79.
8. Inner-lateral view of Pb element; D903-2.
9. Inner-lateral view of Pc element; D903-1.
10. Inner-lateral view of Pd element; D904-4.
11. Posterior view of M element; D904-3.
12. Posterior view of Sb element; D905-5.
13. Inner-lateral view of Sc element; D905-6.

14. Figs 14, 15. *Pterospathodus rhodesi* Savage
Specimens from sample PC 574, Prongs Creek. Both x30.
14. Upper view of Pa element; D785-57.
15. Lateral view of Pb element; D786-58.

Figs 16, 17. *Carniodus carnulus* elements
Specimens from sample AI 668, Chicotte Formation, Anticosti Island, x60
16. Lateral view of element; D848-28A.
17. Lateral view of element; D848-28 B.
PLATE 20

Figs 1-7 Walliserodus blackstonensis McCracken
Specimens from sample PC 570, Prongs Creek. All x60.
1. Lateral view of aequaliform element; D901-45A.
2. Lateral view of aequaliform element; D901-45B.
3. Lateral view of falciform element; D900-44A.
4. Lateral view of falciform element; D900-44B.
5. Lateral view of arcuatiform element; D900-43B.
6. Lateral view of graciliform element; D900-43A.
7. Lateral view of arcuatiform element; D901-46.

Figs 8-13 Walliserodus curvatus (Branson & Branson)
Specimens from sample PC 548, Prongs Creek, x60.
8. Lateral view of aequaliform element; D871-88.
9. Lateral view of falciform element; D872-90A.
10. Lateral view of falciform element; D872-90B.
11. Lateral view of graciliform element; D872-91.
12. Lateral view of falciform element; D873-92.
13. Lateral view of tortiform element; D872-89A.

Figs 14-23 Walliserodus sancticlairi Cooper
Specimens from sample PC 559, Prongs Creek, x60.
14. Lateral view of aequaliform element; D895-34B.
15. Lateral view of aequaliform element; D895-34A.
16. Lateral view of aequaliform element; D895-33B.
17. Lateral view of aequaliform element; D895-33A.
18. Lateral view of arcuatiform element; D894-32B.
19. Lateral view of arcuatiform element; D894-32A.
20. Lateral view of graciliform element; D896-35B.
21. Lateral view of graciliform element; D896-35A.
22. Lateral view of tortiform element; D894-31B.
23. Lateral view of tortiform element; D894-31A.
PLATE 21

Figs 1-5. *Dapsilodus obliquicostatus* (Branson & Mehl)
Specimens from sample PC 559, Prongs Creek, x60.
1. Lateral view of aequaliform element; D885-14B.
2. Lateral view of graciliform element; D885-14A.
3. Lateral view of graciliform element; D870-86.
4. Lateral view of arcuatiform element; D869-84.
5. Lateral view of arcuatiform element; D870-85.

Specimens from sample PC 561, Prongs Creek. All x60.
6. Lateral view of graciliform element; D887-18B.
7. Lateral view of graciliform element; D887-18A.
8. Lateral view of graciliform element; D887-17B.
9. Lateral view of arcuatiform element; D887-17A.

Figs 10-15. *Decoriconus costulatus* (Rexroad)
Specimens from sample PC 548, Prongs Creek, x60.
10. Lateral view of aequaliform element; D868-80.
11. Lateral view of aequaliform element; D888-20.
12. Lateral view of graciliform element; D888-19B.
13. Lateral view of graciliform element; D888-19A.
14. Lateral view of arcuatiform element; D868-79B.
15. Lateral view of arcuatiform element; D868-79A.

Figs 16-22. *Decoriconus fragilis* (Branson & Mehl)
Specimens from sample PC 552, Prongs Creek, x60.
16. Lateral view of aequaliform element; D884-12A.
17. Lateral view of aequaliform element; D884-12B.
18. Lateral view of graciliform element; D885-13B.
19. Lateral view of graciliform element; D885-13A.
20. Lateral view of arcuatiform element; D884-11B.
21. Lateral view of arcuatiform element; D88411A.
PLATE 22

Figs 1-3. Thelodonts
Specimens from the Evanturel Creek Formation, Lake Timiskaming.
1. Thelodont, x180; D712-17 from sample LT 269.
2. Thelodont, x 60; D720-14 from sample LT 261.
3. Thelodont, x 120; D720-15 from sample LT 261.

Figs 4-5. Clusters
Specimens from Prongs Creek.
4. Cluster of *Panderodus* elements, x 120; D750-73 from sample PC 564.
5. Cluster of *Pseudolonchodina* elements, x 60; D723-21 from sample PC 562.

Figs 6-10. Genus et. sp. indet.
Specimens from sample PC 547, Prongs Creek. All x30.
7. Lateral view of Pb element; D784-54.
8. Lateral view of M element; D784-55.
9. Lateral view of M element; D785-56A.
10. Lateral view of M element; D785-56B.
PLATE 23

Figs 1-8 Panderodus acostatus (Branson & Branson) Specimens from Anticosti Island, x60.
1. Lateral view of falciform element; D867-78 from sample AI 647.
2. Lateral view of aequaliform element; D769-16 from sample AI 618.
3. Lateral view of truncatiform element; D769-17 from sample AI 618.
4. Lateral view of graciliform element; D770-18 from sample AI 618.
5. Lateral view of graciliform element; D768-14 from sample AI 618.
6. Lateral view of arcuatiform element; D866-76 from sample AI 647.
7. Lateral view of arcuatiform element; D867-77 from sample AI 647.
8. Lateral view of arcuatiform element with a serrate edge; D771-21 from sample AI 625.

Figs 9-17 Panderodus langkawiensis (Igo & Koike) Specimens from sample PC 561, Prongs Creek, x60.
9. Lateral view of falciform element; D897-38A.
10. Lateral view of aequaliform element; D897-37.
11. Lateral view of falciform element; D897-38B.
12. Lateral view of graciliform element; D898-40A.
13. Lateral view of graciliform element; D898-40B.
14. Lateral view of arcuatiform element; D899-42B.
15. Lateral view of arcuatiform element; D899-42A.
16. Lateral view of graciliform element; D898-39B.
17. Lateral view of graciliform element; D898-39A.

Fig. 18 Panderodus sp. C Specimen from sample PC 547, Prongs Creek, x60.
18. Posterior view of graciliform element; D876-3A.

Fig. 19 Staufferella cf. S. inaligera McCracken & Barnes. Specimen D767-11 from AI 594, Ellis Bay Formation, Anticosti Island, x60.

Fig. 20 Walliserodus cf. W. curvatus (Branson & Branson) Specimen D764-5 from sample AI 628, Ellis Bay Formation, Anticosti Island, x60.
20. Lateral View of element;

Fig. 21 Drepanoistodus suberectus (Branson & Mehl) Specimen D764-4 from sample AI 628, Ellis Bay Formation, Anticosti Island, x60.
21. Lateral view of element, x60.
PLATE 24

Figs 1-6 *Panderodus panderi* (Stauffer)
Specimens from sample AI 670, Jupiter Formation (Ferrum Member), Anticosti Island, x60.
1. Lateral view of falciform element; D791-73.
2. Lateral view of falciform element; D792-74.
3. Lateral view of truncatiform element; D792-75.
4. Lateral view of truncatiform element; D793-76.
5. Lateral view of graciliform element; D793-77.
6. Lateral view of graciliform element; D793-78.

Figs 7-15 *Panderodus acostatus* (Branson & Branson)
Specimens from sample AI 670, Jupiter Formation (Ferrum Member), Anticosti Island, x60.
7. Lateral view of tortiform element; D850-43A.
8. Lateral view of tortiform element; D850-43B.
9. Lateral view of falciform element; D796-84.
10. Lateral view of falciform element; D797-85.
11. Lateral view of aequaliform element; D797-86.
12. Lateral view of truncatiform element; D849-42.
13. Lateral view of graciliform element; D850-44A.
14. Lateral view of graciliform element; D850-44B.
15. Lateral view of arcuatiform element; D850-45.
PLATE 25

Figs 1-5 *Panderodus unicostatus* (Branson & Mehl)
Specimens from Lake Timiskaming, x60.
1. Lateral view of falciform element from sample 265; D889-22.
2. Lateral view of falciform element from sample 265; D891-26.
3. Lateral view of graciliform element from sample 264; D891-25.
4. Lateral view of graciliform element from sample 253; D890-23.
5. Lateral view of arcuatiform element from sample 253; D890-24.

Figs 6-10 *Panderodus* sp. A
Specimens from sample LT 262, Lake Timiskaming, x60.
6. Lateral view of falciform element; D796-82.
7. Lateral view of aequaliform element; D795-81.
8. Lateral view of truncatiform element; D796-83.
9. Lateral view of arcuatiform element; D794-79.
10. Lateral view of graciliform element; D795-80.

Figs 11, 12 *Panderodus* sp. B
Specimens from sample LT 265, Lake Timiskaming. All at x60.
11. Lateral view of falciform element; D889-21A.
12. Lateral view of arcuatiform element; D889-21B.
PLATE 26

Figs 1, 2 *Pseudooneotodus beckmanni* (Bischoff & Sannemann).
Specimens from sample AI 611, Anticosti Island, x60.
1. Lateral view of element; D768-12.

Figs 3, 4 *Pseudooneotodus* sp. A.
Specimens from the Jupiter Formation (Pavillion Member), Anticosti Island, x60.
3. Lateral view from sample AI 665; D877-5.
4. Upper view from sample AI 654; D853-33.

Figs 5-7 *Pseudooneotodus tricornis* Drygant.
Specimens from the Chicotte Formation, Anticosti Island.
5. Upper view of tridenticulate squat conical element, x120; D726-28 from sample AI 661.
6. Lateral view of unidenticulate slender conical element, x60; D852-32 from sample AI 668.
7. Upper view of unidenticulate squat conical element, x60; D852-31 from sample AI 668.

Fig. 8 *Belodina* ? sp. A
Sample from sample PC 552, Prongs Creek, x120.
8. Lateral view of unknown element; D801-96.

Figs 9, 10 *Pseudobelodella silurica* Armstrong
Specimen D728-32 from sample PC 570, Prongs Creek.
9. Lateral view, x90.

Fig. 11 *Belodina* ? sp. B
Specimen D724-23 from sample PC 542, Prongs Creek.
11. Lateral view of element, x60.
Appendix B

Abundance tables and percentages

B.1 Anticosti Island

Point Laframboise (AI 1) and Lac Wickenden Road sections (AI 17a).
- Abundance Charts
- Percentages

Cap a l’Aigle section (AI 2).
- Abundance Charts
- Percentages

Becscie, Merrimack and Gun River Formations at various localities.
- Abundance Charts
- Percentages

Gun River and Jupiter Formations at various localities.
- Abundance Charts
- Percentages

Upper Jupiter and Chicotte Formations at Brisants Jumpers (AI 5) and other localities.
- Abundance Charts
- Percentages

B.2 Lake Timiskaming

- Abundance Charts
- Percentages

B.1 Prongs Creek

Transitional Limestone Unit.
- Abundance Charts
- Percentages

Road River Group.
- Abundance Charts
- Percentages
| Sample Number | Abundance | Pa | Pb | Bi | Co | Cr | Cu | Fe | Hg | Ni | Se | Sn | Zn | Zr | Al | Si | Mg | Ca | K | Na | Ti | V | Mn | Cr | Co | Ni | Cu | Zn | Pb | Bi | Hg | Se | Sn | Zr | Al | Si | Mg | Ca |
|---------------|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| AEB 605      | 1         | 1  | 1  | 1  | 1  | 3  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AEB 606      | 2         | 3  | 1  | 1  | 3  | 1  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AEB 607      | 6         | 2  | 1  | 1  | 1  | 2  | 1  | 1  | 1  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AEB 608      | 8         | 1  | 1  | 1  | 3  | 1  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AEB 609      | 8         | 2  | 2  | 1  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

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| Gastropod                     | # # |

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**Subtotal**

|       | 10 | 2  | 179 | 115 | 3  | 2  | 12  | 232 | 3     |

**Fragments**

|       | 2  | 0  | 112 | 66  | 0  | 0  | 6   | 140 | 0     |

**Total**

|       | 12 | 2  | 291 | 181 | 3  | 2  | 18  | 372 | 3     |

**Graptolite**

|       | #  | #  | #   |

**Scolocodont**

|       | #  | #  | #   |

**Ostracod**

|       | #  | #  | #   |

**Gastropods**

|       | #  | #  | #   |

**Brachiopods**

|       | #  | #  | #   |

**Crinoid ossicles**

|       | #  |     |

B7
### Percentages - Gun River and Jupiter Formations, Anticosti Island

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| Total                          | 10     | 2      | 182    | 115    | 3      | 4      | 19     | 234    | 3      |

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Note: The table represents the abundance of different species across various dimensions.
## Abundance Charts - Lake Timiskaming

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### Notes
- The chart provides data on the abundance of various species over different months.
- Specific values are given for each month.
Percentages - Lake Timiskaming Section

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- **Aulacognathus aff. A. bullatus**
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- **Deciconus costulatus**
  - Percentages: 13% 13% 9% 1% 1% 7% 10% 13% 13% 20% 35% 40%

- **Distomodus kentuckyensis**
  - Percentages: 3% 5% 9% 1% 4% 6% 4% 6% 2%

- **Oulodus ? kentuckyensis**
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- **Oulodus ? nathani**
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- **Oulodus cf. O. panuarensis**
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- **Ozarkodina hassi**
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- **Ozarkodina oldhamensis**
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- **Panderodus langkawiensis**
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- **Panderodus panderi**
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- **Panderodus unicostatus**
  - Percentages: 62% 17% 12% 5% 5% 7% 3% 6% 7% 3% 1% 1%

- **Panderodus sp. C**
  - Percentages: 4%

- **Pranognathus cf. P. tenuis**
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- **Pseudolonchodina sp.**
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- **Pseudooneotodus beckmanni**
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- **Walliserodus curvatus**
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- **Walliserodus sanctofianus**
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- **Genus sp. indet.**
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**Total**
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**Abundance Charts**

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<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
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<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Percentages - Prongs Creek Section (2)
Appendix C

Localities and conodont samples

C.1 Introduction

C.2 Sampling areas

C.2.1 Anticosti Island (Québec)
   C.2.1a Samples collected during field work
   C.2.1b Samples collected during the Third International
   Brachiopod Congress Field Trip, Anticosti Island
   (Led by P. Copper & J. Jisuo)

C.2.2 Lake Timiskaming (Ontario)

C.2.3 Prongs Creek (northern Yukon Territories)
Appendix C

Localities and conodont samples

C.1 Introduction

Within this thesis conodont samples of Ordovician and Silurian age have been studied from three areas: Anticosti Island (Québec), Lake Timiskaming (Ontario), Prongs Creek (Yukon Territories).

Figure C.1 A map of Canada showing the locations of Lake Timiskaming, Anticosti Island and Prongs Creek.
C.2 Sampling areas

C.2.1 Anticosti Island (Québec)

The samples were collected in 1995 by G. Radcliffe. Sample descriptions are taken from field notes by G. Radcliffe.

Sample numbers that are prefixed with GR refer to sample number assigned in the field. The sample numbers were then changed to Durham University numbers, which are prefixed with the letter D. In the rest of this thesis the Durham University number has been used but prefixed with the letters AI (Anticosti Island).

![Diagram of Conodont sampling localities on Anticosti Island: Point Laframboise (AI 1), Cap à l' Aigle (AI 2), Jupiter 24 Lodge (AI 3), Cap Ottawa (AI 4), Brisants Jumpers (AI 5), Pointe du sud-ouest (AI 6), Rivière du Brick Road (AI 7), Cap Jupiter (AI 8), Rivière Dauphine Road (AI 9, AI 10b, AI 11b, AI 11c), Main Sandtop Road (AI 13), Baie Innommée (AI 15), Meeting of Sandtop road and Ruis de la Chute (AI 15a), Cap Sandtop (AI 16), Lac Wickenden Road (AI 17a, AI 17c), and Rivière Galiote Road (AI 20).]
### C.2.1a Samples collected during field work

#### Locality AI 1

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Height</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/15/1) D628</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>0.3m</td>
<td></td>
</tr>
<tr>
<td>(GR/15/2) D629</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>0.54m</td>
<td></td>
</tr>
<tr>
<td>(GR/15/3) D630</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>1.46m</td>
<td></td>
</tr>
<tr>
<td>(GR/15/5) D634</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>2.12m</td>
<td></td>
</tr>
<tr>
<td>(GR/15/6) D641</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>2.95m</td>
<td>Uppermost bed</td>
</tr>
<tr>
<td>(GR/15/9) D636</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>3.02m</td>
<td>O.P.B.</td>
</tr>
<tr>
<td>(GR/15/7) D635</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>3.18m</td>
<td>O.P.B.</td>
</tr>
</tbody>
</table>

#### Section 2

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Height</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/1/159) D594</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.08m</td>
<td>Very top of oncolite bed</td>
</tr>
<tr>
<td>(GR/1/162) D612</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.1m</td>
<td>Lying on top of oncolite bed</td>
</tr>
<tr>
<td>(GR/1/164) D595</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.22m</td>
<td>Inter bioherm 12cm above onc.</td>
</tr>
<tr>
<td>(GR/1/160) D620</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.5m</td>
<td>Inter bioherm 40cm above onc.</td>
</tr>
<tr>
<td>(GR/1/161) D605</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.66m</td>
<td>Inter bioherm 55cm above onc.</td>
</tr>
<tr>
<td>(GR/1/173) D606</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>0.94m</td>
<td>Inter bioherm 30cm above recessive beds (?)</td>
</tr>
<tr>
<td>(GR/1/174) D596</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>1.26m</td>
<td>Inter bioherm 30cm above 173</td>
</tr>
<tr>
<td>(GR/1/175) D613</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>1.95m</td>
<td>Inter bioherm 70cm above 174</td>
</tr>
<tr>
<td>(GR/1/176) D607</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>2.30m</td>
<td>Inter bioherm 35cm above 175</td>
</tr>
<tr>
<td>(GR/1/177) D602</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>2.50m</td>
<td>Inter bioherm Uppermost bed of marls below sand.</td>
</tr>
</tbody>
</table>
### Appendix C Localities and conodont samples

#### Section 3

<table>
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<th>Member</th>
<th>Height</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/1/166) D615</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>-</td>
<td>marl layer directly below sand</td>
</tr>
<tr>
<td>(GR/1/165) D618</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>5 cm above base of sand</td>
</tr>
<tr>
<td>(GR/1/167) D616</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>Nodular band 35 cm above base of sand</td>
</tr>
<tr>
<td>(GR/1/168) D617</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>Unit 5 of Becscie</td>
</tr>
<tr>
<td>(GR/1/169) D622</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>Base of unit 6 (bottom 5 cm)</td>
</tr>
<tr>
<td>(GR/1/170) D627</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>Base of unit 7</td>
</tr>
<tr>
<td>(GR/1/171) D610</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>135 cm above base of unit 7</td>
</tr>
<tr>
<td>(GR/1/172) D626</td>
<td>Becscie</td>
<td>-</td>
<td>-</td>
<td>160 cm above sample 171</td>
</tr>
</tbody>
</table>

#### Section 4

<table>
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<th>Formation</th>
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<th>Height</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/1/153) D611</td>
<td>Becscie?</td>
<td>-</td>
<td>-</td>
<td>1st sand bed interbedded with bioherms</td>
</tr>
<tr>
<td>(GR/1/154) D614</td>
<td>Becscie?</td>
<td>-</td>
<td>-</td>
<td>1st sand body that interfingers with bioherms</td>
</tr>
<tr>
<td>(GR/1/155) D619</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>-</td>
<td>marly layer from centre of bioherm.</td>
</tr>
</tbody>
</table>

### Locality Al 2

#### Location:
Cap à l'Aigle

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Height</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/4/189) D579</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>-</td>
<td>Shaley bed directly below platey bed.</td>
</tr>
<tr>
<td>(GR/4/182) D603</td>
<td>Ellis Bay</td>
<td>Lousy Cove</td>
<td>-</td>
<td>(Uppermost bed) platey bed</td>
</tr>
<tr>
<td>(GR/4/181) D604</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>-</td>
<td>O.P.B.</td>
</tr>
<tr>
<td>(GR/4/184) D575</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>-</td>
<td>O.P.B. shale directly below the true O.P.B.</td>
</tr>
<tr>
<td>(GR/4/183) D578</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>-</td>
<td>True O.P.B.</td>
</tr>
</tbody>
</table>
### Appendix C Localities and conodont samples

<table>
<thead>
<tr>
<th>Locality</th>
<th>Location</th>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI 3</td>
<td>Rivière Jupiter (down stream of Jupiter 24 Lodge)</td>
<td>(GR/16/15) D672</td>
<td>Becscie</td>
<td>-</td>
<td>base of bed 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/17/25) D673</td>
<td>Becscie</td>
<td>-</td>
<td>Top of bed 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/17/28) D674</td>
<td>Merrimack</td>
<td>-</td>
<td>bed 6 9cm from base of bed 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/17/27) D675</td>
<td>Merrimack</td>
<td>-</td>
<td>base of bed 8</td>
</tr>
<tr>
<td>AI 4</td>
<td>Cap Ottawa</td>
<td>(GR/18/29) D678</td>
<td>Jupiter</td>
<td>Cyble</td>
<td>-</td>
</tr>
<tr>
<td>AI 5</td>
<td>Brisants Jumpers</td>
<td>GR/20/45 D640</td>
<td>Jupiter</td>
<td>Ferrum</td>
<td>0.26m 10-0cm below top.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GR/20/42 D642</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>1.17m -</td>
</tr>
</tbody>
</table>
### Appendix C

**Localities and conodont samples**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Location</th>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locality AI 6</td>
<td>Pointe du sud-ouest</td>
<td>(GR/20/41) D652</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>1.42m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/20/47) D639</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>2.28m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/20/48) D643</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>2.80m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/20/49) D651</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>4.23-432m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/20/43) D654</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>4.73m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/54) D656</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>5.33m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/53) D658</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>6.75m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/60) D653</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>7.92m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/61) D665</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>8.93m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/56) D657</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>9.79m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/57) D659</td>
<td>Jupiter</td>
<td>Pavillion</td>
<td>9.95m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/58) D655</td>
<td>Chicotte</td>
<td>-</td>
<td>10.07m</td>
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<tr>
<td></td>
<td></td>
<td>(GR/21/71) D669</td>
<td>Chicotte</td>
<td>-</td>
<td>11.15m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/70) D667</td>
<td>Chicotte</td>
<td>-</td>
<td>12.04m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(GR/21/69) D668</td>
<td>Chicotte</td>
<td>-</td>
<td>12.95m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Locality AI 7</th>
<th>Location: Rivière du Brick road just south of Chalet Brick</th>
</tr>
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<tbody>
<tr>
<td>Sample number</td>
<td>Form</td>
</tr>
<tr>
<td>(GR/194) D661</td>
<td>Chicotte</td>
</tr>
<tr>
<td>and D662</td>
<td>Chicotte</td>
</tr>
</tbody>
</table>
C.2.1b Samples collected during the Third International Brachiopod Congress Field Trip, Anticosti Island (Led by P. Copper & J. Jisuo)

**Stop AI 9**

<table>
<thead>
<tr>
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<th>Rivière Dauphiné Road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample number</strong></td>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>(GR/27/96) D749</td>
<td>Gunriver</td>
</tr>
<tr>
<td>(GR/27/97) D750</td>
<td>Jupiter</td>
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</table>

**Stop AI 10b**

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</thead>
<tbody>
<tr>
<td><strong>Sample number</strong></td>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>(GR/27I02) D677</td>
<td>Jupiter</td>
</tr>
</tbody>
</table>

**Stop AI 11b**

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<tbody>
<tr>
<td><strong>Sample number</strong></td>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>(GR/27/107) D670</td>
<td>Jupiter</td>
</tr>
</tbody>
</table>

**Stop AI 11c**

<table>
<thead>
<tr>
<th>Location:</th>
<th>Rivière Dauphiné Road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample number</strong></td>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>(GR/27/108) D647</td>
<td>Jupiter</td>
</tr>
</tbody>
</table>

**Stop AI 13**

<table>
<thead>
<tr>
<th>Location:</th>
<th>Main Sandtop Road, 2.4 km E of Box Road turn off.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample number</strong></td>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>(GR/28/113) D646</td>
<td>Jupiter</td>
</tr>
<tr>
<td>(GR/28/114) D645</td>
<td>Jupiter</td>
</tr>
</tbody>
</table>

C7
## Appendix C  Localities and conodont samples

### Stop AI 15

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/28/117) D666</td>
<td>Merrimack</td>
<td>Middle part, Unit 1-3</td>
<td>-</td>
</tr>
</tbody>
</table>

### Stop AI 15a

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/28/123) D676</td>
<td>Gun River</td>
<td>La chute</td>
<td>1m below the boundary with the Innommée member.</td>
</tr>
</tbody>
</table>

### Stop AI 16

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/28/125) D650</td>
<td>Gun River</td>
<td>Macgilvray</td>
<td>Uppermost bed of the Macgilvray member (70cm below road).</td>
</tr>
<tr>
<td>(GR/28/124) D649</td>
<td>Jupiter</td>
<td>Goeland</td>
<td>Fallen block of <em>Pentamerus</em> beds, basal Goeland member.</td>
</tr>
</tbody>
</table>

### Stop AI 17a

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/29/128) D664</td>
<td>Ellis Bay</td>
<td>Laframboise</td>
<td>O.P.B.</td>
</tr>
</tbody>
</table>

### Stop AI 17c

<table>
<thead>
<tr>
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<th>Formation</th>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GR/29/129) D751</td>
<td>Gun River</td>
<td>Sandtop</td>
<td>Many silicified horn corals.</td>
</tr>
</tbody>
</table>
### Stop AI 20

<table>
<thead>
<tr>
<th>Location:</th>
<th>Rivière Galiote road, 5 km E of the Rivière du Brick bridge.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample number</td>
<td>Formation</td>
</tr>
<tr>
<td>(GR/29/135) D648</td>
<td>Chicotte</td>
</tr>
<tr>
<td>(GR/29/136) D663</td>
<td>Chicotte</td>
</tr>
</tbody>
</table>
C.2.2 Lake Timiskaming (Ontario)

Seven sections were collected through the Lower Silurian of Lake Timiskaming by A. D. McCracken and T. E. Bolton in 1994 for the Geological Survey of Canada. The samples were processed using standard conodont preparation techniques (at the Geological Survey of Canada, Ottawa).

Sample numbers that are prefixed with O have been given by the Geological Survey of Canada (G.S.C.) In the rest of this thesis the G.S.C. sample numbers have been abbreviated (last three digits only) and prefixed with the letters LT (Lake Timiskaming).

![Map of Lake Timiskaming area](image)

**Figure C.3** Conodont sampling localities in the Lake Timiskaming area: Loach Quarry (LT 2), Highway 65 Roadcut (LT 3), Middleton Quarry (LT 7), Dawson Point (LT 8), Evanturel Creek (LT 17) and McNamara Quarry (LT 25).
### Localities and conodont samples

#### Locality LT 2

<table>
<thead>
<tr>
<th>Location:</th>
<th>Loach Quarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group:</td>
<td>Wabi</td>
</tr>
<tr>
<td>Formation:</td>
<td>Evanturel Creek</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.S.C. Sample number:</th>
<th>Height (A.B.S.):</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-106261</td>
<td>0.0m</td>
<td>-</td>
</tr>
<tr>
<td>O-106262</td>
<td>2.3 m</td>
<td>Thin bedded limestone.</td>
</tr>
<tr>
<td>O-106263</td>
<td>3.3 m</td>
<td>5 cm bed of fossiliferous limestone.</td>
</tr>
</tbody>
</table>

#### Locality LT 3

<table>
<thead>
<tr>
<th>Location:</th>
<th>Highway 65 Roadcut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude:</td>
<td>473400N</td>
</tr>
<tr>
<td>Longitude:</td>
<td>0793700W</td>
</tr>
<tr>
<td>Formation:</td>
<td>Earlton</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.S.C. Sample number:</th>
<th>Height (A.B.S.):</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-106264</td>
<td>0.90-1.05m</td>
<td>Fossiliferous, ostracode limestone.</td>
</tr>
<tr>
<td>O-106265</td>
<td>0.70-0.75m</td>
<td>Oolitic Limestone.</td>
</tr>
<tr>
<td>O-106266</td>
<td>1.12-1.27m</td>
<td>Burrowed limestone.</td>
</tr>
</tbody>
</table>

#### Locality LT 7

<table>
<thead>
<tr>
<th>Location:</th>
<th>Middleton Quarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude:</td>
<td>474000N</td>
</tr>
<tr>
<td>Longitude:</td>
<td>0794500W</td>
</tr>
<tr>
<td>Formation:</td>
<td>Thornloe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.S.C. Sample number:</th>
<th>Height (A.B.S.):</th>
<th>Description:</th>
</tr>
</thead>
</table>
### Appendix C Localities and conodont samples

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-106279</td>
<td>0.0m</td>
<td>Brown / grey, fossiliferous limestone with muddy matrix.</td>
</tr>
<tr>
<td>O-106278</td>
<td>1.5m</td>
<td>Medium brown, fine grained limestone.</td>
</tr>
<tr>
<td>O-106280</td>
<td>5.3m</td>
<td>Light brown calcilutite.</td>
</tr>
</tbody>
</table>

### Locality LT 8

<table>
<thead>
<tr>
<th>Location: Dawson Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude: 472900N</td>
</tr>
<tr>
<td>Longitude: 0793600W</td>
</tr>
<tr>
<td>Formation: Thornloe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-106273</td>
<td>0.0m</td>
<td>Med. brown calcicrinite with brachiopods crinoids, trace fossils, and Favositid corals.</td>
</tr>
<tr>
<td>O-106271</td>
<td>4.7m</td>
<td>Brown, crinoidal, burrowed calcilutite.</td>
</tr>
<tr>
<td>O-106272</td>
<td>6.0m</td>
<td>Resistant crinoidal limestone.</td>
</tr>
</tbody>
</table>

### Locality LT 17

<table>
<thead>
<tr>
<th>Location: Evanturel Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude: 473400N</td>
</tr>
<tr>
<td>Longitude: 0793700W</td>
</tr>
<tr>
<td>Formation: Evanturel Creek</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-106267</td>
<td>1.1-1.2m</td>
<td>Nodular dolomitic limestone</td>
</tr>
<tr>
<td>O-106268</td>
<td>1.75-1.8m</td>
<td>V. fossiliferous limestone with clams, ostracodes, gastropods.</td>
</tr>
<tr>
<td>O-106269</td>
<td>2.95-2.98m</td>
<td>Limestone with ostracodes.</td>
</tr>
</tbody>
</table>

### Locality LT 25

<table>
<thead>
<tr>
<th>Location: McNamara Quarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude: 474500N</td>
</tr>
</tbody>
</table>
### Appendix C

#### Localities and conodont samples

| Longitude: | 0794900W |
| Formation: | Earlton |
| G.S.C. Sample number: | Height (A.B.S.): | Description: |
| O-106253 | 2.65m | 5cm of thin bedded fossiliferous limestone with crinoid ossicles and brachiopods. |
| O-106270 | 3.53-3.7m | 5cm bed of brown / buff limestone with numerous trilobite tails and zy gobol. ostracods. |
Appendix C  Localities and conodont samples

C.2.3 Prongs Creek (northern Yukon Territories)

Conodont samples were collected by A.D. McCracken in 1986 from Upper Prongs Creek section (a tributary off the main creek). A preliminary report documenting tentative identifications was published in 1989. The descriptions below are taken from A.D. McCracken's field notes.

Sample numbers that are prefixed with C have been given by the Geological Survey of Canada (G.S.C.) In the rest of this thesis the G.S.C. sample numbers have been abbreviated (last three digits only) and prefixed with the letters PC (Prongs Creek).

Figure C.4 The location of the Prongs Creek section.
### Locality PC 1

**Location:** Upper Prongs Creek, tributary off the main Prongs Creek  
**Latitude:** 65° 17' N  
**Longitude:** 135° 42' W

#### Section 3

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-150542</td>
<td>8.0m</td>
<td>Light grey / medium grey calcilutite.</td>
</tr>
<tr>
<td>C-150543</td>
<td>18.7m</td>
<td>Light grey / dark grey, styloitic, calcarenite.</td>
</tr>
<tr>
<td>C-150544</td>
<td>23.0m</td>
<td>Light grey / medium grey, calcilutite.</td>
</tr>
<tr>
<td>C-150545</td>
<td>27.0m</td>
<td>Light grey / medium grey, mottled calcarenite. Fossiliferous with pyrite.</td>
</tr>
</tbody>
</table>

#### Transitional Limestone Unit

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-150546</td>
<td>30.5m</td>
<td>Light grey / medium grey, calcilutite. Burrow mottling.</td>
</tr>
<tr>
<td>C-150547</td>
<td>31.0m</td>
<td>Uppermost 6cm of coral unit.</td>
</tr>
<tr>
<td>C-150548</td>
<td>31.05 - 31.15m</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Section 1

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-150552</td>
<td>0.5m</td>
<td>Grey, medium bedded, calcarenite. No fossils visible.</td>
</tr>
<tr>
<td>C-150553</td>
<td>1.0m</td>
<td>Grey, medium bedded, calcarenite with very abundant brachiopods, and trilobite pygidia.</td>
</tr>
<tr>
<td>C-150554</td>
<td>1.2m</td>
<td>Grey, thin bedded, calcarenite with abundant brachiopods.</td>
</tr>
<tr>
<td>C-150555</td>
<td>1.7m</td>
<td>Thin bedded, grey, calcarenite with trilobite pygidia and a gastropod.</td>
</tr>
<tr>
<td>C-150556</td>
<td>2.0m</td>
<td>Thin bedded, grey, calcarenite.</td>
</tr>
<tr>
<td>C-150557</td>
<td>2.6m</td>
<td>Thin to medium bedded with fewer fossils than below. The Hummocky bed surface.</td>
</tr>
<tr>
<td>C-150558</td>
<td>2.7m</td>
<td>Thin bedded, grey calcarenite, with numerous brachiopods and trilobites.</td>
</tr>
</tbody>
</table>

#### Road River Group

<table>
<thead>
<tr>
<th>G.S.C. Sample number</th>
<th>Height (A.B.S.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Code</td>
<td>Depth (m)</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>C-150559</td>
<td>3.7</td>
<td>Upper 15 cm of 50 cm massive bed of grey, fine calcarenite with no fossils.</td>
</tr>
<tr>
<td>C-150560</td>
<td>6.2</td>
<td>15 cm bed with same lithology as 559, plus pyrite nodules.</td>
</tr>
<tr>
<td>C-150561</td>
<td>7.7</td>
<td>Grey, medium bedded, dense calcarenite, with small pyrite nodules but lacking fossils.</td>
</tr>
<tr>
<td>C-150562</td>
<td>8.9</td>
<td>Grey, very dense calcarenite (30cm thick bed), with pyrite nodules, faint laminae, and no fossils.</td>
</tr>
<tr>
<td>C-150563</td>
<td>9.4</td>
<td>50 cm bed of the same lithology as below.</td>
</tr>
<tr>
<td>C-150564</td>
<td>10.3</td>
<td>15 cm bed of the same lithology as below.</td>
</tr>
<tr>
<td>C-150565</td>
<td>11.6</td>
<td>20 cm bed of same lithology as below.</td>
</tr>
<tr>
<td>C-150566</td>
<td>12.1</td>
<td>20 cm bed, with same lithology as below.</td>
</tr>
<tr>
<td>C-150567</td>
<td>12.8</td>
<td>30cm thick bed with the same lithology as below.</td>
</tr>
<tr>
<td>C-150568</td>
<td>13.0</td>
<td>30cm thick bed, with same lithology as below with Laminae.</td>
</tr>
<tr>
<td>C-150569</td>
<td>13.5</td>
<td>15cm thick bed, with same lithology as below, but lacks laminae.</td>
</tr>
<tr>
<td>C-150570</td>
<td>14.4</td>
<td>30 cm thick bed, with same lithology as below and lacks laminae.</td>
</tr>
<tr>
<td>C-150571</td>
<td>15.4</td>
<td>Sample from the upper 20 cm of a 50 cm unit (2 beds) of the same lithology as below, with no laminae.</td>
</tr>
<tr>
<td>C-150572</td>
<td>16.8</td>
<td>Sample from the upper 20 cm of 40 cm bed.</td>
</tr>
<tr>
<td>C-150573</td>
<td>18.5</td>
<td>Sample from a 15cm thick bed, of the same lithology as below with laminae and iron staining.</td>
</tr>
<tr>
<td>C-150574</td>
<td>20.0</td>
<td>Lithology as below, with no laminae.</td>
</tr>
<tr>
<td>C-150575</td>
<td>39.5</td>
<td>Sample from above the <em>spiralis</em> Biozone, from a 4cm thick bed.</td>
</tr>
</tbody>
</table>
Appendix D

Sample preparation and collections studied

D.1 Sample Preparation

D.1.1 Sample Preparation at the University of Durham
D.1.2 Sample Preparation at the Geological Survey of Canada

D.2 Collections viewed

D.3 Samples On Loan
Appendix D

Sample preparation and collections studied

D.1 Sample Preparation

D.1.1 Sample Preparation at the University of Durham

Samples from Anticosti Island were processed by the author at the University of Durham using the following method. The samples were broken up in to small pieces (by using a hammer or crushing machine dependent on the rock type) and placed in a clean bucket. A solution of 10 % acetic acid was then added to the bucket (solution made by diluting 80% acetic acid with hot tap water). After one week, the spent acid was decanted through a coarse top sieve (1mm) with a 60 micron sieve below. The coarse fraction was returned to the bucket and fresh acid was added. This process was continued until the rock had been totally digested. The fine fraction was collected and dried after each sieving and then separated using a heavy liquid, bromoform (tribromomethane). The heavy residues were dried again and then picked for conodont elements using a standard grid tray and a fine brush wetted with water.

D.1.2 Sample Preparation at the Geological Survey of Canada

The samples from Lake Timiskaming and Prongs Creek were processed at the Geological Survey of Canada labs in Ottawa and Calgary respectively. The rock samples were dissolved using the standard technique outlined above (10-15% acetic acid). The sieve sized used was 150. The residues were then separated using tetrabromomethane. Further processing of some samples was undertaken with the use of Methylene Iodide and/or magnetic separation. The lake Timiskaming samples were fully picked at the Geological Survey of Canada, whereas the Prongs Creek samples were only partially picked. Completion of picking was undertaken by the author at the University of Durham.
D.2 Collections viewed

During the course of this project the author has been able to visit the following institutions in order to study the conodont collections housed there:

University of Leicester

M. Idris thesis collection (kind permission of Prof. R. J. Aldridge).

University of Birmingham

Dr. Ivan Sansom’s collection of *Panderodus* elements.

The Geological Survey of Canada, Calgary

The following collections were viewed with the kind permission of Dr. G. S. Nowlan and Dr. T. T. Uyeno:


Nowlan (1982): Conodonts from the Ordovician - Silurian boundary at the eastern end of Anticosti Island.


Unpublished conodont samples (collected by Dr. G. S. Nowlan) from Manitoulin Island and the Gaspé Peninsula.
The Geological Survey of Canada, Ottawa

Figured specimens from the following publications were viewed by the kind permission of Mrs. B. J. Dougherty (Curator, The National Type Fossil Collection):


D.3 Samples On Loan

Samples loaned to the author by Dr. A. D. McCracken (Geological Survey of Canada) include:

Conodont samples from the McCracken & Barnes (1981) collection.

Conodont samples from the Lower Silurian of Lake Timiskaming, Ontario.

Ordovician - Silurian conodont samples from Prongs Creek, The Yukon.