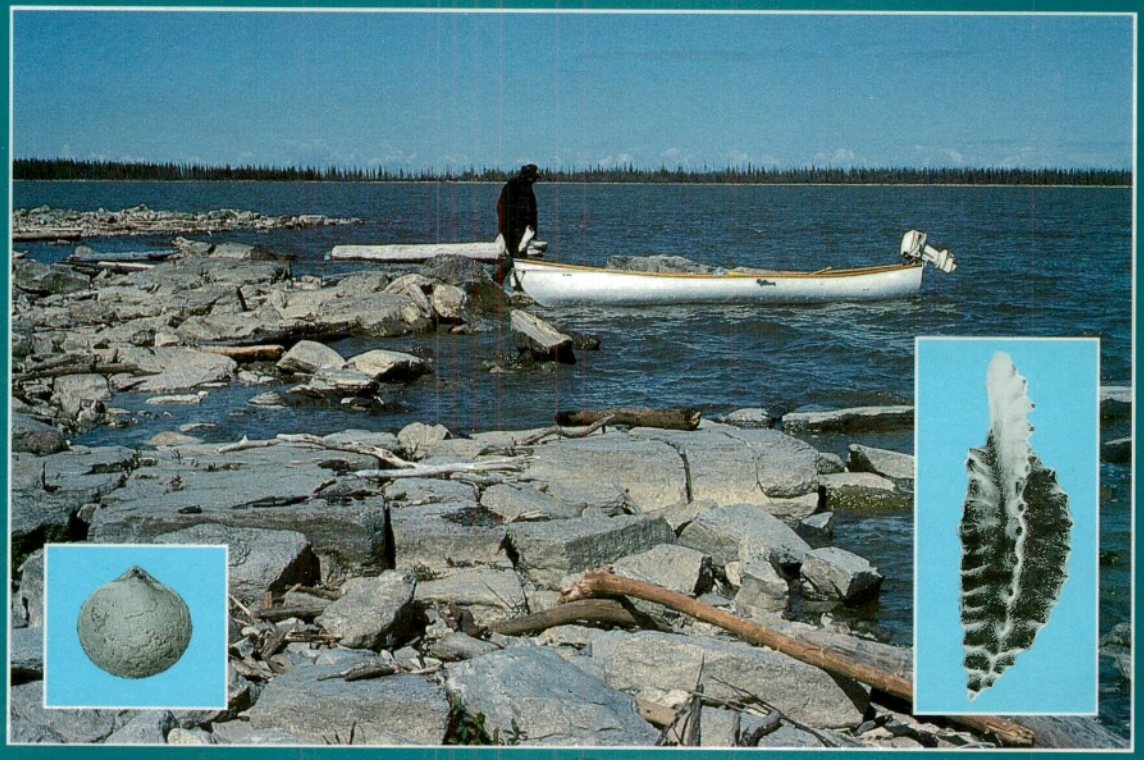
GEOLOGICAL SURVEY OF CANADA
BULLETIN 522

MIDDLE DEVONIAN BRACHIOPODS, CONODONTS, STRATIGRAPHY, AND TRANSGRESSIVE-REGRESSIVE CYCLES, PINE POINT AREA, SOUTH OF GREAT SLAVE LAKE, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

PART I: Stratigraphy and brachiopod faunas
A.W. Norris

PART II: Conodont faunas
T.T. Uyeno



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Cover illustration
Fossiliferous beds of Bituminous limestone member of the Pine Point Formation exposed at station 28NB on the northwest end of McKay Island, about 3.2 km from the south shore of Great Slave Lake. ISPG photo AWN-1981.
Brachial view of brachiopod *Leptathyris obsolescens* (lower left) and upper view of *Polygnathus linguiformis* Hinde predelta morphotype (new) (lower right).

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PREFACE

The Pine Point area on the south shore of Great Slave Lake was one of Canada's major lead and zinc producers from 1965 to 1990. The host rocks for the Mississippi Valley-type ore deposits are Middle Devonian carbonate strata within the Pine Point carbonate barrier complex, which separates a shale basin in the north and northwest from an evaporite basin in the south.

This bulletin describes the biostratigraphy of the Middle Devonian strata of the south shore of Great Slave Lake, and from adjacent areas. The data are relevant for correlating the rock units and understanding their interfingering relationships. It presents an update of the complete Devonian stratigraphic succession of the region, and timing data for the transgressive–regressive cycles of the Middle Devonian. Two major fossil groups, brachiopods and conodonts, are of particular importance for correlation and dating, because they provide biostratigraphic control in the carbonate and shaley facies respectively. Important species of these groups are documented by detailed taxonomic descriptions.

This work is the product of ongoing detailed paleontological studies in support of the correlation, mapping, and exploration of Devonian rocks in western Canada, where they are major sources of hydrocarbon and mineral resources.

M.D. Everell
Assistant Deputy Minister
Earth Sciences Sector

PRÉFACE

La région de Pine Point, sur la rive sud du Grand lac des Esclaves, est l'une des régions canadiennes dont la production de plomb et de zinc a été parmi les plus élevées entre 1965 et 1990. Les roches hôtes des gisements de type Mississippi-Valley de ce secteur sont des couches carbonatées du Dévonien moyen appartenant au complexe de barrière carbonaté de Pine Point, qui sépare un bassin de shale au nord et au nord-ouest d'un bassin d'évaporites au sud.

Le présent bulletin contient une description de la biostratigraphie de la succession du Dévonien moyen présente sur la rive sud du Grand lac des Esclaves et dans les régions adjacentes. Les données qui sont présentées permettent de corréler les unités lithologiques et de comprendre les relations d'interdigitation qui les caractérisent. Le bulletin contient une mise à jour de la stratigraphie de lensemble de la succession dévonienne de la région, ainsi que des données ayant trait à la chronologie des cycles de trangression-régression au Dévonien moyen. Deux principaux groupes de fossiles, les brachiopodes et les conodontes, sont particulièrement importants pour la corrélation et la datation des couches, assurant un bon contrôle biostratigraphique dans les faciès de roches carbonatées pour les premiers et dans les shales pour les seconds. Les espèces importantes de ces groupes sont documentées par des descriptions taxonomiques détaillées.

Ce compte rendu est le produit d'études paléontologiques détaillées en cours qui visent à appuyer les travaux de corrélation, de cartographie et d'exploration des roches dévoniennes de l'Ouest du Canada, là où celles-ci constituent d'importantes sources d'hydrocarbures et de minéraux économiques.

M.D. Everell
Sous-ministre adjoint
Secteur des sciences de la Terre

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MIDDLE DEVONIAN BRACHIOPODS, CONODONTS, STRATIGRAPHY, AND TRANSGRESSIVE-REGRESSIVE CYCLES, PINE POINT AREA, SOUTH OF GREAT SLAVE LAKE, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

PART I: Stratigraphy and brachiopod faunas

Abstract

From the richly fossiliferous Bituminous limestone member, 21 brachiopod taxa are described of which 5 are new, comprising: ***Rhyssochonetes aurora medialis*** *n. subsp.,* ***Emanuella caldwelli*** *n. sp.,* ***Warrenella parafranklinii*** *n. sp.,* ***W. posteruskirki*** *n. sp., and* ***W. whittakeri*** *n. sp. The Bituminous limestone member yields conodonts of the upper* ***ensensis*** *Zone, and the Lower and part of the Middle* ***varcus*** *subzones of Givetian, late Middle Devonian, age. Associated tentaculitids in the Bituminous limestone member include* ***Nowakia otomari,*** ***Striatostyliolina roemeri*** *and* ***Styliolina fissurella,*** *which occur typically in lower to middle Givetian rocks of Czechoslovakia. Some associated rhynchonellid brachiopods in the Bituminous limestone member, which are important for correlation and as zonal fossils, include:* ***Eliorhynchus castanea,*** ***Stenoglossaiorhynchus awokanak*** *and* ***Droharhynchia intermissa.***

*From the reefal Sulphur Point Formation at Presqu'ile Point, 4 brachiopod taxa are described of which one is new (****Gypidula? presquilensis*** *n. sp.). Other important fossils include:* ***Elita?*** *sp.,* ***Stringocephalus*** *sp. B, and* ***Hypothyridina cameroni,*** *which indicate correlation with the conodont* ***hermanni*** *Zone of late Givetian age.*

The described Devonian succession along and west of Slave River includes the La Loche, Fitzgerald (Ernestina Lake), Cold Lake (equivalent), Evaporite and Hay Camp members of the Chinchaga Formation. The Devonian sequence along the south side of Great Slave Lake includes the Keg River Formation and equivalent rock units; Fine-grained dolostone, Bituminous limestone, and Buffalo River members of the Pine Point Formation; and the Sulphur Point, Watt Mountain, Slave Point, and Hay River formations.

Résumé

Dans le membre de Calcaire bitumineux à riche faune fossile, on a dénombré 21 taxons de brachiopodes dont cinq sont nouveaux : ***Rhyssochonetes aurora medialis*** *n. subsp.,* ***Emanuella caldwelli*** *n. sp.,* ***Warrenella parafranklinii*** *n. sp.,* ***W. posteruskirki*** *n. sp., et* ***W. whittakeri*** *n. sp. Le membre de Calcaire bitumineux a livré des conodontes du Givétien (fin du Dévonien moyen) appartenant à la partie supérieure de la Zone à ensensis, à la partie inférieure de la Sous-zone à* ***varcus*** *et à une portion de la partie intermédiaire de cette dernière zone. Dans le membre de Calcaire bitumineux, les tentaculitidés associés incluent* ***Nowakia otomari,*** ***Striatostyliolina roemeri*** *et* ***Styliolina fissurella,*** *que l'on rencontre de manière caractéristique dans les roches du Givétien inférieur et moyen en Tchécoslovaquie. Dans la même unité stratigraphique, les brachiopodes rhynchonellidés associés, qui sont importants pour établir des corrélations et jouer le rôle de fossiles stratigraphiques, sont représentés entre autres par :* ***Eliorhynchus castanea,*** ***Stenoglossaiorhynchus awokanak*** *et* ***Droharhynchia intermissa.***

*Du faciès récifal de la Formation de Sulphur Point à la pointe Presqu'ile, quatre taxons de brachiopodes sont décrits dont l'un est nouveau (****Gypidula? presquilensis*** *n. sp.). Parmi les autres fossiles importants, mentionnons* ***Elita?*** *n. sp.,* ***Stringocephalus*** *sp. B et* ***Hypothyridina cameroni*** *qui indiquent une corrélation avec la Zone de conodontes à* ***hermanni*** *du Givétien tardif.*

La succession dévonienne présente le long et à l'ouest de la rivière Slave qui est décrite inclut les formations de La Loche, de Fitzgerald (Ernestina Lake) et de Cold Lake (Équivalent), ainsi que les membres d'Évaporite et de Hay Camp de la Formation de Chinchaga. La séquence dévonienne située le long de la rive sud du Grand lac des Esclaves inclut les unités suivantes : la Formation de Keg River et des unités lithologiques équivalentes; les membres de Dolomie à grain fin, de Calcaire bitumineux et de Buffalo River de la Formation de Pine Point; et les formations de Sulphur Point, de Watt Mountain, de Slave Point et de Hay River.

Summary

In this report, Middle Devonian brachiopods are described and illustrated from the richly fossiliferous Bituminous limestone member of the Pine Point Formation and from the Sulphur Point Formation, both on the north flank of the Pine Point carbonate barrier complex on the south side of Great Slave Lake. In the companion study of this report, conodonts from the Middle Devonian strata are studied.

Devonian rock units which crop out along and immediately west of Slave River in northern Alberta and southern District of Mackenzie include the following, in ascending sequence: La Loche, Fitzgerald (Ernestina Lake), Cold Lake (equivalent) formations, the evaporites, Hay Camp and Dolostone members of the Chinchaga Formation, La Butte and Limestone and dolostone members of the Keg River Formation, and its correlative, the Methy Formation of northeastern Alberta.

Stratigraphically higher Devonian rock units which outcrop along the south shore and offshore islands of Great Slave Lake between Fort Resolution in the east and Hay River in the west include the following: Fine-grained dolostone, Bituminous limestone, and Buffalo River members of the Pine Point Formation; Sulphur Point, Watt Mountain, Slave Point, and Hay River formations.

The La Loche Formation is the basal Phanerozoic rock unit consisting of sandstone, conglomerate and weathered igneous detritus overlying unaltered Precambrian igneous rocks and overlain by dolostone of the Fitzgerald (Ernestina Lake) Formation. It is exposed in depressions developed on Precambrian bedrock along the banks and on some of the islands of Slave River where its thickness varies from 2 to 5.7 m. It is unfossiliferous and its age is undetermined.

The Fitzgerald Formation consists of dolomitic limestones and dolostones exposed along Slave River, overlying the La Loche Formation, and underlying evaporites of the Elk Point Group. Thicknesses vary from 1.07 to 8.05 m. The Fitzgerald Formation of the outcrop belt correlates with the Ernestina Lake Formation in the subsurface west of Slave River.

The main fossils from the Fitzgerald Formation include the colonial coral *Planetophyllum planetum* and associated megafossils and microfossils in the lower part, and a restricted ostracode fauna, *Welleria meadowlakensis*, in the upper part of the formation. It is these two fossils which demonstrate the correlation between the Fitzgerald and Ernestina Lake formations. However, the most diagnostic fossil is the giant ostracode, *Moelleritia canadensis*, which indicates a late Early Devonian (Emsian) age for the Fitzgerald Formation, based on its range in the Yukon Territory and the Arctic Archipelago.

In the Bede Embayment of northern Alberta, a sequence of halite, the Cold Lake Formation, overlies the Fitzgerald (Ernestina Lake) Formation, and underlies the Chinchaga Formation. The presence of halite in the subsurface west of Slave River is suggested by a number of salt springs along the base of the escarpment near Salt River. In the subsurface south of Great Slave Lake, the Cold Lake Formation is represented by about 15 m of red mudstone breccia, the Cold Lake Equivalent.

In outcrops along and west of Slave River, gypsum of the Chinchaga Formation overlies halite of the Cold Lake Formation, or brecciated redbeds of the Cold Lake Equivalent, and underlies brecciated carbonates of the Hay Camp Member. A section of the Chinchaga Formation on Little Buffalo River has been subdivided into three members. The lower member (38.3 m thick) consists of white and grey, soft gypsum, containing silt and clay. Near the top of this member is a thin unit (1.8 m thick) of finely granular, porous dolomite containing sparse brachiopods. They are suggestive of *Spinatrypa andersonensis* and *Carinatrypa dysmorphostrota* which occur typically in the Eifelian upper Hume Formation. The *C. dysmorphostrota* Zone is within the conodont *kockelianus* Zone of late Eifelian age. The middle, Ebbut Member (about 12.2 m thick), consists of light grey gypsum with interbeds and laminae of light grey shale, and with brecciated fragments of

green shale. The upper member, 13.7 m thick, consists of laminated, white, dark grey to black gypsum.

The Hay Camp Member is a partially brecciated carbonate unit exposed along the Slave and Salt rivers which overlies gypsum of the Chinchaga Formation and is unconformably overlain by carbonates of the Keg River Formation and equivalent rocks. In this and some previous reports this rock unit is considered the uppermost member of the Chinchaga Formation. At the type section on Slave River, it is 6.1 m thick and consists of coarsely brecciated fragments of gypsiferous dolomite, fissile limestone, and calcareous shale, in a matrix of more finely brecciated fragments of the same rock types. A few fossils from the type section include *Desquamatia aperanta* and *Emanuella* sp. cf. *E. meristoides*, which indicate an Eifelian age.

The Keg River Formation, in its type area of northern Alberta, consists of dolomite and/or limestone overlying evaporites and carbonates of the Chinchaga Formation, and underlying anhydrite, dolomite and some limestone of the Muskeg Formation. At the type drillhole, the Keg River Formation is 80.8 m thick. In the Rainbow Sub-basin, it has been subdivided into Lower and Upper Keg River members, and a reefal Rainbow Member. The name has been extended by some workers to apply to the carbonate rocks forming the escarpment west of Slave River, and to the rocks forming the lower part of the Pine Point Formation in the Great Slave Lake area. The Keg River Formation is approximately equivalent to the Methy Formation of the Clearwater River area of northeastern Alberta and northwestern Saskatchewan, the La Butte Formation exposed along Slave River north of Lake Athabasca, and the upper part of the Little Buffalo Formation exposed along the river cutting through the escarpment west of Slave River. For the sake of precision in stratigraphy, all of these local names should be used.

Some of the more important fossils from the thin bedded calcareous dolostone Lower member of the Methy Formation include: *Variatrypa arctica*, *Desquamatia perfimbriata*, *Spinatrypa andersonensis*, and *Emanuella sublineata*. The distinctive *V. arctica* suggests a correlation with the Elm Point Formation of Manitoba; the lower part of the Pine Point Formation (lower Keg River equivalent) of the Great Slave Lake area; the Murray Island Formation of the Hudson Bay Lowlands; and the thin lower part of the Rogers City Formation of Michigan. The thick bedded reefal dolostone Upper member of the Methy Formation is lithologically and faunally similar to the Winnipegosis Formation of Manitoba. Fossils in common include: *Sphaerospongia tessellata*, a thin, flat form of *Stringocephalus* sp., *Schizophoria manitobensis*, *Mastigospira alata*, and others.

The La Butte Member of the Keg River Formation along Slave River consists of limestone and minor carbonaceous shale which unconformably overlie brecciated limestones and dolomitic limestones of the Hay Camp Member of the Chinchaga Formation. The upper contact with evaporites of the Muskeg Formation is not exposed. The La Butte Member appears to be a condensed sequence of the Keg River Formation with possible truncation at the top. Some of the more important fossils of the rich fauna include: *Variatrypa arctica*, *Desquamatia* sp. cf. *D. aperanta*, *Emanuella meristoides*, and *Lobobactrites* sp. cf. *L. ellipticus*. *V. arctica* occurs typically in argillaceous beds transitional between the upper Hume and lower Hare Indian formations in the Mackenzie River area, and is the name bearer of the *V. arctica* Zone of Middle Devonian age and straddles the Eifelian-Givetian boundary.

The Limestone and dolostone member of the Keg River Formation is the resistant capping rock unit of the upper escarpment exposed in the vicinity of the falls on Little Buffalo River west of Slave River, where about 12.2 m of section are exposed. It overlies, probably disconformably, the Dolostone member of the Chinchaga Formation, and is overlain by evaporites of the Muskeg Formation. Fossils from the limestone parts of the section include: *Variatrypa* sp. cf. *V. arctica*, *Desquamatia* sp. cf. *D. perfimbriata*, *Emanuella meristoides*, and *Mastigospira* sp.

In the Pine Point area, the Keg River Formation is a relatively homogeneous unit of grey-brown dolostone, with some limestone at the base, with a uniform thickness of 65 m. It overlies evaporites of the Chinchaga Formation, and is overlain by various carbonate barrier facies of the Pine Point

Formation, and partly by evaporites and dolostones of the Muskeg Formation. Three shale or shaly dolomite beds known as E-shale markers consistently occur 3 to 6 m below the top of the rock unit. Fossils from a Limestone member exposed at Fort Resolution, originally defined as the basal part of the Pine Point Formation, include the following: *Nowakia* sp., *Variatrypa* sp. cf. *V. arctica*, *Emanuella* sp. cf. *E. sublineata*, *Cyrtina* sp., and others. These are typical fossils of the *Variatrypa arctica* Zone which ranges from the upper part of the conodont *kockelianus* to the *ensensis* Zone, of late Eifelian to early Givetian age.

A small part of the Fine-grained dolostone member of the Pine Point Formation is represented along the south shore of Great Slave Lake east of Dawson Landing and on the offshore islands where it overlies the Keg River Formation and underlies the Bituminous limestone member of the Pine Point Formation. It is referred to as the B Spongy Member by Pine Point geologists. It has a thickness of about 18 m, and consists of argillaceous dolomite hosting 5 to 20 volume per cent of stromatoporoids, corals and brachiopods in a grainstone to packstone matrix. The rock has been strongly leached to give a fossil moldic porosity. Identifiable fossils are sparse and poorly preserved because of recrystallization. Molds suggestive of *Stringocephalus* sp. cf. *S. glaphyrus* were noted on Mission Island at or near the base of the member. *Stringocephalus chasmognathus* has been collected from a higher stratigraphic level near the top of the member, from the middle island of the Burnt Islands Group, which suggests a correlation with the upper reefal part of the Methy Formation of northeastern Alberta and northwestern Saskatchewan. Both stringocephalids indicate a Givetian age.

The outcrop belt of the Bituminous limestone member occurs along the south shore of Great Slave Lake from 2.2 km west of Isle du Mort to 1.1 km east of Dawson Landing wharf, and on Green and McKay islands, 3.2 km offshore. In the type drillhole (Cominco G-4), near Sulphur Point, the member is 35 m thick, and overlies the Fine-grained dolostone member, and is overlain by the Buffalo River Member. It consists of richly fossiliferous, dark grey, highly bituminous, and argillaceoous limestone, with interbeds of medium to dark brown, micritic, nodular limestone, and medium to dark brown, irregularly thin bedded, fine grained, petroliferous limestone.

This is the most richly fossiliferous rock unit in the Great Slave Lake area. Brachiopods from the Bituminous limestone comprise: *Barroisella*? *minuta*, *Schizophoria mcfarlanei*, *Cymostrophia*? sp., *Floweria*? sp., *Rhyssochonetes aurora medialis* n. subsp., *Productella verecunda*, *Devonoproductus primus*, *Anatrypa* (*Variatrypa*) *exoleta*, *Spinatrypa* sp. A, *Spinatrypina* sp. A, *Leptathyrus obsolescens*, *Emanuella caldwelli* n. sp., *Emanuella meristoides*, *Emanuella sublineata*, *Echinocoelia* sp., *Cyrtina* sp., *Warrenella parafranklinii* n. sp., *Warrenella plicata*, *Warrenella posteruskirki* n. sp., *Warrenella whittakeri* n. sp., and *Cryptonella*? sp. These brachiopods occur within an interval spanning the upper part of the conodont *ensensis* Zone, through the Lower *varcus*, lower part of the Middle *varcus* and into the upper part of the Middle *varcus* subzones, of early to middle Givetian age.

Some of the more useful associated fossils include the following thin-shelled tentaculitids: *Nowakia otomari*, *Striatostyliolina roemeri* and *Styliolina fissurella*. *S. otomari* occurs typically in the Kačák Shales of Czechoslovakia where this rock unit forms the base of the Givetian. In the Kačák Shales it is always associated with *S. roemeri* and *S. fissurella*.

Corals from the Bituminous limestone member, identified by A.E.H. Pedder, comprise the tabulate genera *Thamnopora* (2 species), and rare *Favosites* and *Alveolites*. The Rugosa are all solitary forms and are assignable to six genera: *Digonophyllum*, *Lekanophyllum*, *Tabulophyllum*, *Moravophyllum* and *Chostophyllum* (2 species). This fauna is younger than the faunas from the Hume and Nahanni formations, and older than the faunas from the Ramparts and Sulphur Point formations. The age is early to middle Givetian.

The rhynchonellid brachiopods from the Bituminous limestone member will be described at a later date by P. Sartenaer. However, the following forms from the member have been described in previous literature and are important as guide fossils. They include: *Eliorhynchus castanea*,

Stenoglossaiorhynchus awokanak, and *Droharhynchia intermissa*. *E. castanea* and *D. intermissa* in the member range from the upper part of the conodont *ensensis* Zone, where they are most abundant, through the Lower *varcus* Subzone, and into the lower part of the Middle *varcus* Subzone, where they are scarce. *S. awokanak* in the member ranges from the upper part of the *ensensis* Zone, through the Lower *varcus* and lower part of the Middle *varcus* subzones, into the lower part of the upper Middle *varcus* Subzone. It is more abundant and its range is longer than the other two forms.

The Buffalo River Member of the upper Pine Point Formation is known only from the subsurface. It forms a northward thickening wedge of grey-green calcareous shales with some interbedded limestone, and reaches a thickness of 56.5 m in the Cominco G-4 drillhole. The member is barren of macrofossils, but contains conodonts of the Middle *varcus* Subzone, of mid-Givetian age.

The Sulphur Point Formation conformably overlies shale of the Buffalo River Member of the Pine Point Formation, and is unconformably overlain by shale and carbonate of the Watt Mountain Formation. It consists of two rock units, a lower fossiliferous reefal limestone (Windy Point Formation of some authors), and an upper unit of limestone with green shale partings. The lower reefal unit is represented by large blocks of fossiliferous limestone along the east shore of Presqu'ile Point where the following fossils have been collected: *Disphyllum* sp. cf. *D. hsanghsiense*, *Gypidula*? *presquilensis* n. sp., *Spinatrypa* sp. A, *Elita*? sp., *Stringocephalus* sp. B, *Hypothyridina cameroni*, and *Cyrtina* sp. As is common with reefal carbonates, no conodonts were recovered from this rock unit. *Stringocephalus* sp. B marks the third and highest level of stringocephalids in the Great Slave Lake area. The *Elita*? sp. is closely similar to *Elytha subundifera* of Wisconsin and Iowa where it is within the lower part of the Givetian *hermanni* Zone. Most of the remaining fossils are common in the upper reefal part of the Ramparts Formation of the Mackenzie Valley area.

In northern Alberta and southern District of Mackenzie, the Watt Mountain Formation disconformably overlies carbonates of the Sulphur Point Formation or evaporites of the Muskeg Formation and is overlain disconformably by evaporites of the Fort Vermilion or carbonates of the Slave Point formations. In the type drillhole (California Standard Steen River 2-22) in northern Alberta the formation is 12.5 m thick, and consists of: (1) a lower shale and limestone rubble member; (2) a middle shale member; and (3) an upper interbedded shale and limestone member. The lithology of the formation in the Pine Point area consists of cream to buff and light grey to light green, micritic limestone, altered, in part, to a fine dense dolomite. Scattered throughout the formation are thin, discontinuous layers of waxy, light green shale or clay. The Watt Mountain Formation is characterized by a paucity of marine fossils. Two species of charophyte oogonia of green algae, *Eochara wickendeni* and *Chovanella burgessi*, are concentrated in some green shale beds, and indicate a brackish environment. *Amphipora* sp. appears in a bed at the top of the formation and is used as a local marker, and indicates a return to marine conditions. Ostracodes of late Givetian (late Midde Devonian) age have been reported from the formation. Conodonts of the *Icriodus subterminus* Fauna have been reported from the upper part of the formation, and also indicate a late Givetian age.

In the Pine Point area, the Slave Point Formation disconformably overlies restricted marine carbonates of the Watt Mountain Formation, and is disconformably overlain by shales of the Hay River Formation. In the Amco Test No. 14 drillhole, located 11.2 km west of Buffalo River, the thickness of the formation is 61.6 m. The Slave Pont Formation has been subdivided into four facies or members as follows, in ascending order: Facies M (Amco Member), Facies N (Tidal flat member), Facies O (Shallow platform member), and Facies P (Deep platform member). The Amco Member consists mainly of grey to bluish-grey calcareous, burrow-mottled shale, in part dolomitic, which contains some disseminated iron sulphides. The bottom and top of the Amco Member are marked by thin limestone beds which are locally altered to dolomite. The thickness of the member rarely exceeds 9.1 m. The Amco Member is a distinctive marker, but is not recognized beyond the Pine Point Mines area. The Tidal flat member consists of buff-grey micritic limestone which is in

places altered to a finely crystalline dolomite where it is associated with minor nodular anhydrite. It varies in thickness from 10.7 to 18.3 m. The Shallow platform member is a buff-brown limestone of sandy micrite and micritic sand, with shaly wisps and black shale laminae. The member is preserved west of Buffalo River where it is 24.4 m thick. The Deep platform member is lithologically very similar to the Shallow platform member, but differs in that *Amphipora* disappear, and are replaced by crinoids. It varies in thickness from 6.1 to 12.2 m.

Brachiopods from the Slave Point Formation are sparse and restricted, and are referred to as the *Emanuella vernilis–Desquamatia* cf. *independensis* Fauna, after the main fossils from beds of the formation at Gypsum Cliffs, Peace River, Alberta. Associated conodonts have been assigned to the *Icriodus subterminus* Fauna which correlates with some part of the late Givetian *disparilis* Zone. Conodonts of the *subterminus* Fauna are recognized in the basal beds of the Amco Member, and probably also in the underlying Watt Mountain Formation. The tetracoral, *Grypophyllum mackenziense,* is a widespread marker for the upper and part of the lower? conodont *disparilis* interval.

The Hay River Formation is currently defined as the shale and some limestone beds disconformably overlying the Slave Point Formation and underlying the Twin Falls Formation of the Grumbler Group. The type section for the higher beds is in outcrops along Hay River, and for the lower beds it is a drillhole near the mouth of Hay River. Its thickness in the Hay River area is about 435 m. The lithology for the lower part of the formation (Waterways equivalent) consists of greyish green fissile shale with thin interbeds of argillaceous and silty fossiliferous limestone. The upper part of the formation (Fort Simpson equivalent) consists mainly of greyish green fissile shale, with interbeds of calcareous shale, argillaceous limestone, and fossiliferous limestone.

On the northwest side of Great Slave Lake, about 3.2 km north-northwest of Sulphur Bay, where 3.2 m of the basal Hay River are exposed, the beds consist of richly fossiliferous, dark grey, argillaceous limestone, interbedded with medium brown, thick bedded dolomite. In the subsurface to the west these beds grade upward and westward to shale. Some of the more important fossils from this outcrop include: *Lingula* sp. cf. *L. spatulata*, *Tecnocyrtina* sp. cf. *T. billingsi*, *Radiatrypa* sp. cf. *R. clarkei*, *Independatrypa* sp. cf. *I. independensis*, and *Ladogioides pax*. These brachiopods are within the *Tecnocyrtina billingsi* Zone, and indicate a correlation with the Firebag and Peace Point members of the Waterways Formation of northeastern Alberta. Conodonts in the Firebag and Peace Point members are within the latest Givetian *norrisi* Zone.

Sommaire

Dans le présent rapport, sont décrits et illustrés des brachiopodes du Dévonien moyen provenant du membre de Calcaire bitumineux à riche faune fossile de la Formation de Pine Point, ainsi que de la Formation de Sulphur Point, deux unités qui sétendent sur le flanc nord du complexe de barrière carbonaté de Pine Point, sur la rive sud du Grand lac des Esclaves. Dans l'étude d'accompagnement du présent rapport, sont étudiés les conodontes de la succession du Dévonien moyen.

Les unités lithologiques du Dévonien qui affleurent le long et immédiatement à l'ouest de la rivière Slave, dans le nord de l'Alberta et le sud du district de Mackenzie, incluent par ordre ascendant : les formations de La Loche, de Fitzgerald (Ernestina Lake) et de Cold Lake (Equivalent); les membres d'Évaporite, de Hay Camp et de Dolomie de la Formation de Chinchaga; les membres de La Butte, de Calcaire et de Dolomie de la Formation de Keg River et celle qui lui est corrélative, la Formation de Methy dans le nord-est de l'Alberta.

Les unités lithologiques du Dévonien occupant un niveau stratigraphique plus élevé qui affleurent le long de la rive sud du Grand lac des Esclaves et dans les îles au large de la côte, entre Fort Resolution, à l'est, et la rivière Hay, à l'ouest, comprennent les suivantes : les membres de Dolomie à grain fin, de Calcaire bitumineux et de Buffalo River de la Formation de Pine Point, ainsi que les formations de Sulphur Point, de Watt Mountain, de Slave Point et de Hay River.

La Formation de La Loche est l'unité lithologique basale du Phanérozoque. Elle se compose de grès, de conglomérats et de débris de roches ignées météorisées qui reposent sur des roches ignées non altérées du Précambrien et elle est surmontée de la dolomie de la Formation de Fitzgerald (Ernestina Lake). Elle affleure dans des dépressions formées dans le socle précambrien le long des rives et dans quelques îles de la rivière Slave où son épaisseur varie de 2 à 5,7 m. Elle n'est pas fossilifère et son âge n'a pas été déterminé.

La Formation de Fitzgerald se compose de calcaires dolomitiques et de dolomies affleurant le long de la rivière Slave; elle surmonte la Formation de La Loche et est recouverte des évaporites du Groupe d'Elk Point. Son épaisseur varie entre 1,07 et 8,05 m. La Formation de Fitzgerald, dans sa bande d'affleurement, peut être mise en corrélation avec la Formation d'Ernestina Lake, qui gît dans la subsurface de la région à l'ouest de la rivière Slave.

Dans la partie supérieure de la Formation de Fitzgerald, les principaux fossiles présents incluent le corail colonial *Planetophyllum planetum*, ainsi que les mégafossiles et microfossiles associés. Dans la partie supérieure de la même formation, on a identifié une faune d'ostracodes à *Welleria meadowlakensis,* qui témoigne d'un milieu à circulation restreinte. Ce sont les deux taxons mentionnés ci-dessus qui permettent d'établir une corrélation entre les formations de Fitzgerald et d'Ernestina Lake. Dans la Formation de Fitzgerald, le meilleur fossile stratigraphique est l'ostracode géant *Moellerita canadensis* qui indique un âge remontant à la fin du Dévonien précoce (Emsien), âge qui a été établi d'après l'extension stratigraphique de ce fossile dans les coupes du Yukon et de l'archipel arctique.

Dans le rentrant de Bede (nord de l'Alberta), une séquence de halite, la Formation de Cold Lake, surmonte la Formation de Fitzgerald (Ernestina Lake) et est recouverte de la Formation de Chinchaga. La présence de halite dans la subsurface de la région à l'ouest de la rivière Slave est déduite de l'existence de sources salées le long de la base de l'escarpement situé près de la rivière Salt. Dans la subsurface de la région au sud du Grand lac des Esclaves, la Formation de Cold Lake est représentée par environ 15 m de brèches de mudstone rouge, une unité appelée «Équivalent de Cold Lake».

Dans les affleurements situés le long et à l'ouest de la rivière Slave, du gypse attribué à la Formation de Chinchaga repose sur la halite de la Formation de Cold Lake ou les couches rouges bréchiques de l'Equivalent de Cold Lake et est surmonté des roches carbonatées bréchiques du Membre de Hay Camp. Une coupe de la Formation de Chinchaga, le long de la Petite rivière Buffalo, a été subdivisée en trois membres. Le membre inférieur (38,3 m d'épaisseur) se compose de gypse tendre blanc et gris contenant du silt et de l'argile. Près du sommet de ce membre s'étend une mince unité (1,8 m d'épaisseur) de dolomie poreuse finement grenue contenant des brachiopodes épars. Ils sont suggestifs de *Spinatrypa andersonensis* et *Carinatrypa dysmorphostrota* que l'on trouve habituellement dans la partie supérieure de la Formation de Hume de l'Eifélien. La Zone à *C. dysmorphostrota* est contenue à l'intérieur de la Zone de conodontes à *kochelianus* de l'Eifélien tardif. Le Membre d'Ebbut (environ 12,2 m d'épaisseur), qui occupe une position intermédiaire, se compose de gypse gris clair dans lequel sont intercalées des couches et des lamines de shale gris clair et des fragments bréchiques de shale vert. Le membre supérieur a 13,7 m d'épaisseur et se compose de gypse laminé blanc et gris foncé à noir.

Le Membre de Hay Camp est une unité de roches carbonatées partiellement bréchifiées qui affleure le long des rivières Slave et Salt, où il surmonte le gypse de la Formation de Chinchaga et est recouvert en discordance des roches carbonatées de la Formation de Keg River et de roches équivalentes. Dans le présent rapport et dans quelques-uns de ceux publiés précédemment, cette unité lithologique est considérée être le membre sommital de la Formation de Chinchaga. À son stratotype sur la rivière Slave, le membre mesure 6,1 m d'épaisseur et se compose d'une brèche constituée de fragments grossiers de dolomie gypsifère, de calcaire fissile et de shale calcareux qui baignent dans une matrice composée des mêmes types de roches se présentant en fragments plus fins. Les fossiles identifiés dans le stratotype incluent notamment *Desquamatia aperanta* et *Emanuella* sp. cf. *E. meristoides* qui indiquent un âge eifélien.

La Formation de Keg River, dans sa région type du nord de l'Alberta, se compose de dolomies ou de calcaires. Elle repose sur les évaporites et les roches carbonatées de la Formation de Chingaga et est surmontée d'anhydrite, de dolomie et d'un peu de calcaire attribués à la Formation de Muskeg. Dans le sondage dans lequel a été défini le stratotype, la Formation de Keg River a une épaisseur de 80,8 m. Dans le sous-bassin de Rainbow, elle a été subdivisée en trois membres, à savoir les membres de Keg River inférieur et supérieur et, entre les deux, le membre de Rainbow, qui est constitué d'un faciès récifal. Cette désignation a été étendue par certains chercheurs aux roches carbonatées formant l'escarpement situé à l'ouest de la rivière Slave et aux roches formant la partie inférieure de la Formation de Pine Point dans la région du Grand lac des Esclaves. La Formation de Keg River est à peu près équivalente à la Formation de Methy de la région de la rivière Clearwater dans le nord-est de l'Alberta et le nord-ouest de la Saskatchewan, à la Formation de La Butte exposée le long de la rivière Slave au nord du lac Athabasca, ainsi qu'à la partie supérieure de la Formation de Little Buffalo affleurant le long de la rivière qui entaille l'escarpement à l'ouest de la rivière Slave. Afin de ne pas entraîner de confusion dans la nomenclature stratigraphique, tous ces noms locaux devraient être utilisés.

Parmi les fossiles les plus importants qui ont été récoltés dans les dolomies calcareuses finement stratifiées formant le membre inférieur de la Formation de Methy, mentionnons : *Variatrypa arctica, Desquamatia perfimbriata, Spinatrypa andersonensis* et *Emanuella sublineata*. La présence du fossile caractéristique *V. arctica* incite à le corréler ce membre avec la Formation d'Elm Point au Manitoba; à la partie inférieure de la Formation de Pine Point (équivalent du membre inférieur de Keg River) de la région du Grand lac des Esclaves; à la Formation de Murray Island dans les basses terres de la baie d'Hudson; et à la mince partie inférieure de la Formation de Rogers City au Michigan. Le membre supérieur de la Formation de Methy, composé de dolomie récifale disposée en couches épaisses, est semblable par la lithologie et la faune à la Formation de Winnipegosis au Manitoba. Les fossiles qu'ils partagent sont : *Sphaerospongia tessellata*, une forme plate et mince de *Stringocephalus* sp., *Schizophoria manitobensis, Mastigospira alata*, etc.

Le long de la rivière Slave, le Membre de La Butte de la Formation de Keg River se compose de calcaire et d'un peu de shale carboné. Il repose en discordance sur des calcaires et des calcaires dolomitiques bréchifiques du Membre de Hay Camp de la Formation de Chinchaga. Le contact supérieur avec les évaporites de la Formation de Muskeg n'affleure pas. Le Membre de La Butte apparaît comme une séquence condensée de la Formation de Keg River, dont le sommet pourrait être tronqué. Quelques-uns des fossiles les plus importants de la riche faune identifiée sont : *Variatrypa arctica, Desquamatia* sp. cf. *D. aperanta, Emanuella meristoides* et *Lobobactrites* sp. cf. *L. ellipticus*. Dans la région du fleuve Mackenzie, *V. arctica* apparaît habituellement dans des couches argileuses assurant la transition entre la partie supérieure de la Formation de Hume et la partie inférieure de la Formation de Hare Indian. Ce taxon a donné son nom à la Zone à *V. arctica* du Dévonien moyen qui chevauche la limite Eifélien-Givétien.

Le membre de Calcaire et dolomie de la Formation de Keg River est l'unité lithologique résistante qui coiffe la partie supérieure de l'escarpement formant les chutes sur la Petite rivière Buffalo, à l'ouest de la rivière Slave, là où affleure une coupe d'environ 12,2 m. Ce membre repose, probablement en discordance, sur le membre de Dolomie de la Formation de Chinchaga et est surmonté des évaporites de la Formation de Muskeg. Les fossiles des parties calcaires de la coupe incluent : *Variatrypa* sp. cf. *V. arctica Desquamatia* sp. cf. *D. perfimbriata, Emanuella miristoides* et *Mastigospira* sp.

Dans la région de Pine Point, la Formation de Keg River est une unité relativement homogène formée de dolomie gris-brun, ainsi que de quelques couches de calcaire à la base, et elle montre une épaisseur constante de 65 m. Elle repose sur les évaporites de la Formation de Chinchaga et est surmontée de divers faciès carbonatés de barrière de la Formation de Pine Point et, en partie, par des évaporites et des dolomies de la Formation de Muskeg. Trois couches de shale ou de dolomie argileuse, appelé repères du shale E, sont présentes, de façon cohérente, entre 3 et 6 m au-dessous du sommet de l'unité lithologique. Les fossiles provenant d'un membre de calcaire affleurant à Fort Resolution, initialement défini comme la partie basale de la Formation de Pine Point, recèlent

notamment : *Nowakia* sp., *Variatrypa* sp. cf ***V. arctica***, ***Emanuella*** sp. cf. *E. Sublineata, Cyrtina* sp., etc. Ce sont des fossiles représentatifs de la Zone à *Variatrypa arctica* qui sétend de la partie supérieure de la Zone de conodontes *à kockelianus* à la Zone à *ensensis* de l'Eifélien tardif-Givétien précoce.

Une petite partie du membre de Dolomie à grain fin de la Formation de Pine Point est représentée le long de la rive sud du Grand lac des Esclaves, à l'est de Dawson Landing, et dans les îles au large des rives du lac où il repose sur la Formation de Keg River et est surmonté du membre de Calcaire bitumineux de la Formation de Pine Point. Les géologues de Pine Point l'appellent Membre spongieux B (B spongy Member). D'une épaisseur d'environ 18 m, il se compose de dolomie argileuse dont 5 à 20 % du volume est formé de stromatoporodés, de coraux et de brachiopodes contenus dans une matrice à texture de grainstone-packstone. La roche a été fortement lessivée, ce qui a produit une porosité de moulages de fossiles. Les fossiles identifiables sont disséminés et mal conservés à cause d'une recristallisation de la roche encaissante. Dans l'île Mission, à la base du membre ou près de celui-ci, des moulages semblent être attribuables à *Stringocephalus* sp. cf. *S. glaphyrus. Stringocephalus chasmognathus* a été récolté à un niveau stratigraphique plus élevé, près du sommet du membre, dans l'île intermédiaire du groupe d'îles Burnt, ce qui incite à proposer une corrélation avec la partie récifale supérieure de la Formation de Methy dans le nord-est de l'Alberta et le nord-ouest de la Saskatchewan. Les deux stringocéphalidés indiquent un âge givétien.

La bande d'affleurement du membre de Calcaire bitumineux le long de la rive sud du Grand lac des Esclaves s'étend d'un point situé à 2,2 km à l'ouest de l'Isle du Mort à un autre situé à 1,1 km à l'est du quai de Dawson Landing, et occupe les îles Green et McKay, à 3,2 km au large de la rive. Dans le sondage type (Cominco G-4), près de la pointe Sulphur, le membre montre une épaisseur de 35 m; il surmonte le membre de Dolomie à grain fin et est recouvert du Membre de Buffalo River. Il se compose de calcaire argileux et très bitumineux de couleur gris foncé et à riche faune fossile, dans lequel sont intercalées des couches de calcaire noduleux à texture micritique de couleur brun moyen à foncé et de calcaire pétrolifère à grain fin de couleur brun moyen à foncé disposé en fines couches irrégulières.

Il s'agit de l'unité lithologique la plus fossilifère de la région du Grand lac des Esclaves. Le membre de Calcaire bitumineux renferme, entre autres, les brachiopodes suivants : *Barroisella? minuta, Schizophoria macfarlanei, Cymostrophia?* sp., *Floweria?* sp., *Rhyssochonetes aurora medialis* n. subsp., *Productella verecunda, Devonoproductus primus, Anatrypa (Variatrypa) exoleta, Spinatrypa* sp. A, *Spinatrypina* sp. A, *Leptathyrus obsolescens, Emanuella caldwelli* n. sp., *Emanuella meristoides, Emanuella sublineata, Echinocoelia* sp., *Cyrtina* sp., *Warrenella parafranklinii* n. sp., *Warrenella plicata, Warrenella posteruskirki* n. sp., *Warrenella whittakeri* n. sp. et *Cryptonella?* sp. Ces brachiopodes occupent un intervalle allant de la partie supérieure de la Zone de conodontes à *ensensis* à la partie supérieure de la Sous-zone à *varcus* intermédiaire en passant par la Sous-zone à *varcus* inférieure et la partie inférieure de la Sous-zone à *varcus* intermédiaire, du Givétien précoce à moyen.

Quelques-uns des fossiles associés les plus utiles incluent les tentaculitidés à coquille mince suivants : *Nowakia otomari, Striatostyliolina roemeri* et *Styliolina fissurella. S. otomari* est présent de manière caractéristique dans les Shales de Kačák en Tchécoslovaquie où cette unité lithologique forme la base du Givétien. Dans les Shales de Kačák, ce fossile est toujours associé à *S. roemeri* et *S. fissurella.*

Les coraux du membre de Calcaire bitumineux, identifiés par A.E.H. Pedder, comprennent les genres de tabulés *Thamnopora* (2 espèces) et plus rarement, *Favosites* et *Alveolites*. Les rugueux sont tous des formes solitaires, attribuées à six genres : *Digonophyllum, Lekanophyllum, Tabulophyllum, Moravophyllum* et *Chostophyllum* (2 espèces). Cette faune est plus récente que les faunes des formations de Hume et de Nahanni et plus ancienne que les faunes des formations de Ramparts et de Sulphur Point. Leur âge se situe au Givétien précoce-moyen.

Les brachiopodes rhynchonellidés du membre de Calcaire bitumineux seront décrits à une date ultérieure par P. Sartenaer. Cependant, les formes suivantes provenant du membre ont été décrites dans des documents antérieurs et constituent des fossiles caractéristiques importants. Ce sont : *Eliorhynchus castanea, Stenoglossaiorhynchus awokanak* et *Droharhynchia intermissa.* Dans le membre de Calcaire bitumineux, *E. castanea* et *D. intermissa* sont présents à des niveaux séchelonnant de la partie supérieure de la Zone de conodontes à *ensensis*, où ils abondent, à la Sous-zone à *varcus* inférieure et, enfin, à la partie inférieure de la Sous-zone à *varcus* intermédiaire où ils sont rares. Dans le même membre, *S. awokanak* est présent à des niveaux s'échelonnant de la partie supérieure de la Zone à *ensensis* à la base de la partie supérieure de la Sous-zone à *varcus* intermédiaire, en passant par la Sous-zone à *varcus* inférieure et la partie inférieure de la Sous-zone à *varcus* intermédiaire. Ce fossile est plus abondant que les deux autres formes et son extension stratigraphique est plus longue.

Le Membre de Buffalo River de la partie supérieure de la Formation de Pine Point n'a été identifié que dans la subsurface. Il forme un prisme de shales calcaires gris-vert s'épaississant vers le nord, dans lequel s'intercalent des couches de calcaire, et son épaisseur atteint 56,5 m dans le sondage Cominco G-4. Ce membre ne renferme aucun macrofossile mais contient des conodontes attribués à la Zone à *varcus* intermédiaire du Givétien moyen.

La Formation de Sulphur Point repose en concordance sur les shales du Membre de Buffalo River de la Formation de Pine Point et est surmonté en discordance des shales et des roches carbonatées de la Formation de Watt Mountain. Il se compose de deux unités lithologiques, soit à la base un calcaire récifal fossilifère (la Formation de Windy Point de certains auteurs), que surmonte une unité de calcaire renfermant des passes de shale vert. L'unité récifale inférieure est représentée par de gros blocs de calcaire fossilifère le long de la rive est de la pointe Presqu'ile où l'on a récolté les fossiles suivants : *Disphyllum* sp. cf, *D. hsanghsiense, Gypidula? presquilensis* n. sp., *Spinatrypa* sp. A *Elita?* sp., *Stringocephalus* sp. B, *Hypothyridina cameroni* et *Cyrtina* sp. Comme c'est habituellement le cas pour les faciès carbonatés récifaux, aucun conodonte n'a été récupéré de cette unité lithologique. *Stringocephalus* sp. B marque le troisième et plus haut niveau d'occurrence de stringocéphalidés dans la région du Grand lac des Esclaves. Le taxon *Elita?* sp. est très semblable à *Elytha subundifera* du Wisconsin et de l'Iowa où ce fossile se situe dans la partie inférieure de la Zone à *hermanni* du Givétien. La présence de la plupart des autres fossiles est commune dans la partie récifale supérieure de la Formation de Ramparts, dans la vallée du Mackenzie.

Dans le nord de l'Alberta et le sud du district de Mackenzie, la Formation de Watt Mountain repose en discordance sur les roches carbonatées de la Formation de Sulphur Point ou les évaporites de la Formation de Muskeg. Elle est surmontée en discordance des évaporites de la Formation de Fort Vermilion ou des roches carbonatées de la Formation de Slave Point. Dans le sondage type (California Standard Steen River 2-22) situé dans le nord de l'Alberta, la formation montre une épaisseur de 12,5 m et se compose des membres suivants : 1) un membre inférieur de blocailles de shale et de calcaire; 2) un membre intermédiaire de shale; et 3) un membre supérieur de shale et de calcaire interstratifiés. Dans la région de Pine Point, la formation est caractérisée d'un point de vue lithologique par un calcaire micritique de couleur chamois et gris clair à vert clair, altéré en partie en une dolomie dense à grain fin. Sont disséminées dans toute la formation de minces couches discontinues de shale ou d'argiles cireux de couleur vert clair. La Formation de Watt Mountain est pauvre en fossiles marins. Deux fossiles d'oogonies de charophyte (algue verte), *Eochara wickendeni* et *Chovanella burgessi*, sont concentrés dans quelques couches de shale vert et indiquent un milieu saumâtre. *Amphipora* sp. est présent dans une couche sise au sommet de la formation et sert de marqueur local, indiquant un retour à des conditions marines. Des ostracodes du Givétien tardif (fin du Dévonien moyen) ont été repérés dans la formation. On a relevé la présence de conodontes de la Faune à *Icriodus subterminus* dans la partie supérieure de la formation, ce qui indique également un âge du Givétien tardif.

Dans la région de Pine Point, la Formation de Slave Point repose en disconformité sur des roches carbonatées de milieu marin à circulation restreinte attribuées à la Formation de Watt

Mountain. Elle est surmontée en disconformité des shales de la Formation de Hay River. Dans le sondage Amco Test No. 14, situé à 11,2 km à l'ouest de la rivière Buffalo, l'épaisseur de la formation est de 61,6 m. On a subdivisé la Formation de Slave Point en quatre faciès, ou membres, qui sont, par ordre ascendant : le Faciès M (Membre d'Amco), le Faciès N (le membre d'estran tidal), le Faciès O (le membre de plate-forme en eau peu profonde) et le Faciès P (membre de plate-forme en eau profonde). Le Membre d'Amco se compose principalement de shale calcareux, en partie dolomitique, qui montre une couleur gris bleuâtre, est criblé de terriers et contient un peu de sulfures de fer disséminés. La base et le sommet du Membre d'Amco correspondent à de minces couches de calcaire par endroits altéré en dolomie. L'épaisseur du membre dépasse rarement 9,1 m. Le Membre d'Amco est un repère distinctif dont la présence n'a pas été décelée au-delà de la région des mines Pine Point. Le membre d'estran tidal est un calcaire micritique de couleur chamois-gris qui, par endroits, est altéré en une dolomie cristalline à grain fin là où il est associé à un peu d'anhydrite nodulaire. Il varie en épaisseur de 10,7 à 18,3 m. Le membre de plate-forme en eau peu profonde est un calcaire de couleur chamois-brun composé de micrite gréseuse et de grès micritique renfermant des traînées argileuses et des lamines de shale noir. Le membre a été préservé de l'érosion à l'ouest de la rivière Buffalo où son épaisseur atteint 24,4 m. Le membre de plate-forme en eau profonde a une lithologie très semblable à celle du membre précédent, mais diffère de celui-ci par le fait que *Amphipora* n'y est plus présent et a été remplacé par des crinoïdes. Son épaisseur varie de 6,1 à 12,2 m.

Les brachiopodes de la Formation de Slave Point sont clairsemés et témoignent de milieux à circulation restreinte; on y fait référence en parlant de Faune à *Emanuella vernilis-Desquamatia* cf. *independensis*, d'après les principaux fossiles présents dans les couches de la formation situées aux falaises de gypse le long de la rivière de la Paix en Alberta. Les conodontes associés ont été attribués à la Faune à *Icriodus subterminus* qui peut être mise en corrélation avec une certaine partie de la Zone à *disparilis* du Givétien tardif. Des conodontes de la Faune à *subterminus* ont été identifiés dans les couches basales du Membre d'Amco et, peut-être également, dans la Formation de Watt Mountain sous-jacente. Le tétracoralliaire *Grypophyllum mackenziense* est un fossile repère répandu dans la partie supérieure et une portion de la partie inférieure? de l'intervalle de conodontes à *disparilis*.

Selon la définition courante qui en est faite, la Formation de Hay River regroupe les couches de shale et les quelques couches de calcaire qui reposent en disconformité sur la Formation de Slave Point et qui sont surmontés de la Formation de Twin Falls du Groupe de Grumbler. Le stratotype des couches supérieures est situé dans des affleurements le long de la rivière Hay; celui des couches inférieures se trouve dans un sondage situé près de l'embouchure de la rivière Hay. Dans la région de la rivière Hay, son épaisseur est d'environ 435 m. La lithologie de la partie inférieure de la formation (équivalente de la Formation de Waterways) est un shale fissile vert grisâtre dans lequel sont interstratifiées de minces couches de calcaire argileux et silteux fossilifère. La partie supérieure de la formation (équivalente de la Formation de Fort Simpson) est principalement composée d'un shale fissile vert grisâtre à interstrates de shale calcaire, de calcaire argileux et de calcaire fossilifère.

Sur la rive nord-ouest du Grand lac des Esclaves, à environ 3,2 km au nord-nord-ouest de la baie Sulphur, là où 3,2 m de la base de la Formation de Hay River sont exposés, les couches se composent de calcaire argileux gris foncé à riche faune fossile, interstratifiés de dolomie brun moyen disposée en couches épaisses. Dans la subsurface, à l'ouest, ces couches passent de manière progressive vers le haut et vers l'ouest à des shales. Parmi les fossiles les plus importants de cet affleurement, mentionnons : *Lingula* sp. cf. *L. spatulata, Tecnocyrtina* sp. cf. *T. billingsi, Radiatrypa* sp. cf. *R. clarkei, Independatrypa* sp. cf. *I. independensis* et *Ladogioides pax*. Ces brachiopodes sont contenus dans la Zone à *Tecnocyrtina billingsi* et ils indiquent une corrélation avec les membres de Firebag et de Peace Point de la Formation de Waterways du nord-est de l'Alberta. Les conodontes des membres de Firebag et de Peace Point font partie de la Zone à *norrisi* du Givétien terminal.

INTRODUCTION

Purpose

The main purpose of this report is to describe and illustrate the brachiopods from the richly fossiliferous Bituminous limestone member of the Pine Point Formation and from the Sulphur Point Formation (Windy Point Member), which outcrop along and near the south shore and on the offshore islands west and east of Pine Point on the south side of Great Slave Lake in the southern District of Mackenzie. In a companion study by T.T. Uyeno (in this report), conodonts are recorded from the above units and also from beds of the Keg River Formation that outcrop near Fort Resolution, and from beds of the Chinchaga Formation at Bell Rock on Slave River near Fort Smith.

As a framework for the described brachiopod and conodont faunas, the stratigraphy and biostratigraphy are described of all the Devonian rock units along and west of Slave River, between Lake Athabasca and Fort Smith in northern Alberta and southern District of Mackenzie, and on the south side of Great Slave Lake, on the north flank of the Pine Point carbonate barrier complex between Fort Resolution and Hay River. The Methy Formation, which outcrops along and near Clearwater River in northeasten Alberta and northwestern Saskatchewan is also reviewed. This rock unit is continuous with the subsurface Keg River Formation of northern Alberta, but is much more fossiliferous.

Present work

The south shore and offshore islands of Great Slave Lake were traversed during the months of June and July, 1981, using a 21 ft. canoe propelled by a 10 h.p. outboard motor. An attempt was made to examine all Devonian outcrops on the south side of the lake between Fort Resolution in the east and Buffalo River in the west. The outcrop at Bell Rock on Slave River near Fort Smith was visited by vehicle and measured and sampled. Dr. Paul Sartenaer spent two weeks with the writer working out of a camp at Dawson Landing collecting rhynchonellid brachiopods. Because of the importance of certain fossils previously recorded from Presqu'ile Point, a second visit to that locality was made in June, 1985, in an attempt to collect additional specimens of *Hypothyridina cameroni* Warren (1944) and other fossils.

Previous fieldwork by the writer in the Great Slave Lake area was done in May and June, 1957, as a member of Operation Mackenzie, a helicopter and fixed wing supported operation of the Geological Survey of Canada.

Methods

The Devonian rocks of the Pine Point area are gently folded with an overall strike of 065° and a dip of 2.4 m per km in the 245° direction. The strike is determined from the axis of the folds, and the overall dip from the slope of the top of the E-shales marker near the top of the Keg River Formation, as illustrated by Norris (1965, fig. 7) and Rhodes et al. (1984, fig. 5).

As most of the exposures along the shore and on the offshore islands are generally less than a metre thick, at or close to lake level, irregularly spaced, gently folded, and lack conspicuous marker beds, the accurate piecing together of the scattered sections, and placement of the samples presented a problem. In an attempt to resolve this problem, all station localities were precisely marked on vertical air photographs, and their positions later transferred to topographic maps (Figs. 1, 2). Bedding attitudes were taken and measurements of beds were done using the lake level as a datum. Distances between station localities marking exposures were scaled from the air photographs or the topographic maps. The relationship of any two adjacent sections was determined by plotting the distance separating the sections, thickness of beds and placement of samples in relation to the datum at each section, and using the apparent dip between the two sections. With the gentle deformation of beds it is assumed that the folding is parallel, that is, the thickness of layers is constant. This was done for all the outcrop localities in the Pine Point area to piece together a composite section. As a check on the composite section a comparison was made with the Cominco G-4 drillhole for thickness of rock units and rock types. This drillhole is within the outcrop belt on the south shore of Great Slave Lake, on the north flank of the Pine Point carbonate barrier complex, and is the type section for some of the rock units, including the Bituminous limestone member of the Pine Point Formation.

A duplicate set of samples was collected from each locality, one for macrofossils and lithology, and the other for conodonts. As a further check on the composite section and sequence of samples, the

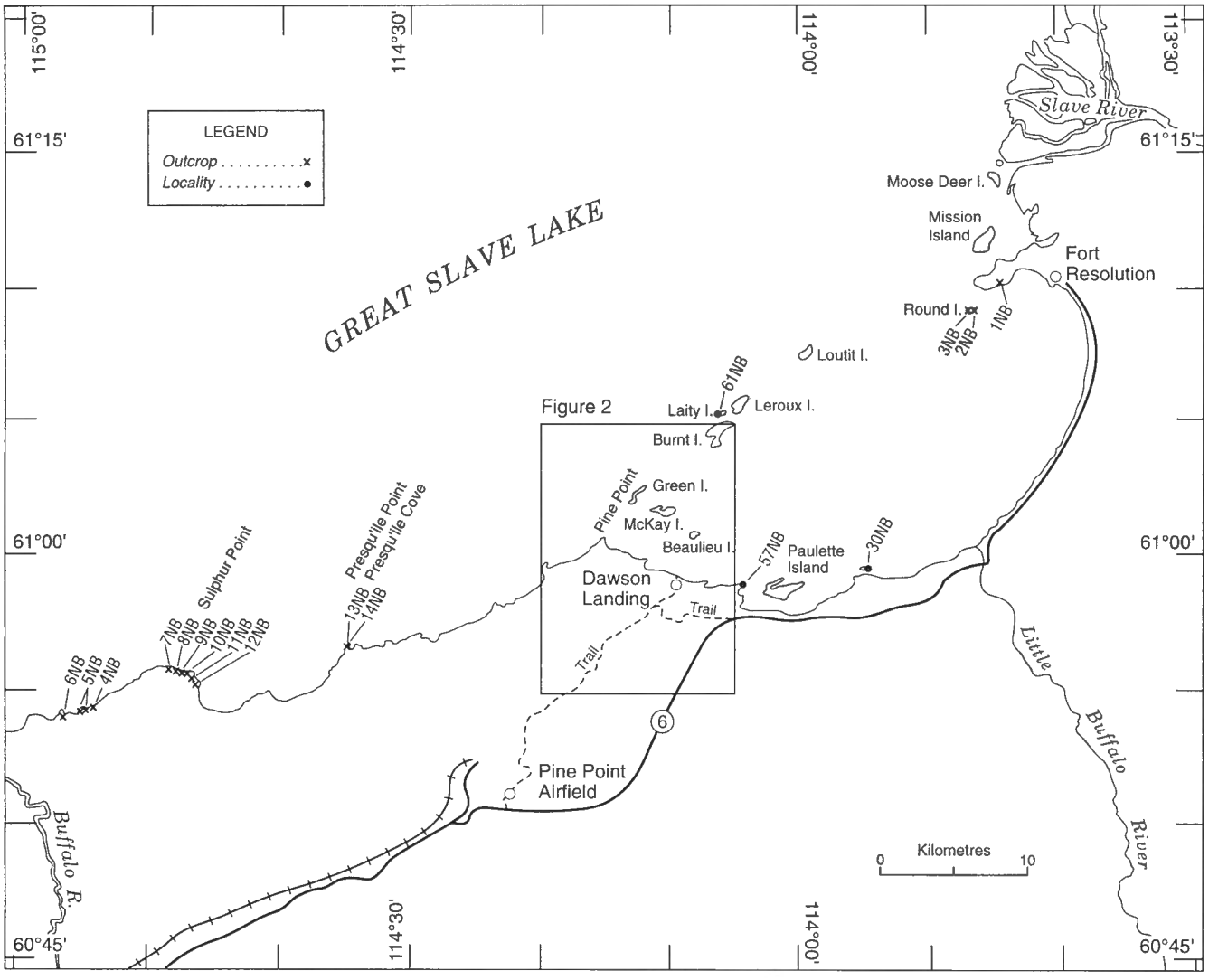

Figure 1. *Sketch map showing station localities along the south shore of Great Slave Lake exclusive of those in the vicinity of Pine Point, which are shown on Figure 2.*

conodonts determined by T.T. Uyeno (Part II of this publication) show the correct sequence of zones and subzones.

Acknowledgments

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The writer is most grateful for the considerable help with the fieldwork provided by D. Gretner in 1981 and R. Gee in 1985.

N.C. Meijer Drees, J. Day and G. Klapper critically reviewed an early version of the manuscript and provided helpful comments for improving the report and are gratefully acknowledged.

STRATIGRAPHY

Introduction

Although this report deals mainly with the faunas of the Bituminous limestone and Fine-grained dolostone members of the Pine Point Formation, and the Windy Point Member of the Sulphur Point Formation,

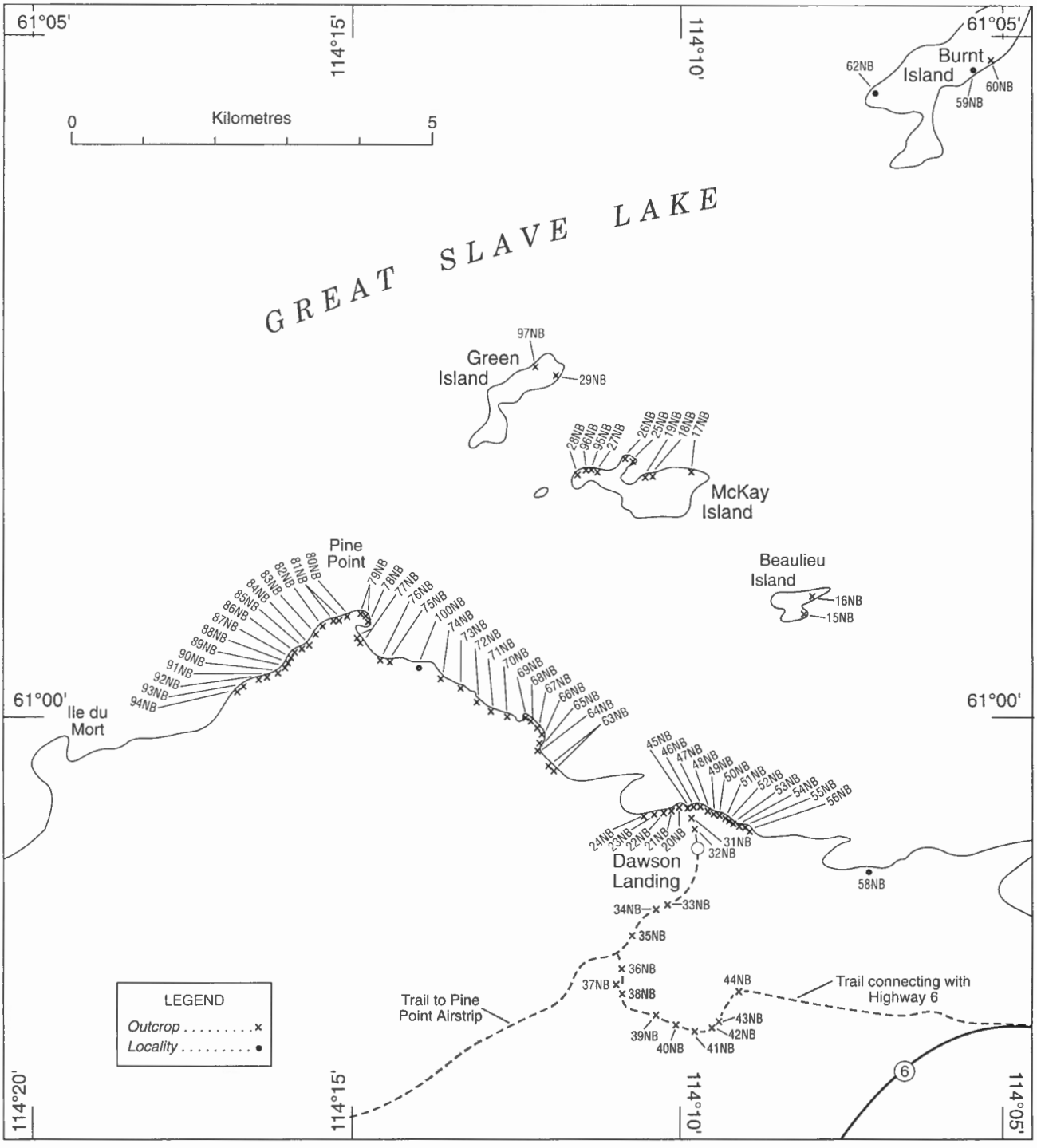
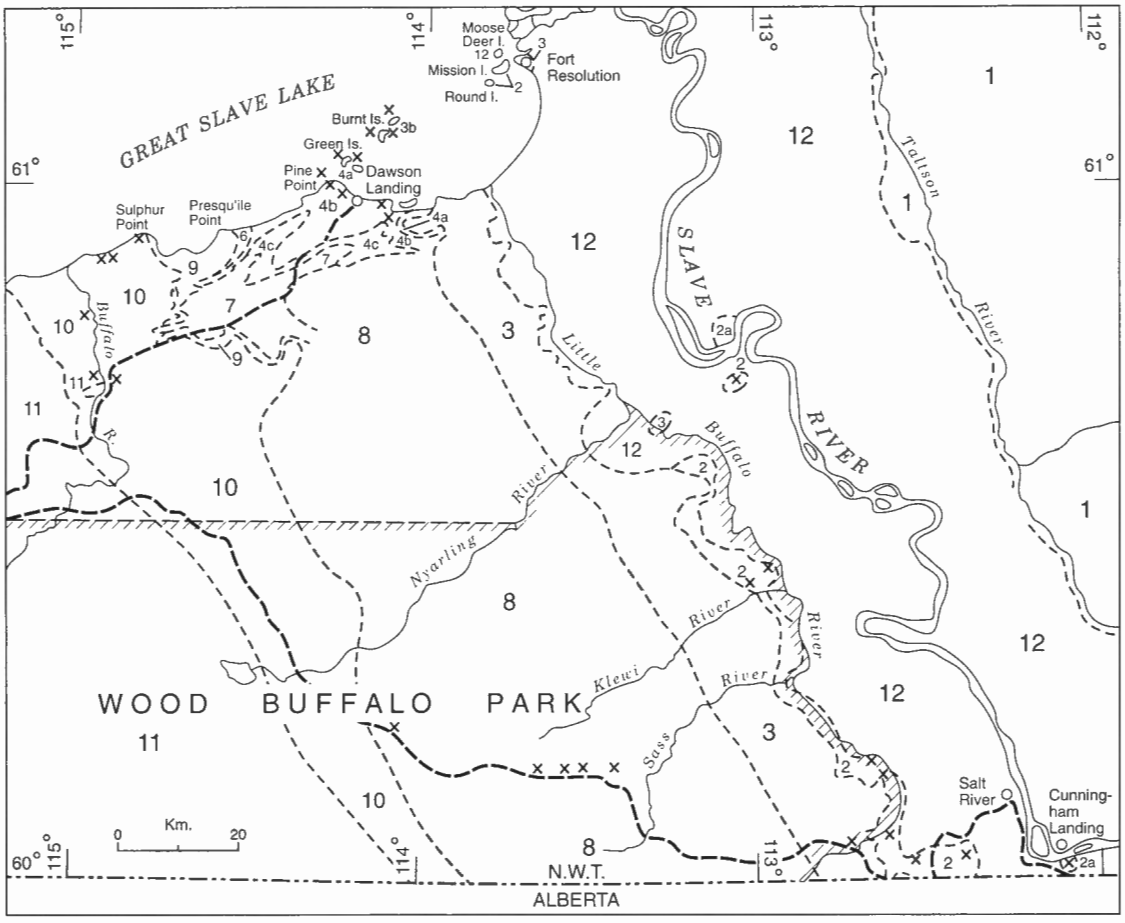


Figure 2. *Enlarged sketch map showing station localities in the Pine Point area on the south side of Great Slave Lake.*

exposed along the south shore and offshore islands in the Pine Point area on the south side of Great Slave Lake (Figs. 3, 4), it includes also the faunas of the Hay Camp Member of the Chinchaga Formation exposed at Bell Rock on Slave River near Fort Smith. For this reason a brief summary is presented here of the Paleozoic (Lower and Middle Devonian) succession exposed along Slave River. The sequence of rocks exposed along the south shore of Great Slave Lake is on the north flank of the carbonate barrier complex in



LEGEND

PLEISTOCENE AND RECENT

12

DEVONIAN

UPPER DEVONIAN

11 *HAY RIVER FORMATION*

MIDDLE DEVONIAN

10 *SLAVE POINT FORMATION*

9 *WATT MOUNTAIN FORMATION*

6 *Windy Point Member* 7 *SULPHUR POINT FM.* 8 *MUSKEG FM.*

PINE POINT FORMATION

5 *Buffalo River Member*

4 4a, *B Spongy member (Fine grained dolostone member);*
4b, *Bituminous limestone member;*
4c, *Clean bioclastic grainstone member*

KEG RIVER FORMATION

3 3, *Undifferentiated;*
3a, *Little Buffalo Member;*
3b, *Fine grained dolostone member*

CHINCHAGA FORMATION

2 2, *Undifferentiated;*
2a, *Hay Camp Member*

PRECAMBRIAN

1 1, *Undifferentiated*

Figure 3. *Geological sketch map of Pine Point and adjacent areas on the south side of Great Slave Lake, District of Mackenzie (after Norris, 1965; Rhodes et al., 1984).*

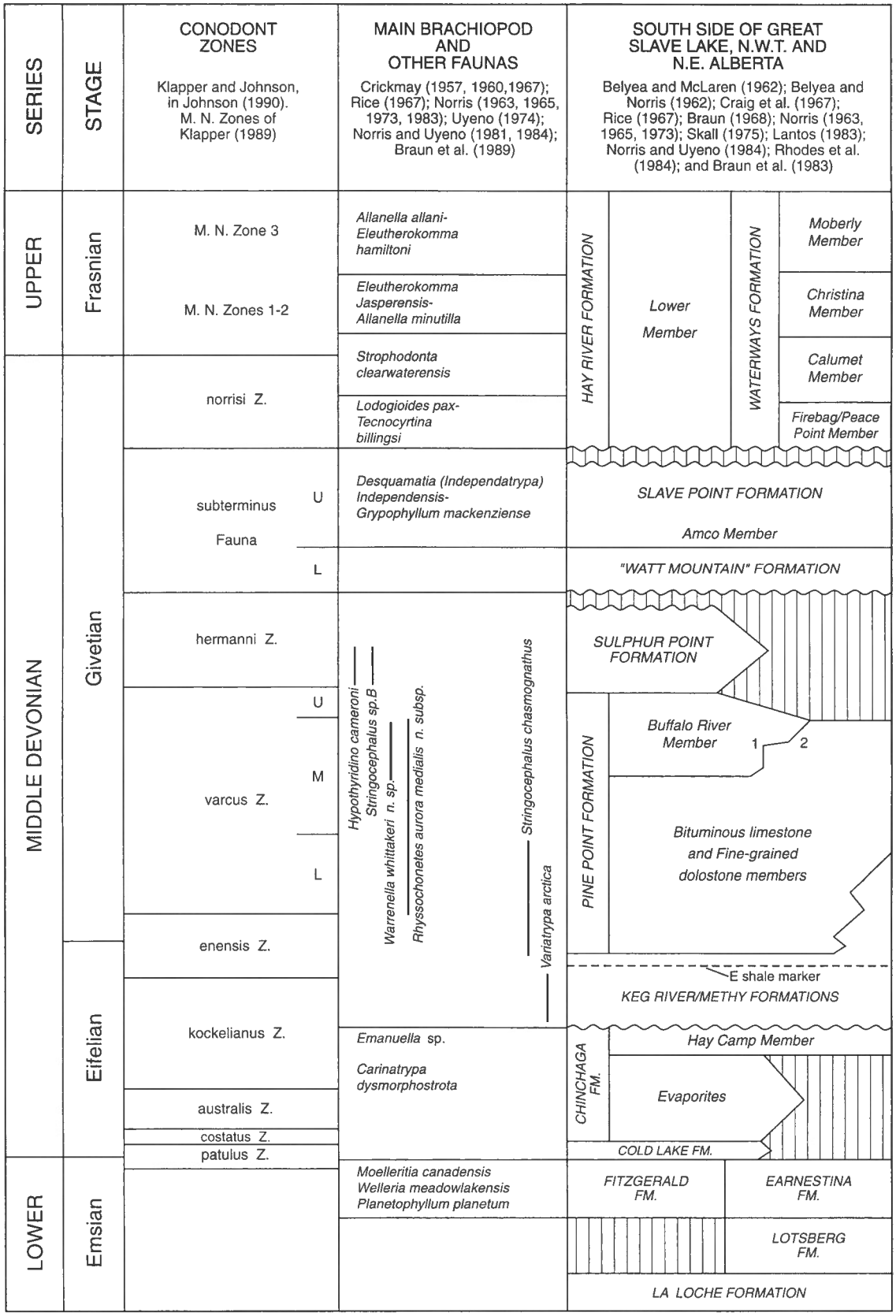


Figure 4. *Devonian rock units, conodont zones and main brachiopod and other faunas on the south side of Great Slave Lake, District of Mackenzie, and along Slave River, northeast Alberta and District of Makenzie. Numbers 1 and 2 mark the conodont occurrences of* ***Polygnathus alveoliposticus*** *and* ***Ozarkodina semialternans****?, repectively.*

the Pine Point Mines area. Strata exposed along Slave River comprises the La Loche, Fitzgerald and Cold Lake formations, and the Hay Camp Member of the Chinchaga Formation. The succession exposed along the south side of Great Slave Lake between Fort Resolution in the east and Buffalo River in the west includes the Hay Camp Member of the Chinchaga Formation, Keg River Formation, Bituminous limestone, Fine-grained dolostone and Buffalo River members of the Pine Point Formation, Windy Point Member of the Sulphur Point Formation, Watt Mountain and Slave Point formations.

La Loche Formation

The name La Loche Formation was introduced by Norris (1963, p. 8, 9) for clastic rocks immediately overlying crystalline rocks of the Canadian Shield along Clearwater River in northeastern Alberta. The name was extended by Norris (1963, p. 45–47) to the Slave River area for sandstone, conglomerate, and weathered igneous detritus overlying unaltered Precambrian igneous rocks and overlain by dolostone of the Fitzgerald Formation. The La Loche Formation is exposed along the banks and on some of the islands of Slave River where the thickness varies from 2 to 5.7 m.

The basal beds of the La Loche Formation consist of a weathered regolith forming a breccia of large angular fragments of igneous rocks grading upwards into finer material. Transitionally overlying the regolith is an alternating succession of lenticular, thin bedded, very coarse grained, arkosic sandstone, conglomeratic sandstone, and some thin beds of sandy mudstone. Near the top of the formation the beds grade to much harder lenticular, thin bedded, fine- to coarse-grained sandy dolostone. The contact with the overlying Fitzgerald Formation is gradational.

No fossils have been found in the La Loche Formation and its age is undetermined.

Fitzgerald Formation

The name Fitzgerald Formation was introduced by Cameron (1918, p. 25). As redefined by Norris (1963, p. 48), the name is applied to the sequence of dolomitic limestones and dolostones exposed along Slave River overlying the La Loche Formation and underlying evaporites of the Elk Point Group. The Fitzgerald is equivalent to the subsurface Ernestina Lake Formation of Sherwin (1962), and the Ostracod Limestone of Van Hees (1958). Rice (1967) correlated the Fitzgerald Formation of the outcrop belt along Slave River with the Ernestina Lake Formation of the subsurface west of Slave River (Fig. 4).

Thicknesses of beds of the Fitzgerald Formation exposed along Slave River, at stations 134NB, 138NB, 146NB, 147NB, 148NB, 150NB, 153NB, 165NB, and 167NB (Fig. 5), vary between 1.07 and 8.05 m.

Representative thicknesses of the formation in the subsurface at a few key drillholes west of Slave River include the following (Rice, 1967, p. 37): Cominco G-4 (60°54′00″N, 114°46′00″W; 13.1 m); Cominco G-1 (60°51′05″N, 114°24′30″W; 11.9 m); Pyramid 202A (60°47′42″N, 114°13′49″W; 12.5 m); and Home et al. Wood Buffalo 14-22 (14-22-110-1W5); 10.1 m).

The lithology of the Fitzgerald Formation is mainly a pale brown, fine grained, granular, commonly vuggy, thin bedded to massive, scarp-forming dolostone and dolomitic limestone, weathering a light orange-brown. A thin bed of carbonaceous dolostone up to 5.1. cm thick is generally present near the base. The beds below the carbonaceous dolostone and above the La Loche Formation consist of sandy and argillaceous dolostones and thin interbeds of gypsum and dolostone with almond-shaped inclusions of gypsum. In the subsurface, a thin unit up to about 6.1 m thick of white to grey-brown, crypto- to microcrystalline anhydrite is commonly developed at the top of the formation (Sherwin, 1962, p. 189; Rice, 1967, p. 38). The lower contact is drawn at the top of the highest sandstone bed of the La Loche Formation.

Biostratigraphy

The two most commonly occurring fossils in the Fitzgerald Formation and equivalent beds are the coral, *Planetophyllum planetum* Crickmay (1960), and the ostracode, *Welleria meadowlakensis* Kesling and Takagi (1961). It is the presence of these fossils in the outcropping Fitzgerald and subsurface Ernestina Lake formations (Rice, 1967, p. 57–61) that has demonstrated beyond a doubt their equivalence. The coral *Planetophyllum planetum* and an associated megafauna and microfauna occur in the lower part of the Fitzgerald Formation, and a restricted fauna of the ostracode *Welleria meadowlakensis* occurs in the upper part of the formation. Unfortunately, these two fossils have not been precisely dated.

A composite list of fossils cited by Norris (1963, p. 48) from the Fitzgerald Formation includes the following:

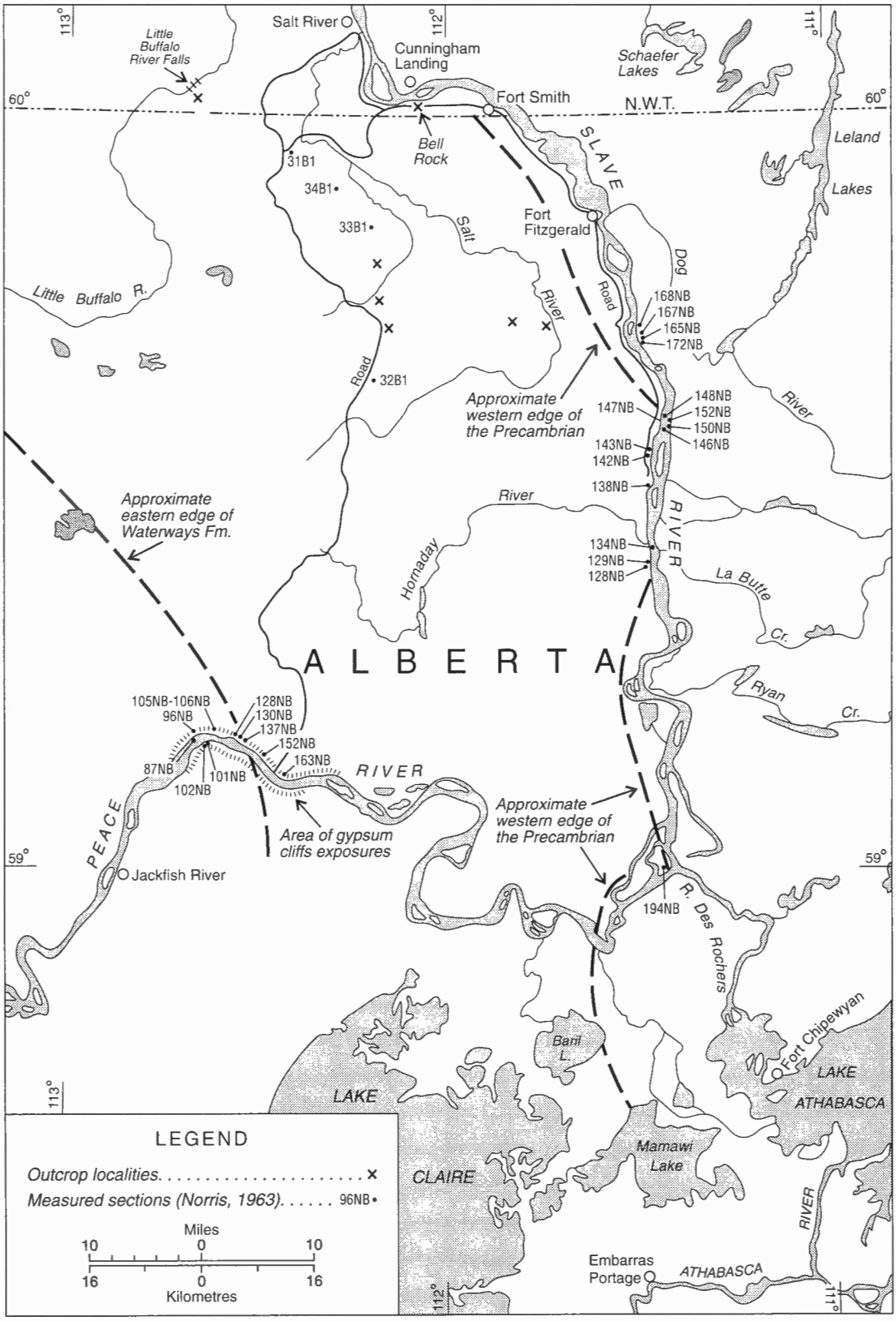


Figure 5. *Location of Devonian exposures along and west of Slave River, northeastern Alberta (from Norris, 1963).*

undet. stromatoporoids, 2 spp.
Amphipora sp.
undet. cup corals
cf. *Michelinoceras* sp.
cf. *Ambocoelia* sp.
cf. *Leperditia* sp.
undet. ostracodes

Norris (1963) pointed out that the presence of *Amphipora* sp. suggested a early or middle Devonian rather than a Silurian age for the Fitzgerald Formation.

Another fossil, perhaps the most diagnostic, and recently collected from outcrops along Slave River by the writer, is the giant ostracode *Moelleritia canadensis* Copeland (1962), which, presumably, was thought to be a pelecypod by some previous workers. The range of this form in the northern Yukon Territory, where it can be correlated with other fossils, is more or less throughout the Emsian Stage of the Lower Devonian (Norris, 1985, fig. 3). This range indicates an Emsian age for the Fitzgerald Formation.

The coral, now identified as *Planetophyllum planetum*, was recorded by Cameron (1922, p. 19) as *Pycnostylus guelphensis* (Whiteaves) which, along with the presence of gypsum, was used to date the Fitzgerald Formation as Silurian. *Pycnostylus guelphensis* was recorded by Cameron (1922, p. 19) also from large loose blocks of limestone on the south shore of the first point (Bloomfield Point) west of Gypsum Point on the northwest side of Great Slave Lake. This location would place the beds, equivalent to the Fitzgerald Formation, in the lowermost part of a rock unit mapped as the Chinchaga Formation by Norris (1965, fig. 9).

Cold Lake Formation

The name Cold Lake Formation was introduced by Sherwin (1962, p. 189–190) to apply to a section of almost pure halite. In the type drillhole at Canadian Seabord Ernestina Lake 10-13 (Lsd. 10, Sec. 13, Twp. 60, Rge. 4W4M) in east-central Alberta, it lies between 982.1 and 1037.9 m and consists of 49.7 m of halite overlying 6.1 m of red calcareous shale.

In the type locality, the formation overlies the Ernestina Lake Formation and is overlain by the Contact Rapids Formation. In the Bede Embayment of northern Alberta, the Cold Lake Formation includes the salt section, which overlies the Fitzgerald Formation and underlies the Chinchaga Formation (Rice, 1967, p. 43) (Fig. 4).

In the subsurface west of Slave River, in northern Alberta, the presence of halite is suggested by a number of salt springs along the base of the escarpment west and south of the forks on Salt River described by Camsell (1917, p. 141). The salt springs served as a source of salt for the natives and early settlers of the area.

In the subsurface on the south side of Great Slave Lake, the Cold Lake Formation is represented by a red mudstone breccia up to 15.5 m thick, which is present in Pyramid 202A, Cominco G-1 and Cominco G-4 drillholes (Rice, 1967, p. 45). The breccia consists of angular fragments of red dolomitic mudstone in a matrix of the same material. In this area the salt and other evaporites presumably have been removed by solution.

Representative thicknesses of the Cold Lake Equivalent south of Great Slave Lake are as follows (Rice, 1967, fig. 4): Pyramid 202A (60°47′42″N, 114°13′49″W; 11.3 m); Cominco G-1 (60°51′05″N, 114°29′30″W; 15.5 m); and Cominco G-4 (60°54′N, 114°56′W; 10.4 m).

In the Bede Embayment west of Slave River in northern Alberta the Cold Lake Formation is unfossiliferous and undated, but by stratigraphic position, it is probably early Middle Devonian (Eifelian) in age (Fig. 4).

Chinchaga Formation

The name Chinchaga Formation was introduced by Law (1955) for a pale coloured unit of anhydrite and anhydritic dolostone widely distributed in northern Alberta, northeastern British Columbia, and in the southern part of the District of Mackenzie. It forms the upper part of the Lower Elk Point Group. In part of northern Alberta it overlies redbeds that are in mappable continuity with the lower part of the Contact Rapids Formation (Sherwin, 1962), and underlies carbonates of the Keg River Formation (Law, 1955). In the subsurface on the south side of Great Slave Lake, and in outcrops along and near Slave River, evaporites of the Chinchaga Formation underlie brecciated carbonate beds of the Hay Camp Formation (Norris, 1963; later redefined as a member, Norris, 1965), and overlie halite of the Cold Lake Formation, or brecciated redbeds of the Cold Lake Equivalent.

Belyea and Norris (1962) and Belyea (1970, 1971) described the Chinchaga Formation in the subsurface and subdivided the formation into two informal members. The Upper member overlies the Lower member with a slight angular unconformity, and includes sandy and shaly beds in the basal part referred to as the Detrital Unit by Rice (1967), and as the Ebbutt Member by Law (1971). Meijer Drees (1993) subdivided the Chinchaga Formation into three parts, a Lower member, a middle Ebbut Member, and an Upper member.

In the type drillhole at California Standard Steen River 2-22 (2-22-117-5W6), in northern Alberta, the Lower member is present between 1725.8 and 1731.2 m; the Ebbutt Member is between 1711.4 and 1725.8 m; and the Upper member occupies the interval between 1668.7 and 1711.4 m.

Immediately south of Great Slave Lake in the Cominco G-4, Cominco G-1, and Pyramid 202A drillholes the thicknesses of the three members in ascending sequence are as follows (see Rice, 1967, fig. 4): 47.4 m, 9.1 m, 39.6 m; 41.8 m, 9.1 m, 39.6 m; and 54 m, 9.1 m, 39.6 m.

In the composite section of the Chinchaga Formation measured by Norris (1963, p. 121–123) on Little Buffalo River, 6.4 km north of the northern boundary of Alberta, and 62.4 km northwest of Fitzgerald, the thicknesses of the three members in ascending sequence are as follows: 33.8 m, about 12.2 m, and 13.7 m.

In the Cominco G-4, Cominco G-1, and Pyramid 202A drillholes, the Lower and Upper members consist of white to light brown, cryptocrystalline anhydrite with interbeds of micro- to medium-grained, light brown anhydritic dolostone. Many of the anhydrite beds are highly deformed and some have angular fragments of mudstone incorporated within them, suggesting flowage of the anhydrite (Rice, 1967). In the middle, Ebbutt Member, the anhydrite is interbedded with thin beds of green calcareous mudstone.

In the section on Little Buffalo River (Norris, 1963, p. 121–123), the Lower member consists of white and grey, soft, powdery gypsum, containing light orange-brown weathering silt and clay. Near the top of the Lower member is a thin unit, about 1.8 m thick, of pale brown, very fine grained, granular, porous, irregularly medium-bedded dolostone containing sparse fossils. The midde, Ebbutt Member, consists of light grey gypsum with dark brownish grey argillaceous laminae and interbeds. Some beds are brecciated, with irregular fragments of green, brittle, hackly fracturing shale. The Upper member consists of laminated white, dark grey to black, even thin to thick-bedded gypsum. The dark impure layers appear to be more resistant.

Along Slave River most of the evaporites of the Chinchaga Formation appear to have been removed by solution (Fig. 6).

Biostratigraphy

Sparse brachiopod fossils collected by Norris (1963, p. 123) from the Chinchaga Formation are from a dolomite unit, 1.8 m thick, between 28.9 and 30.8 m below the top of the evaporites on Little Buffalo River (Fig. 6). They are suggestive of *Spinatrypa andersonensis* (Warren, 1944) and *Carinatrypa dysmorphostrota* (Crickmay, 1960), which occur typically in the upper Hume Formation of the lower Mackenzie River area (Copper, 1978). They indicate an Eifelian age. Megafossils of the *Carinatrypa dysmorphostrota* Zone of Pedder (1975, p. 572), marking the upper quarter of the Hume Formation, are associated with conodonts of the *kockelianus* Zone (Braun et al. (1989) of late Eifelian age (Fig. 4).

Hay Camp Member along Slave River

The name Hay Camp Formation was applied by Norris (1963, p. 49–51) to a partly brecciated carbonate unit exposed along Slave River, which overlies evaporites and is unconformably overlain by a limestone unit named by Norris (1963, p. 51–53) the La Butte Formation. In this and a previous report (Norris, 1965, p. 36–37) the brecciated beds are treated as a member within the uppermost part of the Chinchaga Formation.

At the type section (station 142NB, Fig. 5) on the west bank of Slave River, 1.9 km north of the Hay Camp, and 14.9 km south of Fitzgerald, 6.1 m of beds are exposed. At this section the Hay Camp Member is a breccia of angular, coarse fragments comprising several lithological types, as follows: pale brown, gypsiferous, lithographic dolomite, in part laminated, and weathering pale orange; light grey, fossiliferous, soft, fissile limestone, and light grey, highly calcareous, thin bedded shale. The fragments are in a matrix of finer material of similar lithological types, in which bedding is only vaguely apparent. In some of the sections a black, tar-like bitumen is present in the upper beds. The upper contact with the La Butte Formation is highly irregular with about 0.3 m of relief

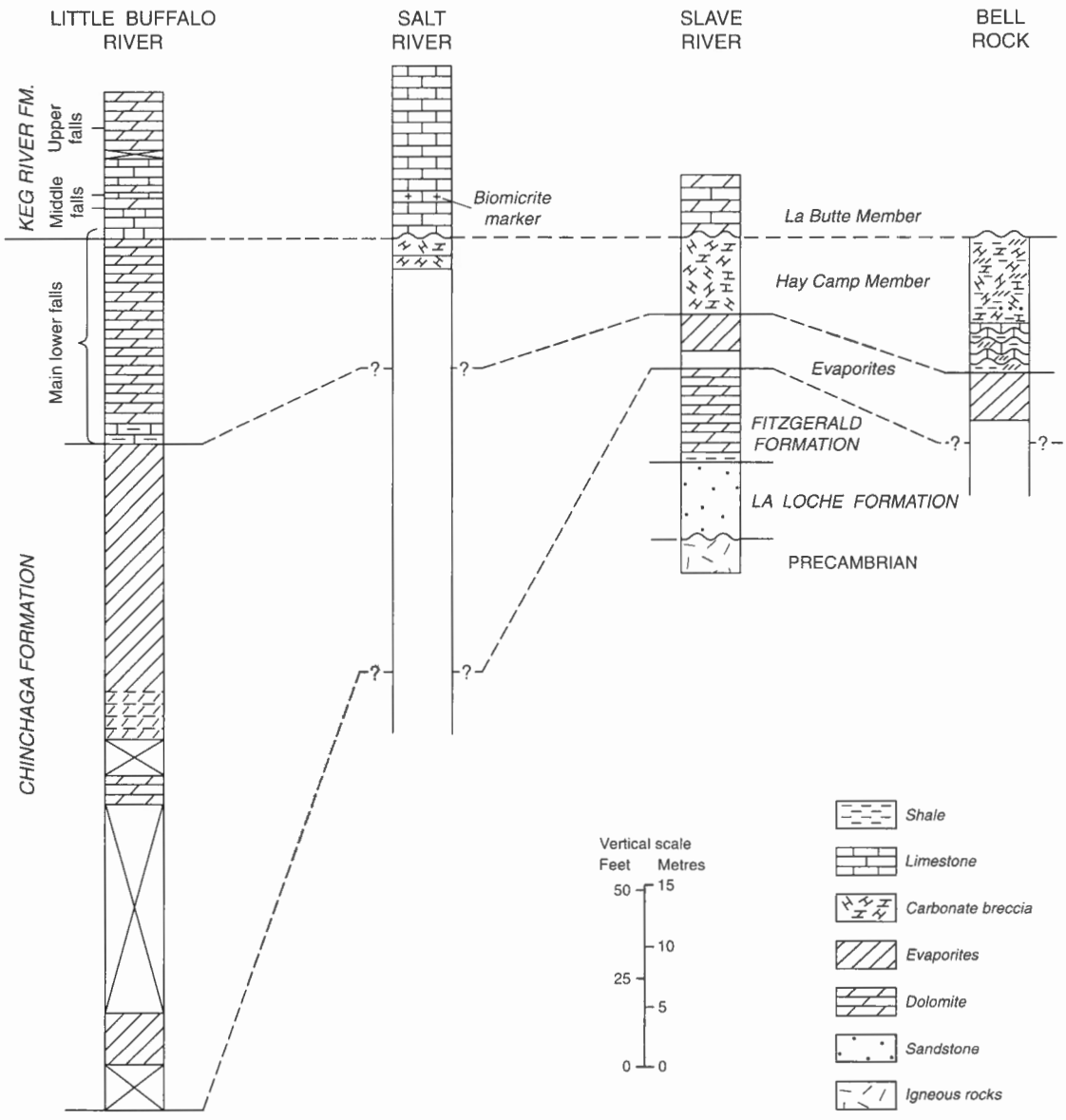


Figure 6. *Relationship of composite sections of Devonian rocks exposed in the vicinity of Little Buffalo River falls, along Salt and Slave rivers, and at Bell Rock on Slave River.*

(Fig. 6). This unconformity appears to be the same as that noted by Park and Jones (1987, fig. 2) between their rock units B and C of the Keg River Formation along Salt River.

Biostratigraphy

A few fossils recorded by Norris (1963, p. 50, 51) from the Hay Camp Member at the type section on Slave River include brachiopods suggestive of *Desquamatia aperanta* Crickmay (1960), [formerly identified as *Atrypa* cf. *A. arctica* Warren], *Spinatrypa* sp., *Emanuella* sp. cf. *E. meristoides* (Meek), and indeterminate pelecypods and gastropods. *Desquamatia* sp. cf. *aperanta* is recorded by Copper (1978, p. 296) from the lower and middle parts of the Hume Formation of the Mackenzie River area, and indicates an Eifelian age.

From the Bell Rock locality on Slave River, Norris (1965, p. 36) reported a poorly preserved brachiopod, suggestive of *Emanuella* sp., from a brecciated limestone fragment from the Hay Camp Member, suggesting a Middle Devonian age.

Hay Camp Member along Salt River

The carbonate strata exposed along Salt River were assigned by Tsui (1982), Tsui and Cruden (1984), and Park and Jones (1987) to the Keg River Formation, and the underlying evaporites were considered to be a part of the Chinchaga Formation. These authors subdivided the exposed part of the Keg River Formation into rock units A, B, and C in ascending sequence. Park and Jones (1987) indicated that a depositional hiatus marks the boundary between unit B and unit C. Commonly, units A and B are dolomitized and locally brecciated. Tsui and Cruden (1984) correlated units A and B with the lower Dolomite member, and unit C with the upper Limestone and dolomite member of Norris (1963, 1965) exposed in the vicinity of the falls on Little Buffalo River. Units A and B of Tsui and Cruden (1984), exposed along Little Buffalo River and along Salt River, are correlated in this report with the brecciated carbonates exposed along Slave River, the Hay Camp Member (Norris, 1963, 1965). This correlation was first suggested by Norris (1963, fig. 10, p. 56), and followed by Craig et al. (1967) (Fig. 6). Park and Jones (1987, p. 425) indicated that the sediments of units A and possibly B were deposited in a subtidal environment which later underwent extensive diagenesis in an intertidal to supratidal setting. In contrast, the lithology and fauna of unit C suggest accumulation in a subtidal environment. The break, which is evident at the top of unit B, probably originated through subaerial exposure in a coastal setting of sediments of units A and B.

The pronounced unconformity at the top of unit B, the scarcity or absence of fossils in units A and B, the presence of distinctive fossils in unit C, and the presence of dolomite in, and brecciation of these two units, suggests that they are more closely related to the Chinchaga rather than the Keg River Formation. It is here proposed that units A and B be referred to as the Hay Camp Member of the Chinchaga Formation after the type section on Slave River described by Norris (1963, p. 49–51, 53–57).

Unit A along Salt River (Park and Jones, 1987, p. 419) is at least 1 m thick, and its lithology consists of laminated to thin bedded, aphanocrystalline limestone with dark brown, wispy, argillaceous, organic-rich layers. It contains up to 10 per cent dolomite which occurs in irregular clusters or as white euhedral crystals.

Unit B along Salt River (Park and Jones, 1987, p. 419) is 1.5 m thick, and is divided into subunits B1, B2 and B3. Subunit B1 is a rubbly, orange-buff to cream-coloured, finely crystalline dolostone with laminae of argillaceoous material. The dolomite is mainly sucrosic with up to 15 per cent remaining as calcite. Subunit B3 is a mottled light grey to orange-buff, thin to medium-bedded, finely crystalliine calcareous dolostone, which is extensively bioturbated and the burrows filled with argillaceous material. Throughout the unit are traces of gypsum and sphaeroidal aggregates of chalcedony. Rare pelecypods are present (Jones and Park, 1987, p. 419).

Units A and B remain undated.

Hay Camp Member at Bell Rock

Cameron (1922, p. 18) referred to Bell Rock as a square, massive-looking cliff, about 11.2 km downstream from Fort Smith (Fig. 7), with exposures of yellowish, brecciated dolomitic limestone underlain by gypsum. Bell Rock is located about 12.8 km north of exposures of brecciated carbonates along Salt River described by Tsui and Cruden (1984) and Park and Jones (1987). Bell Rock appears to be an erosional remnant forming an outlier of brecciated carbonates underlain by gypsum closely similar to the beds exposed along Salt River. Three units were measured at Bell Rock (Appendix 3). All three rock units are part of the Chinchaga Formation. The basal, unit 1 is referred to informally as Evaporite beds, and the overlying units 2 and 3 of brecciated carbonates are assigned to the Hay Camp Member (Norris, 1963) (Fig. 6).

Unit 1, about 4 m thick and exposed at the base of the succession, consists of thick bedded white and grey deformed gypsum which is fibrous, soft, and has scattered dark argilaceous laminae. The overlying unit 2, about 3.8 m thick, consists of thick, irregularly interbedded shale and limestone. The shale is laminated, dark and medium grey, fissile, hard, and weathers slate grey and orange brown. The limestone is brown, fine grained, and contains finely brecciated fragments of limestone. Both the shale and limestone beds are partly brecciated and associated with fragments of deformed gypsum. The uppermost 6.8 m of exposed strata, unit 3, consists of large blocks of finely brecciated, medium to light brown dolomitic limestone weathering orange brown, in a matrix of more finely brecciated fragments of the same composition.

Dolostone member on Little Buffalo River

The name Little Buffalo Formation was applied by Norris (1965, p. 37–39) to resistant carbonate beds

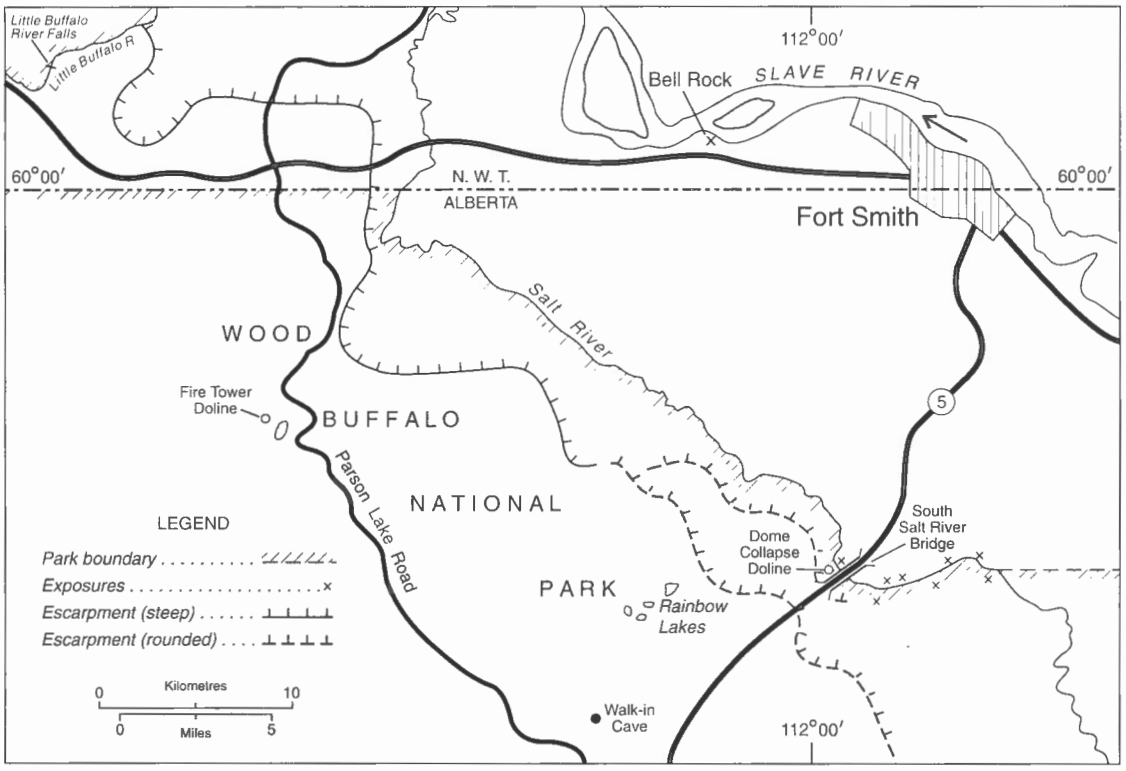


Figure 7. *Enlarged map of Fort Smith area of northeastern Alberta and southern District of Mackenzie showing locations of main areas of Devonian exposures at Bell Rock on Slave River, at Little Buffalo River falls, along escarpments west of Slave River, and along Salt River (from Tsui and Cruden, 1984).*

exposed along Little Buffalo River in the vicinity of the waterfalls (Fig. 7). Little Buffalo strata overlie evaporitic beds of the Chinchaga Formation and underlie evaporitic beds of the Nyarling (Muskeg) Formation. The name is after Little Buffalo River where it cuts through the eastward facing escarpment about 44.8 km west of Fort Smith. It consists of two main rock units, a lower Dolostone member, about 17.1 m thick, and an upper Limestone and dolostone member, about 12.2 m thick. In this report the name Little Buffalo Formation is considered obsolete because the two members probably are separated by an unconformity.

The lower, Dolostone member is here assigned to the upper part of the Chinchaga Formation, and is correlated with the brecciated carbonates of the Hay Camp Member along Slave River, and the brecciated carbonates along Salt River (Fig. 6). The Dolostone member of the Chinchaga Formation consists of pale to dark brown, aphanitic to medium grained, thick bedded to massive dolostone; some coarsely vuggy, massive dolostone; some carbonaceous laminated dolostone near the base; and banded dark grey to black, in part brecciated, carbonaceous limestone at the base. The contact with the underlying gypsum beds is sharp and appears to be conformable.

The Dolostone member is barren of megafossils and is undated.

Little Buffalo Formation (abandoned)

The name Little Buffalo Formation was applied by Norris (1965, p. 37–39) to resistant carbonate beds exposed in the escarpment west of Slave River overlying evaporitic beds of the Chinchaga Formation and underlying evaporitic beds of the Nyarling (Muskeg) Formation. The name is after Little Buffalo River, which cuts through the eastward facing escarpment about 44.8 km west of Fort Smith. It consists of two main rock units, a lower, Dolostone member about 17.1 m thick, and an upper, Limestone and dolostone member about 12.2 m thick. However, the two members can be assigned to other stratigraphic units and usage of the formation name is being abandoned.

The Dolostone member consists of pale to dark brown, aphanitic to medium grained, thick-bedded to massive dolostone; some coarsely vuggy, massive dolostone; some carbonaceous laminated dolostone near the base; and banded dark grey to black, in part brecciated, carbonaceous limestone at the base. The contact with the underlying gypsum beds of the Chinchaga Formation is sharp and appears to be conformable.

In this report the Dolostone member is assigned to the upper part of the Chinchaga Formation, and is correlated with the brecciated carbonates of the Hay Camp Member along Slave River (Fig. 6).

The Limestone and dolostone member is the resistant capping rock of the upper escarpment west of Slave River, and consists of the following, in ascending sequence: medium brown, aphanitic, rubbly, thin bedded fossiliferous limestone separated by argillaceous limestone and shale partings of the same colour (6.1 m thick) and within this rock unit are recessive beds of brown, medium grained granular dolostone (0.9 m thick) about 3.7 m above the base of the member; a covered interval (0.6 m thick) and medium to dark brown, fine- to coarse-grained, irregularly bedded, gypsiferous dolostone (about 4.6 m thick). The Limestone and dolostone member is overlain by gypsum of the Nyarling (Muskeg) Formation but the contact is not exposed.

In this report the Limestone and dolostone member is correlated with the La Butte beds along Slave River which mark the base of the Keg River Formation along and west of Slave River (Fig. 6).

Methy Formation

In the Clearwater–Athabasca rivers area of northeastern Alberta the name Methy Formation has a long record of usage, perhaps longer than the equivalent Keg River Formation. The formal detailed lithological description of the Methy Formation and designation of a type section (Bear Westmount No. 2 drillhole; 9-36-88-8-W4M) first appeared in a paper by Greiner (1956) based on a M.Sc. thesis completed in the spring of 1951 at the University of Alberta. In the Clearwater–Athabasca rivers area of northeastern Alberta the Methy Formation overlies the McLean River Formation of Norris (1963), and is overlain by the Prairie Evaporite Formation of Baillie (1953a, b, p. 24). In the subsurface west and northwest of the Clearwater–Athabasca rivers area, the Methy Formation is continuous with the Keg River Formation of Law (1955a, b) (Fig. 4).

In the outcrop belt of the Clearwater River area, the Methy Formation consists of a thin bedded Lower member and a massively bedded Upper member (Norris, 1963, p. 13, 85; 1973, p. 25). The Lower member consists of light brown, fine grained, granular, in part vuggy, highly calcareous dolostone, occurring as recessive weathering, even, thin beds. Fossils are moderately abundant and better preserved than in the overlying member. The Upper member consists of light brown, in places mottled light and medium brown, in part vuggy, resistant, cliff-forming, irregularly thick bedded to massive reefoid dolostone.

In the subsurface the thickness of the Methy Formation varies from a minimum of about 36.6 m to a maximum of about 82.3 m, with maximum reef buildup occurring towards the edge of the Canadian Shield.

Biostratigraphy

The more important fossils from the Methy Formation listed by Norris (1973, p. 26) include:

Sphaerospongia tessellata (Phillips)
Dendrostella disjuncta (Whiteaves)
Schizophoria sp. cf. *S. manitobensis* Whiteaves
Variatrypa arctica (Warren)
Desquamatia perfimbriata (Crickmay)
Spinatrypa andersonensis (Warren)
Emanuella sublineata (Meek)
Warrenella sp.
Stringocephalus spp.
Mastigospira alata (Whiteaves)

The presence of the distinctive brachiopod, *Variatrypa arctica*, in the lower part of the Methy Formation suggests a correlation with the Elm Point Formation of Manitoba; the lower part of the Pine Point Formation in the sense of Norris (1965) in the Great Slave Lake area; the Murray Island Formation of the Hudson Bay Lowlands (Sanford and Norris, 1975), and a thin interval in the lower part of the Rogers City Limestone of Michigan (Ehlers and Kesling, 1970, p. 21, Textfig. 1).

The reefal Upper member is lithologically and faunally similar to the Winnipegosis Formation of Manitoba. Fossils common to both rock units include: *Sphaerospongia tessellata* (Phillips), *Variatrypa* sp. cf. *V. arctica* (Warren), a thin, flat form of *Stringocephalus* sp., *Schizophoria manitobensis* Whiteaves, *Mastigospira alata* (Whiteaves), and others. Accordingly, by comparison with the Winnipegosis Formation of Manitoba (Norris et al., 1982; Witzke

et al., 1989), the Methy Formation appears to range in age from late Eifelian in its lower part to middle Givetian in its upper part.

The Lower member of the Methy Formation appears to mark a strong marine transgression because it is beds of this member that overstep older Devonian rock units to rest directly on Precambrian rocks of the Canadian Shield north of the Clearwater River and east of the Athabasca River in northeastern Alberta (Norris, 1973).

Keg River Formation

The name Keg River Formation of Law (1955a, b) has been extended from its type area of northern Alberta to the carbonate rocks forming the escarpment west of and the outcrops along Slave River in northeastern Alberta (Craig et al., 1967) and into the Pine Point area (Skall, 1975, 1977; Rhodes et al., 1984) (Figs. 3, 4, 6). The type section of the Keg River Formation is at the California Standard Steen River No. 2-22 drillhole (2-22-117-5W6) between 1588.3 and 1668.8 m, where it is 80.8 m thick.

The Keg River Formation in the type area commonly consists of either dolostone or limestone, and where both occur, the dolostone is generally in the upper beds. The dolostone is dark brown to brownish grey, and microcrystalline to crypotcrystalline with some poor intercrystalline or vuggy porosity. More rarely, the texture is fragmental or granular, and in places the rock is slightly argillaceous. The limestone is brown and cryptocrystalline, slightly argillaceous in part, and contains rare ostracodes, brachiopods and crinoids. In the type drillhole both the lower and upper contacts are gradational.

In the Rainbow Sub-basin, Hriskevich (1966) subdivided the formation into a Lower Keg River Member, an Upper Keg River Member, and a reefal Rainbow Member. In the Zama Sub-basin, McCamis and Griffith (1967) proposed the upper, Keg River Reef Member.

Biostratigraphy

The Keg River Formation is approximately equivalent to the Methy Formation of Greiner (1956) of the Clearwater River area of northeastern Alberta and northwestern Saskatachewan (Fig. 9); the La Butte Formation of Norris (1963) exposed along Slave River north of Lake Athabasca in northeastern Alberta (Fig. 6); and the upper part of the Little Buffalo Formation of Norris (1965) exposed along the river cutting through the escarpment west of Slave River in the southern District of Mackenzie. Although some authors consider it desirable to retain all four names in western Canada several of the stratigraphic names have been abandoned and their component beds assigned to other units.

La Butte Member along Slave River

The name La Butte Formation was applied by Norris (1963, p. 51–53; 113–115) to Middle Devonian limestone and minor carbonaceous shale unconformably overlying partly brecciated limestones and dolomitic limestones of the Hay Camp Formation exposed along Slave River (Fig. 6). It is now considered to be a member of the Keg River Formation. The upper contact with evaporites of the Muskeg Formation is not exposed. La Butte beds appear to be a condensed sequence of the Limestone and dolostone unit of the Keg River Formation exposed at the upper and middle falls on Little Buffalo River west of Slave River. The maximum thickness of the La Butte Member is present at the type section on the west bank of Slave River opposite La Butte Creek (station 129NB, Fig. 5) 51.2 km south of Fitzgerald, where it is 5.4 m thick. At this locality the lithology consists of an alternating sequence of resistant, thick bedded to massive, medium brown, fine grained limestone, and less resistant, thin bedded, dark to medium brown, fine grained limestone separated by thin beds and partings of light to dark brownish grey carbonaceous shale. Some of the beds contain abundant fossils, and some bitumen is present in the basal beds at the type section.

La Butte Member along Salt River

It appears that unit C of Tsui and Cruden (1984, p. 950) on Salt River is equivalent to the upper Limestone and dolomite unit of Norris (1963, p. 56) on Little Buffalo River, which in turn correlates with La Butte strata of Norris (1963, p. 56) on Slave River (Fig. 6). These units appear to mark the base of the Keg River Formation along and west of Slave River in northeastern Alberta and southern District of Mackenzie. This basal unit will be referred to as the La Butte Member of the Keg River Formation after the type section on Slave River (Norris, 1963, p. 51–53).

Unit C of Park and Jones (1987, p. 419) on Salt River is at least 14 m thick, and is divided into subunits C1 and C2 in ascending sequence. Subunit C1 is a light

grey to orange-buff, mottled, highly bioturbated, very finely crystalline rubbly limestone. The material in the burrows is slightly dolomitized and is more argillaceous than the host rock. Blebs of dolomite are scattered throughout. The unit contains an abundant and diverse fauna of echinoderm ossicles, brachiopods, corals, bryozoans, gastropods and tentaculitids.

Subunit C2 is lithologically similar to subunit C1, although there is less dolomitization of burrow fill, and a greater abundance of fossils. Algae are common. At the base of subunit C2 is a bed of biomicrite 0.25 to 0.35 m thick (Fig. 6), which occurs throughout the Salt River area. The unit is recessive, extremely rubbly, and formed of irregularly shaped lumps of micrite up to 4 cm in diameter, in an argillaceous matrix. The biomicrite contains tentaculitids, bryozoans, gastropods, echinoderm ossicles, algae, brachiopods and rare trilobites.

Biostratigraphy

A composite revised list of fossils from the La Butte beds is as follows:

Zonophyllum sp. A
Variatrypa arctica (Warren)
Desquamatia sp. cf. *D. aperanta* (Crickmay)
Emanuella meristoides (Meek)
Mastigospira sp.
Lobobactrites sp. cf. *L. ellipticus* (Frech)
undet. large orthoconic cephalopod
undet. pelecypods
Tentacultes sp.
echinoderm ossicles
fish bone fragments
Tasmanites sp.

Some of the fossils from beds of La Butte Member have been illustrated by McLaren et al. (1962, p. 20, Pl. 9) and by Craig et al. (1967, p. 136, Pl. 1).

Variatrypa arctica occurs typically in the upper Hume and lower Hare Indian formations in the lower Mackenzie Valley area. It is the name bearer of the *arctica* Zone of Crickmay (1960, p. 2, 3, 19) which he indicated as occurring in the lower Hare Indian Formation. However, there is no agreement amongst workers on placement of the transitional argillaceous beds between the Hume and Hare Indian formations which commonly contain *Variatrypa arctica*, *Eliorhynchus castanea*, and numerous other fossils.

The form suggestive of *Lobobactrites ellipticus* (Frech) was identified by D.H. Collins in a letter to the writer dated 25 April 1967. The species occurs typically in the Middle Devonian of Germany (Erben, 1964, p. K502).

Craig et al. (1967, p. 134) proposed an amended list of diagnostic fossils from the *arctica* Zone of Crickmay (1960) as follows:

Sphaerospongia tesselata (Phillips, 1841)
Favosites sp.
Eliorhynchus castanea (Meek, 1867)
Spinatrypa andersonensis (Warren, 1944)
Variatrypa arctica (Warren, 1944)
Elita compacta (Meek, 1867)
Warrenella franklinii (Meek, 1867)
Emanuella sublineata (Meek, 1867)
Emanuella meristoides (Meek, 1867)
Devonoproductus sp.

The above fauna appears to be composite because it includes forms such as *Elita compacta* and *Warrenella franklinii*, which generally occur above the upper range of *Variatrypa arctica*. However, most of the composite fauna suggest a correlation with the combined lower and upper members of the Methy Formation of the Clearwater River area of northeastern Alberta and northwestern Saskatchewan, and with the combined Elm Point and Winnipegosis formations of the Devonian outcrop belt of southwestern Manitoba.

Limestone and dolostone member on Little Buffalo River

The Limestone and dolostone member of the Keg River Formation is the resistant capping rock of the upper escarpment exposed in the vicinity of the falls on Little Buffalo River. It overlies, probably unconformably, the Dolostone member of the Chinchaga Formation, and is overlain by evaporites of the Muskeg (Nyarling) Formation, although the contact is not exposed.

The Limestone and dolostone member consists of the following rock units, in ascending sequence: medium brown, aphanitic, rubbly, thin bedded, fossiliferous limestone separated by argillaceous limestone and shale partings of the same colour (6.1 m thick); within this rock unit are recessive beds of brown, medium grained granular dolostone (0.9 m thick); about 3.7 m above the base of the member; a covered interval (0.6 m thick); and medium to dark brown, fine- to coarse-grained, irregularly bedded gypsiferous dolostone about 4.6 m thick.

In this report, the Limestone and dolostone member is correlated with the La Butte beds along Slave River, which mark the base of the Keg River Formation along and west of Slave River (Fig. 6).

Biostratigraphy

Some of the limestone beds in the Limestone and dolostone member are abundantly fossiliferous and include the following forms (Norris, 1965, p. 39):

sponge spicules
undet. cup coral
Gypidula? sp.
Variatrypa sp. cf. *V. arctica* (Warren, 1944)
Desquamatia sp. cf. *D. perfimbriata* (Crickmay, 1957)
Spinatrypa sp.
Emanuella meristoides (Meek, 1867)
cf. *Emanuella* sp.
Mastigospira sp.
undet. gastropods
undet. pelecypods
cf. *Michelinoceras* sp.
Dechenella sp.
echinoderm ossicles

The occurrence of the form suggestive of *Desquamatia perfimbriata* (Crickmay, 1957, p. 13) in the Bear Westmount No. 1 drillhole (14-9-86-7W4) is from 460.6 to 494.7 m, that is, 74.7 to 108.8 m below the top of the Elk Point Group. Its principal associate is *Emanuella sublineata* (Meek). In the Bear Rodeo No. 2 drillhole (9-17-91-9W4) the range of *Desquamatia perfimbriata* (Crickmay, 1957, p. 13) is from above the highest occurrence of *Stringocephalus* sp. down to the highest occurrence of *Variatrypa arctica*, or from 116.7 to 137.8 m below the top of the Elk Point Group. The fossiliferous Limestone and dolostone member of the Keg River Formation is dated as Middle Devonian (Givetian) because some of its fauna, particularly *Mastigospira* sp. and *Desquamatia perfimbriata* are commonly associated with *Stringocephalus* sp. On the basis of the fauna and stratigraphic position, the Limestone and dolostone member is probably in part equivalent to the La Butte Member of the Keg River Formation along Slave River, and the Lower and Upper members of the Methy Formation along Clearwater River in northeastern Alberta and northwestern Saskatchewan, and the Elm Point and Winnipegosis formations of southwestern Manitoba.

Keg River Formation in Fort Resolution area

In the Pine Point area, from Wood Buffalo Park in the south to the south shore of Great Slave Lake in the north, the Keg River Formation was defined by Skall (1975, p. 27) as a marine deposit, underlain by the Chinchaga Formation and overlain by various barrier facies of the Pine Point Group and partly by dolostone and evaporites of the Muskeg Formation. In this area, Skall (1975, 1977, p. 26) referred to the Keg River Formation as Facies A, or the Marine Platform Facies. The formation is described as consisting of fine, dense to sucrosic, grey-brown to buff-brown dolomite with varying amounts of argillaceous and carbonaceous matter and about 65 m thick. Chert and chert nodules are present locally. Where preserved as limestone, it consists of mudstone and wackestone. The formation contains one to three grey marly beds, termed E-shales by Campbell (1950), that occur within an interval of 4.6 to 10.7 m. The upper marlstone bed is used as a time marker in the Pine Point Mines area, which consistently occurs 3 to 6 m below the top of the formation.

The Keg River Formation is interpreted as a homogenous marine platform deposit that developed over a wide area as a result of a widespread marine transgression that terminated evaporite deposition of the Chinchaga Formation (Skall, 1975; Rhodes et al., 1984) (Figs. 3, 4, 8, 9).

One of the few places where part of the Keg River Formation was once exposed is in the wharf area at Fort Resolution and in a rock quarry immediately north of the townsite. The exposed beds were referred to by Norris (1965, p. 46–49) as the Limestone member of the Pine Point Formation. The beds in the wharf area are now covered by the construction of a road, and the rock quarry is now buried by an airstrip.

In outcrops, the Limestone member consists of medium brown, thin to thick bedded, hard, micritic, conchoidally fracturing limestone, weathering mainly to a light brownish grey, interbedded with minor nodular argillaceous limestone and shale, all of the same colour (Norris, 1965, p. 46).

In the subsurface west of Fort Resolution, the Limestone member of the Pine Point Formation was penetrated by a number of drillholes including the Cominco Pine Point Test G-1 (60°51′05″N, 114°24′30″W) where the member is 25.2 m thick between depths 180.5 and 205.7 m (Belyea and Norris, 1962, fig. 3).

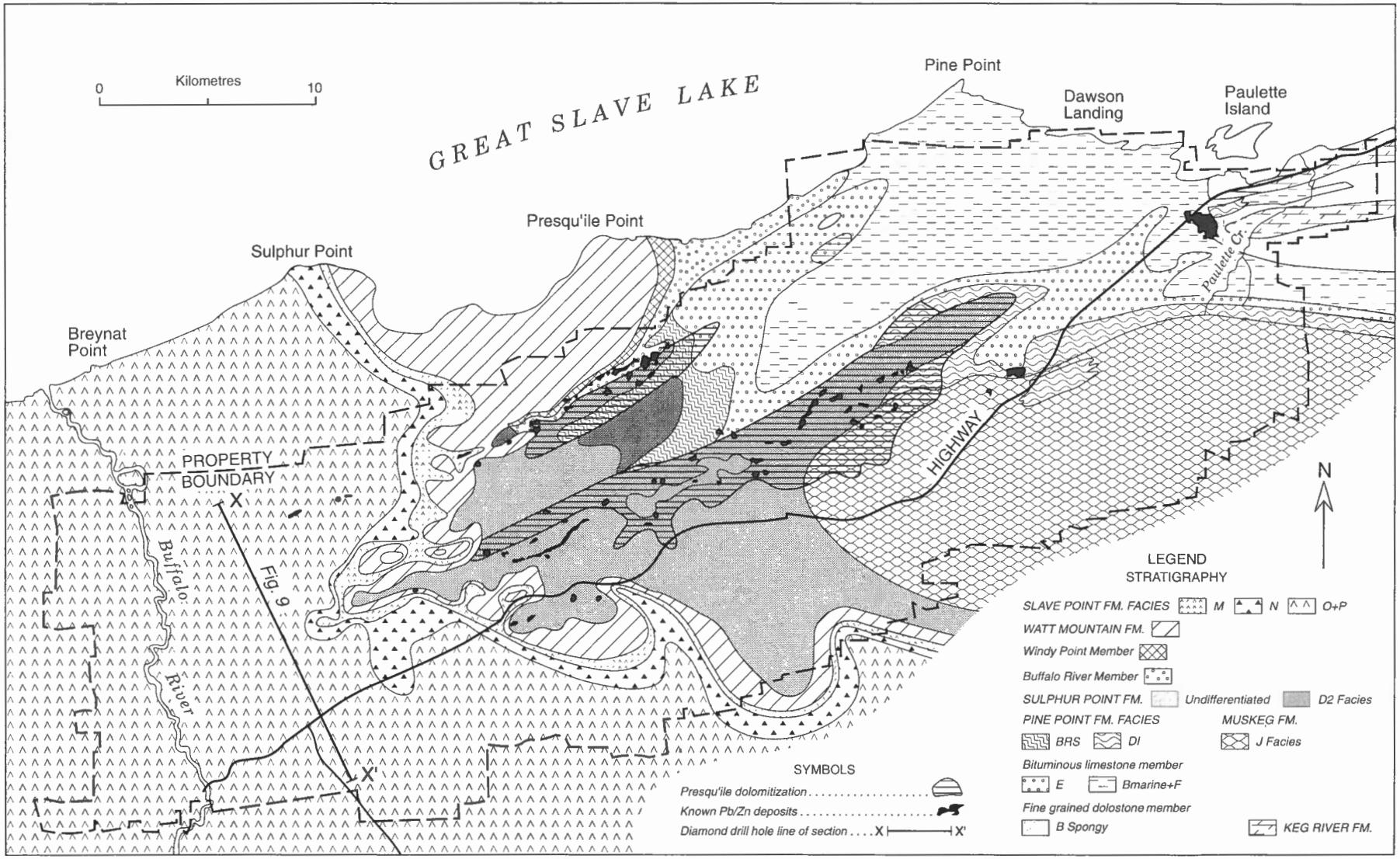


Figure 8. *A detailed subcrop geological map of Devonian rocks of the Pine Point mining area based on closely spaced drillholes (modified from Rhodes et al., 1984).*

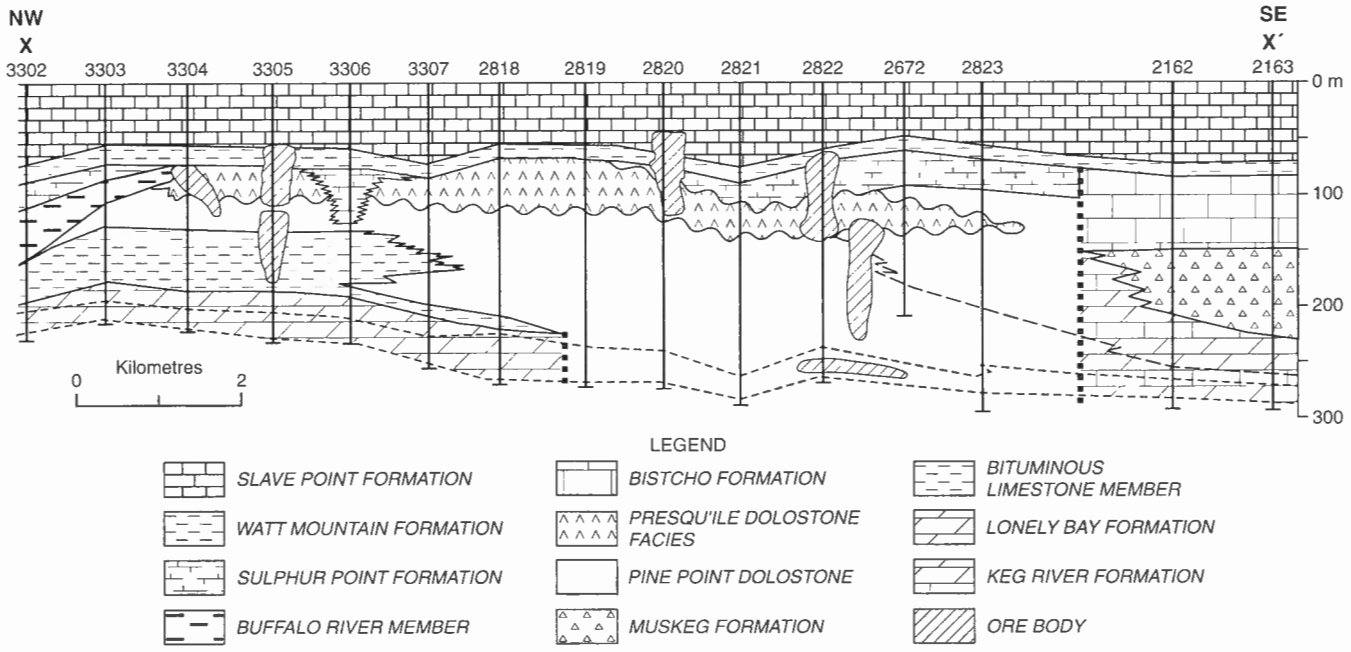


Figure 9. *A schematic cross-section between X and X' of Figure 8, across the Pine Point carbonate barrier complex east of Buffalo River (modified from Rhodes et al., 1984; Meijer Drees, 1993).*

Thin sequences of dolostone beds of the Keg River Formation are exposed along the shore just above lake level at two localities on the south side of Mission Island and on Round Island, immediately west of Fort Resolution. The beds consist of pale brown, finely granular, slightly irregularly bedded dolostone in beds 7 to 8 cm thick and weathering medium brownish grey. Some of the beds are vuggy, and some of the vugs are lined with crystalline calcite. The composite section on Mission Island is about 2 m thick, and that on Round Island is about 1 m thick. These beds probably occur above the Limestone member exposed at Fort Resolution, and formerly were included by Norris (1965, p. 142–144) in the Fine-grained dolomite member of the Pine Point Formation.

Biostratigraphy

Fossils recorded by Norris (1965, p. 48) from exposures of the Limestone member of the Pine Point Formation include the following:

stromatoporoids
Nowakia sp.
Variatrypa sp. cf. *V. arctica* (Warren, 1944)
Desquamatia sp.
Spinatrypa sp.
Emanuella sp. cf. *E. sublineata* (Meek, 1868)
Cyrtina sp.
echinoderm ossicles

Cameron (1922, p. 20) noted the conspicuous abundance of *Atrypa reticularis* var. a (*Variatrypa* sp. cf. *V. arctica* (Warren, 1944) in the Limestone member at and near Fort Resolution, and referred to these beds as the *Atrypa reticularis* var. a Zone. The *Variatrypa arctica* Zone was erected by Crickmay (1960), and the range of the name-giving species is equated approximately with the *Eliorhynchus castanea* Zone of Pedder (1975), which occurs typically in transitional beds between the uppermost Hume and lowermost Hare Indian formations of the Mackenzie River area. Elements of the *Variatrypa arctica* Zone occur in the lower Keg River Formation (La Butte Formation of Norris, 1963) along Slave River; in the lower member of the Methy Formation of northeastern Alberta and northwestern Saskatchewan (Norris, 1963, 1975); in the Elm Point Formation or lower part of the Winnipegosis Formation of southwestern Manitoba (Norris et al., 1982); in the Murray Island Formation of the Moose River Basin of northern Ontario (Sanford and Norris, 1975), and in the lower Rogers City Limestone of Michigan (Ehlers and Kesling, 1970).

The conodonts occurring in the Elm Point Formation of southwestern Manitoba associated with *Variatrypa arctica* are assigned by Witzke et al. (1989) to the upper part of the *kockelianus* and lower part of the *ensensis* zones of late Eifelian age.

Pine Point Formation

The name Pine Point Formation was introduced by Cameron (1918, p. 25, 26) to apply to the lower part of the Middle Devonian succession in the Great Slave Lake area, and included beds exposed along the south shore of the lake and offshore islands between Fort Resolution and Pine Point. Belyea and Norris (1962), and Norris (1965) defined the Pine Point Formation as the rocks between the top of the evaporites of the Chinchaga Formation and the base of carbonates of the Sulphur Point Formation and equivalent rocks. Five rock units, informally designated by Norris (1965) as members of the Pine Point Formation, were recognized on the north flank of the Pine Point carbonate barrier complex. In ascending sequence the members are: (1) Limestone member; (2) Fine-grained dolomite member; (3) Bituminous limestone member; (4) Brown limestone member, and (5) Buffalo River Member. Of the above rock units, the Limestone member has been included in the Keg River Formation by Skall (1975, 1977) and Rhodes et al. (1984), and the Brown limestone member was not differentiated and apparently was included in the upper part of the Bituminous limestone member by these same authors. Rock units here treated as part of the Pine Point Formation on the north flank of the carbonate barrier complex include: the Fine-grained dolostone member, Bituminous limestone member, and the Buffalo River Member.

Fine-grained dolostone member

The informally designated Fine-grained dolostone member of the Pine Point Formation was introduced by Belyea and Norris (1962, p. 6, 7), and Norris (1965, p. 55–58) with the type section in the Cominco Test G-1 drillhole (60°51′05″N, 114°24′30″W). In this drillhole the member was defined as overlying the Limestone member of the Pine Point Formation at 180.4 m and underlying the Presqu'ile Formation at 40.5 m depth, with a thickness of 133.9 m. Meijer Drees (1989, 1993) used the term Pine Point dolostone in the same sense as the Fine-grained dolomite member of Belyea and Norris (1962), and Norris (1965). These broadly defined stratigraphic units are more useful than the detailed facies designations used by Skall (1975, 1977), Lantos (1983), and Rhodes et al. (1984) which cannot be correlated beyond the closely spaced drilling of the Pine Point Mines area. In this report, the base of the Fine-grained dolostone member in the type drillhole is raised to 144.5 m which also marks the top of the Keg River Formation. This level is 10.4 m above the top of the E-shales marker beds and is at the base of a sequence of dolostone beds containing corals. The revised thickness of the Fine-grained dolostone member in this drillhole is 103.9 m.

Comparing the sequence of the Fine-grained dolostone member in the Cominco Test G-1 drillhole with that in the Cominco Sulphur Point Test G-4 drillhole (Belyea and Norris, 1962, fig. 3), it is apparent that this member is approximately equivalent to the combined Bituminous limestone member and Buffalo River Member.

The G-4 hole, because of its location near Sulphur Point on the north flank of the Pine Point carbonate barrier complex, more closely portrays the sequence and types of rocks exposed along the south shore of the lake and on the offshore islands.

Parts of the Fine-grained dolostone member crop out along the south shore of Great Slave Lake from a point 1.2 km east of Dawson Landing wharf, eastward to the mouth of Little Buffalo River. This member is present also on Beaulieu Island of the Green Islands Group, and on Burnt and Leroux islands of the Burnt Islands Group, and also possibly underlies Paulette, Birch and Loutit islands (Fig. 4).

The lithology of the Fine-grained dolostone member in the reference drillhole (Norris, 1965, p. 57) consists mainly of light brown, fine grained, sandy or sugary textured, porous dolostone. Roughly 6.1 m of the basal part of this unit is harder, finer grained, more compact, and greyish rather than light brown in colour as compared to the remainder of the member. Carbonaceous wisps are present in this interval between 30.5 and 39.6 m above the top of the E-shales marker. The Fine-grained dolostone member is capped, in most places of the Pine Point area (Campbell, 1957, fig. 1), by a unit averaging about 2.1 m thick and consisting of fine grained dolostone with numerous stromatoporoids, corals and bryozons.

The part of the Fine-grained dolostone member represented along the south shore of Great Slave Lake east of Dawson Landing and on the offshore islands underlying the Bituminous limestone member of the Pine Point Formation and overlying the Keg River Formation, is referred to by Rhodes et al. (1984, p. 999) as the B Spongy member. This unit forms the base of the Pine Point Formation, and was not designated as a separate facies by Skall (1975). It varies in thickness from 12 to 18 m, and is present beneath the entire barrier complex and extends south of the barrier beneath the Muskeg Formation where its probable correlative is the Upper Keg River Member of McCamis and Griffith (1967). To the northwest, it was correlated by Rhodes et al. (1984) with the upper

Lonely Bay Formation of Norris (1965). In the reference Cominco G-1 drillhole, the B Spongy member occurs between 144.5 and 102.1 m. The unit is a floatstone with 5 to 20 volume per cent of stromatoporids, corals and brachiopods in a grainstone and packstone matrix. Argillaceous material is present in the matrix as discontinuous wisps. The rock has been dolomitized and strongly leached to give a fossil moldic vuggy porosity.

Biostratigraphy

Identifiable megafossils in this rock unit are sparse and poorly preserved because of recrystallization. A revised list of megafossils recorded by Norris (1965, p. 58) from the Fine-grained dolostone member of the Pine Point Formation include the following:

Cladopora sp.
Favosites sp.
undet. coral
undet. bryozoa
Gypidula? sp.
Atrypa? sp.
Atrypa sp. (finely costate)
Atrypa sp. (medium costate)
Spinatrypa sp.
Hadrorhynchia sp. cf. *H. intermissa* Crickmay, 1963
Emanuella sp. cf. *E. meristoides* (Meek, 1868)
Stringocephalus chasmognathus Crickmay, 1960
Stringocephalus sp. cf. *S. glaphyrus* Crickmay, 1960
echinoderm ossicles

Molds suggestive of *Stringocephalus* sp. were noted by Norris (1965, p. 57, 58) on Mission Island which is probably at or near the base of the member, relatively close to the contact with the underlying Limestone member of the Keg River Formation. The form is assignable probably to *Stringocephalus glaphyrus* Crickmay (1960), which occurs low in the sequence of stringocephalids so far known from northwestern Canada.

Another *Stringocephalus* from a higher stratigraphic level is recorded by Cameron (1922, p. 22) from the middle island of the Burnt Islands group. Warren and Stelck (1962, p. 282, fig. 7, profiles 22a, b) referred to this form as *Stringocephalus chasmognathus* Crickmay (1960). Judging from section A–B of figure 7 of Norris (1965) this level is below the base of the Bituminous limestone member of the Pine Point Formation and about 30.5 m or more above the top of the E-shales marker beds, which is 3 to 6 m below the top of the Keg River Formation. *S. chasmognathus* suggests a correlation with the highest part of the reef development in the upper member of the Methy Formation of northeastern Alberta and northwestern Saskatchewan. The stratigraphic level of the *S. chasmognathus* occurrence is well below the level of *Stringocephalus* sp. B of Warren and Stelck (1960) in the Windy Point Member of the Sulphur Point Formation at Presqu'ile Point on the south shore of Great Slave Lake.

The form suggestive of *Hadrorhynchia intermissa* Crickmay (1963) is abundantly represented in the overlying Bituminous limestone member of the Pine Point Formation, and is discussed under that heading.

The range of *Emanuella meristoides* (Meek, 1868) in the Great Slave Lake area, is shown by Caldwell (1968, p. 611, fig. 4) as extending through the upper part of the Chinchaga Formation into the lower three-quarters of the Pine Point Formation, in the sense of Norris (1965). In the lower Mackenzie Valley area, the form ranges from the upper half of the Hume Formation, throughout the Hare Indian Formation, and into the bedded platform beds of the lower Ramparts Formation.

Bituminous limestone member

The informal descriptive name Bituminous shale and limestone member of the Pine Point Formation was introduced by Norris (Belyea and Norris, 1962; Norris, 1965). The name is here shortened to Bituminous limestone member. The outcrop belt of the Bituminous limestone member occurs along the south shore of Great Slave Lake from about 2.2 km west of Ile du Mort to about 1.1 km east of Dawson Landing wharf. Outcrops of the member are present also along the shores of Green and McKay islands of the Green Islands group located about 3.2 km offshore. For distribution of the member, refer to the map by Norris (1965, fig. 7) rather than the map by Rhodes et al. (1984, fig. 5) because the latter is misleading. Two facies, the B marine and F, are included by Rhodes et al. (1984) in one map unit on their cross-section (op. cit., fig. 4) and subcrop map (op. cit., fig. 5), and probably are equivalent to the Bituminous limestone member of this report (Figs. 4, 8, 9). The F facies refers to a bituminous, planar laminated mudstone. The B marine facies applies to thin, bituminous, argillaceous, mudstone and wackestone units which underlie and overlie the Bituminous limestone member. The underlying beds were placed by Norris (1965) in the Fine-grained dolostone member, and the overlying beds were placed in the Brown limestone member of the Pine Point Formation. Near the outcrop area, the

Bituminous limestone member has been completely penetrated by the Cominco Test G-4 drillhole (approximately 60°54′N, 114°46′W), immediately southeast of Sulphur Point, and is treated as the type section. In this drillhole the member is represented by the 34.9 m thick sequence between 109.1 and 144.0 m, where it overlies the Fine-grained dolostone member and is overlain by the Buffalo River Member (Belyea and Norris, 1962, fig. 3). The member pinches out southward within the Pine Point barrier complex.

In the subsurface, the Bituminous limestone member can be traced westward across Great Slave Lake and west of the lake along and north of the Mackenzie River (Macqueen et al., 1975, fig. 1). Underlying Great Slave Lake, the Bituminous limestone member overlies the Fine-grained dolostone member and underlies the Buffalo River Member of the Pine Point Formation; west and northwest of the lake, the Bituminous limestone member overlies the Lonely Bay Formation of Norris (1965) and is continuous with the thin basal Bituminous member of the shale and limestone of the Horn River Formation.

Two main types of lithologies are present in outcrops in the Great Slave Lake area. One type, present in the vicinity of Pine Point and on Green and McKay islands, consists of dark grey to black, richly fossiliferous, highly calcareous, bituminous shale (actually a limestone), interbedded with medium to dark brown, fine grained to micritic, in part nodular, limestone. On weathered surfaces, the more argillaceous parts of the succession are thinly and evenly laminated, light to medium grey. This is the Facies F of Skall (1975), or the Bituminous planar laminated mudstone facies of Rhodes et al. (1984). The other type, present along the shore east of Dawson Landing and along the road south of the landing, consists of medium to dark brown, irregularly thin bedded, very fine grained, in part petroliferous, limestone. The petroleum varies from very soft to hard and commonly partly fills cavities formerly occupied by brachiopod shells. This rock unit is also, in part, richly fossiliferous. This is the B marine or Bituminous argillaceous mudstone and wackestone facies of Rhodes et al. (1984).

Representative approximate thicknesses in selected drillholes along a southeast to northwest cross-section illustated by Meijer Drees (1993, fig. 33) that extends from near the mouth of Hay River to northwest of Great Slave Lake, are as follows: Hay River B-52 (60°51′47″N, 115°40′17″W), 71.6 m; NWT Deep Bay 3 (61°20′00″N, 115°42′30″W), 43.6 m; Punch Deep Bay 3 (61°22′30″N, 116°42′30″W), 61 m; Deep Bay B-01 (61°20′06″N, 117°00′43″W), 30.6 m; and IOE Providence A-47 (61°26′14.34″N, 117°22′32.73″W), 19.8 m. Between Hay River B-52 and NWT Deep Bay 3 drillholes, the Bituminous limestone member overlies carbonates of the Lonely Bay Formation and underlies the Buffalo River Member. Between Punch Deep Bay 3 and Providence A-47 drillholes the Bituminous limestone member overlies the Lonely Bay Formation and underlies a Black shale unit of the Spence River Formation. In one drillhole, the Deep Bay B-01, the Bituminous limestone member underlies a carbonate buildup referred to the Sulphur Point Formation (Meijer Drees, 1993, fig. 33, p. 61). A short distance west of the Laferte River M-16 drillhole (61°41′52″N, 118°33′30.99″W), the Bituminoous limestone member pinches out between the Lonely Bay Formation (below) and the Black shale unit of the Spence River Formation (above) (Meijer Drees, 1993, fig. 31, p. 59).

Biostratigraphy

Brachiopods from the Bituminous limestone member of the Pine Point Formation that are described and illustrated in this report include the following (Fig. 10):

Barroisella? *minuta* (Meek, 1868)
Schizophoria mcfarlanei (Meek, 1868)
Cymostrophia? sp.
Floweria? sp.
Rhyssochonetes aurora medialis Norris n. subsp.
Productella verecunda Crickmay, 1963
Devonoproductus primus Crickmay, 1963
Anatrypa (*Variatrypa*) *exoleta* Johnson, 1974
Spinatrypa sp. A
Spinatrypina sp. A
Leptathyris obsolescens Johnson, 1974
Emanuella caldwelli Norris n. sp.
Emanuella meristoides (Meek, 1868)
Emanuella sublineata (Meek, 1868)
Echinocoelia sp.
Cyrtina sp.
Warrenella parafranklinii Norris n. sp.
Warrenella plicata Johnson, 1974
Warrenella posteruskirki Norris n. sp.
Warrenella whittakeri Norris n. sp.
Cryptonella? sp.

Of the described and illustrated brachiopods, the following occur more or less throughout the Bituminous limestone member (Fig. 10):

Barroisella? *minuta*
Schizophoria mcfarlanei
Rhyssochonetes aurora medialis n. subsp.
Productella verecunda
Devonoproductus primus

Emanuella meristoides
Emanuella sublineata
Cyrtina sp.

The above listed forms range through the upper part of the conodont *ensensis* Zone, Lower *varcus*, and lower and upper parts of the Middle *varcus* subzones of Givetian, late Middle Devonian, age (Uyeno, this report).

Barroisella? *minuta* ranges more or less throughout the Bituminous limestone member, except for the uppermost beds which are highly calcareous. Although present at many localities, it is always a minor component of the brachiopod fauna. Linguloid brachiopods are a long ranging group that appeared in the Early Cambrian and persist to the present. The "*Lingula*" of the Paleozoic appears to be very closely comparable to modern *Lingula*, and this is taken to indicate deposition in tropical shallow water near the shore for Paleozoic forms (Cooper, 1936, 1937, p. 34). However, some workers including Pickerill (1973), Percival (1978), Cherns (1979) and others, interpret some Paleozoic lingulids as indicating deeper water, normal marine environments of deposition, based primarily on associated fossils.

An analogous occurrence of a linguloid brachiopod is that of *Lingula* cf. *spatulata* Vanuxem recorded by Warren and Stelck (1956, Pl. 10, fig. 24) from dark shale at the base of the Waterways Formation in the Athabasca–Clearwater rivers area of northeastern Alberta. This is one of the forms that marks the initial transgression of the Waterways Formation in that area within the conodont *norrisi* Zone of late Givetian, late Middle Devonian, age.

Another analogous occurrence of linguloid brachiopods of younger Devonian age is that of *Lingula* sp. and *Lingulipora* sp. recorded by Norris (*in* Norris et al., 1992) from the Long Rapids Formation in the Moose River Basin of northern Ontario. These forms are associated with *Manticoceras* sp. cf. *M. sinuosum* (Hall) and conodonts of the upper part of Zone [MN]10 and lower part of Zone [MN]11 of Klapper (1989a) or Zone [A]4b of Klapper and Lane (1989), of early Frasnian, early Late Devonian age.

Schizophoria mcfarlanei (Meek) is another brachiopod species that ranges more or less throughout the Bituminous limestone member but is not abundant and is poorly preserved at all localities. The type specimens of Meek (1868, p. 89, 90) are from two localities: (1) on Mackenzie River, 64.4 km below Fort Good Hope, and (2) on Lockhart (=Carnwath) a tributary of Anderson River. According to A.E.H. Pedder (1979, pers. comm.) the preservation of specimens suggests that those from the Mackenzie River locality are from the Ramparts Formation, and those from the Lockhart River are from the *Eliorhynchus castanea* beds of the Hare Indian Formation.

A specimen of *Schizophoria mcfarlanei* illustrated by Warren and Stelck (1956, Pl. 3, figs. 8–10) is recorded as part of the *Ambocoelia meristoides* fauna in the Hare Indian Formation of the Anderson River area, where it is associated with *Variatrypa arctica* and other fossils, suggesting that it is also from the *Eliorhynchus castanea* beds.

A stratigraphically higher occurrence of a form recorded as *Schizophoria* cf. *mcfarlanei* (Meek) was listed by Crickmay (1970, p. 73, 74, 77) from an interval 16.5 m thick, 2.4 to 3.05 m below the top of the Ramparts Formation on Carcajou Ridge at 65°38′N, 128°15′W where it is associated with *Leiorhynchus hippocastanea* (Crickmay), *Hadrorhynchia sandersoni* (Warren), *Warrenella timetea* (Crickmay), *Cyrtina* cf. *panda* Meek, and other fossils. The presence of *L. hippocastanea* suggests a correlation with the upper *hermanni* and *disparilis* zones of late Givetian, late Middle Devonian age (Braun et al., 1989), which probably marks the upper range of *Schizophoria mcfarlanei*.

From Nevada, *Schizophoria mcfarlanei* (Meek) was described and illustrated by Johnson (1974, p. 53, 54, Pl. 1, figs. 4–12) from the *Eliorhychus castanea* Zone in the Denay and Woodpecker limestones.

In the Pine Point area, *Rhyssochonetes aurora medialis* n. subsp. ranges from 7.5 m above the base to the top of the Bituminous limestone member where it occurs most abundantly in the more argillaceous beds of the middle part of the member. The span of this distinctive form in terms of conodont zonation, from the upper part of the *ensensis* Zone to the upper part of the Middle *varcus* Subzone, is the longest so far demonstrated in the Devonian of western and northwestern Canada.

In the Mackenzie River area, *Rhyssochonetes aurora* s.l. occurs in the upper Hare Indian and lower part of the Ramparts formations within the conodont Middle *varcus* Subzone of Givetian, late Middle Devonian, age (Braun et al., 1989). In the Devonian outcrop belt of southwestern Manitoba, *R. aurora* s.l. occurs in Members B and C of the Dawson Bay Formation within the Middle *varcus* Subzone (Norris et al., 1982).

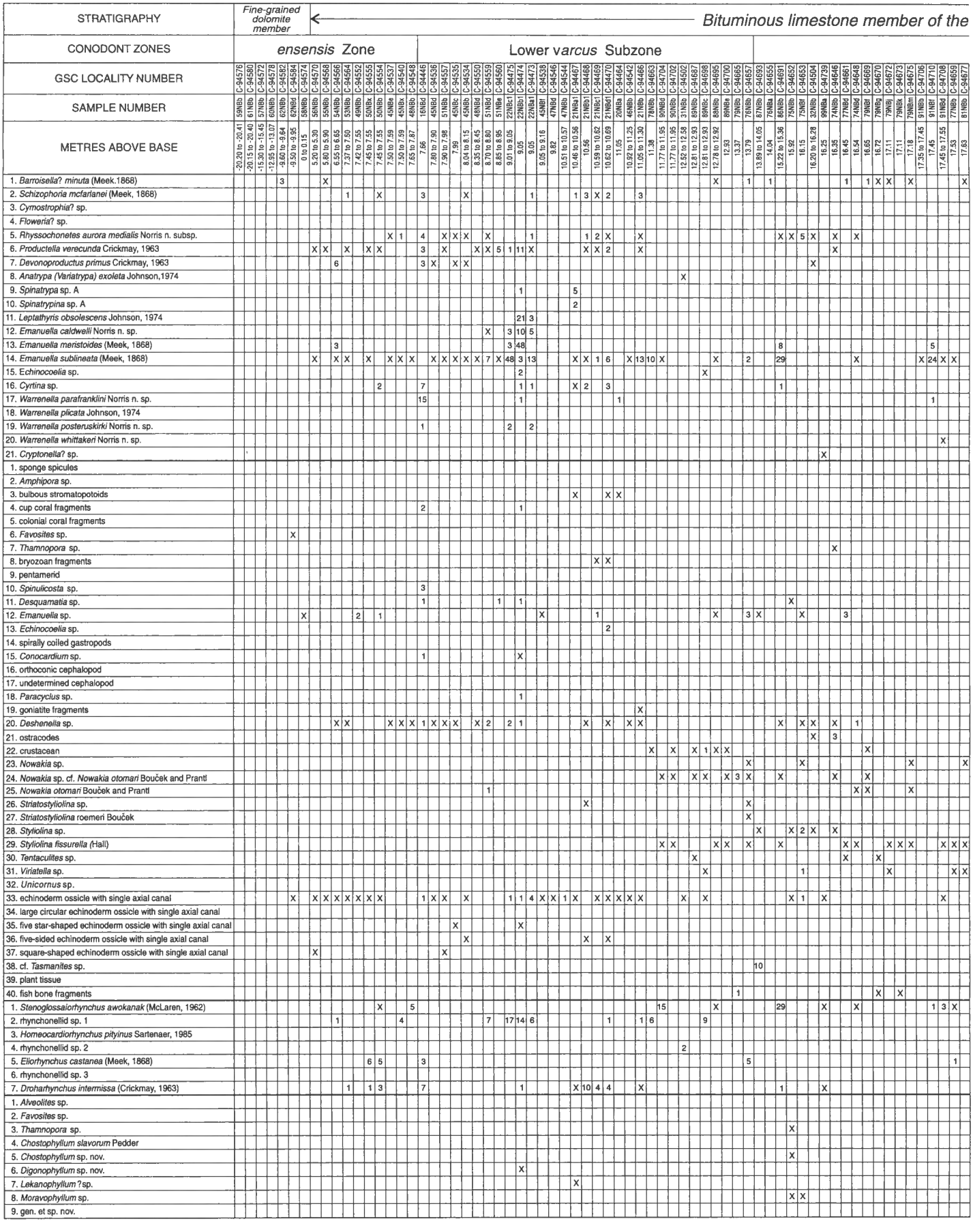


Figure 10. *Chart showing distibution and ranges of brachiopods, corals and other megafossils in the Bituminous limestone member of the Pine Point Formation. (X, present in sample; 9, number of specimens present in sample).*

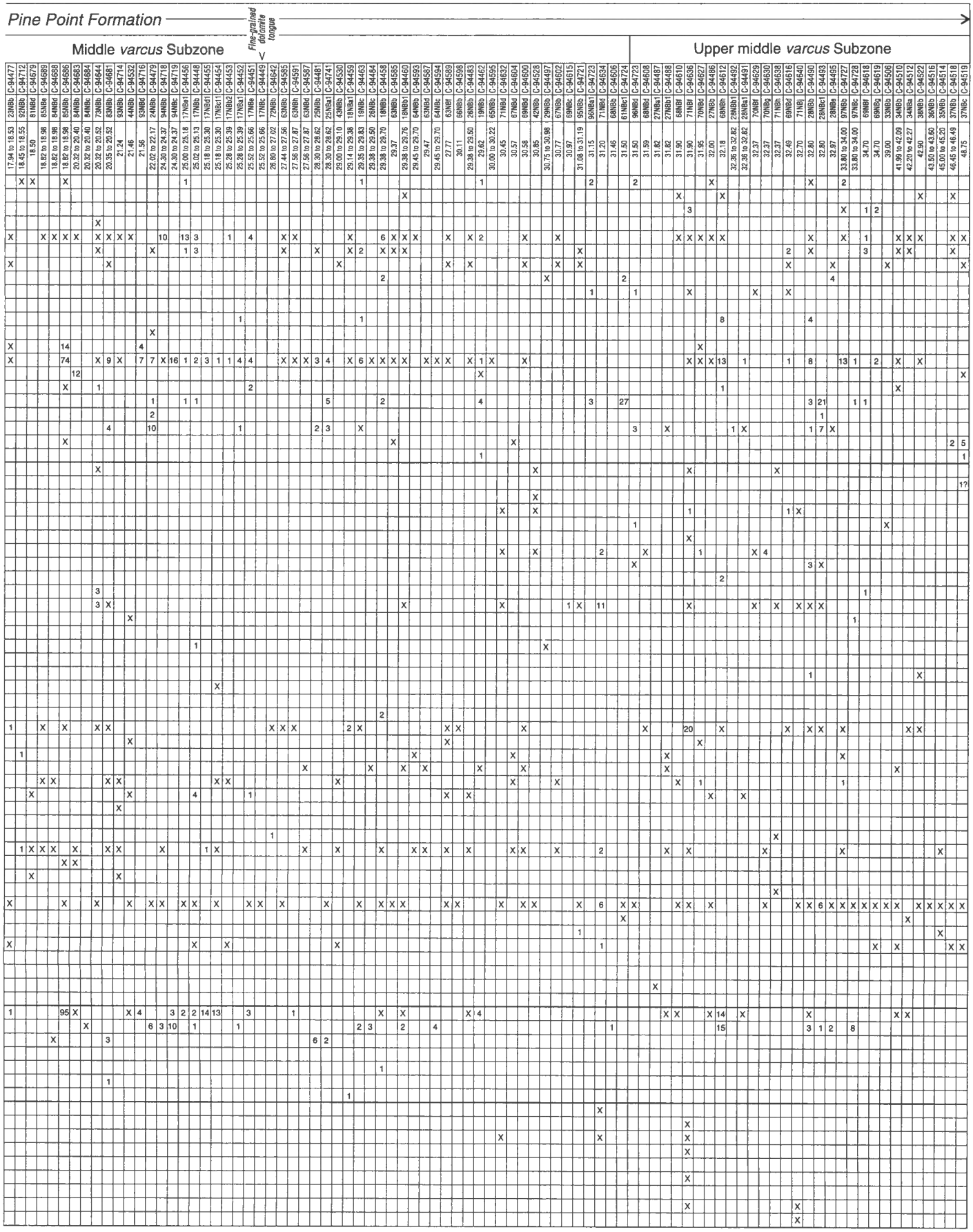


Figure 10. *(cont'd.)*

In the Iowa Basin of central and eastern Iowa, *Rhyssochonetes bellarugosus* (Stainbrook, 1943) occurs in the upper Solon Member of the Little Cedar Formation of the Cedar Valley Group, which is correlated with the upper part of the *varcus* Zone (Day, in press, fig. 3).

In New York State, *Rhyssochonetes aurora aurora* (Hall) occurs in the Apulia Member of the Tully Formation (Johnson, 1970), which is within the Middle *varcus* Subzone (Ziegler, Klapper and Johnson, 1976, p. 116, fig. 3).

Productella verecunda Crickmay (1963), in the Pine Point area, ranges from 5.2 to 46.49 m above the base of the Bituminous limestone member of the Pine Point Formation. The type specimens of *P. verecunda* are recorded by Crickmay (1963, p. 20) from the Pine Point Formation at Dawson Landing on Great Slave Lake.

Devonoproductus primus Crickmay (1963) in the Pine Point area occurs from between 6.55 and 48.75 m above the base of the Bituminous limestone member. It occurs most abundantly in the lower and upper parts, which are more calcareous than the middle part of the member. Crickmay (1963, p. 24, 25) cited a fine grained, brown limestone of the Pine Point Formation, Dawson Landing, south shore of Great Slave Lake, N.W.T., as one of the main source areas of this species. The brown limestone of Crickmay (1963) presumably is the same rock unit as the Brown limestone member of Norris (1965) which outcrops on and along the road south of Dawson Landing wharf. In this report, the Brown limestone member is included as the upper part of the Bituminous limestone member of the Pine Point Formation.

Emanuella meristoides (Meek, 1868) occurs between 6.55 and 31.95 m above the base of the Bituminous limestone member. It appears to be most abundant in the lower part of the conodont Lower *varcus* Subzone.

Emanuella sublineata (Meek, 1868) occurs between 5.20 and 42.90 m above the base of the Bituminous limestone member. It is the most abundant *Emanuella* species in the Bituminous limestone member.

Cyrtina sp. occurs between 7.45 and 42.09 m above the base of the Bituminous limestone member. Its occurrence is sparse and preservation is poor.

Brachiopods from the Bituminous limestone member that range from the Lower to upper Middle *varcus* subzones include the following taxa (Fig. 10):

Anatrypa (*Variatrypa*) *exoleta* Johnson, 1974
Spinatrypa sp. A
Warrenella parafranklinii n. sp.
Warrenella posteruskirki n. sp.

Anatrypa (*Variatrypa*) *exoleta* Johnson (1974) occurs between 12.58 and 32.97 m above the base of the Bituminous limestone member. In Nevada, this species is typically an element of the *Eliorhynchus castanea* Zone, which occurs in two parallel outcrop belts, the Denay Limestone in the west, and the Woodpecker Limestone in the east (Johnson, 1974, p. 53).

Spinatrypa sp. A occurs between 9.05 and 32.49 m above the base of the Bituminous limestone member, but is a rare form within the unit. A closely comparable *Spinatrypa* sp. is also a rare form in the *Eliorhynchus castanea* Zone in Nevada.

Warrenella parafranklii n. sp. occurs between 7.66 and 34.70 m above the base of the Bituminous limestone member. The closely comparable *Warrenella franklinii* (Meek, 1868) has been recorded by Caldwell (1971, p. 14, Pl. 2, figs. 6a–6d) from calcareous shale of the Hare Indian Formation, about 15.2 m below the contact with the overlying Ramparts Formation, at the northern end of the "Ramparts of the Mackenzie", Fort Good Hope, District of Mackenzie. In Nevada, *Warrenella franklinii* (Meek) is recorded by Johnson (1974, p. 72, Table 1) from the *Eliorhynchus castanea* Zone in the Denay and Woodpecker limestones.

Warrenella posteruskirki n. sp. occurs between 7.66 and 32.97 m above the base of the Bituminous limestone member. The comparable *Warrenella kirki* (Merriam, 1940) occurs typically in the Upper *Warrenella kirki* Zone, upper Eifelian, Lone Mountain, Nevada (Johnson, 1974, Pl. 7, explanation). In northwest Canada, *Warrenella kirki* is recognized in the upper Nahanni Formation (Caldwell, 1971, Pl. 2, explanation), upper Headless Formation, and in the upper Ogilvie Formation (Ludvigsen and Perry, 1975, p. 62, Textfig. 13).

Warrenella posteruskirki n. sp. was referred to as *Martinia*? *kirki* Merriam by Warren and Stelck (1956, Pl. 4, figs. 25–27) who considered it to be a part of their *Ambocoelia meristoides* fauna in the Pine Point Formation of the Great Slave Lake area.

Emanuella caldwelli n. sp. is the only brachiopod from the Bituminous limestone member which ranges through most of the conodont Lower to upper Middle *varcus* Subzone. It occurs between 8.70 and 22.17 m

above the base of the member. Warren and Stelck (1956, Pl. 4, figs. 13–15, 16–18) referred to this form as *Martinia*? *richardsoni* Meek, and considered it to be a part of their *Ambocoelia meristoides* fauna in the Pine Point Formation of the Pine Point area of Great Slave Lake.

Brachiopods from the Bituminous limestone member that range from the lower to the upper part of the Middle *varcus* Subzone include the following (Fig. 10):

Warrenella plicata Johnson, 1974
Warrenella whittakeri n. sp.
Cryptonella? sp.

Warrenella plicata ranges from 22.02 to 32.80 m above the base of the Bituminous limestone member, and is an exceedingly rare form in the member. *W. plicata* Johnson (1974, p. 52, Table 1) is recorded from the *Eliorhynchus castanea* Zone of the Woodpecker Limestone. Johnson (1974, p. 51) concluded that the *E. castanea* Zone of Nevada correlates with some lower part of the conodont *varcus* Zone.

Warrenella whittakeri n. sp. ranges from 17.45 to 48.75 m above the base of the Bituminous limestone member but occurs mainly in the upper part of the member, which outcrops south of the Dawson Landing wharf, where it was referred to by Norris (1965) as the Brown Limestone member of the Pine Point Formation.

Cryptonella? sp. ranges from 16.25 to 48.75 m above the base of the Bituminous limestone member. It is exceedingly rare in the member, and is represented by fragmentary, poorly preserved specimens. It occurs in beds dated as lower Middle and upper middle *varcus* Subzone of Givetian age.

Brachiopods from the Bituminous limestone member that have a limited range in the member include the following (Fig. 10):

Floweria? sp.
Cymostrophia? sp.

Floweria? sp. has been collected from only one sample from an interval between 20.32 and 20.52 m above the base of the Bituminous limestone member. It occurs within the conodont lower Middle *varcus* Subzone.

Cymostrophia? sp. ranges from between 31.90 and 34.70 m above the base of the Bituminous limestone member where it is an exceedingly rare form. It occurs within the conodont upper Middle *varcus* Subzone. *Cymostrophia* sp. previously had been recorded by Norris (*in* McLaren and Norris, 1964, p. 40, 41, Pl. 13, figs. 15a–16b) from outcrops of the Horn Plateau Formation, a pinnacle reef partly exposed northwest of Great Slave Lake, 85.3 km north of Fort Providence. Conodonts from the exposed part of the reef are indicative of the *varcus* Zone, of Givetian, late Middle Devonian age.

Because the rhynchonellid brachiopods are a very important component of the brachiopod fauna, it is necessary to comment briefly here on some of the more important forms, especially those that have been used for dating, correlation, and as zone fossils.

McLaren (1962) in his study of Middle and lower Upper Devonian rhynchonelloid brachiopods from Western Canada, recognized, described and illustrated three rhynchonelloid brachiopods from the Bituminous limestone member as follows: *Leiorhynchus castanea* (Meek, 1868), *Leiorhynchus awokanak* McLaren, 1962, and *Hadrorhynchia sandersoni* (Warren, 1944). In the forthcoming study of the rhynchonelloids from the Bituminous limestone member by P. Sartenaer, he has recognized seven or eight taxa.

Sartenaer (1987) erected a new genus, *Eliorhynchus*, with *Rhynchonella castanea* Meek, 1868, as the type species from the type area on Lockhart River, a tributary of Anderson River. *Eliorhynchus castanea* (Meek, 1868) is widespread in the lower Mackenzie Valley area where it is known from a relatively thin interval of transitional argillaceous beds between the Hume and Hare Indian formations. At some localities, *E. castanea* forms coquina beds, and at other localities, it is associated with an abundant, diverse fauna. Bassett (1961), Tassonyi (1969), Caldwell (1971) and others, by definition, considered the *castanea*-bearing beds as a thin, basal part of the Hare Indian Formation. These beds are dated (Uyeno, 1978; Braun et al., 1989) as within the upper *ensensis* Zone of early Givetian age.

In the Bituminous limestone member, *Eliorhynchus castanea* ranges from between 7.45 and 29.70 m above the base of the member (Fig. 10). In terms of conodont zones by Uyeno (this report) it occurs relatively abundantly in the upper part of the *ensensis* Zone, it is present in one sample in the upper Lower *varcus* Subzone, and in two samples in the lower part of the Middle *varcus* Subzone. It is apparent that McLaren (1962) included the whole range of forms from the Bituminous limestone member on the south side of Great Slave Lake in *E. castanea*. He also included *Caryorhynchus castanea* (Meek) (var.) of Warren and

Stelck (1956, p. 81, figs. 29–31) and *Caryorhynchus hippocastanea* Crickmay (1960a), both from the Carcajou Ridge area as a large variant of *E. castanea*. *Leiorhynchus hippocastanea* (Crickmay, 1960a) occurs typically in the upper Ramparts Formation of the Carcajou Ridge area, mainly within the conodont *disparilis* Zone of late Givetian age (Braun et al., 1989, fig. 2, p. 96).

Braun, Norris and Uyeno (1989, fig. 2, p. 96) tentatively treated the lower forms in the Bituminous limestone member as *E. castanea* (Meek, 1868) in the sense of the type material from the basal Hare Indian Formation of the Anderson River area. The stratigraphically higher forms were treated as *E.* sp. cf. *E. castanea* (Meek, 1868). *E. castanea* (Meek, 1868) and *L. hippocastanea* (Crickmay, 1960a) appear to be end members of a *castanea–hippocastanea* lineage. However, there are no known sections in northwestern Canada, Nevada, or New York where the complete lineage is found. Probably the most complete sequence of *castanea*-like forms is that present in the Bituminous limestone member on the south side of Great Slave Lake, and most other occurrences are commonly referred to as condensed sequences (Meijer Drees, 1993).

On the northwest side of Great Slave Lake, *Eliorhynchus castanea* has been collected by McLaren (1962, p. 84) from two localities of brown, argillaceous limestone interbedded with dark shale of the Horn River Formation, which outcrop along Clive River, a tributary of Willowlake River.

A revised list of fossils from limestone beds interbedded with shale of the Horn River Formation in core from between 265.18 and 277.37 m in the NWT Deep Bay No. 3 drillhole located at the northwest end of Deep Bay (61°20′00″N, 116°42′30″W), on the northwest side of Great Slave Lake, is indicated below (Norris, 1965, p. 44). These beds have since been placed in the Bituminous limestone member of the Pine Point Formation by Meijer Drees (1993, section 6, fig. 33, p. 61).

undetermined sponge spicules
Buchiola? sp.
cf. *Ontaria* sp.
undetermind orthoconic nautiloid
Schizophoria sp.
Productella spp.
Variatrypa sp. cf. *V. arctica* (Warren)
Desquamatia sp. cf. *D. perfimbriata* Crickmay
Spinatrypa sp. cf. *S. andersonensis* (Warren)
Spinatrypa sp. cf. *S. lata* (Warren)
Hadrorhynchia intermissa Crickmay
cf. *Eliorhynchus castanea* (Meek)
Eliorhynchus castanea (Meek)
Emanuella meristoides (Meek)
undetermined brachiopods
Dechenella sp.
echinoderm ossicles

From the fossils in this core it is apparent that the *E. castanea* beds are not confined to a thin interval, and the composition of the fossils is closely similar to that in the Bituminous limestone member on the south side of Great Slave Lake.

In northeastern British Columbia, *Eliorhynchus castanea* and other fossils occur in a thin band about 0.30 m thick, here placed near the top of the Dunedin Formation at One Ten Creek on the Alaska Highway (Hughes, 1963, p. 4, 5), unconformably overlain by the Muskwa Member of the (Horn River) Besa River Formation. The fauna consists of the following:

Lingula sp. cf. *Lingula minuta* Meek
Devonoproductus sp. cf. *D.* sp. D (=*Productus*? Meek, 1868)
Desquamatia sp.
Desquamatia sp. cf. *D. aperanta* (Crickmay)
Desquamatia aperanta Crickmay
Emanuella? sp.
Emanuella meristoides (Meek)
Warrenella sp. cf. *W. franklinii* (Meek)
Eliorhynchus castanea (Meek)
Hadrorhynchia sp.

At the same section, *Styliolina* sp. and *Nowakia* sp. are abundant in a thin interval of shales and limestones overlying the brachiopod band, and presumably below the unconformity at the base of Musqwa Member (Gray and Kassube, 1963) in the Horn River Formation.

In northeastern British Columbia, Taylor and MacKenzie (1970, p. 15, 16) showed that the top of the Dunedin is diachronous and ranges in age from Eifelian in the north, to Givetian in the south. In the north, "*Schuchertella*" sp. cf. "*S.*" *adoceta* occurs at the top of the Dunedin, and suggests correlation with the lower part of the Hume Formation (Eifelian) of the Mackenzie Valley region. In the central part of the area, *Eliorhynchus castanea* occurs at the top of the Dunedin Formation, which is correlated with the lower part of the Hare Indian Formation (early Givetian). In the southern part of the area, the uppermost beds of the Dunedin Formation contain *Hadrorhynchia sandersoni* and *Halloceras logani*, and in places, *Stringocephalus* sp., of probable mid-Givetian age.

The top of the Nahanni Formation is also diachronous from place to place with fossils typical of the upper Hume Formation in dark shale of the Horn River Formation overlapping the top of the Nahanni Formation at the mountain front south of Nahanni River, seen by the writer in 1957. At other localities, *Eliorhynchus castanea* occurs in a thin, argillaceous limestone layer at the top of the Nahanni Formation, suggesting correlation of that level with the basal Hare Indian Formation (McLaren, 1962, p. 84, hypotypes I, J, K, L, M).

Along the Mackenzie Mountain front, immediately east of Arctic Red River at section 1 (65°21′N, 130°46′W), in the western District of Mackenzie, a rich *castanea* fauna occurs in the 0.6 m of basal beds of the Hare Indian Formation recorded by Norris (1968b, p. 37; 1985, p. 29). The fauna includes:

productellid n. genus and sp.
Spinulicosta sp.
Schizophoria sp. cf. *S. mcfarlanei* (Meek)
Variatrypa sp. cf. *V. arctica* (Warren), and other atrypid species
Hadrorhynchia intermissa Crickmay
Stenoglossaiorhynchus awokanak (McLaren)
Eliorhynchus castanea (Meek)
Emanuella meristoides (Meek)
Warrenella kirki (Merriam)
cf. *Straparolus* sp.

This is one of the few sections known to the writer where the upper range of forms suggestive of *Variatrypa arctica* overlap with the lower range of *Eliorhynchus castanea*. Usually, these two taxa are mutually exclusive.

The type specimens of *Stenoglossaiorhynchus awokanak* (McLaren, 1962) are from the Bituminous limestone member of the Pine Point Formation on the south side of Great Slave Lake. The species ranges from between 7.45 and 42.27 m above the base of the member (Fig. 10). In terms of conodont zonation, it ranges from the upper part of the *ensensis* Zone, through the Lower *varcus* and lower part of the Middle *varcus* subzones, into the lower part of the upper Middle *varcus* Subzone of Uyeno (this report). It is more abundant and its range is longer into younger beds compared to the range of *Eliorhynchus castanea* in the Bituminous limestone member.

The *Hadrorhynchia sandersoni* (Warren) recognized by McLaren (1962, hypotypes GSC nos. 15333, 15334, 15335, 15337, 15338, 15340) in the Bituminous limestone member, was renamed *Hadrorhynchia intermissa* Crickmay (1963, p. 2, 3, Pl. 1, figs, 1, 2; Pl. 7, figs. 1–10). In a report by Sartenaer (1985, p. 218, 220) this species was placed in the genus *Droharhynchia*. The range of *Droharhynchia intermissa* (Crickmay, 1963) in the Bituminous limestone member is from between 7.37 and 29.38 m above the base of the member (Fig. 10). In terms of conodont zonation, *D. intermissa* ranges from the upper *ensensis* Zone, through the Lower *varcus* Subzone, and into the lower part of the Middle *varcus* Subzone where it is scarce. Its range, in the Bituminous limestone member, is almost identical to that of *Eliorhynchus castanea* (Meek).

The type specimens of *Homeocardiorhynchus pityinus* Sartenaer (1985, p. 220, 221, Pl. 26-1, figs. A–C) are from the Bituminous limestone member of the Pine Point Formation on the south side of Great Slave Lake. The range of this species is from 18.82 to 28.62 m above the base of the member, that is, within the middle part of the conodont Middle *varcus* Subzone.

The remaining rhynchonellid brachiopods from the Bituminous limestone member will be described and named in a forthcoming report by P. Sartenaer. On Figure 10 of this report they are indicated informally.

Corals from the Bituminous limestone member of the Pine Point Formation, identified by A.E.H. Pedder (1983b, Internal GSC Report No. AWN-109-AEHP-1983), are as follows (Fig. 10):

Alveolites sp.
Favosites sp.
Thamnopora sp.
Chostophyllum slavorum Pedder
Chostophyllum sp. nov.
Digonophyllum sp. nov.
Lekanophyllum? sp.
Moravophyllum sp.
gen. et sp. nov.

Pedder (1983b) indicated that all of the corals from the Bituminous limestone member on the south side of Great Slave Lake are silicified around the periphery of the coralum, and most of the larger specimens are also impregnated with bitumen. Three of the collections were represented by acid residues only, after treatment for conodont recovery.

According to Pedder (1983), the coral fauna from the Pine Point–Dawson Landing area is not known from any other formational unit, and does not seem to be related to the fauna of the subsurface Pine Point Formation, southwest of Great Slave Lake. Tabulate genera in the fauna comprise *Thamnopora* (2 species)

and rare examples of *Favosites* and *Alveolites*. The Rugosa are all solitary forms and are assignable to six genera: *Digonophyllum* (2 species), *Lekanophyllum*, a new genus close to *Lekanophyllum, Tabulophyllum* (not represented in this collection), *Moravophyllum* and *Chostophyllum* (2 species). This fauna is younger than the faunas from the Hume and Nahanni formations. The relative abundance of cystimorph genera indicate that it is older than the Ramparts and Sulphur Point faunas. On this evidence, Pedder (1983) concluded that the age is early to middle Givetian.

Other macrofossils noted in the Bituminous limestone member, but not described nor illustrated, include the following (Fig. 10):

sponge spicules
Amphipora sp.
bulbous stromatoporoids
cup coral fragments
colonial coral fragments
Favosites sp.
Thamnopora sp.
bryozoan fragments
pentamerids
Spinulicosta sp.
Desquamatia sp.
Emanuella sp.
Echinocoelia sp.
spirally coiled gastropods
Conocardium sp.
orthoconic cephalopod
undetermined cephalopod
Paracyclas sp.
goniatite fragments
Dechenella sp.
ostracodes
crustacean
Nowakia sp.
Nowakia sp. cf. *Nowakia otomari* Bouček and Prantl
Nowakia otomari Bouček and Prantl
Striatostyliolina sp.
Striatostyliolina roemeri Bouček
Styliolina sp.
Styliolina fissurella (Hall)
Tentaculites sp.
Variatella sp.
Unicornus sp.
echinoderm ossicle with single axial canal
large echinoderm ossicle with single axial canal
five star-shaped echinoderm ossicle with single axial canal
five-sided echinoderm ossicle with single axial canal
square-shaped echinoderm ossicle with single axial canal
cf. *Tasmanites* sp.
plant tissue
fish bone fragments

Some of the more significant and useful macrofossils in the above list include the following dacryoconarids (thin-shelled tentaculitids) (Fig. 10):

Nowakia otomari Bouček and Prantl
Striatostyliolina roemeri Bouček
Styliolina fissurella (Hall)

Nowakia otomari occurs typically in the Kačák Shales of Czechoslovakia (Bouček, 1964, p. 94) where this rock unit forms the base of the Givetian, of late Middle Devonian age, and occurs sparingly in the overlying Roblin Beds, also of Givetian age. In the Kačák Shales it is always associated with *Styliolina fissurella* and *Striatostyliolina roemeri*. Lardeux (1969, Table 12, p. 204) also records a *N.* cf. *otomari* from beds of Givetian age in North Africa.

Revised datings of the range of *N. otomari* by Lutke (1979) and Alberti (1979) indicated that in western Europe this form occurs within the conodont *ensensis* Zone. Alberti (1979) erected *Nowakia bianulifera* n. sp. for a nowakiid occurring above *N. otomari* and ranging within a part of the conodont *varcus* Zone.

N. otomari in the Bituminous limestone member occurs between 16.54 and 32.82 m above the base of the member. It ranges more or less throughout the lower Middle into the lower part of the upper Middle *varcus* Subzone as determined by Uyeno (this report).

Striatostyliolina roemeri in the Bohemian Basin of Czechoslovakia is rare in the Daleje Shales, moderately abundant in the Třebotov Limestones, both of Eifelian age, and rare in the Kačák Shales of early Givetian age (Bouček, 1964, Table 5).

Styliolina fissurella in Czechoslovakia occurs abundantly in the Daleje Shales, is moderately abundant in the lower and upper parts of the Trevbotov Limestones of early Eifelian age, moderately abundant in the Choteč Limestones of late Eifelian age, abundant in the Kačák Shales of early Givetian age, and is questionably present in the Roblin Beds of Givetian age (Bouček, 1964, Table 5).

S. fissurella in the Bituminous limestone member occurs in almost every sample between 11.77 and 45.20 m above the base of the member (Fig. 10). It ranges from the upper part of the Lower *varcus*, through the lower part of the Middle, and into the lower part of the upper Middle *varcus* Subzones of Uyeno (this report).

Fisher (1962, p. W105) has indicated that the thin-shelled tentaculitids, the dacryoconarids, were pelagic (principally planktonic), which inhabited the upper levels of the oceans, and achieved rapid world-wide disperal via transoceanic currents. It is these features of dacryoconarids which enhances their value for dating and correlation.

Five morphotypes of echinoderm ossicles are recognized in the Bituminous limestone member, and are informally designated as follows (Fig. 10):

echinoderm ossicle with single axial canal
large, circular echinoderm ossicle with single axial canal
five star axial canal with single axial canal
five-sided echinoderm ossicle with single axial canal
square echinoderm ossicle with single axial canal

One morphotype, an echinoderm ossicle with single axial canal, ranges throughout the Bituminous limestone member.

Two morphotypes, a five star-shaped echinoderm ossicle with single axial canal, and a five-sided echinoderm ossicle with single axial canal, range throughout most of the Bituminous limestone member except for the lower part of the sequence which is equated with the conodont *ensensis* Zone of Uyeno (this report).

One morphotype, a square-shaped echinoderm ossicle with single axial canal, has a limited distribution from between 5.20 and 7.98 m above the base of the Bituminous limestone member. This range is aligned with the upper part of the conodont *ensensis* Zone, and the lower part of the Lower *varcus* Subzone of Uyeno (this report).

One morphotype, a large echinoderm ossicle with single axial canal, has a limited distribution in the upper part of the Bituminous limestone member, between 31.50 and 42.47 m above the base of the member. This range is aligned essentially with the conodont upper Middle *varcus* Subzone of Uyeno (this report).

Skall (1975, p. 27) in interpreting the paleoenvironments of the sediments of the Pine Point lead–zinc district placed considerable emphasis on the crinoid–brachiopod-coral assemblages as indicators of open marine conditions. The relative amounts of argillaceous and carbonaceous material were used as indicators of the "energy level" of the medium depositing the sediments. He used the appearance of *Tentaculites* sp. (probably *Nowakia* sp.) and *Styliolina* sp. to mark the transition from a platform to a pelagic (basinal) facies.

Audretsch (1968, p. 837, 846) reported that the upper beds between 109.1 and 118.3 m of the Bituminous limestone member of the Pine Point Formation in the Cominco G-4 borehole (60°54′N, 114°46′W) contain prolific megaspore-like entities, but nothing else, assigned to the microplankton (acritarch) genus *Leiosphaeridium*. They are not yet useful for precise dating but appear to characterize some dark shale facies such as the Exshaw Shale of Alberta and part of the Bituminous limestone member.

Buffalo River Member

The name Buffalo River Formation was proposed by Campbell (1950, p. 94) for a unit of green shale more than 30.5 m thick penetrated by two drillholes immediately west of the mouth of Buffalo River (see Norris, 1965, fig. 7, section C–D) on the north flank of the Pine Point carbonate barrier complex. In these drillholes the shale lies below a southward-thinning unit of fine grained porous dolomite of the Fine-grained dolomite member, and above argillaceous limestone of the Bituminous limestone member, both of the Pine Point Formation. Later, Campbell (1957, p. 169) redefined the unit to the Buffalo River Member, consisting of bluish-grey to dark green, fissile, calcareous shale containing concretionary iron sulphide. He gave a thickness of 50.3 m on data from the Cominco Test G-4 drillhole (60°54′N, 114°46′W). Belyea and Norris (1962) and Norris (1965, p. 53) raised the upper boundary above that selected by Campbell (1957) to include an additional 6.2 m of shale and limestone (total thickness 56.5 m). As revised, the Buffalo River Member is 56.5 m thick in the Cominco Test G-4 drillhole, which is the type section of the member. In this drillhole, the Buffalo River Member underlies the Windy Point Member of Rhodes et al. (1984), of the revised Sulphur Point Formation, and overlies the Bituminous limestone member of the Pine Point Formation (Figs. 4, 8, 9). The Buffalo River Member is not represented in outcrops.

The Buffalo River Member is described by Rhodes et al. (1984, p. 1004, 1005), on the basis of closely spaced drillholes, as a southward thinning wedge of grey-green shales and some carbonates flanking the north side of the Pine Point carbonate barrier complex. The member can be traced westwards in the subsurface across Great Slave Lake to the west end of the lake where it terminates within the Bituminous limestone member (see Meijer Drees, 1993, fig. 33).

Representative thicknesses in the subsurface across the west half of the lake are as follows: about 34.4 m in the Hay River B-52 drillhole near the mouth of Hay River (60°51′04″N, 115°40′17″W); 39.6 m in the Big Island O-78 drillhole at the east end of the island (61°07′47″N, 116°28′38″W), and about 40.2 m in the NWT Deep Bay 3 drillhole near the northwest end of Deep Bay (61°20′00″N, 116°42′30″W) (Meijer Drees, 1993, fig. 33).

Five lithostratigraphic units are recognized by Lantos (1983) within the Buffalo River Member: the G–B (bioturbated limestone) lithofacies, G5 (dolarenite) lithofacies, G1 (shale) lithofacies, G2 (nodular) lithofacies, and G–B marker bed.

The G–B lithofacies of Lantos (1983, p. 30–32) is the basal unit of the Buffalo River Member where it conformably overlies Skall's (1975) marine B and F facies of the Pine Point Formation. It has a maximum thickness of 6.5 m in the northernmost drillholes, and consists mainly of light grey-brown, dense micritic limestone, which shows a well developed bioturbated and burrowed texture.

The G5 lithofacies of Lantos (1983, p. 32–34) is the basal unit of the Buffalo River Member, where it overlies the various fore-reef facies of the Pine Point Formation. The average maximum thickness is 1.5 m. It is primarily a brownish grey, fine to medium crystalline, fairly dense, massive calcarenite. It is rarely preserved as limestone, but is nearly always dolomitized.

The G1 lithofacies of Lantos (1983, p. 34–36) is the predominant and characteristic unit within the Buffalo River Member, and consists of greenish grey, fissile, calcareous shale. In the Cominco Test G-4 drillhole it has a maximum thickness of 48 m. It shows a marked paucity of macrofauna, with the exception of rare brachiopod shells.

The G2 lithofacies of Lantos (1983, p. 36–38) occurs primarily as two distinct interbeds within the G1 lithofacies. The beds reach a maximum thickness of 3.5 m and pinch out toward the north and south. This lithofacies is a nodular, argillaceous limestone, and is considerably more competent than the surrounding shales. The nodules are variable in size, ranging up to 5 cm in thickness, and are generally elongate parallel to bedding. Macrofossils are more abundant here than in the G1 lithofacies, with brachiopods occurring sporadically.

The G–B marker bed of Lantos (1983, p. 38–39) occurs as a thin, uniform and laterally continuous unit towards the top of the Buffalo River Member, and consists of a medium to dark brown, fine grained carbonate, with some argillaceous laminae. It is both underlain and overlain by G1 (shale) lithofacies, and has an average thickness of 0.5 m. Paucity of fauna suggests inhospitable conditions of deposition.

Biostratigraphy

Lantos (1983) indicated that all of the Buffalo River lithofacies are barren of macrofossils except for the northern part of the G–B marker bed, which contains a diverse fauna including thamnoporid corals, pancake/tabular stromatoporoids, and occasional thin-shelled brachiopods, which have not been studied. However, Lantos (1983, p. 68, fig. 14) reported conodonts from all five of the lithofacies, which she dated as Middle *varcus* Subzone of mid-Givetian age.

Audretsch (1968) described a microfloral assemblage of eighteen spores, two chitinozoans and five acritarchs from the Buffalo River Member of the Pine Point Formation in the Cominco G-4 borehole between 52.4 and 109.1 m depths. The microflora from the Buffalo River Member most closely resembles an assemblage described by Naumova (1953) from the Middle Devonian (upper Givetian) of the Russian Platform.

Sulphur Point Formation

The name Sulphur Point Formation was introduced by Belyea and Norris (1962) as a map unit in the Great Slave Lake area, with the type section in the Cominco Test G-4 drillhole between 6.1 and 52.7 m depths. Meijer Drees (1993) redefined the Sulphur Point Formation in this drillhole to apply to an interval between 35 and 53 m depths.

The above redefinition by Meijer Drees (1993) restricts the stratigraphic interval of the map unit in the Great Slave Lake region but leaves it in its intended original form in the area west of the lake where the Watt Mountain Formation is a mappable unit. At the time of its defintion, geologists working in the Pine Point Mines District, on the south side of Great Slave Lake, did not use the Watt Mountain as a map unit. Thus, beds now recognized as equivalents of the Watt Mountain Formation were formerly included within the Sulphur Point Formation. However, in the region west of Great Slave Lake, where the Watt Mountain is easily recognizable, the top of the Sulphur Point Formation was defined below the Watt Mountain Formation (Belyea and Norris, 1962, fig. 3).

Rhodes et al. (1984) introduced the name Windy Point Formation for the restricted lower part of the Sulphur Point Formation in the type Cominco Test G-4 drillhole. However, they continued to use the Sulphur Point Formation as a regional map unit for strata between the Watt Mountain Formation (above) and the Pine Point or Muskeg formations (below). In this report the Windy Point beds of Rhodes et al. (1984) present around Presqu'ile Point are treated as a member of the Sulphur Point Formation.

The cores of the Cominco Test G-4 drillhole are not easily accessible to the public, and the section does not include a set of geophysical borehole logs. Therefore, Meijer Drees (1993, p. 137) proposed to use the section between 179.2 and 223.7 m in the Horn River et al. Hay River B-52 drillhole (60°51′04″N, 115°40′17″W) as a reference for the redefined Sulphur Point Formation.

Lantos (1983) and Rhodes et al. (1984) suggested that the carbonates between the Watt Mountain Formation and the Buffalo River Member of the Pine Point Formation in the area north of the Presqu'ile Barrier are significantly younger and not in mappable continuity with the carbonates situated between the Muskeg and Watt Mountain formations south of the barrier (see Meijer Drees, 1993, fig. 60, p. 131). However, the regional information presented by Meijer Drees (1993) indicates that the Sulphur Point Formation, as currently restricted, is in mappable continuity with the carbonates (Bistcho Formation) south of the barrier.

Lantos (1983, p. 127) redescribed the type section of the Sulphur Point Formation of Belyea and Norris (1962), and assigned the upper part to the Watt Mountain Formation, and the lower part to the informal "Biostromal" unit (the Windy Point Formation of Rhodes et al., 1984). The redefined Sulphur Point Formation includes a lower, massive biostromal unit (the Windy Point Member) composed of light brown, stromatoporoidal and coralline limestones and dolostones, and an upper unit of interbedded limestone and shale. According to Campbell (1957), the biostromal unit is 6.7 m thick, and according to Lantos (1983) it is 10.3 m thick. The upper unit is a grey, very fine textured limestone that includes scattered green shale partings. This unit is 10.8 m thick according to Lantos (1983). She considered the upper unit to be a lower member (the "Basal Marine" member) of the Watt Mountain Formation. Meijer Drees (1993, p. 138) included the "Basal Marine" member with the redefined Sulphur Point Formation, and following the usage of Belyea and Norris (1962), he selected the boundary between the Sulphur Point and Watt Mountain formations at the base of the "Lower Shale" member of Lantos (1983).

The subdivision of the redefined Sulphur Point Formation in the Pine Point Mines District into lower and upper members is applicable also in the western part of Great Slave Lake (Meijer Drees, 1993, p. 138).

In the Horn River et al. Hay River B-52 drillhole (60°51′04″N, 115°40′17″W), the lower part of the Sulphur Point Formation between 211.8 and 223.7 m consists of greyish brown to brown limestone, in part argillaceous, and in part fossiliferous, with crinoid ossicles, ostracodes and brachiopods. The upper part, between 179.2 and 211.8 m, is a light greyish brown, very finely to finely, or finely to coarsely crystalline, in part porous, dolostone (Meijer Drees, 1993, p. 138–140).

In the McDermott et al. Hay River I-41 drillhole (61°00′37″N, 115°37′58″W), located about 27 km north of the Hay River B-52 drillhole, the Sulphur Point Formation is present between 92 and 117.9 m, and is sharply overlain by silty limestone of the Watt Mountain Formation. The lower member of the formation (Windy Point Member) consists of massive, greyish brown, fine or very fine grained, partly dolomitized packstone, which grades locally into a stromatoporoidal floatstone. At 99.9 m, the Windy Point Member is overlain by the Upper member, a succession of interbedded greyish brown and light greyish brown limestone. This succession includes very thin interbeds of dark grey marlstone and limestone containing minor amounts of brown clay and quartz silt (Meijer Drees, 1993, p. 140).

On the north tip and along the east shore of Presqu'ile Point there are discontinuous accumulations of large, massive blocks of limestone of the Lower member (Windy Point Member) of the Sulphur Point Formation. These blocks are up to about one metre in maximum diameter, and are derived, presumably, from outcrops a short distance offshore below lake level. They have been transported to the shore by storm waves and moving ice during periods of spring breakup. Cameron (1922, p. 22) indicated that the beds now represented by blocks were formerly exposed at low-water level around Presqu'ile Point (Figs. 4, 8, 9).

The predominant lithology of the blocks is a light brownish grey, finely granular, massive limestone, weathering a pale orange-brown, that has been incipiently and variably dolomitized. The blocks contain numerous, generally fragmentary thick-shelled brachiopods, thamnoporid corals and stromato-

poroids. Where the rock has been dolomitized, it has a more granular texture, is highly porous and relatively soft, and generally weathers to a pronounced orange colour.

Biostratigraphy

The lower reefal unit is represented by large blocks of fossiliferous limestone extending from the northern tip along the east shore of Presqu'ile Point. The following fossils have been collected from the Presqu'ile Point locality:

Disphyllum sp. cf. *D. hsianghsiense* Yoh (identified by Pedder, 1983)
Gypidula? *presquilensis* Norris n. sp.
Spinatrypa sp. A
Elita? sp.
Stringocephalus sp. B of Warren and Stelck, 1962
Hypothyridina cameroni Warren, 1944
Cyrtina sp.

The coral, *Disphyllum* sp. cf. *D. hsianghsiense* Yoh, identified by Pedder (1983), is characterized by rhomboid dissepiments and coarse, rather flat-lying trabeculae. It is closely related to Givetian cerioid species, such as *Argutastrea arguta* Crickmay, which occurs in the Ramparts Formation of Givetian, late Middle Devonian, age.

The brachiopod *Gypidula? presquilensis* Norris n. sp. is sparsely represented in the blocks of reefal limestone along the east side of Presqu'ile Point. This form has some similarities with an undescribed species referred to as *Gypicula* sp. B by A.E. Wilson (*in* Martison, 1953, p. 44, 59), which was collected by W.S. Dyer (1928, p. 27) from the Williams Island Formation on the west side of Williams Island, Abitibi River, northern Ontario (Royal Ontario Museum specimen 26372, Toronto). *Gypidula* sp. B was derived, presumably, from the Upper member of the Williams Island Formation, which ranges from the Middle *varcus* Subzone to the lower part of the *disparilis* Zone, of Givetian age.

Gypidula? *presquilensis* Norris n. sp. is most closely similar to a form designated as *Gypidula* sp. cf. *G. comis* (Owen) by Warren and Stelck (1956, Pl. 5, figs. 5–8) collected from the Ramparts Limestone, Hanna River, District of Mackenie. This form is considered by Warren and Stelck (1956) to be a typical element of their "*Stringocephalus burtini* fauna" of Givetian age.

Spinatrypa sp. A somewhat resembles *Spinatrypa hornensis* Norris, (*in* McLaren and Norris, 1964, p. 55, 56, Pl. 16, figs. 3–8) which occurs in the upper beds of a pinnacle reef at the top of the Horn Plateau Formation exposed northwest of Great Slave Lake, District of Mackenzie. The top of the reef contains conodonts of the *varcus* Zone of Givetian age.

Elita? sp. from the Sulphur Point Formation on Presqu'ile Point is closely comparable to *Elytha subundifera* (Meek and Worthen, 1868), which occurs in the Berthlet Member of the Milwaukee Formation at Milwaukee, Wisconsin (Griesemer, 1965, p. 285; Schumacher, *in* Clark, 1971, p. 65), and in the "*Atrypa*" *bellula* and "*Acervularia*" zones of the Cedar Valley Limestone of Iowa (Stainbrook, 1940, p. 414–415, Pl. 1, figs. 1–5, 7, 8; Pl. 2, fig. 8). The Berthlet Member and *bellula* Zone are correlated with the lower part of the conodont *hermanni* Zone of Givetian age. The "*Acervularia*" Zone in the upper part of the Solon Member is correlated with the upper part of the conodont *varcus* Zone of Givetian age (Witzke et al., 1989, fig. 15, p. 248). The genus *Elita* appears to be commonly associated with stringocephallids as indicated by Crickmay (1960, p. 878, 879, 883).

The blocks of reefal limestone of the Sulphur Point Formation at the tip and along the east shore at Presqu'ile Point are the main source of specimens of *Stringocephalus* collected from the Great Slave Lake area by E.M. Kindle and E.J. Whittaker in 1917 (Field Note Books; Kindle, 1921, p. 21, 24), by Cameron (1922, p. 14, 22) in 1916 and 1920, and by others. The stringocephalids from this locality were designated informally as *Stringocephalus* sp. B by Warren and Stelck (1962, p. 288, 289), and for lack of more and better preserved specimens their informal designation is followed here. Fragmentary specimens are abundant but complete specimens are exceedingly rare. It appears to be the youngest *Stringocephalus* so far collected from northwestern Canada. As is common for reefal carbonates, two large samples from the Presqu'ile Point locality were processed and found to be barren of conodonts.

The east side of Presqu'ile Point is also the type locality for *Hypothyridina cameroni* Warren (1944, p. 114, 115, Pl. 2, figs. 11, 12). It appears to be a very rare form because Warren (1944) indicated that his description was based on only three specimens. In spite of several days of careful searching at this locality, no additional specimens were found. However, a poorly preserved specimen of *H. cameroni* was collected from

a small erosional remnant of limestone, probably Sulphur Point Formation, overlying brown, fine grained dolomite of the "Presqu'ile" Formation, located 3 km east of the southern quarter of Prairie Lake on the northwest side of Great Slave Lake.

Another form that has not been duplicated at the Presqu'ile Point locality is an elongate *Cyrtina* sp. with an angular V-shaped sulcus, as seen in profile, on the pedicle valve. This form was illustrated by McLaren et al. (1962, Pl. 10, figs. 1–3, p. 22), and was collected by E.M. Kindle and E.J. Whittaker in 1917. It is closely similar to one of the specimens of *Cyrtina hamiltonensis* Hall, described and illustrated by Meek (1868, p. 99, 100, Pl. 14, figs. 7a, 7b) which was collected from the "Ramparts" on Mackenzie River. The carbonate beds forming the "Ramparts" are the lower bedded platform and upper reefal parts of the Ramparts Formation in the sense of Braun (1966).

The interval of limestone, dolomite and shale between 45.1 and 58.5 m in the Cominco G-4 drillhole is within the lower part of the Sulphur Point Formation and uppermost part of the Buffalo River Member of the Pine Point Formation of Belyea and Norris (1962, fig. 3). From this interval, Skall (1975, p. 27) reported the following ostracodes, identified by Peter McGill:

Sulcella refrathensis Krommelbein, 1952
Rozhdestvenskayites sp. cf. *R. diuturna* McGill, 1966
Winchellatia sp.
Hypotetragona sp.
Libumella sp.
Bairdiocypris sp.
Aparchites keescarpensis McGill, 1968
Falsipollex sp. cf. *F. sufflatus* Becker, 1964

The above ostracodes were dated by McGill as mid-Givetian.

The tetracoral *Grypophyllum mackenziense* (Pedder, 1962, 1967, p. 107–111, Pl. 13, figs. 7–12; Pl. 14, figs. 1–8; Pl. 15, figs. 1–3, ?4, 5–10; textfigs. 48–58), and the brachiopod *Emanuella vernilis* Crickmay (1967, p. 8, 9, Pl. 22, figs. 13–19; Pl. 3, figs. 7–9) have been collected from beds of stromatoporoidal limestone (biolithite) mapped by Norris (1965) as the Sulphur Point Formation in the Burnt Point area on the northwest side of Great Slave Lake. This lower level of *G. mackenziense* is dated by conodonts as within the *hermanni* Zone of Givetian, late Middle Devonian, age in the Powell Creek area (Pedder, 1973, p. 111).

Emanuella vernilis Crickmay (1967, p. 8, 9) occurs also at a higher level in the Slave Point Formation at Gypsum Cliffs, Peace River, northern Alberta. This upper level of occurrences is within the conodont *subterminus* fauna of late Givetian, late Middle Devonian, age (Braun et al., 1989, p. 96, 97).

Watt Mountain Formation

The Watt Mountain Formation of Law (1955) was redefined by Belyea and Norris (1962) to apply to a relatively thin, subsurface map unit consisting of green, silty and pyritic shale, arkosic or quartzose sandstone, nodular and argillaceoous limestone or dolostone, limestone breccia, and minor amounts of anhydrite. The formation forms a useful regional log-marker in the subsurface of central and northern Alberta, northeastern British Columbia, and the southern District of Mackenzie. In northern Alberta and southern District of Mackenzie, the formation overlies the Sulphur Point or Muskeg formations and is overlain by the Fort Vermilion or Slave Point Formation (Meijer Drees, 1993, p. 148) (Fig. 4).

At the type section in northern Alberta, the California Standard Steen River 2-22 drillhole (2-22-117-5W6), the redefined Watt Mountain Formation is 12.5 m thick and includes, in ascending order (Meijer Drees, 1993, p. 151): (1) a lower shale and limestone rubble member (4.1 m thick), (2) a middle shale member (1.7 m thick), and (3) an upper, interbedded shale and limestone member (6.7 m thick).

In the Great Slave Lake area, the lithology of the Watt Mountain Formation is described by Skall (1975, p. 33, 34) from the Cominco G-4 drillhole as consisting of cream to buff and light grey to light green, micritic limestone, altered in part to a finely crystalline dense dolomite. Scattered throughout the formation are discontinuous thin layers of waxy, light green shale or clay. The formation occurs between depths of 16.2 to 44.2 m.

In the Great Slave Lake area, the Watt Mountain Formation does not include a limestone breccia. Wiley (1970), Skall (1975), Lantos (1983), and Rhodes et al. (1984) described the Watt Mountain succession in the Cominco Pine Point Mines district. At the time of preparation of the reports by Belyea and Norris (1962) and Norris (1965) there were far fewer drillholes in the Pine Point area on which to assess the presence of the Watt Mountain Formation, although the formation was easily recognized to the south and west. At the time, the Amco shale and underlying limestone with

charophyte oogonia were identified by Law (1955, p. 1951, 1952) as possibly being coeval with the Watt Mountain Formation. In addition, Campbell (1950, 1966, p. 956) identified five beds within a vertical interval of 9.1 m of fragmental limestone and bluish green clay or shale underlying the Amco shale, containing abundant charophyte oogonia. These green algae, along with the residual clay, pointed to a change from marine to fresh- or brackish-water conditions and a local disconformity at the base of the sequence.

Braun, Norris and Uyeno (1989) have suggested, on the basis of faunal evidence, that the Watt Mountain Formation in the Pine Point area is considerably younger than that on the north flank of the Peace River Arch, Alberta, and in the Swan Hills area, Alberta.

Lantos (1983, p. 47) indicated that the Watt Mountain is generally less than 10 m in thickness where it disconformably overlies the central portion of the Pine Point barrier complex, but thickens northward reaching a maximum thickness of 32.5 m on the north flank of the barrier.

Lantos (1983) subdivided the Watt Mountain Formation into seven members, as follows: (1) Lower shale member, (2) Silty dolomite member, (3) Lower micrite member, (4) Upper shale member, (5) Upper micrite member, (6) Gritty member, and (7) Blotchy member. This subdivision of lithologies by Lantos is quite different from that proposed by Wiley (1970), but it is the breakdown used by the geologists of Pine Point Mines Limited.

The Lower shale member (Lantos, 1983, p. 48–52) reaches a maximum thickness of 9.8 m and consists of a sequence of blue-green marl, or argillaceous limestone and dolomite, together with some highly intraclastic beds of cleaner, cream coloured micrite. Gypsum and/or anhydrite is developed locally in the north within the marls. The unit contains rare charophyte oogonia.

The Silty dolomite member (Lantos, 1983, p. 52, 53) averages 3 m in thickness over the barrier complex, but increases in thickness towards the north. The member is a distinctive, light cream-brown coloured dolomite, in places with a finely laminated appearance. The member is barren of fossils.

The Lower micrite member (Lantos, 1983, p. 53, 54) overlies the Silty dolomite member and is overlain by the Upper shale member. It averages approximately 3 m in thickness, and consists of a fairly dense, very light creamy brown, micritic limestone with some darker brown mottling and faint laminae. The interval is devoid of fossils.

The Upper shale member (Lantos, 1983, p. 54, 55) generally averages less than 3 m in thickness, and it immediately overlies the Lower micrite member and is in turn overlain by the Upper micrite member. It consists of a heterogenous sequence of shales and dull coloured earthy marls that are soft and fissile. The central third of the interval, 1.0 to 1.5 m in thickness, is dominated by dark, blue-green, limy shales. Rare charophyte oogonia are sporadically preserved, but commonly the interval is barren of shelly fossils.

The Upper micrite member (Lantos, 1983, p. 55) averages 3 m in thickness. It consists of a light creamy white, homogenous, micritic limestone that is strongly stylolitic and exhibits cellular vugginess, interpreted as leached molds of gypsum crystals. The interval is devoid of fossils.

The Gritty member (Lantos, 1983, p. 55–57) is discontinuous, but where present it averages approximately 1.5 m in thickness. The member consists of a competent, milky blue-green, dull coloured, earthy, argillaceous limestone. The interval is characterized by two features which, together, impart a "gritty" texture. Firstly, the member contains abundant charophyte oogonia, and secondly, a fine, intraclastic texture is commonly developed.

The Blotchy member (Lantos, 1983, p. 57–59) is by far the thickest member, averaging approximately 7.5 m. It is the uppermost member of the Watt Mountain Formation, and hosts a laterally continuous *Amphipora* marker bed. The member is primarily a dense, micritic limestone, light creamy grey to brownish grey in colour. It has a blotchy or mottled appearance due to reduction of iron sulphide concentrations. The mottles are medium to dark bluish grey in colour. The *Amphipora* bed is generally less than 0.2 m thick and is typically darker brown in colour than the surrounding limestone. Scattered charophyte oogonia and amphiporids are present. The latter are interpreted to indicate a change to more open-marine conditions, in constrast to the generally brackish water conditions for the bulk of the formation.

Biostratigraphy

From an interval between 18.6 and 39.0 m in the Cominco G-4 drillhole, Skall (1975, p. 34) reported ostracodes of late Givetian age, presumably identified and dated by Peter McGill.

The charophyte oogonia in the Watt Mountain Formation were assigned by Wiley (1970, p. 22, 23) to two species: *Eochara wickendeni* Choquette and *Chovanella burgessi* Peck and Eyer, which had been described by Peck and Morales (1966, p. 309, 310) from the Elk Point Group of Alberta, as well as from the Watt Mountain and Slave Point formations of Alberta. Fossil charophytes are widely accepted as indicating a nonmarine fresh to brackish water depositional environment (Loranger, 1965; Peck and Morales, 1966; Rice, 1970). However, Racki (1982) has pointed out that some charophytes in Devonian rocks of central Poland point to an autochthonous open marine environment, and suggests that their presence should be interpreted with caution.

Elements of the conodont *Icriodus subterminus* fauna are possibly present in the upper part of the Watt Mountain Formation along and near the south shore of Great Slave Lake (Uyeno, *in* Braun et al., 1989). If this is correct, the so called Watt Mountain Formation of the Great Slave Lake area is of late Givetian age, and considerably younger than the Watt Mountain Formation of the Swan Hills and north flank of the Peace River arch areas of northern Alberta.

Slave Point Formation

The Slave Point Formation forms the uppermost map unit of the Middle Devonian carbonate succession in northern Alberta, northeastern British Columbia and southern District of Mackenzie (Meijer Drees, 1993, p. 158). Throughout a large part of this area, it conformably overlies the Fort Vermilion Formation and is sharply and disconformably overlain by Middle Devonian shale beds (Braun et al., 1989).

The term Slave Point was first used in the Great Slave Lake area by Cameron (1918, 1922) and later by Campbell (1950, 1957). The formation is discontinuously and poorly exposed, consequently Cameron was unable to give a complete description. The definition of the Slave Point Formation was formalized by Law (1955) who selected a reference section in the subsurface of northern Alberta, the California Standard Steen River 2-22 drillhole (2-22-117-5W6). Law (1955) included within the Slave Point Formation a lower anhydritic unit, the Fort Vermilion Member, which is not present in the outcrop areas of Great Slave Lake. Law's (1955) definition of the Slave Point Formation was followed by numerous workers including Belyea and Norris (1962), Grayston et al. (1964), Norris (1965), Griffin (1965), McCamis and Griffith (1967), Belyea (1971), and Rhodes et al. (1984). Norris (1963) raised the Fort Vermilion to formation rank based on the exposed sequence at Gypsum Cliffs on Peace River in northern Alberta.

Meijer Drees (1993, p. 160) proposed the name Steen Member for a distinct basal member of the Slave Point Formation about 1.5 m thick, consisting of an argillaceous and pyritic limestone bed, and dolostone and aphanitic limestone beds, overlying the Fort Vermilion Formation, between 1348.1 and 1349.7 m in the Steen River 2-22 drillhole.

Meijer Drees (1993, p. 161) applied the informal name Limestone member to the upper part of the Slave Point Formation in the interval between 1301.5 and 1348.4 m in the Steen River 2-22 drillhole. This interval consists of interbedded, brownish grey, brown and olive-grey, aphanitic, microfragmental and fossiliferous, in part dolomitic or anhydritic, limestone. In the fossiliferous beds are scattered brachiopods, stromatoporoids, ostracodes and gastropods (Law, 1955).

In the Imperial Yates River 16-18 drillhole (16-18-126-14W5), the Limestone member of the Slave Point Formation is 44.2 m thick. It consists of nodular, greyish brown, dolomitic limestone, and massive, fine peloidal, and very fossiliferous wackestone, which contains scattered, rounded fragments of bulbous and digitate stromatoporoids, gastropods, brachiopods, and small limestone pebbles (Meijer Drees, 1993, p. 163).

The lithology of the Slave Point in the CDR Wood Buffalo C-74 drillhole (60°33′07.79″N, 114°44′05.02″W), in the District of Mackenzie just north of the northern boundary of Wood Buffalo National Park, is similar to the lithology in the Imperial Yates River drillhole. At this location the Limestone member is 65.5 m thick (Meijer Drees, 1993, p. 163).

On the south side of Great Slave Lake, there are a few outcrops of the Slave Point Formation along the shore east of the mouth of Buffalo River and along the river (Norris, 1965, fig. 7). The formation was penetrated by a large number of drillholes in the vicinity of Buffalo River in the Cominco Pine Point Mines area (Rhodes et al., 1984).

In the Pine Point Mines area, the Slave Point Formation disconformably overlies the Watt Mountain Formation, and is disconformably overlain by the Hay River Formation (Fig. 4). In this area, it has been described by Belyea and Norris (1962), Norris (1965), Richmond (1965), Skall (1975, 1977), and others.

Thin sequences of Slave Point beds are exposed beween 3.6 and 4.0 km east of the west side of Breynat Point (Norris, 1965, p. 75, fig. 7). The beds consist of light to medium brown and greyish brown, fine- to medium-grained, thin bedded limestone, which is in part dolomitic and in part brecciated. Some of the beds contain wisps and laminae of black carbonaceous material.

Stratigraphically higher thin sequences of beds of the Slave Point Formation are exposed at four main localities along the lower stretch of Buffalo River (Norris, 1965, p. 75, fig. 7). Beds represented consist of massive, quartzose sandy limestone; light brown aphanitic limestone, thinly interbedded with fine grained granular limestone containing dark carbonaceous wisps; massive light brown limestone; coarse grained clastic limestone; and dark grey to black medium-grained sandy limestone. A thin bed of flat pebble conglomerate is present near the top of the discontinuously exposed sequence.

In the Amco Test No. 14 drillhole (60°43′N, 115°01′W), located 11.4 km west of Buffalo River, the thickness of the Slave Point Formation between the base of the Hay River Formation and the base of the Amco shale is 61.6 m (Belyea and Norris, 1962, fig. 3).

In the subsurface of the Pine Point Mines area, the Slave Point Formation has been subdivided by Skall (1975, 1977) into four facies or members as follows, in ascending order: Facies M (Amco Member), Facies N (Tidal flat member), Facies O (Shallow platform member), and Facies P (Deep platform member).

Facies M (Amco Member)

Facies M (Skall, 1975, p. 35; 1977, p. 35) consists of a grey to bluish-grey limy, burrow-mottled shale, in part dolomitic, which contains some disseminated iron sulphides. The shale occurs between two limestone units, which are locally altered to a dense dolomite. The limestone is buff to buff-brown, slightly argillaceous to argillaceous sandy micrite, containing abundant carbonaceous wisps, and some disseminated bitumen. The thickness of the limy shale is fairly uniform at about 6.1 m. The limestone units are generally thin but reach a maximum development of a few metres. The total thickness of the facies rarely exceeds 9.1 m. The Amco Member is a distinctive marker, but unfortunately cannot be recognized beyond the Pine Point Mines area (Skall, 1975, p. 35; 1977, p. 35).

Facies N (Tidal flat member)

Facies N of Skall (1975, p. 35; 1977, p. 35) consists of buff-grey micritic limestone which is in places altered to fine grained, dense dolomite where associated with minor nodular anhydrite. The limestone is generally stylolitic, laminated, and thin bedded. Blotchy bedding, birds-eyes, and stromatolites are common. Blade-like crystal molds after gypsum, and traces of sulphur occur sporadically, suggesting correlation with the Fort Vermillion Formation of northern Alberta. The member varies in thickness from 10.7 to 18.3 m and grades upward into Facies O of the Slave Point Formation.

Facies O (Shallow platform member)

Facies O of Skall (1975, p. 35, 36; 1977, p. 37) is a buff-brown limestone composed of sandy micrite and micritic sandstone. Large intraclasts, greater than 2 mm, are common and characteristic of the facies. The limestone is slightly argillaceous, with shaly wisps and black shale laminae. The common buff-brown colour can change locally to dark brown and black due to disseminated bitumen. Intercalated with this slightly argillaceous wackestone are a few discontinuous layers of the underlying Facies N.

Facies O is preserved west of Buffalo River only, where a thickness of approximately 24.4 m was measured.

Facies P (Deep platform member)

Facies O of Skall (1975, p. 36; 1977, p. 37) grades upward into a deeper marine transitional lithofacies that occupies the uppermost 6.1 to 12.2 m of the Slave Point Formation. It is lithologicalally very similar to Facies O, but differs in that *Amphipora* disappear, and are replaced by crinoids. The deepening of the platform foreshadows the open marine sedimentation of the succeeding Hay River Formation.

Biostratigraphy

The marlstone of Facies M (Amco Member) contains traces of crinoids and thick-shelled brachiopods, and the limestones at the bottom and top of the member contain massive stromatoporoids.

Facies N (Tidal flat member) contains sporadic *Amphipora*, charophyte oogonia, and traces of brachiopods and ostracodes.

Facies O (Shallow platform member) contains, in order of abundance, thin-shelled brachiopods, bulbous stromatoporoids, *Amphipora* sp., corals, and gastropods.

Facies P (Deep platform member) is very similar to Facies O, but differs in the absence of *Amphipora*, and the presence of crinoids.

Brachiopods from the Slave Point Formation are sparse and restricted, and are referred to as the *Emanuella vernilis–Desquamatia* cf. *independensis* fauna, after the main fossils in beds of the formation at Gypsum Cliffs, Peace River, Alberta (Norris and Uyeno, 1983). Conodonts associated with the brachiopod fauna at Gypsum Cliffs are assigned by Witzke et al. (1985, p. 38) to the *Icriodus subterminus* Fauna, which correlates with some part of the *disparilis* Zone of late Givetian age. Elements of the *subterminus* Fauna are recognized also in the basal beds of the Amco Member of the Slave Point Formation, and probably also in the underlying Watt Mountain Formation, along and near the south shore of Great Slave Lake on the north flank of the Pine Point carbonate barrier complex (Braun et al., 1989, p. 98).

The tetracoral *Grypophyllum mackenziense* (Pedder, 1963, 1972, 1973) is a widespread marker for the upper and part of the lower? conodont *disparilis* interval, but is restricted to biostromal and biohermal facies. In the Mackenzie Valley region, *G. mackenziense* commonly occurs in the upper, reefal part of the Ramparts Formation (Kee Scarp reef), mostly above, but also within beds equivalent to the *Warrenella timetea* and *Leiorhynchus hippocastanea* occurrences and corresponds to an interval represented by the ostracode Upper DM7 assemblage and part, or possibly all, of the Upper DM9 ostracode assemblage (Braun et al., 1989, p. 98). *G. mackenziense* is recorded also in the upper platform beds of the Swan Hills Formation of northern Alberta, which correlate in part with the Slave Point Formation.

McGill (1966) described and illustrated eighteen species of ostracodes from the carbonate part of the Slave Point Formation in two drillholes, the Homestead et al. Joussard 10-32-72-13W5 and the Guyer Imperial Driftpile 4-7-73-11W5, located near the south shore of Lesser Slave Lake in north-central Alberta. These ostracodes are as follows:

Selebrantina pustulodentata McGill, 1966
Pokornyites shouldici McGill, 1966
Pribylites sp. cf. *P. hanaicus* Pokorny, 1950
Rozhdestvenskayites diuturna McGill, 1966
Ellesclavus fluitatus McGill, 1966
Geisina meneleyiana McGill, 1966
Kloedenellitina paxfluvii McGill, 1966
Margasaccus devini McGill, 1966
Evlanella joussardensis McGill, 1966
Ancillacuna lacrimosa McGill, 1966
Bairdia navicula Martinova (*in* Polenova, 1955)
Rectobairdia affluens (Rozhdestvenskaya, 1959) n. comb.
Rectobairdia canigranulosa McGill, 1966
Bairdiacypris sp. cf. *B. irregularis* Polenova, 1953
Bekena homolibera McGill, 1966
Cytherellina voluptuosa McGill, 1966
Microcheilinella boweni McGill, 1966
Velapezoides shaveri McGill, 1966

McGill dated this fauna as latest Givetian in age, by comparison with forms from western Europe and the U.S.S.R. This dating was done at a time when the Middle–Upper Devonian boundary in western Canada was drawn at the contact between the Slave Point and Waterways formations or equivalent beds.

Hay River Formation

The Hay River Formation has been studied by numerous workers including Cameron (1918), Crickmay (1953, 1957), Belyea and McLaren (1962), and others. It is currently defined by Meijer Drees (1993, p. 174) as including all the beds between the top of the Slave Point Formation and the base of the Twin Falls Formation, which is the lowest rock unit of the Grumbler Group. The type section is along Hay River below Alexandra Falls. A supplemental subsurface section was added by Belyea and McLaren (1962) to cover the lower part of the section not exposed along Hay River. This section is in the Frobisher Hay River No. 4 drillhole (60°42′18″N, 115°33′10″W), between 10.9 and 164.3 m.

A complete thickness of 435.8 m of the Hay River Formation is present in the Union Alexandra Falls Test No. 1 drillhole (60°27′15″N, 116°21′00″W) (Belyea and McLaren, 1962, fig. 3). In the subsurface of the Kakisa and Tathlina lakes area, the thickness ranges from 301.4 to 411.4 m, according to Williams (1977).

The lithology of the lower part of the Hay River Formation (Waterways Formation equivalent; Fig. 4) in the Kakisa Lake area consists of greyish green fissile shale with thin interbeds of argillaceous and silty fossiliferous limestone (Meijer Drees, 1993). The upper part of Hay River Formation (Fort Simpson Formation equivalent) consists mainly of greyish green, fissile

shale. It includes interbeds of calcareous shale, argillaceous limestone and fossiliferous limestone (Meijer Drees, 1993).

A thin sequence of the basal beds of the Hay River Formation was recorded by Norris (1965, p. 83–85, fig. 8) north of Sulphur Bay on the northwest side of Great Slave Lake. These beds unconformably overlap the western flank of a carbonate buildup, the facies front of Griffith (1965a), consisting of light coloured coarsely crystalline vuggy dolomite. Scattered shallow drillholes by the Windy Point Mining Company (Malcolm, 1956) and cross-sections by Griffith (1965a, figs. 4, 5) indicate that beds of the Hay River Formation underlie the area immediately west of the carbonate buildup.

At the outcrop located about 1.6 km west and about 3.2 km north of Sulphur Bay, where 3.23 m are exposed, the basal beds of the Hay River Formation consist of richly fossiliferous, medium to dark grey, argillaceous limestone with shaly partings; interbedded with pale to medium brown, medium to coarsely crystalline, more thick bedded, sparsely fossiliferous dolomite. Drillholes across Prairie Lake indicate that these basal beds grade westward and upward to shale.

Biostratigraphy

A revised list of macrofossils from the exposures north of Sulphur Bay include the following (Norris, 1965, p. 84, 85, 158, 159):

undetermined cup corals
Cladopora sp.
undetermined gastropod
Lingula sp. cf. *L. spatulata* Vanuxem
Schizophoria sp.
Tecnocyrtina sp. cf. *T. billingsi* (Meek)
Radiatrypa sp. cf. *R. clarkei* (Warren)
Independatrypa sp. cf. *I. independensis* (Webster)
Atrypa? spp.
Spinatrypa sp. cf. *S. albertensis* (Warren)
Spinatrypa? sp.
Ladogioides pax McLaren
Leiorhynchus? sp.
echinoderm ossicles

These macrofossils are within the *Tecnocyrtina billingsi* Zone of Pedder (1975) and indicate a correlation with the Firebag Member of the Waterways Formation of the Clearwater–Athabasca rivers area, and with the Peace Point Member of the Waterways Formation at Gypsum Cliffs on Peace River, both in northeastern Alberta. Conodonts in the Firebag and Peace Point members are assigned to the *norrisi* Zone of Klapper and Johnson (1990) of latest Givetian age.

Cores of the Waterways Formation from the Texan Whitesand 5-35 drillhole (5-35-126-12W5) include rock types similar to those of the Hay River Formation in the N.W.T. Heart Lake No. 2 drillhole (60°50′30″N, 116°37′30″W). Macrofossils from the Whitesand core at 463.8 m were identified by Norris (*in* Meijer Drees, 1993, p. 175, 219) as follows:

auloporid impression
Shizophoria lata Stainbrook
Ladogioides pax McLaren (fragment)
Desquamatia sp.
Tecnocyrtina billingsi (Meek)
Eleutherokomma impennis Crickmay
Spirorbis sp.
echinoderm ossicle with single axial canal

These macrofossils from at or near the base of the Waterways Formation are typical of the *Tecnocyrtina billingsi* Zone, which is within the conodont *norrisi* Zone, of latest Givetian age.

Uyeno (*in* Meijer Drees, 1993, p. 215) reported the following conodonts from the Hay River Formation in the N.W.T. Heart Lake No. 2 drillhole (60°50′30″N, 116°37′30″W) as follows:

367.6–368.2 m	*Icriodus subterminus* Youngquist *Polygnathus norrisi* Uyeno *Polygnathus* cf. *P. pacificus* Savage and Funai Age: Lowermost *asymmetrica* Zone (= *norrisi* Zone)
368.2–368.5 m	*Icriodus subterminus* Youngquist Age: Middle *varcus* Subzone to Lower *asymmetrica* Zone

The Middle–Upper Devonian Series boundary coincides with the lower boundary of the Frasnian Stage. The Subcommission on Devonian Stratigraphy selected the lower boundary of the conodont Lower *asymmetrica* Zone, which is marked by the first occurrence of *Ancyrodella rotundiloba* (Bryant) as the base of the Upper Devonian Series (Ziegler and Klapper, 1985, p. 107). This boundary occurs within the Calumet Member of the Waterways Formation of northeastern Alberta, which is within the brachiopod *Strophodonta clearwaterensis* Zone of Norris (1963).

Braun (1968) showed that ostracodes are abundant and well preserved in the Hay River Formation of the Great Slave Lake area, and in the Waterways, Cooking Lake and Ireton formations of northeastern Alberta. In the Hay River Formation, five ostracode assemblage zones are present as follows, in ascending sequence: DFR1, lower and upper DFR2, lower and Upper DFR3, lower and upper DFR4, and lower DFR5. A peculiarity of the basal part of the Hay River Formation is that part of the DRF1 assemblage zone appears to be missing by onlap. In the Waterways Formation, the DFR1 assemblage zone occurs in the Firebag and Calumet members, and the lower and upper DFR2 assemblage zone occurs in the Christina, Moberly and Mildred members. The lower DFR3 assemblage zone occurs in the Cooking Lake Formation, and the upper DFR3 and the lower DFR4 assemblage zones occur in the Ireton Formation.

SYSTEMATIC PALEONTOLOGY

The geographic location, source beds and other data for each sample are given under the GSC locality and/or field number of the Locality Registers (Appendices 1–3) of this report. The station localities along the south side of Great Slave Lake between Buffalo River and Fort Resolution and including the offshore islands are indicated on Figures 1 and 2. A composite chart (Fig. 10) shows the range and distribution of brachiopods and other fossils in the Bituminous limestone and Fine-grained dolostone members of the Pine Point Formation on the south side of Great Slave Lake.

All described and illustrated specimens are designated by GSC type numbers and placed in the National Type Collection of Plant and Invertebrate Fossils stored at the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8.

Abbreviations are as follows: D, depth; D/W, depth/width ratio; Ha, hinge angle (in degrees); L, length; L/W, length to width ratio; Loc., GSC locality number; Lhl, length of hinge line; Lpv, length of pv; Lbv, Length of bv; Lbv/W, length of bv/width ratio; Lbv/Lpv, length of bv/length of pv ratio; Lpv/L, length of pv/length ratio; Lpv/W, length of pv/width ratio; No., GSC type number; W, width.

Order LINGULIDA Waagen, 1885

Superfamily LINGULACEA Menke, 1828

Family LINGULIDAE Menke, 1828

Genus *Barroisella* Hall and Clarke, 1892, p. 62

Type species. Barroisella campbelli Cooper, 1942, p. 228 (nom. subst. pro *Lingula subspatulata* Meek and Worthen, 1868, p. 437, non Hall and Meek, 1856; OD) [= *Barroisella* Hall and Clarke, 1889, p. 43 (nom. nud.)].

Barroisella? *minuta* (Meek)

Plate 1, figures 1–10

1868 *Lingula minuta* Meek, p. 87, Pl. 13, fig. 1.
1965 *Lingula minuta* Meek, Norris, p. 52, 145.

Diagnosis. A species of *Barroisella*? of very small size, linguiform shape, very thin lateral profile, thin, fragile shell material with shiny exterior surface, and fine concentric colour banding.

Material. Represented by 12 specimens from scattered localities of the Bituminous shale and limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75536	75537	75538	75539
GSC locality no.	C-94886	C-94462	C-94582	C-94463
Length (L)	4.0	5.5	3.5	6.3
Width (W)	2.3	3.7	2.4	3.4
Ratio: L/W	1.74	1.49	1.46	1.85

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E	F	G[1]	H[2]
	Hypotype	Hypotype	—	—
GSC no.	75540	75541		
GSC locality no.	C-94463	C-94473	—	—
Length (L)	7.7 est.	7.5 est.	1.52	1.66
Width (W)	4.4	3.2	1.27	0.98
Ratio: L/W	1.75	2.34	1.20	1.69

[1]*Lingula minuta* Meek (1868, p. 87) (Dimensions from text)
[2]*Lingula minuta* Meek (1868, Pl. 13, fig. 1) (Dimensions from figure)

Description. Shell of small size, linguiform or subspatula-shaped, rounded wedge-shaped towards the beaks, smoothly and broadly rounded anteriorly; longer than wide with greatest width between one-half to two-thirds length from beak; length to width ratio varies from 1.46 to 2.34 amongst measured specimens; valves of very low convexity in lateral profile.

Shell material very thin, fragile, shiny, generally black but also pale brown with dark grey, finely banded, concentric growth markings; surface of valves

marked by concentric growth lines and very faint radial markings seen on one valve exterior.

Interior of pedicle valve (GSC 75541) with two closely spaced slightly diverging markings that straddle the midline and extend from the pedicle opening to about midlength of valve; also originating from the pedicle opening are two slightly curved markings that are directed anterolaterally and intersect the sides of the valve about one-third length from beak.

Interior of brachial valve (GSC 75540) with a low, broad median ridge that bifurcates near the midlength of the valve; between the bifurcation is a second low ridge, possibly site of anterior lateral muscle scars.

Remarks. The markings on the interiors of the valves of this species are closely similar to those for *Barroisella campbelli* Cooper (*in* Shimer and Shrock, 1944, p. 285, Pl. 107, figs. 29–32). If the assignment of *Lingula minuta* Meek to the genus *Barroisella* is correct, it would extend the range of this genus from the Upper Devonian to Mississippian in eastern North America down to Middle Devonian of western North America.

Figured specimens. Hypotype GSC 75536, a small individual from GSC locality C-94868; hypotype GSC 75537, an adult individual from GSC locality C-94462; hypotype GSC 75538, an impression of a small individual from GSC locality C-94582; hypotype GSC 75539, impression of exterior of a valve, and hypotype GSC 75540, interior of a brachial valve, both from GSC locality C-94463; and hypotype GSC 75541, a partly exfoliated pedicle valve of an adult individual, from GSC locality C-94473.

Locality data. GSC locality C-94886 (sample 85NBb) at station 85NB on the south shore of Great Slave Lake at 61°00′21″N, 114°16′15″W, 0.93 km southwest of Pine Point; from a large loose block of the Bituminous limestone member of the Pine Point Formation overlying outcrop of which 24 cm are in sight.

GSC locality C-94462 (sample 19NBb) at station 19NB on the mid north shore of McKay Island at 61°01′40″N, 114°10′15″W; from an outcrop, 60 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94582 (sample 62NBb) at station 62NB on the west tip of Burnt Island at 61°04′35″N, 114°07′40″W, bearing 044T at 10.3 km from Pine Point; from an outcrop, 37 cm exposed, of black bituminous dolomite of the Pine Point Formation.

GSC locality C-94463 (sample 19NBc) at station 19NB on the mid north shore of McKay Island at 61°01′40″N, 114°10′35″W; from a large loose block of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94473 (sample 22NBal) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.41 km west of Dawson Landing wharf; from an exposure, 7 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Although *Barroisella minuta* (Meek) is widely distributed in the Bituminous limestone member of the Pine Point Formation, it is a rare constituent of the fauna at all localities.

Superfamily ENTELETACEA Waagen, 1884

Family SCHIZOPHORIIDAE
Schuchert and Levene, 1929

Subfamily SCHIZOPHORIINAE
Schuchert and Levene, 1929

Genus *Schizophoria* King, 1850

Type species. Conchyliolithus Anomites resupinatus Martin, 1809, Pl. 49, figs. 13, 14.

Schizophoria mcfarlanei (Meek, 1868)

Plate 1, figures 11–16

1868 *Orthis mcfarlanei* Meek, p. 88, Pl. 12, figs. 1a–1h, (1867).
1932 *Schizophoria mcfarlani* (Meek), Schuchert and Cooper, p. 143, 144.
1944 *Schizophoria mcfarlani* (Meek), Cooper in Shimer and Shrock, p. 357, Pl. 140, figs. 1–3.
1956 *Schizophoria mcfarlanei* (Meek), Warren and Stelck, Pl. 3, figs. 8–10.
1965 *Schizophoria mcfarlanei* (Meek), Norris, p. 52, 146.
1974 *Schizophoria mcfarlanei* (Meek), Johnson, p. 53, Pl. 1, figs. 4–12.
1975 *Schizophoria mcfarlanei* (Meek), Pedder in MacKenzie, Pedder and Uyeno, p. 551.

Diagnosis. A species of *Schizophoria* characterized by its very short hinge line, considerable convexity of its dorsal valve, narrow umbonal regions of both valves,

and a highly inflated umbo of the dorsal valve (Meek, 1868, p. 89).

Material. Represented by 16 poorly preserved, incomplete specimens.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D[1]
	Hypotype	Hypotype	Hypotype	—
GSC no.	75542	75543	75544	
GSC locality no.	C-94466	C-94612	C-94554	—
Length of pv (Lpv)	32.0	24.6+	—	40.6
Length of bv (Lbv)	27.2	—	—	—
		est.	est.	
Width (W)	29.4	21.5	31.4	38.1
Depth (D)	22.2	—	—	29.5
Length of hinge line (Lhl)	19.0	—	—	19.6
Ratio: Lpv/W	1.09	1.14	—	1.07
Ratio: Lbv/W	0.93	—	—	—
Ratio: Lhl/W	0.65	—	—	0.51

[1]*Orthis mcfarlanei* Meek (1868, p. 89, Pl. 12, fig. 1)

Description. Size of shell at maturity is relatively small for the genus. Rounded, subtriangular-shaped in outline and very unequally biconvex in lateral profile. Posterior part of shell relatively narrow with greatest width at about three-quarters length from brachial umbo. Length of hinge line is 0.65 of the maximum width of shell in most complete specimen. Anterior margin outline is straight with uniplicate anterior commissure.

Pedicle valve considerably smaller than brachial valve, very weakly convex in posterior medial region, highest over the umbo. Beak is small and inconspicuous. Interarea is relatively high, very slightly curved, procline to almost catacline. Sulcus is very shallow, broadly rounded; it originates about one-quarter length from beak and gradually deepens and broadens anteriorly to produce a U-shaped tongue in the opposite valve.

Larger brachial valve is extremely convex, highest about midlength, and accounts for more than four-fifths total depth of shell. Fold is very low, broadly rounded, and apparent only on anterior mesial part of valve. Umbo is highly gibbous and projects a considerable distance beyond beak of opposite valve. Interarea is relatively low, narrow, strongly curved, and apsacline. Beak is small and strongly inturned.

Ornament consists of fine, uniform, radiating costellae, separated by considerably narrower intercostellae furrows. Where measured, 5 costellae occur in a space of 2 mm at about 22 mm from pedicle beak. Abraded parts of shell show very tiny, closely spaced punctae.

Some of the features of the interior of the brachial valve can be seen in specimen C (GSC 75544). Cardinal process is small. On each side of the cardinal process in the notothyrial cavity are rounded elevations. Dental supporting plates are nearly vertical and diverge anteriorly; they are extended anteriorly as slightly elevated ridges along the lateral margins of the muscle field. Muscle area is divided longitudinaly by a thick rounded myrophram; each half of the area is subdivided by indented diagonal and curved markings. Pallial sinuses are prominent, six in number, originating near anterior margin of muscle area and extending anteriorly in a subparallel arrangement.

Interior of pedicle valve not seen.

Remarks. Although the specimens at hand are rather poorly preserved, the distinctive morphological features they display strongly suggest assignment to *Schizophoria mcfarlanei* (Meek, 1868). These features include the pronounced depth and curvature of the brachial valve, the greater length of brachial valve over that of the pedicle valve, the elongate outline with broad anterior and narrow posterior ends, and thick deposits of secondary shell material in the posterior ends of the valves, especially in the brachial valve.

Figured specimens. Hypotype GSC 75542, a partly exfoliated gerontic specimen, from GSC locality C-94466; hypotype GSC 75543, part of brachial valve of a young adult individual, from GSC locality C-94612; and hypotype GSC 75544, an internal mold of brachial valve of an adult individual, from GSC locality C-94554.

Locality data. GSC locality C-94466 (sample 21NBb) at station 21NB on the south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, 0.18 km west of Dawson Landing; from uppermost 20 cm of an outcrop 53 cm thick of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94612 (sample 68NBh) at station 68NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′27″W, 2.7 km northwest of Dawson Landing wharf; from a unit 30 cm thick from top of an outcrop 88 cm thick of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94554 (sample 50NBb) at station 50NB on the south shore of Great Slave Lake at 60°59′16″N, 114°09′10″W, 0.28 km east of Dawson Landing wharf; from an outcrop 8 cm thick of the Bituminous limestone member of the Pine Point Formation.

Occurrence. *Schizophoria mcfarlanei* (Meek) is a relatively rare form in the Bituminous limestone member of the Pine Point Formation in the Pine Point area.

The type specimens of *Schizophoria mcfarlanei* are recorded by Meek (1868, p. 89, 90) from two localities as follows: (1) on Mackenzie River 64.4 km below Fort Good Hope, and (2) on Lockhart (=Carnwath) a tributary of Anderson River at 67°15′N, 126°00′W. A.E.H. Pedder (pers. comm., April 11, 1979) has examined the Meek collection and provided the following information. Three specimens collected by R.W. Mcfarlane with the number 24421 are from a cliff of limestone from the Mackenzie River locality. These have the Ramparts Formation type preservation with one specimen illustrated by figures 1c, 1e–1h of plate 12 of Meek (1868); another is the basis of figure 1d; and the third specimen is not figured. Two specimens with the number 5901 also collected by R.W. Mcfarlane are from the Lockhart (Carnwath) River locality. One of these is illustrated by figure 1a of plate 12 of Meek (1868). Preservation of these specimens, according to Pedder, suggest derivation from beds bearing the *Eliorhynchus castanea* fauna. The small size of the two specimens of *Schizophoria mcfarlani* (Meek) illustrated by Cooper (*in* Shimer and Schrock, 1944, p. 357, Pl. 140, figs. 1–3) suggest that they are from the Anderson River area and probably part of the collection studied by Meek (1868).

The specimen of *Schizophoria mcfarlanei* (Meek) illustrated by Warren and Stelck (1956, Pl. 3, figs. 8–10) is recorded as part of the *Ambocoelia meristoides* fauna in the Hare Indian Formation of the Anderson River area.

In Nevada, *Schizophoria mcfarlanei* (Meek) was described by Johnson (1974, p. 53, 54, Pl. 1, figs. 4–12) from the *Eliorhynchus castanea* Zone of the Denay and Woodpecker limestones.

Pedder (*in* Mackenzie, Pedder and Uyeno, 1975, p. 552) recorded *Schizophoria mcfarlanei* (Meek) from 4.3 to 9.4 m above base and 4.3 to 9.4 m below top of an unnamed sandstone unit in the Grandview Hills area, District of Mackenzie, associated with an abundant fauna assigned to the *Stringocephalus aleskanus* megafaunal Zone and the *Polygnathus varcus* conodont Zone.

Family STROPHEODONTIDAE Caster, 1939

Subfamily STROPHEODONTINAE Caster, 1939

Genus *Cymostrophia* Caster, 1939, p. 48

Type species. *Leptaena stephani* Barrande, 1879, p. 308; OD. [=*Corrugatella* Khalfin, 1948, p. 236 (obj.)].

Cymostrophia? sp.

Plate 1, figures 17–22

Diagnosis. A species of *Cymostrophia*? with a subsemicircular-shaped outline, considerably wider than long, a denticulate hinge margin, and with acute cardinal angles that appear to be slightly extended.

Material. Represented by two incomplete specimens.

Dimensions (in mm) and other parameters.

Specimen	A	B
	Hypotype	Hypotype
GSC no.	75545	75546
GSC locality no.	C-94618	C-94619
Length (L)	11.9	13.2
Width (W)	est. 20.1	22.3
Ratio: L/W	0.59	0.59

Remarks. The fragmentary specimens are insufficient for an adequate description or reliable comparison with other forms. The ornament appears to be parvicostellate, with the major costellae interrupting weakly developed, irregular, concentric rugae. The shape outline is subsemicircular, with a length to width ratio of 0.59. Lateral profile appears to be planoconvex. Hinge line is straight and completely denticulate. Cardinal angles are acute and possibly slightly extended. Shell substance is very thin with fine, closely spaced pseudopunctae arranged in a radial pattern.

Figured specimens. Hypotype GSC 75545, an abraded exterior of a brachial valve, from GSC locality C-94618; hypotype GSC 75546, impression of exterior of a pedicle valve, from GSC locality C-94619.

Locality data. GSC locality C-94618 (sample 69NBf) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.82 km northwest of Dawson Landing; from about 135 cm above the base of an outcrop, 265 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94619 (sample 69NBg) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.82 km northwest of Dawson Landing; collected from a loose block of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Cymostrophia? sp. is an exceedingly rare element in the Bituminous limestone member of the Pine Point Formation on the south side of Great Slave Lake.

Fragmentary specimens of *Cymostrophia* sp. have been recorded by Norris (*in* McLaren and Norris, 1964, p. 40, 41, Pl. 13, figs. 15a–16b) from outcrops of the Horn Plateau Formation, a pinnacle reef partly exposed 85.3 km north of Fort Providence. Conodonts from the exposed part of this reef are assigned to the *varcus* Zone.

Family uncertain

Genus *Floweria* Cooper and Dutro, 1982, p. 53

Type species. Orthis prava Hall, 1858, p. 490 [= *Schuchertella prava* (Hall), Fenton and Fenton, 1924, p. 117, Pl. 20, figs. 21–28].

Floweria? sp.

Plate 1, figures 23–29

Diagnosis. A species of *Floweria*? of medium size at maturity, with a transversely suboval outline, a straight hinge line, obtuse cardinal angles, and a suggestion of parvicostellate ornamentation on the brachial valve.

Material. Represented by 8 incomplete specimens of brachial valves.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75547	75548	75549	75550
GSC locality no.	C-94650	C-94650	C-94644	C-94644
Length (L)	est. 10.2	10.0	12.9	12.9
Width (W)	14.0	11.8	15.8	15.8
Ratio: L/W	0.73	0.85	0.82	0.82
Costellae per 5 mm, 5 mm from break	—	13	12	12

Description. Shells attain a medium size at maturity; transversely suboval in outline; wider than long with greatest width near midlength; ratio of length to width amongst measured specimens varies from 0.73 to 0.85; weakly biconvex in lateral profile; hinge line straight; cardinal angles obtuse.

Interior of brachial valve with weak, broadly divergent socket plates joined to a bilobate cardinal process; a low median ridge extends a short distance anteriorly from the anterior end of the cardinal process. Adductor muscle field is vaguely defined.

Ornament consists of radial costellae which increase in number anteriorly mainly by intercalation. Number of costellae varies from 12 to 13 at 5 mm from beak. Specimen A (GSC hypotype 75547) is distinctly parvicostellate. Concentric growth lines are closely spaced, irregular, and in places thickenings are produced where they cross the costellae. Internally, along the anterior and lateral margins of the brachial valve, the positions of the costellae are deeply impressed. Shell substance is impunctate.

Remarks. G.A. Cooper (*in* Johnson, 1970, p. 107) has pointed out that *Schuchertella lens* (White, 1862, p. 28), the type species of *Schuchertella*, is pseudopunctate, whereas all pre-Famennian schuchertelloid species studied by him lack pseudopunctae. The shell material of the form from Great Slave Lake is also impunctate. Unfortunately, all of the material is fragmentary and none of the specimens shows a pedicle valve. More recently, Cooper and Dutro (1982, p. 54) in erecting the genus *Floweria* pointed out that this genus is similar in form, outline and ornament to *Schuchertella*, but differs in having a much reduced dorsal interarea and having no pseudopunctae. They further stated that *Floweria* is similar to *Eoschuchertella* Gratsianova (1974) but differs from the Russian form in the shape of the cardinalia. They indicated also that *Schuchertellopsis* Maillieux (1939) is close to, or the same as, *Floweria*, but its inner features are not known. Internal features of the dorsal valve of the form from Great Slave Lake seem to be more closely similar to *Floweria prava* (Hall) (see Fenton and Fenton, 1924, Pl. 20, fig. 28) than they are to *Eoschuchertella papovi* Gratsianova (1974, Pl. 13, fig. 7).

Figured specimens. Hypotype GSC 75547, exterior of brachial valve of a small adult individual, and hypotype GSC 75548, an impression of exterior of brachial valve of a young adult individual, from GSC locality C-94650; hypotype GSC 75549, interior of brachial valve of an adult individual, and hypotype GSC 75550, impression of interior of brachial valve of an adult individual (a negative impression of hypotype GSC 75549), from GSC locality C-94644.

Locality data. GSC locality C-94650 (sample 74NBf) at station 74NB on the south shore of Great Slave Lake at 61°00′12″N, 114°13′58″W, 1.4 km southeast of Pine

Point; from the upper 89 cm of an outcrop, 120 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94644 (sample 73NBb) at station 73NB on the south shore of Great Slave Lake at 61°00′08″N, 114°13′35″W, 1.8 km southeast of Pine Point; from an outcrop, 22 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETACEA Bronn, 1862

Family CHONETIDAE Bronn, 1862

Subfamily CHONETINAE Bronn, 1862

Genus *Rhyssochonetes* Johnson, 1970, p. 2095

Type species. Rhyssochonetes aurora solox Johnson, 1970, p. 2095; OD.

Rhyssochonetes aurora medialis Norris n. subsp.

Plate 1, figures 30–37; Plate 2, figures 1–10

1868 *Chonetes pusilla* Hall?, Meek, p. 93, Pl. 13, figs. 2a–2d.
1965 *Chonetes aurora* Hall, Norris, p. 52, 55, 145, 147–150, 152.

Etymology. The subspecies name *medialis* is from the Latin *medialis*, meaning middle, in the middle; in allusion to the intermediate development of radial costae and concentric rugae.

Diagnosis. A subspecies of *Rhyssochonetes aurora* with intermediate development of radial costae and concentric rugae; up to three spines on each side of the pedicle beak along the cardinal margin; cardinal angles commonly slightly extended but some are rounded; and lateral margins of shell are slightly indented immediately anterior of the cardinal angles.

Material. Represented by exceedingly numerous specimens at many localities in the Pine Point area, especially in the more argillaceous beds of the Bituminous limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A Paratype	B Paratype	C Paratype	D Paratype	E Holotype
GSC no.	75551	75552	75553	75554	75555
GSC locality no.	C-94686	C-94650	C-94689	C-94612	C-94686
Length of pv (Lpv)	3.8	3.9	5.3	6.1	7.8
Length of bv (Lbv)	—	—	—	—	—
Width (W)	4.8	5.4	ca. 7	7.9	9.1
Ratio: W/Lpv	1.26	1.38	1.32	1.30	1.17
Ratio: W/Lbv	—	—	—	—	—
Costae per 2 mm, 3 mm from beak	pv 7 bv —	pv 8 bv —	pv 7 bv —	pv 7 bv —	pv 7 bv —

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	F Paratype	G Paratype	H Paratype	I Paratype
GSC no.	75556	75557	75558	75559
GSC locality no.	C-94650	C-94646	C-94683	C-94683
Length of pv (Lpv)	—	3.1	—	4.9
Length of bv (Lbv)	5.4	—	5.7	—
Width (W)	6.3	4.0	8.2	6.2
Ratio: W/Lpv	—	1.29	—	1.27
Ratio: W/Lbv	1.17	—	1.44	—
Costae per 2 mm, 3 mm from beak	pv — bv 9	pv 7 bv —	pv — bv 7	pv 9 bv —

Description. Shell is very small, which is usual for the genus; valves moderately concavo-convex; wider than long with the greatest width occurring at or slightly anterior of the hinge line; ratio of length to width amongst measured specimens varies from 1.17 to 1.44; subrectangular to semielliptical in outline; cardinal angles rounded but slightly extended in some specimens. A slight indentation of the lateral margins immediately anterior of the cardinal angles is evident in some specimens.

Pedicle valve is weakly to moderately convex, highest between one-third and one-half length from beak. Umbonal region moderately convex; beak very small, inturned. Interarea not seen. Interior unknown.

Brachial valve shallowly concave, deepest at about one-third length from beak; elevated areas on each side of beak bordering the cardinal margin widen toward the cardinal extremeties; beak small and slightly extended beyond the cardinal margin. Interior not seen.

Valves marked by low, rounded radiating costellae which increase slightly in strength anteriorly and increase in number by bifurcation and implanation.

These are crossed by closely spaced, irregular, concentric rugae. Amongst the numerous specimens at hand there is considerable variation in the strength of the radial and concentric ornament that seems to be related to the mode of preservation of shell. In those specimens where the outer shell material is more or less preserved, it is the radial ornament that is more conspicuous, whereas, in those specimens showing some removal of outer shell material it is the concentric ornament that becomes more evident. This feature is well illustrated by Cooper and Dutro (1982, Pl. 11, fig. 38) for *Rhyssochonetes johnsoni*.

On mature adult specimens up to three spines occur on each side of the beak of the pedicle valve along the cardinal margin; these are long, slender, and fragile and generally only the spine bases are evident, but where preserved they extend posteriorlaterally and curve distally toward the midline.

Some abraded specimens of the exterior of the brachial valve show closely spaced, radial pustulose markings suggestive of a pseudopunctate shell.

Comparison. Rhyssochonetes aurora medialis n. subsp. is closely similar but distinguishable from *Rhyssochonetes aurora* (Hall) illustrated by Caldwell (1971, p. 14, Pl. 2, figs. 9, 10) from the upper part of the Hare Indian Formation outcropping near Fort Good Hope on the Mackenzie River, by the following features: proportionately wider and markedly less convex; less conspicuous indentations of lateral margins immediately anterior of the cardinal angles; and slightly coarser concentric rugae.

From *Rhyssochonetes aurora* (Hall) described and illustrated by McCammon (1960, p. 47, Pl. 8, figs. 1, 2) from the Dawson Bay Formation of Manitoba, the form from Great Slave Lake is recognized by its considerably smaller size at maturity; its slightly coarser concentric rugae; and by its considerably less transverse outline. Comparison of many specimens of the Manitoba form collected by Norris (*in* Norris, Uyeno and McCabe, 1982) indicate that hypotype GSC 14797 illustrated by McCammon (1960, Pl. 8, fig. 2) is atypical in having unusually coarse costellae. The more common and typical form is characterized by much finer costellae.

Rhyssochonetes aurora medialis n. subsp. differs from *Rhyssochonetes aurora aurora* Johnson from the Tully Formation of New York as described and illustrated by Cooper and Williams (1935, p. 838, 839, Pl. 57, figs. 2, 5–7, 9) and Johnson (1970, p. 2095, Pl. 1, fig. 1), by its larger size, more transverse outline, greater convexity of pedicle valve, and a more strongly developed concentric ornament.

Rhyssochonetes aurora medialis n. subsp. is distinguished from *Rhyssochonetes aurora solox* Johnson (1970, p. 2097, Pl. 1, figs. 2–16), from the Denay Limestone of of Nevada, by its greater size at maturity, greater convexity, and stronger development of concentric rugue. Comparison of the latter feature is difficult because of the difference in preservation of the two forms.

Rhyssochonetes johnsoni Cooper and Dutro (1982, p. 59, 60, Pl. 11, figs. 37–43) from the Oñate Formation of New Mexico was noted by these authors to be closely comparable in size and ornamentation to the form from the south side of Great Slave Lake. *R. a. medialis* n. subsp. can be distinguished from the New Mexico form by its generally coarser concentric ornament, its more indented lateral margins near the cardinal angles, and absence of spines at the cardinal angles. Although up to three spines have been noted on each side of the beak along the cardinal margin of the pedicle valve on the Great Slave Lake form, none occurs at the cardinal angles.

Figured specimens. Paratype GSC 75551, exterior of pedicle valve of a young individual, and holotype GSC 75555, exterior of pedicle valve of a large adult individual, from GSC locality C-94686; paratype GSC 75552, exterior of pedicle valve of a young individual, and paratype GSC 75556, exterior of brachial valve of an adult individual, from GSC locality C-94650; paratype GSC 75553, exterior of pedicle valve of a young adult individual, from GSC locality C-94689; paratype GSC 75554, exterior of pedicle valve of an adult individual showing cardinal spines, from GSC locality C-94612; paratype GSC 75557, exterior of pedicle valve of a young individual showing cardinal spines, from GSC locality C-94646; paratype GSC 75558, exterior of brachial valve of an adult individual, and paratype GSC 75559, exterior of pedicle valve of a young adult individual, from GSC locality C-94683.

Locality data. GSC locality C-94686 (sample 85NBb) at station 85NB on the south shore of Great Slave Lake, 0.93 km southwest of Pine Point at 61°00′21″N, 114°16′15″W; from a large loose block overlying an outcrop, 24 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94650 (sample 74NBf) at station 74NB on the south shore of Great Slave Lake, 1.4 km southeast of Pine Point at 61°00′12″N, 114°13′28″W;

from 100 cm above the base of an outcrop 120 cm thick of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94689 (sample 85NBe) at station 85NB on the south shore of Great Slave Lake, 0.93 km southwest of Pine Point at 61°00′21″N, 114°16′15″W; from the top of an outcrop 24 cm thick of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94612 (sample 68NBh) at station 68NB on the south shore of Great Slave Lake, 2.7 km northwest of Dawson Landing at 61°00′03″N, 114°12′27″W; from the top of an outcrop, 88 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94646 (sample 74NBb) at station 74NB on the south shore of Great Slave Lake, 1.4 km southeast of Pine Point at 61°00′12″N, 114°13′58″W; from the lower 11 cm of an outcrop 120 cm thick of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94683 (sample 84NBb) at station 84NB on the south shore of Great Slave Lake, 0.74 km southwest of Pine Point at 61°00′23″N, 114°16′05″W; from a large loose block overlying an outcrop 4 cm thick of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Rhyssochonetes aurora medialis n. subsp. has been collected from numerous localities in the Pine Point area, where it is a common element in the middle, more argillaceous parts of the Bituminous limestone member of the Pine Point Formation.

In the lower Mackenzie River Valley area, *Rhyssochonetes aurora* (Hall) is recorded by Caldwell (1971, p. 8, 14, Textfig. 3) from the upper part of the Hare Indian Formation. Some specimens in Geological Survey of Canada collections are recorded also from the lower part of the overlying Ramparts Formation in an argillaceous limestone lithology that seems to be transitional between the two formations. Pedder (1975, p. 573) assigned this form to the lower part of his *Ectorensselandia laevis* Zone and noted that the earliest occurrences of *R. aurora* immediately precede those of *E. laevis*.

In the Devonian outcrop belt of Manitoba, *Rhyssochonetes aurora* (Hall) was recorded by McCammon (1960, p. 48, 97) from the Dawson Bay Formation. Norris (*in* Norris, Uyeno and McCabe, 1982, p. 14, fig. 3, 55) noted that this form occurs sparsely in Member B and abundantly in Member C of the Dawson Bay Formation.

The *Rhyssochonetes aurora* (Hall) in the Tully Formation of New York is recorded by Cooper and Williams (1935, p. 839) as being most abundant in the Tinkers Falls Member and less common in the Apulia Member of central New York, and is present also in the Laurens Member of east-central New York.

In central Nevada, *Rhyssochonetes aurora solox* Johnson (1970, p. 2097; 1977, p. 25, Table 3) occurs in the Denay Limestone where the *Rhyssochonetes* fauna is associated with conodonts assigned to the Middle *varcus* Subzone.

Family PRODUCTELLIDAE
Schuchert and Levene, 1929

Subfamily PRODUCTELLINAE
Schuchert and Levene, 1929

Genus *Productella* Hall, 1867, p. 153

Type species. Productus subaculeatus Murchison, 1840, p. 255; SD Oehlert, 1887, p. 1279.

Productella verecunda Crickmay, 1963

Plate 2, figures 11–34

1963 *Productella verecunda* Crickmay, p. 20, Pl. 13, figs. 1–8.

Diagnosis. A species of *Productella* characterized by its nearly semicircular shape in early growth stages and becoming nearly equidimensioonal at maturity; strongly concavo-convex in lateral profile; cardinal angles generally not extended; and hinge is less than maximum width (Crickmay, 1963, p. 20).

Material. Relatively abundant at scattered localities in the more calcareous parts of the Bituminous limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75560	75561	75562	75563
GSC locality no.	C-94478	C-94479	C-94473	C-94473
Length of pv (Lpv)	12.8+	20.7	19.8	ca. 18.9
Length of bv (Lbv)	—	18.0	16.7	16.7
Width (W)	16.0+	22.0	23.8	22.4
Depth (D)	5.6	11.1	11.5	9.3

Length of hinge line (Lhl)	ca. 13.8	—	18.0	18.3
Ratio: Lpv/W	0.80	0.94	0.83	0.84
Ratio: Lbv/W	—	0.82	0.70	0.75
Ratio: Lhl/W	0.86	—	0.76	0.82

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E	F	G
	Hypotype	Hypotype	Hypotype
GSC no.	75564	75565	75566
GSC locality no.	C-94474	C-94490	C-94446
Length of pv (Lpv)	21.2	ca. 21.9	11.4
Length of bv (Lbv)	18.3	18.7	—
Width (W)	23.0	27.4	13.4
Depth (D)	10.2	ca. 13.0	—
Length of hinge line (Lhl)	ca. 23.4	ca. 23.6	ca. 10.6
Ratio: Lpv/W	0.92	0.80	0.88
Ratio: Lbv/W	0.80	0.68	—
Ratio: Lhl/W	1.02	0.86	0.79

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	H	I	J
	Hypotype	Hypotype	Hypotype
GSC no.	75567	75568	75569
GSC locality no.	C-94475	C-94456	C-94459
Length of pv (Lpv)	14.4	—	—
Length of bv (Lbv)	—	14.4	—
Width (W)	19.4	20.9	ca. 26.8
Depth (D)	ca. 6.4	—	—
Length of hinge line (Lhl)	14.2	19.6	—
Ratio: Lpv/W	0.74	—	—
Ratio: Lbv/W	—	0.69	—
Ratio: Lhl/W	0.73	0.94	—

Description. Shell of small to medium size at maturity; subquadrate to subsemicircular in outline; ratio of length to width varies from 0.74 to 0.94 amongst measured specimens; hinge line length generally less than maximum width of shell; this ratio varies from 0.73 to 1.02 amongst measured specimens; plano-convex in lateral profile; cardinal extremities rounded and slightly extended in some specimens; body cavity small.

Pedicle valve moderately to strongly convex, highest between one-third and one-half length from umbo, flattening towards the postero-lateral angles in some specimens; umbo strongly convex and projecting considerably beyond hinge line; beak small, inturned; interarea very low, broad, decreasing in height laterally, anacline; delthyrium not seen.

Brachial valve is moderately to strongly concave; flattened towards posterior margin and at postero-lateral angles; umbo small, depressed slightly below surrounding area of valve; interarea absent.

Exterior of pedicle valve marked by widely and irregularly spaced spine bases with no particular pattern over the disc; along the hinge margin they appear to occur in a row; spines are erect, long, slender, hollow, exceedingly fragile, and partly preserved only in attached matrix; the valve is also covered by coarse, irregular, concentric rugae; superimposed on the rugae are fine concentric growth lines seen only on better preserved parts of shell; one specimen shows a very narrow, shallow sulcus extending along the midline from near the umbo to the anterior margin of valve.

Exterior of brachial valve marked by coarse concentric rugae which in turn are marked by fine, concentric growth lines; spine bases appear to be absent from this valve.

Interior of pedicle valve not seen; however, abraded parts of shell show closely spaced endospines covering a part of the interior of the valve.

Interior of brachial valve with bilobed cardinal process; median breviseptum extending about three-quarters length of valve; small closely spaced endospines covering much of interior of valve.

Remarks. Although this species is relatively common in some samples from the more calcareous parts of the Bituminous limestone member of the Pine Point Formation, it is seldom, if ever, well preserved. Most of the shell material including spines, and surface ornamentation, are almost always destroyed when extracting shell from matrix. For this reason it is difficult to make reliable comparisons with other described species.

The form described as *Productella concentrica* (Hall) by McCammon (1960, p. 48, 49, Pl. 8, fig. 6a–6c, 7) from the Dawson Bay Formation of Manitoba is easily distinguished from that of Great Slave Lake, and appears to belong to the genus *Spinulicosta* Nalivkin (1937) rather than the genus *Productella* Hall (1867). The Manitoba form has spines located at the anterior ends of spine ridges on the pedicle valve, and coarse dimples or spine bases on the brachial valve. These features are not present on the form from Great Slave Lake.

Figured specimens. Hypotype GSC 75560, a young adult individual, from GSC locality C-94478; hypotype GSC 75561, a mature adult individual, from GSC locality C-94479; hypotype GSC 75562, a mature adult individual showing exteriors of both valves, and hypotype GSC 75563, a mature adult individual

showing exterior of pedicle valve, from GSC locality C-94473; hypotype GSC 75564, specimen showing exfoliated exteriors of both valves, from GSC locality C-94474; hypotype GSC 75565, a large adult individual showing exterior of pedicle valve, from GSC locality C-94490; hypotype GSC 75566, exterior of pedicle valve of a small adult individual embedded in matrix and showing spines, from GSC locality C-94446; hypotype GSC 75567, exterior of pedicle valve of an adult individual, from GSC locality C-94475; hypotype GSC 75568, impression of exterior of a brachial valve, from GSC locality C-94456; and hypotype GSC 75569, exterior of a pedicle valve of a large adult individual, from GSC locality C-94459.

Locality data. GSC locality C-94478 (sample 24NBa) and GSC locality C-94479 (sample 24NBb) at station 24NB on the south shore of Great Slave Lake at 60°59′27″N, 114°10′05″W, about 0.73 km west of Dawson Landing; from an outcrop about 10 cm exposed and about 0.5 m above lake level of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94473 (sample 22NBa1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.41 km west of Dawson Landing; from upper 7 cm of an outcrop, 18 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94474 (sample 22NBb1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.41 km west of Dawson Landing; loose blocks on top of an outcrop, 18 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94490 (sample 28NBb) at station 28NB on the west end of McKay Island at 61°01′30″N, 114°11′35″W, bearing 057T, at 3.9 km from Pine Point; from an outcrop, 50 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94446 (sample 16NBd) at station 16NB on the mid east shore of Beaulieu Island at 61°00′50″N, 114°08′10″W, bearing 086T, at 6.6 km from Pine Point; collected from loose blocks of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94475 (sample 22NBc1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.41 km west of Dawson Landing; from a small patch of outcrop, about 4 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94456 (sample 17NBe1) at station 17NB on the northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, bearing 065T, at 5.3 km from Pine Point; from lowest beds, 15 cm thick, of an oucrop, 50 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94459 (sample 18NBa1) at station 18NB on the mid north shore of McKay Island at 61°01′45″N, 114°10′30″W, bearing 064T, at 4.8 km from Pine Point; from upper resistant beds, 38 cm thick, of an outcrop, 62 cm thick, of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Crickmay (1963, p. 20) recorded *Productella verecunda* from the Pine Point Formation at Dawson Landing on Great Slave Lake. Outcrops at this locality are part of the Bituminous limestone member of the Pine Point Formation.

Superfamily PRODUCTACEA Gray, 1840

Family LEIOPRODUCTINAE
Muir-Wood and Cooper, 1960

Subfamily DEVONOPRODUCTINAE
Muir-Wood and Cooper, 1960

Genus *Devonoproductus* Stainbrook, 1943, p. 55

Type species. Productella walcotti Fenton and Fenton, 1924, p. 119 [=*Productus dissimilis* Hall, 1858, p. 497, non deKoninck, 1847, p. 255] [=*P.* (*Productella*) *hallana* Walcott, 1884, p. 130, partim]; OD. [=*Striatoproductus* Nalivkin, 1947, p. 75 (type, *Orthis sericea* von Buch, 1838, p. 68)].

Devonoproductus primus Crickmay, 1963

Plate 2, figures 35–57; Plate 3, figures 1–9

1868 *Productus*?, Meek, p. 91, Pl. 13, figs. 4a–4d, (1867).
1956 *Productella* sp., Warren and Stelck, Pl. 4, figs. 34, 35.
1963 *Devonoproductus primus* Crickmay, p. 24, Pl. 5, figs. 16; Pl. 14, figs. 1–5.
1965 *Devonoproductus* sp. D, Norris, p. 52, 55, 145, 149, 152.

Diagnosis. D. primus is distinguishable from most forms of the genus by its close approach to a semicircular shape, and by the high degree of resemblance in ornament of the two valves (Crickmay, 1963, p. 25).

Material. Represented by numerous specimens in some samples from the more calcareous parts of the Bituminous limestone member and Brown limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A Hypotype	B Hypotype	C Hypotype	D Hypotype
GSC no.	75570	75571	75572	75573
GSC locality no.	C-94477	C-94566	C-94566	C-94566
Length of pv (Lpv)	7.5	9.8	10.4	11.1
Length of bv (Lbv)	6.5	8.9	9.6	—
Width (W)	8.9	12.5	12.8	13.0
Depth (D)	2.7	4.1	4.3	4.6
Length of hinge line (Lhl)	7.0	ca. 11	12.5	11.4
Ratio: Lpv/W	0.84	0.78	0.81	0.85
Ratio: Lbv/W	0.73	0.71	0.75	—
Ratio: Lhl/W	0.79	0.88	0.98	0.88

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E Hypotype	F Hypotype	G Hypotype
GSC no.	75574	75575	75576
GSC locality no.	C-94566	C-94598	C-94598
Length of pv (Lpv)	—	—	—
Length of bv (Lbv)	8.5	7.9	10.5
Width (W)	ca. 11.6	10.6	12.1
Depth (D)	—	—	—
Length of hinge line (Lhl)	—	9.1	8.6
Ratio: Lpv/W	—	—	—
Ratio: Lbv/W	0.73	0.75	0.87
Ratio: Lhl/W	—	0.86	0.71

Dimensions (in mm) and other parameters. (cont'd.)

Specimen GSC no.	H Hypotype 75577	I Hypotype 75578	J Hypotype 75579
GSC locality no.	C-94519	C-94519	C-94519
Length of pv (Lpv)	—	15.4	—
Length of bv (Lbv)	11.5	—	9.9
Width (W)	16.0	17.4	12.9
Depth (D)	—	—	—
Length of hinge line (Lhl)	ca. 14	17.6	11.4
Ratio: Lpv/W	—	0.89	—
Ratio: Lbv/W	0.72	—	0.77
Ratio: Lhl/W	0.88	1.01	0.88

Description. Shell of small size; subsemicircular in outline; concavo-convex in lateral profile; non-geniculate; hinge line generally less than greatest width of shell, ratio of Lhl/W varying from 0.71 to 1.01 amongst measured specimens; lateral margins commonly slightly indented immediately anterior of cardinal angles to produce slightly extended 'ears'.

Pedicle valve moderately convex, highest at about one-third length from beak; small, circular, slightly indented cicatrix of attachment near tip of umbo evident on some specimens; beak small, short, barely overhanging posterior border; interarea linear, broad, low, decreasing in height laterally; delthyrium small, triangular-shaped, pseudodeltium absent.

Brachial valve weakly to moderately concave; no interarea.

External ornament on pedicle valve of fine, irregular, wavy radial costellae that are interrupted by irregular concentric relatively coarse growth ridges and lamellae. Spine bases small, sparsely and irregularly scattered over disc of valve, and more evenly along posterior margin of valve, the latter are up to four in number on each side of the umbo and are directed posterolaterally. Spines are very fine, fragile, and seen only in attached matrix.

External ornament on brachial valve of strong, concentric, relatively coarse lamellae; each lamella marked by very fine, faint, radial costellae which are less conspicuous than those on the pedicle valve.

Interior of pedicle valve not seen.

Interior of brachial valve with bilobate cardinal process of medium size; a low, rounded median septum is joined to the base of cardinal process and extends anteriorly for about four-fifths length of valve; floor of valve is indented on each side of the septum; closely spaced endospines covering a large part of interior of valve surrounding a vaguely defined muscle area.

Remarks. Apart from the presence of spine bases on the pedicle valve and their absence from the brachial valve, the distinction between the radial ornament on the two valves is much more pronounced than that suggested by Crickmay (1963, p. 24). The radial costellae on the brachial valve are considerably less conspicuous than those on the pedicle valve in the specimens at hand.

Figured specimens. Hypotype GSC 75570, a young adult specimen, from GSC locality C-94477; hypotype GSC 75571, an adult specimen, hypotype GSC 75572, a mature adult specimen, hypotype GSC 75573, exterior of pedicle valve of a rotund specimen, and hypotype 75574, interior of a brachial valve, from GSC

locality C-94566; hypotype GSC 75575, exterior of a brachial valve of an adult individual, and hypotype GSC 75576, interior of a brachial valve of an adult individual, from GSC locality C-94598; hypotype GSC 75577, interior of a brachial valve of a large adult individual, hypotype GSC 75578, exterior of a pedicle valve of a large adult individual, and hypotype GSC 75579, exterior of a brachial valve of an adult individual, from GSC locality C-94519.

Locality data. GSC locality C-94477 (sample 23NBb) at station 23NB on the south shore of Great Slave Lake at 60°53′28″N, 114°10′00″W, about 0.54 km west of Dawson Landing wharf; from an outcrop, 43 cm thick, about 1 m above lake level of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94566 (sample 54NBb) at station 54NB on the south shore of Great Slave Lake at 60°53′08″N, 140°08′40″W, about 0.64 km east of Dawson Landing wharf; from a small outcrop, about 10 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94598 (sample 66NBb) at station 66NB on the south shore of Great Slave Lake at 61°59′58″N, 114°12′10″W, about 2.4 km west northwest of Dawson Landing wharf; from the lower beds, 18 cm thick, of an outcrop, 65 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94519 (sample 37NBc) at station 66NB at 60°57′50″N, 114°10′35″W, cliff section on west side of road, 2.6 km bearing 200T from Dawson Landing wharf; from loose blocks derived from an outcrop at top of cliff, 3.7 m thick, of the Brown limestone member of the Pine Point Formation.

Occurrence. The type specimens of *Devonoproductus primus* are recorded by Crickmay (1963, p. 24, 25) from the Pine Point Formation outcropping in the vicinity of Dawson Landing on the south shore of Great Slave Lake. The species is recorded also by Crickmay (1963, p. 25) from the subsurface in N.W.T. Deep Bay No. 2 well (61°18′00″N, 116°48′00″W) at 306.3 m in dark grey shale of the Pine Point Formation, 106.7 m below an occurrence of *Stringocephalus*. In northeastern British Columbia, the species has been recorded by Crickmay (1963, p. 25) from Middle Devonian shale on Richards Creek (57°34′N, 123°55′W) north of Tuchodi Lake, on Besa River, and on Prairie Mountain.

The specimens of *Productus*? described and illustrated by Meek (1868, p. 92, Pl. 13, figs. 4a–4d) are recorded from dark bituminous limestone, on the south side of Great Slave Lake, near Fort Resolution.

The specimens of *Productella* sp. illustrated by Warren and Stelck (1956, Pl. 4, figs. 34, 35) are recorded as part of the *Ambocoelia meristoides* fauna from the Pine Point Limestone, Pine Point, Great Slave Lake, Northwest Territories.

The present study shows that *Devonoproductus primus* occurs in the more calcareous parts of the Bituminous limestone member in the the lower and upper parts of the member of the Pine Point Formation on the south side of Great Slave Lake.

Family PENTAMERIDAE M'Coy, 1844

Subfamily GYPIDULINAE Schuchert and LeVene, 1929

Genus *Gypidula* Hall, 1867, p. 163

Type species. Gypidula typicalis Amsden, 1953, p. 140 [(pro *Pentamerus occidentalis* Hall, 1858, p. 514, non Hall 1852); OD Hall, 1867, p. 380].

Gypidula? *presquilensis* Norris n. sp.

Plate 3, figures 10–19; Plate 10, figures 6–10

Etymology. The trivial name *presquilensis* is after Presqu'ile Point on the south side of Great Slave Lake where this form was recovered from loose blocks of the Windy Point Member of the Sulphur Point Formation.

Diagnosis. On mature specimens this species is characterized by its highly inflated pedicle valve; a long raised fold on the pedicle valve with three broad ribs; and a short anterior sulcus on the brachial valve with two weakly developed broad ribs.

Material. Represented by six specimens, only two of which are complete, from three localities on the north tip and east side of Presqu'ile Point.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Paratype	Paratype	Paratype	Holotype
GSC no.	75580	75581	75582	76443
GSC locality no.	C-94439	C-94439	C-94440	C-126452
Length of pv (Lpv)	9.9	19.8	27.9	22.6
Length of bv (Lbv)	9.3	—	—	14.5
Width (W)	10.6	21.0	ca. 29.8	20.0
Depth (D)	7.7	—	—	18.1

Ratio: W/Lpv	1.07	1.06	1.07	0.88
Ratio: D/W	0.73	—	—	0.91
Ratio: Lbv/Lpv	0.94	—	—	0.64
Costae on pv	0-3-0	3?-3-3?	2?-4-2?	2-3-2
Costae on bv	0-2?-0	—	—	0-2-0

Description. Shell attains a medium size at maturity; galeatiform; strongly biconvex in lateral profile; slightly wider than long in youthful and young adult stages, becoming conspicuously longer than wide in mature adult stages; indented anterior margin; sulcate anterior commissure.

Pedicle valve strongly and smoothly convex, highest about midlength, accounting for 0.64 total depth of shell in specimen D; very low fold on anterior two-thirds of valve of adult specimens, the sides of which are marked by prominent, broadly rounded, raised ribs; the area between the ribs is depressed but is still above the highest level of the flanks; a prominent low rounded rib occurs along the midline which originates over the anterior part of the umbo and increases in strength anteriorly. Umbo highly inflated, broadly rounded and strongly inturned; beak bluntly rounded, strongly inturned; interarea low and narrow; delthyrium not seen.

Brachial valve moderately convex, highest about one-fifth length from beak; beak is small, straight, bluntly rounded; interarea very low. On mature specimens a broad, shallow sulcus originates near the anterior margin of valve, which is abruptly geniculated and extended as a rectangular-shaped tongue fitting into a recess of the opposite valve. The end of the tongue is marked by a zig-zag suture where it abuts the anterior end of the fold of the pedicle valve.

Both valves smooth in young growth stages; in adult stages three, low, broadly rounded ribs are developed on the fold of the pedicle valve; the rib along the midline is the longest and originates over umbo and gradually increases in width anteriorly; the two lateral ribs of the fold originate anteriorly of the central rib but more abruptly increase in width and height anteriorly to become the dominant ribs on the shell. Two to three very faint ribs are barely discernible on the anterior parts of the flanks of the pedicle valve. Two faint, closely spaced, rounded ribs, separated by a faint narrow depression, are present in the shallow sulcus on the brachial valve which extends onto the geniculate tongue on the anterior ventral side of the shell.

Interior of pedicle valve not seen, but the trace along floor of valve of a short median septum is evident through the translucent shell material of specimen D which extends from beneath the beak a short distance anteriorly.

Interior of brachial valve not seen, but the traces of two plates along the floor of valve can be seen through the translucent shell material of specimen D that meet beneath the beak and diverge and extend a short distance anteriorly.

Remarks. In the development of an indented anterior margin and a geniculate tongue of the dorsal valve fitting into a trapezoidal re-entrant in the pedicle valve, *Gypidula*? *presquilensis* n. sp. bears some resemblance to *Gypidula pelagica* (Barrande) as illustrated by Johnson (1970, Pl. 15, figs. 12–15) from Gedinnian age beds, upper Roberts Mountains Formation, northern Roberts Mountains, Nevada. *G.*? *presquilensis* n. sp. is distinguished from the Nevada form by its narrower and more elongate outline, its much longer pedicle valve relative to the brachial valve, and its more strongly recurved or geniculated tongue which occupies a much longer re-entrant in the pedicle valve.

Gypidula? *presquilensis* n. sp. has some similarities in common with an undescribed species referred to as *Gypidula* sp. B by A.E. Wilson (*in* Martison, 1953, p. 44, 59), which was collected by W.S. Dyer (1928, p. 27) from the Williams Island Formation on the west side of Williams Island, Abitibi River, northern Ontario (Royal Ontario Museum specimen 26372, Toronto). *G.*? *presquilensis* n. sp. is distinguished from the Williams Island form by its narrower and more elongate pedicle profile, its more inflated and extended pedicle umbo, its less indented anterior margin, and its more indented and more strongly plicate pedicle fold.

In the development of the long raised fold on the pedicle valve and short anterior sulcus on the brachial valve, *Gypidula? presquilensis* is very closely similar to a form designated as *Gypidula* sp. cf. *G. comis* (Owen) by Warren and Stelck (1956, Pl. 5, figs. 5–8), collected from the Ramparts limestone on Hanna River, District of Mackenzie. *G.? presquilensis* is distinguished by the much more conspicuous development of the broad costae on the fold and flanks of the pedicle valve, and on the sulcus of the brachial valve; by the narrower width of its shell, and by its lower elevation of the fold on the pedicle valve.

Figured specimens. Paratype GSC 75580, a young rotund individual, and paratype GSC 75581, a latex postive replica of pedicle valve of a young adult individual, from GSC locality C-94439; paratype GSC 75582, a partly crushed pedicle valve of an adult individual, from GSC locality C-94440; and holotype GSC 76443, a mature adult individual, from GSC locality C-126452.

Locality data. GSC locality C-94439 (sample 13NBa) at station 13NB on the east side and near north tip of Presqu'ile Point on the south shore of Great Slave Lake at 60°56′50″N, 114°34′30″W; from large loose blocks of brown reefal limestone derived from the lower part of the Sulphur Point Formation.

GSC locality C-94440 (sample 14NBa) at station 14NB on the mid east side of Presqu'ile Point on the south shore of Great Slave Lake at 60°56′45″N, 114°34′40″W; from large loose blocks of brown reefal limestone derived from the lower part of the Sulphur Point Formation.

GSC locality C-126452 (sample 1NBb) at station 1NB on the north tip of Presqu'ile Point on the south shore of Great Slave Lake at 60°57′00″N, 114°34′42″W; from large loose blocks of brown reefal limestone of the lower part of the Sulphur Point Formation.

Occurrence. Gypidula? *presquilensis* n. sp. is a rare element in the Sulphur Point Formation. Important associated fossils at the Presqu'ile Point locality include *Hypothyridina cameroni* Warren and *Stringocephalus* sp. B of Warren and Stelck (1962).

Superfamily ATRYPACEA Gill, 1871

Family ATRYPIDAE Gill, 1871

Subfamily ATRYPINAE Gill, 1871

Genus *Anatrypa* Nalivkin, 1941, p. 172

Subgenus VARIATRYPA Copper, 1966

Type species. Desquamatia ajugata Copper, 1965a, p. 316, Pl. 27, figs. 1, 2, Textfigs. 3–12.

Anatrypa (*Variatrypa*) *exoleta* Johnson, 1974

Plate 3, figures 20–24

1974 *Anatrypa* (*Variatrypa*) *exoleta* Johnson, p. 60, 61, Pl. 6, figs. 1–21; Pl. 7, figs. 1–8; Textfig. 5.

Diagnosis. Large, coarsely costate, dorsi-biconvex *Variatrypa* (Johnson, 1974, p. 60).

Material. Represented by very few poorly preserved specimens at a few stations on the south side of Great Slave Lake.

Dimensions (in mm) and other parameters.

Specimen	A Hypotype	B Hypotype
GSC no.	75619	75620
GSC locality no.	C-94458	C-94724
Length of pv (Lpv)	32.1	ca. 33.3
Length of bv (Lbv)	30.0	—
Width (W)	37.9	ca. 43.3
Depth (Depth)	24.1	—
Length of hinge line (Lhl)	ca. 29.4	36.1
Ratio: Lpv/W	0.85	0.77
Ratio: Lbv/W	0.79	—
Ratio: Lhl/W	0.66	0.83
Costae per 5 mm, 10 mm from beak	pv 11 bv 11	pv 8 bv —
Costae per 5 mm, 20 mm from beak	pv 8 bv 7?	pv 6 bv —

Description. Shells attain a large size at maturity; transversely oval in outline, maximum width about midlength; dorsi-biconvex lateral profile; hinge line relatively straight, hinge length varies between 0.66 and 0.83 of maxmium width amongst measured specimens; low uniplicate anterior commissure.

Pedicle valve is weakly to moderately convex, highest about one-third length from beak; beak is slender, slightly incurved, and extended beyond umbo of brachial valve; interarea very low, anacline; sulcus on anterior third of valve is very broad and shallow and is barely perceptible, it is extended as a low rounded tongue in the opposite valve.

Brachial valve strongly convex, highest about midlength, accounting for about three-quarters total depth of shell; beak is strongly inturned and covered by opposite valve; fold is barely perceptible on anterior third of valve.

Valves ornamented with straight, tubular costae that increase in strength anteriorly to become relatively coarse; they are separated by rounded depressions of approximately the same width as the costae; increase in number of costae on both valves is mainly by bifurcation; widely and irregularly spaced coarse concentric growth ridges marking sites of alate lamellae that are commonly broken when shell is removed from matrix.

Remarks. A comparison with species described from the Middle Devonian of northwestern Canada shows that *Anatrypa* (*Variatrypa*) *exoleta* Johnson is easily distinguished from *Anatrypa* (*Independatrypa*) *aperanta* Crickmay, 1960) and *Variatrypa* (*Variatrypa*) *arctica* (Warren, 1944) by its much coarser costae as well as other shape and size differences. *Anatrypa* (*Variatrypa*) *exoleta* is closely similar to *Anatrypa*

(*Independatrypa*) *perfimbriata* (Crickmay, 1957) described from the Methy Formation of northeastern Alberta, but can be distinguished from this species by its straighter hinge line, larger size at maturity, and more unequally biconvex lateral profile. From *Desatrypa nasuta* (Norris, *in* McLaren and Norris, 1964; Copper, 1979, p. 312, 313, Textfig. 6) described from the Horn Plateau Formation, northwest of Great Slave Lake, *Anatrypa* (*Variatrypa*) *exoleta* is distinguished by its finer costae, much larger size at maturity, straighter hinge line, and the presence of coarse concentric growth ridges on both valves.

Figured specimens. Hypotype GSC 75619, a thick adult individual, from GSC locality C-94458; and hypotype GSC 75620, pedicle valve of a large adult individual, from GSC locality C-94724.

Locality data. GSC locality C-94458 (sample 18NBb) at station 18NB on the mid north shore of McKay Island at 61°01′45″N, 114°10′30″W, bearing 064T, at 4.8 km from Pine Point; from an outcrop, 39 cm exposed, along shore just above lake level, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94724 (sample 96NBa) at station 96NB on the north shore and near the west end of McKay Island at 61°01′48″N, 114°11′28″W; from the upper part of an outcrop, 42 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Anatrypa (*Variatrypa*) *exoleta* Johnson is a rare form in the Bituminous limestone member of the Pine Point Formation on the south side of Great Slave Lake where it has been recovered from only a few localities. *Anatrypa* (*Variatrypa*) *exoleta* is recorded by Johnson (1974, p. 52, Table 1) from the Denay and Woodpecker limestones of Nevada where it is associated with brachiopods of the *Eliorhynchus castanea* Zone.

In northwestern Canada, the closely similar form, *Anatrypa* (*Independatrypa*) *perfimbriata* (Crickmay, 1957, p. 13, Pl. 1, figs. 12–14), is reported from the Bear Westmount No. 1 borehole (Lsd. 14, Sec. 9, Tp. 86, R. 7, W4M) between 460.6 and 494.7 m depths, and also from the Bear Rodeo No. 2 borehole (Lsd. 5, Sec. 17, Tp. 91, R. 9, W4M) where the depth information is less precise. Both of these occurrences are within the Methy Formation described and illustrated by Norris (1973, p. 24–27, fig. 7). In the Bear Westmount No. 1 borehole the most conspicuous associated fossil is *Emanuella sublineata* (Meek); and in the Bear Rodeo No. 2 borehole, *Anatrypa* (*Independatrypa*) *perfimbriata* is reported to range in the Methy Formation from well above the occurrence of *Stringocephalus* sp. down to the highest occurrence of *Anatrypa* (*Variatrypa*) *arctica* (Warren). *Atrypa perfimbriata* Crickmay is classified by Copper (1979, p. 296) as *Desquamatia* (*Independatrypa*) *perfimbriata* (Crickmay).

Subfamily SPINATRYPINAE Copper, 1979

Genus *Spinatrypa* Stainbrook, 1951, p. 196

Type species. Atrypa hystrix var. *occidentalis* Hall, 1858, (errore pro *Atrypa aspera* var. *occidentalis* Hall, 1858, p. 515) (=*Atrypa occidentalis*, nom. transl. Stainbrook, 1938, p. 241); OD.

Spinatrypa sp. A

Plate 3, figures 25–28

Diagnosis. A *Spinatrypa* of small to medium size at maturity, with a transversely oval outline, a small pedicle beak, and fine to medium costae.

Material. Represented by eighteen poorly preserved specimens.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75621	75622	75623	75624
GSC locality no.	C-94439	C-94439	C-94439	C-94439
Length of pv (Lpv)	13.8	—	est. 16.5	est. 13.5
Length of bv (Lbv)	—	15.7	—	—
Width (W)	ca. 17.4	20.1	19.1	ca. 17.6
Depth (D)	—	—	—	—
Length of hinge line (Lhl)	—	14.6	—	—
Ratio: Lpv/W	0.79	—	0.86	0.77
Costae per 5 mm, 10 mm from beak	pv 6 bv —	pv — bv 4	pv 4 bv —	pv 4.5 bv —

Description. Shells of small to medium size; subequally and weakly to moderately biconvex; transversely suboval in outline, maximum width about midlength; hinge line slightly curved and less than maximum width of shell; anterior commissure varies from rectimarginate to weakly uniplicate.

Pedicle valve weakly convex, highest about midlength; some specimens show a reversal of curvature on flanks toward lateral margins; anterior median part of valve is weakly geniculate to produce a small tongue in the opposite valve, evident only in some specimens;

beak small, straight, bluntly rounded, barely extended beyond the opposite valve; foramen small, circular, marked by a slightly raised lip, submesothyridid; deltidial plates not seen; interarea low, not sharply delineated.

Brachial valve weakly to moderately convex, generally accounting for slightly more than one-half total depth of shell; a shallow median sulcus originating over the umbo but which does not extend to the anterior margin is evident on one specimen.

Costae relatively strong, varying from 4 to 6 per 5 mm at 10 mm from beaks; the two median costae on pedicle valve are slightly larger than adjacent costae; increase in number is by bifurcation; costae are crossed by strong frilly growth lamellae which anteriorly form hollow, cylindroidal spines on the crests of costae and are seen embedded in attached matrix.

Interiors of valves not seen.

Remarks. Although the material of *Spinatrypa* sp. A is fragmentary and poorly preserved, it is sufficiently adequate for gross comparisons with described and illustrated forms.

From *Spinatrypa* (*Spinatrypa*) *undulata* Copper (1979, p. 298, 299, Pl. 1, figs. 5–9) described from the Hare Indian Shale, on Simpson Creek, Anderson River, District of Mackenzie, *Spinatrypa* sp. A is distinguished by its transversely oval outline rather than a rounded subquadrate outline, a less sloping hinge line, and slightly finer costae.

Spinatrypa sp. A slightly resembles *Spinatrypa hornensis* Norris (*in* McLaren and Norris, 1964, p. 55, 56, Pl. 16, figs. 3–8) described from the upper beds of a pinnacle reef of Givetian age at the top of the Horn Plateau Formation outcropping northwest of Great Slave Lake, District of Mackenzie. *Spinatrypa* sp. A is differentiated from *S. hornensis* by its smaller, less extended pedicle beak, its transversely oval outline, and its slightly finer radial costae.

Spinatrypa sp. A also bears some resemblance to *Spinatrypa asperoides* Biernat (1964, p. 313, 314, Pl. 6, figs. 1–5, 12; Pl. 7, figs. 7, 8; Textfigs. 8 (6), 14) described from the lower Givetian (?upper Eifelian) Skaly beds, Lysogory region, Holy Cross Mountains of Poland. However, *Spinatrypa* sp. A differs from the species from Poland by its transversely oval outline, its straighter pedicle beak, less sloping hinge line, and slightly coarser costae.

Figured specimens. Hypotype GSC 75621, pedicle valve of an adult individual embedded in matrix, hypotype GSC 75622, brachial valve of an adult individual embedded in matrix, hypotype GSC 75623, pedicle valve of an adult individual embedded in matrix, and hypotype GSC 75624, part of pedicle valve of a young adult individual; all four specimens from GSC locality C-94439.

Locality data. GSC locality C-94439 (sample 13NBa) at station 13NB on the east side and near north tip of Presqu'ile Point, south shore of Great Slave Lake at 60°56′50″N, 114°34′40″W; from large loose blocks of brown reefal limestone derived from the Sulphur Point Formation.

Occurrence. Spinatrypa sp. A occurs as a small 'nest' of closely packed fossils in a block derived from the Sulphur Point Formation associated with *Stringocephalus* sp. B of Warren and Stelck, 1962, and other fossils.

Subfamily SPINATRYPINAE Copper, 1979

Genus *Spinatrypina* Rzhonsnitskaya, 1964

Type species. Spinatrypina margaritoides Rzhonsnitskaya, 1964, p. 101–103, Pl. 1, figs. 1–8.

Spinatrypina sp. A

Plate 3, figures 29–40

Diagnosis. A species of *Spinatryina* of small size at maturity; almost equally biconvex in lateral profile; anterior commissure weakly uniplicate; and with two median costae on the umbones of both valves which are slightly larger than adjacent costae.

Material. Represented by eight fragmentary specimens.

Dimensions (in mm) and other parameters.

Specimen	A	B
	Hypotype	Hypotype
GSC no.	75625	75626
GSC locality no.	C-94467	C-94467
Length of pv (Lpv)	13.0+	—
Length of bv (Lbv)	12.7	11.5
Width (W)	14.4	12.5
Depth (D)	7.4	—
Length of hinge line (Lhl)	ca. 12.4	ca. 10.0
Costae per 5 mm, 0 mm from beaks	pv 6 bv 5	pv — bv 5

Description. Shell of small size; transversely suboval in outline; almost equally biconvex in lateral profile; anterior commissure weakly uniplicate; hinge angle of about 146 degrees; length of hinge line less than maximum width of shell.

Pedicle valve weakly and evenly convex, highest about one-third length from beak; very shallow indistinct sulcus devloped at and near the anterior median margin of the valve; beak not seen.

Brachial valve weakly and evenly convex, accounting for about one-half total depth of shell, highest about midlength; beak small, inturned, covered by opposite valve.

Valves covered with relatively coarse, radial tubular costae that are crossed by closely and irregularly spaced, coarse concentric growth lamellae; spines apparently were not produced; the two median costae on the umbones of both valves are slightly larger than adjacent costae; separating the costae are narrow, U-shaped interspaces; costae increase slightly in strength anteriorly, they increase in numbers anteriorly by bifurcation and intercalation.

Interiors of valves not seen.

Figured specimens. Hypotype GSC 75625, incomplete specimen of a young adult individual; hypotype GSC 75626, fragment of brachial valve of a young adult individual; both specimens from GSC locality C-94467.

Locality data. GSC locality C-94467 (sample 21NBa1) at station 21NB on the south shore of Great Slave Lake at 60°59′30″N, 114°09′40″W, about 61 m west of Dawson Landing wharf; from lower 13 cm of an outcrop 59 cm exposed of the Bituminous limestone member of the Pine Point Formation.

Occurrence. Spinatrypina sp. A is an exceedingly rare element in the more calcareous parts of the Bituminous limestone member of the Pine Point Formation.

Remarks. Material is too limited and fragmentary for comparison with other species.

According to Copper (1967a, b, p. 123), the genus *Spinatrypina* Rzhonsnitskaya (1964) is distinguished from the genus *Spinatrypa* Stainbrook (1951) by its tubular-imbricate, rather than flat and nodose ribs, by its lack of spines, and by its distinctly exposed area and dominantly orthocline beak. In a later paper, Copper (1979, p. 299) classified *Spinatrypina* as a subgenus of *Spinatrypa*.

Superfamily ATHYRIDACEA M'Coy, 1844

Family ATHYRIDIDAE M'Coy, 1844

Subfamily ATHYRIDINAE M'Coy, 1844

Genus *Leptathyris* Siehl, 1962, p. 212.

Type species. Leptathyris gryphis Siehl, 1962, p. 212; OD.

Leptathyris obsolescens Johnson, 1974

Plate 3, figures 41, 42; Plate 4, figures 1–46; Textfigure 11

1974 *Leptathyris obsolescens* Johnson, p. 62. Pl. 7, figs. 9–23.

Diagnosis. Leptathyris with a minute, nearly obsolescent, apically situated cardinal plate (Johnson, 1974, p. 62).

Material. Represented in five samples from the Bituminous limestone member of the Pine Point Formation in which it is rare in four samples and exceedingly abundant in one sample.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D*
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75627	75628	75629	75630
GSC locality no.	C-94474	C-94490	C-94474	C-94474
Length of pv (Lpv)	6.1	7.9	9.1	10.1
Length of bv (Lbv)	5.3	7.4	8.4	9.3
Width (W)	5.9	7.9	8.9	9.9
Depth (D)	3.0	4.3	5.1	5.6
Ratio: W/Lpv	0.96	1.00	0.97	0.98

*Serially sectioned

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E	F	G
	Hypotype	Hypotype	Hypotype
GSC no.	75631	75632	75633
GSC locality no.	C-94474	C-94463	C-94612
Length of pv (Lpv)	10.0	12.1	13.4
Length of bv (Lbv)	8.9	10.1	11.8
Width (W)	9.8	11.4	12.3
Depth (D)	5.2	6.5	7.8
Ratio: W/Lpv	0.98	0.94	0.92

Description. Shell of very small size; outline is subcircular to elliptical in young stages, subpentagonal in later growth stages; length slightly greater than width; lateral profile lenticular, subequally biconvex with the pedicle valve of slightly greater depth than the opposite valve. Anterior commissure rectimarginate to slightly uniplicate, and where the latter condition is developed the anterior margin of shell is slightly indented.

Pedicle valve nearly evenly convex in lateral profile with maximum depth located at or near midlength. Anterior profile fairly evenly convex. On some specimens a broad, very shallow, U-shaped sulcus originates in anterior fifth of valve which becomes more pronounced anteriorly. Umbonal region wedge-shaped, pointed, with a slightly incurved beak, pierced by a permesothyrid foramen. Beak ridges rounded. Cardinal area curved, apsacline near hinge line to anacline towards beak. Delthyrium triangular-shaped and presumably covered with conjunct deltidial plates.

Brachial valve smoothly convex in lateral profile with highest point within the posterior half of the valve, generally accounting for slightly less than half the depth of shell. Anterior profile narrowly and strongly convex in median region with gently convex lateral flanks. Beak small, rounded, weakly inturned, and in contact with the opposite valve.

Shell substance thin, largely missing on most specimens, but where present it is smooth except for widely spaced faint concentric growth lines.

Interior of pedicle valve (Fig. 11) with dental lamellae that are laterally convex and which enclose an oval shaped delthyrial cavity. Lateral cavities are small and irregular in shape. Teeth are relatively small and are projected obliquely inward where the valves are articulated. On some exfoliated specimens the impressions of faint radial markings can be seen in the medial region of the posterior third of the valve. Interior of brachial valve (Fig. 11) with dental sockets situated on the floor of valve between inner margins of the valve and inner socket ridges. Notothyrial cavity is small and is enclosed by the floor of the valve and two inwardly directed processes that coalesce near the apex of the beak. Muscle scars are not impressed.

Remarks. On the basis of morphological features described and illustrated by Johnson (1974, p. 62, Pl. 7, figs. 9–23) for *Lepthyris obsolescens* from the *Eliorhyncus castanea* Zone in the Denay Limestone of Nevada, the form from the Great Slave Lake area appears to be very closely related and is probably conspecific. The slight differences in external morphology noted between the Great Slave Lake and Nevada forms include a more circular outline compared to an elongate outline, and the presence in some specimens of a shallow anterior median sulcus on the pedicle valve compared to a smooth pedicle valve for the Nevada form.

The recognition of *Leptathyris obsolescens* from the Great Slave Lake area is the first recorded occurrence of this genus in the Devonian of northwestern Canada. Another possible representative of this genus in Canada, which should be further investigated, is a form described as *Cranaena*? *cryptonelloides* by Norris (*in* McLaren and Norris, 1964, p. 66, 67, Pl. 13a–15c) from the Middle Devonian Horn Plateau Formation outcropping northwest of Great Slave Lake. Although *Cranaena*? *cryptonelloides* bears some superficial resemblance to the genus *Cranaena*, punctae were not positively determined in the shell material of this form.

Leptathyris obsolescens from the Great Slave area differs from *Leptathyris gryphis* Siehl (1962, p. 212), the type species of the genus from Eifelian rocks of Germany, by having a much thinner shell substance, by its generally smooth shell or weak development of a sulcus on the anterior medial part of the pedicle valve in contrast to a bisulcate shell for the German species, and by its more circular outline compared to an elongate, subpentagonal outline for the type species. The major difference between the North American and European forms is the thin shell material for the former and very thick shell material for the latter form, a difference that may suggest that they belong in different genera.

Figured specimens. Hypotypes GSC 75627, 75629, 75630, 75631, and 75632, from GSC locality C-94474; hypotype GSC 75628 from GSC locality C-94490; hypotype GSC 75632 from GSC locality C-94463; and hypotype GSC 75633 from GSC locality C-94612.

Locality data. GSC locality C-94474 (sample 22NBb1) at station 22NB, on the south side of Great Slave Lake 412 m west of Dawson Landing at 260°59′29″N, 114°09′55″W, fossils collected loose from the top of an outcrop, 18 cm thick, from the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94490 (sample 28NBb) at station 28NB on the west end of McKay Island at 3.9 km, bearing 057T, from Pine Point at 61°01′30″N, 114°11′35″W; from the upper part of beds 50 cm thick exposed in a gentle synclinal fold, a part of the Bituminous limestone member of the Pine Point Formation.

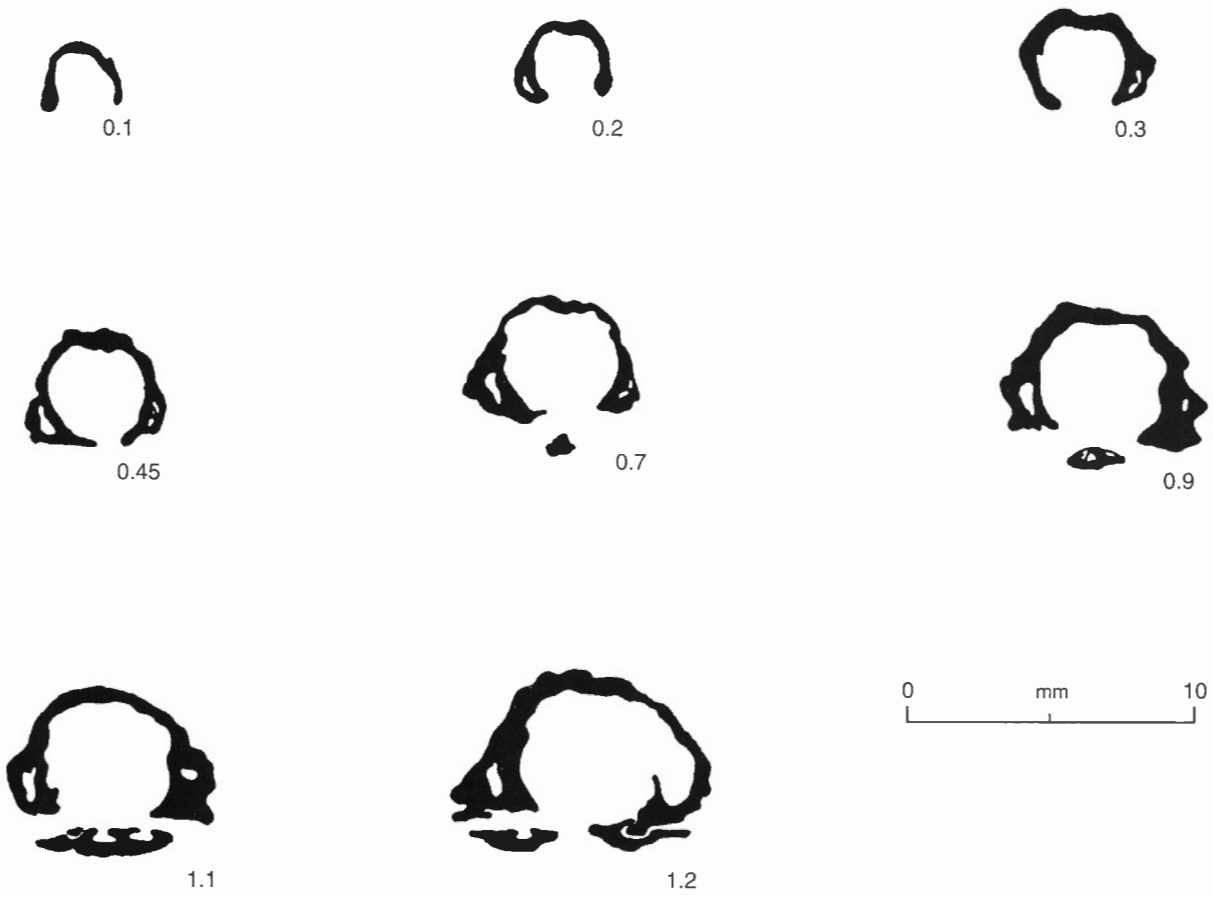


Figure 11. *Transverse serial sections of* ***Leptathyris obsolescens*** *Johnson, 1974. Distances are in millimetres forward of the beak of the pedicle valve. Hypotype GSC 75630. GSC locality C-94474.*

GSC locality C-94463 (sample 19NBc) at station 19NB on the mid north shore of McKay Island at 61°01′40″N, 114°10′35″W; from large loose blocks derived from an outcrop 60 cm thick, part of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94612 (sample 68NBh) at station 68NB on the south shore of Great Slave Lake, 2.7 km northwest of Dawson Landing at 61°00′03″N, 114°12′27″W; from top of unit 4, which is about 30 cm thick, and top of outcrop which is 88 cm thick, part of the Bituminous limestone member of the Pine Point Formation.

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily CYRTIACEA Frederiks (1919), 1924

Family AMBOCOELIIDAE George, 1931

Genus *Emanuella* Grabau, 1923

Type species. Nucleospira takwanensis Kayser, 1883, p. 86; Grabau, 1923, p. 192; OD.

Emanuella caldwelli Norris n. sp.

Plate 4, figures 47–52; Plate 5, figures 1–26; Textfigure 12

1956 *Martinia*? *richardsoni* Meek, Warren and Stelck, Pl. 4, figs. 13–15 (Dv. 1344-1), figs. 16–18 (Dv. 1343).
1960 *Emanuella richardsoni* (Meek), McCammon, p. 57, Pl. 10, figs. 11a–11c, Textfig. 2.
1968 *Emanuella* sp. 1 Caldwell, p. 609, Pl. 1, figs. 12a–12d, 13a–13d, (1967).
1971 *Emanuella* sp. 1 Caldwell, Pl. 2, figs. 12a–12c.

Diagnosis. A species of *Emanuella* with a wide transverse outline; a relatively long hinge line with rounded cardinal angles; a high catacline to apsacline pedicle interarea; and a relatively small size at maturity.

Material. Represented by about three dozen specimens from scattered localities.

Etymology. The trivial name *caldwelli* is after Dr. W.G.E. Caldwell in recognition of his important work on ambocoeliid brachiopods from northwestern Canada.

Dimensions (in mm) and other parameters.

Specimen	A Paratype	B Paratype	C Holotype
GSC no.	75634	75635	75636
GSC locality no.	C-94474	C-94558	C-94473
Length of pv (Lpv)	5.2	7.0	6.8
Length of bv (Lbv)	4.6	6.5	5.9
Width (W)	7.0	9.2	9.4
Depth (D)	3.6	5.1	6.7
Length of hinge line (Lhl)	6.7	9.1	9.3
Ratio: W/Lpv	1.35	1.31	1.38
Ratio: Lhl/W	0.96	0.99	0.99

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	D Paratype	E Paratype	F* Paratype
GSC no.	75637	75638	75639
GSC locality no.	C-94473	C-94478	C-94478
Length of pv (Lpv)	7.0	ca. 8.7	6.8
Length of bv (Lbv)	5.9	6.9	6.2
Width (W)	10.7	12.1	9.8
Depth (D)	5.0	6.5	5.0
Length of hinge line (Lhl)	10.7	11.4	8.4
Ratio: W/Lpv	1.53	1.39	1.44
Ratio: Lhl/W	1.00	0.94	0.86

*Serially sectioned

Description. Shell of small to medium size for the genus; unequally biconvex; subcircular to subtriangular; width considerably greater than length, this ratio varying between 1.31 to 1.53 for measured specimens; postero-lateral extremities rounded; length of hinge line generally slightly less than width of shell, this ratio for measured specimens varies between 0.86 to 1.00.

Pedicle valve strongly arched, highest over the umbonal region, accounting for about four-fifths total depth of shell; beak prominent, erect, pointed; beak ridges rounded; interarea very high, triangular-shaped, incurved, catacline near hinge line and changing to apsacline towards the beak; delthyrium triangular-shaped, filled with matrix in all specimens seen.

Brachial valve moderately to weakly convex, highest at about one-quarter length from beak; beak very small, slightly extended beyond the hinge line; interarea orthocline to apsacline.

Surface of both valves smooth except for very fine concentric growth lines seen only on a few shells because most shells are completely or partly exfoliated. Characteristic micro-ornament of *Emanuella* not seen. Some specimens show a barely perceptible very narrow sinus along the midline of the pedicle valve.

Internal structures of this species in the material at hand are very poorly preserved. Interior of pedicle valve (Fig. 12) with dental ridges that border the delthyrium and project obliquely inward but which do not reach the valve floor. Small, slender hinge teeth located at the anterior ends of the dental ridges are projected obliquely inwards. Muscle impressions are not apparent.

Interior of brachial valve (Fig. 12) with dental sockets supported by thin crural plates that converge towards the floor of the valve and continue anteriorly, close together, beyond the region of articulation, as reduced subparallel tracks. Muscle impressions are not apparent.

Remarks. Although the name *Emanuella richardsoni* (Meek) has been used by some workers to apply to wide forms of *Emanuella* from northwestern Canada, Schuchert (1905, p. 616) has pointed out that the holotype of *Spirifer* (*Martinia*) *richardsoni* Meek (1868, p. 104, Pl. 14, figs. 2a–2c) is a young specimen of "*Plectospirifer*" *compactus* (Meek). To avoid this uncertainty of nomenclature, the name *Emanuella caldwelli* Norris n. sp. is introduced here.

Emanuella caldwelli n. sp. is easily distinguished from the associated *E. sublineata* (Meek) and *E. meristoides* (Meek) by its wide transverse outline, relatively long hinge line, relatively small size at maturity, and by its high catacline to apsacline pedicle interarea.

Occurrence. Emanuella caldwelli n. sp. is a relatively rare form in the Bituminous limestone member of the Pine Point Formation on the south side of Great Slave Lake.

The specimens of *Martinia*? *richardsoni* Meek illustrated by Warren and Stelck (1956, Pl. 4, figs. 13–18) are recorded as part of the *Ambocoelia meristoides* fauna from the Pine Point Limestone, Pine Point area, Great Slave Lake, Northwest Territories.

The specimens of *Emanuella richardsoni* (Meek) illustrated by McCammon (1960, p. 57, 58, Pl. 10, figs. 11a–11c, Textfig. 1) are from the north bank of the Red Deer River, about 91.4 m west of Highway 10, and from a locality on Snake Island, near the south

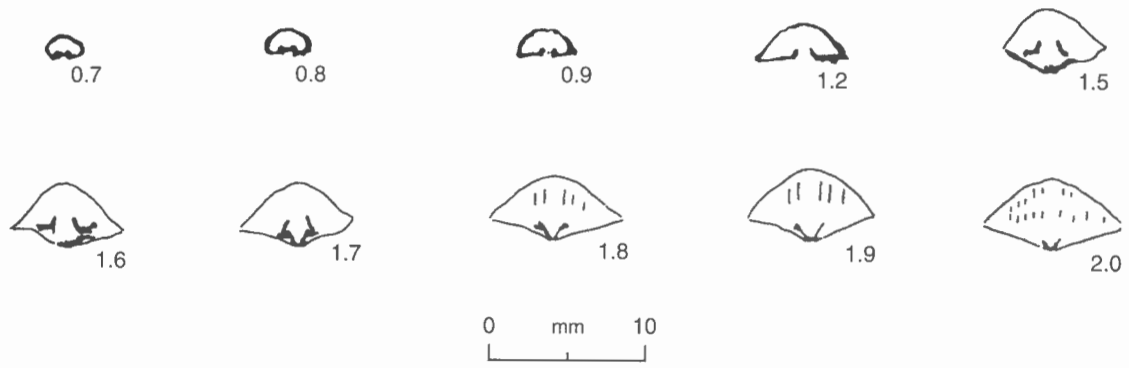


Figure 12. *Transverse serial sections of* ***Emanuella caldwelli*** *Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype GSC 75639. GSC locality C-94478.*

end of Lake Winnipegosis, Manitoba. From data presented by Norris *in* Norris et al. (1982, p. 55) the specimens illustrated by McCammon were probably derived from Members B or C of the Dawson Bay Formation.

The *Emanuella* sp. 1 illustrated by Caldwell (1968, p. 612, Pl. 1, figs. 12a–12d) is recorded from calcareous shales, near the top of the Hare Indian Formation, from a low embankment at the extreme northwest end of Jan Lake, Carcajou Ridge, Mackenzie River, District of Mackenzie.

A narrower form of *Emanuella* sp. 1 illustrated by Caldwell (1968, p. 612, Pl. 1, figs. 13a–13d) is from limestones with shales, 3.05 to 12.2 m below the top of the Hume Formation, north side of Powell Creek (65°16′N, 128°46″W), tributary of Mountain River, Canyon Ranges, Mackenzie Mountains, District of Mackenzie.

Figured specimens. Paratype GSC 75634 from GSC locality C-94474; Paratype GSC 75635 from GSC locality C-94558; holotype GSC 75636 and paratype GSC 75637 from GSC locality C-94473; and paratype GSC 75638 and paratype GSC 75639 from GSC locality C-94478.

Locality data. GSC locality C-94474 (sample 22NB1) at station 22NB on the south shore of Great Slave Lake 412 m west of Dawson Landing at 60°59′29″N, 114°09′53″W; from loose blocks lying on top of an outcrop, 18 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94558 (sample 51NBc) at station 51NB on the south shore of Great Slave Lake, 335 m east of Dawson Landing at 60°59′04″N, 114°09′06″W; from 90 cm above the base of an outcrop, 104 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94473 (sample 22NBa1) at station 22NB on the south shore of Great Slave Lake, 412 m west of Dawson Landing at 60°59′29″N, 114°09′53″W; from the top of an outcrop, 18 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94478 (sample 24NBa) at station 24NB on the south shore of Great Slave Lake, 732 m west of Dawson Landing at 60°59′27″N, 114°10′05″W; from an outcrop, 9 cm thick, of the Bituminous limestone member of the Pine Point Formation.

Emanuella meristoides (Meek, 1868)

Plate 5, figures 27–56; Plate 6, figures 1–11; Textfigure 13

1868 *Spirifer* (*Martinia*) *meristoides* Meek, p. 106, Pl. 14, figs. 3a–3h (1867).
1940 *Martinia meristoides* Meek, Merriam, Pl. 8, fig. 21.
1956 *Ambocoelia meristoides* (Meek), Warren and Stelck, Pl. 4, figs. 22–24.
1967 *Emanuella meristoides* (Meek), Crickmay, p. 7, Pl. 2, figs. 4–7; Pl. 3, fig. 21.
1968 "*Emanuella*" *meristoides* (Meek), Caldwell, p. 612, Pl. 1, figs. 7a–7d, 8a–8d (1967).
1971 "*Emanuella*" *meristoides* (Meek), Caldwell, Pl. 2, figs. 11a–11d.
1974 *Emanuella meristoides* (Meek), Johnson, p. 64, Pl. 10, figs. 16–31, Textfig. 7.

Diagnosis. A species of *Emanuella* Grabau (1923) with an elongate oval outline; an extremely short hinge line; rounded lateral margins; and pedicle umbo and beak strongly incurved to cover opposite valve (Meek, 1868, p. 106).

Material. This species is the second most abundant brachiopod in the Bituminous limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A	B	C
	Hypotype	Hypotype	Hypotype
GSC no.	75640	75641	75642
GSC locality no.	C-94474	C-94686	C-94686
Length of pv (Lpv)	12.9	12.1	13.0
Length of bv (Lbv)	10.5	11.0	11.5
Width (W)	11.1	11.7	12.6
Depth (D)	8.8	7.9	9.0
Length of hinge line (Lhl)	7.5	7.5	8.7
Ratio: W/Lpv	0.86	0.97	0.97
Ratio: Lhl/W	0.68	0.64	0.69

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	D	E	F*
	Hypotype	Hypotype	Hypotype
GSC no.	75643	75644	75645
GSC locality no.	C-94475	C-94566	C-94686
Length of pv (Lpv)	14.6	15.0	15.4
Length of bv (Lbv)	12.1	13.7	13.6
Width (W)	14.0	14.4	14.3
Depth (D)	9.9	10.4	11.0
Length of hinge line (Lhl)	9.2	10.0	9.8
Ratio: W/Lpv	0.96	0.96	0.93
Ratio: Lhl/W	0.66	0.69	0.69

*Serially sectioned

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	G	H	I
	Hypotype	Hypotype	Hypotype
GSC no.	75646	75647	75648
GSC locality no.	C-94686	C-94686	C-94710
Length of pv (Lpv)	15.2	15.1	18.2
Length of bv (Lbv)	13.3	13.3	15.0
Width (W)	15.0	14.5	16.4
Depth (D)	11.0	10.9	17.6
Length of hinge line (Lhl)	10.4	10.1	10.2
Ratio: W/Lpv	0.99	0.96	0.90
Ratio: Lhl/W	0.69	0.70	0.62

Description. Mature specimens of medium to large size for the genus; elongate oval outline; unevenly biconvex in lateral profile; anterior commissure generally rectimarginate, with some gerontic specimens weakly uniplicate; hinge line relatively short, varying between 0.62 and 0.70 of width of shell amongst measured specimens.

Pedicle valve strongly convex, generally highest about midlength, commonly accounting for about three-quarters of total depth of shell; a few mature specimens show a very weakly developed, broad, shallow sulcus that originates about midlength and gradually widens anteriorly to produce a barely perceptible tongue in the opposite valve; umbo broadly rounded; beak strongly inturned; interarea apsacline near hinge line and anacline towards beak.

Brachial valve weakly convex, highest at about one-fifth to one-quarter length from beak; beak small, broadly rounded, projecting a little beyond the hinge line; valve is smooth with no trace of a fold.

Interior of pedicle valve (Fig. 13) with hinge teeth attached to the anterior ends of ill defined dental ridges along the margins of the delthyrium. The teeth are slender and project obliquely inward. Dental lamellae are absent. Thick, secondary shell material deposited in the delthyrial cavity of valve. Muscle impressions are not evident.

Interior of brachial valve (Fig. 13) with thin crural plates that converge toward the floor of valve where they nearly meet. The crural plates are buttressed laterally to the floor of the valve by very short plates. Dental sockets are developed within these short hinge plates with the ventral ends of the crural plates acting as inner socket ridges, and lateral parts of the valve floor serving as outer socket ridges. Caldwell (1968, p. 607) has referred to this type of structure as "sessile" sockets. Small, lobe-shaped cardinal process present along midline near posterior end of notothyrial cavity which anteriorly becomes centrally hollow. Muscle impressions are not apparent.

Shell material is thin over most areas of the valves, with some thickening over the umbonal region of the pedicle valve. Surface ornamentation consists of closely spaced concentric growth lines; on large gerontic shells there are widely and irregularly spaced narrow concentric bands where the shell surface is slightly indented which probably mark short periods of interrupted or retarded growth. The indented growth lamellae described by Veevers (1959, p. 903, 904, Textfig. 3) for the type species of *Emanuella* were not seen on any of the specimens from the Pine Point area, presumably because of poor shell preservation. The micro-ornament of *Emanuella meristoides* has been described and illustrated by Crickmay (1967, p. 7,

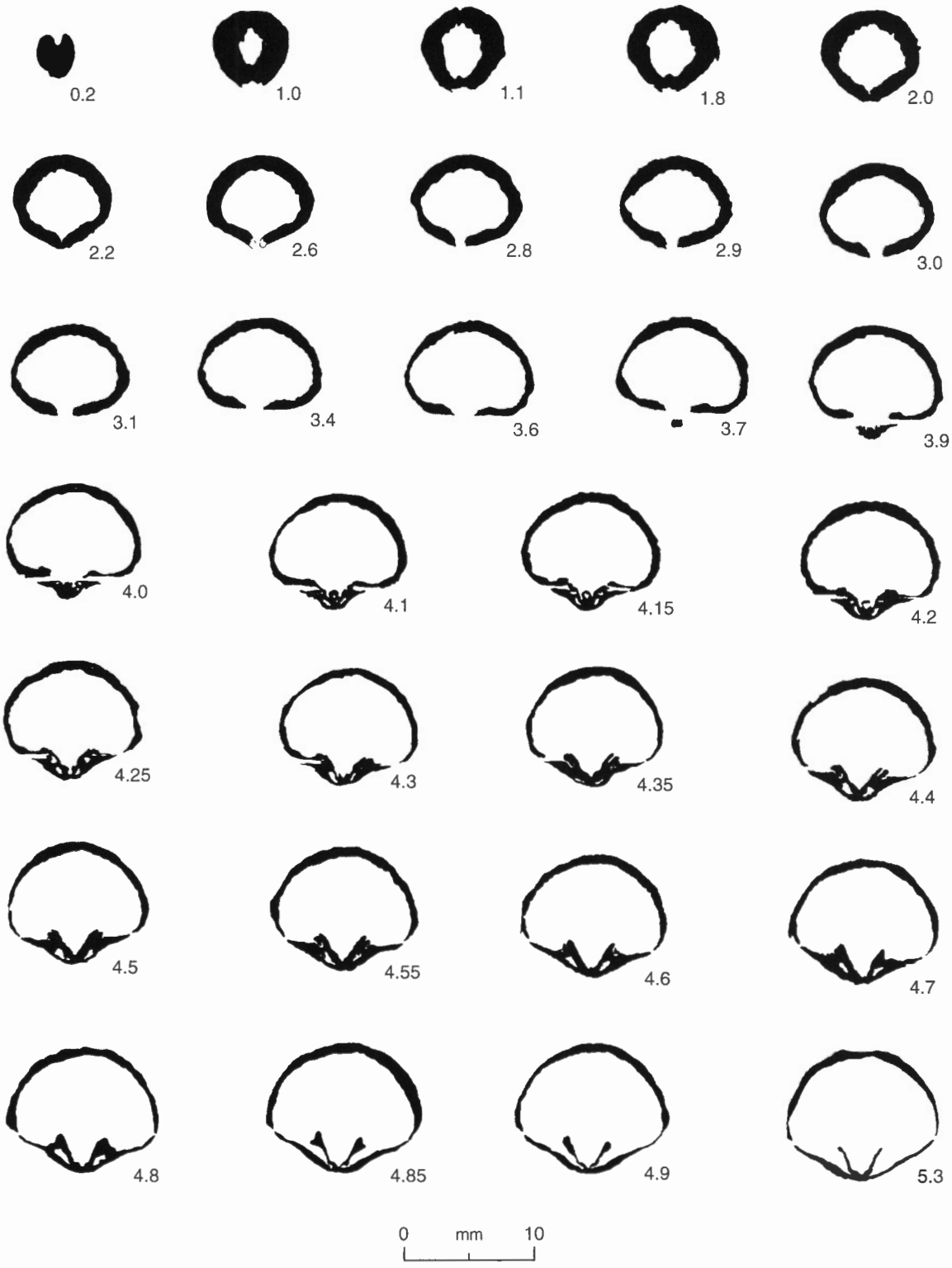


Figure 13. *Transverse serial sections of a specimen of* ***Emanuella meristoides*** *(Meek, 1868). Distances are in millimetres forward of the beak of the pedicle valve. Hypotype GSC 75645. GSC locality C-94686.*

Pl. 3, fig. 21) of a specimen from the northern Northwest Territories collected from near the base of the Hare Indian Formation.

Remarks. Emanuella meristoides is distinguished from *Emanuella sublineata* with which it is commonly associated by its elongate oval outline and the strongly incurved ventral beak, as well as other shape differences.

In the elongate oval outline there is some superficial resemblance between adult specimens of *Emanuella meristoides* and young specimens of *Warrenella kirki* (Merriam, 1940, p. 85, Pl. 8, figs. 26–29). However, *Emanuella meristoides* lacks the narrow sulcus present on both the brachial and pedicle valves of *W. kirki*.

Occurrence. (Meek, 1868, p. 106, 107) described *Spirifer* (*Martinia*) *meristoides* from the Anderson and Lockhart (=Carnwath) rivers with co-ordinates 67°15′N, 126°00′W, but as pointed out by McLaren (1962, p. 55) and Caldwell (1968, p. 606), these co-ordinates are inaccurate. Caldwell (op. cit.) indicated that "*Emanuella*" *meristoides* is common in the highest beds of the Hume Formation outcropping on Carnwath River at 67°57′N, 128°55′W, a tributary of Anderson River, District of Mackenzie, and this location could be at or close to the type locality.

The specimen of *Ambocoelia meristoides* (Meek) illustrated by Warren and Stelck (1956, Pl. 4, figs. 22–24) is recorded as part of their *Ambocoelia meristoides* fauna from the Pine Point Limestone, Pine Point, Great Slave Lake, Northwest Territories. From this information one can reasonably assume that the source area is limited to the known distribution of outcrops of the Bituminous limestone member of the Pine Point Formation in the Pine Point area on the south side of Great Slave Lake (see Norris, 1965, fig. 7).

The specimens of *Emanuella meristoides* (Meek) described and illustrated by Johnson (1974, p. 64, Pl. 10, figs. 16–31, Textfig. 7, Table 1) are from his *Eliorhynchus castanea* Zone in the Woodpecker Limestone of Nevada.

The specimens of *Emanuella meristoides* (Meek) described and illustrated in this report are from scattered outcrops of the Bituminous limestone member of the Pine Point Formation in the Pine Point area.

Figured specimens. Hypotype GSC 75640 from GSC locality C-94474; hypotypes GSC 75641, 75642, 75645, 75646 and 75647, from GSC locality C-94686; hypotype GSC 75643, from GSC locality C-94475; hypotype GSC 75644, from GSC locality C-94566; and hypotype GSC 75648, from GSC locality C-94710.

Locality data. GSC locality C-94474 (sample 22NBb) from station 22NB, on the south shore of Great Slave Lake, 412 m west of Dawson Landing wharf at 60°59′29″N, 114°09′55″W, from the top of an outcrop, 18 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94686 (sample 85NBb) at station 85NB on the south shore of Great Slave Lake, 0.93 km southwest of Pine Point at 61°00′21″N, 114°16′15″W, from a loose block lying on an outcrop, 24 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94475 (sample 22NBc1) at station 22NB on the south shore of Great Slave Lake, 412 m west of Dawson Landing at 60°59′29″N, 114°09′55″W; from the upper part of an outcrop, 18 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94566 (sample 54NBb) at station 54NB on the south shore of Great Slave Lake at 60°59′08″N, 114°08′40″W; from an outcrop, 10 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94710 (sample 91NBf) at station 96NB on the south shore of Great Slave Lake, 1.6 km southwest of Pine Point at 61°00′09″N, 114°16′45″W; from loose blocks lying on top of an outcrop, 10 cm thick, of the Bituminous limestone member of the Pine Point Formation.

Emanuella sublineata (Meek, 1868)

Plate 6, figures 12–50; Textfigure 14

1868 *Spirifer* (*Martinia*) *sublineatus* Meek, p. 103, Pl. 14, fig. 1c; probably not figs. 1a–1b (1867).
1944 *Martinia sublineata* Meek, Warren, p. 127, Pl. 3, figs. 22–25.
1956 *Martinia*? *sublineata* Meek, Warren and Stelck, Pl. 4, figs. 19–21.
1962 *Emanuella meristoides* (Meek), McLaren, Norris and McGregor, p. 20, Pl. 9, figs. 19–22.
1967 *Emanuella sublineata* (Meek), Crickmay, p. 7, Pl. 2, figs. 1–3.
1968 "*Emanuella*" *sublineata* (Meek), Caldwell, p. 612, Pl. 1, figs. 10a–10d, 11a–11d (1967).

Diagnosis. This species of *Emanuella* is characterized by its subcircular outline, which is wider than long; short hinge line; pedicle valve accounting for two-thirds or more total depth of shell; and with a weak mesial sinus on the pedicle valve of some specimens.

Material. This species is by far the most abundant form in the Bituminous limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A	B	C
	Hypotype	Hypotype	Hypotype
GSC no.	75649	75650	75651
GSC locality no.	C-94658	C-94490	C-94475
Length of pv (Lpv)	7.9	10.9	10.8
Length of bv (Lbv)	6.3	10.1	9.6
Width (W)	8.6	11.4	10.9
Depth (D)	4.7	7.7	6.9
Length of hinge line (Lhl)	6.7	9.4	8.2
Ratio: W/Lpv	1.09	1.04	1.01
Ratio: Lhl/W	0.78	0.82	0.75

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	D	E*	F
	Hypotype	Hypotype	Hypotype
GSC no.	75652	75653	75654
GSC locality no.	C-94710	C-94490	C-94475
Length of pv (Lpv)	12.0	12.4	14.0
Length of bv (Lbv)	10.3	10.9	11.8
Width (W)	12.3	13.4	15.2
Depth (D)	6.3	8.4	9.4
Length of hinge line (Lhl)	9.2	10.3	10.3
Ratio: W/Lpv	1.03	1.08	1.09
Ratio: Lhl/W	0.75	0.77	0.68

*Serially sectioned

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	G	H	I
	Hypotype	Neotype	Hypotype
GSC no.	75655	75656	75657
GSC locality no.	C-94681	C-94691	C-94478
Length of pv (Lpv)	16.8	16.6	16.6
Length of bv (Lbv)	14.5	13.9	14.5
Width (W)	17.3	18.0	18.9
Depth (D)	11.3	11.8	10.7
Length of hinge line (Lhl)	13.5	14.3	14.2
Ratio: W/Lpv	1.03	1.08	1.14
Ratio: Lhl/W	0.78	0.79	0.75

Description. Size about average for the genus; unequally biconvex in lateral profile; subcircular outline in younger specimens to transversely subelliptical outline in more mature specimens; wider than long with greatest width slightly anterior of rounded postero-lateral angles; hinge line length varies between 0.68 and 0.82 of width of shell amongst measured specimens; anterior commisssure is rectimarginate in young stages and becomes weakly uniplicate in adult stages.

Pedicle valve strongly arched, deep, highest at about one-third length from umbo, generally accounting for two-thirds or more of the depth of the shell; strongly arched in anterior profile; flanks sloping steeply and almost flat; some specimens show a weak, narrow, shallow U-shaped sulcus extending along the midline of the valve which gradually widens anteriorly; umbonal region rounded with a strongly inturned beak; beak ridges rounded; cardinal area moderately to strongly curved, apsacline near the hinge line and anacline towards beak; delthyrium triangular-shaped, generally covered by matrix; deltidial plates not seen.

Brachial valve weakly to moderately convex, highest at about one-fifth length from beak; in anterior profile greatest convexity along midline, flattening towards flanks; beak small, inturned, extending a short distance beyond the hinge line; valve is smooth with no trace of a fold.

Interior of pedicle valve (Fig. 14) with dorsally directed dental ridges along anterior margins of the delthyrium. Slender elongate teeth located on the dorsal side of the junction of the inner shell margin and dental ridges, and these project dorsally and obliquely inward where the valves are articulated. Some secondary shell material filling the delthyrial cavity at and near the posterior end of valve. Muscle impressions are not apparent.

Interior of brachial valve (Fig. 14) with thin, V-shaped crural plates that meet medianly along the floor of the valve. Short, stout, outer hinge plates connect laterally the crural plates with the floor of the valve. Small dental sockets are developed on the ventral sides of the hinge plates. Distal extensions of the crural plates form the inner socket ridges and part of the inner valve floor serve as outer socket ridges. Cardinal process is tiny, lobe-shaped, and occurs in the notothyrial cavity between the posterior ends of the crural plates. Muscle impressions are not apparent.

Shell surface ornamented with weakly developed, closely spaced, concentric growth lines, some of which are slightly thickened at irregular intervals. Growth lamellae were seen only on one specimen (hypotype 75655) where the shell material is well preserved, and it shows the lamellae indented in the manner illustrated by Veevers (1959, p. 904, Textfig. 3) for *Emanuella takwanensis* (Kayser).

Remarks. There are several problems involved in the recognition of the species *Emanuella sublineata* (Meek) which has hindered workers over the years. Unfortunately, Meek's (1968) type specimens of this species have been lost, and of the two specimens illustrated (Meek, 1868, Pl. 14, figs. 1a–1c), one appears to be an immature individual, and the other is an adult individual showing considerable abrasion of the pedicle valve. In view of the great abundance of this species in the Pine Point area, it is unfortunate that Meek (1968) did not illustrate more specimens, especially of a complete adult individual. From the description of this species by Meek (1868, p. 103, 104) it is obvious that his collection included other specimens because the dimensions given by him of a large individual are comparable to measurements given here. Of the young specimen illustrated by Meek (1868, Pl. 14, figs. 1a–1b) one is left with the impression that it may not be an *Emanuella* because it has some similarities to a form referred to as *Leptothyris obsolescens* Johnson (1974) in this report. The latter species is not abundant in the area but is found associated with *Emanuella sublineata* in a few beds. However, judging from the overall description and

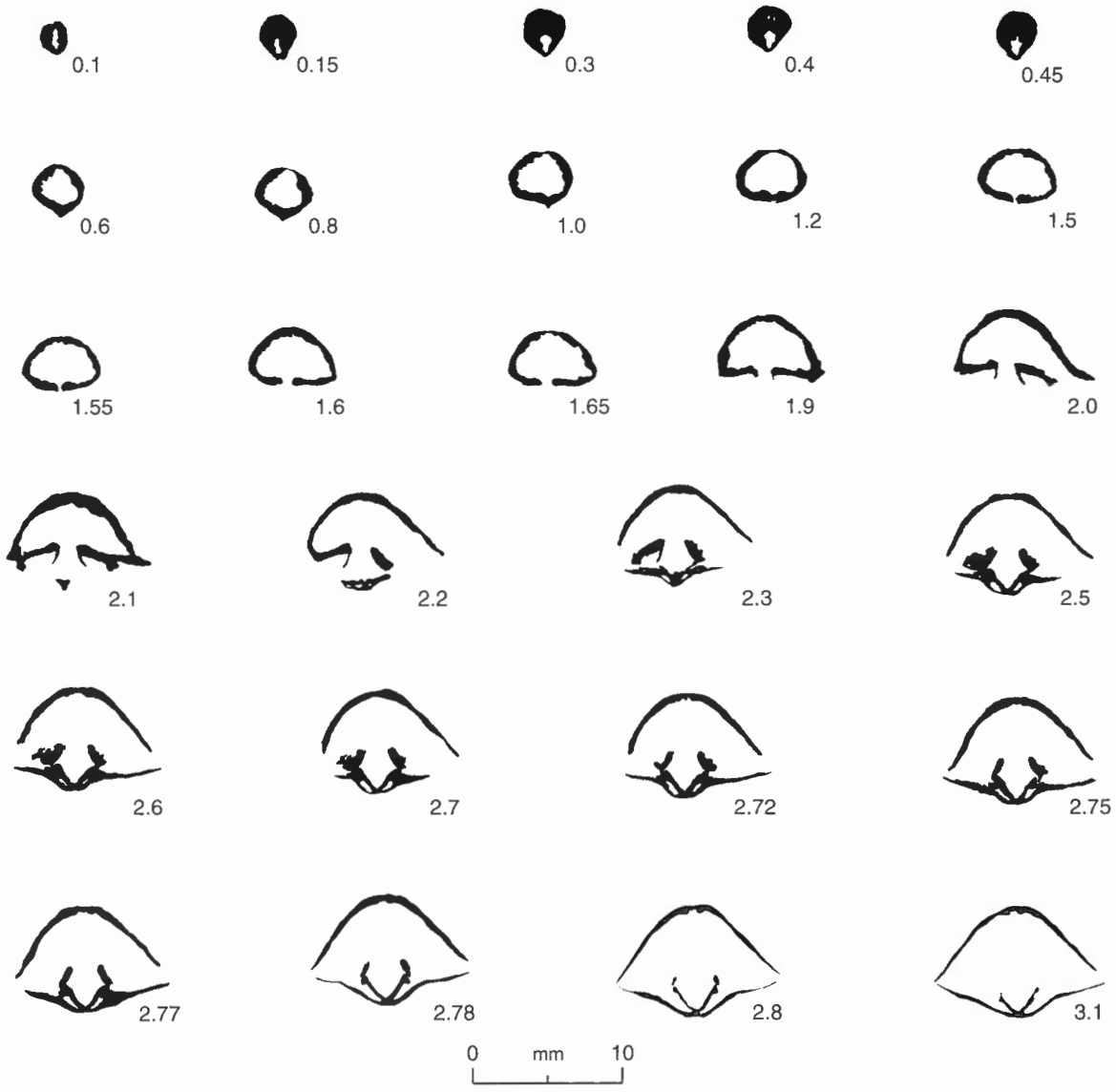


Figure 14. *Transverse serial sections of a specimen of* ***Emanuella sublineata*** *(Meek, 1868). Distances are in millimetres forward of the beak of the pedicle valve. Hypotype GSC 75653. GSC locality C-94490.*

comparisons of adult specimens of *Emanuella sublineata* by Meek (1868, p. 103, 104) one can be reasonably certain of the range of forms he intended to include in the species. If this is accepted as valid, and the writer believes that it is, then a neotype should be selected from topotypic material. The neotype, here selected, is specimen H (GSC 75656).

Occurrence. This species is recorded by Meek (1868, p. 104) as common in the dark bituminous limestone, near Fort Resolution, on the south side of Great Slave Lake. Norris (1965, p. 49–53, 144–151, fig. 7) has shown the distribution of the Bituminous limestone member of the Pine Point Formation with scattered outcrops extending from immediately east of Dawson Landing to immediately west of Pine Point along the south shore of Great Slave Lake. The same beds crop out also on McKay and Green islands, northeast of and near Pine Point. The type locality of Meek's (1868) specimens may be confidently narrowed down to the relatively small area of outcrops known along the south shore of the lake where *Emanuella sublineata* is exceedingly abundant throughout most of the member.

Figured specimens. Hypotype GSC 75649, a young specimen, from GSC locality C-94658; hypotypes GSC 75650, a young, elongate specimen, and 75653, a thick, subpentagonal adult specimen, from GSC locality C-94490; hypotypes GSC 75651, a young adult specimen, and 75654, a thick, biconvex, adult specimen, from GSC locality C-94475; hypotype GSC 75652, a thin, young adult specimen, from GSC locality C-94710; hypotype GSC 75655, a large, adult specimen showing shell ornament, from GSC locality C-94681; neotype GSC 75656, a large, thick, adult specimen, from GSC locality C-94691; and hypotype GSC 75657, a very large, wide specimen, from GSC locality C-94478.

Locality data. GSC locality C-94658 (sample 77NBa) at station 77NB, on the south shore of Great Slave Lake on the east side of Pine Point Peninsula at 61°00′30″N, 114°15′12″W; from upper part of unit 4, 53 cm thick, of an outcrop, 105 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94490 (sample 28NBb) at station 28NBb on the west end of McKay Island bearing 057T, at 3.9 km from Pine Point at 61°01′30″N, 114°11′35″W; from an outcrop, 50 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94475 (sample 22NBc1) at station 22NB, on the south shore of Great Slave Lake, 412 m west of Dawson Landing at 60°59′29″N, 114°09′55″W; from an outcrop 4 cm exposed, from the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94710 (sample 91NBf) at station 91NB, on the south shore of Great Slave Lake, southwest of Pine Point at 61°00′09″N, 114°16′45″W; from loose blocks lying on top of an outcrop, 11 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94681 (sample 83NBb) at station 83NB on the south shore of Great Slave Lake, 0.36 km southwest of the tip of Pine Point at 61°00′26″N, 114°15′45″W; from loose blocks of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94691 (sample 86NBb) at station 86NB on the south shore of Great Slave Lake, 1.05 km southwest of the tip of Pine Point at 61°00′17″N, 114°16′20″W; from a loose block of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94478 (sample 24NBa) at station 24NB on the south shore of Great Slave Lake about 732 m west of Dawson Landing at 60°59′27″N, 114°10′05″W; from an outcrop, 10 cm exposed, of the Bituminous limestone member of the Pine Point Formation.

Family AMBOCOELIIDAE George, 1931

Genus *Echinocoelia*
Cooper and Williams, 1935, p. 844

Type species. Echinocoelia ambocoelioides Cooper and Williams, 1935, p. 844; OD.

Echinocoelia sp.

Plate 7, figures 1–13

Diagnosis. A lateral profile of shell that is strongly unequally biconvex; with a deep, subconical pedicle valve, and a 'cap'-like brachial valve.

Material. Represented by only half a dozen or so poorly preserved exfoliated specimens. The specimens are fragile and difficult to extract from the hard matrix without breakage.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75658	75659	75660	75661
GSC locality no.	C-94519	C-94462	C-94474	C-94474
Length of pv (Lpv)	6.4	10.2	12.8	ca. 12.0
Length of bv (Lbv)	4.5	—	—	—
Width (W)	6.7	9.8	16.0	ca. 14.5
Depth (D)	4.6	—	ca. 7.4	ca. 8.9
Ratio: (W/Lpv)	1.05	0.96	1.25	1.21

Description. Mature specimens attain a large size for the genus. Outline highly variable, but generally characterized by an elongate pedicle valve, and a transversely subsemicircular brachial valve. Lateral profile strongly unequally biconvex, with a deep, subconical pedicle valve, and a 'cap'-like brachial valve. Maximum width at or slightly anterior of hinge line. Anterior commissure rectimarginate. Cardinal angles rounded; hinge line length slightly less than maximum width of shell.

Pedicle valve strongly and evenly convex, accounting for most of the depth of the shell; beak narrow, pointed; interarea long, triangular-shaped, gently incurved, apsacline, with rounded beak ridges; delthyrium narrow, covered with matrix in all specimens seen. Three of the four illustrated specimens show a weak, narrow, shallow sulcus extending along the midline from the beak to the anterior margin.

Brachial valve almost flat; covered by matrix in three of four illustrated specimens.

Surface ornamentation of fine simple spines characteristic of *Echinocoelia* was not seen due to exfoliation of all specimens; but widely spaced concentric growth lines are evident.

Remarks. The poorly preserved specimens are inadequate for a comparison with other known species of *Echinocoelia*.

Occurrence. This form is a rare element in the Bituminous limestone member of the Pine Point Formation. The two specimens of *Echinocoelia* illustrated by Caldwell (1968, p. 612, Pl. 1, figs. 4a–4d, 5a–5d) are from calcareous shale near the top of the Hare Indian Formation from an outcrop in a low embankment at the extreme northwest end of Jan Lake, Carcajou Ridge, Mackenzie River, District of Mackenzie. The data given by Caldwell (1968) would suggest that the Jan Lake specimens occur at the same or slightly higher stratigraphic level than those from the Great Slave Lake area.

Figured specimens. Hypotype GSC 75658, a young specimen, from GSC locality C-94519; hypotype GSC 75659, part of a pedicle valve of a young adult specimen, from GSC locality C-94462; and hypotypes GSC 75660, pedicle valve of a wide, adult individual, and GSC 75661, pedicle valve of an adult individual, from GSC locality C-94474.

Locality data. GSC locality C-94519 (sample 45NBg) at station 45NB from the south shore of Great Slave Lake, 30.5 m east of Dawson Landing at 60°59′18″N, 114°09′30″W; from 8 cm above the base of an outcrop, 120 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94462 (sample 19NBb) at station 19NB from the mid north shore of McKay Island at 61°01′40″N, 114°10′35″W; from 41 cm above base of an outcrop, 60 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94474 (sample 22NB1) from station 22NB on the south shore of Great Slave Lake, west of Dawson Landing at 60°59′29″N, 114°09′55″W; from loose blocks on top of an outcrop, 19 cm thick, of the Bituminous limestone member of the Pine Point Formation.

Superfamily CYRTINACEA Frederiks, 1912

Family CYRTINIDAE Frederiks, 1912

Genus *Cyrtina* Davidson, 1858, p. 66

Type species. Calceola heteroclita Defrance, 1824, p. 306; SD Hall and Clarke, 1894, p. 44. [=*Spinocyrtina* Frederiks, 1916, p. 18 (type, *Cyrtina hamiltonensis* Hall, 1857); *Cyrtinaellina* Frederiks, 1926, p. 414 (type, *Cyrtina acutirostris* Shumard, 1855)].

Cyrtina sp.

Plate 7, figures 14–25

Diagnosis. A *Cyrtina* with a pedicle valve which is subpyramidal in shape, with a rounded V-shaped smooth sulcus, and with four to five costae on the flanks. A brachial valve which is weakly convex, subelliptical in outline, with a smoothly rounded mesial fold, and with four to five costae on the flanks. Shell material with fine, closely spaced endopunctae.

Material. Represented by relatively few, very poorly preserved specimens, in the Bituminous limestone member of the Pine Point Formation.

Dimensions (in mm) and other parameters.

Specimen	A	B	C
	Hypotype	Hypotype	Hypotype
GSC no.	75662	75663	75664
GSC locality no.	C-94473	C-94539	C-94474
Length of pv (Lpv)	—	9.0+	10.9
Length of bv (Lbv)	7.2	7.3	ca. 9.5
Width (W)	10.5	9.4	ca. 13.3
Depth (D)	—	6.4	ca. 11.2
Costae on pv	5-0-5	4-0-?	?-0-5
Costae on bv	5-0-4	4-0-4	?-0-?

Description. Shell attains a medium size for genus at maturity; subsemicircular to transversely subtrigonal in outline, and unequally biconvex in lateral profile; wider than long with greatest width immediately anterior of hinge line, which is long and straight; cardinal extremities obtusely angular or rounded.

Pedicle valve is strongly convex and subpyramidal in shape; interarea is long, slightly curved, and catacline to apsacline; beak in some adult specimens is slightly twisted to one side; beak ridges are sharp; delthyrium is long, narrow, slightly convex and slightly elevated above level of interarea, and forms an angle of about 25 degrees. Pedicle valve bears a relatively broad, shallow, rounded V-shaped, smooth sulcus that originates at the apex of the beak, widens anteriorly, and is extended as a tongue in the opposite valve.

Brachial valve is subelliptical in outline, and gently convex in lateral profile; beak is inconspicuous; mesial fold is broad, rounded, non-costate, and markedly elevated above flanks of valve.

Costae on flanks of valves are low, rounded, and are separated by shallow U-shaped interspaces; those bordering the sulcus and fold originate on the beaks and are the most conspicuous; those originating laterally of the umbones are smaller. Concentric growth lines where preserved occur at irregular intervals. Abraded shell material shows fine, very closely spaced endopunctae(?).

Remarks. This form is not compared with described species because of the very poor preservation of specimens.

Figured specimens. Hypotype GSC 75662, incomplete shell of a small individual, from GSC locality C-94473; hypotype GSC 75663, mold of a young adult specimen, from GSC locality C-94539; and hypotype GSC 75664, exfoliated specimen of an adult individual partly embedded in matrix, from GSC locality C-94474.

Locality data. GSC locality C-94473 (sample 22NBa1) at station 22NB on the south shore of Great Slave Lake, 0.42 km west of Dawson Landing wharf at 60°59′29″N, 114°09′55″W; from top of an outcrop, 7 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94539 (sample 45NBg) at station 45NB on the south shore of Great Slave Lake, 30.5 m east of Dawson Landing wharf at 60°59′18″N, 114°09′30″W; from basal bed, 10 cm thick, of an outcrop, 48 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94474 (sample 22NB1) at station 22NB on the south shore of Great Slave Lake, 0.42 km west of Dawson Landing wharf at 60°59′29″N, 114°09′55″W; from a loose block of Bituminous limestone member of the Pine Point Formation overlying an outcrop, 7 cm thick.

Superfamily DELTHYRIDACEA Phillips, 1841

Family RETICULARIIDAE Waagen, 1883

Genus *Warrenella* Crickmay, 1953

Type species. Warrenella eclecta Crickmay, 1953, p. 596; OD. [=*Minatothyris* Vandercammen, 1957, p. 1 (type, *Spirifer euryglossus* Schnur, 1851)].

Warrenella parafranklinii Norris n. sp.

Plate 7, figures 26–37; Plate 8, figures 1–7;
Textfigure 15

Diagnosis. A *Warrenella* of large size for the genus at maturity; with a subheptagonal outline; a pronounced V-shaped flare at anterior end of the fold on brachial valve, and a rounded V-shaped sulcus on pedicle valve.

Material. Represented by in excess of 77 specimens from the upper part of the Bituminous limestone member of the Pine Point Formation from outcrops located mainly on the offshore islands on the south side of Great Slave Lake.

Etymology. The new trivial name *parafranklinii* is from *para*, Greek, meaning beside, near, by, plus *franklinii*, in allusion to the close similarity to *Warrenella franklinii* (Meek), but distinctly different morphology of the new species.

Dimensions (in mm) and other parameters.

Specimen	A Paratype	B Paratype	C Holotype
GSC no.	75665	75666	75667
GSC locality no.	C-94493	C-94493	C-94493
Length of pv (Lpv)	23.2	31.5	34.9
Length of bv (Lbv)	18.7	29.2	30.5
Width (W)	24.5	33.0	38.9
Depth (D)	15.9	28.5	25.2
Length of hinge line (Lhl)	18.8	ca. 21	30.4
Ratio: W/Lpv	1.06	1.05	1.11
Ratio: D/W	0.65	0.86	0.65
Ratio: Lhl/W	0.77	0.64	0.78
Hinge angle (in degrees)	161	140	145

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	D Paratype	E* Paratype
GSC no.	75668	75669
GSC locality no.	C-94724	C-94446
Length of pv (Lpv)	45.8	29.6
Length of bv (Lbv)	—	24.4
Width (W)	50.6	31.6
Depth (D)	—	18.8
Length of hinge line (Lhl)	—	22.6
Ratio: W/Lpv	1.10	1.07
Ratio: D/W	—	0.59
Ratio: Lhl/W	—	0.72
Hinge angle (in degrees)	—	154

*Serially sectioned

Description. Shell attains a very large size at maturity for the genus. Transversely subheptagonal in outline; width greater than length with maximum width generally at or near midlength. Valves unequally biconvex in lateral profile with maximum depth occurring between one-quarter and one-third length from pedicle umbo. Ratio of hinge line length to width of shell varying between 0.64 and 0.78 amongst measured specimens. Hinge angle varying between 140 and 161 degrees amongst the same specimens. Anterior commissure is uniplicate.

Pedicle valve fairly evenly and moderately convex and accounts for two-thirds to three-quarters total depth of shell; highest at one-third to one-half length from umbo. The sulcus originates over the umbo and gradually widens and deepens anteriorly; it is rounded, V-shaped in outline, and extended as a rounded, V-shaped tongue in the opposite valve. Umbo strongly rounded; beak strongly incurved and in contact with opposing valve in most adult specimens. Interarea low, triangular-shaped, apsacline, visible only in younger specimens. Beak ridges rounded but generally covered in older specimens. Delthyrium not seen. Foramen presumably closed.

Brachial valve is weakly to moderately convex, highest at about one-fifth length from beak. The fold originates over the umbo where it is low and narrow and gradually widens anteriorly to about four-fifths length from beak where it abruptly widens to a V-shaped flare. The fold is indented along the midline throughout most of its length by a shallow, rounded, narrow furrow. Beak is inturned and covered by the opposing valve.

Shell material is thick, especially over the umbones and beaks. Micro-ornament consists of irregularly spaced concentric growth lamellae, which are indented somewhat like the teeth of a comb at their anterior margins. The tiny spinules are comparable to those described by Veevers (1959, p. 903, 904, Textfig. 3) for *Emanuella takwanensis* (Kayser). The spinules are recumbant and do not appear to project obliquely from the shell surface as illustrated for *Warrenella transversa* Ludvigsen and Perry (1975, p. 73, Textfig. 16). Also present are fine, closely spaced radial fila seen only on better preserved parts of the shell exterior.

Interior of pedicle valve (Fig. 15) with thin, basally divergent, subparallel dental plates. Posterior parts of dental plates are lodged in thick secondary deposits lining delthyrial cavity. Hinge teeth small, oriented dorsally and obliquely inward in plane of articulation. Delthyrium covered by a dorsally convex fused plate, which anteriorly separates into two curved plates along the margins of the delthyrium. Muscle field is deeply impressed and is separated by a low, indistinct myophragm along the midline.

Interior of brachial valve (Fig. 15) with widely divergent, moderately deep dental sockets. Inner socket ridges are stout, and curved ventro-laterally to confine hinge teeth. Parts of the inner valve floor serve as outer dental socket ridges in posterior part of valve, which anteriorly are separated from floor of valve by small lateral cavities. Cardinal process is a flaring, comb-like structure in the ventro-medial part of notothyrial cavity. Crural processes are attached to the anterior ends of the inner socket ridges. Considerable secondary shell material lining notothrial cavity.

Remarks. Warrenella parafranklinii Norris n. sp. is part of the *Warrenella franklinii* lineage described by Ludvigsen and Perry (1975, p. 64–67, Textfig. 14) from

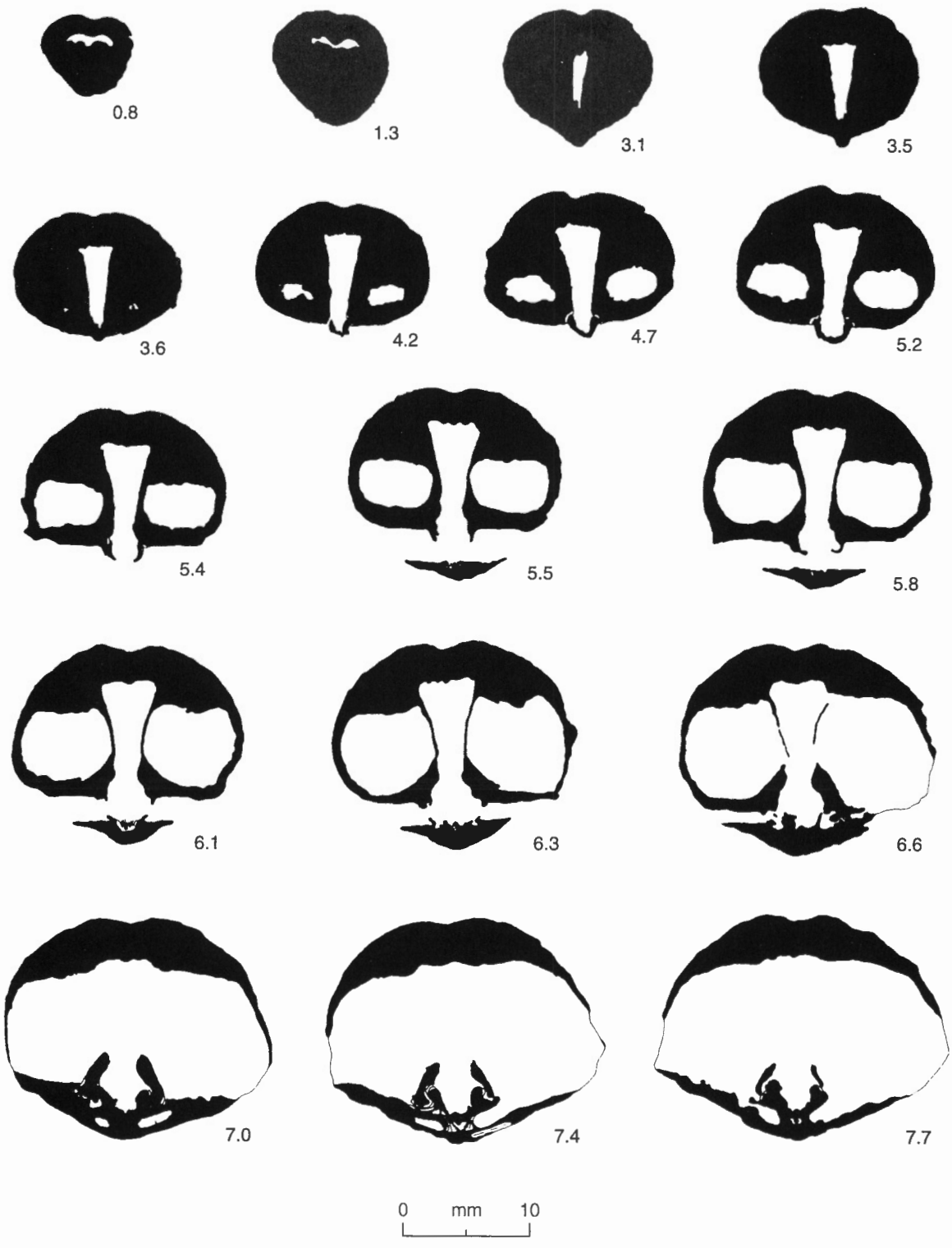


Figure 15. *Transverse serial sections of a specimen of* ***Warrenella parafranklinii*** *Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype GSC 75669. GSC locality C-94446.*

northwestern Canada. In such characters as relatively large size, transverse outline, and median furrow in the brachial fold this new species is very closely related to *Warrenella franklinii* (Meek, 1968, p. 107, 108, Pl. 14, figs. 12a–12c). However, *Warrenella parafranklinii* n. sp. is easily distinguished from *Warrenella franklinii* (Meek) by its subheptagonal and less pronounced transverse outline, more pronounced V-shaped flare at

the anterior end of the fold on the brachial valve, more inflated and more inturned pedicle beak so that the pedicle interarea is generally covered, a much more indented medial anterior margin where the fold and sulcus meet, and a rounded V-shaped, rather than a U-shaped ventral sulcus.

For comparison, photographic illustrations of specimens of *Warrenella franklinii* (Meek, 1868) from the type area have been provided by Merriam (1940, Pl. 8, fig. 24), Caldwell (1971, Pl. 2, figs. 6a–6d), and Ludvigsen and Perry (1975, p. 79, Pl. 14, figs. 26–30). Representative material of this species in Nevada has been described and illustrated by Johnson (1974, p. 62–64, Pl. 8, figs. 17–24; Pl. 9, figs. 1–16, Textfig. 6).

Occurrence. Warrenella parafranklinii Norris n. sp. occurs throughout the Bituminous limestone member of the Pine Point Formation, especially in the upper more argillaceous parts of the member, represented in outcrops on the off-shore islands on the south side of Great Slave Lake.

The closely related *Warrenella franklinii* (Meek, 1868, p. 108) is recorded from the Mackenzie River, 64.4 km below the "Ramparts". The specimen of this species illustrated by Caldwell (1971, p. 14, Pl. 2, figs. 6a–6d) is from calcareous shale of the Hare Indian Formation, about 15.2 m below the contact with the overlying Ramparts Formation, east bank of Mackenzie River at the northern end of the "Ramparts of Mackenzie", Fort Good Hope, District of Mackenzie.

Warrenella franklinii (Meek) is recorded by Johnson (1974, p. 72, Table 1) from the *Leiorhynchus castanea* Zone in the Denay Limestone and Woodpecker Limestone of central Nevada.

Figured specimens. Paratypes GSC 75665, a young individual, and 75666, a thick, young adult individual, and holotype GSC 75667, a thick, wide, young adult individual, from GSC locality C-94493; paratype GSC 75668, pedicle valve embedded in matrix of a large, mature adult individual, from GSC locality C-94724; and paratype GSC 75669, a thin, young adult individual (serially sectioned), from GSC locality C-94446.

Locality data. GSC locality C-94493 (sample 28NBc1) at station 28NB from the west end of McKay Island at 61°01′30″N, 114°11′35″W, bearing 057T and 3.9 km from the tip of Pine Point; from the top of a 49 cm thick outcrop, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94724 (sample 96NB1) at station 96NB from the north shore and near the west end of McKay Island at 61°01′48″N, 114°11′28″W; from loose blocks lying on top of an outcrop, 42 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94446 (sample 16NBd) at station 16NB on the mid-east shore of Bieulieu Island at 61°00′50″N, 114°08′10″W; from large loose blocks of the Bituminous limestone member of the Pine Point Formation.

Warrenella plicata Johnson, 1974

Plate 8, figures 8–18

1974 *Warrenella plicata* Johnson, p. 64, Pl. 8, figs. 1–16.

Diagnosis. Warrenella with faint anterior plications (Johnson, 1974, p. 64).

Material. This is an exceedingly rare form in the Bituminous limestone member of the Pine Point Formation, being represented by only three specimens.

Dimensions (in mm) and other parameters.

Specimen	A	B	C
	Hypotype	Hypotype	Hypotype
GSC no.	75670	75671	75672
GSC locality no.	C-94493	C-94479	C-94479
Length of pv (Lpv)	24.4	—	25.6
Length of bv (Lbv)	19.5	21.7	20.8
Width (W)	22.9	23.5	24.0
Depth (D)	17.5	15.8	18.6
Length of hinge line (Lhl)	15.9	16.3	ca. 16.2
Ratio: W/Lpv	0.94	—	0.94
Ratio: D/W	0.76	0.67	0.78
Ratio: Lhl/W	0.69	0.69	0.68
Ratio: Lbv/Lpv	0.80	—	0.81
Hinge angle (in degrees)	151	156	ca. 160

Description. Shell of small size for the genus. Outline is elongate subheptagonal. Width is less than length, with greatest width occurring between two-thirds and three-quarters length from beak; ratio of width to pedicle valve length is 0.94 for two specimens. Lateral profile is ventribiconvex, with maximum depth about midlength. Hinge line is straight, relatively short; ratio of length of hinge line to width of shell varies from 0.68 to 0.69 amongst measured specimens. Anterior commissure is moderately uniplicate.

Pedicle valve is moderately convex, highest about midlength, and generally accounts for slightly more than one-half total depth of shell. Umbo is inflated, broadly and evenly rounded; beak is strongly inturned. Interarea is low and broad, triangular, apsacline towards cardinal margin and becoming strongly anacline towards apex of beak. Sulcus originates over the umbo where it is barely discernible, it gradually deepens and widens anteriorly and becomes conspicuous about midlength; on the anterior part of valve it is relatively broad, shallow and U-shaped.

Brachial valve is moderately convex, highest about one-fifth length from beak. Length of brachial valve about one-fifth shorter than that of pedicle valve. The beak is small, inturned, and in contact with the opposing valve. Fold is very low, originates about midlength, and is conspicuous only on the anterior one-fifth of valve where it abruptly strengthens and widens.

Interiors of both valves not seen, and material is insufficent for serial sectioning.

Shell material is relatively thick over umbonal region of pedicle valve, but is relatively thin over the remainder of shell. Concentric growth lamellae are irregularly spaced and where strongly developed are impressed on interior of shell. Micro-ornament is not preserved. Weakly developed, irregular, round-top plicae are present on the anterior parts of the flanks of both valves, and are present also in the anterior part of the sulcus of the pedicle valve of one specimen.

Remarks. In shape outline, size at maturity, and weak development of plicae on the flanks of the shell, this form from Great Slave Lake resembles *Warrenella plicata* Johnson (1974, p. 64, Pl. 8, figs. 1–16) from Nevada. Minor differences between the Great Slave Lake and Nevada forms include a proportionately thicker brachial valve, and weak development of costae in the sulcus of the pedicle valve of the former form.

Occurrence. In the District of Mackenzie, *Warrenella plicata* Johnson has been collected from the upper part of the Bituminous limestone member of the Pine Point Formation on the off-shore islands and along the south shore of Great Slave Lake west of Dawson Landing.

In Nevada, *Warrenella plicata* Johnson (1974, p. 52, Table 1) is recorded from the *Eliorhynchus castanea* Zone of the Woodpecker Limestone.

Figured specimens. Hypotype GSC 75670, from GSC locality C-94493; and hypotypes GSC 75671 and 75672, from GSC locality C-94479.

Locality data. GSC locality C-94493 (sample 28NBc1) at station 28NB on the west end of McKay Island at 61°01′30″N, 114°11′35″W; from the uppermost beds of an outcrop, 50 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94479 (sample 24NBb) at station 28NB on the south shore of Great Slave Lake, 732 m west of Dawson Landing at 60°59′27″N, 114°10′05″W; from an outcrop, 10 cm thick, about 0.5 m above lake level, of the Bituminous limestone member of the Pine Point Formation.

Warrenella posteruskirki Norris n. sp.

Plate 8, figures 19–28; Plate 9, figures 1–12; Textfigure 16

1956 *Martinia*? *kirki* Merriam, Warren and Stelck, Pl. 4, figs. 25–27.

Diagnosis. A *Warrenella* distinguished by: its elongate and narrow outline; considerable difference in length between the pedicle and brachial valves; and high convexities of both the pedicle and brachial valves.

Material. Represented by in excess of 38 specimens from a number of localities on the off-shore islands on the south side of Great Slave Lake.

Etymology. The trivial name *posteruskirki* is from *posterus*, Latin, meaning following, plus *kirki*, to indicate that this new species somewhat resembles and occurs later than *Warrenella kirki* (Merriam, 1940).

Dimensions (in mm) and other parameters.

Specimen	A	C*	D
	Paratype	Paratype	Paratype
GSC no.	75673	75674	75675
GSC locality no.	C-94493	C-94481	C-94446
Length of pv (Lpv)	20.2	27.0	36.4
Length of bv (Lbv)	16.4	22.0	26.3
Width (W)	18.3	25.5	33.7
Depth (D)	17.9	17.7	25.8
Length of hinge line (Lhl)	12.9	17.2	26.9
Ratio: W/Lpv	0.91	0.94	0.93
Ratio: D/W	0.98	0.69	0.77
Ratio: Lhl/W	0.70	0.67	0.80
Ratio: Lbv/Lpv	0.81	0.81	0.72
Hinge angle (in degrees)	158	161	163

*Serially sectioned

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E Paratype	F Holotype
GSC no.	75676	75677
GSC locality no.	C-94446	C-94493
Length of pv (Lpv)	39.4	43.2
Length of bv (Lbv)	28.2	33.7
Width (W)	39.1	39.6
Depth (D)	29.0	30.9
Length of hinge line (Lhl)	26.2	32.2
Ratio: W/Lpv	0.99	0.92
Ratio: D/W	0.74	0.78
Ratio: Lhl/W	0.67	0.81
Ratio: Lbv/Lpv	0.72	0.78
Hinge angle (in degrees)	ca. 159	155

Description. Shell attains a fairly large size at maturity, but is smaller than *Warrenella franklinii* (Meek), *W. parafranklinii* Norris n. sp., and *W. timetea* (Crickmay). Outline is elongate ellipsoidal or elongate subheptagonal. Width is less than length, with the width to length ratio varying between 0.91 to 0.99 amongst measured specimens; greatest width is between one-half to two-thirds length from beak. Valves almost equally biconvex in lateral profile with maximum depth occurring at or near one-third length from pedicle umbo. Hinge line is relatively straight, with the ratio of hinge line length to width of shell varying between 0.65 and 0.81 amongst measured specimens. Hinge angle amongst measured specimens varies from 150 to 163 degrees. Anterior commissure is uniplicate; the median part of the anterior margin where the sulcus and fold meet is markedly extended anteriorly in mature adult specimens.

Pedicle valve is strongly and fairly evenly convex, highest about mid-length, generally accounting for slightly more than one-half total depth of shell. Umbo is broadly rounded, considerably extended posteriorly beyond umbo of the opposing valve; beak ridges are rounded; interarea is triangular-shaped, curved, apsacline anteriorly and changing to anacline posteriorly; delthyrium was not seen; foramen is closed. Sulcus originates over the umbo and gradually deepens and widens anteriorly; it is relatively narrow, shallow, rounded V-shaped, where extended as a tongue in opposing valve the depth of sulcus becomes shallower.

Brachial valve length is considerably shorter than that of pedicle valve; ratio varying between 0.72 and 0.81 amongst measured specimens; moderately convex with greatest depth at about one-fifth length from beak. The beak is relatively small, inturned, and covered by the opposing valve. Fold originates over anterior part of umbo where it is barely evident, and gradually strengthens and widens anteriorly; near the anterior margin it abruptly widens to produce a V-shaped flare. The fold is indented along the midline by a shallow, rounded U-shaped furrow.

Shell material is very thick, especially over the posterior parts of shell. Concentric growth lamellae are spaced about 1 mm or less apart. They appear to be minutely fimbriated along their anterior margins. Minute, closely spaced radial markings are present on better preserved parts of shell.

Interior of pedicle valve (Fig. 16) with small hinge teeth supported by stout dental plates, which are in turn attached to the floor in posterior part of the valve. The dental plates form the sides of a deeply impressed muscle attachment area, with the impressed area continuing some distance beyond the anterior ends of the plates. Considerable secondary shell material lining and filling the delthyrial cavity.

Interior of brachial valve (Fig. 16) with divided hinge plates supported from the floor of the valve by thin crural plates in the posterior part of the valve. Inner socket ridges are stout, overhanging notothyrial cavity, with distal ends strongly curved ventrolaterally. Outer socket ridges are small. Cardinal process is a comb-like structure located at the apex of the notothyrial cavity. Crura are developed as thin dorso-medially directed plates at the anterior ends of the crural plates. Muscle impressions are weakly impressed, they are bounded laterally by low ridges and divided medianly by a low myophragm. Considerable secondary shell material lining notothyrial cavity, but it is not as thick as that in the opposite valve.

Remarks. Warrenella posteruskirki n. sp. is easily distinguished from *W. parafranklinii* n. sp., with which it is commonly associated, by its more elongate and narrower outline, its much higher pedicle interarea, its greater difference in length between the pedicle and brachial valves, and its proportionately greater thickness.

Characters such as elongate outline and a furrow in the brachial fold are reminiscent of *Warrenella kirki* (Merriam, 1940, p. 85, 86, Pl. 8, figs. 26–29), which occurs in older Middle Devonian rocks in Nevada and northwestern Canada. *Warrenella posteruskirki* n. sp. is separated from *W. kirki* (Merriam) by attaining a much larger size at maturity, possessing a much higher pedicle interarea along with a pedicle beak that extends a greater distance beyond the cardinal margin, and a subheptagonal outline rather than an elongate subelliptical outline, especially for mature adult specimens.

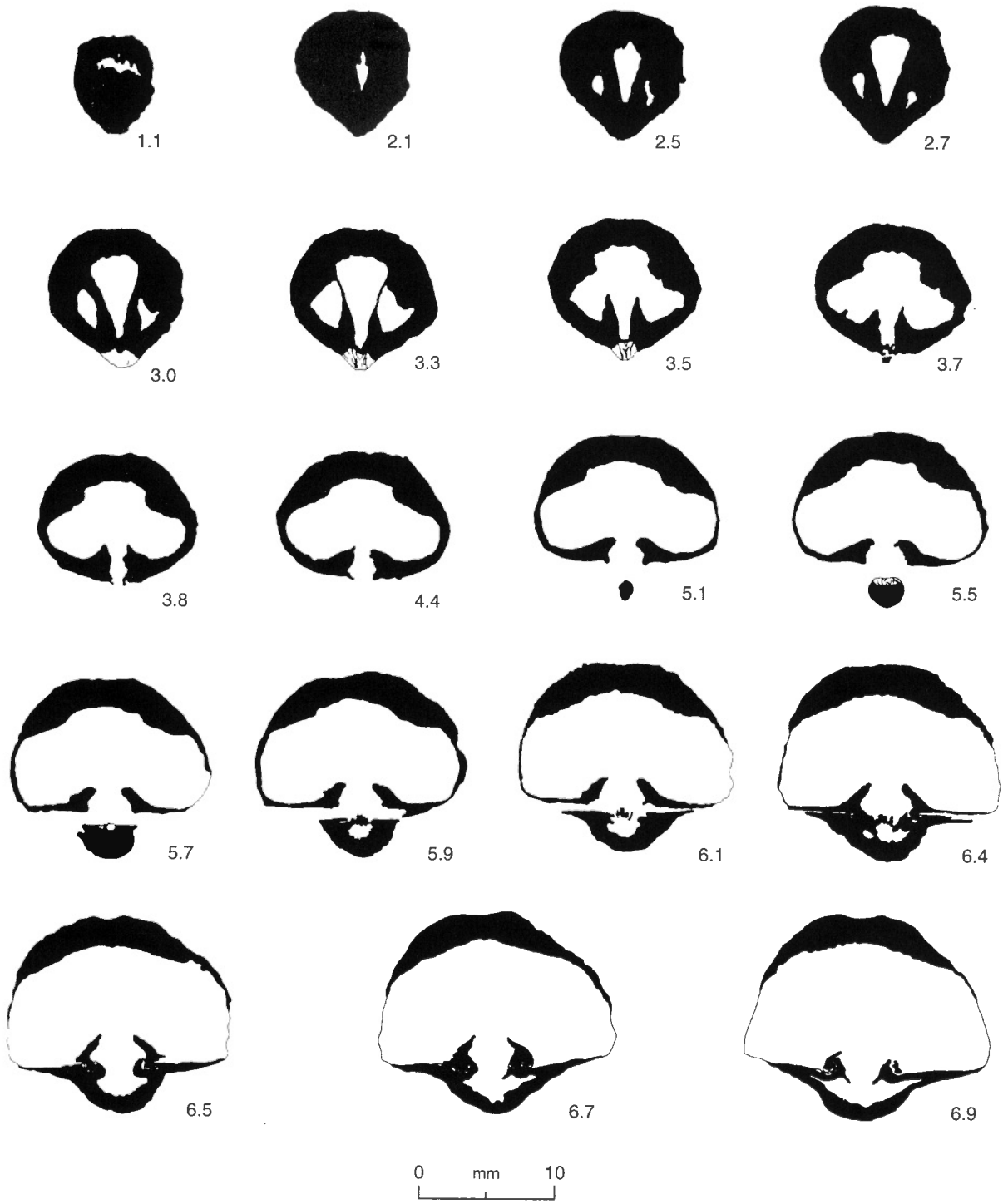


Figure 16. *Transverse serial sections of a specimen of* ***Warrenella posteruskirki*** *Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype GSC 75674. GSC locality C-94481.*

W. posteruskirki n. sp. is distinguished from *Warrenella crickmayi* Ludvigsen and Perry (1975, p. 78, 79, Pl. 15, figs. 10–32, Textfig. 20) by its larger size at maturity, its more extended pedicle beak and higher pedicle interarea, its more extended pedicle tongue, and more pronounced flare at the anterior end of the brachial fold.

Occurrence. *Warrenella posteruskirki* n. sp. occurs in the upper part of the Bituminous limestone member of the Pine Point Formation, which is represented in outcrops on the offshore islands on the south side of Great Slave Lake.

Warrenella kirki (Merriam, 1940, p. 85, 86, Pl. 8, figs. 26–29) occurs typically in the Upper *Warrenella kirki* Zone, upper Eifelian, Lone Mountain, Nevada (Johnson, 1974, Pl. 7, explanation). In northwestern Canada, *W. kirki* has been reported from numerous localities including limestones and shales of the upper Nahanni Formation at 61°39′N, 125°07′W, in southeastern Yukon Territory (Caldwell, 1971, p. 14, Pl. 2, explanation); from the upper part of the Headless Formation in the southern, central and western Mackenzie Mountains; and from the upper Ogilvie Formation in the Ogilvie River area (Ludvigsen and Perry, 1975, p. 62, Textfig. 3).

Warrenella crickmayi Ludvigsen and Perry (1975, p. 62, 78, Textfig. 13) occurs typically in the upper Nahanni Formation of central and western Mackenzie Mountains and in the upper "Hare Indian" Formation (now placed in the Mount Baird Formation by Norris, 1985, p. 26, 27) in the Snake River area.

Figured specimens. Paratype GSC 75673, a very young individual, and holotype GSC 75677, a very thick and elongate adult individual, from GSC locality C-94493; paratype GSC 75674, a wide, young adult individual, from GSC locality C-94481; and paratypes GSC 75675, an elongate, thick, adult individual, and GSC 75676, a very thick and wide adult individual, from GSC locality C-94446.

Locality data. GSC locality C-94493 (sample 28NBc1) at station 28NB on the west end of McKay Island at 61°01′30″N, 114°11′35″W; from the uppermost bed of an outcrop, 50 cm thick, of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94481 (sample 25NBb) at station 25NB on the tip of a peninsula on the western third of the north shore of McKay Island at 61°01′31″N, 114°11′35″W; from large, loose blocks of the more argillaceous middle part of the Bituminous limestone member of the Pine Point Formation.

GSC locality C-94446 (sample 16NBd) at station 16NB on the mid east shore of Beaulieu Island at 61°00′50″N, 114°08′10″W; from large, loose blocks of the more argillaceous middle part of the Bituminous limestone member of the Pine Point Formation.

Warrenella whittakeri Norris n. sp.

Plate 9, figures 13–19; Plate 10, figures 1, 2

1956 *Martinia*? *franklinii* Meek, Warren and Stelck, Pl. 2, figs. 1–3.
1956 *Martinia*? *kirki* var. *occidentalis* Merriam?, Warren and Stelck, Pl. 4, figs. 9–12.
1962 *Warrenella* cf. *W. franklini* (Meek), McLaren, Norris and McGregor, p. 20, Pl. 9, figs. 23–25.
1975 *Warrenella* cf. *W. maureri* (Holzapfel), Ludvigsen and Perry, p. 85, Pl. 17, figs. 1–10.

Diagnosis. A *Warrenella* of medium size and thickness for the genus at maturity; a relatively small pedicle interarea; narrow fold and sulcus with abrupt flaring at the anterior margins; and a faint furrow along midline of brachial fold.

Material. Represented by in excess of 10 specimens, most of which are firmly embedded in and difficult to extract from a hard limestone matrix. Shell material of some of the specimens has been partly altered to beekite.

Etymology. The trivial name *whittakeri* is after Dr. E.J. Whittaker, a former officer of the Geological Survey of Canada, who along with Dr. E.M. Kindle collected Devonian fossils from the Pine Point area in 1917.

Dimensions (in mm) and other parameters.

Specimen	A Paratype	B Holotype
GSC no.	75678	75679
GSC locality no.	C-94518	C-94519
Length of pv (Lpv)	26.9	31.0
Length of bv (Lbv)	23.1	26.7
Width (W)	32.0	35.9
Depth (D)	17.4	19.9
Length of hinge line (Lhl)	17.3	23.3
Ratio: W/Lpv	1.19	1.16
Ratio: D/W	0.54	0.55
Ratio: Lhl/W	0.54	0.65
Ratio: Lbv/Lpv	0.86	0.86
Hinge angle (in degrees)	153	160

Description. Shell attains a medium size at maturity for genus. Outline is transversely suboval with greatest width at about midlength. Valves are almost equally biconvex in lateral profile with greatest depth occurring at about one-third length from pedicle beak. Length of hinge line is markedly shorter than maximum width of shell; for two measured specimens this ratio varies from 0.54 to 0.65. Cardinal angles are rounded and

obtuse. Hinge angle varies from 153 to 160 degrees. Anterior commissure is uniplicate.

Pedicle valve is fairly evenly and moderately convex, highest between one-third and one-half length from beak. Umbo is rounded, and beak is relatively slender and strongly inturned. Interarea is low, triangular-shaped, curved, varying from apsacline to anacline. Sulcus originates over the umbo and gradually deepens and widens anteriorly; it is shallow, narrow, rounded V-shaped, and abruptly widens and deepens near the anterior margin where it is extended as a tongue in the opposite valve.

Brachial valve is moderately convex with greatest depth at one-quarter length from beak. Beak is small, inturned and in contact with opposing valve. A very low, rounded fold originates at about one-third length from beak and gradually strengthens anteriorly to near anterior margin where it abruptly widens. There is a faint trace of a furrow along the midline of the fold.

Shell substance is relatively thin. Shell surface is marked with fine, closely spaced concentric growth lines; growth lamellae are not preserved. Micro-ornament of very fine radiating lines, about 15 of which occur in an arc of 1 mm.

Interiors of valves were not seen.

Remarks. Although *Warrenella whittakeri* n. sp. bears some superficial resemblance to *Warrenella maureri* (Holzapfel, 1893, 1895) from Middle Devonian beds, Rhenish Mountains, Germany, the two forms are distinctly different. *Warrenella whittakeri* n. sp. is distinguished from the German form by its more angular cardinal angles, its much smaller pedicle interarea, its slightly indented rather than slightly extended anterior margin; its narrower fold and sulcus with pronounced flaring near the anterior margin; and the faint development of a furrow along the midline of the brachial fold. This latter feature suggests that *W. whittakeri* n. sp. is part of the *Warrenella franklinii* lineage of Ludvigsen and Perry (1975, p. 64–68).

Occurrence. Warrenella whittakeri n. sp. occurs mainly in the Brown limestone member of the Pine Point Formation, and appears to be the youngest *Warrenella* in the Pine Point area. The Brown limestone member occurs above and to the south of the Bituminous limestone member of the Pine Point Formation, but in this report it is treated as an upper part of the Bituminous limestone member.

Specimens of this species from the Pine Point area are recorded as *Martinia*? *kirki* var. *occidentalis* Merriam? by Warren and Stelck (1956, Pl. 4, figs. 9–12); as *Warrenella* cf. *franklini* (Meek) by McLaren, Norris and McGregor (1962, p. 20, Pl. 9, figs. 23–25); and as *Warrenella* cf. *W. maureri* (Holzapfel) by Ludvigsen and Perry (1975, p. 85, Pl. 17, figs. 1–10), and all appear to be from the same rock unit and locality recorded below.

Figured specimens. Paratype GSC 75678 from GSC locality C-94518; and holotype GSC 75679 from GSC locality C-94519.

Locality data. GSC locality C-94518 (sample 37NBb) at station 37NB, a cliff section on the west side of a winding dirt road connecting Dawson Landing wharf with the gravel road (Highway 6) to the south, at 60°57′50″N, 114°10′35″W, bearing 200T and 2.6 km from Dawson Landing; from base of exposure, 3.7 m thick, of the Brown limestone member of the Pine Point Formation.

GSC locality C-94519 (sample 37NBc) at station 37NB; fossils collected loose from the same locality and beds recorded above.

Superfamily RETICULARIACEA Waagen, 1883

Family ELYTHIDAE Frederiks, 1919 (1924)

Genus *Elita* Frederiks, 1918, p. 87

Type species. Delthyris fimbriata Conrad, 1842, p. 263; OD [=*Elytha* Frederiks, 1919 (1924), p. 304 (nom. van.); *Elyta* Ivanova, 1960, p. 277 (nom. null.)].

Elita? sp.

Material. Represented by a single specimen of a pedicle valve.

Dimensions (in mm) and other parameters.

Specimen	A
	Hypotype
GSC no.	75680
GSC locality no.	C-94440
Length of pv (Lpv)	22.3
Width (W)	25.0
Ratio: L/Lpv	1.12

Remarks. Photographic illustrations of this specimen are omitted because of very poor preservation.

Overall shape, low rounded plications on flanks, relatively smooth sulcus, and micro-ornament on this form suggest assignment to the genus *Elita* Frederiks (1918). However, the dental plates and median septum in the pedicle valve that are characteristic of this genus have not been firmly demonstrated in the single specimen at hand.

From *E. fimbriata* (Conrad), the type species of the genus (Cooper, *in* Shimer and Shrock, 1944, p. 327, Pl. 126, figs. 1–3), the form from Presqu'ile Point is distinguished by its more angular cardinal extremities, subpentagonal rather than a transversely elliptical outline, and a shallower pedicle sulcus.

From *"Plectospirifer" compactus* (Meek, 1868, p. 102, 103, Pl. 14, figs. 11a–11d; see also Caldwell, 1971, p. 14, Pl. 2, figs. 1a–1d), the form at hand differs in having more weakly developed plicae on the flanks of the pedicle valve, a much shallower, flat bottomed rather than a deep V-shaped pedicle sulcus, and less conspicuous concentric growth lamellae.

Elita? sp. in external form somewhat resembles *Elytha* cf. *E. subundifera* (Meek and Worthen, 1868) as described and illustrated by Griesemer (1965, p. 285, Pl. 5, figs. 20, 21) from the Milwaukee Formation of Wisconsin. However, the form from Presqu'ile Point has a shallower flat-bottomed sulcus in contrast to a shallow V-shaped sulcus, and more weakly developed plications on the flanks of the pedicle valve. Dental plates are clearly evident in the pedicle valve of the form from Wisconsin, a feature not clearly evident in the specimen from Presqu'ile Point.

Described specimen. Hypotype GSC 75680, from GSC locality C-94440.

Locality data. GSC locality C-94440 (sample 14NBa) at station 14NB on the mid east side of Presqu'ile Point, south shore of Great Slave Lake at 60°56′45″N, 114°34′40″W; from a large loose block of brown limestone derived from the lower part of the Sulphur Point Formation.

Occurrence. The *Elita*? sp. is associated with *Stringocephalus* sp. B of Warren and Stelck, 1962, in the lower Sulphur Point Formation at Presqu'ile Point. The association of *Elita* with stringocephalids may be relatively common as suggested by Crickmay (1960, p. 878, 879, 883) who reported *Elytha compacta* associated with *S. chasmognathus*, and *Elytha* sp. associated with *S. sapiens*.

Elytha fimbriata (Conrad) is recorded by Cooper (*in* Shimer and Shrock, 1944, p. 327) from the Hamilton and Tully formations and equivalent rocks of eastern North America.

The *"Plectospirifer" compactus* (Meek) illustrated by Caldwell (1971, p. 14, Pl. 2, figs. 1a–1d) is recorded from the upper Hume Formation, 23.5 m below the top of the formation in a section exposed in a creek (65°17′N, 129°13′W) between Gayna and Mountain rivers, Mackenzie Mountain front, District of Mackenzie. The form illustrated by Caldwell (1971) is proportionately wider than the form illustrated by Meek (1868).

Elytha cf. *E. subundifera* (Meek and Worthen, 1868) is recorded by Griesemer (1965, p 285) from the Berthlet Member of the Milwaukee Formation at Estabrook Park, Milwaukee, Wisconsin. Conodonts in the Berthlet Member have been aligned by Schumacher (*in* Clark, 1971, p. 65, figs. 15) with the Lower *Schmidtognathus hermanni–Polygnathus cristatus* Subzone.

Elytha subundifera (Meek and Worthen) has been described and illustrated by Stainbrook (1940, p. 414, 415, Pl. 1, figs. 1–5, 7, 8; Pl. 2, fig. 8) from the *"Acervularia" profunda* Zone and *"Atrypa" bellula* Zone of the Cedar Valley Limestone of Iowa. The *profunda* Zone in the Solon Member yields conodonts of the *varcus* Zone, and the *bellula* Zone in the lower Rapid Member yields conodonts of the *hermanni* Zone (Witzke et al., 1989).

Superfamily STRINGOCEPHALACEA King, 1850

Family STRINGOCEPHALIDAE King, 1850

Subfamily STRINGOCEPHALINAE King, 1850

Genus *Stringocephalus*
Defrance *in* de Blainville, 1825, p. 511
[nom. subst. Sandberger, 1842, p. 386
(pro *Strygocephale* Defrance in de Blainville, 1825, p. 511) (ICZN pend.)].

Type species. Terebratula Burtini Defrance in de Blainville, 1825, p. 511; OD [= *Strygocephalus* Defrance in de Blainville, 1827, Pl. 53, fig. 1 (obj); = *Strigocephalus* Sowerby, 1839, Pl. 56, fig. 10 (obj.)].

Stringocephalus sp. B of Warren and Stelck, 1962

Plate 10, figures 3–5

1921 *Stringocephalus burtoni*; Kindle, p. 21, 24.
1962 *Stringocephalus* n. sp. B, Warren and Stelck, p. 288, fig. 7, 30a–30c.
1962 *Stringocephalus* sp., McLaren, Norris and McGregor, p. 22, Pl. 10, figs. 4, 5.

Diagnosis. Shell is characterized by a medium to large size for the genus at maturity; rounded and highly inflated lateral and posterior profiles, with about equal convexities for the pedicle and brachial valves, and with a moderately extended and slightly inturned pedicle beak.

Material. Represented by numerous fragmentary specimens in loose blocks of limestone of the Sulphur Point Formation on the east side of Presqu'ile Point.

Dimensions (in mm) and other parameters.

Specimen	A	B	C	D
	Hypotype	Hypotype	Hypotype	Hypotype
GSC no.	75681	75682	75683	75684
GSC locality no.	C-94440	C-94439	C-94440	C-94440
Length of pv (Lpv)	—	—	—	—
Length of bv (Lbv)	—	—	—	—
Width (W)	—	43.1	53.9	60.4
Depth (D)	—	51.0	47.7	50.6
Ratio: Lpv/W	—	—	—	—

Dimensions (in mm) and other parameters. (cont'd.)

Specimen	E	F[1]	G[2] Dv1702
	Hypotype	Hypotype	
GSC no.	75685	16705	
GSC locality no.	C-94440	5668	—
Length of pv (Lpv)	—	70.5	96.9
Length of bv (Lbv)	—	68.0	81.2
Width (W)	-?-	89.9	92.1
Depth (D)	ca. 69	57.8	68.0
Ratio: Lpv/W	—	0.78	1.05

[1]*Stringocephalus* sp. McLaren, Norris & McGregor (1962, p. 22, Pl. 10, figs. 4, 5)
[2]*Stringocephalus* n. sp. B Warren & Stelck (1962, fig. 7, 30a–30c)

Description. Shell attains a medium to large size at maturity, fragments exhibit variable form, subcircular in outline, strongly and fairly evenly biconvex in lateral profile.

Pedicle valve moderately convex, rounded outline, accounting for approximately one-half total depth of shell; beak inflated, nearly straight in young stages, becoming incurved in adult stages; interarea large, apsacline towards cardinal margin and anacline towards apex of beak; deltidium and foramen not seen; cardinal margin curved dorsally.

Brachial valve roundish in outline, moderately convex; beak hidden by opposing valve.

Interior of pedicle valve with well developed hinge teeth, supported by strong dental lamellae and internal callus; median septum low, thick at the base and acute dorsally in umbonal region, becoming thin anteriorly, estimated to extend about 60 per cent length of valve.

Interior of brachial valve with thick hinge plate indented by deep dental sockets; cardinal process large, curved, deeply divided, supported by median septum and crural plates; median septum thick, of variable form and length, divided longitudinally into symmetrical halves by a conspicuous median separation plane; raised irregular mounds on each side of median septum immediately anterior of hinge plate; irregular radial ridges in umbonal cavity region.

Shell substance thick in umbonal regions, much thinner anteriorly; shell surface smooth; conspicuous, closely spaced concentric markings preserved on one young specimen (hypotype GSC 75681); punctae fine, closely spaced, evident only in an inner shell layer; an outer shell layer appears impunctate.

Remarks. The numerous specimens, mainly fragmentary, from the Presqu'ile Point locality appear to represent a single species here assigned to *Stringocephalus* sp. B of Warren and Stelck (1962). Other species, *S. sapiens and S. chasmognathus*, were reported also by Crickmay (1960, p. 877) from the same locality, but were not recognized by Norris in the collections at hand.

The more or less complete specimen of *S.* sp. B of Warren and Stelck (1962, p. 283, 288, fig. 7, 30a–30c) (hypotype GSC 16705; GSC locality 5668) illustrated by McLaren, Norris and McGregor (1962, p. 22, Pl. 10, figs. 4, 5), is from the same well known locality and was collected by E. M. Kindle and E. J. Whittaker in 1917. In commenting on this form, Kindle (1921, p. 21) referred to it as "*Stringocephalus burtoni*", a species described from western Europe.

Figured specimens. Hypotype GSC 75681, fragment of pedicle valve of a young individual; hypotype GSC 75683, transverse section of an adult individual; hypotype GSC 75684, oblique transverse section of an adult individual; and hypotype GSC 75685, posterior part of a large, adult individual; from GSC locality C-94440; and hypotype GSC 75682, transverse section of a young adult individual; from GSC C-94439.

Locality data. GSC locality C-94440 (sample 14NBa) at station 14NB on the mid east side of Presqu'ile Point, south shore of Great Slave Lake at 60°56′45″N, 114°34′40″W; from large, loose blocks of brown limestone derived from the lower part of the Sulphur Point Formation.

GSC locality C-94439 (sample 13NBa) at station 13NB on the east side and near north tip of Presqu'ile Point, south shore of Great Slave Lake at 60°56′50″N, 114°34′40″W; from large loose blocks of brown limestone derived from the lower part of the Sulphur Point Formation.

Occurrence. The specimens illustrated in this report are from loose blocks of brown limestone strewn along the shore just above lake level on the east side of Presqu'ile Point. The large, angular blocks have not travelled far and are presumbably derived from offshore reefal carbonate intersecting the bottom of Great Slave Lake very near Presqu'ile Point. Stratigraphically, these beds would occupy a position near the base of the Sulphur Point Formation where they overlie shale of the Buffalo River Member of the Pine Point Formation (see Norris, 1965, fig. 7). Conodonts from the basal Buffalo River Member of the Pine Point Formation have been assigned by Lantos (1983, p. 68, fig. 14) to the Middle *Polygnathus varcus* Subzone, which would suggest that the lower beds of the overlying Sulphur Point Formation are possibly assignable to the same or more likely a younger conodont zone.

Stringocephalus n. sp. B of Warren and Stelck (1962, fig. 4, p. 283; fig. 7, profiles 30a–30c, p. 288, 289) is recorded from the Presqu'ile Dolomite, Great Slave Lake, which is the Presqu'ile Point locality of the older literature. This locality marks the highest level of stringocephalids in the Great Slave Lake area, in the Windy Point Member of the Sulphur Point Formation.

Suborder TEREBRATELLIDINA Muir-Wood, 1955

Superfamily CRYPTONELLACEA Thomson, 1926

Family CRYPTONELLIDAE Thomson, 1926

Genus *Cryptonella* Hall, 1861, p. 101

Type species. Terebratula rectirostra Hall, 1860, p. 88; SD Hall and Clarke, 1894, p. 861.

Cryptonella? sp.

Material. Represented by a single complete specimen and a few fragmentary specimens.

Dimensions (in mm) and other parameters.

Specimen	A
GSC no.	Hypotype 75686
GSC locality no.	C-94739
Length of pv (Lpv)	6.3
Length of bv (Lbv)	5.6
Width (W)	6.5
Depth (D)	—
Ratio: Lpv/W	0.97
Ratio: Lbv/W	0.86

Description. Shell is of small size; subcircular in outline with width slightly greater than length; greatest width a little anterior of midlength, moderately biconvex, lenticular in lateral profile, greatest convexity about midlength; anterior commissure rectimarginate; anterior margin smoothly rounded; lateral margins smoothly rounded anteriorly but nearly straight posteriorly, where they converge to form a wedge-shaped pedicle beak; cardinal margin terebratulid; ventral palintropes low, about one-third as wide as width of shell, marked posterolaterally by subangular beak ridges; beak nearly straight; pedicle foramen mesothyridid, attrite; edge of opening slightly raised and rounded; deltidial plates relatively large, conjunct, slightly notched apically.

Shell surface has been abraded, but appears to have been originally smooth; punctae small, closely spaced, arranged in an uneven quincunxial pattern.

Remarks. Photographic illlustrations of this taxon are omitted because of very poor preservation.

Although the material is limited to one specimen embedded in matrix, features such as erect beak, mesothyridid position of the foramen, and character of deltidial plates suggest assignment to the genus *Cryptonella* Hall (1861) rather than the genus *Cranaena* Hall and Clarke (1893). However, the thickened margin of the foramen, evident in the specimen at hand, is a feature suggestive of the genus *Cranaena*, according to Cloud (1942, p. 133).

Specimen. Hypotype GSC 75686 from GSC locality C-94739.

Locality data. GSC locality C-94739 (sample 99NBa) at station 99NB on the south shore of Great Slave Lake at 60°59′36″N, 114°10′45″W, 0.6 km west of Dawson Point; from a loose block of the Bituminous limestone member of the Pine Point Formation.

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APPENDIX 1

Locality register

Samples are listed by GSC locality numbers in ascending sequence followed by field sample numbers in brackets. See also Figures 1 and 2 for locations of station localities. Where two samples are indicated from the same level or interval, one is for conodonts and the other is for macrofossils. Samples from Bell Rock on Slave River are indicated also in Appendix 3 of this report.

GSC locality C-94401 (sample 1NBa) at station 1NB, on south shore of Mission Island immediately west of vacant Mission House at 61°10′12″N, 113°44′33″W, 3.8 km bearing 261T from Fort Resolution. Sample is from 0 to 10 cm above base of outcrop of dolomite which is 198.5 cm thick; estimated to be from between 5.0 and 5.1 m above base of the Keg River Formation. Beds measured and sampled by A.W. Norris, 9 June 1981.

GSC locality C-94402 (sample 1NBb) and **GSC locality C-94403 (sample 1NBc)** at station 1NB, on south shore of Mission Island, immediately west of vacant Mission House at 61°10′12″N, 113°44′33″W, 3.8 km bearing 261T from Fort Resolution. Samples are from 10.8 to 11.8 cm above base of outcrop of dolomite which is 198.5 cm thick; estimated to be from between 6.08 and 6.18 m above base of the Keg River Formation. Beds measured and sampled by A.W. Norris, 9 June 1981.

GSC locality C-94404 (sample 1NBd) and **GSC locality C-94405 (sample 1NBe)** at station 1NB, on south shore of Mission Island, immediately west of vacant Mission House at 61°10′12″N, 113°44′33″W, 3.8 km bearing 261T from Fort Resolution. Samples are from between 190 and 198.5 cm above base of outcrop, which is 198.5 cm thick; estimated to be from between 6.90 and 6.95 m above base of Keg River Formation. Beds measured and sampled by A.W. Norris, 9 June 1981.

GSC locality C-94406 (sample 2NB1) and **GSC locality C-94407 (sample 2NBa)** at station 2NB, on north shore near east end of Round Island at 61°09′11″N, 113°46′30″W, 5.8 km bearing 248T from Fort Resolution. Samples are from between 23 and 35 cm above the base of an outcrop of dolomite, 35 cm exposed; estimated to be from between 9.23 and 9.35 m above base of the Keg River Formation. Beds measured and sampled by A.W. Norris, 10 June 1981.

GSC locality C-94419 (sample 7NBb) and **GSC locality C-94420 (sample 7NBc)** at station 7NB, on south shore of Great Slave Lake on Sulphur Point at 60°55′57″N, 114°48′06″W, 1.3 km east of Sulphur Cove. Samples are from top 6 cm of pavement outcrop, 20 cm exposed, just above and below lake level; estimated to be from about 32.8 m above the base of the "Watt Mountain" Formation of Rhodes et al. (1984). Beds measured and sampled by A.W. Norris, 14 June 1981.

GSC locality C-94423 (sample 9NBa) and **GSC locality C-94424 (sample 9NBb)** at station 9NB, on south shore of Great Slave Lake at 60°55′55″N, 114°47′20″W, 11.5 km west of the north tip of Presqu'ile Point. Pavement outcrop, 5 cm exposed, just above the lake level. Samples estimated to be from about 32.3 cm above base of "Watt Mountain" Formation of Rhodes et al. (1984), where formation is about 46.5 m thick. Beds measured and sampled by A.W. Norris, 14 June 1981.

GSC locality C-94434 (sample 12NBa) and **GSC locality C-94435 (sample 12NBb)** at station 12NB, on south shore of Great Slave Lake at 60°55′25″N, 114°46′10″W, most easterly outcrop on Sulphur Point. A low cliff with 1.18 m of limestone beds exposed. Base of outcrop is 1.2 m above lake level. Samples are from the basal 10 cm of outcrop, which are estimated to be 31.3 m above base of the "Watt Mountain" Formation of Rhodes et al. (1984). Beds measured and sampled by A.W. Norris, 14 June 1981.

GSC locality C-94439 (sample 13NBa) at station 13NB on the east side and near north tip of Presqu'ile Point on the south shore of Great Slave Lake at 60°56′50″N, 114°34′40″W; from a large loose block of brown reefal limestone derived from the lower part of the Sulphur Point Formation. Judging from the abundance of the large blocks of the Sulphur Point Formation, this rock unit presumably forms the bottom of the lake near the north tip of Presqu'ile Point. The large blocks have been transported to the shore by moving ice and large storm waves. Examined by A.W. Norris, 14 June 1981.

GSC locality C-94440 (sample 14NBa) and **GSC locality C-94441 (sample 14NBb)** at station 14NB on the mid-east side of Presqu'ile Point on the south shore of Great Slave Lake at 60°56′45″N, 114°34′40″W. Numerous large loose blocks of reefal limestone of the Windy Point Member of the Sulphur Point Formation scattered along the shore. This is the type locality for *Hypothyridina cameroni* Warren, 1944, and the main locality of *Stringocephalus* spp. in the Great Slave Lake area. Beds examined by A.W. Norris, 15 June 1981. Windy Point Member of the Sulphur Point Formation is 20 m thick in the nearby Cominco Sulphur Point Test G-4 well (Belyea and Norris, 1962).

GSC locality C-94442 (sample 15NBa) and **GSC locality C-94443 (sample 15NBb)** at station 15NB, on the southeast shore of Beaulieu Island at 61°00′45″N, 114°08′25″W, bearing 088T from north tip of Pine Point at 6.2 km. Samples are estimated to be from between 8.13 and 8.33 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94444 (sample 16NBb) at station 16NB, on the mid-east shore of Beaulieu Island at 61°00′50″N, 114°08′10″W, 6.6 km bearing 086T from the north tip of Pine Point. Sample is estimated to be from between 7.45 and 7.66 m above the base of the Bituminous limestone member of the Pine Point Formation. Beds sampled and measured by A.W. Norris, 17 June 1981.

GSC locality C-94445 (sample 16NBc) and **GSC locality C-94446 (sample 16NBd)** at station 16NB on the mid-east shore of Beaulieu Island at 61°00′50″N, 114°08′10″W, bearing 086T at 6.6 km from Pine Point; collected from a loose block of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 7.50 and 7.69 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality 94447 (sample 17NBa) and **GSC locality C-94448 (sample 17NBb)** at station 17NB on northeast shore of McKay Island

at 61°01′50″N, 114°09′50″W, at 5.3 km bearing 065T from the north tip of Pine Point. Samples are estimated to be from between 25.02 and 25.13 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94449 (sample 17NBc) at station 17NB, on the northeast shore of McKay Island at 5.3 km bearing 065T from north tip of Pine Point. Sample is estimated to be from between 25.52 and 25.66 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94451 (sample 17NBe) at station 17NB, on northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, at 5.3 km bearing 065T from the north tip of Pine Point. Sample is estimated to be from between 25.52 and 25.66 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94452 (sample 17NBa1) at station 17NB, on the northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, at 5.3 km bearing 065T from the north tip of Pine Point. Sample is estimated to be from between 25.28 and 25.39 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94453 (sample 17NBb2) at station 17NB, on northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, at 5.3 km bearing 065T from north tip of Pine Point. Sample is estimated to be from between 25.28 and 25.39 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94454 (sample 17NBc1) at station 17NB, on northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, at 5.3 km bearing 065T from north tip of Pine Point. Sample is estimated to be from between 25.18 and 25.30 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94455 (sample 17NBd1) at station 17NB, on northeast shore of McKay Island at 61°01′50″N, 114°04′50″W, at 5.3 km bearing 065T from north tip of Pine Point. Sample is estimated to be from between 25.18 and 25.30 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94456 (sample 17NBe1) at station 17NB on the northeast shore of McKay Island at 61°01′50″N, 114°09′50″W, bearing 065T at 5.3 km from north tip of Pine Point; from lowest beds, 15 cm thick, of an outcrop, 50 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 25.00 and 25.18 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94457 (sample 18NBa) and **GSC locality C-94458 (sample 18NBb)** at station 18NB on the mid-north shore of McKay Island at 61°01′45″N, 114°10′30″W, bearing 064T at 4.8 km from Pine Point; from an outcrop, 39 cm exposed, along shore just above lake level, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 29.38 and 29.70 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94459 (sample 18NBa1) at station 18NB on the mid-north shore of McKay Island at 61°01′45″N, 114°10′30″W, bearing 064T at 4.8 km from north tip of Pine Point; from an *Emanuella* coquina bed, 24 cm thick, forming lower part of an outcrop 62 cm thick, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 29.14 and 29.38 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94460 (sample 18NBb1) at station 18NB, on the mid-north shore of McKay Island at 61°01′45″N, 114°10′50″W, bearing 064T at 4.8 km from the north tip of Pine Point, from upper 38 cm of an outcrop 62 cm thick, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 29.38 and 29.76 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94461 (sample 19NBa) and **GSC locality C-94462 (sample 19NBb)** at station 19NB on the mid-north shore of McKay Island at 61°01′40″N, 114°10′35″W; from 41 cm above base of an outcrop, 60 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from 29.62 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94463 (sample 19NBc) at station 19NB on the mid-north shore of McKay Island at 61°01′40″N, 114°10′35″W; from a large loose block derived from an outcrop 60 cm thick, part of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 29.35 and 29.83 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94464 (sample 20NBa) at station 20NB, on the south shore of Great Slave Lake at 60°59′30″N, 114°09′49″W, 0.17 km west of Dawson Landing wharf; from top of pavement outcrop of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 11.05 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 17 June 1981.

GSC locality C-94465 (sample 21NBa) and **GSC locality C-94466 (sample 21NBb)** at station 21NB on the south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, 0.18 km west of Dawson Landing wharf; from uppermost 20 cm of an outcrop 53 cm thick of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 11.05 and 11.30 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 18 June 1981.

GSC locality C-94467 (sample 21NBa1) at station 21NB, on south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, about 60 m west of Dawson Landing wharf; from lower 13 cm of an outcrop 59 cm exposed of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 10.46 and 10.59 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981. (see GSC Internal Fossil Report AWN-109-AEHP-83).

GSC locality C-94468 (sample 21NBb1) at station 21NB, on the south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, about 60 m west of Dawson Landing wharf; from upper 3 cm of a bed 59 cm exposed of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 10.56 and

10.59 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94469 (sample 21NBc1) at station 21NB, on the south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, about 60 m west of Dawson Landing wharf; from the top 3 cm of an outcrop with 59 cm exposed of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be between 10.59 and 10.62 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94470 (sample 21NBd1) at station 21NB, on the south shore of Great Slave Lake at 60°59′30″N, 114°09′50″W, about 60 m west of Dawson Landing wharf; from a bed 7 cm thick of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be between 10.62 and 10.69 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94471 (sample 22NBa) and **GSC locality C-94472 (sample 22NBb)** on north shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, 0.41 km west of Dawson Landing wharf. Samples are estimated to be from about 9.05 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 18 June 1981.

GSC locality C-94473 (sample 22NBa1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.41 km west of Dawson Landing wharf; from upper 7 cm of an outcrop, 18 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be about 9.05 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94474 (sample 22NBb1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, about 0.42 km west of Dawson Landing wharf; loose blocks on top of an outcrop, 18 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 9.05 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981. (see GSC Internal Fossil Report AWN-109-AEHP-83).

GSC locality C-94475 (sample 22NBc1) at station 22NB on the south shore of Great Slave Lake at 60°59′29″N, 114°09′55″W, 0.42 km west of Dawson Landing wharf; from a small patch of outcrop, about 4 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 9.01 and 9.05 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94476 (sample 23NBa) and **GSC locality C-94477 (sample 23NBb)** at station 23NB on the south shore of Great Slave Lake at 60°59′28″N, 114°10′00″W, about 0.54 km west of Dawson Landing wharf; from an outcrop, 43 cm thick, about 1 m above lake level of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 17.94 and 18.53 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 18 June 1981.

GSC locality C-94478 (sample 24NBa) and **GSC locality C-94479 (sample 24NBb)** at station 24NB on the south shore of Great Slave Lake at 60°59′27″N, 114°10′05″W, about 0.73 km west of Dawson Landing wharf; from an outcrop about 10 cm exposed and about 0.5 cm above lake level of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 22.02 and 22.17 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 18 June 1981.

GSC locality C-94480 (sample 25NBa) and **GSC locality C-94481 (sample 25NBb)** at station 25NB on tip of peninsula on the western third of the north shore of McKay Island at 61°01′31″N, 114°11′35″W; from a large loose block of the more argillaceous part of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 28.30 and 28.62 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 19 June 1981.

GSC locality C-94482 (sample 26NBa) and **GSC locality C-94483 (sample 26NBb)** at station 26NB on the northwest shore of McKay Island at 61°01′55″N, 114°11′10″W, 4.3 km bearing 059T from the north tip of Pine Point. Samples are estimated to be from between 29.38 and 29.50 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 19 June 1981.

GSC locality C-94484 (sample 26NBc) at station 26NB, on the northwest shore of McKay Island at 61°01′55″N, 114°11′10″W, 4.3 km bearing 059T from the north tip of Pine Point. Sample is estimated to be from between 29.38 and 29.50 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 19 June 1981.

GSC locality C-94485 (sample 27NBa) and **GSC locality C-94486 (sample 27NBb)** on the northwest shore of McKay Island at 61°01′45″N, 114°11′25″W, from the north tip of Pine Point. Sample is estimated to be about 32.0 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 19 June 1981.

GSC locality C-94487 (sample 27NBa1) at station 27NB, on the northwest shore of McKay Island at 61°01′45″N, 114°11′25″W, 4.0 km bearing 058T from the north tip of Pine Point. Sample is estimated to be about 31.82 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94488 (sample 27NBb1) at station 27NB, on the northwest shore of McKay Island at 61°01′45″N, 114°11′25″W, 4.0 km bearing 058T from the north tip of Pine Point. Sample is estimated to be about 31.82 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94489 (sample 28NBa) and **GSC locality C-94490 (sample 28NBb)** at station 28NB on the west end of McKay Island at 61°01′30″N, 114°11′35″W, bearing 057T at 3.9 km from Pine Point; from an outcrop, 50 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 32.80 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94491 (sample 28NBa1) and **GSC locality C-94494 (sample 28NBd1)** at station 28NB at 61°01′30″N, 114°11′35″W, 3.8 km bearing 057T from the north tip of Pine Point. Samples are estimated to be from between 32.36 and 32.82 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94492 (sample 28NBb1) at station 28NB (revisited), at the west end of McKay Island at 61°01′30″N, 114°11′35″W,

3.8 km bearing 057T from the north tip of Pine Point. Sample is estimated to be from between 32.36 and 32.52 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94493 (sample 28NBc1) at station 28NB from the west end of McKay Island at 61°01′30″N, 114°11′35″W, bearing 057T from the tip of Pine Point at 3.9 km; from the top of an outcrop, 49 cm thick, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 22.80 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94495 (sample 28NBe1) at station 28NB, on the west end of McKay Island at 61°01′30″N, 114°11′35″W, 3.8 km bearing 057T from the north tip of Pine Point. Sample is estimated to be about 32.97 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94496 (sample 29NBa) and **GSC locality C-94497 (sample 29NBb)** at station 29NB, on the northeast tip of Green Island at 61°02′30″N, 114°12′10″W, 4.5 km bearing 042T from the north tip of Pine Point. Samples are estimated to be from between 30.75 and 30.90 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 19 June 1981.

GSC locality C-94499 (sample 30NBa) and **GSC locality C-94500 (sample 30NBb)** at station 30NB, on the east end of a small island at 60°59′35″N, 113°54′50″W, 12.6 km west of the mouth of Little Buffalo River. Samples are from loose blocks of thick bedded, finely granular, coarsely vuggy dolomite of the Keg River Formation. Examined by A.W. Norris, 20 June 1981.

GSC locality C-94501 (sample 31NBa) and **GSC locality C-94502 (sample 31NBb)** at station 31NB, on road south of Dawson Landing wharf, at 60°59′15″N, 114°09′40″W, at 0.16 km bearing 177T from the wharf. Samples are estimated to be from between 12.52 and 12.58 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94503 (sample 32NBa) and **GSC locality C-945043 (sample 32NBb)** at station 32 NB, at 60°59′12″N, 114°09′35″W, on road at 0.32 km bearing 177T from Dawson Landing wharf. Samples are estimated to be from between 16.20 and 16.28 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 June 1981.

GSC locality C-94505 (sample 33NBa) and **GSC locality C-94506 (sample 33NBb)** at station 33NB, on road at 60°58′35″N, 114°09′58″W, 1.3 km bearing 194T from Dawson Landing wharf; estimated to be from about 39.00 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94507 (sample 33NBc) and **GSC locality C-94508 (sample 33NB8)** at station 33NB, on road at 60°58′35″N, 114°09′58″W, 1.3 km bearing 194T from Dawson Landing wharf. Samples are estimated to be from between 40.09 and 40.20 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94509 (sample 34NBa) and **GSC locality C-94510 (sample 34NBb)** at station 33NB, on road at 60°58′30″N, 114°10′05″W, 1.4 km bearing 199T from Dawson Landing wharf. Samples are estimated to be from between 41.99 and 42.09 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94511 (sample 34NBc) and **GSC locality C-94512 (sample 34NBd)** at station 34NB, on road at 60°58′30″N, 114°10′05″W, 1.4 km bearing 199T from Dawson Landing wharf. Samples are estimated to be from between 42.22 and 42.27 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94513 (sample 35NBa) and **GSC locality C-94514 (sample 35NBb)** at station 35NB, on road at 60°58′20″N, 114°10′30″W, 1.9 km bearing 204T from the Dawson Landing wharf. Sample is estimated to be from between 45.00 and 44.20 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94515 (sample 36NBa) at station 36NB, on road at 60°58′00″N, 114°11′40″W, 2.4 km bearing 204T from Dawson Landing wharf. Sample is estimated to be from between 43.50 and 43.60 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94517 (sample 37NBa) and **GSC locality C-94518 (sample 37NBb)** at station 37NB, a cliff section on the west side of a winding dirt road connecting Dawson Landing wharf with the gravel road of Highway 6 to the south, at 60°57′50″N, 114°10′35″W, bearing 200T from Dawson Landing wharf at 2.6 km; from base of exposure, 3.7 m thick, of the Brown limestone member of the Pine Point Formation. Samples are estimated to be from between 46.45 and 46.49 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94519 (sample 37NBc) at station 37NB, 60°57′50″N, 114°10′35″W, cliff section on west side of road, 2.6 km bearing 200T from Dawson Landing wharf; from a loose block derived from an outcrop at top of cliff, 3.7 m thick, of the Brown limestone member of the Pine Point Formation. Sample is estimated to be from about 48.75 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94520 (sample 37NBd) at station 37NB, on road at 60°57′50″N, 114°10′35″W, 2.6 km bearing 200T from Dawson Landing wharf. Sample is estimated to be from between 49.87 and 50.03 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94525 (sample 40NBa) and **GSC locality C-94526 (sample 40NBb)** at station 40NB, on road at 60°57′38″N, 114°09′55″W, 3.04 km bearing 183T from Dawson Landing wharf. Samples are estimated to be from about 39.32 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94527 (sample 42NBa) and **GSC locality C-94528 (sample 42NBb)** at station 42NB, on road at 60°57′34″N, 114°09′45″W, at 3.2 km bearing 175T from Dawson Landing wharf. Samples are estimated to be about 30.85 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981. (see GSC Internal Fossil Report F1-2-DCM-83 for sample 42NBb).

GSC locality C-94529 (sample 43NBa) and **GSC locality C-94530 (sample 43NBb)** at station 43NB, on road at 60°57′35″N, 114°09′15″W, 3.04 km bearing 171T from Dawson Landing wharf.

Samples are estimated to be from between 29.00 and 29.10 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94531 (sample 44NBa) and **GSC locality C-94532 (sample 44NBb)** at station 44NB, on road at 60°57′45″N, 114°08′57″W, 2.9 km bearing 167T from Dawson Landing wharf. Samples are estimated to be from about 21.46 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 21 June 1981.

GSC locality C-94533 (sample 45NBa) and **GSC locality C-94534 (sample 45NBb)** at station 45NB, at 60°59′18″N, 114°09′30″W, 30.5 m east of Dawson Landing wharf on the south shore of Great Slave Lake. Samples are estimated to be from between 8.04 and 8.15 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94536 (sample 45NBd) at station 45NB, on the south shore of Great Slave Lake at 60°59′18″N, 114°09′30″W, 30.5 m east of Dawson Landing wharf. Sample is estimated to be from between 7.80 and 7.90 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94538 (sample 45NBf) at station 45NB on the south shore of Great Slave Lake at 60°59′18″N, 114°09′30″W, 30.5 m east of Dawson Landing wharf. Sample is from basal 10 cm of a sequence of 122 cm of exposure, estimated to be between 9.05 and 9.16 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94537 (sample 45NBe) and **GSC locality C-94539 (sample 45NBg)** at station 45NB on the south shore of Great Slave Lake, 30.5 m east of Dawson Landing wharf at 60°59′18″N, 114°09′30″W; from basal bed, 10 cm thick, of an outcrop, 48 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 7.50 and 7.59 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94540 (sample 45NBx) at station 45NB, on the south shore of Great Slave Lake, 30.5 m east of Dawson Landing wharf at 60°59′18″N, 114°09′30″W; from the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 7.50 to 7.59 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94541 (sample 46NBa) and **GSC locality C-94542 (sample 46NBb)** at station 46NB, on the south shore of Great Slave Lake at 60°59′19″N, 114°09′27″W, about 76.2 m east of the Dawson Landing wharf. Samples are estimated to be from between 10.98 and 11.25 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94543 (sample 47NBa) and **GSC locality C-94544 (sample 47NBb)** at station 47NB, on the south shore of Great Slave Lake at 60°59′18″N, 114°09′27″W, about 137.2 m east of Dawson Landing wharf. Samples are estimated to be from between 10.51 and 10.57 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94545 (sample 47NBc) and **GSC locality C-94546 (sample 47NBd)** at station 47NB, on the south shore of Great Slave Lake at 60°59′18″N, 114°09′22″W, about 137.2 m east of Dawson Landing wharf. Samples are estimated to be from about 9.82 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94547 (sample 48NBa) and **GSC locality C-94548 (sample 48NBb)** at station 48NB, on the south shore of Great Slave Lake at 60°59′18″N, 114°09′20″W, about 182.9 m east of the Dawson Landing wharf. Samples are estimated to be from between 7.65 and 7.87 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94549 (sample 48NBc) and **GSC locality C-94550 (sample 48NBd)** at station 48NB, on the south shore of Great Slave Lake at 60°59′18″N, 114°09′20″W, about 182.9 m east of Dawson Landing wharf. Samples are from the top of an outcrop and estimated to be from between 8.35 and 8.45 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94551 (sample 49NBa) and **GSC locality C-94552 (sample 49NBb)** at station 49NB, on the south shore of Great Slave Lake at 60°59′10″N, 114°09′15″W, 244 m east of Dawson Landing wharf. Samples are from the Bituminous limestone member of the Pine Point Formation, estimated to be from between 7.42 and 7.55 m above base of the member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94553 (sample 50NBa) and **GSC locality C-94554 (sample 50NBb)** at station 50NB on the south shore of Great Slave Lake at 60°59′16″N, 114°09′10″W, 0.28 km east of Dawson Landing wharf; from an outcrop 8 cm thick of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 7.45 and 7.55 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94555 (sample 50NBx) at station 50NB on the south shore of Great Slave Lake at 60°59′16″N, 114°09′10″W, about 290 m east of Dawson Landing wharf. Sample is from the Bituminous limestone member of the Pine Point Formation, estimated to be from between 7.45 and 7.55 m above the base of the member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-94556 (sample 51NBa) and **GSC locality C-94557 (sample 51NBb)** at station 51NB, on the south shore of Great Slave Lake, 0.33 km east of Dawson Landing wharf, at 60°59′04″N, 114°09′06″W. Sample is from an interval 10 cm thick at base of unit 104 cm thick. Sample is estimated to be from between 7.90 and 8.00 m above base of the Bituminous limestsone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94558 (sample 51NBc) and **GSC locality C-94559 (sample 51NBd)** at station 51NB on the south shore of Great Slave Lake, 0.33 km east of Dawson Landing wharf, at 60°59′04″N, 114°09′06″W; from 90 cm above the base of an outcrop, 104 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 8.70 and 8.80 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94560 (sample 51NBe) at station 51NB, on the south shore of Great Slave Lake, 60°59′04″N, 114°09′06″W, about 335.3 m east of Dawson Landing wharf. Sample is estimated to be from between 8.85 and 8.95 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94561 (sample 52NBa) and **GSC locality C-94562 (sample 52NBb)** at station 52NB, on the south shore of Great Slave Lake at 60°59′10″N, 114°09′01″W, about 426.7 m east of Dawson Landing wharf. Samples are estimated to be from between 7.85 and 7.94 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94563 (sample 53NBa) and **GSC locality C-94564 (sample 53NBb)** at station 53NB, on the south shore of Great Slave Lake about 0.1 km east of Dawson Landing wharf at 60°59′17″N, 114°08′55″W. Samples are from lower 10 cm of an outcrop, 49 cm exposed. Samples are estimated to be from between 7.37 and 7.50 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 June 1981.

GSC locality C-94565 (sample 54NBa) and **GSC locality C-94566 (sample 54NBb)** at station 54NB on the south shore of Great Slave Lake at 60°53′08″N, 140°08′40″W, about 0.64 km east of Dawson Landing wharf; from a small outcrop, about 10 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 6.55 and 6.65 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94567 (sample 55NBa) and **GSC locality C-94568 (sample 55NBb)** at station 55NB on the south shore of Great Slave Lake at 60°59′07″N, 140°08′45″W, 0.8 km east of Dawson Landing wharf. Samples from between 5.80 and 5.90 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981.

GSC locality C-94569 (sample 56NBa) and **GSC locality C-94570 (sample 56NBb)** at station 56NB on the south shore of Great Slave Lake at 60°59′10″N, 114°08′40″W, 0.96 km east of Dawson Landing wharf. Samples are from between 5.20 and 5.30 m above base of the member. Beds measured and sampled by A.W. Norris, 27 June 1981.

GSC locality C-94571 (sample 57NBa) and **GSC locality C-94572 (sample 57NBb)** at station 57NB on the south shore of Great Slave Lake at 60°59′00″N, 140°04′20″W, 4.96 km east of Dawson Landing wharf. Samples are estimated to be from between 15.30 and 15.45 m below base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 27 June 1981.

GSC locality C-94573 (sample 58NBa) and **GSC locality C-94574 (sample 58NBb)** at station 58NB on the south shore of Great Slave Lake at 60°58′45″N, 114°06′40″W, 2.7 km east of Dawson Landing wharf. Samples are from a loose block estimated to be from between 0 and 0.15 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 27 June 1981.

GSC locality C-94575 (sample 59NBa) and **GSC locality C-94576 (sample 59NBb)** at station 59NB on the east side of Burnt Island at 61°04′40″N, 114°05′40″W, 11.5 km bearing 049T from the north tip of Pine Point; loose fragments of the Dolomite member of the Pine Point Formation. Samples are estimated to be from between 20.20 and 20.41 m below base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-94577 (sample 60NBa) and **GSC locality C-94578 (sample 60NBb)** at station 60NB, on the northeast side of Burnt Island at 61°04′45″N, 114°05′30″W, 11.7 km bearing 049T from the north tip of Pine Point. Samples are from dolomite beds estimated to be from between 12.95 and 13.07 m below base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-94579 (sample 61NBa) and **GSC locality C-94580 (sample 61NBb)** at station 61NB, on the southwest tip of Laity Island at 61°05′15″N, 114°06′45″W, 11.5 km bearing 042T from the north tip of Pine Point. Loose fragments of the Dolomite member of the Pine Point Formation. Samples are estimated to be from between 20.15 and 20.40 m below base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-94581 (sample 62NBa) and **GSC locality C-94582 (sample 62NBb)** at station 62NB on the west tip of Burnt Island at 61°04′35″N, 114°07′40″W, bearing 044T at 10.3 km from Pine Point; from an outcrop, 37 cm exposed, of black bituminous dolomite of the the Pine Point Formation. Samples are estimated to be from about 9.64 m below the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-94583 (sample 62NBc) and **GSC locality C-94584 (sample 62NBd)** at station 62NB, on the west tip of Burnt Island at 61°04′35″N, 114°07′40″W, 10.2 km bearing 044T from the north tip of Pine Point. Samples are from a loose block of the Dolomite member, estimated to be from between 9.50 and 9.95 m below base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 28 June 1981.

GSC locality C-130853 (sample 63NBa) and **GSC locality C-94585 (sample 63NBb)** at station 63NB(W), on the south shore of Great Slave Lake at 60°59′35″N, 114°11′52″W, 1.9 km west of Dawson Landing wharf. Samples are estimated to be from about 27.44 to 27.56 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94587 (sample 63NBd) and **GSC locality C-94588 (sample 63NBe)** at station 63NB, on the south shore of Great Slave Lake at 60°59′35″N, 114°11′52″W, 1.9 km west of Dawson Landing wharf. Samples are estimated to be from between 27.56 and 28.87 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94589 (sample 63NBf) and **GSC locality C-94590 (sample 63NBg)** at station 63NB, on the south shore of Great Slave Lake at 60°59′35″N, 114°11′52″W, 1.9 km west of Dawson Landing wharf. Samples are estimated to be from about 27.77 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94591 (sample 63NBh) at station 63NB, on the south shore of Great Slave Lake at 60°59′35″N, 114°11′52″W, 1.9 km west of Dawson Landing wharf. Sample is estimated to be from between 27.56 and 27.87 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94592 (sample 64NBa) and **GSC locality C-94593 (sample 64NBb)** at station 64NB, on the south shore of Great Slave Lake at 60°59′40″N, 114°12′05″W, 2.2 km west of Dawson Landing wharf. Samples are estimated to be from between 29.45 and 29.70 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94594 (sample 64NBc) at station 64NB, on the south shore of Great Slave Lake at 60°59′40″N, 114°12′05″W, 2.2 km west of Dawson Landing wharf. Sample is estimated to be from between 29.45 and 29.70 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94595 (sample 65NBa) and **GSC locality C-94596 (sample 65NBb)** at station 65NB, on the south shore of Great Slave

Lake at 60°59′50″N, 114°12′00″W, 2.3 km west of Dawson Landing wharf. Samples are estimated to be from between 30.00 and 30.32 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94597 (sample 66NBa) and **GSC locality C-94598 (sample 66NBb)** at station 66NB on the south shore of Great Slave Lake at 60°59′58″N, 114°12′10″W, about 2.4 km west northwest of Dawson Landing wharf; from the lower beds, 18 cm thick, of an outcrop, 65 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 30.11 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94599 (sample 66NBc) and **GSC locality C-94600 (sample 66NBd)** at station 66NB on the south shore of Great Slave Lake at 60°59′59″N, 114°12′10″W, about 2.4 km west northwest of Dawson Landing wharf. Samples are estimated to be from about 30.58 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94601 (sample 67NBa) and **GSC locality C-94602 (sample 67NBb)** at station 67NB on the south shore of Great Slave Lake at 61°00′00″N, 114°12′20″W, about 2.6 km northwest of Dawson Landing wharf. Samples are estimated to be from about 30.77 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94603 (sample 67NBc) and **GSC locality C-94604 (sample 67NBd)** at station 67NB on the south shore of Great Slave Lake at 61°00′00″N, 114°12′20″W, 2.6 km northwest of Dawson Landing wharf. Samples are estimated to be from about 30.57 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94605 (sample 68NBa) and **GSC locality C-94606 (sample 68NBb)** at station 68NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′27″W, 2.7 km northwest of Dawson Landing wharf. Samples are estimated to be from about 31.46 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94607 (sample 68NBc) and **GSC locality C-94608 (sample 68NBd)** at station 68NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′27″W, 2.7 km northwest of Dawson Landing wharf. Samples are estimated to be from about 31.59 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94609 (sample 68NBe) and **GSC locality C-94610 (sample 68NBf)** at station 68NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′27″W, 2.7 km northwest of Dawson Landing wharf. Samples are estimated to be from about 31.90 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94611 (sample 68NBg) and **GSC locality C-94612 (sample 68NBh)** at station 68NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′27″W, 2.7 km northwest of Dawson Landing wharf; from a unit 30 cm thick from top of an outcrop 88 cm thick of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 32.18 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94613 (sample 69NBa) at station 69NB, on south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, northwest of Dawson Bay at 2.8 km bearing 300T from Dawson Landing. Sample is estimated to be from about 31.3 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Noris, 29 June 1981.

GSC locality C-94615 (sample 69NBc) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′20″W, 2.8 km northwest of Dawson Landing wharf. Sample is estimated to be from about 30.97 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94616 (sample 69NBd) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf. Sample is estimated to be from about 32.49 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

GSC locality C-94618 (sample 69NBf) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf. Sample is from about 135 cm above the base of an outcrop, 265 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 34.79 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94619 (sample 69NBg) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf; collected from a loose block of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 34.70 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94620 (sample 69NBh) and **GSC locality C-94621 (sample 69NBi)** at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf. Samples are estimated to be from about 35.45 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94622 (sample 69NBj) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf. Sample is estimated to be from about 31.28 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94623 (sample 69NBk) at station 69NB on the south shore of Great Slave Lake at 61°00′02″N, 114°12′40″W, 2.8 km northwest of Dawson Landing wharf. Sample is estimated to be from about 31.28 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94624 (sample 70NBa) and **GSC locality C-94625 (sample 70NBb)** at station 70NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′50″W, 3.04 km northwest of Dawson Bay bearing 296T from Dawson Landing wharf. Sample is estimated to be from about 31.60 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94626 (sample 70NBc) and **GSC locality C-94627 (sample 70NBd)** at station 70NB on the south shore of Great Slave

Lake at 61°00′03″N, 114°12′50″W, 3.04 km east of Dawson Landing wharf. Samples are estimated to be from about 31.95 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94628 (sample 70NBe) and **GSC locality C-94629 (sample 70NBf)** at station 70NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′50″W, 3.04 km east of Dawson Landing wharf. Samples are estimated to be from about 32.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94630 (sample 70NBg) at station 70NB on the south shore of Great Slave Lake at 61°00′03″N, 114°12′50″W, 3.04 km northwest of Dawson Landing wharf. Sample is estimated to be from about 32.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94631 (sample 71NBa) and **GSC locality C-94632 (sample 71NBb)** at station 71NB on the south shore of Great Slave Lake at 61°00′02″N, 114°13′05″W, 3.2 km northwest of Dawson Landing wharf. Samples are estimated to be from about 30.45 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94633 (sample 71NBc) and **GSC locality C-94634 (sample 71NBd)** at station 71NB on the south shore of Great Slave Lake at 61°00′02″N, 114°13′05″W, 3.2 km northwest of Dawson Landing wharf. Samples are estimated to be from about 31.20 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981. (see GSC Internal Fossil Report AWN-109-AEPH-83 for sample 71NBd).

GSC locality C-94635 (sample 71NBe) and **GSC locality C-94636 (sample 71NBf)** at station 71NB on the south shore of Great Slave Lake at 61°00′02″N, 114°13′05″W, 3.2 km northwest of Dawson Landing wharf. Samples are estimated to be from about 31.90 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981. (see GSC Internal Fossil Report AWN-109-AEPH-83 for samples 71NBf and 71NBe).

GSC locality C-94637 (sample 71NBg) and **GSC locality C-94638 (sample 71NBh)** at station 71NB on the south shore of Great Slave Lake at 61°00′02″N, 114°13′05″W, 3.2 km bearing 294T from Landing wharf. Sample is estimated to be about 32.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94639 (sample 71NBi) and **GSC locality C-94640 (sample 71NBj)** at station 71NB on the south shore of Great Slave Lake at 61°00′02″N, 114°13′05″W, 3.2 km northwest of Dawson Landing wharf. Sample is estimated to be about 32.70 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981. (see Internal Fossil Report AWN-109-AEHP-83 for sample 71NBj).

GSC locality C-94641 (sample 72NBa) and **GSC locality C-94642 (sample 72NBb)** at station 72NB on the south shore of Great Slave Lake at 61°00′04″N, 114°13′20″W, 2.1 km southeast of the north tip of Pine Point. Samples are estimated to be from between 26.80 and 27.02 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 30 June 1981.

GSC locality C-94643 (sample 73NBa) and **GSC locality C-94644 (sample 73NBb)** at station 73NB on the south shore of Great Slave Lake at 61°00′08″N, 114°13′35″W, 1.8 km southeast of the north tip of Pine Point. Samples are from an outcrop, 22 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 20.32 and 20.52 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94645 (sample 74NBa) and **GSC locality C-94646 (sample 74NBb)** at station 74NB on the south shore of Great Slave Lake, 1.4 km southeast of the north tip of Pine Point at 61°00′12″N, 114°13′58″W; from the lower 11 cm of an outcrop, 120 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 16.35 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94647 (sample 74NBc) and **GSC locality C-94648 (sample 74NBd)** at station 74NB on the south shore of Great Slave Lake, at 61°00′12″N, 114°13′58″W, 1.4 km southeast of the north tip of Pine Point. Samples are estimated to be about 16.54 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94649 (sample 74NBe) and **GSC locality C-94650 (sample 74NBf)** at station 74NB on the south shore of Great Slave Lake at 61°00′12″N, 114°13′58″W, 1.4 km southwest of the north tip of Pine Point; from the upper 89 cm of an outcrop, 120 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 17.20 m above the base of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 12 July 1981.

GSC locality C-94652 (sample 75NBb) at station 75NB on the south shore of Great Slave Lake at 61°00′15″N, 114°14′50″W, 0.8 km south of the north tip of Pine Point. Sample is estimated to be about 15.92 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981. (see GSC Internal Fossil Report AWN-109-AEHP-83).

GSC locality C-94651 (sample 75NBa) and **GSC locality C-94653 (sample 75NBf)** at station 75NB on the south shore of Great Slave Lake at 61°00′15″N, 114°14′50″W, 0.8 km south of the north tip of Pine Point. Samples are estimated to be about 16.15 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 23 June 1981. (see GSC Internal Fossil Report AWN-109-AEHP-83 for sample 75NBa).

GSC locality C-94654 (sample 76NBa) and **GSC locality C-94655 (sample 76NBb)** at station 76NB on the south shore of Great Slave Lake at 61°00′20″N, 114°15′05″W, 0.6 km south of the north tip of Pine Point. Samples are estimated to be about 14.04 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94656 (sample 76NBc) and **GSC locality C-94657 (sample 76NBd)** at station 76NB on the south shore of Great Slave Lake at 61°00′20″N, 114°15′05″W, 0.6 km south of the north tip of Pine Point. Samples are estimated to be about 13.79 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94658 (sample 77NBa) and **GSC locality C-94659 (sample 77NBb)** at station 77NB, on the south shore of Great Slave Lake on the east side of Pine Point peninsula at 61°00′30″N, 114°15′12″W; from upper part of unit 4, 53 cm thick, of an

outcrop, 105 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 17.53 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94660 (sample 77NBc) and **GSC locality C-94661 (sample 77NBd)** at station 77NB, on the south shore of Great Slave Lake on the east side of Pine Point at 61°00′30″N, 114°15′12″W; estimated to be from about 16.45 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 2 July 1981.

GSC locality C-94662 (sample 78NBa) and **GSC locality C-94663 (sample 78NBb)** at station 78NB, on the south shore of Great Slave Lake at 61°00′37″N, 114°15′10″W, 0.13 km west of the north tip of Pine Point. Samples are estimated to be from about 11.38 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94664 (sample 79NBa) and **GSC locality C-94665 (sample 79NBb)** at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Samples are estimated to be from about 13.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94666 (sample 79NBc) and **GSC locality C-94667 (sample 79NBd)** at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Samples are estimated to be from about 14.53 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94668 (sample 79NBe) and **GSC locality C-94669 (sample 79NBf)** at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Samples are estimated to be from about 16.65 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94670 (sample 79NBg) at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Sample is estimated to be from 16.72 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94671 (sample 79NBi) and **GSC locality C-94672 (sample 79NBj)** at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Samples are estimated to be from about 17.11 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94673 (sample 79NBk) and **GSC locality C-94674 (sample 79NBl)** at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Samples are estimated to be from about 17.11 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94675 (sample 79NBm) at station 79NB, on the south shore of Great Slave Lake at 61°00′40″N, 114°15′15″W, on the north tip of Pine Point. Sample is estimated to be about 17.18 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94676 (sample 81NBa) and **GSC locality C-94677 (sample 81NBb)** at station 81NB, on the south shore of Great Slave Lake at 61°00′32″N, 114°15′25″W, 0.39 km west of the north tip of Pine Point. Samples are estimated to be from about 17.63 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94678 (sample 81NBc) and **GSC locality C-94679 (sample 81NBd)** at station 81NB, on the south shore of Great Slave Lake at 61°00′32″N, 114°15′25″W, at 0.39 km bearing 231T from Pine Point. Samples are estimated to be about 18.50 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94680 (sample 83NBa) and **GSC locality C-94681 (sample 83NBb)** at station 83NB on the south shore of Great Slave Lake, 0.36 km southwest of the tip of Pine Point, at 61°00′26″N, 114°15′45″W; from a loose block of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 20.35 and 20.52 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94682 (sample 84NBa) at station 84NB on the south shore of Great Slave Lake at 61°00′23″N, 114°16′05″W, bearing 227T at 0.74 km from the north tip of Pine Point. Sample is estimated to be from 20.32 to 20.40 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94683 (sample 84NBb) and **GSC locality C-94684 (sample 84NBc)** at station 84NB on the south shore of Great Slave Lake, 0.74 km southwest of Pine Point at 61°00′23″N, 114°16′05″W; from a large loose block overlying an outcrop 4 cm thick of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 20.32 and 20.40 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94685 (sample 85NBa) and **GSC locality C-94686 (sample 85NBb)** at station 85NB on the south shore of Great Slave Lake, 0.93 km southwest of the north tip of Pine Point at 61°00′21″N, 114°16′15″W, from a loose block lying on an outcrop, 24 cm thick, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 18.82 and 18.98 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 3 July 1981.

GSC locality C-94686 (sample 85NBb) and **GSC locality C-94687 (sample 85NBc)** at station 85NB, (revisited) at 61°00′21″N, 114°14′15″W, on the south shore of Great Slave Lake, 1 km southwest of the north tip of Pine Point. Samples are estimated to be from between 18.80 and 19.00 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94688 (sample 85NBd) and **GSC locality C-94689 (sample 85NBe)** at station 85NB on the south shore of Great Slave Lake, 0.93 km southwest of Pine Point at 61°00′21″N, 114°16′15″W; from the top of an outcrop, 24 cm thick, of the

Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from between 18.82 and 19.98 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94690 (sample 86NBa) and **GSC locality C-94691 (sample 86NBb)** at station 86NB on the south shore of Great Slave Lake, 1.05 km southwest of the north tip of Pine Point, at 61°00′17″N, 114°16′20″W; from a loose block of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from between 15.22 and 15.36 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94692 (sample 87NBa) and **GSC locality C-94693 (sample 87NBb)** at station 87NB on the south shore of Great Slave Lake, at 61°00′14″N, 114°16′25″W; 1.12 km southwest of the north tip of Pine Point. Samples are estimated to be from between 13.89 and 14.05 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94694 (sample 88NBa) and **GSC locality C-94695 (sample 88NBb)** at station 88NB on the south shore of Great Slave Lake, at 61°00′13″N, 114°16′30″W; 1.2 km southwest of the north tip of Pine Point. Samples are estimated to be from between 12.78 and 12.92 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94696 (sample 89NBa) and **GSC locality C-94697 (sample 89NBb)** at station 89NB on the south shore of Great Slave Lake, at 61°00′12″N, 114°16′35″W; 1.33 km southwest of Pine Point. Samples are estimated to be from between 12.81 and 12.93 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94698 (sample 89NBc) at station 89NB on the south shore of Great Slave Lake, at 61°00′12″N, 114°16′35″W; 1.33 km southwest of Pine Point. Sample is estimated to be from between 12.81 and 12.93 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94700 (sample 89NBe) at station 89NB on the south shore of Great Slave Lake, at 61°00′12″N, 114°16′35″W; 1.33 km southwest of the north tip of Pine Point. Sample is estimated to be from about 12.93 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94701 (sample 90NBa) and **GSC locality C-94702 (sample 90NBb)** at station 90NB on the south shore of Great Slave Lake, at 61°00′10″N, 114°16′40″W; 1.49 km southwest of the north tip of Pine Point. Samples are estimated to be from between 11.77 and 11.95 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94703 (sample 90NBc) and **GSC locality C-94704 (sample 90NBd)** at station 90NB on the south shore of Great Slave Lake, at 61°00′10″N, 114°16′40″W; 1.49 km southwest of the north tip of Pine Point. Samples are estimated to be from between 11.77 and 11.95 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94705 (sample 91NBa) and **GSC locality C-94706 (sample 91NBb)** at station 91NB on the south shore of Great Slave Lake, at 61°00′09″N, 114°16′45″W; 1.6 km southwest of the north tip of Pine Point. Samples are estimated to be from between 17.35 and 17.45 m above the base of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94707 (sample 91NBc) and **GSC locality C-94708 (sample 91NBd)** at station 91NB on the south shore of Great Slave Lake, at 61°00′09″N, 114°16′45″W; 1.6 km southwest of the north tip of Pine Point. Samples are estimated to be from between 17.45 and 17.55 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94709 (sample 91NBe) at station 91NB on the south shore of Great Slave Lake, at 61°00′09″N, 114°16′45″W; 1.8 km southwest of the north tip of Pine Point. Sample is from a loose block at west end of outcrop where 11 cm are exposed; estimated to be from between 17.35 and 17.58 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 5 July 1981.

GSC locality C-94710 (sample 91NBf) at station 96NB on the south shore of Great Slave Lake, 1.6 km southwest of Pine Point at 61°00′09″N, 114°16′45″W; from a loose block lying on top of an outcrop, 10 cm thick, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 17.45 m above the base of the Bituminous limestone member.

GSC locality C-94711 (sample 92NBa) and **GSC locality C-94712 (sample 92NBb)** at station 92NB on the south shore of Great Slave Lake, at 61°00′08″N, 114°16′52″W, 1.76 km southwest of the north tip of Pine Point. Samples are estimated to be from about 18.45 and 18.55 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94713 (sample 93NBa) and **GSC locality C-94714 (sample 93NBb)** at station 93NB on the south shore of Great Slave Lake, at 61°00′06″N, 114°16′57″W, 2.1 km southwest of the north tip of Pine Point. Samples are estimated to be from about 21.24 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94715 (sample 93NBc) and **GSC locality C-94716 (sample 93NBd)** at station 93NB on the south shore of Great Slave Lake, at 61°00′06″N, 114°16′57″W, 2.1 km southwest of the north tip of Pine Point. Samples are estimated to be from about 21.56 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94717 (sample 94NBa) and **GSC locality C-94718 (sample 94NBb)** at station 94NB at 61°00′04″N, 114°17′00″W, bearing 229T at 2.24 km from the north tip of Pine Point. Samples are estimated to be from 24.30 to 24.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94719 (sample 94NBc) at station 94NB on the south shore of Great Slave Lake, at 61°00′04″N, 114°17′00″W, 2.2 km southwest of the north tip of Pine Point. Sample is estimated to be from between 24.30 and 24.37 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 4 July 1981.

GSC locality C-94720 (sample 95NBa) and **GSC locality C-94720 (sample 95NBb)** at station 95NB, on the northwest shore of McKay Island at 61°01′48″N, 114°11′25″W at 4.2 km bearing 058T from

the north tip of Pine Point. Samples are estimated to be from between 31.05 and 31.19 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94722 (sample 96NBa) and **GSC locality C-97423 (sample 96NBb)** at station 96NB on the north shore and near the west end of McKay Island at 61°01′48″N, 114°11′28″W; from the upper part of an outcrop, 42 cm exposed, of the Bituminous limestone member of the Pine Point Formation. Samples are estimated to be from about 31.50 m above the base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94724 (sample 96NBa1) and **GSC locality C-97425 (sample 96NBa2)** at station 96NB on the north shore and near west tip of McKay Island at 61°01′48″N, 114°11′28″W. Samples are estimated to be from about 31.15 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94724a (sample 96NBc1) at station 96NB from the north shore and near the west end of McKay Island at 61°01′48″N, 114°11′28″W, from a loose block lying on top of outcrop, 42 cm thick, of the Bituminous limestone member of the Pine Point Formation. Sample is estimated to be from about 31.50 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94726 (sample 97NBa) and **GSC locality C-94727 (sample 97NBb)** at station 97NB, on the northwest shore of Green Island at 61°02′35″N, 114°12′18″W, 4.5 km bearing 037T from the north tip of Pine Point. Samples are estimated to be from between 33.80 and 34.00 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94728 (sample 97NBc) and **GSC locality C-94729 (sample 97NBd)** at station 97NB, on the northwest shore of Green Island at 61°02′35″N, 114°12′18″W, 4.5 km bearing 037T from the north tip of Pine Point. Samples are estimated to be from between 33.80 and 34.00 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-94730 (sample 98NBa) and **GSC locality C-94731 (sample 98NBb)** at station 98NB, at Bell Rock on the south bank of Slave River at 60°01′20″N, 112°05′10″W, 8 km west of Fort Smith. Bell Rock is an irregular mound of contorted and brecciated carbonates, gypsum and shales exposed between 3.10 and 15.97 m above river level. The mound appears to be an erosional remnant rising above the levee of the river bank, the top of which is about 3.18 m above river level. Maximum rock exposure of 12.87 m occurs at the south end of Bell Rock. The assemblage of beds exposed here is suggestive of the Hay Camp Member of Norris (1973) exposed to the south along Slave River and within the Chinchaga Formation of Law (1955). Samples are from finely brecciated carbonate at the base of the outcrop at the south end of Bell Rock. Beds measured and sampled by A.W. Norris, 7 July 1981.

GSC locality C-94733 (sample 98NBd) and **GSC locality C-94734 (sample 98NBe)** at station 98NB, at Bell Rock at 60°01′20″N, 112°05′10″W (see GSC locality C-94730 for more detail). Samples are from hard, greenish grey contorted shale with thin interbeds of limestone, collected at 1 m above base of outcrop at the northwest end of Bell Rock. Hay Camp Member of the Chinchaga Formation. Beds measured and sampled by A.W. Norris, 7 July 1981.

GSC locality C-94735 (sample 98NBf) and **GSC locality C-94736 (sample 98NBg)** at station 98NB, at Bell Rock at 60°01′20″N, 112°05′10″W (see GSC locality C-94730 for more detail). Samples are from thick, irregularly bedded limestone and shale taken 1.5 m above base of outcrop near the east-northeast end of Bell Rock. Samples from the Hay Camp Member of the Chinchaga Formation. Beds measured and sampled by A.W. Norris, 7 July 1981.

GSC locality C-94737 (sample 98NBh) and **GSC locality C-94738 (sample 98NBi)** at station 98NB, at Bell Rock at 60°01′20″N, 112°05′10″W (see GSC locality C-94730 for more detail). Samples are from the top of a unit of large blocks of brecciated carbonate taken from the highest part of Bell Rock, 12.87 m above base of outcrop. Hay Camp Member within Chinchaga Formation. Beds measured and sampled by A.W. Norris, 7 July 1981.

GSC locality C-94739 (sample 99NBa) at station 99NB on the south shore of Great Slave Lake at 60°59′36″N, 114°10′45″W, 0.6 km west of Dawson Point; from a loose block of the Bituminous limestone member of the Pine Point Formation, estimated to be about 16.25 m above base of the Bituminous limestone member of the Pine Point Formation. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94740 (sample 100NBa) at station 100NB on the south shore of Great Slave Lake at 61°00′15″N, 114°14′15″W at 0.96 km bearing 128T from the north tip of Pine Point. Samples are estimated to be from between 16.65 and 16.79 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 8 July 1981.

GSC locality C-94741 (sample 25NBa1) at station 25NB (revisited) on the west tip of McKay Island at 61°01′50″N, 114°01′50″W. Sample is estimated to be from between 28.30 and 28.62 m above base of the Bituminous limestone member. Beds measured and sampled by A.W. Norris, 6 July 1981.

GSC locality C-126452 (sample 1NBb) at station 1NB (revisited), on the north tip of Presqu'ile Point on the south shore of Great Slave Lake at 60°57′00″N, 114°34′42″W; from large loose blocks of brown reefal limestone of the Windy Point Member of the Sulphur Point Formation. Examined by A.W. Norris, 21 June 1985.

GSC locality C-130853 (sample 63NBa) at station 63NBa, on the south shore of Great Slave Lake at 60°59′35″N, 114°11′52″W, west of Dawson Bay at 1.9 km bearing 284T from Dawson Landing wharf. Sample is estimated to be from about 29.39 m above base of Bituminous limestone member. Beds measured and sampled by A.W. Norris, 29 June 1981.

APPENDIX 2

Locality register of rhynchonellid brachiopods collected by Paul Sartenaer

The following samples were collected by Paul Sartenaer who spent several weeks with the writer (AWN) on the south side of Great Slave Lake during the summer of 1981. His samples are equated as closely as possible with the GSC locality and field sample numbers of the **locality register** where location and other data are provided for each sample.

Sample NWT-91-3a is approximately equivalent to **GSC locality C-94448 (sample 17NBb)** which is estimated to be from between 25.02 and 25.13 m above base of the Bituminous limestone member.

Sample NWT-81-3b is approximately equivalent to **GSC locality C-94458 (sample 18NBb)** which is estimated to be from between 29.38 and 29.70 m above base of the Bituminous limestone member.

Sample NWT-81-1c and **NWT-81-1c′** are approximately equivalent to **GSC locality C-94466 (sample 21NBb)** which are estimated to be from between 11.05 and 11.30 m above base of the Bituminous limestone member.

Sample NWT-81-1d is approximately equivalent to **GSC locality C-94477 (sample 23NBb)** which is estimated to be from between 17.94 and 18.53 m above base of the Bituminous limestone member.

Sample NWT-81-1e is approximately equivalent to **GSC locality C-94479 (sample 24NBb)** which is estimated to be from between 22.02 and 22.17 m above base of the Bituminous limestone member.

Sample NWT-81-3c is approximately equivalent to **GSC locality C-94481 (sample 25NBb)** which is estimated to be from between 28.30 and 28.62 m above base of the Bituminous limestone member.

Sample NWT-81-3d is approximately equivalent to **GSC locality C-94490 (sample 28NBb)** which is estimated to be from about 32.80 m above base of the Bituminous limestone member.

Sample NWT-81-1b is approximately equivalent to **GSC locality C-94534 (sample 45NBb)** which is estimated to be from between 8.04 and 8.15 m above base of the Bituminous limestone member.

Sample NWT-81-1a is approximately equivalent to **GSC locality C-94554 (sample 50NBb)** which is estimated to be from between 7.45 and 7.55 m above base of the Bituminous limestone member.

Sample NWT-81-1f is approximately equivalent to **GSC locality C-94568 (sample 55NBb)** which is estimated to be from between 5.80 and 5.90 m above base of the Bituminous limestone member.

Sample NWT-81-2a and **NWT-81-2a′** are approximately equivalent to the combined **GSC locality C-94606 (sample 68NBb)** from 31.46 m above base of the Bituminous limestone member and **GSC locality C-94615 (sample 68NBc)** from 30.97 m above base of the Bituminous limestone member.

Sample NWT-81-2b, NWT-81-2c, NWT-81-2d and **NWT-81-2d′** are approximately equivalent to the combined **GSC locality C-94652 (sample 75NBb)** from 15.92 m above base of the Bituminous limestone member and **GSC locality C-94655 (sample 76NBb)** from 14.04 m above base of the Bituminous limestone member.

Sample NWT-81-2e is approximately equivalent to **GSC locality C-94659 (sample 77NBb)** from 17.53 m above base of the Bituminous limestone member.

Sample NWT-81-2f is approximately equivalent to **GSC locality C-94681 (sample 83NBb)** from between 20.35 and 20.52 m above base of the Bituminous limestone member.

Sample NWT-81-2g is approximately equivalent to **GSC locality C-94686 (sample 85NBb)** from between 18.82 and 18.98 m above base of the Bituminous limestone member.

Sample NWT-81-2g′ is approximately equivalent to **GSC locality C-94691 (sample 86NBb)** from between 15.22 and 15.36 m above base of the Bituminous limestone member.

Sample NWT-81-2h is approximately equivalent to **GSC locality C-94695 (sample 88NBb)** from between 12.78 and 12.92 m above base of the Bituminous limestone member.

Sample NWT-81-2i is approximately equivalent to **GSC locality C-94697 (sample 89NBb)** from between 12.81 and 12.93 m above base of the Bituminous limestone member.

Sample NWT-81-2j is approximately equivalent to the combined **GSC locality C-94712 (sample 92NBb)** from between 18.45 and 18.55 m above base and **GSC locality C-94714 (sample 93NBb)** from 21.24 m above base of the Bituminous limestone member.

Sample NWT-81-4 is approximately equivalent to **GSC locality C-94727 (sample 97NBb)** from between 33.80 and 34.00 m above base of the Bituminous limestone member.

APPENDIX 3

Described section at Bell Rock on Slave River

The outcrop at Bell Rock on the south bank of Slave River, 11.2 km west of Fort Smith, and 2 km upstream from Cunningham Landing on Slave River, District of Mackenzie, was reinvestigated and resampled on 7 July 1981. The mound forming Bell Rock is 12.9 m high, and about 27.4 m in maximum diameter along the base, marked by a dirt road on its west side. The base of the outcrop is at the top of the bank of the river, about 3.1 m above river level. Three main rocks units, which are considered a part of the Chinchaga Formation are evident in the mound; the upper two units are assigned to the Hay Camp Member of Norris (1963, p. 49–51), and the basal unit is referred to informally as Evaporite beds.

Chinchaga Formation

Hay Camp Member

Unit 3

Large blocks, chaotically oriented, of finely brecciated, dolomitic limestone, very fine grained, thick irregularly bedded, medium and light grey colour, weathering orange brown. There are at least two cycles of brecciation evident in some of the blocks. The larger fragments are in a matrix of smaller brecciated fragments of dolomitic limestone, dark shale and white gypsum, which are vaguely bedded.

Thickness: 6.8 m exposed.

Sample 98NBh (GSC locality C-94737): for conodonts taken at top of outcrop, 6.8 m above base of unit 1.

Sample 98NBi (GSC locality C-94738): for lithology taken at top of outcrop, 6.8 m above base of unit 1.

Sample 98NBa (GSC locality C-94730): for conodonts taken at base of unit 1.

Sample 98NBb (GSC locality C-94731): for lithology taken at base of unit 1.

Unit 2

Thick, irregularly interbedded shale and limestone. The shale is finely laminated, dark and medium grey, fissile, fairly hard, and weathers a slate grey and orange brown. The limestone is brown, fine grained, and contains finely brecciated fragments of limestone. Both the shale and limestone beds are partly brecciated and are associated with large fragments of deformed gypsum.

Thickness: 3.8 m.

Sample 98NBf (GSC locality C-94753: for conodonts, 1.5 m above base of unit 2 and near southeast end of outcrop.

Sample 98NBg (GSC locality C-94736): for lithology, 1.5 m above base of unit 2 and from near southeast end of outcrop.

Sample 98NBe (GSC locality C-94734): for lithology taken at base of unit 2.

Sample 98NBd (GSC locality C-94733): for conodonts taken at base of unit 2.

Evaporite beds

Unit 1

Thickly bedded white and grey deformed gypsum, creamy white on a fresh surface, fibrous, soft, and with scattered dark laminae. In places, the unit is stained a rusty orange. Unit 1 is exposed at the northeast and southwest sides of the outcrop.

Thickness: 4 m exposed.

Sample 98NBc (GSC locality C-94732): for lithology taken near base of unit 1 near the northwest end of the outcrop.

PLATES 1–10

PLATE 1

Figures 1–10. *Barroisella*? *minuta* (Meek)

1, 2. Views of incomplete specimen embedded in matrix (figs. 1, 2; x6, x4) showing widely spaced growth lines, hypotype GSC 75538; Field no. 85NBb (GSC loc. C-94686).

3, 4. Views of specimen embedded in matrix (figs. 3, 4; x6, x4) showing crinkling of shell along and near lateral and anterior margins, hypotype GSC 75537; Field no. 19NBb (GSC loc. C-94462).

5, 6. Views of specimen embedded in matrix (figs. 5, 6; x6, x4) showing irregularly spaced growth lines, hypotype GSC 75539; Field no. 19NBc (GSC loc. C-94463).

7, 8. Views of specimen embedded in matrix (figs. 7, 8; x6, x4) with crushed lateral margins, hypotype GSC 75540; Field no. 19NBc (GSC loc. C-94463).

9, 10. Views of specimen embedded in matrix (figs. 9, 10; x6, x4) showing light and dark colour banding, hypotype GSC 75541; Field no. 22NBa1 (GSC loc. C-94473).

Figures 11–16. *Schizophoria mcfarlanei* (Meek)

11–13. Posterior (fig. 11; x1), brachial (fig. 12; x1), and anterior (fig. 13; x1) views of an adult shell, hypotype GSC 75542; Field no. 21NBb (GSC loc. C-94466).

14, 15. Brachial (figs. 14, 15; x1, x2) views of an adult shell, hypotype GSC 75543; Field no. 68NBh (GSC loc. C-94612).

16. Posterior (fig. 16; x1) view of an incomplete shell, hypotype GSC 75544; Field no. 50NBb (GSC loc. C-94554).

Figures 17–22. *Cymostrophia*? sp.

17, 18. Views of abraded exterior of a brachial valve (figs. 17, 18; x1, x2) of a specimen embedded in matrix, hypotype GSC 75545; Field no. 69NBf (GSC loc. C-94618).

19–22. Views of exterior of an impression in matrix of a pedicle valve (figs. 19, 21; x1, x2) and positive latex impression of same specimen (figs. 20, 22; x1, x2), hypotype GSC 75546; Field no. 69NBg (GSC loc. C-94619).

Figures 23–29. *Floweria*? sp.

23. Exterior of brachial valve of a small incomplete adult shell embedded in matrix (fig. 23; x2), hypotype GSC 75547; Field no. 74NBf (GSC loc. C-94650).

24, 25. An impression of exterior of a brachial valve (figs. 24, 25; x1, x2) of a young adult shell, hypotype GSC 75548; Field no. 74NBf (GSC loc. C-94650).

26, 27. Interior of brachial valve (figs. 26, 27; x2, x1) of an adult shell, hypotype GSC 75549; Field no. 73NBb (GSC loc. C-94644).

28, 29. Impression of exterior of brachial valve of an adult shell, hypotype GSC 75550; Field no. 73NBb (GSC loc. C-94644).

Figures 30–37. *Rhyssochonetes aurora medialis* Norris n. subsp.

30, 31. Exterior of pedicle valve (figs. 30, 31; x3, x5) of a young shell, paratype GSC 75551; Field no. 85NBb (GSC loc. C-94686).

32, 33. Exterior of pedicle valve (figs. 32, 33; x3, x4) of a young shell, paratype GSC 75553; Field no. 85NBe (GSC loc. C-94689).

34, 35. Exterior of pedicle valve (figs. 34, 35; x3, x4) of a young shell, paratype GSC 75552; Field no. 74NBf (GSC loc. C-94650).

36, 37. Exterior of pedicle valve (figs. 36, 37; x3, x4) of an adult shell showing spines along the cardinal margin, paratype GSC 75554; Field no. 68NBh (GSC loc. C-94612).


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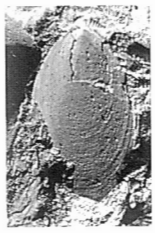
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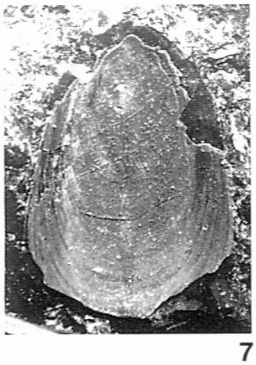
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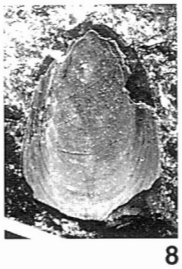
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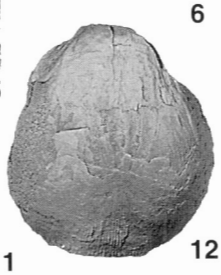
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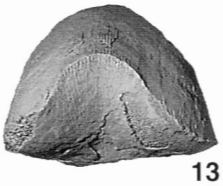
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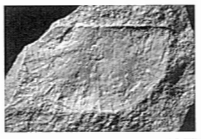
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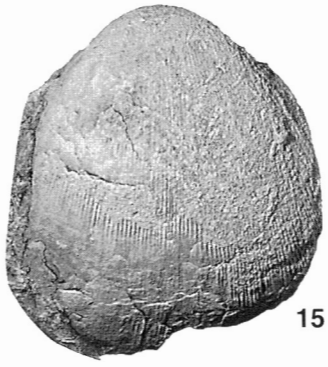
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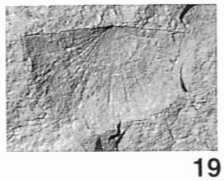
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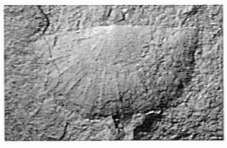
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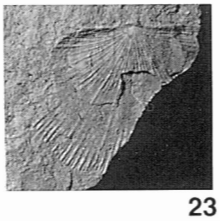
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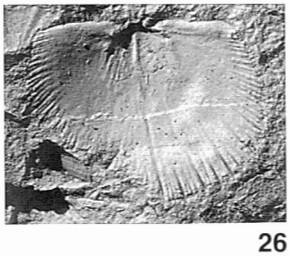
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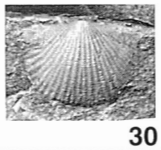
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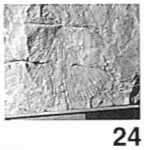
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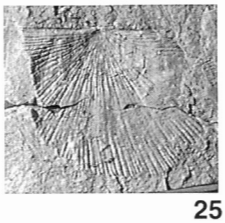
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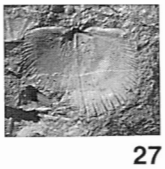
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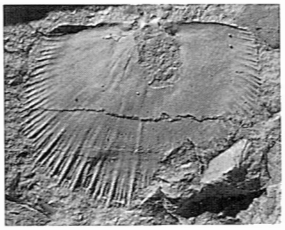
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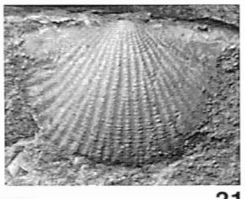
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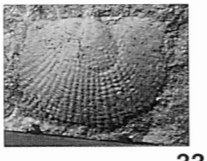
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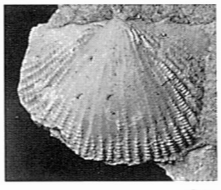
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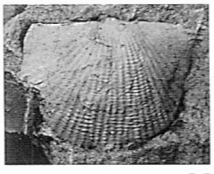
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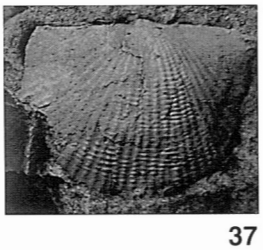
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PLATE 2

Figures 1–10. *Rhyssochonetes aurora medialis* Norris n. subsp.

1, 2. Exterior of a pedicle valve (figs. 1, 2; x3, x4) of a large adult shell showing a spine at cardinal extremity, holotype GSC 75555; Field no. 85NBb (GSC loc. C-94686).

3, 4. Exterior of brachial valve (figs. 3, 4; x3, x4) of an adult shell, paratype GSC 75556; Field no. 74NBf (GSC loc. C-94650).

5, 6. Exterior of pedicle valve (figs. 5, 6; x5, x3) of an adult shell, paratype GSC 75557; Field no. 74NBb (GSC loc. C-94646).

7, 8. Exterior of brachial valve (figs. 7, 8; x3, x4) of an adult shell, paratype GSC 75558; Field no. 84NBb (GSC loc. C-94683).

9, 10. Exterior of pedicle valve (figs. 9, 10; x3, x4) of a young adult shell, paratype GSC 75559; Field no. 84NBb (GSC loc. C-94683).

Figures 11–34. *Productella verecunda* Crickmay

11–14. Exterior of pedicle valve (figs. 11, 12; x2, x1) and exterior of brachial valve (Figs. 13, 14; x1, x2) of a young adult shell, hypotype GSC 75560; Field no. 24NBa (GSC loc. C-94478).

15–17. Pedicle (fig. 15; x1), brachial (fig. 16; x1) and lateral (fig. 17; x1) views of a mature adult shell, hypotype GSC 75561; Field no. 24NBb (GSC loc. C-94479).

18–20. Pedicle (fig. 18; x1), lateral (fig. 19; x1) and brachial (fig. 20; x1) views of a mature adult shell, hypotype GSC 75562; Field no. 22NBa1 (GSC loc. C-94473).

21–24. Pedicle (fig. 21; x1), lateral (fig. 22; x1), posterior (fig. 23; x1) and anterior (fig. 24; x1) views of a mature adult shell, hypotype GSC 75563; Field no. 22NBa1 (GSC loc. C-94473).

25–27. Pedicle (fig. 25; x1), lateral (fig. 26; x1), and brachial (fig. 27; x1) views of a mature adult shell showing exfoliated exteriors of both valves, hypotype GSC 75564; Field no. 22NBb1 (GSC loc. C-94474).

28–30. Pedicle (fig. 28; x1), posterior (fig. 29; x1), and lateral (fig. 30; x1) views of a large adult shell, hypotype GSC 75565; Field no. 28NBb (GSC loc. C-94490).

31. Pedicle (fig. 31; x1) view of a small adult shell embedded in matrix, hypotype GSC 75566; Field no. 16NBd (GSC loc. C-94446).

32. Pedicle (fig. 32; x1) view of a small adult shell embedded in matrix, hypotype GSC 75567; Field no. 22NBc1 (GSC loc. C-94475).

33. View (fig. 33; x1) of impression of exterior of brachial valve, hypotype GSC 75568; Field no. 17NBe1 (GSC loc. C-94456).

34. Pedicle (fig. 34; x1) view of a large adult shell embedded in matrix, hypotype GSC 75569; Field no. 18NBa1 (GSC loc. C-94459).

Figures 35–57. *Devonoproductus primus* Crickmay

35–38. Pedicle (figs. 35, 36; x1, x2) and brachial (figs. 37, 38; x2, x1) views of a young adult shell, hypotype GSC 75570; Field no. 23NBb (GSC loc. C-94477).

39–46. Pedicle (39, 40; x2, x1), brachial (figs. 41, 42; x1, x2), posterior (43, 44; x2, x1) and lateral views (45, 46; x1, x2) of an adult shell, hypotype GSC 75571; Field no. 54NBb (GSC loc. C-94566).

47–54. Brachial (figs. 47, 48; x2, x1), pedicle (figs. 49, 50; x1, x2), posterior (figs. 51, 52; x1, x2), and lateral (figs. 53, 54; x1, x2) views of a mature adult shell, hypotype GSC 75572; Field no. 54NBb (GSC loc. C-94566).

55–57. Lateral (fig. 55; x2) and pedicle (figs. 56, 57; x2, x1) views of exterior of pedicle valve of a rotund shell, hypotype GSC 75573; Field no. 54NBb (GSC loc. C-94566).

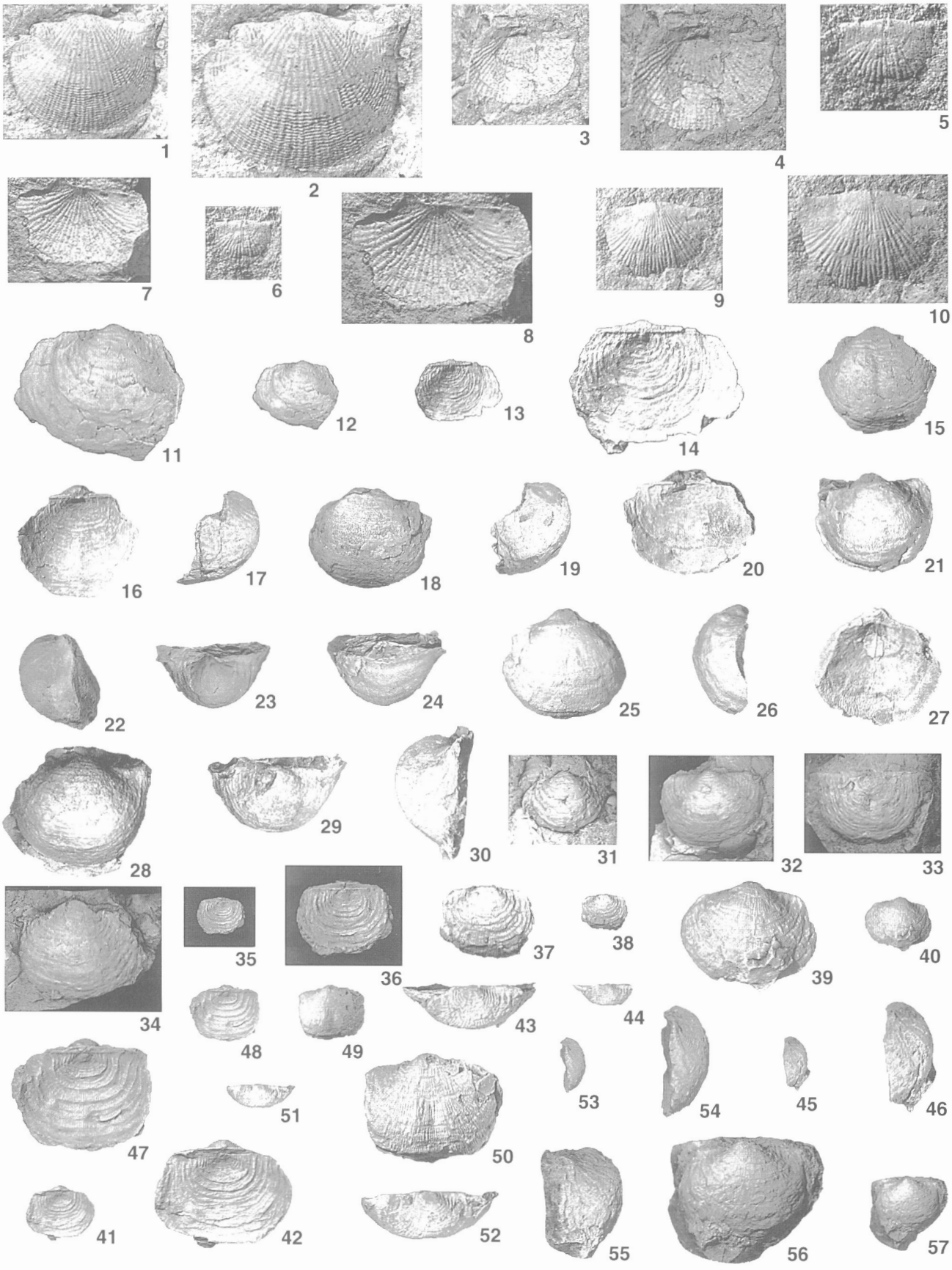
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PLATE 3

Figures 1–9. *Devonoproductus primus* Crickmay

1. View of interior of brachial valve (fig. 1; x2) of an adult shell embedded in matrix, hypotype GSC 75574; Field no. 54NBb (GSC loc. C-94566).

2, 3. Views of exterior of brachial valve (figs. 2, 3; x2, x1) of an adult shell embedded in matrix, hypotype GSC 75575; Field no. 66NBb (GSC loc. C-94598).

4, 5. Views of interior of brachial valve (figs. 4, 5; x2, x1) of an adult shell, hypotype GSC 75576; Field no. 66NBb (GSC loc. C-94598).

6, 7. Views of interior of brachial valve (figs. 6, 7; x1, x2) of a large adult shell embedded in matrix, hypotype GSC 75577; Field no. 37NBc (GSC loc. C-94519).

8, 9. Views of exterior of pedicle valve (figs. 8, 9; x1, x2) of a large adult shell embedded in matrix, hypotype GSC 75578; Field no. 37NBc (GSC loc. C-94519).

Figures 10–19. *Gypidula*? *presquilensis* Norris n. sp.

10–17. Pedicle (figs. 10, 11; x2, x1), lateral (figs. 12, 13; x2, x1), anterior (figs. 14, 15; x1, x2) and brachial (figs. 16, 17; x1, x2) views of a young rotund shell, paratype GSC 75580; Field no. 13NBa (GSC loc. C-94439).

18. View (fig. 18; x1) of a latex positive replica of a young adult shell formerly embedded in matrix, paratype 75581; Field no. 13NBa (GSC loc. C-94439).

19. Slightly oblique pedicle view (fig. 19; x1) of a pedicle valve of a moderately crushed adult shell embedded in matrix, paratype GSC 75582; Field no. 14NBa (GSC loc. C-94440).

Views of holotype of this species are shown on Plate 10, figures 6–10.

Figures 20–24. *Anatrypa* (*Variatrypa*) *exoleta* Johnson

20–23. Pedicle (fig. 20; x1) brachial (fig. 21; x1), posterior (fig. 22; x1), and lateral (fig. 23; x1) views of a thick adult shell, hypotype GSC 75619; Field no. 18NBb (GSC loc. C-94458).

24. Pedicle (fig. 24; x1) valve view of an adult shell embedded in matrix showing fragmentary marginal frill, hypotype GSC 75620; Field no. 96NBa1 (GSC loc. C-94724).

Figures 25–28. *Spinatrypa* sp. A

25. View of pedicle valve (fig. 25; x1) of an adult shell embedded in matrix, hypotype GSC 75621; Field no. 13NBa (GSC loc. C-94439).

26. View of brachial valve (fig. 26; x1) of an adult shell embedded in matrix, hypotype GSC 75622; Field no. 13NBa (GSC loc. C-94439).

27. View of an incomplete pedicle valve (fig. 27; x1) of an adult shell embedded in matrix, hypotype GSC 75623; Field no. 13NBa (GSC loc. C-94439).

28. View of an incomplete pedicle valve (fig. 28; x1) of a young adult shell, hypotype GSC 75624; Field no. 13NBa (GSC loc. C-94439).

Figures 29–40. *Spinatrypina* sp. A

29–38. Views of brachial (figs. 29, 30; x1, x2), posterior (figs. 31, 32; x1, x2), lateral (figs. 33, 34; x1, x2), anterior (figs. 35, 36; x2, x1), and pedicle (figs. 37, 38; x1, x2) valve of an incomplete specimen of a young shell, hypotype GSC 75625; Field no. 21NBa1 (GSC loc. C-94467).

39, 40. Views of brachial (39, 40; x2, x1) valve of an incomplete specimen of a young adult shell, hypotype GSC 75626; Field no. 21NBa1 (GSC loc. C-94467).

Figures 41, 42. *Leptathyris obsolescens* Johnson

41, 42. Views of brachial (figs. 41, 42; x1, x2) valve of an adult specimen, hypotype GSC 75627; Field no. 22NBa1 (GSC loc. C-94474).

Other views of this specimen are illustrated on Plate 4, figures 1–8.

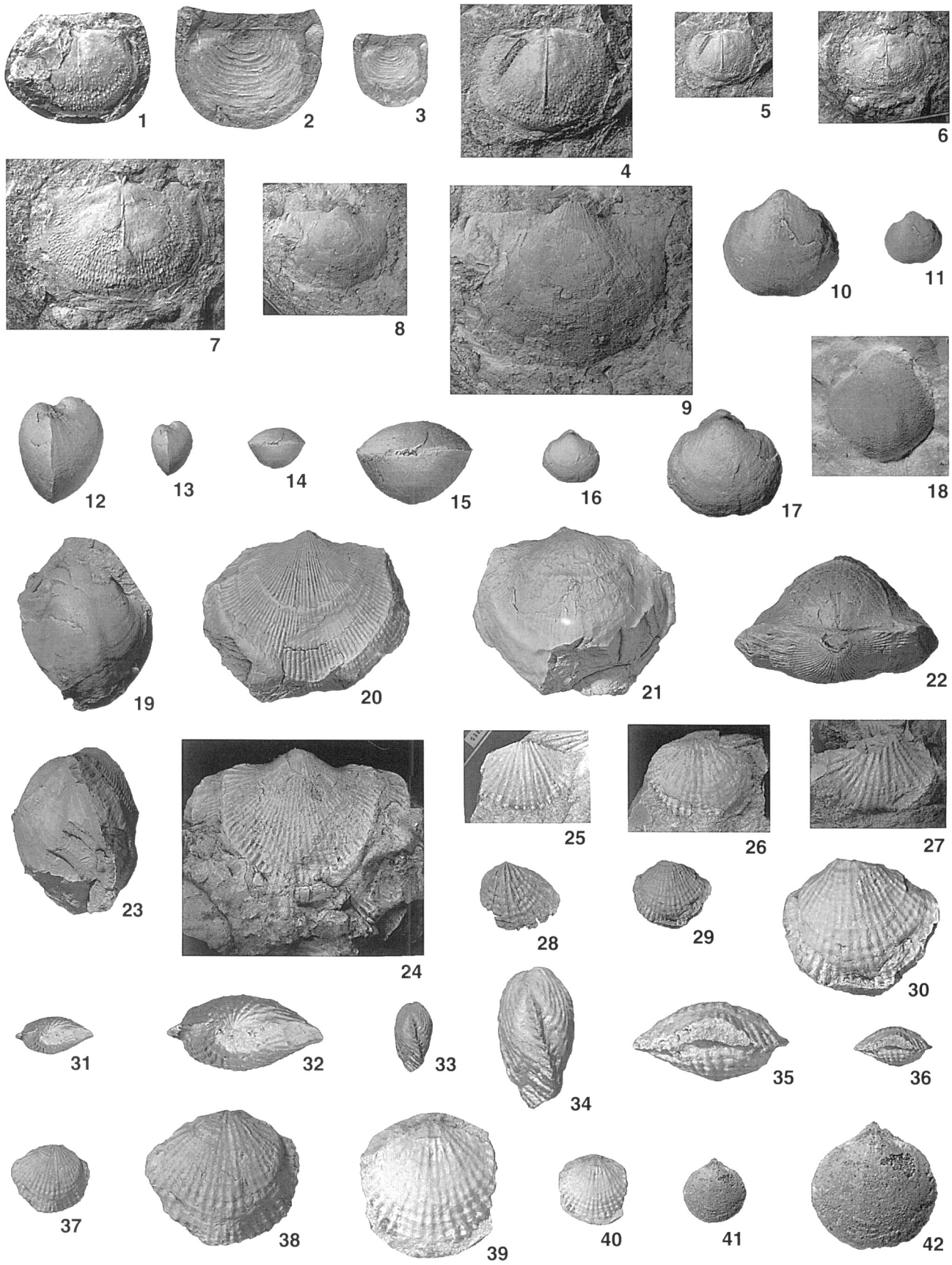
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PLATE 4

Figures 1–46. *Leptathyris obsolescens* Johnson

1–8. Pedicle (figs. 1, 2; x2, x1), posterior (figs. 3, 4; x2, x1), lateral (figs. 5, 6; x1, x2), and anterior (figs. 7, 8; x2, x1) views of an adult shell with circular outline, hypotype GSC 75627; Field no. 22NBb1 (GSC loc. C-94474).

Other views of this specimen are illustrated on Plate 3, figures 41, 42.

9–18. Brachial (figs. 9, 10; x2, x1), pedicle (figs. 11, 12; x2, x1), posterior (figs. 13, 14; x1, x2), lateral (figs. 15, 16; x1, x2), and anterior views (figs. 17, 18; x1, x2) of an adult shell, hypotype GSC 75628; Field no. 28NBb (GSC loc. C-94490).

19–23. Brachial (fig. 19; x1), pedicle (fig. 20; x1), posterior (fig. 21; x1), lateral (fig. 22; x1), and anterior (fig. 23; x1) views of an adult shell, hypotype GSC 75629; Field no. 22NBb1 (GSC loc. C-94474).

24–28. Brachial (fig. 24; x1), pedicle (fig. 25; x1), posterior (fig. 26; x1), lateral (fig. 27; x1) and anterior (fig. 28; x1) views of an adult shell, hypotype GSC 75631; Field no. 22NBb1 (GSC loc. C-94474).

29–36. Brachial (figs. 29, 30; x2, x1), pedicle (figs. 31, 32; x1, x2), anterior (figs. 33, 34; x1, x2), and lateral (figs. 35, 36; x1, x2) views of an adult shell, hypotype GSC 75632; Field no. 19NBc (GSC loc. C-94463).

37–46. Brachial (figs. 37, 38; x2, x1), pedicle (figs. 39, 40; x2, x1), posterior (figs. 41, 42; x2, x1), lateral (figs. 43, 44; x1, x2), and anterior (figs. 45, 46; x2, x1) views of an adult shell, hypotype GSC 75633; Field no. 68NBh (GSC loc. C-94612).

Figures 47–52. *Emanuella caldwelli* Norris n. sp.

47–52. Pedicle (figs. 47, 48; x2, x1), brachial (figs. 49, 50; x1, x2), and posterior (figs. 51, 52; x1, x2) views of an adult shell, paratype GSC 75634; Field no. 22NB1 (GSC loc. C-94474).

Other views of this specimen are illustrated on Plate 5, figures 1–3.

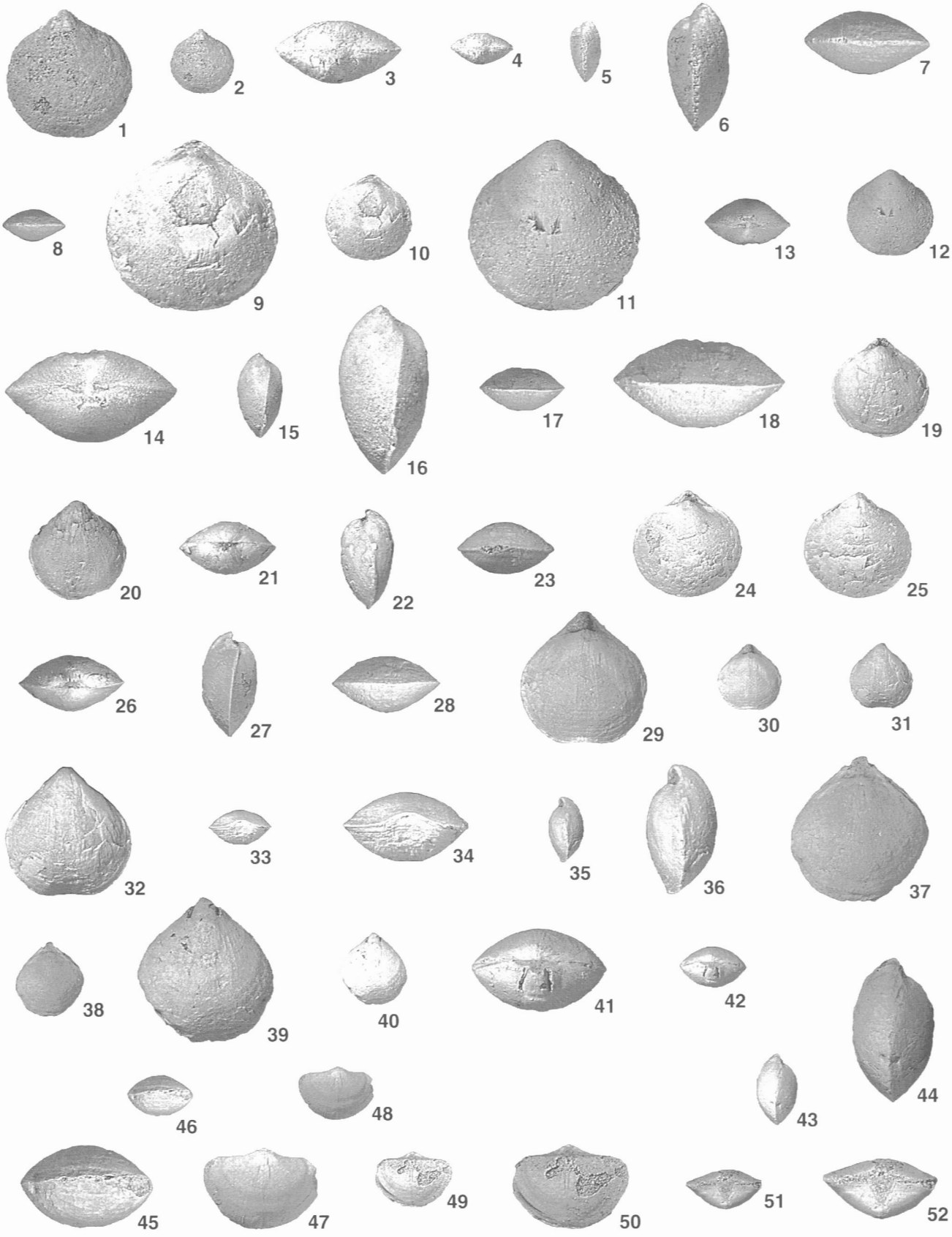
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PLATE 5

Figures 1–26. *Emanuella caldwelli* Norris n. sp.

1–3. Lateral (fig. 1; x2), and anterior (figs. 2, 3; x1, x3) views of an adult shell, paratype GSC 75634; Field no. 22NBb1 (GSC loc. C-94474).

Other views of this specimen are illustrated on Plate 4, figures 47–52.

4–12. Pedicle (figs. 4, 5; x1, x2), brachial (figs. 6, 7; x1, x2), posterior (figs. 8, 9; x1, x2), lateral (figs. 10, 11; x2, x1), and anterior (fig. 12; x1) views of an adult shell, paratype GSC 75635; Field no. 51NBc (GSC loc. C-94558).

13–18. Pedicle (fig. 13; x1), brachial (figs. 14, 15; x2, x1), posterior (fig. 16; x1), lateral (fig. 17; x1), and anterior (fig. 18; x1) views of an adult shell, holotype GSC 75636; Field no. 22NBa1 (GSC loc. C-94473).

19–23. Pedicle (fig. 19; x2), brachial (fig. 20; x2), posterior (fig. 21; x2), anterior (fig. 22; x2), and lateral (fig. 23; x2) views of an adult shell, paratype GSC 75637; Field no. 22NBa1 (GSC loc. C-94473).

24–26. Brachial (figs. 24, 25; x3, x2), and anterior (fig. 26; x2) views of an incomplete adult shell, paratype GSC 75638; Field no. 24NBa (GSC loc. C-94478).

Figures 27–56. *Emanuella meristoides* (Meek)

27–31. Pedicle (fig. 27; x1), brachial (fig. 28; x1), posterior (fig. 29; x1), lateral (fig. 30; x1), and anterior (fig. 31; x1) views of an adult shell, hypotype GSC 75640; Field no. 22NBb1 (GSC loc. C-94474).

32–36. Brachial (fig. 32; x1), pedicle (figs. 33, 34; x1, x3), lateral (fig. 35; x1), and posterior (fig. 36; x1) views of an adult shell, hypotype GSC 75641; Field no. 85NBb (GSC loc. C-94686).

37–41. Pedicle (fig. 37; x1), brachial (fig. 38; x1), posterior (fig. 39; x1), anterior (fig. 40; x1), and lateral (fig. 41; x1) views of an adult shell, hypotype GSC 75642; Field no. 85NBb (GSC loc. C-94686).

42–46. Pedicle (fig. 42; x1), brachial (fig. 43; x1), posterior (fig. 44; x1), anterior (fig. 45; x1), and lateral (fig. 46; x1) views of an adult shell, hypotype GSC 75643; Field no. 22NBc1 (GSC loc. C-94475).

47–51. Pedicle (fig. 47; x1), brachial (fig. 48; x1), posterior (fig. 49; x1), anterior (fig. 50; x1) and lateral (fig. 51; x1) views of an adult shell, hypotype GSC 75644; Field no. 54NBb (GSC loc. C-94566).

52–56. Pedicle (figs. 52, 53; x3, x1), lateral (fig. 54; x1), and brachial (figs. 55, 56; x1, x3) views of an adult shell, hypotype GSC 75646; Field no. 85NBb (GSC loc. C-94686).

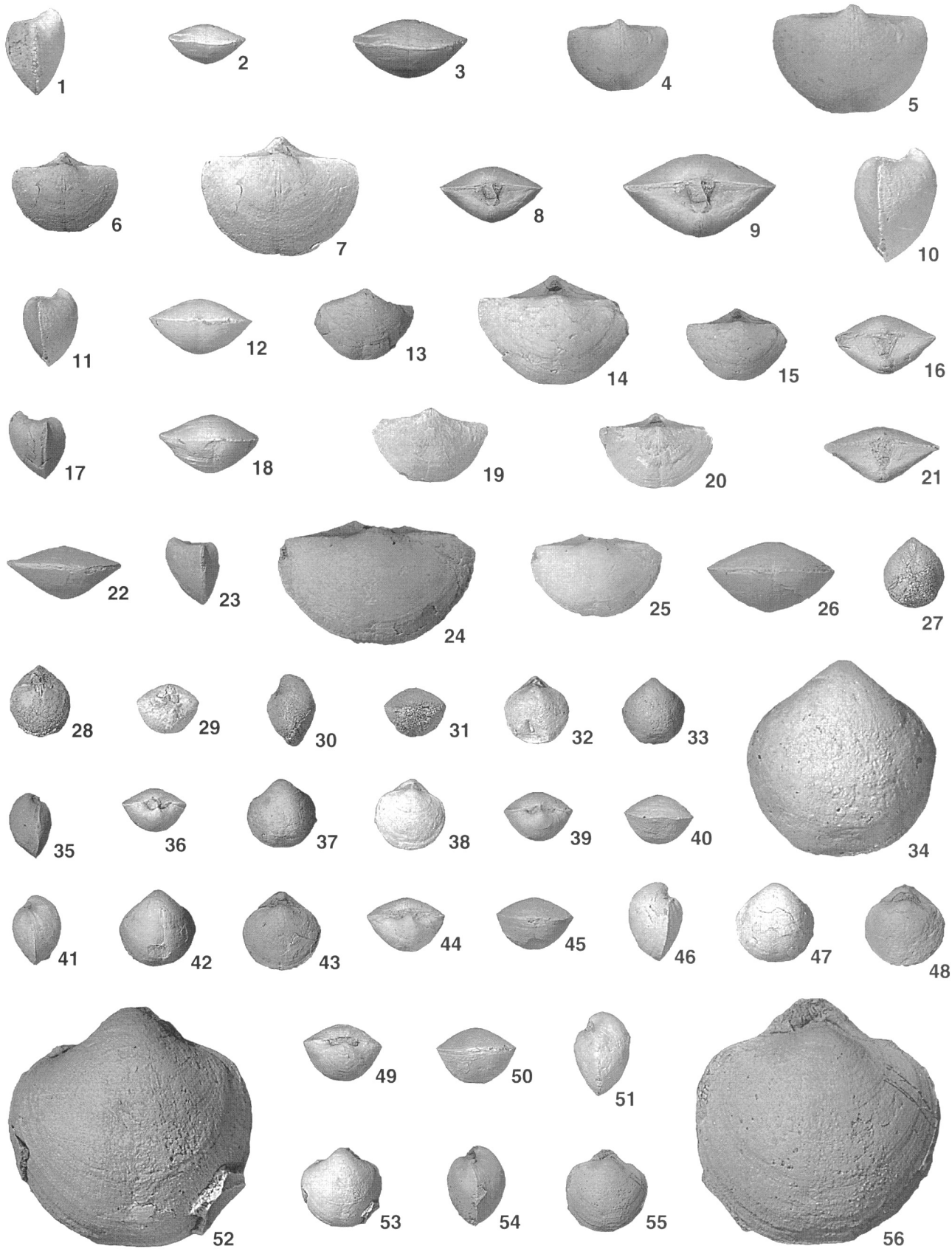
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PLATE 6

Figures 1–11. *Emanualla meristoides* (Meek)

1–5. Pedicle (fig. 1; x1), brachial (fig. 2; x1), lateral (fig. 3; x1), posterior (fig. 4; x1), and anterior (fig. 5; x1) views of an adult shell, hypotype GSC 75647; Field no. 85NBb (GSC loc. C-94686).

6–11. Brachial (fig. 6; x1), lateral (fig. 7; x1), pedicle (figs. 8, 9; x1, x3), posterior (fig. 10; x1), and anterior (fig. 11; x1) views of an adult shell, hypotype GSC 75648; Field no. 91NBf (GSC loc. C-94710).

Figures 12–50. *Emanuella sublineata* (Meek)

12–16. Brachial (fig. 12; x1), pedicle (fig. 13; x1), lateral (fig. 14; x1), posterior (fig. 15; x1), and anterior (fig. 16; x1) views of an adult shell, hypotype GSC 75649; Field no. 77NBa (GSC loc. C-94658).

17–22. Brachial (figs. 17, 18; x2, x1), pedicle (fig. 19; x1), lateral (fig. 20; x1), posterior (fig. 21; x1), and anterior (fig. 22; x1) views of an adult shell, hypotype GSC 75650; Field no. 28NBb (GSC loc. C-94490).

23–27. Brachial (fig. 23; x1), pedicle (fig. 24; x1), lateral (fig. 25; x1), posterior (fig. 26; x1), and anterior (fig. 27; x1) views of a young adult shell, hypotype GSC 75651; Field no. 22NBc1 (GSC loc. C-94475).

28–33. Brachial (fig. 28; x1), pedicle (figs. 29, 30; x1, x3), posterior (fig. 31; x1), lateral (fig. 32; x1), and anterior (fig. 33; x1) views of a thin young adult shell, hypotype GSC 75652; Field no. 91NBf (GSC loc. C-94710).

34–36. Pedicle (fig. 34; x1), lateral (fig. 35; x1), and anterior (fig. 36; x1) view of a thick biconvex adult shell, hypotype GSC 75654; Field no. 22NBc1 (GSC loc. C-94475).

37–40. Pedicle (figs. 37, 38; x1, x3), enlarged in the latter to show micro-ornament, posterior (fig. 39; x1), and lateral (fig. 40; x1) views of a large adult shell, hypotype GSC 75655; Field no. 83NBb (GSC loc. C-94681).

41–45. Brachial (fig. 41; x1), pedicle (fig. 42; x1), anterior (fig. 43; x1), lateral (fig. 44; x1), and posterior (fig. 45; x1) views of a large, thick adult shell. Neotype GSC 75656; Field no. 86NBb (GSC loc. C-94691).

46–50. Brachial (fig. 46; x1), lateral (fig. 47; x1), pedicle (fig. 48; x1), posterior (fig. 49, x1), and anterior (fig. 50; x1) views of a very large, wide shell, hypotype GSC 75657; Field no. 24NBa (GSC loc. C-94478).

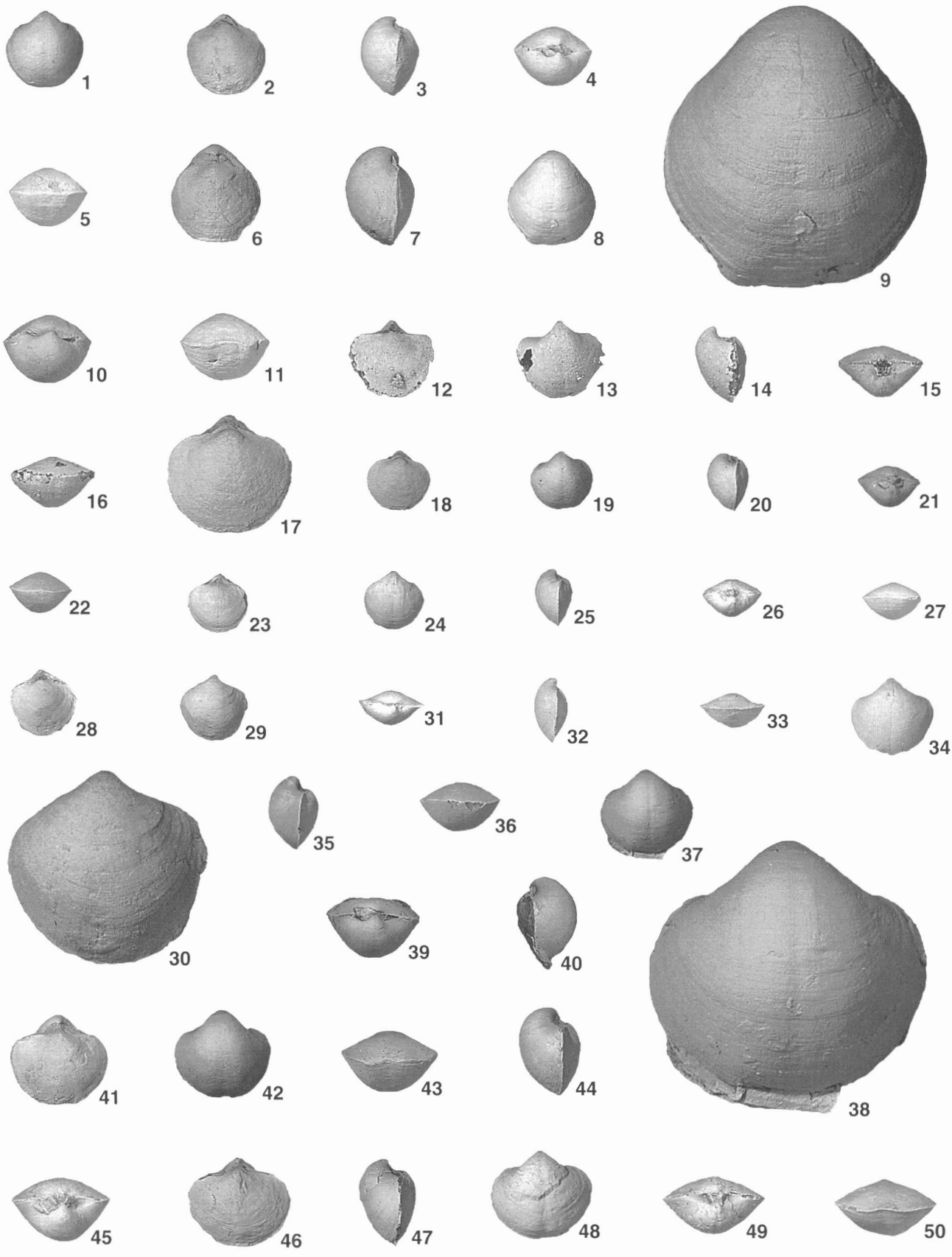
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PLATE 7

Figures 1–13. *Echinocoelia* sp.

1–5. Pedicle (fig. 1; x1), brachial (fig. 2; x1), lateral (fig. 3; x1), posterior (fig. 4; x1), and anterior (fig. 5; x1) views of a young exfoliated specimen, hypotype GSC 75658; Field no. 37NBc (GSC loc. C-94519).

6, 7. Pedicle (figs. 6, 7; x1, x2) views of an incomplete young adult specimen, hypotype GSC 75659; Field no. 19NBb (GSC loc. C-94462).

8–11. Pedicle (figs. 8, 9; x1, x2) and lateral (figs. 10, 11; x1, x2) views of a wide adult shell embedded in matrix, hypotype GSC loc. 75660; Field no. 22NBb1 (GSC loc. C-94474).

12, 13. Posterior (fig. 12; x1) and lateral (fig. 13; x1) views of an adult shell embedded in matrix, hypotype GSC 75661; Field no. 22NBb1 (GSC loc. C-94474).

Figures 14–25. *Cyrtina* sp.

14–17. Brachial (figs. 14, 15; x2, x1 and pedicle (figs. 16, 17; x1, x2) views of an incomplete small adult shell, hypotype GSC 75662; Field no. 22NBa1 (GSC loc. C-94473).

18–23. Posterior (figs. 18, 19; x1, x2), anterior (figs. 20, 21; x1, x2), and brachial (figs. 22, 23; x2, x1) views of a mold of a young adult specimen, hypotype GSC 75663; Field no. 45NBg (GSC loc. C-94539).

24, 25. Pedicle (figs. 24, 25; x2, x1) views of an exfoliated adult specimen partly embedded in matrix, hypotype GSC 75664; Field no. 22NBb1 (GSC loc. C-94474).

Figures 26–37. *Warrenella parafranklinii* Norris n. sp.

26–31. Pedicle (fig. 26; x1), brachial (figs. 27, 28; x2, x1), posterior (fig. 29; x1), anterior (fig. 30; x1), and lateral (fig. 31; x1) views of a young shell, paratype GSC 75665; Field no. 28NBc1 (GSC loc. C-94493).

32–37. Pedicle (figs. 32, 33; x1, x2), the latter view showing micro-ornament of radial spine-like projections on the anterior margins of the growth lamellae, anterior (fig. 34; x1), lateral (fig. 35; x1), brachial (fig. 36; x1), and posterior (fig. 37; x1) views of a thick adult shell, paratype GSC 75666; Field no. 28NBc1 (GSC loc. C-94493).

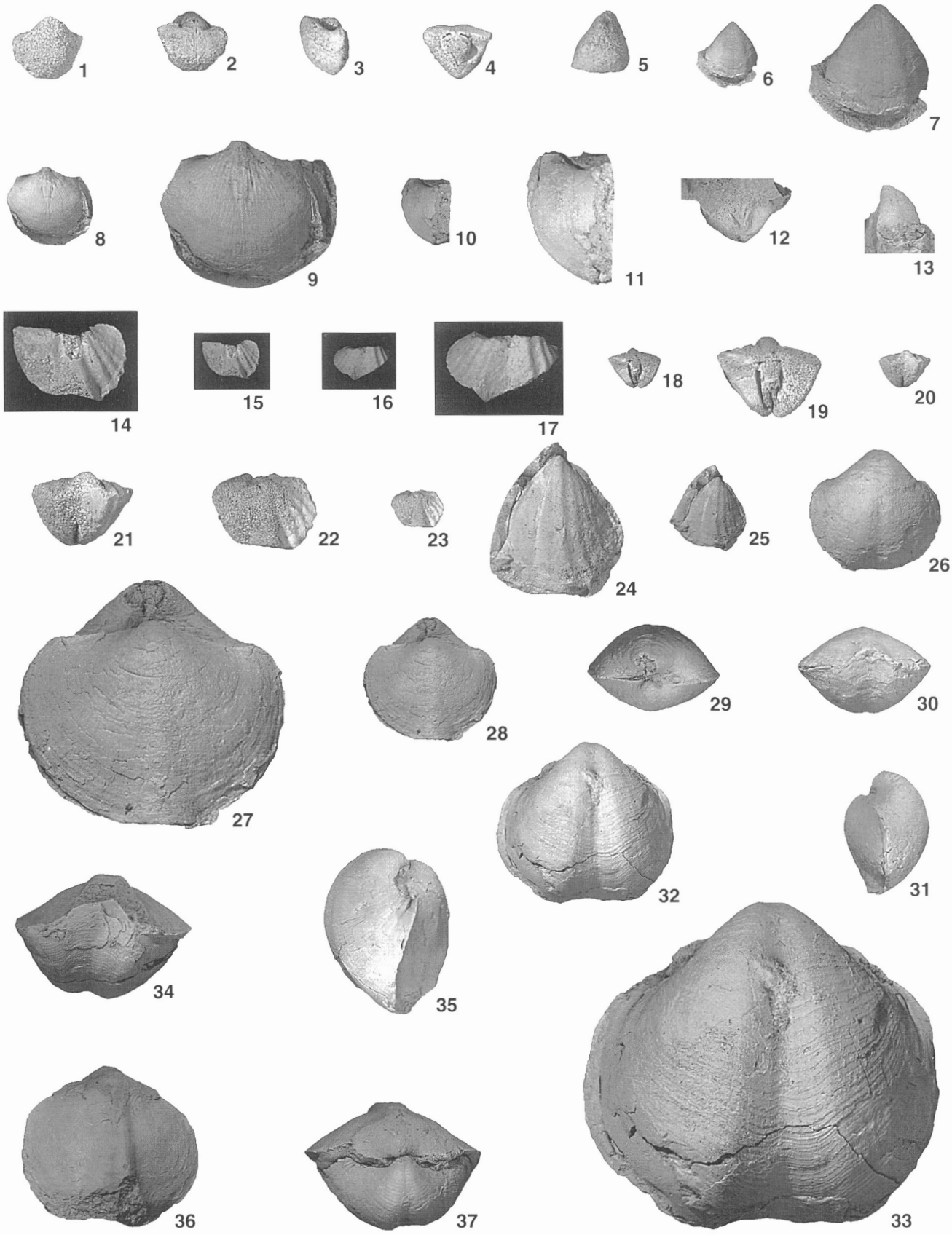
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PLATE 8

Figures 1–7. *Warrenella parafranklinii* Norris n. sp.

1–5. Pedicle (fig. 1; x1), brachial (fig. 2; x1), lateral (fig. 3; x1), anterior (fig. 4; x1), and posterior (fig. 5; x1) views of a thick, wide young adult shell, holotype GSC 75667; Field no. 28NBc1 (GSC loc. C-94493).

6, 7. Pedicle (figs. 6, 7; x1, x4) views, magnified in the latter to show micro-ornament of spine-like projections on the alate growth lamellae of a large, mature shell embedded in matrix, paratype GSC 75668; Field no. 96NBa1 (GSC loc. C-94724).

Figures 8–18. *Warrenella plicata* Johnson

8–12. Pedicle (fig. 8; x1), brachial (fig. 9; x1), lateral (fig. 10; x1), anterior (fig. 11; x1), and posterior (fig. 12; x1) views of an adult shell, hypotype GSC 75670; Field no. 28NBc1 (GSC loc. C-94493).

13, 14. Anterior (fig. 13; x1) and brachial (fig. 14; x1) views of an adult shell, hypotype GSC 75671; Field no. 24NBb (GSC loc. C-94479).

15–18. Pedicle (fig. 15; x1), anterior (fig. 16; x1), posterior (fig. 17; x1), and lateral (fig. 18; x1) views of an adult shell. In figures 15 and 18, note the broad, weak plicae on the flanks of the shell, hypotype GSC 75672; Field no. 24NBb (GSC loc. C-94479).

Figures 19–28. *Warrenella posteruskirki* Norris n. sp.

19–23. Brachial (fig. 19; x1), pedicle (fig. 20; x1), lateral (fig. 21; x1), posterior (fig. 22; x1) and anterior (fig. 23; x1) views of a very young shell, paratype GSC 75673; Field no. 28NBc1 (GSC loc. C-94493).

24–28. Posterior (fig. 24; x1), anterior (fig. 25; x1), brachial (fig. 26; x1), pedicle (fig. 27; x1), and lateral (fig. 28; x1) views of an elongate, thick adult shell, paratype GSC 75675; Field no. 16NBd (GSC loc. C-94446).

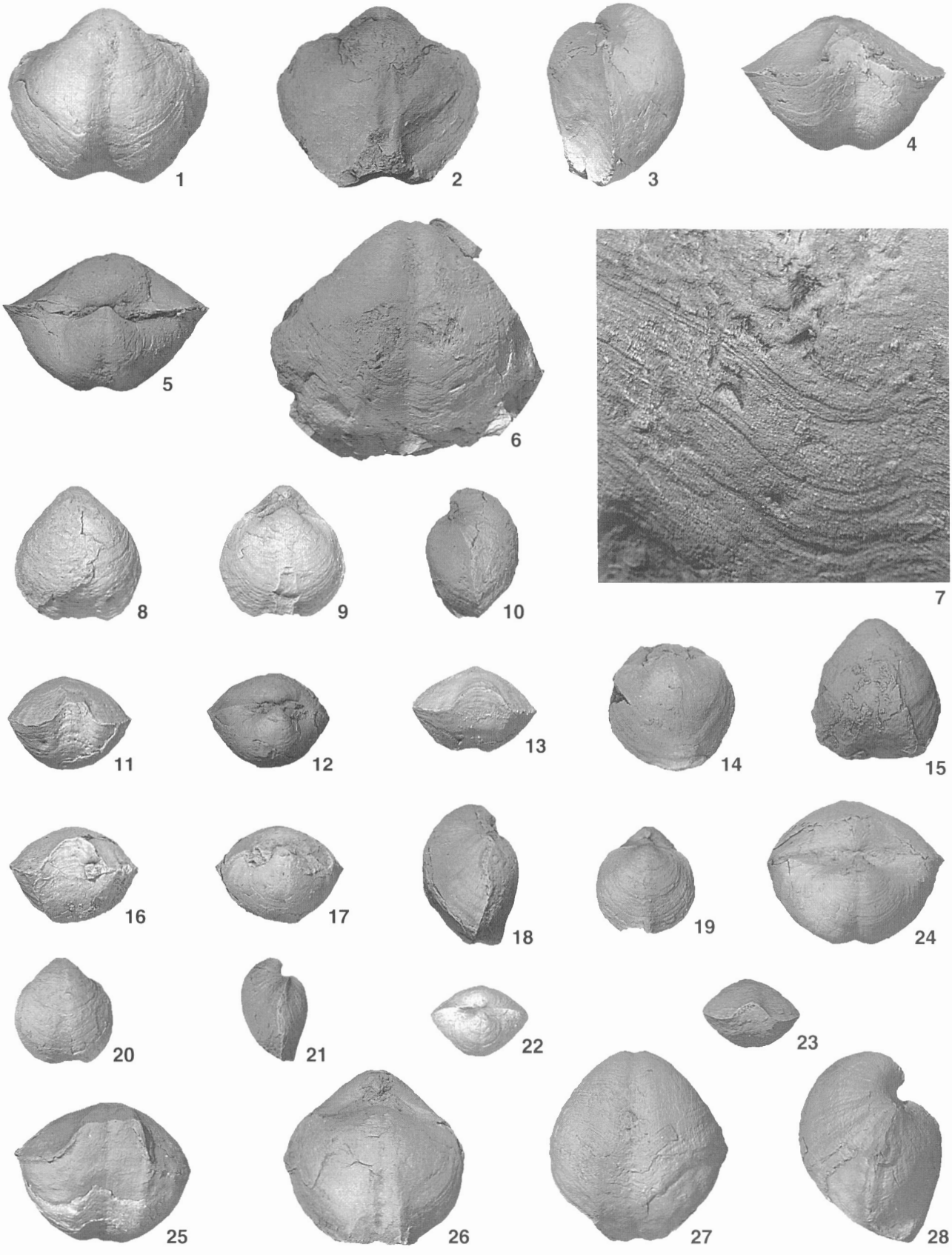
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PLATE 9

Figures 1–12. *Warrenella posteruskirki* Norris n. sp.

1–6. Pedicle and a magnified part of exterior of valve to show micro-ornament (figs. 1, 2; x1, x4), brachial (fig. 3; x1), anterior (fig. 4; x1), posterior (fig. 5; x1), and lateral (fig. 6; x1) views of a very thick and wide adult shell, paratype GSC 75676; Field no. 16NBd (GSC loc. C-94446).

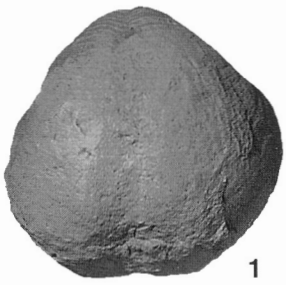
7–12. Brachial (fig. 7; x1) pedicle (fig. 8; x1), magnified part of exterior of pedicle valve to show micro-ornament (fig. 9; x4), anterior (fig. 10; x1), posterior (fig. 11; x1), and lateral (fig. 12; x1) views of a very thick and elongate shell, holotype GSC 75677; Field no. 28NBc1 (GSC loc. C-94493).

Figures 13–19. *Warrenella whittakeri* Norris n. sp.

13–17. Pedicle (fig. 13; x1), lateral (fig. 14; x1), anterior (fig. 15; x1), posterior (fig. 16; x1), and brachial (fig. 17; x1) views of an adult specimen, paratype GSC 75678; Field no. 37NBb (GSC loc. C-94518).

18, 19. Brachial (fig. 18; x1) and pedicle (fig. 19; x1) views of an adult shell, holotype GSC 75679; Field no. 37NBc (GSC loc. C-94519).

Other views of this specimen are shown on Plate 10, figures 1 and 2.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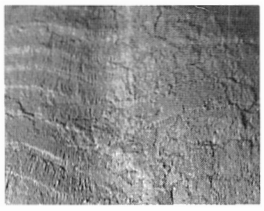
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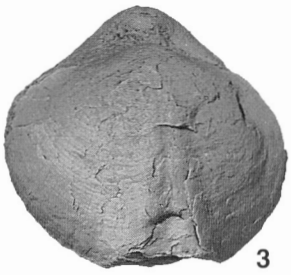
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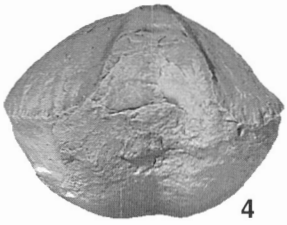
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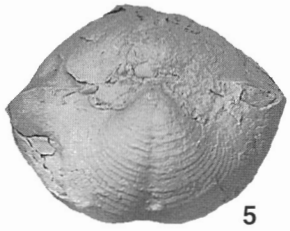
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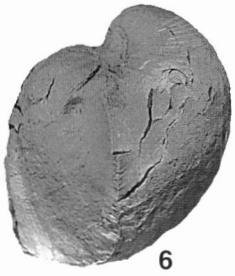
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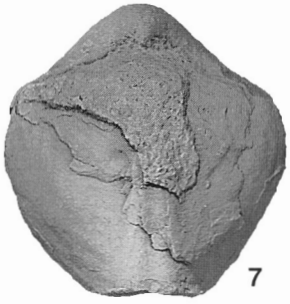
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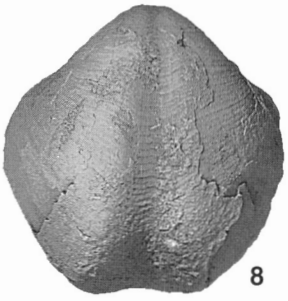
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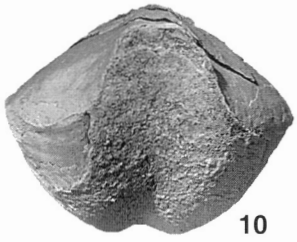
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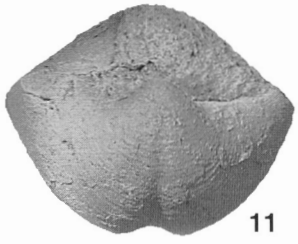
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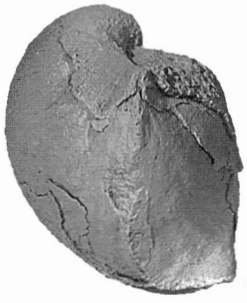
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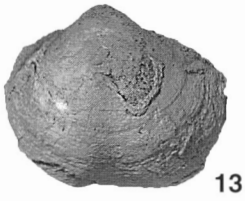
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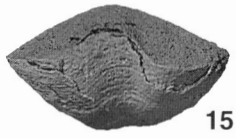
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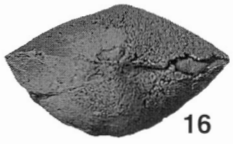
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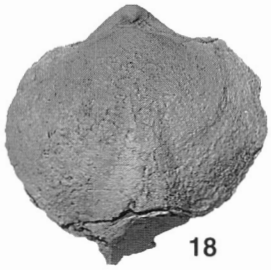
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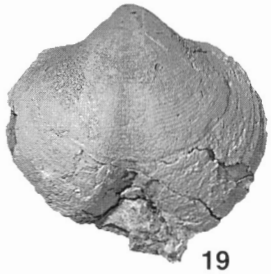
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PLATE 10

Figures 1, 2. *Warrenella whittakeri* Norris n. sp.

1, 2. Posterior (fig. 1; x1), and lateral (fig. 2; x1) views of an adult shell, holotype GSC 75679; Field no. 37NBc (GSC loc. C-94519).

Other views of this specimen are shown on Plate 9, figures 18 and 19.

Figures 3–5. *Stringocephalus* sp. B of Warren and Stelck, 1962

3. View (fig. 3; x1) of a cross-section of a young adult shell embedded in matrix showing a median septa in both the pedicle and brachial valves, hypotype GSC 75682; Field no. 13NBa (GSC loc. C-94439).

4. View (fig. 4; x1) of a cross-section of a mature adult shell embedded in matrix showing a median septa in both pedicle and brachial valves and part of the supports for the dental sockets of the brachial valve, hypotype GSC 75683; Field no. 14NBa (GSC loc. C-94440).

5. View (fig. 5; x1) of a cross-section of a mature adult shell embedded in matrix showing a median septa in both the pedicle and brachial valves, hinge plates and teeth of the pedicle valve, and teeth sockets in the hinge plate of the brachial valve, hypotype GSC 75684; Field no. 14NBa (GSC loc. C-94440).

Figures 6–10. *Gypidula*? *presquilensis* Norris n. sp.

6–10. Posterior (fig. 6; x1), pedicle (fig. 7; x1), brachial (fig. 8; x1), posterior (fig. 9; x1), and lateral (fig. 10; x1) views of an adult shell, holotype GSC 76443; Field no. 1NBb (GSC loc. C-126452).

Views of other specimens of this species are shown on Plate 3, figures 10–19.

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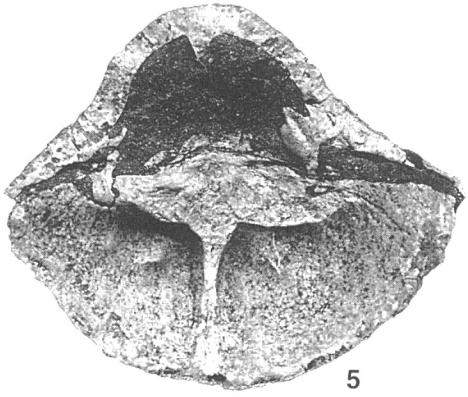

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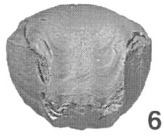

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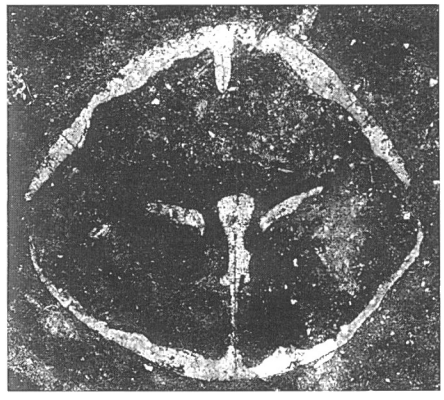

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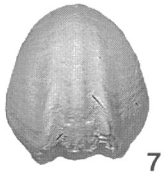

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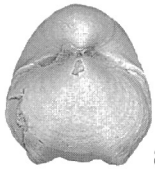

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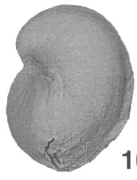

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PART II: Conodont faunas

Abstract

Conodonts from Middle Devonian rocks on the south side of Great Slave Lake range in age from late Eifelian to late Givetian, and are generally well preserved, with Colour Alteration Indices (CAI) of 1 to 1.5. Twenty-three species (including three species with their seven morphotypes) and seven subspecies were recovered. The six formations studied (in ascending order), and their zonal assignments, are as follows: the Chinchaga Formation (probable *australis* to *kockelianus* zones); the Keg River Formation (*kockelianus* to *ensensis* zones); the Bituminous limestone and Fine-grained dolostone members of the Pine Point Formation (probably the upper (Givetian) part of the *ensensis* Zone to upper part of the Middle *varcus* Subzone, and the Buffalo River Member (upper part of the Middle to possibly Upper *varcus* subzones); the Windy Point Member of the Sulphur Point Formation (possibly Upper *varcus* Subzone to *hermanni* Zone); the Watt Mountain Formation (probable Lower *subterminus* Fauna); and the Slave Point Formation (Upper *subterminus* Fauna). Samples from the Slave Point Formation were barren in the study area, consequently conodonts from that unit in northeastern Alberta are discussed. Correspondence of these zones with the stratigraphic ranges of megafossils, especially brachiopods, are made in the accompanying paper by A.W. Norris.

Middle Devonian strata on the south side of Great Slave Lake can be closely correlated with successions in the Powell Creek area, northern Mackenzie Shelf and Peel Shelf, Mackenzie Mountains, District of Mackenzie, and in southeastern Elk Point Basin (Saskatchewan sub-Basin) in southern and central Manitoba. Equivalent strata in the Powell Creek area are, in ascending order, the Hume, Hare Indian, Ramparts, and the lowest part of the Allochthonous Beds (= Allochthonous foreslope limestone facies of the Ramparts reef complex; Muir et al., 1984). In southern and central Manitoba, they are the Ashern, Elm Point, Winnipegosis, and Dawson Bay formations, and the Point Wilkins Member of the Souris River Formation.

The transgressive-regressive (T-R) cycles (Johnson et al., 1985) of the Great Slave Lake area can be most closely matched with those of Manitoba, a not unexpected result since Middle Devonian strata of both areas were deposited in inner shelf environments of an interconnected, intracratonic sea. The Powell Creek area, on the other hand, during the deposition of the upper part of its succession, was the site of deeper water, middle shelf environments. Deposits of the T-R cycle Ie (start within the *kockelianus* Zone) are represented by the Keg River and Elm Point formations. The start of Cycle If (within the *ensensis* Zone) is at the bases of the Pine Point and Hare Indian formations, and in the upper part of the Winnipegosis Formation. The start of Taghanic Onlap (start upper part of Middle *varcus* Subzone; Cycle IIa of Johnson et al., 1985; IIa-1 of Day et al., 1994, in press) is at the bases of the Buffalo River Member of the Pine Point Formation and of the B Member of the Dawson Bay Formation. The start of Cycle IIa-2 (start Upper *subterminus* Fauna) is at the bases of the Slave Point Formation, and the Argillaceous limestone beds of the Point Wilkins Member, Souris River Formation; in the Powell Creek area, it marked the beginning of the deposition of the Allochthonous Beds. A more detailed discussion on the T-R cycles, and their close correlations of the south side of Great Slave Lake, southern and central Manitoba, and eastern Iowa, is presented by Day et al. (1994, in press).

A new morphotype of *Polygnathus linguiformis* Hinde, similar to that previously described as morphotype "delta" by Ziegler and Klapper (1976), is described herein and referred to as morphotype "predelta".

Résumé

Les conodontes récoltés dans des roches du Dévonien moyen au sud du Grand lac des Esclaves ont livré des âges séchelonnant de l'Eifélien tardif au Givétien tardif; ils sont généralement bien conservés comme en témoigne un indice d'altération de la couleur variant de 1 à 1,5. Vingt-trois espèces (incluant trois espèces avec leurs sept morphotypes) et sept sous-espèces ont été identifiées dans ces roches. Les six formations étudiées (par ordre ascendant) et leur attribution zonale sont les suivantes : la Formation de Chinchanga (probablement de la Zone à *australis* à la Zone à *kockelianus*); la Formation de Keg River (de la Zone à *kockelianus* à *la Zone à ensensis*); le membre de Calcaire bitumineux et le membre de Dolomie à grain fin de la Formation de Pine Point (probablement de la partie supérieure [Givétien] de la Zone à *ensensis* à la partie supérieure de la Sous-zone à *varcus* intermédiaire) et le Membre de Buffalo River (partie supérieure de la Sous-zone à *varcus* intermédiaire à probablement la Sous-zone à *varcus* supérieure); le Membre de Windy Point de la Formation de Sulphur Point (probablement de la Sous-zone à *varcus* supérieure à la Zone à *hermanni*); la Formation de Watt Mountain (probablement la Faune à *subterminus* inférieure); et la Formation de Slave Point (Faune à *subterminus* supérieure). Les échantillons de la Formation de Slave Point étaient dépourvues de fossiles dans la région à l'étude, de sorte quil a été nécessaire d'analyser les conodontes présents dans cette unité dans des coupes du nord-est de l'Alberta. La correspondance de ces zones avec les intervalles d'extension stratigraphique des mégafossiles, en particulier des brachiopodes, est établie dans l'étude d'accompagnement de A.W. Norris.

Il est possible de corréler avec précision les successions du Dévonien moyen au sud du Grand lac des Esclaves avec les successions équivalents de la région du ruisseau Powell; de la partie nord de la plate-forme continentale de Mackenzie et la plate-forme de Peel; dans les monts Mackenzie du district de Mackenzie; et dans le sud-est du bassin d'Elk Point (sous-bassin de la Saskatchewan) dans le sud et le centre du Manitoba. Les unités équivalentes dans la région du ruisseau Powell sont, par ordre ascendant, les formations de Hume, de Hare Indian et de Ramparts, ainsi que la partie basale des Couches allochtones (= faciès de calcaire allochtone de talus frontal du complexe récifal de Ramparts; Muir et al., 1984). Dans le sud et le centre du Manitoba, s'étendent les formations d'Ashern, d'Elm Point, de Winnipegosis et de Dawson Bay et le Membre de Point Wilkins de la Formation de Souris River.

Les cycles de transgression-régression (Johnson et al., 1985) de la région du Grand lac des Esclaves peuvent être mis en correspondance étroite avec ceux du Manitoba, résultat inattendu étant donné que les successions du Dévonien moyen dans ces deux régions se sont déposées dans des milieux de plate-forme continentale interne interconnectés d'une mer intracratonique. Dans la région du ruisseau Powell, par ailleurs, la sédimentation de la partie supérieure de la succession a eu lieu dans un milieu d'eau plus profonde sur la partie intermédiaire d'une plate-forme continentale. Les sédiments du cycle de transgression-régression Ie (débutant à l'intérieur de la Zone à *kockelianus*) sont représentés par les formations de Keg River et d'Elm Point. Le début du cycle If (à l'intérieur de la Zone à *ensensis*) correspond à la base des formations de Pine Point et de Hare Indian et à la partie supérieure de la Formation de Winnipegosis. Le début de la transgression de Taghanic (début dans la partie supérieure de la Sous-zone à *varcus* intermédiaire; cycle IIa de Johnson et al., 1985; IIa-1 de Day et al., 1994, sous presse) correspond à la base du Membre de Buffalo River de la Formation de Pine Point et du Membre B de la Formation de Dawson Bay. Le début du cycle IIa-2 (début de la Faune à *subterminus* supérieure) correspond à la base de la Formation de Slave Point et des couches de calcaire argileux du Membre de Point Wilkins de la Formation de Souris River; dans la région du ruisseau Powell, il a marqué le début du dépôt des Couches allochtones. On trouvera dans Day et al. (1994, sous presse) un traitement plus détaillé des cycles de transgression-régression et leur étroite corrélation entre les régions du sud du Grand lac des Esclaves, du sud et du centre du Manitoba et de l'est de l'Iowa.

Un nouveau morphotype de *Polygnathus linguiformis* Hinde, semblable à celui décrit antérieurement comme le morphotype «delta» par Ziegler et Klapper (1976), est décrit et appelé morphotype «predelta».

CONODONT FAUNAS

Introduction

The conodont elements are generally well preserved with a Colour Alteration Index (CAI) of 1 to 1.5 (Epstein et al., 1977). This light colour is consistent with the estimated maximum burial temperature of Middle Devonian rocks in the Pine Point area of about 66°C (Qing and Mountjoy, 1992). It is also consistent with the primary fluid inclusion homogenization temperature in sphalerite, which has its peak in the 70° to 90°C range (Sangster et al., 1994). It is, however, in contrast with temperatures in the range of 120° to 170°C estimated by Kirste et al. (1989), on the basis of bitumen reflectance measurements.

As shown on the list below, and on the accompanying Table 1 and appendix, the Bituminous limestone member of the Pine Point Formation by far yielded the best preserved and most abundant and diverse faunas. Those from the more restricted facies such as the Chinchaga and Slave Point formations and Windy Point Member, Sulphur Point Formation tended to be corroded and few in number; several samples from these units were also barren of conodonts.

Six formations were studied (in ascending order, with number of samples studied and total weights of samples processed in brackets): Chinchaga (4, 3.3 kg); Keg River (5, 7.5 kg); Fine-grained dolostone member (6, 8.8 kg) and Bituminous limestone member (114, 153.1 kg), Pine Point; Windy Point Member, Sulphur Point Formation (3, 5.4 kg); Watt Mountain (9, 10.9 kg); and Slave Point (2, 4.0 kg).

Twenty-three species (including three species with their seven morphotypes) and seven subspecies were recovered. They are as follows:

Chinchaga Formation

Icriodus orri Klapper and Barrick
Icriodus cf. *I.* sp. A of Uyeno (1982)
Ozarkodina raaschi Klapper and Barrick
Polygnathus parawebbi Chatterton beta morphotype

Keg River Formation

Icriodus orri Klapper and Barrick
Icriodus sp. A of Uyeno (1982) → *I. orri* Klapper and Barrick
Ozarkodina cf. *O. raaschi* Klapper and Barrick
Polygnathus linguiformis linguiformis Hinde
Polygnathus parawebbi Chatterton alpha, beta, and gamma morphotypes
Polygnathus pseudofoliatus Wittekindt

Pine Point Formation (Fine-grained dolostone and Bituminous limestone members)

Icriodus arkonensis Stauffer
Icriodus brevis Stauffer
Icriodus difficilis Ziegler and Klapper
Icriodus cf. *I. lindensis* Weddige
Icriodus orri Klapper and Barrick
Icriodus sp. A of Uyeno (1982) → *I. orri* Klapper and Barrick
Ozarkodina brevis (Bischoff and Ziegler)
Ozarkodina raaschi Klapper and Barrick?
Ozarkodina semialternans (Wirth)?
Polygnathus ansatus Ziegler and Klapper
Polygnathus aff. *P. dubius* Hinde *sensu* Chatterton (1979)
Polygnathus hemiansatus Bultynck
Polygnathus cf. *P. latifossatus* Wirth
Polygnathus linguiformis linguiformis Hinde
Polygnathus linguiformis klapperi Clausen, Leuteritz and Ziegler
Polygnathus linguiformis mucronatus Wittekindt
Polygnathus linguiformis transversus Wittekindt
Polygnathus linguiformis weddigei Clausen, Leuteritz and Ziegler
Polygnathus linguiformis Hinde iota morphotype *sensu* Klapper (*in* Johnson et al., 1980) → *P. linguiformis klapperi* Clausen, Leuteritz and Ziegler
Polygnathus linguiformis Hinde predelta morphotype (new herein)
Polygnathus parawebbi Chatterton alpha, beta, and gamma morphotypes
Polygnathus pseudofoliatus Wittekindt
Polygnathus timorensis Klapper, Philip and Jackson
Polygnathus xylus ensensis Ziegler and Klapper
Polygnathus xylus ensensis Ziegler and Klapper → *Polygnathus xylus xylus* Stauffer
Polygnathus xylus xylus Stauffer
Pseudooneotodus sp., A and B morphotypes
Tortodus cf. *T. variabilis* (Bischoff and Ziegler)

Sulphur Point Formation, Windy Point Member

Panderodus sp.

Watt Mountain Formation

Icriodus subterminus Youngquist
Ozarkodina brevis (Bischoff and Ziegler)

Slave Point Formation

No conodonts recovered

In this study, simple cone elements are identified to generic level only. The apparatuses of *Ozarkodina brevis* and species of *Icriodus* are reconstructed and all their constituent elements counted. No such attempt was made for the apparatuses of species of *Polygnathus*, and only their Pa elements were identified. The number of all the recognizable ramiform elements are recorded, however, and listed as 'unassigned elements'. The principal reason for taking this approach is the near impossibility of assigning the various ramiform elements to any particular *Polygnathus* species. Intraspecific variability of *Ozarkodina brevis* is demonstrated by illustrations of reconstructed apparatuses from the Winnipegosis Formation and the 'First Red Beds' member, Souris River Formation of the Manitoba outcrop belt, the Waterways Formation on Birch River in northeastern Alberta, and the Horn Plateau Formation of southwestern District of Mackenzie.

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BIOSTRATIGRAPHY AND CORRELATION WITH POWELL CREEK AREA, N.W.T., AND CENTRAL AND SOUTHERN MANITOBA

Introduction

Conodonts from the Chinchaga through Slave Point formations can be assigned to three zones, two subzones, and two faunal units (Fig. 17), ranging from the probable *australis* Zone (mid-Eifelian) to Upper *subterminus* Fauna (late Givetian). The interval between the Middle *varcus* Subzone and the Lower *subterminus* Fauna can only be assigned by position since no diagnostic taxa have been recovered thus far. The sequence in the northeastern Elk Point Basin (Northern Alberta sub-Basin) of the Great Slave Lake area (and areas of northeastern Alberta for the Slave Point Formation) can be closely compared with that in the Powell Creek area in the Mackenzie Mountains, western District of Mackenzie (Uyeno, 1979; Uyeno *in* Muir, 1988), and with that in the outcrop belt of southeastern Elk Point Basin (Saskatchewan sub-Basin) in central and southern Manitoba (Uyeno, 1982; Witzke et al., 1989; Day et al., 1994, in press) (Fig. 17). In the Powell Creek area, the site of deposition during the Hume–Dunedin Assemblage (Hume, Hare Indian and Ramparts formations; *costatus* Zone to Lower *disparilis* Subzone) was in the northern Mackenzie Shelf, and later during the Fairholme Assemblage (Allochthonous Beds and younger; Upper *disparilis* Subzone to late Frasnian), in the Peel Shelf (Morrow and Geldsetzer, 1989; Uyeno, 1991). That the three areas can be closely correlated is not surprising in view of the fact that they were parts of an interconnected, large, cratonic seaway (Fig. 18; see also, e.g., Witzke and Heckel, 1989, fig. 1B; Day, 1992, fig. 1). This close comparison can be extended to an area southeast of Manitoba, and to central and eastern parts of the state of Iowa (Witzke et al., 1989; Day et al., 1991, 1994, in press; Parse and Plumley, 1992). In terms of North American eustatic fluctuations, the Great Slave Lake sequence displays four transgressions, three of which are major and traceable through the Midcontinent. They are T–R Cycles Ie (start within *kockelianus* Zone), If (start within *ensensis* Zone), and IIa (start within Middle *varcus* Subzone; Taghanic Onlap of Johnson, 1970) of Johnson et al. (1985). A secondary transgression occurred at the base of the Slave Point Formation, at the start of the Upper *subterminus* Fauna, within the interval of T–R Cycle IIa, and referred to as IIa-2 (Fig. 17; Day et al., 1994, in press).

In the following discussion, only brief, cursory descriptions of the lithologies of the formations are given in order to put the conodont faunas in context with the rock types. A thorough discussion of the formations is given in Part I of this bulletin.

Chinchaga Formation

The australis? to kockelianus zones

The Chinchaga Formation forms the upper part of the Lower Elk Point Group, and generally comprises anhydrite and anhydritic dolostone. The formation was sampled at Bell Rock on Slave River where it is a yellowish, brecciated dolomitic limestone. There, it contains *Ozarkodina raaschi*, *Polygnathus parawebbi*

Table 1

Distribution of conodonts in the Fine-grained dolostone and Bituminous limestone members of the Pine Point Formation, outcrops on south side of Great Slave Lake

STRATIGRAPHY	CONODONT ZONES	GSC LOCALITY NUMBER	FIELD NUMBER	INTERVAL (metres) above/below base of member	WEIGHT OF SAMPLE (kg)	*Pol. linguiformis linguiformis*	*Pol. parawebbi* alpha morphotype	*Pol. parawebbi* beta morphotype	*Pseudooneotodus* sp., B morphotype	*Icriodus* sp. indet.	*Ozarkodina brevis* (Pa)	*Ozarkodina brevis* (Pb)	*Ozarkodina brevis* (M)	*Ozarkodina brevis* (Sa)	*Ozarkodina brevis* (Sb)	*Ozarkodina brevis* (Sc)	*Pol. pseudofoliatus*	*Pol. parawebbi* morphotype indet.	*Pol.* sp. indet.
PINE POINT FORMATION, *Bituminous limestone member*	Middle *varcus* Subzone	C-94520	37NBd	49.87-50.03	2.0	1													
		C-94517	37NBa	46.45-46.49	1.2						1								
		C-94513	35NBa	45.00-45.20	1.7														1
		C-94515	36NBa	43.50-43.60	1.0		INDETERMINATE FRAGMENTS ONLY												
		C-94521	38NBa	42.90	0.9		5												
		C-94511	34NBc	42.22-42.7	1.6														
		C-94509	34NBa	41.99-42.09	2.0														1
		C-94523	39NBa	40.6-40.75	0.7		BARREN												
		C-94507	33NBc	40.09-40.20	0.9														
		C-94525	40NBa	39.3-39.4	1.1		BARREN												
		C-94505	33NBa	39.00	0.8	2	3												
		C-94620	69NBh	35.45	1.4														1
		C-94729	97NBd	33.80-34.00	1.2	3	5										1		
		C-94726	97NBa	33.80-34.00	1.0	4	15		14								9		
		C-94489	28NBa	32.80	2.0	7	12	1											
		C-94639	71NBi	32.70	1.6						1	1						1	
		C-94617	69NBe	32.49	1.7					3	3		1		1	1			
		C-94637	71NBg	32.37	0.5		2												
		C-94628	70NBe	32.37	1.2	1	4												
		C-94611	68NBg	32.18	1.6	2	8		8		5						1		
		C-94485	27NBa	32.00	2.0	5	12		2										
		C-94626	70NBc	31.95	1.2		1												
		C-94635	71NBe	31.9-32.0	1.3		BARREN												
		C-94609	68NBe	31.90	1.4	1				1									
		C-94624	70NBa	31.60	1.6		INDETERMINATE FRAGMENTS ONLY												
		C-94607	68NBc	31.59	0.7		BARREN												
		C-94722	96NBa	31.50	1.1	14	13	7	10								2		
		C-94605	68NBa	31.46	0.9		3	3	57		12;1cf		1				3		
		C-94613	69NBa	31.3	1.1		BARREN												
		C-94622	69NBj	31.28	1.2		BARREN												
		C-94633	71NBc	31.20	1.1		3?												
		C-94720	95NBa	31.05-31.15	0.9	1	4		1		1						5		
		C-94527	42NBa	30.85	0.9	1?													
		C-94601	67NBa	30.77	1.2	3	41		7		1						38		
		C-94592	64NBa	30.75-31.10	1.1		BARREN												
		C-94496	29NBa	30.75-30.98	2.0		8		2								37		
		C-94599	66NBc	30.58	1.0	2	7		1		6				1				
		C-94603	67NBc	30.57	1.0		INDETERMINATE FRAGMENTS ONLY												
		C-94631	71NBa	30.45	1.8		2				2	1	3		2	1			
		C-94597	66NBa	30.11	2.1	3	29				4				1		2		
		C-94595	65NBa	30.00-30.22	1.2	35	60		5		2						17		
		C-94461	19NBa	29.62	1.5	23	29	1				1					24		
		C-130853	63NBa	29.39	1.0	3	17		1				1						
		C-94457	18NBa	29.38-29.70	1.7	11	21		2		1						34		
		C-94482	26NBa	29.38-29.50	2.0	25	31	2			1						191		
		C-94529	43NBa	29.00-29.10	1.0		INDETERMINATE FRAGMENTS ONLY												
		C-94480	25NBa	28.30-28.62	2.0	15	27		2								5		
		C-94590	63NBg	27.77	2.1	9	29		6	1	10	1	1		1				
		C-94588	63NBe	27.56-27.87	2.0	15	122		10		7		1						
		C-94586	63NBc	27.56-27.87	1.0	9	29	5	>150		21	4					2		
		C-94641	72NBa	26.80-27.02	1.0														
		C-94450	17NBd	25.2-25.3	2.1	24	31	3									19		
		C-94447	17NBa	25.02-25.13	1.1	26	24	11			2						8		
		C-94717	94NBa	24.30-24.37	0.7												1		1

GSC LOCALITY NUMBER	*Icriodus* sp. A (Uyeno 1982) → *I. orri*	*Icriodus* cf. *I. lindensis*	*Icriodus orri* (I)	*Icriodus orri* (S2a)	*Icriodus orri* (S2c)	*Tortodus* cf. *T. variabilis*	*Pseudooneotodus* sp., A morphotype	*Pol. xylus ensensis*	*Pol. l. linguiformis* iota → *P. l. klapperi*	*Pol. linguiformis klapperi*	*Pol. linguiformis* predelta morphotype	*Pol. parawebbi* gamma morphotype	*Pol. xylus xylus*	*Pol.* aff. *P. dubuis* (Chatterton 1979)	*Icriodus brevis* (I)	*Icriodus brevis* (S2a)	*Icriodus brevis* (S2b)	*Icriodus brevis* (S2c)	*Pol. timorensis*	*Pol. hemiansatus*	*Pol. ansatus*	*Pol. linguiformis transversus*	*Icriodus difficilis* (I)	*Icriodus difficilis* (S2a)	*Icriodus difficilis* (S2b)	*Icriodus difficilis* (S2c)
C-94520															8	4	2	4	1		1					
C-94517															2	1	1	3	3							
C-94513																										
C-94515																										
C-94521										1?					4											
C-94511																										
C-94509															1											
C-94523																										
C-94507															6				3				2			
C-94525																										
C-94505										2													8	1		
C-94620																										
C-94729						1																				
C-94726						3	2							2								1?				
C-94489						2	4	3																		
C-94639																										
C-94617																										
C-94637																										
C-94628																										
C-94611								2																		
C-94485						2	15																			
C-94626											2												6	5		4
C-94635																										
C-94609																										
C-94624																										
C-94607																										
C-94722						4																				
C-94605						2		4			1															
C-94613																										
C-94622																										
C-94633																										
C-94720							1																			
C-94527																										
C-94601						38	15	4		1	2															
C-94592																										
C-94496						2																				
C-94599						1	13																			
C-94603																										
C-94631																										
C-94597						13	7	6		1	1															
C-94595						10																				
C-94461						6		1																		
C-130853								13		2																
C-94457						5																				
C-94482						48	161	19		4	18															
C-94529																										
C-94480						4																				
C-94590								3;11cf		1																
C-94588								28;23cf		9													3	1		
C-94586						2	12	15		18	3											3				
C-94641																										
C-94450						8																				
C-94447						7																				
C-94717																							2	1		2

GSC LOCALITY NUMBER	*Pol. linguiformis weddigei*	*Pol.* cf. *P. latifossatus*	*Pol. linguiformis mucronatus*	*Pol. xylus ensensis* → *P. xylus xylus*	*Ozarkodina raaschi* ?	*Icriodus arkonensis* (I)	*Icriodus arkonensis* (S2a)	*Ozarkodina semialternans* ?	Unassigned icriodontid element (S2a)	Unassigned icriodontid element (S2b)	Unassigned icriodontid element (S2c)	Unassigned element (Pa)	Unassigned element (Pb)	Unassigned element (M)	Unassigned element (Sa)	Unassigned element (Sb)	Unassigned element (Sc)	*Panderodus*	*Coelocerodontus* ?	*Neopanderodus*	*Dvorakia*	*Belodella*	Indeterminate simple cones
C-94520												2	6	5	4	12	10	X	X			X	
C-94517													1	5			1					X	
C-94513									1		1						1?					X	
C-94515																							
C-94521														1	1	1	2		X		X	X	
C-94511																						?	
C-94509																							
C-94523																							
C-94507											1		2	1	1	2	2					X	
C-94525																							
C-94505													1	2							?	X	
C-94620																							
C-94729												2	9	12	5	3	5			X		X	
C-94726													13	17	10	14	10					X	
C-94489													8	11	4	3	6					X	
C-94639													1	3	1	3	3					X	
C-94617									4	2	4		10	25	13	9	12		X		X	X	X
C-94637													1	1		1					X	X	
C-94628														3	1	1	1				X	X	
C-94611	2												8	11	1	2	2	X				X	
C-94485													22	26	16	33	13					X	
C-94626													4	6		1	4					X	
C-94635																							
C-94609															1	1							
C-94624																							
C-94607																							
C-94722						33	2	1					6	7	1	6	4		X				
C-94605			2	1									10	30	9	11	11	X				X	
C-94613																							
C-94622																							
C-94633																							
C-94720													5	3	1	3	1	X				X	
C-94527																							
C-94601	2											1	72	96	42	69	112	X		X		X	
C-94592																							
C-94496													9	6	2	9	6	X	X	X		X	
C-94599													4	13	2	3	11	X		X	X	X	
C-94603																							
C-94631													3	4	2	6	1		X			X	
C-94597					1							2	24	23	5	10	13	X	X	X	X	X	
C-94595													14	26	9	18	15	X			X	X	
C-94461													11	22	6	20	14		X	X	X	X	
C-130853		2											7	11	6	8	4		X	X		X	
C-94457												2	13	20	8	7	14	X				X	
C-94482	8											3	96	87	32	50	52	X		X	X	X	
C-94529																							
C-94480													4	5	2	6	2			X		X	
C-94590												1	33	27	8	17	11		X		X	X	
C-94588				2									50	26	17	22	24		X		X	X	
C-94586	3	22	7									1	43	29	10	31	27		X	X		X	
C-94641																					?		
C-94450													8	26	5	14	9	X	X	X		X	
C-94447													3	23	6	8	1	X	X	X		X	
C-94717													1				1						

Table 1 (cont'd.)

PINE POINT FORMATION; Bituminous limestone member; Middle *varcus* Subzone	C-94478	24NBa	22.02-22.17	2.0	14	30											6										6	2			1																																			5	16	3	8	3	X				X	
	C-94715	93NBc	21.56	0.7	10					1									2											1?										2				1																			6	1	2	1	1					X	
	C-94531	44NBa	21.46	1.6	1	4													5																																																			X	
	C-94713	93NBa	21.24	0.7	1																									1?																																	3						
	C-94680	83NBa	20.35-20.52	0.6	1			2								1																																								1		1		1						
	C-94643	73NBa	20.32-20.52	1.1					3										4																																					2		2		2	2	3	1	7					X	
	C-94682	84NBa	20.32-20.40	0.8	42				1	1																		1					2				5																					11	16	4	6	3					X	
	C-94685	85NBa	18.82-18.98	1.4	21																																	1				2			1													2	5	2	2	3					X	
	C-94687	85NBc	18.80-19.00	1.6	4													3																																									2	3	1	2					X	
	C-94678	81NBc	18.50	1.0															5																											1												6	5	6	1	8	5					X	
	C-94711	92NBa	18.45-18.55	0.6		BARREN																																																													
	C-94476	23NBa	17.94-18.53	1.7		5				1			1			11								2	42			1																													6	9	3	4	3	X	X	X		X	
	C-94674	79NBi	17.75-17.88	1.7		BARREN																																																													
	C-94676	81NBa	17.63	1.2						1																			4								16																					1	9	23	11	14	16					X	
	C-94658	77NBa	17.53	0.7	2			22		2						4													4										2																	1		11	23	3	20	5	X				X	
	C-94707	91NBc	17.45-17.55	0.7						1?																												1		5																				2	1		4						
	C-94709	91NBe	17.35-17.58	1.4	5					1						16												1															37	14	9	16												1	2	1	4	2	5					X	
	C-94705	91NBa	17.35-17.45	0.9						3?																												3		5																2				1	7	1	3	1						
	C-94649	74NBe	17.20	2.1	2	15				1																		3															15																	1	4	2				X			X	
	C-94671	79NBi	17.11	1.1		BARREN																																																													
	C-94668	79NBe	16.65	2.0		INDETERMINATE FRAGMENTS ONLY																																																													
	C-94647	74NBc	16.54	1.5		BARREN																																																													
	C-94660	77NBc	16.45	1.0	9			1		1	1		1			36																																											13	18	2	15	10		X		X	X	X
	C-94645	74NBa	16.35	1.0		2				2								1											2																																	4	4	1	2	3					X	X	
	C-94503	32NBa	16.20-16.22	1.1		63		1		1	1														25	2	35																				4												1	34	25	8	18	19			X	X	X	
	C-94651	75NBa	16.15	1.7		7		4		25	14	13	1	6	7																																										3	9	6	1	3	X	X		X	X	
	C-94690	86NBa	15.22-15.36	1.5	83												4								1cf		1		8									8		1		4	1															1	18	14		8	4		X			X	
	C-94666	79NBc	14.53	1.0		INDETERMINATE FRAGMENTS ONLY																																																													
	C-94654	76NBa	14.04	2.0		21	1	9		6														2;3cf		3		17	1										2cf		1																			11	10	3	4	10	X	X	X		X	
Lower *varcus* Subzone	C-94692	87NBa	13.89-14.05	0.5	1					4?																														2	7																					3	1	1					X	
	C-94656	76NBc	13.79	0.9	1	14	2																				17											1																							5	2	3	6					X	
	C-94664	79NBa	13.37	0.9																																																					1	1			2					X	
	C-94696	89NBa	12.81-12.93	2.0						2								1																	3?				2																															
	C-94694	88NBa	12.78-12.92	1.4	1																																																					1									
	C-94501	31NBa	12.52-12.58	1.3	53	8	2			1						7								9	31	32					2																											1	13	5	1	1	X	X	X		X	
	C-94701	90NBa	11.77-11.95	1.5																					2									5				5																								3									
	C-94703	90NBc	11.77-11.95	0.7					1									2																																											2	1	1	1	1					X	X
	C-94662	78NBa	11.38	0.9	1?													2																																											2	3	1	2	2						
	C-94465	21NBa	11.05-11.30	2.0	6	21	3	4		1														3		1						1																											1	6	3	2	5	X	X	X	X	X	
	C-94541	46NBa	10.98-11.25	0.9	6	11		1		1	1			1										1	4	1																																	7	12	6	9	6	X		X	X	X	X
	C-94543	47NBa	10.51-10.57	0.7	1	9	2										3																																												2	3	1			X	X	X	X	X	X
	C-94545	47NBc	9.82	1.5	3	14		1									2				1	1			1						5																											5	6	1	2	2	X	X		X	X	
	C-94471	22NBa	9.05	2.0	10	16		4		1						1								1							2																											3	4	2	2	1	X		X	X	X	
	C-94558	51NBc	8.70-8.80	2.0	4	11	3																				1	1																																			8	12	4	8	11	X	X	X		X	
	C-94549	48NBc	8.35-8.45	1.2	8	6		3		1	1			1		10								3																																							2	10	3	7	9	X	X	X	X	X	
	C-94442	15NBa	8.13-8.15	1.6	4	1	1																																																					4		2		X		X			
	C-94533	45NBa	8.04-8.15	1.0	45	11	2			1						4								6	5	14																																	2	14	15	6	9	7	X	X		X	X	
	C-94556	51NBa	7.90-7.98	2.0	9	12	1			1		1				3								2		1																																			13	10	3	6	5	X	X	X	X	X	X
	C-94561	52NBa	7.85-7.94	0.6	33	7	1			1						5								7	9	26																																			7	8	6	5	5	X	X	X		X	X
	C-94547	48NBa	7.65-7.87	1.1	5	8	5	1		4						10															3																											4	6	3	5	2	X	X	X		X	X
	C-94445	16NBc	7.50-7.69	2.0	5	12	5	2								1					2	1	1	3							2																											3	4	3	4	2					X	
ensensis Zone	C-94539	45NBg	7.50-7.59	1.5	18	9	8	2								9								8						5																													9	14	2		5	X	X			X	X
	C-94444	16NBa	7.45-7.66	2.0	3	49	20	4								1					4	2			10					2																													7	1	1	5	4	X			X	X	X
	C-94553	50NBa	7.45-7.55	2.0	28	20	10			3	1						17								11	7					1																													4	7	1	1	1	X	X	X	X	X	X
	C-94551	49NBa	7.42-7.55	1.3	6	15	1	1								5								3						2																													6	12	3	2	2	X	X	X	X	X	X
	C-94563	53NBa	7.37-7.50	1.6	16	28	1			2				1		2								6	1	1				4																											2	13	21	8	9	12	X	X		X	X	
	C-94565	54NBa	6.55-6.65	1.7	9	6										6													1cf	1?																																5	1	1		1	X	X	X		X	
	C-94567	55NBa	5.80-5.90	0.8	18	5	3										27								6	7	2	1																																9	16	2	4	4	X	X	X		X	
	C-94569	56NBa	5.20-5.30	2.0	7	1				2						2								3	1																																				3	4	1	1	4	X	X	X		X	
	C-94573	58NBa	0-0.15	1.7	1	12				1				1						4	2?																																								5	10	3	4	6	X	X		X		
Fine-grained dolostone mbr.	C-94583	62NBc	(-)9.50-9.95	0.9															1																																								1	1				X					
	C-94581	62NBa	(-)9.64	1.5	1						1			1		1	1	2																																								3		1	1		X				
	C-94577	60NBa	(-)12.95-13.07	1.8	1?	1		1	2	1																																																			X	X			X	
	C-94571	57NBa	(-)15.30-15.45	1.3		1																																																						?				X	
	C-94579	61NBa	(-)20.15-20.40	1.7			1																																																									X		
	C-94575	59NBa	(-)20.20-20.41	1.6	1	2																																																	2		1			X			X	X	

Note that the succession is composite, resulting in some overlaps of sampling intervals. Locations with negative stratigraphic intervals belong to the fine grained dolostone member. Non-icriodontid simple cones were not counted.

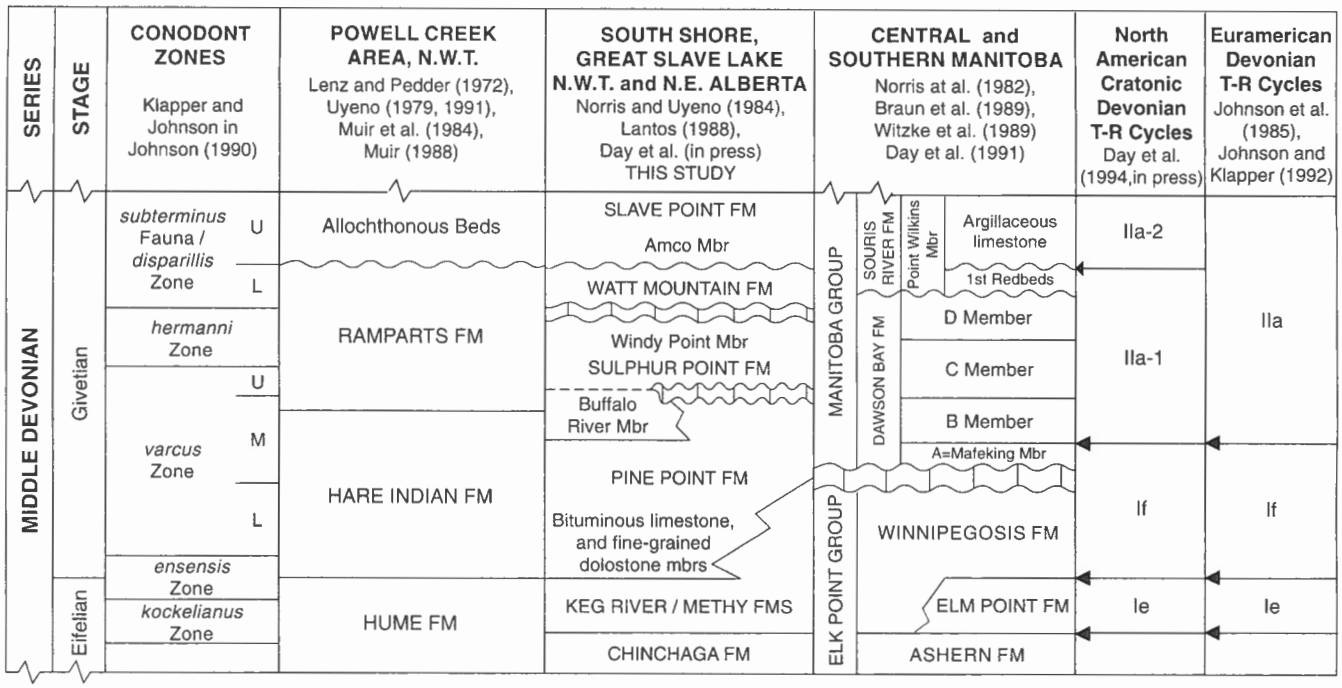

Figure 17. *Stratigraphic and biostratigraphic frameworks for Middle Devonian (late Eifelian–late Givetian) strata in the study areas. Conodont zones and their relative spacing are after Klapper and Johnson (in Johnson, 1990). Relative sea-level events designated as North American cratonic Devonian transgressive–regressive (T–R) cycles are after Johnson et al. (1985) and Johnson and Klapper (1992). Subdivision of T–R Cycle IIa, designated as IIa-1 and IIa-2, is after Day et al. (1994, in press).*

beta morphotype of Chatterton (1979), *Icriodus orri*, and *I.* cf. *I.* sp. A of Uyeno (1982). The occurrence of *O. raaschi* below the first appearance of *O. brevis*, was previously reported from the lower part of the Spillville Formation of northern Iowa and southern Minnesota (Klapper and Barrick, 1983, p. 1217, 1218). There, *O. raaschi* occurs with *Polygnathus curtigladius*, and was tentatively correlated with the *curtigladius* Fauna, an approximate equivalent of the *kockelianus* Zone. In the study area, *O. brevis* makes its first appearance in the Fine-grained dolostone member of the Pine Point Formation (Table 1). In the absence of *P. curtigladius*, the Chinchaga Formation may include a part of the older *australis* Zone. *Icriodus* cf. *I.* sp. A is similar to that reported by Uyeno (1982, p. 79) from the Elm Point Formation of Manitoba; it is also similar to a form reported by Klug (1983) from the Speeds Member of the North Vernon Limestone of southern Indiana (see Systematics).

Based primarily on position, the Chinchaga Formation is correlated with the Ashern Formation of Manitoba (Fig. 17). Since the latter unit carries *Polygnathus pseudofoliatus*, it is considered to be no older than the *australis* Zone (Klapper and Johnson, 1980). It is also correlated with an interval within the Hume Formation of the Powell Creek area, primarily with the *pedderi-parawebbi* Faunal Unit, and parts of the overlying *angusticostatus-curtigladius* Faunal Unit (subsequently considered as approximately equivalent to the *australis* and *kockelianus* zones, respectively, by Klapper and Johnson, 1980). The former faunal unit lies in the interval of the Hume Formation, which is also included in the *Eoschuchertella adoceta* Zone (Lenz and Pedder, 1972).

Keg River Formation

The kockelianus and ensensis zones

The Keg River Formation was sampled in the Fort Resolution area, where it is a marine platformal deposit of sucrosic dolostone and limestone (mudstone and wackestone). There, it yields *Polygnathus parawebbi* alpha, beta, and gamma morphotypes of Chatterton (1979), *P. pseudofoliatus*, *P. linguiformis linguiformis*, *Icriodus orri*, *I.* sp. A of Uyeno (1982) transitional to *I. orri*, and *Ozarkodina* cf. *O. raaschi*. The gamma morphotype of *P. parawebbi* is very close to the form described from the Elm Point Formation of Manitoba (Uyeno, 1982) and from the uppermost Nahanni or Hume Formation of western Northwest Territories (Chatterton, 1979). In Salair and

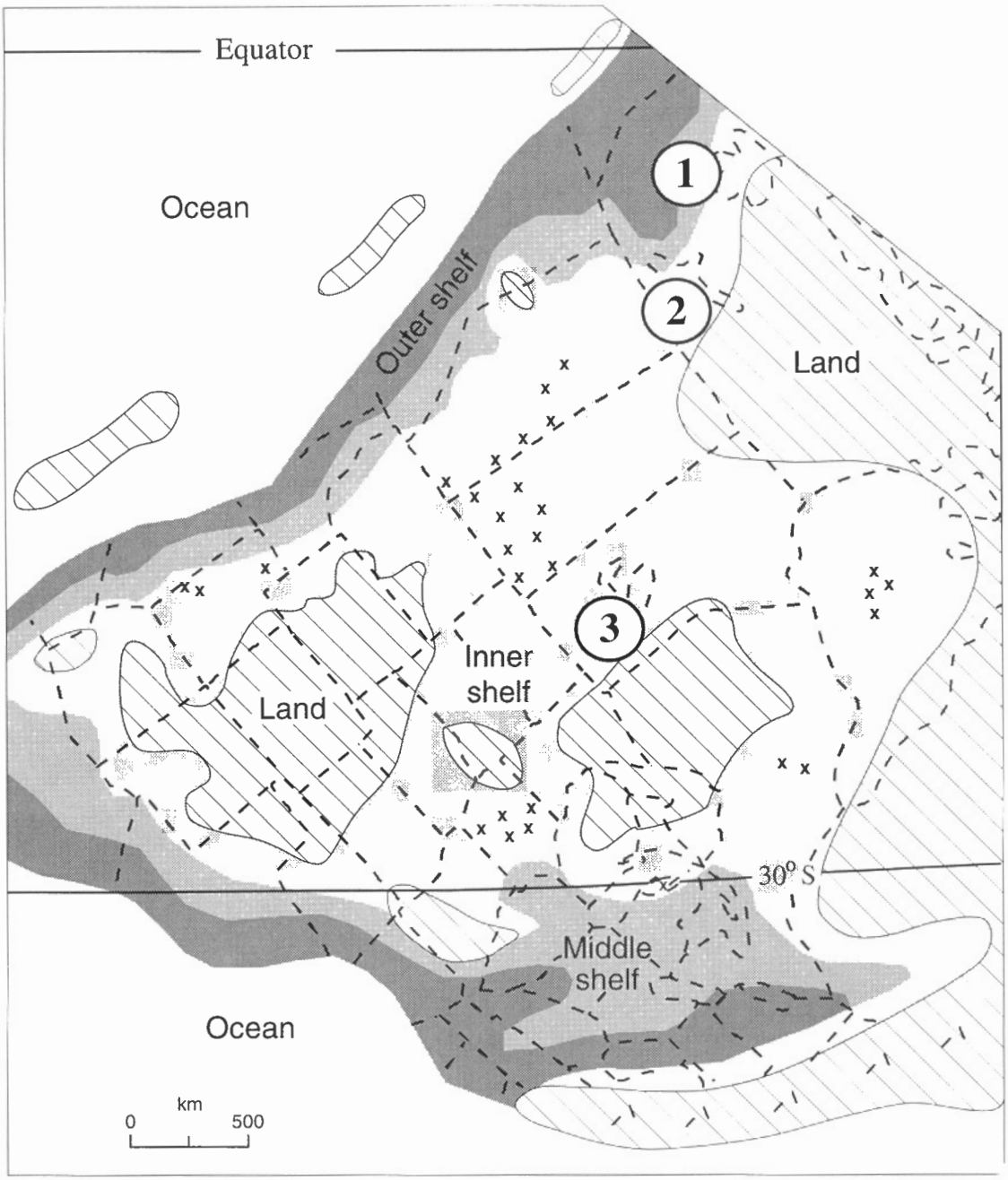

Figure 18. *Late Middle Devonian (Givetian) paleogeographic reconstruction of western Laurentia, showing extent of cratonic seaways during transgressive–regressive (T–R) cycle IIa (of Johnson et al., 1985), and locations of study areas. Cratonic study areas: 1 – Peel Shelf, Powell Creek area, Mackenzie Mountains, western District of Mackenzie; 2 – northeastern Elk Point Basin (Northern Alberta sub-Basin), south shore of Great Slave Lake, northeastern Alberta, and northwestern Saskatchewan; 3 – southeastern Elk Point Basin (Saskatchewan sub-Basin), central and southern Manitoba. (From Day et al., in press, Fig. 1).*

northeastern Russia, the gamma morphotype was reported from the *kockelianus* Zone by Gagiev and Rodygin (1988). The Elm Point Formation, with *Polygnathus curtigladius*, *P. angusticostatus* (Wittekindt), and *Tortodus intermedius* (Bultynck), is now considered to span parts of the *kockelianus* and *ensensis* zones (Witzke et al., 1989). The presence of *Ozarkodina* cf. *O. raaschi* is based on Pb(?) elements that are close to those of *O. raaschi* (see Systematics). If the latter species is indeed represented, the formation is probably no younger than the *ensensis* Zone. The icriodid form transitional between *I.* sp. A and *I. orri*, mentioned above, is identical to specimens present in the lower Pine Point Formation in the interval that is correlated here with the *ensensis* Zone.

The Keg River Formation is correlated with the Elm Point Formation and may include the lower part of the overlying Winnipegosis Formation of the Manitoba outcrop belt. In the Powell Creek area, its correlative is the upper part of the Hume Formation with the *angusticostatus-curtigladius* Faunal Unit, including *Polygnathus angustipennatus* Bischoff and Ziegler, and elements of the brachiopod *Carinatrypa dysmorphostrota* Zone, which includes, in its lower part, *Variatrypa arctica* (Warren) (Lenz and Pedder, 1972).

Both the Keg River and Elm Point formations were deposited during the widespread marine transgression that is referred to T–R Cycle Ie of Johnson et al. (1985). The lower parts of both units also contain *Variatrypa arctica* (Warren) (Braun et al., 1989).

Pine Point Formation

Conodonts from the outcropping Pine Point Formation included in this study were derived from the Fine-grained dolostone member and the Bituminous limestone member. The Fine-grained dolostone member consists of fine-grained, sandy or sugary textured, porous dolostone and the Bituminous limestone member comprises a dark, fossiliferous, highly calcareous, bituminous limestone, and a brownish, thin-bedded, very fine-grained limestone.

The ensensis Zone

Polygnathus parawebbi gamma morphotype of Chatterton (1979) extends up from the underlying Keg River Formation. In current understanding, the upper part of the Elm Point Formation, and the uppermost Nahanni and Hume formations are assignable to the *ensensis* Zone (see Klapper and Johnson, 1980, p. 410, 413; Witzke et al., 1989, fig. 15, p. 248).

Also occurring within the *ensensis* Zone interval is a single specimen that is morphologically transitional between *Polygnathus linguiformis linguiformis* iota morphotype of Klapper (*in* Johnson et al., 1980) and *P. l. klapperi*. The iota morphotype was previously reported from the *ensensis* Zone in the lower part of the Denay Formation of northern Antelope Range, central Nevada.

An icriodid element that is morphologically transitional between *Icriodus* sp. A of Uyeno (1982) and *I. orri*, is present at locality C-94583 (30.1 m above base of section). This is the same form as that present in the underlying Keg River Formation. A form similar to *Icriodus lindensis* Weddige is present at locality C-94573 (20.5 m above base of section). The latter species was reported from the Mont d'Haurs section at Givet, northeastern France, with a range of upper *ensensis* Zone to within the Lower *varcus* Subzone (Bultynck, 1987), and from the Eifelian area of Germany (Weddige, 1977).

The *ensensis* Zone interval of the Pine Point Formation is correlated with the upper part of the Winnipegosis Formation of the Manitoba outcrop belt. It is also correlated with the lowermost part of the Hare Indian Formation that contains *Leiorhynchus castanea* (Meek) at West Powell Creek (located about 1.5 km northwest of the Powell Creek section) and at Francis Creek (approximately 15 km southeast of Norman Wells, lat. 65°14′20″N, long. 126°23′40″W; undescribed collection of Uyeno). At the latter locality, conodonts include *Tortodus variabilis* (Bischoff and Ziegler), which is not known to occur below the Givetian. The *castanea*-bearing beds were placed in the uppermost part of the underlying Hume Formation by Lenz and Pedder (1972, p. 35) and Uyeno (1979, p. 238). But Bassett (1961, fig. 3) Tassonyi (1969, p. 72), and Caldwell (1971, p. 6) assigned these beds to the Hare Indian Formation, a placement that makes eminent sense in terms of depositional cycles. The deposition of the Pine Point and Hare Indian formations was initiated by transgression during T–R Cycle If of Johnson et al. (1985).

The Lower varcus Subzone

The base of the Lower *varcus* Subzone is placed at the lowest occurrence of a form transitional between *Polygnathus xylus ensensis* and *P. xylus xylus*, 28.0 m above the base of section at locality C-94445 (see Ziegler et al., 1976, p. 113; Klapper and Johnson, 1980, Table 10). *Polygnathus timorensis*, the definer of the base of this subzone (Ziegler et al., ibid.), however, has its first occurrence stratigraphically higher in the

Pine Point Formation at 32.3 m above base of the section. Within the Pine Point Formation, *Icriodus orri* occurs at localities C-94445 (with *P. xylus ensensis*→*P. xylus xylus*) and C-94545 (30.23 m above base of section). *I. orri* has been reported in the literature as ranging to into the *ensensis* Zone (Klapper and Barrick, 1983, p. 1217, 1218), thus the Pine Point occurrences suggest either that these levels are still within the *ensensis* Zone, or that the species may range into the lowest part of the overlying Lower *varcus* Subzone. Yet another possible explanation is that the estimation of the relative positions of the samples may be in slight error.

The Lower *varcus* Subzone interval of the Pine Point Formation is correlated with the uppermost part of the Winnipegosis Formation of the Manitoba outcrop belt. The latter unit carries *Icriodus brevis* and *Polygnathus xylus xylus*. It is also correlated with the lowest parts of the Hare Indian Formation, where nodules contain the ammonoid *Cabrieroceras karpinskyi* (Holzapfel), at Francis Creek, western District of Mackenzie (see above; Uyeno, undescribed collection).

The Middle varcus Subzone

The interval of this subzone spans over 36 m of the Pine Point Formation. *Polygnathus ansatus*, the definer of the base of the Middle *varcus* Subzone (Ziegler et al., 1976, p. 113), first appears at locality C-94692 (34.4 m above base of section). Other species occurring in this subzone include *Polygnathus linguiformis transversus*, *P. l. weddigei*, *P. l. mucronatus*, *P.* cf. *P. latifossatus*, *Icriodus difficilis*, *I. arkonensis*, *I. brevis*, and questionably, *Ozarkodina semialternans*. The presence of *Polygnathus* cf. *P. latifossatus*, which is close to a transitional form between *Ozarkodina semialternans* and *P. latifossatus* (see Systematics) is intriguing. It occurs at localities C-94586 and C-130853 (48.1 m and 49.8 m above base of section, respectively), well within the interval correlated with the Middle *varcus* Subzone. A single specimen, questionably assigned to *O. semialternans*, occurs above *P.* cf. *P. latifossatus*, at locality C-94722 (51.9 m above base of section). If this assignment is correct, it suggests a position high in the Middle *varcus* Subzone, and further suggests an approximate position equivalent to the start of T-R cycle IIa, the Taghanic Onlap (Johnson et al., 1985, p. 578).

The Middle *varcus* Subzone interval of the Pine Point Formation is correlated with the Mafeking and B members of the Dawson Bay Formation of the Manitoba outcrop belt. The B Member carries *Polygnathus ansatus*, *P. alveoliposticus*, *P. ovatinodosus*, and *P. linguiformis klapperi*, suggesting a position high in the Middle *varcus* Subzone, and correlation with the Buffalo River Member (see below), and with the upper part of the Bituminous limestone member at the level yielding a possible *Ozarkodina semialternans*. Conodonts of the subzone are also found in the upper parts of the Hare Indian Formation at Powell Creek (Uyeno, 1979, updated in Johnson et al.,1985, p. 574), where it occurs just below faunas of the brachiopod *Ectorensselandia laevis* Zone (Lenz and Pedder, 1972), and in the lower Ramparts Formation.

Pine Point Formation, Buffalo River Member

The upper Middle varcus to possibly Upper varcus subzones

The Buffalo River Member consists of various rock types, but is predominantly greenish grey, fissile, calcareous shale. This unit was not sampled for this investigation, but was studied by Lantos (1983). Lantos (ibid., fig. 14, p. 68) reported *Polygnathus alveoliposticus* Orr and Klapper and *P. ansatus* from the member, which indicate correlation with the upper part of the Middle *varcus* Subzone. The initiation of deposition of the Buffalo River Member marks the transgression of T-R Cycle IIa-1, and the Taghanic Onlap. Since this subzone occupies such a thick interval in the Bituminous limestone member, and the Buffalo River Member has a small areal distribution, and is partly surrounded by the former unit (Norris, 1965, fig. 7; Rhodes et al., 1984, fig. 5), it is likely that the two units interfinger, at least in part, as suggested by Rhodes et al. (1984, fig. 3, p. 996) (see also discussion in Part I of this bulletin).

Sulphur Point Formation, Windy Point Member

Possibly Upper varcus Subzone to hermanni Zone

The Windy Point Member constitutes the lower, massive, biostromal unit of the Sulphur Point Formation, and generally consists of light brown, stromatoporoidal and coraliferous limestones and dolostones. The present samples are from blocks that were transported to the shore; they are brownish grey, finely granular, massive dolostone.

The three samples from the Windy Point Member processed for conodonts yielded a species of *Panderodus*, and some indeterminate fragments of

ramiform elements. Its age, however, is constrained by its position between an upper part of the Middle *varcus* Subzone below and a probable Lower *subterminus* Fauna above.

The Windy Point Member is, by position, correlated with the C Member of the Dawson Bay Formation. The latter unit was assigned to the *hermanni* Zone by Witzke et al. (1989, fig. 15). In the Powell Creek area, the interval is presumably represented within the Ramparts Formation, where no diagnostic taxa have been recovered thus far.

Watt Mountain Formation

Probable Lower subterminus Fauna

In the Great Slave Lake area, the Watt Mountain Formation consists of various rock types, but the thickest unit is light coloured, fine micritic limestone, altered in part to a fine dense dolostone.

The Watt Mountain Formation yielded *Icriodus subterminus* and *Ozarkodina brevis*. Although both species are long-ranging, in the absence of other taxa, and a position immediately below the Slave Point Formation and its Amco Member, a likely correlation is with the Lower *subterminus* Fauna (Witzke et al., 1985, 1989). The *subterminus* Fauna is characteristic of cratonic and inner shelf sequences, and was suggested to be an approximate correlative of the *disparilis* Zone, developed in basinal-outer shelf conodont biofacies (Witzke et al., 1985, p. 38). The base of the Fauna is recognized by the first occurrence of *Icriodus subterminus*; it was subdivided into lower and upper parts on the basis of the lowest occurrences of *Mehlina gradata* (Youngquist) and *Polygnathus angustidiscus* Youngquist (Witzke et al., 1989).

The Watt Mountain Formation is correlated with the uppermost part of the D Member of the Dawson Bay Formation and the "First Red Beds" of the Souris River Formation of the Manitoba outcrop belt (Fig. 17). The uppermost part of the D Member carries the earliest occurrence of *Icriodus subterminus* in the Manitoba sequence. The uppermost beds of the "First Red Beds", which may possibly belong to the overlying "Argillaceous limestone beds", have yielded *I. subterminus* with the addition of *Polygnathus angustidiscus*. At Powell Creek, conodonts of the Lower *disparilis* Subzone occur in the upper parts of the Ramparts Formation and include, among other species, *Palmatolepis disparilis* Ziegler and Klapper, *P. disparata* Ziegler and Klapper, *Polygnathus dubius* Hinde, and *Schmidtognathus peracutus* (Bryant). That collections from the Powell Creek area carry conodonts of the *disparilis* Zone is reflective of the location of the area within the deeper-water middle shelf environment (Fig. 18; see also Morrow and Geldsetzer, 1989, Table 1).

Slave Point Formation

Upper subterminus Fauna

In the Pine Point area, the Slave Point Formation consists in part of brownish, fine- to medium-grained, thinly bedded, partly dolomitic and brecciated limestone. The lowest unit of the formation, the Amco Member, consists of grey, limy, burrow-mottled shale that is partly dolomitic, and brown, argillaceous, micritic limestone.

The two samples of the Slave Point Formation (undivided) processed for this study were both barren of conodonts. However, in the Gypsum Cliffs area on Peace River in northeastern Alberta, located about 250 km southeast of the present study area, the Slave Point Formation (undivided) yielded *Polygnathus angustidiscus* and *Icriodus subterminus*, below the *insita* Fauna of the Waterways Formation (Norris and Uyeno, 1984). There, it can be assigned to the Upper *subterminus* Fauna (Witzke et al., 1985, p. 38; 1989).

In the Pine Point area, Lantos (1983) reported *Polygnathus angustidiscus* (identified as *P.* aff. *P. brevilaminus*) from the Amco Member. In Iowa and Manitoba, Witzke et al. (1989, fig. 15) showed *P. angustidiscus* as occurring within the Upper *subterminus* Fauna. The available evidence, then, although from disparate areas, would suggest an assignment of the Slave Point Formation, at least in part, to the Upper *subterminus* Fauna.

The Slave Point Formation, including its Amco Member, are correlated with the "Argillaceous limestone beds" (B Member) of the Souris River Formation of the Manitoba outcrop belt (Fig. 17). The B Member carries *Polygnathus angustidiscus*, *Icriodus subterminus*, *Mehlina gradata* and *Ozarkodina semialternans*. At Powell Creek, the interval is represented in the lower parts of the "reef cycle" of the Ramparts Formation (Muir et al., 1984; Muir, 1988), or of the "Allochthonous Beds" (MacKenzie, 1970). There, among other species, it contains *Polygnathus dengleri* Bischoff and Ziegler and *Palmatolepis disparalvea* Ziegler and Klapper, an association characteristic of the Upper *disparilis* Zone. The Amco Member, Slave Point Formation, the "Argillaceous limestone beds", Souris River

Formation, and the lower "Allochthonous Beds" were the result of deposition during a transgression that can be placed within T-R Cycle IIa of Johnson et al. (1985), and termed T-R Cycle IIa-2 by Day et al. (1994, in press).

SYSTEMATIC PALEONTOLOGY

The classification used herein follows that in Dzik (1991) and, for the genus *Tortodus*, that in Sweet (1988). The locational notation used in Supplement 2 of Part W of the Treatise on Invertebrate Paleontology (Robison, 1981) is followed, with the exception of icriodontid apparatuses. For the Icriodontidae, the scheme introduced by Klapper and Philip (1971, 1972), and subsequently expanded by Johnson and Klapper (1981), is used. After years of deliberation, the conodonts have been placed fairly conclusively with the chordates (Briggs, 1992; Sansom et al., 1992).

The figured specimens are deposited in the National Type collections of the Geological Survey of Canada, 601 Booth Street, Ottawa.

Class CONODONTA Pander, 1856

Order PRIONIODONTIDA Dzik, 1976

Superfamily PRIONIODONTACEA Bassler, 1925

Family ICRIODONTIDAE Müller and Müller, 1957

Genus *Icriodus* Branson and Mehl, 1938

Type species. Icriodus expansus Branson and Mehl, 1938.

Icriodus arkonensis Stauffer

Plate 16, figures 16–19

1938 *Icriodus arkonensis* n.sp., Stauffer, p. 429, Pl. 52, figs. 10, 15.
1987 *Icriodus arkonennsis* [*sic*] Stauffer, García-López, p. 71–72, Pl. 9, figs. 1–6 (synonymy).
1988 *Icriodus arkonensis* Stauffer, Sparling, Textfig. 18(2).

Remarks. One I element (Pl. 16, figs. 16, 17) from the Pine Point Formation appears to be transitional to *I. orri*. A more typical *I. arkonensis* (Pl. 16, figs. 18, 19) has more numerous denticles in all three rows of the spindle, with those on the middle row small and longitudinally interconnected, in comparison with *I. orri*.

Icriodus brevis Stauffer

Plate 12, figure 21; Plate 16, figures 29–31

1940 *Icriodus brevis* n. sp., Stauffer, p. 424, Pl. 60, figs. 36, 43, 44, 52.
1978 *Icriodus brevis* Stauffer, Uyeno, p. 18, Pl. 4, figs. 28–44.
1979 *Icriodus brevis* Stauffer, Uyeno, p. 248, Pl. 2, figs. 4–6.
1982 *Icriodus brevis* Stauffer, Morzadec and Weyant, p. 32, Pl. 1, figs. 23(?), 24.
1982 *Icriodus brevis* Stauffer, Bultynck, p. 38, Pl. 2, figs. 17–19.
1983 *Icriodus brevis* Stauffer, Klug, p. 85–86, Textfigs. 12P–R (synonymy).
1983a *Icriodus brevis* Stauffer, Wang and Ziegler, Fig. 2(16).
1983b *Icriodus brevis* Stauffer, Wang and Ziegler, Pl. 1, fig. 23.
1985 *Icriodus brevis* Stauffer, Orchard *in* Austin et al., p. 144, Pl. 4.4, figs. 9, 10 (reillustration of Orchard, 1978, Pl. 1, figs. 14, 20).
1987 *Icriodus brevis* Stauffer, Bultynck, p. 158, Pl. 6, figs. 1–14.
1991 *Icriodus brevis* Stauffer, Uyeno, Pl. 3, fig. 1.

Remarks. In the literature, it appears that the general concept of this species includes those specimens with only gradually posteriorly widening basal cavity (e.g., Klapper *in* Ziegler (ed.), 1975, *Icriodus* Pl. 3, fig. 3a). The concept has been expanded by some (e.g., Bultynck, 1987, Pl. 6, figs. 9, 13) to include those forms with widely flaring posterior half of the basal cavity, and in this sense, some Pine Point specimens can be included herein (Pl. 12, fig. 21).

Icriodus difficilis Ziegler and Klapper

Plate 16, figures 1–15, 20, 21

1976 *Icriodus difficilis* n. sp., Ziegler and Klapper, p. 117–118, Pl. 1, figs. 1–7, 17 (synonymy).
1977 *Icriodus difficilis* Ziegler and Klapper, Weddige, p. 292, Pl. 2, fig. 36, Textfig. 3(11).
1979 *Icriodus difficilis* Ziegler and Klapper, Savage and Amundson, Pl. 1, figs. 1, 2.
1980 *Icriodus difficilis* Ziegler and Klapper, Schönlaub, Pl. 9, fig. 8.
1983 *Icriodus difficilis* Ziegler and Klapper, Klapper and Barrick, Textfigs. 9AB, AC.

1983 *Icriodus difficilis* Ziegler, Klapper and Johnson [*sic*], Wang and Ziegler, Pl. 1, fig. 21.
1985 *Icriodus difficilis* Ziegler and Klapper, Orchard *in* Austin et al., p. 146, Pl. 4.4, figs. 11, 12 (reillustration of Orchard, 1978, Pl. 109, figs. 9, 16).
1986 *Icriodus difficilis* Ziegler and Klapper, Bardashev and Ziegler, Pl. 2, fig. 24.
1987 *Icriodus difficilis* Ziegler and Klapper, Bultynck, Pl. 9, figs. 25, 26.
1991 *Icriodus difficilis* Ziegler and Klapper, Uyeno, Pl. 5, fig. 4.

Remarks. Three kinds of S_2 (acodinan) elements are present, associated with *I. difficilis*, and all three have costae although some are more pronounced than others. The S_{2a} element, as noted by Klapper and Barrick (1983, p. 1231), has the anterior and posterior keels that characteristically rise from the lower margin more or less vertically for a short distance. Beyond that point, it may meet the cusp in broad, concave curves (Pl. 16, figs. 1, 11) or in straight lines (Pl. 16, figs. 2, 12). The S_{2b} element may have a triangular outline (Pl. 16, fig. 4) or an arch with convex sides (Pl. 16, fig. 3). The S_{2c} element is a slender cone with an oval basal cavity outline.

Icriodus cf. *I. lindensis* Weddige

Plate 11, figures 24–27

cf. 1977 *Icriodus lindensis* n. sp., Weddige, p. 293, 294, Pl. 2, figs. 38, 39, Textfig. 3(15).
cf. 1987 *Icriodus lindensis* Weddige, Bultynck, p. 159, Pl. 4, figs. 17–22.

Remarks. The Pine Point specimens are similar to those reported from the type Eifelian area of Germany (Weddige, 1977) and from the Mont d'Haurs section at Givet, northeastern France (Bultynck, 1987). They differ slightly in their shorter spindle and lower number of denticles of the lateral and medial rows. A feature in common with the latter collections is the posterior extension of the medial row, which, in lateral view, increases regularly in height. The spindle is also slightly biconvex.

Icriodus orri Klapper and Barrick

Plate 11, figures 6, 7, 12;
Plate 12, figures 7, 22, 23, 26

1983 *Icriodus orri* n. sp., Klapper and Barrick, p. 1230–1231, Textfigs. 9A–U, X–AA, AD–AG.
1983 *Icriodus* sp. A, Klug, p. 87–88, Textfigs. 9S–X.

Remarks. A single S_{2a} element was recovered from the lower Pine Point Formation (GSC loc. C-94545). The species also occurs in the Chinchaga and Keg River formations.

Icriodus subterminus Youngquist

Plate 18, figures 21–26

1947 *Icriodus subterminus* n. sp., Youngquist, p. 103, Pl. 25, fig. 14.
1981 *Icriodus subterminus* Youngquist, Uyeno *in* Norris and Uyeno, p. 25, Pl. 10, figs. 1–13, 23–27.
1983 *Icriodus subterminus* Youngquist, Uyeno *in* Norris and Uyeno, p. 36, Pl. 1, figs. 9–22, 25–27.
1984 *Icriodus subterminus* Youngquist, Sandberg and Dreesen, p. 157, Pl. 1, fig. 1 (synonymy).
1985 *Icriodus subterminus* Youngquist, Klapper and Lane, p. 920, Figs. 11.6, 11.8, 11.9.
1986b *Icriodus subterminus* Youngquist, Bultynck, Pl. 2, figs. 13, 14.
1989 *Icriodus subterminus* Youngquist, Metzger, p. 516, Figs. 13.20, 13.24.
1991 *Icriodus subterminus* Youngquist, Uyeno, Pl. 5, figs. 5, 24.

Remarks. Uyeno (*in* Norris and Uyeno, 1981, 1983) illustrated the three S_2 (acodinan) elements in the apparatus of *I. subterminus*. In the Watt Mountain Formation, only the S_{2a} element was recovered.

Icriodus cf. *I.* sp. A of Uyeno (1982)

Plate 11, figures 4, 5, 13, 14

cf. 1982 *Icriodus* sp. A, Uyeno, p. 79, Pl. 31, figs. 8–10, 14–16.

Remarks. In comparison with *Icriodus orri*, one specimen (Pl. 11, figs. 4, 5) from the Chinchaga Formation exhibits a basal cavity that is only slightly expanded posteriorly and more rounded denticles of lateral rows. It thus approaches *Icriodus* sp. A of Uyeno (1982) from the Elm Point Formation of Manitoba. This morphotype also approaches a form considered by Klug (1983, Figs. 9P–R) to be transitional between *Icriodus* n. sp. E of Weddige (1977) and *I. orri*, and reported from the Speeds Member, North Vernon Limestone of southern Indiana.

Specimens from the Keg River (one illustrated on Pl. 11, figs. 13, 14) and lower Pine Point formations have a lower surface outline closely similar to that of *I.* sp. A of Uyeno (1982). The elongated lateral row denticles, which almost or actually touch those of the median row, suggest that it morphologically approaches *I. orri*.

Order OZARKODINIDA Dzik, 1976

Suborder OZARKODININA Dzik, 1976

Superfamily POLYGNATHACEA Bassler, 1925

Family SPATHOGNATHODONTIDAE Hass, 1959

Genus *Ozarkodina* Branson and Mehl, 1933

Type species. Ozarkodina typica Branson and Mehl, 1933.

Ozarkodina brevis (Bischoff and Ziegler)

Plate 12, figures 8, 9; Plate 17, figures 1–26; Plate 18, figures 1–20, 27

1957 *Spathognathodus brevis* n. sp., Bischoff and Ziegler, p. 116–117, Pl. 19, figs. 24, 27–29.
1982 *Ozarkodina brevis* (Bischoff and Ziegler), Bultynck, Pl. 1, figs. 4–6.
1983 *Ozarkodina brevis* (Bischoff and Ziegler), Klapper and Barrick, p. 1234, Textfigs. 10L, O, P (synonymy).
1985 *Ozarkodina brevis* (Bischoff and Ziegler), Orchard *in* Austin et al., p. 142, Pl. 4.3, figs. 4, 5.
1985 *Ozarkodina brevis* (Bischoff and Ziegler), Nicoll, p. 139–144, Textfigs. 6–9.
1985 *Ozarkodina brevis* (Bischoff and Ziegler), Olivieri, p. 290, Pl. 2, figs. 9–11.

Remarks. Nicoll (1985) reported on clusters, as well as on several hundred disparate elements, of *Ozarkodina brevis*, derived from the Napier Formation, Canning Basin, Western Australia. The apparatus from Australia is close to that from western Canada in most ways, with the exception of the M element.

The M element recovered from the Pine Point Formation is identical to that reported by Uyeno (1982, Pl. 32, figs. 33, 34; also illustrated herein on Pl. 18, figs. 1–6) from the Winnipegosis Formation of Manitoba, and from the Waterways Formation on Birch River, northeastern Alberta (Pl. 18, figs. 7–9). That is, it is a highly modified dolabrate element, with a strongly recurved cusp that has a ridge extending from its tip to the base along the inner side of its anterior margin. Developed on this ridge are as many as four small curved denticles; the posterior process is represented by an extension of the base. The downward-extending outer lateral process is developed at the base of the cusp; it bears several (more than 12) small, acicular denticles. In most specimens, the outer lateral process is broken and only a small stub remains.

The Pine Point M element differs from its Australian counterpart in its cusp being strongly recurved and the base extended posteriorly to form a process. Rather than being attached near the base of the cusp, the outer lateral process in the Australian element is an extension of the outer lateral ridge of the cusp. The small denticles on the inner side of the cusp differ in size and orientation.

The M element is similar to a form reported from the Spillville Formation of northern Iowa by Klapper and Barrick (1983, figs. 7N, O). That element, although earlier suggested by Uyeno (1990, p. 102) as a possible candidate for the M element of *Ozarkodina raaschi* Klapper and Barrick, more probably belongs to the apparatus of *O. brevis*. This revised opinion stems not only from the close morphological similarities of the Spillville and Pine Point specimens, but also in the distribution of conodont elements in the Spillville sections (Klapper and Barrick, 1983, figs. 4, 5). As noted above, and as with most Pine Point specimens, the outer lateral process appears to be missing in one of the illustrated Spillville specimens (ibid., Textfig. 7N).

The morphology of the M element is highly variable, perhaps even to the extent that the species may be taxonomically divisible on that basis. The apparatus reconstructed from the Horn Plateau Reef in southwestern District of Mackenzie has an M element without the outer lateral process (Pl. 18, figs. 17, 18). Indeed it closely resembles the Pine Point and Winnipegosis M element with the lateral process broken off, but its lower outer lateral side is smooth and there is no trace of a stub. The age of the outcropping part of the Horn Plateau Formation is Middle *varcus* Subzone (unpublished material; Pedder et al., 1992; see also Fuller and Pollock, 1972).

The shape and size of the basal cavity of the Pa element vary considerably. In a typical element, the cavity is located at the extreme posterior end, and is round to oval (Pl. 18, fig. 11; see also Klapper and Barrick, 1983, Textfig. 10L), but may be bilobate (Pl. 18, figs. 13, 20). There may be as many as three small denticles situated posteriorly of the cusp, the number possibly increasing during ontogeny (Nicoll, 1985, p. 141). The cusp is developed over the basal cavity.

Ozarkodina raaschi Klapper and Barrick

Plate 11, figures 8–10

1983 *Ozarkodina raaschi* n. sp., Klapper and Barrick, p. 1234, 1235, 1237, Figs. 10K, N; 11A–W.

Remarks. The Pa and Pb elements in the Chinchaga collections are closest to those illustrated by Klapper and Barrick (1983, figs. 11R, S, V) from the Spillville Formation at Spillville (loc. 6(2A)), and which includes the holotype specimen. Although the Chichaga specimens are fragmentary, they are sufficiently complete to allow specific identifications. A groove running the length of the cavity and to the anterior end of the unit, is clearly visible in one of the Pa elements (Pl. 11, fig. 8). The Pb element is concave upwards, with upturned anterior and posterior halves.

Owing to their small size and poor state of preservation, the two specimens from the Keg River Formation are only referred to *O.* cf. *O. raaschi*. They both appear to be the Pb element (Pl. 11, figs. 17, 18). One Pa element from the Pine Point Formation superficially, at least, shows morphological similarities to *O. raaschi* (Pl. 16, fig. 28). The basal cavity is relatively narrow and elongated, with a groove running throughout its length and to the posterior tip. It differs from *O. raaschi* in that, with the exception of the second to the anteriormost denticle, the denticles are remarkably uniform in size and, consequently, there is no cusp. The form is herein only questionably referred to *O. raaschi*.

Genus *Tortodus* Weddige, 1977

Type species. Polygnathus kockeliana Bischoff and Ziegler, 1957.

Tortodus cf. *T. variabilis* (Bischoff and Ziegler)

Plate 11, figures 23, 29, 30; Plate 12, figure 25; Plate 15, figures 9–21

cf. 1957 *Polygnathus? variabilis* n. sp., Bischoff and Ziegler, p. 99–100, Pl. 18, figs. 8–17; Pl. 19, figs. 10, 11, 17.

1978 *Tortodus* sp., Requadt and Weddige, p. 212, Textfig. 13c (only).

Remarks. The Pine Point specimens assigned to this taxon exhibit considerable morphological variation. Some have almost planar lateral surfaces with only incipient ridges at the posterior third of the blade (Pl. 11, fig. 23; Pl. 12, fig. 25), whereas others are thicker, with low ridges throughout the length of the blade (Pl. 15, figs. 9, 11, 12). The ridges may develop nodes or an incipient platform at the extreme posterior end (Pl. 15, figs. 15–18). The basal cavity has an oval to elongated pit located at midlength to slightly posterior of midlength of the blade, and is commonly inverted anteriorly and posteriorly. The outline of the lower margin as laterally viewed also shows variation; that part anterior of the pit is typically straight, whereas its posterior counterpart may be straight (Pl. 15, figs. 10, 21), slightly arched (Pl. 11, fig. 30; Pl. 15, fig. 13), or strongly arched and extended downward (Pl. 15, fig. 19). In those forms with arches, the basal cavity is invariably located at the junction of the straight and arched parts of the blade. In upper view, the posterior part of the blade may be slightly bent inwardly (Pl. 15, fig. 16). For this reason, the species was referred to the genus *Tortodus* by Weddige (1977, p. 330).

The spectrum of variation noted above is broader than that ascribed to *Tortodus variabilis* by Bischoff and Ziegler (1957). Their concept does not include the form with almost planar surfaces. On the other hand, there are forms that match closely with the species (Pl. 15, fig. 18).

One specimen (Pl. 15, fig. 22) exhibits the widest part of its basal cavity under the arched posterior part of the blade and in this respect, approaches *Ozarkodina semialternans* (Wirth). In that species, however, the arched part forms the posterior third of the blade. Since the extreme distal part of the blade is missing in the Pine Point specimen, the proportion of the arched part to the overall unit length is uncertain. Judging from other specimens in the group, however, it is probably about half. In other specimens (Pl. 11, fig. 29; Pl. 15, fig. 20) the lower margin is arched under both the anterior and posterior parts of the blade.

Requadt and Weddige (1978, p. 212) illustrated a specimen from the Lower *varcus* Subzone in the Rupbach Slates at the Lahn Syncline, Rhenish Slate Mountains, that is very close to one of the Pine Point forms (Pl. 15, fig. 11). *Tortodus* cf. *T. variabilis* differs from *Polygnathus* cf. *P. latifossatus* Wirth described herein, in several significant features, as discussed under the latter taxon.

Family POLYGNATHIDAE Bassler, 1925

Genus *Polygnathus* Hinde, 1879

Type species. Polygnathus dubius Hinde, 1879.

Polygnathus ansatus Ziegler and Klapper

Plate 12, figure 28; Plate 15, figures 7, 8

1976 *Polygnathus ansatus* n. sp., Ziegler and Klapper, p. 119–120, Pl. 2, figs. 11–26.
1982 *Polygnathus ansatus* Ziegler and Klapper, Uyeno, p. 73, Pl. 36, figs. 1–12.
1983 *Polygnathus ansatus* Ziegler and Klapper, Klapper and Barrick, p. 1237, Figs. 12L, M, O, P, R–U.
1984 *Polygnathus ansatus* Ziegler and Klapper, Weddige, Pl. 2, fig. 34.
1985 *Polygnathus ansatus* Ziegler and Klapper, Racki, Pl. 3, figs. 2, 7.
1985 *Polygnathus ansatus* Ziegler, Klapper and Johnson, Orchard *in* Austin et al., p. 144, Pl. 4.4, fig. 2.
1987 *Polygnathus ansatus* Ziegler and Klapper, Bultynck, p. 161, Pl. 8, figs. 10–14.
1987 *Polygnathus ansatus* Ziegler and Klapper, García-López, p. 86–88, Pl. 12, figs. 1–13.
1991 *Polygnathus ansatus* Ziegler and Klapper, Uyeno, Pl. 3, fig. 3.

Polygnathus aff. *P. dubius* Hinde *sensu* Chatterton (1979)

Plate 14, figure 32

1979 *Polygnathus* aff. *P. dubius* Hinde, Chatterton, p. 193, Pl. 3, figs. 23–28.

Remarks. The Pine Point form appears to be very close to those described and illustrated by Chatterton (1979). One of the characteristics is the unusually wide carina. Chatterton (ibid., Table 4) reported this species from the upper Nahanni and lower Hare Indian formations, a stratigraphic interval now thought to range from the *kockelianus* to *ensensis* zones (see Uyeno, 1991, Fig. 4).

Polygnathus hemiansatus Bultynck

Plate 12, figures 29, 30

1987 *Polygnathus hemiansatus* n. sp., Bultynck, p. 161–162, Pl. 7, figs. 16–27; Pl. 8, figs. 1–7.
1989 *Polygnathus hemiansatus* Bultynck, Bultynck, p. 99, Pl. 2, figs. 6, 7, 10, 11.
1991 *Polygnathus hemiansatus* Bultynck, Walliser, Pl. 4, figs. 2, 3, 8; Pl. 5, figs. 3–8; Pl. 6, figs. 5–8; Pl. 7, figs. 1, 5–7; Pl. 8, figs. 1, 5–7.

Polygnathus cf. *P. latifossatus* Wirth

Plate 15, figures 23–34

cf. 1967 Übergangsform zwischen *Spathognathodus semialternans* [Wirth] und *Polygnathus latifossata* [Wirth], Wirth, p. 227, Pl. 23, fig. 11, Textfigs. 14c–f.

Remarks. The Pine Point specimens are closest to the form illustrated by Wirth (1967, Textfigs. 14d, e) from Quinto Real in the Spanish western Pyrenees. Features in common include the relatively few number of denticles (about 15 maximum), the narrow platform, and the widely flaring, inverted basal cavity under the anteriormost part of the platform. The other Spanish specimens assigned to this taxon have a free blade that is about twice as long as the platform, and smaller, more numerous denticles (20 or more).

The present collection, mostly from one locality (C-94586), but two additional specimens from another (C-130853), contains a growth series of the Pa element. Throughout its ontogeny, the anterior half of the lower margin, as laterally viewed, remains straight. The posterior half is nearly straight in early stages, and becomes progressively and gently arched. Small nodes occur on low ridges on the posterior half on both lateral sides of the blade in early stages. The ridges develop into an incipient platform with small nodes (Pl. 15, figs. 27, 28), and finally into a narrow platform that is about half of unit length and set with small nodes along the edges (Pl. 15, figs. 33, 34).

A small pit occurs at midlength of the blade, surrounded by an inverted basal cavity that is expanded for a short distance anteriorly, and for a longer distance posteriorly. The cavity has a semicircular outline anteriorly, and narrowly tapers to the anterior tip of the free blade; posteriorly, it abruptly tapers to about mid-position under the platform. The sharp median keel on the lower side of the platform can be traced into the inverted cavity, where it is represented by a thin, shallow groove; the groove continues under the free blade. The basal cavity is relatively large in small specimens, and gradually becomes inverted posteriorly. Posterior to the cavity, the lower surface of the platform on either side of the median keel displays fine ridges owing to this inversion process.

Small forms assigned to *Tortodus* cf. *T. variabilis* herein are superficially similar to *P.* cf. *P. latifossatus* (cf. Pl. 15, figs. 15, 16 and Pl. 15, figs. 31, 32). In the latter, however, the denticles on the anterior half are about the same height, followed posteriorly by

markedly shorter denticles. In *T.* cf. *T. variabilis*, the denticles in the mid-part of the anterior third to half of the blade are the highest, and the lateral profile is similarly arched over the posterior half to two-thirds of the blade.

Polygnathus linguiformis Hinde

Remarks. The Pine Point Formation yielded specimens the form of which may be regarded as morphologically transitional between *P. l. linguiformis* gamma morphotype (of Bultynck, 1970) and *P. parawebbi* Chatterton. A similar form has been observed in collections from the Elm Point Formation of Manitoba (Uyeno, 1982, p. 74).

Polygnathus linguiformis linguiformis Hinde

Plate 12, figures 2, 3, 20; Pl. 14, figs. 12–14

1879 *Polygnathus linguiformis*, Hinde, p. 367, Pl. 17, fig. 15.
1970 *Polygnathus linguiformis linguiformis* Hinde gamma forma nova, Bultynck, p. 126, 127, Pl. 11, figs. 1–6; Pl. 12, figs. 1–6.

Remarks. The gamma morphotype of Bultynck (1970) is considered synonymous with the nominal subspecies (see Weddige, 1977, p. 312–316).

Two specimens (Pl. 14, figs. 12, 13) display a rounded edge on the outer lateral margin, where typically a sharp flange occurs. In the larger specimen, which is considered to be a gerontic form, the tongue has a series of small nodes, slightly aligned transversely, with a trace of a carina.

Polygnathus linguiformis klapperi Clausen, Leuteritz and Ziegler

Plate 13, figures 22–27; Plate 14, figures 1–11

1976 *Polygnathus linguiformis linguiformis* Hinde, epsilon morphotype, Ziegler and Klapper, p. 123–124, Pl. 4, figs. 3, 12, 14, 24.
1978 *Polygnathus linguiformis* "epsilon" Morphotyp sensu Ziegler & Klapper, 1976, Requadt and Weddige, p. 212, Textfigs. 12i, j.
1979 *Polygnathus linguiformis klapperi* n. ssp., Clausen, Leuteritz and Ziegler, p. 32, Pl. 1, figs. 7, 8 (reillustration of Ziegler and Klapper, 1976, Pl. 4, figs. 14, 24).
1979 *Polygnathus linguiformis linguiformis* Hinde epsilon morphotype Ziegler and Klapper, 1976, Savage and Amundson, Pl. 1, figs. 19–24.
1982 *Polygnathus linguiformis linguiformis* Hinde, epsilon morphotype of Ziegler and Klapper (1976), Uyeno, p. 74–75, Pl. 34, figs. 20–22; Pl. 35, figs. 13–15.
1983b *Polygnathus linguiformis linguiformis* Hinde epsilon morphotype, Wang and Ziegler, Pl. 7, fig. 24 (only).
1983 *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler, Klug, p. 90, Textfigs. 11R–T (synonymy).
1985 *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler, Orchard *in* Austin et al., p. 142, Pl. 4.3, figs. 7, 8.
1985 *Polygnathus linguiformis linguiformis* Hinde epsilon morphotype *sensu* Ziegler and Klapper (1976), Olivieri, p. 303, Pl. 2, fig. 22.
1987 *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler, Fuchs, Pl. 11, figs. 7, 8.
1987 *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler, García-López, p. 92–93, Pl. 13, figs. 11, 12.

Remarks. This subspecies, as currently understood, takes in a wide variety of forms. The underlying characteristics are the relatively flat platform and the tongue extending posteriorly and downward so that the outer, posterior platform margin forms a smooth arc. The tongue may be constricted and the outer margin is more sinuous in such specimens. The development of the tongue is also rather variable, ranging from short and constricted (Pl. 13, fig. 24) to broad and long (Pl. 13, fig. 22). A form transitional to *P. l. mucronatus* Wittekindt is present (Pl. 14, fig. 4), but differs from the latter in its more flattened platform.

The Pine Point material contains an ontogenetic series. The earliest forms have an abbreviated platform with carina, consisting of high denticles, extending beyond it (Pl. 14, figs. 5, 11). The transverse ridges on the tongue commence shortly after this initial stage (Pl. 14, figs. 6, 10).

A single specimen (Pl. 11, figs. 21, 22) from the Pine Point Formation appears to be morphologically transitional between *P. l. linguiformis* iota morphotype of Klapper (*in* Johnson et al., 1980, Pl. 4, figs. 6–8) and *P. l. klapperi*. Like the iota morphotype, it has an abbreviated flat platform with a narrow tongue, a large pit, and a high free blade and carina. In contrast to that morphotype, however, the tongue is wider and does not have a trace of carina as nodes, and the upper

surface of the platform has coarser transverse ridges along its lateral margins. In these features, the form appears to approach *P. l. klapperi*.

Polygnathus linguiformis mucronatus Wittekindt

Plate 13, figures 17–21

1966 *Polygnathus linguiformis mucronata* n. subsp., Wittekindt, p. 636, Pl. 2, figs. 13–15.
1976 *Polygnathus linguiformis linguiformis* Hinde, zeta morphotype, Ziegler and Klapper, p. 124, Pl. 4, figs. 20, 21.
1977 *Polygnathus linguiformis linguiformis* Hinde, zeta morphotype, Klapper *in* Ziegler (ed.), p. 465, *Polygnathus* Pl. 10, figs. 4, 7, 8 (synonymy).
1980 *Polygnathus linguiformis mucronatus* Wittekindt, Bultynck and Hollard, p. 44, Pl. 7, figs. 12, 13.
1985 *Polygnathus linguiformis mucronata* Wittekindt, Orchard *in* Austin et al., p. 146, Pl. 4.4, fig. 17.
1985 *Polygnathus linguiformis mucronatus* Wittekindt, Olivieri, p. 303–304, Pl. 2, fig. 16 (synonymy).
1987 *Polygnathus linguiformis mucronatus* Wittekindt, Bultynck, Pl. 9, fig. 22.

Polygnathus linguiformis transversus Wittekindt

Plate 13, figures 1–6

1966 *Polygnathus linguiformis transversa* n. subsp., Wittekindt, p. 636–637, Pl. 2, figs. 16–18.
1976 *Polygnathus linguiformis linguiformis* Hinde, eta morphotype, Ziegler and Klapper, p. 124, Pl. 4, fig. 25.
1977 *Polygnathus linguiformis linguiformis* Hinde, eta morphotype, Klapper *in* Ziegler (ed.), p. 465, *Polygnathus* Pl. 10, fig. 6.
1987 *Polygnathus linguiformis transversus* Wittekindt, Bultynck, Pl. 9, fig. 19.

Remarks. One illustrated specimen (Pl. 13, fig. 1) may represent a gerontic form of this subspecies. The anterior part of the platform bears traces of two converging rostral ridges, one on each side of the carina. The upper platform surface has a series of parallel ridges arranged nearly perpendicular to the carina.

Polygnathus linguiformis weddigei Clausen, Leuteritz and Ziegler

Plate 13, figures 14–16

1976 *Polygnathus linguiformis linguiformis* Hinde, delta morphotype, Ziegler and Klapper, p. 123, Pl. 4, figs. 4–8.
1978 *Polygnathus linguiformis* "delta"-Morphotyp sensu Ziegler & Klapper, 1976, Requadt and Weddige, p. 211, Textfigs. 12a, b.
1979 *Polygnathus linguiformis weddigei* n. ssp., Clausen, Leuteritz and Ziegler, p. 30–31, Pl. 1, figs. 4, 9–12 [reillustration of Ziegler and Klapper, 1976].
1980 *Polygnathus ling. linguiformis* Hinde delta MT, Schönlaub, Pl. 9, figs. 18, 19.
1983 *Polygnathus linguiformis weddigei* Clausen, Leuteritz, and Ziegler, Klug, p. 90, 108, Textfigs. 11L–N (synonymy).
1985 *Polygnathus linguiformis weddigei* Clausen, Leuteritz and Ziegler, Orchard *in* Austin et al., p. 144, Pl. 4.4, fig. 5 [only; fig. 6 = *P. linguiformis klapperi* Clausen, Leuteritz and Ziegler?]
1985 *Polygnathus linguiformis linguiformis* Hinde, delta morphotype *sensu* Ziegler and Klapper, 1976, Olivieri, p. 303, Pl. 2, figs. 12, 13 (synonymy).
1987 *Polygnathus linguiformis weddigei* Clausen, Leuteritz and Ziegler, Bultynck, Pl. 8, figs. 25, 26.
1987 *Polygnathus linguiformis weddigei* Clausen, Leuteritz and Ziegler, Fuchs, Pl. 11, fig. 6 (only).

Remarks. The inner platform margin of this subspecies is typically straight. One Pine Point specimen (Pl. 13, fig. 14), however, exhibits a wider, convex inner platform margin near the anterior end.

Polygnathus linguiformis Hinde predelta morphotype

Plate 12, figure 1; Plate 13, figures 7–13

1976 *Polygnathus linguiformis linguiformis* Hinde cf. delta morphotype, Ziegler and Klapper, p. 123, Pl. 4, figs. 1, 2.

Remarks. As noted by Ziegler and Klapper (*in* Ziegler et al., 1976, p. 123), this morphotype with its short, high free blade, is similar to *P. kluepfeli* Wittekindt.

The latter differs from the delta morphotype (=*P. linguiformis weddigei* Clausen, Leuteritz and Ziegler) by its triangular, outer platform margin and a platform with its widest part located more anteriorly.

The Pine Point material contains forms that appear to be transitional between predelta and delta morphotypes (Pl. 13, figs. 8, 9, 13). The anterior part of the outer platform margin of the predelta morphotype is rounded, whereas in the delta morphotype this part is parallel to the carina and free blade; in the transitional form it is intermediate, so that the widest part of the platform is located correspondingly more posteriorly than in predelta. The pit in the illustrated transitional form is large and situated at the anterior end of the platform, whereas it is small and located more posteriorly in predelta; this is not a consistent feature, however.

The carina in predelta typically reaches the posterior end. In one specimen (Pl. 13, fig. 12), it is represented by nodes flanked by transverse ridges at the posterior tip of the platform.

Polygnathus parawebbi Chatterton

Plate 11, figures 1–3, 15, 16, 19; Plate 12, figures 6, 10–12, 24, 27; Plate 14, figures 15–18

1974 *Polygnathus parawebbi* n. sp., Chatterton, p. 1473–1474, 1476, 1478, Pl. 1, figs. 12, 15–19, 25–27; Pl. 2, figs. 1–9; Pl. 3, fig. 15.
1979 *Polygnathus parawebbi* Chatterton, Savage and Amundson, Pl. 1, figs. 30–33.
1982 *Polygnathus parawebbi* Chatterton, Harris *in* Hose et al., Pl. 7, figs. 20, 21; Pl. 8, figs. 1, 2.
1982 *Polygnathus parawebbi* Chatterton, Uyeno, p. 75, Pl. 31, figs. 20–22, 26–29, 32–35; Pl. 33, figs. 8, 13–15.
1983 *Polygnathus parawebbi* Chatterton, Klapper and Barrick, p. 1239–1240, Figs. 12Q, W, X, AA (synonymy).
1983 *Polygnathus* cf. *P. parawebbi* Chatterton, Sparling, p. 855, Figs. 10AP–AR.
(?)1987 *Polygnathus parawebbi* Chatterton, Bultynck, Pl. 9, fig. 14 [=*P. linguiformis linguiformis* Hinde?]
1991 *Polygnathus parawebbi* Chatterton, Uyeno, p. 144, Pl. 3, fig. 14.

Remarks. Although the specimens (Pl. 11, figs. 1–3) from the Chinchaga Formation that are assigned to this species have the free blade missing, the remaining platform suggests the assignment.

Chatterton (1979) recognized three morphotypes within *P. parawebbi*, designated alpha, beta, and gamma. The first two were distinguished mainly by the outline of the outer platform margin, whereas the last-named was characterized as having a rostral ridge on the outer platform. All three morphotypes occur in the Keg River and Pine Point formations, while only the beta morphotype was recovered from the Chinchaga Formation. Gagiev and Rodygin (1988) reported the alpha morphotype from the Middle *varcus* Subzone, the beta morphotype from the *australis* Zone to Lower *varcus* Subzone, and the gamma morphotype from the *kockelianus* Zone, in deposits at Salair and northeastern Russia.

The gamma morphotype recorded herein is most similar to those reported by Uyeno (1982, Pl. 31, figs. 20–22) from the Elm Point Formation in Manitoba, and by Chatterton (1979, p. 197, Pl. 4, figs. 5–7) from the uppermost Nahanni or Hume Formation. The latter author suggested that it may have biostratigraphic value owing to its rather restricted range. In current usage, the Elm Point Formation, with the exception of its lower part, and the uppermost Nahanni and Hume formations are assignable to the *ensensis* Zone (see Klapper and Johnson, 1980, p. 410, 413; Witzke et al., 1989, Fig. 15, p. 248).

Polygnathus pseudofoliatus Wittekindt

Plate 11, figures 11, 20; Plate 12, figures 5, 13–15; Plate 14, figures 19–21

1966 *Polygnathus pseudofoliata* n. sp., Wittekindt, p. 637–638, Pl. 2, figs. 20–23.
1982 *Polygnathus pseudofoliatus* Wittekindt, Uyeno, p. 76, Pl. 31, fig. 1.
1983 *Polygnathus pseudofoliatus* Wittekindt, Sparling, p. 855–856, Figs. 11S, T, AD, AE; 12K–M; 13X, Y, AK, AL (synonymy).
1983 *Polygnathus pseudofoliatus* Wittekindt, Klug, p. 108, Figs. 10M–R (synonymy).
1983b *Polygnathus pseudofoliatus* Wittekindt, Wang and Ziegler, Pl. 6, figs. 14, 15.
1986 *Polygnathus pseudofoliatus* Wittekindt, Bultynck, Pl. 7, fig. 13.
1986 *Polygnathus pseudofoliatus* Wittekindt, Schönlaub, Pl. 5, fig. 4 (only).
1986 *Polygnathus pseudofoliatus* Wittekindt, Bardashev and Ziegler, Pl. 1, figs. 22, 23.
1987 *Polygnathus pseudofoliatus* Wittekindt, Bultynck, Pl. 8, figs. 19, 20.
1989 *Polygnathus pseudofoliatus* Wittekindt, Bultynck, Pl. 2, figs. 1, 2.

1991 *Po. pseudofoliatus* Wittekindt, Walliser, Pl. 1, figs. 1–5; Pl. 2, figs. 2, 9; Pl. 7, figs. 3, 8, 9.
1991 *Polygnathus pseudofoliatus* Wittekindt, Uyeno, Pl. 2, fig. 24.

Remarks. Walliser (1991, Pl. 7, figs. 3, 8, 9) included within this species those forms with long, parallel anterior margins of the platform, and designated them as late morphotypes. Such forms are also present in the Pine Point Formation (Pl. 2, fig. 13).

Klapper (*in* Johnson et al., 1980, p. 103) regarded those Antelope Range specimens that have serrated anterior margins and down-arched posterior platform, but also a posteriorly-expanded outer platform outline, as transitional between *P. pseudofoliatus* and *P. xylus ensensis* Ziegler and Klapper. Such transitional forms are also present in the Pine Point Formation (Pl. 11, fig. 20; Pl. 14, figs. 21, 22). The specimen illustrated by Orchard (*in* Austin et al., 1985, Pl. 4.3, fig. 13) may also be a transitional form.

Polygnathus timorensis Klapper, Philip and Jackson

Plate 12, figures 18, 19; Plate 15, figures 3–6

1970 *Polygnathus timorensis* sp. nov., Klapper, Philip and Jackson, p. 655–656, Pl. 1, figs. 1–3, 7–10.
1983 *Polygnathus timorensis* Klapper, Philip and Jackson, Klug, p. 108, Figs. 11I–K (synonymy).
1985 *Polygnathus timorensis* Klapper, Philip and Jackson, Orchard *in* Austin et al., p. 144, Pl. 4.4, fig. 3.
1987 *Polygnathus timorensis* Klapper, Philip and Jackson, Bultynck, p. 162, Pl. 7, figs. 9–12 (synonymy).
1991 *Polygnathus timorensis* Klapper, Philip and Jackson, Uyeno, Pl. 3, fig. 3.

Polygnathus xylus Stauffer

Polygnathus xylus xylus Stauffer

1940 *Polygnathus xylus* n. sp., Stauffer, p. 430–431, Pl. 60. figs. 54, 66, 72–74.
1976 *Polygnathus xylus xylus* Stauffer, Ziegler and Klapper, p. 125, Pl. 3, fig. 1 (synonymy).
1982 *Polygnathus xylus xylus* Stauffer, Uyeno, Pl. 33, figs. 1–3, Pl. 34. figs. 1–5, Pl. 36, figs. 13–15, Pl. 38, figs. 11–13.
1991 *Polygnathus xylus xylus* Stauffer, Uyeno, Pl. 3, fig. 4.
1993 *Polygnathus xylus xylus* Stauffer, Racki, Figs. 31A, N.

Polygnathus xylus ensensis Ziegler and Klapper

Plate 12, figures 4, 16; Plate 14, figures 23–31; Plate 15, figures 1, 2

1976 *Polygnathus xylus ensensis* n. subsp., Ziegler and Klapper, p. 125–127, Pl. 3, figs. 4–9.
1983b *Polygnathus xylus ensensis* Ziegler and Klapper, Wang and Ziegler, Pl. 7, figs. 14, 15.
1985 *Polygnathus xilus* [*sic*] *ensensis* Ziegler and Klapper, Olivieri, p. 305, Pl. 2, fig. 7 (only) (synonymy).
1985 *Polygnathus xylus ensensis* Ziegler, Klapper and Johnson, Orchard *in* Austin et al., p. 142, Pl. 4.3, fig. 12.
1986 *Polygnathus xylus ensensis* Ziegler and Klapper, Ziegler and Wang, Pl. 1, fig. 24.
1986 *Polygnathus x. ensensis* Ziegler, Klapper and Johnson, Bardashev and Ziegler, Pl. 1, fig. 24.
1986 *Polygnathus xylus ensensis* Weddige, Schönlaub, Pl. 5, figs. 34–37.
1987 *Polygnathus ensensis* Ziegler and Klapper, Bultynck, p. 161, Pl. 7, figs. 1–6.
1989 *Polygnathus ensensis* Ziegler and Klapper, Bultynck, p. 97, 99, Pl. 2, figs. 12–21.
1991 *Po. ensensis* group, Walliser, Pl. 3, figs. 1, 4–6, 10, 12 (only).

Remarks. Most of the Pine Point specimens included in this subspecies have parallel platform margins in the anterior one-third that gently widen posteriorly. The serration pattern on the anterior platform margin appears to hold no particular stratigraphic order; a similar suggestion was made by Bultynck (1989, p. 99). A few specimens (Pl. 14, figs. 29–31) have platform lateral margins that are parallel throughout, a feature more in common with the nominate subspecies. In other respects, such as serration and downward arching of the posterior part of the platform, they are characteristic of *P. xylus ensensis*.

A form morphologically transitional between *P. xylus ensensis* and *P. timorensis* was recovered from the Pine Point Formation (Pl. 15, figs. 1, 2). It exhibits a slender platform more characteristic of *P. timorensis*, and serration at the geniculation points and steeply declining anterior trough margins that are traits of *P. xylus ensensis*.

?Order PANDERODONTIDA Sweet, 1988

?Superfamily CORDYLODONTACEA Lindström, 1970

?Family FRYXELLODONTIDAE Miller, 1981

Genus *Pseudooneotodus* Drygant, 1974

Type species. Oneotodus? beckmanni Bischoff and Sannemann, 1958.

Remarks. If the generic assignment of the Pine Point forms is correct, the range of *Pseudooneotodus*, earlier suggested to be Llandovery (Early Silurian) to Early Devonian (Barrick, 1977, p. 57), is extended to the Givetian.

Two morphological types were recovered, although they are similar in their size, position of basal cavity, and in their near bilateral symmetry. The lack of an obvious symmetry transition series precludes the application of locational notation (see also Barrick, 1977). The morphotypes are unnamed and designated as morphotypes A and B.

Pseudooneotodus sp.

Plate 16, figures 22–27, 32–35

Description. Morphotype A (Pl. 16, figs. 32–35). The squat conical element is bilaterally symmetrical, with the line of symmetry lying in the postero-anterior plane. The unit, which is finely striated throughout, is convexo-concave in lateral view. The cavity extends to the tip of the cusp and the element is hyaline. The inner face is essentially smooth; the outer face displays a semicircular ridge which arcs from the base at the lateral edges to about midheight of the face. Below the ridge, the face is shallowly concave and slightly more coarsely striate. Lateral ridges run from the base to the tip of the cusp. In lower view, the basal margin forms a roughly semicicular outline. In some specimens, the basal attachment material is preserved.

Morphotype B (Pl. 16, figs. 22–25). This form is similar to morphotype A in most aspects. The principal difference is the oval to circular basal margin and the lack of lateral ridges. There is a ridge, however, that encircles the cone and which is at a slightly higher position on the outer side and, in this respect, in outer views the two morphotypes are similar. The area below the ridge is similarly more coarsely striate. A form that is similar but is consistently smaller and more slender is herein referred to as the "slim variety" (Pl. 16, figs. 26, 27).

Remarks. Morphotype B is most similar to the single-denticle, squat conical element of *Pseudooneotodus bicornis* Drygant (see Barrick, 1977, Pl. 2, fig. 19; Uyeno and Barnes, 1983, Pl. 3, figs. 25, 26, 28). It is not referred to that species, however, since it is not found associated with a two-denticle squat conical element, and there is a considerable stratigraphic gap between them.

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APPENDIX 1

List of samples from the Pine Point Formation

The following is a list of samples from stratigraphic units other than the Fine-grained dolostone and Bituminous limestone members of the Pine Point Formation, that were processed for conodonts in this study. Figures in parentheses are numbers of specimens recovered. Unless otherwise noted, stratigraphic and geographic information of the localities is given in the accompanying part by A.W. Norris, under "Appendix 1: Locality register". For information on samples from the Pine Point Formation, refer to Table 1.

CHINCHAGA FORMATION

GSC loc. C-94730. Stn. 98NB, Field no. 98NBa, weight of sample = 0.8 kg; base of outcrop
indeterminate conodont fragments only

GSC loc. C-94733. Stn. 98NB, Field no. 98NBd, weight of sample = 0.8 kg; 1 m above base of outcrop
Polygnathus parawebbi beta morphotype: Pa(2)

GSC loc. C-94735. Stn. 98NB, Field no. 98NBf, weight of sample = 0.8 kg; 1.5 m above base of outcrop
indeterminate conodont fragments only

GSC loc. C-94737. Stn. 98NB, Field no. 98NBh, weight of sample = 0.9 kg; 12.87 m above base of outcrop
Icriodus orri: I(3)
Icriodus cf. *I.* sp. A of Uyeno (1982): I(4)
Ozarkodina raaschi: Pa(3), Pb(2), Sa(1), fragmentary ramiforms
Polygnathus parawebbi beta morphotype: Pa(4)
Dvorakia sp. (2)
Panderodus sp. (18)

KEG RIVER FORMATION

GSC loc. C-94401. Stn. 1NB, Field no. 1NBa, weight of sample = 1.3 kg; approximately 5.0 to 5.1 m above base of formation
Polygnathus linguiformis linguiformis: Pa(2)
Polygnathus parawebbi alpha morphotype: Pa(3), and gamma morphotype: Pa(1)
Belodella sp. (1)
Coelocerodontus? sp. (2)
Dvorakia sp. (1)
Panderodus sp. (2)
unassigned element: M(1)

GSC loc. C-94403. Stn. 1NB, Field no. 1NBc, weight of sample = 2.0 kg; approximately 6.08 to 6.18 m above base of formation
Icriodus orri: I(1)
Polygnathus linguiformis linguiformis: Pa(3)
Polygnathus parawebbi alpha morphotype: Pa(1), and gamma morphotype: Pa(1)
Polygnathus pseudofoliatus: Pa(1)
Ozarkodina? sp. (2 fragmentary spathognathodiform elements)
Belodella sp. (6)
Coelocerodontus? sp. (3)
Dvorakia sp. (4)
unassigned elements: M(2), Sb(1), Sc?(1)

GSC loc. C-94405. Stn. 1NB, Field no. 1NBe, weight of sample = 1.3 kg; approximately 6.90 to 6.95 m above base of formation
Polygnathus linguiformis linguiformis: Pa(1)
Polygnathus parawebbi alpha morphotype: Pa(1)
Belodella sp. (2)
Coelocerodontus? sp. (1)
Dvorakia sp. (2)
unassigned element: Sb(1)

GSC loc. C-94407. Stn. 2NB, Field no. 2NBa, weight of sample = 1.2 kg; approximately 9.23 to 9.35 m above base of formation
Icriodus sp. indet.: I(1)
Ozarkodina cf. *O. raaschi*: Pb?(2)
Polygnathus parawebbi beta morphotype: Pa(1), and gamma morphotype: Pa(1)
Coelocerodontus? sp. (1)
Dvorakia sp. (3)
Panderodus sp. (6)

GSC loc. C-94499. Stn. 30NB, Field no. 30NBa, weight of sample = 1.7 kg; loose sample
Icriodus sp. A of Uyeno (1982) → *I. orri*: I(4)
Polygnathus parawebbi alpha morphotype: Pa(1), and beta morphotype: Pa(1)
unassigned element: M(1)

WINDY POINT MEMBER, SULPHUR POINT FORMATION

GSC loc. C-94439. Stn. 13NB, Field no. 13NBa, weight of sample = 1.7 kg; loose sample
a single indeterminate fragment

GSC loc. C-94441. Stn. 14NB, Field no. 14NBb, weight of sample = 2.1 kg; loose sample
Panderodus sp. (2)
indeterminate ramiform fragments

GSC loc. C-126452. Stn. 1NB(1985), Field no. 1NBb, weight of sample = 1.3 kg; loose sample
Panderodus sp. (1)

WATT MOUNTAIN FORMATION

GSC loc. C-94434. Stn. 12NB, Field no. 12NBa, weight of sample = 1.2 kg; 31.3 m above base of formation
Ozarkodina brevis: Pa(2)
unassigned elements: Sb(1), M(1)

GSC loc. C-94436. Stn. 12NB, Field no. 12NBc, weight of sample = 1.1 kg; southeast of Station 11NB, 60°55′25″N, 114°46′10″W; 31.7 m above base of formation
no conodonts recovered

GSC loc. C-94430. Stn. 11NB, Field no. 11NBa, weight of sample = 1.4 kg; southeast of Station 10NB, 60°55′40″N, 114°46′45″W; 32.1 m above base of formation
no conodonts recovered

GSC loc. C-94432. Stn. 11NB, Field no. 11NBc, weight of sample = 1.0 kg; southeast of Station 10NB, 60°55′40″N, 114°46′45″W; 32.2 m above base of formation
no conodonts recovered

GSC loc. C-94424. Stn. 9NB, Field no. 9NBb, weight of sample = 1.1 kg; approximately 32.3 m above base of formation
Icriodus subterminus: I(3), S_{2a} (3)
Ozarkodina brevis: Pa(1)

GSC loc. C-94426. Stn. 10NB, Field no. 10NBa, weight of sample = 1.0 kg; immediately east of Station 9NB, 60°55′55″N, 114°47′10″W; 32.3 m above base of formation
no conodonts recovered

GSC loc. C-94428. Stn. 10NB, Field no. 10NBc, weight of sample = 1.0 kg; immediately east of Station 9NB, 60°55′55″N, 114°47′10″W; 32.4 m above base of formation
no conodonts recovered

GSC loc. C-94420. Stn. 7NB, Field no. 7NBc, weight of sample = 1.4 kg; approximately 32.8 m above base of formation
Ozarkodina brevis: Pa(1), Sb(1)
unassigned elements: Sb(1), simple cone (1)

GSC loc. C-94421. Stn. 8NB, Field no. 8NBa, weight of sample = 1.6 kg; immediately east of Station 7NB, 60°55′55″N, 114°47′30″W; 34.9 m above base of formation
no conodonts recovered

SLAVE POINT FORMATION

GSC loc. C-94415. Stn. 5NB, Field no. 5NBd, weight of sample = 2.0 kg; approximately 2.25 miles east of Breynat Point, 60°54′10″N, 114°55′00″W; approximately 6.8 m above base of formation
no conodonts recovered

GSC loc. C-94417. Stn. 6NB, Field no. 6NBb, weight of sample = 2.0 kg; approximately 1.5 miles east of Breynat Point, 60°53′55″N, 114°56′00″W; approximately 13.7 m above base of formation
no conodonts recovered

APPENDIX 2

Comparative material illustrated in this publication

WATERWAYS FORMATION

The following localities, with the exception of O-62695, are cited in Norris and Uyeno (1981, Figs. 3, 4, p. 10, 11), to which the reader is referred for additional information.

GSC loc. C-74190. Field no. 20NBa, East bank of Birch River, northeastern Alberta, 58°19′12″N, 113°07′55″W, 16.65 to 16.75 m above base of Waterways outcrops; Unit IV

GSC loc. C-74194. Field no. 21NBb, East bank of Birch River, northeastern Alberta, 58°18′57″N, 113°07′55″W, 18.45 to 18.55 m above base of Waterways outcrops; Unit VI

GSC loc. C-74199. Field no. 23NBa, South bank of Birch River, northeastern Alberta, 58°18′29″N, 113°06′30″W, 19.95 to 20.05 m above base of Waterways outcrops; Unit VI

GSC loc. C-74182. Field no. 17NBa, South bank of Birch River, northeastern Alberta, 58°18′20″N, 113°09′00″W, 21.65 to 21.75 m above base of Waterways outcrops; Unit VII

GSC loc. O-62695. Athabasca River, northeastern Alberta, west bank, 0.6 mile (1 km) downstream from Fort MacKay Settlement (see Uyeno, 1974, p. 52, Table 4(a)), Moberly Member, Waterways Formation, Station 92, Rock unit 37, 29.8–31.8 ft (10.2–10.9 m) above river level

WINNIPEGOSIS FORMATION

GSC loc. C-29046. Station 2NB-73, weight of sample = 2.0 kg, Manitoba Hydro Quarry located 2.25 km east of The Narrows, south-central Manitoba, NW13-14-24-10WPM (see Norris et al., 1982, p. 33, Station 508NB; Chart 7, p. 249), in southwest corner and near top of quarry.

Ozarkodina brevis (Bischoff and Ziegler): Pa(10), Pb(6), M(7), Sa(7), Sb(9), Sb-Sc(7), Sc(8) [note: i) illustrated in Uyeno, 1982, Pl. 32, figs. 29–38; ii) Klapper and Barrick (1983, p. 1234) considered Sb as one kind of Sc, and Sb-Sc transitional as Sb]

Polygnathus parawebbi Chatterton: Pa(7, all beta morphotype), M(1), Sb(1), Sc(2) [note: illustrated in Uyeno, 1982, Pl. 33, figs. 8, 13–15]

Belodella sp. (40)

Coelocerodontus? sp. (3)

unassigned element: scolopodontan (1)

HORN PLATEAU FORMATION

GSC loc. C-28091. weight of sample = 4.8 kg, Northeastern periphery, Horn Plateau Reef, 62°08.2′N, 117°39′W, District of Mackenzie

"Organic biolithite microfacies" of Vopni and Lerbekmo (1972)

The following conodont taxa were recovered: (note: the number of specimens recovered was not recorded)

Icriodus cf. *I. brevis* Stauffer

Ozarkodina brevis (Bischoff and Ziegler)

Polygnathus linguiformis klapperi Clausen, Leuteritz and Ziegler

RAMPARTS FORMATION

GSC loc. C-3881. Powell Creek, 65°16′30″N, 128°46′W, western District of Mackenzie (see Uyeno, 1979, Table 1), 13.1–14.6 m above base of formation

SOURIS RIVER FORMATION

'First Red Beds' member (but may perhaps belong to the lower parts of the overlying Member B, 'Argillaceous limestone beds')

GSC loc. C-29053. Stn. 6NB-73, Field no. 6NB1, weight of sample = 2 kg

Immediately west of Highway 10, approximately 1 km south of Red Deer River crossing, south-central Manitoba. This locality is listed in Norris et al. (1982, p. 65, same loc. as M-13-71 drillhole; Chart 9, p. 254), to which the reader is referred for additional information.

Icriodus subterminus Youngquist: I(9)

Ozarkodina brevis (Bischoff and Ziegler): Pa(4)

Polygnathus angustidiscus Youngquist: Pa(5)

unassigned elements: M(2), Sa(1)

PLATES 11–18

PLATE 11

Conodonts from the Chinchaga Formation (Figs. 1–10), Keg River Formation (Figs. 11–18) (see Appendix for detailed locations) and the Bituminous limestone member (Figs. 19–30) of the Pine Point Formation (*ensensis* Zone)

Figures 1–3. *Polygnathus parawebbi* Chatterton, beta morphotype of Chatterton (1979)

1, 2. GSC 105946 and 105947, upper view of two Pa elements (x61 and x70), GSC loc. C-94733.

3. GSC 105948, upper view of Pa element (x76), GSC loc. C-94737.

Figures 4, 5. *Icriodus* cf. *I.* sp. A of Uyeno (1982)

GSC 105949, upper and lateral views of I element (x76), GSC loc. C-94737.

Figures 6, 7. *Icriodus orri* Klapper and Barrick

GSC 105950, lower and upper views of I element (x73), GSC loc. C-94737.

Figures 8–10. *Ozarkodina raaschi* Klapper and Barrick

8, 10. GSC 105951 and 105952, lateral view of two Pa elements (x188 and x111).

9. GSC 105953, lateral view of Pb element (x111), all from GSC loc. C-94737.

Figure 11. *Polygnathus pseudofoliatus* Wittekindt

GSC 105954, upper view of Pa element (x54), GSC loc. C-94403.

Figure 12. *Icriodus orri* Klapper and Barrick

GSC 105955, upper view of I element (x102), GSC loc. C-94403.

Figures 13, 14. *Icriodus* sp. A of Uyeno (1982) (transitional to *Icriodus orri* Klapper and Barrick)

GSC 105956, upper and lower views of I element (x73), GSC loc. C-94499.

Figures 15, 16. *Polygnathus parawebbi* Chatterton, gamma morphotype of Chatterton (1979)

GSC 105957 and 105958, upper view of two Pa elements (x80 and x58), GSC locs. C-94401 and C-94403, respectively.

Figures 17, 18. *Ozarkodina* cf. *O. raaschi* Klapper and Barrick

GSC 105959 and 105960, lateral view of two Pb(?) elements (x140 and x210), GSC loc. C-94407.

Figure 19. *Polygnathus parawebbi* Chatterton, alpha morphotype of Chatterton (1979)

GSC 105961, oblique lateral view of Pa element (x33), GSC loc. C-94569, Field no. 56NBa, 5.20–5.30 m above base of member.

Figure 20. *Polygnathus pseudofoliatus* Wittekindt (transitional to *P. xylus ensensis* Ziegler and Klapper)

GSC 105962, upper view of Pa element (x36), GSC loc. C-94567, Field no. 55NBa, 5.80–5.90 m above base of member.

Figures 21, 22. *Polygnathus linguiformis linguiformis* Hinde, iota morphotype of Klapper (*in* Johnson et al., 1980) (transitional to *P. l. klapperi* Clausen, Leuteritz and Ziegler)

GSC 105963, upper and oblique lateral views of Pa element (x26), GSC loc. C-94567, Field no. 55NBa, 5.80–5.90 m above base of member.

Figures 23, 29, 30. *Tortodus* cf. *T. variabilis* (Bischoff and Ziegler)

23, 29. GSC 105964 and 105965, lateral view of two Pa elements (x30 and x33), GSC loc. C-94569, Field no. 56NBa, 5.20–5.30 m above base of member.

30. GSC 105966, lateral view of Pa element (x35), GSC loc. C-94567, Field no. 55NBa, 5.80–5.90 m above base of member.

Figures 24–27. *Icriodus* cf. *I. lindensis* Weddige

GSC 105967 and 105968, lateral and upper views of two I elements (x96 and x89), GSC loc. C-94573, Field no. 58NBa, 0.0–0.15 m above base of member.

Figure 28. *Polygnathus linguiformis* cf. *P. l. klapperi* Clausen, Leuteritz and Ziegler

GSC 105969, upper view of Pa element (x26), GSC loc. C-94565, Field no. 54NBa, 6.55–6.65 m above base of member.

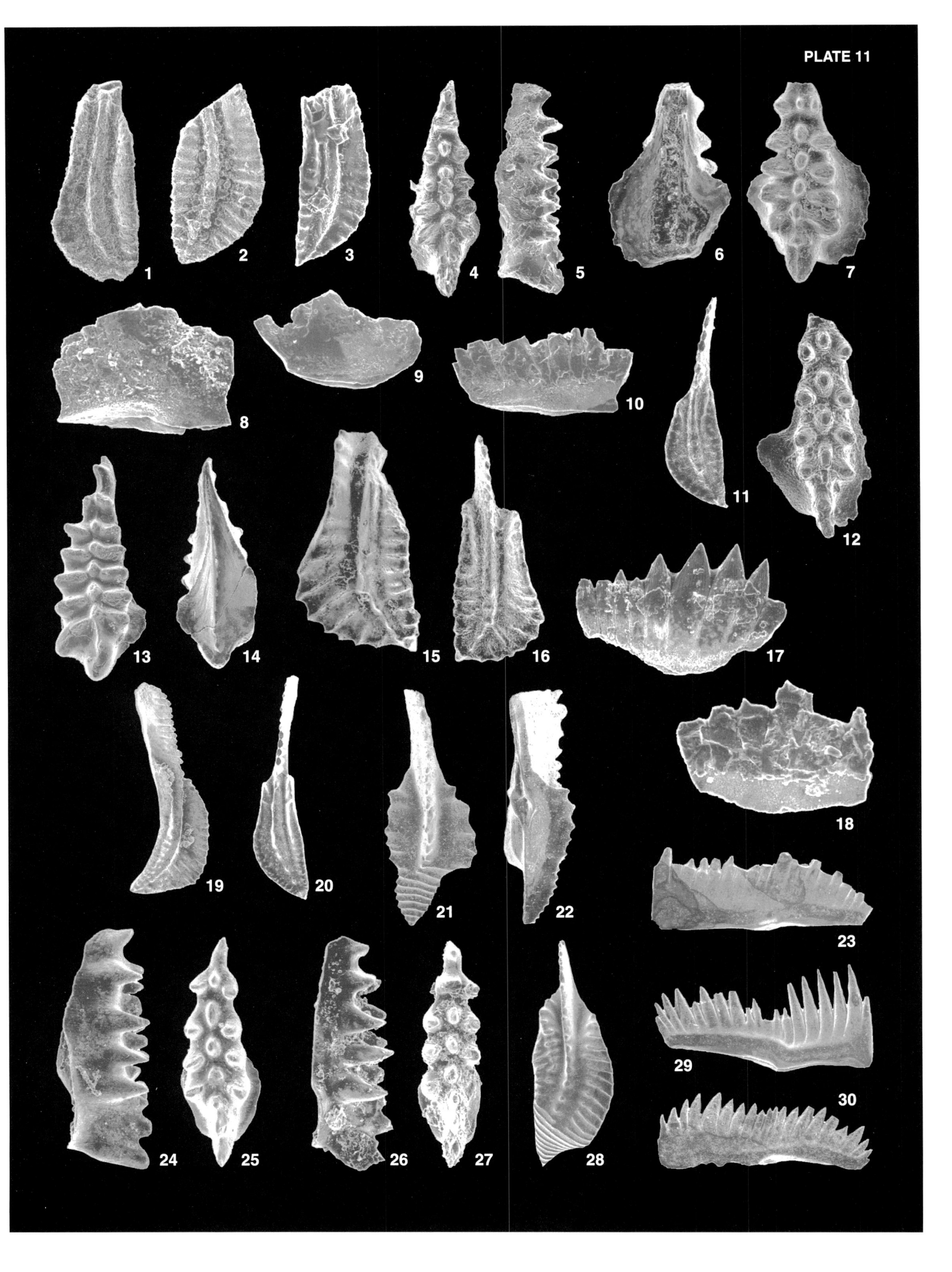
PLATE 11
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PLATE 12

Conodonts from the Bituminous limestone member of the Pine Point Formation. Those illustrated in Figures 1–12 from the *ensensis* Zone, in Figures 13–27 from the Lower *varcus* Subzone, and in Figures 28–30 from the Middle *varcus* Subzone

Figure 1. *Polygnathus linguiformis* Hinde predelta morphotype

GSC 105970, upper view of Pa element (x61), GSC loc. C-94565, Field no. 54NBa, 6.55–6.65 m above base of member.

Figures 2, 3. *Polygnathus linguiformis linguiformis* Hinde

2. GSC 105971, upper view of Pa element (x22), GSC loc. C-94565, Field no. 54NBa, 6.55–6.65 m above base of member.

3. GSC 105972, upper view of Pa element (x38), GSC loc. C-94563, Field no. 53NBa, 7.37–7.50 m above base of member.

Figure 4. *Polygnathus xylus ensensis* Ziegler and Klapper

GSC 105973, upper view of Pa element (x42), GSC loc. C-94563, Field no. 53NBa, 7.37–7.50 m above base of member.

Figure 5. *Polygnathus pseudofoliatus* Wittekindt

GSC 105974, oblique upper view of Pa element (x41), GSC loc. C-94551, Field no. 49NBa, 7.42–7.55 m above base of member.

Figure 6. *Polygnathus parawebbi* Chatterton gamma morphotype of Chatterton (1979)

GSC 105975, oblique upper view of Pa element (x37), GSC loc. C-94444, Field no. 16NBa, 7.45–7.66 m above base of member.

Figure 7. *Icriodus orri* Barrick and Klapper

GSC 105976, upper view of I element (x55), GSC loc. C-94444, Field no. 16NBa, 7.45–7.66 m above base of member.

Figures 8, 9. *Ozarkodina brevis* (Bischoff and Ziegler)

GSC 105977 and 105978, lateral view of Pa and Pb elements (both x99), GSC loc. C-94553, Field no. 50NBa, 7.45–7.55 m above base of member.

Figures 10–12. *Polygnathus parawebbi* Chatterton gamma morphotype of Chatterton (1979)

10. GSC 105979, upper view of Pa element (x48), GSC loc. C-94553, Field no. 50NBa, 7.45–7.55 m above base of member.

11. GSC 105980, upper view of Pa element (x57), GSC loc. C-94551, Field no. 49NBa, 7.42–7.55 m above base of member.

12. GSC 105981, upper view of Pa element (x44), GSC loc. C-94539, Field no. 45NBg, 7.50–7.59 m above base of member.

Figures 13–15, 17. *Polygnathus pseudofoliatus* Wittekindt

13. GSC 105982, upper view of Pa element (x32), GSC loc. C-94561, Field no. 52NBa, 7.85–7.94 m above base of member.

14. GSC 105983, upper view of Pa element (x48), GSC loc. C-94533, Field no. 45NBa, 8.04–8.15 m above base of member.

15. GSC 105984, oblique lateral view of Pa element (x45), GSC loc. C-94545, Field no. 47NBc, 9.82 m above base of member.

17. GSC 105985, upper view of small (juvenile?) Pa element (x64), GSC loc. C-94545, Field no. 47NBc, 9.82 m above base of member.

Figure 16. *Polygnathus xylus ensensis* Ziegler and Klapper

GSC 105986, upper view of Pa element (x64), GSC loc. C-94561, Field no. 52NBa, 7.85–7.94 m above base of member.

Figures 18, 19. *Polygnathus timorensis* Klapper, Philip and Jackson

18. GSC 105987, upper view of Pa element (x73), GSC loc. C-94701, Field no. 90NBa, 11.77–11.95 m above base of member.

19. GSC 105988, upper view of Pa element (x41), GSC loc. C-94696, Field no. 89NBa, 12.81–12.93 m above base of member.

Figure 20. *Polygnathus linguiformis linguiformis* Hinde

GSC 105989, upper view of Pa element (x23), GSC loc. C-94561, Field no. 52NBa, 7.85–7.94 m above base of member.

Figure 21. *Icriodus brevis* Stauffer

GSC 105990, upper view of I element (x64), GSC loc. C-94701, Field no. 90NBa, 11.77–11.95 m above base of member.

Figures 22, 23, 26. *Icriodus orri* Klapper and Barrick

22, 26. GSC 105991 and 105992, upper view of I element (x59) and inner lateral view of S_{2a} element (x67), GSC loc. C-94545, Field no. 47NBc, 9.82 m above base of member.

23. GSC 105993, upper view of I element (x55), GSC loc. C-94445, Field no. 16NBc, 7.50–7.69 m above base of member.

Figures 24, 27. *Polygnathus parawebbi* Chatterton beta morphotype of Chatterton (1979)

GSC 105994 and 105995, oblique upper view of two Pa elements (x27 and x35), GSC loc. C-94445, Field no. 16NBc, 7.50–7.69 m above base of member.

Figure 25. *Tortodus* cf. *T. variabilis* (Bischoff and Ziegler)

GSC 105996, lateral view of Pa element (x57), GSC loc. C-94533, Field no. 45NBa, 8.04–8.15 m above base of member.

Figure 28. *Polygnathus ansatus* Ziegler and Klapper

GSC 105997, upper view of Pa element (x70), GSC loc. C-94692, Field no. 87NBa, 13.89–14.05 m above base of member.

Figures 29, 30. *Polygnathus hemiansatus* Bultynck

GSC 105998 and 105999, upper view of two Pa elements (x34 and x62), GSC loc. C-94692, Field no. 87NBa, 13.89–14.05 m above base of member.

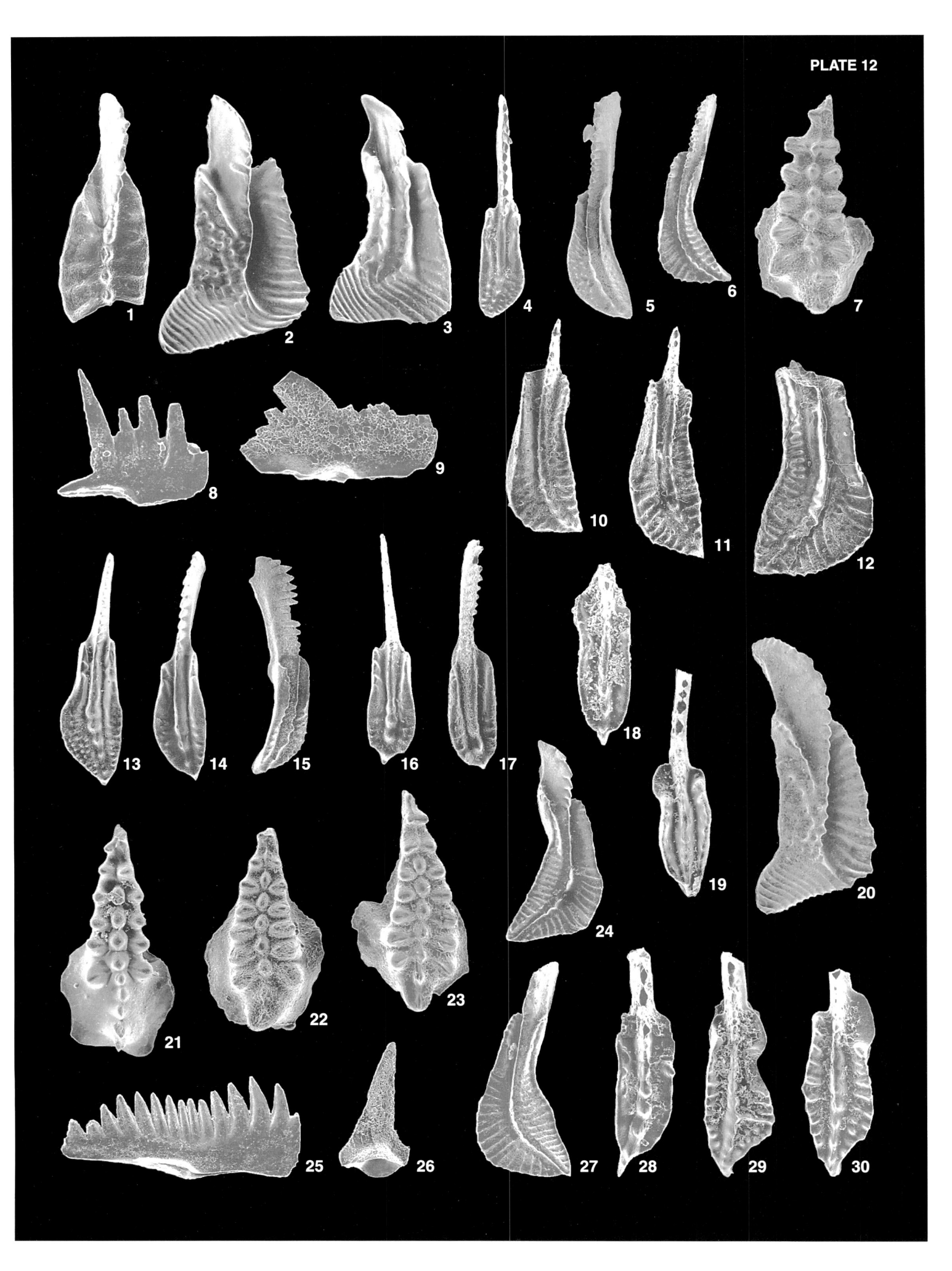
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PLATE 13

Conodonts from the Bituminous limestone member of the Pine Point Formation (Middle *varcus* Subzone)

Figures 1–6. *Polygnathus linguiformis transversus* Wittekindt

1. GSC 106000, upper view of gerontic(?) Pa element (x23), GSC loc. C-94726, Field no. 97NBa, 33.80–34.00 m above base of member.

2, 3. GSC 106001, upper and lower views of Pa element (x46), GSC loc. C-94654, Field no. 76NBa, 14.04 m above base of member.

4–6. GSC 106002, oblique lateral view of Pa element (x50), and GSC 106003, upper and lower views of Pa element (x42), both from GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

Figures 7–13. *Polygnathus linguiformis* Hinde predelta morphotype

7, 12. GSC 106004 and 106005, upper view of two Pa elements (x67 and x48), both from GSC loc. C-94482, Field no. 26NBa, 29.38–29.50 m above base of member.

8, 9. GSC 106006, upper and lower views of Pa element (x86), GSC loc. C-94626, Field no. 70NBc, 31.95 m above base of member.

10, 11. GSC 106007, lower and upper views of Pa element (x55), GSC loc. C-94597, Field no. 66NBa, 30.11 m above base of member.

13. GSC 106008, upper view of Pa element (x73), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

Figures 14–16. *Polygnathus linguiformis weddigei* Clausen, Leuteritz and Ziegler

14. GSC 106009, upper view of Pa element (x64), GSC loc. C-94601, Field no. 67NBa, 30.77 m above base of member.

15. GSC 106010, upper view of Pa element (x54), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

16. GSC 106011, upper view of Pa element (x80), GSC loc. C-94678, Field no. 81NBc, 18.50 m above base of member.

Figures 17–21. *Polygnathus linguiformis mucronatus* Wittekindt

17–19. GSC 106012, 106013, and 106014, upper, upper, and oblique lateral views of three Pa elements (x34, x28, and x36, respectively), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

20, 21. GSC 106015 and 106016, upper view of two Pa elements (x30 and x39), GSC loc. C-94605, Field no. 68NBa, 31.46 m above base of member.

Figures 22–27. *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler

22. GSC 106017, oblique upper view of gerontic Pa element (x22), GSC loc. C-94476, Field no. 23NBa, 17.94–18.53 m above base of member.

23. GSC 106018, upper view of Pa element (x26), GSC loc. C-94601, Field no. 67NBa, 30.77 m above base of member.

24. GSC 106019, upper view of Pa element (x37), GSC loc. C-94611, Field no. 68NBg, 32.18 m above base of member.

25. GSC 106020, oblique lateral view of Pa element (x31), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

26. GSC 106021, upper view of Pa element (x26), GSC loc. C-94597, Field no. 66NBa, 30.11 m above base of member.

27. GSC 106022, upper view of gerontic Pa element (x29), GSC loc. C-94482, Field no. 26NBa, 29.38–29.50 m above base of member.

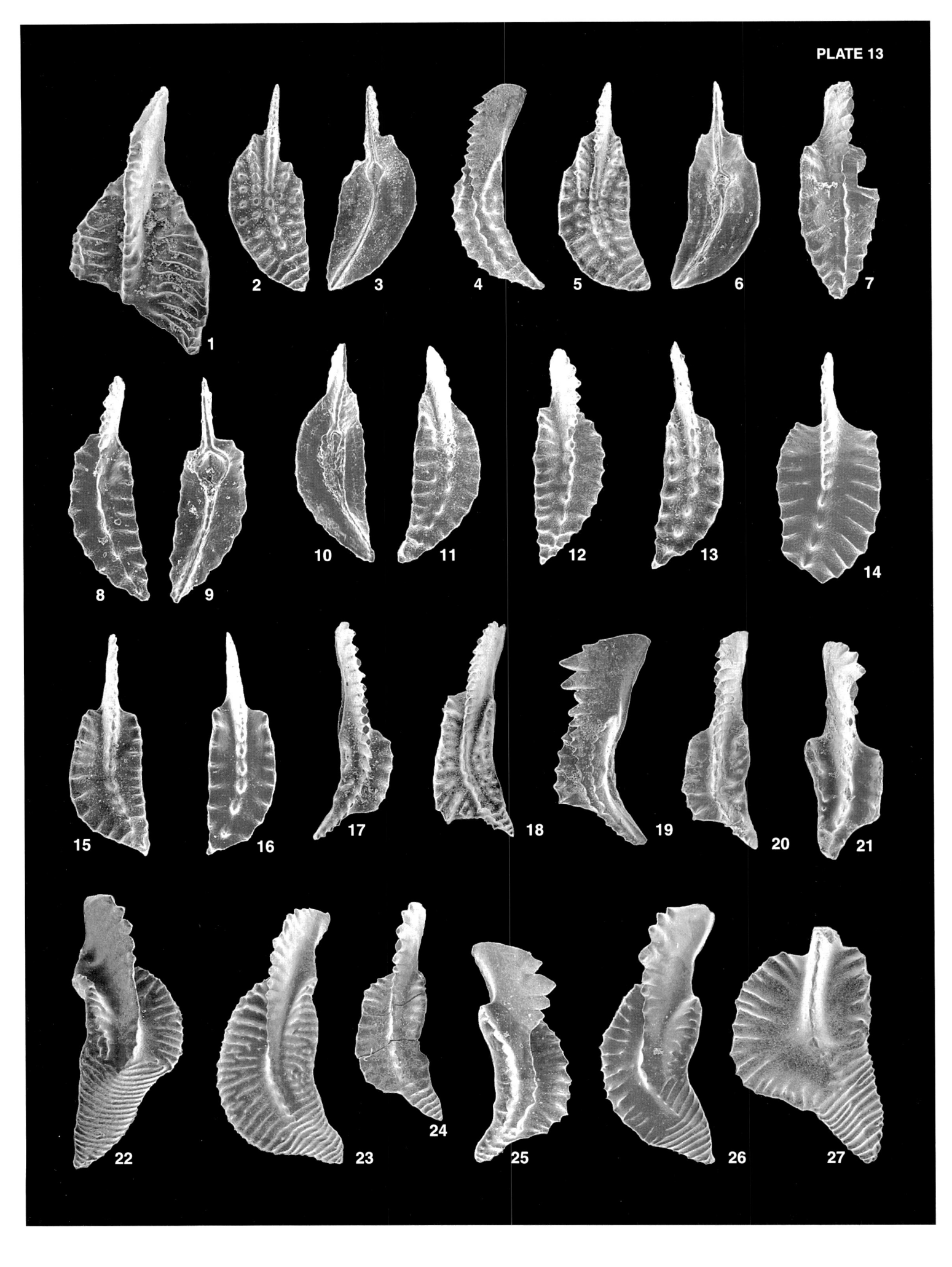
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PLATE 14

Conodonts from the Bituminous limestone member of the Pine Point Formation (Middle *varcus* Subzone)

Figures 1–11. *Polygnathus linguiformis klapperi* Clausen, Leuteritz and Ziegler

1. GSC 106023, oblique upper view of Pa element (x28), GSC loc. C-94482, Field no. 26NBa, 29.38–29.50 m above base of member.

2. GSC 106024, upper view of small Pa element (x41), GSC loc. C-94658, Field no. 77NBa, 17.53 m above base of member.

3. GSC 106025, lateral view of Pa element (x64), GSC loc. C-94715, Field no. 93NBc, 21.56 m above base of member.

4. GSC 106026, oblique lateral view of Pa element (x29), GSC loc. C-94682, Field no. 84NBa, 20.32–20.40 m above base of member.

5–8. GSC 106027, 106028, 106029, and 106030, all oblique upper view of four Pa elements (x76, x54, x39 and x39, respectively), showing growth series, all from GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

9–11. GSC 106031, 106032, and 106033, upper view of three Pa elements (x35, x45, and x73, respectively), showing growth series, all from GSC loc. C-94654, Field no. 76NBa, 14.04 m above base of member.

Figures 12–14. *Polygnathus linguiformis linguiformis* Hinde

12. GSC 106034, oblique lateral view of Pa element (x33), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

13. GSC 106035, oblique upper view of gerontic Pa element (x20), GSC loc. C-94482, Field no. 26NBa, 29.38–29.50 m above base of member.

14. GSC 106036, upper view of Pa element (x32), GSC loc. C-94601, Field no. 67NBa, 30.77 m above base of member.

Figures 15, 16. *Polygnathus parawebbi* Chatterton alpha morphotype of Chatterton (1979)

15. GSC 106037, upper view of Pa element (x43), GSC loc. C-94476, Field no. 23NBa, 17.94–18.53 m above base of member.

16. GSC 106038, upper view of Pa element (x43), GSC loc. C-94503, Field no. 32NBa, 16.20–16.22 m above base of member.

Figures 17, 18. *Polygnathus parawebbi* Chatterton beta morphotype of Chatterton (1979)

17. GSC 106039, upper view of Pa element (x36), GSC loc. C-94447, Field no. 17NBa, 25.02–25.13 m above base of member.

18. GSC 106040, upper view of Pa element (x36), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

Figures 19, 20. *Polygnathus pseudofoliatus* Wittekindt

19. GSC 106041, upper view of Pa element (x41), GSC loc. C-94601, Field no. 67NBa, 30.77 m above base of member.

20. GSC 106042, upper view of Pa element (x33), GSC loc. C-94660, Field no. 77NBc, 16.45 m above base of member.

Figures 21, 22. *Polygnathus pseudofoliatus* Wittekindt (transitional to *P. xylus ensensis* Ziegler and Klapper)

21. GSC 106043, upper view of Pa element (x39), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

22. GSC 106044, upper view of Pa element (x34), GSC loc. C-94595, Field no. 65NBa, 30.00–30.22 m above base of member.

Figures 23–28. *Polygnathus xylus ensensis* Ziegler and Klapper

23–26. All from GSC loc. C-94503, Field no. 32NBa, 16.20–16.22 m above base of member.

23. GSC 106045, upper view of Pa element (x49).

24, 25. GSC 106046, upper and outer lateral views of Pa element (x54).

26. GSC 106047, upper view of Pa element (x55).

27, 28. GSC 106048 and 106049, upper and lateral views of two Pa elements (x54 and x37), both from GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

Figures 29–31. *Polygnathus xylus ensensis* Ziegler and Klapper (transitional to *P. xylus xylus* Stauffer)

29. GSC 106050, upper view of Pa element (x45), GSC loc. C-94605, Field no. 68NBa, 31.46 m above base of member.

30, 31. GSC 106051 and 106052, upper and lateral views of two Pa elements (x40 and x38), both from GSC loc. C-94588, Field no. 63NBe, 27.56–27.87 m above base of member.

Figure 32. *Polygnathus* aff. *P. dubius* Hinde *sensu* Chatterton (1979)

GSC 106053, oblique upper view of Pa element (x31), GSC loc. C-94726, Field no. 97NBa, 33.80–34.00 m above base of member.

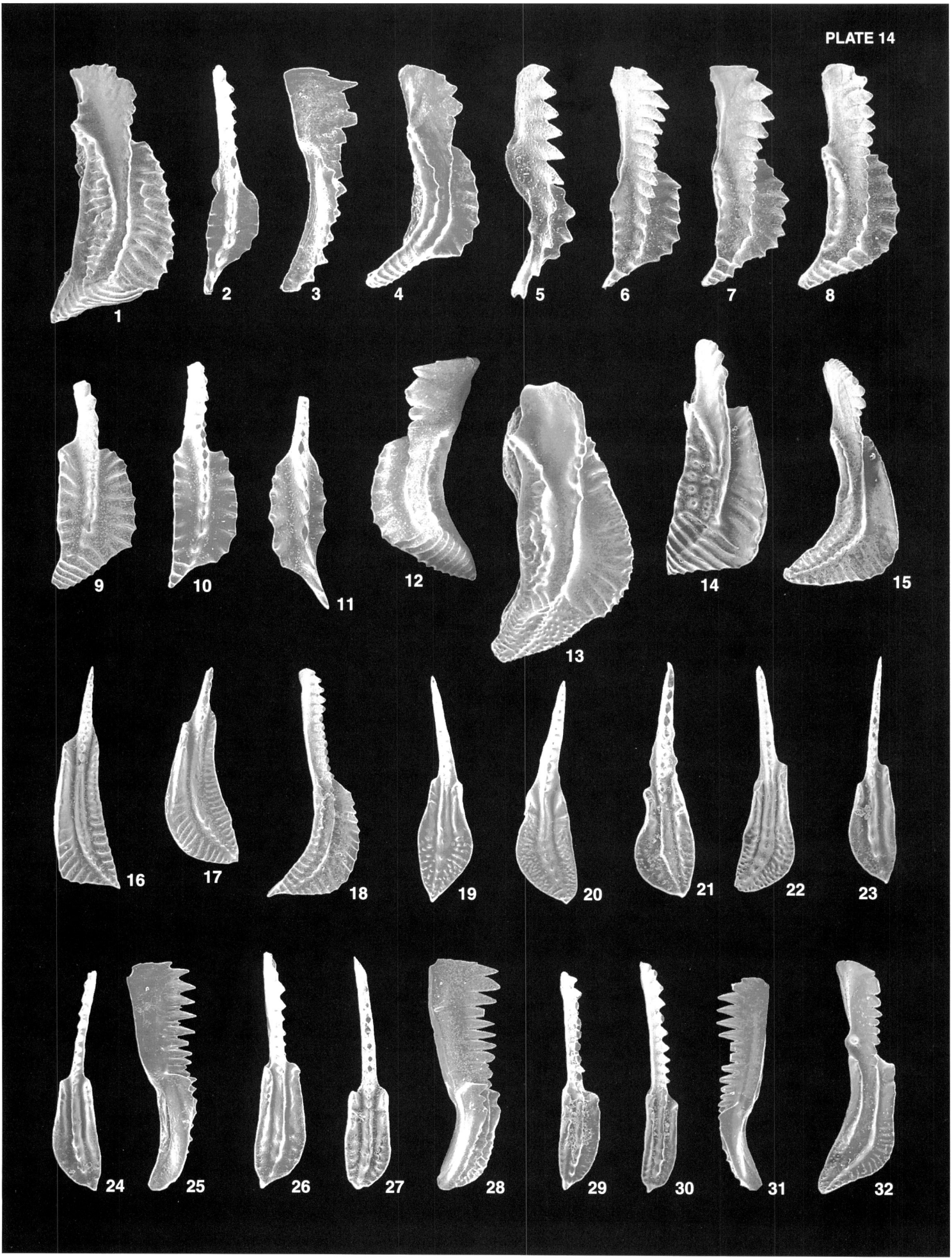
PLATE 14
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PLATE 15

Conodonts from the Bituminous limestone member of the Pine Point Formation (Middle *varcus* Subzone)

Figures 1, 2. *Polygnathus xylus ensensis* Ziegler and Klapper (transitional to *P. timorensis* Klapper, Philip and Jackson)

GSC 106054 and 106055, lateral and upper views of two Pa elements (both x54), GSC loc. C-94590, Field no. 63NBg, 27.77 m above base of member.

Figures 3–6. *Polygnathus timorensis* Klapper, Philip and Jackson

3, 4. GSC 106056 and 106057, upper and lateral views of two Pa elements (x40 and x44), GSC loc. C-94676, Field no. 81NBa, 17.63 m above base of member.

5. GSC 106058, upper view of Pa element (x45), GSC loc. C-94705, Field no. 91NBa, 17.35–17.45 m above base of member.

6. GSC 106059, upper view of Pa element (x43), GSC loc. C-94507, Field no. 33NBc, 40.09–40.20 m above base of member.

Figures 7, 8. *Polygnathus ansatus* Ziegler and Klapper

7. GSC 106060, upper view of Pa element (x45), GSC loc. C-94705, Field no. 91NBa, 17.35–17.45 m above base of member.

8. GSC 106061, upper view of Pa element (x36), GSC loc. C-94707, Field no. 91NBc, 17.45–17.55 m above base of member.

Figures 9–21. *Tortodus* cf. *T. variabilis* (Bischoff and Ziegler)

9, 12. GSC 106062, upper and lateral views of Pa element (x47), GSC loc. C-130853, Field no. 63NBa, 29.39 m above base of member.

10, 11, 13, 14. All lateral view of Pa elements.

10, 14. GSC 106063 and 106064 (both x35), GSC loc. C-94457, Field no. 18NBa, 29.38–29.70 m above base of member.

11. GSC 106065 (x27), GSC loc. C-94482, Field no. 26NBa, 29.38–29.50 m above base of member.

13. GSC 106066 (x35), GSC loc. C-94595, Field no. 65NBa, 30.00–30.22 m above base of member.

15, 16. GSC 106067, inner lateral and upper views of Pa element (x51), GSC loc. C-94654, Field no. 76NBa, 14.04 m above base of member.

17, 18. GSC 106068, upper and inner lateral views of Pa element (x46), GSC loc. C-94654, Field no. 76NBa, 14.04 m above base of member.

19–21. All lateral views of Pa elements.

19. GSC 106069 (x37), GSC loc. C-94601, Field no. 67NBa, 30.77 m above base of member.

20. GSC 106070 (x39), GSC loc. C-94597, Field no. 66NBa, 30.11 m above base of member.

21. GSC 106071 (x30), GSC loc. C-94503, Field no. 32NBa, 16.20–16.22 m above base of member.

Figure 22. *Ozarkodina semialternans* (Wirth)?

GSC 106072, lateral view of Pa element (x31), GSC loc. C-94722, Field no. 96NBa, 31.50 m above base of member.

Figures 23–34. *Polygnathus* cf. *P. latifossatus* Wirth

All figures from GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

23–27. GSC 106073, 106074, 106075, 106076, and 106077, respectively, all lateral view of Pa elements (all x54).

28. GSC 106078, upper view of Pa element (x54).

29, 30. GSC 106079, upper and lower views of Pa element (x51).

31, 32. GSC 106080, outer lateral and lower views of Pa element (x46).

33, 34. GSC 106081, upper and lower views of Pa element (x52).

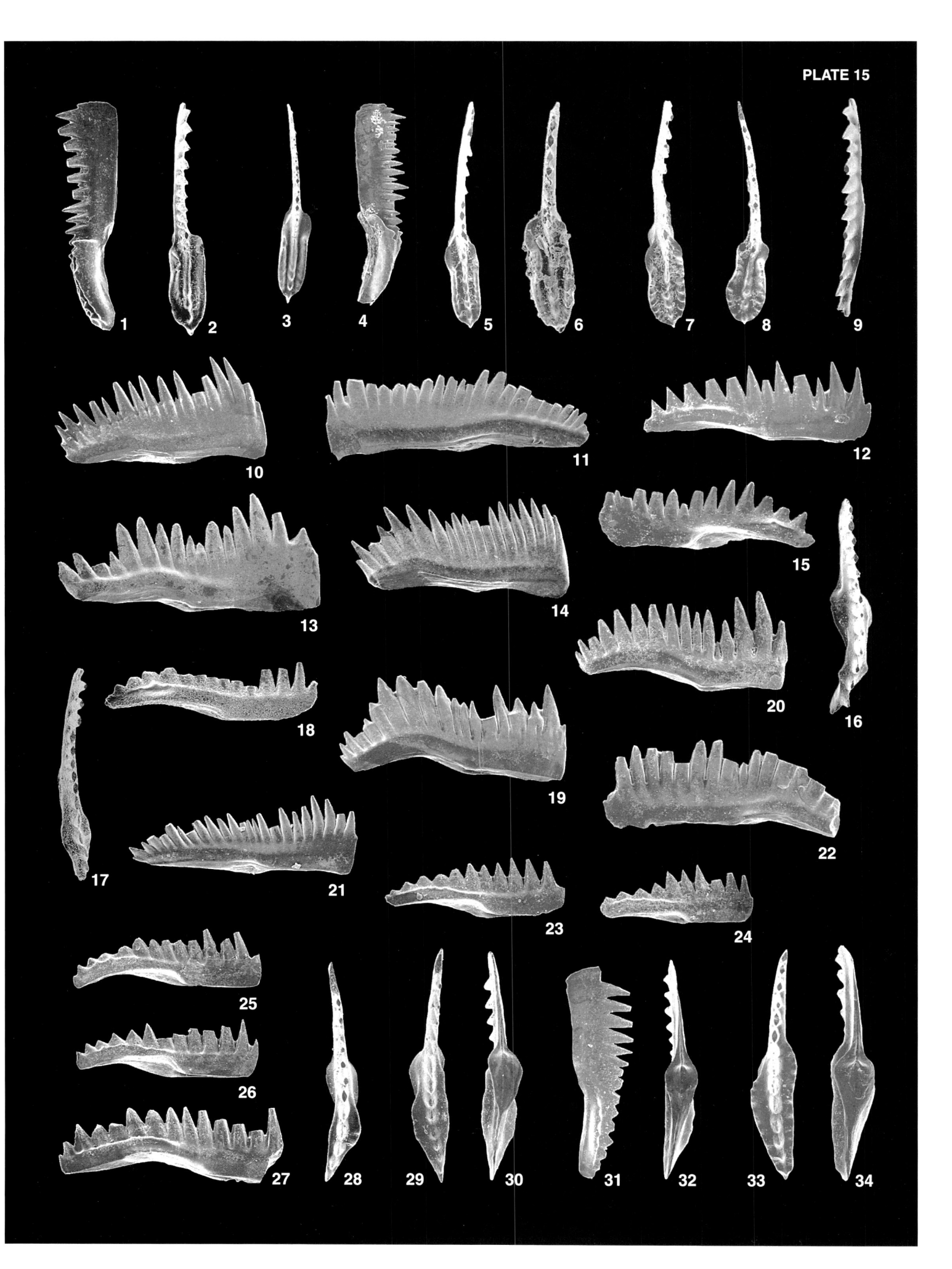
PLATE 15
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PLATE 16

Conodonts from the Bituminous limestone member of the Pine Point Formation (Middle *varcus* Subzone)

Figures 1–15, 20, 21. *Icriodus difficilis* Ziegler and Klapper

1–8. All figures from GSC loc. C-94709, Field no. 91NBe, 17.35–17.58 m above base of member.

1, 2. GSC 106082 and 106083, lateral view of two S_{2a} elements (x59 and x111).

3, 4. GSC 106084 and 106085, lateral view of two S_{2b} elements (x121 and x111).

5. GSC 106086, lateral view of S_{2c} element (x96).

6–8. GSC 106087, 106088, and 106089, upper view of three I elements (x45, x38, and x56).

9–12. All figures from GSC loc. C-94626, Field no. 70NBc, 31.95 m above base of member.

9, 10. GSC 106090 and 106091, upper view of two I elements (x49 and x48).

11. GSC 106258, lateral view of S_{2b} element (x105).

12. GSC 106259, lateral view of S_{2a} element (x99).

13–15, 20, 21. Upper views of I elements (unless otherwise indicated).

13. GSC 106260, GSC loc. C-94715, Field no. 93NBc, 21.56 m above base of member (x45).

14. GSC 106261, GSC loc. C-94505, Field no. 33NBa, 39.00 m above base of member (x61).

15. GSC 106262, GSC loc. C-94717, Field no. 94NBa, 24.30–24.37 m above base of member (x43).

20. GSC 106263, GSC loc. C-94690, Field no. 86NBa, 15.22–15.36 m above base of member (x47).

21. GSC 106264, GSC loc. C-94649, Field no. 74NBe, 17.20 m above base of member (x62).

Figures 16–19. *Icriodus arkonensis* Stauffer

GSC 106265 and 106266, lower and upper views of two I elements (x46 and x45), GSC loc. C-94722, Field no. 96NBa, 31.50 m above base of member.

Figures 22–25. *Pseudooneotodus* sp. morphotype B

GSC 106267, 106268, 106269, and 106270, respectively, anterior, posterior, upper, and lateral views (all x119), GSC loc. C-94586, Field no. 63NBc, 27.56–27.87 m above base of member.

Figures 26, 27. *Pseudooneotodus* sp. morphotype B, slim variety

GSC 106271 and 106272, lateral view (both x119), GSC loc. C-94605, Field no. 68NBa, 31.46 m above base of member.

Figure 28. *Ozarkodina raaschi* Klapper and Barrick?

GSC 106273, lateral view of Pa element (x60), GSC loc. C-94597, Field no. 66NBa, 30.11 m above base of member.

Figures 29–31. *Icriodus brevis* Stauffer

29, 30. GSC 106274, upper and lateral views of I element (x80), GSC loc. C-94520, Field no. 37NBd, 49.87–50.03 m above base of member.

31. GSC 106275, upper view of I element (x61), GSC loc. C-94507, Field no. 33NBc, 40.09–40.20 m above base of member.

Figures 32–35. *Pseudooneotodus* sp. morphotype A

GSC 106276, 106277, 106278, and 106279, respectively, posterior, anterior, upper, and lateral views (all x105), GSC loc. C-94476, Field no. 23NBa, 17.94–18.53 m above base of member.

PLATE 16

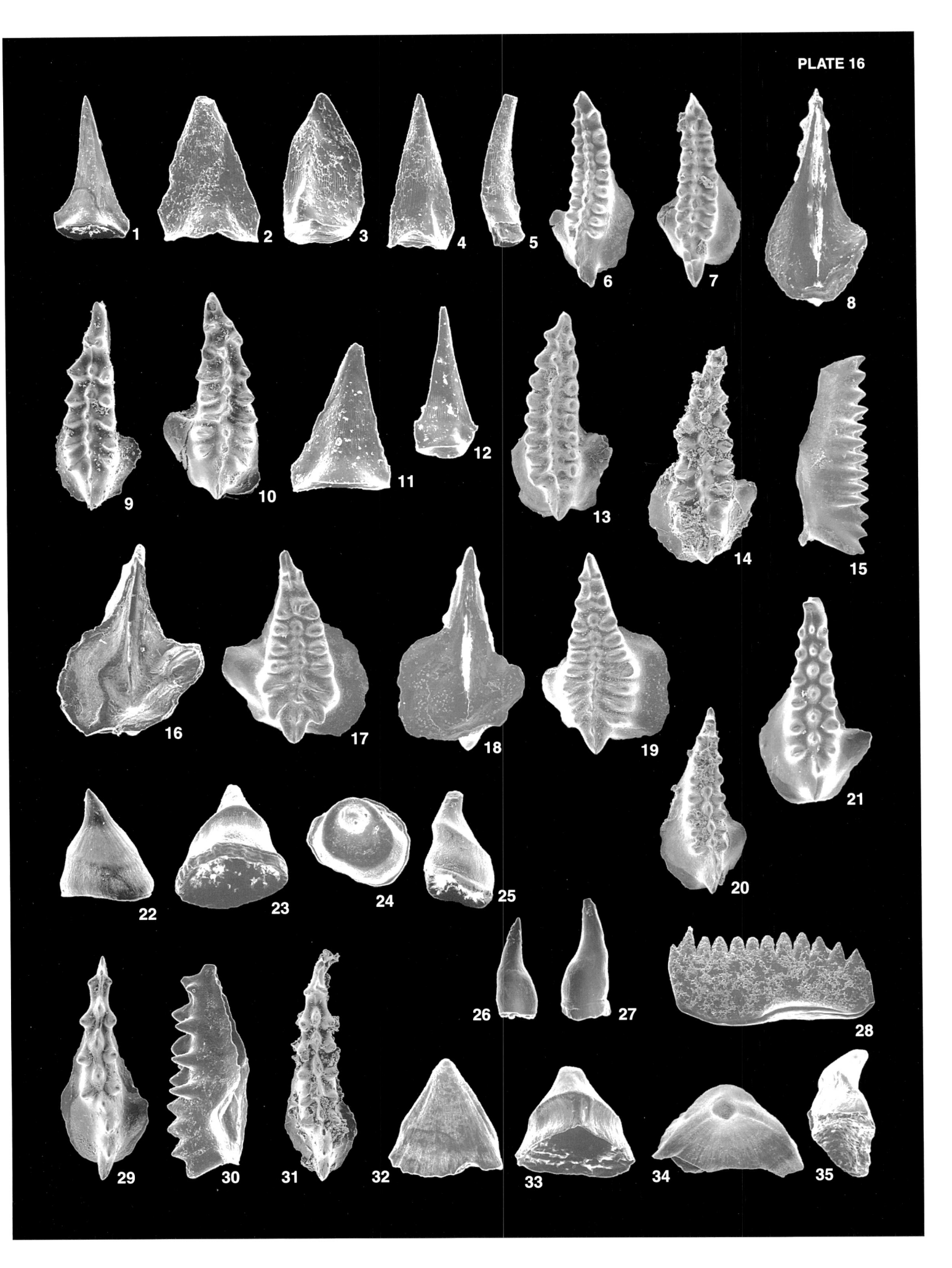
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PLATE 17

Ozarkodina brevis (Bischoff and Ziegler). Except for conodonts illustrated in Figures 14 and 18, all specimens from the Bituminous limestone member of the Pine Point Formation (Middle *varcus* Subzone)

Figures 1–4. GSC loc. C-94631, Field no. 71NBa, 30.45 m above base of member

1. GSC 106280, lateral view of Pa element (x86).

2. GSC 106281, lateral view of Pb element (x67).

Figures 5–7. GSC loc. C-94617, Field no. 69NBe, 32.49 m above base of member

5. GSC 106284, lateral view of Pa element (x127).

6. GSC 106285, lateral view of Pb element (x137).

7. GSC 106286, lateral view of M element (x213).

Figures 8, 9. GSC loc. C-94660, Field no. 77NBc, 16.45 m above base of member

8. GSC 106287, lateral view of Pa element (x96).

9. GSC 106288, outer lateral view of M element (x137).

Figure 10. GSC loc. C-94635, Field no. 71NBe, 31.9–32.0 m above base of member

GSC 106289, lateral view of Pa element (x99).

Figures 11, 12. GSC loc. C-94503, Field no. 32NBa, 16.20–16.22 m above base of member

11. GSC 106290, lateral view of Pa element (x83).

12. GSC 106291, lateral view of Pb element (x70).

Figure 13. GSC loc. C-94597, Field no. 66NBa, 30.11 m above base of member

GSC 106292, lateral view of Pa element (x89).

Figure 14. GSC loc. O-62695, Moberly Member, Waterways Formation, Station 92, Rock unit 37, 29.8–31.8 ft (10.2–10.9 m) above river level, Athabasca River, northeastern Alberta [see Uyeno, 1974, p. 52, Table 4(a)]

GSC 106293, lateral view of Pa element (x90).

Figure 15. GSC loc. C-94476, Field no. 23NBa, 17.94–18.53 m above base of member

GSC 106294, lateral view of Pa element (x86).

Figure 16. GSC loc. C-94605, Field no. 68NBa, 31.46 m above base of member

GSC 106295, lateral view of Pa element (x169).

Figure 17. GSC loc. C-94599, Field no. 66NBc, 30.58 m above base of member

GSC 106296, lateral view of Pa element (x140).

Figure 18. GSC loc. C-3881, Ramparts Formation, 13.1–14.6 m above base of formation, Powell Creek, western District of Mackenzie (see Uyeno, 1979, Table 1)

GSC 106297, lateral view of Pa element (x90).

Figures 19–26. GSC loc. C-94651, Field no. 75NBa, 16.15 m above base of member

19. GSC 106298, lateral view of Pa element (x67).

20. GSC 106299, posterior view of Sa element (x105).

21. GSC 106300, inner lateral view of Sc element (x96).

22. GSC 106301, inner lateral view of Sb element (x45).

23. GSC 106302, lateral view of Pb element (x86).

24–26. GSC 106303, 106304, and 106305, respectively, outer, inner, and outer lateral views, of three M elements (x188, x150, and x140, respectively).

PLATE 17

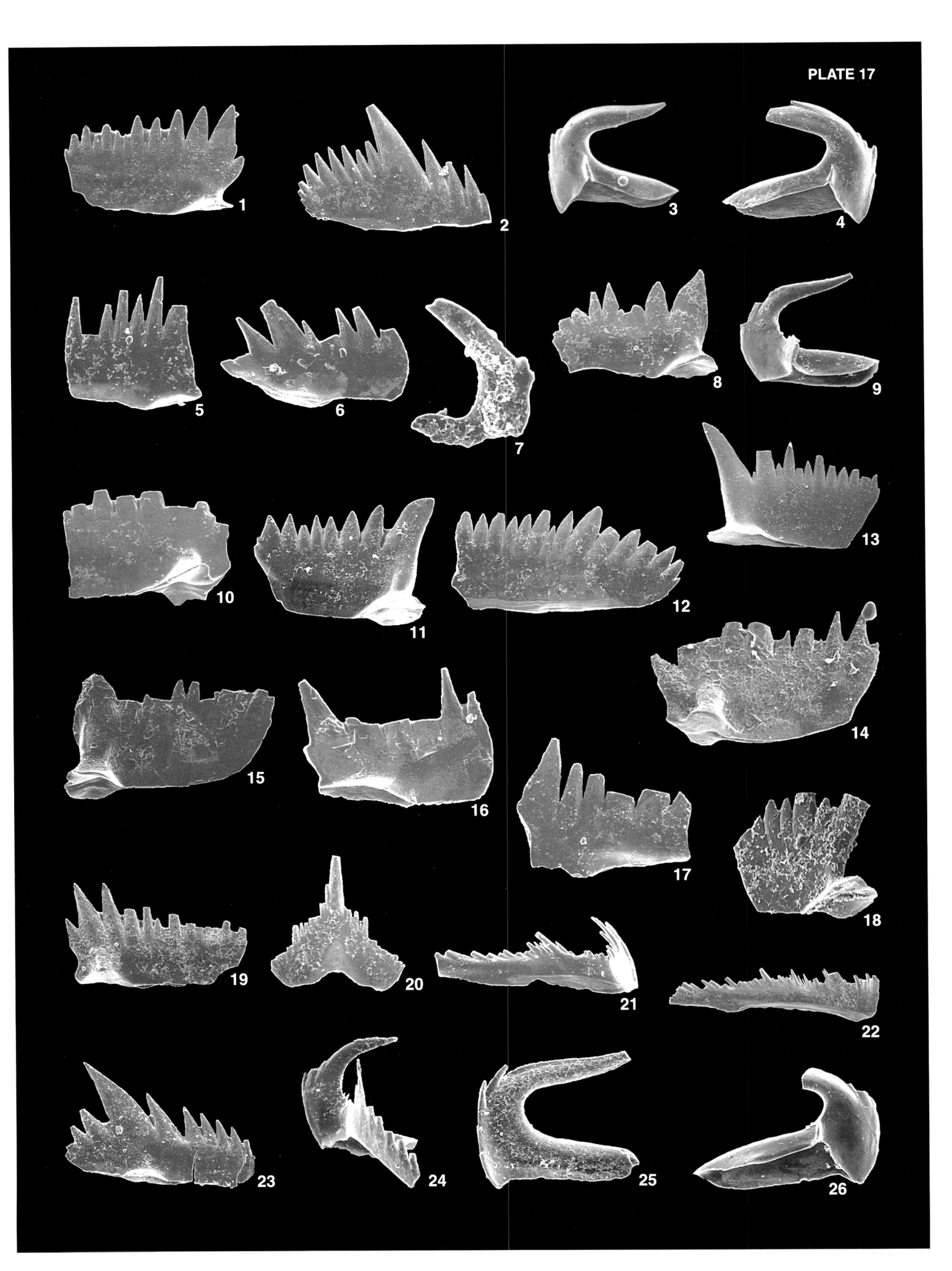


PLATE 18

Ozarkodina brevis (Bischoff and Ziegler) and *Icriodus subterminus* Youngquist (Figs. 21–26)

Figures 1–6. GSC loc. C-29046, Winnipegosis Formation, near top of abandoned former Manitoba Hydro quarry located east of The Narrows, southwestern Manitoba (see also Uyeno, 1982, Pl. 32, figs. 29–38); probable *ensensis* Zone

1. GSC 106306, lateral view of Pa element (x125).
2. GSC 106307, inner lateral view of Pb element (x120).
3. GSC 106308, oblique inner lateral view of M element (x130).
4. GSC 106309, posterior view of Sa element (x110).
5. GSC 106310, inner lateral view of Sb element (x75).
6. GSC 106311, inner lateral view of Sc element (x75).

Figures 7–9. Waterways Formation, Birch River, northeastern Alberta (see Norris and Uyeno, 1981, Fig. 4); Montagne Noire Zone 1 of Klapper, 1989, p. 450

7. GSC 106312, lateral view of Pa element (x115), from GSC loc. C-74182, Field no. 17NBa, Rock Unit VII.
8. GSC 106313, inner lateral view of Pb element (x145), from GSC loc. C-74194, Field no. 21NBb, Rock Unit VI.
9. GSC 106314, oblique inner lateral view of M element (x155), from GSC loc. C-74199, Field no. 23NBa, Rock Unit VI.

Figures 10, 13–18. GSC loc. C-28091, Horn Plateau Formation, located at 62°08.2′N, 117°39′W, District of Mackenzie (see McLaren and Norris, 1964; Pedder et al., 1992); Middle *varcus* Subzone

13–15. GSC 106316, 106317, and 106318, respectively, oblique lower, upper, and lateral views of three Pa elements (all x68).

16. GSC 106319, inner lateral view of Sc element (x85).

17, 18. GSC 106320 and 106321, outer and inner lateral views of two M elements (both x75).

Figures 11, 12. GSC 106322 and 106323, lower and lateral views of two Pa elements (x185 and x120), from GSC loc. C-29053, Souris River Formation, 'First Red Beds' member (but may perhaps belong to the lower parts of the overlying Member B, 'Argillaceous limestone beds'), southwestern Manitoba, see Appendix for detailed locality information

Figures 19, 20, 27.

19, 20. GSC 106324 and 106325, lateral and upper views of two Pa elements (x137 and x201), from GSC loc. C-94434, Watt Mountain Formation, see Appendix for detailed locality information.

27. GSC 106326, lateral view of Pa element (x143), from GSC loc. C-94424, Watt Mountain Formation, see Appendix for detailed locality information.

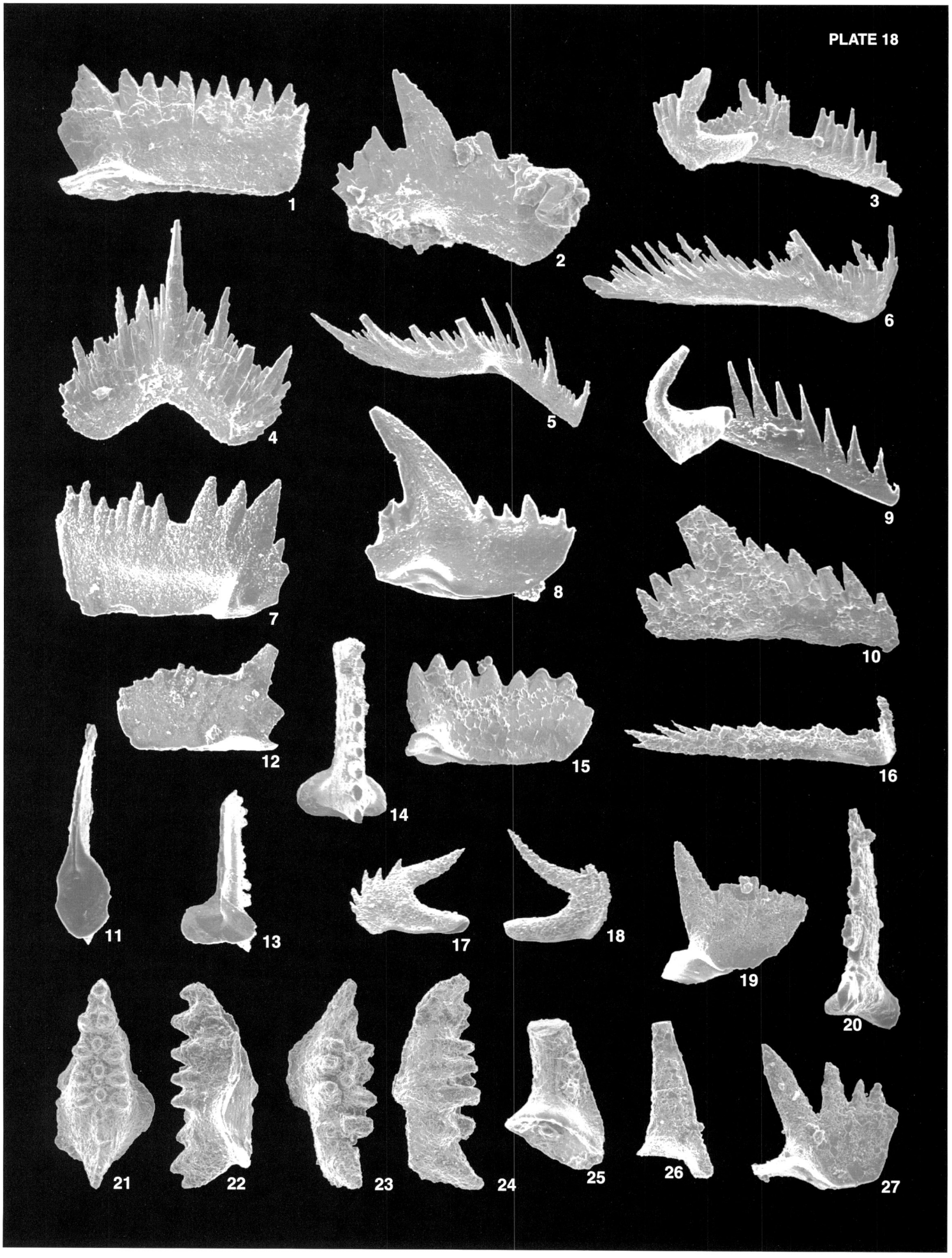
Figures 21–26. *Icriodus subterminus* Youngquist

GSC loc. C94424, Watt Mountain Formation, see Appendix for detailed locality information.

21, 22. GSC 106327, upper and lateral view of I element (x86).

23, 24. GSC 106328, oblique upper and lateral views of I element (x83).

25, 26. GSC 106329 and 106330, lateral view of two S_{2a} elements (x115 and x99).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