LOWER ORDOVICIAN CONODONTS FROM THE ST. GEORGE GROUP OF PORT AU PORT PENINSULA, WESTERN NEWFOUNDLAND

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by

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ABSTRACT

The St. George Group on the Port au Port Peninsula of western Newfoundland is little deformed, well exposed and provides a nearly complete sequence through the Lower Ordovician. The about 600 m thick succession records two depositional megacycles, and is divided into four formations in ascending order, the Watts Bight, Boat Harbour, Catoche and Aguathuna formations.

Over 45,000 conodonts have been recovered from 432 3.5 kg samples from 10 sections comprising two composite sections through the St. George Group. The conodonts show excellent preservation with a low conodont Colour Alteration Index (CAI) of 1. Detailed taxonomic study of these faunas has permitted major revision to the reconstruction of Lower Ordovician multielement apparatuses, new interpretation of the phylogenetic relationships of Lower Ordovician, Midcontinent Province conodonts, and the establishment of a new and more refined Lower Ordovician conodont zonation for the Midcontinent Province.

One of the major objectives of this study is to examine the Lower Ordovician conodont taxonomy. Seventy-five multielement species, representing 28 genera, have been described and illustrated, among them 7 new genera, 33 new species and 70 newly reconstructed multielement species. The new genera are <u>Glyptodontus</u>, <u>Loxodentatus</u>, <u>Loxognathus</u>,

Polycostatus, Striatodontus, Stultodontus and Tricostatus. The new species are: Acodus primus, Clavohamulus longicuspis, C. neoelongatus, C. reniformis, C. sphearicus, Cristodus ethingtoni, Drepanodus nowlani, Glyptoconus felicitii, G. multiplicatus, G. priscus, Glyptodontus constrictus, G. expansus, G. tumidus, Loxodentatus bipinnatus, Loxognathus phyllodus, Loxodus latibasis, Macerodus crassatus, M. gracilis, M. wattsbightensis, Polycostatus falsioneotensis, P. minutus, Protopanderodus prolatus, Scolopodus subrex, Stritodontus lanceolatus, S. prolificus, S retractus, S. teridontus, Stultodontus ovatus, S. pygmaeus, Teridontus obesus, Tricostatus glyptus, Utahconus longipinnatus and Variabiloconus neobassleri.

Three apparatus types, apparatus Type I, II and III, are redefined. Type I apparatuses consist of only a and e elements, and are characterized by stubby coniforms and extremely flattened forms. Type II apparatuses have three element morphotypes including a, c and e elements. Type III apparatuses contain four or five skeletal morphotypes: a, b, c, e and, commonly f elements.

Following the taxonomic study, the local, regional and global stratigraphic range of the taxa were examined to help interpret evolutionary lineages. Nearly twenty such lineages have been recognized. Most are closely related to the Teridontus lineage, and belong to the Teridontus evolutionary complex. The evolutionary relationships of multielement taxa in the *Teridontus* complex show that the *Teridontus* lineage spread widely, evolving into both the *Clavohamulus* and *Semiacontiodus* lineages during the latest Cambrian. The latter probably produced the *Variabiloconus* and *Polycostatus* lineages during the earliest Tremadoc. Two important lineages, *Glyptoconus* and *Striatodontus*, appear suddenly, spreading widely, and diversifing rapidly during the early and middle Arenig. The late Tremadoc extinction is one of the most profound crises in conodont evolutionary history. This extinction leads to the demise of more than seven lineages including over 35 species.

The conodonts recovered indicate that the St. George Group ranges in age from earliest Canadian to the earliest Whiterockian. Eight conodont Assemblage Zones have been established for the shallow-water (SW) facies of the typical Midcontinent Province. Six deeper-water (DW) conodont Assemblage or Lineage Zones have been recognized or redefined, and include some taxa with affinities to the North Atlantic Province. All the SW Assemblage Zones represent limited stratigraphic intervals in the Lower Ordovician, most can be recognized with other low latitude cratons, such as Australia, Siberia, and North China. In contrast, the DW Assemblage or Lineage Zones can be correlated through the critical biostratigraphic tie-points with the North Atlantic Province zonation.

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CHAPTER 1

INTRODUCTION

This thesis examines the conodont taxonomy, phylogeny and biostratigraphy of the Lower Ordovician St. George Group, Port au Port Peninsula, western Newfoundland. The St. George Group represents part of the extensive sequence of platform carbonates which accumulated during the Early Ordovician in a variety of shallow subtidal and peritidal environments near the outer edge of a low latitude continental margin (Pratt and James, 1986; Knight and James, 1987; James and Stevens, 1986; James & al., 1989). The St. George Group, nearly 600 m thick, is divided into four formations: Watts Bight Formation, Boat Harbour Formation, Catoche Formation and Aguathuna Formation, in ascending stratigraphic order.

Over 45,000 conodonts have been recovered from 432 samples, averaging 3.5 kilograms each from ten sections totalling 1,500 meters in thickness. Seventy five multi-element species, representing 28 genera, have been described and illustrated, among them 7 new genera, 33 new species and nearly 70 newly reconstructed multielement species. The conodonts from these strata are abundant and superbly preserved with a conodont Colour Alteration Index (CAI) of 1.0, reflecting burial temperatures of less than 90 degrees (Nowlan and Barnes, 1987a, b).

The present study not only reconstructs most Lower

Ordovician apparatuses of Midcontinent Province conodonts, and but also establishes many phylogenetic relationships of these difficult forms, and resolves much biostratigraphic chaos. Nearly twenty evoltionary lineages, 8 shallow-water Assemblage Zones and 6 deeper-water Lineage or Assemblage Zones are established or recognized. Most of these zones can be identified on other Ordovician low latitude cratons, such as Australia, Siberia, North China, and some can be correlated with the zonation for the North Atlantic Province.

Location and Geological Setting

The Lower Ordovician St. George Group outcrops in a sinuous belt which skirts the margin of the allochthons and the Long Range massif, extending a distance of over 400 km from the Port au Port Peninsula in the south to the northern tip of the Great Northern Peninsula (Knight and James, 1987; James & al., 1989). Tectonically, the St. George Group in western Newfoundland occurs within the Humber Zone of the Appalachian Orogen (Williams, 1979). The Humber Zone is the tectono-stratigraphic subdivision that comprises the deposits of the Lower Paleozoic outer continental shelf and margin in eastern North America which fringed the ProtoAtlantic Iapetus Ocean (Williams and Stevens, 1974). Different elements of this margin are now preserved as two contemporaneous, juxtaposed terranes. They are an autochthon of shallow-water shelf strata tied to the basement and two allochthons of deep-water strata and oceanic lithosphere (Rodgers and Neale, 1963; Keen & al., 1986). The St. George Group is deformed along the eastern margin of the Humber Arm Allochthon and extensively covered with woodland except for exposures along the margin of two fiords, Goose Arm and Bonne Bay (Knight and James, 1987). North of the Humber Arm Allochton, between Table Point and Cape Norman, strata are well documented (Kluyver, 1974; Stouge, 1982; and Knight and James, 1987). Correlative strata far to the west on the Mingan Islands, separated from western Newfoundland by the Gulf of St. Lawrence, are called the Romaine Formation (Nowlan, 1981; Desrochers, 1986), and equate to the upper part of the St. George Group. In Arctic Canada, local uplifts, different lithofacies and variable stratigraphic nomenclature do not facilitate easy correlation with the St. George Group (Barnes, 1977; Barnes, Norford and Skevington, 1981; Knight and James, 1987). In eastern Greenland, Cambrian-Ordovician strata are still poorly known and comparison with the St. George Group is tentative.

Ten excellent sections of undeformed Lower Ordovician carbonate rocks were measured in detail on the southern shore of Port au Port Peninsula, at the Aguathuna Quarry of the Port au Port Peninsula and on the Table Mountain where strata, although cut by high angle Acadian and Carboniferous faulting (Fig. 1:1) are well exposed. The St. George Group is a 550-560 m thick sequence of carbonates exposed along the south and east coasts of the Port au Port Peninsula and Smelt Canyon of

Figure 1:1. Geologic map of Port au Port Peninsula after Levesque (1977) and Williams' map (1985), with changes to stratigraphy of the St. George Group indicated by this study.

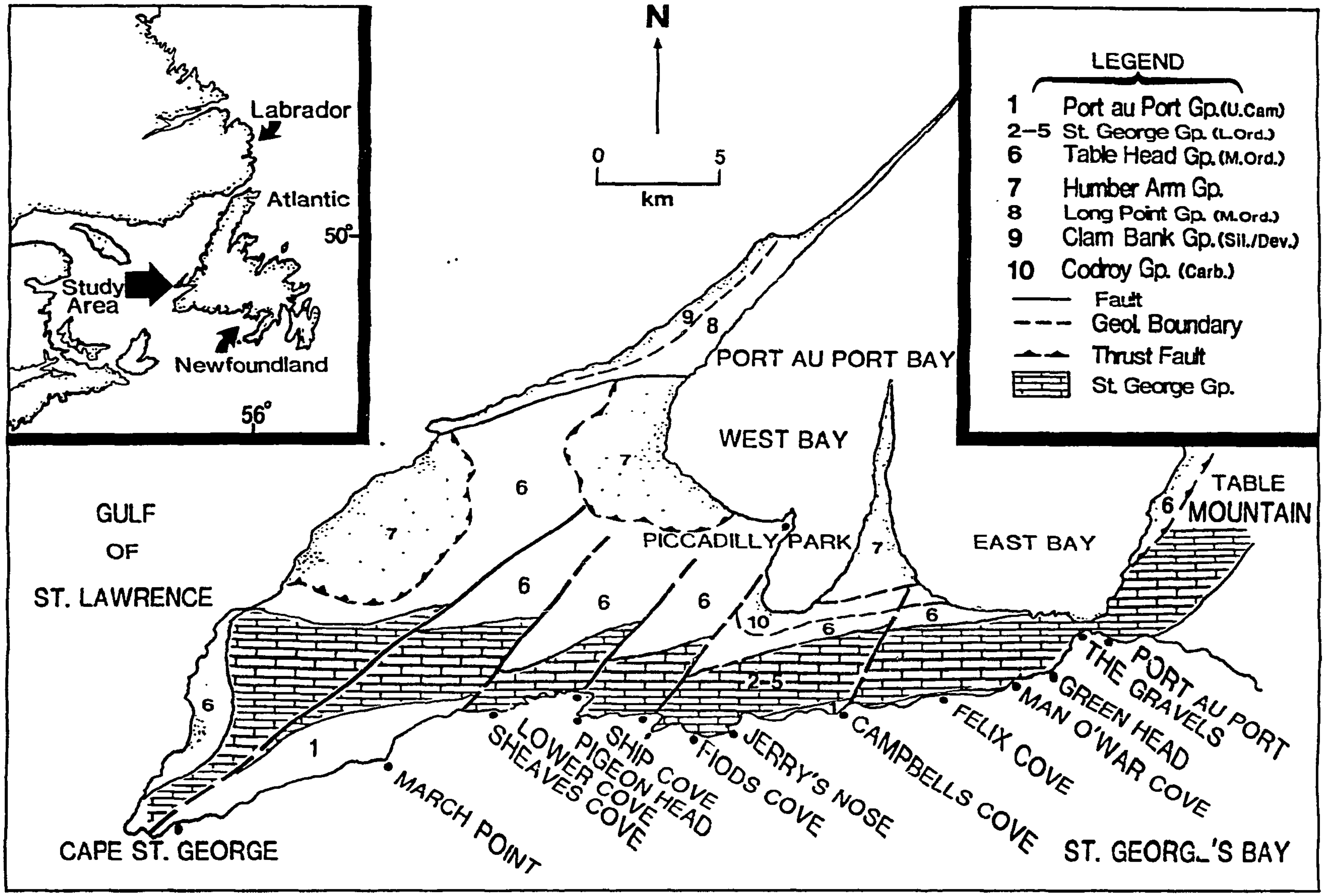
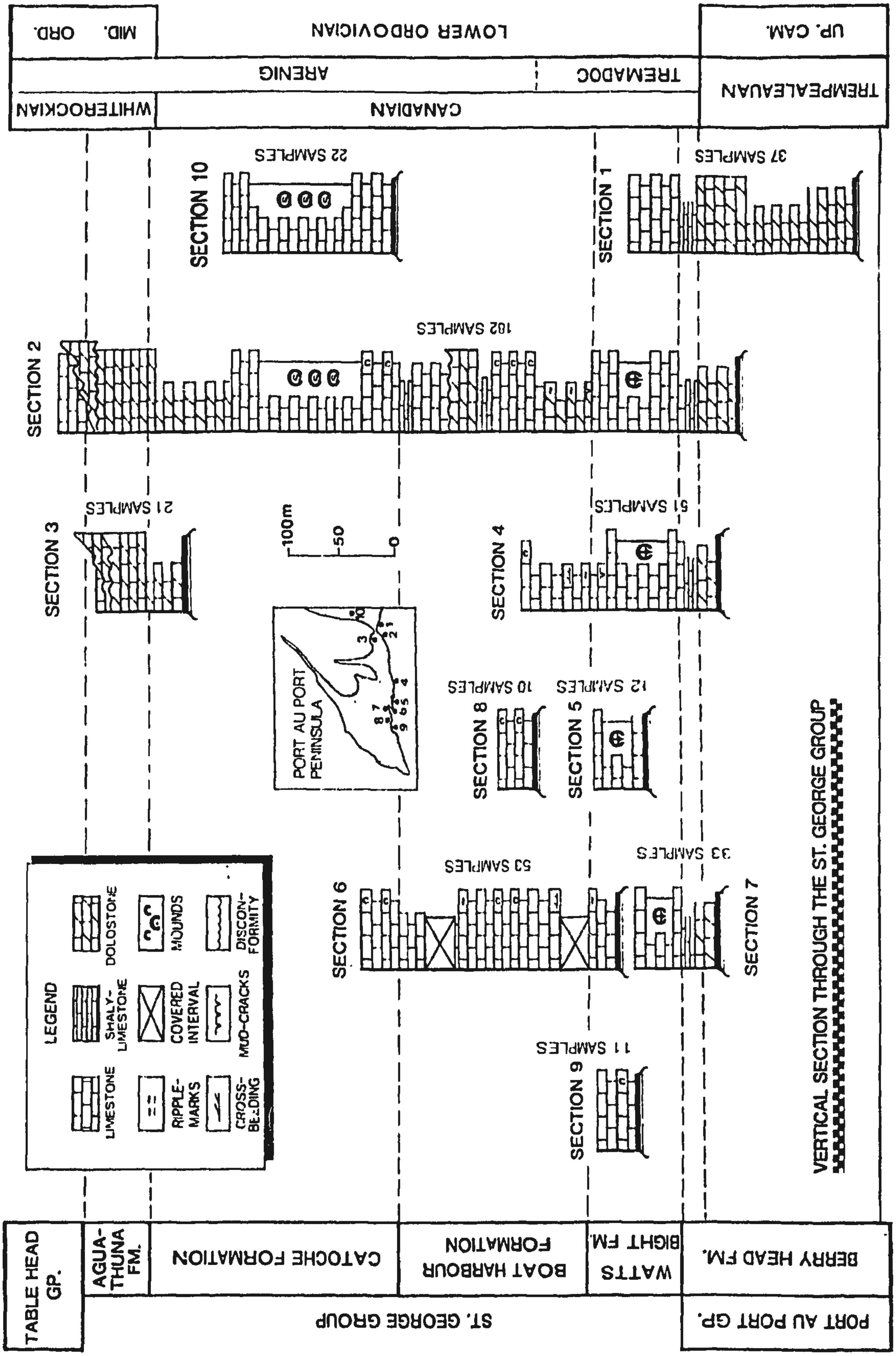

Labrador
Atlantic
50°
Study Area
Newfoundland
56°
N
0 5
km
LEGEND
1 Port au Port Gp.(U.Cam)
2–5 St. George Gp. (L.Ord.)
6 Table Head Gp.(M.Ord.)
7 Humber Arm Gp.
8 Long Point Gp. (M.Ord.)
9 Clam Bank Gp.(Sil./Dev.)
10 Codroy Gp. (Carb.)
Fault
Geol. Boundary
Thrust Fault
St. George Gp.
PORT AU PORT BAY
WEST BAY
TABLE MOUNTAIN
GULF OF ST. LAWRENCE
PICCADILLY PARK
EAST BAY
PORT AU PORT
THE GRAVELS
GREEN HEAD
MAN O'WAR COVE
FELIX COVE
CAMPBELLS COVE
JERRY'S NOSE
FIODS COVE
SHIP COVE
PIGEON HEAD
LOWER COVE
SHEAVES COVE
MARCH POINT
CAPE ST. GEORGE
ST. GEORG_'S BAY

Figure 1:2. Vertical sections through the St. George Group of the Port au Port Peninsula, western Newfoundland.



VERTICAL SECTION THROUGH THE ST. GEORGE GROUP

Table Mountain overlies the Port au Port Group and underlies the Table Head Group. Access to some sections on the shoreline of the Port au Port Peninsula is best achieved at low tide.

Purpose of this study

The objectives of this study are three-fold: (1) to provide a detailed taxonomic study of the conodonts from the Lower Ordovician St. George Group; (2) to attempt to reconstruct phylogenetic lineages for the Lower Ordovician Midcontinent Province conodonts. (3) to establish a systematic Lower Ordovician conodont zonation sequence for the North American Midcontinent Province, and to correlate the conodont faunas, where possible, with equivalent conodont faunas recovered elsewhere in the world.

Methodology

All the goals of this thesis are achieved through a combination of field work and laboratory analysis and research. Nearly two months of field work were involved in the section descriptions and conodont sample collections. The 432 conodont samples, each weighing 3.5 kg were taken at approximately 3 m stratigraphic intervals along ten sections measured through the St. George Group on the Port au Port during July and August 1986 and July 1987. The thickness was measured across strike using a Brunton compass, tape, and a

Jacob's staff.

Three kilograms of each sample were processed, using the standard conodont analysis techniques (Collinson, 1963). A 200-mesh screen was used to wet-sieve the acidized residues. All the residues were passed through heavy liquid (Sodium Polytungstate=$3Na_2WO_4.9WO_3.H_2O$) prior to hand picking under a binocular microscope.

Most conodonts illustrated were photographed on a Cambridge Scanning Electron Microscope, and a few conodonts (Cordylodus) were photographed with a Zeiss Photomicroscope III at the Geological Survey of Canada in Ottawa.

Previous work

1. Stratigraphy

Schuchert and Dunbar (1934), in their study of the stratigraphy of western Newfoundland, first proposed the name of St. George Series for the Lower Ordovician shallow water carbonate rocks. They defined the type section for the strata occurring along the southern shore of the Port au Port Peninsula from March Point to north of "The Gravels" (see Fig. 1:1).

Mapping by Sullivan (1940) and Besaw (1974) on the Port au Port Peninsula and the Geological Map of Stephenville by Williams (1985) added to knowledge of the distribution and subdivision of the St. George Group. Levesque (1977) in his M.Sc. study produced a synthesis of the Cambrian-Ordovician sedimentary rocks in western Newfoundland and subdivided the St. George Group into a lower cyclic member, a middle limestone member and an upper cyclic member. An M.Sc. thesis by Pratt (1979) focussed on the sedimentology of the St. George Group and led to publications of cryptalgal mounds (Pratt and James, 1982), cryptalgal fabrics (Pratt, 1982a and b), and a tidal flat island model for carbonate sedimentation in shallow epeiric seas (Pratt and James, 1986). In their papers, James and Pratt informally named the three units of Levesque (1977), in ascending order, the Isthmus Bay Formation (=Lower Cyclic Member), the Catoche Formation (=Middle Limestone), and the Aguathuna Formation (=Upper Cyclic Member). Knight and James (1987) divided the Isthmus Bay Formation into two formations which correspond to the Watts Bight and the Boat Harbour units of the Great Northern Peninsula and Port au Port Peninsula. Chow (1986) in her Ph.D. thesis, and Chow and James (1987) proposed the name of the Berry Head Formation (upper unit of the Port au Port Group) for the latest Cambrian and earliest Ordovician shallow-water carbonate rocks.

2. Biostratigraphy

Fossil collecting from the St. George Group was not pursued in any systematic fashion during the early years. Fossils collected by Richardson were monographed by Billings (1865). Subsequent documentation was in the form of faunal lists reported together with stratigraphic sections (Schuchert and Dunbar, 1934). Johnson (1949) provided information on both lithologies and fossils, but his description was unfortunately not published. The detailed biostratigraphic investigation of the St. George Group was begun by Whittington and Kindle (1969). They described trilobites in the Port au Port section and showed that much of the St. George Group, as defined by Schuchert and Dunbar (1934), was of Cambrian age. Since then the nature of various faunas has been documented by different paleontologists, including trilobites by Fortey (1979) and Boyce (1973a, 1983a, 1983b, 1985), cephalopods by Flower (1978), and graptolites by Cumming (1967) and Williams & al. (1987).

Barnes and Tuke (1970) first described conodonts from the St. George Group from two isolated localites in the Great Northern Peninsula of western Newfoundland. The most detailed conodont succession of the St. George Group known to date was described by Stouge (1982) from the Great Northern Peninsula of western Newfoundland. These works were, however, very limited in their finding and scope.

3. Lower Ordovician conodont taxonomy

Studies of Cambrian and Lower Ordovician conodonts are still at an early stage, especially Lower Ordovician multielement taxonomy of the Midcontinent Province (e.g. Ethington and Clark, 1964, 1965, 1971, 1981; Barnes and Tuke, 1970; Miller, 1969, 1980; Kennedy, 1980; Repetski, 1982;

Nowlan, 1985). The paper by Miller (1980) dealt with the Cambrian-Ordovician conodonts in detail, but within a limited stratigraphic interval; Ethington and Clark (1981) described conodonts from the Ibex Area of Utah in a major publication, but these conodonts are not the typical Midcontinent faunas; the paper by Repetski (1982) is a detailed Lower Ordovician conodont taxonomic work, but based on partially deformed sequences. Key publications dealing with the Lower Ordovician conodonts include those of Druce and Jones (1971) from Australia, Abaimova (1971, 1975) from Siberia, Serpagli (1973) from Argentina, Lindström (1971), van Wamel (1974) from Europe, An and others (1983) from North China, An (1987) from South China.

CHAPTER 2

STRATIGRAPHY

Four formations (Knight and James, 1987) of the St. George Group are considered in this study. These are, in ascending stratigraphic order, the Watts Bight, Boat Harbour, Catoche and Aguathuna formations (Fig. 2:1). The middle and upper parts of the Berry Head Formation, which conformably underlies the St. George Group, are also considered. Appendix B provides detailed descriptions of ten measured and sampled sections.

Berry Head Formation

The formation, about 100 m thick, is exposed along the west and the east shorelines of Isthmus Bay, and at Jerry Nose (see Fig. 1:1). The base of the formation is not exposed, and the top of the formation is defined at the conformable contact with overlying the Watts Bight Formation. This formation includes intercalated pale grey limestones and yellow weathering syngenetic dolostones and shales (Fig. 2:2). The formation is poorly fossiliferous, except for common stromatolite mounds, and is of latest Cambrian age (Chow and James, 1987).

Figure 2:1. A simplified stratigraphic column with summary of lithologies and depositional environments of the St. George Group (modified from Knight and James, 1987).

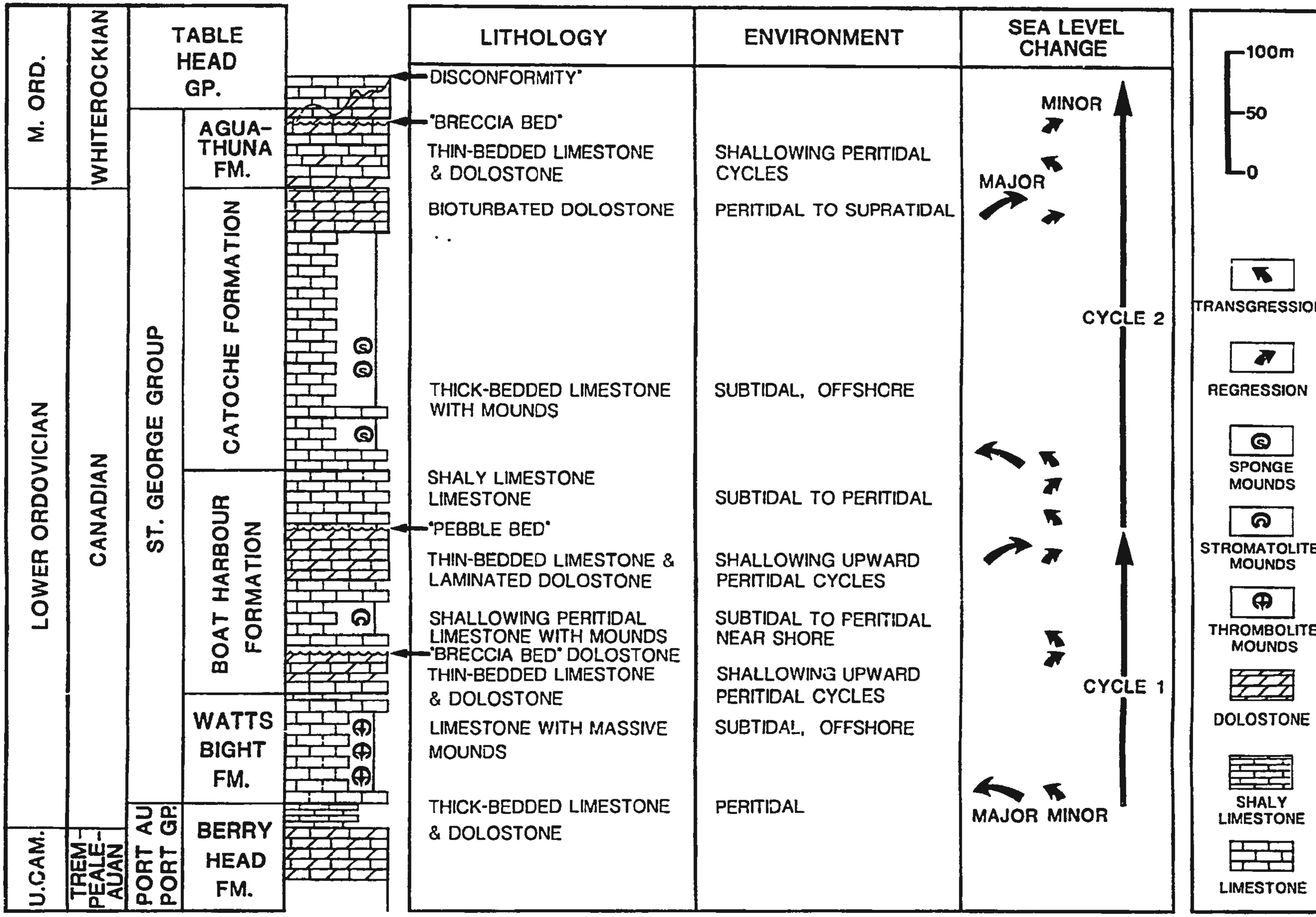

M. ORD.
WHITEROCKIAN
TABLE HEAD GP.
LOWER ORDOVICIAN
CANADIAN
ST. GEORGE GROUP
AGUA-THUNA FM.
CATOCHE FORMATION
BOAT HARBOUR FORMATION
WATTS BIGHT FM.
U.CAM.
TREM-PEALE-AUAN
PORT AU PORT GP.
BERRY HEAD FM.
LITHOLOGY
ENVIRONMENT
SEA LEVEL CHANGE
"DISCONFORMITY"
"BRECCIA BED"
THIN-BEDDED LIMESTONE & DOLOSTONE
SHALLOWING PERITIDAL CYCLES
BIOTURBATED DOLOSTONE
PERITIDAL TO SUPRATIDAL
THICK-BEDDED LIMESTONE WITH MOUNDS
SUBTIDAL, OFFSHORE
SHALY LIMESTONE
LIMESTONE
SUBTIDAL TO PERITIDAL
"PEBBLE BED"
THIN-BEDDED LIMESTONE & LAMINATED DOLOSTONE
SHALLOWING UPWARD PERITIDAL CYCLES
SHALLOWING PERITIDAL LIMESTONE WITH MOUNDS
SUBTIDAL TO PERITIDAL NEAR SHORE
"BRECCIA BED" DOLOSTONE
THIN-BEDDED LIMESTONE & DOLOSTONE
SHALLOWING UPWARD PERITIDAL CYCLES
LIMESTONE WITH MASSIVE MOUNDS
SUBTIDAL, OFFSHORE
THICK-BEDDED LIMESTONE & DOLOSTONE
PERITIDAL
MINOR
MAJOR
CYCLE 2
CYCLE 1
MAJOR MINOR
100m
50
0
TRANSGRESSION
REGRESSION
SPONGE MOUNDS
STROMATOLITE MOUNDS
THROMBOLITE MOUNDS
DOLOSTONE
SHALY LIMESTONE
LIMESTONE

Figure 2:2. Views of section sampled and sedimentary characteristics of the Berry Head Formation and Watts Bight Formation. (1). Shaly dolostone of the upper Berry Head Formation; (2). Dolostone of the middle Berry Head Formation; (3). Bedding plane view of thrombolite mounds of the Watts Bight Formation at Green Head; (4). View of the Watts Bight Formation at Green Head; (5). Digitated and coalesced thrombolite mounds of the Watts Bight Formation at Green Head; (6). Several small thrombolite mounds of the upper Watts Bight Formation; (7). Boundary of the Watts Bight and Boat Harbour formations (at the 1.5 m staff bottom).

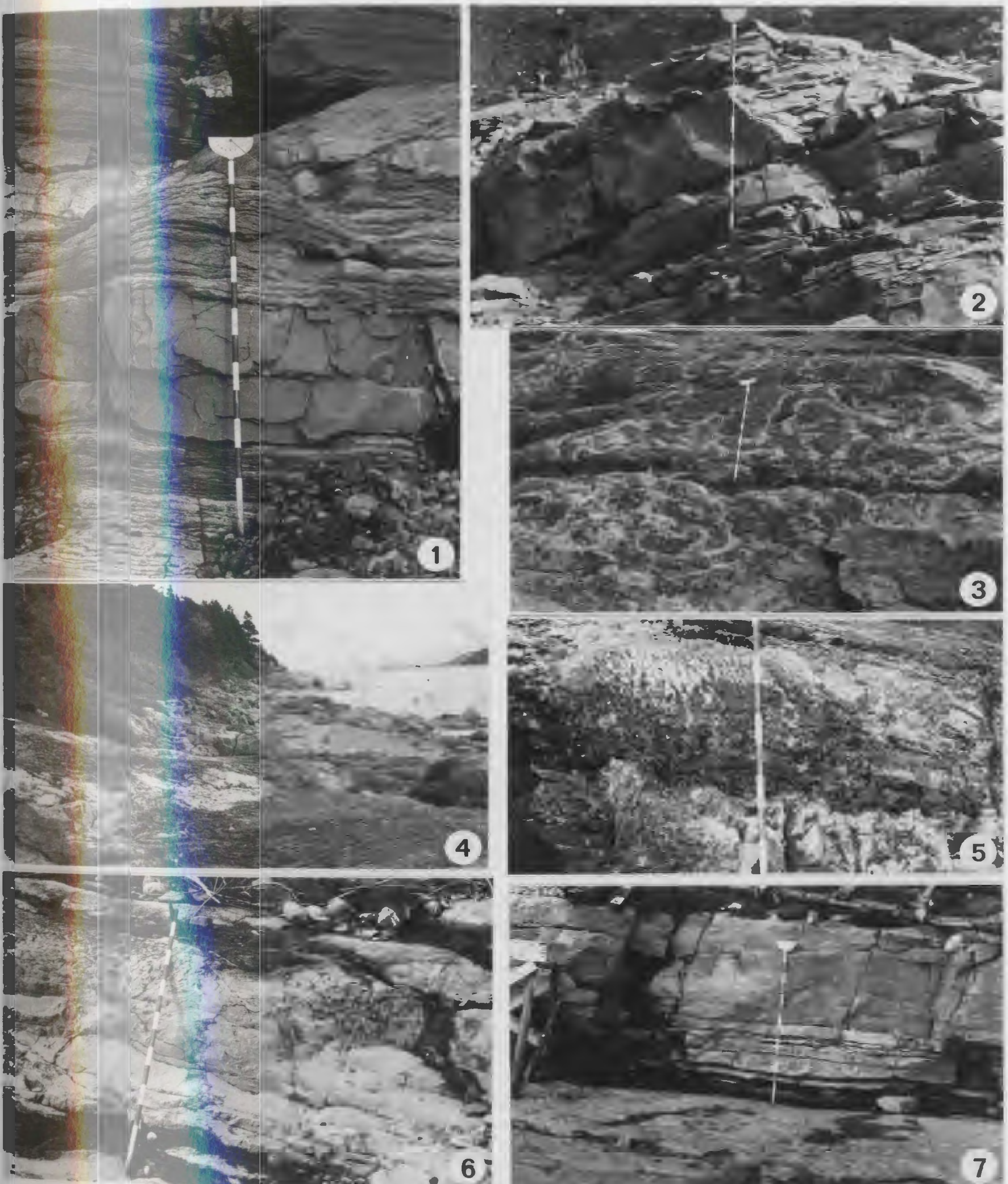

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Figure 2:3. View of section sampled and sedimentary characteristics of the Boat Harbour Formation at western Isthmus Bay. (1). A large stromatolite mound of the middle Boat Harbour Formation; (2). Hardground (at the top of staff) of the Boat Harbour Formation; (3). Shaly limestone of the upper Boat Harbour Formation; (4). finely laminated dolostone with cracks; (5). Nodular and wavy-bedded parted limestone of the middle Boat Harbour Formation; (6). Mudcracks of the upper Boat Harbour Formation; (7). Trace fossils of the middle Boat Harbour Formation; (8). Boundary of the Boat Harbour and Catoche formations (at the 1.5 m staff bottom).

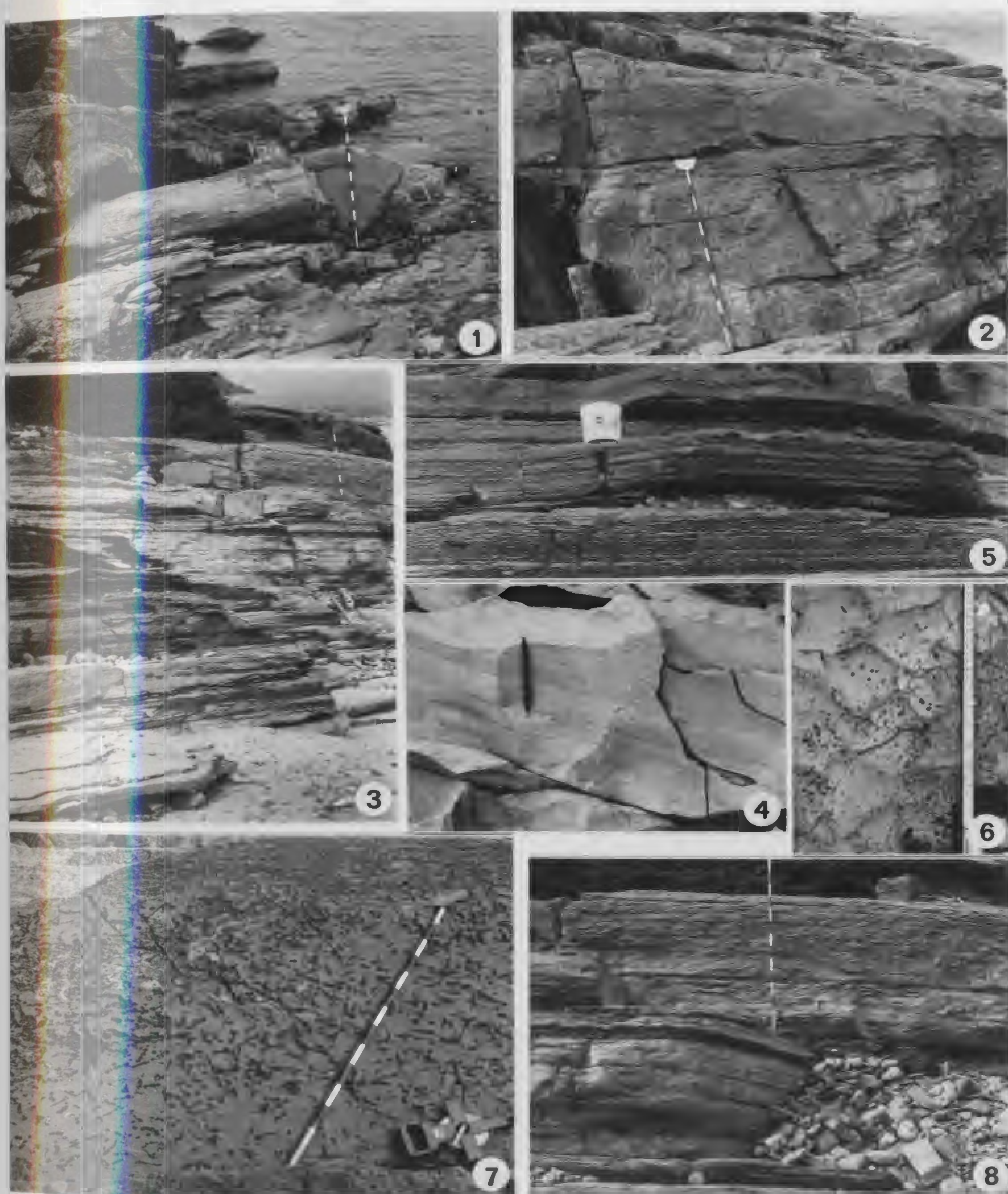
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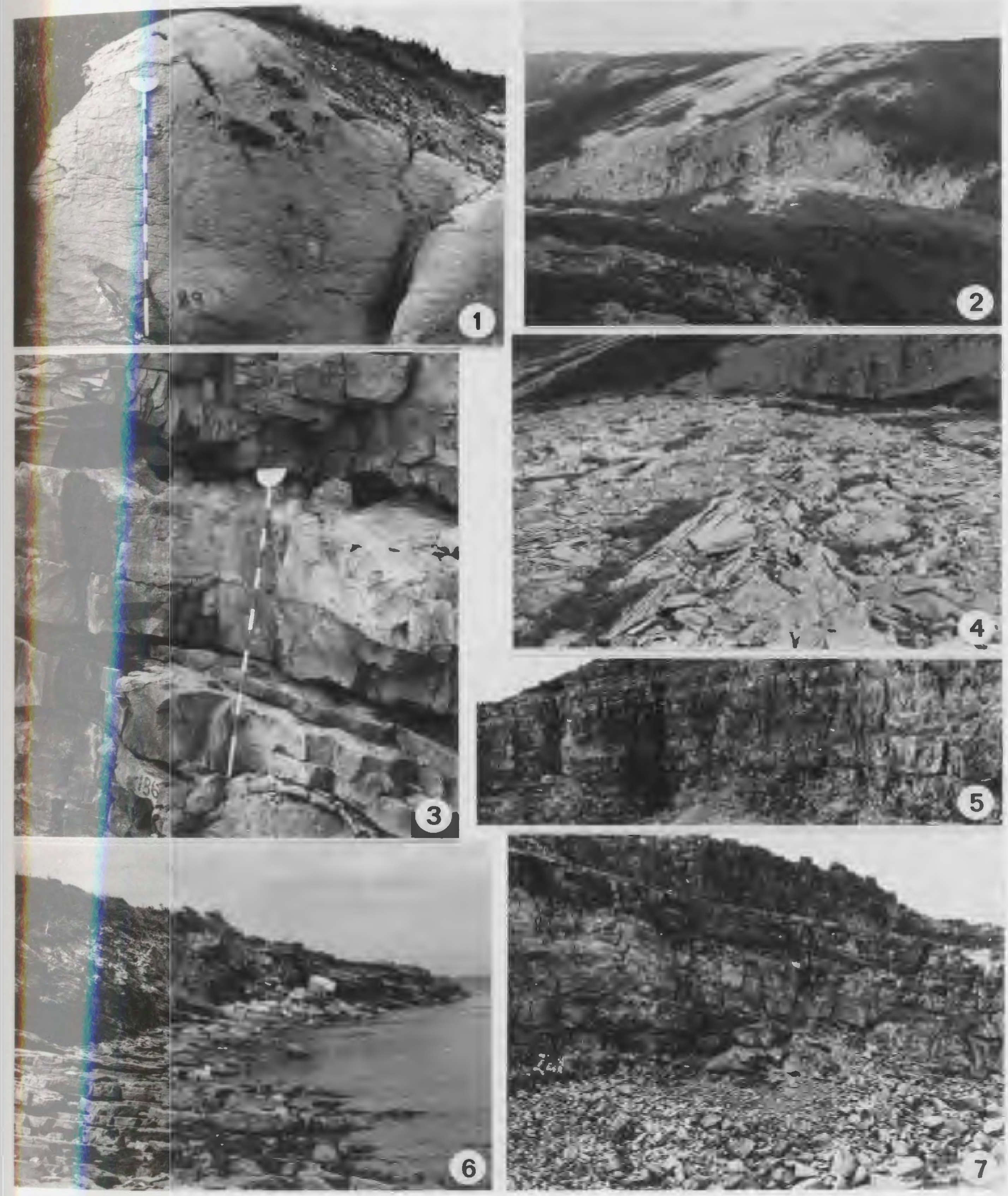
Figure 2:4. View of section sampled and sedimentary characteristics of the Catoche and Aguathuna formations. (1). Sponge mounds of the Catoche Formation at the Gravels; (2). View of the Catoche Formation at Table Mountain; (3). Erosive surface (the top of staff) of the Aguathuna Formation at East Bay; (4). Dolomitized limestone of the upper Catoche Formation at Table Mountain; (5). View of Aguathuna Formation at Aguathuna Quarry; (6). View of Aguathuna Formation at East Bay; (7) Boundary of the Aguathuna Formation (lower and middle pale limestone) and the Table Head Group (upper dark limestone). The length of Jacob's staff is 1.5 m.



Watts Bight Formation

The formation is 87 meters thick exposed completely along the west coast of Isthmus Bay, and also partially exposed along the east coast of Isthmus Bay, and the shorelines at Jerry Nose, Pigeon Head, Lower Cove and Sheaves Cove (see Fig. 1:1). This formation includes muddy, bioturbated carbonates of generally subtidal and locally peritidal aspect characterized by the presence of relatively large and complex thrombolite mounds (Knight and James,1987) (Fig. 2:2). Sediments vary from dolomitized limestone at the Isthmus Bay, Jerry Nose of the eastern Port au Port Peninsula to almost entirely limestone at Pigeon Head, Ship Cove, the highway cut of Lower Cove and Sheaves Cove of the western Port au Port Peninsula. The formation is fossiliferous, especially the middle and upper parts. The base of the Watts Bight Formation is defined by the first appearance of dominantly subtidal carbonates that overlies thinly bedded, boturbated, finely crystalline, grey dolostone of the Berry Head Formation (Knight and James, 1987).

Boat Harbour Formation

The Boat Harbour Formation is exposed completely along the west coast of Isthmus Bay (see Fig. 1:1), and partially along the shorelines of Fiods Cove, Ship Island, Pigeon Head and Lower Cove. The formation is about 180 m thick, and is conformably overlain by the Catoche Formation. Within the upper part of the formation, a "Pebble Bed" marks a disconformable break in sedimentation (Fortey, 1984; Knight, 1978; Boyce, 1979). The formation includes a series of complete or partial shallowing-upward sequences, with flaser and lenticular bedded, thinly stratified and laminated, frequently shaly and mud-cracked, minor dolomitic lime mudstones, limestones and dolostones (see Fig. 2:3). The formation is conspicuously fossiliferous. Its base is defined by the first appearance of distinctively interbedded dark grey limestone and buff to light grey dolostone that conformably overlie the Watts Bight Formation (Knight and James, 1987) (see Fig. 2:2).

Three second order depositional cycles can be recognized within this formation. The first is about 50 m thick at west Isthmus Bay, and occurs from the base of the formation to the thick-bedded dolostone; the second begins at the base of the massive thrombolite and stromatolite mounds which may represent the beginning of new transgressive phase, terminates at the top of the "Pebble Bed", and is about 80 m thick in Section 2; the third cycle corresponds to the remaining upper part of the formation, and is about 50 m thick. Each cycle represents a complete or nearly complete shallowing-upward sequence, from the subtidal to peritidal or supratidal environments, within which there are similar third order, meter-scale cycles.

Catoche Formation

The Catoche Formation is exposed partially along the west coast of Isthmus Bay, Smelt Canyon of Table Mountain, at the Aguathuna Quarry (see Fig. 1:1) and it is as thick as 225 meters on the west coast of Isthmus Bay. It is conformably overlain by the Aguathuna Formation. The formation includes well bedded, extremely fossiliferous, bioturbated, grey limestones in the lower part, and grey to pale bioturbated limestones with brownish weathering chert and light grey weathering sucrosic dolomite and white to pale fenestral and peloidal limestone in the upper part. The lower Catoche limestones are generally highly fossiliferous, the upper Catoche rocks yield fewer fossils. The base is defined by the first thick-bedded, rubbly weathering, fossiliferous grey limestone that conformably overlies the last thick bed of laminated and mud-cracked, shaly dolomitic lime mudstone or dolostone of the Boat Harbour Formation (Knight and James, 1987) (Fig. 2:4).

Aguathuna Formation

This formation, about 63 meters thick, is well exposed along the western shoreline of East Bay, at the Aguathuna Quarry and Smelt Canyon of Table Mountain, Port au Port (see Fig. 1:1). It consists of poorly fossiliferous interbedded dolostones and minor limestones. The formation overlies the Catoche Formation conformably and is disconformably overlain by the Middle Ordovician Table Head Formation (Fig. 2:4). Its base is defined as the first appearance of grey to light grey, finely crystalline, bioturbated, and laminated dolostone beds that overlie dark grey dolostones of the Catoche Formation (Fig. 2:4).

Summary

The St. George Group on the Port au Port Peninsula of western Newfoundland represents a part of the extensive Lower Ordovician sequence of platform carbonates which accumulated originally during the Early Ordovician in a series of shallow subtidal and peritidal environments near the outer edge of a low latitude continental margin (Pratt and James, 1986; Knight and James, 1987; James & al., 1989). There are two distinct lithological associations within the St. George Group (James and Stevens 1986; Knight and James, 1987): (1) cyclic carbonates representing numerous peritidal shallowing-upward cycles grading from subtidal limestone to mottled dolostone to planar laminated, locally mudcracked dolostone; (2) thick-bedded, dark grey, fossiliferous, subtidal limestone or dolomitized subtidal limestone. Two major cycles have been recognized by James and Stevens (1986) and Knight and James, (1987): the lower cycle includes the Watts Bight and lower and middle Boat Harbour formations; the upper cycle embraces the upper Boat Harbour, Catoche and Aguathuna formations. Three secondary cycles can be readily recognized within the Boat

Harbour Formation.

Several major subaerial disconformities have been recognized throughout western Newfoundland: the best known is the "Pebble Bed" near the top of the Boat Harbour Formation (Knight, 1978; Pratt, 1979; Boyce, 1979; James and Stevens, 1986), and others are near the top and/or at the top of Aguathuna Formation (Schuchert and Dunbar, 1934; Levesque, 1977; Pratt, 1977; James and Stevens, 1986; Knight and James, 1987; James & al., 1989). In the Great Northern Peninsula, lead-zinc mineralization is associated with disconformities, with a producing mine at Daniel's Harbour, north of Cow Head.

CHAPTER 3

MULTIELEMENT TAXONOMY

Lower Ordovician conodonts of the Midcontinent Province have received only moderate taxonomic study, mainly during the last two decades. Many apparatus reconstructions have been based on limited or poorly preserved material. Fundamental revisions to apparatus reconstructions are proposed herein based on study of over 75 apparatus species, representing some 29 genera, determined from 45,000 well preserved conodonts.

Three main apparatus types are proposed: Type I, Type II and Type III. A minority of the studied apparatuses contain only a (subsymmetrical, subrounded), and e (symmetrical or asymmetrical, orally compressed) in a modified Type I apparatus (Barnes & al., 1979), and examples of this group include Clavohamulus, Stultodontus n. gen. (stubby "Scolopodus"), and Macerodus (extremely flattened forms). Some other modified Type II apparatuses (Type III, Barnes & al., 1979) consists of a (subsymmetrical, subrounded), c (symmetrical, suberect, laterally compressed), and e (asymmetrical, laterally compressed), and examples of this group include Utahconus, Drepanodus, Acanthodus, Polycostatus and possibly Cordylodus as well. The majority of apparatuses consist of the following element morphotypes: a (subsymmetrical, subrounded with two variants), b (asymmetrical, transitional), c (symmetrical, suberect, posteriorly compressed), _e_ (asymmetrical, laterally or orally compressed usually with two variants), _f_ (symmetrical, suberect, laterally compressed). Examples of this group include _Teridontus_, _Semiacontiodus_, _Variabiloconus_, _Glyptoconus_, _Acodus_, _Pteracontiodus_, _Striatodontus_ n. gen. and _Scolopodus_. This study shows that there are far fewer Lower Ordovician taxa than previously assumed (Sweet, 1985), and helps clarify the systematic and phylogenetic relationships of these difficult and rather neglected conodonts that represented part of the important initial evolutionary diversification of euconodonts.

Historical review of multielement taxonomy

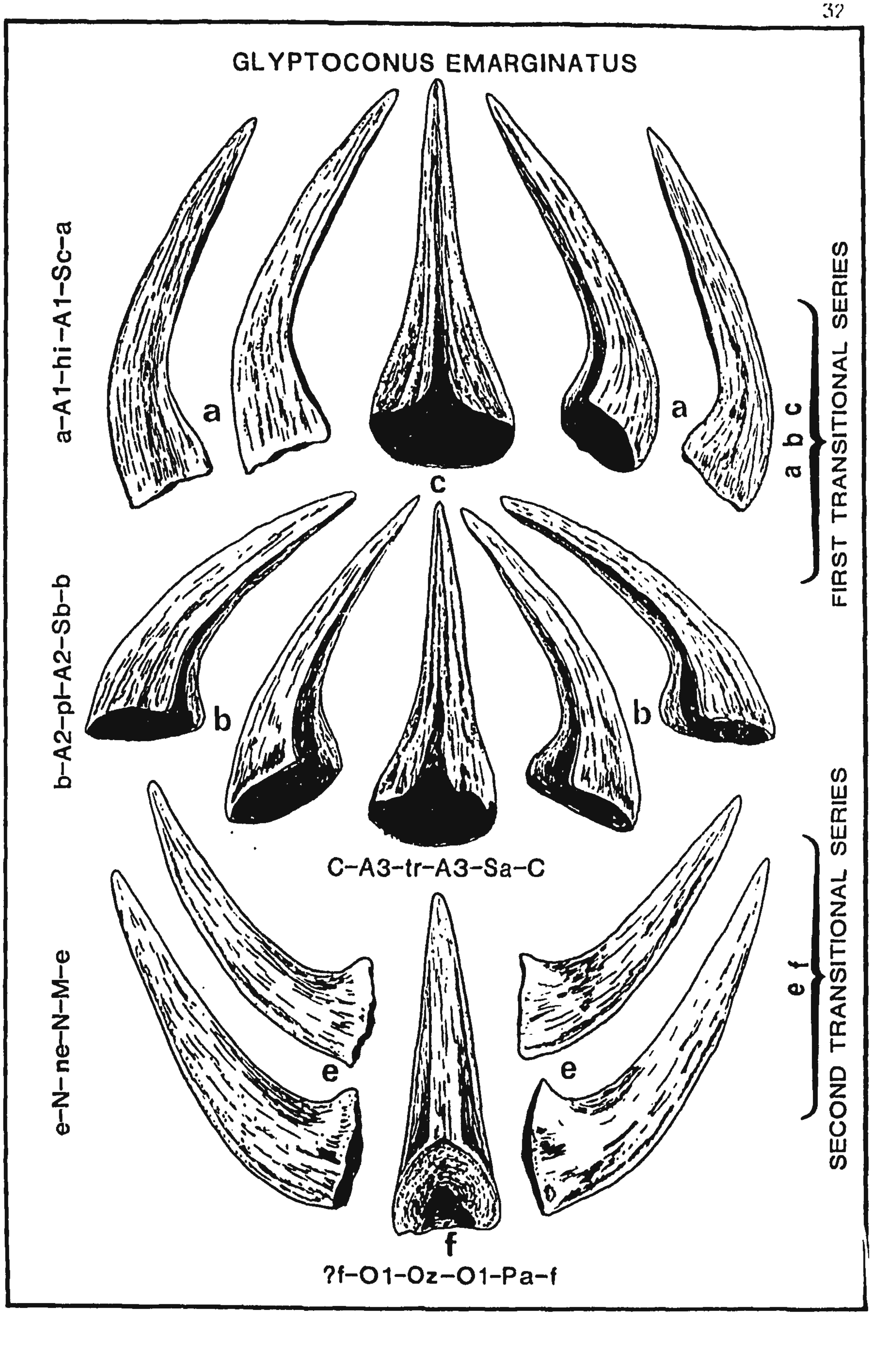
Studies of Ordovician conodonts began with Pander's remarkable monograph of 1856, in which many taxa were first described. From 1856 to the early 1950's. Lower Ordovician conodont studies were few and based on small collections, often of poorly preserved material, with limited contribution to taxonomy. Lindström (1955, 1964) proposed the concept of form-transition series of elements within conodont apparatuses. His approach was based on morphological gradation between e`ements. This concept of transition series was an important step in the development of the Lower Ordovician multielement taxonomy. The works of Bergström and Sweet (1966), Schopf (1966) and Webers (1966) initiated a movement away from form taxonomy towards multielement taxonomy. Sweet and Bergström (1972) reviewed the taxonomy of some coniform apparatuses, but their work mainly focused on the Middle and Upper Ordovician conodont apparatuses. Barnes and others (1979) devised a classification scheme for all known Ordovician conodont apparatuses. Five main apparatus group (Type I-V) and seventeen subtypes were defined on the basis of symmetry, curvature, and number of the element types, with a clear distinction being made between the first and second transition series.

Miller (1980) established Teridontus, Semiacontiodus, Monocostodus and Utahconus from the Lower Ordovician of western Utah. He considered that Teridontus, Semiacontiodus and Monocostodus possessed mono-elemental apparatuses, whereas Utahconus comprised unicostate and bicostate elements within a symmetry transition series. His elemental terminology, rounded and compressed, used for Cambrooistodus, Cordylodus and Ecocondontus essentially distinguishes the first and second transition series of Barnes & al. (1979), but has obscured the recognition of distinct morphotypes within these categories (Barnes, 1988). Repetski and Ethington (1983) established Rossodus as a Lower Ordovician conodont genus whose apparatus comprises slightly compressed and keeled coniform elements herein interpreted as comprising both a first transition series and oistodiform elements (second transition series). Numerous other conodont workers (e.g. van Wamel, 1974; Dzik, 1976; Löfgren, 1978; Sweet, 1979; Clark and others, 1981) have also reconstructed the coniform apparatuses of the Ordovician conodonts in recent years. Fåhræus and Hunter (1985) emphasized that the degree or variation of curvature of the cusp appears to be an integral part of some coniform apparatuses.

On the basis of the St. George Group collections, the detailed taxonomic treatment of the faunas, and many clues from these previous works, a major revision is proposed for the apparatuses of the majority of the Lower Ordovician conodonts from the Midcontinent Province.

Jeppsson (1971), Klapper and Philip (1971), Sweet & al. (1975), Sweet and Schonlaub (1975), and Barnes & al. (1979) each instituted different notation schemes for conodont elements and used these to describe elemental morphotypes in apparatuses (Figure 3:1). These have been reviewed in detail in the Treatise Volume (Clark & al., 1981). Herein, the letter code for the Lower Ordovician conodont elements by Barnes & al. (1979) is used, but slightly modified. They designed three different sets of letter code: *s*, *t*, *u* letters in the first group (Type I apparatus) were represented three different elemental morphotypes in the majority of Lower Ordovician coniform apparatuses which show continuous and morphologically plastic symmetry transition series; *p*, *q*, *r* letters were used in the second group (Type III apparatus) for three distinct elemental morphotypes on the basis of the degree of curvature of the cusp with respect to the base as shown by

Figure 3:1. Comparison of different notation schemes proposed by this study, Klapper and Philip (1971), Jeppsson (1971), Sweet & al. (1971), Sweet and Schonlaub (1975), Barnes & al. (1979) for conodont elements in an apparatus (*Glyptoconus emarginatus* (Barnes and Tuke)) with five element morphotypes.


GLYPTOCONUS EMARGINATUS
a-A1-hi-A1-Sc-a
a
c
a
a b c
FIRST TRANSITIONAL SERIES
b-A2-pl-A2-Sb-b
b
b
C-A3-tr-A3-Sa-C
SECOND TRANSITIONAL SERIES
e f
e-N-ne-N-M-e
e
e
f
?f-O1-Oz-O1-Pa-f

Drepanoistodus; a, b, c, and e, f, g letters referred to the elemental morphotypes within the first and second transition series, respectively, were used in the third and fourth groups (Types III and IV apparatuses). Some taxa were shown to possess reduced apparatuses (Type V) containing some or all of the second transition series elements (e, f, g). It is considered that Barnes and others' (1979) first (s, t, u) and second (p, q, r) sets of letters can now be homologized with their third set of letters (a-g); consequently a simplified system using only morphotypes a to f is adopted herein.

The letter codes for the Lower Ordovician faunas are redefined as follows: a elements within three apparatus types (Types I, II and III) are characterized by symmetrical to asymmetrical, rounded to subrounded with variation in curvature of the cusp; b elements which are asymmetrical, slightly compressed laterally show intermediate morphologies between a elements and c elements; c elements are symmetrical, suberect, posteriorly compressed; e elements are characterized by having asymmetrical, compressed unit with variation in curvature of the cusp; f elements are symmetrical, suberect, laterally compressed without distinct variation. The first transition series is represented by a, b and c elements, and the second transition series is comprised of e and f elements. The d and g elements, of the first and second transition series, respectively, of Barnes & al. (1979), are generally absent in the apparatuses of the St. George Group faunas.

Types of multielement apparatuses

As many authors have emphasized previously, sound multielement taxonomy must be based on large collections of well preserved conodonts, preferably of low CAI to reveal internal and basal cavity characteristics, with strong dependence on good descriptions of form-taxa by previous authors, and using a variety of criteria for apparatus reconstruction. The present study has been able to use all the criteria for multielement analysis.

This principal contribution to Lower Ordovician apparatus reconstructions is to formally define the skeletal types. Three major apparatus types are redefined (Types I, II and III) in which the majority of known Lower Ordovician, Midcontinent Province, conodont genera can be accommodated. The skeletal plans of apparatus Types I, III, II and IV which were proposed by Barnes & al. (1979) are modified to be Type I, Type II and Type III respectively. Two particular morphotypes are present in all three apparatus types, namely: a subrounded morphotype usually with two variants and e compressed morphotype also having two variants.

The suberect symmetrical morphotype in the first transition series is important in apparatuses Type II and Type III. The transitional elements (b) within the first transition series, and the suberect symmetrical elements (f) within the second transition series are present in Type III apparatuses only.

All the skeletal elements are symbolized from the notation scheme of Barnes & al. (1979) as follows (Fig. 3:1): a=subsymmetrical subrounded elements with two variants; b=asymmetrical transitional elements showing intermediate morphology between a and c elements; c=suberect symmetrical, posteriorly compressed elements; e=asymmetrical, laterally compressed elements usually with two variants; f=suberect symmetrical, laterally compressed elements. Elements a-c belong to the first transition series and elements e and f occur in the second transition series (Barnes & al., 1979).

Some conodont workers consider that the existing framework of form-element names should be retained as a scheme of parataxa, supplementary to a parallel multielement classification and nomenclature (Moore and Sylvester Bradley, 1957), and also for easy understanding and communication in multielement taxonomy than only using the letter code.

In general, within each Lower Ordovician apparatus the subrounded elements (a) and compressed elements (e) are the most common forms, transitional elements (b) are less common, suberect symmetrical elements (c) and suberect symmetrical elements (f) are usually rare within each apparatus species. During the earliest and latest stages of apparatus evolution, a certain species may lack suberect symmetrical (c and *f*) elements within Type III.

In a literature review of Lower Ordovician Midcontinent faunas, it was noticed that all the subrounded to rounded elements (*a*) that are usually associated with the transitional elements (*b*) as well as the compressed elements (*e*) and symmetrical suberect elements (*c* and *f*), are reported frequently together. This is the case for the following multielement taxa: 1. *Glyptoconus floweri* (Repetski) has *a*, *b*, *c*, and *e* elements; 2. *Glyptoconus quadraplicatus* (Branson and Mehl) has the following morphotypes (with form species names): *a* *S*. *quadraplicatus* Branson and Mehl, *b* *S*. *triplicatus* Ethington and Clark, *c* "*Acontiodus*" *staufferi* Furnish, *e* "*Drepanodus*" *parallelus* Branson and Mehl, "*Drepanodus*" *simplex* Branson and Mehl and "*Drepanodus*" *arcuatus* Branson and Mehl, and *f* *Ulrichodina abnormalis* Branson and Mehl; 3. *Glyptoconus emarginatus* (Barnes and Tuke) contains *a* and *b* elements, as well as *c* "*Acontiodus staufferi*" Furnish, *e* "*Drepanodus*" *toomeyi* Ethington and Clark and *f* *Ulrichodina prima* Furnish; 4. *Variabiloconus bassleri* (Furnish) has *a*, *b*, *c*, and *e* elements, namely *a*, *b*, *c* bassleriform and *e* variabiliform; 5. *Acodus delicatus* Branson and Mehl, and *A*. *comptus* Branson and Mehl have fully developed *a*, *b*, *c*, *e*, and *f* elements, namely: *a* distacodiform, *b* acodiform, *c* suberect distacodiform, *e* oistodiform and *f* deltaform; 6. finely striated scolopodid *Striatodontus simplex* (Furnish) has *a*, *b*, *c*, and *e* elements.

In some other conodont apparatuses some slightly flattened subrounded elements (a) are usually associated with both the suberect symmetrical elements (c) and the compressed elements (e). Examples of this group include: 1. Drepanodus usually with a, c, and e elements; 2. Cordylodus with a (may include b morphotype as noted by Barnes, 1988), c, and e elements; 3. Utahconus with a, c, and e elements; 4. some oldest or youngest species of Glyptoconus having a, c, and e morphotypes.

In another group of taxa, the majority of stubby subrounded simple cones are only associated with slightly compressed or orally compressed elements, such as: 1. Clavohamulus with a acontiodiform and e clavohamuliform; 2. stubby scolopodid Stultodontus n. gen. with a and e elements. The most extremely flattened forms usually have two major morphotypes, such as: 1. Macerodus with a and e elements; Loxodus, Loxodentatus and Loxognathus with one or two elemental morphotypes.

All these apparatuses were recognized or established through examining the stratigraphic range (see summary of ranges of selected conodonts in Appendix A), comparable frequency and cooccurrence, similarity in morphologic and micromorphologic features, and in their colour, symmetry pattern, and distribution of the white matter.

1. Apparatus Type I

Apparatus Type I is basically modified from Barnes and others' (1979) Apparatus Type I. It consists of two morphotypes (a subrounded and e compressed elements) and includes a few genera characterized by the stubby coniform (Type IA) and extremely flattened forms (Type IB) rather than three morphotypes (a, b, c) found in early Ordovician simple cone genera. Type IA apparatus is presented in only a few genera which are usually stubby coniform. Type IB includes a few genera characterized by having extremely flattened cusp and base.

The morphotypes in Type IA apparatuses (Fig. 3:2) are characterized as follows: a=subsymmetrical elements with rounded to subrounded cross-section, e=asymmetrical elements with antero-posteriorly or orally compressed cusp. Clavohamulus and Stultodontus n. gen. belong within this group. Clavohamulus has an apparatus consisting of a (acontiodiform) elements and e (clavohamuliform) elements, and both a and e elements have no distinct variants (see under Systematic Paleontology). Most stubby forms of scolopodids and oneotodids, such as Striatodontus carlae (Repetski), S. restractus n. gen., Stultodontus costatus (Ethington and Brand), Stultodontus ovatus n. sp., and Stultodontus pygmaeus n. sp. usually have an apparatus consisting of a elements with subrounded cross-section, and e elements with antero-posteriorly or orally compressed cusp. All Type IA apparatuses contain stubby coniforms with rapidly tapered cusp and circular to subcircular basal cross-section in both a and e elements, and antero-posteriorly or orally compressed cusp with reduced base in e elements. Both a and e elements within Type IA may usually have two subtle variants (slightly compressed and strongly compressed). Some a elements of Type IA generally are quite distinct from e elements, though some e elements bear some similarities in the base, basal cavity and general profile to a elements. For example, acontiodiform (a) elements generally differ from clavohamuliform (e) elements within the Clavohamulus apparatus, but both elements exhibit similar morphologies in their short bases and shallow basal cavities marked by faint concentric growth lines. Other a elements are closely similar to e elements, such as most stubby forms of scolopodid and oneotodid elements, and it may be difficult to distinguish between them.

Type IB apparatuses have two element morphotypes (Fig. 3:3): a subrounded elements and e compressed elements. Most species of Macerodus, Cristodus, and probably Loxodus belong within this group. Macerodus has an apparatus consisting of a subrounded (curved macerodiform) elements and e compressed (straight macerodiform) elements. Cristodus has two morphotypes too, one subrounded element characterized by having more denticles, and another compressed element having a single denticle. Loxodus probably has two morphotypes, but it is difficult to distinguish them. Some a elements of Type IA apparatuses are usually distinct from e elements,

Figure 3:2. Apparatus Type IA with *a* subrounded and *e* orally compressed morphotypes, including the most stubby coniforms, with examples of *Clavohamulus reniformis* n. sp. and *Stultodontus ovatus* n. sp.

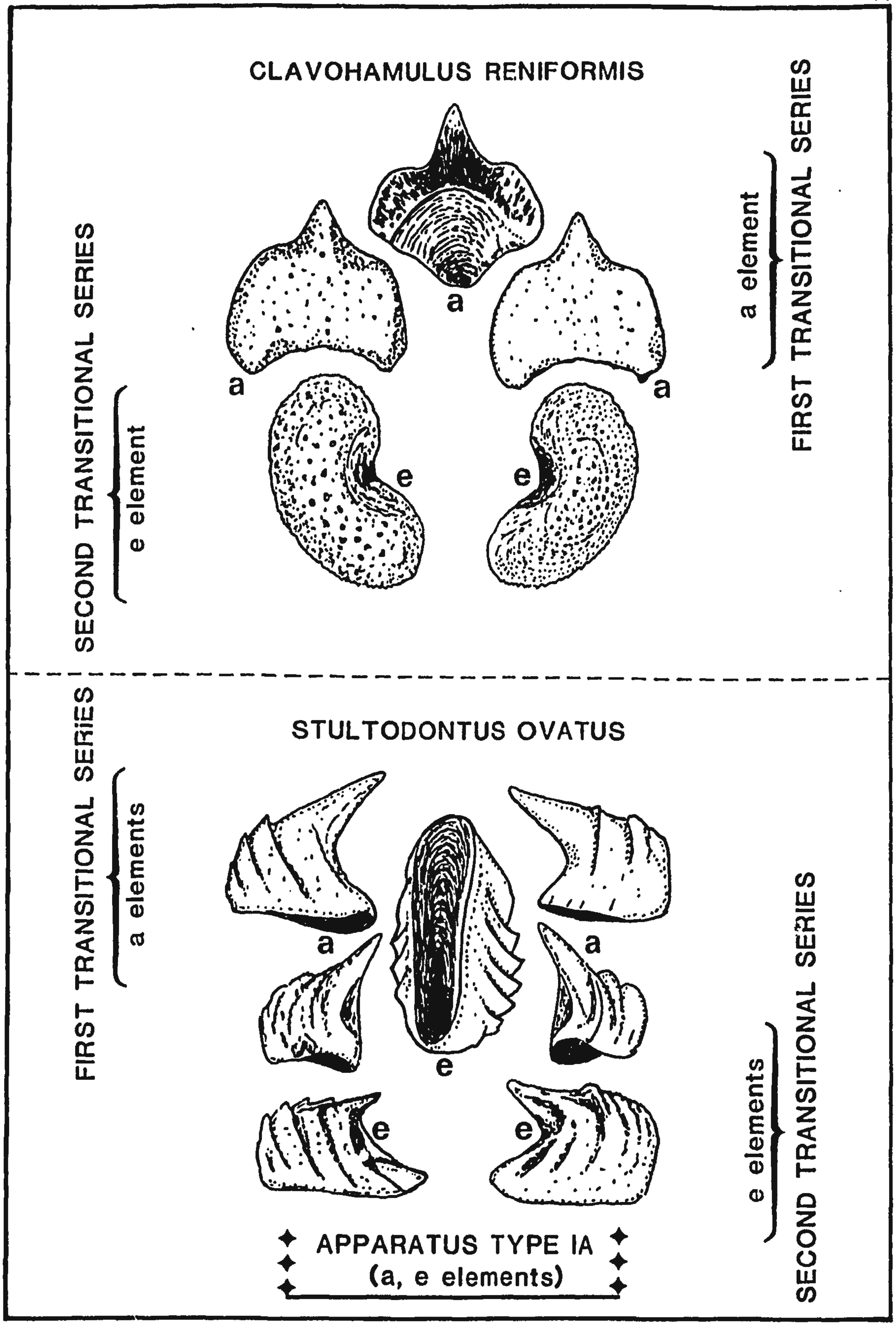
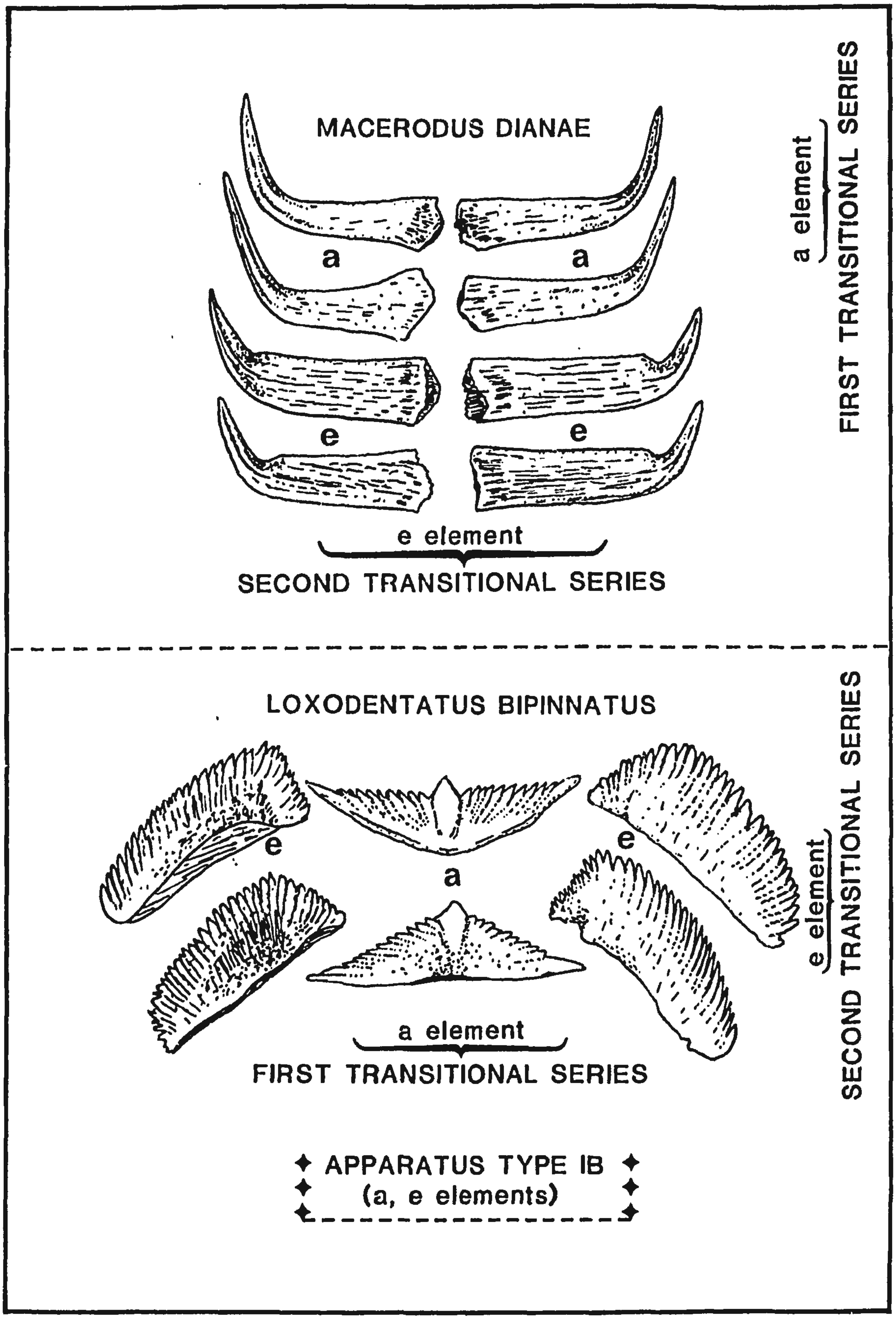

CLAVOHAMULUS RENIFORMIS
a
a
a
e
e
a element
FIRST TRANSITIONAL SERIES
e element
SECOND TRANSITIONAL SERIES
STULTODONTUS OVATUS
a
a
e
e
e
a elements
FIRST TRANSITIONAL SERIES
e elements
SECOND TRANSITIONAL SERIES
APPARATUS TYPE IA
(a, e elements)

Figure 3:3. Apparatus Type IB with a "subrounded" and e laterally compressed morphotypes, including the most flattened conodonts, with examples of Macerodus dianae Fahraeus and Nowlan and Loxodentatus bipinnatus n. gen. & sp.


MACERODUS DIANAE
a
a
e
e
e element
SECOND TRANSITIONAL SERIES
a element
FIRST TRANSITIONAL SERIES
LOXODENTATUS BIPINNATUS
e
a
e
a element
FIRST TRANSITIONAL SERIES
e element
SECOND TRANSITIONAL SERIES
APPARATUS TYPE IB
(a, e elements)

especially species of Cristodus, in contrast other taxa bear a elements that are similar to e elements, such as species of Macerodus.

2. Apparatus Type II

Apparatus Type II is a modified version of the Type III apparatuses of Barnes & al. (1979). As noted above, Barnes and others'(1979) q, p, r morphotypes in Type III are homologized with a, c, e morphotypes, respectively. Apparatus Type II usually consists of three major morphotypes: a subsymmetrical and subrounded elements; c suberect symmetrical, laterally compressed elements and e asymmetrical, laterally compressed elements. The morphotypes of apparatus Type II (Fig. 3:4 and Fig. 3:5) are symbolized from the notation scheme of Barnes & al. (1979) as follows: a=elements that are subsymmetrical, subrounded, moderately recurved; c=elements that are bilaterally symmetrical, erect to suberect, slightly laterally compressed or antero-posteriorly compressed; e=elements that are laterally compressed, asymmetrical, sharply reclined. Most conodonts of Type II are coniforms with a slightly to strongly compressed cusp or base; however, some are denticulated forms with laterally compressed cusp and base. Two subgroups can be recognized, Type IIA (Fig. 3:4) and Type IIB. Type IIA includes Cordylodus, Drepanodus, Acanthodus and Utahconus. Type IIB contains multicostate Polycostatus (such as P. oneotensis, P. sulcatus

Figure 3:4. Apparatus Type IIA with a subrounded, c suberect and e compressed elemental morphotypes, including the coniforms with slightly to strongly compressed cusp or base, with examples of Drepanodus nowlani n. sp. and Cordylodus intermedius Furnish.

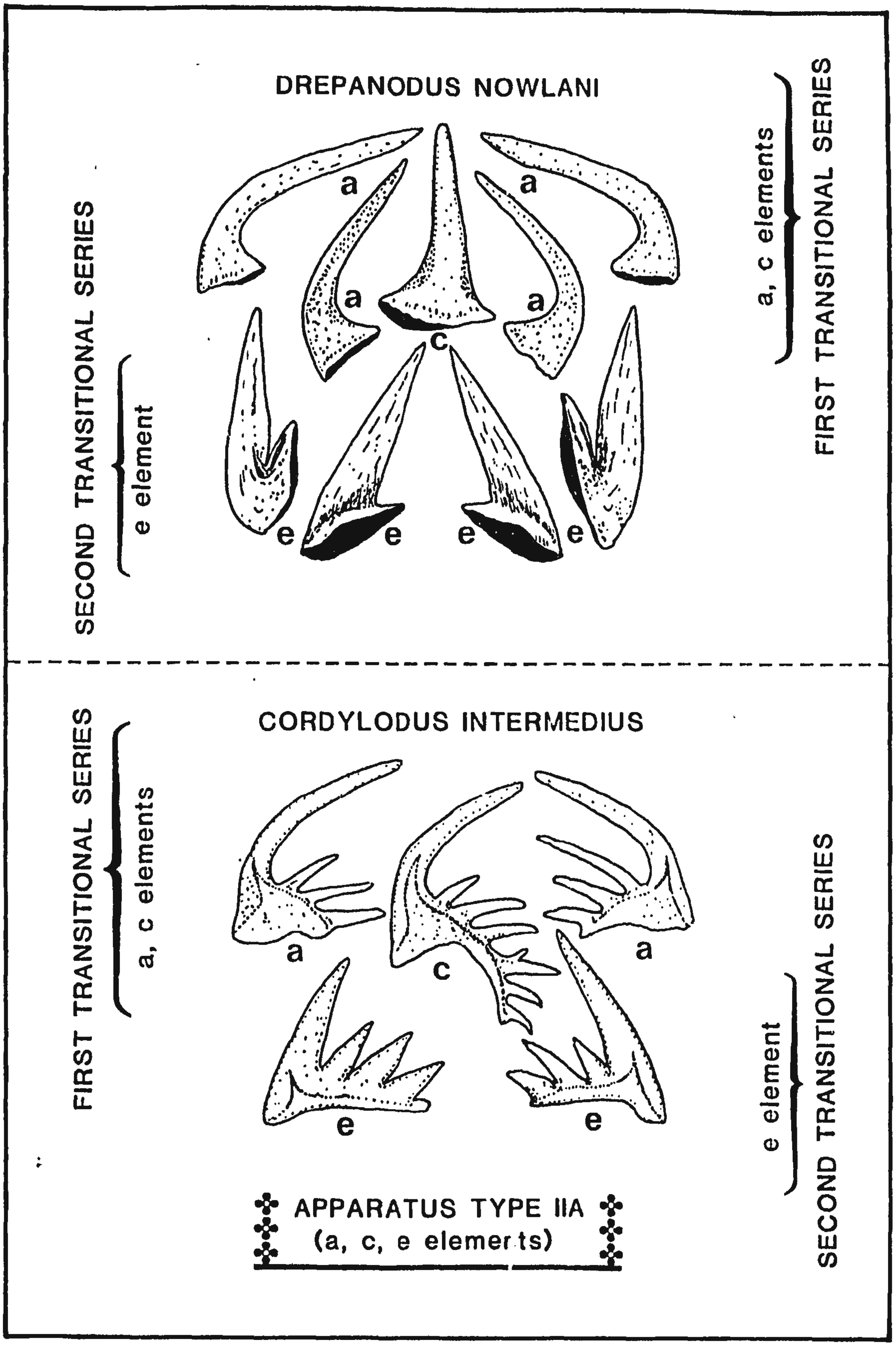
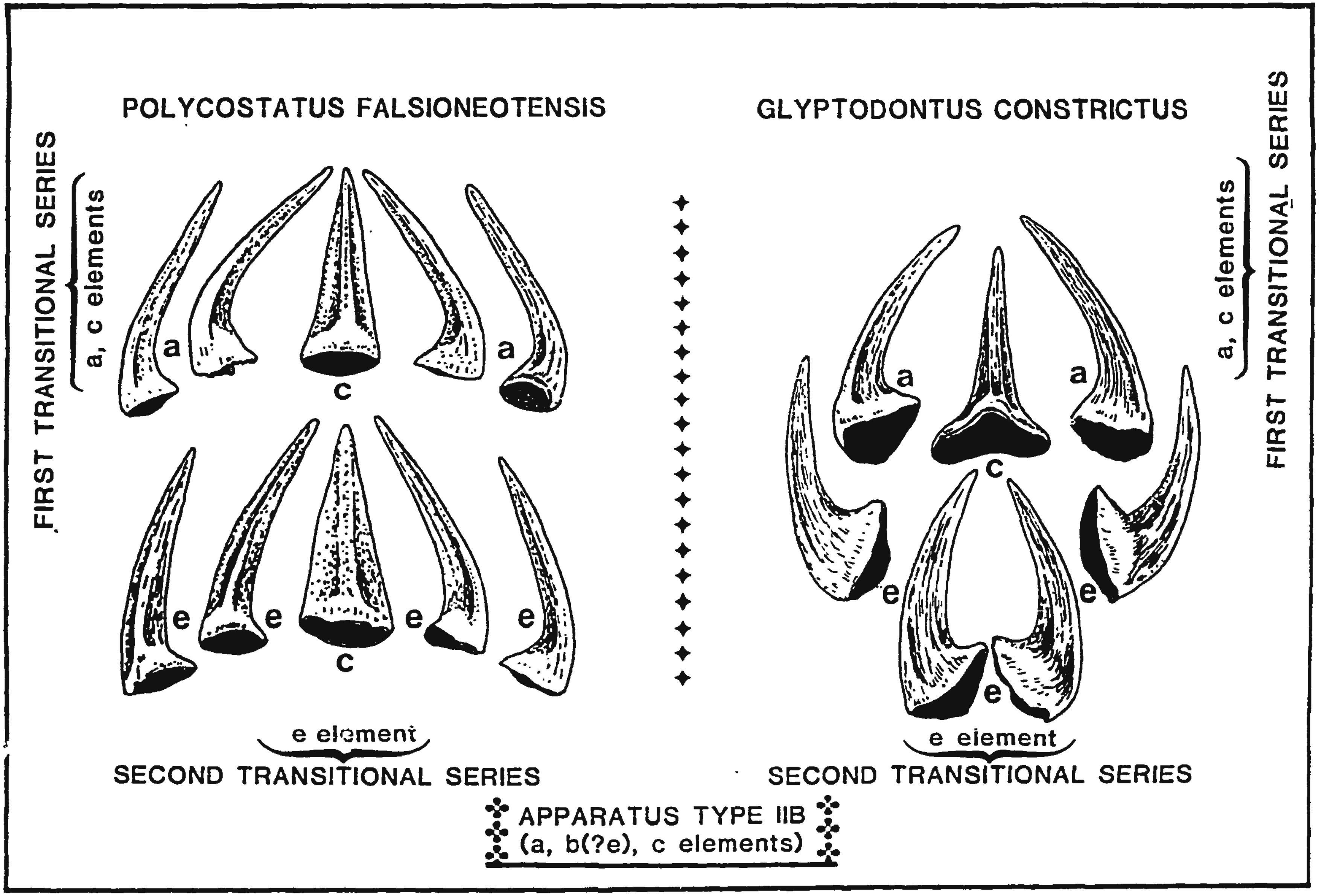

DREPANODUS NOWLANI
a
a
a
a
c
e
e
e
e
a, c elements
FIRST TRANSITIONAL SERIES
SECOND TRANSITIONAL SERIES
e element
CORDYLODUS INTERMEDIUS
a
c
a
e
e
FIRST TRANSITIONAL SERIES
a, c elements
e element
SECOND TRANSITIONAL SERIES
APPARATUS TYPE IIA
(a, c, e elements)

Figure 3:5. Apparatus Type IIB with a subrounded, c suberect and e compressed elemental morphotypes, including the coniforms with keeled and grooved cusp, with examples of *Polycostatus falsioneotensis* n. sp. and *Glyptoconus constrictus* n. sp.


POLYCOSTATUS FALSIONEOTENSIS
GLYPTODONTUS CONSTRICTUS
FIRST TRANSITIONAL SERIES
a, c elements
a
c
e
e element
SECOND TRANSITIONAL SERIES
APPARATUS TYPE IIB
(a, b(?e), c elements)

and P. falsioneotensis n. sp.), and some of the oldest species of Glyptoconus.

Drepanodus is regarded as having an apparatus consisting of a drepanodiform elements, c suberectiform elements, and e oistodiform elements (Fig. 3:4). The drepanodiform elements belong to the part of first transition series usually with two variants recognized by Kennedy (1980) as the arcuatiform and sculponeaform elements; the oistodiform elements represent the second transition series usually with two variants which were named by Kennedy (1980) as the graciliform and pipaform elements: the suberectiform elements as a part of the first transitional series tend to be bilaterally symmetrical, rare, and with little morphological variation. The earliest species of Drepanodus has an apparatus containing three elements, but e elements characterized by slightly compressed drepanodiform are different from those oistodiform of younger species of Drepanodus.

The apparatus of Acanthodus consists of a subrounded drepanodiform elements, c symmetrical suberectiform elements and e compressed drepanodiform elements. Both a and c elements of Acanthodus are closely similar to those of Drepanodus, but its compressed elements are quite different from the oistodiform elements of Drepanodus.

Cordylodus has an apparatus consisting of a subrounded elements with two variants and c symmetrical somewhat suberect element together named by Barnes (1988) as p1, p2, and p3 respectively; e compressed elements with two variants in some species based on this study. The subrounded elements of Cordylodus are usually subsymmetrical with subrounded cusp and denticles, and comprise the first transition series with two variants; the compressed e elements are asymmetrical, strongly compressed laterally to produce sharp edges, and represent the second transition series with one or two variants. The suberect symmetrical c elements are similar to the subrounded a elements and comprise the first transition series, but their cusps and base are slightly compressed and usually the basal rim is strongly arched with an extended posterior basal portion.

The apparatus of Utahconus also consists of three morphotypes: a subrounded elements named by Miller (1980) as the unicostate elements, c suberect symmetrical elements, and e compressed elements (the bicostate element named by Miller, 1980). The subrounded a elements of Utahconus are usually asymmetrical, unicostate forms with right or left lateral costa; the compressed e elements are asymmetrical, bicostate forms with lateral and postero-lateral costae; the suberect symmetrical c elements are generally staufferiform cones with a posterior carina and two sharp-edged lateral costae.

The majority of species in multicostate Polycostatus n. gen. have an apparatus consisting of three major morphotypes: a subrounded oneotensiform elements, c suberect symmetrical staufferiform elements and e compressed elements. The a elements and c elements form the first transition series, and the e elements, commonly with two variants, belong to the second transition series.

It should be noted that the apparatuses of two oldest species of Glyptoconus, G. bolites (Repetski) and G. felicitii n. sp. are different from those of the younger species of Glyptoconus in possessing only a, c and e elements. Glyptoconus triplicatus (Ethington and Clark) and G. priscus n. sp. may have three major morphotypes, but their e compressed elements are difficult to distinguish from the a elements.

Most a elements of apparatus Type II have some similarities to the e elements, but are usually distinguished by their symmetry, curvature and degree of compression. Within Type II apparatuses, c elements are characteristically erect to suberect and symmetrical, and are quite distinct from both a elements and e elements, though most of them share some common features in base, basal cavity, and shape of the cusp.

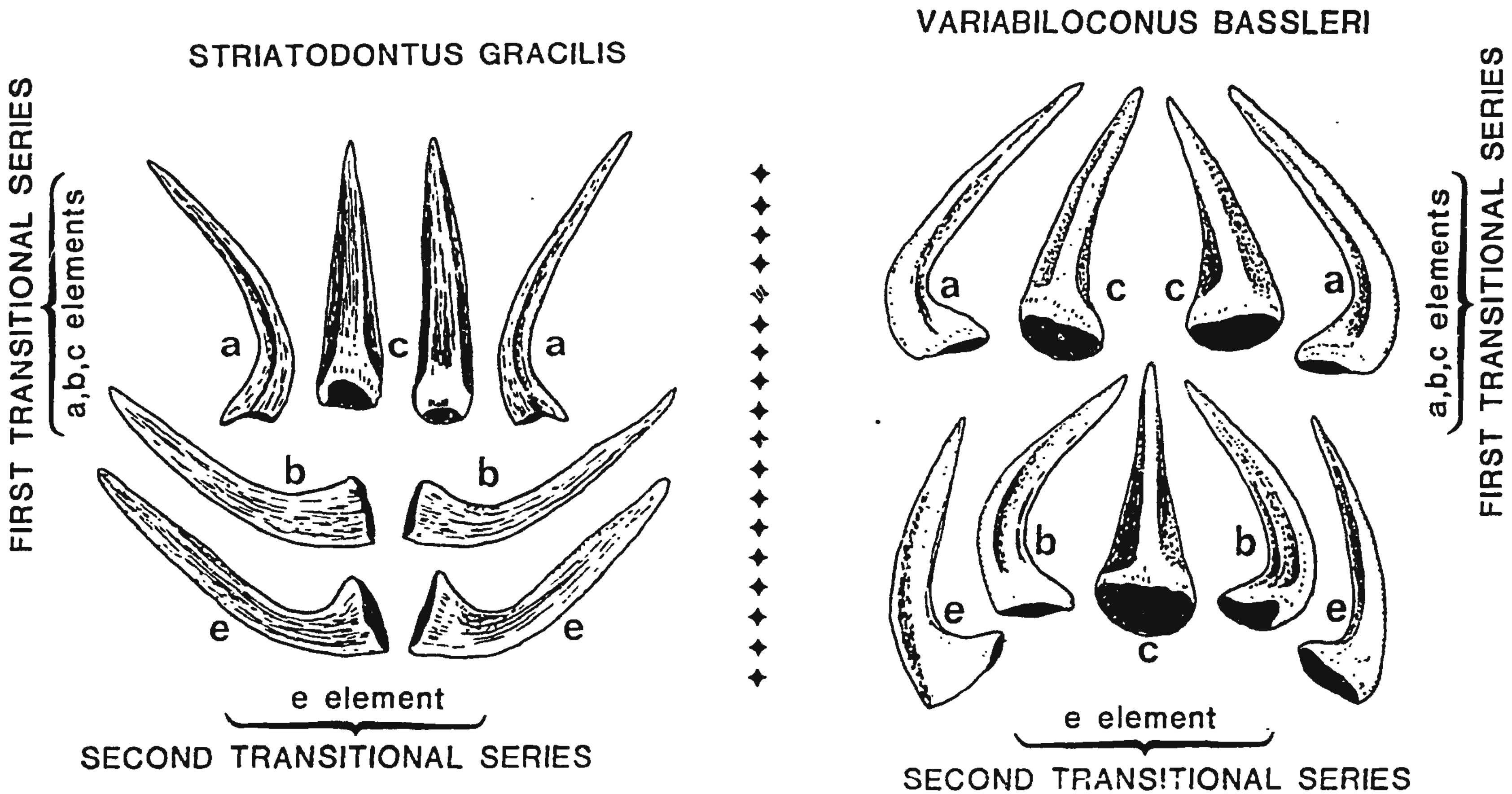
3. Apparatus Type III

The majority of apparatuses of Lower Ordovician slender coniforms belong within apparatus Type III, and consist of four to five morphotypes: a subrounded subsymmetrical elements, b asymmetrical transitional elements, c suberect staufferiform elements, e asymmetrical compressed elements, and f suberect symmetrical elements. This apparatus type is a combination of Type II and Type IV apparatuses of Barnes & al. (1979).

Type III can be divided into the Type IIIA with four element morphotypes (Fig. 3:6) and the Type IIIB with five element morphotypes (Fig. 3:7). Type III apparatuses have fully developed and distinct morphotypes, each of which shows significant elemental variability. The morphotypes of apparatus Type III (Fig. 3:6, Fig. 3:7) are symbolized as follows: a=elements that are subsymmetrical, subrounded, reclined to recurved slender forms; b=elements that are similar to the a elements, but they are asymmetrical and slightly compressed with intermediate features between a elements and c elements; c=elements that are usually suberect, bilaterally symmetrical, antero-posteriorly compressed, staufferiform-like type with expanded base, suberect cusp, and well developed posterior carina; e=elements that are asymmetrical, laterally compressed, reclined to strongly recurved, and usually drepanodiform-like coniform; f=elements that are ulrichodiniform-like with bilaterally symmetrical, laterally compressed, anteriorly thickened, and posteriorly keeled cusp and small basal cavity. Acodus, Glyptoconus, Rossodus, Pteracontiodus, Semiacontiodus, Striatodontus n. gen., Teridontus and Variabiloconus, all belong within this group.

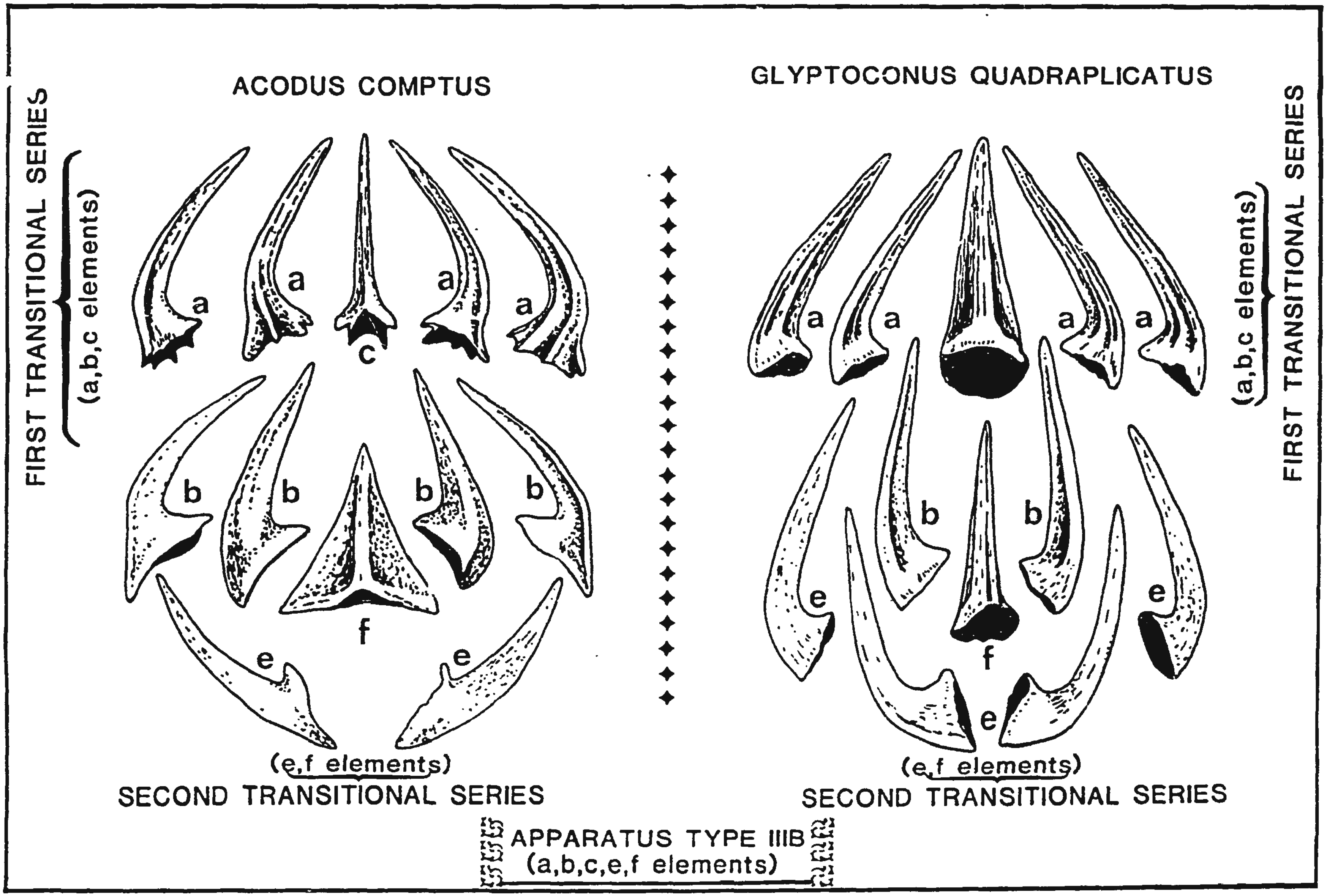
Teridontus and Semiacontiodus are regarded as having an apparatus consisting of a nakamuraiform (subrounded) elements,

Figure 3:6. Apparatus Type IIIA with four morphotypes: a subrounded, b transitional, c suberect and e compressed elements, with examples of Striatodontus gracilis (Ethington and Clark) and Variabiloconus bassleri (Furnish).



APPARATUS TYPE IIIA
(a,b,c,e elements)

Figure 3:7. Apparatus Type IIIB with five morphotypes: _a_ subrounded, _b_ transitional, _c_ suberect, _e_ compressed and _f_ suberect elements, including most slender coniforms, with examples of _Acodus_ _comptus_ (Branson and Mehl) and _Glyptoconus_ _quadraplicatus_ (Branson and Mehl).



ACODUS COMPTUS
GLYPTOCONUS QUADRAPLICATUS
FIRST TRANSITIONAL SERIES
(a,b,c elements)
a
a
c
a
a
b
b
f
b
b
e
e
(e,f elements)
SECOND TRANSITIONAL SERIES
a
a
a
a
b
b
e
f
e
e
(a,b,c elements)
FIRST TRANSITIONAL SERIES
(e,f elements)
SECOND TRANSITIONAL SERIES
APPARATUS TYPE IIIB
(a,b,c,e,f elements)

b semiacontiodiform (transitional) elements, c suberectiform or staufferiform (bilaterally symmetrical) elements, and e monocostodiform (compressed) elements. However, the earliest apparatuses of Teridontus and Semiacontiodus probably lack the compressed elements and suberect symmetrical elements.

Variabiloconus usually has an apparatus consisting of a (symmetrical) and b (asymmetrical) bassleriform elements, c slender staufferiform elements, and e variabiliform elements, as in V. bassleri (Furnish) (Fig. 3:6).

The apparatus of Glyptoconus usually contains five element morphotypes: a subrounded, symmetrical multicostate elements; b transitional asymmetrical tricostate elements; c suberect, antero-posteriorly compressed, symmetrical staufferiform elements; e compressed asymmetrical drepanodi-form-like elements, and f suberect symmetrical, laterally compressed ulrichodiniform elements, such as G. quadraplicatus (Branson and Mehl) (Fig. 3:7) and G. emarginatus (Barnes and Tuke) (Fig. 3:1). The a elements of Glyptoconus are usually subsymmetrical with elongate and slightly arcuate cusps which are grooved on either the lateral and/or posterior faces; b elements are similar to the subrounded elements, but with fewer costae and grooves; c suberect symmetrical staufferiform elements are bilaterally symmetrical with an expanded base and a very strong posterior carina; e elements are asymmetrical, drepanodiform-like coniforms with postero-laterally compressed, sharp-edged, recurved and slightly twisted cusps;

and <u>f</u> suberect symmetrical, laterally compressed ulrichodiniform elements which are characterized by having bilaterally symmetrical cusp and posteriorly keeled margin. The <u>a</u>, <u>b</u>, and <u>c</u> elements belong to the first transition series, in which the <u>a</u> element consists of two variants (sharply costate form and rounded costate form), the <u>b</u> and <u>c</u> elements show little morphological variation. The <u>e</u> and <u>f</u> elements comprise the second transition series, in which the <u>e</u> element contains two variants (one sharp-edged, another rounded-edged), and the <u>f</u> element has no morphological variants.

<u>Rossodus</u> has an apparatus usually consisting of <u>a</u> subrounded costate acontiodiform elements, <u>b</u> transitional drepanodiform elements, <u>c</u> suberect symmetrical elements and <u>e</u> compressed oistodiform elements. The <u>a</u>, <u>b</u>, and <u>c</u> elements comprise the first transitional series; the <u>e</u> elements belong to the second transition series. The earliest <u>Rossodus</u> species may lack <u>b</u> elements.

Most slender species of <u>Striatodontus</u> n. gen. exhibit fine striations and contain four morphotypes, <u>a</u>, <u>b</u>, <u>c</u>, and <u>e</u> elements. For example, <u>Striatodontus</u> <u>prolificus</u> n. sp. has an apparatus consisting of <u>a</u> subrounded oneotodiform elements, <u>b</u> transitional triangulariform elements, <u>c</u> suberect symmetrical oneotodiform elements and <u>e</u> compressed drepanodiform elements. All four morphotypes within the apparatus of <u>Striatodontus</u> <u>prolificus</u> are distinct from one another, but were previously assigned to three different form species; all bear similarities in having fine striations and a posterior groove. Striatodontus gracilis (Ethington and Clark) has a, b, c and e elements.

Acodus and Pteracontiodus have fully developed apparatuses as noted by many authors (e.g. McTavish, 1973; Lindström, 1977; Barnes, 1977; Kennedy, 1980; Ethington and Clark, 1981; Repetski, 1982) which comprise two transition series usually with five morphotypes: a distacodiform elements, b acodiform elements, c symmetrical distacodiform elements, e oistodiform elements and f deltaform elements (Fig. 3:7).

Among the five morphotypes within the apparatuses of Acodus and Pteracontiodus: a elements are quite distinct from e elements; b elements exhibit intermediate morphologies between a elements and e elements; c suberect symmetrical distacodiform elements are similar to a elements; f deltiform elements are distinct from all others. The a elements together with b and c elements comprise the first transition series, the e and f elements belong to the second transition series.

Summary

Multielement taxonomy of the Lower Ordovician conodonts is still in an early stage, limited mainly to a few comprehensive studies appearing only in the last two decades. This present study reviews and summarizes the multielement taxonomy of Lower Ordovician conodonts principally of the Midcontinent Province, based on over 70 newly reconstructed apparatuses. New skeletal apparatus types are established to accommodate the many reconstructed conodont apparatuses. Three apparatus types, apparatus Types I, II and III, are redefined. The Type I apparatus species consist of only a subrounded elements and e strongly antero-posteriorly or orally compressed elements, and are characterized by stubby coniforms and extremely flattened forms. The Type II apparatus has three major morphotypes which include a subrounded elements, c suberect symmetrical elements and e compressed elements. Those apparatuses of the Type III contain four (Type IIIA) or five (Type IIIB) skeletal morphotypes: a subrounded elements, b transitional elements, c suberect symmetrical antero-posteriorly compressed elements, e compressed elements and f suberect symmetrical laterally compressed elements.

In general, a subrounded, e compressed and c suberect symmetrical elements are the predominant elements in most Lower Ordovician conodont apparatuses of the Midcontinent Province. The a, b, and c elements comprise the first transition series; the e and f elements make up the second transition series. Both a and e elements may have two variants in some apparatuses of Type II and Type III.

Finally, it is important to note that most of the earliest and latest evolutionary stages of Lower Ordovician conodont apparatuses lack *c* suberect symmetrical elements, and commonly even transitional elements. For example, *c* and *f* suberect symmetrical elements are not found in the earliest and latest species of *Glyptoconus*, *Striatodontus* and several other genera. This appears to be a common phenomenon in the evolution of many conodont taxa. It should be also noted that most specialized conodont apparatuses usually have the fewest element morphotypes in comparison with those of common species, such as *Clavohamulus*, *Loxodus*, *Macerodus*, and *Stultodontus*.

CHAPTER 4

PHYLOGENY OF EARLY ORDOVICIAN CONODONTS

Although several important papers including those by Lindström (1970), Sweet and Bergström (1970, 1972), Bengtson (1976), Barnes and others (1979), Miller (1980), Repetski (1982), and Ethington and Clark (1981) discussed the evolution of Lower Ordovician conodonts, many were based mainly on form-taxonomy or incomplete multielement taxonomy. More recently, papers by Dzik (1983), Bengtson (1983), Miller (1984), and Sweet (1985, 1988) included some consideration of the phylogeny of Lower Ordovician conodonts, but their studies still involved some incomplete multielement taxonomy. As noted by Sweet and Bergström (1970), and Lindström (1971), the development of multielement taxonomy enabled consideration of phylogenetic relationships. The present study has reconstructed most Lower Ordovician apparatuses for the Midcontinent Province conodonts. Figures 4:1 to 4:4 illustrate an interpretation of the phylogenetic relationships of these difficult and rather neglected conodonts that represent part of the initial evolutionary diversification of euconodonts.

Miller (1980, 1984) proposed that Late Cambrian to Early Ordovician conodonts can be divided into two evolutionary lineages, one including *Proconodontus* and the other *Teridontus*, each characterized by skeletal apparatuses

Figure 4:1. Phylogeny of _Teridontus_ complex with the most of lineages represented in the Watts Bight Formation and the lower Boat Harbour Formation.

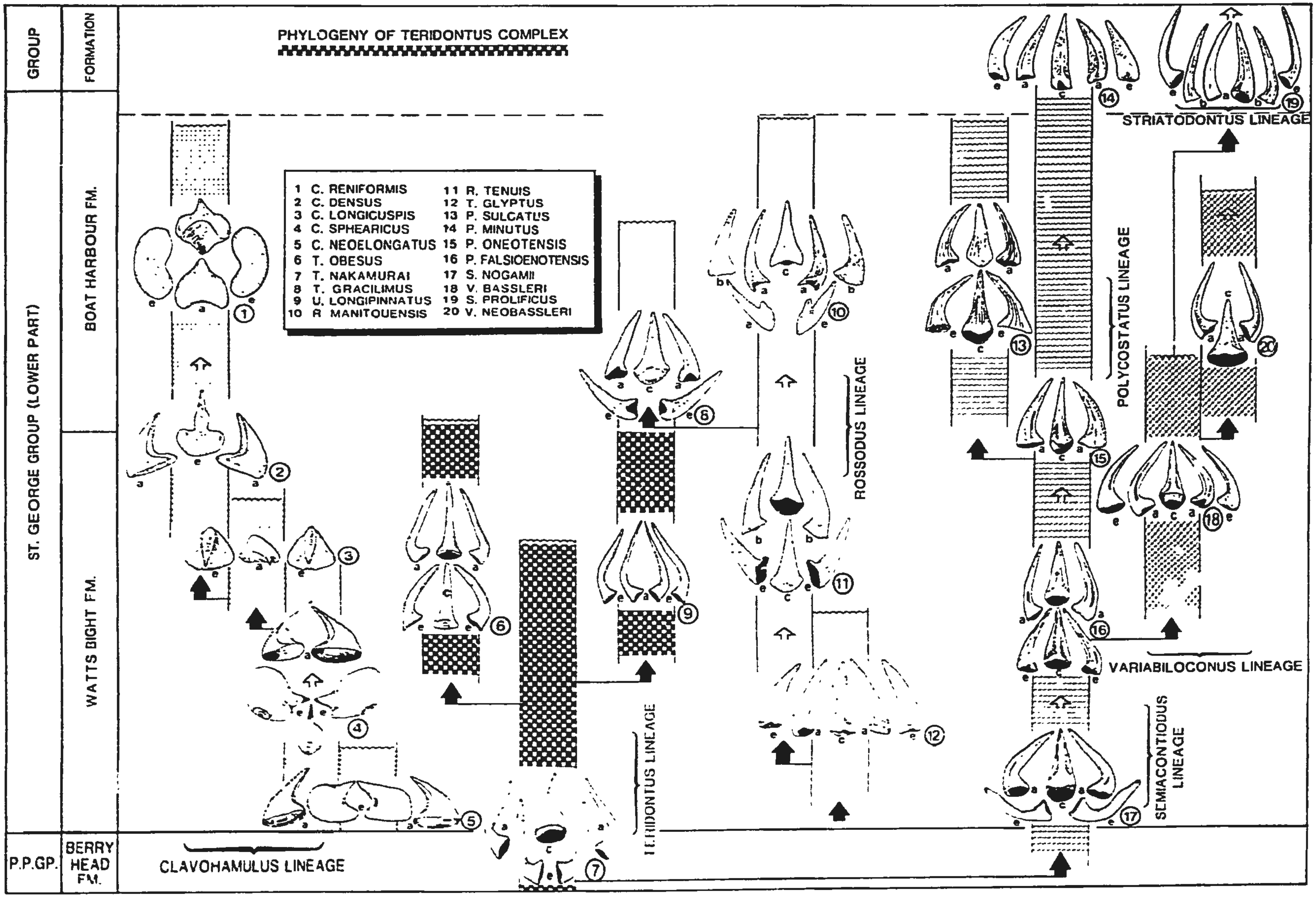

PHYLOGENY OF TERIDONTUS COMPLEX
GROUP
FORMATION
ST. GEORGE GROUP (LOWER PART)
BOAT HARBOUR FM.
WATTS BIGHT FM.
P.P.GP.
BERRY HEAD FM.
1 C. RENIFORMIS
2 C. DENSUS
3 C. LONGICUSPIS
4 C. SPHEARICUS
5 C. NEOELONGATUS
6 T. OBESUS
7 T. NAKAMURAI
8 T. GRACILIMUS
9 U. LONGIPINNATUS
10 R MANITOUENSIS
11 R. TENUIS
12 T. GLYPTUS
13 P. SULCATUS
14 P. MINUTUS
15 P. ONEOTENSIS
16 P. FALSIOENOTENSIS
17 S. NOGAMII
18 V. BASSLERI
19 S. PROLIFICUS
20 V. NEOBASSLERI
CLAVOHAMULUS LINEAGE
TERIDONTUS LINEAGE
ROSSODUS LINEAGE
POLYCOSTATUS LINEAGE
STRIATODONTUS LINEAGE
VARIABILOCONUS LINEAGE
SEMIACONTIODUS LINEAGE

Figure 4:2. Phylogeny of *Loxodus*, *Drepanodus* and *Cordylodus* lineages represented in the Watts Bight Formation and the lower Boat Harbour Formation.

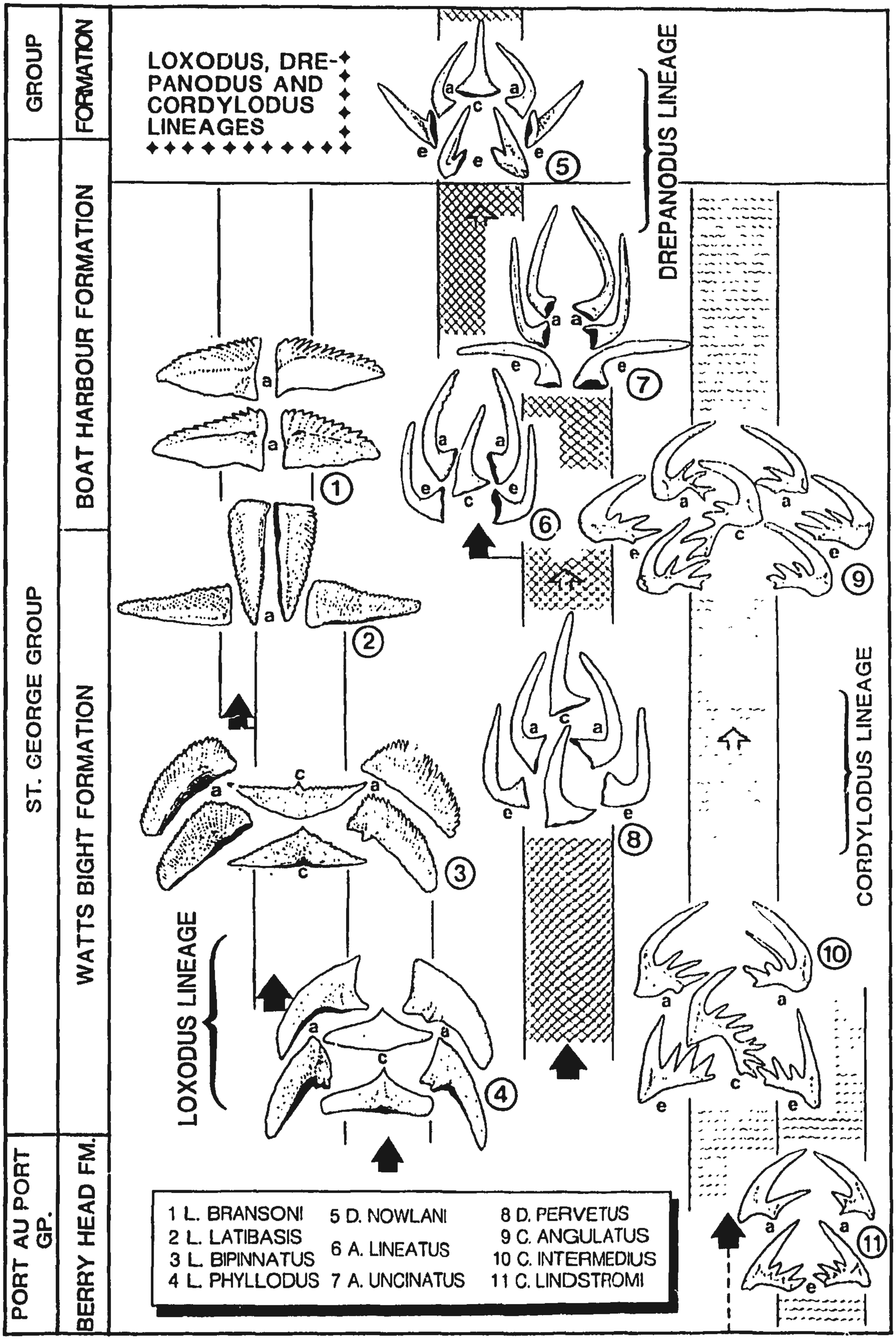
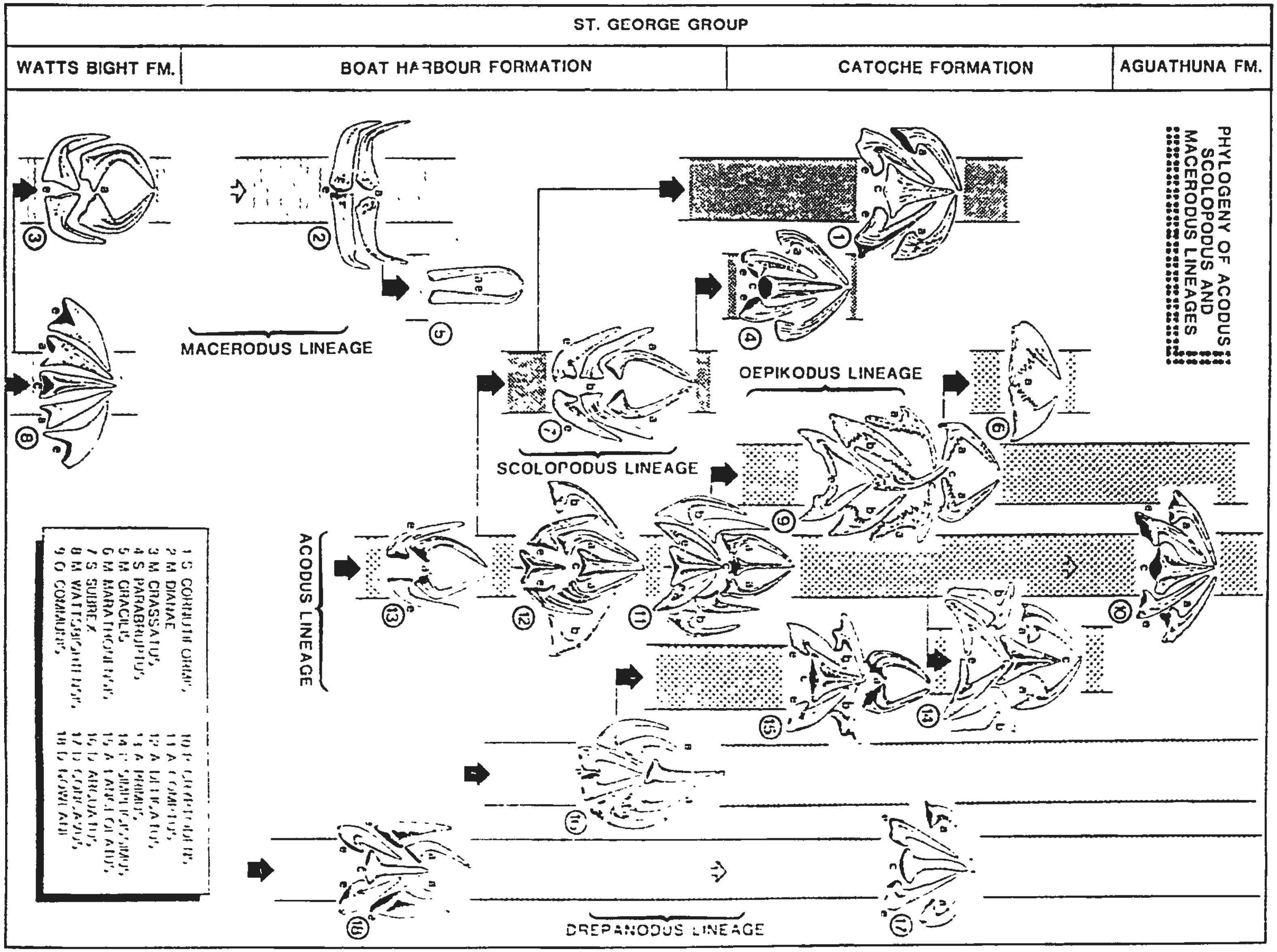
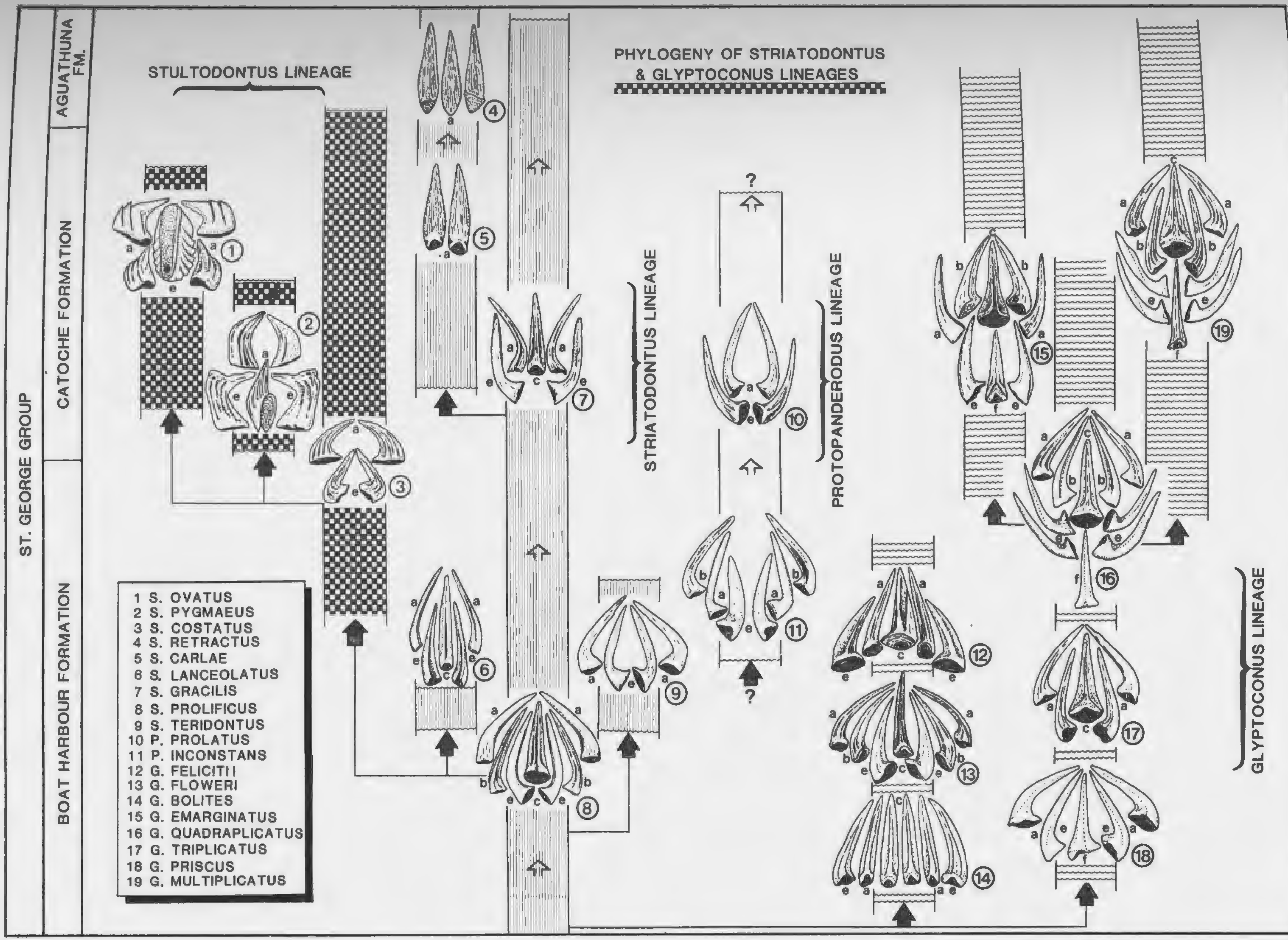

GROUP
FORMATION
ST. GEORGE GROUP
BOAT HARBOUR FORMATION
WATTS BIGHT FORMATION
PORT AU PORT GP.
BERRY HEAD FM.
LOXODUS, DREPANODUS AND CORDYLODUS LINEAGES
DREPANODUS LINEAGE
CORDYLODUS LINEAGE
LOXODUS LINEAGE
1 L. BRANSONI
2 L. LATIBASIS
3 L. BIPINNATUS
4 L. PHYLLODUS
5 D. NOWLANI
6 A. LINEATUS
7 A. UNCINATUS
8 D. PERVETUS
9 C. ANGULATUS
10 C. INTERMEDIUS
11 C. LINDSTROMI

Figure 4:3. Phylogeny of _Acodus_, _Macerodus_ and _Scolopodus_ lineages represented in the St. George Group.



ST. GEORGE GROUP
WATTS BIGHT FM.
BOAT HARBOUR FORMATION
CATOCHE FORMATION
AGUATHUNA FM.
PHYLOGENY OF ACODUS SCOLOPODUS AND MACERODUS LINEAGES
MACERODUS LINEAGE
SCOLOPODUS LINEAGE
OEPIKODUS LINEAGE
ACODUS LINEAGE
DREPANODUS LINEAGE
1 S. CORNUTIFORMIS
2 M. DIANAE
3 M. CRASSATUS
4 S. PARABRUPTUS
5 M. GRACILIS
6 M. MARATHONENSIS
7 S. SUBREX
8 M. WATTSBIGHTENSIS
9 O. COMMUNIS
10 P. CRYPTODENS
11 A. COMPTUS
12 A. DELICATUS
13 A. PRIMUS
14 P. SIMPLICISSIMUS
15 A. LANCEOLATUS
16 D. ARCUATUS
17 D. CONCAVUS
18 D. NOWLANI

Figure 4:4. Phylogeny of Striatodontus and Glyptoconus lineages represented in the rocks from the middle Boat Harbour Formation through the Catoche Formation to the top of Aguathuna Formation.


PHYLOGENY OF STRIATODONTUS
& GLYPTOCONUS LINEAGES
STULTODONTUS LINEAGE
STRIATODONTUS LINEAGE
PROTOPANDERODUS LINEAGE
GLYPTOCONUS LINEAGE
ST. GEORGE GROUP
AGUATHUNA FM.
CATOCHE FORMATION
BOAT HARBOUR FORMATION
1 S. OVATUS
2 S. PYGMAEUS
3 S. COSTATUS
4 S. RETRACTUS
5 S. CARLAE
6 S. LANCEOLATUS
7 S. GRACILIS
8 S. PROLIFICUS
9 S. TERIDONTUS
10 P. PROLATUS
11 P. INCONSTANS
12 G. FELICITII
13 G. FLOWERI
14 G. BOLITES
15 G. EMARGINATUS
16 G. QUADRAPLICATUS
17 G. TRIPLICATUS
18 G. PRISCUS
19 G. MULTIPLICATUS

composed of a morphologically undifferentiated array of coniform elements. It may be true that there are two distinct early evolutionary stocks. However, it is considered that conodonts in the Teridontus complex (including several lineages which are closely related to Teridontus lineage), bearing either apparatus Type I (with a rounded to subrounded, and e compressed elements) or apparatus Type III (with a rounded to subrounded, and b transitional, c suberect symmetrical and posteriorly compressed, e compressed, and f suberect symmetrical elements) belong predominantly to the Midcontinent Province. In contrast, those conodonts within the Proconodontus complex (which contains Cordylodus, Drepanodus and Paltodus lineages) that are characterized by apparatus Type II (with flattened a, c, e elements) belong predominantly to the North Atlantic Province. However, some lineages within both complexes clearly show migrations between the two provinces. Pohler and Barnes (in press) elevate these provinces to the rank of realms. Several other lineages are neither related neither to the Teridontus complex, nor to the Proconodontus complex.

Teridontus complex

The Teridontus evolutionary complex first appears in the Late Cambrian (Miller, 1980, 1984), spreading widely, and differentiating rapidly in terms of apparatus morphology (Fig. 4:1). However, it did not attain as high a peak in species diversity as previously considered (Sweet, 1985, Figs. 7-8), because many form species are now combined in the new apparatus reconstructions of this present study.

The Teridontus lineage first diversified during the Late Cambrian (Miller, 1980, 1984). Hirsutodontus and its descendant, Clavohamulus, appear and constitute special lineages of this complex (Fig. 4:1). Landing and Barnes (1980, p. 15) suggested that species of Clavohamulus lineage might have been adapted to variable and/or elevated salinities and temperatures of the restricted marine conditions of the inner shelf. Indeed, this lineage is largely restricted to the carbonate platform sequences bearing Midcontinent Province faunas. The oldest representative of the Teridontus lineage, T. nakamurai (Nogami), seems to possess a, b, c, and e elements, but the earliest forms may lack c and e elements. Both Teridontus obesus n. sp. and T. gracilimus Nowlan have apparently evolved from T. nakamurai (see under Systematic Paleontology).

Semiacontiodus nogamii Miller of the Semiacontiodus lineage with four elemental morphotypes is considered to be the first descendant of T. nakamurai (Nogamii) as noted by Miller (1980), and to produce both the multicostate Polycostatus falsioneotensis n. sp. (with a, c, and e elements) and the unicostate to tricostate Variabiloconus bassleri Furnish (with a, b, c, and e elements) based on this study, comparison of many morphological and stratigraphic data show that the Semiacontiodus lineage has an evolutionary relationship distinct from the Teridontus lineage, and both the Polycostatus and the Variabiloconus lineages are closely related with the Semiacontiodus lineage (see Fig. 4:1). The evolutionary trends from Teridontus nakamurai (Nogami) to Semiacontiodus nogamii (Miller), and from S. nogamii to both Variabiloconus bassleri (Furnish) and Polycostatus falsioneotensis n. sp. clearly show that posterior and lateral faces became differentiated, and costae and keels or grooves developed as characteristic features (Fig. 4:1). Both P. oneotensis (Furnish) and P. sulcatus (Furnish) are related to P. falsioneotensis. Utahconus and related taxa may have been derived from Semiacontiodus nogamii, or developed from Teridontus nakamurai as suggested by Miller (1980, p. 36; 1984). Variabiloconus bassleri (Furnish), which apparently evolved from the Semiacontiodus lineage, may be the ancestor of the major branch of Teridontus complex, comprising all the slender finely striated Striatodontus (n. gen.) lineage that evolved during the late Tremadoc (see Fig. 4:1).

Striatodontus probably evolved from Variabiloconus or even from Semiacontiodus, because its b transitional elements are quite close to those of V. bassleri, but its a subrounded elements are similar to those of S. nogamii (see under Systematic Paleontology). The apparatus of taxa within the Striatodontus lineage consists of a, b, c, and e elements. Species are characterized by having a well developed posterior groove and fine longitudinal striations on the surface. The apparatuses of _Stultodontus_ n. gen. have only _a_ and _e_ elements, whereas most taxa in the _Glyptoconus_ lineage have fully developed apparatuses with _a_, _b_, _c_, _e_, and _f_ elements. Both _Stultodontus_ and _Glyptoconus_ may have evolved from the earliest species of finely striated _Striatodontus_ lineage (Fig. 4:4). The _Striatodontus_ lineage ranges from the late Tremadoc to late Arenig, it is well known in the Midcontinent Province, and is a dominant component of the _Teridontus_ complex.

The species of the _Stultodontus_ lineage are characterized by having stubby _a_ elements and antero-posteriorly compressed or orally compressed _e_ elements. _Striatodontus prolificus_ n. sp. may have produced the costate _Stultodontus costatus_ (Ethington and Clark), because _a_ elements within both species are closely related. Two extremely stubby costate species, _Stultodontus ovatus_ n. sp. and _S. pygmaeus_ n. sp. (Fig. 4:4) clearly evolved from _S. costatus_.

The _Glyptoconus_ lineage has somewhat close evolutionary relationship with the _Striatodontus_ lineage as illustrated in Figure 4:4, with species bearing an apparatus consisting of three morphotypes (_a_, _c_ or _f_, _e_ elements), or five morphotypes (_a_, _b_, _c_, _e_, and _f_ elements). The species of _Glyptoconus_ lineage are characterized by having coarse costae and deep grooves (Kennedy, 1980). The oldest representative of the lineage, _Glyptoconus bolites_ (Repetski) produced _G. floweri_

(Repetski) (see Fig. 4:4 and under Systematic Paleontology). This latter species has an apparatus consisting of *a*, *b*, *c*, *e* elements which are characterized by having a slender long cusp, with well developed costae and grooves, and small base and basal cavity; it has a short stratigraphic range. *G. felicitii* n. sp. is probably related to *G. floweri* as determined from similarities of the morphology and apparatus pattern. *Glyptoconus triplicatus* (Ethington and Clark) and other two related species *G. quadraplicatus* (Branson and Mehl) and *G. multiplicatus* n. sp., distinctive descendants of *G. priscus* n. sp. are the dominant species of this lineage in terms of their abundances (see Appendix A) and widespread distributions. The apparatus of *G. quadraplicatus* and *G. multiplicatus* n. sp. contain five fully developed morphotypes which include *a* quadraplicatiform elements, *b* triplicatiform elements, *c* staufferiform elements, *e* paralleliform elements and *f* ulrichodiniform elements. *G. emarginatus* (Barnes and Tuke) may be closely related to *G. quadraplicatus*, because it has the same apparatus pattern with similar *c*, *e*, and *f* elements as *G. quadraplicatus*, although it has a shorter stratigraphic range (see Appendix A). The *Glyptoconus* lineage ranges from the latest Tremadoc to the earliest Llanvirn.

Other major lineages

The *Loxodus* lineage (Fig. 4:2) which contains three genera, first appeared in the early Tremadoc. The oldest representative of the lineage, Loxognathus phyllodus n. gen. & sp. is characterized by having asymmetrical blade elements and bilaterally symmetrical elements produced Loxodentatus bipinnatus n. gen. & sp. with the increasing differentiation of the blade into fused denticles. It is apparent that Loxodus bransoni is derived from Loxodentatus bipinnatus by the differentiation of denticles.

Most species of the Macerodus lineage are characterized by having only two morphotypes. Macerodus dianae Fåhræus and Nowlan is closely related to M. crassatus n. sp. in terms of morphological similarity and stratigraphic range. The specialized species, M. gracilis n. sp., may be derived from M. dianae by developing a more slender unit. Macerodus? wattsbightensis n. sp. is most likely the oldest representative of this lineage (Figure 4:3).

As noted by Repetski and Ethington (1983), at the species level within the Rossodus lineage, Utahconus utahensis (Miller) was ancestral to Rossodus tenuis (Miller), the direct ancestor of R. manitouensis Repetski and Ethington. The latter species has a fully developed apparatus consisting of a acontiodiform elements, b drepanodiform elements, c symmetrical elements and e oistodiform elements, in contrast, both early species U. utahensis and R. tenuis have apparatuses with fewer morphotypes. It seems most likely that Tricostatus glyptus n. sp. is a descendant of Utahconus utahensis and closely related to R. tenuis (see Fig. 4:1 and under Systematic Paleontology).

The earliest species of the Acodus lineage (Fig. 4:3), probably one of the immigrants from North Atlantic Province, and has no close evolutionary relationship with any Midcontinent Province forms. This lineage is characterized by fully developed apparatuses bearing five morphotypes: a distacodiform elements, b acodiform elements, c symmetrical distacodiform elements, e oistodiform elements, and f deltaform elements. Within this lineage, one new species A. primus, probably the oldest immigrant of Acodus with three to four weak costae, seems to produce both Scolopodus subrex n. sp. and Acodus delicatus (Branson and Mehl). Acodus comptus (Branson and Mehl) with completely developed apparatus may have evolved

from A. delicatus, and Striatodontus carlae (Repetski) whose apparatus consists of only a subrounded and e compressed elements may be related with S. subrex n. sp. It is apparent that Striatodontus retractus n. sp. evolved from S. carlae (see Fig. 4:4 and under Systematic Paleontology).

Lindström (1977) suggested that Pteracontiodus Harris and Harris is close to Acodus Pander in the components of its apparatus. Both Pteracontiondus and Oepikodus may have evolved from the Acodus lineage (Fig. 4:3) in terms of morphological similarity (see under Systematic Paleontology) and stratigraphic range (see Appendix A).

Scolopodus lineage (Fig. 4:3), which may have evolved from the earliest species of the Acodus lineage (see under Systematic Paleontology), are characterized by having three (a, c, e) or four (a, b, c, e) morphotypes. The oldest representative of the lineage, Scolopodus subrex n. sp. with a, b, c and e morphotypes is closely related to Acodus primus n. sp. as determined from similarities in morphology and apparatus pattern. Both Scolopodus cornutiformis (Branson and Mehl) and S. parabruptus Repetski are derived from S. subrex by developing a more posteriorly extended oistodiform-like base in the e element morphotype.

Proconodontus complex

Lindström (1977) noted that Cordylodus probably evolved from the adentate Upper Cambrian-basal Ordovician genus Proconodontus Miller. Miller (1980) concluded that Cordylodus was derived from Eoconodontus which is a descendant of Proconodontus. The Drepanodus lineage is most closely related to Paltodus Pander, and to Paroistodus Lindström as noted by Lindström (1977). The Cordylodus and Drepanodus lineages are predominantly components of the North Atlantic Province. Both lineages are found mainly in the subtidal facies of the North American platform. Therefore, the evolutionary relationship of Cordylodus, Drepanodus and Paltodus lineages with other lineages within the Proconodontus complex are better clarified from the slope sequences of the

Cow Head Group (Pohler & al., 1987; Bagnoli & al., 1987; Barnes, 1988) rather than the St. George Group.

As with the Drepanodus lineage, the Acanthodus lineage may belong within Proconodontus complex, although most species of Acanthodus have been only recovered in the Midcontinent Province. It is difficult to recognize the ancestor of Acanthodus based on this study, but it may be related to Variabiloconus neobassleri. Drepanodus nowlani n. sp. apparently evolved from Acanthodus uncinatus Furnish in terms of morphology (see Fig. 4:2 and under Systematic Paleontology) and stratigraphic range (see Appendix A).

Summary

The evolutionary relationships of multielement taxa in the Teridontus complex show that species of the Teridontus lineage spread widely, evolving into the earliest species of both the Clavohamulus lineage and Semiacontiodus lineage. Semiacontiodus nogamii probably produced the earliest species of the Variabiloconus and Polycostatus lineages during the earliest Ordovician. The Rossodus, Macerodus and Loxodus lineages appear approximately at same time, but with low species diversity and abundance. Most of these lineages, such as Clavohamulus, Cordylodus, Loxodus, Rossodus, Semiacontiodus, Teridontus, and Variabiloconus lineages, become completely extinct near the end of Tremadoc (see

Appendix A).

Conodont species diversity reached the second peak near the beginning of Arenig after this first major extinction. Two important lineages, Glyptoconus and Striatodontus, appear suddenly, spreading widely, and diversifing rapidly.
The Striatodontus lineage is probably derived from the Variabiloconus lineage, with the Glyptoconus lineage also related to the oldest representative of Striatodontus. The appearance of abundant hyaline conodonts may reflect the environment with warm-water, rather hypersaline, marine conditions.

The third peak of species diversity in the Early Ordovician is near the end of the early Arenig. Below this level, a few species become completely extinct, and above several new lineages appear suddenly, diversifing rapidly, with most continuing throughout the Early Ordovician (e.g. Acodus, Cristodus, Scolopodus, Stultodontus and Protopanderodus lineages).

During the late Arenig, the species diversity reached the last high peak in the Early Ordovician and some evolutionary radiation occurred in the Stultodontus, Scolopodus, and Protopanderodus lineages. The Oepikodus lineage appears at this level (Ethington and Clark, 1964, 1982; Repetski, 1982) during periods of maximum transgression.

The Proconodontus complex has three major lineages including Cordylodus and Drepanodus. Although these lineages appear in the St. George Group, and are associated with the _Teridontus_ and other lineages, their evolutionary relationships are better clarified from the slope sequences of the Cow Head Group (Pohler & al., 1987; Barnes, 1988) in faunas of the North Atlantic Province.

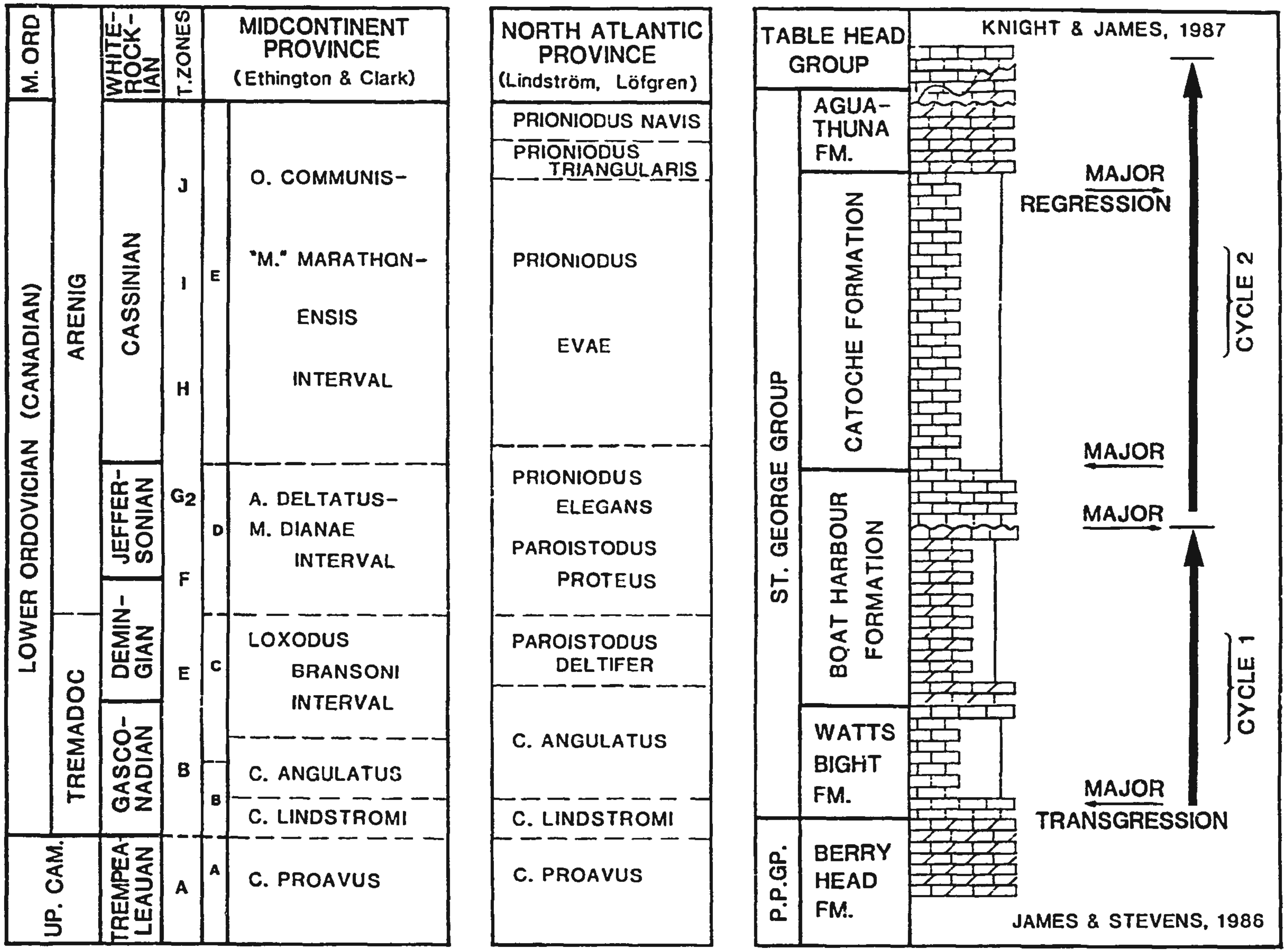
CHAPTER 5

CONODONT BIOSTRATIGRAPHY

Over 45,000 conodonts have been recovered from 432 samples of the St. George Group. The majority of the conodonts are excellently preserved. Some samples, particularly those from the middle and upper parts of the Watts Bight Formation, the Boat Harbour Formation and the lower part of the Catoche Formation, each produced several hundreds of specimens. Other samples have sparse faunas, such as those from the Berry Head Formation, the lower part of the Watts Bight Formation, the upper part of the Catoche Formation, and the Aguathuna Formation. The relationship of conodonts to rock type indicates that the subtidal to peritidal rocks yielded conodonts, but supratidal rocks were barren.

The conodonts recovered indicate that the St. George Group ranges in age from the earliest Canadian to the earliest Whiterockian. The conodonts from the upper Berry Head Formation of the Port au Port Group range in age from the latest Cambrian to the earliest Ordovician; those of the Watts Bight Formation are early Tremadoc to middle Tremadoc in age; those from the Boat Harbour Formation range in age from late Tremadoc to early Arenig; those of the Catoche Formation are middle Arenig in age; those from the Aguathuna Formation range in age from late middle Arenig to early late Arenig.

Figure 5:1. A simplified stratigraphic column of the St. George Group (modified from James and Stevens, 1986, and Knight and James, 1987), with conodont zonation of both the Midcontinent Province (Ethington and Clark, 1971) and the North Atlantic Province (Lindstrom, 1971; Lofgren, 1978), and with trilobite zonation (T. zones).



M. ORD
LOWER ORDOVICIAN (CANADIAN)
UP. CAM.
ARENIG
TREMADOC
WHITE-ROCK-IAN
CASSINIAN
JEFFER-SONIAN
DEMIN-GIAN
GASCO-NADIAN
TREMPEA-LEAUAN
T.ZONES
J
I
H
G2
F
E
B
A
E
D
C
B
A
MIDCONTINENT PROVINCE
(Ethington & Clark)
O. COMMUNIS-
"M." MARATHON-
ENSIS
INTERVAL
A. DELTATUS-
M. DIANAE
INTERVAL
LOXODUS
BRANSONI
INTERVAL
C. ANGULATUS
C. LINDSTROMI
C. PROAVUS
NORTH ATLANTIC PROVINCE
(Lindström, Löfgren)
PRIONIODUS NAVIS
PRIONIODUS TRIANGULARIS
PRIONIODUS
EVAE
PRIONIODUS
ELEGANS
PAROISTODUS
PROTEUS
PAROISTODUS
DELTIFER
C. ANGULATUS
C. LINDSTROMI
C. PROAVUS
TABLE HEAD GROUP
ST. GEORGE GROUP
P.P.GP.
AGUA-THUNA FM.
CATOCHE FORMATION
BOAT HARBOUR FORMATION
WATTS BIGHT FM.
BERRY HEAD FM.
KNIGHT & JAMES, 1987
MAJOR REGRESSION
MAJOR
MAJOR
MAJOR TRANSGRESSION
CYCLE 2
CYCLE 1
JAMES & STEVENS, 1986

The Lower Ordovician conodont zonation for the North Atlantic Province faunas has been well developed by Bergström (1971), Lindström (1971), Löfgren (1978), Johnston (1986), Pohler & al. (1987) and Barnes (1988) (Figs. 5:1 and 5:2). However, only a preliminary Lower Ordovician zonation exists for the conodont faunas of the Midcontinent Province with an informal succession of faunas defined by Ethington and Clark (1971, 1982) (Fig. 5:1) and a zonation of the latest Cambrian and the earliest Ordovician recognized by (Miller, 1980, 1984).

Because of the excellently exposed sections, which have been well documented by many sedimentologists (Levesque, 1977; Pratt, 1979; Pratt and James, 1982; Knight and James, 1987; James & al., 1989), which yield superbly preserved conodonts (see plates 1-25) intensively studied herein (see both the Systematic Paleontology and the Multielement Taxonomy chapters), it is now possible to establish a complete zonation for the Midcontinent Province.

Eight shallowing-water Assemblage Zone and six deeper-water Lineage and Assemblage Zones are formally defined below.

<u>Assemblage and Lineage Zones</u>

The St. George Group conodont faunas are mainly of the Midcontinent Province affinities, but also show some North Atlantic faunal components. This is because migration of the North Atlantic Province faunas onto the craton led to a mixing with the typical Midcontinent faunas during sea-level rise (Pohler & al., 1987). Hence two sets of assemblage zones are required: shallow-water (SH) zones for totally Midcontinent faunas and deeper-water (DW) zones for mixed faunas bearing North Atlantic Province components.

1. Shallow-water Zones (SW Zones) A-H (Midcontinent Province faunas)

Based on this study, eight conodont Assemblage Zones can be recognized in the shallow-water environments of the St. George Group, represented by the shallower subtidal, and peritidal facies (Figs. 5:2 and 5:3). These zones are described in ascending stratigraphic order.

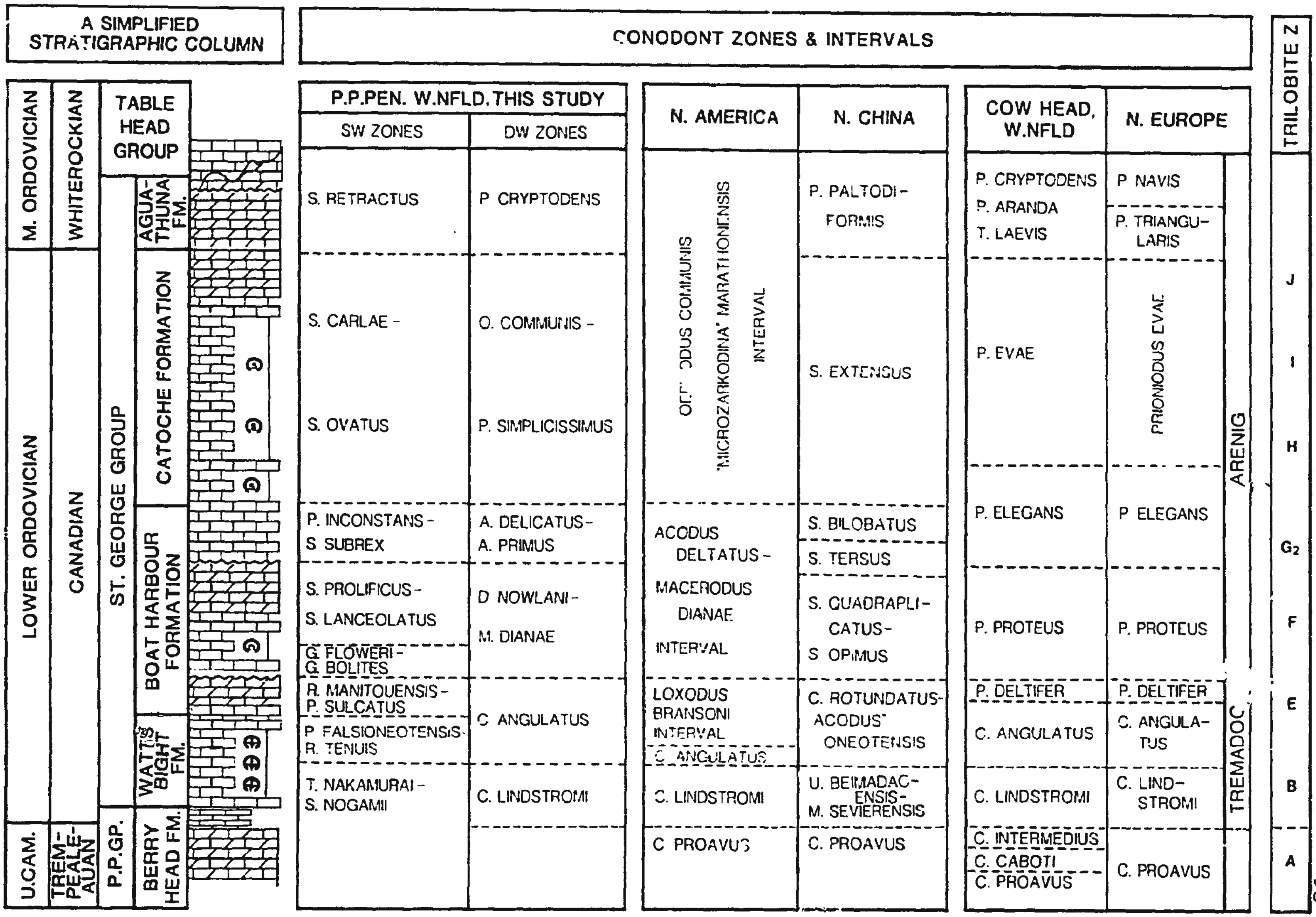
A. Teridontus nakamurai-Semiacontiodus nogamii Assemblage Zone: This Assemblage Zone ranges from 40 m below the top of the Berry Head Formation to 30 m above the base of Watts Bight Formation (base of the Green Head massive mounds complex) in Section 2 (Figs. 5:2 and 5:3). The zone is defined by the assemblage of several characteristic species, such as Clavohamulus neoelongatus n. sp., Loxodentatus bipinnatus n. sp., Loxognathus phyllodus n. sp., Semiacontiodus nogamii (Miller), Teridontus nakamurai (Nogami), and by the association of Cordylodus proavus Müller, C. intermedius Furnish, C. lindstromi Druce and Jones. The base of the zone coincides with the first occurrence of Teridontus nakamurai.

Figure 5:2. A proposed conodont zonation for the Midcontinent Province (Eight SW Zones and Six DW Zones), and correlation with the zonation of Cow Head conodonts.

STRATIGRAPHIC UNIT				P.P.PEN. W.NFLD, THIS STUDY			
				SW ZONES		DW ZONES	
M.ORD.	WHITE-ROCKIAN	ST. GEORGE GROUP	AGUA-THUNA FM.	H	S. RETRACTUS	F	P. CRYPTODENS
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	CATOCHE FORMATION	G	S. CARLAE- S. OVATUS	E	P. SIMPLICISSIMUS- O. COMMUNIS
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	BOAT HARBOUR FORMATION	F	P. INCONSTANS- S. SUBREX	D	A. DELICATUS- A. PRIMUS
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	BOAT HARBOUR FORMATION	E	S. PROLIFICUS- S. LANCEOLATUS	C	D. NOWLANI- M. DIANAE
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	BOAT HARBOUR FORMATION	D	G. FLOWERI- G. BOLITES	C	
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	BOAT HARBOUR FORMATION	C	R. MANITOUENSIS- P. SULCATUS	B	C. ANGULATUS
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	WATTS BIGHT FM.	B	P. FALSIONEOTENSIS- R. TENUIS	B	
LOWER ORDOVICIAN	CANADIAN	ST. GEORGE GROUP	WATTS BIGHT FM.	A	S. NOGAMII- T. NAKAMURAI	A	C. LINDSTROMI
U.CAM.	TREMPEA-LEAUAN	P.P.GP.	BERRY HEAD FM.	A		A	

COW HEAD. W.NFLD (BARNES.POHLER.JOHNSTON)	
P. CRYPTODENS P. ARANDA T. LAEVIS	ARENIG
P. EVAE	ARENIG
P. ELEGANS	ARENIG
P. PROTEUS	ARENIG
P. DELTIFER	TREMADOC
C. ANGULATUS	TREMADOC
C. LINDSTROMI	TREMADOC
C. INTERMEDIUS	TREMADOC
C. CABOTI	TREMADOC
C. PROAVUS	TREMADOC

Figure 5:3. Correlation chart of this study with other key areas, such as North America (Ethington and Clark, 1971), North China (An & al., 1983), Cow Head (Fahraeus and Nowlan, 1978; Barnes, 1988), North Europe (Lindstrom, 1971; Lofgren, 1978).


A SIMPLIFIED STRATIGRAPHIC COLUMN
M. ORDOVICIAN
LOWER ORDOVICIAN
U.CAM.
WHITEROCKIAN
CANADIAN
TREM-PEALE-AUAN
TABLE HEAD GROUP
ST. GEORGE GROUP
P.P.GP.
AGUA-THUNA FM.
CATOCHE FORMATION
BOAT HARBOUR FORMATION
WATTS BIGHT FM.
BERRY HEAD FM.
CONODONT ZONES & INTERVALS
P.P.PEN. W.NFLD.THIS STUDY
SW ZONES
DW ZONES
S. RETRACTUS
P. CRYPTODENS
S. CARLAE -
O. COMMUNIS -
S. OVATUS
P. SIMPLICISSIMUS
P. INCONSTANS -
S SUBREX
A. DELICATUS -
A. PRIMUS
S. PROLIFICUS -
S. LANCEOLATUS
D NOWLANI -
M. DIANAE
G. FLOWERI -
G. BOLITES
R. MANITOUENSIS -
P. SULCATUS
C ANGULATUS
P FALSIONEOTENSIS -
R. TENUIS
T. NAKAMURAI -
S. NOGAMII
C. LINDSTROMI
N. AMERICA
OEPIKODUS COMMUNIS
'MICROZARKODINA' MARATHONENSIS
INTERVAL
ACODUS DELTATUS -
MACERODUS DIANAE
INTERVAL
LOXODUS BRANSONI
INTERVAL
C. ANGULATUS
C. LINDSTROMI
C PROAVUS
N. CHINA
P. PALTODI-FORMIS
S. EXTENSUS
S. BILOBATUS
S. TERSUS
S. QUADRAPLI-CATUS -
S OPIMUS
C. ROTUNDATUS -
ACODUS ONEOTENSIS
U. BEIMADAC-ENSIS -
M. SEVIERENSIS
C. PROAVUS
COW HEAD, W.NFLD
N. EUROPE
P. CRYPTODENS
P. ARANDA
T. LAEVIS
P NAVIS
P. TRIANGU-LARIS
P. EVAE
PRIONIODUS EVAE
P. ELEGANS
P ELEGANS
P. PROTEUS
P. PROTEUS
P. DELTIFER
P. DELTIFER
C. ANGULATUS
C. ANGULA-TUS
C. LINDSTROMI
C. LIND-STROMI
C. INTERMEDIUS
C. CABOTI
C. PROAVUS
C. PROAVUS
ARENIG
TREMADOC
TRILOBITE Z
J
I
H
G2
F
E
B
A

Both *Teridontus nakamurai* and *Semiacontiodus nogamii* are widespread species known from North America, Australia, Sweden, Iran, Soviet Union, Korea, and North China, which typically range from the latest Cambrian through the early Tremadoc (Miller, 1984).

The zone may be correlated with the upper *Cordylodus proavus*, *C. caboti*, *C. intermedius* and and *C. lindstromi* Zones of the North Atlantic Province (Barnes, 1988), and to the previously established Midcontinent Province Fauna A to middle Fauna B of Ethington and Clark (1971) (Figs. 5:2 and 5:3). The age of the zone therefore probably ranges from the latest Cambrian into the earliest Ordovician. The zone is between 65 and 70 m thick in the most sections of the Port au Port Peninsula.

The zone can be recognized in widely, for example, Australia (Druce and Jones, 1971; Jones, 1971), North China (An & al., 1983), Canadian Arctic (Nowlan, 1985), Siberia (Abaimova, 1971, 1972), and Utah (Miller, 1969, 1980).

B. Polycostatus falsioenotensis-Rossodus tenuis Assemblage Zone: This Assemblage Zone ranges from 30 m to 87 m above the base of Watts Bight Formation (from the middle to the top of the Watts Bight Formation) in Section 2 (Figs. 5:2 and 5:3). The zone is defined by several characteristic species, such as *Clavohamulus sphearicus* n. sp., *C. densus* Furnish, *Glyptodontus constrictus* n. sp., *G. expansus* n. sp., *Loxodus* bransoni Furnish, L. latibasis n. sp., Polycostatus falsioneotensis n. sp., Rossodus tenuis (Miller), Teridontus gracillimus Nowlan, T. obesus n. sp., Variabiloconus bassleri (Furnish), and also by an association including Cordylodus angulatus Pander. The lower boundary of this zone is marked by the level of the first appearance of Rossodus tenuis.

Three species, most characteristic of this zone, Polycostatus falsioneotensis, Rossodus tenuis and Variabiloconus bassleri are widespread species known from several continents ranging from early to middle Tremadoc.

The zone is coeval with the lower and middle parts of the Deeper-water Lineage Zone B Cordylodus angulatus, and is correlated with upper Fauna B to the lower Fauna C of Ethington and Clark (1971) (Fig. 5:3). The thickness of the zone is between 55 and 60 m in the study area. This is a widespread biostratigraphic unit, and can be recognized in many localities, such as Australia (Druce and Jones, 1971; Jones, 1971), China (An & al. 1983), Siberia (Abaimova, 1971; 1972), North America (Ethington and Clark, 1971; Nowlan, 1985; Repetski and Ethington, 1983). The top of this unit constitutes a pronounced change in the conodont faunas, in which several species disappear near the upper boundary (see Appendix A).

C. Rossodus manitouensis-Polycostatus sulcatus Assemblage Zone: This Assemblage Zone ranges from the base to 45 m above the base of the Boat Harbour Formation in Section 2 (Figs. 5:2 and 5:3). The zone is defined by the association of Clavohamulus reniformis n. sp., Polycostatus oneotensis (Furnish), P. sulcatus (Furnish) and Rossodus manitouensis Repetski and Ethington, all of which are restricted to a narrow stratigraphic interval in the Lower Ordovician over wide regions of several continents (e.g. Druce and Jones, 1971; An & al., 1983; Repetski and Ethington, 1983; Landing & al., 1986). This zone also contains Acanthodus lineatus (Furnish), A. uncinatus Furnish, Drepanodus pervetus (Nowlan), Variabiloconus neobassleri n. sp., and Utahconus longipinnatus n. sp. Cordylodus angulatus Pander and Loxodus bransoni Furnish are still abundant in the lower part of the zone. The base of this zone is marked by the first appearance of Rossodus manitouensis. The top of this zone is characterized by the disappearance of several major lineages, such as the Cordylodus, Clavohamulus, Glyptodontus, Loxodus, Rossodus, Semiacontiodus, Teridontus and Variabiloconus lineages (see Appendix A).

The important component of this zone, Rossodus manitouensis, occurs within a limited stratigraphic interval in the Lower Ordovician over a widespread distribution in several continents, making this zone valuable for regional and intercontinental correlation (Repetski and Ethington, 1983; Landing & al., 1986).

The age of this zone corresponds to the middle to late

Tremadoc, and is roughly equivalent to trilobite Zone E of Hintze (1973) and to the middle and upper conodont Fauna C of Ethington and Clark (1971) (Fig. 5:3). The zone is about 45 m thick in the study area.

D. Glyptoconus floweri-Glyptoconus bolites Assemblage Zone: This Assemblage Zone ranges from 45 m to 77 m above the base of Boat Harbour Formation (Figs. 5:2). The zone is defined by the assemblage of several characteristic species, including Glyptoconus floweri (Repetski), G. bolites (Repetski), and Polycostatus minutus n. sp., in association with Drepanodus nowlani n. sp., Glyptoconus priscus n. sp., and Striatodontus prolificus n. sp. Both Glyptoconus floweri and G. bolites are the most common species, and are restricted to this zone. Glyptoconus floweri is a widespread species known from North America (Repetski, 1982; G. S. Nowlan's Arctic collections; R. L. Ethington's Oklahoma collections) and North China (An & al., 1983).

The age of this zone is roughly equivalent to the upper part of Fauna C of Ethington and Clark (1971), and is of earliest Arenig age (Fig. 5:3). The thickness of the zone is about 30 to 35 m in the study area.

The base of this zone can be easily recognized by the disappearance below of several important species, such as Rossodus manitouensis, Polycostatus oneotensis, P. sulcatus, Acanthodus lineatus, A. uncinatus, and by first appearance of several species as noted above within this zone. The base of this zone can be traced in North America (Repetski, 1982; Ethington, Engel and Elliott, 1987) and North China (An & al., 1983). Although this zone has a short stratigraphic range, it is an important and distinctive biostratigraphic unit for the correlation. The fauna in this unit also shows that several older lineages became extinct just below the boundary, and several younger lineages, particularly hyaline conodonts, appear near the base, spreading widely, and differentiating rapidly in terms of apparatus pattern and species diversity (see Figs. 4:1, 4:2, and Appendix A).

E. Striatodontus prolificus-Striatodontus lanceolatus Assemblage Zone: This Assemblage Zone ranges from 77 m above the base of Boat Harbour Formation to the top of "the pebble bed" (129 m above the base of Boat Harbour Formation) (Fig. 5:2). The base of the zone is characterized locally by the abundance of Striatodontus prolificus n. sp. Both Striatodontus prolificus and Macerodus dianae Fåhræus and Nowlan disappear at the top of the zone. The zone is defined by an assemblage of few species, such as Striatodontus prolificus n. sp., S. teridontus n. sp., S. lanceolatus n. sp., Macerodus dianae Fåhraeus and Nowlan, M. gracilis n. sp. and Drepanodus nowlani n. sp., but all species except M. gracilis n. sp., are abundantly represented. Glyptoconus triplicatus (Ethington and Clark) is common almost throughout this zone.

The age of the zone is early Arenig, and corresponds to Fauna D of Ethington and Clark (1971) (Fig. 5:3). The zone is about 50 to 55 m thick in the studied sections. This zone represents a relatively long biostratigraphic interval in the Lower Ordovician in the Midcontinent Province. Two species, Striatodontus prolificus and Macerodus dianae, are particularly valuable for regional and intercontinent correlation, being recovered from many widespread localities (?Lindström, 1955; Mound, 1968; Abaimova, 1975; Nowlan, 1976; Fåhræus and Nowlan, 1978; Ethington and Clark, 1971, 1982; Repetski, 1982).

F. Protopanderodus inconstans-Scolopodus subrex Assemblage Zone: This Assemblage Zone ranges from 129 m above the base of Boat Harbour Formation to the top of Boat Harbour Formation (Fig. 5:2). The lower boundary of this zone is defined by the first appearance of Protopanderodus inconstans (Branson and Mehl) which is roughly equivalent to the "Pebble Bed". The zone is characterized by an assemblage including Protopanderodus inconstans (Branson and Mehl) and Scolopodus subrex n. sp., both extremely abundant, Acodus delicatus (Branson and Mehl) and A. comptus (Branson and Mehl), Drepanodus arcuatus Pander, D. concavus (Branson and Mehl), Glyptoconus emarginatus (Barnes and Tuke), G. quadraplicatus (Branson and Mehl), and Stultodontus costatus (Ethington and Brand). Several specialized species, such as Cristodus loxoides Repetski, C. ethingtoni n. sp. and Histiodella donnae Repetski, are present, but with a limited number of specimens.

The age of this zone is probably late early Arenig, and corresponds to upper Fauna D of Ethington and Clark (1971), and to trilobite Zone G2 of Hintze (1973) (Fig. 5:3). The zone is about 50 to 55 m thick in the studied sections on the Port au Port Peninsula of western Newfoundland.

This is a widespread zone of considerable value for regional and intercontinental correlation. Both Protopanderodus inconstans and Scolopodus subrex can be recognized throughout the Midcontinent Province (Ethington and Clark, 1965, 1971, 1982; Lee, 1970, 1975; Barnes and Poplawski, 1973; Repetski, 1982; An & al. 1983; Ethington, Engel and Elliott, 1987), and can be correlated with similar forms in the North Atlantic Province (Lindström, 1955; Stouge and Bagnoli, 1989).

G. Striatodontus carlae-Stultodontus ovatus Assemblage Zone: This Assemblage Zone ranges from the base of Catoche Formation to the top of the Catoche Formation (Fig. 5:2). The base of this zone is recognized by the first appearance of Stultodontus ovatus n. sp., associated with Striatodontus carlae (Repetski) and Oepikodus communis (Ethington and Clark). This zone is defined by assemblage of several important widespread species, such as Acodus comptus (Branson and Mehl), Drepanodus concavus (Branson and Mehl), D. arcuatus Pander, Glyptoconus emarginatus (Barnes and Tuke), G. multiplicatus n. sp., Oepikodus communis (Ethington and Clark), Protoprioniodus simplicissimus (McTavish), Protopanderodus prolatus n. sp., Striatodontus carlae (Repetski), S. gracilis (Ethington and Clark), Stultodontus ovatus n. sp., and S. pygmaeus n. sp.

This zone is late Arenig in age, and is equivalent to Fauna E of Ethington and Clark (1971) (Fig. 5:3). The thickness of this zone is about 225 m in the studied area.

Ethington and Clark (1971, 1982) provided a detailed discussion of this biostratigraphic interval. Based on the present study, this biostratigraphic unit represents an important interval in the Lower Ordovician which can be readily correlated not only within the Midcontinent Province, but into the North Atlantic Province as well. The base of this zone, which coincides with the beginning of a major transgresson within the second cycle (James and Stevens, 1986; James & al., 1989), is a distinctive boundary for regional and intercontinental correlation. As indicated in Figures 4:2 and 4:3, and shown in Appendix A, a few new lineages with several new species appear near the base of this unit, spreading widely, and differentiating rapidly in terms of species diversity and apparatus morphology.

H. Striatodontus retractus Assemblage Zone: This Assemblage Zone ranges from the base to the top of Aguathuna Formation. The base of this zone is recognized by the first appearance of Striatodontus retractus n. sp. The assemblage contains a few species with limited abundance, such as Glyptoconus emarginatus (Barnes and Tuke) and G. multiplicatus n. sp., Oepikodus communis (Ethington and Clark), Pteracontiodus cryptodens (Mound), Striatodontus retractus n. sp., and Stultodontus costatus (Ethington and Brand).

The zone is probably earliest Whiterockian in age, and corresponds to the upper Fauna E of Ethington and Clark (1971)(Fig. 5:2) and/or top the Fauna E-1 of Stouge (1982). The thickness of this zone is about 63 m in the studied sections on the Port au Port Peninsula.

Striatodontus retractus n. sp has been found in other localities (e.g. G. S. Nowlan's Arctic collections, 1976; R. C. Ethington's unpublished collections from Oklahoma). Pteracontiodus cryptodens (Mound) which has also been widely recognized in the North America (Mound, 1965; Ethington and Clark, 1982; Sweet, Ethington and Barnes, 1971; Barnes, 1977) can be easily correlated within the Midcontinent Province.

2. Deeper-water Zones (DW Zones) A-F (related to North Atlantic Province)

Six lineage and assemblage zones can be recognized in the one complete section (Section 2) and several other sections within the study area, which contain taxa characteristic of the North Atlantic Province. Most of the zones may be represented in the deeper-water facies, such as the transgressive subtidal environments.

A. Cordylodus lindstromi Lineage Zone: This Lineage Zone ranges from 20 m below the top of Berry Head Formation to 30 m above the base of Watts Bight Formation (Fig. 5:2). The zone can be recognized in many localities in the world (e.g. Druce and Jones, 1971, Müller, 1973; Miller, 1980; Ethington and Clark, 1982; An & al., 1983; Appollonov & al., 1988; Barnes, 1988; Miller, 1988; Bruton & al., 1988; Chen & al., 1988). The base of zone is not well defined locally because only a few specimens have been recovered (see Appendix A), but is taken as the first appearance of Cordylodus lindstromi. The base of this zone represents an important boundary, being the proposed base of the Ordovician System (e.g. Barnes, 1988). Many new conodont lineages appear just above this level (see Figs. 4:1 and 4:2, and Appendix A).

The zone contains several important widespread species, such as Cordylodus intermedius Furnish, C. lindstromi Druce and Jones, and Utahconus utahensis Miller, and also includes most taxa which are listed in the shallow-water (SH) Assemblage Zone A of this study.

This Lineage Zone is equivalent to the middle and upper

SW Zone A. The age of this zone is early Tremadoc, and corresponds to the Fauna B of Ethington and Clark (1971,1982) (Fig. 5:3). The thickness of the zone is between 45 and 50 m in the studied sections; beds below are largely barren of conodonts so the precise base has not been determined.

This zone represents a widespread biostratigraphic unit which can be correlated within both the Midcontinent Province and the North Atlantic Province. It represents a critical biostratigraphic tie-point for correlation between the two provinces.

B. Cordylodus angulatus Lineage Zone: This Lineage Zone ranges from 30 m above the base of Watts Bight Formation to 45 m above the base of Boat Harbour Formation in Section 2 (Fig. 5:2). The zone is established and recognized in many widespread localities in both the Midcontinent Province (Druce and Jones, 1971; Jones, 1971; Miller, 1980; Landing and Barnes, 1981; Ethington and Clark, 1982; An & al., Chen and Gong, 1986; Miller, 1988) and the North Atlantic Province (Lindström, 1955; van Wamel, 1974; Bagnoli & al., 1987; Barnes, 1988). The lower boundary of this zone can be placed at the first appearance of Cordylodus angulatus Pander which corresponds to the base of SW Assemblage Zone B of this study. This biostratigraphic unit contains variety of species (see taxa listed in SW B and C Zones and Appendix A).

This biostratigraphic interval represents one of the major conodont radiations in the entire evolutionary history of conodonts.

The age of this zone is probably middle to late Tremadoc, and corresponds to upper Fauna B through Fauna C of Ethington and Clark (1971) (Fig. 5:3). The zone is about 100 m thick in the study sections.

C. Drepanodus nowlani-Macerodus dianae Assemblage Zone

This assemblage Zone ranges from 45 m to 129 m (top of "the pebble bed") above the base of Boat Harbour Formation (Fig. 5:2). The base of the zone is defined by the first appearance of Drepanodus nowlani n. sp. or Macerodus dianae Fåhræus and Nowlan. The zone is characterized by an assemblage including Macerodus dianae, M. gracilis n. sp., Drepanodus nowlani n. sp., and by an association including taxa which are listed in SW Assemblage Zone D and Zone E. Drepanodus nowlani n. sp. is apparently related to North Atlantic forms in terms of apparatus pattern and general morphology (see Systematic Paleontology chapter). Macerodus dianae Fåhræus and Nowlan is characteristic of deeper water (subtidal) facies (e.g. Fåhræus and Nowlan, 1978; Ethington and Clark, 1982).

The zone is equivalent to the SW Assemblage Zone D and E of this study. The thickness of this zone is between 80 and 85 m in the study area.

As noted by many conodont workers (Nowlan, 1976; Ethington and Clark, 1982; Repetski, 1982; Ethington, Engel and Elliott, 1987; probably Mound, 1968), the base of this interval, which constitutes one of the most pronounced changes in the entire conodont history can be readily correlated within the Midcontinent Province.

D. Acodus primus-Acodus delicatus Assemblage Zone: This Assemblage Zone ranges from 129 m (top of "the pebble bed") above the base to the top of the Boat Harbour Formation (Fig. 5:2). The base of zone is defined by the first appearence of Acodus delicatus (Branson and Mehl). The zone is characterized by an assemblage including Acodus delicatus (Branson and Mehl), A. primus n. sp., and Cristodus ethingtoni n. sp., and by an association containing taxa which are listed in SW Assemblage Zone F. Acodus primus n. sp. has a short stratigraphic range in the St. George Group. A. delicatus (Branson and Mehl) is almost restricted to the interval between the top of "pebble bed" and the top of the Boat Harbour Formation.

The base of this zone represents a major change of the conodont succession (see Figures 4:2 and 4:3, and Appendix A), and roughly coincides with the lithologic change ("the Pebble Bed"). The zone almost corresponds to the SW Assemblage Zone F of this study. The thickness of this zone is between 50 and 55 m in tne study area.

E. Oepikodus communis-Protoprioniodus simplicissimus

Assemblage Zone: This Assemblage Zone ranges from the base of Catoche Formation to the top of Catoche Formation. The base of the zone is defined by the first appearance of *Oepikodus communis* (Ethington and Clark), where it is associated with the characteristic taxa of SW Assemblage Zone G. *Oepikodus communis* (Ethington and Clark) and *Protoprioniodus simplicissimus* (McTavish) are largely restricted to this zone and occur in abundance, especially *Oepikodus communis*. The first appearance of *O. communis* is only few meters above the base of the Catoche Formation in Section 2. The base of this interval constitutes a major change of the conodont succession in the Midcontinent Province, where several new species occur (see Figure 4:2, and Appendix A). Both *Oepikodus communis* and *Protoprioniodus simplicissimus* are widespread species known from several continents (see Systematic Paleontology chapter of this study).

The zone is equivalent to the SW Zone G of this study. The thickness of this zone is about 225 m in Section 2 (Fig. 5:3).

F. *Pteracontiodus cryptodens* Assemblage Zone: This Assemblage Zone ranges from the base of Aguathuna Formation to the top of Aguathuna Formation. The base of the zone is defined by the first appearance of *Pteracontiodus cryptodens* (Mound). The zone is characterized by an assemblage including *Pteracontiodus cryptodens* (Mound), *Drepanodus arcuatus* Pander and D. concavus (Branson and Mehl), and by an association containing the taxa which are listed in SW Assemblage Zone H (also see Appendix A).

Pteracontiodus cryptodens (Mound) is a widespread species (as noted above), and is restricted within this zone.

The zone is almost equivalent to the SW Zone H of this study. The thickness of this zone is about 65 m in the study sections.

Cambrian-Ordovician Boundary

The International Working Group on the Cambrian-Ordovician Boundary was formed in 1974 as a formal working group of the International Commission on Stratigraphy (ICS) within the International Union of Geological Sciences (IUGS). The task of the Working Group is to recommend a global stratotype section and point (GSSP) (Cowie & al., 1986; Norford, 1986) in a secure and accessible location. The Working Group has made several important and significant decisions (Norford, 1986): (1) it was agreed that conodonts will be used as the primary biostratigraphic indicator to determine the placement of a boundary horizon, Cordylodus proavus Zone is a poor horizon for the boundary and should be rejected, one strong candidates seemed to be the base of Cordylodus lindstromi Zone; (2) the two strongest stratotype candidates are at Green Point in the Cow Head Group, western Newfoundland and a section at Dayangcha, Jilin Province, P. R.

China. At the Fifth International Symposium on the Ordovician System (VISOS), Memorial University of Newfoundland, August 1988 and at the Working Group meeting at the 28th International Geological Congress, Washington, D.C., July 1989, it was generally agreed that the Cordylodus lindstromi Zone can be used to redefine the base of the System and hence the Tremadoc (and Ibexian) Series.

In the Cow Head Group, sections were searched for this boundary by Fortey and Skevington (1980), Fortey, Landing and Skevington (1982), and more recently by Barnes (1988), Erdtmann (1988) and several new localities have been discovered. It is proposed by Barnes (1988) that the Green Point section be the global boundary stratotype and point (GSSP) for the Cambrian-Ordovician Boundary at the base of Bed 23 (base of the Broom Point Member), defined by the base of the Cordylodus lindstromi Zone, at the Green Point Section.

The boundary of the Cambrian-Ordovician was drawn at the base of the St. George Group on limited biostratigraphic data (Knight and James, 1987). On the Port au Port Peninsula, the dark-coloured limestones and diagenetic dolostones of the St. George Group, dominated by cryptalgal boundstones and bioturbation, overlie the Berry Head Formation of the Port au Port Group which consists of intercalated pale grey limestone, and yellow weathering syngenetic dolostones and shale. The present study shows that the boundary of the Cambrian-Ordovician should be placed within the uppermost part of the Berry Head Formation, roughly 20 meters below the base of the St. George Group on the Port au Port Peninsula. A small number of conodont specimens have been recovered near the top of the Berry Head Formation including Cordylodus lindstromi. These conodonts indicate that Cambrian-Ordovician boundary lies within the uppermost part of the Berry Head Formation rather than at the base of the St. George Group.

Summary

Ethington and Clark (1971) and Sweet, Ethington and Barnes (1971) established a sequence of informal conodont Faunas for the Ordovician of North America, although some authors have treated them almost as biostratigraphic zones in the last two decades. In other studies, many conodont faunas or zonations have been based on incomplete stratigraphic sequences or limited and poorly preserved material. Over 430 samples collected from ten superbly exposed sections of a nearly complete, 600 m thick, Lower Ordovician carbonate succession through the St. George Group in western Newfoundland, have yielded more than 45,000 excellently preserved conodonts. These excellent faunas not only permit major revision to the reconstruction of Lower Ordovician multielement taxa (see Systematic Paleontology and Multi-element Taxonomy chapters), but also enable the establishment of a new and systematic Lower Ordovician conodont zonation for the Midcontinent Province.

Eight conodont Assemblage Zones (SW Zones A-H) have been established for the shallow-water typical Midcontinent Province (Fig. 5:3) in this study, of which two are present in the Watts Bight Formation, four within the Boat Harbour Formation, one each within the Catoche Formation and Aguathuna Formation. Six deeper-water conodont Assemblage Zones (DW Zones A-F) have been recognized, most are related to the transgressive facies (subtidal environment), but can be correlated into the shallow-water Zones.

As indicated in the Figures 5:2 and 5:3, all these shallow-water Assemblage Zones represent limited stratigraphic intervals in the Lower Ordovician, most can be recognized on other low latitude cratons, such as Australia, Siberia, and North China. Because the western Newfoundland sequence was deposited close to the ancient continent margin, it was periodically invaded by conodonts from the North Atlantic Province. Therefore, in the St. George Group, both the shallow-water Zones and the deeper-water Zones can be correlated through the critical biostratigraphic tie-points.

Based on the limited conodont data, the Cambrian-Ordovician boundary is shown to lie within the uppermost part of the Berry Head Formation of the Port au Port Group rather than at the base of the St. George Group.

The present study is only to develop a standard Lower Ordovician conodont zonation for the Midcontinent Province, therefore, the correlation of rocks of the St. George Group with the rocks of other localites is not pursued any more detail than those studies by Barnes & al. (Ordovician correlation chart of IUGS, 1981) and Knight and James (1987).

CHAPTER 6

SYSTEMATIC PALEONTOLOGY

Multielement conodont associations (apparatus species) are fully considered for all taxa which are described in this systematic paleontology chapter. Seventy five multielement species, representing 28 genera, have been described and illustrated; among them are 7 new genera, 33 new species and nearly 70 newly reconstructed multielement species.

Various designations for conodont element morphotypes have been proposed by many previous workers. However, the notation scheme for the Ordovician conodont elements by Barnes & al. (1979) is used rather than the letter codes (P, M, and S) by Sweet in Clark & al. (1981). A detailed discussion dealing with the conodont multielement taxonomy is provided in Chapter 3 (Multielement Taxonomy).

Most conodonts illustrated herein were photographed by SEM and a few conodonts were photographed with a Zeiss Photomicroscope III at the Geological Survey of Canada in Ottawa.

All the line drawings for the outlines and cross-sections are traced from the SEM photos and conodont specimens. All the figured specimens are deposited in the National Type Collections of the Geological Survey of Canada, Ottawa.

Genus Acanthodus Furnish, 1938

Type species: Acanthodus uncinatus Furnish, 1938

Emended diagnosis: A multielement genus consisting of three element morphotypes: a subrounded denticulated drepanodiform elements, c symmetrical suberect elements, and e compressed undenticulated drepanodiform elements. Both a elements and e elements characterized by having transitional variants comprise the first transition series and the second transition series respectively; c elements are symmetrical suberectiform and form a part of the first transition series.

Remarks: Furnish (1938) established this genus as a transitional type between simple and compound conodonts. He also concluded that the serrations do not correspond to the denticles of such elements as the beolodinids which appear in rather younger Ordovician strata. Lindström (1964, p. 84) noted the symmetry transitions of Acanthodus. Sweet and Bergström (1972, p. 32) suggested that Acanthodus elements are part of an apparatus species which also includes a variety of other morphotypes, such as scandodiform, acodiform, and oistodiform elements. However, this study shows that the apparatus pattern of Acanthodus is very similar to that of Drepanodus.

Based on this preliminary study of Acanthodus, it is considered that Acanthodus is probably an ancestor of Drepanodus.

Acanthodus lineatus (Furnish)

Plate 1, figs. 1-8; Text-fig. 6:1A

Subrounded element

Acanthodus lineatus Furnish, 1938, p. 328, Pl. 41, figs. 33, 34; text-fig. 1H.

Acanthodus sp. A., Hass, in Sando, 1958, p. 841-842, Pl. 2, fig. 20.

Acanthodus cf. uncinatus Furnish. Lindström, 1964, p. 137, text-fig. 47f.

Distacodus n. sp. Ethington and Clark, 1965, p. 190, Pl. 2, figs. 1, 2.

Acanthodus lineatus (Furnish). Ethington and Clark, 1971, p. 73, Pl. 1, fig. 4; Abaimova, 1972, text-fig. 1 (18); Abaimova, 1975, p. 29-30, Pl. 1, figs. 1-5; text-fig. 6(1, 2); Repetski and Ethington, 1977, p. 95-96, pl. 1, fig. 7; Ethington and Clark, 1981, p. 17, Pl. 1, fig. 7.

Acanthodus lineatus (Furnish) s.f. Repetski, 1982, p. 10, Pl. 1, figs. 1a-1c.

?Acanthodus costatus Druce and Jones, 1971, p. 54-55, Pl. 5, figs. 1a-5c; text-fig. 19a; Müller, 1973, p. 26, Pl. 8, figs. 8-9, 11-12, not fig. 10 (=compressed element of *A. lineatus*).

?*Acanthodus*? *costatus* Druce and Jones, 1971, p. 42-43, Pl. 1, figs. 4a-4b.

"*Acanthodus*" *lineatus* (Furnish). Landing, Barnes and Stevens, 1986, p. 1935-1936, Pl. 3, figs. 11, 12.

Compressed element

Acodus n. sp. Ethington and Clark, 1965, p. 190, Pl. 2, figs. 3, 4.

?*Acanthodus* *lineatus* (Furnish). Repetski, 1982, p. 10, Pl. 1, figs. 3a-3c.

Scandodus? sp. A. Jones, 1971, p. 61, Pl. 1, figs. 2a-2b.

Emended diagnosis: A multielement species containing two element morphotypes: *a* subrounded acanthodiform elements, and *e* compressed drepanodiform elements. Both subrounded and compressed elements are extremely slender and albid coniforms. Subrounded elements consists of two variants: one with well developed lateral costa, another usually without lateral costa; compressed elements comprise two variants: one drepanodiform-like, and another scandodiform-like.

Remarks: Furnish (1938) described this species as a strongly recurved form with a flared base. He also noted that this species is represented by numerous specimens which resemble one another closely. Ethington and Clark (1965, p. 187, Acodus n. sp.; p. 190, Distacodus n. sp.) suggested that Acanthodus lineatus may contain a symmetry-transition series with three end-member morphologies.

Landing, Barnes and Stevens (1986) noted that the apparatus of A. lineatus is composed of nongeniculate elements including asymmetrical forms with one lateral costa and symmetrical forms with a costa on both sides, as well as noncostate symmetrical elements (E. Landing, unpublished data).

Based on this study, it is considered that the apparatus of A. lineatus probably contains two element morphotypes: a subrounded elements with weak serrations on the distal part of the cusp, e compressed elements without serrations on the distal part of the cusp. Both a elements with two variants and e elements with two variants comprise the first transition series and the second transition series. The c symmetrical suberectiform may be not present in this specialized species.

Acanthodus lineatus (Furnish) has been reported from many places around the world. It has a relatively short stratigraphic range, and appears valuable for the correlation.

Occurrence: This species is present in the uppermost Watts Bight Formation and the lower part of the Boat Harbour Formation in samples from Z2-20 to Z2-32 of Section 2; in samples from Z4-19 to Z4-32 of Section 4; in samples Z6-10B of Section 6.

Number of specimens: Total 375; a subrounded acanthodiform element, 204; e compressed drepanodiform element, 171.

Types: GSC 95682-95689.

Acanthodus uncinatus (Furnish)

Plate 1, figs. 9-13; Text-fig. 6:1B

Subrounded element

Acanthodus uncinatus Furnish, 1938, p. 337, Pl. 42, fig. 30, text-fig. 2B; Hass, 1962, p. 45, text-fig. 23(3); Lindström, 1964, p. 138, text-fig. 10D; Druce and Jones, 1971, p. 55-56, Pl. 6, figs. 9a-12c; text-fig. 19b; Ethington and Clark, 1981, p. 17, Pl. 1, fig. 8; Landing, Barnes and Stevens, 1986, p. 1936, Pl. 3, fig. 8, text fig. 3A.

non *Acanthodus* cf. *uncinatus* Furnish. Lindström, 1964, p. 137, text-fig. 47f(=*Acanthodus lineatus* Furnish).

Compressed element

?*Acanthodus uncinatus* Furnish s.f., Repetski, 1982, p. 10, Pl. 1, fig. 4.

Remarks: Both subrounded (a) elements with well developed serrations and compressed (e) elements without or with weak serrations of this species are fully described by many former authors as noted in synonymy. The subrounded elements are characterized by having serrations along the posterior side of the cusp, one rounded lateral face and one compressed lateral face; however, the compressed (e) elements are laterally compressed without or with weakly developed serrations on the cusp. The c symmetrical suberectiform characterized by having extended base and laterally compressed cusp and by not having serrations is present at the least in the late stage of this multielement species.

Occurrence: This species is present in the uppermost Watts Bight Formation and the lower part of the Boat Harbour Formation in samples from Z2-20 to Z2-33 of Section 3; in samples from Z4-24 to Z4-36 of Section 4; in samples from Z6-6B to Z6-13 of Section 6; in samples from Z8-2 to Z8-3 of Section 8; in samples from Z9-9 of Section 9.

Number of specimens: Total 941; a subrounded acanthodiform element, 510; c symmetrical suberectiform element, 36; e compressed drepanodiform element, 395.

Types: GSC 95690-95694.

Genus Acodus Pander, 1856

Type species: Acodus erectus Pander, 1856.

Emended diagnosis: A multielement genus consisting of two to five element morphotypes: a subrounded distacodiform elements, b transitional acodiform elements, c suberect symmetrical distacodiform, e compressed oistodiform elements, and f deltaform elements. Subrounded elements with various orientations of costae are arranged in the first transition series, usually associated with suberect symmetrical distacodiform elements and transitional acodiform elements; compressed oistodiform elements that exhibit different curvature associated with suberect symmetrical deltaform elements comprise second transitional series.

Remarks: Pander (1856) established this genus as "more or less bent teeth with front and back keels, usually of different size, unsymmetrical side faces, one convex form and other having sharp carina." Lindström (1973, 1977) redefined Acodus as a multielement genus with prioniodiform, ramiform and oistodiform elements. Subsequently, McTavish (1973), Serpagli (1974), and Kennedy (1978, 1980) discussed in depth the elemental composition of the apparatus of Acodus. The reconstruction and re-definition of Acodus by Lindström (1977) are fully supported by this study, but different nomenclature is used.

On the basis of the western Newfoundland collections, Acodus Pander is considered to be one of the immigrants from the North Atlantic Province (Ji and Barnes, in press). However, it seems to be related to Rossodus Repetski and Ethington, because it has almost same apparatus plan and bears superficial similarity in having subrounded, transitional and compressed elements.

It is true, as suggested by Lindström (1977), that Acodus exhibits intermediate morphology between the distacodont conodonts and the prioniodonts. Acodus also appears to be very close to Pteracontiodus Harris and Harris, but the latter is hyaline, and may be fully developed in the apparatus and some characteristic features view.

Acodus comptus (Branson and Mehl)

Plate 2, figs. 1-21; Text-fig. 6:2A

Distacodiform element

Paltodus comptus Branson and Mehl, 1933, p. 61, Pl. 4, Fig. 9.

Scolopodus pseudoquadratus Branson and Mehl, 1933, p. 63, Pl. 4, fig. 19.

Tropodus comptus (Branson and Mehl). Kennedy, 1980, p. 65, Pl. 2, figs. 20-27.

Walliserodus comptus (Branson and Mehl). Ethington and Clark, 1982, p. 114-116, Pl. 13, figs. 6, 7, 11-12 (non fig. 13); fig. 34.

Paltodus comptus Branson and Mehl. Repetski, 1982, p. 37, Pl. 14, fig. 10.

Tropodus comptus (Branson and Mehl). Stouge, 1982, Pl. 4, figs. 6-8; Stouge and Boyce, 1983, Pl. 3, fig. 13 only (non fig. 14).

Tropodus comptus (Branson and Mehl). Stouge and Bagnoli, 1988, p. 141-142, Pl. 16, figs. 6-7.

Acodiform element

?New Genus. Ethington and Clark, 1982, p. 117, Pl. 13, fig. 17.

?*Diaphorodus delicatus* (Branson and Mehl). Kennedy, 1980, acodiform element, p. 52-54, Pl. 1, figs. 4-5 (non figs. 3, 6-8).

New Genus C. Kennedy, 1980, >>acodiform<< element, Pl. 2, fig. 39.

Acodus sp. cf. *A*. *deltatus* Lindström. Stouge, 1982, Pl. 3, figs. 11-12; Stouge and Boyce, 1983, Pl. 2, fig. 2.

Acodus? sp. cf. *A*. *delicatus* Branson and Mehl. Stouge, 1982, Pl. 4, fig. 5.

Tropodus comptus (Branson and Mehl). Stouge and Bagnoli, 1988, p. 141-142, Pl. 16, figs. 2, 9.

Oistodiform element

Oistodus expansus Branson and Mehl, 1933, p. 60, 109, Pl. 4, Fig. 4.

Acodus? sp. cf. A. delicatus Branson and Mehl. Stouge, 1982, oistodiform element, Pl. 4, fig. 2; Stouge and Boyce, 1983, oistodiform element, Pl. 3, fig. 15.

?Diaphorodus delicatus (Branson and Mehl). Kennedy, 1980, oistodiform element of D. delicatus delicatus, p. 52-54, Pl. 1, figs. 20-22.

Tropodus comptus (Branson and Mehl). Stouge and Bagnoli, 1988, p. 141-142, Pl. 16, fig. 1.

Symmetrical distacodiform and deltatiform element

Walliserodus comptus (Branson and Mehl). Ethington and Clark, 1981, p. 114-116, Pl. 13, fig. 13 only.

Tropodus comptus (Branson and Mehl). Stouge, 1982, Pl. 4, figs. 3-4; Stouge and Boyce, 1983, Pl. 3, fig. 14.

Oistodus? sp. Stouge, 1982, Pl. 4, fig. 17.

Oistodus sp. cf. O. delta Lindström. Stouge, 1982, Pl. 4, fig. 21.

Oistodus delta Lindström. Stouge and Boyce, 1983, Pl. 3, fig. 10.

Tropodus comptus (Branson and Mehl). Stouge and Bagnoli, 1988, p. 141-142, Pl. 16, figs. 3, 8.

<u>Emended diagnosis</u>: A species of <u>Acodus</u> containing five element morphotypes: <u>a</u> subrounded distacodiform elements with five major costae, <u>b</u> transitional acodiform elements with laterally compressed cusp and base, <u>c</u> suberect symmetrical distacodiform elements, <u>e</u> compressed oistodiform elements with slightly twisted broad cusp and posteriorly extended base, and <u>f</u> deltaform elements with thinly sheathed base and antero-posteriorly compressed cusp. The distacodiform elements (<u>a</u> and <u>c</u>) together with acodiform elements (<u>b</u>), and oistodiform elements (<u>e</u>) associated with deltaform elements (<u>f</u>) comprise the first and second transition series respectively. Elements are usually albid, adentate and have moderately developed keels.

Subrounded (<u>a</u>) element

<u>Description</u>: Elements are asymmetrical distacodiform with five variably ornamented major costae. Cusp is usually reclined to recurved, laterally compressed, and filled with white matter. Cross-section of cusp is subrectangular. Outer face has two strongly and one moderately developed costae; inner face is occupied by two sharp costae. Basal margin is indented between the costae. Basal cavity is deep.

Transitional (<u>b</u>) element

<u>Description</u>: Elements consist of two slightly different acodi-

form elements: one is laterally compressed, drepanodiform cone with strongly curved cusp and modestly inflated basal region; other is acodiform-like cone, laterally compressed only on one lateral face with suberect cusp, moderately developed anterior and posterior keels, lateral carina on inner face, and a small base with slightly flared inner basal margin.

Suberect symmetrical (c) element

Description: Elements are symmetrical distacodiform characterized by five well developed costae (two on anterior, one on posterior and two on each postero-lateral side) and an expanded base.

Compressed (e) element

Description: Elements are oistodiform with a broad, slightly recurved cusp which is twisted about its axis so that anterior margin is turned inwards. Cusp is recurved and filled with white matter. Both edges of cusp are strongly keeled. Inner face of cusp has a low, asymmetrical carina which flattens to posterior edge of cusp. Base is extended slightly to the posterior and in an aboral-anterior direction and it is flared on inner side.

Suberect symmetrical (f) element

Description: Elements are deltaform with a thinly sheathed base which is expanded laterally and posteriorly, and extremely antero-posteriorly compressed cusp which bears a prominent, sharp, posteriorly directed median costa and two lateral knife-edged costae.

Remarks: This apparatus species has never been correctly recognized in any publication to date, although Serpagli (1974), Kennedy (1980), Repetski (1982) and Stouge and Bagnoli (1988) described all the elements of the species in detail. As the elemental composition of the apparatus of Acodus delicatus Branson and Mehl, this species also comprises five-element morphotypes. Repetski (1982) suggested that Paltodus (=Tropodus or Walliserodus) comptus Branson and Mehl may be a five-costae paltodiform element of the Acodus delicatus apparatus. On the basis of western Newfoundland collections, Paltodus comptus having the transition series together with the misindentified distacodiform, acodiform, and oistodiform elements of Acodus delicatus or A. deltatus as indicated in the synonymy should be assigned to a new apparatus species Acodus comptus (Branson and Mehl).

Among the five major elements of the species, a subrounded distacodiform elements associated with b transition acodiform and c suberect symmetrical distacodiform elements form a complete (first) transition series; e compressed oistodiform elements together with f suberect symmetrical deltaform elements comprise the second transition series. However, within the b elements, the drepanodiform-like form is very close to the distacodiform, and acodiform-like form bears similarity to the oistodiform.

The elements of A. comptus are similar to those of A. delicatus, but its subrounded distacodiform element differs by having five major costae; transitional acodiform elements differs by weakly developed anterior and posterior keels and lateral carina on the inner side; compressed oistodiform element can be distinguished by a broad, slightly recurved cusp which is twisted about its axis and anterior extended base with flared basal margin on the inner side; suberect symmetrical distacodiform is easily distinguished by five well developed costae, and deltaform element with slightly thinner and more curved cusp is usually difficult to distinguish with that of A. delicatus. Generally, morphological overlap of subrounded distacodiform elements and compressed oistodiform elements among the species of Acodus makes reconstruction of the apparatus and recognition of the species difficult although some differences exist among them. Some specimens named by Ethington and Clark (1981) as Walliserodus comptus (Branson and Mehl) are similar to those of A. comptus (Branson and Mehl) of the St. George Group, but their major costae are well developed.

Occurrence: This apparatus species is present in the upper part of the Boat Harbour Formation through the Catoche Formation to the lower part of the Aguathuna Formation in samples from Z2-70 to Z2-139 of Section 2; in samples from Z3-1 to Z3-20 of Section 3; in samples from Z6-27 to Z6-46 of Section 6; in samples from Z10-A to Z10-F and from Z10-1 to Z10-9 of Section 10.

Number of specimens: Total, 3027; a subrounded distacodiform element, 1017; b transitional acodiform element, 1069; c suberect symmetrical distacodiform element, 138; e compressed oistodiform element, 746; f deltaform element, 62.

Types: GSC 95709-95727.

Acodus delicatus Branson and Mehl

Plate 1, figs. 14-27; Text-fig. 6:2B

Distacodiform element

Paltodus distortus Branson and Mehl, 1933, p. 62, Pl. 4, fig. 12; Graves and Ellison, 1941, p. 4, 5, 7, Pl. 1, fig. 19 only.

Acodus brevis Branson and Mehl. Lindström in Klapper et al. 1977, ramiform element, p. 5-6, Pl. 2, figs. 3, 5.

Diaphorodus delicatus (Branson and Mehl). Kennedy, 1980, distacodiform element, p. 52-53, Pl. 1, figs. 18-19.

Acodus delicatus Branson and Mehl. Repetski, 1982, paltodiform element, p. 10-12, Pl. 1, fig. 6.

?<u>Acodus deltatus deltatus</u> Lindström. McTavish, 1973, tetraprioniodiform element, p. 39-40, Pl. 1, figs 3, 4, Text-fig. 3s.

?<u>Distacodus baikiticus</u> Moskalenko, 1967, p. 104, Pl. 22, figs. 8-10.

non <u>Paltodus distortus</u> Branson and Mehl. Abaimova, 1972a, p. 126; Abaimova, 1972b, chart-Fig. 29; Abaimova, 1975, p. 89-90, Pl. 8, figs. 3-5.

Acodiform element

<u>Acodus delicatus</u> Branson and Mehl, 1933, p. 56, Pl. 4, Fig. 4; Kennedy, 1980, acodiform element, p. 52-53, Pl. 1, Figs. 3, 6-8; drepanodiform element, p. 52, Pl. 1, Figs. 9-13; Repetski, 1982, cordylodiform element, p. 10, Pl. 1 Figs. 5a-5c, acodiform element, p. 10, Pl. 1 Figs. 9a-9c; Ethington and Clark, 1981, drepanodiform element, Pl. 1, fig. 2, prioniodiform element, Pl. 1, fig. 3.

<u>Cordylodus simplex</u> Branson and Mehl, 1933, p. 64, Pl. 4, Fig. 11; Graves and Ellison, 1941, p. 3, 7, Pl. 1, Fig. 4 only.

<u>Acodus brevis</u> Branson and Mehl. Lindström in Klapper, 1977, prioniodiform element, p. 5-6, P. 2, Fig. 2 only.

?<u>Drepanodus tenus</u> Moskalenko, 1967, p. 107-108, Pl. 23, Figs. 5, 11, Text-fig. 9; Moskalenko, 1973, p. 88, Pl. 15, Fig. 8.

?Acodus deltatus deltatus Lindström. McTavish, 1973, p. 39 Pl. 1, Fig. 13 Text-fig. 3r.

Oistodiform element

?Oistodus vulgaris Branson and Mehl, 1933, p. 60, Pl. 4, Fig. 5.

Acodus sibiricus Moskalenko, p. 102-103, P. 22, Figs. 5-6.

Acodus deltatus deltatus Lindström. McTavish, 1973, p. 39 40, Pl. 1, Figs. 5, 8, Text-Fig. 3t.

Acodus bervis Branson and Mehl. Lindström in Klapper et al., 1977, oistodiform element, p. 5-6, Acodus-Pl. 2, Fig. 4 only.

Diaphorodus delicatus (Branson and Mehl). Kennedy, 1980, oistodiform element of D. delicatus vulgaris, p. 52-53, Pl. 1, Figs. 23-25 (non figs. 20-22).

Acodus delicatus Branson and Mehl. Repetski, 1982, oistodiform element, p. 10, Pl. 1, Figs. 7a-7b.

Symmetrical distacodiform and deltaform elements

Acodus deltatus Lindström. Ethington and Clark, 1982, Pl. 1, fig. 6.

Diaphorodus delicatus (Branson and Mehl). Kennedy, 1980, acontiodiform element, p. 52, Pl. 1, Figs. 14-15.

Acodus delicatus Branson and Mehl. Repetski, 1982, trichono delliform element, p. 10, Pl. 1, Figs. 8a-8c.

"Acontiodus" aff. "A." latus Pander s.f. Ethington and

Clark, 1981, Pl. 1, fig. 18.

Emended diagnosis: A species of *Acodus* in which multielement apparatus consists of five element morphotypes: *a* subrounded distacodiform elements with four major costae, *b* transitional acodiform elements with posteriorly expanded large base, *c* suberect symmetrical distacodiform element with laterally expanded base, *e* compressed oistodiform-like elements with three keeled costae and *f* deltaform elements. Elements possess moderately extended bases and sharp keeled costae, and are partially albid or composed of white matter.

Subrounded (*a*) element

Description: Elements are distacodiform with four variably developed, asymmetrically disposed costae. Cusp is usually reclined with four costae on anterior, posterior, two lateral sides respectively. Cross-section of cusp is subrounded. Base is relatively large and basal cavity is deep.

Transitional (*b*) element

Description: Elements are two slightly different acodiform with suberect to reclined cusp, moderately developed anterior, posterior and/or lateral keels, and large base. One is strongly compressed laterally without distinct lateral costa; other is compressed only one side of lateral face with a triangular base.

Suberect symmetrical (c) element

Description: Elements are symmetrical distacodiform characterized by having a suberect cusp with five costae on the posterior and four antero-lateral and postero-lateral sides respectively, and a slightly expanded base and large basal cavity.

Compressed (e) element

Description: Elements are oistodiform-like with slightly variably developed cusp and base. Cusp is usually suberect to reclined with three keeled edges. Inner face of cusp has a low, asymmetrical carina which disappears near tip of cusp, and strongly keeled near basal region. Basal outline is triangular, and formed thin sheaths enclosing basal cavity between edges.

Suberect symmetrical (f) element

Description: Elements are deltaform with a thinly sheathed base which is expanded laterally and posteriorly, an extremely wide anterior face and a well developed posterior costa.

Remarks: All the elements have been described in detail previously by Branson and Mehl (1933), Moskalenko (1967), Kennedy (1980) and Repetski (1982). Brief descriptions are provided for the arrangement of new apparatus plan of the species.

A. delicatus is closely similar to *A. comptus*, but slight differences exist in their four major elements. The subrounded distacodiform elements are characterized by four well developed costae; the transitional acodiform elements have three keeled edges (one anterior, one posterior and another lateral); the compressed oistodiform elements are characterized by posteriorly extended base, well developed lateral carina on the inner lateral side and extremely keeled edges; the suberect symmetrical distacodiform elements are triangular in cross-section; the deltaform elements are slightly curved with extremely keeled posterior costa and two lateral costae.

Among the four elements, *a* distacodiform elements having variably developed costae together with *b* transition and *c* suberect symmetrical elements form the first transition series; and *e* oistodiform elements possessing variable cusp and base as well as inner face carina associated with *f* deltaform elements comprise the second transitional series. Generally, distacodiform elements are quite distinct from oistodiform elements, however, acodiform elements show the intermediate morphology between the distacodiform elements and the oistodiform elements.

Occurrence: The species is found in the upper part of the Boat Harbour Formation in samples from Z2-67 to Z2-76 of Section

2.

<u>Number of specimens</u>: Total, 673; <u>a</u> subrounded distacodiform element, 211; <u>b</u> transitional acodiform element, 185; <u>c</u> suberect symmetrical distacodiform element, 37; <u>e</u> compressed oistodiform element, 235; <u>f</u> suberect deltaform element, 5.

<u>Types</u>: GSC 95695-95708.

<u>Acodus</u> <u>lanceolatus</u> (Pander)

Plate 3, figs. 1-10; Text-fig. 6:1C

Distacodiform element

<u>Oistodus</u> <u>lanceolatus</u> Pander, 1856, Mon. fos. Fische Silur. Sys. russ-balt. Gouvernements, p. 27, Pl. 2, fig. 19 only.

<u>Paltodus</u> <u>jeffersonensis</u> Branson and Mehl, 1933, Pl. 4, fig. 18.

<u>Oistodus</u> sp. Ethington and Clark, 1964, p. 694, Pl. 114, fig. 21.

<u>Oistodus</u> n. sp. Repetski, 1982, paltodiform element, p. 32-33, Pl. 11, Figs. 4a-4c.

<u>Oistodus</u> <u>lanceolatus</u> Pander. Bergström, 1988, geniculate element, p. 241, Pl. 2, fig. 19.

Triangulariform element

<u>Oistodus</u> <u>lanceolatus</u> Pander, 1856, Mon. fos. Fische Silur. Sys. russ-balt. Gouvernements, p. 27, Pl. 2, fig. 17 only. ?<u>Oistodus</u> <u>longiramis</u> Lindström. Ethington and Clark, 1964, Pl. 114, figs. 2, 7.

<u>Oistodus</u> n. sp. Repetski, 1982, triangulariform element, p. 32-33, Pl. 11, figs. 11a-11c.

<u>Oistodus</u> aff. <u>O</u>. <u>lanceolatus</u> Pander. Stouge and Bagnoli, 1988, p. 123, Pl. 6, figs. 1, 2, 3, 5.

Oistodiform element

<u>Oistodus</u> <u>lanceolatus</u> Pander, 1856, Mon. fos. Fische Silur. Sys. russ-balt. Gouvernements, p. 27, Pl. 2, fig. 18 only. <u>Oistodus</u> <u>lanceolatus</u> Pander. Ethington and Clark, 1964, Pl. 113, fig. 12, Pl. 114, figs. 1, 5.

<u>Oistodus</u> n. sp. Repetski, 1982, oistodiform element, p. 32-33. Pl. 11, figs. 9a-9c.

<u>Oistodus</u> <u>lanceolatus</u> Pander. Bergström, 1988, geniculate element, p. 241, Pl. 2, fig. 18.

Deltaform element

<u>Oistodus</u> n. sp. Repetski, 1982, deltaform element, p. 32-33, Pl. 11, figs. 3a-3c.

<u>Oistodus</u> <u>lanceolatus</u> Pander. Bergström, 1988, modified alate element, p. 241, Pl. 2, fig. 17.

Emended diagnosis: A species of *Acodus* containing four element morphotypes: *a* subrounded distacodiform elements with four well developed costae and deep pyramidal basal cavity, *b* transitional triangulariform elements with three costae and triangular-shaped base, *e* compressed oistodiform elements with bowed and slightly twisted cusp and deep basal cavity, and *f* suberect symmetrical deltaform elements having extremely keeled lateral costae and posterior costa. Elements are usually hyaline, and finely striated.

Subrounded (*a*) element

Description: Elements are asymmetrical distacodiform with four major costae. Cusp is usually strongly recurved. Cross-section of cusp is subrectangular. Costae are thickened basically and extend a short distance beyond basal margin except for two lateral costae which extend near tip of cusp. Basal margin between costae is thin sheath. A deep pyramidal basal cavity extends as a shallow groove below extension of each costa. As with other subrounded elements of *Acodus*, costae at basal margin extend into projections.

Transitional (*b*) element

Description: Elements are asymmetrical triangulariform with three costae. Cusp is laterally compressed, sharply reclined. Lateral faces of cusp bear a median carina which is generally stronger on one side than the other. Base is continued anteriorly and posteriorly as laterally compressed processes with sharp oral edges. Anterior basal process is normally short and rectangular or rounded in outline; posterior process is long, and triangular-shaped. Basal cavity is wide and deep located posteriorly to the center of the cusp.

Compressed (e) element

Description: Elements are finely striated oistodiform with laterally compressed, bowed and slightly twisted cusp. Cusp is reclined to recurved with greatest curvature at about one-third of its length about base. Both edges of cusp are strongly keeled. Lateral faces have weakly developed carina. Base is extended posteriorly and anteriorly. Basal cavity is deep, but narrow.

Suberect symmetrical (f) element

Description: Elements are deltaform with two prominent antero-lateral costae situated symmetrically. Cusp is triangular, posteriorly compressed. One posterior costa is well developed and extremely keeled; anterior face is flat without any costae. Base is extended laterally, basal cavity is deep.

Remarks: Although Pander (1856) recognized most elemental morphotypes of this species, unfortunately, it has never been correctly identified in any publication to date. As noted in the synonymy, Pander (1856) illustrated three major elements: a subrounded distacodiform elements, b triangulariform elements and e compressed oistodiform elements.

The specimens of compressed oistodiform element collected from the St. George Group are almost same as the specimens which Ethington and Clark (1964) figured on Plate 113, figure 12, Plate 114, figures 1, 5, but they are slightly different from Pander's illustrated types characterized by well developed posterior portion of the base and the prominence of the lateral carina or costae. The specimens of transitional triangulariform elements are close to those of Pander's illustrated figures, and also similar to those of Ethington and Clark (1964), named as Oistodus longiramis Lindström. The specimens illustrated as Oistodus n. sp. by Repetski (1982) are similar to our material, in terms of the morphology and apparatus plan.

This apparatus species is assigned to Acodus, because its subrounded elements characterized by having four major costae together with transitional acodiform-like elements, suberect symmetrical deltaform elements, and compressed oistodiform elements are quite close to those of Acodus delicatus and A. comptus. However, all elements of the species are hyaline or partially albid which can be easily distinguished from all other species of Acodus. It seems to be most likely that this species shows superficial similarity to Scolopodus cornutiformis (Branson and Mehl) in terms of the hyaline condition and apparatus pattern.

Occurrence: This species is present in the upper Boat Harbour Formation and the lower Catoche Formation in samples from Z2-68 to Z2-101 of Section 2; in samples from Z6-34B to Z6-46 of Section 6; in samples from Z10-1 to Z10-4 of Section 10.

Number of specimens: Total, 173; a subrounded distacodiform element, 23; b transitional triangulariform element, 43; e compressed oistodiform element, 100; f suberect symmetrical deltaform element, 7.

Types: GSC 95734-95742.

Acodus primus n. sp.

Plate 2, figs. 22-27

Derivation of name: From the Latin "primus", meaning this species is probably the first species of Acodus to immigrate into the Midcontinent Province.

Diagnosis: A species of Acodus consisting of two element morphotypes: a subrounded elements and e compressed elements. Subrounded elements are distacodiform with three to four poorly developed costae; compressed elements are drepanodiform with recurved cusp. Elements are usually albid, and have weakly developed keels.

Subrounded (a) element

Description: Elements are distacodiform with three to four weakly developed, asymmetrically disposed costae. Cusp is usually reclined to strongly recurved, slightly laterally compressed, and filled with white matter. Cross-section of cusp is subrectangular to subrounded. Outer face has two weakly developed costae; inner face is occupied by one sharp and one weak costae. Basal margin is indented between the posterior costae. Basal cavity is relatively deep.

Compressed (e) element

Description: Elements are drepanodiform with strongly recurved cusp that is unequally biconvex in cross-section with sharp edges. Cusp is usually slightly twisted or somewhat flexed near the cusp-base junction. Antero-lateral face is rounded; postero-lateral face is compressed with a weakly developed costa. Both edges of cusp are strongly keeled. Base is extended slightly to the postero-lateral and antero-lateral sides. Basal cavity is moderately deep.

Remarks: This species is probably the oldest immigrant species of Acodus into the Midcontinent Province, and bears only two elemental morphotypes: *a* subrounded distacodiform elements and *e* compressed drepanodiform elements. The *a* elements are similar to those of *A*. *comptus* and *A*. *delicatus*, but their cusps have only weakly developed costae; the *e* elements bear resemblance to those of *A*. *comptus* (Branson and Mehl) and *A*. *delicatus* Branson and Mehl, but their postero-lateral faces are not strongly compressed, and the bases are not extended either posteriorly or anteriorly. From *A*. *primus* n. sp. to *A*. *delicatus*, then from *A*. *delicatus* to *A*. *comptus* clearly show that posterior and anterior faces became differentiated, and costae and keels developed as characteristic features, and that apparatus plans became complicated, and *b*, *c*, and *f* morphotypes developed as complete apparatus pattern. The *a* elements are closely related to those of *Scolopodus* *subrex* n. sp. in terms of the morphology and stratigraphic range.

Occurrnece: The species is present in the middle part of the Boat Harbour Formation in sample Z2-66 of Section 2.

Number of specimens: Total, 70; *a* subrounded distacodiform element, 40; *e* compressed drepanodiform element, 30.

Types: GSC 95728-95733.

Genus *Clavohamulus* Furnish, 1938

Type species: Clavohamulus densus Furnish, 1938

Emended diagnosis: A multielement apparatus consists of two element morphotypes: a subrounded acontiodiform element, and an orally compressed clavohamuliform element. Subrounded elements are small, low, bilaterally symmetrical or asymmetrical and triangular in cross-section; they have a small, shallow basal cavity and a strongly recurved cusp. Orally compressed elements lack bases or have very short bases, and have bulbous cusps with or without a posteriorly directed tip, and have very shallow basal cavities. Anterior faces of subrounded elements are covered by widely separated tiny nodes. Anterior surface of orally compressed element is faintly pustulate.

Remarks: Furnish (1938, p. 326) established the genus as follows: "A bulbous pitted basal portion, which is not excavated by a basal cavity, is joined to a slender bladelike cusp". Lindström (1964, p. 143) described this genus as: "...a single denticle that is widened into a faintly ornate platform at the base. Basal cavity usually shallow, or flat, but wide...". Miller (1969, p. 422) identified three new form species and redefined the genus as "very small conodonts, some species lacking a cusp entirely, such forms are subspherical to nearly wheel-shaped. Some species possess a posterior cusp which may be larger or smaller than bulbous basal portion. All types are bilaterally symmetrical, some lacking a cusp approach radial symmetry...". Miller (1980) also considered that all species of Clavohamulus seems to have possessed a simple, one element apparatus. In the present study, several hundred Clavohamulus specimens were recovered from the St. George Group, allowing the reconstruction of two multielement species named previously and the establishment of four additional new multielement species. This not only requires modification of the original description by Furnish (1938), the re-definition by Lindström (1964, 1973) and Miller (1969), but also requires the revision of the terminology. Clavohamuliform elements of Clavohamulus are orally compressed elements, usually asymmetrical, and are characterized by a squashed bulbous cusp with single, rather short, posteriorly directed point, and by a greatly reduced or nearly absent basal cavity. Acontiodiform elements usually bear a superficial similarity to clavohamuliform elements in cusp, base and basal cavity.

No subrounded acontiodiform elements have been described by early authors, probably because they are tiny, and similar to some species of Acontiodus and not as distinct as the clavohamuliform elements.

Clavohamulus densus Furnish

Plate 3, figs. 11-14

Acontiodiform element

?"_Scolopodus_" n. sp. A s.f. Landing and Barnes, 1981, Pl. 1, fig. 1 (non fig. 5).

Clavohamuliform element

Clavohamulus _densus_ Furnish, 1938, p. 327, Pl. 42, figs. 18 21; ?Ethington and Clark, 1971, p. 72, Pl. 1, fig. 13; ?Landing and Barnes, 1981, Pl. 2, figs. 11-14; Ethington and Clark, 1981, p. 30, Pl. 2, fig. 21; Repetski, 1982, p. 15, Pl. 4, fig. 6; Nowlan, 1985, Fig. 4-4.16-4-4.17.

Emended diagnosis: A multielement species having an apparatus that consists of two element morphotypes: _a_ subrounded, triangular acontiodiform elements and _e_ orally compressed clavohamuliform elements. Both acontiodiform and clavohamuliform elements are characterized by extremely short base and shallow basal cavity, and covered by separated tiny nodes.

Subrounded (_a_) element

Description: Elements are not only orally compressed, but also antero-posteriorly compressed, and are triangular shaped in cross-section. Cusp is rather short, curved and tapers rapidly to a small peg-like point. Anterior face of element is smoothly and broadly convex, and has widely separated tiny nodes; lateral faces are slightly rounded; posterior face is strongly concave with a few faint concentric ridges and very tiny nodes. A sharp-edged shoulder or keel-like costa is well developed on each side of the posterior face. Base is extremely short. Basal cavity is a semi-oval concave depression marked by faint concentric ridges.

Orally compressed (e) element

Description: Elements are orally compressed, T-shaped when viewed posteriorly. Cusp is rather bulbous with a slender and small posteriorly directed point. Anterior face is broadly rounded, and ornamented with faint concentric ridges covered by separated very tiny nodes. In most specimens, basal cavity is extremely shallow, T-shaped, and is not only located posteriorly at the junction of the upper part of cusp, but also extended laterally as a shallow, inverted attachment surface under the anterior bulbous cusp. Basal cavity is usually a depression marked by a few concentric growth line.

Remarks: Furnish (1938) described the clavohamuliform element of this species as the type species of genus Clavohamulus based on a single large specimen. Since then, Ethington and Clark (1971, 1982), and several other authors have re-described and recorded this orally compressed element. However, no subrounded element has been recognized and described by the early workers. Probably, because the subrounded element is less common than the orally compressed element and/or is similar to other stubby forms, it is difficult to find or it may be misidentified and confused this element with other forms. The specimen described by Landing and Barnes (1981) as "<u>Scolopodus</u>" n. sp. A s.f. with extremely shallow basal cavity and short cusp should be included in this species as the acontiodiform element.

The acontiodiform element is characterized by having a triangular cusp which is curved, slightly orally compressed and also antero-posteriorly compressed; the clavohamuliform element is T-shaped when is viewed posteriorly, and has a bulbous cusp with a posteriorly directed point. As in other apparatuses of <u>Clavohamulus</u>, the acontiodiform element generally is quite distinct from the clavohamuliform element, however, both elemental morphotypes are characterized by a small peg-like tip and very tiny nodes on the anterior face.

Within this apparatus, the orally compressed elements are most common, the subrounded elements are less common than the orally compressed elements in number.

<u>Occurrence</u>: This apparatus species is present in the uppermost part of Watts Bight Formation and the lower part of Boat Harbour Formation in samples from Z2-9B to Z2-28 of Section 2; in samples from Z4-19B to Z4-31B of Section 4; in samples from Z6-10B to Z6-11 of Section 6.

Number of specimens: Total, 85; *a* subrounded acontiodiform element, 35; *e* compressed clavohamuliform element, 50.

Types: GSC 95743-95745.

Clavohamulus hintzei Miller

Plate 3, figs. 18-20

Clavohamulus hintzei Miller, 1969, p. 422, Pl. 64, figs. 19 24.

Emended diagnosis: A multielement apparatus consisting of two element morphotypes: *a* subrounded acontiodiform elements and *e* orally compressed clavohamuliform elements. Acontiodiform elements are strongly compressed antero-posteriorly, subtriangular in profile; clavohamuliform elements are both orally compressed and antero-posteriorly compressed, and are semi-oblate in profile. Elements are characterized by extremely shallow, small basal cavity and short cusp ornamented with tiny nodes.

Subrounded (*a*) element

Description: Acontiodiform elements are strongly compressed antero-posteriorly, and usually also orally compressed, and sub-triangular in shape. Cusp is rather short, suberect to reclined, and tapers rapidly. Anterior face of cusp is smoothly and broadly rounded; posterior face is slightly concave near the base, and slightly convex near tip. A sharp-edged shoulder on each side of posterior face or on each lateral side is well developed. Basal cavity is very shallow with a few concentric growth laminae or lines, and cavity tip points toward anterior basal margin. Anterior faces of some specimens have a few separated tiny nodes.

Orally compressed (e) element

Description: Elements are not only orally compressed, but also antero-posteriorly compressed, and are the greater semi-oblate shaped, or if oriented with the basal cavity downward, they are shaped like a wheel having a concave bottom. Wheel-shaped cusp has no a pointed tip. Anterior face is usually more broadly rounded than the posterior face, which is rather flat or slightly rounded. Except for basal area, surface is covered with very small nodes on concentric ridges. Basal cavity is shallow, but slightly deeper than other species of the genus. In some specimens, concentric growth lines surround the basal cavity. Cavity tip points toward anterior basal margin. Elements are generally wider than long.

Remarks: Miller (1969) noted that the clavohamuliform element, characterized by having no pointed tip on the semi-oblate cusp, is readily distinguishable from the other species of the genus. The acontiodiform elements can be distinguished from that of other species by having a short cusp which is antero-posteriorly compressed and tapers rapidly. Only a few St. George Group specimens conform in general to the description of this species as reported by Miller (1969). However, all of the specimens are very small, and are the greater semi-oblate shaped.

Occurrence: This species is present in the lower part of Boat Harbour Formation in samples Z4-26 and Z4-28 of Section 4; in samples from Z6-6 to Z6-10 of Section 6.

Number of specimens: Total, 17; a subrounded acontiodiform element, 6; e compressed clavohamuliform element, 11.

Types: GSC 95748-95750.

Clavohamulus longicuspis n. sp.

Plate 3, figs. 15-17

Derivation of name: From the Latin "longicuspis" meaning long cusp, characteristic of the clavohamuliform element of this species.

Diagnosis: A species of *Clavohamulus* in which the acontiodiform element is characterized by a very long-triangular cusp with a posteriorly directed tip and with a clavohamuliform element prossessing a triangular-oblate cusp with a extremely long posteriorly directed tip.

Subrounded (*a*) element

Description: Elements are small, somewhat long and triangular in profile. Cusp is usually reclined to recurved, and tapers slowly to a sharp point. Anterior face of cusp is sharply rounded; lateral faces are slightly convex; posterior face is slightly concave, but with a faint medial convexity. A sharp-edged shoulder occurs on each side of posterior face. Anterior and lateral faces are covered by separated tiny nodes. Basal cavity is shallow depression with a series of concentric growth lines. In some specimens, base is extremely short, and slightly flared posteriorly.

Orally compressed (*e*) element

Description: Elements are small, somewhat triangular-oblate shaped but with a posteriorly directed handle, and flattened on basal side. Cusp is strongly orally compressed, and is divided into two parts. Lower part of cusp is triangular-oblate shaped; upper part of cusp is blade-like or handle-like, and tapers to a sharp point. Anterior face of the cusp is ornamented with very fine nodes on faint concentric ridges. Base is nearly absent by orally compression. Basal cavity is an extremely shallow depression, marked by faint concentric growth lines, that is usually located anteroposteriorly.

Remarks: This species is very similar to *C. densus* Furnish and *C. sphaericus* n. sp., but it can be distinguished from *C. densus* by the cusp, which is triangular-oblate shaped in lower part and is long, blade-like and sharp-pointed in upper part, and by the basal cavity which is neither T-shaped or extended laterally. This species is readily distinguished from *C. sphaericus* by the long, blade-like and sharp-pointed upper cusp and the triangular-oblate shaped main (lower) cusp. The acontiodiform element of this species differs from the other species of the genus by having a long cusp with sharp-pointed tip.

A few specimens both the subrounded elements and orally compressed elements have been found in this study, so it is difficult to determine which element is most common in this apparatus.

Occurrence: This apparatus species is found in the middle part of Watts Bight Formation in sample Z2-13 of Section 2.

Number of specimens: Total, 5; *a* subrounded acontiodiform element, 2; *e* compressed clavohamuliform element, 3.

Types: GSC 95746-95747.

Clavohamulus neoelongatus n. sp.

Plate 4, figs. 1-5

Clavohamulus elongatus Miller, 1969, p. 422, Pl. 64, figs. 17-18 only.

Derivation of name: From the Latin "neo-" and "elongatus", referring to the fact that this species is thought to be derived from C. elongatus Miller.

Diagnosis: A species of Clavohamulus in which apparatus consists of a subrounded acontiodiform element morphotype characterized by subtriangular-shaped cusp and elongate basal cavity, and e orally compressed clavohamuliform element morphotype characterized by being tear-shaped with bulbous cusp having a posteriorly directed point.

Subrounded (a) element

Description: Elements are very small, laterally compressed, somewhat triangular-shaped. Cusp is reclined to recurved and tapers rapidly to an pointed apex and is usually extremely short and stubby. Anterior face of cusp is sharply rounded;

lateral faces are usually slightly convex; posterior face is slightly concave or flattened. A rounded to sharp-edged shoulder on each side of posterior face is well developed. Base is extremely short and suboval in cross-section. Basal cavity is elongate antero-posteriorly, and is usually extremely shallow. Anterior faces of some specimens are covered by separated, very tiny nodes.

Orally compressed (e) element

Description: Elements are very small, slightly laterally compressed, somewhat tear-shaped, but flattened on basal side, and elongated antero-posteriorly. Cusp is bulbous, with a posteriorly directed tip or point. Anterior face of cusp is ornamented with very fine nodes. Base and basal cavity are greatly reduced by orally compression, so base is present but very short, and basal cavity is very shallow marked by faint concentric lines. Basal cavity is usually elongate antero-posteriorly. Cross-section of element is subrounded near the tip, and shape of basal outline is more or less flat, having a depression caused by flattened basal cavity.

Remarks: This species is distinctive because of its laterally compressed cusp with posteriorly directed point. The clavohamuliform element bears resemblance to that of C. elongatus Miller, but a new species has laterally compressed cusp with small point, and nodes are much less pronounced, as well as it is found the Fauna B. The specimen illustrated by Miller as paratype (Pl. 64, figs. 17,18) of C. elongatus is included in this new species. The subrounded element is characterized by having a triangular-shaped stunted cusp, and a shallow and elongate basal cavity; the orally compressed element has a bulbous cusp, and a shallow and elongate basal cavity. Hence, the subrounded element bears a superficial similarity to the orally compressed clavohamuliform element in terms of the shape of base, basal cavity and the curvature of cusp.

In this apparatus, the subrounded elements are much less common than the orally compressed elements in most of my samples.

Occurrence: This apparatus species is present in the lower part of the Watts Bight Formation in sample Z1-32 of Section 1; in samples from Z2-3 to Z2-3C of Section 2; in sample Z5-3 of Section 5.

Number of specimens: Total, 41; a subrounded acontiodiform element, 7; e compressed clavohamuliform element, 34.

Types: GSC 95754-95757.

Clavohamulus reniformis n. sp.

Plate 4, figs. 11-20

Subrounded element

Clavohamulus? sp. Repetski, 1980, Pl. 2, fig. 4 .

Compressed element

Clavohamulus densus Furnish. Repetski, 1980, Pl. 1, figs. 1 2, 16.

Derivation of name: From the Latin "reniformis", referring to kidney bean shape of the clavohamuliform element of this species.

Diagnosis: A species of *Clavohamulus* in which both *a* acontiodiform element and *e* clavohamuliform element morphotypes are strongly orally compressed, and slightly anteroposteriorly compressed. Acontiodiform element is usually symmetrical, somewhat pyramidal-shaped, but with concave posterior face; clavohamuliform element is kidney-bean shaped, and its cusp has no pointed tip.

Subrounded (*a*) element

Description: Elements are symmetrical, small, somewhat three dimension triangular-shaped in profile. Cusp is usually reclined to strongly recurved, and tapers rapidly to an blunt apex, and may be extremely short and stubby in some specimens. Anterior face of cusp is gently rounded, with faint concentric growth lines or laminae in some well preserved specimens; posterior face is moderately to strongly concave except for a medial convexity which extends toward blunt tip of cusp. An extremely sharp-edged shoulder on each side of posterior face is well developed. Basal cavity is shallow, triangular-shaped depression marked by faint concentric growth lines, and with cavity tip is located anteriorly in basal margin. Basal margin is strongly flared posteriorly. Element is usually covered by discrete tiny nodes.

Orally compressed (e) element

Description: Elements are small, strongly orally compressed and slightly compressed antero-posteriorly, kidney-bean shaped in profile. Cusp is major part of the element, and with a shape like a tiny broad bean, without a directed tip as other species of the genus. Anterior and posterior sides are slightly and broadly rounded. Base and basal cavity are greatly reduced not only by orally compression, but also by antero-posterior compression, and are nearly absent. In most specimens, basal cavity is very small depression with a few faint concentric growth laminae or lines. Except for basal area, surface is ornamented with small nodes on faint concentric ridges.

Remarks: This new species may be a youngest form of Clavohamulus in which the clavohamuliform element and acontiodiform element are specialized in their general features. The acontiodiform element which is characterized by short, pyramidal in profile is distinguished from that of other species of the genus; the clavohamuliform element, with its kidney bean shape, is distinct from other morphotypes of the genus. This species may have evolved from C. hintzei Miller by the loss of the basal cavity and the trend toward sphericity of the clavohamuliform element, and toward a stubby cusp in the acontiodiform element.

Several specimens assigned to the acontiodiform element may represent the transitional element of this species, because they are asymmetrical forms in which one side of cusp is larger than the other.

In this apparatus, the subrounded elements are less common than the orally compressed elements.

Occurrence: This species has been found in the upper lower part of Boat Harbour Formation in samples from Z2-29 to Z2-33 of Section 2; in samples from Z4-29 to Z4-34 of Section 4.

Number of specimens: Total, 395; a subrounded acontiodiform element, 113; e compressed clavohamuliform element, 282.

Types: GSC 95763-95771.

Clavohamulus sphearicus n. sp.

Plate 4, figs. 6-10

Derivation of name: From the Latin "sphearicus", meaning rounded or ball-shaped, referring the clavohamuliform element of this species.

Diagnosis: A species of Clavohamulus in which a acontiodiform elements has elongate triangular profile, with a slowly tapering and strongly recurved cusp, and with e clavohamuliform element that is a spherical form bearing a ball cusp with a small triangular point.

Subrounded (a) element

Description: Elements are small, somewhat triangular in profile, and usually laterally compressed. Cusp is moderately recurved and tapers slowly to a pointed apex. Anterior face of cusp is sharply rounded; two lateral faces are rather flattened; anterior and lateral faces bear widely separated tiny nodes; posterior face is strongly concave with a faint medial convexity. A strongly sharp-edged shoulder or sharp-edged costa is present on each side of the posterior face. Basal cavity is an extremely shallow depression marked by a few faint concentric growth lamellae or lines.

Orally compressed (*e*) element

Description: Elements are quite small, and spherical in profile. Cusp is ball-shaped or bulbous, with a posteriorly directed point which is short and triangular. Anterior and lateral faces are rounded, and are ornamented with very fine nodes on faint linear concentric ridges. Base and basal cavity are greatly reduced by orally compression, so base is very short, and basal cavity is extremely shallow. Basal cavity is rather elongated anteroposteriorly with a series of faint concentric growth lamellae or lines.

Remarks: This new species has similar in its contained morphotypes to that of *Clavohamulus neoelongatus* n. sp. and *C. densus* Furnish. However, the acontiodiform element of this species can be distinguished from *C. neoelongatus* n. sp. and *C. densus* by the laterally compressed and slowly tapering cusp; the clavohamuliform element is readily distinguished by spherical or balled-shaped cusp, with a small, triangular point. Miller (1969) concluded that the specimens with a small, posteriorly directed point of *C. neoelongatus* n. sp.(=Miller's *C. elongatus*) are transitional with *C. densus*. However, *C. densus* has a bulbous cusp that is expanded laterally; in contrast, *C. neoelongatus* n. sp. has a bulbous cusp elongated anteroposteriorly, with a very small tip. The new species has a basal cavity which is almost the same as that of *C. neoelongatus* n. sp., and a spherical cusp with a long posteriorly directed tip which is similar to that of _C. densus_. Therefore, _C. sphaericus_ is considered to be a transitional form from _C. neoelongatus_ n. sp. into _C. densus_.

In this apparatus, the subrounded elements are generally common as the orally compressed elements, but in some samples the subrounded elements may be fewer than the orally compressed elements.

Occurrence: This species is present in the middle part of Watts Bight Formation in samples from Z2-4 to Z2-9C of Section 2; in sample Z4-15 of Section 4; in samples from Z5-6 to Z5-11 of Section 5; in sample Z6-6B of Section 6; in sample Z9-9 of Section 9.

Number of specimens: Total 53; _a_ subrounded acontiodiform element, 30; _e_ compressed clavohamuliform element, 23.

Types: 95758-95762.

Clavohamulus sp. A

Plate 3, fig. 21

Description: This element is orally compressed clavohamuliform, triangular bulb when viewed anteriorly. Cusp is rather bulbous with a short and strong posteriorly directed point. Anterior face is triangular, gently rounded, and ornamented with faint concentric ridges covered by separated tiny nodes. Both lateral sides near the base are extended to the projections. Base is near absent. Basal cavity is an extremely shallow depression marked by faint concentric ridges.

Remarks: This element is similar to *C. densus*, but differs by having a triangular bulb, not a rounded bulbous cusp as in the latter species. Only a few specimens are present, but no the subrounded element specimens are found.

Occurrence: This element is present in the uppermost Watts Bight Formation in sample Z4-20 of Section 4.

Number of specimens: Total, 4; *e* compressed clavohamuliform element.

Types: GSC 95753.

Clavohamulus sp. B

Plate 3, figs. 22-23

Remarks: Two specimens which are recovered and illustrated belong to *Clavohamulus* sp. B. The element is similar to the compressed element of *Clavohamulus reniformis* n. sp., but strongly compressed and much more elongate kidney-bean shaped.

This element may be closely related to *Clavohamulus reniformis* n. sp.

Occurrence: The element is present in the uppermost part of Watts Bight Formation in sample Z4-20 of Section 4.

Number of specimens: Total 2; *e* clavohamuliform element, 2.

Types: GSC 99752-99753.

Genus *Cordylodus* Pander, 1856

Type species: *Cordylodus* *angulatus* Pander, 1856

Emended diagnosis: A multielement genus consisting of three element morphotypes: *a* subrounded elements, *c* suberect symmetrical elements and *e* compressed elements. Subrounded elements are usually symmetrical to asymmetrical with subrounded cusp and denticles; suberect elements are standard symmetrical forms with subrounded cusp, and strongly arched and extended posterior process; compressed elements are asymmetrical with laterally compressed cusp and denticles. Both subrounded and compressed elements have transitional variants.

Remarks: *Cordylodus* Pander has been described by many conodont workers in the last several decades, because it is an important and ubiquitous component of uppermost Cambrian and lower Ordovician conodont faunas. However, the apparatus pattern of *Cordylodus* has not been fully understood until recent years. Miller (1980) recognized that *Cordylodus* consists of two elements: rounded and compressed elements. Bagnoli & al. (1987) considered that the apparatus of *Cordylodus* consists of two morphotypes (a variable transition series of *p* elements and a *q* element) in a Type

IIIB apparatus of Barnes & al. (1979). Andres (1988) illustrated three-elemental morphotypes of *Cordylodus proavus* and *C. lindstromi*. Barnes (1988) redefined the apparatus of *Cordylodus* to consist of four morphotypes namely *p*1, *p*2, *p*3 and *q* (*r*) elements. Based on this study, the apparatus of *Cordylodus* contains three elemental morphotypes as exactly illustrated by Andres (1988): *a* subrounded elements with two variants (*p*1 and *p*2 of Barnes 1988), *c* suberect elements (*q* (*r*) element of Barnes, 1988), and *e* compressed elements with two variants (*p*3 element of Barnes, 1988): one slightly compressed and another strongly compressed.

Cordylodus angulatus Pander

Plate 5, figs. 1-9

Subrounded angulatiform element

Cordylodus angulatus Pander. Müller, 1973, p. 27-29, Pl. 11, figs. 1-6, (not fig. 7=suberect element); Chen & al., 1986, Pl. 34, figs. ?-4; Bagnoli, Barnes and Stevens, 1987, *p* element, p. 150-152, Pl. 1, fig. 20 (contains complete synonymy through 1987); Barnes, 1988, Fig. 13 (m only).

Compressed rotundatiform element

Cordylodus rotundatus Pander. Chen & al., 1986, Pl. 37, figs. 3, 8, 18.

Cordylodus angulatus Pander. Bagnoli, Barnes and Stevens, 1987, q element, Pl. 1, figs. 19, 21 (contains complete synonymy through 1987).

Suberect element

?Cordylodus angulatus Pander. Müller, p. 27-29, Pl. 11, fig. 7 only.

Emended diagnosis: A species of Cordylodus containing three elemental morphotypes: a subrounded angulatiform elements, c suberect elements and e compressed rotundatiform elements. Angulatiform elements are characterized by having a subrounded cusp and less rounded antero-basal margin; rotundatiform elements are laterally compressed with well rounded antero-basal margin and laterally compressed denticles; suberect elements are symmetrical forms with a subrounded cusp, and extremely arched and extended posterior process.

Remarks: This study is basically in agreement with the synonymy and remarks of Cordylodus angulatus by Bagnoli & al. (1987) for the subrounded (p) elements and compressed (q) elements. Because it is less abundant than other two elements, the suberect element of C. angulatus has not been well described and illustrated by many authors.

Occurrence: This species is present in the upper part of the Watts Bight Formation and the lower part of Boat Harbour Formation in samples from Z2-3B to Z2-31 of Section 2; in samples from Z4-15B to Z4-32 of Section 4; in samples from Z5-6 to Z5-8 of Section 5; in sample Z6-8 of Section 6; in samples from Z7-13B to Z7-16 of Section 7; in samples from Z9-4 to Z9-2 of Section 9.

Number of specimens: Total, 224; a subrounded angulatiform element, 149; c suberect element, 20; e compressed rotundatiform element, 55.

Types: GSC 95772-95780.

Cordylodus intermedius Furnish

Plate 5, figs. 10-18

Subrounded element

Cordylodus intermedius Furnish, 1938, p. 338, Pl. 42, fig. 31, text-fig. 2c; Chen & al., 1986, Pl. 37, figs. 4, 9 only; Bagnoli, Barnes and Stevens, 1987, p elements (contains complete synonymy through 1987); ?Viira, 1987, p. 148-149, Pl. 3, figs. 9, 10, 13, text-figs. 3, ?23, 26; Barnes, 1988, Figure 13g-h.

Cordylodus lenzi Müller, 1973, p. 31. text-fig. 5, Pl. 10, figs. 5-6, and 8-9 (not fig. 7=suberect element).

Compressed element

Cordylodus prion Druce and Jones, 1971, p. 70, text-figs. 23i, k-o, Pl. 2, figs. 1-7.

Cordylodus prion Müller, 1973, p. 33, text-figs. 2E, 8, Pl. 10, fig. 4; Van Wamel, 1974, p. 59, Pl. 1, figs. 8-9.

Cordylodus intermedius Furnish. Miller, 1980, text-fig. 4M, Pl. 1, fig. 17; ?Chen & al., 1986, Pl. 37, figs. 5, 7 only.

?(In part) Cordylodus caboti Bagnoli, Barnes and Stevens, 1987, p. 152, Pl. 1, fig. 10 only.

Crytoniodus prion Ethington and Clark, 1971, Pl. 1, fig. 21; Miller, 1971, p. 79, Pl. 1, figs. 14-16 (not fig. 17).

Suberect elerent

Cordylodus lenzi Müller, 1973, p. 31, text-fig. 2F, Pl. 10, fig. 7.

Emended diagnosis: A species of Cordylodus consisting of three elemental morphotypes: a subrounded intermediform elements, c suberect symmetrical elements and e compressed prioniform elements. The intermediform elements have a subrounded erect to recurved cusp and a distinctive basal cavity with concave anterior edge; prioniform elements are characterized by laterally compressed cusp and denticles; suberect elements are standard symmetrical forms with a large basal cavity, and strongly arched and extended posterior process.

Remarks: As noted by many earlier authors, *Cordylodus intermedius* is the evolutionary intermediate between *C. proavus* and *C. angulatus* or *C. caboti* and *C. angulatus* (Barnes, 1988). The subrounded elements of the species are easily distinguishable from those of both *C. proavus* and *C. angulatus*. The compressed elements as noted by Miller (1980) are variable, with laterally compressed cusp and denticles which have sharp edges and fused bases. The suberect elements which are characterized by having a large basal cavity and strongly arched and extended posterior process are much less abundant than both subrounded and compressed elements, so very few specimens have been described. It is considered that Müller's (1973) *C. lenzi* (in part as synonymy), which is symmetrical with a large basal cavity and strongly arched posterior process, should be assigned to the suberect element of *C. intermedius*.

Occurrence: The apparatus species ranges almost through the Watts Bight Formation in samples from Z2-3B to Z2-11 of Section 2; in samples from Z4-14B to Z4-18 of Section 4; in samples from Z5-1 to Z5-12 of Section 5; in samples from Z6-1 to Z6-11 of Section 6; in samples from Z7-6 to Z7-14 of Section 7; in samples from Z9-4 to Z9-5 of Section 9.

Number of specimens: Total, 167; a subrounded intermediform element, 124; c suberect symmetrical element, 6; e compressed prioniform element, 37.

Types: GSC 95781-95787.

Cordylodus lindstromi Druce and Jones

Plate 5, figs. 19-22

Subrounded element

Cordylodus lindstromi Druce and Jones, 1971, p. 68-69, Pl. 1, figs. 7a-8b (not figs. 9a-b = compressed elements of C. lindstromi); Pl. 2, figs. 8a-c; Jones, 1971, p. 47, Pl. 2, figs. 4a-c; Müller, 1973, p. 32, Pl. 9, fig. 10 only (fig. 11 =?suberect element), text-figs. 2D, 6a-b; Chen & al., 1986, p. 129-130, Pl. 34, figs. 1, 6-8; ?Viira, 1987, Pl. 2, fig. 7; Pl. 2, fig. 7; Pl. 3, figs. 4, 7, 8; Barnes, 1988, p element, p. 408-409, Figure 13, i, k, l; Andres, 1988, p. 134-136, Abb. 36 (middle fig.).

Cordylodus angulatus Pander. Lindström, 1955, in part, p. 551-552, text-fig. 3E (not fig. 3G), ?not Pl. 5, fig. 9.

Cordylodus lindstromi Druce and Jones s.f. Repetski, 1982,

p. 17-18, Pl. 5, figs. 4-5.

Compressed element

Cordylodus lindstromi Druce and Jones, 1971, p. 68-69, Pl. 1, figs. 9a-b, text-fig. . .; Barnes, 1988, q element, p. 408-409, Figure 13 j; Andres, 1988, p. 134-136, Abb 36 (lower fig.).

?*Cordylodus oklahomensis* Müller. Miller, 1969, in part, p. 423-424, Pl. 65, figs. 52-53 only (not figs. 46-51).

?*Crytoniodus prion* Miller (part), 1971, p. 79, Pl. 1, fig. 17(not figs. 14-16).

?*Cordylodus intermedius* Furnish. Chen & al., 1986, Pl. 37, figs. 2, 13.

Suberect element

Cordylodus lindstromi Druce and Jones. Andres, 1988, p. 134-136, Abb. 36 (upper fig.).

?*Cordylodus lindstromi* Druce and Jones. Müller, 1973, p. 32, Pl. 9, fig. 11.

?*Cordylodus lindstromi* Druce and Jones. Chen & al., 1986, Pl. 34, fig. 5 only.

Remarks: A species of *Cordylodus* consisting of three element morphotypes: *a* subrounded elements, *c* suberect symmetrical elements and *e* compressed elements. All three elements are usually characterized by the secondary apex of the basal cavity which distinguishes those of other species. Subrounded elements with two variants and suberect elements may comprise the first transition series; compressed elements with two variants comprise the second transition series.

This worldwide index species has been described in many papers since it was first recognized by Druce and Jones (1971). However, the apparatus of C. lindstromi has not been fully understood. Druce and Jones (1971) illustrated the subrounded and compressed elements, but gave no detail descriptions. Miller (1980) emended the definition and recognized two major elements of the species. Andres (1988) gave an excellent illustration with three elements of the species. Based on this study, three element morphotypes can be recognized in the apparatus of C. lindstromi, and both subrounded and compressed elements show transitional variations in curvature of the cusp, the shape of basal cavity, and the type of symmetry. As with other Cordylodus species, the subrounded elements are much more common than the compressed elements, the suberect elements are relatively rare within the apparatus.

Occurrence: The species ranges through the lower part to the upper middle part of Watts Bight Formation in samples from Z1-22 to Z1-31 of Section 1; in samples from Z2-2 to Z2-3 of Section 2; in sample Z5-4 of Section 5; in samples from Z7-2B to Z7-5B of Section 7.

Number of specimens: Total, 64; a subrounded, 41; c suberect symmetrical element, 1; e compressed element, 22.

Types: GSC 95788-95791.

Genus *Cristodus* Repetski, 1982

Type species: *Cristodus loxoides* Repetski, 1982.

Remarks: Repetski (1982) established this genus as a multielement genus having two hyaline element types: one having a single denticle, and another having several denticles above a long posteriorly tapering base. It is considered that the single denticle element probably represents the e compressed element and the multidenticle element is the a subrounded element.

As Repetski (1982) noted that subrounded multidenticulate elements of *Cristodus* resemble those of *Loxodus*, but they differ by having fewer denticles and shallow basal cavities.

Cristodus ethingtoni n. sp.

Plate 6, figs. 1-4

Subrounded element

?*Rhipidognathus* sp. Ethington and Clark, 1964, p. 695-698.

New Genus 2, Ethington and Clark, 1981, p. 117-118, Pl. 13, figs. 18-19..

Jumudontus sp. Stouge and Bagnoli, 1988, p. 120, Pl. 3, fig. 17.

Compressed element

New Genus 2, Ethington and Clark, 1981, p. 117-118, Pl. 13, figs. 20, 24.

Derivation of name: After R. L. Ethington, who together with D. Clark (1964) first recovered the species.

Diagnosis: A species of *Cristodus* containing two element morphotypes: *a* subrounded multidenticulate elements and *e* compressed monodenticulate elements. Subrounded elements are characterized by having an erect to reclined, poorly differentiated cusp with one flat face and one strongly carinate face and serrated oral margin, compressed elements are triangular without any major carinae or costae. Both elements are hyaline.

Subrounded (*a*) element

Description: Elements are multidenticulate conodonts with two variants: one having a restricted base, and another with an unrestricted base. Both variants are characterized by having a reclined, poorly differentiated cusp with one flat face and one strongly carinate face. Lateral sides of the elements are compressed, and display faint striae that begin at the basal margin and continue to the distal edge. The restricted-base forms have rather a smaller and shallower basal cavity than that of unrestricted-base forms.

Compressed (e) element

Description: Elements are monodenticulaform with laterally compressed cusp. Cusp is suberect, triangular in laterally view. Anterior side is rounded; lateral sides are compressed without any carinae or costae; posterior side is keeled, and sharp-edged. Base is extended posteriorly with slightly swollen basal margin. Basal cavity is moderately deep, but narrow.

Remarks: Ethington and Clark (1964, 1981) gave a detailed description of this species, first assigning it tentatively to *Rhipidognathus* sp. and then (1981) suggesting that it represents a new genus, recognizing the transitional variation of the subrounded elements. Based on the collections from the St. George Group, this species has two major elemental morphotypes which are similar to those of *Cristodus loxoides* Repetski in terms of superficial features and apparatus plan.

Occurrence: This species is present in the upper Boat Harbour Formation in samples from Z2-69 to Z2-77 of Section 2; in sample Z6-30 of Section 6.

Number of specimens: Total, 32; _a_ subrounded multidenticulatiform element, 18; _e_ compressed monodenticulatiform element, 14.

Types: GSC 95792-95795.

Cristodus _loxoides_ Repetski

Plate 6, figs. 5-10

Loxodiform element

Loxodus sp. aff. _L_. _bransoni_ Furnish. Barnes and Tuke, 1970, p. 87, Pl. 20, figs. 1, 4, 15-17.

Cristodus _loxoides_ Repetski, 1982, p. 18-19, Pl. 5, figs. 6, 7.

Loxodus? sp. aff. _Loxodus_ _bransoni_ Furnish. Stouge and Boyce, 1983, Pl. 3, figs. 1, 2.

Remarks: Barnes and Tuke (1970) recovered the subrounded element of this species from the St. George Group, assigning it to _Loxodus_. Repetski (1982) gave a detailed description of this species based on the conodonts from the El Paso Group, and named it as new species of the new genus Cristodus.

The apparatus consists of the subrounded loxodiform (multidenticulate) elements and compressed oistodiform-like elements-. On the basis of the collections of the St, George Group, transitional variations are significant in both the subrounded element and compressed element.

Occurrence: The species is found in the middle and upper parts of the Boat Harbour Formation and the Catoche Formation in samples from Z2-68 to Z2-100 of Section 2; in samples from Z6-30 to Z6-34B of Section 6; in sample Z10-B of Section 10.

Number of specimens: Total, 52; a subrounded loxodiform element, 19; e compressed oistodiform-like element, 33.

Types: GSC 95796-95801.

Genus Drepanodus Pander, 1856

Type species: Drepanodus arcuatus Pander, 1856

Emended diagnosis: A multielement apparatus containing three element morphotypes: a subrounded drepanodiform elements characterized by having the long, slender, recurved cusp; c suberect symmetrical suberectiform elements having the antero-posteriorly expanded base and erect slender cusp; and e compressed oistodiform elements with the long, reclined cusp, and posteriorly flared and extended base. Subrounded elements associated with suberect symmetrical elements, and compressed elements comprise the first and second transition series respectively.

Remarks: Lindström (1971) emended the definition of Drepanodus Pander as a multielement genus with drepanodiform elements and scandodus-like elements. He also established the new genus Drepanoistodus as another multielement genus which consists of drepanodiform, oistodiform and suberectiform elements. However, it is considered that Drepanoistodus Lindström may be synonymous with Drepanodus, because the elemental components of the apparatus in Drepanodus are almost same as those in Drepanoistodus. Van Wamel (1974, p. 61) noted that four-element types are present in D. arcuatus. Kennedy (1980, p. 55-57) placed four elements in D. concavus as similar elemental components. However, based on this study, their arcuatiform and partial sculponeaform elements comprise the first transitional series; graciliform, partial sculponeaform, and probably partial pipaform elements constitute the second transition series; suberectiform elements should be included as part of the apparatus in Drepanodus Pander.

<u>Drepanodus</u> <u>arcuatus</u> Pander

Plate 6, figs. 11-20

Drepanodiform element

<u>Drepanodus</u> <u>arcuatus</u> Pander, 1856, p. 20, Pl. 1, figs. 2, 4, 5, 17 (non figs. 30, 31); Lindström, 1955a, p. 558, Pl. 30-33, Text-fig. 3J; Van Wamel, 1974, arcuatiform element, p. 61-62, Pl. 1, figs. 10; ?Repetski, 1982, p. 19, Pl. 6, figs. 1a-1b; ?Stouge and Bagnoli, 1988, p. 115-116, Pl. 2, fig. 3.

<u>Drepanodus</u> <u>homocurvatus</u> Lindström. Ethington and Clark, 1964, p. 688-689, Pl. 113, figs. 13, 16.

<u>Drepanodus</u> <u>arcuatus</u> Pander, emend. Lindström, 1971, p. 41, figs. 4, 8.

<u>Drepanodus</u> cf. <u>arcuatus</u> Pander. Lindström, 1955a, p. 560, Pl. 2, figs. 45, 46, Text-fig. 4c.

?<u>Drepanoistodus</u> <u>lucidus</u> Stouge and Bagnoli, 1988, Pl. 3, figs. 2, 3 only.

Oistodiform element

?<u>Drepanodus</u> <u>flexuosus</u> Pander, 1856, p. 20, Pl. 1, figs. 6-8.

<u>Drepanodus</u> <u>sculponea</u> Lindström, 1955a, p. 567, Pl. 4, fig. 40, Text-fig. 3L.

<u>Drepanodus</u> <u>arcuatus</u> Pander. Van Wamel, 1974, sculponeaform

and pipaform elements, p. 61-62, Pl. 1, figs. 11, 12; Stouge and Bagnoli, 1988, p. 115-116, Pl. 2, figs. 1, 2, 4, 6.

Suberectiform element

?*Acodus erectus* Pander, 1856, p. 21, Pl. 1, fig. 1.

Drepanodus suberectus (Branson and Mehl). Lindström, 1955a, p. 568, Pl. 2, figs. 21-22.

Emended diagnosis: A species of *Drepanodus* consisting of three element morphotypes: *a* subrounded drepanodiform elements with recurved slender cusp and slightly expanded base; *c* suberect symmetrical suberectiform elements with extended base and laterally compressed straight cusp; *e* compressed oistodiform-like elements having curved cusp and subrectangular base. All three elements are usually albid, slender, relatively small in size with extremely curved cusp, posteriorly and anteriorly expanded base, and small basal cavity.

Subrounded (*a*) element

Description: Elements are drepanodiform with recurved, slender cusp and slightly expanded base. Cusp is laterally compressed, strongly curved, smooth, moderately biconvex, and filled with white matter. Convexity of outer side of cusp is greater than on inner side. Posterior and anterior edges of cusp are sharp. Base is slightly expanded posteriorly and anteriorly, and compressed in region of antero-basal corner. Basal cavity is shallow. Postero-oral portion of cavity margin is evenly concave; antero-aboral portion of cavity margin is slightly convex. Apex of cavity is small and situated slightly aborally and anterior to center of base.

Suberect symmetrical (c) element

Description: Elements are bilaterally symmetrical suberectiform with extended base and laterally compressed, straight cusp. Cusp has sharp anterior anterior and posterior edges and moderately convex lateral faces; it is filled with white matter. Base is slightly extended anteriorly but compressed in region of anterobasal corner, and flared posteriorly and postero-laterally. Basal cavity is large but shallow with slightly concave postero-oral portion and convex antero-aboral portion and small centrally situated apex.

Compressed (e) element

Description: Elements are oistodiform-like forms with curved cusp and subrectangular, posteriorly extended base. Cusp is laterally compressed, moderately biconvex and filled with white matter. Anterior edge of cusp is sharp keeled; posterior edge of cusp is narrowly rounded. Base is subrectangular in lateral view, and laterally compressed in region of antero-basal corner. Basal cavity is relatively large with concave postero-oral portion and convex anteroaboral portion and small centrally situated apex.

Remarks: Several hundred specimens referrable to this species have been recovered from the St. George Group. The majority of specimens referred to the subrounded and compressed elements concur well with Lindström (1955) and Van Wamel's (1974) description and illustrations. This species characterized by small, albid cusp and shallow, small basal cavity, can be easily distinguished from other species of the genus. Most specimens of the species co-occur with and bear some similarities to those of Drepanodus concavus, but they are two distinct species.

On the basis of the western Newfoundland collection, it is considered that this species contains three element morphotypes: subrounded drepanodiform elements, compressed oistodiform elements and suberect symmetrical suberectiform elements.

Occurrence: The species is present in the middle part of the Boat Harbour Formation through the Catoche Formation in samples from Z2-45 to Z2-137 of Section 2; in samples from Z6-16 to Z6-46 of Section 6; in samples from Z8-5 to Z8-10 of Section 8; in samples from Z10-A to Z10-G and from Z10-1 to Z10-6 of Section 10.

Number of specimens: Total, 2023; *a* subrounded drepanodiform element, 1267; *c* symmetrical suberectiform element, 144; *e* compressed oistodiform element, 612.

Types: GSC 95802-95809.

Drepanodus concavus (Branson and Mehl)

Plate 7, figs. 1-7

Drepanodiform element

Drepanodus concavus (Branson and Mehl). Kennedy , 1980, arcuatiform element and part of sculponeaform element, p. 55-57, Pl. 1, figs. 26-27, 29-30 (contains synonymy through 1980).

?*Drepanoistodus* aff. *D. forceps* (Lindström). Ethington and Clark, 1981, homocurvatiform element, p. 43, Pl. 3, fig. 24.

Drepanodus concavus (Branson and Mehl) s.f. Repetski, 1982, p. 20, Pl. 6, figs. 11a-11c.

?*Drepanoistodus suberectus* subsp. A, n. subsp. (Branson and Mehl). Repetski, 1982, homocurvatiform element, p. 25, Pl. 8, figs. 5a-5b.

Oistodiform element

Drepanodus concavus (Branson and Mehl). Kennedy, 1980, graciliform element and part of sculponeaform element, p. 55-57, Pl. 1, figs. 28, 32-34 (contains synonymy through 1980).

?Drepanodus sculponea Lindström s.f. Repetski, 1982, p. 22, Pl. 7, figs. 9a-9c.

Suberectiform element

?Drepanoistodus aff. D. forceps (Lindström). Ethington and Clark, 1981, suberectiform element, p. 43, Pl. 3, fig. 22.

?Drepanoistodus suberectus subsp. A, n. subsp. (Branson and Mehl). Repetski, 1982, suberectiform element, p. 25, Pl. 7, fig. 13a-13b (contains partial synonymy through 1982).

Emended diagnosis: A species of Drepanodus that contains three element morphotypes: a subrounded drepanodiform elements with large recurved cusp and posteriorly extended base; c suberect symmetrical suberectiform elements with large basal region and straight cusp; e compressed oistodiform elements having long reclined cusp and large subrectangular base. Drepanodiform elements associated with suberect symmetrical elements, and oistodiform elements comprise the first and second transition series respectively. Elements are hyaline, usually robust with large base and relatively shallow basal cavity.

Subrounded (*a*) element

Description: Elements are robust, arcuate drepanodiform with large recurved cusp and posteriorly extended base. Elements have a transitional series showing considerable variation in the shape of the basal margin and basal cavity. A detailed description of the elements (arcuatiform and sculponeaform elements) was given by Kennedy (1980).

Suberect symmetrical (*c*) element

Description: Elements are symmetrical, large, and robust suberectiform with a relatively large basal region and laterally compressed straight cusp. Cusp is biconvex with sharp anterior and posterior edges. Base is posteriorly expanded. Basal cavity is large but not deep. Element has been well described in many other reports.

Compressed (*e*) element

Description: Elements are graciliform and pipaform with a long, evenly tapered, reclined cusp and a large subrectangular, posteriorly extended base. A transitional series with variation in the shape of the basal margin and in the degree of curvature of the cusp is present in the elements. Kennedy (1980) gave a detailed description under the graciliform and pipaform elements.

Remarks: Several thousand specimens referable to this species have been recovered from the St. George Group. It clearly shows that D. concavus has an apparatus consisting of subrounded drepanodiform elements, compressed oistodiform elements and suberect symmetrical suderectiform elements. Kennedy (1980) noted that four element types are present in D. concavus. However, his arcuatiform elements and sculponeaform elements comprise a first transitional series corresponding to the subrounded drepanodiform elements; his graciliform elements and pipaform elements constitute a second transitional series referable to the compressed oistodiform elements; no suberectiform elements were described and illustrated in his report.

The element morphotypes in D. concavus are very similar to the corresponding elements of species of D. arcuatus. However, the two species can be easily distinguished: the elements of D. concavus are hyaline, very large conodonts whereas those of D. arcuatus are usually albid, relatively smaller cones.

Occurrence: This species is found in the middle part of the Boat Harbour Formation through the Catoche Formation and Aguathuna Formation in samples from Z2-45 to Z2-140 of Section 2; in samples from Z3-11 to Z3-21 of Section 3; in samples from Z6-16 to Z6-46 of Section 6; in samples from Z8-6 to Z8-10 of Section 8; in samples from Z10-A to Z10-F and from Z10-3 to Z10-11 of Section 10.

Number of specimens: Total 2705; a subrounded drepanodiform element, 1568; c symmetrical suberectiform element, 208; e compressed oistodiform element, 929.

Types: GSC 95810-95816

Drepanodus nowlani n. sp.

Plate 7, figs. 8-20; Text-fig. 6:3A

Drepanodiform element

Drepanodus n. sp. 3 s.f. Repetski, 1982, p. 24, Pl. 7, figs. 11, 12.

Oistodiform element

Scandodus aff. *S. furnishi* Lindström s.f. Repetski, 1982, p. 42, Pl. 20, figs. 6-7.

Derivation of name: Nowlani in honor of Dr. G. S. Nowlan of the Geological Survey of Canada whose many suggestions have been invaluable in this study.

Diagnosis: A species of *Drepanodus* consisting of three element morphotypes which include: a subrounded drepanodiform elements with slender cusp, high base and deep basal cavity; c suberect symmetrical suberectiform elements having straight cusp, extremely expanded base and large basal cavity; e compressed oistodiform elements with bladelike reclined cusp and posteriorly expanded large base. Elements are laterally compressed, partially albid, simple cones with a high (or large in oistodiform element) base and a deep basal cavity.

Subrounded (a) element

Description: Elements are drepanodiform with long cusp, high base and very deep basal cavity. Cusp is usually reclined to slightly recurved and twisted, partially albid and laterally compressed. Anterior side of cusp is thinly keeled; posterior side of cusp is usually narrowly rounded near the base and sharp keeled near the tip. Inner lateral face of cusp is rather flat except for a slightly convex basal margin and distal part of cusp. Outer lateral face of cusp is broadly rounded. Basal margin is straight in profile. Base is quite high, laterally compressed. Basal cavity is very deep and appears as a right-angled triangle in lateral view. Apex of cavity is situated near the antero-lateral side of cusp. Growth axis is straight and erect above the cavity tip.

Suberect symmetrical (c) element

Description: Elements are suberectiform with a straight cusp, an anteriorly and posteriorly expanded base and a relatively large basal cavity. Cusp is strongly laterally compressed, straight, bilaterally symmetrical, and partially filled with white matter. Anterior and posterior margins of cusp are sharp keeled. Two lateral faces are moderately convex. Base is flared on posterior and two lateral sides. Basal cavity is relatively deep, triangular-shaped in lateral view. Apex of cavity is slightly pointed anterior side and centrally situated.

Compressed (e) element

Description: Elements are oistodiform with reclined cusp and posteriorly expanded base. Cusp is blade-like, slightly twisted above base, laterally compressed and partially filled with white matter. Anterior and posterior edges of cusp are extremely sharp as knife-like costae. Both lateral faces are broadly carinate medially, which are defined by shallow grooves adjacent to the sharp anterior and posterior edges. Angle between the posterior edge of cusp and oral edge of the base is acute, more than 45 degrees. Base is relatively small, posteriorly expanded, and slightly compressed in the region of antero-basal corner. Basal cavity is rather shallow with slightly concave postero-aboral portion and anterio-basally pointed apex.

Remarks: Repetski (1982) described drepanodiform elements of this species as Drepanodus n. sp. 3 s.f. and oistodiform elements as Scandodus aff. S. furnish Lindström s.f. Nowlan

(1976) also recorded the drepanodiform elements and oistodiform elements as a new genus. Unfortunately, neither illustrated the suberectiform elements.

A large number of well preserved specimens of this species have been recovered from the St. George Group. Three major elements of the species not only co-occur in these collections, but also bear similarities in the shape of the base and basal cavity, in sharp keeled anterior and posterior costae, and in the colour of partially albid cusp. Two major elements, subrounded and compressed elements, having two elemental variants form the major parts of the first and second transition series. The suberect symmetrical suberectiform elements with little morphological variation belong within the first transition series.

On the basis of the apparatus plan, this species which contains drepanodiform elements, oistodiform elements and suberectiform elements should be certainly assigned to Drepanodus Pander. However, this species can be distinguished from other species of the genus by the laterally compressed elements with a high base and a deep basal cavity. In some respect, the drepanodiform element species resembles the compressed monocostatiform element of Teridontus obesus n. sp., the paralleliform element of Glyptoconus quadraplicatus (Branson & Mehl) and the drepanodiform elements of the other species, but it differs from all of them by the large base and deep basal cavity, and the partially albid cusp; Repetski noted that the oistodiform element of the species is close to the illustration of Oistodus contractus s.f. of Barnes and Poplawski (1973, Pl. 4, fig. 14), but their figured specimen does not show a sharp antero basal angle.

Occurrence: This species is present in the middle part of the Boat Harbour Formation in samples from Z2-35 to Z2-63 of Section 2; in samples from Z4-36B to Z4-37 of Section 4; in samples from Z6-14 to Z6-25 of Section 6; in samples from Z8-1 to Z8-10 of Section 8.

Number of specimens: Total, 2142; a subrounded drepanodiform element, 1204; c symmetrical suberectiform element, 195; c compressed oistodiform element, 743.

Types: GSC 95817-95827.

Drepanodus pervetus (Nowlan)

Plate 7, figs. 21-27; Text-fig. 6:3B

Subrounded element

Drepanoistodus? pervetus Nowlan, 1985, homocurvatiform, p. 112-113, Figures 5.55; 6.3 (contains complete synonymy through 1985).

Suberect element

Drepanoistodus? pervetus Nowlan, 1985, suberectiform, p. 112-113, Figures 5.54; 6.2.

Compressed element

Drepanoistodus? pervetus Nowlan, 1985, oistodiform, p. 112-113, Figures 5.53; 6.1.

Remarks: Nowlan (1985) gave an excellent description of this species based on conodonts from the Canadian Arctic Islands. He assigned it to Drepanoistodus, but suggested this species may represent a separate genus.

The apparatus consists of *a* subrounded drepanodiform elements, *c* symmetrical suberectiform elements and *e* compressed oistodiform-like elements. All three elements of this species show significant similarity to those of Acanthodus uncinatus, but without the serrations on the cusps. This species is also similar to most species of Drepanodus in terms of morphology and apparatus pattern.

It is considered that this species is probably an ancestor of Acanthodus on the basis of this study.

Occurrence: This species is present in the Watts Bight Formation and the lower Boat Harbour Formation in samples from Z1-27A to Z1-27C of Section 1; in samples from Z2-F to Z2-29 of Section 2; in samples from Z4-15B to Z4-28B of Section 4;

in samples from Z5-4 to Z5-11 of Section 5; in samples from Z6-4 to Z6-10 of Section 6; in samples from Z7-4 to Z7-17 of Section 7; in samples from Z9-4 to Z9-9 of Section 9.

Number of specimens: Total, 213; a subrounded drepanodiform element, 111; c symmetrical suberectiform element, 56; e compressed oistodiform element, 46.

Types: GSC 95828-95834.

Genus Glyptoconus Kennedy, 1980

Type species: Scolopodus quadraplicatus Branson and Mehl.

Emended diagnosis: An apparatus usually bearing hyaline, suberect, symmetrical and asymmetrical simple cones characterized by having coarse costae and deep grooves. Apparatus plan is that most species have four to five major elements morphotypes; there are a subrounded multicostate scolopodiform elements, b transitional tricostate scolopodiform elements, c suberect symmetrical staufferiform elements, e compressed drepanodiform elements and f erect to suberect symmetrical ulrichodiniform element. However, some other species have only two to three morphotypes, a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are usually elongate, and slightly arcuate cusps which are grooved on either the lateral and/or posterior faces; transitional elements are closely similar to subrounded elements, but with fewer costae and grooves; suberect symmetrical staufferiform elements are bilaterally symmetrical, base expanded posteriorly, and usually with strong posterior carina usually having a central groove; suberect symmetrical ulrichodiniform elements are present in some species of the genus, and are characterized by having bilaterally symmetrical cusps, and posteriorly keeled margins.

Remarks: Many early conodont workers have discussed some of the problems of definition for Scolopodus, but only a few have documented the nature of variation, evolutionary relationships, and apparatus structure. Kennedy (1980) noted that the symmetrical and asymmetrical simple cones with coarse carinae and deep grooves on either the lateral and/or posterior faces should be assigned to the new genus Glyptoconus. However, his new genus only included a single species, G. quadraplicatus (Branson and Mehl).

A great variety of forms described from the Lower Ordovician have morphologies that are broadly similar to G. quadraplicatus (Branson and Mehl) and G. floweri (Repetski). In this study only eight multielement species are reassigned to genus Glyptoconus: G. bolites (Repetski), G. emarginatus (Barnes and Tuke), G. floweri (Repetski), G. quadraplicatus (Branson and Mehl), G. triplicatus (Ethington and Clark), G. felicitii n. sp., G. multiplicatus n. sp. and G. priscus n. sp. Other similar species are assigned separately to apparatuses of the new genus Striatodontus (those with very fine striations) and the genus Scolopodus (those with fine costae).

Glyptoconus bolites (Repetski)

Plate 8, figs. 8-13; Text-fig. 6:4A

Subrounded element

Scolopodus bolites Repetski, 1982, pp. 46-47, Pl. 21, fig. 10.

Suberect element

Scolopodus bolites Repetski, 1982, pp. 46-47, Pl. 21, figs. 9, 11.

Emended diagnosis: A multielement apparatus consisting of three element morphotypes: *a* subrounded elements, *c* suberect symmetrical elements and *e* compressed elements. Subrounded elements are asymmetrical forms with posterior carina, very long cusp and small basal cavity; suberect symmetrical elements are slender staufferiform with well developed posterior carina, and keeled lateral sides; compressed elements are extremely compressed postero-laterally with slightly twisted cusp and small basal cavity. Elements have long slender cusp and small base, and are partially albid, and finely striated.

Subrounded (*a*) element

Description: Elements are characterized by a well developed posterior carina and small basal cavity. Cusp is suberect, and gently bent distally, and tapers slowly with pointed apex. Anterior face is broadly and smoothly rounded, lacking costae and grooves; posterior face is flattened except for posterior carina; two lateral sides are keeled as knife-edged lateral costae. Posterior carina is sturdy, slightly twisted, usually without shallow median groove. Base is slightly expanded posteriorly and anteriorly, and very short with a restricted basal opening that is smaller in diameter than the maximum basal expansion and is oval in crosssection. Basal cavity is conical in profile, and the apex of cavity is situated near the anterior side. Elements are covered by very fine striations.

Suberect (c) element

Description: Elements are symmetrical slender staufferiform with well developed posterior carina and small basal cavity. Cusp is usually erect, and gently bent distally, and tapers slowly with pointed apex. Anterior face is flattened or broadly rounded; posterior face is compressed except for the posterior carina; two lateral sides are extremely keeled as knife-edged costae. Posterior carina usually has a prominent shallow median groove that begins just above basal margin and dies out almost at tip of cusp. Base is slightly expanded posteriorly, short with a restricted basal opening. Basal cavity is triangular-shaped in profile; apex of cavity is situated near anterior side. Elements are covered by very fine striations.

C mpressed (e) element

Description: Elements are postero-laterally compressed with twisted cusp. Cusp is usually erect or gently bent distally. Anterior face is smoothly rounded; posterior face is flattened, but with a weak carina which has a faint prominent median groove; two lateral sides are keeled as knife-edged lateral costae which begin just above the basal margin and continue almost to tip of cusp. Base is slightly expanded posteriorly, short with an unrestricted basal opening, and is oval in profile. Basal cavity is shallow, and its apex is situated near anterior side. Elements are finely striated.

Remarks: The suberect symmetrical element of the species is very similar to that of Glyptoconus floweri (Repetski), but differs in having a small base and restricted basal opening. The compressed element is close to that of G. floweri, but it has a weak posterior carina. On the basis of this study, it is considered that G. bolites (Repetski) may be ancestral to the costate species G. floweri (Repetski).

Repetski (1982) named this species as a form with long, gently curved, proclined cusp, and constricted basal margin. He recognized two elements: one symmetrical and another asymmetrical. His asymmetrical elements are assigned to the subrounded elements (a), and his symmetrical elements to the suberect symmetrical elements (c).

Occurrence: This species is only present in the middle part of the Boat Harbour Formation in samples from Z2-35 to Z2-35A of Section 2.

Number of specimens: Total, 103; a subrounded element, 50; c suberect symmetrical element, 18; e compressed element, 35.

Types: GSC 95841-95846.

Glyptoconus emarginatus (Barnes and Tuke)

Plate 9, figs. 1-13; Text-fig. 6:5A

Subrounded and transitional emarginatiform elements

Paltodus n. sp. Mehl and Ryan in Branson, 1944, p. 25, Pl. 7, figs. 17-18.

Scolopodus emarginatus Barnes and Tuke, 1970, p. 91-92, Pl. 18, figs 2, 6-8, text-fig. 6C; Repetski, 1982, p. 47, Pl. 22, fig. 3.

"Scolopodus" emarginatus Barnes and Tuke. Ethington and Clark, 1981, p. 99-100, Pl. 11, figs. 15-16.

Parapanderodus emarginatus (Barnes and Tuke). Stouge and Bagnoli, 1988, p. 126-127, Pl. 7, figs. 1,3.

Toomeyiform element

Drepanodus toomeyi Ethington and Clark, 1964, p. 690, Pl. 113, figs. 15, 17 and Pl. 114, fig. 22, text-fig. 2H; Barnes and Tuke, 1970, p. 86, Pl. 19, figs. 9-11, text fig. 6I; Ethington and Clark, 1981, p. 39, Pl. 3, fig. 11; Repetski, 1982, p. 22, Pl. 7, fig. 4.

Drepanodus subarcuatus Furnish. Ethington and Clark, 1964, p. 689, Pl. 113, fig. 15 only.

?Scandodus sp. Ethington and Clark, 1964, p. 698, Pl. 114, fig. 20.

?Drepanodus toomeyi Ethington and Clark. NIEPER, 1969, Pl. O VII, fig. 3; Barnes and Poplawski, 1973, p. 773, Pl. 2, fig. 10.

non Drepanodus cf. D. toomeyi Ethington and Clark. Cooper and Druce, 1975, Pl. 1, figs. 17-18.

Eucharodus toomeyi (Ethington and Clark). Stouge and Bagnoli, 1988, p. 118, Pl. 3, figs. 15-16.

Staufferiform element

Ulrichodina n. sp. Mehl and Ryan in Branson, 1944, Pl. 6, figs. 22, 24.

Acontiodus staufferi Furnish. Ethington and Clark, 1964, p. 687-688, Pl. 113, figs. 4, 9.

Parapanderodus emarginatus (Barnes and Tuke). Stouge and Bagnoli, 1988, p. 126-127, Pl. 7, fig. 2.

Ulrichodiniform element

Acontiodus abnormalis Branson and Mehl, 1933, p. 57, Pl. 4, figs. 24-25.

Ulrichodina prima Furnish, 1938, p. 335, Pl. 41, figs. 21-22; Barnes and Tuke, 1970, p. 94, Pl. 20, fig. 12; Kennedy, 1980, p. 67, Pl. 2, fig. 28-30.

?*Ulrichodina prima* Furnish. Greggs and Bond, 1970, p. 1469 1470, Pl. 1, fig. 11.

Ulrichodina cristata Harris and Harris, 1965, p. 40-41, Pl. 1, figs. 5a-5d; Ethington and Clark, 1981, p. 112-113, Pl. 12, fig. 22.

Ulrichodina sp. Stouge and Boyce, 1983, Pl. 3, fig. 12.

Emended diagnosis: A species of *Glyptoconus* containing five element morphotypes: *a* subrounded emarginatiform elements, *b* transitional emarginatiform elements, *c* suberect symmetrical staufferiform elements, *e* compressed toomeyiform elements and *f* erect to suberect symmetrical ulrichodiniform element. Elements are hyaline, fairly robust and usually suberect to reclined simple cones with remarkably fine striations, deep basal cavities, and deep entrenched posterior groove except for toomeyiform element and suberect symmetrical (*f*) element.

Subrounded (*a*) element

Description: The majority of subrounded elements are fairly robust, suberect, symmetrical or slightly asymmetrical forms. Cusp is short, and terminates at a rather blunt point and is somewhat thickened in basal region. A deep entrenched posterior groove that increases in width and depth towards basal margin is flanked by sharp posterior margins of the lateral faces. Basal cavity usually lies close to anterior margin. Basal margin is elliptical to oval with a deep notch in posterior end as the margin moves up into groove.

Transitional (b) element

Description: Elements are very similar to the subrounded emarginatiform elements in general features, especially some slightly asymmetrical transitional elements. However, differences between the two forms exist. One lateral face of transitional element is wider, and somewhat flat than other side producing distinctive asymmetrical units. Both lateral sides of element are usually smooth, but in some specimens a faint wide shallow groove runs along narrowest side. Elements are much more laterally compressed, and normally have shorter cusps than those of subrounded elements.

Suberect symmetrical (c) element

Description: The most distinguishing feature of the species is a suberect symmetrical element characterized by a strong posterior carina having a prominent median groove which is broadest and deepest near base and disappears at about two-thirds along length of unit. Anterior face is broadly convex. In posterior view, cusp is posteriorly compressed, and tapers slowly and regularly to a sharp tip. Basal outline is broad anteriorly but narrows posteriorly beneath carina. Base is expanded laterally. Basal cavity is relatively large and deep, subtriangular to subcircular in cross-section.

Compressed (e) element

Description: Elements are drepanodiform, usually postero-laterally compressed, sharp-edged, recurved and slightly twisted. Cusp is short, slightly recurved, and usually tapers rapidly. Majority of elements are bowed, and linear concavity near anterior margin is confined to base on the one side. Basal outline is asymmetrically ovate with greatest width in posterior region. Basal cavity is relatively deep, conical, and opens somewhat to the side as a result of lateral curvature of element.

Suberect symmetrical (f) element

Description: Elements are normally larger than other ulrichodiniform, and develop weak grooves along antero-lateral faces and anterior keel on subrounded or flattened margin. Cusp is bilaterally symmetrical, laterally compressed, anteriorly thickened, and strongly keeled posteriorly. Cross-section of cusp is triangular. Base is very short, and flares moderately on both sides and on postero-lateral corner. Basal cavity is very shallow.

Remarks: The subrounded emarginatiform element is characterized by having a deep entrenched posterior groove, and deep, conical sharp-pointed basal cavity; the transitional element is almost the same as subrounded element, but it is an asymmetrical form in which one side is wider than the other producing a mildly asymmetrical unit; the subrounded and transitional elements are generally distinct from the compressed toomeyiform element characterized by postero-laterally compressed and sharp-edged cusp, although their fine striae and the deeper and sharp pointed basal cavity bear a superficial similarity to the toomeyiform element; the suberect symmetrical staufferiform element is a bilaterally symmetrical, posteriorly compressed form, and its strong posterior carina having a prominent median groove which is broadest and deepest near the base; the suberect symmetrical ulrichodiniform element is similar to that of G. quadraplicatus, but its anterior keel and antero-lateral grooves are extremely well developed.

Within the apparatus, the subrounded emarginatiform element is so closely similar to the transitional emarginatiform element and they have not been distinguished previously. However, the transitional emarginatifrom element is a significant element of Glyptoconus emarginatus.

The compressed element shows less similarity with the subrounded element and transitional element in superficial features, but its curvature of cusp and degree of basal flaring bear similarity to both the subrounded and the transitional elements. As with other apparatuses of this genus, the curvature of the base-cusp junction gradually increases, and the base becomes strongly flared posteriorly from the subrounded element through the transitional element to the compressed element. The suberect symmetrical staufferiform and ulrichodiniform elements are morphologically distinct from the three other major elements. However, they all bear fine striae and have a similar distribution of white matter. The suberect staufferiform, the subrounded and the transitional elements comprise the first transition series; the suberect ulrichodiniform and the compressed drepanodiform elements make up the second transition series.

The specimens described by Ethington and Clark (1981) as "Scolopodus" emarginatus, "Drepanodus" toomeyi and Ulrichodina cristata are strongly compressed and keeled, slightly different from those of the St. George Group. All five elements co-occur in almost all the samples of Barnes and Tuke (1970), Nowlan (1976), Ethington and Clark (1964, 1981) and this collection.

The subrounded and transitional elements are the most common forms within this apparatus, and compressed elements are moderately common. Suberect symmetrical staufferiform and suberect symmetrical ulrichodiniform elements are relatively rare, especially in the earliest stage of the apparatus.

Occurrence: Samples from Z2-68B to Z2-134 in Section 2; samples from Z6-27 to Z -46 in Section 6; samples from Z10-A to Z10-C and from Z10-1 to Z10-3 in Section 10. This multielement apparatus ranges through the upper middle part of Boat Harbour Formation and the lower part of Catoche Formation in the St. George Group.

Number of specimens: Total, 1348; a subrounded emarginatiform element, 561; b transitional emarginatiform element, 347; c suberect symmetrical staufferiform element, 72; e compressed toomeyiform element, 314; f suberect ulrichodini-form element, 54.

Types: GSC 95860-95871.

Glyptoconus felicitii n. sp.

Plate 8, figs. 1-7; Text-fig. 6:4C

Derivation of name: After Felicity H. C. O'Brien, Memorial University of Newfoundland, who provided assistance throughout the early stage of this research.

Diagnosis: A multielement species with three element morphotypes: a subrounded paltodiform-like elements, c suberect symmetrical staufferiform-like elements, and e compressed scandodiform-like elements. Subrounded elements are not robust and have proclined to erect cusp and small base; suberect elements are compressed posteriorly with extremely flared posterior base and shallow basal cavity; compressed elements are postero-laterally compressed with robust cusp and large base and basal cavity. Elements are partially albid, and have a well developed posterior carina.

Subrounded (a) element

Description: Elements are characterized by a well developed posterior rounded carina and small basal cavity. Cusp is proclined to erect, and tapers slowly to pointed apex. Anterior face is sharply rounded; posterior face is slightly compressed with a strong carina which begins at basal margin and dies out almost at tip of cusp; two lateral sides are keeled as knife-edged lateral costae. Base is small, and expanded posteriorly. Basal cavity is conical in profile, and the apex of cavity is centrally situated. Elements have only weak striations.

Suberect (c) element

Description: Elements are posteriorly compressed staufferiform with extremely short base and shallow basal cavity. Cusp is erect, and tapers rapidly to sharp apex. Anterior face is broadly rounded; two lateral sides are keeled as knife-edged costae; posterior face is compressed except posterior carina and strongly flared base. Posterior carina begins above the basal margin, and dies out almost at tip of cusp. Base is extremely short, basal margin is flared posteriorly. Basal cavity is extremely shallow with concentric growth lines, and its apex is situated near the anterior margin.

Remarks: *G. felicitii* n. sp. is similar to *G. bolites* (Repetski) in general features and apparatus plan, but it differs by having a more robust cusp, much sturdier posterior carina, more strongly posteriorly flared basal margin, and by not having well developed fine striations. This species also is partially albid, and different from all other hyaline species of *Glyptoconus*.

G. felicitii n. sp. apparently evolved from *G. bolites* by loss of hyaline condition and fine striations, and by becoming much more sturdy, especially the suberect staufferiform element and the compressed elements.

Occurrence: This species is present in the middle Boat Harbour Formation in samples from Z2-55 to Z2-66 of Section 2.

Number of specimens: Total, 37; *a* subrounded paltodiform-like element, 24; *c* suberect staufferiform-like element, 3; *e* compressed scandodiform-like element, 10.

Types: GSC 95835-95840.

Glyptoconus floweri (Repetski)

Plate 8, figs. 14-26; Text-fig. 6:4B

Scolopodus floweri Repetski, 1982, p. 47-48, Pl. 24, figs. 7, 9, 10; Pl. 25, figs. 1, 4.

Scolopodus quadraplicatus Branson and Mehl. An, 1983, p. 146-147, Pl. 12, figs. 8-9.

Emended diagnosis: A species of Glyptoconus having an apparatus that consists of four element morphotypes: a subrounded multicostate elements, b transitional elements with minor costae, c suberect symmetrical staufferiform-like elements and e compressed scandodiform-like elements. Elements are usually slender, costate, hyaline cones having longer cusps, posteriorly flared small bases and relative small basal cavities.

Subrounded (a) element

Description: Elements are typical slender multicostate forms having four major costae: two antero-lateral and two postero-lateral, and sometimes one posterior minor costa. Cusp is usually reclined to erect, sharply bent in region of cusp-base junction, and then gently recurved distally. Base is small, flared posteriorly, and basal margin is a smooth rim with the costae arising from just above rim. Basal cross-section is usually subrounded, and cusp cross-section is quadrate shaped. Basal cavity is small, and directed anteriorly. Cavity apex is situated near anterior margin.

Transitional (b) element

Description: Transitional elements are similar to subrounded elements, but having only two or three major costae as well as other minor costae. Elements are normally compressed postero-laterally, so their inner posterior costae are not present, or ill-developed. Cusp is strongly reclined to recurved, and base is more posteriorly flared and expanded than subrounded element. Basal margin is same as subrounded element. Basal cross-section is subrounded, and the cusp cross-section is triplicate.

Suberect symmetrical (c) element

Description: Elements are bilaterally symmetrical, robust, costate, very similar to subrounded and transitional elements, but antero-posteriorly compressed with well-developed posterior carina which has a prominent median groove. Posterior carina begins just above basal margin and continues towards cusp tip. Median groove is usually broadest and deepest near base, and disappears near tip of long cusp. Cusp is strongly reclined, and tapers slowly. Base is extremely laterally expanded, and flared posteriorly. Just above basal region, anterior or antero-lateral face is convex, and not robust, sometimes with minor costae or striae; all other intercostal areas are strongly concave. Basal cavity is small in comparison with cusp, and conical with apex pointed to anterior side.

Compressed (e) element

Description: Elements are slender, costate forms as subrounded and transitional elements, but strongly compressed postero-laterally, and with or without minor, inner posterior costae. Outer face and inner face of this element are usually smooth, and flattened, but sometimes with ill-developed minor costae. Cusp is strongly reclined to recurved, and slightly twisted. Base is small, strongly flared posteriorly, and slightly expanded laterally. Basal outline is, therefore, ovoid shaped. As other three elements, basal cavity is small, conical with apex near anterior margin.

Remarks: Repetski (1982) described this species as a symmetry-transition series which includes scandodiform elements possessing only two major costae and multicostate elements having four major costae (two antero-lateral and two postero-lateral and bilaterally symmetrical, and forms intermediate between these end members). Here, it is considered that his multicostate elements are the subrounded elements, the scandodiform elements with two major costae belong to both the transitional and the compressed elements, bilateral symmetrical elements are assigned to the suberect symmetrical elements. An & al.(1983) assigned the subrounded elements to "juvenile" of Scolopodus quadraplicatus Branson and Mehl, because it is distinctly different from that the subrounded element of G. quadraplicatus (Branson and Mehl).

As mentioned above, this species consists of a subrounded element, a transitional element, a suberect symmetrical staufferiform-like element and a compressed scandodiform element, but without a suberect symmetrical ulrichodiniform element. This early species of Glyptoconus appears to lack the suberect symmetrical ulrichodiniform element. In this apparatus, the subrounded elements are characterized by having four major costae, and subcircular cross-section at the base, and are similar to the subrounded elements of G. quadraplicatus, but they differ by having a longer cusp and a posteriorly flared base. The transitional elements, characterized by having two or three major costae, resemble those of G. quadraplicatus in general profile, however, they differ by having longer cusp and posteriorly flared base. The compressed elements are quite similar to the toomeyiform elements of G. emarginatus, but they have a flared base, and strongly reclined laterally keeled cusp. The suberect symmetrical elements are distinctive forms with a slender cusp and a prominent median groove, and differ from all the suberect symmetrical elements of other species in genus Glyptoconus.

G. floweri (Repetski) is one of the best examples of the four elemental morphotypes with two transition series, and all four elements co-occur in both Repetski's (1982), and the St. George Group collections.

Generally speaking, the subrounded elements are the most common forms, and successively, transitional elements and compressed elements are less common. As in other species of the genus, the suberect symmetrical c and f elements are rare.

This species has very short range in the Port au Port Peninsula sections. As noted above, it is emphasized that the subrounded and transitional elements of this species can be confused with quadraplicatiform and triplicatiform elements of G. quadraplicatus (Branson and Mehl), especially those from badly preserved samples.

Occurrence: samples from Z2-37B to Z2-44B in Section 2; samples from Z6-13 to Z6-23 of Section 6; sample Z8-3 in Section 8. All the samples collected from the middle part of the Boat Harbour Formation.

Number of specimens: Total, 670; a subrounded multicostate element, 236; b transitional element, 195; c suberect staufferiform-like element, 54; _e_ compressed scandodiform element, 185.

Types: GSC 95847-95859.

Glyptoconus _multiplicatus_ n. sp.

Plate 9, figs. 14-28; Text-fig. 6:5B

Subrounded element

?_Scolopodus_ _quadraplicatus_ Branson and Mehl. Barnes and Tuke, 1970, p. 93, Pl. 18, figs. 13-14; Repetski and Perry, 1980, Pl. 2, fig. 2.

?_Glyptoconus_ _quadraplicatus_ (Branson and Mehl). Ethington, Engel and Elliott, 1987, pp. 112-113, Pl. 8.1, fig. 3.

Compressed element

Drepanodus _arcuatus_ n. sp. Branson and Mehl, 1933, Pl. 4, figs. 13, 16 (not figs. 7-8).

Drepanodus _simplex_ Branson and Mehl, 1933, p. 58, Pl. 4, fig. 2; Barnes and Tuke, 1970, p. 86, Pl. 19, figs. 8, 12-13.

Drepanodus _parallelus_ Branson and Mehl. Jones, 1971, p. 52-53, Pl. 8, figs. 5a-c.

Eucharodus _parallelus_ (Branson and Mehl). Kennedy, 1980, p. 58-60, Pl. 1, figs. 37-38; Ethington, Engel and

Elliott, 1987, Pl. 2, fig. 4.

Suberect staufferiform element

>>Acontiodus<< staufferi Furnish. Kennedy, 1980, Pl. 2, fig. 38.

Derivation of name: From the Latin "multi-" and "-plicatus"; referring the subrounded elements of this species have more than four major costae.

Diagnosis: A species of Glyptoconus consisting of five element morphotypes: a subrounded multicostatiform elements, b transitional triplicatiform elements, c suberect staufferiform elements, e compressed paralleliform elements and f suberect ulrichodiniform elements. Subrounded elements together with transitional elements and suberect staufferiform elements comprise the first transition series; compressed elements and suberect ulrichodiniform elements consists of the second transition series. Elements are hyaline, more robust than other species of the group, usually twisted, recurved to strongly recurved with relatively small basal cavity. Subrounded, transitional and suberect staufferiform elements are characterized by having secondary costae; compressed and suberect ulrichodiniform elements have an markedly keeled cusp.

Subrounded (a) element

Description: Elements are robust multicostatiform with relatively small base and strongly recurved robust cusp. Four major grooves and four major costae, as well as secondary grooves and costae are well developed. Posterior groove is usually widest and deepest with nearly vertical walls flanked by two sharply keeled postero-lateral costae. Base is small, slightly expanded posteriorly. Basal outline is quadrate, basal margin is usually restricted. Basal cavity is small.

Transitional (b) element

Description: Elements are triplicatiform, characterized by having a weakly developed, slightly twisted, posterior groove. Secondary costae and grooves are well developed on both base and cusp. Cusp is almost same as quadraplicatiform element, but is more strongly recurved at cusp-base junction, with three major costae; triplicate in cross-section. Base is small, and basal margin is slightly restricted. Basal cavity is small.

Suberect (c) element

Description: Elements are staufferiform with expanded base and antero-posteriorly compressed cusp. Anterior face is broadly rounded, and coarsely striated; posterior face is strongly compressed, with a well developed posterior carina characterized by having a prominent median groove; two lateral sides are sharply rounded to slightly keeled. Base is expanded laterally and posteriorly. Basal margin is slightly restricted. Basal cavity is shallow, but moderately large.

Compressed (e) element

Description: Elements are paralleliform with small base and strongly laterally compressed, keeled and slightly twisted cusp. Cusp tapers slowly, and is strongly recurved in region of cusp-base junction, usually most slender element in apparatus. Cross-section of cusp is compressed biconvex; and edges are sharply rounded to moderately keeled. Base is relatively small, slightly expanded posteriorly. Basal margin is nearly straight, but slightly restricted. As with other elements, basal cavity is small, cusp is striated. Two variants are recognized, namely simplexiform variant and arcuatiform variant.

Suberect (f) element

Description: Elements are ulrichodiniform, with small base and slender cusp, and coarsely striated. Cusp is bilaterally symmetrical, strongly laterally compressed, slightly thickened anteriorly, and keeled posteriorly. Cross-section of cusp is triangular. Base is short, flares slightly on both sides and on postero-lateral corners. Basal cavity is extremely shallow, but acuminate at apex. Apex of cavity is centrally situated, and growth axis is essentially straight.

Remarks: Both G. multiplicatus n. sp. and G. priscus n. sp. are distinctive forms, and are separated from G. quadraplicatus. The well developed major costae and grooves, as well as the secondary costae and grooves, small base and basal cavity, strongly keeled cusp are the distinctive features of G. multiplicatus n. sp. In the superficial morphology and apparatus plan, this species is similar to that of G. quadraplicatus. However, the subrounded elements, transitional elements and suberect staufferiform elements differ in their costae arrangement and basal cavity shape; the compressed and suberect ulrichodiniform elements differ in having strongly laterally compressed cusp, small base and well developed striations.

G. multiplicatus n. sp. is considered to be the youngest representative within the genus Glyptoconus, characterized by having well developed major costae and grooves, secondary costae, and relatively small base and basal cavity. G. multiplicatus n. sp., G. quadraplicatus, G. triplicatus, even G. floweri may be difficult to distinguish, especially when specimens are poorly preserved.

Occurrence: This species is present in the upper Boat Harbour Formation, the Catoche Formation and Aguathuna Formation in samples from Z2-71B to Z2-140 of Section 2; in samples from Z3-5 to Z3-22 of Section 3; in samples from Z6-27 to Z6-46 of

Section 6; in samples from Z10-A to Z10-F and from Z10-1 to Z10-5 of Section 10.

Number of specimens: Total, 2868; a subrounded multicostatiform element, 1182; b transitional triplicatiform element, 602; c suberect staufferiform element, 99; e compressed paralleliform element, 928; f suberect ulrichodiniform element, 57.

Types: GSC 95872-95886.

Glyptoconus priscus n. sp.

Plate 10, figs. 1-7; Text-fig. 6:6A

Derivation of name: From the Latin "priscus", meaning this species is a primitive species of Glyptoconus.

Diagnosis: A species of Glyptoconus consisting of three element morphotypes: a subrounded pseudo-quadraplicatiform elements, e compressed pseudo-drepanodiform elements, f suberect symmetrical ulrichodiniform elements. Subrounded elements are robust teridontiform-like cones with large base and weakly costate cusp; compressed elements are more slender, but similar to subrounded elements; suberect ulrichodiniform elements have extremely large base. Subrounded elements, and compressed elements together with suberect symmetrical elements represent the first and second transition series respectively. Elements are partially albid or hyaline, robust simple cones with a relatively large base, large basal cavity and subcircular to quadrate cross-section to cusp.

Subrounded (a) element

Description: Elements are pseudo-quadraplicatiform or teridontiform cones with large base and subcircular to pseudo-quadrate cusp in cross-section. Cusp is reclined to recurved, slightly laterally compressed, and partially albid. Anterior face is smoothly rounded; posterior face is rounded but with faint shallow groove; two lateral faces have extremely shallow grooves near base-cusp junction. Base is slightly expanded anteriorly and laterally, but strongly posteriorly expanded with rounded cross-section. Basal cavity is deep, conical with a centrally situated apex.

Compressed (e) element

Description: Elements are pseudo-drepanodiform cones with large base and subcircular cusp in cross-section. Cusp is recurved, laterally compressed. Anterior side is rather keeled, and posterior face is rounded. Base is large, and basal cavity is fairly deep.

Suberect symmetrical (f) element

Description: Elements are ulrichodiniform with straight cusp and expanded base. Cusp is bilaterally symmetrical, slightly laterally compressed, and partially albid with subrounded cross-section. Anterior face is thickened with shallow groove near base; antero-lateral sides are slightly keeled; two lateral faces are flattened with weak shallow grooves; posterior face is sharply rounded or slightly keeled. Base is flared on posterior side and both lateral sides. Basal cavity is relatively deep with a centrally situated apex.

Remarks: It is considered that this species is intermediate between species of Striatodontus n. gen. (S. prolificus n. sp.) and Glyptoconus quadraplicatus (Branson and Mehl). However, the species can be distinguished from the species of Striatodontus by having lateral grooves, and is easily distinguished from G. quadraplicatus by lacking well developed costae and grooves.

G. priscus n. sp. has a primitive apparatus with only three element morphotypes. The compressed element is similar to the subrounded element in profile, but it differs in having compressed cusp and relatively small base.

Two specimens which are illustrated (Plate 10, figs. 3, 4) seems to be the regrown broken "teeth" of the conodont animal, and apparently belong to a element of G. priscus.

Occurrence: The species is found in the upper lower part of the Boat Harbour Formation in samples from Z2-36 to Z2-50 of Section 2; in samples from Z4-36B to Z4-37 of Section 4; in samples from Z6-14 to Z6-19 of Section 6.

Number of specimens: Total, 220; a subrounded teridontiform-like element, 130; e compressed drepanodiform element, 71; f suberect ulrichodiniform element, 19.

Types: GSC 95887-95893.

Glyptoconus quadraplicatus (Branson and Mehl)

Plate 10, figs. 8-20; Text-fig. 6:6B

Quadraplicatiform element

Scolopodus quadraplicatus Branson and Mehl, 1933, p. 63, Pl. 4, fig. 14; Furnish, 1938, p. 332, Pl. 41, figs. 1-4, 8-12 only (non figs. 5-7 = triplicatiform), text-fig. 1J; Mehl and Ryan, in Branson, 1944, Pl. 6, figs. 31-37; Sando, 1958, Pl. 2, fig. 21; Moskalenko, 1967, p. 114-115, Pl. 25, figs. 3-5; Ethington and Clark, 1971, p. 73, Pl. 2, fig. 5; Greggs and Bond, 1971, pp. 1468-1469, Pl. 2, figs. 3-6b; Moskalenko, 1973, Pl. 15, fig. 13; Repetski and Ethington, 1977, pp. 96-97, 100, Pl. 2, fig. 15.

non Scolopodus quadraplicatus Branson and Mehl. Druce and Jones, 1971, pp. 93-94, Pl. 18, figs. 6a-7c, text-fig. 30f; Jones, 1971; p. 65, Pl. 6, fig. 6.

?Scolopodus cf. S. quadraplicatus Branson and Mehl. Cooper and Druce, 1975, p. 578, fig. 25.

?Scolopodus quadraplicatus Branson and Mehl. Abaimova, 1975, p. 103-104, Pl. 9, figs. 11, 14; text-fig. 8 (16, 21, 23).

Glyptoconus quadraplicatus (Branson and Mehl). Kennedy, 1980, p. 61-63, Pl. 1, figs. 39-41, 45; An, 1987, Pl. 6, fig. 33.

Scolopodus quadraplicatus Branson and Mehl s.f. Repetski, 1982, p. 50, Pl. 23, figs. 4-5.

?"Scolopodus" quadraplicatus Branson and Mehl. Ethington and Clark, 1981, p. 103-104, Pl. 11, figs. 24, 30; Stouge and Boyce, 1983, Pl. 2, figs. 3-5.

Scolopodus nogamii Lee. An & al., 1983, p. 144, Pl. 13, figs. 20, 25.

Triplicatiform element

Scolopodus quadraplicatus Branson and Mehl, 1933, p. 63, Pl. 4, fig. 15.

?Glyptoconus quadraplicatus (Branson and Mehl). Kennedy, 1980, p. 61-63, Pl. 1, figs. 42-44.

Paralleliform element

Drepanodus parallelus Branson and Mehl, 1933, p. 59, Pl. 4, fig. 17; Lee, 1975a, p. 85-86, Pl. 1, fig. 16, text-fig. 3-M; Abaimova, 1975, pp. 63-64, Pl. 6, text-fig. 7-6, 40; Repetski, 1982, p. 21, Pl. 6, figs. 9-10.

Drepanodus subarcuatus Furni.n, 1938, p. 328, Pl. 41, figs. 25, 32; Ethington and Clark, 1964, p. 689, Pl. 113, fig. 20 only (fig. 15=?*G. emarginatus*); ?Druce and Jones, 1971, pp. 74-75, Pl. 20, figs. 1a-4c, text-fig. 24c; Ethington and Clark, 1971, p. 72-74, Pl. 2, fig. 1; Abaimova, 1975, pp. 66-67, Pl. 5, figs. 1-5, 7, 9, text-fig. 7-1.

Eucharodus parallelus (Branson and Mehl). Kennedy, 1980, p. 58-60, Pl. 1, figs. 35-36 (not figs. 37-38).

"*Drepanodus*" *parallelus* Branson and Mehl. Ethington and Clark, 1981, p. 38-39, Pl. 3, fig. 8.

?*Drepanodus parallelus* Branson and Mehl. An & al., 1983, p. 92-93, Pl. 9, figs. 1-2.

Staufferiform element

Scolopodus shakopeensis Furnish, 1938, p. 332, Pl. 41, fig. 13.

Acontiodus staufferi Furnish. Barnes and Tuke, 1970, p. 84, Pl. 19, figs.1-2.

?*Acontiodus staufferi* Furnish. Repetski, 1982, p. 15, Pl. 4, figs. 4-5.

?*Scolopodus staufferi* (Furnish). Druce and Jones, 1971,

p. 94, Pl. 18, figs. 8a-8d.

Acontiodus aff. staufferi Furnish. An, 1987, Pl. 6, fig. 31.

Ulrichodiniform element

?Ulrichodina wisconsinensis Furnish, 1938, p. 335, Pl. 41, figs. 19-20.

?Ulrichodina abnormalis (Branson and Mehl). Mehl and Ryan in Branson, 1944, p. 45, Pl. 6, figs. 4-8; Repetski, 1982, p. 55, Pl. 26, figs. 9a-9c.

Emended diagnosis: A hyaline, species of Glyptoconus having an apparatus that consists of a subrounded quadraplicatiform elements, quadracostate, with well developed deep grooves, b transitional triplicatiform elements, tricostate, with weakly developed posterior groove, c suberect symmetrical stauffe-riform elements with posteriorly expanded base, e compressed paralleliform elements without any grooves and f suberect symmetrical urichodinifrom elements with slightly flared base. Elements are fairly robust, and are covered by weak striations.

Subrounded (a) element

Description: Subrounded elements are usually robust quadri-costate forms which have prominent grooves on both lateral faces and on posterior face. Posterior groove is usually widest, deepest with nearly vertical walls flanked by two sharply rounded postero-lateral costae. Secondary costae and grooves are not well developed. Cusp is usually suberect to reclined. Base is moderately large, slightly expanded posteriorly. Basal outline is subcircular to circular, and basal margin is normally straight. Basal cavity is moderately deep.

Transitional (b) element

Description: Triplicatiform element is considered to be the transitional element which has a weakly developed posterior carina or costa. Cusp is asymmetrical, but similar to quadraplicatiform element, and is usually slightly short, much strongly recurved at cusp-base junction, with less costae, and is basically triplicate in cross-section. Base is moderately flared, and usually expanded posteriorly. Basal outline is subcircular, and basal margin is almost straight. Basal cavity is moderately deep.

Suberect symmetrical (c) element

Description: Elements are usually antero-posteriorly compressed, typically bilateral symmetrical forms. Anterior face is broadly rounded; posterior face is usually flattened but with well developed posterior carina; two lateral sides are sharply rounded or slightly keeled. In the most specimens, posterior carinae are usually simple, rounded without median groove, and their bases are moderately expanded or strongly flared posteriorly. Basal cavity is moderately shallow and expansive, but relatively deep.

Compressed (e) element

Description: Paralleliform element is firmly considered to be the compressed element of apparatus which normally lacks the groove (only few specimens show weak posterior groove), and usually has smooth surface on both the base and cusp. Cusp tapers slowly, and is most strongly recurved near cusp-base junction, and is usually longer than other elements. Cross-section of cusp is moderately biconvex, and edges are sharply rounded. Base is strongly flared, and expanded posteriorly. Basal margin is straight, and laterally compressed basal outline is ovate. As with other elements, basal cavity is moderately deep, cusp has obscure striae, and growth axis starts at apex of cavity and continues along cusp parallel with and close to posterior margin. Two variants can be recognized, namely subarcuatiform variant and paralleliform variant.

Suberect symmetrical (f) element

Description: Some ulrichodiniform elements are assigned to this form, but with less confidence. Elements are usually slender, anteriorly extended, straight simple cones which have a moderate posterior keel and a rounded, anterior face. Cusp is bilaterally symmetrical, laterally compressed, anteriorly thickened, and posteriorly keeled. Cross-section of cusp is triangular. Base is very short, and flares slightly on both sides and on postero-lateral corners. Basal cavity is extremely shallow but acuminate at apex. Apex of cavity is situated near anterior side and growth axis is essentially straight.

<u>Remarks</u>: Repetski (1975) found "paralleliform" specimens, 63 m below the first occurrence of quadraplicatiform elements. Kennedy (1980) rejected the concept of an apparatus consisting of paralleliform and quadraplicatiform elements proposed by Brand and Rust (1977). He argued that the different stratigraphic ranges in the El Paso Group in Texas (Repetski, 1975), that no transitional elements were known, and that the apparatus was quite unlike any known Lower Ordovician apparatuses. However, many authors reported frequently that quadraplicatiform, triplicatiform, paralleliform, staufferiform and ulrichodiniform elements were found together in many localities, and they do co-occur in all the St. George Group collections. The suggestion, albeit indirectly, by Brand and Rust (1977) that the quadraplicatiform, triplicatiform and paralleliform elements comprised a single apparatus, is fully supported by this new multielement apparatus plan, but this apparatus also includes a staufferiform element, and may include ulrichodiniform element as suggested by Dzik (1983, Fig. 4:2).

As noted above, this apparatus consists of five major elements. It is one of the most fully developed and most complex apparatuses in the Lower Ordovician. Within this apparatus, a subrounded elements are usually robust, with moderate base and long cusp, well developed four major costae and three grooves; b transitional elements are close to subrounded elements, but with fewer costae and shallow grooves; c suberect symmetrical elements have extremely expanded bases, well developed posterior carinae; e compressed elements are asymmetrical, drepanodiform-like elements, without any lateral grooves; f suberect symmetrical elements are ulrichodiniform conodonts with bilaterally symmetrical cusps, and posteriorly keeled margins. However, as Ethington and Clark (1981) noted a continuous transitional range in morphology usually exists between the quadraplicatiform and triplicatiform elements. Moreover, the morphological transitional among the five elements is distinct. The transitional triplicatiform element exhibits intermediate morphology in terms of the curvature near the base-cusp junction between the subrounded and suberect symmetrical staufferiform elements. In general, the curvature of the cusp gradually increases, and the base becomes more strongly flared posteriorly from the subrounded through the transitional to the compressed element. The staufferiform element and the ulrichodiniform element are distinct from the other three elements, but they do have fine striae and similar distribution of white matter.

Within this species, the subrounded and compressed elements are most common, transitional elements are less common, suberect symmetrical c and f elements are rare. The earliest and latest apparatuses may both lack suberect symmetrical elements.

Occurrence: In the St. George Group, the species ranges through the upper middle part of Boat Harbour Formation to the Aguathuna Formation, but it is dominant in the upper part of Boat Harbour and the lower part of Catoche Formation. Samples from Z2-66 to Z2-98 in Section 2; samples from Z6-26 to Z6-44 in Section 6.

Number of specimens: Total, 3354; a subrounded quadraplicatiform element, 1437; b transitional triplicatiform element, 730; c suberect staufferiform element, 118; e compressed paralleliform element, 983; f suberect ulrichodiniform element, 86.

Types: GSC 95894-95905.

Glyptoconus triplicatus (Ethington and Clark)

Plate 10, figs. 21-27; Text-fig. 6:6C

Subrounded element

Scolopodus triplicatus Ethington and Clark, 1964, p. 700-701, Pl. 115, figs. 20, 22-24; text-fig. 2C.

Scolopodus quadraplicatus Branson and Mehl. Barnes and Tuke, 1970, p. 93, Pl. 18. fig. 17.

Scolopodus triplicatus Ethington and Clark. Repetski, 1982, p. 52, Pl. 24, figs. 1, 4 (contains complete synonymy through 1982).

Emended diagnosis: A species of Glyptoconus consisting of two element morphotypes: a subrounded triplicatiform elements with slender cusp and large base; c suberect staufferiform elements with suberect cusp and expanded laterally. Elements are hyaline, fairly robust and usually reclined simple cones having weakly developed costae and grooves, flared base and moderately deep basal cavity.

Subrounded (a) element

Description: Elements are triplicatiform having relatively large base and slender cusp. Cusp is reclined, sharply bent in near cusp-base junction. Anterior face is usually rounded without any costae; posterior face has a well developed carina which is flanked by one rounded postero-lateral costa and one sharply rounded lateral costa; one lateral side is smoothly rounded without any grooves or with a very shallow groove. Base is expanded posteriorly. Basal outline is circular to subcircular, basal margin is normally straight. Basal cavity is relatively deep.

Suberect (c) element

Description: Elements are bilaterally symmetrical staufferiform, usually antero-posteriorly compressed. Cusp is suberect, and tapers slowly. Anterior face is smoothly rounded; posterior face is flattened, or concave with a weakly developed carina that begins above basal margin, and continues towards cusp tip. Both lateral sides are sharply rounded. Base is expanded laterally, and flared posteriorly. Basal cavity is shallow, but large, and conical with an apex pointed to anterior.

Remarks: Ethington and Clark (1964) established *G. triplicatus* as a form species lacking one lateral groove and being less strongly curved as compared with *G. quadraplicatus* (Branson and Mehl). Repetski (1982) considered this species as probably part of the apparatus that includes *G. quadraplicatus*.

Based on the study of specimens from the St. George Group, it is considered that typical *G. triplicatus* form species, together with a staufferiform element having a posteriorly flattened cusp, comprise an apparatus species characterized by having only the first transition series. In the specimens figured by Ethington and Clark (1964), and Repetski (1982), the typical *G. triplicatus* form species has a slight flattening of the cusp along the non-grooved side and a circular basal cross-section. Some triplicatiform specimens which are similar to those of G. triplicatus are considered to be part of apparatus of G. quadraplicatus or G. multiplicatus n. sp. because they have deep grooves on both lateral sides and subcircular to quadrate cross-section of the base.

The specimens of G. triplicatus found in the middle part of Boat Harbour Formation are among the oldest representatives of genus Glyptoconus, and in which the second transition series has not been developed. In general, the earliest and latest apparatuses may lack the transitional, compressed, and two suberect symmetrical elements. G. triplicatus is closely related to G. priscus n. sp. in the apparatus plan and general feature, but the hyaline condition, shape of the basal cavity, and the development of costae and grooves are different.

Occurrence: This species is present in the middle Boat Harbour Formation in samples from Z2-36B to Z2-65B of Section 2; in samples from Z4-36B to Z4-37 of Section 4; in sample Z8-1 of Section 8.

Number of specimens: Total, 418; a subrounded triplicatiform element, 396; c suberect staufferiform element, 22.

Types: GSC 95906-95911.

Genus *Glyptodontus* n. gen.

Type species: *Glyptodontus constrictus* n. sp.

Derivation of name: From Latin "glypto-" and "dontus", meaning carved cone.

Diagnosis: Albid, or partialy albid, triangular simple cones. Apparatus plan includes three, or may have four morphotypes: *a* subrounded elements are characterized by having a well developed posterior costa, two lateral costae, and triangularshaped base in cross-section; *b* transitional elements have a posterior costa similar to the compressed elements; *c* suberect symmetrical elements are staufferiform-like conodonts which have well developed posterior costa; *e* compressed elements are triangular in profile, lateral or postero-laterally compressed, with a weak posterior costa.

Remarks: The genus is readily distinguishable from other genera. However, the subrounded elements of the genus are similar to those of *Polycostatus* except for the triangular-base; the suberect symmetrical elements are staufferiform conodonts, but they are characterized by having a well developed posterior costa; the compressed elements are distinctive forms which are triangular in profile, with a expanded base. The _a-c_ elements and the _e_ elements comprise the first and second transitional series respectively.

Three species are recognized in the genus, they are _G. constrictus_ n. sp., _G. expansus_ n. sp., and _G. tumidus_ n. sp. _G. constrictus_ n. sp. probably evolved from _G. tumidus_ n. sp., and _G. expansus_ n. sp. might have evolved from _G. constrictus_ n. sp. based on the study of specimens from the St. George Group.

Glyptodontus constrictus n. sp.

Plate 11, figs. 1-9; Text-fig. 6:7A

Drepanodiform element

?_Drepanodus_ sp. B. s.f., Landing and Barnes, 1981, p. 1615, Pl. 4, fig. 17; Fig. 3-3.

Staufferiform element

Acontiodus iowensis Furnish s.f. Nowlan, 1985, p. 105, Fig. 4.12.

Derivation of name: From the Latin "constrictus", referring to the restricted basal opening.

Diagnosis: A species of *Glyptodontus* consisting of four element morphotypes: a subrounded elements, b transitional elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are characterized by having a subrounded or subtriangular-shaped base, and well developed posterior costa; transitional elements are lateral-posteriorly compressed, and have a offseted posterior costa and triangular basal cross-section; suberect symmetrical elements are staufferiform-like, and have a posterior costa or narrow carina; compressed elements are triangular-shaped, with lateral expanded base. All of elements have a restricted basal opening that is smaller in diameter than the maximum basal expansion, and an extremely expanded base.

Subrounded (a) element

Description: Elements are characterized by having a posterior costa and two weakly developed lateral costae. Cusp is usually erect to reclined, and tapers more rapidly near base, then slowly towards pointed tip. Cross-section of cusp is subrounded. Anterior face is smoothly rounded, with very faint costa in some specimens; posterior face has a well developed broadly rounded posterior costa which runs from basal margin towards tip of cusp. Two lateral sides are slightly keeled. Base is expanded, and is subrounded to subtriangular in profile. Basal cavity is conical, with a restricted basal opening.

Transitional (b) element

Description: Elements are asymmetrical forms with triangular profile, and have a offset posterior costa. Cusp is usually recurved, and lateral-posteriorly compressed, with a variation in offset posterior costa. Anterior face is smoothly rounded, but in some specimens with faint anterior costa; posterior face is usually compressed, and is slightly concave, with a sharp-edged costa; one lateral side is slightly rounded or keeled, other side is sharp-keeled shoulder. Base is triangular in cross-section. Basal cavity is moderately deep, with a slightly restricted basal opening.

Suberect symmetrical (c) element

Description: Elements are staufferiform-like conodonts with extremely well developed posterior costa, and are triangular in posterior outline. Cusp is strongly curved posteriorly, and tapers rapidly. Anterior face is broadly smoothly rounded; posterior face is compressed, with an extremely well developed high costa or carina having a very weak median groove; two lateral sides are keeled. Base is extremely expanded, with triangular cross-section. Basal cavity is small, with a characteristic restricted basal opening.

Compressed (e) element

Description: Elements are scandodiform forms, usually postero-laerally compressed with a faint posterior costa. Cusp is strongly lateral-posteriorly flattened, and is slightly reclined over large base. Anterior face is usually smoothly rounded, but with faint carina or costa; posterior face is concave, with a weak costa or carina near one lateral side; two lateral sides are keeled, but one side is extremely knife-edged. Base is extremely expanded. Basal cavity is shallow with a slightly restricted basal opening.

Remarks: This species can be distinguished from others by the sharp-edged posterior costa of the subrounded element, triangular-shaped with offset costa of the transitional and compressed elements, and by the characteristic triangular posterior outline with a high costa of the suberect symmetrical element. However, the compressed element of the species is similar to the scandodiform elements of other species of the genus, but it has a weak posterior carina or costa; the suberect symmetrical element is close to the staufferiform elements of other species, but it is triangular-shaped, and is characterized by having a very high costa or carina.

G. constrictus n. sp. can be distinguished from G. expansus n. sp. by the restricted basal opening and rapidly tapered cusp near the base-cusp junction. Landing and Barnes (1981) recovered Drepanodus sp. A s.f. with triangular outline which is very similar to the compressed element of the species. The specimens referred by Nowlan (1985) to Acontiodus iowensis with slightly restricted basal opening and triangular outline should be the suberect symmetrical elements of the species.

Within this apparatus, the subrounded and compressed elements are quite common forms, the transitional elements are less common. As in other species, the suberect symmetrical elements are rare.

Occurrence: The species is found in the upper part of Watts Bight Formation in samples from Z2-10 to Z2-14 of Section 2; in samples from Z4-17 to Z4-20B of Section of 4; in samples from Z5-6 to Z5-11 of Section 5; in samples from Z6-5 to Z6-7 of Section 6; in samples from Z9-2 to Z9-9 of Section 9.

Number of specimens: Total, 132; a subrounded element, 56; b transitional element, 12; c suberect staufferiform-like element, 6; e compressed scandodiform element, 38.

Types: GSC 95912-95919.

Glyptodontus expansus n. sp.

Plate 11, figs. 10-17; Text-fig. 6:7B

Derivation of name: From the Latin "expansus", meaning expanded, referring the base of this species.

Diagnosis: A species of Glyptodontus consisting of a subrounded elements, c suberect symmetrical elements and e compressed elements, and may contains b transitional elements as well. Subrounded elements are triangular, with extremely expanded base; compressed elements are postero-laterally compressed, and triangular drepanodiform forms; suberect symmetrical elements are characterized by the triangular posterior outline, with well developed posterior costa; transitional elements may be same as the subrounded elements, but with a variation in offset posterior costa.

Subrounded (a) element

Description: Elements are robust, triangular in profile, with extremely expanded triangular base. Cusp is usually reclined, postero-laterally compressed, with a triangular cross-section. Anterior face is smoothly rounded, but usually has very weak costa near the basal region; posterior face is slightly concave, with a posterior carina or costa flanked by shallow grooves; two lateral sides are keeled, but one side is extremely sharp-edged. Base is triangular in cross-section, and extremely expanded postero-laterally. Basal cavity is relatively large, deep and triangular.

Suberect symmetrical (c) element

Description: Elements are bilaterally symmetrical staufferi-form-like cones, with typical triangular outline. Cusp is usually curved, with a sharp tip. Anterior face is broadly smoothly rounded; posterior face is concave except a very high costa which is flanked by two triangular flattened regions; two lateral sides are sharp-keeled. Base is expanded laterally, and also expanded posteriorly under posterior costa, and is triangular in cross-section. Basal cavity is moderately deep, triangular in profile.

Compressed (e) element

Description: Elements are drepanodiform-like cones, lateral-posteriorly compressed, and triangular-shaped in profile. Cusp is usually reclined or recurved. Anterior face is smoothly rounded with or without weak costa near basal region; posterior face is extremely compressed, with weak posterior costa or carina flanked by one shallow groove and one flattened triangular area; two lateral sides are keeled. Base is extremely expanded posteriorly. Basal cavity is relatively deep, and its apex is located near one lateral side of anterior face.

Remarks: The subrounded and compressed elements of this species are quite similar to those of _G_. _constrictus_ n. sp. in general features, but they are robust, and have a larger and deeper basal cavity. However, the suberect symmetrical element characterized by the triangular outline and a high posterior costa is almost the same as to that of _G_. _constrictus_ n. sp. except for the posterior costa or carina without a median shallow groove. The suberect symmetrical element is staufferiform with an extremely expanded base and a short posterior costa.

This species may possess the transitional element, however, only a few specimens are referable to the subrounded element of this species whereas many compressed specimens were recovered, the transitional elements may be indistinguishable from most compressed elements, except for those with a developed posterior costa.

Occurrence: This species is present in the upper part of Watts Bight Formation in sample Z1-29 of Section 1; in samples from Z2-3 to Z2-17 of Section 2; in samples from Z4-17 to Z4-20B of Section 4; in samples from Z5-3 to Z5-6 of Section 5; in samples from Z6-5 to Z6-6 of Section 6; in sample from Z7-13B of Section 7; in samples from Z9-4 to Z9-9 of Section 9.

Number of specimens: Total, 81; _a_ subrounded element, 23; _b_ transitional element, 7; _c_ suberect staufferiform-like element, 12; e compressed element, 39.

Types: GSC 95920-95927.

Glyptodontus tumidus n. sp.

Plate 11, figs. 18-22; Text-fig. 6:7C

Derivation of name: From the Latin "tumidus", referring to the base of this species.

Diagnosis: A species of Glyptodontus containing three element morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements have short cusp bearing three strong rounded costae, and postero--laterally expanded large base; suberect elements are staufferiform with extremely large base and deep basal cavity; compressed elements have slightly compressed cusp. Elements are albid, extremely robust and stubby forms usually with three major costae, extremely expanded base, and large and deep basal cavity.

Subrounded (a) element

Description: Elements are usually robust and stubby with three major costae. Cusp is usually erect to reclined, and is very short and sharply pointed, bearing three strong rounded costae, extending on to base. Anterior side has one major costa which terminates just above basal margin; posterior side is concave with a wide groove, a rounded strong costa on each side of posterior face is well developed; one lateral face is smoothly rounded, other lateral side has a wide groove. Base is extremely expanded posteriorly and laterally. Basal cavity is large and deep, conical in profile.

Suberect symmetrical (c) element

Description: Elements are staufferiform-like cones with well developed posterior carina and two lateral costae, as well as extremely large base and extremely large and deep basal cavity. Cusp is robust, stubby, usually proclined to erect, and tapers rapidly. Anterior face is smoothly and broadly rounded and slightly flattened wide region without any costae and grooves; posterior face is concave except a rounded strong posterior carina; two lateral sides are keeled with rounded costae. Base is extremely expanded posteriorly and laterally, and is oval in cross-section. Basal cavity is extremely large and deep, and apex of cavity is situated near anterior side.

Compressed (e) element

Description: Elements are similar to the subrounded elements, but with postero-laterally compressed cusp, extremely posteriorly expanded base which is sub-oval in cross-section. Cusp is usually reclined, sturdy, bearing two rounded costae and one sharply rounded posteriorly costa. Base is expanded posteriorly and laterally as well. Basal cavity is deep and wide, and suboval in profile.

Remarks: The species is characterized by three rounded costae and extremely expanded base and very large basal cavity which distinguish it from other species of the genus. However, the subrounded elements of this species bear some superficial similarity to those of *Polycostatus falsioneotensis* n. sp., but the latter elements are not stubby, their bases are not extremely expanded and their basal cavities are not extremely large and deep. This species is also similar to *G. expansus* n. sp., but the latter has relatively small base and keeled costae. It co-occurs with *Polycostatus falsioneotensis* n. sp., but it is not a common species in the collections.

Occurrence: The species is found in the upper middle part of Boat Harbour Formation in sample Z1-32 of Section 1; in sample Z2-8 of Section 2; in samples from Z4-15B to Z4-19 of Section 4; in samples from Z5-6 to Z5-12 of Section 5; in samples from Z9-4 to Z9-9 of Section 9.

Number of specimens: Total, 76; *a* subrounded element, 43; *c* suberect element, 2; *e* compressed element, 31.

Types: GSC 95928-95931.

Genus *Histiodella* Harris, 1962

Type species: *Histiodella altifrons* Harris, 1962

Histiodella donnae Repetski

Plate 13, figs. 1-2

Histiodella donnae Repetski, 1982, pp. 25-26, Pl. 8, figs. 6-7.

Remarks: Repetski (1982, pp. 25-26) gave a detailed description for this species. The two specimens recovered from the St. George Group are slightly different in having a triangular-shaped and strongly concavo-convex cusp.

Occurrence: This species is only found in the middle Boat Harbour Formation in sample Z2-64 of Section 2.

Number of specimens: Total, 2.

Types: GSC 95945-95946.

Genus *Loxodus* Furnish, 1938

Type species: _Loxodus_ _bransoni_ Furnish, 1938, p. 339.

Emended diagnosis: An apparatus consisting of only albid or partially albid, blade-like dextral and sinistral elements. Elements are characterized by having a series of posteriorly reclined denticles fused to form a bladelike structure. Basal cavity is narrow, and extends lengthwise and is but slightly expanded beneath anterior denticle.

Remarks: _Loxodus_ is similar to _Loxognathodus_ n. gen. and _Loxodentatus_ n. gen. which are present in the strata of the St. George Group just below the horizon of _Loxodus_. It is considered that the ancestor of _Loxodus_ is _Loxodentatus_ n. gen. which may have also produced by _Loxognathodus_ n. gen. _Loxodus_ is an unique form among Lower Ordovician conodonts, and appears to be valuable biostratigraphically, having a restricted stratigraphic range.

Loxodus _bransoni_ Furnish

Plate 12, figs. 18-21; Text-fig. 6:8A

Loxodus _bransoni_ Furnish, 1938, p. 339, Pl. 42, figs. 33-34, text-fig. 2A; Repetski, 1982, p. 27, Pl. 9, fig. 7 (contains complete synonymy to 1982); Ethington and

Clark, 1981, p. 52, Pl. 5, fig. 15; Nowlan, 1985, Fig. 4-29; Ethington, Engel and Elliott, 1987, Pl. 8.1 fig. 20; Orndorff, 1987, Pl. 1, fig. 22.

Emended diagnosis: Single element apparatus, with dextral and sinistral blade-like morphotypes: Element bears a row of erect to posteriorly reclined denticles. Anterior denticle is usually erect, with posterior denticles becoming progressively more reclined. Denticles are fused with albid axes. Basal margin is essentially straight. Basal cavity is narrow, but relatively deep.

Remarks: The specimens of *Loxodus* recovered from the St. George Group comprise two forms: one assigned to *Loxodus bransoni* that conforms well with Furnish's (1938) original description; the other is relatively small with an extremely large basal portion and a very deep basal cavity, which is assigned to *L. latibasis* n. sp. *Loxodentatus pinnatus* n. gen. & sp., found in slightly older strata in the St, George Group, is considered the ancestor of *L. bransoni*.

The apparatus plan of *Loxodus* is still uncertain, containing only one major blade-like element, but which may represent the entire first transitional series with a rare "suberect" symmetrical element.

Occurrence: The species is found in the upper part of Watts

Bight Formation and the lower part of Boat Harbour Formation in samples from Z2-9B1 to Z2-33 of Section 2; in samples from Z4-16 to Z4-32 of Section 4; in sample Z5-12 of Section 5; in samples from Z6-4 to Z6-6B of Section 6; in samples from Z7-13B to Z7-17 of Section 7; in samples from Z9-7 to Z9-2 of Section 9.

Number of specimens: Total, 218.

Types: GSC 95943-95944.

Loxodus latibasis n. sp.

Plate 12, figs. 14-17; Text-fig. 6:8B

?Loxodus bransoni Furnish. Ethington and Clark, 1981, p. 52, Pl. 5, fig. 15.

Derivation of name: From the Latin "latibasis", meaning "deep-base".

Diagnosis: A species of Loxodus containing only one blade-like denticulate element, with both sinistral and dextral form. Elements are asymmetrical, albid to partially albid, small, and consist of several posteriorly reclined sturdy denticles. Basal portion is extremely large, and basal cavity is extremely deep.

Description: Element consists of several posteriorly reclined sturdy denticles, and is flexed along a line just below base of denticle row. Denticles are fused only near the base, and are discrete distally. Basal portion is very deep and is about same height as upper denticulate portion. Basal cavity is very narrow and extremely deep near anterior portion. Faint striations are present on base, starting at anterior portion and continue to the posterior portion merging in a line just below base of denticle.

Remarks: The new species is similar to *L. bransoni* Furnish, but differs in having very deep basal portion or extremely deep basal cavity, as well as slightly discrete denticles. Most specimens of this species are flexed along a line between the basal portion and denticle portion, but those of *L. bransoni* are not flexed.

Occurrence: The species is present in the upper part of the Watts Bight Formation and the lower part of the Boat Harbour Formation in samples from Z2-9B1 to Z2-21B of Section 2; in samples from Z4-26 to Z4-32 of Section 4; in sample Z6-11 of Section 6; in samples from Z9-8 to Z9-9 of Section 9.

Number of specimens: Total, 71.

Types: GSC 95941-95942.

Genus *Loxognathodus* n. gen.

Type species: *Loxognathodus phyllodus* n. sp.

Derivation of name: From the Latin "Loxo-" and "-gnathodus", referring to the morphology of asymmetrical element in this genus.

Diagnosis: An apparatus containing two element morphotypes: a "suberect" symmetrical blade-shaped form and e asymmetrical blade-shaped form. "Suberect" symmetrical elements are subtriangular with mid-denticle, laterally extended process and elongate basal cavity. Asymmetrical elements are usually dextral and sinistral forms, blade is oblique-triangular in profile with well developed mid-denticle, posteriorly extended process, with elongate basal cavity; Elements are albid in all but their basal regions.

Remarks: The new genus is very similar to *Histiodella* Harris, but it differs by having a symmetrically and asymmetrically triangular "cusp" without denticles and a deeper elongate basal cavity. The genus is found in strata much older than those bearing _Histiodella_.

Loxognathodus phyllodus n. sp.

Plate 12, figs. 8-13; Text-fig. 6:8D

Derivation of name: From the Latin "phyllodus", referring to the leaf-like shape of asymmetrical element of this species.

Diagnosis: A species of _Loxognathodus_ consisting of _a_ "suberect" symmetrical element and _e_ asymmetrical element. "Suberect" symmetrical elements are subtriangular-shaped with median carina which extends to the tip of the blade. Asymmetrical elements are blade-shaped forms with posteriorly extended bar or process. Elements are albid, and have a central denticle and a series of fused denticles.

"Suberect" symmetrical (_a_) element

Description: Elements are extremely thin, strongly concavo-convex, symmetrical subtriangular blades. Blade is extremely compressed posteriorly, triangular in posterior view with two laterally extended processes and central denticle, and is composed of white matter in all but the its basal portion. Anterior face is smoothly convex; posterior face is strongly concave; two lateral processes are extremely extend distally. Central denticle extends to tip of blade and resembles one central carina. Base is wide under central denticle, and gradually becomes narrow towards two lateral sides. Basal cavity is very deep under central denticle and is slitlike in two lateral processes. A series of indistinct and irregular thread-like structures are longitudinally developed on blade, and resemble a very early stage of differentiation of blade into fused denticles.

Asymmetrical (e) element

Description: Elements are thin, dextral and sinistral, strongly concavo-convex oblique triangular-shaped blades. Blade is extremely compressed laterally, oblique triangular in lateral view with posteriorly extended process and axial central denticle near anterior portion, and is composed of white matter in all but its basal margin. Bar is a continuation of posterior process, and is long with sharp-pointed end. Axial central denticle which extends to tip of blade, and is located near the anterior process. Basal cavity is moderately deep, and is slit-like in posterior process and is irregular triangle in the anterior process. In some specimens, a series of indistinct and irregular thread-like structures which may represent differentiation of blade into fused denticles are longitudinally developed on blade.

Remarks: The species resembles some species of Histiodella, but differs by having a deep basal cavity and no distinct denticles, and it occurs in much older strata than those bearing *Histiodella*. On the basis of the western Newfoundland collections, *Loxognathodus phyllodus* n. sp. is considered to be an ancestor of *Loxodentatus pinnatus* n. sp. with the increasing differentiation of the blade into fused denticles.

Within this apparatus, the asymmetrical elements are much more common than "suberect" symmetrical elements.

Occurrence: The species is found in the middle part of the Watts Bight Formation in sample Z1-31 of Section 1; in smaples from Z2-2 to Z2-8B of Section 2; in sample Z5-1 of Section 5; in samples from Z7-7 to Z7-11 of Section 7.

Number of specimens: Total, 27; *a* symmetrical element, 7; *e* asymmetrical element, 20.

Types: GSC 95936-95940.

Genus *Loxodentatus* n. gen.

Type species: *Loxodentatus pinnatus* n. sp.

Derivation of name: From the Latin "Loxo-" and "dentatus", meaning "oblique tooth".

Diagnosis: Apparatus contains two major element morphotypes: *a* "suberect" bilaterally symmetrical form and *e* asymmetrical blade-like form. Suberect symmetrical elements are wing-shaped with a central denticle and two laterally extended processes. Asymmetrical elements are characterized by having a series of straight denticles which are completely fused except at tips. Elements are albid, and have a shallower, slit-like basal cavity.

Remarks: This genus resembles *Loxognathodus* n. gen., but displays a series of indistinct small denticles and has a shallower basal cavity. The genus is also similar to *Histiodella* in general appearance, but differs in having small indistinct denticles and an extended posterior process in the asymmetrical element and two laterally extended processes in the "suberect" symmetrical element.

Loxodentatus bipinnatus n. sp.

Plate 12, figs. 1-7; Text-fig. 6:8C

Derivation of name: From the Latin "bi-" and "pinnatus", referring the shape of "suberect" symmetrical element.

Diagnosis: As for the diagnosis of genus.

"Suberect" symmetrical element

Description: Elements are symmetrical, thin, wing-shaped, strongly concavoconvex blades. Blade is extremely compressed posteriorly, subtriangular in posterior view with two extremely extended lateral processes, and consists of a series of small denticles which are fused laterally and one relatively large central denticle. All of small denticles are laterally inclined, whereas central denticle is straight and sharply pointed. Anterior face is strongly convex, especially near centre; posterior face is strongly concave; each lateral process has one strongly inclined lateral-most denticle which is extremely extended to form the sharp-pointed end. Base is relatively low, but slightly higher just under central denticle. Basal cavity is shallow, especially two lateral processes, and is slitlike in profile.

Asymmetrical element

Description: Elements are asymmetrical, dextral and sinistral, thin, strongly concavo-convex, leaf-like blades. Blade is strongly compressed laterally, subtriangular or suboval in lateral view, and consists of a series of straight denticles which are completely fused laterally except at tips. Anterior process of blade is rounded with or without central denticle; posterior process of blade is extended to form a bar with slightly rounded end. Base is very narrow in posterior process, and is slightly wide in anterior portion. Basal cavity is relatively shallow, and slitlike in profile.

Occurrence: The species is present in the middle part of the Watts Bight Formation in samples from Z2-3 to Z2-3B of Section 2; in sample Z4-23 of Seciton 4; in samples from Z5-5 to Z5-8 of Section 5; in samples from Z6-6 to Z6-9 of Section 6; in samples from Z7-15 to Z7-17 of Section 7; in samples from Z9-4 to Z9-9 of Section 9.

Number of specimens: Total, 56; a symmetrical element, 14; e asymmetrical element, 42.

Types: GSC 95932-95935.

Genus Macerodus Fåhræus and Nowlan, 1978

Type species: Macerodus dianae Fåhræus and Nowlan

Emended disgnosis: An apparatus containing two element morphotypes: a subrounded curved macerodiform elements and e compressed straight macerodiform elements. Elements are laterally compressed, finely striated, and albid with extremely long base and deep basal cavity. Subrounded elements have quadrate cross-section near tip of cusp, and show slightly variation.

Remarks: Fåhræus and Nowlan (1978) established this genus based on only 13 specimens. Ethington and Clark (1981) gave a detail remarks about the genus, dealing with the apparatus pattern and relationship with other taxa.

Several hundreds of excellently preserved specimens have been recovered from the St. George Group. The majority of specimens can be grouped into two morphologies: subrounded curved elements and compressed straight elements, assignable to Macerodus dianae Fåhræus and Nowlan. A few specimens belong to a new species M. gracilis n. sp. Several tens of specimens which have been found in the middle Watts Bight Formation resemble Macerodus dianae, but are assigned to two new species of Macerodus, M. crassatus and M. wattsbightensis.

Macerodus crassatus n. sp.

Plate 13, figs. 3-8; Text-fig. 7:9A

Juanognathus? sp. B, Landing and Barnes, 1981, p. 1168, Pl. 3, figs. 1, 2, 4, 5 (not figs. 6, 8, 9, 10); text figs. 17, 18.

Diagnosis: A species of Macerodus consisting of two element morphotypes: a subrounded distacodiform-like elements, and e compressed distacodiform-like elements. Subrounded elements are symmetrical, and have a laterally compressed base and strongly curved cusp with triangular cross-section. Compressed are asymmetrical, and have a large base and recurved Elements are albid coniforms with slightly compressed cusp, and extremely long base and deep basal cavity.

Subrounded (*a*) element

Description: Elements are subrounded, symmetrical distacodi-form-like cones having large, slightly laterally compressed base and strongly curved cusp. Cusp is strongly recurved with triangular cross-section. Posterior face has a well developed posterior groove which is flanked by two posterolateral sharp-edged costae; anterior face is gently rounded; both lateral sides are compressed having well developed shallow groove. Base is extremely large, and extended posteriorly with a broadly rounded carina. Basal cavity is extremely deep.

Compressed (*e*) element

Description: Elements are slightly asymmetrical, laterally compressed distacodiform-like cones with large base and recurved cusp. Anterior face is sharply rounded; posterior face is flattened, sometimes with shallow groove which is flanked by sharp-edged postero-lateral costae; both lateral sides are flattened, usually without lateral shallow groove. Base is large, and extended posteriorly as a sharply rounded carina. Basal cavity is deep.

<u>Remarks</u>: Only a few specimens from Canadian Arctic were described by Landing and Barnes (1981) as <u>Juanognathus</u>? sp. B. having an apparatus with acodiform and distacodiform elements. The specimens from the St. George Group confirm that their acodiform and distacodiform specimens probably belong to two different species as noted in the synonymy.

<u>Occurrence</u>: This species is present in the middle Watts Bight Formation in samples from Z2-2 to Z2-6 of Section 2; in samples from Z7-8 to Z7-11 of Section 7; in samples from Z9-8 to Z9-9 of Section 9.

<u>Number of specimens</u>: Total, 49; <u>a</u> subrounded distacodiform element, 31; <u>e</u> compressed distacodiform-like element, 18.

<u>Types</u>: GSC 95947-95952.

<u>Macerodus</u> <u>dianae</u> Fåhræus and Nowlan

Plate 13, figs. 9-18; Text-fig. 6:9B

Subrounded distacodiform element

<u>Macerodus</u> <u>dianae</u> Fåhræus and Nowlan. Ethington and Clark, 1981, p. 53-54, Pl. 5, fig. 16, Text-fig. 14 (contains complete synonymy through 1981); Ethington, Engel and

Elliott, 1987, Pl. 8.1, fig. 11.

Macerodus dianae Fåhræus and Nowlan. Repetski, 1982, p. 28, Pl. 15, figs. 10-11.

Emended diagnosis: A species of Macerodus containing two element morphotypes: a subrounded curved distacodiform-like elements and e compressed straight distacodiform-like elements. Subrounded elements have a long, curved cusp with quadrate cross-section. Compressed elements are characterized by having wide, straight, strongly compressed, large base and short cusp. Elements are albid, finely striated.

Subrounded (a) element

Description: Elements are characterized by having a continuously recurved and slightly compressed, long cusp with well developed grooves on the both lateral faces and on the posterior face, as well as a slightly expanded base. Two variants can be recognized: one with a slender base and cusp, another having a slightly expanded base and a short cusp.

Compressed (e) element

Description: Elements are strongly compressed laterally with relatively short cusp and long straight base. Cusp is straight with tip bent sharply at almost a right angle to lower reaches. Anterior side is slightly keeled; both lateral face bear extremely shallow grooves; posterior side has faint shallow groove. Base is not expanded, straight with flattened inner side and smoothly rounded outer side. Both anterior and posterior sides of base are slightly keeled. Basal cavity is deep, and apex of cavity is located at level of strongest curvature.

Remarks: Ethington and Clark (1981) noted that elements of *Macerodus dianae* contain both curved and straight morphologies, and suggested that the two morphologies can be subdivided. The specimens recovered from the St. George Group indicate that the two morphotypes have some similarities in their stratigraphic ranges, relative frequency, and their general features. Hence, it is considered that the more abundant, curved morphotype form with a less compressed cusp belongs to the subrounded element, and that the relatively rare, straight morphotype with strongly compressed cusp represents the compressed element of the species.

M. dianae Fåhræus and Nowlan is a distinctive form among the Lower Ordovician conodonts, with a restricted biostratigraphic range.

Occurrence: This species is found in the middle part of the Boat Harbour Formation in samples from Z2-37 to Z2-62 of Section 2; in samples from Z6-12 to Z6-25 of Section 6; in samples from Z8-1 to Z8-10 of Section 8.

Number of specimens: Total, 393; a subrounded distacodiform element, 169; e compressed distacodiform-like element, 224.

Types: GSC 95953-95962.

Macerodus gracilis n. sp.

Plate 14, figs. 17-18; Text-fig. 6:9C

Diagnosis: A species of Macerodus consisting of two element morphotypes: subrounded graciliform elements and compressed graciliform elements. Elements are extremely slender cones with very short cusp, and extremely long base and deep basal cavity. Subrounded elements have a curved cusp with lateral grooves; compressed elements have an extremely compressed, twisted cusp.

Subrounded (a) element

Description: Elements are extremely slender forms with long base, deep basal cavity and curved cusp. Cusp is short, curved, and slightly compressed. Both lateral faces have shallow grooves beginning near base-cusp junction; posterior face has a faint shallow groove. Base is extremely long, straight, and partially albid. Basal cavity is very deep; a strongly tapered apical part extends slightly into cusp.

Compressed (e) element

Description: Elements are extremely slender forms. Cusp is relatively short, curved, strongly laterally compressed, and slightly twisted. Both lateral faces are flattened without any grooves; posterior and anterior sides are keeled. Base is extremely long, laterally compressed, partially albid, but with broadly rounded inner lateral face and flattened outer lateral face. Basal cavity is extremely deep; a strongly tapered and twisted apical part extends into cusp.

Remarks: This new species is characterized by extremely slender base, very short cusp and extremely deep basal cavity and can be readily distinguished from *M. dianae* Fåhræus and Nowlan.

Occurrence: This species is present in the middle part of the Boat Harbour Formation in samples Z2-55 to Z2-62 of Section 2; in sample Z6-18 of Section 6; in samples from Z8-4 to Z8-10 of Section 8.

Number of specimens: Total, 17; a subrounded element, 7; compressed element, 10.

Types: GSC 95984-95985.

Macerodus? wattsbightensis n. sp.

Plate 13, figs. 19-23; Text-fig. 6:9D

Derivation of name: After the Watts Bight Formation.

Diagnosis: A species of *Macerodus* comprising three element morphotypes: *a* subrounded elements, *c* suberect elements, and *e* compressed elements. Subrounded elements are juanognathiform-like with expanded base and postero-laterally compressed cusp; suberect elements are stuafferiform-like with slender cusp and triangular-shaped, expanded base; compressed elements have postero-laterally compressed cusp and expanded base. Elements are albid, posteriorly compressed coniforms with expanded base and rapidly tapering cusp.

Subrounded (*a*) element

Description: Elements are juanognathiform-like cones with expanded base and postero-laterally compressed cusp. Cusp is usually proclined to erect. Antero-lateral face is broadly rounded; postero-lateral face is flattened except for carina; both lateral-anterior and lateral-posterior sides are keeled. Base is expanded, and triangular-shaped in cross-section. Basal cavity is moderately deep, and irregularly shaped in general profile.

Suberect (*c*) element

Description: Elements are staufferiform with slender cusp and expanded base. Cusp is erect, slightly curved posteriorly. Anterior face is broadly rounded; posterior face is compressed except centrally situated posterior carina which begins at basal margin and dies out tip of cusp; both lateral sides are keeled. Base is extended laterally, and slightly flared posteriorly. Basal cavity is small, and pyramid-shaped.

Compressed (e) element

Description: Elements are juanognathiform-like cones with postero-laterally compressed cusp and expanded base. Cusp is erect to slightly reclined, and tapers rapidly. Antero-lateral face is broadly rounded with wide shallow groove near base; postero-lateral face is strongly compressed, and concave except for broad carina near base; both lateral-anterior and lateral-posterior sides are keeled. Base is large and extended both antero-laterally and posterolaterally. Basal cavity is irregularly shaped and relatively small as compared with other species of Macerodus.

Remarks: M. wattsbightensis n. sp. is similar to Juanoganthus variablis Serpagli in general profile, but differs by having an expanded base, and strongly compressed cusp, and by not having a well developed posterior carina. Some subrounded and compressed elements are similar to those of Macerodus crassatus n. sp. and differ in having an asymmetrical and twisted cusp and a small basal cavity. These are assigned to *Macerodus*, because they are closely related to *M. crassatus* n. sp. This species probably is the oldest representative in *Macerodus* lineage. In terms of the morphology, the *Loxodus* lineage which includes *Loxognathus*, *Loxodentatus* and *Loxodus*, probably evolved initially from *M. wattsbightensis* n. sp. by having more expanded base and a differentiated cusp.

Occurrence: This species is present in the middle Watts Bight Formation in sample Z2-3B of Section 2; in samples from Z7-7 to Z7-9B of Section 7.

Number of speciemns: Total, 14; *a* subrounded element, 10; *c* suberect symmetrical element, 1; *e* compressed element, 3.

Types: GSC 95963-95967.

Genus *Microzarkodina* Lindström, 1971

Type species: *Microzarkodina flabellum* (Lindstrom, 1955).

Microzarkodina? *marathonensis* (Bradshaw)

Plate 14, figs. 23-24

"*Microzarkodina*" *marathonensis* (Bradshaw). Ethington and Clark, 1981, pp. 55-56, Pl. 5, figs. 14, 19, 20, 23, 24, 27.

Microzarkodina? cf. *M. marathonensis* (Bradshaw). Repetski, 1982, pp. 28-29, Pl. 10, figs. 1-7, 9 (contains complete synonymy through 1982).

Remarks: Only cordylodiform (=ozarkodiniform) elements have been recovered in these collections. The elements are characterized by having a broad, reclined cusp with sharp edges, and followed by series of basally crowded, thin denticles bearing lateral costae.

Occurrence: This species is present in the Catoche Formation in samples from Z2-101 to Z2-126 of Section 2; in samples from Z6-42B to Z6-46 of Section 6.

Number of specimens: Total, 11; *a* subronuded element, 6; *e* compressed element, 5.

Types: GSC 95990-95991.

Genus *Oepikodus* Lindström, 1955

Type species: *Oepikodus smithensis* Lindström, 1955.

Remarks: An apparatus consisting of four element morphotypes: a subrounded oepikodiform elements, b transitional prioniodiform elements, c suberect symmetrical oepikodiform elements and e compressed oistodiform elements. Oepikodiform elements have a subrounded cusp with sharply keeled edges leading to one major posterior process with numerous fused denticles and two lateral processes without denticles; prioniodiform elements are characterized by having a posterior denticulate process and an inner lateral adenti-culate process; oistodiform elements have an slightly arched posterior process bearing an arched oral keel; symmetrical oepikodiform elements are similar to the subrounded oepikodiform elements, but symmetrical with well developed lateral processes.

Based on the St. George Group collections and previous descriptions by Ethington and Clark (1964, 1981) and Repetski (1982), Oepikodus has four element morphotypes that represent the two transitional series. The first transition series consists of a asymmetrical and c symmetrical oepikodiform elements and b prioniodiform elements; the second transition series comprises e oistodiform elements.

Oepikodus communis (Ethington and Clark)

Plate 14, figs. 1-16

Oepikodiform element

Gothodus communis Ethington and Clark, 1964, p. 692-693, Pl. 113, figs. 6, 8, 10, 11, 14.

Oepikodus communis (Ethington and Clark). Repetski, 1982, ramiform elements, p. 30-31, Pl. 11, figs. 8, 10 (contains complete synonymy through 1982).

Prioniodiform elements

Gothodus communis Ethington and Clark, 1964, p. 690, 692, Pl. 114, figs. 6, 14; text-fig. 2F.

Oepikodus communis (Ethington and Clark). Repetski, 1982, prioniodiform elements, p. 30-31, Pl. 11, figs. 5-6 (contains complete synonymy through 1982).

Oistodiform elements

Oepikodus communis (Ethington and Clark). Repetski, 1982, falodiform elements, p. 30-31, Pl. 11, figs. 12a-c (contains complete synonymy through 1982).

Remarks: A species of Oepikodus containing four element morphotype within two transition series: a subrounded asymmetrical and c symmetrical oepikodiform elements associated with b prionioform elements may comprise the first transition series, the oistodiform elements with two variants comprise the second transition series.

Oepikodus communis has been widely reported. Based on this study, the definition of *Oepikodus* followed by Fåhræus and Nowlan (1978, p. 463) is basically adopted, but it is considered that *O. communis* has an apparatus consisting of four element morphotypes.

Occurrence: This species is found in the lowest Catoche Formation and through the middle part of Aguathuna Formation in samples from Z2-83 to Z2-136 of Section 2; in samples from Z6-29 to Z6-46 of Section 6; in samples from Z10-A to Z10-F and from Z10-1 to Z10-4 of Section 10.

Number of specimens: Total, 2845; *a* subrounded element, 1136; *b* transitional element, 843; *c* suberect symmetrical element, 89; *e* compressed oistodiform element, 777.

Types: GSC 95968-95983.

Genus *Polycostatus* n. gen.

Type species: *Acodus oneotensis* Furnish, 1938.

Derivation of name: From the Latin "Poly-" and "costatus", meaning "multicostate".

Diagnosis: An apparatus consisting of three element morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are usually characterized by multicostate cusps which include two lateral costae and one posterior costa; suberect symmetrical elements are typical staufferiform with well developed posterior carina having a prominent median groove; compressed elements are postero-laterally compressed with or without posterior costa; Elements are albid, multicostate, and usually have well developed posterior carina or major costa, and a large and deep basal cavity.

Remarks: The new genus is established based on Acodus oneotensis Furnish. On the basis of the western Newfoundland collections, A. oneotensis with three other multicostate species are assigned to the new genus Polycostatus. This multicostate group is clearly not assignable to the multielement genus Paltodus as recognized by Lindström (1971), or to Variabiloconus as established by Landing and Barnes (1986).

Four species are recognized within Polycostatus. From Polycostatus falsioneotensis n. sp., through P. oneotensis (Furnish), to P. sulcatus (Furnish), there is a clear trend showing that posterior, anterior and lateral faces became differentiated, and costae, grooves, and secondary costae and grooves developed as characteristic features. P. minutus

n. sp. is a distinctive species and is also the youngest representative recognized within the genus, which probably evolved from P. oneotensis by a weakening of the posterior carina.

Polycostatus falsioneotensis n. sp.

Plate 15. figs. 1-12; Text-fig. 6:10C

Oneotensiform element

Juanognathus? sp. A, Landing and Barnes, 1981, p. 1616, 1618, Pl. 3, figs. 13, 16, non. Pl. 4. figs. 1-6, 8-10.

Utahconus? bassleri (Furnish). Landing and Barnes, 1981, p. 1622-1624, Pl. 3, figs. 14-15, 17-21.

Scolopodus pingquanensis Zhang in An & al., p. 145, Pl. 10, figs. 16-23, text-figs.10-10, 10-11.

"Paltodus bassleri Furnish, Group". Nowlan, 1985, p. 118, Figure 10 (1-6, 8-10).

Variabiloconus bassleri (Furnish). Landing and Barnes, 1986, p. 1946-1947, Pl. 3, fig. 2.

Staufferiform element

?Acontiodus iowensis Furnish, 1938, p. 325-326, Pl. 42, figs. 16, 17.

?"Acontiodus" iowensis Furnish. Landing and Barnes, 1981, p. 1614, Pl. 4, figs. 12, 13.

"Acontiodus" staufferi Furnish. Ethington and Clark, 1981, p. 24, Pl. 1, fig. 24.

?Acontiodus staufferi Furnish. Repetski, 1982, p. 15, Pl. 4. figs. 4-5.

Derivation of name: From the Latin "falsi-", and the name of "oneotensis", meaning this species related to P. oneotensis.

Diagnosis: A species of Polycostatus containing three element morphotypes: a subrounded elements, c suberect symmetrical elements, and e compressed elements. Subrounded elements are symmetrical oneotensiform with circular basal cross-section and long cusp which has four major costae; suberect elements are symmetrical staufferiform with expanded base and long cusp; compressed elements are asymmetrical oneotensiform with posteriorly expanded base and postero-laterally compressed cusp. Elements are albid, robust, multicostate, and have moderately expanded base and large, relatively deep basal cavity.

Subrounded (a) element

Description: Elements are usually symmetrical, robust, suberect simple cones having circular basal cross-section, rather deep basal cavity, and four prominent costae. Cusp is reclined or slightly recurved. Anterior face is usually rounded without any major costae or grooves; posterior face has two major costae which is separated by a major posterior groove and is flanked by two lateral grooves; two lateral costae are well developed. All four costae arise immediately above basal margin. Base is slightly expanded posteriorly and circular in cross-section. Basal cavity is rather deep and its height is approximately one-third height of element.

Suberect symmetrical (c) element

Description: Elements are staufferiform-like cones. Cusp is slightly curved but bilaterally symmetrical with strong posterior carina. Anterior face is smoothly broadly rounded without any major costae and grooves; two lateral sides are keeled with sharp-edged costae; posterior face is slightly concave or flattened except posterior carina. Posterior carina, which is broader and divided medially by a faint depression or groove, is characteristic of most specimens. However, in few cases, carina is simple without a faint groove. Base is extremely expanded laterally and posteriorly, and is oval in cross-section. Basal cavity is relatively deep and large.

Compressed (e) element

Description: Elements are asymmetrical, robust, suberect cones having an elliptical to circular basal cross-section, and a rather deep basal cavity and three or two major costae. Cusp is reclined to recurved, and postero-laterally compressed. Anterior face is usually rounded; posterior face has a wide groove in one side, and sharp posterior or lateral-posterior costa on other side; if one lateral side has lateral groove and costa, and other side only has lateral costae. Base is posteriorly expanded, and is usually elliptical to circular in cross-section. Basal cavity is usually larger and deeper than that of subrounded element.

Remarks: *P. falsioneotensis* n. sp. is closely similar to *P. oneotensis* (Furnish) in its apparatus plan, and general morphology, but differs in having slender subrounded cusp and relatively small base, and by not having the secondary costae and triangular cross-section at base and cusp. This species, which probably evolved from a species of *Semiacontiodus* (Miller), is considered to be the oldest representative of *Polycostatus*.

Occurrence: This species is present in the upper part of Watts Bight Formation in samples from Z2-3B to Z2-16 of Section 2; in samples from Z4-13 to Z4-24 of Section 4; in samples from Z5-1 to Z5-12 of Section 5; in samples from Z6-1 to Z6-7 of Section 6; in samples from Z7-5B to Z7-17 of Section 7; in samples from Z9-4 to Z9-2 of Section 9.

Number of specimens: Total, 1689; *a* subrounded element, 874; *c* suberect staufferiform element, 126; *e* compressed element, 689.

Types: GSC 95992-96003.

Polycostatus minutus n. sp

Plate 16, figs. 1-7; Text-fig. 6:11A

Derivation of name: From the Latin "minutus", referring to the small size of these elements.

Diagnosis: A species of Polycostatus containing three element morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are asymmetrical, small paltodiform-like, and have a restricted base and compressed, twisted cusp; suberect elements are symmetrical, slender staufferiform with keeled lateral costae and posterior costa and small base; compressed elements are asymmetrical coniform having strongly compressed cusp and restricted base. Elements are partially albid, small, compressed, and have a restricted base, a small basal cavity, together with a sharp-edged posterior carina or costa.

Subrounded (a) element

Description: Elements are asymmetrical, small coniforms having a restricted base, rather small basal cavity, with a postero-laterally compressed and twisted cusp. Cusp is erect to reclined, and gently tapered. Antero-lateral face is broadly rounded, with a wide carina in some specimens; postero-lateral face is strongly compressed with a sharp-edged costa which begins just above basal margin and extends to cusp tip; both lateral-anterior and lateral-posterior sides have sharp-edged costae. Base is small with a restricted basal opening. Basal cavity is small and conical.

Suberect (c) element

Description: Elements are symmetrical, slender staufferiform having well developed lateral costae and posterior costa, and restricted base. Cusp is erect, but slightly curved posteriorly, and tapers slowly. Anterior face is smoothly rounded without costae; posterior face is compressed, and slightly concave having a sharp-edged costa which begins just above basal margin and extends to cusp tip; both lateral sides are sharply keeled. Base is slightly restricted and flared posteriorly. Basal cavity is small and conical.

Compressed (e) element

Description: Elements are asymmetrical coniforms having strongly laterally compressed cusp and restricted base. Cusp is usually erect to slightly reclined, and twisted near base-cusp junction. Both lateral sides are flattened, except for one side having a weak costa; anterior side is sharply rounded; posterior side is keeled. Base is restricted, especially anterior basal margin.

Remarks: *P. minutus* n. sp. is a distinctive species and probably the youngest representative of new genus *Polycostatus*. All three elements of *P. minutus* are readily distinguishable from those of the other three species within this genus by having a postero-laterally compressed cusp and a restricted basal opening. The subrounded element is similar to *Protopanderodus asymmetricus* (Barnes and Poplawski) in general features, but differs by having a sharp-edged posterior costa, partially albid cusp, and in lacking well developed fine striations.

Occurrence: This species is present in the lower Boat Harbour Formation in sample Z2-39 of Section 2.

Number of specimens: Total, 10; *a* subrounded element, 5; *c* suberect symmetrical element, 1; *e* compressed element, 4.

Types: GSC 96018-96024.

Polycostatus oneotensis (Furnish)

Plate 15, figs. 13-19; Text-fig. 6:10B

Subrounded and transitional elements

Acodus oneotensis Furnish, 1938, p. 325, Pl. 42, figs. 26-29, text-fig. 1N; Ethington and Clark, 1971, Pl. 1, figs. 6, 8, (not fig. 3=Variabiloconus bassleri); Repetski, 1982, p. 12, Pl. 2, figs. 7, 8.

Non Acodus oneotensis Furnish. Druce and Jones, 1971, p. 56, Pl. 12, figs. 3-7; Jones, 1971, p. 44, Pl. 1, figs. 5-7.

non "Acodus" oneotensis Furnish. Ethington and Clark, 1981, p. 21, Pl. 1, fig. 16; An & al. 1983, p. 67, Pl. 10, figs. 1-8.

"Paltodus bassleri" Group, Furnish. Nowlan, 1985, pp. 118 119, Figure 10-7 only.

Emended diagnosis: A species of Polycostatus containing three element morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are paltodiform with expanded triangular basal cross-section and shorter cusp; suberect elements are symmetrical staufferiform with slightly expanded base and slender cusp; compressed elements are paltodiform-like with expanded base and lateral-posterorly compressed cusp. Elements are albid, small multicostate forms with expanded base, deep basal cavity, and secondary costae.

Subrounded (a) element

Description: Elements are usually small paltodiform with expanded triangular basal cross-section, and three major costae. Cusp is usually erect to reclined with triangular-shaped cross-section. Anterior face is broadly rounded with several secondary costae; posterior face is laterally compressed with major costa which is broadest near basal margin and disappears near tip of cusp; one lateral side is flattened, but with shallow groove, and another lateral side has well developed groove. Base is expanded, and flared posteriorly. Basal cavity is large and deep.

Suberect (c) element

Description: Elements are symmetrical staufferiform with expanded base and posteriorly compressed cusp. Anterior face is broadly rounded with weakly developed secondary costae, and extended basal margin; two lateral sides have extremely keeled costae; posterior face is concave with a strong posterior carina. In most specimens, posterior carina has a median shallow groove. Base is expanded laterally, and is oval in cross-section. Basal cavity is deep.

Compressed (e) element

Description: Element is similar to subrounded form, but one of its lateral sides is strongly compressed, posterior carina is ill-developed, base is strongly flared posterior, and both lateral costae are extremely keeled.

Remarks: Furnish (1938) assigned this species to Acodus. This species has been misassigned by some authors, although widely cited. Lindström (1977) and Sweet and Bergström (1972) considered that "A." oneotensis is part of apparatus which they believed to also include Paltodus bassleri Furnish, Paltodus variabilis Furnish and Oistodus? triangularis Furnish, and which they interpreted to represent the apparatus of Paltodus Pander. Nowlan (1985) suggested that Paltodus bassleri, P. variabilis and Acodus oneotensis are included in the "Paltodus bassleri" Group, although he excluded Oistodus? triangularis from this group. Landing and Barnes (1986) assigned this species to a new genus Variabiloconus, and considered that the apparatus of V. bassleri contains an asymmetrical tricostate element (=Acodus oneotensis), symmetrical tricostate element (=Paltodus bassleri), asymmetrical tricostate element (=P. variabilis), and noncostate and nonsulcate drepanodiform element with subrounded cross-section. All of these elements mentioned above are present in the St. George Group, and also excellently preserved, but they do not co-occur abundantly in all the samples.

Based on the St. George Group specimens, the form species Paltodus bassleri Furnish and P. variabilis Furnish with suberect symmetrical P. bassleri are assigned to Variabiloconus bassleri multielement species; Furnish's Acodus oneotensis together with suberect symmetrical finely costate staufferiform ("Acodus staufferi") belong to the multielement species Polycostatus oneotensis (Furnish); some other forms in this group are assigned to Polycostatus falsioneotensis n. sp. which appear in the older strata.

Occurrence: This species is present in the uppermost Watts Bight Formation and the lower Boat Harbour Formation in samples from Z2-21B to Z2-32 of Section 2; in samples from Z4-25 to Z4-34 of Section 4; in sample Z6-10 of Section 6.

Number of speciemns: Total, 304; a subrounded element, 164; c suberect staufferiform element, 22; e compressed element, 118.

Types: GSC 96004-96010.

Polycostatus sulcatus (Furnish)

Plate 15, figs. 20-29; Text-fig. 6:10A

Subrounded and compressed elements

Scolopodus sulcatus Furnish, 1938, p. 334, Pl. 41, figs. 14 15.

Scolopodus sexplicatus Jones, 1971, p. 65, Pl. 5. figs. 4a c, 5a-c, 7a-c, 8a-c, Pl. 9, figs. 4a-c, text-figs. 16a-c; Cooper and Druce, 1975, p. 578, 579, fig. 29.

aff. "Scolopodus" sexplicatus? Jones. Ethington and Clark, 1981, p. 105, Pl. 12, figs. 3, 4.

?Drepanoistodus? sp. cf. D. inaequalis (Pander) Landing 1983, p. 1174, 1175, Figs. 7A, C (non Figs. 7B, E and 8J-V).

Utahconus utahensis (Miller). Ni & al. 1983, Pl. 1, fig. 30.

Acodus? oneotensis Furnish. Ni & al. 1983, Pl. 1 figs. 33, 38, 40, 41.

Rossodus? highgatensis Landing and Barnes, 1986, p. 1938-1940, Pl. 3, figs. 10, 13-18, 20, 25, text-figs. 3K, L, P.

?Scolopodus sulcatus Furnish. Repetski, 1988, Figure 2 (B-E).

Staufferiform element

"Acontiodus" iowensis Furnish. Landing and Barnes, 1981, Pl. 4, figs. 7, 11, 16, 21 (not figs. 12-14, 17-20).

?Semiacontiodus iowensis (Furnish). Landing and Barnes, 1986, p. 1942-1944, Pl. 1, figs. 6, 10 (non fig. 4), text-figs. 3C, H (non fig. 3B).

Scolopodus sp. cf. iowensis (Furnish). Jones, 1971, p. 65, Pl. 6, figs. 5a-c.

Emended diagnosis: A species of Polycostatus containing three element morphotypes: a subrounded element, c suberect symmetrical elements and e compressed elements. Elements are albid, multicostate, robust, and have expanded, relatively large base. Subrounded elements are robust, symmetrical with five to seven costae; suberect symmetrical elements are staufferiform-like cones with well developed small costae on the anterior face; e compressed elements are usually asymmetrical forms with slightly compressed bases, four to six costae.

Subrounded (a) element

Description: Elements are usually robust, multicostate forms with slightly expanded base and large basal cavity. Cusp is usually erect to reclined, or proclined in some specimens, short and sharply pointed, bearing four or more strong rounded costae, extending on base, where they become sharply keeled and are accompanied by two more keeled costae. All the costae terminate slightly above basal margin. Base varies from slightly to moderately expanded and is subcircular in cross-section. Basal cavity is relatively large and deep.

Suberect symmetrical (c) element

Description: Elements are staufferiform-like cones with several small costae on anterior face. Cusp is usually proclined or slightly curved posteriorly. Anterior face is usually ornamented by a major central costa, with two smaller costae on each side, or ornamented by five to seven smaller costae; posterior face is marked by a broad posterior carina, with one or two smaller costae on each side; two lateral sides are keeled. Base is expanded laterally and posteriorly, and is elliptical with lateral dimension the greatest. Basal cavity is relatively large and deep with apex near anterior side.

Compressed (e) element

Description: Elements are robust, multicostate, and laterally compressed forms with extremely expanded bases. Cusp is erect to reclined, usually short and sharply pointed, bearing four or less strong rounded costae, normally with three extending on base where they become sharply keeled. All costae terminate slightly just basal margin. Base is strongly compressed laterally or lateralposteriorly, and is subtriangular in cross-section. Basal cavity is large and deep, and apex of cavity is situated near lateral-anterior face.

Remarks: Jones (1971) established *Scolopodus sexplicatus* as a short proclined scolopodid form species with six keeled costae on the base. We suspect that his *S. sexplicatus* is the subrounded element, and a junior synonym of *P. sulcatus* (Furnish) multielement species as suggested by Repetski (1982, p. 51-52). Landing and Barnes (1986) described the new multielement species *Rossodus? highgatensis* which contains oistodiform and ramiform elements composing a completely transitional series from noncostate to variably costate elements. However, it is considered here that the variably costate elements of Rossodus? highgatensis probably belong to the subrounded and compressed elements of P. sulcatus; Landing and Barnes's oistodiforms may belong to R. manitouensis Repetski and Ethington; and their noncostate elements may be the subrounded and suberect symmetrical elements of Drepanodus pervetus Nowlan.

P. sulcatus can be easily distinguished from Polycostatus oneotensis by having more than four major costae, being much sturdier, and with well developed secondary costae in all elements. The compressed elements are similar to the compressed elements of Glyptodontus constrictus n. sp. and G. expansus n. sp., but the latter two species have fewer costae, and have strongly compressed bases. The suberect symmetrical elements of this species characterized by well developed anterior costae can be readily distinguished from those of Glyptodontus constrictus n. sp. and G. expansus n. sp. as well as other species which are related to Polycostatus sulcatus.

Within this apparatus species, the subrounded elements and compressed elements are the most common forms, but the suberect symmetrical elements are much less common.

Occurrence: This species is present in the lower part of Boat Harbour Formation in samples from Z2-20 to Z2-34 of Section 2; in samples from Z4-25 to Z4-32 of Section 4; in sample

Z6-10 of Section 6.

Number of specimens: Total, 520; a subrounded element, 287; c suberect staufferiform element, 53; e compressed element, 180.

Types: GSC 96011-96017.

Genus Protoprioniodus McTavish, 1973

Type species: Protoprioniodus simplicissimus McTavish, 1973.

Remarks: A multielement genus consisting of four element morphotypes: a subrounded ramiform elements, b transitional prioniodiform elements, c suberect symmetrical deltaform elements, and e compressed oistodiform elements, based on this study. Elements are usually small, albid, with adentate processes.

McTavish (1973) established Protoprioniodus as a multielement genus consisting of prioniodiform elements, ramiform elements that display a Cordylodus-Roundya transition series, and oistodiform elements.

Ethington and Clark (1981) gave detailed remarks on this genus but noted that they could not distinguish prioniodiform and ramiform types among their collections, and they found a transition series in which the principal variation is in the cross section of cusp.

The collections from the St. George Group show that subrounded elements, together with transitional elements and suberect elements comprise the first transition series, and compressed oistodiform elements, having two variants, form the second transition series.

Protoprioniodus undoubtedly evolved from *Acodus*, as noted by Cooper (1981, p. 175), probably from *Acodus lanceolatus* Pander.

Protoprioniodus simplicissimus McTavish

Plate 16, figs. 8-18

Subrounded element

Protoprioniodus simplicissimus McTavish, 1973, pp. 48-49, Pl. 2, fig. 8 only.

Oistodus triangularis Lindström. Ethington and Clark, 1964, p. 694, Pl. 114, fig. 4.

Oistodus delta Lindström. Ethington and Clark, 1965, p. 194, Pl. 2, fig. 7 only.

Protoprioniodus cf. *simplicissimus* McTavish. Löfgren, 1978, pp. 95-96, Pl. 9, figs. 13-14.

New genus A, Sweet, Ethington and Barnes. Tipnis, Chatterton and Ludvigsen, 1978, Pl. 3, figs. 12-13.

Transitional element

Protoprioniodus simplicissimus McTavish, 1973, PP. 48-49, Pl. 2, fig. 6 only.

New genus and species, Ethington and Clark, 1965, p. 203, Pl. 2, fig. 17.

New genus A, Sweet, Ethington and Barnes, 1971, p. 168, 170, Pl. 1, fig. 19 only; Barnes, 1974, p. 231, Pl. 1, fig. 5 (not fig. 4); Tipnis, Chatterton and Ludvigsen, 1978, Pl. 3, fig. 14 only.

Protoprioniodus cf. simplicissimus McTavish. Löfgren, 1978, pp. 95-96, Pl. 9, fig. 12 only.

Protoprioniodus aranda Cooper, 1981, pp. 175-176, P. 30, figs. 1, 6, 7 (not figs. 10, 12); Ethington and Clark, 1981, pp. 86-87, Pl. 9, figs. 24, 27, 28 only.

Protoprioniodus sp. A. Stouge, 1982, Pl. 5, figs. 5-6; Stouge and Boyce, 1983, Pl. 4, fig. 5.

Suberect element

?Oistodus delta Lindström. Ethington and Clark, 1965, p. 194, Pl. 2, fig. 13 only.

Compressed element

Protoprioniodus simplicissimus McTavish, 1973, pp. 48-49, Pl. 2, fig. 9 only.

Protoprioniodus sp. A. Stouge, 1982, Pl. 5. fig. 7; Stouge and Boyce, 1983, Pl. 4, fig. 8.

Emended diagnosis: A species of *Protoprioniodus* containing four element morphotypes: *a* subrounded elements, *b* transitional elements, *c* suberect symmetrical elements, and *e* compressed elements. Subrounded elements are ramiform with recurved cusp and short posterior process; transitional elements are prioniodiform having longer posterior blade-like process; suberect elements are symmetrical deltaform with high posterior costa and sharp lateral costae. Elements are usually small, finely striated, albid forms with well developed posterior processes which are adentate, with small basal cavity.

Suberect symmetrical (*c*) element

Description: Elements are suberect, symmetrical deltaform with strongly posteriorly compressed cusp except for posterior costa. Cusp is erect, and tapers rapidly. Anterior face is broadly rounded; posterior face is compressed with sharp-edged triangular-shaped high costa which begins at basal margin, and extends to near cusp tip; both lateral sides are keeled, and extend aborally as triangular lateral processes.

Remarks: McTavish (1973, pp. 48-49) gave a detailed description on the elements of this species except for the suberect symmetrical deltaform elements. His ramiform element is assigned to the a subrounded element, prioniodiform element to the b transitional element, and his oistodiform element to the e compressed element. Based on the St. George collections, a part of Cooper (1981)'s Protoprioniodus aranda probably belongs to P. simplicissimus. McTavish (1973) also suggested that specimens of "New genus and species" and Oistodus sp. B figured by Ethington and Clark (1965), and New Genus A figured by Sweet, Ethington and Barnes (1971) do not seem to belong in P. simplicissimus. However, if the apparatus of P. simplicissimus reconstructed herein is correct, all specimens described and noted above from Australia and North America should probably be assigned to same multielement species. Subrounded ramiform elements of this species are characterized by having a recurved cusp and a short posterior process; transitional prioniodiform elements by having longer posterior blade-like process; suberect symmetrical elements by having high posterior costa and triangular-shaped lateral costae; compressed oistodiform elements by having sharpedged cusp, longer anterior portion and posterior process. Two variants can be recognized within the compressed oistodiform elements: one has slightly a curved cusp, a relatively small anterior process, another has a relatively small cusp and a large anterior portion.

Occurrence: This species is present in the Catoche Formation in samples from Z2-91 to Z2-131 of Section 2; in samples from

Z6-32 to Z6-46 of Section 6.

<u>Number of specimens</u>: Total, 125; <u>a</u> subrounded element, 19; <u>b</u> transitional element, 42; <u>c</u> suberect symmetrical element, 7; <u>e</u> compressed element, 57.

<u>Types</u>: GSC 96025-96035.

Genus Protopanderodus Lindström, 1971

Type species: Acontiodus rectus Lindström, 1955.

Remarks: An apparatus containing three element morphotypes: a subrounded elements, b transitional elements, and e compressed elements. Elements are partially albid, slender coniforms with costae and grooves, and faintly developed longitudinal striations, and usually have small base and long cusp. Subrounded elements together with transitional elements and compressed elements form the first and second transition series respectively.

Lindström (1971, p. 50) established Protopanderodus for an apparatus composed of symmetrical and asymmetrical elements, but without oistodiform elements. He also noted that Protopanderodus includes panderodans with a cusp that is higher than base. Herein, it is considered that the apparatus has no oistodiform elements, and probably no suberect symmetrical elements. However, as with other slender coniforms, variation in the shape of cusp cross-section (subrounded, transitional and compressed), is a diagnostic feature of this genus. Most species have three major elements: a subrounded with symmetrical or asymmetrical unit and subcircular cross-section at the cusp, b transitional with asymmetrical unit and oval cross-section at the cusp, e compressed with asymmetrical unit and suboval cross-section. The degree of compression at the cusp increases from the subrounded through transitional to compressed elements.

Protopanderodus inconstans (Branson and Mehl)

Plate 18, figs. 7-14; Text-fig. 6:11B

Scolopodus inconstans Branson and Mehl, 1933, pp. 63-64, Pl. 4, fig. 1.

Emended diagnosis: A species of *Protopanderodus* consisting of three element morphotypes: *a* subrounded elements, *b* transitional elements, and *e* compressed elements. Subrounded elements are slender teridontiform having subcircular cross-section at base and cusp; transitional elements are drepanodiform-like with laterally compressed cusp and small base; compressed elements are slender scandodiform with two keeled costae. Elements are partially whited, and have slender cusp and short base with oval cross-section. Posterior median costa is well developed, and prominent in most specimens.

Subrounded (a) element

Description: Elements are slender teridontiform with subcircular cross-section at base and cusp, and without lateral costae. Cusp is generally reclined to recurved, and tapers slowly. Anterior face is usually sharply rounded; posterior face is from sharply rounded to slightly keeled as posterior costa; both lateral face are smoothly rounded without major costae and grooves. Base is flared or expanded posteriorly, with circular to oval outline. Basal cavity is conical in profile, and moderately deep. Most specimens have well developed fine striations.

Transitional (b) element

Description: Elements are laterally compressed drepanodiform-like forms with slender cusp and small base. Cusp is generally recurved to strongly recurved with lenticular cross-section. Both anterior and posterior sides are keeled; both lateral faces are strongly compressed with shallow grooves which begin just above basal margin, and die out near tip of cusp. Base is flared posteriorly, and oval in cross-section. Basal cavity is conical, and moderately deep. Most specimens are finely striated. There are two variants in this element: one strongly curved and laterally compressed, and one similar to subrounded element.

Compressed (e) element

Description: Elements are slender scandodiform, with two extremely keeled costae, and posteriorly flared base. Cusp is curved, and twisted at base-cusp junction. Inner face of cusp is flattened or slightly convex; outer face is smoothly rounded; both antero-lateral and postero-lateral sides are keeled. Base is strongly extended or flared postero-laterally as typical scandodiform feature at base-cusp junction. Basal cavity is moderately deep, and oval in cross-section. Most specimens are finely striated.

Remarks: The specimens of the transitional element from the St. George Group are similar to the type specimens described by Branson and Mehl (1933). The subrounded elements, transitional elements and compressed elements clearly show that the cusp became flattened by compression, with the anterior and posterior faces becoming gradually keeled as sharp-edged costae.

Occurrence: This species is present in the middle Boat Harbour Formation in samples from Z2-65 to Z2-65B of Section 2.

Number of specimens: Total, 151; a subrounded element, 55; b transitional element, 61; e compressed element, 35.

Types: GSC 96069-96076.

Protopanderodus prolatus n. sp.

Plate 18, figs. 1-6; Text-fig. 6:11C

Scandodus? n. sp. Ethington and Clark, 1965, p. 199, Pl. 1, fig. 6. aff. "Scandodus" flexuosus Barnes and Poplawski. Ethington and Clark, 1981, pp. 93-94, Pl. 10, figs. 20-22.

Derivation of name: From the Latin "prolatus", referring to the shape of the cusp.

Diagnosis: A species of Protopanderodus composing three element morphotypes: a subrounded elements, b transitional elements, and e compressed elements. Subrounded elements are slender protopanderodiform with small base and extremely long cusp; transitional elements are laterally compressed protopanderodiform having posteriorly flared base and slightly twisted slender cusp; compressed elements are scandodiform-like with strongly flared base and recurved cusp. Elements are partially albid, finely striated, and have small base and elongated cusp.

Subrounded (a) element

Description: Elements are slender protopanderodiform with small base and long cusp. Cusp is reclined to recurved, and tapers slowly. Cross-section at cusp is suboval in profile. Anterior face is rounded; posterior face has a wide posterior carina which begins basal margin, terminating near tip of cusp; both lateral sides are keeled, and in some specimens possess a poorly developed second costae. Base is small, and flared posteriorly, and cross-section is subcircular to quadrate-shaped.

Transitional (b) element

Description: Elements are laterally compressed, proto-panderodiform with posteriorly flared base and slightly twisted slender cusp. Cusp is recurved, and slightly twisted near base-cusp junction. One antero-lateral face is rounded, another side is keeled; one postero-lateral side is keeled, another side has a broad carina. Base is small, and oval in cross-section. Basal cavity is shallow, and conical in profile.

Compressed (e) element

Description: Elements are scandodiform-like slender cones with strongly flared base and recurved cusp. Cusp is strongly recurved, and slightly twisted near base-cusp junction, and lenticular in cross-section. Outer face is broadly rounded; inner face is generally flattened except broadly faint carina; both antero-lateral and postero-lateral sides are keeled. Base is flared posteriorly, and oval in cross-section. Basal cavity is conical in profile.

Remarks: Repetski (1982) suggested that *Scandodus* n. sp. of Ethington and Clark (1965) is different from *P. leonardii*

Serpagli (1974) by having lateral costae. Ethington and Clark (1981) named this species as aff. "Scandodus" flexuosus Barnes and Poplawski. However, typical S. flexuosus is extremely compressed, and has a short cusp without posterior carina, and lacks fine striations. Furthermore, P. prolatus n. sp. is also similar to P. elongatus, P. gradatus and P. leonardii of Serpagli (1974), it differs in having a subcircular cross-section to the base, a well developed broad posterior carina, and lacking a sharp-edged posterior costa and a number of secondary costae.

Occurrence: This species is present in the Catoche Formation in samples from Z2-85B to Z2-102 of Section 2; in samples Z10-F to Z10-G and from Z10-1 to Z10-11 of Section 10.

Number of specimens: Total, 174; a subrounded element, 86; b transitional element, 35; e compressed element, 53.

Types: GSC 96064-96068.

Genus Pteracontiodus Harris and Harris, 1965

Type species: Pteracontiodus aquilatus Harris and Harris, 1965.

<u>Emended diagnosis</u>: An apparatus consisting of five element morphotypes: <u>a</u> subrounded elements, <u>b</u> transitional elements, <u>c</u> suberect symmetrical elements, <u>e</u> compressed elements, and <u>f</u> suberect symmetrical elements. Subrounded elements are distacodiform with slender and multicostate cusp; transitional elements comprise acodiform-like cones with laterally compressed base and posteriorly and anteriorly keeled cusp; suberect symmetrical (<u>c</u>) elements are symmetrical distacodiform, characterized by suberect cusp and slightly expanded base; compressed elements are oistodiform with slightly twisted cusp and strongly expanded base; suberect symmetrical (<u>f</u>) elements are bilaterally symmetrical deltaform cones with posteriorly compressed cusp and extremely expanded base. Elements are hyaline, robust, large coniforms.

<u>Remarks</u>: <u>Pteracontiodus</u> is characterized by five major morphotypes that usually display two transitional series: subrounded distacodiform transitional series (<u>a</u>-<u>c</u>, first) and compressed oistodiform transitional series (<u>e</u>-<u>f</u>, second). For the former, the elements are symmetrical and asymmetrical, ornamented with four or more prominent keel-like costae whose orientations are variable; in the latter, the elements show a wide range of variation in oistodiform-like cones. The acodiform elements exhibit intermediate morphologies between the subrounded and compressed elements, but are associated with the first transition series. Generally, there is a suberect symmetrical

element within each transitional series.

Lindström (1977, p. 2) suggested that Pteracontiodus Harris and Harris is close to Acodus Pander in the components of its apparatus. It is true that Pteracontiodus not only has same apparatus plan as Acodus, but also closely related to Acodus, on the basis of western Newfoundland collections.

Pteracontiodus cryptodens (Mound)

Plate 16, figs. 19-26

Eoneoprioniodus cryptodens Mound, 1965a, p. 197-198, text-figs. 1, 2, 12, 13.

Pteracontiodus cryptodens (Mound). Ethington and Clark, 1981, p. 88, Pl. 10, figs. 1-4, 6-10 (contains complete synonymy through 1981).

Remarks: This species was described by Ethington and Clark as a multielement species characterized by elements that display a symmetry transitional series including cordylodiform, acodiform, distacodiform, trichonodelliform, and oistodiform elements, respectively. In order to use the same nomenclature to identify them as other species in this study, the asymmetrical distacodiform elements should be the subrounded element, the acodiform elements are equivalent to the transitional elements, the oistodiform elements are the compressed elements, the symmetrical distacodiform elements and trichonodelliform elements are assigned to the suberect symmetrical (c and f) elements.

As noted above under the remarks for the genus, two transitional series can be recognized. The first series consists of asymmetrical distacodiform elements whose lateral costae may vary in their orientations, and suberect symmetrical distacodiform elements; the second series contains compressed oistodiform elements having variation in their curvature near the base-cusp junction and in their suberect symmetrical deltaform elements; the transitional acodiform elements exhibit intermediate morphologies between the subrounded and compressed elements, but belong to the first transition series.

Occurrence: This species is found in the upmost Catoche Formation and through the Aguathuna Formation in samples from Z2-118 to Z2-134 of Section 2; in samples from Z3-16 to Z3-18 of Section 3.

Number of specimens: Total, 28; a subrounded element, 10; b transitional element, 6; c suberect symmetrical element, 1; e compressed element, 5; f suberect deltaform element, 6.

Types: GSC 96036-96041.

Genus *Rossodus* Repetski and Ethington, 1983

Type species: *Rossodus manitouensis* Repetski and Ethington, 1983.

Remarks: Repetski and Ethington (1983) established this genus for an apparatus comprising blade-like coniform elements that have a symmetry transition and oistodontiform elements. They also suggested that *Rossodus* is closely related to *Juanognathus* Serpagli and *Utahconus* Miller, because of morphologic similarity among the some of elements within these genera. However, on the basis of west Newfoundland collections, *Rossodus* has an apparatus containing four element morphotypes: *a* subrounded costate acontiodiform elements, *b* transitional drepanodontiform elements, *c* suberect symmetrical elements, and *e* compressed oistodontiform or scandodiform elements. *Rossodus* may not be related to *Juanogathus*, but clearly derived from *Rossodus tenuis* Miller which, in turn, was originally developed from *Utahconus utahensis* Miller or from *Tricostatus glyptus* n. sp.

Rossodus manitouensis Repetski and Ethington

Plate 17, figs. 1-9

Rossodus manitouensis Repetski and Ethington, 1983, p

289-301, Figs. 1-5 (contains complete synonymy through 1983).

"Oistodus" sp. A s.f. Nowlan, 1985, pp. 113-114, Figs. 4.13 4.15.

Semiacontiodus? sp. A Nowlan, 1985, pp. 114-115, Figs. 5.56, 7.1-7.3.

Rossodus manitouensis Repetski and Ethington. Landing, Barnes and Stevens, 1987, p. 1940, Pl. 2, figs. 10, 11, 14, 18; Ethington, Engel and Elliott, 1987, Pl. 8.1, fig. 14; Repetski, 1988, Figure 2-R-V.

Rossodus? highgatensis Landing, Barnes and Stevens, 1987, pp. 1938-1940, Pl. 3, figs. 10, 13-26; Text-figs. 3 K, L, N-P.

Emended diagnosis: A species of Rossodus consisting of four element morphotypes: a subrounded costate acontiodiform elements, b transitional drepanodiform elements, c suberect symmetrical elements and e compressed oistodiform elements. Subrounded element is costate form with rounded carina located antero-laterally on a blade-like cusp; transitional element is drepanodiform with compressed base and blade-like cusp; compressed element has a small angle between the posterior and oral edges and is drawn out at antero-basal corner; and suberect symmetrical element is blade-like form with laterally expanded base.

Subrounded (a) element

Description: Elements are relatively subrounded forms with well developed anterior carina. Cusp is usually proclined to erect, and composed entirely of white matter. Anterior face is sharply rounded near base and smoothly rounded close to tip of cusp with sharply rounded anterior carina; posterior face is slightly concave with faint carina beginning above basal margin and extending to tip of cusp; two lateral sides are keeled. Base is relatively small and expanded anteriorly and posteriorly. Basal cavity is rather shallow with apex located near anterior side.

Transitional (b) element

Description: Elements are usually postero-laterally compressed, very thin, drepanodiform with faint anterior carina. Cusp is usually proclined to erect and filled entirely with white matter. Anterior or antero-lateral face is smoothly rounded, but with faint anterior carina; posterior or postero-lateral face is flattened or slightly convex with faint posterior carina; two lateral sides are extremely keeled. Base is small and expanded posteriorly and anteriorly. Basal cavity is shallow, with its apex situated near one lateral side.

Suberect symmetrical (c) element

Description: Elements are symmetrical acontiodontiform elements with laterally expanded bases. Cusp is usually proclined to erect and tapers gradually above basal region. Anterior face is smoothly rounded with a faint carina that follows midline and continues aborally across basal margin; posterior face is slightly concave with faint central carina that usually begins at about level of basal cavity apex and becomes more prominent higher on cusp; two lateral sides are keeled. Base is strongly expanded laterally and slightly posteriorly. Basal cavity is rather shallow and its apex is located near anterior side.

Compressed (e) element

Description: Elements are oistodiform cones. Cusp is blade-like and filled with white matter. Inner face of cusp bears a narrow, sharply defined carina that approximately follows midline and continues aborally across basal region. Outer face of cusp is transversely convex. Two lateral sides are sharply edged. Basal region is somewhat flared medially to inside, with region of flare continuing upward to meet proximal end of carina. Basal margin is sinuous in lateral view. Basal cavity is shallow, its apex is located near one lateral side.

Remarks: Repetski and Ethington (1983) established the species for an apparatus containing a symmetry transition series of costate, conelike to blade-like coniform elements and an oistodontiform element. On the basis of the apparatus morphotypes recognized in this study, their asymmetrical conelike element should be reassigned to the subrounded element (a), their blade-like coniform element to the transitional element (b), their oistodontiform element is equivalent to the compressed element (e) and their symmetrical element with laterally expanded base is the suberect symmetrical element (c).

Occurrence: This species is present in the lower part of the Boat Harbour Formation in samples from Z2-24 to Z2-31 of Section 2; in samples from Z4-24 to Z4-36 of Section 4; in samples from Z6-10 to Z6-11 of Section 6.

Number of specimens: Total 584; a subrounded element, 195; b transitional element, 127; c suberect symmetrical element, 46; e compressed oistodiform element, 216.

Types: GSC 96042-96049.

Rossodus tenuis (Miller)

Plate 17, figs. 10-19

Compressed element

Oistodus minutus Miller (part), 1969, p. 443, Pl. 66, figs.

5-7 (notfigs.1-4).

Utahconus tenuis (Miller), 1980, Pl. 2, figs. 5-7; Figure 4T.

Emended diagnosis: A species of Rossodus containing three element morphotypes: a subrounded elements, c suberect symmetrical elements, and e compressed elements. All of three elements are characterized by having expanded basal cavity. Subrounded elements are lateral-posteriorly compressed with three major costae; compressed elements are scandodiform-like cones with posteriorly expanded base; suberect symmetrical elements are characterized by long, slender cusp.

Subrounded (a) element

Description: Elements are characterized by having two lateral costae and one weak anterior costa. Cusp is usually proclined, subtriangular in cross-section, and filled with white matter. Anterior face is gently rounded with weak anterior costa; posterior face is flattened with very weak carina; two lateral sides are keeled. Base is not only expanded posteriorly, but also laterally, and subquadrate in cross-section. Basal cavity is large.

Suberect symmetrical (c) element

Description: Elements are staufferiform-like cones with long slender cusp. Cusp is proclined to erect, strongly curved at base, and tapering rapidly, posteriorly compressed, and composed mostly of white matter. Anterior face is rounded with a weak median costa, and slightly expanded anterior margin; posterior face is flattened or smoothly rounded with faint costa extended to tip of cusp; two lateral sides are sharply rounded or keeled. Base is expanded laterally and posteriorly, and oval in cross-section. Basal cavity is large and deep.

Compressed (e) element

Description: Elements are scandodiform-like coniforms with posteriorly expanded base and two lateral costae. Cusp is proclined, oblate-oval in cross-section, and composed mostly of white matter. Anterior face is smoothly rounded, but with a faint costa; posterior face is smoothly rounded or flattened with a very weak carina in some specimens; two lateral sides are keeled. Lateral costa near posterior side joins posterior extension of base at gentle acute angle. Base is expanded posteriorly and laterally, and suboval or subquadrate in cross-section. Basal cavity is large and deep.

Remarks: The subrounded and compressed elements of this species are very similar to those of *Tricostatus glyptus* n. sp., but the elements have a large and deeper basal cavity than those of *T. glyptus* n. sp. The suberect symmetrical element of *R. tenuis* can be readily distinguished from those of other species which is related to this species by having a flattened posterior face. The subrounded elements and compressed elements are common forms, the suberect symmetrical elements are rare.

Occurrence: This species is present in the upper part of Watts Bight Formation in samples from Z2-8 to Z2-15 of Section 2; in samples from Z4-18C to Z4-20 of Section 4; in samples from Z6-3 to Z6-7 of Section 6; in samples from Z7-3B1 to Z7-7 of Section 7; in samples from Z9-7 to Z9-9 of Section 9.

Number of specimens: Total, 102; a subrounded element, 39; c suberect symmetrical element, 10; e compressed element, 53.

Types: GSC 96050-96057.

Genus Scolopodus Pander, 1856

Type species: Scolopodus sublaevis Pander, 1856.

Emended diagnosis: An apparatus which includes hyaline and partly albid, finely costate simple conodonts whose apparatus consists of a subrounded elements, b transitional elements, e compressed element, and/or associated with c or f suberect symmetrical elements in some species. Subrounded elements are scolopodiform having circular to ellipsoidal cross-section, well developed sharp-edged fine costae; transitional elements are paltodiform-like with fewer sharp-edged costae and laterally compressed cusp; compressed elements are asymmetrical scandodiform-like with few fine costae and slightly twisted and strongly compressed cusp; suberect (c) elements are costate staufferiform-like with small base; suberect (f) elements are ulrichodiniform-like with well developed fine costae.

Remarks: Pander (1856) described this genus as "slender, differently sharped teeth with white colour and lack of keels". Sweet and Bergström (1962) discussed some problems of the definition for Scolopodus, especially the difficulties of adequately separating Scolopodus and Paltodus. Lindström (1971) emended the definition of Scolopodus to include multicostate, symmetrical, simple conodonts with or without posterior and anterior keels. van Wamel (1974, p.93) suggested that the hyaline and partly white conodonts with the presence of fine costae belong to Scolopodus. Fåhræus (1982) also emended Scolopodus as the hyaline panderodontacean conodont-apparatus with simple symmetry transition series. However, it is considered that Scolopodus should be restricted to hyaline and partly albid, finely costate simple conodonts whose apparatus consists of three to four elements.

This genus is similar to Striatodontus n. gen., but differs by having coarser striae or fine costae and no posterior groove. Scolopodus is also close to Glyptoconus in general features, but its costae and grooves are not well developed. Scolopodus exhibits intermediate morphology between Striatodontus n. gen. and Glyptoconus in terms of the fineness of striae or costae and its hyaline structure.

Three apparatus species are included in this genus, they are S. cornutiformis Branson and Mehl, S. parabruptus Repetski and S. subrex n. sp.

Scolopodus cornutiformis (Branson and Mehl)

Plate 18, figs. 15-26; Text-fig. 6:12A

Subrounded cornutiformiform element

Scolopodus cornutiformis Branson and Mehl, 1933, p. 62, Pl. 4, fig. 23.

Scolopodus cornutiformis Branson and Mehl s.f. Repetski, 1982, p. 47, Pl. 21, figs. 4, 6 (contains complete synonymy through 1982).

Scolopodus n. sp. Mehl and Ryan, in Branson, 1944, Pl. 6, figs. 46, 47 (non figs. 27-30).

?Scandodus? n. sp. Ethington and Clark, 1965, p. 199, Pl. 1 fig. 6.

?Scolopodus multicostatus Barnes and Tuke, 1970, p. 92-93, Pl. 18, figs. 5, 9, 15, 16. Text-fig. 6D.

?Scolopodus multicostatus Barnes and Tuke. Ethington and

Clark, 1981, p. 101-102, Pl. 11, fig. 19 (non fig. 20).

Multicorrugatiform (=oistodiform) element

?Distacodus? n. sp. Mehl and Ryan, in Branson, 1944, Pl. 6, figs. 25-26.

Oistodus multicorrugatus Harris, 1962, p. 204, Pl. 1, figs. 2a-2c; Ethington and Clark, 1981, p. 68-70, Pl. 7, figs. 9, 10, 12-14 (contains synonymy through 1981).

?Oistodus aff. O. multicorrugatus Harris. Stouge and Bagnoli, 1988, p. 123-124, Pl. 6, figs. 9, 12, 13.

?Oistodus aff. O. lanceolatus Pander. Stouge and Bagnoli, 1988, p. 123, Pl. 6, figs. 6, 7.

Deltaform element

Oistodus delta Lindström. Ethington and Clark, 1965, p. 194, Pl. 2 fig. 13 (non fig. 7 = multicorrugatiform element).

Emended diagnosis: A species of Scolopodus containing four element morphotypes: a subrounded scolopodiform elements, b transitional scolopodiform elements, e compressed oistodiform elements, and f suberect deltaform elements. Subrounded elements are robust, strongly recurved, multicostate, and laterally compressed with anterior and posterior costae; transitional elements have strongly compressed cusp and anteriorly and posteriorly expanded base; compressed elements are characterized by having a blade-like, posteriorly recurved, multicorrugated cusp and laterally compressed, extremely posteriorly expanded base; suberect symmetrical elements are triangular-shaped deltaform with well developed lateral costae and posterior median costa. Elements are hyaline.

Subrounded (a) element

Description: Elements are scolopodiform, robust, and multicostate. Cusp is strongly recurved, laterally compressed with sharp anterior and posterior costae. Both lateral faces are ornamented by numerous sharp, fine costae. Base is slightly expanded posteriorly. Basal cavity is relatively deep being conical in shape. A detail description was given by Branson and Mehl (1933) and Barnes and Tuke (1970). Two variants can be recognized: one has extremely curved cusp and anteriorly and posteriorly expanded base, another has no expanded base but slender cusp.

Transitional (b) element

Description: Elements are similar to subrounded elements, but have more strongly compressed cusp and anteriorly and posteriorly expanded base.

Compressed (e) element

Description: Elements have transitional series with two major elemental variations: cladognathodiform morphotype and cordylodiform morphotype. Cladognathodiform morphotype is characterized by having broadly reclined cusp with two anterior costae separated by a depression and a posterior sharply keeled costa as well as two or three minor costae on each lateral face, and strongly keeled extended base with triangular cross-section. Cordylodiform morphotype has a reclined, strongly laterally compressed, posteriorly and anteriorly keeled, broad blade-like cusp with two faint minor costae on each lateral face, and posteriorly expanded, extremely keeled base.

Suberect symmetrical (f) element

Description: Elements are deltaform usually with stout cusp and triangular base in cross-section. Cusp is strongly curved, antero-posteriorly compressed and tapers rapidly with sharply pointed tip. Anterior face of cusp is broadly rounded or flattened with a faint median costa; both lateral sides are strongly keeled; posterior face is slightly flattened except a median posterior costa, and two minor costae on each small triangular area. Base is strongly expanded laterally and slightly posteriorly, and triangular in cross-section. Basal cavity is relatively large, but shallow.

Remarks: The species has been described and discussed previously by many authors. However, brief descriptions and remarks for three major elements are necessary, because the apparatus is newly reconstructed under the revised apparatus plan.

On the basis of the St. George Group collections, this species consists of two transition series: the first transition series containing the subrounded and transitional cornutiformiform elements; the compressed oistodiform elements comprising the second transitional series with two major elemental variants: cladognathodiform and cordylodiform coniforms. The suberect deltaform elements may go with the second transition series.

It is considered that this species is closely related to Scolopodus subrex with similar apparatus pattern and general feature, but two species can be easily distinguished.

Occurrence: This species is present in the lower part of the Catoche Formation in samples from Z2-70B to Z2-92 of Section 2; in samples from Z6-30 to Z6-46 of Section 6; in sample Z10-1 of Section 10.

Number of specimens: Total, 101; a subrounded element, 28; b. transitional element, 18; e compressed element, 48; f suberect symmetrical element, 7.

Types: GSC 96077-96084.

Scolopodus parabruptus Repetski

Plate 19, figs. 16-24; Text-fig. 6:13B

Subrounded rexiform

aff Scolopodus rex Lindström. Ethington and Clark, 1981, p. 104-105, Pl. 12, fig. 2 only.

Scolopodus parabruptus Repetski, 1982, p. 49, Pl. 22, figs. 4, 7(contains complete synonymy through 1982).

Emended diagnosis: A species of Scolopodus consisting of four element morphotypes: a subrounded scolopodiform elements, b transitional paltodiform elements, c suberect scolopodiform elements and e compressed scandodiform elements. Both a and b elements are characterized by having slightly contracted base and slightly stubby cusp bearing two or three strong longitudinal, posteriorly directed, lateral costae. Suberect element is symmetrical coniform with expanded base and costate cusp. Compressed scandodiform element has slightly expanded and twisted base and rapidly tapering cusp bearinq two moderate longitudinal lateral costae on one lateral side. Elements are partially albid.

Subrounded (a) element

Description: Symmetrical to asymmetrical, slightly stubby scolopodiform elements having circular to ellipsoidal cross-section, with two well developed sharp-edged costae that extend almost entire length of the element. Cusp is usually moderately recurved. Base is somewhat expanded in posterior direction, but is contracted around basal margin. Basal cavity is shallow.

Transitional (b) element

Description: Elements are asymmetrical and rather paltodiform. Cusp is strongly recurved above base and laterally compressed with lenticular cross-section. Two major costae that extend almost entire length of element are well developed. Base is somewhat contracted, slightly expanded in posterior direction in some specimens.

Suberect symmetrical (c) element

Description: Elements are rather stubby, symmetrical scolopodiform. Cusp is antero-posteriorly compressed, suberect. Anterior face is smooth without any major costae; both lateral sides bear two well developed costae running from basal margin to almost distal end of the cusp; posterior face bears one wide carina extending almost entire length of element. Base is not expanded, short. Basal cavity is rather shallow.

Compressed (e) elements

Description: Elements are asymmetrical scandodiform, but twisted near cusp-base junction. Cusp is postero-laterally compressed with lenticular cross-section, and tapers rapidly near base, but gently near end of cusp. Two strong longitudinal costae on inner face of cusp running from basal margin to about two-third up cusp. Outer face of cusp is usually smooth without costae. Base is expanded both antero-laterally and postero-laterally. Basal cavity is relatively shallow.

Remarks: Repetski (1982, p. 49) gave a detailed description for the subrounded element of this species. He noted that the subrounded element is similar to that of S. rex s.f. (=S. subrex n. sp.) in shape, and is distinguished from the latter by the albid cusp and by the strongly developed lateral costae on the new species. The other three elements of S. parabruptus can be readily distinguished from those of S. rex s.f. by the shape of cusp and base.

Occurrence: This apparatus species is present in the lower middle part of the Catoche Formation in samples from Z2-92 to Z2-97 of Section 2; in samples from Z6-40 to Z6-45 of Section 6.

Number of specimens: Total, 42; a subrounded element, 17; c suberect symmetrical element, 1; b transitional element, 10; e compressed element, 14.

Types: GSC 96099-96105.

Scolopodus subrex n. sp.

Plate 19, figs. 1-15; Text-fig. 6:13A

Subrounded and transitional scolopodiform elements

Scolopodus rex Lindström. Lee, 1970, p. 334, Pl. 8, figs. 8 9; Bergström and others, 1972, p. D38, Pl. 1, fig. b; Ethington, 1972, p. 22, Pl. 1, fig. 17; Lee, 1975, p. 89, Pl. 2, fig. 13; text fig. 4-I; Repetski, 1982, p. 50-51, Pl. 23, fig. 6, and Pl. 24, fig. 2; Ethington, Engel and Elliott, 1987, Pl. 8.(1), fig. 5.

Scolopodus cornutiformis Branson and Mehl. Ethington and Clark, 1965, p. 200, Pl. 1, fig. 10, 12; Ethington and Clark, 1971, p. 73, Pl. 2, figs. 21-22.

Scolopodus aff. *S. cornutiformis* Branson and Mehl. Barnes and Poplawski, 1973, p. 786, Pl. 1, figs. 9-10.

aff. *Scolopodus rex* Lindström. Ethington and Clark, 1982, p. 104, Pl. 12, fig. 1.

?*Scolopodus rex* Lindström. Abaimova, 1975, p. 104, Pl. 9, figs. 12, 15, 17, 20, 21, text-figs. 8 (22, 26).

?*Scolopodus* sp. Abaimova, 1975, p. 106, 107, Pl.9, figs. 13, 18, text-figs. 8 (32, 33).

?*Scolopodus rex houlianzhaiensis* An and Xu, 1983, p. 148, Pl. 12, figs. 23-27, text-figs. 11-7, 11-8.

Compressed scandodiform element

Scolopodus rex paltodiformis Lindström. Repetski, 1982, p. 51, Pl. 23, figs. 8, 10, 11.

Derivation of name: From the Latin "sub-" and "rex", meaning this species is similar to *Scolopodus rex* Lindström.

Diagnosis: A species of *Scolopodus* consisting of *a* subrounded scolopodiform elements, *b* transitional paltodiform elements, *e* compressed scandodiform elements and *f* suberect symmetrical ulrichodiniform elements. Subrounded elements are round with sharp-edged costae; transitional element is characterized by having laterally compressed cusp with costae that die out about halfway to two-thirds up cusp; compressed scandodiform element has a slightly twisted bladelike cusp with costae confined to base and lower part of cusp; suberect symmetrical ulrchodiniform element is straight simple cone with well developed costae.

Subrounded (*a*) element

Description: Elements are slender scolopodiform-like conodonts having circular to ellipsoidal cross-section, well developed sharp-edged costae that extend entire length of element. Costae have posterior face that is normal to surface near basal margin and on distal portion of cusp. Strongest costae occur in posterior portion of unit in most specimens. Cusp is usually suberect to recurved. Base is somewhat expanded in posterior direction, but is not flared laterally. Basal margin is subcircular to circular. Basal cavity is moderately deep.

Transitional (b) element

Description: Transitional elements are paltodiform-like, asymmetrical conodonts. Cusp is short, strongly recurved above base, and laterally compressed with lenticular cross-section. Costae are confined to basal region and to lower two-thirds of cusp. Two strongly sharp-edged costae or keels on lateral sides run from base to tip of cusp. These two costae are prominent in this element associated with several small shorter costae on base and lower part of cusp. Base is circular in outline. Basal cavity is small, directed laterally from plane of cusp.

Compressed (e) element

Description: Elements have a slightly twisted bladelike cusp above base whose posterior margin is bluntly biconvex. Costae are well developed, and confined to base and lower part of cusp. Inner face of cusp is only slightly convex. Cusp has antero-lateral and postero-lateral keels. Element recurved above base with cusp subtending an angle of more than 90 degree with axis of base. Most specimens have as many as three or four costae on outer cusp face in an antero-lateral position; a few specimens have less costae. Base is suboval in outline. Basal cavity is moderately deep.

Suberect symmetrical (f) element

Description: Elements are ulrichodiniform-like, proclined, simple cones. Cusp is bilaterally symmetrical, usually laterally compressed, anteriorly subrounded and thickened, and posteriorly slightly keeled. Cross-section of cusp is subtriangular to suboval. Base is quite short, and flared strongly on both sides and on posterior portion. Basal cavity is shallow. Elements have fine costae that extend entire length of element.

Remarks: Typical Scolopodus rex (?=Scolopodus quadratus Pander as suggested by Fåhræus, (1982)) has been well described by Lindström (1955). However, similar forms has been reported by Ethington and Clark (1981), Repetski (1982), and An & al. (1983). It is considered that Scolopodus subrex n. sp is the Midcontinent Province form, and differs from the forms described from the Atlantic Province by having fewer costae and a smoothly rounded anterior face. Ethington and Clark (1981) noted that significant differences exist in morphology between S. rex of Lindström (1955) and the North American form. So the Midcontinent form is assigned to new species S. subrex n. sp.

Ethington and Clark (1981) described two forms referred herein to this species, one was a scolopodiform element which is assigned as the subrounded element, another was a paltodiform element which is equivalent to the transitional element. Repetski (1982) described three major elements, unfortunately, he assigned the subrounded element to S. rex Lindström, the transitional element to the paltodiform element and the compressed scandodiform element to the scandodiform element of S. rex paltodiformis Lindström, because of lacking precise information on their stratigraphic and geographic distribution. Two forms of this species, symmetrical and asymmetrical elements have been described by An and Xu (1983); these are the subrounded and the transitional elements of S. subrex n. sp., respectively.

Of the four major elements, the subrounded elements are a symmetrical form with round cross-section and well developed sharp-edged costae that extend almost entire length of the element; the transitional elements are asymmetrical elements whose cusp cross-sections are lenticular, and the costae are not developed on the upper part of the cusp; the compressed elements resemble scandodiform elements with slightly twisted blade-like cusps, and costae that are confined at the base or the lower part of cusp; the suberect symmetrical elements are ulrichodiniform elements similar to those of species of Glyptoconus, but differ in having well developed costae.

Within this species, the subrounded and transitional elements are the most common forms; compressed elements are slightly less common form; the suberect symmetrical elements are rare.

Occurrence: This apparatus species is present in the upper part of the Boat Harbour Formation in samples from Z2-67B to Z2-72 in Section 2. The species has a short range in the St George Group and a widespread distribution in the Midcontinent Province.

Number of specimens: Total, 189; a subrounded element, 92; b transitional element, 33; e compressed element, 64; f suberect element, 2.

Types: GSC 96085-96098.

Genus *Semiacontiodus* Miller 1980

Type species: *Acontiodus* (*Semiacontiodus*) *nogamii* Miller, 1969.

Emended diagnosis: An apparatus containing four element morphotypes: a subrounded semiacontiodiform elements, b transitional semiacontiodiform elements, and c suberect symmetrical staufferiform-like elements and e compressed drepanodiform elements. Subrounded element is symmetrical with rounded cross-section at base and lateral costae on both lateral sides; transitional element is asymmetrical with oval cross-section at base and one lateral costa which results in dextral and sinistral forms; suberect symmetrical element has two lateral costae and posterior carina and expanded base; compressed element is asymmetrical with laterally compressed cusp and posteriorly keeled costa.

Remarks: Semiacontiodus Miller originally described as a subgenus of Acontiodus Pander by Miller (1969) was raised to generic rank by Lindström (1973, p. 437), and redefined by Miller (1980) as a multielement conodont consisting of a symmetry transition of two types of erect to reclined simple cones. On the basis of the St. George Group collections, Semiacontiodus is probably contains four element morphotypes.

As noted by Miller (1980), the ancestor of Semiacontiodus is probably Teridontus, because the apparatus pattern and the elements of both genera show a general similarity. Semiacontiodus may produce both Variabiloconus Landing and Barnes and Polycostatus n. gen., in terms of their apparatus plan and the similarity of the elements among these three genera.

Semiacontiodus is close to Teridontus, but differs in having a slightly expanded base, stubby cusp, well developed lateral shallow grooves in the subrounded and transitional elements, and well developed posterior carina in the suberect symmetrical elements.

Semiacontiodus nogamii (Miller)

Plate 22, figs. 1-12; Text-fig. 6:12B

Subrounded and transitional semiacontiodiform elements

Acontiodus (*Semiacontiodus*) *nogamii* Miller, 1969, p. 421, text-fig. 3G, Pl. 63, figs. 41-50.

Semiacontiodus nogamii Miller, 1980, p. 32, Pl. 2, figs. 11-12 (non. fig. 10 = *S. obesus* n. sp.) (contains complete synonymy through 1980).

Semiacontiodus nogamii? Miller. Nowlan, 1985, p. 114, Figs. 5.36, 5.44.

Semiacontiodus sp. Landing and Barnes, 1986, p. 1944, Pl. 1, figs. 3, 7.

Drepanodiform element

?*Acodus sevierensis* Miller, 1969, P. 418, Pl. 63, figs. 29 30.

Staufferiform element

Semiacontiodus lavadamensis (Miller). Miller, 1980, p. 33, Pl. 2, fig. 4 (contains complete synonymy through 1980).

Emended diagnosis: As for the genus, the apparatus contains four major elements which are albid, stubby forms.

Subrounded (a) element

Description: Elements are usually symmetrical forms. Cusp is usually erect to reclined, and filled with white matter. Anterior face is rounded without any costae; two lateral sides are keeled with two lateral costae; posterior face has a wide posterior costa flanked by two lateral shallow grooves. Costae begin near basal margin and continue to tip of cusp. Base is slightly expanded posteriorly, and is subcircular in cross-section. Basal cavity is moderately deep, and extends about to bend of cusp.

Transitional (b) element

Description: Elements are asymmetrical, laterally compressed cones. Cusp is erect to reclined and filled with white matter. Anterior face is rounded; posterior side has a wide offset posterior carina, resulting in dextral and sinistral forms; broad groove often present on one lateral side. One lateral costa usually begins very close to basal margin and continues to cusp tip. Base is expanded posteriorly with round to oval cross-section. Basal cavity is moderately deep, and extends to bend of cusp.

Suberect symmetrical (c) element

Description: Elements are symmetrical, somewhat staufferiform like simple cones with two lateral costae and central posterior costa. Cusp is usually erect to reclined, having a middle posterior costa that extends from tip of cusp to basal margin, and having two lateral costae that extend from basal margin to tip of cusp. Anterior face is rounded; posterior face is slightly concave or flattened. Base is expanded laterally, slightly expanded posteriorly and is oval in cross-section. Basal cavity is usually fairly shallow and is conical in profile.

Compressed (e) element

Description: Elements are laterally compressed with either very weak or no costae. Cusp is reclined to recurved, and filled with white matter. Shallow posterior groove is present in some specimens; anterior and posterior sides are keeled in other specimens. Base is oval in cross-section, and expanded posteriorly. Basal cavity is moderately deep, and extends to tip of cusp.

Remarks: This species was originally described by Miller (1969) as Acontiodus (Semiacontiodus) nogamii form species, and was emended by Miller (1980) as a multielement species consisting of two types of symmetrical and asymmetrical simple cones. Miller (1969, 1980) also described S. lavadamensis as symmetrical coniform elements with lateral costae and central posterior costa. On the basis of the Newfoundland collections, the apparatus of this species may contain four element morphotypes: subrounded element, transitional element, compressed element and suberect symmetrical element. It is considered that Miller's symmetrical and asymmetrical elements of S. nogamii may belong separately to the subrounded elements and transitional elements; Miller's S. lavadamensis may be the suberect symmetrical element; some elements of Miller's Monocostodus sevierensis probably represent the compressed element of this species.

It may be true that the ancestor of S. nogamii is Teridontus nakamurai (Nogami) as Miller (1980) noted, the differences between the two species is that S. nogamii has costae and lacks a circular cross-section.

The compressed element and suberect symmetrical element are uncommon forms, whereas the subrounded element and transitional element are common in this multielement species.

Occurrence: The species is present in the lower part of Watts Bight Formation in samples from Z1-22 to Z1-32 of Section 1; in samples from Z2-B to Z2-G and from Z2-1 to Z2-9 of Section 2; in samples from Z4-6 to Z4-14B of Section 4; in samples from Z5-1 to Z5-10 of Section 5; in sample Z6-2 of Section 6; in samples from Z7-2B to Z7-12 of Section 7; in samples from Z9-4 to Z9-3 of Section 9.

Number of specimens: Total, 764; a subrounded element, 387;

b transitional element, 239; c suberect symmetrical element, 37; e compressed element, 101.

Types: GSC 96156-96166.

Genus *Striatodontus* n. gen.

Type species: *Striatodontus prolificus* n. sp.

Derivation of name: From the Latin "striat-" and "-dontus", meaning finely striated tooth.

Diagnosis: An apparatus characterized by slender simple cones with weakly or unexpanded bases bearing well developed posterior groove and containing a subrounded oneotodiform elements, b transitional triangulariform element, c suberect symmetrical staufferiform elements and e compressed drepanodiform elements, and in some species may includes f suberect symmetrical ulrichodiniform element as well. However, a few species have only one or two-element morphotypes, such as *Striatodontus carlae* (Repetski), and *S. retractus* n. sp. All of elements are albid or partially hyaline and well striated longitudinally.

Description: Oneotodiform elements are characterized by stubby cusp with posteriorly expanded base and shallow posterior groove; triangulariform elements are simple cones with triangular cusps in transverse section, an unexpanded base and a broad trough or wide groove on the posterior face; drepanodiform elements are laterally compressed forms with longer cusps and very narrow posterior groove; suberect symmetrical staufferiform elements are characterized by extremely expanded bases, well developed keels and grooves on the lateral faces and posterior face; suberect symmetrical ulrichodiniform elements are straight forms characterized by unflared bases and well developed lateral grooves.

Remarks: Nowlan (1976) in his Ph.D. thesis, erected the same new genus, for several species formerly assigned to Scolopodus Pander. As the name has never been published, it seems appropriate to use the name here. As Nowlan (1976) noted, the new genus is erected for albid and partially hyaline, small, finely striated, slender cones which bear a posterior groove. The apparatus of this genus contains subrounded elements, transitional elements, compressed elements, suberect symmetrical staufferiform elements, and probably suberect symmetrical ulrichodiniform elements.

Striatodontus carlae (Repetski)

Plate 21, figs. 24-25; Text-fig. 6:14B

Scolopodus carlae Repetski, 1982, p. 49, Pl. 23, figs. 1, 2.

Remarks: A species of *Striatodontus* consisting of one or two element morphotypes of symmetrical or slightly asymmetrical small simple cones, hyaline or partially albid, finely striated, usually reclined with restricted basal opening.

Only a few specimens of this species are present in these collections. As described by Repetski, the elements of the species are characterized by having a reclined, antero-posteriorly compressed finely striated cusp and a constricted base, as well as a very shallow basal cavity. Based on this study, two elements are probably present in the apparatus: one is a subrounded element with circular basal margin and relatively well developed posterior median carina; another is a compressed element with antero-posteriorly compressed cusp, oval basal margin and faint posterior median carina. However, the differences between the subrounded element and compressed element are subtle.

S. carlae has an apparatus plan which is very similar to that of *Stultodontus costatus* (Ethington and Brand). On the basis of this study, *S. carlae* (Repetski) was probably derived from *Striatodontus gracilis* (Ethington and Clark) by strongly antero-posteriorly compression and loss of the basal cavity, as well as loss of the subrounded and transitional elements. *S. carlae* is probably the ancestor of *S. retractus* n. sp.

Occurrence: This species is found in the lower part of the Catoche Formation in samples from Z2-88 to Z2-128 of Section 2; in samples from Z6-35B to Z6-46 of Section 6; in samples from Z10-E to Z10-F and from Z10-1 to Z10-4 of Section 10.

Number of specimens: Total, 30.

Types: GSC 96150-96151.

Striatodontus gracilis (Ethington and Clark)

Plate 21, figs. 1-10; Text-fig. 6:14A

Subrounded element

Scolopodus gracilis Ethington and Clark, 1964, p. 699, Pl. 115, figs. 8, 9.

Scolopodus quadraplicatus Branson and Mehl. Ethington and Clark, 1964, pp. 699-700, Pl. 115, figs. 12, 25.

Scolopodus variabilis Ethington and Clark, 1964, p. 701, Pl. 115, fig. 14 only.

Transitional element

Scolopodus striolatus Harris and Harris, 1965, p. 38, Pl. 1, figs. 6a-d.

?Scolopodus gracilis Ethington and Clark. Barnes and

Poplawski, 1973, p. 786-787, Pl. 3, figs. 6-8.

"*Scolopodus*" *gracilis* Ethington and Clark, 1981, p. 100-101, Pl. 11, fig. 28 (non fig. 27); Stouge, 1982, Pl. 5, figs. 10-11.

Suberect symmetrical element

Scolopodus *paracornuformis* Ethington and Clark, 1981, p. 102, Pl. 11, figs. 21, text-fig. 25.

Semiacontiodus *asymmetricus* (Barnes and Poplawski). Stouge, 1982, Pl. 5, figs. 15-16 (non fig. 14).

Compressed element

Scolopodus *gracilis* Ethington and Clark, 1964, p. 699, Pl. 115, figs. 2, 3, 4.

Semiacontiodus sp. cf. *S*. *cordis* (Hamar). Stouge, 1982, Pl. 5, figs. 12-13.

Emended diagnosis: A species of *Striatodontus* consisting of *a* subrounded scolopodiform elements with well developed wide posterior carina, *b* transitional scolopodiform elements with shallow posterior groove, *c* suberect symmetrical elements with posterior carina having a very shallow median groove, and *e* compressed drepanodiform elements. All four element morphotypes are hyaline and slender with long cusp and cylindrical base and are finely striated.

Subrounded (a) element

Description: Elements are symmetrical, extremely slender forms with wide posterior carina flanked by two postero-lateral grooves. Cusp is usually reclined to recurved and tapers very slowly. Anterior face is smoothly rounded; posterior face has wide posterior carina flanked by two postero-lateral grooves which begin at basal margin and continue towards tip of cusp; two lateral sides are sharply rounded. Base is cylindrical, slightly expanded posteriorly. Basal cavity is conical, and apex of cavity is situated near the anterior side.

Transitional (b) element

Description: Elements are slightly asymmetrical forms with posterior groove. Cusp is usually reclined to recurved, slightly twisted, and tapers slowly. Cross-section of cusp is subcircular. Anterior face is rounded; two lateral faces are slightly compressed; posterior face has a prominent median groove which begins basal margin towards tip of cusp. Base is cylindrical in profile. Basal cavity is slightly deep and conical, and its apex is located near anterior side.

Suberect symmetrical (c) element

Description: Elements are symmetrical forms with slender cusp. Cusp is suberect to slightly reclined posteriorly, and posteriorly compressed. Anterior face is broad, smoothly rounded; posterior face is slightly flattened but with wide prominent carina having very shallow median groove; two lateral faces are keeled as sharp-edged costae. Base is oval in cross-section and slightly expanded posteriorly. Basal margin of posterior side is longer than that of anterior side. Basal cavity is conical and its apex is situated quite near anterior side.

Compressed (e) element

Description: Elements are slender drepanodiform with laterally compressed cusp and cylindrical base. Cusp is recurved, slightly twisted and tapers slowly. Cross-section of cusp is moderately biconvex, and edges are sharply rounded or keeled. Base is cylindrical or slightly expanded posteriorly. Basal margin is straight. Basal cavity is moderately deep, and its apex is located near anterior side. Growth axis starts at apex of cavity and continues along cusp parallel with and close to posterior margin.

Remarks: Ethington and Clark (1964) described the subrounded and compressed elements of this multielement species. However, most their specimens seem to be slightly different from all other collections (Mound, 1968; Repetski, 1982; this collection) in possessing an extremely slender cusp with a shallow lateral groove or costa. Furthermore, some of their specimens are close to smaller and slender subrounded and transitional elements of *Glyptoconus quadraplicatus* and

G. multiplicatus n. sp. A further investigation of Striatodontus gracilis is needed. Harris and Harris (1965) described the transitional element of this species as the form species Scolopodus striolatus which is characterized by a well developed posterior groove. Ethington and Clark (1981) named the suberect symmetrical element of the species as form species Scolopodus paracornuformis which is characterized by a rounded median posterior carina.

The species is similar to several species in its general features, but differences are present in several elements of the apparatus. The subrounded element resembles form species Scolopodus filosus Ethington and Clark, but differs in its characteristic posterior carina flanked by postero-lateral shallow groove; the transitional element is similar to the drepanodiform element of Striatodontus prolificus apparatus species, however, it is not laterally compressed; the compresed element resembles the paralleliform element of Glyptoconus quadraplicatus apparatus species, but it is finely striated with very slender cusp and cylindrical base. The compressed (graciliform) elements may be confused with those of Striatodontus prolificus n. sp., but they differ by having well developed fine striations and in being hyaline.

Within this species, the subrounded and transitional elements are quite common, but the compressed and suberect symmetrical elements are rare.

Occurrence: The species is found in the lower part of the Catoche Formation in samples from Z2-85B to Z2-140 of Section 2; in samples from Z3-2 to Z3-14 of Section 3; in samples from Z6-31 to Z6-46 of Section 6; in samples from Z10-B to Z10-F and from Z10-1 to Z10-8 of Section 10.

Number of specimens: Total, 273; a subrounded element, 60; b transitional element, 109; c suberect symmetrical element, 29; e compressed element, 78.

Types: GSC 96128-96136.

Striatodontus lanceolatus n. sp.

Plate 21, figs. 17-23; Text-fig. 6:14D

Derivation of name: From the Latin "Lanceolatus", meaning "lanceolate", referring the suberect elements of this species.

Diagnosis: A species of Striatodontus consisting of three element morphotypes: a subrounded elements, c suberect elements and e compressed elements. Elements are partially albid, antero-posteriorly compressed, laterally keeled, finely striated, and have slender cusp with shallow and narrow posterior groove and small restricted base.

Subrounded (a) element

Description: Elements are extremely slender coniforms with restricted base and antero-posteriorly compressed cusp. Cusp is usually reclined, and tapers slowly. Anterior face is sharply rounded; posterior face is compressed with faint posterior broad carina having a prominent median groove which begins base margin and dies out tip of cusp; both lateral sides are keeled. Base is small, restricted, and oval or circular in cross-section. Basal cavity is small, but deep and conical in profile.

Suberect (c) element

Description: Elements are erect slender coniforms with extremely long cusp and short base. Cusp is proclined to erect, and tapers slowly. Anterior face is flattened by antero-posteriorly compression; posterior face is strongly compressed except faint posterior carina having a prominent posterior groove which cuts basal margin and dies out at tip of cusp; both lateral sides are extremely keeled. Base is small, slightly restricted, and oval in cross-section. Basal cavity is small, but deep, and conical in profile.

Compressed (e) element

Description: Elements are slightly twisted slender coniforms with restricted base and strongly antero-posteriorly compressed cusp. Cusp is usually reclined, and tapers gently near the base. Anterior face is gently rounded; posterior face is flattened with poorly developed carina which usually has a prominent posterior groove through entire unit; both lateral sides are strongly keeled. Base is restricted with limited basal opening. Base cavity is small, oval in profile.

Remarks: *S. lanceolatus* n. sp. is a distinctive species, and is clearly related *S. prolificus* n. sp in terms of the stratigraphic range and the general features. Some specimens figured by Mound (1968) as *Scolopodus gracilis* Ethington and Clark also probably belong within this species.

Occurrence: This species is present in the middle Boat Harbour Formation in sample Z2-59 of the section 2; in sample Z6-16 of Section 6; in samples from Z8-6 to Z8-10 of Section 8.

Number of specimens: Total, 66; *a* subrounded element, 33; *c* suberect symmetrical element, 11; *e* compressed element, 22.

Types: GSC 96143-96149.

Striatodontus prolificus n. sp.

Plate 20, figs. 1-26; Text-fig. 6:15A

Oneotodiform element

?Distacodus? simplex Furnish, 1938, p. 328, Pl. 42, figs. 24-25.

?Oneotodus simplex Lindström, 1955, pp. 581-582.

?Oneotodus simplex (Furnish). Ethington and CLark, 1964, p. 695, Pl. 114, fig. 13.

?Oneotodus simplex (Furnish) s.f. Repetski, 1982, p. 36, Pl. 14, figs. 9, 11.

?Oneotodus cf. O. variabilis Lindström s.f. Repetski, 1982, p. 36-37, Pl. 14, figs. 13-14.

Oneotodus simplex (Furnish). Ethington and Brand, 1981, p. 239-247, Text-figs. 1-A, C, E, F, I; Text-figs. 2-B, C.

?Scolopodus sp. cf. S. robustus Ethington and Clark. Mound, 1968, p. 420, Pl. 6, fig. 24 (non figs. 27-29).

?Scolopodus quadraplicatus hemisphaericus Mound, n. sp., 1968, p. 418-419, Pl. 5, figs. 41, 47, 50-51, 58.

Triangulariform element

?Scolopodus triangularis Ethington and Clark. Longwell and Mound, 1967, p. 410, Pl. 1; Mound, 1968, p. 420, Pl. 6, figs. 30-38, 40; Abaimova, 1975, p. 104-105, Pl. 4, fig. 16, text-fig. 8 (20).

Scolopodus gracilis Ethington and Clark. Repetski, 1982, p. 48, Pl. 22, fig. 5 only.

Scolopodus n. sp. Mehl and Ryan, in Branson, 1944, Pl. 7, fig. 31.

Drepanodiform element

?Scolopodus gracilis Ethington and Clark. Repetski, 1982, p. 48, Pl. 22, fig. 8 only.

Scolopodus? gracilis Ethington and Clark. Stouge and Boyce, 1983, Pl. 1, fig. 12.

?Scolopodus n. sp. Mehl and Ryan, in Branson, 1944, Pl. 7, fig. 32.

Derivation of name: From the Latin "prolificus", referring the abundance of this taxon in many collections. The name was used by Nowlan (1976) for the same new species, but has remained unpublished and is retained herein.

Diagnosis: A species of Striatodontus containing a subrounded elements, b transitional elements, c suberect symmetrical elements, e compressed elements, and probably f suberect symmetrical elements as well. Subrounded elements are small oneotodiform-like coniforms with posteriorly compressed cusp and expanded base; transitional elements are small triangulariform with well developed posterior groove; suberect (c) elements are slender small staufferiform-like with strongly posteriorly compressed cusp and expanded base; compressed elements are drepanodiform with slender biconvex cusp and longitudinal posterior groove. Elements of this species are small, albid, finely striated longitudinally, and with well developed posterior groove.

Subrounded (a) element

Description: Elements are usually small, stubby, simple cones with an expanded base, which have a well developed groove posteriorly. Short stout cusp is moderately to strongly recurved near base and straight distally. Anterior face of cusp is broadly rounded; posterior face is weakly flattened with a rounded or sharp-edged shoulder on each side and a median groove starting at basal margin towards almost to distal tip; lateral faces bear angular or blunt posteriorly directed costae. Basal outline is circular to elliptical. Basal cavity is moderately deep.

Transitional (b) element

Description: Elements are small triangulariform usually with two variants: one is slender triangulariform with unexpanded base, another is stout triangulariform with slightly expanded base. Both variants are characterized by well developed wide posterior groove, their cusps are triangular in transverse section; slightly recurved above base; anterior faces are blunt; antero-lateral faces are flattened with shallow longitudinal groove near the anterior margin; posterior faces are occupied by broad trough which becomes increasing shallow toward tip of cusp. Edges on either side of posterior groove are very sharp in both variants. Basal outline is triangular. Basal cavities are moderately deep.

Suberect symmetrical (c) element

Description: Elements are relatively stunted forms with an moderately expanded base. Cusp is usually short, straight or slightly curved. Anterior and lateral faces are rounded; posterior face is flattened, with posterior carina having a prominent narrow median groove starting at base toward almost tip of cusp. A rounded or sharp-edged shoulder on each side of posterior face is well developed. Basal outline is oval to subcircular in cross-section. Basal cavity is deep.

Compressed (e) element

Description: Elements are drepanodiform, laterally compressed with a longitudinal posterior groove. Cusps are very long, slender, slightly curved, moderately biconvex in cross-section, and are slightly twisted in some long cusp specimens. Anterior and lateral faces are smooth without any grooves; posterior face is ornamented only by longitudinal posterior groove which is very narrow but deep from base through zone of curvature and toward tip of cusp. Basal outline is subcircular in cross-section. Basal cavity is moderately deep, with apex lying close to anterior margin.

Remarks: Distacodus? simplex described by Furnish (1938), probably is the subrounded element of S. prolificus n. sp. If this is so, S. prolificus n. sp. should be a junior synonym of Distacodus? simplex Furnish. The compressed elements in this species resemble the form species Scolopodus gracilis Ethington and Clark, but they are albid with faint striations; the transitional elements are similar to the form species Scolopodus triangularis Ethington and Clark, but they are albid, less slender and well finely striated. However, some poorly preserved specimens could be confused with these taxa. It may be important to check the hyaline condition and stratigraphic occurrence carefully.

In this apparatus, subrounded oneotodiform elements are characterized by an expanded base and short cusp; transitional elements have a triangular cusp in transverse section and a very wide posterior groove; compressed elements are characterized by having a smooth long and slender cusp indented by a narrow longitudinal posterior groove; suberect symmetrical staufferiform elements are forms with extremely expanded bases and a posterior carina which is divided by a prominent groove, deeping towards the base. The morphological transitional series among these four element morphotypes is clearly evident. The subrounded elements show a superficial similarity to the transitional elements; the compressed elements generally are quite distinct from both the subrounded elements and transitional elements, although some slender transitional elements with a narrower posterior groove bear a remarkable similarity to compressed elements. Moreover, the curvatures of the elements become increasingly great from straight suberect symmetrical staufferiform element, reclined subrounded element and transitional element, to strongly recurved compressed element. All the elements are finely striated, and are characterized by having a slender cusp with posterior groove and by a similar distribution of white matter.

Within this multielement species, the subrounded elements and transitional elements are most common forms; compressed elements are common, but less than subrounded or transitional elements suberect symmetrical staufferiform elements are rare, especially in the earliest forms staufferiform elements may be absent. A few specimens of an ulrichodiniform element have been found, and they have the same stratigraphic ranges and similarities in general features to the subrounded elements and the other three elements of this species; these specimens may represent the suberect symmetrical ulrichodiniform element within this apparatus.

Occurrence: This apparatus species is found in the middle part of Boat Harbour Formation in samples from Z2-35 to Z2-65 in Section 2; in samples from Z4-36 to Z4-37 in Section 4; in samples from Z6-12 to Z6-25 in Section 6; in samples from Z8-1 to Z8-10 in Section 8. This species is one of the most abundant species of collection.

Number of specimens: Total, 4386; a subrounded element, 2261; b transitional element, 1494; c suberect staufferiform-like element, 81; e compressed element, 546; f suberect ulrichodiniform-like element, 4.

Types: GSC 96106-96127.

Striatodontus retractus n. sp

Plate 21, figs. 26-29; Text-fig. 6:14C

Parapanderodus carlae (Repetski). Stouge and Bagnoli, 1988, Pl. 7, figs. 4-5.

Derivation of name: From the Latin "retractus", referring to the retracted base of this species.

Diagnosis: A species of Striatodontus consisting of one or two element morphotypes: a subrounded and/or e compressed elements. Elements are small symmetrical and asymmetrical cones, usually erect or straight, antero-posteriorly compressed, partially albid, finely striated with extremely contracted base and extremely small basal cavity.

Description: Elements are slightly antero-posteriorly compressed, small simple cones with extremely contracted base and very small basal cavity. Cusp is erect and tapers gently to distal tip. Lateral width increases above base so that base of cusp is almost one and a half times wider than basal rim. Anterior face is smoothly convex; posterior face is usually flattened or smoothly convex, with very low but wide median carina; two lateral sides are keeled as sharp edges. Base is extremely contracted near basal margin and slightly expanded at region of base-cusp junction. Basal cavity is very small or not present. Elements are finely striated longitudinally; striae on posterior face are coarser than those on anterior face.

Remarks: This species may be a descendant of Striatodontus carlae (Repetski), because both species have a contracted base and both are ornamented with fine striae. However, this new species differs by having an extremely contracted base and a very small basal cavity. Both S. carlae and this new species may have two elements, in which one is slightly rounded, and another is slightly compressed antero-posteriorly.

S. retractus n. sp. is a distinctive species, and has a short stratigraphic range, with widespread distribution in the Midcontinent Province (recognized by the author in G. S. Nowlan's Arctic collections; R. L. Ethington's unpublished collections from Oklahoma).

Occurrence: This species is found in the lower part of the Aguathuna Formation in samples from Z2-124 to Z2-126 of Section 2; in samples from Z3-6 to Z3-11 of Section 3.

Number of specimens: Total, 67.

Types: GSC 96152-96155.

Striatodontus teridontus n. sp.

Plate 21, figs. 11-16; Text-fig. 6:15B

Derivation of name: From the Latin "teri-", and "-dontus", referring the subrounded element of the species.

Diagnosis: A species of Striatodontus consisting of two element morphotypes: a subrounded elements and e compressed elements. Subrounded elements are teridontiform-like forms with slender cusp and slightly expanded base; compressed elements are drepanodiform-like forms with laterally compressed cusp, two moderately keeled costae, and posteriorly flared and expanded base. Elements are albid, finely striated.

Subrounded (a) element

Description: Elements are teridontiform-like coniforms with slender cusp and slightly expanded base. Cusp is reclined to slightly recurved, and is long with round cross-section. Base is short with circular cross-section, and slightly expanded posteriorly in some specimens. Basal cavity is large but moderately deep, and conical with centrally situated apex.

Compressed (e) element

Description: Elements are drepanodiform-like coniform with strongly laterally compressed cusp, and anteriorly and posteriorly expanded base. Cusp is recurved to strongly recurved, and tapers slowly with anterior and posterior knife-edges, and has lenticular cross-section. Anterior sharp costa begins near bend of cusp and extends to tip; posterior knife-edge present along almost entire cusp. Base is laterally compressed, expanded posteriorly, having oval cross-section. Basal cavity is large and moderately deep.

Remarks: This multielement species is a distinctive form, characterized by having subrounded teridontiform-like element and compressed drepanodiform-like element, and well developed longitudinal fine striations. The subrounded element is similar to that of *Teridontus obesus* n. sp., but it is slender with coarser striations. The compressed element is distinguished from that of *Striatodontus gracilis* (Ethington and Clark) and those paralleliform elements of *Glyptoconus* by having albid cusp.

Striatodontus teridontus n. sp. is regarded as a descendant of *S. prolificus* n. sp. by specialization in loss of both the transitional element and the suberect (*c*) element.

Occurrence: This species is present in the middle Boat Harbour Formation in samples from Z2-50 to Z2-55 of Section 2; in sample Z6-24 of Section 6.

Number of specimens: Total, 25; *a* subrounded teridontiformlike element, 20; *e* compressed drepanodiform-like element, 5.

Types: GSC 96137-96142.

Genus Stultodontus n. gen.

Type species: Oneotodus costatus Ethington and Brand, 1981.

Derivation of name: From the Latin "stult-" and "-dontus", meaning stubby tooth, referring to the general profile of the genus.

Diagnosis: An apparatus containing two element morphotypes: a subrounded stubby oneotodiform elements and e antero-posteriorly and orally compressed stubby oneotodiform elements. This genus is characterized by stubby, albid and partially albid coniform elements ornamented by several stout, asymmetrical, longitudinal costae.

Remarks: Elements belonging to this genus have been recorded by many conodont workers in the last several decades (e.g., Mehl and Ryan in Branson, 1944; Ethington and Clark, 1964; Barnes and Tuke, 1970; Barnes, 1974; Barnes and Slack, 1975; Ethington in Toomey and Nitecki, 1979; Ethington and Brand, 1981; Repetski, 1982). Most of these species were placed in Scolopodus, although some species were assigned to Oneotodus. However, few workers have studied them in great detail except Ethington and Brand (1981). Based on the present study of several thousand specimens, these forms are sufficiently distinct from both Oneotodus and Scolopodus, and are assigned to a new genus.

The new genus is erected for stubby coniform ornamented by stout longitudinal costae. The apparatus of this genus contains only two element morphotypes, a subrounded oneotodiform and e antero-posteriorly and orally compressed oneotodiform elements. As noted by Ethington and Brand (1981), the genus differs from "Oneotodus" (=Striatodontus) by having well developed stout costae, and also by lacking a posterior groove. The genus can be distinguished from Scolopodus by the stubby cusp and expanded base with well developed stout costae, albid to partially hyaline condition, as well as having two fewer elemental morphotypes in the apparatus plan.

Stultodontus costatus (Ethington and Brand)

Plate 22, figs. 13-22

Subrounded and compressed cornutiform elements

Acontiodus viriosus Chui, in An & al. 1983, p. 71, Pl. 16, figs. 5-8, text-fig.12-12.

Oneotodus costatus Ethington and Brand, 1981, p. 242, Text-figs. 1B, D, G, H, and Text-figs. 2A, D-M (contains synonymy through 1981); Stouge and Boyce, 1983, Pl. 3, fig. 7.

Emended diagnosis: A species of Stultodontus consisting of simple cones having an apparatus of a subrounded to rounded multicostate oneotodiform elements with robust cusp and base, and e compressed oneotodiform elements with posteriorly or laterally compressed and slightly twisted cusp. Elements are extremely robust, usually costate, partially hyaline, and have short cusp and expanded base.

Subrounded (a) element

Description: Subrounded elements are robust multicostae, and extremely stubby elements characterized by ellipsoidal to circular transverse sections. Surfaces are ornamented by stout, asymmetrical, longitudinal costae which extend along faces from edge of base and terminate at point of cusp. Most specimens show relatively few but strongly sharp-edged, widely spaced costae, but some early forms have numerous, closely crowded ridges. Cusp is suberect to erect and tapers moderately in most elements. Basal outline is round to subovate. Basal cavity is very large, and conical in shape.

Compressed (e) element

Description: Compressed elements are multicostate, extremely stubby simple conodonts characterized by oval to ellipsoidal cross-section. The lateral faces are ornamented with stout, longitudinal costae. Two lateral costae of posterior face are well developed, and extend along edge of base and terminate at tip of cusp; other costae on lateral faces are not well developed, and are confined to the base and lower part of cusp. Posterior and anterior surfaces are usually smooth on most compressed specimens. Cusp is reclined to suberect, and tapers rapidly. Elements are compressed laterally and posteriorly, or may be orally compressed. Base is strongly expanded posteriorly. Basal cross-section is oval. Basal cavity is conical, and its posterior wall is long and straight in profile.

Remarks: Ethington and Brand (1981) considered the apparatus of this species to consist wholly of "simple cone" elements displaying variations in development of costae, in curvature along their lengths, and in overall relative dimensions. Indeed, the apparatus of an early stage of the species consists of only subrounded elements and/or compressed elements. The subrounded elements are characterized by having well developed costae and small curvature; the compressed elements have fewer costae and marked curvature. In the late stage, the apparatus of this species has two distinct element morphotypes: subrounded element and compressed element. No distinctive variations of the costae and the curvature exist between the early stage forms and the late stage forms in subrounded element and compressed element. In general, the curvature gradually increases from the subrounded element to compressed element.

In this multielement species, both the subrounded and compressed elements are equally common forms.

Occurrence: This apparatus species is present in the upper part of Boat Harbour Formation and the Lower part of Catoche Formation in samples from Z2-67 to Z2-139 of Section 2; in samples from Z3-10 to Z3-22 of Section 3; in samples from Z6-26 to Z6-46 of Section 6; in samples from Z10-A to Z10-F and from Z10-1 to Z10-4 of Section 10.

Number of specimens: Total, 1315; a subrounded element, 842; e compressed element, 473.

Types: GSC 96167-96174.

Stultodontus ovatus n. sp.

Plate 23, figs. 1-9

Subrounded element

Scolopodus? sp. Stouge, 1982, Pl. 3, figs. 16-18; Stouge and Boyce, 1983, Pl. 3, fig. 3.

?Scolopodus abruptus Repetski, 1982, p. 45, Pl. 21, figs. 3a-c (non fig. 1a-c = S. pygmaeus n. sp).

Derivation of name: From the Latin "ovatus", meaning oval-shaped and referring the shape of orally compressed element.

Diagnosis: A species of Stultodontus consisting of two element morphotypes: a subrounded abruptiform element and e oral compressed armadilloform element. Subrounded elements are extremely short and stubby with numerous strong, evenly spaced, posteriorly directed costae; oral-compressed elements are shaped like armadillo's armour with numerous serrated, posteriorly directed costae.

Subrounded (a) element

Description: Elements are extremely stubby cones with expanded bases. Cusp tapers rapidly to pointed apex, and consists of white matter beginning at base-cusp juncture. Cusp bears numerous strong posteriorly directed costae. Costae diverge on expanded base and die out before reaching basal margin. Anterior face of cusp is rounded, and posterior face is slightly flattened or concave. A sharply rounded shoulder on each side of posterior face is well developed. Base is extremely short and is suboval in cross-section. Basal cavity is conical and its posterior wall is long.

Oral-compressed (e) element

Description: Elements are relatively small, tear drop-shaped or resembling the shape of armadillo's armour, and are oral-compressed and posteriorly compressed. Cusp is extremely recurved, and may be extremely short and stubby with pointed end. Small aperture is present on anterior face from base to more pointed end. Anterior face or oral surface is ornamented by number of serrated costae which are directed towards aperture. Posterior face is concave, oval in profile. Basal region is very short. Basal cavity is shallow, and is long oval.

Remarks: This new species is interpreted here as bearing a two morphotype apparatus consisting of subrounded abruptiform and oral-compressed armadilloform elements. The abruptiform and armadilloform elements probably evolved from the compressed element of Stultodontus costatus (Ethington and Brand), with the extreme oral-compression of the cusp and the shortening of the basal cavity.

Repetski (1982) illustrated several specimens, which he referred to new species S. abruptus, but one of them (Pl. 21, fig. 3), with an extremely short and stubby cusp and a posteriorly expanded base, is probably the subrounded element of this new species. The specimens illustrated by Stouge (1982) and Stouge and Boyce (1983) as Scolopodus sp. should belong to the oral-compressed element of S. ovatus n. sp.

Occurrence: This species is present in the lower part of the Catoche Formation in samples from Z2-85B to Z2-102 of Section 2; in samples from Z6-34B to Z6-46 of Section 6; in samples from Z10-A to Z10-E and from Z10-1 to Z10-10 of Section 10.

Number of specimens: Total, 301; a subrounded element, 130; e compressed element, 171.

Types: GSC 96175-96182.

Stultodontus pygmaeus n. sp.

Plate 23, figs. 10-19

?Scolopodus abruptus Repetski, 1982, p. 45, Pl. 21, figs. 1 a-b.

Diagnosis: A species of Stultodontus consisting of two element morphotypes: a subrounded abruptiform elements and e oral-compressed pygmaeform element. Subrounded elements are stubby with reclined to recurved cusp which has four to six major costae; oral-compressed elements are extremely stubby with extremely expanded base, swollen cusp and pointed tip of cusp.

Subrounded (a) element

Description: Elements are stubby and slightly oral-compressed with four to six costae. Cusp is usually reclined to recurved with pointed apex, and partially albid. Anterior face is smoothly rounded without costae; posterior face is slightly concave with four minor costae and one central and two lateral shallow grooves; each lateral face has two or three major costae beginning just above basal margin and joining in with costae of other side near tip of cusp. Base and lower portion of cusp are usually hyaline, and base extremely expands posteriorly. Cross-section of base is oval. In most specimens, basal cavity is moderately deep and elongate in profile; but some other specimens, cavity is slitlike and extended posteriorly and anteriorly.

Oral-compressed (e) element

Description: Elements are extremely stubby with oral-compressed cusp and expanded base. Cusp is strongly recurved extremely short and stubby with pointed apex, slightly swollen in region of cusp and base junction, and resembles a bird's head in profile. A small and faint linear suture is present on the anterior face. Anterior face or oral face is ornamented by a number of costae which are directed towards suture; posterior face is slightly concave with three very shallow grooves and four minor costae; lateral costa on each side of posterior face is well developed as sharp-edged shoulder. Base is extremely expanded posteriorly and usually elongate in cross-section. Basal cavity is moderately deep and elongate to slitlike. Anterior wall of cavity is very short and posterior wall is extremely long. Apex of cavity is located at anterior side.

Remarks: This apparatus species contains two major element morphotypes as described above. However, the transitional element, with a more orally compressed base and a strongly reclined or recurved cusp, this is similar to the subrounded element. Paratype specimens of *Scolopodus abruptus* Repetski (1982) may be the subrounded element of the new species, because they have almost same shape of cusp and base. If Repetski's specimens are exactly same as the specimens described here, the name of this species should be *Stultodontus abruptus*. Subrounded elements of this species are similar to those of *S. ovatus* n. sp. but they differ in having an elongate cusp with less costae and an extremely expanded base posteriorly. The oral-compressed elements are readily distinguished from those of *S. ovatus* n. sp.

Within this apparatus, the subrounded elements are most common forms and the oral-compressed elements are relatively rare.

Occurrence: This species is found in the lower part of the Catoche Formation in samples from Z2-85B to Z2-92 of Section 2; in samples from Z6-44 to Z6-46 of Section 6; in sample Z10-1 of Section 10.

Number of specimens: Total, 31; *a* subrounded element, 15; *e* compressed element, 16.

Types: GSC 96183-96190.

Genus *Teridontus* Miller, 1980

Type species: *Oneotodus nakamurai* Nogami, 1967

Emended diagnosis: The apparatus consists of four element morphotypes: *a* symmetrical subrounded elements, *b* transitional elements, *c* suberect symmetrical elements and *e* compressed elements. Subrounded elements are usually suberect to reclined, without any keels and costae; transitional elements are normally reclined to recurved, with one very shallow groove on one side; compressed elements are characterized by laterally compressed cusp with two costae of which one is near anterior side, and another is near posterior side; suberect symmetrical elements are straight cones with expanded and subrounded base. Elements are albid, and finely striated (well preserved specimens).

Remarks: Miller (1980) established the genus *Teridontus* as one-element apparatus consisting of symmetrical simple cones, usually erect to reclined, lacking keels and costae and with a cusp composed almost entirely of white matter. Miller (1980) also established the genus Monocostodus as a one element apparatus consisting of a symmetry transition series with slender, erect to reclined simple cones. However, it is considered that Teridontus has a four element apparatus consisting of subrounded, transitional, compressed and suberect symmetrical elements, and that some forms assigned to Monocostodus by Miller (1980) are the compressed elements of Teridontus. It is also considered that the early stages of the apparatus of Teridontus in the earliest stage may lack the compressed element, transitional element and suberect symmetrical element.

Three multielement species are included in this genus, they are T. nakamaruai (Nogami), T. gracillimus Nowlan, and T. obesus n. sp.

Teridontus gracillimus Nowlan

Plate 24, figs. 18-25; Text-fig. 6:15A

Gracillimiform element

Teridontus gracillimus Nowlan, 1985, p. 116, Figs. 8.2-8.3.

?Oneotodus? sp. A s.f. Landing and Barnes, 1981, p. 1618, Pl. 1, fig. 6; text-fig. 3(30).

?Teridontus nakamurai (Nogamii). An & el. 1983, p. 156, Pl. 6, fig. 4.

Monocostodiform element

?Acodus sevierensis Miller, 1969, p. 418, Pl. 63, figs. 25 28.

?Monocostodus sevierensis (Miller), 1980, p. 27, Fig. 4U, Pl. 2, figs. 8-9.

Emended diagnosis: A species of Teridontus consisting of four element morphotypes: a subrounded slender teridontiform elements with round cusp and base cross-section, b transitional slender teridontiform elements with shallow groove on one lateral side, and e compressed slender drepanodiform elements with compressed cusp. All of elements are small, extremely slender simple cones. All of elements are very finely striated.

Subrounded (a) element

Description: Elements are very slender teridontiform cones. Cusp is usually suberect to reclined, very long, and filled with white matter. Base comprises one-quarter total length of element. Basal cavity is very slender, and is moderately deep. Tip of cavity is near center. Cross-section of both cusp and base is round.

Transitional (b) element

Description: Element is almost same as subrounded element, but it has a very shallow groove on one lateral side, and its cusp is usually reclined. Some specimens of this element are slightly compressed laterally, so cross-section is round to oval at base.

Compressed (e) element

Description: Elements are extremely slender drepanodiform. Cusp is suberect to reclined, very long, laterally compressed with a anterior knife-edge and a posterior sharp-edge, and composed entirely of white matter. medial portion of cusp is wide. Cross-section of base and lower cusp is round to oval. Base is slightly compressed laterally, and slightly expanded posteriorly. Basal cavity is moderately deep with medially situated apex.

Remarks: Nowlan (1985) established this species as a form species. It is characterized by small, extremely slender simple cones with a round cross-section and narrow basal cavity. Herein, this species is considered to have an apparatus with four major elements, but no suberect symmetrical element has been found. The species bears a resemblance to the type species of Teridontus (T. nakamurai), but the latter is much bigger, broader, and has a wider basal cavity in all four elements.

Occurrence: T. gracillimus is present in the middle part of Watts Bight Formation in samples from Z2-10 to Z2-16 of

Section 2; in samples from Z4-16 to Z4-20B of Section 4; in samples from Z5-7 to Z5-8 of Section 5; in samples from Z7-9 to Z7-17 of Section 7; in samples from Z9-4 to Z9-9 of Section 9.

Number of specimens: Total, 351; a subrounded element, 194; b transitional element, 95; e compressed element, 77.

Types: GSC 96208-96213.

Teridontus nakamurai (Nogami)

Plate 24, figs. 1-9; Text-fig. 6:15C

Nakamuraiform element

Oneotodus nakamurai Nogami, 1967, p. 216-217, Pl. 1, figs. 9, 12, text-figs. 3A, 3B.

Teridontus nakamurai (Nogami). Miller, 1980, p. 34, 35, Pl. 2, figs. 15, 16, text-fig. 40 (contains complete synonymy through 1980); Landing and Barnes, 1981, p. 1614, Pl. 1, figs. 15-17, 20, text-fig. 3(16); An & al., 1983, p. 156-157, Pl. 6, figs. 1-3, 5 (non fig. 4); Nowlan, 1985, p. 116, figs. 5.26-5.32; Bagnoli, Barnes and Stevens, 1987, Pl. 2, figs. 17-18.

Monocostodiform element

?*Acontiodus* (*Semiacontiodus*) *unicostatus* Miller (part), 1969, p. 421, Pl. 64, figs. 49-54.

Monocostodus *sevierensis* (Miller). Nowlan, 1985, p. 113, figs. 5.33-5.35; An & al., 1983, p. 108, Pl. 6, figs. 19-23.

Erectiform element

?*Oneotodus* *erectus* Druce and Jones, 1971, p. 80, Pl. 15, figs. 2, 3, 4, 6.

Teridontus *erectus* (Druce and Jones). Al & al., 1983, p. 155, Pl. 6, fig. 9.

Teridontus n. sp. A. Nowlan, 1985, p 116-117, figs. 4.27, 4.28, 8.1.

Emended diagnosis: A species of *Teridontus* containing four element morphotypes: *a* subrounded and *b* transitional nakamuraiform elements, *c* suberect symmetrical teridontiform elements and *e* compressed monocostodiform elements. Subrounded elements are reclined, without any keels, costae or grooves; transitional elements are characterized by having a very weak groove on one of the lateral side; compressed elements are laterally compressed with two major costae on anterior and posterior sides; suberect symmetrical elements are straight cones with expanded bases.

Subrounded (*a*) element

<u>Description</u>: Elements are symmetrical forms, characterized by simple morphology. Cusp is suberect to reclined, and tapers slowly to apex, composed almost entirely of white matter. Cross-section is circular at either base or cusp. Base is moderately long, slightly narrow at basal margin in some specimens. Basal cavity is moderately deep. Tip of cavity is near center. Surface of cusp and base is covered by microstriae in majority of specimens.

Transitional (<u>b</u>) element

<u>Description</u>: Elements are asymmetrical forms with a very shallow groove on one lateral side, characterized by slightly variable morphology. Cusp is reclined to recurved, and tapers gradually to apex, composed entirely of white matter. Cross-section is subcircular or nearly so at the cusp, and is circular at base. Base is moderately long, and slightly expanded at posterior basal margin. Basal cavity is large, but not very deep, and tip of cavity is near center or slightly close to anterior side. Elements are covered by microstriae.

Suberect symmetrical (<u>c</u>) element

<u>Description</u>: Elements are suberect symmetrical forms with weak posterior carina, and expanded base. Cusp is usually erect, stubby, composed of white matter. Cross-section is round at cusp and is oval at cusp. Anterior face is broadly convex. A

weak posterior carina without a median groove is developed. Base is expanded laterally and posteriorly. Basal cavity is large but relatively shallow.

Compressed (e) element

Description: Elements are asymmetrical cones, characterized by laterally compressed cusp with two sharp costae. Cusp is reclined to recurved, laterally compressed with both anterior costa and posterior costa, and composed entirely of white matter. Cross-section is round to oval at base, and is oval to oblate at cusp. Base is moderately long, slightly compressed laterally, and expanded posteriorly. Basal cavity is large, but moderately deep as that of the rounded element. Elements are weakly covered by fine striae.

Remarks: Miller (1980) considered that both Teridontus nakamurai (Nogami) and Monocostodus sevierensis (Miller) are one morphotype apparatuses, and that T. nakamurai produced the costate simple cone genera Monocostodus, Semiacontiodus, and Utahconus, each with a different apparatus. However, it is found that T. nakamurai, Monocostodus and the suberect symmetrical teridontiform elements consistently co-occur, and also have a general similarity in the shape of basal cavity, distribution of white matter and very fine striae on the surface. So Teridontus nakamurai is interpreted herein as a multielement species, which consists of rounded nakamuraiform elements, transitional nakamuraiform elements, compressed monocostodiform elements and suberect symmetrical teridontiform elements.

Among these four morphotypes, the transitional and compressed elements with circular cross-section at the base bear a superficial similarity to the subrounded element. The suberect symmetrical element is distinctive from other three elements, but its distribution of white matter and rounded base are almost identical to those of the subrounded element.

The subrounded elements are the most common forms than other three forms and suberect symmetrical elements are very rare. The earliest representives may lack compressed element and suberect symmetrical element.

Occurrence: This multielement species is cosmopolitan. In the St. George Group, it ranges through the upper part of the Berry Head Formation and lowest part of Watts Bight Formation to the lowest part of Boat Harbour Formation in samples from Z1-18 to Z1-23 of Section 1; in samples from Z2-B to Z2-G and from Z2-1 to Z2-4 of Section 2; in samples from Z4-7 to Z4-15 of Section 4; in samples from Z5-5 to Z5-6 of Section 5; in samples from Z6-1 to Z6-4 of Section 6; in samples Z7-1 to Z7-12 of Section 7; in sample Z9-4 of Section 9.

Number of specimens: Total, 602; a subrounded element, 304; b transitional element, 199; c suberect symmetrical element, 15; e compressed element, 84.

Types: GSC 96191-96199.

Teridontus obesus n. sp.

Plate 24, figs. 10-17; Text-fig. 6:15B

?Semiacontiodus nogamii Miller, 1980, p. 32, Fig. 4W, Pl. 2, fig. 12.

Diagnosis: A species of Teridontus consisting of a subrounded elements, b transitional elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are large and broad teridontiform with an expanded basal margin; transitional elements are characterized by having a very weak groove on one lateral side; compressed elements are laterally compressed monocostodiform with anterior and posterior knife-edges; suberect symmetrical elements are characterized by having a straight cusp, and conical basal cavity with a centrally situated apex. All four elements bear faint microstriae.

Subrounded (a) element

Description: Elements are large and broad simple cones with expanded base. Cusp is usually reclined, and is long with round cross-section, and composed entirely of white matter. Base is short with circular cross-section, wide at basal margin, or strongly expanded posteriorly. Basal cavity is moderately deep, and is conical with a centrally situated apex.

Transitional (b) element

Description: Elements are characterized by having a very shallow groove on one side of lower cusp. Cusp is reclined to recurved, and tapers slowly with subround to round cross-section. A very shallow groove often present on one side of cusp near base. Base is not long with subcircular cross-section, and is strongly expanded posteriorly. Basal cavity is not very deep and is conical with a centrally situated apex.

Suberect symmetrical (c) element

Description: Elements are straight, proclined to erect simple cones with rounded cross-section. Cusp is rounded in cross-section without or with a faint posterior depression, is filled with white matter, and it rises erect from base. One very weak costa is present on each lateral side near base. Base is roundly expanded. Basal cavity is shallow, typical conical in profile, with cavity tip centrally situated.

Compressed (*e*) element

Description: Elements are asymmetrical, extremely compressed laterally with anterior and posterior knife-edges. Cusp is usually recurved, slightly twisted, and is wider at medial portion. Anterior sharp costa begins near bend of cusp and extends to tip; posterior knife-edge present along almost entire cusp. Base is laterally compressed, extremely expanded posteriorly, with oval cross-section. Basal cavity is large and moderately deep.

Remarks: This multielement species is a distinctive form, because of its slightly larger and broader shape, as well as expanded base. The subrounded element is very similar to that of *T. nakamurai*, but it is broader with a more expanded base. The suberect symmetrical element is distinguished by its extremely straight cusp, expanded base and its conical basal cavity. The transitional element is distinguished from the subrounded element of *Semiacontiodus nagamii* by lacking of costa. The specimen which was illustrated and assigned to *Semiacontiodus nagamii* by Miller (1980, Plate 2, fig. 12) may belong to the transitional element of this new species.

Teridontus obesus n. sp. is regarded as a descendant of *T. nakamurai* (Nogami), both species have a general similarity, and both are ornamented with fine striae. However, *T. obesus* n. sp. is found in higher strata.

In this species, the subrounded elements are the most common forms, the transitional and compressed elements are much less common, and the suberect symmetrical elements are relatively rare.

Occurrence: The apparatus species is found in the upper part of Watts Bight Formation in samples from Z2-7 to Z2-14 of Section 2; in samples from Z4-13 to Z4-23 of Section 4; in samples from Z6-3 to Z6-9 of Section 6; in samples from Z7-10 to Z7-17 of Section 7; in samples from Z9-4 to Z9-2 of Section 9.

Number of specimens: Total, 1057; a subrounded element, 536; b transitional element, 268; c suberect symmetrical element, 49; e compressed element, 204.

Types: GSC 96200-96207.

Genus *Tricostatus* n. gen.

Type species: *Tricostatus glyptus* n. sp.

Derivation of name: From the Latin "tricostatus", referring the shape of the subrounded elements of this genus.

Diagnosis: An apparatus consisting of three simple cone morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are characterized by triple costae which include two lateral costae and one anterior costa; suberect symmetrical elements are slender staufferiform-like cones with shallow basal cavity; compressed elements are utahconiform-like cones with extremely postero-laterally compressed cusp and base.

Remarks: This genus exhibits the compressed and suberect symmetrical elements which are similar to those of *Utahconus*. However, the subrounded elements with their characteristic triple costae are markly different from those of *Utahconus*. Within the collections at hand, no subrounded element has been found which is similar to the subrounded element of *Utahconus*, so only the compressed elements are assigned to this genus.

Only one new species, *Tricostatus glyptus* is described within this genus. A sccession from *T. glyptus* n. sp., through *Rossodus tenuis* (Miller) to *Rossodus manitouensis* Repetski and Ethington clearly shows that the posterior costa of the suberect elements became nearly eliminated and that the curvature at the base-cusp junction in the compressed elements became differentiated (from scandodiform to oistodiform).

<u>Tricostatus glyptus</u> n. sp.

Plate 17, figs. 20-25

<u>Derivation of name</u>: From the Latin "glyptus", meaning carved referring the costate and grooved cusp of the species.

<u>Diagnosis</u>: A species of <u>Tricostatus</u> containing <u>a</u> subrounded elements, <u>c</u> suberect symmetrical elements and <u>e</u> compressed elements. Subrounded element is posteriorly compressed with anterior weak costa and two lateral costae; compressed elements are postero-laterally compressed with two lateral costae and one anterior faint costa and one posterior weak costa in some specimens; suberect symmetrical elements are characterized by having a knife-edged posterior costa, slowly tapering cusp, and small basal cavity.

Subrounded (<u>a</u>) element

<u>Description</u>: Elements are posteriorly compressed with three costae. Cusp is proclined and filled with white matter. Anterior face has half-flattened and half-smoothly rounded areas separated by a faint costa; posterior face is slightly concave, or flattened with a very faint carina in some specimens; two lateral sides are keeled with sharp-edged costae. Base is small with slightly restricted base opening. Basal cavity is small, and moderately deep, and conical in profile.

Compressed (e) element

Description: Elements are postero-laterally compressed, utahconiform-like cones with two major lateral costae. Cusp is usually proclined, and filled with white matter. Anterior face is smoothly rounded, with a very weak costa; posterior face is very gently concave or flattened with faint costa; two lateral sides are keeled with sharp-edged costae. Base is small, postero-laterally compressed with oval cross-section. Basal cavity is shallow, with apex situated close anterior margin.

Suberect symmetrical (c) element

Description: Elements are symmetrical cones, with leaf-like cusp. Cusp is usually proclined, posteriorly compressed, slightly curved in some specimens, and filled with white matter. Anterior face is wide, smoothly rounded region with faint costa; posterior face is concave, except for high posterior carina extending from base towards tip of cusp and separates two flattened posterior regions; two lateral side are keeled. Base is very small, oval in cross-section. Basal cavity is small, and its apex is situated near anterior margin.

Remarks: The subrounded elements of *Tricostatus glyptus* n. sp. bearing three major costae, are characteristic forms which can be distinguishable from those of _Utahconus utahensis_. The suberect symmetrical elements are quite different from those of _Utahconus utahensis_, and _U. longipinnatus_ n. sp. in general features. However, the compressed elements are very similar to those of other species of _Utahconus_, only slight differences are apparent. In the compressed element of _T. glyptus_ n. sp., the basal cavity is smaller than those of _Utahconus_, and the anterior face has a faint costa. In this species, the subrounded elements and compressed elements are usually much more abundant than the suberect symmetrical elements.

Occurrence: This species is present in the upper part of Watts Bight Formation in samples from Z2-9B1 to Z2-14 of Section 2; in sample Z4-19B of Section 4; in samples from Z6-5 to Z6-6 of Section 6; in samples from Z7-13 to Z7-15B of Section 7; in samples from Z9-4 to Z9-8 of Section 9.

Number of specimens: Total, 79; _a_ subrounded element, 45; _c_ suberect element, 8; _e_ compressed element, 26.

Types: GSC 96058-96063.

Genus _Utahconus_ Miller, 1980

Type species: Paltodus utahensis Miller, 1969, p. 436.

Emended diagnosis: An apparatus consisting of three simple cone morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are usually asymmetrical forms with right or left lateral costa, and/or with weak posterior costa; compressed elements are postero-laterally compressed, with two lateral costae; compressed elements are staufferiform-like cones, with posterior costa or carina, and two sharp-edged lateral costae; transitional elements are included in the subrounded elements, because they do not share the distinctive features of the subrounded elements.

Remarks: Miller's (1980) definition and discussion of this genus outlines the morphotypes of Utahconus apparatus morphotypes. He described this genus as an apparatus consisting of unicostate and bicostate elements. However, on the basis of the collections at hand, Utahconus has an apparatus consisting of three major elements. Miller's unicostate element is assigned to the rounded element, and his bicostate element to the compressed element. Miller did not illustrate the suberect symmetrical element, it may be rare, or absent in the early representives of this species.

Utahconus longipinnatus n. sp.

Plate 25, figs. 1-8; Text-fig. 6:16A

Scandodiform elements (subrounded and compressed)

?Utahconus aff. U. utahenisis (Miller). Nowlan, 1985, p. 117, Figs. 5.45-5.52.

Scandodus furnishi Lindström. Druce and Jones, 1971, p. 88, text-fig. 29, Pl. 13, figs. 9a-9c.

Staufferiform element

?Acontiodus propinquus Furnish s.f. Nowlan, 1985, p. 107, fig. 4.11.

Derivation of name: From the Latin "longi-" and "-pinnatus", referring to the shape of the subrounded and compressed elements.

Diagnosis: A species of Utahconus consisting of three morphotypes: a subrounded elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are usually symmetrical or asymmetrical with one lateral costa and one smoothly rounded lateral face; compressed elements are postero-laterally compressed with two lateral costae and one faint posterior costa or carina; suberect symmetrical elements are staufferiform cones with two lateral costae and a posterior carina.

Subrounded (a) element

Description: Elements are characterized by having a long cusp and a shallow basal cavity. Cusp is usually proclined to erect, and filled with white matter, and is compressed lateral-posteriorly with sharp lateral-posterior costa and subrounded lateral-anterior edge. Anterior face is smoothly rounded on one side and flattened on other side; posterior face is slightly concave, one lateral side rounded, other sharply keeled. Base is short, and slightly expanded one lateral-posterior side. Basal cavity resembles a right-angled triangle in lateral view; apex of cavity is situated at anterior side or close to anterior margin.

Suberect symmetrical (c) element

Description: Elements are generally staufferiform-like cones with long cusp. Cusp is straight, slightly curved posteriorly, posteriorly compressed, and tapers slowly. Anterior face is gently rounded, with expanded anterior margin, and with faint anterior carina or costa in some specimens; posterior face is concave, with unexpanded posterior basal margin and weak posterior carina which runs from basal margin towards tip of cusp; two lateral sides are keeled with sharp edges. Basal cavity is small and shallow, and is oval or conical in profile.

Compressed (e) element

Description: Elements are bicostate, lateral-posteriorly compressed forms. Cusp is long, broad near base, and filled with white matter. Anterior face is smoothly rounded on one side, and is flattened and laterally expanded to sharp edge on other side; posterior face is concave, but with a wide and gentle posterior carina which is flanked by one or two faint shallow grooves; two lateral sides are keeled. Basal cavity is deeper than in subrounded elements and its apex is situated to the anterior of midline or at anterior margin.

Remarks: The elements of this species are broadly similar to those of Utahconus utahensis Miller. However, the subrounded and compressed elements have longer cusps, and their basal cavities are shallower than typical U. utahensis. The specimens described by Nowlan (1985) as U. aff. U. utahensis which bear no marked differences with this new species are included in this species. Nowlan's unicostate elements are assigned to the subrounded elements; his bicostate elements belong to the compressed elements; Nowlan's Acontiodus propinquus Furnish s.f. is probably the suberect symmetrical element of U. longipinnatus n. sp. This species co-occurs consistently with Variabiloconus neobassleri n. sp. in samples from three sections, and the suberect symmetrical elements of U. longipinnatus are similar to those of V. neobassleri n. sp., and may belong to the same multielement species. If so, this fully developed species has two major transitional morphotypes which are homologous to the compressed elements of _V_. _neobassleri_ n. sp. and to the subrounded elements of _U_. _longipinnatus_ n. sp.

Within this species, the subrounded elements and compressed elements are equally common forms, and the suberect symmetrical elements are rare.

Occurrence: The species is found in the lower part of Boat Harbour Formation in samples from Z2-20 to Z2-33 of Section 2; in samples from Z4-25 to Z4- 34 of Section 4; in samples from Z6-10 to Z6-11 of Section 6.

Number of specimens: Total, 1455; _a_ subrounded element, 675; _c_ suberect staufferiform element, 83; _e_ compressed element, 697.

Types: GSC 96214-96221.

Genus _Variabiloconus_ Landing and Barnes, 1986

Type species: _Paltodus_ _bassleri_ Furnish, 1938

Diagnosis: An apparatus of simple cones consisting of four element morphotypes: _a_ subrounded elements, _b_ transitional elements, c suberect symmetrical elements and e compressed elements. Subrounded elements are characterized by having a wide posterior carina; transitional elements are asymmetrical forms which have an offset posterior carina; compressed elements are laterally compressed forms with or without a posterior groove and a shallow lateral groove on only one side; suberect symmetrical elements are characterized by having a slightly expanded base and a posterior carina.

Remarks: Landing and Barnes (1986) established Variabiloconus new genus for a multielement simple cone apparatus including noncostate and nonsulcate drepanodiform elements. However, based on three multielement species which are newly reconstructed in this study, it is considered that Variabiloconus has an apparatus plan consisting of subrounded and transitional bassleriform elements, suberect symmetrical staufferiform-like elements and compressed drepanodiform elements. The genus can be distinguished from Utahconus Miller by a wide posterior carina; it is distinguished from Semiacontiodus Miller by having a slender and long cusp and well developed costae in most elements.

Variabiloconus bassleri (Furnish, 1938)

Plate 25, figs. 14-16; Text-fig. 6:16B

Bassleriform element (subrounded and transitional)

Paltodus bassleri Furnish, 1938, p. 325, Pl. 42, fig. 1; Ethington and Clark, 1971, p. 72, Pl. 2, figs. 2, 4, 6; ?Repetski, 1982, p. 37, Pl. 14, fig. 12.

Utahconus? bassleri (Furnish). Landing and Barnes, 1981, p. 1622, 1624, Pl. 1, fig. 19.

"Paltodus bassleri" Group, Nowlan, 1985, p. 118-120, Fig. 10.12, 10.14, and may also include fig. 10.11.

?Scolopodus asymmetricus Druce and Jones, 1971, p. 89, Pl. 19, figs. 3a-7c, text-fig. 30a.

Variabiliform element (compressed)

Paltoconus variablis Furnish, 1938, p. 331, Pl. 42, figs. 9 10;

?Utahconus? bassleri (Furnish). Landing and Barnes, 1981, p. 1622, Pl. 4, fig. 15.

Variabiloconus bassleri (Furnish). Landing and Barnes, 1986, p. 1944, Pl. 3, fig. 7.

Emended diagnosis: A species of Variabiloconus consisting of four element morphotypes: a subrounded, b transitional, c suberect symmetrical and e compressed elements. The a subrounded elements are symmetrical bassleriform elements which have a very wide posterior carina flanked by lateral-posterior shallow grooves; b transitional elements are asymmetrical bassleriform elements which have a variety of offset posterior carina; c suberect symmetrical elements are staufferi-like forms with long cusp and well developed posterior carina; e compressed elements are laterally compressed variabiliform with a compressed lateral-posterior carina. All the elements are characterized by having a wide posterior carina, and are covered by faint striations.

Subrounded (a) element

Description: Elements are symmetrical, posteriorly carinate forms. Cusp is long, and is usually reclined to recurved, gently bent near cusp-base junction, and then slowly recurved distally. Wide posterior carina is centrally located and the grooves on either side are equally developed. Base is expanded and slightly flared posteriorly. Cross-section of base is round to subrounded. Basal cavity is moderately deep, and tip of cavity is almost centrally located.

Transition (b) element

Description: Elements are slightly smaller, asymmetrical forms with offset posterior carina, and are laterally compressed on only one side. Cusp is more strongly recurved in most specimens, and is slightly twisted in a few specimens. Posterior carina is usually offset to one side and grooves are not equally developed. Base is subrounded in cross-section, and is slightly expanded. Basal cavity is moderately deep, with apex near anterior margin.

Suberect symmetrical (c) element

Description: Elements are antero-posteriorly compressed, staufferiform-like, symmetrical forms with posterior carina. Cusp is curved, and tapers slowly with a well developed wide posterior carina which is extended to pointed end, and is flanked by two posterior very shallow grooves. Anterior face is smoothly rounded; posterior face is slightly concave. A sharp rounded shoulder on each side of posterior face is well developed. Basal cavity is elongate or suboval laterally, and moderately deep.

Compressed (e) element

Description: Elements are asymmetrical forms bearing a lateral-posterior carina. Cusp is usually reclined to recurved, and laterally compressed with triangular cross-section. Anterior side of cusp is sharply rounded; one lateral side is smooth rounded or flat, the other side is flat, but grooved in antero-lateral position; posterior side has a shallow groove which is equivalent to the grooved side of subrounded element. Basal cavity is moderate in size with apex near anterior margin.

Remarks: Furnish (1938) established the form species Paltodus bassleri and P. variablis, and noted that these two are closely related. Sweet and Bergström (1972), Lindström (1977), Landing and Barnes (1981), Landing, Barnes and Stevens (1986), Nowlan (1985) suggested that the form taxa of Furnish (1938), Acodus oneotodus, Paltodus bassleri, P. variablis, Oistodus? triangularis and other similar form species belong to a single apparatus species. Ethington and Clark (1981) considered that "A." oneotensis and "O." triangularis represent independent species and cannot be parts of a common apparatus, and that neither is related to Paltodus. They also interpreted of P. bassleri and P. variablis as a transition series. Their remarks are strongly supported by this study.

On the basis on the St. George Group collection, Paltodus bassleri and P. variablis belong to the same species, but are reassigned separately to the subrounded and compressed elements, respectively, of Variabiloconus bassleri (Furnish); Furnish's Acodus oneotodus is reassigned to new genus Polycostatus, because it differs from Variabiloconus bassleri in its costate and grooved cusp. Druce and Jones (1971) described a new species, Scolopodus asymmetricus, with asymmetrical lateral costae and a compressed posterior carina which is similar to V. bassleri, and is herein assigned to the transitional elements of V. bassleri (Furnish).

The ancestor of V. bassleri may be Semiacontiodus nogamii Miller. Both species have same apparatus plan, and the elements of both species bear a superficial similarity and both have a well developed posterior costa. However, V. bassleri differs by a having slender cusp with well developed posterior carina, small base and basal cavity.

All of the four morphotypes of this species have a well developed posterior carina and fine striations on the surface. However, the carina of the subrounded and suberect symmetrical elements is postero-centrally located, whereas the carina of the transitional and compressed elements are laterally compressed and lateral-posteriorly situated. Within this apparatus, subrounded elements and transitional elements are the most common forms, compressed elements are less common, but suberect symmetrical elements are rare.

Occurrence: This species is found in the upper part of Watts Bight Formation and the lower part of Boat Harbour formation in samples from Z2-6 to Z2-22 of Section 2; in samples from Z4-15B to Z4-28 of Section 4; in samples from Z5-6 to Z5-12 of Section 5; in samples from Z6-2 to Z6-11 of Section 6; in samples from Z7-13 to Z7-17 of Section 7; in samples from Z9-4 to Z9-8 of Section 9.

Number of specimens: Total, 1701; a subrounded element, 773; b transitional element, 490; c suberect element, 106; e compressed element, 332.

Types: GSC 96227-96239.

Variabiloconus neobassleri n. sp.

Plate 25, figs. 9-13; Text-fig. 6:16C

Bassleriform element (subrounded and transitional)

?Utahconus? bassleri (Furnish). Landing and Barnes, 1981, p. 1622, Pl. 1, figs. 18, 21, 22.

?Paltodus bassleri Furnish. Abaimova, 1975, p. 88-89, Pl. 7, figs. 14, 15, 17, 19 (non fig. 18), text-figs. 44-45 (may be not figs. 41, 42, and 46). Ethington and Clark, 1981, p. 75, Pl. 8, figs. 11, 12.

Variabiliform or drepanodiform element

?Drepanodus tenuis Moskalenko. Druce and Jones, 1971, p. 75, Pl. 12, figs. 8a-c, text-fig. 24e.

?Paltodus (?) variabilis Furnish. Abaimova, 1975, p. 92-93, Pl. 7, figs. 12, 16, text-figs. 8 (2, 3).

Diagnosis: A species of Variabiloconus containing four morphotypes which are albid, sturdy, and have a wide posterior or lateral-posterior carina: a symmetrical bassleri-like subrounded elements with well developed posterior carina, b asymmetrical bassleri-like transitional elements with offset posterior carina, c staufferiform suberect symmetrical elements with expanded base, and e compressed drepanodiform-like elements with lateral-posterior carina.

Subrounded (a) element

Description: Elements are rather sturdy, and have extremely wide posterior carina with or without a very shallow median groove. Cusp is usually reclined, and has very wide posterior carina flanked by lateral shallow groove or well developed lateral costae. In some specimens, median groove is developed on wide posterior carina. Anterior face of cusp is smoothly rounded. Base is subround in cross-section, and expanded posteriorly. Basal cavity is conical in profile, and apex of cavity is centrally situated or near anterior side.

Transitional (b) element

Description: Elements are asymmetrical forms with an offset posterior carina. Cusp is usually reclined to recurved, and slightly compressed laterally with a variant with offset posterior carina which does not have median groove. In most specimens, carina is flanked by lateral costae, but one lateral costa is well developed. Base is expanded posteriorly, or expanded lateral-posteriorly, and is round to subrounded in cross-section. Basal cavity is conical in profile, and apex of cavity is located near antero-lateral side.

Suberect symmetrical (c) element

Description: Elements are rather staufferiform-like symmetrical forms with well developed posterior carina, and moderately expanded base. Cusp is usually proclined to erect, and tapers slowly. Anterior face is smoothly rounded; posterior face is usually flattened in profile, with a wide posterior carina which is smoothly rounded, and is flanked by very shallow grooves or by flattened area; two lateral sides are keeled. Base is expanded or slightly flared posteriorly, and is extended anteriorly. Basal cavity is large, and suboval to oval in cross-section.

Compressed (e) element

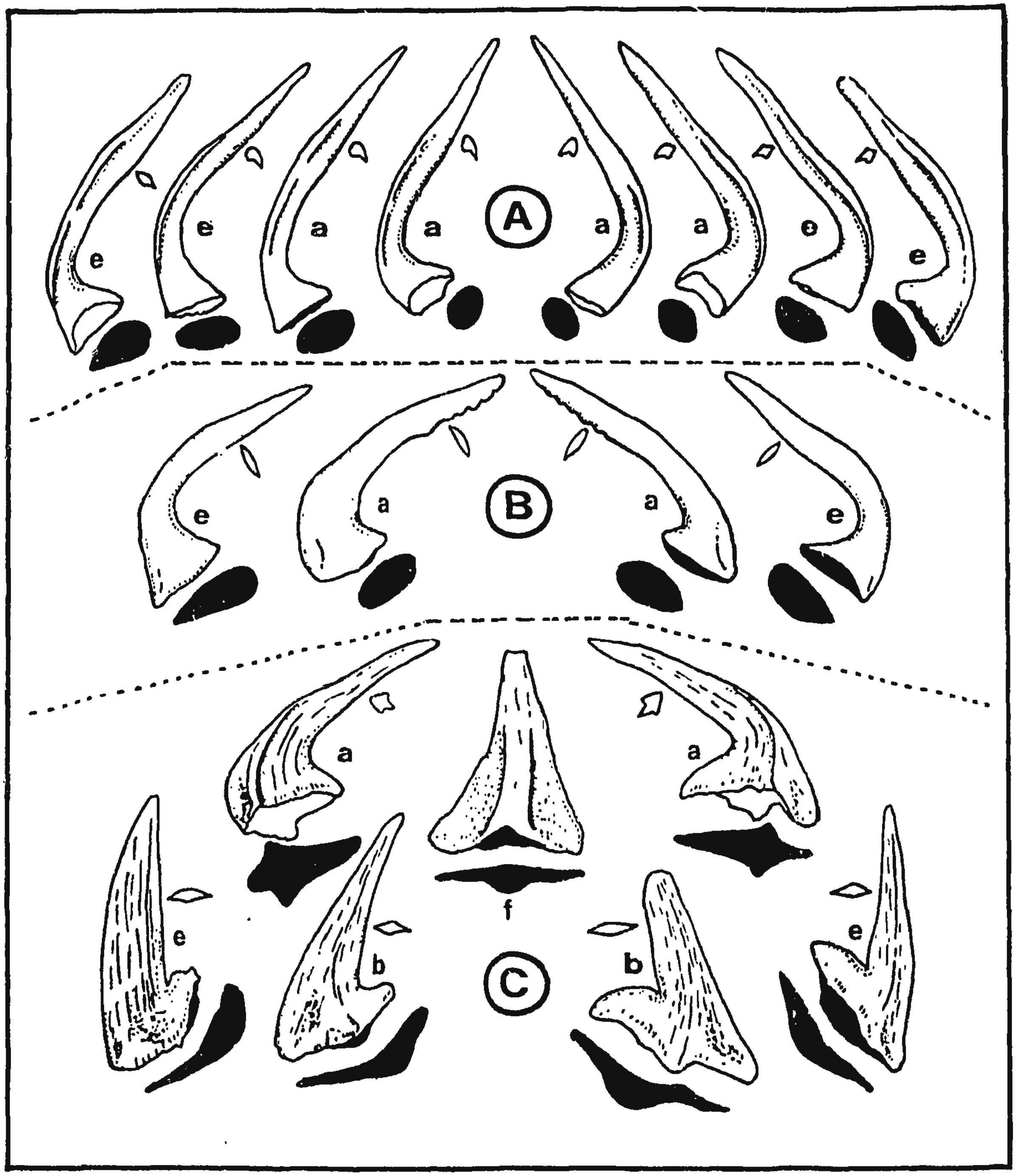
Description: Elements are asymmetrical forms with a lateral--posterior carina, and compressed laterally with one well developed lateral costa. Cusp is recurved to strongly recurved. Anterior or lateral-anterior face is smooth rounded; posterior or lateral-posterior face has carina which is flanked by only a well developed lateral groove; one lateral side has a knife-edged costa which is well developed and slightly curved in basal region. A few specimens are extremely compressed laterally, with very weak grooves or lateral costae. Base is expanded posteriorly, and is oval in cross-section.

Remarks: *Variabiloconus neobassleri* n. sp. may be a descendant of *Variabiloconus bassleri*, being very similar to *V. bassleri* in general features. However, *V. neobassleri* can be distinguished from *V. bassleri* and *V. restrictus* by the robust, and well developed lateral costae. The specimens referred to *Drepanodus tenuis* Moskalenko by Druce and Jones (1971) could belong to the compressed elements of this species, but they have rather slender cusp. The specimens described by Landing and Barnes (1981) as a part of *Utahconus*? *bassleri* (Furnish) should be included in this species, because they are robust, with a well developed lateral costa. The specimens illustrated by Ethington and Clark (1981) as *Paltodus bassleri* with a well developed lateral costa may also belong to this species.

Occurrence: This species is present in the lower Boat Harbour Formation in samples from Z2-21 to Z2-33 of Section 2; in samples from Z4-25 to Z4-34 of Section 4; in samples Z6-10 to Z6-11 of Section 6.

Number of specimens: Total, 1467; *a* subrounded element, 602; *b* transitional element, 412; *c* suberect staufferiform-like element, 80; *e* compressed element, 373.

Types: GSC 96222-96226.



Text-fig. 6:1. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Acanthodus lineatus (Furnish): a denticulatiform element, e drepanodiform element.

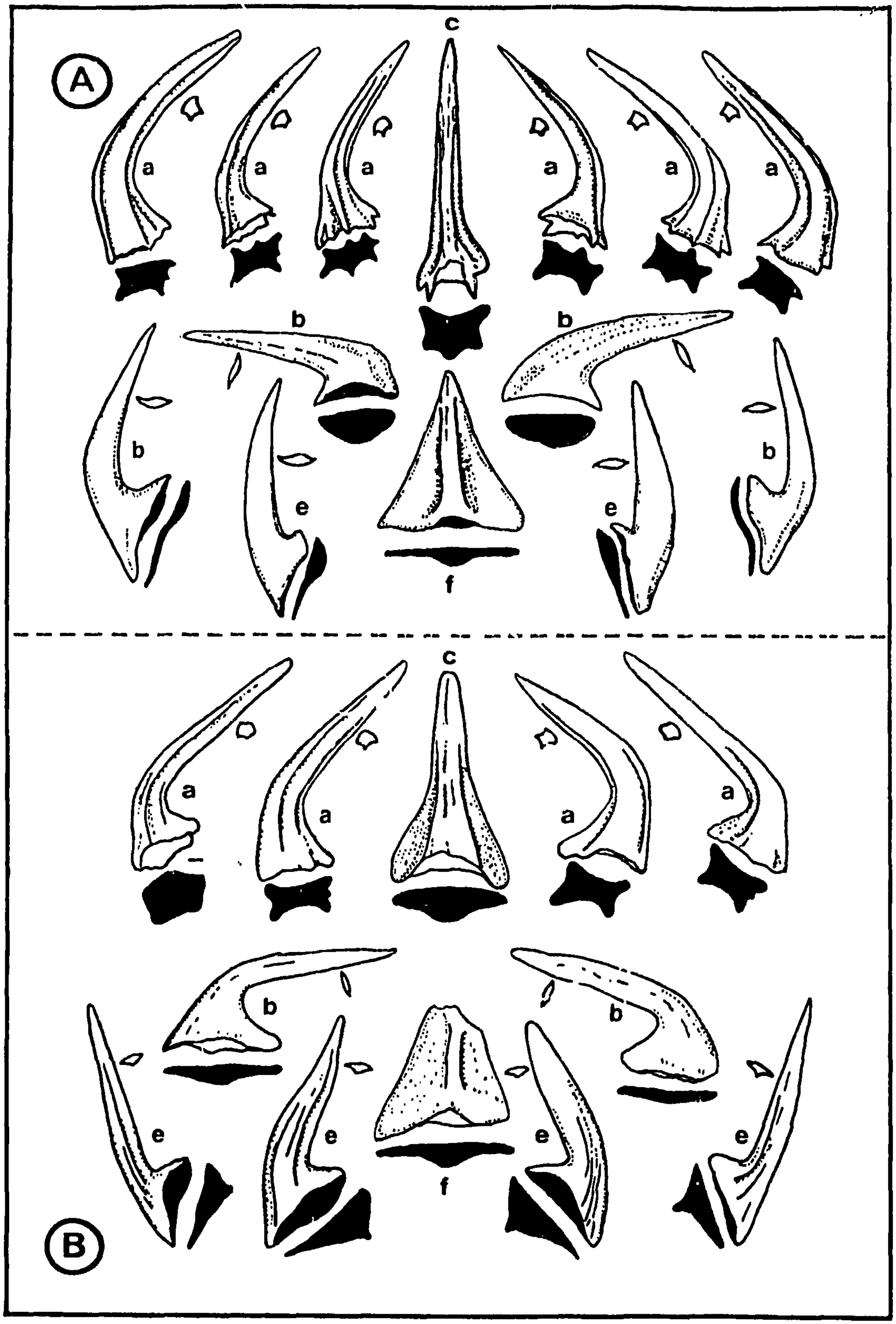
(B). Acanthodus uncinatus (Furnish): a denticulatiform element, c suberectiform element, e drepanodiform element.

(C). Acodus lanceolatus (Pander): a distacodiform element, b triangulariform element, e oistodiform element, f deltaform element.

Text-fig. 6:2. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Acodus comptus (Branson and Mehl): a distacodiform element, b acodiform element, c symmetrical distacodiform element, e oistodiform element, f deltaform element.

(B). Acodus delicatus (Branson and Mehl): a distacodiform element, b acodiform element, c symmetrical distacodiform element, e oistodiform element, f deltaform element.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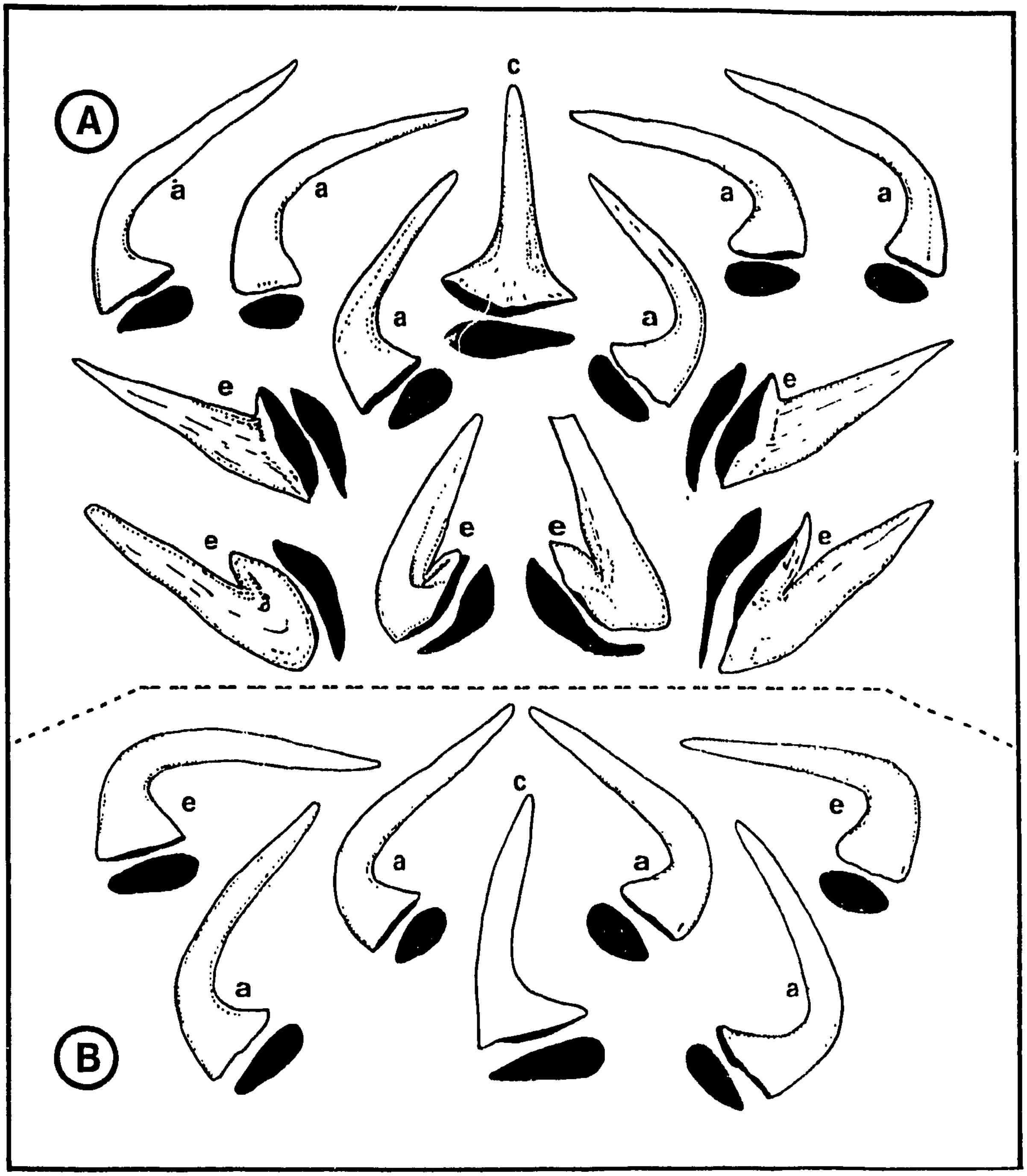
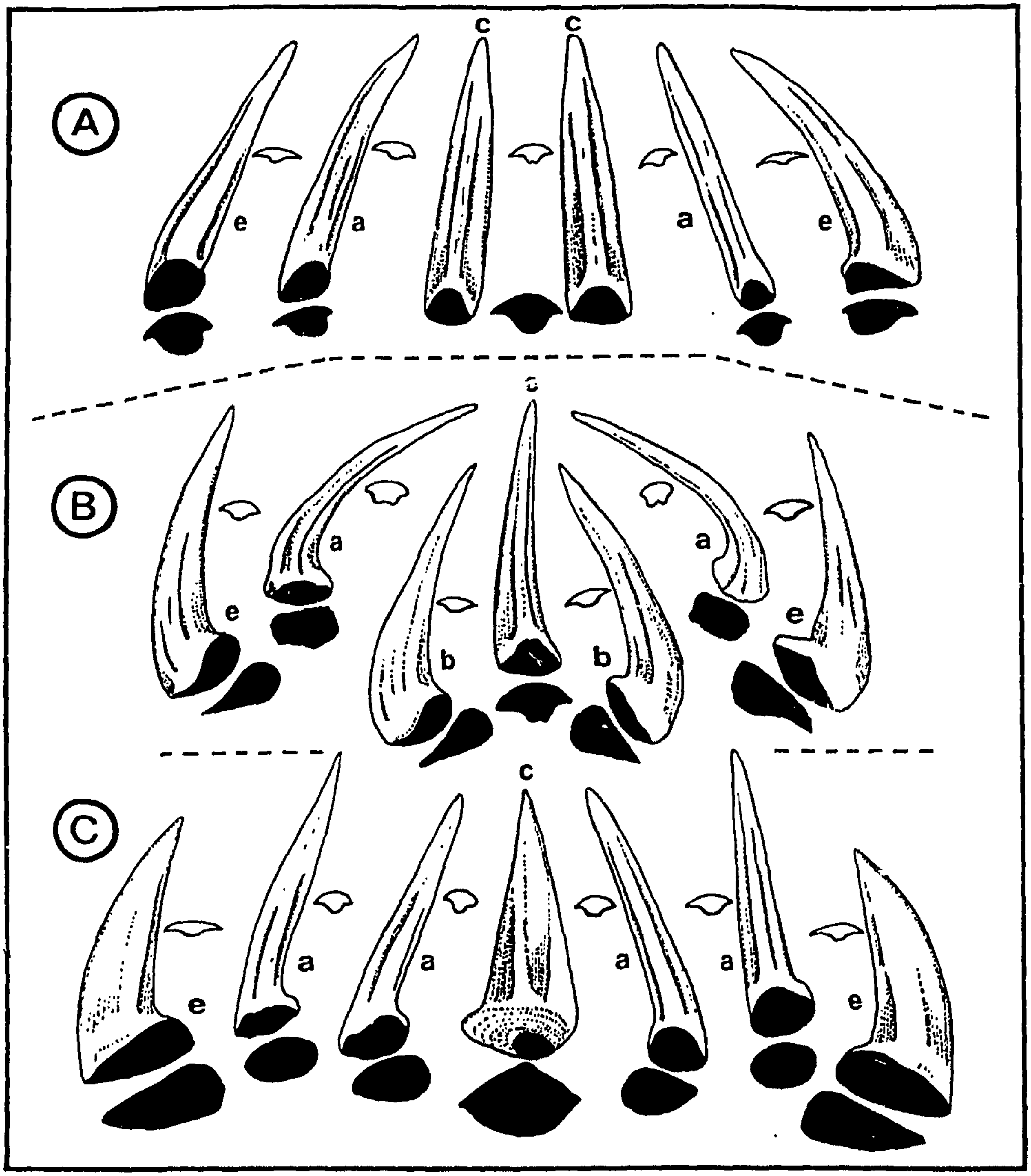


Text-fig. 6:3. Outline drawing of conodont element morphotypes showing shapes of basal cavities and cross-sections.
(A). <u>Drepanodus</u> <u>nowlani</u> n. sp.: <u>a</u> drepanodiform element, suberectiform element, <u>e</u> oistodiform element.
(B). <u>Drepanodus</u> <u>pervetus</u> (Nowlan): <u>a</u> drepanodiform element, <u>c</u> suberectiform element, <u>e</u> oistodiform-like element.

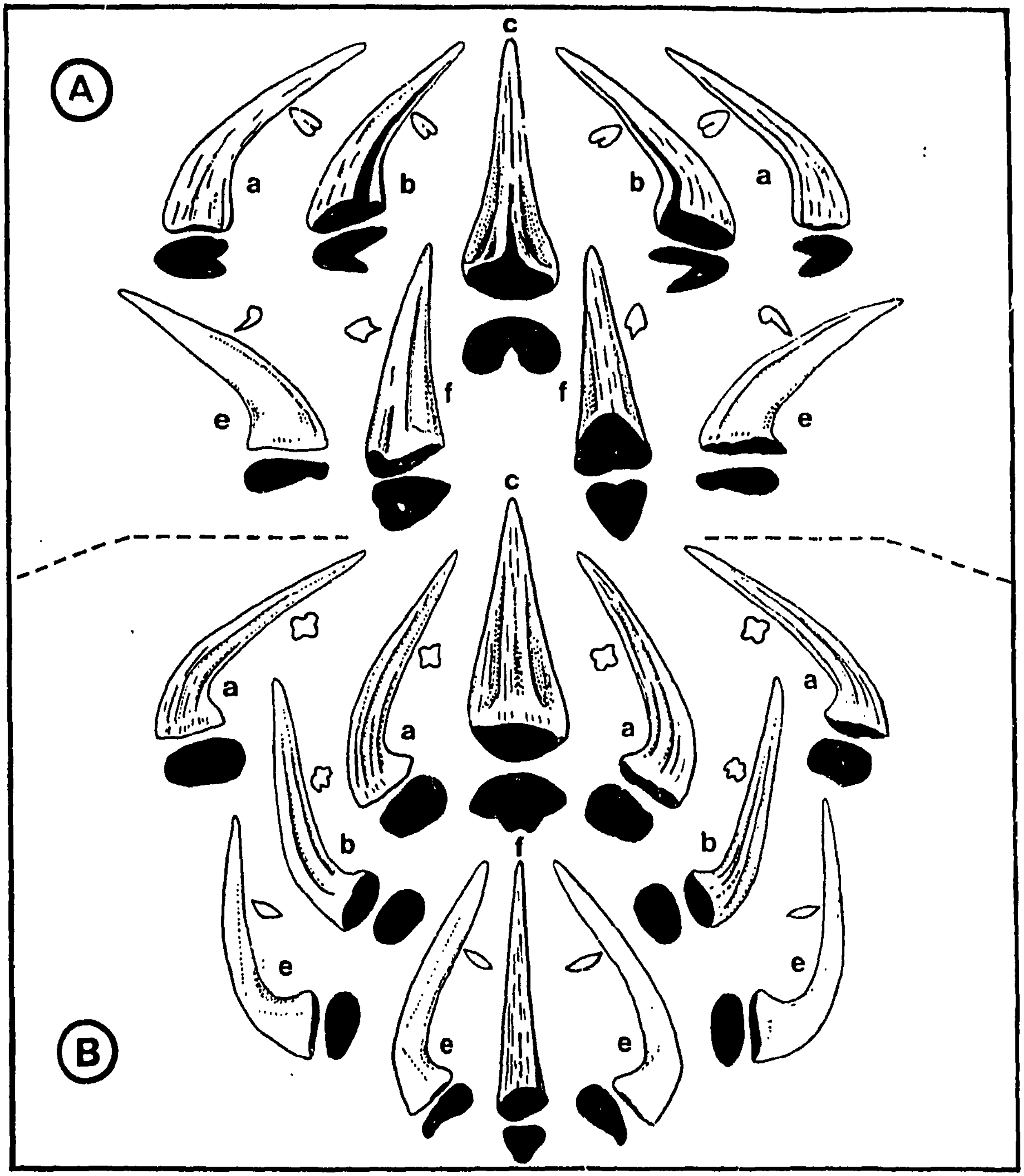


Text-fig. 6:4. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Glyptoconus bolites (Repetski): a subrounded element, c staufferiform element, e scandidiform element.

(B). Glyptoconus floweri (Repetski): a subrounded element, b transitional element, c staufferiform element, e scandodiform element.

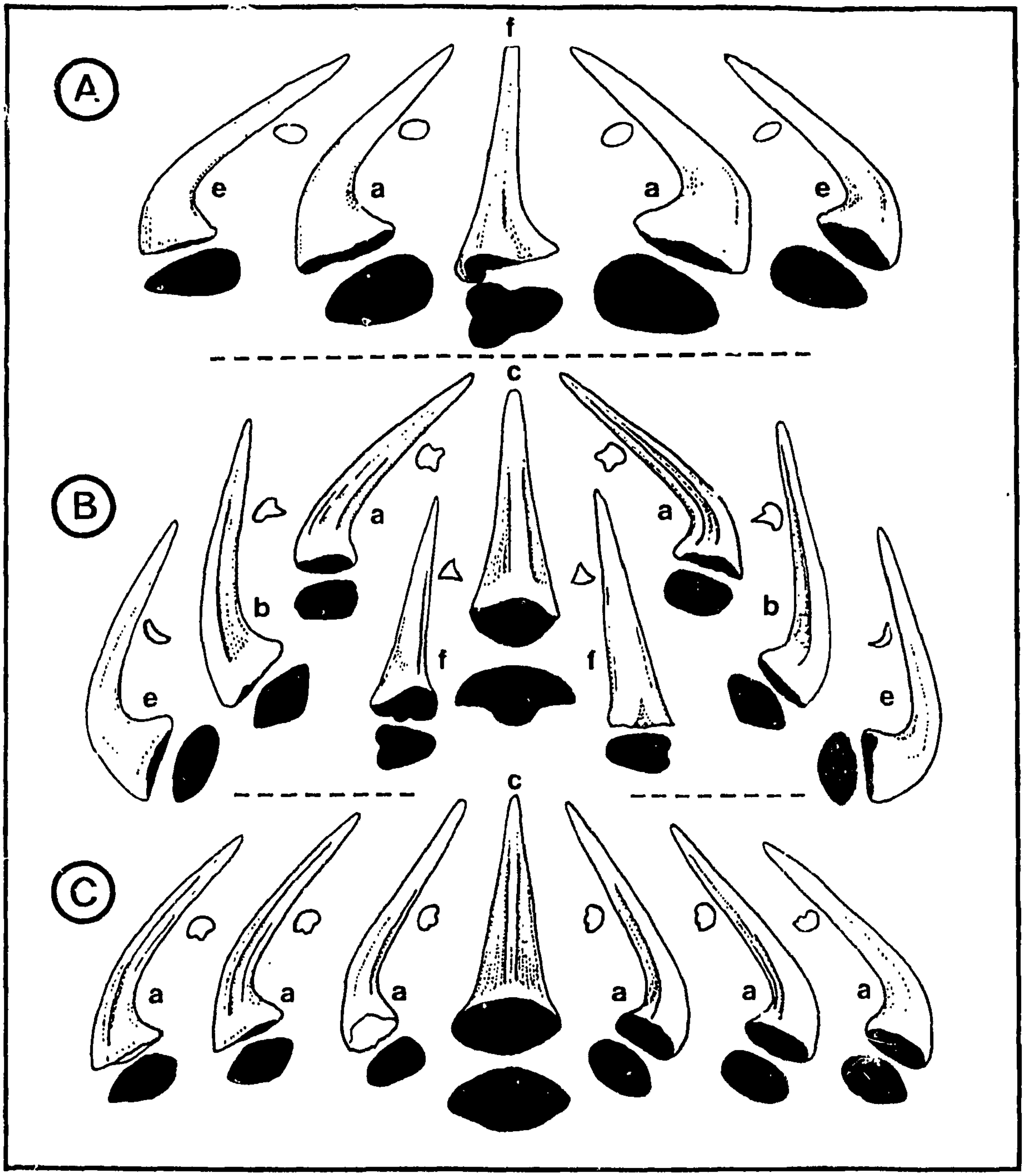
(C). Glyptoconus felicitii n. sp.: a Paltodiform-like element, c staufferiform-like element, e scandodiform like element.



Text-fig. 6:5. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Glyptoconus emarginatus (Barnes and Tuke): a subrounded element, b transitional element, c staufferiform element, e toomeyiform element, f ulrichodiniform element.

(B). Glyptoconus multiplicatus n. sp.: a multicostatiform element, b triplicatiform element, c staufferiform element, e paralleliform element, f ulrichodiniform element.

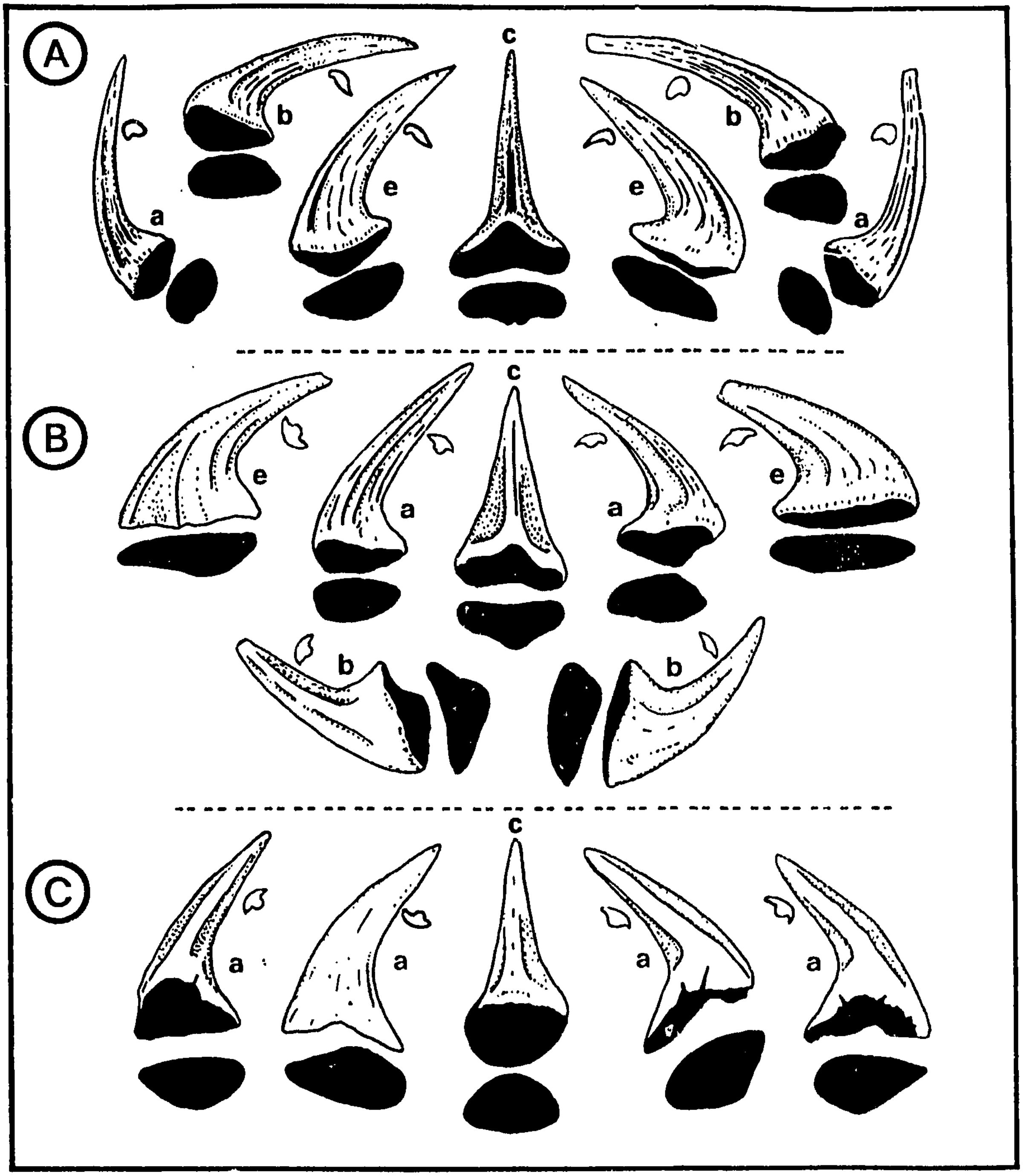


Text-fig. 6:6. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Glyptoconus priscus n. sp.: a pseudo-quadraplicatiform element, e pseudo-drepanodiform element, f ulrichodiniform element.

(B). Glyptoconus quadraplicatus (Branson and Mehl): a quadraplicatiform element, b triplicatiform element, c staufferiform element, e paralleliform element, f ulrichodiniform element.

(C). Glyptoconus triplicatus (Ethington and Clark): a triplicatiform element, c staufferiform element.

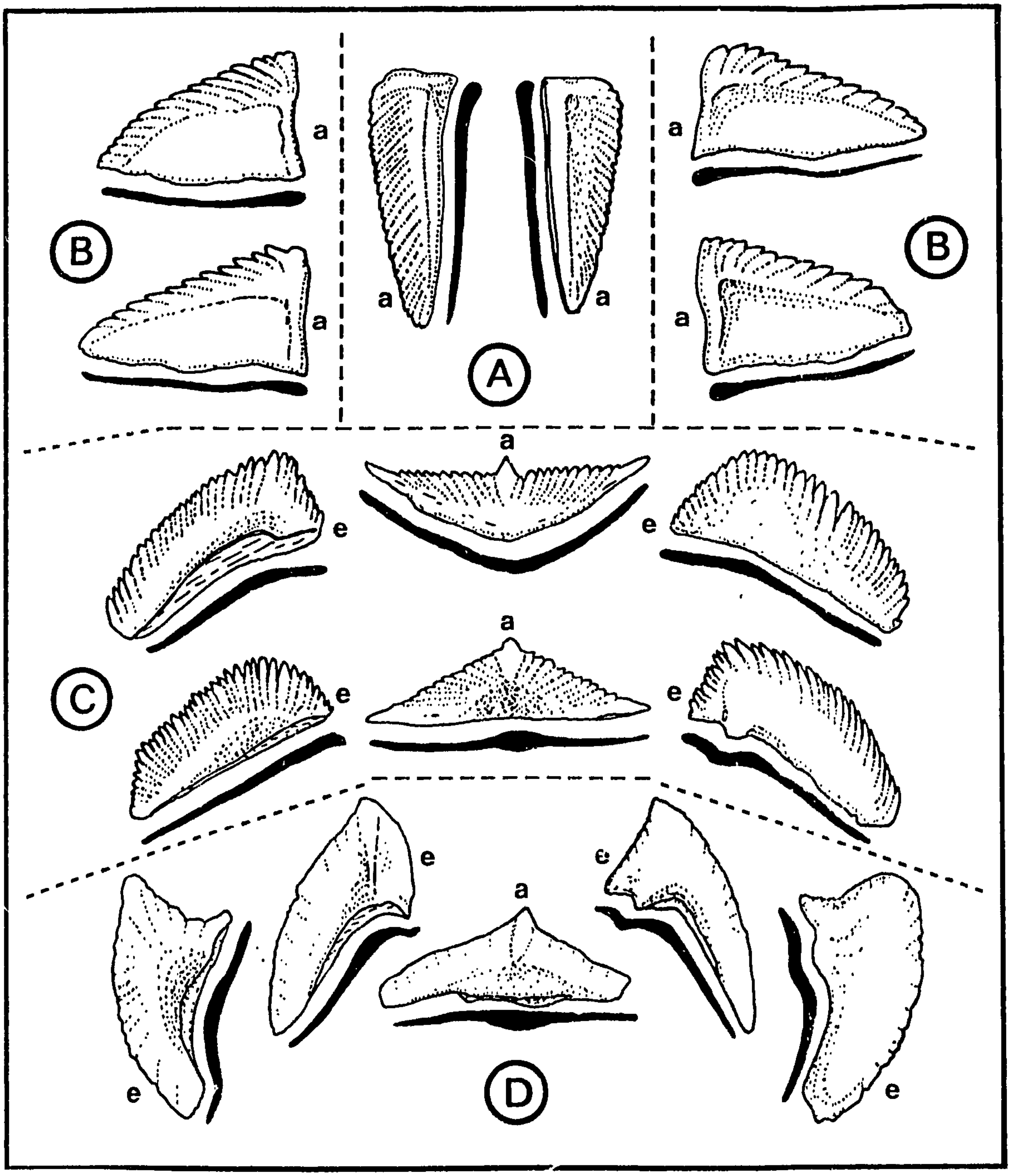


Text-fig. 6:7. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Glyptodontus constrictus n. sp.: a subrounded element, b transitional element, c staufferiform element, e compressed element.

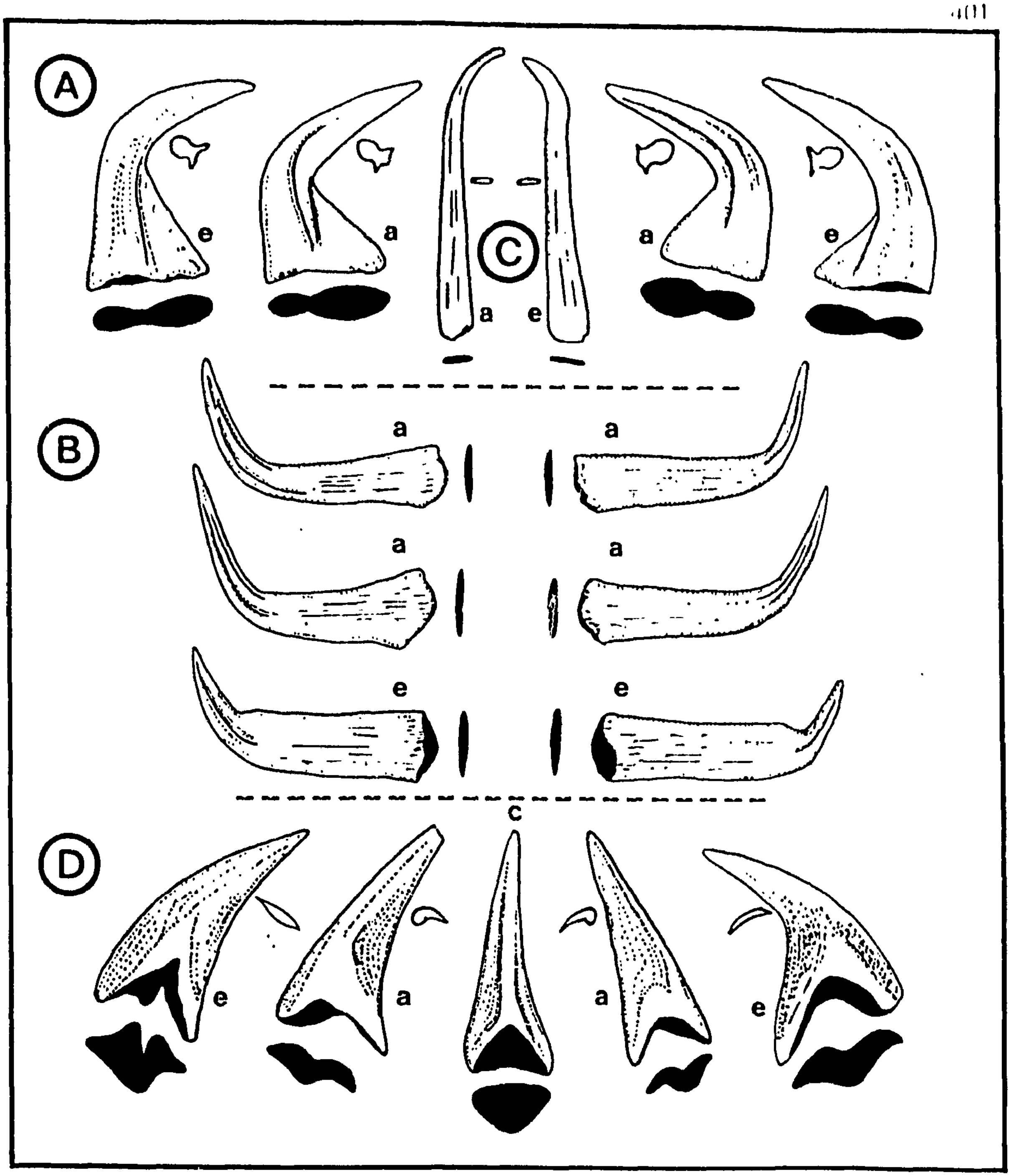
(B). Glyptodontus expansus n. sp.: a subrounded element, b transitional element, c staufferiform element, e compressed element.

(C). Glyptoconus tumidus n. sp.: a subrounded element, c staufferiform element.



Text-fig. 6:8. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Loxodus bransoni Furnish: a element.
(B). Loxodus latibasis n. sp.: a element.
(C). Loxodentatus bipinnatus n. sp.: a symmetrical element, e asymmetrical element.
(D). Loxognathus phyllodus n. sp.: a symmetrical element, e asymmetrical element.



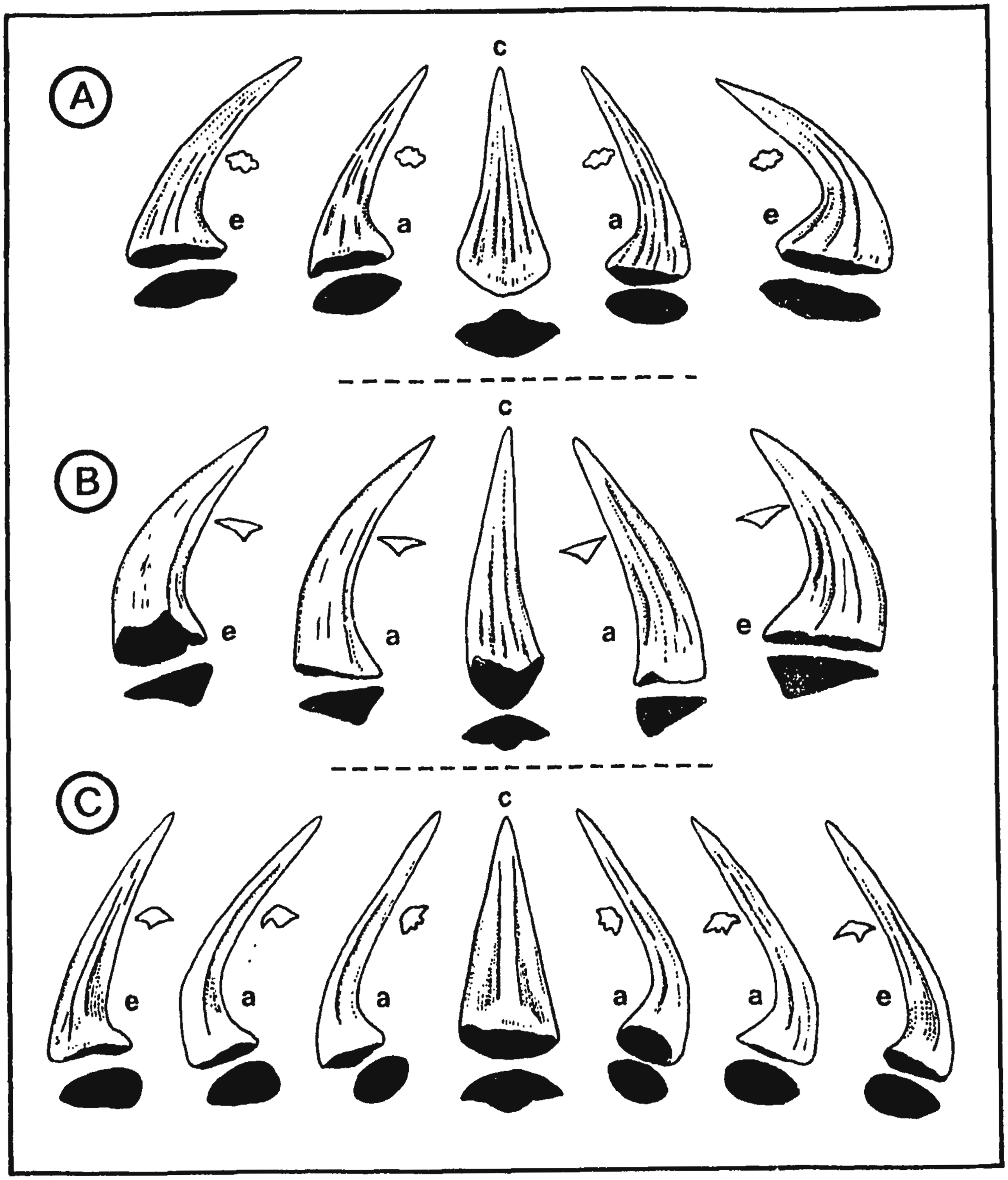
Text-fig. 6:9. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Macerodus crassatus n. sp.: a subrounded element, e compressed element.

(B). Macerodus dianae Fåhraeus and Nowlan: a curved distacodiform element, e straight distacodiform element.

(C). Macerodus gracilis n. sp.: a curved graciliform element, e straight graciliform element.

(D). M.? wattsbightensis n. sp.: a, c & e elements.

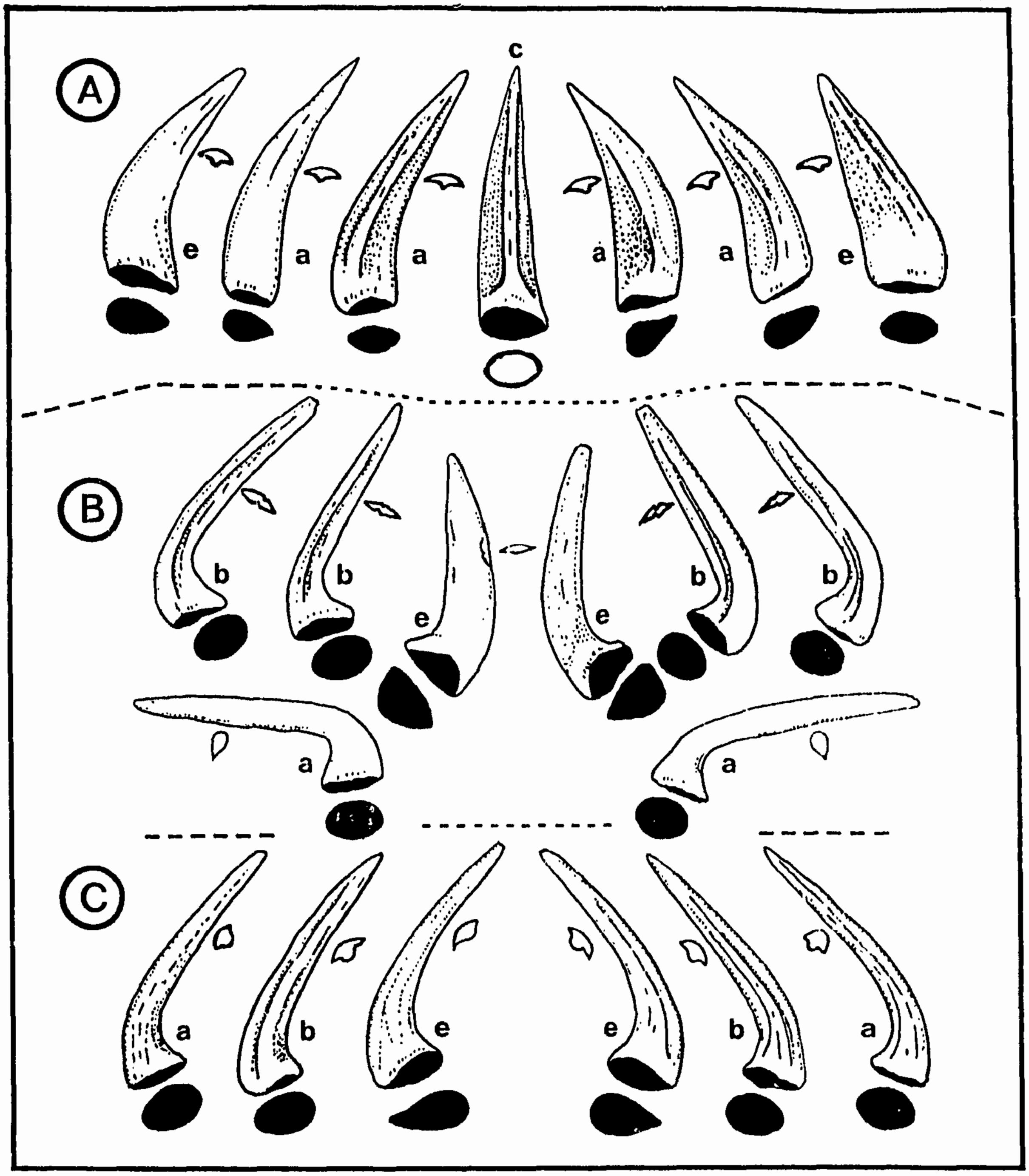


Text-fig. 6:10. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Polycostatus sulcatus (Furnish): a subrounded element, c staufferiform element, e compressed element.

(B). Polycostatus oneotensis (Furnish): a paltodiform element, c staufferiform element, e compressed paltodi form element.

(C). Polycostatus falsioneotensis n. sp.: a subrounded element, c staufferiform element, e compressed element.

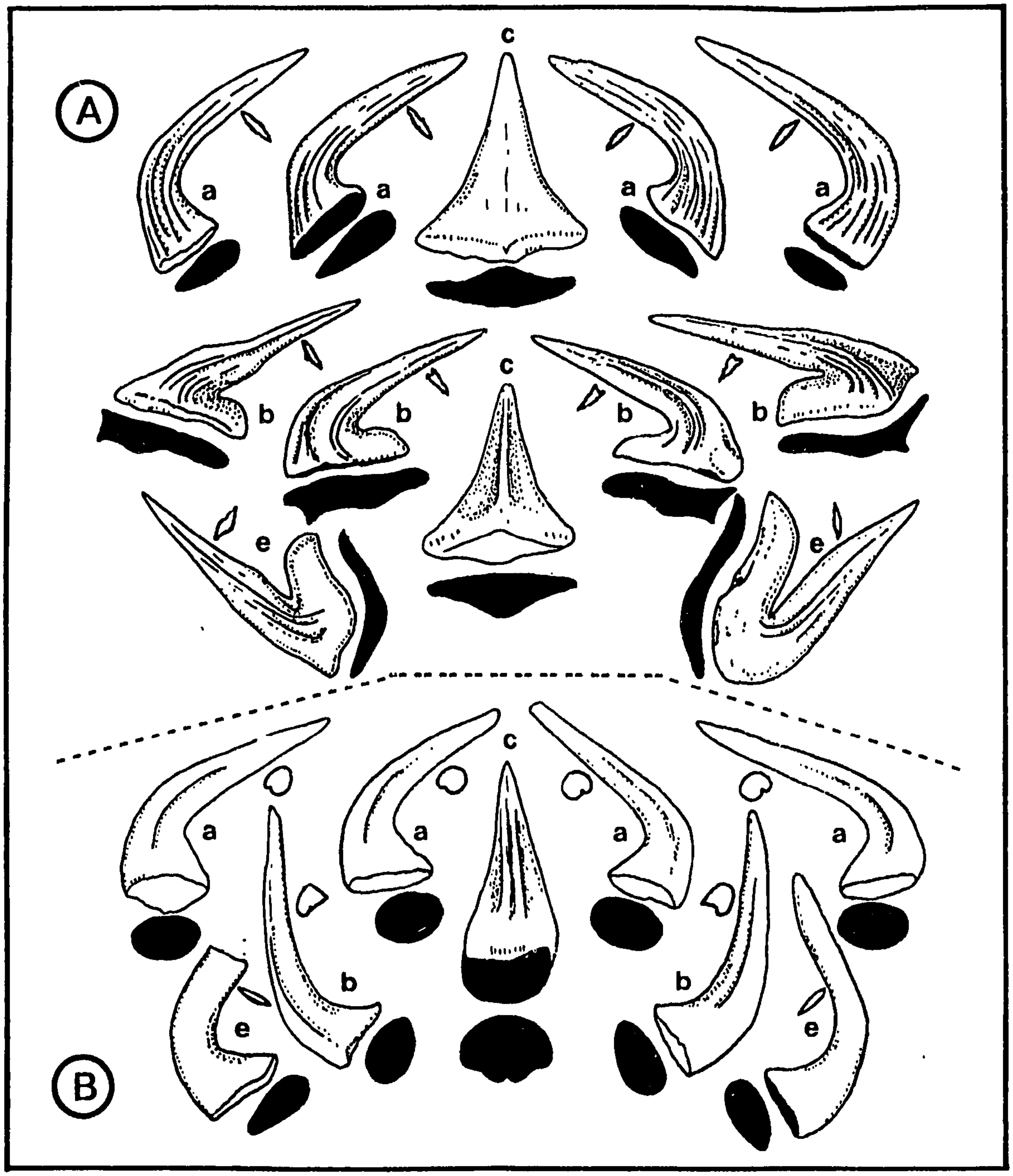


Text-fig. 6:11. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Polycostatus minutus n. sp.: a paltodiform element, c staufferiform-like element, e compressed paltodiform element.

(B). Ptrotopanderodus inconstans (Branson and Mehl): a teridontiform element, b transitional drepanodiform element, e compressed scandodiform element.

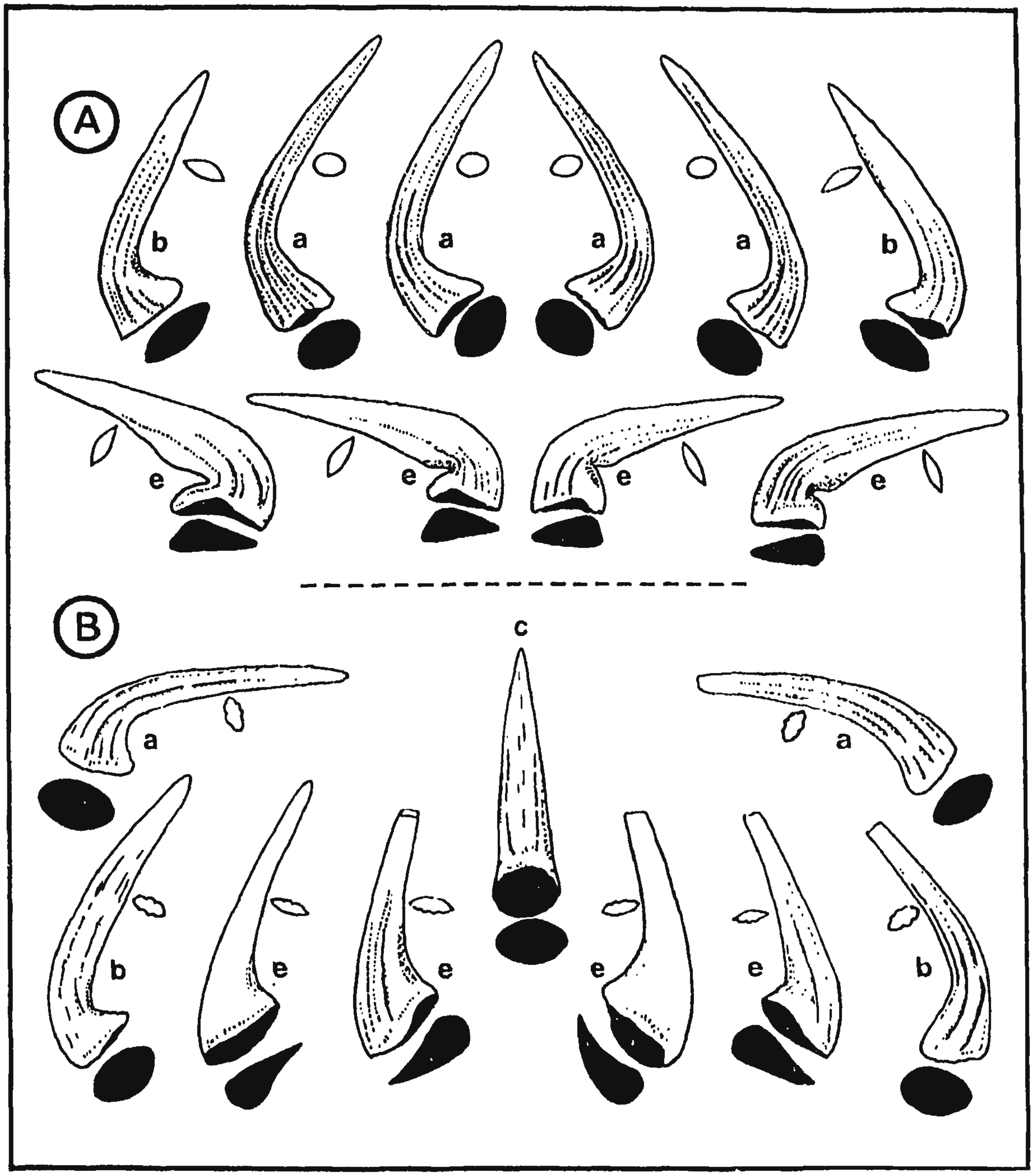
(C). Protopanderodus prolatus n. sp.: a protopanderodiform element, b transitional protopanderodiform element, e scandodiform element.



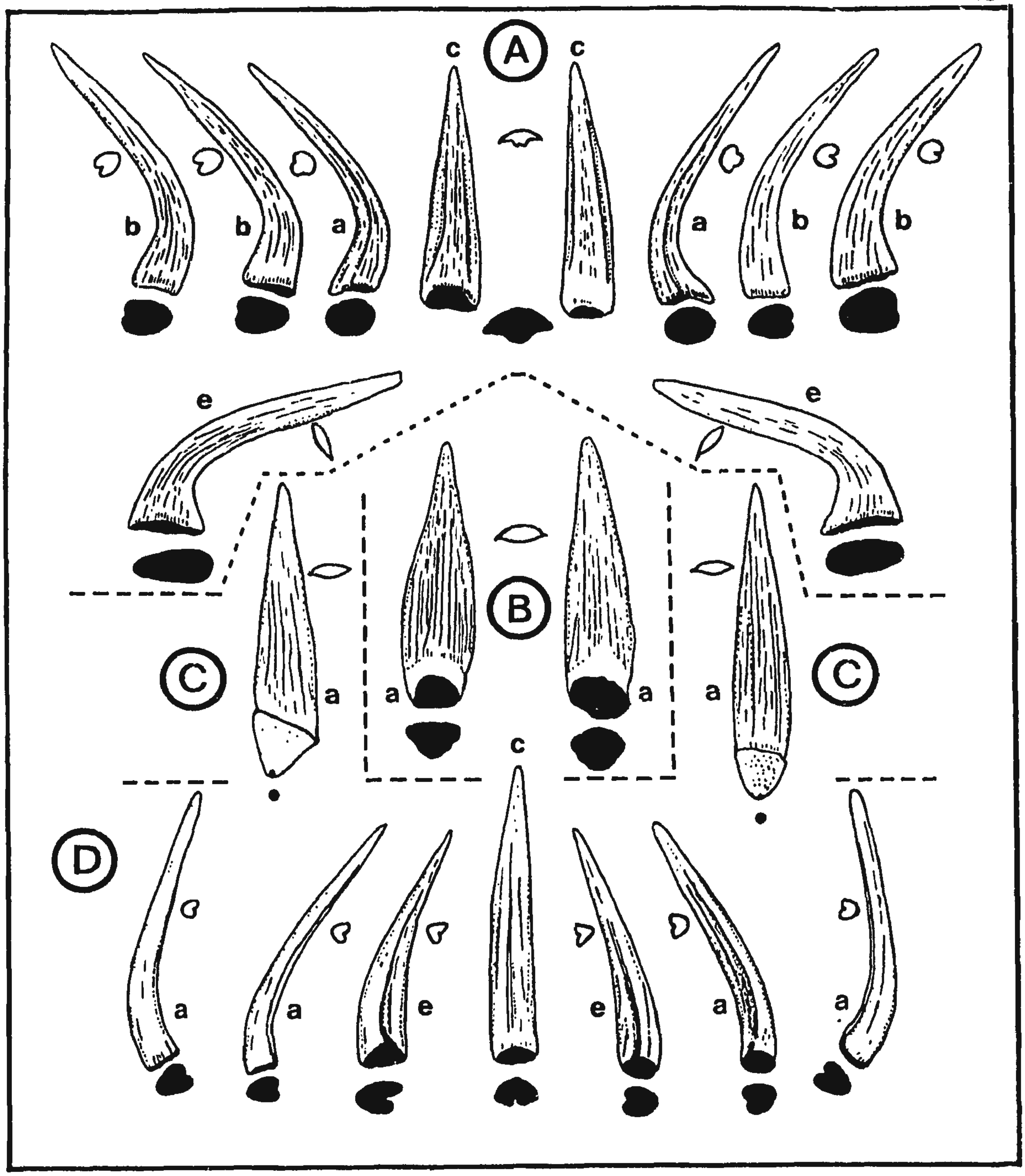
Text-fig. 6:12. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Scolopodus cornutiformis (Branson and Mehl): a cornuti formiform element, b transitional element, e oistodi form element, f deltaform element.

(B). Semiacontiodus nogamii (Miller): a subrounded element, b transitional element, c staufferiform-like element, e monocostodiform element.



Text-fig. 6:13. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.
(A). Scolopodus subrex n. sp.: a scolopodiform element, b paltodiform element, e scandodiform element.
(B). Scolopodus parabruptus Repetski: a scolopodiform element, b paltodiform element, c staufferiform element, e scandodiform element.



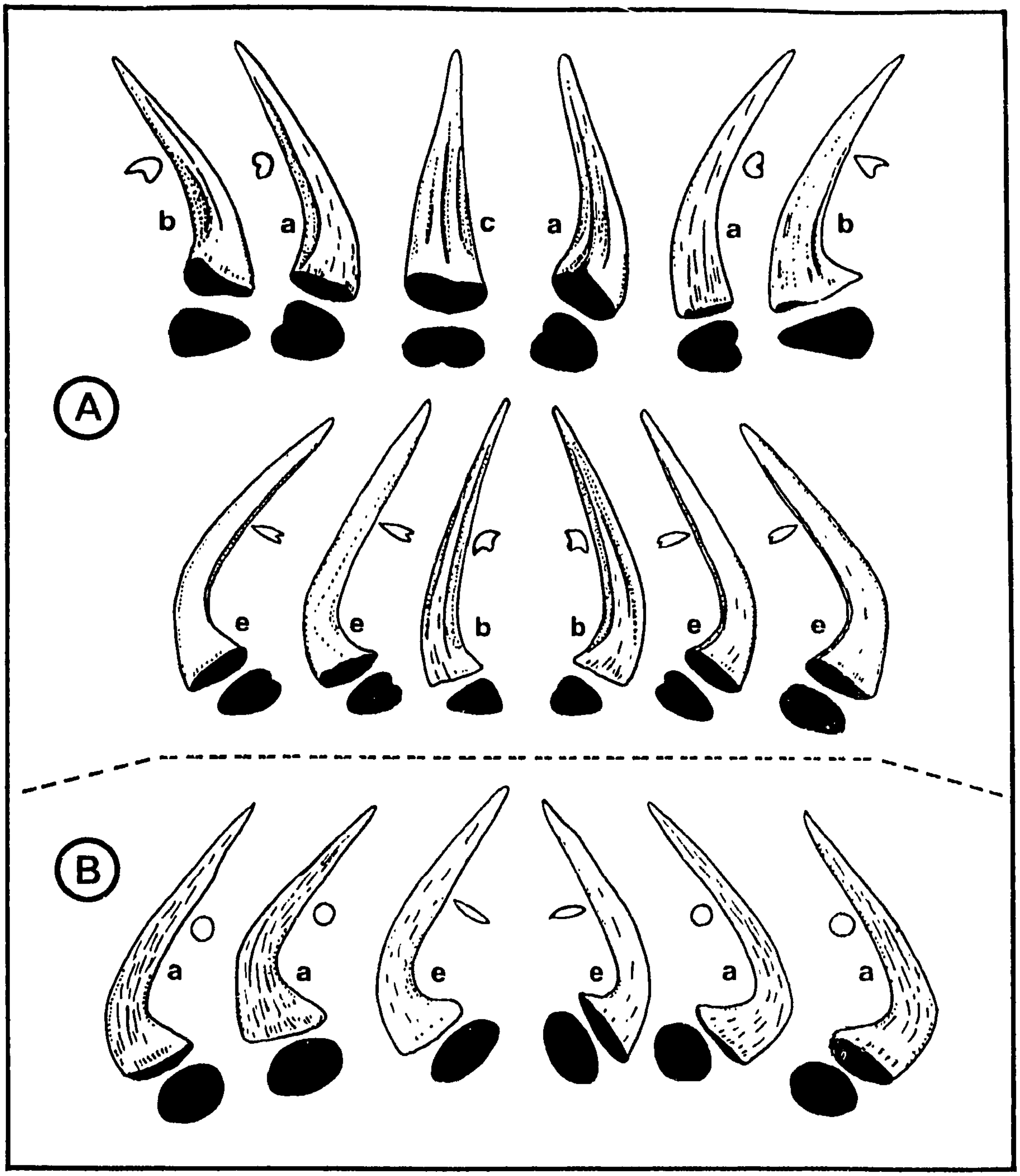
Text-fig. 6:14: Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-section.

(A). Striatodontus gracilis (Ethington and Clark): a subrounded scolopodiform element, b transitional scolopodiform element, c staufferiform-like element, e drepanodiform element.

(B). Striatodontus carlae (Repetski): a element.

(C). Striatodontus retractus n. sp.: a element.

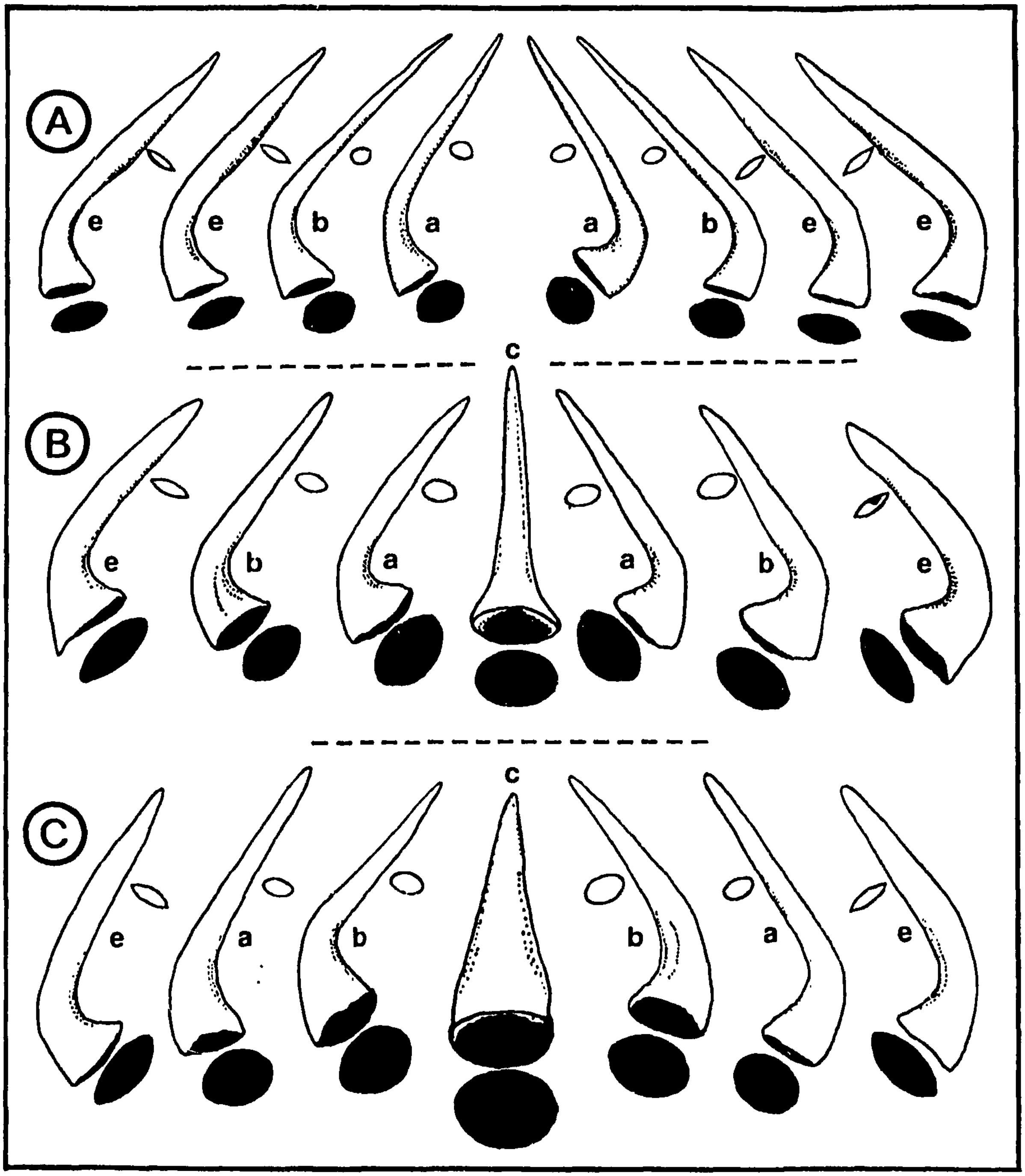
(D). Striatodontus lanceolatus n. sp.: a subrounded element, c staufferiform-like element, e compressed element.



Text-fig. 6:15. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Striatodontus prolificus n. sp.: a oneotodiform element, b triangulariform element, c staufferiform-like element, e drepanodiform element.

(B). Striatodontus teridontus n. sp.: a teridontiform element, e drepanodiform element.

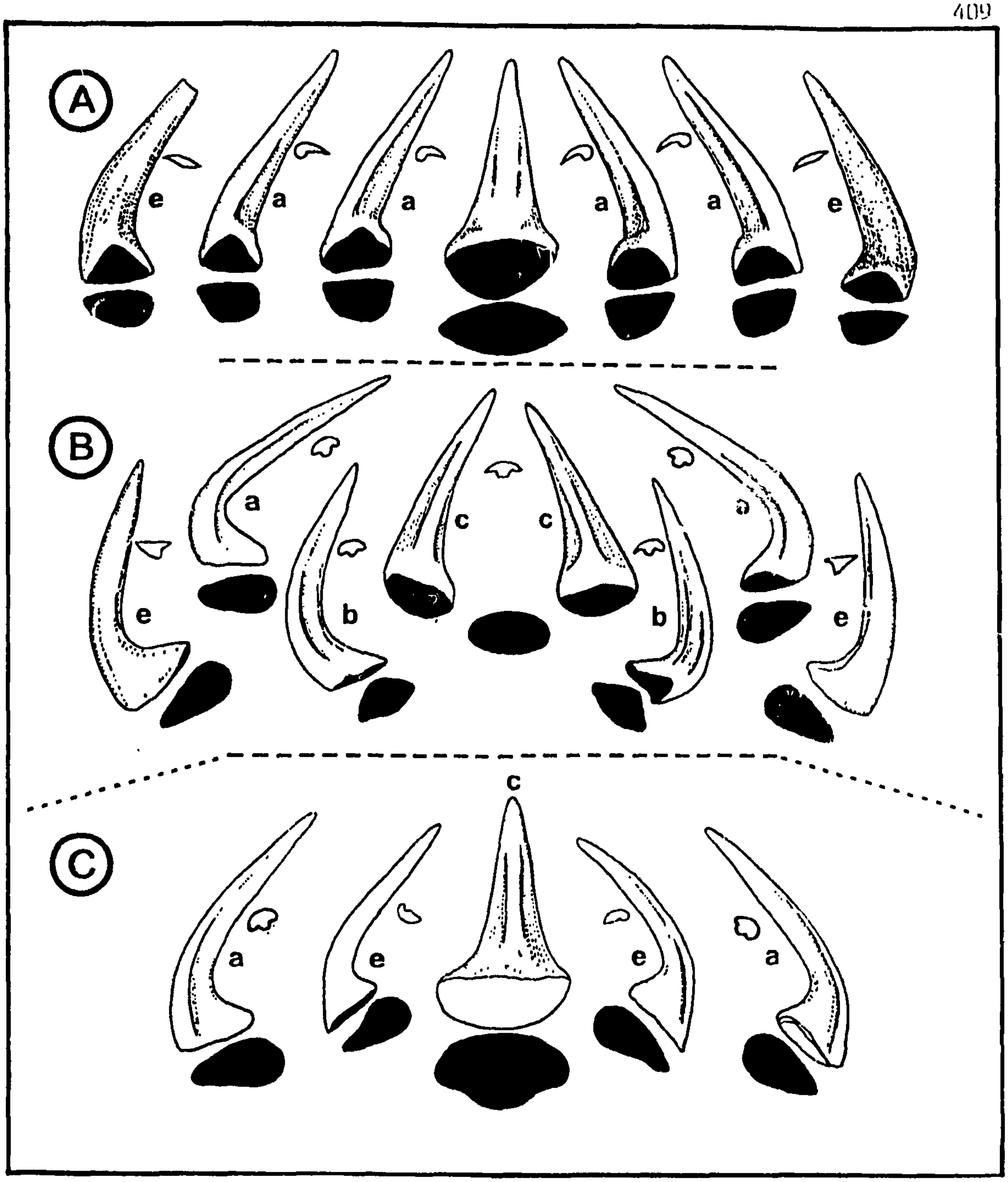


Text-fig. 6:16. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Teridontus gracillimus Nowlan: a subrounded element, b transitional element, e compressed drepanodiform element.

(B). Teridontus obesus n. sp.: a teridontiform element, b transitional teridontiform element, c suberectiform element, e monocostodiform element.

(C). Teridontus nakamurai (Nogami): a teridontiform element, b transitional element, c suberectiform element, e monocostodiform element.



Text-fig. 6:17. Outline drawings of conodont element morphotypes showing shapes of basal cavities and cross-sections.

(A). Utahconus longipinnatus n. sp.: a subrounded element, c staufferiform element, e compressed element.

(B). Variabiloconus bassleri (Furnish): a bassleriform element, b transitional element, c staufferiform-like element, e variabiliform element.

(C). Variabiloconus neobassleri n. sp.: a bassleriform-like element, c staufferiform element, e drepanodiform like element.

PLATE 1

Figures 1-8. _Acanthodus_ _lineatus_ (Furnish). Hypotypes.
1. Lateral view, _a_ element, x 80, GSC 95682, from Z4-31B.
2. Lateral view, _a_ element, x 85, GSC 95683, from Z6-10B.
3. Lateral view, _a_ element, x 50, GSC 95684, from Z4-31B.
4. Lateral view, _a_ element, x 55, GSC 95685, from Z4-31B.
5. Lateral view, _a_ element, x 85, GSC 95686, from Z6-10B.
6. Lateral view, _a_ element, x 75, GSC 95687, from Z4-31B.
7. Lateral view, _e_ element, x 50, GSC 95688, from Z2-24.
8. Lateral view, _e_ element, x 50, GSC 95689, from Z2-24.

Figures 9-13. _Acanthodus_ _uncinatus_ Furnish. Hypotypes.
9. Lateral view, _a_ element, x 35, GSC 95690, from Z4-28.
10. Lateral view, _a_ element, x 45, GSC 95691, from Z4-26.
11. Lateral view, _c_ element, x 60, GSC 95692, from Z4-31.
12. Lateral view, _e_ element, x 50, GSC 95693, from Z4-26.
13. Lateral view, _e_ element, x 60, GSC 95694, from Z4-25.

Figures 14-27. _Acodus_ _delicatus_ Branson and Mehl. Hypotypes.
14. Lateral view, _a_ element, x 55, GSC 95695, from Z2-73B.
15. Lateral view, _a_ element, x 60, GSC 95696, from Z2-73B.
16. Lateral view, _a_ element, x 80, GSC 95697, from Z2-73B.
17. Lateral view, _a_ element, x 60, GSC 95698, from Z2-73B.
18. Lateral view, _b_ element, x 75, GSC 95699, from Z2-73B.
19. Lateral view, _b_ element, x 60, GSC 95700, from Z2-73B.
20. Inner-lateral view, ?_b_ element, x 75, GSC 95701, from Z2-73B.
21. Inner-lateral view, ?_b_ element, x 75, GSC 95702, from Z2-73B.
22. Posterior view, _c_ element, x 80, GSC 95703, from Z2-73B.
23. Inner-lateral view, _e_ element, x 40, GSC 95704, from Z2-73B.
24. Inner-lateral view, _e_ element, x 55, GSC 95705, from Z2-73B.
25. Inner-lateral view, _e_ element, x 75, GSC 95706, from Z2-73B.
26. Inner-lateral view, _e_ element, x 50, GSC 95707, from Z2-73B.
27. Posterior view, _f_ element, x 55, GSC 95708, from Z2-73B.

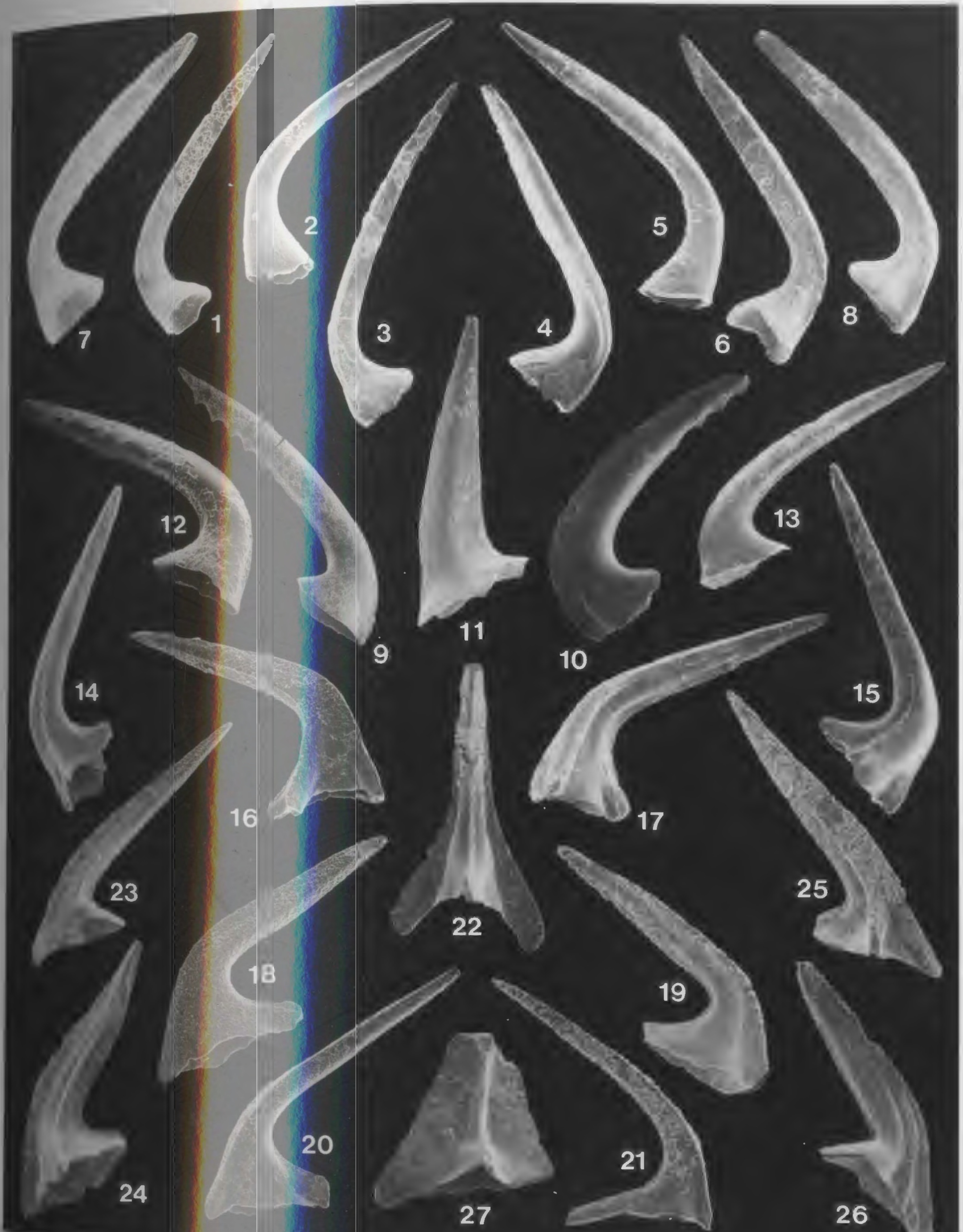

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PLATE 2

Figures 1-21. Acodus comptus (Branson and Mehl). Hypotypes.
1. Lateral view, a element, x 35, GSC 95709, from Z6-45.
2. Lateral view, a element, x 35, GSC 95710, from Z6-45.
3-4. Lateral views, a element, x 30, x 35, GSC 95711, from Z2-77.
5. Lateral view, a element, x 35, GSC 95712, from Z2-77.
6. Lateral view, a element, x 45, GSC 95713, from Z2-92.
7. Inner-lateral view, b element, x 45, GSC 95714, from Z2-77.
8. Inner-lateral view, b element, x 60, GSC 95715, from Z2-98.
9. Inner-lateral view, b element, x 45, GSC 95716, from Z6-27.
10. Inner-lateral view, b element, x 50, GSC 95717, from Z6-45.
11. Outer-lateral view, b element, x 35, GSC 95718, from Z2-97.
12. Outer-lateral view, b element, x 35, GSC 95719, from Z2-97.
13. Inner-lateral view, b element, x 30, GSC 95720, from Z2-97.
14. Inner-lateral view, b element, x 45, GSC 95721, from Z6-39.
15-16. Posterior views, c element, x 30, x 35, GSC 95722, from Z6-39.
17. Lateral view, e element, x 30, GSC 95723, from Z2-97.
18. Lateral view, e element, x 30, GSC 95724, from Z2-97.
19. Lateral view, e element, x 30, GSC 95725, from Z2-92.
20. Lateral view, e element, x 35, GSC 95726, from Z2-97.
21. Posterior view, f element, x 50, GSC 95727, from Z6-45.

Figures 22-27. Acodus primus n. sp. Holotype (22); Paratypes (23-27).
22. Lateral view, a element, x 80, GSC 95728, from Z2-66.
23. Lateral view, a element, x 60, GSC 95729, from Z2-66.
24. Lateral view, a element, x 60, GSC 95730, from Z2-66.
25. Lateral view, a element, x 60, GSC 95731, from Z2-66.
26. Inner-lateral view, e element, x 80, GSC 95732, from Z2-66.
27. Inner-lateral view, e element, GSC 95733, from Z2-66.

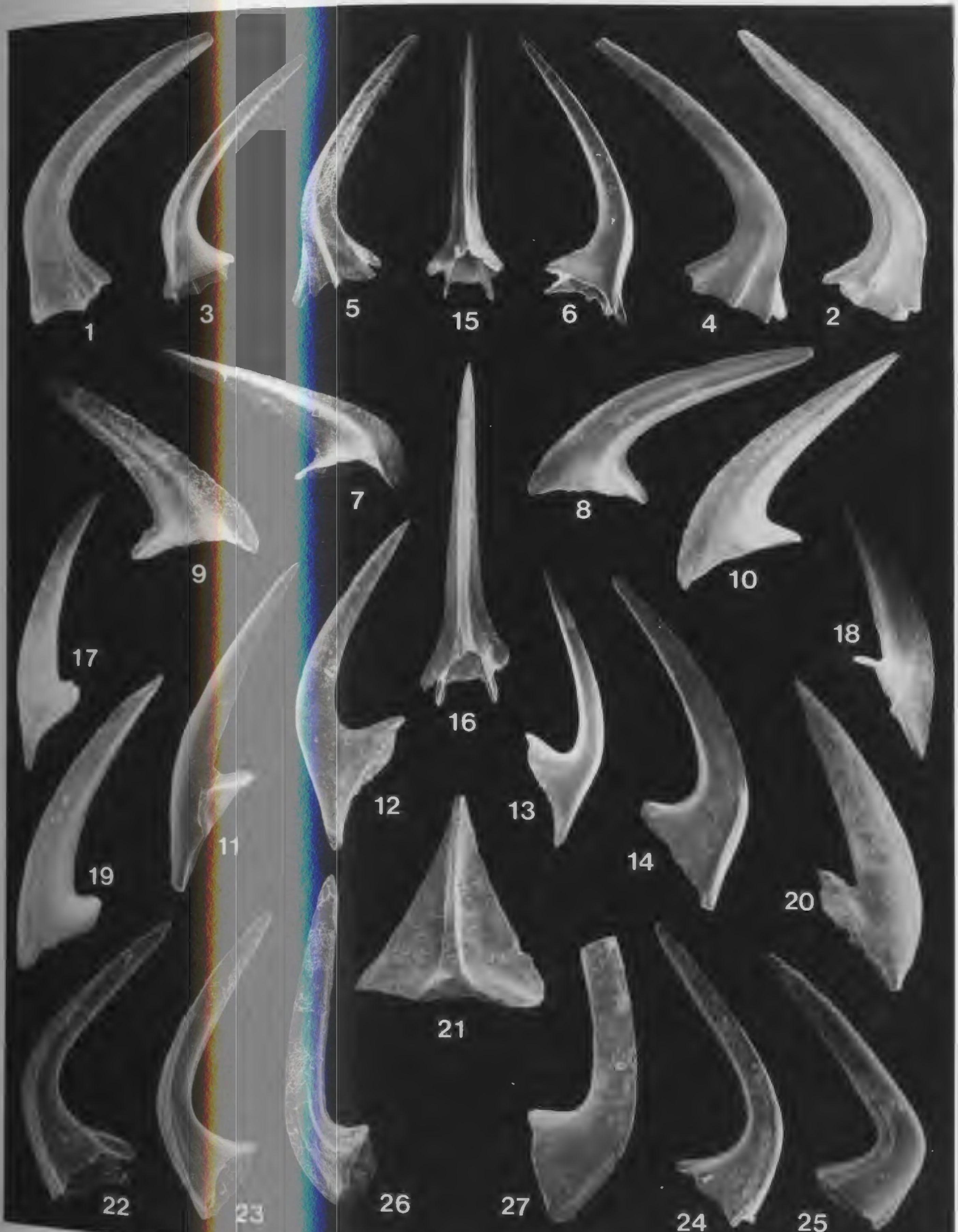
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PLATE 3

Figures 1-10. Acodus lanceolatus (Pander). Hypotypes.
1. Lateral view, a element, x 55, GSC 95734, from Z2-92.
2. Lateral view, a element, x 60, GSC 95735, from Z10-3.
3. Lateral view, b element, x 65, GSC 95736, from Z2-98.
4. Lateral view, b element, x 40, GSC 95737, from Z2-92.
5. Lateral view, b element, x 60, GSC 95738, from Z2-92.
6. Lateral view, b element, x 65, GSC 95739, from Z2-98.
7-8. Lateral views, e element, x 40, GSC 95740, from Z2-92.
9. Posterior view, f element, x 60, GSC 95741, from Z2-68B.
10. Posterior view, f element, x 110, GSC 95742, from Z2-68B.

Figures 11-14. Clavohamulus densus (Furnish). Hypotypes.
11-12. Lateral views, a element, x 160, x 160, GSC 95743, from Z4-20.
13. Antero-lateral view, e element, x 270, GSC 95744, from Z2-9B.
14. Anterior view, e element, x 160, GSC 95745, from Z4-20.

Figures 15-17. Clavohamulus longicuspis n. sp. Holotype (16-17); Paratypes (15).
15. Apical view, a element, x 145, GSC 95746, from Z2-13.
16-17. Apical view, e element, x 145, x 145, GSC 95747, from Z2-13.

Figures 18-20. Clavohamulus hintzei Miller. Hypotypes.
18. Posterior view, a element, x 165, GSC 95748, from Z4-26.
19. Lateral view, e element, x 200, GSC 95749, from Z4-26.
20. Lateral view, e element, x 200, GSC 95750, from Z4-26.

Figures 21. Clavohamulus sp. A
21. Apical view, e element, x 180, GSC 95751, from Z4-27.

Figures 22-23. Clavohamulus sp. B
22. Lateral view, e element, x 185, GSC 95752, from Z4-20.
23. Lateral view, e element, x 185, GSC 95753, from Z4-20.

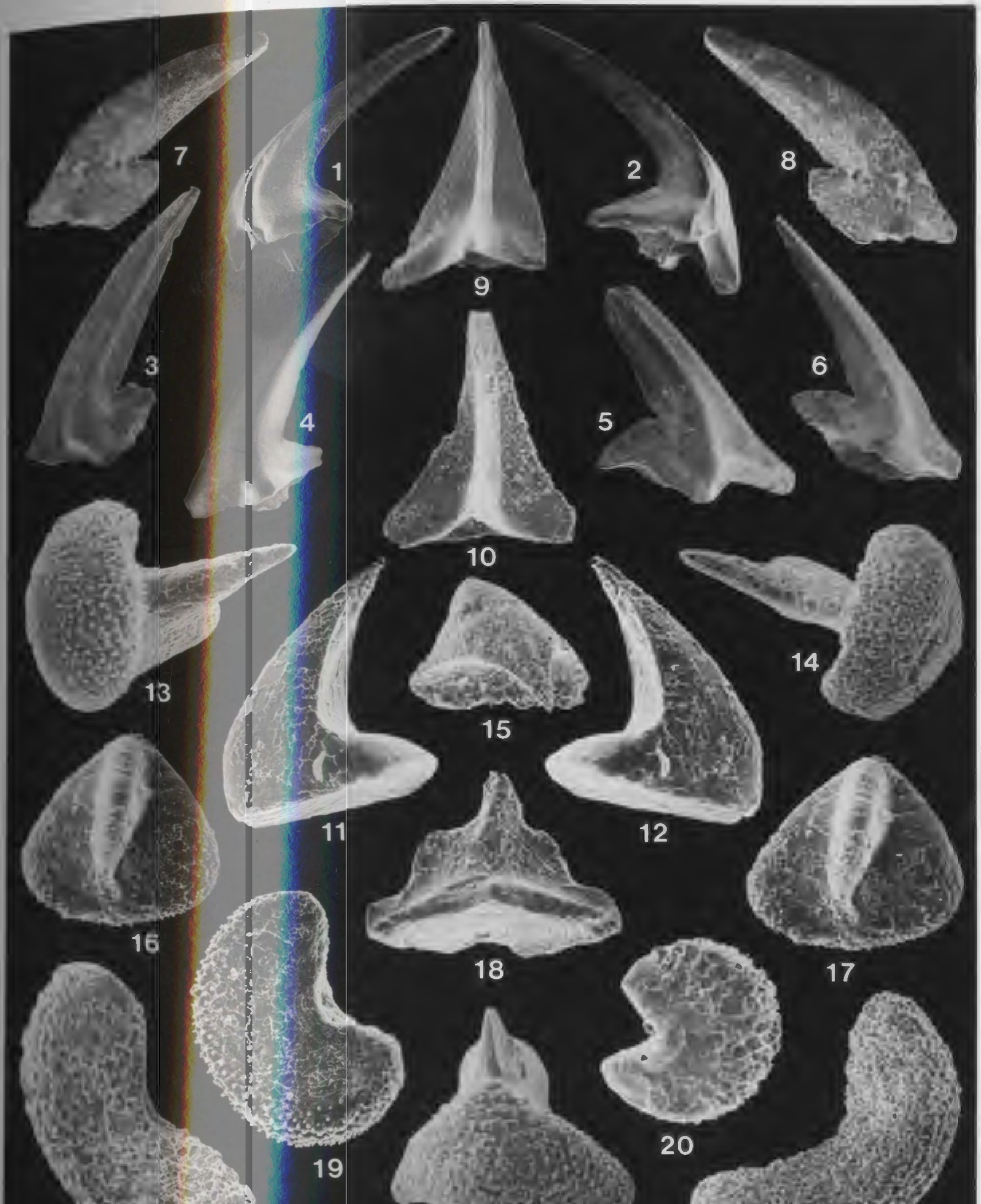
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PLATE 4

Figures 1-5. Clavohamulus neoelongatus n. sp. Holotype (5); Paratypes (1-4).

1-2. Lateral view, a element, x 165, x 165, GSC 95754, from Z2-3.
3. Lateral view, e element, x 165, GSC 95755, from Z2-3.
4. Lateral view, e element, x 125, GSC 95756, from Z2-3.
5. Basal view, e element, x 185, GSC 95757, from Z2-3.

Figures 6-10. Clavohamulus sphearicus n. sp. Holoptype (8); Paratypes (6-7, 9-10).

6. Lateral-posterior view, a element, x 130, GSC 95758, from Z2-8B.
7. Lateral view, a element, x 205, GSC 95759, from Z2-8B.
8. Lateral view, e element, x 185, GSC 95760, from Z2-8B.
9. Lateral view, e element, x 160, GSC 95761, from Z2-8B.
10. Lateral view, e element, x 165, GSC 95762, from Z2-8B.

Figures 11-20. Clavohamulus reniformis n. sp. Holotype (14-15); Paratypes (11-13, 16-20).

11. Anterior view, a element, x 125, GSC 95763, from Z4-32.
12. Posterior view, a element, x 105, GSC 95764, from Z4-32.
13. Anterior view, a element, x 130, GSC 95765, from Z4-32.
14-15. Postero-basal view, a element, x 145, x165, GSC 95766, from Z4-32.
16. Lateral view, e element, x 135, GSC 95767, from Z4-31.
17. Lateral view, e element, x 125, GSC 95768, from Z4-32.
18. Lateral view, e element, x 125, GSC 95769, from Z4-32.
19. Inner-lateral view, e element, x 135, GSC 95770, from Z4-31.
20. Lateral view showing small nodes, x 395, GSC 95771, from Z4-32.

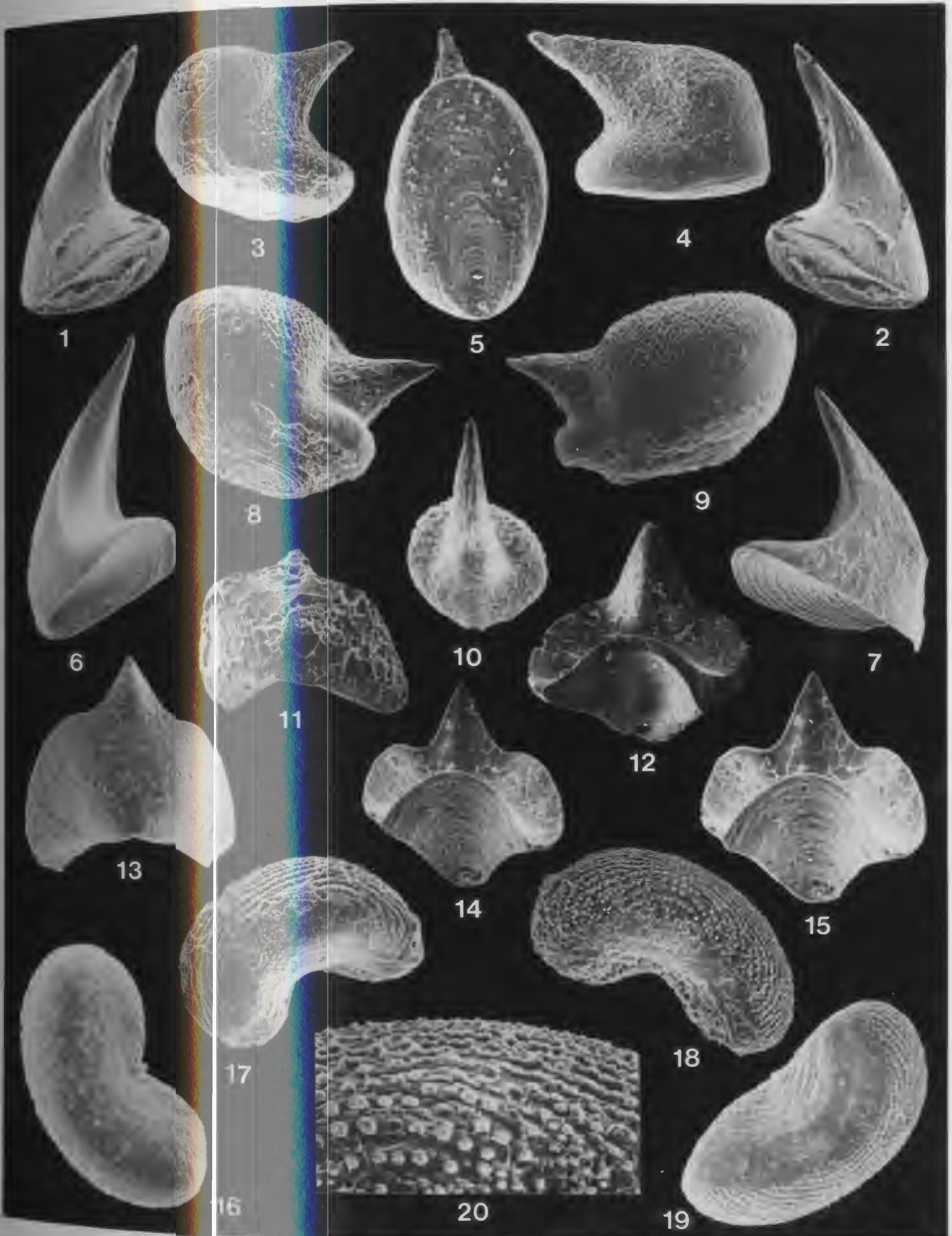
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PLATE 5

Figures 1-9. Cordylodus angulatus Pander. Hypotypes.
1. Lateral view, a element, x 35, GSC 95772, from Z4-26.
2. Lateral view, a element, x 35, GSC 95773, from Z7-15.
3. Lateral view, a element, x 35, GSC 95774, from Z4-31B.
4. Lateral view, a element, x 35, GSC 95775, from Z7-15.
5. Lateral view, c element, x 35, GSC 95776, from Z4-32.
6. Lateral view, e element, x 35, GSC 95777, from Z4-31B.
7. Lateral view, e element, x 35, GSC 95778, from Z4-31B.
8. Lateral view, e element, x 35, GSC 95779, from Z4-31B.
9. Lateral view, e element, x 35, GSC 95780, from Z4-31B.

Figures 10-18. Cordylodus intermedius Furnish. Hypotypes.
10. Lateral view, a element, x 35, GSC 95781, from Z6-6B.
11. Lateral view, a element, x 40, GSC 95782, from Z9-4.
12. Lateral view, a element, x 40, GSC 95783, from Z9-4.
13. Lateral view, a element, x 35, GSC 95784, from Z5-3.
14-15. Lateral views, c element, all x 40, GSC 95785, from 2-9B.
16. Lateral view, c element, x 35, GSC 95786, from Z5-3.
17-18. Lateral view, ?e element, x 35, GSC 95787, from Z9-4.

Figures 19-22. Cordylodus lindstromi Druce and Jones. Hypotypes.
19. Lateral view, a element, x 40, GSC 95788, from Z4-22.
20. Lateral view, a element, x 40, GSC 95789, from Z4-22.
21. Lateral view, e element, x 40, GSC 95790, from Z4-22.
22. Lateral view, e element, x 40, GSC 95791, from Z5-8.

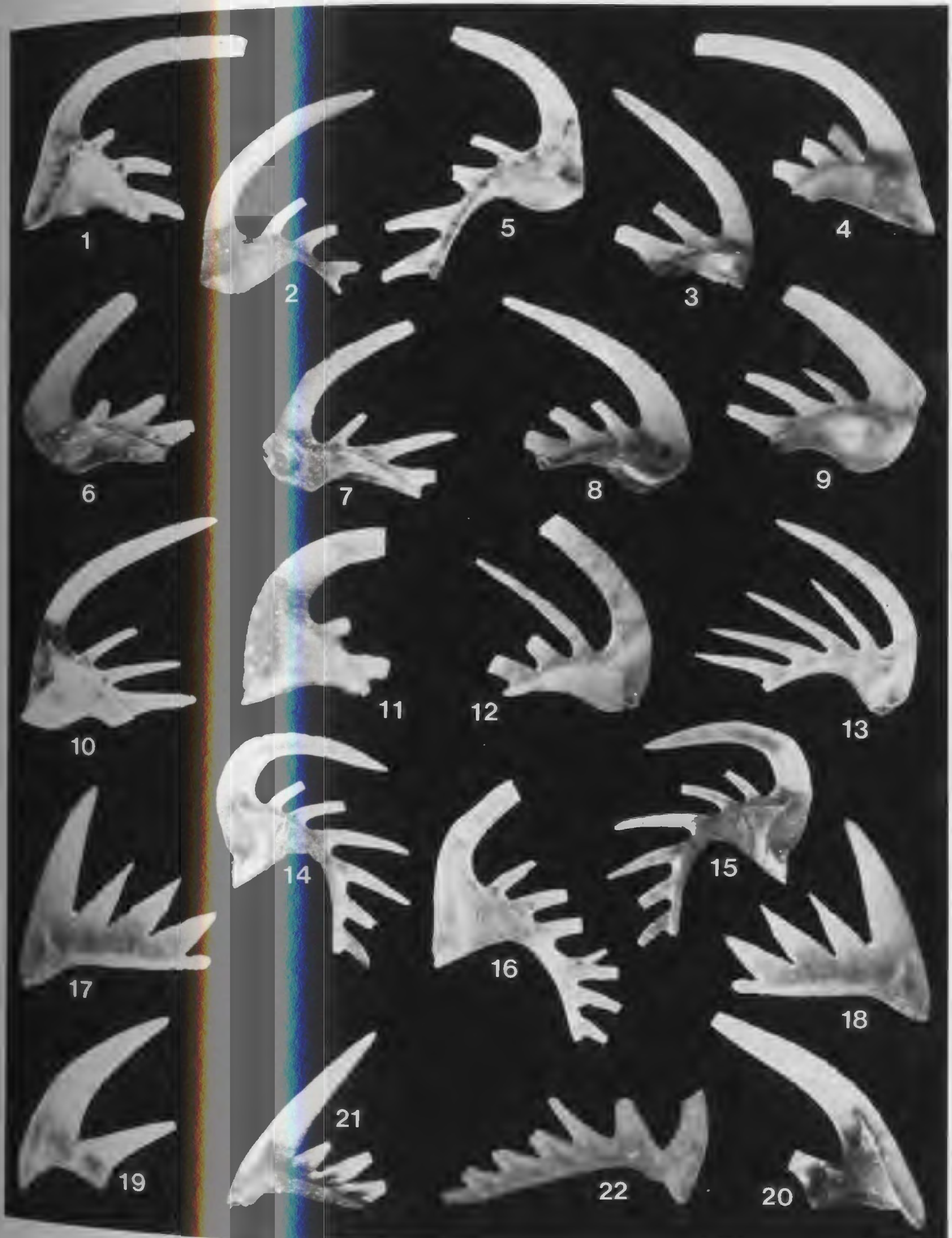
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PLATE 6

Figures 1-4. Cristodus ethingtoni n. sp. Holotype (3); Paratypes (1, 2, 4).

1. Lateral view, a element, x 85, GSC 95792, from Z2-76.
2. Anterior view, e element, x 125, GSC 95793, from Z2-72.
3. Posterior view, e element, x 70, GSC 95794, from Z6-43B.
4. Anterior view, e element, x 70, GSC 95795, from Z2-76.

Figures 5-10. Cristodus loxoides Repetski. Hypotypes.

5. Lateral view, a element, x 105, GSC 95796, from Z6-43B.
6. Lateral view, a element, x 60, GSC 95797 from Z2-68B.
7. Outer-lateral view, e element, x 105, GSC 95798, from Z6-43B.
8. Outer-lateral view, e element, x 100, GSC 95799, from Z6-43B.
9. Inner-lateral view, e element, x 70, GSC 95800, from Z6-43B.
10. Outer lateral view, e element, x 70, GSC 95801, from Z6-43B.

Figures 11-20. Drepanodus arcuatus Pander. Hypotypes.

11. Inner-lateral view, a element, x 50, GSC 95802, from Z2-46B.
12. Outer-lateral view, a element, x 55, GSC 95803, from Z2-46B.
13. Outer-lateral view, a element, x 50, GSC 95804, from Z2-46B.
14. Outer-lateral view, a element, x 70, GSC 95805, from Z2-94B.
15. Outer-lateral view, a element, x 70, GSC 95806, from Z2-94B.
16. Inner-lateral view, a element, x 50, GSC 95807, from Z2-46B.

17,20. Inner and outer lateral views, e element, x 55, GSC 95808, from Z2-94B.

18-19. Lateral view, e element, x 80, x55, GSC 95809, from Z2-94B.

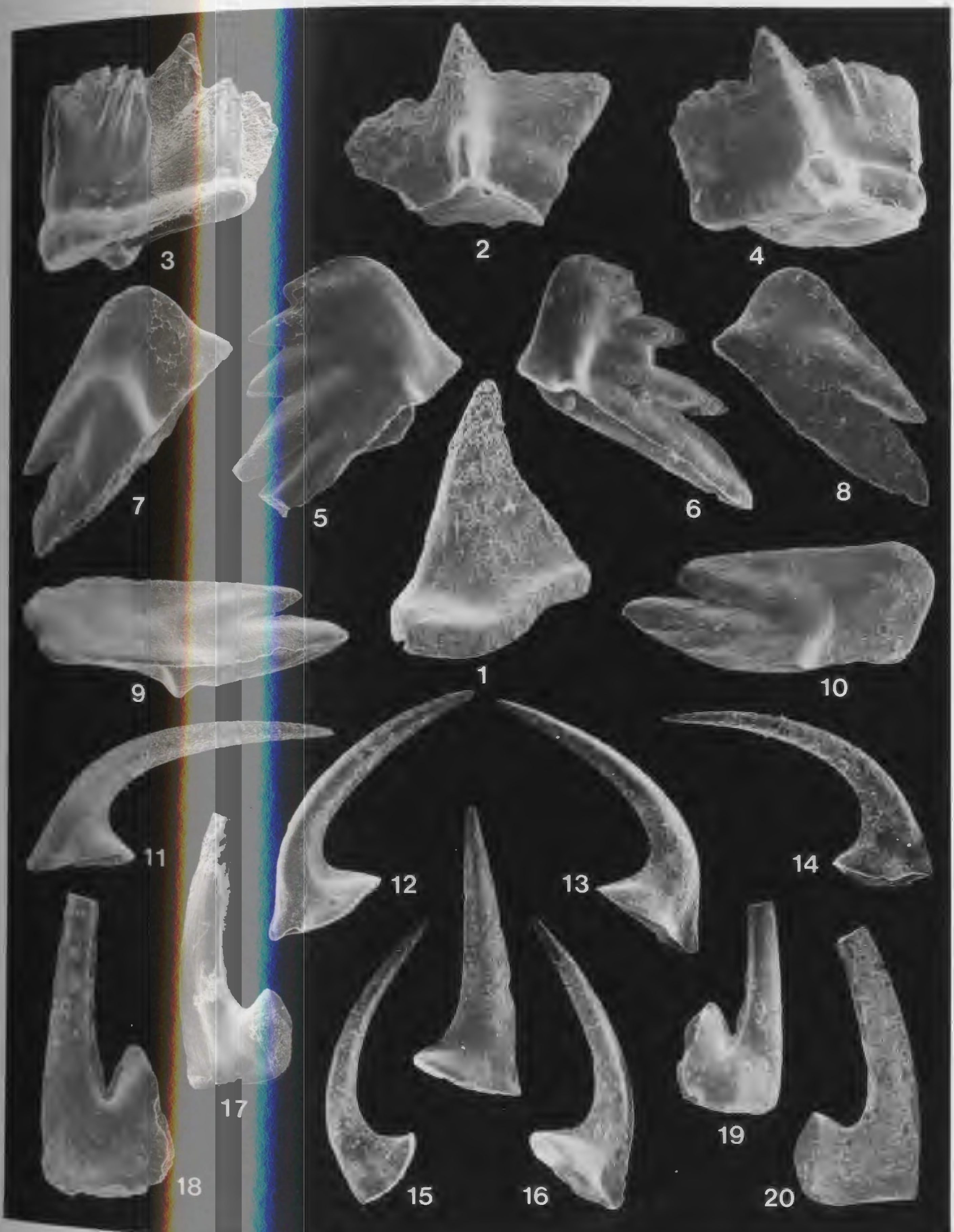
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PLATE 7

Figures 1-7. Drepanodus concavus (Branson and Mehl). Hypotypes.
1. Outer-lateral view, a element, x 30, GSC 95810, from Z2-77.
2. Outer-lateral view, a element, x 40, GSC 95811, from Z2-77.
3. Inner-lateral view, a element, x 30, GSC 95812, from Z2-77.
4. Outer-lateral view, a element, x 30, GSC 95813, from Z6-27.
5. Lateral view, c element, x 30, GSC 95814, from Z2-77.
6. Lateral view, e element, x 20, GSC 95815, from Z2-77.
7. Lateral view, e element, x 30, GSC 95816, from Z2-77.

Figures 8-20. Drepanodus nowlani n. sp. Holotype (8, 12); Paratypes (9-11, 13-20).

8,12. Outer and inner lateral views, a element, all x 40, GSC 95817, from Z2-46B.

9. Outer-lateral view, a element, x 70, GSC 95818, from Z2-46B.

10. Outer-lateral view, a element, x 50, GSC 95819, from Z2-46B.

11. Inner-lateral view, a element, x 65, GSC 95820, from Z2-46B.

13. Outer-lateral view, a element, x 50, GSC 95821, from Z2-46B.

14. Lateral view, c element, x 70, GSC 95822, from Z8-8.

15-16. Inner-lateral views, e element, all x 70, GSC 95823, from Z8-8.

17. Lateral view, e element, x 85, GSC 95824, from Z2-46B.

18. Lateral view, e element, x 70, GSC 95825, from Z2-46B.

19. Outer-lateral view, e element, x 70, GSC 95826, from Z2-46B.

20. Inner-lateral view, e element, x 70, GSC 95827, from Z8-8.

Figures 21-27. Drepanodus pervetus (Nowlan). Hypotypes.

21. Lateral view, a element, x 45, GSC 95828, from Z9-4.
22. Outer-lateral view, a element, x 60, GSC 95829, from Z9-4.
23. Outer-lateral view, a element, x 60, GSC 95830, from Z9-4.
24. Inner-lateral view, a element, x 90, GSC 95831, from Z9-4.
25. Outer-lateral view, e element, x 40, GSC 95832, from Z7-17.
26. Outer lateral view, e element, x 40, GSC 95833, from Z7-13.
27. Lateral view, c element, x 35, GSC 95834, from Z5-8.

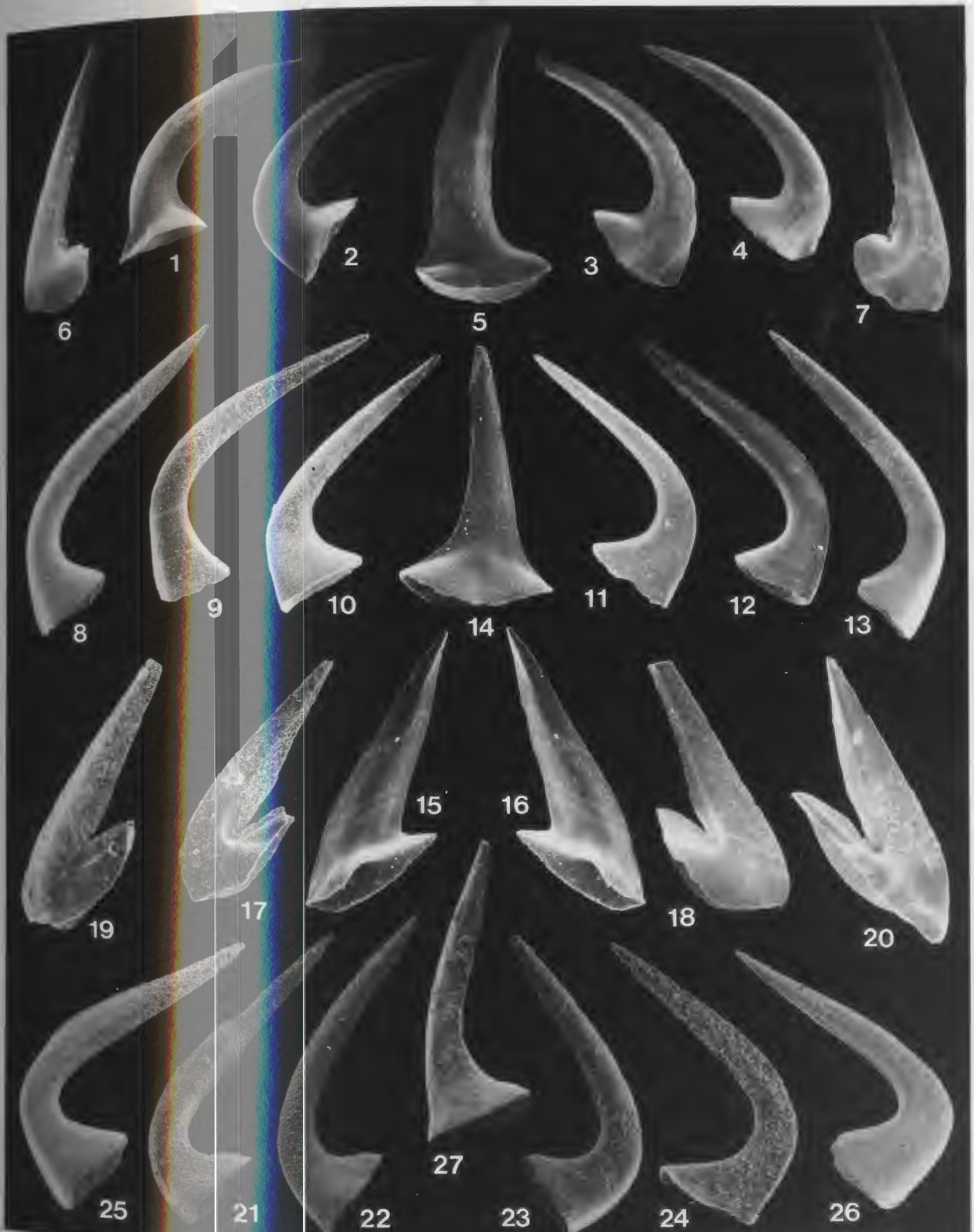
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PLATE 8

Figures 1-7. <u>Glyptoconus</u> <u>felicitii</u> n. sp. Holotype (5); Paratypes (1-4, 6-7).

1. Lateral view, <u>a</u> element, x 60, GSC 95835, from Z2-64.
2. Lateral-posterior view, <u>a</u> element, x 60, GSC 95836, from Z2-64.
3. Posterior view, <u>a</u> element, x 45, GSC 95837, from Z2-64.
4. Posterior view, <u>a</u> element, x 45, GSC 95838, from Z2-64.
5. Posterior view, <u>c</u> element, x 85, GSC 95839, from Z2-64.

6-7. Lateral-posterior view, <u>e</u> element, x 75, GSC 95840, from Z2-64.

Figures 8-13. <u>Glyptoconus</u> <u>bolites</u> (Repetski). Hypotypes.

8. Posterior view, <u>a</u> element, x 80, GSC 95841, from Z2-35B.
9. Posterior view, <u>a</u> element, x 70, GSC 95842, from Z2_35B.
10. Posterior view, <u>a</u> element, x 50, GSC 95843, from Z2-35.
11. Postero-lateral view, <u>e</u> element, x 60, GSC 95844, from Z2-35.
12. Posterior view, <u>c</u> element, GSC 95845, from Z2-35.
13. Posterior view, <u>c</u> element, GSC 95846, from Z2-35B.

Figures 14-26. <u>Glyptoconus</u> <u>floweri</u> (Repetski). Hypotypes.

14. Lateral view, <u>a</u> element, x 50, GSC 95847, from Z2-37B.
15. Lateral view, <u>a</u> element, x 40, GSC 95848, from Z2-37B.
16. Lateral view, <u>a</u> element, x 40, GSC 95849, from Z6-20.
17. Lateral view, <u>a</u> element, x 40, GSC 95850, from Z8-3.
18. Lateral view, <u>a</u> element, x 80, GSC 95851, from Z6-20.
19. Lateral view, <u>a</u> element, x 35, GSC 95852, from Z2-37B.
20. Lateral-potsreior view, <u>b</u> element, x 40, GSC 95853, from Z2-37B.
21. Lateral-posterior view, <u>b</u> element, x 60, GSC 95854, from Z2-37B.
22. Lateral-posterior view, <u>b</u> element, x 40, GSC 95855, from Z2-37B.
23. Lateral-posterior view, <u>b</u> element, x 40, GSC 95856, from Z2-37B.
24. Posterior view, <u>c</u> element, x 60, GSC 95857, from Z8-3.
25. Lateral-posterior view, <u>e</u> element, x 35, GSC 95858, from Z2-37B.
26. Lateral-posterior view, <u>e</u> element, x 35, GSC 95859, from Z6-20.

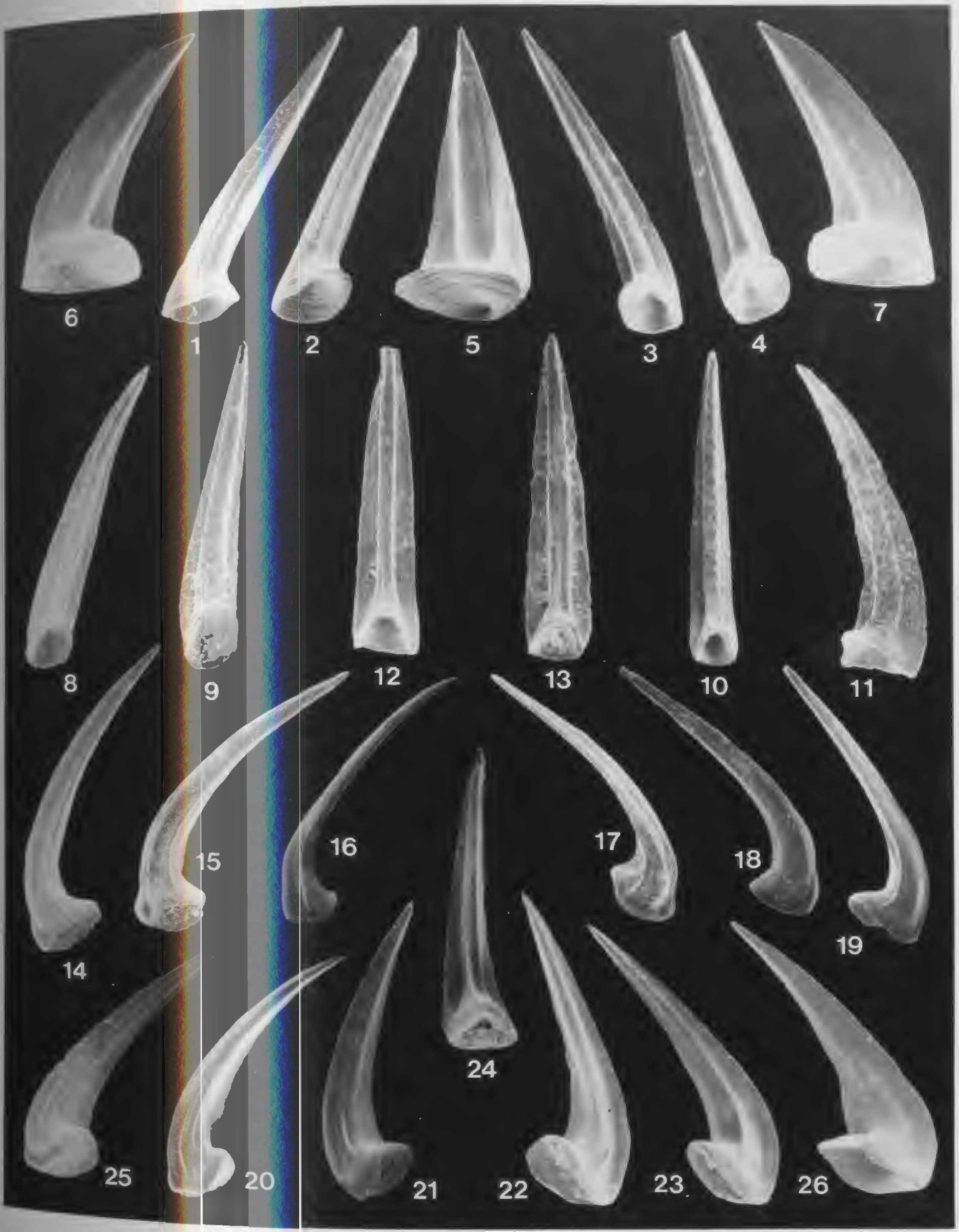
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PLATE 9

Figures 1-13. Glyptoconus emarginatus (Barnes and Tuke). Hypotypes.

1. Lateral view, *a* element, x 60, GSC 95860, from Z6-45.
2. Lateral view, *a* element, x 45, GSC 95861, from Z6-44B.
3. Lateral view, *a* element, x 55, GSC 95862, from Z6-45.
4. Lateral view, *a* element, x 85, GSC 95863, from Z6-45.
5. Lateral view, *b* element, x 70, GSC 95864, from Z6-45.
6. Lateral view, *b* element, x 50, GSC 95865, from Z6-44B.
7. Posterior view, *c* element, x 65, GSC 95866, from Z6-44B.
8. Outer-lateral view, *e* element, x 45, GSC 95867, from Z6-44B.
9. Inner-lateral view, *e* element, x 40, GSC 95868, from Z6-45.
10. Outer-lateral view, *e* element, x 40, GSC 95869, from Z6-45.
11. Inner-lateral view, *e* element, x 40, GSC 95870, from Z6-45.

12-13. Lateral and posterior view, *f* element, x 45, GSC 95871, from Z6-44B.

Figures 14-28. Glyptoconus multiplicatus n. sp. Holotype (23); Paratypes (14-22, 24-28).

14. Lateral view, *a* element, x 40, GSC 95872, from Z2-94B.
15. Lateral view, *a* element, x 40, GSC 95873, from Z6-43B.
16. Lateral view, *a* element, x 45, GSC 95874, from Z6-43B.
17. Lateral view, *a* element, x 40, GSC 95875, from Z6-43B.
18. Lateral view, *b* element, x 45, GSC 95876, from Z2-94B.
19. Lateral view, *b* element, x 40, GSC 95877, from Z6-43B.
20. Postero-lateral view, *b* element, x 40, GSC 95878, from Z6-43B.
21. Lateral view *b* element, x 40, GSC 95879, from Z6-43B.
22. Anterior view, *c* element, x 80, GSC 95880, from Z2-94B.
23. Posterior view, *c* element, x 80, GSC 95881, from Z2-94B.
24. Lateral view, *e* element, x 65, GSC 95882, from Z6-43B.
25. Outer-lateral view, *e* element, x 45, GSC 95883, from Z6-43B.
26. Lateral view, *e* element, x 45, GSC 95884, from Z6-43B.
27. Outer-lateral view, *e* element, x 35, GSC 95885, from Z2-94B.
28. Posterior view, *f* element, x 80, GSC 95886, from Z2-94B.

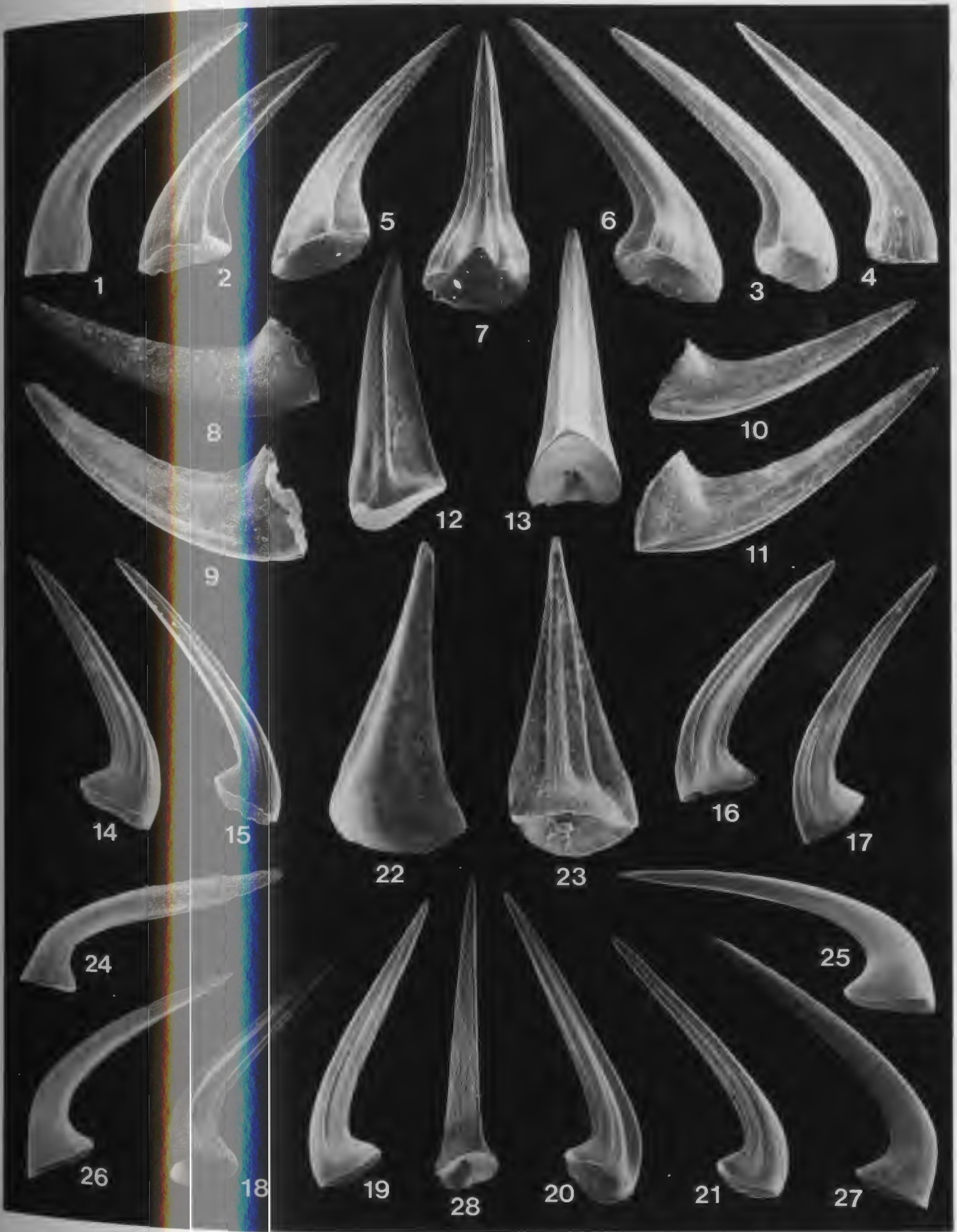
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PLATE 10

Figures 1-7. Glyptoconus priscus n. sp. Holotype (1); Paratypes (2-7).

1. Lateral view, a element, x 55, GSC 95887, from Z6-17.
2. Lateral view, a element, x 55, GSC 95888, from Z6-17.
3. Lateral view, a element, x 65, GSC 95889, from Z6-17.
4. Lateral view, a element, x 65, GSC 95890, from Z6-17.
5. Lateral view, e element, x 55, GSC 95891, from Z6-17.
6. Lateral view, e element, x 55, GSC 95892, from Z6-17.
7. Lateral view, f element, x 55, GSC 95893, from Z6-17.

Figures 8-20. Glyptoconus quadraplicatus (Branson and Mehl). Hypotypes.

8,13. Lateral views, b element, all x 55, GSC 95894, from Z2-76.
9. Lateral view, a element, x 45, GSC 95895, from Z2-76.
10. Lateral view, a element, x 45, GSC 95896, from Z2-76.
11. Lateral view, a element, x 45, GSC 95897, from Z2-76.
12. Lateral view, b element, x 50, GSC 95898, from Z2-77.
14. Posterior view, c element, x 85, GSC 95899, from Z6-27.
15. Outer-lateral view, e element, x 35, GSC 95900, from Z2-77.
16. Outer-lateral view, e element, x 55, GSC 95901, from Z2-76.
17. Outer-lateral view, e element, x 35, GSC 95902, from Z6-27.
18. Outer-lateral view, e element, x 45, GSC 95903, from Z2-76.
19. Posterior view, f element, x 60, GSC 95904, from Z2-76.
20. Anterior view, f element, x 50, GSC 95905, from Z2-77.

Figures 21-27. Glyptoconus triplicatus (Ethington and Clark). Hypotypes.

21-22. Lateral views, a element, all x 45, GSC 95906, from Z2-43.
23. Lateral view, a element, x 60, GSC 95907, from Z4-37.
24. Lateral view, a element, x 60, GSC 95908, from Z4-37.
25. Lateral view, a element, x 60, GSC 95909, from Z2-43.
26. Lateral view, c element, x 60, GSC 95910, from Z2-43.
27. Posterior view, c element, x 80, GSC 95911, from Z4-37.

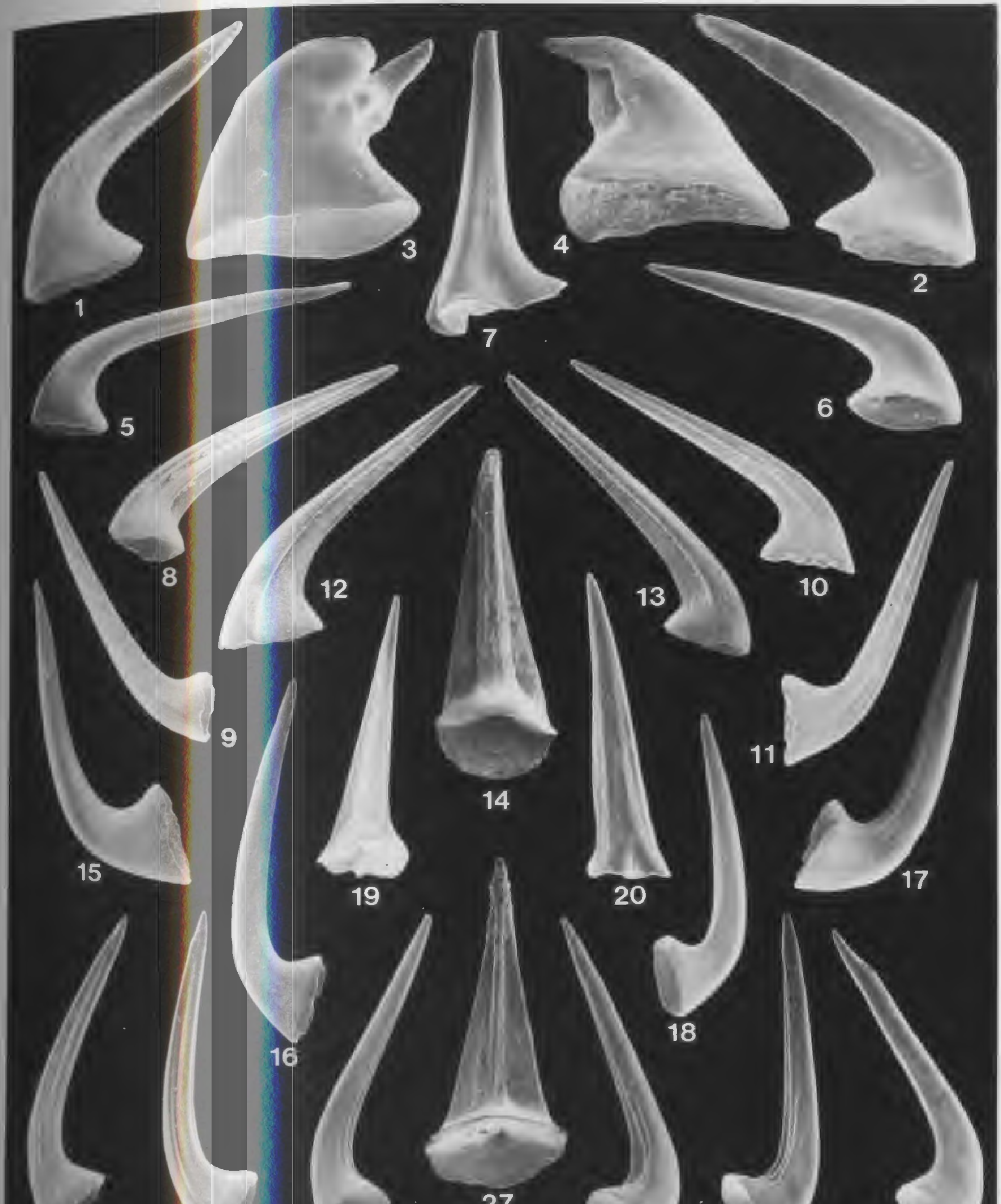
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PLATE 11

Figures 1-9. Glyptodontus constrictus n. sp. Holotype (1); Paratypes (2-9).

1. Lateral view, a element, x 80, GSC 95912, from Z6-7.
2. Lateral view, a element, x 80, GSC 95913, from Z6-7.
3-4. Lateral views, a element, x 120, GSC 95914, from Z6-7.
5. Inner-lateral view, e element, x 120, GSC 95915, from Z4-20B.
6. Inner-lateral view, e element, x 110, GSC 95916, from Z6-7.
7. Inner-lateral view, e element, x 80, GSC 95917, from Z4-20B.
8. Inner-lateral view, e element, x 75, GSC 95918, from Z4-20B.
9. Posterior view, c element, x 75, GSC 95919, from Z4-20B.

Figures 10-17. Glyptodontus expansus n. sp. Holotype (11); Paratypes (10, 12-17).

10. Inner-lateral view, a element, x 75, GSC 95920, from Z6-5.
11. Inner-lateral view, a element, x 75, GSC 95921, from Z6-5.
12. Outer-lateral view, e element, x 60, GSC 95922, from Z4-19.
13. Inner-lateral view, e element, x 100, GSC 95923, from Z6-5.
14. Outer-lateral view, e element, x 60, GSC 95924, from Z4-19.
15. Inner-lateral view, e element, x 75, GSC 95925, from Z6-5.
16. Posterior view, c element, x 75, GSC 95926, from Z6-5.
17. Anterior view, c element, x 75, GSC 95927, from Z6-5.

Figures 18-22. Glyptodontus tumidus n. sp. Holotype (19, 21); Paratypes (18, 20, 22).

18. Inner-lateral view, a element, x 40, GSC 95928, from Z5-8.
19,21. Outer and inner lateral view, a element, x 60, x 55, GSC 95929, from Z4-19.
20. Inner-lateral view, a element, x 40, GSC 95930, from Z4-19.
22. Posterior view, c element, x 40, GSC 95931, from Z4-19.

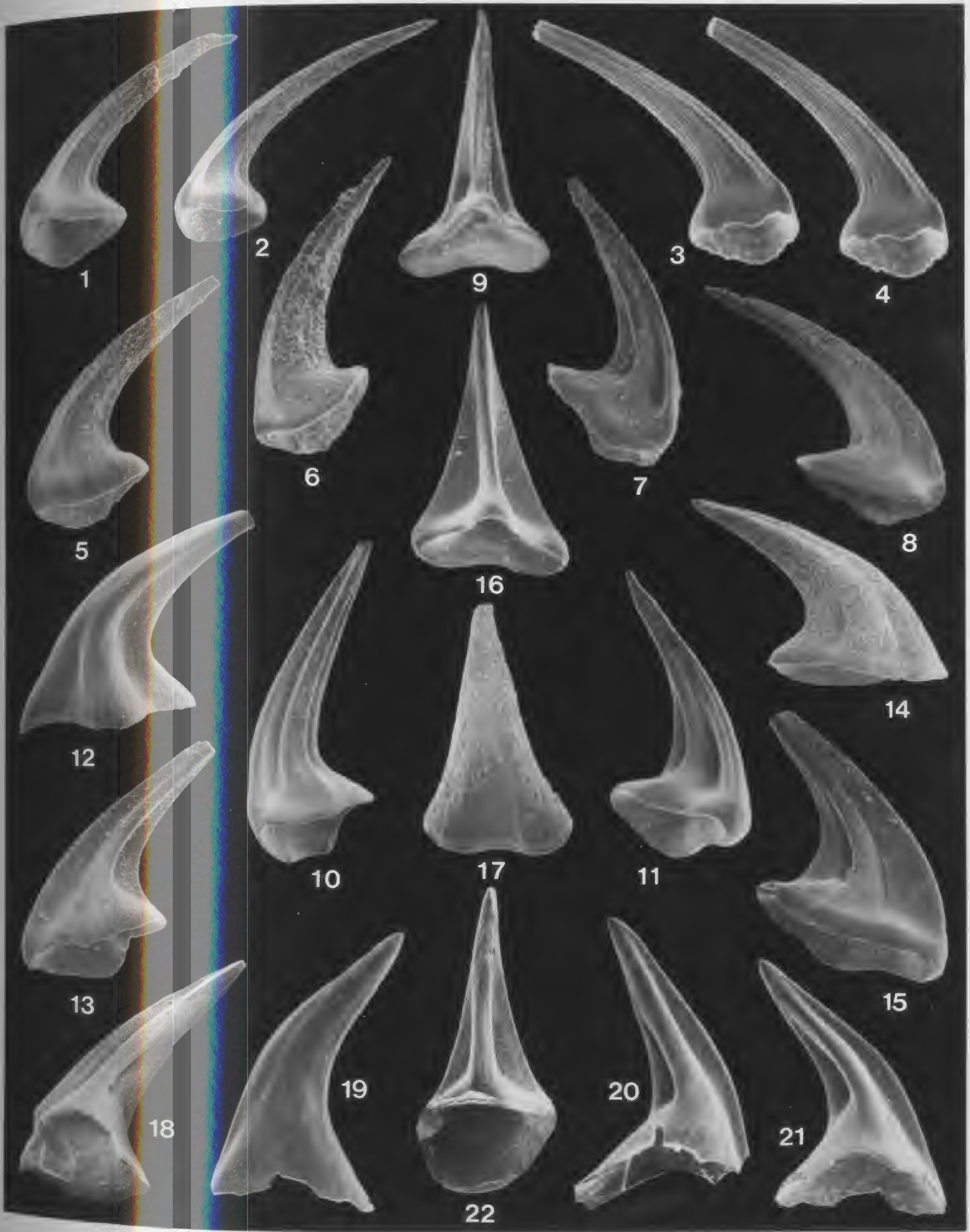
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PLATE 12

Figures 1-7. Loxodentatus bipinnatus n. sp. Holotype (4, 7); Paratypes (1-3, 5-6).

1-2. Anterior and posterior views, a element, x 55, x 60, GSC 95932, from Z7-15.

3. Posterior view, a element, x 60, GSC 95933, from Z7-15.

4,7. Inner and outer lateral views, e element, all x 40, GSC 95934, from Z6-9.

5,6. Inner and Outer lateral views, e element, x 50, x 55, GSC 95935, from Z2-3B.

Figures 8-13. Loxognathus phyllodus n. sp. Holotype (12); Paratypes (8-11, 13).

8. Posterior view, a element, x 60, GSC 95936, from Z7-7.

9. Anterior view, a element, x 60, GSC 95937, from Z7-7.

10-11. Inner and outer lateral views, e element, all x 40, GSC 95938, from Z7-9B.

12. Inner-lateral view, e element, x 40, GSC 95939, from Z7-9B.

13. Inner-lateral view, e element, x 40, GSC 95940, from Z7-7.

Figures 14-17. Loxodus latibasis n. sp. Holotype (15-16); Paratypes (14, 17).

14,17. Outer and Inner lateral views, all x 60, GSC 95941, from Z2-9B1.

15-16. Inner and outer lateral views, all x 60, GSC 95942, from Z2-9B1.

Figures 18-21. Loxodus bransoni Furnish. Hypotypes.

18,21. Inner and outer lateral views, x 35, GSC 95943, from Z6-6.

19,20. Outer and inner lateral views, x 35, GSC 95944, from Z6-6.

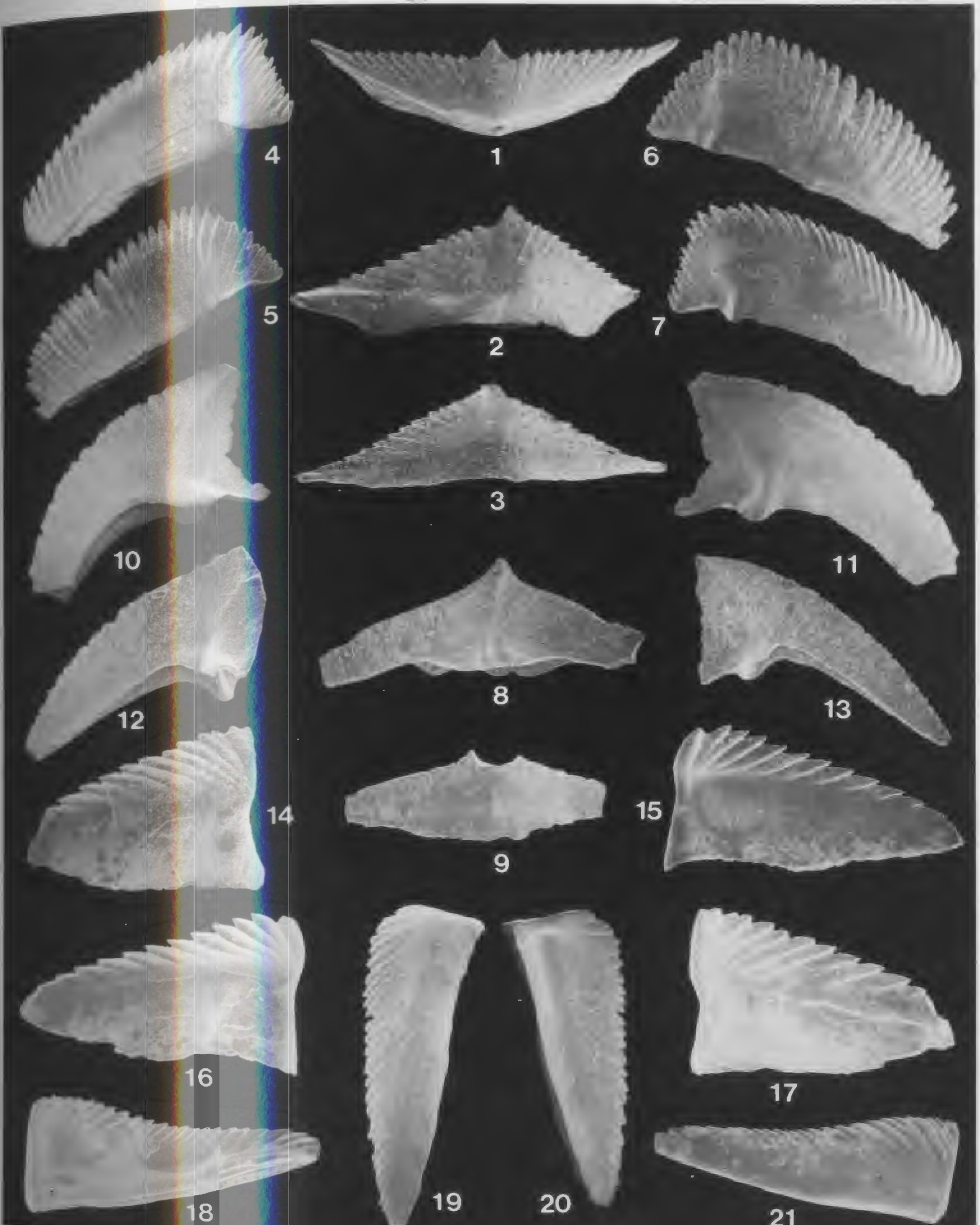
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PLATE 13

Figures 1-2. Histiodella donnae Repetski. Hypotypes.
1. Posterior view, x 105, GSC 95945, from Z2-64.
2. Anterior view, x 140, GSC 95946, from Z2-64.

Figures 3-8. Macerodus crassatus n. sp. Holotype (3); Paratypes (4-8).
3. Lateral view, a element, x 75, GSC 95947, from Z2-3B.
4. Lateral view, a element, x 100, GSC 95948, from Z2-3B.
5. Lateral view, a element, x 90, GSC 95949, from Z2-3B.
6. Lateral view, a element, x 75, GSC 95950, from Z2-3B.
7. Lateral view, e element, x 120, GSC 95951, from Z2-3B.
8. Lateral view, e element, x 120, GSC 95952, from Z2-3B.

Figures 9-18. Macerodus dianae Fahraeus and Nowlan. Hypotypes.
9. Lateral view, a element, x 70, GSC 95953, from Z8-8.
10. Lateral view, a element, x 85, GSC 95954, from Z2-52.
11. Lateral view, a element, x 70, GSC 95955, from Z2-52.
12. Lateral view, a element, x 70, GSC 95956, from Z8-4.
13. Lateral view, a element, x 70, GSC 95957, from Z8-4.
14. Lateral view, a element, x 70, GSC 95958, from Z8-4.
15. Lateral view, e element, x 125, GSC 95959, from Z8-8.
16. Lateral view, e element, x 95, GSC 95960, from Z8-8.
17. Lateral view, e element, x 85, GSC 95961, from Z8-4.
18. Lateral view, e element, x 85, GSC 95962, from Z8-4.

Figures 19-23. Macerodus wattsbightensis n. sp. Holotype (22); Paratypes (19-21, 23).
19. Inner-lateral view, a element, x 75, GSC 95963, from Z7-7.
20. Lateral view, a element, x 65, GSC 95964, from Z7-7.
21. Posterior view, c element, x 95, GSC 95965, from Z7-7.
22. Inner-lateral view, e element, x 60, GSC 95966, from Z7-7.
23. Inner-lateral view, e element, x 60, GSC 95967, from Z7-7.

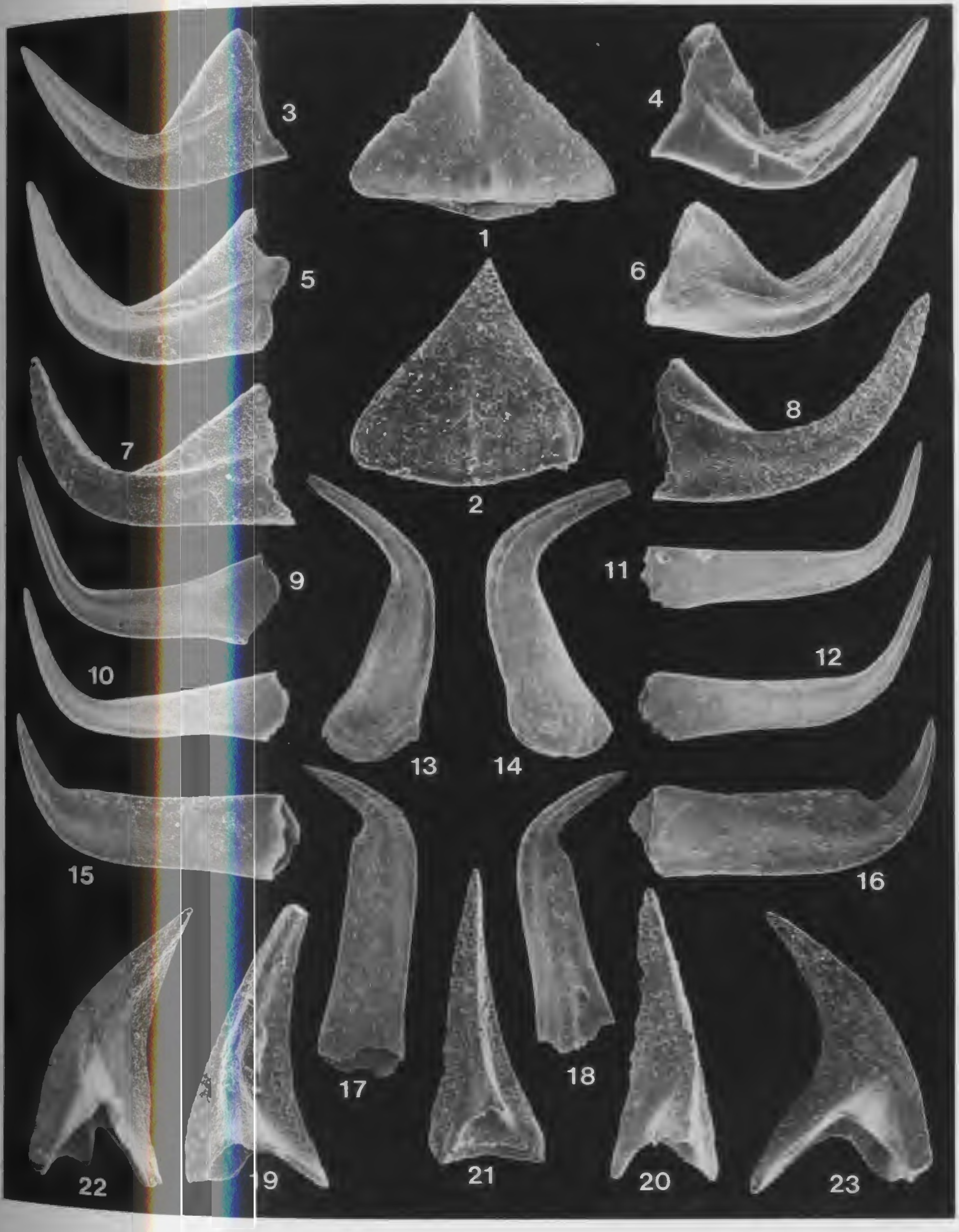
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PLATE 14

Figures 1-16. Oepikodus communis (Ethington and Clark). Hypotypes.

1. Lateral view, a element, x 85, GSC 95968, from Z2-98.
2. Lateral view, a element, x 85, GSC 95969, from Z2-98.
3. Lateral view, a element, x 70, GSC 95970, from Z2-98.
4. Lateral view, a element, x 85, GSC 95971, from Z6-46.
5. Lateral view, a element, x 70, GSC 95972, from Z2-98.
6. Lateral view, a element, x 85, GSC 95973, from Z6-46.
7. Lateral view, a element, x 70, GSC 95974, from Z6-44.
8. Lateral view, a element, x 85, GSC 95975, from Z2-98.
9. Lateral view, b element, x 85, GSC 95976, from Z2-98.
10. Lateral view, b element, x 60, GSC 95977, from Z2-98.
11. Lateral view, c element, x 85, GSC 95978, from Z6-44.
12. Lateral view, c element, x 85, GSC 95979, from Z2-86.
13. Lateral view, e element, x 85, GSC 95980, from Z6-44.
14. Lateral view, e element, x 100, GSC 95981, from Z6-44.
15. Lateral view, e element, x 85, GSC 95982, from Z2-98.
16. Lateral view, e element, x 65, GSC 95983, from Z6-44.

Figures 17-18. Macerodus gracilis n. sp. Holotype (18); Paratypes (17).

17. Lateral view, a element, x 120, GSC 95984, from Z8-4.
18. Lateral view, e element, x 90, GSC 95985, from Z8-4.

Figures 19-22. Juanognathus sp.

19. Lateral view, a element, x 100, GSC 95986, from Z4-36B.
20. Postero-lateral view, a element, x 100, GSC 95987, from Z4-36B.
21. Inner-lateral view, e element, x 100, GSC 95988, from Z4-36B.
22. Inner-lateral view, e element, x 100, GSC 95989, from Z4-36B.

Figures 23-24. Microzarkodina marathonensis (Bradshaw). Hypotypes.

23. Lateral view, ?a element, x 75, GSC 95990, from Z6-45.
24. Lateral view, ?a element, x 75, GSC 95991, from Z6-45.

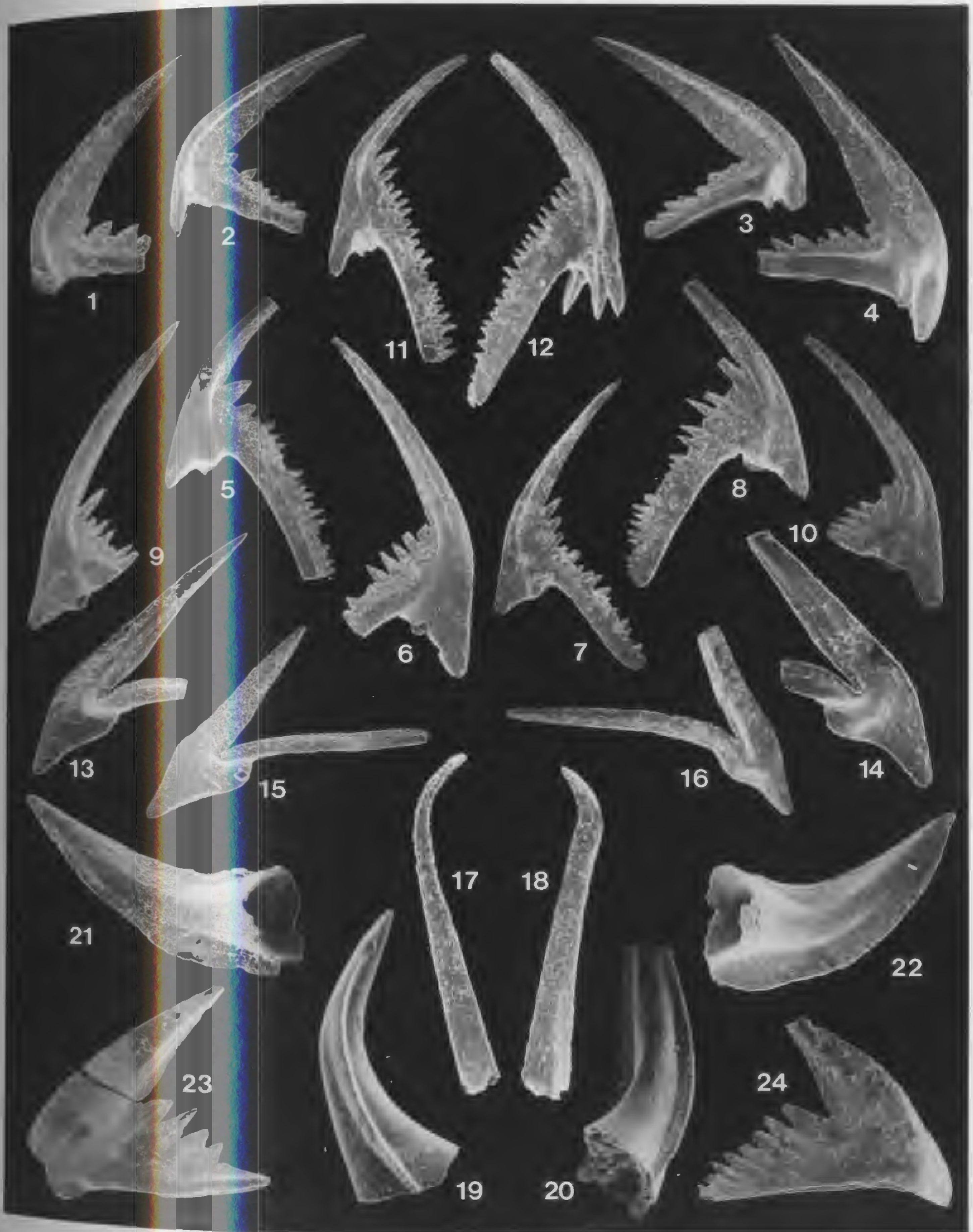
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PLATE 15

Figures 1-12. Polycostatus falsioneotensis n. sp. Holotype (3); Paratypes (1-2, 4-12).

1. Lateral view, a element, x 60, GSC 95992, from Z2-10.
2. Lateral view, a element, x 60, GSC 95993, from Z2-10.
3. Lateral view, a element, x 50, GSC 95994, from Z2-10.
4. Lateral view, a element, x 55, GSC 95995, from Z9-7.
5. Lateral view, a element, x 50, GSC 95996, from Z9=9.
6. Lateral view, a element, x 50, GSC 95997, from Z9-9.
7. Posterior view, c element, x 65, GSC 95998, from Z2-10.
8. Posterior view, c element, x 65, GSC 95999, from Z2-10.
9. Inner-lateral view, e element, x 50, GSC 96000, from Z9-9.
10. Inner-lateral view, e element, x 50, GSC 96001, from Z9-9.
11. Lateral view, e element, x 60, GSC 96002, from Z2-10.
12. Lateral view, a element, x 50, GSC 96003, from Z9-9.

Figures 13-19. Polycostatus oneotensis (Furnish). Hypotypes.

13. Lateral view, a element, x 90, GSC 96004, from Z4-32.
14. Lateral view, a element, x 90, GSC 96005, from Z4-32.
15. Inner-lateral view, a element x 90, GSC 96006, from Z4-32.
16. Lateral view, a element, x 90, GSC 96007, from Z4-32.
17. Posterior view, c element, x 100, GSC 96008, from Z4-32.
18. Inner-lateral view, e element, x 90, GSC 96009, from Z4-32.
19. Inner-lateral view, e element, x 80, GSC 96010, from Z4-32.

Figures 20-29. Polycostatus sulcatus (Furnish). Hypotypes.

20,25. Lateral views, a element, x 55, x 60, GSC 96011, from Z6-10.
21. Lateral view, a element, x 55, GSC 96012, from Z4-32.
22. Lateral view, a element, x 55, GSC 96013, from Z4-32.
23. Lateral view, a element, x 55, GSC 96014, from Z4-32.
24,28. Lateral views, ?e element, x 55, x 60, GSC 96015, from Z6-10.
27,27. Posterior and anterior views, c element, x 60, x 55, GSC 96016, from Z6-10.
29. Lateral view, e element, x 45, GSC 96017, from Z6-10.

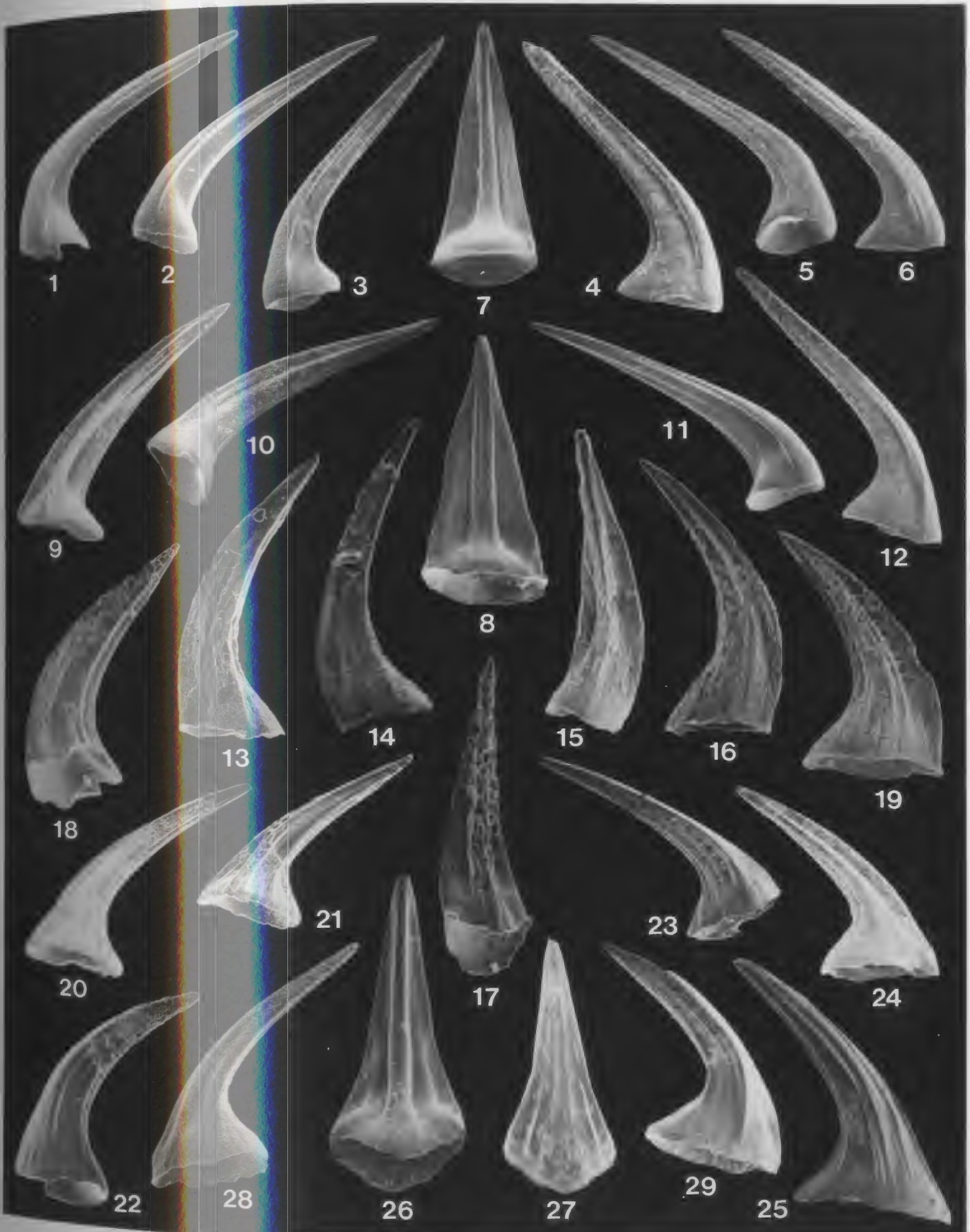
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PLATE 16

Figures 1-7. *Polycostatus minutus* n. sp. Holotype (2); Paratypes (1, 3-7).

1. Lateral view, ?*a* element, x 110, GSC 96018, from Z2-39.
2. Inner-lateral view, *a* element, x 110, GSC 96019, from Z2-35.
3. Inner-lateral view, *a* element, x 145, GSC 96020, from Z2-39.
4. Inner-lateral view, *a* element, x 110, GSC 96021, from Z2-39.
5. Posterior view, *c* element, x 150, GSC 96022, from Z2-39.
6. Lateral view, *e* element, x 110, GSC 96023, from Z2-39.
7. Lateral view, *e* element, x 85, GSC 96024, from Z2-35.

Figures 8-18. *Protoprioniodus simplicissimus* McTavish. Hypotypes.

8. Outer-lateral view, *a* element, x 85, GSC 96025, from Z6-41.
9. Outer-lateral view, *a* element, x 85, GSC 96026, from Z10-F.
10. Lateral view, *b* element, x 66, GSC 96027, from Z2-92.
11. Lateral view, *b* element, x 55, GSC 96028, from Z2-92.
12. Posterior view, *c* (or *f*) element, x 75, GSC 96029, from Z6-41.
13. Lateral view, ?*b* element, x 55, GSC 96030, from Z2-93.
14. Lateral view, ?*b* element, x 110, GSC 96031, from Z10-F.
15. Lateral view, *e* element, x 110, GSC 96032, from Z6-41.
16. Lateral view, *e* element, x 85, GSC 96033, from Z6-41.
17. Lateral view, ?*e* element, x 60, GSC 96034, from Z2-92.
18. Lateral view, ?*e* element, x 60, GSC 96035, from Z6-41.

Figures 19-26. *Pteracontiodus cryptodens* (Mound). Hypotypes.

19,20. Lateral views, *a* element, x 60, GSC 96036, from Z2-134.
21,22. Lateral views, *b* element, x 60, GSC 96037, from Z2-134.
23. Posterior view, *c* element, x 60, GSC 96038, from Z2-134.
24. Postreior view, *c* element, x 55, GSC 96039, from Z2-134.
25. Inner-lateral view, *e* element, x 45, GSC 96040, from Z2-134.
26. Inner-lateral view, *e* element, x 60, GSC 96041, from Z2-134.

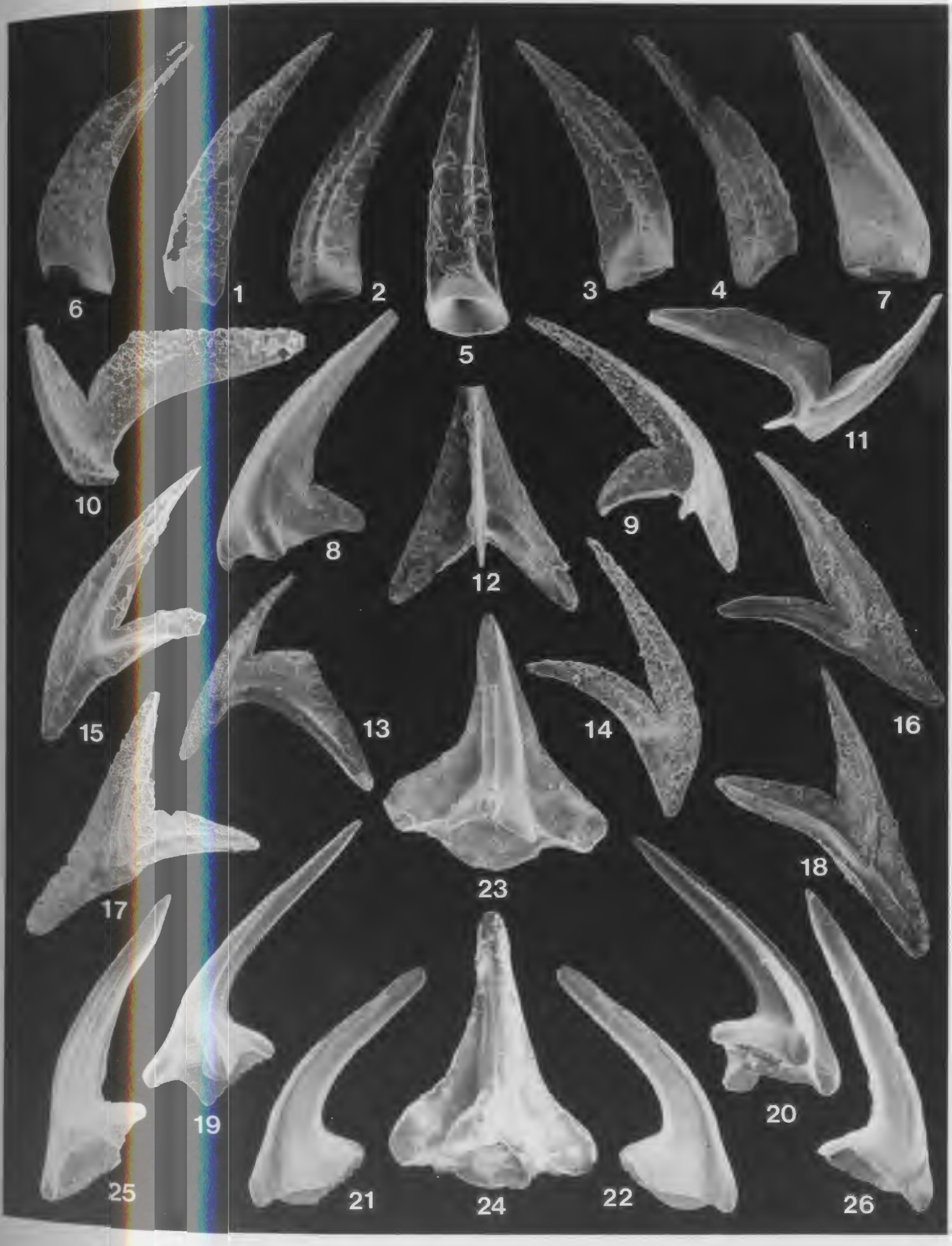
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PLATE 17

Figures 1-9. *Rossodus manitouensis* Repetski and Ethington. Hypotypes.

1-2. Lateral and postero-lateral views, *a* element, x 75, x 70, GSC 96042, from Z4-32.
3. Inner-lateral view, *b* element, x 85, GSC 96043, from Z4-26.
4. Inner-lateral view, *b* element, x 85, GSC 96044, from Z4-26.
5. Posterior view, *c* element, x 85, GSC 96045, from Z4-26.
6. Posterior view, *c* element, x 75, GSC 96046, from Z4-32.
7. Anterior view, *c* element, x 65, GSC 96047, from Z4-26.
8. Lateral view, *e* element, x 85, GSC 96048, from Z4-26.
9. Lateral view, *e* element, x 85, GSC 96049, from Z4-26.

Figures 10-19. *Rossodus tenuis* (Miller). Hypotypes.

10. Inner-lateral view, *a* element, x 60, GSC 96050, from Z6-5.
11. Inner-lateral view, *a* element, x 105, GSC 96051, from Z6-5.
12. Inner-lateral view, *b* element, x 60, GSC 96052, from Z9-9.
13. Inner-lateral view, *b* element, x 75, GSC 96053, from Z6-5.
14. Posterior view, *c* element, x 75, GSC 96054, from Z6-5.
15. Posterior view, *c* element, x 60, GSC 96055, from Z9-9.

16-17. Inner-lateral views, *e* element, x 60, GSC 96056, from Z9-9.

18-19. Inner-lateral views, *e* element, all x 85, GSC 96057, from Z6-5.

Figures 20-25. *Tricostatus glyptus* n. sp. Holotype (22); Paratypes (20-21, 23-25).

20. Lateral view, [illegible] element, x 85, GSC 96058, from Z7-15B.
21. Inner-lateral view, *a* element, x 85, GSC 96059, from Z7-15B.
22. Posterior view, *c* element, x 75, GSC 96060, from Z6-5.
23. Posterior view, *c* element, x 100, GSC 96061, from Z7-15B.
24. Inner-lateral view, *e* element, x 85, GSC 96062, from Z7-15B.
25. Inner-lateral view, *e* element, x 100, GSC 96063, from Z7-15B.

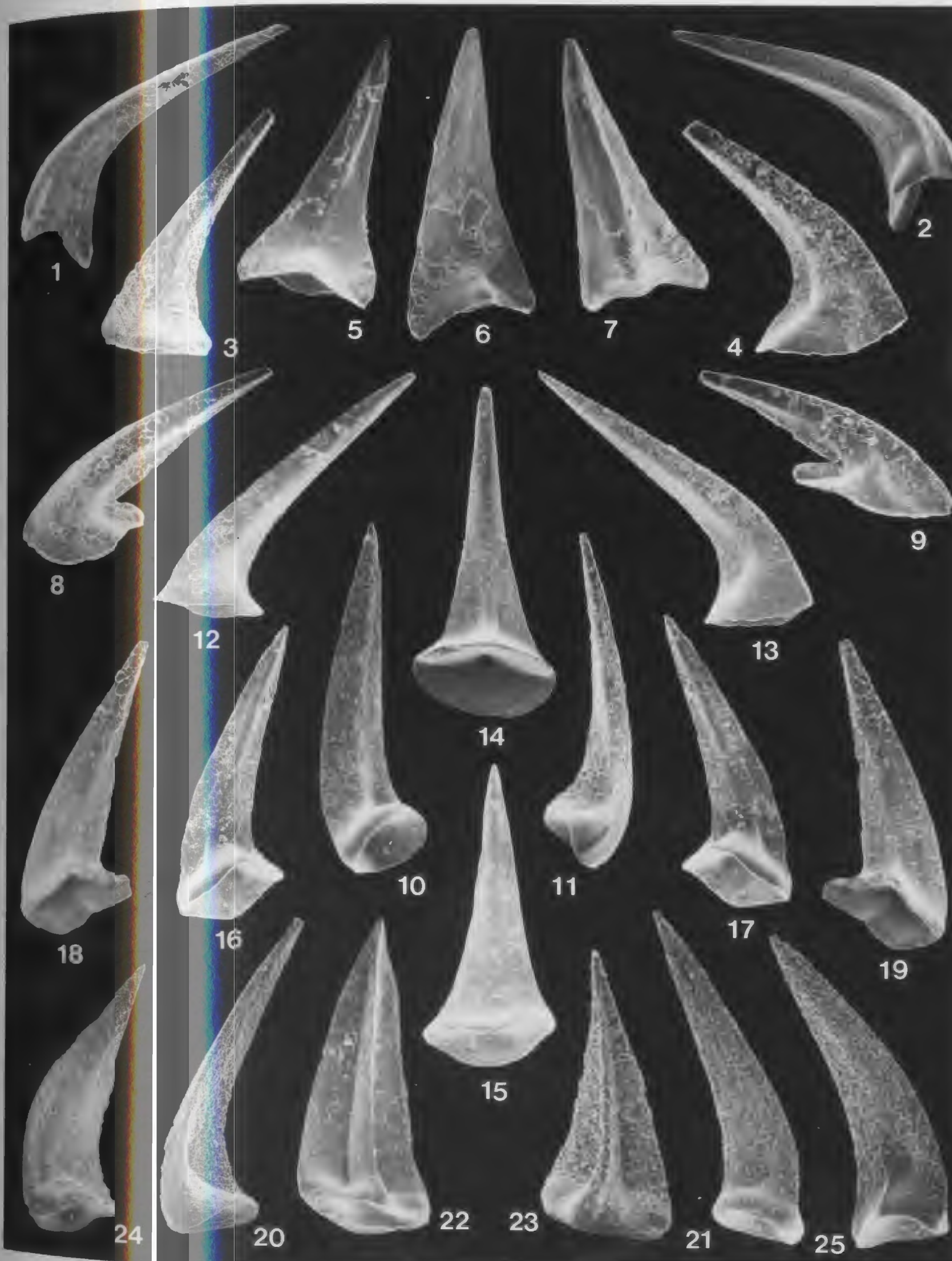
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PLATE 18

Figures 1-6. Protopanderodus prolatus n. sp. Holotype (5-6); Paratypes (1-4).

1. Lateral view, a element, x 25, GSC 96064, from Z2-95.
2. Lateral view, a element, x 30, GSC 96065, from Z6-39.
3. Inner-lateral view, a element, x 35, GSC 96066, from Z6-39.
4. Inner-lateral view, a element, x 30, GSC 96067, from Z6-39.

5-6. Inner-lateral views, e element, all x 35, GSC 96068, from Z2-95.

Figures 7-14. Protopanderodus inconstans (Branson and Mehl). Hypotypes.

7. Lateral view, ?a element, x 50, GSC 96069, from Z2-65.
8. Lateral view, ?a element, x 55, GSC 96070, from Z2-65.
9. Lateral view, b element, x 55, GSC 96071, from Z2-65.
10. Lateral view, b element, x 50, GSC 96072, from Z2-65.
11. Lateral view, b element, x 40, GSC 96073, from Z2-65.
12. Lateral view, b element, x 50, GSC 96074, from Z2-65.
13. Inner-lateral view, e element, x 60, GSC 96075, from Z2-65.
14. Inner-lateral view, e element, x 60, GSC 96076, from Z2-65.

Figures 15-26. Scolopodus cornutiformis (Branson and Mehl). Hypotypes.

15,16. Lateral view, b element, all x 35, GSC 96077, from Z6-43.

17,18. Lateral view, a element, x 35, x 40, GSC 96078, from Z6-36.

19. Lateral view, e element, x 40, GSC 96079, from Z6-36.
20. Lateral view, e element, x 30, GSC 96080, from Z6-36.
21. Lateral view, e element, x 40, GSC 96081, from Z6-36.

22-23. Lateral views, e element, x 30, GSC 96082, from Z6-43.

24. Lateral view, e element, x 40, GSC 96083, from Z6-43.

25-26. Anterior and posterior views, f element, x 50, x 40, GSC 96084, from Z6-43.

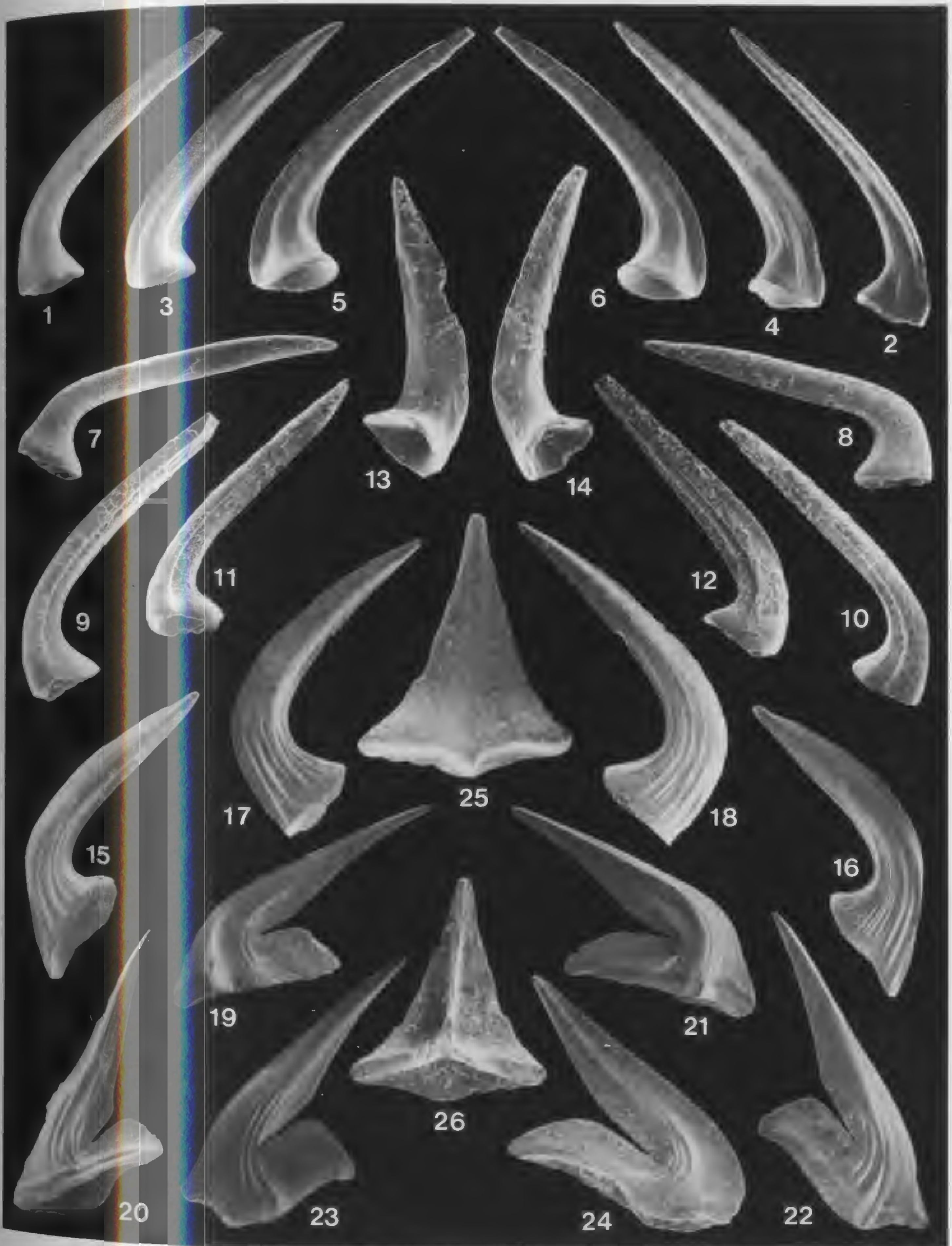
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PLATE 19

Figures 1-15. Scolopodus subrex n. sp. Holotype (3-4); Paratypes (1-2, 5-15).

1. Lateral view, a element, x 50, GSC 96085, from Z2-69.
2. Lateral view, a element, x 60, GSC 96086, from Z2-69.
3-4. Lateral view, a element, x 40, x 45, GSC 96087, from Z2-71.
5. Lateral view, a element, x 75, GSC 96088, from Z2-71.
6. Lateral view, a element, x 60, GSC 96089, from Z2-71.
7. Lateral view, b element, x 60, GSC 96090, from Z2-71.
8. Lateral view, b element, x 50, GSC 96091, from Z2-71.
9. Inner-lateral view, e element, x 70, GSC 96092, from Z2-71.
10. Inner-lateral view, e element, x 85, GSC 96093, from Z2-71.
11. Inner-lateral view, e element, x 60, GSC 96094, from Z2-71.
12. Inner-lateral view, e element, x 85, GSC 96095, from Z2-71.
13. Inner-lateral view, e element, x 40, GSC 96096, from Z2-71.
14. Outer-lateral view, e element, x 55, GSC 96097, from Z2-71.
15. Lateral view, ?f element, x 40, GSC 96098, from Z2-69.

Figures 16-24. Scolopodus parabruptus Repetski. Hypotypes.

16. Lateral view, a element, x 45, GSC 96099, from Z2-92.
17. Lateral view, a element, x 45, GSC 96100, from Z2-92.
18. Lateral view, a element, x 45, GSC 96101, from Z2-92.
19. Lateral view, b element, x 35, GSC 96102, from Z2-92.
20-21. Outer and inner lateral views, e element, x 45, x 35, GSC 96103, from Z2-92.
22-23. Inner and outer lateral views, x 45, x 50, GSC 96104, from Z2-92.
24. Posterior view, c element, x 50, GSC 96105, from Z2-92.

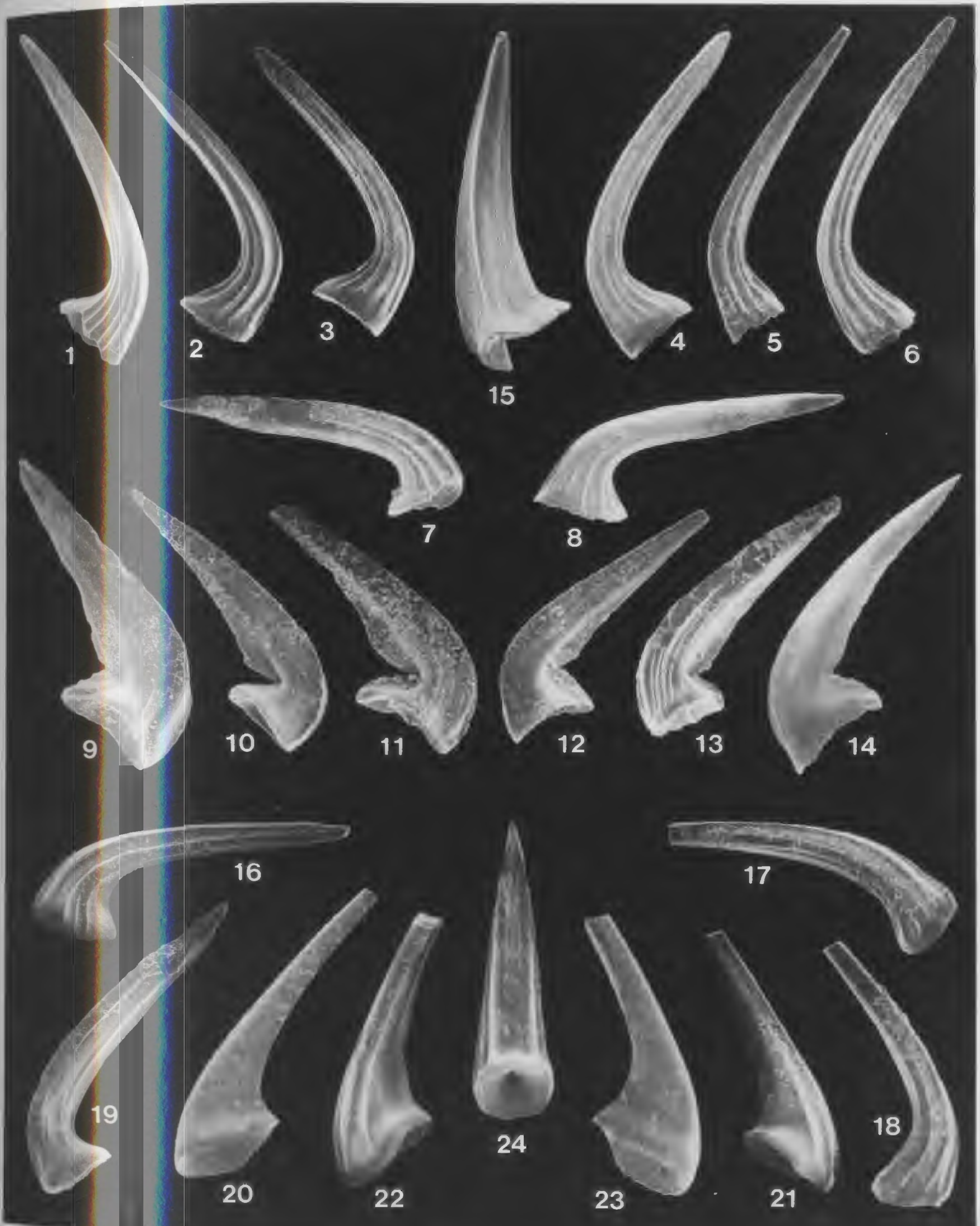
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PLATE 20

Figures 1-26. Striatodontus prolificus n. sp. Holotype (1); Paratypes (2-26).

1. Lateral view, a element, x 85, GSC 96106, from Z2-46B.
2. Lateral view, a element, x 85, GSC 96107, from Z8-8.
3. Lateral view, a element, x 85, GSC 96108, from Z2-65.
4. Lateral view, a element, x 85, GSC 96109, from Z8-8.
5. Lateral view, ?b element, x 75, GSC 96110, from Z2-46B.
6. Lateral view, ?b element, x 60, GSC 96111, from Z2-46B.
7. Inner-lateral view, ?b element, x 60, GSC 96112, from Z2-46B.
8. Inner-lateral view, ?b element, x 75, GSC 96113, from Z2-46B.

9,12. Lateral views, b element, all x 85, GSC 96114, from Z8-8.

10,14. Lateral views, b element, x 80, x 85, GSC 96115, from Z8-8.

11,13. Lateral views, b element, all x 85, GSC 96116, from Z8-8.

15. Posterior view, c element, x 85, GSC 96117, from Z8-2.
16. Posterior view, a element, x 75, GSC 96118, from Z2-46B.
17. Posterior view, c element, x 75 GSC 96119, from Z2-65.
18. Posterior view, ?a element, x 165, GSC 96120, from Z8-6.
19. Lateral view, e element, x 75, GSC 96121, from Z8-8.

20,22. Lateral views, e element, all x 60, GSC 96122, from Z8-2.

21. Lateral view, e element, x 60, GSC 96123, from Z2-46B.
23. Lateral view, e element, x 75, GSC 96124, from Z8-8.
24. Lateral view, e element, x 60, GSC 96125, from Z2-46B.
25. Lateral view, e element, x 85, GSC 96126, from Z2-39.
26. Posterior view, ?f element, x 85, GSC 96127, from Z2-47.


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PLATE 21

Figures 1-10. Striatodontus gracilis (Ethington and Clark). Hypotypes.

1. Lateral view, a element, x 50, GSC 96128, from Z6-35B.
2. Lateral view, a element, x 40, GSC 96129, from Z6-35B.
3. Lateral view, b element, x 60, GSC 96130, from Z6-35B.
4. Lateral view, b element, x 50, GSC 96131, from Z6-35B.
5. Lateral view, b element, x 90, GSC 96132, from Z6-35B.
6. Lateral view, b element, x 75, GSC 96133, from Z6-35B.
7. Posterior view, c element, x 90, GSC 96134, from Z6-35B.
8. Posterior view, c element, x 60, GSC 96135, from Z6-35B.

9-10. Lateral views, e element, all x 50, GSC 96136, from Z6-35B.

Figures 11-16. Striatodontus teridontus n. sp. Holotype (11); Paratypes (12-16).

11. Lateral view, a element, x 75, GSC 96137, from Z2-52.
12. Lateral view, a element, x 105, GSC 96138, from Z2-52.
13. Lateral view, a element, x 75, GSC 96139, from Z2-52.
14. Lateral view, a element, x 75, GSC 96140, from Z2-52.
15. Lateral view, e element, x 90, GSC 96141, from Z2-52.
16. Lateral view, e element, x 90, GSC 96142, from Z2-52.

Figures 17-23. Striatodontus lanceolatus n. sp. Holotype (23); Paratypes (17-22).

17. Lateral view, a element, x 90, GSC 96143, from Z6-16.
18. Lateral view, a element, x 90, GSC 96144, from Z8-6.
19. Postero-lateral view, a element, x 70, GSC 96145, from Z8-6.
20. Lateral view, a element, x 70, GSC 96146, from Z6-16.
21. Postero-lateral view, b element, x 105, GSC 96147, from Z8-6.
22. Postero-lateral view, b element, x 90, GSC 96148, from Z8-6.
23. Posterior view, c element, x 70, GSC 96149, from Z6-16.

Figures 24-25. Striatodontus carlae (Repetski). Hypotypes.

24. Posterior view, x 115, GSC 96150, from Z2-91.
25. Posterior view, x 115, GSC 96151, from Z2-91.

Figures 26-29. Striatodontus retractus n. sp. Holotype (27); Paratypes (26, 28-29).

26. Posterior view, x 85, GSC 96152, from Z2-132.
27. Posterior view, x 70, GSC 96153, from Z2-132.
28. Anterior view, x 85, GSC 96154, from Z2-132.
29. Posterior view, x 85, GSC 96155, from Z2-132.


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PLATE 22

Figures 1-12. Semiacontiodus nogamii (Miller). Hypotypes.
1. Lateral view, a element, x 85, GSC 96156, from Z7-5B.
2. Lateral view, a element, x 105, GSC 96157, from Z7-5B.
3. Lateral view, a element, x 85, GSC 96158, from Z7-5B.
4. Lateral view, a element, x 65, GSC 96159, from Z2-3B.
5. Lateral view, b element, x 65, GSC 96160, from Z2-3B.
6. Lateral view, b element, x 60, GSC 96161, from Z2-3B.
7. Lateral view, b element, x 75, GSC 96162, from Z2-3.
8. Lateral view, b element, x 75, GSC 96163, from Z7-5B.

9-10. Posterior view, c element, x 85, GSC 96164, from Z7-5B.

11. Lateral view, e element, x 75, GSC 96165, from Z2-3.
12. Lateral view, e element, x 60, GSC 96166, from Z2-8B.

Figures 13-22. Stultodontus costatus (Ethington and Clark). Hypotypes.

13-14. Lateral views, a element, all x 60, GSC 96167, from Z2-71.

15-16. Lateral views, a element, x 80, x 85, GSC 96168, from Z2-75.

17. Lateral view, a element, x 60, GSC 96169, from Z2-92.
18. Lateral view, a element, x 60, GSC 96170, from Z2-92.
19. Lateral view, a element, x 70, GSC 96171, from Z6-45.
20. Lateral view, a element, x 70, GSC 96172, from Z2-75.
21. Lateral view, e element, x 60, GSC 96173, from Z2-92.
22. Lateral view, e element, x 60. GSC 96174, from Z2-92.

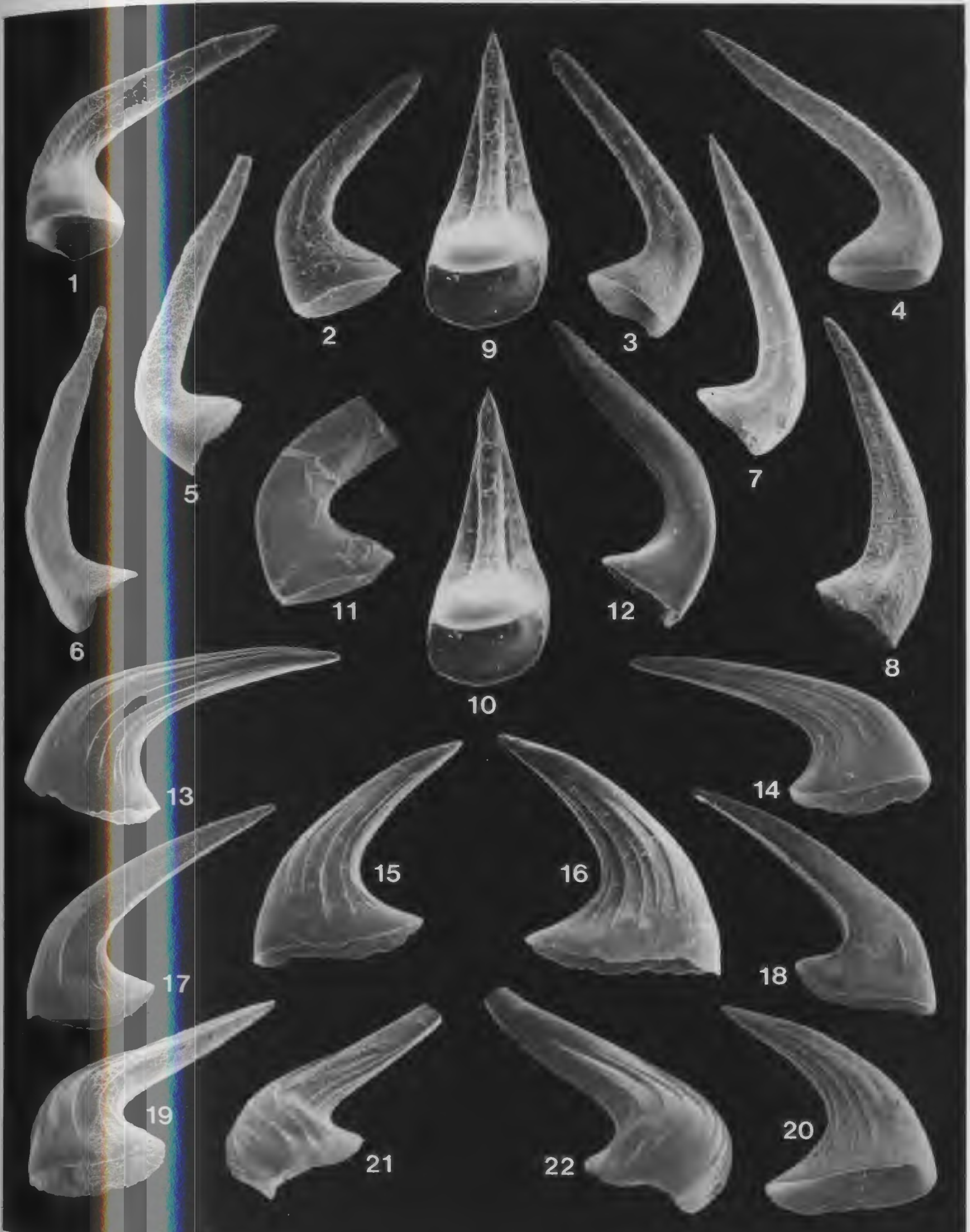
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PLATE 23

Figures 1-9. Stultodontus ovatus n. sp. Holotype (8); Paratypes (1-7, 9).

1. Lateral view, a element, x 105, GSC 96175, from Z6-45.
2-3. Lateral-posterior views, a element, x 105, GSC 96176, from Z6-45.
4. Lateral view, a element, 140, GSC, 96177, from Z6-46.
5. Lateral view, a element, x 160, GSC 96178, from Z2-86.
6. Lateral view, e element, x 125, GSC 96179, from Z2-46.
7. Lateral view, e element, x 105, GSC 96180, from Z6-45.
8. Basal view, e element, x 185, GSC 96181, from Z6-45.
9. Lateral view, e element, x 140, GSC 96182, from Z6-46.

Figures 10-19. Stultodontus pygmaeus n. sp. Holotype (16, 18-19); Paratypes (10-15, 17).

10. Postero-lateral view, a element, x 145, GSC 96183, from Z2-92.
11. Lateral view, a element, x 105, GSC 96184, from Z2-92.
12. Antero-basal view, a element, x 145, GSC 96185, from Z2-92.
13. Postero-basal view, a element, x 145, GSC 96186, from Z2-92.
14. Lateral view, a element, x 105, GSC 96187, from Z2-92.
15. Lateral view, a element, x 105, GSC 96188, from Z2-92.
16,18,19. Lateral views, e element, x 105, x 140, x 140, GSC 96189, from Z2-92.
17. Lateral view, e element, x 105, GSC 96190, from Z6-44B.


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PLATE 24

Figures 1-9. Teridontus nakamurai (Nogami). Hypotypes.
1. Lateral view, a element, x 85, GSC 96191, from Z7-2C.
2. Lateral view, a element, x 100, GSC 96192, from Z7-2C.
3. Lateral view, a element, x 85, GSC 96193, from Z7-2C.
4. Lateral view, b element, x 85, GSC 96194, from Z7-2C.
5. Posterior view, c element, x 160, GSC 96195, from Z7-2C.
6. Lateral view, e element, x 140, GSC 96196, from Z7-2C.
7. Lateral view, e element, x 100, GSC 96197, from Z7-2C.
8. Lateral view, e element, x 85, GSC 96198, from Z7-2C.
9. Lateral view, e element, x 100, GSC 96199, from Z7-2C.

Figures 10-17. Teridontus obesus n. sp. Holotype (14); Paratypes (10-13, 15-17).
10. Lateral view, a element, x 50, GSC 96200, from Z4-18.
11. Lateral view, a element, x 40, GSC 96201, from Z4-18.
12. Lateral view, b element, x 75, GSC 96202, from Z4-18.
13. Lateral view, b element, x 50, GSC 96203, from Z4-19.
14. Posterior view, c element, x 50, GSC 96204, from Z4-19.
15. Posterior view, c element, x 60, GSC 96205, from Z4-19.
16. Lateral view, e element, x 40, GSC 96206, from Z4-19.
17. Lateral view, e element, x 60, GSC 96207, from Z4-19.

Figures 18-25. Teridontus gracillimus Nowlan. Holotypes.
18. Lateral view, a element, x 85, GSC 96208, from Z7-13.
19. Lateral view, a element, x 85, GSC 96209, from Z7-13.
20. Lateral view, a element, x 80, GSC 96210, from Z9-9.
21. Lateral view, a element, x 85, GSC 96211, from Z9-9.

22.24. Lateral views, e element, x 90, x 105, GSC 96212, from Z9-4.

23,25. Lateral views, e element, x 90, 105, GSC 96213, from Z7-13.


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PLATE 25

Figures 1-8. Utahconus longipinnatus n. sp. Holotype (1); Paratypes (2-8).

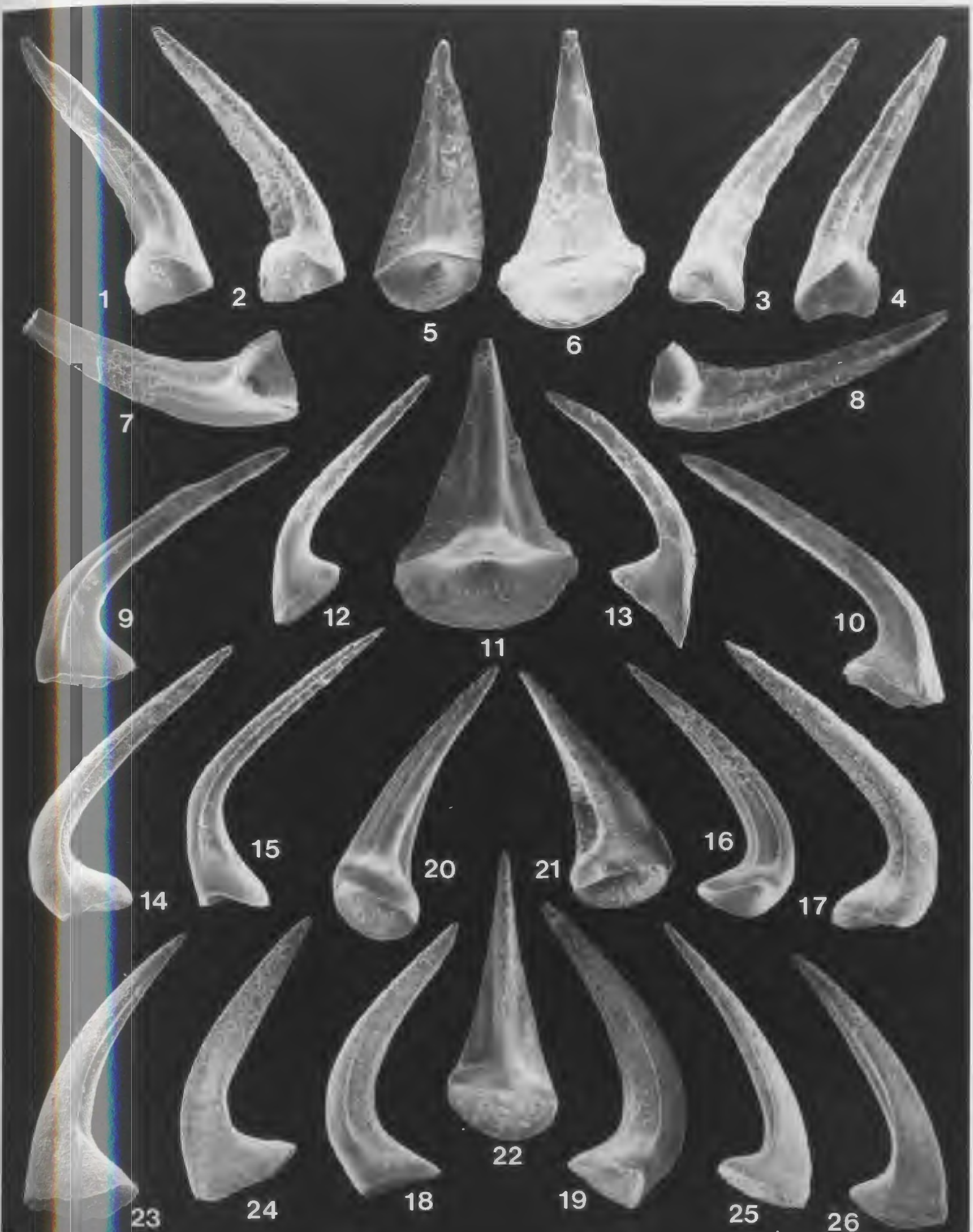
1. Inner-lateral view, a element, x 60, GSC 96214, from Z2-21B.
2. Inner-lateral view, a element, x 45, GSC 96215, from Z2-21B.
3. Inner-lateral view, a element, x 50, GSC 96216, from Z2-21B.
4. Inner-lateral view, a element, x 50, GSC 96217, from Z6-10.
5. Posterior view, c element, x 80, GSC 96218, from Z6-10.
6. Posterior view, c element, x 85, GSC 96219, from Z4-31B.
7. Inner-lateral view, e element, x 50, GSC 96220, from Z6-10.
8. Inner-lateral view, e element, x 50, GSC 96221, from Z6-10.

Figures 9-13. Variabiloconus neobassleri n. sp. Holotype (9); Paratypes (10-13).

9. Lateral view, a element, x 60, GSC 96222, from Z6-10.
10. Lateral view, a element, x 60, GSC 96223, from Z6-10.
11. Posterior view, c element, x 65, GSC 96224, from Z6-10.
12. Outer-lateral view, e element, x 45, GSC 96225, from Z6-10.
13. Inner-lateral view, e element, x 45, GSC 96226, from Z6-10.

Figures 14-26. Variabiloconus bassleri (Furnish). Hypotypes.

14. Lateral view, a element, x 75, GSC 96227, from Z4-20.
15. Lateral view, a element, x 80, GSC 96228, from Z4-20.
16. Lateral view, b element, x 60, GSC 96229, from Z4-18C.
17. Lateral view, a element, x 80, GSC 96230, from Z4-20.
18. Lateral view, b element, x 80, GSC 96231, from Z4-20B.
19. Lateral view, b element, x 75, GSC 96232, from Z4-20B.
20. Posterior view, c element, x 80, GSC 96233, from Z4-18C.
21. Posterior view, c element, x 80, GSC 96234, from Z4-20B.
22. Posterior view, c element, x 80, GSC 96235, from Z4-20B.
23. Lateral view, e element, x 80, GSC 96236, from Z4-20B.
24. Lateral view, e element, x 75, GSC 96237, from Z4-20B.
25. Lateral view, e element, x 60, GSC 96238, from Z4-20B.
26. Lateral view, e element, x 60, GSC 96239, from Z4-20B.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CHAPTER 7

CONCLUSIONS

The objectives of this thesis are to provide a detailed taxonomic study of the conodonts from the Lower Ordovician St. George Group, to interpret phylogenetic relationships of these Lower Ordovician Midcontinent Province conodonts, and to refine Lower Ordovician conodont zonation for the Midcontinent Province.

The conodonts of this study were collected from the St. George Group of the Port au Port Peninsula, western Newfoundland. The St. George Group is a nearly 600 m thick carbonate sequence which accumlated during the Early Ordovician in a variety of peritidal and shallow subtidal environments near the continental margin of a low-latitude craton.

Stratigraphy

The St. George Group is divided into four formations, in ascending order, the Watts Bight, Boat Harbour, Catoche and Aguathuna formations. There are two distinct lithological associations (cyclic shallowing-upward peritidal carbonates and subtidal fossiliferous, thick-bedded limestones) within the St. George Group. Two depositional megacycles are developed, the lower cycle (including the Watts Bight and lower and middle Boat Harbour formations) and the upper cycle (containing the upper Boat Harbour, Catoche and Aguathuna formations) comprise the St. George Group. Three second order cycles can be recognized within the Boat Harbour Formation.

Within this overall stratigraphic framework, ten sections were measured and closely sampled for conodonts. They provide two composite sections through the St. George Group. Over 430 3kg samples yielded more than 45,000 superbly preserved conodonts with a conodont Colour Alteration Index (CAI) of 1 indicating burial termperatures less than 90 C degrees.

Systematic paleontology

Through detailed taxonomic study, 75 multielement species, representing 28 genera, have been described and illustrated. Among them are 7 new genera, 33 new species and nearly 70 newly reconstructed multielement species. The new genera are *Glyptodontus*, *Loxodentatus*, *Loxognathus*, *Polycostatus*, *Striatodontus*, *Stultodontus* and *Tricostatus*). The new species are *Acodus primus*, *Clavohamulus longicuspis*, *C. neoelongatus*, *C. reniformis*, *C. sphearicus*, *Cristodus ethingtoni*, *Drepanodus nowlani*, *Glyptoconus felicitii*, *G. multiplicatus*, *G. priscus*, *Glyptodontus constrictus*, *G. expansus*, *G. tumidus*, *Loxodentatus bipinnatus*, *Loxodus latibasis*, *Loxognathus phyllodus*, *Macerodus crassatus*, *M. gracilis*, *M. wattsbightensis*, *Polycostatus falsioenotensis*, *P. minutus*, *Protopanderodus prolatus*, *Scolopodus subrex*, *Striatodontus lanceolatus*, *S. prolificus*, *S. retractus*, *S. teridontus*, *Stultodontus ovatus*, *S. pygmaeus*, *Teridontus obesus*, *Tricostatus glyptus*, *Utahconus longipinnatus*, and *Variabiloconus neobassleri*.

Multielement taxonomy

The present study reviews and summarizes the multielement taxonomy of Lower Ordovician conodonts, principally of the North American Midcontinent Province, based on over 70 newly reconstructed apparatuses. Three apparatus types, Apparatus Types I, II and III, are redefined in which the majority of known Lower Ordovician, Midcontinent Province, conodont genera and species can be accommodated. The skeletal plans of apparatus Type I, III, II and IV which were proposed by Barnes & al. (1979) are modified to be Type I, Type II and Type III respectively. Two particular morphotypes are present in all three apparatus types, namely: *a* subrounded morphotype and *e* compressed morphotype. The suberect symmetrical morphotype (*c*) is a pronounced element within apparatus Type II and Type III. The Type I species consists of only *a* subrounded elements and *e* strongly antero-posteriorly or orally compressed elements, and are characterized by stubby coniforms (Type IA) and extremely flattened forms (Type IB). The Type II apparatus has three major morphoytpes which include *a* subrounded elements, *c* suberect symmetrical elements and *e* compressed elements. Those apparatuses of Type III contain four (Type IIIA) and/or five (Type IIIB) skeletal morphotypes: *a*, *b*, *c*, e and f elements.

Phylogeny of Early Ordovician conodonts

In comparing the western Newfoundland data with other Lower Ordovician conodont studies, a series of interpretations on conodont phylogeny is possible. As noted by several authors, the first euconodonts appear in the late Cambrian and shortly after, conodont species diversity reached an high peak in the conodont evolutionary history.

Conodont species diversity reached the first peak near the middle Tremadoc. The Teridontus lineage that appears in the latest Cambrian spread widely, evolving into both the Clavohamulus lineage and Semiacontiodus lineage. The latter probably produced both the Variabiloconus and Polycostatus lineages. Loxodus, Macerodus and Rossodus lineages appear approximately the same time, but each with low species diversity and abundance. Near the end of Tremadoc, most of these lineages became extinct. This extinction bioevent appear to be one of the most profound crises in the conodont evolutionary history and nearly 40 species became extinct in the western Newfoundland sections.

Two major lineages, Glyptoconus and Striatodontus, appear suddenly, spreading widely, and diversifing rapidly at the beginning of Arenig. The Striatodontus lineage is probably derived from the Variabiloconus, and the Glyptoconus lineage is related to the oldest representative of *Striatodontus*.

The third peak of species diversity in the Early Ordovician is near the middle Arenig. Below this level ("the pebble bed" of the Boat Harbour Formation), a few species become extinct, and above several new lineages (*Acodus*, *Cristodus*, *Protopanderodus* and *Scolopodus*) occur suddenly, diversifing rapidly.

Some evolutionary radiation occurred in the *Protopanderodus*, *Scolopodus* and *Stultodontus* lineages during the middle Arenig. The *Oepikodus* lineage appears at this level as an immigrant into the Midcontinent Province during a period of maximum transgression.

Although the *Cordylodus* and *Drepanodus* lineages of the *Proconodontus* complex appear in the St. George Group, their evolutionary relationships are better clarified from the North Atlantic Province faunas of the Cow Head Group (slope facies).

Biostratigraphy

From an analysis of the vertical range of the many abundant conodont taxa in the St. George Group, it is possible to establish a new and more refined Lower Ordovician conodont zonation for the Midcontinent Province.

The conodonts recovered indicate that the St. George Group ranges in age from the earliest Canadian to the earliest Whiterockian.

Eight shallow-water Assemblage Zones (SW Zones A-H) have been established for the North American Midcontinent Province, of which two are present in the Watts Bight Formation, four within the Boat Harbour Formation, one each within the Catoche and Aguathuna formations. Six deeper-water conodont Assemblage or Lineage Zone have been recognized, of which two each are present in the Watts Bight and Boat Harbour fomations, one each within the Catoche and Aguathuna formations. The SW Assemblage Zones in ascending order are: A) Teridontus nakamurai-Semiacontiodus nogamii, (B) Polycostatus falsionentensis-Rossodus tenuis, (C) Rossodus manitouensis-Polycostatus sulcatus, (D) Glyptoconus floweri-G. bolites, (E) Striatodontus prolificus-S. lanceolatus, (F) Protopanderodus inconstans-Scolopodus subrex, (G) Stultodontus carlae-S. ovatus, (H) Striatodontus retractus. The DW Lineage and Assemblage Zones are: (A) Cordylodus lindstromi, (B) Cordylodus angulatus, (C) Drepanodus nowlani-Macerodus dianae, (D) Acodus delicatus-A. primus, (E) Protoprioniodus simplicissimus-Oepikodus communis.

Most DW Zones are related to the transgressive facies, but can be correlated into the shallow-water zones. Most SW Assemblage Zonescan be recognized on other low latitude cratons, such as Australia, Siberia and North China. The deeper-water Zones can be tentatively correlated into the North Atlantic Province zonation.

REFERENCES

Abaimova, G. P., 1971: New Early Ordovician conodonts from the southeastern Siberian Platform: Paleontologicheski Zhurnal, 1971, no. 4, pp. 74-81.

Abaimova, G. P., 1972: Conodont complexes in the Ordovician of the southeastern Siberian Platform: Sovietskaya Geologiya, 1972, no. 10, pp. 124-130.

Abaimova, G. P., 1975: Early Ordovician conodonts of the middle fork of the Lena River: Trudy Sibirskogo Nauchno-Issledovatel skogo Instituta, Geologii, Geofiziki i Mineralnogo Sirya (SNIGGIMS), vyp. 207, 129p (In Russian).

Abaimova, G. P. and Markov, E. P., 1977: First discovered conodonts of the Lower Ordovician zone of Cordylodus proavus from the southern Siberian Platform: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, vyp. 372, pp. 86-94 (In Russian).

Aldridge, R. J., 1987: Conodont palaeobiology: a historical review. in Aldridge (ed.), Palaeobiology of conodonts, British Micropalaeontological Society Series, pp. 1-34.

Aldridge, R. J., Briggs, D. E. G., Clarkson, E. N. K. and Smith, M. P., 1986: The affinities of conodonts--new evidence from the Carboniferous of Edinburgh, Scotland. Lethaia, v. 19, p. 279.

An Tai-Xiang, 1981: Recent progress in Cambrian and Ordovician conodont biostratigraphy of China, in Teichert, Curt, Liu Lu ed., Paleontology in China, 1979: Geological Society of American Special Paper, 187, pp. 209-225.

An Tai-Xiang, 1982: Study on the Cambrian conodonts from north and northeast China. University of Tsukuba, Science Reports of the Institute of Geoscience, Section B, 3, pp. 113-159.

An Tai-Xiang and others, 1983: Conodonts of North China and the adjacent regions. Chinese Science Publishing House. 223p.

Andres, D., 1988: Structures, apparatuses and phylogeny of primitive conodonts. Palaeontographica Abt. A 200, pp. 105-152.

Appollonov, M. K., Chugaeva, M. N., Dubinina, S. V. and Zhemchuzhnikov, V. G., 1988: Batyrbay Section, South Kazakhstan, U.S.S.R. -Potential stratotype for the Cambrian-Ordovician Boundary. Geol. Mag., V. 125, No. 4, pp. 445-449.

Austin, R. L., (ed.), 1987: Conodonts: Investigative techniques and applications. Ellis Horwood Limited, Chichester, 416p.

Bagnoli, G., Barnes, C. R. and Stevens, R. K., 1987: Tremadocian conodonts from Broom Point and Green Point, western Newfoundland. Bolletino della Societa Paleontologica Italiano, 35, pp. 145-158.

Barnes, C. R., 1974: Ordovician conodont biostratigraphy of the Canadian Arctic. pp. 221-240 in J. D. Aitken, and .D J. Glass (eds.): Canadian Arctic Geology. Geol. Assoc. of Canada and Canadian Society of Petroleum Geologists, Special Volume. Calgary.

Barnes, C. R., 1977: Ordovician conodonts from the Ship Point and Bad Cache Rapids Formations, Melville Peninsula, southeastern District of Franklin. Geological Survey of Canada, Bulletin 269, pp. 99-119.

Barnes, C. R., 1988: The proposed Cambrian-Ordovician global boundary stratotype and point (GSSP) in western Newfoundland, Canada. Geol. Mag. 125, V. 125, No.4, pp. 381-414.

Barnes, C. R. and Fåhræus, L. E., 1975: Province, communities, and the proposed nektobenthic habit of Ordovician conodontophorids. Lethaia 8, pp.133-149.

Barnes, C. R., Kennedy, D. J., McCracken, A. D., Nowlan, G. S. and Tarrant, G. A., 1979: The structure and evolution of Ordovician conodont apparatuses. Lethaia 12, pp. 125-151.

Barnes, C. R., Norford, B. S. and Skevington, D., 1981: The Ordovician System in Canada. International Union of Geological Sciences, Publication No. 8:1-27.

Barnes, C. R. and Poplawski, M. L. S., 1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada: Journal of Paleontology, v. 47, pp. 760-790.

Barnes, C. R., Rexroad. C. B. and Miller, J. F., 1973: Lower Paleozoic conodont provincialism. In Rhodes, F. H. T. (ed.): Conodont Paleozoology. Geol. Soc. Am. Spec. Pap. 141, 157-190.

Barnes, C. R. and Slack, D. J., 1975: Conodont ultrastructure: The subfamily Acanthodontinae: Royal Ontario Museum, Life Sciences Contribution, v. 106, 21p.

Barnes, C. R. and Tuke, M. F., 1970: Conodonts from the St. George Formation (Ordovician), northern Newfoundland: Geological Survey of Canada Bulletin, v. 187, pp. 79-97.

Bengtson, S., 1976: The structure of some Middle Cambrian conodonts, and the early evolution of conodont structure and function. Lethaia 9, pp.185-206.

Bengtson, S.,1983: The early history of the Conodonta. Fossils and Strata 15, pp. 5-19.

Bergström, S. M., 1970: Evolutionary trends in prioniodid conodonts (abstract). Geol. Soc. America, Abstracts with Programs 2 (6): 377, Bouder 1970.

Bergström, S. M., 1971: Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. Geological Society of America, Memoir 127: pp. 83-161.

Bergström, S. M., 1988: On Pander's Ordovician conodonts: distribution and significance of the <u>Prioniodus</u> <u>elegans</u>

fauna in Baltoscandia. Senckenbergiana Lethaea, V. 69, No. 3/4, pp. 217-251.

Bergström, S. M. and Sweet, W. C., 1966: Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. Bull. Am. Paleontol. 50, no. 229, pp. 271-441.

Besaw, D., 1974: Limestone evaluation, Port au Port Peninsula. In Limestone Resources of Newfoundland and Labrador. Edited by J. R. DeGrace, Newfoundland and Labrador Depatrment of Mines and Energy, Report 74-2.

Billings, E., 1865: Paleozoic fossils. V. 1 Geological Survey of Canada, Separate Report 431.

Boyce, W. D., 1979: Further developments in western Newfoundland Cambrian-Ordivician bistratigraphy. Newfoundland Department of Mines and Energy, Report 79-1, pp. 7-10.

Boyce, W. D., 1983b: Early Ordovician trilobite faunas of the Boat Harbour and Catoche formations (St. George Group) in the Boat Harbour-Cape Norman area. Great Northern Peninsula, western Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Nfld.

Brand, Uwe, and Rust, B. R., 1977: The age and upper boundary of the Nepean Formation in its type section near Ottawa, Ontario: Canadian Journal of Earth Sciences, v. 14, no. 9, pp. 2002-2006.

Branson, E. B., 1944: The geology of Missouri: University of

Missouri Studies, v. 19, no. 3, 535p.

Branson, E. B. and Mehl, M. G., 1933: Conodont studies, numbers 1 and 2: University of Missouri Studies, v. 8, nos. 1, 2, pp. 1-167.

Briggs, D. E. G., Clarkson, E. N. K. and Aldridge, R. J., 1983: The conodont animal. Lethaia, 16: pp.1-14.

Bruton, D. L., Koch, L. and Repetski, J. E., 1988: The Naersnes Section, Olso Region, Norway: trilobite, graptolite and conodont fossils reviewed. Geological Magazine, v. 125, no. 4, pp. 451-455.

Chen Jun-Yuan and Gong, We-li, 1986: Conodonts. In Aspects of Cambrian-Ordovician Boundary in Dayangcha, China (ed. Chen Jun-Yuan), pp. 93-223. Contribution to Dayangcha International Conference on Cambrian-Ordovician Boundary, Beijing: China Prospect Publishing House.

Chen Jun-Yuan, Qian Yi-Yuan, Zhang Jun-Ming, Lin Yao-Kun, Yin Lei-Ming, Wang Zhi-Hao, Wang Zong-Zhi, Yang Jie-Dong and Wang Ying-Xi, 1988: The recommended Cambrian-Ordovician global Boundary stratotype of the Xiaoyangqiao section (Dayangcha, Jilin Province), China. Geol. Mag., V. 125, No. 4, pp. 415-444.

Chow, N., 1986: Sedimentology and diagenesis of Middle and Upper Cambrian platform carbonates and siliciclastics. Port-au-Port Peninsula, western Newfoundland: Unpulished Ph.D. Dissertation, Memorial University of Newfoundland, St. John's, 458p.

Chow, N. and James, N. P., 1987: Cambrian Grand Cycles: A northern Appalachian perspective: Geological Society of America Bulletin, 98, pp. 418-429.

Clark, D. L., Sweet, W. C., Bergström, S. M., Klapper, G., Austin, R. L., Rhodes, F. H. T., Müller, K. J., Ziegler, W., Lindström, M., Miller, J. F. and Harris, A. G., 1981: Treatise on Invertebrate Paleontology pt. W. Miscellanaea, suppl. 2, Conodonta. The Geological Society of America, Inc. and the University of Kansas, Boulder, Colorado and Lawrence, Kansas, 202p.

Collinson, C. W., 1963: Techniques for the collecting and processing of conodonts: Illinois State Geological Survey. Circ. 343, pp. 1-16.

Cooper, B. J., 1981: Early Ordovician conodonts from the Horn Vally Siltstone, central Australia. Palaeontology V. 24, pp. 147-183.

Cooper, R. A., and Druce, E. C., 1975: Lower Ordovician sequence and conodonts, Mount Patriarch, northwest Nelson, New Zealand Journal of Geology and Geophysics, v. 18, no. 4, pp. 551-582.

Cowie, J. A., Ziegler, W., Boucot, A. J., Bassett, M. G., and Remane, J., 1986: Guidelines and Statutes of the International Commission of Stratigraphy (IGS). Courier Forschungsinstitut Senkenberg 83, pp. 1-14.

Cumming. L. M., 1967: Clonograptus from the St. George Formation, Newfoundland. In Repot of activities, Part B, Nov. 1966-Apr. 1967. Geol. Survey of Canada, Paper 67-1B, pp. 61-63.

Desrochers, A., 1985: The Lower and Middle Ordovician platform carbonites of the Mingan Island, Quebec: Stratigraphy, Sedimentology, Paleokarst, and Limestone digenesis. Unpublished Ph.D. thesis, Memorial University of Newfoundland.

Druce, E. C. and Jones, P. J. 1971: Cambrian-Ordovician conodonts from the Burke River structural belt, Queensland. Australia Bureau of Mineral Resources, Bulletin, 110, 159p.

Dzik, J. 1976: Remarks on the evolution of Ordovician conodonts. Acta Palaeontologica Polonica 21, pp. 395-455.

Erdtmann, B. -D., 1988: The Early Ordovician nematophorid graptolites: taxonomy and correlation. Geol. Mag. V. 125, No. 4.

Ethington, R. L., 1972: Lower Ordovician (Arenigian) conodonts from the Pogonip Group, central Nevada: Geologica et Palaeontologica, Sonderband 1, pp. 17-28.

Ethington, R. L. and Brand, U., 1981: Oneotodus simplex (Furnish) and the genus Oneotodus (Conodonta). Journal of Paleontology, v. 55, pp. 239-247.

Ethington, R. L. and Clark, D. L., 1964: Conodonts from the El Paso Formation (Ordovician) of Texas and Arizona: Journal of Paleontology, v. 38, pp. 685-704.

Ethington, R. L. and Clark, D. L., 1965: Lower Ordovician conodonts and other microfossils from the Columbia Ice Fields Section, Alberta, Canada: Brigham Young University Geology Studies, v. 12, pp. 185-205.

Ethington, R. L. and Clark, D. L. 1971: Lower Ordovician conodonts in North America. In Sweet, W. C. and Bergström, S. M.(eds.): Symposium on Conodont Biostratigraphy. Geol. Soc. Am. Mem. 127, pp. 63-82.

Ethington, R. L. and Clark, D. L. 1981: Lower and Middle Ordovician conodonts from the Ibex area, Western Millard County, Utah. Brigham Young University Geology Studies 28, part 2, 155p.

Ethington, R. L., Engel, K. M. and Elliott, K. L., 1987: An abrupt change in conodont faunas in the Lower Ordovician of the Midcontinent Province. In R. J. Aldridge (ed.), Palaeobiology of conodonts, British Micropalaeontological Society Series, pp. 111-127.

Ethington, R. L. and Repetski, J. E., 1984: Paleobiogeographic distribution of Early Ordovician conodonts in central and western United States. Geological Society of America, Special Paper 196, pp. 89-101.

Fåhræus, L. E., 1970: Conodont-based correlations of Lower and Middle Ordovician strata in western Newfoundland: Geological Society of America Bulletin, v. 81, pp. 2061-2076.

Fåhræus, L. E., 1977: Correlation of the Canadian/Champlainian series boundary and the Whiterock Stage of North America with western European conodont and graptolite zones. Bulletin of Canadian Petroleum Geology, V. 25, pp. 981-994.

Fåhræus, L. E., 1982: Recognition and redescription of Pander's (1856) Scolopodus (form-)species-Constituents of multi-element taxa (Conodontophorida, Ordovician. Geol. & Palaeont., V. 16, pp. 19-28.

Fåhræus, L. E., and Nowlan, G. S., 1978: Franconian (Late Cambrian) to early Champlainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland: Journal of Paleontology, v. 52, pp. 444-471.

Fåhræus, L. E. and Hunter, D. R., 1985: The curvature-transition series: integral part of some simple-cone conodont apparatuses (Panderodontacea, Distacodontacea, Conodontata), Acta Palaeontologica, Polonica, 30, pp. 177-189.

Flower, R. H., 1978: St. George and Table Head cephalopod zonation in west Newfoundland. In Current Research, part A, Geological Survey od Canada, Paper 78-1A, pp. 217-224. Fortey, R. A., 1979: Early Ordovician trilobites from the Catoche Formation (St. George Group), western Newfoundland. Geological Survey of Canada, Bulletin 321, pp. 61-114.

Fortey, R. A., 1979: Early Ordovician trilobites from the Catoche Formation (St. George Group), western Newfoundland. In Contribution to Canadian paleontology.

Geol. Survey of Canada, Bulletin, 321, pp. 61-114.

Fortey, R. A., 1984: Global early Ordovician transgressions and regressions and their biological implications. In D. L. Bruton (ed.), Aspects of the Ordovician System, Paleontological Contributions from the University of Oslo, 295, pp. 37-50.

Fortey, R. A. and Barnes, C. R., 1977: Early Ordovician conodont and trilobite communities of Spitsbergen: Infuence on biogeography. Alcheringa, v. 1, pp. 297-309.

Fortey, R. A., Landing, E. and Skevington, D., 1982: Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. The Cambrian-Ordovician Boundary: Sections, Fossil Distributions and correlations (ed. M. G. Bassett and W. T. Dean), pp. 95-129. Cardiff: National Museum of Wales, Geological Series No. 3.

Fortey, R. A. and Skevington, D., 1980: Correlation of Cambrian-Ordovician boundary between Europe and North America: new data from western Newfoundland. Canadian Journal of Earth Sciences, V. 17, pp. 382-388.

Furnish, W. M. 1938: Conodonts from the Prairie du Chien beds of the upper Mississippi Valley. J. Paleontology, no. 12, pp. 318-340.

Graves, R. W., Jr. and Ellison, S., 1941: Ordovician conodonts of the Marathon Basin, Texas. University of Missouri

School of Mines and Metallurgy Bulletin, Technical Series, 14, pp. 1-26.

Greggs, R. G. and Bond, I. J., 1971: Conodonts from the March and Oxford Formations in the Brockville a: . Ontario: Canadian Journal of Earth Sciences, v. 8, pp. 1455-1471.

Harris, R. W., 1962: New conodonts from the Joins (Ordovician) Formation of Oklahoma: Oklahoma Geology Notes, v. 22, pp. 199-211.

Harris, R. W. and Harris, Beth, 1965: Some West Spring Creek (Ordovician Arbuckle) conodonts from Oklahoma: Oklahoma Geology Notes, v. 25, pp. 34-47.

Harris, A. G., Harris, L. D. and Epstein, J. B., 1978: Oil and gas data from Paleozoic rocks in the Appalachian basin: maps for assessing hydrocarbon potential and thermal maturity (conodont color alteration isograds and overburden isopachs): U.S. Geological survey Miscellaneous Investigations Maps I-917-E, scale 1:2,500,000.

Harris, A. G., Repetski, J. E., Tull, J. F., and Bearce, D. N., 1984, Early Paleonzoic conodonts from the Talladega slate belt of the Alabama Appalachians-Tectonic implications: Geological Society of America Abstracts with Programs, v. 16, p. 143.

Hass, W. H., 1962: Conodonts: Treatise on invertebrate Paleontology Section W p. w3-w69.

Hintze, L. F., 1973: Lower and Middle Ordovician stratigraphic section in the Ibex area, Millard County, Utah,Brigham University Geol. Studies, 20(4), pp. 3-36.

James, N. P. and Stevens, R. K, 1986: Stratigraphy and correlation of the Cambro-Ordovician Cow Head Group, western Newfoundland. Geol. Survey, of Canada, Bulletin 366, 143p.

James, N. P., Stevens, R. K., Barnes, C. R. and Knight, I, 1989: Evolution of a Lower Paleozoic continental Margin carbonate platform, northern Canadian Appalachians. In Controls on Carbonate Platforms and Basin Development. Crevelo, T., Sarg. R. Read, J. F. and Wilson J. L., editors, Society of Economic Paleontologists and Mineralogists Special Publication, No. 44, pp. 123-146.

Jeppsson, L. 1971: Element arrangement in conodont apparatuses of Hindeodella type and similar forms. Lethaia 4, pp. 101-123.

Ji Zailiang and Barnes, C. R., 1988: Revision to apparatus reconstructions of Lower Ordovician, Midcontinent Province, conodonts (abstract). In Ziegler, W. (ed.), 1st International Senckenberg Conference and 5th European Conodont Symposium (ECOS V) contributions I, Courier Forschungsinstitut Senckenberg, v. 102, pp. 243-244.

Ji Zailiang and Barnes, C. R., (in press), Apparatus reconstructions of Lower Ordovician conodonts from the Midcontinent Province. In Ziegler, W. editor, Contributions III of 5th European Conodont Symposium (ECOS V), Courier Forschungsinstitut Senckenberg.

Ji Zailiang and Barnes, C. R., 1989: Preliminary Lower Ordovician conodont zonation in the Midcontinent Province. In Abstracts 28th International Geological Congress, V. 2 of 3, pp. 123-124.

Jones, P. J., 1971: Lower Ordovician conodonts from the Bonaparte Gulf Basin and the Daly River Basin, north-western Australia: Australia Bureau of Mineral Resources, Geology and Geophysics, Bulletin 117, 80p.

Johnson, H., 1949: Geology of western Newfoundland. Geological Survey of Newfoundland. unpublished report.

Kennedy, D. J. 1980: A restudy of conodonts described by Branson and Mehl, 1933, from the Jefferson City Formation, Lower Ordovician, Missouri. Geologica & Palaeontologica, 14, pp. 45-76.

Kindle, C. H., and Whittington, H. B., 1958: Stratigraphy of the Cow Head region, western Newfoundland: Geological Society of America Bulletin, v. 69, pp. 315-342.

Knight, I., 1978: Platformal sediments on the Great Northern Peninsula: stratigraphic studies and geological mapping of north St. Barbe district. Newfoundland Department of Mines and Energy, Mineral Divison, Report 78-1, pp. 140-150.

Knight, I. and James, N. P. 1987: The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: the interaction between eustasy and tectonics. Can. J. Earth Sci. 24, pp. 1927-1951.

Klapper, G. and Philip, G. M. 1971: Devonian conodont apparatuses and their vicarious skeletal elements. Lethaia 4, 429-452.

Kluyver, H. M., 1975: Stratigraphy of the Ordovician St. Geroge Group in the Port au Choix area, western Newfoundland. Canadian Journal of Earth Sciences, v. 12, pp. 589-594.

Landing, Ed, 1976: Early Ordovician (Arenigian) conodonts and graptolite biostratigraphy of the Taconic allochthon, eastern New York: Journal of Paleontology, v. 50, pp. 614-646.

Landing, E. and Barnes, C. R., 1980: Conodonts from the Cape Clay Formation (Lower Ordovician), southern Devon Island, Arctic Archipelago. Canadian Journal of Earth Sciences, 18, pp.1609-1628.

Landing, E., Barnes, C. R. and Stevens, R, K. 1986: Tempo of earliest Ordovician graptolite faunal succession: conodont based correlation from the Tremadocian of Quebec. Can. J. Earth Sci. 23, pp.1928-1949.

Landing, Ed, Ludvigsen, Rolf, and von Bitter, P. H., 1980: Upper Cambrian to Lower Ordovician conodont biostratigraphy and biofacies, Rabbitkettle Formation, District of Mackenzie: Royal Ontario Museum Life Sciences Contributions, v. 126, 42p.

Landing, Ed, Taylor, M. F., and Erdtmann, B.-D., 1978: Correlation of the Cambro-Ordovician boundary between the Acado-Baltic and North American Provinces: Geology, v. 6, pp. 75-78.

Lee, Ha-young, 1970: Conodonten aus dem Choson-Gruppe (Unteres Ordovizium) von Korea: Neues Jahrbuch fur Geologica und Palaontologica Abhandlungen, 136, pp. 303-344.

Lee, Ha-young, 1975a: Conodonts from the Dumugol Formation (Lower Ordovician), South Korea: Journal of the Geological Society of Korea, v. 11, no. 2, pp. 75-93.

Lee, Ha-young, 1975b: Conodonten aus dem Unteren und Mittleren Ordovician von Nordkorea (Conodonts from the Lower and Middle Ordovician of North Korea): Paleontographica, v. 150, pp. 161-186.

Levesque, R. J., 1977: Stratigraphy and sedimentology of Middle Cambrian to Lower Ordovician shallow water carbonate rocks, western Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, 276p.

Lindström, M., 1955: Conodonts from the lower-most Ordovician strata of south-central Sweden: Geologiska i Stockholm, Forhandlingar 76, pp. 517-604. Lindström, M. 1964: Conodonts. 196p. Elsevier, Amsterdam, London, New York.

Lindström, M. 1970: A suprageneric taxonomy of the conodonts. Lethaia 3, pp. 427-445.

Lindström, M. 1971: Lower Ordovician conodonts of Europe. in Sweet, W. C. & Bergström, S. M. (eds.): Symposium on Conodont Biostratigraphy. Geol. Soc. Am. Mem. 127, 21-61.

Lindström, M. and Ziegler, W. (eds.) 1972: Symposium on Conodont Taxonomy. Geologica et Palaeontologica SB 1. pp. 158. Marburg.

Löfgren, Anita, 1978: Arenigian and Llanvirnian conodonts from Jamtland, northern Sweden: Fossils and Strata, v. 13, 129p.

Longwell, C. R. and Mound, M. C., 1967: A new Ordovician formation in Nevada dated by conodonts: Geological Society of America Bulletin, v. 78, pp. 405-412.

McTavish, R. A. 1973: Prioniodontacean conodonts from the Emanuel Formation (Lower Ordovician) of Western Australia. Geologica & Palaeontologica 7, pp. 27-58.

Mehl, M. G. and Ryan, R., 1944: in the Geology of Missouri, by E. B. Branson: University of Missouri Studies, v. 19, no. 3, pp. 45 and 52.

Miller, J. F. 1969: Conodont fauna from the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah. J. Paleontology, 43, pp. 413-439.

Miller, J. F. 1980: Taxonomic revisions of some Upper Cambrian and Lower Ordovician conodonts with comments on their evolution. University of Kansas Paleontological Contributions, Paper 99, pp. 1-39.

Miller, J. F. 1984: Cambrian and earliest Ordovician conodont evolution, biofacies, and provincialism. Geological Society of America Special Paper 196, pp. 43 68.

Miller, J. F., 1988: Conodonts as biostratigraphic tools for redefinition and correlation of the Cambrian-Ordovician Boundary. Geol. Mag., V. 125, No. 4, pp. 349-362.

Moskalenko, T. A., 1967: Conodonts from the Chunsky Stage (Lower Ordovician) of the rivers Moiero and Podkamen-naya Tunguska, in New data on the biostratigraphy of the lower Paleozoic deposits of the Siberian platform, A. B. Ivanovskii and B. S. Sokolov (eds.): Akademiya Nauk SSSR, Sibirskoye Otdeleniye, Instituta Geologii i Geofiziki, pp. 98-116.

Moskalenko, T. A., 1972: Ordovician conoodnts of the Siberian Platform and their bearing on multielement taxonomy: Geological & Paleontologica, Sonderband 1, pp. 47-56.

Moskalenko, T. A., 1973: General survey of Ordovician conodonts of the Siberian Platform: Akademiya Nauk USSR, Siberia Branch, Trudy Instituta Geologii i Geofiziki, v. 47, pp. 87-135 (in Russian).

Mound, M. C., 1965: A conodont fauna from the Joins Formation (Ordovician), Oklahoma: Tulane Studies in Geology and Paleontology, v. 4, pp. 1-45.

Mound, M. C. 1968: Conodonts and biostratigraphy of the lower Arbuckle Group (Ordovician), Arbuckle Mountains, Oklahoma: Micropaleontology, v. 14, pp. 383-434.

Müller, 1973: Late Cambrian and early Ordovician conodonts from northern Iran: Geological Survey of Iran, Report 30, 77p.

Ni S., Wang X., Xu G., Zhou T., Zeng Q., Li Z., Xiang L. and Lai C., 1983: Cambrian-Ordovician boundary section at Huanghuachang, Yichang, Hubei, China. Bulletin of the Yichang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences, 6, pp. 79-95.

Nogami, Yasuo, 1967: Kambrische Conodonten von China, Teil 2. Conodonten aus den hoch oberkambrischen Yencho-Schichten: Memoirs of the College of Science, University of Kyoto, Series B, v. 33, Geology and Mineralogy, p. 211-218.

Nowlan, G. S. 1976: Later Cambrian to Late Ordovician conodont evolution and biostratigraphy of the Franklinian miogeosyncline, eastern Canadian Arctic Islands. Unpublished Ph.D. dissert., University of Waterloo, Ontario, 591p.

Nowlan, G. S., 1981: Stratigraphy and conodont faunas of the Lower and Middle Ordovician Romaine and Mingan Formations, Mingan Islands, Quebec. Maritime Sediments and Atlantic Geology, v. 12, pp. 67.

Nowlan, G. S. 1985: Cambrian-Ordovician conodonts from the

Franklinian Miogeosyncline, Canadian Arctic Islands. J. Paleontology, v. 59, No. 1, pp. 96-122, 10 Figs.

Nowlan, G. S. & Barnes, C. R., 1987a: Thermal maturation of Paleozoic strata in eastern Canada from conodont colour alteration index (CAI) data with implications for burial history, tectonic evolution, hotspot tracks and mineral and hydrocarbon exploration. Geol. Survey of Canada, Bulletin 367, pp.1-47.

Nowlan, G. S. and Barnes, C. R.,1987b: Application of conodont colour alteration indices to regional and economic geology. In Conodonts Investigative Techniques and Applications, Austin, R. L. (ed.), pp. 188-202.

Orndorff, R. C., 1988: Latest Cambrian and Earliest Ordovician conodonts from the Conococheague and Stonehenge Limestone of northwestern Virginia. U. S. Geol. Survey Bulletin 1837.

Pander, C. H., 1856: Monographie der fossilen Fische des silurischen systems des russisch-baltischen Gouvernements: St. Petersburg, Akademie de Wissenschaften, i-x, pp. 1-91.

Pohler, S. L., Barnes, C. R. and James, N. P., 1987: Reconstructing a lost faunal realm: conodonts from megaconglomerates of the Ordovician Cow Head Group, western Newfoundland. In conodonts: Investigative Techniques and Applications (ed. R. L. Austin), pp. 341-362. Ellis Horwood, British Micropalaeontological Society Series.

Pohler, S. L., 1987: Conodont biofacies and carbonate lithofacies of Lower Ordovician megaconglomerates, Cow Head Group, western Newfoundland. Unpublished Ph. D. dissert, Memorial University of Newfoundland, 546p.

Pratt, B., 1979: The St. George Group (Lower Ordovician), western Newfoundland: sedimentology, diagenesis, and cryptalgal structures. Unpublished M.Sc. thesis, Memorial University of Newfoundland, 254p.

Pratt, B., 1982a: Stromatolitic framework of carbonate mud mounds. Journal of Sedimentary Petrology, 52: pp. 1203-1228.

Pratt, B., 1982b: Stromatolite decline-a reconsideration. Geology, 10: pp. 512-515.

Pratt, B. R., and James, N. P. 1986: The St. George Group (Lower Ordovician) of western Newfoundland: tidal flat island model for carbonate sedimentation in shallow epeiric seas. Sedimentology, 29: 543-569.

Repetski, J. 1982: Conodonts from El Paso Group (Lower Ordovician) of westernmost Texas and southern New Mexico. Mexico Bureau of Mines & Mineral Resources, Memoir 40.

Repetski, J. 1988: Ordovician conodonts from the Bliss Sandstone in its type area, west Texas. New Mexico Bureau of Mines & Mineral Resources Memoir 44, pp. 123-127.

Repetski, J. and Ethington R. L. 1983: Rossodus manitouensis (Conodonta), a new early Ordovician index fossil. J. Paleontology, 57, pp. 289-301.

Repetski, J. and Perry, W. J. Jr., 1980: Conodonts from structural windows through the Bane Dome, Girles County, Virginia. Virginia Division of Mineral Resources Publication 27, pp. 12-22.

Robison, R. A. (ed.), 1981: Treatise on Invertebrate Paleontology, part W, Miscellanea. Supplement 2, Conodonta. The Geological Society of America, Inc. and the University of Kansas, Boulder, Colorado, and Lawrence, Kansas, 202p.

Rodgers, J. and Neale, E. R. W. 1963: Possible "Taconic" klippen in western Newfoundland. American Journal of Science, 261, pp. 713-730.

Ross, R. J. Jr., 1975: Early Paleozoic trilobite, sedimentary facies lithospheric plates, and ocean currents. Fossils and Strata, 4: pp. 307-329.

Sando, W. J., 1958: Lower Ordovician section near Chambersburg Pennsylvania. Geol. Soci. of Amer. V. 69, pp. 837-854.

Schuchert, C. and Dunbar, C. O., (1934): Stratigraphy of western Newfoundland. Memoir Geological Society of America, v. 1, 123p.

Schopf, T. J. M. 1966: Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec. Bull. New York State Mus. 405, 105p. Albany, New York.

Seddon, G. and Sweet, W. C., 1971: An ecologic model for conodonts. Journal Paleontology. v. 45, pp. 869-880, Tulsa.

Serpagli, E. 1974. Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). Societa Palaeontologica Italiana, Bolletino, 13, pp. 17-93.

Stouge, S., 1982: Preliminary conodont biostratigraphy and correlation of Lower to Middle Ordovician carbonates the St. George Group. Great Northern Peninsula, Newfoundland. Mineral Department Division, Report 82-3, 59p.

Stouge, S. and Boyce, W. D., 1983: Fossils of Northwestern Newfoundland and southeastern Labrador: conodonts and trilobites. Mineral Department Division, Report 83-3, 55p.

Stouge, S. and Bagnoli, B., 1988: Early Ordovician conodonts from Cow Head Peninsula, western Newfoundland. Palaeontographia Italica, 75, pp. 89-179.

Sweet, W. C. 1985: Conodonts: those fascinating little whatzits. Jour. of Paleont. 59, pp. 485-494.

Sweet, W. C., 1988: The Conodonta: morphology, taxonomy, paleoecology and evolutionary history of a long extinct animal phylum: Oxford Monographs on Geology and Geophysics no. 10, Oxford Univ. Press, 212 p., 94 figs.

Sweet, W. C. and Bergström, S. M. 1970: Generic concept in palaeontology: North American Paleo. Congr. Proc.,pt.C. pp. 157-173.

Sweet, W. C. and Bergström, S. M., 1972: Multielement taxonomy and Ordovician conodonts. In Lindström, M. & Ziegler,

W. (eds.): Symposium on Conodont Taxonomy. Geologica et Palaeontologica SB 1, pp. 29-42.

Sweet, W. C., Ethington, R. L., and Barnes, C. R., 1971: North American Middle and Upper Ordovician conodont faunas, in Symposium on conodont biostratigraphy, W. C. Sweet and S. M. Bergström, eds.: Geological Society of America, Mem. 127, pp. 163-193.

Sweet, W. C. and Schönlaub, H. P. 1975: Conodonts of the genus Oulodus Branson & Mehl, 1933. Geologica & Palaeontologica 9, 41-59.

Sweet, W. C., Thompson, T. L. and Satterfield, I. R. 1975: Conodont stratigraphy of the Cape Limestone (Maysvillian) of eastern Missouri. Missouri Geol. Surv. Rept. Invest. 57, 1-59. Rolla, Missouri.

Tipnis, R. S., Chatterton, B. D. E. and Ludvigsen, R., 1978: Ordovician conodont biostratigraphy of the southern district of Mackenzie, Canada, G. A. C. Special Paper, 18.

Van Wamel, W. A. 1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of north-western Oland, south eastern Sweden. Utrecht Micropaleont. Bulletins 10. 126p.

Viira, Viive, 1974: Ordovician conodonts of the east Baltic: Institut Geologii Akademii Nauk Estonskoi SSSR, Tallin, 142p.

Viira, Viive, 1987: Earliest representatives of the genus

Cordylodus (Conodonta) from Cambro-Ordovician boundary beds of North Estonia and Leningrad Region.

Wang Z. H., 1983: Outline of uppermost Cambrian and lowermost Ordovician conodonts in north and northwestern China with some suggestions as to the Cambrian-Ordovi cian boundary. In Papers for the Symposium on the Cambrian-Ordovician and Ordovician-Silurian boundaries, Nanjing, China. Nanjing Institute of Geology and Palaeontology, Academica Sinica, pp. 31-39.

Webers, G. F. 1966: The Middle and Upper Ordovician conodont faunas of Minnesota, Minnesota Geol. Surv. Spec. Publ. 4, pp. 123. Minneapolis, Minnesota.

Whittington, H. B. and Kindle, C. H., 1969: Cambrian and Ordovician stratigraphy of western Newfoundland. In North Atlantic Geology and continental drift. Edited by Kay, America Association of Petroleum Geologists, Memoir 12, pp. 655-664.

Williams, H., 1979: Appalachian Orogen in Canada. Canadian Journal of Earth Sciences, v. 16, pp. 792-807.

Williams, H., 1985: The Geological Map of Stephenville. Geol. Surv. of Canada, Map 1579.

Williams, H. and Stevens, R. K., 1974: The ancient continental margin of eastern North America. In the geology of continental margins. Edited by C. A. Burk and C. L. Drake. Spinger-Verlag, New York, NY, pp. 781-796.

Williams, S. H., Boyce, W. D. and James, N. P., 1987: Graptolites from the Lower-Middle Ordovician St. George and Table Head groups, western Newfoundland, and their correlation with trilobites, brachiopods and conodont zones. Canadian Journal of Earth Sciences. v. 24, pp. 456-470.

Zeng Q., Ni S., Xu G., Zhou T., Wang X., Li. Z., Li C., and Xiang L., 1983: Subdivision and correlation on [sic] the Ordovician in the eastern Yangtze gorges, China. Bulletin of the Yichang Institute of Geology and Mineral Resources, Chinese Academy of Geological Science, 6, pp. 21-68.

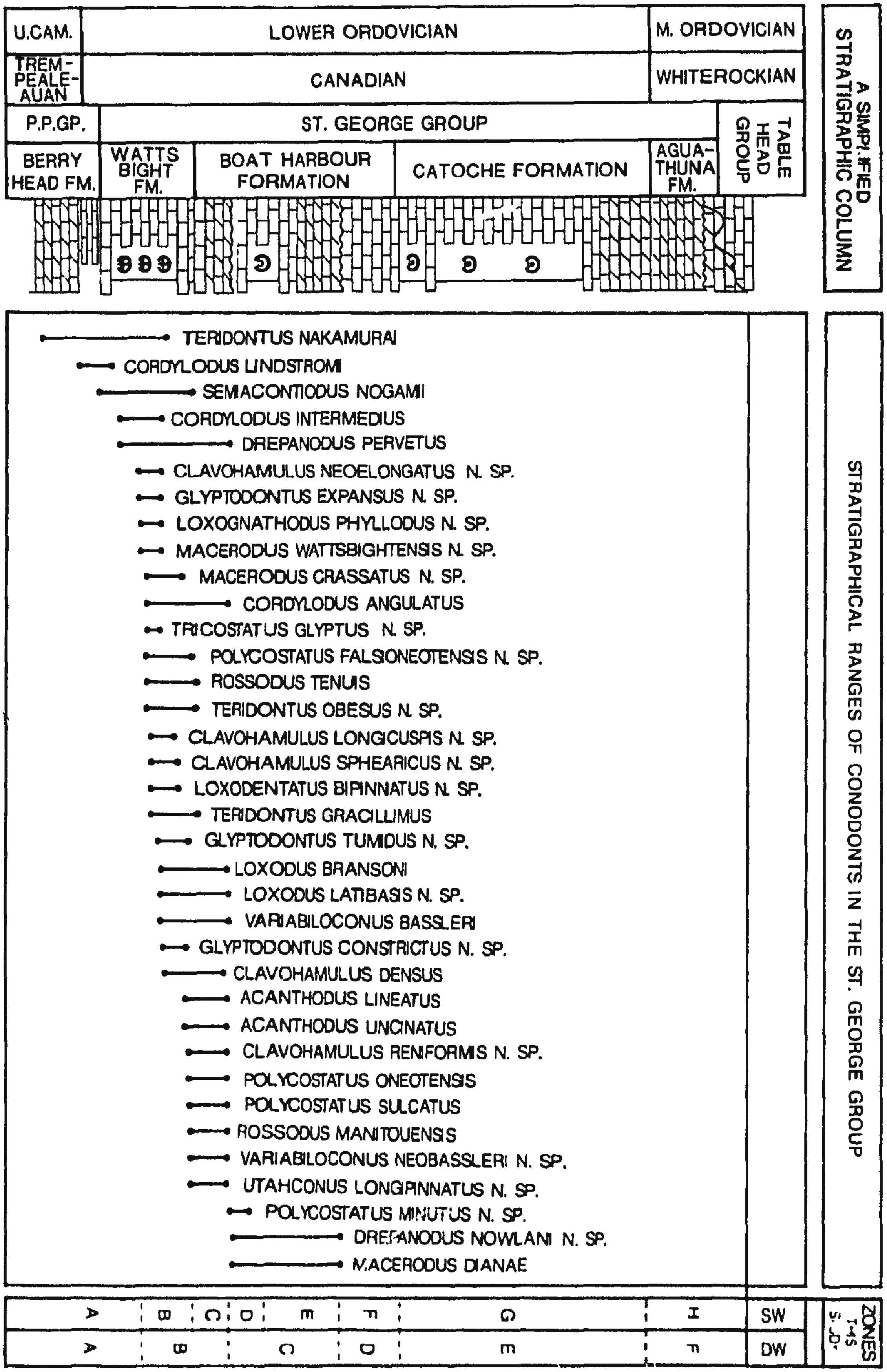
Ziegler, W. 1973: Catelogue of Conodonts. Volumes 1-4. Schweizerbart'sche, Stuttgart.

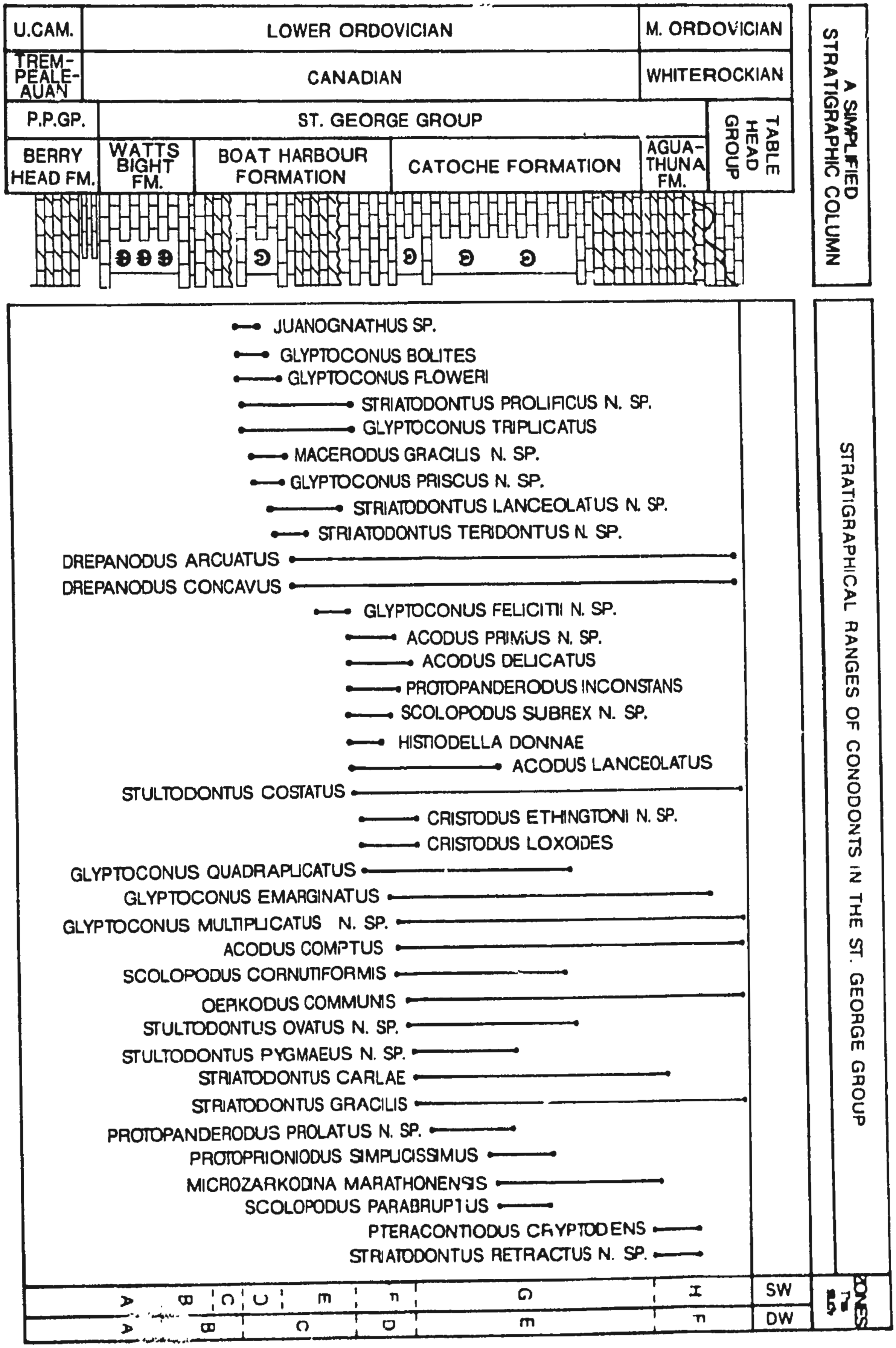
APPENDIX A

SUMMARY OF RANGES OF SELECTED CONODONTS FROM THE ST. GEORGE GROUP (TABLE 492A-B).

CONODONT DISTRIBUTION TABLES (TABLE 1-10)

Numerical distribution of conodont species in samples from Section 1 to Section 10. Genera and species are listed alphabetically; samples are listed in ascending stratigraphic order from left to right. Supercalc 4 (SC4) computer programme used for all the tables. *=n. sp.


U.CAM.
LOWER ORDOVICIAN
M. ORDOVICIAN
TREMPEALEAUAN
CANADIAN
WHITEROCKIAN
P.P.GP.
ST. GEORGE GROUP
TABLE HEAD GROUP
BERRY HEAD FM.
WATTS BIGHT FM.
BOAT HARBOUR FORMATION
CATOCHE FORMATION
AGUATHUNA FM.
A SIMPLIFIED STRATIGRAPHIC COLUMN
TERIDONTUS NAKAMURAI
CORDYLODUS LINDSTROMI
SEMIACONTIODUS NOGAMII
CORDYLODUS INTERMEDIUS
DREPANODUS PERVETUS
CLAVOHAMULUS NEOELONGATUS N. SP.
GLYPTODONTUS EXPANSUS N. SP.
LOXOGNATHODUS PHYLLODUS N. SP.
MACERODUS WATTSBIGHTENSIS N. SP.
MACERODUS CRASSATUS N. SP.
CORDYLODUS ANGULATUS
TRICOSTATUS GLYPTUS N. SP.
POLYCOSTATUS FALSIONEOTENSIS N. SP.
ROSSODUS TENUIS
TERIDONTUS OBESUS N. SP.
CLAVOHAMULUS LONGICUSPIS N. SP.
CLAVOHAMULUS SPHEARICUS N. SP.
LOXODENTATUS BIPINNATUS N. SP.
TERIDONTUS GRACILLIMUS
GLYPTODONTUS TUMIDUS N. SP.
LOXODUS BRANSONI
LOXODUS LATIBASIS N. SP.
VARIABILOCONUS BASSLERI
GLYPTODONTUS CONSTRICTUS N. SP.
CLAVOHAMULUS DENSUS
ACANTHODUS LINEATUS
ACANTHODUS UNCINATUS
CLAVOHAMULUS RENIFORMIS N. SP.
POLYCOSTATUS ONEOTENSIS
POLYCOSTATUS SULCATUS
ROSSODUS MANITOUENSIS
VARIABILOCONUS NEOBASSLERI N. SP.
UTAHCONUS LONGIPINNATUS N. SP.
POLYCOSTATUS MINUTUS N. SP.
DREPANODUS NOWLANI N. SP.
MACERODUS DIANAE
STRATIGRAPHICAL RANGES OF CONODONTS IN THE ST. GEORGE GROUP
A
B
C
D
E
F
G
H
SW
A
B
C
D
E
F
DW
ZONES T-45 S. J.



U.CAM.
LOWER ORDOVICIAN
M. ORDOVICIAN
TREM-PEALE-AUAN
CANADIAN
WHITEROCKIAN
P.P.GP.
ST. GEORGE GROUP
TABLE HEAD GROUP
BERRY HEAD FM.
WATTS BIGHT FM.
BOAT HARBOUR FORMATION
CATOCHE FORMATION
AGUA-THUNA FM.
A SIMPLIFIED STRATIGRAPHIC COLUMN
JUANOGNATHUS SP.
GLYPTOCONUS BOLITES
GLYPTOCONUS FLOWERI
STRIATODONTUS PROLIFICUS N. SP.
GLYPTOCONUS TRIPLICATUS
MACERODUS GRACILIS N. SP.
GLYPTOCONUS PRISCUS N. SP.
STRIATODONTUS LANCEOLATUS N. SP.
STRIATODONTUS TERIDONTUS N. SP.
DREPANODUS ARCUATUS
DREPANODUS CONCAVUS
GLYPTOCONUS FELICITII N. SP.
ACODUS PRIMUS N. SP.
ACODUS DELICATUS
PROTOPANDERODUS INCONSTANS
SCOLOPODUS SUBREX N. SP.
HISTIODELLA DONNAE
ACODUS LANCEOLATUS
STULTODONTUS COSTATUS
CRISTODUS ETHINGTONI N. SP.
CRISTODUS LOXOIDES
GLYPTOCONUS QUADRAPLICATUS
GLYPTOCONUS EMARGINATUS
GLYPTOCONUS MULTIPLICATUS N. SP.
ACODUS COMPTUS
SCOLOPODUS CORNUTIFORMIS
OEPIKODUS COMMUNIS
STULTODONTUS OVATUS N. SP.
STULTODONTUS PYGMAEUS N. SP.
STRIATODONTUS CARLAE
STRIATODONTUS GRACILIS
PROTOPANDERODUS PROLATUS N. SP.
PROTOPRIONIODUS SIMPLICISSIMUS
MICROZARKODINA MARATHONENSIS
SCOLOPODUS PARABRUPTUS
PTERACONTIODUS CRYPTODENS
STRIATODONTUS RETRACTUS N. SP.
STRATIGRAPHICAL RANGES OF CONODONTS IN THE ST. GEORGE GROUP
A B C C E F G H
SW
A B C D E F
DW
ZONES

FORMATION	BERRY HEAD FORMATION													
DISTANCE (m) ABOVE THE BASE	6.3	11.3	19.1	22	40	50.8	60.9	63	67.5	72	78.5	80	85	89.5
SPECIES/SAMPLE	Z1-1	Z1-2	Z1-3	Z1-4	Z1-5	Z1-6	Z1-7	Z1-8	Z1-9	Z1-10	Z1-11	Z1-12	Z1-13	Z1-14
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eoconodontus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BERRY HEAD FORMATION												
DISTANCE (m) ABOVE THE BASE	90.7	96	103.7	111	111.2	117	121.8	124.8	126.	129	134.	141	146
SPECIES/SAMPLE	Z1-15	Z1-16	Z1-17	Z1-18	Z1-18B	Z1-19	Z1-20	Z1-20B	Z1-21	Z1-22	Z1-23	Z1-24	Z1-25
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	1	1	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	0	0
Eoconodontus sp.	0	0	0	0	0	0	0	0	0	0	0	1	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	5	0	0	0
Teridontus nakamurai	0	0	0	2	1	0	0	3	0	4	1	0	0
TOTAL	0	0	0	2	1	0	0	3	0	10	2	1	0

FORMATION	B. HEAD FM.		WATTS BIGHT FORMATION								
DISTANCE (m) ABOVE THE BASE	151.5	154	157.4	157.7	162.7	162.9	174	183.	187	205	
SPECIES/SAMPLE	Z1-26	Z1-27A	Z1-27B	Z1-27C	Z1-28	Z1-29	Z1-30	Z1-31	Z1-32	Z1-33	TOTAL
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	1	0	1
Cordylodus lindstromi	0	0	2	0	0	0	0	1	0	0	5
Drepanodus pervetus	0	1	0	2	0	0	0	0	0	0	3
Eoconodontus sp.	0	0	0	0	0	0	0	0	0	0	1
Glyptodontus expansus*	0	0	0	0	0	1	0	0	0	0	1
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	1	0	1
Loxognathus phyllodus*	0	0	0	0	0	0	0	1	0	0	1
Semiacontiodus nogamii	0	4	2	0	0	3	0	4	7	0	25
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	11
TOTAL	0	5	4	2	0	4	0	6	9	0	49

FORMATION	B.H.FM		WATTS BIGHT FM												
DISTANCE (m) ABOVE THE BASE	.3	4.5	8	11.	14.	17.	18.5	22.3	25.8	36.8	38.3	39.8	45.3	47.1	51.5
SPECIES/SAMPLE	Z2-A	Z2-B	Z2-C	Z2-D	Z2-E	Z2-F	Z2-G	Z2-1	Z2-2	Z2-3	Z2-3B	Z2-3C	Z2-4	Z2-5	Z2-6
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	16	18	3	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0	0	3	1	9
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	8	4	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	3	0	11	2	5	0	2
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FORMATION	B.H.FM		WATTS BIGHT FM												
DISTANCE (m) ABOVE THE BASE	.3	4.5	8	11.	14.	17.	18.5	22.3	25.8	36.8	38.3	39.8	45.3	47.1	51.5
SPECIES/SAMPLE	Z2-A	Z2-B	Z2-C	Z2-D	Z2-E	Z2-F	Z2-G	Z2-1	Z2-2	Z2-3	Z2-3B	Z2-3C	Z2-4	Z2-5	Z2-6
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	4	0	1	2	3
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	4	0	0	0	0	0	0	21	28	26	9	11	2	8
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	3	0	10	0	4	0	0	0	0	0	0	3	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	7	0	10	0	5	0	0	31	55	71	14	23	5	23

FORMATION	WATTS BWATTS BIGHT FORMATION									
DISTANCE (m) ABOVE THE BASE	55.3	58.8	61.3	61.6	62.4	63.1	63.3	64.4	65.1	67.8
SPECIES/SAMPLE	Z2-7	Z2-8	Z2-8B	Z2-9	Z2-9B	Z2-9B1	Z2-9B2	Z2-9C	Z2-10	Z2-11
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	1	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	1	0	0	0	0	1	0
Clavohamulus sphearicus*	0	0	5	0	0	2	0	2	0	0
Cordylodus angulatus	0	0	0	0	0	1	0	0	0	2
Cordylodus intermedius	0	2	0	4	5	0	0	3	0	1
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	2	0	1	3	4	0	11	6
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	14	0
Glyptodontus expansus*	0	0	0	7	0	2	1	3	0	0
Glyptodontus tumidus*	0	4	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	1	1	1	1	3	0	0	4	0
Loxodus latibasis*	0	0	0	0	0	2	0	0	0	0
Loxognathus phyllodus*	0	0	1	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0

FORMATION	WATTS BIGHT FORMATION									
DISTANCE (m) ABOVE THE BASE	55.3	58.8	61.3	61.6	62.4	63.1	63.3	64.4	65.1	67.8
SPECIES/SAMPLE	Z2-7	Z2-8	Z2-8B	Z2-9	Z2-9B	Z2-9B1	Z2-9B2	Z2-9C	Z2-10	Z2-11
Polycostatus falsioneotensis*	17	31	24	28	11	14	15	48	88	85
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	4	3	3	0	0	0	0	6	6
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	4	5	4	0	0	0	0	3	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	1	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	3	20	11	19	14	15	0	11	0	13
Tricostatus glyptus*	0	0	0	0	0	5	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	3	0	5	2	11	6	8	3	3	6
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0
TOTAL	27	67	56	65	44	53	28	73	128	119

FORMATION		FORMATION			WATTS BIWATTS BIGHT FURMATION				I		
DISTANCE (m) ABOVE THE BASE	72.3	74.3	76.3	78.1	80.8	83.8	88.8	91.1	94.5	95	96.5
SPECIES/SAMPLE	Z2-12	Z2-13	Z2-14	Z2-15	Z2-16	Z2-17	Z2-18	Z2-19	Z2-20	Z2-21	Z2-21B
Acanthodus lineatus	0	0	0	0	0	0	0	0	5	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	7	40	85
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	1	1	0	20	3
Clavohamulus longicuspis*	0	5	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	1	1	0	1	0	0	0	0	0	5
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	1	4	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus con[illegible]ctus*	0	0	3	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	1	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	2	0	0	0	0	0	0	0	10	30
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	8	10
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	WATTS BIGHT FORMATION										
DISTANCE (m) ABOVE THE BASE	72.3	74.3	76.3	78.1	80.8	83.8	88.8	91.1	94.5	95	96.5
SPECIES/SAMPLE	Z2-12	Z2-13	Z2-14	Z2-15	Z2-16	Z2-17	Z2-18	Z2-19	Z2-20	Z2-21	Z2-21B
Polycostatus falsioneotensis*	1	3	0	0	1	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	30
Polycostatus sulcatus	0	0	0	0	0	0	0	0	15	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimu	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	1	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	3	0	1	2	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	11	7	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	7	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	13	150	285
Variabiloconus bassleri	0	9	6	4	0	2	0	0	35	25	25
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	155	275
TOTAL	1	34	24	6	4	3	2	5	75	408	748

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	98	100.5	103.8	107	109.3	113.1	117.3	118.3	123.3	126.3	129.8
SPECIES/SAMPLE	Z2-22	Z2-23	Z2-24	Z2-25	Z2-26	Z2-27	Z2-28	Z2-29	Z2-30	Z2-31	Z2-32
Acanthodus lineatus	0	15	25	0	0	0	0	30	0	0	3
Acanthodus uncinatus	0	15	20	10	18	9	13	145	2	7	5
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	4	0	0	3	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	50	7	0	8
Clavohamulus n.sp.	0	0	0	0	0	0	13	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	2	0	0	0	0	1	0	1	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	1	0	0	0	0	0	0	13	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	12	4	0	5	1	5	1	3	0	3
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	98	100.5	103.8	107	109.3	113.1	117.3	118.3	123.3	126.3	129.8
SPECIES/SAMPLE	Z2-22	Z2-23	Z2-24	Z2-25	Z2-26	Z2-27	Z2-28	Z2-29	Z2-30	Z2-31	Z2-32
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	8	0	0	2
Polycostatus sulcatus	7	40	35	15	16	0	18	28	9	2	6
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	25	7	4	0	0	38	3	1	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	2	45	80	15	20	5	5	25	5	3	11
Variabiloconus bassleri	4	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	55	80	22	14	10	14	44	15	7	24
TOTAL	14	182	271	73	77	25	71	383	44	21	62

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	135.5	140.3	142.7	142.8	145.4	145.7	146.1	149.2	149.4	149.8	150.4
SPECIES/SAMPLE	Z2-33	Z2-34	Z2-35	Z2-35A	Z2-35B	Z2-35C	Z2-36	Z2-36B	Z2-36C	Z2-36D	Z2-37
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	5	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	1	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	53	45	0	0	3	10	0	0	40
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	53	50	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	5	15	0	2	15
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	25	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	2	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	4
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	135.5	140.3	142.7	142.8	145.4	145.7	146.1	149.2	149.4	149.8	150.4
SPECIES/SAMPLE	Z2-33	Z2-34	Z2-35	Z2-35A	Z2-35B	Z2-35C	Z2-36	Z2-36B	Z2-36C	Z2-36D	Z2-37
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	2	1	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	51	55	0	0	5	10	0	3	128
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	3	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	7	0	0	0	0	0	0	0	0	0	0
TOTAL	20	1	157	150	0	0	13	60	0	5	187

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	151.7	152.4	153.5	155.1	158.6	161.1	163.1	166.8	167.7	172.1	174.8
SPECIES/SAMPLE	Z2-37B	Z2-38	Z2-39	Z2-40	Z2-41	Z2-42	Z2-43	Z2-44	Z2-44B	Z2-45	Z2-46
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	[illegible]	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	16	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	47	0
Drepanodus nowlani*	56	35	40	24	20	6	69	100	80	32	18
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	170	78	2	15	40	0	0	55	50	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	10	14	0	20	0	5	48	0	5	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	3	5	2	2	0	0	5	0	1	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	151.7	152.4	153.5	155.1	158.6	161.1	163.1	166.8	167.7	172.1	174.8
SPECIES/SAMPLE	Z2-37B	Z2-38	Z2-39	Z2-40	Z2-41	Z2-42	Z2-43	Z2-44	Z2 44B	Z2-45	Z2-46
Polycostatus falsioneotensic*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	10	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	48	103	60	74	35	7	62	55	60	60	71
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	284	233	117	135	97	18	179	215	195	156	89

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	176.1	177.6	182.6	184.6	186.2	187.4	188.6	189.7	191.2	194.6	198.3
SPECIES/SAMPLE	Z2-46B	Z2-47	Z2-48	Z2-49	Z2-50	Z2-50B	Z2-51	Z2-51B	Z2-52	Z2-53	Z2-54
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	22	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	10	15	0	15	0	0	0	0	0	0
Drepanodus nowlani*	105	130	30	30	35	3	5	18	33	38	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	16	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	5	0	0	22	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	2	0	0	0	15	0	0	1	13	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	176.1	177.6	182.6	184.6	186.2	187.4	188.6	189.7	191.2	194.6	198.3
SPECIES/SAMPLE	Z2-46B	Z2-47	Z2-48	Z2-49	Z2-50	Z2-50B	Z2-51	Z2-51B	Z2-52	Z2-53	Z2-54
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	245	225	45	55	140	17	15	45	70	80	6
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	2	0	0	0	16	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	379	365	90	107	207	36	20	64	132	118	6

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	200.7	205.3	207.2	210.6	214.6	219.7	221.9	225.8	228.8	230.6	238.5
SPECIES/SAMPLE	22-55	22-56	22-57	22-58	22-59	22-60	22-61	22-62	22-63	22-64	22-65
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	2	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	5	225
Drepanodus nowlani*	2	9	3	0	0	6	7	12	3	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	3	0	5	0	0	5	2	2	0	20	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	5	0	1	0	0	0	1	0	0	0	0
Glyp[illegible]tus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	2	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	6	3	0	0	0	0	0	12	0	0	0
Macerodus gracilis*	2	0	0	0	0	0	0	1	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	200.7	205.3	207.2	210.6	214.6	219.7	221.9	225.8	228.0	230.6	238.5
SPECIES/SAMPLE	Z2-55	Z2-56	Z2-57	Z2-58	Z2-59	Z2-60	Z2-61	Z2-62	Z2-63	Z2-64	Z2-65
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	130
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus cariae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	1	0	0	0	0	0	0
Striatodontus prolificus*	17	25	12	0	4	28	25	35	16	32	145
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	1	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	36	37	21	0	5	39	35	62	19	61	500

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	238.8	239.6	242.5	244.9	246.1	247.1	248.6	250.1	250.9	252.3	253.5
SPECIES/SAMPLE	Z2-65B	Z2-66	Z2-67	Z2-67B	Z2-68	Z2-68B	Z2-69	Z2-70	Z2-70B	Z2-71	Z2-71B
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	10	32	0	11
Acodus delicatus	0	0	62	6	15	0	3	25	0	0	0
Acodus lanceolatus	0	0	0	0	7	34	0	0	20	22	5
Acodus primus*	0	70	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavoh[illegible]us n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	2	3	4	0	0
Cristodus loxoides	0	0	0	0	2	4	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	35	27	15	0	17	37	7
Drepanodus concavus	10	10	32	7	11	45	55	35	30	48	10
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	2	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	20
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	75	57	20	58	170	105	62	100	225	37
Glyptoconus triplicatus	10	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllo[illegible]s*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	238.8	239.6	242.5	244.9	246.1	247.1	248.6	250.1	250.9	252.3	253.5
SPECIES/SAMPLE	Z2-65B	Z2-66	Z2-67	Z2-67B	Z2-68	Z2-68B	Z2-69	Z2-70	Z2-70B	Z2-71	Z2-71B
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	21	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	2	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	1	0	0	16	28	45	70	16
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	3	2	10	14	3	2	0	50	1
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	41	155	154	36	138	296	199	165	250	452	107

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	254.1	255.6	256.2	257.3	258.3	260.3	262.7	263.3	263.9	264.6	266.6
SPECIES/SAMPLE	Z2-72	Z2-73	Z2-73B	Z2-74	Z2-75	Z2-76	Z2-76B	Z2-77	Z2-77A	Z2-77B	Z2-78
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	18	55	0	2	0	0	73	130	10	28	40
Acodus delicatus	0	240	195	10	22	95	0	0	0	0	0
Acodus lonceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	3	0	5	0	0	6	0	5	0	0	0
Cristodus loxoides	0	0	0	0	0	0	6	10	0	0	0
Drepanodus arcuatus	18	0	18	15	23	37	30	35	3	6	17
Drepanodus concavus	13	0	17	7	65	35	35	300	10	25	55
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	5	4	0	30	0	22	0	38	45
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0		0	0	0	0	0	0
Glyptoconus multiplicatus*	20	16	65	20	70	52	53	160	0	49	68
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	68	73	230	59	190	158	76	370	15	105	100
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	254.1	255.6	256.2	257.3	258.3	260.3	262.7	263.3	263.9	264.6	266.6
SPECIES/SAMPLE	Z2-72	Z2-73	Z2-73B	Z2-74	Z2-75	Z2-76	Z2-76B	Z2-77	Z2-77A	Z2-77B	Z2-78
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissim_	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	2	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	13	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	4	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	7	15	7	50	45	20	130	5	40	30
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	157	391	550	124	420	458	295	1162	43	291	355

FORMATION	B.H.FM.						CATOCHE FORMATION				
DISTANCE (m) ABOVE THE BASE	267.5	268	269.3	271.8	274.3	275.3	278.5	279.8	284	287.8	290.4
SPECIES/SAMPLE	Z2-78A	Z2-78B	Z2-79	Z2-80	Z2-81	Z2-82	Z2-83	Z2-84	Z2-85	Z2-85B	Z2-86
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	110	65	115	0	0	5	145	6	63	74
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	4	0	0	0
Drepanodus arcuatus	0	60	57	0	0	0	0	55	2	16	135
Drepanodus concavus	3	25	45	4	4	16	4	85	0	37	55
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	68	37	5	2	13	0	37	0	23	9
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	127	58	19	0	12	14	87	0	53	56
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	13	188	81	52	10	3	0	47	14	0	59
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	50	0	3	23	450

FORMATION	B.H.FM.			|			CATOCHE FORMATION				
DISTANCE (m) ABOVE THE BASE	267.5	268	269.3	271.8	274.3	275.3	278.5	279.8	284	287.8	290.4
SPECIES/SAMPLE	Z2-78A	Z2-78B	Z2-79	Z2-80	Z2-81	Z2-82	Z2-83	Z2-84	Z2-85	Z2-85B	Z2-86
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	5	7
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	1	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	15	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	50	25	5	0	0	2	15	4	35	15
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	5	2
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	4	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	628	368	200	16	45	75	475	29	279	862

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	291	291.8	294.3	297.8	299.3	310.3	313.4	314.8	319.3	324.8	327.5
SPECIES/SAMPLE	Z2-86B	Z2-87	Z2-88	Z2-89	Z2-90	Z2-91	Z2-91B	Z2-92	Z2-93	Z2-94	Z2-94B
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	13	20	18	0	0	4	0	153	0	13	155
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	5	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	3
Drepanodus arcuatus	5	10	8	0	0	23	8	190	50	0	55
Drepanodus concavus	18	45	14	0	0	0	0	35	0	20	17
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	15	14	10	0	0	0	0	44	17	4	85
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	12	35	20	0	0	0	0	92	20	20	132
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	19	9	10	5	1	6	0	20	27	17	25
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	9	2	0	30	48	230	35	25	295

Oepikodus communis	0	0	9	2	0	30	48	230	35	25	295
FORMATION						CATOCHE FORMATION					
DISTANCE (m) ABOVE THE BASE	291	291.8	294.3	297.8	299.3	310.3	313.4	314.8	319.3	324.8	327.5
SPECIES/SAMPLE	Z2-86B	Z2-87	Z2-88	Z2-89	Z2-90	Z2-91	Z2-91B	Z2-92	Z2-93	Z2-94	Z2-94B
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	1	1	20	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	5	2	11	5	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	3	3	0	0	0	1	0	2	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	20	0	0	3
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	2	0	0	4	0	0	0	0	0
Striatodontus gracilis	0	0	0	2	1	0	0	36	15	4	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	[illegible]	0	0	0	0	0	0
Stultodontus costatus	5	0	10	3	0	0	0	42	10	6	50
Stultodontus ovatus*	0	0	0	0	0	0	4	55	4	0	0
Stultodontus pygmaeus*	2	0	0	0	0	0	0	9	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	92	136	101	12	2	74	63	959	188	109	820

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	328.4	331.8	335.3	340	345	350.8	354.8	363.8	365.3	371.8	389.3
SPECIES/SAMPLE	Z2-95	Z2-96	Z2-97	Z2-98	Z2-99	Z2-100	Z2-101	Z2-102	Z2-103	Z2-104	Z2-105
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	55	3	82	41	13	40	22	0	0	0	0
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	1	0	7	0	7	2	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	4	0	1	0	0	0	0	0
Drepanodus arcuatus	0	0	165	60	15	35	25	3	0	0	0
Drepanodus concavus	8	0	85	35	5	12	13	0	2	1	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	75	20	9	13	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	15	4	70	54	15	63	27	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	13	0	0	15	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	2	0	0	0	0
Oepikodus communis	55	6	230	170	60	95	10	0	0	0	0

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	328.4	331.8	335.3	340	345	350.8	354.8	363.8	365.3	371.8	389.3
SPECIES/SAMPLE	Z2-95	Z2-96	Z2-97	Z2-98	Z2-99	Z2-100	Z2-101	Z2-102	Z2-103	Z2-104	Z2-105
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	8	0	5	0	0	8	12	2	0	0	0
Protoprioniodus simplicissimus	0	0	0	11	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	5	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	3	0	0	2	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	8	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	20	1	20	25	5	25	8	0	2	0	0
Stultodontus ovatus*	15	0	7	35	8	4	3	1	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	189	15	747	477	138	305	124	6	4	1	0

FORMATION	CATOCHE FORMATION											
DISTANCE (m) ABOVE THE BASE	400.3	404	409.3	416.3	424	427.3	437.3	443.3	445.3	448.8	453.3	465.9
SPECIES/SAMPLE	Z2-106	Z2-107	Z2-108	Z2-109	Z2-110	Z2-111	Z2-112	Z2-113	Z2-114	Z2-115	Z2-116	Z2-117
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0	1
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	1	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	2	1	4	1
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0	0

FORMATION	CATOCHE FORMATION											
DISTANCE (m) ABOVE THE BASE	400.3	404	409.3	416.3	424	427.3	437.3	443.3	445.3	448.8	453.3	465.9
SPECIES/SAMPLE	Z2-106	Z2-107	Z2-108	Z2-109	Z2-110	Z2-111	Z2-112	Z2-113	Z2-114	Z2-115	Z2-116	Z2-117
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	1	0	0	2	1	4	2

FORMATION	C. FM.					AGUATHUNA FORMATION						
DISTANCE (m) ABOVE THE BASE	471.8	497.3	503.1	504.3	508.8	511.8	517.2	519.8	523.8	526.3	529.1	533.5
SPECIES/SAMPLE	Z2-118	Z2-119	Z2-120	Z2-121	Z2-122	Z2-123	Z2-124	Z2-125	Z2-126	Z2-127	Z2-128	Z2-129
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	12	6	2	0	1	1	0	0	14	0	19	4
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0	0
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	5	0	0	0	0
Drepanodus concavus	3	0	4	1	1	1	22	4	12	0	2	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	2	0	0	0	0
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	7	2	4	0	0	1	18	5	3	2	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	2	0	0	0
Oepikodus communis	0	1	0	0	0	0	7	0	2	0	2	0

FORMATION	C. FM.		AGUATHUNA FORMATION									
DISTANCE (m) ABOVE THE BASE	471.8	497.3	503.1	504.3	508.8	511.8	517.2	519.8	523.8	526.3	529.1	533.5
SPECIES/SAMPLE	Z2-118	Z2-119	Z2-120	Z2-121	Z2-122	Z2-123	Z2-124	Z2-125	Z2-126	Z2-127	Z2-128	Z2-129
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus cryptodens	0	0	3	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	1	0
Striatodontus gracilis	0	0	8	6	0	1	8	7	10	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus retractus*	0	0	0	0	0	0	12	0	5	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	3	0	7	2	0	0	0	2	2	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	25	9	28	9	2	4	67	25	50	2	24	4

FORMATION	AGUATHUNA FORMATION											
DISTANCE (m) ABOVE THE B\SE	536.3	540.4	543.7	544.4	548.7	550.8	555.8	558.4	560.3	563.2	564.4	
SPECIES/SAMPLE	Z2-130	Z2-131	Z2-132	Z2-133	Z2-134	Z2-135	Z2-136	Z2-137	Z2-138	Z2-139	Z2-140	TOTAL
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	78
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	381
Acodus comptus	98	0	73	0	39	9	8	0	0	2	0	1913
Acodus delicatus	0	0	0	0	0	0	0	0	0	0	0	673
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0	110
Acodus primus*	0	0	0	0	0	0	0	0	0	0	0	70
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	33
Clavohamulus longicuspis*	0	0	0	0	0	0	0	0	0	0	0	5
Clavohamulus neoelongatus*	0	0	0	0	0	0	0	0	0	0	0	37
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	66
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0	13
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	2
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0	22
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0	16
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0	18
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0	3
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0	28
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0	34
Drepanodus arcuatus	0	0	30	0	0	0	0	1	0	0	0	1394
Drepanodus concavus	0	9	15	22	23	0	0	0	3	0	2	1884
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	1100
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	47
Glyptoconus bolites	0	0	0	0	0	0	0	0	0	0	0	103
Glyptoconus emarginatus	0	0	13	0	4	0	0	0	0	0	0	665
Glyptoconus felicitii*	0	0	0	0	0	0	0	0	0	0	0	37
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0	410
Glyptoconus multiplicatus*	0	0	40	5	28	0	1	0	0	1	3	1726
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	53
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0	2987
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	171
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0	17
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	16
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	4
Histiodella donnae	0	0	0	0	0	0	0	0	0	0	0	2
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0	12
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	89
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	20
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0	6
Macerodus crassatus*	0	0	0	0	0	0	0	0	0	0	0	23
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0	74
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0	3
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0	4
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0	4
Oepikodus communis	0	1	65	0	6	0	1	0	0	0	0	1911

FORMATION	AGUATHUNA FORMATION										
DISTANCE (m) ABOVE THE BASE	536.3	540.4	543.7	544.4	548.7	550.8	555.8	558.4	560.3	563.2	564.4	
SPECIES/SAMPLE	Z2-130	Z2-131	Z2-132	Z2-133	Z2-134	Z2-135	Z2-136	Z2-137	Z2-138	Z2-139	Z2-140	TOTAL
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0	376
Polycostatus minutus*	0	0	0	0	0	0	0	0	0	0	0	10
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	40
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	194
Protopanderodus inconstans	0	0	0	0	0	0	0	0	0	0	0	151
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0	69
Protoprioniodus simplicissimus	0	1	0	0	0	0	0	0	0	0	0	35
Pteracontiodus cryptodens	0	0	0	0	19	0	0	0	0	0	0	22
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	78
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0	23
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0	14
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0	28
Scolopodus subrex*	0	0	0	0	0	0	0	0	0	0	0	189
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0	125
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0	12
Striatodontus gracilis	0	16	0	2	0	0	0	0	2	0	12	153
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	1
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	2169
Striatodontus retractus*	0	0	40	2	1	0	0	1	0	0	0	61
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0	23
Stultodontus costatus	0	0	30	0	0	0	0	2	0	1	0	866
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0	143
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0	15
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0	7
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0	20
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0	124
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	12
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	667
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0	158
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	722
TOTAL	98	27	306	31	120	9	10	4	5	4	17	22771

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	.1	3.3	6	8.6	12	15.5	18.5	21	23	24.8	27.7
SPECIES/SAMPLE	Z3-1	Z3-2	Z3-3	Z3-4	Z3-5	Z3-6	Z3-7	Z3-8	Z3-9	Z3-10	Z3-11
Acodus comptus	4	0	0	2	0	28	8	2	36	2	50
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	10
Glyptoconus multiplicatus*	0	0	0	0	4	13	5	3	3	4	3
Pteracontiodus cryptodens	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	1	0	0	0	8	2	2	1	0	0
Striatodontus retractus*	0	0	0	0	0	3	0	0	0	0	3
Stultodontus costatus	0	0	0	0	0	0	0	0	0	1	0
TOTAL	4	1	0	2	4	52	15	7	40	7	66

FORMATION	AGUATHUNA FORMATION									T.H.FM.		
DISTANCE (m) ABOVE THE BASE	29.3	34.2	36.8	41	47	51.4	56.6	60	64.6	67.6	71.5	
SPECIES/SAMPLE	Z3-12	Z3-13	Z3-14	Z3-15	Z3-16	Z3-17	Z3-18	Z3-19	Z3-20	Z3-21	Z3-22	TOTAL
Acodus comptus	0	1	2	0	2	0	15	19	1	0	0	172
Drepanodus concavus	0	0	7	0	2	0	0	3	2	4	0	28
Glyptoconus multiplicatus*	0	1	2	0	1	1	1	2	1	4	1	49
Pteracontiodus cryptodens	0	0	0	0	3	2	1	0	0	0	0	6
Striatodontus gracilis	0	2	4	0	0	0	0	0	0	0	0	20
Striatodontus retractus*	0	0	0	0	0	0	0	0	0	0	0	6
Stultodontus costatus	0	0	0	0	0	0	0	0	1	2	2	6
TOTAL	0	4	15	0	8	3	17	24	5	10	3	287

FORMATION	BERRY HEAD FM.					WATTS BIGHT FORMATION							
DISTANCE (m) ABOVE THE BASE	.4	3	9.4	18.5	22	26.5	30.5	35	40.7	44.5	45	48	51.2
SPECIES/SAMPLE	Z4-1	Z4-2	Z4-3	Z4-4	Z4-5	Z4-6	Z4-7	Z4-8	Z4-9A	Z4-9B	Z4-10	Z4-11	Z4-12
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphaericus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	2	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	3	2	0	0	0	0	3
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	2	3	2	0	0	0	0	3

FORMATION	WATTS BIGHT FORMATION											
DISTANCE (m) ABOVE THE BASE	56.5	60.5	62	63.5	68.4	68.5	71	73	75.4	79.4	80.5	83.4
SPECIES/SAMPLE	Z4-13	Z4-14	Z4-14B	Z4-15	Z4-15B	Z4-16	Z4-16B	Z4-17	Z4-18	Z4-18B	Z4-18C	Z4-19
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0	2
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphaericus*	0	0	0	1	0	0	0	0	0	0	0	0
Clavohamulus sp. A	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	7	0	1	0	0	1	6	0
Cordylodus intermedius	0	0	3	4	0	0	0	1	1	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	3	0	0	0	2	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	2	0	0	0	3
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0	15
Glyptodontus tumidus*	0	0	0	0	12	0	9	0	0	12	10	6
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	1	0	2	5	0	0	7
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus falsioneotensis*	3	4	0	6	35	8	17	3	17	22	17	52
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	2	2
Semiacontiodus nogamii	0	0	3	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	0	0	0	0	0	6	20	0	30	0	35	0
Teridontus nakamurai	0	7	7	9	0	0	0	0	0	0	0	0
Teridontus obesus*	12	0	0	0	19	8	6	14	24	7	53	31
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	7	2	33	14	64	21	115	70
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	15	11	13	20	83	25	86	36	143	63	238	188

FORMATION					BOAT HARBOUR FORMATION						BOAT
DISTANCE (m) ABOVE THE BASE	86	89.3	94.1	100.3	102	106.2	107.9	110.6	116.5	119	120.2	123.
SPECIES/SAMPLE	Z4-19B	Z4-20	Z4-20B	Z4-20C	Z4-23	Z4-24	Z4-25	Z4-26	Z4-27	Z4-28	Z4-28B	Z4-29
Acanthodus lineatus	2	0	0	0	0	0	0	40	8	10	25	0
Acanthodus uncinatus	0	0	0	0	0	2	15	60	23	20	10	0
Clavohamulus densus	2	16	0	0	0	0	2	6	4	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	0	5	0	4	0	0
Clavohamulus reniformis*	0	0	0	0	0	0	0	0	0	0	0	1
Clavohamulus sphaericus*	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. A	0	4	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	2	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	1	1	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	4	7	1	0	0	0	11	6	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	4	0	0	0	0	0	0	0	0	3	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	10	8	6	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	12	9	0	0	0	0	0	0	0	0	0
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	2	0	0	0	0	0	0	0
Loxodus bransoni	0	16	0	0	2	3	0	5	0	25	5	0
Loxodus latibasis*	0	0	0	0	0	0	0	15	2	10	0	0
Polycostatus falsioneotensis*	0	12	0	0	7	13	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	16	35	10	0	10	0
Polycostatus sulcatus	0	0	0	0	0	0	20	45	10	17	28	0
Rossodus manitouensis	0	0	0	0	0	21	45	55	40	65	13	0
Rossodus tenuis	0	9	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracillimus	7	0	15	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	37	29	0	8	0	0	0	0	0	0	0
Tricostatus glyptus*	4	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	45	55	5	65	12	0
Variabiloconus bassleri	13	135	130	19	16	30	0	10	0	55	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	65	50	0	70	13	0
TOTAL	39	260	196	20	35	69	208	392	108	341	119	1

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	126.	128	128.6	130.4	134.1	137.5	139.8	143.4	151	154	
SPECIES/SAMPLE	Z4-30	Z4-31	Z4-31B	Z4-32	Z4-33	Z4-34	Z4-35	Z4-36	Z4-36B	Z4-37	TOTAL
Acanthodus lineatus	10	20	50	95	0	0	0	0	0	0	262
Acanthodus uncinatus	20	42	65	65	15	8	2	10	0	0	357
Clavohamulus densus	2	0	5	0	0	0	0	0	0	0	37
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0	9
Clavohamulus reniformis*	0	80	25	205	17	1	0	0	0	0	329
Clavohamulus sphaericus*	0	0	0	0	0	0	0	0	0	0	1
Clavohamulus sp. A	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. B	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	2
Cordylodus angulatus	1	12	21	32	0	0	0	0	0	0	110
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	9
Drepanodus nowlani*	0	0	0	0	0	0	0	0	30	85	115
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	12
Glyptoconus priscus*	0	0	0	0	0	0	0	0	5	8	13
Glyptoconus triplicatus	0	0	0	0	0	0	0	0	60	165	225
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	29
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	36
Glyptodontus tumidus*	0	0	0	0	0	0	0	0	0	0	49
Juanognathus sp.	0	0	0	0	0	0	0	0	23	0	23
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	2
Loxodus bransoni	5	0	5	5	0	0	0	0	0	0	86
Loxodus latibasis*	3	3	5	5	0	0	0	0	0	0	43
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	216
Polycostatus oneotensis	6	10	55	95	0	5	0	0	0	0	242
Polycostatus sulcatus	0	16	0	85	0	0	0	0	0	0	221
Rossodus manitouensis	0	12	10	75	14	3	0	25	0	0	378
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	13
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	5
Striatodontus prolificus*	0	0	0	0	0	0	0	88	120	90	298
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	113
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	31
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	248
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	4
Utahconus longipinnatus*	42	40	135	85	15	11	0	0	0	0	510
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	734
Variabiloconus neobassleri*	52	35	95	90	20	20	0	0	0	0	510
TOTAL	141	270	471	837	81	48	2	123	238	348	5272

FORMATION	WATTS BIGHT FORMATION												
DISTANCE (m) ABOVE THE BASE	5	6.7	9.2	11.8	15	17.5	19	22.5	24.5	27.5	29.5	35.5	
SPECIES/SAMPLE	Z5-1	Z5-2	Z5-3	Z5-4	Z5-5	Z5-6	Z5-7	Z5-8	Z5-9	Z5-10	Z5-11	Z5-12	TOTAL
Clavohamulus neoelongatus*	0	0	3	0	0	0	0	0	0	0	0	0	3
Clavohamulus sphearicus*	0	0	0	0	0	10	0	3	0	0	3	0	16
Clavohamulus sp.	1	0	0	0	0	0	0	0	0	0	0	2	3
Cordylodus angulatus	0	0	0	0	0	3	0	2	0	0	0	0	5
Cordylodus intermedius	1	0	6	0	0	3	3	12	0	1	4	4	34
Cordylodus lindstromi	0	0	0	1	0	0	0	0	0	0	0	0	1
Drepanodus pervetus	0	0	0	3	3	4	0	8	0	0	7	0	25
Glyptodontus constrictus*	0	0	0	0	0	4	0	4	0	0	5	0	13
Glyptodontus expansus*	0	0	1	2	0	4	0	0	0	0	0	0	7
Glyptodontus tumidus*	0	0	0	0	0	7	0	3	0	0	0	5	15
Loxodentatus bipinnatus*	0	0	0	0	1	0	0	2	0	0	0	0	3
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0	1	1
Loxognathus phyllodus*	1	0	0	0	0	0	0	0	0	0	0	0	1
Polycostatus falsioneotensis*	2	2	3	4	0	13	8	22	2	0	7	13	76
Semiacontiodus nogamii	1	5	12	7	0	9	10	0	5	6	0	0	55
Teridontus gracillimus	0	0	0	0	0	0	3	25	0	0	0	0	28
Teridontus nakamurai	0	0	0	0	7	18	0	0	0	0	0	0	25
Teridontus obesus*	0	0	0	0	0	40	0	21	0	0	15	7	83
Utahconus cf. utahensis	0	0	3	2	0	0	0	0	0	0	0	0	5
Variabiloconus bassleri	0	0	0	0	0	21	0	37	0	8	13	6	85
TOTAL	6	7	28	19	11	136	24	139	7	15	54	38	484

FORMATION					WATTS BIGHT FORMATION						|B.H.FM
DISTANCE (m) ABOVE THE BASE	3	6.8	8.5	11.6	13.8	15.3	17.2	19	20.3	23.4	25.3
SPECIES/SAMPLE	Z6-1	Z6-2	Z6-3	Z6-4	Z6-5	Z6-5B	Z6-6	Z6-6B	Z6-7	Z6-8	Z6-9
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	2	0	31	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	1	0	2	0	0
Clavohamulus n. sp.	0	0	0	0	2	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	1
Clavohamulus sphearicus*	0	0	0	0	0	0	0	8	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	3	0
Cordylodus intermedius	3	0	1	8	5	11	6	5	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus concavus	0	0	0	0	0	0	0	0	0	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	2	11	0	7	5	6	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	19	0	0	18	6	0	0
Glyptodontus expansus*	0	0	0	0	2	9	4	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	3	0	0	0	5
Loxodentatus bipinnatus*	0	0	0	0	0	0	9	0	0	0	14
Loxodus bransoni	0	0	0	1	15	5	3	2	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	WATTS BIGHT FORMATION										
DISTANCE (m) ABOVE THE BASE	3	6.8	8.5	11.6	13.8	15.3	17.2	19	20.3	23.4	25.3
SPECIES/SAMPLE	Z6-1	Z6-2	Z6-3	Z6-4	Z6-5	Z6-5B	Z6-6	Z6-6B	Z6-7	Z6-8	Z6-9
Polycostatus falsioneotensis*	8	10	12	19	50	55	33	5	105	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sp.	0	0	0	0	40	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	5	0	16	0	0	3	7	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	3	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	3	0	0	3	0	0	0	0	0	0	0
Teridontus obesus*	0	0	6	0	32	12	32	43	41	27	4
Tricostatus glyptus*	0	0	0	0	13	0	9	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	3	0	2	32	75	48	69	25	21	35
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	16	24	35	237	167	155	160	192	82	59

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	27.2	28.8	32.5	42	48.4	53	63	70.2	72.4	75	78
SPECIES/SAMPLE	Z6-10	Z6-10B	Z6-11	Z6-12	Z6-13	Z6-14	Z6-15	Z6-16	Z6-17	Z6-18	Z6-19
Acanthodus lineatus	0	35	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	63	31	25	10	1	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	0	0	0	0
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	3	12	0	0	0	0	0	0	0	0
Clavohamulus hintzei	5	0	0	0	0	0	0	0	0	0	0
Clavohamulus n. sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	1	3	1	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	22	0	12	0
Drepanodus concavus	0	0	0	0	0	0	0	20	0	0	0
Drepanodus nowlani*	0	0	0	0	0	37	20	45	42	47	230
Drepanodus pervetus	35	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus floweri	0	0	0	0	1	1	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus priscus*	0	0	0	0	0	4	75	0	55	5	15
Glyptoconus quadraplicatus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	2	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	6	0	1	0	40	0	40	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	3	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	0

FORMATION	BOAT HARBOUR FORMATION										
DISTANCE (m) ABOVE THE BASE	27.2	28.8	32.5	42	48.4	53	63	70.2	72.4	75	78
SPECIES/SAMPLE	Z6-10	Z6-10B	Z6-11	Z6-12	Z6-13	Z6-14	Z6-15	Z6-16	Z6-17	Z6-18	Z6-19
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	22	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	40	31	34	0	0	0	0	0	0	0	0
Polycostatus sp.	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	42	44	32	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	6	0	0	0
Striatodontus prolificus*	0	0	0	6	5	50	70	92	72	115	280
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	0
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	181	45	52	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	21	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	135	65	35	0	0	0	0	0	0	0	0
TOTAL	524	257	214	22	7	93	165	225	169	222	525

FORMATION	BOAT HARBOUR FM									
DISTANCE (m) ABOVE THE BASE	84	89	91.3	94.5	96	98.8	104.3	107.2	108.4	114.2
SPECIES/SAMPLE	Z6-20	Z6-21	Z6-22	Z6-23	Z6-24	Z6-25	Z6-26	Z6-27	Z6-28	Z6-29
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0
Acodus comptus	0	0	0	0	0	0	0	139	25	6
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0
Clavohamulus n. sp.	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	0	0	40	6	14
Drepanodus concavus	0	0	0	0	0	0	30	115	45	6
Drepanodus nowlani*	15	3	0	0	9	1	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	0	0	0	0	0	0	0	23	5	1
Glyptoconus floweri	33	0	0	4	0	0	0	0	0	0
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	46	13	13
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	0	0	0	0	0	0	59	175	10	12
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	1	1	0	4	1	1	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	0	0	0	0	0	0	0	0	0	7

FORMATION	BOAT HARBOUR FM									
DISTANCE (m) ABOVE THE BASE	84	89	91.3	94.5	96	98.8	104.3	107.2	108.4	114.2
SPECIES/SAMPLE	Z6-20	Z6-21	Z6-22	Z6-23	Z6-24	Z6-25	Z6-26	Z6-27	Z6-28	Z6-29
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0
Polycostatus sp.	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	0	0	0	0	0	0	0	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	0	0	0	0	0	0	0	0	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0
Striatodontus gracilis	0	0	0	0	0	0	0	0	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	33	6	4	5	60	1	0	0	0	0
Striatodontus teridontus*	0	0	0	0	2	0	0	0	0	0
Stultodontus costatus	0	0	0	0	0	0	15	25	7	1
Stultodontus ovatus*	0	0	0	0	0	0	0	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0
TOTAL	82	10	4	13	72	3	104	563	111	60

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	124.	127	129.5	131.5	133.5	135.7	136.7	139.5	140.5	144	145.8
SPECIES/SAMPLE	Z6-30	Z6-31	Z6-32	Z6-33	Z6-34	Z6-34B	Z6-35	Z6-35B	Z6-36	Z6-37	Z6-38
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Acodus comptus	72	1	0	0	0	52	52	0	32	0	6
Acodus lanceolatus	0	0	0	0	0	4	8	0	4	0	0
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n. sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cristodus ethingtoni*	4	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	2	0	0	0	0	3	0	0	0	0	0
Drepanodus arcuatus	14	1	0	3	0	30	35	22	20	1	8
Drepanodus concavus	38	0	1	1	0	30	38	10	12	0	0
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	0
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus emarginatus	6	0	2	0	3	17	20	12	12	0	13
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus multiplicatus*	40	0	4	0	2	25	36	7	10	1	17
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	0
Glyptoconus quadraplicatus	7	2	3	3	5	20	0	12	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	0
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	0
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	0
Microzarkodina marathonensis	0	0	0	0	0	0	0	0	0	0	0
Oepikodus communis	15	2	0	1	2	26	68	7	20	0	20

FORMATION					CATOCHE FORMATION						
DISTANCE (m) ABOVE THE BASE	124.	127	129.5	131.5	133.5	135.7	136.7	139.5	140.5	144	145.8
SPECIES/SAMPLE	Z6-30	Z6-31	Z6-32	Z6-33	Z6-34	Z6-34B	Z6-35	Z6-35B	Z6-36	Z6-37	Z6-38
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	0
Polycostatus sp.	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus prolatus*	0	0	3	0	0	9	2	0	13	1	0
Protoprioniodus simplicissimus	0	0	0	0	0	0	10	0	0	0	0
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	0
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	0
Scolopodus cornutiformis	1	0	0	0	3	0	0	0	15	0	0
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	0
Striatodontus carlae	0	0	0	0	0	0	0	2	0	0	0
Striatodontus gracilis	0	4	0	0	0	6	1	10	3	0	0
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	0
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	0
Stultodontus costatus	16	0	3	1	5	30	30	10	14	0	0
Stultodontus ovatus*	0	0	0	0	0	9	12	10	0	0	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	0
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	0
TOTAL	215	10	16	9	20	261	312	102	155	3	64

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	149	151	153	157.1	161.5	162.4	163.9	165	167	168.5	
SPECIES/SAMPLE	Z6-39	Z6-40	Z6-41	Z6-42	Z6-43	Z6-43B	Z6-44	Z6-44B	Z6-45	Z6-46	TOTAL
Acanthodus lineatus	0	0	0	0	0	0	0	0	0	0	35
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	163
Acodus comptus	32	9	17	1	17	75	96	50	65	61	808
Acodus lanceolatus	0	0	0	0	0	25	0	3	7	8	59
Clavohamulus densus	0	0	0	0	0	0	0	0	0	0	15
Clavohamulus hintzei	0	0	0	0	0	0	0	0	0	0	8
Clavohamulus n. sp.	0	0	0	0	0	0	0	0	0	0	2
Clavohamulus sp. C	0	0	0	0	0	0	0	0	0	0	1
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	0	0	8
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	3
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	44
Cristodus ethingtoni*	0	0	0	0	0	0	0	0	0	0	4
Cristodus loxoides	0	0	1	0	0	8	2	0	0	0	16
Drepanodus arcuatus	15	8	22	1	2	35	50	15	65	55	496
Drepanodus concavus	35	17	13	2	5	47	80	35	30	50	660
Drepanodus nowlani*	0	0	0	0	0	0	0	0	0	0	449
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	66
Glyptoconus emarginatus	7	7	25	0	7	103	111	57	105	78	614
Glyptoconus floweri	0	0	0	0	0	0	0	0	0	0	39
Glyptoconus multiplicatus*	45	36	79	2	6	88	117	183	116	87	973
Glyptoconus priscus*	0	0	0	0	0	0	0	0	0	0	154
Glyptoconus quadraplicatus	15	0	0	0	0	0	44	0	0	0	367
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	43
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	15
Juanognathus sp.	0	0	0	0	0	0	0	0	0	0	8
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	23
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	26
Loxodus latibasis*	0	0	0	0	0	0	0	0	0	0	2
Macerodus dianae	0	0	0	0	0	0	0	0	0	0	95
Macerodus gracilis*	0	0	0	0	0	0	0	0	0	0	3
Microzarkodina marathonensis	0	0	0	1	1	0	0	0	5	0	7
Oepikodus communis	25	10	65	0	16	30	250	13	95	111	783

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	149	151	153	157.1	161.5	162.4	163.9	165	167	168.5	
SPECIES/SAMPLE	Z6-39	Z6-40	Z6-41	Z6-42	Z6-43	Z6-43B	Z6-44	Z6-44B	Z6-45	Z6-46	TOTAL
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	297
Polycostatus oneotensis	0	0	0	0	0	0	0	0	0	0	22
Polycostatus sulcatus	0	0	0	0	0	0	0	0	0	0	105
Polycostatus sp.	0	0	0	0	0	0	0	0	0	0	40
Protopanderodus prolatus*	12	0	0	0	0	0	11	10	8	6	75
Protoprioniodus simplicissimus	13	2	13	0	4	0	4	0	14	4	64
Rossodus manitouensis	0	0	0	0	0	0	0	0	0	0	118
Rossodus tenuis	0	0	0	0	0	0	0	0	0	0	31
Scolopodus cornutiformis	0	5	0	0	0	31	9	8	7	5	84
Scolopodus parabruptus	0	2	0	0	0	0	0	0	9	0	11
Semiacontiodus nogamii	0	0	0	0	0	0	0	0	0	0	3
Striatodontus carlae	0	0	0	0	2	3	0	0	3	3	13
Striatodontus gracilis	6	0	0	0	1	12	0	0	14	6	63
Striatodontus lanceolatus*	0	0	0	0	0	0	0	0	0	0	6
Striatodontus prolificus*	0	0	0	0	0	0	0	0	0	0	799
Striatodontus teridontus*	0	0	0	0	0	0	0	0	0	0	2
Stultodontus costatus	30	1	2	2	10	45	35	40	35	30	387
Stultodontus ovatus*	0	0	9	0	0	0	0	45	12	15	112
Stultodontus pygmaeus*	0	0	0	0	0	0	0	9	0	2	11
Teridontus nakamurai	0	0	0	0	0	0	0	0	0	0	6
Teridontus obesus*	0		0	0	0	0	0	0	0	0	197
Tricostatus glyptus*	0	0	0	0	0	0	0	0	0	0	22
Utahconus longipinnatus*	0	0	0	0	0	0	0	0	0	0	278
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	331
Variabiloconus neobassleri*	0	0	0	0	0	0	0	0	0	0	235
TOTAL	235	97	246	9	71	502	809	468	590	521	9301

FORMATION	BERRY HEAD FORMATION										
DISTANCE (m) ABOVE THE BASE	-5	.3	2.3	4.5	5	6	6.8	7.8	9.4	10	10.7
SPECIES/SAMPLE	27-A	27-B	27-1	27-1A	27-1B	27-2	27-2B	27-2C	27-3	27-3B	27-3B1
Acanthodus uncinatus	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp.	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	0	0	0	0	0	0	15	0	0	0	34
Drepanodus pervetus	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus crasssatus*	0	0	0	0	0	0	0	0	0	0	0
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0
Polycostatus falsioneotensis*	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	0	0	0	0	77	85	9	0	8
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	0	0
Teridontus nakamurai	0	0	0	0	0	32	49	132	27	0	52
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricodus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus sp.	0	0	0	0	0	0	0	0	0	0	2
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	32	141	217	36	0	96

FORMATION	B. HEAD FM.		WATTS BIGHT FORMATION								
DISTANCE (m) ABOVE THE BASE	11.5	12.5	15.2	17.6	19	22.5	24.4	25.9	33.1	36	38
SPECIES/SAMPLE	Z7-3C	Z7-4	Z7-5	Z7-5A	Z7-5B	Z7-6	Z7-6A	Z7-7	Z7-8	Z7-9	Z7-9B
Acanthodus uncinatus	0	0	0	0	0	2	0	0	0	0	0
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus sp.	0	0	0	0	0	0	0	1	0	0	2
Cordylodus angulatus	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	0	0	0	0	0	1	2	1	8	0	4
Cordylodus lindstromi	1	1	0	0	4	0	0	0	0	0	0
Drepanodus pervetus	0	2	0	0	0	0	0	0	2	0	0
Glyptodontus constrictus*	0	0	0	0	0	0	0	0	0	0	0
Glyptodontus expansus*	0	0	0	0	0	0	0	0	0	0	0
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	0	0	0	0
Loxodus bransoni	0	0	0	0	0	0	0	0	0	0	0
Loxognathus phyllodus*	0	0	0	0	0	0	0	5	2	2	8
Macerodus crasssatus*	0	0	0	0	0	0	0	0	6	0	5
Macerodus wattsbightensis*	0	0	0	0	0	0	0	5	0	2	3
Polycostatus falsioneotensis*	0	0	0	0	8	0	0	9	16	8	17
Semiacontiodus nogamii	6	30	0	15	31	33	7	28	40	3	37
Teridontus gracillimus	0	0	0	0	0	0	0	0	0	8	0
Teridontus nakamurai	0	42	0	47	10	30	0	24	13	4	21
Teridontus obesus*	0	0	0	0	0	0	0	0	0	0	0
Tricodus glyptus*	0	0	0	0	0	0	0	0	0	0	0
Utahconus sp.	0	5	0	0	4	0	0	4	0	0	0
Variabiloconus bassleri	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7	80	0	62	57	66	9	77	87	27	97

FORMATION	WATTS BIGHT FORMATION											
DISTANCE (m) ABOVE THE BASE	42.2	45	48.2	51.3	54.1	56	56.5	60	61.5	64.7	69	
SPECIES/SAMPLE	27-10	27-11	27-12	27-13	27-13B	27-13C	27-14	27-15	27-15B	27-16	27-17	TOTAL
Acanthodus uncinatus	0	2	0	0	0	5	0	0	2	0	0	11
Clavohamulus n.sp.	0	0	0	0	6	0	4	0	0	2	0	12
Clavohamulus sp.	0	0	0	0	0	0	0	0	0	0	0	3
Cordylodus angulatus	0	0	0	0	11	3	2	13	5	6	0	40
Cordylodus intermedius	0	1	8	2	0	0	8	0	0	0	0	35
Cordylodus lindstromi	0	0	0	0	0	0	0	0	0	0	0	55
Drepanodus pervetus	0	0	5	0	3	1	3	0	0	0	7	23
Glyptodontus constrictus*	0	0	0	0	2	0	0	0	0	0	2	4
Glyptodontus expansus*	0	0	0	0	2	0	0	0	0	0	0	2
Loxodentatus bipinnatus*	0	0	0	0	0	0	0	3	0	0	1	4
Loxodus bransoni	0	0	0	0	1	0	0	0	1	1	1	4
Loxognathus phyllodus*	2	1	0	0	0	0	0	0	0	0	0	20
Macerodus crasssatus*	2	3	0	2	0	0	0	0	0	2	0	20
Macerodus wattsbightensis*	0	0	0	0	0	0	0	0	0	0	0	10
Polycostatus falsioneotensis*	5	4	6	12	33	26	20	21	33	27	7	252
Semiacontiodus nogamii	9	9	16	0	0	0	0	0	0	0	0	443
Teridontus gracillimus	0	0	0	25	17	12	14	10	17	6	5	114
Teridontus nakamurai	0	0	9	9	0	0	0	0	0	0	0	501
Teridontus obesus*	3	9	8	0	12	12	27	15	8	12	8	114
Tricodus glyptus*	0	0	0	0	2	0	5	0	9	0	0	16
Utahconus sp.	0	0	0	0	0	0	0	0	0	0	0	15
Variabiloconus bassleri	0	0	0	22	40	25	42	43	65	30	7	274
TOTAL	21	29	52	72	129	84	125	105	140	86	38	1972

FORMATION					BOAT HARBOUR FORMATION						
DISTANCE (m) ABOVE THE BASE	.2	3.3	4.9	9.4	13.4	18	21.3	23.8	25.8	28.4	
SPECIES/SAMPLE	Z8-1	Z8-2	Z8-3	Z8-4	Z8-5	Z8-6	Z8-7	Z8-8	Z8-9	Z8-10	TOTAL
Acanthodus uncinatus	0	2	2	0	0	0	0	0	0	0	4
Drepanodus arcuatus	0	0	0	0	12	55	0	0	0	14	81
Drepanodus concavus	0	0	0	0	0	32	0	0	0	27	59
Drepanodus nowlani*	10	48	9	5	105	75	32	80	60	55	479
Glyptoconus floweri	0	0	195	0	0	0	0	0	0	16	211
Glyptoconus triplicatus	22	0	0	0	0	0	0	0	0	0	22
Macerodus dianae	1	1	0	30	10	90	4	60	3	25	224
Macerodus gracilis*	0	0	0	3	0	2	0	2	2	2	11
Striatodontus lanceolatus*	0	0	0	0	0	53	4	0	0	2	59
Striatodontus prolificus*	55	82	90	34	90	205	55	192	147	170	1120
TOTAL	88	133	296	72	217	512	95	334	212	311	2270

FORMATION					WATTS BOAT HARBOUR FORMATION						
DISTANCE (m) ABOVE THE BASE	2	2.2	5.9	7	9.7	11.5	17.1	20.1	25	28.8	
SPECIES/SAMPLE	Z9-4	Z9-1A	Z9-1B	Z9-3	Z9-5	Z9-6	Z9-7	Z9-8	Z9-9	Z9-2	TOTAL
Acanthodus unicinatus	0	0	0	0	0	0	0	0	25	0	25
Clavohamulus n.sp.	0	0	0	0	0	0	0	0	2	0	2
Clavohamulus sphearicus*	0	0	0	0	0	0	0	0	6	0	6
Clavohamulus sp.	5	0	0	0	0	0	1	0	0	0	6
Cordylodus angulatus	29	0	0	0	0	1	6	2	8	4	50
Cordylodus intermedius	2	3	19	1	2	0	0	0	0	0	27
Drepanodus pervetus	13	9	9	1	2	0	0	0	13	0	47
Glyptodontus constrictus*	0	0	0	0	2	0	7	0	6	11	26
Glyptodontus expansus*	2	0	0	0	0	0	0	0	2	0	4
Glyptodontus tumidus*	0	0	0	0	5	2	0	0	0	0	7
Loxodentatus bipinnatus*	2	1	0	0	0	0	4	0	5	0	12
Loxodus bransoni	0	0	0	0	0	0	2	1	3	2	8
Loxodus latibasis*	0	0	0	0	0	0	0	2	4	0	6
Macerodus crasssatus*	4	0	0	0	2	0	0	0	0	0	6
Polycostatus falsioneotensis*	28	17	68	7	8	5	95	12	196	36	472
Rossodus tenuis	0	0	0	0	0	0	11	0	7	0	18
Semiacontiodus nogamii	10	10	75	13	0	0	0	0	0	0	108
Teridontus gracillimus	40	0	0	0	7	0	0	0	25	17	89
Teridontus nakamurai	8	0	0	0	0	0	0	0	0	0	8
Teridontus obesus*	27	32	18	12	14	5	52	0	73	58	291
Tricodus glyptus*	5	0	0	0	0	0	0	0	20	0	25
Variabiloconus bassleri	43	0	0	0	26	15	27	8	0	0	119
TOTAL	218	72	189	34	68	28	205	25	395	128	1362

FORMATION	CATOCHE FORMATION											
DISTANCE (m) ABOVE THE BASE	3.5	11.5	18.5	25.5	36	45.3	55.3	65.5	72	77.5	83.5	89.5
SPECIES/SAMPLE	Z10-A	Z10-B	Z10-C	Z10-D	Z10-E	Z10-F	Z10-G	Z10-1	Z10-2	Z10-3	Z10-4	Z10-5
Acodus comptus	20	15	2	0	21	21	0	16	14	12	8	2
Acodus lanceolatus	0	0	0	0	0	0	0	2	0	0	2	0
Bergstromgnathus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Cristodus loxoides	0	2	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	17	0	0	0	0	12	1	17	2	0	0	2
Drepanodus concavus	23	17	4	5	4	5	0	0	0	10	2	0
Glyptoconus emarginatus	34	11	2	0	0	0	0	13	0	9	0	0
Glyptoconus multiplicatus*	41	10	0	2	4	5	0	23	0	28	6	1
Oepikodus communis	13	15	0	2	9	40	0	55	0	10	7	0
Protopanderodus prolatus*	0	0	0	0	0	3	0	7	3	6	3	0
Protoprioniodus simplicissimus	0	5	0	0	0	17	1	0	0	0	0	3
Scolopodus cornitiformis	0	0	0	0	0	0	0	3	0	0	0	0
Scolopodus parabruptus	0	0	0	0	2	0	0	0	0	0	0	1
Striatodontus carlae	0	0	0	0	2	2	0	0	0	0	1	0
Striatodontus gracilis	0	5	1	2	6	5	0	8	3	0	5	0
Stultodontus costatus	15	10	2	1	7	4	0	7	0	4	6	0
Stultodontus ovatus*	7	10	0	0	6	0	0	11	0	2	2	0
Stultodontus pygmaeus*	0	0	0	0	0	0	0	5	0	0	0	0
TOTAL	170	100	11	12	61	114	2	167	22	81	42	9

FORMATION	CATOCHE FORMATION										
DISTANCE (m) ABOVE THE BASE	95	101.5	106.5	113.3	119.8	127.7	135.2	140	146	152	
SPECIES/SAMPLE	Z10-6	Z10-7	Z10-8	Z10-9	Z10-10	Z10-11	Z10-12	Z10-13	Z10-14	Z10-15	TOTAL
Acodus comptus	0	1	1	1	0	0	0	0	0	0	134
Acodus lanceolatus	0	0	0	0	0	0	0	0	0	0	4
Bergstromgnathus sp.	0	1	0	0	0	0	0	0	0	0	1
Cristodus loxoides	0	0	0	0	0	0	0	0	0	0	2
Drepanodus arcuatus	1	0	0	0	0	0	0	0	0	0	52
Drepanodus concavus	0	0	0	0	1	3	0	0	0	0	74
Glyptoconus emarginatus	0	0	0	0	0	0	0	0	0	0	69
Glyptoconus multiplicatus*	0	0	0	0	0	0	0	0	0	0	120
Oepikodus communis	0	0	0	0	0	0	0	0	0	0	151
Protopanderodus prolatus*	0	0	0	0	0	4	0	0	0	0	26
Protoprioniodus simplicissimus	0	0	0	0	0	0	0	0	0	0	26
Scolopodus cornitiformis	0	0	0	0	0	0	0	0	0	0	3
Scolopodus parabruptus	0	0	0	0	0	0	0	0	0	0	3
Striatodontus carlae	0	0	0	0	0	0	0	0	0	0	5
Striatodontus gracilis	0	0	2	0	0	0	0	0	0	0	37
Stultodontus costatus	0	0	0	0	0	0	0	0	0	0	56
Stultodontus ovatus*	0	0	0	1	1	0	0	0	0	0	40
Stultodontus pygmaeus*	0	0	0	0	0	0	0	0	0	0	5
TOTAL	1	2	3	2	2	7	0	0	0	0	808

APPENDIX B

Stratigraphic Sections of the St. George Group

Appendix B contains the description of logged stratigraphic sections with location of conodont samples. Section locations are shown on Figures 1:1 and 1:2. The lithologic descriptions are brief, generally referring to the beds from which the conodont samples were taken (see Appendix A, exact distance (m) above the section base).

10 sections are located by area in the following sequence:

Section 1:	East Isthmus Bay
Section 2:	West Isthmus Bay
Section 3:	Aguathuna Quarry
Section 4:	Jerrys Nose
Section 5:	Ship Cove
Section 6:	Pigeon Head
Section 7:	Lower Cove Highway Cut
Section 8:	Sheaves Cove Highway Cut
Section 9:	Sheaves Cove
Section 10:	Table Mountain

EAST ISTHMUS SECTION (SECTION 1)

The section is located about 1000 m at the southwest of Romaines, the shoreline of the east Isthmus Bay. The section starts the corner point of east Isthmus Bay, continues about 1 km northwestward along the shoreline, and terminates the end of the rocky coast.

Conodont sample	Thick-ness	Height above base	Description
			<u>BERRY HEAD FORMATION</u>
Z1-1	6.80	6.80	Dolostone, buff weathering, medium to thick, laminated, fine grained
Z1-2	8.40	15.20	Dolostone, red and buff, thin to medium, finely laminated, with stromatolites.
Z1-3 Z1-4	15.30	30.50	Dolostone, buff, medium to thick, laminated, with occasional shaly dolostone.

	2.00	32.50	Dolomitized breccias, red, thick bedded.
Z1-5 Z1-6	18.30	50.80	Dolostone, red and buff, thick bedded, with common breccias.
Z1-7 Z1-8 Z1-9	21.10	71.90	Dolostone, red, medium to thick, laminated, fine grained with common oolitic dolostone.
Z1-10 Z1-11 Z1-12 Z1-13	13.60	85.50	Dolostone, grey and buff weathering, medium bedded, with intraclast layers, and stromatolite and thrombolite beds.
Z1-14 Z1-15	9.50	95.00	Dolostone, buff, thin to medium bedded, laminated, burrowed or bioturbated, with common oolitic grainstone.
Z1-16	8.60	103.60	Dolomitized limestone, grey, medium bedded, with stromatolite mounds and trace fossils.
Z1-17 Z1-18 Z1-18B	13.20	116.80	Dolostone with intraclasts, grey, medium bedded, stromatolite mounds, commonly with dolomitized limestone.
Z1-19	5.00	121.80	Dolostone, grey, medium to thick bedded, with thin breccia layers.
Z1-20 Z1-20B Z1-21	7.00	128.80	Dolomitized limestone, dark grey, medium bedded, with chert and ooliti layers, and stromatolite and thrombolite mounds.
Z1-22	2.00	130.80	Oolitic limestone, dark grey, thick bedded.
Z1-23	9.60	140.40	Dolostone and dolomitized limestone, grey, medium to thick bedded, finely laminated.
Z1-24 Z1-25 Z1-26 Z1-27	17.10	157.50	Dolomitized limestone, grey, thick bedded, with medium stromatolite and thrombolite mounds, chert layers in the lower part. Thin bedded, finely laminated dolotone in the upper part, with trace fossils.

			WATTS BIGHT FORMATION
Z1-27B Z1-27C Z1-28	8.50	166.00	Limestone, dark grey medium to thick bedded, with stromatolite and thrombolite mounds, and some thin chert layers, the top of unit with erosion surface.
	1.20	167.20	Dolostone,finely laminated, with remarkble desiccation cracks.
Z1-29 Z1-30 Z1-31 Z1-32 Z1-33	38.80	206.00	Limestone, wackestone to grainstone, dark grey, thick bedded with massive thrombolite mounds complex, some chert layers, upper part extensively dolomitized.

WEST ISTHMUS BAY SECTION (SECTION 2)

The section is located at the shoreline of West Isthmus Bay. The section begins about 100 m west of Green Head, and continues about 3.0 km northeastward along the western shoreline of Isthmus Bay with minor covered interval in the Catoche Formation, and terminates near the northwest head of East Bay. All parts of the section are accessible and can be reached from numerous small trails that lead down from the highway along the southern shore of Port au Port Peninsula.

Conodont sample	Thick-ness	Height above base	Description
			BERRY HEAD FORMATION
Z2-A Z2-B	8.00	8.00	Dolostone, fine grainstone, buff weathering, medium bedded,laminated, bioturbated, some chert, the upper part with occasional dolomitized finely laminated and shaly limestone.
			WATTS BIGHT FORMATION
Z2-C Z2-D	9.00	17.00	Limestone, wackestone to grainstone, grey to dark grey, medium to thick

Z2-E Z2-F			bedded, bioturbated, some chert with erosive top.
	1.30	18.30	Dolostone, finely laminated, buff weathering, with desiccation cracks.
Z2-G Z2-1 Z2-2	15.20	33.50	Limestone, wackestone to grainstone, dark grey, massive thick bedded, mottled to poorly laminated, with some chert, small stromatolite and thrombolite mounds in lower and middle parts, upper part of the unit with a few massive mounds.
Z2-3 Z2-3B Z2-3C Z2-4 Z2-5	16.30	49.80	Limestone (at Green Head), the well known "Green Head mound complex"(a complex succession of fossiliferous thrombolite mounds and coarse grainstone intermound calcarenites), these are well described and illustrated by Pratt and James (1982, 1986), Knight and James (1987).
Z2-6 Z2-7 Z2-8	10.00	59.80	Dolomitized limestone, light grey, thick bedded, fine to coarse grainstone, with digitate thrombolite mounds.
Z2-8B Z2-9 Z2-9B Z2-9B1 Z2-9B2 Z2-9C Z2-10 Z2-11 Z2-12	12.50	72.30	Limestone to dolomitized limestone, wackestone to fine grainstone, dark grey to light grey, medium to thick bedded, three microcycles are present in the unit from bioturbated wackestone to laminated dolomitized grainstone (shallowing upwards) with abundant gastropods and trace fossils.
Z2-13 Z2-14 Z2-15 Z2-16	11.50	83.80	Limestone to dolomitized limestone, wackestone to fine grainstone, dark grey to light grey, with abundant burrows and gastropods in the lower part.
Z2-17 Z2-18 Z2-19	10.70	94.50	Limestone to dolomitized limestone, packstone to coarse grainstone, dark grey to buff weathering, thick bedded, lower part with some chert layers and thrombolite mounds, upper part with cross-bedded and silica mottled grainstone. A few

Z2-20			digitate thrombolite mounds occur in the uppermost part of unit.
			<u>BOAT HARBOUR FORMATION</u>
Z2-21 Z2-22 Z2-23 Z2-24	11.90	106.40	Two limestone to dolostone microcycles (at a boat cove), dark grey to light grey, thin bedded, laminated, extremely abundant brachiopods and gastropods within wackestone, packstone and grainstone, with sinuous to rhomboid ripples and mud-cracks.
Z2-25 Z2-26 Z2-27	10.80	117.20	Dolomitized limestone to dolostone, light grey to buff weathering, thin bedded, well laminated fine grainstone, with sinuous ripples, mud cracks and cross-bedding, with some beds containing abundant gastropods, brachiopods and also intraclasts and flat pebbles.
Z2-28 Z2-29 Z2-30 Z2-31 Z2-32	12.60	129.80	Two dolomitized limestone to dolostone microcycles, thinely interbedded lime grainstone and dolostone, with occasional cross-beddings; the lower part dolostone is light grey, vuggy and moldic.
Z2-33 Z2-34 Z2-35	8.50	138.30	Dolostone, light grey to buff weathering, thin to medium bedded, burrowed and bioturbated, three omission surfaces with silica lined vugs are present in upper part of the unit.
			<u>FAULT</u>: Strike approximately N-S, the western limb is upthrown, likely 3.0 m displacement.
Z2-35B1 Z2-35B2 Z2-35C Z2-36 Z2-36B Z2-36C Z2-36D Z2-37 Z2-37B Z2-38	20.10	158.40	Limestone to finely laminated dolostone, a conspicuous unit of interbedded lower relief stromatolite, digitate thrombolite and coarse grainstone, some chert, burrows and abundant gastropods and brachiopods; uppermost 3.0 m dolostone with fine laminations and desiccation cracks;three microcycles (shallowing upwards) are present in lower part of the unit; this unit is

Z2-39 Z2-40			well described and illustrated by Levesque (1977), Pratt and James (1982), and Knight and James (1987), and is easily correlated with the same unit of other sections.
Z2-41	2.40	160.80	Limestone to dolostone, grey to buff, thin bedded, well laminated; dolostone with desiccation cracks.
Z2-42 Z2-43 Z2-44 Z2-44B	10.40	171.20	Two limestone to dolostone microcy cles, wackestone to grainstone, dark grey to buff, stromatolite and thrombolite mounds, hardgrounds, chert layers and burrows are present in lower part' ɔth dolostone beds with finely laminations and desiccation cracks.
Z2-45 Z2-46 Z2-46B Z2-47 Z2-48	13.00	184.20	Four limestone to dolostone microcycles, the limestones are thinly interbedded wackestones, packstones and grainstones with burrows, cross-bedding and ripples, and/or with stromatolite and thrombolite mounds; the dolostones are finely laminated with desiccation cracks.
Z2-49 Z2-50 Z2-50B Z2-51 Z2-51B Z2-52 Z2-53 Z2-54	16.00	200.20	Four limestone to dolostone microcycles, light grey to buff, medium bedded; two lower limestone beds are fenestral mudstones to wackestone;both upper part limestone beds are wackestones with small, low relief stromatolite mounds and small digitate thrombolite mounds; four dolostone beds are well laminated with diesiccation cracks.
Z2-55 Z2-56 Z2-57 Z2-58 Z2-59 Z2-60 Z2-61	26.60	226.80	Four limestone to dolostone microcycles, dark to buff, medium bedded; limestones are wackstones to grainstones with samll stromatolite and thrombolite mounds, some chert layers, vugs and burrows; dolostones are laminated, with chert layers and vugs; the upper part of the unit is a clast and dolomite conglomerate with some flat pebbles, and is interpreted as a zone of paleo-exposure correlated with the Boat Harbour "pebble bed" (Fortey,

Z2-62			1984; Knight and James, 1987).
Z2-63	11.00	237.80	Two microcycles from limestone to dolostone, dark to light grey,
Z2-64 Z2-65			thick bedded; the limestones are wackstones to grainstones with some small stromatolite and thrombolite mounds, burrows and abundant gastropods; the dolostones are laminated with some chert nodules and vugs.
Z2-65B Z2-66 Z2-67 Z2-67B Z2-68 Z2-68B Z2-69 Z2-70 Z2-70B Z2-71 Z2-71B Z2-72 Z2-73 Z2-73B Z2-74	19.60	257.40	Limestone, mainly wackestones to packstones, but with interbedded mudstones, grainstones and rud stone; dark grey to light grey; the limestones are thin to medium bedded, rubbly to nodular, commonly fossiliferous, bioclastic and/or oolitic; most wackestones and packstones exhibit dolomitized burrows, small stromatolite and thrombolite mounds; the dolostone are laminated with occasional desiccation cracks, commonly alternating with big packages of lime stones; this unit is represent several microcycles from thick bedded wackestone, grainstone to minor well laminated mudstone and dolostone.
Z2-75 Z2-76	4.90	262.30	Dolomitized limestone to finely laminated dolostone or shaly mud stone, grey to buff weathering; the lithologies of limestones are similar to the last unit, rich in fossils.
Z2-76B Z2-77 Z2-77A Z2-77B Z2-78	11.70	274.00	Two limestone to shaly dolostone microcycles, buff weathering, thin bedded; the limestones are wackestone to grainstone which are rich in fossils and exhibit dolomitized burrows; the dolostones are argillaceous dololaminites, finely laminated, almost shales.
Z2-78A Z2-78B Z2-79 Z2-80			the upper part of unit is mainly dololaminites with well developed desiccation cracks or "mud" cracks.

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Z2-81 Z2-82 Z2-83 Z2-84	8.10	282.10	Limestone, mainly grainstones to rudstones, grey, thick bedded, extremely fossiliferous, biotur bated; the unit conformably overlies mudcracked, laminated dolomitic lime mudstone unit forming top of Boat Harbour Formation.
Z2-85	1.90	284.00	Shaly dolomitized and silicified limestone, light grey, thin bedded with laminations and desiccation cracks.
Z2-85B Z2-86 Z2-86B Z2-87 Z2-88	11.30	295.30	Limestone, wackestones to rudstones, dark grey, medium to thick bedded, laminated; some wackestone beds are lumpy to wavy thin bedded, burrowed, extremely fossiliferous with intraclastic and biocalstic grainstone lenses.
Z2-89 Z2-90	5.00	300.30	Limestone, thrombolitic-sponge boundstone mounds with abundant shelly fauna; the mounds are separated by thinly-bedded skeletal wackestone and some cross-bedded grainstone.
Z2-91 Z2-91B Z2-92	18.50	318.80	Limestone, pale weathering, wackestone and packstone interspered with scour-based, skeletal, intraclastic grainstones and some small thrombolitic-sponge rudstones; fossiliferous with brachiopods, high spired and planispiral gastropods, cephalopods and trilobites; some dolomitized burrows in wackestone beds.
Z2-93 Z2-94 Z2-94B Z2-95	12.50	331.30	Limestone, dark grey, dominantly composed of well bedded, intensely and moderately bioturbated wackestone-packstone with grainstone layers and lenses; very fossiliferous.
Z2-96 Z2-97 Z2-98	22.50	353.80	Limestone, grey, thin to medium bedded laminated, intensely bioturbated and burrowed wackestone

Z2-99 Z2-100			packstone with some intraclastic and bioclastic grainstone beds; fossiliferous in lower and middle parts.
Z2-101 Z2-102 Z2-103 Z2-104 Z2-105 Z2-106 Z2-107 Z2-108 Z2-109	70.20	424.00	Intensely bioturbated, burrowed, mottled, dolomitized grainstones and fine to medium crystalline dolostone with abundant porosity and white sparry dolomite; light grey, thick bedded; some fossils in lower part and then dominantly rich in trace fossils; some covered intervals in upper unit; this massive unit may be represent a shallower subtidal environment with rapid depositions or massive thrombolite mound buildups.
Z2-110 Z2-111 Z2-112 Z2-113 Z2-114 Z2-115 Z2-116	39.30	463.30	Moderately bioturbated and burrowed dolomitized limestone, light grey to pale or white, fine to medium grained; upper part limestones are characterized by having abundant porosity, bioclasts, peloids and fenestral textures; the middle part fenestral limestones are rich in trilobites, brachiopods and gastropods.
Z2-117 Z2-118	33.00	496.30	Dolomitized limestone, light grey to white, slightly bioturbated and burrowed, thick bedded; some covered interals (by Highway and houses).
Z2-119	4.00	500.30	Limestone, grey, thin bedded, well laminated, mudstones to wackstones; with some chert and grainstone lenses; a erosive surface is present in the top of the unit.
			<u>AGUATHUNA FORMATION</u>
Z2-120 Z2-121 Z2-122	10.70	511.00	Dolostone, light grey or buff weathering, medium bedded,laminated; the dolostones are dominantly argillaceous dololaminites, with interbedded dolomitized limestones which contains some cephalopods and gastropods; one 0.6 m thick green shaly mudstone bed is present just 2.0 m above the base of unit.

Z2-123	7.90	518.90	Dolostone, buff weathering, medium to thick bedded, finely laminated; the lower part (about 1.0 m) of the unit is dolomitized limestones with scattered bioturbation, small stromatolite mounds and some chert layers; dolostones are well laminated, microcrystalline,
Z2-124			occasionally with desiccation cracks.
Z2-125	7.40	526.30	Dolomitized limestone, tan weathering, laminated, commonly burrowed and mudcracked dolostone; the
Z2-126			limestones are lime mudstones to grainstones, burrowed, fossiliferous
Z2-127			with small stromatolite and thrombolite mounds.
Z2-128	3.00	529.30	Dolostone, tan to buff weathering, medium bedded, laminated, some chert nodules and small lower relief stromatolite mounds; top of the unit with erosive surface.
Z2-129	9.00	538.30	Dolomitized limestone with interbedded microcrystalline, planar to occasionally cross-laminated and rippled dolostones; the limestones are lime mudstones with lower relief small stromatolite mounds, fossili ferous wackestone-packstone with dolomitized burrows and chert
Z2-130			nodules; top of unit with erosive surface.
Z2-131	5.00	543.30	Dolostone, tan to buff weathering, medium bedded, some burrows, cross-bedding and chert nodules; two 0.5 m thick interbedded wackestone with minor fossils.
Z2-132	7.40	550.70	Limestone to dolostone, tan to buff weathering; the limestones are lime mudstones and fossiliferous wacke-
Z2-133			stones containing small stromatolite mounds; the dolostones are finely laminated crystalline dololaminites; minor interbedded shales are conglo-
Z2-134			meratic with clasts of limestone and chert.

Z2-135 Z2-136	6.60	557.30	Dolostone, with minor 0.5 m. dolomitized limestone in the lower part, massive, thick-bedded, tan weathering; dolostones are characterized by irregular laminations,burrows and small stromatolite mounds; two conspicuous irregular dissolution horizons which were described by Fortey (1984) and Knight and James (1987) just the top and 1 m below.
Z2-137 Z2-138 Z2-139	6.00	563.30	Massive dolostone, tan weathering, thick bedded, bioturbated and burrowed; top of the unit with some chert, seems to be erosive surface.
			<u>TABLE HEAD FORMATION</u>
Z2-140	2.00	565.30	Thick bedded, dark grey, limestone.

AGUATHUNA QUARRY SECTION (SECTION 3)

The section is located at the Aguathuna Quarry. It begins the west edge of small quarry, about 600 m south west of the large quarry, and continues about 700 m northeastward along north side of the quarry and the road cut by the creek, and terminates the south side of the large quarry.

Conodont sample	Thickness	Height above base	Description
			<u>CATOCHE FORMATION</u>
Z3-1 Z3-2 Z3-3 Z3-4	13.50	13.50	Limestone, pale-grey medium to thick bedded, mainly wackestones to fine grainstone; some chert layers, and intensive burrows which were dolomitized; some medium mounds commonly surrounded by grainstones; some fossiliferous beds in middle and upper parts of the unit.
Z3-5 Z3-6 Z3-7 Z3-8	7.50	21.00	Limestone, wackestone to grainstone, pale-grey, well laminated in upper unit, burrowed and bioturbated; some chert and cross-bedding in the lower part of the unit, with some fossils.

Z3-9	3.70	24.70	Limestone, dark grey, massive thick bedded, fine grainstone, well laminated; the top surface seems to be eroded.
Z3-10 Z3-11	4.10	28.80	Limestone, grey, medium bedded, wackestone to fine grainstone, laminated, with erosive top surface.
			<u>AGUATHUNA FORMATION</u>
Z3-12 Z3-13	5.00	33.80	Dolomitized limestone and shaly mudstone; the limestones are grey, medium bedded, well laminated fine grainstone; the mudstones are green, finely laminated, like shales, and are present in middle unit.
Z3-14	4.40	38.20	Limestone to dolomitized limestone, grey, medium bedded, burrowed and bioturbated, with some fossiliferous beds; some interbedded shaly mudstones.
Z3-15	5.30	43.50	Argillaceous dolostone with interbedded shaly mudstone, pale to buff weathering, microcrystalline, laminated, with a few burrows and chert layers.
Z3-16	6.10	49.60	Limestone, grey, medium to thick bedded, mainly wackestone to fine grainstone, intensively burrowed, bioturbated, but some interbedded finely laminated mudstones in the middle and uppermost parts of the unit.
Z3-17	8.00	57.60	Several repeated limestone, dolomitized limestone to shaly mudstone microcycles; the limestones are wackestones to grainstones with burrows and stromatolite mounds; the shaly mudstones are finely laminated.
Z3-19	7.20	64.80	Dolomitized limestone, light-grey, medium to thick bedded, microcrystalline, commonly burrowed; some

Z3-20			minor interbedded shaly mudstones; two conspicous irregular dissolution horizons just 1.0 m below top and top surface.
Z3-21	6.20	71.00	Limestone, grey, massive thick bedded, intensively burrowed and bioturbated, some fossils; the top surface eroded.
			TABLE HEAD FORMATION
Z3-22	1.00	72.00	Limestone, dark grey, thick bedded, fossiliferous wackestone to grainstone.

JERRYS NOSE SECTION (SECTION 4)

The section is located at the rocky coastal cliff from the Jerrys Nose to the Fiods Cove. The section begins the point of Jerrys Nose, and continues 1.3 km. northwestward along the rocy cliff, and ends in the east side of Fiods Cove.

Conodont sample	Thickness	Height above base	Description
			BERRY HEAD FORMATION
Z4-1	2.90	2.90	Dolostone, medium bedded, mottled, well laminted, with intraclasts and flat pebbles, and some chert.
Z4-2	1.10	4.00	Limestone and dolomitized limestone, dark grey, thick bedded; the limestones are oolitic grainstones with intraclasts.
	5.00	9.00	Dolostone, mottled, medium to thick bedded, well laminated, some beds with small stromatolite mounds.
Z4-3	7.80	16.80	Dolostone, mottled, medium to thick bedded, well laminated, some stromatolite mounds interbedded, and some chert and intraclastic layers.
Z4-4	6.40	23.20	Dolostone, mottled, thin to medium bedded; lower part dolostones are laminated, but burrowed and biotur

Z4-5			bated; the middle and upper part dolostones are laminated; some medium stromatolite mounds in the middle part of the unit.
			Several small high-angle normal faults, striking approximately W-E, interrupt this unit, but with minor displacements.
			WATTS BIGHT FORMATION
Z4-6	5.30	28.50	Dolostone, mottled, thick bedded, burrowed and bioturbated, stromatolite and thrombolite mounds, some chert layers, with eroded top surface.
			Several minor displacement high-angle faults through this unit, striking W-E.
Z4-7	5.10	33.60	Dolostone, finely laminated, buff and mottled weathering, with desiccation cracks in some beds; some stromatolite mounds in middle and upper parts of unit; several chert layers between finely laminated and thick bedded dolostones.
Z4-8	1.90	35.50	Dolostone, buff weathering, thin to medium bedded, finely laminated, the upper part with some chert layers and small mounds.
Z4-9 Z4-9B Z4-10 Z4-11	13.00	48.50	Dolostone, mottled, massive bedded, some chert layers, and massive stromatolite and thrombolite mounds, the unit is mostly like a complex succession of fossiliferous thrombolite mounds and coarse-grained intermound calcarenites, but is strongly dolomitized and silicified.
			Several high-angle normal minor displacement faults, striking approximately W-E; however, one big fault just interrupts the top of the unit, about 15 m displacement.
Z4-12	16.00	64.50	Limestone, dark grey, massive

Z4-13 Z4-14 Z4-14B Z4-15 Z4-15B			bedded; the limestones are wackestones to grainstones, burrowed and bioturbated, fossiliferous with massive thrombolite mounds; high angle fault through this unit, striking W-E, probably with minor displacement.
Z4-16 Z4-16B Z4-17 Z4-18 Z4-18B	12.50	77.00	Limestone, dark grey, medium to thick bedded; the limestones are wackestones to grainstones, burrowed and bioturbated, very fossiliferous, some medium thrombolite mounds; some minor interbedded dolostones with laminations.
Z4-18C Z4-19	10.60	87.60	Limestone, grey, medium bedded,laminated; most limestones are wackestones to fine grainstones, burrowed and bioturbated, some bioclasts and intraclasts lenses, fossiliferous, some thrombolite mounds; some minor interbedded finely laminated mud stones in middle and upper parts of the unit.
Z4-19B Z4-20 Z4-20B	6.80	94.40	Limestone with minor interbedded finely laminated dolostone; the limestones are light grey, thin to medium bedded wackestones to grainstones, burrowed and bioturbated, some bioclasts and intraclasts, some sinous ripples, very fossiliferous.
Z4-21	5.90	100.30	Limestone, wackestone to grainstone, light grey, medium bedded, laminated, slightly burrowed and bioturbated, some intraclasts, bioclasts and lime sand lens and mudstone layers, quite fossiliferous.
			One big high-angle normal fault is just located 5 m south of the huge cliff, a small additional secton (where were samples from Z4-22A to Z4-22D collected from) was measured in the south side of the fault.

<u>BOAT HARBOUR FORMATION</u>

Z4-23	13.20	113.50	Limestone, several repeated mudstone

Z4-24 Z4-25 Z4-26			to grainstone microcycles, light grey, thin to medium bedded, finely laminated, with intraclasts, bioclasts; ripple marke, cross-bedding are common in this unit, very fossiliferous with abundant trace fossils.
Z4-27 Z4-28 Z4-28B	8.30	121.80	Limestone, several repeated mudstone to grainstone microcycles; the mudstones are laminated, slightly dolomitized, with abundant trace fossils; the wackstones, packestones and grainstones are thin bedded, laminated, burrowed and bioturbated, with intraclastic and bioclastic layers, ripples and cross-bedding. Along the top bedding plane of the unit, the continuing section is down northwestward about 200 m to the east head of Fiods Cove.
Z4-29 Z4-30	6.60	128.40	Limestone and minor shaly mudstone, red-grey or buff weathering, thin to medium bedded, well laminated; the limestones are burrowed and bioturbated, intraclastic and bioclastic wackstones and grainstones with lime sands, ripples and cross-bedding, very fossiliferous; the mudstones are finely laminated, slightly dolomitized.
Z4-31 Z4-31B Z4-32 Z4-33 Z4-34	9.10	137.50	Limestone and minor shaly mudstone, reddish grey, thin to medium bedded, well laminated; the limestones are bioclastic and intraclastic wackestones to fine grainstones, burrowed and bioturbated; the interbedded minor mudstones are dolomitized, with fine laminations and a few burrows and fossils.
Z4-35 Z4-36	13.00	150.50	Dolomitized limestone, light grey to buff weathering, fine grained, medium to thick bedded, burrowed and bioturbated.
Z4-36B	3.50	154.00	Limestone, light grey, bioclastic burrowed and bioturbated wackestones to fine grainstones, thick bedded,

Z4-37			fossiliferous; some stromatolite and thrombolite mounds in upper part of the unit.
			<u>WATTS BIGHT FORMATION (ADDITIONAL PARTOF THE SECTION 4)</u>
			Additional part of this section is located at the rocky cliff, south side of the major fault, about 80 south of the main section (south of Z4-21 and Z4-23). The fault is a high-angle normal fault (south side up and north side down), so south side of the section belong to the Watts Bight Formation.
Z4-22B	2.80	2.80	Limestone to dolostone, reddish grey, thin to medium bedded; the limestones are wackestones with burrows, and stromatolite and thrombolite mounds; the dolostones are finely laminated.
Z4-22C	1.90	4.70	Limestone to dolostone, reddish-grey, thin to medium bedded; the limestones are wackstones to grainstones with intraclasts and burrows; the dolostones are buff weathering, well laminated.
Z4-22D	2.60	7.30	Limestone to dolostone; the lime stones are dark-grey, thick bedded with high relief stromatolite mounds and some digitated thrombolite mounds, burrowed and bioturbated; the upper part dolostones are buff weathering, well laminated.
Z4-22A	3.20	10.50	Limestone, dark-grey, medium bedded, burrowed and slightly bioturbated wackestone.

SHIP COVE SECTION (5)

The section is located at the small rocky cliff in the cove between the west Ship Cove and the east Pigeon Head. It begins the head of cliff near sea-level and continues about 150 m northward along the slope of the cliff, and terminates near the top edge of small red cove (filled with Carboniferous rocks). The section is accessible and can be reached from small trail that leads down from the highway near the west end of Ship Cove.

Conodont sample	Thick-ness	Height above base	Description
			WATTS BIGHT FORMATION
Z5-1 Z5-2	7.00	7.00	Limestone, dark-grey or reddish-grey, massive thick bedded, burrowed and bioturbated wackestone to coarse grainstone, very fossiliferous with gastropods, cephalopods; some massive thrombolite-sponge mounds; some chert layers and grainstone lenses.
Z5-3 Z5-4 Z5-5	10.00	17.00	Limestone, dark-grey to grey, massive thick bedded, burrowed and bioturbated wackestone to grainstone, fossiliferous with medium thrombolite mounds; some chert layers or nodules, and lime-sand or intraclastic and bioclastic lens.
Z5-6 Z5-7 Z5-8 Z5-9 Z5-10	12.00	29.00	Limestone, light-grey, medium to thick bedded, wackestone to coarse intermound grainstone, massive thrombolite mounds; most wackestones are burrowed and bioturbated; some bioclastic lime-sand lenses are extremely fossiliferous; a few interbedded minor dolostones are well laminated with a few burrows and fossils.
Z5-11 Z5-12	7.00	36.00	Limestone and minor dolostone,light grey, thin to medium bedded; the limestones are wackestones to grainstones, intensively burrowed and bioturbated, some chert layers and small stromatolite mounds, fossiliferous; the dolostones are laminated, with burrows and a few fossils.

PIGEON HEAD SECTION (SECTION)

The section is located at Pigeon Head and Lower Cove of Port au Port Peninsula. It begins the small cliff, about 300 m southeast of Pigeon Head, and continues about 2.0 km northwestward along the top edge of the Pigoen Head cliff, down to the shoreline of the Lower Cove, and terminates at the highway cut cliff of Lower Cove. All parts of the section are accessible and can be easily reached from numerous small trails that lead down from the highway between the Ship Cove and Lower Cove.

Conodont sample	Thick-ness	Height above base	Description
			WATTS BIGHT FORMATION
Z6-1 Z6-2 Z6-3 Z6-4 Z6-5 Z6-5B	17.00	17.00	Limestone, dark grey, medium to thick bedded, mudstones to grainstones; the mudstones are present in the upper part of unit, well laminated; the wackestones to grainstones are burrowed and bioturbated, with intraclastic and bioclastic lens, extremely fossiliferous with gastropods, cephalopods, trilobites, brachiopods, some medium thrombolite mounds; some ripples in the upper part of the unit.
Z6-6 Z6-6B Z6-7 Z6-8	6.70	23.70	Limestone to dolomitized limestone, dark-grey, thick bedded; the limestones are wackestones to grainstones, burrowed and bioturbated, with thrombolite mounds, and intraclastic, bioclastic and lime-sand lens, ripple marks, as well as abundant fossils; the dolomitized limestones are present in the upper part, laminated, intensively burrowed and bioturbated, some chert layers, and stromatolite and thrombolite mounds; some medium to big stromatolite and thrombolite mounds and coarse-grained intermound calcarenites are present in the upper part of unit.
			A high-angle normal fault, striking nearly W-E, with minor displacement.
			BOAT HARBOUR FORMATION
Z6-9 Z6-10	11.50	33.00	Limestone with minor interbedded dolomitized limestone; the limestones are several repeated wackestone to grainstone microcycles, laminated,

Z6-10B Z6-11			burrowed and bioturbated, with stromatolite and thrombolite mounds, some chert and lime-sand lens, ripples and cross-bedding, extremely fossiliferous; dolomitized limestones are intensively burrowed and bioturbated, with well laminations.
	9.00	42.00	Two parallel high-angle normal faults both striking near W-E, about 10 m displacement interrupt the section. The interrupted and covered section has to be moved to the top edge of Pigeon Head cliff, about 9 m is missing, and did not collect conodont samples.
Z6-12 Z6-13 Z6-14	14.30	56.30	Several limestone to dolostone microcycles; the limestones are dark-grey, thin to medium bedded wackstones, packstones and grainstones, burrowed and bioturbated, some intraclastic and bioclastic lens, some stromatolite and thrombolite mounds, fossiliferous; the dolostones are buff weathering, laminated, a few burrows.
Z6-15	8.30	64.60	Two limestone to dolostone microcycles; limestones are wackestones to grainstones, dark-grey, thin to medium bedded, some stromatolite mounds and chert layers, burrowed and slightly bioturbated, some ripples and cross-bedding, fossiliferous; dolostones are buff weathering, medium bedded, well laminated with a few desiccation cracks.
Z6-16	6.20	70.80	Limestone to dolostone; the limestones are grey, thin bedded, finely laminated shaly, fossiliferous some intraclastic and bioclastic lens; the dolostones are buff weathering, finely laminated, shaly mudstones, with desiccation cracks.
Z6-17	6.50	77.30	Limestone to dolostone; the limestones are wackestones to grainstones, burrowed, very fossiliferous, with some stromatolite mounds, lime-sand, intraclastic and bio-

Z6-18			clastic lens; the dolostones are similar to the last unit.
Z6-19 Z6-20	9.20	86.50	Limestone to dolostone; the limestones are thicker than dolostones, dark-grey, thin to medium bedded, laminated, fossiliferous; some minor interbedded mudstones are similar to the buff weathering dolostones, finely laminated; the upper part dolostones are similar to the last unit.
			Along the strike of the top bedding plane of the last unit, the continuing section is located northward about 150 m to the shoreline of the Lower Cove.
Z6-21 Z6-22	6.90	93.40	Dolomitized limestone to dolostone, grey, medium to thick bedded intensively burrowed and bioturbated, with some chert layers or nodules and some lower relief stromatolite mounds, some mud-cracks and ripples are present in the upper part.
Z6-23 Z6-24 Z6-25	7.10	100.50	As above unit, but the limestones are strongly dolomitized, intensively burrowed and bioturbated, with more chert layers and more stromatolite mounds.
Z6-26 Z6-27 Z6-28	8.00	108.50	Limestone, grey, thin to medium bedded, bioclastic and intraclastic, laminated, fossiliferous wackestone to grainstone; upper part of the unit with some thin bedded shaly mudstones to wackestones.
			Along the top bedding plane of the unit, the continuing section extends up the top edge of the cliff, and then down to the Lower Cove.
			<u>CATOCHE FORMATION</u>
Z6-29	14.10	122.60	Limestone, grey, medium to thick bedded, intraclastic and bioclastic wackestone to grainstone, very fossiliferous (some boundstone mounds rich

			in sponges, trilobite, gastropods, cephalopods and ect.).
Z6-30 Z6-31 Z6-32 Z6-33	8.90	131.50	Limestone, grey, thick bedded, bioclastic and intraclastic, extremely fossiliferous wackestone to grainstone with gastropods, cephalopods, trilobites and brachiopods, some thrombolite and sponge boundstone mounds; the upper part with minor shaly mudstone.
			Along the top unit of the bedding plane, the continuing section is down the shoreline into Lower Cove.
Z6-34 Z6-34B Z6-35 Z6-35B	5.60	137.10	Limestone, dark-grey, medium to thick bedded, intraclastic and bioclastic wackestones, packstones, grainstones and boundstones, extremely fossiliferous with gastropods, cephalopods, trilibites and brachiopods, some thrombolite-sponge massive mounds, and intermound grainstones and interbedded mudstones.
Z6-36 Z6-37	7.40	144.50	Limestone, grey, medium to thick bedded, fossiliferous with large cephalopods, plani- and high-spired gastropods and e few trilobites, bioclastic and intraclastic wacke stone, packestone, and grainstone, some mudstones and boundstones in lower and upper parts; some minor interbedded shaly wackestones in the middle part.
Z6-38 Z6-39	4.70	149.20	Two thin to thick bedded limestone microcycles; the thick bedded limestones are dark-grey, wackestones to grainstones, very fossiliferous, and with thrmobolite-sponge mounds, bioclastic and intraclastic lens, some ripples and cross-beddings; the thin bedded limestones are mudstones to wackestones, with fewer fossils and mounds.
Z6-40 Z6-41	8.30	157.50	Limestone, dark-grey, medium to thick bedded, extremely fossiliferous, bioclastic, peloid and intraclastic wackestone to coarse grainstone, some

Z6-42			thrombolite-sponge mounds and huge sinuous ripples.
	3.00	160.50	As above, but partially covered by the highway.
Z6-43 Z6-43B Z6-44 Z6-44B Z6-45 Z6-46	9.50	170.00	Limestone, dark-grey, thin to thick bedded, laminated, very fossiliferous with gastropods, cephalopods, a few trilobites, bioclastic, peloid and intraclastic wackestone and grain-stone, some medium thrombolite mounds; the lower part of unit is mainly thick bedded wackestones and interbedded grainstones; the middle and upper parts are laminated, thin bedded wackstones and some interbed-ded mudstones.

LOWER COVE HIGHWAY CUT SECTION (7)

The section is located at the highway cut west of Lower Cove. It begins the east end of the highway cut, and continues about 300 m westward along the highway slope, and terminates until the end of the highway cut. All parts of the section are excellently exposed by highway construction and easily accessible.

Conodont sample	Thick-ness	Height above base	Description
			<u>BERRY HEAD FORMATION</u>
Z7-A			The sample was collected from 100 m west cliff, about 5-10 m true thick-ness below the begining of the sec-tion, the uppermost part of the Berry Head Formation, mainly burrowed and bioturbated limestone, but slightly dolomitized.
Z7-B Z7-1	4.00	4.00	Limestone to dolostone; the lime stones are grey, very thick bedded, laminated, burrowed wackestones to fine grainstones, with some minor interbedded mudstones; the dolostones are light-grey or rusty and buff weathering, finely laminated, with a few burrows.

Z7-1B Z7-1C Z7-2 Z7-2B Z7-2C	4.70	8.70	Limestone to dolostone; the limestones are similar to the last unit, but with thrombolite and stromatolite mounds, and more bioclasts; the dolostones are light-grey or buff and reddish weathering, laminated, with some low relief stromatolite mounds.
Z7-3 Z7-3B Z7-3C Z7-4	5.00	13.70	Limestone to dolostone; the lime stones are grey to dark grey, thin to thick bedded, laminated wackestones, packstones and fine grainstones, with thrombolite mounds, fossiliferous with cephalopods, gastropods and brachipods; the dolostones are light grey or buff and tan weathering, medium bedded, well laminated, with lower relief stromatolite mounds and desiccation cracks.
			A high-angle normal fault, striking nearly S-N, about 1.0 m displacement.

WATTS BIGHT FORMATION

Z7-5 Z7-5A	5.20	18.90	Limestone to dolostone; the lime stones are grey, thick bedded, laminated, burrowed and bioturbated, bioclastic wackestones, packstones and grainstones, with thrombolite and stromatolite mounds, and fossiliferous; the dolostones are only present in upper part, about 0.60 m thick, rusty weathering, thin bedded, well laminated.
Z7-5B Z7-6 Z7-6A	4.80	23.70	Limestone to dolostone; the limestones are as last unit, but moderately to strongly burrowed and bioturbated, with more mounds and some chert layers or nodules; the dolostones are present in the middle part, rusty weathering, well laminated with stromatolite mounds.
Z7-7	4.20	27.90	Limestone, dark-grey, thin to medium bedded, laminated to well laminated, bioclastic, burrowed and bioturbated wackestones, some interbedded mudstones, some medium stromatolite

			mounds and chert nodules; top of the unit with 1.0 m finely laminated mudstones to wackestones.
Z7-8 Z7-9 Z7-9B Z7-10	14.40	42.30	Limestone, dark-grey, massive thick bedded, poorly laminated, intensively burrowed and bioturbated, bioclastic and intraclastic wackestones, with abundant gastropods, cephalopods, and some thrombolite mounds and inter mound lime-sand lenses.
Z7-11 Z7-12 Z7-13 Z7-13B Z7-13C Z7-14 Z7-15 Z7-15B	21.20	63.50	Limestone, dark-grey, massive thick bedded, intensively burrowed and bioturbated, very fossiliferous intraclastic and bioclastic wackestones to grainstones; some massive thrombolite mounds and intermound lime-sand grainstones, and chert nodules, as well as abundant trace fossils; this unit may be represent a deeper subtidal environment, with rapid depositions including massive thrombolite mounds buildup.
Z7-16 Z7-17	5.80	69.00	Limestone, as above, but with more peloids, bioclasts and intraclasts, laminated, moderately burrowed and bioturbated, very fossiliferous, but with fewer trace fossils and thrombo lite and stromatolite mounds.

SHEAVES COVE HIGHWAY CUT SECTION (SECTION 8)

The section is located at the small hill, the midway between the Lower Cove and Sheaves Cove. The section begins on the west side of the highway cut, near the small creek, and continues about 150 m eastward along the highway cut, and terminates at the top of the hill. All parts of the section are excellently exposed, and can be easily reached.

Conodont sample	Thick-ness	Height above base	Description
			<u>BOAT HARBOUR FORMATION</u>
Z8-1	4.30	4.30	Limestone, dark-grey, medium to thick bedded wackestone to grainstones; the lower part wackestones are well lami-

Z8-2			nated, fossiliferous with medium stromatolite mounds; the middle part limestones are mainly oolitic grainstones and some interbedded well laminated shaly mudstones, with chert nodules and fossils; the upper part limestones are finely laminated mudstones, with burrows and a few fossils.
Z8-3	3.00	7.30	Limestone, grey to light grey, thin to medium bedded, laminated mudstones to wackestones; the mudstones are buff weathering, finely laminated, with some bioclastic and intraclastic lens, and are present in upper part of the unit; the wackestones are very fossiliferous with gastropods, cephalopods and other fossils, with abundant bioclasts, intraclasts and oolitic grains.
Z8-4	3.70	11.00	Limestone, as above unit, but the wackestones and mudstones have more bioclasts, intraclasts, and peloids, as well as more fossils; the wacke stones in the upper part are intensively burrowed and bioturbated.
Z8-5	3.30	14.30	Limestone, wackestone to mudstone microcycles; the wackestones are dark-grey, thin bedded, fossiliferous, with bioclasts, peloids and intraclasts, burrowed and bioturbated; the mudstones are buff weathering, laminated, and shaly.
	3.00	17.30	About 3.0 m true thickness missing, because the covered interval between the two outcrops of the highway cut.
Z8-6	6.50	24.00	Two limestone to dolostone microcycles; the limestones are dark grey, thick bedded, bioclastic and intraclastic wackestone, with medium high relief beautiful stromatolite mounds; the dolostones are buff weathering, well laminated with desiccation cracks.
Z8-7	3.20	27.20	Limestone, dark-grey, medium to thick bedded, laminated, with abundant

Z8-8			bioclasts, small intraclasts and peloids, wackestone to fine grainstone; some medium high relief stromatolite mounds with chert nodules or layers; the top surface seems to be eroded.
	1.60	28.60	Dolostone, buff weathering, finely laminated, with desiccation cracks.
Z8-9	2.90	31.50	Limestone, mainly wackestone and fine grainstone; the wackestones are burrowed and bioturbated, rich in gastropods, cephalopods and other fossils; the grainstones are slightly dolomitized, laminated, with some chert nodules and small low relief stromatolite mounds, intensively burrowed and bioturbated.

SHEAVES COVE SECTION (SECTION 9)

The section is located at the Sheaves Cove, about 300 m west of the Sheaves Cove village community. It begins 40 m below the Sheaves Cove cliff, at the sea-level, and continues northeastward about 40 m upward the cliff, and terminates near the highway of top cliff. All parts of the section are accessible, but dangerous during high tide and during wet weather.

Conodont sample	Thickness	Height above base	Description
			WATTS BIGHT FORMATION
Z9-4 Z9-1A Z9-1B Z9-3 Z9-5 Z9-6	13.30	13.30	Limestone, grey, medium thick bedded wackestone, with bioclasts and burrows, and some thrombolite mounds fossiliferous with gastropods, cephalopods and other fossils, some lime-sand lens and mudstone beds; the upper part limestones are mainly grainstones, very fossiliferous, with medium thrombolite mounds; this unit may be represent a deeper subtidal environment with rapid depositions including the thrombolite mound buildups.
Z9-7	12.30	19.30	Limestone, grey, thick bedded,

Conodont sample	Thickness	Height above base	Description
			basically wackestones and grainstones, laminated, burrowed and bioturbated, very fossiliferous, from 15.0 m upward with massive thrombolite mounds and intermound lime-sand grainstones.
Z9-8	7.70	27.00	Limestone, as above unit, but wackestones and grainstones are intensively burrowed and bioturbated, extremely fossiliferous, some chert nodules and layers, as well as medium thrombolite mounds.
Z9-9 Z9-2	3.00	30.00	Limestone, light grey, thin bedded, bioclastic and intraclastic wackestones and interbedded mudstones; the wackestones are very fossiliferous, intensively burrowed and bioturbated, with some chert and small thrombolite mounds; the mudstones are laminated, with less bioclasts and fossils.

TABLE MOUNTAIN SECTION (SECTION 10)

The section is located at the south-west side of Smelt Canyon of the Table Mountain. It begins at the confluence of two tributaries, and continues about 600 m northwestward along the southwest edge of the Canyon, and terminates about 400 m northward of the Radar Station, the end of the outcrop is no the north slope of the Table Mountain. All parts of the section are excellently exposed, can be reached from the Radar Station of the Table Mountain.

Conodont sample	Thick-ness	Height above base	Description
			<u>CATOCHE FORMATION</u>
	2.00	2.00	Silicified shaly limestone, dark grey, thin bedded, finely laminated, with some fossils.
Z10-A	8.80	10.80	Limestone, two microcycles from thick bedded to thin bedded; the thick bedded limestones are wackestones to grainstones with thrombolite-sponge mounds, very fossiliferous; the thin bedded limestones are mainly mud-

			stones to wackestones with laminations and fewer fossils.
Z10-B	7.20	18.00	Limestone, as above unit, but with more thrombolite-sponge mounds and fossils.
Z10-C Z10-D	9.30	27.30	Limestone, dark grey, thick bedded wackestone to grainstone, with intraclasts, bioclasts and peloids, as well as abundant gastropods, cephalopods, trilobites and brachipods.
Z10-E Z10-F	27.70	55.00	Limestone, dark grey, thin to thick bedded wackestone to grainstone, with intraclasts, bioclasts and peloids, sparsely burrowed and bioturbated, very fossiliferous.
Z10-G	10.00	65.00	Limestone, as above unit, but moderately burrowed and bioturbated, with less fossils.
Z10-1 Z10-2 Z10-3	13.00	78.00	Limestone, as above unit, but mainly thin bedded wackestones, and some interbedded mudstones and fine grainstones, with abundant fossils, and moderately burrowed and bioturbated.
Z10-4	7.00	85.00	Limestone, as above unit, but medium to thick bedded, bioclastic and intraclastic, burrowed and bioturbated wackestone to grainstone with thrombolite-sponge mounds, and abundant gastropods, cephalopods, trilobites and brachiopods.
Z10-5	13.00	98.00	Limestone, dark grey, medium to thick bedded, fine to medium grained grainstone with minor interbedded wackestone, intensively burrowed and bioturbated, and with abundant fossils.
Z10-6 Z10-7 Z10-8	13.50	111.50	Limestone, light grey, medium bedded, rubbly weathering, fine grainstone and interbedded wackestone, intensively burrowed and bioturbated, and some fossils and chert nodules or layers.
Z10-9	9.00	120.50	Limestone, grey but pale weathering, intensively burrowed and bioturbated

Z10-10			fine grainstone with interbedded minor wackestone, quite commmon chert nodules and layers, and some small mounds.
Z10-11 Z10-12	18.50	139.00	Dolomitized limestone, grey or pale and rubbly weathering, mainly fine grainstone and interbedded minor wackestone, intensively burrowed and bioturbated, some mounds and chert nodules, with a few fossils.
Z10-13 Z10-14 Z10-15	14.00	153.00	Dolomitized limestone, as above unit, but with white and rubbly weathering, fine grainstone, some mounds with intermound wackestone, and chert nodules, as well as cross-bedding.
	3.00	156.00	Dolomitized limestone, as above unit, but the fine grainstone with more mounds, chert nodules, and slightly silicified.