UPPER CANADIAN TO WHITEROCKIAN (ORDOVICIAN) CONODONT BIOSTRATIGRAPHY OF THE UPPER ST. GEORGE GROUP, WESTERN NEWFOUNDLAND

KATHLEEN ANNE STAIT, B.Sc.(Hons.)

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by

© KATHLEEN ANNE STAIT, B.Sc. (Hons.)

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ABSTRACT

The St. George Group of western Newfoundland is a sequence of limestones and dolostones deposited on the North American platform margin of the Lower Ordovician Iapetus Ocean. The upper half of this sequence records a shoaling-upwards megacycle of deposition, which is found in the upper Boat Harbour, Catoche and Aguathuna formations.

Much of this megacycle was sampled for conodonts in order to establish a refined biostratigraphy and to shed light upon lithostratigraphic problems within Catoche and Aguathuna formations. Over 130 core samples from the Daniel's Harbour mine and approximately 110 outcrop samples from localities throughout western Newfoundland yielded approximately 5,000 conodonts.

In total, 72 species from 43 genera are herein described from the upper megacycle of the St. George Group. *Striatodontus* n. gen. is described, with *S. kakivangus* n. sp. and *S. carlae* (Repetski) both found in the St. George Group. Elements probably forming part of a previously unknown apparatus (?New Genus 1) are described, but remain unnamed. New species are *Bergstroemognathus alus*, *Clavohamulus cavus*, *Diaphorodus gravelsensis*, *D. stevensi*, *Leptochirognathus planus*, *Parapanderodus aequalis* and *Rossodus symmetricus*. In addition, species of *Ansella* Fåhraeus & Hunter, ?*Erismodus*

Branson & Mehl, Protoprioniodus McTavish, ?Reutterodus Serpagli, and new species of Scalpellodus Dzik, Variabiliconus Landing et al. and the unnamed new (?) genus remain in open nomenclature pending the availability of more abundant material.

Seven successive informal conodont assemblages are recognised within the faunal succession. These are based upon morphological changes within species of Parapanderodus Stouge and Diaphorodus Kennedy, and concurrent ranges of a number of species.

Assemblage I correlates with North American trilobite Zone H, which is equivalent to early Midcontinent Province Fauna E of the North American conodont zonation; coeval Baltic Province conodonts are found in the Prioniodus elegans Zone. Assemblage II may correlate with the Prioniodus elegans Zone and Midcontinent Fauna E. Assemblage III is demonstrably contemporaneous with the Oepikodus evae Zone and with the shelly fossil Zone I of the North American succession, but younger assemblages can only be directly related to North American faunas. Faunas are initially of mixed Midcontinent and Baltic affinity, but shallowing of the depositional environment was accompanied by restriction of Baltic forms from uppermost Catoche and Aguathuna formations.

Assemblage IV, at approximately the base of the Aguathuna Formation, contains the last occurrence of Oepikodus communis (Ethington & Clark) and conodonts of

Canadian age interspersed with species more common within Whiterockian strata (e.g. Tripodus laevis Bradshaw). Conodonts equivalent in age to zones J and K are found in Assemblage IV. All but the longest-ranging Canadian conodonts disappear by Assemblage V, which is the first assemblage completely within the Whiterockian: early Whiterockian species include Pteracontiodus cryptodens (Mound), Diaphorodus gravelsensis n. sp. and D. stevensi n. sp. Assemblage VI, commencing with the incoming of Drepanodus sp. cf. D. gracilis (Branson & Mehl) and consisting of early Whiterockian conodonts, is of limited stratigraphic range. The succeeding Assemblage VII, with Drepanoistodus angulensis (Harris), Scandodus sinuosus Mound and Glyptoconus rectus (Stouge) at the base, later contains a diverse and abundant fauna showing affinity with conodonts correlated with shelly fossil Zone M of the Ibex area. This fauna, which continues several metres into the overlying Table Point Formation, is almost completely of Midcontinent Province aspect. It consists primarily of neurodont and lamellar forms such as Leptochirognathus quadrata Branson & Mehl, Multioistodus subdentatus Cullison, Paraprioniodus costatus Ethington & Clark, Erismodus spp. and several previously undescribed species.

The upper St. George Group conodont succession is broken at two levels within the Aguathuna Formation: significant hiatuses separate assemblages IV and V, and assemblages VI

and VII. The lower hiatus is recognized at the same level across western Newfoundland, but the upper hiatus occcurs at different levels both locally and regionally. This pattern of faunal occurrences is explained with reference to the tectonic setting of the platform margin during deposition of the Aguathuna Formation.

ACKNOWLEDGMENTS

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Access to facilities whilst in Australia was provided by Prof. B.N. Runnegar and the Electron Microscope Unit of the University of New England; and by Drs. R.S. Nicoll and E. Trusswell of the Bureau of Mineral Resources in Canber.a. The extensive libraries of Prof. Barnes and Dr. C.F. Burrett were made available in initial stages of this study. Technical assistance of F. O'Brien is gratefully acknowledged.

Discussions with staff (Profs. L.E. Fåhraeus and R.K. Stevens, Dr. S.H. Williams) and students (D. Johnston, S. Pohler, T. Lane, S. Stenzel) of Memorial University of Newfoundland were also beneficial.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1:1. GEOLOGICAL SETTING

Newfoundland represents the northernmost extension of the Appalachian Orogen on the North American continent. On the basis of preserved terranes and stratigraphic associations, it has been subdivided into four major zones (Williams 1978; Fig. 1:1). Rocks of the westernmost division, the Humber Tectono-stratigraphic Zone, have been interpreted as recording the establishment and collapse of the tropical, originally south-facing, North American margin of the Lower Palaeozoic Iapetus Ocean (Burrett 1973, Ross 1975, Scotese et al. 1979). Those of the Dunnage Zone preserve remnants of the Iapetus Ocean Basin which was situated to the southeast of the continental land mass (James & Stevens 1982).

Although platform margin facies of the Appalachians are commonly buried beneath thrust slices of oceanic crust and only sporadically exposed, in western Newfoundland the Lower Palaeozoic shallow platform, slope and distal slope facies are exposed in a 400 km, north-south trending sinuous belt (James & Stevens 1982). These rocks are least disturbed along the western margin of the Humber Zone (James & Stevens 1982,

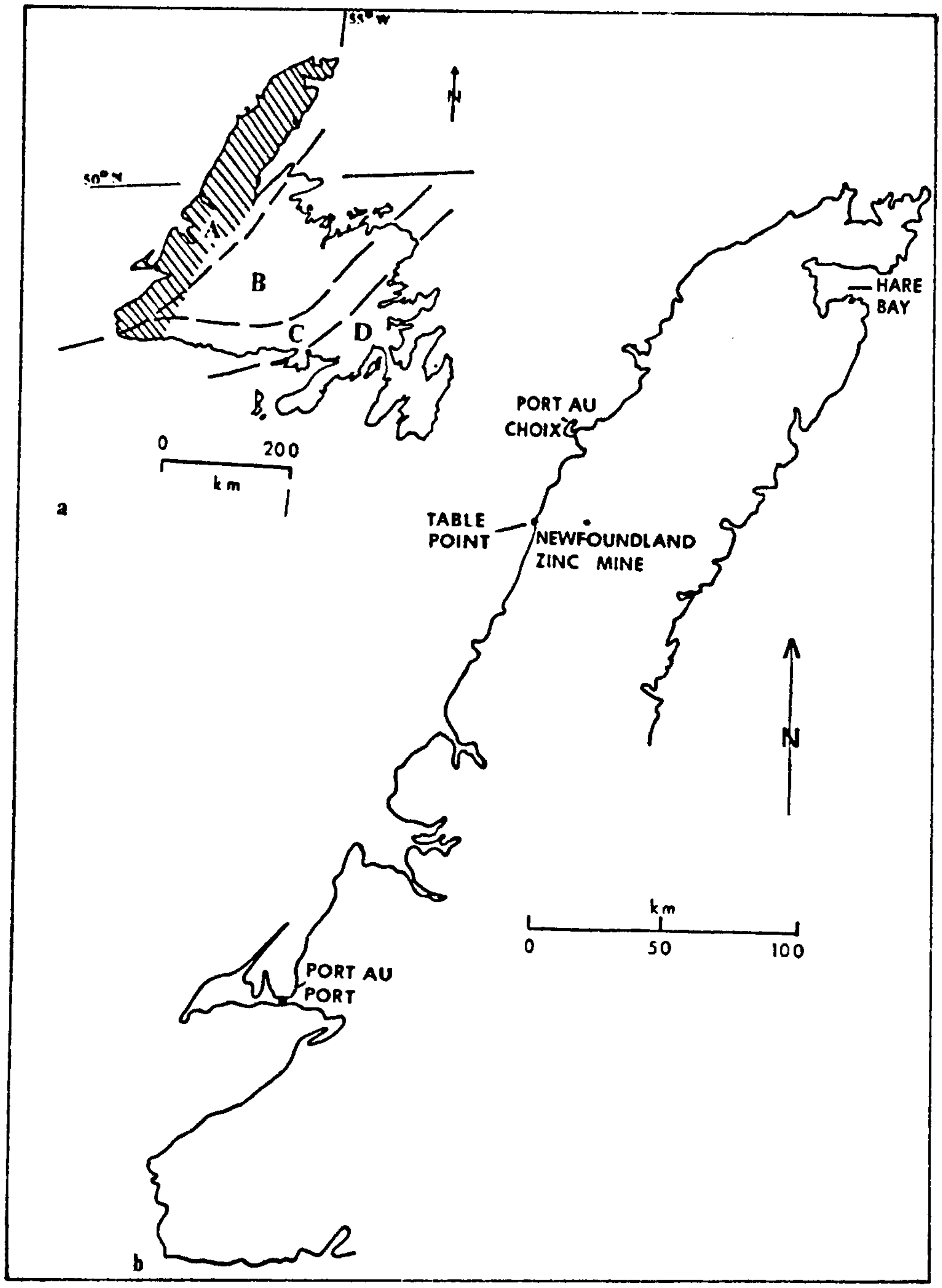


Fig. 1:1. Locality map of Newfoundland.
a) Tectono-stratigraphic zonation: A is the Humber Zone; B the Dunnage Zone; C the Gander Zone and D the Avalon Zone of Williams 1978 (after Lane 1984).
b) Enlargement of shaded area of a, indicating areas discussed in text.

Williams & Hatcher 1982), and outcrop as excellent coastal exposure.

1:2. GEOLOGIC HISTORY OF THE HUMBER TECTONO-STRATIGRAPHIC ZONE

An uplifted Grenville basement (1.7Ma; Lane 1984) of granitic and gneissic rocks forms the geographic and geologic backbone of the Humber Zone (James & Stevens 1982). Lower Cambrian autochthonous and unconformable sedimentary cover comprises shallow water siliciclastics and minor carbonates of the Labrador Group (Nyman *et al*. 1984). Carbonate sediments of the succeeding Upper Cambrian March Point and Petit Jardin formations record the development and maintenance of a stable platform margin at the edge of the Iapetus Ocean (James & Stevens 1982, Lane 1984, Stouge 1984). They consist of both low-energy shallow water and thickly bedded shoaling upward cyclic sequences (James & Stevens 1982, James *et al*. 1988).

Overlying these, the Lower Ordovician St. George Group records two shoaling upward megacycles. Each is terminated by an extensively dolomitized sequence below a disconformity interpreted as an erosion surface (Knight 1985).

The Table Point Formation of the Table Head Group overlies the St. George Group (Klappa *et al*. 1980). Sediments of this formation indicate an initially slow deepening of the platform (Stouge 1984). With deposition of the Table Cove Formation, deep marine conditions were established as a consequence of collapse of the platform (Klappa et al. 1980). A progressive clastic transgression from west to east across the subsiding continental margin is indicated by the overlying Mainland Sandstone (Williams & Hatcher 1982, Stouge 1984).

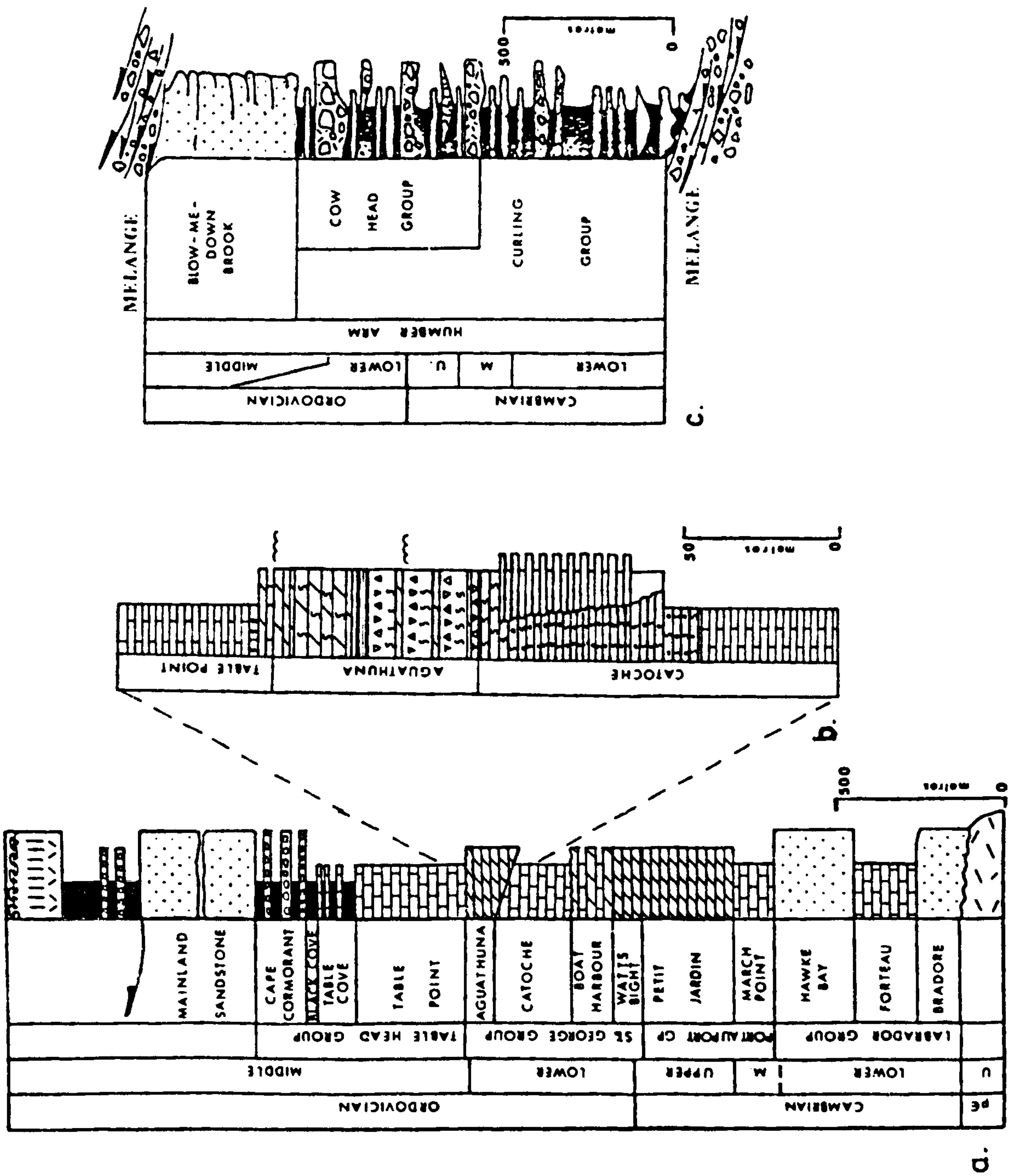
Westward transportation of large allochthons, which were probably related to eastward subduction and attempted submergence of the North American margin beneath an over-riding oceanic plate (Williams & Hatcher 1982), brought sedimentary, volcanic and igneous rocks, and ophiolite suites in close juxtaposition with the autochthonous sequences. Earliest obducted slices carried some of the allochthonous distal to proximal slope facies (Curling and Cow Head groups), which were coeval with the platform sequences (Williams & Hatcher 1982, James et al. 1987, Williams & Cawood 1986; Fig. 1:2).

Marine conditions prevailed after emplacement of the Taconic Allochthon, as evidenced by the neoautochthonous Middle Ordovician Long Point Group. Shallow marine and dominantly terrestrial conditions are developed later with the Clam Bank Formation (uppermost Silurian-lowermost Devonian; Berry & Boucot 1970) of the Port au Port Peninsula and successive Carboniferous deposits of the St. George, Deer Lake and St. Lawrence basins (Lane 1984).

Devonian (Acadian) orogenesis uplifted the Grenvillian basement, and faulted cover rocks through a series of north

Fig. 1:2. Stratigraphic succession of autochthonous and allochthonous Cambrian to middle Ordovician sequences of western Newfoundland.

a) Autochthonous sequence (after Lane 1984);
b) Enlargement of stratigraphic sequence studied herein (after Lane 1984);
c) Allochthonous sequence (after James & Stevens 1982).


c.
CAMBRIAN
ORDOVICIAN
LOWER
M
U.
LOWER
MIDDLE
HUMBER ARM
MELANGE
BLOW-ME-DOWN BROOK
COW HEAD GROUP
CURLING GROUP
MELANGE
500
metres
0
b.
CATOCHE
AGUATHUNA
TABLE POINT
50
metres
0
a.
pC
CAMBRIAN
ORDOVICIAN
U
LOWER
M
UPPER
LOWER
MIDDLE
LABRADOR GROUP
PORT AU PORT GP
St. GEORGE GROUP
TABLE HEAD GROUP
BRADORE
FORTEAU
HAWKE BAY
MARCH POINT
PETIT JARDIN
WATTS BIGHT
BOAT HARBOUR
CATOCHE
AGUATHUNA
TABLE POINT
TABLE COVE
BLACK COVE
CAPE CORMORANT
SANDSTONE
MAINLAND
500
metres
0

trending faults (Lane 1984). Mississippi Valley type mineralisation has affected Cambrian and Ordovician platform strata. Mineralised zones are most commonly related to the north trending faults (Lane 1984).

1:3. PREVIOUS STUDIES

The earliest documentation of Newfoundland geology was in Logan's (1864) discussion of the geology of Canada, closely followed by Billings' (1865) documentation of Lower Paleozoic fossils then known on the North American continent. Both works considered Geological Survey of Canada collections assembled by James Richardson during field work in western Newfoundland.

Further regional studies culminated in Schuchert & Dunbar's (1934) stratigraphy of western Newfoundland. Lower parts of the Ordovician were described as consisting of a thick series of greenish shales and shaly limestones (the Green Point Series), unconformably overlain by shallow water rocks of the St. George Series, which were in turn succeeded "with sharp erosional contact" (Schuchert & Dunbar 1934, p. 64) by the Middle Ordovician Table Head Series.

Contemporaneity of Cow Head Group strata with the above-mentioned sequences was later established (Kindle & Whittington 1958, Whittington & Kindle 1963). Further studies by Rodgers & Neale (1963), Stevens (1970) and Williams (1978) provided a plausible mechanism for their juxtaposition, with overlying ophiolites, by means of thrust slices obducted during attempted submergence of continental margin beneath an over-riding oceanic lithosphere during closure of the Iapetus Ocean.

Recent lithostratigraphic investigations (Kluyver 1975, Knight 1977, 1978, 1980, 1985, Klappa & James 1980, Pratt & James 1982, Cumming 1983, Stouge 1983a, 1983b, Haywick & James 1984, Lane 1984, James and Stevens 1986, Pohler et al. 1987, James et al. 1987, Knight and James 1987) has established the succession and paleoenvironments of Lower to Middle Ordovician sequences throughout much of the Great Northern Peninsula. The Table Head Group (Klappa et al. 1980) and St. George Group (Knight & James 1987) have recently been redefined.

Varying thicknesses of Lower Ordovician platformal rocks throughout this area are apparent, and the presence throughout much of western Newfoundland of at least two unconformities is postulated on lithologic grounds (Stouge 1983b, Knight 1985). The uppermost, affecting the upper part of the Aguathuna Formation is thought to represent the Knox-Beekmantown Unconformity of continental North America which separates the Sauk and Tippecanoe sequences of Sloss (1963). Deposition of the St. George Group is thought to have taken place on a platform of irregular relief and to have been affected by transgressive-regressive sea-level cycles (James & Stevens 1982, Barnes 1984, Knight & James 1987).

Preliminary faunal studies (Raymond 1925, Reudemann 1947, Erdtmann 1971, 1976, Berry 1972, Fortey 1975, 1979, Ross 1975, Flower 1978) indicated a diverse and abundant macrofauna both on the platform, with tropical reefs and mounds, and on the continental slope. These faunas have been used to correlate with the trilobite and brachiopod zones of North America (Boyce 1985), and graptolite zones of Europe (Bergström et al. 1974) and Australia (Williams et al. 1987). Occurrence of the macrofauna within the St. George Group is limited and poorly studied, and therefore allows correlation of only a few isolated horizons. The Cow Head Group has a more diverse fauna, and is more easily correlated on regional and global scales.

Pioneering biostratigraphic studies on conodonts (e.g. Ethington & Clark 1971, Sweet et al. 1971), encouraged several reconnaissance studies of conodonts from Ordovician and Upper Cambrian rocks of Newfoundland (Barnes & Tuke 1970, Fåhraeus 1970, 1977, Fåhraeus & Nowlan 1978, Bergström 1979, Stouge 1982, Stouge & Boyce 1983, Pohler et al. 1986, Bagnoli et al. in press, Barnes in press). Conodonts of the St. George Group were first described by Barnes & Tuke (1970), for which only two northern localities were sampled, yielding only a limited fauna. A detailed study of the Table Head Group (Stouge 1984) was preceded by publication of a preliminary zonation of the underlying St. George Group conodonts (Stouge 1982). The cyclic appearance of North

Atlantic and Midcontinent province conodont faunas was related to sea level changes, with influx of North Atlantic Province conodonts representing a response to transgression, and dominance of Midcontinent faunas corresponding with periods of regression (see also Barnes & Fåhraeus 1975). Only conodonts of proven biostratigraphic utility were documented, and multielement reconstructions of some of the recovered conodonts were not possible (Stouge 1982, p. 2). Stouge stated (p. 10) that a substantial interval of the Aguathuna Formation was barren of conodonts. Subsequent collections by T. Lane from these strata, as part of a study of mineralization in and around the Daniels Harbour area, and by this author, has yielded a conodont fauna. It is therefore evident that Stouge's (1982) conodont zonation was as relatively imprecise as that of macrofossils (Boyce 1985).

These studies are currently being amplified by detailed biostratigraphic, paleoecologic and taxonomic investigations of allochthonous and autochthonous sequence conodonts (Boyce 1985, Kenna 1985, Pohler et al. 1986, Bagnoli in press, Barnes in press).

Conodonts around the Canadian-Whiterock boundary are not well known (Stouge 1982). Canadian faunas in the North American continent are dominated by conodontophorids with simple cone apparatuses (Ethington & Clark 1971); those of the Whiterock more commonly bear a number of denticulate processes and develop more complex apparatuses (Sweet et al.

1971). Rocks recording transitional faunas are uncommon in North America, which was affected by widespread regression and lack of deposition at this time (Flower 1978).

1:4. PURPOSE OF THIS STUDY

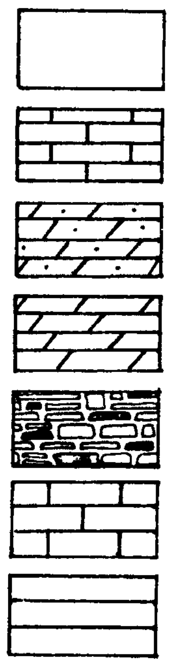
This study therefore has four principal aims: (1) to provide a taxonomic study of middle Lower to lower Middle Ordovician conodonts of the Catoche and Aguathuna formations of the St. George Group and the basal Table Head Group; (2) to construct a detailed conodont biostratigraphy of this interval by comparison of a number of sequences within the one depositional basin; (3) to compare the conodonts faunas with those from correlative sequences elsewhere in western Newfoundland to provide a more precise correlation; and (4) to compare these platform faunas with those of deeper water sequences, and to assess the paleoecological preferences and controls of selected taxa.

1:5. METHOD OF APPROACH

Eight cores through strata surrounding the Mississippi Valley type sphalerite deposits at Daniels Harbour were sampled for conodonts at regular intervals (Fig. 1:3). One hundred and fourty nine samples were processed from a stratigraphic interval of approximately 160 m. A complete section exposed at nearby Table Point was also sampled at

Fig. 1:3. Surface geology of the Daniel's Harbour - Table Point - Newfoundland Zinc Mines area, indicating location of sampled drill cores (after Teck Ltd. preliminary geology map NTS 12-I,3-6,10,11. Included with permission of T. Lane.) Grid reference information from Bellburns topographic 1:50,000 sheet 12-I/6 and 12-I/5 edition 2 MCE Series A781.

LEGEND



Humber Arm/unnamed

Table Head Group

Aguathuna Formation

Upper Catoche Formation

Pseudobreccia

Catoche Formation below ore horizon

Older sequences

A1 Location of drill hole, number D.D.H. A1

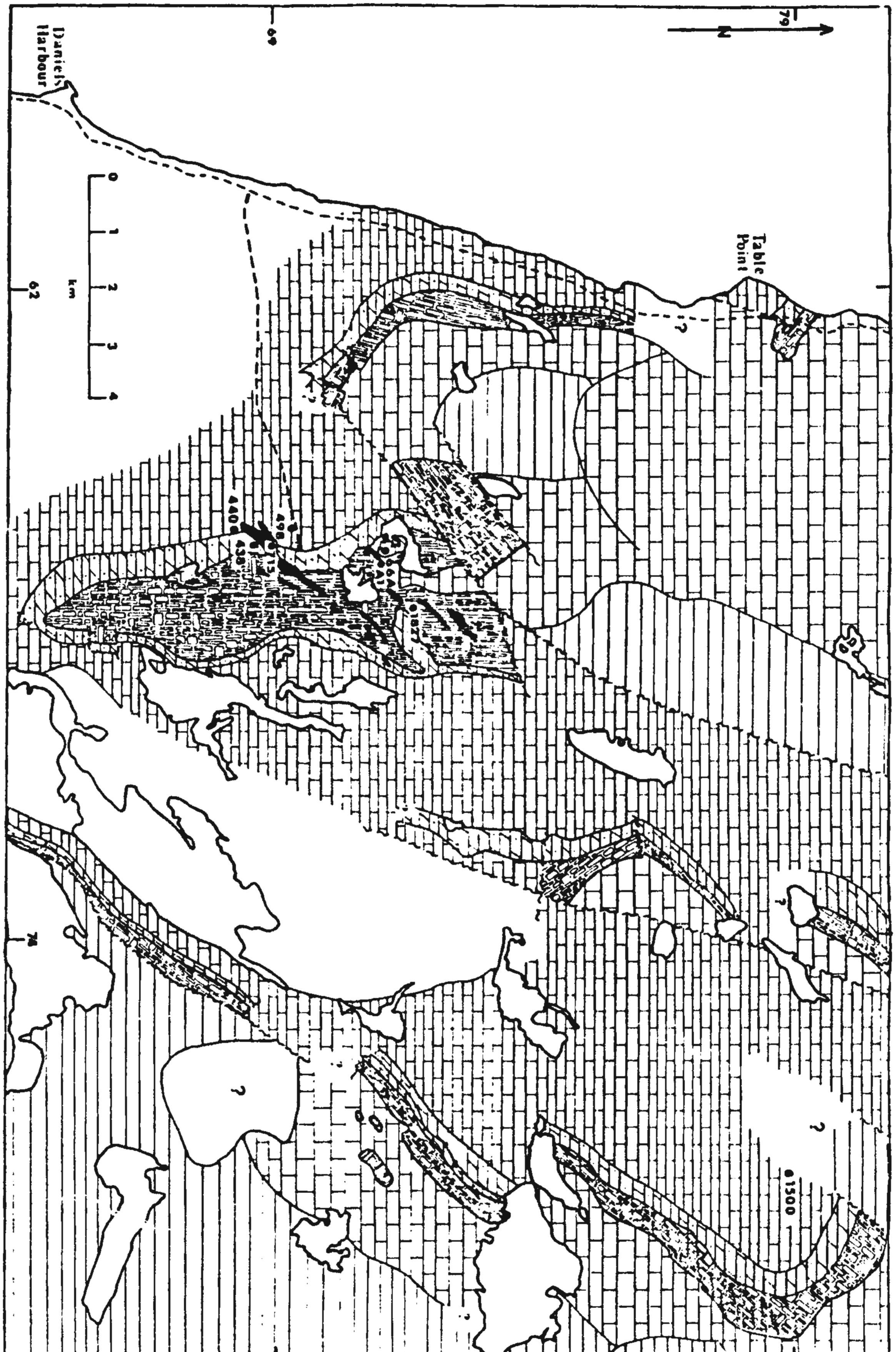
? Relationship of strata unknown

------ Paved road

Conformable contact

~~~~ Fault

Ore concentration
~~~~


Daniels Harbour
Table Point
km
0
1
2
3
4
62
69
74
79
N
?
1500
1877

approximately two metre intervals (40 samples). Similarly, a complete section of rocks lithostratigraphically equivalent to those collected at Table Point was collected from west of the Gravels on Port au Port Peninsula (32 samples). Samples taken from core ranged from 200 to 500 g; those taken from outcrop averaged two kg.

Thirty-six additional samples of upper Catoche, Aguathuna and lower Table Head lithologies from outcrop at Hare Bay (Fig. 1:4), Port au Choix (Fig. 1:5), east of The Gravels and the Aguathuna area of Port au Port (Fig. 1:6) were collected by N.P. James and B. Stait. In total, 149 core samples and 108 outcrop samples were included in this study.

Outcrop localities were easily reached by road, except for the Hare Bay outcrop, which was only accessible by boat (see locality maps 1:3 to 1:6). Drill cores taken from the area of Newfoundland Zinc Mines Daniels Harbour operations were made available by T. Lane of Teck Explorations Ltd.

Most of the samples were dolostone, or dolomitized limestone, and required digestion in dilute (10%) formic acid. To prevent etching and severe surface alteration of the liberated conodonts, acid-resistant residues were sieved daily using 25 (710 um) and 200 (75 um) mesh sieves. The few limestone samples collected were digested in dilute (10%) acetic acid. Tetrabromoethane was used in heavy liquid separation of the insoluble residues. The heavy fraction of the residue was then picked for conodonts.

Fig. 1:4. Location of samples collected from the Hare Bay area. Large dots indicate collecting locality; towns represented by small dots; roads shown as dashed lines. Grid reference from St. Julien's 1:50,000 topographic sheet 2M/4 edition 2 series A 781.

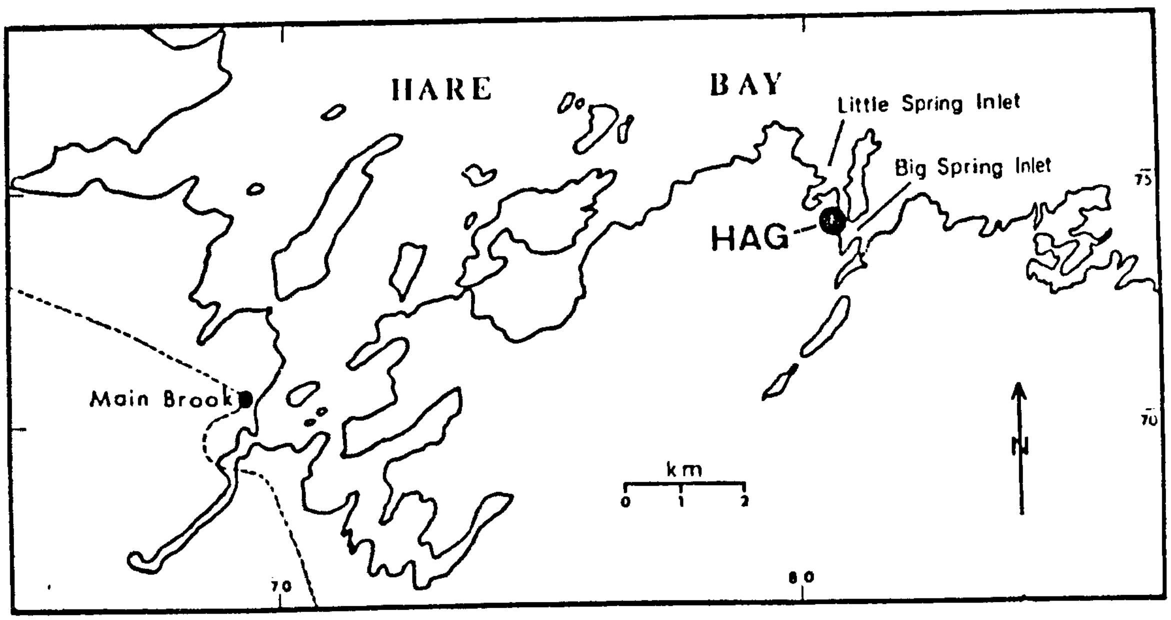


Fig. 1:5. Location of samples collected from the region of Port au Choix Peninsula. Settlements are indicated by concentration of dots; bold letters refer to sample numbers; major roads are shown as solid lines; otherwise symbols as for Fig. 1:4. Grid information from Port Saunders 1:50,000 topographic sheet 12-I/11 edition 2 MCE Series A 781.

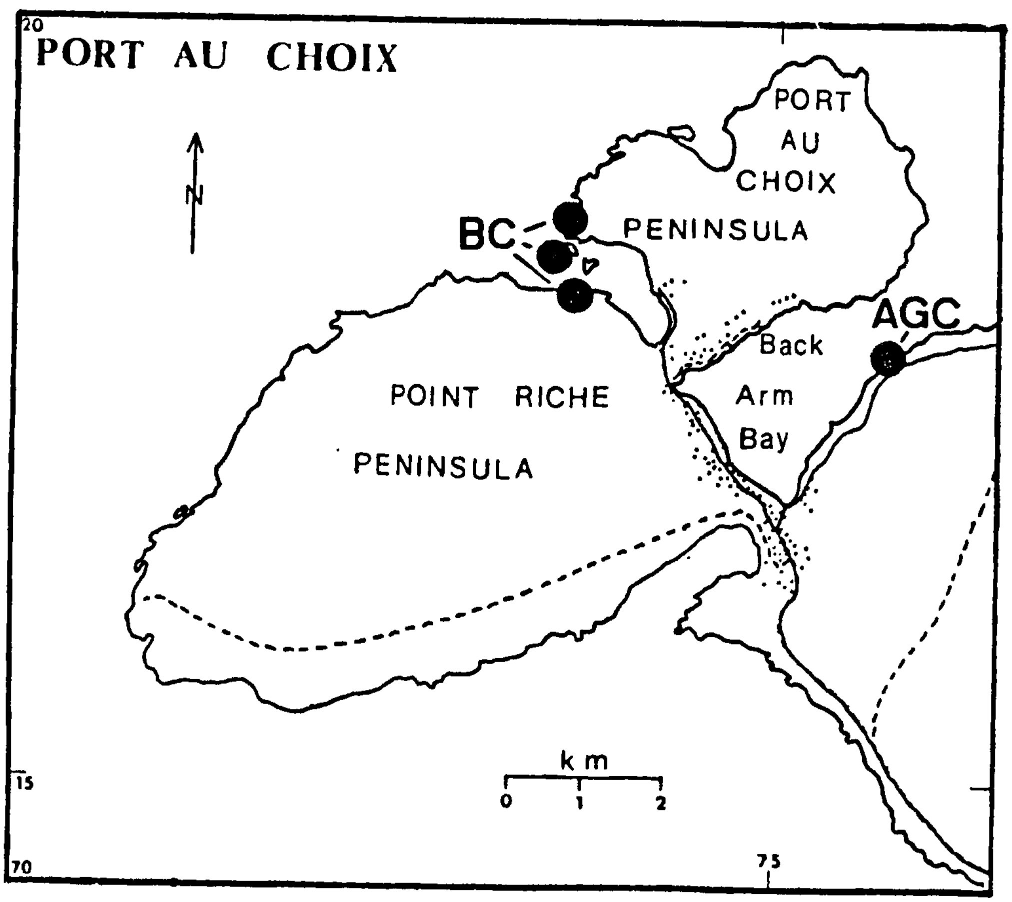
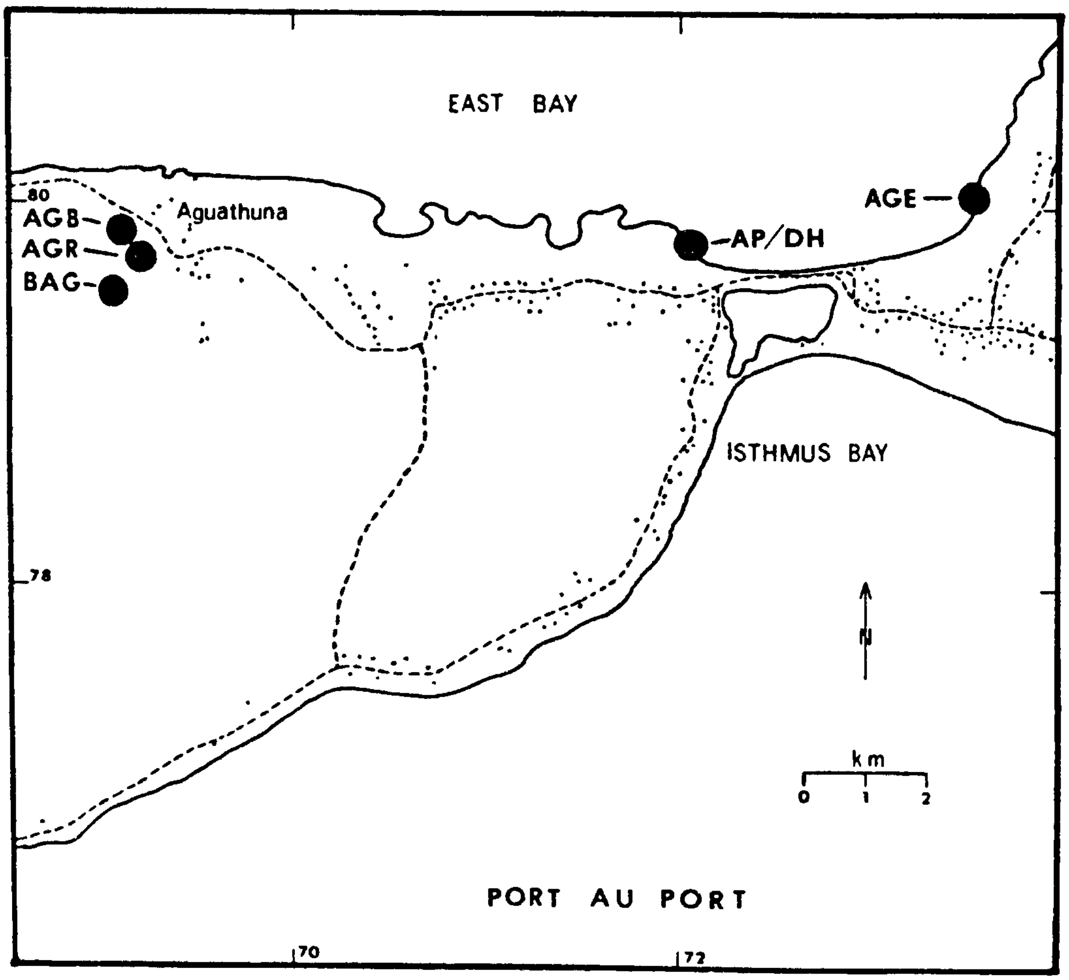


Fig. 1:6. Location of samples collected from on and near Port au Port Peninsula. Symbols as for Fig. 1:5. Grid information from Stevenville 1:50,000 topographic sheet 12-B/10 edition 5 MCE Series A 781.



Conodont specimens were photographed using a Wild M400 Photomakroscop. Specimens were not coated with ammonium chloride so that details of internal structure remained visible. Where depth of field required other than light photography, specimens were photographed using a Joel Scanning Electron Microscope.

Chapter 2

LITHOSTRATIGRAPHY

2:1. INTRODUCTION

The St. George Group (Lower Ordovician) is one of the upper units of autochthonous platformal carbonates deposited in a miogeoclinal setting along the margin of the Lower Paleozoic Iapetus Ocean now preserved in western Newfoundland (Klappa & James 1980, Fig. 2:1). Sequences studied herein comprise the upper St. George Group, from lower Catoche Formation through the Aguathuna Formation, and into the lowermost Table Point Formation of the Table Head Group. This comprises much of the younger shallowing upwards megacycle of the St. George Group (Knight & James 1987).

The St. George Group crops out along a discontinuous sinuous belt from the Port au Port Peninsula in the south, to Cape Norman and Hare Bay in the north (Pratt & James 1982, Stouge 1982; Fig. 2:1).

Coastal sequences are readily accessible by road, or by boat. The more densely vegetated inland outcrop is commonly accessible only by helicopter, or on foot. Consequently the better understood sequences are located close to settlements, mineralized areas, or along shorelines. Recent investigations have delineated previously unknown, less readily accessible outcrop of St. George strata in the

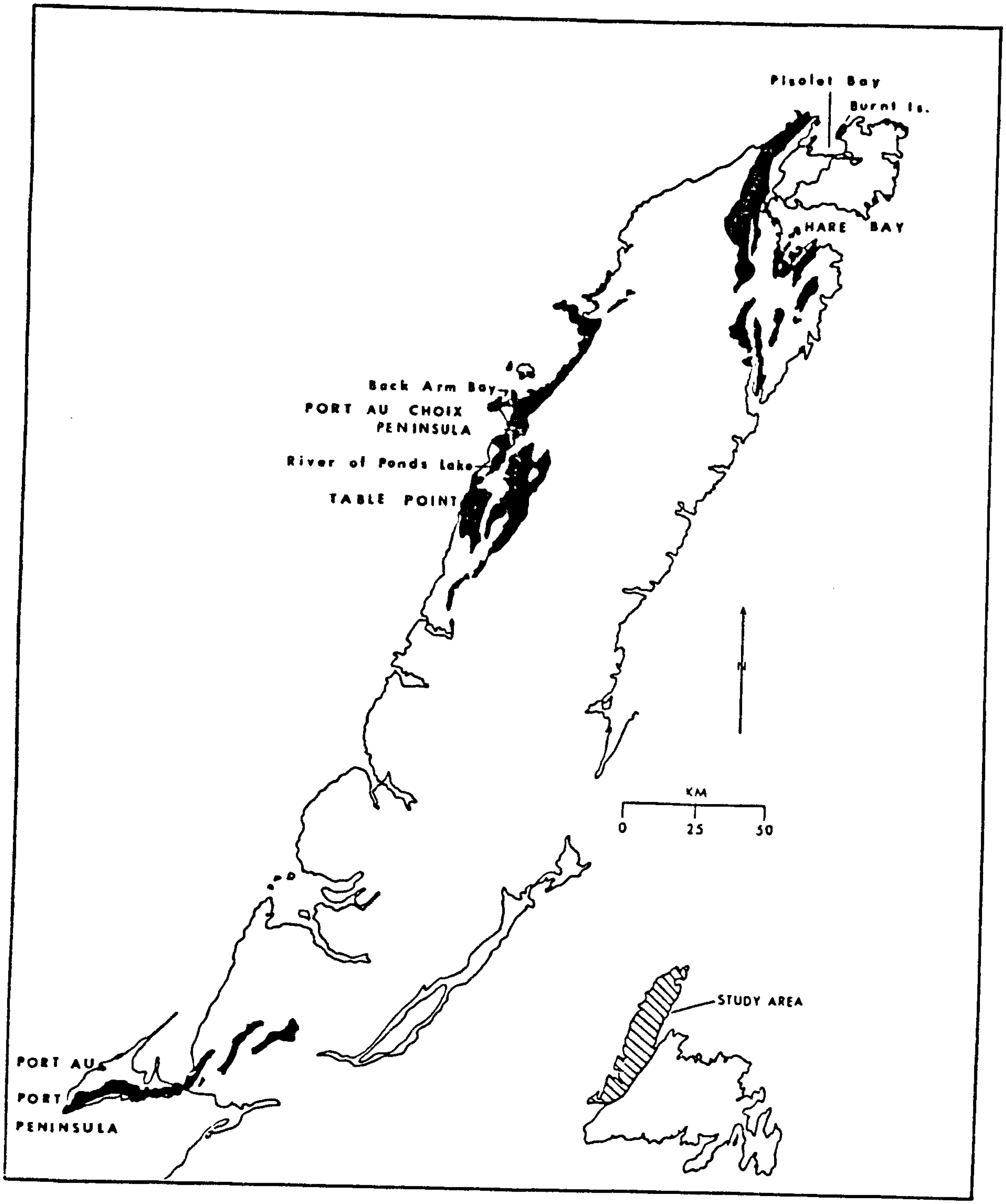


Fig. 2:1. Outcrop of the St. George Group in western Newfoundland (modified from Haywick & James 1984).

Portland Creek area (Knight, pers. comm., 1985) and near Cape Norman (James, pers. comm., 1986).

The Great Northern Peninsula is dominated by a system of north to north-east trending faults, with both vertical and horizontal components of movement (Stouge 1984). A second north-west trending set of faults locally affects St. George Group strata. Steepened bedding is common close to major faults. All strata sampled are relatively flat-lying and undeformed, although Ordovician autochthonous strata in the Daniel's Harbour-Table Point area is folded into large synclines and anticlines (Stouge 1984, Fig. 1:3). Drill cores are, in most cases, oriented perpendicular to dip, and thus record real stratigraphic thickness.

2:2. NOMENCLATURE AND GENERAL OVERVIEW

The development of nomenclature for the St. George Group, together with that for over- and underlying units is summarized in Table 2:1. The terminology of Knight & James (1987) is followed herein.

2:2:1. ST. GEORGE GROUP

The St. George Group was first delineated as a sequence of distinct strata by Schuchert & Dunbar (1934). Although lower portions of their St. George Formation are now included in the Port au Port Group (Knight 1980b), much of the St.

Table 2:1. Stratigraphic nomenclature used for Lower Ordovician autochthonous rocks in western Newfoundland, indicating approximate stratigraphic equivalence of rock units of different authors (modified from Knight & James 1987).

- 23 -

AUTHOR YEAR	AREA	OVERLYING UNIT	LOWER ORDOVICIAN NOMENCLATURE	UNDERLYING UNIT
LOGAN 1863	W NFLD	M TO K	QUEBEC GROUP: I TO D	POTSDAM GROUP A TO C
SCHUCHERT & DUNBAR 1934	W NFLD	ORDOVICIAN: TABLE HEAD SERIES	ORDOVICIAN: ST GEORGE SERIES	CAMBRIAN: MARCH POINT SERIES & LABRADOR SERIES
COOPER 1937	HARE BAY	MAIN ISLAND LST	SOUTHERN ARM LST BRENT ISLAND LST ?	
WHITTINGTON & KINDLE 1963,5,9	W NFLD	TABLE HEAD FMN	ST GEORGE FMN	PETIT JARDIN & MARCH POINT FMNS
BESAW 1974	PORT AU PORT	TABLE HEAD GROUP	ST GEORGE GP: PORT AU PORT UNIT WHITE HILLS UNIT PINE TREE UNIT PIGEON HEAD UNIT LOWER COVE UNIT	
KLUYVER 1975	PORT AU CHOIX	TABLE HEAD GROUP	PORT AU CHOIX FMN CATOCHE FMN BARBACE POINT FMN ?	
COLLINS & SMITH 1975	DANIELS HARBOUR	TABLE HEAD FMN	CYCLIC DOLOMITES DARK GRAY DOLOMITE LOWER LIMESTONE ?	
LEVESQUE 1977	PORT AU PORT TO PORT AU CHOIX		ST GEORGE FMN: UPPER CYCLIC MBR MIDDLE LIMESTONE MBR LOWER CYCLIC MBR	PETIT JARDIN & MARCH POINT FMNS
KNIGHT 1977	NORTHERN PENINSULA	TABLE HEAD FMN	ST GEORGE GP: SILICEOUS DOLOMITE FMN DIAGENETIC CARBONATES CATOCHE FMN WATTS BIGHT FMN UNFORTUNATE COVE FMN	DOLOMITE & MICRITE FMN
KNIGHT 1980	NORTHERN PENINSULA	TABLE HEAD GROUP	ST GEORGE GP: BELLBURNS FMN CATOCHE FMN BOAT HARBOUR FMN WATTS BIGHT FMN	PETIT JARDIN & MARCH POINT FMNS
JAMES & STEVENS 1982	W NFLD	TABLE HEAD GROUP	ST GEORGE GP: AGUATHUNA FMN CATOCHE FMN ISTHMUS BAY FMN	PETIT JARDIN & MARCH POINT FMNS
KNIGHT & JAMES 1987	W NFLD	TABLE HEAD GROUP	ST GEORGE GP: AGUATHUNA FMN CATOCHE FMN BOAT HARBOUR FMN BIGHT FMN	PORT AU PORT GROUP

George sequence has long been recognized as a coherent unit, separate from overlying Table Head Group strata.

The rocks are a sequence of shallow-water platformal sediments deposited under shallow subtidal to peritidal conditions (Pratt & James 1982, 1986). Constituent lithologies include limestone, dolomitic limestone, dolostone, with minor dolomitic and calcareous shales. They are less siliciclastic, and more fossiliferous than underlying Cambrian carbonates of the Port au Port Group (Knight 1977, Knight & James, 1987). The overlying Table Head Group is distinguished by less dolomitization; basal strata are typically rubbly weathering, dark grey limestone which are distinct from the laminated to massive tan to light grey dolostone of the underlying Aguathuna Formation (Fig. 2:2).

The St. George Group is predominantly of Lower Ordovician (Canadian) age, ranging from Gasconadian through to Lower Whiterock (Flower 1978, Stouge 1984). Two significant hiatuses (Knight 1985), corresponding with regressive stages of two transgressive-regressive megacycles (Knight & James 1987), are proposed within these strata. Trilobites (Boyce 1985) and cephalopods (Flower 1978) indicate that the shelly fossil Zone G_1 of Utah is missing from the lower sequence. The upper omission surface may correspond with an uppermost Canadian (Valhallan?) - lower Whiterock interval (Fortey 1979, Stouge 1982, see Chapter 3 of this study).

Fig. 2:2. Dark grey rubbly weathering limestones of the Table Point Formation (T) overlying the buff to light grey dolostones of the Aguathuna Formation (A) at Table Point. Vertical distance between level of letters A and T is approximately 1.5 m.

A network of collapse breccias is located close to the north-east trending faults. Some of these postdate deposition of the Catoche Formation and may be stratiform or discordant (Knight 1985). Pronounced development of such breccias in the upper Catoche and Aguathuna formations in the Daniel's Harbour mine area may be associated with structural depressions in the pre-Middle Ordovician landscape (Lane 1984). Intraformational breccias represent early diagenetic dissolution surfaces resulting from exposure and the transition from subtidal to supratidal lithofacies (Lane 1984). Oligomictic breccias, formed by stratabound dissolution beneath the exposed platform (Lane 1984) may be the result of karst development, and collapse of shallow caves (Twidale 1973, Knight 1985, Mussman & Read 1986). Polymictic breccias of the Catoche and Aguathuna formations accumulated in vertical dilation openings along the margins of structural depressions. Their genesis is considered to be related to an unconformity within the upper part of the Aguathuna Formation (Lane 1984, Knight 1985, Mussman & Read 1986), and recognized throughout the Appalachians as the Knox-Beekmantown unconformity (Quinlan & Beaumont 1984, Mussman & Read 1986).

Formal revision of constituent formations is complete (Knight & James, 1987). Four formations are recognized: the lowermost a predominantly subtidal unit (Watts Bight Formation), overlain by the peritidal Boat Harbour Formation, followed by a repetition of the subtidal (Catoche Formation)-peritidal (Aguathuna Formation) cycle.

2:2:2. WATTS BIGHT FORMATION

Generally subtidal, muddy bioturbated carbonates with well-developed thrombolite mounds are characteristic of this formation. Sediments vary from dolostone to limestone. Commonly with conformable lower and upper contacts (Haywick & James 1984), this formation is 70 to 90 m thick, and contains ellesmerocerid cephalopods, gastropods, trilobites and conodonts in modest to high abundance (Knight & James, 1987).

Deposition is presumed to have taken place in a generally subtidal, open shelf environment with peritidal lithologies at base recording periods of slowed subsidence relative to sea level (Haywick & James 1984).

2:2:3. BOAT HARBOUR FORMATION

Repetitive sequences of interbedded dark grey limestone with buff to light grey dolostone within a series of complete or partial shallowing-upward sequences comprise the Boat Harbour Formation (Stouge & Boyce 1983, Haywick & James 1984). The base of this formation is locally extensively dolomitized, often with dolostone-chert breccia beds (Haywick & James 1984), and is succeeded by a variable (60 to 160 m) thickness of low-energy sediments containing trilobites, gastropods, cephalopods, ostracods, pelmatozoan echinoderms, brachiopods, conodonts and calcareous algae (Stouge 1982, Knight & James, 1987). Both lower and upper formational contacts are conformable.

A bed 17 to 36 m from the top of the formation rich in chert and dolomite pebbles and regional in extent (Pratt 1979), is thought to be an exposure surface representing non-deposition or erosion during Hintze's (1951) Zone G_1 (Haywick & James 1984, Boyce 1985). It also marks a change in lithology: lower beds are fossiliferous and typically intensely bioturbated mudstone to packstone and dolostone; above the disconformity, limestone is more common, with grainstone, stromatolites and thrombolitic mounds more abundant.

The basal part of the formation indicates low energy, muddy peritidal and shallow subtidal sedimentation with some shallow open subtidal environments, intertidal carbonate mud flats and higher energy subtidal boundstone mound-dominated areas. This was followed by subaerial exposure accompanied by widespread dolomitization and silicification, the formation of dolomite breccias, solution surfaces and caves (N. James, pers. comm. 1987). Exposure surfaces were later covered by cyclic, somewhat higher energy, shallow, low intertidal to supratidal sediments deposited on mixed carbonate sand and mud flats (Knight 1985, Knight & James, 1987).

2:2:4. CATOCHE FORMATION

This is an approximately 160 m thick sequence of rubbly, well bedded, bioturbated and fossiliferous dark grey limestones with minor ripple marked grainstone lenses (Stouge & Boyce 1983, Haywick & James 1984, Knight 1985). Limestones are texturally mudstones to wackestones (Knight 1985). Dolomitization is common. Dolomite is commonly localized to burrows and skeletal particles , or is scattered in the matrix between elements (Haywick & James 1984). The uppermost 30 to 50 m is commonly affected by several phases of dolomitization (Fortey 1979, Knight 1985), culminating in the precipitation of white saddle dolomite into voids and fractures. This last phase also involved replacement of existing rock with the saddle dolomite. The resultant fabric has been termed pseudobreccia and this is coeval with, and frequently host to, sphalerite mineralization (Lane 1984, Haywick & James 1984, Knight 1985). In the north, pseudobreccias are located towards the middle of the Catoche Formation.

The Catoche Formation represents an apparently continuous succession from its conformable contact with the underlying last thick bed of laminated and mud-cracked, shaly dolomitic mudstone or dolostone of the Boat Harbour Formation to the conformably overlying Aguathuna Formation (Stouge 1982). Its upper contact is placed above the last bed of well bedded, finely crystalline, diagenetic dolostone and below the the first bed of yellow weathering, light grey to grey, frequently laminated, microcrystalline dolostone.

Trilobites (Fortey, 1979, Boyce 1985) indicate a late Canadian age corresponding with trilobite zones (Hintze 1951) H (Fortey 1979) or I and J (Boyce 1985). Cephalopods of the Catoche Formation are of Jeffersonian and Cassinian age (Flower 1978, Pratt & James 1982). Graptolites are not common within this sequence, but specimens from basal Aguathuna Formation and Catoche Formation correlate with Ibexian faunas (early Arenig; Williams et al. 1987). The constituent fauna also includes gastropods, ostracodes, pelmatozoan echinoderms, sponges, receptaculitids, corals, calcareous algae, brachiopods and conodonts, commonly with stromatolite and thrombolite mounds (Knight & James, 1987). A more restricted fauna is found towards the top of the formation, with greatest diversity and abundance in the middle (Stouge 1982).

These dominantly open shelf subtidal limestones are thought to have been deposited in a subtidal setting (Fortey 1979, Haywick & James 1984) which gradually shallowed as deposition began to outpace relative subsidence (Lane 1984). Contact with the open ocean is indicated by the occurrence of cosmopolitan and pelagic trilobites and graptolites (Fortey 1979).

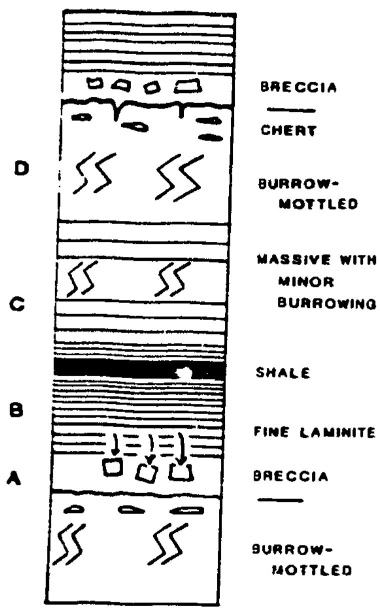
2:2:5. AGUATHUNA FORMATION

Within this formation, thick-bedded, burrowed, commonly microcrystalline dolostone is intercalated with shale and limestone (Stouge & Boyce 1983, Knight 1985, Knight & James, 1987). Limestone, texturally mudstone to packstone, is locally fossiliferous. Chert is common as thin veins, nodules and rounded pebbles (Stouge 1982). Much of this unit is peritidal, with cyclic sedimentation (Lane 1984, Knight 1985, Fig. 2:3).

The lower boundary of the Aguathuna Formation has been placed at the base of grey to light grey, finely crystalline, bioturbated and laminated dolostone beds overlying dark grey dolostone or limestone of the Catoche Formation. The contact is usually conformable (Haywick & James 1984), although strata at Back Arm Bay record only uppermost Aguathuna lithologies and contact with the Catoche Formation is possibly obscured by soil (B. Stait, pers. comm., 1985).

The upper contact, with Table Head Group, is placed where rubbly blue-black nodular limestone overlies fine, crystalline blue-grey dolostone. It may be conformable, as at Table Point, throughout much of the Daniel's Harbour mine and Port au Port areas, Port au Choix and Hare Bay (Stouge 1983a,b). However, a significant erosion surface separates these two units at the Aguathuna Quarry on Port au Port Peninsula (Flower 1978; Fig. 2:4).

The Aguathuna Formation is of variable thickness,



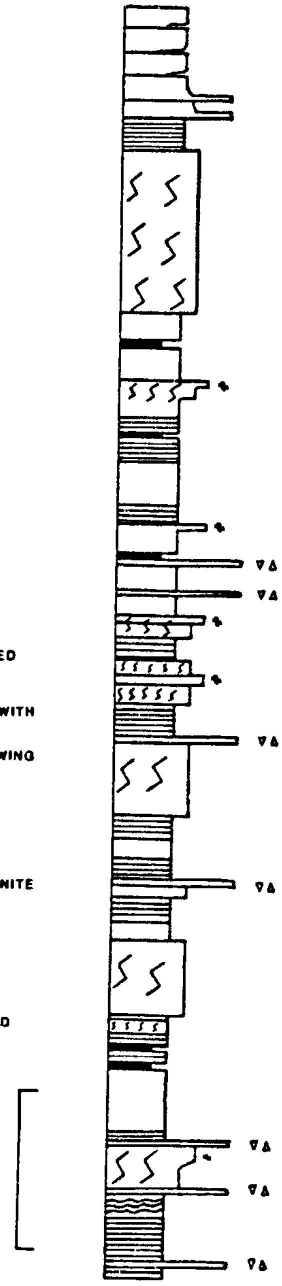


Fig. 2:3. Cyclicity in the Aguathuna Formation (after Lane, ms).

a) Idealized cycles, with A = breccia with clasts of fine laminite; B = fine laminates with or without shale; C = massive carbonates with minor burrow-mottling, and D = massive, burrow-mottled carbonate.

b) Cycles as preserved at Table Point.

lithology and age (Knight & James, 1987). This formation is usually 60 to 70 m thick, but varies greatly, being five metres at Back Arm Bay, 15 m on the western shore of River of Ponds Lake although it is 60 m thick on the eastern shore of this lake, seven to 16 m in the Pisolet Bay area, and is demonstrably absent on Burnt Island (Knight 1985). Regional variations in thickness are similar to those of the Knox - Beekmantown unconformity in the southern Appalachians (Fortey 1979). Within the Daniel's Harbour area, significant variations in stratigraphic thickness are related to structural depressions associated with breccia bodies, with increased thickness restricted to uppermost strata (Lane 1984; Fig. 2:5). The overlying Table Point Formation is not affected by such thickening (Lane 1984). Consequently, structural depressions and the associated breccia bodies probably formed prior to deposition of the upper part of the Aguathuna Formation.

Pebble beds are common within this sequence. They are composed of angular fragments of dolostone, limestone and chert associated with green shale and stromatolitic dolostone (Fig. 2.6). A regional hiatus is thought to correspond to a pebble bed developed 15 m from the top of the Aguathuna Formation throughout the study area (Whittington & Kindle 1963, Stouge 1983, Knight 1985). This pebble bed contains thin limestone remnants, and brecciated lithologies similar to those overlying the pebble bed, supported by a matrix of

Fig. 2:4. Table Point (T) and Aguathuna formations at northernmost Aguathuna Quarry, Port au Port Peninsula. The unconformity cut down into the Aguathuna Formation (centre), and the resulting depression was later filled by Table Point Formation sediments. The exposed bedding plane surface is 12 m above the rubble at the lower end.

Fig. 2:5. Stratigraphic position of breccias in Catoche and Aguathuna formations at the Daniel's Harbour zinc mine, and their relationship with paleodepressions developed during deposition of the Aguathuna Formation. Dashed lines indicate lowest extent of dolomitization front; dotted lines enclose polymictic fine rock matrix breccias (BX3); BX1 = intraformational breccias; BX2 = oligomictic fine rock matrix breccias; ore bodies (not illustrated) are developed at level of BX2 in the upper Catoche Formation (Modified from Lane ms).

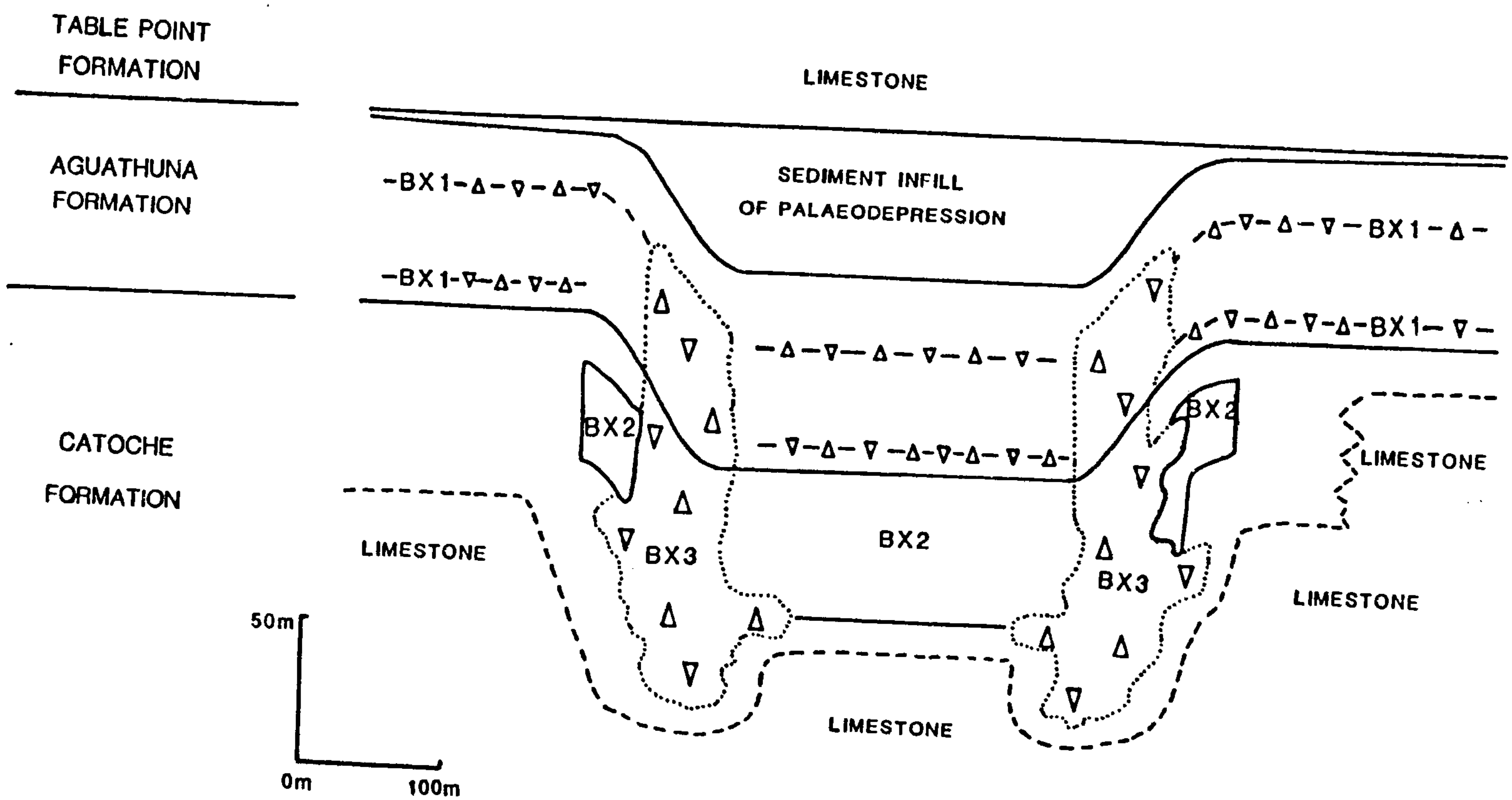


TABLE POINT FORMATION
AGUATHUNA FORMATION
CATOCHE FORMATION
LIMESTONE
SEDIMENT INFILL OF PALAEODEPRESSION
BX1
BX2
BX3
BX2
BX3
BX2
BX2
LIMESTONE
LIMESTONE
LIMESTONE
LIMESTONE
50m
0m
100m

Fig. 2:6. Pebble bed with chert and lithic fragments in dolomitic matrix, middle Aguathuna Formation, Table Point. Lens cap is approximately 5 cm in diameter.

medium crystalline dolomite. It is thought to have originated by dissolution and collapse, and account for some of the thickness variations within the Aguathuna Formation (Lane 1984).

The upper Catoche and Aguathuna formations contain few diagnostic macrofossils. Rare cephalopods indicate a Jeffersonian age for the majority of the Aguathuna Formation (Flower 1978, Pratt & James 1982). In the Daniels Harbour area, the uppermost Aguathuna Formation has yielded a sparse early Whiterock trilobite and ostracode fauna. This age is corroborated by the presence of a diverse fauna of conodonts of Midcontinent Fauna 4 affinity (Stouge 1982, this study). At Table Point, Bendigonian-4 stage graptolites (Arenig) are found low in the Aguathuna Formation (Williams et al. 1987).

Deposition in a predominantly intertidal-supratidal mudflat setting with periodic subaerial exposure, accompanied by weathering, dissolution and diagenesis is suggested by the cycles of the Aguathuna Formation (Lane 1984). Lateral variation of relief along exposure surfaces, rubble zones of chert fragments and lithic clasts, remnants of undissolved limestone resulted from karst dissolution (Knight 1985).

The upper Aguathuna Formation is characteristic of subtidal to intertidal mud deposition periodically interrupted by periods of non-deposition, possibly due to subaerial exposure, or build-up of mud flats to a level at which deposition was not possible (Lane 1984).

Tectonic instability during deposition of the Aguathuna Formation is suggested by variation in thickness and the development of structurally and lithostratigraphically controlled collapse breccias (Knight & James 1987).

2:3. LITHOSTRATIGRAPHIC SUCCESSION

In keeping with standard mine practice, drill core was logged in feet, down from the top; measurements were then recalculated to indicate stratigraphic thickness in metres above the base of core or collected interval.

Measured sections were logged under the premise that the base of the Aguathuna Formation is defined at the first laminated dolostones above microcrystalline dolostone. Subsequent redefinition (Knight & James 1987) of basal Aguathuna strata lowered this boundary several metres: the mine marker known as the "Worms" Marker, previously considered to be five to six metres beneath the Aguathuna Formation was therein included within this latter formation. In all following lithostratigraphic discussions pertaining to the Table Point-Daniel's Harbour region, the base of the Aguathuna Formation must therefore be considered to be from five to six metres lower than herein stated.

Drill cores D.D.H. 438, 440, A1, 498 were logged and sampled by the writer. Cores D.D.H. 1827, 66A and 715, logged and sampled by personnel of Teck Explorations Ltd., were made available by T. Lane. Samples from these were used to assist in the clarification of problems associated with provenance of breccias, relative ages of various horizons and occurrence and duration of possible depositional hiatuses. D.D.H. 1500, which was logged by T. Lane, was sampled by the writer.

Outcrop of the Aguathuna Formation at Table Point, west of The Gravels and the northernmost limestone quarry at Aguathuna on Port au Port Peninsula were measured and sampled by the author. Other sections included were measured by Professor N.P. James and Dr. B.A. Stait, with samples made available to provide a detailed biostratigraphic framework complementing ongoing regional lithostratigraphic and sedimentologic studies throughout western Newfoundland.

2:3:1. DANIEL'S HARBOUR MINE AREA

Location of all cores described below is given in Fig. 1:3.

2:3:1:1. - D.D.H. A1

This section comprises 77 m of the Catoche Formation (Figs. 3:5,3:6; Appendix A:1) of which 37 m are of the "Nodular Member", 20 m of "Burrowed Wackestone Member" and 20 m of the "Pelloidal Member" of Lane (ms).

The basal 37 m is a sequence of light to dark grey thickly bedded, calcareous mudstone, with nodular bands.

Rare chert nodules, and thin grainstone beds are preserved in this interval.

The succeeding 20 m consists of light to dark grey, brown weathering, burrow-mottled, commonly bioclastic limestones. Mottling in light and darker greys is variably developed. The limestones are texturally intraclastic mudstones. Flat-pebble conglomerate is common at the base of beds.

The overlying (and uppermost) 20 m consists of vuggy, sucrosic dolostone with pseudobreccias developed in the uppermost 13 m. Interbeds are massive, stylolitised, commonly bioturbated limestone with body fossils (common crinoid columnals and gastropods); stromatolitic laminae are visible;and grainstone layers and matrix dolomites are also present.

2:3:1:2. - D.D.H. 1827

This core samples 34 m of Catoche Formation, with the "Oval Mottles" marker bed 20 m from the base and the "66 Aquifer" marker 18 m from the base (Fig. 3:12, Appendix A:2). Lowermost strata consist of 10 m of moderately well developed pseudobreccia alternating with burrow mottled to massive limestone. The overlying 16 m comprises weakly developed pseudobreccia with interspersed massive to vuggy dolomite and one two metre thick bed of dololaminite. The uppermost eight metres of this core consists of light grey, massive limestone containing shaly stylolites and shale bands.

2:3:1:3. - D.D.H. 66A

Brecciated limestone and dolostone, 152 m thick, were sampled from this core (Fig. 3:13; Appendix A:3). The lower 26 m belong to the Catoche Formation. Disturbed textures are preserved in the lowermost five metres and uppermost 10 m of this interval; the middle portion consists of fine grained, massive dolostones.

The contact between Catoche and Aguathuna formations has been obscured by brecciation. This is usually placed at the base of the lowest laminates of the Aguathuna Formation, but lowest undisturbed laminates occur at a level correlated with middle Aguathuna Formation elsewhere. Similarly, the uppermost Catoche Formation may also be brecciated.

Polymictic breccia, 28 m thick, overlies the sequence of Catoche Formation lithology. Chert-rich horizons are common. Clasts of Aguathuna Formation lithology have been identified within these breccias.

The overlying 18 m, of oligomictic breccia, has many dark horizons containing shaly residues. Laminated clasts, possibly derived from the Aguathuna Formation, increase in abundance towards the top of this sequence.

Breccias of the succeeding 69 m are characterised by large to microscopic, mottled and laminated clasts. Breccias comprise approximately 60 per cent of this interval.

Massive, commonly mottled dolostone, with some dololaminite are preserved between breccias in thin to medium thick beds. Argillaceous residues and infill are common. Thinly bedded grainstones are present within uppermost strata. The lowest coherent laminated dolostone is located 23 m below the top of the uppermost breccia horizon; the mine marker bed termed the "Upper Argillite" is eight metres below this last breccia bed.

The uppermost 12 m of this section consists of mottled, or laminated, fine grained dolostone comparable with upper lithologies of the Aguathuna Formation.

2:3:1:4. - D.D.H. 438

The sampled sequence consists of approximately 56 m of Catoche Formation, overlain by 34 m of Aguathuna Formation (Fig. 3:14; Appendix A:4).

Below a pseudobreccia sequence, massive, light to heavily mottled dark to light grey or brown limestone is common, typically commencing with a thin layer of stylolitised flat-pebble conglomerate which grades upwards into massive to mottled limestone.

Development of pseudobreccias extends over a stratigraphic interval of 20 m. Only a few horizons have been altered past a vuggy sucrosic texture. The lowermost pseudobreccia bed has its base 25 m above the base of core. Interbeds in pseudobreccias may be vuggy, or pervasively dolomitized, but most commonly consist of stylolitized, burrow mottled limestone with shaly residues.

Above the pseudobreccia, the Catoche Formation consists of variously mottled, massive dark grey limestone to dolostone. The "Worms Marker" is 51 m above the base of section. Body fossils, such as crinoid columnals, shells and some gastropods are preserved in this interval.

Contact with the overlying Aguathuna Formation is apparently conformable. This is placed below the first laminated light to dark grey dolostone, and above the last light grey, weakly mottled, stylolitized limestone containing obvious body fossils.

The 34 m of the Aguathuna Formation is initially a sequence of laminites interspersed with brown to light grey mottled massive dolostone. Breccias, up to 0.5 m thick, with darker infill, and rounded pebble to vein cherts are common throughout this interval. Stouge's (1982) "Breccia Bed" at Table Point may correlate with a breccia containing rounded chert fragments, subangular clasts of light grey dolostone and shales at base and top, which is found 70 m above the base of this core.

Above this breccia bed, dolostones between laminates show pronounced burrow mottling. Laminae suggestive of stromatolites are preserved 75 m above the base. Typical complete or partial peritidal cycles of breccia or flat-pebble conglomerate to dololaminites to massive to burrow mottled dolostone are continued to the top of this sequence.

2:3:1:5. - D.D.H. 1500

Although drilled through Table Head Group and Aguathuna Formation strata, the uppermost 150 m was not cored. The sampled sequence commenced with 38 m of the upper Catoche Formation, conformably succeeded by 10 m of basal Aguathuna Formation (Fig. 3:15; Appendix A:5).

At the base, 12 m of locally burrow mottled, light grey to brown limestone are capped by the "Oval Mottles" marker. This is followed by 11 m of weakly developed pseudobreccia. Pseudobreccia beds, commonly less than 0.5 m thick, are separated by up to three metres thick sequences of vuggy to massive fine grained dolostone. The overlying 11 m, of dark grey dolostone and burrow mottled to massive fine grained limestone, contains the "Worms Marker" 32 m above the base of the succession.

The lower Aguathuna Formation, in this core, consists almost entirely of fine grained, massive dolostone with occasional thin dololaminite.

2:3:1:6. - D.D.H. 715

Dolostones from the middle Catoche Formation through to the upper Aguathuna Formation are recorded in this core:

approximately 46 m of the Catoche Formation are overlain by 64 m of the Aguathuna Formation (Fig. 3:16; Appendix A:6).

An initial 14 m interval of vuggy, sucrosic light grey to tan dolostone with thin pseudobreccia beds is overlain by 13 m of grey dolostone with well developed pseudobreccia.

These were followed by 20 m of dolomitized and burrow mottled dark to light grey, stylolitic massive dolostone, containing the "Oval Mottles" marker at its base and "Worms Marker" 41 m above the base of section. Minor brecciation is evident. Comparison of stratigraphic level of marker beds with other sections indicates possible thinning of this sequence (Fig. 2:7).

The boundary between Catoche and Aguathuna formations is apparently conformable. The Aguathuna Formation sequence is the typical cyclic peritidal succession. A chert band with breccias 13 m above the Catoche-Aguathuna Formation contact is most likely the breccia bed of Stouge (1982).

2:3:1:7. - D.D.H. 440 E/W

This drill hole extended 35 m into the Aguathuna Formation. Three metres of the Table Point Formation were also cored (Fig. 3:17, Appendix A:7). A continuous sequence through the upper Catoche and Aguathuna formations into basal Table Point Formation is recorded in a composite section of D.D.H. 438 and 440.

The cyclic deposition recorded earlier in the Aguathuna

Fig. 2:7. Lithostratigraphic correlation of Table Point, Aguathuna, Catoche and Boat Harbour formations in the Daniel's Harbour mine - Table Point area. Note thinning of the Catoche Formation in D.D.H. 715 when compared with D.D.H. 438 and 1500. Scale on sections is in 10 m increments; formation boundaries are indicated by bold lines, and major pseudobreccia development by PsBx; marker beds are indicated by numerals:-

1. upper unconformity surface near the top of the Aguathuna Formation;
2. "Upper Argillite" marker;
3. "Worms Marker";
4. "Mottled Chert" marker;
5. "Oval Mottles" marker;
6. "66 Aquifer" marker; and
7. unconformity surface near top of the Boat Harbour Formation.

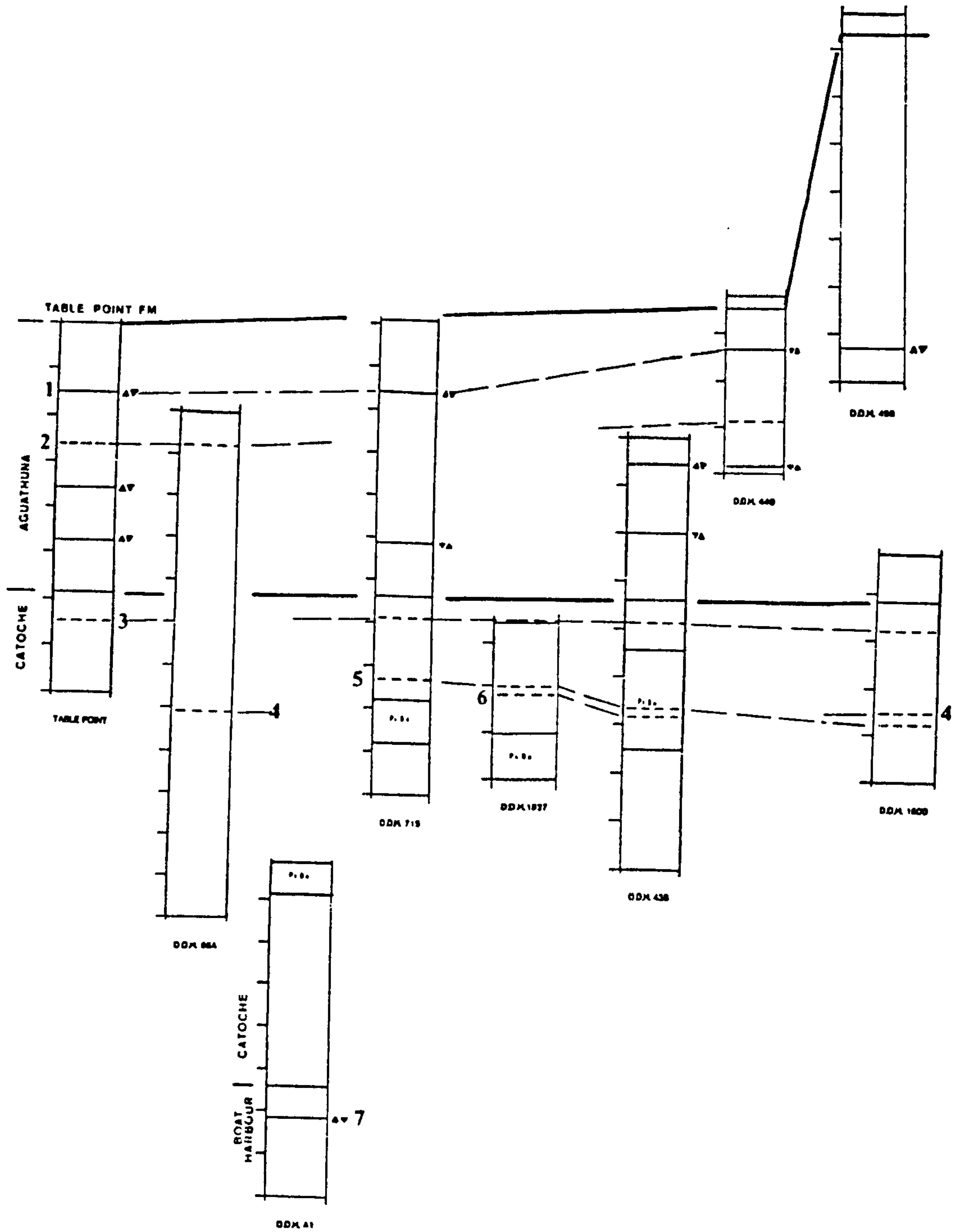


TABLE POINT FM
AGUATHUNA
CATOCHE
TABLE POINT
1
2
3
4
5
6
7
DDH 719
DDH 1837
DDH 438
CATOCHE
BOAT HARBOUR
4

Formation (D.D.H. 438) is continued in the lower 24 m of this core.

Above this interval, a chaotic pebble bed with chert and lithic fragments in a stylolitized matrix represents the regional unconformity preserved near or at the top of the Aguathuna Formation. In this core, it is 10 m below the contact of the Aguathuna and Table Point formations.

Strata overlying the pebble bed consist of massive, fine grained, commonly laminated, dolostone. Pebble lags and eroded hardgrounds are common at the base of beds.

The contact betweeen Aguathuna and Table Point formations is conformable within this section.

2:3:1:8. - D.D.H. 498

This section was drilled through a thick (137 m) sequence of the Aguathuna Formation. Included at the top is four metres of basal Table Point Formation (Fig. 3:18; Appendix A:8).

The usual cyclic pattern of lower Aguathuna Formation is preserved in the lowermost seven metres sampled. This interval is terminated by the unconformity surface normally preserved less than 15 m below the Table Point Formation: in this core section, it is 70 m below the base of the Table Point Formation.

Above this is a 43 m thick sequence of massive, burrow mottled, laminated to coarsely laminated dolostone with breccia. Breccias contain clasts of burrow mottled, laminated and rotated fragments.

The remaining 27 m of the Aguathuna Formation consists of grey dolostone with laminates and laminated, mud-supported rubble breccia, and rare massive horizons. Intercalated wackestones and shaly layers are preserved in the uppermost three metres of the Aguathuna Formation.

The Table Point Formation commences with a breccia containing rounded to subangular clasts, overlying the uppermost laminated dolostones of the Aguathuna Formation.

2:3:2. TABLE POINT - FRESHWATER COVE

An 80 m thick continuous sequence, from the stratigraphic level of pseudobreccias preserved in the Daniels Harbour mine, to basal Table Point Formation was sampled from a shore section between Freshwater Cove and Table Point (Figs. 1:3, 2:8, 3:4; Appendix A:9).

The basal nine metres thick pseudobreccia interval, with fine grained limestone interbeds and horizons with concentrations of chert nodules, is succeeded by 12 m of fine grained, burrow mottled dolostone. The "Worms Marker" occurs 15 m above the base of this section.

Contact between the Catoche and Aguathuna formations, 21 m above the base, is conformable. Seven metres above this contact is a prominent breccia bed, with shaly remnants and chert and lithic fragments ("Breccia bed" of Stouge 1982).

Fig. 2:8. Outcrop of the Aguathuna Formation north of Table Point. Approximately 60 m of the Aguathuna Formation is exposed before the inlet in middle distance. The prominent, resistant horizon exposed close to the base (arrow) is the "Breccia Bed" of Stouge (1982).

Below this horizon, Aguathuna Formation strata consist of fine grained light to dark grey burrow mottled to laminated dolostone, with several minor chert - breccia horizons.

A further breccia horizon (Fig. 2:6) is developed 25 m above the base of the Aguathuna Formation.

Successive peritidal cycles, of 0.5 to five metres stratigraphic thickness, are recorded in the overlying 35 m of section (Fig. 2:8). This interval is capped by a 0.3 m thick pebble bed containing rounded to angular chert and lithic fragments, shaly residues and limestone remnants in a matrix of light grey laminated dolostone. This unconformity surface is located 15 m below the Table Point Formation.

The uppermost 15 m of the Aguathuna Formation commences with a thin bed of dark grey shale interlaminated with blue-grey dolostone, grading into an eight metres thick sequence of medium to thin bedded blue-grey dolostone with shale laminae. The succeeding seven metres of thick bedded blue-grey dolostone has many chert-rich horizons, often with rounded chert pebbles embedded in hardground surfaces. Microfauna and macrofauna are considerably more abundant than that of the underlying strata.

Contact of the Aguathuna Formation with the overlying Table Point Formation is 80 m above the base of this section, and is conformable. It is placed between the first nodular, rubbly weathering blue-black limestone and last blue-grey massive dolostone of the Aguathuna Formation (Fig. 2:2).

2:3:3. HARE BAY

Approximately 31.5 m of the middle to upper Aguathuna Formation are exposed along the northern shore of Big Spring Inlet (Figs. 1:4, 2:9, 3:20; Appendix A:10). The underlying lower to middle Aguathuna Formation has been recrystallized following injection of a mafic dyke into these strata. The Aguathuna Formation is conformably overlain by the Table Point Formation.

The measured and sampled Aguathuna Formation commences with four metres of laminated and dolomitized limestone, followed by three metres of buff weathering laminated microcrystalline dolostone. Above this, five metres of the section is obscured by cover, with only isolated outcrop of light grey massive, fine grained dolostone.

The overlying 20 m consists of alternating limestone and dolostone. Limestones are commonly stylonodular, fossiliferous and bioturbated mudstone to grainstone. Dolostones are light to medium grey buff weathering, commonly laminated and mudcracked. A red hardground is preserved 15 m from the base of the section. Solution horizons within sequences of microcrystalline dolostone are present at approximately 19.5 m and 28 m from the base of the measured section: this latter occurrence consists of several such horizons with overlying stromatolites. A limestone and stromatolite horizon 26 m above the base is almost identical

Fig. 2:9. Aguathuna (A) and Table Point (T) formations at Big Spring Inlet, viewed from basal Table Point bed.

with stromatolites developed in limestone on the Port au Port Peninsula.

The Table Point Formation commences with a 2.5 m thick sequence of alternating stylomottled to stylonodular limestone and light grey, buff weathering dolostone with crinkly laminations. This interval is overlain by fine grained, thin bedded, fossiliferous limestones with flat pebble conglomerates.

2:3:4. PORT AU CHOIX PENINSULA

Localities on, and near, Port au Choix Peninsula are shown in Fig. 1:5.

2:3:4:1. Back Arm Bay

A 26 m thick section exposed at the garbage dump on the eastern side of Back Arm Bay contain Catoche Formation and Table Point Formation strata separated by a thin interval which has been correlated with the Aguathuna Formation (Fig. 3.21; Appendix A:11).

The basal 10 m, of the Catoche Formation, commences with six metres of massive, intensively burrowed coarsely crystalline dolostone overlain by a thin series of lenticular laminates containing rare chert. The overlying four metres, of medium to coarsely crystalline dolostone, conformably underlies the Aguathuna Formation.

The Aguathuna Formation consists of approximately three metres of blue grey, tan weathering microcrystalline dolostone, the top of which is laminated. Two siliceous, irregular horizons in the middle of this interval may represent solution horizons.

Apparently conformable above this, the Table Point Formation consists of a seven metres thick sequence of stylonodular limestones and mudcracked massive dolostones with intercalated shales and laminates, overlain by the more typical stylonodular and fossiliferous limestones of the Table Point Formation. The contact of this lithology with that below is 20 m above the base of section. Approximately six metres of typical Table Point Formation is preserved at this locality.

2:3:4:2. Port au Choix Peninsula

Three samples were collected from immediately below, above and within the "Laignet Point Member" of the Catoche Formation in order to clarify its biostratigraphic position. The section was not measured.

2:3:5. PORT AU PORT PENINSULA

2:3:5:1. West of The Gravels

Approximately 67 m of the Aguathuna Formation (Fig.

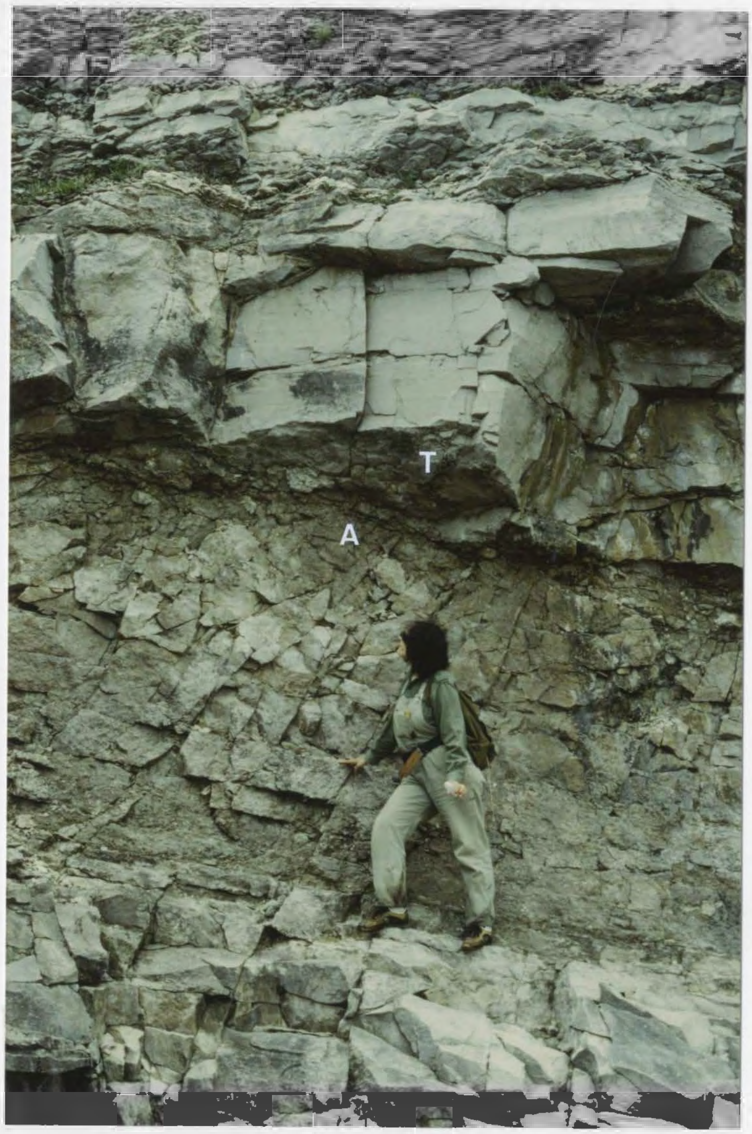
3:22; Appendix A:12) is exposed on a shore section facing East Bay, northwest of The Gravels (Fig. 1:6).

The lowermost 19 m stratigraphic thickness includes only four metres exposure: the lowermost metre consists of massive, fine grained, medium bedded dolostone conformably above the Catoche Formation. A three metres thick sequence of massive, medium bedded limestone with fenestrae and rare grainstone lenses commences four metres above this. The shore section is 11 m stratigraphically above this last outcrop: intervening strata are covered by gravel, and by the road.

The shore section is a sequence of laminated to shaly, fine grained and fine to medium bedded dolostone, commonly mudcracked and rarely fossiliferous. Fine grained to intraclastic, medium to thick bedded, fossiliferous limestone alternates with dolostone. Red-weathering microcrystalline dolostone beds are common throughout the sequence. Stromatolites are developed at several horizons. Breccias, with chert pebbles, subangular to angular chert and lithic clasts in a predominantly shaly matrix are exposed below several massive dolostone units. Bedding is normally irregular. The more prominent of the breccia horizons are underlain by surfaces with up to 0.4 m relief.

Contact with the blue-black, nodular, rubbly weathering Table Point Formation overlying these strata is an irregular surface (Fig 2:10) and may be disconformable.

Fig. 2:10. Contact between Aguathuna (A) and Table Point (T) formations west of The Gravels, Port au Port Peninsula. Rubbly weathering, nodular limestone, characteristic of basal Table Point Formation is 1 m above contact.



2:3:3:2. East of The Gravels

This section is exposed along the shore facing East Bay east of The Gravels (Fig. 1.6). It is separated from the section northwest of The Gravels by a cobble beach and a fault.

Only the uppermost 33.5 m of the Aguathuna Formation is exposed (Fig. 3:23; Appendix A:13). At the base of this latter sequence, a large, shallow angle fault separates the Aguathuna Formation from the underlying Boat Harbour Formation.

This sequence consists predominantly of shaly laminated to medium bedded, fine grained brown to red weathering dolostone with rare teepee structures. Intercalated limestones are commonly fossiliferous, bioturbated, and may contain stromatolites. Bedding planes are commonly irregular, especially where overlain by breccias and shaly residues. A two metres thick conglomerate with limestone matrix is preserved between four and six metres above the base of this succession.

Contact with the overlying Table Point Formation is in places disconformable: buff dololaminites of the Aguathuna Formation are overlain by successive wedges of cryptalgal dolomitic limestone, argillaceous calcarenites and massive fossiliferous limestones. The usual nodular, blue-black, rubbly weathering limestones of the Table Point Formation overlie this latter sequence.

2:3:5:3. Aguathuna Quarries and Road Section

The three quarries at Aguathuna (Fig. 1.6), with their connecting road, record 80 m of strata from the upper Catoche Formation to basal Table Point Formation (Fig. 3:24a,b; Appendix A:14). Approximately 22.5 m of the upper Catoche Formation is preserved in the third (most southern) quarry and the base ofthe middle quarry.

Medium to thick bedded limestone of the Catoche Formation is lightly dolomitized within four metres of the contact with the Aguathuna Formation and in patches within the lowermost four metres of the measured section. The basal seven metres of fossiliferous, massive, thick bedded limestone is succeeded by a 15 m thick sequence of relatively unfossiliferous, medium bedded, stylonodular to massive, mudcracked limestone with fenestrae, pellets, arenitic horizons and occasional laminates (Costa Bay Member; Knight & James 1987). Its conformable contact with the Aguathuna Formation is exposed in the middle quarry.

The Aguathuna Formation commences with five metres of buff weathering, massive dolostone. Beds in the middle of this interval are red weathering, laminated to shaly, and are succeeded by 1.5 m of stylonodular dolostone. Above this five metres interval, a 2.5 m thick sequence of bioturbated, arenitic to fine grained limestone is terminated by a mudcracked horizon with fenestrae. This horizon forms the top of the second quarry face. It is not exposed in the road section but is located under part of the nine metres stratigraphic thickness covered by talus surrounding this level.

The road section has 29 m of cyclic dolostone and laminates. An irregular, probably erosion, surface overlain by breccias is exposed 12 m above the base, with a conglomerate 1.5 m above this. A dolomitic horizon, commencing with breccias which are rapidly succeeded by domed stromatolites, has its base 13 m above the conglomerate.

The 24 m thick section of the major, northernmost, quarry commences directly above the last bed of the road section. This quarry section is predominantly a sequence of thick to thin bedded massive, fine grained dolostone with intercalated laminates and shale (Figs 2:4, 2.11). It is terminated by six metres of bioturbated, massive, fine grained and thick bedded dolostone. Another stromatolite horizon has its base nine metres stratigraphically above the quarry floor. Two irregular (solution?) surfaces are developed four metres and 5 metres respectively above this horizon: the younger surface underlies the uppermost sequence of bioturbated dolostone (Fig. 2.4).

Contact between the Aguathuna and Table Point formations is an erosion surface with eight metres of relief across 200 m of lateral extent. Irregular, shallow pits along this

Fig. 2:11. Laminates of the upper Aguathuna Formation, Aguathuna Quarry, Port au Port Peninsula. Lens cap is approximately 5 cm in diameter.

surface are infilled by the overlying sediments. It is likely that this surface was a karst erosion surface.

2:4. LITHOSTRATIGRAPHIC CORRELATION

Intraregional lithostratigraphic correlations within the Daniels Harbour Mine area are accomplished by use of shaly, bioturbated or chert-rich marker beds. These have been shown to be consistently preserved at the same stratigraphic level (Lane pers. comm. 1984, Fig. 2:12). Throughout this area, pseudobreccias characterize strata from the middle to upper Catoche Formation. Within the Aguathuna Formation, correlation of breccias overlying irregular solution or erosion surfaces, or correlation of these surfaces, is most common (Fig. 2:13). Biostratigraphic evidence supports some, but not all, of the above correlations (Chapter 3 herein).

Formation boundaries are regionally correlated according to rock type: the base of the Aguathuna Formation is placed immediately below the lowest buff weathering dololaminite; the base of the Table Point Formation immediately underlies the lowest blue black nodular limestone bed above buff weathering dolostone (Knight & James 1987).

The above provides a baseline framework for the input of biostratigraphic data acquired during field and subsequent laboratory studies. This biostratigraphy is intended to provide answers to questions of contemporaneity arising from studies based on purely lithostratigraphic criteria.

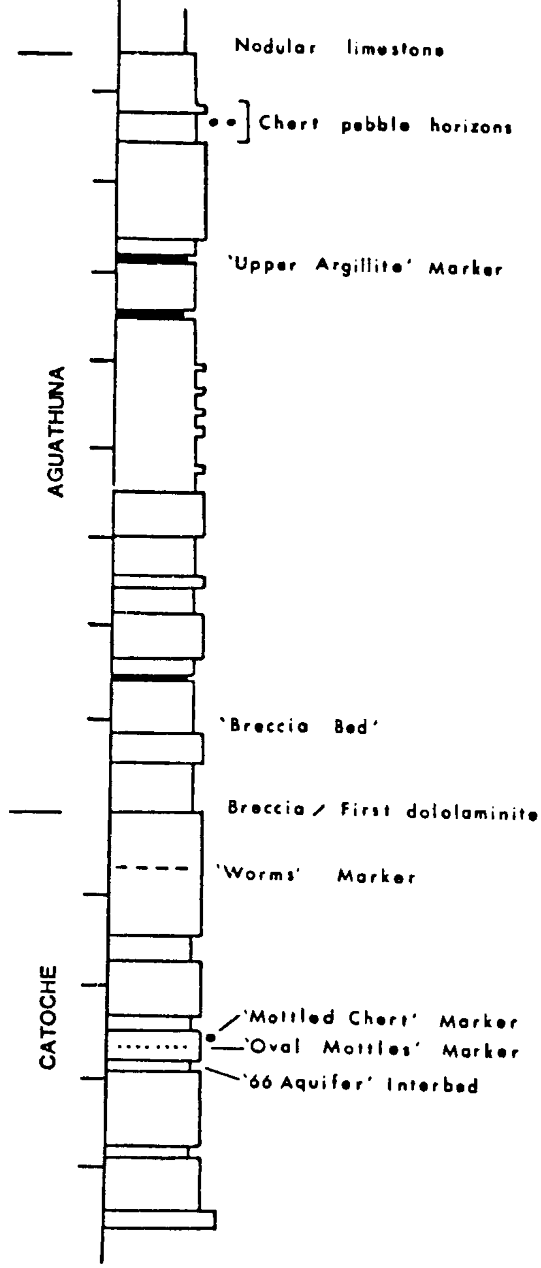


Fig. 2:12. Stratigraphic position of marker beds in the upper Catoche and Aguathuna formations in the Daniel's Harbour area. Increments along side of column indicate 10 m intervals (modified from Lane, ms).

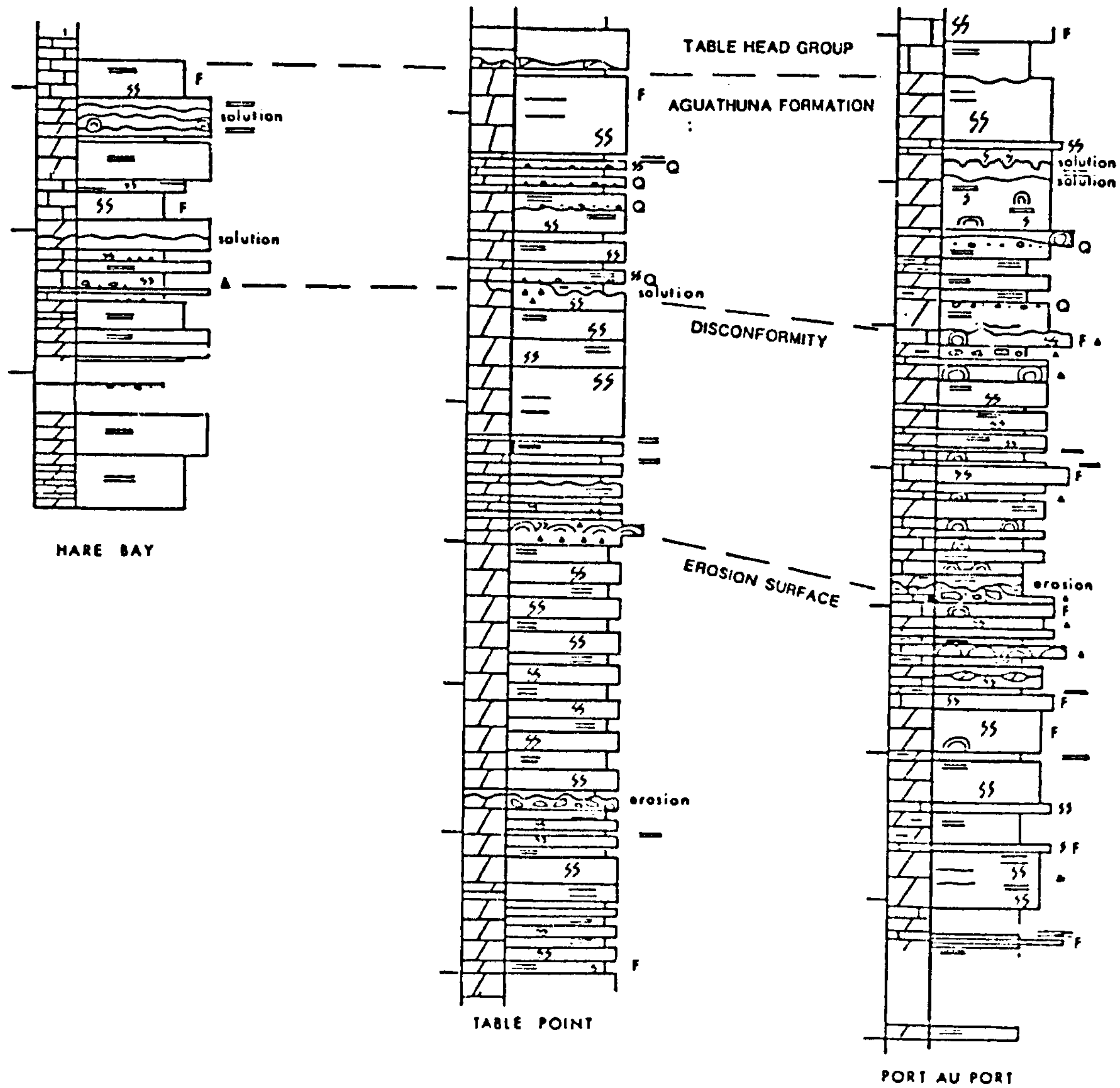


Fig. 2:13. Lithostratigraphic correlations across the study area (modified from Knight & James 1987).

Chapter 3

BIOSTRATIGRAPHY

3:1. INTRODUCTION

Strata sampled for this study range through Catoche and Aguathuna formations to basal Table Head Group.

Detailed lithostratigraphic studies of this interval were recently completed (Lane 1984, Knight & James 1987). Preliminary biostratigraphic data (Flower 1978, Stouge 1982, Stouge & Boyce 1983) and more detailed analyses (Boyce 1985, Williams et al. 1987, Ross & James 1987) have indicated that more closely collected conodont samples than previously available are essential for a meaningful and useful conodont biostratigraphy.

Consideration of previous studies, palaeoecology, together with conodont lineages and faunal succession within samples taken from the upper megacycle of the St. George Group led to the establishment of the seven informal assemblages described below.

3:2. PREVIOUS BIOSTRATIGRAPHIC STUDIES

Various horizons within the studied section contain trilobites, graptolites and brachiopods which have enabled correlation of these levels with the shelly fossil

(Ross-Hintze) zones of Utah (Ross et al. 1982), graptolite zonation of the Cow Head Group and, thereby, with the Australian graptolite zonation (Williams et al. 1987).

Shelly fossil Zone G_2 trilobites have been found in the uppermost Boat Harbour Formation, and Catoche Formation trilobites are of upper Canadian age (Boyce 1985). Benthamaspis sp. cf. B. diminutiva Hintze occurs in the uppermost Catoche Formation at Table Point. As this species is restricted to Zone J in Utah, uppermost Catoche Formation strata near Table Point are of similar age. The uppermost Catoche Formation at Port au Choix, however, contains Zone I trilobites (Boyce 1985). Possibly the Catoche-Aguathuna boundary is diachronous, or known ranges of taxa are extended by the Newfoundland material.

Graptolites are known from eight horizons within the Catoche Formation (Williams et al. 1988). These span the Tetragraptus approximatus and early T. akzharensis zones of the Cow Head Group zonation (Williams & Stevens 1987), indicating an early Arenig (upper Canadian) age for the entire Catoche Formation.

Basal Aguathuna Formation near Table Point contains Didymograptus (Extensograptus) nitidus (Hall) of Pendeograptus fruticosus Zone morphology. Thus the basal Aguathuna Formation strata are equivalent to Bendigonian 3 or 4 of the Australian graptolite zonation (Williams & Stevens 1987). Associated trilobites, of shelly fossil Zone I affinities (Knight & James 1987), support an uppermost Canadian age for the base of the Aguathuna Formation.

The uppermost Aguathuna Formation at Table Point, Back Arm Bay and Hare Bay contains either or both of the trilobites Acidophorus pseudobathyurus Ross and Bathyurus perplexus Billings (Stouge 1984, Ross & James 1987). By comparison with similar species of Bathyurus, B. perplexus from Newfoundland is likely to correlate with part of shelly fossil zones L to O. Acidophorus pseudobathyurus is generally considered to be of Zone L age (Williams et al. 1987). The occurrence of Zone M trilobites within the overlying Table Point Formation (Stouge 1984) further strengthens correlation of uppermost Aguathuna Formation with shelly fossil Zone L.

In support, Ross & James (1987) placed the base of Table Point Formation low in the Anomalorthis (brachiopod) Zone, and believed that the Aguathuna Formation correlated with the Orthidiella to early Anomalorthis zones. The age is therefore latest Canadian to early Whiterockian.

3:3. PREVIOUS CONODONT STUDIES

Barnes and Tuke (1970) described taxa from two productive samples of St. George Group lithology collected from near Cape Norman. The fauna is of primarily Midcontinent Province affinity, and of early Arenig (late Canadian) age (Barnes & Tuke 1970). Samples were located 70 and 85 m below the top of the St. George Group, and contain a fauna characteristic of the upper Catoche Formation (*Parapanderodus striatus* (Graves & Ellison) = Barnes & Tuke's *Scolopodus gracilis* Ethington & Clark, *Drepanoistodus inaequalis* (Pander) = their *Oistodus* sp. cf. *O. inaequalis*, *Paroistodus parallelus* (Pander) = their *Oistodus parallelus*) or lower Aguathuna Formation (*Oneotodus costatus* Ethington & Brand = their *Scolopodus cornutiformis* Branson & Mehl, *Diaphorodus gravelsensis* = their *Oepikodus* n. sp. A and *Cristodus* sp. cf. *C. loxoides* Repetski = their *Loxodus* sp. aff. *L. bransoni* Furnish).

After preliminary study of the Great Northern Peninsula conodont faunas, Stouge (1982) proposed six informal assemblage zones on the basis of conodonts recovered from Boat Harbour, Catoche and Aguathuna formations. Correlation of units from one area to another was "still uncertain" (Stouge 1982, p. 1). At the time Stouge prepared his manuscript, multielement taxonomy of most Lower and lower Middle Ordovician conodont apparatuses was poorly known. Subsequently published monographic works (Ethington & Clark 1981, Repetski 1982) have clarified some relationships.

In essence, Stouge's faunas commence with Midcontinent Fauna C or D, and end at the level of Midcontinent Fauna 3-4. Within this interval, the basal Catoche Formation correlated with Midcontinent Fauna E, and Midcontinent Fauna 1 species were found in the uppermost Catoche Formation. The middle part of the Aguathuna Formation appeared to be barren of conodonts, and succeeded by a peritidal sequence containing an effectively endemic conodont fauna (Stouge 1982, Williams et al. 1987).

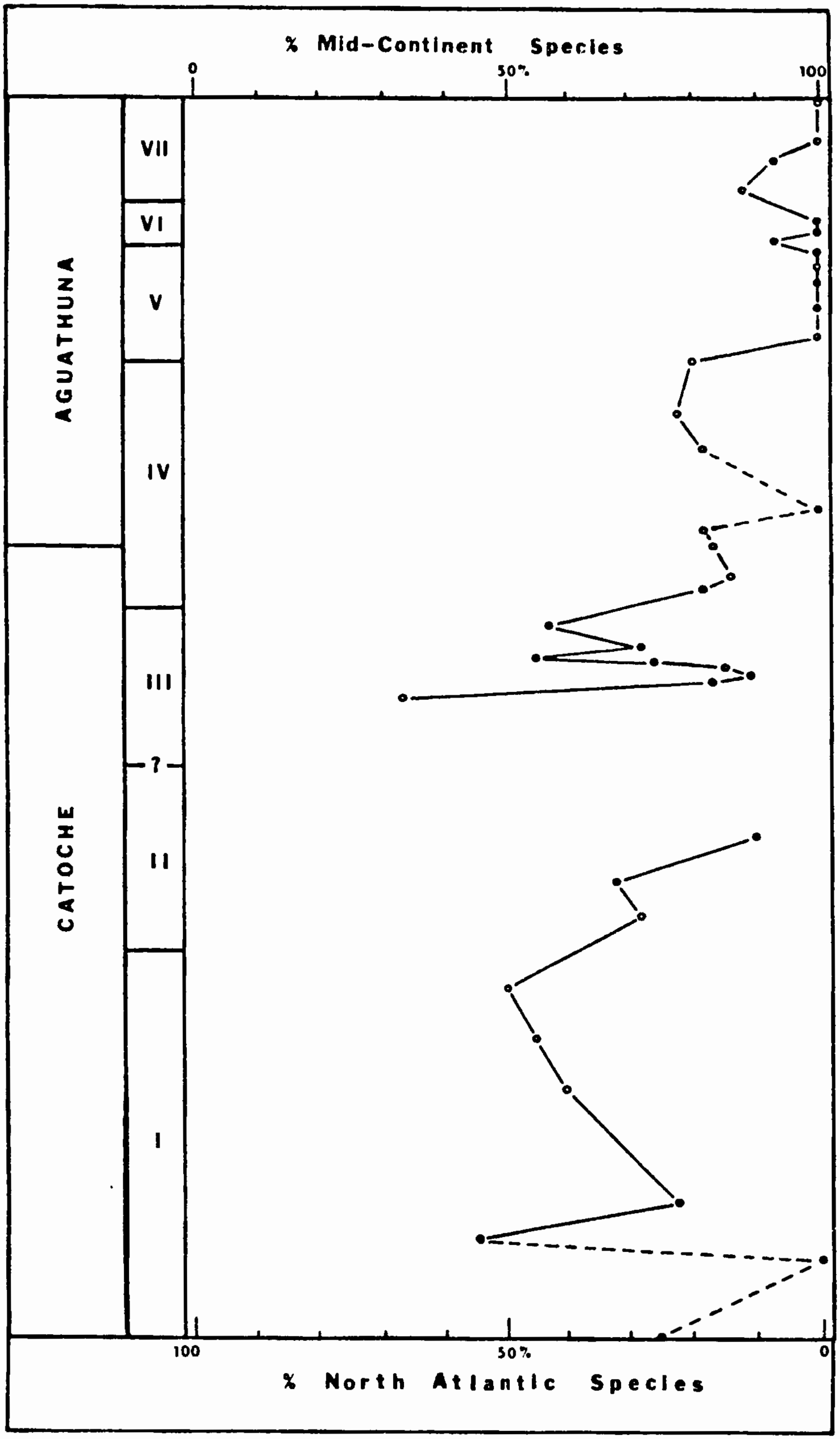
3:4. THE UPPER ST. GEORGE FAUNAL SUCCESSION

3:4:1. PALAEOECOLOGICAL CONSIDERATIONS

By at least the late Canadian (early Arenig), two main conodont provinces were established. One centred on the Baltic region, and the other on Midcontinent North America (Barnes et al. 1973, Ethington & Repetski 1984). Faunas of the Catoche Formation are of mixed affinity, containing conodonts characteristic of both North Atlantic and Midcontinent provinces in varying ratios. Taxa are considered as having North Atlantic Province affinity if reported occurrences in the Baltic region are considerably more numerous than occurrences within North America.

The relative abundances of St. George Group taxa considered to be of either Midcontinent or North Atlantic Province affinity are plotted as a function of stratigraphic position within the reference section in Fig. 3:1. A primarily Midcontinent fauna is evident, with incursions of North Atlantic Province faunas at various levels. A greater proportion of North Atlantic taxa occurs in the primarily subtidal Catoche Formation than in the peritidal Aguathuna

Fig. 3:1. Relative abundance of Midcontinent and North Atlantic province conodonts plotted as a function of stratigraphic height for the Freshwater Cove to Table Point section. Dashed lines indicate trends based upon samples with only a few conodont species or specimens.


% Mid-Continent Species
0
50%
100
AGUATHUNA
CATOCHE
VII
VI
V
IV
III
?
II
I
100
50%
0
% North Atlantic Species

Formation. The pattern of relative abundances, best seen in Assemblage III, is a response to environmental parameters. Assemblage boundaries can be seen to be independent of these changes.

The alternation of North Atlantic and Midcontinent Province taxa is also reflected in the occurrence of certain pairs of related taxa. As an example, Drepanodus concavus (Branson & Mehl), known mainly from the Midcontinent Province, and Drepanodus arcuatus Pander (North Atlantic) rarely co-occur in samples from the Catoche Formation, although both range into the Aguathuna Formation. Similarly, Semiacontiodus cordis (Hamar), of North Atlantic affinity and Semiacontiodus asymmetricus (Barnes & Poplawski), from the Midcontinent Province, occur at different stratigraphic levels, in spite of almost completely overlapping ranges.

Sporadic occurrence of long ranging taxa (e.g. Eucharodus parallelus (Branson & Mehl), Oneotodus costatus, Striatodontus kakivangus n. gen. et n. sp. and Jumudontus gananda Cooper), may also be explained by the shifting of suitable environments for these basically Midcontinent stenotopic species.

Biostratigraphic assemblages were therefore constructed only from taxa without demonstrable environmental control, or from taxa displaying morphologic gradients indicative of evolutionary lineages.

3:4:2. THE *DIAPHORODUS* SUCCESSION

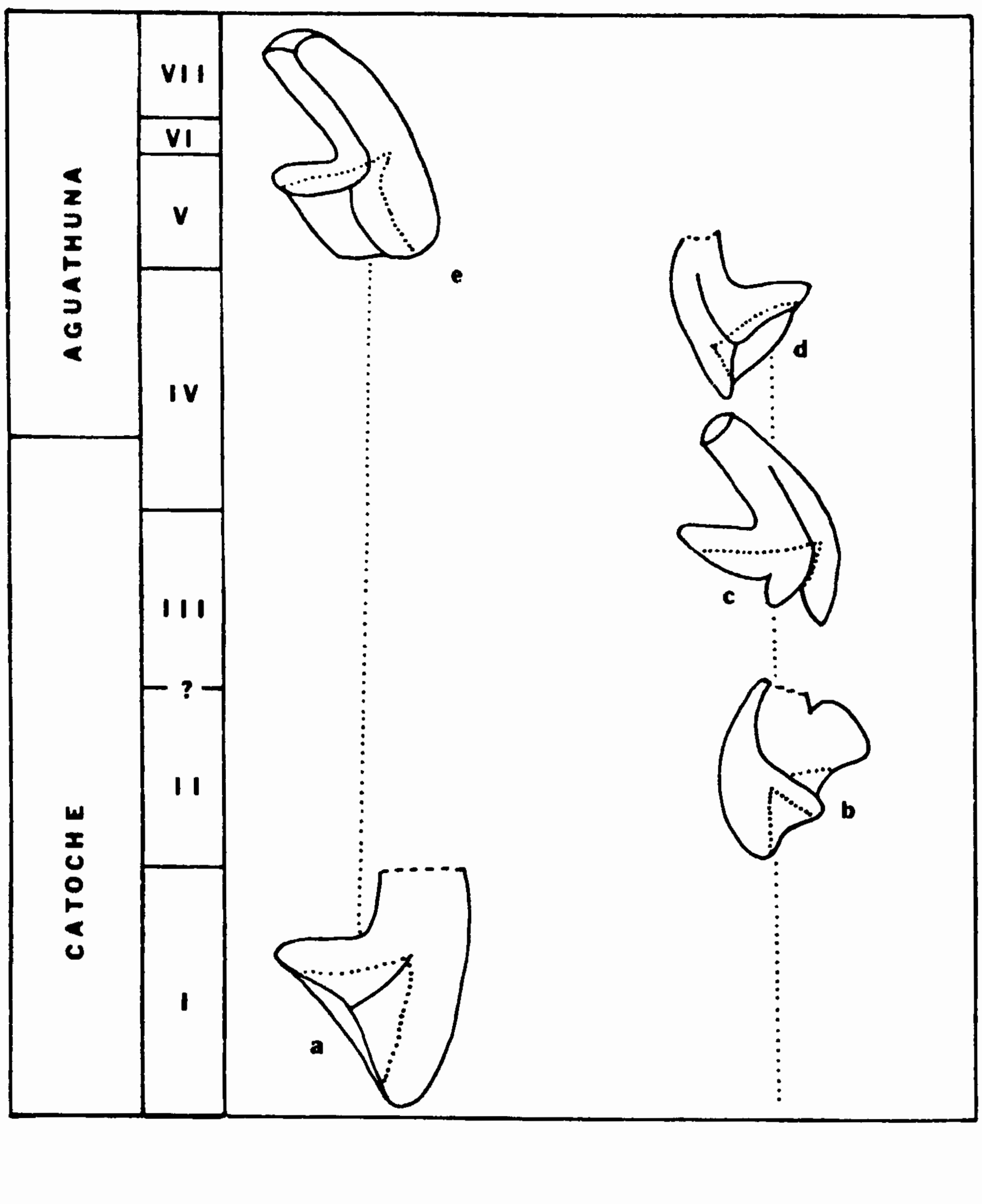
Illustrated in Fig. 3:2, the *Diaphorodus* succession in western Newfoundland commences within the range of *Diaphorodus delicatus* (Branson and Mehl). *Diaphorodus russoi* (Serpagli) occurs through Assemblage II and early Assemblage III; *D. emanuelensis* (McTavish) appears briefly early in Assemblage IV, and is followed by *D. stevensi* n. sp. and *D. gravelsensis* n. sp. *Diaphorodus gravelsensis* may range as low as Assemblage IV; *D. stevensi* first appears in Assemblage V.

Diaphorodus delicatus has an apparatus of costate cones. All elements of *Diaphorodus russoi* and *D. emanuelensis* have processes. *Diaphorodus stevensi* shows affinity with *D. delicatus* in lacking distinct processes, whereas *D. gravelsensis* is distinguished from *D. emanuelensis* by the possession of unequal processes.

It is therefore possible that two lineages are represented by the above species. All of these species, however, follow the prioniodontid apparatus plan, and may be derived from the preceding species by simple modification of basal extension and process development. In view of the similar apparatus reconstructions, it is possible that *D. russoi* represents an isolated, short-lived modification of a *Diaphorodus* apparatus.

Fig. 3:2. Species of *Diaphorodus* Kennedy found in the St. George Group, showing morphological changes in diagnostic prioniodontiform element with stratigraphic position.

a. *Diaphorodus delicatus* (Branson & Mehl)
b. ?*Diaphorodus russoi* (Serpagli)
c. *Diaphorodus emanuelensis* (McTavish)
d. *Diaphorodus gravelsensis* n.sp.
e. *Diaphorodus stevensi* n.sp.


AGUATHUNA
CATOCHE
VII
VI
V
IV
III
?
II
I
a
b
c
d
e

3:4:3. THE PARAPANDERODUS LINEAGE

The St. George Group contains only hyaline Parapanderodus species. These vary systematically up section in the degree of lateral compression, and in size of the basal cavity. Parapanderodus striatus, with a circular cross-section, deep and conical basal cavity, is found in upper Boat Harbour and Catoche formations (assemblages I to III). The succeeding P. aequalis n. sp. has moderately laterally compressed cusp and reduced conical basal cavity. It is found in uppermost Catoche and lower Aguathuna formation strata (assemblages III to IV). The cusp of all P. striolatus (Harris & Harris) elements is laterally compressed, with a shallow and narrow basal cavity. This species occurs through the middle and upper Aguathuna and into lower Table Point formations. The succeeding P. arcuatus Stouge, from the Table Point Formation, is even more laterally compressed and has reduced basal cavity. It is also albid. This lineage is summarized in Fig. 3:3.

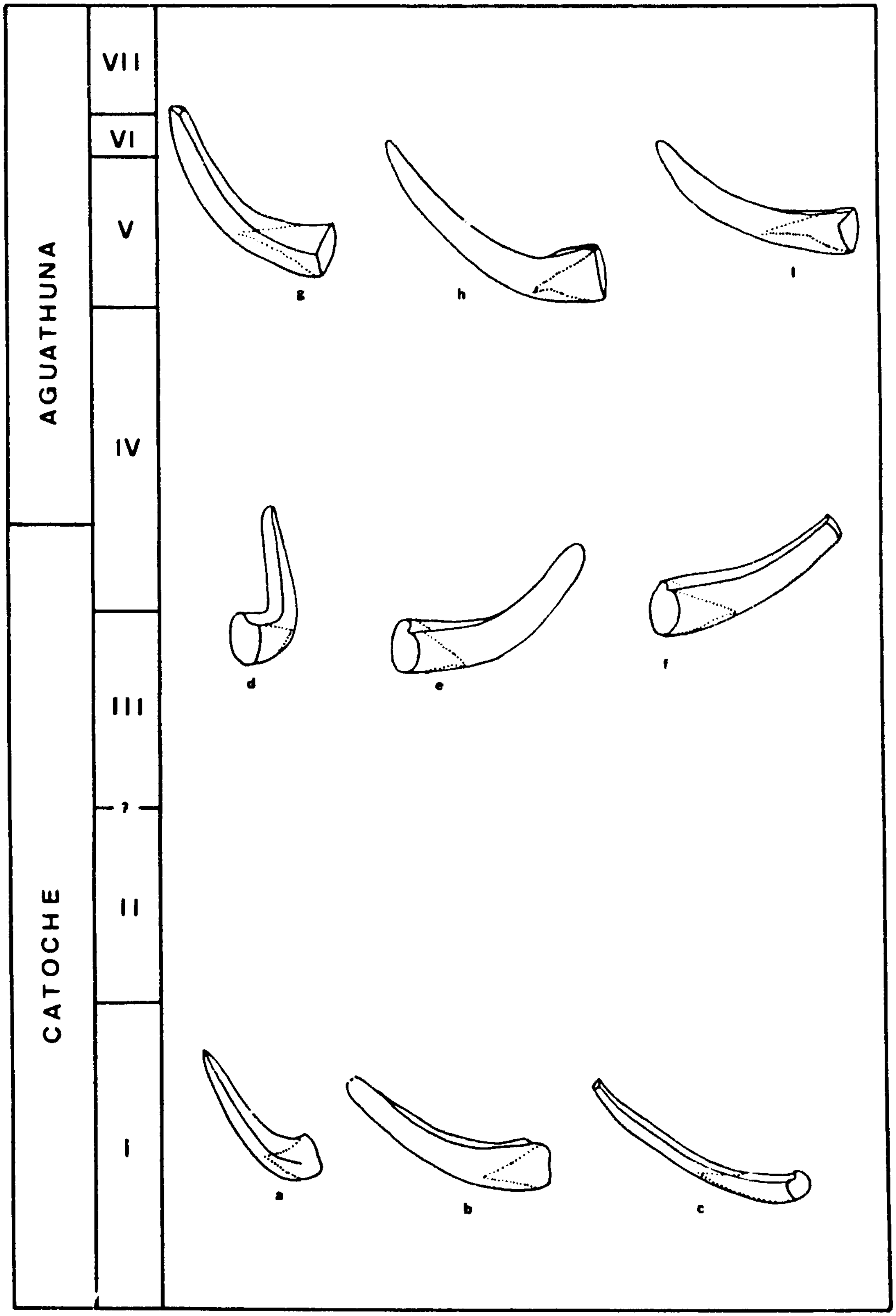
3:4:4. REWORKING OF FAUNAS

Peritidal sediments of the Aguathuna Formation contain many levels at which hardgrounds are preserved. This is particularly common in middle and upper parts of the Aguathuna Formation (Knight & James 1987). Disconformity surfaces preserved within this formation show evidence of

Fig. 3:3. Species of *Parapanderodus* Stouge found in the St. George Group and overlying Table Point Formation, showing morphological changes in all elements with stratigraphic position.

a-c. *Parapanderodus striatus* (Graves & Ellison)
d-f. *Parapanderodus aequalis* n.sp.
g-i. *Parapanderodus striolatus* (Harris & Harris)
a,d,g. triangulariform elements
b,e,h. short based elements
c,f,i. lomng based elements

Parapanderodus striatus (Graves & Ellison), characterized by round cusp section and deep basal cavity parallel to anterior margin, is present through Assemblages I to III. *Parapanderodus aequalis* n.sp. is found in Assemblages III and IV; it has reduced basal cavity and cusp is moderately laterally compressed. *Parapanderodus striolatus* (Harris & Harris) continues from Assemblage IV into the Table Point Formation. This species shows further basal cavity reduction, and a greater degree of lateral compression.


AGUATHUNA
CATOCHE
VII
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erosion and reworking of sediments. The anomalously late occurrence of some conodont specimens with frosted surfaces is therefore interpreted as evidence of reworking of these conodonts. Such reworked specimens were not included within the biostratigraphic scheme: only well preserved specimens without frosted surfaces were considered in defining the assemblages.

3:5. CONODONT BIOSTRATIGRAPHY

The conodont succession was initially determined from the shore section from Freshwater Cove to Table Point (Fig. 3:4). This locality was chosen because it is the type section for the Aguathuna Formation. Collection of large samples was possible and the lithostratigraphy of the section has been well documented (Knight & James 1987).

As a consequence of the environmental differences between the two areas, the conodont biostratigraphy of the Ibex area was not found to be applicable to the sequence of conodonts preserved in the St. George Group. Different, informal assemblages are therefore proposed for the St. George Group, based upon concurrent ranges of a large number of species within these strata, and upon acme of abundances of certain species (Table 3:1). These assemblages are at least in part environmentally controlled. They are recognizable within autochthonous platformal sequences throughout western Newfoundland, but not internationally, nor

Fig. 3:4. Stratigraphic section of upper Catoche to lowermost Table Point exposed between Freshwater Cove and Table Point, with location of samples. Conodont assemblages are shown to right of section. In ascending order, marker horizons are the "Oval Mottles", "Worms Marker", "Breccia Bed", solution surface of the middle Aguathuna, "Upper Argillite" and upper Aguathuna solution surface. Symbols as for Fig. 3:5. Modified from stratigraphic section measured by T. Lane.

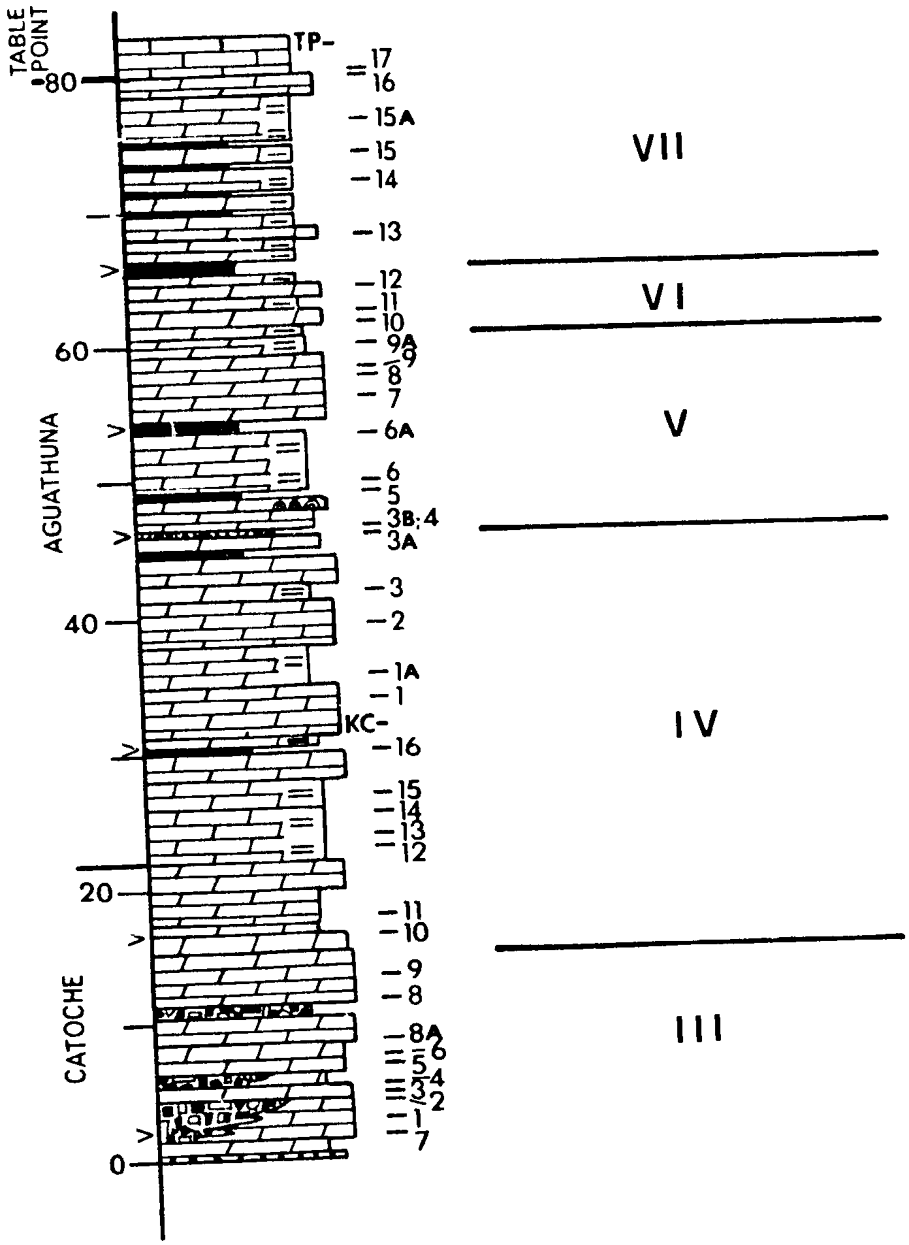


TABLE POINT
AGUATHUNA
CATOCHE
TP-
17
16
15A
15
14
13
12
11
10
9A
9
8
7
6A
6
5
3B; 4
3A
3
2
1A
1
KC-
16
15
14
13
12
11
10
9
8
8A
6
5
4
3
2
1
7
80
60
40
20
0
VII
VI
V
IV
III

TABLE 3:1: Fauna, stratigraphic level and correlation of upper St. George Group assemblages. Conodont species are listed in order of abundance for each assemblage. Species marked with asterisk are also important in the succeeding Assemblage; Midcontinent conodont zonation denoted by M/C; shelly fossil zones of the Ibex section denoted SF; + indicates acme of long-ranging species.

Assemblage	Strat. level	Fauna	Correlatives
I	Lower Catoche Fm.	*Oepikodus communis Paltodus sweeti "Scolopodus" filosus Drepanoistodus inaequalis *Diaphorodus delicatus Glyptoconus quadraplicatus *Parapanderodus striatus Rossodus highgatensis "Scolopodus" emarginatus	Early M/C Fauna E; SF Zone G_2; Prioniodus elegans Zone.
II	upper part of lower to low in upper upper Catoche Fm.	Bergstroemog. extensus Diaphorodus russoi Paroistodus parallelus Fryxellodontus corbatoi Clavohamulus cavus *Drepanoistodus forceps ?Microz. marathonensis *Diaphorodus delicatus	M/C Fauna E; SF Zone H; Faunas A and B of San Juan Fm. of Argentina.
III	upper Catoche Fm.	Parapanderodus aequalis Oistodus bransoni Drepanoistodus basiovalis Scalpellodus n.sp. Variabiliconus n.sp. A	M/C Fauna E; SF Zone I; u. Jefferson City Dolom.; Oepikodus evae Zone.
IV	uppermost Catoche and lower Aguathuna fms.	Diaphorodus emanuelensis *Parapand. abemarginatus +Eucharodus parallelus +Oneotodus costatus +Drepanodus concavus Diaphorodus gravelsensis Parapanderodus striolatus	M/C Fauna E/1.

TABLE 3:1 (ctd.)

V	middle Aguathuna Fm.	*Pteracontiodus cryptodens* *Oistodus multicorrugatus* *Oepikodus intermedius* *Diaphorodus stevensi* *Diaphorodus gravelsensis*	M/C Fauna 1/2.
VI	low in upper Agauthuna Fm.	*Drepanodus* sp. cf. *D. gracilis* *Reutterodus* sp. +*Oneotodus costatus*	M/C Fauna 1/2.
VII	Upper Aguathuna and lower Table Point fms.	*Paraprioniodus costatus* *Scandodus sinuosus* *Leptochirogn. quadrata* *Multioistodus subdentatus* *Drepanoistodus angulensis*	M/C Fauna 4; Kanosh and Lehman fms. of Utah.

between environmental settings preserved in autochthonous and allochthonous sequences of western Newfoundland. They have therefore not been formally described herein.

Generally, the bases of assemblages are marked by the incoming of a suite of previously unknown species: thus Assemblage II commences with the incoming of a fauna described by Serpagli (1974) from the Lower Ordovician of Argentina; Assemblage III with the earliest *Oistodus bransoni* Ethington & Clark, *Jumudontus gananda* and endemic forms (*Parapanderodus aequalis* and *Scalpellodus* n. sp.). Assemblage IV, during which the conodont fauna becomes increasingly impoverished, commences with the first *Diaphorodus emanuelensis*, and is characterized by this species together with *Parapanderodus abemarginatus* n. sp. and (in places) *P. gravelsensis*. Assemblage V is distinguished by the appearance of *Diaphorodus stevensi* and *Pteracontiodus cryptodens* (Mound); Assemblage VI by *Drepanodus* sp. cf. *D. gracilis* (Branson & Mehl) and ?*Reutterodus* sp., and Assemblage VII by the incoming of *Drepanoistodus angulensis* (Harris) and *Scandodus sinuosus* Mound, commonly with a diverse and abundant conodont fauna.

Assemblages I and II are described from D.D.H. A1 since lowest strata sampled at Freshwater Cove contain an initially impoverished Assemblage III fauna. The contact with Assemblage II is not recorded in this section, but is found in D.D.H. 438, 715 and 1827. Transition to Assemblage IV, approximately 10 m beneath the base of the Aguathuna Formation, is gradual. The faunal change is initially a difference in dominance rather than occurrence (see Appendices B:3 and B:4). Thus Oepikodus communis (Ethington & Clark), Scalpellodus n. sp., Drepanodus concavus and Eucharodus parallelus are all present in both assemblages, but the first two are characteristic of Assemblage III and the latter two are typical of, and dominate, Assemblage IV.

Assemblage IV faunas continue to 25 m above the base of the Aguathuna Formation. At this level, there is a solution surface, above which Assemblage V conodonts are found. Only long-ranging taxa continue from Assemblage IV into Assemblage V.

The last appearance of exclusively Canadian age conodonts characterizes the base of Assemblage VI. This is found 20 m below the base of the Table Point Formation, and followed five metres higher by Assemblage VII faunas. Assemblage VII overlies an upper solution surface. It contains a number of species no older than Midcontinent Fauna 4.

Samples taken from drill core made available from the Daniel's Harbour mine enabled extension of the biostratigraphic succession downwards into the lower Catoche Formation. There is no significant break in the faunal succession between uppermost faunas of D.D.H. Al (Assemblage II) and the lowest sample taken from Freshwater Cove

(Assemblage III), as the same faunal sequence is recorded in complete sections of D.D.H. 438, 1827 and 715.

3:5:1. ASSEMBLAGE I

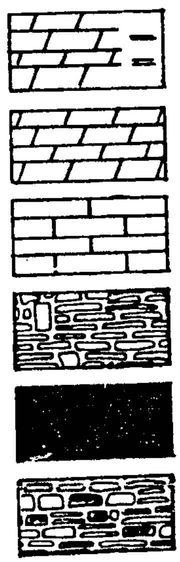
Oepikodus communis dominates Assemblage I. Alternating sequences of faunas show affinity with Midcontinent faunas D and E. Midcontinent Fauna D faunas, including Glyptoconus quadraplicatus (Branson & Mehl) and Rossodus highgatensis Landing et al. alternate with Midcontinent Fauna E conodonts. These latter include Paltodus sweeti Serpagli, ?Microzarkodina marathonensis (Bradshaw), Diaphorodus delicatus, Drepanodus concavus, and are commonly of low abundance compared with their occurrence in subsequent faunas.

The lower limit of Assemblage I is unknown. The faunas of this assemblage, however, are found in the lower Catoche Formation.

Assemblage I is dominated by Oepikodus communis, which is represented by considerably reduced abundances in Assemblage II. Oepikodus communis is commonly accompanied, within Assemblage I (Fig. 3:5), by Paltodus sweeti, "Scolopodus" filosus Ethington & Clark, Eucharodus parallelus, Drepanoistodus forceps (Lindström) and Drepanoistodus inaequalis. Minor constituents of the fauna include Glyptoconus quadraplicatus, Parapanderodus striatus, Paroistodus parallelus, ?Protroprioniodus papilosus (van

Fig. 3:5. Stratigraphic section of lower and middle Catoche formations from D.D.H. A1, with associated range chart of Assemblage I conodonts. Symbols defined below also refer to subsequent range charts and stratigraphic sections.

LEGEND



Laminated dolostones

Dolostone

Limestone

Breccia

Shale

Pseudobreccia

~~ Wavy laminations

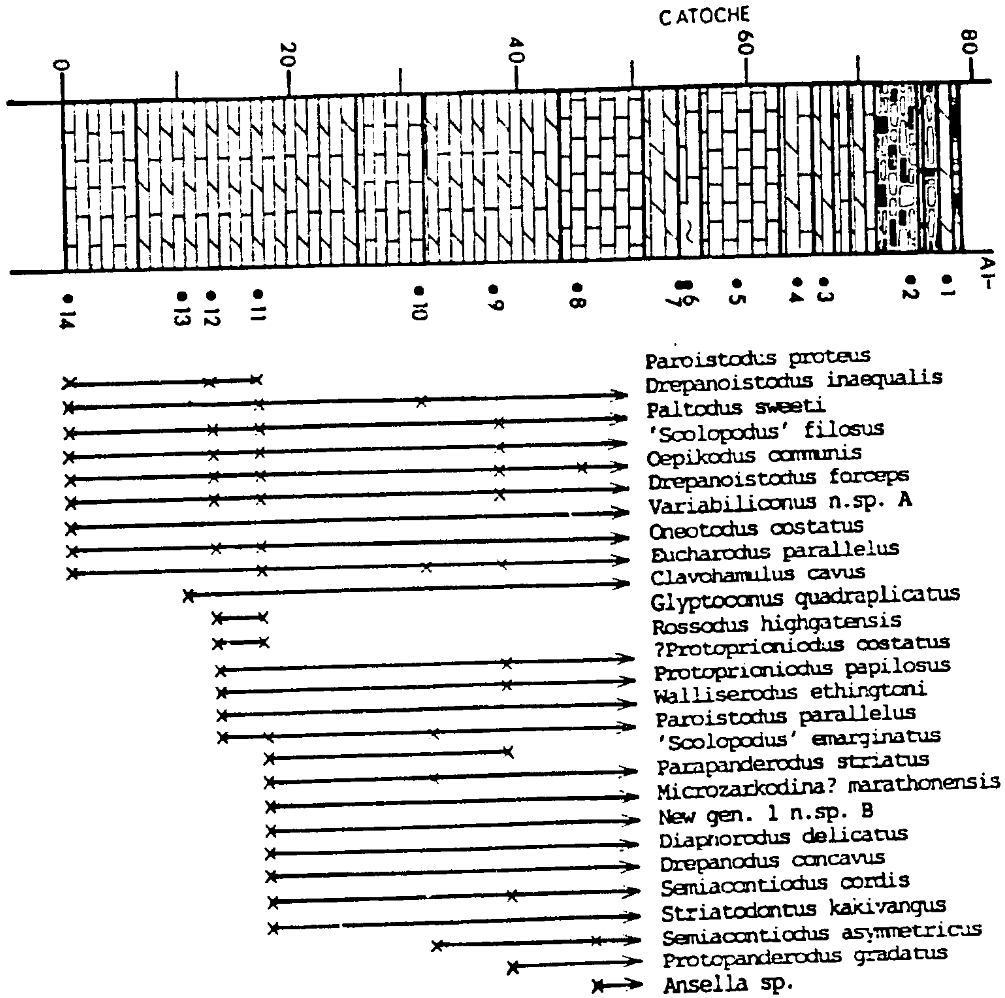
ΔVΔ Brecciated horizons

Domal stromatolites

Pebble horizons

> Stratigraphic level of mine marker beds

● 11 Stratigraphic location of sample A1.11.


CATOCHE
0
20
40
60
80
AI-
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Paroistodus proteus
Drepanoistodus inaequalis
Paltodus sweeti
'Scolopodus' filosus
Oepikodus communis
Drepanoistodus forceps
Variabiliconus n.sp. A
Oneotodus costatus
Eucharodus parallelus
Clavohamulus cavus
Glyptoconus quadraplicatus
Rossodus highgatensis
?Protoprioniodus costatus
Protoprioniodus papilosus
Walliserodus ethingtoni
Paroistodus parallelus
'Scolopodus' emarginatus
Parapanderodus striatus
Microzarkodina? marathonensis
New gen. 1 n.sp. B
Diaphorodus delicatus
Drepanodus concavus
Semiacontiodus cordis
Striatodontus kakivangus
Semiacontiodus asymmetricus
Protopanderodus gradatus
Ansella sp.

Wamel), Rossodus highgatensis and "Scolopodus" emarginatus Barnes & Tuke. The long-ranging Oneotodus costatus, Semiacontiodus asymmetricus, Semiacontiodus cordis, Striatodontus kakivangus and Walliserodus ethingtoni (Fåhraeus) are found in this assemblage.

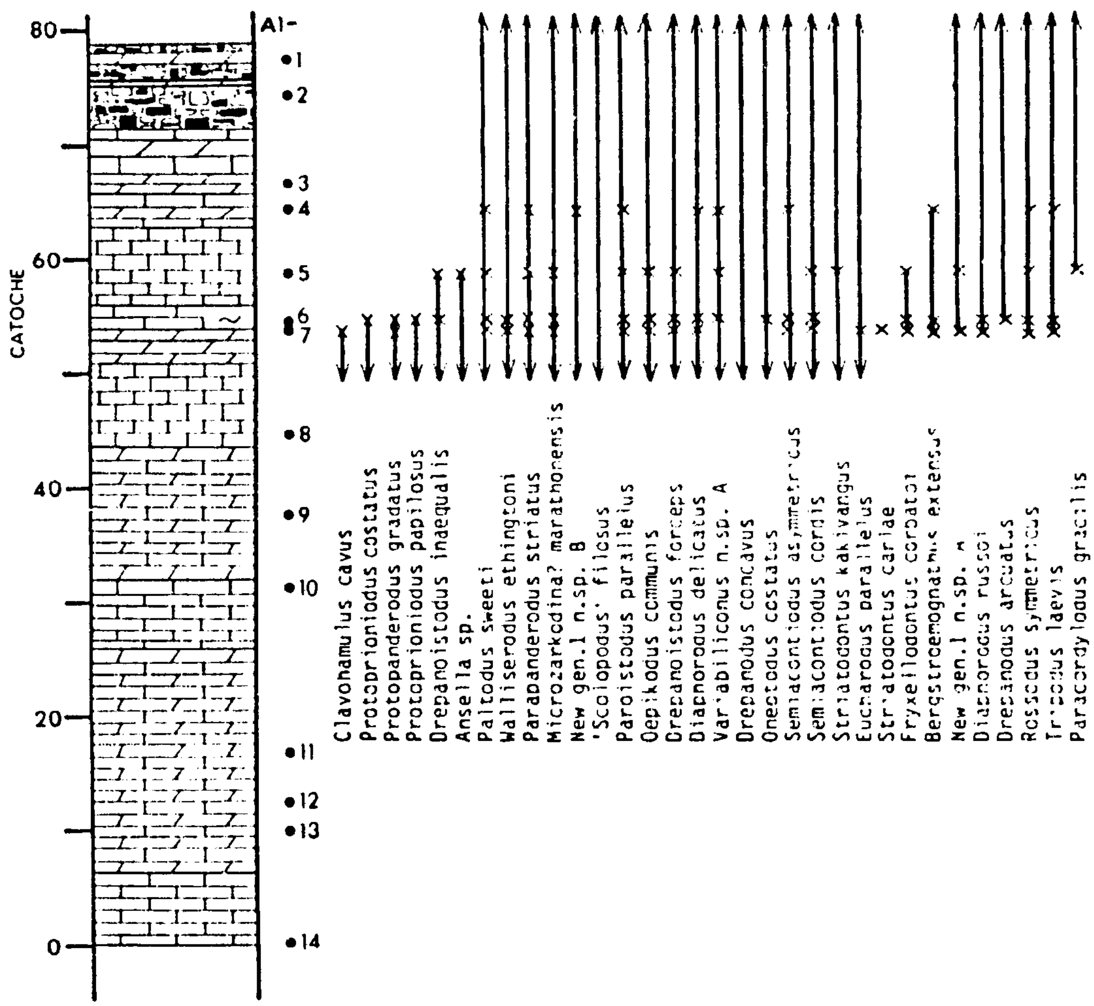
Many of the taxa dominating Assemblage II (Fig. 3:6) are present as sporadic, isolated elements throughout Assemblage I (Appendix B:1, B:2). These include Paroistodus parallelus, Drepanodus arcuatus, ?Protoprioniodus costatus, Microzarkodina? marathonensis, Variabiliconus n. sp. A and Clavohamulus cavus n. sp.

The base of Midcontinent Fauna E is defined by Ethington & Repetski (1984) at the first occurrence of Oepikodus communis. Assemblage I of this study is therefore correlated with Midcontinent Fauna E. The presence of Glyptoconus quadraplicatus, with an abundance of Parapanderodus striatus is consistent with lower Fauna E of Ethington and Repetski (1984).

Within the studied sections, Glyptoconus quadraplicatus and Rossodus highgatensis are not found in populations younger than Assemblage I.

This assemblage is known from lower half of D.D.H. A1, lowest sample from D.D.H. 66A, and possibly upper Catoche Formation at the southernmost Aguathuna quarry, immediately underlying the Costa Bay Member.

Fig. 3:6. Stratigraphic section of D.D.H. A1 sequence, with associated range chart of Assemblage II conodonts. Symbols as for Fig. 3:5.



3:5:2. ASSEMBLAGE II

Assemblage II is recognized by the abundance of Midcontinent Fauna E species, particularly *Parapanderodus striatus*, *Microzarkodina? marathonensis*, *Bergstroemognathus extensus* Serpagli, *Fryxellodontus corbatoi* Serpagli, and *Diaphorodus delicatus*.

Assemblage II (Fig. 3:6) commences with the incoming of *Bergstroemognathus extensus*, *Diaphorodus russoi*, *Fryxellodontus corbatoi*, *Rossodus symmetricus* n. sp., *Tripodus laevis* (Bradshaw) and New gen. 1 n. sp. A. Of these species, *B. extensus* and *F. corbatoi* are restricted to this assemblage, and *D. russoi* is only found in abundance in Assemblage II (Appendix B:2).

This assemblage first appears high in the lower Catoche Formation, and continues through medial strata of this formation. Assemblage II taxa are known from upper D.D.H. A1, basal D.D.H. 715, entirity of D.D.H. 1827, and upper two samples of D.D.H. 66A, possibly upper strata of D.D.H. 438 of Newfoundland Zinc Mines, and from low medial to upper Catoche Formation at Port au Choix.

Drepanoistodus inaequalis, *Clavohamulus cavus*, ?*Protoprioniodus costatus* (van Wamel), *Protoprioniodus papilosus*, *Protopanderodus gradatus* Serpagli are last found in Assemblage II. Only in Assemblage II is *Paroistodus parallelus* preserved in abundance: prior and subsequent occurrences are rare and sporadic.

Assemblage II is the most abundant and diverse assemblage, containing conodonts of both Midcontinent and North Atlantic Province affinities. It correlates with the San Juan Formation of Argentina (Serpagli 1974), and has characteristics of the North Atlantic Prioniodus elegans Zone.

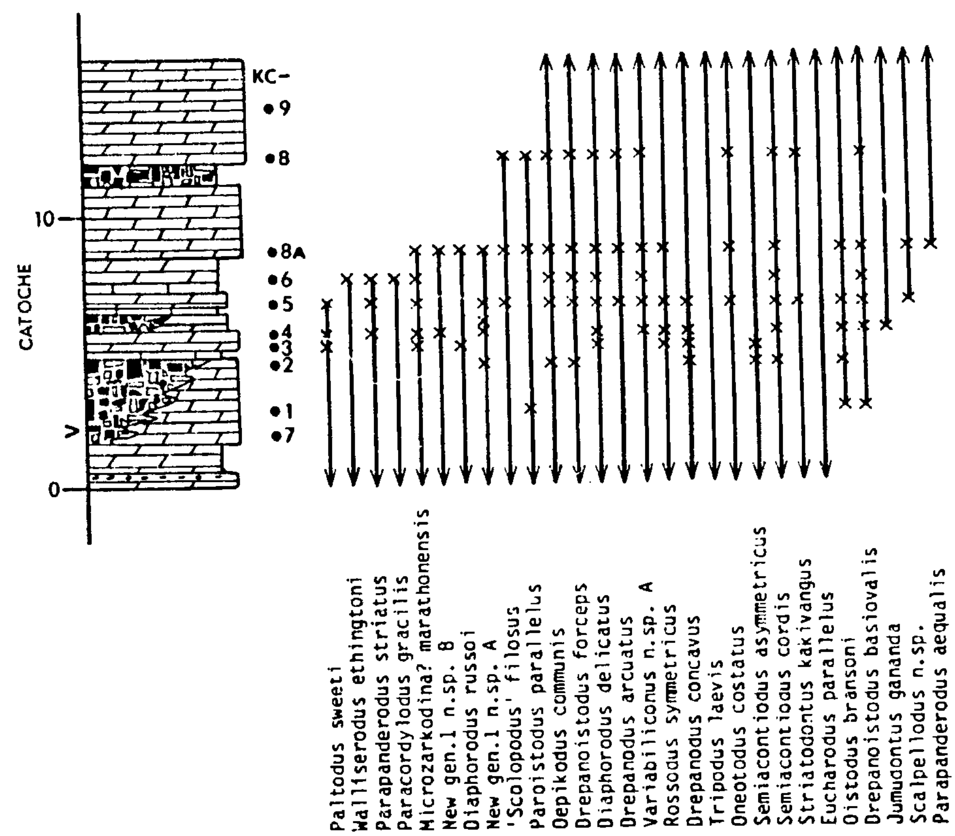
3:5:3. ASSEMBLAGE III

Major components of Assemblage III populations include Drepanodus concavus, Scalpellodus n. sp., and both Drepanoistodus basiovalis (Sergeeva) and D. forceps. Elements of Oistodus bransoni comprise minor, but conspicuous, components of conodont populations.

Drepanoistodus basiovalis and Oistodus bransoni first occur early in Assemblage III; the incoming of Parapanderodus aequalis and Scalpellodus n. sp. occurs later in Assemblage III (Fig. 3:7). Paltodus sweeti, "Scolopodus" filosus, Paroistodus parallelus, ?Microzarkodina marathonensis, Parapanderodus striatus, N. gen. 1 n. sp. B, Diaphorodus russoi, Paracordylodus gracilis Lindström and N. gen. 1 n. sp. A are all last found within this assemblage. Walliserodus ethingtoni is last found in Assemblage III of the studied section, but is also known from the Table Head Group (Stouge 1984).

Assemblage III is known from the upper Catoche Formation, and does not extend into the Aguathuna Formation

Fig. 3:7. Stratigraphic section of upper Catoche Formation exposed in Freshwater Cove, with associated range chart of Assemblage III conodonts. Symbols as in Fig. 3:5 (From section measured by T. Lane).



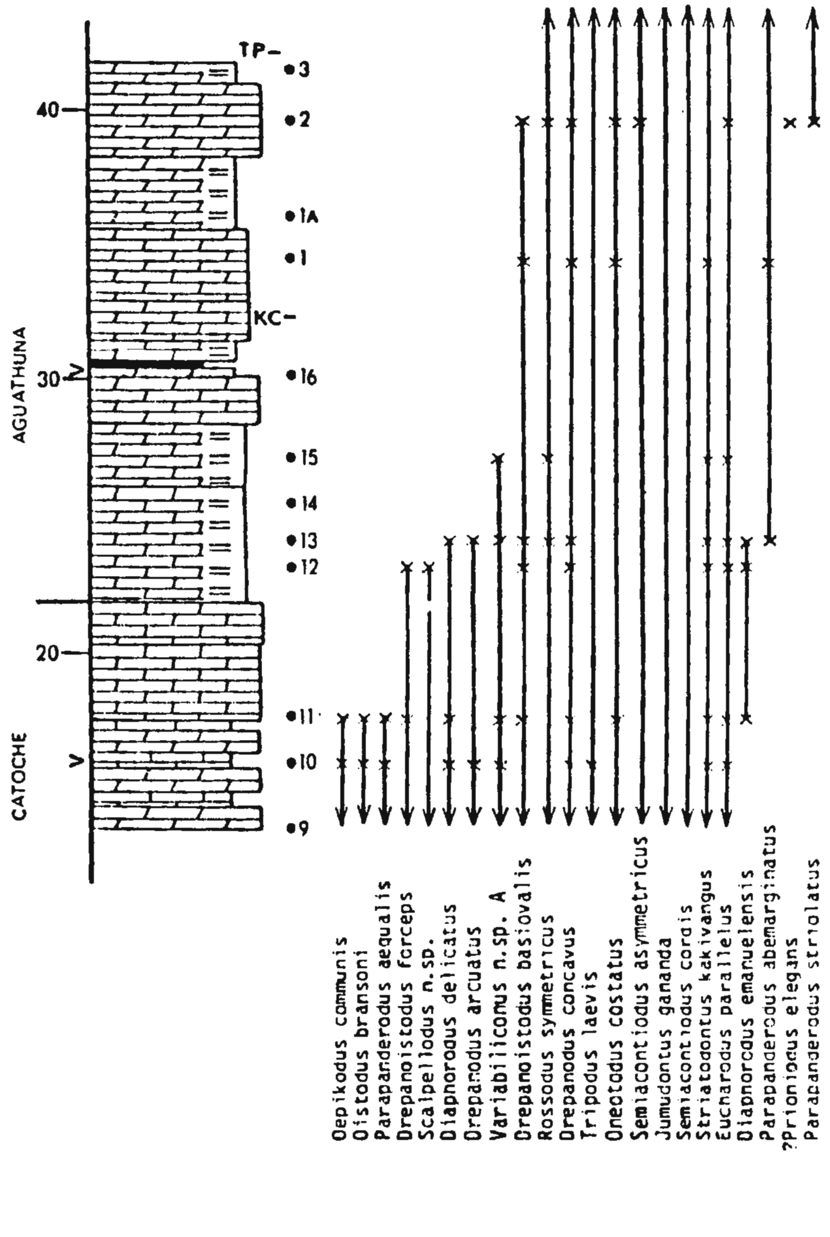
of the Daniel's Harbour region, except in D.D.H. 715 where it ranges from 15 m below the Aguathuna Formation to 20 m into this formation. It has been documented from within the shore section at Freshwater Cove, north of Table Point, basal strata and probably uppermost few m of D.D.H. 438, from lowest collected sample to five metres below the base of the Aguathuna Formation in D.D.H. 1500. An anomalous occurrence in D.D.H. 440, from 33 to 13 m beneath the base of the Table Point Formation, is probably fault-controlled. Absent or obscured at Aguathuna, Assemblage III is found in uppermost Catoche Formation of Back Arm Bay, and middle Aguathuna Formation east of The Gravels.

Based on the occurrence of Oistodus bransoni with relatively abundant specimens of Diaphorodus delicatus, this assemblage corresponds to shallow cratonic deposits of upper Jefferson City Dolomite (Ethington & Repetski 1984). Drepanoistodus basiovalis and D. forceps occur in approximately equal numbers, indicating an age close to lower or middle Volkhovian of the Baltic sequence (Löfgren 1978).

3:5:4. ASSEMBLAGE IV

Assemblage IV is characterised by lower conodont diversity (Fig. 3:8) and abundance (Appendix B:4) than lower assemblages. Long ranging taxa dominate, particularly later in the assemblage. These include unusually high abundances of Eucharodus parallelus, Oneotodus costatus, Drepanodus

Fig. 3:8. Stratigraphic section of uppermost Catoche Formation and lower Aguathuna Formation exposed in Freshwater Cove, with associated range chart of Assemblage IV conodonts. Marker beds are the "Worms" Marker (lower) and "Breccia Bed" of Stouge (1982; upper). Symbols as for Fig. 3:5. Modified from section drawn by T. Lane.



concavus, Semiacontiodus cordis, Striatodontus kakivangus, and Semiacontiodus asymmetricus.

Few species are first found in Assemblage IV. Diaphorodus emanuelensis is only known from early to mid Assemblage IV; Parapanderodus abemarginatus first occurs in the middle of this assemblage; Parapanderodus striolatus first appears late in this assemblage.

Half of the species continuing from Assemblage III disappear by mid assemblage: these include Drepanoistodus forceps, Oepikodus communis, Variabiliconus n. sp. A, Diaphorodus delicatus, Drepanodus arcuatus, Oistodus bransoni, Parapanderodus aequalis and Scalpellodus n. sp. Drepanoistodus basiovalis also disappears from the Table Point section before the emergence of Assemblage V.

The disappearance of Oepikodus communis, together with the presence of Tripodus laevis, is indicative of Whiterockian age (Ethington & Repetski 1984).

Assemblage IV is recorded from uppermost Catoche and lower Aguathuna formation of the shore section north of Table Point, middle Aguathuna Formation of D.D.H. 438 and 715, the base of D.D.H. 498, and is correlated with middle of the Aguathuna Formation at Hare Bay, and all but uppermost 12 m of Aguathuna Formation west of The Gravels and at Aguathuna quarries.

3:5:5. ASSEMBLAGE V

The incoming of Diaphorodus stevensi, together with the presence of Pteracontiodus cryptodens, Oistodus multicorrugatus Harris and Oepikodus intermedius Serpagli are indicative of Assemblage V.

With the exception of Rossodus symmetricus, long ranging forms of Assemblage IV continue through the entirity of Assemblage V (Fig. 3:9).

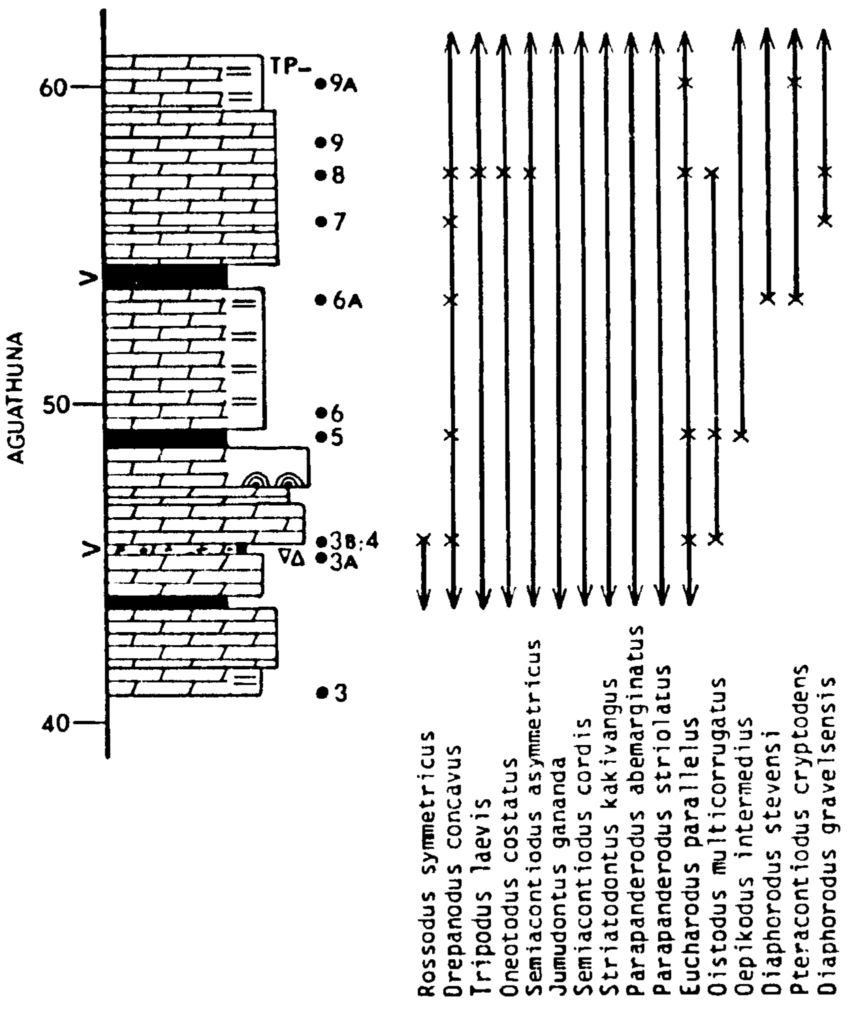
These species are joined by Pteracontiodus cryptodens, Oistodus multicorrugatus, Oepikodus intermedius, Diaphorodus stevensi and Diaphorodus gravelsensis. The first two of these indicate an early Whiterockian age (Sweet et al. 1971). Diaphorodus gravelsensis appears earl. er in the sequence at Port au Port Peninsula.

This assemblage is known from the middle Aguathuna of the shore section north of Table Point and in D.D.H. 715, from middle part of D.D.H. 498, and from upper Aguathuna Formation of Hare Bay and west of The Gravels.

3:5:6. ASSEMBLAGE VI

This assemblage is distinguished from previous assemblages by the last occurrence of Drepanodus concavus and Tripodus laevis and first appearance of Drepanodus sp. cf. D. gracilis and ?Reutterodus sp. Conodonts are of low abundance and diversity, dominated by Oneotodus costatus

Fig. 3:9. Stratigraphic section of middle Aguathuna Formation north of Table Point, with range chart of associated Assemblage V conodonts. Symbols are explained in Fig 3:5. The prominent solution horizon of the Middle Aguathuna Formation is the lower marker; the "Upper Argillite" is the upper marker. Modified from section measured by T. Lane.



(Fig. 3:10, Appendix B:6).

Consisting of long-ranging, endemic species, this assemblage is difficult to correlate. The last occurrence of T. laevis indicates correlation with Fort Pena Formation of Texas rather than Juab of Utah (Ethington & Clark 1981). The base of the former corresponds with Midcontinent Fauna 3 or 4. However, the presence of ?Reutterodus sp. indicates an early Whiterockian age. It is likely that T. laevis was excluded from the St. George Group earlier than in other areas.

Assemblage VI is found within a thin interval, low in the upper Aguathuna Formation of the shore section north of Table Point, and also in D.D.H. 440 and D.D.H. 498. Species diagnostic of this assemblage are missing from D.D.H. 715. West of The Gravels, Assemblage VI occurs in uppermost Aguathuna Formation.

3:5:7. ASSEMBLAGE VII

The incoming of a highly abundant, diverse fauna marks the beginning of Assemblage VII. Drepanoistodus angulensis, Erismodus asymmetricus, Leptochirognathus quadrata Branson and Mehl, ?Multioistodus auritus (Harris & Harris) sensu Ethington & Clark, M. subdentatus Cullison, Paraprioniodus costatus Ethington & Clark, Protopanderodus strigatus Barnes and Poplawski, Scandodus sinuosus and endemic species (Fig. 3:11), are all found in the lowest sample of this assemblage,

Fig. 3:10. Stratigraphic section of upper Aguathuna Formation at Table Point, with range chart of associated Assemblage VI conodonts. Symbols as for Fig. 3:5. The prominent solution surface of the upper Aguathuna Formation is marked. Modified from section measured by T. Lane.

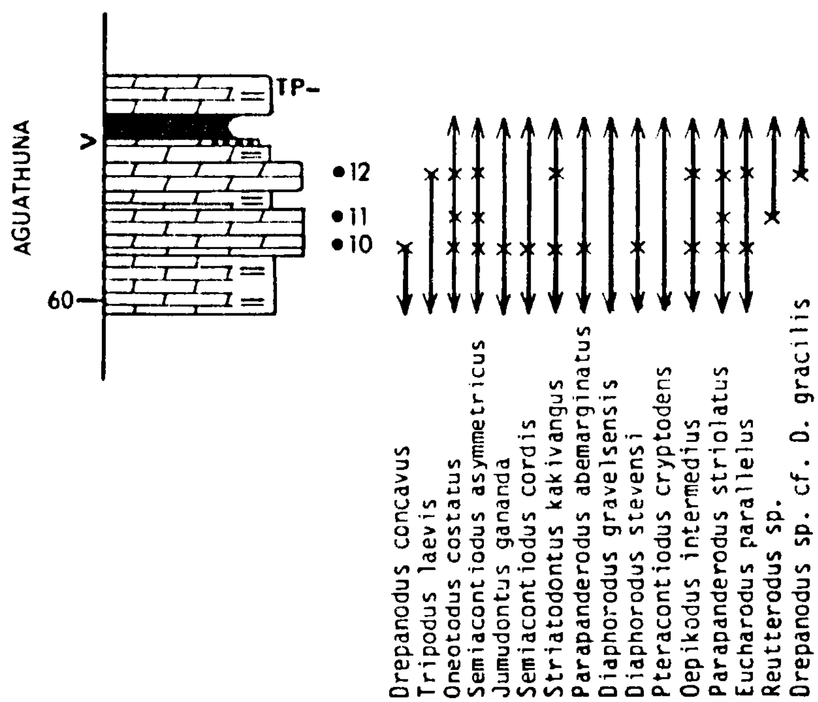
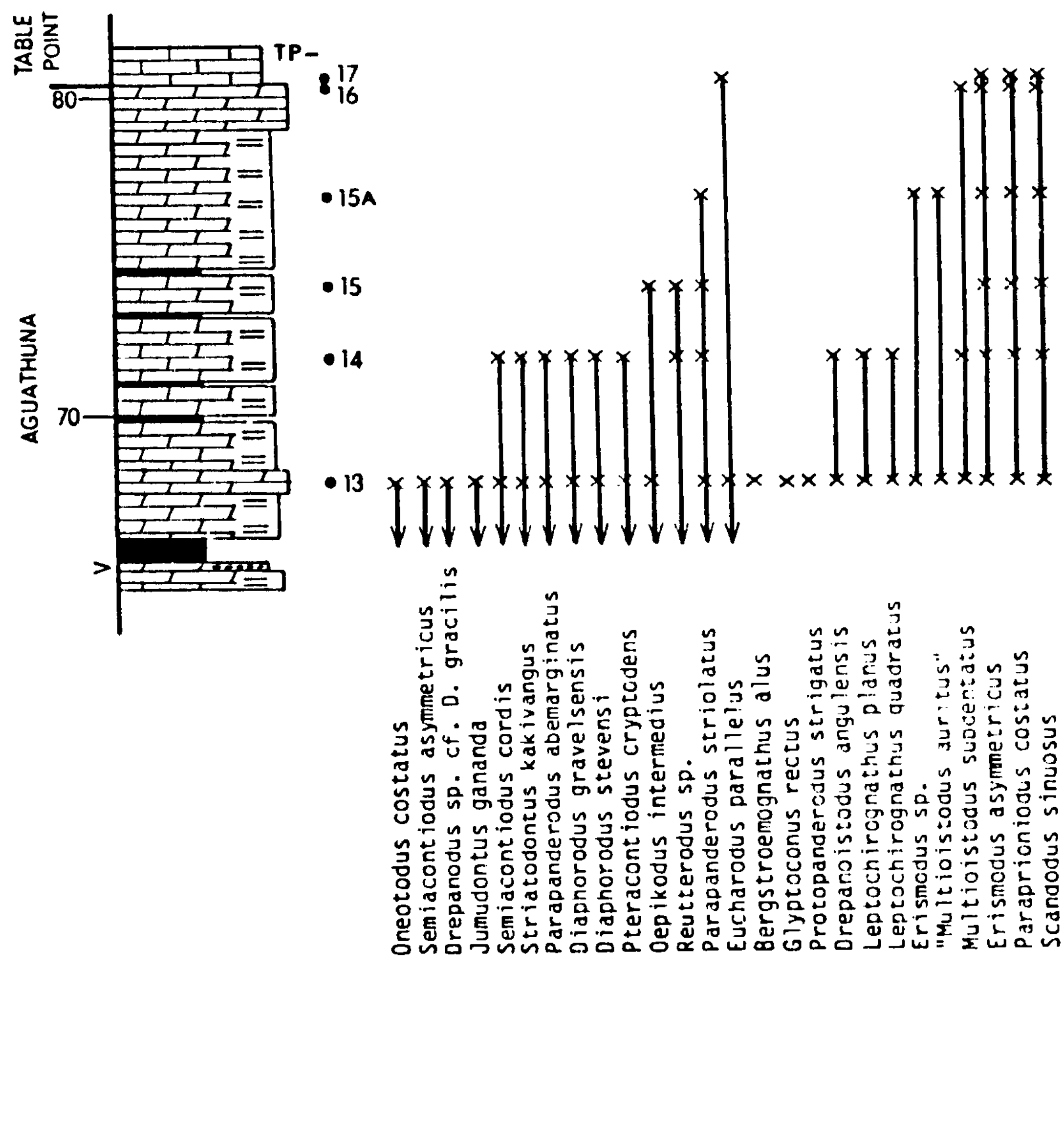


Fig. 3:11. Stratigraphic section of uppermost Aguathuna and lowermost Table Point formations at Table Point, with range chart of associated Assemblage VII conodonts. Symbols as for Fig. 3:5. Modified from section measured by T. Lane.



and continue through to uppermost Aguathuna Formation.

Jumudontus gananda, Oepikodus intermedius, Oneotodus costatus, Parapanderodus abemarginatus, Pteracontiodus cryptodens, ?Reutterodus sp. and Striatodontus kakivangus do not continue into the Table Point Formation (Stouge 1984).

This Assemblage is found in the uppermost 15 m of the Aguathuna Formation and basal Table Point Formation at Table Point. It is also present within upper levels of D.D.H. 440, D.D.H. 715 and D.D.H. 498. At Back Arm Bay, an Assemblage VII conodont fauna is found in both post-Catoche samples, indicating a considerable hiatus representing the omission of most of the Aguathuna Formation at this locality. This assemblage is represented by a diminished fauna on Port au Port Peninsula, this and is only completely developed in Table Point Formation.

The incoming of Assemblage VII is not abrupt on Port au Port Peninsula, as occurs at the section north of Table Point. This indicates a hiatus in the Daniel's Harbour region immediately prior to the incoming of this fauna.

Species of Multioistodus Cullison, common within this assemblage, are indicative of correlation with Lehman Formation of Utah. Scandodus sinuosus is characteristic of the Kanosh Shale in Utah (Ethington & Clark 1981), and Joins Formation of Oklahoma (Mound 1965b).

3:6. NEWFOUNDLAND ZINC MINES DRILL CORE

D.D.H. A1 was used as the basis for assemblages I and II. Biostratigraphy of this drill core is described above.

3:6:1. D.D.H. 1827

Spot samples collected from above and within the ore zone yield an Assemblage II fauna at the base (Fig. 3:12). Uppermost sample contains *Variabiliconus* n. sp. B, which is not found below Assemblage III elsewhere. Samples contain few conodont elements, and a more precise correlation is therefore not possible.

3:6:2. D.D.H. 66A

Three samples were collected from upper middle Catoche Formation (Fig. 3:13). The presence of *Glyptoconus quadraplicatus* in the lowest sample indicates correlation with Assemblage I. *Drepanodus arcuatus* and *Tripodus laevis* are not found earlier than Assemblage II. It is therefore likely that samples correlate with late Assemblage I and early Assemblage II.

3:6:3. D.D.H. 438

Samples taken from the mineralized zone were barren (Fig. 3:14). At 35 m below the base of the Aguathuna

Fig. 3:12. Stratigraphic section of the upper Catoche Formation from D.D.H. 1827, with associated conodont range chart. Markers are the "66 Aquifer" (lower) and the "Oval Mottles". Symbols as in Fig. 3:5. Modified from core log by T. Lane.

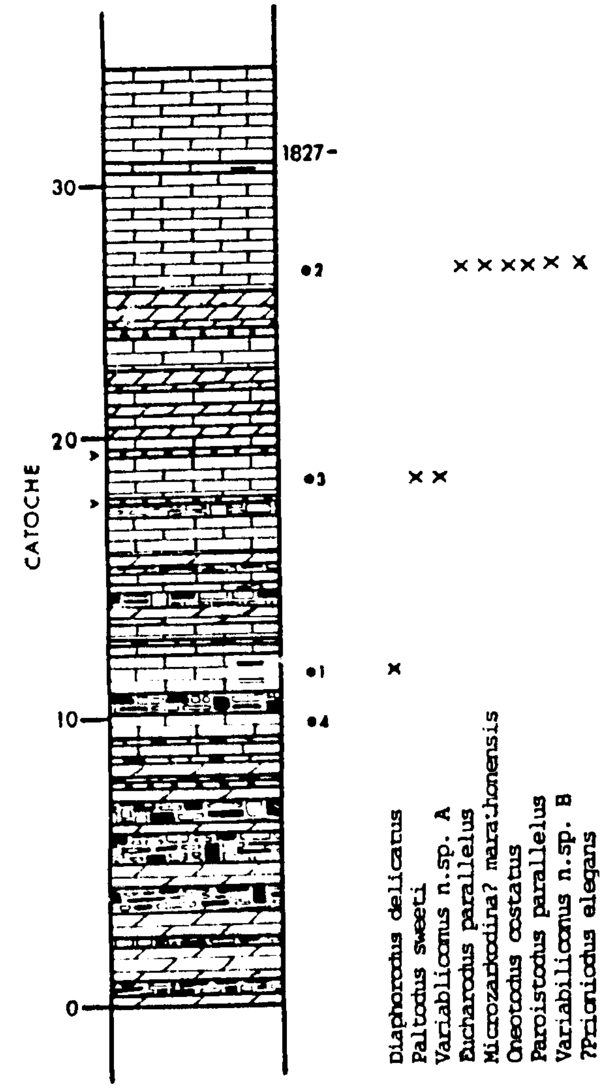


Fig. 3:13. Stratigraphic section of lower Catoche to upper Aguathuna formations from D.D.H. 66A. Only the section marked A-A' was sampled: this is enlarged, with associated conodont range chart, to right of complete section. Symbols as for Fig. 3:5. The lower marker is the "Mottled Chert", and the upper marker is the "Upper Argillite". Modified from section drawn by T. Lane.

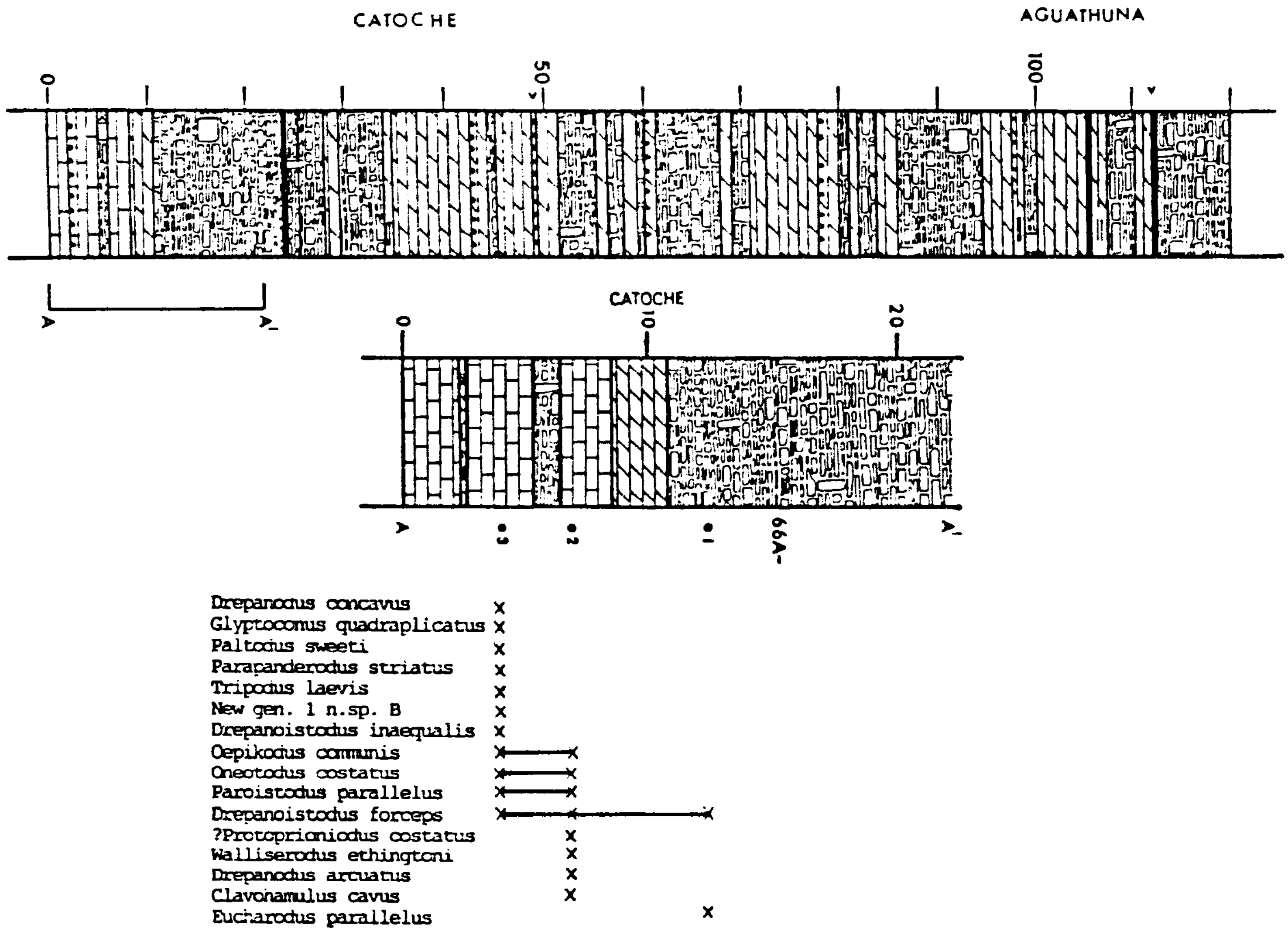
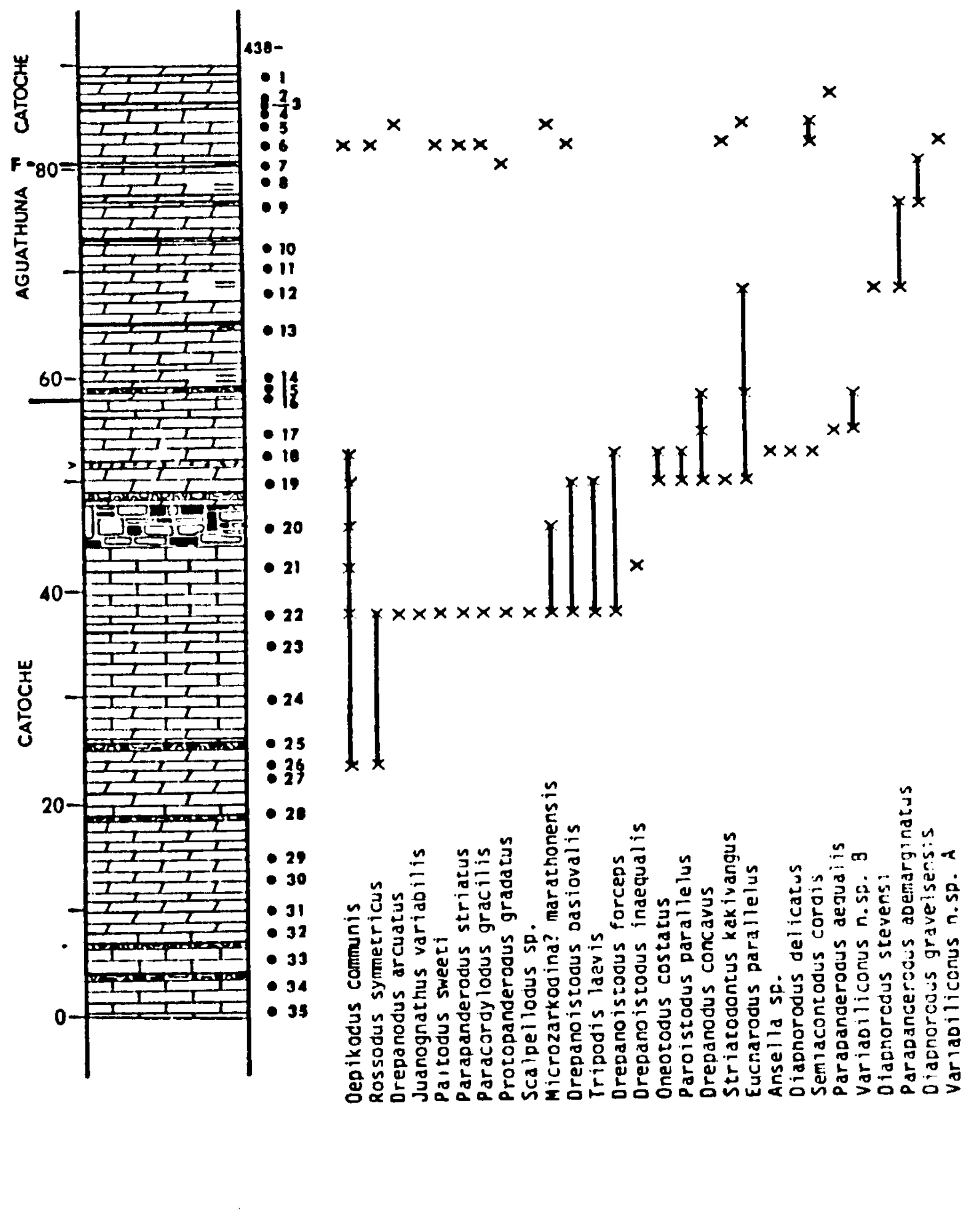

CATOCHE
AGUATHUNA
0
50
100
A
A'
CATOCHE
0
10
20
3
2
1
66A-
Drepanodus concavus
Glyptoconus quadraplicatus
Paltodus sweeti
Parapanderodus striatus
Tripodus laevis
New gen. 1 n.sp. B
Drepanoistodus inaequalis
Oepikodus communis
Oneotodus costatus
Paroistodus parallelus
Drepanoistodus forceps
?Protoprioniodus costatus
Walliserodus ethingtoni
Drepanodus arcuatus
Clavohamulus cavus
Eucharodus parallelus

Fig. 3:14. Stratigraphic section of Catoche and Aguathuna formations from D.D.H. 438, with associated conodont range chart. The indicated horizon in the uppermost Catoche Formation is the "Worms" Marker; F indicates the level of the fault between Aguathuna and Catoche Formation strata. Symbols as for Fig. 3:5.

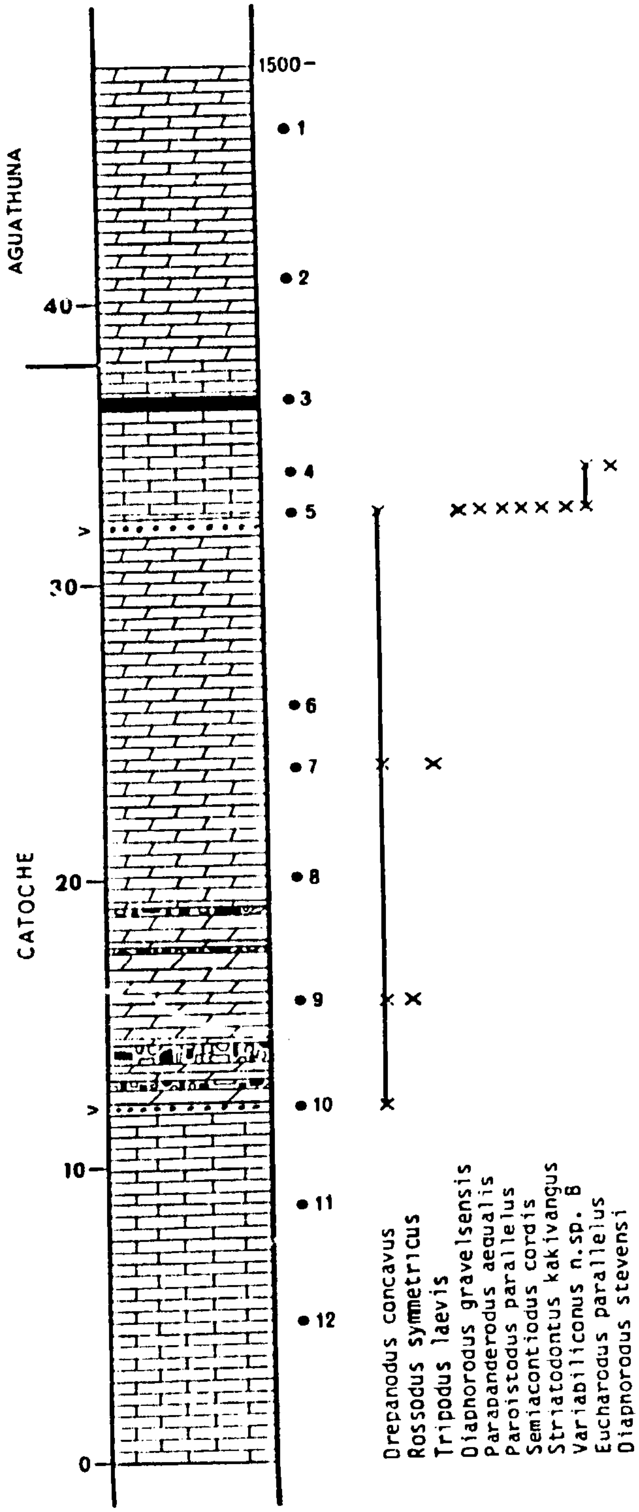


Formation, a sample containing Oepikodus communis and Rossodus symmetricus is correlated with either Assemblage II or III. The occurrence of Drepanoistodus basiovalis and Scalpellodus n. sp., 15 m higher, correlates with Assemblage III. The known range of Drepanoistodus inaequalis is extended to Assemblage III. The next faunal change occurs eight metres above the base of the Aguathuna Formation. Here, Assemblage IV is represented by Parapanderodus abemarginatus and Diaphorodus stevensi. This assemblage is succeeded, 24 m above the base of the Aguathuna Formation by an Assemblage II fauna including Protopanderodus gradatus and Oepikodus communis and rapidly superceded by Assemblage III species (e.g. Parapanderodus aequalis and Drepanoistodus basiovalis). It is therefore likely that a fault or reworking of sediments has affected upper levels of this section.

3:6:4. D.D.H. 1500

Conodont-bearing samples were all collected from the upper Catoche Formation. Early faunas are sparse, containing Drepanodus concavus, with Rossodus symmetricus or Tripodus laevis. These are correlated with Assemblage III, and succeeded five metres below the base of the Aguathuna Formation by an Assemblage IV fauna (Fig. 3:15). Diaphorodus gravelsensis and D. stevensi co-occur with Parapanderodus aequalis.

Fig. 3:15. Stratigraphic section of upper Catoche and lower Aguathuna formations of D.D.H. 1500, with associated conodont range chart. The "Oval Mottles" is the lower marker, the "Worms" marker is the upper marker. Symbols as in Fig. 3:5. Modified from stratigraphic log by R. Hodgson, Teck Explorations Ltd.



3:6:5. D.D.H. 715

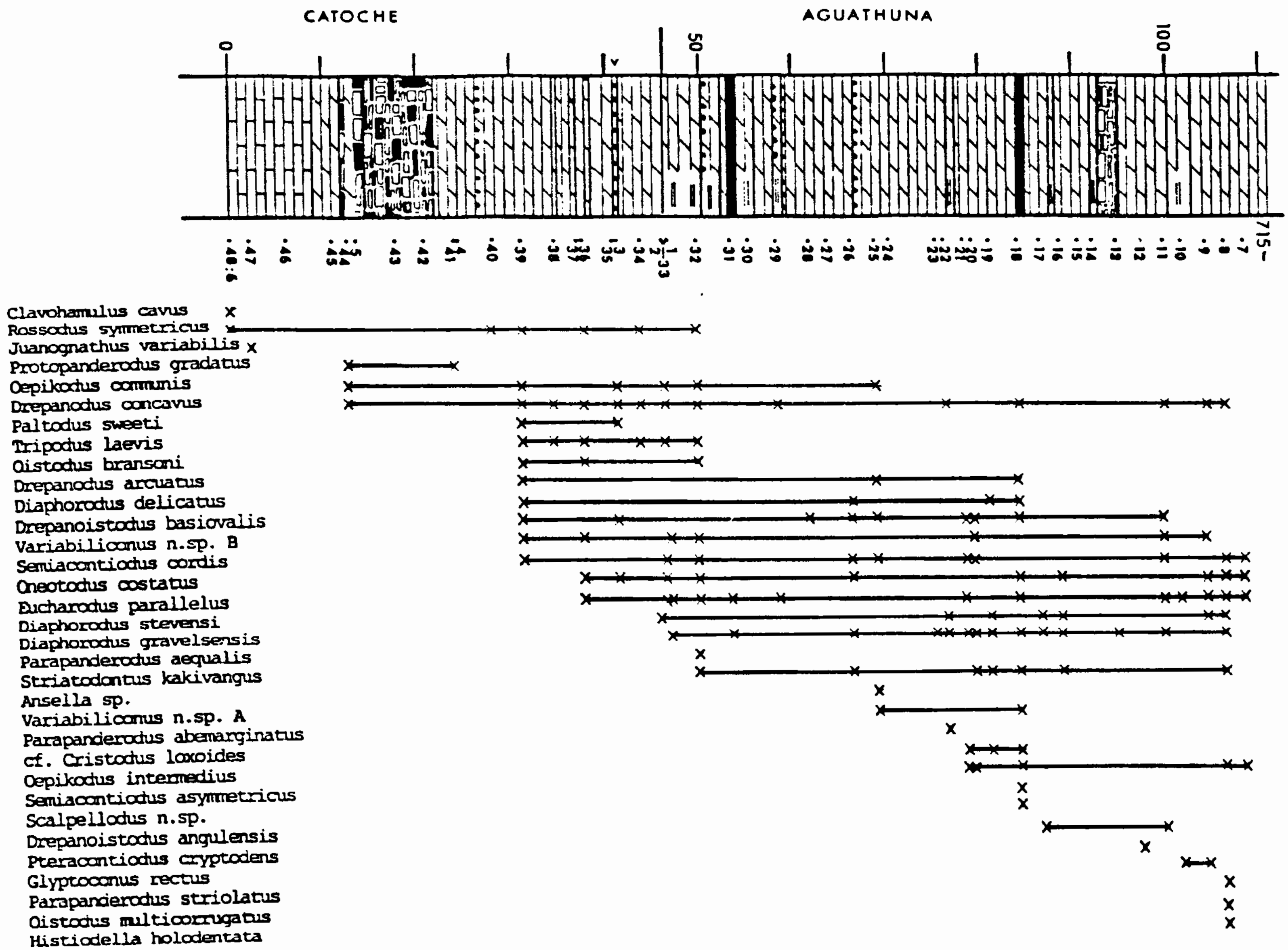
Drill core intersects upper Aguathuna to middle Catoche formation (Fig. 3:16). Lowest samples, at the level of upper ore zone, contain Juanognathus variabilis Serpagli, and Protopanderodus gradatus, Oepikodus communis and Drepanodus concavus. This interval most likely correlates with upper Assemblage II, or lower Assemblage III.

Assemblage III, with Oistodus bransoni, Drepanoistodus basiovalis and Variabiliconus n. sp. B, is found approximately 15 m beneath the base of the Aguathuna Formation. Species characteristic of Assemblage IV, Parapanderodus abemarginatus and P. striolatus first appear approximately 30 m above the base of the Aguathuna Formation. The numerical dominance of Eucharodus parallelus, Drepanodus concavus and Oneotodus costatus commences approximately 20 m above the base of the Aguathuna. Assemblage IV probably starts at about this level.

Assemblage V, with Oepikodus intermedius, commences approximately 35 m above the base of the Aguathuna Formation. Cristodus sp. cf. C. loxoides Repetski also ranges within Assemblage V in D.D.H. 715.

Representative species of Assemblage VI are missing from this section. Assemblage VII, beginning with the first appearance of Glyptoconus rectus (Stouge), is first found 55 m above the base of the Aguathuna Formation. Fauna of Assemblage VII in this section is unusual in that Histiodella

Fig. 3:16. Stratigraphic section of upper Catoche Formation and most of the Aguathuna Formation from D.D.H. 715 with associated conodont range chart; marked horizon is the "Worms" marker. Symbols as in Fig. 3:5. Modified from stratigraphic log by A.J. Hartlein, Teck Explorations Ltd.


CATOCHE
AGUATHUNA
0
50
100
Clavohamulus cavus
Rossodus symmetricus
Juanognathus variabilis
Protopanderodus gradatus
Oepikodus communis
Drepanodus concavus
Paltodus sweeti
Tripodus laevis
Oistodus bransoni
Drepanodus arcuatus
Diaphorodus delicatus
Drepanoistodus basiovalis
Variabiliconus n.sp. B
Semiacontiodus cordis
Oneotodus costatus
Eucharodus parallelus
Diaphorodus stevensi
Diaphorodus gravelsensis
Parapanderodus aequalis
Striatodontus kakivangus
Ansella sp.
Variabiliconus n.sp. A
Parapanderodus abemarginatus
cf. Cristodus loxoides
Oepikodus intermedius
Semiacontiodus asymmetricus
Scalpellodus n.sp.
Drepanoistodus angulensis
Pteracontiodus cryptodens
Glyptoconus rectus
Parapanderodus striolatus
Oistodus multicorrugatus
Histiodella holodentata

holodentata Ethington & Clark is found in the Aguathuna Formation, rather than the Table Point Formation.

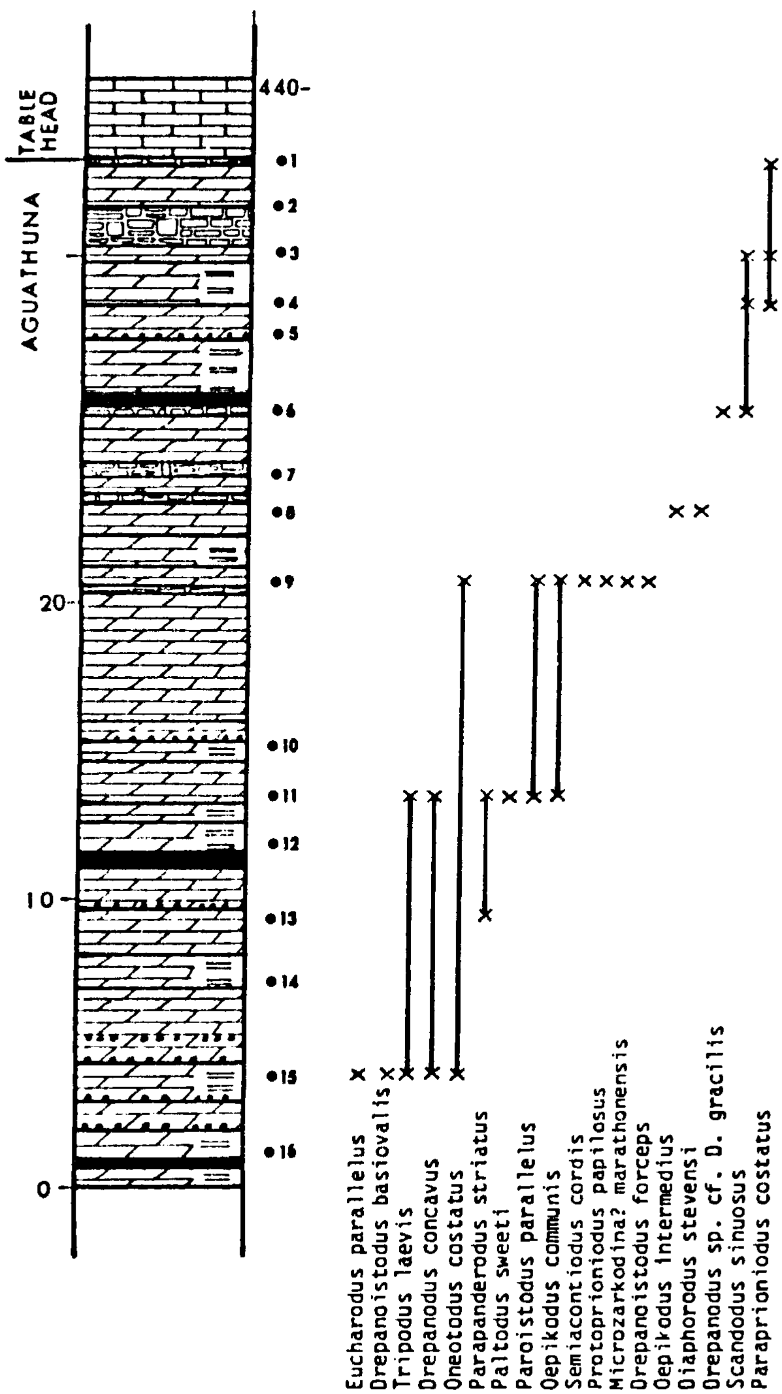
Ranges of *Diaphorodus stevensi* and *D. gravelsensis* are unusually low in this section. This is also true of *Drepanoistodus angulensis*. Other species are found uncommonly high in the section (Fig. 3:16): for example, *Oistodus multicorrugatus* and *Pteracontiodus cryptodens*. This must be a consequence of differing environments during deposition between Table Point and the region sampled by D.D.H. 715.

3:6:6. D.D.H. 440 E/W

This core commences 33 m below base of Table Point Formation and continues to three metres above base of the Table Point Formation (Fig. 3:17). Lowest faunas show affinity with Assemblage III or IV, as indicated by the occurrence of *Drepanoistodus basiovalis* in the lowest sample. The range of ?*Protoprioniodus papilosus* is extended upwards in this section, and more closely corresponds with occurrences in the Baltic sequence.

Between 13 and 10 m below the base of the Table Point Formation, this Assemblage is replaced by faunas of Assemblage V or VI, and rapidly followed by Assemblage VII two metres higher in section (Fig. 3:17). D.D.H. 440 was taken from close to the location of D.D.H. 438. It is likely that the fault or reworking affecting this latter sequence is present in the former.

Fig. 3:17. Stratigraphic section of middle and upper Aguathuna Formation of D.D.H. 440 E/W, with associated conodont range chart. Symbols as for Fig. 3:5.

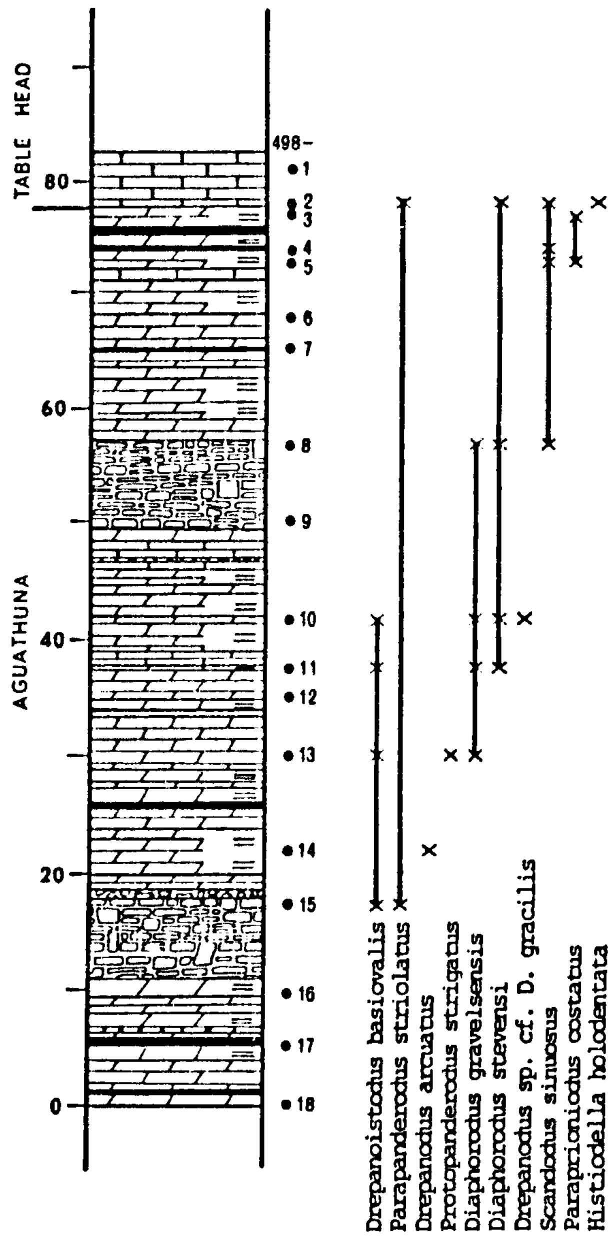


3:6:7. D.D.H. 498

Fifty-nine metres of core were sampled (Fig. 3:18), with the highest sample in basal Table Point Formation. Samples yielded populations of low abundance and diversity (Appendix B:14). The base of the section contained Drepanoistodus basiovalis and Parapanderodus striolatus, that is Assemblage IV. Diaphorodus gravelsensis, and probably Assemblage V, are first found 12 m higher. Drepanodus sp. cf. D. gracilis occurs 10 m above this, signifying the presence of Assemblage VI. Incoming of Assemblage VII is recorded approximately 20 m beneath the Table Point Formation with the presence of Scandodus sinuosus and subsequent appearance of Paraprioniodus costatus.

The above interpretation of the fauna of D.D.H. 498 is considered most likely. However, with the exception of the lowest sample, containing Drepanoistodus basiovalis, all subsequent samples contain species found in Assemblage VII. Assemblage VII may continue from immediately above this level to top of the section. This is more consistent with the lithostratigraphic evidence of a thickened uppermost Aguathuna Formation in this area of the Daniel's Harbour mine.

Fig. 3:18. Stratigraphic section of upper Aguathuna and lowermost Table Point formations of D.D.H. 498. Symbols as for Fig. 3:5. Modified from stratigraphic section prepared by T. Lane.



3:6:8. CORRELATION WITHIN THE DANIEL'S HARBOUR AREA

The reference section at Table Point (Fig. 3:4) was used as the standard for regional conodont biostratigraphy. All drill cores were correlated with this section (Fig. 3:19). Each core was also correlated with other cores to provide a biostratigraphic framework for the mine area. It is probable that uppermost D.D.H. A1 is several tens of metres stratigraphically beneath lowermost collected samples from the Table Point - Freshwater Cove section. The constructed faunal sequence is also recognized in the mine area (Fig. 3:19), so it is unlikely that the missing sequence contains a marked faunal change.

The absence of Assemblage VI from D.D.H. 715 and 498 may be a consequence of erosion associated with the omission surface preserved underneath strata containing Assemblage VI at Table Point, or may be due to environmental factors.

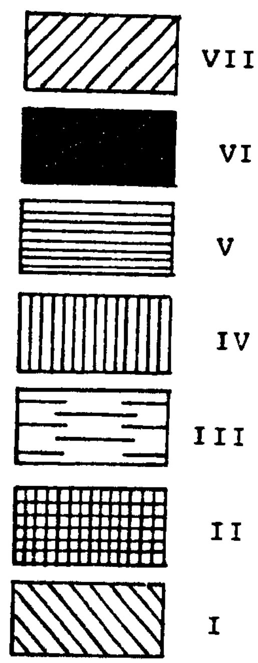
Strata containing Assemblage IV are of varying thickness throughout the Daniel's Harbour region. This may be the result of differing rates of sedimentation.

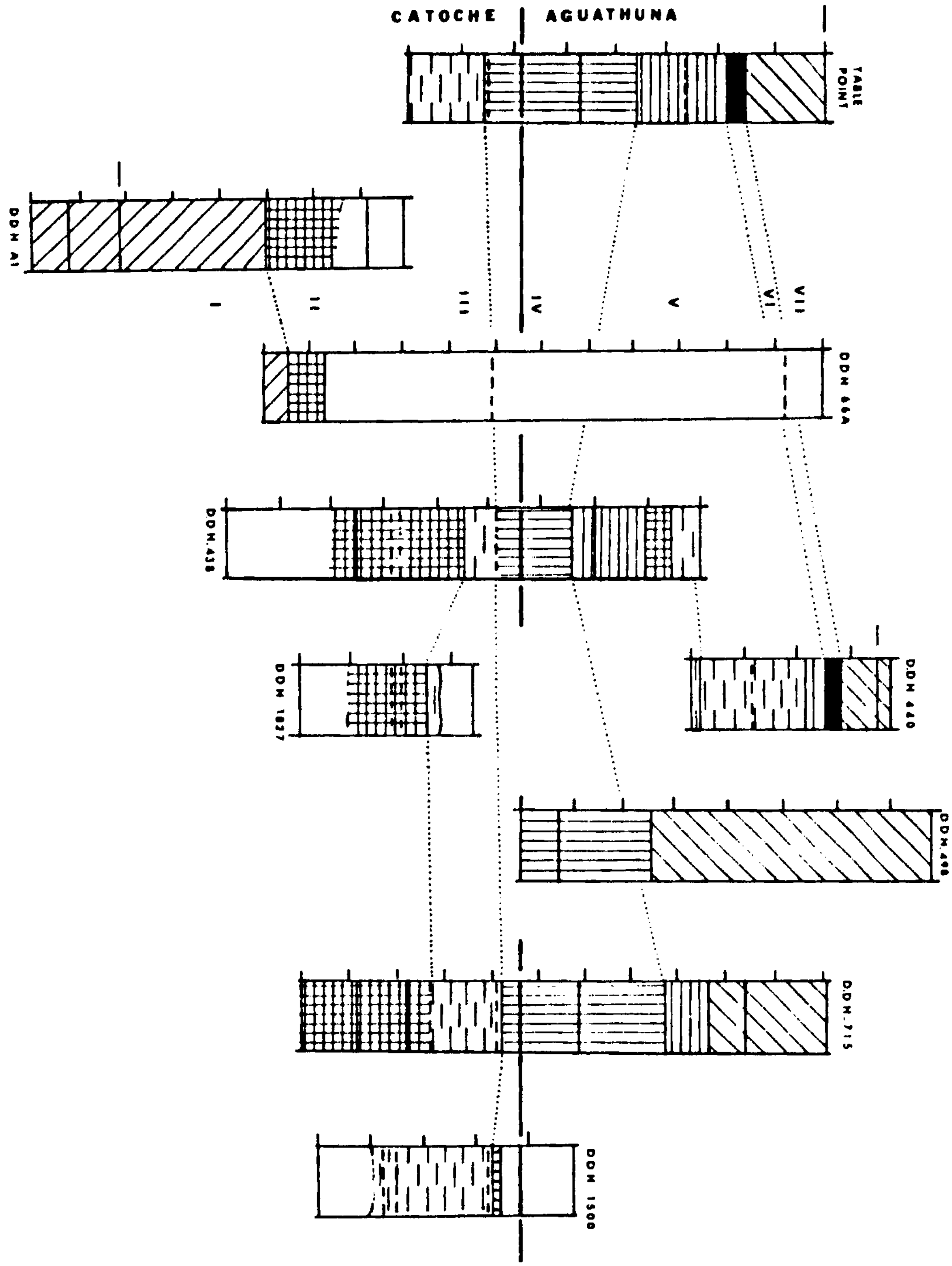
3:7. <u>OTHER SECTIONS</u>

Samples of primarily Aguathuna Formation lithology were collected from Hare Bay, Back Arm Bay, west and east of The Gravels, and road and quarry sections at Aguathuna.

Fig. 3:19. Correlation of faunal assemblages between the reference section at Table Point and drill core in the Daniel's Harbour mine area. The indicated levels within sections, explained in Fig. 2:7, are lithostratigraphic marker horizons used for correlation within the mine. Dotted lines join biostratigraphically equivalent strata. Barren intervals are left blank; stratigraphic position of the conodont assemblages are shown in Roman numerals, otherwise symbols are as below.

<u>Faunal assemblage</u>




CATOCHE
AGUATHUNA

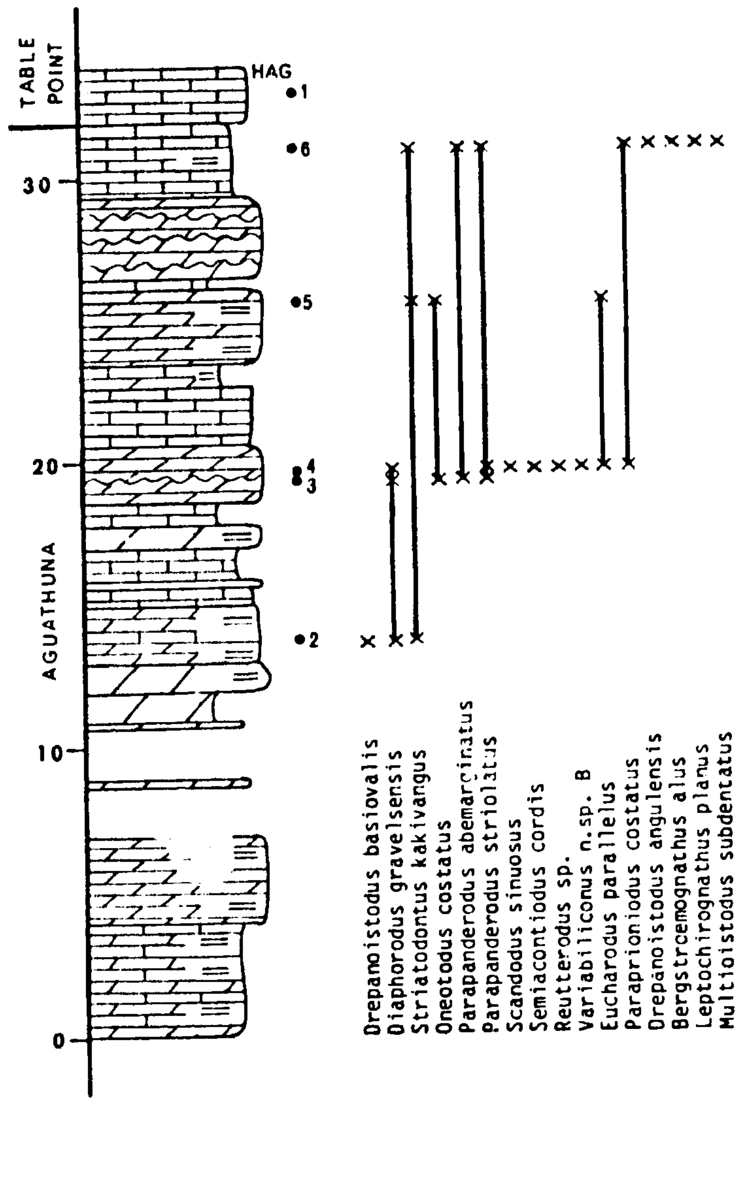
3:7:1. HARE BAY

Approximately 20 m of Aguathuna Formation lithology immediately underlying the base of the Table Point Formation were sampled at Big Spring Inlet, Hare Bay (Fig. 3:20).

The isolated appearance of Drepanoistodus basiovalis in the lowest sample indicates correlation with Assemblage IV. This is accompanied at a higher level by Diaphorodus gravelsensis, which first appears in Assemblage V at Table Point: either the true range of Drepanoistodus basiovalis extends above that of the Table Point section, or Diaphorodus gravelsensis extends lower than Assemblage V. Diaphorodus gravelsensis is found close to the Catoche - Aguathuna boundary in drill core taken from the Daniel's Harbour area, and on Port au Port Peninsula.

Incoming of Assemblage VII species commences approximately 10 m beneath the base of the Table Point Formation with Scandodus sinuosus and Paraprioniodus costatus. The majority of species associated with earliest Assemblage VII are not found until immediately underlying the base of the Table Point Formation. These include Multioistodus subdentatus, Leptochirognathus planus n. sp., Bergstroemognathus alus n. sp. and Drepanoistodus angulensis. At Table Point, earliest Assemblage VII immediately overlies an erosion surface, which may represent the strata deposited between uppermost two bearing samples at Hare Bay.

Fig. 3:20. Stratigraphic section of upper Aguathuna and lowermost Table Point formations from Big Spring Inlet of Hare Bay, with range chart of associated conodonts. Symbols as in Fig. 3:5. Drawn from stratigraphic log measured by N.P. James and B. Stait.



The overwhelming predominance of Multioistodus subdentatus elements over other species in uppermost Aguathuna Formation implies correlation with the Dutchtown Formation of Indiana (Rexroad et al. 1982). Clearly, uppermost Aguathuna Formation at Hare Bay and the Dutchtown Formation were deposited under similar environmental conditions. The presence of Paraprioniodus costatus with Leptochirognathus species suggests correlation with the Everton Dolomite of Indiana.

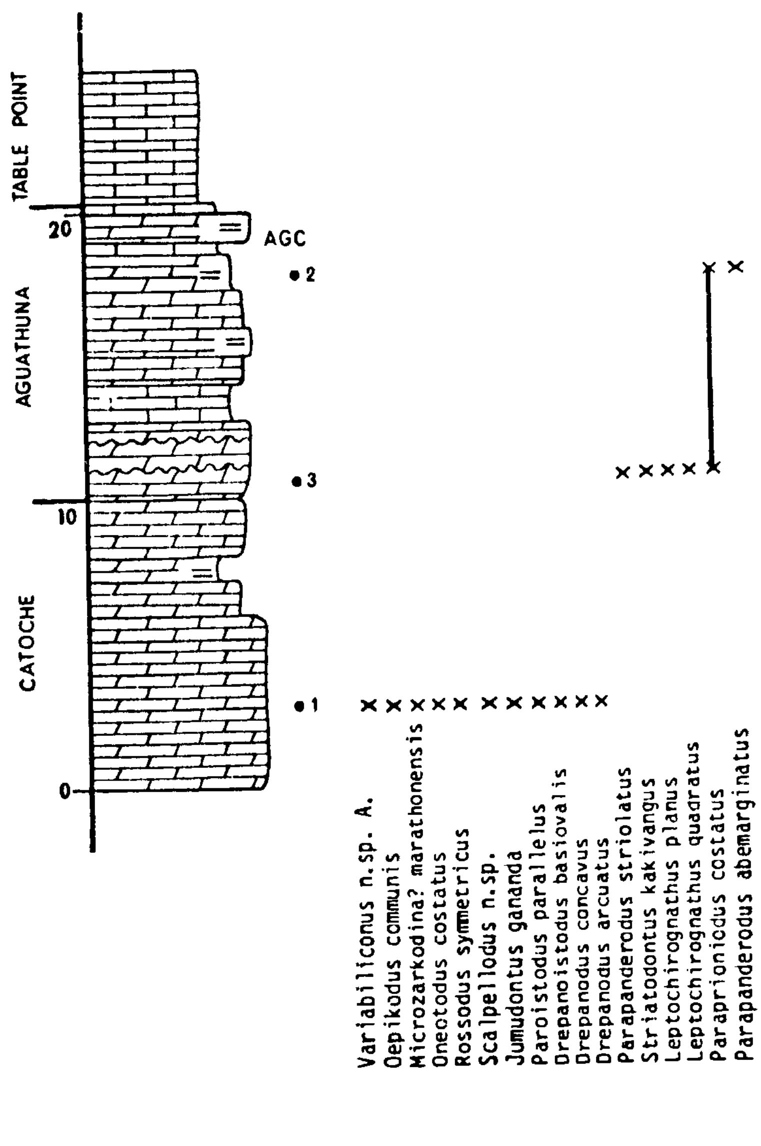
3:7:2. BACK ARM BAY

Three samples, one each of uppermost Catoche, lower and upper Aguathuna Formation lithology, were collected on the eastern side of Back Arm Bay to test lithologic correlations.

The lowest sample (Fig. 3:21), containing Scalpellodus n. sp. and Drepanoistodus basiovalis, together with an abundance of upper middle to upper Catoche species (Assemblage III), confirms lithologic affinities.

Middle and upper samples have approximately the same fauna (Assemblage VII), which is that of uppermost Aguathuna and lowest Table Point formations from the section north of Table Point. These include Paraprioniodus costatus, Leptochirognathus planus and L. quadrata, and species also ranging lower in the Aguathuna Formation, such as Parapanderodus abemarginatus, P. striolatus and Striatodontus

Fig. 3:21. Stratigraphic section of Catoche, Aguathuna and Table Point formations exposed at the garbage dump on Back Arm Bay, opposite Port au Choix Peninsula, with range chart of associated conodonts. Symbols as for Fig. 3:5. Drawn from section measured by N.P. James and B. Stait.



kakivangus.

Evidently, the majority of the Aguathuna Formation is missing at Back Arm Bay with only that part deposited above the uppermost erosional level at Table Point preserved. The uppermost sample contains *Parapanderodus abemarginatus*, which has not been shown to occur within the Table Point Formation. Consequently, the upper two Back Arm Bay samples probably correlate with the Aguathuna Formation north of Table Point.

3:7:3. WEST OF THE GRAVELS

At the base of this section, the lower (but not lowest) Aguathuna Formation, contains *Diaphorodus gravelsensis* of Assemblage IV or V affinity. Approximately 66 m of Aguathuna Formation and the overlying six metres of Table Point Formation lithology were sampled (Fig. 3:22) to determine the faunal succession in the light of absences east of The Gravels.

Twelve metres above the base, a *Parapanderodus abemarginatus* - *P. aequalis* - *Variabiliconus* n. sp. B - *Eucharodus parallelus* fauna is well established. This corresponds with early Assemblage IV at Table Point, and continues to 20 m beneath the base of the Table Point Formation. Here Assemblage V is present, with *Oepikodus intermedius* first appearing, and *Diaphorodus stevensi* and *D. gravelsensis* well established. Assemblage VI fauna containing *Drepanodus* sp. cf. *D. gracilis* appears 2.5 m

Fig. 3:22. Stratigraphic section of Aguathuna and lower Table Point formations exposed to west of The Gravels, Port au Port Peninsula, with range chart of associated conodonts. Stratigraphically lowermost sample (AP10) has only *Diaphorodus gravelsensis* n.sp. Symbols as for Fig. 3:5. Section modified from that measured by D. Haywick.

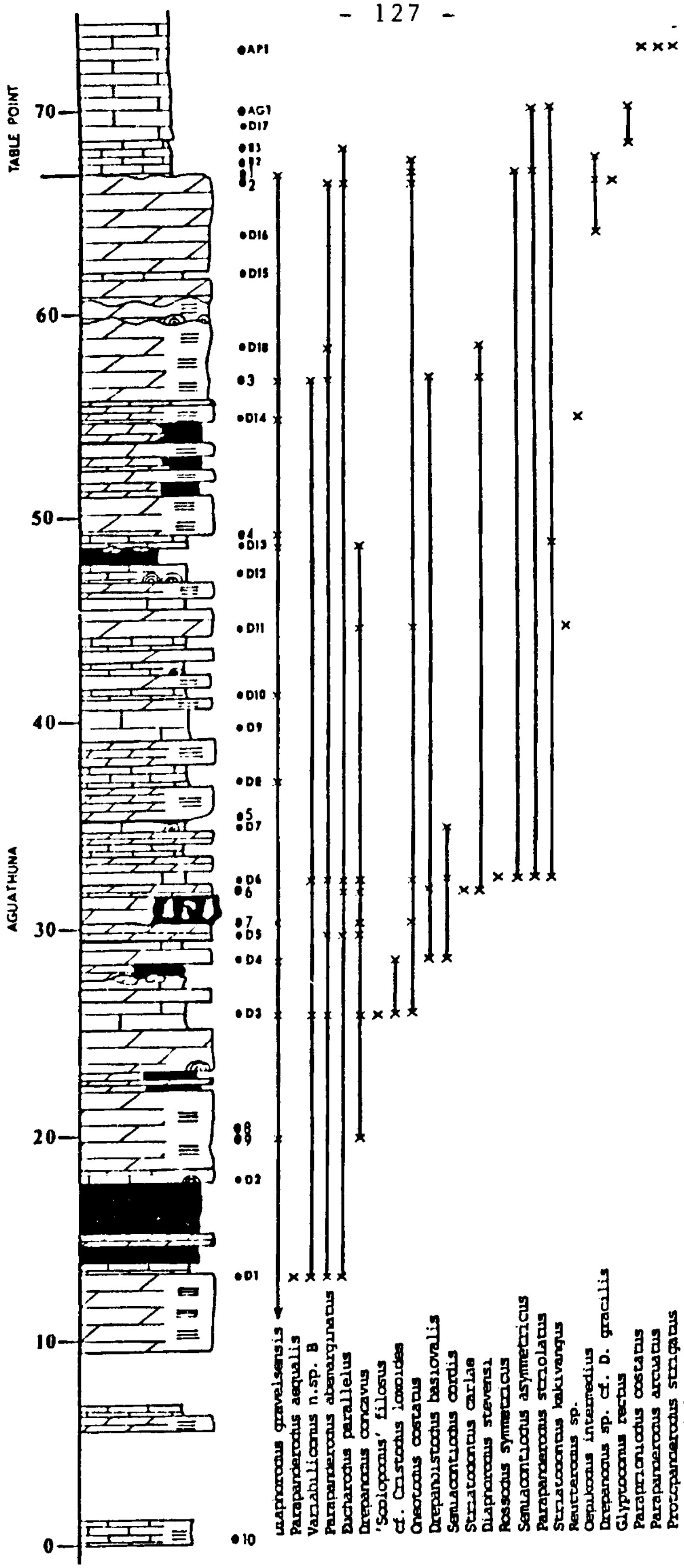


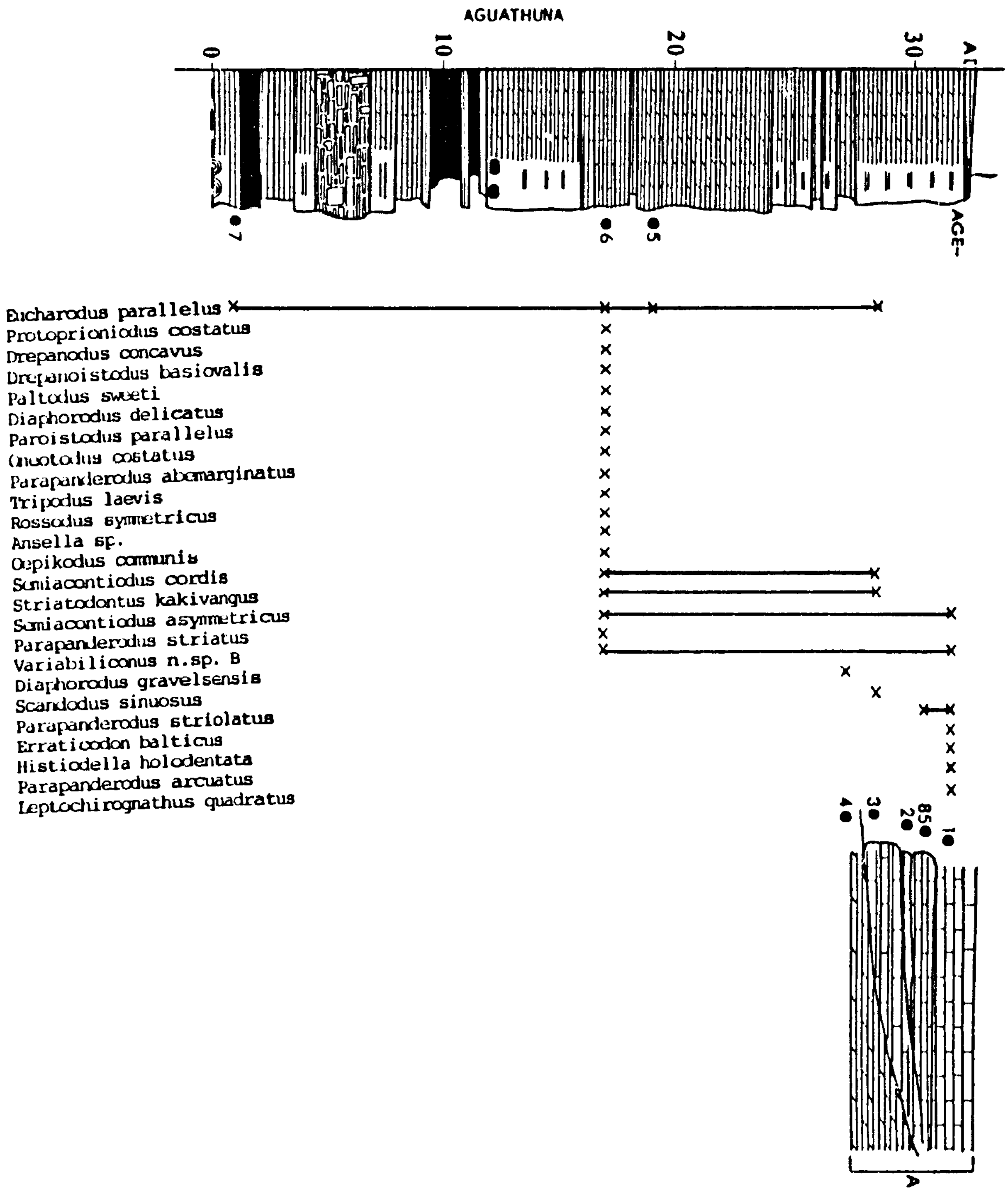
TABLE POINT
AGUATHUNA
0
10
20
30
40
50
60
70
AP1
AG1
D17
D16
D15
D18
D14
D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
10
Diaphorodus gravelsensis
Parapanderodus aequalis
Variabiliconus n.sp. B
Parapanderodus abenarginatus
Bucharodus parallelus
Drepanodus concavus
'Scolopodus' filosus
cf. Cristodus loxoides
Oneotodus costatus
Drepanoistodus basiovalis
Semiacontiodus cordis
Striatodontus carlae
Diaphorodus stevensi
Rossodus symmetricus
Semiacontiodus asymmetricus
Parapanderodus striolatus
Striatodontus kakivangus
Reutterodus sp.
Oepikodus intermedius
Drepanodus sp. cf. D. gracilis
Glyptoconus rectus
Paraprioniodus costatus
Parapanderodus arcuatus
Protopanderodus strigatus
Erraticodon balticus

beneath the base of the Table Point Formation. Glyptoconus rectus, as first representative of Assemblage VII, appears in uppermost Aguathuna Formation. Paraprioniodus costatus, characteristic of Assemblage VII at Table Point, does not appear in this section until 1.5 m above the base of the Table Point Formation, and only occurs for a further 1.5 m. Above this is a fauna dominated by Parapanderodus arcuatus, Protopanderodus strigatus and Erraticodon balticus Dzik. Many of the components of Assemblage VII were not found in this section, indicating differing environmental conditions, including the possibility of non-deposition or erosion of different levels in different areas.

3:7:4. EAST OF THE GRAVELS

Approximately 35 m of Aguathuna and Table Point formation lithologies were sampled (Fig. 3:23). Boat Harbour Formation lithology underlies the lowest sample, and is separated from the Aguathuna Formation by a major fault. The lowest sample contains only Eucharodus parallelus. The following sample yielded ?Protoprioniodus costatus, Drepanoistodus basiovalis, Diaphorodus delicatus, Paroistodus parallelus and Ansella sp., indicative of Assemblage II or III. Parapanderodus abemarginatus is moderately abundant within this sample. The absence of Diaphorodus gravelsensis, common to dominant in Aguathuna Formation of other sections on the Port au Port Peninsula, is indicative of strata lower

Fig. 3:23. Stratigraphic section of Aguathuna and lower Table point formations exposed east of The Gravels near Port au Port Peninsula, with range chart of associated conodonts. Note scale change between AGE 5 and AGE 4. Symbols defined in Fig. 3:5. Modified from section measured by N.P. James and B. Stait.


AGUATHUNA
0
10
20
30
AGE
7
6
5
Eucharodus parallelus
Protoprioniodus costatus
Drepanodus concavus
Drepanoistodus basiovalis
Paltodus sweeti
Diaphorodus delicatus
Paroistodus parallelus
Cnuotodus costatus
Parapanderodus abemarginatus
Tripodus laevis
Rossodus symmetricus
Ansella sp.
Oepikodus communis
Semiacontiodus cordis
Striatodontus kakivangus
Semiacontiodus asymmetricus
Parapanderodus striatus
Variabiliconus n.sp. B
Diaphorodus gravelsensis
Scandodus sinuosus
Parapanderodus striolatus
Erraticodon balticus
Histiodella holodentata
Parapanderodus arcuatus
Leptochirognathus quadratus
4
3
2
85
1
A

than Costa Bay Member. It is likely that the assemblage referred to above correlates with upper Assemblage II of the Daniel's Harbour area.

The succeeding sample, with Variabiliconus n. sp. B and Parapanderodus striatus correlates with mid-Assemblage III or older strata.

Remaining samples were collected from the level of the Aguathuna-Table Point boundary, in order to clarify relationships of the various lithologies (Fig. 3:23). An upper Aguathuna Formation fauna (Assemblage VII) with Diaphorodus gravelsensis and Scandodus sinuosus is closely followed by a lower (but not lowermost at Table Point) Table Point Formation assemblage containing Leptochirognathus quadrata, Parapanderodus arcuatus, an abundance of Histiodella holodentata, Erraticodon balticus and Parapanderodus striolatus.

The Paraprioniodus costatus fauna at top of Aguathuna Formation at Table Point is missing from this section. Possibly there is a hiatus at the Aguathuna Formation boundary to account for the absence of P. costatus. It is also possible that the Erraticodon balticus fauna is contemporaneous with Paraprioniodus costatus but these two are environmentally restricted. Some hiatus is suggested by the co-occurrence of Parapanderodus arcuatus in this uppermost sample. Parapanderodus arcuatus is not found in the section west of The Gravels until five to six metres above the base of the Table Point Formation, 25 to 30 m above the St. George Group at Table Point.

A hiatus is demonstrable close to the top of the section, between AgE3 and AgE4, representing a gap of up to two assemblage zones. Closer and larger samples are required to more accurately determine the extent.

3:7:5. AGUATHUNA QUARRIES AND ROAD SECTION

A section from immediately below the Costa Bay Member (Knight & James 1987) through all of the Aguathuna Formation to low in Table Point Formation was collected (Fig. 3:24a,b).

The lowermost sample, taken from upper Catoche Formation, contains "Scolopodus" emarginatus, Parapanderodus striatus, Diaphorodus delicatus, Oneotodus costatus and Ansella sp. "Scolopodus" emarginatus is only known from Assemblage I of the Daniel's Harbour mine; Ansella sp. from assemblages I and II. At youngest, the upper Catoche at Aguathuna correlates with upper Assemblage I or lower Assemblage II at the Daniel's Harbour mine. The presence of Diaphorodus gravelsensis in abundance, together with longer ranging forms, in the Costa Bay Member, indicates correlation with Assemblage IV of Table Point section. Basal Aguathuna samples contain an Assemblage IV fauna with Drepanoistodus basiovalis, Parapanderodus aequalis and Variabiliconus n. sp. B. Cristodus sp. cf. C. loxoides, normally restricted to Assemblage V, is found with the incoming of Diaphorodus

Fig. 3:24a. Catoche and Aguathuna formations exposed in the southernmost quarry at Aguathuna, and associated conodont range chart. Arrows indicate taxa which are also found higher in the section , shown in Fig. 3:24b. Symbols as in Fig. 3:5. Modified from section measured by N.P. James and B. Stait.

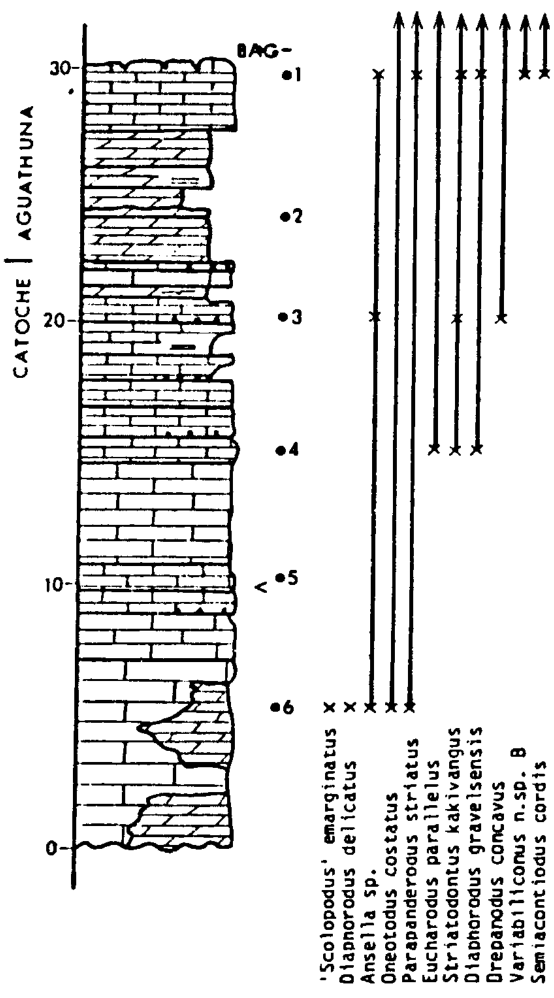
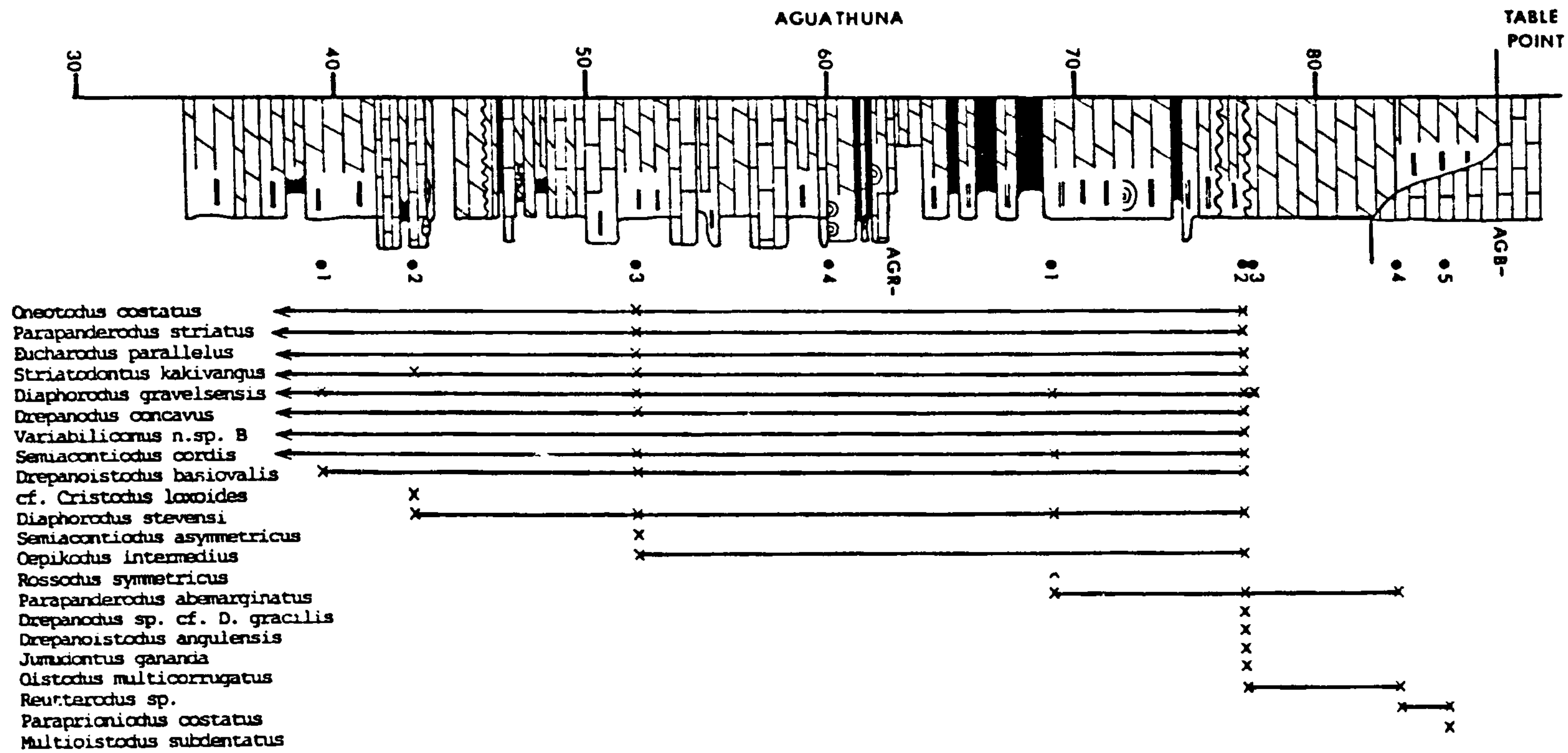


Fig. 3:24b. Aguathuna and Table Point formations exposed between southernmost and top of northernmost quarry at Aguathuna, with range chart of associated conodonts. This section continues from that illustrated in Fig. 3:24a; arrows indicate taxa also found in lower part of section. Symbols as in Fig. 3:5. Modified from section measured by N.P. James and B. Stait.


AGUATHUNA
TABLE POINT
30
40
50
60
70
80
AGR-
AGB-
Oneotodus costatus
Parapanderodus striatus
Eucharodus parallelus
Striatodontus kakivangus
Diaphorodus gravelsensis
Drepanodus concavus
Variabiliconus n.sp. B
Semiacontiodus cordis
Drepanoistodus basiovalis
cf. Cristodus loxoides
Diaphorodus stevensi
Semiacontiodus asymmetricus
Oepikodus intermedius
Rossodus symmetricus
Parapanderodus abemarginatus
Drepanodus sp. cf. D. gracilis
Drepanoistodus angulensis
Jumudontus ganada
Oistodus multicorrugatus
Reutterodus sp.
Paraprioniodus costatus
Multioistodus subdentatus

stevensi in middle Aguathuna Formation, as is the incoming of *Oepikodus intermedius*.

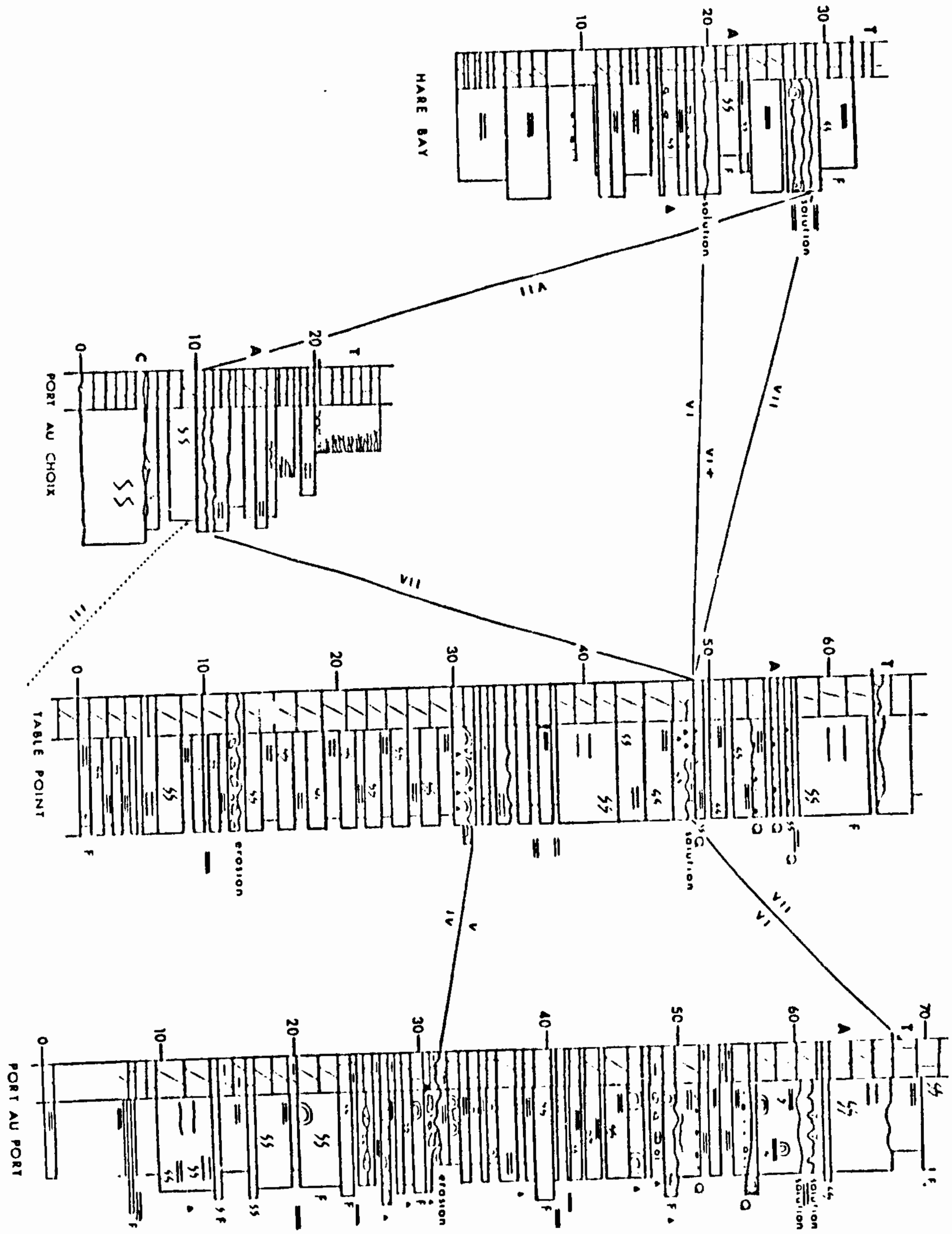
As in the section west of the Gravels, Assemblage VI is first known from uppermost Aguathuna Formation. *Drepanoistodus angulensis*, normally considered restricted to Assemblage VII, is found at the same level. *Paraprioniodus costatus* and *Multioistodus subdentatus*, characteristic of Assemblage VII, are only found several metres above the (irregular) Aguathuna - Table Point Formation boundary.

3:7:6. CORRELATION THROUGHOUT WESTERN NEWFOUNDLAND

Biostratigraphic relationships between the Port au Port, Table Point, Port au Choix and Hare Bay sections are illustrated in Fig. 3:25.

From this it can be seen that Aguathuna Formation on Port au Port Peninsula terminates earlier than similar sediments of the Table Point - Daniel's Harbour region. All but uppermost Aguathuna Formation at Back Arm Bay near Port au Choix is missing from the section: uppermost Aguathuna rests disconformably upon uppermost Catoche Formation in this area. At Hare Bay, a solution horizon approximately 13 m beneath the base of the Table Point Formation represents a stratigraphic break of two local assemblages.

Fig. 3:25. Biostratigraphic correlations between Port au Port, Table Point, Back Arm Bay and Hare Bay sections. Coeval strata are joined by continuous lines. Dotted line indicates correlation with stratum not shown in figure. Roman numerals refer to conodont assemblage, where VI+ is a conodont fauna with some of the species of Assemblage VII whose ranges commence earlier than other Assemblage VII species, but without most of the Assemblage VII fauna. Scale on section in metres; short, stout horizontal lines correspond to formation boundaries: T = Table Point Formation; A = Aguathuna Formation; C = Catoche Formation. Modified from Knight and James (1987).


HARE BAY
PORT AU CHOIX
TABLE POINT
PORT AU PORT
solution
erosion
VII
VI
VI+
IV
V
III

3:7:7. COMPLETENESS OF SECTION

Assemblages within the Catoche Formation are generally recognizable throughout the Daniel's Harbour area, Port au Choix Peninsula, Back Arm Bay and Port au Port Peninsula. From lithological evidence, the sequence of faunas in the Aguathuna Formation is probably disrupted within Assemblage IV (the "Breccia Bed" of Stouge 1982), between assemblages IV and V, and between assemblages VI and VII.

No significant break in the faunal succession is recorded at the level of the Breccia Bed.

The Assemblage IV-V transition is represented by an erosion surface both north of Table Point and west of The Gravels on Port au Port Peninsula. At Aguathuna Quarries, an apparently conformable transition shows approximately the same faunal sequence (Compare Figs. 3:9,10,22,24b). The erosion surface is therefore not likely to represent a significant hiatus.

The Assemblage VI-VII transition is represented at Hare Bay and Table Point by an omission surface. Comparison of faunas between these two localities suggests hiatuses in both successions (Fig. 3:25). The hiatus at Hare Bay commenced earlier than that north of Table Point. Strata either side of the solution surface north of Table Point correlate with strata separated by approximately 10 m of section at Hare Bay. Oscillating relative sea levels are indicated by the occurrence of four omission surfaces within this interval.

The Aguathuna Formation west of The Gravels has a more complete section than that north of Table Point. Assemblage VII is not found until uppermost Aguathuna Formation, and populations comparable with lowermost Assemblage VII at Table Point are not recorded until several metres into the Table Point Formation on west of The Gravels. Faunal differences between these two correlated levels are accounted for by reference to environmental differences: the Aguathuna Formation on Port au Port Peninsula being deposited in deeper water than that at Table Point (Knight & James 1987).

3:8. CORRELATIONS

Correlation of conodont assemblages of the platformal St. George Group succession with allochthonous sequences in western Newfoundland, other successions of mainland Canada, and Midcontinent Province sequences of North and South America are documented below. Detailed discussion of correlation to North Atlantic Province sequences is also included. Where correlation of the upper St. George Group conodonts with other areas is possible, the appropriate strata and faunas are later mentioned. Few species are common to both St. George Group and Baltic sequences, and tentative correlations are therefore not included on the generalized correlation chart (Fig. 3:26). Similarly, other regions mentioned are omitted from Fig. 3:26 due to lack of data.

3:8:1. COW HEAD GROUP, WESTERN NEWFOUNDLAND

According to Fåhraeus and Nowlan (1978), Bed 11 of the Cow Head Group contains *Glyptoconus quadraplicatus*, *Paroistodus parallelus*, *Drepanoistodus forceps*, *Drepanodus arcuatus*. Pohler *et al*. (1987) also found *Oepikodus communis*, *Bergstroemognathus extensus* and *Paltodus sweeti* at this level, which therefore probably correlates with Assemblage I or II of the St. George Group.

Elements of ?New gen. 1 n. sp. A, and *Paroistodus proteus* (Lindström) are known from Bed 9 of the Cow Head succession (S. Pohler, pers. comm. 1988). *P. proteus* is found only in Assemblage I, and ?New gen. 1 n. sp. A is rare in assemblages I and II of the platformal succession. Assemblage I is therefore likely to correlate with upper Bed 9.

It is evident that ranges of some species do not correspond between Cow Head Group and St. George Group sections. As an example, ranges of *Drepanoistodus basiovalis* and *Pteracontiodus cryptodens* exactly correspond in the Cow Head Group (Pohler *et al*. 1987), but do not overlap in the St. George Group. Correlation with Cow Head sequences above Bed 11 is based on graptolites because of the low numbers of conodonts common to these and St. George strata. Correlation using the graptolite zonation of Williams and Stevens (1988) is shown in Fig. 3:26.

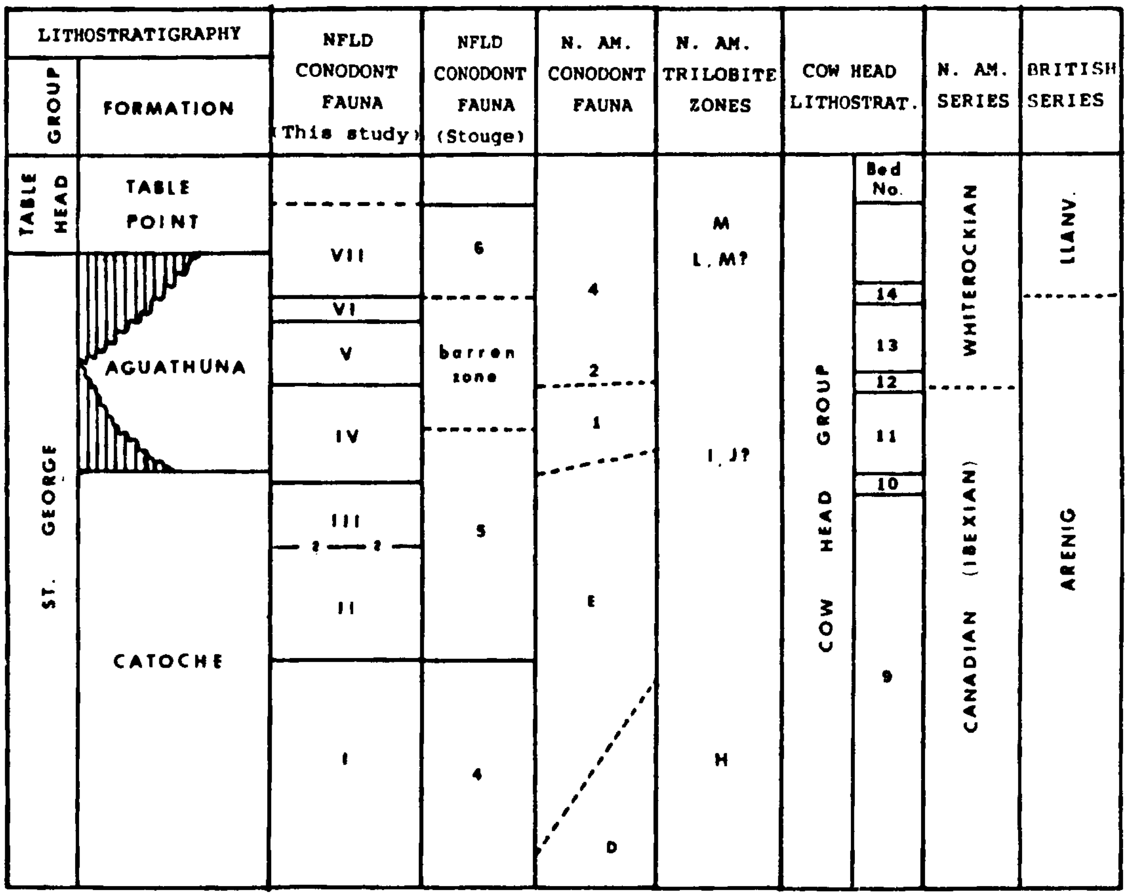


Fig. 3:26. Correlation chart for the conodont assemblages of the St. George Group. Newfoundland Conodont Fauna of Stouge from Stouge (1982); Cow Head correlations from Pohler et al. 1987 (Bed 14), Williams et al. (1987) and this study; North American conodont fauna, representing occurrences found in the St. George Group, with Midcontinent Faunas 1 and 2 interfingering and Fauna 3 absent; other data from Williams et al. (1987).

3:8:2. OTHER AREAS OF CANADA

Lower to Middle Ordovician conodonts are known from the Appalachians of Quebec (e.g. Uyeno & Barnes 1970, Barnes & Poplawski 1973, Landing Barnes & Stevens 1986), the Arctic Platform (e.g. Barnes 1974, 1977, Barnes et al. 1981, Landing & Barnes 1981, Nowlan 1985) and Mackenzie Mountains, Northwest Territories (e.g. Tipnis et al. 1978).

The upper Lévis Formation (Zone D) of Quebec with Histiodella holodentata, elements of Paraprioniodus costatus and Parapanderodus striolatus is of similar age to upper Aguathuna Formation (Uyeno & Barnes 1970). The Mystic Conglomerate also contains a fauna comparable with that of Assemblage VII. Conodont taxa in the entire Aguathuna Formation occur within the Mystic Conglomerate (Barnes & Poplawski 1973), which also contains species from the Table Point Formation (Stouge 1984).

Presence of Parapanderodus striatus, Glyptoconus quadraplicatus and Drepanodus arcuatus within the Baumann Fiord Formation of Arctic Canada (Barnes 1974) indicates contemporaneity with the lower Catoche Formation. Although many of the faunal elements the Eleanor River Formation are missing from the St. George Group, Oistodus multicorrugatus, Semiacontiodus asymmetricus and New gen A of Sweet et al. 1971 are found in both. The Eleanor River Formation probably correlates with the middle Aguathuna Formation. Upper Ship

Point (Barnes 1977) and lower Bay Fiord (Barnes 1974) formations have elements of Assemblage VII: these are likely to be approximately coeval with the uppermost Aguathuna Formation. The conodont fauna of the Bad Cache Rapids Formation (Barnes 1977) is younger than any found in the St. George Group .

Middle Broken Skull Formation conodonts (Tipnis et al. 1978) are similar to those of St. George Group Assemblage I. The uppermost Assemblage (VII) of the Aguathuna Formation is found low in the Sunblood Formation of the Mackenzie Mountains. The Mackenzie Mountains sequence is similar to that found in the St. George Group, although Midcontinent Fauna 3 (typified by Multioistodus species) is preserved in part of the Sunblood Formation, but missing from the St. George Group.

3:8:3. MIDCONTINENT NORTH AMERICA

Some of the biostratigraphically important species found in the Lower and Middle Ordovician of Midcontinent North America are not present in the shallow platform deposits of the upper St. George Group. Taxa important in the outer margin faunas of the Ibex section are rare and sporadic within the St. George Group. Thus, for example, ?Reutterodus sp., Oistodus bransoni, Jumudontus gananda cannot be used exclusively to correlate with successive levels within Fauna E as is the case in the Ibex area. Other associations and events are sufficient to achieve the same result at most levels. Thus faunas of outer cratonic sequences of the Ibex area, El Paso Group and others may be correlated with the St. George Group (Fig. 3:26) due to the common co-occurrence of a considerable number of species.

Midcontinent Fauna E is defined by the incoming of Oepikodus communis (Ethington & Repetski 1984). This occurs in, or prior to, earliest Assemblage I, which is consequently correlated with Fauna E. Oepikodus communis is known throughout North America from above middle Ross-Hintze Zone G_2. Co-occurring "Scolopodus" emarginatus and Protopanderodus gradatus are consistent with correlation to shelly fossil Zone H of the Ibex section (upper Oepikodus communis - Microzarkodina? marathonensis Interval of Ethington and Clark 1981).

Correlation of Assemblage II is strongest with the San Juan Formation of Argentina (Serpagli 1974). This characteristic fauna has also been recorded from the Ninemile Formation of central Nevada (Ethington & Repetski 1984), which accumulated in upper slope or outer shelf conditions (Ross 1977).

Species arising in Assemblage III, especially Jumudontus gananda and Oistodus bransoni, are typical of later faunas of the Oepikodus communis - Microzarkodina? marathonensis Interval of Ethington and Clark (1981). There is no record of a stratigraphic break within rocks of this Interval. Probably

Assemblage II represents lateral facies equivalents of faunas occurring within the Oepikodus communis - Microzarkodina? marathonensis Interval. This assemblage is found in lower to middle Catoche Formation rocks due to a short lived deepening of the site of deposition (Knight & James 1987, p. 1930).

Assemblage IV is also dissimilar to faunas of outer cratonic North America. Early faunas of Assemblage IV contain remnants of previously abundant species, which do not continue past this level. Drepanodus arcuatus, Variabiliconus n. sp. A (= aff Scandodus flexuosus of Ethington & Clark 1981), Paroistodus parallelus, Oistodus bransoni and Oepikodus communis all disappear from St. George Group sections at approximately the same level. A similar disappearance is found in the Ibex section, and it is possible these may be approximately contemporaneous. In western Newfoundland, this disappearance is recorded in uppermost Catoche Formation, which is thereby correlated with early Ross - Hintze Zone J. In both sections, this is followed by the incoming of Oistodus multicorrugatus and Pteracontiodus cryptodens, which (together with two species of Diaphorodus) characterise Assemblage V at Table Point. Assemblage V contains early Midcontinent Fauna 1 (of Sweet et al. 1971), which Ethington and Repetski (1984, p. 97) place just above the first appearance of Pteracontiodus cryptodens. The incoming of Midcontinent Fauna 1 also closely follows the first appearance of "Acodus sp. 2 of McHargue (1981)"

(Ethington & Repetski 1984, p. 97). This species is likely to be conspecific with either Diaphorodus stevensi or D. gravelsensis. Thus the Whiterockian is first recorded approximately 28 m beneath the Table Point Formation at Table Point.

The succeeding Midcontinent Fauna 2 species are either missing from the St. George Group, or represented by long-ranging species in basal Assemblage VII. Assemblage VI, probably of only local significance, has Oistodus multicorrugatus, Pteracontiodus cryptodens, with Jumudontus gananda, Tripodus laevis and remnant species from previous assemblages. As noted by Ethington and Clark (1981, p. 12), the range of T. laevis at Ibex is only part of its potential occurrence. This latter species ranges through much of the studied section. Half of the range of Pteracontiodus cryptodens in the St. George Group preceeds the appearance therein of Drepanoistodus angulensis and Scandodus sinuosus. These three species coexist for the entire range of P. cryptodens in the Ibex area. It is therefore possible, also, that P. cryptodens occurs earlier in the St. George Group than it does in the Ibex section. It is likely that upper Assemblage V and Assemblage VI correlate with Midcontinent Fauna 1.

Assemblage VII, with its initial abundance of coexisting Scandodus sinuosus, Drepanoistodus angulensis, Paraprioniodus costatus, Multioistodus subdentatus, ?Multioistodus auritus sensu Ethington & Clark, and Erismodus asymmetricus is correlated with Ross - Hintze Zone M at oldest, and possibly Zone N. The presence of P. costatus and M. subdentatus with D. angulensis is indicative of correlation with Midcontinent Fauna 4; E. asymmetricus is commonly found higher in the stratigraphic sequence (Midcontinent Fauna 5 to 6). In Canada, it is likely that the range of E. asymmetricus commences lower in the stratigraphic succession than in much of North America, and that Assemblage VII of the St. George Group correlates with Midcontinent Fauna 4.

3:8:4. SOUTH AMERICA

Serpagli (1974) delineated several tentative local assemblage zones from the San Juan Formation of Precordilleran Argentina. The first (A) and second (B) of these correspond in many details with assemblages I and II of this study. Paltodus sweeti, Paracordylodus gracilis, Bergstroemognathus extensus, Paroistodus parallelus, Drepanoistodus forceps, Fryxellodontus corbatoi, Protopanderodus gradatus, Spathognathodus sp. of Serpagli (= Jumudontus gananda), Juanognathus variabilis, Acodus (= Diaphorodus) russoi, ?Protoprioniodus papilosus (= Gen. nov. B. n. sp. 1 of Serpagli 1974) are all found within either of the first two assemblages of both sections. Succeeding assemblages of Serpagli (1974) have some elements in common with St. George Group faunas, but the two successions cannot be directly correlated after Assemblage II. This probably reflects a shallowing of the St. George sequence contemporaneously with a deepening of the San Juan sequence.

3:8:5. BALTIC AREA

The most recent conodont zonation for early Ordovician strata of the Baltic area (Löfgren 1978) was based on previous schemes of Lindström (1971) and Bergström (1971).

St. George Group conodont faunas show affinity primarily with those of Midcontinent North America. Consequently, abundance patterns of the Baltic zone are not applicable to this study. In many cases, the nominate zonal species is missing from the St. George Group, probably as a consequence of environmental differences between the two sequences. More eurytopic species of the Baltic succession, however, are represented in low abundance within the St. George Group. Limited correlation between the St. George Group and the accepted Baltic zonation is possible by comparing sequences and relative abundances of several conodont species.

Links between these two sequences are based upon levels of incoming, and of maximum abundance, of *Paroistodus parallelus*, *Drepanoistodus forceps* and *D. basiovalis*, *Drepanodus arcuatus*, and *Parapanderodus aequalis* (*Scolopodus*? aff. *gracilis* of Löfgren 1978). These species are consistent in occurrence through the St. George Group sections. Correspondence in these patterns between western Newfoundland sequences and those of the Baltic area are therefore unlikely to be fortuitous. Homeomorphs of some of the above species are suspected to be present in the Lower and Middle Ordovician of the Midcontinent Province. As an example, forms referred to _Drepanoistodus_ aff. _D_. _basiovalis_ and _Drepanoistodus_ aff. _D_. _forceps_ by Ethington and Clark (1981, pp. 42, 43) are distinct from both _D_. _basiovalis_ and _D_. _forceps_ from the Baltic region (Ethington & Clark 1981, p. 43). St. George Group forms are more similar to those of the Baltic area.

On the basis of co-occurrence of _Paroistodus_ _parallelus_ and _Drepanoistodus_ _forceps_ in reduced abundances compared with those of later populations, the St. George Group sections commence within the _Prioniodus_ _elegans_ Zone. It is likely that all of Assemblage I correlates with this zone. The incoming of Assemblage II corresponds with earliest _Prioniodus_ (Oepikodus) _evae_ Zone. Within both, previously minor faunal components become dominant (Lindström 1971, p. 29). Thus _Drepanoistodus_ _forceps_ and _Paroistodus_ _parallelus_ become important constituents of the fauna, and facilitate correlation with basal _P_. (_O_.) _evae_ Zone. Löfgren (1978) found no increase in abundance of _P_. _parallelus_, but noted large numbers of acostate _Paroistodus_ throughout most of this zone. The occurrence of ?_Protoprioniodus_ _costatus_ is correlated with the final appearance of _Prioniodus_ _elegans_ in Baltic sequences (van Wamel 1974, p. 30) and hence with early *P.* (*O.*) *evae* Zone (Lindström 1971, Löfgren 1978).

Assemblage III, with the incoming of *Drepanoistodus basiovalis* and continued abundance of *Drepanoistodus forceps*, correlates with the *Prioniodus* (*Baltoniodus*) *triangularis* and *P.* (*B.*) *navis* zones. The Baltic *Paroistodus originalis* Zone, marked by numerical dominance of *D. basiovalis* over *D. forceps*, can be correlated with early Assemblage IV of the St. George Group. Disappearance of *Parapanderodus aequalis* by the end of Assemblage IV suggests correlation with the *Microzarkodina flabellum parva* Zone of Löfgren (1978, pp. 25-26).

Subsequent St. George Group strata are only correlated with Baltic sequences indirectly.

3:8:6. OTHER AREAS

Assemblage I of the St. George Group correlates with the Kimaian Stage of the Siberian Platform. Faunal elements typical of Midcontinent faunas 1 to 4 are found in upper levels of this stage (Moskalenko 1983). Some species occurring in the Vihorevian Stage of the Siberian Platform (*Erismodus asymmetricus*, for example) are found in the upper Aguathuna Formation. Thus most of the upper St. George Group sequence probably correlates with the Kimaian Stage of the Siberian Platform, with uppermost Aguathuna Formation possibly coeval with earliest Vihorevian Stage.

The St. George Group sequence has few species in common with either North or South China (e.g. An 1981). In South China, the Honghuayuan Formation, with Juanognathus variabilis and Protopanderodus gradatus as minor faunal constituents may correlate with Assemblage I. The succeeding Dawan Formation, containing abundant Drepanoistodus forceps and minor Drepanodus arcuatus and Paroistodus parallelus, may correspond with assemblages I to III. Bergstroemognathus extensus at the base of the Dawan Formation indicates correlation with Assemblage II at this level. Fauna of the overlying Guniutan Formation is distinct from that of the St. George Group sequence.

Glyptoconus quadraplicatus is present in the Yeli Formation (Tremadoc) of North China. No other species in common are found until the Fengfeng Formation (?Caradoc), where Erismodus asymmetricus elements constitute a conspicuous part of the fauna. Glyptoconus quadraplicatus is found in lowermost Assemblage I of the St. George Group; E. asymmetricus throughout Assemblage VII. Probably the upper St. George Group correlates with the stratigraphic interval between the Yeli and Fengfeng formations.

The Dumugol Formation of the Choson Group, Korea has conodont species in common with the Catoche Formation (Lee 1970). The Mandal Formation (Lee 1978) contains similar faunas to that of the middle Catoche to Aguathuna Formation, whereas conodonts from the Ganggye district (Lee 1978) are apparently younger than those of the St. George Group.

Lower Paleozoic conodonts from Turatao Islands of southern Thailand correspond with faunas of the Catoche Formation, with *Oepikodus communis* and *Drepanoistodus* species (Teraoka *et al*. 1982). The lowermost part of the Setul Limestone may show affinity with the Aguathuna Formation (Igo and Koike 1967).

The occurrence of *Diaphorodus emanuelensis* enables correlation of a thin interval of the Emanuel Formation in the Canning Basin, Western Australia (McTavish 1973) with the uppermost Catoche to lowermost Aguathuna formations.

Ordovician conodonts of the Warburton Basin in central Australia are not diagnostic, but apparently of Canadian age (Cooper 1986). Some of the Warburton Basin species are found in the Catoche Formation.

The Victorian conodont sequence, interfingered with graptolitic shales, is entirely of North Atlantic aspect (Stewart *In* Cas *et al*. 1988). The occurrence of *Paracordylodus gracilis*, *Oepikodus communis*, *Prioniodus elegans*, and *Paroistodus proteus* allows correlation of the Be 1 Zone with the North Atlantic *P. elegans* Zone. This is slightly older than the upper St. George Group. The presence of *Bergstroemognathus extensus* and North Atlantic *Oepikodus evae* conodonts suggests correlation of Be 3 Zone to Ch 2 Zone graptolites with Catoche Formation conodonts. Direct correlation with overlying Da 4 Zone conodonts is not possible because of the exclusion of North Atlantic zone conodonts from the appropriate part of the Aguathuna Formation.

Conodonts of Mount Arrowsmith, northwest New South Wales, are of similar age to the Horn Valley Siltstone (Cooper 1981), and probably correlate with the lower to middle Aguathuna Formation (assemblages IV to V).

Tasmanian sequences bear poor conodont faunas. A faunule from the basal Karmberg Limestone, with Oepikodus communis and Bergstroemognathus extensus, is of similar age to the lower Catoche Formation (Webby et al. 1981). This correlation is further strengthened by the Juanognathus variabilis in both formations. Higher Karmberg faunas are of Midcontinent Fauna 3 age (Burrett In Webby et al. 1981), which is apparently missing (or excluded) from the Aguathuna Formation. Above this level, conodonts are considerably younger than those found in the St. George Group.

Chapter 4

CONODONT ALTERATION

4:1. CONODONT COLOUR ALTERATION

The original colour of conodont elements is changed upon prolonged action of elevated temperatures, probably as a consequence of degradation, first, of organic matter and, later, of crystalline structure (Epstein et al. 1977). While confined pressure alone does not appreciably affect colour alteration, a high water vapour pressure retards colour changes to some degree (Epstein et al. 1977, Rejebian et al. 1987).

In general, within the limitations described below, conodont colour alteration may be used to determine burial temperature (Mayr et al. 1978, Legall et al. 1981, Nowlan and Barnes 1987a,b), indicate ancient hotspot paths (Crough 1981, Nowlan and Barnes 1987a,b) and tectonic development (Legall et al. 1981, Nowlan and Barnes 1987b). Conodont colour alteration is effected by low temperatures, commencing around 50^{o} C. Conodont Colour Alteration Index may be used to indicate the level of oil and gas maturation. Other microfossils which contain organic matter are suitable for similar temperature determinations, but are generally less abundant and eurytopic than conodonts. Additionally, calibration of temperature-colour changes is, as yet, less precise.

Alteration of the originally pale yellow conodont elements has been graded into eight experimentally verified stages (Colour Alteration Index, CAI 1-8). Most of the stages are sufficiently distinct that intermediates are recognizable (Epstein et al. 1977).

It has been shown that colour, or apparent colour alteration, is dependent upon size of the conodont element: larger specimens within a sample appear darker than smaller specimens of the same elment within the one taxon. More light is transmitted through thin translucent bodies than thicker bodies with the same optical properties. The greater amount of organic matter incorporated within the structure of larger individuals results in an initially more opaque specimen (Epstein et al. 1977). Where only large, or robust, specimens are available for CAI determination, this must be performed only on edges or thin parts of the specimen.

Neurodont conodonts are generally robust, and darker than accompanying finer lamellar conodonts or forms with albid cusp and denticles. Colour differences are probably a response to their different internal structures, which are genetically determined, as well as size (Barnes et al. 1973, Epstein et al. 1977). Heat induced colour alteration of neurodont conodonts is apparently accelerated, possibly as a result of increased organic matter within their structure

(Epstein et al. 1977). Because of the differences in response of conodont taxa to the effects of temperature, published conodont colour alteration charts show a selection of conodont taxa and elements. To standardize comparisons, it is important that CAI determination be performed on similar specimens from all samples.

Conodont specimens from shales or argillaceous carbonates may be darker than those from carbonates which have been affected by the same thermal regime (Mayr et al. 1978, Legall et al. 1981). It has been found (Legall et al. 1981), that amber to reddish colours are characteristic of conodonts from interbedded shale-carbonate sequences; conodonts from shales have colours ranging through shades of brown, and conodonts from cleaner carbonates exhibit the more familiar straw yellow through black sequence. Colour charts pertinent to each situation have been published (Epstein et al. 1977, Legall et al. 1981, Rejebian et al. 1987). It is important that an evaluation of conodont CAI takes account of host rock.

At high CAI (5.5 to 8), hydrothermal solutions buffer the reactions which result in increased CAI (Rejebian et al. 1987). Hence the host rock temperature as determined by other means is higher than that indicated by CAI where conodonts are contained within a hydrothermally altered sequence. Anomalously low conodont temperature determinations may therefore be indicative of higher temperature hydrothermal mineralization.

4:2. CAI OF UPPER ST. GEORGE GROUP CONODONTS

In the light of the above discussion, Colour Alteration Index of conodonts of the upper St. George Group was determined from translucent, small elements of the same genus wherever possible. The genus Diaphorodus Kennedy ranges throughout most of the sequence, and is present in most samples and was hence used for CAI determination wherever possible. Several of the more abundant samples from within each section or drill core were examined; within each selected sample, every suitable element was used for CAI determination.

All sections except that collected at Hare Bay yielded conodonts with consistent CAI, to within 0.5. Results are summarized in Table 4:1. These show almost thermally unaltered strata on Port au Port Peninsula (CAI 1 to 1.5), little variation within the Daniel's Harbour area (CAI 1.5 to 2.5), with similar values on Port au Choix Peninsula. These results are consistent with those of Nowlan and Barnes (1987a), and inconsistent with a model requiring higher temperature hydrothermal mineralization. It is therefore apparent that the Daniel's Harbour Mine, was affected only by low temperature solutions, confirming previous estimates of ore emplacement temperature (Collins and Smith 1975, Lane ms).

Table 4:1. Conodont CAI from upper St. George Group.

Section	CAI
Aguathuna Quarries	1.5
East of The Gravels	1.5
West of The Gravels	1-1.5
Table Point	2-2.5
D.D.H. A1	2-2.5
D.D.H. 66A	2-2.5
D.D.H. 438	2-2.5
D.D.H. 440	1.5-2
D.D.H. 498	2-2.5
D.D.H. 1827	2-2.5
D.D.H. 715	1.5-2
D.D.H. 1500	2-2.5
Port au Choix (BC)	2-2.5
Back Arm Bay	1.5-2
Hare Bay	5.5-7

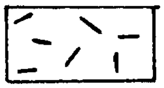
Table 4:2. Conodont CAI of Hare Bay Aguathuna Formation conodonts.

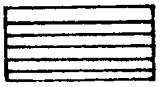
Stratigraphic Height in section	CAI
14 m	6-7
19 m	6
19.5 m	6
25 m	5-6
32 m	5.5

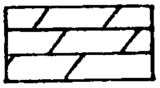
4:3. HARE BAY: CONODONTS FROM CONTACT METAMORPHIC ROCKS

Colour Alteration Index of conodonts taken from Big Spring Inlet, Hare Bay are not of consistent value, but decrease in value with stratigraphic position. Within each sample, variation of up to one CAI unit is possible (Table 4:2). This is characteristic of rocks subjected to contact metamorphism (Rejebian et al. 1987). Samples were collected to within 10 m of a basic dyke (Fig. 4:1). Conodonts from the basal sample had a CAI of 6 to 7. The CAI decreased from this value to 5-5.5 over a stratigraphic distance of approximately 20 m, a scale inconsistent with that of Nicoll (1981), and of Armstrong and Strens (1987). Subsurface morphology of the dyke near the sampled Aguathuna Formation section is unknown: possibly, this is closer than indicated by outcrop to upper Aguathuna Formation strata. However, contact metamorphism is known to occur on several scales: that cited by Nicoll was from a small lucite-lamprolite volcanic plug, emplaced at 600°C. The temperature of the dyke is likely to have been considerably higher, and the volume of hot rock considerably larger. The study of Armstrong and Strens (1987) more closely corresponds to that at Big Spring Inlet. Their results also indicate a diminished CAI metamorphic "aureole". Local deviations in conodont alteration are, however, known to be due to variations in physical and chemical conditions (Kovacs and Arkai 1987). Clearly, further study of contact

Fig. 4:1. a. Schematic diagram of location of samples collected at Big Spring Inlet, Hare Bay with respect to their distance along surface from the mafic dyke. Scale is in metres; symbols as below:-

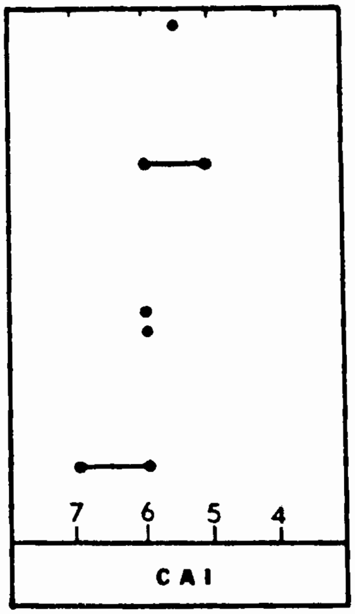
 Mafic dyke

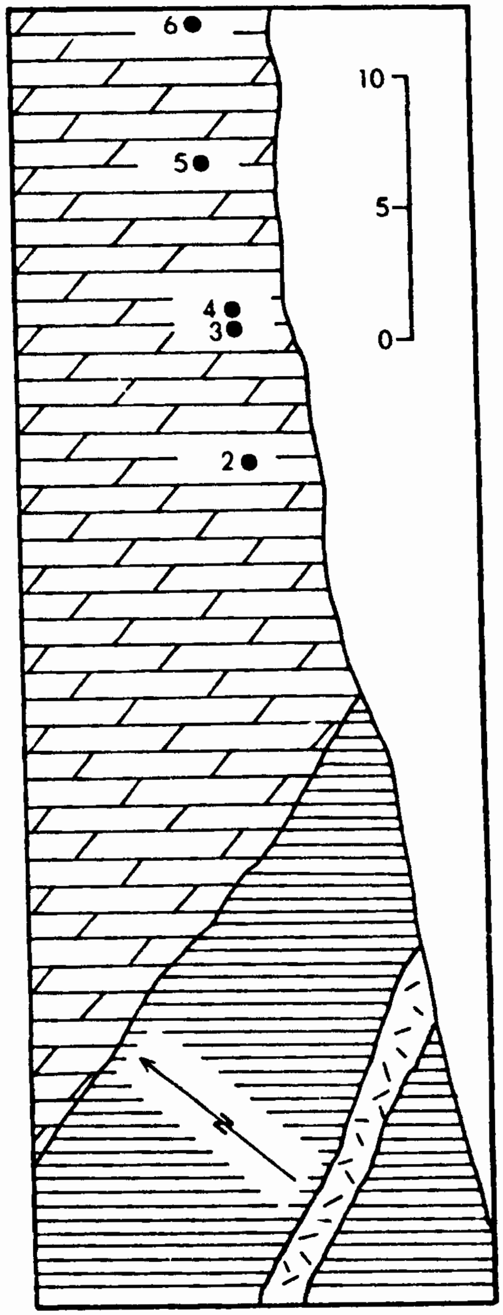
 Recrystallized carbonates

 Aguathuna Formation

• 6 Sample location and number

b. Plot of CAI against distance away from intrusion on surface, assumed representative of real distance from intrusion. Same scale as a; sample localities extrapolated across from a.


7
6
5
4
CAI


6
5
4
3
2
10
5
0

metamorphic effects on conodonts is warranted.

4:4. SURFACE ALTERATION

"The uniformity or variability of CAI values within a sample, together with conodont texture, can help to distinguish grades and environments of metamorphism, particularly in metacarbonate sequences." (Rejebian et al. 1987, p. 471)

Textural alteration of conodonts may be due to contact metamorphism, hydrothermal alteration, and contact with low temperature solutions (Rejebian et al. 1987): where high temperature contact metamorphism is not associated with hydrothermal solutions, conodonts may remain texturally unaltered in rocks which have reached up to 350°C; above this threshold, conodonts are almost invariably corroded or recrystallized, with some plastic deformation (Rejebian et al. 1987). Diagenetically altered conodonts may be frosted to pitted, or deeply corroded, possibly with mineral overgrowths (Rejebian et al. 1987).

In the field, particularly in the upper St. George Group, where several phases of dolomitization have differentially affected strata (Haywick and James 1984), it is difficult to distinguish between causes of textural alteration. However, degree of alteration must be related to diagenetic and hydrothermal history of conodonts, as well as burial depth.

Patterns of textural alteration described and illustrated by Rejebian et al. 1987 are found within the St. George Group conodonts. They can be selected to support the above findings, (Pl. 9, figs. 9-10, 13-14, 17-23) but each sample has a broad range of textures, particularly in the Daniel's Harbour area. Further field evidence is required, to evaluate the action of low temperature diagenetic and mineralizing solutions in isolation.

Chapter 5

SYSTEMATIC PALAEONTOLOGY

All taxa herein are considered in terms of natural multielement assemblages. Monoelemental apparatuses are possible, as is the case with *Clavohamulus cavus* n. sp. Bimembrate (*Semiacontiodus* Miller), trimembrate (*Parapanderodus* Stouge), quadrimembrate (*Drepanoistodus* Lindström), pentamembrate (*Oepikodus* Lindström), seximembrate (*Erismodus* Branson and Mehl) and septamembrate apparatuses are all known from the Lower and Middle Ordovician.

Complete higher taxonomic groupings currently available assume the apparent stability of later apparatuses, which are commonly sexi- or septamembrate. A higher taxonomy appropriate to the rapidly changing, seemingly reduced apparatuses of Lower and Middle Ordovician is as yet unavailable (e.g. Ethington and Clark 1981, Fåhraeus 1984, Stouge 1984, p.45, Landing *et al*. 1986). Taxonomy is therefore herein presented in alphabetical order of genera.

Terminology and apparatus geometry of Barnes *et al*. (1979), is used in conjunction with descriptive nomenclature for specific element morphotypes. The former is non-derivative and indicative only of element geometry and position within the various apparatus types. The descriptive term distinguishes between subtypes within possible morphotypes for a particular apparatus position. As an example, the _a_ position may be occupied by (among others), cordylodontiform or drepanodontiform elements.

Terminology not related to apparatus reconstruction or higher taxonomy is used as defined within Treatise on Invertebrate Paleontology, Part W, Supplement 2 (Robison 1981).

Taxonomic studies were initially based upon large samples collected from the geologically uncomplicated shore section immediately north of Table Point. Samples taken from drill core yielded low numbers of conodonts. Sufficiently large samples of core to yield a reasonably large conodont population required an unacceptably broad stratigraphic range for each sample. Ancillary material collected from Port au Choix Peninsula was used to clarify some of the taxonomic problems. Material collected from outside the Daniel's Harbour region, and some mine samples, were used only for biostratigraphic purposes, to solve specific stratigraphic problems. Elemental abundances take no account of samples from Hare Bay, Back Arm Bay or Port au Port Peninsula.

Strata close to the Mississippi Valley deposits of the Daniel's Harbour mine have been subjected to the passage of ore and diagenetic fluids. Many of the contained conodonts are consequently corroded, with pitted or overgrown surfaces (Rejebian _et al_. 1987). Surface micromorphology is therefore largely indeterminate, visible only on a few of the better preserved specimens. Upper Aguathuna Formation conodonts, especially those collected from the level of probable hardground surfaces, are unusually abraded and frosted. Strata are relatively thermally unaltered, with contained conodonts rarely exceeding CAI of 2.5 (Nowlan and Barnes 1987a). Internal features of elements are consequently easily ascertained.

Taxonomic importance of white matter is not yet resolved (Repetski 1982, Stouge 1984), nor is its functional significance (Barnes, Sass and Munroe 1973, Lindström and Ziegler 1981). Muller (1981, p. 35) regarded its position and structure as taxonomically important, but did not elaborate. Conventionally, some genera are regarded as exclusively hyaline (e.g. Oistodus Pander, see Löfgren 1978, p. 63) or albid (e.g. Acodus Pander, see Ethington and Clark 1981, p. 18; Protoprioniodus McTavish, see Ethington and Clark 1981, p. 85). Similar apparatuses with different white matter distribut on are usually referred to other genera. Recently, the presence or absence of white matter has been regarded as a specific characteristic within certain genera. Species of Drepanodus (Kennedy 1980) and Parapanderodus (Stouge 1984) have been distinguished on basis of differing white matter distribution, commonly in combination with other factors.

No species examined during this study differ only in white matter distribution, with the reported exception of

Cristodus sp. cf. *C. loxoides* as discussed under this genus. In all other species, the accepted convention as regards taxonomic importance of white matter is followed herein. It seems that white matter concentration is usually taxonomically important at the species level. Some genera are composed wholly of species with one white matter distribution or the other; others are heterogeneous in this regard.

All illustrated specimens are deposited with the Geological Survey of Canada, Ottawa. Several species were found in insufficient numbers to allow new taxonomic interpretation. These are consequently not discussed, but are figured, and their occurrences tabulated (Appendix B). These are:

Bergstroemognathus extensus Serpagli
Drepanoistodus angulensis (Harris)
Eucharodus parallelus (Branson and Mehl)
Juanognathus variabilis Serpagli
Juanognathus jaanussoni Serpagli
Macerodus dianae Fåhraeus and Nowlan
Paroistodus proteus (Lindström)
Pteracontiodus cryptodens (Mound)
"*Scolopodus*" *emarginatus* Barnes and Tuke

Genus **ANSELLA** Fåhraeus & Hunter, 1985

Type species.- Belodella jemtlandica Löfgren, 1978.

ANSELLA sp.
Pl. 1, figs. 1,2; Text-fig. 5:1:1.

Belodella sp. A. Fåhraeus. FÅHRAEUS & NOWLAN, 1978, p. 461, Pl. 3, fig. 21.
? Belodella erecta (Rhodes & Dineley). BARNES, 1977, p. 101, Pl. 2, fig. 7 (synonomy of B. erecta to 1974).
? Belodella sp. STOUGE & BOYCE, 1983, p. 34, Pl. 6, fig. 5.

Remarks.- Denticulate specimens have an extended anterior margin and may have costate sides. Costae are asymmetrically positioned. In this, the tetraprioniodontiform element shows affinities with Serpagli's (1974) "Belodella" sp. B which has asymmetrically flared sides to the base. Basal cavity morphology and dentition is similar to that of specimens referred to B. erecta (Rhodes & Dinely), for which a tetraprioniodontiform element has not been reported.

Ansella is distinguished from Belodella Ethington by the inclusion of a geniculate element within its apparatus. St. George specimens are therefore referred to Ansella.

Occurrence.- Ansella sp. is currently only known from the St. George Group of Newfoundland, within which it occurs in the Catoche Formation (uppermost Assemblage I to Assemblage II). It has also been found in the Costa Bay

Member and lowest Aguathuna Formation of the quarry section at Aguathuna, Port au Port Peninsula. Material from the Canadian Arctic (Barnes 1977) may be conspecific with the above specimens.

Material.- 5 specimens: 1 cordylodontiform (a); 1 zygognathodontiform (b); 1 tetraprioniodontiform (d) and 2 oistodontiform (e) elements.

Repository.- Figured specimens GSC 93029-30.

Fig. 5:1. Outline drawings of selected conodont taxa. Broken lines indicate outline of basal cavity. All views, except acontiodontiform elements, are lateral. Acontiodontiform elements, except where specified, are viewed from posterior.

Ansella sp.: 1. Tetraprioniodontiform (d)element, GSC 93029, D.D.H. A1.05, X80.

Bergstroemognathus extensus Serpagli: 2. falodontiform (e) element, hypotype, GSC 93039, BC2, X50; 6. cordylodontiform (a) element, hypotype, GSC 93036, BC2, X50.

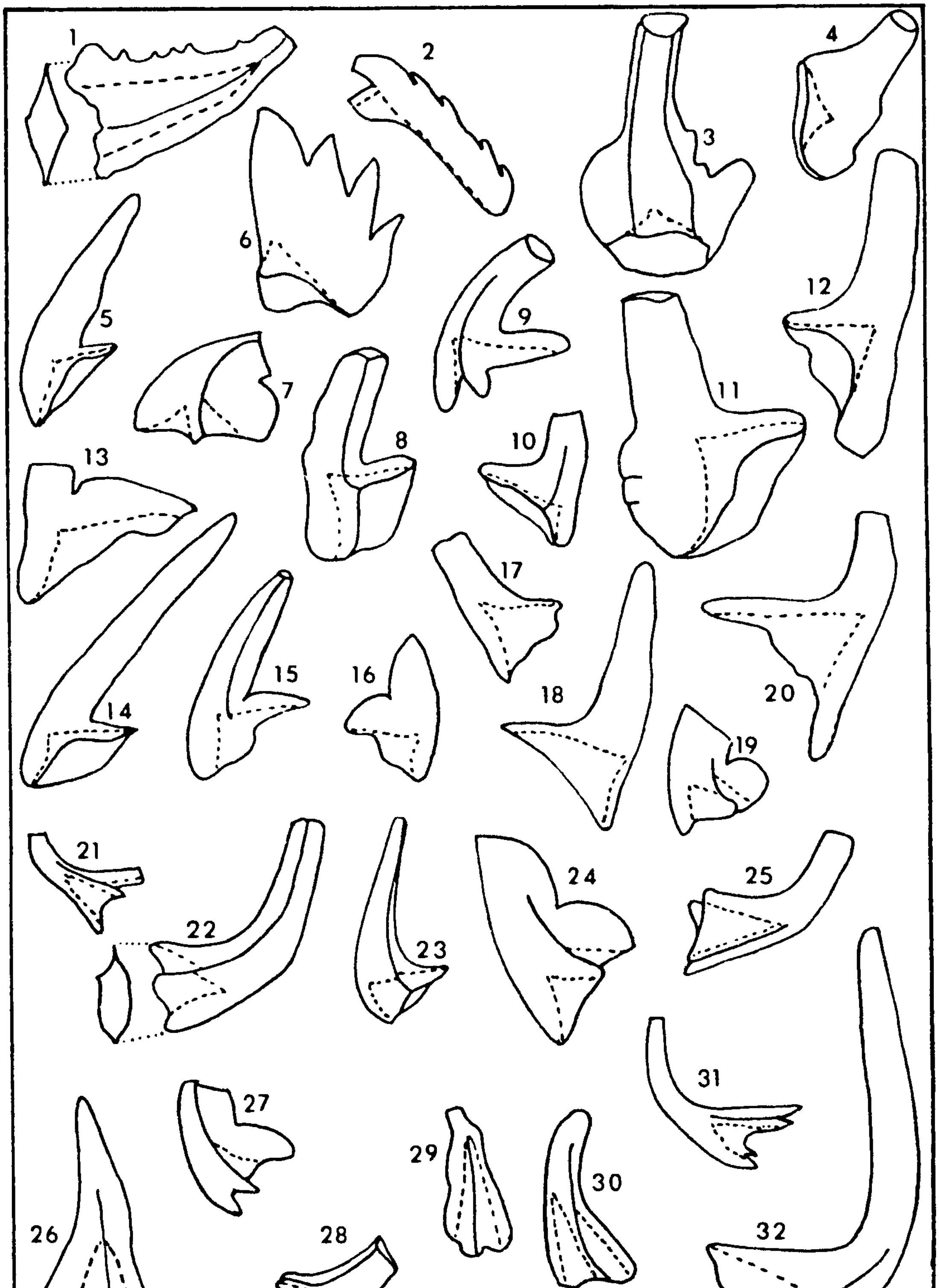
Bergstroemognathus alus n.sp.: 3. trichonodelliform (c) element, paratype, GSC 93033, TP13, X80; 4. cordylodontiform (a) element, paratype, GSC 93031, TP13, X80; 11. prioniodontiform (f) element, holotype, GSC 93035, TP13, X80; 12. falodontiform (e) element, paratype, GSC 93034, TP13, X80.

Diaphorodus gravelsensis n.sp.: 5. oistodontiform (e) element, paratype, GSC 93063, D.D.H. 715.17, X60; 10. prioniodontiform (f) element, holotype, GSC 93064, D.D.H. 715.17, X60; 18. drepanodontiform (a) element, paratype, GSC 93058, AGR3, X60; 22. gothodontiform (b) element, paratype, GSC 93059, D.D.H. 715.17, X100; 28. acontiodontiform (c) element, paratype, GSC 93060, posterolateral, D.D.H. 715.17, X50; 32. distacodontiform (d) element, paratype, GSC 93062, D.D.H. 715.17, X50.

?Diaphorodus russoi (Serpagli): 7. belodontiform (=prioniodontiform, f) element, GSC 93071, D.D.H. A1.06, X100; 13. oistodontiform (e) element, GSC 93070, D.D.H. A1.07, X90; 16. cordylodontiform (a) element, GSC 93065, D.D.H. A1.06, X100; 19. tetraprioniodontiform (d) element, GSC 93068, D.D.H. A1.06, X100; 24. gothodontiform (b) element, GSC 93066, D.D.H. A1.07, X100; 27. acontiodontiform (c) element, GSC 93067, D.D.H. A1.06, X100.

Diaphorodus stevensi n.sp.: 8. prioniodontiform (f) element, holotype, GSC 93078, D.D.H. 715.22, X50; 14. oistodontiform (e) element, paratype, GSC 93077, AP3, X40; 17. drepanodontiform (a) element, paratype, GSC 93072, AGR3, X80; 23. gothodontiform (b) element, paratype, GSC 93073, D.D.H. 715.22, X60; 25. distacodontiform (d) element, paratype, GSC 93076, D.D.H. 715.17, X60; 26. acontiodontiform (c) element, paratype, GSC 93074, AP3, X70.

Diaphorodus emanuelensis (McTavish): 9. prioniodontiform (_f_) element, GSC 93057, KC13, X60; 15. oistodontiform (_e_) element, GSC 93056, KC13, X60; 20. drepanodontiform (_a_) element, GSC 93052, KC13, X60; 21. gothodontiform (_b_) element, GSC 93053, KC11, X60; 29. acontiodontiform (_c_) element, GSC 93054, KC13, X40; 30. acontiodontiform (_c_) element, same specimen, lateral, GSC 93054, KC13, X60; 31. tetraprioniodontiform (_d_) element, GSC 93055, KC13, X60.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Genus **BERGSTROEMOGNATHUS** Serpagli, 1974

Type species.- Oistodus extensus Graves & Ellison, 1941.

Remarks.- Serpagli (1974, p. 40) reconstructed the apparatus of Bergstroemognathus with trichonodelliform and falodontiform elements and a symmetry transition of prioniodontiform elements. Available material shows a first transition series from strongly asymmetrical (cordylodontiform, a) elements through slightly asymmetrical (zygognathodontiform, b) elements to trichonodelliform (c) elements. It most closely fits a Type IVE apparatus plan of Barnes et al. (1979).

BERGSTROEMOGNATHUS ALUS n. sp.
Pl. 1, figs. 3-7; Text-figs. 5:1:3-4,11-12.

Derivation of name.- A reference to winglike nature of processes.

Diagnosis.- A species of Bergstroemognathus with short processes, and denticles rounded and fused for much of length; basal cavity moderately deep.

Description.- All elements have hyaline base, except for smaller individuals, white matter concentrated in tips of cusp and denticles; cusp has fine growth axis; processes short, composed of fused denticles with rounded tips.

Cusp of a element biconvex, sharp edged; posterior margin gently curved from tip of cusp to oral region of base, oral margin straight, intersects aboral margin at right angle; anterior margin with short, laterally curved process; basal cavity conical, anteriorly directed tip situated near anterior margin at level of intersection of cusp with first denticle; aboral margin teardrop shaped.

Cusp of b element with triangular cross-section, rounded anterior face opposing a strongly carinate face; lateral and posterolateral processes separated by 130° to 140°; aboral margin triangular, approximately equilateral.

Trichonodelliform (c) element similar, but has equally developed lateral processes, with up to three fused denticles.

Falodontiform (e) element adenticulate; cusp unequally biconvex, sharp edged; anterior margin extended downwards in flat tonguelike anticusp; basal cavity flared to inner lateral face; aboral opening teardrop shaped.

Prioniodontiform (f) element similar to a element except oral margin directed away from cusp rather than parallel with cusp midline, and basal cavity flares toward inner lateral face.

Remarks.-All elements have reduced processes. The falodontiform element, while unusual for *Bergstroemognathus*, has the characteristic white matter and base development of other elements. *B. alus* n. sp. is distinguished from *B.*

extensus Serpagli by its adenticulate falodontiform element, and in possessing short, blunt denticles.

Occurrence.-This species is only known from western Newfoundland at present, where it is found in upper Aguathuna Formation (Assemblage VII) at Table Point, and uppermost Aguathuna Formation at Hare Bay.

Material.-36 specimens: 8 cordylodontiform (*a*); 5 zygonathodontiform (*b*); 6 trichonodelliform (*c*); 9 falodontiform (*e*) and 8 cyrtoniodontiform (*f*) elements.

Type stratum.-(TP 13) fine grained laminates exactly 12.9 m below base of Table Head Group on shoreline section at Table Point (Grid reference 617790 on Bellburns sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

Repository.- GSC 93031-35 (See Appendix C); holotype GSC 93035.

Genus **CLAVOHAMULUS** Furnish, 1938

Type species.- C. densus Furnish, 1938.

Remarks.- Miller (1969, p. 422) revised this genus to include small conodonts with rudimentary cusp, or without a cusp. His definition is followed herein, with the exception that the form described could not be considered to be small. It is often one of the larger, more robust constituents of a conodont fauna.

Following Ethington and Clark (1981, p. 30), the basal excavation may be considered the aboral surface; cusp is posterior and tip of basal cavity anterior.

Clavohamulus Furnish differs from Serratognathus Lee in the possession of a shallow basal cavity and the possession of a posterior process, albeit rudimentary.

CLAVOHAMULUS CAVUS n. sp.
Pl. 1, figs. 13-14.

Scolopodus? sp. C s.f. STOUGE, 1982, p.44. Pl. 3, figs. 16-18; STOUGE & BOYCE, 1983, p. 28, Pl. 3, fig. 3.

Derivation of name.- Cavus, latin meaning excavation, a reference to the excavated posterior of the element.

Diagnosis.- A large species of Clavohamulus with six to eight lateral ridges paralleling a posterior excavation; spine extending from posterior of oral surface; basal excavation deep, longer than wide, with anteriorly located tip.

Description.- Element with rudimentary, spine-like cusp posterior of a bulbous base. Bulbose region divided into two lobes by a median constriction of the oral surfaces: constriction most pronounced medially, faint anteriorly and not evident at posterior of oral surface. Lobes slightly to moderately swollen. Cusp spine-like, projects a short distance from posterior of oral surface, overhangs concave excavation of posterior face of base, rarely extends further than posteriormost portion of aboral margin. Basal excavation extends entire width and length of base; postero-anterior distance greater than width; entire surface of excavation occupied by concentric growth ridges centred around anteriorly located tip of basal cavity. Surface of bulbous region bears six to eight well-defined ridges, which interfinger at median constriction: ridges parallel outlines of posterior excavation when viewed laterally. Anterior surface of bulb covered with irregularly positioned, small, granular nodules. White matter restricted to upper half of bulbous region and to cusp; aboral region hyaline.

Remarks.- This species is similar to Clavohamulus n. sp. of Ethington & Clark (1981) in ornament pattern, but differs in that ridges on the bulbous region of this latter species are of finer scale; it also has a distinct cusp. *Clavohamulus cavus* is therefore probably not conspecific with *C.* n. sp. of Ethington & Clark (1981).

Morphology of *C. cavus* is consistent with Miller's (1969) concept of *Clavohamulus*. It is comparable with species occurring within the Notch Peak Limestone, but is readily distinguished by its excavated posterior.

Miller (1969) suggested that *C. densus* Furnish descended from noncuspate forms early in the Tremadoc. *Clavohamulus cavus* is probably also descended from such stock, and is the youngest species of this lineage currently known.

Clavohamulus cavus n. sp. does not have the antero-posterior compression seen in the superficially similar type species of *Serratognathus* (Lee 1970). The possession of lamellae surrounding an apical pit to the basal excavation, and a separate posterior spine in *C. cavus* differs markedly from the radially disposed ribs of *Serratognathus*.

Occurrence.- *Clavohamulus cavus* is at present only known from the St. George Group of Newfoundland, within which it ranges from lower to middle Catoche Formation (Assemblage I and lower Assemblage II). It is known from subsurface of Daniel's Harbour area, and outcrop at Port au Choix.

Material.- 10 specimens.

Type stratum.- DDH A1.07 (Grid reference 666714 Bellburn sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

<u>Repository</u>.- GSC 93041 (holotype), GSC 93042 (paratype).

Genus **CRISTODUS** Repetski, 1982

Type species.- Cristodus loxoides Repetski, 1982.

CRISTODUS sp. cf. C. **LOXOIDES** Repetski, 1982
Pl. 1, figs. 15-16; Text-fig. 5:2:1

Multidenticulate element
Loxodus sp. aff. L. bransoni Furnish. BARNES & TUKE, 1970, p. 87, Pl. XX, figs. 1,4,15-17.
Multielement reconstructions
cf. Cristodus loxoides n.sp. REPETSKI, 1982, pp. 18-19, Pl. 5, figs. 6,7.
Gen. nov. A sp. nov. A. STOUGE, 1982, p. 52, Pl. 4, figs. 14,15.
Loxodus? sp. aff. Loxodus bransoni Furnish. STOUGE & BOYCE, 1983, p. 28, Pl. 3, figs. 1,2.

Remarks.- Repetski's (1982) specimens were of "two hyaline element types" (1982, p. 18). St. George Group specimens have a milky white matter above a line parallel with aboral margin and intersecting junction of denticle with base. In some specimens, white matter is better developed at either end of element, and wispy above tip of basal cavity, but is present in all specimens of each element. Taxonomic importance of white matter is unresolved: similarity of El Paso and St. George group forms, aside from distinction in the amount of white matter present, is indicative of its relative unimportance.

Occurrence.- Cristodus loxoides Repetski is reported from the upper middle El Paso Group of Texas, Jefferson City Dolomite of Missouri, West Spring Creek Formation of

Oklahoma, and Eleanor River Formation of the Canadian Arctic (Repetski 1982). Aside from El Paso specimens, it is unknown which of these are hyaline, and which are albid.

Albid elements of the same morphology are found in Assemblage IV, and middle Aguathuna Formation from subsurface Daniel's Harbour region, west of the Gravels and Aguathuna Quarry section on Port au Port Peninsula. Stouge and Boyce (1983, p. 28) report this species from only the lower Catoche.

Material.- 11 specimens: 9 monodenticulate and 2 multidenticulate elements.

Repository.- GSC 93043-44.

Fig. 5:2. Outline drawings of selected conodont taxa.

Cristodus sp. cf. C. loxoides Repetski: 1. multidenticulate element, GSC 93043, D.D.H. 715.19, X100; finely dotted line is boundary of white matter.
Drepanoistodus forceps (Lindstrom): 2. oistodontiform (e) element, GSC 93106, BC1, X150.
Erismodus sp.: 3. cordylodontiform (a) element, GSC 93115, TP13, X50; 4. oulodontiform (f) element, GSC 93119, TP13, X50; 5. aphelognathodontiform (g) element, GSC 93120, TP13, X50; 10. trichonodelliform (c) element, GSC 93117, TP15A, X45; 11. strachanognathodontiform (e) element, GSC 93118, TP15A, X50.
Drepanoistodus inaequalis (Pander): 6. oistodontiform (r) element, GSC 93109, BC1, X70; 12. homocurvatiform (q) element, GSC 93108, D.D.H. A1.14, X80; 17. suberectiform (p) element, GSC 93107, D.D.H. A1.14, X80.
Drepanoistodus basiovalis (Sergeeva): 7. oistodontiform (r) element, GSC 93103, AGC1, X90.
Drepanoistodus angulensis (Harris): 8. oistodontiform (r) element, GSC 93100, D.D.H. 715.22, X80.
Glyptoconus rectus (Stouge): 9. quadraplicatiform (p) element, GSC 93136, D.D.H. 715.10, X60.
Glyptoconus quadraplicatus (Branson and Mehl): 14. triplicatiform (q) element, GSC 93135 D.D.H. A1.11, X60; 15. quadraplicatiform (p) element, GSC 93134, D.D.H. A1.11, X40.
Leptochirognathus quadrata Branson and Mehl: 13. cordylodontiform (a) element, GSC 93146, TP13, X100; 20. zygognathodontiform (b) element, GSC 93147, TP13, X80; 21. trichonodelliform (c) element, GSC 93148, TP13, X80; 23. oistodontiform (e) element, GSC 93149, TP13, X90; 25. cyrtoniodontiform (f) element, GSC 93150, TP13, X100.
Eucharodus parallelus (Branson and Mehl): 16. GSC 93129, D.D.H. A1.14, X50.
Leptochirognathus planus n.sp.: 18. cordylodontiform (a) element, paratype, GSC 93151, TP13, X80; 19. zygognathodontiform (b) element, paratype, GSC 93152, TP13, X80; 22. trichonodelliform (c) element, paratype, GSC 93153, TP13, X80; 24. oistodontiform (e) element, paratype, GSC 93154, TP13, X80; 26. cyrtoniodontiform (f) element, holotype, GSC 93155, TP13, X80.
Parapanderodus striolatus (Harris and Harris): 27. triangulariform (t) element, GSC 93204, AGW1, X60; 34. short based (s) element, GSC 93202, D.D.H. 498.02, X50; 37. long based (s') element, GSC 93203, AGW1, X60.
Parapanderodus aequalis n.sp.: 28. triangulariform (t) element, paratype, GSC 93198, BC1, X80; 33. short based (s) element, holotype, GSC 93196, KC1, X100; 35. long based (s') element, paratype, GSC 93197, BC1, X90.

Parapanderodus striatus (Graves and Ellison): 29. triangulariform (t) element, GSC 93201, D.D.H. A1.11, X80; 32. short based (s) element, GSC 93199, D.D.H. A1.07, X80; 36. long based (s') element, GSC 93200, BC1, X80.

Parapanderodus abemarginatus n.sp.: 30. ungrooved element (s) element, paratype, GSC 93194, AGR2, X60; 31. emarginatiform (t) element, holotype, GSC 93195, AGE6, X60.


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Genus **DIAPHORODUS** Kennedy, 1980

Type species.- Acodus delicatus Branson & Mehl, 1933.

Remarks.- The apparatus plan of the type species of Acodus, A. erectus Pander, is inadequately known for reliable assignment of other species to this genus. Kennedy (1980) therefore defined the apparatus containing Acodus delicatus Branson & Mehl s.f. as Diaphorodus. His approach is followed herein, with the exception that a gothodontiform element is considered to be distinct from acodontiform element, as suggested by McTavish (1973). Thus Diaphorodus has a prioniodontid (modified Type IVD) apparatus of adenticulate drepanodontiform (a), acontiodontiform (c), distacodontiform (d), oistodontiform (e) and acodontiform (f) elements. Species with well-developed processes have apparatuses consisting of cordylodontiform (a), gothodontiform (b), trichonodelliform (c), tetraprioniodontiform (d), oistodontiform (e) and prioniodontiform (f) elements.

DIAPHORODUS DELICATUS (Branson & Mehl, 1933)
Pl. 2, figs. 1-6.

Diaphorodus delicatus (Branson & Mehl). KENNEDY, 1980, pp. 52-54, Pl. 1, figs. 3-7,9-25 (with synonomy to 1978).
Acodus delicatus Branson & Mehl. REPETSKI, 1982, pp. 10, 12, Pl. 1, figs. 5-9.
Acodus? sp. cf. A. delicatus Branson & Mehl. STOUGE,

1982, p. 33, Pl. 4, figs. 1-2, 5; STOUGE & BOYCE, 1983, p. 28, Pl. 3, fig. 15.

Remarks.- Specimens compared by Stouge (1982) with this species are seen, from larger samples, to be within the bounds of intraspecific variation as described by Kennedy (1980) as *Diaphorodus delicatus*.

Occurrence.- A common constituent of Midcontinent Province conodont faunas of late Canadian age throughout the North American continent (Kennedy 1980, Ethington & Clark 1981), *Diaphorodus delicatus* occurs in the upper 213 m of the Kindblade Formation and most of the West Spring Creek Formation, Oklahoma; Jefferson City Dolomite of Missouri; upper El Paso Group of western Texas. It may also occur in upper Canadian strata of Utah and Nevada, the Emanuel Formation of Western Australia and the Chun'sk Stage in Siberia (Moskalenko 1967, Kennedy 1980, Ethington & Clark 1981, Repetski 1982).

In western Newfoundland, this species has been recovered from throughout the Catoche Formation (Stouge 1982, this study), to lower Aguathuna Formation of subsurface Daniel's Harbour region (assemblages I to IV), and Port au Choix.

Material.- 83 specimens: 18 drepanodontiform (*a*); 3 gothodontiform (*b*); 6 acontiodontiform (*c*); 10 distacodontiform (*d*); 30 oistodontiform (*e*) and 16 acodontiform (*f*) elements.

Repository.- GSC 93045-50.

DIAPHORODUS EMANUELENSIS (McTavish, 1973)
Pl. 2, figs. 7-13; Text-figs. 5:1:9,15,20-21,29-31.

Distacodus? sp. BARNES & POPLAWSKI, 1973, p. 772, Pl. 3, fig. 11.
Acodus emanuelensis. McTAVISH, 1973, pp. 40-41, Pl. 2, figs. 16-21, text-fig. 3e-i; COOPER, 1981, (?in part), pp. 1158-1160, Pl. 28, figs 5,6 only.
non Acodus? aff. A. emanuelensis McTavish. ETHINGTON & CLARK, 1981, pp. 19-20, Pl. 1, figs. 9-13, Text-fig. 5.

Remarks.- Forms compared with Acodus emanuelensis McTavish by Ethington & Clark (1981) differ in not possessing subequal processes, a property considered by McTavish (1973, p. 40) to be diagnostic of the species. Drepanodontiform, acontiodontiform and oistodontiform elements figured by Cooper (1981, Pl. 28, figs. 1,9,10) appear sufficiently distinct from descriptions of McTavish for conspecificity to be unlikely. These differ in aboral outline when viewed laterally. In addition, drepanodontiform and acontiodontiform from the Emanuel Formation have angular posterobasal intersection, while this region of Horn Valley Siltstone specimens is smoothly curved. Oistodontiform elements vary in acuteness of angle between posterior and oral margins.

Occurrence.- Diaphorodus emanuelensis is known from a narrow interval in mid Emanuel Formation of the Canning Basin, Western Australia (McTavish 1973) and may be present in the Horn Valley Siltstone, Amadeus Basin, central Australia (Cooper 1981). It is found in a brief interval at the beginning of Assemblage IV, in uppermost Catoche and lowermost Aguathuna strata of Table Point and Port au Port Peninsula.

Material.- 58 elements: 13 drepanodontiform (a); 9 gothodontiform (b); 11 acontiodontiform (c); 10 distacodontiform (d); 7 oistodontiform (e) and 8 acodontiform (f) elements.

Repository.- GSC 93051-57.

DIAPHORODUS GRAVELSENSIS n. sp.
Pl. 2, figs. 14-19; Text-figs. 5:1:5,10,18,22,28,32.

Acodus combsi Bradshaw. STOUGE & BOYCE, 1983, p. 36, Pl. 7, fig. 4 only.
Acodontiform (f) element
cf. Acodus combsi. BRADSHAW, 1969, p. 1147, Pl. 132, figs. 11,12; STOUGE, 1984, p. 76, Pl. 14, fig. 13 only.

Derivation of name.- Named for The Gravels, the isthmus separating Port au Port Peninsula from Newfoundland mainland. Many of the samples collected from near The Gravels are dominated by elements of this species.

Diagnosis.- A species of Diaphorodus with shallow to only moderately deep basal cavity, relatively poorly developed costae and completely albid cusp above, posterior and anterior to basal cavity.

Description.- All elements completely albid excepting region of basal cavity. All but acontiodontiform element with pronounced anterior keel, which extends beyond aboral margin as brief anticusp or process. Posterior and oral margins keeled on all elements.

Drepanodontiform (a) element with erect cusp, short base, conical basal cavity with convex (towards cavity) anterior margin, straight posterior margin and anteriorly directed tip situated at level of postero-oral intersection and close to anterior margin. Postero-oral intersection obtuse, approximately 120°; oral margin intersets aboral margin at 60°. Cusp and aboral opening unequally biconvex.

Gothodontiform (b) element as cordylodontiform element but has broad anterior keel and more curved postero-oral intersection; outer face with low, narrow costa on cusp and base; basal cavity smoothly swollen on inner side of element, swelling localised to region of costa on outer face.

Acontiodontiform (c) element with downwards projecting lateral flanges and posterior process; cusp proclined, tapering slowly and evenly to tip; basal cavity of moderate depth.

Distacodontiform (d) element with subcircular, proclined cusp and base; narrow lateral costae, at least one of which may not extend to cusp tip; lateral costae not symmetrically positioned, but neither is close to either posterior or anterior costa; costae extend only briefly beyond aboral margin, or may terminate at aboral margin.

Oistodontiform (e) element with very shallow basal cavity; anteriorly-directed, medial tip; broad median carina on inner lateral face of cusp; outer lateral face convex; carina curves distally onto base, which flares to inner side under posterior process; both anterior and posterior of base drawn out into thin, keeled processes: this variable in extent.

Acodontiform (f) element with similarly drawn out anterior and posterior processes; costa on inner lateral face of cusp, also present on base above anterolateral flare of basal cavity; basal cavity as that of drepanodontiform.

Remarks.- Acodontiform and oistodontiform elements are superficially similar to those of Stouge's (1984) *Acodus combsi*. Other elements cited by Stouge as part of *A. combsi* apparatus do not co-occur with acodontiforms described above. The close similarity of the two species is suggestive of an ancestor - descendant relationship, with *D. gravelsensis* n. sp. the ancestor of *D. combsi* (Stouge).

Occurrence.- At present, *D. gravelsensis* is known thoughout the Aguathuna Formation (Assemblage IV to early Assemblage VII). It is sparse until middle Aguathuna, where large populations are common, and subsequently diminishes. It does not extend to the top of Aguathuna Formation at Table Point. On Port au Port Peninsula, *D. gravelsensis* ranges from middle Costa Bay Member through Aguathuna Formation. This species is also known from upper Aguathuna Formation at Hare Bay.

Material.- 112 specimens: 34 drepanodontiform (a); 11 gothodontiform (b); 17 acontiodontiform (c); 18 distacodontiform (d); 18 oistodontiform (e) and 14 acodontiform (f) elements.

Type stratum.- Very fine grained, mottled dolostone exactly 23.3 m below base of the Table Head Group along shore section at Table Point (Grid reference 617698 on Bellburns sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

Repository.- GSC 93058-64; holotype GSC 93064.

?DIAPHORODUS RUSSOI (Serpagli, 1974)
Pl. 2, figs. 20-25; Text-figs. 5:1:7,13,16,19,24,27.

Acodus? russoi SERPAGLI, 1974, pp. 35-37, Pl. 8, figs. 1a-5b, Pl. 20, figs. 7-8, Text-fig. 5 (with synonomy to 1970); REPETSKI, 1982, p. 13, Pl. 3, figs. 1-5.

Remarks.- Elements described by Serpagli (1974, p. 36) as Acodus? russoi are accompanied by cordylodontiform elements which occupy the a position within the apparatus. The belodontiform element most likely occupies the f position, as suggested by Repetski (1982, p. 13). The "oepikodontiform" element is more consistent with the b position of this apparatus, with the tetraprioniodontiform element occuping the d position. The complete apparatus, consistent with the prioniodontid interpretation of McTavish (1973), is Type IVD.

All but the cordylodontiform (a) element have been described previously by Serpagli (1974) or Lindström (1955). This has basal cavity, posterior process and white matter distribution similar to that of other ramiform elements. Cusp is slightly twisted, asymmetrically biconvex, meets posterior process at acute angle of approximately 70° to 75°. Anterobasal region slightly elongate. Aboral margin sinuous in side view and also when viewed aborally.

Cordylodontiform element could be confused with oistodontiform element, but is less laterally compressed, with more acute anterobasal angle. Oistodontiform element, when viewed from side, has straight aboral margin, whereas that of cordylodontiform is sinuous.

Adenticulate, tongue-like posterior process distinguishes ?*D*. *russoi* from other species of the genus. This form of process is common in species of *Oistodus* Pander and *Protoprioniodus* McTavish of approximately similar age, but ?*D*. *russoi* does not have the elemental composition of these genera. Processes of elements of *Diaphorodus* are almost equally developed, whereas elements of *Protoprioniodus* are dominated by the posterior process, and most commonly have a basal ridge parallel to the aboral margin.

Occurrence.- Originally described from Precordilleran Argentina (Serpagli 1974), elements from this apparatus have been reported from Sweden (Lindström 1955), middle strata of the El Paso Group of Texas (Repetski 1982), and St. George strata of northwestern Newfoundland (Barnes & Tuke 1970).

?*Diaphorodus* *russoi* (Serpagli) first appears in lower medial and continues to uppermost Catoche Formation (assemblages II to III) of Daniel's Harbour region and Port au Choix Peninsula.

Material.- 30 elements: 8 cordylodontiform (a), 3 acontiodontiform (c), 3 tetraprioniodontiform (d), 9 oistodontiform (e) and 7 belodontiform (acodontiform, f) elements.

Repository.- GSC 93066-71.

DIAPHORODUS STEVENSI, n. sp.
Pl. 2, figs. 30-35; Text-figs. 5:1:8,14,17,23,25-26.

Protopanderodus n. sp. BARNES & POPLAWSKI, 1973, pp. 784-785, Pl. 2, figs 5?,6,12, Pl. 3, fig. 10, Text-fig. 2C,D.
Acodus? n. sp. A. STOUGE, 1984, pp. 76-77, Pl. 14, figs. 21,23?,24?,25?,26,28 only.

Derivation of name.- Named for R.K. Stevens, in recognition of his contribution to the understanding of the geology of western Newfoundland.

Diagnosis.- A species of Diaphorodus with well developed, strong costae on second transition series elements, only moderately well developed anterior, posterior and oral keels; neither costae nor keels project far beyond aboral margin; deep basal cavity; white matter restricted to cusp; with hyaline material above basal cavity.

Description.- All elements as for diagnosis. Ramiform elements with straight anterior margin of cusp and base, but curved at junction of cusp and base.

Drepanodontiform (a) element proclined, unequally biconvex, moderately laterally compressed; basal cavity conical, with distally directed submedial tip; anterior margin extends short distance below aboral margin.

Gothodontiform (*b*) element as drepanodontiform, except cusp reclined; lateral costa does not project as process; basal cavity with anteriorly-directed tip located close to anterior margin.

Acontiodontiform (*c*) element has broad posterior ridge; when viewed from posterior, cusp and basal outlines are smoothly expanding from tip to aboral margin; lateral keels extend a short distance beyond aboral margin; anterior face smooth.

Distacodontiform (*d*) element has asymmetrically positioned lateral costae.

Oistodontiform (*e*) element has short base; wide medial carina on inner lateral face; carina continues onto base; base flared and opens laterally immediately posterior of junction of base and cusp; basal cavity with submedial, anteriorly directed tip, posterior margin of cavity sinuous, anterior margin convex towards cavity.

Acodontiform (*f*) element has reclined cusp; anterior margin terminates at aboral margin; lateral costa separated from brief posterior keel by wide, deep groove which continues onto base; base with sharp, wide flare to inner side; cusp cross section and aboral opening triangular.

Remarks.- *Diaphorodus stevensi* is distinguished from all other species of *Diaphorodus* by the deeply grooved prioniodontiform with indented inner lateral margin to base. The oistodontiform is also distinct in its laterally flared posterior part of the aboral margin.

Within the Aguathuna Formation, D. stevensi commonly co-occurs with D. gravelsensis. Stratigraphic ranges do not exactly correspond, with D. stevensi continuing into the Table Head Group (Stouge 1984), and D. gravelsensis restricted to the Aguathuna Formation. In no case are intermediates between morphotypes of the two species preserved, and it is considered they are both valid species.

Occurrence.- Diaphorodus stevensi is found in the Mystic Conglomerate of Quebec (Barnes & Poplawski 1973). It ranges sparsely through the middle and upper Aguathuna Formation (Assemblage V to VII) of Daniel's Harbour area, and Port au Port Peninsula. Stouge (1984) reports elements of this apparatus in strata up to lower Table Cove Formation.

Material.- 54 specimens: 9 drepanodontiform (a); 15 gothodontiform (b); 4 acontiodontiform (c); 6 distacodontiform (d); 13 oistodontiform (e) and 7 acodontiform (f) elements.

Type stratum.- Fine grained laminated dolostone 12.9 m stratigraphically below base of Table Head Group at Table Point shore section (Grid ref 617790 on Bellburns sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

Repository.- GSC 93072-78; holotype GSC 93078.

Genus **DREPANODUS** Pander 1856

Type species.- Drepanodus arcuatus Pander, 1856.

DREPANODUS ARCUATUS Pander, 1856
Pl. 1, figs. 17-21.

Arcuatiform element
Drepanodus arcuatus Pander. ETHINGTON, 1979, p. 2, fig. 3B; REPETSKI, 1982, p. 19, Pl. 6, fig. 1.
Short-based arcuatiform element
Drepanodus cf. D. arcuatus Lindström s.f. REPETSKI, 1982, p. 20, Pl. 6, fig. 4.
Sculponeaform element
? Drepanodus? gracilis (Branson & Mehl). STOUGE, 1982, p. 34, Pl. 3, fig. 3 only; STOUGE & BOYCE, 1983, p. 26, Pl. 2, fig. 6 only.
Pipaform element
Scandodus pipa Lindström. UYENO & BARNES, 1970, p. 115, Pl. 22, figs. 6,7, Text-fig. 7C.
? Drepanodus? gracilis (Branson & Mehl). STOUGE, 1982, p. 34, Pl. 3, fig. 2 only; STOUGE & BOYCE, 1983, p. 26, Pl. 2, fig. 7 only.
Multielement reconstructions
Drepanodus arcuatus Pander. ? BEDNARCZYK, 1979, p. 424, Pl. 5, figs. 14-16, Pl. 6, figs. 4,10,11,13; ETHINGTON & CLARK, 1981, pp .36-37, Pl. 3, figs. 4-6,12 (with synonomy to 1978).

Remarks.- Drepanodus arcuatus Pander sensu Löfgren (1978, p. 51) occurs only sporadically within the St. George Group. The apparatus has sculponeaform, arcuatiform and pipaform elements, with occasional homocurvatiform and acontiodontiform elements. These may be considered either modified drepanodontiform or oistodontiform elements, possibly of a Type IIIC apparatus. Element types are consequently described with p, q and r, following the nomenclature of Barnes et al. (1979).

Occurrence.- This species is found in exclusively Lower Ordovician strata of northern Europe (Lindström 1955, Viira 1967, Löfgren 1978), Argentina (Serpagli 1974) and North America (Tipnis et al. 1978, Ethington & Clark 1981).

Known from the Cow Head Group of western Newfoundland (Fåhraeus & Nowlan 1978), it is also present in the Catoche and lower Aguathuna formations (assemblages II to IV) of the St. George Group (Stouge 1982, this study) at Table Point, Daniel's Harbour mine area and Port au Choix Peninsula.

Material.- 66 specimens: 32 arcuatiform (p), 14 sculponeaform (p'), 3 homocurvatiform (p"), 1 acontiodontiform (p"'), and 16 pipaform (q) elements.

Repository.- GSC 93079-83.

DREPANODUS CONCAVUS (Branson & Mehl, 1933)
Pl. 1, figs. 20-21,24-27.

Drepanodus concavus (Branson & Mehl). KENNEDY, 1980, pp. 55-57, Pl. 1, figs. 26-34 (with synonomy to 1975); REPETSKI, 1982, p. 20, Pl. 6, fig. 11.
Drepanodus? gracilis (Branson & Mehl). STOUGE, 1982, p. 34, Pl. 3, figs. 2,3; STOUGE & BOYCE, 1983, p. 26, Pl. 2, figs 6,7.
"Hyaline drepanodids". STOUGE, 1982, p. 35, Pl. 2, figs. 23,24.

Remarks.- Both "hyaline drepanododids" (Oistodus concavus Branson & Mehl s.f., Scolopodus inconstans Branson & Mehl s.f. and Drepanodus homocurvatus sensu Barnes & Tuke, 1970) and Drepanodus? gracilis sensu Stouge (1982, pp. 34,35) co-occur in the St. George Group throughout their entire range. These morphologically similar elements are, consequently, considered to be part of the one apparatus. As *Oistodus concavus* Branson & Mehl s.f. (1933, p. 59) has page priority over *Oistodus gracilis* Branson & Mehl s.f. (1933, p. 60), *D. concavus* is the correct name for such an apparatus.

Kennedy (1980) proposed an apparatus of arcuatiform, sculponeaform, pipaform and graciliform elements for *Drepanodus concavus*. Similar homocurvatiform and suberectiform elements also appear with this association in a modified Type IVB apparatus. All of these elements are united by similarities in overall and basal cavity morphology, white matter distribution, size, and surface texture.

The apparatus reconstruction of "*D.*" *concavus* differs from that of *D. arcuatus* Pander. It may therefore be better assigned to a different genus, but the complete apparatus of *D. arcuatus* is not well known (see Ethington & Clark 1981, p. 37 for discussion), and may later be reconstructed with apparatus as described above for *Drepanodus concavus* sensu Kennedy.

The presence of homocurvatiform and suberectiform elements is suggestive of affinity with *Drepanoistodus*, but this latter genus is not known to possess sculponeaform, arcuatiform (as distinct from homocurvatiform), nor pipaform elements.

Homocurvatiform element is similar to arcuatiform element described by Kennedy (1980, p. 56). It has a more pronounced inner lateral flare of the basal cavity, and a markedly twisted cusp. It is also less laterally compressed.

Suberectiform element has distally curved to completely erect, robust, symmetrically biconvex cusp, with sharp anterior and posterior edges. Anterior edge meets anterior extension of base at approximately 100° ; posterior edge curves evenly into keeled oral edge. These latter are approximately perpendicular. Base laterally flared and extended in both posterior and anterior directions: posteriorly to two-thirds maximum cusp width, and anteriorly to one-quarter maximum cusp width. Oral edge with straight, narrow keel. Anterior and posterior margins to basal cavity flat except for tip, which is situated slightly posterior of cusp midline. Thin growth line extends from tip, slowly and evenly curving towards posterior margin of cusp.

Lateral faces of base of asymmetrical elements are unequal: outer extends further posteriorly than inner. This effect may be pronounced or barely visible. Similarly, proximal concavity close to anterior margin on base of arcuatiform element may be reduced. Aboral margin of graciliform and sculponeaform elements may be straight when viewed laterally, or sinuous.

As suggested by Kennedy (1980, p. 57), Drepanodus concavus is most simply distinguished from D. arcuatus Pander by its hyaline cusp. The base of D. arcuatus is commonly more rectangular than that of D. concavus, which frequently has a concave posterior margin. The apparatus composition described for D. concavus has yet to be demonstrated for D. arcuatus.

Occurrence.- Kennedy (1980, p. 57) reports this species as ranging from upper Canadian to lower Whiterockian, being known from Kindblade and West Spring Creek formations, Joins Formation, Ninemile Formation and El Paso Group in North America, with occurrences in strata of similar age in Siberia and Australia.

It is present at isolated horizons through Catoche and Aguathuna formations, and is last recorded approximately 15 m below base of Table Point Formation (assemblages I to VI).

Material.- 157 specimens: 26 homocurvatiform (a), 37 arcuatiform (b), 12 suberectiform (c), 26 pipaform (e), 30 sculponeaform (f) and 26 graciliform (g) elements.

Repository.- GSC 93084-89.

DREPANODUS? sp. cf. D. GRACILIS (Branson & Mehl, 1933)
Pl. 3, figs. 1-6.

Drepanodus cf. gracilis (Branson & Mehl). STOUGE, 1984, pp. 46-47, Pl. 1, figs. 12-18 (with synonomy to 1980).
Drepanodus? gracilis (Branson & Mehl) s.f. REPETSKI, 1982, p. 20. Pl. 6, fig. 6.

Remarks.-Apparatus follows the same plan as that of

Drepanodus concavus, from which Drepanodus sp. cf. D. gracilis is probably descended. This latter species has a shallower basal cavity, and the antero-basal "nose" of some D. concavus elements is considerably reduced in corresponding elements of Drepanodus sp. cf. D. gracilis. Elements of D. concavus with subrectangular base (sculponeaform, pipaform and graciliform elements) are more rounded posteriorly than those of other species of Drepanodus. This trend is more pronounced in Drepanodus sp. cf. D. gracilis.

Occurrence.-Drepanodus sp. cf. D. gracilis occurs in the Mystic Conglomerate in Quebec (Barnes & Poplawski 1973), lower Table Point and lower Table Cove formations of western Newfoundland (Stouge 1984) and the upper Aguathuna Formation (assemblages VI and VII).

Material.-67 specimens: 6 homocurvatiform (a); 13 arcuatiform (b); 5 suberectiform (c); 14 pipaform (e); 22 sculponeaform (f) and 7 graciliform (g) elements.

Repository.- GSC 93090-95.

Genus **DREPANOISTODUS** Lindström, 1971

Type species.- Oistodus forceps Lindström, 1955.

Remarks.- Species currently assigned to this genus include a variable number of elements in their apparatuses. All species of this genus have two forms of drepanodontiform, viz. homocurviform and suberectiform, and oistodontiform elements. In some species, a scandodontiform (modified drepanodontiform) element has been included in the apparatus (Ethington & Clark 1981, p. 41). The inclusion of an acodontiform element in apparatuses of species of Drepanoistodus, as suggested by van Wamel (1974, p. 62), is not upheld within available samples containing Drepanoistodus forceps. The apparatus is most likely modified Type IIIA.

Morphotypes included within the apparatus of Drepanoistodus are consistent wi h the analysis of such apparatuses by Fåhraeus & Hunter (1986).

DREPANOISTODUS FORC PS (Lindström, 1955)
Pl. 3, figs. 14-15; Text-fig. 5:2:2.

Oistodontiform element:
? ?Paroistodus parallelus (Pander). STOUGE, 1982, p. 56, Pl. 6, fig. 8 only.

Multielement reconstructions:
Drepanoistodus forceps (Lindström). LÖFGREN, 1978, pp. 53-55, Pl. 1, figs. 1-6, Text-fig. 26A (with synonomy to 1977); FÅHRAEUS & NOWLAN, 1978, p. 459, Pl. 1, figs. 22-25; TIPNIS, CHATTERTON & LUDVIGSEN, 1978, p. 51,

Pl. III, fig. 9; BEDNARCZYK, 1979, p. 425, Pl. 5, figs. 7,17 only; AN, 1981, p. 215, Pl. 3, figs. ?7,?12,13; DZIK, 1983, pp. 337-338, Pl. 3, figs. 1-4.

non Drepanoistodus forceps (Lindström). TERAOKA, SAWATA, YOSHIDA & PUNGRASSAMI, 1982, Pl. III, figs. 4-7; STOUGE, 1984, pp. 53-54, Pl. 3, figs. 24,25.

Remarks.- Oistodontiform elements of Drepanoistodus forceps may vary in depth of base relative to cusp height, acuteness of antero-basal angle, development of lateral costa and flexure of the cusp (Ethington & Clark 1981, p. 43). These two authors differentiated a similar species occurring within the Midcontinent Province on the basis of the above criteria, while stating that their specimens are morphologically similar to one end of the range of variation within topotype material of D. forceps. Specimens from the St. George Group conform more closely with the original designation of D. forceps rather than that of North American specimens, although variation within populations encompasses both forms. Specimens from the Table Head Group, with their pronounced inner flare (Stouge 1984, p. 54), are not considered to belong to this species.

Oistodontiform elements dominate collections of D. forceps within much of its range in the studied sections.

Occurrence.- Serpagli (1974, p. 47) maintained that D. forceps is most likely to be restricted to strata older than youngest Arenig, and to the North Atlantic Province. Forms found in midcontinent North America can not with certainty be considered conspecific with those of the Baltic region, which is known from Billingian to early Volkovian (middle Arenig) of Jämtland, Sweden, Norway, Estonia, the Leningrad area, Poland and Turkey. Forms considered conspecific with St. George Group specimens are found in the San Juan Formation of Argentina (Serpagli 1974), the Dawan Formation of South China (An 1981), the Mackenzie Mountains of Canada (Tipnis *et al*. 1978), possibly the Canning Basin of Western Australia (McTavish & Legg 1976) and the Columbia Ice Fields section of Alberta (Ethington & Clark 1965).

Drepanoistodus forceps s.s. is found in the Cow Head Group, lower to upper Catoche Formation (assemblages I to IV) of Daniel's Harbour area and Port au Choix Peninsula.

Material.- 123 specimens: 15 suberectiform (*p*); 15 homocurvatiform (*q*) and 93 oistodontiform (*r*) elements.

Repository.- GSC 93104-106.

DREPANOISTODUS BASIOVALIS (Sergeeva 1963)
Pl. 3, figs. 11-13; Text-fig. 5:2:7.

Homocurvatiform (*q*) element
Drepanodus homocurvatus Lindström. VIIRA, 1967, Fig. 1:16.
Drepanodus planus Lindström. VIIRA, 1967, Fig.1:17; BEDNARCZYK, 1971, p. 582, Pl.1, fig. 3.

Oistodontiform element
Oistodus basiovalis. SERGEEVA, 1963, p. 96, Pl. 7, figs. 6,7, Text-fig. 3; VIIRA, 1967, Fig. 1:10; BEDNARCZYK, 1971, p. 582, Pl. 1, fig. 2; VIIRA, 1974, Pl. V, figs. 9,10.
Paroistodus parallelus (Pander). GEDIK, 1977, Pl. 1, fig. 8.
? *Paroistodus amoenus* (Lindström). TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. II, fig. 4.

Multielement reconstructions
Drepanoistodus basiovalis (Sergeeva). LINDSTRÖM, 1971, p. 43, Text-figs. 6,8; BARNES & POPLAWSKI, 1973, p.

775, Pl. 4, figs. 3,4,7; LINDSTRÖM (in ZEIGLER), 1973, p. 73, Pl. 1, figs. 3,4; WORKUM, BOLTON & BARNES, 1976, Pl. 4, fig. 2 only; BARNES, 1977, p. 99, Pl. 1, figs. 4-6; BEDNARCZYK, 1979, pp. 424-425, Pl. 4, figs. 13,14; TERAOKA, SAWATA, YOSHIDA & PUNGRASSAMI, 1982, Pl. 3, fig. 2; STOUGE, 1984, p. 53, Pl. 3, figs. 18-20.

? *Drepanoistodus* cf. *basiovalis* (Sergeeva). STOUGE, 1984, p. 53, Pl. 3, figs. 21-23.

? *Drepanoistodus* sp. A. STOUGE & BOYCE, 1982, p. 24, Pl. 1, figs. 13-15; STOUGE, 1983, p. 36, Pl. 1, figs. 16,18, 21-23.

Drepanoistodus sp. B. STOUGE, 1983, p. 36, Pl. 2, figs. 15,16,?17.

Drepanoistodus suberectus forceps (Lindström). DZIK, 1976, Text-fig. 19:?c,d,e,f,h,?i,k.

Drepanoistodus forceps (Lindström). STOUGE, 1984, p. 53, Pl. 3, fig. 25 only.

Remarks.- *Drepanoistodus basiovalis* (Sergeeva) has an apparatus of both forms of drepanodontiform, which may be indistinguishable from those of *D. forceps* (Lindström), and an oistodontiform element. These two species are distinguished by shape of the upper margin of basal cavity (Ethington & Clark 1981), with a more rounded anteroaboral region for *D. basiovalis*. Additionally, oral margin of *D. basiovalis* is generally shorter relative to cusp length than is that of *D. forceps*. Specimens of *Drepanoistodus basiovalis* from western Newfoundland are extremely variable, showing a similar range of forms as that found by Löfgren (1978). This latter species was distinguished from *D. forceps* and *D. suberectus* by the lesser development of costae on all, particularly oistodontiform, elements.

As in European sequences, specimens of *Drepanoistodus basiovalis* (Sergeeva) in the Catoche and Aguathuna formations of Newfoundland range stratigraphically higher than

Drepanoistodus forceps. It is possible that occurrences reported by Ethington and Clark (1981) of species comparable with *D. forceps* stratigraphically above their *D.* aff. *D. basiovalis* is indeed a different species, with slightly different drepanodontiform elements to those of the former species.

Occurrence.- A cosmopolitan species, *Drepanoistodus basiovalis* is found in the lower Ordovician (middle Arenig to middle Llanvirn) of Sweden (Lindström 1971), Norway (Kohut 1972), Poland (Bednarczyk 1971), the Leningrad area (Sergeeva 1963), Estonia (Viira 1974), Latvia (Ul'st *et al*. 1982), Middle Taurus of Turkey (Gedik 1977), Canning Basin of Western Australia (McTavish & Legg 1976), Tarutao Island off Thailand (Teraoka *et al*. 1982), lower parts of the Fillmore Formation of Utah (Ethington & Clark 1981). In Canada, it is known from the Lower Ordovician of Akpatok Island (Workum *et al*. 1976), Ship Point Formation of the Melville Peninsula (Barnes 1977), and possibly the Broken Skull Formation of the District of MacKenzie (Tipnis *et al*. 1978). Stouge (1984) reported this species from the lower and middle Table Head Group: both his *D. basiovalis* and *D.* cf. *D. basiovalis* are considered to fall within bounds of intraspecific variation within *D. basiovalis* (Sergeeva).

This species has been found throughout "Laignet Point" Member and correlatives, upper Catoche and Aguathuna formations (assemblages III and IV). It is probable that

Drepanoistodus sp. B of Stouge (1983) is conspecific with D. basiovalis. If so, this latter species ranges through middle Catoche Formation to lower middle Table Head Group.

Material.- 74 specimens: 13 suberectiform (p); 33 homocurvatiform (q) and 28 oistodontiform (r) elements.

Repository.- GSC 93101-103.

DREPANOISTODUS INAEQUALIS (Pander, 1856)
emended van Wamel, 1974.
Pl. 3, figs. 16-18; Text-figs. 5:2:6,12,17.

Drepanoistodus inaequalis (Pander). VAN WAMEL, 1974, pp. 65-66, Pl. 2, figs. 7-13 (with synonomy to 1971).
Oistodus inaequalis Pander s.f. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. II, fig. 20; AN et al., 1983, pp. 110-111, Pl. XIV, figs. 19-21; STOUGE, 1982, p. 52, Pl. 4, fig. 16; STOUGE & BOYCE, 1983, p. 26, Pl. 2, fig. 2.
"Oistodus" inaequalis Pander s.f. ETHINGTON & CLARK, 1981, pp. 67-68, Pl. 7, fig. 7, Text-fig. 15.
Drepanodus gracilis (Branson & Mehl) sensu Lindström 1955. ETHINGTON & CLARK, 1981, pp. 37-38, Pl. 3, fig. 7, Text-fig. 10; STOUGE, 1982, P. 34, Pl. 3, figs. 2,3; STOUGE & BOYCE, 1983, p. 26, Pl. 2, figs. 6,7.

Remarks.- St. George Group specimens are dominated by oistodontiform elements which co-occur with Drepanoistodus forceps Lindström. A small number of drepanodontiform elements are distinct from those of D. forceps in size and colour. They are also morphologically distinct from D. forceps, but agree well with van Wamel's descriptions of D. inaequalis. In addition, the assigned suberectiform also has the characteristic unequal development of inner and outer faces of the base.

Ethington & Clark (1981) found oistodontiform elements, but no drepanodontiforms. Paucity of homocurvatiform elements may be a consequence of relative fragility of the base; the cavity is restricted to a widely flaring, thin base. This is likely to be abraded more rapidly than other elements. *Drepanodus gracilis sensu* Lindström, described by Ethington & Clark (1981, pp. 37-38), strongly resembles the suberectiform from the St. George Group. This, moreover, has a range within the Pogonip Group comparable with that of "*Oistodus*" *inaequalis*.

Occurrence.- This species is found within the lower Planilimbata Limestone and middle part of the Köpingsklint Formation of Sweden (Lindström 1955, van Wamel 1974) and through much of the Fillmore Formation in Utah (Ethington & Clark 1981), and occurs in the lower Catoche formation (assemblages I to II) in western Newfoundland.

Material.- 24 specimens: 5 suberectiform (*p*); 7 homocurvatiform (*q*) and 12 oistodontiform (*r*) elements.

Repository.- GSC 93107-109.

Genus **ERRATICODON** Dzik, 1978

Type species.- Erraticodon balticus Dzik, 1965.

Remarks.- Dzik (1978, p. 66) described Erraticodon as a multielement apparatus with spathognathodontiform, ozarkodinaform, plectospathodontiform, hindeodelliform, neoprioniodontiform and trichonodelliform elements. Cooper (1981, p. 166) reconstructed the apparatus of a stratigraphically older species (E. patu Cooper) to include neoprioniodontiform (e), modified oulodontiform (f) and oulodontiform (g) with a first symmetry transition of hindeodelliform or cordylodontiform (a), plectospathodontiform (b) and trichonodelliform (c) elements. This is a Type IVB apparatus.

ERRATICODON BALTICUS Dzik, 1978
Pl. 4, figs. 1-7.

Hindeodelliform (a) element
Chirognathus sp. FÅHRAEUS, 1970, p. 2064, fig. 3M; VIIRA, 1974, p. 63, Pl. XI, fig. 22.
Gen. et sp. indet. LÖFGREN, 1978, p. 118, Pl. 1, figs. 41,44.
Phragmodus inflexus Stauffer. LEE, 1975, pp. 138-139, Pl. 2, fig. 11 (not fig. 10).
Plectospathognathodontiform (b) element
Erismodus horridus Harris s.f. BARNES, 1977, p. 103, Pl. 2, fig. 8.
Trichonodelliform (c) element
? Chirognathus sp. LINDSTRÖM, 1960, p. 95, fig. 7:16.
? "Chirognathus" sp. VIIRA, 1974, p. 63, Pl. XI, figs. 15,21.

Neoprioniodontiform (e) element
? Chirognathus sp. LINDSTRÖM, 1960, p. 95, Fig. 7:9.
Gen. et sp. indet. B. LÖFGREN, 1978, p. 118, Pl. 1, fig. 42.
"Cyrtoniodus" sp. LEE, 1975, p. 131, Pl. 2, figs. 1,2.
Ozarkodinaform (f) element
Chirognathus sp. FÅHRAEUS, 1970, p. 2064, fig. 3L.
Fibrous conodont (curtognathid). BARNES & POPLAWSKI, 1973, pp. 787-788, Pl. 4, fig. 21.
Gen et sp. indet. B. LÖFGREN, 1978, p. 118, Pl. 1, fig. 43.
Prioniodontiform (g) element
? Fibrous conodont (erismodid). BARNES & POPLAWSKI, 1973, pp. 787-788, Pl. 5, fig. 14.
Oepikodus? sp. LEE, 1975, pp. 135-136, Pl. 2, fig. 13.
Multielement reconstructions
Erraticodon balticus. DZIK, 1978, p. 66, Pl. 15, figs. 1-3,5,6, text-fig. 6.
? Erraticodon aff. E. balticus Dzik. ETHINGTON & CLARK, 1981, p. 45, Pl. 4, figs. 15,17,23,24.
?Erraticodon balticus Dzik. STOUGE & BOYCE, 1983, p. 32, Pl. 5, figs. 9-12; STOUGE, 1984, pp. 84-85, Pl. 17, figs. 9-19.

Remarks.- The apparatus of specimens from the base of the Table Point Formation may be considered as comprising hindeodelliform (a), plectospathognathodontiform (b), trichonodelliform (c), neoprioniodontiform (e), ozarkodiniform (f) and prioniodontiform (g) elements. An additional cardiodelliform element associated with these may occupy the d position within the apparatus, but is closer to the morphology of a modified f element.

Variation within populations, and stratigraphically, is evident. Based on a large collection of specimens throughout a considerable stratigraphic range, Stouge (1984, p. 85) described an evolutionary sequence within Erraticodon in which ozarkodiniforms and hindeodelliforms remained conservative. Prioniodontiforms gradually decreased in size relative to other elements, and neoprioniodontiforms developed and extended an inner basal flare.

Specimens from the base of the Table Point Formation differ from those of Ethington and Clark (1981) most markedly in the position of costae on denticles and cusp: all elements have symmetrically disposed median costae, whereas development and positioning in those from the Ibex area is variable, but most commonly asymmetrical. The relative heights of denticles also differs between specimens from these two collections. It is, therefore, probable that the Ibex specimens represent a more advanced form than those considered herein. The distinction between species must await further study on larger populations.

Occurrence.- *Erraticodon balticus* Dzik has been recovered from Whiterock strata of Canada, including lower to middle Table Head Group of western Newfoundland (Fåhraeus 1970, Stouge 1984), the Mystic Formation of Quebec (Barnes & Poplawski 1973), and the Ship Point Formation of the Melville Peninsula (Barnes 1977). It is known from the Llanvirn of Sweden (Dzik 1978, Löfgren 1978), Estonia (Viira 1974, Dzik 1978), and the Llandeilo of Sweden (Lindström 1960).

It is diagnostic of lower Table Point Formation strata, and is found several metres above the base of the Table Point Formation at Table Point and east of The Gravels.

Material.- 49 specimens: 7 hindeodelliform (*a*), 8 plectospathodontiform (*b*), 3 trichonodelliform (*c*), 11 neoprioniodontiform (e), 11 ozarkodinaform (f) and 8 prioniodontiform (g) and 1 cardiodelliform (?f') elements.

Repository.- GSC 93121-27.

Genus **ERISMODUS** Branson & Mehl, 1933

Type species.- Erismodus typus Branson & Mehl, 1933.

Remarks.- Andrews (1967) reconstructed Erismodus as a multielement genus with symmetry transition comprising species of Branson & Mehl's (1933 a,b) form genera Erismodus, Microcoelodus and Pteroconus (now Ptiloconus). Moskalenko (1984) considered Erismodus to have two types of elements, which she designated erismodiform and microcoelodiform. Andrews' (1967) scheme is followed by Ethington & Clark (1981, p. 44), although Sweet & Schonlaub (1975, p. 44) indicated the likelihood of a seximembrate apparatus comparable with that of Oulodus Branson & Mehl. Such an apparatus is composed of cordylodontiform (a), zygognathodontiform (b), trichonodelliform (c), cyrtoniodontiform or neoprioniodontiform (e), aphelognathodontiform (g) and oulodontiform (f) elements. This apparatus, Type IVB, is developed in upper Aguathuna Formation occurrences of Erismodus, with the exception that the e element is strachanognathodontiform.

ERISMODUS ASYMMETRICUS (Branson & Mehl, 1933)
Pl. 3, figs. 19-23.

Erismodus asymmetricus (Branson & Mehl). TIPNIS, CHATTERTON & LUDVIGSEN, 1978, p. 57, Pl. v, figs. 18-22; ETHINGTON & CLARK, 1981, pp. 44-45, Pl. 4, figs. 19-22 (with synonomy to 1967); REXROAD, DROSTE & ETHINGTON, 1982, p. 8, Pl. 2, figs. 7-10; MOSKALENKO, 1982, p. 115, Pl. 28, fig. 12; MOSKALENKO, 1983, fig. 3H; MOSKALENKO, 1984, p. 124, Pl. 16, fig. 8.
Microcoelodus asymmetricus Branson & Mehl. AN, 1981, p. 215, Pl. 3, fig. 26.
Microcoelodus symmetricus Branson & Mehl. AN, 1981, p. 215, Pl. 3, figs. 24,25.
Erimsodus sp. A. STOUGE, 1984, p. 70, Pl 11, figs. 7-9.

Description.- Zygognathiform (b), trichonodelliform (c) and oulodontiform (f) were figured and discussed by Ethington & Clark (1981). Other elements are described below.

All elements hyaline, robust cusp, denticles discrete; well developed, expansive basal cavity.

Cordylodontiform (a) element with unequally biconvex cusp and anteriorly and posteriorly keeled, slightly twisted; inner face of cusp with broad median swelling. Base large, with posterior process and lateral flare; anterobasal intersection acute (approximately 60°); posterior margin of cusp perpendicular to oral margin of base, or angle slightly obtuse. Posterior process with discrete, albid directed distally denticles. Basal cavity a deep "phrygian cap"; tip close to anterior margin of cusp; cavity flared posterolaterally beneath posterior margin of cusp, proximally rapidly becoming slit beneath process. Outer lateral face of cusp and base smooth.

Zygognathodontiform (b) element as above, with anterobasal region drawn out into denticulate or adenticulate anticusp; processes separated by 150° to 160°; cusp with anterolateral and posterior keels.

Trichonodelliform element as above but lateral flare to base developed as posterior boss; cusp with anterolateral keels and posterior edge.

Oulodontiform (f) element has posterior and anterior bosses, and flares to basal cavity.

Aphelognathiform (g) element has smooth anterior region to base; slight posterior lip, but no appreciable flare; cusp with narrow lateral keels and unequally biconvex cusp.

Remarks.- Within small collections of *Erismodus* specimens, five of Sweet & Schonlaub's (1975) element types were identified. The e element is missing, but this is not unusual in such a small sample.

Erismodus asymmetricus is distinguished from other species of *Erismodus* by the long processes, sharp pointed denticles and deep basal cavity. *Paraprioniodus costatus* (Mound) has elements which are superficially similar and may co-occur with this species, but has a d element and greater development of white matter in keels on the cusp.

Occurrence.- Ethington & Clark (1981, p. 44) report the presence of the apparently long-ranging *Erismodus asymmetricus* in the Crystal Peak Dolomite of Utah, Joachim and Dutchtown (and possibly Plattin) formations of Missouri and Bromide Formation of Oklahoma. It may also be found in the lower Middle Ordovician of the Ottawa Valley (Barnes 1967) and New York State (Schopf 1966), the Glenwood Formation of Minnesota (Webers 1966), Vihorevian Stage of the Siberian Platform (Moskalenko 1983), Fauna 5 of the Sunblood Formation (Tipnis et al. 1978), and the Fengfeng Formation of North China (An 1981).

Its occurrence is restricted to Assemblage VII (upper Aguathuna Formation) at Table Point, where it is present in every sample, but is not yet known from other localities of western Newfoundland.

Material.- 25 specimens: 8 cordylodontiform (a); 5 zygognathodontiform (b); 3 trichonodelliform (c); 3 oulodontiform (f) and 6 apheloganthodontiform (g) elements.

Repository.- 93110-14.

?ERISMODUS sp.
Pl. 3, figs. 24-29; Text-figs. 5:2:3-5,10-11.

Diagnosis.- A species of Erismodus in which first symmetry transition consists of modified conical elements, and monodenticulate to short processes on all but cordylodontiform elements; very shallow basal cavity; elements completely hyaline.

Description.- All elements robust, few (usually one) denticles on processes; very shallow basal cavity; all elements totally hyaline.

Cordylodontiform (a) element conical; biconvex cusp, with straight and evenly tapering sides, postericr and anterior margins sharp, short oral edge; base very small,acute anterobasal region; basal cavity broad and shallow, tip in anterior portion, aboral margin straight, aboral opening ovate to subcircular.

Zygognathodontiform (b) element similar to cordylodontiform, but has one lateral denticle projecting anterolaterally; cusp cross-section and aboral opening rounded triangular.

Trichonodelliform (c) element similar, with or without posterior denticle.

Strachanognathodontiform (e) element laterally compressed, cusp with one smoothly convex lateral face; inner lateral face with flared basal region below rounded carina which separates anterior and posterior keels; antero-aboral region drawn out; basal cavity with central tip.

Oulodontiform (f) element with sharp edged cusp; anterolateral denticle fused with cusp for half its height, posterolateral denticle isolate with sweeping curve between cusp and denticle, subcentral tip to basal cavity.

Aphelognathodontiform (g) element apparently adenticulate, but base with posterolateral and anterolateral bosses, anterior salient; cusp biconvex, with unequal faces.

Remarks.- All elements are united by robust nature. The first transition series are modified, straight cones, with lateral denticles. The second transition series is linked with the first by possession of only one denticle on processes and unusually shallow basal cavity. Both conical elements and short processes are unusual in Erismodus, but the genus is poorly known as yet. The apparatus as reconstructed agrees with that of other species of the genus in elemental composition.

Occurrence.- This species is only known from western Newfoundland. It is restricted to lower beds of the upper Aguathuna (Assemblage VII).

Material.- 30 specimens: 7 cordylodontiform (a); 12 zygognathodontiform (b); 5 trichonodelliform (c); 3 strachanagnathodontiform (e); 2 oulodontiform (f) and 1 aphelognathodontiform (g) elements.

Repository.- 93115-20.

Genus **FRYXELLODONTUS** Miller, 1969

Type species.- *F. inornatus* Miller, 1969.

Remarks.- Early species of *Fryxellodontus* had either three or four different elements in their apparatus (Type IIB of Barnes *et al*., 1979). *F. inornatus* Miller, with four element types, had two of these in the *a* position. By the Upper Canadian, the apparatus had stabilised with only the "*planus*" element in the *a* position. This was accompanied by "*intermedius*" (*b*) and "*symmetricus*" (*c*) elements.

FRYXELLODONTUS CORBATOI Serpagli, 1974
Pl. 4, figs. 9-10,12.

Fryxellodontus corbatoi. SERPAGLI, 1974, pp. 47-48, Pl. 10, figs. 1a-6c, Pl. 22, figs. 1-5.

Remarks.- "*Symmetricus*" and "*intermedius*" elements are intergradational (Serpagli 1974, p. 48). The "*planus*" element, previously undescribed, appears to be the other end-member of this symmetry transition.

The "*planus*" element has two faces, one of whch is convex, and the other concave. It differs from "*symmetricus*" and "*intermedius*" elements described by Serpagli (1974, p. 48) also in possession of a lenticular cross-section, with two ridges extending from apex of the element, rather than three ridges.

Occurrence.- Originally described from the *Oepikodus evae* Zone of Precordilleran Argentina (Serpagli 1974), this species is restricted to the lower part of the Catoche Formation (lower Assemblage II).

Material.- 14 specimens: 4 "*planus*" (*a*); 5 "*intermedius*" (*b*) and 5 "*symmetricus*" (*c*) elements.

Repository.- GSC 93131-33.

Genus **GLYPTOCONUS** (Branson & Mehl, 1933

Type species.- Scolopodus quadraplicatus Branson & Mehl, 1933.

GLYPTOCONUS QUADRAPLICATUS (Branson & Mehl, 1933)
Pl. 4, figs. 18-19; Text-figs. 5:2:14-15.

Glyptoconus quadraplicatus Branson & Mehl. KENNEDY, 1980, pp. 61-63, Pl. 1, figs. 39-45 (with synonomy prior to 1979).
Scolopodus quadraplicatus Branson & Mehl. ETHINGTON & CLARK, 1981, pp. 103-104, Pl. 11, figs. 24,30; AN, 1981, Pl. 2, figs. 1,8; MOSKALENKO, 1982, pp. 138-139, Pl. 27, figs. 12,16,17; MOSKALENKO, 1983, p.90, figs. 3e,f; MOSKALENKO, 1984, p. 135, Pl. 13, figs. 9-11.
Scolopodus quadraplicatus Branson & Mehl, s.f. REPETSKI, 1982, p. 52, Pl. 23, figs. 4,5.
"Scolopodus" quadraplicatus Branson & Mehl, s.f. STOUGE, 1982, p. 43, Pl. 3, figs. 5-7; STOUGE & BOYCE, 1983, p. 26, Pl. 2, figs. 3-5.
? cf. "Scolopodus" quadraplicatus Branson & Mehl. MAYR, UYENO, TIPNIS & BARNES, 1980, p. 211, Pl. 32.1, fig.7.
Scolopodus triplicatus Ethington & Clark, s.f. REPETSKI, 1982, p. 52, Pl. 24, figs. 1,4.

Remarks.- Specimens agree closely with Kennedy's (1980) description of this species. St. George Group specimens are extremely variable, especially in relative development of lateral grooves and, consequently, cusp cross-section. Triangulariform, quadraplicatiform and gargantuan elements are all found in the St. George Group, but insufficient material is as yet available to construct a full apparatus.

Occurrence.- A common constituent of Midcontinent Province conodont faunas of upper Canadian age throughout the North American continent (Kennedy 1980, Ethington & Clark 1981), Glyptoconus quadraplicatus is known also from the Kimaian Stage of the Siberian Platform and north-western U.S.S.R. (Moskalenko 1982, 1983).

In western Newfoundland, Stouge (1982) reports this species from strata above the "Pebble Bed" in the Boat Harbour Formation through the lower Catoche Formation. It was identified in this study from Assemblage I only (lower Catoche Formation).

Material.- 11 specimens: comprising 6 quadraplicatiform and 5 triplicatiform elements.

Repository.- GSC 93134-35.

GLYPTOCONUS RECTUS (Stouge, 1984)
Pl. 4, figs. 15-16,22; Text-fig. 5:2:9.

"Scolopodus" sp. cf. "S." quadraplicatus. STOUGE, 1982, p. 58, Pl. 7, figs. 9,14.
Trigonodus rectus. STOUGE, 1984, pp. 80-81, Pl. 6, figs. 10-12.
cf. Scolopodus floweri. REPETSKI, 1982, pp. 47-48, Pl. 24, figs. 7,9-10, Pl. 25, figs. 1,4.

Remarks.- Stouge (1984, p. 81) noted that specimens he referred to Trigonodus rectus compare closely with Glyptoconus quadraplicatus (Branson & Mehl). Trigonodus Nieper was synonomised by Bergström (1981, p. 138) into Eoneoprioniodus Mound, at approximately the same time as Cooper (1981, p. 179) redefined Trigonodus. Cooper's emended diagnosis described a Type IVD apparatus. In spite of the paucity of available specimens, it is apparent that not all these element types are included within the apparatus of "*Trigonodus*" *rectus*. Furthermore, elements of this latter species have deep grooves on cusp; cusp ornament does not extend to the aboral margin. This species is therefore assigned to *Glyptoconus* Kennedy.

Scolopodus floweri Repetski is similar to, and possibly conspecific with, *Glyptoconus rectus* (Stouge), but is distinguished by its more compressed aboral opening in most elements and fewer costae on some elements. No specimens of *G. rectus* with only two costae have yet been found.

Occurrence.- *Glyptoconus rectus* is currently only known from Newfoundland, where it ranges from the top of the Aguathuna Formation through to the lowest Table Point Formation (Assemblage VII and younger) at the western Gravels section, and in subsurface of the Daniel's Harbour area.

Material.- 4 specimens: 2 triplicatiform and 2 quadraplicatiform elements.

Repository.- GSC 93136-38.

Genus **HISTIODELLA** Harris, 1962

Type species.- Histiodella altifrons Harris, 1962.

Remarks.- McHargue (1983, p. 1412) demonstrated that the apparatus of Histiodella consists of a large number of bryantodontiform elements associated with a lesser number of zygognathodontiform, trichonodelliform and oistodontiform elements. Bryantodontiform elements may be of the type previously referred to Spathognathodus s.f., and also as twisted bryantodontiform elements. Short bryantodontiform (a), zygognathodontiform (b) and trichonodelliform (c) elements comprise the first symmetry transition series. Oistodontiform (e), twisted bryantodontiform (f) and large bryantodontiform (g= spathognathodontiform of earlier authors) elements complete a Type IVB apparatus (Barnes et al. 1979).

HISTIODELLA HOLODENTATA Ethington & Clark, 1981
Pl. 4, figs. 13-14,20-21.

? Spathognathus sp. LINDSTRÖM, 1960, text-fig. 5:3; FÅHRAEUS, 1970, p. 2073, fig. 3I; UYENO & BARNES, 1970, p. 117, Pl. 24, figs. 12,13.
? Histiodella sp. A. SWEET, ETHINGTON & BARNES, 1971, p. 167, Pl. 1, fig. 16.
Histiodella sinuosa (Graves & Ellison). BARNES & POPLAWSKI, 1973, P. 776. Pl. 1, figs. 17,18.
Histiodella serrata Harris. LANDING, 1976, text-fig. 12d; DZIK, 1978, p. 53, Pl. 14, fig. 7, text-fig. 1:21.
Histiodella n.sp. 1. HARRIS, BERGSTRÖM, ETHINGTON &

ROSS, 1979, Pl. 1, fig. 9.
<u>Histiodella</u> spp. STOUGE & BOYCE, 1983, p. 36, Pl. 7, figs. 1,2,?3.
<u>Histiodella holodentata</u> Ethington & Clark. NOWLAN & THURLOW, 1984, p. 289, Pl. 1, figs. 1,2,?3,5.

Multielement reconstructions
<u>Histiodella holodentata</u> ETHINGTON & CLARK, 1981, pp. 47-48, Pl. 4, figs. 1,3,4,16.
<u>Histiodella</u> cf. <u>serrata</u> Harris. MOSKALENKO, 1982, p. 120, Pl. 27, figs. 22,23.
<u>Histiodella tableheadensis</u> STOUGE, 1984, pp. 87-88, Pl. 18, figs. 8, 12-14, text-fig. 17.
? <u>Histiodella kristinae</u> STOUGE, 1984, p. 87, Pl. 18, figs. 2,3,6,7, text-fig. 17.

<u>Remarks</u>.- Although Ethington & Clark (1981) did not describe oistodontiform elements, nor short or twisted bryantodontiform elements, it is clear that <u>H</u>. <u>holodentata</u> is conspecific with <u>H</u>. <u>tableheadensis</u> Stouge, a number of specimens of which have been recovered from uppermost samples collected for this study. It is confirmed that short bryantodontiform (<u>a</u>) and twisted short bryantodontiform (<u>f</u>) elements are associated with spathognathodontiform elements identical to the nominated holotype of <u>H</u>. <u>holodentata</u>. No trichonodelliform, zygognathodontiform nor oistodontiform elements have yet been recovered in this study, but are usually reported in such low ratios (Ethington & Clark 1981, p. 48) that this fact is not remarkable given the small number of spathognathodontiforms recovered.

The spathognathodontiform element is considered to be the most diagnostic element for species determination within this genus (McHargue 1983, Stouge 1984). Samples collected at Port au Port Peninsula from strata equivalent to the lower Table Point Formation show spathognathodontiforms which vary from morphology of H. holodentata to forms closely resembling H. kristinae Stouge. It is therefore likely that Stouge's (1984) "advanced form" of H. holodentata may be found throughout the range of H. holodentata in the Table Point Formation, with H. holodentata and H. kristinae being conspecific.

Occurrence.- Histiodella holodentata is widely distributed throughout strata of Middle Ordovician age in North America: from Antelope Valley Limestone of central Nevada (Harris et al. 1979), the Mystic Conglomerate of Quebec (Barnes & Poplawski 1973), the Buchans Group of central Newfoundland (Nowlan & Thurlow 1984), Table Point Formation of western Newfoundland (Stouge 1984; this study), the upper Lehman Formation and lower Watson Ranch Quartzite of the Ibex area, Utah (Ethington & Clark 1981), and the Deepkill Shale of New York (Landing 1976). It is also known from the Nita Formation of the Canning Basin, Australia (Watson 1986), Hølonda Limestone of Norway (Bergström 1978), and is present in the Mójcza Limestone of the Holy Cross Mountains, Poland (Dzik 1978). Moskalenko (1982) reported its presence in the Kimaian Stage (middle to upper Arenig) of the Siberian Platform.

Histiodella holodentata has been found in uppermost Aguathuna (Assemblage VII) Formation west of The Gravels on Port au Port Penisula, and in subsurface samples from Daniel's Harbour area. It is otherwise only known, in abundance, from Table Point Formation.

Material.- 17 specimens: 2 short bryantodontiform (a); 1

zygognathodontiform (b); 1 oistodontiform (e) and 11 spathognathodontiform (g) elements.

Repository.- GSC 93139-42.

Genus JUMUDONTUS Cooper, 1981

Type species.- Jumudontus gananda Cooper, 1981.

JUMUDONTUS GANANDA Cooper, 1981
Pl. 4, fig. 27.

Spathognathodus sp. ETHINGTON & CLARK, 1965, p. 201, Pl. 2, fig. 5; LANDING, 1976, p. 640, Pl. 4, fig. 15.
New Genus B. ?SWEET, ETHINGTON & BARNES, 1971, Pl. 1, fig. 34; BARNES, 1974, p. 230, Pl. 1, fig. 9; BARNES, 1977, p. 104, Pl. 1, figs. 16-18; TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. 3, fig. 17.
"Spathognathodus" sp. SERPAGLI, 1974, pp. 71-72, Pl. 19, figs. 11a,b, Pl. 29, fig. 16.
Histiodella n. sp. A s.f. FÅHRAEUS & NOWLAN, 1978, pp. 460-461, Pl. 3, fig. 14.
Jumudontus gananda COOPER, 1981, pp. 170, 172, Pl. 31, fig. 13; ETHINGTON & CLARK, 1981, pp. 51-52, Pl. 2, figs. 9,10.

Remarks.- Specimens from the Aguathuna Formation agree closely with those described by Cooper (1981). Within specimens figured by all above authors denticle orientation varies from almost completely erect along the bar, with only posterior-most denticles reclined, to forms in which denticles are progressively reclined away from a central denticle (compare Sweet et al. 1971, Barnes 1974 with Barnes 1977, this study). This variation does not show a consistent stratigraphic trend, so is probably not representative of different species.

Occurrence.- Jumudontus gananda appears to have been cosmopolitan in its distribution: it is known from the Lower

Ordovician of Sweden (*P. elegans* Zone) and low in the San Juan Formation of Argentina (Serpagli, 1974), the Ship Point and Eleanor River formations of the Canadian Arctic (Nowlan 1976, Barnes 1977), the Deepkill Shale of New York (Landing 1976), upper Spring Creek Formation of Oklahoma (Cooper 1981), upper Fillmore Formation to lower Juab Limestone in the Ibex area of Utah (Ethington & Clark 1981). It has been reported from the Cow Head Group of western Newfoundland (Fåhraeus & Nowlan 1978), and occurs sporadically in the Catoche and Aguathuna formations (assemblages III, VI and VII of this study).

Material.- 6 specimens.

Repository.- GSC 93145.

Genus **LEPTOCHIROGNATHUS** Branson & Mehl, 1943, emended Bergström 1981, and herein

Type species.- *Leptochirognathus quadrata* Branson & Mehl, 1943.

Diagnosis.- Apparatus follows the *Paracordylodus* plan (Type IVE) characterised by cordylodontiform (*a*), zygognathodontiform (*b*) and trichonodelliform (*c*) elements in first symmetry transition, accompanied by falodontiform (*e*) and cyrtoniodontiform (*f*) elements.

Genus is based on pectiniform, mostly palmate units consisting of shallowly excavated base with a few denticles along upper margin. Denticles strongly laterally compressed with sharp edges, wide at base, confluent basally but mainly distally discrete. Cusp situated above widest part of basal cavity, usually only slightly larger than denticles. Denticle orientation varies within specimens from suberect to almost parallel to aboral margin.

Remarks.- The above diagnosis, emended from Bergström (1981), differs mainly in the determination of a distinct cusp. In all elements one denticle is larger than others. This enlarged denticle is situated above the widest part of the basal cavity. Some specimens show the basal cavity extending up this denticle.

With respect to orientation of denticles relative to the cusp, specimens may then be shown to be symmetrical or asymmetrical.

It is unusual for representatives of this genus to be preserved in large numbers. Consequently, they are commonly reported in open nomenclature (e.g. Bergström 1979a, Harris *et al*. 1979). It is apparent, however, that individual species of *Leptochirognathus* may be restricted to narrow stratigraphic intervals (e.g. Tipnis *et al*. 1978, Harris *et al*. 1979, this study), and are likely to be biostratigraphically useful.

LEPTOCHIROGNATHUS QUADRATA Branson & Mehl, 1943
Pl. 4, figs. 25-26, 28; Pl. 5, figs. 1-2;
Text-figs. 5:2:13,20-21,23,25.

Cordylodontiform (*a*) element
Leptochirognathus n.sp. HARRIS, BERGSTRÖM, ETHINGTON & ROSS, 1979, Pl. 1, fig. 18.
Leptochirognathus sp. A. STOUGE, 1982, p. 58, Pl. 7, fig. 18.
Leptochirognathus prima Branson & Mehl. STOUGE & BOYCE, 1983, p. 32, Pl. 5, fig. 8; STOUGE, 1984, p. 70, Pl. 12, fig. 7.
Zygognathodontiform (*b*) element
Leptochirognathus quadrata n.sp. BRANSON & MEHL, 1943, pp. 378-379, Pl. 63, figs. 23-28.
Leptochirognathus sp. A. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, p. 56, Pl. 4, figs. 2,3.
Leptochirognathus n.sp. HARRIS, BERGSTRÖM, ETHINGTON & ROSS, 1979, Pl. 1, figs. 16,17.
Leptochirognathus prima Branson & Mehl. STOUGE & BOYCE, 1983, p. 32, Pl. 5, fig. 8; STOUGE, 1984, p. 70, Pl. 12, fig. 6.
Leptochirognathus cf. *quadrata* Branson & Mehl. STOUGE, 1984, p. 70, Pl. 12, fig. 2.
Trichonodelliform (*c*) element
Leptochirognathus cf. *quadrata* Branson & Mehl. STOUGE, 1984, p. 70, Pl. 12, fig. 3.

Emended Diagnosis.- A species of *Leptochirognathus* in which all elements have sinuous aboral margin with basal cavity expanded beneath cusp and considerably reduced beneath processes. Denticles arranged in a fan shape around basal cavity. All elements with keeled and medially carinate denticles.

Description.- All elements palmate with concave inner surface and moderately convex outer surface. Denticles decrease in height, become increasingly confluent and proclined away from cusp. Denticles laterally compressed, keeled with median carina extending entire height of each denticle. Basal cavity flared beneath cusp; continues as thin parting along processes. Elements completely hyaline.

Cordylodontiform (*a*) element has two or three, rarely four, denticles. Cusp confluent with adjacent denticle to half cusp height, and approximately two-thirds height of denticle. Most proximal denticle almost completely fused to adjacent denticle. Basal excavation shallow, with no discernible tip. Cusp intersects aboral margin at approximately 90°.

Zygognathodontiform (*b*) element with short anterolateral processes bearing either one or two fused denticles, and posterolateral process.

Processes of trichonodelliform (*c*) element separated by 120 to 150°. Basal cavity conical, tip at approximately half cusp height.

Cusp of falodontiform (_e_) element intersects oral margin at approximately 60°.

Cyrtoniodontiform (_f_) element similar to other elements, except for extension of cusp below aboral margin as short, node-like anterior process. Cusp intersects aboral margin at approximately 60°.

Remarks.- This species is readily distinguished from _Leptochirognathus planus_ by its more robust elements, confluent denticulation and sinuous aboral margin. Elements of _L. quadrata_ are usually more curved than those of _L. planus_ which are commonly planar. Zygognathodontiform and trichonodelliform elements of _L. quadrata_ compare closely with _L. semiflorealis_ Branson & Mehl s.f., but do not have the prominent aboral ridge characteristic of this latter species.

Occurrence.- Elements of _Leptochirognathus quadrata_ are found in the lower Antelope Valley Limestone of Nevada and co-occur with conodonts of Midcontinent Fauna 3 age (Harris _et al_. 1979). It is also found in the Sunblood Formation of southern Mackenzie Mountains, Canada (Tipnis _et al_. 1978).

This species has been previously reported from the uppermost Aguathuna and lower Table Point formations (Stouge 1982, 1984). It first occurs in Assemblage VII, known in abundance only from the level of first appearance, and is found also at Hare Bay in upper Aguathuna Formation and east of The Gravels, Port au Port Peninsula in lowest Table Point

Formation.

Material.- 168 specimens: 57 cordylodontiform (a); 60 zygognathodontiform (b); 22 trichonodelliform (c); 20 falodontiform (e) and 9 cyrtoniodontiform (f) elements.

Repository.- GSC 93146-50.

LEPTOCHIROGNATHUS PLANUS n.sp.
Pl. 5, figs. 3-6,10; Text-figs. 5:2:18-19,22,24,26.

Derivation of name.- From Latin, planum, a reference to relatively flat, unadorned surfaces.

Diagnosis.- All elements have straight aboral margin; basal cavity slightly expanded beneath cusp and continues as a groove beneath processes. Denticles unornamented, almost discrete at cusp but confluent along most of length at distal end of processes. All but trichonodelliform element are planar.

Description.- All elements palmate with slightly concave inner surface and convex to planar outer surface. Successive denticles progressively proclined away from cusp. Denticles laterally compressed although needle-like in plan, unornamented, of approximately equal length. Denticles adjacent to cusp confluent with cusp for short distance, whereas proximal two denticles are commonly fused: denticles progressively more fused along processes. Aboral margin straight. Basal cavity shallow with no apparent tip, slightly expanded beneath cusp and continues as groove along entire length of processes. Elements completely hyaline.

Posterior process of cordylodontiform (a) element has two or three, rarely four, denticles. Cusp confluent with adjacent denticle to one-quarter cusp height, and approximately one-third length of denticle. Cusp intersects aboral margin in a smooth curve; anterior margin is approximately perpendicular to aboral margin.

Zygognathodontiform (b) element with short anterolateral process bearing one or two denticles. Cusp intersects aboral margin at an angle of 60 to 75°.

Processes of trichonodelliform (c) element separated by approximately 150°. Basal cavity extends only a short height up cusp.

Falodontiform (e) element has one large denticle anterior to cusp. Both cusp and denticle are of approximately equal height, confluent to up to one third cusp length, and subparallel.

Cusp of cyrtoniodontiform (f) element reclined; anterior process short and adenticulate. Cusp intersects aboral margin at approximately 45°.

Remarks.- Characteristics distinguishing this species from *L. quadrata* are discussed under that species. Zygognathodontiform and trichonodelliform elements of *Leptochirognathus planus* n.sp. compare closely with *L. tridactyla* Branson & Mehl s.f. and *L. erecta* Branson & Mehl s.f., but do not have the prominent aboral ridge on the inner face of these latter species.

Occurrence.- This species has not been reported previously. It is restricted to a brief interval of the upper Aguathuna Formation (Assemblage VII) at Table Point, and is also present in the upper Aguathuna Formation of Back Arm Bay, Port au Choix.

Material.- 55 specimens: 22 cordylodontiform (*a*); 21 zygognathodontiform (*b*); 3 trichonodelliform (*c*), 8 falodontiform (*e*) and 1 cyrtoniodontiform (*f*) elements.

Type stratum.- Fine grained laminated dolostones exactly 12.9 m beneath base of Table Point Formation along shore section at Table Point (Grid reference 617790 Bellburns sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

Repository.- GSC 93151-54, paratypes; GSC 93155 holotype.

Genus **MICROZARKODINA** Lindström, 1955
(emended Lindström, 1971)

Type species.- Prioniodina flabellum Lindström, 1955.

?MICROZARKODINA MARATHONENSIS (Bradshaw, 1969)
Pl. 5, figs. 7,9,11-14.

Cordylodontiform (a) element
Cordylodus flexuosus (Branson & Mehl). MOUND, 1965b, p. 14, Pl. 1, fig. 26.
Paracordylodus sp. BRADSHAW, 1969, p. 1159, Pl. 136, figs. 12-13.
Cordylodiform? element. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. 3, fig. 8.
?Microzarkodina marathonensis (Bradshaw). STOUGE & BOYCE, 1983, p. 30, Pl. 4, fig. 12.
Gothodontiform (b) element
Gothodus? n. sp. ETHINGTON & CLARK, 1965, p. 193.
Gothodus marathonensis. BRADSHAW, 1969, p. 1151, Pl. 137, figs. 13-15.
Prioniodus cf. P. sp. C McTavish. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. 3, fig. 6.
Trichonodelliform (c) element
Gothodus communis Ethington & Clark. MOUND, 1965b, p. 20, Pl. 2, figs. 24,?25.
Roundya sp. BRADSHAW, 1969, p. 1160, Pl. 137, fig. 17, text-fig. 3A.
Multielement reconstructions
"Microzarkodina" marathonensis (Bradshaw). ETHINGTON & CLARK, 1981, pp. 55-56, Pl. 5, figs. 14,19,20,23,24,27.
?Microzarkodina marathonensis (Bradshaw). STOUGE, 1982, p. 38, Pl. 7, figs. 1-5.
Microzarkodina? cf. M. marathonensis (Bradshaw). REPETSKI, 1982, pp. 28-29, Pl. 10, figs. 1-7,9.

Remarks.- Of the 40 specimens from 10 different samples, two varieties of "ozarkodiniform", one oistodontiform and three different ramiforms have been recognized. All elements have a "shoulder" along the posterior process, or posterior extension of the base (oistodontiform element). Distribution of white matter and dark basal zone concurs with that of Bradshaw's (1969) description of the holotype. The symmetry transition series of ramiforms includes cordylodontiform, gothodontiform and trichonodelliform elements. The oistodontiform elements have a costate cusp, and knob at the intersection of costa and basal "shoulder". Ozarkodiniform elements may have an anteriorly extended base and straight aboral margin, with a flare to the outer side of the basal cavity beneath the first denticle, or bear an arched aboral margin with downwardly deflected anterior process. It is unknown, and not demonstrable from available specimens, whether the variety of ozarkodiniform elements reflects intraspecific variation, or is due to differing positions within one apparatus.

This species does not closely fit within Lindström's (1971) diagnosis of Microzarkodina, as also noted by Ethington and Clark (1981). Oistodontiform elements assigned to this species possess an anterior extension; ozarkodiniform elements have an adenticulate anterior region such that these elements would be better described as "neoprioniodontiform". First symmetry transition elements of true Microzarkodina generally bear depleted posterior processes: those assigned by all authors to ?M. marathonensis are dominated by their posterior processes. As noted by Ethington & Clark (1981) and Cooper (1981) the appearance of the basal shoulder, distribution of white matter and general element morphology is suggestive of a close relationship to Protoprioniodus McTavish (1973). This genus, however, is not known to include elements with denticulate processes. Paucity of specimens has prevented the definition of a new genus for this species, although most probably a separate genus, related to Protoprioniodus, will be later shown to be most appropriate.

Occurrence.- ?Microzarkodina marathonensis has been reported with certainty only from North America. It is known from the Fort Peña (Bradshaw, 1969) and upper El Paso (Repetski, 1982) formations of Texas; high in the Western Spring Creek (Ethington & Clark, 1981) and Joins (Mound, 1965b) formations of Oklahoma; uppermost Jefferson City Dolomite, Missouri (Ethington & Clark, 1981). It ranges from the upper half of the Fillmore Formation through to the Kanosh Formation of the Pogonip Group, Utah (Ethington & Clark, 1981), and occurs in the Broken Skull Formation of southern District of Franklin, Canada (Tipnis et al., 1978).

Stouge (1982) reported the occurrence of this species in the "Laignet Point Member" of Port au Choix, and the uppermost Catoche Formation north of Table Point, Newfoundland. It has also been found in samples 50 to 80 m below the base of the Aguathuna Formation at the Daniel's Harbour zinc mine (D.D.H. A1): it ranges from lower to upper Catoche of the Daniel's Harbour region (assemblages I to III).

Material.- 58 specimens: 7 cordylodontiform (a); 20

gothodontiform (b); 7 trichonodelliform (c); 12 oistodontiform (e) and 12 ozarkodiniform (f?) elements. Of the ozarkodiniforms, 3 bear arched aboral margins (f? element) and 8 have straight aboral margins, with a lateral flare of the base (g? elements).

Repository.- GSC 93157-62.

Genus **MULTIOISTODUS** Cullison, 1938

Type species.- Multioistodus subdentatus Cullison, 1938.

MULTIOISTODUS SUBDENTATUS Cullison, 1938
Pl. 5, figs. 15,19-20,22.

Multioistodus subdentatus Cullison. ETHINGTON & CLARK, 1981, pp. 59-60, Pl. 6, figs. 12-14 (with synonomy to 1970); HARRIS, BERGSTRÖM, ETHINGTON & ROSS, 1979, p. 27, Pl. 2, fig. 5; REXROAD, DROSTE & ETHINGTON, 1982, pp. 8-9, Pl. 2, figs. 15-32.
Multioistodus sp. cf. M. subdentatus Cullison. STOUGE, 1982, p. 58, Pl. 7, fig. 16 only.

Remarks.- Multioistodus subdentatus is distinguished from M. compressus (Harris & Harris 1965) primarily by its lack of anterior boss on base of cordylodontiform element, and from other co-occurring species of Multioistodus by having denticles rather than alae.

Occurrence.- M. subdentatus occurs in the Everton Dolomite of Indiana (Rexroad et al. 1982) and northern Arkansas (Ethington & Clark 1981), Dutchtown Formation of southeastern Missouri (Cullison 1938), Oil Creek Formation and Burgen Sandstone of Oklahoma (Harris 1964), Lehman Formation and low in the Watson Ranch Quartzite of Utah (Ethington & Clark 1981).

It is a minor component of upper Aguathuna Formation (Assemblage VII) at Table Point, but dominates faunas of this level at Hare Bay. It has been found no lower at Aguathuna than low in the Table Head Group.

Material.- 53 specimens: 30 cordylodontiform (a); 15 acodontiform (b); 3 trichonodelliform (c) and 5 distacodontiform (d) elements in a Type IIA apparatus.

Repository.- GSC 93166-69.

?MULTIOISTODUS AURITUS (Harris & Harris) sensu
Ethington & Clark 1981
Pl. 5, figs. 16-18.

?Multioistodus auritus (Harris & Harris). ETHINGTON & CLARK, 1981, p. 58, Pl. 6, figs. 5-7 (Synonomy to 1975).

Remarks.- Ethington and Clark (1981, p. 58) reported specimens of Multioistodus with angular postero-oral intersection and alae instead of denticles. As these specimens were confined to one sample, and trichonodelliform elements were not recovered, they did not formally describe a new species, but considered that such would be shown to be necessary with more material.

Specimens possessing the above characteristics are found, in one sample, in the upper Aguathuna Formation. Cordylodontiform (a), acodontiform (b) and trichonodelliform (c) elements appear conspecific with "?Multioistodus auritus" of Ethington & Clark (1981). It is apparent that this species will be biostratigraphically useful.

Occurrence.- This species is known from the upper Lehman Formation of Utah, and possibly Joins Formation of southern

Oklahoma and Simpson Group equivalents of west Texas (Ethington & Clark 1981).

It is found in only one sample from the upper Aguathuna Formation (early Assemblage VII) north of Table Point.

Material.- 9 specimens: 1 cordylodontiform (a); 4 acodontiform (b) and 4 trichonodelliform (c) elements.

Repository.- GSC 93163-65.

Genus OEPIKODUS Lindström, 1955

Type species.- *Oepikodus smithensis* Lindström, 1955.

Remarks.- Multielement apparatuses of *Prioniodus evae* Lindström and "*Prioniodus*" *communis* (Ethington & Clark) both lack the hibbardelliform element present in the type species of *Prioniodus*, *P. elegans* Pander. The oepikodontiform element associated with *P. evae* s.f. was first described as *Oepikodus smithensis* Lindström (1955), leading Bergström (1968) to suggest the separation of *P. elegans* and *P. evae* type apparatuses into the subgenera *Prioniodus* (*Prioniodus*) and *Prioniodus* (*Oepikodus*). Serpagli (1974) implemented this suggestion. On the basis of the elemental composition of reconstructed apparatuses, differences in denticulation of individual elements, with marked dissimilarity between these subgenera, Ethington and Clark (1981) treated *Oepikodus* and *Prioniodus* as different, although related, genera. Their approach is followed herein.

Oepikodus follows a Type IVD apparatus plan of Barnes *et al.* (1979), with prioniodontiform (*f*) and falodontiform (*e*) elements comprising the second transition series. The first transition series consists of cordylodontiform (*a*), gothodontiform (*b*) and tetraprioniodontiform (*d*) elements. Ethington (1972) suggested the inclusion of a dichognathodontiform element in the ramiform transition series of Oepikodus quadratus, but this has not been found associated with the ramiform elements of Oepikodus in the present study. It is likely that the first transition series consists of a reduced tetraprioniodontiform symmetry transition.

OEPIKODUS COMMUNIS (Ethington & Clark, 1964)
Pl. 5, figs. 21,28-31.

Oepikodus communis (Ethington & Clark). ETHINGTON & CLARK, 1981, pp. 61-62, Pl. 6, figs. 18,22,25 (with synonomy prior to 1980); REPETSKI, 1982, pp. 30-31, Pl. 11, figs. 5-8,10,12; STOUGE, 1982, pp. 38-39, Pl. 4, figs. 9-12; STOUGE & BOYCE, 1983, p. 28, Pl. 3, figs. 4-6.

Oepikodus sp. cf. O. communis (Ethington & Clark). STOUGE, 1982, p. 40, Pl. 6, figs. 17-20; STOUGE & BOYCE, 1983, p. 30, Pl. 4, fig. 10.

non Prioniodus (Oepikodus) intermedius SERPAGLI, 1974, pp. 69-73, Pl. 15, figs. 1a-4b, Pl. 27, figs. 1-7, Pl. 31, figs. 2a-6.

non Baltoniodus communis Ethington & Clark. AN, 1981, Pl. 4, figs. 20-23,25-29.

Remarks.- The first symmetry transition was figured by Ethington (1972) as Oepikodus quadratus (Graves & Ellison). Cordylodontiform (a), gothodontiform (b) and tetraprioniodontiform (d) elements are common throughout the Catoche Formation. It is probable that the first symmetry transition of the O. communis apparatus has only three elements.

Falodontiform (e) elements have an acostate, unkeeled posterior process, the oral margin of which meets the cusp at an acute angle of usually less than 45°. Elements figured by

Serpagli (1974) and Ethington & Clark (1964) as *Oistodus longiramis* are closer in affinity to *Oelandodus costatus* van Wamel. This latter species frequently co-occurs with *O. communis* in the Catoche Formation. Within these samples, they are usually easily distinguished by a disparity in size: elements of *Oepikodus communis* are considerably smaller than those of "*Oelandodus*" *costatus*.

It has been suggested (Ethington & Clark 1981, p. 61, Repetski 1982, p. 31) that *Oepikodus intermedius* Serpagli is a junior synonym of *O. communis*. Serpagli (1974) distinguished between these two species according to the direction of the anterior process, degree of arching and upwards curvature of prioniodontiform elements' posterior process, and by the pattern of dentition of ramiform elements. Intergradation of these properties within populations was reported by Ethington and Clark (1981). Specimens of both *O. communis* and *O. intermedius* from Catoche and Aguathuna formations have varying denticle pattern along posterior process: denticles are uneven in both species, and some degree of hindeodellid pattern can be argued for most specimens. Arching of the posterior process is also an intraspecific variable. All tetraprioniodontiform and prioniodontiform elements of *O. communis* have posterior processes which are laterally deflected at their distal extremities, which is not seen in corresponding elements of *O. intermedius*. These two species are distinct, and can be readily distinguished by a reduction of the basal sheath of most elements, the less posteriorly directed anterior process of prioniodontiform elements, and the reduction of lateral processes to flares of the basal sheath of tetraprioniodontiform elements of *O. intermedius*. Additionally, the anterior process of first transition series elements of *O. intermedius* is consistently shorter than those of *O. communis*.

Occurrence.- *Oepikodus communis* is known from the upper Canadian of North America and Australia. It has been recovered from the Columbia Ice Fields of Alberta (Ethington & Clark 1965), Arctic Canada (Barnes 1974), Pogonip Group of western Utah and central Nevada (Ethington 1972), Jefferson City Formation of Missouri (Repetski 1982), New York (Landing 1976), Ouachita Mountains of Arkansas (Repetski & Ethington 1977), El Paso Group of western Texas (Repetski 1982) and the Emanuel Formation of Western Australia (McTavish 1973).

In western Newfoundland, *O. communis* ranges through the Catoche and early Aguathuna formations (assemblages I to IV). It is found in the Daniel's Harbour area, and at Back Arm Bay near Port au Choix.

Material.- 985 specimens: 208 cordylodontiform (*a*), 236 gothodontiform (*b*), 134 tetraprioniodontiform (*d*), 173 falodontiform (*e*) and 234 prioniodontiform (*f*) elements.

Repository.- GSC 93170-74.

OEPIKODUS INTERMEDIUS Serpagli, 1974
Pl. 5, figs. 26-27,32-34.

Gothodontiform (b) element
? Gothodus sp. MOSKALENKO, 1982, p. 118, Pl. 28, fig. 20.
Tetraprioniodontiform (d) element
? Oepikodus quadratus (Graves & Ellison). SWEET, ETHINGTON & BARNES, 1971, p. 166, Pl. 1, fig. 20.
Prioniodontiform (f) element
Gothodus communis (Ethington & Clark). ETHINGTON & CLARK, 1971, Pl. 2, fig. 24; SWEET, ETHINGTON & BARNES, 1971, pp. 166-167, Pl. 1, fig. 27.
Multielement reconstructions
Prioniodus (Oepikodus) intermedius SERPAGLI, 1974, pp. 69-73, Pl. 15, figs. 1a-4b, Pl. 27, figs. 1-7, Pl. 31, figs. 2a-6.

Remarks.- Specimens from the middle part of the Aguathuna Formation agree closely with Serpali's (1974) original description of Oepikodus intermedius, with the exception that costae are not quite as pronounced.

Oepikodus sp. cf. O. communis described by Stouge (1982) and by Stouge & Boyce (1983) from the middle and upper parts of the Catoche Formation, and tentatively compared with O. intermedius is considered to fall within the definition of O. communis (Ethington & Clark). Although populations are consistently unusual in denticulation and other factors, a comparison of populations throughout the Catoche Formation with those of the upper parts of the Aguathuna Formation shows two distinct morphologies. These morphologies are separated by approximately 10 m of section immediately above the base of the Aguathuna Formation in which neither form has yet been found. Oepikodus sp. cf. O. communis is of intermediate morphology between *O. communis* and *O. intermedius*.

Occurrence.- This species has been recovered from the Pogonip Group of western Utah and central Nevada (Sweet *et al*. 1971) and the San Juan Formation of Precordilleran Argentina (Serpagli 1974). It occurs in middle to upper Aguathuna Formation at Aguathuna and near The Gravels on Port au Port Peninsula, and subsurface and outcrop in the Daniel's Harbour area (assemblages V to VII).

Material.- 98 specimens: 14 cordylodontiform (*a*); 20 gothodontiform (*f*); 8 tetraprioniodontiform (*d*); 22 falodontiform (*e*) and 34 prioniodontiform (*f*) elements.

Repository.- GSC 93175-79.

Genus OISTODUS Pander, 1856

Type species.- *Oistodus lanceolatus* Pander, 1856.

OISTODUS BRANSONI Ethington & Clark, 1981

Pl. 6, figs. 1-5.

Oistodus bransoni. ETHINGTON & CLARK, 1981, pp. 65-66, Pl. 7, figs. 1-3,5,6, Text-fig. 17 (with synonomy to 1981).
Oistodus n.sp. REPETSKI, 1982, pp. 32-33, Pl. 11, figs. 3,4,9,11.

Remarks.- The apparatus reconstruction by Ethington and Clark (1981, pp. 65-66), with cordylodontiform (*a*), cladognathodontiform (*b*), trichonodelliform (*c*), distacodontiform (*d*) and oulodontiform (?*f*) elements, is upheld by St. George Group material. This differs from the apparatus of *Oistodus lanceolatus* Pander discussed by Löfgren (1978, pp. 63-64)in the presence of distacodontiform and oulodontiform elements. It is possible, therefore, that these species are not congeneric, but additional material is required to clarify their relationship.

The oulodiform element may or may not be continued posteriorly beyond the cusp, although the posterior margin is uniformly curved on all specimens. This element may occupy the a position, or may be part of the second transition series, probably as f element.

Occurrence.- Oistodus bransoni is known from the upper Jefferson City Formation of Missouri (Branson & Mehl 1933a), El Paso Group of west Texas (Repetski 1982) and upper Fillmore Formation in Utah (Ethington & Clark 1981).

It is found only in the upper Catoche Formation of the Daniel's Harbour area, first appearing high in Assemblage III and continuing to lowest Assemblage IV.

Material.- 32 specimens: 5 cordylodontiform (a), 8 cladognathodontiform (b), 9 trichonodelliform (c), 6 distacodontiform (d) and 4 oulodontiform (?f) elements.

Repository.- GSC 93180-84.

OISTODUS MULTICORRUGATUS Harris, 1962
Pl. 6, figs. 6,10-11.

Oistodus multicorrugatus Harris. ETHINGTON & CLARK, 1981, pp. 68-70, Pl. 7, figs. 9,10,12-14,17, Text-fig. 17 (with synonomy to 1978).
Oistodus scalenocarinatus Mound. COOPER, 1981, p. 172, Pl. 26, figs. 9,12,13,15.

Remarks.- Very few specimens of this species were recovered. They include oulodontiform elements, indicating that this species is probably congeneric with O. bransoni.

Occurrence.- Apparently restricted to late Arenig and Llanvirn age (Barnes 1977), Oistodus multicorrugatus is known from the middle and upper Joins Formation (Mound 1965b) and upper West Spring Creek Formation of Oklahoma (Ethington & Clark 1981), Lévis Formation of Quebec (Uyeno & Barnes 1970), Ship Point (Barnes 1974, 1977) Formation of the Canadian Arctic, the Broken Skull Formation of western Canada (Tipnis et al. 1978), and from the Fort Peña Formation (Bradshaw 1969) and Simpson Group equivalents (Ethington & Clark 1981) of Texas.

It has been found approximately 20-25 m below the base of the Table Head Group (middle Aguathuna Formation, uppermost Assemblage V) at Table Point, and uppermost Aguathuna Formation at Aguathuna, Port au Port Peninsula.

Material.- 7 specimens: 1 cordylodontiform (a), 2 cladognathodontiform (b), 2 trichonodelliform (c) and 2 oulodontiform (?f) elements.

Repository.- GSC 93185-87.

Genus **ONEOTODUS** Lindstrom, 1955

Type species.- Distacodus? simplex Furnish, 1938.

ONEOTODUS COSTATUS Ethington and Brand, 1981
Pl. 6, figs. 9-10.

Oneotodus costatus ETHINGTON AND BRAND, 1981, p. 242, Text-fig. 1-B,D,G,H, Text-fig. 2-A,D-M. (Contains complete synonomy up to 1981); STOUGE, 1982, p. 41, Pl. 2, figs. 18,19,25.
aff. Oneotodus simplex (Furnish). ETHINGTON AND CLARK, 1981, pp. 73-74, Pl. 8, fig. 7.

Remarks.- Ethington and Brand (1981), in a revision of Oneotodus Lindström, separated O. costatus from the morphologically similar O. simplex (Furnish) on the basis of its deeper basal cavity and costate cusp. Considering the costae to be amplification and continued development of striate microstructure of the cusp of O. simplex, they retained their new species within Oneotodus. Furthermore, O. costatus appears to replace O. simplex stratigraphically (Ethington and Brand 1981).

Specimens are rarely found in even moderate abundance within the one sample; most commonly only one or two individual elements co-occur. Thus the apparatus of this species has been previously unknown. Ethington and Brand (1981) noted an incomplete curvature symmetry transition (p. 242) and suggested that a multicostate element and an element bearing few costae should be included within the apparatus

(p. 244).

Several samples from the St. George Group contain a significant number of O. costatus elements. Specimens from the Boat Harbour and Catoche formations of western Newfoundland conform entirely with descriptions of Ethington and Brand (1981). Elements may be suberect, erect or proclined. Aboral outline is commonly ovate to ellipsoidal; costae are more widely separated towards anterior of the cusp, whereas posterior face commonly bears closely crowded ridges. Costae may be symmetrically or asymmetrically arranged. Elements are mildly laterally compressed; no anteroposteriorly compressed elements are known. The apparatus may be Type 1B of Barnes et al. (1979), but is as yet unresolved.

Occurrence.- Apparently restricted to middle and upper Canadian strata of North America, O. costatus is present in the El Paso Group (Ethington and Clark 1964), Marathon and Ellenberger formations (Ethington 1979) of Texas; the Cool Creek (Mound 1968), Kindblade and Spring Creek of southern Oklahoma (Ethington and Brand 1981); Fillmore Formation of western Utah (Ethington and Calrk 1981); Knox Group in southern Kentucky (Ethington and Brand 1981); the Jefferson City Formation of central Missouri (Mehl and Ryan 1944). In Canada, it is known from the Eleanor River Formation (Nowlan 1976) and Baumann Fiord Formation (Barnes 1974) of Arctic Canada.

In the Daniel's Harbour area, *Oneotodus costatus* is first found in lower middle Catoche Formation, reaches peak abundance by upper Catoche and lower Aguathuna, and continues as a minor component of Assemblage IV to lower Assemblage VI. It is also found in uppermost Catoche, but not Aguathuna, of Back Arm Bay; uppermost Catoche, Costa Bay Member and Aguathuna Formation of Port au Port Peninsula; and lower strata of upper Aguathuna Formation of Hare Bay.

Material.- 168 specimens.

Repository.- GSC 93188-89.

Genus **PALTODUS** Pander, 1856
emended Lindström, 1971

Type species.- P. subaequalis Pander, 1856.

PALTODUS SWEETI Serpagli, 1974
Pl. 6, figs. 11-12.

Scandodus sp. HÜNICKEN & GALLINO, 1970, Pl. 1, fig. 2; HÜNICKEN, 1971, p. 46, Pl. 1, figs. 11a-13, Pl. 3, figs. 16-18.
Paltodus sp. B. ETHINGTON & CLARK, 1971, pp. 67,73, Pl. 2, fig. 13.
"Paltodus"? sweeti. SERPAGLI, 1974, pp. 58-59, Pl. 14, figs. 13a-14b, Pl. 24, figs. 8-10, Text-fig. 12; REPETSKI, 1982, p. 38, Pl. 15, fig. 8.
"Scandodus" robustus. SERPAGLI, 1974, p. 85, Pl. 18, figs. 3a-4d, Pl. 28, figs. 12,13; ETHINGTON, 1979, p. 2, Text-fig. 2; ETHINGTON & CLARK, 1981, p.94, Pl. 10, figs. 25-27.
? Drepanodus aff. D. sp. 3 of Serpagli (1974) s.f. REPETSKI, 1982, p. 22, Pl. 7, fig. 3.
Acodus sp. cf. A. deltatus Lindström (in part). STOUGE, 1982, p. 34, Pl. 3, fig. 8 only; STOUGE & BOYCE, 1983, p. 26, Pl. 2, fig. 10 only.

Remarks.- The association of "Scandodus" robustus Serpagli s.f. and a basally costate variant noted by Ethington & Clark (1981, p. 94) is also found in studied material. In both collections the costate element is comparatively rare, and the inner flare of the acostate element varies from a gentle swelling to a ridge-like prominence.

The anticusp-like anterobasal region varies both in length and degree of flexure. In general, anterobasal projection of smaller and less robust elements are shorter and less twisted than those of the more robust elements, although such differences may be seen between individuals of similar size.

Costate element always bears a shorter and less flexed anticusp than acostate elements of comparable size. Elements of "Paltodus" sweeti s.f. are members of the same apparatus, as suggested by Ethington & Clark (1981, p. 94). This view is reinforced by their common co-occurrence in this and previous studies.

Apparatus is Type IB. Acostate elements, with base extending about as far anteriorly as posteriorly, and angular posterobasal intersection are herein considered oistodontiform elements. Costate elements are then considered to be modified drepanodontiform elements.

Occurrence.- This species is currently known from lower San Juan Formation of Precordilleran Argentina (Serpagli 1974), and upper Wah Wah and Juab limestones of the Pogonip Group in Utah (Ethington & Clark 1981), and is also found in the El Paso Group of west Texas (Repetski 1982).

It occurs in assemblages I to III, ranging from lower to upper Catoche Formation of the Daniel's Harbour area. It is also known from lower to middle Catoche of Port au Choix Peninsula, and lower middle Aguathuna east of The Gravels.

Material.- 83 specimens: 9 drepanodontiform (p), 34 modified drepanodontiform (p') and 40 "oistodontiform" (q) elements.

Repository.- GSC 93190-91.

Genus **PARACORDYLODUS** Lindström, 1955

Type species.- Paracordylodus gracilis Lindström, 1955.

PARACORDYLODUS GRACILIS Lindström, 1955
Pl. 6, figs. 13-14.

Paracordylodus gracilis Lindström. LÖFGREN, 1978, pp. 67-68, Pl. 9, figs. 15,16 (with synonomy to 1976); REPETSKI, 1982, p. 38, Pl. 15, figs. 3,5,7.

Remarks.- Only five specimens were found. They are associated with taxa normally found stratigraphically higher than Paracordylodus gracilis in Baltic and El Paso sequences. They are likely therefore to be reworked, although surface morphology is not appreciably abraded.

Occurrence.- Repetski (1982) and Löfgren (1978) summarise occurrence of this species in strata of early Arenig or slightly later age of Sweden, Norway, Southern Uplands of Scotland, Hamburg Klippe of eastern Pennsylvania, South Catcher Pond in Newfoundland, Mystic Formation of Quebec, eastern New York State, Ninemile Formation of Nevada, low in El Paso Group of western Texas, Ouachita Mountains of Oklahoma, San Juan Formation of Argentina and the Emanuel Formation of Western Australia.

Specimens found were all from middle Catoche Formation (assemblages II and III) at Daniel's Harbour mine and Port au Choix.

Material.- 5 specimens: 2 paracordylodontiform (*b*,*c*) , 1 oistodontiform (*e*) and 2 cyrtoniodontiform (*f*) elements.

Repository.- GSC 93192-93.

Genus **PARAPANDERODUS** Stouge, 1984

Type species.- Parapanderodus arcuatus Stouge, 1984.

Remarks.- Hyaline posteriorly grooved distacontids are found throughout the studied section. In most samples, Parapanderodus striatus (Graves & Ellison), Parapanderodus elegans Stouge and Parapanderodus sp. aff. P. triangularis (Ethington & Clark) co-occur. Although remaining within the specific diagnoses as currently understood, variability within these species is marked and appears to be related to stratigraphic position: similar variations are restricted to the same stratigraphic intervals.

Examination of samples containing the type species determined three element types, corresponding with the above three species. Stouge's (1984, p. 66) description of P. arcuatus included elements analogous with P. triangularis (his element type 2) and element type 1, which is comparable with either Drepanodus striatus Graves & Ellison s.f. or Parapanderodus elegans.

It is therefore proposed that Parapanderodus had a modified Type IB apparatus, with an s' morphotype distinguished by longer base than that of the other elements. Short based s element is comparable with P. striatus, the t element is triangulariform and the long based s' element is comparable with P. elegans. Weakly developed symmetry transitions mentioned by Stouge (1984) are within the bounds of intraspecific variability. Species may be hyaline or albid.

PARAPANDERODUS ABEMARGINATUS n.sp.
Pl. 6, figs. 15-16; Text-fig. 5:2:30-31.

Asymmetrical element
Scolopodus emarginatus Barnes & Tuke s.f. REPETSKI, 1982, p. 47, Pl. 22, fig. 3.

Derivation of name.- From Latin. *ab*- meaning from, in the sense of this species being derived from "*Scolopodus*" *emarginatus* Barnes & Tuke s.f.

Diagnosis.- A species of *Parapanderodus* with shallow basal cavity, and low, rounded striae, frequently not visible using light microscope; *t* element has deep, wide groove along posterior margin.

Description.- Both elements have subcircular, proclined cusp. Cusp and base striate over entire surface; base unexpanded, so outlines of element taper evenly from aboral margin to tip. Basal cavity shallow, posterior margin concave towards cavity, anterior margin brief and convex toward cavity; tip anteriorly directed, situated anterior of element midline. Aboral margin subcircular. Both elements hyaline, with growth axis extending from tip of basal cavity up cusp midline to tip of element.

Symmetrical (*s*) element as described above; asymmetrical (*t*) element with deep groove extending over up to posterior third of one lateral face; groove extends from aboral margin to tip of element.

Remarks.- Parapanderodus abemarginatus differs from "S." emarginatus s.f. in the diminution of striae, and basal cavity morphology. Of reported occurrences of "S." emarginatus s.f., that figured from El Paso Group (Repetski 1982) is of P. abemarginatus and that of the Pogonip Group is most likely to be "S." emarginatus s.f. Other occurrences are difficult to evaluate, but appear also to belong to this latter species.

Occurrence.- Parapanderodus abemarginatus is found in the upper El Paso Group of west Texas, and in the lower to upper Aguathuna Formation (Assemblages IV to VII) of the Daniel's Harbour area; Aguathuna Formation of Back Arm Bay; middle and upper Aguathuna at Hare Bay and upper lower Aguathuna to lower Table Point formations at Port au Port Peninsula.

Material.- 30 specimens: 15 drepanodontiform (s) and 15 emarginatiform (grooved, t) elements.

Type stratum.- Base of bed of massive dolostone, 15 m beneath the base of the Table Point Formation, east of The Gravels, Port au Port Peninsula. Grid reference 736800 on Stevenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

Repository.- GSC 93194, paratype; 93195, holotype.

PARAPANDERODUS AEQUALIS n.sp.
Pl. 6, figs. 17-19; Text-figs. 5:2:28,33,35.

Scolopodus gracilis Ethington & Clark. BARNES & POPLAWSKI, 1973, pp. 786-787, Pl. 3, fig. ?8; FÅHRAEUS & NOWLAN, 1978, p.468, Pl. 1, figs. 10,11.
Scolopodus? aff. gracilis (Ethington & Clark). LÖFGREN, 1978, p. 110, Pl. 8, figs. 10A-B.
"Scolopodus" gracilis Ethington & Clark s.f. STOUGE, 1982, p. 42, Pl. 5, figs. 10,11.

Derivation of name.- A reference to the equal faces of triangulariform elements.

Diagnosis.- A species of Parapanderodus with very shallow but broad basal cavity; triangulariform element laterally compressed with inner and outer lateral faces of approximately equal width.

Description.- All elements similar to those of P. striatus, with proclined, striate, slowly tapering, subcircular to slightly laterally compressed cusp, and unexpanded base; posterior furrow on all elements; striae do not extend to aboral margin of element; basal cavity shallow and lateral faces of all elements broad. White matter restricted to narrow growth axis.

Short based (s) element has straight posterior and anterior outlines on cusp; base occupies one-tenth to one-eighth height of element; basal cavity with anterior margin curved, so that distal half is not parallel to anterior margin of cusp; posterior margin of basal cavity sinuous; tip at anterior margin, anteriorly directed.

Long based (s') element as short-based element except that tip to basal cavity is at approximately one quarter cusp height.

Triangulariform (t) element similar, but lateral furrow is shallow and asymmetrically positioned; cusp is proclined to suberect.

Remarks.- *Parapanderodus aequalis* n.sp. is distinguished from *P. arcuatus* and *P. striolatus* by lack of anterior keel, and from *P. striatus* by markedly shallower basal cavity and broader elements relative to height.

Some of the forms figured by Barnes and Poplawski (1973) may belong with *P. aequalis* rather than *P. striatus*.

Occurrence.- Only known at present from late Arenig to early Llanvirn of Jämtland and Öland (Löfgren 1978), possibly the Mystic Formation of Quebec (Barnes & Poplawski 1973). In western Newfoundland, *P. aequalis* is found in the Cow Head Group (Bed 13?, Fåhraeus & Nowlan 1978) and uppermost Catoche Formation (upper Assemblage III and early Assemblage IV) of the Daniel's Harbour region. It also occurs from just below the Costa Bay Member to low in the Aguathuna Formation on Port au Port Peninsula.

Material.- 36 specimens: 10 short based (s); 21 long based (s') ; and 5 triangulariform (t) elements.

Type stratum.- The base of the burrowed, massive sucrosic dolostone bed 4 m beneath the base of the Aguathuna Formation exposed in Freshwater Cove; grid reference 623797 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

Repository.- GSC 93196-98.

PARAPANDERODUS STRIATUS (Graves & Ellison)
Pl. 6, figs. 23-25; Text-figs. 5:2:29,32,36.

Drepanodus striatus GRAVES & ELLISON, 1941, p. 11, Pl. 1, figs. 3,12.
Scolopodus gracilis ETHINGTON & CLARK, 1964, p. 699, Pl. 115, figs. 2-4,8,9; ETHINGTON & CLARK, 1965, p. 200; BARNES & TUKE, 1970, p. 92, Pl. 18, figs. 11,12, Text-fig. 6E; ETHINGTON & CLARK, 1971, p. 76, Pl. 2, figs. 3,9; BARNES & POPLAWSKI, 1973, pp. 786-787, Pl. 3, figs. 6,6a,7,7a,8,8a, Text-figs. 2G,H; BARNES, 1974, pp. 227-228, Pl. 1, fig. 2; REPETSKI & ETHINGTON, 1977, p. 96; AN, 1981, p. 222, Pl. 3, fig. 6.
non Scolopodus gracilis Ethington & Clark. BARNES, 1977, p. 99, Pl. 1, figs. 14,15 (this is albid).
"Scolopodus" gracilis Ethington & Clark. MAYR, UYENO, TIPNIS & BARNES, 1980, Pl. 32.1, fig. 2; ETHINGTON & CLARK, 1981, pp. 100-101, Pl. 11, fig. 28 only; STOUGE, 1982, p. 43, Pl. 2, figs. 12,13,; STOUGE & BOYCE, 1983, p. 28, Pl. 3, figs. 8,9.
Scolopodus triangularis ETHINGTON & CLARK, 1964, p. 700, Pl. 115, figs. 6,11,13,17; text-fig. 21; ETHINGTON & CLARK, 1965, p. 201; ABAIMOVA, 1975, pp. 104-105, Pl. 9, fig. 16; REPETSKI & ETHINGTON, 1977, p. 96.

Emended diagnosis.- A hyaline species of Parapanderodus bearing a deep basal cavity with anterior margin close to and paralleling anterior margin of element; anterolateral groove of triangulariform element is broad and shallow.

Description.- All elements proclined, distally straight with evenly curved, unexpanded base; posterior margin grooved; anterior margin rounded; entire cusp striate; base with nonstriate rim at aboral margin; basal cavity conical, occupies much of base up to level of greatest curvature.

Short-based (s) element has tip of basal cavity at anterior margin; element wider and more laterally compressed than other elements; cusp cross-section and aboral opening ovate; base occupies approximately one-fifth height of element.

Triangulariform (t) element has plano-convex cusp; posterior groove laterally displaced so that flattened lateral face is narrower than convex face; anterior edge may be displaced laterally towards planar face; broad, wide furrow may be developed between anterior edge and posterior region. Aboral opening subcircular.

Long based (s') element as s element, with tip of basal cavity at one third length of element; cusp cross section round with notch posteriorly; aboral opening circular.

Remarks.- Although similar to *P. arcuatus*, *P. striatus* is distinguished from this latter species by weaker development of costae, straight aboral outline, and completely hyaline elements. Anterior margin is not keeled in any of *P. striatus* elements, whereas all elements of *P. arcuatus* are strongly keeled.

Following Ethington and Clark (1981, p. 101), the correct name for this apparatus is *Parapanderodus striatus* (Graves & Ellison) since this species is removed from *Scolopodus* Pander, and the specific name is no longer preoccupied.

Occurrence.- Found primarily in the Lower Ordovician

Midcontinent Province, *Parapanderodus striatus* has also been reported from Siberia (Abaimova 1975). An (1981) noted its occurrence in the late Arenig Xiaotan Formation of Anhui Province, China. Within the North American continent, *P. striatus* is known from the Marathon Formation of the Marathon Basin (Graves & Ellison 1941), the El Paso Formation (Ethington & Clark 1964) of western Texas, "Lukfata" Formation of western Ouachita Mountains (Repetski & Ethington 1977), Fillmore Formation in Utah (Ethington & Clark 1981), the St. George Group (Barnes & Tuke 1970, Stouge 1982), Mystic Formation of eastern Canada (Barnes & Poplawski 1973), Baumann Fiord Formation and equivalents of the Canadian Arctic (Barnes 1974, 1977, Mayr *et al*. 1980).

In the Daniel's Harbour area, it is found in the lower Catoche Formation up to within uppermost few metres of the Catoche formations (assemblages I to III), and is also known from equivalent strata on Port au Port Peninsula.

Material.- 51 specimens, comprising 22 (*s*) short based, 15 long based (*s'*) and 14 triangulariform (*t*) elements.

Repository.- GSC 93199-201.

PARAPANDERODUS STRIOLATUS (Harris & Harris)
Pl. 6, figs. 23-25; Text-figs. 5:2:27,34,37.

Scolopodus striolatus. HARRIS & HARRIS, 1965, pp. 38-39, Pl. 1, figs. 6a-d.
Scolopodus filosus Ethington & Clark. MOUND, 1965b, p.

34, Pl. 4, figs. 27,32.
Scolopodus quadraplicatus Branson & Mehl. MOUND, 1965b, p. 34, Pl. 4, figs. 26,30.
Scolopodus cf. *S. quadraplicatus* Branson & Mehl. BRADSHAW, 1969, p. 1163, Pl. 132, figs. 8,9, Text-fig. 4E,F.
Scolopodus gracilis Ethington & Clark. UYENO & BARNES, 1970, p. 116, Pl. 22, figs. 9,10; WORKUM, BOLTON & BARNES, 1976, Pl. 4, fig. 6; REPETSKI, 1982, p. 48, Pl. 22, figs. 5, 8-11.
"*Scolopodus*" sp. BERGSTRÖM, 1979a, pp. 302-303, Pl. 4, figs. B,D.
"*Scolopodus*" *gracilis* Ethington & Clark. ETHINGTON & CLARK, 1981, pp. 100-101, Pl. 11, fig. 27 only.
Parapanderodus cf. *consmilis* (Moskalenko). STOUGE, 1984, p. 66, Pl. 9, figs. 16-19.
Parapanderodus elegans. STOUGE, 1984, pp. 66-67, Pl. 9, figs. 20-27.
Parapanderodus striatus (Graves & Ellison). STOUGE, 1984, p. 67, Pl. 10, fig. 1-3
Parapanderodus aff. *triangularis* (Ethington & Clark). STOUGE, 1984, pp. 67-68, Pl. 10, fig. 4.

Remarks.- Although elements of this apparatus may possess some characteristics of *Scolopodus triangularis*, this latter species is distinct and part of the apparatus of *P. striatus*. *Scolopodus striolatus* Harris & Harris is the first published species name for an element of the present apparatus.

Stouge (1984, p. 67) described short- and long-based elements of this species as *P.* cf. *consmilis* (Moskalenko), and the triangulariform element as *P.*? aff. *triangularis*. They are united in basal cavity morphology, with convex (towards cavity) anterior margin, leaving a ledge or keel on anterobasal region. All three elements are laterally furrowed, although extent differs with element type: short based (*s*) elements are plano-convex with only shallow, broad furrow; long based (*s'*) elements has broad, shallow groove on cusp; triangulariform (*t*) elements have a deep groove on one lateral face and a broad, shallow trough on the opposing lateral face.

Furrow and groove development and an anterior keel extending to the base distinguish *P. striolatus* and *P. arcuatus* from other species of *Parapanderodus*. These latter two species are distinguished most easily by white matter content: *P. striolatus* is hyaline, with a narrow growth axis; *P. arcuatus* is totally albid. *P. arcuatus* elements are also considerably more laterally compressed than corresponding elements of *P. striolatus*.

Occurrence.- *Parapanderodus striolatus* is known from the West Spring Creek Formation of Oklahoma (Harris & Harris 1965). It has been illustrated from the Pogonip Group of Utah (Ethington & Clark 1981), Fort Peña Formation (Bradshaw 1969) and El Paso Group of Texas (Repetski 1982), Joins Formation of Oklahoma (Mound 1965b), Lévis Formation of Quebec (Uyeno & Barnes 1970), early Middle Ordovician of Akpatok Island, Canadian Arctic (Workum *et al*. 1976) and Hølonda Limestone of the Norwegian Caledonides (Bergström 1979a).

It has been found in the lower middle to upper Aguathuna Formation (Assemblages IV to VII) of the Daniel's Harbour region; most of Aguathuna Formation at Hare Bay and Back Arm Bay; middle Aguathuna Formation to low in Table Point Formation of the Port au Port Peninsula.

Material.- 55 specimens: 18 short based (*s*); 21 long based (*s*') and 16 triangulariform (*t*) elements.

Repository.- GSC 93202-04.

Genus **PARAPRIONIODUS** Ethington & Clark, 1981

Type species.- Tetraprioniodus costatus Mound, 1965b.

Remarks.- The apparatus of this genus is Type IVD of Barnes et al. (1979).

PARAPRIONIODUS COSTATUS Ethington & Clark, 1981
Pl. 6, figs. 26-30.

Paraprioniodus costatus (Mound). ETHINGTON & CLARK, 1981, pp. 77-79, Pl. 8, figs. 20-26 (with synonomy to 1979).
Eoneoprioniodus? sp. 1. STOUGE, 1984, p. 78-79, Pl. 15, figs. ?7,8-10,?11,12,?13.
Eoneoprioniodus? sp. 2. STOUGE, 1984, p. 79, Pl. 15, figs. 14,17-20.

Remarks.- Although P. costatus is present in most upper Aguathuna Formation samples of the Daniel's Harbour region, it occurs in insufficent abundance to reconstruct this species apparatus with certainty. It is probable that the b position is occupied by a zygognathodontiform element of similar morphology to other first symmetry transition elements.

Occurrence.- Paraprioniodus costatus has not been found outside North America. It is recorded from the upper half of the Joins Formation of southern Oklahoma (Mound 1965b), the Everton Formation of northern Arkansas, equivalents of the Simpson Group in the Beach Mountains of west Texas, the middle Lehman Formation to low in the Watson Ranch Quartzite of Utah (Ethington & Clark 1981), upper Antelope Valley Limestone in central Nevada (Harris *et al*. 1979) and the Sunblood Formation of the southern District of Franklin, Canada (Tipnis *et al*. 1978). It is restricted to Fauna 4 of Sweet *et al*. (1971).

First appearing, in Daniel's Harbour region, in the highest beds of the Aguathuna Formation (Assemblage VII), this species ranges into the Table Head Group (Stouge 1984). It is found in uppermost Aguathuna Formation of Back Arm Bay and Hare Bay, but does not appear before lower Table Point Formation on Port au Port Peninsula.

Material.- 35 specimens: 4 cordylodontiform (*a*); 7 zygognathodontiform (*b*); 2 trichonodontiform (*c*); 4 tetraprioniodontiform (*d*); 7 cyrtioniodontiform (*e*); 5 extended prioniodontiform (*f*) and 6 pendant prioniodontiform (*g*) elements.

Repository.- GSC 93205-09.

Genus **PAROISTODUS** Lindström, 1971

Type species.- *Oistodus parallelus* Pander, 1856.

PAROISTODUS PARALLELUS (Pander, 1856)
Pl. 7, figs. 1-5.

Paroistodus parallelus (Pander). LÖFGREN, 1978, pp. 68-69, Pl. 1, figs. 18-21 (with synonomy to 1978); BEDNARCZYK, 1979, p. 431, Pl. 5, figs. 3,8-9,11; AN, 1981, p. 214, Pl. 3, fig. 20; ETHINGTON & CLARK, 1981, p. 79, Pl. 9, fig. 1; STOUGE, 1982, Pl. 6, figs. 5-8.
Distacodus expansus (Graves & Ellison) s.f. REPETSKI, 1982, p. 19, Pl. 6, fig. 2.
Oistodus cf. *O. parallelus* Pander s.f. REPETSKI, 1982, p. 35, Pl. 13, fig. 5.

Remarks.- While the apparatus of this species has been considered to be composed basically of oistodontiform and drepanodontiform elements (Lindström 1971, Löfgren 1978, Stouge 1984), material in this collection shows a variation within drepanodontiform elements. A "modified drepanodontiform" element with twisted cusp and outwardly flared base is included in the apparatus (van Wamel 1974, Löfgren 1978, Stouge 1984). Costae on drepanodontiform elements may be reduced or prominent (Kohut 1972, Landing 1976). Elements previously described as *Acodus expansus* and *Distacodus expansus* by Graves & Ellison (1941) undoubtedly belong in the apparatus. St. George Group samples contain these forms in moderate abundance and consistent association. A combination of acostate (albeit carinate) drepanodontiform, acodontiform, distacodontiform, oistodontiform and "modified drepanodontiform" elements conform with the Type IVE apparatus of Barnes et al. (1979). It is likely that such an apparatus is more appropriate to Paroistodus parallelus.

Occurrence.- Paroistodus parallelus is known from early to early middle Arenig strata of Europe, North America and Canada, and Australia. Löfgren (1978) and Ethington & Clark (1981) documented the previously reported localites. It is also now known from the Dawan Formation (early to middle Arenig) of South China (An 1981), the Lower Ordovician of the Leba Elevation, Poland (Bednarczyk 1979)

In western Newfoundland, it occurs in the Cow Head Group, and from lower to middle Catoche Formation of the St. George Group (assemblages I to III) near Daniel's Harbour, uppermost Catoche of Back Arm Bay; and possibly the middle Aguathuna Formation of the Port au Port Peninsula.

Material.- 179 specimens: 41 acostate drepanodontiform (a); 40 acodontiform (b); 45 distacodontiform (c); 47 oistodontiform (e) and 6 "modified drepanodontiform" (f) elements.

Repository.- GSC 93210-14.

Genus **PRIONIODUS** Pander, 1856

Type species.- *Prioniodus elegans* Pander, 1856.

?PRIONIODUS ELEGANS Pander, 1856
sensu van Wamel, 1974.
Pl. 7, figs. 8-10.

Prioniodus elegans Pander. VAN WAMEL, 1974, pp. 87-89, Pl. 6, figs. 1-6; LÖFGREN, 1978, pp. 78-79, Pl. 9, figs. 1-6 (with synonomy to 1977).

Remarks.- Although no falodontiform elements of *P. elegans* were found, specimens from middle Catoche Formation are similar to first symmetry transition of *Prioniodus elegans* figured by van Wamel (1974, Pl. 6, figs. 3,4).

These specimens are important, enabling correlation with Baltic sequences and sequences with conodonts of North Atlantic Province affinities (e.g. Cow Head Group of western Newfoundland).

Occurrence.- Known from beds of Billingian (early middle Arenig) age in Sweden, Estonia, the Leningrad area, Southern Uplands of Scotland, South Catcher Pond in central Newfoundland, Hamburg Klippe in Pennsylvania, Cow Head Group of western Newfoundland, Canning Basin of Western Australia (Löfgren 1978), it has also been reported from Poland, the Middle Taurus in Turkey and the Ninemile Formation of central Nevada (Löfgren 1978).

Prioniodus elegans was found in the medial and upper Catoche Formation (assemblages III and IV) of the Daniel's Harbour area and Port au Choix Peninsula.

Material.- 5 specimens: ?1 cordylodontiform (a); 1 gothodontiform (b) and 3 tetraprioniodontiform (d).

Repository.- GSC 93217-19.

Genus **PROTOPANDERODUS** Lindström, 1971

Type species.- Acontiodus rectus Lindström, 1955.

PROTOPANDERODUS GRADATUS Serpagli, 1974
Pl. 7, figs. 11-13.

Protopanderodus gradatus. SERPAGLI, 1974, pp. 75-77, Pl. 15, figs. 5a-8b, Pl. 26, figs. 11-15, Pl. 30, figs. 1a, 1b, Text-fig. 17 (synonomy to 1970); LANDING, 1976, p. 639, Pl. 4, figs. 8,9,11,12; ETHINGTON & CLARK, 1981, pp. 84-85, Pl. 9, figs. 16,17,20,21; REPETSKI, 1982, p. 39, Pl. 17, figs. 1-5; ? LANDING & LUDVIGSEN, 1984, Pl 1, fig. 7.

Remarks.- In keeping with observations of Ethington and Clark (1981, p. 84), unicostate elements may or may not be twisted. Consequently, scandodontiform elements are also herein considered to be part of the symmetry transition of Protopanderodus gradatus.

Occurrence.- Ethington and Clark (1981, p. 84) list occurrences of this species in North America. These include upper El Paso Formation of Texas, Columbia Ice Fields section of Alberta, upper West Spring Creek Formation of southern Oklahoma, upper Fillmore, Wah Wah, Juab and Kanosh formations of Utah, and the Marathon Limestone of Texas. It has been reported from the Arenig of the Taconic Allochthon of eastern New York (Landing 1976). Protopanderodus gradatus may also be present in middle Arenig strata of Quebec (Landing & Ludvigsen 1984), the Durness Limestone of Scotland (Higgins

1967) and Dumugol Schicten of Korea (Lee 1970).

Protopanderodus gradatus is found in middle strata of the Catoche Formation (assemblages I and II) near Daniel's Harbour and on Port au Choix Peninsula.

Material.- 30 specimens: 6 scandodontiform (*a*); 15 paltodontiform (*b*) and 9 acontiodontiform (*c*) elements.

Repository.- GSC 93220-22..

PROTOPANDERODUS STRIGATUS Barnes & Poplawski, 1973
Pl. 7, figs. 16,23-24.

Protopanderodus strigatus. BARNES & POPLAWSKI, 1973, p. 784, Pl. 3, figs. 14,17, Text-fig. 2E (synonomy to 1970); STOUGE, 1984, pp. 50-51. Pl. 2, figs. 15-16,18-24.

Remarks.- The few specimens found in the Aguathuna Formation were restricted to one, extremely abundant, sample. Scandodontiform elements described by Stouge (1984, p. 50) co-occur in this particular sample with acontiodontiform and paltodontiform elements described from the Mystic Formation of Quebec by Barnes and Poplawski (1973).

Costae of acontiodontiform elements are similar to those of elements of *Walliserodus ethingtoni* (Fåhraeus) in their higher concentration of white matter than that of cusp. There are, however, no coeval multicostate elements of *W. ethingtoni*, and such a similarity is probably fortuitious.

Occurrence.- At present, *Protopanderodus strigatus* is known from the Mystic Formation of Quebec (Barnes & Poplawski 1973), and Lower and lower Middle Table Head Group (Stouge 1984). Its lower limit in autochthonous western Newfoundland sequence is upper Aguathuna Formation (Assemblage VII). It does not appear in uppermost Aguathuna north of Table Point, nor is it found in strata lower than Table Point Formation at other localities.

Material.- 21 specimens: 7 scandodontiform (a); 6 paltodontiform (b) and 8 acontiodontiform (c) elements.

Repository.- GSC 93223-25.

Genus **PROTOPRIONIODUS** McTavish, 1973

Type species.- *Protoprioniodus simplissimus* McTavish, 1973.

Remarks.- Following Lindström's (1971) redefinition of *Oistodus* Pander to include only hyaline elements, van Wamel (1974, p. 75) reported a variable white matter distribution and abundance within *Oistodus*. This has not been supported by subsequent studies (Löfgren 1978, Ethington & Clark, 1981). Current practise of assigning only hyaline specimens to *Oistodus* is followed herein, with albid specimens more properly described as a separate genus. *Protoprioniodus* McTavish has first transition series consisting of elements comparable with those of *Oistodus* except for their possession of white matter. Oistodontiform and prioniodontiform elements complete the apparatus.

Specimens described and figured by van Wamel (1974) as *Oelandodus* are similar to some of those of *Protoprioniodus* and as described by Cooper (1981).

?PROTOPRIONIODUS COSTATUS van Wamel, 1974
Pl. 5, figs. 23-25.

Oelandodus costatus. VAN WAMEL, 1974, pp. 72-74, Pl. 7, figs. 5-7.
Oelandodus cf. *O. costatus* van Wamel. REPETSKI, 1982, p. 29, Pl. 10, figs. 8,10,12.

Remarks.- "Elongatiform" and oistodontiform elements, indistinguishable from those described by van Wamel, are found in modest abundance through the upper Boat Harbour and Lower Catoche formations. Accompanying "triangulariform" elements are rare, and similar to oistodontiform elements of ?Microzarkodina marathonensis.

"Oelandodus" costatus van Wamel has trichonodelliform (c; van Wamel 1974, Pl. 7, figs. 6a,b), oistodontiform (e; ibid, Pl. 7, figs. 7a,b) and possibly a prioniodontiform (f; ibid, Pl. 7, figs. 5a,b) element. This is therefore probably a species of Protoprioniodus, although its low oral keel and reduced inner lateral flare of the prioniodontiform element is unusual in species of this genus (e.g. Cooper 1981, pp. 174-176).

Elements of ?Protoprioniodus costatus are distinguished from those of "Oelandodus" elongatus van Wamel by differences in degree of lateral compression. Base morphology and size preclude conspecificity: in particular, O. costatus has a prominent basal ledge on all elements; this is missing from all elements of "O". elongatus.

Occurrence.- At present, specimens of ?Protoprioniodus costatus are known only from the Lower Ordovician of Sweden (van Wamel 1974), the El Paso Group of Texas (Repetski 1982) and lower to middle Catoche Formation (Assemblage I and lower Assemblage II) of western Newfoundland.

Material.- 26 specimens: 6 triangulariform (c); 13 oistodontiform (e); and 7 elongatiform (f) elements .

Repository.- GSC 93226-28.

?PROTOPRIONIODUS PAPILOSUS (van Wamel, 1974)
Pl. 7, figs. 18-20.

Oistodus papilosus. VAN WAMEL, 1974, pp. 76-77, Pl. 1, figs. 18-20.
Gen. nov. B n. sp. 1 SERPAGLI, 1974, p. 93, Pl. 19, figs. 4a,b, Pl. 29, figs. 4,5, Text-fig. 26.
Protoprioniodus papilosus (van Wamel). ETHINGTON & CLARK, 1981, pp. 87-88, Pl. 10, fig. 5.

Remarks.- Triangulariform elements of Oistodus papilosus occur rarely and in isolation. They have the basal ridge, general morphology and white matter distribution of better known species of Protoprioniodus, and have therefore been assigned to this latter genus. Ethington and Clark (1981, p. 88) suggested that such elements may be rare variants of ramiform elements of Protoprioniodus aranda Cooper, but these two species have separate ranges in Newfoundland.

Occurrence.- ?Protoprioniodus papilosus occurs in the Lower Ordovician of Sweden (Van Wamel 1974), Precordilleran Argentina (San Juan Formation, Serpagli 1974), southern Oklahoma (Kindblade Formation) and the Ibex Area, Utah (Wah Wah and Juab limestones, Ethington & Clark 1981).

Its range within the St. George Group is restricted to lower Catoche formation (assemblages I and II) of the Daniel's Harbour region and Port au Choix Peninsula.

Material.- 7 specimens: 2 gothodontiform (b); 1 trichonodelliform (c); 1 tetraprioniodontiform (d) and 3 prioniodontiform (f) elements.

Repository.- GSC 93231-33.

Genus **REUTTERODUS** Serpagli, 1974

Type species.- Reutterodus andinus Serpagli, 1974.

?REUTTERODUS sp.
Pl. 7, figs. 23-24.

Reutterodus andinus Serpagli. ETHINGTON & CLARK, 1981, p. 91, Pl. 10, fig. 18 (with synonomy to 1974).
Reutterodus andinus? Serpagli. REPETSKI, 1982, p. 41, Pl. 19, figs. 2,3 only.

Remarks.- Serpagli (1974, pp. 79-81) described "cone-like", "unibranched" and "bibranched" (denticulate) elements within Reutterodus andinus. Ethington and Clark (1981) did not find denticulate elements at the same stratigraphic level as cone-like elements. Repetski (1982) could not locate bibranched elements. This indicates the "cone-like" element may be distinct from the apparatus bearing the holotype of Reutterodus andinus, although the direction of anterolateral costa and their relationship with the cusp is similar to that of denticulate elements.

Only cone-like elements were recovered from the St. George Group.

Occurrence.- This species is currently known from San Juan Formation of Argentina (Serpagli 1974), upper El Paso Group of Texas (Repetski 1982), upper Fillmore Formation and Wah Wah Limestone of Utah (Ethington & Clark 1981) and the St. George Group of Newfoundland. Near Daniel's Harbour it is only found low in the upper Aguathuna Formation (assemblages VI and VII). It is also found in lower middle Aguathuna Formation of Hare Bay, and upper middle Aguathuna Formation to low in Table Point Formation on Port au Port Peninsula.

Material.- 5 cone-like elements.

Repository.- GSC 93236-37.

Genus **ROSSODUS** Repetski & Ethington, 1983

Type species.- *R. manitouensis* Repetski & Ethington, 1983.

Remarks.- Repetski and Ethington (1983, p. 290) described *Rossodus* as an apparatus containing oistodontiform elements and a transition series of costate cones which vary from nearly symmetrical drepanodontiform elements through asymmetrical scandodontiform elements to bilaterally symmetrical acontiodontiform elements.

Landing *et al*. (1986) added suberectiform elements to the apparatus of their species of *Rossodus*, and considered quadricostate and pentacostate forms as part of the symmetry transition. The apparatus is modified Type IV, possibly IVD. Pentacostate and tricostate elements appear to co-occupy *c* position; they are designated *c* and *c'* respectively.

While *Rossodus symmetricus* n. sp. does not appear to contain a suberectiform element, pentacostate and quadricostate forms both with and without vicarious costae are included. It is probable that *Rossodus symmetricus* is descended from *Rossodus highgatensis* Landing *et al*.

ROSSODUS HIGHGATENSIS Landing, Barnes & Stevens, 1986
Pl. 7, figs. 25-27; Text-fig. 5:3:7.

Rossodus? highgatensis. LANDING, BARNES & STEVENS, 1986, pp. 1938-1940, Pl. 3, figs. 10,13-26, Text-figs. 3K,L,N-P (with synonomy to 1986).

Remarks.- A few specimens are found in only one sample. This species is an unusual representative of the genus (Landing *et al*. 1986, p. 1938). Descendent species, unquestionably *Rossodus*, indicate close affinity of these specimens with *Rossodus*.

Occurrence.- *Rossodus highgatensis* is known from upper-middle to upper Tremadoc equivalent strata of Quebec (Landing *et al*. 1986), northwestern Vermont (Landing 1983), and probably occurs in New Zealand (Cooper & Druce 1975) and northern China (Zeng *et al*. 1983, quoted in Landing *et al*. 1986).

It is found in the lower Catoche Formation (Assemblage I) of the Table Point section.

Material.- 16 specimens: 2 drepanodontiform (*a*); 1 tricostate (*c*); 1 pentacostate (*c'*); 1 trapezognathodontiform (*d*); 9 oistodontiform (*e*) and 2 scandodontiform (*f*) elements.

Repository.- GSC 93238-40.

Fig. 5:3. Outline drawings of selected conodont taxa.

Rossodus symmetricus n.sp.: 1. scandodontiform (f) element, paratype, GSC 93249, D.D.H. A1.06, X35; 2. oistodontiform (e) element, paratype, GSC 93248, BC2, X50; 3. pentacostate (c') element, paratype, GSC 93244, BC2, X50; 4. trapezognathodontiform (d), paratype, GSC 93246, D.D.H. A1.07, X50; 6. drepanodontiform (a) element, paratype, GSC 93241, BC2, X80; 8. trapezognathodontiform (d) element, paratype, GSC 93247, D.D.H. A1.05, X25; 13. acontiodontiform (c) element, paratype, GSC 93243, BC2, X50.

Scalpellodus n.sp.: all X60; 5. long based (s') element, GSC 93251, KC5; 9. short based (s) element, GSC 93250, KC5; 14. scandodontiform (t) element, GSC 93252, AGC1.

Rossodus highgatensis Landing et al.: 7. oistodontiform (e) element, GSC 93240, D.D.H. A1.11, X130.

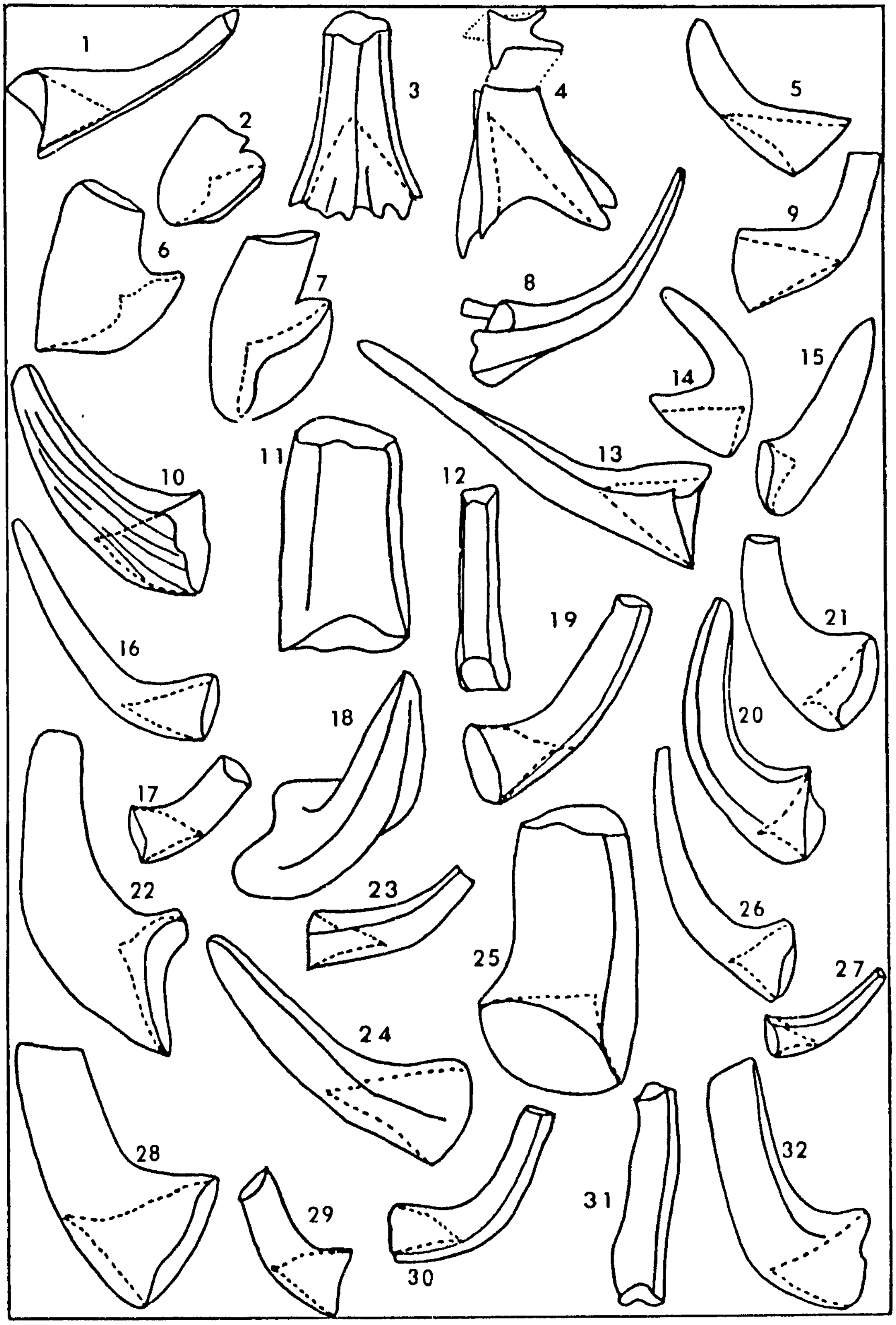
"Scolopodus" emarginatus Barnes and Tuke: 10. GSC 93259, BC1, X125.

Variabiliconus n.sp. A: 11. quadricostate (d) element, GSC 93275, BC2, X100; 18. posteriorly and anteriorly sulcate (d') element, GSC 93276, D.D.H. A1.05, X60; 22. scandodontiform (g) element, GSC 93279, D.D.H. A1.14, X60; 24. acontiodontiform (c) element, GSC 93274, D.D.H. A1.05, X50; 25. laterally unicostate (a) element, GSC 93273, BC2, X50; 28. drepanodontiform (f) element, GSC 93278, BC2, X50; 32. posteriorly sulcate (e) element, GSC 93277, BC1, X70.

Variabiliconus n.sp. B: all from KC13; 12. quadricostate (d) element, GSC 93283, X55; 17. scandodontiform (g) element, GSC 93286, X55; 19. laterally unicostate (a) element, GSC 93280, X55; 23. quadricostate (d) element, GSC 93283, X55; 27. posteriorly sulcate (e) element, GSC 93284, X55; 29. drepanodontiform (f) element, GSC 93285, X55; 30. acontiodontiform (c) element, GSC 93282, lateral, X55; 31. laterally unicostate (a) element, GSC 93280, X50.

Scandodus sinuosus Mound: all from TP13; 15. oistodontiform (e) element, GSC 93256, X70; 20. acodontiform (g) element, GSC 93258, X60; 21. scandodontiform (f) element, GSC 93257, X70; 26. drepanodontiform (a) element, GSC 93253, X40.

"Scolopodus" filosus Ethington and Clark: 16. GSC 93260, BC1, X80.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ROSSODUS SYMMETRICUS n.sp.
Pl. 7, figs. 28-33; Text-figs. 5:3:1-4,6,8,13.

Walliserodus sp. aff. W. australis Serpagli. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, p. 53, Pl. 2, figs. 27,29.
Tropodus comptus (Branson & Mehl). STOUGE, 1982, p. 45, Pl. 4, figs. 3,4,6,7 only; STOUGE & BOYCE, 1983, p. 28, Pl. 3, figs. 13,14.

Derivation of name.- Symmetricus, from Greek, a reference to the relative symmetry of multicostate elements when compared with other species of Rossodus.

Diagnosis.- A species of Rossodus with drepanodontiform, tricostate, pentacostate, trapezognathodontiform oistodontiform and scandodontiform elements. Multicostate elements may bear vicarious costae close to major costae, and are commonly almost symmetrical.

Description.- All elements robust with albid cusp above hyaline base. Cusp microstriate. Tip of basal cavity at approximate level of greatest curvature of cusp, shallow in compressed elements, of moderate depth in tri-, quadri- and pentacostate elements. All costae with steeper posterior side; anterior flanks generally gently sloping.

Drepanodontiform (a) element with erect, biconvex cusp, shallow basal cavity, wide anterior keel and sharp posterior edge. Basal cavity with anteriorly directed tip situated anterior of midline of element.

Tricostate (c) element with erect cusp, sharp lateral costae terminating in processes which extend below plane of aboral opening, and short, stubby posterior process. Anterior surface smoothly convex. Vicarious costae may be present close to lateral costae only near base of element.

Pentacostate (c') element with posterior and four lateral costae in subsymmetric arrangement. Anterior face convex. Vicarious costae possible on base, usually close to main costae.

Trapezognathodontiform (d) elements as tricostate, except all processes equal and cusp almost symmetrical. No vicarious costae on available specimens.

Oistodontiform (e) element of similar morphologyy to oistodontiforms of other spec.es of Rossodus with well defined carina on one lateral face continuing across base as lateral flare, shallow basal cavity and broad, sharp-edged cusp. Anteroaboral intersection curved to subangular, angle approximately 60 $^{\circ}$.

Scandodontiform (c) element similar, except one lateral face with sharp posterolateral costa and deep groove between costa and posterior edge. Anterior of costa gently sloping to anterior margin. Arrangement of costa with respect to posterior and anterior edges gives appearance of squashed acontiodontiform. Cusp is markedly twisted, with acontiodontiform cross-section rotated 90° near tip compared with orientation of aboral opening.

Remarks.- Rossodus symmetricus differs from previously described species of Rossodus in the unusual degree of symmetry of multicostae elements together with presence of quadri- and pentacostate elements.

Occurrence.- This species is only known from the Broken Skull Formation in southern District of Mackenzie, Canada (Tipnis *et al*. 1978) and the St. George Formation of western Newfoundland (Stouge 1982).

Rossodus symmetricus first appears in the St. George Group in lower Catoche Formation, and continues through the Catoche to lower Aguathuna formations (Assemblage II through lowest Assemblage V).

Material.- 132 specimens: 19 drepanodontiform (*a*); 28 trichonodelliform (*c*); 16 pentacostate (*c*'); 21 trapezognathodontoform (*d*); 36 oistodontiform (*e*); and 12 scandodontiform (*f*) elements.

Repository.- GSC 93241-49.

Genus **SCALPELLODUS** Dzik, 1976

Type species.- Protopanderodus latus van Wamel, 1974.

Remarks.- Cusp of elements of Protopanderodus latus van Wamel lack the grooves and costae characteristic of Protopanderodus. Hence Dzik (1976, p. 421) assigned this species to a new genus, Scalpellodus. Löfgren (1978, p. 98), however, on the basis of inconsistent elemental apparatuses of species included within Scalpellodus, emended Dzik's original diagnosis of the genus. Her interpretation is followed herein.

Apparatus may be considered as modified Type IB with long- and short-based s elements; scandodontiform is t element.

SCALPELLODUS n. sp.
Pl. 7, figs. 34-36; Text-figs. 5:3:5,9,14.

Diagnosis.- A species of Scalpellodus which has long- and short-based and scandodontiform elements; having relatively inconspicuous edges to anterior and posterior region of drepanodontiforms and wide anterior keel on much of base of scandodontiform element.

Description.- All elements striate except for narrow band around aboral margin; base height less than that of cusp; cusp with milky white matter and dark base. In lateral view, anterior margin straight to top of base, then uniformly and gently curved to tip of cusp; posterior edge evenly and gently curving to tip of cusp; aboral margin straight. Aboral opening generally oval; may be triangular and widest anteriorly, or pear-shaped; basal cavity triangular, convex towards basal cavity at anterior and concave towards cavity posteriorly, tip situated at point of greatest curvature of element, anterior of midline and commonly close to anterior margin.

Drepanodontiform (s and s') elements proclined to suberect; anterior edge may migrate laterally in plan view. Long-based (s') element with short, fine edged, oral margin; aboral opening less than twice width of cusp at maximum curvature. Anterior margin of short-based (s) element gently curved from aboral margin to top of base, then more convex to tip of cusp; aboral opening 2.5 to 3 times maximum width of cusp.

Base of scandodontiform (t) element wide (3 to 4 times cusp width), rapidly tapering to point of maximum curvature; distally cusp more gently tapering; cusp suberect; basal opening directed aborally and towards inner lateral face; blocky keel occupies anterior third to half of base; oral margin straight, thinly keeled to half base height; posterior margin a fine, rapidly curving edge.

Remarks.- Drepanodontiform elements are superficially similar to those of Cornuodus Fåhraeus, particularly in the lack of keeled anterior and posterior margins. Cornuodus, however, has a posteriorly grooved element completing the apparatus, which does not co-occur with those drepanodontiform elements described above. The more highly compressed, anteriorly keeled and slightly twisted scandodontiform element is similar to drepanodontiform elements in surface microstructure, basal cavity and cusp morphology. In spite of the moderate abundance of samples containing such elements, it is more likely that this scandodontiform be part of the apparatus containing the drepanodontiform elements than that a grooved element be missing.

This species is distinguished from those previously known by the reduction of keels in drepanodontform and scandodontiform elements. The scandodontiform element is distinctive in having a wider keel proximal to anteroaboral region than that of *S. gracilis* (Sergeeva).

Occurrence.- This species is currently only known from the St. George Group of Newfoundland. Here, it has only been found in middle and upper Catoche (assemblages III and IV) of the Daniel's Harbour region, and Port au Choix Peninsula.

Material.- 38 specimens: 8 short-based drepanodontiform (*s*), 22 long-based drepanodontiform (*s'*) and 8 scandodontiform (*t*) elements.

Repository.- GSC 93250-52.

Genus SCANDODUS Lindström, 1955

Type species.- Scandodus furnishi Lindström, 1955.

SCANDODUS SINUOSUS Mound, 1965
Pl. 8, figs. 1-6; Text-figs. 5:3:15,20-21,26.

Scandodus sinuosus Mound. ETHINGTON & CLARK, 1981, pp. 94-96, Pl. 11, figs. 1-5 (with synonomy to 1978).
Trigonodus carinatus STOUGE, 1984, p. 80, Pl. 6, figs. 1-7.

Remarks.- St. George Group material has drepanodontiform elements co-occurring with those described by Ethington and Clark (1981) as S. sinuosus. Apparatus is Type IVC, and consists of drepanodontiform (a), planoconvex (b), acontiodontiform (c), distacodontiform (d), oistodontiform (e), scandodontiform (f) and acodontiform (g) elements. All elements are characterised by reduction of keels, in most instances to mere edges. The b and d elements are distinguished by cusp cross-section rather than costae: distacodontiform element has quadrate cross-section distinct from modified triangular cross-section of b and c elements.

This species falls within the emended definition of Scandodus by Lindström (1971, p. 39) as hyaline, essentially drepanodontiform elements with symmetry transitions.

Mound (1965b, Pl.2, figs. 8,10) figured the a element as Drepanodus homocurvatus. It is robust, dark in colour, with erect to proclined cusp, short base, slowly but evenly tapering cusp. Posterior margin of cusp has sharp edge offset laterally on base and proximal portions of cusp. Anterior margin with sharp costa: at aboral margin is anterior of element, but above base costa occupies anterolateral position; anterolateral costa and posterolateral edge occupy opposite lateral faces. Base laterally compressed, moderately expanded posteriorly; basal cavity shallow, tip does not reach anterior margin nor level of maximum curvature of cusp; posterior margin of cavity straight, anterior margin convex towards cavity; tip in anterior third of element. Aboral opening ovate.

Most of remaining elements were described by Ethington and Clark (1981, pp. 95-96). Planoconvex (b) element was described by Mound (1965b) as Acodus campanula n. sp., acontiodontiform (c) element as Acontiodus curvatus n. sp., distacodontiform (d) element as Distacodus symmetricus n. sp., oistodontiform (e) element as Oistodus abundans Branson & Mehl, and scandodontiform (f) element as Scandodus sinuosus n. sp. Acodontiform (g) element as those previously described, except that inner lateral face has median edge and cusp is more laterally compressed than first symmetry transition elements.

The basic morphology of Triangulodus sp. C of Tipnis et al. (1978) is similar to elements of Scandodus sinuosus. They are distinguished, however, by the oral keel and longer base of the former. The long base is also characteristic of

Bradshaw's (1969) material which Ethington and Clark (1981, p. 95) assigned questionably to *S. sinuosus*. It is most likely that both *Triangulodus* sp. C of Tipnis *et al.* and Bradshaw's material represent different species of *Scandodus*, and are not *S. sinuosus*.

Occurrence.- *Scandodus sinuosus* occurs throughout all but lowest Joins Formation (Mound 1965b) and in the Sunblood Formation of the southern District of Mackenzie. In the St. George Group, it is found only in the upper Aguathuna Formation (Assemblage VII) of Daniel's Harbour area, Hare Bay and Port au Port Peninsula. It ranges up to 20 m into the Table Point Formation (Stouge 1984).

Material.- 648 specimens: 69 drepanodontiform (*a*); 65 plano-convex (*b*); 73 acontiodontiform (*c*), 182 distacodontiform (*d*), 31 oistodontiform (*e*), 80 scandodontiform (*f*) and 148 acodontiform (*g*) elements.

Repository.- GSC 93253-58.

Genus **SCOLOPODUS** Pander, 1856

Type species.- Scolopodus sublaevis Pander, 1856.

"SCOLOPODUS" FILOSUS Ethington & Clark, 1964
Pl. 8, fig. 8; Text-fig. 5:3:16.

"Scolopodus" filosus Ethington & Clark. ETHINGTON & CLARK, 1981, p. 100, Pl. 11, fig. 22 (With synonomy to 1978); REPETSKI, 1982, p.47, Pl. 22, fig. 2.

Remarks.- One specimen of "S." filosus from the lower Catoche Formation had an erect, rather than the more common proclined, cusp. It is possible that the apparatus of this species includes a curvature transition of proclined to erect cones.

Ethington and Clark (1981, p. 100) suggested that "S." filosus and "S." gracilis Ethington & Clark (= Parapanderodus striatus) may have been part of a common apparatus. Within specimens from the St. George Group, the basal cavity of these two forms are distinctly different. Although they co-occur, "S." filosus is most abundant in Assemblage I, in which Parapanderodus (= "S.") gracilis occurs in reduced numbers. This latter species is considerably more common within Assemblage II.

Occurrence.- "Scolopodus" filosus is known from the El Paso Formation of Texas, the Jefferson City Formation of Missouri

(Repetski 1982), the Columbia Ice Fields section in Alberta (Ethington & Clark 1965), the Cow Head Group of western Newfoundland (Fåhraeus & Nowlan 1978), and northwestern Australia (Jones 1971). It has been reported from Oklahoma (Mound 1968) and New Zealand (Cooper & Druce 1975).

It is found in the lower and middle Catoche formations of the Daniel's Harbour area (assemblages I to III). The lower limit of its range within the St. George Group is unknown.

Material.- 18 specimens: 1 erect element and 17 proclined elements.

Repository.- GSC 93260.

Genus **SEMIACONTIODUS** Miller, 1969

Type species.- Acontiodus (Semiacontiodus) nogami Miller, 1969.

SEMIACONTIODUS ASYMMETRICUS (Barnes & Poplawski, 1973)
Pl. 8, figs. 9-10.

Symmetrical (s) element
? Scolopodus paracornuformis. ETHINGTON & CLARK, 1981, p. 102, Pl. 11, fig. 21, Text-fig. 25.
? Protopanderous sp. B. TIPNIS, CHATTERTON & LUDVIGSEN, 1978, Pl. 2, figs. 5-7 only.
Asymmetrical (t) element
Paltodus sp. A. SWEET, ETHINGTON & BARNES, 1971, p. 168, Pl. 1, fig. 14.
Protopanderodus asymmetricus. BARNES & POPLAWSKI, 1973, pp. 781-782, Pl. 1, figs. 12,12a,14,16, Text-fig. 2A; ETHINGTON & CLARK, 1981, pp. 83-84, Pl. 9, figs. 11,12,14,19; REPETSKI, 1982, p. 39, Pl. 15, fig. 1.
Acontiodus iowensis Furnish. ETHINGTON & CLARK, 1964, p. 687, Pl. 113, fig. 3.
Paltodus sp. A. SWEET, ETHINGTON & BARNES, 1971, Pl. 1, fig. 14.
Multielement reconstructions
Semiacontiodus sp. cf. S. asymmetricus (Barnes & Poplawski). STOUGE & BOYCE, 1983, p. 30, Pl. 4, figs. 3,4,7.
Juanognathus asymmetricus (Barnes & Poplawski). BERGSTRÖM, 1979a, p. 303, figs. 4C,4E.
Semiacontiodus asymmetricus (Barnes & Poplawski). STOUGE, 1982, p. 54, Pl. 5, figs. 14-16; STOUGE, 1984, p. 68, Pl. 10, figs. 5-10,15.
Semiacontiodus preasymmetricus. STOUGE, 1984, pp. 68-69, Pl. 10, figs. 16-19.

Remarks.- Throughout the studied section, symmetrical elements similar to those described as Scolopodus paracornuformis Ethington & Clark and Protopanderodus sp. B Tipnis et al. coincide with occurrences of Protopanderodus asymmetricus. Similarities in surface and basal cavity morphology, and position of posterolateral faces are consistent with inclusion within the one apparatus. The apparatus plan is similar to that of Juanognathus Serpagli (Type IA of Barnes et al. 1979). These latter two genera differ primarily in length of posterolateral faces: Juanognathus has at least one face extending beyond the aboral margin. Posterolateral faces or grooves of Semiacontiodus do not extend to the aboral margin.

Intraspecific variation is marked within this long-ranging species. Criteria used by Stouge (1984) to separate S. preasymmetricus from the younger S. asymmetricus may or may not be preserved in the older specimens studied herein. Costae may be prominent or reduced; aboral margin may be subcircular to oval; and collections from low in the Catoche Formation contain rare blade-like elements. Such variation may be seen within the one population, and indicates conspecificity of S. asymmetricus and S. preasymmetricus.

Occurrence.- Semiacontiodus asymmetricus is found in abundance in the Hølonda Limestone (Whiterock) of the Norwegian Caledonides (Bergström 1979a), and is known throughout the Mystic Formation of Quebec (lower Arenig to lower Llanvirn, Barnes & Poplawski 1973), the upper El Paso Group of Texas (upper Canadian, Repetski 1982), Wah Wah Formation (upper Canadian, Sweet et al. 1971) of Utah, upper West Spring Creek Formation of Oklahoma (Potter 1975, cited in Ethington & Clark 1981)), Anomalorthis Zone of the

Antelope Valley Limestone in Nevada and the Fort Peña Formation of west Texas (Bergström 1979a). It may also occur in the Broken Skull Formation, southern District of Mackenzie, Canada (uppermost Canadian to Whiterock, Tipnis et al. 1978).

North of Table Point, this species is found low in the Catoche Formation (middle of Assemblage I), and continues sporadically through this and the succeeding Aguathuna Formation. It is known also from the overlying Table Head Group (Stouge 1984), and has been found in middle Aguathuna to Table Point formations of Port au Port Peninsula.

Material.- 41 specimens: 20 symmetrical (s) elements and 21 asymmetrical (t) elements.

Repository.- GSC 93261-62.

?SEMIACONTIODUS CORDIS (Hamar, 1966)
Pl. 8, figs. 11-13.

Scolopodus cordis. HAMAR, 1966, pp. 74-75, Pl. 3, figs. 4-6, Text-fig. 2:5.
Oneotodus gracilis (Furnish). BARNES & POPLAWSKI, 1973, pp. 777-778, Pl. 1, figs. 1,2.
Semiacontiodus cf. cordis (Hamar). STOUGE, 1982, p. 54, Pl. 5, figs. 12,13; STOUGE & BOYCE, 1983, p. 30, Pl. 4, fig. 11; STOUGE, 1984, p. 69, Pl. 11, figs. 1-6.
Scolopodus? sp. C s.f. STOUGE, 1982, p.44. Pl. 3, figs. 16-18; STOUGE & BOYCE, 1983, p. 28, Pl. 3, fig. 3.

Remarks.- Elements of ?Semiacontiodus cordis sensu Stouge (1984) vary in the development of the posterior groove, lateral carinae and expansion of the base. Symmetrical elements may be acarinate, or bear carinae on both lateral faces. Posterior of cusp of carinate forms is commonly either flat or slightly concave. Posteriorly grooved forms may be symmetrically biconvex, or have one approximately planar lateral face.

It is therefore possible that the reconstruction of Stouge (1984) is incomplete. Insufficient specimens are available to herein more closely delineate this apparatus.

Occurrence.- This species is currently known from the Chasmops Limestone of the central Oslo District of Sweden (Hamar 1966), the Mystic Formation of Quebec (Barnes & Poplawski 1973), and Lower to Middle Ordovician platformal sequences of western Newfoundland. Stouge (1982, 1984) reports its occurrence from the Catoche Formation to middle Table Head Group.

It was found in lower Catoche to upper Aguathuna of the Daniel's Harbour region, Catoche Formation of Port au Choix Peninsula, middle Aguathuna Formation at Hare Bay, and throughout the Aguathuna Formation of Port au Port Peninsula.

Material.- 93 specimens: 39 posteriorly grooved, symmetrical elements; 36 posteriorly grooved asymmetrical elements; and 18 bicarinate elements.

Repository.- GSC 93263-65.

Genus **STRIATODONTUS** n. gen.

Type species.- Striatodontus kakivangus n. sp.

Derivation of name.- From stria, latin meaning a furrow.

Diagnosis.- Albid simple cones with Type IB apparatus plan. Both elements anterolaterally compressed with constricted base and fine grooves or striae on posterior face.

Remarks.- Elements of Striatodontus n.gen. may be distinguished from those of Scolopodus Pander, as amended by Fåhraeus (1982), by their pronounced constriction of the base. Scolopodus carlae Repetski is herein assigned to Striatodontus.

STRIATODONTUS KAKIVANGUS, n. sp.
Pl. 8, figs. 15-16.

Derivation of name.- After "kakivang", the Inuit word for a fish spear, because of the spear-shaped outline of the cusp. This specific name was used in an unpublished doctoral thesis by Nowlan (1976). This thesis was based upon material collected from the Canadian Arctic.

Diagnosis.- A species of Striatodontus with basal outline width less than half width of cusp, only slightly to moderately laterally compressed.

Description.- Cusp spear-shaped in posterior view, widest at approximately one-third cusp height, anteroposteriorly compressed with elliptical cross-section. Lateral edges sharp, posterolaterally directed. Anterior face smooth, slightly convex. Posterior face convex with four to six fine, regularly spaced grooves upon broad posterior carina. Carina of variable width relative to cusp width, but commonly occupying entire posterior face; may have flat areas between carina and lateral edges. Base severely constricted, less than one-third maximum width of cusp, base with subcircular cross-section. Basal cavity slender and shallow; centrally situated in *s* element, and opening slightly to one side in *t* element.

Remarks.- Specimens agree closely with those in collections from the Eleanor River Formation of the eastern Canadian Arctic islands (Nowlan 1976, Carson 1980).

Striatodontus kakivangus is less anteroposteriorly compressed than *Striatodontus carlae*, which it succeeds stratigraphically.

Occurrence.- *S. kakivangus* occurs sporadically and sparsely through the Catoche Formation and sporadically but in moderate abundance through all but the uppermost 15 m of the Aguathuna Formation. It is present in the Aguathuna Formation of Back Arm Bay and Hare Bay; middle Pine Tree Member to upper Aguthuna of the Port au Port Peninsula, and is known from low in Table Point Formation from Western Gravels section on Port au Port Peninsula. It is also known from the Eleanor River Formation of the Canadian Arctic (Nowlan 1976, Carson 1980).

Material.- 72 specimens: 40 s elements and 32 t elements.

Type stratum.- (TP13) Fine grained laminates exactly 12.9 metres below base of Table Point Formation on shoreline section at Table Point (Grid reference 617790 on Bellburns sheet 1:50,000 12-I/6 and 12-I/5, Edn 2).

Repository.- GSC 93267-68.

STRIATODONTUS CARLAE (Repetski, 1982)
Pl. 8, fig. 15.

Scolopodus carlae n.sp. s.f. REPETSKI, 1982, pp. 49-50, Pl. 23, figs. 1,2.

Remarks.- Both s and t elements were figured and described by Repetski (1982, pp. 49-50). The lanceolate, anteroposteriorly compressed cusp above a restricted base is typical of Striatodontus.

Occurrence.- According to Repetski (1982, p. 50), Striatodontus carlae may be found in the Jefferson City Dolomite of Missouri, the Ninemile Formation of Nevada, the West Spring Creek Formation of Oklahoma and middle and upper El Paso Group of western Texas.

It occurs in the middle Catoche Formation of the St. George Group (Assemblage II).

Material.- 2 specimens: both s elements.

Repository.- GSC 93266.

Genus TRIPODUS Bradshaw, 1969

Type species.- *Tripodus laevis* Bradshaw, 1969.

TRIPODUS LAEVIS Bradshaw, 1969
Pl. 8, figs. 17-20.

Tripodus laevis Bradshaw. ETHINGTON & CLARK, 1981, pp. 110-112, Pl. 12, figs. 24,25,27-29, Text-fig. 33 (with synonomy to 1974).
non *Acodus combsi* Bradshaw. STOUGE, 1984, p. 76, Pl. 14, figs. 13-19.

Remarks.- Stouge (1984, p. 76) considered the paltodontiform element described by Bradshaw (1969, p. 1164) as *Tripodus laevis* s.f. to be the distacodontiform element of *Acodus combsi* Bradshaw, s.f. Ethington and Clark (1981, p. 110) illustrated and described an apparatus which included *Tripodus laevis* s.f. This latter association is also indicated by St. George Group specimens. Distacodontiform elements of *Diaphorodus combsi* have lateral costae which are positioned symmetrically, whereas paltodontiform elements of *Tripodus laevis* have markedly asymmetrical cusp cross section. Ranges of these species do not coincide.

Occurrence.- *Tripodus laevis* occurs in the Fort Peña Formation of west Texas (Bradshaw 1969), lower Antelope Valley Limestone of central Nevada and upper Wah Wah and Juab limestones of Utah (Ethington & Clark 1981).

This species is common low in the upper Catoche Formation, is found in middle Aguathuna Formation (assemblages II to VI), and also occurs in Catoche Formation of Port au Choix Peninsula and middle Aguathuna of Port au Port Peninsula.

Material.- 73 specimens: 17 drepanodontiform (*a*), 4 distacodontiform (*b*), 21 trichonodelliform (*c*) - 8 with vicarious costae, 27 oistodontiform (*e*) and 4 paltodontiform (*f*) elements.

Repository.- GSC 93269-72.

Genus **VARIABILICONUS** Landing, Barnes & Stevens, 1986

Type species.- Paltodus bassleri Furnish, 1938.

Remarks.- Apparatus is Type IVC with laterally unicostate (a), bicostate (b), acontiodontiform (c), quadricostate (d), posteriorly unisulcate (e), drepanodontiform (f) and scandodontiform (g) elements.

VARIABILICONUS n. sp. A
Pl. 8, figs. 21-27; Text-figs. 5:3:11,18,22,24-25,28,32.

Acontiodontiform element
? Protopanderodus? sp. BARNES & POPLAWSKI, 1973, p. 785, Pl. 1, fig. 15.
Drepanodontiform element
? Scandodous mysticus. BARNES & POPLAWSKI, 1973, p. 786, Pl. 4, figs. 1,2, Text-fig. 2K.
Drepanodus n.sp. C s.f. BARNES & POPLAWSKI, 1973, pp. 773-774, Pl. 2, figs. 11,11a,13, Text-fig. 2J.
Scandodontiform element
Scandodus flexuosus. BARNES & POPLAWSKI, 1973, pp. 785-786, Pl. 2, figs. 1,4, Text-fig. 2L.
Multielement reconstructions
? Parapaltodus flexuosus (Barnes & Poplawski). STOUGE, 1984, p. 48, Pl. 1, figs. 19,22-25 (Incomplete).

Diagnosis.- A species of Variabiliconus with shallow basal cavity, posterior and lateral costae moderately and constantly tapering through length of cusp, rather than rapidly expanding basally; costae and intervening sulci may reach aboral margin.

Description.- All elements robust, with slowly tapering cusp, albid above basal cavity.

Drepanodontiform and scandodontiform elements were described by Barnes and Poplawski (1973).

Unisulcate (a) elements recurved, with sharp anterior margin and deep posterior sulcus, not visibly striate; basal cavity moderately deep, conical with tip situated just anterior of cusp midline.

Acontiodontiform (c) elements all with blocky lateral keels, and expanded posterior region of base. Lateral sulcus may not persist to tip of cusp and generally do not reach aboral margin, but aboral opening always mimics cusp cross-section. Basal cavity conical, with tip situated close to anterior face, does not extend to region of maximun curvature of cusp.

Posteriorly and anteriorly sulcate acontiodontiform (quadricostate, d) elements as above, except that anterior sulcus extends to aboral margin.

Remarks.- This species is distinguished by a distinct basal "lip" to posterior of acontiodontiform, and inner lateral face of drepanodontiform and scandodontiform elements. This, together with relatively unexpanded basal region of posterior costa, distinguishes V. n. sp. A from V. bassleri Landing et al. (1986).

It is possible that Scandodus mysticus (Barnes & Poplawski) is a variant of the drepanodontiform element. Alternatively, Scandodus flexuosus s.f. is a conservative element of several apparatuses.

No bicostate element has yet been located for this apparatus.

Occurrence.- This species is currently only known from the Mystic Formation of Quebec (Barnes & Poplawski 1973) and the St. George Group. It ranges through the Catoche Formation (assemblages I to IV), of Daniel's Harbour and Port au Choix areas.

Material.- 88 specimens: 21 laterally unicostate (a); 14 acontiodontiform (c); 7 posteriorly sulcate acontiodontiform (quadricostate, d); 9 unisulcate (e); 16 drepanodontiform (f) and 21 scandodontiform (g) elements.

Repository.- GSC 93273-79.

VARIABILICONUS n. sp. B
Pl. 9, figs. 6-8,11-12,15-16;
Text-figs. 5:3:12,17,19,23,27,29-31.

Tricostate element
Coelocerodontus ? sp. s.f. BARNES & POPLAWSKI, 1973, p. 770, Pl. 5, figs. 19,19a.

Diagnosis.- A species of Variabiliconus with long, slowly tapering, striate cusp; moderate to deep basal cavity; costae may be reduced to sharp edges, with anterolateral edges best developed.

Description.- All elements striate with albid, slowly tapering cusp above dark, hyaline base. Base slightly to moderately expanded. Asymmetric elements with both right and left handed forms. Basal cavity extends distally to point of greatest curvature of cusp, where tip is situated close to, and directed towards, anterior margin of cusp; anterior margin of basal cavity convex towards cavity, posterior margin of basal cavity sinuous, concave towards cavity proximal to aboral margin but convex towards cavity near tip.

Laterally unicostate (a) element with one anterolateral costa and sharp posterior margin which becomes keeled for a short distance at region of utmost curvature. Aboral opening concave towards costate lateral (inner) face; cusp cross-section lenticular.

Cusp of bicostate (b) element twisted through up to 90°; costae at anterior and posterior proximally but on lateral faces distally; central carina on inner face; aboral opening and cusp cross-section lenticular.

Acontiodontiform (c) element has short anterolateral flanges separated from cusp by deep groove; posterior edge sharp; commonly also bears two sharp, posterolateral edges. Cusp and aboral cross-sections triangular, posteriorly rounded and laterally angular.

Quadricostate (d) element with either one or two brief anterolateral keels and two sharp, posterolateral edges; cusp and aboral cross-sections subquadrate and anteriorly splayed.

Unisulcate (e) element asymmetric, laterally compressed, with biconvex cusp, subquadrate to oval aboral opening; posterior groove does not extend to aboral margin but is only developed above posterior part of basal cavity.

Drepanodontiform (f) element with keeled anterior and posterior margins; plano-convex cusp, and median carina central to inner face; posterior keel pronounced at region of maximum curvature; aboral opening ovate.

Scandodontiform (g) element as drepanodontiform, except for posterolateral flaring of inner face of base, twisted cusp, reduced median carina and subcircular aboral outline.

Remarks.- Elements belonging to this apparatus are of two types: one has relatively unexpanded base; the other has a moderately posteriorly expanded base. All elements of the apparatus show this variation. Basal cavity of both extend to point of maximum curvature and have the same outline. In addition, costae and sharp edges are arranged in similar position and relationship on both forms. The two forms co-occur within the one sample, and have similar ranges. It is probable, therefore, that this variation is intraspecific.

Elements with relatively unexpanded base may be mistaken for Scalpellodus, Parapanderodus or Semiacontiodus sensu Stouge. Apparatus differences aside, costae and sharp edges of Variabiliconus n.sp. B are sufficient to separate this latter species from the others. Unisulcate element was referred to Variabiliconus on the grounds of co-occurrence with other elements and its position in _V. bassleri_: it is slightly smaller than other elements of _V._ n.sp. B, but unusually large for elements of _Parapanderodus_ or _Semiacontiodus_. _Scalpellodus_ has no unisulcate element.

Elements with posteriorly expanded base are similar to _Oneotodus costatus_ Ethington & Brand, with which they frequently co-occur. It is possible that multicostate _Oneotodus costatus_ completes the apparatus of _V._ n.sp. B, and that the unisulcate element is part of a different apparatus. The basal cavity of _O. costatus_ is sufficiently distinct from that of all described elements of _V._ n.sp. B to render this supposition unlikely. Available material is inadequate to the solution of these problems.

Occurrence.- _Variabiliconus_ n.sp. B is known only from the uppermost Catoche and lower Aguathuna formations of Daniel's Harbour region (Assemblage IV), middle Aguathuna Formation at Hare Bay and middle Aguathuna Formation to lowest Table Point Formation of Port au Port Peninsula.

Material.- 42 elements: 4 laterally unicostate (_a_); 6 bicostate (_b_); 11 acontiodontiform (_c_); 4 quadricostate (_d_); 5 unisulcate (?_e_); 5 drepanodontiform (_f_) and 7 scandodontiform (_g_) elements.

Repository.- GSC 93280-86.

Genus **WALLISERODUS** Serpagli, 1967

Type species.- Acodus curvatus Branson & Branson, 1947.

WALLISERODUS ETHINGTONI (Fåhraeus, 1966)
sensu Löfgren, 1978
Pl. 9, fig. 3.

Walliserodus ethingtoni (Fåhraeus). LÖFGREN, 1978, pp. 114-116, Pl. 4, figs. 27-35, Text-fig. 33 (with synonomy to 1976); REPETSKI & ETHINGTON, 1977, p. 99, pl. 1, fig. 9; TIPNIS, CHATTERTON & LUDVIGSEN, 1978, p. 54, Pl. 9, fig. 23; AN, 1981, Pl. 3, fig. 16; ETHINGTON & CLARK, 1981, pp. 116-117, Pl. 13, figs. 10,14-16, Text-fig. 35; NOWLAN & THURLOW, 1984, p. 294, Pl. 2, fig. 15; STOUGE, 1984, pp. 64-65, Pl. 9, figs. 1-9.
Walliserodus cf. ethintoni (Fåhraeus). LÖFGREN, 1978, pp. 113-114, Pl. 4, figs. 13-14.

Remarks.- Rare, isolated specimens agree well with Löfgren's (1978) descriptions of Walliserodus ethingtoni and W. cf. ethingtoni. Both forms are present at similar stratigraphic levels.

All specimens are asymmetrical. Varying numbers of posteriorly facing costae are unevenly distributed on lateral faces, ranging from elements with one acostate lateral face and five costae on the opposing face to a subsymmetrical element with three costae on each lateral face.

Occurrence.- This species has been found in Lower (Löfgren 1978) and Middle (Fåhraeus 1966) Ordovician beds of Sweden, Middle Ordovician erratic boulders in Poland (Dzik 1976), the Womble Shale (Lower to Middle Ordovician) of the Ouachita

Mountains and the majority of the Fillmore Formation of Utah (Lower Ordovician, Ethington & Clark 1981). An (1981) reported its occurrence in the Xiaotan Formation (late Arenig to Llanvirn) of North China.

Bergström *et al*. (1974) and Nowlan and Thurlow (1984) recovered *Walliserodus ethingtoni* from Middle Ordovician rocks of central Newfoundland, Fåhraeus (1970) and Stouge (1984) from the Table Head Group of western Newfoundland. It also occurs in the Catoche Formation (assemblages I to III) of Port au Choix and Daniel's Harbour area.

Material.- 7 specimens.

Repository.- GSC 93287.

?NEW GENUS 1

Description.- Elements which may be described as drepanodontiform, cordylodontiform, acodontiform and cladognathiform are included within a common apparatus. Other, as yet unrecognized, elements are likely to be included within the same apparatus.

Remarks.- Taken in isolation, these elements do not agree with any currently recognised apparatus plan. It is likely that elements from both first and second symmetry transitions are represented, with other elements not yet known. Positions within the apparatus are therefore not assigned at present.

General morphology of these elements is suggestive of the genera *Oistodus*, *Protoprioniodus* and *Oelandodus*, but no triangulariform or trichonodelliform elements, nor second symmetry transition elements, have yet been shown to belong to the same apparatus.

?NEW GENUS 1 n. sp. A
Pl. 9, figs. 1-2,4-5.

cf. *Oistodus elongatus* LINDSTRÖM, 1955, p. 574, Pl. 4, figs. 32,?33, Text-fig. 5b.

? *Oistodus* n.sp. 1. SERPAGLI, 1974, pp. 53-54, Pl. 12, figs. 1,?3 ONLY, Pl. 24, figs. 1,3,?4 ONLY, Text-fig. 11 (in part).

cf. *Oelandodus elongatus* (Lindström). VAN WAMEL, 1974, pp. 71-72, Pl. 7, figs. 1,?2 ONLY.

Oistodus sp. s.f. REPETSKI, 1982, p. 36, Pl. 13, fig. 11.

Description.- All elements laterally compressed, with wide anterior keel to cusp and base. Posterior keel narrower, but pronounced. Cusp broad, generally wider than half base. Basal cavity convex posteriorly and concave anteriorly when viewed from side,; tip anteriorly directed and always just posterior of pronounced costa. Striae not visible at resolution of light microscope. All of cusp albid except for a narrow zone surrounding basal cavity; base (including keels) hyaline.

Drepanodontiform element with erect, plano-convex cusp. Lateral faces acostate. Posterior and anterior keels reduced; oral keel high and only gently curved. Anterobasal intersection slightly obtuse. Aboral margin straight when viewed from side, opening is a narrow slit which is flared laterally underneath tip of basal cavity.

Cordylodontiform element as above, except cusp reclined, anterobasal intersection markedly acute (approximately 70 $^{\circ}$), oral keel uniformly curved for entire length. Aboral margin sinuous to straight in side view. Strong, posteriorly facing costa developed on outer lateral face continues onto base, but does not reach aboral margin. Inner lateral face planar to slightly concave.

Cladognathiform element as cordylodontiform except inner lateral face also with broad medial costa, which does not reach aboral margin.

Acodontiform element differs from cordylodontiform element in that lateral costa reaches aboral margin and projects a very short distance as a lateral process.

Remarks.- With the material to hand, it is not possible to reconstruct complete apparatus composition. The "drepanodontiform" may either be an a, f or g element; cordylodontiform a or b; acodontiform b or f and cladognathiform is most likely a b element.

These elements described above are linked by basal cavity morphology, surface microstructure, white matter distribution and nature of oral, posterior and anterior keels. It is most likely they form part of a common apparatus. It is also probable that other elements be included within this apparatus. If this is not so, the apparatus is extremely unusual, composed entirely of asymmetrical elements.

Oelandodus elongatus (Lindström) of van Wamel (1974) has elongatiform element identical with acodontiform (b) element of this apparatus. Many of the albid apparatuses composed almost entirely of geniculate elements have been assigned to Protoprioniodus, following Cooper (1981). The element described as Oistodus elongatus s.f. is only similar to elements of Protoprioniodus in being albid and geniculate. Associated elements do not fit a first symmetry transition based on the prioniodid plan: they vary in number and position of costae rather than processes; they do not have the characteristic basal ledge common to all known species of

Protoprioniodus. In addition, to date no associated second symmetry transition elements have been found. Because of all these, and the extreme lateral compression of elements, this association is separated from the genus Protoprioniodus.

The apparatus of Oelandodus elongatus as constructed by van Wamel (1974) appears to have elements with tip of the basal cavity either posterior of the cusp midline (Pl. 7, fig. 1), or close to the anterior margin (Pl. 7, figs. 2,3a,b,?4). It is more likely that the apparatus consists of elements with tip of basal cavity only in posterior of cusp. The holotype of Oistodus elongatus s.f. is indeterminate in this regard, and it is not known whether the elongatiform of van Wamel's (1974) Oelandodus elongatus is conspecific with St. George Group material. This species is consequently left in open nomenclature.

Elements described by Serpagli as Oistodus n.sp. 1 are similar to those described above. The orientation of tip of basal cavity differs between these species, but they are most likely closely related.

Occurrence.- This species is currently only known from the St. George Group of Newfoundland, within which it occurs in the middle Catoche Formation (Assemblage II). It has been found north of Table Point in subsurface at Daniel's Harbour mine, and in middle Catoche Formation of the Port au Choix Peninsula.

Material.- 18 specimens: 2 drepanodontiform; 3

cordylodontiform; 10 acodontiform and 3 cladognathiform elements.

Repository.- GSC 93288-91.

?NEW GENUS 1 n. sp. B
Pl. 8, figs. 26-29.

aff. "Oistodus" selenopsis. SERPAGLI, 1974, pp. 56-57, Pl. 13, figs. 4a-6b, Pl. 23, figs. 8,9.

Diagnosis.- A species of ?New Genus 1 with broad, twisted cusp, basal cavity with tip anterior of cusp midline.

Description.- All elements with broad, twisted cusp; posterior and anterior edges keeled; broad carina on inner lateral face of cusp, posterior edge of cusp sigmoidal, meets oral edge of base at angle of approximately 60°; oral edge with high keel, outline strongly convex in lateral view; anterior edge uniformly curved from base to tip of cusp. Anteroaboral intersection acute but not drawn out, approximately 70 to 80 $^{\circ}$. Base short. Basal cavity of moderate depth, straight posterior margin and sigmoidal anterior margins in lateral view. Except for a narrow margin above basal cavity entirity of cusp filled with dense white matter.

Cordylodontiform, acodontiform and cladognathiform elements of this morphology have been identified. Cordylodontiform element is more laterally compressed than other elements; carina reduced to a broad convexity; cusp plano-convex in cross section. Acodontiform element with lateral flare of base as continuation of lateral carina; flare intersects aboral margin centrally. Cladognathiform element with both lateral faces costate.

Remarks.- Serpagli (1974) did not state whether his specimens of "*Oistodus*" *selenopsis* were albid, but noted that Lindström (1971) restricted *Oistodus* to hyaline elements. Serpagli (1974, Pl.13, figs. 4, 5) figured both cladognathiform and "acodontiform" elements which differ from the above elements only in a more pronounced curvature change on anterior margin near the top of the base.

Occurrence.- Sparsely scattered through lower to upper Catoche Formation strata (assemblages I to III) north of Table Point, these specimens may be conspecific with elements found through the San Juan Formation of Argentina (Serpagli 1974).

Material.- 8 specimens: 4 cordylodontiform; 2 acodontiform and 2 cladognathiform elements.

Repository.- GSC 93292-95.

Chapter 6

CONCLUSIONS

6:1. INTRODUCTION

The St. George Group of western Newfoundland is a sequence of shallow water platform carbonates deposited on the North American margin of the Lower Ordovician Iapetus Ocean.

Two shoaling-upward megacycles are recorded within this sequence (Knight and James 1987): the upper megacycle is preserved in sediments of the upper Boat Harbour, Catoche and Aguathuna formations. Much of the upper megacycle is examined in this study, which commences low within the predominantly subtidal Catoche Formation, and continues through peritidal sediments of the Aguathuna Formation into basal Table Point Formation.

6:2. THE CONODONT FAUNA

Seventy-one species from 43 genera of conodonts are described herein from the Catoche and Aguathuna formations.

Because of the very shallow setting of the depositional environment, shallow water species represented only by isolated specimens in many other sections are preserved in the Aguathuna Formation in abundance. Proliferation and abundance of such species was enhanced by the long-lived peritidal setting of the middle and upper Aguathuna Formation.

Thus, the apparatus of the genus *Leptochirognathus* Branson and Mehl has been reconstructed. This is Type IVE of Barnes *et al*. (1979), with reduced first symmetry transition consisting of cordylodontiform (*a*), zygognathodontiform (*b*) and trichonodelliform (*c*) elements. The second series consists only of falodontiform (*e*) and cyrtoniodontiform (*f*) elements.

The apparatus of *Drepanodus concavus* (Branson and Mehl) is also emended. In addition to arcuatiform (= drepanodontiform), and sculponeaform and pipaform (= oistodontiform) elements previously included within the *Drepanodus* apparatus, the consistent co-occurrence of homocurvatiform, graciliform and suberectiform elements indicates the apparatus of *D. concavus* is modified Type IVB (Barnes *et al*. 1979).

6:3. ALTERATION OF CONODONT ELEMENTS

Conodonts contained within this sequence are relatively unaltered, except at Hare Bay in the vicinity of a mafic dyke. Conodont CAI of most upper St. George Group conodonts indicate burial temperatures of less than 150-200°C. The Port au Port Peninsula appears to have been effected by temperatures less than 80^{o}C. Conodonts sampled from close to Mississippi Valley type mineralization at Daniel's Harbour mine have similar CAI to that of other conodonts of this area. Consequently, the ore was probably emplaced by low temperature hydrothermal solutions.

Conodont CAI's evaluated from Hare Bay samples indicate that contact metamorphic effects may extend a distance of a few tens of metres from the hot body. Continuously decreasing temperature effects accompanied increasing distance from the body. Previously documented studies of CAI indicated no change in CAI to within two metres from the igneous body (Nicoll 1981, Armstrong and Strens, 1987). Evidently, contact metamorphism has varying effects on conodonts as well as country rock, depending (in part) on the type and size of heat source.

The surface of many conodont specimens is frosted, overgrown by diagenetic crystals, or pitted and corroded. While taxonomically important details were not obscured, conodont surface alteration provided useful indicators to the subsequent history of enveloping strata. Further study is required before the various effects of diagenesis, passage of hydrothermal (ore-bearing) solutions and physical abrasion may be defined.

6:4. BIOSTRATIGRAPHY

Long-ranging species within the upper megacycle include

Eucharodus parallelus (Branson and Mehl), Semiacontiodus cordis (Hamar), S. asymmetricus (Barnes and Poplawski), Striatodontus kakivangus n.gen. n.sp. and Oneotodus costatus Ethington and Brand. All but the last species range through the entire studied section, and some of them continue into the Table Point Formation.

Drepanodus concavus (Branson and Mehl) and D. arcuatus Pander alternate in the succession, probably in response to environmental changes, with D. arcuatus found in generally deeper water strata than D. concavus. This relationship is also seen with Semiacontiodus cordis (Hamar) and S. asymmetricus (Barnes and Poplawski). S. asymmetricus is more common in deeper water sediments, while S. cordis is dominant in laminated, and more dolomitic, samples.

The conodont fauna of the lower Catoche to basal Table Point formations is subdivided into seven successive informal assemblages (Table 6:1). Originally described from the type section of the Aguathuna Formation north of Table Point, and extended down into the lower Catoche Formation using nearby subsurface data (D.D.H. A1), these assemblages are recognizable throughout the study area. They are defined with particular reference to changes in species of Parapanderodus Stouge and Diaphorodus Kennedy; to concurrent ranges of several species. Environmentally controlled occurrences exhibited by some (particularly Baltic) species excluded these species from being used for assemblage

TABLE 6:1: Fauna, stratigraphic level and correlation of upper St. George Group assemblages. Conodont species are listed in order of abundance for each assemblage. Species marked with asterisk are also important in the succeeding Assemblage; Midcontinent conodont zonation denoted by M/C; shelly fossil zones of the Ibex section denoted SF; + indicates acme of long-ranging species.

Assemblage	Strat. level	Fauna	Correlatives
I	Lower Catoche Fm.	**Oepikodus communis* *Paltodus sweeti* "*Scolopodus*" *filosus* *Drepanoistodus inaequalis* **Diaphorodus delicatus* *Glyptoconus quadraplicatus* **Parapanderodus striatus* *Rossodus highgatensis* "*Scolopodus*" *emarginatus*	Early M/C Fauna E; SF Zone G_2; *Prioniodus elegans* Zone.
II	upper part of lower to low in upper upper Catoche Fm.	*Bergstroemog*. *extensus* *Diaphorodus russoi* *Paroistodus parallelus* *Fryxellodontus corbatoi* *Clavohamulus cavus* **Drepanoistodus forceps* ?*Microz*. *marathonensis* **Diaphorodus delicatus*	M/C Fauna E; SF Zone H; Faunas A and B of San Juan Fm. of Argentina.
III	upper Catoche Fm.	*Parapanderodus aequalis* *Oistodus bransoni* *Drepanoistodus basiovalis* *Scalpellodus* n.sp. *Variabiliconus* n.sp. A	M/C Fauna E; SF Zone I; u. Jefferson City Dolom.; *Oepikodus evae* Zone.
IV	uppermost Catoche and lower Aguathuna fms.	*Diaphorodus emanuelensis* **Parapand*. *abemarginatus* +*Eucharodus parallelus* +*Oneotodus costatus* +*Drepanodus concavus* *Diaphorodus gravelsensis* *Parapanderodus striolatus*	M/C Fauna E/1.

TABLE 6:1 (ctd.)

V	middle Aguathuna Fm.	Pteracontiodus cryptodens Oistodus multicorrugatus Oepikodus intermedius Diaphorodus stevensi Diaphorodus gravelsensis	M/C Fauna 1/2.
VI	low in upper Agauthuna Fm.	Drepanodus sp. cf. D. gracilis Reutterodus sp. +Oneotodus costatus	M/C Fauna 1/2.
VII	Upper Aguathuna and lower Table Point fms.	Paraprioniodus costatus Scandodus sinuosus Leptochirogn. quadrata Multioistodus subdentatus Drepanoistodus angulensis	M/C Fauna 4; Kanosh and Lehman fms. of Utah.

definition.

The conodont fauna of the Catoche and Aguathuna formations does not correspond exactly with any previously described succession, but contains many elements of the Midcontinent zonation. While the Ibex section represents deposition in a shallow margin setting during the upper Canadian regression (Barnes 1984), the St. George Group developed into a sequence of peritidal sediments. This resulted in the divergence of Ibex section and St. George Group faunas as the St. George Group became shallower (upper Catoche and Aguathuna formations).

Generally, the studied faunas show a decrease in North Atlantic Province affinity up section, with a corresponding increase in Midcontinent Province affinity and endemism (Fig. 3:1), accompanying the shallowing of the depositional environment. Correlation with many extraregional conodont faunas is therefore possible for earlier assemblages, while only Midcontinent zonations are applicable to Aguathuna Formation faunas.

Earliest faunas within this sequence correlate with early Midcontinent Fauna E (upper Canadian) of Ethington and Repetski (1984), and with the Prioniodus elegans Zone of the Baltic (Middle Arenig). This is the level of North American trilobite Zone H. Some of the Cow Head Group Bed 9 conodont species are present in earliest samples of this study (S. Pohler, pers. comm., 1988), indicating correlation with early in the Prioniodus elegans Zone.

Correlation with Baltic (North Atlantic Province) conodonts is only possible up to Oepikodus evae Zone, corresponding with Assemblage III of the St. George sequence.

Faunas of the St. George Group range up to early Whiterock age.

6:5. STRATIGRAPHIC RELATIONSHIPS

Utility of this conodont biostratigraphic scheme is illustrated in the Daniel's Harbour mine by marking the level at which reworking of faunas (i.e. sediments) becomes important, testing the possibility of thickening of strata, and assessing the contemporaneity and duration of omission and erosion surfaces.

Using this succession of faunas, D.D.H. 438. records reworking of middle Catoche Formation faunas into middle lower Aguathuna Formation. The simplest explanation for such reworking involves upfaulted Catoche Formation which was eroded into the depositional environment sampled by D.D.H. 438. This fault, with throw of probably 50 m, brought rocks containing Assemblage II faunas above sediments containing Assemblage V (Fig. 3:14). Thus synsedimentary faulting (Knight 1985, Knight and James 1987) was active during deposition of middle and upper Aguathuna Formation.

Breccia bodies within the Aguathuna and Catoche formations of the Daniel's Harbour area may be intraformational or crosscutting (Lane 1984). Fine rock matrix breccias may be localized and associated with structural depressions (Lane 1984), possibly formed in response to synsedimentary faulting (Knight and James 1987, Pohler *et al*. 1987, James *et al*. 1987). The location of such breccias within considerably thickened sequences further strengthens arguments for synsedimentary faults: such is the case within D.D.H. 498, in which 50 m of strata containing species found in Assemblage VII are preserved in the uppermost Aguathuna Formation.

Assemblage VI is not recorded within D.D.H. 498 and 715. This latter drill hole has an unusual succession, in which *Drepanoistodus angulensis* (Assemblage VII) immediately precedes *Pteracontiodus cryptodens* (Assemblage V); *Glyptoconus rectus* is found almost 15 m higher, and is closely followed by *Histiodella holodentata*, which is only found in the Table Point Formation elsewhere. The common Assemblage VII indicator species, *Paraprioniodus costatus*, *Erismodus* spp., *Scandodus sinuosus*, *Multioistodus* spp. and *Leptochirognathus* spp. are not present in D.D.H. 715 at all. Brecciated zones, 30 to 50 m above the base of the Aguathuna Formation in this core (See Appendix A:6), are suggestive of removal of strata at several levels and consistent with subsurface karst reorganisation (Lane 1984, Knight and James 1987). It is likely that rocks containing

Assemblage VI and some of Assemblage VII were removed during formation of these brecciated zones.

6:6. HIATUSES

Correlation of faunas throughout the upper St. George Group of western Newfoundland and with those of the Ibex area has revealed two major hiatuses in the Aguathuna Formation.

6:6:1. THE LOWER HIATUS

The lower hiatus, in middle Aguathuna Formation, is marked by brecciated horizons in core and solution surfaces in outcrop (see Fig. 3:25) which separates Assemblage IV below from Assemblage V above. Omission surfaces representing this lower hiatus are synchronous between Table Point and Port au Port Peninsula, and apparently represent widespread regression throughout the platform margin.

Such an event may also be recognized in coeval rocks of western Newfoundland. During Early and Middle Ordovician, sedimentation on slope and toe of slope was dependent upon source material from the platform (James *et al*. 1987). Slope sequences equivalent to Catoche and Aguathuna formations have been described as the upper Cow Head Group. This consists of pelagic deep water sediments interrupted by megaconglomerates. Megaconglomerate Bed 12 of the Cow Head Group, an extensive unit sampling the entire margin facies as large clasts in a vast volume of sediments, has been interpreted as recording wholesale collapse of the upper slope or shelf edge (James and Stevens 1986).

Lower portions of Arenig strata at Lobster Cove Head are lateral correlatives of the Cow Head Group. Sedimentation in the style of the Cow Head Group is terminated by a hiatus, and overlain by quiet water sediments. Evidently, a platform source of sediments was unavailable, probably due to "drowning" (James et al. 1987), while a source of sediments for deposition of upper parts of the Cow Head Group at Cow Head was maintained. The rapid platform margin subsidence which resulted in drowning of the source area for the Lobster Cove Head sequence was apparently a consequence of margin fragmentation and probably related to faulting (James et al. 1987). This is presumed to be an effect of the initial stage of the Taconic Orogeny on the stable North American platform margin of Iapetus Ocean.

Bed 12 of the Cow Head Group is considered to be the first representation of the Taconic Orogeny in western Newfoundland (James et al. 1987), and is thought to correspond with a major regression on the platform. Bed 12 correlates with Assemblage V in the platformal sequence, based on the first occurrence of *Pteracontiodus cryptodens*, and faunas of definite Whiterockian aspect. Assemblage V overlies a regional hiatus. This hiatus represents the regression coeval with deposition of megaconglomerate Bed 12, and therefore records the first effects of the Taconic Orogeny on platformal sequences.

Continental margin flexure consequent upon westward migration of peripheral bulge and the allochthons induced instability on the platform margin. In addition to the foundering of platform margin feeding the Lobster Cove Head sequence, synsedimentary faulting seen in the Aguathuna Formation at Hawkes Bay (Knight and Boyce 1984) is likely to have been initiated after this major regression and megaconglomerate flow. Synsedimentary faulting is presumed to be responsible for thickness variations in the Aguathuna Formation. Thickened upper Aguathuna Formation sections in the Daniel's Harbour region, and tectonic instability recorded in the Table Point Formation and in flysh overlying Lobster Cove Head sequences, are indications that synsedimentary faulting continued for some time after deposition of the Aguathuna Formation.

6:6:2. THE UPPER HIATUS

The upper hiatus, preserved in upper or uppermost Aguathuna Formation as a disconformity surface, does not everywhere appear at the same stratigraphic level. At Table Point, such a hiatus separates assemblages VI and VII, and this latter assemblage commences with a diverse and abundant conodont fauna. Conodonts from below the disconformity are correlated with early Midcontinent Fauna 2; those above the disconformity are of Midcontinent Fauna 4 age. The disconformity coincides with much of Midcontinent Fauna 2, all of Midcontinent Fauna 3, and possibly part of Midcontinent Zone 4. Correlation throughout western Newfoundland indicates that different sequences of the faunal succession have been omitted from various sections, and it is evident that both upper and lower surfaces bounding this hiatus are diachronous throughout the study area (Fig. 6:1).

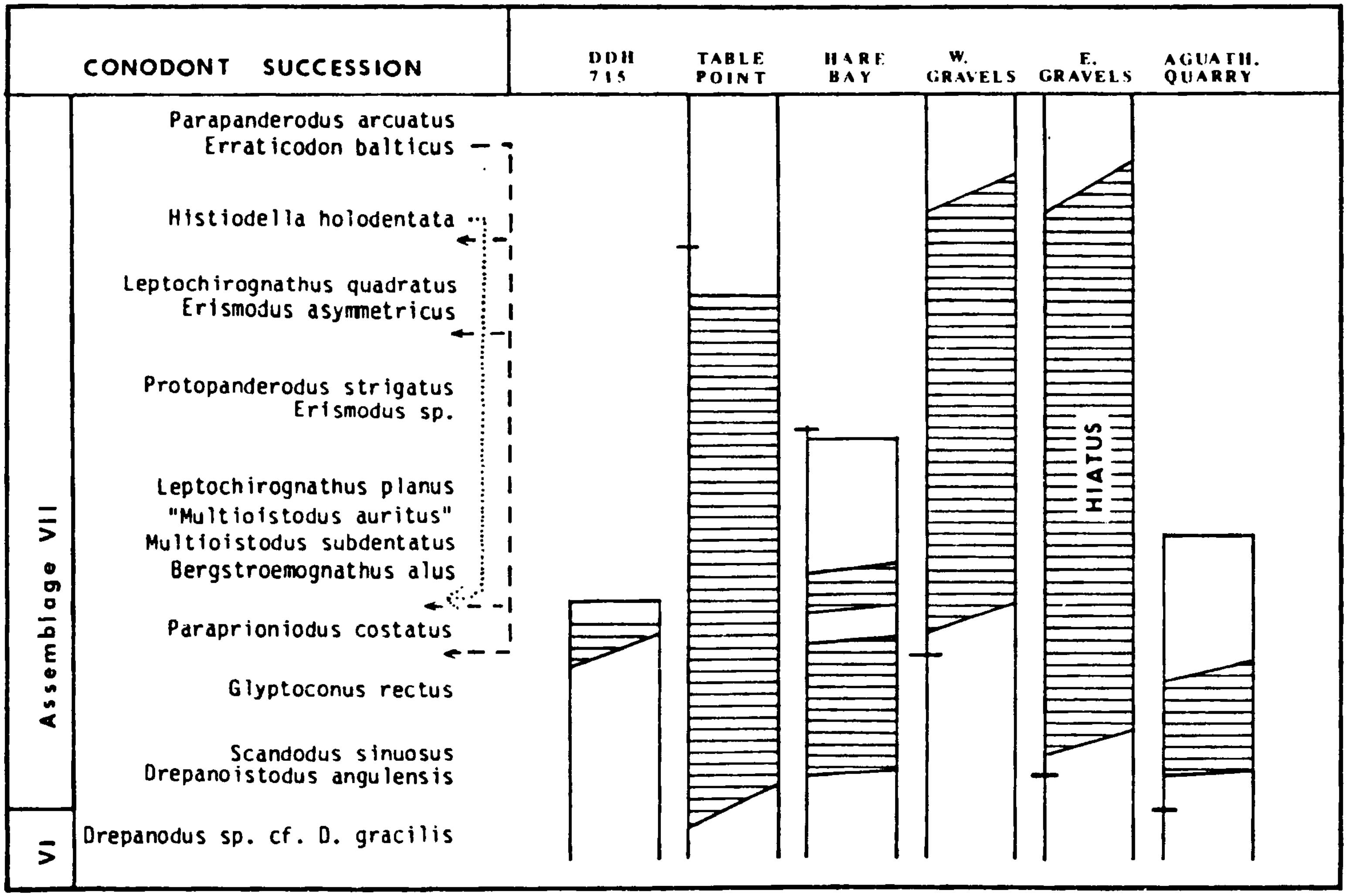
In parautochthonous strata at Big Spring Inlet, Hare Bay, approximately 10 m of the upper Aguathuna Formation is preserved in the interval between first appearance of exclusively Assemblage VII taxa and development of the complete fauna recorded in the first Assemblage VII sample at Table Point.

At Back Arm Bay, the hiatus overlies upper Catoche Formation strata: only the uppermost Aguathuna Formation, containing well developed Assemblage VII populations, is preserved.

Sections on the Port au Port Peninsula do not show these faunas until 1.5m into the Table Point Formation. Evidently, peritidal sedimentation terminated earlier at Port au Port localities than at Table Point. Given the more outboard location of Port au Port localities, this must be a response to relative sea level rise, or more open water conditions permitting deposition of limestone.

A complete faunal sequence for Assemblage VII may be

Fig. 6:1. Biostratigraphic correlation of the upper hiatus of the Aguathuna Formation. The uninterrupted faunal succession is indicated in left column. Species grouped together first appear at approximately the same level. *Histiodella holodentata* is found before *Multioistodus subdentatus* in Utah, but not before species higher on section (dotted lines); dashed lines indicate lower first occurrence of *Erraticodon balticus* in the Ibex area. Stratigraphic columns for one drill core and all sections at which sufficient data was available are shown to right side of diagram. Sections commence below lowest Assemblage VII. Hiatus marked by horizontal lines; first appearance of each species is considered to be at the same level in each column. Upper level of hiatus drawn at or above level of first occurrence of biostratigraphically highest species within first sample collected from above the hiatus. Lower limit of hiatus drawn between level of first occurrence of species within fauna immediately below hiatus. Contact between Aguathuna and Table Point formations in each column is marked by a short line on left-hand side. D.D.H. 715 does not sample the Table Point Formation; section ends at horizontal line low in column, as does that at Hare Bay and Aguathuna Quarry. The fauna of the base of the Table Point Formation at Hare Bay is not yet known. The section west and east of the Gravels, and at Table Point continues higher, apparently unbroken.


CONODONT SUCCESSION
DDH 715
TABLE POINT
HARE BAY
W. GRAVELS
E. GRAVELS
AGUATH. QUARRY
Parapanderodus arcuatus
Erraticodon balticus
Histiodella holodentata
Leptochirognathus quadratus
Erismodus asymmetricus
Protopanderodus strigatus
Erismodus sp.
Leptochirognathus planus
"Multioistodus auritus"
Multioistodus subdentatus
Bergstroemognathus alus
Paraprioniodus costatus
Glyptoconus rectus
Scandodus sinuosus
Drepanoistodus angulensis
Drepanodus sp. cf. D. gracilis
Assemblage VII
VI
HIATUS

constructed by consideration of the succession through each of the sections (Fig. 6:1). This corresponds well with that preserved in the Ibex area of Utah, indicating that Assemblage VII at Table Point commenced at a time equivalent to early Midcontinent Fauna 4, i.e. North American shelly fossil Zone M (Hintze 1951).

Irregularities of surface, thickness variations in the Aguathuna Formation, and diachroneity of hiatuses preserved in the upper Aguathuna or lower Table Point formations may all be explained by the continuation of synsedimentary faulting in response to the approach of Taconic allochthons. Uplift and erosion of the Back Arm Bay region was accomplished between the uppermost Catoche Formation and uppermost Aguathuna Formation, since the hiatus in this region is bounded by upper Catoche and upper Aguathuna sediments. Within the bounds of the model of James et al. (1987), this uplift is most likely to have occurred during or after the deposition of Cow Head Group Bed 12, i.e. after the hiatus preserved in the middle Aguathuna Formation at Table Point. The Hare Bay area, outboard to both Table Point and Port au Port sites during deposition of the Aguathuna Formation, records a hiatus diachronous with that of Table Point. More of the section is preserved, probably because sedimentation is more complete in deeper water sequences during a regression (Vail et al. 1984). At Port au Port, the upper hiatus is generally preserved in the Table Point

Formation. These strata were outside the scope of this study, but preliminary collection of basal strata indicate several metres of relief across the uppermost Aguathuna and lowermost Table Point formations of the Aguathuna Quarry. These findings are consistent with a shifting island on tidal flat model, with faulting also elevating some areas. From the conodont biostratigraphy, it is clear that the break recorded high in the Aguathuna Formation in the Great Northern Peninsula of western Newfoundland correlates partly in time with the erosional disconformity at Aguathuna which separates this formation from the overlying Table Head limestone, but commenced earlier, was of longer duration, and affected limestones of the Springs Inlet Member rather than the dolostones of the underlying Aguathuna Formation (see Fig. 6:1).

6:7. OVERVIEW

In summary, the Catoche and Aguathuna formations of the St. George Group records deposition in an upward shallowing sequence. Earlier conodont faunas indicate open marine conditions, and communication with Baltic forms of the deeper water environments. Continuing shallowing of the depositional setting resulted in the exclusion of species of Baltic affinity, and incoming and dominance of Midcontinent Province species. The upper part of the sequence was deposited in extremely shallow water around laterally and vertically accreting islands and structural highs. This setting was perturbed, according to conodont occurrences during deposition of the middle Aguathuna Formation, by the initial effects of the Taconic Orogeny on the platform. Such effects included catastrophic megaconglomerate slumps and the initiation of a period of synsedimentary faulting, which finally culminated in the foundering of the platform margin during deposition of the succeeding Table Head Group.

REFERENCES

Abaimova, G.P. 1975. Ranneordovikskie konodonty srednego techeniya R. Leny (Early Ordovician conodonts of the middle flow of the Lena River). Trudy SNIIGGIMS, 207, Novosibirsk, 129p. [In Russian]

An, T. 1981: Recent progress in Cambrian and Ordovician conodont biostratigraphy of China. Geological Society of America, Special Paper 187:209-224.

An, T., Zhang, F., Xiang W., Zhang, Y, Xu, W., Zhang, H., Jiang, D., Yang, C., Lin, L., Cui, Z. and Yang X. 1983. THE CONODONTS OF NORTH CHINA AND THE ADJACENT REGIONS. Science Press, Beijing, 223pp.

Andrews, H.E. 1967. Middle Ordovician conodonts from the Joachim Dolomite of eastern Missouri. Journal of Paleontology, 41:881-901.

Armstrong, H.A. and Strens, M.R. 1987. Contact metamorphism of conodonts as a test of colour alteration index temperatures; pp. 203-208 In R.L. Austin (Ed.) CONODONTS: INVESTIGATIVE TECHNIQUES AND APPLICATIONS. Ellis Horwood Limited, Chichester.

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 Società Paleontologica Italiano, 35:145-158.

Barnes, C.R. 1967. A questionable natural conodont assemblage from Middle Ordovician limestone, Ottawa, Canada. Journal of Paleontology, 41:1557-1560.

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. Geological Association 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 269:99-119.

Barnes, C.R. 1984. Early Ordovician eustatic events in Canada. pp. 51-63 In D.L. Bruton (Ed.): ASPECTS OF THE ORDOVICIAN SYSTEM. Universitetsforlaget, Oslo, 228 pp.

Barnes, C.R. 1988. The proposed Cambro-Ordovician global Boundary stratotype and point (GSST) in Western Newfoundland, Canada. Geological Magazine, 125:381-414.

Barnes, C.R. and Fåhraeus, L.E. 1975. Provinces, communities, and the proposed nektobenthic habit of Ordovician conodontophorids. Lethaia, 8:133-149.

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, 12:125-151.

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, 47:760-790.

Barnes, C.R., Rexroad, C.B. and Miller, J.F. 1973. Lower Paleozoic conodont provincialism. Geological Society of America, Special Paper 141:157-190.

Barnes, C.R., Sass, D.B. and Monroe, E.A. 1973. Ultrastructure of some Ordovician conodonts. Geological Society of America, Special Paper 141:1-30.

Barnes, C.R. and Tuke, M.F. 1970. Conodonts from the St. George Formation (Ordovician), northern Newfoundland. Geological Survey of Canada, Bulletin 187:79-97.

Bednarczyk, W. 1971. Stratigraphy and palaeogeography of the Ordovician in the Holy Cross Mts. Acta Geologica Polonica, 21:573-616.

Bednarczyk, W. 1979. Upper Cambrian to Lower Ordovician conodonts of the Leba Elevation, NW Poland, and their stratigraphic significance. Acta Geologica Polonica, 29:409-442.

Bergström, S.M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. Geological Society of America, Memoir 127:83-161.

Bergström, S.M. 1979a. Whiterockian (Ordovician) conodonts from the Hølonda Limestone of the Trondheim region, Norwegian Caledonides. Norsk Geologisk Tidsskrift, 59:295-307.

Bergström, S.M. 1979b. First report of the enignatic Ordovician microfossil Konyrium in North America. Journal of Paleontology, 53:723-754.

Bergström, S.M. 1981. Superfamily Chirognathacea. pp. 136-140 In R.A. Robison (Ed.): TREATISE ON INVERTEBRATE PALEONTOLOGY, Part W, Miscellanea, Supplement 2, Conodonta. Geological Society of America and University of Kansas Press (New York and Lawrence). 202pp.

Bergström, S.M., Riva, J. and Kay, M. 1974. Significance of conodonts, graptolites, and shelly faunas from the Ordovician of western and north-central Newfoundland. Canadian Journal of Earth Sciences, 11:1625-1660.

Berry, W.B. 1972. Early Ordovician bathyurid province lithofacies, biofacies and correlations - their relationship to a proto-Atlanic Ocean. Lethaia, 5:69-83.

Berry, W.B.N. and Boucot, A.J. 1970. Correlation of the North American Silurian rocks. Geological Society of America, Special Paper 102, 289pp.

Besaw, D. 1974. Limestone evaluation, Port au Port Peninsula. In J.R. DeGrace (Ed.): LIMESTONE RESOURCES OF NEWFOUNDLAND AND LABRADOR. Newfoundland and Labrador Department of Mines and Energy, Report 74-2, 117 pp.

Billings, E. 1865. PALAEOZOIC FOSSILS. Vol. 1. Containing descriptions and figures of new or little known species of organic remains from Silurian rocks, 1861-1865. Geological Survey of Canada. 426pp.

Boyce, W.D. 1985. Cambrian-Ordovician biostratigraphic investigations, Great Northern Peninsula, western Newfoundland. pp. 60-70 In R.V. Gibbons (Ed.) Current Research. Newfoundland Department of Mines and Energy. Mineral Development Division, Report 85-1.

Bradshaw, L.E. 1969. Conodonts from the Fort Peña Formation (Middle Ordovician), Marathon Basin, Texas. Journal of Paleontology, 43:1137-1168.

Branson, E.B. and Branson, C.C. 1947. Lower Silurian conodonts from Kentucky. Journal of Paleontology, 21:549-556.

Branson, E.B. and Mehl, M.G. 1933a. Conodonts from the Jefferson City (Lower Ordovician) of Missouri. University of Missouri Studies, 8:53-64.

Branson, E.B. and Mehl, M.G. 1933b. Conodonts from the Joachim (Middle Ordovician) of Missouri. University of Missouri Studies, 8:77-100.

Branson, E.B. and Mehl, M.G. 1933c. Conodonts from the Plattin (Middle Ordovician) of Missouri. University of Missouri Studies, 8:101-119.

Branson, E.B. and Mehl, M.G. 1943. Ordovician conodont faunas from Oklahoma. Journal of Paleontology, 17:374-387.

Burrett, C.F. 1973. Ordovician biogeography and continental drift. Palaeogeography, Palaeoclimatology, Palaeoecology, 13:161-201.

Carson, D.M. 1980. Canadian-Whiterockian (Ordovician) conodont biostratigraphy of the Arctic Platform, southern Devon Island, eastern Canadian Arctic Archipelago. M.Sc thesis, University of Waterloo, Waterloo, Ontario.

Cas, R.A.F. and VandenBerg, A.H.M. 1988. Ordovician; pp. 63-102 in J.G. Douglas and J.A. Fergusson (Eds.) GEOLOGY OF VICTORIA, Revised Edition. Victorian Division of the Geological Society of Australia.

Collins, J.A. and Smith, L. 1975. Zinc deposits related to diagenesis and intrakarstic sedimentation in the Lower Ordovician St George Formation, western Newfoundland. Canadian Petroleum Geology, Bulletin, 23:393-427.

Coniglio, M. 1986. Synsedimentary submarine slope failure and tectonic deformation in deep-water carbonates, Cow Head Group, western Newfoundland. Canadian Journal of Earth Sciences, 23:476-490.

Cooper, B.J. 1981. Early Ordovician conodonts from the Horn Valley Sitlstone, central Australia. Palaeontology, 24:147-183.

Cooper, B.J. 1986. A record of Ordovician conodonts from the Warburton Basin, South Australia. Quarterly geological notes of the Geological Survey of South Australia, 100:8-14.

Cooper, J.R. 1937. Geology and mineral deposits of the Hare Bay area. Newfoundland Department of Natural Resources, Geology Section, Bulletin 9, 36 pp.

Cooper, R.A. and Druce, E.C. 1975. Lower Ordovician sequence and conodonts, Mount Patriarch, north-west Nelson, New Zealand. New Zealand Journal of Geology and Geophysics, 18:551-582.

Crespin, I. 1943. Conodonts from Waterhouse Range, central Australia. Transactions of the Royal Society of South Australia, 67:231-232.

Crough, S.T. 1981. Mesozoic hotspot epeirogeny in eastern North America. Geology, 9:2-6.

Cullison, J.S. 1938. Dutchtown fauna of southeastern Missouri. Journal of Paleontology, 12:219-228.

Cumming, L.M. 1983. Lower Paleozoic autochthonous strata of the Strait of Belle Isle area. Geological Survey of Canada, Memoir 400:75-108.

Druce, E.C. and Jones, P.J. 1971. Cambro-Ordovician conodonts from the Burke River structural belt, Queensland. Australia Bureau of Mineral Resources, Geology and Geophysics, Bulletin 110. 158pp.

Dzik, J. 1976. Remarks on the evolution of Ordovician conodonts. Acta Palaeontologica Polonica, 21:395-455.

Dzik, J. 1978. Conodont biostratigraphy and paleogeographical relations of the Ordovician Mojcza Limestone (Holy Cross Mts, Poland). Acta Palaeontologica Polonica, 23:51-72.

Dzik, J. 1983. Relationships between Ordovician Baltic and North American Midcontinent conodont faunas. Fossils and Strata, 15:59-85.

Epstein, A.G., Epstein J.B. and Harris, L.D. 1977. Conodont colour alteration- an index to organic matamorphism. U.S. Geological Survey Professional Paper 995, 1-27.

Erdtmann, B.-D. 1971. Ordovician graptolite zones of western Newfoundland in relation to palaeogeography of the North Atlantic. Geological Society of America, Bulletin 82:1509-1528.

Erdtmann, B.-D. 1976. Ecostratigraphy of Ordovician graptoloids. pp. 621-643 In M.G. Bassett (Ed.) THE ORDOVICIAN SYSTEM: PROCEEDINGS OF A PALAEONTOLOGICAL ASSOCIATION SYMPOSIUM, BIRMINGHAM, SEPTEMBER, 1974. University of Wales Press and National University of Wales, Cardiff.

Ethington, R.L. 1972. Lower Ordovician (Arenigian) conodonts from the Pogonip Group, central Nevada. Geologica et Palaeontologica, Sonderband 1:17-28.

Ethington, R.L. 1979. Conodonts from the Pre-Eureka Ordovician of the Great Basin. Brigham Young University Geology Studies, 26:1-6.

Ethington, R.L. and Brand, U. 1981. Oneotodus simplex (Furnish) and the genus Oneotodus (Conodonta). Journal of Paleontology, 55:239-247.

Ethington, R.L. and Clark, D.L. 1964. Conodonts from the El Paso Formation (Ordovician) of Texas and Arizona. Journal of Paleontology, 38:685-704.

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, 12:185-205.

Ethington, R.L. and Clark, D.L. 1971. Lower Orddovician conodonts of North America. Geological Society of America, Memoir 127:63-82.

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(2):1-160.

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 196:89-101.

Fåhraeus, L.E. 1966. Lower Viruan (Middle Ordovician) conodonts from the Gullhogen Quarry, southern central Sweden. Sveriges Geologiska Undersokning, 60:1-40.

Fåhraeus, L.E. 1970. Conodont-based correlations of Lower and Middle Ordovician strata in western Newfoundland. Geological Society of America Bulletin, 81:2061-2076.

Fåhraeus, 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, 25:981-994.

Fåhraeus, L.E. 1982. Recognition and redescription of Pander's (1856) Scolopodus (form-)species - constituents of multi-element taxa (Conodontophorida, Ordovician). Geologica et Palaeontologica, Sonderdruck, 16:19-28.

Fåhraeus, L.E. 1984. A critical look at the Treatise family-group classification of Conodonta: an exercise in eclecticism. Lethaia, 17:293-305.

Fåhraeus, L.E. and Hunter, D.R. 1981. Paleoecology of selected conodontophorid species from the Cobbs Arm Formation (middle Ordovician), New World Island, north-central Newfoundland. Canadian Journal of Earth

Sciences, 18:1653-1665.

Fåhraeus, L.E. and Hunter, D. 1986. The curvature-transition series: Integral part of some simple-cone conodont apparatuses (Panderodontacea, Distacodontacea, Conodontata). Acta Palaeontologica Polonica, 30:177-189.

Fåhraeus, 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, 52:444-471.

Flower, R.H. 1978. St. George and Table Head cephalopod zonation in western Newfoundland. In CURRENT RESEARCH, Part A. Geological Survey of Canada, Paper 78-1A:217-224.

Fortey, R.A. 1975. Early Ordovician trilobite communities. Fossils and Strata, 4:339-360.

Fortey, R.A. 1979. Early Ordovician trilobites from the Catoche Formation (St. George Group), western Newfoundland. Geological Survey of Canada Bulletin, 321:61-114.

Furnish, W.M. 1938. Conodonts from the Prairie du Chien (Lower Ordovician) of the upper Mississippi Valley. Journal of Paleontology, 12:318-340.

Gedik, I. 1977. Conodont biostratigraphy in the middle Taurus. Türkiye Jeoloji Kuruku Bülteni, 20:35-48.

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, 14:1-26.

Greggs, R.G. and Bond, I.J. 1971. Conodonts from the March and Oxford Formations in the Brockville area, Ontario. Canadian Journal of Earth Sciences, 8:1455-1471.

Hamar, G. 1966. The Middle Ordovician of the Oslo region, Norway. Norsk Geologisk Tidsskrift, 46:27-83.

Harris, A.G., Bergström, S.M., Ethington, R.L. and Ross, R.J.,Jr. 1979. Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions. Brigham Young University Geology Studies, 26:7-43.

Harris, R.W. 1964. Subgenera of the conodont genus Multioistodus in Simpson-Burgen (Ordovician) of

Oklahoma. Oklahoma Geology Notes, 22:199-211.

Harris, R.W. and Harris, B. 1965. Some West Spring Creek (Ordovician Arbuckle) conodonts from Oklahoma. Oklahoma Geology Notes, 25:34-47.

Haywick, D.W. and James, N.P. 1984. Dolomites and dolomitization of the Lower Ordovician St. George Group of western Newfoundland. pp. 531-536 In R.V. Gibbons (Ed.) CURRENT RESEARCH. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 84-1.

Higgins, A.C. 1967. The age of the Durine Member of the Durness Limestone Formation at Durness. Scottish Journal of Geology, 3:382-387.

Hintze, L.F. 1951. Lower Ordovician detailed stratigraphic sections for western Utah and eaastern Nevada. Utah Geological and Mineralogical Survey Bulletin, 39:1-99.

Hünicken, M.A. 1971. Sobre el allazgo de conodontes en las calizas de la formacion San Juan (Ordovicico, Llanvirniano) Quebrada Petrerillos, Sierra de Yanso, Dpto. Jachal (Prov. de San Juan). Ameghiniana, 8:37-51.

Hünicken, M.A. and Gallino, E.J. 1970. Les conodontes de la Formacion San Juan (Llanvirniano). Revista de la Facultad de Ciencias Exactas, Fisicas y naturales de la Universitad de Cordoba, Serie Ciencias geologicas, 1:5-12.

Igo, H. and Koike, T. 1967. Ordovician and Silurian conodonts from the Langkawi Islands, Malaya. Geology and Palaeontology of Southeast Asia, III:1-29.

James, N.P., Botsford, J.W. and Williams, S.H. 1987. Allochthonous slope sequence at Lobster Cove Head: evidence for a complex Middle Ordovician platform margin in western Newfoundland. Canadian Journal of Earth Sciences, 24:1199-1211.

James, N.P., Knight, I., Stevens, R.K. and Barnes, C.R. 1988. Sedimentology and paleontology of an early Paleozoic continental margin, western Newfoundland. Geological Association of Canada, Mineralogical Association of Canada, Canadian Society of Petroleum Geologists, Field Trip Guidebook, Trip B1. Geological Association of Canada, Newfoundland Section, St. John's, 121pp.

James, N.P. and Stevens, R.K. 1982. Anatomy and evolution of a Lower Paleozoic continental margin, western Newfoundland. ELEVENTH INTERNATIONAL CONGRESS ON SEDIMENTOLOGY, FIELD EXCURSION 2B GUIDE BOOK. 75 pp.

James, N.P. and Stevens, R.K. 1986. Stratigraphy and correlation of the Cambro-Ordovician Cow Head Group, western Newfoundland. Geological Survey of Canada, Bulletin 366:142 pp.

Jones, P.I. 1971. Lower Ordovician conodonts from the Bonaparte Gulf Basin and the Daly River Basin, Northwestern Australia. Australia Bureau of Mineral Resources, Geology and Geophysics, Bulletin 117, 1-80.

Kenna, K. 1985. Upper Canadian to Whiterock conodonts of the upper St. George Group, western Newfoundland. Canadian Paleontology and Biostratigraphy Seminar, 1985. Programme with Abstracts, p.45.

Kennedy, D.J. 1980. A restudy of conodonts described by Branson and Mehl, 1933, from the Jefferson City Formation, Lower Ordovician, Missouri. Geologica et Palaeontologica, Sonderdruck, 14:45-76.

Kindle, C.H. and Whittington, H.B. 1958. Stratigraphy of the Cow Head region, western Newfoundland. Geological Society of America Bulletin, 60:315-342.

Klappa, C.F. and James, N.P. 1980. Small lithistid sponge bioherms, early Middle Ordovician Table Head Group, western Newfoundland. Bulletin of Canadian Petroleum Geology, 28:425-451.

Klappa, C.F., Opalinski, P.R. and James, N.P. 1980. Middle Ordovician Table Head Group of western Newfoundland: a revised stratigraphy. Canadian Journal of Earth Sciences, 17:1007-1019.

Kluyver, H.M. 1975. Stratigraphy of the Ordovician St. George Group in the Port au Choix area, western Newfoundland. Canadian Journal of Earth Sciences, 12:589-594.

Knight, I. 1977. Cambro-Ordovician platformal rocks of the Northern Peninsula, Newfoundland. pp. 1-27 In R.V. Gibbons (Ed.) CURRENT RESEARCH. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 77-6.

Knight, I. 1978. Platformal sediments on the Great Northern Peninsula: stratigraphic studies and geological mapping of the north St. Barbe District. pp. 140-150 In R.V. Gibbons (Ed.) Report of Activities for 1977. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 78-1.

Knight, I. 1980. Cambro-Ordovician carbonate stratigraphy of western Newfoundland; sedimentation, diagenesis and zinc-lead mineralization. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. 1154. 43 pp.

Knight, I. 1985. Geological mapping of Cambrian and Ordovician sedimentary rocks of the Bellburns (121/5/6), Portland Creek (121/4) and Indian Lookout (121/3) map areas, Great Northern Peninsula, Newfoundland. pp. 79-88 In K. Brewer, D. Walsh and R.V. Gibbons (Eds.) CURRENT RESEARCH. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 85-1.

Knight, I. and Boyce, W.D. 1984. Geological mapping of the Port Saunders (12I/11), St. John Island (12I/14) and parts of the Torrent River (12I/10) and Bellburns (12I/6) map sheets, northwestern Newfoundland. pp. 114-124 In M.J. Murray, J.G. Whelan and R.V. Gibbons (Eds.) CURRENT RESEARCH. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 84-1.

Knight, I. and James, N.P. 1987. The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: the interaction between eustasy and tectonics. Canadian Journal of Earth Sciences, 24:1927-1951.

Kohut, J.J. 1972. Conodont biostratigraphy of the Lower Ordovician Orthoceras and Stein Limestones (3c), Norway. Norsk Geologisk Tidsskrift, 52:427-445.

Kovács, S. and Árkai, P. 1987. Conodont alteration in metamorphosed limestones from northern Hungary, and its relationship to carbonate texture, illite crystallinity and vitrinite reflectance; pp. 209-229 In R.L. Austin (Ed.) CONODONTS: INVESTIGATIVE TECHNIQUES AND APPLICATIONS. Ellis Horwood Limited, Chichester.

Landing, E. 1976. Early Ordovician (Arenigian) conodont and graptolite biostratigraphy of the Taconic Allochthon, eastern New York. Journal of Paleontology, 50:614-646.

Landing, E. 1983. Highgate Gorge: Upper Cambrian and Lower Ordovician continental slope deposition and biostratigraphy, northwestern Vermont. Journal of Paleontology, 57:1149-1187.

Landing, E. and Barnes, C.R. 1981. Conodonts from the Cape Clay Formation (Lower Ordovician), southern Devon Island, Arctic Archipelago. Canadian Journal of Earth Sciences, 18:1609-1628.

Landing, E., Barnes, C.R. and Stevens, R.K. 1986. Tempo of earliest Ordovician graptolite faunal succession:

conodont-based correlations from the Tremadocian of Quebec. Canadian Journal of Earth Sciences, 23:1928-1949.

Landing, E. and Ludvigsen, R. 1984. Classification and conodont-based age of the Ordovician trilobite Ellsaspis (middle Arenigian, Ville Guay, Quebec). Canadian Journal of Earth Sciences, 21:1483-1490.

Lane, T.E. 1984. Preliminary classification of carbonate breccias, Newfoundland Zinc Mines, Daniel's Harbour, Newfoundland. pp. 505-512 In R.V. Gibbons (Ed.): CURRENT RESEARCH. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 84-1.

Lee, H.-Y. 1970. Conodonten aus der Choson-Gruppe (Unteres Ordovizium) von Korea. Neues Jahrbuch für Geologie und Palaontologie. Abhandlungen 136:303-344.(In german)

Lee, H.-Y. 1975. Conodonts from the Lower and Middle Ordovician of North Korea. Palaeontographica Abt. A, 150:161-186.

Legall, F.D., Barnes, C.R. and MacQueen, R.W. 1981. Thermal maturation, burial history and hotspot development, Paleozoic strata of southern Ontario-Quebec, from conodont and acritarch colour alteration studies. Bulletin of Canadian Petrology Geology, 29:492-539.

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, St. John's, Newfoundland, 276 pp.

Lindström, M. 1955. Conodonts from the lowermost Ordovician strata of south-central Sweden. Geologiska Foreningen i Stockholm Forhandlingar, 76:517-604.

Lindström, M. 1960. A Lower-Middle Ordovician succession of conodont faunas. International Geological Congress, 21st Session, Part 7:88-96.

Lindström, M. 1971. Lower Ordovician conodonts of Europe. Geological Society of America, Memoir 127:21-61.

Lindström, M. and Ziegler, W. 1981. Surface micro-ornamentation and observations on internal composition. pp. 41-52 In R.A. Robison (Ed.) TREATISE ON INVERTEBRATE PALEONTOLOGY, Part W, Miscellanea. Supplement 2, Conodonta. The Geological Society of America and University of Kansas, Boulder, Colorado, and Lawrence, Kansas.

Löfgren, A. 1978. Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. Fossils and Strata, 13,1-129.

Logan, W.E. 1864. Geology of Canada. Geological Survey of Canada, Progress to 1863. 983pp.

McHargue, T.R. 1983. Ontogeny, philogeny, and apparatus reconstruction of the conodont genus Histiodella, Joins Fm., Arbuckle Mountains, Oklahoma. Journal of Paleontology, 56:1410-1433.

McTavish, R.A. 1973. Prioniodontacean conodonts from the Emanuel Formation (Lower Ordovician) of Western Australia. Geologica et Palaeontologica, Sonderdruck, 7:27-58.

McTavish, R.A. and Legg, D.P. 1976. The Ordovician of the Canning Basin, Western Australia. pp. 447-478 In M.G. Bassett (Ed.) THE ORDOVICIAN SYSTEM: PROCEEDINGS OF A PALAEONTOLOGICAL ASSOCIATION SYMPOSIUM, BIRMINGHAM, SEPTEMBER 1974. University of Wales Press and National Museum of Wales, Cardiff. 696pp.

Mayr, U., Uyeno. T.T. and Barnes, C.R. 1978. Subsurface stratigraphy, conodont zonation, and organic metamorphism of the Lower Paleozoic succession, Bjorne Peninsula, Ellesmere Island, District of Franklin. In CURRENT RESEARCH, Part A, Geological Survey of Canada, Paper 78-1A:393-398.

Mehl, M.G. and Ryan, W.A. 1944. Conodonts from the Jefferson City. University of Missouri Studies, 19:45-52.

Miller, J.F. 1969. Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah. Journal of Paleontology, 43:413-439.

Moskalenko, T.A. 1967. Konodonty chun'skogo yarusa (nizhniy Ordovik) rek Moyero i Podkamennaya Tunguska [Lower Ordovician conodonts of Chunsk Stage from River Moiero and Podkamennaya Tunguska]. pp. 98-116 In A.B. Ivanovskiy and B.S. Sokolov (Eds.): NOVYE DANNYE PO BIOSTRATIGRAFIY NIZHNEGO PALEOZOYA SIBIRSKOI PLATFORMY [NEW DATA ON THE BIOSTRATIGRAPHY OF THE LOWER PALEOZOIC OF THE SIBERIAN PLATFORM]. Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Geologii i Geofiziki. Izdatel'stvo "Nauka", Moskva. 162pp. [In Russian]

Moskalenko, T.A. 1982. Konodonty [Conodonts]. pp. 100-144 In B.S. Sokolov (Ed.): ORDOVIK SIBIRSKOI PLATFORMY (OPORNYI RAZREZ NA R. KULYUMBE) [ORDOVICIAN OF THE SIBERIAN PLATFORM(KEY SECTION ON THE KULUMBE RIVER)]. Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Geologii i

Geofiziki, Trudy 506. Izdatel'stvo "Nauka", Moskva. 223pp. [In Russian]

Moskalenko, T.A. 1983. Conodonts and biostratigraphy in the Ordovician of the Siberian Platform. Fossils and Strata, 15:87-94.

Moskalenko, T.A. 1984. Gruppa Conodontophorida. pp. 113-137 In T.A. Moskalenko (Ed.): ORDOVIK SIBIRSKOI PLATFORMY. PALEONTOLOGICHESKIY ATLAS [PALAEONTOLOGICAL ATLAS OF THE ORDOVICIAN OF THE SIBERIAN PLATFORM]. Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, Vypusk 590. Izdalet'stvo "Nauka", Novosibirsk. 242pp. [In Russian]

Mound, M.C. 1965a. Two new conodont genera from the joins Formation (lower Middle Ordovician) of Oklahoma. Biological Society of Washington Proceedings, 7:193-200.

Mound, M.C. 1965b. A conodont fauna from the Joins Formation (Ordovician), Oklahoma. Talune Studies in Geology, 4:1-46.

Mound, M.C. 1968. Conodonts and biostratigraphy of the lower Arbuckle Group (Ordovician), Arbuckle Mountains, Oklahoma. Micropaleontology, 14:393-434.

Muller, K.J. 1981. Micromorphology of elements. pp. 20-41 In R.A. Robison (Ed.) 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.

Mussman, W.J. and Read, J.F. 1986. Sedimentology and development of a passive- to convergent-margin unconformity: Middle Ordovician Knox unconformity, Virginia Appalachians. Geological Society of America, Bulletin 97:282-295.

Nicoll, R.S. 1981. Conodont colour alteration adjacent to a volcanic plug, Canning Basin, Western Australia. BMR Journal of Australian Geology and Geophysics, 6:265-267.

Nowlan, G.S. 1976. Late Cambrian to Late Ordovician conodont evolution and biostratigraphy of the Franklinian Miogeosyncline, eastern Canadian Arctic Islands. Ph.D. dissertation, University of Waterloo, Waterloo, Ontario. 590pp.

Nowlan, G.S. and 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. Geological Survey of Canada, Bulletin 367, 1-47.

Nowlan, G.S. and Barnes, C.R. 1987b. Application of conodont colour alteration indices to regional and economic geology; pp. 188-202 In R.L. Austin (Ed.) CONODONTS: INVESTIGATIVE TECHNIQUES AND APPLICATIONS. Ellis Horwood Limited, Chichester.

Nowlan, G.S. and Thurlow, J.G. 1984. Middle Ordovician conodonts from the Buchans Group, central Newfoundalnd, and their significance for regional stratigraphy of the Central Volcanic Belt. Canadian Journal of Earth Sciences, 21:284-296.

Nyman, M., Quinn, L., Reusch, D.N. and Williams, H. 1984. Geology of Lomond map area, Newfoundland. In CURRENT RESEARCH, Part A, Geological Survey of Canada, Paper 84-1A:157-164.

Pohler, S.L., Barnes, C.R. and James, N.P. 1987. Reconstructing a lost faunal realm: conodonts from mega-conglomerates of the Ordovician Cow Head Group, western Newfoundland. pp. 341-362 In R.L. Austin (Ed.): CONODONTS: INVESTIGATIVE TECHNIQUES AND APPLICATIONS. Ellis Horwood Ltd, Chichester.

Pratt, B.R. 1979. Sedimentology, diagenesis and cryptalgal structures, the St. George Group, (Lower Ordovician), western Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 231 pp.

Pratt, B.R. and James, N.P. 1982. Cryptalgal-metazoan bioherms of early Ordovician age in the St. George Group, western Newfoundland. Sedimentology, 29:543-569.

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, 33:313-344.

Quinlan, G.M. and Beaumont, C. 1984. Appalachian thrusting, lithospheric flexure, and the Paleozoic stratigraphy of the eastern interior of North America. Canadian Journal of Earth Sciences, 21:973-996.

Raymond, P.E. 1925. Some trilobites of the Lower Middle Ordovician of eastern North America. Museum of Comparative Zoology Bulletin, 67:1-180.

Rejebian, V.A., Harris, A.G. and Huebner, J.S. 1987. Conodont colour and textural alteration; An index to regional metamorphism, contact metamorphism, and hydrothermal alteration. Geological Society of America, Bulletin 99:471-479.

Repetski, J.E. 1982. Conodonts from El Paso Group (Lower Ordovician) of westernmost Texas and southern New Mexico. New Mexico Bureau of Mines and Mineral Resources, Memoir 40:1-121.

Repetski, J.E. and Ethington, R.L. 1977. Conodonts from graptolite facies of the Ouachita Mountains, Arkansas and Oklahoma. ARKANSAS GEOLOGICAL COMMISSION, SYMPOSIUM ON THE GEOLOGY OF THE OUACHITA MOUNTAINS, VOL. 1:92-106.

Repetski, J.E. and Ethington, R.L. 1983. Rossodus manitouensis (Conodonta), a new early Ordovician index fossil. Journal of Paleontology, 57:289-310.

Rexroad, C.B., Droste, J.B. and Ethington, R.L. 1982. Conodonts from the Everton Dolomite and the St. Peter Sandstone (lower Middle Ordovician) in a core from southwestern Indiana. Indiana Geological Survey Occasional Paper 39:1-13.

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, ard Lawrence, Kansas, 202pp.

Rodgers, J. and Neale, E.R.W. 1963. Possible "Taconic" klippen in western Newfoundland. American Journal of Science, 261:713-730.

Ross, R.J.,Jr. 1975. Early Paleozoic trilobites, sedimentary facies, lithosphere plates and ocean currents. Fossils and Strata, 4: 307-330.

Ross, R.J.,Jr. 1977. Ordovician paleogeography of western United States. pp. 19-38 In J.H. Stewart, C.H. Stevens, and A.E. Fritsche, (Eds.):PALEOZOIC PALEOGEOGRAPHY OF WESTERN UNITED STATES. Pacific Section, Society of Economic Paleontologists and Mineralogists. Pacific Coast Paleogeography Symposium 1.

Ross, R.J.,Jr, Adler, F.J., Amsden, T.W., Bregstrom, D., Bergström, S.M., Carter, C., Churkin, M., Cressman, E.A., Derby, J.R., Dutro, J.T.,Jr., Ethington, R.L., Finney, S.C., Fisher, D.W., Fisher, J.H., Harris, A.G., Hintze, L.F., Ketner, K.B., Kolata, D.L., Landing, E., Neuman, R.B., Sweet, W.C., Pojeta, J.,Jr., Potter, A.W., Rader, E.K., Repetski, J.E., Shaver, R.H., Thompson, T.L. and Webers, G.F. 1982. The Ordovician System in the United States. International Union of Geological Sciences, Publication No. 12:1-73.

Ross, R.J.,Jr. and James, N.P. 1987. Brachiopod biostratigraphy of the middle Ordovician Cow Head and Table Head groups, western Newfoundland. Canadian Journal of Earth Sciences, 24:70-95.

Ruedemann, R. 1947. Graptolites of North America. Geological Society of America, Memoir 19, 625 p.

Schopf, T.J.M. 1966. Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec. New York State Museum and Science Service Bulletin, 405:1-105.

Schuchert, C. and Dunbar, C.O. 1934. Stratigraphy of western Newfoundland. Geological Society of America, Memoir 1:1-123.

Scotese, C.R., Bambach, R.K., van der Voo, R. and Zeigler, A.M. 1979. Paleozoic base maps. Journal of Geology, 87:217-277.

Sergeeva, S.P. 1963. Conodonts from the Lower Ordovician of the Leningrad region. Paleontologicheskii Zhurnal, 2:93-108.

Serpagli, E. 1974. Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). Bollettino della Società Paleontologica Italiana, 13:17-98.

Sloss, L.L. 1963. Sequences in the cratonic interior of North America. Geological Society of America Bulletin, 74:93-113.

Stevens, R.K. 1970. Cambro-Ordovician flysch sedimentation and tectonics in west Newfoundland and their possible bearing on a proto-Atlanic Ocean. Geological Association of Canada, Special Paper No. 7:165-177.

Stockmal, G.S., Colman-Sadd, S.P., Keen, C.E., O'Brien, S.J. and Quinlan, G. 1987. Collision along an irregular margin: a regional plate tectonic interpretation of the Canadian Appalachians. Canadian Journal of Earth Sciences, 24:1098-1107.

Stouge, S.S. 1982. Preliminary conodont biostratigraphy and correlation of Lower to Middle Ordovician carbonates of the St. George Group, Great Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 82-3, 59pp.

Stouge, S.S. 1983a. Notes on the geology of the St. Juliens's map area (2M/4), Great Northern Peninsula, Newfoundland. (To accompany Map 82-68). Newfoundland Department of Mines and Energy. Mineral Development Division. 15 pp.

Stouge, S.S. 1983b. Notes on the geology of the Salmon River map area (12P/1), Great Northern Peninsula, Newfoundland. (To accompany Map 82-69). Newfoundland Department of Mines and Energy. Mineral Development Division. 11 pp.

Stouge, S.S. 1984. Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. Fossils and Strata, 16:1-145.

Stouge, S.S. and Boyce, W.D. 1983. Fossils of northwestern Newfoundland and southeastern Labrador: conodonts and trilobites. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 83-3. 55pp.

Sweet, W.C., Ethington, R.L. and Barnes, C.R. 1971. North American Middle and Upper Ordovician conodont faunas. Geological Society of America, Memoir 127:163-193.

Sweet, W.C. and Schonlaub, H.P. 1975. Conodonts of the genus Oulodus Branson and Mehl, 1933. Geologica et Palaeontologica, Sonderdruck, 9:41-59.

Teraoka, Y., Sawata, H., Yoshida, T. and Pungrassami, T. 1982. Lower Paleozoic formations of the Tarutao Islands, southern Thailand. Prince of Songkhla University Geological Research Project, Pub. No. 6:1-54.

Tipnis, R.S., Chatterton, B.D.E. and Ludvigsen, R. 1978. Ordovician conodont biostratigraphy of the southern District of Mackenzie, Canada. Geological Association of Canada, Special Paper 18:39-91.

Twidale, C.R. 1973. GEOMORPHOLOGY. Thomas Nelson (Aust.) Ltd, Melbourne, 406 pp.

Ul'st, R. Zh., Gailite, L.K. and Yakovleva, V.I. 1982. ORDOVIK LATVII [THE ORDOVICIAN OF LATVIA]. Ministerstvo Gazovoi Promytslennosti SSSR, Vsesoyuzniy nauchno-issledovatel'skii Institut Morskoi Geologii i Geofiziki. Riga "Zinatne". 294pp. [In Russian]

Uyeno, T.T. and Barnes, C.R. 1970. Conodonts from the Lévis Formation (Zone D1) (Middle Ordovician), Levis, Quebec. Geological Survey of Canada, Bulletin 187:99-123.

Vail, P.R., Hardenbol, J. and Todd, R.G. 1984. Jurassic unconformities, chronostratigraphy, and sea level changes from seismic stratigraphy and biostratigraphy. pp. 129-144 In J.S. Schlee (Ed.) INTERREGIONAL UNCONFORMITIES AND HYDROCARBON ACCUMULATION. A.A.P.G. Memoir 36. 184pp.

van Wamel, W.A. 1974. Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of north-western Öland, south-eastern Sweden. Utrecht Micropaleontological Bulletins, 10:1-126.

Viira, V. 1967. Ordovician conodont succession in the Ohesaare core. Akademii Nauk Estonskoi SSR Izvestiya, 16:319-329.

Viira, V. 1974. KONODONTY ORDOVIKA PRIBALTIKI [ORDOVICIAN CONODONTS OF THE EAST BALTIC]. Institut Geologii Akademii Nauk Estonskoi SSR, Tallin, 142pp. [In Russian]

Watson, S.T. (in press). Conodonts from Santalum No. 1A core of the Nita and Goldwyer formations (lower Middle Ordovician) of the Canning Basin, Western Australia. Palaeontographica.

Webers, J.F. 1966. The Middle and Upper Ordovician conodont faunas of Minnesota. Minnesota Geological Survey Special Publication, 4:1-123.

Webby, B.D., VandenBerg, A.H.M., Cooper, R.A., Banks, M.R., Burrett, C.F., Henderson, R.A., Clarkson, P.D., Hughes, C.P., Laurie, J., Stait, B., Thomson, M.R.A. and Webers, G.F. 1981. The Ordovician System in Australia, New Zealand and Antarctica. International Union of Geological Sciences, Publication No. 6:1-64.

Whittington, H.B. and Kindle, C.H. 1963. Middle Ordovician Table Head Formation, western Newfoundland. Geological Society of America Bulletin, 74:745-758.

Williams, H. 197[illegible]. Tectonic - lithofacies map of the Appalachian Orogen (1:1.000.000). Department of Geology, Memorial University of Newfoundland. Map No. 1, St. John's.

Williams, H. and Hatcher, R.D., Jr. 1982. Suspect terranes and accretionary history of the Appalachian orogen. Geology, 10:530-536.

Williams, H. and Cawood, P.A. 1986. The Cow Head Group and its regional setting in western Newfoundland. Geological Association of Canada, Program with Abstracts, 11:145.

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 trilobite, brachiopod and conodont zones. Canadian Journal of Earth Sciences, 24:456-470.

Williams, S.H. and Stevens, R.K. 1987. Summary account of the Lower Ordovician (Arenig) graptolite biostratigraphy of the Cow Head Group, western Newfoundland. Bulletin of the Geological Society of Denmark, 35:259-270.

Williams, S.H. and Stevens, R.K. (1988). Arenig graptolites of the Cow Head Group, western Newfoundland. Palaeontographica Canadiana, No. 5, 167pp.

Workum, R.H., Bolton, T.E. and Barnes, C.R. 1976. Ordovician geology of Akpatok Island, Ungava Bay, District of Franklin. Canadian Journal of Earth Sciences, 13:157-178.

Ziegler, W. 1973. CATELOGUE OF CONODONTS, vol. 1. E. Schweizerbart'sche, Stuttgart, 504pp.

Plate 1

All light photographs unless otherwise indicated.

Figs. 1,2. Ansella sp.: 1. oistodontiform, figured specimen GSC 93030, lateral, D.D.H. A1.05, X80; 2. tetraprioniodontiform, figured specimen GSC 93029, lateral, D.D.H. A1.05, X80.

Figs. 3-7. Bergstroemognathus alus n.sp.: all x80; 3. zygognathodontiform (b) element, paratype, GSC 93032, posterolateral, TP13, SEM; 4. prioniodontiform (f) element, paratype, GSC 93035, posterolateral, TP13, SEM; 5.cordylodontiform (a) element, paratype, GSC 93031, posterior, TP13, SEM; 6. falodontiform (e) element, paratype, GSC 93034, inner lateral, TP13, SEM; 7. trichonodelliform (c) element, holotype, GSC 93033, posterolateral view of inner face, TP13, SEM.

Figs. 8-12. Bergstroemognathus extensus Serpagli: all X50; 8. prioniodontiform (f) element, hypotype, GSC 93040, inner lateral, BC2; 9. trichonodelliform (c) element, hypotype, GSC 93038, posterior view, BC2; 10. falodontiform (e) element, hypotype, GSC 93039, inner, BC2; 11. zygognathodontiform (b) element, hypotype, GSC 93037, lateral, BC2, SEM; 12. cordylodontiform (a) element, hypotype, GSC 93036, inner, BC2.

Figs. 13-14. Clavohamulus cavus n.sp.: 13. Holotype, GSC 93041, lateral, D.D.H. A1.07, X100, SEM; 14. paratype, GSC 93042, aboral, D.D.H. A1.07, X120, SEM.

Figs. 15-16. Cristodus sp. cf. C. loxoides Repetski: 15. monodenticulate, hypotype, GSC 93044, lateral, AGR2, X80. 16. multidenticulate element, hypotype, GSC 93043, inner, D.D.H. 715.19, X80.

Figs. 17-21. Drepanodus arcuatus Pander: 17. sulponeaform (p') element, hypotype, GSC 93080, lateral, BC2, X50; 18. homocurvatiform (p"), hypotype, GSC 93081, lateral, BC2, X50; 19. acontiodontiform (p'") element, hypotype, GSC 93082, lateral, BC2, X50, SEM; 20. pipaform (q) element, hypotype, GSC 93083, lateral, BC2, X100; 21. arcuatiform (p) element, hypotype, GSC 93079, lateral, BC2, X50.

Figs. 22-27. Drepanodus concavus Branson and Mehl: all X50; 22. graciliform (g) element, hypotype, GSC 93089, lateral, KC11; 23. pipaform (e) element, hypotype, GSC 93087, lateral, D.D.H. 715.11; 24. arcuatiform (b) element, hypotype, GSC 93085, lateral, KC 10; 25. sculponeaform (f) element, hypotype, GSC 93088, lateral, D.D.H. A1.11; 26. homocurvatiform (a) element, hypotype, GSC 93084, lateral, KC10; 27. suberectiform (c) element, hypotype, GSC 93086, lateral, KC11.

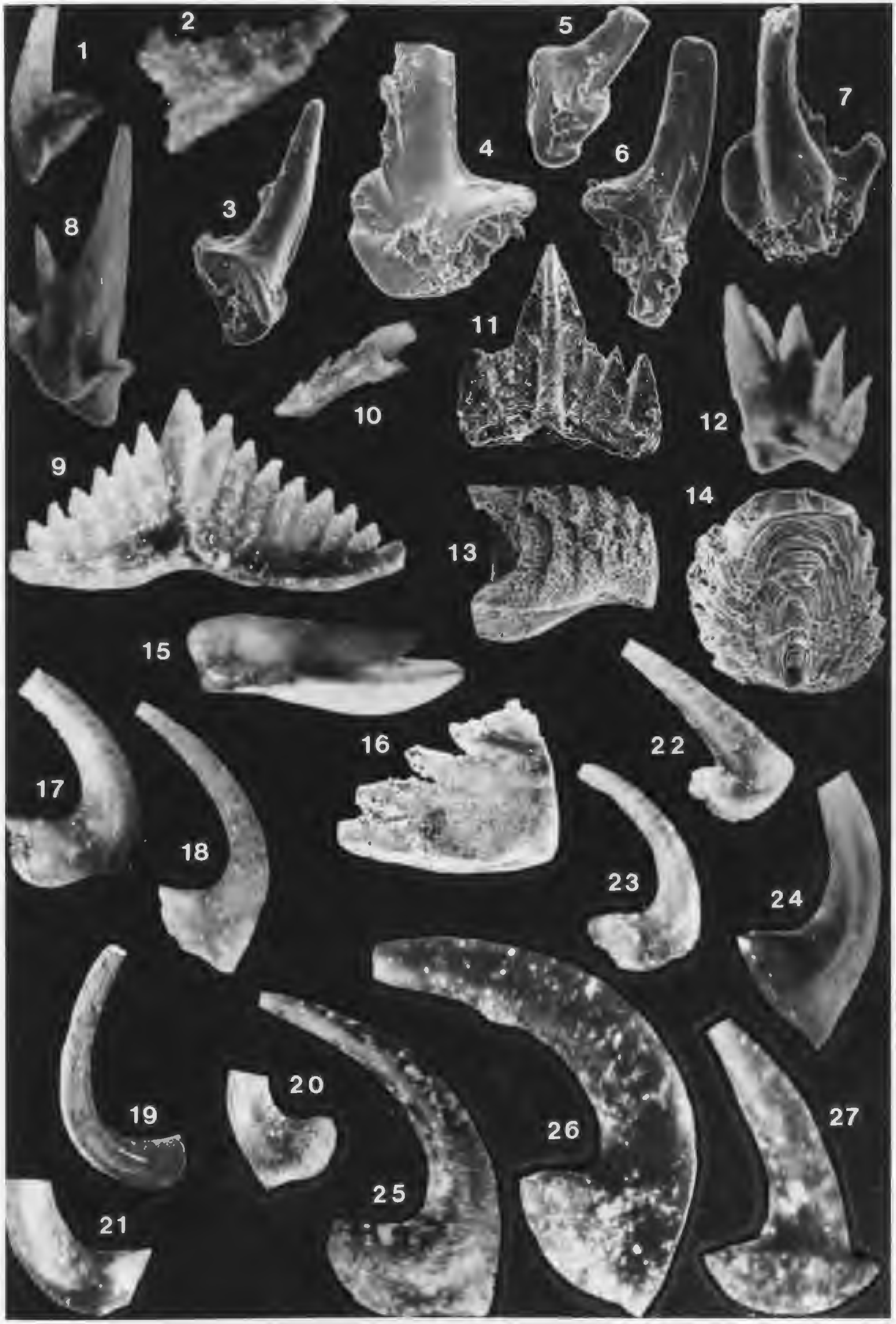

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Plate 2

Figs. 1-6. Diaphorodus delicatus (Branson and Mehl): all X100; 1. drepanodontiform (a) element, hypotype, GSC 93045, lateral, D.D.H. A1.09, SEM; 2. gothodontiform (b) element, hypotype, GSC 93046, lateral, BC1, SEM; 3. distacodontiform (d) element, hypotype, GSC 93048, lateral, BC1; 4. acontiodontiform (c) element, hypotype, GSC 93047, inner lateral, BC1, SEM; 5. oistodontiform (e) element, hypotype, GSC 93049, inner lateral, BC1; 6. prioniodontiform (f) element, hypotype, GSC 93050, posterolateral, D.D.H. A1.07.

Figs. 7-13. Diaphorodus emanuelensis (McTavish): all X100; 7. drepanodontiform (a) element, hypotype, GSC 93052, lateral, KC13, SEM; 8. drepanodontiform (a) element, hypotype, GSC 93051, lateral, KC11; 9. gothodontiform (b) element, hypotype, GSC 93053, posterior, KC13, SEM; 10. acontiodontiform (c) element, hypotype, GSC 93054, inner lateral, KC13 SEM; 11. tetraprioniodontiform (d) element, hypotype, GSC 93055, inner lateral, KC13, SEM; 12. oistodontiform (e) element, hypotype, GSC 93056, lateral, KC13, SEM; 13. prioniodontiform (f) element, hypotype, GSC 93057, inner lateral, KC13, SEM.

Figs. 14-19. Diaphorodus gravelsensis n.sp.: 14. drepanodontiform (a) element, paratype, GSC 93058, inner lateral, AgR3, X60; 15. gothodontiform (b) element, paratype, GSC 93059, inner lateral, D.D.H. 715.17, X100, SEM; 16. acontiodontiform (c) element, paratype, GSC 93060, posterolateral, D.D.H. 715.17, X80, SEM; 17. distacodontiform (d) element, paratype, GSC 93062, lateral, D.D.H. 715.22, X80, SEM; 18. oistodontiform (e) element, paratype, GSC 93063, lateral, D.D.H. 715.17, X60; 19. prioniodontiform (f) element, holotype, GSC 93064, inner lateral, D.D.H. 715.17, X100, SEM.

Figs. 20-25. ?Diaphorodus russoi (Serpagli): all X100, all SEM; 20. cordylodontiform (a) element, hypotype, GSC 93065, lateral, D.D.H. A1.06; 21. gothodontiform (b) element, hypotype, GSC 93066, inner lateral, D.D.H. A1.07; 22. acontiodontiform (c) element, hypotype, GSC 93067, anterolateral, D.D.H. A1.06; 23. tetraprioniodontiform (d) element, hypotype, GSC 93068, lateral, D.D.H. A1.06; 24. oistodontiform (e) element, (cusp broken), hypotype, GSC 93069, inner lateral, D.D.H. A1.06; 25. belodontiform (f) element (broken), hypotype, GSC 93071, inner lateral, D.D.H. A1.06.

Figs. 26-32. Diaphorodus stevensi n.sp.: 26. drepanodontiform (a) element, paratype, GSC 93072, lateral, AGR3, X60; 27. gothodontiform (b) element, paratype, GSC 93073, inner lateral, D.D.H. 715.22, X60; 28. acontiodontiform (c) element, paratype, GSC 93074, posterior, AP3, X70, SEM; 29. distacodontiform (d) element, paratype, GSC 93075, posterolateral, AgR3, X100, SEM; 30. distacodontiform (d) element, paratype, GSC 93076, anterolateral, D.D.H. 715.17, X60; 31. oistodontiform (e) element, paratype, GSC 93077, inner lateral, AP3, X40, SEM; 32. prioniodontiform (f) element, holotype, GSC 93078, inner lateral, D.D.H. 715.02, X60, SEM.

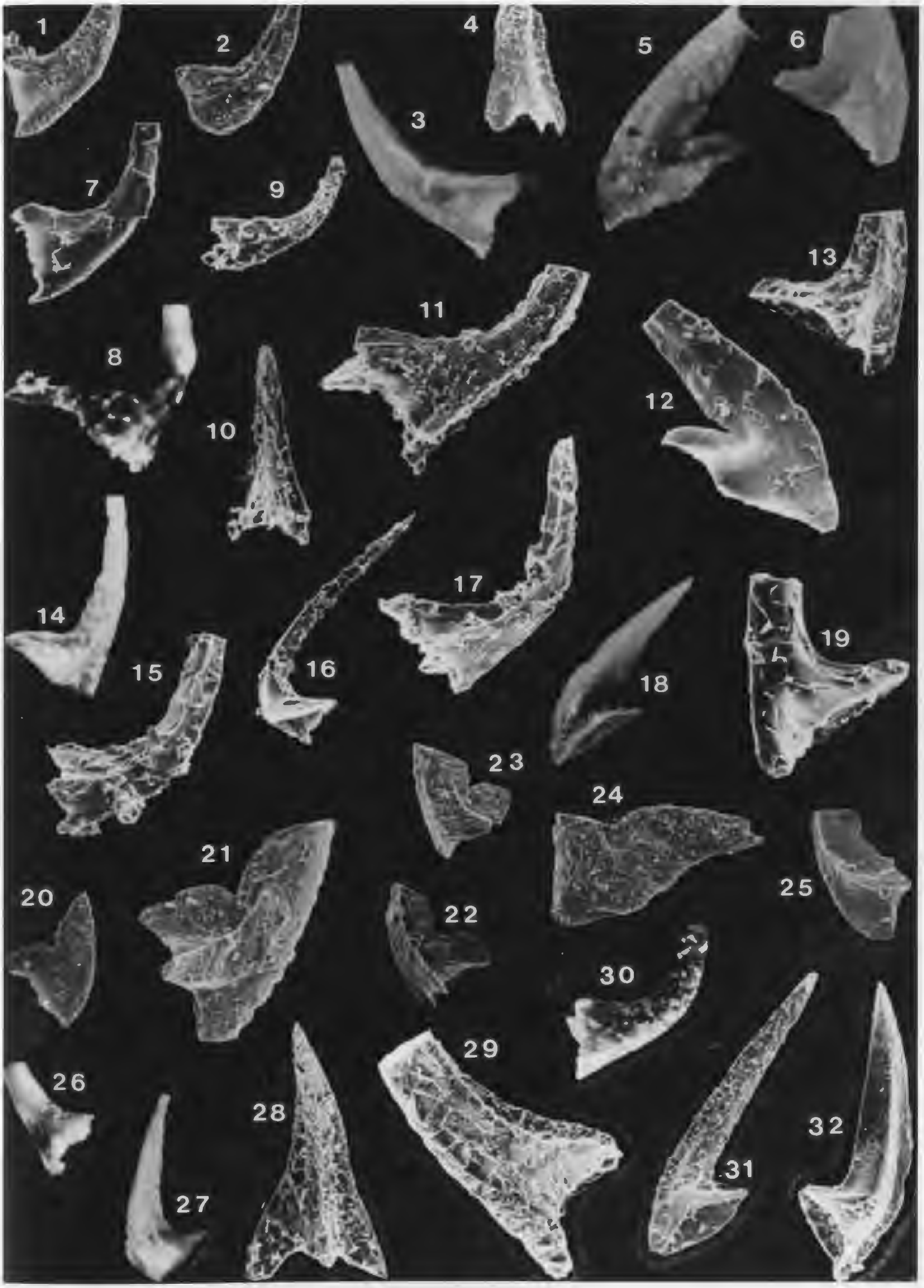
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Plate 3

Figs. 1-6. Drepanodus sp. cf. D. gracilis (Branson and Mehl): all X50; 1. homocurvatiform (a) element, figured specimen GSC 93090, lateral, AGB2; 2. arcuatiform (b) element, figured specimen GSC 93091, lateral, TP13; 3. suberectiform (c) element, figured specimen GSC 93092, lateral, TP13; 4. pipaform (e) element, figured specimen GSC 93093, lateral, TP13; 5. sculponeaform (f) element, figured specimen GSC 93094, lateral, TP12; 6. graciliform (g) element, figured specimen GSC 93095, lateral, TP13.

Figs. 7-10. Drepanoistodus angulensis (Harris): all X100, all SEM; 7. homocurvatiform (q) element, hypotype, GSC 93097, lateral, TP13; 8. oistodontiform (r) element, hypotype, GSC 93099, aboral, D.D.H. 715.17; 9. scandodontiform (q') element, hypotype, GSC 93098, inner lateral, D.D.H. 715.11; 10. suberectiform (p) element (broken), hypotype, GSC 93096, lateral, TP13.

Figs. 11-13. Drepanoistodus basiovalis (Sergeeva): 11. oistodontiform (r) element, hypotype, GSC 93103, lateral, AGC1, X90, SEM; 12. suberectiform (p) element, hypotype, GSC 93101, lateral, AGC1, X80, SEM; 13. homocurvatiform (q) element, hypotype, GSC 93102, lateral, BC1, X80.

Figs. 14-15. Drepanoistodus forceps (Lindström): both X80; 14. oistodontiform (r) element, hypotype, GSC 93105, inner lateral, BC2, SEM; 15. homocurvatiform (q) element, hypotype, GSC 93104, lateral, AgC1, SEM.

Figs. 16-18. Drepanoistodus inaequalis (Pander): all X80; 16. homocurvatiform (q) element, hypotype, GSC 93108, lateral, D.D.H. A1.14; 17. oistodontiform (r) element, hypotype, GSC 93109, lateral, D.D.H. A1.14; 18. suberectiform (p) element, hypotype, GSC 93107, lateral, D.D.H. A1.14.

Figs. 19-23. Erismodus asymmetricus Branson and Mehl: all X50, all SEM; 19. cordylodontiform (a) element, hypotype, GSC 93110, inner lateral, TP13; 20. zygognathodontiform (b) element, hypotype, GSC 93111, posterolateral, TP16; 21. trichonodelliform (c) element, hypotype, GSC 93112, posterior, TP13; 22. aphelognathodontiform (q) element, hypotype, GSC 93114, posterior, TP13; 23. oulodontiform (f) element, hypotype GSC 93113, posterior, TP13.

Figs. 24-29. ?Erismodus sp.: all SEM; 24. cordylodontiform (a) element, figured specimen GSC 93115, lateral, TP13, X50; 25. zygognathodontiform (b) element, figured specimen GSC 93116, aboral, TP13, X30; 26. trichonodelliform (c) element, figured specimen GSC 93117, lateral, TP15A, X50; 27. strachanognathodontiform (e) element, figured specimen GSC 93118, lateral, TP15A, X50; 28. aphelognathodontiform (g) element, figured specimen GSC 93120, posterolateral, TP13, X50; 29. oulodontiform (f) element, figured specimen GSC 93119, posterolateral, TP13, X50.

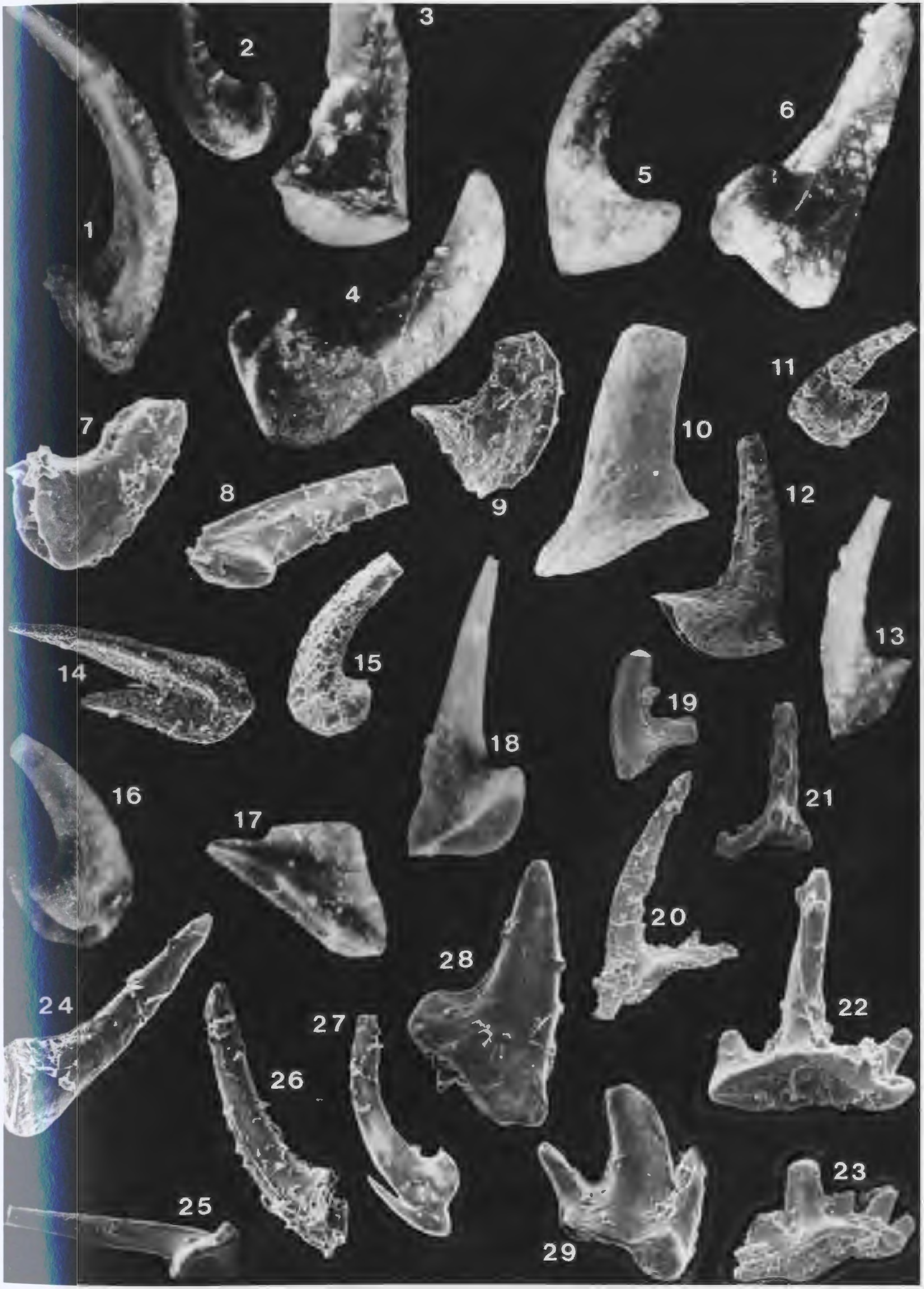
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Plate 4

Figs. 1-7. Erraticodon balticus Dzik: all X50; 1. hindeodelliform (a) element, hypotype, GSC 93121, lateral, AGE1; 2. zygognathodontiform (b) element, hypotype, GSC 93122, lateral, AGE1; 3. cardiodelliform (f') element, hypotype, GSC 93127, oral, AGE1; 4. neoprioniodontiform (e) element, hypotype, GSC 93124, lateral, AGE1; 5. prioniodontiform (g) element, hypotype, GSC 93125, lateral, AGE1; 6. trichonodelliform (c) element, hypotype, GSC 93123, anterolateral, AGE1; 7. ozarkodiniform (f) element, hypotype, GSC 93126, posterolateral, AGE1.

Figs. 8,11,17. Eucharodus parallelus (Branson and Mehl): 8. plano-convex element, hypotype, GSC 93128, aboral, KC11, X30, SEM; 11. Hypotype, GSC 93129, lateral, D.D.H. A1.14, X50; 17. element with ovate aboral opening, hypotype, GSC 93130, KC11, X30, SEM.

Figs. 9,10,12. Fryxellodontus corbatoi Serpagli: 9. "symmetricus" (c) element, hypotype, GSC 93133, outer, BC2, X120, SEM; 10. "intermedius" (b) element, hypotype, GSC 93132, inner, BC2, X70, SEM; 12. "planus" (a) element, hypotype, GSC 93131, oral, D.D.H. A1.06, X120, SEM.

Figs. 18-19. Glyptoconus quadraplicatus (Branson and Mehl): both X50; 18. quadriplicatiform element, hypotype, GSC 93134, lateral, D.D.H. A1.11; 19. triplicatiform element, hypotype, GSC 93135, inner lateral, D.D.H. A1.11.

Figs. 15-16,22. Glyptoconus rectus (Stouge): 15. triplicatiform element, hypotype, GSC 93137, lateral, D.D.H. 715.10, X50; 16. triplicatiform element, hypotype, GSC 93138, posterolateral, D.D.H. 715.09, X100, SEM; 22. quadraplicatiform element, hypotype, GSC 93136, lateral, D.D.H. 715.10, X50, SEM.

Figs. 13-14,20-21. Histiodella holodentata Ethington and Clark: all X80; 13. short bryantodontiform (a) element, hypotype, GSC 93139, lateral, AGE1; 14. oistodontiform (e) element, hypotype, GSC 93140, lateral, AGE1; 20. spathognathodontiform (g) element, hypotype, GSC 93141, inner, D.D.H. 498.02; 21. spathognathodontiform (g) element, hypotype, GSC 93142, inner, AGE1.

Fig. 23. Juanognathus jaanussoni Serpagli: 23. Hypotype, GSC 93144, posterior, TP11, X60.

Fig. 24. Juanognathus variabilis Serpagli: 24. Hypotype, GSC 93143, posterolateral, BC3, X60.

Fig. 27. Jumudontus gananda Cooper: 27. Hypotype, GSC 93145, inner, TP10, X60.

Figs. 25-26,28. *Leptochirognathus quadrata* Branson and Mehl: 25. cordylodontiform (*a*) element, hypotype, GSC 93146, inner, TP13, X100, SEM; 26. trichonodelliform (*c*) element, hypotype, GSC 93148, inner, TP13, X80, SEM; 28. zygognathodontiform (*b*) element, hypotype, GSC 93147, inner, TP13, X80.

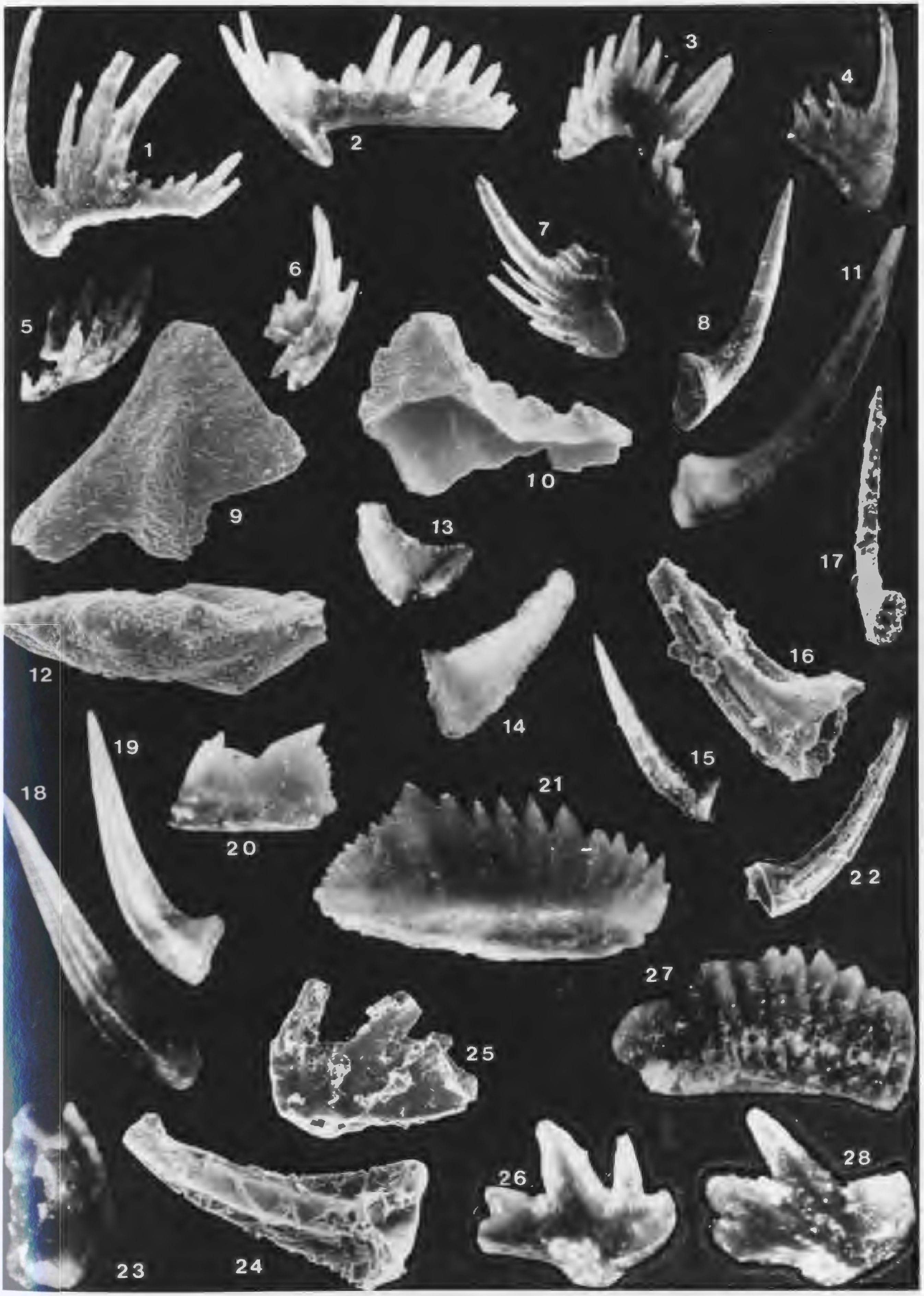
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Plate 5

Figs. 1-2. Leptochirognathus quadrata Branson and Mehl: 1. oistodontiform (e) element, hypotype, GSC 93149, inner, TP13, X90, SEM; 2. cyrtoniodontiform (f) element, hypotype, GSC 93150, inner, TP13, X100, SEM.

Figs. 3-6,10. Leptochirognathus planus n.sp.: 3. cordylodontiform (a) element, paratype, GSC 93151, inner, TP13, X90, SEM; 4. zygognathodontiform (b), paratype, GSC 93152, inner, TP13, X80; 5. trichonodelliform (c) element, paratype, GSC 93153, outer, TP13, X80; 6. cyrtoniodontiform (f) element, holotype, GSC 93155, inner, TP13, X80; 10. oistodontiform (e) element, paratype, GSC 93154, inner, TP13, X80.

Fig. 8. Macerodus dianae Fåhraeus and Nowlan: 8. Hypotype, GSC 93156, lateral, BC1, X70.

Figs. 7,9,11-14. ?Microzarkodina marathonensis (Bradshaw): all X70; 7. gothodontiform (b) element, hypotype, GSC 93157, inner lateral, BC2; 9. prioniodontiform (f) element, hypotype, GSC 93160, inner lateral, BC2; 11. arched ozarkodiniform (g) element, hypotype, GSC 93161, lateral, BC2; 12. straight ozarkodinaform (g') element, hypotype, GSC 93162, lateral, BC2; 13. trichonodelliform (c) element, hypotype, GSC 93158, lateral, D.D.H. 438.22; 14. oistodontiform (e) element, hypotype, GSC 93159, lateral (broken anterior), BC2.

Figs. 16-18. ?Multioistodus auritus (Harris and Harris): All X55; 16. acodontiform (b) element, hypotype, GSC 93164, lateral, TP13, SEM; 17. trichonodelliform (c) element, hypotype, GSC 93165, lateral, TP13, SEM; 18. cordylodontiform (a) element, hypotype, GSC 93163, lateral, TP13, SEM.

Figs. 15,19-20,22. Multioistodus subdentus Cullison: 15. acodontiform (b) element, hypotype, GSC 93167, lateral, TP13, X50, SEM; 19. distacodontiform (d) element, hypotype, GSC 93169, lateral, TP13, X40, SEM; 20. trichonodelliform (c) element, hypotype, GSC 93168, anterior, TP13, X50, SEM; 22. cordylodontiform (a) element, hypotype, GSC 93166, lateral, TP13, X150, SEM.

Figs. 21,28-31. Oepikodus communis (Ethington and Clark): 21. prioniodontiform (f) element, hypotype, GSC 93174, outer lateral, KC5, X100, SEM; 28. cordylodontiform (a) element, hypotype, GSC 93170, lateral, D.D.H. A1.11, X60; 29. gothodontiform (b) element, hypotype, GSC 93171, lateral, D.D.H. A1.11, X100; 30. tetraprioniodontiform (d) element, hypotype, GSC 93172, lateral, BC2, X60; 31. falodontiform (e) element, hypotype, GSC 93173, lateral, BC2, X60.

Figs. 26-27,32-34. Oepikodus intermedius Serpagli: All X60; 26. prioniodontiform (f) element, hypotype, GSC 93179, inner lateral, D.D.H. 715.08; 27 falodontiform (e) element, hypotype, GSC 93178, lateral, D.D.H. 715.20; 32. cordylodontiform (a) element, hypotype, GSC 93175, lateral, D.D.H. 715.20; 33. tetraprioniodontiform (d) element, hypotype, GSC 93177, lateral, D.D.H. 715.25; 34. gothodontiform (b) element, hypotype, GSC 93176, inner lateral, D.D.H. 715.25.

Figs. 23-25. ?Protoprioniodus costatus van Wamel: all X60; 23. oistodontiform (e) element, hypotype, GSC 93227, lateral, D.D.H. A1.06; 24. elongatiform (f) element, hypotype, GSC 93228, lateral, D.D.H. A1.06; 25. gothodontiform (b) element, hypotype, GSC 93226, lateral, D.D.H. A1.06.


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Plate 6

Figs. 1-5. Oistodus bransoni Ethington and Clark: All X30; 1. trichonodelliform (c) element, hypotype, GSC 93182, BC2; 2. cordylodontiform (a) element, hypotype, GSC 93180, lateral, KC4; 3. distacodontiform (d) element, hypotype, GSC 93183, lateral, KC5, SEM; 4. cladognathodontiform (b) element, hypotype, GSC 93181, lateral, BC2; 5. oulodontiform (a'?) element, hypotype, GSC 93184, inner lateral, BC2.

Figs. 6-8. Oistodus multicorrugatus Harris: all X30, SEM; 6. trichonodelliform (c) element, hypotype, GSC 93187, lateral, D.D.H. 438.19; 7. cordylodontiform (a) element, hypotype, GSC 93185, lateral, TP8; 8. cladognathodontiform (b) element, hypotype, GSC 93186, lateral, TP8.

Figs. 9-10. Oneotodus costatus Ethington and Clark: All X60; 9. Hypotype, GSC 93189, posterolateral, D.D.H. 66A.02; 10. Hypotype, GSC 93188, lateral, D.D.H. A1.14.

Figs. 11-12. Paltodus sweeti Serpagli: All X50; 11. robustiform (drepanodontiform, p) element, hypotype, GSC 93190, outer lateral, BC2; 12. sweetiform (oistodontiform, q) element, hypotype, GSC 93191, inner lateral, BC2.

Figs. 13-14. Paracordylodus gracilis Lindström: 13. gothodontiform (b) element, hypotype, GSC 93192, lateral, D.D.H.A1.06, X90; 14. oistodontiform (e) element, hypotype, GSC 93193, lateral, D.D.H. A1.05, X100, SEM.

Figs. 15-16. Parapanderodus abemarginatus n.sp.: All X60; 15. emarginatiform (posteriorly grooved, t) element, holotype, GSC 93195, lateral, AGE6, SEM; 16. drepanodontiform (ungrooved, s) element, paratype, GSC 93194, lateral, AGB2.

Figs. 17-19. Parapanderodus aequalis n.sp.: 17. short based (s) element, holotype, GSC 93196, lateral, KC1, X100, SEM; 18. triangulariform (t) element, paratype, GSC 93198, posterolateral, BC1, X80, SEM; 19. long based (s') element, paratype, GSC 93197, posterolateral, BC1, X90, SEM.

Figs. 20-22. Parapanderodus striolatus (Harris and Harris): 20. triangulariform (t) element, hypotype, GSC 93204, lateral, AgW1, X60; 21. long based (s') element, hypotype, GSC 93203, lateral, TP13, X60; 22. short based (s) element, hypotype, GSC 93202, lateral, D.D.H. 498.02, X50.

Figs. 23-25. Parapanderodus striatus (Graves and Ellison): All X80; 23. triangulariform (t) element, hypotype, GSC 93201, lateral, D.D.H. A1.11; 24. long based (s') element, hypotype, GSC 93200, posterolateral, BC1; 25. short based (s) element, hypotype, GSC 93199, lateral, D.D.H. A1.07.

Figs. 26-30. Paraprioniodus costatus Ethington and Clark: 26. trichonodelliform (c) element, hypotype, GSC 93207, posterolateral, TP13, X50; 27. zygognathodontiform (b) element, hypotype, GSC 93206, lateral, AGW1, X50; 28. extended prioniodontiform (f) element, hypotype, GSC 93209, anterior, TP13, AGW1, X50; 29. tetraprioniodontiform (d) element, hypotype, GSC 93208, lateral, AGW1, X50; 30. cordylodontiform (a) element, hypotype, GSC 93205, lateral, TP15, X30, SEM.

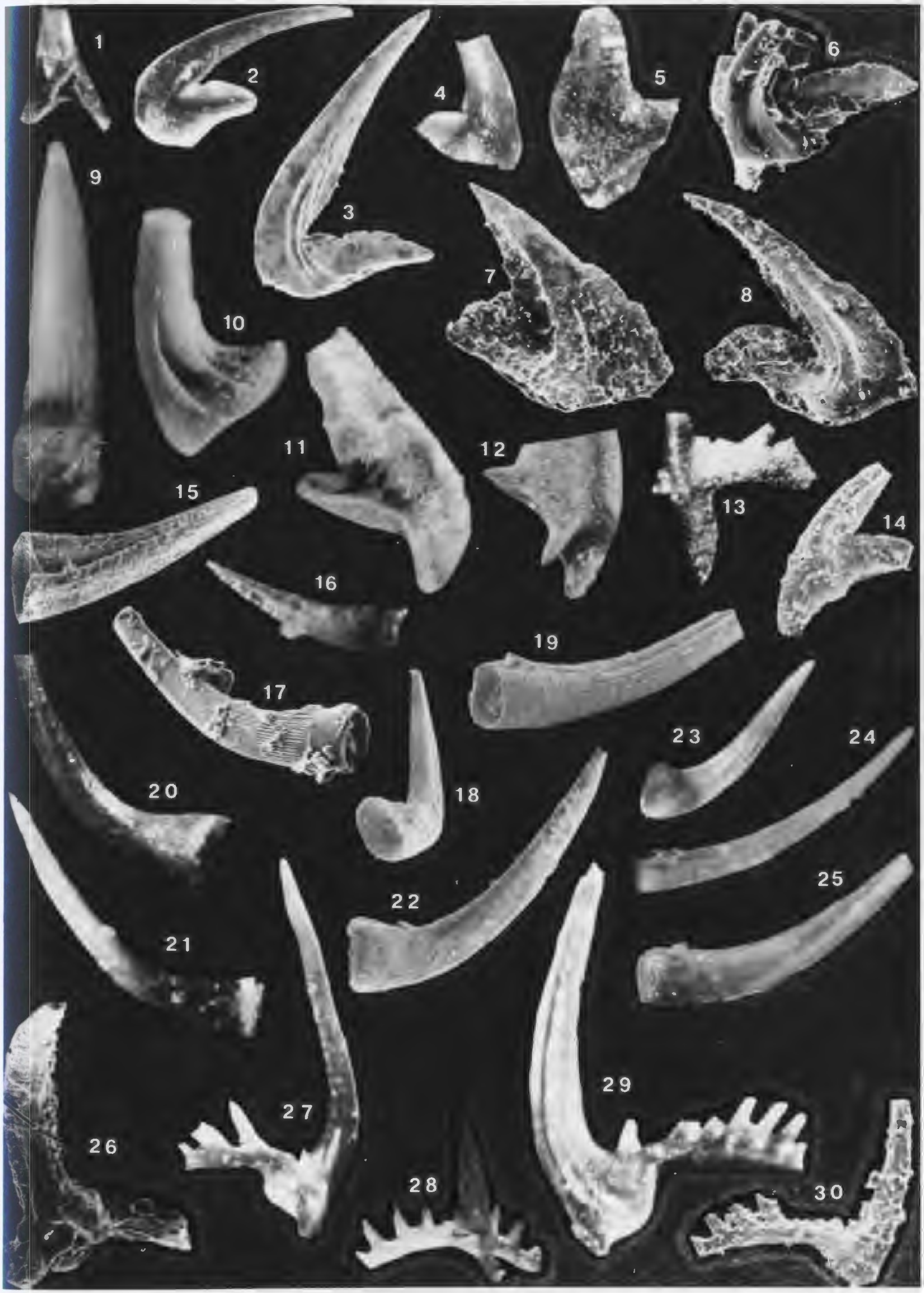
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Plate 7

Figs. 1-5. Paroistodus parallelus (Pander): all X50; 1. drepanodontiform (a) element, hypotype, GSC 93210, aboral, BC2, SEM; 2. acodontiform (b) element, hypotype, GSC 93211, lateral, BC2, SEM; 3. oistodontiform (e) element, hypotype, GSC 93213, lateral, BC2, SEM; 4. distacodontiform (d) element, hypotype, GSC 93212, lateral, BC2; 5. scandodontiform (f) element, hypotype, GSC 93214, lateral, D.D.H. A1.07.

Figs. 6-7. Paroistodus proteus (Lindström): 6. drepanodontiform (a) element, hypotype, GSC 93215, lateral, BC2; 7. oistodontiform (e) element, hypotype, GSC 93216, lateral, D.D.H. A1.14.

Figs. 8-10. ?Prioniodus elegans Pander sensu van Wamel: all X70; 8. gothodontiform (b) element, hypotype, GSC 93218, inner lateral, TP2, SEM; 9. tetraprioniodontiform (d) element, hypotype, GSC 93219, lateral, BC2; 10. ?cordylodontiform (a) element, hypotype, GSC 93217, lateral, BC2.

Figs. 11-13. Protopanderodus gradatus Serpagli: all X70; 11. acontiodontiform (c) element, hypotype, GSC 93222, lateral, BC1; 12. scandodontiform (a) element, hypotype, GSC 93220, lateral, D.D.H. A1.09, SEM; 13. paltodontiform (b) element, hypotype, GSC 93221, lateral, D.D.H. A1.06, SEM.

Figs. 14-17. Protopanderodus strigatus Barnes and Poplawski: 14. scandodontiform (a), hypotype, GSC 93223, lateral, TP13, X100, SEM; 15. paltodontiform (b) element, hypotype, GSC 93224, outer lateral, APO2, X60; 16. paltodontiform (b) element, hypotype, GSC 93224 (same specimen), inner lateral, APO2, X60; 17. acontiodontiform (c) element, hypotype, GSC 93225, lateral, TP13, X70, SEM.

Figs. 18-20. ?Protoprioniodus papilosus (van Wamel): 18. cordylodontiform (a) element, hypotype, GSC 93231, lateral, D.D.H. 440.09, X100, SEM; 19. trichonodelliform (c) element, hypotype, GSC 93232, anterolateral, BC2, X130, SEM; 20. prioniodontiform (f) element, hypotype, GSC 93233, lateral, D.D.H. A1.12, X70, SEM.

Figs. 21-22. Pteracontiodus cryptodens (Mound): All X40; 21. acodontiform (b) element, hypotype, GSC 93235, inner lateral, TP9A, SEM; 22. cordylodontiform (a) element, hypotype, GSC 93234, lateral, D.D.H. 715.12, SEM.

Figs. 23-24. ?Reutterodus sp.: 23. Hypotype, GSC 93237, inner lateral, TP14, X100, SEM; 24. Hypotype, GSC 93236, inner lateral, TP11, X60, SEM.

Figs. 25-27. Rossodus highgatensis Landing, Barnes and Stevens: all X100, all from D.D.H. A1.11; 25. pentacostate (c') element, hypotype, GSC 93238, lateral; 26. oistodontiform (e) element, hypotype, GSC 93240, lateral; 27. trapezognathodontiform (d) element, hypotype, GSC 93239, lateral.

Figs. 28-33. Rossodus symmetricus n.sp.: 28. trapezognathodontiform (d) element, holotype, GSC 93245, posterior, D.D.H. A1.07, X50; 29. pentacostate (c') element, paratype, GSC 93244, lateral, BC2, X100; 30. drepanodontiform (a) element, paratype, GSC 93241, lateral, BC2, X50; 31. acontiodontiform (c) element, paratype, GSC 93242, posterior, D.D.H. A1.06, X50; 32. scandodontiform (f) element, paratype, GSC 93249, lateral, D.D.H. A1.06, X50; 33. oistodontiform (e) element, paratype, GSC 93248, lateral, BC2, X50.

Figs. 34-36. Scalpellodus n.sp.: all X60, all from KC5; 34. scandodontiform (t) element, hypotype, GSC 93252, lateral; 35. long based (s') element, hypotype, GSC 93251, lateral; 36. short based (s) element, hypotype, GSC 93250, lateral.

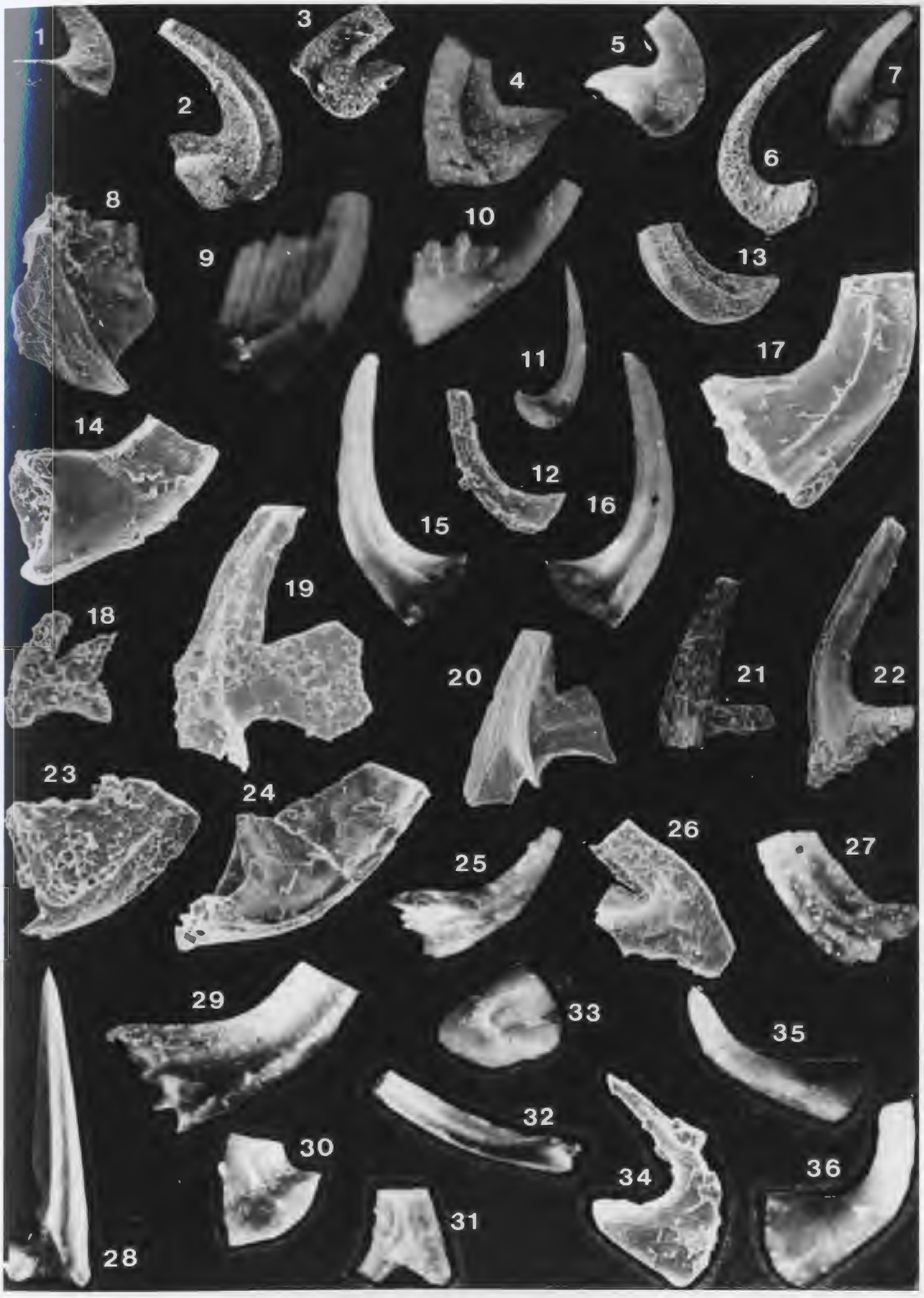
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Plate 8

Figs. 1-6. Scandodus sinuosus Mound: all SEM; 1. oistodontiform (e) element, hypotype, GSC 93256, posterolateral, TP13, X70; 2. distacodontiform (d) element, hypotype, GSC 93255, aboral, TP13, X70; 3. acodontiform (g) element, hypotype, GSC 93258, lateral, TP 13, X60; 4. acontiodontiform (c) element, hypotype, GSC 93254, posterior, TP13, X60; 5. drepanodontiform (a) element, hypotype, GSC 93253, lateral, TP13, X40; 6. scandodontiform (f) element, hypotype, GSC 93257, lateral, TP13, X70.

Fig. 7. "Scolopodus" emarginatus Barnes and Tuke: 7. Hypotype, GSC 93259, lateral, BC1, X125, SEM.

Fig. 8. "Scolopodus" filosus Ethington and Clark: 8. Hypotype, GSC 93260, lateral, BC1, X80.

Figs. 9-10. Semiacontiodus asymmetricus (Barnes and Poplawski): all X100; 9. asymmetrical (t) element, hypotype, GSC 93262, posterior, BC1, SEM; 10. symmetrical (s) element, hypotype, GSC 93261, posterior, BC1, SEM.

Figs. 11-13. ?Semiacontiodus cordis (Hamar): 11. posteriorly grooved (s) element, hypotype, GSC 93263, lateral, BC1, X120, SEM; 12. ungrooved asymmetrical (t) element, hypotype, GSC 93264, lateral, BC1, X70; 13. bicostate (u) element, hypotype, GSC 93265, lateral, D.D.H. A1.07, X70.

Figs. 14. Striatodontus carlae (Repetski): 14. Symmetrical (s) element, hypotype, GSC 93266, posterior, D.D.H. A1.07, X80.

Figs. 15-16. Striatodontus kakivangus n.sp.: all X80; 15. asymmetrical (t) element, paratype, GSC 93268, posterior, TP13, SEM; 16. symmetrical (s) element, holotype, GSC 93267, posterior, TP1.

Figs. 17-20. Tripodus laevis Bradshaw: all X60; 17. paltodontiform (f) element, hypotype, GSC 93272, anterolateral, TP8, SEM; 18. oistodontiform (e) element, hypotype, GSC 93271, inner lateral, KC4; 19. drepanodontiform (a) element, hypotype, GSC 93269, lateral, KC3; 20. trichonodelliform (c) element, hypotype, GSC 93270, posterolateral, D.D.H. A1.05, SEM.

Figs. 21-27. Variabiliconus n.sp. A: 21. drepanodontiform (f) element, figured specimen, GSC 93278, posterolateral, BC2, X50, SEM: 22. posteriorly and anteriorly sulcate (d') element, figured specimen, GSC 93276, posterior, D.D.H. A1.05, X60, SEM; 23. quadricostate (d) element, figured specimen, GSC 93275, posterolateral, BC2, X100, SEM; 24. acontiodontiform (c) element, figured specimen, GSC 93274, posterolateral, D.D.H. A1.05, X50, SEM; 25. laterally unicostate (a) element, figured specimen, GSC 93273, posterolateral, BC2, X50, SEM; 26. scandodontiform (g) element, figured specimen, GSC 93279, inner lateral, D.D.H. A1.14, X60, SEM; 27. posteriorly sulcate (e) element, figured specimen, GSC 93277, posterolateral, BC1, X70.

Figs. 28-31. ?New gen. 1 n.sp. B: all X90; 28. cordylodontiform (a) element, figured specimen GSC 93292, lateral, BC2; 29. acodontiform (b) element, figured specimen GSC 93294, lateral, BC2; 30. distacodontiform (d) element, figured specimen GSC 93295, aboral, D.D.H. A1.11; 31. acodontiform (b) element, figured specimen GSC 93291, inner lateral, BC1.


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Plate 9

Figs. 1-2,4-5. ?New gen. 1 n.sp. A: all X60; 1. distacodontiform (d) element, figured specimen GSC 93291, lateral, BC2; 2. cladognathodontiform (c) element, figured specimen GSC 93290, lateral, BC2; 4. acodontiform (b) element, figured specimen GSC 93289, inner lateral, BC2; 5. drepanodontiform (a) element, figured specimen GSC 93288, lateral, BC2.

Fig. 3. Walliserodus ethingtoni (Fåhraeus): 3. Figured specimen GSC 93287, lateral, D.D.H. 66A.03, X50.

Figs. 6-8,11-12,15-16. Variabiliconus n.sp. B: 6. scandodontiform (g) element, figured specimen GSC 93286, posterolateral, KC13, X50, SEM; 7. quadricostate (d) element, figured specimen GSC 93283, posterolateral, KC13, X50, SEM; 8. drepanodontiform (f) element, figured specimen GSC 93285, lateral, KC13, X50, SEM; 11. bicostate (b) element, figured specimen GSC 93281, posterior, KC11, X50, SEM; 12. laterally unicostate (a) element, figured specimen GSC 93280, posterolateral, KC13, X50, SEM; 15. acontiodontiform (c) element, GSC 93282, lateral, KC13; 16. posteriorly sulcate (e) element, figured specimen GSC 93284, lateral, KC13, X50, SEM.

Surface alteration:-

Standard: 9. zygognathodontiform (b) element, GSC 93296, AgW1, X50; 19. enlargement of cusp, X250.

Effect of diagenetic fluids: 10. homocurvatiform (a) element of Drepanodus sp. cf. D. gracilis, GSC 93297, TP11, X25; 20. enlargement of GSC 93297, X250; 23. Eucharodus parallelus, detail of cusp, GSC 93298, TP12, X250.

Contact metamorphism: 13. drepanodontiform (a) element, GSC 93299, HAG2, X50; 17, enlargement of previous, X250; 14. Multioistodus subdentatus, lower grade metamorphism, GSC 93300, HAG6, X25; 21. enlargement of GSC 93300.

Conodonts from ore zone: 18. broken drepanodontiform (a) element, GSC 93301, D.D.H. 1827.03, X50; 22. enlargement of cusp of previous specimen, X250.


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APPENDIX A:1. Stratigraphic log of D.D.H. A1, measured by K. Stait.

Distance down drill hole (metres)	Lithology
	Catoche Formation
0 - 6.6	Boulders and disconnected rubble. Predominantly dolostone; vuggy, light grey; base with 1.6 m well developed pseudobreccia.
6.6 - 7.2	Pseudobreccia; grading upwards into vuggy, light grey, sucrosic dolostone.
7.2 - 8.4	Dolostone; medium to coarse grained, medium grey, with rounded fossil intraclasts.
8.4 - 9.4	Pseudobreccia in thin bands within above lithology; some stylolites.
9.4 - 9.9	Dolostone; fine to medium grained, light to medium grey mottles.
9.9 - 10.5	Pseudobreccia within above lithology.
10.5 - 11.0	Dolostone; sucrosic, light grey to buff; partly obliterated stylolites.
11.0 - 11.4	Pseudobreccia.
11.4 - 12.3	Dolostone; fine grained grading up to medium grained, light grey, stylolites and shaly concentrations into wavy black bands; chert nodules and spar veins.
12.3 - 12.8	Pseudobreccia.

12.8 - 13.1	Limestone; medium grained, grey, bioturbated; stylolites concentrated near base; sparry white veins.
13.1 - 13.7	Pseudobreccia within previous lithology.
13.7 - 14.8	Dolostone; medium to fine grained, grey, bioturbated; stylolites.
14.8 - 16.3	Dolostone; medium grained to sucrosic, vuggy.
16.3 - 16.5	Dolostone, medium grained, grey, crinoid columnals and other bioclasts.
16.5 - 17.2	Dolostone; medium grained, buff to light grey; vuggy, sucrosic texture.
17.2 - 17.9	Dolostone; fine-grained, light grey, bioturbated and stylolitized.
17.9 - 18.6	Dolostone, medium grained, light grey to buff, sucrosic; some white sparry dolomite.
18.6 - 22.4	Dolostone; fine-grained, light grey with brown burrow mottles.
22.4 - 29.8	Limestone; massive, fine-grained, grey; intramuros dolomites around stylolites, some bioturbation and round white intraclasts.
29.8 - 30.8	Limestone; fine-grained, light grey, intraformational breccia at base of beds.
30.8 - 30.9	Dolostone; medium grained, buff, sucrosic, partly obliterated stylolites.
30.9 - 36.4	Limestone; massive, fine-grained, light grey with brown intramuros dolomite surrounding

	stylolites; intraformational breccia at base.
36.4 - 40.1	Limestone; massive to nodular, fine-grained, light to dark grey; stylolites concentrated at intervals.
40.1 - 41.7	Limestone; massive to nodular where stylolites concentrated; light grey, some intramuros dolomite around stylolites.
41.7 - 67.5	Limestone; massive, fine-grained, mottling in light and dark grey; stylolites and some intramuros dolomites.
67.5 - 78.5	Limestone; massive, fine-grained, burrow-mottles in light and dark grey; thin (<0.05 m) grainstone layers separated by up to 0.1m.
78.5 - 78.9	Limestone; medium grained, grey matrix, with angular to subrounded chert fragments.
78.9 - 86.9	Limestone; massive, fine-grained, light to dark grey burrow mottles grading upwards into massive, fine-grained, light grey limestone.

APPENDIX A:2. Lithologic log of D.D.H. 1827, logged by T. Lane, Teck Exploration Ltd.

Distance down drill hole (metres)	Lithology
0 - 3.4	Overburden.
	Catoche Formation
3.4 - 6.7	Dolostone; massive, fine-grained, light grey.
6.7 - 6.9	Shaly layers in base of above lithology.
6.9 - 11.3	Dolostone; massive, fine-grained, dark grey.
11.3 - 12.6	Dolostone; massive, fine-grained, medium grey; recrystallized dolomite in above lithology at 11.6 to 11.9 m.
12.6 - 12.9	Dolostone; recrystallized dolomite, medium crystalline, tan; solution disruption.
12.9 - 17.1	Dolostone; massive, fine-grained, medium grey; 0.3 to 0.6 m of recrystallized dolomites - bases at 14.8, 15.7 and 16.5 m.
17.1	OVAL MOTTLES MARKER
17.1 - 18.6	Dolostone; massive, fine-grained, medium grey; recrystallized dolomite at top.
18.6	66 AQUIFER MARKER
18.6 - 20.6	Dolostone; massive, fine-grained, medium grey; silica concentrated at 18.7-18.9, 19.2 and 19.3 m.
20.6 - 21.1	Dolostone; medium crystalline, tan,

	recrystallized.
21.1 - 21.3	Matrix breccia.
21.3 - 21.6	Dolostone; massive, fine-grained, basal 0.05m silicified.
21.6 - 21.9	Dolostone; finely laminated, fine grained, greenish; argillaceous.
21.9 - 22.6	Breccia.
22.6 - 22.8	Dolostone; massive, fine-grained, medium to light grey.
22.8 - 23.2	Dolostone; medium crystalline, tan; recrystallized; infilling of light grey, fine-grained dolomite.
23.2 - 23.9	Dolostone; massive, fine-grained, light grey; brecciated in basal 0.3 m.
23.9 - 24.2	Dolostone; massive, medium crystalline, dark grey; recrystallized.
24.2 - 25.4	Dolostone; finely laminated, fine grained, light grey.
25.4 - 25.5	Dolostone; massive, medium crystalline, dark grey, recrystallized.
25.5 - 25.8	Dolostone; laminated, fine-grained, light grey; breccia at top.
25.8 - 26.0	Dolostone; massive, medium crystalline, grey; recrystallized; vein filled with light grey, very fine-grained dolomite.
26.0 - 26.6	Dolostone; massive, fine-grained, light grey;

	0.1 m matrix breccia at base.
26.6 - 27.1	Dolostone; massive, fine to very fine grained, light grey (=interbed).
27.1 - 27.4	Pseudobreccia.
27.4 - 27.8	Interbed.
27.8 - 28.0	Pseudobreccia.
28.0 - 28.5	Interbed.
28.5 - 28.7	Dolomite vein.
28.7 - 28.9	Interbed.
28.9 - 29.1	Dolomite vein.
29.1 - 29.4	Interbed with brecciation, veining and infilling of light grey dolomite.
29.4 - 29.6	Pseudobreccia.
29.6 - 29.7	Interbed.
29.7 - 30.2	Pseudobreccia.
30.2 - 30.4	Interbed.
30.4 - 31.5	Pseudobreccia.
31.5 - 32.3	Interbed.
32.2 - 33.2	Fragmental pseudobreccia.
33.2 - 34.1	Interbed.
34.1 - 34.4	Pseudobreccia.
34.4 - 35.7	Interbed.
35.7 - 36.1	Fragmental pseudobreccia.

APPENDIX A:3. Lithologic log of D.D.H. 66A, logged by T. Lane, Teck Explorations Ltd.

Distance down drill hole (metres)	Lithology
	Aguathuna Formation
0 - 26	Dolostone; fine-grained, laminated; local disruption at 2.4 m; chert at 2.7 m.
2.8 - 7.9	Dolostone; massive, fine-grained, mottled grey and tan.
7.9 - 8.2	Dolostone; coarsely laminated, fine-grained.
8.2 - 12.4	Dolostone; massive, fine-grained, mottled grey and tan.
12.4 - 12.9	Dolostone; massive, fine-grained; irregular and abrupt upper contact.
12.9 - 13.1	Breccia; intraformational.
13.1 - 19.2	Breccia; angular to subangular clasts of argillaceous, laminated or mottled dolostone clasts in infilled medium crystalline grey matrix; irregular and abrupt upper contact; 3 similar sequences with bases at 16.2, 18.6 and 19.2 m.
19.2 - 20.0	Dolostone; massive, fine-grained, light grey, tan mottling.
20.0 - 20.4	UPPER ARGILLITE MARKER.

20.4 - 21.9	Dolostone; massive, fine-grained, tan; siliceous brecciated near top, fine veinlets.
21.9 - 22.6	Breccia; very small clasts with fine-grained grey dolomite infill; argillaceous residues around stylolites.
22.6 - 25.0	Dolostone; massive, fine-grained, medium grey; tan mottling, breccia in middle of interval with light grey medium-grained infill; vertical stylolites lined with green argillaceous material; irregular and abrupt upper and lower contacts.
25.0 - 26.3	Dolostone; coarsely laminated, thin black argillaceous layer at base.
26.3 - 26.5	Dolostone; massive, medium crystalline; recrystallized with clay residues near base.
26.5 - 26.8	Dolostone; massive, fine-grained, light grey; infilled fractures at top.
26.8 - 27.7	Dolostone; massive, medium-grained, medium grey; slight mottling; fractures near base.
27.7 - 29.4	Dolostone; massive, fine-grained, light grey; brittle fracture zone in middle of interval; black argillaceous infill at top.
29.4 - 30.0	Dolostone; coarsely laminated, fine-grained; horizontal mottling.
30.0 - 30.4	Dolostone; massive, fine-grained; mottled.

30.4 - 32.2	Dolostone; massive, very fine-grained, light grey; mottled, brittle fracture zone at top capped by black residue, breccia at base.
32.2 - 33.1	Dolostone; massive to laminated, very fine-grained, tan, mottled; brittle fracture zone at top, breccia at base.
33.1 - 33.5	Dolostone; finely laminated, slightly argillaceous; contorted laminae.
33.5 - 37.8	Dolostone; massive, very fine-grained, light grey; mottled, brittle fracture zones with associated breccias at base and upper part of interval, chert at top.
37.8 - 38.4	Breccia; medium grained grey dolomite matrix.
38.4 - 41.7	Breccia; large (1 cm) to small (1 mm) mottled and laminated dolostone clasts; grey medium grained matrix.
41.7 - 43.1	Dolostone; massive, fine-grained, light grey; sharp, irregular lower contact, but gradational upper contact.
43.1 - 44.0	Breccia; as above, in irregular layers.
44.0 - 44.6	Dolostone; massive, fine-grained, light grey; mottled.
44.6 - 46.5	Breccia; clasts predominately laminated with laminae oriented vertically.
46.5 - 48.2	Dolostone; massive, fine-grained, light grey.
48.2 - 50.0	Breccia; light grey and grey laminated

	dolostone clasts.
50.0 - 50.9	Dolostone; massive, fine-grained, grey.
50.9 - 51.8	Breccia; gravelly matrix; clasts less abundant than in above, breccias matrix supported.
51.8 - 53.2	Dolostone; massive, very fine-grained, light grey; mottled.
53.2 - 58.4	Dolostone; massive, fine-grained, light grey; mottled, thin breccias at 54.9, 55.9 and 56.7m; infill of 0.3 m deep cracks at top.
58.4 - 59.1	Breccia; clasts light grey; clast supported.
59.1 - 60.8	Breccia; polymictic, light and medium grey clasts.
60.8 - 61.0	Dolostone; massive, fine-grained light grey.
61.0 - 62.8	Breccia; grey laminated dolostone, grey massive dolostone and chert clasts; tight gravelly matrix.
62.8 - 63.7	Dolostone; massive, fine-grained.
63.7 - 67.2	Breccia; tight clusters of "jigsaw" shards; 0.5 to 5 cm clasts of grey laminated or light grey very fine-grained dolostone; matrix light grey medium grained dolomite.
67.2 - 70.9	Dolostone; fine-grained, grey; brecciated in thin layers at 68.3, 68.9, 70.1 and 70.9m.
70.9 - 72.1	Breccia; mosaic of light grey dolostone

	clasts; matrix medium grained light grey dolomite; styolites around fragments.
72.1 - 72.7	Dolostone; massive, fine-grained.
72.7 - 72.9	Breccia; local grey dolostone clasts; matrix dark.
72.9 - 73.1	Dolostone; massive, fine-grained, grey.
73.1 - 73.4	Breccia, oligomictic.
73.4 - 73.8	Dolostone; disturbed texture, fine-grained, grey; mottled.
73.8 - 77.4	Dolostone; fine-grained, grey; thin (0.2 m) beds of breccia at 76.5, 75.0, 74.4 and 74.1 m.
77.4 - 79.6	Dolostone; fine-grained, grey; predominately brecciated with clasts of this lithology, brittle fracture zone near top.
79.6 - 80.2	Breccia; scattered clasts of fine-grained grey dolostone and white silica; black residue at base.
80.2 - 82.6	Dolostone; fine-grained, grey; with disturbed layers and horizons with black residues.
82.6 - 82.9	MOTTLES CHERT MARKER
82.9 - 85.3	Dolostone; fine-grained, grey; with disturbed layers and horizons with black residues, rounded 0.5 to 1.0 cm matrix-supported clasts

	near base.
85.3 - 86.1	Dolostone; massive, fine-grained, grey.
86.1 - 96.6	Dolostone; fine-grained, grey; diffuse disturbed layers and horizons with black residues.
96.6 - 97.2	Dolostone; massive, fine-grained, grey; thin band of laminated dolostone at base.
97.2 - 102.1	Sequences of breccia with large clasts grading through massive dolostone, occasionally coarsely laminated, first light dolostone clast at middle of interval.
102.1 - 103.0	Dolostone; massive, fine-grained, grey; mottled with irregular residue boundaries.
103.0 - 103.6	Breccia; clasts 0.5 to 1.0 cm, sutured rounded dolostone clasts.
103.6 - 106.5	Breccia; polymictic 0.5 to 2.0 cm clasts, predominantly of mottled dolostone; chert horizons sparry matrix at some beds.
106.5 - 107.0	Dolostone; coarsley laminated, fine-grained, grey.
107.0 - 110.9	Breccia; polymictal clasts generally fining upwards.
110.9 - 111.9	Dolostone; fine-grained, grey; vague disturbed texture.
111.9 - 123.7	Breccia; polymictic, large (3-9 cm) clasts.
123.7 - 127.7	Dolostone; fine-grained, grey; dark residues

	with grey vague breccia at 125.1 - 125.3 m and 125.7 - 126.0 m.
127.7 - 128.0	Limestone; massive, fine-grained, medium grey.
128.0 - 129.0	Dolostone; disturbed texture, fine-grained, grey, elongate chert nodules near base.
129.0 - 129.2	Limestone; massive, fine-grained, medium grey.
129.2 - 129.5	Dolostone; massive, fine-grained, grey.
129.5 - 129.8	Limestone; massive, fine-grained, medium grey.
129.8 - 130.1	Dolostone; massive, fine-grained, grey.
130.1 - 130.4	Limestone; massive, fine-grained, medium grey.
130.4 - 131.7	Dolostone; massive, fine-grained, grey; chert concentrated at 131.1 m.
131.7 - 132.0	Breccia; grey.
132.0 - 134.1	Dolostone; disturbed texture, fine-grained, grey.

APPENDIX A:4. Stratigraphic log of D.D.H. 438, logged by K. Stait.

<u>Distance down drill hole</u> (metres)	<u>Lithology</u>
0 - 2.4	Overburden.
	<u>Catoche Formation</u>
2.4 - 3.0	Limestone; massive, light grey, grading upwards into laminates.
3.0 - 3.6	Limestone; evenly laminated, grey.
3.6 - 5.9	Limestone; burrow-mottled, light grey; chert bands.
5.9 - 6.4	Limestone; massive, light grey, with stylolites, grading into dark grey algalaminate.
6.4 - 7.2	Shale; medium grey, with algalaminate.
7.2 - 8.2	Limestone; burrow-mottled, dark to light grey, birdseyes, stylolites; flat-pebble conglomerate horizons.
8.2 - 11.4	Limestone; massive, light grey, stylolites, chert concentrations at 10.0 to 10.4 m.
	<u>Aguathuna Formation</u>
11.4 - 14.9	Dolostone; laminated to thinly bedded, light and dark grey.
14.9 - 16.3	Dolostone; burrow mottled, rare thin bands of laminates; birdseyes.
16.3 - 16.6	Dolostone; laminated, light grey.

16.6 - 16.8	MISSING.
16.8 - 19.7	Dolostone; burrow-mottled, stylolites, chert nodules.
19.7 - 24.8	Dolostone; cyclic sequences (0.1 to 0.5 m thick) of flat pebble conglomerate grading through mottled, massive dolostone to laminates and shales.
24.8 - 25.9	Dolostone; laminated to thinly bedded, light grey.
25.9 - 26.5	Dolostone; burrow-mottled, stylolites.
26.5 - 29.3	Dolostone; laminated, light and dark grey; brecciated at 27.4 m; chert.
29.3 - 31.4	Dolostone; burrow-mottled to massive, medium grey.
31.4 - 34.1	Dolostone; laminated, light to dark grey; rare shaly partings.
34.1 - 35.6	Dolostone; laminated to thinly bedded, brecciated at 34.4 m.
	Catoche Formation
35.6 - 36.4	Dolostone; massive to lightly burrow-mottled, light grey, body fossils.
36.4 - 37.2	Limestone; massive, medium grey; shaly partings; flat pebble conglomerate in middle.
37.2 - 37.5	Dolostone; some burrow-mottling, medium grey; stylolites.

37.5 - 38.6	Limestone; massive, dark grey, stylolites, thick chert concentrations.
38.6 - 40.4	Dolostone; burrow-mottled, medium grey.
40.4 - 41.0	"WORMS MARKER"
41.0 - 43.0	Dolostone; massive, light grey to buff.
43.0 - 43.7	Limestone; massive, dark grey, stylolites, body fossils.
43.7 - 46.0	Dolostone; massive, light to dark grey, buff weathering, chert concentrations.
46.0 - 47.0	Limestone; massive, medium burrow-mottling, light to dark grey.
47.0 - 50.1	Pseudobreccia: dark and light grey, coarsely crystalline dolostone.
50.1 - 55.5	Limestone; bioturbated, intramural dolomites, body fossils.
55.5 - 56.3	Pseudobreccia
56.3 - 62.5	Dolostone; massive, light to medium grey, chert concentrations common.
62.5 - 66.1	Limestone; massive, dark to light grey, chert concentrations.
66.1 - 67.1	Limestone; massive, light to dark grey, intramural dolomite, stylolites, rip-up clasts.
67.1 - 68.3	Pseudobreccia.
68.3 - 68.6	Dolostone; massive, light grey; chert nodules at base.

68.6 - 68.9	MISSING.
68.9 - 70.2	Dolostone; vuggy, sucrosic, Pseudobreccia at 69.2 m.
70.2 - 73.5	Limestone; massive, medium grey to brown; chert concentrations, intramural dolomite.
73.5 - 77.7	Limestone; medium bedded, intraformational conglomerate at base of beds, light grey, chert rich horizons.
77.7 - 77.9	MISSING.
77.9 - 78.2	Dolostone; massive, buff to medium grey.
78.2 - 79.4	Limestone; massive, light grey; stylolites, some rip-up clasts.
79.4 - 79.9	Dolostone; massive, buff to medium grey.
79.9 - 85.3	Limestone; massive, brown to medium to light grey, styolites.
85.3 - 86.1	Limestone; burrow-mottled, some intraformational conglomerate, grey to brown; stylolites; sequence between 85.5 and 86.0 m missing.
86.1 - 88.1	Limestone; massive, light grey, stylolites, bioturbated, intramural dolomites.
88.1 - 91.8	Limestone; burrow mottled, intraformational conglomerate, light to medium grey, stylolites, chert.

APPENDIX A:5. Stratigraphic log of D.D.H. 1500, logged by R. Hodgson, Teck Explorations Ltd.

Distance down drill hole (metres)	Lithology
	Table Point and upper Aguathuna formations
0 - 137.2	No core.
	Aguathuna Formation
137.2 - 147.5	Dolostone; predominantly massive to laminated, fine-grained, tan; biomottled.
	Catoche Formation
147.5 - 148.7	Dolostone; massive, fine-grained, dark grey.
148.7 - 149.0	Shale.
149.0 - 153.0	Dolostone; massive, fine-grained, dark grey.
153.0 - 153.6	WORMS MARKER: Dolostone; intraclastic, fine-grained matrix, dark grey; bioclastic and chert pebbles in chaotic array.
153.6 - 162.5	Dolostone; massive, fine-grained, dark grey; scattered incipient pseudobreccia near base.
162.5 - 166.1	Dolostone; massive, fine-grained, dark grey.
166.1 - 166.4	Pseudobreccia.
166.4 - 167.5	Dolostone; massive, fine-grained, dark grey.
167.5 - 167.8	Pseudobreccia.
167.8 - 171.0	Dolostone; massive, fine-grained, dark grey.
171.0 - 171.6	Pseudobreccia; UPPER CHERT marker with base at 171.3 m.

171.6 - 172.2	Dolostone; massive, fine-grained, dark grey.
172.2 - 172.5	Pseudobreccia.
172.5 - 173.1	Dolostone; massive, fine-grained, dark grey.
173.1	OVAL MOTTLES MARKER.
173.1 - 173.4	Dolostone; massive, fine-grained, dark grey.
173.4 - 185.3	Limestone; massive to stylonodular, fine-grained, light to dark grey; minor dolostone interbeds.

APPENDIX A:6. Stratigraphic log of D.D.H. 715, logged by A.J. Hartlein, Teck Explorations Ltd.

Distance down drill hole (metres)	Lithology
0 - 9.3	Overburden.
	Aguathuna Formation
9.3 - 20.1	Dolostone; massive, fine-grained, light grey; siliceous, occasional buff mottling, silty zones between 10.4 and 12.8 m.
20.1 - 20.8	Dolostone; finely to coarsely laminated, fine-grained, green-grey.
20.8 - 24.7	Dolostone; massive, fine-grained, pale light grey grey chert at 21.1 m.
24.7 - 25.5	Dolostone; finely to coarsely laminated, fine-grained, green-grey.
25.5 - 27.9	Dolostone; massive, fine-grained, pale light grey
27.9 - 28.2	Breccia - fracture / collapse zone.
28.2 - 35.7	Dolostone; massive, fine-grained, light grey; coarse-grained green glauconitic zone at 29.6 to 29.7 m.
35.7 - 35.8	Dolostone to shale; thin bedded, very fine-grained, green-grey.
35.8 - 36.3	Dolostone; massive, fine-grained, pale light grey.
36.3 - 36.5	Collapse breccia; green, glauconitic matrix.

36.5 - 46.0	Dolostone; massive, fine-grained, pale light grey.
46.0 - 46.3	Collapse breccia; green glauconitic matrix.
46.3 - 53.4	Dolostone; massive, fine-grained, pale light grey.
53.4 - 53.6	Collapse breccia; white chert clasts.
53.6 - 53.9	Dolostone; massive, fine-grained, pale light grey.
53.9 - 54.7	UPPER ARGILLITE MARKER: Shale; thin bedded, very fine-grained dark green to dark grey.
54.7 - 55.4	Dolostone; massive, fine-grained, smokey grey; medium to thick beds, chert nodules and beds.
55.4 - 56.6	Dolostone; massive, fine-grained, dark grey; random black wisps.
55.6 - 59.0	Dolostone; thinly bedded, fine-grained, light and dark grey.
59.0 - 59.9	Dolostone; coarse grained, white, traces of pyrite and green glauconite in stylolites.
59.9 - 60.7	Dolostone; massive, fine-grained, light grey; patchy mottles.
60.7 - 63.7	Dolostone; thickly to thinly bedded, fine-grained, dark grey; wavy black wisps at top.
63.7 - 66.4	Dolostone; massive, fine-grained, light grey; thin beds at base.
	<u>Catoche Formation</u>
66.4 - 71.3	Dolostone; massive, fine-grained, interbanded

	medium to dark grey zones; stylolitic with black organic residue in stylolites.
71.3 - 71.7	"WORMS MARKER".
71.7 - 81.0	Dolostone; massive, fine-grained, dark grey with breccia, fracture zones with white sparry dolomite at 74.9 - 75.2, 76.1 - 76.6 and 78.0 - 78.1 m.
81.0 - 81.1	Dolostone and limestone interbanded; dolostone dark grey.
81.1 - 82.1	Limestone; massive to nodular, fine-grained medium grey; stylolitic, sharp undulating lower contact on stylolite.
82.1 - 83.0	Dolostone; sucrosic to fine-grained, medium to dark grey; stylolites partly obliterated, recrystallized.
83.0 - 83.9	Limestone; massive, fine-grained, medium grey; stylolitic; sharp, undulating lower contact.
83.9 - 90.6	Interbed [= dolostone, massive, fine-grained medium to dark grey; stylolitic]; oval pellet mottling.
90.6 - 91.0	Pseudobreccia with sucrosic to coarse-grained dolomites; occationally vuggy.
91.0 - 92.0	Interbed [see 83.9 - 90.6].
92.0 - 92.6	Pseudobreccia [see 90.6 - 91].
92.6 - 93.1	Interbed
93.1 - 93.5	Pseudobreccia

93.5 - 95.1	Interbed
95.1 - 95.6	Pseudobreccia
95.6 - 96.6	Interbed
96.6 - 97.1	Pseudobreccia
97.1 - 97.6	Interbed
97.6 - 98.0	Pseudobreccia
98.0 - 98.5	Interbed
98.5 - 99.5	Pseudobreccia
99.5 - 118.0	Dolostone; sucrosic to coarse grained, pale light grey to tan, often vuggy; stylolites obscured; few rounded white chert nodules; white spary dolomites; pseudobreccia developed through approximately 40% of section.

APPENDIX A:7. Stratigraphic log of D.D.H. 440 E/W, logged by K. Stait.

Distance down drill hole (metres)	Lithology
0 - 2.1	Overburden.
	Table Point Formation
2.1 - 4.1	Limestone; massive, fine-grained, light grey, bioturbated with buff to dark grey mottles.
4.1 - 4.9	Limestone; fine-grained, light to dark grey, nodular; thin layers of intraformational conglomerate.
	Aguathuna Formation
4.9 - 8.2	Dolostone; massive, light grey with brown burrow-mottles; microbreccia with chert pebbles at top of beds.
8.2 - 10.8	Dolostone; massive, lightly burrow-mottled; faint laminations throughout.
10.8 - 11.0	Dolostone; laminated, with intraformational breccia at base.
11.0 - 12.8	Limestone; massive, light grey; occasional stylolites and shaly laminae.
12.8 - 13.6	Dolostone; laminated, fine-grained,

	intraformational breccia at base; some brown mottles.
13.6 - 14.6	Dolostone; massive, fine-grained, light grey to buff, occasional stylolites.
14.6 - 14.8	Unconformity; chaotic chert bed.
14.8 - 15.2	Dolostone; massive, fine-grained, light grey to buff, occasional stylolites.
15.2 - 15.7	Dolostone; intraformational breccia.
15.7 - 17.8	Dolostone; massive, fine-grained, dark to light grey, with brown mottles; chert horizon at 16.0 m.
17.8 - 18.7	Dolostone; grainstone horizons with chert nodules within massive fine-grained, grey, lightly burrow-mottled lithology.
18.7 - 27.4	Dolostone; massive, fine-grained, burrow-mottled, various chert-rich horizons.
27.4 - 29.1	UPPER ARGILLITE marker bed: dolostone; massive, fine-grained, light grey; laminated, grading into shales at 27.4 and 28.7 m; chert above shale at 27.4 m.
29.1 - 29.9	Dolostone; massive, fine-grained, light grey, with some dark bands.
29.9 - 30.4	Dolostone; massive, fine-grained, medium grey, burrow-mottled near top.
30.4 - 30.5	Chaotic chert breccia.
30.5 - 33.2	Dolostone; massive, fine-grained, light

	grey, with darker bands, grading into shales; chert-rich horizons.
33.2 - 35.8	Dolostone; massive, fine-grained, burrow-mottled, and occasionally stylolitized; chert-rich horizons.
35.8 - 36.6	Limestone; massive, fine-grained, light grey, stylolites, light mottling, bioturbated.
36.6 - 37.2	Dolostone; massive, fine-grained, burrow-mottled; chert-rich horizons.
37.2 - 37.9	Limestone; massive, fine-grained, light grey, stylolites.
37.9 - 39.0	Dolostone; massive, fine-grained, light grey, with medium grey burrow-mottles.
39.0 - 39.3	Dolostone; massive, fine-grained, light to medium grained; laminated with laminae grading into shale at top.
39.3 - 39.9	Dolostone; massive, fine-grained, light grey, buff mottles; grades down into shaly laminations.

APPENDIX A:8. Stratigraphic log of D.D.H. 498, measured by T. Lane, Teck Explorations Ltd.

Distance down drill hole (metres)	Lithology
0 - 12.2	Overburden, rubble.
	Table Point Formation
12.2 - 18.6	Dolostone; nodular, fine-grained, dark grey.
	Aguathuna Formation
18.6 - 19.7	Dolostone; massive, fine-grained, tan; occasional intraformational breccia.
19.7 - 27.4	Dolostone; finely laminated, fine-grained, grey to dark grey with brown burrow-mottles; intercalated wackestones.
27.4 - 30.9	Dolostone; faint laminations, grey; concentrations of rounded chert; intraformational breccia at base of beds.
30.9 - 31.0	Shale; fissile.
31.0 - 32.0	Dolostone; laminated, dark grey with light grey; brown mottles.
32.0 - 35.6	Dolostone; laminated, very light grey.
35.6 - 36.6	Dolostone; massive, fine-grained, light grey.
36.6 - 44.8	Breccia; mud-supported "rubble" breccias, rounded to subangular clasts, grey matrix; intercalated laminates.
44.8 - 46.8	Dolostone; fine to medium grained, tan;

	laminations at angle to bedding.
46.8 - 48.2	Dolostone; massive, fine-grained, tan.
48.2 - 48.8	Breccia; small chert and lithic clasts in light grey to tan mottled dolostone matrix.
48.8 - 49.1	Dolostone; massive, fine-grained, tan.
49.1 - 50.1	Dolostone; finely laminated, fine-grained, light to dark grey.
50.1 - 52.1	Dolostone; massive, fine-grained, medium grey with tan mottles.
52.1 - 55.9	Dolostone; fine-grained, light and dark grey bands, disturbed in middle of interval.
55.9 - 57.9	Dolostone; massive, fine-grained, tan.
57.9 - 58.5	Dolostone; laminated, fine-grained, light and dark grey.
58.5 - 60.7	Breccia of disturbed laminae in previous lithology; chert pebbles.
60.7 - 61.6	Dolostone; massive, fine-grained, tan.
61.6 - 66.1	Breccia as above (60 m); recrystallized at base.
66.1 - 71.3	Dolostone; laminated, dark grey, thin breccias within unit at 67.7 m and 69.5 m.
71.3 - 75.0	Breccia, as above; microfractures in lower portion.
75.0 - 76.8	Dolostone; massive, finee-grained, tan.
76/8 - 77.4	Breccia; clasts laminated and rotated, dolomitic matrix. Sequence disrupted at base.

77.4 - 84.4	Breccia; angular to subangular clasts of burrow-mottled dolostone; fine-grained dolomitic matrix; clasts largest at middle of interval - up to 0.05m diameter.
84.4 - 86.9	Dolostone, laminated, fine-grained, grey to dark grey; intraformational breccia at base.
86.9 - 89.0	As previous lithology, cherts also at base.
89.0 - 89.6	Dolostone, laminated, fine-grained, grey to dark grey.
89.6 - 89.9	Shale with fine dolostone / shaly laminae at top.
89.9 - 91.4	Dolostone; coarsely laminated to massive, fine-grained.
91.4 - 93.7	Dolostone; massive, fine-grained, light grey.
93.7 - 93.9	Dolostone; finely laminated, fine-grained, light to dark grey.
93.9 - 94.5	Intraformational breccia as above.
94.5 - 95.1	Dolostone; massive, fine-grained, light grey.
95.1 - 96.0	Dolostone; massive to coarsely laminated, light to dark grey.
96.0 - 99.0	Dolostone; massive, fine-grained, light grey to tan, burrow-mottled; 0.5 m breccia in middle of interval.
99.0 - 99.7	Dolostone; laminated, fine-grained, light and dark grey.
99.7 - 106.7	Dolostone; massive, fine-grained, light grey

	to tan, burrow-mottled, recrystallized at base; 0.3 m thick white vein dolomite at 102.1 m.
106.7 - 110.0	Dolostone; massive, fine-grained, light grey.
110.0 - 111.3	UPPER ARGILLITE: shale with finely parted silty dolostone at top.
111.3 - 113.7	Dolostone; coarsely laminated fine-grained, light to dark grey.

APPENDIX A:9 Stratigraphic log of the section collected at Table Point and Freshwater Cove, measured by T. Lane, and K. Stait.

Distance up section (metres)	Lithology
	Catoche Formation
0.0 - 9.1	Pseudobreccia interbedded with limestone; minor microcrystalline dolostone; white silica concentrated at 2.4 m, "Oval Mottles" marker at 5.1 m, black chert nodules at 7.0 m; limestones bioclastic, with gastropods.
9.1 - 11.0	Pseudobreccia interbedded with microcrystalline dolostone; gastropods.
11.0 - 14.0	Dolostone; massive, interbedded micro- and coarse crystalline, dark grey; burrow-mottled where less altered.
14.0 - 14.6	Pseudobreccia.
14.6 - 19.4	Dolostone; massive, micro- to medium crystalline, dark grey; burrow-mottled.
19.4 - 19.5	WORMS MARKER
19.5 - 25.0	Dolostone; massive, microcrystalline, dark grey; burrow-mottled.
	Aguathuna Formation
25.0 - 25.3	Dolostone; laminated, microcrystalline, light grey, buff weathering; chert and breccia at

	base; with graptolites.
25.3 - 27.4	Dolostone, laminated, microcrystalline, grey; breccia at base.
27.4 - 29.0	Dolostone; massive, microcrystalline; burrow-mottled, with gastropods, wavy laminations.
29.0 - 31.7	Dolostone, laminated, microcrystalline, dark grey.
31.7 - 33.5	Dolostone; massive, microcrystalline, burrow-mottled.
33.5 - 33.7	Dolostone, laminated, microcrystalline, with gastropods.
33.7 - 34.1	"BRECCIA BED": breccia; chert and lithic clasts in shaly matrix.
34.1 - 34.3	Dolostone; massive, microcrystalline.
34.3 - 34.7	Dolostone; finely laminated, microcrystalline.
34.7 - 38.1	Dolostone; bioclastic, microcrystalline, burrow-mottled.
38.1 - 38.9	Dolostone; recrystallized, medium crystalline, light grey, brecciated.
38.9 - 39.6	Dolostone; laminated, microcrystalline, light grey.
39.6 - 40.7	Dolostone; bioclastic, microcrystalline, dark grey.
40.7 - 41.8	Dolostone; laminated, microcrystalline, light grey.

41.8 - 44.2	Dolostone; massive, microcrystalline, burrow-mottled.
44.2 - 45.1	Dolostone; laminated, microcrystalline.
45.1 - 46.8	Dolostone; massive, micro- to medium crystalline, burrow-mottled; recrystallized with chert in middle; undulose upper contact.
46.8 - 47.2	Dolostone; finely laminated, microcrystalline, very light grey.
47.2 - 48.8	Dolostone; laminated, microcrystalline, very light grey.
48.8 - 48.9	Shale, intraformational breccia, with silica.
48.9 - 49.4	Dolostone; massive, microcrystalline, burrow-mottled.
49.4 - 50.3	Dolostone; massive, microcrystalline.
50.3 - 50.4	Dolostone; laminated, microcrystalline.
50.4 - 51.1	Dolostone; massive, microcrystalline, burrow-mottled.
51.1 - 52.4	Dolostone; hummocky, stromatolites; breccia, chert and clay infill at base.
52.4 - 52.9	Dolostone; massive, microcrystalline, burrow-mottled.
52.9 - 53.0	Dolostone; laminated, microcrystalline, chert at top.
53.0 - 53.6	Shale; greenish grey.
53.6 - 57.5	Dolostone; massive, microcrystalline, tan to dark grey; mudcracks, teepees.

57.5 - 58.2	UPPER ARGILLITE: shale; greenish grey.
58.2 - 63.1	Dolostone; massive, microcrystalline, tan; thick to thin bedded, burrow-mottled.
63.1 - 65.1	Dolostone; laminated, microcrystalline, light grey to buff.
65.1 - 66.6	Dolostone; massive, microcrystalline, dark tan; burrow-mottled.
66.6 - 67.1	Dolostone; massive, microcrystalline, tan.
67.1 - 67.7	Dolostone; finely bedded, microcrystalline, brown - white; burrow-mottled.
67.7 - 68.3	Dolostone; laminated, microcrystalline, light grey.
68.3 - 68.4	Concentration of chert.
68.4 - 69.8	Shale; dark grey.
69.8 - 78.3	Dolostone; massive to finely bedded, microcrystalline, blue-grey; with argillite intercalations.
78.3 - 84.4	Dolostone; massive, microcrystalline, blue-grey; thick bedding; upper beds with mudcracks, occasional chert pebbles and grains along bedding planes.
	<u>Table Point Formation</u> (<u>Springs Inlet Member</u>)
84.4 - 85.0	Limestone; stylonodular, wackestone to packstone; undulose lower contact.

APPENDIX A:10. Stratigraphic log of the Aguathuna Formation preserved at Hare Bay.

Distance up section (metres)	Lithology
	Aguathuna Formation
0 - 4.0	Alternating 20 to 40 cm thick beds of burrowed limestone that is dolomitized, and laminated limestone and / or dolostone.
4.0 - 7.0	Dolostone to dolomitic limestone; laminated to massive, fine crystalline, light grey, buff weathering.
7.0 - 9.0	Cover, with 20 cm burrowed, fine grainstone at top.
9.0 - 11.0	Cover, with very fine crystalline to massive light grey dolostone at top.
11.0 - 12.0	Cover, with 20 cm of previous lithology at top.
12.0 - 13.0	Dolostone; laminated, buff weathering; mud cracks and symmetrical ripples.
13.0 - 13.5	Dolostone; microcrystalline, medium grey, with laminations.
13.5 - 13.8	Limestone; laminated to cross laminated, peloidal grainstone, light grey to white; fenestrae.
13.8 - 15.0	Dolostone; microcrystalline, laminated, light grey; 20 cm rust weathering band at top;

	mud cracks.
15.0 - 15.7	Limestone; laminated to cross laminated, peloidal grainstone, light grey to white; fenestrae.
15.7 - 15.9	Dolostone; microcrystalline, light buff weathering.
15.9 - 17.0	Limestone; stylonodular, medium grey, mottled; sheared, conglomerates and grainstone layers.
17.0 - 17.8	Dolostone; laminated, medium grey buff weathering; mud cracks and teepees.
17.8 - 18.6	Limestone; stylonodular, medium grey, mottled; sheared, conglomerates and grainstone layers.
18.6 - 20.6	Dolostone; microcrystalline, medium grey, buff weathering; dissolution surface with cherts in middle of interval.
20.6 - 22.6	Limestone; burrow-mottled and stylomottled; fossiliferous, dolomitized.
22.6 - 22.9	Dolostone; laminated, light grey.
22.9 - 23.1	Limestone; burrow-mottled and stylomottled; fossiliferous, dolomitized.
23.1 - 23.4	Dolostone; laminated, light grey.
23.4 - 25.0	Limestone; burrow-mottled and stylomottled; fossiliferous, dolomitized.
25.0 - 25.3	Limestone; stromatolites; mostly covered.
25.3 - 28.1	Dolostone; microcrystalline, massive to laminated to cross-laminated, light grey;

	stromatolites, buff weathering at top; several solution layers.
28.1 - 28.7	Limestone; laminated, grey; dolomitized, crinkly laminations, fossiliferous (trilobites, ostracodes).
28.7 - 29.0	Limestone; stylonodular, burrowed, dolomitized.
29.0 - 30.0	Limestone; laminated, grey alternating with fossiliferous grainstone layers approximately 5 cm thick.
30.0 - 30.6	Limestone; grainstone, thin bedded.
30.6 - 30.7	Limestone; microcrystalline, black, buff weathering.
	Table Point Formation (Springs Inlet Member)
30.7 - 32.5	Limestone; stylomottled, sheared, stylonodular.

APPENDIX A:11. Stratigraphic log of the sampled section at Back Arm Bay, measured by N.P. James and B. Stait.

Distance up section (metres)	Lithology
	Catoche Formation
0 - 6.0	Dolostone; massive, coarse crystalline; very burrowed.
6.0 - 6.1	Laminated series of lenses with rare chert.
6.1 - 7.0	Dolostone; massive, coarse crystalline, burrowed.
7.0 - 8.0	Dolostone; medium grained, interbedded with fine-grained, fossiliferous dolostone.
8.0 - 10.0	Dolostone; massive, coarse crystalline; very burrowed.
	? Aguathuna Formation
10.0 - 11.7	Dolostone; fine-grained, blue-grey with tan markings; finely bedded at base, laminated at top; two siliceous solution horizons at 10.8 and 11.4m.
	? Table Point Formation
11.7 - 14.0	Shale and stylonodular limestone; recessive weathering.
14.0 - 15.0	Dolostone; massive, fine-grained; stylonodular.
15.0 - 15.9	Dolostone; laminated, fine-grained; brown to buff weathering; tan weathering at top.

15.9 - 17.1	Dolostone; massive, microcrystalline; mud cracked.
17.1 - 17.5	Limestone; stylonodular.
17.5 - 18.1	Limestone; laminated to coarsely laminated; ?mud cracks.
18.1 - 18.6	Cover.
18.6 - 19.6	Dolostone; microcrystalline, tan laminated; buff weathering.
19.6 - 20.0	Limestone; laminated with mudcracks.
	<u>Table Point Formation</u>
20.0 - 26+	Limestone; stylonodular, very fossiliferous.

APPENDIX A:12. Lithologic log of Aguathuna Formation west of The Gravels, measured by K. Stait.

Distance up section (metres)	Lithology
	Aguathuna Formation
0 - 1.6	Limestone; massive to laminated, burrow-mottled wackestone; trilobites and oncolites at base to laminated microcrystalline mudstone with fenestrae at top.
1.6 - 6.0	Cover.
6.0 - 6.6	Dolostone; massive to laminated, microcrystalline, burrow-mottled.
6.6 - 7.0	Limestone; thinly bedded to laminated; bioclastic wackestone.
7.0 - 8.8	Interbedded dolostone and limestone; mostly covered by scree.
8.8 - 13.0	Dolostone; coarsely to finely laminated, microcrystalline; pelloidal and burrow-mottled towards top; mudcracks and breccia at top.
13.0 - 13.4	Limestone; bioclastic wackestone to packstone, burrow-mottled; with pelloids, nautiloids, gastropods; upper contact undulose.
13.4 - 15.4	Shale to finely laminated dolostone.
15.4 - 16.2	Limestone; stylonodular, microcrystalline, burrow-mottled and dolomitic; with pelloids.

16.2 - 19.2	Dolostone; laminated, microcrystalline, burrow-mottled.
19.2 - 19.8	Shale to finely laminated microcrystalline dolostone.
19.8 - 22.4	Dolostone; massive, microcrystalline, bioclastic, with domal stromatolites at base, planispiral gastropods and pelloids.
22.4 - 23.4	Limestone; lithoclastic, burrow-mottled, with planispiral and spired gastropods, nautiloids and trilobites.
23.4 - 24.0	Shale with finely laminated, microcrystalline dolostone.
24.0 - 25.0	Limestone; massive, microcrystalline, burrow-mottled; upper contact irregular.
25.0 - 25.4	Dolostone; massive, microcrystalline.
25.4 - 26.0	Shale with finely laminated limestone.
26.0 - 26.4	Limestone; massive, microcrystalline; domal and laterally linked stromatolites.
26.4 - 27.4	Dolostone; laminated, microcrystalline.
27.4 - 28.0	Limestone; bioclastic, microcrystalline; with planispiral gastropods, nautiloids and peloids.
28.0 - 29.0	Dolostone; massive, microcrystalline, burrow-mottled and brecciated.
29.0 - 30.0	Limestone; bioclastic, microcrystalline; with oncolites, domal and columnar stromatolites, planispiral gastropods, abundant silicified

	nautiloids.
30.0 - 31.2	Limestone; bioclastic, microcrystalline; brecciated.
31.2 - 31.8	Shale to finely laminated microcrystalline dolostone.
31.8 - 32.8	Limestone; massive, microcrystalline; with domal stromatolites, breccia at base.
32.8 - 33.6	Dolostone; coarsely to finely laminated, microcrystalline.
33.6 - 34.4	Limestone; massive, microcrystalline; with domal stromatolites.
34.4 - 35.0	Dolostone; laminated, microcrystalline.
35.0 - 35.8	Limestone; massive, microcrystalline; with domal stromatolites.
35.8 - 36.8	Limestone; massive, microcrystalline; with domal stromatolites, breccia at base.
36.8 - 37.4	Dolostone; coarsely to finely laminated, microcrystalline.
37.4 - 37.8	Limestone; massive, microcrystalline; domal stromatolites, breccia at top.
37.8 - 38.4	Dolostone; coarsely to finely laminated, microcrystalline; burrow-mottled and brecciated.
38.4 - 40.0	Limestone; bioclastic, microcrystalline, burrow-mottled.
40.0 - 40.2	Dolostone; finely laminated, microcrystalline.

40.2 - 40.8	Limestone; massive, microcrystalline; with domal stromatolites.
40.8 - 41.0	Dolostone; finely laminated, microcrystalline.
41.0 - 44.0	Dolostone; massive, microcrystalline, burrow-mottled.
44.0 - 44.6	Limestone; massive, microcrystalline, burrow-mottled.
44.6 - 45.6	Dolostone; coarsely to finely laminated, microcrystalline; breccia at top.
45.6 - 46.6	Dolostone; massive, microcrystalline; domal stromatolites.
46.6 - 47.0	Limestone; massive, microcrystalline.
47.0 - 48.0	Dolostone; lithoclastic, matrix microcrystalline, some shales; undulating bedding near top.
48.0 - 49.0	Limestone; bioclastic, microcrystalline; with oncolites, Teiichispira, spired gastropods, nautiloids and domal stromatolites; brecciated.
49.0 - 51.4	Dolostone; coarsely to finely laminated, microcrystalline, red to green.
51.4 - 52.4	Dolostone; coarsely to finely laminated; with shale, some brecciation.
52.4 - 53.0	Dolostone; laminated, microcrystalline; with mudcracks.
53.0 - 53.8	Dolostone; finely laminated, with shales, microcrystalline, red.
53.8 - 54.6	Dolostone; laminated, microcrystalline; with

	mudcracks.
54.6 - 56.0	Dolostone; coarsely to finely laminated, microcrystalline; some shales; breccia at top, upper contact undulose.
56.0 - 56.2	Limestone; massive, microcrystalline; with domal stromatolites; lower contact cuts down 0.6 m into underlying lithology.
56.2 - 60.0	Dolostone; massive to laminated, microcrystalline; massive intervals with domal stromatolites, brecciated; upper contact gently undulose.
60.0 - 60.7	Dolostone; laminated, microcrystalline; solution surface at upper contact.
60.7 - 62.0	Dolostone; massive, microcrystalline, burrow-mottled.
62.0 - 62.4	Limestone; bioclastic, microcrystalline matrix, burrow-mottled.
62.4 - 67.0	Dolostone; massive, microcrystalline, burrow-mottled, buff weathering; upper contact gently undulose.
	Table Point Formation
67.0 - 68.0	Limestone; massive, microcrystalline, medium grey; fenestrae.
68.0 - 69.8	Limestone; coarsely to finely laminated, microcrystalline, fenestrae.
69.8 - 70.8	Limestone; stylonodular, microcrystalline,

	dark grey.
70.8 - 72.2	Limestone; massive to laminated, microcrystalline.
72.2 - 73.4	Limestone; laminated at base and top, stylonodular in middle, microcrystalline.
73.4 - 75.4	Limestone; bioclastic to stylonodular, microcrystalline matrix, burrow-mottled; with graptolites, trilobites, spired gastropods, nautiloids and oncolites.

APPENDIX A:13. Stratigraphic log of Aguathuna Formation on the shore section east of The Gravels.
Measured by N.P. James and B. Stait.

Distance up section (metres)	Lithology
	Aguathuna Formation
0.0 - 1.0	Limestone; fine-grained; with mound structures; fault at base, overlying Boat Harbour lithology.
1.0 - 1.6	Dolostone; finely crystalline, red.
1.6 - 3.1	Limestone; bioclastic, fine-grained; with some undulose bedding, Teiichispira, nautiloids, oncolites and spired gastropods.
3.1 - 4.4	Dolostone; fine crystalline, red.
4.4 - 6.4	Limestone; mounds with crystalgal laminated at base, grading into and succeeded by conglomerate.
6.4 - 7.4	Dolostone; laminated, fine-grained.
7.4 - 8.4	Limestone; cross bedding, bioturbated.
8.4 - 9.0	Limestone; fine-grained, with argillaceous partings.
9.0 - 10.2	Limestone and argillaceous dolostone intercalated.
10.2 - 10.8	Dolostone; massive, microcrystalline.
10.8 - 11.0	Shale with thin bands of limestone.

11.0 - 11.4	Limestone; fine crystalline, chert at base, laterally linked and domal stromatolites; wedged lower contact.
11.4 - 16.4	Dolostone; massive, fine-grained, red weathering; chert at base; laminated at intervals.
16.4 - 16.5	Limestone; mounds.
16.5 - 17.6	Limestone; thin bedding, bioturbated, red to grey.
17.6 - 18.2	Limestone; stromatolitic, bioclastioc grainstone.
18.2 - 18.4	Limestone; microcrystalline, grey with red burrows, prominent bedding plane.
18.4 - 24.4	Dolostone; bioturbated, fine-grained, interfingered with calcareous dolomite, undulose upper contact.
24.4 - 25.0	Dolostone; laminated, microcrystalline, green shale at base.
25.0 - 25.3	Dolostone; bioturbated, microcrystalline.
25.3 - 26.5	Dolostone; laminated, microcrystalline.
26.5 - 26.8	Limestone; bioclastic, microcrystalline matrix; with cherts, algal structures, high-spired gastropods.
26.8 - 27.4	Dolostone; laminated, microcrystalline.
27.4 - 28.0	Dolostone; massive, microcrystalline, intensly burrow mottled.
28.0 - 33.6	Dolostone; laminated to massive, microcrystal-

	line, buff weathering, intercalated laminites at base; red matrix with cherts at middle of interval, laminates with teepee structures succeeded by cherts at top, upper contact irregular, wedging.
33.6 - 34.0	Wedges of cryptalgal dolomitic limestone succeeded by thin shale, overlain by massive fossiliferous limestone.
	<u>Table Point Formation</u>
36.0 -	Limestone; stylonodular, dark grey.

APPENDIX A:14. Stratigraphic log of section exposed in the Aguathuna quarries and connecting road, measured by N.P. James and B.A. Stait.

Distance up section (metres)	Lithology
QUARRY 1	
	Catoche Formation
0 - 7.0	Limestone; massive, microcrystalline; dolomitized in patches, thick bedded; with trilobites.
	Costa Bay Member
7.0 - 8.8	Limestone; massive, microcrystalline; fenestrae.
8.8 - 9.8	Limestone; massive, coarse grained pebbles.
QUARRY 2	
	Costa Bay Member
9.8 - 10.7	Limestone; massive, microcrystalline; fenestrae.
10.7 - 12.0	Limestone; massive, thick bedded, microcrystalline; fenestrae.
12.0 - 13.2	Limestone; massive, coarse grained.
13.2 - 14.6	Limestone; bioclastic, microcrystalline; fenestrae.
14.6 - 15.6	Limestone; massive, coarse grained at base to

	microcrystalline at top; fenestrae.
15.6 - 16.8	Limestone; stylonodular, microcrystalline.
16.8 - 17.8	Limestone; stylonodular, medium to coarse grained; fenestrae.
17.8 - 18.8	Limestone; thinly bedded near base to massive near top, medium to coarse grained; oncolites.
18.8 - 19.2	Dolostone; laminated, microcrystalline.
19.2 - 20.9	Limestone; massive, medium to coarse grained; fenestrae.
20.9 - 21.4	Dolostone; finely laminated with shale; microcrystalline, red.
21.4 - 22.0	Limestone; massive, thick bedded, microcrystalline; fenestrae.
22.0 - 22.3	Limestone; pelloidal and breccia.
	Aquathuna Formation
22.3 - 24.4	Dolostone; wavy laminations and intraformational breccia; microcrystalline.
24.4 - 25.2	Dolostone; laminated with intercalated shales, microcrystalline, red, earthy.
25.2 - 26.0	Dolostone; laminated, microcrystalline.
26.0 - 27.4	Dolostone; stylonodular, microcrystalline.
27.4 - 30.0	Limestone; massive, microcrystalline; burrow-mottled and pelloidal at base; fenestrae.

ROAD SECTION

30.0 - 34.0	Cover: top of second quarry correlates approximately with a level 4 m below first outcrop on road section.
	<u>Aquathuna Formation</u>
34.0 - 36.0	Dolostone; laminated, microcrystalline.
36.0 - 37.0	Dolostone; massive, microcrystalline; burrow-mottled.
37.0 - 38.0	Dolostone; laminated, microcrystalline.
38.0 - 38.8	Dolostone; finely laminated, argillaceous, microcrystalline.
38.8 - 41.6	Dolostone; massive to laminated, microcrystalline; laminated at base and top, burrow-mottled in middle.
41.6 - 42.6	Limestone; bioclastic, microcrystalline matrix; burrow-mottled with nautiloids and spired gastropods.
42.6 - 43.0	Dolostone; finely laminated with intercalated shales, microcrystalline.
43.0 - 43.8	Limestone; wavy laminations, microcrystalline; large nodules of dolostone at upper contact.
43.8 - 44.0	Dolostone; massive, microcrystalline.
44.0 - 44.8	Cover.
44.8 - 46.0	Dolostone; massive, microcrystalline; upper contact undulose.
46.0 - 46.6	Dolostone; massive, microcrystalline; burrow-mottled, breccia within shale at base.

46.6 - 46.8	Shale, dolomitic.
46.8 - 47.2	Limestone; laminated, microcrystalline; pelloidal and oncolitic.
47.2 - 47.6	Dolostone; with quartz pebble conglomerate.
47.6 - 48.0	Dolostone; wavy laminations, microcrystalline.
48.0 - 48.4	Dolostone; finely laminated, argillaceous, microcrystalline.
48.4 - 50.0	Limestone; dolomitic, wavy to planar laminations, microcrystalline.
50.0 - 51.2	Limestone; thick beds of laminates, microcrystalline.
51.2 - 53.4	Dolostone; laminated, microcrystalline; shale at base.
53.4 - 54.6	Limestone; laminated (wavy to planar), microcrystalline.
54.6 - 55.4	Limestone; dolomitic, laminated, microcrystalline.
55.4 - 57.0	Dolostone; massive, microcrystalline, burrow-mottled.
57.0 - 58.4	Limestone; bioclastic, microcrystalline; with oncolites.
58.4 - 59.8	Dolostone; laminated, microcrystalline.
59.8 - 60.1	Limestone; massive, microcrystalline.
60.1 - 61.2	Dolostone; massive, microcrystalline matrix with chert breccia at base; domal stromatolites.

61.2 - 61.4	Shale.
61.4 - 61.8	Limestone; platy laminae, microcrystalline.
61.8 - 62.0	Shale.
62.0 - 62.5	Limestone; massive, microcrystalline; mounds.
62.5 - 62.8	Limestone; massive, microcrystalline.

QUARRY 3

62.8 - 63.8	Cover (Dolostone underneath).
	<u>Aquathuna Formation</u>
63.8 - 65.0	Dolostone; laminated, microcrystalline.
65.0 - 65.4	Shale.
65.4 - 66.2	Dolostone; laminated, microcrystalline, red and green.
66.2 - 67.0	Dolostone; laminated, argillaceous, microcrystalline, red.
67.0 - 67.8	Dolostone; laminated, microcrystalline.
67.8 - 68.8	Dolostone; laminated, argillaceous.
68.8 - 74.0	Dolostone; massive, to laminated microcrystalline; domal stromatolites.
74.0 - 74.2	Dolostone; laminated, argillaceous.
74.2 - 75.0	Limestone; dolomitic, laminated, microcrystalline.
75.0 - 76.0	Dolostone; laminated, microcrystalline; upper contact undulose.
76.0 - 77.0	Dolostone; massive, microcrystalline; upper contact undulose.

77.0 - 83.0	Dolostone; massive, microcrystalline, burrow-mottled.
83.0 - 85.6	Dolostone; laminated, microcrystalline; upper contact with solution pits and dropped stones within pits; this surface cuts down at least 8 m into lower lithologies.
	<u>Table Point Formation</u>
85.6 - 87.4	Dolostone; massive to laminated, blue grey.

APPENDIX B:1. Occurrence and abundance of conodonts from Assemblage I.

D.D.H. A1:	14	13	12	11	10	09	08	TOTAL
ANSELLA sp.								
oistodontiform							1	1
CLAVOHAMULUS CAVUS		1						1
DIAPHORODUS DELICATUS								
drepanodontiform						2		2
acontiodontiform			1					1
distacodontiform				2			1	3
oistodontiform			2	3				5
acodontiform			1					1
DREPANODUS CONCAVUS								
sculponeaform				1				1
graciliform				1				1
DREPANOISTODUS FORCEPS								
homocurviform	1					1		2
suberectiform				1				1
oistodontiform	1			1		1		3
scandodontiform	1							1
DREPANOISTODUS INAEQUALIS								
homocurviform	1			2				3
suberectiform	1							1
oistodontiform	1			1	1			3
EUCHARODUS PARALLELUS								
plano-convex	1			2	1			4
ovate	1			1		1		3
GLYPTOCONUS QUADRAPLICATUS								
triplicatiform			1	2				3
quadraplicatiform				5				5
MICROZARKODINA? MARATHONENSIS								
straight ozarkodiniform				1				1
?PROTOPRIONIODUS COSTATUS								
oistodontiform			1			1		2
OEPIKODUS COMMUNIS								
cordylodontiform	1		5	17		8		31
gothodontiform			5	18		6		29
tetraprioniodontiform	1		3	11		3	1	19
falodontiform	4		2	15		1		22
prioniodontiform	3		4	20		4	1	32
ONEOTODUS COSTATUS	1		1	2				4
PALTODUS SWEETI								
robustiform	2		2	6		1		11
intermediate			1					1
sweetiform	2							2
PARAPANDERODUS STRIATUS								
long-based				1				1
short-based				1	1			2

APPENDIX B:1 (ctd.)

D.D.H. Al:	14	13	12	11	10	09	08	TOTAL
PAROISTODUS PARALLELUS								
drepanodontiform			2	1	1			4
PAROISTODUS PROTEUS								
drepanodontiform	2			1				3
oistodontiform	1		1	3				5
PROTOPANDERODUS GRADATUS								
sym. acontiodontiform						1		1
PROTOPRIONIODUS PAPILOSUS								
trichonodelliform			1					1
prioniodontiform						1		1
ROSSODUS HIGHGATENSIS								
drepanodontiform			1	3				4
acontiodontiform				1				1
asym. tricostate				1				1
pentacostate				1				1
oistodontiform				6				6
scandodontiform			1	1				2
"SCOLOPODUS" EMARGINATUS				6		1		7
"SCOLOPODUS" FILOSUS								
proclined	1		1	2		1		5
erect	1							1
SEMIACONTIODUS ASYMMETRICUS								
symmetrical					1		1	2
SEMIACONTIODUS CORDIS								
asymmetrical						1		1
bicostate				1				1
STRIATODONTUS KAKIVANGUS								
symmetrical				1				1
asymmetrical				1				1
VARIABILICONUS n.sp. A								
scandodontiform	1							1
WALLISERODUS ETHINGTONI			1					1
NEW GEN. I N.SP. B								
cladognathodontiform				1				1
TOTAL	28	1	37	141	5	35	5	252

APPENDIX B:2. Occurrence and abundance of conodonts from Assemblage II.

	A1.07	A1.06	A1.05	A1.04	TOTAL
ANSELLA sp.					
tetraprioniodontiform			1		1
oistodontiform			1		1
BERGSTROEMOGNATHUS EXTENSUS					
falodontiform	3	2		1	6
CLAVOHAMULUS CAVUS	3				3
DIAPHORODUS DELICATUS					
drepanodontiform		2			2
gothodontiform	1				1
acontiodontiform		1			1
distacodontiform		2		1	3
oistodontiform		3			3
acodontiform	2	2			4
DIAPHORODUS RUSSOI					
cordylodontiform	2	6			8
acontiodontiform		2			2
distacodontiform	1	1			2
oistodontiform	6	3			9
acodontiform	3	4			7
DREPANODUS ARCUATUS					
arcuatiform		4			4
pipaform		2			2
DREPANOISTODUS FORCEPS					
homocurviform		2	1		3
suberectiform	2				2
oistodontiform		14			14
scandodontiform	1				1
DREPANOISTODUS INAEQUALIS					
suberectiform		2	2		4
oistodontiform		1			1
EUCHARODUS PARALLELUS					
plano-convex base	1				1
FRYXELLODONTUS CORBATOI					
"planus" element		2			2
"symmetricus" element	1	1	1		3
"intermedius" element	1	2			3
MICROZARKODINA? MARATHONENSIS					
cordylodontiform	1				1
gothodontiform	4	2			6
oistodontiform	3	4			7
straight ozarkodiniform	1				1
arched ozarkodiniform			1		1
OEPIKODUS COMMUNIS					
cordylodontiform	2	10			12
gothodontiform	6	26			32
tetraprioniodontiform	4	21			25
falodontiform	3	13			16
prioniodontiform	6	22	1		29
ONEOTODUS COSTATUS		1			1
PALTODUS SWEETI					
sweetiform		1		1	2
robustiform	2	1	1		4
acodontiform	2	1			3
PARACORDYLODUS GRACILIS					
paracordylodontiform		1			1
oistodontiform			1		1

APPENDIX B:2 (ctd.)

	A1.07	A1.06	A1.05	A1.04	TOTAL
PARAPANDERODUS STRIATUS					
long-based	1	2	1	1	5
short-based	4	2	1		7
triangulariform	2	2	1	1	6
PAROISTODUS PARALLELUS					
drepanodontiform	2	6			8
acodontiform	5	1	1	1	8
paltodontiform	3	12	1		16
oistodontiform	4	4	1		9
scandodontiform	3	2	1		6
PROTOPANDERODUS GRADATUS					
unicostate		1	1		2
3-grooved element	2				2
subsym. acontiodontiform		2			2
asym. acontiodontiform	3				3
scandodontiform	1	1			2
?PROTOPRIONIODUS COSTATUS					
trichonodelliform		1			1
elongatiform		2			2
PROTOPRIONIODUS PAPILOSUS					
trichonodelliform		1			1
ROSSODUS SYMMETRICUS					
drepanodontiform			1		1
tricostate		2		1	3
trapezognathiform	2	1	1		4
pentacostate	3	2	1		6
oistodontiform	4	4	2	1	11
scandodontiform	1	2	3		6
SEMIACONTIODUS ASYMMETRICUS					
symmetrical	1	3			4
asymmetrical	1	2		1	4
SEMIACONTIODUS CORDIS					
acontiodontiform	1				1
symmetrical	1	2	2		5
asymmetric element		3			3
STRIATODONTUS KAKIVANGUS					
symmetrical			1		1
STRIATODONTUS CARLAE					
symmetrical element	1				1
TRIPODUS LAEVIS					
trichonodelliform	3	1		1	5
distacodontiform				1	1
VARIABILICONUS n.sp. A					
drepanodontiform	1				1
laterally unicostate	1				1
acontiodontiform			1		1
anteriorly sulcate			1		1
scandodontiform			3	1	4
WALLISERODUS ETHINGTONI	1	1			2
NEW GEN. 1 N. SP. A					
cordylodontiform		2	1		3
acodontiform	1	3	1		5
cladognathodontiform		1		1	2
NEW GEN. 1 N. SP. B					
cordylodontiform			1		1
acodontiform				1	1
cladognathiform				1	1
TOTAL	113	229	37	15	394

APPENDIX B:3. Occurrence and abundance of conodonts from Assemblage III.

	KC1	KC2	KC3	KC4	KC5	KC6	KC8a	KC8	TOTAL
DIAPHORODUS DELICATUS									
drepanodontiform			2	1	1		1	1	6
acontiodontiform			3						3
distacodontiform					1				1
oistodontiform			1	3	5		3	2	14
acodontiform				3	1		1	2	7
DIAPHORODUS RUSSOI									
acontiodontiform			1						1
distacodontiform							1		1
DREPANODUS ARCUATUS									
arcuatiform					1		1	2	4
homocurviform							1		1
pipaform							2	2	4
sculponeaform					1			1	2
DREPANODUS CONCAVUS									
arcuatiform		1		2				1	4
homocurviform				3					3
suberectiform		1							1
pipaform			2	2					4
sculponeaform			1	2	1				4
graciliform			1	1	2				4
DREPANOISTODUS BASIOVALIS									
homocurviform	1			1				1	3
suberectiform				1	1	2	1	1	6
oistodontiform					4	1	1	1	7
DREPANOISTODUS FORCEPS									
homocurviform					3				3
suberectiform					1				1
oistodontiform					2	1	1	4	8
scandodontiform					2				2
JUMUDONTUS GANANDA				2					2
MICROZARKODINA? MARATHONENSIS									
gothodontiform			2	2		1	1		6
oistodontiform			1	1	1				3
straight ozarkodiniform				1	1				2
arched ozarkodiniform			1	1					2
OEPIKODUS COMMUNIS									
cordylodontiform		3			27	1	7	14	52
gothodontiform		1			27		7	7	42
tetraprioniodontiform					10		2	4	16
falodontiform		1			15		3	14	33
prioniodontiform					33		12	11	56
OISTODUS BRANSONI									
cordylodontiform				1	2				3
cladognathiform					2				2
trichonodelliform	1				2		1		4
distacodontiform		1			2		1		4
oulodontiform					1		1		2
ONEOTODUS COSTATUS					9		12	7	28
PALTODUS SWEETI									
robustiform			2	2	5				9
acodontiform				3	3				6
PARACORDYLODUS GRACILIS									
cordylodontiform						1			1

APPENDIX B:3 (ctd.)

	KC1	KC2	KC3	KC4	KC5	KC6	KC8a	KC8	TOTAL
PARAPANDERODUS AEQUALIS									
long-based							1		1
short-based							1		1
PARAPANDERODUS STRIATUS									
long-based					1	1			2
short-based				2	1	1			4
triangulariform						1			1
PAROISTODUS PARALLELUS									
drepanodontiform	1							3	4
oistodontiform	1						1	1	3
ROSSODUS SYMMETRICUS									
drepanodontiform				2	1		1		4
tricostate			1	3	4		3		11
trapezognathiform				2	4				6
pentacostate					2				2
oistodontiform				3	2				5
scandodontiform				1					1
SCALPELLODUS n.sp.									
long-based					20		1		21
short-based					6		1		7
scandodontiform					7				7
"SCOLOPODUS" FILOSUS									
proclined element					3		5	4	12
SEMIACONTIODUS ASYMMETRICUS									
symmetrical			2						2
asymmetrical		2							2
SEMIACONTIODUS CORDIS									
acontiodontiform					1	1			2
symmetrical						1	1	1	3
asymmetric element		1			1	2	2		6
ungrooved element				1	1				2
STRIATODONTUS KAKIVANGUS									
asymmetrical					1			1	2
TRIPODUS LAEVIS									
drepanodontiform			1	2	2			1	6
trichonodelliform		1	1	2	2				6
paltodontiform				1					1
distacodontiform					1				1
oistodontiform		1	1	3	1		5		11
VARIABILICONUS n.sp. A									
drepanodontiform				1	2		2		5
laterally unicostate					1	1			2
acontiodontiform					2		4	2	8
anteriorly sulcate									
posteriorly sulcate					1				1
scandodontiform				1	2				3
unisulcate				1					1
WALLISERODUS ETHINGTONI					1				1
NEW GEN. 1 N. SP. B									
cordylodontiform				1			1		2
acodontiform				1					1
TOTAL	4	13	23	59	236	15	89	88	527

APPENDIX B:4. Occurrence and abundance of conodonts from Assemblage IV.

	KC10	KC11	KC12	KC13	KC15	TP1	TP2	TOTAL
DIAPHORODUS DELICATUS								
drepanodontiform	2	1		2				5
acontiodontiform				2				2
distacodontiform		1		1				2
oistodontiform		1		2				3
acodontiform	1	1		4				6
DIAPHORODUS EMANUELENSIS								
cordylodontiform		5	6	2				13
acontiodontiform		1	4	6				11
distacodontiform		4	2	4				10
oistodontiform		4	1	2				7
acodontiform		3	3	11				17
DREPANODUS ARCUATUS								
arcuatiform	1							1
sculponeaform				1				1
DREPANODUS CONCAVUS								
arcuatiform	4	1		2		1	1	9
homocurviform	4	2					2	8
suberectiform	3	1					1	5
pipaform	3	2	1	1			2	9
sculponeaform	6	2						8
graciliform	2	3		1			2	8
DREPANOISTODUS BASIOVALIS								
homocurviform		2	2	3		1		8
suberectiform				1		1	4	6
oistodontiform		2	3			1		6
DREPANOISTODUS FORCEPS								
homocurviform		2	1					3
suberectiform			1					1
oistodontiform		1	4					5
EUCHARODUS PARALLELUS								
plano-convex base	6	11	2	2			5	26
ovate	12	14		3			5	34
OEPIKODUS COMMUNIS								
cordylodontiform		2						2
gothodontiform		2						2
tetraprioniodontiform		1						1
falodontiform	4	3						7
prioniodontiform	2	1						3
OISTODUS BRANSONI								
cladognathodontiform	1							1
trichonodelliform		1						1
distacodontiform		1						1
oulodontiform	1							1
ONEOTODUS COSTATUS		3				1	4	8
PARAPANDERODUS ABEMARGINATUS								
grooved				1		1		2
ungrooved				1		1		2
PARAPANDERODUS AEQUALIS								
long-based	1	16						17
short-based	3	5						8
triangulariform	1	4						5

APPENDIX B:4 (ctd.)

	KC10	KC11	KC12	KC13	KC15	TP1	TP2	TOTAL
PARAPANDERODUS STRIOLATUS								
long-based							4	4
short-based							2	2
scandodontiform							2	2
?PRIONIODUS ELEGANS								
gothodontiform							1	1
oistodontiform							3	3
ROSSODUS SYMMETRICUS								
acontiodontiform					2		1	3
trapezognathiform				1			2	3
pentacostate							1	1
oistodontiform				1			2	3
scandodontiform				1				1
SCALPELLODUS n.sp.								
long-based			1					1
SEMIACONTIODUS ASYMMETRICUS								
symmetrical							3	3
asymmetrical							2	2
STRIATODONTUS KAKIVANGUS								
symmetrical	3	11	2	2		1		19
asymmetrical	4	7		3				14
TRIPODUS LAEVIS								
paltodontiform	1							1
VARIABILICONUS n.sp. A								
drepanodontiform				3				3
laterally unicostate	5	3		3	1			12
acontiodontiform		2		1				3
anteriorly sulcate	4							4
posteriorly sulcate		2		1				3
scandodontiform	2	1		3			1	7
TOTAL	76	129	33	71	3	8	50	370

APPENDIX B:5. Occurrence and abundance of conodonts from Assemblage V.

	TP4	TP5	TP6A	TP7	TP8	TP9A	TOTAL
DIAPHORODUS GRAVELSENSIS							
drepanodontiform					1		1
gothodontiform					1		1
distacodontiform					1		1
oistodontiform				1			1
acodontiform					1		1
DIAPHORODUS STEVENSI							
gothodontiform			1				1
oistodontiform			1				1
DREPANODUS CONCAVUS							
arcuatiform	1	1			1		3
homocurviform	1				1		2
suberectiform					2		2
pipaform	2				2		4
sculponeaform	1	2		1	1		5
graciliform	1	1			1		3
EUCHARODUS PARALLELUS							
plano-convex base		1			1		2
oval aboral opening	1				1	1	3
OEPIKODUS INTERMEDIUS							
tetraprioniodontiform		1					1
OISTODUS MULTICORRUGATUS							
cordylodontiform					1		1
cladognathiform					1		1
trichonodelliform					1		1
oulodontiform	1	1					2
ONEOTODUS COSTATUS					3		3
PTERACONTIODUS CRYPTODENS							
cordylodontiform			2			3	5
acodontiform						1	1
trichonodelliform						1	1
ROSSODUS SYMMETRICUS							
trichonodelliform	1						1
trapezognathiform	1						1
SEMIACONTIODUS ASYMMETRICUS							
symmetrical					1		1
TRIPODUS LAEVIS							
drepanodontiform					1		1
paltodontiform					1		1
oistodontiform					1		1
TOTAL	10	7	4	2	24	6	53

APPENDIX B:6. Occurrence and abundance of conodonts from Assemblage VI.

	TP10	TP11	TP12	TOTAL
DIAPHORODUS STEVENSI				
drepanodontiform	1			1
trichonodelliform	1			1
oistodontiform	1			1
DREPANODUS CONCAVUS				
arcuatiform	2			2
homocurviform	1			1
pipaform	2			2
sculponeaform	3			3
graciliform	1			1
DREPANODUS sp. cf. D. GRACILIS				
arcuatiform			2	2
suberectiform			1	1
pipaform			1	1
sculponeaform			3	3
EUCHARODUS PARALLELUS				
plano-convex base	2			2
oval aboral opening	4		2	6
JUMUDONTUS GANANDA	1			1
OEPIKODUS INTERMEDIUS				
coraylodontiform			1	1
gothodontiform	1		1	2
falodontiform	2		2	4
prioniodontiform	2			2
ONEOTODUS COSTATUS	10	6	9	25
PARAPANDERODUS ABEMARGINATUS				
grooved	2			2
ungrooved	1			1
PARAPANDERODUS STRIOLATUS				
long-based	1	1	3	5
short-based		1	1	2
triangulariform		1	3	4
REUTTERODUS sp.				
cone-like		2		2
SEMIACONTIODUS ASYMMETRICUS				
symmetrical	1	1		2
asymmetric		1	2	3
SEMIACONTIODUS CORDIS				
symmetrical	1			1
STRIATODONTUS KAKIVANGUS				
symmetrical	1			1
asymmetrical			2	2
TRIPODUS LAEVIS				
drepanodontiform			1	1
distacodontiform			1	1
oistodontiform			1	1
TOTAL	41	13	36	90

APPENDIX B:7. Occurrence and abundance of conodonts from Assemblage VII.

	TP13	TP14	TP15	TP15A	TP16	TP17	TOTAL
BERGSTROEMOGNATHUS ALUS							
cordylodontiform	8						8
zygognathodontiform	5						5
trichonodelliform	6						6
falodontiform	9						9
prioniodontiform	8						8
DIAPHORODUS GRAVELSENSIS							
drepanodontiform	2						2
gothodontiform	1	1					2
acontiodontiform	1						1
acodontiform	1	2					3
DIAPHORODUS STEVENSI							
drepanodontiform	1						1
gothodontiform	9						9
trichonodelliform	1						1
tetraprioniodontiform	1	1					2
oistodontiform	1						1
acodontiform	1						1
DREPANOISTODUS ANGULENSIS							
homocurviform	5	2					7
suberectiform	2						2
oistodontiform	10	3					13
scandodontiform	4	1					5
ERISMODUS ASYMMETRICUS							
cordylodontiform	5	1		1	1		8
zygognathodontiform	2	1	1	1			5
trichonodelliform	2				1		3
aphelognathodontiform	3		1		1	1	6
oulodontiform	3						3
ERISMODUS sp.							
cordylodontiform	7						7
zygognathodontiform	10			2			12
trichonodelliform	3			2			5
neoprioniodontiform	2			1			3
aphelognathodontiform	1						1
oulodontiform	2						2
EUCHARODUS PARALLELUS							
plano-convex	17						17
ovate	14					1	15
GLYPTOCONUS RECTUS							
triplicatiform	1						1
JUMUDONTUS GANANDA	4						4
LEPTOCHIROGNATHUS PLANUS							
cordylodontiform	20	2					22
zygognathodontiform	19	2					21
trichonodelliform	3						3
oistodontiform	4	4					8
cyrtoniodontiform	1						1
LEPTOCHIROGNATHUS QUADRATUS							
cordylodontiform	52	5					57
zygognathodontiform	55	5					60
trichonodelliform	18	4					22
oistodontiform	15	5					20
cyrtoniodontiform	8	1					9
"? MULTIOISTODUS AURITUS"							
cordylodontiform	1						1
acodontiform	4						4
trichonodelliform	3			1			4

APPENDIX B:7 (ctd.)

	TP13	TP14	TP15	TP15A	TP16	TP17	TOTAL
MULTIOISTODUS SUBDENTATUS							
cordylodontiform	8	1			1		10
acodontiform	6						6
trichonodelliform	2						2
distacodontiform	3						3
OEPIKODUS INTERMEDIUS							
cordylodontiform	1		1				2
gothodontiform	1		2				3
tetraprioniodontiform			1				1
prioniodontiform	1		1				2
ONEOTODUS COSTATUS	65						65
PARAPANDERODUS ABEMARGINATUS							
emarginatiform	10						10
ungrooved	9	1					10
PARAPANDERODUS STRIOLATUS							
long-based	7	1	1	1			10
short-based	7	1					8
triangulariform	4						4
PARAPRIONIODUS COSTATUS							
cordylodontiform	3	1					4
zygognathodontiform	1			1	3		5
trichonodelliform	1			1			2
tetraprioniodontiform	2		1				3
cyrtoniodontiform	5	1			1		7
extended prioniodontiform	2		2				4
pendant prioniodontiform	1			2		1	4
PROTOPANDERODUS STRIGATUS							
subsym. acontiodontiform	7						7
asym. acontiodontiform	4						4
"acodontiform"	2						2
scandodontiform	3						3
PTERACONTIODUS CRYPTODENS							
cordylodontiform	1	2					3
acodontiform	1						1
trichonodelliform	2						2
distacodontiform	1						1
oistodontiform		1					1
REUTTERODUS sp.		2	1				3
SCANDODUS SINUOSUS							
drepanodontiform	49	14		4	2		69
bicostate (plano-convex)	53	5	2	2	3		65
acontiodontiform	52	4		4	6		66
distacodontiform	165	5		5	4	1	180
oistodontiform	28	2			1		31
scandodontiform	68	5		4	1	1	79
acodontiform	136	3	2	3	1		145
SEMIACONTIODUS ASYMMETRICUS							
symmetrical	6						6
asymmetrical	7						7
SEMIACONTIODUS CORDIS							
symmetrical	2	2					4
asymmetrical	4	2					6
bicostate	2	1					3
STRIATODONTUS KAKIVANGUS							
symmetrical	6	1					7
asymmetrical	5	1					6
TOTAL	1098	96	16	35	26	5	1275

APPENDIX B:8. Occurrence and abundance of conodonts from D.D.H. 1827.

	1827.01	1827.02	1827.03	TOTAL
DIAPHORODUS DELICATUS gothodontiform	1			1
EUCHARODUS PARALLELUS plano-convex		1		1
MICROZARKODINA? MARATHONENSIS gothodontiform		1		1
ONEOTODUS COSTATUS		1		1
PALTODUS SWEETI robustiform			1	1
PAROISTODUS PARALLELUS oistodontiform		1		1
?PRIONIODUS ELEGANS tetraprioniodontiform		1		1
VARIABILICONUS n.sp. A drepanodontiform			1	1
VARIABILICONUS n.sp. B bicostate		1		1
TOTAL	1	6	2	9

APPENDIX B:9. Occurrence and abundance of conodonts from D.D.H. 66A.

	66A.01	66A.02	66A.03	TOTAL
CLAVOHAMULUS CAVUS		1		1
DREPANODUS ARCUATUS				
arcuatiform		2		2
DREPANODUS CONCAVUS				
homocurviform			1	1
DREPANOISTODUS FORCEPS				
suberectiform	1	1		2
oistodontiform			1	1
DREPANOISTODUS INAEQUALIS				
homocurviform			1	1
oistodontiform			1	1
EUCHARODUS PARALLELUS				
plano-convex	1			1
GLYPTOCONUS QUADRAPLICATUS				
triangulariform			1	1
quadraplicatiform			1	1
OEPIKODUS COMMUNIS				
cordylodontiform			2	2
gothodontiform		1	1	2
tetraprioniodontiform			2	2
falodontiform			1	1
prioniodontiform		1	1	2
ONEOTODUS COSTATUS		3	1	4
PALTODUS SWEETI				
robustiform			1	1
PARAPANDERODUS STRIATUS				
triangulariform			1	1
PAROISTODUS PARALLELUS				
drepanodontiform		1	1	2
?PROTOPRIONIODUS COSTATUS				
elongatiform		1		1
TRIPODUS LAEVIS				
drepanodontiform			1	1
trichonodelliform			1	1
WALLISERODUS ETHINGTONI		1		1
NEW GEN. 1 N.SP. B				
cordylodontiform			1	1
TOTAL	2	12	20	34

APPENDIX B:10. Occurrence and abundance of conodonts from D.D.H. 438.

D.D.H. 438:	02	05	06	07	09	12	16	17	18	19	20	21	22	26	TOTAL
ANSELLA sp.															
cordylodontiform									1						1
DIAPHORODUS DELICATUS															
oistodontiform									1						1
DIAPHORODUS GRAVELSENSIS															
drepanodontiform				1											1
acontiodontiform				2											2
distacodontiform				1											1
oistodontiform				1	1										2
acodontiform				1											1
DIAPHORODUS STEVENSI															
drepanodontiform						1									1
distacodontiform						1									1
oistodontiform						1									1
DREPANODUS ARCUATUS															
arcuatiform		1											1		2
sculponeaform													1		1
pipaform													1		1
DREPANODUS CONCAVUS															
arcuatiform										1					1
homocurviform							1	1							2
suberectiform							1								1
pipaform							1	1							2
graciliform							1			1					2
DREPANOISTODUS BASIOVALIS															
homocurviform			2												2
oistodontiform			2							2			1		5
DREPANOISTODUS FORCEPS															
homocurviform									1						1
scandodontiform									1						1
oistodontiform									1				2		3
DREPANOISTODUS INAEQUALIS															
homocurviform												1			1
EUCHARODUS PARALLELUS															
plano-convex		1					1								2
ovate						1				1					2
JUANOGNATHUS VARIABLIIS													1		1
MICROZARKODINA? MARATHONENSIS															
gothodontiform		1													1
trichonodelliform													1		1
straight ozarkodinaform		1													1
arched ozarkodinaform		1													1
prioniodontiform		1									1				2
OEPIKODUS COMMUNIS															
cordylodontiform									12	2	1			1	16
gothodontiform			1						12	1	1		1		16
tetraprioniodontiform			1						4	1				1	7
falodontiform									13			1	1		15
prioniodontiform									17	1			1		19

APPENDIX B:10 (ctd.)

D.D.H. 438:	02	05	06	07	09	12	16	17	18	19	20	21	22	26	TOTAL
OISTODUS MULTICORRUGATUS															
trichonodelliform										1					1
ONEOTODUS COSTATUS									1	1					2
PALTODUS SWEETI															
robustiform													1		1
intermediate			1										1		2
PARACORDYLODUS GRACILIS															
paracordylodontiform													1		1
PARAPANDERODUS ABEMARGINATUS															
ungrooved					1	1									2
PARAPANDERODUS AEQUALIS															
long-based	1							1							2
short-based	1														1
PARAPANDERODUS STRIATUS															
long-based			2												2
short-based			1												1
triangulariform			1										1		2
PAROISTODUS PARALLELUS															
acodontiform									1						1
oistodontiform									2						2
PROTOPANDERODUS GRADATUS															
asym. acontiodontiform				1									1		2
ROSSODUS SYMMETRICUS															
drepanodontiforms													3		3
trichonodelliform													1		1
trapezognathodontiform			1												1
pentacostate													1		1
oistodontiform													4		4
scandodontiform														1	1
SCALPELLODUS n.sp.															
short-based													1		1
SEMIACONTIODUS CORDIS															
symmetrical, grooved		1	3						1						5
asymmetrical, grooved		1	1						1						3
bicostate			1						1						2
STRIATODONTUS KAKIVANGUS															
symmetrical			2												2
asymmetrical			1							1					2
TRIPODUS LAEVIS															
drepanodontiform										1					1
trichonodelliform										2			2		4
oistodontiform										1			4		5
VARIABILICONUS n.sp. A															
acontiodontiform			1												1
VARIABILICONUS n.sp. B															
drepanodontiform							1								1
bicostate								1							1
acontiodontiform							1								1
TOTAL	2	8	21	7	2	5	7	4	70	17	3	2	32	3	183

APPENDIX B:11. Occurrence and abundance of conodonts from D.D.H. 1500.

	1500.04	1500.05	1500.07	1500.09	1500.10	TOTAL
DIAPHORODUS GRAVELSENSIS						
drepanodontiform		1				1
gothodontiform		1				1
oistodontiform		1				1
DIAPHORODUS STEVENSI						
gothodontiform	1					1
distacodontiform	1					1
oistodontiform	1					1
prioniodontiform	1					1
DREPANODUS CONCAVUS						
arcuatiform		4			1	5
homocurviform		1				1
sculponeaform		1				1
pipaform			1			1
graciliform		1	1	1		3
EUCHARODUS PARALLELUS						
plano-convex		2				2
ovate	1	2				3
PARAPANDERODUS AEQUALIS						
long-based		1				1
short-based		3				3
triangulariform		2				2
PAROISTODUS PARALLELUS						
acodontiform		1				1
ROSSODUS SYMMETRICUS						
trichonodelliform				1		1
SEMIACONTIODUS CORDIS						
symmetrical		3				3
asymmetrical		2				2
STRIATODONTUS KAKIVANGUS						
symmetrical		1				1
asymmetrical		1				1
TRIPODUS LAEVIS						
oistodontiform			1			1
VARIABILICONUS n.sp. B						
bicostate		1				1
acontiodontiorm		1				1
quadricostate		1				1
scandodontiform		1				1
TOTAL	5	32	3	2	1	43

APPENDIX B:12. Occurrence and abundance of conodonts from D.D.H. 715.

D.D.H. 715:	07	08	09	10	11	12	13	16	17	18	19	20
ANSELLA sp.												
gothodontiform												
cf. CRISTODUS LOXOIDES												
monodenticulate										1	3	
multidenticulate											2	
DIAPHORODUS DELICATUS												
drepanodontiform										1		
distacodontiform												
oistodontiform										1	1	
acodontiform												
DIAPHORODUS GRAVELSENSIS												
drepanodontiform		1			2		1		7	2	2	
gothodontiform									3		1	
acontiodontiform									5	1		
distacodontiform		1			1				3		1	
oistodontiform					3				2			1
acodontiform								1	2			
DIAPHORODUS STEVENSI												
drepanodontiform		1						1				
gothodontiform								1				
acontiodontiform			1									
distacodontiform									1			
oistodontiform								1	1		1	
acodontiform								2			1	
DREPANODUS ARCUATUS												
arcuatiform												
sculponeaform												
pipaform										1		
DREPANODUS CONCAVUS												
arcuatiform		1	1		2							
homocurviform		2								1		
suberectiform		1			1							
sculponeaform		1	1		1							
pipaform		2										1
graciliform					1					1		
DREPANOISTODUS ANGULENSIS												
homocurviform					1				1			
suberectiform					1				1			
oistodontiform					2				1			
DREPANOISTODUS BASIOVALIS												
homocurviform					1					1		1
oistodontiform												2
EUCHARODUS PARALLELUS												
plano-convex	2	2	1	1						2		
ovate		1			1							
GLYPTOCONUS RECTUS												
triplicatiform			1									
quadraplicatiform				1								
HISTIODELLA HOLODENTATA												
short bryantodontiform		1										
JUANOGNATHUS VARIABILIS												
OEPIKODUS COMMUNIS												
cordylodontiform												
gothodontiform												
falodontiform												
prioniodontiform												
OEPIKODUS INTERMEDIUS												
cordylodontiform												3
gothodontiform	1											4
tetraprioniodontiform												
falodontiform		2										5
prioniodontiform	1	2								3		3

APPENDIX B:12 (ctd.)

D.D.H. 715:	07	08	09	10	11	12	13	16	17	18	19	20
OISTODUS BRANSONI												
cordylodontiform												
cladognathodontiform												
trichonodelliform												
OISTODUS MULTICORRUGATUS												
cladognathodontiform		1										
ONEOTODUS COSTATUS	1	4	1					1		8		
PALTODUS SWEETI												
robustiform												
intermediate												
sweetiform												
PARAPANDERODUS ABEMARGINATUS												
emarginatiform												
PARAPANDERODUS AEQUALIS												
long-based												
PARAPANDERODUS STRIOLATUS												
long-based		1										
triangulariform		2										
PROTOPANDERODUS GRADATUS												
unicostate												
tricostate												
PTERACONTIODUS CRYPTODENS												
cordylodontiform						1						
ROSSODUS SYMMETRICUS												
drepanodontiform												
tricostate												
pentacostate												
oistodontiform												
scandodontiform												
SCALPELLODUS n.sp.												
scandodontiform										1		
SEMIACONTIODUS ASYMMETRICUS												
asymmetrical										1		
SEMIACONTIODUS CORDIS												
symmetrical		1										3
asymmetrical		1			1							
bicostate	1	1										1
STRIATODONTUS KAKIVANGUS												
symmetrical		1						1		1	1	1
asymmetrical		1								1		
TRIPODUS LAEVIS												
drepanodontiform												
trichonodelliform												
paltodontiform												
oistodontiform												
VARIABILICONUS n.sp. A												
drepanodontiform										1		
acontiodontiform										1		
scandodontiform												
posteriorly unisulcate										1		
VARIABILICONUS n.sp. B												
drepanodontiform												1
acontiodontiform												1
quadricostate			1									
scandodontiform												1
posteriorly unisulcate					1							
NEW GEN. 1 N.SP. A												
acodontiform												
oistodontiform	1											
elongatiform	1											
TOTAL	8	31	7	2	19	1	1	8	27	30	13	28

APPENDIX B:12 (ctd.)

D.D.H. 715:	21	22	23	25	26	28	29	31	32	01	33	02
ANSELLA sp.												
gothodontiform				1								
cf. CRISTODUS LOXOIDES												
monodenticulate	2											
multidenticulate												
DIAPHORODUS DELICATUS												
drepanodontiform					2							
distacodontiform					1							
oistodontiform					1							
acodontiform					1							
DIAPHORODUS GRAVELSENSIS												
drepanodontiform	3	4	1		5							
gothodontiform		2										
acontiodontiform	3	2			1			1		1		
distacodontiform	2	3	2		1			1				
oistodontiform	2		1		3					1		
acodontiform		1	1		1							
DIAPHORODUS STEVENSI												
drepanodontiform		2										1
gothodontiform		1										1
acontiodontiform												1
distacodontiform		1										
oistodontiform		1										2
acodontiform		1										
DREPANODUS ARCUATUS												
arcuatiform				2								
sculponeaform				1								
pipaform												
DREPANODUS CONCAVUS												
arcuatiform							1				3	
homocurviform							1		1		1	
suberectiform												
sculponeaform									2			
pipaform												
graciliform												
DREPANOISTODUS ANGULENSIS												
homocurviform												
suberectiform												
oistodontiform												
DREPANOISTODUS BASIOVALIS												
homocurviform	2				2	1						
oistodontiform	1			5								
EUCHARODUS PARALLELUS												
plano-convex	1						1		3	1	1	
ovate	1							1	1	1	2	
GLYPTOCONUS RECTUS												
triplicatiform												
quadraplicatiform												
HISTIODELLA HOLODENTATA												
short bryantodontiform												
JUANOGNATHUS VARIABILIS												
OEPIKODUS COMMUNIS												
cordylodontiform				1								
gothodontiform				4					1		1	
falodontiform				3							1	
prioniodontiform				3							1	
OEPIKODUS INTERMEDIUS												
cordylodontiform												
gothodontiform												
tetraprioniodontiform	1											
falodontiform												
prioniodontiform	1											

APPENDIX B:12 (ctd.)

D.D.H. 715:	21	22	23	25	26	28	29	31	32	01	33	02
OISTODUS BRANSONI												
cordylodontiform									1			
cladognathodontiform									1			
trichonodelliform												
OISTODUS MULTICORRUGATUS												
cladognathodontiform												
ONEOTODUS COSTATUS					4				2		1	
PALTODUS SWEETI												
robustiform												
intermediate												
sweetiform												
PARAPANDERODUS ABEMARGINATUS												
emarginatiform		1										
PARAPANDERODUS AEQUALIS												
long-based									1			
PARAPANDERODUS STRIOLATUS												
lcng-based												
triangulariform												
PROTOPANDERODUS GRADATUS												
unicostate												
tricostate												
PTERACONTIODUS CRYPTODENS												
cordylodontiform												
ROSSODUS SYMMETRICUS												
drepanodontiform									1			
tricostate												
pentacostate									1			
oistodontiform												
scandodontiform									1			
SCALPELLODUS n.sp.												
scandodontiform												
SEMIACONTIODUS ASYMMETRICUS												
asymmetrical												
SEMIACONTIODUS CORDIS												
symmetrical	1			2	1				2		1	
asymmetrical	2			1	2				1		1	
bicostate												
STRIATODONTUS KAKIVANGUS												
symmetrical									2			
asymmetrical					1				1			
TRIPODUS LAEVIS												
drepanodontiform											1	
trichonodelliform												
paltodontiform												
oistodontiform									1		1	
VARIABILICONUS n.sp. A												
drepanodontiform				1								
acontiodontiform												
scandodontiform				1								
posteriorly unisulcate												
VARIABILICONUS n.sp. B												
drepanodontiform									1			
acontiodontiform									4	1		
quadricostate												
scandodontiform												
posteriorly unisulcate									2	1		
NEW GEN. 1 N.SP. A												
acodontiform												
oistodontiform												
elongatiform												
TOTAL	22	19	5	25	26	1	3	3	30	6	15	5

APPENDIX B:12 (ctd.)

D.D.H. 715:	34	35	36	37	38	39	40	41	44	47	TOTAL
ANSELLA sp.											
gothodontiform											1
cf. CRISTODUS LOXOIDES											
monodenticulate											6
multidenticulate											2
DIAPHORODUS DELICATUS											
drepanodontiform						1					4
distacodontiform											1
oistodontiform						3					6
acodontiform											1
DIAPHORODUS GRAVELSENSIS											
drepanodontiform											28
gothodontiform											6
acontiodontiform											14
distacodontiform											15
oistodontiform											13
acodontiform											6
DIAPHORODUS STEVENSI											
drepanodontiform											5
gothodontiform											3
acontiodontiform											2
distacodontiform											2
oistodontiform											6
acodontiform											4
DREPANODUS ARCUATUS											
arcuatiform						2					4
sculponeaform											1
pipaform											1
DREPANODUS CONCAVUS											
arcuatiform		3							1		12
homocurviform	1				1	1					9
suberectiform											2
sculponeaform											5
pipaform											3
graciliform		1	1								4
DREPANOISTODUS ANGULENSIS											
homocurviform											2
suberectiform											2
oistodontiform											3
DREPANOISTODUS BASIOVALIS											
homocurviform		4									12
oistodontiform						1					9
EUCHARODUS PARALLELUS											
plano-convex			1								16
ovate											8
GLYPTOCONUS RECTUS											
triplicatiform											1
quadraplicatiform											1
HISTIODELLA HOLODENTATA											
short bryantodontiform											1
JUANOGNATHUS VARIABILIS										4	4
OEPIKODUS COMMUNIS											
cordylodontiform						2					3
gothodontiform		2				1					9
falodontiform		1							1		6
prioniodontiform											4
OEPIKODUS INTERMEDIUS											
cordylodontiform											3
gothodontiform											5
tetraprioniodontiform											1
falodontiform											7
prioniodontiform											10

APPENDIX B:12 (ctd.)

D.D.H. 715:	34	35	36	37	38	39	40	41	44	47	TOTAL
OISTODUS BRANSONI											
cordylodontiform											1
cladognathodontiform			1								2
trichonodelliform						1					1
OISTODUS MULTICORRUGATUS											
cladognathodontiform											1
ONEOTODUS COSTATUS		4	1								27
PALTODUS SWEETI											
robustiform						1					1
intermediate						2					2
sweetiform		1				1					2
PARAPANDERODUS ABEMARGINATUS											
emarginatiform											1
PARAPANDERODUS AEQUALIS											
long-based											1
PARAPANDERODUS STRIOLATUS											
long-based											1
triangulariform											2
PROTOPANDERODUS GRADATUS											
unicostate								1			1
tricostate									1		1
PTERACONTIODUS CRYPTODENS											
cordylodontiform											1
ROSSODUS SYMMETRICUS											
drepanodontiform	1		2			2					6
tricostate						4	1				5
pentacostate						1					2
oistodontiform						4					4
scandodontiform			1								2
SCALPELLODUS n.sp.											
scandodontiform											1
SEMIACONTIODUS ASYMMETRICUS											
asymmetrical											1
SEMIACONTIODUS CORDIS											
symmetrical											11
asymmetrical						1					10
bicostate											3
STRIATODONTUS KAKIVANGUS											
symmetrical											7
asymmetrical											4
TRIPODUS LAEVIS											
drepanodontiform						3					4
trichonodelliform	1					2					3
paltodontiform				1		1					2
oistodontiform					1	4					7
VARIABILICONUS n.sp. A											
drepanodontiform											2
acontiodontiform											1
scandodontiform											1
posteriorly unisulcate											1
VARIABILICONUS n.sp. B											
drepanodontiform						2					4
acontiodontiform			1			2					9
quadricostate			1			1					3
scandodontiform											1
posteriorly unisulcate						1					5
NEW GEN. 1 N.SP. A											
acodontiform						1					1
oistodontiform											1
elongatiform											1
TOTAL	3	16	9	1	2	45	1	1	3	4	420

APPENDIX B:13. Occurrence and abundance of conodonts from D.D.H. 440.

D.D.H. 440:	01	03	04	06	08	09	11	13	15	TOTAL
DIAPHORODUS STEVENSI										
acontiodontiform					1					1
DREPANODUS CONCAVUS										
arcuatiform							1			1
sculponeaform							2		1	3
pipaform							1			1
DREPANODUS sp. cf. D. GRACILIS										
arcuatiform				1						1
DREPANOISTODUS BASIOVALIS										
homocurviform									2	2
DREPANOISTODUS FORCEPS										
suberectiform						1				1
oistodontiform						7				7
EUCHARODUS PARALLELUS										
planoconvex									1	1
ovate									1	1
MICROZARKODINA? MARATHONENSIS										
oistodontiform						1				1
arched ozarkodinaform						1				1
OEPIKODUS COMMUNIS										
cordylodontiform						2				2
gothodontiform						2	1			3
tetraprioniodontiform						2				2
falodontiform						6	1			7
prioniodontiform						3	1			4
OEPIKODUS INTERMEDIUS										
gothodontiform					1					1
prioniodontiform					1					1
ONEOTODUS COSTATUS						2			2	4
PALTODUS SWEETI										
intermediate							1			1
PARAPANDERODUS STRIATUS										
short-based							1			1
triangulariform								1		1
PARAPRIONIODUS COSTATUS										
prioniodinaform		1	1							2
cladognathodontiform	1									1
tetraprioniodontiform		1								1
prioniodontiform			1							1
roundyaform		1								1
PAROISTODUS PARALLELUS										
drepanodontiform							1			1
oistodontiform						1	3			4
PROTOPRIONIODUS PAPILOSUS										
tetraprioniodontiform						1				1
prioniodontiform						1				1
SCANDODUS SINUOSUS										
acodontiform		1	1							2
acontiodontiform				3						3
SEMIACONTIODUS CORDIS										
symmetrical						1				1
asymmetrical						1				1
TRIPODUS LAEVIS										
drepanodontiform							1		1	2
trichonodelliform							1			1
oistodontiform							1			1
TOTAL	1	4	3	4	3	32	16	1	8	72

APPENDIX B:14. Occurrence and abundance of conodonts from D.D.H. 498.

D.D.H. 498:	02	03	04	05	08	10	11	13	14	15	TOTAL
DIAPHORODUS GRAVELSENSIS											
drepanodontiform								1			1
gothodontiform							1				1
distacodontiform								1			1
oistodontiform								1			1
acodontiform					1	1		1			3
DIAPHORODUS STEVENSI											
drepanodontiform					1						1
gothodontiform					1						1
oistodontiform	1						1				2
acodontiform						1					1
DREPANODUS ARCUATUS											
homocurviform									1		1
DREPANODUS sp. cf. D. GRACILIS											
graciliform						1					1
DREPANOISTODUS BASIOVALIS											
homocurviform						1	1	3		1	6
suberectiform								1			1
oistodontiform								1			1
HISTIODELLA HOLODENTATA											
spathognathodontiform	1										1
PARAPANDERODUS STRIOLATUS											
long-based	1										1
short-based	5									1	6
triangulariform	3									1	4
PARAPRIONIODUS COSTATUS											
cladognathodontiform				1							1
prioniodontiform		1									1
PROTOPANDERODUS STRIGATUS											
asymm. acontiodontiform								1			1
SCANDODUS SINUOSUS											
acodontiform				1							1
acontiodontiform			1	2	1						4
distacodontiform	1			1							2
scandodontiform			1								1
TOTAL	12	1	2	5	4	4	3	10	1	3	45

APPENDIX C: Catalogue of type and figured specimens, all deposited in the conodont collections of the Geological Survey of Canada. Catalogue numbers are preceded by the letters GSC. Letters at end of each description refer to grid reference co-ordinates of the sample collecting locality (listed in Appendix D).

Catalogue Number	Subject
GSC 93029	Ansella sp., tetraprioniodontiform (d) element, figured specimen, D.D.H. A1.05, P.
GSC 93030	Ansella sp., oistodontiform (e) element, figured specimen, D.D.H. A1.05 P.
GSC 93031	Bergstroemognathus alus n.sp., cordylodontiform (a) element, paratype, TP13, S.
GSC 93032	Bergstroemognathus alus n.sp., zygognathodontiform (b) element, paratype, TP13, S.
GSC 93033	Bergstroemognathus alus n.sp., trichonodelliform (c) element, paratype, TP13, S.
GSC 93034	Bergstroemognathus alus n.sp., falodontiform (e) element, paratype, TP13, S.
GSC 93035	Bergstroemognathus alus n.sp., prioniodontiform (f) element, holotype, TP13, S.
GSC 93036	Bergstroemognathus extensus Serpagli, cordylodontiform (a) element, hypotype, BC2, I.
GSC 93037	Bergstroemognathus extensus Serpagli, zygognathodontiform (b) element, hypotype,

BC2, I.

GSC 93038 Bergstroemognathus extensus Serpagli, trichonodelliform (c) element, hypotype, BC2, I.

GSC 93039 Bergstroemognathus extensus Serpagli, falodontiform (e) element, hypotype, BC2, I.

GSC 93040 Bergstroemognathus extensus Serpagli, prioniodontiform (f) element, hypotype, BC2, I.

GSC 93041 Clavohamulus cavus n.sp., holotype, D.D.H. A1.07, P.

GSC 93042 Clavohamulus cavus n.sp., paratype, D.D.H. A1.07, P.

GSC 93043 cf. Cristodus loxoides Repetski, multidenticulate element, hypotype, D.D.H. 715.19, N.

GSC 93044 cf. Cristodus loxoides Repetski, monodenticulate element, hypotype, AgR2, E.

GSC 93045 Diaphorodus delicatus (Branson and Mehl), drepanodontiform (a) element, hypotype, BC1, H.

GSC 93046 Diaphorodus delicatus (Branson and Mehl), gothodontiform (b) element, hypotype, D.D.H. A1.07, P.

GSC 93047 Diaphorodus delicatus (Branson and Mehl), acontiodontiform (c) element, hypotype, D.D.H. A1.06, P.

GSC 93048 Diaphorodus delicatus (Branson and Mehl), distacodontiform (d) element, hypotype, D.D.H. A1.04, P.

GSC 93049 Diaphorodus delicatus (Branson and Mehl), oistodontiform (e) element, hypotype, BCl, H.

GSC 93050 Diaphorodus delicatus (Branson and Mehl), prioniodontiform (f) element, hypotype, BCl, H.

GSC 93051 Diaphorodus emanuelensis (McTavish), drepanodontiform (a) element, hypotype, KC11, T.

GSC 93052 Diaphorodus emanuelensis (McTavish), drepanodontiform (a) element, hypotype, KC13, T.

GSC 93053 Diaphorodus emanuelensis (McTavish), gothodontiform (b) element, hypotype, KC13, T.

GSC 93054 Diaphorodus emanuelensis (McTavish), acontiodontiform (c) element, hypotype, KC13, T.

GSC 93055 Diaphorodus emanuelensis (McTavish). tetraprioniodontiform (d) element, hypotype, KC13, T.

GSC 93056 Diaphorodus emanuelensis (McTavish), oistodontiform (e) element, hypotype, KC13, T.

GSC 93057 Diaphorodus emanuelensis (McTavish), prioniodontiform (f) element, hypotype, KC13, T.

GSC 93058 Diaphorodus gravelsensis n.sp., drepanodontiform (a) element, paratype, AgR3, E.

GSC 93059 Diaphorodus gravelsensis n.sp., gothodontiform (b) element, paratype, D.D.H. 715.17, N.

GSC 93060 Diaphorodus gravelsensis n.sp., acontiodontiform (c) element, paratype, D.D.H. 715.17, N.

GSC 93061 Diaphorodus gravelsensis n.sp., acontiodontiform (c) element, paratype, D.D.H. 715.22, N.

GSC 93062 Diaphorodus gravelsensis n.sp., distacodontiform (d) element, paratype, D.D.H. 715.22, N.

GSC 93063 Diaphorodus gravelsensis n.sp., oistodontiform (e) element, paratype, D.D.H. 715.17, N.

GSC 93064 Diaphorodus gravelsensis n.sp., prioniodontiform (f) element, holotype, D.D.H. 715.17, N.

GSC 93065 Diaphorodus russoi (Serpagli), cordylodontiform (a) element, hypotype, D.D.H. A1.06, P.

GSC 93066 Diaphorodus russoi (Serpagli), gothodontiform (b) element, hypotype, D.D.H. A1.07, P.

GSC 93067 Diaphorodus russoi (Serpagli), acontiodontiform (c) element, hypotype, D.D.H. A1.06, P.

GSC 93068 Diaphorodus russoi (Serpagli), tetraprioniodontiform (d) element, hypotype, D.D.H. A1.06, P.

GSC 93069 Diaphorodus russoi (Serpagli), oistodontiform (e) element, hypotype, D.D.H. A1.06, P.

GSC 93070 Diaphorodus russoi (Serpagli), oistodontiform (e) element, hypotype, D.D.H. A1.07, P.

GSC 93071 Diaphorodus russoi (Serpagli), belodontiform (f) element, hypotype, D.D.H. A1.06, P.

GSC 93072 *Diaphorodus stevensi* n.sp. drepanodontiform (*a*) element, paratype, AgR3, E.

GSC 93073 *Diaphorodus stevensi* n.sp. gothodontiform (*b*) element, paratype, D.D.H. 715.22, N.

GSC 93074 *Diaphorodus stevensi* n.sp. acontiodontiform (*c*) element, paratype, AP3, C.

GSC 93075 *Diaphorodus stevensi* n.sp. distacodontiform (*d*) element, paratype, AgR3, E.

GSC 93076 *Diaphorodus stevensi* n.sp. distacodontiform (*d*) element, paratype, D.D.H. 715.17, N.

GSC 93077 *Diaphorodus stevensi* n.sp. oistodontiform (*e*) element, paratype, AP3, C.

GSC 93078 *Diaphorodus stevensi* n.sp. prioniodontiform (*f*) element, holotype, D.D.H. 715.02, N.

GSC 93079 *Drepanodus arcuatus* Pander, arcuatiform (*p*) element, hypotype, BC2, I.

GSC 93080 *Drepanodus arcuatus* Pander, sculponeaform (*p'*) element, hypotype, BC2, I.

GSC 93081 *Drepanodus arcuatus* Pander, homocurvatiform (*p"*) element, hypotype, BC2, I.

GSC 93082 *Drepanodus arcuatus* Pander, acontiodontiform (*p'"*) element, hypotype, BC2, I.

GSC 93083 *Drepanodus arcuatus* Pander, pipaform (*q*) element, hypotype, BC2, I.

GSC 93084 *Drepanodus concavus* (Branson and Mehl), homocurvatiform (*a*) element, hypotype, KC10, T.

GSC 93085 Drepanodus concavus (Branson and Mehl), arcuatiform (b) element, hypotype, D.D.H. A1.11, P.

GSC 93086 Drepanodus concavus (Branson and Mehl), suberectiform (c) element, hypotype, KC11, T.

GSC 93087 Drepanodus concavus (Branson and Mehl), pipaform (e) element, hypotype, KC11, T.

GSC 93088 Drepanodus concavus (Branson and Mehl), sculponeaform (f) element, hypotype, KC10, T.

GSC 93089 Drepanodus concavus (Branson and Mehl), graciliform (g) element, hypotype, D.D.H. 715.11, N.

GSC 93090 Drepanodus sp. cf. D. gracilis (Branson and Mehl), homocurvatiform (a) element, figured specimen, AgB2, D.

GSC 93091 Drepanodus sp. cf. D. gracilis (Branson and Mehl), arcuatiform (b) element, figured specimen, TP13, S.

GSC 93092 Drepanodus sp. cf. D. gracilis (Branson and Mehl), suberectiform (c) element, figured specimen, TP13, S.

GSC 93093 Drepanodus sp. cf. D. gracilis (Branson and Mehl), pipaform (e) element, figured specimen, TP13, S.

GSC 93094 Drepanodus sp. cf. D. gracilis (Branson and Mehl), sculponeaform (f) element, figured specimen, TP12, S.

GSC 93095 Drepanodus sp. cf. D. gracilis (Branson and Mehl), graciliform (q) element, figured specimen, TP13, S.

GSC 93096 *Drepanoistodus angulensis* (Harris), suberectiform (p) element, hypotype, TP13, S.

GSC 93097 *Drepanoistodus angulensis* (Harris), homocurvatiform (q) element, hypotype, TP13, S.

GSC 93098 *Drepanoistodus angulensis* (Harris), scandodontiform (q') element, hypotype, D.D.H. 715.11, N.

GSC 93099 *Drepanoistodus angulensis* (Harris), oistodontiform (r) element, hypotype, D.D.H. 715.17, N.

GSC 93100 *Drepanoistodus angulensis* (Harris), oistodontiform (r) element, hypotype, D.D.H. 715.22, N.

GSC 93101 *Drepanoistodus basiovalis* (Sergeeva), suberectiform (p) element, hypotype, AgC1, G.

GSC 93102 *Drepanoistodus basiovalis* (Sergeeva), homocurvatiform (q) element, hypotype, BC1, H.

GSC 93103 *Drepanoistodus basiovalis* (Sergeeva), oistodontiform (r) element, hypotype, AgC1, G.

GSC 93104 *Drepanoistodus forceps* (Lindström), homocurvatiform (q) element, hypotype, AgC1, I.

GSC 93105 *Drepanoistodus forceps* (Lindström), oistodontiform (r) element, hypotype, BC2, I.

GSC 93106 *Drepanoistodus forceps* (Lindström), oistodontiform (r) element, hypotype, BC1, H.

GSC 93107 *Drepanoistodus inaequalis* (Pander), suberectiform (p) element, hypotype, D.D.H. A1.14, P.

GSC 93108 Drepanoistodus inaequalis (Pander), homocurvatiform (q) element, hypotype, D.D.H. A1.14, P.

GSC 93109 Drepanoistodus inaequalis (Pander), oistodontiform (r) element, hypotype, D.D.H. A1.14, P.

GSC 93110 Erismodus asymmetricus (Branson and Mehl), cordylodontiform (a) element, hypotype, TP13, S.

GSC 93111 Erismodus asymmetricus (Branson and Mehl), zygognathodontiform (b) element, hypotype, TP16, S.

GSC 93112 Erismodus asymmetricus (Branson and Mehl), trichonodelliform (c) element, hypotype, TP13, S.

GSC 93113 Erismodus asymmetricus (Branson and Mehl), oulodontiform (f) element, hypotype, TP13, S.

GSC 93114 Erismodus asymmetricus (Branson and Mehl), aphelognathodontiform (g) element, hypotype, TP13, S.

GSC 93115 Erismodus sp., cordylodontiform (a) element, figured specimen, TP13, S.

GSC 93116 Erismodus sp., zygognathodontiform (b) element, figured specimen, TP13, S.

GSC 93117 Erismodus sp., trichonodelliform (c) element, figured specimen, TP15A, S.

GSC 93118 Erismodus sp., strachanognathodontiform (e) element, figured specimen, TP15, S.

GSC 93119 <u>Erismodus</u> sp., oulodontiform (<u>f</u>) element, figured specimen, TP13, S.

GSC 93120 <u>Erismodus</u> sp., aphelognathodontiform (<u>g</u>) element, figured specimen, TP13, S.

GSC 93121 <u>Erraticodon</u> <u>balticus</u> Dzik, hindeodelliform (<u>a</u>) element, hypotype, AgE1, B.

GSC 93122 <u>Erraticodon</u> <u>balticus</u> Dzik, zygognathodontiform (<u>b</u>) element, hypotype, AgE1, B.

GSC 93123 <u>Erraticodon</u> <u>balticus</u> Dzik, trichonodelliform (<u>c</u>) element, hypotype, AgE1, B.

GSC 93124 <u>Erraticodon</u> <u>balticus</u> Dzik, neoprioniodontiform (<u>e</u>) element, hypotype, AgE1, B.

GSC 93125 <u>Erraticodon</u> <u>balticus</u> Dzik, prioniodontiform (<u>f</u>) element, hypotype, AgE1, B.

GSC 93126 <u>Erraticodon</u> <u>balticus</u> Dzik, ozarkodiniform (<u>g</u>) element, hypotype, AgE1, B.

GSC 93127 <u>Erraticodon</u> <u>balticus</u> Dzik, cardiodelliform (<u>g</u>') element, hypotype, AgE1, B.

GSC 93128 <u>Eucharodus</u> <u>parallelus</u> (Branson and Mehl), plano-convex element, hypotype, KC11, T.

GSC 93129 <u>Eucharodus</u> <u>parallelus</u> (Branson and Mehl), hypotype, D.D.H. A1.14, P.

GSC 93130 <u>Eucharodus</u> <u>parallelus</u> (Branson and Mehl), element with ovate aboral opening, KC11, T.

GSC 93131 <u>Fryxellodontus</u> <u>corbatoi</u> Serpagli, "planus" element, hypotype, D.D.H. A1.06, P.

GSC 93132 <u>Fryxellodontus</u> <u>corbatoi</u> Serpagli, "intermedius" element, hypotype, BC2, I.

GSC 93133 <u>Fryxellodontus</u> <u>corbatoi</u> Serpagli, "symmetricus" element, hypotype, BC2, I.

GSC 93134 <u>Glyptoconus</u> <u>quadraplicatus</u> (Branson and Mehl) quadraplicatiform (<u>p</u>) element, hypotype, D.D.H. A1.11, P.

GSC 93135 <u>Glyptoconus</u> <u>quadraplicatus</u> (Branson and Mehl) triplicatiform (<u>q</u>) element, hypotype, D.D.H. A1.11, P.

GSC 93136 <u>Glyptoconus</u> <u>rectus</u> (Stouge), quadraplicatiform (<u>p</u>) element, hypotype, D.D.H. 715.10, N.

GSC 93137 <u>Glyptoconus</u> <u>rectus</u> (Stouge), triplicatiform (<u>q</u>) element, hypotype, D.D.H. 715.10, N.

GSC 93138 <u>Glyptoconus</u> <u>rectus</u> (Stouge), triplicatiform (<u>q</u>) element, hypotype, D.D.H. 715.09, N.

GSC 93139 <u>Histiodella</u> <u>holodentata</u> Ethington and Clark, short bryantodontiform (<u>a</u>) element, hypotype, AgE1, B.

GSC 93140 <u>Histiodella</u> <u>holodentata</u> Ethington and Clark, oistodontiform (<u>e</u>) element, hypotype, AgE1, B.

GSC 93141 <u>Histiodella</u> <u>holodentata</u> Ethington and Clark, spathognathodontiform (<u>f</u>) element, hypotype, D.D.H. 498.02, O.

GSC 93142 <u>Histiodella</u> <u>holodentata</u> Ethington and Clark, spathognathodontiform (<u>f</u>) element, hypotype, AgE1, B.

GSC 93143 Juanognathus variabilis Serpagli, hypotype, BC3, J.

GSC 93144 Juanognathus jaanussoni Serpagli, hypotype, TP11, S.

GSC 93145 Jumudontus gananda Cooper, hypotype, TP10, S.

GSC 93146 Leptochirognathus quadrata Branson and Mehl, cordylodontiform (a) element, hypotype, TP13, S.

GSC 93147 Leptochirognathus quadrata Branson and Mehl, zygognathodontiform (b) element, hypotype, TP13, S.

GSC 93148 Leptochirognathus quadrata Branson and Mehl, trichonodelliform (c) element, hypotype, TP13, S.

GSC 93149 Leptochirognathus quadrata Branson and Mehl, oistodontiform (e) element, hypotype, TP13, S.

GSC 93150 Leptochirognathus quadrata Branson and Mehl, cyrtoniodontiform (f) element, hypotype, TP13, S.

GSC 93151 Leptochirognathus planus n.sp., cordylodontiform (a) element, paratype, TP13, S.

GSC 93152 Leptochirognathus planus n.sp., zygognathodontiform, (b) element, paratype, TP13, S.

GSC 93153 Leptochirognathus planus n.sp., trichonodelliform (c) element, paratype, TP13, S.

GSC 93154 Leptochirognathus planus n.sp., oistodontiform (e) element, paratype, TP13, S.

GSC 93155 Leptochirognathus planus n.sp., cyrtoniodontiform (f) element, holotype, TP13, S.

GSC 93156 Macerodus dianae Fåhraeus and Nowlan, figured specimen, BC1, H.

GSC 93157 Microzarkodina? marathonensis (Bradshaw), gothodontiform (b) element, hypotype, BC2, I.

GSC 93158 Microzarkodina? marathonensis (Bradshaw), trichonodelliform (c) element, hypotype, D.D.H. 438.22, M.

GSC 93159 Microzarkodina? marathonensis (Bradshaw), oistodontiform (e) element, hypotype, BC2, I.

GSC 93160 Microzarkodina? marathonensis (Bradshaw), prioniodontiform (f) element, hypotype, BC2, I.

GSC 93161 Microzarkodina? marathonensis (Bradshaw), arched ozarkodinaform (g) element, hypotype, BC2, I.

GSC 93162 Microzarkodina? marathonensis (Bradshaw), straight ozarkodinaform (g') element, hypotype, BC2, I.

GSC 93163 ?Multioistodus auritus (Harris and Harris), cordylodontiform (a) element, hypotype, TP13, S.

GSC 93164 ?Multioistodus auritus (Harris and Harris), acodontiform (b) element, hypotype, TP13, S.

GSC 93165 ?Multioistodus auritus (Harris and Harris), trichonodelliform (c) element, hypotype, TP13, S.

GSC 93166 Multioistodus subdentatus Cullison, cordylodontiform (a) element, hypotype, TP13, S.

GSC 93167 Multioistodus subdentatus Cullison, acodontiform (b) element, hypotype, TP13, S.

GSC 93168 Multioistodus subdentatus Cullison, trichonodelliform (c) element, hypotype, TP13, S.

GSC 93169 Multioistodus subdentatus Cullison, distacodontiform (d) element, hypotype, TP13, S.

GSC 93170 Oepikodus communis (Ethington and Clark), cordylodontiform (a) element, hypotype, D.D.H. A1.11, P.

GSC 93171 Oepikodus communis (Ethington and Clark), gothodontiform (b) element, hypotype, D.D.H. A1.11, P.

GSC 93172 Oepikodus communis (Ethington and Clark), tetraprioniodontiform (d) element, hypotype, BC2, I.

GSC 93173 Oepikodus communis (Ethington and Clark), falodontiform (e) element, hypotype, BC2, I.

GSC 93174 Oepikodus communis (Ethington and Clark), prioniodontiform (f) element, hypotype, KC5, T.

GSC 93175 Oepikodus intermedius Serpagli, cordylodontiform (a) element, hypotype, D.D.H. 715.20, N.

GSC 93176 Oepikodus intermedius Serpagli, gothodontiform (b) element, hypotype, D.D.H. 715.25, N.

GSC 93177 Oepikodus intermedius Serpagli, tetraprioniodontiform (d) element, hypotype, D.D.H. 715.25, N.

GSC 93178 <u>Oepikodus</u> <u>intermedius</u> Serpagli, falodontiform (<u>e</u>) element, hypotype, D.D.H. 715.20, N.

GSC 93179 <u>Oepikodus</u> <u>intermedius</u> Serpagli, prioniodontiform (<u>f</u>) element, hypotype, D.D.H 715.08, N.

GSC 93180 <u>Oistodus</u> <u>bransoni</u> Ethington and Clark, cordylodontiform (<u>a</u>) element, hypotype, KC4, T.

GSC 93181 <u>Oistodus</u> <u>bransoni</u> Ethington and Clark, cladognathodontiform (<u>b</u>) element, hypotype, BC2, I.

GSC 93182 <u>Oistodus</u> <u>bransoni</u> Ethington and Clark, trichonodelliform (<u>c</u>) element, hypotype, BC2, I.

GSC 93183 <u>Oistodus</u> <u>bransoni</u> Ethington and Clark, distacodontiform (<u>d</u>) element, hypotype, KC5, T.

GSC 93184 <u>Oistodus</u> <u>bransoni</u> Ethington and Clark, oulodontiform (<u>f</u>) element, hypotype, BC2, I.

GSC 93185 <u>Oistodus</u> <u>multicorrugatus</u> Harris, cordylodontiform (<u>a</u>) element, hypotype, TP8, S.

GSC 93186 <u>Oistodus</u> <u>multicorrugatus</u> Harris, cladognathodontiform (<u>b</u>) element, hypotype, TP8, S.

GSC 93187 <u>Oistodus</u> <u>multicorrugatus</u> Harris, trichonodelliform (<u>c</u>) element, hypotype, D.D.H. 438.19, M.

GSC 93188 <u>Oneotodus</u> <u>costatus</u> Ethington and Brand, figured specimen, D.D.H. A1.14, P.

GSC 93189 <u>Oneotodus</u> <u>costatus</u> Ethington and Brand, figured specimen, D.D.H. 66A.02, Q.

GSC 93190 <u>Paltodus</u> <u>sweeti</u> Serpagli, drepanodontiform (<u>p</u>)

element, hypotype, BC2, I.

GSC 93191 _Paltodus_ _sweeti_ Serpagli, oistodontiform (_q'_) element, hypotype, BC2, I.

GSC 93192 _Paracordylodus_ _gracilis_ Lindström, gothodontiform (_b_) element, hypotype, D.D.H. A1.06, P.

GSC 93193 _Paracordylodus_ _gracilis_ Lindström, oistodontiform (_e_) element, hypotype, D.D.H. A1.05, P.

GSC 93194 _Parapanderodus_ _abemarginatus_ n.sp., drepanodontiform (_s_, ungrooved) element, paratype, AgB2, D.

GSC 93195 _Parapanderodus_ _abemarginatus_ n.sp., posteriorly grooved (_t_) element, holotype, AgE6, B.

GSC 93196 _Parapanderodus_ _aequalis_ n.sp., short based (_s_) element, holotype, KC1, T.

GSC 93197 _Parapanderodus_ _aequalis_ n.sp., long based (_s'_) element, paratype, BC1, H.

GSC 93198 _Parapanderodus_ _aequalis_ n.sp., triangulariform (_t_) element, paratype, BC1, H.

GSC 93199 _Parapanderodus_ _striatus_ (Graves and Ellison), short based (_s_) element, hypotype, D.D.H. A1.07, P.

GSC 93200 _Parapanderodus_ _striatus_ (Graves and Ellison), long based (_s'_) element, hypotype, BC1, H.

GSC 93201 _Parapanderodus_ _striatus_ (Graves and Ellison), triangulariform (_t_) element, hypotype, D.D.H. A1.11, P.

GSC 93202 Parapanderodus striolatus (Harris and Harris) short based (s) element, hypotype, D.D.H. 498.02, O.

GSC 93203 Parapanderodus striolatus (Harris and Harris) long based (s') element, hypotype, TP13, S.

GSC 93204 Parapanderodus striolatus (Harris and Harris) triangulariform (t) element, hypotype, AgWl, C.

GSC 93205 Paraprioniodus costatus Ethington and Clark, cordylodontiform (a) element, hypotype, TP15, S.

GSC 93206 Paraprioniodus costatus Ethington and Clark, zygognathodontiform (b) element, hypotype, AgWl, C.

GSC 93207 Paraprioniodus costatus Ethington and Clark, trichonodelliform (c) element, hypotype, TP13, S.

GSC 93208 Paraprioniodus costatus Ethington and Clark, tetraprioniodontiform (d) element, hypotype, AgWl, C.

GSC 93209 Paraprioniodus costatus Ethington and Clark, extended prioniodontiform (f) element, hypotype, TP13, S.

GSC 93210 Paroistodus parallelus (Pander), drepanodontiform (a) element, hypotype, BC2, I.

GSC 93211 Paroistodus parallelus (Pander), acodontiform (b) element, hypotype, BC2, I.

GSC 93212 <u>Paroistodus parallelus</u> (Pander), distacodontiform (<u>d</u>) element, hypotype, BC2, I.

GSC 93213 <u>Paroistodus parallelus</u> (Pander), oistodontiform (<u>e</u>) element, hypotype, BC2, I.

GSC 93214 <u>Paroistodus parallelus</u> (Pander), scandodontiform (<u>f</u>) element, hypotype, D.D.H. A1.07, P.

GSC 93215 <u>Paroistodus proteus</u> (Lindström), oistodontiform (<u>e</u>) element, hypotype, BC2, I.

GSC 93216 <u>Paroistodus proteus</u> (Lindström), drepanodontiform (<u>a</u>) element, hypotype, D.D.H. A1.14, P.

GSC 93217 ?<u>Prioniodus elegans</u> Pander, cordylodontiform (<u>a</u>) element, hypotype, BC2, I.

GSC 93218 ?<u>Prioniodus elegans</u> Pander, gothodontiform (<u>b</u>) element, hypotype, TP2, S.

GSC 93219 ?<u>Prioniodus elegans</u> Pander, tetraprioniodontiform (<u>d</u>) element, hypotype, BC2, I.

GSC 93220 <u>Protopanderodus gradatus</u> Serpagli, scandodontiform (<u>a</u>) element, hypotype, D.D.H. A1.09, P.

GSC 93221 <u>Protopanderodus gradatus</u> Serpagli, paltodontiform (<u>b</u>) element, hypotype, D.D.H. A1.06, P.

GSC 93222 <u>Protopanderodus gradatus</u> Serpagli, acontiodontiform (<u>c</u>) element, hypotype, BC1,H.

GSC 93223 <u>Protopanderodus strigatus</u> Barnes and Poplawski, scandodontiform (<u>a</u>) element, hypotype, TP13, S.

GSC 93224 <u>Protopanderodus strigatus</u> Barnes and Poplawski, paltodontiform (<u>b</u>) element, hypotype, APO2, C.

GSC 93225 *Protopanderodus strigatus* Barnes and Poplawski, acontiodontiform (*c*) element, hypotype, TP13, S.

GSC 93226 ?*Protoprioniodus costatus* van Wamel, gothodontiform (*b*) element, hypotype, D.D.H. A1.06, P.

GSC 93227 ?*Protoprioniodus costatus* van Wamel, oistodontiform (*e*) element, hypotype, D.D.H. A1.06, P.

GSC 93228 ?*Protoprioniodus costatus* van Wamel, elongatiform (*f*) element, hypotype, D.D.H. A1.06, P.

GSC 93231 *Protoprioniodus papilosus* (van Wamel), cordylodontiform (*a*) element, hypotype, D.D.H. 440.09, L.

GSC 93232 *Protoprioniodus papilosus* (van Wamel), trichonodelliform (*c*) element, hypotype, BC2, I.

GSC 93233 *Protoprioniodus papilosus* (van Wamel), prioniodontiform (*f*) element, hypotype, D.D.H. A1.12, P.

GSC 93234 *Pteracontiodus cryptodens* (Mound), cordylodontiform (*a*) element, hypotype, D.D.H. 715.12, N.

GSC 93235 *Pteracontiodus cryptodens* (Mound), acodontiform (*f*) element, hypotype, TP9A, S.

GSC 93236 *Reutterodus* sp., cone-like element, figured specimen, TP11, S.

GSC 93237 *Reutterodus* sp., cone-like element, figured specimen, TP14, S.

GSC 93238 *Rossodus highgatensis* Landing *et al.*, pentacostate (*c'*) element, hypotype, D.D.H. A1.11, P.

GSC 93239 *Rossodus highgatensis* Landing *et al*., trapezognathodontiform (*d*) element, hypotype, D.D.H. A1.11, P.

GSC 93240 *Rossodus highgatensis* Landing *et al*., oistodontiform (*e*) element, hypotype, D.D.H. A1.11, P.

GSC 93241 *Rossodus symmetricus* n.sp., drepanodontiform (*a*) element, paratype, BC2, I.

GSC 93242 *Rossodus symmetricus* n.sp., acontiodontiform (*c*) element, paratype, D.D.H. A1.06, P.

GSC 93243 *Rossodus symmetricus* n.sp., acontiodontiform (*c*) element, paratype, BC2, I.

GSC 93244 *Rossodus symmetricus* n.sp., pentacostate (*c'*) element, paratype, BC2, I.

GSC 93245 *Rossodus symmetricus* n.sp., trapezognathodontiform (*d*) element, holotype, D.D.H. A1.07, P.

GSC 93246 *Rossodus symmetricus* n.sp., trapezognathodontiform (*d*) element, paratype, D.D.H. A1.07, P.

GSC 93247 *Rossodus symmetricus* n.sp., trapezognathodontiform (*d*) element, paratype, D.D.H. A1.05, P.

GSC 93248 *Rossodus symmetricus* n.sp., oistodontiform (*e*) element, paratype, BC2, I.

GSC 93249 *Rossodus symmetricus* n.sp., scandodontiform (*f*) element, paratype, D.D.H. A1.06, P.

GSC 93250 *Scalpellodus* n.sp., short based drepanodontiform (*s*) element, figured specimen, KC5, T.

GSC 93251 Scalpellodus n.sp., long based drepanodontiform (s') element, figured specimen, KC5, T.

GSC 93252 Scalpellodus n.sp., scandodontiform (t) element, figured specimen, KC5, T.

GSC 93253 Scandodus sinuosus Mound, drepanodontiform (a) element, hypotype, TP13, S.

GSC 93254 Scandodus sinuosus Mound, acontiodontiform (c) element, hypotype, TP13, S.

GSC 93255 Scandodus sinuosus Mound, distacodontiform (d) element, hypotype, TP13, S.

GSC 93256 Scandodus sinuosus Mound, oistodontiform (e) element, hypotype, TP13, S.

GSC 93257 Scandodus sinuosus Mound, scandodontiform (f) element, hypotype, TP13, S.

GSC 93258 Scandodus sinuosus Mound, acodontiform (g) element, hypotype, TP13, S.

GSC 93259 "Scolopodus" emarginatus Barnes and Tuke, hypotype, BC1, H.

GSC 93260 "Scolopodus" filosus Ethington and Clark, hypotype, BC1, H.

GSC 93261 Semiacontiodus asymmetricus (Barnes and Poplawski) symmetrical (s) element, hypotype, BC1, H.

GSC 93262 Semiacontiodus asymmetricus (Barnes and Poplawski) asymmetrical (t) element, hypotype, BC1, H.

GSC 93263 Semiacontiodus cordis (Hamar), posteriorly grooved, symmetrical (s) element, hypotype, BC1, H.

GSC 93264 Semiacontiodus cordis (Hamar), ungrooved, asymmetrical (t) element, hypotype, BC1, H.

GSC 93265 Semiacontiodus cordis (Hamar), bicostate (u) element, hypotype, D.D.H. A1.07, P.

GSC 93266 Striatodontus carlae (Repetski), symmetrical (s) element, hypotype, D.D.H. A1.07, P.

GSC 93267 Striatodontus kakivangus n.sp., symmetrical (s) element, holotype, TP1, S.

GSC 93268 Striatodontus kakivangus n.sp., asymmetrical (t) element, paratype, TP13, S.

GSC 93269 Tripodus laevis Bradshaw, drepanodontiform (a) element, hypotype, KC3, T.

GSC 93270 Tripodus laevis Bradshaw, trichonodelliform (c) element, hypotype, D.D.H. A1.05, P.

GSC 93271 Tripodus laevis Bradshaw, oistodontiform (e) element, hypotype, KC4, T.

GSC 93272 Tripodus laevis Bradshaw, paltodontiform (f) element, hypotype, TP8, S.

GSC 93273 Variabiliconus n.sp. A, laterally unicostate (a) element, figured specimen, BC2, I.

GSC 93274 Variabiliconus n.sp. A, acontiodontiform (c) element, figured specimen, D.D.H. A1.05, P.

GSC 93275 Variabiliconus n.sp. A, quadricostate (d) element, figured specimen, BC2, I.

GSC 93276 Variabiliconus n.sp. A, posteriorly and anteriorly sulcate (d') element, figured specimen, D.D.H. A1.05, P.

GSC 93277 *Variabiliconus* n.sp. A, unisulcate (*e*) element, figured specimen, BC1, H.

GSC 93278 *Variabiliconus* n.sp. A, drepanodontiform (*f*) element, figured specimen, BC2, I.

GSC 93279 *Variabiliconus* n.sp. A, scandodontiform (*g*) element, D.D.H. A1.14, P.

GSC 93280 *Variabiliconus* n.sp. B, laterally unicostate (*a*) element, figured specimen, KC13, T.

GSC 93281 *Variabiliconus* n.sp. B, bicostate (*b*) element, figured specimen, KC11, T.

GSC 93282 *Variabiliconus* n.sp. B, acontiodontiform (*c*) element, figured specimen, KC13, T.

GSC 93283 *Variabiliconus* n.sp. B, quadricostate (*d*) element, figured specimen, KC13, T.

GSC 93284 *Variabiliconus* n.sp. B, posteriorly unisulcate (*e*) element, figured specimen, KC13, T.

GSC 93285 *Variabiliconus* n.sp. B, drepanodontiform (*f*) element, figured specimen, KC13, T.

GSC 93286 *Variabiliconus* n.sp. B, scandodontiform (*g*) element, figured specimen, KC13, T.

GSC 93287 *Walliserodus ethingtoni* (Fåhraeus), hypotype, D.D.H. 66A.03, Q.

GSC 93288 New genus 1 new species A, drepanodontiform (*a*) element, figured specimen, BC2, I.

GSC 93289 New genus 1 new species A, acodontiform (*b*) element, figured specimen, BC2, I.

GSC 93290 New genus 1 new species A, cladognathodontiform (c) element, figured specimen, BC2, I.

GSC 93291 New genus 1 new species A, distacodontiform (d) element, figured specimen, BC2, I.

GSC 93292 New genus 1 new species B, cordylodontiform (a) element, figured specimen, BC2, I.

GSC 93293 New genus 1 new species B, acodontiform (b) element, figured specimen, BC1, H.

GSC 93294 New genus 1 new species B, acodontiform (b) element, figured specimen, BC2, I.

GSC 93295 New genus 1 new species B, distacodontiform (d) element, figured specimen, D.D.H. A1.11, P.

Alteration suite, figured specimens:

GSC 93296 Zygognathodontiform (b) element, standard, AgW1, C.

GSC 93297 *Drepanodus* sp. cf. *D. gracilis* (Branson and Mehl), homocurviform element, from strata with complex diagenetic history, TP11, S.

GSC 93298 *Eucharodus parallelus* (Branson and Mehl), from strata with complex diagenetic history, TP12, S.

GSC 93299 Drepanodontiform (a) element, from strata subjected to high degree contact metamorphism, HAg2, A.

GSC 93300 *Multioistodus subdentatus* Cullison, cordylodontiform (a) element from strata subjected to lower degree of contact metamorphism, HAg6, A.

GSC 93301 Drepanodontiform (a) element, from level of the ore zone at Daniel's Harbour mine, D.D.H. 1827.03, R.

APPENDIX D: Collecting localities and location of drill holes. Each locality is represented by a letter in Appendix C: this and the abbreviation used as part of field number is given in brackets prior to grid reference.

Hare Bay (A; HAg): 804738 on St. Julien's topographic 1:50,000 sheet 2M/4 Edition 2 MCE Series A 781.

East of The Gravels (B; AgE): 736800 on Stephenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

West of The Gravels (C; D, AP, AgW, BW): 720797 on Stephenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

Northernmost Aguathuna Quarry (D; AgB): 692798 on Stephenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

Aguathuna Quarries, road section and middle quarry (E; AgR): 693797 on Stephenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

Southernmost Aguathuna Quarry (F; BAg): 691795 on Stephenville topographic 1:50,000 sheet 12B/10 Edition 5 MCE Series A 781.

Back Arm Bay (G; AgC) 757178 on Port Saunders topographic 1:50,000 sheet 12I/11 Edition 2 MCE Series A 781.

Port au Choix spot sample 1 (H; BC1): 737187 on Port Saunders topographic 1:50,000 sheet 12I/11 Edition 2 MCE Series A 781.

Port au Choix spot sample 2 (I; BC2): 735185 on Port Saunders topographic 1:50,000 sheet 12I/11 Edition 2 MCE Series A 781.

Port au Choix spot sample 3 (J; BC3): 737182 on Port Saunders topographic 1:50,000 sheet 12I/11 Edition 2 MCE Series A 781.

D.D.H. 1500 (K; 1500): 785789 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 440 (L; 440): 661683 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 438 (M; 438): 664688 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 715 (N; 715): 664692 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 498 (O; 498): 660694 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. A1 (P; A1): 666713 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 66A (Q; 66A): 664714 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

D.D.H. 1827 (R; 1827): 672715 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

Table Point, middle and upper Aguathuna Formation (S; TP): 617790 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.

Table Point, Catoche and lower Aguathuna formations (T; KC): 623797 on Bellburns topographic 1:50,000 sheet 12I/6 and 12I/5 Edition 2 MCE Series A 781.