# CONODONTS OF THE TABLE HEAD FORMATION (MIDDLE ORDOVICIAN), WESTERN NEWFOUNDLAND



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# CONODONTS OF THE TABLE HEAD FORMATION (MIDDLE ORDOVICIAN), WESTERN NEWFOUNDLAND

by

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ABSTRACT

On the Great Northern Peninsula, western Newfoundland, the transgressive Table Head Formation (Middle Ordovician) overlies the Lower Ordovician St. George Group. The Table Head strata are overlain by carbonate breccias and easterly derived flysch deposits. The Table Head sediments include limestones, mainly rubbly, with dolostones at the base (lower Table Head), overlain by limestones interbedded with shales (middle Table Head) and black graptolitiferous shales at the top (upper Table Head). The lower Table Head limestones represent the last platform carbonate deposit before the bank foundered probably due to the emplacement of Lower Ordovician allochthons in western Newfoundland.

The formation has been studied in detail from eight localities in the area from Bellburns community in the south to St. John Island in the north. Additional information from localities on Port au Port Peninsula and Hare Bay is included. The Table Head sediments all along on the west coast of Newfoundland compare with those in the study area. The thickness of the different units varies considerably and reaches its maximum at Table Point. The detailed investigation of the rocks revealed that carbonate accumulation was interrupted by "catastrophic" downwarps of the shelf. These may be related to the emplacement of the allochthons.

A total of approximately 17.000 conodonts was recorded within the study area. An additional 3.000 were recorded from elsewhere in western Newfoundland. The conodont fauna is described in multi-element taxonomy, and a supragenetic classification is applied. 35 genera and

Panderodontidae, and the new recognized family Cornuodontidae n. fam..

Two phylo-zones and four biointerval-zones are defined. The phylo-zones are based on phylogenetically related and facies independent species of Histiodella. The species from the basal lower Table Head on Newfoundland belong to Midcontinent Fauna 4, and are correlative with strata from North America. The conodonts reinforce trilobite and cephalopod data that indicate a late Whiterockian (early Llanvirnian) age for these strata. The North Atlantic Province conodonts from the middle Table Head have a number of species in common with the Eoplacognathus suecicus Zone of Scandinavia. The top of the middle Table Head at Table Point may be as young as the E. suecicus-P. sulcatus Subzone.

The Table Head strata accumulated in lagoonal, shelf (inner-outer) and slope environments. The lateral distribution of conodonts can be directly related to these depositional environments, and a sequence of three biofacies and sub-biofacies is introduced. The lagoonal (Midcontinent Province) and slope (North Atlantic Province) biofacies are distinct, whereas the shelf biofacies is less distinct. The occurrence of occasional invaders from the open oceanic biofacies can be related to the oscillating transgression.

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# CHAPTER 1

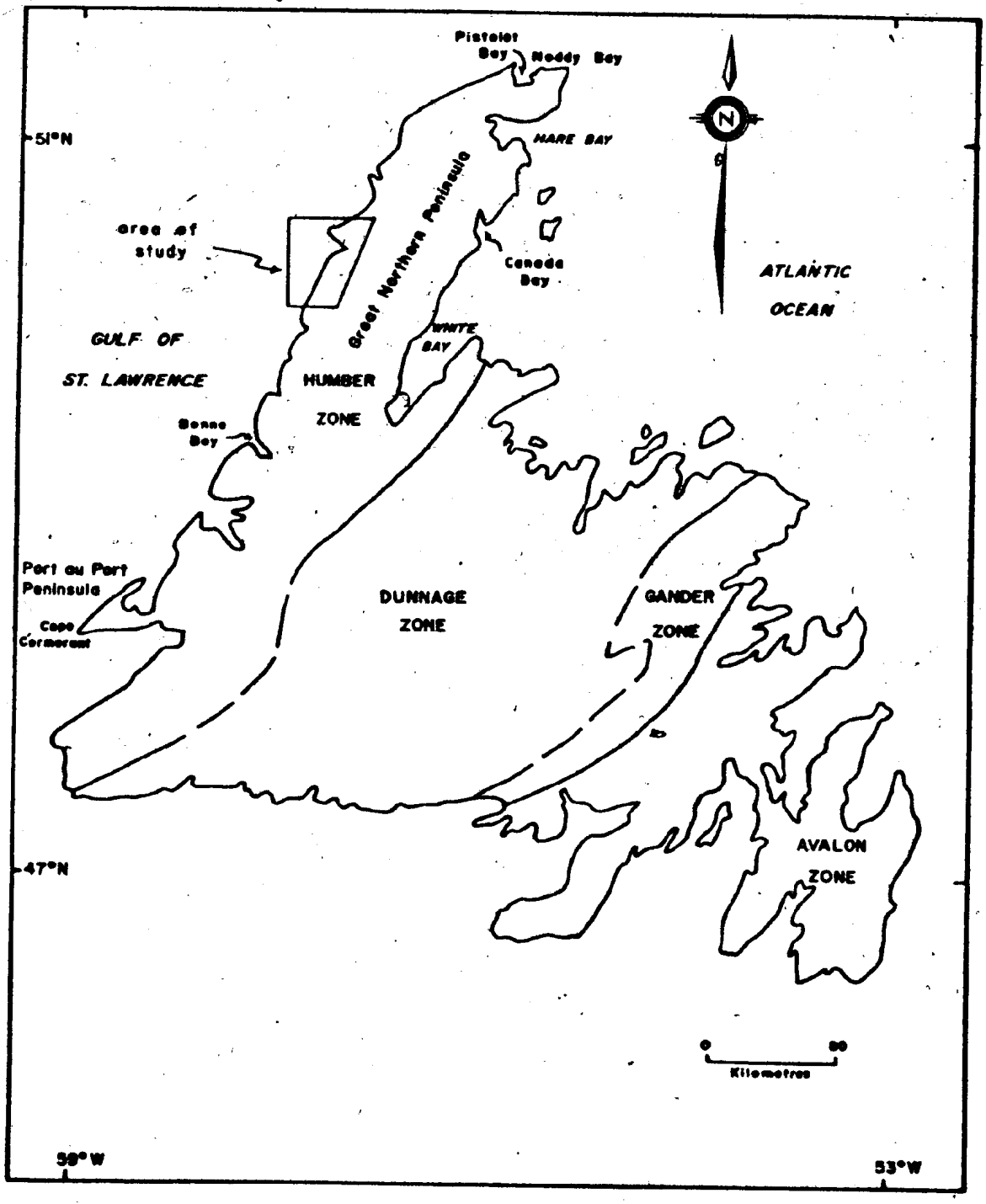
## 1.1 Introduction

The Table Head Formation of the Great Northern Peninsula, western Newfoundland, is composed in ascending order of marine carbonates, interstratified carbonates and shales, and black shales. These sediments were deposited during the marine transgression in the early part of the Champlainian Epoch of the Ordovician Period. Table Head strata can be traced from Noddy Bay in the north to Cape Cormorant on Port au Port Peninsula in the south, a distance of over 400 kilometres. Table Head strata are exposed from Cape Cormorant in the west to Hare Bay in the east, which is a distance of over 200 kilometres. The area of study is within the central part of Great Northern Peninsula (Fig. 1.1).

## 1.2 Geological setting

The Great Northern Peninsula forms part of the westernmost geologic-tectonic division of Newfoundland (Williams, 1964; Williams et al. 1974; Williams, 1978 a, b; Fig. 1.1). The geology of the western Humber zone consists of a Precambrian (Greenvillian) crystalline basement overlain by autochthonous lower Paleozoic sediments, that occur in a broad north-trending belt. The lower Paleozoic is represented by autochthonous platform carbonates and clastics including a basal Lower Cambrian shallow-water sandstone unit. The sediments of this unit are derived from the

Fig. 1.1 The geologic-tectonic divisions of Newfoundland (after Williams, 1964; Williams et al., 1974; Williams, 1978 a, b), and the location of the area investigated in this study.


Pistolet Bay
Noddy Bay
51°N
HARE BAY
Great Northern Peninsula
area of study
Canada Bay
ATLANTIC OCEAN
GULF OF ST. LAWRENCE
WHITE BAY
HUMBER ZONE
Bonne Bay
Port au Port Peninsula
Cape Cormorant
DUNNAGE ZONE
GANDER ZONE
AVALON ZONE
47°N
Kilometres
59°W
53°W

west. The lower part of the carbonates and sandstones is the Labrador Group (Lower Cambrian). The overlying Unnamed Group (Upper Cambrian) and the St. George Group (Lower/Middle Ordovician) represent a stable shallow-water carbonate bank that covered all of west Newfoundland by Late Cambrian time (Knight, 1977 a, b; 1978; Knight & Saltman, 1980; Levesque, 1977). The Table Head Formation rests on the St. George Group (Schuchert and Dunbar, 1934). Table Head strata include rubbly weathering, poorly bedded limestones, limestones and black to brown shales. Due to the transgressive nature of the sedimentation the formation is diachronous and forms a westward migrating series of bank-edge, slope to basinal deposits (Stevens, 1970). The upper authochthonous succession comprises a sequence of flysch deposits, which were derived from the east in contrast to the lower units.

Allochthonous sequences as recognized in western Newfoundland, are (1) the Cow Head Group, consisting of a condensed succession of carbonate breccias with intercalated thin beds of limestone and shale; (2) the Humber Arm Group, which includes clastic sequences and carbonate breccias, limestone beds and shales. These are interpreted as distal facies equivalents to the Cow Head Group (Stevens, 1970); and (3) an ophiolite sequence, which forms the uppermost allochthonous slices (Stevens, 1970).

The strata are succeeded by neo-autochthonous marine upper Middle Ordovician carbonates (Long Point Group) and continental red, clastic sediments of (? Late Ordovician to) Silurian age.

## 1.3. Previous Work and development of ideas

Richardson (in Logan, 1863) designated stratigraphic units by letters of the alphabet. Some of the units in this older classification were

never clearly defined and in some cases a type section was not specified. Moreover, Richardson's descriptions, correlations and stratigraphic successions did not correspond to the stratigraphy of the actual rocks (Schuchert and Dunbar, 1934). Therefore, the concepts of the stratigraphy of certain divisions have changed considerably from author to author (Schuchert and Dunbar, 1934; Whittington and Kindle, 1963; Woodard, 1957; Cumming, 1967 a, b; Table 1.1).

The litho-stratigraphic nomenclature used within the study area is derived from the work of Schuchert and Twenhofel in 1910 and Schuchert and Dunbar, 1918. Their work was summarized in the memoir of Schuchert and Dunbar (1934), which was the first great step forward in the understanding of the geology of the west coast of Newfoundland.

Schuchert and Dunbar (1934) divided the Table Head Formation into three units, which they informally labelled lower, middle, and upper Table Head. They also noted that the Table Head Formation rests on the St. George with a disconformity, and that the upper boundary of Table Head Formation possibly is conformable, though they noted that the uppermost beds are disrupted and disturbed. They reported the thickness of upper Table Head to be 300 feet (100 metres).

Schuchert and Dunbar (1934) based the boundary between the St. George and Table Head divisions on the presence of a regional disconformity between the two. This boundary also coincided with the boundary between the Lower and Middle Ordovician. The boundary was later described as a surface with karst topography and associated Pb-Zn mineralization (Collins and Smith, 1972, 1975). The time-gap should correspond to 10-15 million years (Collins and Smith, 1972, 1975). Fåhraeus (1977 b), Knight (1977 b),

Table 1.1 History of stratigraphic nomenclature.

| RICHARDSON IN LOGAN (1863) | | | | | SCHUCHERT & DUNBAR 1934 | | | NELSON 1955 | | WOODARD 1957 | | WHITTINGTON & KINDLE 1963 | | KNIGHT 1977 a, b | | | THIS STUDY | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1861 | | 1862 | | | | | | | | | | | | | | | | | |
| | Div. | Loc. | Div. | Sub-Div. | | Div. | Sub-Div. | | | | | | | | | | | | |
| POINTE RICHE LIMESTONES | 13 | TABLE HEAD POINTE RICHE | N | 3 | TABLE HEAD SERIES | UPPER | 20 | TABLE HEAD GROUP | UPPER | TABLE HEAD GROUP | UPPER | TABLE HEAD FORMATION | UPPER | NEW GROUP | TABLE HEAD FORMATION | UPPER | TABLE HEAD FORMATION | UPPER | |
| | | | | 2 | | MIDDLE | 19 — 9 | | MIDDLE | | MIDDLE | | MIDDLE | | | MIDDLE | | MIDDLE | $B_4$, $B_3$, $B_2$, $B_1$ |
| | | | | 1 | | | | | LOWER | | | | | ST. GEORGE GROUP | | LOWER | | | |
| | 12 | | M | 2, 1 | | LOWER | 8 — 1 | | | | LOWER | | LOWER | | | | | LOWER | $A_3$, $A_2$, $A_1$ |
| | 11 | | L | 4, 1, 1 | | | | | | | | | | | | | | | |
| | 10 | | K | | | | | | | | | | | | | | | | |
| | 9, 8, 7, 6 | | I, H, G, F | | ST. GEORGE SERIES | | | ST. GEORGE GROUP | | ST. GEORGE GROUP | | ST. GEORGE GROUP | | | SILICEOUS DOLOMITE FM & DIAGENETIC CARBONATE | | ST. GEORGE GROUP | | |

and Levesque (1977) described the contact as conformable, because the karst topography is not evident in coastal exposures. The breccia-filled fractures penetrating vertically into the upper strata of St. George are interpreted to represent a stratabound collapse breccia related to solution of evaporites (Knight, 1977 b; see James, 1979). This led to the conclusion that earlier definitions of litho-stratigraphic units such as the St. George and Table Head Group/Formation were not definitive, since rock units to which these names have been commonly applied, are actually stratigraphically recurrent and of laterally diverse facies (Woodard, 1957; Knight, 1977 a, b; Levesque, 1977).

Recent biostratigraphical data show that a faunal hiatus (Flower, 1978; Fåhraeus, 1977 a, b; Fortey, 1979, 1980; Stouge, 1978a, b, in press) is present, and this could support the presence of a disconformity. Because the uppermost St. George is developed as non-fossiliferous dolostones, the stratigraphic interpretation of this succession is equivocal. It could represent either a depositional hiatus or continuing deposition of non-fossiliferous strata. In general, however, it is agreed upon that the disconformity is present to the south, on Port au Port Peninsula, whereas the boundary is conformable to the north in the Hare Bay area (e.g., Flower, 1978; Fåhraeus, 1977 b; Stouge, in press).

Whittington and Kindle (1963) described the stratigraphic succession and the ranges of trilobites of the Table Head Formation at Table Point. They corrected the thickness of upper Table Head from the 300 feet of Schuchert and Dunbar (1934) to 30 feet (10 metres). They also noted that the middle Table Head strata are predominantly slumped at Table Point. They found Table Head trilobites in the "Isolated Blocks"

of Schuchert and Dunbar (1934). Rather than changing the name Table Head, Whittington and Kindle (1963) recommended continued application of the name Table Head for the formation, so well established in the literature for the rocks at Table Point; a practice that has been followed since.

Recent work is concentrated on detailed investigations and reclassifications of Middle and Lower Ordovician rock successions on Port aux Choix Peninsula (Kluyver, 1975), Hawkes Bay to Cape Norman (Knight, 1977 a, b; 1978, 1980), and Port au Port at Eddies Cove West (Levesque, 1977; Nelson, 1955; Woodard, 1957).

The use of fossils for correlation of Ordovician rock units including Table Head strata in western Newfoundland dates back over one hundred years (i.e., to Logan, 1863).

Taxonomic descriptions of faunas from the Table Head Formation were published by Billings (1865) and Raymond (1925). Cooper (1956, 1976) dated the formation as Whiterock (lower Middle Ordovician); he indicated that the Whiterockian genera Orthidiella, Anomalorthis, and Rhysostrophia are present in the Table Head Formation. The exact ranges of the brachiopod species occurring in the Table Head Formation are unknown. Flower (1978) recently reported Whiterockian cephalopods from the Table Head. However, their distributions and ranges within the formation are unknown.

Detailed biostratigraphical analyses of Table Head strata have appeared in relatively recent years based on trilobites, graptolites and conodonts.

The trilobite faunas of the Table Head Formation were listed, and their ranges shown by Whittington and Kindle (1963), and monographed by Whittington (1965). Extensive collections from Table Point and Bellburns implied correlation with much of the Antelope Valley Limestone in Ikes Canyon, Nevada, and with trilobite Zones M and N of the Utah sections (Hintze, 1953; Whittington and Kindle, 1963). This fauna is of latest Arenig to early Llanvirn in age (Whittington, 1968; Fortey, 1979, 1980). Whittington (1968) furthermore considered the Table Head fauna at Table Point to correlate with the trilobite fauna in Bed 12 of the Cow Head Group.

Graptolites from the middle and upper Table Head belong to the Paraglossograptus "etheridgei" Zone (Erdtmann, 1971; Morris and Kay, 1966). This is Zone 9 of Berry's (1960) graptolite zonation established in Texas. In terms of the Australian graptolite zonation (Thomas, 1960), the Table Head fauna correlates with the Diplograptus decoratus Zone (or Da 3 Zone) of the Darriwil Stage (Finney and Skevington, 1979). This is near or above the Didymograptus 'bifidus'/Didymograptus murchisoni zonal boundary (Llanvirn) (Finney and Skevington, 1979). Erdtmann (1971) indicated that the fauna at Table Point was transitional between faunas 9 and 10 of Berry (1960), and was slightly younger than that of Black Cove in the south (Morris and Kay, 1966).

Fahraeus (1970) reported on the conodonts from Table Point and Hare Bay to the north. He concluded that the faunas were mainly of early Llanvirn age, ranging from the top of Didymograptus hirundo Zone through the D. bifidus graptolite Zone. He also indicated that the middle Table Head conodont fauna to the north (Hare Bay) was as old as the fauna from

the lower Table Head at Table Point. Subsequent work on conodonts (Fahraeus, 1977 a, b; Stouge, 1977) has settled the age of the Table Head Formation as mainly Lower Llanvirn, or Midcontinent Fauna 4 of Sweet et al. (1971). Bergström et al. (1972) and Fahraeus (1977 a, b) also showed that correlation of the middle Table Head with Bed 12 of the Cow Head Group, as Whittington (1968) suggested based on trilobites, could not be correct. Bed 12 is early middle Arenig age (Fåhraeus and Nowlan, 1978) or Prioniodus (Oepikodus) evae Zone of the Scandinavian conodont succession, and the middle Table Head is of early Llanvirn age.

## 1.4 Purpose of this study

The purpose of this study is to describe the lower Middle Ordovician (Whiterockian) conodont fauna and its succession at Table Point on the Great Northern Peninsula, Newfoundland, and to propose some tentative correlations on the basis of conodonts previously described from Europe and North America.

The distribution of conodonts relative to the rock type is also taken into consideration, and this is compared with present knowledge of the distribution of other fossil groups, in particular the trilobites.

## 1.5 Technique

Fieldwork for this study commenced in June, 1976 at Table Point, where the major part of the month was spent, mapping, measuring, and collecting samples from the sequence. From July onwards, detailed mapping and sample collection were continued in the Pistolet Bay area (Fig. 1.1). Late July fieldwork continued in the Hare Bay area in the

northeast. In August section-measuring and sample collection in the Port aux Choix area commenced, and by the end of August reconnaissance in the Port au Port area was completed. In 1977 fieldwork was concentrated at Table Point with additional visits to Hare Bay and Canada Bay.

Eight sections were measured and studied. The sections are Table Point, Bellburns, Pointe Riche, Gargamelle Cove East and West, Back Arm, Port Saunders and St. John Island. The sections are readily accessible, though access to St. John Island is difficult at times of strong winds and heavy seas (i.e., throughout the field season). Most of the sections are generally well exposed and structurally uncomplicated, though a combination of poor exposure and dolomitization confuse the interpretations at Back Arm, and at Gargamelle Cove West structures are not well understood and some questions still remain to be clarified. Collectively, the sections provide a reasonably comprehensive representation of rock units within the study area. Minor road sections and coastal exposures have added further information.

The sections were collected at regular intervals for conodont research and lithological study. The intervals were usually 5 to 10 metres within uniform lithologies. With a varied lithology and at lithologic boundaries, the collecting intervals were smaller or bed by bed. All rock types were collected and processed for content of conodonts. Altogether 252 4-15 kg samples were collected of which 201 were processed.

Gross lithological characteristics were studied in the field. For detailed sediment investigation 88 thin-sections and 42 acetate peels were studied, mainly to aid in classification of the sediments and the

study of depositional environments involved (Chapter 4). This investigation was concentrated on three of the sections, namely Table Point, Pointe Riche, and Back Arm east of Port aux Choix.

The limestones were classified according to Folk's (1962) classification, and a combination of field observations and the results of laboratory research allowed an informal litho-stratigraphic subdivision.

Processing of limestone samples for conodont studies followed standard procedure (Lindström, 1964). The residues were washed through a sieve with the size of 63 um (230 mesh) sieve. After heavy liquid separation the residues were completely picked. Black shales of the upper Table Head were broken down with $H_2O_2$.

# CHAPTER 2

# STRATIGRAPHY

## 2.1 The Study area

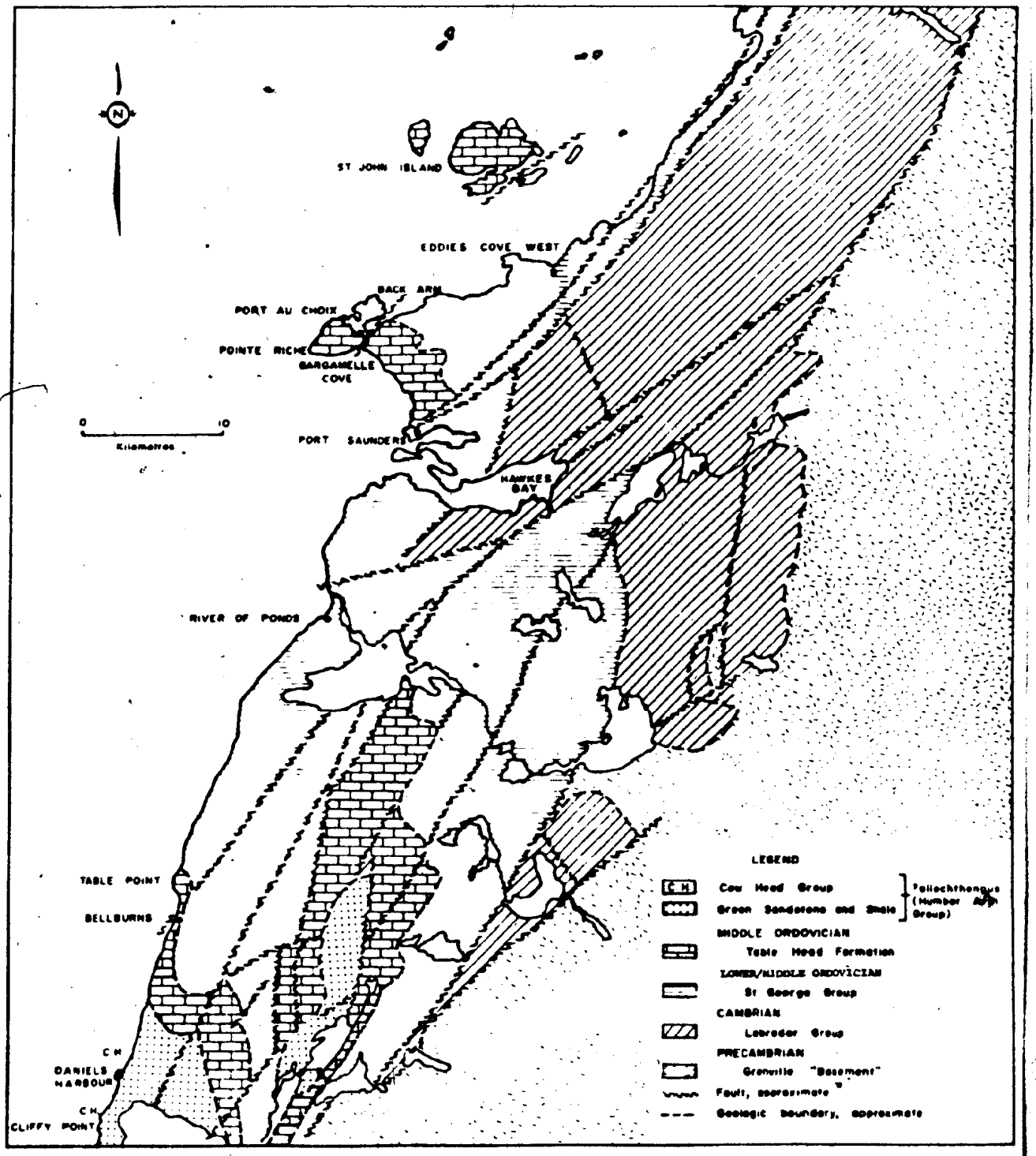
In the central part of the Great Northern Peninsula the Table Head Formation is exposed between Spudgels Cove in the south and St. John Island in the north. The study area includes the coastal exposures from Cliffy Point in the south to St. John Island in the north (Fig. 2.1).

This particular area has been important in previous work on Lower to Middle Ordovician stratigraphy and paleontology of western Newfoundland, and, indeed, North America as a whole. The section at Table Point has been chosen as the stratotype for the Tableheadian Substage of the Whiterockian Stage (Kay, 1962; Fähraeus, 1977 b). Stratigraphy of the Pointe Riche Peninsula, St. John Island and Port au Choix areas has been the topic of controversy in separation of Table Head carbonates from St. George carbonates (Logan, 1863; Schuchert and Dunbar, 1934; Cumming, 1967a, b, 1968; Woodard, 1957). Port au Choix Peninsula has been used as the type area for subdivision of the St. George Group (Kluyver, 1975), and part of the area has been subjected to detailed lithologic and paleo-environmental studies (Knight, 1977 a, b, 1978; Levesque, 1977; Levesque et al., 1977; Klappa, 1980).

## 2.2 Stratigraphical succession

The divisions of the lower Paleozoic succession in the study area are: (1) the Lower-Middle Ordovician St. George Group; (2) the Middle Ordovician Table Head Formation and Table Cove sandstone and shale; and

Fig. 2.1 Generalized geological map of the study area. (Modified after DeGrace, 1974; Knight, pers. comm., 1976-1980; and this study).



(3) the Middle Ordovician Cow Head Group and the overlying green sandstones (Schuchert and Dunbar, 1934).

The Lower-Middle Ordovician St. George Group, the Middle Ordovician Table Cove sandstone and shale, and Middle Ordovician Cow Head Group are not the topic of this study. They are only briefly discussed below.

### 2.2.1 St. George Group (Lower-Middle Ordovician)

The St. George Group was first named by Schuchert and Dunbar (1934) as the St. George Series. Later workers changed the rank to Group (Kluyver, 1975; Knight, 1977 a, b) and to Formation (Whittington and Kindle, 1963; Collins and Smith, 1972; Levesque, 1977; Levesque et al., 1977).

The St. George Group was divided by Kluyver (1975) and Knight (1977a, b; 1978) into several formations, whereas Levesque (1977), because of uncertainty of the precise meaning of older formation names, assigned St. George sediments to informal members designated by the word "cyclic". The ascending order of the formations are Watts Bight Formation, Boat Harbour Formation, Catoche Formation, and Siliceous Dolomite Formation.

The St. George Group is mainly composed of carbonates, which vary considerably in composition and color. They are predominantly of supratidal to shallow-water subtidal origin. Cyclic stromatolite units at the base (Watts Bight Formation and Boat Harbour Formation) alternate with primarily subtidal biomicrites and biosparites (Boat Harbour Formation, and the Catoche Formation). This succession is followed by a cyclic dolomitic sequence of the Siliceous Dolomite Formation of intertidal to supratidal environments.

The total range of the age of the St. George Group is not completely known at present. Flower (1978) reported on the succession of cephalopod faunas. He found the Canadian (Lower Ordovician) to be completely represented in the St. George. Whittington and Kindle (1969) reported upper Canadian shelly faunas from Port au Choix Peninsula. Fortey (1979) described the trilobite fauna from the Catoche Formation, which is late Canadian age (Zone G-H Ross/Hintze). Boyce (1978, 1979) reviewed the trilobite zones present in the St. George Group. According to him (Boyce, 1978, 1979) the Zones B through G of Ross (1951) and Hintze (1953) are represented in the St. George. A faunal break corresponding to the Subzone G1 is present in the Boat Harbour Formation. Cumming (1967 c) and Collins and Smith (1972, 1975) recovered graptolites in the upper dolomitic part of the St. George, and they are of middle to late Arenig age. The St. George conodont faunal succession range from early Canadian (Mid-continent Fauna B of Ethington and Clark, 1971) to late Canadian (Barnes and Tuke, 1970). The top of St. George Group is of Whiterockian age (Mid-continent Fauna 2-3 of Sweet et al., 1971) (Stouge in press; this study).

### 2.2.2. Table Cove sandstones and shales (Middle Ordovician)

This informal name refers to the unnamed green sandstones and shales (Kindle and Whittington, 1958), which overlie the Table Head Formation south of Table Point (Schuchert and Dunbar, 1934; Hubert et al., 1977).

The sequence consists of graded-bedded, green to grey sandstones interbedded with grey micaceous siltstones. Loadcasts and flutecasts are common sedimentary structures. The exposed thickness is about 42 metres. The sequence is exposed along the shore in the tidal zone between Table

Point and Table Cove. The upper boundary has not been observed and is probably not exposed in the study area.

Graptolites from this sequence are Zone 9-10 of Berry (1960), (D. Skevington, pers. comm.). This is equivalent to the upper Table Head (Erdtmann, 1971; Finney and Skevington, 1979).

### 2.2.3 Cow Head Group (Middle Ordovician)

In the southern part of the study area two localities are referred to the Cow Head Group. At Cliffy Point clasts of dominantly lower Table Head lithologic affinity are present. The clasts vary from walnut-size to 25 metres in the maximum dimension. The matrix is grey micrite. Clasts of a white mottled dolomite of unknown affinity are also common. Daniel's Harbour Peninsula is composed of a calcareous breccia, with boulders of lower Table Head, middle Table Head and Table Cove lithologies. Graptolites indicate a Zone 9 age (Whittington and Rickards, 1969; Finney and Skevington, 1979), which correlates with middle Table Head (Erdtmann, 1971; Finney and Skevington, 1979). The western part of the peninsula is dominated by clasts of a light grey to white mottled dolomitized micrite with clear sparry calcite filled vugs; these clasts are of unknown or of St. George affinity.

## 2.3 Structure

The strata within the study area are generally gently warped, but locally they are more severely disrupted by faulting and folding. The major structural features are the Hawkes Bay Fault, the Sandy Fault at Port Saunders, and the Gargamelle Cove Fault; the Table Point/Bellburns

syn- and anticlines (Fig. 2.2); and the fault on St. John Island, possibly an overthrust.

The major NNE-trending Hawkes Bay Fault extends inland and can be traced to Hawkes Bay east of the study area. The fault is marked by spectacular dolomitized fault breccia zones. At Port Saunders, the Sandy Fault trends NNE and brings St. George Group in structural contact with the Table Head Formation, but the fault itself is not exposed. It is marked by a gravel beach that separates the outcrops of the two units.

The faults appear to be a combination of lateral and vertical displacement, as the Table Head Formation is exposed on both sides of the fault zone at Bellburns, but further north strata of the St. George Group are juxtaposed against the Table Head Formation to the west. Similarly along the Back Arm/Gargamelle Cove Fault, strata of Table Head Formation are exposed on both sides of the fault in Gargamelle Cove, but Table Head strata on St. John Island to the west are juxtaposed against strata of St. George Group to the east on Hare Island.

Minor faults and joints within the Table Head Formation and the St. George Group are abundant. Displacement along these faults is not always directly measureable within the Table Head Formation, mainly due to the lack of marker beds. The faults are associated with white calcite veins and sometimes with pronounced slickensides. Most are vertical to steeply dipping although bedding plane faults are common. The importance and effect of the faults cannot be estimated, but it is believed that the thickness of the formation has been affected, as at Bellburns, where some beds are thrust over each other.

At Pointe Riche a fault breccia occurs trending NNE across the peninsula. A similar breccia is exposed at Gargamelle Cove East, but no direct evidence of the presence of a fault was observed.

St. John Island is a gentle dome. Pointe Riche is almost flat-lying but in detail it is very gently folded. Strata at Table Point, Table Cove and Bellburns are folded, and close to the fault zone in Table Cove the western limb of an anticline becomes very steep.

At Table Point and Bellburns, strata at the hinges of the folds are completely recrystallized to large calcite crystals, surrounded by dolomitic aureoles of former limestone. Furthermore, the dolomitisation is associated with calcite veins and dolomite dikes along joints or open fractures. On Pointe Riche Peninsula and St. John Island vuggy white dolomite cuts vertically through the section and also extends along mainly slumped layers (Cumming's (1968) disconformity). This dolomitisation is associated with mineralization on St. John Island and has been described as "pseudobreccia" (Cumming, 1968).

The Cow Head facies at Daniel's Harbour and Cliffy Point is considered either to be transported (Stevens, 1970; Hubert et al., 1977) or autochthonous (James et al., 1979; Finney and Skevington, 1979). The outcrops are separated by gravel beaches, and no fault plane is exposed.

## 2.4. Table Head Formation and boundaries of the study area.

The Table Head sequence is considered to have the rank of formation in this study.

The lowest occurrence of dark-grey argillaceous biomicrite, which is characterized by ostracodes, trilobites and cephalopods, unlike the

St. George Group, which is almost free of fossils in its uppermost part, is chosen as a base for the formation in this study. The top is the upper boundary of the upper Table Head.

The Table Head Formation is 340 metres (1020 feet) in total thickness at Table Point (formerly Table Head - the type section). The cliffs along the shore provide continuous exposure for about two kilometres from immediately north of Table Point to Table Cove (fig. 2.2). Less continuous and shorter ranging sections are exposed on Pointe Riche Peninsula, St. John Island, Gargamelle Cove East to Port Saunders, and along the coast at Bellburns (fig. 2.1). The upper Table Head is now known to be much thinner (Whittington and Kindle 1963) and the lower Table Head to be somewhat thinner (this study) than reported by Schuchert and Dunbar (1934).

For the purpose of this study the Table Head Formation is divided into lettered units (Table 2.1). The divisions are broadly similar to those of Schuchert and Dunbar (1934).

## 2.5. Lithological characteristics of the Table Head Formation.

Rubbly-weathering micrites and mottled dolostone are the most characteristic and abundant rock types in the main part of the Table Head. They are associated with a variety of other limestone types (bioclastic, pelletoidal, and arenaceous). Rocks that are predominantly detrital (silty limestones and shales), occur mainly

Table 2.1. Lithostratigraphic units of the Table Head Formation. See Fig. 1.2. for comparison with other subdivisions.

| Formation | Member | Subunit | Predominant Lithology |
|---|---|---|---|
| TABLE HEAD | Upper | | Black shale with claystone and siltstone. |
| | | $B_4$ | Black micrite, in places laminated, brown to black shale. |
| | | $B_3$ | Dark-grey, unsorted biosparite interbedded with brown shale. |
| | Middle | $B_2$ | Black micrite interbedded with brown to black shale. |
| | | $B_1$ | Dark-grey, argillaceous biomicrite and biosparite. |
| | | $A_3$ | Grey biomicrite and biosparite. |
| | Lower | $A_2$ | Grey biomicrite and fine-grained dolostone. |
| | | $A_1$ | Light-grey dolostone, micrite. |

in the upper part of the sequence. Because most of the rock types conform to Folk's standard definitions and descriptions, they will not be described in detail.

The rubbly, argillaceous micrite, so characteristic of the formation, will, however, be described in some detail. This lithology consists of hard, irregular lumps of micrite (dismicrite) in an argillaceous matrix. The lumps are rarely larger than 2 centimetres (maximum diameter) and appear to be randomly oriented. Locally, the lumps are in contact with each other, but more commonly they are separated by zones of argillaceous material. The combination of resistant limestone lumps with a softer argillaceous matrix is responsible for the distinctive rubbly weathering of the rock in outcrop; commonly stratification is poorly defined in these units.

The limestone lumps consist of micritic calcite and microspar. The argillaceous material consists of clay- to silt-sized quartz, clay minerals, and dolomite. In some varieties of this rock type the dolomite is in the forms of rhombs (longest axis up to 0.03 mm), which partly replace calcite shell fragments.

This rock type commonly contains large numbers of brachiopods, cephalopods, trilobites, and ostracodes.

## 2.6 Litho-stratigraphic successions

The Table Point section is used as a reference section. Lithological units identified in other sections are whenever possible referred to this standard section.

Details of lithologies and litho-stratigraphic relationships of the eight stratigraphic sections studies are depicted in Fig. 2.5. The evidence to support these correlations is described below and in Appendices A to H.

### 2.6.1 Table Point Section (Fig. 2.2; 2.5; Section I)

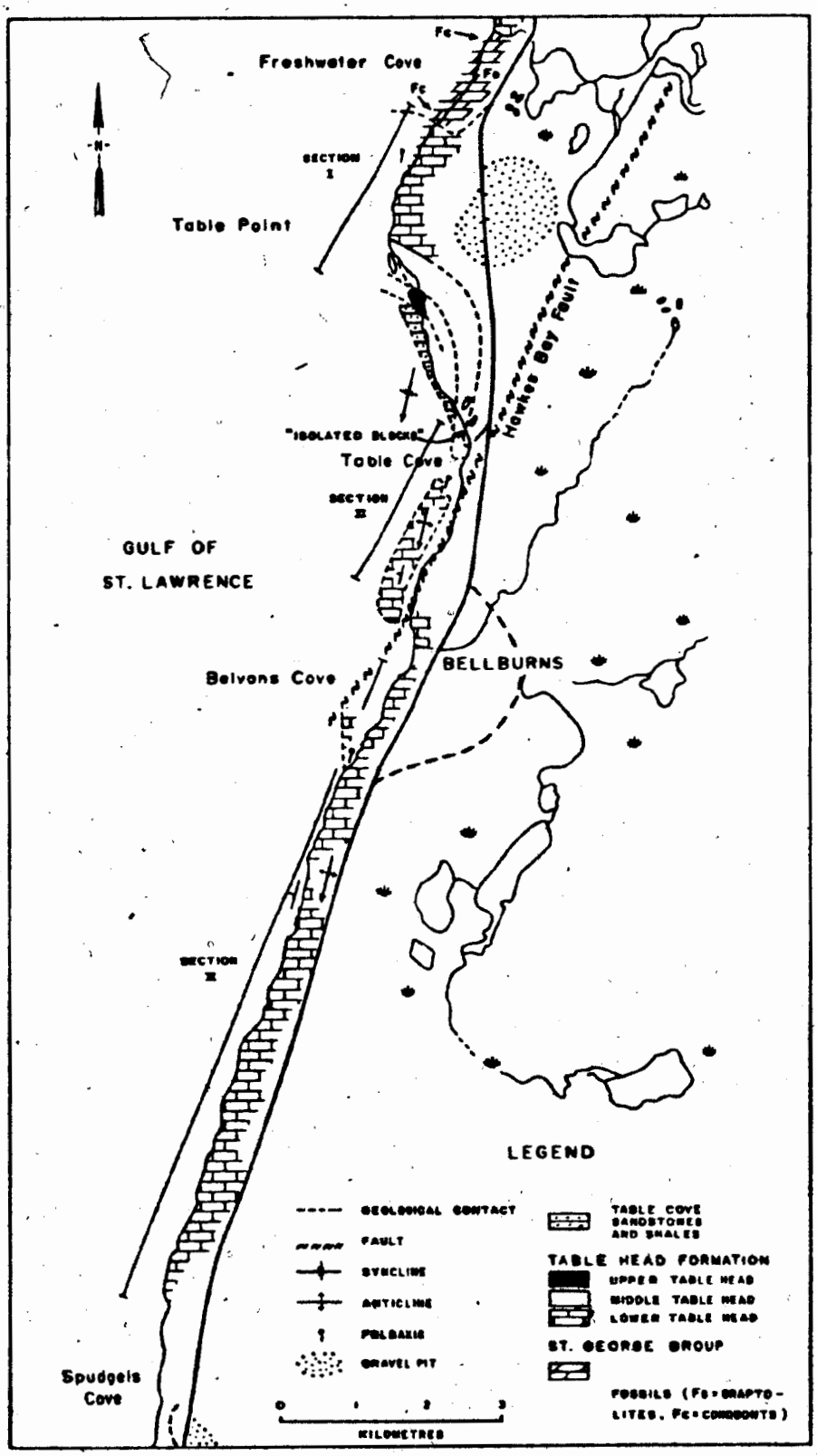
#### Location

The Table Point Section is exposed along the shore north and south of Table Point. Measuring of the section was started south of the river in Freshwater Cove (new name - see Levesque, 1977, p. 111; Fig. 2.2), and was continued southwest along the coast for about 2 kilometres.

The rocks dip SSW ($142^{\circ}/7^{\circ}$ - $154^{\circ}/8^{\circ}$) to SE ($58^{\circ}/16^{\circ}$), thus forming a southwest plunging syncline. The strata are cut by numerous joints and faults, marked by white calcite veins. Secondary dolomitisation along these structures is common.

The sediments comprise the uppermost part of the St. George Group, the entire Table Head, and part of the Table Cove sandstone and shale. About 80 metres of dolostones of the Siliceous Dolomite Formation were measured from the river to the upper boundary of the St. George Group. Graptolites occur in grey, yellow weathering fine grained dolostone about 65 metres below the base of the Table Head Formation (Fig. 2.2).

Fig. 2.2 Location map of the Table Point and the Bellburns areas


Freshwater Cove
Fc
Fs
SECTION I
Table Point
Hawkes Bay Fault
"ISOLATED BLOCKS"
Table Cove
SECTION II
GULF OF
ST. LAWRENCE
Belvons Cove
BELLBURNS
SECTION III
Spudgels Cove
LEGEND
GEOLOGICAL CONTACT
FAULT
SYNCLINE
ANTICLINE
PLUNGE AXIS
GRAVEL PIT
TABLE COVE SANDSTONES AND SHALES
TABLE HEAD FORMATION
UPPER TABLE HEAD
MIDDLE TABLE HEAD
LOWER TABLE HEAD
ST. GEORGE GROUP
FOSSILS (Fs = GRAPTOLITES, Fc = CONODONTS)
0 1 2 3
KILOMETRES

The section forms the type of the Table Head Series of Schuchert & Dunbar (1934). Logan (1863) described the divisions M and N from Table Head (now Table Point).

Stratigraphic succession

The section has been divided into three parts; lower, middle and upper Table Head, which again can be subdivided into smaller units. Herein the lower Table Head comprises the units $A_1$, $A_2$, and $A_3$ (Table 2.1).

$A_1$ is 8 metres thick. It is predominantly mottled dolostone, dolostone, and bird's-eye dolostone associated with minor argillaceous micrite. Dolomitic pelmicrite is secondarily present. Unit $A_1$ has a restricted fauna of gastropods (Hormotoma sp.) and predominantly leperditiid ostracodes. Cephalopods and trilobites were rarely found. Bird's-eye structures are associated with mudcracks and minor laminated beds.

$A_2$ is about 48 metres thick. It consists of argillaceous micrite, rubbly argillaceous micrite, dolomitic micrite and minor quantities of biomicrite, silty dolostone and breccias. Grey micrite has distinctive red iron oxide coating (yellow weathering). Compared to unit $A_1$, the fauna is more abundant and more diverse. It includes gastropods (Hormotoma sp., Maclurites sp.), straight and coiled cephalopods, ostracodes and brachiopods. Trilobites are rarely present.

In the central part of unit $A_2$ and at the top of unit $A_2$ two pronounced slumped layers are present. The lower is characterized by chert nodules, and the upper by breccias. Mudcracks, ripple marks and burrows are very common in the upper part of unit $A_2$. The top of unit $A_2$ grades into unit $A_3$.

$A_3$ is 186 metres thick. It is predominantly micrite, biomicrite, and rubbly argillaceous micrite with lenses of biosparite. Color varies from dark-grey to grey. Bedding is thin to massive. The upper middle part of unit $A_3$ is more thinly bedded than the rest of the unit. Chert is common throughout the sequence (Fig. 2.5). Slumped beds of biomicrite and biosparite are present. Secondary dolomitisation and calcification associated with dolomite dikes are common in the upper part of unit $A_3$.

The top of unit $A_3$ consists of rubbly argillaceous micrite and biosparite with funnel-shaped biogenic structures (e.g., sponges).

The lower and middle parts of unit $A_3$ contain cephalopods, trilobites, and a few crinoids. The upper part of the unit, particularly the sponge bed, contains an abundant bryozoan fauna (Klappa, 1980), along with large cephalopods and trilobites, and crinoids.

Middle Table Head is characterized by an increasing amount of clastic material; it forms a transition from a predominantly carbonate regime to a predominantly clastic regime. In the Table Point Section the beds form open folds or are clearly slumped. This prohibits bed to bed measuring. There is also prominent lateral variation. Middle Table Head is subdivided into four units: $B_1$, $B_2$, $B_3$, and $B_4$ (Table 2.1).

$B_1$ is 21 metres thick. It consists of nodular to irregularly bedded, dark-grey, argillaceous biomicrite and biosparite. The beds are 2 cm thick in average. Brachiopods and trilobites are common, but gastropods, cephalopods, and ostracodes, are missing.

$B_2$ is 16 metres thick. It consists of black micrite interbedded with dark-brown calcareous shales. The micrite beds are 3-5 centimetres thick.

The limestones contain trilobites and phosphatic brachiopods. Graptolites are common in the shales.

$B_3$ is 6 metres thick. It consists predominantly of argillaceous biosparite interbedded with dark-brown to black shale. The unit contains an abundant trilobite fauna. The fossils display a random orientation, and were probably transported by slumping.

$B_4$ is 43 metres thick. It comprises the top of the middle Table Head Section. Unit $B_4$ is predominantly dark-grey to black micrite interbedded with dark-brown to black calcareous and non-calcareous shales. The micrite is hard and may have fine laminae of bituminous layers or, rarely, silty material. The amount of shale increases toward the top of the section. Limestone breccias are present within this unit. The limestones contain trilobites and phosphatic brachiopods. Graptolites are common in the shales, but occur in the limestones also.

The upper Table Head is 14 metres thick. It is a black, non-calcareous, graptolitiferous shale. The graptolites are associated with phosphatic brachiopods.

Upper Table Head is overlain by about 42 metres of the Table Cove sandstones and shales. Hubert et al. (1977), however, reported a total of 100 metres for this unit.

### 2.6.2 Bellburns Section (Figs. 2.2; 2.5; Section II)

#### Location

The Bellburns Section is exposed from about 0.5 kilometres north of Bellburns community and along the coast south of Bellburns to Spudgels Cove.

The section is interrupted by the Hawkes Bay Fault, and is part of a major anticline associated with the fault. The section has undergone secondary dolomitisation particularly in the centre of the anticline and in the fault-zone.

The Bellburns Section has not been studied in detail, but field identifications are adequate for a general description of the succession. The structure of this area permits inspection of only incomplete sections and a composite section has been compiled.

Measuring of this section began close to the Hawkes Bay Fault, and was continued south for about 3 kilometres, with several offsets along strike. Toward the north, information was obtained from several outcrops, which are isolated from the remainder of the strata ("Isolated Blocks" of Whittington and Kindle, 1963).

Stratigraphic succession

The general sequence at this locality is very similar to that of Section 1 at Table Point, and this easily permits confident lithological correlations (Fig. 2.5).

The lower boundary to the St. George Group has not been observed with certainty. Dolomitisation, which affects the Table Head Formation at the Hawkes Bay Fault, prohibits a safe separation between lithologies of the two sequences.

The Bellburns Section includes lower and middle Table Head, and the lithological units $A_2$ (in part), $A_3$, $B_1$ and $B_2$ are exposed. Units $A_1$, $A_2$ (in part), $B_3$, $B_4$ and the upper Table Head are not exposed or have not been observed with certainty at this locality.

$A_3$ is possibly 120 metres thick. It consists of massive, bedded, rubbly grey biomicrite and minor biosparite. The fauna includes trilobites, cephalopods, brachiopods, gastropods and occasional crinoids. The unit is exposed along the coast south of Bellburns. The boundary with the middle Table Head is exposed at the "Isolated Blocks" (Fig. 2.2). This upper part of $A_3$ consists of grey micrite with sponges.

$B_1$ is 10 metres thick. It consists of rubbly argillaceous micrite with nodular bedding. Trilobites are common in this unit. $B_1$ is exposed at the "Isolated Blocks" and in the tidal zone north of Bellburns.

$B_2$ is approximately 7 metres thick. It consists of black micrites interbedded with brown to black shale. The fauna includes graptolites and some trilobites. This unit is exposed in the tidal zone in Table Cove. It is overlain by Table Cove sandstones and shales.

The Table Cove sandstones and shales consist of about 22 metres of green-colored, massive-bedded sandstones and siltstones. The top of this unit was not observed.

### 2.6.3 Port Saunders Section (Fig. 2.3; 2.5; Section III)

**Location**

The Port Saunders Section is exposed along the coast 0.5 kilometres west of Port Saunders.

This section was started at the cove where the Sandy Fault (N 38°E) separates the St. George Group from the Table Head Formation.

The section generally dips west (35°/23°W) and is gently folded into a broad westward plunging syncline. The section is internally disrupted by faults and joints; bedding is often difficult to observe.

Stratigraphic succession

The lower 23 metres consist of micrites, biosparites and breccias. Fossils are trilobites, brachiopods and cephalopods.

The upper part of the section is 24 metres thick. It consists of grey to dark-grey biomicrite, interbedded with argillaceous micrite. Sponges and large cephalopods at the top are similar to those found on St. John Island and at Table Point.

This section was referred to division L in Logan (1863) and to the lower Table Head in Schuchert & Dunbar (1934, p. 56).

2.6.4 Gargamelle Cove East Section (Figs. 2.3; 2.5; Section IV)

Location

The Gargamelle Cove East Section is exposed in the coastal cliffs along the east side of Gargamelle Cove, southeast of Port aux Choix.

Measuring of the Gargamelle Cove East Section was started south of the inner part of the cove, and was continued south-southeast to the head of the cove.

The beds of this section are gently dipping ($69^{\circ}/9^{\circ}E$) to subhorizontal. The beds are cut by joints and small faults.

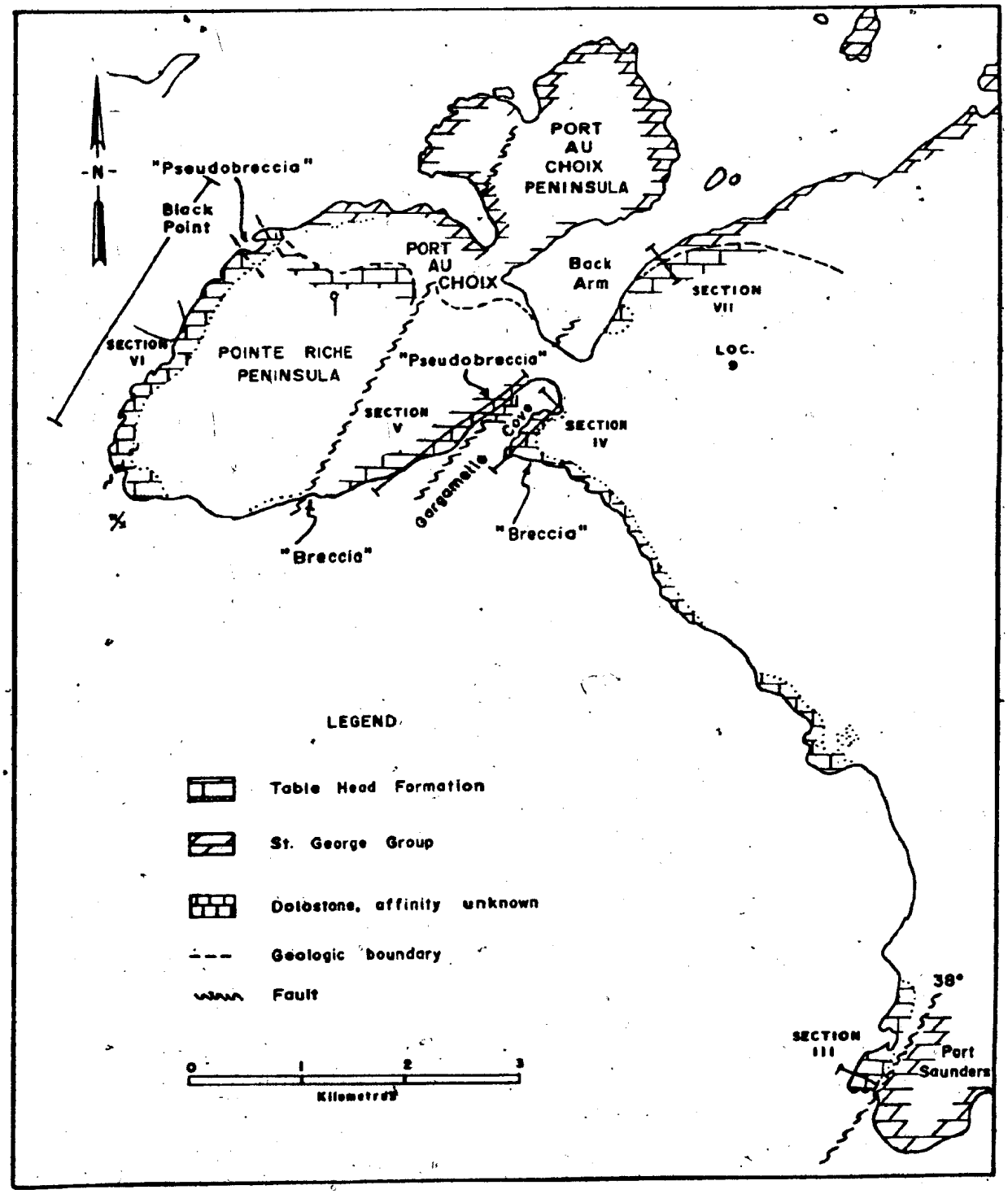
Stratigraphic succession

The section can be divided into two parts, IVa and IVb (Fig. 2.5)

IVa consists of about 5 metres of massive, bedded, grey micrite.

IVb is 30.5 metres thick. The lower 25 metres consist predominantly of grey, rubbly weathering micrite and minor biosparites. Cephalopods are common, and sponges are sparingly present at the top.

Fig. 2.3 Location map of the Pointe Riche, Port au Choix and Port Saunders areas.


-N-
"Pseudobreccia"
Black Point
PORT AU CHOIX PENINSULA
PORT AU CHOIX
Back Arm
SECTION VII
LOC. 9
SECTION VI
POINTE RICHE PENINSULA
"Pseudobreccia"
SECTION V
Cove
SECTION IV
Gargamelle
"Breccia"
"Breccia"
LEGEND
Table Head Formation
St. George Group
Dolostone, affinity unknown
Geologic boundary
Fault
0 1 2 3
Kilometres
38°
SECTION III
Port Saunders

The upper 5.5 metres are disrupted by folding and faulting. This unit consists of micrite lumps (25 x 10 cm) in an argillaceous matrix. Lack of distinct bedding makes this unit unique. Also the litho-stratigraphic classification of the breccias must remain unsettled. They occupy the same stratigraphic position as in unit $A_3$ of the Table Point Section, but are not typical unit $A_3$ lithology. Because of uncertain derivation of these rocks, they are here informally termed "breccia" beds. A similar unit is exposed at Pointe Riche Peninsula.

### 2.6.5 Gargamelle Cove West Section (Pointe Riche Peninsula) (Figs. 2.3; 2.5; Section V)

#### Location

The Gargamelle Cove West Section is exposed along the seacliffs of the east coast of Pointe Riche Peninsula. This section was started close to the Port aux Choix community.

The beds are sub-horizontal to westerly dipping ($7^{o}/2^{o}W$). At the base of this section grey to reddish, massive to thin-bedded micrites are exposed. These beds have been referred to the St. George Group by several authors (Schuchert & Dunbar, 1934; Cumming, 1968; Whittington, 1968; Kluyver, 1975). The upper part was referred to division K, i.e., Table Head Formation of Logan (1863) and the lower part to division I of Logan (1863) by Schuchert & Dunbar (1934), i.e., the St. George Group. Part of the section is heavily dolomitized. The dolomite/limestone boundary is sharp and cuts vertically through the section. A prominent horizontal layer is dolomitized and filled with white vuggy dolomite, but can be

traced inland as a non-dolomitized slumped bed. This particular layer was described as the disconformity between the St. George Group and the Table Head Formation by Cumming (1968). The section is separated from the Pointe Riche Section to the west by a fault, trending NNE across the Pointe Riche Peninsula (Fig. 2.3).

Stratigraphic succession

The lower 13 metres are micrite, grey to moderate orange-pink with some argillaceous stringers. Stromatolite-like mounds are present.

The upper 36 metres consist of fine to massive bedded micrite with minor biosparite beds. Some beds are slumped. Fossils are common and include trilobites, cephalopods, brachiopods, and gastropods (Maclurites sp.).

2.6.6 Pointe Riche Section (Fig. 2.3; 2.5; Section VI)

Location

The Pointe Riche Section is exposed along the seacliffs from Black Point in the northeast to the lighthouse in the southwest of the peninsula.

The section was measured from as close to the St. George Group as possible to the north and towards the south to the lighthouse. Four incomplete sections were measured of which the composite section is shown (fig. 2.5).

The strata of Pointe Riche, though generally flat-lying are folded into gentle synclines and anticlines. Dolomitization occurs in the cones of the structures both along bedding places and vertical fractures. Vuggy white dolomite and dolostone is present in the Table Head Formation. To the north of Black Point dolostones of the St. George

Group underlie the Table Head Formation. The actual boundary is not exposed (Schuchert & Dunbar, 1934), and a covered interval of 40 metres of strata is present (Levesque, 1977). The lowest exposures of the Table Head strata form an irregular dolomitized layer, which was described as the St. George/Table Head disconformity by Cumming (1968) and Kluyver (1975). Herein it is interpreted as dolomitized Table Head strata, rather than a disconformity. The irregular boundary is either a slumped layer, which is dolomitized, or represents the dolomitic "front" at this locality (N.P. James, pers. comm., 1978). The dolomitization is not restricted to the irregular layer, but occurs independent of the bed. To the south of the lighthouse folding and minor overthrusting of beds occur.

Stratigraphic succession

The lower 27 metres consist of grey massive bedded micrite with minor biosparite lenses. Occasional minor chert layers are present. Several small slumped biosparite beds are present. The base of the section is the dolomitized wavy-bedded micrite.

The upper 12 metres consist of argillaceous, hard, grey, yellow-weathering micrite. One prominent slumped bed separates the lower lithologies from the upper lithologies. This bed thins out to the north, and becomes dolomitized distally.

Remarks

The Pointe Riche Section was the basis for Richardson's divisions K and L (in Logan, 1863). Schuchert & Dunbar (1934) reported that 200

feet (66 metres) of lower Table Head limestones are present, which is about 25 metres more than measured in this study.

### 2.6.7 Back Arm East Section (Fig. 2.3; 2.5; Section VII)

#### Location

The Back Arm East Section is exposed in the cliffs along the east shore of Back Arm (Fig. 2.3). The cliffs are within the dump area of the Port aux Choix community. Because of the amount of garbage the exposure varies from moderate to covered - a situation that changes from season to season.

The beds in the section are sub-horizontal to slightly dipping southward.

At the base and to the north the St. George Group dolostones and dolomitic micrites conformably underlie the section.

#### Stratigraphic succession

The lower 5 metres consist of fossiliferous micrite, dolomitic micrite, calcareous dolostone, and dolostone. Dolostone predominates in the lower part, in places associated with fine laminations. These beds contain a restricted fauna (principally ostracodes).

The upper 13 metres consist of grey, reddish-colored (caused by distinctive red iron oxide coatings), rubbly-weathering micrite.

## 2.6.8 St. John Island Section (Fig. 2.4; 2.5; Section VIII)

### Location

The St. John Island Section is exposed from Photographic Point to the cliffs on the south side of the St. John Island Harbour (Fig. 2.4).

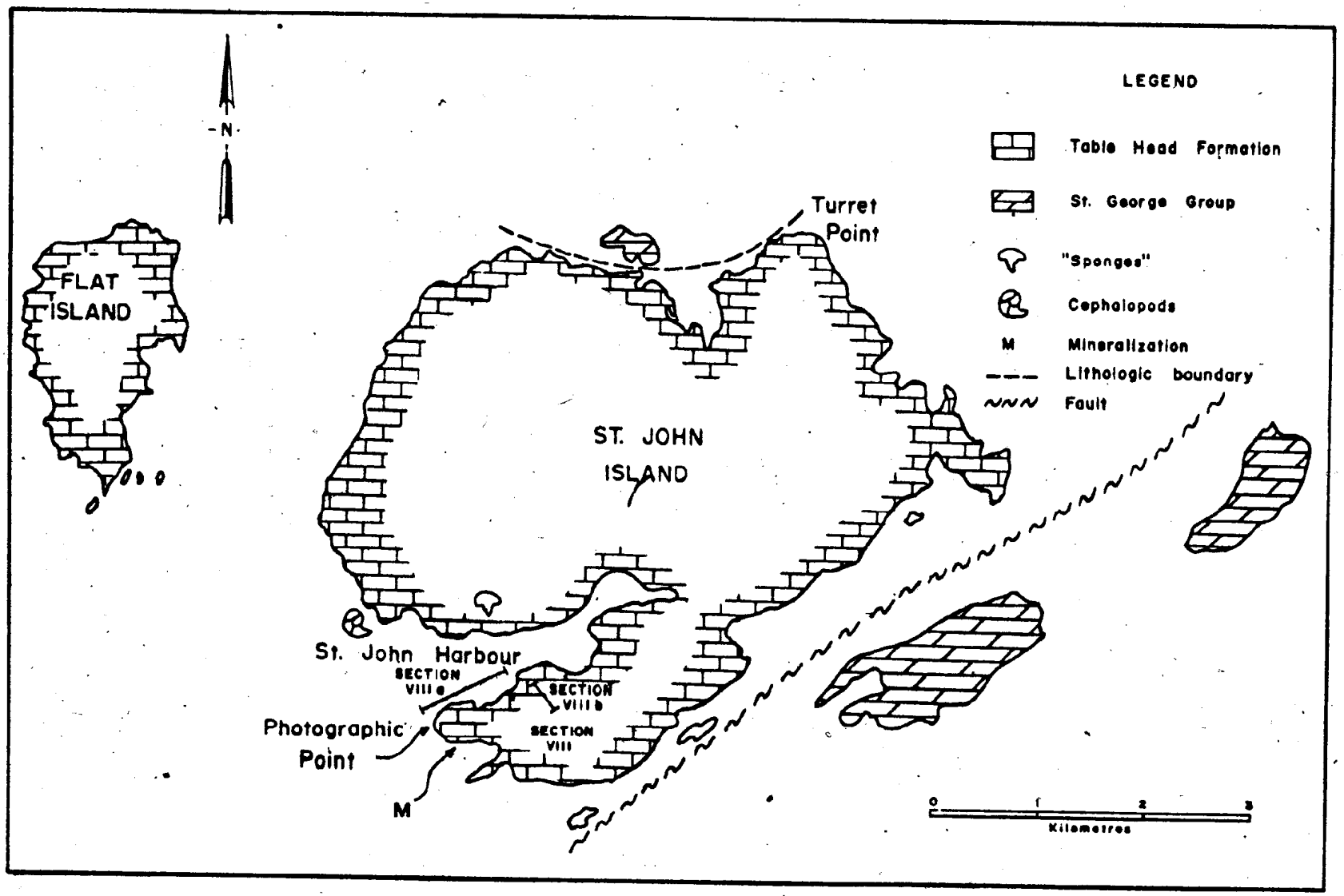
St. John Island is a large dome. The strata of the St. John Island Section form part of the structure, the other flank is the northern side of the St. John Harbour. At Photographic Point and along the south coast predominantly dolomitized and mineralized Table Head strata are exposed. A thrust is present along the dolomitized layers (Levesque, 1977).

The St. George Group/Table Head Formation boundary as described by Woodard (1957) on the eastern coast of the island is related to a setting similar to Pointe Riche Peninsula (Section VII) i.e., within the dolomitized Table Head strata. Flower (1978) recorded a typical Table Head fauna from these dolostones.

### Stratigraphical succession

The St. John Section was started close to the dolomitized beds at Photographic Point. The top of the section is exposed on the crest of the hill to the east of Photographic Point. Two incomplete sections VIIIa and VIIIb were measured. The exact relative positions were difficult to determine, and a minor gap in the composite section exists between the western part (Section VIIIa) and the eastern part (Section VIIIb), because debris covered bedding planes. The top of Section VIIIb is marked by rubbly debris. The composite section comprises only part of the total Table Head strata exposed on St. John Island.

Fig. 2.4 Location map of the St. John Island.


LEGEND
Table Head Formation
St. George Group
"Sponges"
Cephalopods
M Mineralization
Lithologic boundary
Fault
N
FLAT ISLAND
ST. JOHN ISLAND
Turret Point
St. John Harbour
SECTION VIII a
SECTION VIII b
SECTION VIII
Photographic Point
M
0 1 2 3
Kilometres

Section VIIIa

This section is 15 metres thick. The predominant rock types are grey fossiliferous micrite and minor biosparite. Towards the top rubbly grey, argillaceous micrite with yellow-colored (? iron stained) bedding-planes are common. Fossils are cephalopods and small sponges. At the top large sponges become common.

Section VIIIb

The section is 9 metres thick. It consists of grey micrite and minor, argillaceous micrite. Trilobites are present.

Remarks

The strata of the north coast of St. John Harbour and from Pigasse's Point to Menhir Point contain a profuse fauna of sponges and large cephapolods, a co-occurrence similar to the Port Saunders and Table Point Sections. Many of the sponges, which may be tall or short and mushroom-shaped, are still in life-position.

Woodard (1957) proposed the name Well Cove Formation for these Table Head limestones. He also included the strata at Eddies Cove West in his formation. Whittington & Kindle (1969, p. 659) found the Eddies Cove West strata to be of St. George age, and they are now correlated with the Boat Harbour Formation and the Catoche Formation of the St. George Group (Knight, 1977 a, b).

### 2.6.9 Small outcrops within the study area

I. Between Port Saunders and Gargamelle Cove East

Table Head strata crops out as sub-horizontal to undulating beds along the beach. Similar beds are exposed along the road connecting Port aux Choix and Port Saunders. A small section of about 12 metres of argillaceous, massive bedded micrite was measured. Cephalopods are common.

II. Central part of Gargamelle Cove

A small outcrop, only exposed at low tide, consists of 5 metres of grey massive micrite with gastropods. These 5 metres are included in the Gargamelle Cove East Section on Fig. 2.5.

III. Road-section about 2.5 kilometres north of Port aux Choix

Along the road towards Eddies Cove West north of Port aux Choix about 1.5 metres of massive bedded grey, micrite is exposed. This is Table Head limestone.

## 2.7 Litho-stratigraphic correlations

Litho-stratigraphic correlations are summarized in Fig. 2.5. The correlations suggested are hampered by structural complications combined with local dolomitization. Thus the lower boundary of the Table Head Formation has been observed only at Table Point. In the Back Arm East Section this boundary is interpreted to be present based on the stratigraphical succession. In the Bellburns Section the Hawkes Bay Fault separates Table Head strata from dolostones, which may be of the St. George Group affinity

or represent dolomitized Table Head limestones. The question is left open in this study.

In general, litho-stratigraphic criteria are, however, good enough to permit precise correlations. Lateral variations are minor and the rock units identified at Table Point can be traced over most of the study area. Only the basal units (i.e., $A_1$ and $A_2$) of the Table Point Section show variation in the presence of dolostones versus limestones.

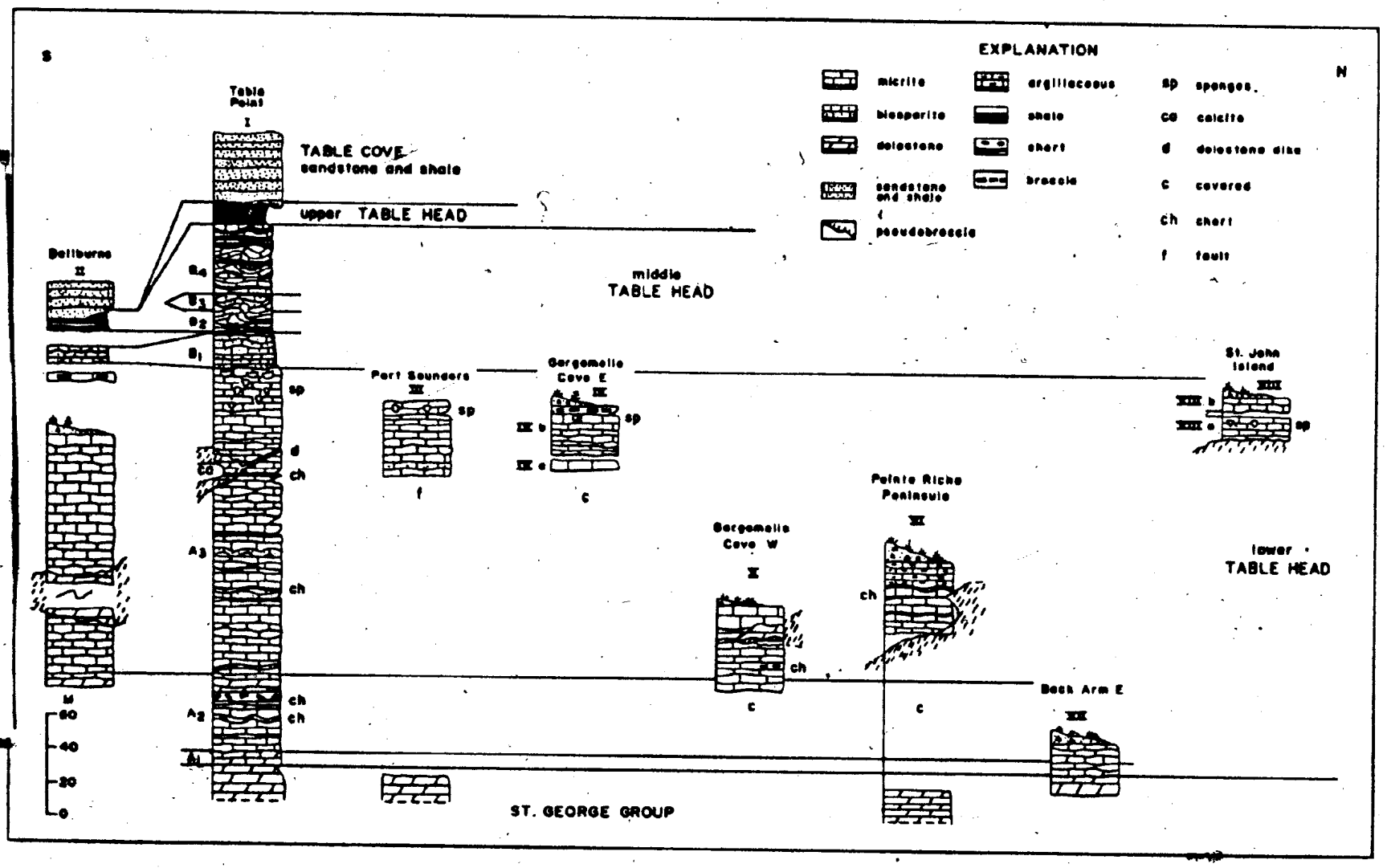
Unit $A_3$ of the Table Point Section is almost complete along the coast of Bellburns and from Pointe Riche to Port Saunders. In the Gargamelle Cove East Section the brecciated micrite ("breccia") occupies about one-fifth of the stratigraphic thickness. Table Head beds of St. John Harbour on St. John Island have the same lithological characteristics as those of Port Saunders, Table Point and Bellburns, but contain a higher number of sponges and fewer large cephalopods.

Middle Table Head of Table Point is incompletely exposed at Bellburns, but the presence of units $B_1$ and $B_2$ could be recognized.

Upper Table Head strata have no lateral equivalents exposed within the study area.

Table Cove sandstones and shales overlie Table Head strata at stratigraphically different positions. They succeed the upper Table Head black shales at Table Point, but overlie unit $B_2$ (middle Table Head) at Bellburns. This difference can be explained as (1) a major disconformity separating the Table Cove sandstones and shales from the Table Head Formation, or as (2) different response (competence) of the units to the regional deformation.

Fig. 2.5 Sections at Bellburns, Table Point, Port Saunders, Gargamelle Cove, Pointe Riche, Back Arm, St. John Island and lithological correlation.



Some implications follow:

1. Regional structural movements have influenced the rocks. Dolomitization and calcification occurs in the centre of synclines and anticlines, along faults, joints and bedding-planes.

2. The disconformable contact between the St. George and Table Head has not been observed in the field. The boundary is only exposed with certainty at Table Point and perhaps Back Arm East. At these places it is conformable. In other areas, where the boundary has been reported to occur, it is the result of dolomitization of Table Head limestones (i.e., Pointe Riche Peninsula and perhaps St. John Island). At Pointe Riche the St. George/Table Head boundary is not exposed, and there is possibly a fault at this locality.

# CHAPTER 3

# BIOSTRATIGRAPHY

## 3.1 Conodont provincialism

Ordovician conodont faunal provinces, the North American Midcontinent Province and the North Atlantic Province, have been reviewed by Barnes et al. (1973 a); Bergström (1971a, 1973c, 1977a); Barnes & Fåhraeus (1975); and Sweet & Bergström (1974).

According to the above authors conodont faunal provincialism was initiated in the Tremadocian. It prevailed to the end of the Ordovician Period, though it was modified as to areal extent and distinctiveness during this time by the closing of the Proto-Atlantic ocean (Fåhraeus, 1976; Bergström, 1977a).

The two main faunal provinces are characterized by two distinctly different conodont faunas, and two zonal schemes have been established (Ethington & Clark, 1971; Sweet et al., 1971; Bergström, 1971a, b; Lindström, 1971). Correlation between these two schemes is difficult resulting in considerable uncertainty regarding precise relations between them. Correlation of the provincial conodont zonations with other faunal successions has been more successful, and the conodont successions are tied into standard graptolite zonations (Lindström, 1971; Bergström, 1971a, 1973c; Sweet & Bergström, 1976; Barnes et al., 1976).

In the Table Head Formation representatives of both faunal provinces occur. The lower part of the lower Table Head includes conodonts of Mid-continent Province affinity. Trigonodus carinatus n. sp. is found in greatest abundance. Other important species of the Table Head collections belonging to the Midcontinent Province are Plectodina? n. sp. A,

Eoneoprioniodus? spp. and Leptochirognathus spp.. In its upper two-thirds the middle Table Head contains a fauna of North Atlantic Province affinity. Notable are the genera Periodon, Cordylodus?, Oistodus?, Polonodus, Protopanderodus, and Walliserodus. The main sequence of the lower Table Head includes genera, which may be present in one or both provinces. There are also genera which to a large degree are restricted to areas transitional between the two faunal provinces. Previous reports of their distribution indicate that they are not restricted to the centre of the Midcontinent or North Atlantic faunal provinces. Belodella, for example, is represented in the lower and middle Table Head and in northern Sweden (Löfgren, 1978) and southern Norway (Fåhraeus, 1970). Some genera cannot be definitely included in either of the presently recognized provinces. ?Erraticodon, for example, has elements with long delicate denticles carried on two or three processes, and can easily be distinguished from the bulk of the hyaline Midcontinent forms.

## 3.2 Conodont collections

A collection of amber to dark-brown conodont elements has been obtained by means of acetic acid dissolution (15%) of limestones. The color is within the range 1½-2 of the CAI (Color Alteration Index) of Epstein et al. (1977), indicating a heating of the strata from 50°C to at least 140°C. Conodonts recovered from dolomites dissolved by formic acid are white in color.

The preservation of the conodonts varies from fragmentary to almost complete elements. Broken specimens are most common in the lower Table Head. Many of these elements show a sucrose surface. Secondary dolomiti-

sation probably influences the preservation, thus generally broken specimens are obtained from dolostones and dolomitic micrite in contrast to generally well preserved conodonts recovered from the biomicrite.

The lower part of the lower Table Head yielded few conodonts: 40% of the samples were barren and another 40% yielded fragmentary conodonts. The remaining 20% yielded conodonts which could be identified to the species level. The yield ranged from 1 to 110 specimens per kilogram of rock. In the higher part of the lower Table Head, conodonts were found in 90% of all samples examined. The yield was affected by secondary dolomitisation. The St. John Island, Port Saunders, and Gargamelle Cove West sections yielded a maximum of 15 specimens per kilogram, whereas the Gargamelle Cove East section yielded many well preserved specimens (85 spms. per kg.).

Unit $B_1$ of the middle Table Head produced the highest number of specimens per kilogram and accounts for 60% of the total fauna. All samples yielded conodonts with a range from 100 to more than 200 conodonts per kilogram. Unit $B_3$ produced a similar number of conodonts, whereas Unit $B_2$ and Unit $B_4$ yielded conodonts in lower abundances, i.e., 30-60 specimens per kilogram. No conodonts were recovered from the shales of the upper and middle Table Head, though a few specimens have been observed on bedding planes with a hand lens. Generally, the Table Head fauna is composed of normal size specimens, but a few genera are composed of quite large elements (1 to 5 mm). This is typical for species of Protopanderodus, Eoneoprioniodus?, and Polonodus.

## 3.3 Stratigraphical distribution

Distribution of conodonts recovered from the Table Head Formation is summarized in Table 3.1 and Fig. 3.2.

Acodus is represented in modest numbers; it occurs in both lower and middle Table Head.

Belodella is a common component, and occurs with two well defined species. Belodella sinuosa n. sp. and Belodella jemtlandica are present; and the latter seems to succeed the former stratigraphically. The phylogeny of B. sinuosa n. sp. is discussed below. Other Belodella species, unnamed, sporadically occur through the strata.

Trigonodus is a hyaline multi-element genus and is present with two species, T. carinatus n. sp. and T. rectus n. sp.. This genus is restricted to the lowermost part of the Table Head.

Eoneoprioniodus? is a hyaline multi-element genus. Two species are present in the lower part of the Table Head Formation.

?Erraticodon balticus is a fairly common component in the lower Table Head and lower part of middle Table Head.

Histiodella occurs as three species which allow a detailed zonation. The phylogenetic relationship of these species is summarized in Fig. 3.1.

Parapaltodus is a new simple-cone genus. It occurs in modest numbers, but is represented by several species all with restricted ranges. The species are separated stratigraphically, and they are not closely related. Parapaltodus angulatus is restricted to the lower part of lower Table Head; P. simplicissimus n. sp. occurs in the higher part of lower Table Head and in the lower middle Table Head, and P. flexuosus occurs mainly in the middle Table Head.

Periodon is represented by a single species, Periodon aculeatus. The phylogenetic relationships with older and younger species have been described by Serpagli (1974), Dzik (1976) and Löfgren (1978).

Polonodus is a rare component of the Table Head fauna and occurs mainly in the lower middle Table Head. It is represented by two species, and provides some of the largest specimens in the fauna. Phylogenetic relationships of this genus are not clear (Dzik, 1976; Löfgren, 1978).

Protopanderodus is well represented with several species, all of which have previously been described from the North Atlantic Province.

Scalpellodus is a common component in the lower Table Head. It is represented by two species, S. biconvexus and S. pointensis n. sp.; the latter succeeds the former stratigraphically.

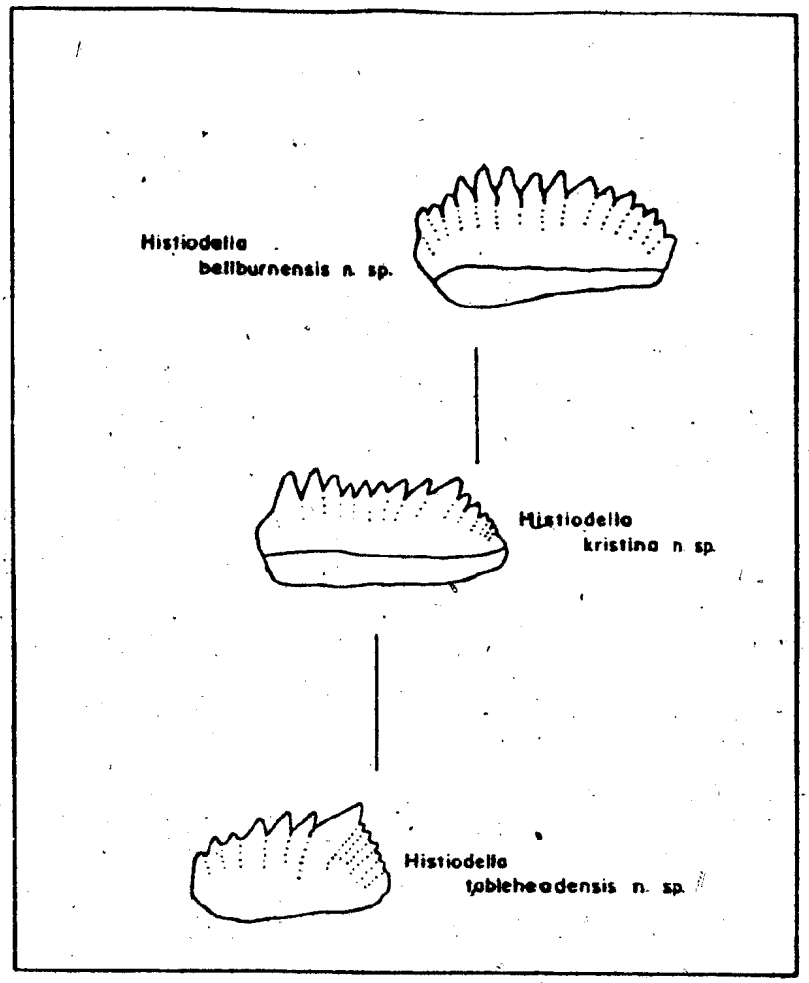
Walliserodus is represented in samples from mainly the upper part of the sequence by W. ethingtoni.

## 3.4 Phylogeny of Forms in Table Head Formation

The distribution of Histiodella is important, because evolutionary changes allow a detailed zonation. The ancestor of Histiodella so far is unknown. Fåhraeus (1970) indicated that Histiodella evolved from a simple cone, but the multi-element apparatus suggests an intermediate ancestor with a ramiform construction. The inferred evolution is expressed mainly in the spathognathodontiforms (Fig. 3.1) whereas the other elements changed very little.

Phylogenetic relationships are also clearly evident between Semiacontiodus preasymmetricus n. sp. and S. asymmetricus, the

Fig. 3.1 Phylogeny of Histiodella species in the Table Head Formation.


Histiodella
bellburnensis n. sp.
Histiodella
kristina n. sp.
Histiodella
tableheadensis n. sp.

latter being the direct descendant of the former. During evolution the posterior carina becomes prominent and distinct.

Phylogenetic relationship between Belodella sinuosa n. sp. and B. jemtlandica is not obvious. The first may be the ancestor to the younger B. nevadensis, and B. jemtlandica is a closely related species. These forms may have developed as lateral stems from a common ancestor.

Scalpellodus biconvexus and Scalpellodus pointensis n. sp. are two closely related species. The second evolved directly from the first.

## 3.5 Conodont Zones

Two phylo-zones based on the evolution of Histiodella have been established for the Table Head Formation. These zones are considered valid for regional correlations.

Some genera and species have a relatively short range (Fig. 3.2), and singly or in combination with others, they characterize four local biointerval-zones.

The zones recognized in the study area are defined and discussed below. Fig. 3.2 illustrates the distribution of conodonts and the zones within the Table Head Formation.

### 3.5.1 Histiodella tableheadensis Phylo-zone

#### Definition

The phylo-zone coincides with much of the stratigraphic range of the species Histiodella tableheadensis. In the Table Point section its base is marked by the first appereance of Histiodella tableheadensis. Histiodella tableheadensis first appears 5 metres above the base of the lower Table Head in the Table Point section. The top of the zone is marked by the first

occurrence of Histiodella kristina in the Table Point section.

Remarks

The base of the phylo-zone cannot at present be defined in the Newfoundland succession, because the ancestor to Histiodella tableheadensis has not been recorded.

Reference section

The Table Point coastal cliffs, Great Northern Peninsula, western Newfoundland (Fig. 2.2.). The top of the phylo-zone is 215 m above the base of the sequence exposed along the coast.

Characteristic conodont species.

The phylo-zone contains a varied fauna of Midcontinent Faunal Province affinity, and a fauna transitional between the two major provinces. Only a small number of elements belong to the North Atlantic Faunal Province.

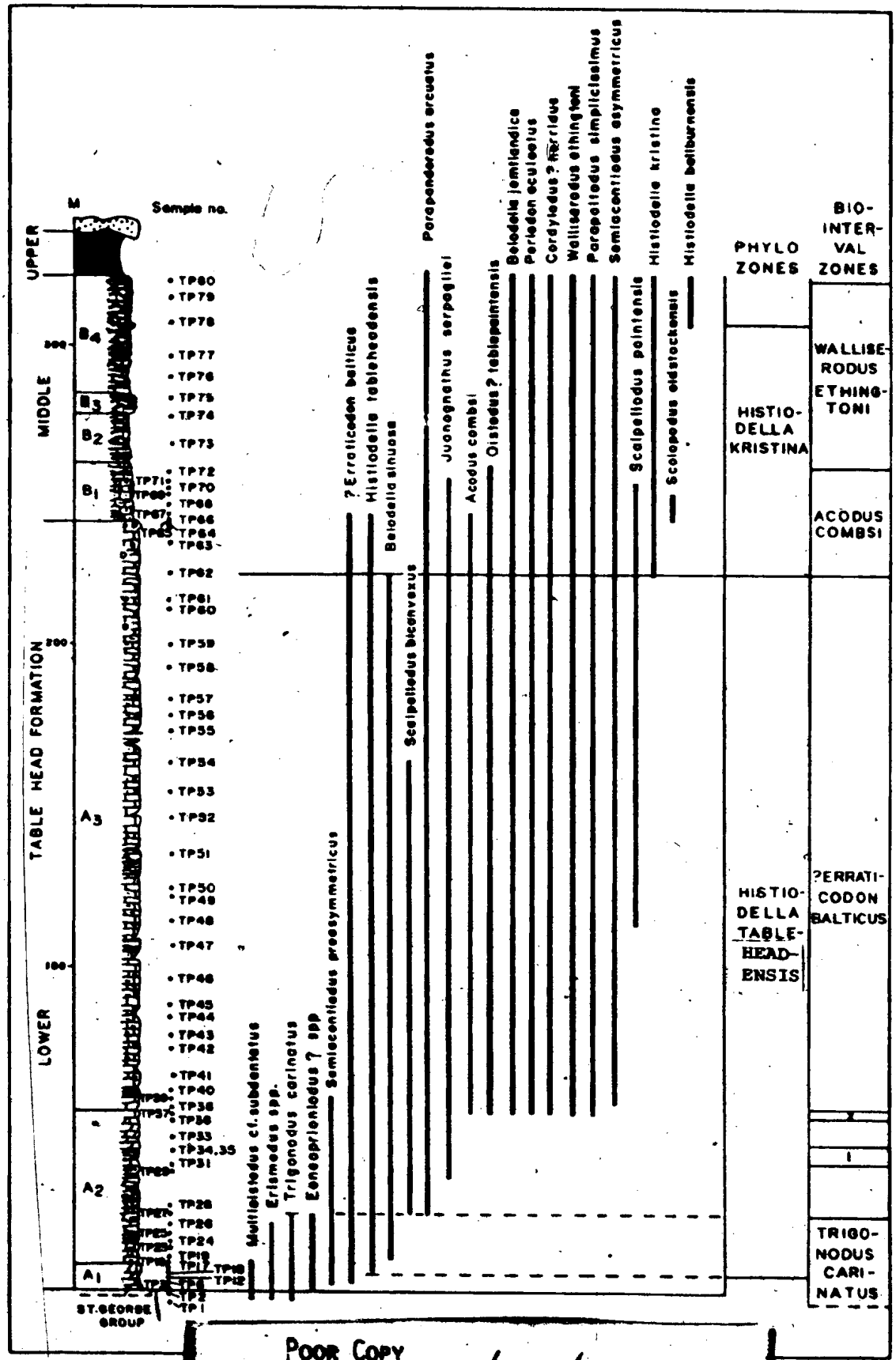
Histiodella tableheadensis is common through the whole zonal interval. Several stratigraphically important hyaline multi-element taxa are restricted to this zone in the study area. These are Eoneoprioniodus? sp. 1, Eoneoprioniodus? sp. 2, Leptochirognathus sp. cf. L. quadrata, Erismodus? sp. 1 and E.? sp. 2. Belodella spp. and ?Erraticodon balticus are common in this zone. Periodon aculeatus and Polonodus spp. are occasionally present.

Conodonts from Histiodella tableheadensis Phylo-zone have been described by Mound (1965a); Uyeno and Barnes (1970); Barnes and Poplawski (1973); Dzik (1978) and Löfgren (1978); additional information has been given by Sweet et al. (1971); Fåhraeus (1970); Bergström (1979) and Harris et al. (1979).

Fig. 3.2 Ranges of selected Table Head conodonts from Table Point. Note that reworked specimens are not included in the rangechart (compare with Table 3.1).

1 - marks a barren interval.

2 - marks a single occurrence of conodonts typical of the *Acodus combsi* Biointerval-zone. This assemblage does not occur again until sample TP 62 (see text).



Remarks

The lower boundary of this zone has not been established, because the ancestor to Histiodella tableheadensis has not been recovered. The full range of this zone is therefore not present at this locality.

The Histiodella tableheadensis Phylo-zone is easily recognized within the study area (Fig. 3.2) and from other localities on the Great Northern Peninsula (Appendix I). It is considered valid over a wide area in much of North America and possibly Australia. The evolutionary transition from Histiodella tableheadensis to Histiodella kristina, which is manifested by development of higher anterior denticles than the cusp of the spathognathodontiform is well documented at the reference section, where it occurs in an interval of 30 metres.

### 3.5.2 Trigonodus carinatus Biointerval-zone

Definition

The base of the biointerval-zone coincides with the first appearance of Trigonodus carinatus n. sp. and Eoneoprioniodus? sp. 1. The top is marked by the disappearance of Trigonodus carinatus.

Reference section

The same as for the Histiodella tableheadensis Phylo-zone. The top of the biointerval-zone is 40 metres above the base of the Table Head Formation. Its base is 3 metres below the base of the Table Head Formation at Table Point. Thus the zone is about 43 metres thick at Table Point.

Characteristic conodont species

The zonal species are restricted to the zone in the study area. Associated species, which are also restricted to the zone in the study area include Erismodus? spp., Lepthochirognathus spp., Plectodina? n. sp. A, and Parapaltodus angulatus. Drepanodus? sp. aff. D.? gracilis and Semiacontiodus preasymmetricus occur in the upper third of the zone. ?Erraticodon balticus occurs within this zone.

Remarks

The biointerval-zone comprises the lowermost beds of lower Table Head (unit $A_1$ and part of unit $A_2$). The conodont fauna is unique, differing markedly from faunas above it, and includes a variety of hyaline species in abundance. The immediately underlying dolostones, of the St. George Group, have so far yielded Trigonodus carinatus, Erismodus sp., Oepikodus sp. and Multioistodus sp. at Table Point, and Eoneoprioniodus? sp., Trigonodus rectus and Leptochirognathus prima at Back Arm.

Elements of this zone have been illustrated by Sweet et al. (1971), Mound (1965a), Uyeno and Barnes (1970), Barnes (1974), Tipnis et al. (1978), and Harris et al. (1979). Sweet et al. (1971) assigned a Mid-continent Fauna 4 age for these elements.

3.5.3 ?Erraticodon balticus Biointerval-zone

Definition

The base of this biointerval-zone in the study area is marked by the appearance of ?Erraticodon balticus and Scalpellodus biconvexus in abundance. This is the same level at which Trigonodus carinatus disappears in the study area. The top is taken at the level at which

Histiodella tableheadensis evolves into Histiodella kristina.

Reference section

The same as for the Histiodella tableheadensis Phylo-zone. The base of the biointerval-zone is about 50 metres above the base of lower Table Head exposed at Table Point. A barren interval is present within and next to the base of the ?Erraticodon balticus biointerval-zone (Fig. 3.2). The top is 220 metres above the base of lower Table Head. The thickness of the zone is approximately 180 metres at the reference section.

Characteristic conodont species

Several species are known to be restricted to this zone. At the reference section the index species associated with Parapanderodus arcuatus characterize the fauna. In this zone the following species occur: Loxodus? curvatus, Semiacontiodus preasymmetricus, Semiacontiodus asymmetricus, and Juanognathus serpagliei. Belodella spp. are common throughout this zone. Locally Acodus combsi, Periodon aculeatus, Cordylodus? horridus, Paroistodus? sp. and Polonodus sp. are present. Many of the species of this zone were described by Barnes and Poplawski (1973); Dzik (1978) and Löfgren (1978).

Remarks

?Erraticon balticus is not restricted to the zonal interval, but occurs also above and below it. Consistent differences between associated faunal elements from the Histiodella tableheadensis and H. kristina Zones make it possible to date material of ?Erraticodon balticus biointerval-zone even in the absence of Histiodella tableheadensis. Within the zone local biostratigraphic ranges and co-occurrences of taxa make a refined local correlation possible.

Scalpellodus biconvexus associated with Protopanderodus strigatus, Parapanderodus striatus, and Belodella sinuosa characterize the lower part of this zone. This level is also characterized by Semiacontiodus preasymmetricus, which is limited to the lower 40 metres of the zone. Above it is followed by its successor S. asymmetricus. Drepanodus? sp. c. D.? gracilis and Parapanderodus sp. cf. P. consimilis also are common associates within this part of the zone. In the middle part of the zone Scalpellodus pointensis and Belodella sinuosa are characteristic species, whereas Juanognathus serpagliei and Belodella jemtlandica, characterize the upper part.

The zone has been identified in the main part of the lower Table Head at many localities on the Great Northern Peninsula (Appendix I).

### 3.5.4 Histiodella kristina Phylo-zone

**Definition**

The lower boundary of this zone is marked by the first appearance of Histiodella kristina n. sp.. The top of this zone is marked by the first appearance of Histiodella bellburnensis n. sp. in the study area.

**Reference section**

The section at Table Point, Great Northern Peninsula, western Newfoundland (Fig. 2.2). The base of the zone is about 16 metres below the top of lower Table Head, and the top of the zone is about 70 metres above the base of middle Table Head. The total thickness of the zone is 86 metres at Table Point.

Characteristic conodont species

The Histiodella kristina Phylo-zone is rich in conodont taxa. The fauna is predominantly of North Atlantic Faunal Province affinity, but many species are new. In addition to the zonal index fossil, the species Belodella jemtlandica, Cordylodus? horridus, Periodon aculeatus, Oistodus? tablepointensis n. sp., Juanognathus serpagliei n. sp., ?Erraticodon balticus, Scolopodus oldstockensis n. sp., Acodus combsi, Walliserodus ethingtoni, and several species of Protopanderodus are important.

Conodont faunas from this zone have been described by Barnes & Poplawski (1973), Uyeno & Barnes (1970), Viira (1974), and Löfgren (1978).

Remarks

Histiodella kristina ranges throughout the middle Table Head. The evolution of H. kristina into its successor occurs in the uppermost beds. It is marked by a reduction in size of the cusp, which obtains a more median position. There is also an increase in height of the anterior denticles (Fig. 3.1).

The faunal elements of the Histiodella kristina Phylo-zone display distinct distributions, and justify a division into two biointerval-zones.

### 3.5.5 Acodus combsi Biointerval-zone

Definition

The lower boundary of this zone in the study area is marked by the appearance of Acodus combsi and Parapaltodus simplicissimus n. sp. in abundance. The top of the zone is taken at the upper limit of the range of Oistodus? tablepointensis n. sp..

Reference section

Same as for the Histiodella kristina Phylo-zone. Acodus combsi appears in abundance close to the top of lower Table Head. The base of the zone is about 16 metres below the lithologic boundary between the lower and middle Table Head. The top of the zone coincides with the lithologic boundary between unit $B_1$ and unit $B_2$ of the middle Table Head. The thickness of the zone is approximately 37 metres at Table Point.

Characteristic conodont species

Several species are restricted to this zone and many species from the Histiodella tableheadensis Phylo-zone below, range through but not above this zone. Acodus combsi and Parapaltodus simplicissimus, dominate the lower third of the zone; Scolopodus oldstockensis and Spinodus cf. spinatus characterize the middle third, and the top is characterized by Oistodus? tablepointensis n. sp.. All these species are restricted to this zone. Other typical associates are Juanognathus serpagliei and ?Erraticodon balticus in the lower third of the zone. Loxodus? curvatus, Drepanoistodus? cf. D.? venustus, Cordylodus? horridus, Periodon aculeatus, and Walliserodus ethingtoni are also important species in this interval.

Remarks

The zone contains the most varied and abundant fauna within the Table Head Formation. Only a few genera and species range into the next zone. The faunal assemblage has also been recorded at the base of unit $A_3$ in the lower Table Head (Fig. 3.2). Reworked specimens of Oistodus? tablepointensis have been recorded above unit $B_1$ (in unit $B_2$ and unit $B_3$). These are excluded from the range of the species in Figure 3.2.

### 3.5.6 Walliserodus ethingtoni Biointerval-zone

**Definition**

The base is at the top of the Acodus combsi Biointerval-zone. The top is the top of the middle Table Head at Table Point.

**Reference section**

The same as for the Histiodella kristina Phylo-zone. The base is 21 metres above the base of the middle Table Head; thus the zone is 64 metres thick at Table Point.

**Characteristic conodont species**

No species is restricted to this zone. Aside from the zonal fossils Periodon aculeatus, Cordylodus? horidus, and Belodella jemtlandica are common through the zone. Histiodella bellburnensis n.sp. and Strachanognathus parvus first appear at the top of the zone.

**Remarks**

The zone can best be distinguished from the underlying Acodus combsi Biointerval-zone by the absence of the key fossils of that zone. The fauna is less varied and usually occurs in low frequencies.

At Table Point this zone is clearly connected to the lithology of unit $B_2$ and unit $B_4$ of the middle Table Head.

## 3.6 Correlation of zones

Fåhraeus (1970, 1977a) has already discussed the conodont fauna from the Table Head Formation and concluded that the main part of the succession at Table Point is of Llanvirn age. Since then conodont taxonomy has drastically changed and also extensive information on conodont biostrati-

graphy has appeared. Despite this no major revisions of previous correlations are proposed here, though some comments and some changes in detail are suggested.

Correlation will be made (1) within the study area; (2) with other Newfoundland localities; and (3) with North America, and western Europe and Australia.

### 3.6.1 Table Point and other localities

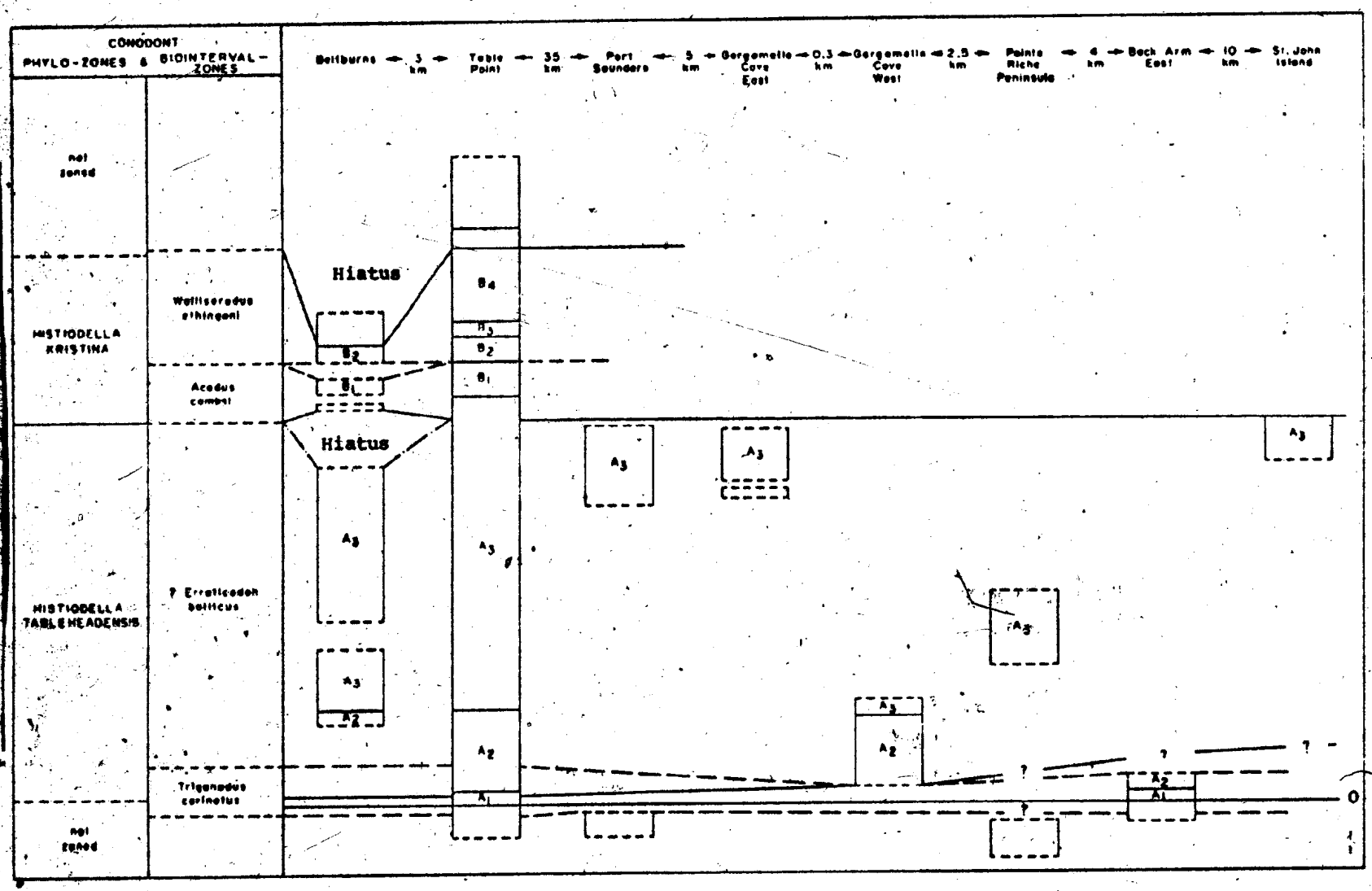
The distribution within the study area of the above defined phylozones and biointerval-zones is outlined in Fig. 3.3.

Elements of Histiodella tableheadensis are present in every section studied. The lower boundary between this species and its immediate ancestor (? H. serrata) has not been recorded in any sections, thus the total range of the H. tableheadensis Phylo-zone is unknown.

The lowest zone, Trigonodus carinatus Biointerval-zone includes unit $A_1$ and part of unit $A_2$ at Table Point, at Back Arm East and at Gargamelle Cove W. It also extends down into the top beds of the St. George Group at Table Point. The thickness at Table Point is 43 metres, and 15 metres at Back Arm where the top of the zone is not exposed.

The ?Erraticodon balticus Biointerval-zone includes the upper part of unit $A_2$ and most of unit $A_3$ at Table Point. At Gargamelle Cove East and West the complete sections are within this zone. The same is true of the Pointe Riche Section, the St. John Island, Port Saunders and Bellburns sections.

Fig. 3.3 Distribution of phylo-zones and biointerval-zones within the study area. Full lines are limits of phylo-zones and the dashed lines are biointerval-zones. See text for further explanation.
The letters in the columns are the lithological units of fig. 2.5. 0 marks the base of the section at Table Point; it is included as reference.


CONODONT
PHYLO-ZONES & BIOINTERVAL-ZONES
Bellburns
3 km
Table Point
35 km
Port Saunders
5 km
Gargamella Cove East
0.3 km
Gargamella Cove West
2.5 km
Pointe Riche Peninsula
4 km
Back Arm East
10 km
St. John Island
not zoned
HISTIODELLA KRISTINA
Wallisseradus ethingoni
Acodus combsi
HISTIODELLA TABLEHEADENSIS
? Erraticodon balticus
Trigonodus carinatus
not zoned
Hiatus
Hiatus
B4
B3
B2
B1
A3
A2
A1
?
0

The Histiodella kristina Phylo-zone and the Acodus combsi Biointerval-zone are present at Bellburns. However, their complete distributions within the section were not established in this investigation.

### 3.6.2 Correlation with Newfoundland examples

Local correlation of Table Head strata is still difficult to suggest, because conodonts have been reported only in a preliminary way (Fåhraeus, 1970), or have not yet been described. Fåhraeus (1970) reported and illustrated conodonts from Little Spring Inlet, Hare Bay. Species in common with Table Point include Polonodus? clivosus and Periodon aculeatus. Fåhraeus (1970) indicated that this fauna could be latest Arenig or earliest Llanvirn in age. Additional samples have been collected from Little Spring Inlet and other localities in Hare Bay, and more information has been obtained (Appendix I). Species in common with the Table Point Section include: Histiodella tableheadensis, Belodella sinuosa, Belodella jemtlandica, and Periodon aculeatus. This fauna correlates with the H. tableheadensis Phylo-zone.

Conodonts from the top of Bed 14 of the Cow Head Group (Fåhraeus, 1970; Fåhraeus & Nowlan, 1978) are present in the lower Table Head. They are: Periodon aculeatus and Belodella sp... Bed 14 may be contemporaneous with the lower part of the Table Point Section or slightly older.

### 3.6.3 International correlation

Two, possibly three, standard zonations are available for reference when assigning an age to the Table Head strata on the basis of contained

conodonts: the Midcontinent Faunal succession (Sweet et al., 1971; Sweet & Bergström, 1976), the Scandinavian conodont succession (Lindström, 1971; Bergström, 1971a, b, 1973a; Löfgren, 1978), and the preliminary Australian conodont succession (McTavish & Legg, 1976).

Midcontinent faunas

The North American Whiterockian Stage comprises conodont Faunas 1 to 4 (Sweet et al., 1971; Sweet and Bergström, 1976). The species Histiodella sinuosa is considered a key species of Midcontinent Fauna 3 (Sweet and Bergström, 1976). Histiodella tableheadensis associated with Eoneoprioniodus? sp. 1 characterize Midcontinent Fauna 4. Histiodella kristina has not yet been described from the Midcontinent Province.

The Table Head Formation has the following species in common with the Midcontinent Faunas, the number in brackets refers to the fauna in which the genera and species have been reported to be characteristic (Sweet et al., 1976); Semiacontiodus preasymmetricus (1), Histiodella tableheadensis (4), Leptochirognathus sp. (4 and higher), Eoneopriodiodus? sp. 1 (4), Multioistodus (2 through 5) and Erismodus? sp. (5).

The key species of Fauna 4 include Histiodella tableheadensis and Eoneoprioniodus? sp. 1. These species occur at the base of the Table Point Section, and Fauna 4 is represented by the Trigonodus carinatus Biointervalzone of this study. Hence the Table Head Formation is not older than Fauna 4. The range of the additional species listed above are consequently extended to include Fauna 4.

Conodonts of Fauna 4 in the USA have been reported from the Everton Formation, Missouri and Arkansas; Oil Creek Formation, south-central Oklahoma; Lehman Formation and lower Swan Peak Quartzite in western Utah,

and the Antelope Valley Formation of Nevada (Sweet et al., 1971; Sweet and Bergström, 1976; Ethington, 1977; Harris et al., 1979). The Joins Formation, south-central Oklahoma (Mound, 1965a) and the Fort Peña Formation, Marathon, Texas, are mainly of Midcontinent Fauna 3 age (Bergström, 1978; Bradshaw, 1969; Sweet and Bergström, 1976).

In Canada Midcontinent Fauna 4 is recorded from the Ship Point and Bay Fiord Formations of Arctic Canada (Barnes, 1974) and from the Sunblood Formation of the Mackenzie Mountains (Tipnis et al., 1978).

A small fauna from Scotland (Higgins, 1967) includes Oistodus multicorrugatus, but lacks Histiodella species, and cannot be evaluated precisely in terms of Table Head zonations. The fauna is probably of Midcontinent Fauna 2 to 4 in age, and it is considered to be older than the Table Head fauna.

Correlation with the North Atlantic Faunal Province.

The Balto-Scandic conodont sequence was summarized by Lindström (1971) and Bergström (1971a) for the Lower and the Middle Ordovician (for a discussion of chrono-stratigraphic classification of Ordovician of the Baltic see Jansusson, 1960). Viira (1974) and Dzik (1978) summarized the conodont successions form the East Baltic area. Refinement of the zonation for the Middle and Upper Ordovician was made by Bergström (1971b, 1973b) and Löfgren (1978). Kohut (1972), Stouge (1975) and Löfgren (1978) commented upon and suggested minor revisions of the upper part of the Lower Ordovician zonation of Lindström (1971). These zonations are now considered standard references for the North Atlantic Province and have been correlated with the standard graptolite zonation (Table 3.2).

In the Table Head fauna no zonal fossils of the Scandinavian zonations have been recorded, but the distributions of Periodon aculeatus,

Walliserodus ethingtoni, and Histiodella kristina allow a confident correlation.

According to Lindström (1971) and Löfgren (1978) Microzarkodina flabellum evolves into M. ozarkodella and Periodon flabellum evolves into P. aculeatus at the same time, i.e., at the base of BIIIb. Skevington (1965) has shown that the oldest Didymograptus 'bifidus' Zone fauna is present at this level, and the boundary between the D. hirundo and D. 'bifidus' graptolite Zones is close to the base of BIIIb (Jaanusson, 1960; Skevington, 1965).

Based on the above information the Table Head fauna cannot be older than the base of the E.? variabilis - M. ozarkodella Subzone of Löfgren (1978), because P. aculeatus ranges through most of the sequence at Table Point. This correlation is furthermore supported by Walliserodus ethingtoni, which first appears in the upper part of the E.? variabilis - M. ozarkodella Subzone (Löfgren, 1978). In the Table Head the lowermost occurrence of W. ethingtoni is close to the base of the ?Erraticodon balticus Biointerval-zone or within the Histiodella tableheadensis Phylozone.

Histiodella kristina has been recorded from the Platyurus Limestone on Öland, South-eastern Sweden (Lindström, 1960); from Estonia (Viira, 1974); and from Poland (Dzik, 1976, 1978), where it ranges through the E. pseudoplanus Zone or the Aluoja Substage ($BIII_{\gamma}$).

The upper limit of the Table Head fauna in terms of conodonts is not clear. Walliserodus ethingtoni, Belodella jemtlandica and Periodon aculeatus occur together through the E. suecicus Zone of Löfgren (1978), and they are also present in the succeeding Zone, i.e., the Pygodus serra

Zone. The lack of P. serra, and possible presence of Pygodus sp. C. Löfgren in the Table Head fauna indicates a correlation with the E. suecicus - P. sulcatus Subzone (Aseri, CIa).

Correlation with North Atlantic Faunal Province faunas outside Scandinavian

The faunal association Periodon, Cordylodus?, Histiodella, Belodella, Protopanderodus and Oistodus?, typical of the middle Table Head is widespread in North America and with an occurrence in Norway. The faunas are of much the same age as the Table Head fauna though with minor differences when studied in detail.

These faunas are reported from Ikes Canyon, Toquima Range, Nevada and Meiklejohn Peak, Nevada (Ethington, 1977; Harris et al., 1979); the Lévis and Mystic Formations, Quebec (Uyeno & Barnes, 1970; Barnes & Poplawski, 1973), which also includes slightly older faunal elements; Deep Kill and Mount Merino section of the Taconic Allochthon, New York (Landing, 1976), which correlates with the Histiodella tableheadensis Phylo-zone, and the Marathon Basin, Texas (Graves & Ellison, 1941; Bergström, 1978; Bergström & Cooper, 1973). In the Marathon Basin the Fort Peña Formation is older than the Table Head fauna (Bergström, 1978). The total range in age of the Fort Peña Formation still needs to be clarified, as Bergström & Cooper (1973) reported the presence of P. serra in the upper part of this formation.

In Europe the Hølonda Limestone of western Norway contains a fauna of Table Head age (Bergström, 1971a, 1977b, 1979a, 1980) or slightly older.

Correlation with the Australian succession

A preliminary conodont zonation in association with graptolites and trilobites has been presented by McTavish & Legg (1976). The faunal elements were not illustrated, and the correlation below is solely based on the identifications of McTavish & Legg (1976). The Australian zonation is based on informal zones designated by letters of the alphabet.

The *Histiodella tableheadensis* Phylo-zone correlates with the upper part of the OCF zone. The following OCG zone is included in the *H. kristina* Phylo-zone. The OCH zone yielded *Phragmodus* cf. *P. flexuosus*, which is a key fossil for Midcontinent Fauna 5 (Sweet *et al.*, 1971). This suggests that the OCH zone is younger than the *Histiodella kristina* Phylo-zone in the study area.

Summary

A summary of the correlations given above is described in Table 3.2.

The Table Head Formation correlates with the *E.? variabilis* - *M. ozarkodella* Subzone and the *E. suecicus* Zone of the Scandinavian conodont zonation. The *Histiodella kristina* Phylo-zone probably correlates with the *Eoplacognathus suecicus* Zone, and the *H. tableheadensis* Phylo-zone with the *E.? variabilis* - *M. ozarkodella* Subzone. The Table Head conodont succession is included in the range of Midcontinent Fauna 4.

In terms of the graptolite zonal succession the Table Head fauna at Table Point comprises the whole of *Didymograptus* '*bifidus*' Zone and ranges into the lower part of the *D. murchisoni* Zone. Upper Table Head graptolites have been correlated with the *D. murchisoni* Zone (Erdtmann, 1971;

Finney & Skevington, 1979). In the North American graptolite zonation the Table Head succession correlates with Zone 9 of Berry (1960). Upper Table Head graptolites are transitional from Zone 9 to Zone 10 (Erdtmann, 1971).

Table 3.2 Correlation and summary of stratigraphic units referred to in the text.

Data for conodont faunas of North America from Ethington and Clark (1971); Sweet *et al.* (1971) and Sweet and Bergström (1976). Data for Scandinavian conodont zones from Lindström (1971); Bergström (1971, 1973a) and Löfgren (1978).

| System | Series | Stages Substages (N. America) | Series (British) | Series Stages Substages (Baltic) | British Graptolite Zones | Formation Group (This Study) | Conodont Phylo-zones and Biostratal zones (This Study) | | Conodont (N. Am.) | Faunas (Australia) | Conodont Zones and Subzones (Scandinavia) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORDOVICIAN | CHAMPLAINIAN | CHAZYAN | LLANVIRN | LASNA (M. AGI) | DIDYMOGRAPTUS (MURCHISONI) | UNNAMED | NOT ZONED | | 5 | | *Pygodus serra* | *Eoplacognathus foliaceus* |
| | | WHITEROCKIAN | | ASERI $C_1$ | | TABLE HEAD FORMATION (M) | MISTIODELLA (KRISTINA) | *Walsorodus ethingtoni* | 1 | DCH | | *Eoplacognathus suecicus - P. suecicus* |
| | | | | KUNDA $B_{III}$ | DIDYMOGRAPTUS "BIFIDUS" | | | *Acodus combei* | 4 | DCG | *Eoplacognathus suecicus* | *Eoplacognathus suecicus - S. gracilis* |
| | | TABLEHEADIAN | | | | | MISTIODELLA (TABLEHEADENSIS) | *Erraticodon balticus* | | DCF | *Eoplacognathus variabilis* | *Eoplacognathus P. variabilis* *Microzarkodina ozarkodella* |
| | | | | | | | | *Trapezodus carnatus* | 1-1 | | | |
| | CANADIAN | VALHALLAN | ARENIG | Aseriu $B_{III}$ | | ST GEORGE GROUP | NOT ZONED or WANTING | | E-1 | OCE | | *E.? variabilis - M. tableheadensis parva* |
| | | | | Hunderum $B_{IIIa}$ | DIDYMOGRAPTUS (HIRUNDO) | | | | | | *Microzarkodina tableheadensis parva* | NOT SUBZONED |
| | | | | VOLKHOV $B_{III}$ | | | | | | | *Paroistodus originalis* | |
| | | | | Langevoja $B_{III\gamma}$ | | | | | | | *Baltoniodus navis* *B. triangularis* | |
| | | | | Limbata $B_{III\beta}$ | | | | | | | | |
| | | | | beds $B_{III\alpha}$ | | | | | | | | |
| | | CASSIAN | | LA-TORP $B_I$ | DIDYMOGRAPTUS EXTENSUS | | | | E | OCD | *Oepikodus evae* | |

# CHAPTER 4

# PALEOENVIRONMENTAL MODELS

## 4.1 Introduction

This section includes an interpretation of the succession of paleo-environments recognized in the study area. The subsequent integration of this information into a sequential paleogeographic interpretation will be dealt with but briefly, as the Table Head stratigraphy is more complex than this investigation would suggest. It would be presumptuous to base a detailed reconstruction on one section. Such a reconstruction must await a three dimensional knowledge of facies distribution and paleogeography, particularly in terms of sea-level fluctuations. The environmental patterns will be illustrated applying Walther's law (Blatt, Middleton and Murray, 1972; Middleton, 1973) to the depositional environments represented in the vertical succession at Table Point.

## 4.2 Criteria of Environmental Importance

The interpretation of ancient sedimentary environments depends largely on comparison with modern analogues (e.g. Bathurst, 1975; Milliman, 1974), and on consideration of fossil faunas as well as lithological criteria and sedimentary structures (e.g. Heckel, 1972; Laporte, 1967, 1969). The following principal criteria are used to distinguish subtidal rocks from intertidal sediments.

Intertidal environments are characterized by unstable energy levels (Laporte, 1967, p. 80) and variable salinity, which creates numerous local micro environments (Friedman & Sanders, 1978). Sediments which accumulate in intertidal environments reflect the complex system of physical

parameters. There are frequent lateral and successional facies changes (Logan et al., 1974). The formation of dolomite and evaporite minerals is commonly associated with these environments (Bathurst, 1975; Friedman & Sanders, 1978). The variety of sedimentary structures, including desiccation cracks, fenestral pores and ripple marks, can also be indicative of an intertidal setting (Logan et al., 1974; Ginsburg, 1975; Grover & Read, 1978). Associated in situ faunas can be sparse or abundant but characteristically are of low diversity (Heckel, 1972).

In contrast, subtidal environments tend to be more stable and sediments deposited there tend to be more extensive vertically and laterally. Limestones of subtidal origin are best distinguished by their autochthonous faunas which may have high individual abundance in addition to diversities distinctly greater than in intertidal strata (Heckel, 1972).

Sessile, colonial faunal elements associated with abundant large macrofaunas represent a structure of biohermal or biostromal type (e.g. Friedman & Sanders, 1978).

Deeper water subtidal environments of open water temperature and salinity are characterized by prolific trilobite faunas and predominantly inarticulate brachiopods, which at further depth are associated with the epi-planktonic graptolites and radiolarians. The latter association indicates an open oceanic environment.

Lithology, when used in conjunction with other factors, can provide other useful clues about the origin of the rocks (Laporte, 1969; Wilson, 1975; Friedman & Sanders, 1978). The proportion of siliciclastic material may increase shorewards (Milliman, 1974) although the reverse has been described (Bathurst, 1975). The ratio of lime mud/lime spar is

a measure of energy, and may indicate distance from a shoreline or depth of the water (Laporte, 1969).

In subtidal rocks slumped layers, chaotic contorted beds, and transported fossils are indications of rapid and early transport along a gradient. This submarine transport may be initiated by a storm or earthquake, or a slope.

## 4.3 Depositional Environments of the Lower Table Head (Table 4.1)

### Unit $A_1$

The basal unit $A_1$ (7-8 metres) of the lower Table Head at Table Point consists predominantly of medium light-grey, dolomitic, pelletal micrite. The unit is characterized by a sparse biota dominated by high spired gastropods (Hormotoma sp.), and smooth ostracodes (leperditiids). Trilobite, cephalopod and brachiopod fragments are scarce or absent. Unit $A_1$ also is characterized by fenestral pores and desiccation cracks, but laminated beds are rare. Evaporites are not present.

Based on the criteria outlined above, these strata are interpreted to have been deposited in a tidal flat complex of the transgressing early Middle Ordovician sea. The water that periodically covered the flat, evaporated and supplied magnesium-rich brines to the underlying aragonite mud, penecontemporaneously replacing it to form dolomite mud. The depositional fabric remained essentially intact after the replacement with no apparent increase in crystal size.

Carbonate tidal flat fabrics without layering and supratidal facies have recently been discussed by Grover & Read (1978), who suggested that a combination of browsing (gastropods), thin inactive algal mats and high

Table 4.1 Summary of Characteristics of the Table Head Formation.

| SEDIMENTARY STRATIGRAPHIC UNITS | TABLE HEAD FORMATION | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LOWER | | | MIDDLE | | | | UPPER |
| | $A_1$ | $A_2$ | $A_3$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ | |
| LITHOLOGY | PELLETS | | SKELETAL DEBRIS<br>CARBONATE MUD<br>TERRIGENOUS<br>SPARITE | MUD | | | | |
| | EARLY DOLOMITE | | | | | | | |
| PALEONTOLOGY | ALGAL STRUCTURES | | ARTICULATE BRACHIOPODS<br>INARTICULATE | BRACHIOPODS | | | | |
| | HORNIOTOMA | | MACLURITES<br>TRILOBITES<br>CEPHALOPODS<br>OSTRACODES<br>SPONGES<br>BRYOZOANS<br>CRINOIDS | | | | GRAPTOLITES<br>RADIOLARIANS | |
| STRUCTURES | MUDCRACKS | | CROSS STRATIFICATION<br>VERTICAL BURROWS<br>HORIZONTAL BORROWS<br>BIOSTROME<br>BIRD'S EYES<br>STYLOLITES | | | | SLUMPS<br>FINELY LAMINATED | |
| ENVIRONMENT | TIDAL FLAT-LAGOON | | SHALLOW SHELF DEEPER SHELF BIOSTROME<br>SLIGHTLY RESTRICTED OPEN OPEN | UPPER SLOPE<br>OPEN MARINE | | | LOWER SLOPE | LOWER SLOPE<br>BASIN<br>LOW ENERGY |
| | POOR CIRCULATION<br>SALINITY ABOVE NORMAL<br>ENERGY LOW<br>TEMP ABOVE NORMAL<br>VARIABLE ENVIRONMENT | | CIRCULATION GOOD<br>SALINITY SLIGHTLY ABOVE NORMAL-NORMAL<br>ENERGY HIGH LOW MODERATE<br>TEMP SLIGHTLY ABOVE NORMAL-NORMAL<br>STABLE ENVIRONMENT HIGHLY<br>VARYING ENVIRONMENT STABLE<br>AGITATION ENVIRONMENT | ENERGY LOW/HIGH LOW LOW<br>CIRCULATION GOOD POOR<br>VARIATIONS<br>CAUSED BY<br>PERIODIC<br>TERRIGENOUS<br>INFLUX | | | | VERY POOR<br>CIRCULATION |

bioturbation rates relative to sedimentation prevailed in these environments. Except for an occasional gastropod, the fossils are scarce and possibly the second factor was important during the Table Head time. Also the paucity of evaporites indicates that the prevailing paleoclimate was humid - a Bahamian type of climate as opposed to a Persian Gulf type - which inhibited the formation of elevated salinities in a humid climate, as features of the arid zone tidal deposits are lacking.

Unit $A_2$

This unit consists of argillaceous micrite and biosparite, and minor dolostone with silty dolomitic stringers and argillaceous material. The unit is mainly thick - or massive bedded and medium to dark grey in color. Yellow weathering, red, silty, dolomitic stringers form the matrix of hard, irregular shaped lumps of micrite. Chert bands and nodules are present; stylolites are common.

This unit includes a characteristic slumped layer with finely-laminated angular clasts that is overlain by conchoidally fractured cross-bedded dolomitic siltstone. The next beds include massive bedded well sorted siliceous or dolomitic siltstones with ripple marks. The beds have vertical and horizontal burrows associated with desiccation cracks. Whole, rolled, highspired gastropods preserved in pockets are characteristic.

The fauna becomes more diverse within unit $A_2$, but gastropods (Hormotoma sp., Maclurites sp.) and ostracodes dominate; cephalopods, trilobites and brachiopods occur in low abundance.

The sequence is interpreted to reflect intertidal to shallow subtidal environments of a lagoon. At the top of the unit, a shallowing of

water depth is inferred. It probably represents a spit. The beds, interpreted to represent a spit, are only exposed in vertical section at Table Point, so any geometry cannot be demonstrated. However, lateral continuity is indicated by the preservation of the top of unit $A_2$ at Bellburns. The lagoons were elongate, and they were bounded on one side by the intertidal environment and on the other side by the spit and the carbonate bank.

Sorting resulted in a trend toward concentration of the finer grains in the centre of the lagoon and the argillaceous rubbly limestone with silty red-colored stringers may represent the deepest part of this environment. The sediments are generally non-laminated probably because of reworking by organisms. The slumping of argillaceous micrite with chert nodules was initiated by periodic storm activity or by periods of high wind activity, when loosely packed sediments slumped into the lagoon (Dickinson, Berryhill, and Holmes, 1972). Presumably, the slumps travelled to the deeper parts of the lagoon.

The depths listed here as shallow to deep were in fact intertidal to barely subtidal. The centre of the lagoon is not considered to be more than one to two metres deep.

Unit $A_3$

Unit $A_3$ can be divided into three sub-units. The lower sub-unit is hemicyclic (ABCABC) formed by argillaceous biomicrite (A), massive micrite (B) and biosparites (C) in thinner beds and lenses. Each sequence varies from 10 to 35 metres in thickness. The two local prominent chert bands at Table Point separate two mega sequences each about 55 metres

thick. At the Pointe Riche Section a well developed sequence is present, where a coarsening upward sequence is obvious.

The fauna is diverse. The gastropod Maclurites sp. dominates the fauna of the massive bedded micrite; leperditiids are predominant in the sparite beds, whereas trilobites, cephalopods, and brachiopods, preferred sediments forming the medium-bedded argillaceous micrite.

The lower sub-unit of unit $A_3$ is interpreted as a shallow marine, nearshore deposit, as indicated by the high amount of sand-sized detritus (shell debris) in lenses. At the base, the environments of unit $A_2$ grade into those of unit $A_3$ and represent a lower intertidal environment. In this environmental zone the carbonate sediments and cements were not affected by penecontemporaneous dolomitization.

The lithological variations reflect variations in the local environments such as mudbanks, with channels between them, and protected, slightly deeper areas of lime mud deposition.

An alternative explanation for the sequences is the variation of subsidence and progradation caused by the carbonate sedimentation. The subsidence was abrupt rather than being a gradual submergence. Once the typical shelf was flooded regressive carbonate outbuilding occurred until it almost reached the surface and came into the high energy zone (biosparite).

The two explanations in combination are favoured here.
Thus the abrupt subsidence was initiated possibly by natural castrophic events and the rapid carbonate sedimentation returned the environment to the shallow water deposits. It is proposed that each megasequence was initiated by such an event, and progradation prevailed within a mega-

sequence until the second abrupt process disturbed the quiet period.

The chert layers probably filled smaller depressions of the bottom of the shallow higher energy zone, as they are not laterally persistent as seen at Pointe Riche Section. The origin of the chert is not known - it could be of pure diagenetic origin - or the result of remobilization of siliceous sponge spicules.

The middle sub-unit of unit $A_3$ consists predominantly of medium bedded micrite with local (packed) biomicrite beds. This middle part also becomes more thin-bedded and argillaceous material increases. The biota becomes dominated by cephalopods, brachiopods and trilobites. These occur generally as disarticulated skeletons and occasionally as complete specimens. Maclurites sp. and ostracodes disappear or become less dominant. The bioclasts of the (packed) biomicrite are derived from the surrounding sediments.

The relatively abundant brachiopod-trilobite-cephalopod biota represents progressive deepening of the water and establishment of widespread subtidal conditions that continued through the deposition of the rocks of unit $A_3$ of the study area. This part may have been deposited in a marine offshore environment of moderate depth (outer shelf).

The upper sub-unit of unit $A_3$ changes in lithology to a grey to light-grey micrite and biomicrite with dark-grey argillaceous material. This lithology is not always easy to separate in the field from the middle sub-unit of unit $A_3$, though the beds tend to be more massive and have an increasing amount of skeletal debris.

A wide variety of invertebrates colonized the sea floor. Relatively abundant brachiopod, trilobite, and crinoid faunas developed periodically, but the most conspicuous were the faunas of sponges and bryozoans

(Table 4.1). The fauna changes gradually with the appearance of sponges and is succeeded by massive or flattened bryozoans. The latter become the most conspicuous up-section and cover whole bedding planes. They are associated with the largest cephalopods recorded in the Table Head Formation.

The upper sub-unit of unit $A_3$ was deposited in a subtidal environment. A depth cannot be determined with certainty. The sponges, so well exposed on St. John Island, have a high height-base diameter ratio suggesting substantially greater vertical than horizontal growth. The presence of small immature mushroom-shaped sponges in some units suggests that conditions were fluctuating enough to kill populations before they reached maturity. These features were probably caused by high sedimentation rates in quiet water environments and/or changes in salinities/temperatures. This is supported by the flattened colonial forms of the bryozoans. A wide surface area is the best adaptation for maximum exposure to water and light in deeper quiet water. Also, the lack of features such as cross-bedding and coarse crinoidal biosparites suggest that the bryozoans grew in a deeper subtidal environment. Possibly the fauna formed only a minor elevation on the sea bottom.

The upper sub-unit $A_3$ may represent a low biostromal structure at the shelf edge.

The construction of large algal bioherms so characteristic for the Lower Ordovician St. George Group (Stevens & James, 1975; Knight & Saltman, 1980) was probably prohibited by the fast Table Head transgression and steady deepening. This resulted in unstable conditions and high stress on the sessile fauna in contrast to the stable conditions of the St. George

Group platform rocks. Based on field experience from various localities of the Table Head Formation, the biostromal structure, formed mainly by bryozoans, was developed only within the study area, and the unit is relatively insignificant compared with the bulk of lower Table Head limestones.

In summary, unit A was deposited on the shelf and represents a cycle of three distinguishable sub-environments, namely shallow subtidal nearshore, deeper subtidal, offshore and deep subtidal offshore respectively.

The shelf was submerged abruptly and without reef growth, which may be due to changes in the climate(?), rate of submergence, rate of sedimentation, or influx of terrigenous sediments (or combination of the four). The factors created conditions that exceeded the tolerance limits of hermatypic organisms.

## 4.4 Depositional Environments of the middle Table Head

The middle Table Head was divided into the four units $B_1$, $B_2$, $B_3$ and $B_4$ (Chapter 2).

### Unit $B_1$

Unit $A_3$ is overlain conformably by nodular bedded, dark-grey biosparites and micrites of unit $B_1$. These nearly black limestones with an increasing amount of argillaceous material contain abundant trilobites and articulate and phosphatic brachiopods. The profuse fauna of large cephalopods at the top of unit $A_3$ disappears.

The undulose beds grade into nodular beds with limestone or shale matrix. This change of bedding style indicates steepening of the bottom

gradient and subsequent water deeping. The fluctuations of micrite to biosparite also indicate unstable energy levels. This environment is interpreted to occupy a high position in the upper slope environment.

Unit $B_2$

The lithologic unit $B_2$ consists mainly of uniformly interbedded black micrite, and dark-brown calcareous to black fissile shales. The dense micrite does not show any features in thin section other than neomorphism where the original lime mud has become recrystallized. The sparse fauna includes trilobites and brachiopods predominantly in the limestones, and graptolites in both lithologies.

Interbeds of fine-grained limestone (micrite) and dark shale occur worldwide in rocks of different ages, and show little variation from place to place (Wilson, 1969, 1975). These beds are often referred to as hemipelagic, because they are a combination of terrigenous sediment and pure pelagic sediment. Wilson (1969) and Keith & Friedman (1977) suggested that the lime mud was formed on the shallow shelf and transported into deeper water. Schlager & James (1978) introduced the term "periplatform ooze" for these shelf derived sediments. The basinward transportation processes could either be nepheloid layers or dilute turbidity currents (Walker & Mutti, 1973; Keith & Friedman, 1977). The sediments could later have been reworked by contour currents (Heezen et al., 1966). Stevens (1970) considered middle Table Head strata to be a carbonate flysch deposit, and in general hemipelagic carbonate beds are commonly associated with turbite sequences (Walker & Mutti, 1973; Wilson, 1975). As discussed by Keith & Friedman (1977) the rhythmic succession of micrite and shale beds of very constant and even thickness cannot be explained

solely by the processes mentioned above. As yet, however, no acceptable depositional process has been proposed.

Unit $B_2$ is interpreted to represent the upper slope environment.

Unit $B_3$

An interval of sparry black biosparite and interbedded shales is very rich in trilobites within the limestones. The random orientation of the trilobites, disarticulated organisms, and the mixed faunal composition indicate transportation from the environments above, i.e., the outer shelf, shelf edge and uppermost slope into the lower environment of unit $B_4$.

Unit $B_4$

The upper unit of $B_4$ consists of evenly bedded, dark, mostly non-calcareous shales of the same lithology as the overlying Table Head, interbedded with evenly laminated micrite and monomictic breccias. The dark laminae of the micrite are the result of concentrations of organic matter, of iron sulfides, or of argillaceous material. The fauna in the limestone is sparse, consisting of trilobites, inarticulate brachiopods and a few radiolarians. The shales, however, produce an abundant graptolite fauna.

Unit $B_4$ probably represents the lower slope, or a transition from the upper slope into the lower slope environments. The seabottom was probably stagnant and reducing in this environment and bottom-scavenging organisms were not present, because bioturbation did not take place and the original laminae were not disturbed. The sporadic occurrence of radiolarians indicates a relatively increased pelagic faunal influence within this unit.

The strata at Table Point show evidence of slumping after deposition and probably represent the initial state of the formation of submarine carbonate breccias as a result of submarine slumping and sliding, in turn probably due to storms or other natural castrophies. The body of sediment could move downslope along a curved surface of displacement or fault (slump scar of Walker, 1966). Such a feature has been observed at Table Point and possibly at Bellburns (Chapter 2; Fig. 2.5). The toe of the slump became incoherent and possibly formed a debris flow. Stratification was destroyed and the sediments moved downslope as gravity flows, forming a chaotic mixture of various sizes of particles.

The slope needs not to be steep, because slumping may take place anywhere on the continental slope. The gradient necessary for initiation may be less than one degree (Johnson, 1970), and only a slight tremor is needed to initiate the slump, especially in metastable sediments (micrites interbedded with soft shales).

To summarize, Unit $B_4$ is partly deposited by contour currents, nepheloid layers, or dilute turbidity currents. The sedimentary mechanism of the rhythmic succession of even-bedded micrite and shales remains unsolved. After deposition, the sediments slumped, were subsequently transported by submarine debris flows and were then deposited as chaotic masses of plastically deformed clasts.

Middle Table Head strata at Table Point are unique. The prominent slumped nature of the strata has been seen only at this locality. Unit B is much thicker at this locality than its lithologic equivalents in other areas, probably due to sediment accumulation, but also to the slumping.

## 4.5 Depositional Environment of the upper Table Head

The upper Table Head is a black bituminous shale. The beds were formed in a quiet euxinic environment. Graptolites are the dominant fauna. The shale probably was deposited in a basin or lower slope environment. Stevens (1970) suggested that the upper Table Head was a pelagic sediment representing a quiet period before clastic influx from the east of orogenic sandstones and shales.

## 4.6 Environmental Reconstruction

The rocks of the Table Head sequence are clearly products of sequential deposition on a shoreline, a shelf and in a slope environment. The depositional mechanisms that were active include (in situ) sediment accumulation (carbonate-, hemipelagic(?)-, and pelagic sedimentation and gravity flows (slumping, debris flows, turbidity currents).

There are problems associated with the reconstruction of the environments of the Table Head sequence. Foremost is the lack of specific modern analogues to be compared with the transgressive Table Head. However, the formation can be compared with generalized modern analogues. The modern example that best fits with Table Head lithofacies is the shelf-slope - (?) basin system. In western Newfoundland, the shelf was 200 km or so in width, as represented by present extent of shelf lithofacies. The shelf comprised a variety of chiefly shallow-water sub-environments. It was fringed by a tidal flat on its landward side, and was separated from the slope by an unimpressive biostromal structure to the oceanward side. The slope that prevailed in Table Head time was generally gentle, and decreased basinward to a flat basin floor. This corresponds to "Depositional Margin

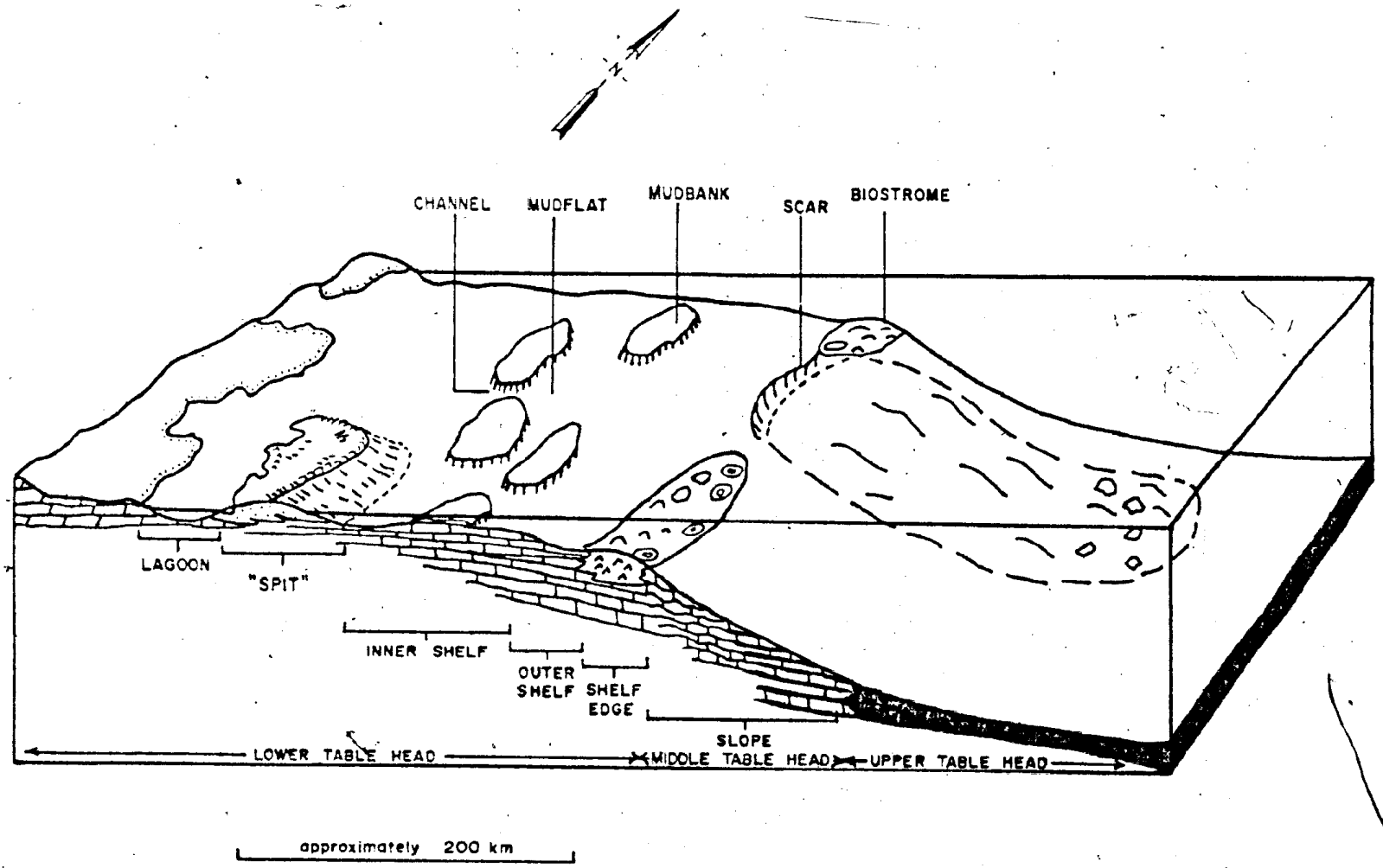
slope" of McIllreath & James (1978). Sediments of the gently inclined slope were characterized mainly by hemipelagic carbonates, except where they were subsequently destroyed by current activity. The slope to basin is represented by the black shales. Subaqueous slumping occurred along the slope, and the sediments were transported out to the deeper semi-flat bottom by sediment gravity flows (Middleton & Hampton, 1976). Deposits and features which could be related to submarine canyons were not observed and possibly the Table Point represents a scar along the gently inclined slope. Fig. 4.1 presents a diagramatic summary of this model.

## 4.7 Paleogeography

In general the Table Head Formation has been interpreted to be transgressive in nature, and therefore markedly diachronous (Stevens, 1970). The transgression was toward the west along a north-south trending coastline. The basal Table Head in the Hare Bay area is the oldest, the Table Point strata are intermediate in age and the Port au Port area displays the youngest strata (Stevens, 1970). The biostratigraphical data gained from the study of conodonts (Fåhraeus, 1970; Stouge, 1977; Appendix I) suggest some modifications to the previously published models with regard to the regional lateral arrangement of environments during particular time intervals.

During the Upper Canadian/Lower Whiterockian, intertidal sabkhalike conditions prevailed in the study area (Levesque, 1977; Levesque et al., 1977; Knight, 1977b), forming the dolomitic and ?evaporitic "Siliceous Dolomite Formation". Further east peritidal conditions in the Hare Bay area prevailed. To the south in the Port au Port area the St. George

Fig. 4.1 Sedimentary environments of the Table Head Formation during *Histiodella kristina* time.


N
CHANNEL
MUDFLAT
MUDBANK
SCAR
BIOSTROME
LAGOON
"SPIT"
INNER SHELF
OUTER SHELF
SHELF EDGE
SLOPE
LOWER TABLE HEAD
MIDDLE TABLE HEAD
UPPER TABLE HEAD
approximately 200 km

surface was subaerially exposed. The spatial distribution of these environments suggests that a shoreline or shoal area lay generally to the southwest of the study area, and the shoreline probably fluctuated during this period.

By early late Whiterockian time - Histiodella tableheadensis time -, the predominantly tidal flat environments in the Hare Bay area were succeeded by subtidal environments of the lower Table Head. These environments graded westward into the generally shallow water lagoon (unit $A_2$) of lower Table Head in the study area and extended further southwest to the shallow subtidal deposits of the lower Table Head in the Port au Port area. Marine invertebrate life flourished in many of the subtidal areas in waters shallow enough to periodically affect the bottom by water turbulence.

During H. tableheadensis time, the shelf began to founder in the Hare Bay area, where the slope to basinal deposits of the middle and upper Table Head were deposited. These depositional facies then spread to the Port au Port area as foundering continued. In the study area carbonate sedimentation continued.

By late H. tableheadensis to early H. kristina time the upper Table Head basinal facies was replaced by Goose Tickle turbidite deposits in the north. In the south, the middle and the upper Table Head slope to basinal facies were formed. In the study area biostromes were constructed.

During H. kristina time all Table Head deposition had disappeared from the Hare Bay area. To the south the basinal upper Table Head sediments were deposited. In the study area slope and basinal facies prevailed.

## 4.8 Conclusions

One conclusion of this study is that the lowest part of the Table Head Formation is not much older in the Hare Bay area to the north than it is in the Port au Port area to the south. In contrast the uppermost beds of the St. George Group are older in the Port au Port area than they are at the study area and in the Hare Bay area (Flower, 1978; Appendix I). Based on the *Histiodella* lineage and the general conodont successions so far known (Ethington & Clark, 1971; Ethington, 1978; Sweet *et al.*, 1971; Sweet & Bergström, 1976) it appears - in contrast to most earlier workers referring to the Table Head transgression - that the initial Table Head transgression in the Port au Port area is not represented by younger strata than that deposited in the north. Resolution of current conodont biostratigraphy is not sufficient to trace the gradual encroachment of the Middle Ordovician sea over the shelf toward the craton to the west by dating the oldest preserved dateable Middle Ordovician Table Head strata.

In this context it should be mentioned that the strata defined as the St. George Group straddles the Lower/Middle Ordovician boundary. Any well-defined boundary between the upper Lower Ordovician and lower Middle Ordovician cannot easily be found in the rock record due to the fact that the time interval is represented by mainly non-fossiliferous regressive dolostones. Fossils of latest Canadian age and lowermost Middle Ordovician (lower Whiterockian) beds (Fåhraeus, 1977a; Appendix I) are present throughout the Great Northern Peninsula (Flower, 1978; Stouge, in press). Further study in the areas mentioned may clarify the age ranges of the faunas recorded, and possibly define a boundary in the rock-sequence. Until then, the exact age difference between the upper strata of the St. George

Group in the Port au Port area to the south, in the study area and in the Hare Bay area to the north likewise cannot be determined. The age difference covers the early Whiterockian or the Didymograptus hirundo graptolite Zone (see also Fortey, 1980).

Another consequence of the dating is that the lower Table Head is everywhere younger than the St. George Group. Such a statement may seem awkward as the Table Head overlies the St. George Group. It, however, refers to earlier proposals (e.g. Stevens, 1970, and others), who indicated that the Table Head represents bank-edge to basinal deposits, and Table Head limestones and shales were lateral equivalents to the St. George Group. The possible equivalents mentioned by Stevens (1970) i.e., Brent Island Limestone in Pistolet Bay and part of the South Arm Limestone in Hare Bay (Cooper, 1937) are lithologically similar to the lower Table Head and the Catoche Formation of the St. George Group, respectively. The first is of Middle Ordovician age and the second is Early Ordovician in age (Appendix I).

The present author generally agrees with the first model, but has reservations concerning the second proposal, i.e., that Table Head strata should be lateral equivalent to the St. George Group. Until recently, basic assumptions were that limestone was generally Table Head Formation or early Middle Ordovician age whereas dolostone was from the St. George Group of Early Ordovician age. Mapping and study of the stratigraphy of the lower Paleozoic of the Northern Peninsula, western Newfoundland (e.g. Knight, 1977, 1978; Knight and Saltman, 1980) has revealed that several megacycles related to major regional transgressive and regressive events occurred during the Middle Cambrian through Lower Ordovician. Each

megacycle consists of (1) a basal limestone of subtidal shelf deposition, and (2) a dolostone sequence of restricted shallow water conditions. Variable salinity conditions prevailed during this sedimentation. These regressive strata contain some major and many minor breaks in sedimentation (disconformities). In Newfoundland the Table Head transgression commenced in the early Middle Ordovician, but the cycle was prevented from being completed by the inception of the Taconic event.

The lack of prominent shelf-edge reef facies in the Table Head Formation is probably related to this inception of the Taconic event. However, variation in the morphology of the ancient margin along western Newfoundland and the style of deposition is also related to this difference. The St. George Group represents a prograding carbonate bank in a stable environment with a reefal shelf-edge and an associated steep slope (Knight & Saltman, 1980; Rodgers, 1968). This is the "By-pass margin" of McIlreath & James (1978). The Table Head was deposited during rapid submergence and fast transgression of the early Middle Ordovician sea. Consequently, the Table Head formed on the gentle slope of the "Depositional Margin" of McIlreath and James (1978).

Also the biostratigraphic data gained from this study suggest modifications to earlier ideas concerning the lateral distribution of the middle Table Head. One important feature, which was also suggested as a possibility by Fåhraeus (1970), Stevens (1970) and Erdtmann (1971), is that middle Table Head strata are older in the Hare Bay area than they are at Table Point. However, in contrast to previous suggestions (see however, Erdtmann, 1971), middle Table Head strata of the Port au Port are slightly older than at Table Point, but are of similar age to strata in

the Hare Bay area. The age difference is not great, but corresponds to one conodont zone.

Another of the notable paleogeographic features indicated by the sequence is the nonlinearity of the shelf-edge. The shelf-edge was probably sinuous in outline, being convex to the west of the Port au Port and the Hare Bay areas.

The explanations for these differences are several. The Lower/Middle Ordovician regressive/transgressive event marks not only a lithological change but also coincides with a regional change. This change has commonly been referred to as the beginning of the desctruction of the carbonate bank (e.g. Dewey 1969; Stevens 1970; Williams & Stevens 1974; Fåhraeus 1976; Williams 1978b) of the Appalachians and the progression of the west moving thrust slices. The present author will not question this interpretation, but suggests caution, because a similar transgressive/regressive event occurs in other areas outside of the Appalachian-Caledonian system. These areas, such as the North Greenland fold belt (Dawes 1976), had an unrelated structural history. It is probable that more than one factor was responsible for the sea level variations.

The transgression in Newfoundland could be a combination of several factors. For example, an eustatic sea level rise may have been combined with the downwarping process created by the allochthonous slices moving onto the former carbonate bank. The result could have been a very rapid transgression across western Newfoundland.

From this study the diachronous character of the regression was much more pronounced than that of the transgression. The conodont data indicate that the regression was strongly diachronous. It began in late

Canadian time and lasted into early Whiterockian time. The surface of the St. George Group did not develop considerable topographic relief, as a prominent basal conglomerate indicating high topography is not present in basal beds of the Table Head Formation, and karst features have not been observed. During the regression a relatively planar surface or a very low-angle surface due to progradation of outbuilding of carbonate-evaporite facies was formed. The subsequent early Middle Ordovician transgression rapidly flooded the entire sub-planar St. George surface. This transgression was not strongly diachronous.

The statement that the St. George Group did not develop a prominent topography is in contrast to Flower (1978). Flower (1978) found the top of the St. George Group represented the Lower Cassinian Zone in Port au Port, but the upper zones were preserved at Port au Choix. He interpreted this as the depth of karstification or depth of weathering. If so, the thickness of the basal shoal water facies of the Table Head Formation could be strongly controlled by relief on the disconformity surface of the St. George Group. For example, the lower Table Head at the Table Point Section is thicker than elsewhere and could be interpreted as having been deposited in a topographic low, whereas sections that are relatively thin (e.g. Hare Bay and Port au Port) could have been deposited on a regional topographic high on the disconformity surface. As a result, relief of tens of metres should be apparent.

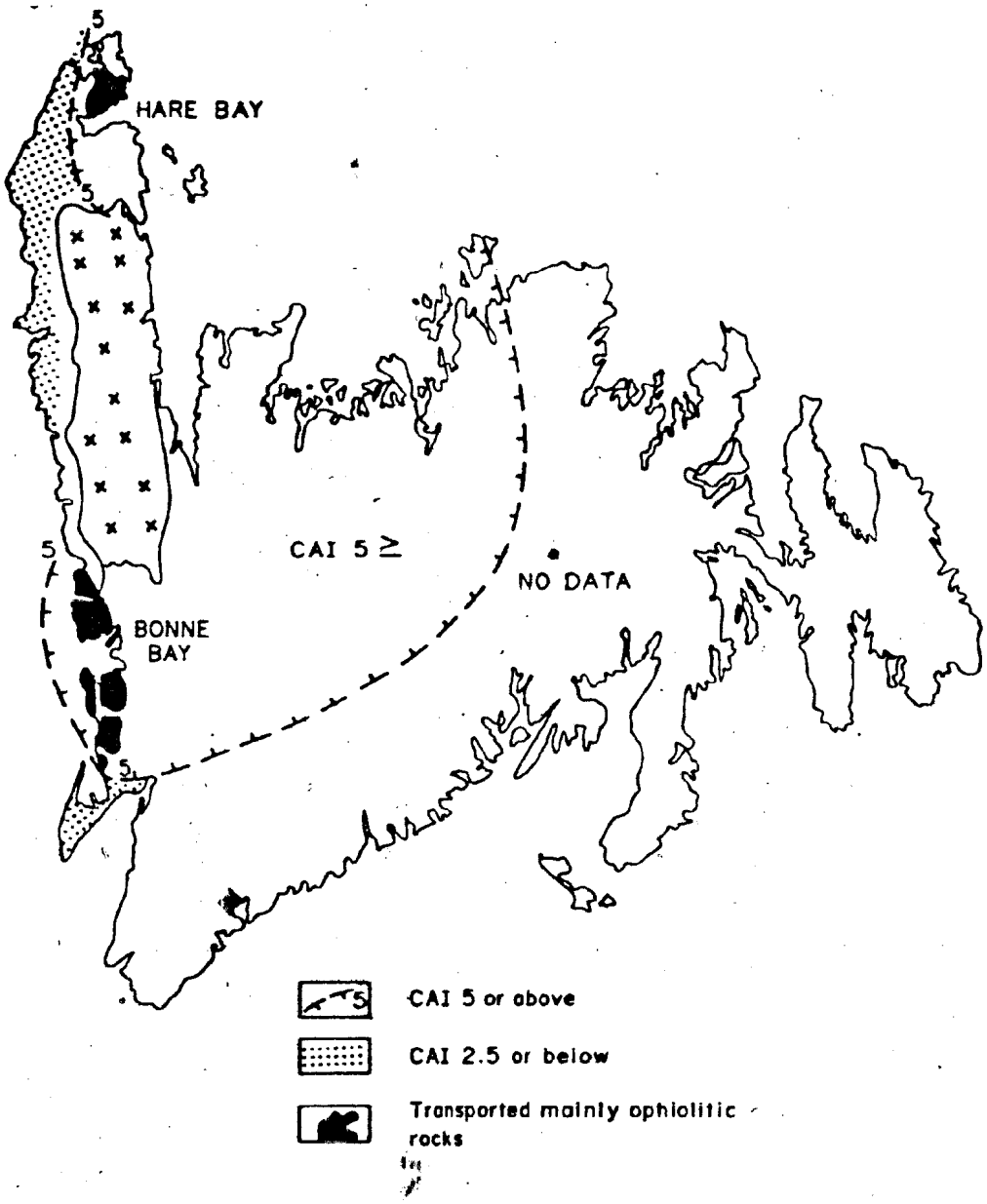
This author prefers the first explanation. The early Middle Ordovician marine strata, which were deposited in the topographically lower areas are not very thick. A relief of only ten metres at the most has been noted in the Aguathuna quarry (Port au Port area). Conodont data support a low

relief, a slow regression, and a fast transgression. Also the time of exposure is short - at most a graptolite zone, but probably much less (Fåhraeus 1977a; Stouge, in press; Appendix I).

The sinuous outline of the transgressive shelf-edge could possibly be caused by the allochthonous depression of the platform, or the sinuous outline could simply be original. If so, then the deposits in the embayments would be thicker. Whatever the reasons for the depressions may be, the sinuous outline is supported by the CAI (conodont alteration index of Epstein et al., 1977) from the various areas of Great Northern Peninsula. CAI is a measure of the temperature or thermal maturity of the host rock, mainly imposed by the amount of overburden. Therefore it indicates differences in depth of burial and (or) geothermal gradient. Figure 4.2 shows the distribution of the CAI on the Great Northern Peninsula. The isograds reflect a curvilinear outline, which is similar to the interpreted outline for the shelf edge. It is also in accordance with the regional geology of Newfoundland (Williams, 1978a, b). CAI 5 or above are within areas which are close to the allochthon ophiolite complexes. The ophiolite may be exposed only at Bonne Bay and Hare Bay areas, because there were deepenings in which gravity sliding could take place.

Fig. 4.2 The distribution of CAI in western Newfoundland.

CAI 5 or above is only present within areas with transported mainly ophiolitic rocks. The data are from the autochthonous St. George Group and Table Head Formation; from the allochthonous Cow Head Group at Cow Head, western Newfoundland. CAI 5 or above were recorded from autochthonous and paraautochthonous St. George Group and Table Head Formation in the Hare Bay area and the Bonne Bay area (Appendix I). The information from central Newfoundland is from Bergström et al. (1974); Hunter (1978) and Stouge (1980a, b).


5
HARE BAY
5
5
CAI 5 ≥
NO DATA
BONNE
BAY
5
CAI 5 or above
CAI 2.5 or below
Transported mainly ophiolitic rocks

# CHAPTER 5

# PALEOECOLOGY

## 5.1 Introduction

It has become increasingly apparent over the last ten years or so that environmental factors influenced conodont distribution, particularly in the Devonian (Druce, 1970) and the Carboniferous (Merrill, 1962; von Bitter, 1972). Detailed work on facies dependence of conodonts in the Ordovician has lagged behind that of the Carboniferous, but an attempt to describe a facies pattern was outlined by Barnes et al. (1973a), and in a general way by Barnes & Fåhraeus (1975). In Barnes (1976) several authors presented detailed analyses of smaller areas within the Midcontinent and the North Atlantic Provinces, demonstrating that particular generic suites of conodonts were confined to particular environments (biofacies).

The main problem is the enigma of the zoological affinity of the conodontophorid (the conodont-bearing animal). Hence, some paleontologists have queried the validity of biofacies analysis (Klapper and Barrick, 1977), because the distributional patterns of conodonts cannot alone reflect the mode of life of the conodontophorid. Several paleontologists have concluded that conodont taxa are not confined to a particular sedimentary facies and that the conodont animal was pelagic. Present day distribution of pelagic taxa is not simple (e.g. Zeitschel, 1978). Thus clustering of taxa is typical across the ocean mainly due to temperature differences and to the access to light and oxygen but is also dependent on the directions of the major currents. Such features have been considered adequate to explain certain abnormalities in the otherwise worldwide distribution of the conodonts (e.g. Müller, 1962; Seddon & Sweet, 1971; Dzik, 1978).

A corollary to this model is that the conodont animal was influenced appreciably by environmental factors in its distribution. Alternatively, arguments for a largely nekto-benthic mode of life have been advocated by Barnes and Fåhraeus (1975). The restricted occurrences of conodont taxa, which could be related to laterally limited habitats were shown by Fåhraeus & Barnes (1975). In addition, Barnes & Fåhraeus (1975) proposed that the conodontophorid could have had a pelagic larval stage similar to other marine invertebrates (Thorsen, 1957).

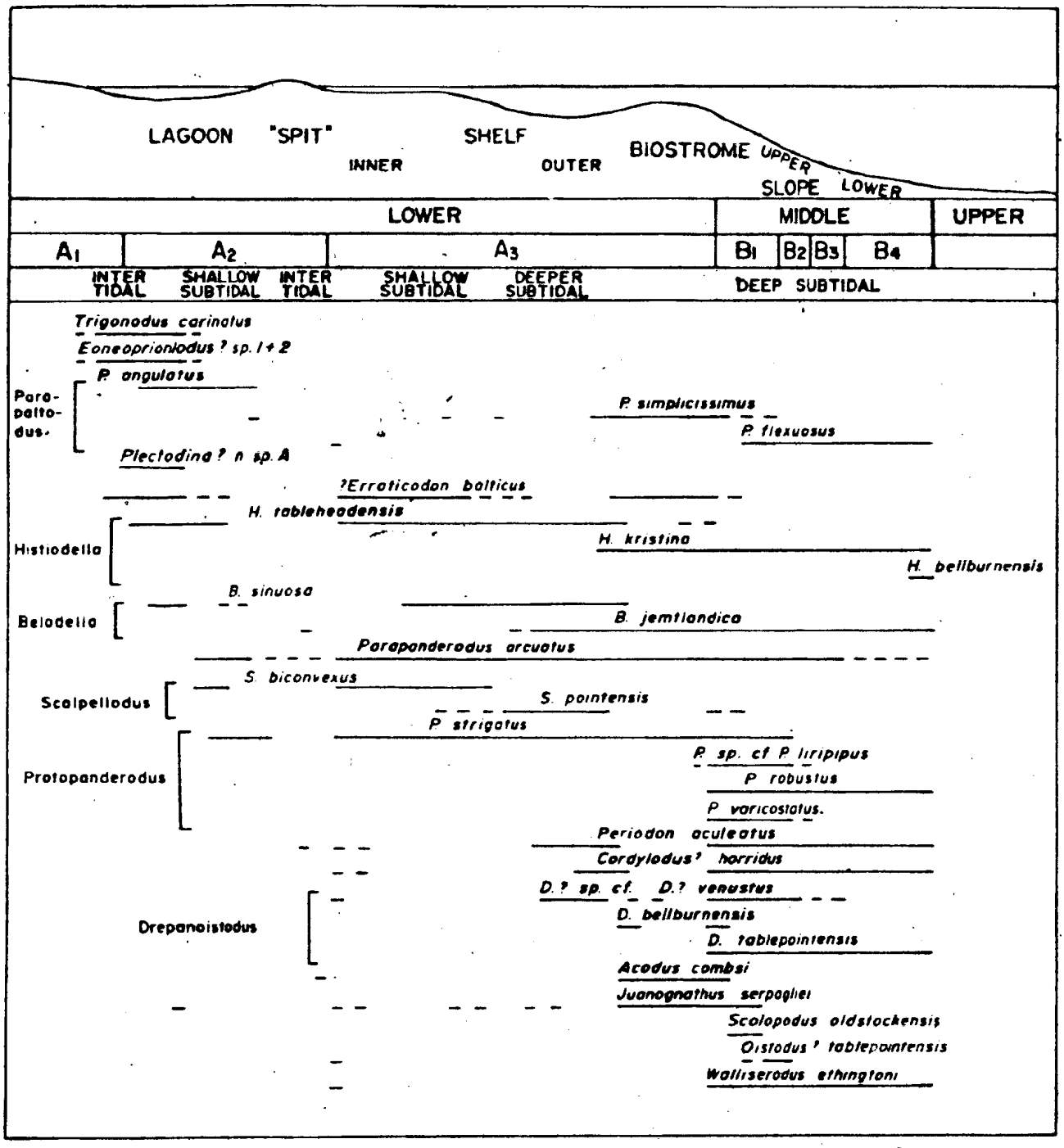
## 5.2 Conodont Associations

The conodont distribution within the Table Head Formation (Figs. 5.1, 5.2, 5.3) is very distinct. Certain genera and species have a limited lateral distribution as indicated in Fig. 5.1. The distribution is closely related to the lithology thus suggesting that the faunas are somehow restricted to certain environments.

Three distinct associations (biofacies) of conodont taxa occur in the *H. tableheadensis* and *H. kristina* Zones. These can be recognized by the percentage compositions of the genera *Trigonodus*, *Eoneoprioniodus*?, *Scalpellodus*, *Belodella*, *Parapanderodus*, *Periodon*, *Cordylodus*?, and *Walliserodus*. Sub-biofacies denoting specialized depositional environments within some of the biofacies have been recognized; these include the genera *Acodus*, *Scolopodus*, and *Oistodus*?.

One biofacies may overlap with a neighbouring biofacies. Species that are distinctive of the *Trigonodus*-*Eoneoprioniodus*? biofacies are absent in the *Parapanderodus*-*Scalpellodus* biofacies. Greater overlap occurs between the *Parapanderodus*-*Scalpellodus* and *Periodon*-*Cordylodus*? biofacies.

Figure 5.1 Distribution of conodonts and paleoenvironments in the Table Head Formation.



## 5.3 Trigonodus-Eoneoprioniodus? biofacies

This biofacies is dominated by Trigonodus carinatus and Eoneoprioniodus? sp. 1 and contains Plectodina n. sp. A and Histiodella tableheadensis; these species represent more than 80% of the fauna. The hyaline forms, Parapanderodus sp., Drepanodus? sp. cf. D? gracilis and ?Erraticodon balticus occur as minor constituents. This biofacies is of the Midcontinent Province affinity.

Stratigraphically, this biofacies is entirely restricted to the lithologic unit $A_1$ and to part of unit $A_2$.

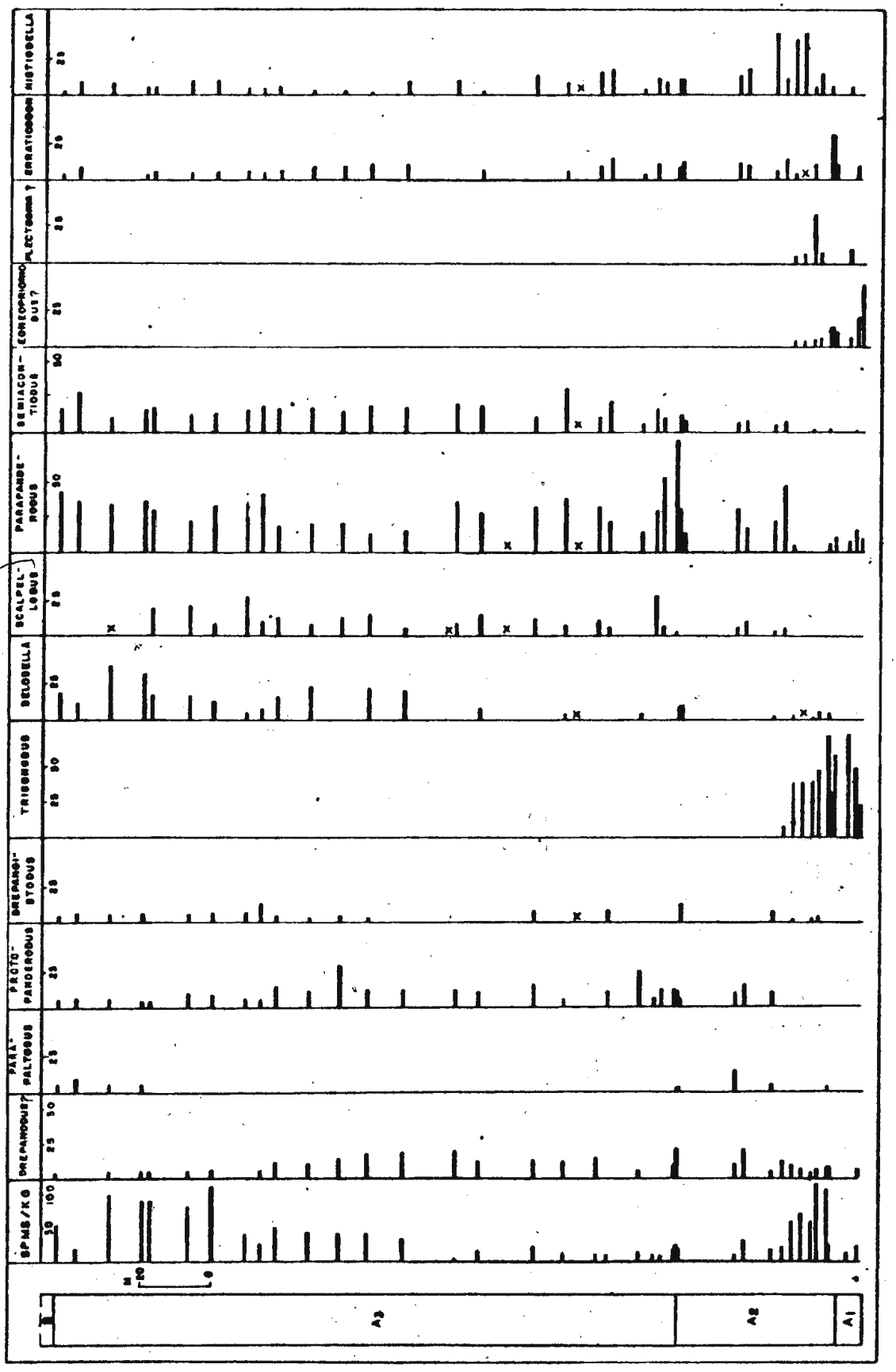
Conodonts from this biofacies are relatively widespread and are present at several localities, i.e., Table Point and Back Arm East sections and the Port au Port area (Appendix I).

The fauna occurred in the shallow, quiet water, subtidal environments of higher temperature and salinities (Chapter 4).

## 5.4 Parapanderodus-Scalpellodus biofacies

This biofacies is usually dominated by Parapanderodus arcuatus and species of Scalpellodus. Typical North Atlantic Province elements such as Walliserodus, Periodon, Drepanoistodus and Cordylodus? are sporadic within this biofacies, and appear to represent occasional invaders from the adjacent open sea. Their abrupt appearance in this biofacies probably is related to the fast transgressive events related to the irregular submergence of the shelf (Chapter 4). Their equally abrupt disappearance is probably a consequence of the relatively fast rate of stabilization of habitats on the shallow shelf.

Fig. 5.2 Relative abundance of the dominant conodont genera in the lower Table Head at Table Point, western Newfoundland. X marks the presence of a genus.



It appears that maxima of Scalpellodus correspond to minima of Belodella, and species of Belodella may dominate over Scalpellodus within the biofacies. Belodella also occurs in the Periodon-Cordylodus? biofacies, where it has its greatest abundance. Species of Parapanderodus occur in other biofacies, but is has its greatest abundance in the Parapanderodus-Scalpellodus biofacies. Species of Semiacontiodus, Drepanodus?, Histiodella, ?Erraticodon and Protopanderodus occur in moderate numbers. Acodus and Parapaltodus are locally common, and Loxodus? is present as an exotic. This fauna cannot be included in the presently defined provinces.

The Parapanderodus-Scalpellodus biofacies occupies the top of lithologic unit $A_2$ and the whole of unit $A_3$. The fauna of this biofacies is widespread. It is represented at most localities in the study area, in the Hare Bay and Port au Port areas (Appendix I).

The deposits representing the shelf are referred to the inner shelf, outer shelf and shelf-edge. The shelf as a whole was inhabited by varied species associations though the inner shelf had a relatively impoverished fauna.

The inner shelf deposits include the genera ?Erraticodon, Scalpellodus, Semiacontiodus, Drepanodus? and Protopanderodus. The outer shelf is dominated by representatives of Scalpellodus pointensis, Belodella, Juanognathus, Semiacontiodus asymmetricus and Parapanderodus. The fauna is typical of the offshore, relatively deeper and muddier low energy environment (below wave base). This trend may allow a further subdivision of the Parapanderodus-Scalpellodus biofacies into two sub-biofacies, one dominated by ?Erraticodon (inner shelf) and one outer shelf biofacies. Better material, however, than the Table Head fauns is necessary to do so.

## 5.5 Acodus combsi sub-biofacies

The conodonts from the bank environment represent an association which may be unique. Juanognathus serpagliei, Acodus combsi and Parapaltodus simplicissimus are common associates in or near to this environment. The fauna is relatively diverse, but the yield as a rule is low, and most of the elements are small. For this fauna the Acodus sub-biofacies is introduced.

## 5.6 Periodon-Cordylodus? biofacies

This biofacies is characteristically dominated by Periodon aculeatus, Cordylodus? horridus, Belodella jemtlandica and Histiodella kristina. Walliserodus, Protopanderodus, Paroistodus? and Drepanoistodus are common associates. Oistodus? and Scolopodus are present in a transitional zone from the Parapanderodus-Scalpellodus biofacies to the Periodon-Cordylodus? biofacies. All these genera belong to the North Atlantic Province.

The fauna is typical for the middle Table Head. Conodonts are abundant in unit $B_1$. This biofacies has been recorded from the Table Point and Bellburns sections.

## 5.7 Scolopodus-Oistodus? sub-biofacies

From a paleoecological point of view, the fauna of unit $B_1$ is of interest because its distribution exhibits a close correlation between types of conodont faunal associations and sedimentary environment reconstructed on lithic and megafossil criteria (Chapter 4). The beds representing the upper slope of a deepening environment yield a distinct fauna, with a restricted occurrence. Scolopodus occurs next to the bank

Fig. 5.3 Relative abundance of the dominant conodont genera in the middle Table Head at Table Point, western Newfoundland. R marks reworked specimens. X marks presence of specimens.


M
10
0
B4
B3
B2
B1
A3
NS/K4
CONDYLODUS?
PARA-PALTODUS
PROTO-PANDERODUS
DREPANOI-STODUS
PAROISTODUS?
BELODELLA
PERIGODON
MISTIODELLA
ACODUS
OISTODUS?
GUANGNATUS
TERRATI-CODON
WALLISE-RODUS
PARA-PANDERODUS
SEMI-ACONTIODUS
0 200
20 40
20
20
20
20 40
20
20 40
20
5
5
5
5
5
20 40
20
R
R
X
X

environment and Oistodus? at lower depth. The two genera form a sub-biofacies of their own and the Scolopodus-Oistodus? sub-biofacies is introduced for this faunal association. Spinodus and Polonodus are characteristic but rare members of this sub-biofacies.

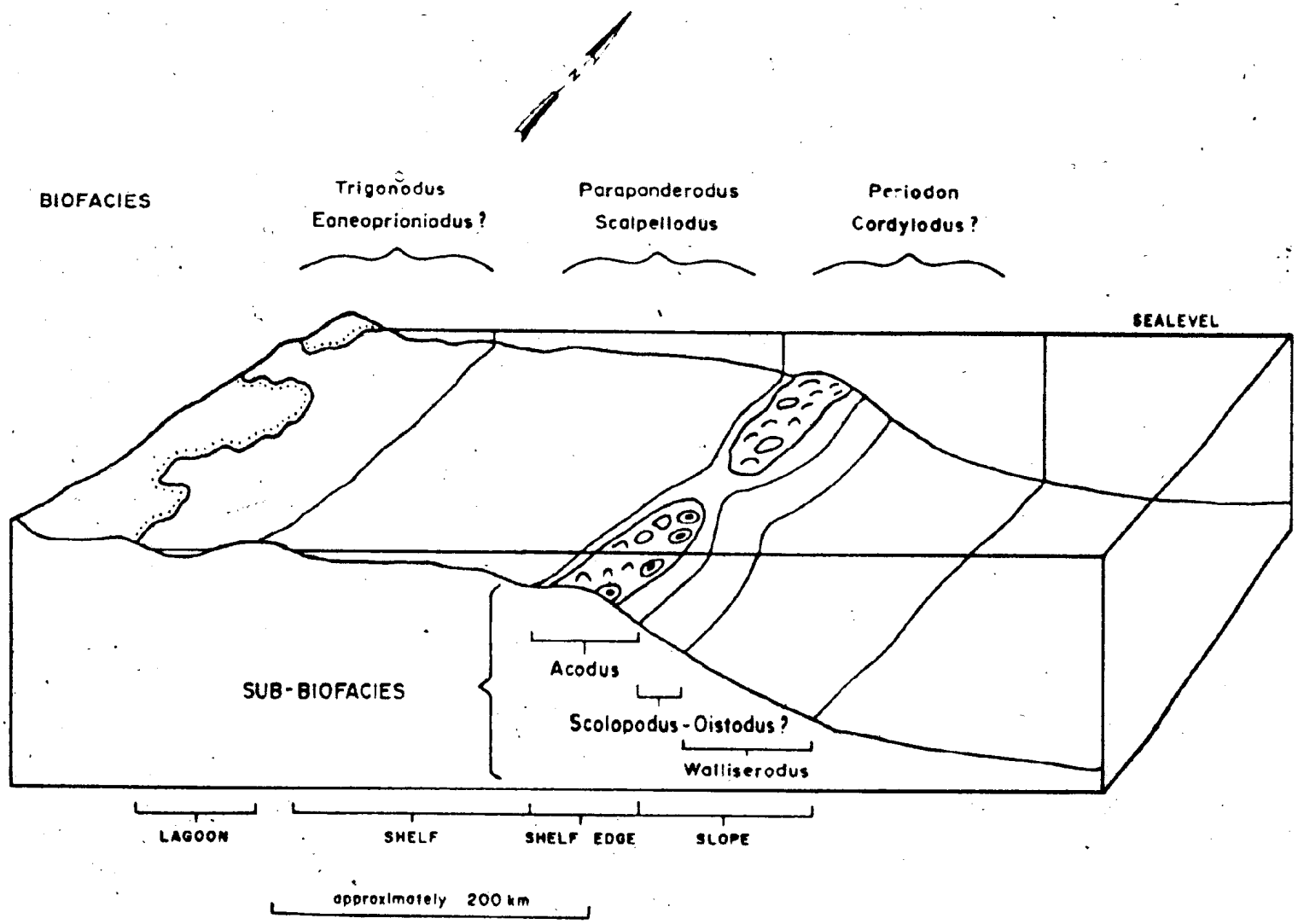
## 5.8 Walliserodus sub-biofacies

Except for unit $B_1$ and unit $B_3$ the average frequency of conodonts in samples from the Periodon-Cordylodus? biofacies is low (25 specimens or less per kilogram). This probably due to the high mud content in many samples, which makes complete digestion in acetic acid difficult, but also, to an original low frequency of specimens in the rock. The conodonts, are, as a rule, small and the diversity is low. The genera Cordylodus?, Periodon, Histiodella, Belodella and with secondary associates as Walliserodus, Parapaltodus, Paroistodus?, Protopanderodus and Drepanoistodus, form over 80% of the total fauna. For this fauna the term Walliserodus sub-biofacies is introduced. Cordylodus? increases in relative numbers at the expense of Periodon and Belodella, and the fauna is associated with the upper slope environment, transitional to the lower slope.

In the upper slope environment many specimens are considered to have been transported from the shelf edge biofacies. These elements are fragmental and often silty material is attached to the specimens. This is in particular true for elements of ?Erraticodon and Oistodus?. This is directly connected with lithic unit $B_3$.

The suggested relationships between biofacies and their environment are summarized in Fig. 5.4.

Fig. 5.4 Upper Whiterockian conodont biofacies and their relations to paleo-tectonic regimes. Note the break that separates shelf from lagoon biofacies (Midcontinent Province) and platform from slope biofacies (North Atlantic Province).


BIOFACIES
Trigonodus
Eoneoprioniodus ?
Paraponderodus
Scalpellodus
Periodon
Cordylodus ?
SEALEVEL
SUB-BIOFACIES
Acodus
Scolopodus - Oistodus ?
Walliserodus
LAGOON
SHELF
SHELF EDGE
SLOPE
approximately 200 km

## 5.9 Mode of Life

From the descriptions above the following modes of life may be concluded:

The shallower portions of the Trigonodus-Eoneoprioniodus? biofacies are dominated by Trigonodus and Eoneoprioniodus?. These genera inhabited environments with the highest temperatures and salinities. It is possible that they were adapted to a burrowing mode of life either for protection or camouflage. If this is correct the conodonts may have been benthic and possibly infaunal. A further speculation could be that hyaline material may be related to such a mode of life, and epifaunal elements, floaters and swimmers, are chiefly conodonts with white matter.

Plectodina? inhabited the deeper, though not very deep, subtidal waters of the lagoon.

Parapanderodus, as a genus, would be interpreted to be pelagic, because it is represented in all biofacies. The species, however, indicate different adaptions, that may have been controlled by the substratum or the source of food. P. arcuatus was probably an active swimmer accepting difference in temperatures, salinities, and energy, but with a preference for the shelf environment. P. striatus inhabited shallow water, probably with slightly elevated temperatures and salinity. It is mainly restricted to the Midcontinent Province. P. sp. cf. P. consimilis inhabited the shallow waters of the inner shelf. It may have been a benthic and an infaunal species. P. elegans inhabited the shelf and the open ocean and was mainly restricted to the North Atlantic Province. It was probably a pelagic species.

Parapaltodus is similar to Parapanderodus with respect to species distribution and similar conclusions using the same arguments may be applicable. P. angulatus was restricted to the lagoonal environments. P. simplicissimus mainly inhabited the open shelf, but never appeared out in the ocean. These species were probably nekto-benthic.

Drepanoistodus and Protopanderodus also show differences in their preferences in habitat. Most species were oceanic and only a few appeared on the shelf. Protopanderodus was more indifferent to environments, as P. strigatus was present on the open shelf and the ocean. It was probably a pelagic species. P. robustus was oceanic and a free swimming species (nekto-benthic). Drepanoistodus? sp. cf. D.? venustus was restricted to the upper slope mainly of the Scolopodus-Oistodus? sub-biofacies. Drepanoistodus bellburnensis inhabited the bank environs and was probably nekto-benthic.

Belodella is represented by two species each with their own preference as to habitat. Belodella sinuosa was a shallow shelf species, whereas B. jemtlandica inhabited the open ocean. This difference was probably due to difference in temperature and salinity. The species were probably nekto-benthic.

Scalpellodus inhabited the relatively shallow waters on the shelf with slightly raised to normal temperatures and salinities. It was probably nekto-benthic. As noted above Scalpellodus and Belodella have an inversely proportional relative abundance. The difference is probably related to differences in the substrate or temperature. At present, their specific differences in the preference of the habitat have not been detected.

Acodus, Scolopodus and Oistodus? were probably specialized to a restricted environment at or near to the bank. Their distinct distribution probably was governed by their different preference in water depth, due to differences of light and/or temperature. These genera may have been benthic and/or nekto-benthic. Thus Acodus lived associated with the biostrome and probably was nekto-benthic, but epifaunal element; Scolopodus and Oistodus? were infaunal and benthic species.

Periodon was mainly oceanic and only appeared sporadically on the shelf. The genus was probably free swimming (nekto-benthic). Cordylodus? preferred a habitat similar to Periodon, and it was possibly a free swimming species (nekto-benthic).

Histiodella species do not have a distinct distribution. H. tableheadensis was indifferent to environment because it occurred on shelf and the slope; H. kristina and H. bellburnensis were oceanic. The species were probably pelagic and/or nekto-benthic.

## 5.10 Relationship to conodont biofacies in other areas

Distribution of the Table Head conodonts can be compared with the ecological model of Barnes & Fåhraeus (1975), which was generally related to depth and distance from a shoreline. Some changes or additions can be applied to the distributions of Barnes & Fåhraeus (1975).

### 5.10.1 Midcontinent Province

The Trigonodus-Eoneoprioniodus? biofacies is similar to Histiodella-Hyaline prioniodids-Multioistodus 'community'. Multioistodus is a rare associate in the Table Head fauna, and Histiodella is more common in the

deeper subtidal lagoon and open shelf of the Parapanderodus-Scalpellodus biofacies, and occurs also in the open ocean. Histiodella may be the fourth most common genus of the North Atlantic Province (Fig. 5.3). It should be noted that the Table Head lagoon was probably not very extensive laterally, and cannot be considered as a pure epeiric sea. Also mixing of faunas of the next biofacies disturb this comparison.

The Parapanderodus-Scalpellodus biofacies is new and occupies the shallow-deeper open shelf. Thus, it cannot be compared to the 'communities' of Barnes & Fåhraeus (1975).

### 5.10.2 North Atlantic Province

The Belodella-Cordylodus 'community' (Barnes & Fåhraeus 1975) probably corresponds to the Periodon-Cordylodus? biofacies of this study, as it was stated to be 'well-developed' in the middle Table Formation (Barnes & Fåhraeus, 1975, p. 142). The deeper position of the Amorphognathus (?=Polonodus)-Oistodus-Periodon 'community' cannot be substantiated by this study. Amorphognathus (?=Polonodus) is a rare associate present in both the Scolopodus-Oistodus? sub-biofacies and in the Parapanderodus-Scalpellodus biofacies. Based on this study the Belodella-Cordylodus 'community' and Amorphognathus-Oistodus-Periodon 'community' occupy the same habitat. The deeper position is occupied by the restricted Walliserodus sub-biofacies.

5.10.3 Comparison of Ordovician biofacies in North America

A few works deal with environmental controls over the distribution of conodonts in the Ordovician Period. These include - one on Early to Middle Ordovician platform to slope conodont 'communities' from Spitsbergen (Fortey & Barnes, 1977), - one on the upper Middle Ordovician platform to slope conodont biofacies from Tennessee (Bergström & Carnes, 1976), - one on the Upper Ordovician to Lower Silurian platform conodont 'communities' from Hudson Bay (Le Fèvre et al., 1976) and one on Middle Ordovician platform conodont 'communities' from Kentucky (Fåhraeus & Barnes, 1975).

Fortey and Barnes (1977) distinguished four possibly five conodont communities - a shallow water assemblage occurring in pure white limestone and consisting of genera of the Midcontinent Province (Scolopodus 'community'), a further offshore assemblage consisting of Walliserodus, Bergstroemognathus and Prioniodus (Oepikodus); a deeper water assemblage occurring in impure dark platy limestones and consisting largely of Periodon and Prioniodus (Oepikodus) (Periodon 'community'); a deep water assemblage in finely laminated and black graptolitic limestones and shales and consisting of Prioniodus (Oepikodus) (Prioniodus 'community'), and a pelagic assemblage consisting of simple cone genera (Drepanodus, Drepanoistodus and Paroistodus), and occurring in all of the above 'communities' (pelagic 'community'). An early Middle Ordovician (Whiterockian) off-shore 'community' included Protopanderodus, Oistodus, Periodon, and ?Belodella. Of the Lower Ordovician 'communities', only the Periodon 'community' has correspondence with any of the three conodont biofacies defined in this study. That is the Periodon-Cordylodus? biofacies. One genus only (Periodon) is shared.

The Whiterockian assemblage, despite the sparse description, has a reasonably clear correspondence to the Periodon-Cordylodus? biofacies. All the genera mentioned are shared and may be equivalent to the Scolopodus-Oistodus? sub-biofacies of this study. The principal difference is the lack of Cordylodus?.

Other Spitsbergen 'communities' are unrepresented or unrecognized. The Prioniodus (Oepikodus) 'community' may be represented by the exclusively graptolitic facies seaward of the Periodon-Cordylodus? biofacies. The pelagic 'community' has not been recognized or the genera are mainly present in the Scolopodus-Oistodus? sub-biofacies. The Scolopodus 'community' may correlate with the Trigonodus-Eoneoprioniodus? biofacies, and the Walliserodus, Bergstroemognathus and Oepikodus 'community' may correlate with the Parapanderodus-Scalpellodus biofacies.

Bergström & Carnes (1976) defined four conodont biofacies (RSA's - recurrent species associations of these authors) - a shallow water association (Leptochirognathus RSA) occurring in rocks of supra-, inter- and high subtidal environments and consisting of a restricted Midcontinent Province fauna (Panderodus, Leptochirognathus, Phragmodus, Belodella, Belodina and hyaline conodonts); a deeper, subtidal relatively nearshore association (Belodella-Phragmodus-Polyplacognathus RSA) and consisting of a Midcontinent Province fauna (Plectodina, Phragmodus and Belodina) and a carbonate bank association (Belodella-Phragmodus-Prioniodus RSA) of mainly Midcontinent Province affinity, but mixed with the North Atlantic Province (Prioniodus, Eoplacognathus - ? specialized genera). A deeper water and muddier more offshore fauna (Periodon-Pygodus RSA) is dominated by North Atlantic Province genera (Pygodus, Periodon, Protopanderodus and Walliserodus). Of these, the Periodon-Pygodus RSA has clear corres-

pondence with the Periodon-Cordylodus? biofacies. A number of genera are shared (Periodon, Protopanderodus and Walliserodus). Cordylodus? is the only significant Periodon-Cordylodus? biofacies element, which is missing in the Periodon-Pygodus RSA. At that time, Cordylodus? was possibly extinct or confined to another unrepresented biofacies.

Some of the Tennessee RSA's are present in considerably altered forms. The Leptochirognathus RSA is similar to the Trigonodus-Eoneoprioniodus? biofacies of this study in that it contains Leptochirognathus, hyaline conodonts and panderodontids. Belodella-Phragmodus-Polyplacognathus RSA and Belodella-Phragmodus-Prioniodus RSA cannot be recognized in the study area. Belodella, the only genus in common, is also represented in the seaward Periodon-Cordylodus? biofacies. The two RSA's from Tennessee are, on the family level, similar to the Parapanderodus-Scalpellodus biofacies and Acodus sub-biofacies in that they contain panderodids, prioniodinidids (?Erraticodon-"Phragmodus" flexuosus), balagnathids (Polonodus-Polyplacognathus) and prioniodontids (Acodus-Prioniodus).

An environmental correlation with Parapanderodus-Scalpellodus biofaeies, Acodus sub-biofacies and the Periodon-Pygodus biofacies cannot be made directly during late Pygodus anserinus time. This is indicated by the occurrence of the Belodella-Phragmodus-Polyplacognathus RSA of the shallow shelf, the Belodella-Phragmodus-Prioniodus RSA of the carbonate bank and the Periodon-Pygodus RSA of the deeper shelf. The principal difference is that the Periodon-Pygodus RSA is typical of the deeper shelf, whereas the deeper shelf is occupied by the Parapanderodus-Scalpellodus biofacies of this study.

Biofacies and environmental correlations cannot be made with the sequence of faunal 'communities' established across very broad epi-continental seas (Fåhraeus & Barnes, 1975; Le Fèvre et al., 1976). Only a few genera and families are shared.

In Fig. 5.5, the distribution of the biofacies and sub-biofacies in the study area are related to the Early Ordovician, and Middle Ordovician environmentally controlled associations of Fortey & Barnes (1977) and Bergström & Carnes (1976).

## 5.11 Comparison with Other Nearly Contemporaneous Faunas

The biofacies introduced in this study can be recognized from other areas of closely similar faunal composition. The faunas from the Fort Peña (Bradshaw, 1969), Lévis (Uyeno & Barnes, 1970) and Mystic Conglomerate (Barnes & Poplawski, 1973), Deep Kill Shale and Styvesant Falls Formations of the Taconic Allochthon (Landing, 1976), Hølonda limestone of the Trondheim Region, Norway (Bergström, 1971a, b, 1977b, 1979a, 1980), Cow Head Group, western Newfoundland (Fåhraeus & Nowlan, 1978) and Lush's Bight, central Newfoundland (Stouge, 1980 b) are distributed within oceanic conditions associated with a high influx of clastic material, and adjacent to a slope. This slope may either be the continental slope or slopes near volcanic environments. In most cases these faunas are obtained from conglomeratic units. This indicates transport of the faunas into another environment, often into the lower slope or rise. Due to the conglomeratic nature these faunas are probably older than the surrounding faunas.

Fig. 5.5 Comparison of conodont 'communities' or biofacies from Lower to Middle Ordovician. The Lower Ordovician 'communities' are those of Fortey and Barnes (1977). The lower Whiterockian communities are from Barnes and Poplawski (1973).

| | Lagoon | Shelf: Inner | Shelf: Outer | Bank | Slope: Upper | Slope: Lower |
|---|---|---|---|---|---|---|
| MIDDLE ORDOVICIAN<br>Late Pygodus anserinus Zone<br>(Bergstrom & Carnes, 1976) | *Leptochirognathus*<br>*RSA* | *Belodella*<br>*Phragmodus*<br>*Polyplacognathus*<br>*RSA* | *Periodon*<br>*Pygodus*<br>*RSA* | *Belodella*<br>*Phragmodus*<br>*Prioniodus*<br>*RSA* | *Periodon*<br>*Pygodus*<br>*RSA* | |
| Pygodus serra<br>(Bergstrom & Carnes, 1976) | *Leptochirognathus*<br>*RSA* | *Belodella*<br>*Phragmodus*<br>*Polyplacognathus*<br>*RSA* | | — | *Periodon*<br>*Pygodus*<br>*RSA* | |
| Upper Whiterockian<br>This Study | *Trigonodus*<br>*Eoneoprioniodus*<br>*Biofacies* | *Parapanderodus*<br>*Scalpellodus*<br>*Biofacies* | | *Acodus*<br>*Sub-biofacies* | *Periodon-Cordylodus ?*<br>*Biofacies*<br>*Scolopodus*<br>*Oistodus*<br>*Sub-biofacies* | *Walliserodus*<br>*Sub-biofacies* |
| Lower Whiterockian<br>(Bradshaw 1969, Barnes & Poplawski 1973) | *Eoneoprioniodus*<br>*Multioistodus* | — | | — | *Periodon*<br>*Protopanderodus*<br>*Oistodus* | *Spinodus*<br>*Eoplacognathus*<br>*Prioniodus* |
| LOWER ORDOVICIAN<br>(Fortey & Barnes, 1977) | *'Scolopodus'*<br>*Acodus* | *'Oepikodus'*<br>*communis* | | *Bergstroemo-gnathus* | *Periodon* | *Oepikodus (evae)* |

### 5.11.1 Fort Peña Formation, Texas

The Fort Peña fauna is dominated by Periodon, Protopanderodus and Drepanoistodus (Bradshaw, 1969). The association of Periodon aculeatus and Protopanderodus cf. P. varicostatus is characteristic. This association may well be the same as the Periodon-Cordylodus? biofacies of this study. The high numbers of Protopanderodus, and the lack of Belodella and Cordylodus? (only sporadic occurrences) could be explained in several ways: the biofacies associations represent slightly different ages in the two areas (this is possible - Chapter 3); the species may be separated paleogeographically; or the environments may have been different in some character that is not obvious to the writer.

The presence of Oistodus?, Histiodella, Scalpellodus, Parapanderodus and Acodus combsi indicates that faunal associations similar to Parapanderodus-Scalpellodus, Acodus and Scolopodus-Oistodus? biofacies and sub-biofacies are represented in the Fort Peña fauna.

### 5.11.2 Lévis Formation, Quebec

The Lévis Formation is dominated by Periodon, Protopanderodus and Paroistodus? (Uyeno & Barnes, 1970). The lack of Cordylodus? and Belodella is characteristic, which in turn is similar to the Fort Peña Formation, and may be explained in the same way. The fauna indicates affinity to the Periodon-Cordylodus? biofacies.

Eoneoprioniodus? and Parapanderodus sp. cf. P. striatus are exclusively known from the Trigonodus-Eoneoprioniodus? biofacies in the study area.

Faunas including Oistodus? and Scolopodus from boulders in third and fourth conglomeratic units of the Lévis indicate affinity to the Scolopodus-Oistodus? biofacies. Other Table Head biofacies may not be represented in the Lévis.

### 5.11.3 Mystic Conglomerate, Quebec

The Mystic fauna shows the closest affinity to the middle Table Head fauna together with Lush's Bight, and the different biofacies of this study can be recognized.

The fauna is dominated by Periodon, Paroistodus? and Protopanderodus (Barnes & Poplawski, 1973). Additional forms are Belodella, Oistodus? and Parapaltodus. Cordylodus? horridus appears in two samples only (GSC 84521, 84533), the latter of which yielded a fairly high number. These two samples can be included in the Periodon-Cordylodus? biofacies. The lack of Cordylodus? is otherwise similar to the faunas from the Fort Peña and Lévis Formations. The presence of Oistodus? indicates an affinity to the Scolopodus-Oistodus? sub-biofacies. Hyaline forms, ?Erraticodon, Scalpellodus, Juanognathus, Semiacontiodus, Acodus? and Parapanderodus are known from the shelf biofacies, i.e., Parapanderodus-Scalpellodus biofacies.

### 5.11.4 Taconic Allochthon, New York

In the Deep Kill Shale and Styvesant Falls Formation several genera (Landing, 1976) are represented common to the biofacies of this study. The sediments represent the upper and lower slope, and some of the conodont faunas were recovered from conglomeratic beds. The genera include

Periodon, Protopanderodus, Histiodella, and Cordylodus?, and the fauna indicates an affinity to the Periodon-Cordylodus? biofacies. The distribution of each genus being present in separate samples at different levels, however, indicates a situation similar to that of the Fort Peña and Lévis Formations. Also the presence of Scolopodus giganteus s.f., a rare but typical element of the Mystic Conglomerate and the Fort Peña Formation could indicate affinity to another biofacies.

### 5.11.5 Hølonda Limestone, Norway

Bergström (1977b, 1979a; 1980) listed a fauna, which is present mainly in the Parapanderodus-Scalpellodus and Periodon-Cordylodus? biofacies. The fauna includes Periodon, Cordylodus? and Paroistodus? The Hølonda Limestone is in a geological setting with clastic dominated sediments and volcanics (Neuman & Bruton, 1974; Bruton & Bockelie, 1980). This sequence probably occupies a position similar to the central volcanic belt of Newfoundland.

### 5.11.6 Cow Head Group, Newfoundland

Beds 13 and 14 of the Cow Head Group yield an almost pure Periodon fauna associated with a few simple cone genera (Fåhraeus & Nowlan, 1978). This fauna may belong to the Periodon-Cordylodus? biofacies, but the lack of Cordylodus? is against such a correlation.

### 5.11.7 Lush's Bight, Central Newfoundland

Limestone conglomerates deposited in a volcanic arc complex produced a large fauna which shares many genera with the Table Head fauna (Stouge 1980b, c; Appendix I). The most common genera are Polonodus?, Oistodus?, Periodon, Cordylodus?, Belodella, Walliserodus and Protopanderodus. Minor components are Histiodella and Acodus?. This fauna is typical of the Periodon-Cordylodus? biofacies of this study.

## 5.12 Conodonts compared with Trilobites

One study combining the information from trilobites and conodonts has been published from Spitsbergen of late Canadian-early Whiterockian age (Fortey & Barnes 1977). The major conclusion of that work was that the conodonts and trilobites seem to occupy the same habitats and have the same modes of life.

The distribution of the Table Head trilobite fauna (Whittington & Kindle, 1963; Whittington, 1965) allows a similar investigation.

The lower Table Head trilobites were included in an (outer) shelf fauna (Shaw & Fortey, 1977), and collected in the Illaenid-Cheirurid 'community' of Fortey (1975). Originally Fortey (1975) suggested an environmental correlation of the Illaenid-Cheirurid 'community' with organic reef facies. That an environmental correlation with the trilobites from lower Table Head cannot be made is obvious from the interpretation of this study (Chapter 4). The Illaenid-Cheirurid 'community' of Fortey is, on the family level, similar to the shelf trilobites in that it contains cheirurids, illaenids, dimeropygids, bathyurids and harpids. Whittington (1965) noted that the fauna was relatively

impoverished in the lower Table Head. This is understandable, because according to the ranges (Whittington & Kindle, 1963) the major part of the fauna was obtained from the lower sub-unit of the lithic unit $A_3$, which represents a nearshore shallow water environment with a restricted conodont fauna.

Most of the trilobite species from the lower Table Head are considered to be benthic (Fortey, 1975; Fåhraeus, 1977b). Among the conodontophorids, Scalpellodus, Semiacontiodus and ?Erraticodon were best adapted to the restricted Illaenid-Cheirurid 'community'.

The middle Table Head trilobites were referred to the upper slope (Shaw & Fortey, 1977), which is mainly the Nileid community of Fortey (1975). The Nileid community corresponds directly to the Periodon-Cordylodus? biofacies of this study. The majority of the trilobites from the Nileid community are benthic (Fortey, 1975). Most genera of the Periodon-Cordylodus? biofacies were interpreted to be active swimmers (nekto-benthic). Fortey & Barnes (1977) concluded that the majority of the conodontophorids were nekto-benthic.

The distribution of the middle Table Head trilobites (Whittington & Kindle, 1963) also indicates that there is an overlap between two benthic communities (Fortey, 1975). A transitional zone suggests that the lower slope environment or Olenid community may be present (Fortey, 1975; Fåhraeus, 1977b; Shaw & Fortey, 1977). This can be compared to the conodonts, and the restricted Walliserodus sub-biofacies is possibly a representative of the lower slope environment. Trilobites from the Olenid community are interpreted as benthic (Fortey, 1975) or pelagic (Bergström, 1973), respectively. The conodonts are interpreted to be

active swimmers and a nekto-benthic mode of life is indicated for this environment.

## 5.13 Concluding remarks

Based on this study the geographical boundaries of the conodont biofacies correspond approximately to the recognized paleoenvironments (e.g. lagoon, shelf and slope). The sub-biofacies may be related to local variations of the environments and to the depth. The marked composition and diversity break between the shelf biofacies and slope biofacies is a boundary separating warm water conodonts from cold water conodonts on the slope.

Ordovician conodont provinces have already been dealt with by many authors (e.g. Bergström, 1971a, 1973c; Barnes et al., 1973a; Serpagli, 1974; Sweet and Bergström, 1974; Barnes and Fåhraeus, 1975; Fåhraeus, 1976 and Lindström, 1976). According to those authors temperature was the prime environmental factor controlling Ordovician conodont geography. In addition, Barnes and Fåhraeus (1975) defined conodont provinces by their communities (following Valentine, 1968). Therefore, biofacies analysis should provide new information about geography in the Ordovician.

The Midcontinent Province faunas were adapted to a high temperature (and salinity). They are restricted to epicontinental seas on the craton in tropical areas. The North Atlantic Province was a cosmopolitan cold water fauna, which occurs in a deeper position at low paleolatitudes and it is found in relatively shallower water at higher latitudes. The presence of the North Atlantic Province colder fauna along the North American craton was probably due to upwelling of cold currents associated with high organic productivity (Fortey and Barnes, 1977).

Based on this study the Trigonodus-Eoneoprioniodus? biofacies appears to be largely limited to North America and possibly Australia. The shelf biofacies includes a number of geographically widespread genera and is restricted to the carbonate shelf areas around the Ordovician equator. The slope biofacies (Periodon-Cordylodus?) is also geographically widespread, but stenohaline and related to the more argillaceous limestones and graptolite bearing beds of the open ocean.

One concusion of this study is that the various biofacies gradually change from being dominated by largely infaunal taxa to be dominated by largely epifaunal taxa. The lagoonal biofacies (Trigonodus-Eoneoprioniodus?) is occupied by relatively more infaunal taxa than the shelf biofacies (Parapanderodus-Scalpellodus). The shelf biofacies is occupied by taxa, which are nekto-benthic. The slope biofacies is largely dominated by free swimmers (nekto-benthic). The upper slope sub-biofacies (Acodus and Scolopodus-Oistodus?) are occupied by relatively more infaunal taxa than the lower slope sub-biofacies (Walliserodus).

This conclusion is paralleled by decreasing endemicity with depth previously proposed for the trilobites (Fortey and Barnes, 1977; Ludvigsen, 1978). Also it is paralleled at the present time, where infauna is generally restricted to very shallow water, whereas the epifauna has a much wider bathymetric range (Thorsen, 1957).

Furthermore, it appears that the type of apparatus could be related to the mode of life. Barnes and Fåhraeus (1975) and Barnes et al. (1979) indicated that the pelagic genera were mainly simple cones. From this study it seems that simple cone apparatuses are restricted to the different biofacies on family level, and a sequence as follows seems to

prevail: acanthodids (Trigonodus) for the lagoon to panderodontids for the shelf (Parapanderodus, Scalpellodus, Semiacontiodus) to distacodontids (Drepanoistodus, Protopanderodus) for the slope environments. A similar trend can be indicated for the apparatus with ramiform elements such as prioniodontids (Eoneoprioniodus?), prioniodinidids (?Erraticodon) to periodontidids (Periodon).

Barnes et al. (1979) stressed the influence of provincialism on the apparatus types. According to those authors the apparatus type evolved independently within each of the two main provinces. If so, then the apparent similarity in the style of the apparatus of the species from the Trigonodus-Eoneoprioniodus? biofacies (Midcontinent Province), from the Parapanderodus-Scalpellodus biofacies (province affinity uncertain) and from the Periodon-Cordylodus? biofacies (North Atlantic Province) is superficial. The explanation for the presence of the apparently similar, but genetically separated, apparatuses within each province could be a question of functional adaption. The various apparatus types had distinct functions within each biofacies, but similar function in all biofacies. For example Trigonodus and ?Erraticodon seem to imitate the apparatus of Semiacontiodus and Periodon, respectively.

The described examples cited earlier suggested a series of shallow to deep water depth-related biofacies coinciding with infaunal to epifaunal trends. During eustatic changes the habitats of the shelf area would decrease (regression) or increase (transgression). In a regressive situation the nearshore, highly adapted species would not be able to respond to rapid environmental alterations. As a result an extinction could occur (Fåhraeus,1976). During a transgression the shelf and slope biofacies would migrate onto the platform into the newly created habitats.

This would result in a reduction of the number of benthic species. Furthermore, the introduction of shelf fauna onto the platform destroys the habitat for the near-shore infaunal species (in our case the hyaline conodonts of the Trigonodus-Eoneoprioniodus? biofacies).

Also the transgression would promote the invasion of species that prior to the transgression, were present in other geographical separate (offshore) areas. These areas may not necessarily have been located on other plates, as different faunal provinces are present on the same plate (Fortey and Barnes, 1977). The conodonts could also have been inhabitants of islands isolated from the craton or volcanic islands (Stouge, 1980c), as is the case of some Ordovician brachiopods (Neuman, 1972) and trilobites (Ludvigsen, 1978; Bruton and Bockelie, 1980).

The Whiterockian transgression is a major transgression at the eastern and northern edges of the North American plate. The migration of North Atlantic Province elements onto the North American craton can be explained as an effect of this transgression.

The rapid faunal replacement during the Whiterockian was accentuated by the collapse of the carbonate bank related to movements of the Taconic Orogeny (Stevens, 1970; Barnes & Fåhraeus, 1975; Fåhraeus, 1976). The main effect of plate movements on the distribution of provinces is that routes of major currents and paleoclimatic regimes are changed. Major transgressive/regressive events, which can be traced beyond the limits of the Appalachians/Caledonians, for example, may not necessarily have to be related to structural events. The change, however, from a steep carbonate bank with little or no lateral segregation of facies to an open shelf and a gentle slope with lateral segregation can be traced and related to the initial destruction of the carbonate bank.

The comparison of closely related Periodon faunas reveals some differences. The principal difference is the general lack of Cordylodus? in many Periodon-Protopanderodus dominated biofacies. If a combination of following factors are considered: (a) the slight age difference of the faunas; (b) the relative geographical position; (c) the configuration of the margins (steep versus gently inclined); (d) the application of a similar principle as Fåhraeus & Barnes (1975) and James et al. 1979 did for the Cow Head Group (i.e., transgressions-regressions related to faunal changes); and (e) the proposed transgressive model above, the following sequence of events may apply (Stouge, 1980c) and explain these differences.

The slight age differences are displayed in the degree of evolution of certain species (Chapter 6). Overall, the Lush's Bight fauna is similar to much of the Mystic Conglomerate, the geologic setting may be similar, both are overlain by Caradocian or interbedded with Llandeilian black shales, and their conodont faunas are about a conodont zone older (i.e., H. tableheadensis Zone) than the fauna at Table Point (H. kristina Zone). The Lévis fauna, the fauna of the Taconic allochthon, the Fort Peña fauna and the Cow Head fauna are in part or generally older than the Table Point fauna.

The Lush's Bight, the Hølonda, and probably the Mystic Conglomerate occupy a position in the open ocean off the craton. The first two are associated with a volcanic arc sequence, and the Mystic Conglomerate was interpreted to be a horst isolated from the craton by Barnes & Poplawski (1973). These areas were inhabited by the Periodon-Cordylodus? biofacies faunal elements. The margin at these areas included a shelf-edge, and upper slope as the faunal elements of these environments were found.

The open shelf apparently was not present in these areas at that time (early H. tableheadensis time).

Some of the faunal elements were apparently restricted to these areas. Cordylodus?, Polonodus and Walliserodus inhabited the environments close to the volcanic sediments (Lush's Bight), but were not able to occupy the habitats along the margins of the craton.

The areas next to the craton i.e., Cow Head, Lévis Formation, Fort Peña Formation and the Taconic conodont faunas were characterized by a Periodon-Protopanderodus biofacies of the slope. It was noted that the biofacies on the shelf (Parapanderodus-Scalpellodus biofacies) was missing in some of the areas along the craton. For example, the Lévis Formation was dominated by Periodon, Protopanderodus and Eoneoprioniodus? in its lower half (Uyeno & Barnes, 1970). Eoneoprioniodus? is one component of the Trigonodus-Eoneoprioniodus? biofacies. This indicates that the slope was steep during that time. This period of time may well be partly contemporaneous with the Late Canadian-Early Whiterockian regression.

Toward the top of the Lévis Formation, Fort Peña and the Taconic conodont-bearing strata, a change in the faunas occurs characterized by the introduction of members of the shelf and shelf-edge biofacies. This change probably represents the initial Table Head transgression and formation of the shelf and the gently inclined slope facies of the Hare Bay area and equivalents.

The transgression, however, also created a dilution and mixing of the biofacies due to the migration of faunal elements in two directions. Cordylodus? horridus, Belodella, Polonodus and Walliserodus migrated landward from the island arc complex and inhabited the slope with Periodon

and Protopanderodus (Taconic sporadic, Fort Peña sporadic, Table Head typical). The shelf facies faunal elements migrated into the area possibly from other places on the craton with an already developed shelf facies. Accordingly, faunal elements of the shelf facies migrated seawards (Histiodella, ?Erraticodon, Scalpellodus, and Parapanderodus) and appeared sporadically in the Mystic, and Lush's Bight areas, and later reached the facies framing the Balto-Scandinavian platforms (outer shelf) together with Belodella, Polonodus and Walliserodus (Dzik, 1976, 1978; Löfgren, 1978). Histiodella was represented by H. kristina in Europe, ?Erraticodon by Erraticodon balticus and Belodella by B. jemtlandica in Sweden and Norway.

# CHAPTER 6

# TAXONOMY

## 6.1 Introduction

The introduction of the multi-element concept has drastically changed the taxonomy of early Middle Ordovician conodonts in recent years. This concept implies that individual conodont elements are arranged into supposed natural groupings, which represent a single (i.e., multi-element) species. It is now widely used by conodont workers and the approach in this study is fully committed to multi-element taxonomy.

The reconstruction of multi-element species is based on the combination of some or all of the following criteria (see Jeppsson, 1971).

- Similarity of stratigraphic ranges of the elements.
- Consistent co-occurrence in the same sample.
- Similarities in color and the occurrence and distribution of white matter.
- Similarity of one or more morphologic features of different elements.
- Elemental composition of already described apparatuses.

The general philosophy of having an objective nomenclature for the conodont apparatuses and their elements appears to be followed by most modern conodont workers. The independent evolution of several kinds of nomenclatural schemes in widely different systems (e.g. Jeppsson 1971 for the Silurian System; Klapper and Philip, 1972 for the Devonian System; Sweet *et al.*, 1975; Sweet and Schönlaub, 1975; and Barnes *et al.*, 1979 for the Ordovician System) strongly suggests that the basic philosophic concept is indeed a valid one.

The principal differences within these systems are matters such as where to draw the boundary lines between apparatuses, nomenclature for the several types, and how to label the single elements within the apparatus.

These arguments are interesting, though somewhat immaterial, for what matters is how well the apparatus and the conodont element is described. Nomenclature is simply a convenient handle, and if everyone would describe conodont apparatuses in a systematic and uniform way, each worker with his own cherished scheme could give it whatever pet name he likes.

Hence in this study, single elements within an apparatus are designated as traditional form-element genera with the suffix - "ontiform", for instance, drepanodontiform derived from the form genus Drepanodus, and should be referred to as drepanodontiform element. This practice is now used by most conodont workers when dealing with taxa of Ordovician age. Fåhraeus and Nowlan (1978) proposed to apply the combined word as a noun rather than an adjective, i.e., drepanodontiform(-s), which is a shorter terminology. Their suggestion is followed in this study. For single elements, where symmetry transition is gradual, such as in Drepanoistodus and other similar cone genera, this practice is not applied. When possible the suffix "-tid" is used for this apparatus, for instance, curvatid or erectid, pending an objective nomenclature in the future.

Complete or incomplete apparatuses, which have been well established elsewhere are assigned to their respective genera and species. Incomplete apparatuses or single elements, which cannot safely be included in established genera or species are referred to in open nomenclature, or with

the designation s.f. (sensu formo) as done by Barnes and Poplawski (1973) and Fåhraeus and Nowlan (1978).

The morphologic terminology is adopted from Lindström (1955a, 1964) and Löfgren (1978, p. 43). One additional term, procurved, is introduced to distinguish single cones with a curved proclined cusp from single cones with straight proclined cusp. The aboral outline refers to the outline of the aboral margin when seen in lateral view.

A genus is considered to consist of a stable apparatus, where every element of the apparatus should be present at all evolutionary stages. Several contemporaneous species may be included in a genus. Species are determined by morphological variation within the apparatus of the genus.

The synonyms of multi-element species are listed and new genera and species are named according to the rules of the I.C.Z.N. Code. In the following descriptions, MUNSS stands for Memorial University of Newfoundland, Svend Stouge. The collection of types is at present stored at the Department of Geology, Memorial University, St. John's. All illustrated specimens are deposited with the Royal Ontario Museum, Toronto, Canada.

## 6.2 Classification of the Order Conodonthophorida

The history of the classification of conodonts has recently been summarized by Lindström (1964) and Huddle (1972), who showed that two main classifications of conodonts, i.e., form-element or utilitarian taxonomy and multi-element or natural taxonomy, exist.

The most elaborate and comprehensive form-element classification of the Order Conodonthophorida to date is that by Hass in the Treatise (Moore 1962). Present knowledge has advanced far beyond the proposals of that

work, and Lindström (1970) introduced a suprageneric classification, which was based on multi-element criteria and evolutionary lineages. Dzik (1976, 1978) and Sweet and Bergström (1972) modified the classification of Lindström (1970) for Ordovician genera. The author will follow Lindström's classification (1970) together with the proposals of Dzik (1976, 1978). Increasing knowledge of conodont taxonomy requires new subdivisions of higher categories and some suggestions are made.

There may be protests to these revisions, probably on the basis that the proposed advancement or classification has not provided the final answer. It is, however, unthinkable that any "final answer" could arise in the next few years, when so much fundamental study remains to be done. Incremental adjustments provide a way of keeping the classification, at least to some degree, relevent to recent advances.

## 6.3 Hyaline versus white matter

The importance of the presence or absence of white matter in suprageneric taxonomy has been discussed by Lindström (1964, 1970), who chose the rank of Superfamily (Chirognathacea) to separate apparatuses with white matter from apparatuses without white matter. Ethington (1972), van Wamel (1974) and Dzik (1976) did not accept the concept hyaline versus white matter to be useful in taxonomy. These authors included both hyaline elements and elements with white matter in the same species or genus and included those within other superfamilies. Müller and Nogami (1971) concluded that the presence or lack of white matter was of ecological rather than taxonomical importance.

In the Table Head material the problem of hyaline versus white matter is simple, as the multi-element genera include species, in which

all elements are either hyaline or filled with white matter. The rank of species seems to be applicable and this practice is followed in this study pending a better understanding of this subject.

## 6.4 Multi-element Taxonomy

INCERTAE SEDIS

Order: CONODONTHOPHORIDA Eichenberg 1930

Superfamily: DISTACODONTACEA (Bassler 1925)

### Diagnosis

Apparatus of mostly simple conodonts with or without one row of denticles. No clearly discernible fine surface ornamentation (Lindström, 1970). The elements of the apparatus form a curvature transition series.

Family: PROCONODONTIDAE Lindström 1970

Subfamily: CORDYLODONTINAE Lindström 1970

### Discussion

Species of Cordylodontinae have apparatuses consisting of elements with a denticulated posterior process. The elements of the apparatus show slight differences in the basal part, curvature and denticulation (van Wamel, 1974). Until now only one Lower Ordovician species of Cordylodus has been established in multi-element taxonomy, i.e., Cordylodus angulatus Pander, which is composed of C. angulatus s.f. and C. rotundatus s.f. (Bergström & Sweet, 1966). Transitional forms exist and the apparatus may be more complicated than surmised by the above authors.

Cordylodus spinatus Hadding s.f. and C. ramosus Hadding s.f. exhibit a different symmetry transition series (Lindström, 1964), and they are included in the Ozarkodinina and referred to the genus Spinodus Dzik.

To judge from the literature Paracordylodus may have a similar transition series as Cordylodus, but Fåhraeus & Nowlan (1978) reported that the apparatus may be more complicated.

Genus CORDYLODUS Pander 1856

Type Species - Cordylodus angulatus Pander 1856

CORDYLODUS? HORRIDUS Barnes and Poplawski

Pl. 1, figs. 1-11

Synonymy

1969 Gen. et species indet. - Bradshaw, p. 1164-1165, Pl. 137: 20-23.

1973 Cordylodus horridus n. sp. - Barnes and Poplawski, p. 771, Pl. 2: 16-18.

1976 Cordylodus horridus Barnes and Poplawski - Landing, p. 631, Pl. 137: 20-23.

1979 "Cordylodus" horridus Barnes and Poplawski - Harris et al., Pl. 1: 6.

Discussion

The Table Head fauna includes forms which have previously been described as Cordylodus horridus by Barnes and Poplawski (1973). The elements exhibit a characteristic curvature transition series. This feature, together with the lack of obvious descendants of Cordylodus described from the Arenig, has led this author to query the generic identification. The morphological similarity also could be attributed to homeomorphy. Possibly, the elements represent a genus of their own.

Diagnosis

A Cordylodus? with a posterior process that varies from almost straight to highly arched. The anterior keel of the cusp continues onto the base as an enlarged anterior basal keel. The basal cavity tends to become inverted anteriorly and posteriorly.

Description

The elements have an anterior, recurved cusp and a denticulated posterior process. They form a curvature transition series superposed by a sinuous outline of the elements. The denticles vary from vertical to reclined at the posterior end of the process. Elements with vertical denticles have a more arcuate posterior process than elements with reclined denticles. The process may be deflected outward. The denticles may increase in height at the middle of the process, usually above the point of sharpest curvature. Large specimens have abundant small auxiliary denticles proximal to the cusp. The denticles are basally fused, and white matter outlines the continuation of the denticles down to the basal cavity. White matter is otherwise confined to the cusp and denticles.

No surface ornamentation, such as microstriations, has been observed. The basal cavity is inverted both anteriorly and posteriorly on many specimens.

Three morphologically different elements are distinguished.

The first element is straight with an arched posterior process. The cusp is suberect to recurved, keeled and with convex faces. The denticles are free and vertical on the process. Characteristically they have an alternating tilt.

The second element has a recurved and keeled cusp with an inner lateral carina on gerontic forms. The outer face is flat. The anterior keel of the cusp continues as a convex ridge. The anterior keel of the base may be deflected outwards. The aboral outline is sinuous extending from the anterior basal junction to the posterior process. The basal cavity is shallow and located underneath the first two denticles. It continues as a small groove underneath the process. The fully denticulate process carries up to eight denticles. These are laterally compressed, free and keeled.

The third type of element is characterized by a keeled cusp, an inner flare of the base, and an upwardly curved and outwardly deflected process. The denticles are reclined. The element may carry up to three free denticles. The anterior edge of the base and aboral margin form an angle of about 90 degrees. The basal cavity is initially wide, but becomes a narrow groove beneath the posterior denticle.

Discussion

Cordylodus? horridus Barnes and Poplawski shares important morphologically characteristics with Paroistodus? sp. cf. P.? originalis (Sergeeva). As noted by Barnes and Poplawski (1973) elements of P.? sp. cf. P.? originalis have an anteriorly enlarged basal keel; a feature which is typical for elements of Cordylodus? horridus. Also the inverted basal cavity is common to both species. Both species have the same stratigraphic range, and occur together in the Mystic Conglomerate, Fort Peña, and the Table Head faunas. Löfgren (1978) reported Paroistodus? sp. from Sweden, but not C.? horridus.

Based on this, it is considered possible that the two species are at least closely related and may belong to the same apparatus. The Cordylodus? horridus elements could be the homologues to the drepanodontiforms of Paroistodus. As noted below no drepanodontiforms were found in

the Table Head fauna, which could be associated with the oistodontiform.

The lack of a constant ratio between Cordylodus? horridus elements and Paroistodus? cf. P. originalis elements through the Table Head fauna and differences in the microstructure preclude inclusion of the two species in the same apparatus. Study from other areas is needed to verify the reconstruction of the possible apparatus.

Remarks

The Table Head forms are similar to the Mystic fauna, which also are included in synonymy. Some differences exist, however, which are similar to separate species of Periodon and Baltoniodus.

The differences include (1) Mystic forms have a conspicuous gap between the cusp and the first denticle. The successive denticles are generally free. Table Head forms do not possess this open space and the successive denticles are basally fused. (2) The aboral margin of specimens of the Mystic fauna is weakly sinuous in lateral view whereas the Table Head specimens have a prominently sinuous aboral margin. The difference is due to the Mystic forms having a higher basal sheath than the Table Head elements. And (3) the Mystic elements are not characterized by the prominent inverted basal cavity as are the Table Head specimens.

These differences may be indicative of two different species, but for the time being, they are all placed in one multi-element species.

Occurrence

Sporadic in lower Table Head, common in middle Table Head at Table Point.

C.? horridus has been recovered from the Mystic Conglomerate, southern Quebec (Barnes & Poplawski, 1973); from the Marathon basin, Fort Peña Formation, Texas (Bradshaw, 1969); from the Taconic allochthon, New York (Landing, 1976); from the Hølonda Limestone, Norway (Bergström, 1977b); and from the Antelope Valley Formation, Nevada (Ethington, 1977; Harris et al., 1979).

Material

Element 1: 777; element 2: 596; element 3: 102.

Family DISTACODONTIDAE Bassler 1925

(emend. Lindström, 1970)

Discussion

Distacodontid apparatuses exclusively comprise drepanodontiforms and oistodontiforms (Lindström, 1970). The elements of the apparatus may be acostate and costate. Most of the apparatuses are characterized by a curvature transition series, which includes homocurvatids, erectids and oistodontiforms (i.e., Drepanoistodus) or homocurvatids and oistodontiforms only (e.g. Paroistodus).

Different development of the transition series is the basis for a twofold subdivision of Distacodontidae. Fåhraeus and Nowlan (1978) subdivided Distacodontidae into the subfamily Drepanodontinae for species with a Drepanodus-type apparatus and the subfamily Drepanoistodinae for species of Drepanoistodus, Paltodus, and Paroistodus.

Originally, Lindström (1970) included Drepanodus in Distacodontidae. Dzik (1976) transferred Drepanodus to Panderodontacea, mainly due to the similarity of Drepanodus and Protopanderodus, and his belief that both

genera evolved from Semiacontiodus.

Panderodontacea includes genera, which may have elements highly striated longitudinally. Protopanderodus includes species with elements which show inconspicuous striations (Lindström 1971; Lindström & Ziegler 1971). Protopanderodus, sensu Löfgren (1978, p. 90) is very similar to Drepanodus. Thus, in contrast to Dzik (1976) and Lindström (1970), Protopanderodus is allocated to Distacodontacea in this study. The result of this procedure is that Drepanodontinae Fåhraeus & Nowlan (1978) becomes a junior synonym of Protopanderodontinae Lindström (1970).

## Subfamily PROTOPANDERODONTINAE Lindström 1970

### Synonymy

1978 Drepanodontinae Fåhraeus & Nowlan.

### Diagnosis

Conodont-apparatus consisting of symmetrical to asymmetrical costate and/or non-costate drepanodontiforms and oistodontiforms with a twisted cusp (scandodontiforms). The asymmetry of the drepanodontiforms is due to the variable presence of lateral costae.

### Remarks

Protopanderodontinae consists of the genera Drepanodus, Parapaltodus n. gen. and Protopanderodus. The genera of Protopanderodontinae predominantly are of the North Atlantic Province affinity.

Genus DREPANODUS Pander 1856

Type Species - Drepanodus arcuatus Pander 1856.

Remarks

Drepanodus includes drepanodontiforms and oistodontiforms. The apparatus has a curvature transition series and a symmetry transition series, the latter of which includes an oistodontiform with a twisted cusp (scandodontiform) (Lindström 1971).

DREPANODUS? sp. cf. D? GRACILIS (Branson and Mehl)

Pl. 1 figs. 12-18.

Synonymy

cf. 1933 Oistodus gracilis n. sp. - Branson and Mehl, p. 60, Pl. 4: 20.

cf. 1933 Oistodus concavus n. sp. - Branson and Mehl, p. 59, Pl. 4: 6.

cf. 1933 Oistodus pandus n. sp. - Branson and Mehl, p. 61, Pl. 4: 21, 22.

1973 Drepanoistodus basiovalis (Sergeeva) - Barnes and Poplawski, p. 775, Pl. 4: 3, 4, ?7.

1977 Drepanoistodus basiovalis (Sergeeva) - Barnes, p. 101, Pl. 1: 4-6.

Discussion

The elements of the apparatus included in Drepanodus in this study resemble Drepanodus Pander in their morphology, usually being fairly large. The oistodontiform, however, is not a typical "pipaform", but

symmetrical (i.e., oistodontiform). Also the drepanodontiforms are similar to Drepanoistodus, being curvatid, but the typical erectid element is not present. The data are considered to be in the favour of a generic assignment to Drepanodus, but it is queried because of the symmetrical oistodontiform.

Diagnosis

Oistodontiforms have a small quadratic base, which forms an angle of 80 to 110 degrees with the anterior edge of the cusp. The drepanodontiforms have a recurved cusp.

Description

Drepanodontiforms have laterally compressed cusp and base, which may flare. The basal cavity occupies the whole base and the tip is situated at the centre of the cusp. Only homocurvatid drepanodontiforms are present in this species. The cusp is recurved to "sub"-erect, but is never straight. The cusp is keeled. The anterior keel continues to the aboral margin and may be flexed to one side. The aboral margin is convex in lateral view. The outline of the basal cavity is convex in lateral view from the oral edge to the tip. From the tip to the anterior junction of base and aboral margin, it is sinuous.

The oistodontiform is strongly reclined. The cusp has well developed keels and an inner carina. The anterior edge of the base meets the aboral margin in an angle, which varies from 80 to 110 degrees. The outline of the aboral margin is first straight and continues as a convex curve to the oral edge. The oral edge is short, straight and keeled. It meets the cusp in an angle of 30 degrees. The basal cavity

occupies the whole base. The base is flared, giving a very open basal cavity.

Remarks

The elements are usually large.

Lower Ordovician elements are similar in morphology to the Table Head specimens. For example Oistodus gracilis Branson and Mehl s.f. and Oistodus pandus Branson and Mehl s.f. form a similar apparatus in the St. George Group (Barnes & Tuke,1970), which, however, differs in that the basal cavity is more triangular in outline in the drepanodontiforms, and that the aboral margin of the oistodontiforms forms an angle of about 50 to 70 degrees with the anterior edge of the base. The Table Head specimens probably represent a new, but closely related species.

The forms from the Mystic Conglomerate (Barnes & Poplawski, 1973) have the open basal cavity, which is typical of the Table Head specimens. The oistodontiforms differ from Oistodus basiovalis Sergeeva s.f. by their short oral edge, more square basal outline and the relatively more wide open basal cavity.

Occurrence

Lower Table Head and lower middle Table Head.

Material

404 drepanodontiforms, 134 oistodontiforms.

## Genus PARAPALTODUS n. gen

Type species - Parapaltodus simplicissimus n. sp.

Derivation of name

Para = (Greek) akin to, referring to the similarity to Paltodus.

Diagnosis

A distacodontacean genus with an apparatus consisting of erect to proclined drepanodontiforms and twisted oistodontiforms (scandodontiforms). The elements have a large laterally compressed cusp with sharp anterior and posterior keels and a triangular base. The basal cavity is triangular.

Remarks

Parapaltodus n. gen. has an oistodontiform with a twisted cusp and is thus consequently included in Protopanderodontinae.

This genus could be confused with Paroistodus or Paltodus, as two types of elements form the apparatus. The apparatus of Paroistodus consists of drepanodontiforms and oistodontiforms, the latter of which has a rectangular base and strong reclined cusp. Paltodus consists of drepanodontiforms and oistodontiforms, the latter of which has a triangular base and a reclined cusp. In Parapaltodus the homologous element is a scandodontiform and it is not strongly reclined.

### PARAPALTODUS ANGULATUS (Bradshaw)

Pl. 2 figs. 1-2.

Synonymy

1969 Oistodus angulatus n. sp. - Bradshaw, p. 1156, Pl. 134: 8, 9.

1969 Drepanodus sp. - Bradshaw, p. 1150, Pl. 131: 1, 2.

1965a Oistodus abundans Branson & Mehl - Mound, p. 26-27. Pl. 3: 22, 23.

cf. 1964 Drepanodus toomeyi n. sp. - Ethington & Clark, p. 690, Pl. 113: 17; Pl. 114: 11; Text - fig. 2H.

cf. Oistodus sp. A - Ethington & Clark 1965, p. 196, Pl. 2: 18.

Description

The scandodontiform of Parapaltodus angulatus has been described by Bradshaw (1969), it has a straight to convex aboral outline. The angle between cusp and oral edge is nearly 90°.

The drepanodontiform is symmetrical, laterally compressed with procurved to recurved cusp. It has a small base with a short oral edge. The anterior edge of the base forms an angle with the aboral margin of about 70° to 90°. The aboral outline is convex to straight. The basal cavity is triangular with convex faces. Its tip is in the centre of the cusp.

Remarks

This species is not abundantly represented, and the material is too small to evaluate the complete variation of this species.

Drepanodus toomeyi Ethington & Clark s.f. has a higher base and a longer oral edge than the Table Head specimens. The anterior basal angle is broken in Oistodus sp. A Ethington & Clark s.f. from the Ice Fields fauna. The angle between cusp and oral edge is smaller for their specimen. Possibly Drepanodus toomeyi s.f. and Oistodus sp. A s.f. represent another species of Parapaltodus.

Occurrence

Unit $A_2$, lower Table Head.

Material

18 drepanodontiforms; 16 oistodontiforms.

PARAPALTODUS FLEXUOSUS (Barnes and Poplawski)

Pl. 1 figs. 19, 22-25.

Synonymy

1973 Scandodus flexuosus n. sp. - Barnes and Poplawski, p. 785-786, Pl. 2: 1, 4; Text - fig. 2L.

1973 Scandodus mysticus n. sp. - Barnes and Poplawski, p. 786, Pl. 4: 1, 2; Text - fig. 2K.

1962 Drepanodus sp. - Sweet and Bergström, p. 1226, Pl. 168: 17.

1970 Nordiodus n. sp. A - Fåhraeus, fig. 3N.

?1960 Scandodus n. sp. 2 Lindström, Fig. 5: 16; fig. 6: 12; fig. 7: 11.

cf. 1978 Paltodus? cf. mysticus (Barnes and Poplawski) - Löfgren, p. 64-65, Pl. 4: 4, 5, 11.

Diagnosis

Elements with a wide cusp and a deep conical cavity. The base is plano-convex or is flexed to the inner side.

Description

P. flexuosus has been fully described by Barnes & Poplawski (1973) as the form species Scandodus flexuosus s.f. and Scandodus mysticus s.f. S. mysticus s.f. is the drepanodontiform with a plano-convex base and S. flexuosus is the scandodontiform with strongly flexed base.

Remarks

Swedish specimens from Jämtland differ from those of P. flexuosus at Table Point in having an antero-posterior extended base (Löfgren 1978, p. 65).

Löfgren (1978, p. 47) proposed that Nordiodus n. sp. A Fåhraeus was a possible adenticulate Belodella element, whereas N. sp. A Fåhraeus was considered to be the drepanodontiform by Barnes and Poplawski (1973). The present material supports the interpretation by the latter authors.

Barnes & Poplawski (1973) noted the general similarity of Scandodus sp. of Lindström (1960) with P. flexuosus. Fåhraeus (1966) described the form species Scandodus formosus s.f., which is synonymous with Scandodus sp. 2 of Lindström (1960). Löfgren (1978) included S. formosus s.f. in Protopanderodus robustus, but not Scandodus sp. 2 s.f.

P. flexuosus differs from P. angulatus by the plano-convex base of the first.

As mentioned in the discussion of Walliserodus ethingtoni these elements could be included in W. ethingtoni. The elements of P. flexuosus have much the same range in the Table Head fauna as W. ethingtoni. P. flexuosus elements have typically laterally compressed cusps, in contrast to the rounded cross-sections of W. ethingtoni elements. P. flexuosus, therefore, is considered to be a separate species.

Occurrence

Rarely found in lower Table Head, common in middle Table Head.

Material

87 drepanodontiforms; 50 oistodontiforms.

PARAPALTODUS SIMPLICISSIMUS n. sp.

Pl. 1 figs. 20, 21, 26, 27, 28A, B.

Synonymy

1973 Drepanodus toomeyi Ethington and Clark - Barnes and Poplawski, p. 773, Pl. 2: 10.

1973 Drepanodus n. sp. C s.f. - Barnes and Poplawski, p. 773, Pl. 2: 11, 11a, 13; Text - Fig. 2J.

cf. 1973 Scanodus sp. - Barnes and Poplawski, p. 786, Pl. 2: 14.

1976 Scalpellodus sp. - Dzik, Fig. 14I.

1978 Drepanodus? sp. A - Löfgren, p. 53, Pl. 1: 36-37.

Derivation of name

Simplicissimus latin = simple; refers to the simple single cones of the skeletal apparatus.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

11 m above the base of middle Table Head, sample TP 68, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 4 (Pl. 1, Fig. 28), a drepanodontiform.

Diagnosis

A species with elements having a laterally compressed, large cusp and a small base with a constricted basal cavity. The elements form a weakly developed symmetry transition series.

Description

The drepanodontiforms are laterally compressed with a wide and keeled procurved cusp and a very small base. The outer face of the cusp has a broad anterior carina, which becomes median in position toward the apex of the cusp. Anteriorly a lateral furrow runs the length of the cusp from the apex to the aboral margin. The anterior keel may be laterally deflexed inwards at the base. The posterior keel continues onto the oral edge. The basal cavity is shallow and triangular with concave sides. The tip is close to the anterior keel of the cusp and directed upwards. The inner side of the base is slightly flared. The aboral outline forms a gently concave curve.

The scandontiforms are similar to the drepanodontiforms, but the asymmetry is formed by a slight torsion of the cusp and the flare of the inner side of the base.

Basal filling is present in many elements. It is black in color and forms a compressed hollow cone. White matter is present in the cusp.

Inconspicuous longitudinal striations may be present. These are restricted to the anterior keel of cusp and form an acute angle with the keel.

Remarks

Scandodus sp. Barnes & Poplawski is similar to the Table Head fauna. The cusp (although broken) seemingly does not taper as fast as in P. simplicissimus n. sp..

P. simplicissimus n. sp. differs from P. flexuosus by its small base, from Drepanodus toomeyi s.f., which has a high triangular base, and from P. angulatus by its rounded antero-basal junction.

Occurrence

Lower Table Head; common in the lower part of middle Table Head.

Material

214 drepanodontiforms; 89 oistodontiforms.

Genus PROTOPANDERODUS Lindström 1971

Type Species - Acontiodus rectus Lindström 1955a

Emended diagnosis

Protopanderodus comprises laterally compressed elements with a cusp that is higher than the base. The longitudinal striations of the cusp are inconspicuous. The cross-section of the cusp may be comma-shaped, lanceolate, or bicostate. Most species include symmetrical as well as asymmetrical drepanodontiforms and scandodontiforms. Most elements are costate and/or sulcate.

Discussion

In the original definition of Protopanderodus given by Lindström (1971) the cross section of the cusp could be subcircular, comma-shaped, lanceolate, or Acontiodus-like. This led van Wamel (1974) to include elements with surface striations in Protopanderodus. Löfgren (1978), however, restricted Protopanderodus to include elements, where striations were inconspicuous only. Furthermore, she (Löfgren, 1978) excluded apparatuses with elements which were anteriorly/posteriorly compressed or had a subcircular cross section of the cusp from Protopanderodus.

Highly striated elements with a rounded cross section of the cusp and the base and with slightly thickened rim toward the posterior edge

of the base were included in Semiacontiodus (Panderodontacea) by Dzik (1976).

Protopanderodus probably evolved from early species of Drepanodus by the development of costae during the early Arenig. Transitional forms between Protopanderodus and Drepanodus exist (see discussion in Fahraeus & Nowlan, 1978, p. 458).

Several species of Protopanderodus have been recovered from the Table Head Formation, most of which have been fully described from Scandinavia (Löfgren, 1978) or from along the continental margin of North America (Barnes & Poplawski, 1973; Landing, 1976; Bradshaw, 1969; Kennedy et al., 1979).

Some of the species in the Table Head fauna are considered to be more closely related than to other species of Protopanderodus. This is similar to the Swedish material from which Löfgren (1978) noted that P. rectus were closely related, but stratigraphically separated by the less closely related Protopanderodus parvibasis.

Protopanderodus parvibasis probably emigrated from a stock geographically separated from Sweden (Löfgren, 1978). This indicates that several contemporaneous species of Protopanderodus existed during the Ordovician period. These include P. rectus-robustus lineage, the P. varicostatus lineage, the P. liripipus-P. insculptus lineage and the P. gradatus-P. strigatus lineage. To judge from the present knowledge of the distribution of the species, P. rectus was mainly a Scandinavian species (Lindström, 1955a, 1971; van Wamel, 1974; Löfgren, 1978); P. varicostatus was most common at island arc complexes (Sweet & Bergström, 1962; Hunter, 1978) whereas P. strigatus (this study) was restricted to faunas on the open shelf.

PROTOPANDERODUS ROBUSTUS (Hadding)

Pl. 2 figs. 3-8.

Synonymy

1913 Drepanodus robustus n. sp. - Hadding, p. 31, Pl. 1: 5.

cf. 1973 Protopanderodus cooperi (Sweet and Bergström) - Barnes & Poplawski, p. 782 (pars), Pl. 3: 4, 5 only.

1978 Protopanderodus robustus (Hadding) - Löfgren, p. 94-95, Pl. 3: 32-35; Text - Fig. 31 G-J (Synonymy through 1978).

Description

Protopanderodus robustus includes symmetrical and asymmetrical acontiodontiforms and scandodontiforms.

The symmetrical acontiodontiform has an erect to recurved cusp with an anterior and a posterior keel. The base varies in length and the short base types may have an antero-basal notch. The long-base types included in this species have a straight aboral outline. The keels and the two postero-lateral costae extend the full length of the unit. Black basal filling may be preserved in some specimens.

The asymmetrical acontiodontiforms are similar to the symmetrical ones, but have a slightly twisted cusp and the inner posterior lateral costa disappears above about the mid-length of the cusp.

The scandodontiform has a twisted keeled cusp and a base which is much shorter than the cusp. The unit is noncostate. The margins of the base are keeled, and the inner face is flared. The element may have an inner median carina.

Remarks

The collection at hand is small, but Löfgren (1978) fully described Protopanderodus robustus from a large collection.

The long-base forms may have an anterior flare of the basal sheath, which is similar to the Swedish material. The scandodontiform may have a slightly shorter base than illustrated by Löfgren (1978), and in this way resembles P. rectus. As discussed by Löfgren (1978) P. rectus and P. robustus are very closely related species, and some of the elements of the two species cannot always be distinguished.

The scandodontiform is also similar to the scandodontiform figured by Barnes & Poplawski (1973) and included in P. cooperi. The base of the Mystic element is, however, smaller than any of the Table Head specimens.

Löfgren (1978) tentatively included Scandodus dubius Brahshaw s.f. in synonymy with P. robustus. S. dubius is here assigned to Scalpellodus biconvexus (Bradshaw).

Occurrence

Sporadic in lower Table Head; common in middle Table Head.

Material

43 symmetrical acontiodontiforms; 99 asymmetrical acontiodontiforms; 24 scandodontiforms.

PROTOPANDERODUS sp. cf. P. LIRIPIPUS Kennedy, Barnes and Uyeno

Pl. 2 figs. 9-14, 17.

Synonymy

?1978 Protopanderodus sp. cf. P. varicostatus (Sweet and Bergström) - Löfgren, p. 91-93 (pars), Pl. 3: 30 only.

cf. 1979 Protopanderodus liripipus n. sp. - Kennedy, Barnes and Uyeno, p. 546-550, Pl. 1: 9-19.

Diagnosis

A Protopanderodus species with a scandodontiform and a transition series of acontiodontiforms. The scandodontiform has an inner groove and the asymmetrical acontiodontiforms have one costa on one side and one costa and one groove on the other side.

Description

The symmetrical acontiodontiform has only been recovered as fragments, and therefore cannot be described completely. The unit has a keeled cusp with two postero-lateral costae. The posterior part of the base is broken.

The asymmetrical units are of two types. One type with a long base and another with a short base.

The long base type has a recurved cusp and a relatively long posteriorly extended base. The cusp has sharp keels, which continue onto the oral and anterior margins of the base. The cusp has one postero-lateral costa, which extends to the aboral margin just beneath the oral edge/cusp junction. The other side of the unit has a posterior lateral costa and a median groove, which extend the whole length of

the unit. The costa reaches the aboral margin at about midlength.

The asymmetrical element with a short base has an erect cusp and one costa on each side of the cusp. The base is keeled. The posterior keel of the cusp meets the oral keeled edge in an abrupt angle of 110 degrees. The aboral outline is convex. This unit is transitional to the scandodontiform.

The scandodontiform has a small base and a recurved keeled cusp. The outer face is smooth and convex. The inner face has a median broad carina and a groove between the carina and the anterior keel. The aboral outline is convex.

Characteristically, all the elements of this species have an extended antero-basal keel.

Remarks

The scandodontiform resembles Scandodus unistriatus s.f. in that it carries one anterior, inner lateral groove. The element is, however, more laterally compressed, and the groove is more median in its position than Scandodus unistriatus s.f.. The differences are subtle and the elements are commonly indistinguishable. The S. unistriatus elements included in P. sp. cf. P. varicostatus in this study differ by the "fluted" keel and a more flexed cusp of the latter species.

The scandodontiform of Löfgren (1978) is similar to P. sp. cf. P. liripipus of this study. The Swedish form has a posteriorly extended oral edge. Löfgren (1978) included the elements in P. sp. cf. P varicostatus, but she mentioned that more than one species was represented in her material.

The apparatus and the elements of P. sp. cf. P. liripipus resemble both Protopanderodus parvibasis Löfgren and P. liripipus Kennedy et al. Characteristically, the elements of these three species are laterally compressed and with well developed keels. P. sp. cf. P. liripipus differs from P. liripipus in its smaller posterior extended base of all elements and from P. parvibasis by the lateral groove of the drepanodontiforms and the prominent inner groove of the scandodontiforms.

The three species are probably closely related and form a phyletic lineage. Löfgren (1978) noted that the ancestor to P. parvibasis was not known. According to Kennedy et al. (1979) P. liripipus is the ancestor to P. insculptus.

P. sp. cf. P. liripipus is also closely related to P. sp. cf. P. varicostatus, and probably the two species evolved from P. parvibasis via forms described as P. sp. cf. P. varicostatus by Löfgren (1978).

Occurrence

Rare in lower Table Head; sporadic in middle Table Head.

Material

9 symmetrical acontiodontiforms; 31 asymmetrical acontiodontiforms; 16 scandodontiforms.

PROTOPANDERODUS STRIGATUS Barnes and Poplawski

Pl. 2 figs. 15-16, 18-24.

Synonymy

1973 Protopanderodus strigatus n. sp. - Barnes and Poplawski, p. 784, Pl. 3: 14,17; Text - fig. 2E.

cf. 1974 Protopanderodus gradatus n. sp. - Serpagli, p. 59-61, Pl. 15: 5a-8b; Pl. 26: 11-15; Pl. 30: 1a, b; Text - fig. 17.

cf. 1976 Protopanderodus gradatus Serpagli - Landing, p. 639, Pl. 4: 8, 9, 11, 12.

Description

This species has an apparatus consisting of four morphotypes of acontiodontiforms being unicostate to multicostate, and with acostate scandodontiforms. All the elements form a simple curvature transition series, and the length and depth of the basal cavity is related to the degree of curvature. Proclined forms have a slender cone and base, which is almost as long as the cusp, and a deep basal cavity. Erect forms have a shorter base than the cusp and a smaller basal cavity. Proclined forms have a reduced base and basal cavity and a tall cusp.

The number of costae on the acontiodontiforms is variable. Based on the number of costae the following types are present: the sub-symmetrical forms have two costae separated by a groove on each side; asymmetrical elements have one or two costae on one side, or one costa on each side; and one costa on one side and two costae on the other side; all the elements have anterior and posterior keels on the cusp.

The subsymmetrical element has a median to lateral groove framed by two costae. The groove widens on the base and disappears close to the

aboral margin. It narrows on the cusp towards the apex. The anterior keel runs from the apex of the cusp to the maximum curvature of cusp. The anterior margin of the base is convex. The posterior keel continues from the cusp onto the oral edge. On each lateral face there are two additional posterior costae between the groove and the posterior keel. The lateral costae disappear a little up on the cusp. The aboral outline is convex on proclined elements, convex to straight or slightly sinuous on elements with an erect to reclined cusp.

The asymmetrical elements are slightly twisted and have unequal numbers of costae associated with grooves on each side. The units vary from being a nontwisted cone with antero-posterior keels with one lateral costa on one side and two lateral costae on the other side separated by a groove to similar forms with a twisted cusp. The torsion of the cusp is both sinistral and dextral. Thus elements with an inner groove and two inner costae and one outer costa occur together with forms with one inner costa and two outer costae and a groove. With increasing torsion the outer side becomes acostate and convex.

The scandodontiforms have a long, robust and keeled cusp. The faces are convex and may carry an inner lateral carina.

Remarks

Barnes and Poplawski (1973) did not include a scandodontiform in this apparatus.

*Protopanderodus gradatus* Serpagli is very similar to *P. strigatus*, and the two species are considered to be closely related. Also both species occupy the same habitat. It is possible that *P. strigatus* evolved from *P. gradatus*.

P. strigatus differs from P. sp. cf. P. varicostatus by its convex outline of the aboral margin of all elements and the symmetrical element has two costae on both faces. The scandodontiform has an inner convex face, which may be carinated, but no groove is present.

Many specimens have large black-colored cones of basal filling similar to those figured by Sweet & Bergström (1962, pl. 168, fig. 2, 9). These cones are also preserved separately and resemble elements of the Cambrian genus Hertzina or the Ordovician Coelocerodontus.

Occurrence

Lower and lower middle Table Head.

Material

109 symmetrical acontiodontiforms; 414 asymmetrical acontiodontiforms; 82 scandodontiforms.

PROTOPANDERODUS sp. cf. P. RECLINATUS (Lindström)

Pl. 3 figs. 6-10.

Synonymy

cf. 1955a Acontiodus reclinatus n. sp. - Lindström, p. 548, Pl. 2: 5, 6; Text - fig. 3C.

? 1969 Panderodus sp. - Bradshaw, p. 1159, Pl. 135: 1, 2.

? 1969 Scandodus cf. S. pipa Lindström - Bradshaw, p. 1161, Pl. 135: 3, 4.

1970 Scandodus pipa Lindström - Uyeno and Barnes, p. 115-116, Pl. 22: 6, 7; Text - fig. 7C.

1973 Oistodus aff. O. parallelus Pander s.f. - Barnes and Poplawski, p. 777, Pl. 5: 1-3.

1973 Protopanderodus cooperi (Sweet and Bergström) - Barnes and Poplawski, p. 782 (pars), Pl. 3:1.

1973 Protopanderodus reclinatus (Lindström) - Barnes and Poplawski, p. 782, 784, Pl. 3: 2, 3.

1976 Drepanodus arcuatus Pander - Landing, p. 632 (pars), Pl. 1: 17-19, 21-23, non 16.

1976 Protopanderodus cooperi (Sweet and Bergström) - Landing, p. 638-639 (pars), Pl. 4: 7, non 6.

Description

The apparatus includes costate acontiodontiforms and acostate scandodontiforms with a long posteriorly extended base.

The acontiodontiform includes symmetrical posteriorly bicostate units with a posteriorly extended base and a recurved cusp. The anterior keel of the base may flare inwards in some elements. These elements tend to be unicostate with a convex outer face. The aboral outline is convex and it meets the keeled oral edge in an angle of 30 degrees.

The scandodontiforms have a twisted recurved cusp and an inner posterior carina. The basal opening varies from a small rounded to a larger oval opening. The aboral outline is convex. The aboral margin meets the oral edge in angles varying from 30 to 80 degrees.

Remarks

The costae vary from being prominent to inconspicuous. The latter forms could be referred to the form genus Drepanodus Pander. Also the apparatus could be referred to the multi-element genus Drepanodus Pander (emend. Lindström, 1971) as Landing (1976) did. However, as the apparatus includes elements, which are Acontiodus-like, the present author prefers to assign the elements to Protopanderodus.

Acontiodus reclinatus Lindström s.f. broadly resembles the scandodontiforms of the Table Head. The base is shorter in the Lower Ordovician specimens. Acontiodus reclinatus s.f. has not yet found its place in a multi-element taxon. Whereas the Table Head specimens are similar to Acontiodus reclinatus s.f., the generic affinity of the elements may suggest that they belong to a new species within the natural genus Protopanderodus.

Occurrence

Sporadic in lower Table Head; present in middle Table Head.

Material

4 symmetrical acontiodontiforms; 22 asymmetrical acontiodontiforms; 11 scandodontiforms.

PROTOPANDERODUS sp. A

Pl. 3 figs. 1-5.

Description

The species comprises asymmetrical acontiodontiforms with one inner median costa on the cusp and an outer lateral groove and scandodontiforms.

The acontiodontiforms are erect to recurved. The unit has a rounded cusp with a small base. The aboral outline is convex to straight. The groove and costae extend the whole length of the unit.

The scandodontiform has a procurved cusp with convex faces and anterior and posterior keels. The inner face may bear a broad carina. The base is small. The cross-section of the basal opening is almost circular. The aboral outline is convex.

Remarks

The elements are smaller than other elements of Protopanderodus. They resemble P. strigatus in that they have an outer groove, and possibly the elements are juveniles of P. strigatus. The apparatus, however, does not include symmetrical units, and the lack of intermediate forms as well as the inconsistent appearance lead the author to refer the elements to a species of their own.

Occurrence

Lower and middle Table Head.

Material

43 asymmetrical acontiodontiforms; 14 scandodontiforms.

PROTOPANDERODUS sp. cf. P. VARICOSTATUS (Sweet and Bergström)

Pl. 3 figs. 11-17.

Synonymy

cf. 1962 Scolopodus varicostatus n. sp. - Sweet and Bergström, p. 1247-1248, Pl. 168: 4-9; Text - fig. 1A, C, K.

cf. 1962 Acontiodus cooperi n. sp. - Sweet and Bergström, p. 1221-1222, Pl. 168: 2, 3; Text - fig. 1G.

cf. 1962 Scandodus unistriatus n. sp. - Sweet and Bergström, p. 1245, Pl. 168: 12; Text - fig. 1E.

? 1964 Acontiodus cooperi Sweet and Bergström - Hamar, p. 247.

cf. 1964 Scolopodus varicostatus Sweet and Bergström - Hamar, p. 284, Pl. 1: 1, 2.

1969 Scandodus unistriatus Sweet and Bergström - Bradshaw, p. 1161, Pl. 135: 5, 6.

1969 Scolopodus varicostatus Sweet and Bergström - Bradshaw, p. 1163, Pl. 132: 10; Pl. 134: 12. 13.

1970 Scolopodus n. sp. 2 - Uyeno and Barnes, p. 116-117, Pl. 22: 3-5; Text - fig. 7A.

1973 Protopanderodus cooperi (Sweet and Bergström) - Barnes and Poplawski, p. 782 (pars), Pl. 4: 8, 15 only.

1974 Scandodus unistriatus Sweet and Bergström - Viira, p. 119, Pl. 5: 30; ?Text - fig. 151b only.

1974 Scolopodus varicostatus Sweet and Bergström - Viira, p. 123 (pars), fig. 160a, b, Pl. 5: 23, 24.

1976 Protopanderodus rectus (Lindström) - Dzik, p. 429, fig. 16, b, c, d.

1978 Protopanderodus sp. cf. P. varicostatus (Sweet and Bergström) - Löfgren, p. 91-93, Pl. 3: 26-29, ?31 (non fig. 30).

non 1973 Protopanderodus cooperi (Sweet and Bergström) - Barnes and Poplawski, p. 782 (pars), Pl. 3: 1, 4, 5.

non 1976 Protopanderodus cooperi (Sweet and Bergström) - Landing, p. 638-639 (pars), Pl. 4: 7 only.

Discussion

P. varicostatus has not been formally described as a multi-element taxon, but the elements are without doubt a valid species of Protopanderodus.

Elements identified with Scolopodus varicostatus Sweet and Bergström s.f. are present in the Table Head material. Some of the elements do not possess the deep anterior notch of S. varicostatus, but the size, and the cross-section of the cusp is similar. Associated with Scolopodus sp. cf. S. varicostatus s.f. is Scandodus unistriatus s.f., and elements morphologically similar to Acontiodus cooperi Sweet and Bergström s.f. are tentatively included in the apparatus, until the nature of P. cooperi is known. As noted by Sweet and Bergström (1962) Acontiodus cooperi s.f. only differs from Scolopodus varicostatus s.f. in having one pair of lateral costae.

The Table Head material is far from complete and can only indicate the composition of the apparatus. The present apparatus, however, is considered closely related to P. varicostatus (Sweet and Bergström).

The apparatus of P. varicostatus and its closely related species consists of a series of symmetrical and asymmetrical variously costate acontiodontiforms and a scandodontiform with an inner lateral groove. In the apparatus Acontiodus cooperi s.f. is included as the symmetrical acontiodontiform. Due to priority the species should be named P. cooperi. The name P. varicostatus is preserved, because the holotype of the apparatus still needs to verify the apparatus, and because of differences in opinion of the composition of P. cooperi.

Barnes and Poplawski (1973) suggested that Protopanderodus cooperi formed an apparatus with a non-grooved scandodontiform (cf. Scandodus rectus s.f.). Landing (1976) followed that procedure, and Kennedy et al. (1979) briefly discussed the apparatus of P. varicostatus as being different from P. liripipus. Löfgren (1978) found an apparatus similar to P. varicostatus and included a scandodontiform with an inner groove (i.e., Scandodus unistriatus s.f.).

The present author shares the opinion of Löfgren (1978) in that the closely related species of Protopanderodus are conservative in the elemental composition of the apparatus, and only minor differences in the morphologies of the elements are present. Therefore, the scandodontiform included in P. cooperi by Barnes and Poplawski (1973) is considered to be related to the P. rectus-robustus lineage rather than to the P. varicostatus lineage (with S. unistriatus s.f.). Such an approach is not contradictary to the Mystic collections, as Acontiodus robustus s.f. also was recovered (P. robustus).

Barnes and Poplawski (1973, Pl. 3, fig. 1) also included a scandodontiform with a relatively large and open base in P. cooperi. Landing

(1976) went a step further and included Protopanderodus reclinatus of Barnes and Poplawski (1973) in the apparatus. The elements of this type are included in Protopanderodus sp. cf. P. reclinatus (Lindström) in this study, and they are not considered closely related to P. cooperi.

The apparatus and the elements of P. sp. cf. P. varicostatus of Lofgren are quite similar to Protopanderodus parvibasis Löfgren. The scandodontiform of P. parvibasis has a weak inner lateral groove and a base of similar height as P. sp. cf. P. varicostatus. Possibly P. parvibasis is the ancestor to the P. varicostatus lineage (and to P. sp. cf. P. liripipus).

Description

P. sp. cf. P. varicostatus exhibits a simple symmetry transition series overprinted by a curvature transition series. The elements are variously costate asymmetrical and symmetrical acontiodontiforms and scandodontiforms with an inner furrow.

The acontiodontiforms are variable in length of the base and development of the anterior basal angle. This may be rounded or sinuous forming an anterior notch. Most elements have one outer costa and two costae on the inner side. These elements vary from symmetrical to slightly asymmetrical due to a twist of the cusp. Other elements may evolve a second outer lateral carina.

Symmetrical elements carry two posterior costae separated by a furrow. The posterior edge is "fluted" and the element is similar to Acontiodus cooperi s.f.

The scandodontiform is similar to S. unistriatus s.f. as described by Sweet and Bergström (1962). It has a large twisted cusp with sharp

keels. The anterior edge of the cusp is convex. The inner face is convex with tendency to develop a median carina. The median carina and the anterior keel are separated by a well-defined furrow, which extends the full length of the unit. The median carina is weakly "fluted". The cusp is highly twisted and the antero-posterior keels are almost vertical in position to the original antero-posterior direction. The base is small with a slightly sinuous aboral outline.

Remarks

The specimens are variable, and only large specimens are "fluted". Most of the elements included in synonymy share the characteristics of P. sp. cf. P. varicostatus, but it is possible that the specimens represent more than one species. For example, in P. sp. cf. P. varicostatus of Löfgren (1978) the furrows of the elements are wider than the Table Head specimens. Also the base of the scandodontiform is higher than the Table Head forms. Landing (1976) illustrated a costate and grooved specimen, which broadly is similar to the P. sp. cf. P. varicostatus. The costae seemingly are finer than the Table Head specimens.

P. sp. cf. P. varicostatus differs from P. strigatus by having a sinuous aboral outline and a scandodontiform with a postero-lateral furrow.

Löfgren (1978) discussed the relationship of P. sp. cf. P. varicostatus with P. gradatus Serpagli, and she concluded that the species were not closely related. The relationship of P. strigatus and P. gradatus is discussed under P. strigatus.

Occurrence

Middle Table Head.

Material

5 symmetrical acontiodontiforms; 47 asymmetrical acontiodontiforms; 19 scandodontiforms.

Subfamily DREPANOISTODINAE Fåhraeus and Nowlan 1978

Remarks

Fåhraeus and Nowlan (1978) established Drepanoistodinae for apparatuses formed by non-, uni- and bilaterally costate drepanodontiforms and symmetrical oistodontiforms. In many of the elements included in Drepanoistodus in this study, the oistodontiforms have well-developed lateral costae. Drepanoistodinae comprises the genera Drepanoistodus, Paltodus, and Paroistodus.

Genus DREPANOISTODUS Lindström 1971

Type species - Oistodus forceps Lindström 1955a.

Remarks

The Drepanoistodus apparatus comprises drepanodontiforms and oistodontiforms (Lindström, 1971), which form a curvature transition series. The drepanodontiforms are distinguished as curvatid and erectid. Van Wamel (1974) separated two additional elements one of which was costate. It is not always possible to differentiate the morphotypes within the species due to the gradual morphologic transition of the elements.

It is considered difficult, if not impossible to separate species on the basis of the drepanodontiforms alone, in particular for closely related species (van Wamel 1974; Dzik 1976). One difference, however, which may appear to be of taxonomic importance is the presence or absence of units with costae in the apparatus. So far, all the species from the North Atlantic Province (D. forceps-D. basiovalis) do have costate drepanodontiforms in the apparatus. Species of the Midcontinent Province have not yet been formally described or have been identified with species of the North Atlantic Province.

At present, two different approaches in separating species of Drepanoistodus exist. The first focuses on the differences in the morphology of the base of the oistodontiforms (Lindström 1971; Löfgren 1978). Thus, according to these authors two distinct species exist, namely D. forceps and D. basiovalis.

In contrast, van Wamel (1974) and Dzik (1976) did not recognize the species D. forceps and D. basiovalis of Lindström (1971) and Löfgren (1978). They found that intraspecific variation both during growth and within the curvature transition series, that otherwise might be interpreted as species indicative, occurred, and only numerical measures were considered valid for separation of species (van Wamel 1974; Dzik 1976).

Several species have been identified from the Table Head mainly following the practice of Löfgren (1978). With the above comments in mind, statistically more reliable material may reduce the number of species separated on the basis of the present material.

DREPANOISTODUS BASIOVALIS (Sergeeva)

Pl. 3 figs. 18-20.

Synonymy

1963 Oistodus basiovalis sp. nov. - Sergeeva, p. 96, Pl. 7: 6, 7; Text - fig. 3.

1971 Drepanoistodus basiovalis (Sergeeva) - Lindström, p. 43, figs. 6, 8.

1973 Drepanoistodus basiovalis (Sergeeva) - Lindström (in Ziegler), p. 73, Pl. 1: 3-4.

1974 Oistodus basiovalis Sergeeva - Viira, Pl. 5: 9, 10.

1976 Drepanoistodus suberectus forceps (Lindström) - Dzik, fig. 19a, b, c, d, f, ?k; non e, g.

1978 Drepanoistodus basiovalis (Sergeeva) - Löfgren, p. 55-56, Pl. 1: 11-17; Text - fig. 26B-c.

Non 1973 Drepanoistodus basiovalis (Sergeeva) - Barnes and Poplawski, p. 775, Pl. 4: 3, 4, 7.

Non 1976 Drepanoistodus basiovalis (Sergeeva) - Barnes ( in Workum et al.), p. 171, 173, Pl. 4: 1, 2.

Non 1977 Drepanoistodus basiovalis (Sergeeva) - Barnes, p. 101, Pl. 1: 4-6.

Remarks

A small collection of oistodontiforms with a small base and large reclined acostate cusp is identified with D. basiovalis. The size of the base and the convex aboral outline is typical of Oistodus basiovalis Sergeeva s.f.

A similar small collection of drepanodontiforms can be associated with the oistodontiforms.

This species has been fully described by Löfgren (1978).

The elements named Drepanoistodus basiovalis by Barnes & Poplawski (1973), Barnes (in Workum et al. 1976), and Barnes (1977) are considered to represent the species Drepanodus? sp. cf. D? gracilis. The oistodontiform of the Bad Cache Rapids Formation (Barnes 1977) has an angular (90°) base/aboral margin junction. In D. basiovalis this is rounded.

Occurrence

Lower and middle Table Head.

Material

17 drepanodontiforms; 23 oistodontiforms.

DREPANOISTODUS sp. cf. D. BASIOVALIS (Sergeeva)

Pl. 3 figs. 21-23.

Synonymy

1969 Oistodus sp. - Bradshaw, p. 1158, Pl. 134: 10, 11.

Diagnosis

A Drepanoistodus with drepanodontiforms having a small base, a convex to straight aboral outline and a convex basal cavity, and oistodontiforms with a base that varies from rectangular to an anteriorly directed relatively pointed base. All specimens are noncostate.

Description

The drepanodontiforms have a long slender, laterally compressed cusp and a small base. The base may be flattened or more widely open. Generally asymmetrical elements have an inner flaring base and symmetrical elements have an open base. The faces of the cusp are convex. The oral

edge is straight and short, but increases relatively in length in large specimens. The basal cavity is small. In lateral view the outline of the basal cavity is a gently convex curve with no characteristic tip. All the elements are curvatid in outline.

The oistodontiforms have a compressed, pointed and keeled cusp that is almost parallel to the posterior part of the aboral margin.

Occurrence

Lower Table Head.

Material

29 drepanodontiforms; 22 oistodontiforms.

DREPANOISTODUS FORCEPS (Lindström)

Pl. 3 figs. 24-25.

Synonymy

1955a Oistodus forceps n. sp. - Lindström, p. 574, Pl. 4: 9-13; Text - fig. 3M.

1955a Acodus gratus n. sp. - Lindström, p. 545, Pl. 2: 27-29.

1955a Drepanodus homocurvatus n. sp. - Lindström, p. 563, Pl. 2: 23-24; Text - fig. 4D.

1955a Drepanodus planus n. sp. - Lindström, p. 565, Pl. 2: 35-37; Text - fig. 4A.

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

1971 Drepanoistodus forceps (Lindström) - Lindström, p. 42-43; Text - fig. 5, 8.

1978 Drepanoistodus forceps (Lindström) - Löfgren , p. 53-55, Pl. 1: 1-6; Text - fig. 26A (includes synonymy through 1978).

Remarks

A small collection of drepanodontiforms and oistodontiforms have been identified with D. forceps. The material differs from D. sp. cf. D. basiovalis both in their lighter color, being more translucent and brighter, and their different stratigraphic position. The inner flare of oistodontiforms typical of D. forceps also separates D. forceps from D. sp. cf. D. basiovalis. The drepanodontiforms are sparsely represented, but include erectids. White matter is present in the cusp.

Löfgren (1978) fully described this species.

Occurrence

Lower Table Head.

Material

9 drepanodontiforms; 7 oistodontiforms.

DREPANOISTODUS BELLBURNENSIS n. sp.

Pl. 4 figs. 1-8.

Synonymy:

1973 Drepanodus sp. B s.f. - Barnes and Poplawski, p. 774, Pl. 5: 4.

1976 Drepanoistodus sp. - Landing, p. 632, Pl. 2: 12.

Derivation of name

Bellburns, a small village south of Table Point.

Type Locality

Table Point, Great Northern Peninsula, Newfoundland

Type stratum

Lower middle Table Head, sample TP 67, *Histiodella kristina* Phylo-zone, late Whiterockian (early Llanvirn).

Holotype

MUNSS 17 (Pl. 4, fig. 4), an oistodontiform.

Diagnosis

A species of *Drepanoistodus* with an oistodontiform which has a base that is short anteriorly and extended posteriorly. The cusp has an inner costa.

Description

This species consists of drepanodontiforms and oistodontiforms. The elements form a curvature transition series from procurved to reclined (oistodontiform). An erectid element can be separated, but is very rare. All the drepanodontiforms are referred to as curvatid elements.

Drepanodontiforms have a large keeled cusp filled with white matter. The cusp may be slightly twisted. The faces are smooth or may carry a broad carina. The anterior edge continues onto the base. It meets the aboral margin in a curve for the procurved elements or an angle in

recurved elements. The posterior keel continues on the oral edge on procurved elements or forms a sharp angle with the oral edge in erect and recurved elements. The aboral outline is convex in most specimens, but may be sinuous. The oral edge is keeled.

The oistodontiforms have a straight reclined cusp and a long keeled oral edge. The angle between cusp and oral edge is about 45 degrees. The aboral margin is convex and flares slightly to the inner side. It meets the anterior edge with an angle of almost 90 degrees.

Remarks

Barnes and Poplawski (1973) suggested that this species could belong to Paroistodus, whereas Landing (1976) included it in Drepanoistodus. The present material suggests that the elements should be included in the latter genus.

The species resembles D. basiovalis, but the oistodontiform has a longer posteriorly extended base.

The drepanodontiforms differ from other drepanodontiforms of Drepanoistodus in their higher base and angular junction of the cusp and the oral edge.

Occurrence

Very rare in most of lower Table Head; common in uppermost part of lower Table Head and lower part of middle Table Head.

Material

101 drepanodontiforms; 59 oistodontiforms.

DREPANOISTODUS TABLEPOINTENSIS n. sp.

Pl. 4 figs. 9-17.

Synonymy

cf. 1962 Oistodus forceps Lindström - Sweet and Bergström, p: 1231-1232, Pl. 168: 14-15; Text - fig. 2E.

1978 Drepanoistodus basiovalis m. s. (Sergeeva) - Tipnis et al., Pl. IX: 21.

Derivation of name

Table Point, Great Northern Peninsula, Newfoundland.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower middle Table Head, sample TP 68, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 19 (Pl. 4, fig. 10), an oistodontiform.

Description

The drepanodontiforms have a long and slender proclined to recurved cusp, which is laterally compressed and keeled. The faces are convex. The base is short and slightly excavated. The anterior part of the base may be flexed outward. The aboral outline is convex.

Oistodontiforms have a compressed pointed and keeled cusp. The antero-basal corner is relatively pointed to rounded. The angle of the base varies between 50 to 80 degrees. The base variably flares inward.

The oral edge is keeled and extends posteriorly one-third of the length of the cusp. The angle between cusp and oral edge varies from 20 to 40 degrees for forms with a weak inner flare to forms with a large flare, respectively. A weak inner carina on the cusp evolves with the angle as well.

Remarks

This species has a ratio of drepanodontiforms: oistodontiforms of 3:1. The species differs from its common associate D.? cf. D.? venustus by its shorter posteriorly extended base and the constant lack of a typical inner costa on the cusp of the oistodontiforms. Also the angle between the oral edge and the cusp is smaller in this species. The drepanodontiforms differ by the lack of costae. The drepanodontiforms cannot easily be separated from other species of Drepanoistodus of the North Atlantic Faunal Province.

The oistodontiforms are similar to ?Oistodus forceps s.f. sensu Sweet and Bergström (1962). The inner sinuous aboral margin of the Pratt Ferry forms is more pronounced than it is in the Table Head forms.

Occurrence

Sporadic in lower Table Head; common through middle Table Head.

Material

167 drepanodontiforms; 56 oistodontiforms.

DREPANOISTODUS? sp. cf. D? VENUSTUS (Stauffer)

Pl. 4 figs. 18-25.

Synonymy

cf. 1935a Oistodus venustus n. sp. - Stauffer, p. 146, 159, Pl. 12: 12.

1976 Drepanoistodus suberectus forceps (Lindström) - Dzik, fig. 19, e, g.

1978 Drepanoistodus? cf. venustus (Stauffer) - Löfgren, p. 56-57, Pl. 1: 7-8.

1978 Drepanoistodus? venustus (Stauffer) - Löfgren, p. 57, Pl. 9-10.

non 1969 Oistodus venustus Stauffer - Bradshaw, p. 1158, Pl. 134: 4-7.

non 1970 Oistodus venustus Stauffer - Uyeno and Barnes, p. 110, Pl. 21: 6-7.

Diagnosis

An apparatus with costate, short to long base oistodontiforms, and costate drepanodontiforms.

Description

Oistodus venustus Stauffer (1935a) s.f. is a very characteristic oistodontiform with sharp keels, well developed costae on the cusp and a long base. It has commonly been reported, but has yet to find its place in multi-element taxonomy.

Bergström and Sweet (1966) and Sweet and Bergström (1972) were not able to connect the venustus-element to any multi-element genera. Barnes and Poplawski (1973) proposed that the venustus-element was part of Acodus? mutatus. Lindström (1971, p. 43) suggested that Oistodus

venustus s.f. was coupled with drepanodontiforms and formed a Drepanoistodus apparatus. A similar approach was tried by Löfgren (1978), but she was not convinced, and she concluded that Oistodus venustus s.f. could be the only type of element in the skeletal apparatus of the species.

One major problem with the venustus apparatus is that it may have included drepanodontiforms, but if so they are indistinguishable from those of other species of Drepanoistodus, with which O. venustus s.f. is commonly associated. For example, specimens of D. suberectus (Branson and Mehl) s.f. are present with O. venustus s.f. (Bergström and Sweet 1966; Webers 1966) or with D. basioyalis (Löfgren 1978). If the approach introduced by van Wamel (1974) and Dzik (1976) is applied the problem may only be minor.

In the material at hand both costate and weakly costate oistodontiforms are present with intermediate forms. This is similar to Webers (1966, p. 34-35), who also referred both costate and acostate elements to Oistodus venustus s.f. In addition, uni-costate to multi-costate drepanodontiforms occur with O. venustus s.f. throughout the sequence, and they are interpreted as part of the Drepanoistodus? venustus apparatus.

Description

The drepanodontiforms are uni-costate to multi-costate with intermediate elements as common associates. Curvatid elements may have an antero-basal pointed flange which may be flexed inwards. Some elements are very strongly flexed and have an outer convex face of the cusp, which may be expressed as a carina or one or two costae. The inner face

may carry one or two costae.

The erectid element is easy to distinguish. It has a large cusp which may carry a carina on each side of the cusp or one or two costae on each side. The base is variously extended anteriorly and posteriorly. The base is often wide and the basal cavity is underneath the whole base. The drepanodontiforms form a gradual and complete curvature transition series.

The oistodontiform - or venustus-element - has a pronounced costa on one side or both sides of the cusp and a rounded basal margin. The upper part of the cusp bends characteristically upwards or in an anterior direction. The antero-basal corners vary from sharply pointed to rounded and may reach over half the length of the cusp. The angle between the cusp and the oral edge varies from 20 to 30 degrees.

Remarks

The apparatus proposed herein is unusual for Drepanoistodus in the sense that the drepanodontiforms can be multicostate. Earlier species, however, do include uni-costate elements, for example, van Wamel (1974) described Drepanoistodus forceps with an apparatus including an acodontiform (Acodus gratus s.f.). Development of more costae is considered possible during growth or as a response to changes in the environment. Thus, increases in energy may support the creation of many costae, which may serve as muscle attachment areas similar to the ones described by Lindström and Ziegler (1971).

The costate elements could be confused with those of Walliserodus, but in Walliserodus they form a symmetry transition series, which includes a symmetrical element with anterior rounded face. The drepano-

dontiforms described above form a curvature transition series typical for Drepanoistodus. Thus, the main reason for grouping these elements together in the same apparatus is their generally similar morphologies. Except for the costae the elements would with no doubt be identified as drepanodontiforms of Drepanoistodus.

Occurrence

Present in lower Table Head, common in middle Table Head.

Material

547 drepanodontiforms; 256 oistodontiforms.

Genus PALTODUS Pander 1856

Type Species - Paltodus subaequalis Pander 1856.

Remarks

According to Lindström (1971) Paltodus includes drepanodontiforms with a "triangular base and a suberect to moderately recurved cusp". Costae may be present. The oistodontiforms have a base, which extends "about as far anteriorly as it does posteriorly".

Van Wamel (1974) allocated Paltodus to Drepanoistodus. Both Dzik (1976) and Löfgren (1978) considered Paltodus valid as a genus of its own. This is accepted here.

PALTODUS? sp. cf. P? JEMTLANDICUS Löfgren

Pl. 4 figs. 26-33.

Synonymy

1976 ? Paltodus (?) sp. - Dzik, fig. 18a.

1978 Paltodus? jemtlandicus n. sp. - Löfgren, p. 65-66, Pl. 4: 1-3, 6-10.

?1978 Gen. et sp. idet. A - Löfgren, p. 118, Pl. 4: 12.

Description

This apparatus consists of noncostate drepanodontiforms with a plano-convex base and oistodontiforms with a slight inner flare of the base.

The drepanodontiform is laterally compressed, and in side view it has a triangular base. The cusp is keeled and curves smoothly onto the straight and keeled oral edge. The aboral outline is straight and meets the anterior margin of the base at an angle of 90 degrees. The anterior part of the base may have an inner flare. The cross-section of the base varies from oval to plano-convex.

The oistodontiform has an anterior extension of the base of about similar length to its posterior extension. It is slightly asymmetrical due to an inner flare of the base. The cusp is large and keeled. The sides of the cusp are smooth.

Remarks

The number of elements is small in each sample. The basal outline of the oistodontiform varies, thus some are quite similar to the

oistodontiform described by Löfgren (1978) as Gen et sp. indet, A, which is tentatively included in the synonymy.

The base of the drepanodontiform varies and may sometimes by indistinguishable from that of the drepanodontiform of Parapaltodus flexuosus as noted by Löfgren (1978). In the Table Head material the color of Paltodus? jemtlandicus elements are always dark-brown with a black colored base. Drepanodontiforms of Parapaltodus flexuosus have a light-brown colored base.

Occurrence

Lower and middle Table Head.

Material

32 drepanodontiforms; 29 oistodontiforms.

Genus PAROISTODUS Lindström 1971

Type species - Oistodus parallelus Pander 1856.

Discussion

Lindström (1971) defined this genus to consist of drepanodontiforms and oistodontiforms only. Van Wamel (1974) revised this definition to include scandodontiforms, but these are in fact slightly asymmetrical drepanodontiforms, and the term drepanodontiform is preferred in this study.

In the present collection oistodontiforms with an outline similar to O. originalis Sergeeva s.f. are present. These could be interpreted as part of a Paroistodus apparatus. The problem, however, is that the oistodontiforms are not only abundant, sometimes dominating in the

collection, but also no drepanodontiforms are represented. A similar dominance of oistodontiforms is found in the Mystic Conglomerate and there no drepanodontiforms were found either (Barnes & Poplawski 1973, Table 1).

It is therefore considered likely that this species only has one kind of element in the apparatus. If so the present apparatus represents a genus of its own. The elements are, however, tentatively included in Paroistodus in this study.

A possible allocation of the elements to Cordylodus? horridus was commented upon under that species.

PAROISTODUS ? sp. cf. P. ORIGINALIS (Sergeeva)

Pl. 5 figs 1-4.

Synonymy

1969 Oistodus venustus Stauffer - Bradshaw, p. 1150, Pl. 134: 4-7.

1970 Oistodus venustus Stauffer - Uyeno and Barnes, Pl. 21: ?6, 7.

1973 Paroistodus aff. P. originalis (Sergeeva) - Barnes and Poplawski, p. 779-780 (pars), Pl. 4: 12 only.

Diagnosis

The oistodontiform has a posteriorly extended base. The species lacks drepanodontiforms.

Description

The oistodontiform has a large, straight cusp and a posteriorly extended base. The base may extend up to two-thirds the length of the cusp. The aboral outline is concave in large specimens but straight in

small specimens. Large forms have a short anterior base which meets the anterior keeled edge of the cusp at an angle of 90 degrees. The anterior part of the base may be inverted. The cusp is strongly reclined and parallel to the aboral margin. A broad carina is present on the inner side of the cusp. The basal cavity occupies the full length of the base.

Remarks

The oistodontiform is similar to that of P. originalis. It differs from the older species by its concave outline of the aboral margin, and the longer base.

Löfgren (1978, p. 70) found that a younger (early Llanvirn) possibly new species of Paroistodus sporadically occurred in her material. This species may be conspecific with the Table Head species. Her figured elements (Löfgren, 1978, Pl. 1, figs. 22-24, ?25), however, belong to Paroistodus originalis.

Barnes and Poplawski (1973) interpreted Paroistodus? sp. cf. P. originalis as the ancestor of Oistodus venustus s.f. The figured elements of Barnes and Poplawski (1973) do not resemble Oistodus venustus Stauffer s.f., and are probably misidentified (see also discussion in Löfgren, 1978, p. 70). Oistodus venustus s.f. is included in a Drepanoistodus apparatus by Lindström (1971) and in this study.

The species is at present interpreted to form a single element apparatus. The morphological similarity to oistodontiform of Paroistodus indicates a close relationship with Paroistodus originalis. If so, the drepanodontiforms may either have been lost during evolution or if present be of another morphology (see discussion of Cordylodus? horridus).

Occurrence

Sporadic in lower Table Head, common to dominating in middle Table Head.

Material

834 specimens.

PAROISTODUS? sp. A

Pl. 5 figs. 5-6.

Synonymy

? 1978 Paroistodus originalis (Sergeeva) - Löfgren, p. 69-71 (pars), Pl. 1: 25, only.

Description

Oistodontiforms with a strongly reclined cusp. The cusp is keeled and the faces are convex, it is slightly twisted inward. The base is large; it has a keeled oral edge and a straight aboral outline, which is parallel to the cusp. It meets the cusp at an angle of 90 degrees. One or two radial costae may be present between the cusp and the base. The basal cavity is large and occupies the whole base.

No associated drepanodontiforms were recovered.

Remarks

The oistodontiform resembles oistodontiforms of Paroistodus, and is tentatively included in that genus. The element is unlike other hitherto described species of Paroistodus. The oistodontiform of P. originalis in Löfgren (1978) has a similar appearance as the Table Head

species but it lacks costae on the base.

Occurrence

Upper lower Table Head.

Material

4 specimens.

PAROISTODUS? sp. B.

Pl. 5 figs. 7-8

Synonymy

? 1965a Oistodus pseudomulticorrugatus n. sp. - Mound, p. 29, Pl. 4: ?3, ?4, ?5, 8, 9; ? Text - fig. 1H.

Description

Oistodontiforms with a small base and a large cusp. The cusp is straight to slightly bent outward with an anteriorly placed rounded carina and a sharp posterior keel. The anterior margin is weakly keeled. The apex of the cusp is rounded rather than pointed.

The oral edge is keeled, short and straight. The aboral outline is straight or convex. The aboral margin meets the anterior edge in an angle of about 80 degrees. The lower inner side of the base may be flared.

Remarks

These elements are tentatively placed in Paroistodus, but no additional drepanodontiforms were recovered. The elements morphologically resemble the oistodontiforms described by Mound (1965a) as Oistodus

pseudomulticorrugatus s.f. The larger specimens as depicted by Mound have not been recorded, but the present material is far too sparse to evaluate the species.

Occurrence

Upper part of lower Table Head.

Material

3 specimens.

Family UNCERTAIN

Genus STRACHANOGNATHUS Rhodes 1955

Type Species - Strachanognathus parvus Rhodes 1955.

Remarks

The variation of the Strachanognathus apparatus was described by Bergström (1961), and Sweet and Bergström (1962). No additional elements have been found, which could be included in the apparatus (Sweet and Bergström, 1972). The elements of the apparatus form a curvature transition series combined with a symmetry transition series. This is similar to Distacodontidae. The additional anterior denticles and the lack of oistodontiforms separates Strachanognathus from Distacodontidae.

STRACHANOGNATHUS PARVUS Rhodes

Pl. 5 fig. 9.

Synonymy

1955 Strachanognathus parvus gen. et sp. nov. - Rhodes, p. 132, Pl. 7: 16, Pl. 18, figs. 1-4.

1978 Strachanognathus parvus Rhodes - Löfgren, p. 112-113, Pl. 1: 29. (Synonymy).

1979 Strachanognathus parvus Rhodes - Kennedy, Barnes and Uyeno, p. 550, Pl. 1: 24. (Synonymy)

Description

Elements of Strachanognathus parvus with an inwardly flexed cusp and with a small base. The unit has a proclined to suberect cusp. The anterior denticle is about two-thirds the height of the main cusp. The aboral outline is convex.

Occurrence

Top of middle Table Head.

Material

4 specimens.

Superfamily PANDERODONTACEA Lindström 1970

Diagnosis

Apparatus of mostly simple conodonts, commonly with longitudinal striations along the cusp. Some elements may have a row of denticles posteriorly. The apparatus usually forms a symmetry transition series.

Discussion

Lindström (1970) divided Panderodontacea into the two families Acanthodontidae and Panderodontidae. The first was subdivided into Acanthodontinae and Protopanderodontinae. Lindström & Ziegler later (1971) referred Protopanderodontinae to its own family. Protopanderodontinae has been included in Distacodontacea in this study, because Protopanderodus is considered to be closely related to Drepanodus.

By definition, the presence of longitudinal striations on the cusp is important in the Panderodontacea. Lindström & Ziegler (1971), Barnes et al. (1973c) and Barnes & Slack (1975) described the ultrastructure of panderodontacean elements. Species of Acanthodontidae have moderate longitudinal striations, whereas Panderodontidae carry abundant longitudinal striae and may display a "radial lamellar" structure (Barnes & Slack, 1975). The genera Cornuodus, Scalpellodus and Belodella carry fine to well-defined striations. Scolopodus (sensu Lindström, 1971) and Walliserodus apparently do not show any surface ornamentation in the Ordovician (Löfgren, 1978), but are present on elements of Walliserodus in the Silurian (Cooper, 1975). Semiacontiodus carries clearly visible fine striations on the base and along the cusp.

The Acanthodontidae are of Midcontinent Faunal Province affinity. According to Barnes & Slack (1975) most genera have an apparatus which forms a symmetry transition series including an antero-posteriorly compressed element, whereas Acanthodus apparently forms an apparatus of rounded to laterally compressed posterior keeled elements with a deep base (Moskalenko, 1972).

Panderodontidae includes elements with a very deep conical basal cavity and a relatively small cusp, which is conspicuously ornamented with longitudinal striations. Genera of Panderodontidae appear in the two major provinces.

A group of genera such as Scalpellodus, Belodella, Cornuodus, Scolopodus and Walliserodus cannot conclusively be placed in Panderodontidae due to the lack of the distinctive furrows diagnostic of Parapanderodus n. gen., Panderodus and some species of Semiacontiodus. Scalpellodus, Belodella and Parapanderodus appear in marginal zones of the two major provinces.

These facts in combination constitute the basis for a subdivision of Panderodontacea into three families. A further subdivision at the suprageneric level is possible, however, more information is necessary and must await a detailed study of large collections.

Panderodontacea probably evolved from Semiacontiodus.

## Family ACANTHODONTIDAE Lindström 1970

### Discussion

Lindström (1970) defined Acanthodontidae as follows: "Species with a relatively long and slender suberect cusp, and the basal cavity not much wider than the cusp. The longitudinal striations, if present, are inconspicuous. Some forms have a couple of lateral longitudinal costae or grooves". Lindström (1970) listed Acanthodus Furnish as the only genus.

Other genera that belong within Acanthodontidae are Juanognathus Serpagli, Staufferella Sweet, Thomson and Satterfield, Trigonodus Nieper

and Ulrichodina Furnish.

Many elements of Acanthodontidae have been described as form species of the form genera Acodus, Acontiodus, Paltodus and Scolopodus. Acodus, Paltodus and Scolopodus have been redefined in multielement taxonomy (Lindström 1971; McTavish 1973), and are not considered related to Acanthodontidae.

The status of Acanthodus is unsettled, as the nature of the apparatus of the type species is so far unknown. Moskalanko (1972), however, described a series of denticulate elements forming a symmetry transition series. The elements are laterally compressed and have deep basal cavities.

Two groups of undoubted suprageneric significance, therefore, can be recognized among the acanthodids. The first group includes Juanognathus, Staufferella, Trigonodus and Ulrichodina with elements which are erect and may be twisted, have shallow basal cavities and a convex anterior margin. This group probably evolved from Semiacontiodus. Ulrichodina may belong within an early stage of the evolution. The group is included in Trigonodoninae n. subfam.

The second group includes Acanthodus. If the compound conodonts described by Moskalenko (1972) are true acanthodids an evolution from simple conodonts with a subelliptical cross-section of the cusp and base to laterally compressed denticulate conodonts with deep basal cavities can be compared with the evolution within Cornuodontidae n. fam. This second group comprises the subfamily Acanthodontinae Lindström 1970.

## Subfamily TRIGONODONTINAE n. subfam.

### Diagnosis

Conodont apparatuses of simple cones with mostly subelliptical cross-section of the cusp and base. The conodonts may be antero-posteriorly compressed with a convex anterior surface. The elements have a shallow basal cavity. The apparatus forms a symmetry transition series. Some of the skeletal elements are characteristically twisted.

### Remarks

The subfamily probably also include the Silurian genus Decoriconus Cooper.

## Genus JUANOGNATHUS Serpagli 1974

Type Species - Juanognathus variabilis Serpagli 1974.

### Diagnosis

Juanognathus includes paired antero-posteriorly compressed simple cones with alate lateral sides forming a symmetry transition series. Elements do not show conspicuous striations.

### Remarks

Juanognathus has an apparatus similar to Staufferella. The elements in Staufferella are, however, more rounded than those of Juanognathus.

JUANOGNATHUS SERPAGLIEI n. sp.

Pl. 5 figs. 10-20.

Synonymy

1979 Juanognathus aff. J. variabilis Serpagli - Harris et al., Pl. 1: 3-5.

cf. 1974 Gen. nov. B - Cooper and Druce, p. 579, fig. 30.

cf. 1973 Protopanderodus? tricarinatus - Barnes and Poplawski, p. 784, Pl. 1: 5; Text - fig. 2B.

? 1973 Protopanderodus? sp. - Barnes and Poplawski, p. 785, Pl. 1: 15.

Derivation of name

Dr. E. Serpagli. Professor at Modena University, Modena, Italy.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower middle Table Head, sample TP 66, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 27 (Pl. 5 fig. 17), a symmetrical element.

Diagnosis

A Juanognathus with lateral, alate, horizontal keels on the symmetrical element.

Description

The apparatus includes a symmetrical element and a prograding series of asymmetrical elements. The elements have a large recurved cusp and a short base.

Symmetrical element

The symmetrical element has a laterally keeled cusp. The keels project as short alate undenticulated processes. The anterior face is convex whereas the posterior face is posteriorly concave, it has a median carina that extends from the apex to the aboral margin. The posterior carina is flanked by two deep longitudinal grooves and it may bear a small median furrow that extends the full length of the carina. The basal cavity is narrow and only developed as a slit beneath the processes. The anterior aboral margin is horizontal and has a median notch. The posterior aboral margin forms a median concave curve.

Asymmetrical element

The asymmetrical elements are generally similar to the symmetrical element. During increasing asymmetry the outer lateral process becomes longer and projects in a posterior direction. The inner lateral process conversely is reduced in size and ultimately disappears. The anterior notch on the aboral margin, the basal cavity and the central anterior carina are gradually reduced, and may disappear with the increasing asymmetry.

A thickened rim along the aboral margin is well developed. In many elements black basal filling may be preserved in the basal cavity.

Remarks

No microstructure such as striations has been observed.

Landing (1976) described an antero-posterior compressed element which resembles Juanognathus serpagliei. His element has conspicuous striations, unlike the Table Head species. It also has a weakly developed median carina.

The Mystic species Protopanderodus? tricarinatus Barnes & Poplawski (1973) is narrower and higher than any of the Table Head specimens. The generic assignment of this element is not certain, but probably represents a species of Juanognathus.

Protopanderodus? sp. differs from J. serpagliei n. sp. by its large basal cavity, and also more rounded cross-section of the element.

Gen. nov. B. Cooper and Druce probably is a species of Juanognathus. The asymmetrical element has a median groove. Perhaps Gen. nov. B and Protopanderodus? tricarinatus Barnes & Poplawski form an apparatus of an older species of Juanognathus than that from the Table Head Formation.

Occurrence

Lower Table Head and lower middle Table Head.

Material

51 symmetrical elements; 103 symmetrical elements.

## Genus TRIGONODUS Nieper 1969

Type Species - Trigonodus triangulatus Nieper sp. nov..

Discussion

Trigonodus Nieper was defined (in Hill et al., 1969) as follows: "Trigonodus gen. nov. Simple symmetrical conodonts with deep, conical basal cavity and triangular basal cross section. Anterior margin smooth, flattened or broadly convex; posterior margin sharp or keeled. Prominent keeled anteriolateral costa on each lateral face." As type species T. triangulatus Nieper sp. nov. (Pl. O VII, fig. 22 in Hill et al. 1969 s.f. The diagnosis of Trigonodus is emended to:

The multi-element genus Trigonodus Nieper has an apparatus of simple costate cones with a rounded base forming a simple symmetry transition series, which includes acontiodontiform (Trigonodus s.f.), paltodontiforms and scandodontiforms. All elements are hyaline.

The genus includes the form species described as Acodus campanula, s.f., Acontiodus curvatus s.f., Scandodus sinuosus s.f. and Scolopodus quadraplicatus s.f. from the Joins Formation (Mound, 1965a).

The relationship of Trigonodus to the Lower Ordovician multi-element genus comprised by hyaline simple cones including Scolopodus quadraplicatus Branson and Mehl s.f. has not been established. The general outline of these units indicates that they may be congeneric with Trigonodus Nieper.

Trigonodus and Decoriconus Cooper are similar in their apparatus composition and elements. The genera may be closely related. Trigonodus resembles Semiacontiodus Miller. It differs by the inclusion of palto-

dontiforms in the apparatus, and in being hyaline.

Barnes (in Workum et al. 1976) described elements similar to Trigonodus, but he included these elements in Eoneoprioniodus (Barnes, 1977). Eoneoprioniodus has an oistodontiform in the apparatus.

TRIGONODUS CARINATUS n.sp.

Pl. 6 figs. 1-7

Synonymy

1969 Trigonodus sp. nov. - Hill, Playford and Woods, p. 0.14, Pl. OVII: 23.

cf. 1965a Acodus campanula n.sp. - Mound, p. 8-9, Pl. 1: 19-21; Text - fig. 1D.

cf. 1965a Acontiodus curvatus n. sp. - Mound, p. 11-12, Pl. 1: 19-21; Text - fig. 1D.

cf. 1965a Drepanodus subarcuatus Furnish - Mound, p. 19, Pl. 2: 14, 18, 19.

cf. 1965a Scandodus sinuosus n. sp. - Mound, p. 33-34, Pl. 4: 21-22, 24; Text - fig. 1J.

cf. 1965a Distacodus symmetricus n. sp. - Mound, p. 16, Pl. 2: 1-3; Text - fig. 1E.

aff. 1971 Acontiodus? curvatus Mound - Sweet, Ethington and Barnes, p. 173, Pl. 2: 35

aff. 1971 Acontiodus coniformis Fåhraeus - Sweet, Ethington and Barnes, p. 173, Pl. 2: 20.

aff. 1971 Distacodus symmetricus Mound - Sweet, Ethington and Barnes, p. 173, Pl. 2: 34.

Derivation of name

Most of the elements have carinae.

Type locality

Table Point, Great Northern Peninsula, Newfoundland

Type stratum

Lower Table Head, sample TP 25, Histiodella tableheadensis Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 29 (Pl. 6 fig.5 ), an acontiodontiform.

Diagnosis

The acontiodontiform has three notches on the aboral margin of the base.

Description

This species has symmetrical bi- and tricostate drepanodontiforms (acontiodontiforms), asymmetrical tri- and quadracostate distacodontiforms and a twisted drepanodontiform (scandodontiform) in its apparatus. The elements form a simple curvature transition series.

Acontiodontiform

The symmetrical acontiodontiform is proclined to recurved with two lateral costae on the cusp and one posterior median costa. The lateral costae continue onto the base and may reach the aboral margin. The anterior margin of the cusp is convex, and the posterior faces are flat or slightly convex. The posterior keeled costa continues from the cusp

to the basal margin. The cross-section of the base is triangular with rounded sides. The aboral margin has a convex outline. It has three pronounced slits at the junction of the costa and the aboral margin. The basal cavity has an anteriorly directed tip. Some specimens may have additional costae on each side of the posterior median costa.

Distacodontiform

The distacodontiform is proclined to recurved and with twisted cusp and rounded to oval base. The costae extend down to the aboral margin. The outer side of the cusp is convex. The inner side is convex, with a broad carina or costa.

Transitional forms between tri-, and quadra-costae elements are present, i.e., having broad carina at the place where the new costae evolve. Elements with five costae are also present.

Scandodontiform

The scandodontiform is proclined to recurved. The cross-section of the base is circular to oval. The faces of the cusp are convex. The cusp is sharply keeled. Transitional forms between distacodontiforms and scandodontiforms are present, i.e., having an inner carina where the costa of the distacodontiform is present.

Remarks

The species from the Joins Formation described by Mound (1965a) differs in the shape of the base, and it does not have a slit. The Joins fauna is considered to contain an older related species. Although the posterior and antero-lateral costae are sharp-edged in the Table Head material, they do not develop into incipient processes as in the Joins

and Kanosh faunas (see Sweet *et al.*, 1971, Pl. 1, figs. 20, 34, 35).

Occurrence

Lower part of lower Table Head.

Material

146 acontiodontiforms; 657 distacodontiforms; 793 scandodontiforms.

TRIGONODUS RECTUS n. sp.

Pl. 6 figs. 10-12.

Synonymy

? 1970 *Acontiodus* sp. 2 - Uyeno and Barnes, p. 104, Pl. 21: 4-5;
Text - fig. 7I.

Derivation of name

The cusp is erect in all specimens.

Type locality

Back Arm East, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, from Gargamelle Cove W, sample GCW 1, *Trigonodus carinatus* Biointerval-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 32 (pl. 6 fig. B), an acontiodontiform.

Diagnosis

The species forms a symmetry transition series due to progressive twisting of the cusp.

Acontiodontiform

The acontiodontiform has an erect to slightly proclined cusp with an anterior convex face. The cusp has two lateral median grooves and one posterior median groove. The grooves are framed by well-developed carinas. The base is wide with an open shallow basal cavity. The unit is slightly asymmetrical due to a lateral bend of the upper part of the cusp near the apex, and due to the slight difference in the flaring of the base. The asymmetrical units are transitional to the distacodontiform.

Distacodontiform

The distacodontiform is similar to the acontiodontiform, but is asymmetrical. The asymmetry is formed by the rotation of the cusp and a corresponding moving of the posterior lateral costa toward the lateral side of unit.

Scandodontiform

A scandodontiform has not been recorded, possibly due to the small collection at hand. A transitional element with one inner lateral groove is included as a scandodontiform. The specimen has one inner carina and two antero-posterior carinas.

Remarks

All the elements are prominently striated on the surface. Trigonodus rectus n. sp. resembles the closely related Scolopodus quadraplicatus Branson and Mehl s.f. The Table Head specimens differ by the lateral bend of the upper part of the cusp and by the wide open base.

Scolopodus quadraplicatus has not yet been established in multielement taxonomy. Its apparatus appears to be identical with Trigonodus rectus n. sp. (Nowlan, pers. comm., 1980) and possibly the generic assignment has to be re-evaluated for Trigonodus rectus. At present the Table Head specimens fit within the definition of Trigonodus.

In form-taxonomy the Acontiodus sp. 2 of Uyeno and Barnes (1970) could be identified with the distacodontiform of the Table Head material. It mainly differs by its sharp costae, whereas the Table Head elements carry carinas.

Occurrence

Top of the St. George Group and basal Table Head Formation.

Material

6 acontiodontiforms; 16 distacodontiforms; 2 scandodontiforms.

Genus ULRICHODINA Furnish 1938

Type Species - Ulrichodina prima Furnish 1938

Remark - Ulrichodina Furnish includes simple conodonts with bilaterally symmetrical cusp with a rounded anterior margin. The genus has not been established in multielement taxonomy.

ULRICHODINA? sp. A s.f.

Pl. 6 figs. 8-9

Description

The elements have a small base and a large, proclined cusp. The cusp is pointed. The anterior margin of the cusp is convex. The lateral faces are straight and the posterior margin is keeled. This posterior keel continues onto the oral edge to the aboral margin. The aboral outline is straight. The aboral margin meets the oral edge with an angle of 90°. The anterior part of the base bends into the cusp and is smooth. The base has a triangular cross-section with rounded corners. The basal cavity is a small funnel and is commonly filled by black-colored basal matter. The cusp is filled by white matter.

The specimens are fully striated on the base and continue onto the cusp along the posterior keel. A rim next to the aboral margin does not show any surface ornamentation.

Remarks

The cross-section of the cusp is similar to that of Ulrichodina, but an anteriorly infolded base is not present in the Table Head species. Hence, the generic assignment is querried.

Occurrence

Lower Table Head.

Material

17 specimens.

## Family CORNUODONTIDAE n. fam.

### Diagnosis

Simple conodonts with relatively long and/or high bases and deep basal cavities. Longitudinal striations, if present, are inconspicuous in early genera and increase in distinctiveness during evolution. Some forms have longitudinal costae. Some forms have denticles posteriorly on the base.

### Remarks

Cornuodontidae n. fam. includes Cornuodus, Scalpellodus, Belodella, Walliserodus, Pseudooneotodus and perhaps Scolopodus.

Cornuodus evolved from Semiacontiodus, and it is the ancestor to Scalpellodus, Belodella and possibly Walliserodus (Dzik 1976).

## Genus BELODELLA Ethington, 1959

Type species - Belodus devonicus Stauffer, 1940.

### Discussion

The history of Belodella has been reviewed by Serpagli (1967) and Löfgren (1978). Löfgren (1978) proposed an apparatus including adenticulate and denticulate elements, both of which display a symmetry transition series, and an oistodontiform. The abundant material at hand supports the apparatus proposed by Löfgren, and it is considered valid. The choice, however, of the genus name and the choice of the Devonian form species Belodus devonicus Stauffer s.f. as the type species may be debated for the Ordovician apparatus.

The oistodontiform has not been found in Silurian (Cooper, 1974, 1976) and Devonian Belodella apparatuses (Clark & Ethington, 1966; Fåhraeus, 1971; Chatterton, 1974). Thus the Silurian and Devonian apparatus is quite different from the Ordovician apparatus. The choice of B. devonicus Stauffer, 1940 as a type may be correct for the Devonian Belodella, but it is far from certain that this is the case for the Ordovician species referred to Belodella. The apparent similarity of the denticulate forms may be a question of homeomorphy.

BELODELLA JEMTLANDICA Löfgren

Pl. 6 figs. 13-23; Pl. 7 figs. 1-4

Synonymy

1970 Belodella sp. A - Fåhraeus, p. 2064, Fig. 3(0)

1978 Belodella jemtlandica n. sp. - Löfgren, p. 46-49, Pl. 15: 1-8; Text - fig. 24 A-D.

cf. 1967 Belodella erecta (Rhodes and Dineley) - Serpagli, p. 54-55, Tav. 11: 1a-6c.

cf. 1967 Drepanodus amplissimus n. sp. - Serpagli, p. 66, Tav. 15: 1a-5b.

cf. 1967 "Oistodus" pseudorobustus n. sp. - Serpagli, p. 80-81, Tav. 21: 1a-4d.

Description

The elements of B. jemtlandica were fully described by Löfgren (1978). Some comments will, however, be made because the apparatus appears to be more variable than surmised by Löfgren.

Four element types characterize Belodella: (1) undenticulate biconvex to plano-convex elements, (2) denticulated plano-convex elements, (3) denticulated triangular elements, and (4) oistodontiforms.

Undenticulated biconvex - planoconvex element

The element is characterized by a base that is about two-thirds the length of the whole unit. In the Table Head specimens the symmetrical forms (biconvex forms) are less common that the asymmetrical forms with a broad carina on the outer side. The asymmetrical forms have an almost plane inner side. The aboral outline is slightly concave. The anterior keel of the base disappears a little before the aboral margin and a narrow rim of small wrinkles is developed. The upper margin of the basal cavity is straight and the tip is directed anteriorly. The tip is located close to the anterior margin of the base.

The element is highly striated on the anterior keel beneath the anterior carina.

Denticulate plano-convex element

The denticulation, the length of the base, and the degree of torsion of the cusp varies. The denticulation can be finely hairlike or the denticles can be wider and apically free. The fine hairlike denticles are usually short and the wider ones are higher. The elements may be plano-convex to asymmetrically triangular due to the development of an outer antero-lateral carina/costa. The strongly twisted elements are similar to those described by Löfgren (1978; Pl. 15, fig. 4). The less twisted elements have coarser denticles and an outer antero-lateral carina.

The elements are typically striated on forms developing an outer lateral carina-costa. These elements evolve prominent striations between the anterior inner keel and the anterior lateral carina. The remaining elements are nonstriated as noted by Löfgren (1978). All elements are characterized by the "wrinkles" at the aboral/anterior base junction.

Denticulated triangular element

In addition to the elements described by Löfgren elements with coarser denticulation as well as elements with hairlike denticulation are included. The elements vary in the length of the base, and long-base variants often carry the hairlike denticles. All the elements have a procurved cusp.

The elements are prominently striated on the anterior rounded margin of the cusp. The striations continue onto the anterior lateral costae. The concave area of the base separating the costae is non-striated. Inconspicuous striations have been observed on the faces of the base.

The elements have the basal "wrinkles" similar to non-denticulated and plano-convex denticulated elements.

Oistodontiform

Two morphotypes can be distinguished. One type of oistodontiform has a cusp/oral edge angle of 80 degrees. The second has a sharper cusp/base angle and the cusp becomes parallel with the aboral margin. The latter type has faint striations on the face at the cusp/base junction. The elements are characterized by a straight aboral outline, an anterior basal margin of equal length as the oral edge, giving an equi-lateral triangular outline of the base when seen in lateral view. Also, a small

tongue-like posterior extension of the oral edge is characteristic.

Remarks

The higher degree of variation displayed by Table Head forms than that of Swedish forms is due to the inclusion of elements with a base of varying length. The elements form a symmetry transition series, and they are similar to Belodella devonica (Stauffer) s.f. These elements are considered to be variants of the B. jemtlandica apparatus.

The relationship to B. sinuosa n. sp. and B. nevadensis (Ethington & Schumacher) is discussed under B. sinuosa n. sp.

The species from the Carnic Alps (Serpagli, 1967) has not been established in multi-element taxonomy. The descriptions of Serpagli (1967), however, suggest that a complete (Ordovician) Belodella type of apparatus is present. Also, it is a B. jemtlandica type of apparatus. Drepanodus amplissimus n. sp. Serpagli (i.e., 1967, Tav. 15, figs. 1-5) is the undenticulate biconvex-planoconvex element. Belodella erecta (Tav. 11, fig. 1) may belong to this group as a denticulated variant. The denticulate plano-convex and triangular element is represented by Belodella erecta (Tav. 11, figs. 2-6). "Oistodus" pseudorobustus n. sp. Serpagli (Tav. 21, figs. 1-4) completes the apparatus as the oistodontiform.

"Oistodus" pseudorobustus has an equi-lateral triangular base with a straight aboral outline, and it resembles the oistodontiform of Belodella jemtlandica. The Carnic Alp species differs from B. jemtlandica by its larger basal cavity with a tip that extends up into the cusp on the undenticulate and denticulate elements. In Belodella jemtlandica the tip does not extend up into the cusp.

Occurrence

Lower and middle Table Head.

Material

373 undenticulated elements; 538 denticulated elements; oistodontiforms.

BELODELLA SINUOSA n. sp.

Pl. 7 figs. 5-14.

Synonymy

? 1973 Belodella erecta (Rhodes and Dineley) s.f. - Barnes and Poplawski, p. 769, Pl. 4: 19, 20.

1973 Belodella n. sp. s.f. - Barnes and Poplawski, p. 769, Pl. 4: 5, 9, 10, 18, 18a; Text - fig. 2F.

1978 Belodella sp. A Fåhraeus - Fåhraeus and Nowlan, p. 461, Pl. 3: 21.

non 1970 Nordiodus sp. A - Fåhraeus. p. 2064, fig. 3(N).

Derivation of name

The outline of the aboral margin of the oistodontiform is sinuous.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 55, Histiodella tableheadensis phylo-zone late Whiterockian (early Llanvirnian).

Holotype

MUNSS 35 (Pl. 7, fig. 10), an oistodontiform.

Diagnosis

Undenticulate elements with a well-developed antero-lateral costa, and a basal cavity, which occupies one-half or less of the length of the unit. Denticulate elements with a procurved to recurved cusp and high denticles. Oistodontiforms have a sinuous aboral outline. The lower margin of the basal cavity is concave and the tip is directed anteriorly in all specimens.

Description

Löfgren (1978) labelled elements of Belodella: undenticulated biconvex, denticulate plano-convex, denticulate triangular, and oistodontiforms.

Undenticulate biconvex element

The unit has an erect to procurved cusp. It is laterally compressed with a high base. The aboral outline is straight to concave. The cusp may be larger than the base. In side view the basal cavity is triangular with a concave anterior margin and a straight to concave posterior margin. The element has sharp posterior and anterior edges. The element varies from almost symmetrical to asymmetrical. The unit has an anterior lateral costa on the base which continues onto the cusp as a broad carina. The element has characteristic striations on the surface along the anterior keel. The edge along the aboral margin is characteristically "wrinkled".

Denticulated plano-convex element

This element has an erect to proclined cusp, a denticulated oral edge and deeply excavated base. In lateral view the basal cavity is deep, triangular with an anterior concave margin and a posterior concave to straight margin. The tip is anterior. The oral edge carries up to ten slender, laterally compressed and basally fused proclined denticles. The denticles increase in size toward the cusp. In some forms the denticles extend up along the cusp. Variation of degree of asymmetry is commonly associated with the length of the base. The most asymmetrical units have a shorter base than those with a smaller torsion of the cusp.

Denticulated triangular element

The cusp is erect to proclined and is provided with two lateral costae, which continue to the anterior margin of the base. The anterior margin of the cusp is convex. The anterior edge of the base is concave between the two costae. The posterior margin of the cusp is sharp and continues onto the oral edge. The oral edge carries basally fused and proclined denticles. The basal cavity is sickle-shaped with an anteriorly directed tip. Due to the outline of the basal cavity the anteriormost denticles are higher than the more posterior ones.

All elements have cusp and denticles filled with white matter. The faces of the base have a characteristically striated pattern on the surface. The convex surface of the cusp and the anterior basal costa are striated.

Oistodontiform

The base is high with a sinuous aboral outline. The oral edge and the aboral margin meet in a sharp angle. The anterior basal angle is about 90 degrees. The cusp is sharp-edged and more or less flexed to the inner side. It is reclined and filled with white matter. The basal cavity is moderately deep and with the tip pointed anteriorly. The anterior margin of the basal cavity does not reach the anterior basal corner. Two morphotypes can be distinguished due to the degree of reclination of the cusp.

Remarks

B. sinuosa n. sp. differs from B. jemtlandica by the basal cavity, the strong costa-like carina and the often smaller base than cusp of the undenticulated element. The oistodontiforms have a sinuous aboral outline and a short rounded anterior basal corner, whereas in B. jemtlandica they have an extended antero-basal corner and a straight aboral outline. The denticulated plano-convex element is difficult to separate from that of B. jemtlandica, but the concave anterior margin of the basal cavity is diagnostic.

The denticulate element includes types with a recurved cusp, which has not been recorded for B. jemtlandica.

Löfgren (1978, p. 47) indicated that Nordiodus sp. A Fåhraeus 1970 could be an undenticulated element of a Belodella species with a large cusp and a short base. These are B. sinuosa characteristics. Nordiodus sp. A, however, is herein included in Parapaltodus flexuosus.

Löfgren (1978) suggested that B. jemtlandica was the ancestor of B. nevadensis (Ethington and Schumacher). The denticulate element of

B. jemtlandica should evolve into a denticulated element of B. nevadensis. An incipient denticulation is marked by the distribution of white matter between the upper margin of the basal cavity and the oral edge. The orientation of these incipient denticles is radial to the curve formed by the posterior edge of the cusp and the oral edge, whereas the denticles are proclined in B. nevadensis.

The Copenhagen fauna elements also differ from B. jemtlandica by concave outline of the anterior margin of the basal cavity rather than straight or convex, and by the presence of the strong antero-lateral furrow and carina. Also the oistodontiform has a sinuous aboral outline. These characteristics are similar to those of B. sinuosa n. sp. which is considered to be the ancestor of B. nevadensis.

Occurrence

Lower Table Head.

Material

129 undenticulated elements; 179 denticulated elements; 91 oistodontiforms.

BELODELLA? sp. A

Pl. 7 figs. 15-16

Synonymy

1973 Belodina sp. - Barnes and Poplawski, p. 770, Pl. 3: 18.

Diagnosis

Denticulated elements with a small basal cavity and a short cusp forming a symmetry transition series.

Description

The apparatus consists of denticulated plano-convex units and weakly denticulated bi-convex elements.

Denticulated plano-convex element

The element has an inner flare of the base, a proclined pointed cusp and bears up to twelve small proclined to erect basally fused denticles. The anterior keel of the base may be twisted outwards.

Denticulated bi-convex element

This element was described by Barnes & Poplawski (1973) as Belodina sp. The element has an antero-lateral carina, a proclined cusp and a small base. The basal cavity is small and triangular in outline. The element is rarely represented in the Table Head collections.

Remarks

The apparatus does not seem to include undenticulate plano-convex elements, oistodontiforms and triangular denticulated elements. This could be a chance coincidence, but the author does not necessarily think so, because although not abundant the elements occur consistently through the section and cannot at present be associated with other elements. The generic assignment, therefore, is querried.

Occurrence

Lower and middle Table Head.

Material

66 specimens.

Genus CORNUODUS Fåhraeus 1966

Type Species - Cornuodus erectus Fåhraeus 1966.

Remarks

Cornuodus has an apparatus of moderately laterally compressed cones forming a symmetry transition series. Dzik (1976) included Cornuodus in Scalpellodus, but Löfgren (1978) revised Scalpellodus and retained Cornuodus as a separate genus.

CORNUODUS LONGIBASIS (Lindström)

Pl. 8 figs. 1-8

Synonymy

1955a Drepanodus longibasis n. sp. - Lindström, p. 564, Pl. 3: 31.

1966 Cornuodus erectus n. sp. - Fåhraeus, p. 20, Pl. 2: 8a, b; Text - fig. 2B.

1967 Cornuodus bergstroemi n. sp. - Serpagli, p. 57, Pl 12: 1a-2c.

1967 Cornuodus erectus Fåhraeus - Serpagli, p. 57, Pl. 12: 5a-8b.

1967 Scandodus? lanzaensis n. sp. - Serpagli, p. 95, Pl. 26: 4a-7d.

1970 Cornuodus erectus Fåhraeus - Lee, p. 315, Pl. 7: 9.

1974 "Cornuodus" longibasis (Lindström) - Serpagli, p. 43, Pl. 7: 2a, b; Pl. 20: 12

1974 Protopanderodus longibasis (Lindström) - van Wamel, p. 92, Pl. 4: 4-6.

1976 Cornuodus longibasis (Lindström) - Landing, p. 631, Pl. 1: 12, 13, 15.

1976 Scalpellodus (?Cornuodus) laevis sp. n. - Dzik, p. 421, Pl. 41: 1; Text - fig. 13a-c.

1978 Cornuodus longibasis (Lindström) - Löfgren, p. 49-51, Pl. 4: 36, 38-42; Text - fig. 25A-C.

1978 Cornuodus bergstroemi Serpagli - Löfgren, Pl. 2: 37; Text - fig. 25D.

Remarks

All the elements of Cornuodus longibasis have been fully described by Serpagli (1967, 1974) and Löfgren (1978). The current interpretation of C. longibasis is broad and probably two species can be distinguished with further taxonomic work.

In contrast to the Swedish material an asymmetrical element intermediate between symmetrical element A and B of Löfgren (1978) is present in the collections.

Single elements formerly referred to as C. bergstroemi s.f. are included in the apparatus, as both material at hand and collections from the Baltic of this author (see Stouge, 1975) confirm this association (compare Löfgren, 1978, p. 50 and follow text - fig. 25 from D-B-A).

Occurrence

Lower and middle Table Head.

Material

41 specimens.

Genus SCALPELLODUS Dzik 1976

Type Species - Protopanderodus latus van Wamel 1974.

Remarks

The diagnosis for Scalpellodus given by Dzik (1976, p. 421) is as follows: "Only asymmetrical conodonts with flattened and posteriorly sharpened denticle. A trend to development of denticulation". Löfgren (1978) based her interpretation of the elemental composition of the apparatus of the type-species, and emended the diagnosis to include twisted scandodontiforms and drepanodontiforms. Furthermore, she added that the elements are finely striated. Elements with a trend to develop denticles were excluded. Thus defined, Scalpellodus includes simple cones forming a symmetry transition series due to torsion of cusp overprinted by a curvature transition series.

The Scalpellodus species present in the Table Head fauna have three distinct morphologic types of elements: the first type has a base shorter than the cusp, the second type has a very long base. Both types display a symmetry transition series. The third type of element has a short triangular base due to the development of an additional outer costa.

SCALPELLODUS BICONVEXUS (Bradshaw)

Pl. 8 figs. 9-14.

Synonymy

1941 Paltodus variabilis Furnish - Graves and Ellison, p. 21, Pl. 2: 17.

1965a Panderodus panderi (Stauffer) - Mound, p. 31, Pl. 4: 1.

1969 Scandodus biconvexus n. sp. - Bradshaw, p. 1161, Pl. 134: 16-18.

1969 Scandodus dubius n. sp. - Bradshaw, p. 1161, Pl. 134: 19-21.

1969 Scandodus? sp. - Bradshaw, p. 1162, Pl. 135: 11, 12.

1973 Paltodus? sp. B - Barnes and Poplawski, p. 778, Pl. 1: 13.

1973 Drepanodus? sp. 4 - Barnes and Poplawski, p. 774, Pl. 3: 13

cf. 1965 Acodus n. sp. - Ethington and Clark, p. 187, Pl. 2: 3, 4.

cf. 1965 Distacodus n. sp. - Ethington and Clark, p. 190, Pl. 2: 1, 2.

Description

The cusp is twisted in all specimens, and the species comprises two types of scandodontiforms (element 1 and 2) and a three-costate element (element 3).

Element 1

The element has a long cusp and a triangular base, which is shorter than the cusp. The cusp varies from recurved to suberect in position. It has two sharp antero-posterior keels, which continue onto the base to the aboral margin. The cusp has a convex outer margin, which may evolve into a broad carina. The inner margin is flat. The aboral outline is straight and becomes weakly sinuous to concave in full mature specimens. The element varies in torsion of the cusp. Highly twisted forms have an inner antero-lateral furrow formed by the upward bend of the keel. The base has an inner posterior flare of these forms. The basal cavity is deep with a medially placed tip.

Element 2

This element has a long, slender base and a long recurved cusp. Cusp and base are of equal lengths. Well-defined keels extend along the whole unit. The aboral outline is straight or convex. The basal cavity is deep with the tip anterior of the maximum curvature. The elements form a symmetry transition series similar to element 1. A weakly developed curvature transition series superposes the symmetry transition series.

Element 3

The element has a recurved cusp and it is strongly twisted. In this way the outer lateral face of the cusp occupies an anterior position, whereas the antero-posterior margins become inner lateral and outer lateral costae, respectively. The outer lateral face develops a prominent carina, and the base becomes triangular in posterior view.

Element 3 is the ultimate state of the symmetry transition series of Element 1, but it can easily be distinguished as a separate element.

Remarks

The evolution of this species into S. pointensis n. sp. is marked by an initial posterior extension of the anterior keel in some specimens of element 1.

The depth of the basal cavity is related to the degree of curvature. Those showing marked curvature have shallow broadly flaring conical cavities. In the less sharply bent forms the basal cavity is a more slender cone, whose tip reaches to midlength near the anterior margin.

Ethington and Clark (1965) noted that their specimens, i.e., Acodus sp. s.f. and Distacodus sp. s.f. may belong to the same species. Also

the elements show variation in the length of the cusp, but their illustrated specimens are all of Element 1 type. When the whole apparatus is reconstructed the elements may belong to Scalpellodus biconvexus.

Ethington and Clark (1965) also mentioned that their specimens resembled Acanthodus Furnish. If this is the case, then the generic assignment of the Table Head specimens may have to be re-evaluated. At present, the general outline of the apparatus falls within the diagnosis of Scalpellodus.

Occurrence

Lower Table Head.

Material

87 element 1; 24 element 2; 9 element 3.

SCALPELLODUS POINTENSIS n. sp.

Pl. 8 figs. 15-19, 22-23.

Derivation of name

The elements have a posteriorly extended pointed anterior costa.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 59, Histiodella tableheadensis Phylo-zone late Whiterockian (early Llanvirnian).

Holotype

MUNSS 40 (Pl. 8, fig. 15), an element type 3.

Diagnosis

A species of Scalpellodus with a well-developed anterior, posteriorly directed extension and a concave aboral outline.

Description

All the elements have a concave aboral outline. The units are continuously curved throughout their length.

Element 1

The element has a recurved cusp and slightly higher base than cusp. The element is antero-posteriorly keeled throughout its length. The anterior keel extends beyond the aboral margin to form a small adenticulate process-like extension. The aboral outline is concave.

Element 2

The element has a cusp and base of equal length. The cusp may have sharp or blunt anterior and posterior margins, an inner median carina, which continues onto the base as a broad lateral carina. The anterior keel and the inner median carina are separated by a furrow. The aboral outline is concave and the anterior keel projects posteriorly as an undenticulated short process. The basal cavity is triangular in lateral view with a tip, which is pointed slightly downwards. The tip is placed close to the anterior margin beneath the maximum curvature of the elements.

Element 3

Element 3, the extreme asymmetrical element, has a short base, which is triangular in posterior view with sharp edges, and a cusp, which is longer than the base.

Remarks

This species differs from S. biconvexus by its concave aboral outline and by its posteriorly projected undenticulated process.

Occurrence

Upper part of lower Table Head; sporadic in lower part of middle Table Head.

Material

153 element 1; 113 element 2; 42 element 3.

? SCALPELLODUS sp. A

Pl. 8 fig. 20-21.

Description

The apparatus is formed by small scandodontiforms. The cusp is antero-posteriorly keeled. The cusp is twisted and its faces are convex. The keels continue onto the base to the aboral margin. The inner face of the cusp continues onto the inner flare of the base via an inner median carina at the maximum curvature. The basal cavity is small.

Occurrence

Upper part of lower Table Head.

Material

31 specimens.

Genus SCOLOPODUS Pander 1856

Type Species - Scolopodus sublaevis Pander 1856.

Remarks

Lindström (1971) redefined Scolopodus in multielement taxonomy: "Scolopodus includes hyaline, drepanodontiform elements with rounded cross section and symmetrical as well as asymmetrical elements. The sides of the elements may be finely costate. The base is not greatly expanded".

Lindström (1971) based the definition on Scolopodus rex Lindstrom, because the nature of the natural association of the holotype Scolopodus sublaevis Pander s.f. is unknown. Scolopodus rex is hyaline and forms a symmetry transition series. The elements are multi-costate, and without surface striations. Based on the hyaline nature of the elements Lindstrom (1970) placed the genus in Oistodontidae.

SCOLOPODUS OLDSTOCKENSIS n. sp.

Pl. 8 figs. 24-30

Derivation

Old Stock, brand name of the author's favorite beer.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 66, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 43 (pl. 8, fig. 28), an asymmetrical element.

Diagnosis

A Scolopodus with a small base and a large cusp. The costae are relatively sparse.

Description

Depending on the degree of asymmetry three types of elements may be distinguished: symmetrical, intermediate, and asymmetrical. The elements may have cloudy white matter along the growth axis. Basal filling commonly is preserved. No surface striations have been observed.

Symmetrical element

The symmetrical element is recurved, with a rounded cusp, and with a convex anterior smooth surface. The posterior margin has a median costa. In addition, up to four smaller postero-lateral costae are present. The cross-section of the base is triangular with rounded edges. Slight asymmetry is only due to a little variation in development of the postero-lateral costae.

Intermediate element

The intermediate element has a laterally compressed proclined to recurved keeled cusp and a small base. It carries two inner central costae, which end close to the apex of the cusp and the aboral margin of the base. The outer rounded face varies from smooth convex to multicostate with up to four fine costae. These costae begin close to the aboral margin leaving a noncostate rim around the base.

Asymmetrical element

This unit is recurved with a small twisted base due to torsion of the cusp. An inner sharp median costa continues throughout the length of the cusp to the apex, and gradually changes into a carina close to the apex. It disappears near the aboral margin. Due to the twist of the cusp this sharp costa rotates toward the anterior side of the cusp, and disappears on the most asymmetrical elements which only have a convex face on the inner side of the cusp. Some elements have two inner sharp costae. The outer surface of the cusp is convex and smooth, or may carry one or two lateral costae.

Remarks

Only two species of Scolopodus as defined above are known. Serpagli (1974), Landing (1976), and Ethington & Clark (1965) identified elements with S. rex. These elements are not conspecific with S. rex, and should be considered a new species, which is partly contemporaneous with S. rex. Scolopodus oldstockensis n. sp. differs from the two species by the presence of the intermediate element. S. oldstockensis n. sp. is the youngest known species of Scolopodus.

Occurrence

Lower middle Table Head.

Material

1 symmetrical; 31 asymmetrical elements.

Genus WALLISERODUS Serpagli 1967

(emend. Cooper, 1975)

Type Species - Acodus curvatus Branson and Branson 1947.

Remarks

Serpagli (1976) was the first to propose Walliserodus as a genus of its own. He selected Paltodus debolti Rexroad 1967 s.f. as the type species.

Cooper (1975, p. 995) emended the diagnosis of Walliserodus to include both Acodus curvatus s.f. and Paltodus debolti s.f. in the same species. He found that Acodus curvatus s.f. had name priority for the type species.

According to Cooper (1975) Walliserodus is a multi-element genus with an acodontiform and a suite of paltodontiforms forming a symmetry transition series. In the Table Head fauna a limited number of elements are all included in Walliserodus ethingtoni, but no acodontiforms could be included in the apparatus. Löfgren (1978) discussed Walliserodus in detail, and she did not include an acodontiform element in the apparatus.

WALLISERODUS ETHINGTONI (Fåhraeus)

Pl. 9 figs. 1-9

Synonymy

1966 Panderodus ethingtoni n. sp. - Fåhraeus, p. 25, Pl. 3: 5a-b.

1974 Walliserodus ethingtoni (Fåhreaus) - Bergström, Riva and Kay, Pl. 1: 12.

1976 Walliserodus ethingtoni (Fåhraeus) - Dzik, fig. 14 o.p.

1978 Walliserodus ethingtoni (Fåhreaus) - Löfgren, p. 114-116, Pl. 4: 27-35; Text - fig. 33.

1978 Walliserodus ethingtoni s.f. (Fåhraeus) - Tipnis et al., Pl. IX: 23-24.

Description

A species of Walliserodus with uni-costate through multi-costate cones. The cones form a limited curvature transition series from proclined to slightly reclined elements. This is associated with differences in the length of cusp and base. Proclined elements have a longer base and a shorter cusp than the elements which are reclined. Due to torsion of cusp the cones form a symmetry transition series. All the elements have a deep, broad basal cavity with the tip near the anterior margin at the maximum curvature of the element. The anterior margin of the base is convex. The cusp may be sharp or rounded anteriorly. The posterior edge of the cusp is sharp. The oral edge of the base is keeled. The aboral outline is slightly sinuous.

Symmetrical element

The symmetrical element is erect to slightly recurved; it has a rounded anterior face on cusp and base, and one posterior sharp keel on the cusp. The keel continues onto the oral edge of the base. There are two antero-lateral costae on the base that extend on the anterior side of the cusp to the point of maximum curvature. Additional (1 to 3) symmetrically placed costae may develop between the lateral and posterior costae. The youngest is closest to the oral margin. They extend to

various lengths of the cusp, but usually do not reach the whole length of the cusp.

Asymmetrical element

The asymmetrical elements are variably costate, from slightly asymmetrical and uni-costate, bi-costate to multi-costate, often with two costae on the outer side and three on the inner side. However, many asymmetrical elements can be derived from the symmetrical cone by a simple rotation of the costae with the cone axis as reference.

No surface ornamentation such as striations was observed.

Remarks

Löfgren (1978) discussed the variable costate elements of Walliserodus ethingtoni in detail. She found that the variability was inconsistent, a conclusion with which the limited material at hand seems to agree.

Löfgren (1978) also discussed the possible association of Paltodus? jemtlandicus and Walliserodus ethingtoni. and concluded that the two are distinct taxa. In this material an association could be considered between Parapaltodus flexuosus and Walliserodus. The elements co-occur, have the same stratigraphic range, and have broadly similar morphology; and P. flexuous could be part of the symmetry transitions series. However, the relatively small number of elements and the lack of possible transitional forms appear to prohibit this.

Walliserodus is close to Scolopodus, in that both are multi-costate simple cones and have a curvature transition series superposed by a symmetry transition series. No surface ornamentation are present on the

elements of the two genera. The main differences are the presence of white matter, the large deep basal cavity and the more prominent costae in Walliserodus.

Occurrence

Through middle Table Head, rare in lower Table Head.

Material

6 symmetrical elements; 62 asymmetrical elements.

Genus PSEUDOONEOTODUS Drygant 1974

Type Species - Oneotodus (?) beckmanni Bischoff and Sannemann 1958.

PSEUDOONEOTODUS MITRATUS MITRATUS (Moskalenko)

(not figured)

Synonymy

1933 Oistodus (?) sp. - Branson and Mehl, Pl. 9: 3.

1966 Form I - Webers, p. 73, Pl. 15: 7.

1973 Ambalodus mitratus mitratus sp. nov. subsp. nov. - Moskalenko, p. 86, Pl. 17: 9-11.

1976 Oneotodus mitratus Moskalenko - Dzik, fig. 12, e.f.

cf. 1967 Gen. et sp. indet B. - Serpagli, p. 107, Pl. 29: 1a, b.

cf. 1977 Pseudooneotodus beckmanni (Bischoff and Sannemann) - Cooper, p. 1068-1069, Pl. 2, figs. 14, 17

1978 Ambalodus mitratus mitratus s.f. Moskalenko - Tipnis et al., Pl. VII: 18.

Description

A bonnet-shaped, irregular simple cone with a small cusp and a high, broad flared base. The oral edge is rounded. The basal cavity occupies the whole of the base. The only element in the collection was fragmental and part of the inner base was broken.

Remarks

Cooper (1977) reported several species of Pseudooneotodus of which P. beckmanni (Bischoff and Sannemann) is closest to P. mitratus mitratus. The Silurian specimens, however, have a higher cusp and a smaller base than the Ordovician forms.

The Table Head specimen was lost during office moving.

Occurrence

Lower Table Head.

Material

1 specimen.

Family PANDERODONTIDAE Lindström 1970

Diagnosis

Conodont apparatuses of simple cones that include laterally compressed elements with a posterior or lateral furrow and some may bear a posterior denticle row. Characteristically Panderodontidae have longitudinal striations.

Remarks

Panderodontidae includes Panderodus, Neopanderodus, Parapanderodus n. gen., Belodina, and Semiacontiodus.

Genus PARAPANDERODUS n. gen.

Type Species - Parapanderodus arcuatus n. sp.

Derivation of name

Para (Gr. para) = akin to; refers to the similarity of the genus to Panderodus.

Diagnosis

A multi-element genus with a skeletal apparatus of simple, slender, laterally compressed, costate drepanodontiforms. The base is rounded to symmetrical oval. The units characteristically have a posterior groove, which extends through the whole length of the element. The elements are finely striated, and contain various amounts of white matter in the cusp. The elements may form a weakly developed symmetry transition series.

Remarks

In all elements of Parapanderodus the striations form an angle with the posterior furrow, and in most species the striations begin next to the aboral margin leaving an unornamented rim.

Parapanderodus n. gen. includes elements, which commonly have been referred to Scolopodus Lindström, the form-genus Drepanodus Pander and Panderodus Ethington.

Scolopodus has recently been restricted to an apparatus with hyaline, multi-costate conodonts forming a symmetry transition series (Lindström 1971) pending a better understanding of S. sublaevis Pander. The elements of Scolopodus are more rounded and they are not striated.

Drepanodus has been redefined in multi-element taxonomy by Lindström (1971). Drepanodus includes a scandodontiform in the apparatus.

Panderodus is very closely related, but the characteristic lateral groove and the basal 'wrinkles' are missing in the new genus.

Semiacontiodus is similar to Parapanderodus in that it may have a posterior furrow and is striated. Semiacontiodus differs by the well developed symmetry transition series including a antero-posteriorly compressed symmetrical element, and the striations are parallel to the length of the cusp.

Parapanderodus resembles the Devonian Neopanderodus Lindström and Ziegler (1971). The principal differences are the coarse surface striations and the postero-lateral position of the groove of Neopanderodus.

PARAPANDERODUS ARCUATUS n. sp.

Pl. 9 figs. 10-15

Synonymy

cf. 1969 Scolopodus cf. S. quadraplicatus Branson & Mehl - Bradshaw, p. 1163, Pl. 132: 8-9; Text - fig. 4, no. E, F.

1973 Scolopodus gracilis Ethington & Clark - Barnes & Poplawski, p. 786-787, Pl. 3: 8, 8a only; Text - fig. H.

Derivation of name

The elements are all gently arched.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 46, *Histiodella tableheadensis* Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 46 (Pl. 9, fig. 10A, B), an element type 1.

Diagnosis

A *Parapanderodus* with elements carrying few costae on lateral and posterior faces. The cross-section of the cusp is 'acontiodus'-like with elements which are heart-shaped in cross-section. All the elements are procurved.

Description

The elements are slightly asymmetrical because the lateral and posterior costae are not exactly in a symmetrical position. An anterior lateral broad furrow is often present. Cusp and base form a gently continuous curve. All the elements have an anterior sharp keel.

The elements are fully striated on the faces of the base. From the base and onto the tip of the cusp the striations are solely developed between the two posterior carinas-costae. The striations form an acute angle with the posterior groove.

Two distinct morphotypes are recognized in P. arcuatus.

The first type has a posterior subsymmetrical, well-developed sharp, outer costa, and two posterior lateral costae. The posterior furrow is situated next to the posterior costa. The sides of the base are either concave or an additional antero-lateral inner carina may be present. The aboral outline is concave. The aboral margin meets the oral edge at an acute angle, which gives a characteristic, short tongue-like elongation of the base. The anterior edge and aboral margin meet at a right to obtuse angle. The keels continue onto the base to the aboral margin. In large specimens a lateral-anterior furrow is developed, and this becomes broader on the base. Small specimens have weakly developed lateral costae. The cusp is about twice as long as the base. The basal cavity is triangular with the tip placed close to the anterior edge and pointed anteriorly. The cusp is filled with white matter.

The second type of element is slender, evenly curved with a posterior groove and one antero-lateral furrow on each side. Two rounded posterior costae surround the central groove. The base is slightly wider than the cusp. The elements are almost symmetrical, and only a slight lateral position of the posterior groove creates asymmetry. The base is excavated by the basal cavity with its tip near the anterior margin. The aboral outline is convex, when seen in lateral view. Basal matter, when preserved, is black. The elements have white matter in the cusp.

Remarks

The elements are very inhomogeneous in the ratios from sample to sample of the two general morphotypes. The feature may be due to variation in the growth, as mainly gerontic forms seem to be costate.

The second morphotype shows variation in the length of the base, and a few short base variants similar to Scolopodus gracilis of Barnes & Poplawski (1973) are included in the species.

S. sp. cf. S. quadraplicatus is slightly different than the Table Head forms in that the basal cavity is small and the elements apparently are not keeled. The general outline of the Fort Peña specimens, however, are similar to P. arcuatus n. sp., and they may be conspecific or closely related.

Occurrence

Common to dominating in the lower Table Head; present in middle Table Head.

Material

954 element 1; 751 element 2.

PARAPANDERODUS sp. cf. P. CONSIMILIS (Moskalenko)

Pl. 9 figs. 16-19

Synonymy

cf. 1973 Scolopodus consimilis n. sp. - Moskalenko, p. 44, Pl. 4: 1-5.

Diagnosis

A Parapanderodus with two posterior lateral furrows in addition to the posterior median groove.

Description

The cone-shaped elements are hyaline and consist of a slender cusp and slightly wider base. Base and cusp are about the same size. The basal cavity is deep and cone-shaped with anteriorly directed tip. The cusp is proclined and has an anterior rounded face. Two posterior lateral furrows on the oral edge continue up to one-third of the length of the cusp. The elements are flattened slightly antero-posteriorly. The lateral faces of the cusp and the base are broadly grooved. The oral edge is straight and meets the aboral margin in an angle of 90 degrees. A small tongue-like posterior extension may be present in some specimens. Juvenile forms are thin and long, and gerontic elements have a more compressed base. All specimens have the two lateral furrows.

The surface ornamentation includes striations on the base with a nonstriated area on the posterior part of the base. The striations on the cusp are restricted to the posterior face and along the median furrow. The striations form an acute angle with the median furrow.

Remarks

P. consimilis of Moskalenko (1973) has a median groove and two lateral posterior costae. The species described above lacks the lateral costae.

Occurrence

Lower Table Head.

Material

62 specimens.

PARAPANDERODUS ELEGANS n. sp.

Pl. 9 figs. 20-27

Synonymy

1978 Scolopodus aff. S. gracilis Ethington & Clark - Löfgren, p. 110, Pl. 8: 10A-B.

Derivation of name

The elements are elegant, i.e., very delicate and slender.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 68, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 49 (Pl. 9, fig. 24).

Diagnosis

A species of Parapanderodus with a long slender base and a deep basal cavity. The aboral outline is straight.

Description

The elements vary in the length of the cusp and the base, but most specimens have a longer base than cusp. The cusp is proclined. The basal cavity may extend through the whole base with the tip beneath the point of maximum curvature of the cusp. Two lateral anterior weakly

developed furrows may be present. The aboral outline is straight. The aboral margin meets the oral edge in an angle of 75 to 90 degrees.

A large nonstriated rim on the base next to the aboral margin is typical for this species. The base is otherwise fully striated by coarse parallel striations. These become finer upwards toward the tip of the cusp. They are restricted to near the posterior furrow on the cusp. The striations meet the furrow in an acute angle, typical of Parapanderodus.

Remarks

The transition from laterally flattened elements to rounded is not strong in this material, but it is indicated by a few flattened elements. The flattened forms tend to have a shorter base than the rounded ones. The aboral outline is straight in most specimens, but a small posterior tongue-like extension of the oral edge may occasionally be developed.

Löfgren (1978) did not find forms with a widened base as described by Ethington & Clark (1964) for S. gracilis s.f. This is similar to the Table Head material, and the specimens are not associated with other elements, which is in accordance with the Swedish material (Löfgren 1978). On the other hand Löfgren (1978) did not find specimens with a deep basal cavity.

P. elegans differs from P. sp. cf. P. consimilis by its lack of posterior lateral grooves. The species resembles P. striatus, but the deep basal cavity and the posterior nonstriated base are diagnostic.

Occurrence

Lower and middle Table Head.

Material

305 specimens.

PARAPANDERODUS STRIATUS (Graves & Ellison)

Pl. 10 figs. 1-3

Synonymy

1941 Drepanodus striatus - Graves & Ellison, p. 11, Pl. 1: 3, 12.

cf. 1970 Scolopodus gracilis Ethington & Clark - Uyeno & Barnes, p. 116, Pl. 22: 9-10.

cf. 1973 Scolopodus gracilis E. & C. - Barnes & Poplawski, p. 786, 787, Pl. 3: 6, 6a, ?7, ?7a; Text - fig. 2G.

? 1964 Scolopodus gracilis - Ethington & Clark, p. 699, Pl. 115: 8 only; Text - fig. 2D.

Discussion

Drepanodus striatus Graves and Ellison s.f. has commonly been identified as Scolopodus gracilis Ethington & Clark s.f. Ethington and Clark (1964) indicated that Scolopodus gracilis s.f. showed affinities with Scolopodus quadraplicatus Branson and Mehl s.f. and with Scolopodus triplicatus Ethington and Clark s.f. In multi-element taxonomy such an association would probably form an apparatus of a new genus. Barnes and Poplawski (1973) suggested that Scolopodus gracilis s.f. and S. triangulatus s.f. form an apparatus. They found support for this in the presence of intermediate forms in the Mystic Conglomerate.

Only slight variation of the cross-sections of the cusp and the base and the size of the posterior furrow is represented by the elements of P. striatus. Also no additional elements were found, which could be included in an apparatus such as those proposed by the above authors.

It therefore seems likely that two or possibly three genera with closely similar morphological elements will be recognized in the future and Parapanderodus is one of them.

Description

Simple cones with a base that is smaller than the cusp. The elements are procurved to proclined. They have a rounded cusp with anteriorly concave faces and a weakly developed anterior keel. The aboral outline is straight to concave. The posterior furrow is well-developed. The basal cavity is funnel-shaped and small. All the specimens are characterized by a slightly thickened rim of the base next to the aboral margin. All specimens are hyaline.

Remarks

The Lévis forms (Uyeno & Barnes 1970) are a little more rounded and the posterior furrow is deeper than in the Table Head elements.

The elements depicted by Barnes & Poplawski (1973) share similarities with both P. striatus and P. arcuatus n. sp. The oval cross-section of the base, the smaller posterior groove and the posterior tongue-like extension of the base are characteristics of P. arcuatus. The rounded cross-section of the element and the small base (Barnes & Poplawski, 1973; Pl. 3, fig. 6) are P. striatus characteristics that are not displayed by P. arcuatus. Possibly P. striatus is the ancestor to P. arcuatus.

Occurrence

Lower Table Head.

Material

66 specimens.

PARAPANDERODUS? sp. aff. P.? TRIANGULARIS (Ethington and Clark).

Pl. 10 fig. 4

Synonymy

aff. 1964 Scolopodus triangularis n. sp. - Ethington and Clark, p. 700, Pl 115: 6, 11, 13, 17; Text - fig. 21.

? 1973 Coelocerodontus? sp. s.f. - Barnes and Poplawski, p. 770, Pl. 5: 19, 19a.

Description

Simple cones with an anterior sharp keel, two postero-lateral costae and a constricted basal cavity are tentatively included in Parapanderodus. The elements are procurved. They form a symmetry transition series due to the inward twist of the cusp, and associated reduction of the inner costae on the base. The elements have a deep posterior groove between the posterior costae. The base and the cusp are equal in length and the basal cavity occupies the whole of the base and with its tip close to the anterior edge.

Remarks

The element broadly resembles S. triangularis s.f. in the presence of a sharp anterior keel and the posterior groove. The present knowledge

of the Lower Ordovician species is still limited and a closer determination of the Table Head species is not possible at present.

Coelocerodontus? sp. s.f. Barnes and Poplawski may represent a gerontic element of this species.

Occurrence

Lower and middle Table Head.

Material

21 specimens.

Genus SEMIACONTIODUS Miller 1969

Type Species - Acontiodus (Semiacontiodus) nogamii Miller 1969.

Diagnosis

Simple cones having a central posterior costa, carina or a groove, two lateral costae and a convex anterior face. The elements generally have longitudinal striations on the surface.

Remarks

Miller (1969) described different "acontiodontiforms" on the level of subgenus. Dzik (1976) considered Semiacontiodus a genus.

Semiacontiodus has a relatively short base with a thickened rim at the aboral margin. Elements of the different species are variable. For example, some species may have a posterior groove, and others have asymmetrical elements, which may become "blade-like" (e.g. S. asymmetricus (Barnes and Poplawski)). All the species, however, have a shallow, rounded cone in the symmetrical position of the apparatus.

Striations are well-developed on elements of Semiacontiodus. They often extend throughout the entire length of the unit.

Semiacontiodus has an apparatus, which is similar to that of the genera Staufferella, Scolopodus, Walliserodus and Juanognathus. All these genera include a symmetrical element with a rounded anterior margin. Staufferella is distinguished by its sharp margins and the lack of striations on the base. Walliserodus and Scolopodus are multi-costate and have no surface striations. Juanognathus lacks the surface striations on the base.

Semiacontiodus is included in Panderodontidae rather than Acanthodontidae, because it is considered to be closely related to Parapanderodus n. gen. The distribution and appearance of striations are similar to Parapanderodus, and also the presence of a posterior groove is some species of Semiacontiodus are characteristics of Parapanderodus. Semiacontiodus is probably the direct ancestor of Parapanderodus.

SEMIACONTIODUS ASYMMETRICUS (Barnes and Poplawski)

Pl. 10 figs. 5-10, 15.

Synonymy

1973 Protopanderodus asymmetricus - Barnes and Poplawski, p. 781-782, Pl. 1: 12, 12a, 14, 16; Text - fig. 2A.

Description

Barnes and Poplawski (1973) described the asymmetrical elements. The symmetrical element is described herein.

It has a slender recurved cusp, an anterior convex face, two lateral costae and a posterior median keel. The cusp curves onto the base. The

base is short and wider than the cusp, and has an oval aboral margin.

Striations are well displayed on the symmetrical element. It has striations on both faces. The element has very coarse striations on the base, and carries symmetrical parallel fine striations on each side of the median posterior costa. In asymmetrical elements the coarse striations on the base almost disappear and the finer striations on the cusp decrease in abundance with increasing asymmetry. Highly asymmetric units are almost non-striated.

Occurrence

Upper lower and middle Table Head.

Material

138 symmetrical elements; 365 asymmetrical elements.

SEMIACONTIODUS sp. cf. S. BULBOSUS (Löfgren)

Pl. 10 figs. 11-14, 20.

Synonymy

cf. 1978 Scolopodus bulbosus n. sp. - Löfgren, p. 107-108, Pl. 7: 7A, B, 8; Pl. 8: 3A, B.

Remarks

Small symmetrical "cornuforms" with recurved cusps were recovered, and they are comparable with those of S. bulbosus Löfgren. The elements differ in the more prominent recurved cusp and no one of the Table Head elements has an erect cusp as the Swedish species. Löfgren (1978) found two element-types: cornuforms and scandodontiforms, and the species is a

typical Semiacontiodus. No scandodontiforms were recovered in the present collection.

The specimens are completely covered by striae.

Occurrence

Lower and middle Table Head.

Material

21 specimens.

SEMIACONTIODUS PREASYMMETRICUS n. sp.

Pl. 10 figs. 16-19

Synonymy

1971 Paltodus n. sp. A - Sweet, Ethington and Barnes, Pl. 1: 14.

?1964 Acontiodus iowensis Furnish - Ethington and Clark, p. 687, Pl. 113: 3.

Derivation of name

Pre = before. The species is considered the ancestor of S. asymmetricus (Barnes and Poplawski).

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 29, Histiodella tableheadensis Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 55 (Pl. 10, fig. 18), a symmetrical element.

Diagnosis

The symmetrical element is without a posterior median costa. The median central costa is weakly developed, but a broad convex carina is present in asymmetrical elements.

Description

This species comprises elements with a small base and a large cusp, which is proclined to recurved. The cusp is pointed and the anterior face is convex. The elements have one lateral sharp costa on each side, and a posterior median rounded carina. The costae continue onto the aboral margin. The oral edge is rounded, short and curves onto the cusp. The aboral margin is sub-circular to oval.

The asymmetrical elements are antero-posteriorly compressed and have laterally extended faces. These continue toward the base and in most elements narrow towards the basal opening. The cusp is recurved.

The symmetrical elements are slender cones with anteriorly convex faces. They may carry a small weakly developed keel. The elements have two lateral costae. The posterior face is convex. The aboral margin is sub-circular.

Remarks

This species differs from Semiacontiodus asymmetricus by the lack of a prominent posterior costa. The symmetrical element has a sub-circular aboral margin. In S. asymmetricus it is oval. The asymmetrical element

with a wide blade-like cusp is not present in P. preasymmetricus. The figured specimen of Ethington and Clark (1964) is possibly a symmetrical, juvenile element.

Occurrence

Lower part of lower Table Head.

Material

38 specimens.

SEMIACONTIODUS sp. cf. S. CORDIS (Hamar)

Pl. 11 figs. 1-6.

Synonymy

cf. 1966 Scolopodus cordis n. sp. - Hamar, p. 74-75, Pl. 3: 4-6; Text - fig. 2, no. 5.

? 1973 Oneotodus gracilis (Furnish) - Barnes and Poplawski, p. 777-778, Pl. 1: 1 only.

Description

Symmetrical elements have a recurved cusp with a rounded or weakly keeled anterior margin. The posterior margin has a narrow furrow, which runs the whole length of the cusp and onto the base. The lateral faces are convex and carry two postero-lateral carinas. The carinas may be developed as weak costae. The base is short, it has convex faces and a rounded cross-section.

The asymmetrical elements are similar to the symmetrical elements. The asymmetry is due to torsion of the cusp. The cusp is proclined and

has sharp anterior and posterior keels and is laterally compressed. The furrow is present on the base and becomes inconspicuous on the cusp.

All the specimens are finely striated on the surface of the whole unit. Striations are best developed on the base, where they begin a short distance away from the aboral margin.

A basal funnel is commonly preserved; it is black.

The distribution of white matter is characteristic. The base and posterior half of the cusp is hyaline or translucent, and white matter fills the anterior of the cusp from the point of maximum curvature of the unit. Above that, white matter completely fills the cusp.

Remarks

S. sp. cf. S. cordis (Hamar) does not carry costae on the lateral faces of the base. This species is similar to Parapanderodus in that it possesses a posterior furrow, but the apparatus is similar to Semiacontiodus.

The Mystic fauna element resembles an asymmetrical element of S. sp. cf. S. cordis. The long base-type (Barnes and Poplawski 1973, Pl. 1, fig. 2) may belong to their species, but it does not fit within the Table Head material.

Occurrence

Lower and middle Table Head.

Material

180 symmetrical elements; 266 asymmetrical elements.

## Superfamily CHIROGNATHACEA (Branson & Mehl 1944)

**Remarks**

Chirognathacea comprises Oistodontidae, Chirognathidae, and Rhipidognathidae (Lindström, 1970). Oistodontidae has an apparatus similar to Prioniodontidae (Dzik, 1976), and is consequently allocated in Prioniodontina.

In this way Chirognathacea comprises apparatuses of asymmetrical and symmetrical elements, mainly hyaline and mainly of Midcontinent Fauna Province affinity.

Dzik (1976) indicated that Chirognathacea could be related to Westergaardodina and belong within Westergaardodinina Lindström (emend. 1970).

## Family CHIROGNATHIDAE Branson and Mehl 1944

**Remarks**

Chirognathidae includes Chirognathus, Erismodus, Microcoelodus, Multioistodus, and Leptochiroghathus. Sweet and Schönlaub (1975) discussed the relation of Microcoelodus (and Erismodus) to Oulodus, and they indicated that the ancestor of Oulodus should be referred to Prioniodinacea.

### Genus ERISMODUS Branson and Mehl 1933

Type Species - Erismodus typus Branson and Mehl 1933.

**Discussion**

Elements of Erismodus have an apical cusp, arched denticulate processes, and an excavated base containing a boss extending aborally

beneath the cusp (Branson and Mehl, 1933, p. 25). Andrews (1967) showed that the form-genera Erismodus, Microcoelodus, and Ptiloconus included components of several closely related form transition series, and four species of Erismodus were described. He also noted that Erismodus formed a roundya-ligonodina transition series of Lindström (1964). Erismodus is presently under revision and a more complex apparatus is to be expected (Sweet and Schönlaub, 1975).

The present material includes elements which are erismodid-like, and the form transitions of Andrews can barely be recognized. The elements are tentatively included in Erismodus.

ERISMODUS? sp. A

Pl. 11 figs. 7-9

Synonymy

? 1978 Erismodus sp. A - Tipnis et al., Pl. IV: 23-24.

Description

The most common element consists of a cusp and has a posterior and an anterior denticulated process. The cusp is reclined, slightly twisted to the inner side and has sharp anterior and posterior keels with smoothly convex faces. The anterior process is directed downward. It carries from three to six rounded denticles. The posterior process carries five to six discrete denticles, which are recurved. The aboral margin has a strong inner flare.

A second element has only been recovered as fragments. It consists of a cusp, which is broken, with denticulated, posterior, anterior, and

lateral processes. The posterior process is nearly straight. It carries from three to five laterally compressed, discrete denticles. The anterior process extends sharply downward and has six small denticles. The lateral process forms a curve. It has six discrete small denticles. The base has a large inner flare.

Remarks

*Erismodus* sp. A Tipnis *et al*. (1978) may belong to this species. The anterior process apparently does not extend downwards as in the Table Head species.

Occurrence

Top of St. George Group and lower Table Head Formation.

Material

40 specimens.

ERISMODUS? sp. B. s.f.

Pl. 12 fig. 1

Synonymy

1973 "Fibrous" conodont elements - Barnes & Poplawski, p. 787-788, Pl. 5: 14.

Description

Single elements with a large cusp and two denticulated processes. An additional anterior small process, directed downward, may evolve as an extension of the anterior keel of the cusp on large specimens. The cusp is recurved, strongly keeled and with a convex outer face. The

keels continue as lateral and posterior processes. The basal cavity has an inner flare.

Remarks

The element differs from prioniodontiforms of Eoneoprioniodus? sp. A by the lack or poor development of an anterior process.

Occurrence

Basal top of St. George Group and basal Table Head Formation

Material

21 specimens.

Genus LEPTOCHIROGNATHUS Branson and Mehl 1943

Type Species - Leptochirognathus quadrata Branson and Mehl 1943.

Remarks

A few leptochirognathodontiforms were recovered in the collections. The elements are constant in their morphology within each sample. The morphology, however, differs from sample to sample. The elements are described as form species, but may be considered as species of a multi-element genus with one element in the apparatus. Sweet & Bergström (1972), however, suggested that Leptochirognathus has an apparatus of elements, which form a symmetry transition series.

LEPTOCHIROGNATHUS sp. cf. L. QUADRATA Branson and Mehl s.f.

Pl. 12 figs. 2 - 3

cf. 1943 Leptochirognathus quadrata - Branson & Mehl, p. 378-379, Pl. 63: 23-28

Description

The specimens are orientated so that the concave side is the inner side. The cusp is directed toward the posterior.

The element consists of a cusp, and denticulated anterior and posterior processes. The cusp is slightly reclined, keeled and has an outer median carina that extends beneath the aboral margin as an apical lip. The inner face carries a well developed carina, which fades at the base. The anterior process carries three denticles; the one next to the cusp is very wide, keeled and much larger than the outer two denticles. The latter are about one-fifth of the width of the first denticle. The denticles are proclined. The posterior process has two denticles, which are reclined and unequal in size. The one next to the cusp is largest and occupies almost the whole length of the process. The second denticle is small and broken in most cases. The elements are deeply excavated by the basal cavity, which is deepest underneath the cusp.

The elements are laterally bent to form an open curve.

The elements have fine striations on the cusp and denticles.

Remarks

The elements differ from L. quadrata by the presence of auxilliary, apical denticles. With larger collections than the Table Head fauna, this possibly is within the variation of L. quadrata.

Occurrence

Lower part of lower Table Head.

Material

10 specimens.

LEPTOCHIROGNATHUS PRIMA Branson and Mehl s.f.

Pl. 12 fig. 6-7.

1943 Leptochirognathus prima - Branson and Mehl, p. 378, Pl. 63: 29-35.

Remarks

The specimens fit those described by Branson and Mehl (1943). No additional elements were recovered, which could be included in the species.

Occurrence

Top of the St. George Group at Back Arm.

Material

5 specimens.

Genus MULTIOISTODUS Cullison 1938

Type species - Multioistodus subdentatus Cullison 1938.

MULTIOISTODUS sp. cf. M. SUBDENTATUS Cullison

Pl. 12 figs. 4-5.

Synonymy

cf. 1938 Multioistodus subdentatus - Cullison, p. 226, Pl. 29: 13a, b.

cf. 1965a Multioistodus subdentatus, Cullison - Mound, p. 25, Pl. 3: ?17, 18, 20, 25.

cf. 1971 Multioistodus subdentatus, Cullison - Sweet, Ethington and Barnes, Pl. 2: 24.

cf. 1965a Multioistodus tridens Cullison - Mound, p. 26, Pl. 3: 19, 24, 26.

Description

The apparatus is incompletely preserved. One asymmetrical element has a large recurved cusp, which is keeled. The posterior keel continues onto the base in a curve. The oral edge is straight and carries a recurved denticle. The denticle may reach half the length of the cusp. The anterior keel of the cusp continues on the base in a smooth curve. The anterior edge of the base may evolve a thin keel. The anterior keel of the base forms an angle of about 90 degrees with the aboral margin. The aboral outline is straight to convex.

The associated fragmental, asymmetrical elements with one lateral denticle on each side complete the apparatus as described by Lindström (1964).

All the specimens are finely striated.

Remarks

M. sp. cf. M. subdentatus differs from M. subdentatus Cullison by its rounded antero-basal junction, whereas M. subdentatus Cullison has an extended anterior base on the symmetrical element.

Occurrence

Top of the St. George Group and lower part of the Table Head Formation.

Material

6 specimens.

Suborder PRIONIODONTINA Dzik 1976

Superfamily PRIONIODONTACEA (Bassler 1925)

Remarks

Lindström (1970) included Periodontidae in Prioniodontacea. Dzik (1976) transferred Periodontidae to Ozardoninina Dzik, which is followed in this study.

Prioniodontacea (Bassler 1925) comprises the families Balognathidae, Icriodontidae, Oistodontidae and Prioniodontidae.

Family BALOGNATHIDAE Hass 1969

Remarks

Balognathidae include apparatuses with two platforms, which may be associated with ramiforms (e.g. Amorphognathus). The family comprises Amorphognathus, Eoplacognathus, Polyplacognathus, and Pygodus (Lindström, 1970) and perhaps Polonodus.

Eoplacognathus, Polonodus and Polyplacognathus have apparatuses with platforms but without ramiforms. Whether all these genera should be included within a single family is questionable. The problem is not considered further in this study.

Genus AMORPHOGNATHUS Branson and Mehl 1933

Type Species - Amorphognathus ordovicicus Branson and Mehl 1933

AMORPHOGNATHUS? sp. A.

Pl. 12 figs. 8-12, 14

Remarks

Dzik (1976, fig. 6) recently figured in a schematical way the apparatus of Amorphognathus variabilis. Löfgren (1978) included the type species (i.e., Amorphognathus variabilis Sergeeva s.f.) in Eoplacognathus? variabilis. From her discussion it must be concluded that A. variabilis sensu Dzik does not include the type species. The elements described below form an apparatus which is similar to Amorphognathus variabilis sensu Dzik.

Description

The apparatus is not complete. It consists of amorphognathodontiform, ambalodontiform and ramiforms.

The amorphognathodontiform has a small cusp, an anterior denticulated process, an antero-lateral process and a posterior denticulated process. The posterior process carries two rows of denticles in large specimens. The possible postero-lateral process is broken in the material on hand.

The ambalodontiform has antero-posterior denticulated processes. The processes are connected with basal sheath. The base is flared to the inner side.

The ramiforms include tetraprioniodontiforms and trichonodelliforms. The tetraprioniodontiforms have an anterior and posterior denticulate process which are in the same plane as the cusp. Two symmetrically placed lateral processes are posteriorly projected.

The trichonodelliforms have three posteriorly directed denticulated processes. The processes are connected by a basal sheath. The cusp is proclined.

Remarks

The apparatus was not completely recovered as figured by Dzik (1976), because holodontiforms have not been found.

Occurrence

Lower and middle Table Head.

Material

13 specimens.

Genus POLONODUS Dzik 1976

Type species - *Ambalodus clivosus* Viira 1974.

Discussion

Dzik (1976) originally defined *Polonodus* as "Conical conodonts with 4 lobes covered with concentric and radial rows of tubercles. Very large basal cavity".

Löfgren (1978) queried the validity of the diagnosis based on the identification of A. clivosus Viira s.f. by Dzik (1976). She noted that two types of four-branched elements were represented - one group with a well developed anterior platform and the second group, which Dzik (1976) assigned to Polonodus. She (Löfgren, 1978), however, did not change the diagnosis of Polonodus, and she preferred to describe the forms as single elements.

The present material confirms that two apparatuses can be distinguished. The first apparatus is composed of paired polyplacognathodontiforms and ambalodontiforms and could be assigned to the genus Polyplacognathus Stauffer, 1935 (emend. Bergström & Sweet, 1966). The Table Head material is still too sparse to propose a definite transfer to Polyplacognathus. In this group the polyplacognathodontiform has a large basal cavity, a large outer, blade-like process and typically an inner anterior notch on the anterior process. The ambalodontiform has four lobes of which the anterior may carry slightly larger denticles. The basal cavity is restricted. The group includes Polonodus clivosus (Viira) sensu Löfgren (1978).

The second group is not as well known. It is considered possible that the group comprises two kinds of elements: polyplacognathodontiform and ambalodontiform. Both elements have four lobes and deep basal cavities.

The polyplacognathodontiform basically forms an X, having four processes. The anterior process carries two rows of denticles, which are connected by a platform. The anterior and outer lateral lobes are of equal length and the largest of the element. The posterior and the inner lateral lobe are also of equal length and generally much smaller than the

anterior process. Typically, additional processes are formed both anteriorly and posteriorly of the outer lateral process.

The ambalodontiform forms an X with straight to curved processes. In this element the anterior process has one denticle ridge.

The elements of the second group were described as Polonodus? sp. A, Polonodus? sp. A and Polonodus clivosus (in pars) by Löfgren (1978). The elements referred to Polonodus clivosus (Viira) by Dzik (1976) have not been recorded in the Table Head material. The general surface ornamentation of the Table Head specimens and the Swedish specimens is similar to that of the Polish forms. Thus, the group is probably taxonomically valid and should be recognized as the genus Polonodus Dzik.

The elements of the Polonodus-group differ from polyplacognathodontiforms of the first group by having small rounded well separated denticles on the outer lateral process.

POLONODUS TABLEPOINTENSIS n. sp.

Pl. 12 fig. 13; Pl. 13 figs. 1-5

Synonymy

1964 Amorphognathus n. sp. - Lindström, p. 93-94, fig. 33C.

1970 Amorphognathus n. sp. cf. Amorphognathus n. sp. Lindström 1964 - Fåhraeus, p. 2065, fig. 3A, B.

1970 Amorphognathus variabilis Sergeeva - Fåhraeus, p. 2065, fig. 3E.

1976 Polondous clivosus (Viira) - Dzik, p. 423, Text - fig. 28C, D (only).

cf. 1976 Polonodus clivosus (Viira) - Dzik, p. 423, Text - fig. 7, Pl. 43: 1.

? 1976 Nov. gen. 1 n. sp. 1 - Landing, p. 642, Pl. 4: 20.

1978 Polonodus? sp. A - Löfgren, p. 76-77, Pl. 16: ?9, 11, 14A, B.

1978 Polonodus? sp. B - Löfgren, p. 77-78, P. 16: 7, 8; Text - fig. 30.

1978 Polonodus clivosus (Viira) - Löfgren, p. 76, Pl. 16: 15A, B, C only.

1979 cf. "Amorphognathus" n. sp. Lindström - Harris et al., Pl. 2: ?11, 15.

Derivation of name

Table Point, Great Northern Peninsula, Newfoundland.

Type locality

Table Point, Great Northern Peninsula, Newfoundland

Type stratum

Middle Table Head, sample TP 74, Histiodella kristina Phylo-zone, Whiterockian (early Llanvirnian).

Holotype

MUNSS 64 (Pl. 13, fig. 3), a polyplacognathodontiform.

Diagnosis

Two types of elements are present: polyplacognathodontiform and ambalodontiform. The anterior process of the polyplacognathodontiform carries two denticle rows, which are separated by a wide platform. The anterior process of the ambalodontiform has a median denticle ridge and an outer small notch. All the processes characteristically become wider distally.

Description

The polyplacognathodontiform has typically an anterior process which has a well-developed wide platform. The anterior process is divided by a deep inner notch or a strongly concave area separating two almost equal size anterior processes. Mature forms develops a very large anterior process. The main denticle row curves inward with a maximum curvature anterior of the cusp. The denticles are rounded and of equal size. The denticles are connected by a thin ridge. The surface of the platform is covered by blunt contoured ridges. The anterior process develops an additional outer denticulated process. The two processes are connected by a wide platform. The outer lateral process is long and straight. It carries small oval denticles, which are equal size and apically free. One or two additional processes evolve during the growth between the anterior and the outer lateral process. An additional process between the outer lateral process and the posterior process is also present.

The ambalodontiform has four straight to curved processes. The anterior process carries one median to outer denticle ridge. The surface is ornamented by transverse ridges. The main denticle row continues onto the posterior process. The outer lateral process is of the same length as the anterior process. Additional processes are formed on the outer lateral process in mature specimens. The outer lateral process carries a median denticle ridge, which initiates just anterior of the cusp. The inner lateral process carries a median to anterior denticle row. The denticle row runs from just posterior of the cusp to over mid-length of the process. The posterior process is straight. The whole

unit has a large basal cavity.

Remarks

The polyplacognathodontiform shows variation in the curvature of the anterior, the inner lateral and the posterior processes. The outer lateral process is always straight. Commonly, the outer lateral process is broken.

Polonodus tablepointensis n. sp. represents the largest conodonts in the collection.

Polonodus? sp. A. Löfgren (1978; Pl. 16, fig. 9) has a strongly concave area separating two almost equal size anterior processes and it belongs within the variation of the polyplacognathodontiform.

Polonodus? sp. A. Löfgren (1978; Pl. 16, figs. 11, 14A, B) is probably a juvenile polyplacognathodontiform.

Polonodus? sp. B. Löfgren (1978; Text - fig. 30) has a large anterior platformal process, and it is a polyplacognathodontiform.

Amorphognathus n. sp. Lindström, Amorphognathus n. sp. cf. A. n. sp. Lindström and A. variabilis (Viira) of Fåhraeus (1970) and Polonodus sp.? B of Löfgren (1978; Pl. 16, figs. 7-8) all have an anterior process without an anterior platformal process. They belong to the ambalodontiform.

Nov. gen. 1 n. sp. 1 of Landing (1976) has a curved anterior process. The element is fragmentary but it possibly belongs within the variation of Polonodus tablepointensis n. sp., as it is similar to Polondus? sp. B Löfgren and A. variabilis (Viira) of Fåhraeus (1970).

Polonodus clivosus (Viira) of Dzik (1976; Text - fig. 7 and Pl. 43, fig. 1) differs from the Table Head species by its larger angle between

the posterior and inner lateral process in the element with straight processes. The specimen with curved processes is higher than the Table Head forms. Possibly the elements represent a different species.

cf. "Amorphognathus" n. sp. Lindström depicted by Harris et al. (1979; Pl. 2, figs. 11, 15) are fragmental, and the anterior process is broken off on both specimens. The appearance (in particular Pl. 2, fig. 15) is similar to the polyplacognathodontiform of Polonodus tablepointensis n. sp.

Polonodus clivosus (Viira) of Löfgren (1978, Pl. 16, fig. 15) differs from P. clivosus by the lack of an inner lateral notch of the anterior process. Instead the notch has an outer position and the element is identified with Polonodus? sp. B Löfgren (1978, Pl. 16, fig. 8). Also the denticle pattern is typical of Polonodus tablepointensis n. sp. rather than Polonodus? clivosus (Viira).

Occurrence

Lower and middle Table Head.

Material

13 polyplacognathodontiforms; 13 ambalodontiforms.

POLONODUS? CLIVOSUS (Viira)

Pl. 13, figs. 6-13

Synonymy

1967 Ambalodus n. sp. - Viira, Fig. 3, no. 24 a, b.

1970 Polyplacognathus n. sp. A. - Fåhraeus, p. 2064, Fig. 3F, G.

1970 Ambalodus n. sp. A. - Fåhraeus, p. 2064, Fig. 3J, K.

1974 Ambalodus clivosus n. sp. - Viira, p. 51-52, Pl. 8: 1; Text - fig. 37, 38.

1978 Polonodus clivosus (Viira) - Löfgren, p. 76 (pars), Pl. 16: 12A, B, 13; non 15A, B, C.

Description

Ambalodontiform. - The unit is X-shaped. The anterior process develops into a straight blade with high apically free, and laterally compressed denticles. The lateral processes are straight with a median row of denticles. The posterior process has a relatively larger platform with a rounded outline. A few denticles continue from the anterior process onto the posterior process. The angle between the anterior and the outer lateral processes is about 90 degrees in juvenile specimens and decreases to almost 45 degrees in adult elements. The inner lateral process forms an angle of 80 degrees or less with the main denticle row. The basal cavity is restricted.

Polyplacognathodontiform. - Two morphotypes are recognized. The first morphotype has an anterior, platformal process, which carries an outer comb-like row of apically free denticles. The platform is covered

by transverse or contoured ridges. A small inner notch is present on the platform. The denticle row is sinuous and continues across the entire unit via a laterally compressed, pointed cusp and onto the inner side of the posterior platform-like process.

The inner lateral process is curved and carries a median denticle ridge. The posterior process is small and weakly ornamented by transverse ridges.

The outer lateral process is straight, blade-like with confluent large denticles which lean posteriorly. An additional process develops during growth between the anterior process and the inner lateral process.

The basal cavity is deep beneath the anterior and the outer lateral processes, weakly developed beneath the inner lateral process, and absent beneath the posterior process.

The second variant has an additional row of denticles on the inner side of the anterior platformal process. The outer lateral denticle ridge consists of laterally compressed denticles. The unit has a high pointed cusp. The inner lateral process is straight. The outer lateral process is straight, but typically not blade-like and does not develop an additional process between the outer lateral and the anterior processes.

Remarks

Some specimens have a dark colored basal filling.

Occurrence

Lower middle Table Head.

Material

18 polyplacognathodontiforms; 13 ambalodontiforms.

POLONODUS? NEWFOUNDLANDENSIS n.sp.

Pl. 13, Figs. 14-16; Text - Fig. 6.1

Derivation of name

Newfoundland.

Type locality

Table Point, Great Northern Peninsula, Newfoundland

Type stratum

Lower Table Head, sample TP 59, *Histiodella tableheadensis* Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 67 (Pl. 13, fig. 16; Text -Fig. 6.1), a polyplacognathodontiform.

Diagnosis

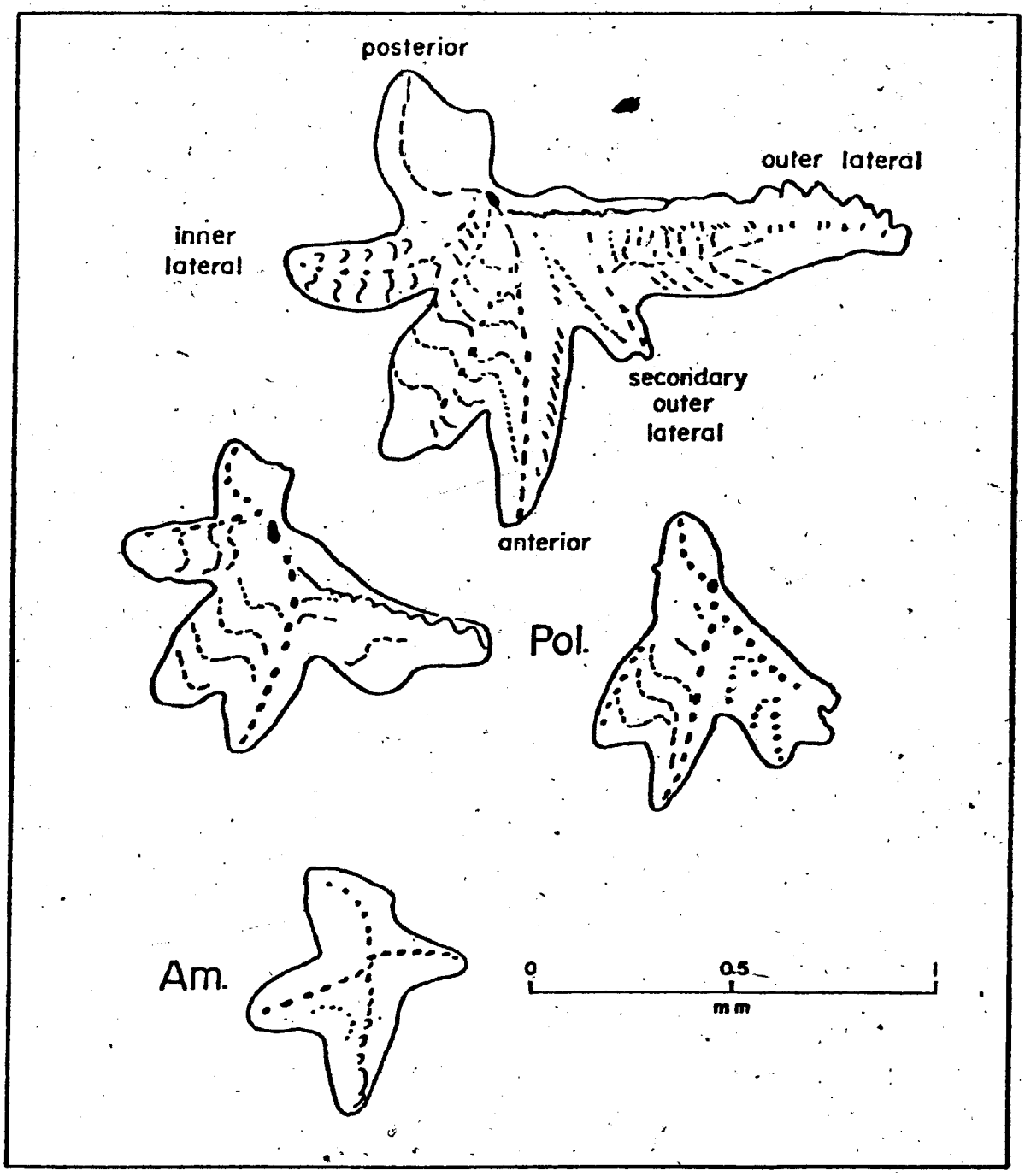
A *Polonodus*? with ambalodontiforms having an angle of 60 degrees between the anterior and outer lateral processes. The denticles are small and blunt. The platform of the anterior process of the polyplacognathodontiform has a deep inner notch.

Description

All elements are four branched in this species.

*Ambalodontiform*. - The ambalodontiform has a straight anterior process which carries small, apically free denticles. The cusp is inconspicuous. The outer lateral process is straight and carries a ridge of small rounded denticles which meets the anterior denticle ridge just anterior of the cusp in an angle of 60 degrees. The inner lateral process extends vertically from the unit and carries a low denticle row. The posterior process is platform-like and only a few blunt denticles are present. The posterior denticle ridge forms an angle close to 90 degrees with the anterior denticle row. The basal cavity is restricted and only narrow slits are present.

Text - Fig. 6.1 Polonodus? newfoundlandensis n. sp. (x 70). Specimens from sample TP 59. am = ambalodontiform; pol = polyplacognathodontiform. The anterior process is directed downwards and the outer lateral process is to the right on the illustration.


posterior
outer lateral
inner lateral
secondary outer lateral
anterior
Pol.
Am.
0
0.5
1
mm

Polyplacognathodontiform. - The anterior process forms a wide platform. It has an outer lateral ridge of small free denticles, and the surface is ornamented by transverse or contoured ridges. The process has a deep inner notch on the platform which separates the main process from an additional inner lateral process in mature elements. The additional inner process is ornamented by a small median ridge of rounded denticles.

The outer lateral process is long, straight and laterally compressed. It carries denticles which are high, laterally compressed and apically free. The angle between the outer lateral denticle ridge and the anterior denticle ridge varies from 45 degrees in juvenile specimens to 70 degrees in adult specimens. In adult elements the outer lateral process becomes much longer than the anterior process.

An additional outer lateral process develops between the anterior and the outer lateral processes during growth of the unit. In juvenile specimens this additional process is only present as an inner flare of the outer lateral process. This additional process is ornamented by a row of small rounded denticles. It meets the main denticle row on the lateral process in an angle of 60 degrees.

The posterior process is rounded and develops a small secondary outer lobe. It is covered by small rounded denticles, which have a lateral inner position on the process.

The inner lateral process is posteriorly curved. It has a median to anteriorly placed row of small rounded denticles. The inner lateral and the posterior processes are equal in size and they are much shorter than the anterior process.

The basal cavity is wide and large and has a small thickened rim along the edge of the element. In some specimens the basal cavity has not been formed underneath the posterior and posterior lateral processes.

Remarks

The species differs from P.? clivosus by the small denticles of the anterior process of the ambalodontiform and by the deep notch on the anterior process of the polyplacognathodontiform.

Occurrence

Lower Table Head.

Material

8 polyplacognathodontiforms; 2 ambalodontiforms.

Genus PYGODUS Lamont and Lindström 1957

Type species - Pygodus anserinus Lamont and Lindström 1957.

Discussion

Bergström (1971a) included two elements, pygodontiform and hadding-odontiform, in Pygodus. Furthermore, he mentioned that ramiforms probably completed the apparatus.

Löfgren (1978) found early forms of Pygodus-like elements. She also included ramiforms in the apparatus. As these early representatives only occurred in small numbers and in frägmental state of preservation the

apparatus was not complete, and she tentatively included the elements in Pygodus?.

In the collections at hand a few ramiforms similar to the ones depicted by Löfgren (1978) are present. These are tentatively referred to Pygodus?.

Fåhraeus (1970) figured a possible haddingodontiform, this element is tentatively included in the apparatus.

PYGODUS? sp. A

Pl. 14, Figs. 1-2

Synonymy

? 1970 Haddingodus serrus (Hadding) - Fåhraeus, fig. 3: 4, 5.

? 1978 Pygodus? sp. B-Löfgren, p. 97, Pl. 16: 2-3; Text - fig. 32F.

Description

The ramiforms are asymmetrical with three processes and have a short cusp, which is recurved. The processes are asymmetrical with three processes and have a short cusp, which is recurved. The processes are connected by a basal sheath.

Remarks

The possible haddingodontiform could belong to the multi-element species Pygodus serra, but it differs in the angle between the anterior and posterior processes being over 90 degrees.

Occurrence

Middle Table Head.

Material

9 specimens.

Family OISTODONTIDAE Lindström 1970

Remarks

The original diagnosis for Oistodontidae was based on the hyaline elements of Oistodus which form a transition series (Lindström, 1964, 1970). Characteristic for Oistodontidae is that the elements have high lateral costae, and that they lack accessory denticles (Dzik, 1976). The architecture of the apparatus is comparable to that of Acodus (Prioniodontidae), which also led Dzik (1976) to include Acodus in Oistodontidae. Acodus is here placed in Prioniodontidae following McTavish (1973).

Lindström (1970) included Scolopodus in Oistodontidae, because it is a hyaline genus. The elements of Scolopodus do not possess high lateral costae, and in overall morphology they differ from the elements of Oistodus, and they are not considered to be closely related. In this study Scolopodus is allocated to Panderodontacea.

Genus OISTODUS Pander

Type species - Oistodus lanceolatus Pander 1856.

Discussion

Oistodus comprises three types of elements: cordylodontiforms, cladognathodontiforms and hibbardelliforms (deltaforms) Lindström (1971).

The apparatus of the collection at hand does not include a deltaform, but consists of prioniodontiforms, ramiforms and oistodontiforms.

Oistodus lanceolatus is well known in much older strata than the the Table Head Formation, and is constantly associated with (van Wamel, 1974; Löfgren, 1978). Younger species are associated with a trichonodelliform (Serpagli, 1974).

McTavish (1973) proposed Protoprioniodus for an apparatus of non-denticulate elements of prioniodontiforms, oistodontiforms and ramiforms. Lindström ( in Ziegler, 1973) discussed the phylogenetic relationship between Protoprioniodus McTavish and Oistodus sensu Lindström and Acodus, and he indicated that Protoprioniodus might be a junior synonym of Oistodus. Dzik (1976), however, suggested that Protoprioniodus and Oistodus were not identical but closely related. This author agrees with Dzik and the present apparatus may be considered as a genus of its own. The generic assignment is therefore queried.

Oelandodus van Wamel has an apparatus similar to Protoprioniodus and probably is a junior synonym of the latter.

OISTODUS? TABLEPOINTENSIS n. sp.

Pl. 14, Figs. 3-12

Synonymy

cf. 1970 Oistodus lanceolatus Pander - Uyeno and Barnes, p. 119, Pl. 24: 23, 24.

1973 Oistodus lanceolatus Pander - Barnes and Poplawski, p. 777, P. 5: 5-7, 10, 11.

Derivation of name

Table Point. The type locality of Table Head strata.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Middle Table Head, sample TP 72, *Histiodella kristina* Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 70 (Pl. 14, fig. 12), a ramiform.

Diagnosis

A species of *Oistodus*? in which the ramiforms have a long extended posterior process.

Description

All specimens have a long laterally compressed weakly recurved to erect cusp with well defined anterior and posterior keels.

*Prioniodontiforms* - The units have a wide almost erect, laterally compressed cusp, which may be either non-, uni- or bicostate. The cusp is widest where it merges with the oral edge. The anterior edge continues down to the anterior basal corner. Some elements may have an anteriorly extended base, as illustrated by Barnes and Poplawski (1973, Pl. 5, fig. 11), forming a small inconspicuous process. The posteriorly extended base reaches about the length of the cusp. The base is compressed, curved and has a high oral keel. The basal cavity begins beneath the centre of the cusp and extends below the entire unit. It is inverted below the cusp.

Ramiforms - The units have slightly recurved cusps and posteriorly extended bases, which may reach the length of the cusp. Two morphotypes are present. The first has one lateral outer costa and an anterior costa which extend from the apex of the cusp to the aboral margin. The face between these costae is concave. The sides of the cusp are broadly convex, and may develop a small costa in the lower part of the cusp, and extend to slightly above the aboral margin. The cusp is slightly twisted. The base forms a convex curve in lateral view, and has a slightly outward twist. The aboral margin is slightly thickened. The basal cavity extends below the posterior process.

The second morphotype has two outer lateral costae separated by a deep groove. These extend down to the aboral margin and disappear at the middle height of the cusp.

Oistodontiforms - These elements have a small posteriorly extended base. The anterior keel may be a little extended and meet the aboral margin in a sharp angle. The elements are asymmetrical having an inner broad carina, and a twisted cusp. The cusp is recurved. The aboral outline is sinuous. The basal cavity fills the whole of the base.

Remarks

Elements of this species have been described as Oistodus lanceolatus Pander from the Mystic Conglomerate (Barnes & Poplawski 1973). The Mystic faunal elements have a slightly different appearance due to a higher base, a wider and more reclined cusp and a shorter posteriorly extended base. Similarly, the prioniodontiform has a higher and wider cusp than any of the Table Head specimens. The Mystic faunal elements

probably represent an early evolutionary state of Oistodus? tablepointensis n. sp.

The specimen from the Lévis (Uyeno and Barnes 1970) has an appearance similar to the ramiforms with one lateral costa. The remaining elements and the preservation of the Levis specimens (broken base) prohibit a definite identification with O.? tableheadensis n. sp.

Occurrence

Sporadic in lower Table Head; common in lower middle Table Head.

Material

70 prioniodontiforms; 120 ramiforms; 52 oistodontiforms.

Family PRIONIODONTIDAE (Bassler 1925)

Discussion

Lindström (1970) included the genera Acodus (Gothodus emend. McTavish 1973; Serpagli 1974), Baltoniodus, and Prioniodus in Prioniodontidae. ?Eoneoprioniodus Mound (emend. Barnes 1977) described below has an apparatus that imitates the prioniodont plan. The ancestor to Eoneoprioniodus is not known, and it is tentatively allocated to Prioniodontidae in this study.

The incorporation of Acodus in Prioniodontidae may be debated as Acodus has been considered to be similar to Oistodontidae, mainly because of its nondenticulated elements (Dzik 1976). Oistodus and Scandodus have an apparatus, which includes hyaline conodonts with symmetry transition from simple elements without any lateral costa, through elements with a strongly developed costa on one side, to elements

with two anterior lateral costae and no anterior edge.

The apparatus of Acodus was established by McTavish (1973) and Serpagli (1974) as a multi-element genus with an apparatus following the prioniodontid plan, and McTavish (1973) considered Acodus deltatus to be the ancestor of the Baltoniodus lineage. Lindström et al. (1972) described longitudinal striations on the cusp of the early prioniodids similar to those on younger species. Acodus was therefore considered to be more closely related to Prioniodus and Baltoniodus than to Oistodus and Scandodus. Consequently Acodus is allocated in Prioniodontidae.

Genus ACODUS Pander 1856

Type species - Acodus erectus Pander 1856.

Remarks

Acodus was first described as a form genus by Pander (1856). Bergström and Sweet (1966) included single form elements Acodus mutatus (Branson and Mehl) s.f. as part of a multi-element apparatus of Acodus. They did, however, express reservations about the use of the genus name Acodus, because the apparatus of the type species (Acodus erectus Pander s.f.) had not yet been established. Lindström (1971) introduced the name Gothodus for elements forming a prioniodont apparatus, but Sweet and Bergström (1972) showed that Gothodus was a junior synonym of Prioniodus. McTavish (1973) and Serpagli (1974) defined Acodus as a multi-element genus including acodontiforms (= prioniodontiforms), oistodontiforms and ramiforms (= trichonodelliforms, cordylodontiforms, and tetraprioniodontiforms). Acodus includes predominantly undenticulated conodonts.

ACODUS COMBSI Bradshaw

Pl. 14, Figs. 13-19

Synonymy

1969 Acodus combsi n. sp. - Bradshaw, p. 1147, Pl. 132: 11, 12.

1969 Scolopodus alatus n. sp. - Bradshaw, p. 1162, Pl. 132: 1-4.

1969 Tripodus laevis n. sp. - Bradshaw, p. 1164, Pl. 135: 9, 10.

1973 Distacodus sp. s.f. - Barnes and Poplawski, p. 772, Pl. 3: 11.

1973 Oistodus n. sp. s.f. - Barnes and Poplawski, p. 777, Pl. 1: 3.

Diagnosis

An Acodus apparatus consisting of undenticulated elements with all processes connected with a basal sheath, and the ramiforms with secondary costae on the inner lateral surface of the specimens.

Description

Acodus combsi Bradshaw s.f. is the prioniodontiform. Scolopodus alatus Bradshaw s.f. is the trichonodelliform and Tripodus laevis Bradshaw s.f. is the tetraprioniodontiform. Distacodus n. sp. s.f. and Oistodus n. sp. s.f. Barnes and Poplawski are the cordylodontiforms. These units were fully described by the respective authors. The ramiforms are unique in the presence of secondary inner lateral costae on many elements.

The oistodontiforms are new, they have a large reclined cusp, which is laterally compressed, keeled and provided with an inner carina. The posterior keel meets the oral edge in an angle of about 80 degrees. The oral edge is short and keeled. The aboral outline is straight with a small inner notch next to the anterior keel. The base is almost

plano-convex with an inwards flaring aboral margin and may resemble the acodontiform. The base is triangular with a flexed outward keel. The anterior keel of the base extends downward to form a small incipient process. The basal cavity is triangular with an anteriorly directed tip.

White matter is confined to the cusp in all specimens.

Occurrence

Lower and lower middle Table Head.

Material

17 acodontiforms; 50 ramiforms; 20 oistodontiforms.

ACODUS? n. sp. A

Pl. 14, Figs. 20-28

Synonymy

cf. 1973 Protopanderodus n. sp. 5 - Barnes and Poplawski, p. 784-785, Pl. 2: 12 only, Text - fig. 2D.

Discussion

A series of undenticulated ramiforms can be associated with acodontiforms and oistodontiforms (scandodontiforms). The ramiforms all include tall, slender, erect, quadricostate units, which form a symmetry transition series. The costae are extended downward slightly beyond the thinly sheathed basal cavity to form short undenticulated processes and the element therefore is to be considered a tetraprioniodontiform.

The apparatus differs from Acodus in the lack of trichonodelliforms, but instead has symmetrical tetraprioniodontiforms. The apparatus

is probably closely related to Acodus, but it is also similar to Scandodus and Triangulodus van Wamel (sensu Dzik 1976). The lack of trichonodelliforms led the author to query the generic assignment.

Diagnosis

An apparatus of undenticulated acodontiforms, cordylodontiforms, scandodontiforms (oistodontiforms) and tetraprioniodontiforms.

Description

The acodontiforms have a wide laterally compressed cusp which is keeled, reclined and has one lateral carina.

The carina continues onto the aboral margin as an apical lip. The aboral outline is straight. The posterior keel of the cusp meets the oral edge in a sharp angle. The base is small, and the basal cavity is a narrow groove, which expands to a small cavity beneath the cusp and the lateral carina.

The ramiforms have a long, slender, erect to slightly reclined cusp which is keeled and has one sharp costa on each lateral face. The costae extend below the aboral margin as undenticulated alate processes. The posterior keel meets the oral edge in a rounded angle. The anterior keel continues onto the base and extends downwards as a small process. The oral edge or posterior process is straight, sharply keeled, and longer than the alate processes. The basal cavity is small, thinly sheathed and cone-shaped. The elements form a tetraprioniodont plan. The position of the lateral and anterior processes changes forming a symmetry transition series, whereas the posterior process remains stable in its position. The symmetrical element is cross-shaped in aboral view, thus having a

sharp anterior keel in the place of a rounded face present in trichonodelliforms.

The oistodontiforms have a reclined, keeled, and relatively wide cusp. The base is flared to the inner side. The oral edge is short and meets the cusp in a sharp angle. The basal cavity is small with a centrally placed tip and extends beneath the whole unit. Juvenile forms are simple triangular laterally compressed cones with a straight aboral outline. During growth the angular junction between the cusp and the oral edge becomes prominent.

Cordylodontiforms are laterally compressed cones with a cusp and triangular base. The cusp forms an angle of about 90 degrees with the oral edge. The oral edge is keeled. The basal cavity extends beneath the whole base as a narrow slit.

Remarks

Juvenile specimens of oistodontiforms resemble *Histiodella minutiserrata* Mound s.f. or *H. altifrons* Harris s.f. The principal differences are the lack of flaring lips and the lack of denticulation of the oistodontiform in *Acodus*? n. sp. A.

*Protopanderodus* sp. 5 of Barnes & Poplawski (1973) is similar in that it is a tetraprioniodontiform. To judge from the description of Barnes & Poplawski (1973) the element is part of a *Triangulodus* apparatus, and the similarity may be due to homeomorphy.

Occurrence

Lower Table Head and lower middle Table Head.

Material

32 acodontiforms; 36 ramiforms; 19 oistodontiforms.

Genus BALTONIODUS Lindström 1971

Type species - Prioniodus navis Lindström 1955a.

Remarks

Fåhraeus and Nowlan (1978) reviewed the history of the genera Prioniodus, Oepikodus, Gothodus and Acodus. Dzik (1976) and Löfgren (1978) found that Baltoniodus was a subgenus of Prioniodus, but Lindström et al. (1974) provided arguments for the rank of genus for Baltoniodus. The present author agrees with Lindström et al. (1974) and is of the opinion that the apparatus of Baltoniodus is well established and easily can be regarded as a separate genus.

Baltoniodus comprises B. triangularis, B. navis and B. prevariabilis as the best known species. Additional species were not described from large collections. Baltoniodus prevariabilis is a transitional form between B. navis and elements described as Prioniodus variabilis (Bergström, 1971a).

Baltoniodus prevariabilis has been separated into three subspecies based on differences in the ramiforms, in particular the tetraprioniodontiform (Dzik, 1976; Löfgren, 1978).

A series of ramiforms including paracordylodontiforms, "gothodontiforms", trichonodelliforms, tetraprioniodontiforms and falodontiforms was recovered in the Table Head fauna. No amorphognathodontiforms and ambalodontiforms were found, and a certain assignment to Baltoniodus, therefore, is not possible. Two possibilities for the affinity of the elements exist.

The first is to assign the elements to Baltoniodus and consider the lack of the remaining elements of the apparatus as a chance coincidence. The general morphology of the elements are in favour of this approach.

The position of the processes of the tetraprioniodontiform is similar to and identified with the medius variant of B. prevariabilis. The falodontiform (Löfgren, 1978, Pl. 12, fig. 34) is identical to the Table Head specimens. Presence of gothodontiforms and paracordylodontiforms characterize the stratigraphically older elements of this subspecies (?middle Kundan into Aserian).

The second possibility would be that the elements could be ramiforms in an apparatus including Polonodus? clivosus (Viira). The apparatus then would be similar to Amorphognathus. At present this possibility is not considered likely, because the collection at hand is sporadic and far from conclusive.

BALTONIODUS? PREVARIABILIS MEDIUS (Dzik)

Pl. 15, Figs. 1-6

Synonymy

? 1973 Baltoniodus prevariabilis? (Fåhraeus) - Barnes and Poplawski, p. 769, Pl. 1: 20.

1976 Prioniodus alatus medius ssp. n. - Dzik, p. 423, Pl. 42: 1; Text - fig. 23A-1 (in pars).

1978 Prioniodus (Baltoniodus) prevariabilis medius Dzik - Löfgren, p. 86-87, Pl. 12: 27-36, Pl. 13: 1A-B, 3, 6A-D.

Description

The collection includes paracordylodontiforms, trichonodelliforms, tetraprioniodontiforms, gothodontiforms and falodontiforms.

Paracordylodontiform - The unit has a recurved, twisted and keeled cusp with an inner median carina and an outer convex face. The keels continue onto the denticulated processes.

Gothodontiform - The gothodontiform has a cusp and three denticulated processes. The cusp is erect and carries three costae. The costae continue onto the processes. The unit has an anterior, a posterior and antero-lateral outer process. All the processes are denticulated. Black basal matter is often attached to the unit.

Trichonodelliform - The trichonodelliform has an erect cusp with three costae. The anterior margin is convex. The lateral and posterior costae continue onto the three denticulated processes.

Tetraprioniodontiform - The unit has two lateral processes, an anterior and a posterior process. The anterior process is almost in a plane with the posterior process, but has a small lateral deflection. The lateral processes are not completely symmetrical in position. All processes are denticulated.

Falodontiform - The falodontiform has a large reclined cusp with well developed keels and a small base. The aboral outline is sinuous. The anterior process is thin and long. It carries up to seven pointed denticles. The posterior basal extension is short, but may be broken. The outline from the cusp to the anterior process is sinuous.

Remarks

The paracordylodontiform and gothodontiform are similar to P. (B.) prevariabilis norrlandicus Löfgren in that the anterior process is denticulated. The angle with the posterior process is about 55 degrees or less. According to Löfgren (1978) these characteristics are also present within early forms of Baltoniodus prevariabilis medius. The nearly symmetrical tetraprioniodontiform is characteristic of B. prevariabilis medius. The lack of a posteriorly extended base on the falodontiform is typical of the Table Head specimens.

The single prioniodontiform element illustrated by Barnes & Poplawski (1973) from the Mystic Conglomerate may complete the apparatus, and it is tentatively included in the synonymy.

Occurrence

Lower and middle Table Head.

Material

30 ramiforms; 18 falodontiforms.

Genus EONEOPRIONIODUS Mound 1965b

(emend. Barnes 1977)

Type species - Oistodus bilongatus Harris 1962.

Discussion

Barnes (1977) redefined Eoneoprioniodus Mound as a multi-element genus consisting of hyaline elements with an apparatus following the prioniodontid plan. The elements of Eoneoprioniodus are mainly adenticulate or weakly denticulated. The apparatus includes oistodontiforms.

The present material is close to the definition of Eoneoprioniodus Mound. Hyaline elements form a prioniodus-like skeletal apparatus, but differs by the possible presence of a cyrtoniodontiform instead of an oistodontiform. The presence of the cyrtoniodontiform in the apparatus is, however, not certain, as the present material is sparse. Possibly an oistodontiform will be found in larger collections. One other principal difference is that all the elements are denticulated. However, it seems best to tentatively include the elements in Eoneoprioniodus pending more information on the nature of the Table Head elements.

The similarity of Eoneoprioniodus with Acodus, and the forms found herein with Prioniodus is striking.

EONEOPRIONIODUS? sp. 1

Pl. 15, Figs. 7-13, 15-16

Synonymy

cf. 1965a *Cordylodus delicatus* Branson and Mehl - Mound, p. 14, Pl. 1: 25, 28, 30.

1965a *Dichognathus extensa* Branson and Mehl - Mound, p. 15, Pl. 1: 27.

1965a *Dichognathus typica* Branson and Mehl - Mound, p. 15-16, Pl. 1: 28.

cf. 1965a *Ozarkodina delecta* Stauffer - Mound, p. 30-31, Pl. : 15.

cf. 1965a *Prioniodus evae* Lindström - Mound, p. 34-35, Pl. 4: 17, 18.

cf. 1965a *Tetraprioniodus costatus* - Mound, p. 34-35, Pl. 4: 19, 25, 31; Text - fig. 1K.

1970 *Prioniodus* aff. *P. evae* Lindström - Uyeno and Barnes, p. 109, Pl. 22: 21, 22.

1971 *Prioniodina*? sp. A - Sweet, Ethington and Barnes, p. 170, Pl. 1: 37.

1971 *Tetraprioniodus* sp. A - Sweet, Ethington and Barnes, p. 170, Pl. 1: 30.

cf. 1971 *Prioniodus* sp. A - Sweet, Ethington and Barnes, p. 170, Pl. 1: 26.

cf. 1971 *Prioniodus* sp. B - Sweet, Ethington and Barnes, p. 170, Pl. 1: 28.

cf. 1977 Hyaline prioniodiform element - Barnes, p. 236, Pl. 1: 14.

1978 Prioniodus sp. B. s.f. Sweet et al. - Tipnis et al., Pl. IV: 11.

1978 Tetraprioniodus sp. A. s.f. Sweet et al. - Tipnis et al., Pl. IV: 21.

1979 "Prioniodus" n. sp. - Harris et al., Pl. 1: 13-15.

Description

Eoneoprioniodus? sp. 1 has an apparatus of prioniodontiforms, paracordylodontiforms, trichonodelliforms, and tetraprioniodontiforms.

Prioniodontiform - The unit has a large straight keeled cusp and three denticulated processes. The keels continue onto the outer anterior process and the postero-lateral process. The outer face of the cusp is convex. An inner antero-lateral costa extends the full length of the cusp and continues onto the inner anterior lateral process. The face between the costa and the posterior keel is convex, whereas the face between the anterior keel and the antero-lateral costa is concave. The outer lateral process is curved. It carries 5-6 free, laterally compressed and pointed denticles. The anterior process is directed downwards and it carries three, free, laterally compressed denticles. The angle between the anterior and the posterior lateral process is about 100 degrees to 110 degrees. The antero-lateral inner process carries 5 to 7 free, laterally compressed denticles. The angle between the cusp and the antero-lateral process varies between $30^{\circ}$-$45^{\circ}$. The two lateral processes may be twisted outwards and they are in the same horizontal plane. All the denticles have white matter whereas the processes and

the cusp are hyaline. The basal cavity is a small cone beneath the cusp and disappears beneath the processes. A basal sheath may be present between the anterior and the posterior processes.

Paracordylodontiform - The unit consists of a costate cusp with a denticulated posterior process and an anterior process. The anterior process is a short, thin extension which may carry denticles. In large specimens the anterior process is well developed and denticulated. The cusp is recurved and more or less twisted, Sharp anterior and posterior keels extend from the apex of the cusp to the base, where they continue onto the anterior and posterior processes. The cross section of the cusp is oval. The posterior process is extended with an outward flexing. It has 3 to 9 laterally compressed, discrete and sharply pointed denticles. The basal cavity has thin walls and is only slightly wider than the cusp. Asymmetrical forms always have denticulated processes.

Trichonodelliform - The unit has a large recurved cusp, two anterolateral denticulated processes and a short posterior denticulated process. The cusp has three costae from the tip to the base and continuing onto the processes. The anterior face of the cusp is convex. The two lateral processes extend downwards and carry from 4 to 7 free denticles. The lateral processes are always longer than the posterior process. The posterior process is convex in lateral view. The basal cavity is shallow and is covered by a thin basal sheath.

Tetraprioniodontiform - The unit consists of a costate cusp with two denticulated posterior processes, one denticulated anterior lateral process and one adenticulate anterior process. The element has a recurved cusp. The outer lateral process is flexed outwards and carries from 4 to 6 laterally compressed denticles. The posterior process is directed straight backwards, and it forms an open arch when seen in lateral view. It carries from 4 to 7 free, laterally compressed denticles which are increasingly tilted toward the posterior. The anterior lateral process, when preserved, carries four free denticles. The process is almost vertical relative to the posterior process. The anterior process is short and directed downwards. All the denticles have white matter whereas the remainder of the unit is hyaline. The basal cavity is a small cone. A basal sheath connects the processes.

Cyrtoniodontiform - The cyrtoniodontiform has a recurved cusp, and a denticulated posterior process. The denticles are free and laterally compressed. The basal cavity is shallow.

Remarks

The paracordylodontiforms of the Joins Formation (Mound, 1965a) differ from the Table Head fauna in their curvature of the cusp and that the denticles are fused. The prioniodontiform has an anterior lateral downwards projected process. The tetraprioniodontiform (T. costatus Mound s.f.) differs in having five costae, whereas the Table Head species have four. Some of the Joins specimens may form an apparatus similar to the Table Head species (e.g. Dichognathus extensa s.f., T. costatus s.f.), but others may belong to a different genus (e.g. Cordylodus delicatulus s.f.).

Prioniodus sp. A and Prioniodus sp. B of Sweet et al. (1971) have a different orientation of the anterior lateral and the anterior processes. The first seemingly is directed downwards on P. sp. A, and the second is directed outwards on P. sp. B. In the Table Head specimens the anterior lateral process is horizontal and the anterior process has a downward direction.

The hyaline prioniodontid element from the Bay Fiord Formation (Barnes, 1977) differs by possessing short lateral processes and an anterior keel.

Occurrence

Lower Table Head.

Material

42 prioniodontiforms; 116 ramiforms.

EONEOPRIONIODUS? sp. 2

Pl. 15, figs. 14, 17-20.

Synonymy

1971 Cyrtoniodus sp. A. Sweet - Ethington and Barnes, p. 170, Pl. 2: 22.

Description

The collection includes hyaline specimens all with an anteriorly keeled base. The elements form a cordylodus-roundya transition series of Lindström (1964).

Cyrtoniodontiform - The element has a large, laterally compressed, keeled and recurved cusp and a denticulated posterior process. The cusp is twisted inwards and the anterior keel continues onto the base to the aboral margin. The denticles are laterally compressed and fused. The basal cavity is initially wide but becomes a narrow furrow beneath the process. The aboral outline is sinuous and the base has an inner flare.

Ramiforms - The ramiforms have one inner lateral denticulated process. The lateral process carries from two to three denticles. The basal cavity is small and extends as a furrow beneath the processes.

Trichonodelliform - The unit has a recurved cusp, two lateral costae, and a posterior costa. All costae continue onto the processes. The anterior face of the cusp is convex. The two lateral processes are short and carry up to two free denticles. The posterior process is long and almost straight.

Remarks

Additional elements of this apparatus have not been found. The elements of this possible species differ from Eoneoprioniodus? sp. 1 by the short lateral processes; the laterally compressed and fused denticles of the cyrtoniodontiform; the prominent anterior keel on the base, and the basal furrow beneath the processes of the elements.

Occurrence

Lower Table Head.

Material

50 specimens.

## Suborder OZARKODININA Dzik 1976

### Diagnosis

Dzik (1976) defined Ozarkodinina as: "Asymmetric two-branched (ozarkodiniform and hindeodelliform) elements predominant functionally in the apparatus".

### Remarks

Dzik (1976) erected this suborder to comprise apparatuses consisting of ozarkodiniforms, asymmetrical to symmetrical elements (cordylodus-roundya transition series of Lindström 1964) and an element with one process reduced in size (i.e., oistodontiforms, neoprioniodontiforms). The apparatus mainly consists of six types of elements, which can be reduced in number or an extra element may be added.

Ozarkodinina apparently originated from simple apparatuses and presumably evolved from Drepanoistodus in the Early Ordovician (Dzik 1976). During evolution the oistodontiforms are replaced by neoprioniodontiforms (Dzik 1976, 1978).

## Superfamily PRIONIODINACEA (Bassler 1925)

## Family PERIODONTIDAE Lindström 1970

### Diagnosis

Apparatus having oistodontiforms without posterior denticles. Anterior denticles may be present on oistodontiforms.

Remarks

Apparatuses with posteriorly denticulated oistodontiforms are included in Prioniodinidae (Dzik 1978). Periodontidae comprises the genera Microzarkodina, Phragmodus and Periodon. Microzarkodina includes trichonodelliforms with or without a short posterior process and oistodontiforms without anterior denticles. Phragmodus has an apparatus with an adenticulate oistodontiform (Bergström and Sweet, 1966; Moskalenko, 1972). According to Dzik (1978) Phragmodus includes a trichonodelliform with a short posterior process. Younger species of Phragmodus have trichonodelliforms with a posterior process (Sweet and Bergström, 1972; Moskalenko, 1972; Uyeno, 1974). Periodon comprises trichonodelliforms with a long denticulated, posterior process and oistodontiforms with or without anterior denticles.

Genus PERIODON Hadding 1913

Type species - Periodon aculeatus Hadding 1913.

Discussion

Bergström & Sweet (1966) redefined Periodon as a multi-element genus with six elements in its apparatus: "Cordylodus-, ligonodina-, cladognathus-, roundya-, prioniodina-, and falodus-like conodont elements". The cordylodus-, ligonodina-, cladognathodus- and roundya-like elements characterize the cordylodus-roundya transition series (Lindström, 1964).

Lindström (1971) suggested that Periodon flabellum did not include a falodontiform (or oistodontiform) in its apparatus. The element should be added to the apparatus during evolution. Subsequent workers (van Wamel,

1974; Serpagli, 1974; Landing, 1976; Fåhraeus & Nowlan, 1978; Löfgren, 1978), however, all found an oistodontiform which completed the apparatus.

Hunter (1978, unpubl. M.Sc. thesis) carefully described two distinct morphotypes: loxognathodontiform and periodontiform within the cordylodus-roundya transition series in Periodon aculeatus. The elements were recovered from the Coobs Arm Limestone, central Newfoundland of Middle Ordovician age (Pygodus serra and Pygodus anserinus Zones).

By comparing elements of P. flabellum (Swedish material available in own collection from Tomten: Middle to Upper Billingen, Lower Ordovician) and P. aculeatus (this study) it appears that a similar structural pattern can be reconstructed in this material as well and it is therefore considered to be characteristic of Periodon.

The definition of Periodon is: Periodon is a multi-element genus with an apparatus consisting of cordylodontiforms, loxognathodontiforms, periodontiforms, trichonodelliforms, ozarkodiniforms and oistodontiforms. The ozarkodiniforms are developed as two morphotypes, i.e., prioniodiniform and oulodontiform.

PERIODON ACULEATUS ZGIERZENSIS Dzik

Pl. 16, Figs. 1-15

Synonymy

cf. 1941 Loxognathus flabellata n. sp. - Graves and Ellison, p. 12, Pl. 2: 29, 31, 32.

1941 Oistodus prodentatus n. sp. - Graves and Ellison, p. 13-14, Pl. 2: 6, 22, 23, 28.

1941 Ozarkodina macrodentata n. sp. - Graves and Ellison, p. 14, Pl. 2: 33, 35, 36.

cf. 1965 Prioniodina? inflata Lindström - Ethington and Clark, p. 199, Pl. 1: 8.

cf. 1965 Trichonodella flabellum Lindström - Ethington and Clark, p. 199, Pl. 2: 8.

1965 Falodus prodentatus (Graves and Ellison) - Ethington and Clark, p. 192-193, Pl. 1: 16.

cf. 1965 Periodon aculeatus Hadding - Ethington and Clark, p. 198, Pl. 2: 10.

1969 Periodon aculeatus Hadding - Bradshaw, p. 1159-1160, Pl. 137: 1, 2, 3, ?4, ?5, 6.

1969 Falodus prodentatus (Graves and Ellison) - Bradshaw, p. 1151, Pl. 135: 16, ?17.

1969 Ligonodina tortilis Sweet and Bergström - Bradshaw, p. 1152-1153, Pl. 137: 18.

1969 Prioniodina macrodentata (Graves and Ellison) - Bradshaw, p. 1160, Pl. 137: 19.

1970 Falodus prodentatus (Graves and Ellison) - Uyeno and Barnes, p. 108, Pl. 22: 8, 14, 18.

1970 Falodus sp. - Uyeno and Barnes, p. 108, Pl. 22: 15.

1970 Periodon aculeatus Hadding - Uyeno and Barnes, p. 112, Pl. 23: 1, 2, 3, 4, ?5, 6, 7.

cf. 1970 Periodon flabellum (Lindström) - Uyeno and Barnes, p. 112, Pl. 23: 10, 15.

1973 Periodon aculeatus Hadding - Barnes and Poplawski, p. 780, Pl. 5: 15, 15a, 16-18, 18a.

1976 Periodon aculeatus zgierzensis ssp. n. - Dzik, p. 424, Pl. 44: 5, 6; Text - fig. 34E-K.

cf. 1976 Periodon aculeatus aculeatus Hadding - Dzik, Text - fig. 34l-r.

1976 Periodon aculeatus Hadding - Landing, p. 636, Pl. 3: 3-6, 14.

1978 Periodon aculeatus Hadding - Fåhraeus and Nowlan, p. 462 (pars), Pl. 3: 1, 7, 8, ?10, 11, 12; Text - fig. 5A, ?H, J, K, L.

cf. 1978 Periodon flabellum Lindström - Fåhraeus and Nowlan, p. 462-463, Pl. 3: 2-6; Text - fig. 5B-F.

1978 Periodon aculeatus Hadding - Löfgren, p- 74-75 (pars), Pl. 10: 1A, B; Pl. 11: 12-18 only.

1978 Periodon cf. P. aculeatus Hadding - Tipnis et al., Pl. VIII: 13-15.

Description

Löfgren (1978) and Hunter (1978) fully described P. aculeatus. The Table Head material fits with the early form of P. aculeatus sensu (Löfgren, 1978) and corresponds to P. aculeatus zgierzensis Dzik (1976). A few remarks are needed, because the Table Head specimens are less advanced than P. aculeatus typical of the upper Llanvirn.

The prioniodiniform has processes of equal length. It carries 3 to 5 denticles on the anterior process and 3 to 6, normally 4, denticles on the posterior process. The anterior process is directed downwards and inwards. It forms an inner angle with the posterior process that varies from 9- to 180 degrees, normally at about 140 degrees.

The oulodontiform has the anterior process deflected outwards. The anterior process forms an angle of 100 to 130 degrees with the posterior process. It normally carries three denticles, and the number varies from 2 to 4. The posterior process carries from 5 to 7 denticles.

The oistodontiform constantly carries anterior denticles. The number of denticles varies from two to five, normally it has three denticles. The unit is asymmetrical due to an inner flare of the base and the cusp may be inward flexed. The oistodontiform varies in morphology and the extremes can be distinguished as two morphotypes. The first type has a strongly reclined cusp, which forms an angle of about 45 degrees with a gently reclined cusp, which forms an angle of about 45 degrees with a gently sinuous oral edge. The anterior basal edge meets the aboral margin in an angle of 45 degrees. The second morphotype has a reclined cusp, which meets the straight distal part of the oral edge in an angle of 60 degrees. The cusp and the oral edge forms an angle of 5 to 10 degrees. The aboral margin is strongly sinuous in outline. This morphotype is finely striated at the point of maximum curvature of the cusp. The two morphotypes were illustrated by Löfgren (1978, Pl. 11, figs. 17, 18).

The cordylodontiforms carry one to three, in juveniles incipient, anterior denticles. The unit is slightly laterally bent. Some elements have an outer lateral carina on the cusp. The number of denticles between the cusp and the large denticle on the posterior process varies from 4 to 5.

The loxognathodontiform is characterized by the presence of an outer-lateral process and an inner antero-lateral process. The posterior

process is distally flexed inward. The inner antero-lateral process carries 3 to 4 denticles. It forms an angle of 130 degrees with the posterior process. The outer lateral process is directed posteriorly. It forms an acute angle with the posterior process. It carries from 2 to 4 denticles. The number of denticles between the cusp and the large denticle on the posterior process varies from 4 to 5.

The periodontiform has an outer carina or costa, which may extend downwards as a nondenticulated process, an inner antero-lateral process, and a posterior process which is distally flexed outward (oulodus-like). The number of denticles between the cusp and the largest denticle on the posterior process varies from 4 to 5.

The trichonodelliform carries 2 to 4 denticles on the lateral processes. The number of smaller denticles between the cusp and the large denticle of the posterior process varies from 4 to 5. The large denticle is posteriorly inclined from 45 degrees in juvenile specimens to 80 degrees in mature units.

Remarks

The variation of the elements in Periodon is gradual and this makes it difficult to separate closely related species (Löfgren, 1978). In general, the oistodontiform is considered to be diagnostic (Serpagli, 1974; Löfgren, 1978) and an increase in the number of denticles from older to younger species is characteristic. P. flabellum has been distinguished from P. aculeatus zgierzensis by the absence of anterior denticles of its oistodontiform, whereas the oistodontiform of P. aculeatus always carries denticles (i.e., falodontiform). According to Löfgren (1978) P. flabellum

does carry anterior denticles on the oistodontiforms, but the same elements should have a less sinuous aboral outline than early forms of P. aculeatus. The increase in the length of the oral edge relative to the length of the cusp, however, is important in evaluation of Periodon species. Thus in P. flabellum the ratio of length of oral edge: length of cusp is 1:2; in P. aculeatus zgierzensis the similar ratio is 3:4, and in P. aculeatus aculeatus the ratio is 1:1. In the Table Head material the variation of the oistodontiform corresponds to that of early members of P. aculeatus (i.e., P. aculeatus zgierzensis).

The remaining elements of P. flabellum and P. aculeatus were discussed by Dzik (1976) and Löfgren (1978), and a general increase in the number of denticles was noted. The basal sheath becomes narrower in younger forms, and an increase in the lateral bend of the elements is also typical. The angular position of the outward directed anterior process of the oulodontiform may appear to be of taxonomical value. Thus in P. flabellum the angle varies from 130 to 170 degrees; in P. aculeatus zgierzensis the angle varies from 100 to 130 degrees, and in P. aculeatus the angular position is 90 to 100 degrees.

The late Llanvirnian Periodon aculeatus (i.e., Hadding, 1913; Lindström, 1955b; Sweet and Bergström, 1962, 1966; Hamar, 1964; Schopf, 1966; Webers, 1966; Viira, 1967, 1974; Bergström, Riva and Kay, 1974; Dzik, 1976; Bergström, 1978; Löfgren, 1978 (Pl. 11, figs, 19-26) and Tipnis (1978)) represents an evolutionary stage which is beyond the one represented by the Table Head fauna.

Uyeno and Barnes (1970) and Fåhraeus and Nowlan (1978) described transitional elements between P. flabellum and P. aculeatus. Their Periodon aculeatus fits with the Table Head specimens. Periodon flabellum, however, has not been recorded in this study. The Albertan species (Ethington and Clark, 1965) may belong with the range of variation of Periodon aculeatus zgierzensis, or belong to the late form of P. flabellum of the Mystic Conglomerate (Uyeno and Barnes, 1970) and the Cow Head Group (Fåhraeus and Nowlan, 1978). The Albertan specimens are fragmental which prohibits a definite species identification.

Bergström and Sweet (1966); Repetski and Ethington (1977); and Kennedy et al. (1979) have discussed the differences between P. aculeatus and its successor P. grandis.

Occurrence

Sporadically in lower Table Head; abundant in middle Table Head.

Material

1322 specimens (specified in Table 3.1).

Genus PHRAGMODUS Branson and Mehl 1933

(emend. Bergström and Sweet, 1966, p. 366)

Type species - Phragmodus primus Branson and Mehl 1933.

Remarks

Uyeno (1974) and Dzik (1978) most recently discussed Phragmodus. The apparatus of Phragmodus comprises at least five elements:

phragmodontiform, dichognathodontiform, oistodontiform and ramiforms forming cordylodontiform-gothodontiform and plectodiniform-cyrtoniodontiform transition series.

Dzik (1978) distinguished Phragmodus from Plectodina and Oulodus by the presence of an oistodontiform in the former and neoprioniodontiform (cyrtoniodontiform) in the latter. Plectodina and Oulodus were included in Prionidinidae Bassler 1925.

PHRAGMODUS? sp. A

Pl. 16, Figs. 16-20

Synonymy

cf. 1979 Phragmodus n.sp. - Harris et al., p. 24, fig. 13.

Remarks

A small collection forms an apparatus including ozarkodiniforms, cordylodontiforms, trichonodelliforms, and oistodontiforms. The trichonodelliform has a long posteriorly extended process and short lateral processes. This apparatus is tentatively assigned to Phragmodus.

Description

The ozarkodiniform has a large straight cusp, which is laterally compressed, keeled and carinate. The cusp is variable in length. The anterior keel continues onto the base through a curve. The antero-basal corner is pointed and flexed outward. The aboral outline is concave and the base has an inner flare. The posterior process is flexed outward. It carries four to six laterally compressed, pointed and reclined denticles. The basal cavity is triangular and covered by a thin basal sheath.

The cordylodontiform has an erect to slightly reclined cusp. The cusp is keeled and the keels continue onto the base. The aboral outline is convex. The posterior process is straight and carries erect laterally compressed denticles. The denticles have an increasing tilt posteriorly from the cusp toward the distal end of the process. The basal cavity is triangular with the tip beneath the centre of the cusp. The antero-basal corner is broken in the present material.

The trichonodelliform has a long slender reclined cusp. The two lateral processes are directed posteriorly and each carries one free denticle. The aboral outline is concave anteriorly and straight posteriorly. The posterior process is curved next to the cusp; beyond that it is straight. The distal part of the posterior process is broken on the Table Head specimens, and the total number of preserved denticles does not exceed five.

The oistodontiform has a strongly reclined cusp with rounded faces. The anterior keel continues onto the base. The antero-basal corner forms an angle of 45 degrees with the aboral margin. The aboral outline is sinuous. The oral edge is keeled and arched. It reaches between 2/3 to 3/4 the length of the cusp. The unit is asymmetrical due to an inward twist of the cusp and the inner flare of the base.

Remarks

Phragmodontiforms have not been recorded in this small collection.

The oistodontiform is the diagnostic element in evaluation of species of this apparatus (Dr. Anita Harris, USGS, Washington D.C. - pers. comm. 1980). *Phragmodus* n. sp. Harris *et al*. has a longer posterior

process than the Table Head species. Phragmodus n. sp. Harris et al. probably represents a younger, closely related species.

Occurrence

Lower and middle Table Head.

Material

30 specimens.

Family PRIONIODINIDAE Bassler 1925

Diagnosis

Conodonts having two-branched ozarkodiniforms and oistodontiforms with a posteriorly denticulated process (neoprioniodontiforms) (Dzik, 1976, 1978).

Remarks

Prioniodinidae evolved from Periodon (Lindström, 1970). It differs from Periodontidae by the transformation of oistodontiforms into neoprioniodontiforms (Dzik, 1976, 1978).

Genus ERRATICODON Dzik 1978

Type species - Erraticodon balticus Dzik 1978.

Discussion

Dzik (1978) defined Erraticodon as: "Three-branched trichonodelliform and plectospathodiform elements. Neoprioniodiform element with a denticulated posterior branch only ("Cyrtoniodus")". The elements are mainly hyaline. The apparatus is comparable to that of Periodon, and

Dzik (1978) found that Erraticodon could be the ancestor of Prioniodinidae.

Dzik (1978) considered Erraticodon balticus, the type species of Erraticodon, to include six types of elements, i.e., spathognathodontiform, ozarkodiniform, plectospathodontiform, hindeodelliform, neoprioniodiniform and trichonodelliform in the apparatus. He (Dzik 1978) chose the specimen illustrated by Viira (1974, Pl. 11, fig. 22) as a spathognathodontiform.

According to the terminology of Dzik (1976) the spathognathodontiform is two-branched, and it does also appear with two branches on the schematic illustration of the apparatus (Dzik 1978, fig. 6). Similarly, elements with two branches have been illustrated from conodont bearing strata (late Llanvirn) younger than those of the Table Head (Lindström, 1955b, Pl. 22, fig. 13; Lindström 1960).

In the Table Head material, however, an element with three processes or prioniodontiform, is always present, and the only two-branched elements present are ozarkodiniforms and and hindeodelliforms. The prioniodontiform of the Table Head Formation is identical to the specimen of Viira (1974), when seen in lateral view. Furthermore, it is common that one process is broken and, therefore, it has an appearance of two branches only. A complete prioniodontiform was illustrated by Müller (1978).

It is not obvious from the data of Dzik (1978, Table 1) if the Polish species in fact carried two branches only or if it was based on identification with Viira's (1974) specimen. Thus, alternatively, it is possible that Erraticodon carried a two-branched unit in younger

species. The third process could either be reduced during evolution or was never present.

Based on the relatively large collection from the Table Head, the positive identification with the "spathognathodontiform" of Viira (1974), and also the presence of a prioniodontiform elsewhere (i.e., Australia, Müller 1978), this author is convinced that Erraticodon includes a three-branched element or prioniodontiform in its apparatus.

In addition to the prioniodontiforms, the plectospathodontiforms can be separated into two distinct morphotypes, here labelled sannemannuliform (after Lindström 1964) and zygognathodiform. The elements carry three denticulated and variously bent processes.

Erraticodon, therefore, is defined as follows:

Erraticodon has an apparatus which consists of prioniodontiforms, hindeodelliforms, ozarkodiniforms, neoprioniodiniforms (cyrtoniodontiforms) and a transition series of elements with three denticulated processes. The transition series comprises symmetrical (trichonodelliforms) and asymmetrical elements (zygognathodiform and sannemannulliform) and prioniodontiform. All elements are hyaline.

?ERRATICODON BALTICUS Dzik

Pl 17, Figs. 9-19

Synonymy

cf. 1913 Polygnathus alternans - Hadding, p. 32, Pl. 1: 7.

cf. 1955b Chirognathus alternans (Hadding) - Lindström, p. 107, Pl. 22: 7, ?13.

? 1960 Chirognathus sp. - Lindström, fig. 7: 16.

cf. 1960 Chirognathus? - Lindstrom, fig. 7: 9.

cf. 1962 "Fibrous" conodont-elements - Sweet & Bergström, p. 1249-1250, Pl. 169: 1, 2, 5, 10, 13, 15, 16.

1966 Phragmodus? n. sp. - Fåhraeus, p. 28, Pl. 3: 12a, b.

cf. 1966 "Fibrous" conodonts - Fåhraeus, p. 32, Pl. 4: 7, 8, 9a, 9b.

1967 "Chirognathus"? - Viira, Fig. 4: 9-11.

1970 Chirognathus sp. - Fåhraeus, p. 2064, fig. 3L, M.

? 1970 Polycaulodus sp. - Uyeno & Barnes, p. 112-113, Pl. 21: 17.

? 1973 "Fibrous" conodont elements - Barnes & Poplawski, p. 787-788 (pars), Pl. 4: 21 only.

1974 "Chirognathus" sp. - Viira, p. 63, Pl. 1: 15, 21, 22.

1978 Gen. et. sp. indet. B. - Löfgren, p. 118, Pl. 1: 41-44.

1978 Prioniodid conodont element - Müller, p. 276.

? 1978 Erraticodon balticus sp. n. - Dzik, p. 66, Pl. 15: 1-3, 5, 6; Text - fig. 6A-E.

cf. 1979 Erraticodon sp. - Harris et al., Pl. 3: 1-5.

Description

The Erraticodon apparatus includes two transition series the first of which includes hindeodelliforms, ozarkodiniforms, and neoprioniodontiforms. This is a simple transition series characterized by a reduction of the anterior process.

Hindeodelliform - The hindeodelliform has a tall, recurved and keeled cusp, a posterior process bearing vertically orientated denticles, and an inner lateral process, which is directed posteriorly. The denticles on the posterior process increase in length distally. About

midlength of the process a large recurved denticle is present. This denticle is about equal in length or slightly longer than the cusp. The inner lateral process bears denticles, which increase in height at the middle of the process.

The inner lateral process is curved and the posterior process is flexed. The whole unit is sinuous.

The aboral outline is convex. The basal cavity is mainly restricted to the base beneath the cusp. The processes are slightly excavated by a narrow groove in some elements. Black colored basal filling is often preserved. The basal filling has a large basal funnel.

Ozarkodiniform - The element consists of a tall recurved cusp and denticulated anterior and posterior processes. The cusp is keeled and has convex faces. The anterior process extends downwards and carries from two to five free denticles. The anterior process has a slight inward twist, and the denticles curve posteriorly. The posterior process is slightly flexed. It carries six to nine, reclined, usually free, denticles. In larger specimens the denticles increase in height about midlength of the process and become basically confluent. The aboral outline is concave. The basal cavity occupies the whole of the base and extends beneath the processes as narrow slits.

Neoprioniodontiform - The neoprioniodontiforms are asymmetrical laterally compressed compound conodonts with short posterior processes bearing suberect reclined, sharp-edged denticles. The unit is slightly flexed and arched. The erect cusp is longer than the denticles. It has sharp keels and is flexed inward distally. The keels continue onto

the base. The posterior process (or extended base) bears up to five flattened denticles, which decrease in size posteriorly. The base is flared inwards and broadly convex to the outer side. The sharp-edged anterior margin of the base may be flexed inward aborally; it meets the aboral margin in a rounded corner. The aboral outline is straight to slightly sinuous. Distally the aboral margin meets the oral edge in an acute angle. The basal cavity is small and distally forms an aboral slit and centrally obtains a moderate width. In general the morphology resembles the form genus Cyrtoniodus.

The second transition series is similar to the Trichonodella-Oulodus transition series (Lindström 1964). This transition series includes trichonodelliforms, zygognathodiforms, and sannemanulliforms.

Trichonodelliform - The trichonodelliform has a large cusp and a posterior denticulated process. It has one, rarely two, lateral denticles, which diverge from the aboral margin of the base.

Zygognathiform - The zygognathiform has a slender recurved cusp, a long posterior process, one short antero-lateral and one long postero-lateral process. The posterior process is curved aborally and flexed outward. The denticles are laterally compressed, keeled, reclined, and free. The basal cavity extends as a shallow groove beneath the three processes. The short lateral process is inclined anteriorly and carries one to two denticles of various height; the distal denticle being the highest in mature forms. The angle between the anterior and posterior processes is 120 degrees. The outer lateral

process is directed posteriorly and forms an acute angle with the posterior process. It carries four to six denticles.

Sannemanulliform - The unit has a slender cusp, two short lateral processes, and a long posterior process. The posterior process is curved aborally and slightly flexed outwards. The denticles are laterally compressed, keeled and reclined. Commonly the distal part of the posterior process is broken. The posteriorly directed lateral process forms an acute to right angle with the posterior process. The process varies in length. It is longer than the outer lateral process, and of equal length or shorter than the posterior process. The outer lateral process is directed downwards and carries two to three denticles of varying height. The denticle proximal to the cusp is highest and the remaining denticles decrease greatly in size. The outer lateral process forms an angle of 90 degrees with the posterior process.

The element is identical with the plectospathodontiform of Dzik (1978).

Prioniodontiform - The prioniodontiform has a tall recurved cusp, an anterior, a posterior, and an antero-lateral process. The cusp has three costae, which continue onto the processes. The anterior process is directed downwards, it carries three to seven recurved and laterally flexed denticles. The process is straight to slightly curved. The posterior process is distally flexed with outward tilted denticles. In some specimens the distal part is sub-horizontal. The process carries four to six flexed denticles.

The antero-lateral process is directed anteriorly. It usually becomes the longest of the processes and curves laterally at about mid-length, forming an open U. The denticles are highest at about mid-length, they are curved inwards. In juvenile specimens the denticles are thin and delicate. The anterior lateral process forms an acute angle (25–35 degrees) with the anterior process.

The narrow basal cavity lies beneath the cusp and a shallow slit occupies the aboral surface of the base.

Characteristically, all the denticles of the three processes curves in the vertical plane. The convex face is regarded as the outer side of the unit in this description. The whole unit has an Oulodus outline, and the element may be included in Oulodus-Trichonodella transition series as the oulodontiform.

Remarks

The elements of Erraticodon vary greatly from juvenile specimens, which are delicate with laterally compressed denticles, to mature forms with rounded robust denticles.

Commonly, the elements are preserved with one or two broken processes. These fragments of Erraticodon can be confused with elements of the form genus Curtognathus s.f. Such elements have been tentatively included in synonymy (e.g. Barnes & Poplawski, 1973).

Stratigraphically a gradual increase in height and numbers of denticles, and length of the outer processes of the prioniodontiforms and sannemanulliforms occur. Also, the neoprioniodontiforms change with an increase of the inner basal flare, the size of the denticles and

development of an anterior basal keel. It appears that these elements are useful and diagnostic for evaluation of the species. Accordingly, the diagnosis of Erraticodon species should concentrate on these elements, as trichonodelliforms, ozarkodiniforms and hindeodelliforms remain conservative.

Based on this information the species from Poland is considered slightly more advanced than the Table Head species. The outer lateral process of the sannemanulliform is shorter, and the cyrtoniodontiform has a higher basal sheath and the base has a smaller flare of the Table Head specimens.

Similarly, the specimens from Sweden (Hadding, 1913; Lindström, 1955a, 1960; Fåhraeus, 1966), from the Pratt Ferry Formation (Sweet & Bergström, 1962) and from the Eureka Quartzite (Harris et al., 1979) are more advanced and represent a new species of Erraticodon. For this species the name Erraticodon alternans (Hadding) is available.

Occurrence

Lower Table Head and lower Middle Table Head.

Material

387 specimens.

## Genus PLECTODINA Stauffer 1935a

Type species - Plectodina aculeata (Stauffer 1935).

### Discussion

In the Table Head collection an apparatus comprises spathognathiforms, dichognathiforms, cordylodontiforms, a symmetry transition series of trichonodelliforms (trichonodelliform, zygognathiform), and oistodontiforms. This apparatus may belong to Plectodina, Oulodus, Aphelognathus or Phragmodus (as defined by Dzik, 1978).

Based on the transition series of trichonodelliforms and zygognathiforms associated with spathognathodontiforms the apparatus is allocated to Plectodina. The genus assignment, however, is queried because the oistodontiform has not been recorded earlier in Plectodina (Moskalenko, 1972; Uyeno, 1974; Sweet and Bergström, 1972).

## PLECTODINA? sp. A

Pl. 17, Figs. 1-8

### Diagnosis

The apparatus includes a spathognathodontiform with a high anterior denticulated process with fused denticles, dichognathiform, hindeodelliform (= cordylodontiform), oistodontiform, and a trichonodelliform transition series, which includes zygognathiforms and trichonodelliforms.

### Description

Spathognathodontiform - Spathognathodontiforms are straight with an anterior denticulated process bearing fused, erect, laterally compressed

denticles, an erect cusp and a posterior process with free denticles. The anterior process is higher and with larger denticles than the posterior process. The aboral outline is straight anterior of the cusp and concave posterior of the cusp. The two processes are equal in length. The denticles are compressed, sharp-edged and filled with white matter. The unit is excavated by a basal furrow which flares on the inner side beneath the cusp. This flare continues as a broad carina onto the cusp.

Dichognathiform - The dichognathiform has a well developed lateral denticulated process, a sharp-edged cusp and a denticulated posterior process. The lateral process forms an acute angle with the cusp.

Hindeodelliform - The hindeodelliform (= cordylodontiform) has a big keeled, slightly proclined cusp with convex faces. The keels continue onto the base. The anterior sharp edge of the base meets the aboral margin in an acute angle. The anterior basal junction is extended aborally. The aboral outline is concave beneath denticles number 3 to 4 and continues posteriorly subparallel to the oral edge. The posterior process tapers distally. It bears eight to ten free, laterally compressed denticles. The denticles are longest in size about midlength of the process, distally they decrease in size.

Trichonodella transition series - The zygognathiform has a submedian cusp and two lateral denticulated processes of unequal length. The unit varies in the number of denticles and may bear up to three on each process. Some variation also exists with respect to symmetry. Also the two processes vary from lateral to posterior directions.

The trichonodelliform is similar to the zygognathiform. It has a large median cusp, two lateral processes bearing one or two denticles, and a small posterior extension of the oral margin. A posterior costa runs the full length of the cusp and onto the base.

Oistodontiform - The oistodontiform has a large, keeled cusp with convex faces. The anterior keel continues onto the base. The anterior margin meets the aboral margin in an angle of about 90 degrees. The aboral margin has a sinuous outline. The base tapers posteriorly. The oral edge is keeled, and meets the cusp in an angle of 40 degrees. The base flares to the inner side.

Occurrence

Lower part of lower Table Head

Material

184 specimens (specified in Table 3.1.)

Family UNCERTAIN

Diagnosis

Conodonts forming an apparatus of blade-like ozarkodiniforms, ramiforms forming a cordylodus-roundya-like transition series, and oistodontiforms.

Remarks

The apparatus of Histiodella is composed of oistodontiforms and two branched ozarkodiniforms. This is typical of Ozarkodinina Dzik. Lindström (1970) tentatively included Histiodella in the superfamily Bryantodontacea. As known so far Bryantodontacea comprises apparatuses with ozarkodiniforms only (Lindström, 1970).

The apparatus of Histiodella, however, resembles the apparatus of Polygnathidae Bassler (emend. Klapper & Philip, 1972; Cooper, 1977) or Spathognathidae Hass (emend. Lindström, 1970). The principal difference

is the presence of oistodontiform in the Histodella apparatus.

The small number of ramiforms in this study prohibits conclusive decisions at the family level.

## Genus HISTIODELLA Harris 1962

Type species - Bryantodina sinuosa Graves and Ellison 1941.

### Discussion

Histiodella has been defined as individual asymmetrical blade-like conodonts, and differences in denticulation are the basis of different species (Harris, 1962; Mound, 1965a). Fåhraeus (1970), Fåhraeus & Nowlan (1978), and Sweet et al. (1971) discussed the evolutionary development of Histiodella. Thus, increasingly denticulated forms of the genus appear through the North American early Middle Ordovician. In contrast, Sweet (1963) and Landing (1976) argued that different ontogenetic stages were identified as different form species.

The Histiodella apparatus was reconstructed by McHargue (1974, unpubl. M.Sc. thesis) from large collections from the Joins Formation, Oklahoma, to comprise bryantodiniforms, ramiforms and an oistodontiform. The present collection supports the reconstruction of the apparatus, and six morphologically distinct elements can be recognized. An additional slender cone, similar to form species Histiodella altifrons, may also be included (Mound, 1965a, pl. 2, fig. 26). The spathognathodontiforms are numerously represented, whereas the ramiforms, usually very small, are only sporadically represented.

The spathognathodontiforms, trichonodelliforms and oistodontiforms are significant in the evaluation of Histiodella species. The spathognathodontiforms are undenticulated in juvenile specimens though partly denticulated in mature specimens of early species of Histiodella (e.g. H. altifrons). Histiodella minutiserrata Mound developed small serrations. Histiodella sinuosa has a well-defined cusp, distinct anterior denticles and denticles defined by partitioning of the white matter in the blade on the oral edge. McHargue (1974) placed the type species of H. sinuosa and H. serrata in synonymy. The ramiforms become denticulated in H. sinuosa.

The Table Head Histiodella species represent a continuation of the evolution of Histiodella (Fig. 3.1). Histiodella tableheadensis n. sp. bears apically free denticles both on the anterior and posterior margins. The evolution continues in H. kristina n. sp., where the anterior blade increases in height and the cusp decreases in size. The youngest species, H. bellburnesis n. sp., has an inconspicuous cusp. The ramiforms are only partly denticulated in H. tableheadensis n. sp. but fully denticulated in H. kristina.

HISTIODELLA BELLBURNENSIS n. sp.

Pl. 17, Figs. 20-21

Derivation of name

Bellburns, a small community on the Great Northern Peninsula, Newfoundland.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Middle Table Head, sample TP 80, Walliserodus ethingtoni Biointerval-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 80 (Pl. 17, fig. 20).

Diagnosis

The spathognathodontiform is fully denticulated with an inconspicuous cusp.

Description

The spathognathodontiform has an inconspicuous cusp in a sub-median position and a large convex denticulated oral edge. The cusp is of equal thickness as the remaining denticles.

Remarks

The cusp cannot always be distinguished from the denticles. The basal excavation marks the position of the cusp.

Occurrence

Top of middle Table Head.

Material

6 spathognathodontiforms.

HISTIODELLA KRISTINA n. sp.

Pl. 18, Figs. 1-7, 9-11

Synonymy

1960 Spathognathus n. sp. - Lindström, fig. 5:3.

1967 Spathognathus sp. - Viira, fig. 4:8.

1970 Spathognathus n. sp. Lindström - Fåhraeus, fig. 3I.

1973 Histiodella sinuosa (Graves and Ellison) - Barnes and Poplawski, p. 776, Pl. 1:18.

1974 Spathognathodus sp. - Viira, p. 125, Pl. 5: 39

1976 Histiodella serrata Harris - Dzik, Text - fig. 12D.

cf. 1978 Histiodella serrata Harris - Dzik, Pl. 14: 6, 7.

Derivation of name

Kristine, a girl's name.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Middle Table Head, sample TP 68, Histiodella kristina Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 83 (Pl. 18, fig. 3 ), a spathognathodontiform.

Diagnosis

Spathognathodontiforms with anterior denticles which are taller than the cusp.

Description

The spathognathodontiform has a well-developed denticulated blade. The cusp is as high as or lower than the anterior denticles. Juvenile specimens always have anterior denticles as high as a line through the apex and parallel to the aboral margin. The cusp is normally 1.5 as wide or less the width of anterior denticles. The oral edge is straight to convex. Cusp is within the distal third of the whole unit.

The ozarkodiniform is a short denticulated unit. It carries one anterior denticle and three to four small posterior denticles. The trichonodelliform is a denticulated Histiodella triquetra Mound s.f.. The hindeodelliform has two to three anterior denticles and six to eight posterior denticles. The oistodontiform has a costate cusp and sharp anterior basal corner. The aboral outline is straight.

Remarks

Histiodella kristina n.sp. differs from Histiodella tableheadensis n. sp. by the height of the anterior denticles on the spathognathodontiform. The ramiforms are similar to Histiodella tableheadensis, but all the elements are denticulated in H. kristina.

The anterior part of the blade is broken on Histiodella serrata Harris (Dzik, 1978). Thus, it cannot safely be identified with H. kristina The cusp, however, is identical to H. kristina, and the Polish specimen is probably H. kristina.

Occurrence

Sporadic in uppermost lower Table Head; common in middle Table Head.

Material

515 spathognathodontiforms; 74 ramiforms; 28 oistodontiforms.

## HISTIODELLA TABLEHEADENSIS n. sp.

Pl. 18, Figs. 8, 12-14

Synonymy

1970 Spathognathodus sp. - Uyeno and Barnes, p. 117, Pl. 24: 12, 13.

1971 Histiodella sp. A - Sweet, Ethington and Barnes, Pl. 1: 16.

aff. 1971 Histiodella serrata Harris - Sweet, Ethington and Barnes, Pl. 1: 39.

1973 Histiodella sinuosa (Graves and Ellison) - Barnes and Poplawski, p. 778, Pl. 1: 17 only.

1976 Histiodella serrata Harris - Landing, p. 633-634, Pl. 1: 20.

1979 Histiodella n. sp. 1 - Harris et al., Pl. 1: 9.

Derivation of name

After Table Head Formation.

Type locality

Table Point, Great Northern Peninsula, Newfoundland.

Type stratum

Lower Table Head, sample TP 43, Histiodella tableheadensis Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 84 (Pl. 18, fig. 14), a spathognathodontiform.

Diagnosis

A Histiodella with fully denticulated spathognathodontiforms. The spathognathodontiform always has a cusp which is higher and is 1.5 to 2 times wider than the anterior denticles.

Description

The spathognathodontiform has an anteriorly and posteriorly denticulated blade. The anterior blade bears up to seven compressed, apically free denticles. The two to three distal denticles are smaller than the others. The next three to four denticles become the highest. The fused denticles are defined by white matter in the blade. The white matter continues down to the thickened rim above the aboral margin. In juvenile specimens the angle from the apex of the cusp to the anterior highest denticle is always below a horizontal line parallel to the aboral margin. In mature specimens this angle is sub-horizontal. The cusp is wide, tilted posteriorly and in juvenile forms the apex reaches beyond the distal part of the posterior blade. The cusp is posterior in position to the midpoint of the blade. The oral edge is straight in small units and becomes convex in large specimens. It is serrated by small equal-sized denticles which are apically free, but basally fused. The denticles are progressively inclined toward the posterior.

The basal margin is straight in lateral view. The basal cavity is constructed below the basal rim and it is a small slit below the entire unit. It is slightly excavated beneath the cusp. Variation from straight, laterally bent to sinuous forms are common. The anterior part of the blade has a typical translucent area just above the thickened rim along the aboral margin.

The ramiforms are partly to fully denticulated. The hindeodelliform is fully denticulated with apically free slender denticles and a cusp. The denticles are reclined. The ozarkodiniform is fully denticulated. The aboral outline is slightly convex. Trichonodelliforms have developed an anteriorly denticulated blade.

The oistodontiforms have a large cusp, which is widest at the base, and has an inner prominent costa. The cusp forms a sharp acute angle with the oral margin which is keeled and convex. The base is about two-thirds the length of the cusp. The basal cavity is shallow and straight, it extends the full length of the unit.

Remarks

Adenticulate ramiforms may resemble Histiodella triquetra Mound s.f. They differ by the margins being convex rather than concave as on the Joins specimens. The trichonodelliforms differ from those of Histiodella serrata (see Harris et al. 1979, Pl. 1, fig. 10) by the lack of the short posterior process. Instead Histiodella tableheadensis has an anterior process.

H. tableheadensis differs from H. kristina n. sp. by its larger cusp and the small posterior denticles.

Occurrence

Lower Table Head.

Material

607 spathognathodontiforms; 131 ramiforms; 29 oistodontiforms.

Family UNCERTAIN

Genus LOXODUS Furnish 1938

Type species - Loxodus bransoni Furnish 1938.

Discussion

This genus was defined by Furnish (1938) in form-element taxonomy. Subsequent work has not revealed any additional elements, and Loxodus most likely forms an apparatus composed by one type of element only.

In this study elements with a morphology similar to Loxodus bransoni have been included in that genus. Barnes & Poplawski (1973) described these elements as ?Coleodus Branson & Mehl. Coleodus is a hyaline genus, which consists of a denticulate bar. Coleodus differs from Loxodus in its denticulation and the basal cavity.

The elements resemble specimens that are included in Appalachignathus delicatulus Bergström, Carnes, Ethington Votaw and Wigley. The ozarkodiniforms of A. delicatulus differ in having larger denticles, but shares the slit-like basal cavity. The spathognathodontiforms have an enlarged basal cavity distally, unlike Loxodus. The species from Table Head is fairly abundantly represented. No other regularly associated elements comparable to the zygognathiforms, trichonodelliforms and eoligonodiniforms of Appalachignathus have been found.

LOXODUS? CURVATUS n. sp.

Pl. 18, Fig. 19

Synonymy

1973 ?Coleodus sp. - Barnes and Poplawski, p. 771, Pl. 1: 19.

?1979 Coleodus? sp. - Harris et al., Pl. 1: 7.

Derivation of name

The unit is commonly curved.

Type locality

Table Point, Great Northern Peninsula, Newfoundland

Type stratum

Lower Table Head, sample TP 59, *Histiodella tableheadensis* Phylo-zone, late Whiterockian (early Llanvirnian).

Holotype

MUNSS 88 (Pl. 18, fig. 19).

Diagnosis

Long, blade-like, bent and bowed denticulated bar with an aboral minor groove. The numerous subequal-sized denticles are fused.

Description

The element is a long bar. It carries numerous, fused denticles along the full length of the unit. The margin is serrate. Prominent white matter outlines the denticles in the bar. The anteriormost denticles are small and erect; towards the middle of the bar the denticles increase in size and become reclined. The unit tapers posteriorly from the middle of the bar. It has a small slit running beneath the whole bar. No definite basal cavity and cusp are present. The aboral outline is straight to concave. The unit varies in lateral bowing from almost straight to 90 degrees. The maximum curvature is at the middle of the bar. The unit is crescent-shaped.

The surface has characteristic striations, which are proclined, i.e., opposite to the orientation of the fused denticles. This gives a typical "cross-lamellar" ornamentation. This feature is an internal structure, and cannot be observed in SEM. Complete specimens are rarely preserved.

Remarks

The specimen from the Antelope Valley Limestone (Harris *et al.*, 1979) has an anterior basal slit which is not present in the Table Head material.

Occurrence

Lower and middle Table Head.

Material

131 specimens.

Family UNCERTAIN

Genus SPINODUS Dzik 1976

Type species - *Cordylodus spinatus* Hadding 1913.

Diagnosis

Apparatus that includes elements which carry posteriorly directed processes and bear long, separate denticles. The elements form a cordylodus-roundya transition series (Lindström, 1964).

Remarks

The affinity of *Spinodus* is not well established. Dzik (1976) suggested that the apparatus should be incorporated in Prioniodontidae, but mentioned that similarity exists between *Multioistodus* (Chirognathidae) and *Spinodus*, because of a similar apparatus.

The apparatus of Spinodus is comparable with those of Periodontidae and Prioniodinidae. Spinodus exhibits a symmetry transition from trichonodelliform, plectospathodontiform to cordylodontiform. Spinodus, therefore, is considered to be more closely related to Ozarkodinina than with Prioniodontina. The apparatus is reduced and at present cannot be included in a family with certainty.

Elements of this genus were described as Cordylodus (Hadding, 1913; Lindström, 1955b; Barnes and Poplawski, 1973). As shown by Lindström (1964) elements of Spinodus form a transition series. This led Bergström and Sweet (1966) and Barnes and Poplawski (1973) to include elements with this transition series in the genus Cordylodus. Subsequent workers, Lindström (1970) and Sweet & Bergström (1972), hesitated in doing so. Dzik (1976) erected the genus Spinodus for these conodonts.

SPINODUS sp. cf. S. SPINATUS (Hadding)

Pl. 18 figs. 17-18

Synonymy

cf. 1913 Cordylodus ramosus - Hadding, p. 31, Pl. 1: 6.

cf. 1913 Cordylodus spinatus - Hadding, p. 32, Pl. 1: 8.

cf. 1955b Cordylodus ramosus Hadding - Lindström, p. 108-109, Pl. 22: 12, 19.

cf. 1964 Cordylodus spinatus Hadding - Lindström, p. 80-81, fig. 27A-D.

cf. 1976 Spinodus spinatus (Hadding) - Dzik, p. 424, fig. 21C.

cf. 1978 Cordylodus spinatus s.f. (Hadding) - Tipnis et al., Pl. VIII: 16.

Remarks

The scarce material available shows similarities to Spinodus spinatus (Hadding). The elements do, however, possess some differences. The number of denticles on the posterior process does not exceed more than two; the size of the denticles is much less than for former descriptions (Hadding 1913; Lindström 1955b); the ligonodiniforms have a horizontal posteriorly directed lateral denticulated process, the denticle next to cusp is aligned with the cusp, whereas the second is tilted inwards. The elements do not have inverted basal cavities.

Occurrence

Middle Table Head.

Material

11 specimens.

Gen. et sp. indet. A

Pl. 18, Fig. 15-16

Diagnosis

Simple hyaline cones with weakly denticulated oral edges.

Description

The element consists of a large recurved, keeled and slightly twisted cusp with convex faces. The posterior keel continues onto the oral edge. The anterior keel continues onto the base where it meets the aboral margin in an angle of 75 to 90 degrees. The aboral outline is straight to slightly sinuous. The base is small and the basal cavity is shallow.

Remarks

This unit is similar to Trigonodus elements. The denticles on the oral edge and a stronger keeled cusp are, however, different from Trigonodus elements.

Occurrence

Basal part of lower Table Head.

Material

16 specimens.

Gen. et sp. indet. B.

Pl. 18, Fig. 20.

Description

The unit is spindle-shaped. It is a platform with one blunt anterior(?) denticle. The element is sub-symmetrical with a median hole. The surface of the platform is unevenly bulbous. A rim runs around the unit next to the aboral margin. The basal cavity occupies the whole unit.

Occurrence

Middle Table Head.

Material

1 specimen.

Gen. et sp. indet. C

Pl. 18, Figs. 21-23

Remarks

Elements of an incomplete apparatus consisting of prioniodontiforms and trichonodelliforms is sparsely represented in the Table Head fauna. The apparatus probably could be included in Ozarkodinina.

Description

The prioniodontiform is incomplete. It carries an anterior outward flexed process, which is broken, an incomplete antero-lateral process with three denticles and a posterior outward flexed posterior process. The cusp is keeled. The basal cavity is shallow.

The trichonodelliform has a high slightly recurved cusp, a long posterior process and two antero-lateral denticles. The cusp is keeled. The keels continue onto the processes. The antero-lateral processes carry one denticle. The posterior process carries 6 to 9 high and free laterally compressed denticles. The basal cavity is shallow. The aboral outline is strongly concave beneath the cusp, otherwise it is straight.

Remarks

The elements resemble those of ?Erraticodon, but they have white matter in the cusp and the denticles, in contrast to ?Erraticodon.

Occurrence

Upper lower Table Head and middle Table Head.

Material

4 specimens.

## AFFINITY UNKNOWN

### Genus PTILONCODUS Harris 1962

Type species - Ptiloncodus simplex Harris 1962.

### PTILONCODUS SIMPLEX Harris

Pl. 18, Fig. 24

Synonymy

1962 Ptiloncodus simplex - Harris, p. 207, Pl. 1: 5A-C, 6.

1965a Ptiloncodus simplex Harris - Ethington and Clark, p. 203-204, Pl. 1: 8.

1965a Ptiloncodus simplex Harris - Mound, p. 33, Pl. 4: 20.

1973 Ptiloncodus simplex Harris - Barnes and Poplawski, p. 785.

1979 Ptiloncodus simplex Harris - Tipnis, Pl. 8.1: 1-7.

Remarks

Elements of this fish-hook-like fossil are present through the Table Head Formation. The affinity of Ptiloncodus has been discussed by Sweet (1963); Lindström (1964); Ethington and Clark (1965), Mound (1965a) and Tipnis (1979). There is a general agreement this is not a conodont, as originally suggested by Harris (1962). The affinity, however, of Ptiloncodus is not agreed upon by the above authors.

The elements are black. They vary from units with a long circular base in cross section and a short strongly recurved cusp to elements with a short base and a long recurved cusp. The aboral margin may be flattened with subovate lobes and with a central vertical slit, as described by

Harris (1962). Other forms only have a rounded aboral margin and a vertical slit. No basal cavity has been observed.

The stratigraphical value is not known yet (Tipnis, 1979).

Occurrence

Lower and middle Table Head.

Material

25 specimens.

## REFERENCES

Andrews, H.E., 1967: Middle Ordovician conodonts from the Joachim Dolomite of eastern Missouri. J. Paleont. 41, 881-901.

Barnes, C.R., 1974: Ordovician conodont biostratigraphy of the Canadian Arctic. In J.D. Aitken & D.J. Glass (eds.): Canadian Arctic geology. Geol. Assoc. Can. - Can. Soc. Petrol. Geol., Spec. Vol., 221-240. Calgary.

Barnes, C.R. (ed.), 1976: Conodont Paleoecology. Geol. Assoc. Can. Spec. Pap. 15, 324 p.

Barnes, C.R., 1977: Ordovician conodonts from the Ship Point and Bad Cache Rapids Formations, Melville Peninsula, Southeastern District of Franklin. Geol. Surv. Can. Bull. 269, 99-111.

Barnes, C.R., and Fåhraeus, L.E., 1975: Provinces, communities, and the proposed nektobenthic habit of Ordovician conodonthophorids. Lethaia 8, 133-150.

Barnes, C.R., Jackson, D.E., and Norford, B.S., 1976: Correlation between Canadian Ordovician zonations based on graptolites, conodonts and benthic macrofossils from key successions. In M.G. Bassett (ed.): The Ordovician System: proceedings of a Paleontological Association symposium, Birmingham, September 1974, 209-226. Cardiff.

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., and Poplawski, M.L. Silvana, 1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada. J. Paleont. 47, 760-790.

Barnes, C.R., Rexroad, C.B., and Miller, J.F., 1973a: Lower Paleozoic conodont provincialism. In F.H.T. Rhodes (ed.): Conodont Paleozoology. Geol. Soc. Am. Spec. Pap. 171, 1-30.

Barnes, C.R., Sass, D.B., and Monroe, E.A., 1973b: Ultrastructure of some Ordovician conodonts. Geol. Soc. Am. Spec. Pap. 141, 1-30.

Barnes, C.R., Sass, D.B., and Poplawski, M.L. Silvana, 1973c: Conodont ultrastructure: The Family Panderodontidae. Life Sci. Contr., R. Ontario Mus. 90, 1-36.

Barnes, C.R., and Slack, D.J., 1975: Conodont ultrastructure: The Subfamily Acanthodontinae. Life Sci. Contr., R. Ontario Mus. 106, 1-21.

Barnes, C.R., and Tuke, M.F., 1970: Conodonts from the St. George Formation (Ordovician), Northern Newfoundland. Geol. Surv. Can. Bull. 187, 79-97. Ottawa.

Bathurst, R.G.C., 1975: Developments in Sedimentology 12: Carbonate sediments and their diagenesis. Elsevier Scientific Publishing Comp. Amsterdam, Oxford, New York, 2nd enlarged ed., 658 p..

Bergström, J., 1973: Organization, life and systematics of trilobites. Fossils and strata 2, 1-69.

Bergström, S.M., 1961: Conodonts from the Ludibundus Limestone (Middle Ordovician) of Tvären area (S.E. Sweden). Arkiv. Miner. Geol. 3 (1), 1-61. Stockholm.

Bergström, S.M.,1971a: Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and Eastern North America. Geol. Soc. Am. Mem. 127, 83-161.

Bergström, S.M., 1971b: Correlation of the North Atlantic Middle and Upper Ordovician conodont zonation with the graptolite succession. Mem. Bir. Rech. Geolg. Min. 73, 177-187.

Bergström, S.M., 1973a: Correlation of the late Lasnamägian Stage (Middle Ordovician) with the graptolite succession. Geol. Fören. Stockholm. Förh. 95, 9-18. Stockholm.

Bergström, S.M., 1973b: Biostratigraphy and facies relations in the lower Middle Ordovician of easternmost Tennessee. Am. J. Sci., Cooper Vol. 273-A, 261-293. New Haven, Connecticut.

Bergström, S.M., 1973c: Ordovician conodonts. In A. Hallam (ed.): Atlas of Palaeobiogeography, 47-58. Elsevier, Amsterdam, London, New York.

Bergström, S.M., 1977a: Early Paleozoic biostratigraphy in the Atlantic Borderlands. In F.M. Swain (ed.): Stratigraphic micropaleontology of Atlantic basin and borderlands, 85-110. Amsterdam.

Bergström, S.M., 1977b: Whiterockian (Ordovician) conodonts from the Hölonda Limestone in the eugeosynclinal Trondheim region, Norwegian Caledonides. Geol. Soc. Am., Abstr. with Progr. 9: 5, 573. New York.

Bergström, S.M., 1978: Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas graptolite zone reference standard. Palaeontology 21, 723-754.

Bergström, S.M., 1979a: Whiterockian (Ordovician) conodonts from the Hölonda Limestone of the Trondheim Region, Norwegian Caledonides. Norsk Geol. Tidsskr. 59, 295-307.

Bergström, S.M., 1979b: First report of the enigmatic Ordovician microfossil Konyrium in North America. J. Paleont. 53, 723-754.

Bergström, S.M., 1980: Paleogeography and biostratigraphy significance of Whiterockian (Ordovician) conodonts in the Hølonda Limestone of the Trondheim Region, central Norwegian Caledonides. In D.R. Wones (ed.): proceedings "The Caledonides in the USA".

I.G.C.P. project 27: Caledonide Orogen 1979 Meeting, Blackburg, Virginia. Department of Geological Sciences; Virginia Polytechnic Institute and State University Memoir 2, 33-40.

Bergström, S.M., and Carnes, J.B., 1976: Conodont biostratigraphy and paleoecology of the Holston Formation (Middle Ordovician) and associated strata in Eastern Tennessee. Geol. Assoc. Can. Spec. Pap. 15, 27-57. Toronto, Ontario.

Bergström, S.M., and Cooper, R.A., 1973: Didymograptus bifidus and the trans-Atlantic correlation of the Lower Ordovician. Lethaia 6, 313-340. Oslo.

Bergström, S.M., Carnes, J.B., Ethington, R.L., Votaw, R.B., and Wigley, P.B., 1974: Appalachignathus, a new multielement conodont genus from the Middle Ordovician of North America. J. Paleont. 48, 227-235.

Bergström, S.M., Epstein, Anita, G., and Epstein, J.B., 1972: Early Ordovician North Atlantic province conodonts in eastern Pennsylvania. U.S. Geol. Surv. Prof. Paper 800-d, D37-D44. Washington, D.C.

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. Can. J. Earth Sci. 11, 1625-1660. Ottawa.

Bergström, S.M., and Sweet, W.C., 1966: Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. Bull. Am. Paleont. 50, 269-441. Ithaca, New York.

Berry, W.B.N., 1960: Graptolite faunas of the Marathon Region, West Texas. Univ. of Texas, Publ. 6005, 179 p..

Billings, E., 1861-65: Paleozoic Fossils, Volume 1. Geol. Surv. Can., 426 p..

Bischoff, G., and Sannemann, D., 1958: Unterdevonische Conodonten aus dem Frankenwald. Notizbl. Hess. Landesamtes Bodenforsch. Wiesbaden 86, 87-110.

von Bitter, P.H., 1972: Environmental control of conodont distribution in the Shawnee Group (Upper Pennsylvanian) of eastern Kansas. Univ. Kansas Paleont. Contr., Art. 59, 105 p..

Blatt, H., Middleton, G., and Murray, R., 1972: Origin of sedimentary rocks. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Boyce, W.D., 1978: Recent developments in Western Newfoundland Cambro-Ordovician trilobite biostratigraphy. In R.V. Gibbons (ed.): Report of Activities for 1977. Newfoundland Department of Mines and Energy. Mineral Development Division, Rept. 78-1, 80-84.

Boyce, W.D., 1979: Further development in western Newfoundland Cambro-Ordovician biostratigraphy. In R.V. Gibbons (ed.): Report of Activities for 1978. Newfoundland Department of Mines and Energy. Mineral Development Division, Rept. 79-1, 7-10.

Bradshaw, Lael E., 1969: Conodonts from the Fort Peña Formation (Middle Ordovician), Marathon Basin, Texas. J. Paleont. 43, 1137-1168. Tulsa, Oklahoma.

Branson, E.B., and Branson, C.C., 1947: Lower Silurian conodonts from Kentucky. J. Paleont. 21, 549-556. Tulsa, Oklahoma.

Branson, E.B., and Mehl, M.G., 1933: Conodonts from the Jefferson City (Lower Ordovician) of Missouri. Univ. of Missouri Studies VIII, 1, 53-64.

Branson, E.B., and Mehl, M.G., 1944: Ordovician conodont faunas from Oklahoma. J. Paleont. 17, 374-387.

Bruton, D.L., and Bockelie, J.F., 1980: Geology and Paleontology of the Hølonda area, western Norway - a fragment of North America? In D.R. Wones (ed.): Proceedings "The Caledonides in the USA". I.G.C.P. project 27: Caledonide Orogen 1979 Meeting, Blackburg, Virginia. Department of Geological Sciences; Virginia Polytechnic Institute and State University Memoir 2, 41-47.

Chatterton, D.D.E., 1974: Middle Devonian Conodonts from the Harrogate Formation, Southeastern British Columbia. Can. J. Earth Sci. 11, 1461-1484.

Clark, D.L., and Ethington, R.L., 1966: Conodonts and biostratigraphy of the Lower and Middle Devonian of Nevada and Utah. J. Paleont. 40, 659-689. Tulsa, Oklahoma.

Collins, J.A., and Smith, L., 1972: Sphalerite as related to the tectonic Movements, deposition, diagenesis and karstification of a carbonate platform. 24th Intern. Geol. Congr., Sec. 6, 208-215.

Collins, J.A., and Smith, L., 1975: Zinc deposits related to diagenesis and intra karstic sedimentation in the Lower Ordovician St. George Formation, Western Newfoundland. Bull. Can. Petrol. Geol. 23, 393-427.

Cooper, B.J., 1974: New forms of Belodella (conodonta) from the Silurian of Australia. J. Paleont. 48, 1120-1125.

Cooper, B.J., 1975: Multielement conodonts from the Brassfield Limestone (Silurian) of southern Ohio. J. Paleont. 49, 984-1008. Tulsa, Oklahoma.

Cooper, B.J., 1975: Multielement conodonts from the St. Clair Limestone (Silurian) of southern Illinois. J. Paleont. 50, 205-217. Tulsa, Oklahoma.

Cooper, B.J., 1977: Toward a familial classification of Silurian conodonts. J. Paleont. 51, 1057-1071.

Cooper, G.A., 1956: Chazyan and related brachiopods. Smithsonian Misc. Colln. 127, Pt. 1. text, 1-1024; Pt. 2, 1025-1245.

Cooper, G.A., 1976: Early Middle Ordovician of the United States. 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. 171-194.

Cooper, J.R., 1937: Geology and Mineral deposits of the Hare Bay Area. Geol. Surv. Nfld. Bull. 9. 36 p.

Cooper, R.A., and Druce, E.C., 1975: Lower Ordovician sequence and conodonts, Mount Patriarch, Northwest Nelson, New Zealand. N. Zealand J. Geol. and Geophys. 18, 551-82.

Cullison, J.S., 1938: Dutchtown fauna of southeastern Missouri. J. Paleont. 12, 219-228.

Cumming, L.M., 1967a: Platform and Klippe Tectonics of Western Newfoundland: a review. Roy. Soc. Can. Spec. Publ. 10 (T.H. Clark, ed.), 10-17.

Cumming, L.M., 1967b: Table Head and St. George Formations, Western Newfoundland. In S.E. Jenness (ed.): Report of Activities for 1966, Pt. A., Geol. Surv. Can., Paper 67-1, 178-179.

Cumming, L.M., 1967c: Clonograptus from the St. George's Formation, Newfoundland. In S.E. Jenness (ed.): Report of Activities for 1966, Pt. B., Geol. Surv. Can., Paper 67-1, 61-63.

Cumming, L.M., 1968: St. George - Table Head disconformity and zinc Mineralization, Western Newfoundland. Canadian Institute of Mining and Metallurgy, Bull. 61, 712-721.

Dawes, P.R., 1976: Precambrian to Tertiary of northern Greenland. In A. Escher and W. Stuart Watt (eds.): Geology of Greenland, 248-303.

Dean, P.L., 1977: A report on the Geology and Metallogeny of the Notre Dame Bay area, to accompany metallogenic maps 12H/1, 8, 9, and 2E/3, 4, 5, 6, 7, 9, 10, 11 and 12. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 77-10, 17 p..

DeGrace, J.R., 1974: Limestone resources of Newfoundland and Labrador. Newfoundland Department of Mines and Energy. Mineral Development Division, Report 74-2, 117 p..

Dewey, J.F., 1969: Evolution of the Appalachian/Caledonian orogen. Nature, London, 222, 124-129.

Dickinson, K.A., Berryhill, H.L., and Holmes, C.W., 1972: Criteria for Recognizing Ancient Barrier Coastlines. In J.K. Rigley and W.K. Hamblin (eds.): Recognition of ancient sedimentary environments. Soc. Econ. Paleont. Mineral. Spec. Publ. 14, 192-214.

Druce, E.C., 1970: Upper Paleozoic conodont distribution. Geol. Soc. Am., Abstr. with Progr. 4: 2, 386. Eastlansing, Michigan.

Drygant, D.M., 1974: Simple conodonts from the Silurian and Lowermost Devonian. Paleontol. Sborn 10, 64-69.

Dzik, J., 1976: Remarks on the evolution of Ordovician conodonts. Acta Palaeont. Polonica 21, 395-455. Warszawa.

Dzik, J., 1978: Conodont biostratigraphy and Paleogeographical relations of the Ordovician Mojcza Limestone (Holy Cross Mts., Poland). Acta Palaeont. Polonica 23, 51-72.

Epstein, Anita G., Epstein, J.B., and Harris, L., 1977: Conodont color alteration - an index to organic metamorphism. U.S. Geol. Surv. Prof. Paper 995, 1-27. Washington, D.C.

Erdtmann, B.D., 1971: Ordovician graptolite zones of western Newfoundland in relation ot paleogeography of the North Atlantic. Geol. Soc. Am. Bull. 82, 1509-1528.

Ethington, R.L., 1959: Conodonts of the Ordovician Galena Formation. J. Paleont. 33, 257-292.

Ethington, R.L., 1972: Lower Ordovician (Arenigian) conodonts from the Pogonip Group, Central Nevada. Geol. Palaeontol. SB 1, 17-28. Marburg.

Ethington, R.L., 1977: Conodonts from the type Whiterockian, central Nevada. 3rd. Int. Symp. Ordovician System. Abstr. with Progr. 1977, 32-33.

Ethington, R.L., 1978: Conodont faunas of the Lower and Middle Ordovician of the House and Confusion Ranges, Utah. In J.F. Miller (ed.): Upper Cambrian to Middle Ordovician conodont faunas of western Utah. Southwest Missouri State Univ. Geosc. Ser. No. 5, 44 p.

Ethington, R.L., and Clark, D.L., 1964: Conodonts from the El Paso Formation (Ordovician) of Texas and Arizona. J. Paleont. 38, 685-704. Tulsa, Oklahoma.

Ethington, R.L., and Clark, D.L., 1965: Lower Ordovician conodonts and other microfossils form the Columbia Ice Fields section, Alberta, Canada. Brigham Young Univ. Geol. Stud. 12, 185-205. Provo, Utah.

Ethington, R.L., and Clark, D.L., 1971: Lower Ordovician conodonts in North America. Geol. Soc. Am. Mem. 127, 63-82. Boulder, Colorado.

Ethington, R.L., and Schumacher, D., 1969: Conodonts of the Copenhagen Formation (Middle Ordovician) in central Nevada. J. Paleont. 43, 440-484. Tulsa, Oklahoma.

Finney, S.C., and Skevington, D., 1979: A mixed Atlantic-Pacific province Middle Ordovician graptolite fauna in western Newfoundland. Can. J. Earth Sci. 16, 1899-1902.

Flower, R.A., 1978: St. George and Table Head cephalopod zonation in Western Newfoundland. Geological Survey of Canada. Paper 78-1A: Current Research, Pt. A, 217-224.

Folk, R.L., 1962: Spectral subdivision of limestone types. In W.E. Ham (ed.): Classification of Carbonate rocks. Am. Assoc. Petrol. Geol. Mem. 1, 62-84.

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 Bull. 321, 61-114.

Fortey, R.F., 1980: The Ordovician of Spitsbergen, and its relevance to the Base of the Middle Ordovician in North America. In D.R. Wones (ed.): proceedings "The Caledonides in the USA". I.G.C.P. project 27: Caledonide Orogen 1979 meeting, Blackburg, Virginia. Department of Geological Sciences; Virginia Polytechnic Institute and State University Memoir 2, 33-40.

Fortey, R.A., and Barnes, C.R., 1977: Early Ordovician conodont and trilobite communities of Spitsbergen: influence on biogeography, Alcheringa 1, 297-309.

Friedman, G.M., and Sanders, J.E., 1978: Principles of sedimentology. New York, John Wiley & Sons.

Furnish, W.H., 1938: Conodonts from the Prairie du Chien beds of the Upper Mississippian Valley. J. Paleont. 12, 318-340. Tulsa, Oklahoma.

Fåhraeus, L.E., 1966: Lower Viruan (Middle Ordovician) conodonts from the Gullhögen quarry, southern central Sweden. Sver. Geol. Unders. C: 610, 1-40. Stockholm.

Fåhraeus, L.E., 1970: Conodont-based correlations of Lower and Middle Ordovician strata in Western Newfoundland. Geol. Soc. Am. Bull. 81, 2061-2076. Boulder, Colorado.

Fåhraeus, L.E., 1971: Lower Devonian conodonts from the Michelle and Prongs Creek Formations, Yukon Territory. J. Paleont. 45, 665-683. Tulsa, Oklahoma.

Fåhraeus, L.E., 1976: Conodonthophorid ecology and evolution related to global tectonics. In C.R. Barnes (ed.): Conodont Paleoecology. Geol. Assoc. Can. Spec. Pap. 15, 11-26.

Fåhraeus, L.E., 1977a: Correlation of the Canadian/Champlainian series boundary and the Whiterock Stage of North America with western European conodont and graptolite zones. Bull. Can. Petrol. Geol. V. 25, 981-994.

Fåhraeus, L.E., 1977b: Isocommunities and correlation of the North America Didymograptus bifidus Zone (Ordovician). Newsl. Stratigr. 6, 85-96.

Fåhraeus, L.E., and Barnes, C.R., 1975: Conodonts as indicators of paleogeographic regimes. Nature 258, No. 5535, 515-518.

Fåhraeus, L.E., and Nowlan, G.S., 1978: Franconian (Late Cambrian) to early Champlainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland. J. Paleont. 52, 444-471.

Gedik, I., 1977: Orta Toroslar'da konodont biyostratigrafisi (Conodont biostratigraphy in the middle Taurus). Türk. Jeol. Kurumu Bül. 20, 35-48. Ankara.

Ginsburg, R.N. (ed.), 1975: Tidal Deposits, a casebook of recent examples and fossil counterparts. New York, Springer-Verlag, 428 p.

Graves, R.W. Jr., and Ellison, E., 1941: Ordovician conodonts of the Marathon Basin, Texas. Univ. Mo. School Mines and Metallurgy Bull., Techn. Ser. 14:2, 1-26, Rolla, Missouri.

Grover, G.J., and Read, J.F., 1978: Fenestral and associated vadose diagenetic fabrics of tidal flat carbonates, Middle Ordovician New Market Limestone, southwestern Virginia. J. Sed. Petrol. 48, 453-473.

Hadding, A.R., 1913: Undre dicellograptusskiffern i Skåne jämte nagra därmed ekvivalenta bildningar. Lunds Univ. Årsskr. N.F. Avd. 2, 9: 15, 1-90. Lund.

Higgins, A.C., 1967: The age of the Durine Member of the Durness Limestone Formation at Durness. Scott. J. Geol. 3, 382-388. Edinburgh.

Hamar, G., 1964: Conodonts from the lower Middle Ordovician of Ringerike. Nor. Geol. Tidsskr. 44, 243-292. Oslo.

Hamar, G., 1966: Preliminary report on conodonts from the Oslo-Asker and Ringerike districts. Nor. Geol. Tidsskr. 46, 27-83. Oslo.

Harris, Anita, 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. In C.A. Sandberg and D.L. Clark (eds.): Conodont Biostratigraphy of the Great Basin and Rocky Mountains. Brigham Young Univ. Geol. Stud. 26, Pt. 3, 7-43.

Harris, R.W., 1962: New conodonts from Joins (Ordovician) Formation of Oklahoma. Oklahoma Geology Notes 22, 199-211.

Heckel, P.H., 1972: Recognition of ancient shallow marine environments. In J.K. Rigby and W.K. Hamblin (eds.): Recognition of Ancient Sedimentary Environments. Soc. Econ. Paleont. Mineral. Spec. Publ. 16, 226-286.

Heezen, B.C., and Ruddiman, W.F., 1966: Shaping of the continental rise by deep geostrophic contour currents. Science 152, 502-508.

Hill, D., Playford, G., and Woods, J.T. (eds.),1969: Ordovician and Silurian fossils of Queensland. Queensland Palaeontographical Society Brisbane, 18 p..

Hintze, L.F., 1953: Lower Ordovisian trilobites from Western Utah and Eastern Nevada. Utah Geological and Mineralogical Survey, Bull. 48, 429 p..

Hubert, J.K., Suchecki, R.K., and Callahan, R.K.M., 1977: The Cow Head Breccia: Sedimentology of the Cambro-Ordovician continental margin, Newfoundland. In H.E. Cook and P. Enos (eds.): Deep-water carbonate environments. Soc. Econ. Paleont. Mineral. Spec. Publ. 25, 125-154.

Huddle, J.W., 1972: Historical introduction to the problem of conodont taxonomy. In M. Lindström and W.Ziegler (eds.): Symposium on Conodont Taxonomy. Geol. Pálaeontol. SB 1, 3-16.

Hunter, D.R., 1978: Conodonts from the Cobbs Arm Formation (Middle Ordovician), north-central Newfoundland. Unpublished M.Sc. Thesis, Memorial Univ. of Nfld, St. John's, Newfoundland.

Jaanusson. V., 1960: Graptoloids from the Ontikan and Viruan (Ordov.) limestones of Estonia and Sweden. Uppsala Univ., Geol. Inst. Bull. 38, 289-366i

James, N.P., 1979: Shallowing upward sequences in carbonates. In E.G. Walker (ed.): Facies Models. Geoscience Canada, Reprint Series 1, 109-119.

James, N.P., Stevens, R.K., and Fortey, R.F., 1979: Correlation and Timing of Platform-Margin Megabreccia Deposition, Cow Head and Related Groups, western Newfoundland. Am. Assoc. Petrol. Geol. Bull. 63: 3, 474.

Jeppsson. L., 1971: Element arrangement in conodont apparatuses of Hindeodella type and in similar forms. Lethaia 4, 101-123.

Johnson, R.M., 1970: Physical processes in geology. Freeman, Cooper and Co.. San Francisco. 571 p..

Kay, M., 1962: Classification of Ordocician Chazyan shelly and graptolite sequences from central Nevada. Am. Geol. Soc. Bull.

73, 1421-1430.

Keith, B.D., and Friedman, G.M., 1977: A slope-fan-basin-plain model, Taconic sequence, New York and Vermont. J. Sed. Petrol. 47, 1220-1241.

Kennedy, D.J., Barnes, C.R., and Uyeno, T.T., 1979: A Middle Ordovician conodont faunule from the Tetagouche Group, Camel Back Mountain, New Brunswick. Can. J. Earth Sci. 16, 540-551.

Kindle C.H., and Whittington, H.B., 1958: Stratigraphy of the Cow Head Region, western Newfoundland. Am. Geol. Soc. Bull. 89, 315-342.

Klappa, C.F., 1980: Community succession within lowermost Middle Ordovician sponge-rich bioherms from western Newfoundland. Geol. Soc. Am. , Abstr. with Progr. 15, 46. Philidelphia.

Klapper, G., and Barrick, J.E., 1977: Conodont ecology: pelagic versus benthic. Lethaia 11, 15-23.

Klapper, G., and Philip, G.M., 1972: Familial classification of reconstructed Devonian conodont apparatuses. In M. Lindström and W. Ziegler (eds.): Symposium on Conodont Taxonomy. Geol. Palaeontol. SB 1, 97-114.

Kluyver, H.M., 1975: Stratigraphy of the Ordovician St. George's Group in the Port au Choix area, western Newfoundland. Can. J. Earth Sci. 12, 589-594.

Knight, I., 1977a: The Cambro-Ordovician platformal rocks of Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division. Report 77-6. 27 p..

Knight, I., 1977b: The Cambro-Ordovician platformal rocks of the Northern Peninsula. In R.V. Gibbons (ed.): Report of Activities for 1976. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 77-1, 27-34.

Knight, I., 1978: Platformal sediments on the Great Northern Peninsula: Stratigraphic studies and geological mapping of the North St. Barbe District. In R.V. Gibbons (ed.): Report of Activities for 1978. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 78-1, 140-150.

Knight, I., 1980: Geological mapping of parts of the Eddies Cove, Salmon River and adjacent map areas. In C.F. O'Driscoll, and R.V. Gibbons (eds.): Current Research. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 80-1, 1-9.

Knight, I., and Saltman, P., 1980: Platformal rocks and geology of the Roddickton map areas, Great Northern Peninsula. In C.F. O'Driscoll and R.V. Gibbons (eds.): Current Research. Newfoundland Department of Mines and Energy. Mineral Development Division. Report 80-1, 10-28.

Kohut, J.J., 1972: Conodont biostratigraphy of the Lower Ordovician Orthoceras and Stein, Limestones (3c), Norway. Nor. Geol. Tidsskr. 52, 427-445. Oslo.

Lamont, A., and Lindström, M., 1957: Arenigian and Llandeilian cherts indentified in the Southern Uplands of Scotland by means of conodonts, etc. Edingburgh Geol. Soc. Trans. 17, 60-70. Edinburgh.

Landing, E., 1976: Early Ordovician (Arenigian) conodont and graptolite biostratigraphy of the Taconic allochthon, eastern New York. J. Paleont. 50, 614-646. Tulsa, Oklahoma.

LaPorte, L.F., 1967: Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State. A. Assoc. Petrol. Geol. Bull. 51, 73-101.

LaPorte, L.F., 1969: Recognition of a transgressive carbonate sequence within an epeiric sea: Helderberg Group (Lower Devonian) of New York State. In G.M. Friedman (ed.): Depositional Environments in Carbonate Rocks. Soc. Econ. Paleont. Mineral. Spec. Publ. 14, 98-119.

Lee, Ha-Young, 1970: Conodonten aus der Choson-Gruppe (Unteres Ordovizium) von Korea. Neues Jahrb. Geol. Palaont. Abh. 136, 303-344. Stuttgart.

Le Fèvre, J., Barnes, C.R., and Tixier, M., 1976: Paleoecology of late Ordovician and early Silurian Conodonthophorids, Hudson Bay Basin. In C.R. Barnes (ed.): Conodont Paleoecology. Geol. Assoc. Can. Spec. Pap. 15, 91-104.

Levesque, R.L., 1977: Stratigraphy and sedimentology of Middle Cambrian to Lower Ordovician shallow water carbonate rocks, western Newfoundland. Unpublished M.Sc. Thesis, Memorial Univ. of Nfld., St. John's, Newfoundland. 276 p..

Levesque, R.L., James, N.P., and Stevens, R.K., 1977: Facies anatomy of Cambro-Ordovician shelf carbonates, northern Maritime Appalachians. Geol. Soc. Am. , Abstr. with Progr. 12, 293-294. Binghamton, New York.

Lindström, M., 1955a: Conodonts from the lowermost Ordovician strata of south-central Sweden. Geol. Fören. Stockholm Förh. 76, 517-604. Stockholm.

Lindström, M., 1955b: The conodonts described by A.R. Hadding, 1913. J. Paleont. 29, 105-111. Tulsa, Oklahoma.

Lindström, M., 1960: A Lower-Middle Ordovician succession of conodont faunas. 21st Internat. Geol. Congr. Repts. 7, 88-96. Copenhagen.

Lindström, M., 1964: Conodonts, 1-196. Elsevier, Amsterdam.

Lindström, M., 1970: A suprageneric taxonomy of the conodonts. Lethaia 3, 427-445. Oslo.

Lindström, M., 1971: Lower Ordovician conodonts of Europe. Geol. Soc. Am. Mem. 127, 21-61. Boulder, Colorado.

Lindström, M., 1976: Conodont Palaeogeography of the Ordovician. In M.G. Basset (ed.): The Ordovician System: proceedings of a Paleontological Association symposium, Birmingham, September, 1974, 209-226. Cardiff.

Lindström, M., McTavish, R.A., and Ziegler, W., 1972: Feinstrukturelle Untersuchungen an Conodonten 2. Einige Prioniodontidae aus dem Ordovicium Australiens. Geol. Palaeontol. 6, 33-43. Marburg.

Lindström, M., Racheboeuf, P.F., and Henry, F.L., 1974: Ordovician conodonts from the Postolonnec Formation (Crozon Peninsula, Massif Armoricain) and their stratigraphic significance. Geol. Palaeont. 8, 15-29.

Lindström, M., and Ziegler, W., 1971: Feinstrukurelle Untersuchungen an Conodonten 1. Die Uberfamilie Panderodontacea. Geol. Palaeont. 5, 9-33. Marburg.

Logan, B.W., Read, J.F., Hagan, G.M., Hoffman, P., Brown, R.G., Woods, P.J., Gebelein, C.D., 1974: Evolution and diagenesis of Quarternary carbonate sequences, Shark Bay, Western Australia. Am. Assoc. Petrol. Geol. Mem. 22, 358 p.

Logan, W.E., 1863: Geology of Canada. Geol. Surv. Can., Rept. Prog., Montreal.

Löfgren, Anita, 1978: Arenigian and Llanvirnian conodonts from Jämtland Northern Sweden. Fossils and strata 13, 1-129. Oslo.

Ludvigsen, R., 1978: Middle Ordovician trilobite biofacies, southern Mackenzie Mountains. In C.R. Stelck and B.D.E. Chatterton (eds.): Western and Arctic Canadian Biostratigraphy. Geol. Assoc. Can. Spec. Pap. 18, 1-37.

McHargue, T.R., 1974: Conodonts of the Joins Formation (Ordovician), Arbuckle Mountains, Oklahoma. Unpublished M.A. Thesis, Univ. of Missouri.

McIllreath, J.A., and James, N.P., 1978: Facies Models 13. Carbonate Slopes. Geoscience Canada 5: 4, 189-199.

McTavish, R.A., 1973: Prioniodontacean conodonts from the Emanuel Formation (Lower Ordovician) of Western Australia. Geol. Palaeont. 7, 27-58, Marburg.

McTavish, R.A., and Legg, D.P., 1976: The Ordovician of the Canning Basin, Western Australia. 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, 447-478.

Merrill, G.L., 1962: Facies relationships in Pennsylvanian conodont faunas. Texas Jour. Science Abstr., 14, 418.

Middleton, G.V., 1973: Johannes Walther's Law of the correlation of facies. Geol. Soc. Am. Bull. 84, 979-988.

Middleton, G.V., and Hampton, M.A., 1976: Subaqueous sediment transport and deposition by sediment gravity flows. In D.J. Stanley and D.J.P. Swift (eds.): Marine Sediment Transport and Environmental Management. Wiley-Interscience, New York. N.Y., 197-218.

Miller, J.F., 1969: Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah. J. Paleont. 43, 413-439.

Milliman, J.D., 1974: Marine carbonates. Springer-Verlag. Berlin-Heidelberg-New York. 375 p.

Moore, R.C. (ed.), 1962: Treatise on invertebrate Paleontology. Part W. Miscellanea. Geol. Soc. Am. New York, and Univ. Kansas Press, Lawrence (Kansas), 259 p.

Morris, R.W., and Kay, M., 1966: Ordovician Graptolites from the Middle Table Head Formation at Black Cove, Port au Port, Nfld., J. Paleont. 40, 1223-1224.

Moskalenko, T.A., 1967: Conodonts from the Lower Chunsk Bed, River Moiero and Lower Stone Tunguska: New data on the biostratigraphy of the Lower Paleozoic of the Siberian Platform. Akad. Sci. USSR, Siberian Div., Trans. Inst. Geol. Geophysics, 98-116, 161-162 (in Russian).

Moskalenko, T.A., 1970: Conodonts from the Krivolutsk Stage of the Siberian Platform. Acad. Sci. USSR, Siberian Div., Trans. Inst. Geol. Geophysics, 61, 116 p. (in Russian).

Moskalenko, T.A., 1972: Ordovician conodonts of the Siberian platform and their bearing on multielement taxonomy. In M. Lindström, and W. Ziegler (eds.): Symposium on Conodont Taxonomy. Geol. Palaeont. SB 1, 47-56.

Moskalenko, T.A., 1973: Conodonts of the Middle and Upper Ordovician on the Siberian platform. Acad. Sci. USSR, Siberian Div., Trans. Inst. Geol. Geophysics, 137, 143 p. (in Russian).

Mound, M.C., 1965a: A conodont fauna from the Joins Formation (Ordovician), Oklahoma. Tulane Study Geol. 4, 1-45. New Orleans, Luisiana.

Mound, M.C., 1965b: Two new conodont genera from the Joins Formation (Lower Middle Ordovician) of Oklahoma. Washington Biol. Soc. Proc. 78, 193-200. Washington, D.C.

Müller, K.J., 1962: Supplement to systematics of conodonts. In R.C. Moore (ed.): Tretise on Invertebrate Paleontology, Part W, Miscellanea: Geol. Soc. America and Univ. Kansas Press, W246-W249.

Müller, K.J., 1978: Conodonts and other phosphatic microfossils. In B.W. Haq and A.C. Boersma (eds.): Introduction to marine micropaleontology. Elsevier, North-Holland. Chap. 12, 276-291.

Müller, K.J., and Nogami, Y., 1971: Über den Feinbau der Conodonten. Mem. Fac. Sci. Kyoto Univ. Ser. Geol. and Min., 38: 1. Kyoto. 87 p.

Nelson, S.F., 1955: Geology of Portland Creek-Port Saunders area, west coast. Geol. Surv. Nfld. Rept. 7, 57 p.

Neuman, R.B., 1972: Brachiopods of early Ordovician volcanic islands. Proc. 24th Int. Geol. Congr. Montreal 7, 297-302.

Neuman, R.B., and Bruton, D.L., 1974: Early Middle Ordovician fossils from Hølanda area, Trondheim region, Norway. Norsk Geol. Tidsskr. 54, 69-115.

Nowlan, G.S., 1979: Report No. 01-GSN-1979. Eastern Paleontological Section, Geological Survey of Canada.

Pander, C.H., 1856: Monographie der fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements. K. Akad. Wiss. St. Petersburg, 1-91. St. Petersburg.

Raymond, P.E., 1925: Some trilobites of the Lower Middle Ordovician of eastern North America. Kus. Comp. Zoology Bull. 67, 1-180.

Repetski, J.E., and Ethington, R.L., 1977: Conodonts from graptolitic facies in the Ouachita Mountains Arkansas and Oklahoma. In Symposium on the geology of the Ouachita Mountains 1, 92-106.

Rexroad, C.B., 1967: Stratigraphy and conodont palaeontology of the Brassfield (Silurian) in the Cincinuati Arch area. Indiana Geol. Surv. Bull. 36, 1-64. Bloomington, Indiana.

Rhodes, F.H.T., 1955: The conodont fauna of the Keisley Limestone. Quart. J. Geol. Soc. London 111, 117-142.

Rodgers, J., 1968: The eastern edge of the North American continent during the Cambrian and Early Ordovician. In E-an Zen, W.S. White, J.B. Hadley, and J.B. Jr. Thompson (eds.): Studies of Appalachian geology: northern and maritima. New York. Wiley-Interscience, 141-149.

Ross, R.J. Jr., 1951: Stratigraphy of the Garden City Formation in northeastern Utah and its trilobite faunas. Yale University. Peabody Museum of Natural History, Bull. 6, 161 p.

Ross, R.J. Jr., and Ingham, J.K., 1970: Distribution of the Toquima - Table Head (Middle Ordovician Whiterock) Faunal Realm in the Northern Hemisphere. Geol. Soc. Am. Bull. 81, 393-408.

Schlager, W., and James, N.P., 1978: Low-magnesian calcite limestones forming at the deep-sea floor, Tongue of the Ocean, Bahamas. Sedimentology 25, 675-702.

Schillereff, S., and Williams, H., 1979: Geology of Stephenville map area, Newfoundland. Current Research, Part A. Geol. Surv. Canada, Paper 79-1A, 327-332.

Schopf, T.J.M., 1966: Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec. New York State Mus. Sci. Service Bull. 405, 1-105. New York.

Schuchert, C., and Dunbar, C.O., 1934: Stratigraphy of western Newfoundland. Geol. Soc. Am. Mem. 1, 123 p.

Seddon, G., and Sweet, W.C., 1971: An ecologic model for conodonts. J. Paleont. 45, 869-880.

Sergeeva, S.P., 1963: Conodonts from the Lower Ordovician in the Leningrad region. Akad. Nauk. SSSR, Paleont. Zh., 1963, 93-108. Moskva. (in Russian).

Sergeeva, S.P., 1974: Some new conodonts from Ordovician strata in the Leningrad region. Paleont. Sb. 1974, 79-84. L'vov. (in Russian).

Serpagli, E., 1967: I conodonti dell'Ordoviciano superiore (Ashgilliano) della Alpi Carniche. Boll. Soc. Paleont. Italiana 6, 30-111. Modena.

Serpagli, E., 1974: Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). Boll. Soc. Paleont. Italiana 13, 17-98. Modena.

Shaw, F.C., and Fortey, R.A., 1977: Middle Ordovician facies and trilobite faunas in N. America. Geol. Mag. 114: 6, 409-443.

Skevington, D., 1965: Graptolites from the Ontikan limestones (Ordovician) of Öland, Sweden. II Graptoloidea and Graptovermida: Uppsala Univ. Geol. Inst. Bull. 43: 3, 74 p.

Stauffer, C.R., 1935a: Conodonts of the Glenwood beds. Geol. Soc. Am. Bull. 46, 125-168. Boulder, Colorado.

Stauffer, C.R., 1935b: The conodont fauna of the Decorah Shale (Ordovician). J. Paleont. 9, 596-620. Tulsa, Oklahoma.

Stauffer, C.R., 1940: Conodonts of the Glenwood beds. Geol. Soc. Am. Bull. 46, 125-168. Boulder, Colorado.

Stevens, R.K., 1970: Cambro-Ordovician flysch sedimentation and tectonics in western Newfoundland and their possible bearing on a Proto-Atlantic Ocean. Geol. Assoc. Can. Spec. Pap. 7, 165-177.

Stevens, R.K., 1972: From Autochthon to Allochthon at Black Cove - Black Point. In E.R.W. Neale: A cross section through the Appalachian Orogen in Newfoundland. 24th Inst. Geol. Congr. Montreal, 1972. A62-C62, 77-79.

Stevens, R.J., and James, N.P., 1975: Large sponge-like reef mounds from the lower Ordovician of west Newfoundland. Geol. Soc. Am., Abstr. with Progr., 1122. Denver, Colorado.

Stouge, S., 1975: Conodontzonerne i orthoceratitkalken (Nedre Ordovicium) pa Bornholm og ved Fågelsang. Dansk Geol. Foren. Årsskr. 1974, 32-38. Copenhagen (in Danish with English summary).

Stouge, S., 1977: The Table Head Group shelf to basinal deposits and the associated conodont fauna from western Newfoundland. Eastern Canadian Paleont. and Biostr. Sem. 1977. Abstr. with Progr., 7-8.

Stouge, S., 1978a: Ordovician conodonts from St. George and Table Head Formations, western Newfoundland. XIII Nordiske Geologiske Vintermøde Jan. 1978. Abstr. with Progr., 14-15.

Stouge, S., 1978b: Upper Canadian (Lower Ordovician) conodonts from central east-Greenland. Geol. Assoc. Can.; Min. Assoc. Can., and Geol. Assoc. Am. Joint Ann. Meeting 1978. Abstr. with Progr., 499.

Stouge, S., 1980a: Conodonts from the Davidsville Group, northeastern Newfoundland. Can. J. Earth Sci. 17: 2, 268-272.

Stouge, S., 1980b: Lower and Middle Ordovician conodonts from central Newfoundland and their correlatives in western Newfoundland. In C.F. O'Driscoll and R.V. Gibbons (eds.): Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division. Report 80-1, 134-142.

Stouge, S., 1980c: Correlation and timing of the migration of conodont faunas from the central Newfoundland limestone deposits onto the western platform. Geol. Assoc. Can., and Min. Assoc. Can. Joint Ann. Meeting 1980. Abstr. with Progr. 5, 83.

Stouge, S., (in press): Preliminary conodont biostratigraphy and correlation of Upper Canadian carbonates from the St. George Group, Great Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division. Report 80- .

Stouge, S., (in press): Cambrian-Middle Ordovician stratigraphy of Salmon River Region, southwest Hare Bay, Great Northern Peninsula. In C.F. O'Driscoll and R.V. Gibbons (eds.): Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 81-1.

Sweet, W.C., 1963: New conodonts from Joins (Ordovician) Formation of Missouri, by R.W. Harris (Review). J. Paleont. 37. 505-506.

Sweet, W.C., and Bergström, S.M., 1962: Conodonts from the Pratt Ferry Formation (Middle Ordovician) of Alabama. J. Paleont. 36, 1214-1252. Tulsa, Oklahoma.

Sweet, W.C., and Bergström, S.M., 1972: Multielement taxonomy and Ordovician conodonts. Geol. Paläeont. SB 1, 29-42. Marburg.

Sweet, W.C. and Bergström, S.M., 1974: Provincialism exhibited by Ordovician conodont faunas. In C.A. Ross (ed.): Paleogeographic Provinces and Provinciality. Soc. Econ. Paleont. Min. Spec. Publ. 21, 189-202.

Sweet, W.C., and Bergström, S.M., 1976: Conodont biostratigraphy of the Middle and Upper Ordovician of the United States Midcontinent. 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, 121-151. Cardiff.

Sweet, W.C., Ethington, R.L., and Barnes, C.R., 1971: North American Middle and Upper Ordovician conodont faunas. Geol. Soc. Am. Mem. 127, 163-193. Boulder, Colorado.

Sweet, W.C., and Schönlaub, H.P., 1975: Conodonts of the genus Oulodus Branson and Mehl, 1933. Geol. Palaeont. 9, 41-59.

Sweet, W.C., Thompson, T.L., and Satterfield, I.R., 1975: Conodont stratigraphy of the Cape Limestone (Maysvillian) of eastern Missouri. Studies in Stratigraphy: Missouri Geol. Surv. Dept. of Nat. Resour. Rept. Inv. 57, 1-59. St. Louis, Missouri.

Thomas, D.E., 1960: The zonal distribution of Australian graptolites. Journal and Proceeding of the Royal Society of New South Wales, 94, 1-58.

Thorsen, G., 1957: Bottom communities (sublittoral or shallow shelf). In J.W. Hedgpeth (ed.): Treatise on marine ecology and paleoecology. Geol. Soc. Am. Mem. 67, 461-534.

Tipnis, R.S., 1978: Early Middle Ordovician conodonts of North Atlantic Province from northeastern Ellesmere Island, Arctic Canada. In Current Research, Part C, Geol. Surv. Can., Paper 78-1C, 75-78.

Tipnis, R.S., 1979: Fused clusters of Ptiloncodus simplex Harris; an Ordovician phosphatic microfossil. In Current Research, Part C, Geol. Surv. Can., Paper 79-1C, 51-54.

Tipnis, R.S., Chatterton, B.D.E., and Ludvigsen, R., 1978: Biostratigraphy of Ordovician conodonts from the Southern Mackenzie Mountains. In C.R.Stelck and D.D.E. Chatterton (eds.): Western and Arctic Canadian Biostratigraphy..Geol. Assoc. Can. Spec. Pap. 18, 39-91.

Uyeno, T.T., 1974: Conodonts of the Hull Formation, Ottawa Group (Middle Ordovician), of the Ottawa-Hull area, Ontario and Quebec. Geol. Surv. Canada Bull. 248, 25 p.

Uyeno, T.T., and Barnes, C.R., 1970: Conodonts from the Lévis Formation (Zone D1)(Middle Ordovician), Lévis, Quebec. Geol. Surv. Canada Bull. 187, 99-123. Ottawa.

Valentine, J.W., 1968: The evolution of ecological units above the population level. J. Paleont. 42, 252-267. Tulsa, Oklahoma.

Viira, Viive, 1967: Ordovician conodont succession in the Ohesaare core: Eesti NSV Tead. Akad. Toim., Koide 16, 319-329. (in Russian with abstract in English).

Viira, Viive, 1974: Ordovician conodonts of the east Baltic. Eesti NSV Tead. Akad. Geol. Inst. Valgus, Tallin. 142 p.

Walker, R.G., 1966: Deep channels in curbite-bearing formations. Am. Assoc. Petrol. Geol. Bull. 50; 9, 1899-1917.

Walker, R.G., and Mutti, E., 1973: Turbidite facies and facies associations. In G.V. Middleton, and A.M. Bouma (eds.): Turbidites and deep sea sedimentation. Soc. Econ. Paleont. Min., Pacific Section, short course, 119-157.

van Wamel, W.A., 1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of north-western Oland, south-eastern Sweden. Utrecht Micropaleontol. Bull. 10, 1-126. Netherlands.

Webers, G.F., 1966: The Middle and Upper Ordovician conodont faunas of Minnesota. Minnesota Geol. Surv. Spec. Publ. ser. SP-4, 1-123. Minneapolis, Minnesota.

Whittington, H.B., 1965: Trilobites of the Ordovician Table Head Formation, western Newfoundland, Harvard Univ. Mus. Comp. Zoology Bull. 132, 277-441.

Whittington, H.B., 1968: Zonation and correlation of Canadian and early Mohawkian Series. In E-an Zen, W.S. White, J.B. Hadley, and J.B. Thompson (eds.): Studies of Appalachian geology: northern and maritime. New York. Wiley-Interscience, 49-60.

Whittington, H.B., and Kindle, C.M., 1963: Middle Ordovician, Table Head Formation, Western Newfoundland. Geol. Soc. Am. Bull. 74, 745-758.

Whittington, H.B., and Kindle, C.M., 1969: Cambrian and Ordovician stratigraphy of western Newfoundland. In M. Kay (ed.): North Atlantic-geology and continental drift, a symposium. Am. Assoc. Petrol. Geol. Mem. 12, 655-664.

Whittington, H.B., and Rickards, R.B., 1969: Development of Glossograptus and Skiagraptus Ordovician graptoloids from Newfoundland. J. Paleont. 43, 800-817.

Williams, H., 1964: The Appalachians in Northeastern Newfoundland - A two-sided symmetrical system. Am. J. Sci. 262, 1137-1158.

Williams,H., 1978a: Tectonic-lithofacies map of the Appalachian Orogen (1:1.000.000). Dept. of Geol., Memorial Univ. of Newfoundland. St. John's. Map no. 1.

Williams, H., 1978b: Geological development of the northern Appalachians: its bearing on the evolution of the British Isles. In D.R. Bowes, and B.E. Leake (eds.): Crustal evolution in northwestern Britain and adjacent regions, 1-22. Seal House Press, Liverpool, England.

Williams, H., Kennedy, M.J., and Neale, E.R.W., 1974: The northeastward termination of the Appalachian Orogen. In A.E.M. Nairn, and F.G. Stehli (eds.): Ocean Basins and Margins 2; 79-123. Plenum Press, New York.

Williams, H., and Smyth, W.R. in press(with Bostock, M.M., Cumming, L.M. and Caska, C.J.): Geological map of the Strait of Belle Isle Region.

Williams, H., and Stevens, R.K., 1974: The ancient continental margin of eastern North America. In C.A. Burk, and C.L. Drake (eds.): The Geology of Continental Margins, 781-796. Springer-Verlag, New York.

Wilson, J.L., 1969: Microfacies and sedimentary structures in "deeper water" lime mudstones. Soc. Econ. Paleont. Min. Spec. Publ. 14, 4-19.

Wilson, J.L., 1975: Carbonate Facies in Geologic History. Springer-Verlag. Berlin-Heidelberg- New York. 471 p.

Woodard, M.M., 1957: Geology of the Port au Choix [illegible]ton River area, Newfoundland. Newfoundland Geol. Surv. Rept. 10, 44 p.

Workum, R.H., Bolton, T.E., and Barnes, C.R., 1976: Ordovician geology of Akpatok Island, Ungava Bay, District of Franklin. Can. J. Earth Sei. 13, 157-178, Ottawa.

Zeitzschel, B., 1978: Oceanographic factors influencing the distribution of plankton in space and time. Micropaleontology 24: 2, 139-159.

Ziegler, W. (ed.), 1973: Catalogue of Conodonts 1, 1-504. Stuttgart.

Ziegler, W., and Lindström, M., 1971: Über Panderodus Ethington 1959 and Neopanderodus n.g. (Conodonta) aus dem Devon. N. Jb. Geol. Palaont. Monatsh., 628-640. Stuttgart.

## APPENDIX A

Lithologic description of the section of Table Head Formation at Table Point, Great Northern Peninsula, Newfoundland (Section I of this study; see Figure 2.5).

The following description is from the base of the Formation and upwards.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | **St. George Group** | | |
| | TP1 | Dolostone, light grey, aphanitic to fine-grained, crossbedded, thick-bedded. | 0.64 + | 1.00 |
| | TP2 | Dolostone, light-grey to grey, aphanitic; vertical burrows at the top filled by clear sparry calcite and quartz; some burrows reach the surface of the lower bed; mudcracks at the base of unit | 0.36 + | 0.36 |
| | | This is the top of St. George Group | | |
| | | **Table Head Formation** | | |
| | | **Lower Table Head (241 metres ± m)** | | |
| **Unit $A_1$** | | | | |
| | TP3 | Micrite, grey to dark-grey, mottled weathering, argillaceous. Bioclasts are trilobites, orthocones brachiopods, ostracodes, gastropods (*Hormotoma* sp.) | 0.00-0.10 | 0.10 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_1$ (Cont'd) | | | Section (Cont'd) | 0.10 |
| | TP4 | Micrite, dolomitized mottled weathering, minor argillaceous stringers | 0.10-0.55 | 0.65 |
| | TP5 | Dolostone, grey to light-grey, bluish, aphanitic to finegrained, pelletoid. Hormotoma-bearing at the top. Minor yellow colored argillaceous stringers. Surface of bed is rippled. | 0.63-0.70 | 1.35 |
| | TP6 | Dolomitic micrite, light grey to grey. | 0.45 | 1.80 |
| | TP7<br>TP8<br>TP9 | Dolostone, light grey, stylolitic; fenestrae common; mudcracks; argillaceous stringers present. Highspired gastropods (Hormotoma sp.) common. | 0.80 | 2.60 |
| | TP10<br>TP11<br>TP12<br>TP13 | Dolostone interbedded with shale, light grey; dolostone fine-bedded to medium-bedded; birds-eye (fenestrae) common; mudcracks are present. Top may have thin lenses of dark grey micrite. | 1.25 | 3.85 |
| | TP14 | Micrite, dolomitic, pelletoid, hard, medium to thick bedded; fractures vertically. Unit not well exposed, probably the same as below. | 0.30<br>0.70 | 4.15<br>4.85 |
| | PT15 | As $G_1$ with thin shaly | | |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_1$ (Cont'd) | | | Section (Cont'd) | 4.85 |
| | | partings. Micrite with micro-laminations and micro-burrows. | 3.00 | 7.85 |
| | TP16 | Pelletoid. Bioclasts are Leperditia sp. gastropods and non-determinable. | | |
| Unit $A_2$ | | | | |
| | TP17<br>TP18 | Micrite, dark-grey, argillaceous, massive bedded, rubbly weathering. Fossils are Hormotoma sp., Leperditia sp., and Maclurites sp. | 2.10 | 9.95 |
| | TP19<br>TP20 | Micrite, dolomitic; dark-grey, hard, weathers yellow, fractures vertically; argillaceous. Fossils are Maclurites sp., Leperditia sp., and ?trilobite. | 0.60 | 10.55 |
| | TP21 | Micrite, dark-grey, rubbly weathering. Thin shaly layers above and below unit. | 0.10 | 10.65 |
| | | Minor fault, displacement possibly 0.35 cm | | |
| | TP22 | Micrite, dolomitic dark-grey, argillaceous, partly vertically fracturing and partly rubbly weathering. At the top a white calcite vein (1/2 cm). | 1.45 | 12.10 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 12.10 |
| | TP23 | Micrite, dolomitic dark-grey, argillaceous, partly vertically fractured and partly rubbly weathering. At the top a white calcite vein (1/2 cm). | 2.60 | 14.70 |
| | | At the top a layer of light-grey siltstone (4 cm). | | |
| | TP24 | Micrite, dark-grey, argillaceous, yellow weathering, red-colored argillaceous matter forms up to 20% of unit; a small chertband and nodules. | 3.90 | 18.60 |
| | TP25 | | | |
| | TP26 | Micrite, dark-grey, rubbly weathering; a few argillaceous stringers. | 2.70 | 21.30 |
| | TP27 | Micrite, dark-grey, up to 20% of argillaceous material; yellow weathering, red colored; small chertbands; white calcite veins present, associated with small faults. | 3.95 | 25.25 |
| | TP28 | Micrite, dark-grey, argillaceous with chertbands; unit is slumped. Direction of axis about 160°. | 1.80 | 27.05 |
| | | Micrite, dark-grey, chert nodules; probably slumped; direction of axis is 160°. Top is | 3.60 | 30.65 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 30.65 |
| | | a white calcite vein (1 cm). Slickensides, direction 146°. | | |
| | | Micrite, dark-grey, with three 1 to 10 cm thick chertbands; lithology the same as slumped beds below. | | |
| | | Micrite, dark-grey; thin (2 cm) chert layer. | 1.00 | 33.10 |
| | | Micrite, light-grey to grey; biosparite (5%) and argillaceous biomicrite (5%) are present. Bioclasts are cephalopods and gastropods (Maclurites). Many fossils are filled with white sparry calcite. | 0.85 | 34.40 |
| | | Argillaceous biomicrite, grey. The unit forms a prominent slope. Leperditia sp. and cephalopods present. | 1.00 | 35.90 |
| | TP29 | Micrite, partly dolomitic, grey; minor biosparite (5-10%); bioclasts are gastropods, cephalopods, ostracodes and trilobites. Weathers partly conchoidal; stylolitic. | 1.15 | 37.05 |
| | TP30 | Micrite, slightly argillaceous; orthocones | 0.60 | 37.65 |
| | TP31 | Micrite, dolomitic, grey; stylolitic | 1.20 | 38.85 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 38.85 |
| | TP32 | Biosparite, brownish; a medium grained, sparry dolomitic limestone runs as an irregular "snake" within and along the bed. Affinity unknown. | 1.25 | 40.20 |
| | | Slumped unit, stratabound. The unit is a folded and contorted breccia. Sharp-edged clasts of flat fine-laminated dolostones floating in argillaceous/dolomitic material. Becomes finer upwards, forming fine laminated argillaceous layers and lime/dolomite mud. Direction of slump is approximately 120°. The top is stylolitic. | 2.00 | 42.55 |
| | | Dolostone, grey; fine-lamellar, slightly burrowed. | 0.45 | 43.00 |
| | | Dolostone, grey, light yellow weathering, finely crystalline; fine-laminated and crossbedded with cut and fill structures. Stylolitic. Wavey bedded and flow structures. Whole specimens of trilobites on bedding planes; Hormotoma sp., partly filled by sparry calcite, in pockets and on bedding planes. | 2.15 | 45.15 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 45.15 |
| | | Dolostone, fine-grained; vertical and some horizontal burrows (Chondrites). Hormotoma sp., sparry calcite-filled in pockets. Chert nodules at the top; mudcracks. | 0.90 | 46.05 |
| | TP33 | Micrite, fine-laminated, sandy; minor beds of biosparite, dolomitic; fossiliferous; Leperditia sp., Hormotoma sp.; Zoophycos. | 1.00 | 47.05 |
| | TP34 | Dolostone, light-grey, finely laminated, fine-grained; minor dolarenite; minor biosparite, some argillaceous stringers; brecciated; burrows in clasts; clasts may be finely laminated; silty argillaceous (qz) material. Fossils in lenses (1 - 1½ m long). Gastropods (Hormotoma sp.) dominate. | 6.45 | 53.50 |
| | TP35 | Increasing amount of $CaCO_3$ toward the top. Stylolites common in lower part. Horizontal burrows predominate in lower half of unit. Gastropods and cephalopods more common toward the top of unit. | | |
| | TP36 | Micrite, dolomitic; biosparite at the top. Bioclasts are brachiopods, cephalopods, gastropods, | 2.00 | 55.50 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 55.50 |
| | TP37 | trilobites. The top of the unit is a prominent bedding plane. | | |
| Unit $A_3$ | | | | |
| | TP38<br>TP39<br>TP40 | Micrite, grey, massive bedded; at 5.70 m a gently folded bed, 20 cm thick of biosparite; bioclasts are trilobites, gastropods (Maclurites sp.), cephalopods. Cut and fill structures. Surface of bedding plane (?) weathers into a white color. Joints and small faults at this place. | 7.00 | 62.50 |
| | TP41 | Micrite as below, various amount of minor argillaceous stringers. At surface a white calcite vein. | 6.60 | 69.10 |
| | TP42<br>TP43 | Micrite, grey, rubbly weathering, massive; argillaceous stringers separate micrite beds of 2 to 25 cm in thickness. Low angle small faults with slickensides. | 10.80 | 79.90 |
| | TP44 | Micrite, grey, fine-bedded 5-7 cm thick. Micrite may be gently slumped. Beds show cut and fill structures. Argillaceous seams 1-5 mm in thickness. | | |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 86.10 |
| | | Pressure solution common. Biosparite, grey, forms lenses and thin beds, 2-5 cm thick. Fossils in biosparite: Leperditids, brachiopods, and trilobites. Top of unit is a prominent (?) bedding plane with white calcite. | | |
| | TP45 | Micrite, grey. Beds 15-30 cm thick. Stylolitic. At 1 m above the base of unit a well developed (?) bedding-plane with white calcite. Surface of unit cuts bedding. White calcite veins along fractures. | 5.40 | 91.50 |
| | TP46 | Micrite, grey, massive bedded in lower 4.90 m; the next 7.10 m are fine bedded with argillaceous seams. The upper 5 m include biosparite lenses up to 20 cm thick and up to 2 m long. Stylolites 4.10, 4.80 and 6.00 m above the base of unit are prominent bedding planes. The surface at 11 m above the base of unit forms a large, prominent slope. Gently folded beds are present close to | 17.00 | 108.50 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 108.50 |
| | | the top of unit. Fossils include gastropods, cephalopods. Some of the fossils are silicified. The surface of unit is the first large chert layer. The chert is black, yellow brownish weathering. The chert layer forms a large prominent slope north of Table Point. | | |
| | TP48<br>TP49<br>TP50 | Micrite fine-bedded, interbedded with micrite with argillaceous seams. Biosparite beds, 5-10 cm thick are present (up to 15%). Leperditia sp. predominates in biosparite beds. | 19.00 | 127.50 |
| | | Micrite, medium-bedded. Biosparite beds form up to 20% of unit. Fossils include brachiopods, ostracodes, cephalopods and gastropods (Maclurites sp.). Micrite, thin-bedded to medium-bedded; argillaceous. Biosparite beds form 5-10% of unit. Pressure solution surfaces are common. Fossils include: ostracodes, brachiopods, cephalopods, trilobites. Between 72-76 m a prominent, probably | 19.50 | 147.00 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 147.00 |
| | TP51 | slumped layer of biosparite. At 81.60m a prominent surface (?bedding plane with white calcite). 91.50m forms the next prominent slope. | | |
| | TP52<br>TP53<br>TP54<br>TP55<br>TP56<br>TP57 | Micrite, grey, massive bedded; biosparite beds present. Fossils are trilobites, ostracodes, brachiopods, cephalopods. At 171,10 and 173,10 m prominent large slopes. At 173,90 m a characteristic bedding plane covered by brownish chert. Highly faulted. Slickensides covered by white calcite (134°) and have various dip (0°-90°). Between 167,50-190,50 m calcification, dolomitisation and associated calcite veins and dolomite dikes cut the bedded limestone. This is associated with the synclinal structure at this locality. The nucleus is formed by the crystalline calcite (scalenoedre) and surrounded by dolomite aureole and associated with calcite veins and dolomite dikes. | 44.50 | 191.50 |
| | TP58 | Micrite, grey, medium and nodular bedded. Pressure | 15.00 | 206.50 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 206.50 |
| | TP59 | solution is common. Faults and joints predominate. Fossils are cephalopods, trilobites, brachiopods, which are evenly distributed in the unit. | | |
| | TP60<br>TP61 | Micrite, massive bedded with thinner beds. Rubbly weathering. Fossils are not abundant. Large flat and high (?sponges) organisms appear at 151 m. | 18.00 | 224.50 |
| | TP62<br>TP63 | Micrite/biomicrite, grey to light grey; bioclasts are fairly common (less than 10%) and include cephalopods, trilobites, brachiopods, ?sponges, bryozoans and crinoids. Large funnel shaped fossil first appears at 175 m. Fossils become more abundant up through the unit. | 13.00 | 237.50 |
| | TP64 | Biomicrite, rubbly, massive. Numerous fossils orthocones, trilobites, brachiopods, crinoids and bryozoans. The prominent slope at Table Point is close to the top of the unit. The surface is rich in flattened bryozoans, crinoids, large | 3.50 | 241.00 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 241.00 |
| | | cephalopods, in particular orthocones, and large complete and disarticulate trilobites. | | |
| Unit $B_1$ | TP65<br>TP66<br>TP67 | Dark grey, biomicrite, biosparite, argillaceous matter 5%; bioclasts are trilobites and brachiopods. Thin bedded, average 2 cm thick, nodular. Occasional dolomitic mottling. | 9.00 | 250.00 |
| | TP68 | Biomicrite, dark grey, wavy bedded, slightly gently open folding slumped). Direction about 160°. | 2.00 | 252.00 |
| | TP69<br>TP70 | Flat lying beds alternating with gently folded beds. Similar lithology to above. | 5.50 | 257.50 |
| | TP71<br>TP72 | Limestone similar to above unit. Slumped. Wavy bedded. | 4.50 | 262.00 |
| Unit $B_2$ | TP73 | Hard black, platy, micrite with shale (Hemipelagic limestone); slumped. Direction about 140°. | 10.50 | 272.50 |
| | | Even bedded, dark grey to black micrite with 10% shale. | 1.30 | 273.80 |
| | | Deformed, brecciated bed | 1.10 | 274.90 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $B_2$ (Cont'd) | | | Section (Cont'd) | 274.90 |
| | | Hard black, platy micrite with shale. | 0.60 | 275.50 |
| | | Brecciated, micrite and shale. | 1.60 | 277.10 |
| | | Hard black, micrite interbedded with shale; unit is slumped. | 1.40 | 278.50 |
| Unit $B_3$ | TP74<br>TP75 | Black, slumped, micrite and biosparite interbedded with shale (30%), dark brown to black. Fossils predominantly trilobites. Random orientation of fossils. | 6.50 | 285.00 |
| Unit $B_4$ | TP76<br>TP77<br>TP78 | Hard, black micrite interbedded with shale. Amount of shale increases toward the top of the section. Limestone beds vary from 2-20 cm in thickness. Whole unit is slumped. Breccias 1 to 2 m thick form 20% of unit. Direction of slumps about 160°. | 33.90 | 318.90 |
| | TP79<br>TP80 | Hard, black micrite with laminations of black organic stringers interbedded with black shale, mainly non calcareous. Breccias 1 to 2 m thick occur in the unit. | 9.20 | 328.10 |
| | | Upper Table Head (12 metres) | | |
| | TP 81 | Black, bituminous, non-calcareous shale. Grap- | 12.00 | 340.10 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $B_4$ (Cont'd) | | | Section (Cont'd) | 340.10 |
| | | tolites predominate, phosphatic brachiopods present. The upper 4.5 metres are disrupted, jointed and cleaved. | | |
| | | This is the top of the Table Head Formation. Table Head Formation is overlain by green sandstones and shales of the Table Cove. | | |

## APPENDIX B

Lithologic description of the partial sections of Table Head Formation at Bellburns, Great Northern Peninsula, Newfoundland. The sections in combination represent Section II of this study.

The following descriptions are from the base of the sections and upward.

Section IIa: Coastal section east of Hawkes Bay Fault. This section is situated close to the Hawkes Bay Fault. Any definite lithologic correlation to the Table Head Formation or to the St. George Group is not possible.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Dolostone, light grey, fine grained | 4.20 | 4.20 |
| | | Micrite, light grey, mottled. | 0.60 | 4.80 |
| | | Dolostone, bluish grey | 0.30 | 5.10 |
| | | Dolostone with yellow argillaceous stringers | 0.40 | 5.50 |
| | BS1 | Micrite, light grey | 1.10 | 6.60 |
| | | Micrite, light grey | 1.80 | 8.40 |
| | | Dolostone | 0.70 | 9.10 |

Section IIb: The section is in Table Cove west of Hawkes Bay Fault. It is part of the Bellburns anticline and includes "Isolated Blocks" of Schuchert & Dunbar (1934). The "Isolated Blocks" are vertical in position; upwards facing west.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Lower Table Head (about 5 metres) | | |
| Unit $A_3$ | $BS_2$ | Micrite, grey, massive bedded, with "sponges" (Isolated Block East) | 5.00 | 5.00 |
| | | Middle Table Head (about 17.00 metres) | | |
| Unit $B_1$ | $BS_3$ | Biosparite, sparry nodular and thin bedded argillaceous. Trilobites predominate the fauna. | 10.00 | 15.00 |
| | | Not exposed | Not determinated | |
| Unit $B_2$ | $BS_4$ | Micrite, thin bedded with shale interbeds. (Hemipelagic limestone) No sign of slumping | 7.00 | 22.00 |
| | | This is the top of the Table Head Formation in Table Cove | | |
| | | Table Cove Sandstones and Shales | | |
| | | Massive bedded sandstone interbedded with siltstones, overlies Unit $B_3$ | | 22.00 |
| | | (Hubert et al. (1977) report a thickness of 100 metres for this unit) | | |

Section IIc: Coastal section south of river measured toward the south to the center of anticline.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Lower Table Head | | |
| Unit $A_2$ | | Dolomitic micrite, fine laminated, cross-bedded, ripple marks "Zoophycos". Gastropods. | 5.80 | 5.80 |
| | | Micrite, dolomitized finely laminated. | 2.30 | 8.10 |
| | $BS_5$ | Micrite, grey, rubbly, argillaceous, partly dolomitized | 9.10 | 17.10 |
| Unit $A_3$ | | Micrite, grey, argillaceous, yellow weathering | 7.80 | 25.00 |
| | $BS_6$ | Micrite, grey, fine-bedded with lenses of calcarenite. Bioclasts are trilobites, cephalopods, gastropods and crinoids | 10.40 | 35.40 |
| | | Bed of slumped biosparite | 0.50 | 35.90 |
| | $BS_7$ | Micrite, grey, massive bedded, argillaceous stringers common | 19.20 | 55.10 |

Section IId: Coastal section south of anticline and toward the south.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Lower Table Head (110 metres) | | |
| Unit $A_3$ | | Micrite, dolomitized, faulted, folded | 20.00 | 20.00 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | $BS_8$ | Micrite, grey to dark grey, massive bedded alternating with zones with thin-bedded micrite, argillaceous. Biosparites (unsorted) are thin bedded individual beds or lenses 5-10 cm thick (10% of unit). The bioclasts include trilobites, cephalopods, brachiopods and gastropods; the latter diminishes toward the top. | 90.00 | 20.00 |
| | $BS_9$ | | | |
| | $BS_{10}$ | | | |
| | | This is the top of the Beliburns Section. A gravel beach separates the strata from the Daniels Harbour lime breccias of Cow Head affinity. | | |

## APPENDIX C

Lithologic descriptions of the section at Port Saunders, Great Northern Peninsula, Newfoundland. (Section III of this study; see Fig. 2.5).

The following description is from the base of the sequence and upward.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Lower Table Head | | |
| Unit $A_3$ | $PS_1$ | Micrite, grey, massive bedded, stylolitic, argillaceous | 4.00 | 4.00 |
| | | Micrite, grey, stylolitic. The upper 10 cm are biosparite, mottled by white calcite. Bioclasts are cephalopods | 1.00 | 5.00 |
| | | Biosparite, brown-grey beds 5-10 cm thick. 20% are argillaceous micrite. Fault at the top of unit (N76°). Joints with white calcite. Minor thrusting | 4.00 | 9.00 |
| | | Micrite, argillaceous 50%. Biosparite (unsorted) brownish 50% of unit. Thrusted (44°/30°W) | 3.00 | 12.00 |
| | | Micrite, grey, rubbly. The top of unit is a fault | 8.00 | 20.00 |
| | | Biomicrite, grey, rubbly. Bioclasts are cephalopods and trilobites. 60 cm above base of unit is a prominent bedding plane | 4.00 | 24.00 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Partsection 3B | Section (Cont'd) | 24.00 |
| Unit $A_3$ | | Biomicrite, grey, argillaceous. Bioclasts are cephalopods and sponges. The top of unit is faulted (N56°) | 2.00 | 26.00 |
| | | Biomicrite, grey, rubbly, biosparite (10%) bedded 5-10 cm. Bioclasts are cephalopods, trilobites, sponges. The top of unit is probably a fault | 3.50 | 29.50 |
| | | Biomicrite, rubbly, argillaceous. Small chert-beds. Several prominent bedding planes. Bioclasts includes cephalopods and sponges | 5.20 | 34.70 |
| | | Micrite (70%) and biosparite (30%). The top of unit is prominently faulted and jointed. Gently folded with a westerly plunging axis. | 3.00 | 37.70 |
| | | Micrite, grey, argillaceous with biosparite (20%) | 0.80 | 38.50 |
| | $PS_2$ | Micrite, grey, argillaceous. Several prominent bedding planes. The unit is jointed and faulted. The top of unit is the westernmost prominent slope | 4.50 | 43.00 |
| | | Biomicrite, grey, argillaceous. This unit has large cephalopods and sponges. This is the top of the section | 5.80 | 48.70 |

## APPENDIX D

Lithologic description of the section at Gargamelle Cove East, Great Northern Peninsula, Newfoundland (Section IV of this study, see Fig. 2.5).

All the sediments correlate with Unit $A_3$ of the Lower Table Head at Table Point. The top of the section represents a lithology that is not typical of Unit $A_3$, and may be related to faults or slumping. The section comprises two local subdivisions: IVA and IVB.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Section IVA | | Lower Table Head | | |
| | | This is the small outcrop in the centre of Gargamelle Cove (only exposed at high tide) | | |
| Unit $A_3$ | $GCI_1$ | Micrite, grey, massive bedded. Ostracodes and gastropods (<u>Maclurites</u> sp.) Orientation 84°/60°S | 4.70 | 4.70 |
| | | Not exposed | | |

Section IVB - Section of coastal cliffs at Gargamelle Cove East. The base was the tidelevel at the present day (12 August, 1977).

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Lower Table Head | | |
| Unit $A_3$ | | Micrite, grey, thick bedded (1 m or more) with argillaceous stringers. Orientation 70°/12°S | 2.60 | 2.60 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | $GCI_2$ | Micrite, rubbly grey. Bioclasts include cephalopods, trilobites and sponges. The top of unit is a very straight bedding plane | 10.30 | 12.90 |
| | | ?Breccia of micrite, coarse inhomogenous, disturbed. ?Slumped or faulted | 5.60 | 30.60 |
| | | This is the top of the section | | |

## APPENDIX E

Lithologic description of the section of Table Head Formation at Gargamelle Cove West (Point Riche Peninsula), Great Northern Peninsula, Newfoundland (Figs. 2.3 and 2.5).

The following description is from the base of the section and upward.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | Table Head Formation | | |
| Unit $A_2$ | $GCW_1$ | Micrite, grey mottled, white dolomite stringers | 1.50 | 1.50 |
| | $GCW_2$ | Micrite, orange-pink, fine laminated | 0.30 | 1.80 |
| | | Micrite, grey, thick bedded, fine laminated at the top | 2.40 | 4.20 |
| | | Micrite, grey, mottled by white calcite | 0.20 | 4.40 |
| | | Micrite, grey to light grey, argillaceous | 2.10 | 6.50 |
| | | Micrite, grey, with "stromatolite"-like fossils | 1.40 | 7.90 |
| | | Micrite, grey, argillaceous, biosparite (unsorted) at the top | 5.00 | 12.90 |
| | | Micrite, grey argillaceous material up to 10%. Chert nodules at the top | 3.00 | 15.90 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_2$ (Cont'd) | | | Section (Cont'd) | 15.90 |
| | $GCW_3$ | Zone of disturbance; joints are common. Biomicrite, grey, with cephalopods | 4.00 | 19.90 |
| | $GCW_4$ | Micrite, grey, dolomitic; argillaceous material relatively prominent (5%) | 3.60 | 23.50 |
| | | Micrite, grey-brownish; dolomitic, stylolitic | 3.40 | 26.90 |
| | | Biomicrite, grey; fossils include cephalopods | 3.10 | 30.00 |
| | | Biosparite, grey, slumped. This bed becomes prominently dolomitized with white, vuggy dolomite in brownish-grey, dolomitized calcilutite out toward the waterfront (?"pseudobreccia"). The surface is wavy with an amplitude up to 30 cm | 0.50 | 30.50 |
| | $GCW_5$ | Micrite, grey-brown, dolomitized. Fossils are brachiopods, trilobites, cephalopods and ostracodes | 3.70 | 34.20 |
| | | Micrite, grey, in places dolomitic, and with white vuggy dolomite. Minor argillaceous stringers | 3.00 | 37.20 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 37.20 |
| Unit $A_3$ | | Micrite, grey, massive, rubbly weathering. Orientation $7^o/2^oW$ | 6.00 | 43.20 |
| | $GCW_6$ | Biomicrite, grey, rubbly; beds are fossiliferous. Bioclasts include trilobites, brachiopods, cephalopods and ostracodes. Small beds (5-10 cm) of biosparite are present | 6.00 | 49.20 |
| | | This is the top of the section. Along the coast southwest of the section is an exposure of "limebreccia". | | |

## APPENDIX F

Lithostratigraphic descriptions of the sections along the western sea cliffs of Pointe Riche Peninsula, Great Northern Peninsula, Newfoundland. Three partial sections were measured and they in combination represent Section VI of this study (Fig. 2.5).

Section VIa - The section was started southwest of prominent vertical dolomitized fracture at Black Point. According to Kluyver (1975) this is a fault, but no displacement was observed, and probably represents the dolomitic "front" at this locality.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ | PRP 9 | Lower Table Head | | |
| | | Micrite, grey, massive; at 8 metres a small slump (Maclurites sp.) | 8.30 | 8.30 |
| | PRP 1 | Micrite, grey, fine bedded (1-4 cm) | 1.20 | 9.50 |
| | | Biosparite lenses. Leperditids and Maclurites sp. | | |
| | | Micrite, grey, medium bedded (20-50 cm). Argillaceous stringers common. Fossils as at PR 1 | 2.50 | 12.00 |
| | | Micrite, grey, thinly bedded, argillaceous. Small beds or lenses of biosparite (5%) | 0.80 | 12.80 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ (Cont'd) | | | Section (Cont'd) | 12.80 |
| | | Micrite, grey, massive bedded | 2.00 | 14.80 |
| | PRP 2 | Micrite, grey medium bedded (20-50 cm); argillaceous | 2.50 | 17.30 |
| | | Biomicrite and biosparite beds and lenses; bioclasts are leperditids, brachiopods, cephalopods and trilobites | 1.75 | 19.05 |
| | PRP 3 | Lithology as PR 2 with shaly material and crinoids | 3.25 | 22.30 |
| | | Vuggy dolomite and dolomitic micrite | 0.70 | 23.00 |
| | | Slumped stratabound bed of micrite. The upper 25 cm are graded from biosparite (unsorted) at the base to yellow weathering, fine laminated (dis-) micrite | 2.30 | 25.30 |
| | PRP 4 | Micrite, dark grey hard, fine bedded (2-10 cm). Yellow weathering. Argillaceous material about one-third of unit. The lower one metre is transitional from the lithologies below. Bioclasts include trilobites, cephalopods and ostracodes. Sparry | 12.00 | 37.30 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 37.30 |
| | | brown calcite commonly fills the chambers of cephalopods. Top of unit covered by debris | | |

Section VIB - At the lighthouse. The section is measured from sea level and toward the east.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ | | Lower Table Head | | |
| | | Micrite, grey mottled by pink dolomite | 1.50 | 1.50 |
| | | Micrite, grey, bedded. Bioclasts are predominantly coiled cephalopods | 5.50 | 7.00 |
| | PRP 6 | Micrite, grey, argillaceous, medium bedded (20-40 cm) | 2.00 | 9.00 |
| | | Micrite, grey, massive bedded; argillaceous stringers present. The surface of 10.80 is a brown-weathering black chert band. It vanishes laterally to the northeast | 1.80 | 10.80 |
| | | Micrite, grey, medium bedded, argillaceous | 1.20 | 12.00 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 12.00 |
| | PRP 7 | Micrite, grey, fine to medium bedded with argillaceous stringers and lenses of biosparite; bioclasts are trilobites, cephalopods, and brachiopods | 3.70 | 15.70 |
| | | Micrite, slumped. Fossiliferous. The layer corresponds to slumped unit at 25.30 metres in Section 1. The unit increases in thickness toward the south. | 3.30 | 19.00 |

Section VIC - This is measured from the dolomitic, undulating micrite with white dolomite ("Pseudobreccia"), and toward the south to Black Point. 4-5 metres is equivalent to the basis of Section VIa.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ | PRP 8 | Lower Table Head | | |
| | | Micrite, grey medium-bedded (10-40 cm) in places dolomitic. Fossils include cephalopods, trilobites, leperditids and gastropods. Minor biosparite | 11.50 | 11.50 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 11.50 |
| | | Slumped bed of micrite and biosparite (30%) Finer beds (10-20 cm) of argillaceous internally laminated (1 cm) lenses. The unit grades up into the following beds | 1.00 | 12.50 |
| | | Micrite, grey, minor biosparite. Fossils are cephalopods and gastropods | 2.00 | 14.50 |
| | | Micrite, grey, argillaceous material abundant | 1.40 | 15.90 |
| | | Micrite, grey, with decreasing amount of argillaceous matter | 4.60 | 20.50 |
| | | Micrite, grey. Brachiopods and cephalopods | 1.00 | 21.50 |
| | | Micrite, grey, massive bedded. Biosparite beds and argillaceous stringers present. "Pseudobreccia" at the base | 3.30 | 24.80 |
| | | Micrite, grey argillaceous (20%). Eroded out of wall | 0.10 | 24.90 |
| | | Grey micrite | 2.00 | 26.90 |
| | | Micrite, grey | 0.40 | 27.30 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 27.30 |
| | | Laterally varied dolomitisation | | |
| 6B | | Micrite, grey argillaceous (5-10%) | 1.20 | 28.50 |

## APPENDIX G

Section at Back Arm East (Dump area of Port au Choix community). The section includes the boundary St. George Group/Table Head Formation. The boundary is placed at first dark grey fossiliferous micrite. The section is partly covered by garbage.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | St. George Group | | |
| | BA 1 | Micrite, dolomitic; light grey yellow weathering. Thick bedded | 2.60 | 2.60 |
| | | Dolostone, light grey, fine grained; thick bedded | 1.10 | 3.70 |
| | | Micrite, dolomitic light grey. The lower 50 cm is a mottled dolostone. The upper part is finely laminated. Yellow weathering | 2.20 | 5.90 |
| | | Not exposed; possibly the same as below | 1.00 | 6.90 |
| | BA 2 | Micrite, dolomitic, grey to dark grey, hard. Laminated at the top | 1.20 | 8.10 |
| | | Not exposed, possibly yellow weathering dolostone | 0.60 | 8.70 |
| | | Micrite, dolomitic, yellow-brown; minor laminations | 0.70 | 9.40 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 9.40 |
| | | Dolostone, light grey to brown, fine grained; homogenous. The section is partly covered by debris. This is the top of St. George Group | 1.00 | 10.40 |
| | | Table Head Formation | | |
| Unit $A_1$ | BA 3 | Micrite, grey mottled; argillaceous stringers present. Fossils include trilobites and leperditids | 0.60 | .60 |
| | BA 4 | Micrite, grey. Fine laminated and thin beds (5 cm). | 0.70 | 1.30 |
| | BA 5 | Leperditids | | |
| | | Micrite, grey, rubbly with argillaceous stringers | 0.90 | 2.20 |
| | | Not exposed | 0.60 | 2.80 |
| | | Micrite, light-yellow weathering; light-grey to light-brown. Fine bedded (2-5 cm). ?Birdseye structures. <u>Leperditia</u> sp. | 1.90 | 4.70 |
| | | Micrite, light grey. Hard. Leperditids | 0.60 | 5.30 |
| Unit $A_2$ | | Micrite, in part dolomitic, grey, rubbly. Various amount of argillaceous material Unit | 5.20 | 10.50 |

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| | | | Section (Cont'd) | 10.50 |
| | | mainly covered by debris | | |
| | BA 6 | Micrite, grey rubbly. Argillaceous material abundant and red colored. | 7.80 | 18.30 |
| | BA 7 | This is top of the section | | |

## APPENDIX H

Section at the western part of St. John Island. Two partial sections have been measured. These sections form only a part of the total strata exposed on the island.

Section VIIIA - The part section was initiated from the Photographic Point and measured toward the east.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ | SJI 1 | Lower Table Head | | |
| | | Micrite, grey dolomitic; calcarenite. Cephalopods dominate | 5.00 | 5.00 |
| | SJI 2 | Biosparite to biomicrite Cephalopods predominate | 2.50 | 7.50 |
| | SJI 3 | Micrite, grey argillaceous, with yellow colored bedding planes. Medium bedded (40-60 cm). Fossils as below | 3.75 | 11.25 |
| | SJI 4 | Micrite, grey with round (10 cm diameter) sponges | 3.75 | 15.00 |
| | | Top of section 8A | | |

Section VIIIB - East of Section VIIIA. The base of Section VIIIB is close to the top of Section VIIIA, i.e. bed with sponges but with a minor slip, due to the lack of exposure.

| Unit | Sample No. | Description | Thickness (metres) | Height above base (metres) |
|---|---|---|---|---|
| Unit $A_3$ | | Micrite, grey, cephalopods and sponges common | 2.40 | 2.40 |
| | | Not exposed | 1.00 | 3.40 |
| | SJI 5 | Biomicrite, grey argillaceous. Trilobites are present. Rubbly material on the top of the section | 6.00 | 9.40 |

# APPENDIX I

## Lithological and conodont paleontological information, correlation and significance.

### I.A. Introduction.

Much of the geological interpretation given in the main body of this report depends on information obtained from outside the study area. This appendix is designed to be a correlation of lithic units outside the study area and to be a record of the conodonts recovered from other areas. Most of the samples were collected by the writer, and in some cases in co-operation with other geologists from Memorial University and from Department of Mines and Energy, St. John's.

For each collection, details of the localities and the sections are given, and a geographic description. Only samples that yielded significant or abundant information are recorded. All lithic information is referred to the Table Point Section, and the conodont zonations and correlations proposes in this study are used.

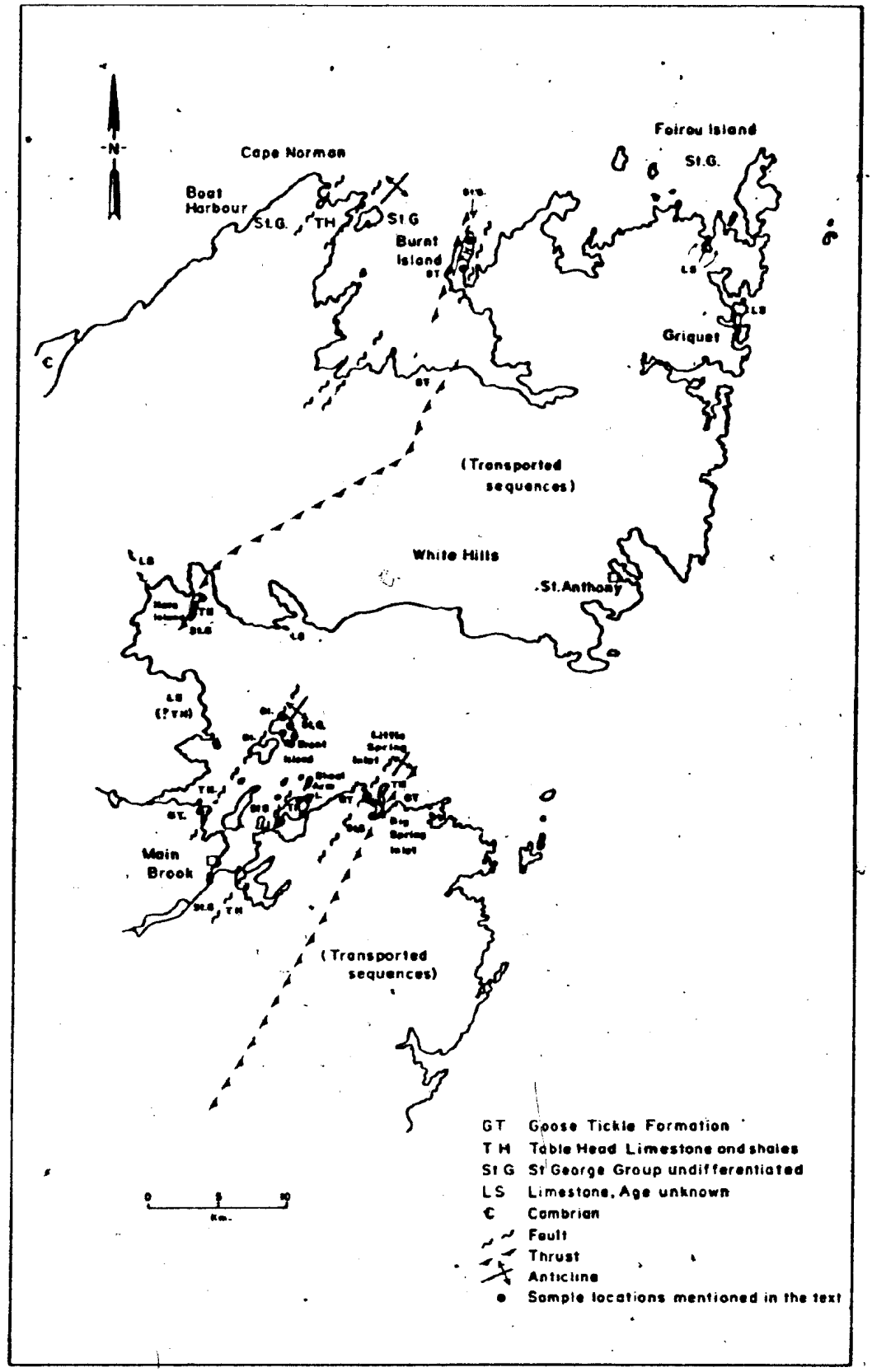
### I.B. Correlation with lithic units outside the study area.

It is possible to correlate the lithologic units proposed herein over a larger area i.e. the Great Northern Peninsula. Two main areas are considered in this context: Hare Bay in the North and Port au Port in the south.

#### Hare Bay

Lower Table Head in Hare Bay has been mapped as Hare Island limestone by Cooper (1937), but subsequently referred to the Table

Fig. AI.1. Location of conodont localities, Hare Bay area. Geology by Cooper (1937); Knight & Saltman (1980); Stouge (in press) and I. Knight. R. Jamieson and R. Talkington pers. comm. 1977-1979.


N
Cape Norman
Boat Harbour
St.G.
TH
St G
Burnt Island
GT
Fairou Island
St.G.
LS
Griquet
(Transported sequences)
White Hills
St.Anthony
LS
(?TH)
Main Brook
(Transported sequences)
0
5
10
Km.
GT Goose Tickle Formation
TH Table Head Limestone and shales
St G St George Group undifferentiated
LS Limestone, Age unknown
Є Cambrian
Fault
Thrust
Anticline
Sample locations mentioned in the text

Head by Williams and Smyth (in press). The sediments consist predominantly of black micrite with several chert horizons. Sponges are present but not as prominent as in the study area. The boundary between the St. George Group and Table Head Formation differs lithologically from the study area. The uppermost St. George Group consists of interbedded dolostones, micrites and stromatolitic horizons. The strata occupies a stratigraphic position equivalent to or just below unit $A_1$ of lower Table Head. In the Big Spring Inlet (fig. A.I.1) unit $A_1$ in turn is overlain by massive bedded black micrite and minor dolostones of unit $A_2$. Lower Table Head unit $A_3$ is the main component of the outcrops in the Hare Bay area.

The lower boundary of the Table Head Formation has been observed in Big Springs Inlet and on Hare Island (fig. A.I.1). Lithologic equivalents to the basal part of the lower Table Head in Hare Bay are exposed on the western side of Shoal Arm Island, but structural disturbances obscure the boundary between the St. George Group and the Table Head Formation at this locality. The upper boundary of the lower Table Head is exposed 3 km north of Main Brook, where micrites of unit $A_3$ are in fault contact with the St. George Group and the middle Table Head. These upper beds of unit $A_3$ are very rich in chert nodules and chert bands, and the biostromal beds typical of the upper unit $A_3$ at Table Point are not prominent at this locality.

Middle Table Head strata in Hare Bay have only been observed 3 km north of Main Brook. They have been reported from Little Spring Inlet (Stevens 1970; Fahraeus 1970). Units $B_1$ and $B_2$ can easily be distinguished and consist of 8 metres of black argillaceous biosparite

(unit $B_1$) and about 9 metres of interbedded black shales and micrites (hemipelagic limestones) of unit $B_2$. Unit $B_2$ yields a profuse fauna of silicified trilobites (R. Fortey, pers. comm. 1978). The middle Table Head is conformably overlain by upper Table Head black shales.

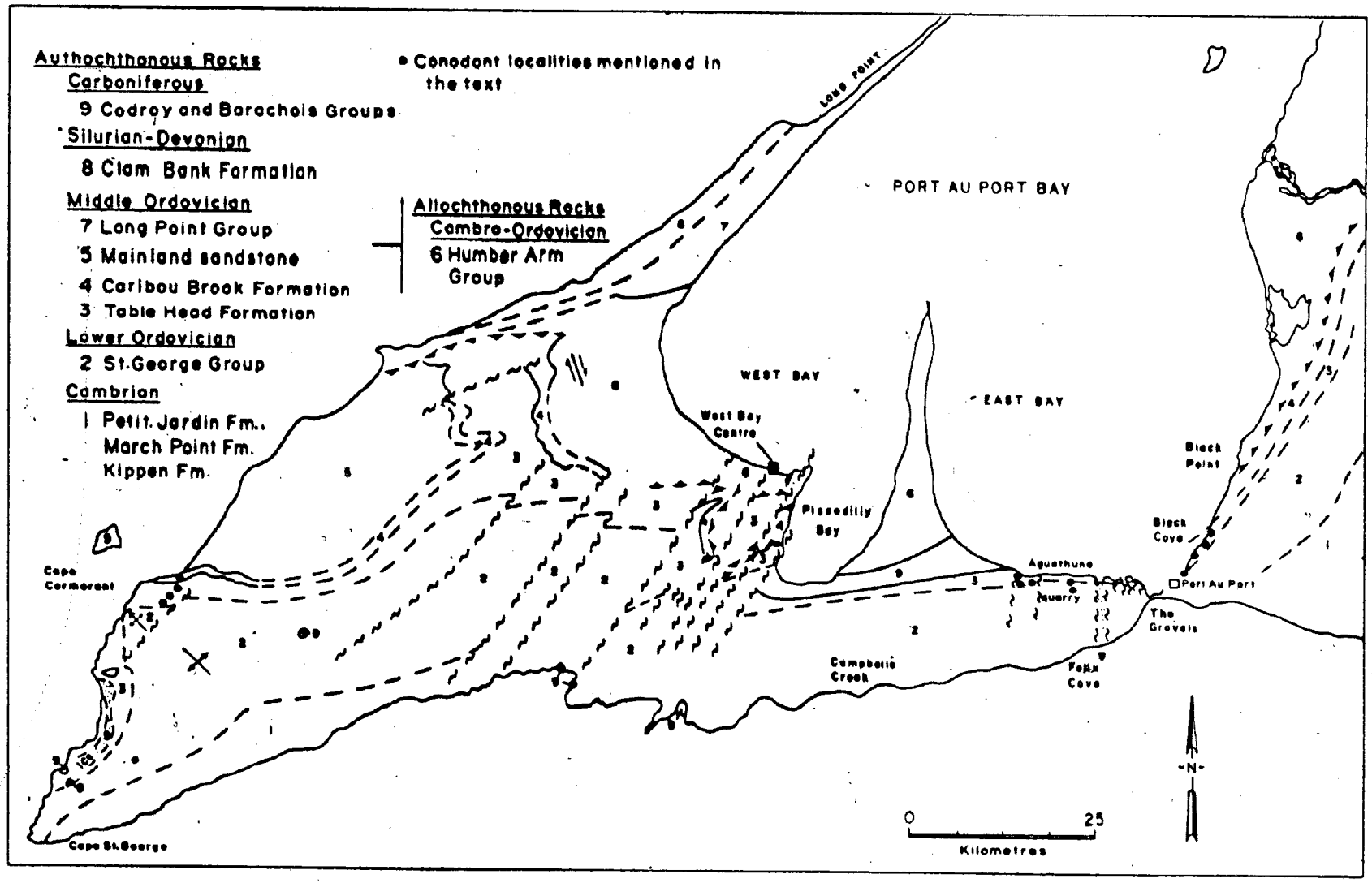
Sediments of upper Table Head lithology are exposed along the east coast of Big Spring Inlet and 3 km north of Main Brook. They may be as thick as 10-15 metres. No fossils were observed. The upper Table Head is overlain by green-grey and brown sandstones, siltstones and shales of the Goose Tickle Formation.

Cooper (1937) reported on sediments in the western part of the inner Hare Bay, where a sequence similar to the Table Head Formation is present. He reported a thickness of 1100 feet for the whole formation, but that is far too much. A thickness of about 100 metres (300 feet) has been estimated in this study.

Port au Port area.

Lower Table Head at Port au Port begins with mottled light-grey limestones and laminated dolomitic micrites. Bird's-eye, dessication cracks and ripple structures are present within this part of the sequence. The sediments correlate with unit $A_1$ at Table Point. Lower Table Head overlies the St. George Group with a disconformity in the Aguathuna Quarry. In the lower part of the sequence red-colored argillaceous micrites of unit $A_2$ are prominent. In general the units $A_1$ and $A_2$ can easily be recognized in this area. They are well exposed in the abandoned quarry of Aguathuna (fig. A.I.2) where they occupy stratigraphic positions similar to those at Table Point. Unit $A_3$ is widespread northeast and west of The Gravels. The boundary

Fig. A.I.2. Location of conodont localities, Port au Port area. Geology modified from DeGrace (1974), and Schillereff and Williams (1979).


Authochthonous Rocks
Carboniferous
9 Codroy and Barachois Groups
Silurian-Devonian
8 Clam Bank Formation
Middle Ordovician
7 Long Point Group
5 Mainland sandstone
4 Caribou Brook Formation
3 Table Head Formation
Lower Ordovician
2 St.George Group
Cambrian
1 Petit Jardin Fm.,
March Point Fm.
Kippen Fm.
• Conodont localities mentioned in the text
Allochthonous Rocks
Cambro-Ordovician
6 Humber Arm Group
PORT AU PORT BAY
LONG POINT
WEST BAY
EAST BAY
West Bay Centre
Piccadilly Bay
Black Point
Black Cove
Port Au Port
Aguathuna
Quarry
The Gravels
Campbells Creek
Felix Cove
Cape Cormorant
Cape St.George
0
25
Kilometres
N

between unit $A_2$ and unit $A_3$ is exposed north-east of The Gravels and in the Aguathuna quarry. Cherts are present in unit $A_3$. Sponges are present close to the top of unit $A_3$. The upper boundary of unit $A_3$ is exposed at Black Cove and Cape Cormorant.

Middle Table Head begins with grey to yellow argillaceous biosparites, which gradually give way to the interbedded shales and limestones of unit $B_2$. This part yields trilobites and brachiopods. At the top of unit $B_2$ the micrites have silty laminae and contain an excellent radiolarian fauna. A bentonite bed is present within the middle Table Head strata in Black Cove. Similar strata are exposed 1 kilometre west of Piccadilly Provincial Park, and have been referred to the middle Table Head (Stevens 1970). The strata at West Bay quarry, however, differ from the middle Table Head by being more silty, and showing graded bedding. In addition they are more silicified and are associated with green chert. These lithologies have not been observed at Table Point, and they are not considered typical of middle Table Head. The beds at West Bay yield an excellent radiolarian fauna (Bergström 1979) and graptolite fauna (Finney and Skevington 1979).

The upper Table Head is about 15 metres thick at Black Cove. Toward the top of the upper Table Head a single bed of silty siliceous micrite is present. The upper Table Head is slumped toward its top at this locality.

The Table Head Formation is overlain by massive grey sandstones, green sandstones and shales and a 30 metre thick limestone conglomerate (Stevens 1972). The clasts in the conglomerate are predominantly of the lower Table Head lithology, though single blocks may represent

St. George lithologies. Similar conglomerate units are exposed at the Piccadilly Provincial Park and at Cape Cormorant (fig. A.I.2). These beds are similar to those described as Cow Head Group at Cliffy Point herein, in that they contain lower Table Head lithologies. They, however, occupy a different stratigraphical position. Schillereff and Williams (1979) introduced the Caribou Brook Formation for the conglomerates in the Port au Port area.

Fig. A.I.3 shows the thicknesses of the main lithological divisions and their correlations.

Conclusions.

In summary three main areas - Hare Bay, Table Point (study area) and Port au Port are key areas. The characteristics of the three areas are summarized in fig. A.I.3 and the following: 1) Lower Table Head is thicker at Table Point, than at any other locality. The thicknesses reported earlier from Hare Bay and Port au Port areas are excessive; 2) the maximum thickness of middle Table Head is obtained from the type locality. It is also predominantly slumped at Table Point, which might affect the measured thickness; 3) thickness of the upper Table Head varies little from area to area, but it is thickest at Black Cove; 4) the presence of a disconformity between the St. George Group and Table Head Formation is well displayed in the Port au Port area; it cannot be substantiated at the Table Point and has not been recognized in the Hare Bay area; in the Hare Bay area the sediments were deposited in peritidal environment; all these areas have a regressive sequence in the upper part of the St. George Group; 5) the upper Canadian-lower Whiterockian strata of supratidal

Fig. A.I.3. Lithologic correlation between Table Point, Port au Port and Hare Bay areas. The thickness of lower Table Head strata from the Hare Bay area is estimated, and it may be less than indicated. The strata from the Port au Port region are faulted.

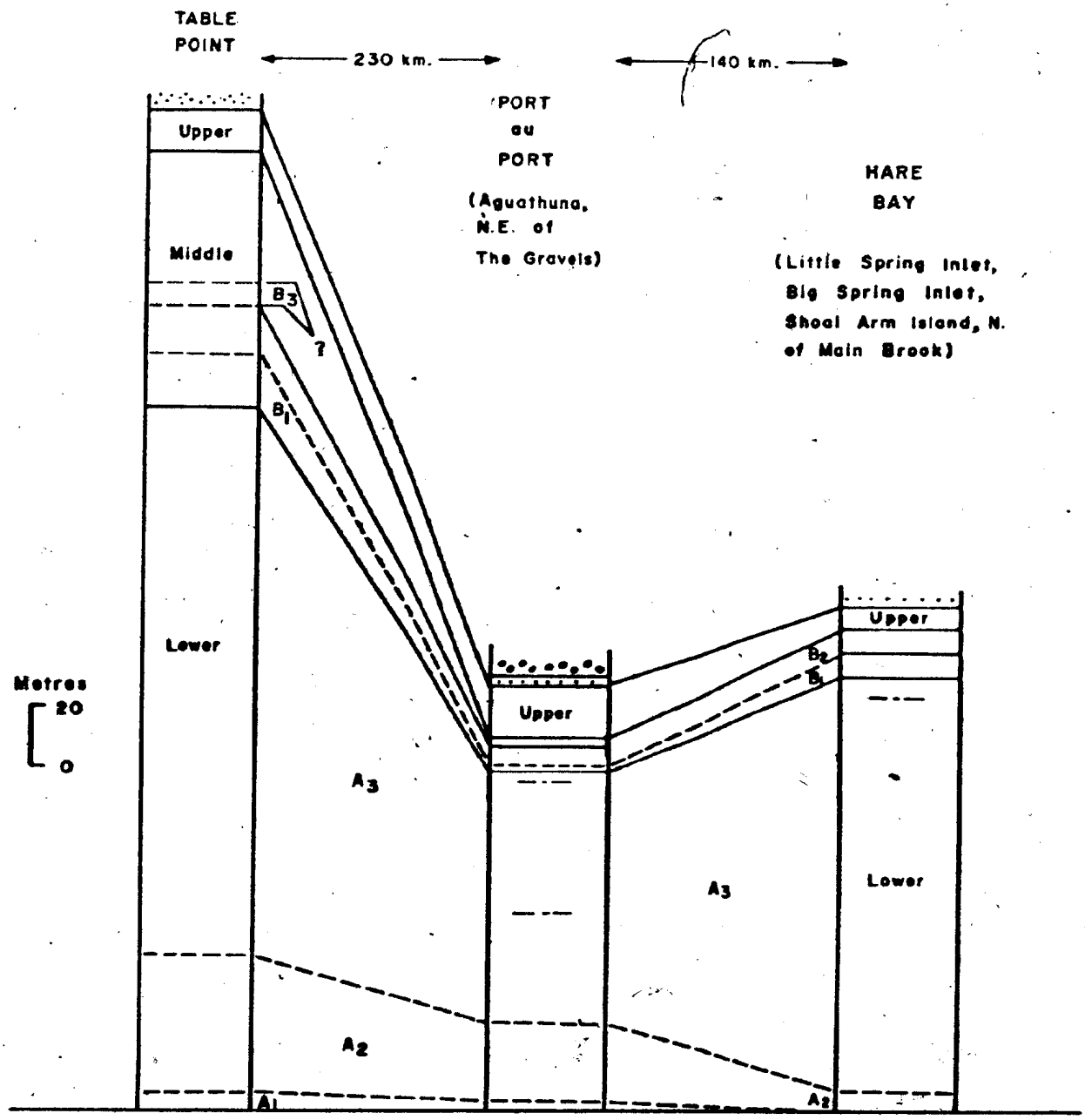


TABLE POINT
230 km.
140 km.
PORT au PORT
(Aguathuna, N.E. of The Gravels)
HARE BAY
(Little Spring Inlet, Big Spring Inlet, Shoal Arm Island, N. of Main Brook)
Upper
Middle
Lower
B3
?
B1
Metres
20
0
A3
A2
A1
Upper
A3
A2
Upper
B2
B1
Lower

and peritidal origin of the study area and the Hare Bay area form a separate lithological unit, which remains to be defined. In this study these strata are excluded from the Table Head Formation and included in the St. George Group, pending a formal definition. A lithologic boundary between the undefined unit and the Table Head Formation could be the boundary between unit $A_1$ and $A_2$ of this study; 6) color of the rocks changes from predominantly black to the north to grey to dark-grey in the study area and to light-grey, yellow brownish or red-colored limestones in the south; 7) chert is more abundant in the lower Table Head in the Hare Bay area than in other areas; 8) sponges are sporadically present in the Port au Port and Hare Bay areas, but are prominent only in the study area. The biostromal bryozoans have only been observed in the study area in the uppermost lower Table Head.

## I.C. Correlation of biozones within Newfoundland.

Additional samples have been collected and processed from areas outside the study area and will be dealt with here briefly. Several stratigraphically important species were recovered; 54 samples have been processes and 35 yielded conodonts. About 3200 conodont elements were examined from various localities.

### I.C.1. Hare Bay

A series of 22 samples were examined from various outcrops across the Hare Bay area. 13 samples failed to yield conodonts; conodonts recovered from the remaining samples are fragmentary. All elements are black (CAI 5), and the yield was low. Conodonts from Brent Island, Shoal Arm Island, North of Main Brook, Hare Island, and Little Spring Inlet and Big Spring Inlet have been studied.

I.C.1.1. Brent Island.

Brent Island consists of black micrite and biosparite referred to Brent Island Limestone and Southern Arm Limestone (Cooper 1937). These are lithologically similar to the Boat Harbour Formation, and the Catoche Formation of the St. George Group, respectively. Eight spot samples collected around the island yielded a large fauna. The conodonts are of Canadian age and the fauna is referred to the conodont faunal succession of Ethington and Clark (1971).

Stratigraphical Horizon.

Catoche Formation or the Southern Arm Limestone.

Fauna.

*Acodus* sp. cf. *A. delicatus* Branson & Mehl

*Drepanodus* sp. cf. *D. arcuatus* Pander

*Drepanoistodus* sp.

*Oepikodus communis* (Ethington & Clark)

*Parapanderodus* cf. *P. striatus* (Graves & Ellison)

? *Reutterodus* sp.

*Drepanodus simplex* Branson & Mehl s.f.

*Scolopodus* sp. cf. *S. quadraplicatus* Branson & Mehl s.f.

*Scolopodus cornutiformis* Branson & Mehl s.f. (*sensu* Barnes & Tuke 1970)

Age of the fauna.

Upper Canadian, Midcontinent Fauna E (Ethington and Clark 1971).

Remarks.

The fauna is similar to that of the Catoche Formation of the St. George Group on the Port au Choix Peninsula (Stouge in press).

I.C.1.2. Shoal Arm Island.

Shoal Arm Island consists of massive bedded, mainly black micrite; several chert bands and siliceous sponges are common.

Ten spot samples collected from around the island of the lower Table Head lithologies were examined. Only 4 of those yielded conodonts, some of which are important.

Stratigraphic Horizon.

Lower Table Head.

Fauna.

*Acodus* sp.

*Belodella* sp.

*Drepanoistodus* sp.

*Histiodella tableheadensis* n.sp.

*Juanognathus* sp.

*Loxodus*? sp.

*Parapaltodus simplicissimus* n.sp.

*Parapanderodus arcuatus* n.sp.

*P.* sp. cf. *P. elegans* n.sp.

*Periodon* sp.

*Polonodus* sp.

*Protopanderodus strigatus* Barnes & Poplawski

*Scalpellodus* sp.

Age of the fauna.

*Histiodella tableheadensis* Phylo-zone.

I.C.1.3. Hare Island.

Hare Island is part of a N-S trending thrust. The lower part of the allochthonous sequence consists of interbedded dolomite and limestone beds of St. George affinity and represents the top of the St. George Group in this area. The St. George Group is overlain by black, massive fossiliferous limestone characteristic of the lower Table Head lithology.

Stratigraphic Horizon.

A para-authochthonous slice of St. George Group lithology.

Fauna.

*Eoneoprioniodus*? sp. 1

*Eoneoprioniodus*? sp. 2

*Eoneoprioniodus* cf. *bialatus* (Mound)

*Parapanderodus arcuatus* n.sp.

*Drepanodus* sp. s.f.

Age of the fauna.

The fauna cannot be correlated with the zonation at Table Point, as it failed to yield *Histiodella* or *Trigonodus*.

Remarks.

*Eoneoprioniodus bialatus* has been described from the Joins Formation of Oklahoma (Mound 1965a), and by Barnes (1977) from the Ship Point Formation of the Canadian Arctic. *Eoneoprioniodus bialatus* is indicative of Midcontinent Fauna 2 or 3 of Sweet *et al*. (1971), or uppermost Arenig to lowermost Llanvirn. The fauna is older than the basal zone at Table Point.

*Eoneoprioniodus bialatus* occurs together with Nov. Gen. B *sensu*

Sweet et al. (1971) in the Ship Point Formation (Barnes, 1977). Nov. Gen. B. (syn. Histiodella n.sp. of Fåhraeus & Nowlan, 1978) has been recorded from Bed 13 of the Cow Head Group.

Geological significance.

The collection represents the youngest St. George Group in the Hare Bay area. The data support the idea that the regression prevailed from Upper Canadian to Lower Whiterockian.

Stratigraphical Horizon.

Para-autochthonous lower Table Head lithology.

Fauna.

?Eoneoprioniodus sp. (fragment)

Age of the fauna.

No definite age can be assigned to this fauna though, it is of Whiterockian age.

I.C.1.4. North of Main Brook.

One section measuring 56 metres of upper part of lower Table Head and through middle Table Head, 3 kilometres north of Main Brook, was sampled over 5 metres intervals. A fault separates the two units. A major fault separates the Table Head Formation from the St. George Group.

Stratigraphical Horizon.

Lower part of middle Table Head.

Fauna.

Acodus combsi Bradshaw

*Cordylodus*? *horridus* Barnes & Poplawski

*Drepanodus*? sp. cf. *D.*? *gracilis* (Branson & Mehl)

*Drepanoistodus* sp. n.sp.

*Drepanoistodus*? sp. cf. *D.*? *venustus* (Stauffer)

*Loxodus*? sp.

*Oistodus*? *tablepointensis* n.sp.

*Parapaltodus flexuosus* (Barnes & Poplawski)

*P. simplicissimus* n.sp.

*Parapanderodus arcuatus* n.sp.

*Periodon aculeatus* Hadding

*Protopanderodus* sp.

*Semiacontiodus asymmetricus* (Barnes & Poplawski)

*Age of the fauna.*

Probably *Histiodella tableheadensis* Phylo-zone.

*Remarks.*

*Histiodella tableheadensis* was not recorded, but the close faunal similarity and the stratigraphical position just beneath the *H. tableheadensis*-bearing samples supports the age determination. The lack or sporadic occurrence of *Histiodella* even in large collections is also typical of the Port au Port area from strata of similar stratigraphic position (Appendix I.C.4.1.). The combination of species is typical of the *Periodon*-*Cordylodus*? biofacies.

*Stratigraphic Horizon.*

Middle Table Head (unit $B_2$).

Fauna.

Belodella jemtlandica Löfgren

Cordylodus? horridus Barnes & Poplawski

Drepanodus arcuatus Pander

Drepanoistodus? sp. cf. D.? venustus (Stauffer)

Histiodella tableheadensis n.sp.

Oistodus? tablepointensis n.sp.

Paltodus? sp.

Paroistodus? sp. aff. P. originalis (Sergeeva)

Parapaltodus flexuosus (Barnes & Poplawski)

P. simplicissimus n.sp.

Parapanderodus sp.

Periodon aculeatus Hadding

Polonodus sp.

Protopanderodus sp. cf. P. varicostatus (Sweet & Bergström)

Ramiform elements (?Baltoniodus sp.)

Semiacontiodus asymmetricus (Barnes & Poplawski)

Age of the fauna.

Histiodella tableheadensis Phylo-zone.

Remarks.

The presence of H. tableheadensis suggests an older age than that of Table Point (H. kristina Phylo-zone) for the middle Table Head. The faunal assemblage is similar to the Periodon-Cordylodus? biofacies.

I.C.1.5. Little Spring Inlet and Big Spring Inlet.

The outcrops of Little Spring Inlet and Big Spring Inlet are folded in an anticline with a N-S trending fold axis. The basal part consists of predominantly light-grey to yellow, fine to massive bedded dolostones and minor micrites. A few horizons with stromatolites are present within the dolostone sequence. These strata correlate with similar beds on Hare Island of the uppermost St. George Group. The Table Head Formation begins with a thin sequence of interbedded grey micrite and dolostone, overlain by massive bedded micrite with chert nodules. Due to the high tide only the lower Table Head lithology was collected.

Stratigraphic Horizon.

Lower Table Head.

Fauna.

*Belodella* sp.

*Drepanodus*? sp. cf. *D.*? *gracilis* (Branson & Mehl)

*Drepanoistodus bellburnensis* n.sp.

*Histiodella tableheadensis* n.sp.

*Parapaltodus simplicissimus* n.sp.

*Parapanderodus arcuatus* n.sp.

*Periodon* sp.

*Protopanderodus strigatus* Barnes & Poplawski

*Semiacontiodus asymmetricus* (Barnes & Poplawski)

Age of the fauna.

*Histiodella tableheadensis* Phylo-zone.

Remarks.

Fahraeus (1970) reported and depicted conodonts from Little Springs Inlet. The fauna included Polonodus sp. B sensu Löfgren (1978) and Periodon sp.. It correlates with the fauna recovered from north of Main Brook (Appendix I.C.1.4), which in turn was correlated with H. tableheadensis Phylo-zone. Fåhraeus (1970) indicated that the fauna could be latest Arenig or earliest Llanvirn in age - a conclusion that is in accordance with the age obtained from north of Main Brook.

Geological Significance.

The data from the Hare Bay area support the idea that the St. George Group is regressive from the upper Midcontinent Fauna E through Midcontinent Fauna 2-3. The age forms the basis for the initial Table Head late Whiterockian transgression. The basal Table Head is included in H. tableheadensis Phylo-zone or Midcontinent Fauna 4 of age.

I.C.2. Burnt Island, Pistolet Bay.

The rocks of Burnt Island consists of light yellow dolostones and micrites of the St. George Group and black to light-grey micrites of lower Table Head lithology. A red pitted wavy surface with carbonate blocks within the upper part of St. George Group, about 40 metres below the basal Table Head strata, probably represents a disconformity. The whole island is cut by numerous NNE-trending faults and joints, which are associated with white calcite veins. The whole island is thrusted over the Goose Tickle Formation.

The conodonts recovered are black (CAI 5).

Stratigraphic Horizon.

Lower Table Head.

Fauna.

*Drepanodus*? sp. cf. *D.*? *gracilis* Branson and Mehl

*Erismodus* sp.

*Parapanderodus arcuatus* n.sp.

*P.* sp. cf. *P. elegans* n.sp.

*Protopanderodus strigatus* Barnes and Poplawski

*Semiacontiodus preasymmetricus* n.sp.

Age of the fauna.

?*Histiodella tableheadensis* Phylo-zone.

Remarks.

The fauna is derived from allochthonous Table Head strata. The age, however, is not considered to differ from that of lower Table Head from Table Point.

I.C.3. Bonne Bay area (East Arm)(Fig. A.I.4).

The Table Head strata are exposed north-east of Neddy Harbour, where they form a narrow, steeply NW-dipping belt. The rocks are all black in color. The conodonts are black (CAI 5).

I.C.3.1. Immediately north-east of Neddy Harbour.

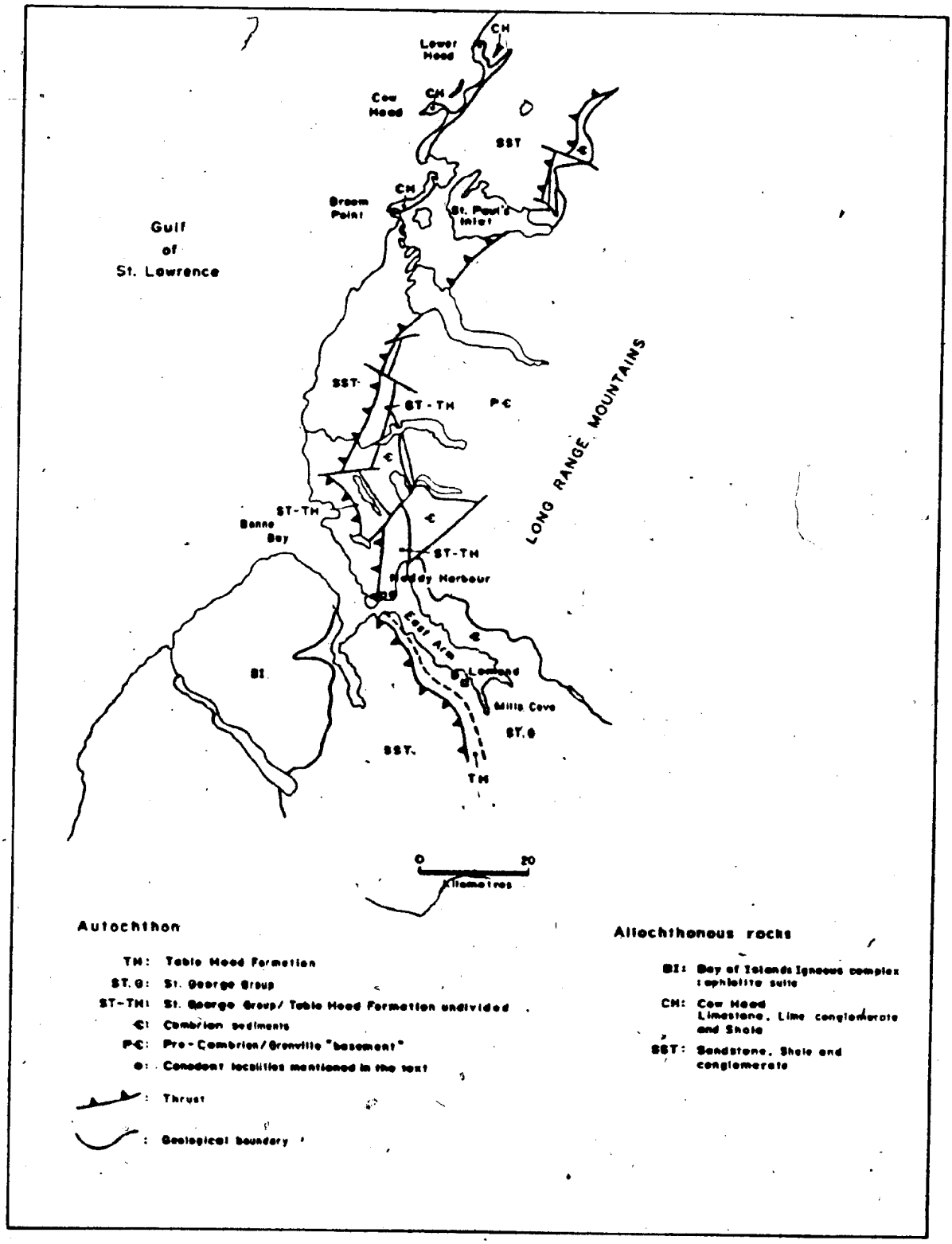
Stratigraphic horizon.

Lower Table Head (unit $A_3$).

Fauna.

*Belodella jemtlandica* Löfgren

Figure. A.I.4. Conodont localities mentioned in the text. Geology modified from DeGrace (1974).


Lower Head
CH
Cow Head
CH
SST
CH
Broom Point
St. Paul's Inlet
Gulf of St. Lawrence
SST
ST-TH
P€
LONG RANGE MOUNTAINS
€
ST-TH
Bonne Bay
€
ST-TH
Bradley Harbour
East Arm
€
BI
Lomond
Mills Cove
ST.G
SST.
TH
0
20
Kilometres
Autochthon
TH: Table Head Formation
ST.G: St. George Group
ST-TH: St. George Group/ Table Head Formation undivided
€: Cambrian sediments
P€: Pre-Cambrian/Grenville "basement"
: Conodont localities mentioned in the text
: Thrust
: Geological boundary
Allochthonous rocks
BI: Bay of Islands Igneous complex ophiolite suite
CH: Cow Head Limestone, Lime conglomerate and Shale
SST: Sandstone, Shale and conglomerate

*Cordylodus*? *horridus* Barnes and Poplawski

*Drepanoistodus*? sp. cf. *D.*? *venustus* (Stauffer)

?*Erraticodon balticus* Dzik

*Histiodella tableheadensis* n.sp.

*Histiodella kristina* n.sp.

*Parapaltodus simplicissimus* n.sp.

*Parapanderodus arcuatus* n.sp.

Platform elements

*Protopanderodus strigatus* Barnes and Poplawski

*Scalpellodus* sp.

*Age of the fauna.*

Basal *Histiodella kristina* Phylo-zone.

*Remarks.*

Neddy Harbour is the only locality outside the study area which can be included in the *H. kristina* Phylo-zone.

*I.C.3.2. Mill Cove 2½ km WNW of Lamond, south-east coast of East Arm (Bonne Bay) (Fig. A.I.4.).*

The rocks are steeply dipping and faulted. The limestones are black. The limestone may correlate with the yellow beds of St. George affinity on Burnt Island (Appendix I.C.2). The conodonts are black (CAI 5).

*Stratigraphic Horizon.*

Upper St. George Group.

*Fauna.*

*Acodus* sp. (?*A. delicatus* Branson and Mehl)

*Eoneoprioniodus*? sp. cf. *E.*? sp. 1

?*Eoneoprioniodus bialatus* (Mound)

*Histiodella* sp. cf. *H. tableheadensis* n.sp.

*Leptochirognathus* sp.

*Multioistodus* sp. cf. *M. subdentatus* Cullison

*Parapanderodus* sp. cf. *P. consimilis* (Moskalenko)

*P. arcuatus* n.sp.

*P.* sp. cf. *P. striatus* (Graves and Ellison)

*Plectodina*? sp. n. A

Ramiforms

*Scolopodus* sp. s.f.

Age of the fauna.

?*Histiodella tableheadensis* Phylo-zone

Remarks.

The fauna is typical of the Midcontinent Faunal Province and represents Midcontinent Fauna 4 of Sweet *et al*. (1971). The Bonne Bay fauna probably correlates with the fauna from Hare Island (top of the St. George Group)(Appendix I.C.1.3).

Geological significance.

The fauna is unique in that it is the only one of its kind so far known from Newfoundland. It is very similar to the Whiterockian fauna described from the Joins Formation (Mound 1965a).

I.C.4. Port au Port area.

Twenty samples have been examined from north of The Gravels, Aguathuna quarry, and Cape Cormorant (Fig. A.I.3). All samples yielded conodonts. They occur in a high number and to date, yielded the best preserved fauna in the Table Head Formation. All specimens are light-brown in color (CAI 2).

I.C.4.1. North of The Gravels.

The most complete section through the Table Head Formation occurs, north of The Gravels, Port au Port Peninsula, but it is strongly affected by faults with an unknown sense of movement.

A complete series of samples was collected through the section and from lithologies of the lower and the middle Table Head. Elements of the *Histiodella tableheadensis* Phylo-zone are present throughout the section.

Stratigraphic Horizon.

Lower Table Head

Fauna.

*Belodella* sp.

*Drepanodus*? sp. cf. *D.*? *gracilis* (Branson and Mehl)

?*Erraticodon balticus* Dzik

*Histiodella tableheadensis* n.sp.

*Parapaltodus simplicissimus* n.sp.

*Parapanderodus arcuatus* n.sp.

*Parapanderodus* sp. cf. *P. consimilis* (Moskalenko)

*Parapanderodus elegans* n.sp.

*Periodon aculeatus* Hadding

*Polonodus* sp.

*Protopanderodus strigatus* Barnes and Poplawski

*Protopanderodus* sp.

*Scalpellodus biconvexus* (Bradshaw)

*Semiacontiodus* sp. cf. *S. cordis* (Hamar)

Age of the fauna.

*Histiodella tableheadensis* Phylo-zone.

Stratigraphic Horizon.

Top of the lower Table Head (Black Cove south).

Fauna.

*Acodus combsi* Bradshaw

*Amorphognathus* sp. cf. *A.* '*variabilis*' Sergeeva

*Belodella jemtlandica* Löfgren

*Cordylodus*? *horridus* Barnes and Poplawski

*Cornuodus longibasis* (Lindström)

*Drepanoistodus* sp.

*Drepanoistodus*? sp. cf. *D.*? *venustus* (Stauffer)

?*Erraticodon* sp.

*Histiodella tableheadensis* n.sp. (rare)

*Parapaltodus simplicissimus* n.sp.

*P. flexuosus* (Barnes and Poplawski)

*Parapanderodus arcuatus* n.sp.

*Parapanderodus elegans* n.sp.

*Paroistodus*? sp. cf. *P. originalis* (Sergeeva)

*Periodon aculeatus* Hadding

?*Polonodus* sp.

*Protopanderodus* sp. cf. *P. robustus* (Hadding)

*P. strigatus* Barnes and Poplawski

*Semiacontiodus* sp. cf. *S. cordis* (Hamar)

Age of the fauna.

*Histiodella tableheadensis* Phylo-zone.

Remarks.

The fauna is typical of the Acodus sub-biofacies of this study. The sparse representation of Histiodella elements is similar to the Hare Bay region (I.C.1.4.).

Stratigraphic Horizon.

Middle Table Head (unit $B_3$).

Fauna.

Belodella jemtlandica Löfgren

Cordylodus? horridus Barnes and Poplawski

Cornuodus longibasis (Lindström)

Drepanoistodus? sp. cf. D.? venustus (Stauffer)

Histiodella tableheadensis n.sp.

Parapanderodus arcuatus n.sp.

P. sp. cf. P. elegans n.sp.

Paroistodus? sp. cf. P. originalis (Sergeeva)

Periodon aculeatus Hadding

Spinodus cf. S. spinatus (Hadding)

Age of the fauna.

Histiodella tableheadensis Phylo-zone.

Remarks.

The uppermost beds of middle Table Head in Black Cove are older than the equivalent uppermost beds at Table Point (H. kristina Phylo-zone).

Geological significance.

The slope to basin facies appeared earlier in the Port au Port area than at Table Point. This may support the idea of a faster submergence on Port au Port, possibly due to the depression caused by the allochthons at that place. Hubert et al. (1977) indicated

a paleoslope trending NNE for the middle Table Head strata. This is in accordance with the idea of a sinuous outline of the shelf edge.

I.C.4.2. Aguathuna Quarry.

Stratigraphical Horizon.

The top of St. George Group.

Identified by..

G.S. Nowlan GSC, Ottawa.

Fauna.

?*Acodus deltatus* Lindström

*Drepanodus*? *gracilis* (Branson and Mehl)

*D. parallelus* Branson and Mehl s.f.

*D. toomeyi* Ethington and Clark s.f.

*Drepanoistodus* sp.

*Oepikodus communis* (Ethington and Clark)

*Scolopodus cornutiformis* Branson and Mehl s.f.

*Scolopodus* n.sp.

*Ulrichodina* sp.

Age of the fauna.

Upper Canadian, Midcontinent Fauna E.

Remarks.

Nowlan (1979) concluded that the overall aspect of the fauna is of Late Canadian age. This material is kept in GSC, Ottawa.

Reference.

Nowlan, G.S., 1979: Report No. 01-GSN-1979

Stratigraphic Horizon.

Basal Table Head.

Identified by.

G.S. Nowlan GSC, Ottawa

Fauna.

?Acodus deltatus Lindström

Drepanodus? gracilis (Branson and Mehl)

D. parallelus Branson and Mehl s.f.

Drepanoistodus sp.

Oepikodus sp.

Scolopodus gracilis Ethington and Clark s.f.

Scolopodus cornutiformis Branson and Mehl s.f.

Age of the fauna.

Upper Canadian.

Remarks.

Nowlan (1979) suggested that the fauna was possibly reworked because of the similarity to the fauna from the top of St. George Group and because the basal unit of the Table Head Formation was intraclastic. This meterial is kept in GSC, Ottawa.

Additional material collected by this author yielded:

Histiodella tableheadensis n.sp.

Nov. Gen. C Sweet et al. 1971

Plectodina? n.sp. A

Protopanderodus strigatus Barnes and Poplawski

Age of the fauna.

Histiodella tableheadensis Phylo-zone.

Geological significance.

The Aguathuna Quarry is considered as the classical locality for the disconformity between the St. George Group and the Table Head Formation. The faunas recorded indicate that a faunal hiatus covering

the lower Whiterockian is present.

The data indicate that the regression initiated in the Port au Port area.

I.C.4.3. Cape Cormorant.

Eleven spot samples collected from the stream section to the summit of Cape Cormorant were examined; two of those were collected from within the autochthonous Humber Arm Group.

Stratigraphic Horizon.

Lower Table Head (unit $A_2$)

Fauna.

*Drepanodus*? sp. cf. *D.*? *gracilis* (Branson and Mehl)

*Drepanoistodus* sp.

*Eoneoprioniodus*? sp. 2

*Erismodus* sp.

*Histiodella tableheadensis* n.sp.

*Parapaltodus angulatus* (Bradshaw)

*Parapanderodus* sp. cf. *P. consimilis* (Moskalenko)

*Plectodina*? n.sp. A

Age of the fauna.

*Histiodella tableheadensis* Phylo-zone.

Stratigraphic Horizon.

Lower Table Head (unit $A_3$).

Fauna.

*Belodella sinuosa* n.sp.

*Drepanodus*? cf. *D.*? *gracilis* (Branson and Mehl)

Histiodella tableheadensis n.sp.

Parapanderodus arcuatus n.sp.

?Periodon sp.

Scalpellodus pointensis n.sp.

Semiacontiodus asymmetricus (Barnes and Poplawski)

Semiacontiodus sp. cf. S. cordis (Hamar)

Age of the fauna.

Histiodella tableheadensis Phylo-zone.

Stratigraphic Horizon.

Conglomerates above Table Head Formation - Humber Arm autochthon (Caribou Formation). Boulders are lower Table Head lithologies.

Fauna.

Drepanodus arcuatus Pander

Juanognathus sp.

Parapaltodus flexuosus (Barnes and Poplawski)

Parapaltodus simplicissimus n.sp.

Paroistodus? aff. P. originalis (Sergeeva)

Protopanderodus sp. cf. P rectus (Lindström)

P. strigatus Barnes and Poplawski

Scalpellodus sp. cf. S. biconvexus (Bradshaw)

Semiacontiodus sp. cf. S. cordis (Hamar)

Semiacontiodus preasymmetricus n.sp.

Age of the fauna.

Possibly Histiodella tableheadensis Phylo-zone.

Remarks.

The elements are white and broken. The conodonts are probably reworked. The appearance of Drepanodus arcuatus compares with Hare

Bay (Appendix I.C.1.5).

In summary, the conodonts from Port au Port area indicate that the Table Head Formation from this area should be included in the *Histiodella tableheadensis* Phylo-zone. The base of the Table Head Formation at Table Point and the base at Port au Port are of similar age, as no difference in the faunas have been observed from the two areas.

I.C.5. Central Newfoundland.

In the community of Lush's Bight, long Island, a limestone unit in the Cutwell Group strikes approximately east-west. The section is composed of approximately 30 metres of steeply dipping limestone breccia interbedded with minor greywacke. It is overlain by black graptolite bearing Llandeilian shale (Dean, 1977).

The clasts of the breccia yielded conodonts. All the elements are black (CAI 5), but the preservation is moderately good and identification to species level is possible.

Stratigraphic Horizon.

?*Acodus* sp.

?*Belodella* sp.

*Cordylodus*? *horridus* Barnes and Poplawski

*Cornuodus longibasis* (Lindström)

*Drepanodus arcuatus* Pander

*Drepanoistodus*? sp. cf. *D.*? *venustus* (Stauffer)

*Histiodella tableheadensis* n.sp.

Hyaline elements

*Loxodus*? sp.

*Oistodus*? sp. cf. *O.*? *tablepointensis* n.sp.

*Parapaltodus flexuosus* (Barnes and Poplawski)

Parapaltodus simplissimus n.sp.

Parapanderodus arcuatus n.sp.

Paroistodus? sp. cf. P. originalis (Sergeeva)

Periodon aculeatus/flabellum Hadding/Lindström

?Polonodus sp.

Protopanderodus sp. cf. P. varicostatus (Sweet and Bergström)

Protopanderodus giganteus (Sweet and Bergström) s.f.

Semiacontiodus sp. cf. S. cordis (Hamar)

Triangulodus sp. cf. T. alatus Dzik

Walliserodus sp. cf. W. ethingtoni (Fahraeus)

Age of the fauna.

Histiodella tableheadensis Phylo-zone.

Remarks.

Many genera and species are in common with the Table Head fauna. In overall aspect, the fauna is older than the Table Head fauna at Table Point. Cordylodus? horridus, Oistodus? sp. cf. O.? tablepointensis n.sp. and Periodon flabellum/aculeatus are all of an earlier evolutionary stage than the Table Point specimens. The species are identical to the Mystic Conglomerate, Quebec (Barnes and Poplawski, 1973).

## ADDENDUM

Following reference was published since the completion of the manuscript:

Klappa, C.F., Opalinski, P.R., and James, N.P., 1980: Middle Ordovician Table Head Group of western Newfoundland: a revised stratigraphy. Can. J. Earth Sci. 17, 1007-1019.

PLATE 1.

Figure 1-11. Cordylodus? horridus Barnes & Poplawski.

All specimens are from the Histiodella kristina Phylo-zone.

1. Element 3, outer side. TP 68. Slide MUNSS 1. x100.
2. Element 3, inner side. TP 68. Slide MUNSS 1. x95.
3. Element 3, inner side. TP 67. Slide MUNSS 1. x85.
4. Element 2, outer side. TP 68. Slide MUNSS 1. x65.
5. Element 2, inner side. TP 67. Slide MUNSS 1 x60.
6. Element 2, inner side. TP 67. Slide MUNSS 1. x60.
7. Element 2, outer side. TP 68. Slide MUNSS 1. x60.
8. Element 1. Note the alternating tilt of the denticles. TP 68. Slide MUNSS 1. x65.
9. Element 2, inner side. TP 66. Slide MUNSS 1. x65.
10. Element 1. TP 71. Slide MUNSS 1. x65.
11. Element 1. TP 66. Slide MUNSS 1. x 55.

Figure 12-18. Drepanodus? sp. cf. D.? gracilis (Branson & Mehl).

All specimens are from the Histiodella tableheadensis Phylo-zone.

12. Homocurvatid drepanodontiform, inner side. TP 52. Slide MUNSS 2. x100.
13. Oistodontiform, inner side. TP 53. Slide MUNSS 2. x90.
14. 'Suberectid' drepanodontiform. TP 52. Slide MUNSS 2. x100.
15. Homocurvatid drepanodontiform, inner side. TP 53. Slide MUNSS 2. x100.

PLATE 1 (cont'd)

16. Homocurvatid drepanodontiform, inner side. TP 55. Slide MUNSS 2. x100.

17. Homocurvatid drepanodontiform. TP 52. Slide MUNSS 2. x90.

18. Oistodontiform, inner side. TP 25. Slide MUNSS 2. x130.

Figure 19, 22-25. Parapaltodus flexuosus (Barnes & Poplawski).

All specimens are from Histiodella kristina Phylo-zone.

19. Drepanodontiform, inner side. TP 72. Slide MUNSS 3. x60.

22. Scandodontiform, inner side. TP 67. Slide MUNSS 3. x115.

23. Drepanodontiform, inner side. TP 74. Slide MUNSS 3. x115.

24. Scandodontiform, inner side. TP 68. Slide MUNSS 3. x120.

25. Scandodontiform, inner side. TP 71. Slide MUNSS 3. x70.

Figure 20-21, 26-28. Parapaltodus simplicissimus n.sp.

All specimens are from Histiodella kristina Phylo-zone.

20. Scandodontiform, inner side. TP 67. Slide MUNSS 5. x65.

21. Drepanodontiform. TP 67. Slide MUNSS 5. x65.

26. Drepanodontiform. TP 72. Slide MUNSS 5. x60.

27. Scandodontiform. TP 67. Slide MUNSS 5. x65.

28. Drepanodontiform. Holotype. TP 68. Slide MUNSS 4.

28A. Detail of basal anterior part of the cusp. Same specimen as figure 28B. x750.

28B. Drepanodontiform with basal funnel. TP 68. Slide MUNSS 4. x55.


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PLATE 2

Figure 1 - 2. Parapaltodus angulatus (Bradshaw).

Specimens from the basal Histiodella tableheadensis Phylo-zone.

1. Drepanodontiform. TP 19. Slide MUNSS 6. x 100.
2. Scandodontiform. TP 19. Slide MUNSS 6. x 100.

Figure 3 - 8. Protopanderodus robustus (Hadding). All specimens are from Histiodella kristina Phylo-zone.

3. Symmetrical acontiodontiform. TP 76. Slide MUNSS 7. x 115.
4. Scandodontiform. TP 67. Slide MUNSS 7. x 125.
5. Symmetrical acontiodontiform. TP 70. Slide MUNSS 7. x 105.
6. Asymmetrical acontiodontiform. TP 76. Slide MUNSS 7. x 100.
7. Symmetrical acontiodontiform. TP 71. Slide MUNSS 7. x 50.
8. Scandodontiform. TP 71. Slide MUNSS 7. x 100.

Figure 9 - 14, 17. Protopanderodus sp. cf. P. liripipus Kennedy, Barnes and Uyeno. All specimens are from Histiodella kristina Phylo-zone.

9. Asymmetrical acontiodontiform, outer side. TP 68. Slide MUNSS 8. x 90.
10. Asymmetrical acontiodontiform, inner side. TP 71. Slide MUNSS 8. x 105.
11. Asymmetrical acontiodontiform, inner side. TP 71. Slide MUNSS 8. x 100.
12. Symmetrical acontiodontiform. TP 68. Slide MUNSS 8. x 90.
13. Subsymmetrical acontiodontiform. TP 68. Slide MUNSS 8. x 100.
14. Asymmetrical acontiodontiform, outer side. TP 71. Slide MUNSS 8. x 100.

PLATE 2 (cont'd)

17A. Scandodontiform, inner side. TP 74. Slide MUNSS 8. x 105.

17B. Detail of base. Same specimen as in 17A. x 280.

Figure 15 - 16, 18 - 24. Protopanderodus strigatus Barnes and Poplawski. All specimens are from Histiodella tableheadensis Phylo-zone.

15. Asymmetrical acontiodontiform, bi-costate side. TP 53. Slide MUNSS 9. x 70.

16. Asymmetrical acontiodontiform, uni-costate side. TP 54. Slide MUNSS 9. x 65.

18. Symmetrical acontiodontiform. TP 52. Slide MUNSS 9. x 70.

19. Asymmetrical acontiodontiform, uni-costate side. TP 53. Slide MUNSS 9. x 65.

20. Symmetrical acontiodontiform. TP 59. Slide MUNSS 9. x 70.

21. Asymmetrical acontiodontiform, bi-costate side. TP 52. Slide MUNSS 9. x 70.

22. Asymmetrical acontiodontiform, uni-costate side. TP 53. Slide MUNSS 9. x 70.

23. Scandodontiform, inner side. TP 59. Slide MUNSS 9. x 65.

24. Asymmetrical acontiodontiform, uni-costate side. TP 53. Slide MUNSS 9. x 65.

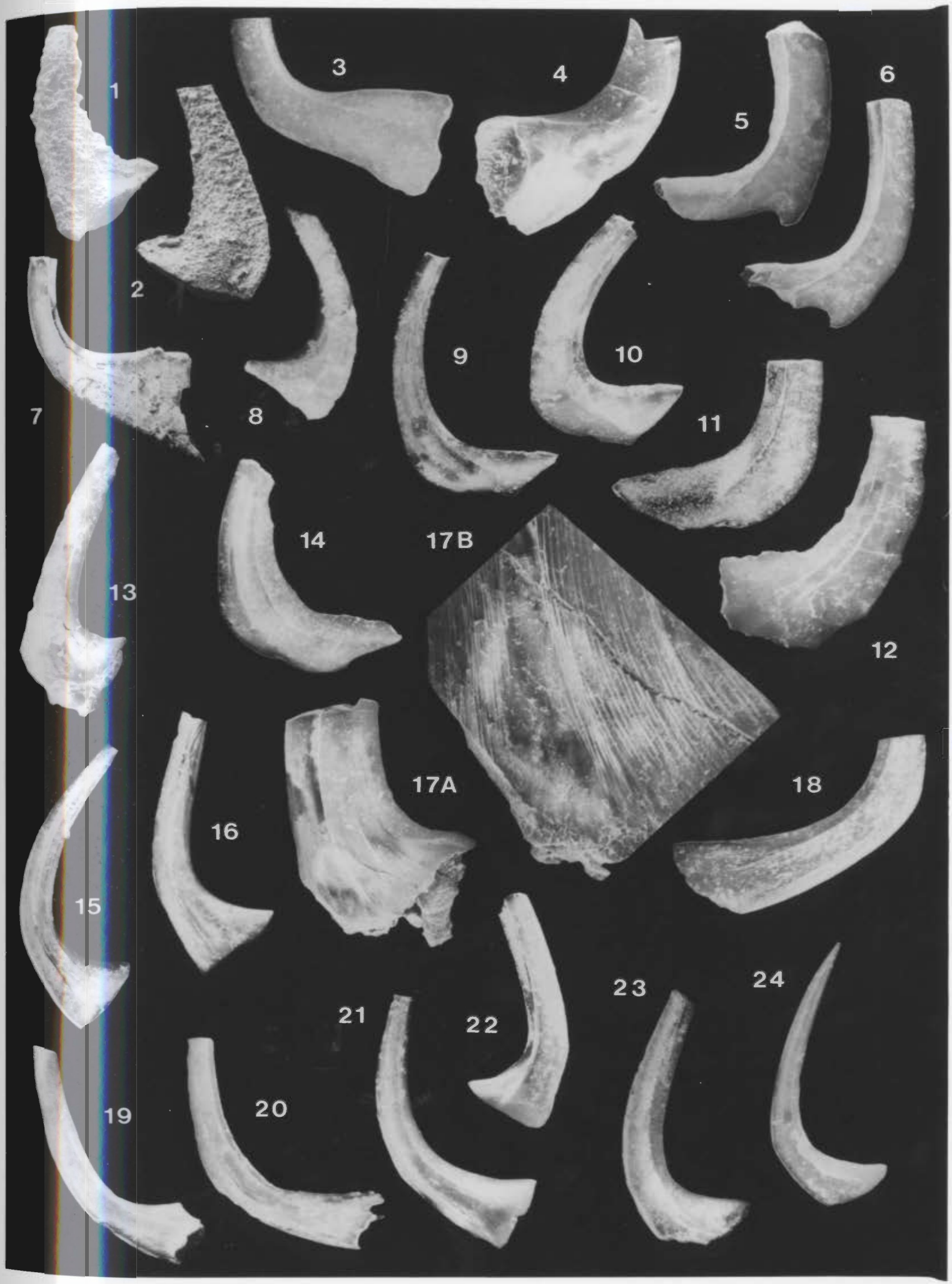
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PLATE 3

Figure 1 - 5. Protopanderodus sp. A. All specimens from Histiodella tableheadensis Phylo-zone.

1A. Scandodontiform, inner side. TP 59. Slide MUNSS 10. x 65.

1B. Detail of basal, posterior part of cusp. Same specimen as in 1A. x 225.

2. Scandodontiform. TP 53. Slide MUNSS 10. x 100.

3. Asymmetrical acontiodontiform. TP 54. Slide MUNSS 10. x 120.

4. Asymmetrical acontiodontiform. TP 59. Slide MUNSS 10. x 70.

5A. Asymmetrical acontiodontiform. TP 61. Slide MUNSS 10. x 65.

5B. Detail of cusp. Same as 5A. x 225.

Figure 6 - 10. Protopanderodus sp. cf. P. reclinatus (Lindström). All specimens from Histiodella kristina Phylo-zone.

6. Scandodontiform. TP 71. Slide MUNSS 11. x 120.

7. Acontiodontiform. TP 77. Slide MUNSS 11. x 80.

8. Acontiodontiform. TP 74. Slide MUNSS 11. x 75.

9. Acontiodontiform. TP 74. Slide MUNSS 11. x 80.

10. Scandodontiform. TP 74. Slide MUNSS 11. x 80.

Figure 11 - 17. Protopanderodus sp. cf. P. varicostatus (Sweet & Bergström). All specimens from Histiodella kristina Phylo-zone.

11. Asymmetrical acontiodontiform. TP 71. Slide MUNSS 12. x 60.

12. Asymmetrical acontiodontiform. TP 72. Slide MUNSS 12. x 65.

13. Scandodontiform. TP 72. Slide MUNSS 12. x 70.

14. Asymmetrical acontiodontiform. TP 74. Slide MUNSS 12. x 70.

PLATE 3 (cont'd)

15. Scandodontiform. TP 74. Slide MUNSS 12. x 50.

16. Symmetrical acontiodontiform ("Acontiodus cooperi"). TP 72. Slide MUNSS 12. x 70.

17A. Detail of base. Same specimen as in 17B. x 320.

17B. Asymmetrical acontiodontiform. TP 72. Slide MUNSS 12. x 60.

Figure 18 - 20. Drepanoistodus basiovalis (Sergeeva). Specimens from Histiodella tableheadensis Phylo-zone.

18. Drepanodontiform. TP 36. Slide MUNSS 13. x 110.

19. Oistodontiform. TP 36. Slide MUNSS 13. x 100.

20. Oistodontiform. TP 36. Slide MUNSS 13. x 90!

Figure 21 - 23. Drepanoistodus sp. cf. D. basiovalis (Sergeeva). Specimens from Histiodella tableheadensis Phylo-zone.

21. Oistodontiform. TP 23. Slide MUNSS 14. x 120.

22. Drepanodontiform. TP 23. Slide MUNSS 14. x 110.

23. Drepanodontiform. TP 23. Slide MUNSS 14. x 100.

Figure 24 - 25. Drepanoistodus forceps (Lindström). Specimens from Histiodella tableheadensis Phylo-zone.

24. Oistodontiform. TP 53. Slide MUNSS 15. x 100.

25. Oistodontiform. TP 46. Slide MUNSS 15. x 190.

Figure 26. Protopanderodus sp. The specimen is from Histiodella kristina Phylo-zone. Basal funnel. TP.71. Slide MUNSS 12. x 60.


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PLATE 4

Figure 1 - 8. Drepanoistodus bellburnensis n. sp. All specimens are from Histiodella kristina Phylo-zone.

1. Erectid drepanodontiform. TP 67. Slide MUNSS 16. x 100.
2. Homocurvatid drepanodontiform, recurved. TP 67. Slide MUNSS 16. x 100.
3. Oistodontiform. TP 68. Slide MUNSS 16. x 75.
4. Oistodontiform. Holotype. TP 67. Slide MUNSS 17. x 100.
5. Homocurvatid drepanodontiform, recurved. TP 66. Slide MUNSS 16. x 80.
6. Homocurvatid drepanodontiform, procurved. TP 68. Slide MUNSS 16. x 80.
7. Homocurvatid drepanodontiform, procurved. TP 66. Slide MUNSS 16. x 110.
8. Drepanodontiform, reclined. TP 68. Slide MUNSS 16. x 100.

Figure 9 - 17. Drepanoistodus tablepointensis n. sp. All specimens from Histiodella kristina Phylo-zone.

9. Erectid drepanodontiform. TP 68. Slide MUNSS 18. x 75.
10. Oistodontiform. Holotype. TP 68. Slide MUNSS 19. x 85.
11. Homocurvatid drepanodontiform. TP 68. Slide MUNSS 18. x 75.
12. Homocurvatid drepanodontiform. TP 67. Slide MUNSS 18. x 70.
13. Homocurvatid drepanodontiform. TP 67. Slide MUNSS 18. x 70.
14. Homocurvatid drepanodontiform. TP 68. Slide MUNSS 18. x 65.
15. Oistodontiform. TP 67. Slide MUNSS 18. x 85.
16. Oistodontiform. TP 68. Slide MUNSS 18. x 90.
17. Oistodontiform. TP 67. Slide MUNSS 18. x 90.

PLATE 4 (cont'd)

Figure 18 - 25. Drepanoistodus? sp. cf. D.? venustus (Stauffer). All specimens from Histiodella kristina Phylo-zone.

18. Oistodontiform ("venustus"-element). TP 71. Slide MUNSS 20. x 70.

19. Erectid drepanodontiform. TP 71. Slide MUNSS 20. x 85.

20. Homocurvatid drepanodontiform. TP 66. Slide MUNSS 20. x 70.

21. Homocurvatid drepanodontiform. TP 66. Slide MUNSS 20. x 80.

22. Oistodontiform. TP 67. Slide MUNSS 20. x 75.

23. Homocurvatid drepanodontiform. TP 71. Slide MUNSS 20. x 80.

24. Homocurvatid drepanodontiform. TP 71. Slide MUNSS 20. x 65.

25. Homocurvatid drepanodontiform. TP 67. Slide MUNSS 20. x 70.

Figure 26 - 33. Paltodus? sp. cf. P.? jemtlandica Löfgren. All specimens from Histiodella kristina Phylo-zone.

26. Oistodontiform. TP 71. Slide MUNSS 21. x 100.

27. Drepanodontiform. TP 71. Slide MUNSS 21. x 105.

28. Drepanodontiform. TP 70. Slide MUNSS 21. x 115.

29. Drepanodontiform. TP 71. Slide MUNSS 21. x 160.

30. Oistodontiform. TP 68. Slide MUNSS 21. x 80.

31. Oistodontiform. TP 71. Slide MUNSS 21. x 105.

32. Drepanodontiform. TP 71. Slide MUNSS 21. x 110.

33. Oistodontiform. TP 71. Slide MUNSS 21. x 110.


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PLATE 5

Figure 1 - 4. Paroistodus? sp. cf. P. originalis (Sergeeva). From Histiodella kristina Phylo-zone.

1. Oistodontiform. TP 67. Slide MUNSS 22. x 110.

2. Oistodontiform. TP 68. Slide MUNSS 22. x 75.

3. Oistodontiform. TP 68. Slide MUNSS 22. x 70.

4. Oistodontiform. TP 70. Slide MUNSS 22. x 90.

Figure 5 - 6. Paroistodus? sp. A. The specimens are from Histiodella tableheadensis Phylo-zone.

5A. Oistodontiform. TP 60. Slide MUNSS 23. x 120.

5B. Detail of posterior keel of cusp near cusp-base junction. Note inconspicuous striations. Same specimen as 5A. x 1175.

6. Oistodontiform. TP 60. Slide MUNSS 23. x 130.

Figure 7 - 8. Paroistodus? sp. B. The specimens are from Histiodella tableheadensis Phylo-zone.

7. From TP 60. Slide MUNSS 24. x 200.

8. From TP 60. Slide MUNSS 24. x 240.

Figure 9. Strachanognathus parvus Rhodes. Specimen from Walliserodus ethingtoni Biointerval-zone. The anterior cusp is broken. From TP 80. Slide MUNSS 25. x 215.

Figure 10 - 20. Juanognathus serpagliei n. sp. All specimens from Histiodella kristina Phylo-zone.

10. Symmetrical element, anterior side. TP 65. Slide MUNSS 26. x 65.

11. Asymmetrical element, posterior view. TP 65. Slide MUNSS 26. x 65.

PLATE 5 (cont'd)

12. Symmetrical element, anterior view. TP 66. Slide MUNSS 26. x 110.

13. Asymmetrical element, posterior view. TP 65. Slide MUNSS 26. x 85.

14. Asymmetrical element, anterior view. TP 66. Slide MUNSS 26. x 80.

15. Asymmetrical element, posterior view. TP 66. Slide MUNSS 26. x 105.

16. Asymmetrical element, posterior view. TP 66. Slide MUNSS 26. x 75.

17. Symmetrical element, posterior view. Holotype. TP 66. MUNSS 27. x 60.

19. Asymmetrical element, posterior view. TP 66. Slide MUNSS 26. x 110.

20. Asymmetrical element, posterior view. TP 66. Slide MUNSS 26. x 80.

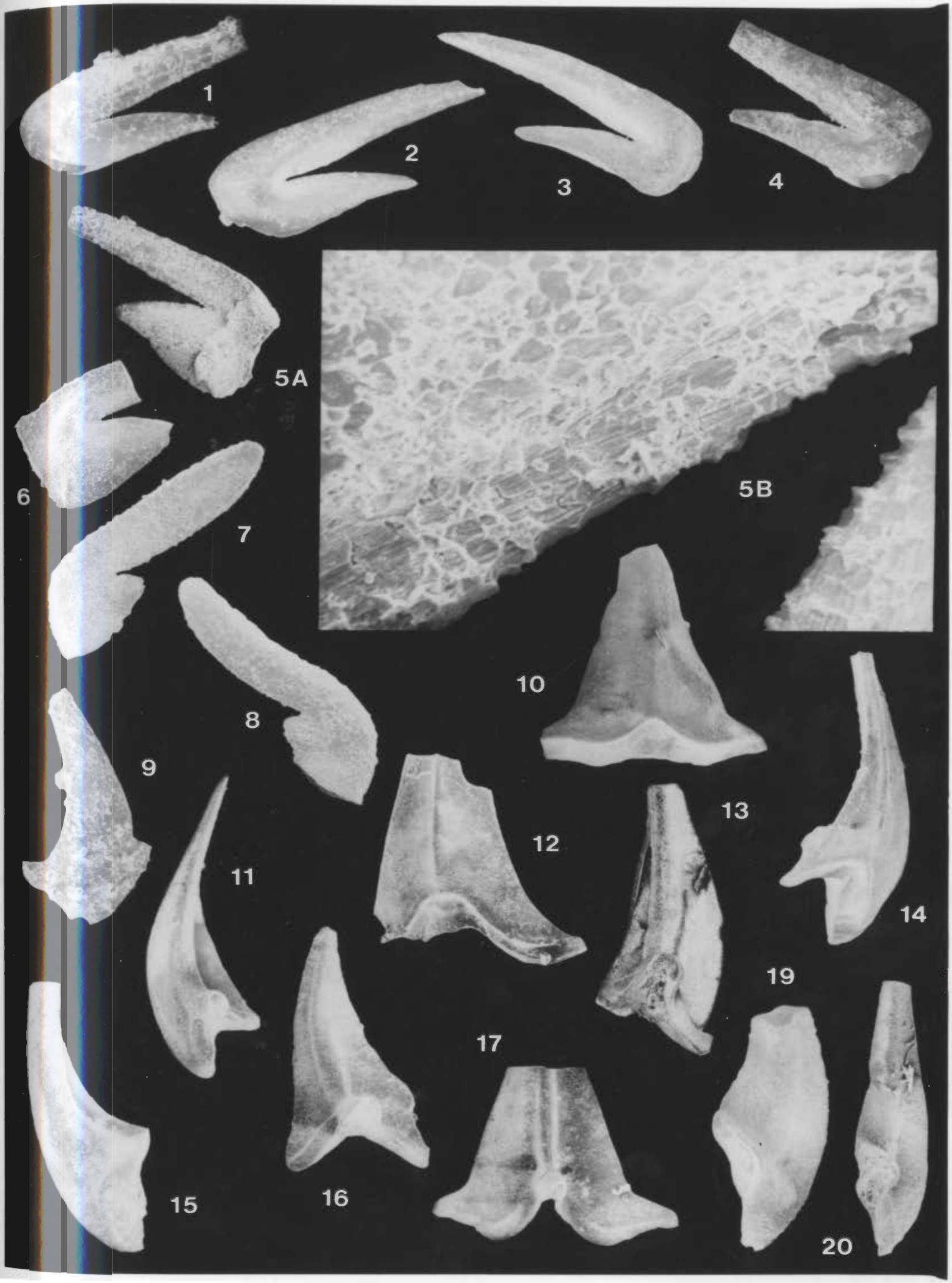
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PLATE 6

Figure 1 - 7. Trigonodus carinatus n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

1. Distacodontiform. TP 25. Slide MUNSS 28. x 60.
2. Distacodontiform. TP 24. Slide MUNSS 28. x 60.
3. Scandodontiform. TP 25. Slide MUNSS 28. x 60
4. Acontiodontiform, posterior view. TP 25. Slide MUNSS 28. x 70.
5. Acontiodontiform, lateral view. Holotype. TP 25. Slide MUNSS 29. x 50.
6. Distacodontiform. TP 24. Slide MUNSS 28. x 55.
7. Distacodontiform. TP 24. Slide MUNSS 28. x 55.

Figure 8 - 9. Ulrichodina? sp. A. From Histiodella tableheadensis Phylo-zone.

8. From TP 60. Slide MUNSS 30. x 140.
9. From TP 60. Slide MUNSS 30. x 155.

Figure 10 - 12. Trigonodus rectus n. sp. From Trigonodus carinatus Biointerval-zone.

10. Distacodontiform. From Back Arm BA 3. Slide MUNSS 31. x 55.
11. Subsymmetrical element. Note the sinuous outline of the cusp. From TP 6. Slide MUNSS 31. x 45.

12A. Acontiodontiform. Holotype. From Gargamelle Cove GCW 1. Slide MUNSS 32. x 75.

12B. Detail of posterior part of cusp of same specimen as in 12A. x 500.

PLATE 6 (cont'd)

Figure 13 - 23. Belodella jemtlandica Löfgren. All specimens from Histiodella tableheadensis Phylo-zone.

13. Denticulated plano-convex element, outer view. TP 58. Slide MUNSS 33. x 80.

14. Denticulated, asymmetrical triangular element, inner view. TP 58. Slide MUNSS 33. x 105.

15. Denticulated, asymmetrical triangular element. TP 60. Slide MUNSS 33. x 80.

16A. Denticulated, asymmetrical triangular element. TP 60. Slide MUNSS 33. x 85.

16B. Detail of posterior part of base. Same specimen as in 16A. x 615.

16C. Detail of anterior part of specimen 16A. Note striations on the inner side of the groove. x 590.

17. Denticulated, asymmetrical triangular element. TP 61. Slide MUNSS 33. x 90.

18. Oistodontiform. TP 61. Slide MUNSS 33. x 80.

19A. Undenticulated element. TP 59. Slide MUNSS 33. x 80.

19B. Detail of base of same specimen as in 19A. x 390.

20. Denticulated plano-convex element. TP 60. Slide MUNSS 33. x 110.

21. Undenticulated element. TP 59. Slide MUNSS 33. x 75.

22. Denticulated plano-convex element. Note the faint denticulation of the oral margin of this specimen. TP 59. Slide MUNSS 33. x 65.

23A. Denticulated, asymmetrical triangular element. TP 60. Slide MUNSS 33. x 80.

PLATE 6 (cont'd)

23B. Detail of the anterior margin of same specimen as in 23A.

x 350.

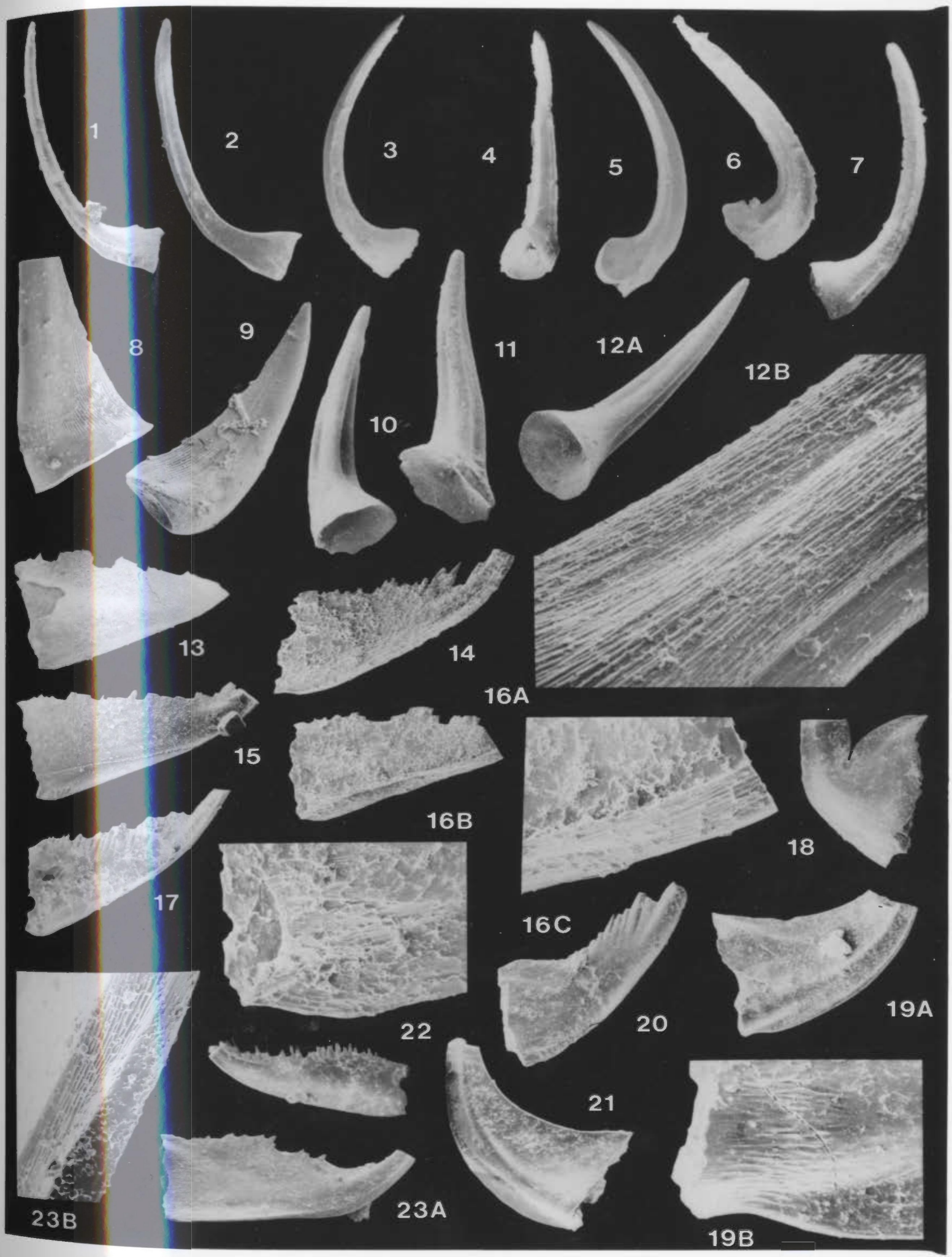
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PLATE 7

Figure 1 - 4. Belodella jemtlandica Löfgren. All specimens from Histiodella kristina Phylo-zone.

1A. Denticulated triangular, symmetrical element. TP 70. Slide MUNSS 33. x 100.

1B. Detail of anterior base and cusp. Same specimen as in 1A. x 485.

1C. Anterior view of denticulate symmetrical element. Same specimen as in 1A. x 90.

2A. Oistodontiform. Note the angle between oral margin and posterior edge of cusp. TP 70. Slide MUNSS 33. x 135.

2B. Detail of junction of oral margin and cusp. Same specimen as in 2A. x 460.

3A. Oistodontiform. TP 70. Slide MUNSS 33. x 110.

3B. Detail of base. Same specimen as in 3A. x 600.

4. Undenticulated element. TP 71. Slide MUNSS 33. x 85.

Figure 5 - 14. Belodella sinuosa n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

5. Asymmetrical, plano-convex element. TP 54. Slide MUNSS 34. x 90.

6. Undenticulated element. TP 54. Slide MUNSS 34. x 105.

7. Undenticulated element. TP 54. Slide MUNSS 34. x 125.

8. Denticulated triangular element. TP 55. Slide MUNSS 34. x 115.

9. Denticulated triangular element. TP 54. Slide MUNSS 34. x 125.

10. Oistodontiform. Holotype. TP 55. Slide MUNSS 35. x 125.

11. Oistodontiform. TP 54. Slide MUNSS 34. x 120.

12. Denticulated, asymmetrical triangular element. TP 52. Slide MUNSS 34. x 110.

PLATE 7 (cont'd)

13. Denticulated, asymmetrical triangular element. TP 52. Slide MUNSS 34. x 110.

14A. Undenticulated element. TP 51. Slide MUNSS 34. x 95.

14B. Detail of anterior part of base showing striations. Same specimen as in 14A. x 285.

Figure 15 - 16. Belodella? sp. A. Specimens from Histiodella tableheadensis Phylo-zone.

15. From TP 61. Slide MUNSS 36. x 120.

16. From TP 61. Slide MUNSS 36. x 110.

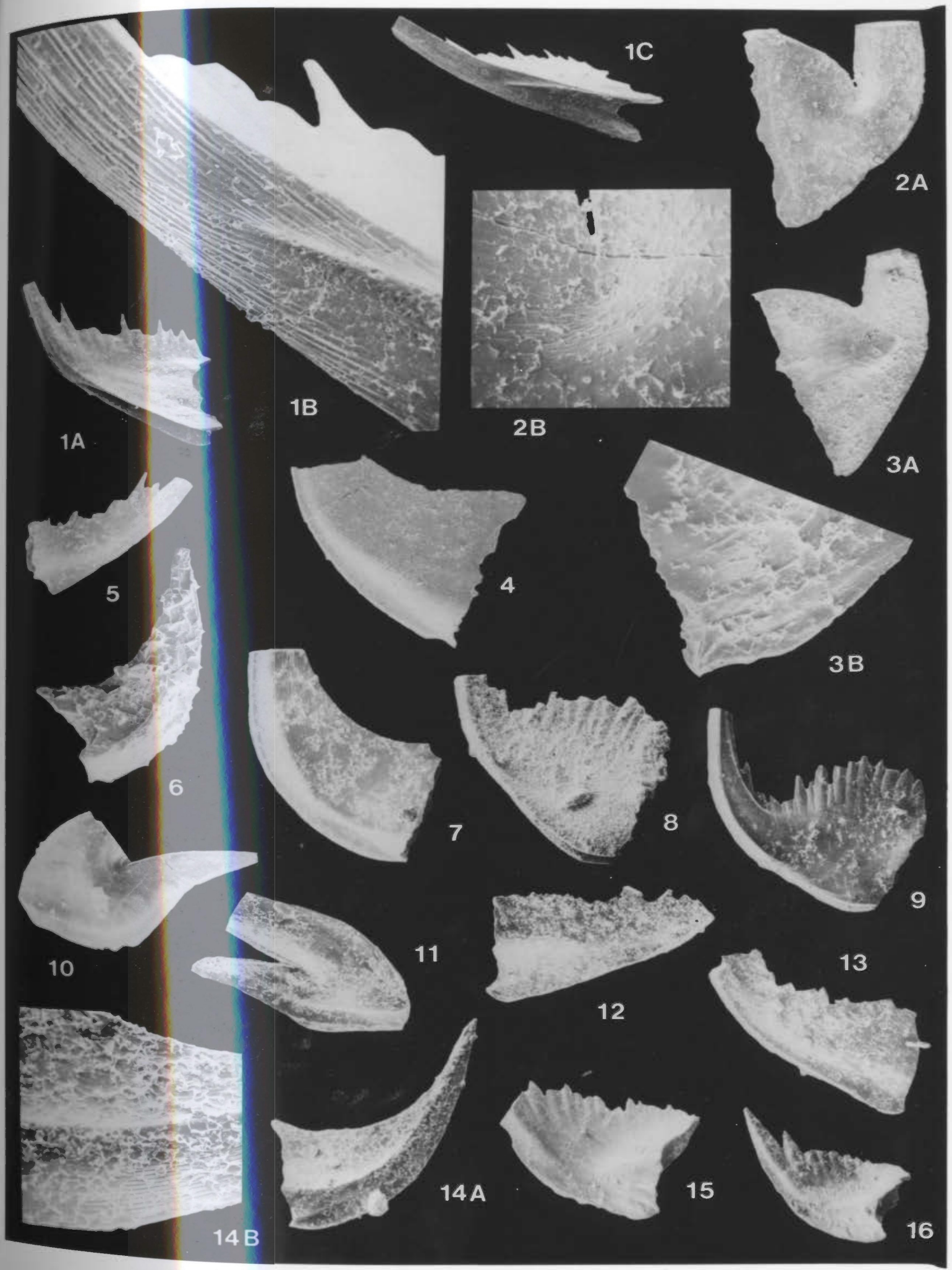
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PLATE 8

Figure 1 - 8. Cornuodus longibasis (Lindström). All specimens from Walliserodus ethingtoni Biointerval-zone.

1. From TP 80. Slide MUNSS 37. x 125.
2. From TP 70. Slide MUNSS 37. x 120.
3A. From TP 74. Slide MUNSS 37. x 120.
3B. Detail of posterior part of cusp of same specimen as in 3A. x 490.
4. From TP 71. Slide MUNSS 37. x 120.
5. From TP 79. Slide MUNSS 37. x 145.
6. TP 78. Slide MUNSS 37. x 110.
7. TP 78. Slide MUNSS 37. x 125.
8. From TP 79. Slide MUNSS 37 ("Cornuodus bergstroemi"). x 160.

Figure 9 - 14. Scalpellodus biconvexus (Bradshaw). All specimens from Histiodella tableheadensis Phylo-zone.

9. Element type 3. From TP 53. Slide MUNSS 38. x 35.
10. Element type 1. From TP 53. Slide MUNSS 38. x 45.
11. Element type 1. From TP 53. Slide MUNSS 38. x 40.
12. Element type 2. From TP 54. Slide MUNSS 38. x 45.
13. Element type 2. From TP 54. Slide MUNSS 38. x 40.
14. Element type 3. From TP 53. Slide MUNSS 38. x 75.

Figure 15 - 19, 22 - 23. Scalpellodus pointensis n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

15. Element type 3. Holotype. TP 59. Slide MUNSS 40. x 45.
16. Element type 2. TP 59. Slide MUNSS 39. x 40.
17. Element type 2. TP 59. Slide MUNSS 39. x 40.

PLATE 8 (cont'd)

18. Element type 1. TP 60. Slide MUNSS 39. x 45.

19. Element type 1. TP 58. Slide MUNSS 39. x 50.

22. Element type 2. TP 58. Slide MUNSS 39. x 40.

23. Element type 2. TP 58. Slide MUNSS 39. x 45.

Figure 20 - 21. ?*Scalpellodus* sp. A. Specimens from *Histiodella tableheadensis* Phylo-zone.

20. Subsymmetrical element. TP 59. Slide MUNSS 41. x 120.

21. Scandodiform. TP 59. Slide MUNSS 41. x 110.

Figure 24 - 30. *Scolopodus oldstockensis* n. sp.. All specimens from *Histiodella kristina* Phylo-zone.

24. Asymmetrical element. TP 67. Slide MUNSS 42. x 65.

25. Asymmetrical element. TP 66. Slide MUNSS 42. x 65.

26. Asymmetrical element. TP 66. Slide MUNNS 42. x 75.

27. Symmetrical element. TP 66. Slide MUNSS 42. x 70.

28. Asymmetrical element. Holotype. TP 66. Slide MUNSS 43. x 60.

29. Asymmetrical element. TP 66. Slide MUNSS 42. x 70.

30. Asymmetrical element. TP 67. Slide MUNNS 42. x 65.

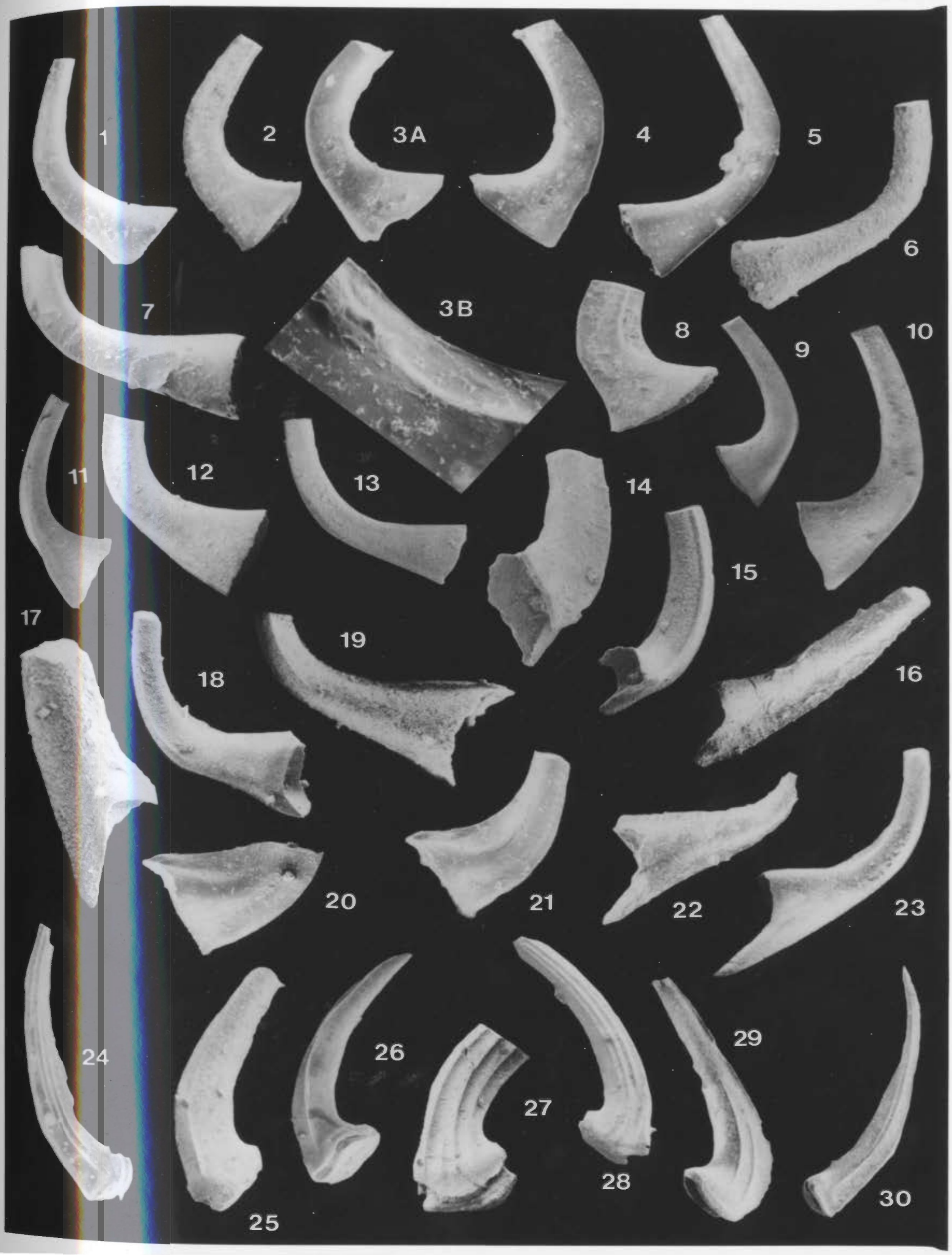
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PLATE 9

Figure 1 - 9. Walliserodus ethingtoni (Fåhraeus). All specimens from Histiodella kristina Phylo-zone.

1. Symmetrical element. TP 68. Slide MUNSS 44. x 95.
2. Asymmetrical element. TP 68. Slide MUNSS 44. x 90.
3. Asymmetrical element. TP 68. Slide MUNSS 44. x 80.
4. Asymmetrical element. TP 74. Slide MUNSS 44. x 75.
5. Asymmetrical element. TP 74. Slide MUNSS 44. x 60.
6. Asymmetrical element. TP 76. Slide MUNSS 44. x 55.
7. Asymmetrical element. TP 77. Slide MUNSS 44. x 50.
8. Asymmetrical element. TP 78. Slide MUNSS 44. x 75.

9A. Asymmetrical element. TP 78. Slide MUNSS 44. x 85.

9B. Detail of base of same specimen as in 9A. x 150.

Figure 10 - 15. Parapanderodus arcuatus n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

10A. Detail of base of same specimen as in 10B. Slide MUNSS 46. x 200.

10B. Element type 1 with a median costa. Holotype. TP 46. Slide MUNSS 46. x 60.

11. Element type 2 with a median groove. TP 59. Slide MUNNS 45. x 60.
12. Element type 2, oral view. TP 59. Slide MUNSS 45. x 60.
13. Element type 1. TP 59. Slide MUNSS 45. x 60.
14. Element type 1. TP 60. Slide MUNSS 45. x 55.
15. Element type 2. TP 60. Slide MUNSS 45. x 55.

Plate 9 (cont'd)

Figure 16 - 19. Parapanderodus sp. cf. P. consimilis (Moskalenko). Specimens from Histiodella tableheadensis Phylo-zone.

16. From TP 19. Slide MUNSS 47. x 70.

17. From TP 19. Slide MUNSS 47. x 80.

18. From TP 19. Oral view. Slide MUNSS 47. x 70.

19A. From TP 19. Slide MUNSS 47. x 70.

19B. Detail of posterior part of base of same specimen as in 19A. x 395.

Figure 20 - 27. Parapanderodus elegans n. sp. 22 - 23 are from Histiodella tableheadensis Phylo-zone. 20 - 21, 24 - 27 are from Histiodella kristina Phylo-zone.

20. From TP 68. Slide MUNSS 48. x 160.

21A. From TP 68. Slide MUNSS 48. x 160.

21B. Detail of base of same specimen as in 21A. x 685.

22. From TP 54. Slide MUNSS 48. x 160.

23. From TP 54. Slide MUNSS 48. x 160.

24. Holotype. From TP 68. Slide MUNSS 49. x 160.

25. From TP 78. Slide MUNNS 48. x 180.

26. From TP 78. Slide MUNSS 48. x 180. Note 22 - 26 form a transition series.

27. From TP 78. Slide MUNSS 48. x 160.

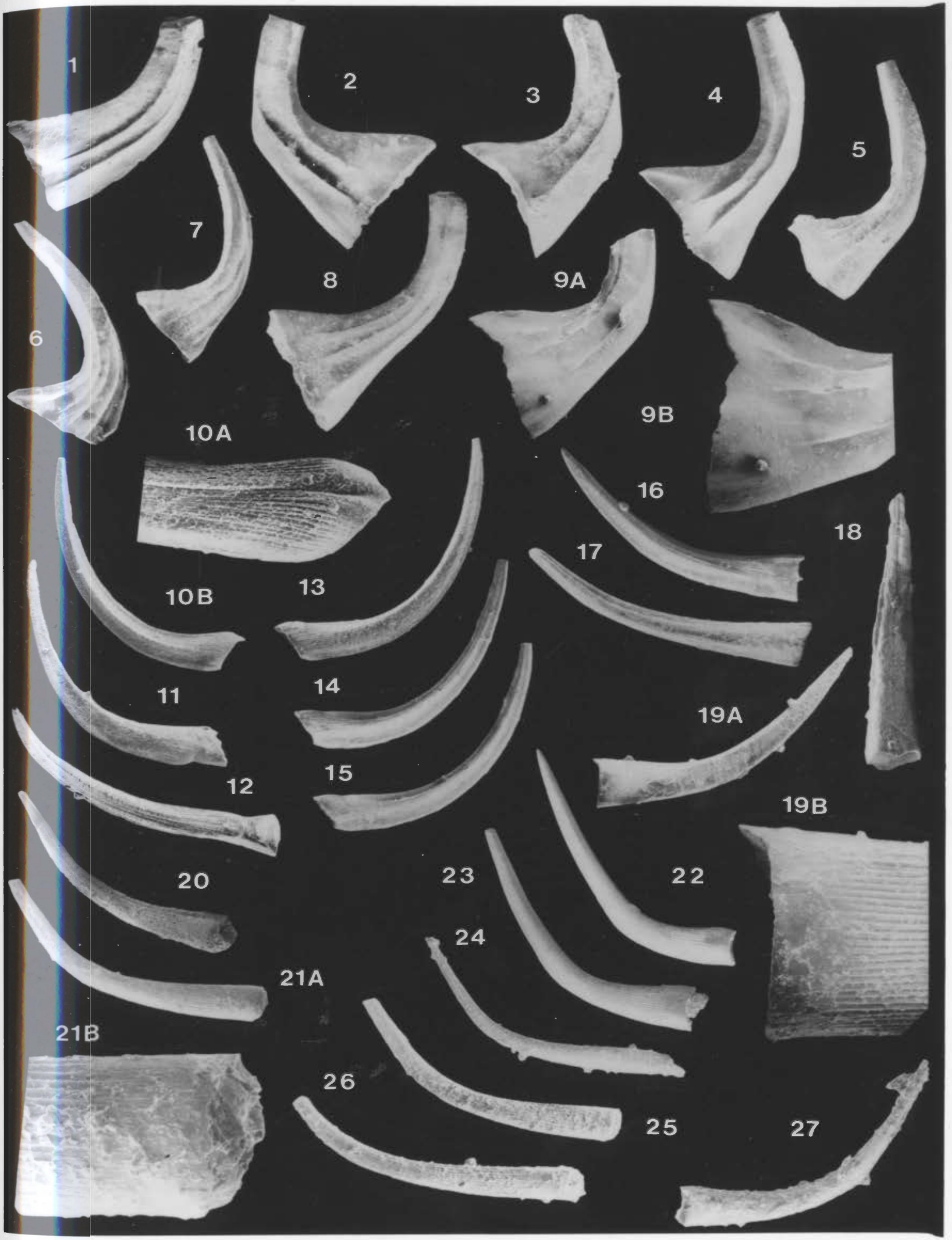
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PLATE 10

Figure 1 - 3. Parapanderodus striatus (Graves & Ellison). Specimens from Trigonodus carinatus Biointerval-zone.

1A. From TP 3. Slide MUNSS 50. x 80.

1B. Detail of base of same specimen as in 1A. x 540.

2A. From TP 3. Slide MUNSS 50. x 75.

2B. Detail of base of same specimen as in 2A. Note the deep furrow of this specimen. x 170.

3A. From TP 25. Slide MUNSS 50. x 70.

3B. Detail of base of same specimen as in 3A. x 240.

Figure 4. Parapanderodus? sp. aff. P.? triangularis (Ethington & Clark). From Histiodella tableheadensis Phylo-zone. From TP 53. Slide MUNSS 51. x 180.

Figure 5 - 10, 15. Semiacontiodus asymmetricus (Barnes & Poplawski). Specimens from Histiodella tableheadensis Phylo-zone.

5. Asymmetrical element. Note the "inverted" basal cavity on the outer side of the specimen. TP 58. Slide MUNSS 52. x 100.

6. Asymmetrical element. TP 58. Slide MUNSS 52. x 105.

7. Symmetrical element. Note the oval and restricted basal opening. TP 59. Slide MUNSS 52. x 160.

8. Asymmetrical element. TP 59. Slide MUNSS 52. x 100.

9. Asymmetrical element. TP 60. Slide MUNSS 52. x 100.

10A. Symmetrical element. TP 59. Slide MUNSS 52. x 80.

10B. Detail of base of same specimen as in 10A. x 270.

15A. Symmetrical element. TP 60. Slide MUNNS 52. x 100.

PLATE 10 (cont'd)

15B. Detail of base and lower posterior part of base. Same specimen as in 15A. x 310.

Figure 11 - 14, 20. Semiacontiodus sp. cf. S. bulbosus (Löfgren). All specimens from Histiodella kristina Phylo-zone.

11. From TP 66. Slide MUNSS 53. x 140.

12. From TP 66. Slide MUNSS 53. x 140.

13. From TP 66. Slide MUNSS 53. x 140.

14. From TP 66. Slide MUNSS 53. x 130.

20. From TP 66. Same as 14. x 145.

Figure 16 - 19. Semiacontiodus preasymmetricus n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

16. Asymmetrical element. TP 39. Slide MUNSS 54. x 120.

17. Asymmetrical element. TP 29. Slide MUNSS 54. x 85.

18. Symmetrical element. Holotype. TP 29. Slide MUNSS 55. x 100.

19. Symmetrical element. TP 27. Slide MUNSS 54. x 200.

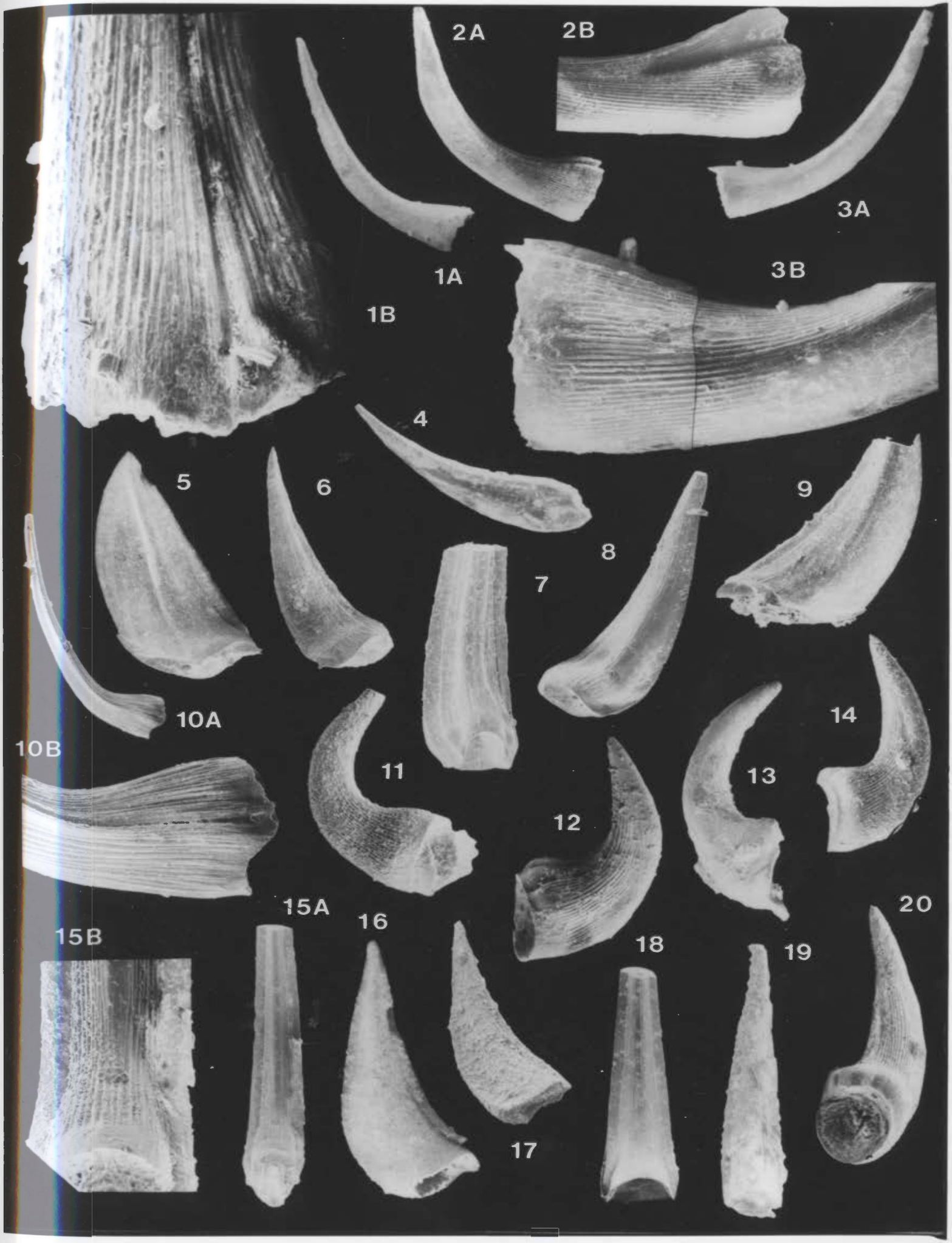
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PLATE 11

Figure 1 - 6. Semiacontiodus sp. cf. S. cordis (Hamar). All specimens from Histiodella tableheadensis Phylo-zone.

1. Asymmetrical element. TP 55. Slide MUNSS 56. x 130.
2. Asymmetrical element. TP 55. Slide MUNSS 56. x 100.
3. Asymmetrical element. TP 55. Slide MUNSS 56. x 100.
4. Asymmetrical element. TP 55. Slide MUNSS 56. x 105.

5A. Symmetrical element. TP 59. Slide MUNSS 56. x 60.

5B. Detail of base, oral view. Same specimen as in 5A. x 200.

5C. Detail of base, lateral view. Same specimen as in 5A. x 150.

6A. Asymmetrical element. TP 59. Slide MUNSS 56. x 75.

6B. Detail of cusp. Note additional finer grooves next to the median groove. Same specimen as in 6A. x 1050.

6C. Detail of base. Same specimen as in 6A. x 350.

Figure 7 - 9. Erismodus? sp. A. Specimens from Trigonodus carinatus Biointerval-zone.

7. From TP 24. Slide MUNSS 57. x 45.

8A. From TP 3. Slide MUNSS 57. x 45.

8B. Detail of anterior margin of cusp. Same specimen as in 8A. x 230.

8C. Aboral view. Same specimen as in 8A. x 65.

9. From TP 3. Slide MUNSS 57. x 45.

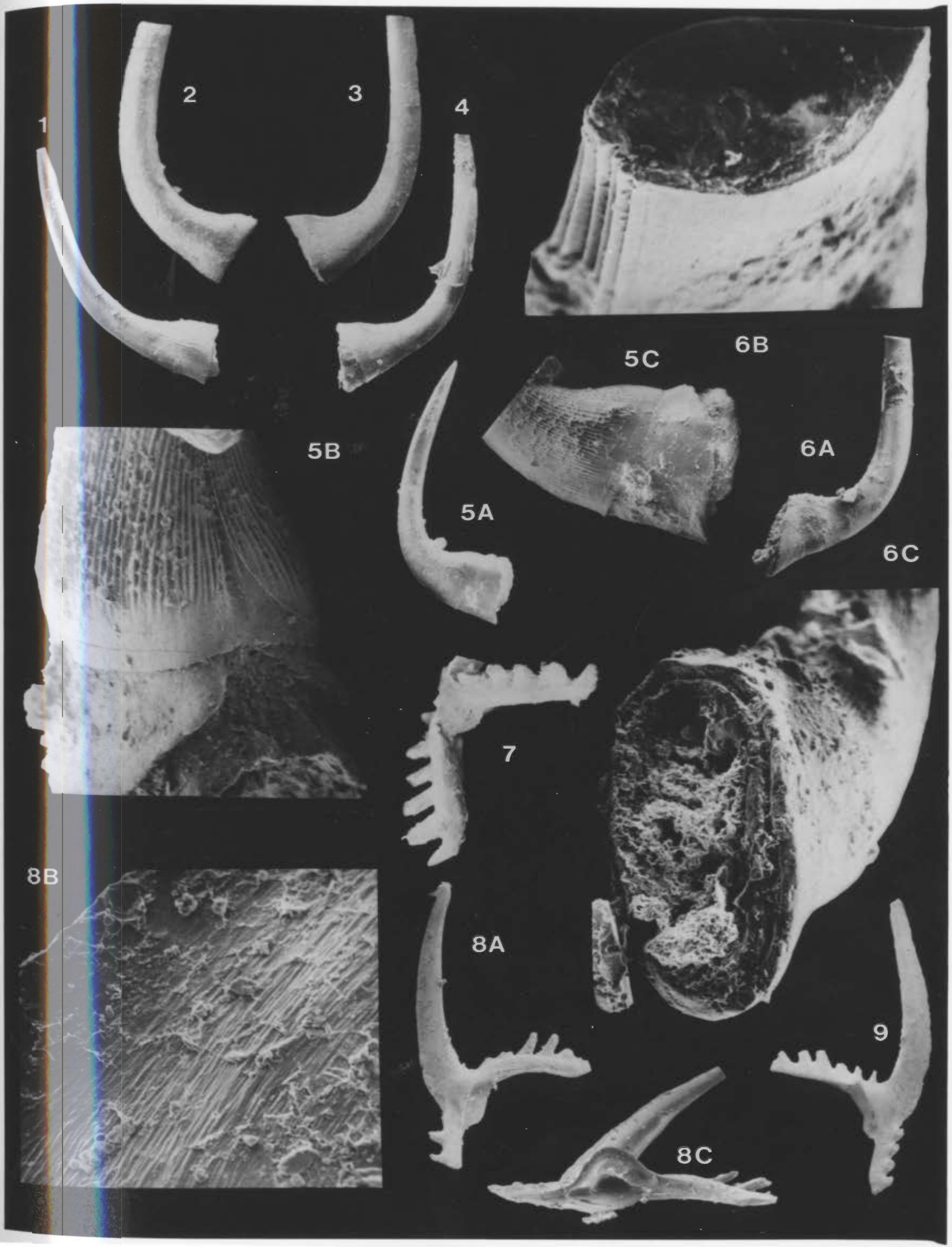
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PLATE 12

Figure 1. Erismodus? sp. B. s.f. From Trigonodus carinatus Biointerval-zone.

1A. From TP 3. Slide MUNSS 58. x 20.

1B. Detail of cusp. Same specimen as 1A. x 230.

Figure 2 - 3. Leptochirognathus sp. cf. L. quadrata Branson & Mehl. From Histiodella tableheadensis Phylo-zone.

2. Inner view. TP 25. Slide MUNSS 59. x 55.

3. Outer view. TP 26. Slide MUNSS 59. x 65.

Figure 4 - 5. Multioistodus sp. cf. M. subdentatus Cullison. From Trigonodus carinatus Biointerval-zone.

4. From TP 1. (St. George Group at Table Point). Slide MUNSS 60. x 145.

5. From TP 3. Slide MUNSS 60. x 220.

Figure 6 - 7. Leptochirognathus prima Branson & Mehl s.f. From Trigonodus carinatus Biointerval-zone.

6. From Back Arm Sample BA 1. Slide MUNSS 61. x 140.

7. From Back Arm Sample BA 1. Slide MUNSS 61. x 140.

Figure 8 - 12, 14. Amorphognathus? sp. A. From Histiodella kristina Phylo-zone.

8. Tetraprioniodontiform. TP 74. Slide MUNSS 62. x 155.

9. Ambalodontiform. TP 74. Slide MUNSS 62. x 190.

10. Amorphognathodontiform. Slide MUNSS 62. x 95.

11. Ambalodontiform. TP 74. Slide MUNSS 62. x 90.

PLATE 12 (cont'd)

12. Ambalodontiform. TP 74. Slide MUNSS 62. x 165.

14A. Trichonodelliform. Slide MUNSS 62. x 160.

14B. Detail of inner side of cusp. Same specimen as in 14B. x 895.

Figure 13. Polonodus tablepointensis n. sp. Specimen from Histiodella kristina Phylo-zone.

13A. Polyplacognathodontiform. TP 66. Slide MUNSS 63. x 30.

13B. Aboral view. Same specimen as in 13A. x 40.

13C. Upper view. Same specimen as in 13A. x 30.

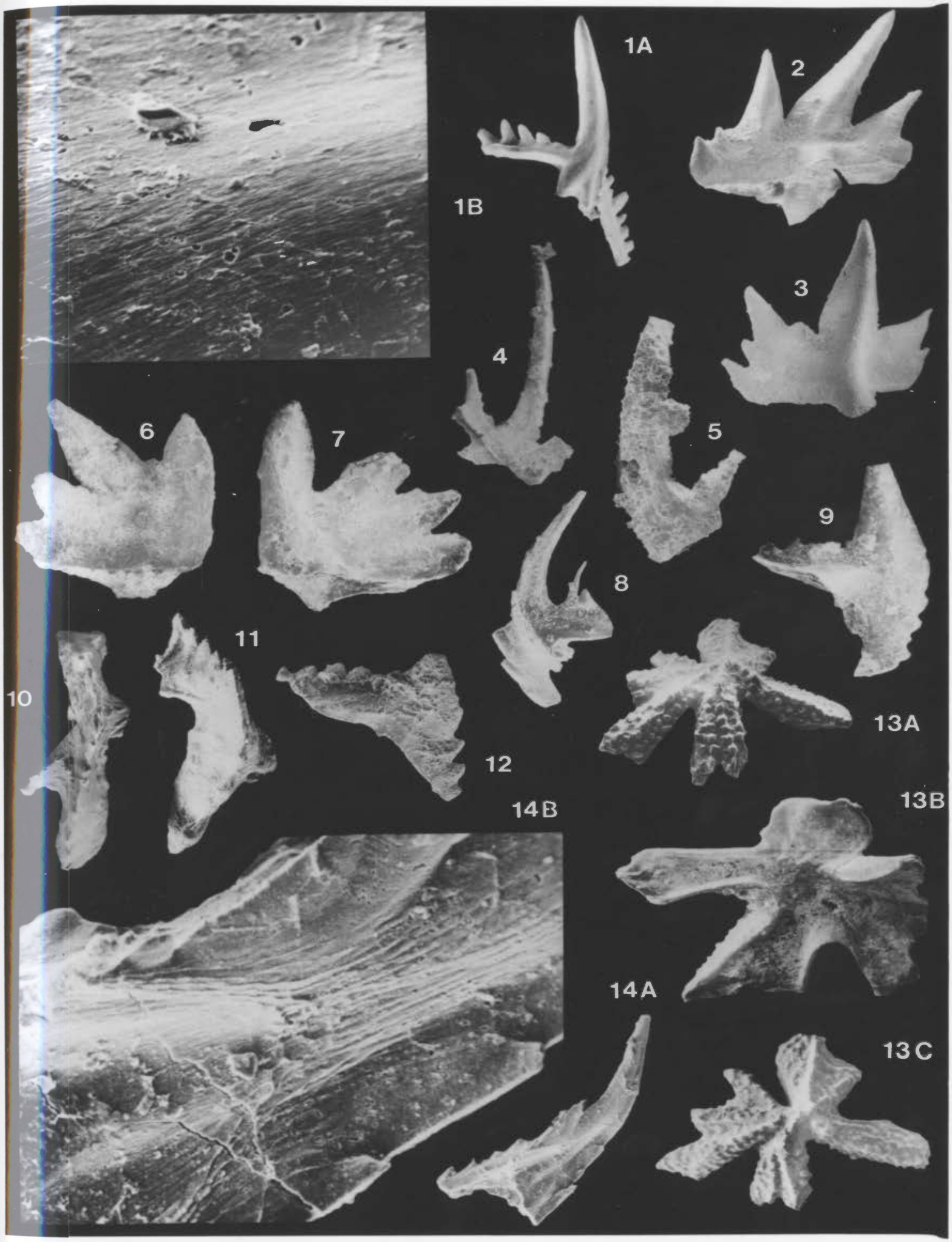
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PLATE 13

Figure 1 - 5. Polonodus tablepointensis n. sp. All specimens from Histiodella kristina Phylo-zone.

1A. Ambalodontiform. From TP 74. Slide MUNSS 63. x 50.

1B. Detail of anterior process. Same specimen as in 1A. x 165.

2. Polyplacognathodontiform. From TP 74. Slide MUNSS 63. x 55.

3. Polyplacognathodontiform. Holotype. TP 74. Slide MUNSS 64. x 15.

4. Polyplacognathodontiform. TP 71. Slide MUNSS 63. x 20.

5. Ambalodontiform. TP 71. Slide MUNSS 63. x 75.

Figure 6 - 13. Polonodus? clivosus (Viira). All specimens from Histiodella kristina Phylo-zone.

6A. Polyplacognathodontiform. TP 74. Slide MUNSS 65. x 125.

6B. Detail of middle part of inner lateral process. Same specimen as in 6A. x 1170.

7. Ambalodontiform. TP 74. Slide MUNSS 65. x 85.

8. Ambalodontiform. TP 74. Slide MUNSS 65. x 100.

9. Polyplacognathodontiform. TP 74. Slide MUNSS 65. x 95.

10. Polyplacognathodontiform. TP 74. Slide MUNSS 65. x 90.

11. Ambalodontiform. TP 74. Slide MUNSS 65. x 110.

12. Ambalodontiform. TP 68. Slide MUNSS 65. x 125.

13. Polyplacognathodontiform. TP 74. Slide MUNSS 65. x 50.

Figure 14 - 16. Polonodus? newfoundlandensis n. sp. All specimens from Histiodella tableheadensis Phylo-zone.

14. Polyplacognathodontiform. TP 59. Slide MUNSS 66. x 65.

PLATE 13 (cont'd)

15. Ambalodontiform. TP 59. Slide MUNSS 66. x 95.

16. Polyplacognathodontiform. Holotype. Note the deep inner notch in the platform of the anterior process. TP 59. Slide MUNSS 67. x 40.

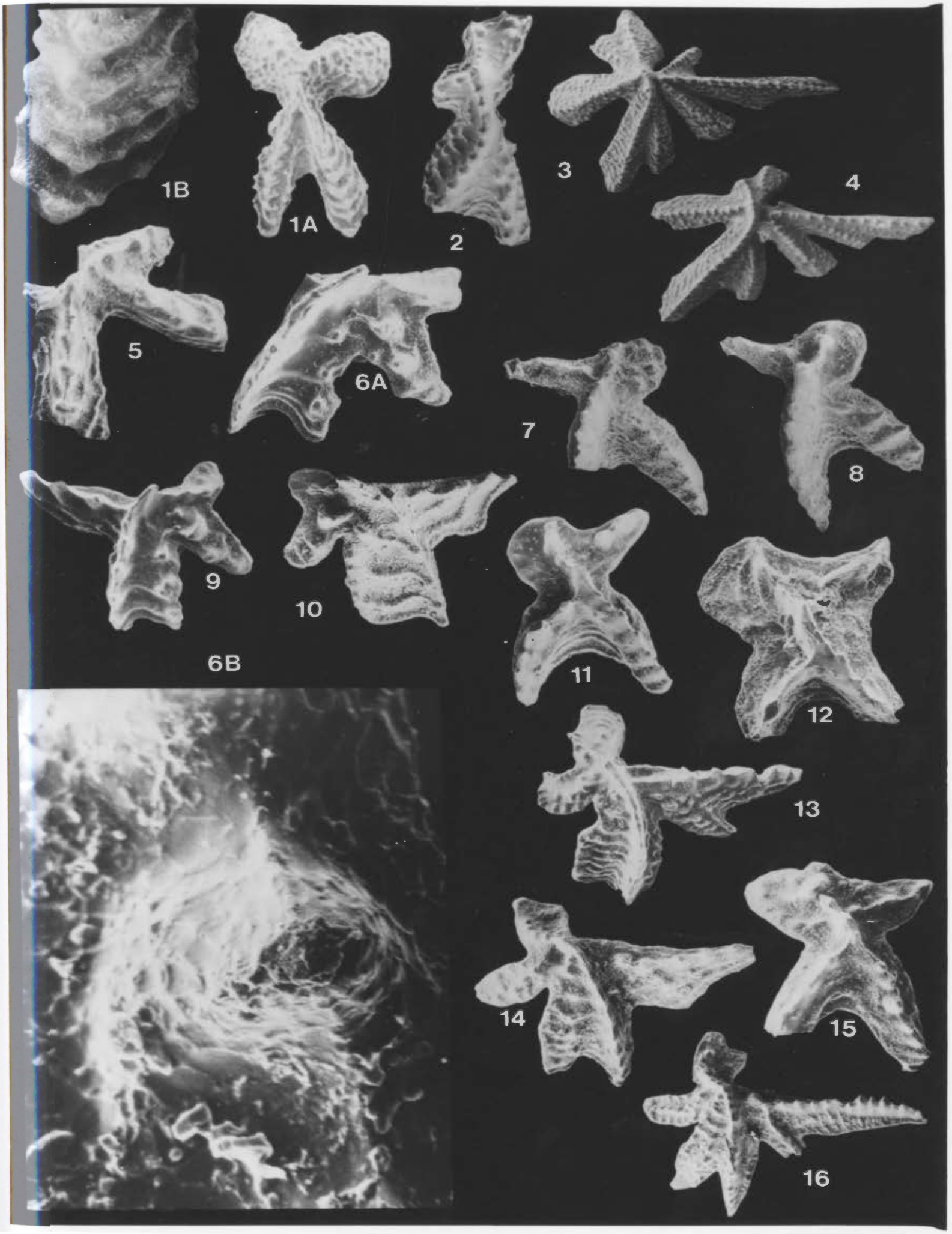
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PLATE 14

Figure 1 - 2. Pygodus? sp. A. Specimens from Histiodella kristina Phylo-zone.

1. Ramiform element. TP 67. Slide MUNSS 68. x 65.
2. Trichonodelliform. TP 68. Slide MUNSS 68. x 75.

Figure 3 - 12. Oistodus? tablepointensis n. sp. All specimens from Histiodella kristina Phylo-zone.

3. Oistodontiform. TP 68. Slide MUNSS 69. x 50.
4. Prioniodontiform. TP 68. Slide MUNSS 69. x 50.
5. Prioniodontiform. TP 68. Slide MUNSS 69. x 60.
6. Oistodontiform. TP 71. Slide MUNSS 69. x 50.
7. Prioniodontiform. TP 72. Slide MUNSS 69. x 55.
8. Oistodontiform. TP 71. Slide MUNSS 69. x 60.
9. Ramiform. TP 71. Slide MUNSS 69. x 50.
10. Prioniodontiform. TP 71. Slide MUNSS 69. x 50.
11. Ramiform. TP 71. Slide MUNSS 69. x 50.
12. Ramiform. Holotype. TP 72. Slide MUNSS 70. x 50.

Figure 13 - 19. Acodus combsi Bradshaw. Specimens from Histiodella kristina Phylo-zone.

13. Prioniodontiform. TP 66. Slide MUNSS 71. x 100.
14. Tetraprioniodontiform, inner side. TP 66. Slide MUNSS 71. x 75.
15. Cordylodontiform, inner side. TP 66. Slide MUNSS 71. x 80.
16. Tetraprioniodontiform, outer side. TP 66. Slide MUNSS 71. x 75.
17. Oistodontiform. TP 66. Slide MUNSS 71. x 70.
18. Cordylodontiform. TP 66. Slide MUNSS 71. x 90.

PLATE 14 (cont'd)

19. Trichonodelliform. TP 66. Slide MUNSS 71. x 70.

Figure 20 - 28. Acodus? n. sp. A. Specimens from Acodus combsi Biointerval-zone.

20. Oistodontiform. TP 66. Slide MUNSS 72. x 120.

21. Ramiform, symmetrical. TP 71. Slide MUNSS 72. x 160.

22. Acodontiform. TP 66. Slide MUNSS 72. x 105.

23. Ramiform, asymmetrical. TP 66. Slide MUNSS 72. x 110.

24. Ramiform, asymmetrical. TP 71. Slide MUNSS 72. x 110.

25. Ramiform, asymmetrical. TP 68. Slide MUNSS 72. x 110.

26. Oistodontiform. TP 71. Slide MUNSS 72. x 100.

27. Cordylodontiform. TP 66. Slide MUNSS 72. x 110.

28. Oistodontiform. TP 66. Slide MUNSS 72. x 70.

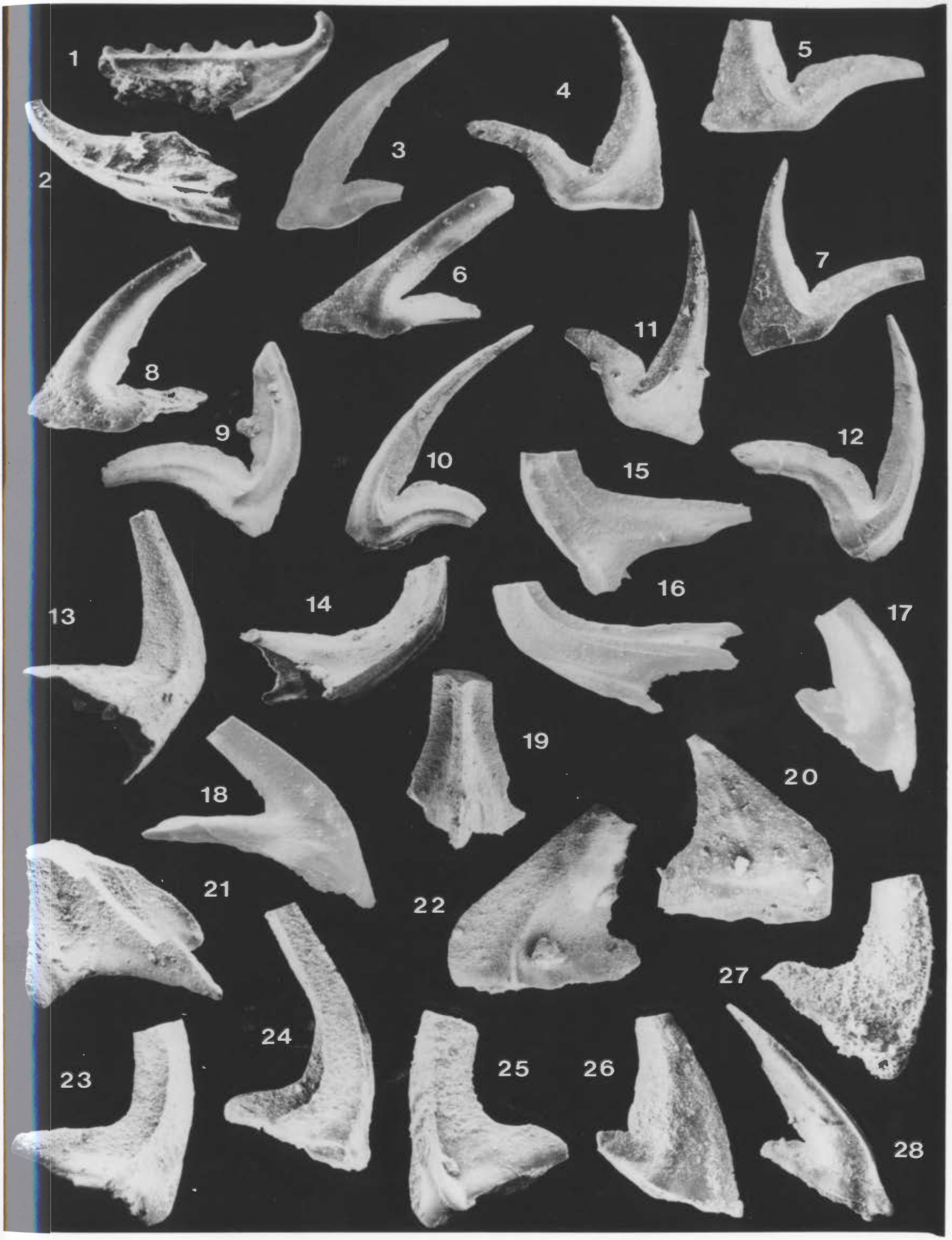
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PLATE 15

Figure 1 - 6. Baltioniodus? prevariabilis medius (Dzik). All specimens from lower Histiodella kristina Phylo-zone.

1. Tetraprioniodontiform. TP 67. Slide MUNSS 73. x 145.
2. Trichonodelliform. TP 67. Slide MUNSS 73. x 145.
3. Paracordylodontiform. TP 67. Slide MUNSS 73. x 145.
4. Falodontiform. TP 74. Slide MUNSS 73. x 70.
5. Falodontiform. TP 74. Slide MUNSS 73. x 100.
6. Tetraprioniodontiform. TP 70. Slide MUNSS 73. x 145.

Figure 7 - 13, 15 - 16. Eoneoprioniodus? sp. 1. All specimens from Trigonodus carinatus Biointerval-zone.

7. Prioniodontiform. From Back Arm Sample BA 2. Slide MUNSS 74. x 50.
8. Prioniodontiform. From TP 3 at Table Point. Slide MUNSS 74. x 50.
9. Tetraprioniodontiform. TP 3. Slide MUNSS 74. x 50.
10. Prioniodontiform. Same specimen as 7. Slide MUNSS 74. x 50.
11. Cyrtoniodontiform. TP 3. Slide MUNSS 74. x 45.
12. Trichonodelliform. From sample BA 2 at Back Arm. Slide MUNSS 74. x 50.
13. Tetraprioniodontiform. TP 3. Slide MUNSS 74. x 50.
15. Paracordylodontiform. TP 3. Slide MUNSS 74. x 45.
16. Paracordylodontiform. Sample BA 2 at Back Arm. Slide MUNSS 74. x 60.

PLATE 15 (cont'd)

Figure 14, 17 - 20. Eoneoprioniodus? sp. 2. 17 from Trigonodus carinatus Biointerval-zone. 14, 18 - 20 from basal Histiodella tableheadensis Phylo-zone.

14. Trichonodelliform. TP 19. Slide MUNSS 75. x 90.

17. Cyrtoniodontiform. From TP 3. Slide MUNSS 75. x 35.

18. Ramiform. TP 19. Slide MUNSS 75. x 70.

19. Ramiform. TP 23. Slide MUNSS 75. x 90.

20. Ramiform. TP 23. Slide MUNSS 75. x 75.

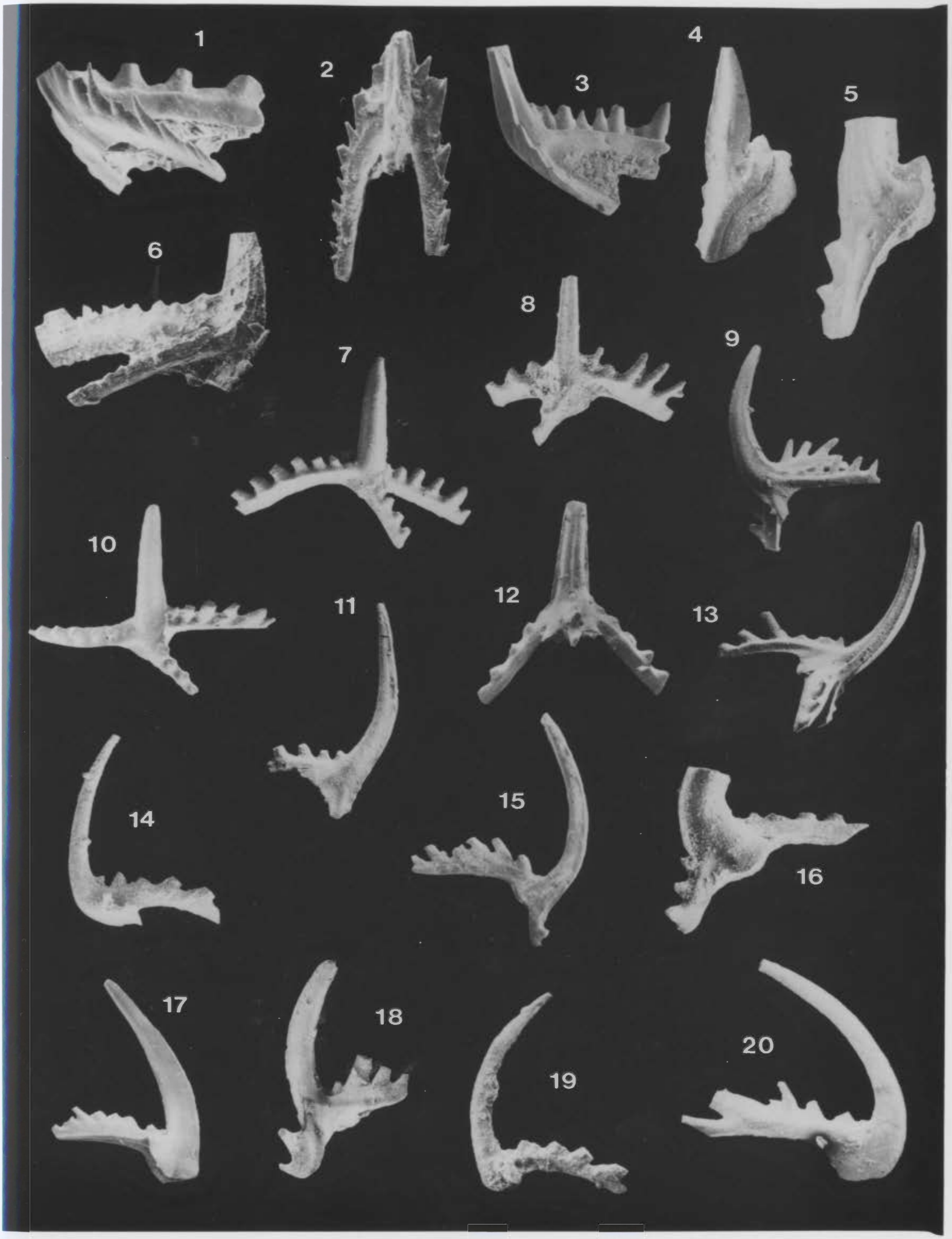
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PLATE 16

Figure 1 - 15. Periodon aculeatus zgierzensis Dzik. All specimens from Histiodella kristina Phylo-zone.

1. Prioniodiniform. TP 67. Slide MUNSS 76. x 75.
2. Oulodontiform. TP 67. Slide MUNSS 76. x 85.
3. Oistodontiform. TP 68. Slide MUNSS 76. x 70.
4. Oistodontiform. TP 68. Slide MUNSS 76. x 75.
5. Cordylodontiform. TP 68. Slide MUNSS 76. x 80.
6. Loxognathodontiform. TP 68. Slide MUNSS 76. x 75.
7. Oistodontiform. TP 67. Slide MUNSS 76. x 60.
8. Prioniodiniform. TP 69. Slide MUNSS 76. x 65.
9. Cordylodontiform. TP 69. Slide MUNSS 76. x 90.
10. Loxognathodontiform. TP 67. Slide MUNSS 76. x 90.
11. Periodontiform. TP 69. Slide MUNSS 76. x 65.
12. Periodontiform. TP 69. Slide MUNSS 76. x 70.
13. Loxognathodontiform. TP 67. Slide MUNSS 76. x 80.

14A. Periodontiform. TP 67. Slide MUNSS 76. x 60.

14B. Detail of inner side of cusp. Same specimen as in 14A. x 410.

15. Trichonodelliform. TP 69. MUNSS 76. x 70.

Figure 16 - 20. Phragmodus? sp. A. Specimens from Histiodella kristina Phylo-zone.

16. Ozarkodiniform. TP 74. Slide MUNSS 77. x 120.
17. Cordylodontiform. TP 77. Slide MUNSS 77. x 140.
18. Cordylodontiform. TP 77. Slide MUNSS 77. x 145.
19. Oistodontiform. TP 79. Slide MUNSS 77. x 120.
20. Trichonodelliform. TP 79. Slide MUNSS 77. x 130.

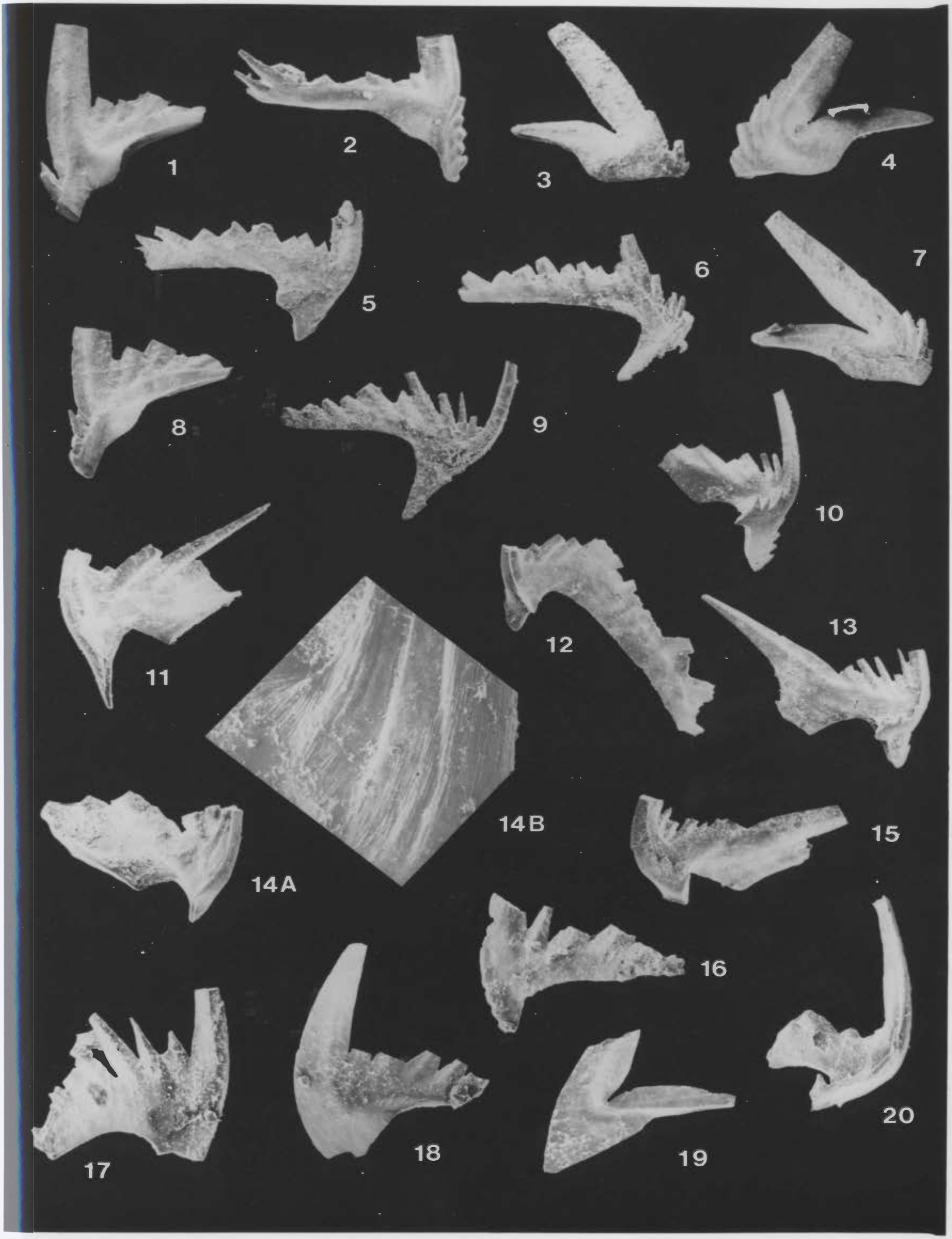
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PLATE 17

Figure 1 - 8. Plectodina? sp. A. Specimens from Trigonodus carinatus Biointerval-zone.

1. Dichognathiform. TP 24. Slide MUNSS 78. x 125.
2. Spathognathodontiform. TP 24. Slide MUNSS 78. x 100.
3. Dichognathiform. TP 24. Slide MUNSS 78. x 100.
4. Cordylodontiform. TP 24. Slide MUNSS 78. x 100.
5. Zygognathiform. TP 24. Slide MUNSS 78. x 110.
6. Zygognathiform. TP 25. Slide MUNSS 78. x 100.
7. Zygognathiform. TP 25. Slide MUNSS 78. x 100.
8. Oistodontiform. TP 25. Slide MUNSS 78. x 125.

Figure 9 - 19. ?Erraticodon balticus Dzik. All specimens from Histiodella tableheadensis Phylo-zone.

9. Ozarkodiniform. TP 29. Slide MUNSS 79. x 40.
10. Ozarkodiniform. TP 52. Slide MUNSS 79. x 85.
11. Neoprioniodontiform. TP 52. Slide MUNSS 79. x 85.
12. Prioniodontiform. TP. 52. Slide MUNSS 79. x 50.
13. Zygognathiform. TP 53. Slide MUNSS 79. x 45.
14. Zygognathiform. TP 54. Slide MUNSS 79. x 30.
15. Sannemanulliform. TP 58. Slide MUNSS 79. x 60.
16. Prioniodontiform. Note that one process is broken. Slide MUNSS 79. x 45.
17. Trichonodelliform. TP 58. Slide MUNSS 79. x 55.
18. Trichonodelliform. TP 54. Slide MUNSS 79. x 60.
19. Hindeodelliform. TP 55. Slide MUNSS 79. x 35.

PLATE 17 (cont'd)

Figure 20 - 21. Histiodella bellburnensis n. sp. Specimens from the top of Walliserodus ethingtoni Biointerval-zone.

20. Spathognathodontiform. Holotype. TP 80. Slide MUNSS 80. x 130.

21. Spathognathodontiform. TP 80. Slide MUNSS 81. x 130.

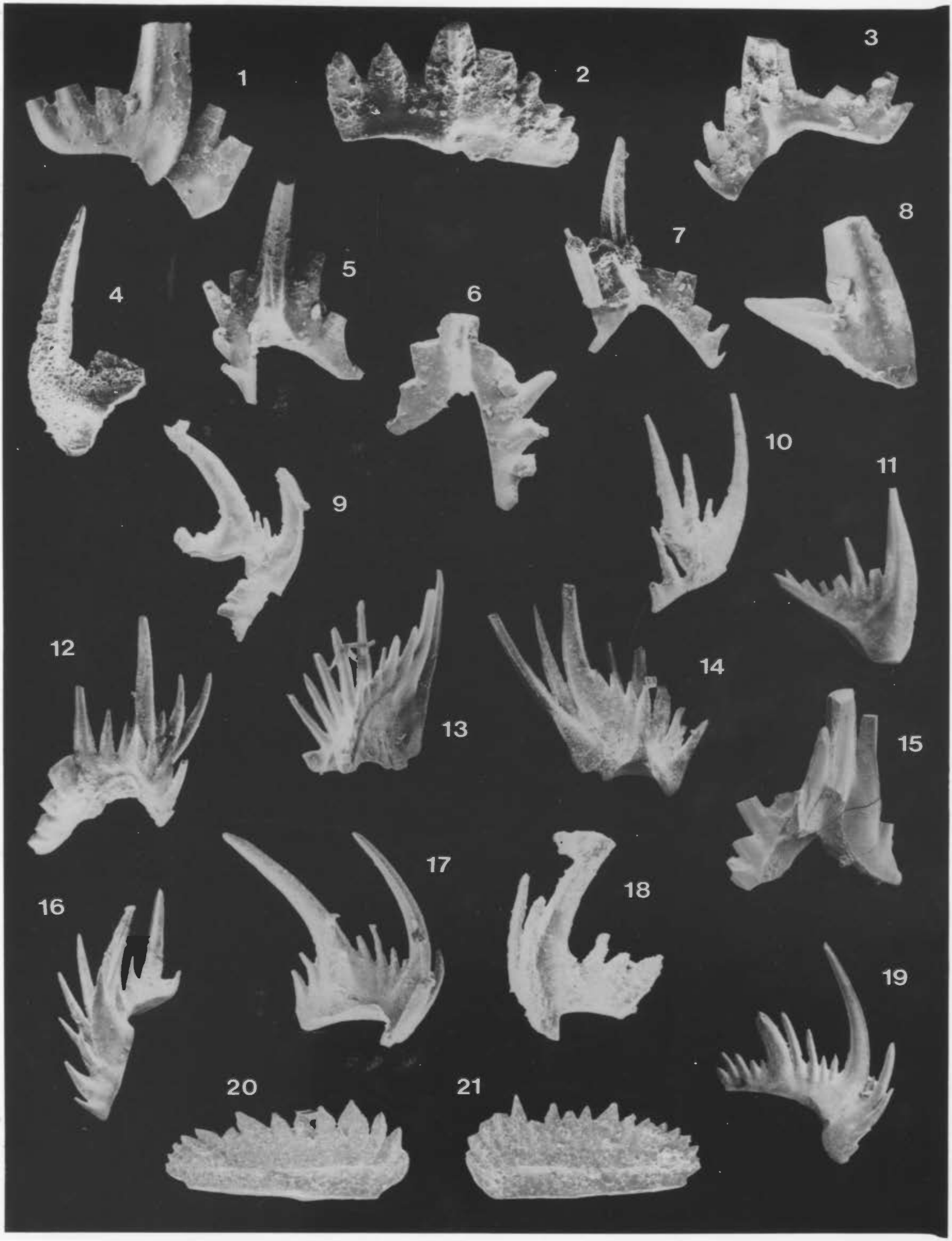
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PLATE 18

Figure 1 - 7, 9 - 11. Histiodella kristina n. sp. All specimens from Histiodella kristina Phylo-zone.

1. Oistodontiform. TP 67. Slide MUNSS 82. x 110.
2. Spathognathodontiform. TP 68. Slide MUNSS 82. x 80.
3. Spathognathodontiform. Holotype. TP 68. Slide MUNSS 83. x 100.
4. Oistodontiform. TP 71. Slide MUNSS 82. x 90.
5. Ramiform. TP 71. Slide MUNSS 82. x 90.
6. Spathognathodontiform. Small specimen. TP 71. Slide MUNSS 82. x 119.
7. Spathognathodontiform. TP 71. Slide MUNSS 82. x 119.
9. Ramiform. TP 71. Slide MUNSS 82. x 80.
10. Ramiform. TP 71. Slide MUNSS 82. x 150.
11. Trichonodelliform. TP 71. Slide MUNSS 82. x 150.

Figure 8, 12 - 14. Histiodella tableheadensis n. sp. Specimens from Histiodella tableheadensis Phylo-zone.

8. Spathognathodontiform. TP 25. Slide MUNSS 84. x 65.
12. Spathognathodontiform. Advanced specimen. TP 61. Slide MUNSS 84. x 65.
13. Spathognathodontiform. TP 46. Slide MUNSS 84. x 115.
14. Spathognathodontiform. Holotype. TP 43. Slide MUNSS 84. x 140.

Figure 15 - 16. Gen. et sp. indet. A. Specimens from Trigonodus carinatus Biointerval-zone.

15. From TP 3. Slide MUNSS 86. x 40.

PLATE 18 (cont'd)

16. From TP 19. Slide MUNSS 86. x 50.

Figure 17 - 18. Spinodus sp. cf. S. spinatus (Hadding). Specimens from Histiodella kristina Phylo-zone.

17. Cordylodontiform. TP 67. Slide MUNSS 87. x 80.

18. Ligonidiniform. TP 74. Slide MUNSS 87. x 75.

Figure 19. Loxodus? curvatus n.sp. From Histiodella tableheadensis Phylo-zone. TP 59. Holotype. Slide MUNSS 88. x 35.

Figure 20. Gen. et sp. indet. B. From Histiodella kristina Phylo-zone. TP 72. Slide MUNSS 89. x 95.

Figure 21 - 23. Gen. et sp. indet. C. From Histiodella tableheadensis Phylo-zone.

21. Trichonodelliform. TP 60. Slide MUNSS 90. x 95.

22. Prioniodontiform. TP 61. Slide MUNSS 90. x 125.

23. Trichonodelliform. TP 63. Slide MUNSS 90. x 125.

Figure 24. Ptiloncodus simplex Harris. Specimen from Histiodella kristina Phylo-zone. TP 79. Slide MUNSS 91. x 100.

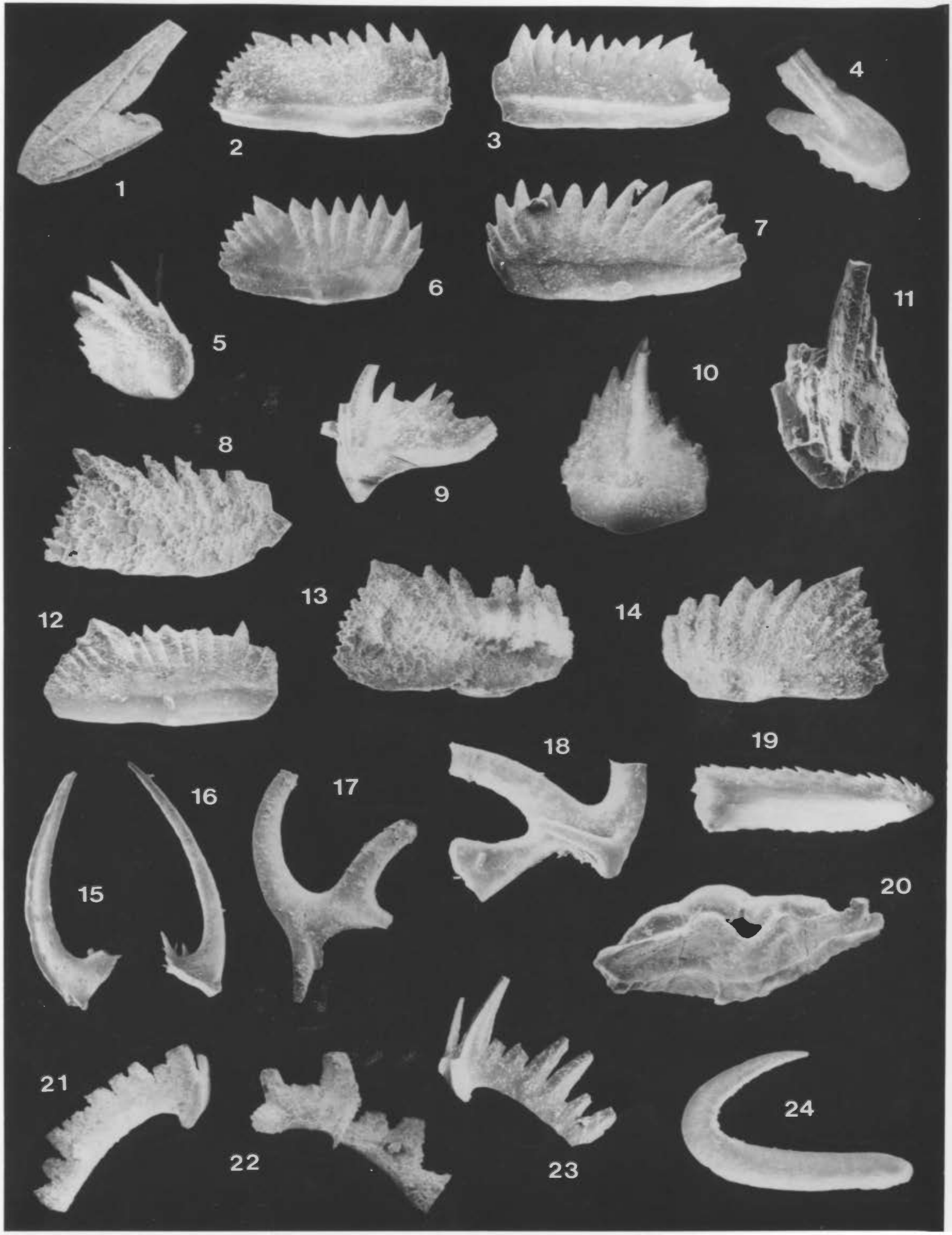
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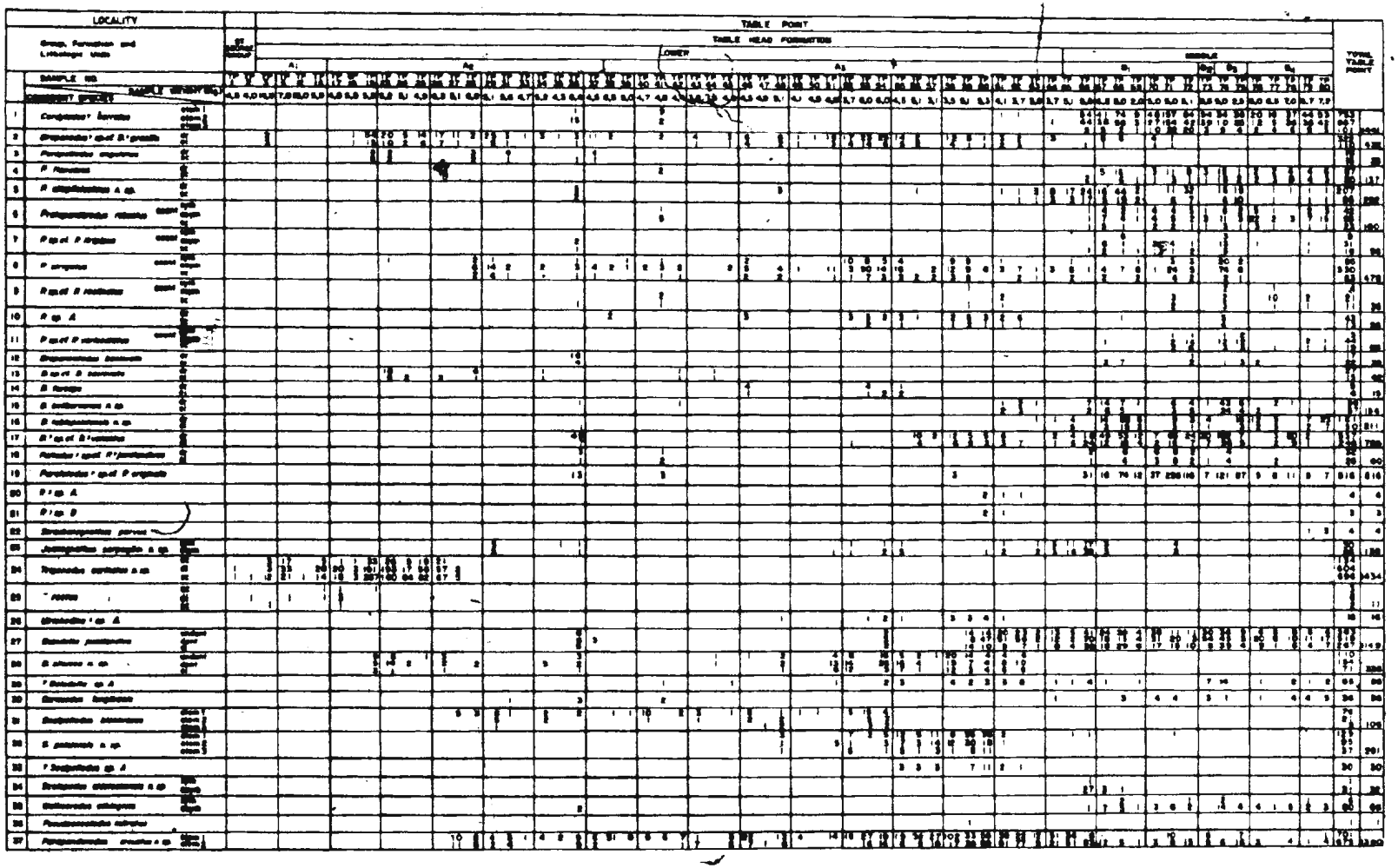
TABLE 3.1 Numerical distribution of zooplankton in the sediments.

Note: the totals of all localities are listed in Chapter 6.

The numbers listed in the left-hand column from other localities (Table Point) correspond to the species listed from Table Point.



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