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Middle Ordovician To Silurian (wenlock) Conodont Taxonomy And Biostratigraphy From Basinal Strata Of The Road River Formation In The Richardson Mountains, Northern Yukon Territory

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LA THÈSE A ÉTÉ
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MIDDLE ORDOVICIAN TO SILURIAN (WENLOCK) CONODONT TAXONOMY AND BIOSTRATIGRAPHY FROM BASINAL STRATA OF THE ROAD RIVER FORMATION IN THE RICHARDSON MOUNTAINS, NORTHERN YUKON TERRITORY

VOLUME I

by
Alexander D. McCracken

Department of Geology

Submitted in partial fulfilment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Graduate Studies
The University of Western Ontario
London, Ontario
June, 1985

ABSTRACT

The Road River Formation of Blackstone and Richardson basinal troughs, northern Yukon, comprises dark graptolitic shale, chert and carbonate. Conodonts from 69 samples collected at five sections in Richardson Mountains range in age from Middle Ordovician to Early Silurian. Additional Late Ordovician conodonts are from 17 samples of the more nearshore carbonate Whittaker Formation in southern Mackenzie Mountains, N.W.T.

Conodont faunas from the Road River Formation are largely represented by offshore and European Province taxa; faunas from the Whittaker Formation are dominated by Panderodus and American Province taxa. Several taxa are common to both strata. New or revised taxa include: Late Ordovician N. gen. A n. sp. A, which differs from known rastrate taxa; Llandovery N. gen. B, which may be related to Oulodus; Astropentagnathus may have additional elements that comprise a symmetry series. Elements currently assigned to Carniodus may be part of Pterospathodus species; these are similar to elements of the older Llandovery P. posteritenuis. P. posteritenuis and the Ordovician G. ensifer may represent an evolutionary lineage.

Eleven Yukon conodont assemblages include: early Llanvirn "Cordylodus" horridus - Spinodus spinatus assemblage, which contains older, reworked elements; and Pygodus serrus Zone, which occurs in the upper

Paraglossograptus tentaculatus Zone and is regarded as late Llanvirn in age. Late Ordovician conodont faunas represent late Fauna 12 and are associated with the Pacificograptus pacificus Zone. Low abundance of Gamachignathus ensifer suggests the late Richmondian G. ensifer Biohorizon rather than the younger Gamachian Fauna 13.

The Ozarkodina n. sp. A - Icriodella sp. B assemblage lies between the P. pacificus and Glyptograptus persculptus? zones. O. n. sp. A has a definite Silurian aspect. The Oulodus fluegeli - Dapsilodus obliquicostatus assemblage corresponds to the mid-Monograptus turriculatus and the Pterospathodus celloni zones, and probably represents an offshore fauna. Higher strata contain Aulacognathus bullatus, Astropentagnathus irregularis and Pterospathodus pennatus angulatus. The P. amorphognathoides Zone?, with Carniodus carnulus, Distomodus staurognathoides and P. p. procerus, occurs below the latest Llandovery Cyrtograptus sakmaricus - C. laqueus Zone; P. amorphognathoides is absent. The Kockelella walliseri Biohorizon (Wenlock) is tentatively recognized.

Rare conodont-bearing carbonates, in contrast to common graptolitic shale, demand that the Ordovician - Silurian boundary in Yukon clastic facies be defined using graptolites.

ACKNOWLEDGEMENTS

Dr. A.C. Lenz deserves acknowlegements for his support during the several years taken to complete this project, for providing the opportunity to study the geology of a number of interesting areas of northern Canada, for the chance to be his co-author on reports of Canadian faunas, and for his patience in allowing my many diversions from the original design of the thesis. Drs. R. Green, S.R. Hicock and C.G. Winder (University of Western Ontario) and Dr. C. Rexroad (Indiana Geological Survey) comprised the thesis examining board; they are thanked for their suggestions for improving the text.

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Colleagues who accompanied me during the field work are: Dr. A.C. Lenz, J.W. Innis (Gulf Canada Resources, Inc.), and Dr. R.W. Macqueen (UW, now with the Geological Survey of Canada). I appreciate the assistance of the Geological Survey of Canada (GSC), particularly of two of its officers, Drs. A.E.H. Pedder and D.G.F. Long, for support and collection of samples from Pat Lake, Yukon during the summer of 1980. Dr. G.S. Nowlan, also of the GSC, reviewed a nearly completed version of the thesis, and offered much needed criticism.

D. Yakobchuk, Department of Anatomy (UWO) operated the scanning elecron microscope, producing the approximately 1000 photomicrographs in the period from 1978 to 1984. His skill and assistance are gratefully acknowledged. C. Riley (Memorial University of Newfoundland) printed the individual figures used in the plates of the Yukon conodonts; S. Wagter (UWO) was keyboard operator during the summer of 1984 when most of the text was typed. J.D. Nowlan of Ottawa picked conodonts from some of the samples collected in 1977; I am grateful to have had someone else doing even part of this tedious task.

The thesis was typed using university computer facilities: assistance in using the computers was provided by L. Bernstein, B.A. Cheadle, S. Simigian and S. Talman (all of UWO), and J. Coleman, A. Prugger and Dr. M. Reeves (U of S).

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Other collegues, and friends who also deserve mention are: J.D. Blackwell, C. Corbett, M. Ferreira, M. Groff-Iannelli, T.R. Iannelli, R. Junnila, L. Levandoski, A. Macdonald, M. Melchin, Dr. W. Nesbitt, D. Parbury, P. Rasmussen, E. Vincent and Dr. G.M. Young. To those individuals not specifically named in the above, I give my apologies; absence of their name in these acknoweldgements is not due to lack of gratitude, but simply due to lack of memory.

Finally, I must acknowledge the continuing support and encouragement of my family, and of my fellow Panderers, especially Drs. C.R. Barnes (Memorial), D.J. Kennedy (Brock University), G.S. Nowlan (GSC) and P. von Bitter (Royal Ontario Museum).

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VOLUME II

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LIST OF FIGURES

CHAPTER 1 -- INTRODUCTION

Conodont samples were collected from five sections of the graptolite-bearing Road River Formation in the Richardson Mountains, northern Yukon (Fig. 1) with the purpose of combining the biostratigraphic scheme of both conodonts and graptolites. A total of 69 samples was collected from the sections at Blackstone (12 samples) and upper Peel (6) rivers in 1977 and at Tetlit Creek (16), lower Peel (11) and Rock (24) rivers in 1978. An additional 9 samples were provided in 1979 by A.C. Lenz (University of Western Ontario) from the section at Pat Lake. Photographs of these sections are provided in Figures 2-7.

At all sites except lower Peel River, graptolites were collected in tandem with the conodont samples. Graptolite identifications used herein were provided by A.C. Lenz.

A number of the samples were found to be barren of conodonts and some were too silicified or siliciclastic to digest with acid. As a result, the ensuing study is a reconnaissance of conodont biostratigraphy in the graptolitic facies of northern Yukon. The emphasis of this study is on the conodont taxonomy, and samples ranging in age from Early Ordovician to Early Silurian were examined. The diversity of the faunas reported herein is great; over 90 conodont taxa are identified, most of which are multielement (Appendix C, Tables 1, 2). The faunas from the Yukon collections comprise 927 Ordovician elements and more than 8500 Silurian elements.

The five Yukon sections (Figs. 2-7) are numbered 1 - 4 and 7 to correspond with the section numbers of Lenz and McCracken (1982). Section 5 of that study, at Clearwater Creek, southern Mackenzie Mountains, N.W.T. contains strata that did not appear promising for conodonts and hence is not included herein. References are made, particularly in the chapter on systematic paleontology, to a number of conodont taxa from 27 samples of the Whittaker Formation at Avalanche Lake in the southern Mackenzie Mountains, N.W.T. (near Clearwater Creek). Taxa from Avalanche Lake are part of a major study of Richmondian - early Llandovery faunas (Nowlan, et al., MS). The present study includes illustrations of these taxa (Appendix A). Section 6, from Lower Peel River (11 samples collected), yielded conodonts but the lack of associated graptolite collections prevents precise correlation; these conodonts are not included in this present study.

The 78 samples from northern Yukon were processed using standard acid-digestion and heavy liquid separation techniques. Each sample processed weighed an average of 2 kg. Additional rock from 16 of these samples were also processed.

FIGURE 1. LOCALITY MAP, YUKON TERRITORY. Solid circles numbered 1-4 and 7 represent the location of sections of the Road River Formation studied in this report. These sections are: 1-Blackstone River (65 26'N, 137 20'W); 2-Pat Lake (65 09'N, 136 42'W); 3-upper Peel River (65 53'N, 135 43'W); 4-Rock River (south branch, 66 48'N, 136 16'W); 7-Tetlit Creek (tributary of Road River, and type section of Road River Formation, 66 44'N, 135 47'W). Locality 6 is the site of the lower Peel River section (not reported in this study); locality 5 is the Clearwater Creek (southwestern N.W.T.) of Lenz and McCracken (1982); locality 8 is the Royal Creek sections of Jackson et al. (1976), and others (discussed in text).

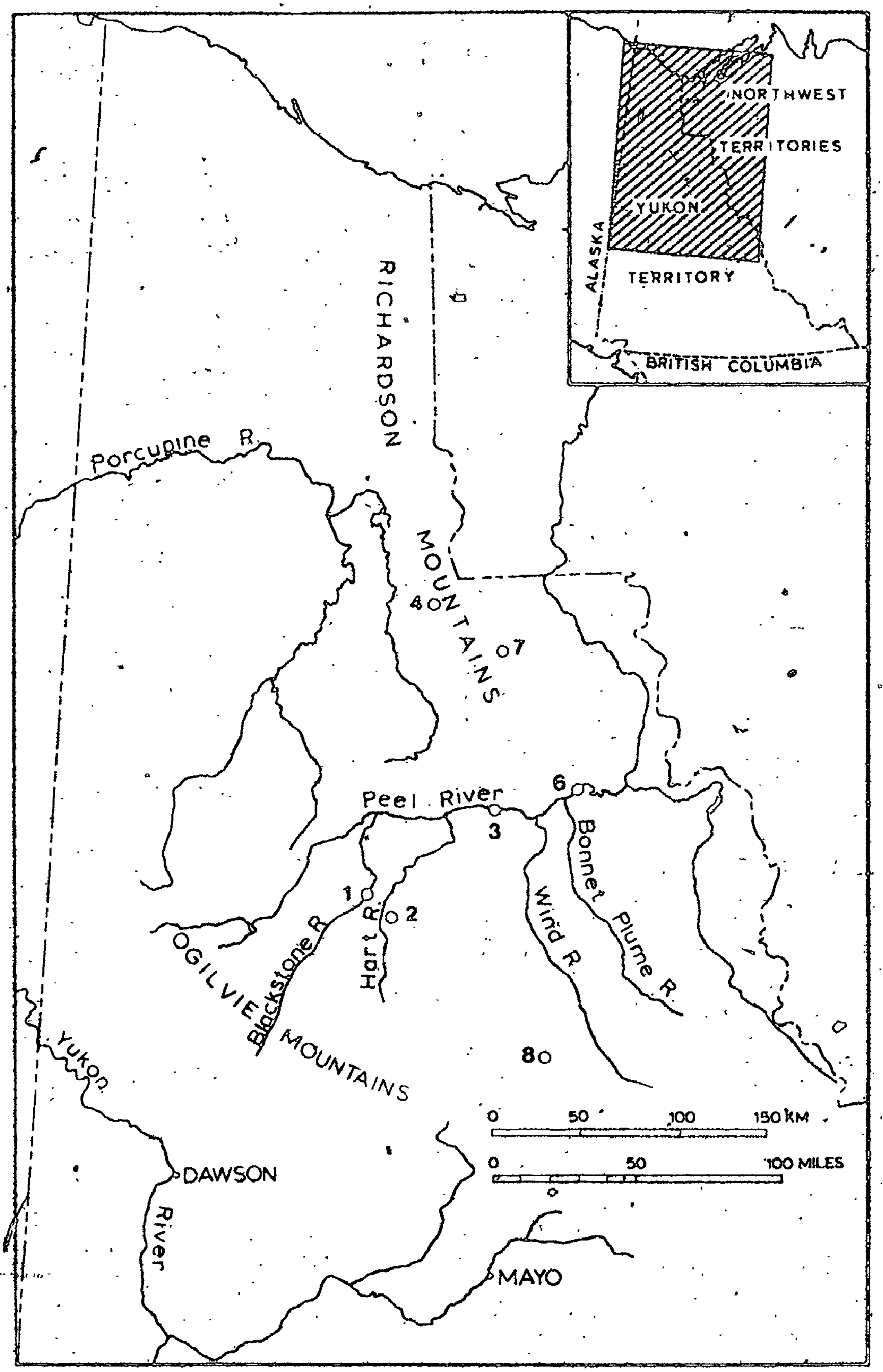

NORTHWEST
TERRITORIES
YUKON
ALASKA
TERRITORY
BRITISH COLUMBIA
RICHARDSON
MOUNTAINS
Porcupine R.
4
7
Peel River
6
3
Bonnet Plume R.
Wind R.
1
2
Hart R.
Blackstone R.
OGILVIE
MOUNTAINS
8
Yukon
River
DAWSON
MAYO
0
50
100
150 KM
0
50
100 MILES

FIGURE 2. SECTION 1, BLACKSTONE RIVER. Llandovery shales and chert.

FIGURE 3. SECTION 2, PAT LAKE. Ashgill graptolitic shale and overlying conodont- and coral-bearing carbonate unit. Graptolites in shale above carbonate are assigned to the Glyptograptus persculptus Zone?

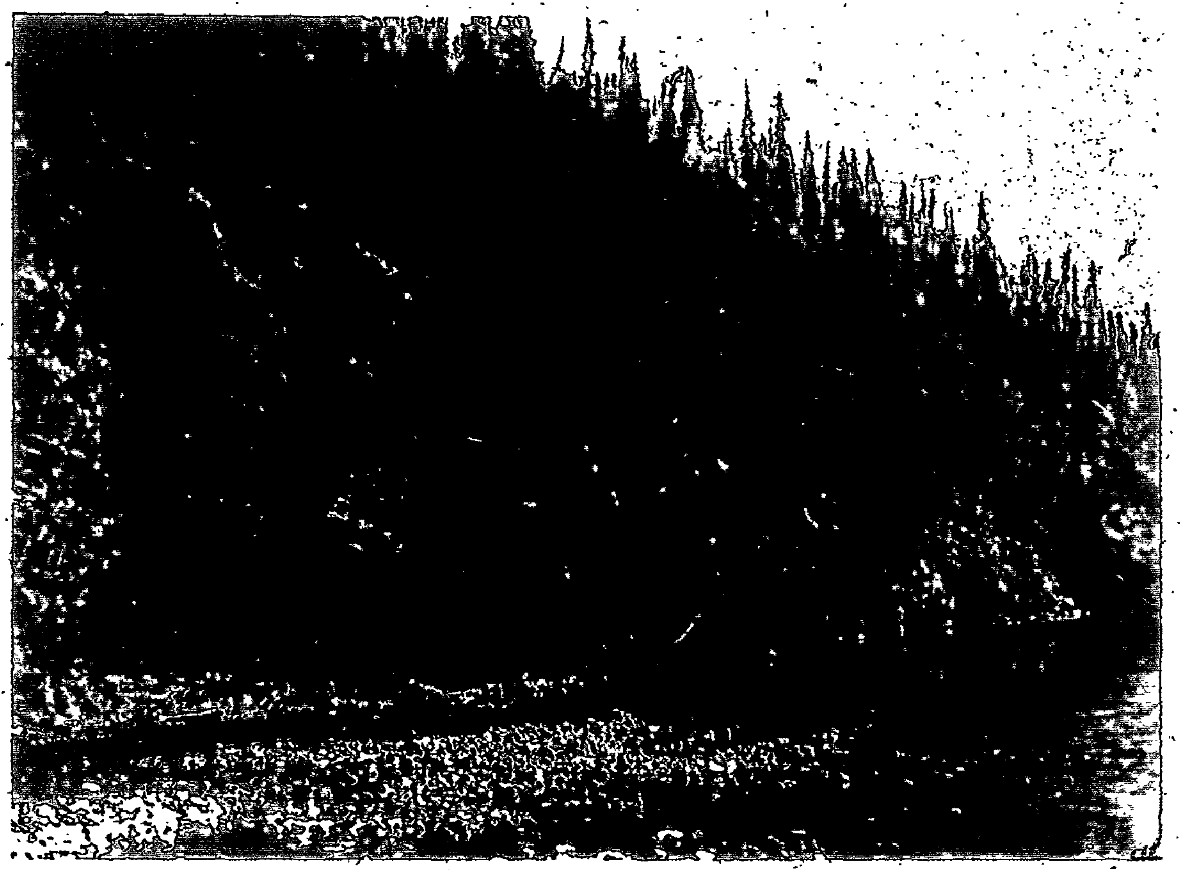


FIGURE 4. SECTION 4, ROCK RIVER. Ashgill strata. Field notebook (lower right) is at 226m, conodont samples are from 225, 226, and 228m. First Llandovery graptolites (A. atavus or L. acinaces Zone) are at 241m.

FIGURE 5. SECTION 4, ROCK RIVER. Llandovery debris bed (at 245m) of crinoid, bryozoan coral fragments, and mixed Ordovician - Silurian conodonts.

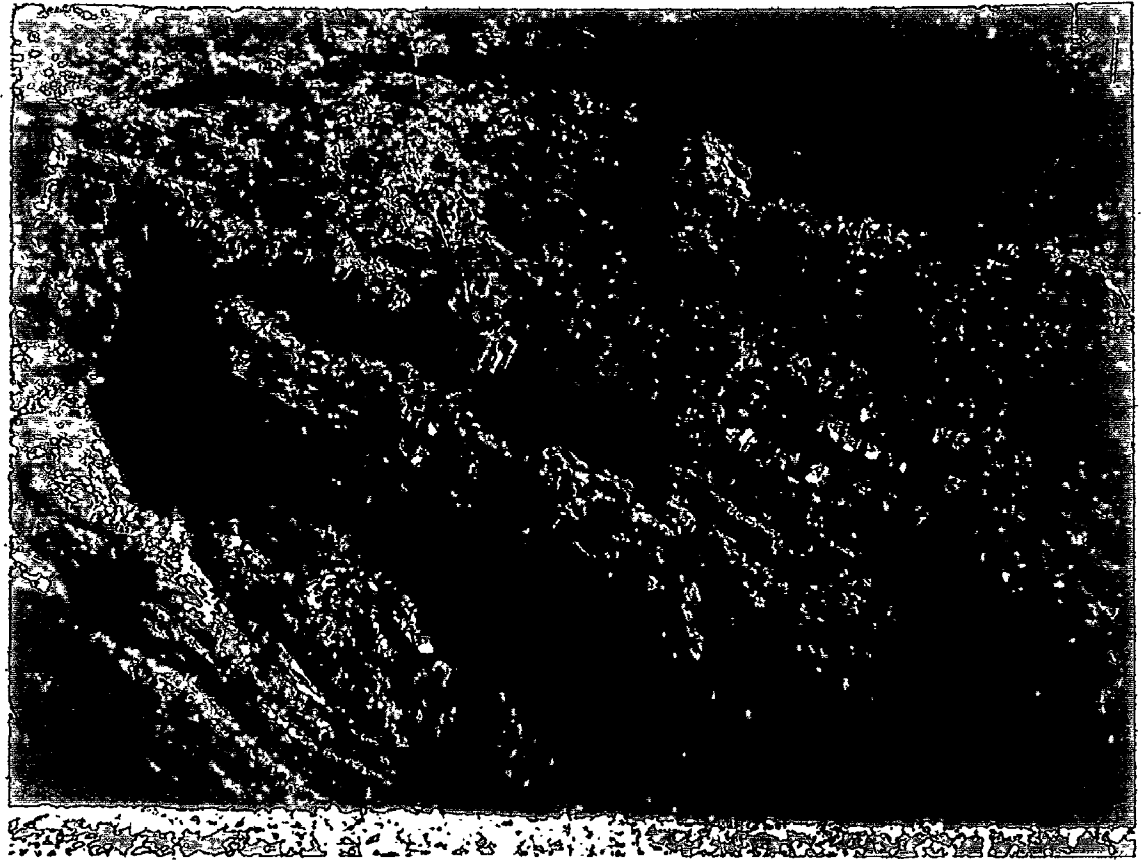


FIGURE 6. SECTION 3, UPPER PEEL RIVER. Ashgill and Llandovery shale and chert.

FIGURE 7. SECTION 7, TETLIT CREEK. Llandovery shale and carbonate.

CHAPTER 2 -- REGIONAL AND LOCAL GEOLOGY

2.1 Stratigraphy of the Road River Formation

The Road River Formation is a thick (up to 3130m), complex sequence of dark shales, limestones and cherts that ranges in age from Late Cambrian to Early Devonian. It was defined by Jackson and Lenz in 1962 at the section on Tetlit Creek (a tributary of the Road River) in the Richardson Mountains and has become a widely used term for strata of graptolite-bearing basinal facies throughout Yukon, east-central Alaska (Churkin and Brabb, 1965), and northeastern British Columbia (Cecile and Norford, 1979). Norford (1979) noted that this belt of graptolitic facies strata extends as far south as Idaho.

The Road River Formation, because of its great spatial and temporal extent, equates to numerous formations of shallower water carbonate facies (Fig. 8). Those formations mentioned in this study are the Sunblood and Whittaker formations of the Mackenzie Mountains (e.g. Tipnis, et al., 1978) and the Ogilvie Formation and the Ronning Group (Peel, Mount Kindle and Franklin Mountain formations) of the Mackenzie and Porcupine platforms (e.g. Pugh, 1983; see Hills, et al., 1981 for a listing of other equivalent formations, and a detailed summary of the Road River Formation).

The Road River Formation was informally divided into two members by Norford (1964), following the suggestion of Jackson and Lenz (1962). Cecile (1978) and others suggested elevating the Road River to group status and subdividing this group into formations. Cecile (1982) later restricted use of the term Road River and instead uses the Hess River, Rabbitkettle, Duo Lake, and Cloudy formations for basinal strata of the Misty Creek Embayment of the northern Mackenzie and Selwyn mountains.

The Road River Formation is at least 910m thick at its type section on Tetlit Creek; the lower part of this section is faulted (Jackson and Lenz, 1962). The maximum known thickness is at Rock River, where it is reported to be 3130m (Norford, 1964).

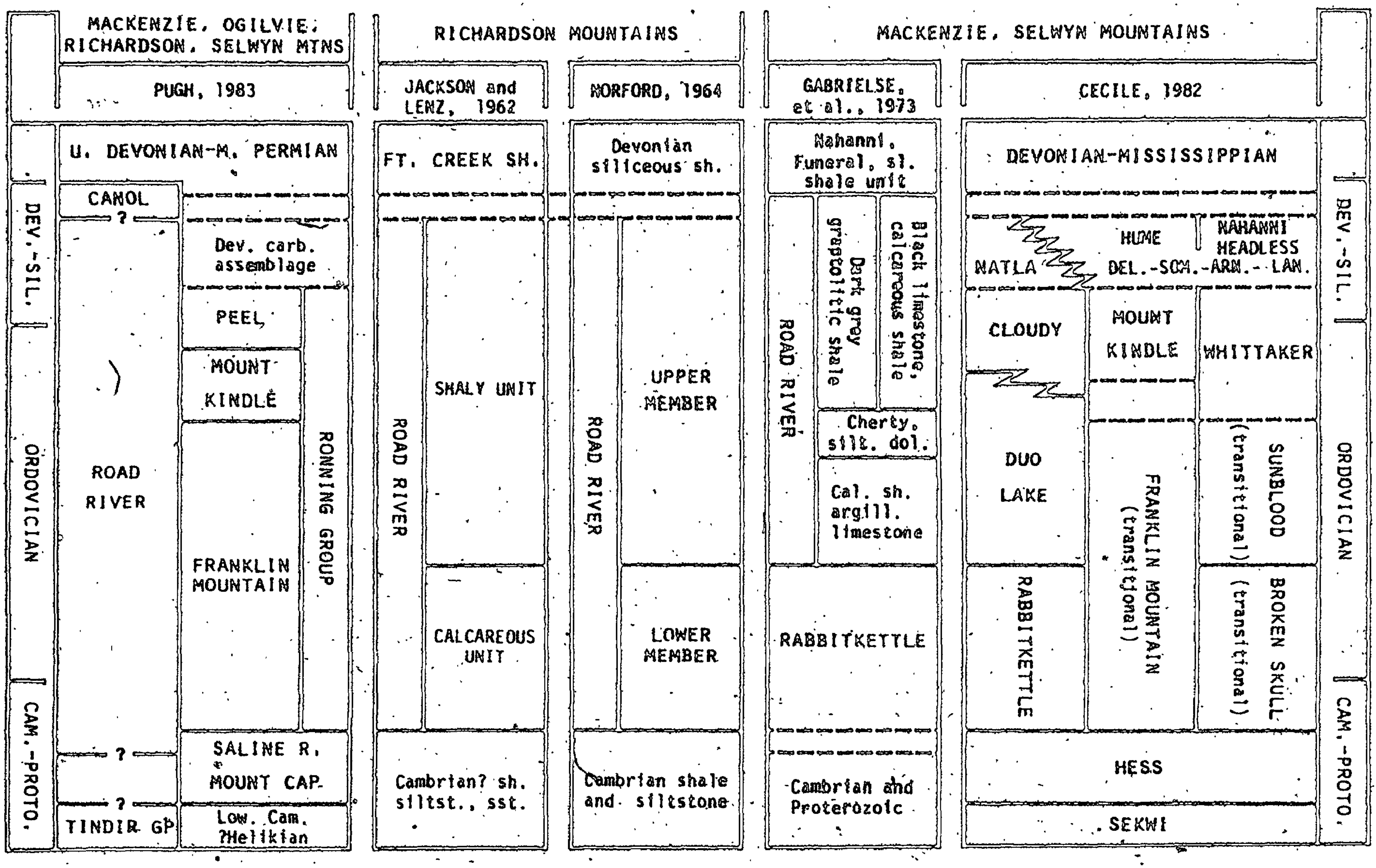
Both Jackson and Lenz (1962) and Norford (1964) recognized strata that probably represent debris flows; Norford (<u>ibid</u>., pp. 5, 6) gave a detailed description of some of these deposits.

2.2 Road River Formation in the Study Area

Descriptions of sections within the study area have previously been given by Jackson and Lenz (1962) for Tetlit Creek, and by Norford (1964) for the sections at Blackstone and Rock rivers, Pat Lake, and Tetlit Creek (among other sections). The Ashgill - Llandovery lithostratigraphy for all except the Tetlit Creek section is summarized in Lenz and McCracken (1982, fig. 2), who also included the Clearwater Creek section of the southern MacKenzie Mountains, N.W.T. The entire upper Peel River section is figured in Lenz and Pedder (1972); the conodonts reported herein were collected using their stratigraphic markers.

Innis (unpublished thesis, 1980) studied the lithostratigraphy of sections 3, 4, 6 and 7 in detail and divided the Ordovician and Silurian part of the Road River Formation into four informal lithostratigraphic units which were recognized to some degree in all of his four sections. Innis also noted numerous mass flow deposits like those reported by Norford (1964) and observed common replacement of the original calcareous sediment by silicification.

FIGURE 8. CORRELATION CHART OF FORMATIONS, NORTHERN CANADIAN CORDILLERA. Stratigraphic terms used by Jackson and Lenz (1962) are shown, with correlative units in other areas of the Cordillera. Under the column from Pugh (1983) are units of the basinal and platform facies (left and right, respectively). The abbreviation "sl. shale" under Gabrielse, et al. (1973) is for "slaty shale". The columns under Cecile (1983) are composites from his Figures 4 and 35: the left column represents basinal strata (which also includes the Hess and Sekwi formations), the middle and right columns represent the transitional (as noted in parentheses) and platform formations. The abbreviations "DEL.-SOM.-ARN.-LAN." is for the Delorme, Sombre, Arnica and Landry formations. Broken lines indicate unconformities and hiatii (modified after Cecile, 1983).


MACKENZIE, OGILVIE, RICHARDSON, SELWYN MTNS
RICHARDSON MOUNTAINS
MACKENZIE, SELWYN MOUNTAINS
PUGH, 1983
JACKSON and LENZ, 1962
NORFORD, 1964
GABRIELSE, et al., 1973
CECILE, 1982
DEV.-SIL.
ORDOVICIAN
CAM.-PROTO.
U. DEVONIAN-M. PERMIAN
CANOL
?
Dev. carb. assemblage
PEEL
MOUNT KINDLE
FRANKLIN MOUNTAIN
RONNING GROUP
ROAD RIVER
SALINE R. MOUNT CAP
TINDIR GP
Low. Cam. ?Helikian
FT. CREEK SH.
SHALY UNIT
CALCAREOUS UNIT
Cambrian? sh. siltst., sst.
Devonian siliceous sh.
UPPER MEMBER
LOWER MEMBER
Cambrian shale and siltstone
Nahanni, Funeral, sl. shale unit
Black limestone, calcareous shale
Dark grey graptolitic shale
Cherty, silt. dol.
Cal. sh. argill. limestone
RABBITKETTLE
Cambrian and Proterozoic
DEVONIAN-MISSISSIPPIAN
NATLA
HUME
DEL.-SCH.-ARN.-LAN.
NAHANNI HEADLESS
CLOUDY
MOUNT KINDLE
WHITTAKER
DUO LAKE
FRANKLIN MOUNTAIN (transitional)
SUNBLOOD (transitional)
BROKEN SKULL (transitional)
HESS
SEKWI

CHAPTER 3 -- DEPOSITIONAL AND TECTONIC HISTORY

3.1 Introduction

Regional paleogeographic and lithofacies maps, and depostional histories of northwestern Canada have been provided by Jeletzky (1962), Norford (1964), Gabrielse (1967), Ziegler (1969), Lenz (1972, 1976, 1982b), Jackson, et al. (1978), Cecile (1982), and Pugh (1983).

The time interval studied herein encompasses the period of Ordovician - Silurian glaciation in North Africa. Effects of this glaciation have been discussed by Lenz (1976) and Lenz and McCracken (1982); a systemic hiatus was thought by these writers to be caused by regression and was defined primarily by the faunal succession in the boundary strata. Lenz and McCracken further observed that this relatively short regressive event also stimulated a change in lithology (see Chapter 6 - Ordovician - Silurian Boundary).

The review by Lenz (1982b) shows that this regressive - transgressive phase was not unique: a number of others occurred in the region and within strata of Ordovician to Devonian age. Some synchroneity of these events exists, however others are distinctly local.

3.2 Regional Tectonic Elements

The tectonic elements of northwestern Canada are illustrated in Figure 9. Several variations of this tectonic framework exist; some of these are briefly discussed below.

The term Yukon Stable Block of Jeletzky (1962) and used by Lenz (1972) is called the Porcupine Platform by Cecile (1982). Pugh (1983, p. 50) used the term Porcupine Platform for the eastern part of the Yukon Stable Block between the David Lord High and the Richardson Trough. Although this trough separates the Porcupine and Mackenzie platforms, Pugh (ibid., p. 14) used the same lithostratigraphy (e.g. Ronning Group) on both platforms to show tectonic and depositional continuity. The southern part of this block, between the Blackstone and Cordilleran (Selwyn Basin of Cecile, 1982) troughs as shown by Lenz (1972), is called the Ogilvie Arch by Cecile (1982).

The Dave Lord High (Lenz, 1972) is regarded as the most positive part of the Yukon Stable Block by Jackson, et al. (1978) but this prominence is not featured in Cecile's tectonic model (1982, fig. 42). The Bonnet Plume High, also of Lenz (1972), was subsequently and greatly reduced in its extent and significance, by Cecile (1982, pp. 28, 29).

The British-Barn Mountains Trough (Lenz, 1972) is illustrated as an unnamed extension of the Richardson Trough by Cecile (1982). A basinal shale connection between the Richardson Trough and the shales of the northwestern Misty Creek Embayment part of the Selwyn Basin (Ziegler, 1969;

Lenz, 1972) is not included in Cecile's interpretation, which instead shows a carbonate platform between the Richardson Trough and the Misty Creek Embayment region of the Selwyn Basin. Both Cecile (1982) and Pugh (1983) agreed that a deep water connection was improbable, preferring to suggest that this connection was via a shallow carbonate sea.

Models of tectonic origin of the Misty Creek Embayment and Richardson Trough have been proposed, respectively, by Cecile (1982) and Pugh (1983). Cecile suggested that the origin of the Misty Creek Embayment was due to extensional faulting and compared it with segments of the east African rift system in Kenya. Pugh interpreted the Richardson Trough as a Paleozoic aulacogen. Both writers noted structural and depositional similarities between the Richardson and Misty Creek basins. Cecile (1982) regarded the tectonic elements of this region as related basins and uplifts; that is, a complex system of grabens, horsts and plateaux.

3.3 Local Tectonic Elements

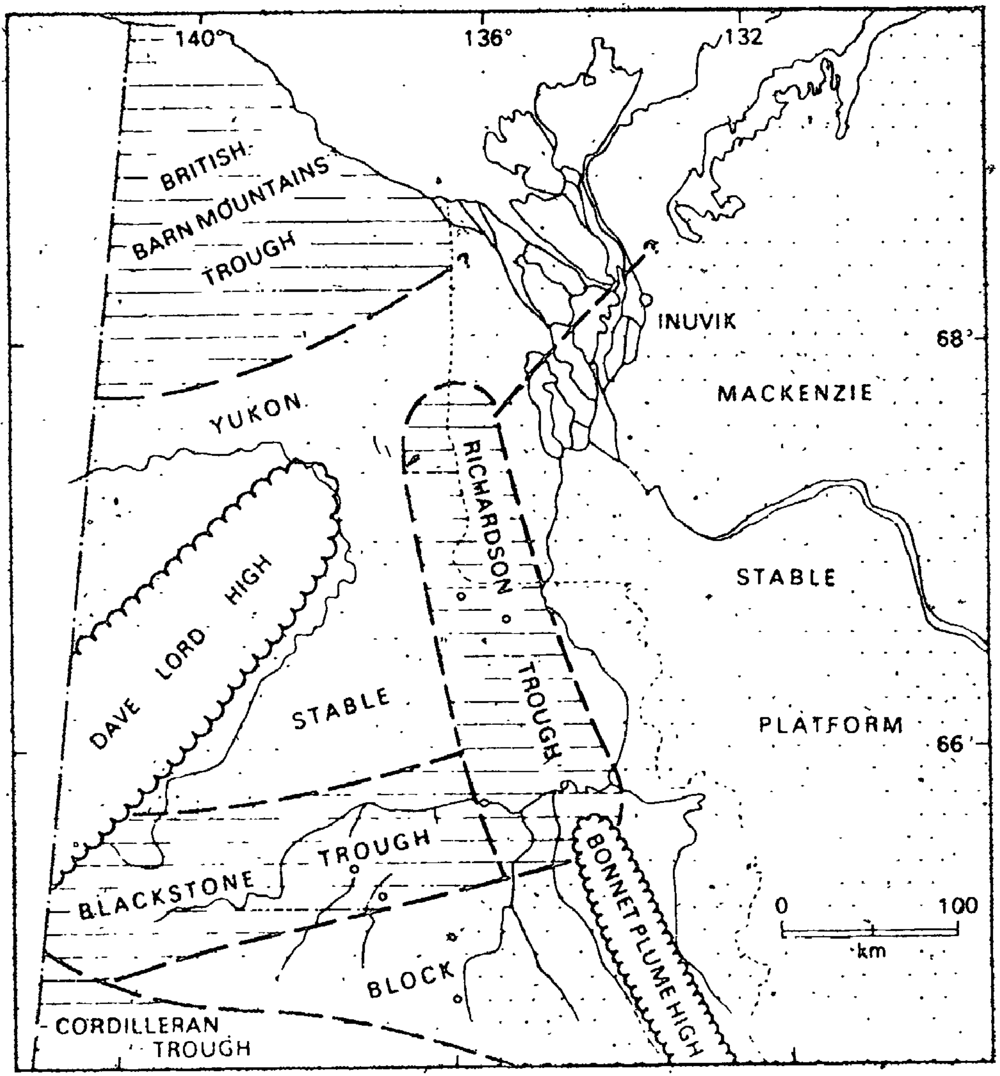
The sections studied herein are part of the Richardson and Blackstone troughs which, whatever their origin, were relatively narrow basins bounded by shallower water platforms (Fig. 9). The Blackstone River, Pat Lake and upper Peel River sections are within the Blackstone Trough; the Rock River and Tetlit Creek sections, are within the Richardson Trough. Proximity to the carbonate shelf margin is in part illustrated by the numerous mass flow deposits.

3.4 Mass-Flow Deposits

Mass-flow deposits from the studied sections were identified on site, by Innis (1980) using field and petrologic techniques and, by the discovery in this study, of obviously mixed conodont faunas. Some of these mixed faunas correspond to mass-flow deposits identified by lithological study; others were from strata not previously recognized as such.

An allocthonous deposit of this type can confuse or compromise the interpretation of conodont biostratigraphy and provincialism, or result in "extension" of the previously known range of the taxa. From an optimistic viewpoint, a naturally contaminated sample can also provide information from strata of ages not sampled and from shallower environments; in effect, an erosionally-induced form of reconnaissance sampling.

FIGURE 9. TECTONIC ELEMENTS, NORTHERN YUKON. The un-numbered solid circles represent the approximate positions of the seven localities shown in Figure 1 (from Jackson, *et al.*, 1976).


140°
136°
132
BRITISH
BARN MOUNTAINS
TROUGH
?
INUVIK
68°
YUKON
MACKENZIE
RICHARDSON
TROUGH
DAVE LORD HIGH
STABLE
STABLE
PLATFORM
66°
TROUGH
BLACKSTONE
BONNET PLUME HIGH
0
100
km
BLOCK
CORDILLERAN
TROUGH

CHAPTER 4 -- CONODONT PALEONTOLOGY

4.1 Previous Conodont Studies

Most previous studies of conodonts from northern Yukon have either been preliminary reports, or have dealt with conodonts either younger or older than those studied herein. A summary of these reports follows.

4.1.1 Richardson Mountains

Norford, _et al_. (1970, 1973) and Pugh (1983) listed taxa (mostly macrofossils) and age determinations from several frontier exploration wells, including some in northern Yukon which penetrated Ordovician and Silurian strata. Silurian and Devonian conodont identifications are included within the reports of Norford, _et al_. (1970, 1973) but the locations of these wells are outside the northern Yukon study area.

Pugh (1983, Appendix 1) included conodont data from a well near the Blackstone River section and two wells near the Tetlit Creek section. Uyeno _in_ Pugh (_ibid_., pp, 28-31) identified _Belodella_ sp., _Ozarkodina excavata excavata_ (Branson and Mehl) and _Panderodus_ spp. from an interval tentatively assigned to the Mount Kindle Formation (Fig. 8). This collection was regarded as Silurian, probably Wenlock to Ludlow in age. Conodonts from the upper part of the underlying Franklin Mountain Formation were assigned a late Middle to early Late Ordovician Fauna 8 - 10 (11?) (Tipnis in Pugh, ibid.). These conodonts were identified as Belodella cf. B. n. sp. 1 sensu Barnes (1977) and Panderodus gracilis (Branson and Mehl).

A well near the Tetlit Creek section yielded conodonts discussed by Tipnis in Pugh (ibid., pp. 51, 52), who reported Drepanoistodus suberectus (Branson and Mehl), P. gracilis, P. spp., Plectodina? sp., Oulodus? sp. and Ozarkodina? sp., and determined the age to be Middle Ordovician to early Silurian. Tipnis (ibid., p. 52) noted "stratigraphic mixing" due to contamination; Early Ordovician taxa (Acanthodus? sp., Loxodus sp.) were also recovered from these samples.

Klapper in Lenz (1972) identified the Wenlock-Pridoli Ozarkodina confluens (Branson and Mehl) and O. excavata excavata (Branson and Mehl) from the Royal Creek section (located on Figs. 1, 9). Klapper also identified the Pridoli O. remscheidensis remscheidensis (Ziegler) and Pelekysgnathus n. sp. A from the same section. These Royal Creek conodonts were collected from the Road River Formation in an area south of the Upper Peel River section.

The monograph of Jackson, et al. (1978) includes conodont identifications by B.D.E. Chatterton (University of Alberta), G. Klapper (University of Iowa) and T.T. Uyeno (G.S.C., Calgary). The oldest northern Yukon fauna discussed is the Pelekysgnathus index assemblage (early Priodli).

Other conodont identifications in Jackson, et al. are from Lower Devonian strata.

Devonian conodonts from northern Yukon have been studied by Fahraeus (1971), Perry, *et al*. (1974) and Uyeno (*in* Pugh, 1983). Fahraeus (1971) studied Early Devonian conodonts near the sections from Blackstone and Upper Peel rivers. Perry, *et al*. (1974) included a biostratigraphic and taxonomic study of Emsian - Givetian conodonts from the Ogilvie and other formations from the same region. A second well near the Tetlit Creek section yielded Late Devonian conodonts (Uyeno *in* Pugh, 1983, Appendix 1, p. 26).

McCracken and Lenz (1980, 1981, 1985) and Lenz and McCracken (1982) discussed the Ashgill and Llandovery graptolite and conodont biostratigraphy of the Road River Formation in the Richardson Mountains. They (1982) recognized the Richmondian conodont Fauna 12 at two, possibly three, of their sections. A fauna from Blackstone River strata contained a rare occurrence of a species recorded from Fauna 13 of Anticosti Island, Québec, but they did not feel that its presence was justification for the recognition of the Gamachian Fauna 13 in Yukon (see Appendix B). At the same section, the systemic boundary was placed within a 3m interval between this conodont fauna and the overlying *Glyptograptus persculptus*? Zone.

The latest Ashgill *Climacograptus extraordinarius* Zone was not recognized in this or any other northern Cordilleran section, thus Lenz and McCracken (1982) interpreted a hiatus as occurring between the youngest Ordovician fauna (either conodont or graptolite) and the Silurian G. persculptus? Zone (now regarded as latest Ashgill; see Chapter 5 - Biostratigraphy, and Appendix B) or younger zones.

Silurian conodont faunas of Lenz and McCracken (1982) from the Pat Lake section are biostratigraphically undiagnostic but are bracketed by graptolites of the underlying Ashgill Pacificograptus pacificus Zone and the overlying G. persculptus? Zone. Above the latter are graptolites of the Parakidograptus acuminatus Zone, now regarded as basal Llandovery (Appendix B). Lenz and McCracken (1982) suggested that a glacially induced regression was responsible for local erosion or non-deposition or lithic changes and probably prevented ready ingress of short-ranging graptolites.

4.1.2 Southern Mackenzie Mountains

Tipnis, et al. (1978) reported on conodonts collected from platform carbonates and strata of the deeper water, fine clastic facies of the southern Mackenzie Mountains in south-eastern Yukon and south-western N.W.T. Strata studied were from the Road River, Whittaker and other formations. Conodonts in their study were reported to range in age from Late Cambrian to Late Ordovician.

The collections of Tipnis, et al. (1978) from platform carbonates yielded conodont faunas that for the most part are characteristic of the North American Midcontinent Conodont Province. They recognized the Late Cambrian - Early Ordovician Proconodontus Zone, Faunas A, B, D and E (Early Ordovician) and the Middle to Late Ordovician Faunas 1-10. Road River strata yielded early Arenig to Llanvirn conodonts of the North Atlantic Province, including those of the Pygodus serrus Zone (Tipnis, et al., 1978, p. 44). Younger collections from this formation were interpreted as latest Middle or earliest Late Ordovician (Fauna 9; Caradoc).

Information on conodonts of the southern Mackenzie Mountains has been summarized recently. The taxonomic report on Avalanche Lake faunas (Whittaker Formation, Late Ordovician - Early Silurian) by McCracken and Nowlan (1984) was followed by a comparison of these faunas from carbonate facies strata and those of clastic facies (Road River Formation) in the Richardson Mountains of northern Yukon (Nowlan and McCracken, 1984). The faunas from the Road River Formation contained several taxa absent in the Whittaker Formation but common to the North Atlantic Conodont Province. Several taxa were similarly restricted to the carbonate facies; the faunas of this facies are more characteristic of the North America Midcontinent Province.

Orchard (1984) gave a brief account of the conodonts from the Nahanni area of the Mackenzie Mountains in southeastern Yukon. His reconnaissance samples yielded conodonts ranging in age from Late Cambrian to Early Triassic; his Silurian faunas included Llandovery taxa.

4.2 Summary of Conodont Taxonomy

The total number of conodont elements (listed in Appendix C, Tables 1, 2) are: 927 - Ordovician, and 8507 - Silurian. In the formal systematic paleontology section of this study, and Appendix A, 95 taxa are recorded. Appendix A is the contribution of this author in a nearly completed manuscript by Nowlan, McCracken and Chatterton on Ordovician - Silurian conodonts from the Avalanche Lake sections in the southern Mackenzie Mountains, N.W.T. Taxa in Appendix A include three formally defined, new Ordovician species of Besselodus, Panderodus? and Walliserodus, and a new coniform genus, Zanklodus.

The fauna from Avalanche Lake represents part of the same time interval as, and is comparable to, that of the Yukon study. Differences between the faunas of the two areas are in part due to paleoecology; Yukon Road River strata represent a deeper or more offshore environment whereas those of the Whittaker Formation, N.W.T. are from a more nearshore, shallower environment that was transitional between trough and platform.

The Conodont Alteration Index (CAI; Epstein, et al., 1977) for conodonts from the Yukon is 4.5-5 CAI; those from the N.W.T. have a value of 5 CAI.

The new species of Besselodus, and a number of other taxa co-occur in both northern Yukon and southern N.W.T. For the Ordovician genera Belodella? and Besselodus, and the Silurian Carniodus, Dapsilodus, Distomodus and Pterospathodus, I offer significantly modified interpretations of their apparatuses. A fused cluster of Ordovician Protopanderodus elements permits a new reconstruction of the taxon.

Two new genera from Yukon are informally proposed; the Ordovician N. gen. A has an apparatus with rastrate elements representing the a and c positions; elements in the b position are unknown. This genus differs in a number of respects from the rastrate genera Belodina and Pseudobelodina. The most significant difference is the symmetrical c element that has a panderodont furrow on both lateral faces. The Silurian N. gen. B has an apparatus comprising a, b, c, e, f and g elements and is generally comparable to Oulodus.

Significant new, but unnamed, species are assigned to the Silurian genera Astropentagnathus, Oulodus, Ozarkodina, Pterospathodus and Walliserodus. Pterospathodus n. sp. A has similarities to P. amorphognathoides Walliser but differs in the relative length of the processes on the platform element. The latter species is absent from the Yukon material.

In general, I prefer to avoid using subspecies designations unless they have been previously established but I have made the exception and identify two subspecies of the Silurian Oulodus fluegeli (Walliser). These may alternatively reflect sexual dimorphism since they co-occur and the differences are rather subtle. A new, unnamed subspecies of Ozarkodina excavata (Branson and Mehl) is also recognized.

I use the term "carniodontid ledge" to refer to the thickened margin on the base of elements of Carniodus. This type of ledge is also present in elements of Pterospathodus. The terms "American Plan" and "European Plan" are in reference to Type IV apparatuses (sensu Barnes, et al., 1979) of these provinces ("European" may alternatively be termed "prioniodid").

The informal assemblages described in the section on paleoecology are associations of taxa. Their temporal distribution cannot be traced because of the reconnaissance nature of the study. These assemblages are not intended to be used as formal biostratigraphic units.

4.3 Conodont Paleoecology

4.3.1 Intraprovincial Conodont Paleoecology

The Ordovician fauna is a mixture of taxa that are typical of two different faunal provinces. These taxa therefore reflect differences at the provincial, not just community level and are best left to the discussion on conodont provincialism below. Only Silurian paleoecology will be stressed in this section, with distributional data and observations drawn from a number of studies.

A significant character of the Yukon Silurian fauna is the relative abundance of coniform versus ramiform taxa. One sample in particular, has an abundance of Dapsilodus and Walliserodus elements. Models of conodont paleoecology suggest that the coniform Panderodus was a pelagic, euryhaline and eurygraphic (Barnes and Fahraeus, 1975). This genus is not particularly abundant in the Yukon samples, but by analogy the same mode of life may be suggested for the two coniform genera named above.

The analogy must be applied with caution however, because there are differing ecologic interpretations of Panderodus and other coniform taxa. Aldridge's (1972, p. 159) preliminary conclusions were that the percentage of Llandovery coniform species increased in samples from progressively deeper water, shelf environment. He later noted (1976, p. 102) that Panderodus and Walliserodus were more abundant in deep-water sediments.

The lateral distribution of the Ordovician Panderodus in the Ellis Bay Formation, Anticosti Island, Québec do not support this model; the greatest abundance of Panderodus is in the intermediate, not offshore, strata (McCracken and

Barnes, 1981a). Furthermore, unpublished community cluster analyses, performed at the species level from the Ordovician of Anticosti, suggests that these species were not entirely ubiquitous.

The more recent work of Aldridge and Mabillard (1981) seems to confirm the preference of the Silurian *Panderodus unicostatus* (Branson and Mehl) for shallow environments. Their study of strata across the Welsh Borderland shelf-basin transition showed a definite decrease in abundance of *P. unicostatus* toward the basin edge.

The earliest Llandovery faunas from the Ellis Bay Formation of Anticosti were reported by McCracken and Barnes (1981a); these are dominated by *Panderodus gracilis* (Branson and Mehl) (=*P. unicostatus*), *Ozarkodina*, *Walliserodus* and *Oulodus*?. *Panderodus* is more abundant in lower strata, *Ozarkodina*, in higher strata. *W. curvatus* (Branson and Branson) is a relatively consistent component throughout. McCracken and Barnes suggested that this change in faunas may represent a progressive shallowing upwards. The slight dominance of *Panderodus* in the lower part of the strata was interpreted as indicating the opportunistic character of this taxon.

P. unicostatus on Anticosti Island was described by Uyeno and Barnes (1983) as ranging throughout their section but as being abundant only at four levels; these strata were believed to represent relatively shallow or nearshore environments. The Llandovery distributional data of Uyeno and Barnes (1983) for *P. unicostatus* seems to be in agreement with that of Aldridge and Mabillard (1981).

The abundance of *P. unicostatus* increases upwards in the Coralliferous Group of Marloes Bay, Wales (Mabillard and Aldridge, 1983), a sequence interpreted as representing a nearshore, progressively shallowing environment. This area was included in the study of Aldridge and Mabillard (1981). The *P. unicostatus* Biofacies of Barrick (1981) is the least diverse and abundant of his three biofacies. It is dominated by this species and is characteristic of shallow water, high energy environments. Nowlan (1983b) concluded that the occurrence of *Panderodus* in all Lower Silurian environments of eastern Canada indicated that it was a widespread pelagic form.

Panderodus unicostatus, and the Ordovician *P. gracilis* are relatively rare in the fine clastic facies of Yukon. This genus is however, a significant component (about 50 percent) in the shallower water carbonate facies of Ordovician strata from the southern Mackenzie Mountains. *Panderodus* occurs in succceeding lower Llandovery strata but the abundance of all genera is quite low and thus the data cannot contribute to an ecologic interpretation (McCracken and Nowlan, 1984).

In regard to other taxa, the faunas of the *P. amorphognathoides* Zone in the Welsh Basin are considered as relatively offshore compared to those from the Coralliferous Group of Wales (Aldridge and Mabillard, 1981; Mabillard and Aldridge, 1983).

The Welsh Basin faunas are characterized by Carniodus, Decoriconus, Pterospathodus amorphognathoides Walliser and Panderodus cf. P. recurvatus (Rhodes) (Aldridge and Mabillard, 1981). The shelf edge area contains peaks in abundance of D. obliquicostatus. The faunas of the Coralliferous Group include species of Apsidognathus, Icriodella?, Kockelella, Ozarkodina, Oulodus and P. unicostatus. The nearshore group of Aldridge and Mabillard includes these taxa and Distomodus.

Only P. unicostatus (see discussion above) and Ozarkodina excavata (Branson and Mehl) show a significant vertical change in abundance in strata of the Coralliferous Group. The latter species is more frequent in lower strata interpreted by Mabillard and Aldridge (1983) to represent relatively deeper water compared to the higher part of the section. Aldridge and Mabillard (1981) found that the distribution of O. excavata varied with age. In pre-P. amorphognathoides Zone strata it varied little across the shelf; in P. amorphognathoides strata it was in the more nearshore group of taxa; and in early Wenlock (post-P. amorphognathoides Zone), offshore. This variation may be reflecting differences at the subspecific level. The occurrences of O. excavata in the Yukon probably relate temporally to their P. amorphognathoides group; the affinity of the Yukon subspecies and O. excavata of Aldridge and Mabillard (1981) are not clear.

The Llandovery shallow water; high energy or littoral environments seem to be characterized by Icriodella (Aldridge, 1976; Nowlan, 1983b) and Distomodus (Le Fèvre, et al., 1976). Cooper (1975) noted that platform elements (presumably of Distomodus and Icriodella) are more abundant in beds that contain fewer elements of P. unicostatus and W. curvatus, species which dominate the rest of his Brassfield Limestone section in southern Ohio. McCracken and Barnes (1981a) noted that the genera found in Ordovician littoral environments commonly displayed similar morphological features and suggested that further study may confirm that Icriodella and Distomodus are relatively nearshore genera. Icriodella is rare in Yukon shale facies, but species of Distomodus are common.

The Anticosti Island study of Uyeno and Barnes (1983), showed that a change in some conodont faunas and zones approximately coincide with lithic changes. The older of their two faunas, the D. staurognathoides fauna occurs in members 1, 3 and lower member 4 of the Jupiter Formation. No comment on ecology can be made since the element yields in this fauna are low.

The younger Ozarkodina aldridgei fauna of Uyeno and Barnes (1983) is found in the upper half of Member 4 (low energy, open marine environment) and includes the nominal species, Dapsilodus obliquicostatus (Branson and Mehl), Decoriconus, P. unicostatus, P. recurvatus, Pseudooneotodus and Walliserodus.

W. sancticlari Cooper occurs with P. unicostatus in lower parts of the Jupiter Formation of Anticosti and has scattered occurrences and low abundances throughout the upper part of the Jupiter and the lower Chicotte formations. These Chicotte strata, which also contain relatively abundant P. unicostatus, were interpreted as indicating the beginning of shallowing phase (Uyeno and Barnes, 1983).

The lithologically similar strata of the succeeding Chicotte Formation of Anticosti includes Apsidognathus, Carniodus, Distomodus, Oulodus?, Ozarkodina, P. celloni (Walliser) and P. pennatus procerus (Walliser) (Uyeno and Barnes, 1983).

Nowlan (1983b) also studied Llandovery faunas from eastern Canada. His fauna from the Chaleurs Bay region, Gaspé, Québec, is dominated by Panderodus but characterized by Apsidognathus, Pterospathodus (but not P. amorphognathoides or P. celloni), and Ozarkodina. Strata bearing this fauna were thought to represent an intermediate to nearshore environment.

The scarcity of P. celloni and Carniodus carnulus (Walliser) from eastern Canada is probably a result of conditions that were too shallow (Nowlan, 1983). Aldridge (1976) and Le Fèvre, et al. (1976) concluded that P. celloni is more common in strata of the more offshore environments.

The dominance of the Yukon *Oulodus fluegeli* - *Dapsilodus obliquicostatus* assemblage by these two species and *Walliserodus* n. sp. A, and the less common occurrence of *W. sancticlari*, certainly reflects environmental factors, albeit unknown. Barrick (1981) drew an analogy of *D. obliquicostatus* to planktic foraminifers, suggesting that this species may have been one of high productivity and also one that favoured offshore or oceanic environments.

However, *O.*? *fluegeli* subsp. A, a synonym of *O. f. petilus* (Nicoll and Rexroad) herein, is found along with *Aulacognathus*, *Distomodus*, *Icriodella*, *Ozarkodina* and *P. unicostatus* in a shallowing phase of Anticosti strata (Uyeno and Barnes, 1983). *D. obliquicostatus* is absent from these Anticosti beds. Strata immediately above lack *O.*? *f.* subsp. A but contain *D. obliquicostatus*. In the succeeding Chicotte Formation, *O.*? *fluegeli* subsp. A is rarer and occurs with *Astropentagnathus*, *Carniodus*, *Distomodus*, *Ozarkodina*, *Pterospathodus amorphognathoides*, *P. celloni*, *P. pennatus procerus* and *Walliserodus sancticlari* Cooper; these beds lack *Dapsilodus*. The lithologies of both intervals are similar suggesting similar depositional environments.

O. fluegeli of Yukon is rarer in an overlying sample that includes species of *Astropentagnathus*, *Distomodus*, *Oulodus* and *Pterospathodus*; the conditions represented by this sample are uncertain.

Cooper (1976) lists conodont distribution through 5 samples of the St. Clair Limestone of southern Illinois. These strata have an unconformable base; they grade upwards into thin bedded siltstones of the Moccasin Springs Formation. The basal conodont sample is dominated by D. obliquicostatus (herein calculated to be about 87 percent of total elements); the remaining fauna includes Ozarkodina excavata, P. unicostatus and W. sancticlari. These relationships are maintained in the succeeding 3 samples. At the top of the St. Clair Limestone, D. obliquicostatus is reduced (about 36 percent) with a corresponding increase in O. excavata (about 10 percent) and P. unicostatus (about 44 percent).

Cooper (1976) did not make an environmental interpretation of these strata and faunas but estimated the age as being near the Llandovery - Wenlock boundary. What is notable is the inverse relationship in the occurrences of D. obliquicostatus, and O. excavata / P. unicostatus: D. obliquicostatus dominates in lower strata, the latter pair of taxa in upper, more clastic-rich strata. The age corresponds to that of the level where O. excavata dominated the nearshore environments, as studied by Aldridge and Mabillard (1981). The occurrences of Dapsilodus and Panderodus species compare to models discussed above, that is, D. obliquicostatus is a relatively offshore taxon, P. unicostatus, a more nearshore species. W. sancticlari comprises less than 3 percent of the faunas throughout the section and is slightly more common in the lowest two samples. The abundance of this species is probably too low to make a conclusive statement about its distribution.

In spite of the seemingly exclusive occurrence of *O.? fluegeli* and *D. obliquicostatus* in Anticosti strata (Uyeno and Barnes, 1983), I prefer to follow the interpretations of Aldridge and Mabillard (1981), and Barrick (1981) for *D. obliquicostatus*, and suggest that the *O.? fluegeli*-*D. obliquicostatus* assemblage inhabited a more offshore environment than the younger *Astropentagnathus* - *Pterospathodus* fauna. Even in its most prolific interval on Anticosti, *O.? f.* subsp. A comprises less than 3 percent of the fauna. The paleoecology of the *O.? fluegeli* faunas of Anticosti and Yukon are likely not comparable.

Environmental interpretations of taxa are summarized as follows. The Ordovician *Panderodus gracilis* and Silurian *P. unicostatus* may have been widely distributed, but the majority of studies cited above suggest that they are characteristic of shallower, rather than deeper, or more offshore environments.

Dapsilodus obliquicostatus has peaks in abundance in shelf edge areas of Wales. Barrick (1981) suggested that this species may have been highly prolific in offshore environments. It is relatively rare in nearshore environments of Anticosti Island but common in Yukon.

Walliserodus curvatus is present in Yukon and rare in the Welsh Borderland; its occurrence is relatively consistent through the Llandovery of Anticosti Island although it is slightly more common in what may be more offshore environments. In Ohio, it is uncommon where *Distomodus* and *Icriodella* are present. *W. sancticlari* and *W.* n. sp. A are not well known; the dominance of the latter in a fauna that contains abundant *D. obliquicostatus* may suggest that it preferred more offshore environments.

Strata of the relatively nearshore environments of Anticosti include *Apsidognathus*, *Astropentagnathus*, *Carniodus*, *Distomodus*, *Pterospathodus celloni* and *P. pennatus procerus*. *Apsidognathus* occurs in the more nearshore group in the Welsh Borderland and is rare in Yukon. Llandovery shallow water, high energy environments seem to be characterized by *Distomodus* and *Icriodella*; the former genus and *Astropentagnathus* are common in some Yukon faunas. Intermediate to nearshore environments in Gaspé are dominated by *Panderodus* but also contain *Apsidognathus* and species of *Pterospathodus* (exclusive of *P. amorphognathoides*, *P. celloni*).

The relative lack of *Carniodus* and *P. celloni* in eastern Canada suggests that they preferred offshore environments. Basinal facies in Wales are characterized by *Carniodus* and *P. amorphognathoides*. *Carniodus*, *P. celloni* and *P.* n. sp. A (similar to *P. amorphognathoides*) occur in Yukon faunas.

The distribution of Ozarkodina excavata in Wales varies through time: middle Llandovery - variably distributed across the shelf; late Llandovery - nearshore; early Wenlock - offshore. This may be a reflection of differences at the subspecific level. The affinity of the Yukon subspecies to the taxon from the Welsh Borderland is not clear.

4.3.2 Provincialism

Ordovician conodontophorids show a high degree of provincialism; this is reflected in differences of element morphology even though homologous apparatus types are present in different provinces (see Barnes, et al., 1979). The North American Midcontinent Conodont Province, or more succinctly, American Province, and the North Atlantic or European Province, each experienced periodic incursions of taxa from the other province but they retained their distinctiveness throughout most of the Ordovician.

Provincialism in the Llandovery is less obvious and probably was not so well documented or defined as in the Ordovician. The following discussion on provincialism draws primarily on the interpretations of the following authors: Barnes, et al. (1973, 1979), Bergström (1971, 1983), and Sweet, et al. (1971) for the Ordovician; Aldridge (1972), and Barnes, et al. (1973) for the Silurian.

On the North American craton, the American Province faunas occupy the interior of the continent. Marginal areas commonly contain a mixture of both the American and European provinces.

This present study, in conjunction with data from the southern Mackenzie Mountains (Tipnis, et al., 1978; Nowlan and McCracken, 1984; Nowlan, et al., MS), provides the opportunity to view conodont provincialism in a marginal area of the North American craton. These three studies provide information from carbonate and shale facies, and from locations both close to, and distant from, one another.

Tipnis, et al. (1978) reported on Ordovician faunas in strata of both lithofacies in the southern Mackenzie Mountains. The dominantly shale Arenig to Llandeilo strata of the Road River Formation yielded the following European Province taxa: Cordylodus (=Spinodus), Drepanoistodus, Eoplacognathus, Periodon, Polyplacognathus (=Cahabagnathus), Protopanderodus and Pygodus. Walliserodus is present and also probably part of this province. The only American Province taxon is Phragmodus. Late Caradoc faunas from the Road River Formation include the European Province genera Amorphognathus, Drepanoistodus, Periodon, Protopanderodus (all European), and the American Province genus Plectodina.

Middle Ordovician and younger strata of the correlative carbonate facies, the Sunblood and Whittaker formations, yielded the following American Province genera:

Aphelognathus, *Belodina*, *Erismodus*, *Leptochirognathus*, *Phragmodus*, *Plectodina* and *Scyphiodus*. European Province genera are: *Amorphognathus*, *Belodella*, *Drepanodus*, *Drepanoistodus*, and *Prioniodus* (Tipnis, *et al.*, 1978).

The succeeding Late Ordovician strata of the Whittaker Formation contain conodonts studied in detail by Nowlan and McCracken (1984) and Nowlan, *et al.* (MS). About half of this fauna is represented by *Panderodus*. American Province taxa include *Aphelognathus*, *Belodina*, *Oulodus*, *Phragmodus* and *Plectodina*. Taxa from the European Province comprise *Drepanoistodus*, *Protopanderodus*, *Scabbardella*, *Walliserodus* and rare elements of what may be *Amorphognathus*.

In the fine clastic facies of northern Yukon, Middle Ordovician faunas studied herein include the following European Province taxa: *Belodella*?, *Periodon* and *Protopanderodus*, representing the more nearshore environments, and *Cordylodus*, *Drepanoistodus*, *Eoplacognathus*?, *Oepikodus*?, *Polonodus*?, *Pygodus* and *Spinodus*, which occupied the more offshore environments (Barnes *et al.*, 1973; Bergström, 1983). Rare constituents of the American Province include *Phragmodus* and *Plectodina*.

Late Ordovician faunas from the Yukon study area include genera from both provinces. *Amorphognathus* and *Scabbardella* are European Province taxa, as are probably *Besselodus*, *Gamachignathus* and *Walliserodus amplissimus* (Serpagli). Genera of the American Province include

Belodina, *Oulodus*, *Plectodina*, and possibly *Noixodontus*.

In the middle and early late Llandovery of North America, two provinces are recognized: northeastern and southeastern. At least two faunal provinces of late middle and early late Llandovery age occur in the Welsh Borderland. These faunas suggest correspondence between the two Welsh and North American provinces (Barnes, *et al.*, 1973). Aldridge (1972, p. 158) noted three geographically distinct areas in the upper Llandovery (upper *P. celloni* Zone) strata of the Welsh Borderland.

The typical European Llandovery genera *Apsidognathus*, *Astropentagnathus* and *Aulacognathus* are rare in North America whereas others such as *Carniodus*, *Distomodus*, *Icriodella*, *Pterospathodus*, *Walliserodus* (Barnes, *et al.*, 1973), and probably *Dapsilodus* and *Decoriconus* are more widespread.

North American occurrences of *Apsidognathus* are in the eastern region (see Helfrich, 1980; Nowlan, 1981b, 1983b; Uyeno and Barnes, 1983) and in northern Yukon (herein). *Astropentagnathus* has been recorded from Nevada (Klapper and Murphy, 1975), western United States (Miller, 1976, 1978) and is common in the present study area. *Aulacognathus* occurs in the central and western United States, eastern Canada and Yukon.

Other significant Yukon genera include *Carniodus*, *Dapsilodus*, *Distomodus*, *Oulodus*, *Ozarkodina*, *Pterospathodus* and Walliserodus. Icriodella is noticeably absent, except for extremely rare fragments.

4.3.3 Summary of Yukon Conodont Paleoecology

Silurian taxa from Yukon include Distomodus, which is commonly regarded as a nearshore taxon. Apsidognathus, Astropentagnathus and P. unicostatus may also represent nearshore environments. In Yukon, Apsidognathus is rare, Astropentagnathus is common to faunas that also contain Distomodus, and P. unicostatus is a relatively minor component of all faunas. The similar Ordovician P. gracilis dominates the more nearshore platform margin carbonate environment in N.W.T. The distribution of Panderodus in Yukon and N.W.T. support the nearshore environmental model for P. gracilis and P. unicostatus.

Carniodus and Pterospathodus celloni probably preferred more offshore environments. P. n. sp. A is possibly a precursor to P. amorphognathoides, a species which characterizes offshore strata of the Welsh Borderland.

Walliserodus is represented in Yukon by four species: W. sancticlari and the Ordovician W. amplissimus are rare and as yet not well known; W. curvatus is not common in Yukon, but is a consistent species in Anticosti Basin and may have preferred more offshore environments; and W. n. sp. A, which is unknown outside of Yukon. Its strong co-occurrence with Dapsilodus obliquicostatus may, however, indicate that it was an offshore taxon.

Dapsilodus obliquicostatus dominates faunas that have low abundances of *P. unicostatus*, *Distomodus* and *Icriodella*, and probably represents an offshore species. Its domination of a Yukon fauna, along with *Oulodus fluegeli* and *Walliserodus* n. sp. A suggests an offshore interpretation for the *O. fluegeli*-*D. obliquicostatus* assemblage.

Taxa from both Ordovician conodont provinces are recognized in Yukon and N.W.T. Those from the American Province are more common in more nearshore platform margin carbonates; taxa from the European, in the more offshore clastic sequences.

The Silurian faunas are characterized by taxa from both North American and European localities. These taxa include *Astropentagnathus*, *Carniodus*, *Distomodus* and species of *Oulodus*, *Ozarkodina* and *Pterospathodus*.

In a most simplistic model, the Road River shale facies strata probably represent a relatively offshore, low energy, deep water environment. The lack of domination by *Panderodus* may reflect this (sensu the evidence of McCracken and Barnes, 1981a; McCracken and Nowlan, 1984).

Some occurrences can be shown to be in mass flow deposits and thus attributable to reworking of shallow and deep water elements, but others cannot. Other possible reasons for the apparent anomaly between offshore or "deeper water", strata and conodonts representing moderate to shallow depths or nearshore environments could be that either the environmental influence was less than is currently thought, or the fine clastic strata might not necessarily be extremely offshore or deep.

CHAPTER 5 -- BIOSTRATIGRAPHY

5.1 Ordovician-Silurian Biostratigraphic Schemes

The conodont fauna of Yukon is diverse, being represented by taxa ranging in age from Early Ordovician to Late Silurian, and by species from both conodont faunal provinces (see Chapter 4.3.0 - Conodont Paleontology). A combination of several biostratigraphic schemes are therefore used (Figs. 10-13). In this chapter, ranges in parentheses and preceded by an "equals" symbol are interpretations derived from published reports, otherwise ranges are directly from the source cited.

Faunas A to E of Ethington and Clark (1971) comprise the Lower Ordovician (Canadian) of North America. The Whiterockian Series (Ross, et al., 1982b) to Richmondian Stage (Middle - Upper Ordovician) are represented by the North American Midcontinent Province faunas 1-12 of Sweet, et al. (1971). A sequence of formal biostratigraphic units, the Pygodus serrus to Amorphognathus ordovicicus zones, was developed by Bergström (1971) for the Middle to Upper Ordovician (Aseri to Ashgill) of the North Atlantic Province. Most recently, McCracken and Barnes (1981a, 1981b) proposed a post-Richmondian, Fauna 13 for the uppermost Ordovician (Gamachian) strata of the Anticosti Basin in eastern Canada.

The Silurian (=Llandovery to Ludlow) zonation for the Carnic Alps of Walliser (1964) has been adapted and modified for North America by Rexroad (1967), Nicoll and Rexroad (1969), Pollock, et al. (1970), Barrick and Klapper (1976), and for the Welsh Borderland by Aldridge (1972). McCracken and Barnes (1981a, 1981b) added the Oulodus? nathani Zone to represent Silurian strata underlying the hitherto lowest Llandovery Distomodus kentuckyensis Zone.

These principal biostratigraphic schemes have been further discussed or modified by Barnes, et al. (1976), Bergström (1983), Sweet and Bergström (1976), (all Ordovician), and Cooper (1975, 1980), Helfrich (1975), Schönlaub (1971), Uyeno and Barnes (1981, 1983), (all Silurian).

Cooper (1980) summarized Silurian conodont zonation and proposed six appearance, and two extinction, datum planes. I advocate futher use of these datum planes and herein propose a new biohorizon (Appendix B), based on a re-interpretation of Fauna 13 and first appearance of Gamachignathus ensifer McCracken, et al.

Jackson and Lenz (1962) established a graptolite zonal scheme when they defined the Road River Formation, and compared their scheme with that of the British Isles. The graptolite biostratigraphic succession used herein (Figs. 10, 11) is a composite one based on the stratigraphic intervals of the following reports: Tremadoc - Gedinne (Lenz and Pedder, 1972); Tremadoc - Ashgill (Chen and Lenz, 1984); Arenig - Llanvirn (Lenz and Jackson, in press); Llandeilo - Ashgill (Lenz and Chen, 1985); Ashgill - early Llandovery (Lenz and McCracken, 1982); Llandovery (Lenz, 1979, 1982a); and Wenlock (Lenz, 1978, 1980).

Published lists of graptolite taxa and their levels from the measured sections studied herein include those of Lenz and Pedder (1972: section 1), Lenz and McCracken (1982: sections 1-5), and Lenz (1982a: sections 1, 3-5, 7). The reports by Lenz (1979: sections 1-5, 7; 1980: section 5; 1982a: section 2) and Lenz and Chen (1985: section 3) tabulate graptolite taxa and their stratigraphic distributions. Graptolite identifications, collection levels and zones that are from published sources are referenced below. All other identifications of graptolites are from unpublished data of A.C. Lenz.

Some workers have previously combined the conodont and graptolite biostratigraphic schemes; notably these include: Walliser (1964), Silurian; Bergström and Cooper (1973), Lower Ordovician; Barnes, et al. (1976, 1981), Ordovician; Landing (1976), Arenig; Sweet and Bergström (1976), Middle to Upper Ordovician; and Repetski and Ethington (1977), Lower to Middle Ordovician.

A correlation chart for the Ordovician of the United States provided in Ross, et al. (1982a, Sheet 1) illustrates the American conodont and graptolite schemes and compares these with the British and Australian graptolite zones.

5.2 Yukon Conodont Assemblages and Zones

The major conodont faunas from the Richardson Mountains are discussed below as formal established biozones and informal assemblages. Some assemblages, including the three identified by number, represent faunas mixed through debris flows. These assemblages are not intended to be used as formal biostratigraphic units or paleoecologic communities but rather they are simply associations of taxa. The sections and sample levels under the heading "stratum" or "strata" are those that form the basis of the discussion.

5.2.1 Assemblage 1

Age: late Arenig-late Llandeilo on basis of conodonts.

Stratum: Tetlit Creek, section 7, 39m.

Significant conodont taxa: *Periodon aculeatus* Hadding, *Protopanderodus* sp. aff. *P. varicostatus* (Sweet and Bergström).

Associated taxa: *Coelocerodontus*? sp. A, *Drepanoistodus suberectus* (Branson and Mehl)?, *D.*? sp. cf. *D.*? *venustus* sensu Löfgren, *Panderodus gracilis* (Branson and Mehl), *Phragmodus* sp. A, *Plectodina* sp. A, *Strachanognathus parvus* Rhodes, *Walliserodus*? sp. A.

Associated graptolite faunas: Arenig-Llanvirn, base of section; *Nemagraptus gracilis* Zone (late Llandeilo-early Caradoc), 75m (unpublished data).

This poorly preserved and corroded conodont fauna occurs in a mass flow unit of angular-pebble conglomerate. The identifications are somewhat tentative due to the poor preservation. Most taxa are either undiagnostic or unidentifiable.

Drepanoistodus? cf. *D*.? *venustus* sensu Löfgren has a range of middle Arenig to early middle Llanvirn. Both *Periodon aculeatus* and *Protopanderodus* sp. aff. *P*. *varicostatus* are found in the late Arenig; the former ranges to latest Llandeilo, the latter to late Llanvirn (Löfgren, 1978).

Considering the state of preservation of this fauna, the identity of the *Periodon* species is probably the most reliable for determining the age; hence I suggest an age within late Arenig to late Llandeilo. The occurrence of elements of *D*. *suberectus*, *Phragmodus* and *Plectodina* may indicate a younger, more precise lower age limit to the time of deposition. Sweet (1984) records early forms of *Phragmodus* from the *P*. "pre-*flexuosus*" chronozone (*E*. *suecicus*-*P*. *serrus* zones), and *D*. *suberectus* and *Plectodina* from the *P*. (=*Cahabagnathus*) *friendvillensis* chronozone (*P*. *serrus*). These elements could indicate a possible reworking of the older Arenig-Llandeilo taxa, providing further evidence in support of mass-flow deposition.

5.2.2 "*Cordylodus*" *horridus*-*Spinodus spinatus* assemblage

Age: late Arenig-early Llanvirn; with reworked Early? Ordovician taxa.

Stratum: Rock River, section 4, 13m.

Significant Conodont Taxa: "Cordylodus" horridus Barnes and Poplawski, Diaphorodus? sp. A, Drepanoistodus sp. cf. D. basiovalis (Sergeeva), Prioniodus (Oepikodus)? sp. A.

Associated taxa: Eoplacognathus? sp. A, Periodon aculeatus Hadding, Polonodus? sp. A, Protopanderodus robustus (Hadding), P. sp. aff. P. varicostatus (Sweet and Bergström), Spinodus spinatus (Hadding), Walliserodus ethingtoni (Fahraeus).

Associated graptolite faunas: glossograptids; 56m above are late Llandeilo or Caradoc graptolites (unpublished data).

The sample is from a unit that has evidence of redeposited sediments: graded, slumped and truncated beds. The conodonts are poorly preserved and hence some identifications are tenuous and are of limited biostratigraphic value. Two taxa are regarded as probably of Early Ordovician age.

Taxa also present but discussed under the Pygodus serrus Zone below comprise Drepanoistodus sp. cf. D. basiovalis, Periodon aculeatus, Protopanderodus robustus, P. sp. aff. P. varicostatus and Walliserodus ethingtoni.

The age and distrubution of "Cordylodus" horridus has been summarized by Nowlan and Thurlow (1984); its age is indicative of the early Whiterockian (latest Arenig - early Llanvirn). Polonodus ranges from late Arenig to middle Llanvirn (Löfgren, 1978; Bergström, 1983). P.? sp. A differs from all previously described species so the range cannot be more precise than that for the genus.

The two taxa suggestive of the Early Ordovician are Diaphorodus? sp. A and Prioniodus (Oepikodus)? sp. A. D.? sp. A is comparable to species ranging in age from Faunas C through E of the North American Midcontinent Province. Repetski (1982) correlates the oldest of these with the AII subdivision of the Estonian sequence (=Tremodoc; Lindström, 1971). Berry (1976) and Barnes, et al. (1976, 1981) place Fauna E within the Lower Ordovician strata (upper Canadian; Arenig).

P. (O.)? sp. A is similar to P. (O.) communis (Ethington and Clark) from Fauna E and Fauna 1 (=late Canadian-early Champlainian) and to a younger species of P. (Baltoniodus) that has a range of early to middle Llanvirn. (see Systematic Paleontology for further discussion).

Although this latter range is within that for most of the taxa present in the sample I suspect a closer affinity to P. (O.) communis and suggest that the presence of this species is the work of sedimentary transport.

The platform elements of Eoplacognathus? sp. A are fragments and cannot be identified, hence are of little biostratigraphic value. The genus is known to range from late Arenig to early Caradoc (Bergström, 1983).

S. spinatus occurs in late Llandeilo of Sweden (Lamont and Lindström, 1957), Middle Ordovician (late Llandeilo) of Alabama (Sweet and Bergström, 1962), early Middle Ordovician of Texas (Bradshaw, 1969) and Québec (Barnes and Poplawski, 1974), early Llanvirn, Québec (Uyeno and Barnes, 1970), early Caradoc, New Brunswick (Nowlan, 1981a), and late Arenig-early Llanvirn, Road River Formation, N.W.T. (Tipnis, et al., 1978).

The conodonts, excluding the forms typical of Early Ordovician form, suggest a late Arenig to early or middle Llanvirn age for this fauna. The occurrence of "C." horridus suggests an upper age limit of early Llanvirn.

5.2.3 Pygodus serrus Zone

Age: middle-late Llanvirn.

Strata: upper Peel River, section 3, 358.4 - 362.9m.

Significant conodont taxa: Belodella? sp. aff. B. nevadensis (Ethington and Schumacher), Pygodus serrus (Hadding), P. sp. cf. P. serrus (Hadding).

Associated conodont taxa: Dapsilodus? sp. C, Drepanoistodus sp. cf. D. basiovalis (Sergeeva), Panderodus sp. cf. P. feulneri (Glenister), P. sp. cf. P. gibber Nowlan and Barnes, P. sp. cf. P. gracilis (Branson and Mehl), Periodon aculeatus Hadding, Protopanderodus parvibasis Löfgren, P. robustus, P. sp. aff. P. varicostatus (Sweet and Bergström), P. sp. A, Scalpellodus? viruensis Löfgren, Walliserodus ethingtoni (Fahraeus).

Associated graptolite faunas: sampled unit (4.5m) is within Paraglossograptus etheridgei Zone of Lenz and Pedder, 1972 (=upper P. tentaculatus Zone of Lenz and Jackson, in press); top of unit is 18.3m below first occurrence of "P. etheridgei or Glyptograptus teretiusculus Zone" of Lenz and Pedder (ibid.) (=Diplograptus decoratus) Zone, 33.6m below G. teretiusculus (=G. euglypus) Zone, and 47.3m below ?Nemagraptus gracilis (=N. gracilis) Zone; base of unit is 4.3m above first occurrence of the upper P. tentaculatus Zone (as indicated by abundant sinograptids), 59.5m above the Isograptus cauduceus Zone (first occurrence of lower P. tentaculatus Zone, as indicated by the first occurrence of I. caduceus nanus Ruedemann) (Lenz and Pedder, 1972; Lenz and Jackson, in press).

The lower boundary of this zone is limted at its base by the first occurrence of Pygodus serrus and at its upper level by the first appearance of the nominal species of the overlying P. anserinus Zone (Bergström, 1971). Elements of Eoplacognathus are not present, thus the subdivisions of the P. serrus Zone cannot be applied.

Bergström (1971) believed the base of the P. anserinus Zone to be equivalent to the base of the type Llandeilo. He later (1983) revised this interpretation and suggests that the base of the Llandeilo lies within the younger of the two subzones of the P. anserinus Zone. Thus both the lower part of the P. anserinus, and upper part of the P. serrus zones are late Llanvirn in age.

Both of the above species of *Pygodus* can occur in the lower part of the *P. anserinus* Zone; this does not create a problem in distinguishing between the zones since the *P. anserinus* Zone is a first-appearance range zone (sensu Hedberg, 1976). However, forms that are morphologically transitional can also occur near the zonal boundary, and in fact, the holotype of *P. anserinus* Lamont and Lindström was regarded as a phylogenetically primitive form by Bergström (1971, p. 149). Transitional forms have been interpreted as evolutionary intermediates and used to mark the base, or proximity to the base, of the *P. anserinus* Zone (e.g. Nowlan, 1981a, p. 7). Alternatively, some of these temporally transient forms may in fact reflect ecologic controls (see Fahraeus and Hunter, 1981; Fahraeus, 1982).

The Yukon P[illegible] cf. *P. serrus* is a morphologically transitional form; with the limited Yukon data, however, I cannot support either the evolutionary or ecological model. It would be a fortunate coincidence that the one sample from this 4.5m interval was precisely from the level of evolutionary transition. The sample cannot be regarded as being younger than earliest *P. anserinus* zone. Since *P. anserinus* s.s. is absent from this fauna, assignment to the older *P. serrus* Zone is preferred.

Belodella? sp. aff. *B.? nevadensis* includes *B. nevadensis* sensu Harris, *et al.* (1979), a species found in the Antelope Valley Limestone in Nevada, which contains conodonts indicative of Faunas 4-5 (=?Llanvirn). This formation at a more northern locality contains taxa of the P. serrus Zone; B. nevadensis sensu Harris, et al. is also present at this northern Nevada site. B. nevadensis s.s. occurs with a fauna suggestive of either the uppermost P. serrus or lowermost P. anserinus zones in the Copenhagen Formation, the stratigraphic unit overlying the Antelope Valley Limestone (Harris, et al., 1979).

Although the interpretations of two biostratigraphically different forms of B.? nevadensis s.l. is prefered herein, it is possible that they may be shown to be equivalent. If so, a combined range is acceptable; this range is compatible with that of P. serrus.

Other Belodella? species that are quite similar in morphology to B.? nevadensis s.l. are B. jemtlandica Löfgren from Sweden (late Arenig? or early Llanvirn, to middle Llanvirn, Löfgren, 1978), and B. sp. B. s.f. of Tipnis, et al. (1978).

Belodella sp. B s.f. is listed by Tipnis, et al. (1978, Table IV) as being Llandeilo in age but elsewhere (ibid., fig. 3, p. 54) they suggest that the fauna belongs to the upper part of the P. serrus Zone due to the occurrence of the nominal species and Polyplacognathus friendvillensis Bergström (=Cahabagnathus friendvillensis, in Bergström, 1983). Bergström (1983, p. 50) notes that the known range of the latter species approximates that of the *P. serrus* Zone. The collection of Tipnis, *et al.* is therefore, unequivocally regarded herein as late Llanvirn; further reference to their fauna and its age is shown as "Llandeilo (=late Llanvirn)".

The ages of some of the more significant accessory taxa are as follows. *Drepanoistodus basiovalis* was reported from the middle Arenig to ?early middle Llanvirn, and questionably from the middle Llanvirn of Sweden (Löfgren, 1978). Barnes and Poplawski (1973) record this species from the early Middle Ordovician (early Llanvirn; middle Whiterockian) of Québec. They also identified *D. basiovalis?* from Lower Ordovician (Lower Arenig) strata. Workum, *et al.* (1976) found *D. basiovalis* in a fauna from Akpatok Island, N.W.T. This fauna suggests an age equivalent to that of Fauna 2, which was equated with the middle Whiterockian (early Llanvirn).

Tipnis, *et al.* (1978, Tables III-V, XV) list *D. basiovalis* from upper Arenig to Caradoc strata of the Road River Fomation, and "Fauna 9 and/or 10" (=Caradoc) of the Sunblood? and Whittaker formations, southern Mackenzie Mountains, N.W.T. Nowlan (1981a) recovered this taxon from New Brunswick in a fauna containing forms diagnostic only of a middle Arenig to Llanvirn age.

Periodon aculeatus ranges from latest Arenig or earliest Llanvirn to latest Llandeilo (Löfgren, 1978). Tipnis, *et al.* (1978) report *P. aculeatus* and *P.* cf. *P.*

aculeatus from Llandeilo (=upper Llanvirn) and upper Arenig to lower Llanvirn strata respectively, of the Road River Formation.

Protopanderodus parvibasis is not well known outside of Sweden; the Yukon location is apparently the only other definite occurrence of the taxon. Löfgren (1978) found this species in lower Llanvirn strata of Sweden and further suggested it may be present in Kunda and Aseri (=upper Arenig-middle Llanvirn) strata of Estonia. P. robustus ranges from the Kundan (=late Arenig) to, at least, the late Llandielo and possibly the Caradoc (Löfgren, 1978). Nowlan and Thurlow (1984) report this species from Whiterockian (uppermost Arenig-lower Llanvirn) strata of Newfoundland.

P. varicostatus s.l. is a common species present in the middle Ordovician of Europe and North America. Tipnis, et al. (1978) record the species from upper Arenig to Llandeilo (=upper Llanvirn) of the Road River Formation, N.W.T.

Protopanderodus sp. A is comparable to form species of Bradshaw (1969) from the Middle Ordovician of the Marathon Basin in Texas. Drepanodus arcuatus Pander sensu Landing (1976), questionably assigned herein to this species, is from the Prioniodus evae Zone of the Taconic Allochthon in New York. Landing's younger P. cooperi (Sweet and Bergström), equated in part with P. sp. A, is from the lower Paraglossograptus tentaculatus Zone and is assigned an age of latest Arenig or Early Llanvirn. The age of P. cooperi of

Landing is in accordance with the fauna from the Peel River sample.

Scalpellodus viruensis was identified in lower middle Llanvirn and higher strata of Sweden by Löfgren (1978). She also suggested it may occur in Kunda to Uhaku (=?upper Arenig-lower Llandeilo) strata of Estonia.

Ages of occurrences of Walliserodus ethingtoni include early Llanvirn and younger in Sweden (Löfgren, 1978), late Early to Middle Ordovician in Newfoundland (Fahraeus, 1970; Bergström, et al., 1974; Bergström, 1979b; Stouge and Boyce, 1983), P. anserinus Zone (=late Llanvirn - Llandeilo) of the Ouachita Mountains, western United States (Repetski and Ethington, 1977), and Llandeilo (=late Llanvirn) of the N.W.T. (Tipnis, et al., 1978).

Lack of definitive taxa from the subzones of the P. serrus Zone, precludes an age determination more precise than middle to late Llanvirn.

5.2.4 Assemblage 2

Age: Middle Caradoc-Late Ashgill

Strata: Rock River, section 4; 207, 225, 228m.

Significant conodont taxa: Belodina confluens Sweet, Protopanderodus insculptus (Branson and Mehl), Pseudobelodina? dispansa (Glenister), Scabbardella altipes subsp. B Orchard, Walliserodus amplissimus (Serpagli).

Associated taxa: Paroistodus sp. A Nowlan and

McCracken, MS, *Strachanognathus parvus* Rhodes.

Associated graptolite faunas: Llandeilo-Caradoc, 56m; *Dicellograptus ornatus* Zone, 220m; *Paraorthograptus pacificus* Zone, 232,235m; *Atavograptus atavus* or *Lagarograptus acinaces* Zone, 241m (Lenz and McCracken, 1982; unpublished data).

Three samples of mass flow deposits yielded a few coniform elements. The thin bed at 207m contains silicified bioclastic debris; the other samples are from a 9m unit composed of conglomerate and calcisiltite beds. Unlike other mass flow deposits in this study, there is no indication of a mixing of a much older conodont fauna with one coincident with the time of deposition.

None of the conodont taxa listed above are particularly diagnostic. The ages and occurrences of these taxa are discussed in detail under Fauna 12 below. The suggested age from this part of the Rock River section is middle Caradoc to late Ashgill, or Edenian to Richmondian; this is in agreement with the age limits indicated by the graptolite faunas.

5.2.5 Upper Fauna 12

Age: late Richmondian (late Ashgill).

Strata: Blackstone River, section 1, 50.3m; upper Peel River, section 3, 452.6m; Rock River, section 4, 228, 235m.

Significant taxa: *A. ordovicicus* Branson and Mehl, *Gamachignathus ensifer* McCracken, *et al.*, *Noixodontus girardeauensis* (Satterfield), *Oulodus rohneri* Ethington and Furnish.

Associated taxa: *Belodina confluens* Sweet, *Besselodus borealis* n. sp. Nowlan and McCracken, MS, *Drepanoistodus suberectus* (Branson and Mehl), *Eocarniodus gracilis* (Rhodes), *Icriodella superba* Rhodes?, *O. ulrichi* (Stone and Furnish), *Panderodus gibber* Nowlan and Barnes, *P. gracilis* (Branson and Mehl), *Paroistodus*? sp. A Nowlan and McCracken, MS, *Plectodina florida* Sweet, *P. tenuis* (Branson and Mehl), *Protopanderodus insculptus* (Branson and Mehl), *P. liripipus* Kennedy, *et al.*, *Pseudobelodina*? *dispansa* (Glenister), *P.* sp. cf. *P. quadrata* Sweet, *P. vulgaris vulgaris* Sweet, *Scabbardella altipes* subsp. B Orchard, *Strachanognathus parvus* Rhodes, *Walliserodus amplissimus*, N. gen. A n. sp. A.

Associated graptolite faunas: Blackstone River, 13.7m above *Paraorthograptus pacificus* Zone, 3m below *Glyptograptus persculptus*? Zone, 8.5m below *Parakidograptus acuminatus* Zone; upper Peel River, within *P. pacificus* Zone, 1.9m below *P. acuminatus* Zone; Rock River, Dicellograptus ornatus Zone at 220m, P. pacificus Zone at 232, 235m, Atavograptus atavus or Lagarograptus acinaces Zone at 241m (Lenz and McCracken, 1982; unpublished data).

Not all of the conodont taxa listed above occur in all three sections. Of the more significant species, A. ordovicicus and G. ensifer occur in the Blackstone and Peel River sections; N. girardeauensis and O. rohneri are found only at Blackstone River. The Rock River fauna is not diagnostic, comprising only rastrate and coniform elements.

The A. ordovicicus Zone of the North Atlantic Province is marked by the first appearance of the nominal species and, as originally defined, was thought to be as old as latest Caradoc (Bergström, 1971). Orchard (1980) placed the boundary of this and the older A. superbus Zone within the lower Cautleyan Stage of the Ashgill but Bergström (1983, p. 51), after studying Orchard's material, believed the evidence for this precision was inconclusive. He stated (ibid.) however, that the zonal boundary is in the early Ashgill. The A. ordovicicus Zone encompasses the upper part of Fauna 11, and Fanua 12 of the North American Midcontinent Province. The exact nature of these two faunas is somewhat obscure and thus some discussion is warranted.

Fauna 12 is distinguished by A. ordovicicus Branson and Mehl, Belodina (=Pseudobelodina) inclinata (Branson and Mehl), Oulodus ulrichi (Stone and Furnish), Panderodus angularis (Branson, Mehl and Branson), P. staufferi

(Branson, Mehl and Branson) and several un-named species (Sweet and Bergström, 1976). Their range chart (ibid., text-fig. 2) shows that the top of Fauna 11 is at the upper level of B. sp. A (=Culumbodina penna Sweet), O. oregonia Branson, Mehl and Branson, and Protopanderodus sp. aff. P. insculptus (Branson and Mehl), and that the base of Fauna 12 coincides with the lower limit of P. insculptus.

Sweet (1979b) illustrated the range of O. ulrichi as being Edenian to Richmondian and that of P. inclinata to be early Maysvillian to Richmondian. O. ulrichi is also reported from the Gamachian (McCracken and Barnes, 1981a). These two species are therefore no longer diagnostic of Fauna 12. The differences between the two species of Protopanderodus may, however, be too subtle to permit distinguishing the taxa.

Sweet, et al. (1971) also listed Plegagnathus dartoni (Stone and Furnish) s.f., P. nelsoni Ethington and Furnish s.f. and Pristognathus bighornensis Stone and Furnish as being characteristic of Fauna 12. The entire range of P. bighornensis and the multielement species P. dartoni are restricted to the Richmondian; the range of P. nelsoni is from uppermost Edenian (i.e. middle Fauna 11 or lower Fauna 12) to post-Richmondian Ordovician (Sweet, 1979b). After reviewing the rather limited number of elements of Plegagnathus (about 80 elements, 40 samples) in their published collections, Nowlan and McCracken (MS) expressed doubts about Sweet's reconstructions of the two species of

Plegagnathus, and thus their biostratigraphic utility. It must be noted, however, that Sweet's interpretation of these species was based on more abundant material (e.g. 228 elements, 49 samples, Sweet, 1979b).

Other species also range into the post-Richmondian or Gamachian. *Oulodus rohneri* is lower Richmondian to post-Richmondian species (Sweet, 1979b) and was reported from Gamachian strata of Anticosti Island (McCracken and Barnes, 1981a). McCracken and Barnes (1981a) identified a *P*. cf. *P. staufferi* from the Gamachian of Anticosti Island. This species is comparable to the post-Edenian multielement species that Barnes (1977) reconstructed from *P. angularis* s.f. and *P. staufferi* s.f. and may also be equivalent to *P. angularis* and *P. staufferi* of Sweet (1984).

The stratigraphic range chart and appendix of Sweet (1979b, fig. 3) can be used to characterize the Richmondian Stage, Fauna 12, *A. ordovicicus* Zone, and *A. divergens* and *A. shatzeri* chronozones in the western North American midcontinent. Listed below are taxa that have their first or last appearances within these intervals: other taxa have extended ranges and thus are not characteristic of these intervals.

The *A. ordovicicus* Zone includes the first occurrence of *Aphelognathus floweri* Sweet, *A.*? sp. Sweet, *Belodina calciprominens* Sweet, *Panderodus Bergstroemi* Sweet, *Pseudobelodina adentata* Sweet, as well as the species restricted to the Richmondian (see below).

Several species that have an upper level above the base of the A. ordovicicus Zone but within the Maysvillian are: Aphelognathus shoshoensis Sweet, B. arca Sweet, B. confluens, Culumbodina occidentalis Sweet, C. penna, Panderodus breviusculus Barnes, Protopanderodus? sp. Sweet and Pseudobelodina torta Sweet. The lower part of the A. ordovicicus Zone thus is in the upper part of Fauna 11 (exact upper boundary is unclear).

Species whose lower range level are within the Richmondian, and thus middle to upper Fauna 12 are: Aphelognathus divergens Sweet, A. shatzeri Sweet, Belodina stonei Sweet, Oulodus rohneri Ethington and Furnish, Pristognathus bighornensis Stone and Furnish, and Pseudobelodina vulgaris ultima Sweet. Three of these, A. shatzeri, O. rohneri and P. v. ultima have a range that extends into the Gamachian.

The A. divergens Chronozone of Sweet (1984) is characterized by the first occurrences of A. divergens Sweet, A. pyramidalis (Branson, Mehl and Branson), O. rohneri, P. angularis, P. staufferi, and the last occurrences of A. divergens Sweet, A. floweri Sweet, A. grandis Branson, Mehl and Branson and Rhipidognathus rowlandensis. The younger A. shatzeri Chronozone spans the Richmondian - Gamachian boundary and is characterized by the first and last occurrences of the nominal species and

Pseudobelodina vulgaris ultima Sweet, and last occurrences of A. ordovicicus, A. pyramidalis, O. rohneri, P. angularis, P. staufferi, Pseudobelodina v. vulgaris Sweet, among other longer ranging taxa.

Late Ordovician faunas of areas in eastern North America are also of significance to the interpretation of these intervals.

Taxa from the Vauréal and Ellis Bay formations on Anticosti Island, Québec represent Fauna 12 and the Gamachian Fauna 13, respectively. The upper Fauna 12 of the Vauréal Formation contains the Gamachignathus ensifer Biohorizon, and Fauna 13 includes the first appearance of Staufferella inaligera McCracken and Barnes and the acme of G. ensifer (see Appendix B). A number of species from Fauna 12 and new species of Panderodus are also found in Fauna 13. Species of Plectodina are not known to occur above the middle of the Vauréal Formation (McCracken and Barnes, 1981a; Nowlan and Barnes, 1981).

Noixodontus girardeauensis (Satterfield) occurs in an eastern midcontinent fauna that was described by McCracken and Barnes (1982, p. 1477) as having the "characteristics of a slightly modified" Fauna 12. In retrospect, there are no other taxa that can be used conclusively to identify Fauna 12 in the Missouri strata. A. grandis occurs in this Missouri fauna, and in the A. grandis and younger A. divergens chronozones of Sweet (1984). These chronozones correspond to the upper Maysvillian to Richmondian stages, and the *A. ordovicicus* Zone. It is the association of *N. girardeauensis* and *G. ensifer* in the Ashgill of Yukon (Lenz and McCracken, 1982) that led to the assignment of a Fauna 12 age.

There is a degree of North American provincialism that unfortunately makes correlation more difficult. Many of the taxa listed above are restricted to either the midcontinent or the marginal regions.

The interpretation of the above zones and faunas is as follows. The base of the *A. ordovicicus* Zone is represented by the first appearance of *A. ordovicicus*; the boundary between Fauna 11 and 12 is unknown but the upper part of Fauna 11, and the lower part of Fauna 12 may be characterized by the last and first occurrences, respectively of several species: the middle to upper Fauna 12 contains species with their first appearances in the Richmondian; the upper part of the offshore or cratonic margins includes the *G. ensifer* Biohorizon; the Gamachian includes Fauna 13 and several species whose upper range level lies above the Richmondian.

The Late Ordovician Yukon faunas are: within the *A. ordovicicus* Zone based on the occurrence of this species; Richmondian based on the occurrence of *O. rohneri* and other taxa; and more precisely, within upper Fauna 12 based on the occurrence of the *G. ensifer* Biohorizon, and *N.*

girardeauensis, and late Ashgill graptolites.

The impoverished faunas from the Rock River section are assigned to late Fauna 12 because of their association with upper Ashgill graptolites. Some of the taxa from these three sections were listed by Lenz and McCracken (1982) but some taxonomic revision has been made herein to the preliminary faunal lists.

The revised identifications (with the revisions in parentheses) are: *Belodina compressa* (Branson and Mehl) (=*B. confluens* Sweet), *Coelocerodontus*? sp. (=*Scabbardella altipes* subsp. B Orchard), *Paroistodus*? *mutatus* (Branson and Mehl) (in part, equals *Besselodus borealis* n. sp. Nowlan and McCracken, MS, *P*.? sp. A Nowlan and McCracken, MS), *Panderodus gibber* Nowlan and Barnes (=*P*.? *gibber*), *Prioniodus*? *girardeauensis* Satterfield (=*Noixodontus girardeauensis*), *Pseudobelodina dispansa* (Glenister) (=*P*.? *dispansa*), *Strachanognathus parvus* Rhodes s.f. (=*S. parvus*, multielement species), and *Walliserodus* cf. *curvatus* (Branson and Branson) (=*W. amplissimus* (Serpagli)). In addition to these revisions, it should be noted that the taxa lists in Lenz and McCracken (1982, Appendix) are not complete (see Appendix C, Tables 1, 2 for a comparison).

A brief discussion of the ranges of most of the associated conodont taxa follows. *Belodina confluens* has been interpreted by Sweet (1979b) as having an age ranging from the Edenian to middle Maysvillian, but *B. compressa*

(Branson and Mehl) from the late Richmondian - Gamachian of Anticosti Island has been included within *B. confluens* by Nowlan and McCracken (*in* Nowlan, *et al.*, MS). Either the range of *B. confluens* must be extended or this Richmondian form is a new species since *B. stonei* Sweet, another Richmondian species is notably different (Sweet, 1979b, p. 60). *Besselodus borealis* n. sp. and *Paroistodus*? sp. A, both of Nowlan and McCracken (MS) are found in Fauna 12 of strata at Avalanche Lake, southern Mackenzie Mountains.

Eocarniodus gracilis and *Scabbardella altipes* (Henningsmoen) have been reported from the Longvill (middle Caradoc) to Ashgill of England and Wales (Orchard, 1980). *Icriodella superba* has been recorded from Middle to Upper Ordovician strata of Wales (Rhodes, 1953), United States (Schopf, 1966; Bergström and Sweet, 1966; Webers, 1966), eastern Canada (Globensky and Jauffred, 1971; Uyeno, 1974), and the Ashgill of England and Wales (Orchard, 1980), and France (Paris, *et al.*, 1981).

Panderodus? *gibber* ranges from Fauna 12 through to the Silurian *Oulodus*? *nathani* Zone of Anticosti Island (McCracken and Barnes, 1981a). *Plectodina florida*, *P. tenuis* and *Pseudobelodina quadrata* occur from Edenian to Richmondian (Sweet, 1979b). *P.*? *dispansa* ranges from Edenian (Sweet, 1979b) to Gamachian (McCracken and Barnes, 1981a). *Protopanderodus liripipus* occurs in the *A. ordovicicus* Zone but also is found in the older *P. undatus* Chronozone (Sweet, 1984), and *Prioniodus gerdae* Subzone (Kennedy, *et al.*, 1979). *Pseudobelodina v. vulgaris* is reported in the Edenian to Richmondian (Sweet, 1979b), and also is found in the Gamachian (McCracken and Barnes, 1981a). *Walliserodus amplissimus* occurs in the *A. ordovicicus* Zone (Orchard, 1980) and Fauna 12 and 13 (Nowlan and Barnes, 1981; McCracken and Barnes, 1981a) but its lower range limit is probably not yet established.

N. gen. A n. sp. A has morphologic features similar to rastrate taxa such as *Belodina* or *Pseudobelodina* but its utility as a biostratigraphic index fossil is unknown.

5.2.6 Assemblage 3

Age: Ashgill-?Llandovery on basis of conodonts; Rhuddanian (upper A4) on basis of graptolites.

Stratum: Rock River, section 4; 245m.

Significant conodont taxa: *Amorphognathus ordovicicus* Branson and Mehl, *Belodina confluens* Sweet, *Panderodus? gibber* Nowlan and Barnes, *Protopanderodus liripipus* Kennedy, *et al.*, *Scabbardella altipes* subsp. B Orchard, *Walliserodus amplissimus* (Serpagli), all Ordovician taxa; *Ozarkodina manitoulinensis* (Pollock, Rexroad and Nicoll)?, *W. curvatus* (Branson and Branson), both Silurian taxa.

Associated taxa: *Dapsilodus obliquicostatus* (Branson and Mehl)? (?Silurian), *Icriodella* sp. A (Ordovician - Silurian), *Paroistodus* sp. A Nowlan and McCracken, MS, (Ordovician).

Associated graptolite faunas: within *Coronograptus* gregarius Zone; 10m above Paraorthograptus pacificus Zone, 2m above Lagarograptus acinaces Zone, 37m below Monograptus turriculatus Zone (Lenz 1982a, Lenz and McCracken 1982).

This fauna is from a mass flow deposit which contains crinoid, bryozoan, coral and other debris. This thin (0.4m) calcarenite bed has an irregular surface and is bounded by strata containing Lower Llandovery graptolites (Lenz, 1982a).

Most of the conodont taxa are like those of upper Fauna 12 from the Blackstone and Peel River sections; notably absent are elements from species of Gamachignathus and Noixodontus. O. manitoulinensis has been recorded from the early Llandovery Oulodus nathani and Distomodus kentuckyensis zones (McCracken and Barnes, 1981a, and others). D. obliquicostatus? is tentatively identified, but since its elements are similar to elements of Late Ordovician Besselodus species, this taxon is not particularly diagnostic.

5.2.7 Ozarkodina n. sp. A-Icriodella sp. B assemblage

Age: early Llandovery on basis of Silurian-type elements of Ozarkodina, latest Ordovician on basis of under- and overlying graptolites and new systemic boundary position.

Strata: Pat Lake, section 2, 70.5 - 79.7m.

Significant conodont taxa: Ozarkodina n. sp. A (=O. sp. Lenz and McCracken).

Associated conodonts: Icriodella sp. B, Ozarkodina sp. A, Panderodus? gibber Nowlan and Barnes, P. sp., Walliserodus sp.

Associated graptolite faunas: lowest level is 1m above Paraorthograptus pacificus Zone; highest level is 6.3m below Glyptograptus persculptus? Zone; 17.3m below Orthograptus (=Parakidograptus) acuminatus Zone (Lenz and McCracken, 1982).

This poorly preserved and corroded fauna is from carbonate strata, which underlie graptolitic shales. The shales contain, in sequence, graptolites assigned tentatively to the Glyptograptus persculptus? Zone and confidently to the younger Orthograptus (=Parakidograptus) acuminatus Zone (Lenz and McCracken, 1982).

Lenz and McCracken (1982) identified the following taxa (with the herein revised names in parentheses): Ozarkodina sp. (=O. n. sp. A), Panderodus gracilis (Branson and Mehl) (=P. sp.) and Walliserodus curvatus (=W. sp.). I avoid assigning specific names to Panderodus and Walliserodus. These are probably either P. gracilis (Branson and Mehl) and W. amplissimus (Serpagli), respectively, if Ordovician, or P. unicostatus (Branson and Mehl) and W. curvatus (Branson and Branson), if Silurian.

The Ozarkodina species have a very Silurian aspect. The genus Icriodella, and P.? gibber span the Ordovician - Silurian boundary elsewhere and thus are not diagnostic of either period.

An early Llandovery age for this fauna was chosen, by Lenz and McCracken (1982) because of the Silurian aspect of the *Ozarkodina* elements, and because they tentatively identified the traditional basal Silurian graptolite zone (*G. persculptus* Zone) above the conodont horizon. Recently, the base of the Silurian has been placed by international agreement at the base of the *P. acuminatus* Zone and thus the underlying G. persculptus? Zone and conodont fauna at Pat Lake should now be regarded as Late Ordovician.

The true age of this fauna is in doubt due to the recent change in the graptolite - based systemic boundary (see below, Chapter 6, and Appendix B).

5.2.8 Oulodus fluegeli-Dapsilodus obliquicostatus assemblage

Age: Llandovery (C4-5 subdivisions).

Stratum: Blackstone River, section 1; 90.2m.

Significant conodont taxa: *O. fluegeli fluegeli* (Walliser), O. f. petilus (Nicoll and Rexroad), Dapsilodus *obliquicostatus* (Branson and Mehl), *Distomodus* sp. cf. *D. kentuckyensis* sensu Cooper, *Ozarkodina* sp. aff. *O. polinclinata* (Nicoll and Rexroad), *O.* sp. B, *Walliserodus sancticlari* Cooper, *W.* n. sp. A.

Associated taxa: *Panderodus* spp.

Associated graptolite faunas: within *Monograptus turriculatus* Zone, 13m above *M. sedgwicki* Zone, 13.4m below *M. spiralis* Zone (Lenz, 1982a).

O. fluegeli s.l. was recorded from the base of the *P. celloni* Zone in the Carnic Alps by Walliser (1964) and from the *I. inconstans* to lower *P. amorphognathoides* zones in the Welsh Borderland (Aldridge, 1972).

Two co-occurring subspecies of *O. fluegeli* are recognized in Yukon; their synonymies (see Chapter 8 - Systematic Paleontology) represent an attempt to subdivide the overall range of the species.

O. f. fluegeli occurs in the *P. celloni* Zone of northern Greenland (Aldridge, 1979), the upper *P. celloni* and *P. amorphognathoides* zones of the Oslo region, Norway (Aldridge and Mohamed, 1982), below the *P. amorphognathoides* extinction datum (Mabillard and Aldridge, 1983) (but probably within *P. amorphognathoides* Zone, based on the co-occurrence of *Johnognathus huddlei* Mashkova; see Uyeno and Barnes, 1983, p. 7), and in California, between the *Spathognathodus* (=*P*?) *celloni* and *P. amorphognathoides* zones (Miller, 1978).

Oulodus f. petilus includes *O.*? *f.* subsp. A of Uyeno and Barnes (1983), which ranges from the uppermost *D. staurognathoides* Zone (C4? subdivision) to about the middle of the *I. inconstans* Zone (C5) on Anticosti Island, Québec. The lower limit of *O. petila* sensu Cooper (1980) is somewhere above the base (C2) of the *D. staurognathoides* Zone but this is not considered a reliable earliest occurrence for the Yukon subspecies. Only part of *Ozarkodina plana* (Walliser) sensu Sweet and Schönlaub (1975) is equated with this subspecies (their sample is from the *P. celloni* Zone of the Carnic Alps in Austria).

Diadelognathus excertus Nicoll and Rexroad s.f. of Miller (1978) occurs only in his *S.* (=*P.*) *celloni* Zone. His other form taxa equated herein to *O. f. petilus* are considered by Miller as being within both the *P. celloni* and *P. amorphognathoides* zones.

Diadelognathus n. sp. A s.f. and *Trichonodella* sp. s.f., both sensu Nicoll and Rexroad (1969) are restricted to their *N.* (=*P.*) *celloni* Zone in Indiana and Kentucky. The other form taxa of Nicoll and Rexroad that are assigned to this subspecies extend from this zone into their *P. amorphognathoides*- *S.* (=*Kockelella*) *ranuliformis* Zone. *Oulodus petilus* from the Ringerike area, Norway, is recorded only from strata of the *P. amorphognathoides* Zone (Aldridge, 1974; Aldridge and Mohamed, 1982). *O. petila* of Cooper (1980, not illustrated) ranges within the *Distomodus staurognathoides* Appearance and *Pterospathodus* Extinction datum planes.

Dapsilodus obliquicostatus has not been reported in strata older than the upper *D. staurognathoides* Zone on Anticosti Island (Uyeno and Barnes, 1983). The one element illustrated by Aldridge (1972) from the Welsh Borderland occurs in the Fronian Stage (C1-3); it also occurs in the

Wenlock of Wales (Aldridge, *et al.*, 1981). Link and Druce (1972) record this taxon from Ludlow and Gedinne strata of New South Wales, Australia.

In Indiana and Kentucky, *D. obliquicostatus* is found in the *N.* (=*P.*) *celloni* zone and younger strata (Nicoll and Rexroad, 1969). This species is restricted to the *K. ranuliformis* to *K. variabilis* zones in Oklahoma (Barrick, 1977). As well as having a range from Lower Silurian to Lower Devonian, there are differences in level of first appearance of *D. obliquicostatus*, a fact possibly reflecting environmental control as suggested by Barrick (1981).

Distomodus sp. cf. *D. kentuckyensis* sensu Cooper occurs in the *Oulodus? nathani* Zone of McCracken and Barnes (1981a) and in the lowest part of the *I. inconstans* Zone (Uyeno and Barnes, 1983) on Anticosti Island.

Ozarkodina sp. aff. *O. polinclinata* has similarities to a species of the same name from the *P. celloni* Zone in Greenland (Aldridge, 1979). *Ozarkodina* sp. B is compared to elements illustrated as *O.* spp. by Mabillard and Aldridge (1983); their sample containing the comparable form is from strata below their *P. amorphognathoides* extinction datum (informal datum plane of Aldridge and Mabillard , 1981).

The species of *Panderodus* and *Walliserodus* n. sp. A are not biostratigraphically useful at present. *W. sancticlari* is not well known: in Oklahoma it ranges from the *P. amorphognathoides* through most of the *K. amsdeni* zones

(Barrick and Klapper, 1976); in Illinois, from the *P. amorphognathoides* Zone to at least the *Ozarkodina saggita* Zone (Cooper, 1976); and on Anticosti Island, from the uppermost *Icriodella discreta*-*I. deflecta* to middle *I. inconstans* zones (Uyeno and Barnes, 1983). Thus, the presently known range of *W. sancticlari* is from middle Llandovery to late Wenlock.

The *Oulodus fluegeli* fauna is equated to the upper *D. staurognathoides* to *I. inconstans* zones (C4-5 subdivisions), sensu Aldridge (1972).

5.2.9 *Pterospathodus celloni* Zone

Age: Llandovery (C5 subdivision).

Stratum: Blackstone River, section 1, 98.5m.

Significant conodont taxa: *Astropentagnathus irregularis* Mostler, *Aulacognathus bullatus* (Nicoll and Rexroad), *Ozarkodina* sp. aff. *O. polinclinata* Nicoll and Rexroad, *Pterospathodus celloni* (Walliser), *P. pennatus angulatus* (Walliser).

Associated taxa: *Astropentagnathus* n. sp. A, *A.* Indet. Elements, *Dapsilodus obliquicostatus* (Branson and Mehl), *Distomodus kentuckyensis* Branson and Branson?, *D.* sp. cf. *D. kentuckyensis* sensu Cooper, *Oulodus fluegeli* (Walliser) s.l., *Oulodus?* n. sp. B, *Pterospathodus* n. sp. A, *P.?* Indet. Elements, N. gen. B n. sp. A.

Associated graptolite faunas: within *Monograptus turriculatus* Zone, 21.3m above *M. sedgwicki* Zone, 5.1m below M. spiralis Zone (Lenz, 1982a). This zone is correlative with the British C5 subdivision and Icriodella inconstans Zone (Barrick and Klapper, 1976). Aldridge (1972) and Uyeno and Barnes (1983) suggest that the P. celloni Zone correlates only with the upper part of the I. inconstans Zone. The lower limit is defined by the first appearance of P. celloni; the upper level is at the first occurrence of P. amorphognathoides Walliser.

Species characteristic of the I. inconstans Zone and younger strata are Apsidognathus tuberculatus Walliser, Aulacognathus bullatus, Astropentagnathus irregularis, Kockelella ranuliformis (Walliser), Ozarkodina polinclinata, O. gulletensis (Aldridge), and P. celloni (Aldridge, 1972; Uyeno and Barnes, 1983). Carniodus carnulus Walliser, Oulodus fluegeli s.l., P. p. angulatus and P. p. pennatus (Walliser) first occur in the P. celloni Zone in the Carnic Alps. Both subspecies of Pterospathodus are restricted to the P. celloni Zone; P. p. pennatus succeeds P. p. angulatus in the upper part of this zone (Walliser, 1964, fig. 1). P. p. procerus (Walliser), restricted by Walliser (ibid.) to the P. amorphognathoides Zone, was identified from within the I. inconstans Zone on Anticosti Island (Uyeno and Barnes, 1983).

Taxa from this Yukon zone include Dapsilodus obliquicostatus, Distomodus sp. cf. D. kentuckyensis, Oulodus fluegeli s.l., Ozarkodina sp. aff. O. polinclinata, O. sp. B and Panderodus spp. These have been discussed above under other assemblages or zones. *Astropentagnathus* n. sp. A, and the indeterminate elements of *Astropentagnathus?* and *Pterospathodus?* have little biostratigraphic value at present.

A. irregularis, *A. bullatus* and *P. celloni* all occur in the *I. inconstans* Zone (C5) of Britain (Aldridge, 1972, 1975). A similar occurrence is noted by Uyeno and Barnes (1983) on Anticosti Island except there the lowest occurrence of *A. bullatus* is in the upper part of the older *Distomodus staurognathoides* Zone. Uyeno and Barnes (*ibid.*, p. 6), however, suggested that in view of the restricted range of this taxon at other localities, the assigned C3-4 level for their lowest sample containing *A. bullatus* could be re-interpreted. *A. bullatus*, in its type area of Indiana and Kentucky, is from the *N.* (=*P.*) *celloni* Zone of Nicoll and Rexroad (1969).

Occurrences of *A. irregularis* in Europe (Mostler, 1967; Schönlaub, 1971), New South Wales (Pickett, 1978), western United States (Miller, 1976, 1978; Klapper and Murphy, 1975), and Anticosti Island (Uyeno and Barnes, 1983) are all in strata equivalent to the *P. celloni* or *I. inconstans* zones.

P. celloni has been shown by Nicoll and Rexroad (1969) to extend into the overlying zone. They (*ibid.*, p. 6) equated a few juvenile forms of *Spathognathodus pennatus angulatus* s.f. from the Carnic Alps to *P.*

amorphognathoides. Similar small elements are found herein but are retained under P. P. angulatus. Nicoll and Rexroad also found similar forms in their material and tried to show an overlap of ranges of P. celloni and P. amorphognathoides. As Walliser (1971) indicated, extension of the ranges is acceptable but a redefinition of the zones based on this information is unnecessary. Barrick and Klapper (1976, p. 64) also noted a slight overlap of ranges of these two species. Spathognathodus angulatus s.f. is identified from the lower P. celloni Zone by Walliser (1971).

D. kentuckyensis s.s., ranges from the B1-3 to C1-2 subdivisions in Britain (Aldridge, 1972, 1975) and occurs in strata older than the L. (=P.) celloni Zone of the North American midcontinent (Cooper, 1975). D. kentuckyensis? from Yukon is questionably identified because of the lack of large, and diagnostic platform elements. Cooper (1980) noted an overlap of the ranges of D. kentuckyensis and D. staurognathoides.

Pterospathodus n. sp. A is remarkably similar to P. amorphognathoides, the species that is used to indicate the P. amorphognathoides Zone. If it is conspecific, then the strata could be regarded as being early P. amorphognathoides Zone in age, where the ranges of P. celloni and P. amorphognathoides overlap. P. n. sp. A may, alternatively, be a geographic equivalent of P. amorphognathoides. Lack of conodont-bearing samples above the level of this sample precludes discovery of any younger

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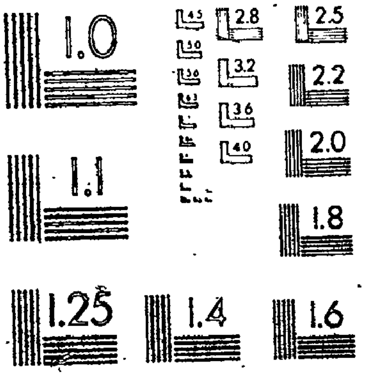


in positively identifying this new species.

Schönlaub (1975) recorded form taxa, which are questionably assigned to N. gen. B n. sp. A, to the lower P. celloni Zone.

5.2.10 Pterospathodus amorphognathoides Zone?

Age: Llandovery (C6)-early Wenlock.

Stratum: Tetlit Creek, section 7; 212m.

Significant conodont taxa: Carniodus carnulus Walliser, Pterospathodus pennatus procerus (Walliser), Oulodus n. sp. A, Ozarkodina sp. C.

Associated taxa: Dapsilodus obliquicostatus (Branson and Mehl), D.? sp. B, Distomodus staurognathoides (Walliser), Oulodus fluegeli (Walliser) s.l., Ozarkodina excavata n. subsp. A, Panderodus spp., Pseudooneotodus tricornis Drygant, Pterospathodus Indet. Elements.

Associated graptolite faunas: 20m above Monograptus spiralis Zone, 1m below Cyrtograptus sakmaricus-C. laqueus Zone, 20m below an indeterminate Wenlock fauna, 61m below the upper Wenlock C. lundgreni Zone (Lenz, 1982a; unpublished data).

I follow the interpretation of Walliser (1964) and others for the lower boundary of this zone; it is defined on the first occurrence of the nominal species. P. amorphognathoides is not known from Yukon and so the zonal identification is tentative. The top of the P. amorphognathoides Zone is marked by the first occurrence of

Kockelella patula (Walliser); in the Clarita Formation of Oklahoma, it is defined by the first appearance of *Pseudooneotodus bicornis* Drygant (Barrick and Klapper, 1976).

P. bicornis is rare in Yukon, occurring in a bed 18m above this stratum (sample at 230m) and is uncommon in the Jupiter Formation of Anticosti Island (Uyeno and Barnes, 1983) where it occurs once in each of the *Distomodus staurognathoides*, *Icriodella inconstans*, and *P. amorphognathoides* zones. In view of the Anticosti Island occurrence, *P. bicornis* is probably not reliable as an index to the *P. amorphognathoides* Zone outside of Oklahoma.

In the Clarita sequence, the *P. amorphognathoides* Zone is further characterized by the first appearance of *C. carnulus* and *P. pennatus procerus*. Other taxa, such as *D. staurognathoides* and *Kockelella ranuliformis* (Walliser), reported as first occurrences by Barrick and Klapper (1976), are known to occur elsewhere in older strata. In one of their sections, *P. celloni* co-occurs with *P. amorphognathoides*, indicating some overlap of ranges.

Cooper (1980) noted that the *Pterospathodus* Extinction Datum (base of the *K. ranuliformis* and *K. patula* zones) approximates the level where *Oulodus petila* (=*O. f. petilus* (Nicoll and Rexroad), herein) and the genera *Apsidognathus*, *Aulacognathus*, *Carniodus*, *Distomodus* and *Llandoverygnathus* (=*Pterospathodus* s.l., herein) disappear.

All these genera except *Apsidognathus* and *Aulacognathus* occur in the sample at 212m. *Apsidognathus tuberculatus* Walliser occurs in strata 6m above and 20m below the sample at 212m; *Aulacognathus bullatus* (Nicoll and Rexroad) occurs in the older *P. celloni* Zone on Blackstone River.

Cooper (1980) lists *C. carnulus* as occurring entirely within the bounds of the *P. amorphognathoides* Appearance and Extinction datum planes but the tables of Walliser (1964), Aldridge (1972), and Uyeno and Barnes (1983) show that some of the constituent form elements appear within the underlying zone. Mabillard and Aldridge (1985) report *C. carnulus* from the *P. celloni* Zone below the *P. amorphognathoides* Zone of the type area of the Wenlock. The range of *P. p. procerus* was originally reported to be within the *P. amorphognathoides* Zone (Walliser, 1964) but Uyeno and Barnes (1983) identify it from the underlying *I. inconstans* Zone of Anticosti.

Oulodus n. sp. A has some similarities to *O. jeannae* Schönlaub of the *P. celloni* Zone. It may also be compared to one element of *O.*? sp. B Mannik (1983, p. 117), which is probably Wenlock in age.

Ozarkodina excavata excavata sensu Barrick and Klapper (1976) ranges from the base of the *K. ranuliformis* Zone through the lower *K. varibilis* and younger zones. Aldridge (1975) shows the range of *O. excavata* to be at least from the Fronian to post-Ludlow. *Ozarkodina* sp. C is compared to

O. sp. C of Mabillard and Aldridge (1983), a species which they show to be below the *P. amorphognathoides* extinction datum (of Aldridge and Mabillard, 1981). No other comment on the Yukon occurrences can be made for this species.

Barrick (1977) shows *P. tricornis* ranging through the *P. amorphognathoides* Zone and possibly into the base of the overlying *K. ranuliformis* Zone in Oklahoma; Uyeno and Barnes (1983) report the species from the *I. inconstans* Zone of Anticosti Island. The range of *Dapsilodus obliquicostatus*, *Oulodus fluegeli* s.l. and the indeterminate elements of *Pterospathodus* have been discussed under the *O. fluegeli* assemblage. No comment regarding the age of *Dapsilodus*? sp. B and *Panderodus* spp. can be made.

The range of the *P. amorphnognathoides* Zone is generally regarded as latest Llandovery (C6) to earliest Wenlock. The interpreted age for the graptolite fauna at the Tetlit Creek section, however locally places an entirely Llandovery age on this particular conodont assemblage.

5.2.11 *Kockelella walliseri* Biohorizon?

Age: ?Llandovery - ?Wenlock.

Stratum: Tetlit Creek, section 7; 230m.

Significant conodont taxa: *Kockelella ranuliformis* (Walliser), *K. walliseri* (Helfrich)?, *Pterospathodus pennatus procerus* (Walliser).

Associated taxa: *Dapsilodus obliquicostatus* (Branson and Mehl), *Ozarkodina excavata* n. sp. A, *O.* sp., *Panderodus* unicostatus (Branson and Mehl), Pseudooneotodus bicornis (Drygant).

Associated graptolite faunas: 2m above Cyrtograptus laqueus - C. sakmaricus Zone, 2m below an indeterminate Wenlock fauna, 43m below C. lundgreni Zone (Lenz, 1982a; unpublished data).

The conodont fauna contains the only occurrence in this study of Kockelella walliseri? The two q elements have the asymmetrical base and short denticulated lateral process described by Barrick and Klapper (1976). The trivial name is queried because of limited material. The fauna is further discussed below (Chapter 5.3.11).

5.3 Conodont / Graptolite Biostratigraphy

5.3.1 Assemblage 1 / Arenig-Llanvirn to Llandeilo-Caradoc graptolite fauna

This poorly preserved conodont assemblage occurs in about the middle of a 75m conglomeratic unit that has obvious sedimentary evidence of mass-flow deposition. Poor graptolite collections limit precise correlation. At the base are Arenig - Llanvirn graptolites; at the top is the late Llandeilo - early Caradoc Nemagraptus gracilis Zone.

The occurrence of Plectodina aculeatus Hadding suggests an age range of late Arenig to late Llandeilo. Rare elements of Drepanoistodus suberectus (Branson and Mehl)?, Phragmodus and Plectodina are also identified and these may give the oldest possible age of deposition. Phragmodus has a lower range limit of middle Llanvirn; the lower limit for D. suberectus and Plectodina is within the late Llanvirn, Pygodus serrus Zone (Sweet, 1984, Appendix). All three taxa have long ranges.

5.3.2 "C." horridus-S. spinatus assemblage / pre-late Llandeilo or Caradoc graptolite fauna

Strata containing these conodonts comprise graded, slumped and truncated beds. Most of the conodonts indicate a late Arenig to early or middle Llanvirn age; "Cordylodus" horridus Barnes and Poplawski limits the youngest age to early Llanvirn. Two conodont taxa likely represent reworked Early Ordovician forms.

Conodonts of this association are not as poorly preserved as those of Assemblage 1; both assemblages are similar in that both are from strata with mass-flow evidence and very poor graptolite biostratigraphic control. The only reliable graptolite collections are 56m above the "C." horridus-S. spinatus level, and are indicative of late Llandeilo or Caradoc.

5.3.3 P. serrus / P. tentaculatus zones

The Pygodus serrus Conodont Zone corresponds to the Didymograptus murchisoni and lower part of the succeeding Glyptograptus teretiusculus zones (Bergström, 1971). These zones are within the uppermost lower Ordovician strata in the British succession, which appears to have a post-Llanvirn and pre-Llandeilo interval that has no series designation. Bergström (1983) considers this interval to be equivalent to most, if not all of the G. teretiusculus Zone, with the top of the D. murchisoni Zone corresponding to the top of the Llanvirn (Fig. 10).

The Australian graptolite scheme of Webby, et al. (1981) considers the G. teretiusculus Zone (Da4) as latest Llanvirn. They (1981) acknowledge the possibility of a post-Llanvirn, pre-Llandeilo interval and equate the succeeding graptolite fauna (pre-Nemagraptus gracilis zone) to this gap and the lowest part of the Llandeilo.

Chen and Lenz (1984) designate their northern Yukon G. euglypus (=G. teretiusculus, Lenz and Chen, 1985) as late Llanvirn.

The conodont sample from the P. serrus Zone on Peel River lies within the upper Paraglossograptus tentaculatus Zone of Lenz and Jackson (in press). The top of this interval containing the conodont fauna is 33.6m below the first occurrence of graptolites of the G. euglypus Zone. The bottom of the conodont-bearing interval is 4.3m above the first occurrence of the upper P. tentaculatus Zone. Lenz and Jackson (in press) equate the lower part of the P. tentaculatus Zone to the Da1 and Da2 of Victoria, which contains the Arenig-Llanvirn boundary (Webby, et al., 1981). The conodont sample is approximately mid-level within strata comprising the Llanvirn, as interpreted from graptolite data.

In the North Atlantic conodont succession, the Llanvirn - Llandeilo boundary is within the *Amorphognathus inaequalis* Subzone (upper *Pygodus anserinus* Zone); the *P. serrus*-*P. anserinus* zonal boundary is pre-Llandeilo strata. The Yukon *Pygodus* elements that differ slightly from *P. serrus* (Hadding) s.s. are not interpreted as representing the *P. serrus*-*P. anserinus* evolutionary transition: the sample is regarded as middle to late, rather than latest, Llanvirn.

5.3.4 Assemblage 2 / Caradoc-*D. ornatus* Zone

Caradoc to late Ashgill conodonts are present within an interval bracketed by Llandeilo or Caradoc graptolites (below) and Ashgill graptolites of the *Dicellograptus ornatus* Zone (above). These few and relatively undiagnostic conodonts are from mass-flow deposits and because of their stratigraphic level a few metres below the *D. ornatus* fauna, were probably redeposited in early Ashgill time.

5.3.5 Fauna 12 / *P. pacificus* Zone

The Late Ordovician *Paraorthograptus pacificus* Zone is succeeded in the British and Russian sequences by the *Climacograptus extraordinarius* and *Glyptograptus persculptus* zones (Williams, 1983), the latter zone until recently being traditionally regarded as earliest Llandovery. The *C. extraordinarius* Zone is not present in the North American

Cordillera, and the *P. persculptus* Zone is only tentatively recognized in some of the Yukon sections.

Lenz and McCracken (1982) have used the absence of the *C. extraordinarius* and *G. persculptus* zones to indicate a major hiatus, reflecting the effects of the North African glaciation, in the latest Ashgill and earliest Llandovery. The duration of this hiatus presumably varies from section to graptolite section and is possibly related to the original elevation of the depostional surface. At the Rock River section, both graptolite zones are absent; at the upper Peel River section, the *P. pacificus* and *Parakidograptus acuminatus* zones are separated by less than 30cm of strata; at Blackstone River section, all except the *C. extraordinarius* Zone are recognized.

The *P. pacificus* Zone contains conodonts assigned to late Fauna 12 in the sections at Blackstone, upper Peel and, probably Rock rivers. The *Gamachignathus ensifer* Biohorizon (Appendix B) is recognized by the rare occurrence of the nominal species in strata of Blackstone and Peel rivers.

As noted in Appendix B, it may be premature to set a percentile for the acme of *G. ensifer* McCracken, *et al.* in Fauna 13. The elements from the Blackstone River section fall close to lowest values calculated (in Appendix B) for faunas assigned to Fauna 13 but I am cautious about contradicting Lenz and McCracken (1982) or in re-assigning this sample to Fauna 13. Evidence for a latest Ordovician age from more than one sample would be preferable.

One difference of note is that Noixodontus girardeauensis (Satterfield) occurs only at the Blackstone River section where the G. persculptus? Zone is also recognized (see percentiles in Appendix B).

Even with the systemic boundary at its new, younger position at the base of the Parakidograptus acuminatus Zone, a glaciation, regardless of age, can still be accepted as the reason for the hiatus between the Paraorthograptus pacificus and younger zones in all Yukon sections except that from Pat Lake. This section has a more complicated biostratigraphic sequence (see below).

As alternatives to a hiatus, the absence, or non-recognition of the C. extraordinarius Zone in Yukon may be due to: 1) restrictive ecological factors; 2) lack of collection because of its extreme thinness, as at Dob's Linn (Williams, 1983); 3) the presence of an unrecognizable or undiagnostic but equivalent fauna; or 4) a pre-systemic boundary hiatus (caused by cyclic fluctuations in eustatic sea-level).

5.3.6 Assemblage 3 / C. gregarius Zone

This conodont fauna is from a mass-flow deposit, which has an irregular bedding surface and contains macrofossil debris. Most of the conodonts are Ordovician; Amorphognathus *ordovicicus* Branson and Mehl indicates the Ashgill zone of the same name. An element tentatively identified as *Ozarkodina manitoulinensis* (Pollock, Rexroad and Nicoll) suggests an early Llandovery age.

This mixture of Ordovician and Silurian condonts within the Rhuddanian *Coronograptus gregarius* Zone (upper A4) is evidence for remorking of sediment via gravity transport.

5.3.7 *O.* n. sp. A-*I.* sp. B assemblage / *G. persculptus*? Zone

The Ordovician - Silurian faunal succession at the Pat Lake section, as defined by Lenz and McCracken (1982) takes exception to the new systemic boundary interpretation. This section has shales with graptolites of the *Paraorthograptus pacificus* Zone underlying an interval of carbonates containing conodonts suggestive of the early Silurian, which in turn are overlain by shales containing in sequence, graptolites tentatively assigned to the *Glyptograptus persculptus* Zone and, slightly higher, confidently assigned to the *Parakidograptus acuminatus* Zone. That is, conodonts that are possibly Silurian are bracketed by what are now by definition, Ordovician graptolites. The conodont elements are not abundant and are extremely corroded.

In spite of these constraints, however, a new species is unquestionably assigned to the genus *Ozarkodina*. There are only a few documented occurrences of this multielement genus in the Ordovician, but it is common in the Silurian.

Repositioning the systemic boundary at the Pat Lake section produces a new late Ordovician species that has the characteristics of Silurian forms. This is not a completely unacceptable interpretation; it does at least provide a potential Late Ordovician ancestor for Silurian representatives of Ozarkodina.

5.3.8 O. fluegeli-D. obliquicostatus assemblage
/ M. turriculatus Zone

The Oulodus fluegeli-Dapsilodus obliquicostatus assemblage is from the Blackstone River section and from about the middle of the Monograptus turriculatus Zone of Lenz (1982a). This level is 13.4m below the first occurrence of the M. spiralis Zone, and 14m above the last sample from the M. sedgwicki Zone.

The lowest occurrence of O. f. petilus (Nicoll and Rexroad) on Anticosti Island, Québec has a minimum lower range level in the upper part of the Distomodus staurognathoides Zone (C4?) and its upper range may be restricted to the Icriodella inconstans or Pterospathodus celloni (C5) Zone (Uyeno and Barnes, 1983). O. f. fluegeli appears to range from at least the P. celloni Zone to the P. amorphognathoides Zone (C6-early Wenlock). The conodont data suggest an age for this assemblage comparable to that of the C4-5 subdivisions.

The graptolite zones listed above, and their correlation to the Llandovery subdivisions, are presented in two schemes that differ in the assigned correlations. The correlations of Cocks, et al. (1971, fig. 2) assign the M. turriculatus Zone to the upper part of the C2-3 subdivisions. The correlations of Ziegler, et al. (1974, fig. 1), Cocks, et al. (1983a, p. 13, fig. 1; 1983b, p. 2), and Worsley, et al. (1983b, fig. 1) differ in that the base of the M. turriculatus Zone is correlated with higher subdivisions.

Ziegler, et al. (1974) correlate the M. turriculatus Zone with the middle C4 to middle C5 subdivisions. The base of this zone in Cocks, et al. (1983a, 1983b) and Worsley, et al. (1983b) is approximately equal to the base of the C5 subdivision. This subdivision comprises the M. turriculatus and succeeding M. crispus and Monoclimacis griestoniensis zones (Worsley, et al.).

Graptolites are not known from near the boundary of the highest Llandovery, Telychian Stage at the type section, but at another locality, graptolites indicative of the M. turriculatus Zone are present above the base of the stage. Cocks, et al. (1983b) concluded that the base of the Telychian and M. turriculatus Zone are approximately correlative and within or near the top of the C4 subdivision. Since the precise correlation between stage, graptolite zone and subdivision is not known, the correlation chart used herein (Fig. 11) follows the scheme of Worsley, et al. (1983b); their chart shows approximate correlations between graptolite and conodont zones.

The graptolite-conodont correlations of Ziegler, et al. (1974) differ from other standards in that their M. turriculatus Zone corresponds to the upper P. celloni and lower P. amorphognathoides zones. Although derived from the conodont succession of Walliser (1964), none of these boundaries equate with the levels defined in the Carnic Alps. The lower boundaries of both the P. celloni and P. amorphognathoides zones, and the upper level of the latter zone, are all too low.

O. f. petilus spans the D. staurognathoides-I. inconstans zonal boundary (C4-C5 boundary) on Anticosti Island and co-occurs at its lower levels with Aulacognathus bullatus (Nicoll and Rexroad) (Uyeno and Barnes, 1983).

A. bullatus is a species that apparently is restricted to the C5 subdivision in Britain and the P. celloni Zone of the Carnic Alps. Uyeno and Barnes (1983, p. 7) believed that the restricted European range of A. bullatus might eventually make it necessary to lower the base of the I. inconstans Zone on Anticosti to the first occurrence of A. bullatus. If so, the lower limit of O. f. petilus may also be at the base of the C5 subdivision.

5.3.9 P. celloni Zone / M. turriculatus Zone

Both the Pterospathodus celloni Zone and Oulodus fluegeli-Dapsilodus obliquicostatus assemblage were identified from the Blackstone River section and are within the approximately 26m of strata of the Monograptus turriculatus Zone. The former fauna is near (5.1m) the lower boundary of the higher M. spiralis Zone; the latter is in lower strata, about mid-level within the M. turriculatus Zone. The slight difference in age was not the reason for distinguishing these two conodont faunas; rather, it was the significant difference in their taxa.

The P. celloni Zone comprises taxa characteristic of this zone at other localities. Of particular importance is Pterospathodus; this genus is absent from the underlying conodont fauna. In addition, the P. celloni fauna is much more diverse, although the elements of the O. fluegeli-D. obliquicostatus fauna are more abundant.

Pterospathodus n. sp. A of the P. celloni Zone in Yukon is comparable to P. amorphognathoides Walliser and it is tempting to equate them, and suggest that this fauna represents the interval where the ranges of P. amorphognathoides and P. celloni Walliser overlap (as indicated by Barrick and Klapper, 1976, and others). P. n. sp. A and P. amorphognathoides are probably not conspecific; no other taxa clearly indicative of the P. amorphognathoides Zone is present.

The P. amorphognathoides Zone (C6) is approximately equal to the Monoclimacis crenulata Zone (Aldridge, 1972; Worsley, et al., 1983a, 1983b). The entire M. spiralis Zone in Yukon equates to the combined M. crispus and Monoclimacis griestoniensis, and possibly the lower part of the M.

crenulata zones of the British Isles (Lenz, 1982a). Thus, the base of the succeeding zone in Yukon, the *Cyrtograptus sakmaricus-C. laqueus* Zone may correlate to, or slightly higher than, the base of the *M. crenulata* Zone.

The *C. sakmaricus-C. laqueus* Zone was not identified at Blackstone River but at Peel River it succeeds about 60m of strata of the *M. spiralis* Zone (Lenz, 1982a). The *M. spiralis* Zone on Blackstone River may not be as thick as this, but still, it is unlikely that the conodonts are assignable to the lowest part of the *P. amorphognathoides* Zone since the *P. celloni* fauna occurs below the *M. spiralis* Zone.

5.3.10 *P. amorphognathoides* Zone? / pre-Wenlock graptolites

At the Tetlit Creek section, the conodonts of the *Pterospathodus amorphognathoides* Zone occur 1m below the lowest part of the *Cyrtograptus sakmaricus-C. laqueus* Zone (upper Llandovery) and 20m above the highest collection of the *Monograptus spiralis* Zone (Lenz, 1982a). Lenz regards this graptolite zone as being entirely Llandovery in age, although other graptolite workers disagree and suggest that it is also earliest Wenlock. Indeterminate Wenlock graptolites occur 18m above this conodont sample.

The *P. amorphognathoides* Zone? from this level at Tetlit Creek is therefore probably equivalent to the C6 subdivision (i.e. highest Llandovery) of the British sequence. This corresponds to the lower part of the range given by Aldridge (1972) and others.

5.3.11 K. walliseri Biohorizon? / Wenlock graptolites

Two metres above the last known graptolites of the C. sakmaricus-C. laqueus Zone and 2m below the indeterminate Wenlock graptolite fauna on Tetlit Creek, a conodont fauna yielded Kockelella ranuliformis (Walliser), K. walliseri (Helfrich)?, Ozarkodina excavata n. subsp. A (Branson and Mehl), Pseudooneotodus bicornis Drygant, and three g elements of Pterospathodus pennatus procerus (Walliser).

K. ranuliformis, K. walliseri and P. bicornis occur in the K. ranuliformis Zone in Oklahoma (Barrick and Klapper, 1976). P. bicornis defines the base of this zone (approximately equal to the base of the K. patula Zone, Barrick and Klapper, 1976; Cooper, 1980), but occurs on Anticosti Island in older strata below the P. amorphognathoides Zone (Uyeno and Barnes, 1983). K. ranuliformis appears first in the underlying P. amorphognathoides Zone. Since both K. ranuliformis and P. bicornis apparently have extended ranges, the K. ranuliformis Zone may not be recognizable in areas outside of Oklahoma.

K. walliseri ranges in Oklahoma from the upper part of the middle Wenlock K. ranuliformis Zone to the K. amsdeni Zone (Barrick and Klapper, 1976) and is reported from the Spathognathodus sagitta bohemicus Zone (upper Wenlock) of the Appalachian Mountains by Helfrich (1975).

Barrick and Klapper (1976) state that there is uncertainty in the correlation of the *K. ranuliformis* Zone of Oklahoma and the *K. patula* Zone of the Cellon section of Walliser (1964, 1971). The *K. ranuliformis* Zone may correlate with the *K. patula* Zone, it may be equal to the lower part of the same zone, or there may be a hiatus in the Cellon zone.

The Yukon co-occurrence of *K. walliseri*? and *Pterospathodus pennatus procerus* is troublesome since Cooper (1980) notes a drastic change in faunas at his *Pterospathodus* Extinction Datum, which lies stratigraphically below the *K. walliseri* First Appearance Biohorizon (=Cooper's Appearance Datum). He further suggested that the *K. walliseri* Datum probably correlates with a level near the top of the *K. patula* Zone at Cellon.

The *Pterospathodus* Extinction Datum approximates the level at which *Aulacognathus* and *Distomodus* (and other taxa) disappear (Cooper, 1980); both genera are found in the lowest part of the *K. ranuliformis* Zone of Oklahoma (Barrick and Klapper, 1976) but not in the Yukon sample. Unless the Yukon *Pterospathodus* elements are exotic, these would indicate an upper level within the *P. amorphognathoides* Zone. However, the occurrence of *K. walliseri*? suggests a higher stratigraphic level: the upper *K. ranuliformis* or lower *K. patula* zones sensu Barrick and Klapper (1976). These unresolvable problems give cause to question the assignment of this fauna to the *K. walliseri* First

Appearance Biohorizon.

In their addendum, Barrick and Klapper (1976) note that graptolites of the Cyrtograptus rigidus Zone (middle Wenlock) occur at the base of the K. patula Zone in the Carnic Alps. At Tetlit Creek, the next identifiable graptolite horizon, the C. lundgreni Zone (upper Wenlock), is 43m above the conodont sample containing Kockelella.

If the C. sakmaricus - C. laqueus Zone is entirely Llandovery (as suggested by Lenz, 1982a), it seems improbable that this Yukon conodont fauna represents the middle Wenlock K. patula Zone since it occurs only 2m above latest Llandovery graptolites (unless there is a hiatus).

If Pterospathodus was introduced into the stratum by gravity-flow, and K. walliseri is a reliable indicator of the middle Wenlock, then the occurrence of this sample immediately above the C. sakmaricus - C. laqueus Zone beds may lend support to the suggestion that this graptolite zone spans the Llandovery - Wenlock boundary. The exact age of the conodont fauna is not known.

FIGURE 10. ORDOVICIAN CORRELATION CHART.

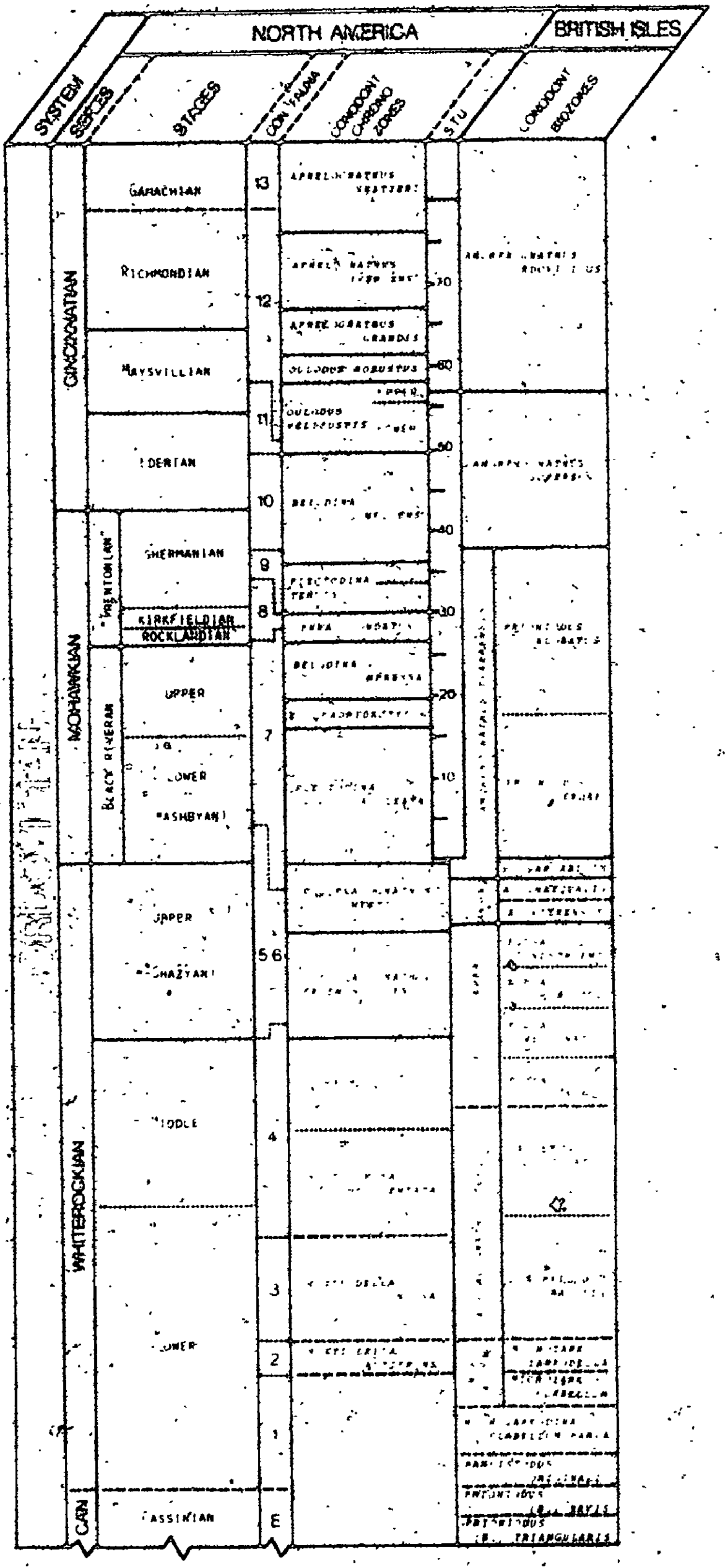
The North American stratigraphic units and the British conodont biozones and their boundary positions are drawn to scale from the Standard Time Units (STU=0.4625 Ma) of Sweet (1984). The fine broken lines in the Series, Conodont Faunas and Chronozone columns of this part of the chart represent approximate positions of boundaries calculated directly from Sweet's figure. The dashed lines represent boundaries given Composite Standard Section values (CSS) by Sweet (1984).

Dashed lines in the remainder of the chart are used to show the degree of uncertainty of correlation. A dashed line that is the complete width of the column indicates that its correlatives are recognized in areas represented by the columns on both sides. For example, the base of the Llanvirn correlates with the M. ozarkodella Zone (left) and the D. "bifidus" Zone (right). A half-line indicates less confidence in correlation - the correlation is of lesser geographic extent (e.g. the equivalent unit to the D. "bifidus" Zone in the northern Cordillera is not known). The fine broken lines are used where the correlations are more questionable, and to graphically separate zones with boundaries that cannot be directly correlated with other units (e.g. Costonian to Onnian).

Sources include: Barnes, et al (1981); Bergström (1971, 1983); Bergström and Cooper (1973); Chen and Lenz (1984); Ethington and Clark (1971); Landing (1976); Lenz and Chen

(1985); Lenz and Jackson (in press); Lenz and McCracken (1982); Lindström (1971); Löfgren (978); McCracken and Barnes (1981a, 1981b); Price (1984); Ross, *et al.* (1982a); Sweet (1984); Sweet and Bergström (1976); Sweet, *et al.* (1971); VandenBerg, *et al.* (1984); Webby, *et al.* (1981); Williams, *et al.* (1972); Williams (1983).

Abbreviations used on the chart are as follows: *A.* = *Amorphognathus*; *ANSER.* = *anserinus*; *B.* = *Baltoniodus*; *C.* = *Climacograptus*; CAN. = Canadian; CASTLE. = Castlemanian; *D.* = *Dicellograptus*; *DIDY.* = *Didymograptus*; *E.* = *Erismodus*; *EOPLAC.* = *Eoplacognathus*; *G.*, *GLYP.* = *Glyptograptus*; *I.* = *Isograptus*; *MICROZARK.* = *Microzarkodina*; *NEMA.* = *Nemagraptus*; *P.* = *Prioniodus*; *PA.* = *Pacificograptus*; *PHRAG.* = *Phragmodus*; *PYGOD.* = *Pygodus*; *V.* = *victoriae*; *VARIAB.* = *variabilis*; YAPEEN. = Yapeenian.



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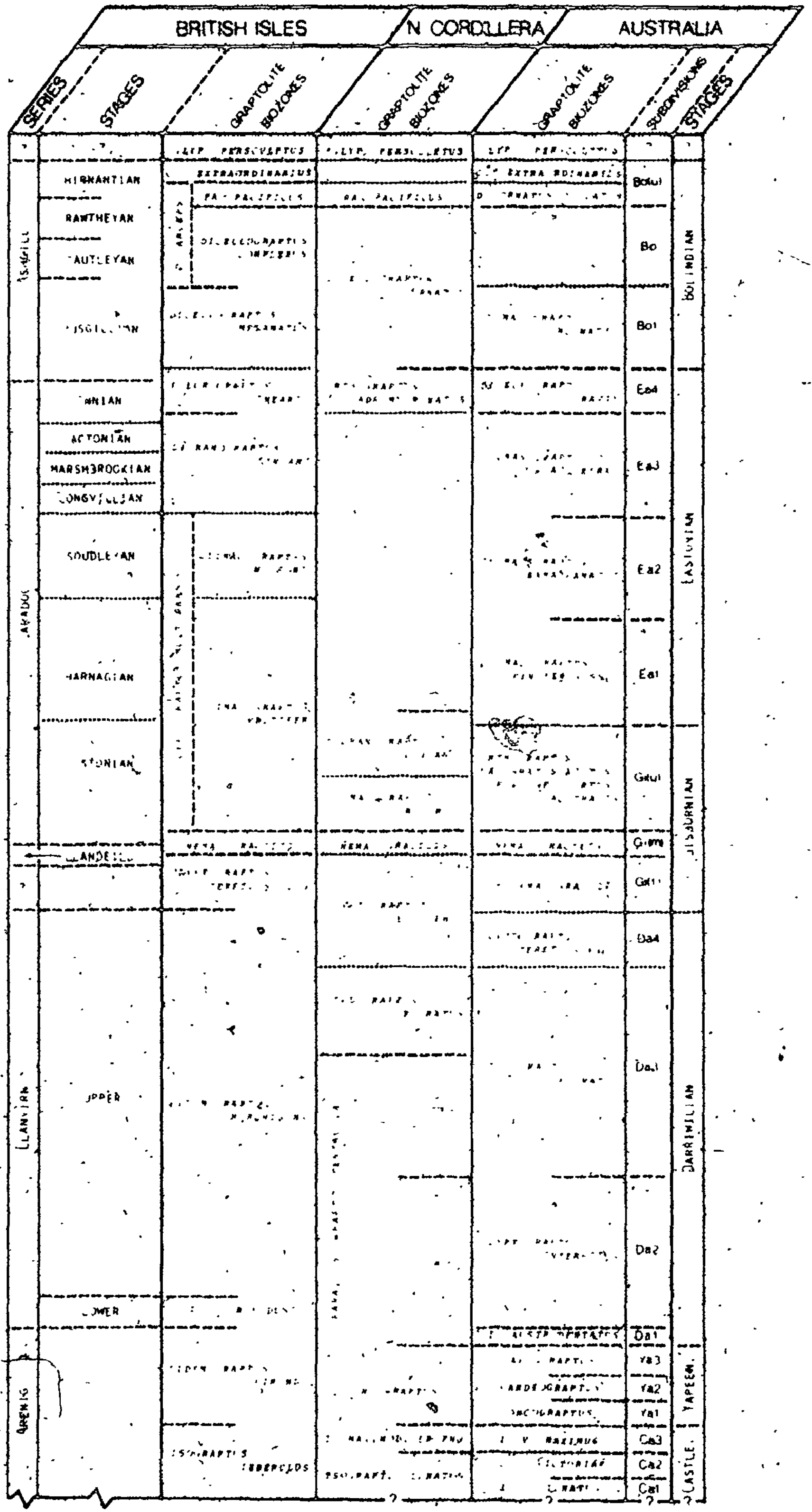
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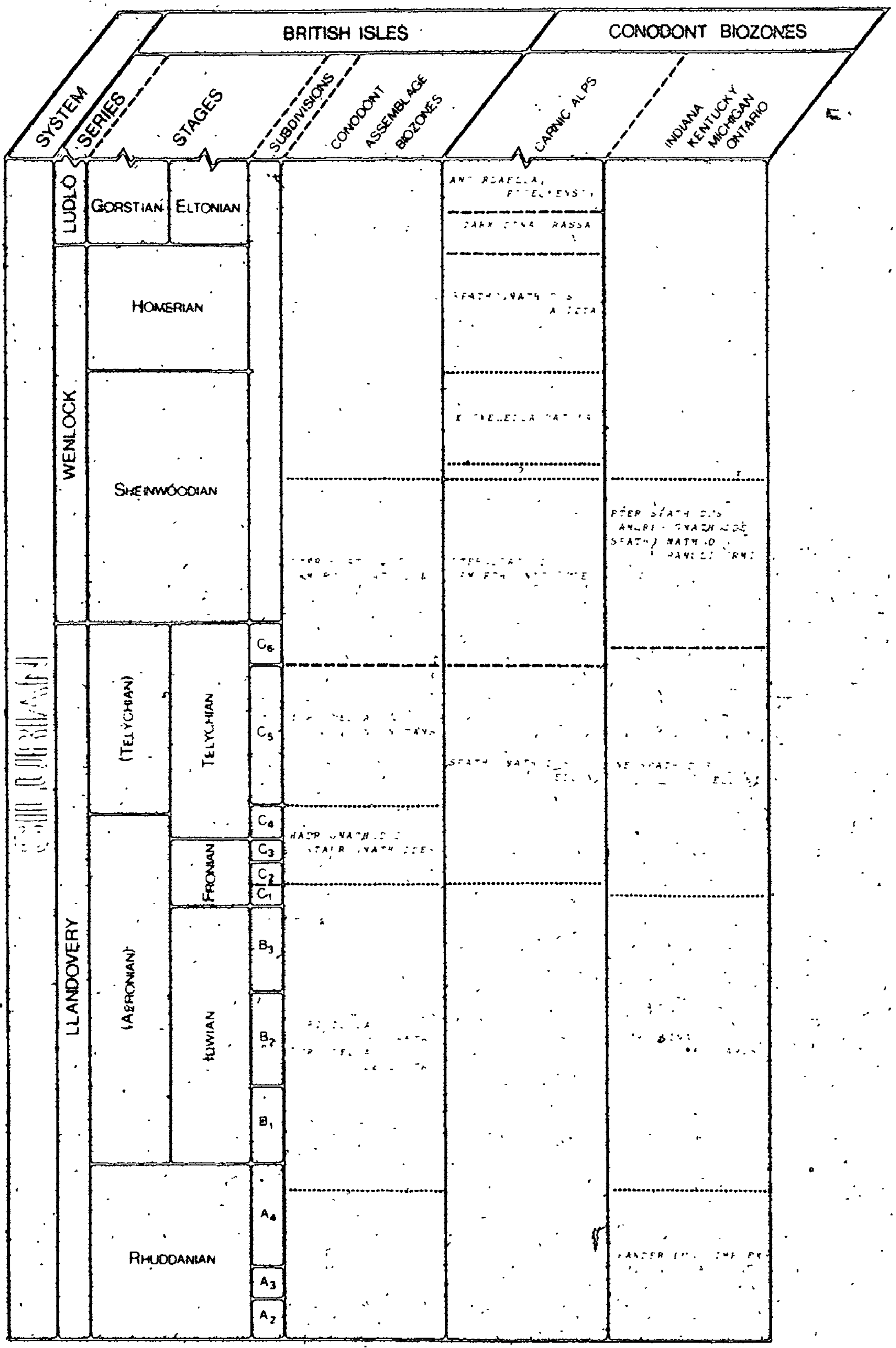
FIGURE 11. SILURIAN CORRELATION CHART.

The levels of the boundaries for the Llandovery graptolite zones are based on age determinations involving thickness of strata by Churkin, et al. (1977) and Carter, et al. (1980). The boundary levels of younger graptolite zones are based on an estimated average duration of about 0.65 Ma. The scale of the Silurian chart is a 3-fold vertical exaggeration of that used for the Ordovician correlation chart (Fig. 10). The degree of confidence in the correlations is shown through the use of fine broken, and dashed lines (see explanation for Fig. 10).

Sources include: Aldridge (1972, 1975); Barnes and McCracken (1981); Barrick and Klapper (1976); Cocks, et al. (1983a, 1983b); Cooper (1975, 1980); Fahraeus and Barnes (1981); Lenz (1979, 1980, 1982a); McCracken and Barnes (1981a, 1981b); Nicoll and Rexroad (1969); Pollock, et al. (1970); Rexroad and Nicoll (1971); Rickards (1976); Schönlaub (1971); Uyeno and Barnes (1981, 1983); Walliser (1964, 1971); Ziegler, et al. (1974).

It must be noted that the conodont zonal names have not been changed from the original sources to conform with multielement taxonomy, generic revisions, and current interpretations of the zones. The chart thus reflects an evolution of conodont biostratigraphy. All workers now use the multielement taxonomic terms.

Abbreviations used on the correlation chart are as follows: *AMORPHOGNATH*. = *amorphognathoides*; *A*. = *Ancordaella*; *C*. = *Cyrtograptus*; *D*., *DISTO*. = *Distomodus*; *ETHERING*. = *etheringtoni*; LUDLO. = Ludlow; *M*. = *Monograptus*; *O*.? = *Oulodus*?; *PER*. = *perneri*; *P*. = *Pterospathodus*; *P*. = *Pristiognathus* *R*. = *Rastrites*; *SAK*. = *sakmaricus*; *STAUR*. = *staurognathoides*; *TURR*. = *turriculatus*.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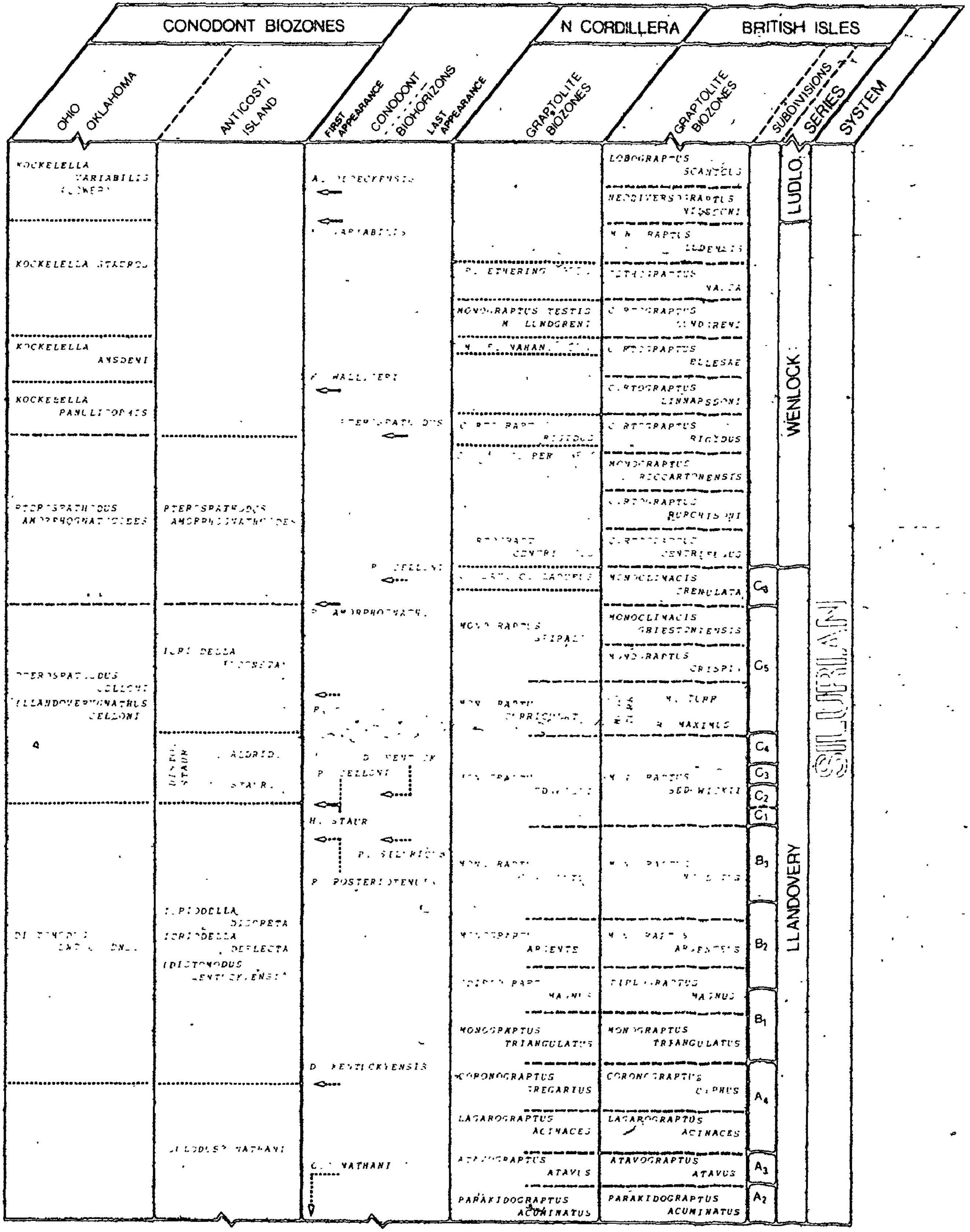
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BRITISH ISLES
OHIO
OKLAHOMA
ANTICOSTI ISLAND
FIRST APPEARANCE
CONODONT BIOHORIZONS
LAST APPEARANCE
GRAPTOLITE BIOZONES
GRAPTOLITE BIOZONES
SUBDIVISIONS
SERIES
SYSTEM
KOCKELELLA VARIABILIS
KOCKELELLA STAURO
KOCKELELLA AMSDENI
KOCKELELLA PATULA
PTEROSPATHODUS AMORPHOGNATHOIDES
PTEROSPATHODUS CELLONI
LLANDOVERYGNATHUS CELLONI
DISTOMODUS KENTUCKYENSIS
PTEROSPATHODUS AMORPHOGNATHOIDES
ICRIODELLA INCONSTANS
ALDRID.
STAUR.
ICRIODELLA DISCRETA
ICRIODELLA DEFLECTA
DISTOMODUS KENTUCKYENSIS
NATHANI
A. PROFECTUS
VARIABILIS
K. WALLISERI
PTEROSPATHODUS
P. CELLONI
P. AMORPHOGNATH.
P.
D. KENTUCKY.
P. CELLONI
H. STAUR
P. SILURICUS
P. POSTERIOTENUIS
D. KENTUCKYENSIS
NATHANI
ETHERING
MONOGRAPTUS TESTIS
M. LUNDGRENI
VAHAN.
RIGIDUS
PER
CENTRI
MONOGRAPTUS SPIRALIS
MONOGRAPTUS CRISPUS
MAXIMUS
MONOGRAPTUS ARGENTEUS
MAGNUS
MONOGRAPTUS TRIANGULATUS
CORONOGRAPTUS GREGARIUS
LAGAROGRAPTUS ACINACES
ATAVOGRAPTUS ATAVUS
PARAKIDOGRAPTUS ACUMINATUS
LOBOGRAPTUS SCANICUS
NEODIVERSOGRAPTUS NILSSONI
M. LUDENSIS
VALIDA
LUNDGRENI
ELLESAE
LINNARSSONI
RIGIDUS
MONOGRAPTUS RICCARTONENSIS
MURCHISONI
CENTRIFUGUS
MONOCLIMACIS CRENULATA
MONOCLIMACIS GRIESTONIENSIS
MONOGRAPTUS CRISPUS
M. TURR
MAXIMUS
SEDGWICKII
MONOGRAPTUS ARGENTEUS
MAGNUS
MONOGRAPTUS TRIANGULATUS
CORONOGRAPTUS CYPHUS
LAGAROGRAPTUS ACINACES
ATAVOGRAPTUS ATAVUS
PARAKIDOGRAPTUS ACUMINATUS
C6
C5
C4
C3
C2
C1
B3
B2
B1
A4
A3
A2
LUDLO.
WENLOCK
LLANDOVERY
SILURIAN

CHAPTER 6 -- THE ORDOVICIAN-SILURIAN BOUNDARY

It is commonly accepted that a North African glaciation was of a magnitude that affected eustatic changes in sea-level (e.g. Dennison, 1976; Brenchley and Newall, 1980; Petryk, 1981a, 1981b, and others) and the Ordovician - Silurian faunal succession.

The underlying question is whether the systemic boundary should directly reflect this glaciation (and thus the precise level representing maximum glaciation may be unrecognizable in most places due to a hiatus) or be placed at a lower or higher level that is correlatable but does not relate to a profound change in faunas.

This question is similar to that posed by McLaren (1970) in his discussion on boundaries. With the former option, the time of maximum glaciation equates to the systemic boundary, with the latter, it is latest Ordovician; in either case, glacial maximum may be represented by a hiatus. Until recently, this hiatus has been correlated with the Ordovician - Silurian boundary.

6.1 Ordovician-Silurian Boundary Revision

By formal international agreement, the traditional basal zone of the Silurian, the Glyptograptus persculptus Zone, is now regarded as uppermost Ordovician, while the base of the Silurian is now equated with the the lowest level of the common and widely distributed Parakidograptus acuminatus Zone. (IUGS Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Circular No. 19, August, 1983 -- proposal put forward to the Commission on Stratigraphy for postal ratification following the International Geological Congress in Moscow, August, 1984).

This new decision permits easier recognition of the graptolite-based systemic boundary but it also relegates the glacially-induced regression to being entirely latest Ordovician. Its more traditional position at the systemic boundary is no longer valid.

6.2 Glaciation Effects and the Systemic Boundary

In a continuous or nearly continuous sequence, a glacially-induced faunal changeover (biohorizon) and the new, graptolite-based systemic boundary may be at two different levels. In fact, changeovers in different taxa need not coincide; different taxa may have different tolerences to eustatic changes and thus faunal changeovers may be slightly staggered. An unstaggered changeover may be indicative of a stratigraphic break. Where the glacial event produced a hiatus, the duration of this hiatus may have been long enough that a faunal changeover and the systemic boundary (new or old position) coincide.

It is obvious that the hiatus produced by Late Ordovician - Silurian glacio-eustatic changes in sea-level represents different lengths of time at different locations, even though the initiation of eustatic changes may have been synchronous. The initiation phase of eustatic change may be correlatable. Hurst (1975) suggested this for a quick, synchronous transgressive event in upper Wenlock Limestone of the Welsh Borderland (but see Bassett, 1976 for a dissension on this Wenlock event).

Brenchley and Newall (1980) studied lithic changes in strata from the Ordovician - Silurian boundary interval in the Oslo area of Norway. They observed a regressive phase represented by oolitic shoals, stromatoporoid bioherms and coquinoid mud mounds. The ensuing transgression is illustrated by an abrupt change from Late Ordovician shallow marine sediments to relatively deep-water muds in Early Silurian. They (1980) concluded that this sea-level rise was rapid and thus of major chronostratigraphic significance. These changes may well be recognizable in other areas but if exposure occurred before transgression, the boundary of lithic change could be slightly diachronous and thus possibly not a reliable systemic benchmark.

The systemic boundary of McCracken and Barnes (1981a) was proposed as occurring in a continuous sequence of strata on Anticosti Island, Québec. The boundary interval is characterized by coral - stromatoporoid bioherms overlying a skeletal-oncolite platform bed, evidence similar to that representing the regressive phase identified in Norway by Brenchley and Newall (1980). The depositional environment of strata contiguous to the systemic boundary on Anticosti was interpreted as shallow subtidal; there is no clear evidence for inter- or supratidal environments (Petryk, 1981a). The Ordovician - Silurian boundary was placed immediately above these bioherms at the major conodont faunal changeover, which is at the base of a thin interval containing a mixture of Ordovician and Silurian taxa.

The early Llandovery conodont zones of Anticosti are in need of some refinement, particularly the boundary between the Oulodus? nathani Zone and Distomodus kentuckyensis or Icriodella discreta-I. deflecta zones (see Appendix B). The top of the O.? nathani Zone may be near the Ellis Bay-Becscie formational boundary since the Becscie Formation is equated with the upper part of the Icriodella discreta-I. deflecta Zone by Fahraeus and Barnes (1981).

The systemic boundary on Anticosti, as determined by Copeland (1981) using ostracodes, is within a 15m interval through the upper Ellis Bay and lower Becscie formations; that is, higher than the conodont-based boundary. Thus the conodont and ostracode faunal changeover is staggered.

Strata of Anticosti Island may indeed represent continuous deposition during the Ordovician - Silurian but unfortunately few comparable sections with the diagnostic Anticosti species have been recorded.

6.3 Ordovician-Silurian Graptolites and Conodonts

The G. persculptus Zone, now suggested as latest Ordovician, was described by Rickards (1976, p. 157) "In terms of graptoloid evolution it is of interest that it follows the late (Ashgill) Ordovician evolutionary 'low' when few new forms appeared and very few species existed, and in this sense allies with the Silurian rather that Ordovician faunas."

Lin and Chen (1983) have noted that their G. persculptus fauna from the Yangtze gorges, China is closely connected with Late Ordovician taxa but is dominated by Silurian forms. They believed that the systemic boundary most logically belonged at the base of the G. persculptus Zone.

Rickards (1976, p. 157) found that a G. persculptus fauna (as opposed to the restricted G. persculptus Zone) may extend downwards below the base of the zone; this he suggested may be an unnamed and undefined zone comprising "mixed" taxa of Ordovician and Silurian elements.

The evolutionary change in conodonts from Fauna 13 to the O.? nathani Zone of Anticosti is comparable to that of boundary graptolites in the sense that conodonts of the O.? nathani Zone are more allied with Silurian rather than Ordovician taxa, and that the strata also contain a "mixed" interval between Fauna 13 and the O.? nathani Zone. Conodont abundance is relatively low in these mixed intervals; earliest Silurian diversity is low.

The boundary between the P. pacificus Subzone and the Climacograptus? extraordinarius Zone at Dob's Linn, Scotland is probably within a thin interval of unfossiliferous mudstone. The C.? extraordinarius Band at the same locality is notably sparse. The boundary between this graptolite zone and the overlying G. persculptus is questionably placed in unfossiliferous strata below the Birkhill Shale (Williams, 1983). The boundary between the G. persculptus and overlying P. acuminatus zones was defined by Williams as being 1.6m above the base of this shale.

The low abundance and change in the conodont faunas of Anticosti during this interval reflect the glacial event. The impoverished or absent graptolite C. extraordinarius Zone, and the evolutionary changes between the P. pacificus and G. persculptus zones discussed above probably represent a similar response to the same event.

The changeover in conodont faunas and the systemic boundary on Anticosti (sensu McCracken and Barnes, 1981a), may be an approximate correlative to either the base of the P. acuminatus Zone or to the base of the underlying G. persculptus Zone. I suggest the latter, correlating levels of distinct faunal changeover. This would place the level equivalent to the base of the P. acuminatus Zone at a higher level in Anticosti strata, probably within or at the top of the O.? nathani Zone.

6.4 Systemic Boundary in Northern Yukon

Coincidentally, the faunal change in the conodont and graptolite sequence from Pat Lake in northern Yukon is staggered according to the new boundary interpretation: Ordovician P. pacificus Zone, followed by conodonts with a Silurian aspect, "Ordovician" G. persculptus? Zone, and Silurian P. acuminatus Zone. I suggest that this staggered changeover at Pat Lake is not comparable to that of Anticosti. Instead it is artificial, the result of redefining the G. persculptus Zone as Ordovician rather than Silurian.

The C. extraordinarius Zone is completely absent in Yukon; in fact, it is absent from the entire North American Cordillera. The P. acuminatus Zone is markedly diverse compared to the thin or absent underlying G. persculptus? Zone. Early Silurian conodont faunas at Pat Lake, and Avalanche Lake, N.W.T., are low in abundance and diversity.

The study of northern Cordillera faunas can contribute little to the debate on the boundary position. If the Ordovician - Silurian boundary in Yukon is to be based on the new graptolite-defined level then it would be between: the G. persculptus? and P. acuminatus zones on Blackstone River and Pat Lake; P. pacificus and P. acuminatus zones, upper Peel River; P. pacificus and Atavograptus atavus - Lagarograptus acinaces zones, Rock River; and Dicellograptus ornatus and P. acuminatus zones, Tetlit Creek (after Jackson and Lenz, 1962; Lenz 1982a; Lenz and McCracken, 1982). Except for the taxa from the Pat Lake section, Yukon, the new boundary position does not affect the conodont taxonomy presented herein.

The correlation charts (Figs. 10-13) in part yield to the new boundary level; the base of the Llandovery is identified with the base of the A2 subdivision and P. acuminatus Zone. The base of the Silurian conodont zones are shown as extending downwards. The G. persculptus Zone corresponds to a queried interval above the Hirnantian.

All studies referenced herein use the traditional position for the base of the Silurian rather than the new, higher level. Where the systemic boundary has to be discussed using both interpretations, it is hoped that clear distinctions have been made. In view of the decision to place the base of the Llandovery in a section presently lacking faunas other than graptolites, and the faunal potential of other sections such as those of the Yangtze gorges, the decision on the Ordovician - Silurian boundary was probably premature.

FIGURE 12. YUKON ORDOVICIAN CONODONT CORRELATION. Conodont assemblages and zones that are discussed herein are correlated with the graptolite zonal scheme used in the northern Canadian Cordillera.

SYSTEM	SERIES	BRITISH ISLES CONODONT ZONES	NORTHERN YUKON CONODONT ASSEMBLAGES	NORTHERN YUKON CONODONT 'ZONES'	N. CORDILLERA GRAPTOLITE ZONES	DIVISIONS	AUSTRALIA STAGES
?	?	?			??G persculptus	?	?
				Ozarkodina n sp. A Icriodella sp B	?		
	ASHGILL	A ordovicicus	G ensifer Biohorizon →	?	?	u	BOLINDIAN
				FAUNA 12 (upper)	P pacificus		
			ASSEMBLAGE 2		D. ornatus	m	
						l	
ORDOVICIAN	CARADOC				O quadrimucronatus	4	EASTONIAN
		A superbus			?	3	
						2	
		A tvaerensis				1	
					D. clingani?		
					C bicornis	u	GISBORNIAN
	LLANDEILO	P. anserinus	ASSEMBLAGE 1		N gracilis	m	
	?				G euglyphus	l	
	LLANVIRN	P. serrus				4	DARRIWILIAN
					D decoratus	3	
		E suecicus		P serrus	P tentaculatus (upper)		
					P. tentaculatus (lower)	2	
		A variabilis		'G' horridus 'S' spinatus		1	
	ARENIG	M f parva			Oncograptus	3	YAPEENIAN
						2	
						1	

FIGURE 13. YUKON SILURIAN CONODONT CORRELATION. Conodont assemblages and zones that are discussed herein are correlated with the graptolite zonal scheme used in the northern Canadian Cordillera.

SYSTEM	SERIES	STAGES	DIVISIONS	N. AMERICAN CONODONT ZONES	N. YUKON CONODONT ZONES	N. CORDILLERA GRAPTOLITE ZONES	DIVISIONS
SILURIAN	WENLOCK	Homerian		K. stauros		?	
						P. etheringtoni beds	
						M. testis C. lundgreni	
		Sheinwoodian		K. amsdeni		M.? nahanniensis beds	
				K. ranuliformis		?	
				P. amorphognathoides		C. rigidus	
						C. cf. C. perneri beds	
						?	
					K. walliseri? → K. ranuliformis P. amorphognathoides?	C. centrifugus	
	LLANDOVERY	Telychian	C_6			C. sakmaricus C. laqueus	C_6
			C_5	I. inconstans	P. celloni	M. spiralis	C_5
					O. fluegeli O. obliquicostatus	M. turriculatus	
			C_4	D. staurognathoides		M. sedgwicki	C_4
		Fronian	C_3				C_3
			C_2				C_2
			C_1	D. kentuckyensis			C_1
		Idwian	B_3			M. convolutus	B_3
						M. argenteus	
			B_2			D. magnus	B_2
			B_1			M. triangulatus	B_1
		Rhuddanian	A_4		Assemblage 3	C. gregarius	A_4
				D.? nathani		C. acinaces	
			A_3			A. atavus	A
			A_1			P. acuminatus	A

CHAPTER 7 -- SUMMARY AND CONCLUSIONS

The Road River Formation comprises up to 3130m of dark graptolitic shale, siltstone, carbonate and chert which range in age from Late Cambrian to Early Devonian. Over 9400 conodonts (CAI 4.5-5) were recovered from 67 samples collected at five well-exposed sections in Yukon; these range from Middle Ordovician to Early Silurian in age. Conodonts from these strata provide correlations with the established graptolite biostratigraphic scheme used in the northern Canadian Cordillera.

Sections in the northern Yukon study area are within the linear and relatively narrow Blackstone and Richardson troughs, which trend west and north-northwest, respectively. Strata of these troughs are bound by carbonates of the Mackenzie Platform (to the east), Ogilvie Arch (south) and Porcupine Platform (north and west) representing more shallow and nearshore subtidal environments. Graded, slumped and truncated units, pebble to boulder conglomerate, irregular bedding surfaces, and reworked conodont faunas attest to gravity-flow from platform margins and the emplacement of turbidites and other mass-flow deposits. Mass-flow beds confound attempts to interpret conodont paleoecology, although the Yukon taxa in general largely represent more offshore and European faunas.

Strata of the Whittaker Formation in the southern Mackenzie Mountains, Yukon and N.W.T., are indicative of deposition in more nearshore, shallower subtidal environments. Dark argillaceous limestone and shale strata of this formation at Avalanche Lake, N.W.T., are lithologically transitional between the fine clastics of the Road River Formation in the Selwyn Basin to the west and the more typical Whittaker Formation carbonates of the Mackenzie Platform to the east. Ordovician conodont faunas from 17 samples of carbonate from the Avalanche Lake section are dominated by Panderodus and American Province taxa.

A number of Ordovician species are present in both the basinal facies of the Road River Formation and the carbonate platform-edge facies of the Whittaker Formation in the N.W.T. These include Belodina confluens, Besselodus borealis n. sp., Dapsilodus sp. A, Oulodus rohneri, O. ulrichi, Panderodus? gibber, P. gracilis, Plectodina florida, P. tenuis, Pseudobelodina? dispansa, P. vulgaris vulgaris, Scabbardella altipes and Walliserodus amplissimus.

N. gen. A n. sp. A is a rastrate taxon found in Fauna 12 of Blackstone River strata. It differs from other rastrate genera in that it has a symmetrical c element with a panderodont groove on both lateral faces; a groove is present on only one face on elements of Belodina and Pseudobelodina.

The Llandovery N. gen. B n. sp. A from the Blackstone River section is represented by a ramiform apparatus and possibly has some affinity with Oulodus.

Present reconstructions of the apparatuses of *Astropentagnathus* and *Pterospathodus* may be only partially complete; elements occurring with those of *Astropentagnathus* may represent the first transition series (*a*-*c*) and *e* elements. A revised, complete apparatus of *Carniodus carnulus* is suggested; this excludes elements previously regarded as junior synonyms and which are remarkably like those of the older Llandovery *Pterospathodus posteritenuis* and the Gamachian *G. ensifer* from Anticosti Island, Québec. If present interpretations of the apparatus of *Pterospathodus* species such as *P. amorphognathoides* and *P. celloni* are correct, then *P. posteritenuis* probably should be reassigned to another genus.

The rare occurrence of conodont-bearing beds in Yukon prevent knowing the full stratigraphic ranges and co-occurrence of elements and thus prohibits more complete study of these apparatus reconstructions. However, the similarities between *f* and *g* elements of *G. ensifer*, *P. posteritenuis* and *P. celloni*, and between the *a*-*e* elements of *G. ensifer* and *P. posteritenuis*, suggest an interesting evolutionary lineage that deserves further investigation.

Eleven assemblages and biozones of conodont taxa are identified from northern Yukon. Some, such as the early Llanvirn "*Cordylodus*" *horridus* - *Spinodus spinatus* assemblage, contain reworked elements representing older ages. Taxa of this assemblage include *Periodon aculeatus*, *Protopanderodus robustus*, *P.* sp. aff. *P. varicostatus*, Walliserodus ethingtoni, and indeterminable species of Eoplacognathus?, Polonodus?, Diaphorodus? and Prioniodus (Oepikodus)? The latter pair of taxa may be redeposited early Ordovician genera. Most of the faunas containing mixed assemblages are from beds with clear evidence of mass-flow deposition.

Graptolites provide good stratigraphic control for most conodont collections from northern Yukon. The Pygodus serrus Zone occurs within the upper Paraglossograptus tentaculatus Zone. Although some platform elements of P. serrus have incipient denticles suggestive of an extra, fourth denticle-row, they are not regarded as evolutionarily intermediate between P. serrus and the younger P. anserinus, and thus do not represent the boundary interval between the the P. serrus and P. anserinus zones. This fauna is well below the Glyptograptus euglyphus Zone and thus late, not latest Llanvirn. Other notable conodont taxa within the P. serrus Zone are: Belodella? sp: aff. B.? nevadensis, P. aculeatus, Protopanderodus parvibasis, P. robustus, P. sp. aff. P. varicostatus and W. ethingtoni.

The precision of graptolite biostratigraphy in Yukon has been well documented; the upper Peel River graptolite succession illustrates this and shows the subtle nature of a Late Ordovician - Early Silurian paraconformity. Only 30cm of strata separate graptolites of the Ashgill Pacificograptus pacificus and Llandovery Parakidograptus acuminatus zones. The intermediate Climacograptus?

extraordinarius and Glyptograptus persculptus zones are missing. Conodonts within the P. pacificus Zone and 1.9m below the P. acuminatus Zone represent the upper part of Fauna 12 and a late Richmondian, late Ashgill age is interpreted for this fauna.

A similar Upper Ordovician fauna is present in Blackstone River strata. This fauna is of interest since it contains rare elements of Noixodontus girardeauensis and Gamachignathus ensifer, and occurs 13.7m above the P. pacificus Zone and 3m below the G. persculptus? Zone. This is the first occurrence of N. girardeauensis outside of mid-western United States where it occurs with species characteristic of the Richmondian Aphelognathus grandis and A. divergens chronozones. The low relative abundance of G. ensifer is believed to represent the G. ensifer Biohorizon. This species occurs in late Richmondian strata and the younger, Gamachian Fauna 13 acme-type zone in eastern Canada. Birksfeldia, a possible synonym of Gamachignathus, is associated with the Diplograptus bohemicus Zone (=C.? extraordinarius Zone) in China. G. ensifer and N. girardeauensis co-occur with the more abundant Plectodina florida and P. tenuis at Blackstone River; both species of Plectodina do not appear to occur in post-Richmondian, pre-Llandovery strata at other North American localities.

Graptolites of the G. persculptus? Zone occur above a carbonate unit, which in turn overlies the P. pacificus Zone at the section of Pat Lake, Yukon. The limestones have yielded a corroded fauna with *Ozarkodina* n. sp. A and coniform taxa. Elements of *O.* n. sp. A have a Silurian aspect, although it is noted that the genus is present but rare in the Ordovician. The remainder of the fauna comprises undiagnostic and unidentifiable elements of *Panderodus*, *Walliserodus* and a fragment of a platform element assigned to *Icriodella*.

The *Oulodus fluegeli* - *Dapsilodus obliquicostatus* assemblage of Blackstone River, Yukon is from about the mid-level of the upper Llandovery *Monograptus turriculatus* Zone. The fauna is dominated by these two conodont species, the latter of which is regarded as an offshore species, and *Walliserodus* n. sp. A. Associated taxa include *Distomodus* sp. cf. *D. kentuckyensis* and *Ozarkodina* sp. aff. *O. polinclinata*. The *O. fluegeli* - *D. obliquicostatus* assemblage is correlated with the upper *D. staurognathoides* to *Icriodella inconstans* zones, approximately equivalent to the *Pterospathodus celloni* Zone.

The *Pterospathodus celloni* Zone at the same section on Blackstone River occurs 3.5m higher in the *Monograptus turriculatus* Zone and about 5m below the *M. spiralis* Zone. Taxa include the nominal species, *Astropentagnathus irregularis*, *Aulacognathus bullatus*, *P. pennatus angulatus*, as well as new species of *Astropentagnathus*, *Pterospathodus*, and N. gen. B n. sp. A. The relatively low abundance of *D. obliquicostatus* and *O. fluegeli*, and greater abundance of elements of platform genera such as *Astropentagnathus*, *Distomodus* and *Pterospathodus* suggest a more nearshore or shallower subtidal habitat for these conodonts; there is no physical evidence for mass-transport and deposition of these sediments and conodonts.

The *P. amorphognathoides* Zone? of Tetlit Creek, Yukon contains elements of *Carniodus carnulus*, *D. obliquicostatus*, *Distomodus staurognahoides*, *P. p. procerus*, *O. fluegeli*, *O.* n. sp. A and *Ozarkodina excavata* n. sp. A. The fauna occurs 1m below latest Llandovery *Cyrtograptus sakmaricus* - *C. laqueus* Zone and 20m below indeterminate Wenlock graptolites. *P. amorphognathoides* is not present; *C. carnulus* is used to identify the conodont zone. The overlying graptolites limit this fauna to uppermost Llandovery, although the conodont zone elsewhere ranges into lowest Wenlock strata.

The *K. walliseri* Biohorizon? is tentatively identified at Tetlit Creek. It occurs 2m above graptolites of the *C. sakmaricus* - *C. laqueus* zone and 2m below indeterminate Wenlock graptolites. The ocurrence of *Pterospathodus pennatus procerus*, indicative of strata below the *Pterospathodus* Last Appearance Biohorizon, with *K. walliseri?* is anomalous. If this level is indeed middle Wenlock, it may suggest either a hiatus, or that the *C. sakmaricus* - *C. laqueus* Zone may have an extended upper range.

The debate on the exact placement of the Ordovician-Silurian boundary is probably not finished. Regardless of the solution, the rare occurrence of conodont-bearing carbonate and common graptolite faunas demand that the boundary in Yukon fine clastic facies be defined using graptolites. The prefered level of the base of the Llandovery in Yukon is at the lower limit of the *G. persculptus* Zone? Although this means that a continuous sequence may not be common in the northern Cordillera, it is complementary to the conodont faunas of the *Ozarkodina* n. sp. A - *Icriodella* sp. B assemblage at Pat Lake, N.W.T., and importantly, reflects the effects of a glacially-induced eustatic change in sea-level.

CHAPTER 8 -- SYSTEMATIC PALEONTOLOGY

All conodont taxa that are formally identified below are multielement; form species mentioned within the text have the abbreviation "s.f." (*sensu formo*). The apparatus and element nomenclature of Barnes, *et al.* (1979) is used with most taxa.

The synonymies of Nowlan, *et al.* (MS) are as current and comprehensive as possible, hence the synonymies of some Yukon taxa are brief, with references made to the Avalanche Lake study.

D. Yakobchuk, Department of Anatomy, University of Western Ontario, operated the scanning electron microscope used to produce the photomicrographs of plates 1-19.

All figured specimens have been assigned numbers (prefixed with ADM) and are presently in repository at the Department of Geology, University of Western Ontario in London, Ontario.

Genus *Amorphognathus* Branson and Mehl, 1933

Type species: *A. ordovicica* Branson and Mehl, 1933.

Amorphognathus ordovicicus Branson and Mehl

Pl. 7, fig. 36

g element

Amorphognathus ordovicica BRANSON and MEHL, 1933, p. 127, Pl. 10, fig. 38; MANARA and VAI, 1970, p. 478, Pl. 62, fig. 4; GLOBENSKY and JAUFFRED, 1971, p. 54, Pl. 2, fig. 6.

Multielement

Amorphognathus ordovicica Branson and Mehl. PALMIERI, 1978, pp. 7, 9, Pl. 11, figs. 1-12, text-fig. 7 (2a-4d).

Amorphognathus ordovicicus Branson and Mehl. BERGSTROM, 1978, Pl. 80, figs. 1-11; HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 4, figs. 3, 6, Pl. 5, fig. 11; ROSS, NOLAN and HARRIS, 1979, Fig. 6(a-f); SWEET, 1979b, p. 55, Fig. 10(1, 13); ORCHARD, 1980, p. 16, Pl. 4, figs. 1-13, 17, 18; NOWLAN and BARNES, 1981, pp. 9, 10, Pl. 1, figs. 1-14 (includes synonymy); WEYANT *in* PARIS, PELHATE and WEYANT, 1981 pp. 19, 20, Pl. 1, figs. 1-13, Pl. 3, figs. 4, 6, 8, 9; McCRACKEN and BARNES, 1982, Pl. 2, fig. 3; LENZ and McCRACKEN, 1982, Pl. 1, figs. 1-5.

cf. *Amorphognathus* cf. *A. ordovicicus* Branson and Mehl. McCRACKEN and BARNES, 1981a, p. 72, Pl. 4, figs. 34-43.

cf. *Amorphognathus* cf. *ordovicicus* Branson and Mehl. NI and LI *in* WANG, *et al.*, 1983, Pl. 8, figs., 10a, b.

cf. *Amorphognathus*? sp. NOWLAN and McCRACKEN *in* NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 1, fig. 1 (Appendix A, herein).

REMARKS

Amorphognathus? sp., listed in the above synonymy, is a solitary fragment of a *g* element from Avalanche Lake, N.W.T. sections (Nowlan, *et al*., MS).

TYPE: Hypotype, ADM 20001.

Genus *Apsidognathus* Walliser

Type species: *A. tuberculatus* Walliser, 1964.

REMARKS

Aldridge (1974) reconstructed the apparatus of *Apsidognathus walmsleyi* Aldridge to include platform and bilaterally symmetrical pygodontiform (=lyriform sensu Mabillard and Aldridge, 1983) elements. He suggested that the apparatus of *A. tuberculatus* Walliser may also include an ambalodontiform element such as *Ambalodus galerus* Walliser s.f. (i.e. *f* element). Mabillard and Aldridge (1983) and Uyeno and Barnes (1983, p. 14) included lenticular and modified ambalodontiform ("Pa2"=*g*-2) elements, respectively in their species of *Apsidognathus*. These elements have the form of *Pygodus lenticularis* Walliser s.f. Uyeno and Barnes (1983) did not include a form similar to *A. galerus* s.f. and instead placed a cruciform element, *Astrognathus tetractis* Walliser s.f. in the apparatus as the f element. This form species was reported to occur in the same time interval as A. galerus s.f., A. tuberculatus s.f. and P. lenticularis s.f. by Aldridge (1975).

A suggested interpretation of these elements of the Apsidognathus apparatus is as follows: lyriform/bilaterally symmetrical pygodontiform (=c); ambalodontiform (=e); cruciform (=f), platform (=g-1); lenticular/modified ambalodiform (=g-2) elements. The apparatus, as this and previous attempts at reconstruction show, is unusual: there are two forms of g elements and no known a and b elements.

Apsidognathus tuberculatus Walliser

Pl. 13, figs. 26-29

Ambalodontiform element

Ambalodus galerus WALLISER, 1964, p. 27, Pl. 6, fig. 1, Pl. 12, figs. 1-7; IGO and KOIKE, 1968, p. 7, Pl. 2, fig. 23; SCHONLAUB, 1971, p. 46, Pl. 2, figs. 16, 17; ALDRIDGE, 1972, p. 163, Pl. 3, figs. 6, 8; ALDRIDGE, 1974, Fig. 1G; ALDRIDGE, 1975, Pl. 3, fig. 9; ?KUWANO, 1976, Pl. 2, fig. 1; LEE, 1982, p. 71, Pl. 1, figs. 13, 16, 17; NOWLAN, 1983b, Fig. 3H.

g element

Apsidognathus tuberculatus WALLISER, 1964, pp. 29, 30, Pl. 5, fig. 1, Pl. 12, figs. 16-22, Pl. 13, figs. 1-5.

Apsidognathus cf. tuberculatus Walliser. MANNIK, 1983, Fig. 4(U).

Multielement

Apsidognathus tuberculatus Walliser. UYENO *in* UYENO and BARNES, 1983, p. 14, Pl. 6, figs. 6-14 (includes synonymy).

?*Apsidognathus tuberculatus* Walliser. HELFRICH, 1980, Pl. 1, figs. 25, 29; NOWLAN, 1981b, Pl. 7, figs. 7, 12-14, 17; NOWLAN, 1983b, Fig. 4(A, B) (may = *A*. sp. B of Mannik, 1983, p. 114, Fig. 5Y).

REMARKS

The *c* (pygodontiform) element (Pl. 13, fig. 27) differs from *Pygodus lyra* Walliser s.f., the *c* element of *Apsiodognathus tuberculatus* sensu Mabillard and Aldridge (1983), in that the lateral ridges are not ornamented. In this sense, it is more similar to the *c* element of *A. walmsleyi* Aldridge. The *e* element (Pl. 13, figs. 26, 28) may be represented by *Ambalodus galerus* Walliser s.f. This form species is represented herein by only two specimens, one of which co-occurs with elements of *A. tuberculatus*. The other specimen occurs 8m above the sample containing *A. tuberculatus*. *A. galerus* s.f. and the *e* element of *Astropentagnathus* n. sp. A are of a similar form.

The *g-1* elements (Pl. 13, fig. 29) are not complete but lack the wide lateral platforms and inner arcuate ridge of denticle nodes found on these elements of *A. walmsleyi*. The platform elements have two radiating rows of nodes, but these are not as distinct as those in *A. tuberculatus* s.f of Walliser (1964).

The Indeterminate Cruciform Element (Pl. 13, fig. 30) is from about 50m below the sample containing A. tuberculatus. It is cruciform with sharp process ridges and smooth inclined sides on the processes. It is similar to Astrognathus tetractis Walliser s.f., the g-2 element of A. tuberculatus as suggested by Uyeno and Barnes (1983) except that one of the processes is distally bifurcated. See the remarks to the Indeterminate Cruciform Element for further discussion of this element.

TYPES: Hypotypes, ADM 20002-20005.

Genus Astropentagnathus Mostler, 1967

Type species: A. irregularis Mostler, 1967.

REMARKS

The apparatus includes a symmetry transition series of at least b and c elements (and a possible a element), and platform-like f and g elements. An e element is identified in A. n. sp. A and is described as modified ozarkodiniform. Other elements may be part of Astropentagnathus but cannot be assigned with confidence to either of the species identified herein. These elements are described below under Astropentagnathus? Indeterminate Elements.

Astropentagnathus irregularis Mostler

Pl. 14, figs. 10, 12-16, 26, 31, 32

Pl. 15, figs. 1-11; Pl. 16, fig. 12

b-*c* elements

"*Rhynchognathodus*" n. sp. SCHONLAUB, 1971, pp. 48, 49, Pl. 3, figs. 15-19.

f element

Neospathognathodus tyrolensis (Mostler). MILLER, 1976, Fig. 8(37).

Spathognathodus tyrolensis MOSTLER, 1967, p. 302, Pl. 1, figs. 17, 19, 20, 23.

g element

Astropentagnathus irregularis MOSTLER, 1967, pp. 298-300, Pl. 1, figs. 1-3, 5-11 (only; fig. 4 is tentatively included under *A*. n. sp. A, below).

Hadrognathus irregularis (Mostler). MILLER, 1976, Fig. 8 (28, 38).

Multielement

Astropentagnathus irregularis Mostler. UYENO *in* UYENO and BARNES, 1983, p. 15, Pl. 4, figs. 23, 24 (includes synonymy); NOWLAN, 1983b, FIG. 4(D).

Hadrognathus irregularis (Mostler). SCHONLAUB, 1971, pp. 42, 43, Pl. 1, figs. 1-3, 5-10 (only; figs. 4, 11 are tentatively included under *A*. n. sp. A, below).

"*Hadrognathus irregularis*" assemblage of Schönlaub, 1972 (sic). MILLER, 1978, p. 341, Pl. 4, figs. 5-7 (reference is to Schönlaub, 1971; figs. 5, 6 = *Pterospathodus tyrolensis* (Mostler), fig. 7 = *A. irregularis* s.f.).

DESCRIPTION

White matter is present in cusp and denticles of all elements.

The a? element (Pl. 14, figs. 10, 12) has a long posterior and "anterior" (or anticusp) processes and a short outer lateral process. Cusp is proclined such that it is horizontal with respect to the posterior process. Distal end of posterior process curves upward; "anterior" process is directed downward and to posterior. "Anterior" and posterior processes are denticulated and platform-like. Denticles number at least 11 and 16 on posterior and "anterior" processes, respectively. They are long, peg-like and erect with respect to processes. Outer process is adenticulate. Basal cavity is deep; element does not have basal sheathing but does have thickened aboral margins.

The b and c elements (Pl. 14, figs. 16, 13, respectively) have a short, recurved cusp and long denticulated lateral and posterior processes. Cusp is nearly subcircular in cross section with anterolateral costae in line with lateral processes. Posterior process has thickened aboral margin on each side and has short discrete triangular denticles. These are laterally compressed and have costae on anterior and posterior edges. In small specimens, interspaces are U-shaped; on large specimens, they are V-shaped. Between cusp and first denticle on posterior process is a U-shaped gap with a width about equal to one denticle. Maximum number of denticles known is eight.

Lateral processes on b and c elements are directed downward, have a thickened aboral margin on posterior side only and have short antero-posteriorly compressed denticles. These are closely packed, confluent for part of length, inclined towards cusp and slightly proclined. Proximal denticle on each lateral process is long and is slightly anterior to cusp. Twenty denticles is maximum number preserved on one lateral process. Anterior face of element is concave between lateral processes and convex where cusp and lateral processes join. Basal cavity is deep and extends under entire length of processes as deep basal excavations.

The b element differs from symmetrical c element in that it has a cusp and posterior process that is slightly deflected towards inner side. Distal ends of long processes are bowed upwards slightly.

The f element (Pl. 14, figs. 15, 26, 31, 32; Pl. 16, fig. 12) is an arched platform with anterior and posterior processes forming a nearly straight line, and posesses short inner and long outer lateral processes. Cusp is short, slightly wider and longer than denticles on either side, and is slightly reclined. All processes have horizontal platforms, but platforms on each side of anterior process are more narrow than on other processes. Inner process has rounded distal margins; other processes are tapered. Anterior and posterior processes are directed downward giving element an arched form. In some elements, both processes are bowed to inner side; in others posterior process is bowed in opposite direction.

Anterior process of f element is longer than other processes and has relatively long, confluent and erect denticles that form a blade. Posterior and other processes have denticles that are shorter and less confluent than denticles of anterior process. Inner process is opposite cusp; it is short and is either adenticulate or with only one or two denticles. Outer process is slightly anterior to cusp and perpendicular to anteroposterior plane. Basal cavity is inverted, is more widely excavated under processes and is not as shallow as it is in g element.

The g element (Pl. 15, figs. 1-11) is a platform with five processes. Anterior and posterior processes form a plane; inner lateral and bifurcating outer lateral processes are directly opposed. Inner and shorter outer processes are directed anterolaterally; longer outer process is directed posterolaterally. Angle of divergence of processes, with respect to anteroposterior plane is about 50 degrees for all processes. Anterior process is about as long, or slightly longer than posterior; both anterolateral processes are about same length, and are shorter than posterolateral; posterolateral process is shorter than posterior. All processes, particularly inner, are directed downwards giving element an arched form. Anterior process is blade-like; others are platform-like with horizontal platforms. Platform processes are tapered distally. Posterior process is distally bowed to inner side. One aberrant element (not illustrated) has a short narrow process with three denticles between the posterior and posterolateral processes.

Denticles on anterior process of *g* element are long, confluent, forming a blade; some are slightly recurved. Platform-like processes have short, peg-like denticles. Inner process has either a ridge of denticles or only one incipient denticle or node. Entire aboral surface is a shallow excavation with inverted margins. Basal cavity is deepest at junction of processes and excavation is deepest beneath anterior processes. Other processes have a narrow aboral groove.

REMARKS

Klapper and Murphy (1975) and Uyeno and Barnes (1983) have previously suggested that "*Rhynchognathodus*" n. sp. Schönlaub s.f. is part of the apparatus of *Astropentagnathus irregularis*. The inclusion of this form herein is based on the short denticulation, colour, and in *A.* n. sp. A (below), having a well developed and ornamented basal sheath between the processes.

The *a*? element has longer and more erect denticles than the same element of *A.* n. sp. A; the outer process is also not as well developed. Basal sheathing between the processes is absent.

One b element (Pl. 14, fig. 14) is like that figured by Uyeno and Barnes (1983, Pl. 4, fig. 23). It has an adenticulate posterior process and the basal sheaths between all processes are convex.

An element representing the e position is not recognized; it could be mistakenly included within the e elements assigned to A. n. sp. A.

There is a degree of variability in the platform development on the f elements. Some elements (cf. Pl. 14, fig. 15) have broad platforms that taper toward the distal ends of the processes; others (cf. Pl. 14, fig. 26) have platforms that are more narrow, and which gradually taper toward the ends of the processes. A similar variation can be seen in the illustrations of Schönlaub (1971, Pl. 1, figs. 7, 8).

The orientation terminology of Aldridge (1972) is followed herein and the blade-like process of the g element is refered to as anterior. This conforms to the interpretation of the f element. Its blade-like process is distinctly anterior as indicated by the reclined denticulation. The inner side of both f and g elements has a weaker process development. The presence or absence of a row of denticles on the short inner lateral process is regarded as intraspecific variation.

The g element is comparable to the same element of Pterospathodus amorphognathoides Walliser in the sense that both have a bifurcated lateral process, straight blade-like anterior and a platform-like, curved posterior process. The g element of P. amorphognathoides differs in that the bifurcated process is outer not inner, the shorter of the pair is posterior not anterior, it is not arched, and it lacks a fifth process. Similarities between the g elements of A. irregularis and P. n. sp. A are discussed under the latter taxon.

The elements of A. irregularis and A. n. sp. A are compared below.

TYPES: Hypotypes, ADM 20007-20022, 20606-20609.

Astropentagnathus n. sp. A

Pl. 14, figs. 1-9, 11; Pl. 15, figs. 22, 23, 25-32

?Astropentagnathus irregularis MOSTLER, 1967, pp. 298-300, Pl. 1, fig. 4 (only).

?Hadrognathus irregularis (Mostler). SCHONLAUB, 1971, pp. 42, 43, Pl. 1, figs. 4, 11 (only).

DIAGNOSIS

Apparatus contains elements that have a confluent basal sheath between most processes; sheath bears widely spaced growth ridges and reticulated ornamentation. The f and g elements have downwardly directed processes with platforms that are composed of basal sheathing. Anterior process of f and g elements is blade-like with long denticles. Other elements include a-c symmetry transition series, and e (modified ozarkodiniform) elements.

DESCRIPTION

A basal sheath is confluent with, and extends between all processes on *a-c* and *e* elements, and between some processes on *f* and *g* elements. Sheath has widely spaced growth ridges that parallel aboral margin. Aboral margin of sheath is narrowly excavated. Oral surface has a reticulated ornamentation (Pl. 14, fig. 7). Most of aboral surface is excavated. All elements have white matter in cusp and denticles. Sinistral and dextral forms of *a*?, *a*/*b*, *b*, *f* and *g* elements are present.

The *a*? element (Pl. 14, figs. 1, 2) has a long denticulated posterior process, a downwardly and posteriorly directed anticusp or "anterior" process and an outer, adenticulate lateral process. "Cusp" is broken but possibly proclined. Anticusp and lateral processes taper to point. Distal end of posterior process is deflected upwards, gently in some elements, sharply in others, and in large elements, it is platform-like. Denticles are numerous (at least 12 on posterior, 22 on anticusp processes), relatively short, triangular and partially confluent. They are inclined towards anterior and slightly curved towards inner side.

The *a*/*b* element (Pl. 14, fig. 3) has a short, subcircular and recurved cusp, long denticulated anticusp ("anterior"), posterior and outer lateral processes. Anticusp process is directed downward and posteriorly lateral process is directed posterolaterally. Denticles number at least 29 on anticusp, 20 on lateral processes and are inclined towards cusp and directed laterally. Denticles are short, and are confluent for most of their length on proximal half, less confluent and more triangular on distal half of anticusp. Denticles on lateral process are short and confluent. Posterior process is broken and has at least 5 denticles and a wide adenticulate area between cusp and first denticle. Anterior margin at junction of processes with cusp is convex; inter-process face of anterior is concave. Basal sheath is planar.

The b (Pl. 14, fig. 9) element has long denticulated posterior and lateral processes. Cusp is short and recurved and has costae on anterolateral margins that merge with processes. Both lateral processes are directed downward and diverge at about same angle in a posterolateral direction. Anterior margin of cusp at junction of lateral processes is convex. Denticulation of lateral processes is like that of lateral process in a element and extends proximally to point of cusp recurvature. Denticles of posterior process are shorter than those of lateral process, triangular, and partially overgrown in some specimens. Basal sheath is slightly concave. Asymmetry is due to a slight flexure of cusp and posterior process to inner side.

The e element (Pl. 14, figs. 4, 8, 11) is like a modified ozarkodiniform element in lateral outline only. Cusp and denticles are slightly to moderately inclined towards short posterior process, which has 7 or more denticles. Anterior process is long with at least 12 denticles. Apical denticle (cusp) and other denticles are relatively long, thin, confluent, and slightly curved toward inner side. Outer face of denticle base is convex; inner face is slightly to moderately concave. Basal margin on inner side is a narrow to moderately wide platform. Lateral margin of base on outer side is flared beneath cusp. Base is nearly straight, except on one element that has a moderately concave inner face, it is arched. This element has denticles on anterior process that are inclined inward and are nearly horizontal. Denticle base of _e_ element has a granular ornamentation like that found on sheath of other elements.

The _f_ element is an arched platform with long anterior and short posterior processes that are in same plane; distal end of posterior process is inwardly bowed. Inner lateral process is long, perpendicular to anteroposterior plane, and anterior to cusp. All processes are denticulate except for short, flared outer lateral process. This process is opposite cusp and more posterior than inner process. On some elements, posterior margin of inner and anterior margin of outer processes are opposed to each other and perpendicular to anteroposterior plane, giving element a cruciform shape in oral view. All processes are directed downward. Posterior process has horizontal platform margins. Lateral processes have margins that are directed downwards; anterior process is blade-like. Distal ends of posterior and inner processes are tapered. Cusp is slightly larger than denticles.

Denticles of f element (Pl. 14, figs. 6, 8) have triangular tips, are slightly and laterally compressed, and number about 14 on anterior, 9 on inner and 7 on posterior processes. Denticles on anterior process are relatively long, confluent and erect with longest situated about two-thirds length from cusp. Denticles on posterior and inner processes are short and confluent; those of posterior process are reclined. A relatively wide adenticulate space is present between proximal denticle of inner and anterior procesess. Basal sheath occupies area between inner and anterior processes. This sheath and that of outer process have relatively wide growth ridges. Ridges are also visible in aboral view. Aboral surface of posterior process is inverted and has a narrow longitudinal groove.

The g element (Pl. 15, figs. 22, 23, 25, 26-32) is a platform with five processes; blade-like anterior process forms a line with as platform-like posterior process. On small elements, posterior process is more blade-like. Outer bifurcating process is directly opposite inner anterolateral process. All processes are joined at cusp; all platform processes taper toward distal ends. Anterior process is longest, outer anterolateral is shortest, others are variable in length. Posterior process is inwardly bowed at distal ends; other processes are straight. All processes are downwardly directed producing an arched element.

Lateral processes diverge at about same angle from anteroposterior plane. Inner process is more downwardly directed than others. Anterior process is connected to both inner and outer anterolateral processes via extensive basal sheath. Less extensive sheath also connects outer posterolateral and posterior processes. Growth ridges are present on oral and aboral sides of sheath.

Denticles of *g* element are slightly compressed laterally. Anterior process has about 12 relatively long denticles that are confluent except for their triangular tips. Profile outline formed by tips is horizontal for proximal two-thirds and curves downward for remainder of anterior process. Longest denticles are just posterior of this downward inflection point. Cusp is indistinct and at intersection of processes; cusp and bounding denticles may be lower than other denticles and completely overgrown or fused. Posterior process has about 12 denticles that are short, confluent except for their triangular tips. Denticles of outer processes are similar; these form two ridges that intersect near anteroposterior plane. A relatively large adenticulate region is present between point of intersection and other processes. Denticles on inner process are either absent, or present only at distal end forming a short indistinct denticle row. Basal excavation is deepest beneath anterior process. Aboral surface beneath posterior and posterolateral processes is inverted with a narrow longitudinal groove.

REMARKS

This new species contains elements, particularly the g element, that are similar to those of Astropentagnathus irregularis Mostler. The most striking difference is the basal sheathing, concentric ridges and ornamentation in all elements of A. n. sp. A. This sheathing in A. n. sp. A forms a downwardly directed platform on the f and g elements. Platform margins on the same elements of A. irregularis are narrow and perpendicular to the denticle rows.

Mostler (1967, Pl. 1, fig. 4) and Schönlaub (1971, Pl. 1, fig. 4) have illustrated g elements that have a similar sheathing and growth lines between the processes. Schönlaub regarded his element as a juvenile form of A. irregularis. In the Yukon material, these elements are found in the same range of size as those of A. irregularis hence the differences cannot be ascribed to ontogeny. Schönlaub (ibid., fig. 11) also illustrated a f element with the same ornamentation.

The denticles of the anterior processes of the f and g elements and the inner lateral process of A. n. sp. A are longer than those in the same elements of A. irregularis. The adenticulate space between the anterior process and inner lateral denticles is much larger on the f and g elements of this new species than in these elements of A. irregularis. The symmetry transition series elements similarily have a longer adenticulate space between the cusp and the proximal denticle of the posterior process. The denticles of A. n. sp. A elements are generally longer, thinner and more numerous than those of A. irregularis.

Elements of these species from the same sample also differ in colour. Those of A. irregularis are a darker grey than elements of A. n. sp. A, which are more brown than grey. This is presumably due to differences in thickness, and possibly surface ornamentation.

As reconstructed herein, neither apparatus may be complete. Other elements may be found in the grouping of Astropentagnathus? Indeterminate Elements below.

TYPES: Figured specimens, ADM 20023-20040.

Astropentagnathus? Indeterminate Elements

Pl. 14, figs. 17-23, 28-30

DESCRIPTION

All elements have processes that bear narrow basal ledges. Basal cavity is deep and extends as a narrow excavation under processes. Aboral surfaces are narrowly everted. Surface is covered with a moderately dense papillose ornamentation.

The b element (Pl. 14, figs. 18, 30) is like the c element except that lateral processes are asymmetrically twisted. Posterior process is short, adenticulate and has a convex posterior margin. Ornamentation is like that of d element but not as dense.

The c element (Pl. 14, fig. 19) has relatively long, closely packed denticles like those of d element. Distal denticles on lateral processes are discrete, nearly erect, triangular and closely packed. Posterior margin of cusp is sharp.

The d (tetraprioniodiniform) element (Pl. 14, figs. 17, 21, 29) is asymmetrical with four long denticulated processes. Cusp is subcircular in cross section, narrow and slightly recurved. Denticles are slightly compressed and inclined towards cusp. Posterior process arises from outer side of cusp and is bowed slightly inwards and upwards. Denticles number at least 9 and are short, triangular and discrete. An adenticulate space is between cusp and first denticle. Remaining three processes are directed downward and to posterior. Denticles number at least 9, 16 and 11 on anterior, inner and outer processes, respectively. These are relatively long, confluent for much of their length and inclined towards cusp. Denticles toward distal ends of processes are smaller and more discrete than proximal ones. Proximal denticles of lateral processes are partially confluent with cusp. Proximal denticle of anterior process is opposite level of fourth denticle on outer process. Anterior process is not symmetrically positioned, being closer to outer than to inner process.

The modified "holodontiform" element (Pl. 14, figs. 20, 22, 23, 28) has an extremely proclined cusp and three denticulated processes that diverge almost directly to posterior. Cusp is slightly recurved, thus these two processes are regarded as lateral, third one constitutes an anterior process. Posterior face of element from cusp to raised basal margin forms a smooth concave arch; face is convex laterally. Denticles are like those of other elements; lateral denticles curve inward. Anterior process is offset to one side; proximal denticle of this process is not near cusp but is opposite fifth denticle of one process. Papillose ornamentation is moderately dense. Basal ledge forms a narrow platform around some processes.

REMARKS

These elements are referred to as Astropentagnathus? Indeterminate Elements because their assignment to this genus is not certain, and even though they co-occur with A. irregularis Mostler and A. n. sp. A, I cannot confidently relate them to either species.

The "holodontiform" element may be homologous to the d element if the short adenticulate posterior base is regarded as the posterior process. The denticulation of these elements differ slightly; the denticles of the d element are longer, narrower and less compressed than those of the "holodontiform" element. The b element has similar denticulation and a short adenticulate posterior process like the "holodontiform" element. The *b* and "holodontiform" element may be part of one multielement species, the *d* part of another. The *c* element also has denticulation more like that of the "holodontiform" than the *d* element.

TYPES: Figured specimens, ADM 20042-20050.

Genus *Aulacognathus* Mostler, 1967

Type species: *A. kuehni* Mostler, 1967.

Aulacognathus bullatus (Nicoll and Rexroad)

Pl. 8, figs. 33, 39, 40

f element

Ozarkodina sp. ex. aff. *Oz. adiutricis* Walliser. WALLISER, 1964, p. 54, Pl. 27, fig. 11, text-fig. 7n.

g element

Neospathognathodus bullatus NICOLL and REXROAD, 1969, pp. 44, 45, Pl. 1, figs. 5-7.

Multielement

Aulacognathus bullatus (Nicoll and Rexroad). UYENO *in* UYENO and BARNES, 1983, p. 15, Pl. 4, figs. 18, 20-22, (includes synonymy); NOWLAN, 1983b, Fig. 4(E, O, P).

REMARKS

The illustrated *f* element (Pl. 8, fig. 23) differs from the form species of Walliser (1964) in that it has the longer lateral process on the inner, not outer side. In this regard, it is like one of the *f* elements of Uyeno and Barnes (1983, Pl. 4, fig. 18).

The g element (Pl. 8, figs. 39, 40) has been well described in the literature and no additional comments can be added from the rare elements of this study.

TYPES: Hypotypes, ADM 20051-20053.

Genus Belodella Ethington, 1959 s.l.

Type species: Belodus devonicus Stauffer, 1940

REMARKS

Klapper and Barrick (1983) revised the diagnosis of Belodella to exclude species that contain oistodontiform elements. Their emended apparatus consists of a symmetry series (a,b,c,d? elements) and an erect and adenticulate e element. They suggested that species with oistodontiform elements should be referred to a new genus. In this present generic discussion, I treat all species as being part of Belodella sensu lato. However, for the Yukon taxon I follow their recommendation and query the generic name.

The a (cordylodontiform) element of Ordovician species is laterally compressed with keeled anterior and posterior margins. It has a long base, a straight oral margin and a narrow cusp. The b (keislognathiform) element has lateral faces that are asymmetrically convex due to the presence of carinae or costae, a short base, poorly keeled anterior and posterior margins, a concave oral edge and a wide, laterally compressed cusp. The denticulation on the b element is as coarse as, and more discrete than, that of the a element.

The *c* and *e* elements are hibbardelliform (symmetrical) and oistodontiform elements, respectively. The *a*-*e* elements of *B.* *erecta* (Rhodes and Dineley), *B.* *jemtlandica* Löfgren and *B.*? aff. *B.*? *nevadensis* (Ethington and Schumacher) sensu this study are comparable.

The remaining element-morphotype of *Belodella* species has asymmetrically developed lateral faces and an adenticulate to finely denticulate upper margin that is basally straight. This element is regarded as a *f* element, possibly homologous to the morphologically more complex prioniodiniform elements of some Type IV apparatuses. The morphologically variable *f* element of *B.* *jemtlandica* was named the adenticulate biconvex element by Löfgren (1978). Elements illustrated by her have a straight oral margin that varies in length and degree of arching. In genera with Type IV apparatuses [illegible] *f* element differs from the *g* element in that the posterior oral margin is shorter (cf. *Phragmodus*) or the element is more arched (cf. *Aphelognathus*, *Gamachignathus*, *Ozarkodina*). The end-members within the the biconvex element (Löfgren, 1978, Pl. 15, figs. 6 and 5) in *B.* *jemtlandica* may be homologous to the *f* and *g* elements respectively, of the more complex genera listed above.

The reconstruction of the Middle Ordovician *B.* *nevadensis* Ethington and Schumacher is more tentative than the above species, both in Löfgren's (1978) and this study's interpretation. *B.* *nevadensis*, as interpreted herein, has an apparatus that consists of *a*, *b*, *c*, *e* and *f* elements. A more detailed discussion of this species follows within the remarks of B.? aff. B.? nevadensis.

In the younger Ordovician species B. erecta, the f or g element may be absent. The biconvex element of B. erecta (sensu Löfgren, 1978) is homologous to this study's b element.

Belodella silurica Barrick (1977), a Silurian species, has an apparatus that lacks a geniculate e element but does include a non-geniculate and adenticulate coelocerodontiform (?e or f) element. The Silurian species B. sp. B. devonica (Stauffer) of Cooper (1976) includes only denticulated symmetrical and asymmetrical elements that are c and a elements, respectively. B. anomalis Cooper (1977a) does not have a cordylodontiform element and instead has an element that may be described as eoligonidiniform. In both species described by Cooper, the b element may be present as an asymmetrical c element and the e element appears to be lacking.

Klapper and Barrick (1983, p. 1229) suggest that Devonian forms referred to as Coelocerodontus s.f. may be part of a Belodella apparatus, thus following Barrick's (1977) interpretation of B. silurica.

In summary, Middle and Late Ordovician species of Belodella have apparatuses that are Type IVE (a,b,c,e,f) or modified Type IVE (a,b,c,e,f,g). The Upper Llandovery-Lower Wenlock species B. sp. cf. B. devonica has a Type IIB (a,b,c) apparatus. The Wenlock B. silurica and Ludlow B. anomalis have modified Type IVE and IIB apparatuses, respectively. The apparatus of the Devonian B. devonica may be a modified Type IVE similar to that of B. silurica.

Species of Belodella s.l. that have a Type IV apparatus ranged from Ordovician through the Devonian while Type IIB species are known only from the Silurian. Species assigned to Belodella s.l. are probably of polyphyletic origin.

Belodella? aff. B.? nevadensis (Ethington and Schumacher)

Pl. 4, figs. 3, 4, 8, 9, 13, 14, 19-31

a element

aff. New Genus A ETHINGTON and SCHUMACHER, 1969, pp. 478, 479, fig. 12, text-fig. 4(J).

b element

aff. Oepikodus copenhagenensis ETHINGTON and SCHUMACHER, 1969, p. 465, Pl. 68, figs. 5, 9, text-fig. 4(L).

c element

aff. Roundya n. sp. SWEET and BERGSTROM, 1962, pp. 1244, 1245, text-fig. 5.

aff. Roundya? n. sp. A ETHINGTON and SCHUMACHER, 1969, p. 475, Pl. 67, fig. 23.

e element

aff. Oistodus nevadensis ETHINGTON and SCHUMACHER, 1969, pp. 467, 468, Pl. 68, figs. 1-4, text-fig. 5(C).

aff. "Oistodus" sp. aff. "O". nevadensis Ethington and Schumacher. TIPNIS, 1978, Pl. 13.1, fig.6.

f element

aff. Oepikodus? aff. O. copenhagenensis ETHINGTON and SCHUMACHER, 1969, p. 465, Pl. 68, fig. 14, text-fig. 4I.

Multielement

Belodella nevadensis (Ethington and Schumacher). HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 3, figs. 10-13.

aff. B. nevadensis (Ethington and Schumacher). BERGSTROM, 1978, Pl. 79, figs. 9, 10; LOFGREN, 1978, text-figs. 24(J- M).

?Belodella sp. A Fahraeus. BERGSTROM, 1979a, p. 306, figs. 4(L, M).

aff. Belodella spp. STOUGE in STOUGE and BOYCE, 1983, Pl. 6, figs. 2-8.

DESCRIPTION

All elements have a triangular basal cavity that extends for full length of base. White matter is present in cusp and denticles. The a, b, c and f elements have denticulated oral margins. Denticulation in f element is weak compared to other elements. Cusp is flexed slightly to inner side in a element; b, e and f elements are bowed slightly to inner side.

The acostate a element (Pl. 4, figs. 8, 9) has a long base with a straight and denticulate oral margin, straight aboral and basal margins and a proclined cusp. Basal cavity extends anteriorly to about two-thirds of element length.

Inner face of base is more narrowly convex than outer face. Micro-ornamentation consists of oblique striae on the antero-aboral corner (Pl. 4, fig. 31). Sharp anterior edge develops apically into a costa and is flexed slightly to inner side. Posterior portion of oral margin is keeled. Denticles are relatively long, fused and have short triangular tips. About 17 or more erect denticles occupy central region of element.

The b element (Pl. 4, figs. 3, 4, 23, 24) is denticulated with a base and proclined cusp that are short. Upper margin forms an arch that is uniformly concave. Basal cavity extends to region of anterior denticles. Posterior oral region is adenticulate. Inner face is slightly convex to planar, outer is more convex. Basal margin is nearly straight.

Inner face of b element has costa that is most prominent at mid-length and diminshes towards posterior and anterior. This face has fine parallel striae between oral margin and costa. Outer face is similarly costate except that costa merges posteriorly with a carina. Cusp is striated between costa and aboral margin. Denticles number about 15 or less, are relatively long, proclined and for the most part discrete.

The c element (Pl. 4, figs. 26, 28-30) is symmetrical and has a short base with a long proclined cusp. Triangular basal cavity is low. Anterior and lateral faces of base are concave producing a basal cross section that is narrowly triangular. Element has faint striae on posterolateral face of cusp. Anterolateral keels extend for full length of element. Cusp is planar in cross section. Denticles are long, fused for most of their length and with discrete triangular tips. They extend from posterior edge of base to cusp, are erect posteriorly, proclined anteriorly producing a palmate blade of denticles. Anterior denticles are longer than posterior denticles. Anterior-most denticle is fused with posterior edge of cusp. Oral edge is slightly extended posteriorly.

The e element (Pl. 4, figs. 25, 27) has aboral margin that is slightly convex towards anteriorly, slightly concave posteriorly. Oral margin is sharply keeled, only slightly convex and has small geniculation angle between cusp and base. Anterior margin of element has relatively strong inflection on one element; this is evenly convex on another element. Angle at antero-aboral corner is variable. Cusp is short, narrow with a strong carina on inner face; other side has a weaker carina. Basal cavity is low, deepest beneath keel and does not extend into cusp. Keel on anterior margin of base is narrow with slight flex to outer side. Anterior and posterior margin of cusp are sharp.

Two forms of f elements have a straight denticulated oral margin and short proclined cusp. Basal cavity extends to region of anterior denticles. Inner face slightly convex to nearly planar; outer is more convex. Ornamentation on inner side of *f*-1 element (Pl. 4, figs. 13, 14, 19, 20) is similar to that of *b* element. Outer face has prominent striae on anterior margin of element. Carina on this face is basally strong and merges with a costa towards cusp. The *f*-2 element (Pl. 4, figs. 21, 22) has basal carina on outer face. Oral margin is finely denticulated, almost serrated. Short denticles with triangular tips number about 15 or more, are proclined, relatively long and fused for most of their length. White matter is not present in small denticles of posterior region of oral margin.

REMARKS

In her reconstruction of *Belodella nevadensis*, Löfgren (1978) tentatively correlated *Oepikodus copenhagenensis* Ethington and Schumacher s.f. with the biconvex element of *B. jemtlandica* in spite of its concavo-convex or plano-convex basal outline. She also considered that *O.*? aff. *O. copenhagenensis* s.f., an element with a concavo-convex basal outline and New Genus A Ethington and Schumacher s.f. to be homologous with the plano-convex and triangular elements respectively, of *B. jemtlandica*. *O.*? aff. *O. copenhagenensis* s.f. differs from *O. copenhagenensis* in that it is more strongly concavo-convex (Ethington and Schumacher, 1969, p. 465) but also the posterior margin weakly as concave and is nearly straight posteriorly. Furthermore, it differs markedly in denticulation compared to the other elements. A similar relationship is noted above for the Peel River species; that is, the *f* element has a finer denticulation than the other elements. These two forms, O. copenhagenensis s.f. and O?. aff. O. copenhagenensis s.f. are homologous to the b and f elements of the species of this study.

N. gen. A s.f. has a basal outline that is concavo-convex and has a keeled lower margin and fused erect denticles. This compares better with the a element of this study than with the triangular (c) element, sensu Löfgren (1978). The triangular basal outline and erect cusp with lateral costae (=?keels) found on Roundya? sp. A Ethington and Schumacher s.f. are characteristic of the c elements of the other species of Belodella.

The a element of B.? aff. B.? nevadensis is similar to the same element of B. jemtlandica (Löfgren, 1978, Pl. 15, fig. 3) especially with regard to basal outline and keeled anterior and posterior margins. However, the denticulation in this species is more erect and the cusp is more proclined than in B. jemtlandica. The a element of B. erecta (sensu Löfgren, ibid., text-fig. 24G) also has erect denticles but differs in having an erect rather than a proclined cusp. N. gen. A. s.f., the a element in B. nevadensis, differs from this element in that one lateral face has a costa and the basal outline is concavo-convex.

The b elements of B. erecta, B. jemtlandica, (Löfgren, 1978, fig. 4) B. nevadensis and B.? aff. B.? nevadensis have relatively coarse denticulation, poorly keeled anterior and posterior margins and are asymmetrically biconvex at the base. The b element of B. jemtlandica lacks lateral costae.

The c element lacks the long base and relatively short denticles of the c elements in B. erecta, B. jemtlandica (Löfgren, 1978, fig. 1) and B. nevadensis. I concur with Löfgren's (ibid.) tentative assignment of B. sp. A. s.f. of Fahraeus (1970) to the c element position in of B. jemtlandica. B. sp. A Fahraeus s.f. sensu Bergström (1979a) has a short base and long denticles similar to the c element described herein, and is therefore questionably assigned to B.? aff. B.? nevadensis. The c element of B. nevadensis has a short base but Ethington and Schumacher (1969) note that their specimens are incomplete. The belodelliform elements of B. nevadensis of Harris, et al. (1979) are comparable to the taxon herein. The high blade-like region of one of their elements (ibid., 1979, Pl. 3, fig. 11) is interpreted to be fused denticles.

The e element of B. erecta and B. jemtlandica (Löfgren, 1978, Pl. 15, figs. 7, 8) and one element of B.? aff. B.? nevadensis (Pl. 4, fig. 25) have a similar sharp inflection of the anterior margin. The e element of B. nevadensis, as does the other figured element of the Yukon study (Pl. 4, fig. 27), has a more evenly curved margin. The geniculation angle is small and the oral margin is short and nearly straight on the e element of B.? aff. B.? nevadensis and B. jemtlandica. The e element of B. erecta and B. nevadensis differ in that the geniculation angle is greater and the oral margin is longer and more convex.

Unlike the basal cavity of the *e* element of *B. jemtlandica*, the cavity tip of the *e* element of *B.* sp. aff. *B. nevadensis* does not extend into the cusp. In this regard, it is similar to the same element in *B. erecta* and *B. nevadensis*. The *e* element of *B. jemtlandica* has a carina on only the inner side of the cusp; the other side is more evenly convex. The *e* element figured by Bergström (1979a, fig. 4M) for *Belodella* sp. A differs in that the basal margin is more sinuous but has a similar narrow and carinate cusp like this element and the incomplete *e* element of *B. nevadensis*, sensu Harris, *et al.* (1979).

The *f* element of *B. jemtlandica* (Löfgren, 1978, figs. 5,6) has the same form as that described herein but is adenticulate, although Löfgren noted that the oral margin may be faintly serrated. The other notable difference is the presence of a costa on this element but not on the same element of *B. jemtlandica*. *O.*?.aff. *O. copenhagenensis* s.f., the *f* element of *B. nevadensis*, differs from other elements in the *B. nevadensis* apparatus in that the denticles are proclined and distally long. *O.*? aff. *O. copenhagenensis* s.f. is quite different from the *f* elements of both *B. jemtlandica* and *B.*? aff. *B.*? *nevadensis*.

B. nevadensis was originally described from the Copenhagen Formation of Nevada. *B. nevadensis* sensu Harris, *et al.*, 1979 (= *B.*? aff. *B.*? *nevadensis*, herein) is from the underlying Antelope Valley Limestone in Nevada. The differences between these two taxa may be due to intraspecific variation, or it may be evolutionary.

TYPES: Figured specimens, ADM 20054-20063.

Belodella silurica Barrick

Multielement

Belodella silurica BARRICK, 1977, p. 50, Pl. 1, figs. 1-6, 9, 10.

REMARKS

Three belodelliform elements (unfigured) are found in association with Carniodus, Distomodus, Oulodus, Pterospathodus pennatus procerus (Walliser) and Walliserodus sancticlari Cooper.

Barrick (1977) reports Belodella silurica from the upper K. amsdeni and lower K. variabilis zones of Oklahoma. The Yukon elements are probably from older strata than those reported by Barrick. The apparatus reconstruction of B. silurica conforms to the restricted definition of the genus suggested by Barrick and Klapper (1983; see generic discussion above).

Genus Belodina Ethington, 1959

Type species: Belodus compressus Branson and Mehl, 1933 (emended Bergström and Sweet, 1966; emended Sweet, 1979b).

Belodina confluens Sweet

Pl. 7, figs. 1-4

Multielement

Belodina compressa (Branson and Mehl). LENZ and McCRACKEN, 1982, Pl. 2, figs. 3, 4, 7.

Belodina confluens SWEET, 1979b, pp. 50, 60, Fig. 5(10, 17), Fig. 6(9) (includes synonymy); NOWLAN, 1983a, pp. 662, 664, Pl.3, figs. 3, 4 (includes synonymy); NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 1, figs. 16-21 (Appendix A, herein; text includes synonymy).

TYPES: Hypotypes, ADM 20064-20067.

Genus Besselodus Aldridge, 1982

Emended Nowlan and McCracken, MS

Type species: B. arcticus Aldridge, 1983.

Besselodus borealis n. sp. Nowlan and McCracken MS

Pl. 6, figs. 18, 23-27, 29-32

Multielement

Besselodus borealis n. sp. NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 2, figs. 1-17 (Appendix A, herein; text includes synonymy).

REMARKS

Some of the rare elements from northern Yukon differ from those of Avalanche Lake, N.W.T. (Nowlan, et al., MS). The bases on some of the Yukon distacodontiform elements are wider than in the type material. The e element also differs in that the anterior part of the aboral margin curves upward rather than being straight. Some distacodontiform elements from both regions display a finely denticulated anterior or lower margin (Pl. 6, figs. 23, 29).

The Yukon elements may represent a new species of Besselodus but one [illegible]not be proposed at this time. The rationale for this is: Yukon material is limited; the genus has only recently been established and the diagnosis may still be in a state of flux; two species, B. arcticus Aldridge (1982) and B. borealis n. sp. have now been recognized, and a possible third species (unpublished) is known. This latter form is from the Ordovician Allen Bay Formation, Cornwallis Island, N.W.T. The distacodontiform and oistodontiform elements of the Allen Bay species differs from the same elements of B. arcticus of Greenland and B. borealis of Avalanche Lake. To propose a fourth species, from Yukon, is premature.

TYPES: Figured specimens, ADM 20068-20074.

Genus Carniodus Walliser, 1964

Type species: C. carnulus Walliser, 1964.

REMARKS

The genus Carniodus, as reconstructed by Barrick and Klapper (1976), has an apparatus comprising six morphotypes. Barrick and Klapper (ibid.) commented that the apparatus is strikingly unlike other Silurian apparatuses but noted a similarity with the apparatus of the Ordovician *Prioniodus*, a European Province taxon. This similarity is presumably between the *a* and *c* elements of both genera since the other elements are unique. The *f* element is termed modified ozarkodiniform (differs from the more typical ozarkodiniform element is found in genera, such as *Ozarkodina*, of the American Province. The *g* element is arched slightly and asymmetrically to symmetrically with two denticulated processes. The *b*, *e*, and *g* elements are atypical of Type IV genera of both of the above conodont faunal provinces but can be regarded as modified types of prioniodiniform, cyrtoniodontiform and spathognathodontiform elements, respectively.

Barrick and Klapper (1976) further recognized that the apparatus of *Carniodus* differs from *Prioniodus* through the absence of the *d* (tetraprioniodiniform) element. This absence is not unique since the genus *Gamachignathus*, which follows the prioniodid plan, also lacks a *d* element.

I propose an alterative reconstruction of the apparatus of *Carniodus*. Symmetry transition (*a*-*c*) elements with distinct hindeodellid-type of denticulation, traditionally part of *Carniodus*, are excluded from the apparatus and are suggested to be part of *Pterospathodus* species (below). An *a* element is recognized in the apparatus of *Carniodus* but it lacks the hindeodellid-type of denticulation. The *a* element is represented by *Neoprioniodus subcarnus* Walliser s.f. (Pl. 17, figs. 15-17). The *b* element is represented by *C. carnus*

Walliser s.f. (Pl. 17, figs. 18-21). The *c* element is a symmetrical form of *C. carnulus* s.f. (Pl. 17, figs. 22-25). The *e*-1 element is cyrtoniodontiform (Pl. 17, fig. 4); the *e*-2 element is a modified prioniodontiform element, *C. carnulus* s.f. (not illustrated). The *f* element is a modified ozarkodiniform element: (?)*C. carinthiacus* Walliser s.f. (Pl. 17, figs. 34, 35). The *g* element is represented by a symmetry series of elements (Pl. 17, figs. 26-29, 32, 33) that have relatively short and wide cusps (*C. carnulus* s.f.). The synonymy below lists the form species of Walliser (1964) under their interpreted positions.

Carniodus carnulus Walliser

Pl. 17, figs. 4, 15-35

a element

?*Neoprioniodus costatus paucidentatus* Walliser. IGO and KOIKE, 1968, p. 12, Pl. 3, fig. 17 (only).

Neoprioniodus subcarnus WALLISER, 1964, pp. 51, 52, Pl. 28, figs. 12, 14, 18 (only); LEE, 1982, pp. 90, 91, Pl. 2, figs. 12, 17.

b element

Carniodus carnus WALLISER, 1964, p. 34, Pl. 5, fig. 3, Pl. 10, fig. 13, Pl. 28, figs. 2-7, text-fig. 4(y-z).

?*Carniodus* sp. B IGO and KOIKE, 1968, p. 8, Pl. 1, fig. 20.

c element

Carniodus carnulus WALLISER, 1964, pp. 32, 33, Pl. 28, fig. 1(only).

e element

Carniodus carnulus WALLISER, 1964, pp. 32, 33, Pl. 10, fig. 20 (only).

(?)Carniodus carthinicus WALLISER, 1964, pp. 31, 32, Pl. 6, fig. 8, Pl. 27, figs. 20-26, text-fig. 4(n).

f element

Carniodus cf. carthinicus Walliser. LEE, 1982, p. 73, Pl. 1, figs. 24, 25.

g element

Carniodus carnulus WALLISER, 1964, pp. 32, 33, Pl. 6, fig. 10, Pl. 10, fig. 21, Pl. 27, figs. 27-38, text-fig. 4(a-f) (only; non Pl. 10, fig. 20 = e-2 element, Pl. 28, fig. 1 = c element).

?Carniodus sp. A IGO and KOIKE, 1968, p. 8, Pl. 1, figs. 2, 3.

Multielement

Carniodus carnulus Walliser. MABILLARD and ALDRIDGE, 1983, Pl. 2, figs. 13, 14; UYENO in UYENO and BARNES, 1983, p. 16, Pl. 5, figs. 1-10 (includes synonymy); ALDRIDGE and MOHAMED, 1982, Pl. 2, figs. 17-24; MABILLARD and ALDRIDGE, 1985, text-fig. 7c.

?Carniodus sp. ALDRIDGE, 1979, Pl. 1, fig. 8.

REMARKS

Previous authors have noted a variation within Carniodus carnulus s.f., the g element of this multielement species. Walliser (1964, Pl. 10, fig. 20), Aldridge (1972, Pl. 5, fig. 14) and Uyeno and Barnes (1983, pl. 5, fig. 4) illustrated a form with a denticulated anterior process.

Uyeno and Barnes considered this element as the M (=*e*) element; I concur except that I further designate it the *e*-2 element. The Yukon material has yielded both varieties of *C. carnulus* s.f.

Elements of Uyeno and Barnes (1983) either lack, or have only subdued basal margins compared to the more typical specimens of *C. carnulus*. This thickened form of basal margin or narrow platform ledge is herein termed carniodontid. All of the elements of this present study have this basal carniodontid ledge.

TYPES: Hypotypes, ADM 20075-20096.

Genus *Coelocerodontus* Ethington, 1959

Type species: *C. trigonius* Ethington, 1959.

Coelocerodontus? sp.

Pl. 1, fig. 16

REMARKS

The single, corroded element occurs in a fauna that includes *Periodon aculeatus* Hadding. It has the triangular outline of the trigoniform element of *Coelocerodontus trigonius* Ethington, but the preservation makes it impossible to determine if the element has a deep basal cavity, a distinguishing character of elements of this genus.

TYPE: Figured specimen, ADM 20601.

Genus Cordylodus Pander, 1856

Emended Bergström and Sweet, 1966

Type species: C. angulatus Pander, 1856.

"Cordylodus" horridus Barnes and Poplawski

Pl. 1, fig. 1

Genus and Species Indeterminate BRADSHAW, 1969, pp. 1164, 1165, Pl. 137, figs. 20-23.

Multielement

Cordylodus horridus BARNES and POPLAWSKI, 1973, p. 771, Pl. 2, figs. 16-18; LANDING, 1976, p. 631, Pl. 1, fig. 11.

"Cordylodus" horridus Barnes and Poplawski. BERGSTROM, 1979a, Fig. 4(J); HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 1, fig. 6; NOWLAN and THURLOW, 1984, p. 291, Pl. 1, figs. 4, 7, 8.

Cordylodus? horridus Barnes and Poplawski. STOUGE in STOUGE and BOYCE, 1983, Pl. 7, figs. 4-6.

REMARKS

Landing (1976) regarded this species as having a monoelemental apparatus. Nowlan and Thurlow (1984) believed that this species does not belong to Cordylodus as redescribed by Miller (1980) and should probably be assigned to a new genus. I follow their example and use quotation marks around the generic name.

This species is a biostratigraphically significant taxon, one which indicates an early Whiterockian age.

TYPE: Hypotype, ADM 20097.

Genus *Dapsilodus* Cooper, 1976

Type species: *Distacodus obliquicostatus* Branson and Mehl, 1933.

REMARKS

Middle Ordovician distacodontiform elements similar to those of *D.*? sp. C previously have been included in *Acodus*? (e.g. Löfgren, 1978), *Besselodus* (e.g. Aldridge, 1982), *Dapsilodus* (e.g. Bergström, 1978) and *Paroistodus*? (e.g. Barnes and Poplawski, 1973; Sweet, 1979a). The apparatuses of *Besselodus* and *Paroistodus*? include an oistodontiform element. Since this type of element was not found in the small Middle Ordovician collection from the Peel River section, these distacodontiform elements are tentatively assigned to *Dapsilodus*?. This is not an entirely satisfactory assignment since it extends the range of the genus. Assignment to *Acodus* is avoided due to the nomenclatural confusion (cf. Cooper, 1976, p. 211; Löfgren, 1978, p. 43).

Oblique striations on the anterior margins noted by the authors of both *Besselodus* and *Dapsilodus* have also been found on specimens of *Belodella* (herein), *Belodina* and *Strachanognathus* by Lenz and McCracken (1982). The suprageneric significance, if any, of these striae is not known.

Small elements of Dapsilodus are similar in form to those of Besselodus and Scabbardella. One of the differences is the micro-ornamentation. Scabbardella lacks oblique striae and instead is very finely and evenly striated about the axis of the element.

Dapsilodus obliquicostatus (Branson and Mehl)

Pl. 19, figs. 11, 13, 14, 16-28, 30-32, 35, 40.

Distacodus obliquicostatus BRANSON and MEHL, 1933, p. 41, Pl. 3, fig. 2; ?MILLER, 1976, Fig. 8(12); MILLER, 1978, Pl. 1, fig. 18; LEE, 1982, pp. 74, 75, Pl. 4, figs. 23, 24.

Multielement

Dapsilodus obliquicostatus (Branson and Mehl). ALDRIDGE, DORNING and SIVETER, 1981, Pl. 2.1, figs. 6-8; UYENO in UYENO and BARNES, 1983, p. 16, Pl. 9, figs. 11, 12 (includes synonymy).

REMARKS

The a element has a subdued costa on one face; the other face is either acostate or with a much weaker costa. The b morphotype is variable. The base length may be either relatively short or long, and in some elements it is posteriorly extended. The end members displaying a variation in basal length may be homologous to the b-1 and b-2 submorphotypes found in the Ordovician Besselodus borealis n. sp. Nowlan and McCracken (above). The elements with a posteriorly extended base are suggestive of b elements in

Scabbardella altipes subsp. B Orchard (below, and Nowlan, et al., MS).

Dapsilodus obliquicostatus is compared to Paroistodus? sp. A from Avalanche Lake, N.W.T. by Nowlan, et al. (MS).

TYPES: Hypotypes, ADM 20098-20116.

Dapsilodus? sp. B

Pl. 19, figs. 29, 34, 36-38

DESCRIPTION

Distacodontiform (a-b) element (Pl. 19, figs. 36-38) has a short base, long recurved cusp and asymmetrically opposed lateral costae. Aboral margin varies in lateral view; either slightly convex from anterior to posterior or posteriorly convex and anteriorly straight. Forms with latter basal profile retain part of their basal filling (Pl. 19, figs. 36, 37). Faint longitudinal striae parallel costae. Coarser oblique striae are present along anterior margin.

The e (acodontiform) element (Pl. 19, figs. 29, 34) is bowed to inner acostate side. Posterior part of inner face has faint longitudinal striae; anterior margin has coarse oblique striae. Outer costate face lacks striae.

REMARKS

These elements co-occur in a sample with Distomodus staurognathoides (Walliser) and other species indicative of the Llandovery. A singular and anomalous occurrence of an element similar to *Oistodus venustus* Stauffer s.f. with this material raises the question whether or not these elements are part of *Paroistodus*? and represent contamination, either via a debris flow or laboratory techniques.

The *a-b* elements have a short bell-shaped base like the *a-b* elements of *Paroistodus*? sp. A Nowlan and McCracken (cf. Pl. 6, figs. 15, 22; Appendix A, Pl. 9, figs. 1-22). The *e* elements are comparable to acodontiform elements of both the Ordovician *Paroistodus*? and *Scabbardella* (cf. Pl. 19. fig. 29, vs. Pl. 6, fig. 12).

The elements of *Dapsilodus*? sp. B differ from those of *Paroistodus*? in that they have oblique and longitudinal striae. This ornamentation is present on *D. obliquicostatus* (Branson and Mehl) and *Besselodus*, the possible ancestor to the genus, but not *Paroistodus*?. Löfgren (1978) has reported longitudinal striae on her Llanvirn *Acodus*? *mutatus* (Branson and Mehl) elements; similar striae are noted herein on elements of the Middle Ordovician *D.*? sp. C. Neither species commonly has elements with oblique striae on the anterior margin although one of Löfgren's elements does have this ornamentation.

The acodontiform and distacodontiform elements may comprise a nearly complete apparatus of a species of *Dapsilodus*. However, the presence of an oistodontiform element similar to Ordovician forms gives cause to query the generic assignment.

TYPES: Figured specimens, ADM 20117-20121.

Dapsilodus? sp. C

Pl. 1, fig. 23, Pl. 4, figs. 1, 2, 5, 6

Multielement

cf. Acodus? mutatus (Branson and Mehl). LOFGREN, 1978, pp. 44-46, Pl. 2, figs. 9-21, text-fig. 23 (includes synonymy).

REMARKS

One "acodontiform" element of this Ordovician taxon appears to lack a costa on either face (Pl. 4, fig. 2). The other illustrated acodontiform element (Pl. 1, fig. 23) is more typical of Belodus? mutatus Branson and Mehl s.f. One of the distacodontiform elements (Pl. 4, fig. 1) is multicostate on the inner face like the acontiodontiform elements of Acodus? mutatus described by Löfgren (1978). Some elements referred to as Dapsilodus mutatus (cf. Bergström, 1978, Pl. 80, figs. 21-23) and Paroistodus? mutatus (cf. Nowlan and Barnes, 1981, Pl. 1, figs. 22, 23 only) from younger Ordovician strata lack costae and instead are finely striated. The generic assignments of these are however probably not correct. Bergström's (1978) elements are equated with Scabbardella altipes (Serpagli) below, and those of Nowlan and Barnes (1981) are of an unknown taxon.

The form of the short-based distacodontiform element (Pl. 4, fig. 5) is like that in P.? mutatus of Nowlan and Barnes (1981, Pl. 1, figs.20, 21, only), which is equated with Paroistodus? sp. A by Nowlan, et al. (MS). The outline of the long-based distacodontiform element (Pl. 4, fig. 6) and that of "A." similaris Rhodes sensu Kennedy, et al. (1979) is similar. The species of Kennedy, et al. was suggested by Nowlan (1983a) to be part of a Scabbardella species. However, the same element of D.? similaris (Rhodes) of Nowlan (1981a) has a longer basal margin than that of this study or Kennedy, et al. (1979).

D.? sp. C may have similarities to A.? mutatus sensu Löfgren (1978) but even if they are conspecific, the taxon is not stratigraphically diagnostic. Elements ranging in age from Middle to Late Ordovician have been assigned to the constituent form species.

TYPES: Figured specimens, ADM 20122-20126.

Genus Decoriconus Cooper, 1975

Type species: Paltodus costulatus Rexroad, 1967.

Decoriconus fragilis (Branson and Mehl)?

Pl. 19, figs. 33, 39

a element

Drepanodus aduncus Nicoll and Rexroad. LEE, 1982, pp. 79, 80, Pl. 3, figs. 27, 28.

b-c element

Paltodus fragilis BRANSON and MEHL, 1933, p. 43, Pl. 3, fig.

6.

Multielement

Decoriconus fragilis (Branson and Mehl). ALDRIDGE, DORNING and SIVETER, 1981, Pl. 2.1, figs. 3-5; UYENO in UYENO and BARNES, 1983, pp. 16, 17, Pl. 9, figs. 1-10, 13-16 (includes synonymy).

REMARKS

Only b and c elements are known from the Yukon collection. As originally diagnosed, Decoriconus fragilis differs from the older D. costulatus (Rexroad) by having an extra morphotype, the a (drepanodontiform) element. A discussion of this difference is given by Nowlan, et al. (MS).

Cooper (1976) noted that the elements of D. fragilis are larger and more robust than those of D. costulatus. Barrick (1977) found that the b elements of both species are nearly identical but the c element of D. fragilis differs in that it is more flattened and symmetrical and lacks striae.

These elements are tentatively assigned to D. fragilis because of the robust nature of the c element and its relatively faint ornamentation.

TYPES: Hypotypes, ADM 20127, 20128.

Genus Diaphorodus Kennedy, 1980

Type species: Acodus delicatus Branson and Mehl, 1933.

Diaphorodus? sp. A

Pl. 1, figs. 3, 4, 8, 9, 12, 19

DESCRIPTION

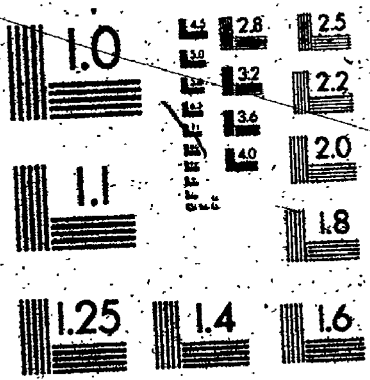
The cordylodontiform element has a triangular base and narrow erect cusp. Inner face of base is slightly flared; outer face is narrowly flared. Anterior and posterior edges of element are sharp.

The oistodontiform element has a sharply curved aboral margin, small angle of geniculation and and a base that is extended to anterior and posterior. Inner face has weak carniae near angle of geniculation and faint longitudunal striae on cusp.

REMARKS

The elements of *D.*? sp. A are comparable to those of *Acodus deltatus deltatus* (Lindström) and *A. triangularis* (Furnish) of Repetski (1982). The cordylodontiform element (Pl. 1, figs. 3, 4, 8, 9) shares characters with the same element of *A. d. deltatus*, and differs from similar elements of *A. triangularis* in that they are not costate. The oistodontiform element (Pl. 1, figs. 12, 19) does not have a base that is as anteriorly extended as it is in *e* elements of *A. d. deltatus*. It is more similar to the oistodontiform element of *A. triangularis*. *A. triangularis* has been found in strata containing Fauna C and Fauna D (of Ethington and Clark, 1971); *A. d. deltatus* in strata with

3



Fauna D and Fauna E by Repetski (1982).

These elements are from a sample that has lithic evidence of mass deposit flow. Other elements from this sample suggest a Llanvirn age. Graptolites about 50m above this site are late Llandeilo or Caradoc. The similarities of Diaphorodus? sp. A and Prioniodus (Oepikodus)? sp. A (herein) to Lower Ordovician conodonts suggests that this sampled interval contains reworked Lower Ordovician material.

TYPES: Figured specimens, ADM 20129-20132.

Genus Distomodus Branson and Branson, 1947
Emended Cooper, 1975

Type species: D. kentuckyensis Branson and Branson, 1947.

REMARKS

The emended diagnosis of Cooper (1975) was expanded by Barrick and Klapper (1976) to accommodate platform (g) elements with four to six processes. Cooper (1975) reconstructed the apparatus of Distomodus kentuckyensis Branson and Branson and listed the constituent form species in the synonymy, including those of Nicoll and Rexroad (1969) and Aldridge (1972). The form species identified by these workers are long ranging and therefore either may be part of the apparatuses of D. kentuckyensis or the younger D. staurognathoides (Walliser).

Cooper (1975) cautiously avoided reference to illustrations by the writers mentioned above when he could not make a distinction between *D. kentuckyensis* and *D. staurognathoides*. Cooper (1977b) later identified the elements from the studies of Nicoll and Rexroad (1969) and Aldridge (1972) that he believed are part of *H.* (=*D.*) *staurognathoides*. The reader is referred to Cooper (1977b) to determine the status of other elements figured by Nicoll and Rexroad (1969), and Aldridge (1972).

Cooper (1975) recognized that the apparatus of both *Distomodus* and *Icriodella* are similar. Because of this similarity, there may have been some confusion in distinguishing the *e* and *f* elements of *Distomodus* and *Icriodella* and hence a brief discussion is necessary. An alternative interpretation of these elements and their positions are offered below.

The *e* element in *Distomodus* is cyrtoniodontiform, represented by forms referred to as *D. kentuckyensis* s.f. Cooper (1975) placed form species such as *Sagittodontus edentatus* (Branson and Branson) s.f. and *S. robustus* Rhodes s.f. in the M (*e*) position of *I. discreta* Pollock, Rexroad and Nicoll. I disagree with this interpretation; the *e* element of *Icriodella* has three processes, which may or may not bear denticles. This form is interpreted as a prioniodontiform element and thus the *f* element.

The *e* element of *Icriodella* is cyrtoniodontiform, as in the apparatus of *Distomodus*, and is represented by *D. triangularis triangularis* (Walliser) s.f. sensu Aldridge (1972). This element has a long anticusp and a denticulated posterior process and was interpreted as the Pb element by Cooper (1975). The anticusp is not denticulated in the *D. t. triangularis* s.f. of Aldridge (1972) but is denticulated in the elements figured by Cooper (1975, p. 1004, Pl. 2, fig. 4 = "Pb, saggitodontiform"), McCracken and Barnes (1981a, p. 78, Pl. 7, figs. 35, 36 = "ambalodiform") and Aldridge and Mohamed (1982, p. 116, Pl. 1, fig. 15 = "M?"). The two forms (with and without denticles on the anticusp) in the apparatus of *Icriodella* may be homologous to the *e*-2 (falodontiform) and *e*-1 (cyrtoniodontiform) elements of *Gamachignathus* (sensu McCracken, *et al.*, 1980, and *Distomodus*, herein).

As interpreted by other workers, the *f* element of *Distomodus* is morphologically variable within each species. In *D. kentuckyensis*, it may have the form of *Drepanodus? arrectus* Rexroad s.f., an element with a denticulated anterior process (i.e. falodontiform, cf. Cooper, 1975, Pl. 2, fig. 11), or an element with denticulated anterior and lateral processes (cf. Aldridge and Mohamed, 1982, Pl. 1, fig. 5). It may be preferable to regard the form with a denticulated anterior process as an *e*-2 element. The apparatuses of *D.* sp. cf. *kentuckyensis* and *D. staurognathoides* (both herein) also have falodontiform *e*-2 elements.

Distomodus kentuckyensis Branson and Branson?

Pl. 8, figs. 12, 14, 17-20, 22-28, 31, 32, 37, 38

e element

?*Distomodus kentuckyensis* BRANSON and BRANSON, 1947, p. 553, Pl. 81, figs. 21-23, 27, 29-33, 36-41.

g element

aff. N. gen. A n. sp. A McCRACKEN and BARNES, 1981a, pp. 91, 92, Pl. 7, fig. 29.

aff. N. gen. A n. sp. B McCRACKEN and BARNES, 1981a, p. 92, Pl. 7, fig. 28.

Multielement

?*Distomodus kentuckyensis* Branson and Branson. COOPER, 1975, pp. 998-1000, Pl. 2, figs. 6, 8, 10, 11, 13, 14 (includes synonymy); ALDRIDGE and MOHAMED, 1982, Pl. 1, figs. 1-6, 8-10 (fig. 7 may = *D. triangularis triangularis* (Walliser) s.f., an element of *Icriodella discreta* Pollock; Rexroad and Nicoll); NOWLAN, 1983b, Fig. 4(M, N).

?"*Distomodus kentuckyensis*" apparatus of Cooper, 1975. MILLER, 1978, Pl. 3, figs. 1, 2, 4-6 (only; figs. 3, 10 are small cyrtoniodontiform elements that have a rounded carina on the inner face, as in *Pterospathodus*? Indeterminate type-2 elements).

aff. *Distomodus* aff. *D. kentuckyensis* Branson and Branson. McCRACKEN and BARNES, 1981a, p. 76, Pl. 7, figs. 22-27.

?*Distomodus* sp. cf. *D. kentuckyensis* Branson and Branson.

FAHRAEUS and BARNES, 1981, Pl. 1, figs. 1-3.

?Distomodus cf. kentuckyensis Branson and Branson. MANNIK, 1983, Fig. 4(D,E,I).

?Icriodella discreta Pollock, Rexroad and Nicoll. ALDRIDGE and MOHAMED, 1982, Pl. 1, fig. 14 (only, may = e-2 or f element of D. kentuckyensis; other elements = I. discreta).

REMARKS

The a through e-2 (eoligonodiniform through falodontiform) elements of the Yukon species are indistinguishable from those of Distomodus kentuckyensis and D. staurognathoides (Walliser).

The single f? element (Pl. 8, fig. 22) has a shallow basal cavity and a long cusp that has a wide base. Two denticulated processes are present; one extending from the anterior margin, the other is lateral. This element occurs with other elements of D. sp. cf. D. kentuckyensis and is similar with respect to the long compressed denticles. It is included herein under D. kentuckyensis? because of its large robust nature, and because the denticles are partially fused (cf. f element in Aldridge and Mohamed, 1982, Pl. 1, fig. 5) rather than discrete as in D. sp. cf. D. kentuckyensis.

The morphology of the g element in Distomodus changes markedly with growth; only large elements of D. kentuckyensis have well developed platforms. The rare g elements of this study (Pl. 8, fig. 31) lack the typical platform development and ornamentation, and instead have more blade-like processes. They compare well with forms illustrated as juvenile elements by Aldridge and Mohamed (1982, Pl. 1, fig. 3). The *g* elements of Yukon and the juvenile elements of these writers are comparable in size to the robust *a-f* elements in their apparatuses. The Yukon *g* elements are probably juvenile forms and since more mature *g* elements are not present, I must query the trivial name.

The *g* elements are found in strata from the Blackstone River and Tetlit Creek sections. Both occurrences are in faunas that are interpreted as representing the *Pterospathodus celloni* Zone (see Biostratigraphy). If the taxon is *D. kentuckyensis* s.s., it suggests either a rather late occurrence of the species, or a reworked fauna. There is no lithological evidence for reworking of older stata at the Blackstone River section; the fauna from Tetlit Creek is from a carbonate conglomerate, which may be reworked.

The *g* and other elements from the Blackstone River section may alternatively be included within *D.* sp. cf. *D. kentuckyensis* sensu Cooper (1975), a species that has a range more comparable with other taxa in the sample. I retain the taxonomic distinction for the following reasons. The apparatus of *D.* sp. cf. *D. kentuckyensis* is composed of elements that are much smaller than those in *D. kentuckyensis*; there are some differences between the first transition series elements; and no complete *g* element of *D.* sp. cf. *D. kentuckyensis* has been recorded in other studies suggesting that it may have been composed of basally fused denticles which commonly fracture.

Included in the synonymy above are forms that have affinities to *D. kentuckyensis*? and *D. kentuckyensis*. s.s. *D.* aff. *D. kentuckyensis* and N. gen. A spp. s.f. from Anticosti Island, Québec, are probably part of the same apparatus. The "*D. kentuckyensis*" apparatus of Cooper, 1975 in Miller (1978) occurs in samples that also contain *Astropentagnathus irregularis* Mostler, *Carniodus carnulus* Walliser, *D. staurognathoides* (Walliser), *Pterospathodus amorphognathoides* (Walliser) and *P. celloni* (Walliser). Miller found a few elements assignable to *Icriodina* sp. s.f. but the other taxa suggest an age younger than that of *D. kentuckyensis* s.s. His "*D. kentuckyensis*" may be comparable to the taxon herein, or to *D. staurognathoides*.

D. sp. cf. *D. kentuckyensis* sensu Fahraeus and Barnes (1981) is tentatively included here rather than below under *D.* sp. cf. *D. kentuckyensis* sensu Cooper (1975); it lacks the delicate nature of the latter taxon. Fahraeus and Barnes noted a closer affinity of their taxon to *D.*? *egregius* s.f. of Aldridge (1972) than to *D. kentuckyensis* of Cooper (1975). Mannik (1983) illustrated robust elements of *D.* cf. *kentuckyensis*, a species that includes a falodontiform (e-2) element that has a circular aboral outline similar to that of *D. kentuckyensis*?. His element differs in that the anterior process is short. Another of Mannik's elements (*ibid.*, Fig.4E) has a denticulated posterior and downwardly directed anterior process.

TYPES: Hypotypes, ADM 20133-20149.

Distomodus sp. cf. *D. kentuckyensis* Branson and Branson
sensu Cooper, 1975
Pl. 8, figs. 21, 29, 30, 34-36

"*Drepanodus suberectus*" (Branson and Mehl) sensu Rexroad. McCRACKEN and BARNES, 1981a, p. 76, Pl. 7, fig. 43 (includes synonymy).

cf. *Distomodus kentuckyensis* BRANSON and BRANSON, 1947, p. 553, Pl. 81, figs. 21-23, 27, 29-33, 36-41.

Multielement

Distomodus sp. cf. *D. kentuckyensis* Branson and Branson. COOPER, 1975, pp. 1000, 1003, Pl. 2, figs. 5, 9 (includes synonymy).

Distomodus sp. cf. *D. kentuckyensis* Branson and Branson of Cooper (1975). UYENO *in* UYENO and BARNES, 1983, p. 17, Pl. 9, figs. 27, 28.

non *Distomodus* sp. cf. *D. kentuckyensis* Branson and Branson. FAHRAEUS and BARNES, 1981, Pl. 1, figs. 1-3 (tentatively included above under *D. kentuckyensis*?).

REMARKS

Cooper (1975) separated small elements of *Distomodus kentuckyensis* as an ecological growth variant of the species. He suggested that the platform element of *D.* sp. cf. *D. kentuckyensis* is composed of a fused series of flattened simple cones previously described as "*Drepanodus* suberectus" (Branson and Mehl) s.f. by Rexroad (1967). McCracken and Barnes (1981a) identified this form species but could not follow Cooper's interpretation since all elements were discrete. Uyeno and Barnes (1983) found a few of these fused cones. A few well preserved elements from Yukon conform to Cooper's suggestion of a fused series of elements. These are discussed below as f? elements.

The a-c elements (Pl. 8, figs. 30, 36) are smaller and less robust than their counterparts in D. kentuckyensis. They also lack the strong costae that extend from the proximal part of the lateral processes to the cusp.

A small falodontiform element (Pl. 8, fig. 21) represents the e-2 element. The denticulated anterior process is not directed downward as it is in D. kentuckyensis.

The f? element (Pl. 8, figs. 29, 34) has long a cusp and denticles. The denticles are on two long and low processes that are not within the anteroposterior plane. The anterior margin at the base of the cusp may have a process: in these specimens, however, this process is broken at the base.

None of the elements tentatively assigned to the f? position compare with the diagnosis of the platform element of Distomodus as emended by Barrick and Klapper (1976). Rather than referring to these forms as g elements and thus expanding the diagnosis to include g elements with three processes, it is suggested that the g element of D. sp. cf. D. kentuckyensis is not yet known.

TYPES: Figured specimens, ADM 20150-20155.

Distomodus staurognathoides (Walliser)

Pl. 8, figs. 1-11, 13, 15, 16

g element

Hadrognathus staurognathoides WALLISER, 1964, p. 35, Pl. 5, fig. 2, Pl. 13, figs. 6-15.

Multielement

Distomodus staurognathoides Walliser. ALDRIDGE and MOHAMED, 1982, Pl. 2, figs. 1-6; MABILLARD and ALDRIDGE, 1983, Pl. 1, figs. 15-20; NOWLAN, 1983b, Fig. 4(F-H); UYENO in UYENO and BARNES, 1983, p. 17, Pl. 3, figs. 1-15 (includes synonymy); MABILLARD and ALDRIDGE, 1985, text-fig. 7d.

REMARKS

Elements of the symmetry transition series (a-c elements) are indistinguishable from those of Distomodus kentuckyensis Branson and Branson? of this study. Barrick and Klapper (1976) noted that these elements tend to have longer and more robust processes than those of D. kentuckyensis. They illustrated (ibid., Pl. 1, figs. 27, 28) one b element of D. staurognathoides with widely diverging lateral processes; the b elements from Yukon material have lateral processes that are not as widely divergent.

The cyrtoniodontiform and falodontiform elements compare with the same elements of *D. kentuckyensis*? (herein) and as suggested for that species, may represent *e*-1 (Pl. 8, figs. 3, 4) and *e*-2 (Pl. 8, fig. 1) submorphotypes. The *f* element is variable. The small illustrated element (Pl. 8, fig. 8) is prioniodiniform; the larger elements have at least two platform-like processes (cf. Pl. 8, fig. 7). The ornamentation on the *g* element varies from an irregular pattern of ridges to nodes (cf. Pl. 8, figs. 11, 15).

Miller (1978) recorded *Hadrognathus staurognathoides* s.f. from the Hidden Valley Dolomite in California. Asociated taxa included an apparatus comparable to *D. kentuckyensis* (cf. *D. kentuckyensis*?, above).

TYPES: Hypotypes, ADM 20156-20169.

Genus *Drepanoistodus* Lindström, 1971

Type species: *Oistodus forceps* Lindström, 1955.

Drepanoistodus cf. *D. basiovalis* (Sergeeva)

Pl. 4, figs. 10-12, 15-18

cf. *Oistodus basiovalis* SERGEEVA, 1963, p. 96, Pl. 7, figs. 6, 7, text-fig. 3.

Multielement

cf. *Drepanoistodus basiovalis* (Sergeeva). WORKUM, BOLTON and BARNES, 1976, pp. 171, 172, Pl. 4, figs. 1, 2; LOFGREN, 1978, pp. 55, 56, Pl. 1, figs. 11-17, text-fig. 26(B, C) (includes synonymy); TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 9, fig. 21; NOWLAN, 1981a, p. 11, Pl. 3, figs. 20-22.

REMARKS

Löfgren (1978) noted that the differences between the suberectiform (p) element of Drepanoistodus basiovalis and D. forceps (Lindström) are subtle. She also admitted difficulty in distinguishing between the homocurvatiform (q) elements of the same two species, especially in samples where they co-occurred. Only q and r elements of this species were recovered from the Peel River samples.

The q elements (Pl. 4, figs. 10, 15-18) are nearly symmetrical with only a slight twist of the cusp and an asymmetrical flare of the base. The anterior margin is variably keeled and the posterior margin may be either slightly keeled or rounded with a faint costa. None of the q elements have the flexed and extended antero-aboral corner found in D. basiovalis (sensu Löfgren, 1978). The q element of D. basiovalis illustrated by Barnes and Poplawski (1973), Workum, et al. (1976) and Löfgren (1978) are all more recurved than those of this study.

The most distinctive element of both D. basiovalis and D. forceps is the r or oistodontiform element. The single r element of this study (Pl. 4, figs. 11, 12) is characterized by a sharp antero-aboral angle and a cusp that is smoothly convex on the outer face with a weakly developed carina on the other . This cusp ornamentation is similar to that of the r element of D. basiovalis. The antero-aboral angle is not as acute as that of D. forceps and is sharper than that of D. basiovalis. The point at which the straight antero-aboral margin curves upward is more anterior in both this element and that of D. basiovalis than in D. forceps. This element differs from the r element of D. basiovalis in that the anterior cusp-base intersection meet at the same level as the geniculation point. This character is similar to that found in D. forceps. With regards to the above, this r element is most like that of D. basiovalis. The r element of D. forceps (sensu Merrill, 1980) is quite similar to those of D. basiovalis.

The range of D. basiovalis is reported by Löfgren (1978) to be middle Arenig to middle Llanvirn. The slight differences in morphology of the elements and the younger age account for the conferred species designation.

TYPES: Figured specimens, ADM 20170-20175.

Drepanoistodus suberectus (Branson and Mehl)

p element

Oistodus suberectus BRANSON and MEHL, 1933, p. 111, Pl. 9, fig. 7.

Multielement

Drepanoistodus suberectus Branson and Mehl. LENZ and McCRACKEN, 1982, Pl. 2, fig. 22; NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 3, figs. 19-22 (Appendix A, herein; text includes synonymy).

Drepanoistodus sp. cf. D. venustus (Stauffer) sensu Löfgren

Pl. 4, fig. 7

r element

Oistodus venustus STAUFFER, 1935, pp. 146, 159, Pl. 12, fig. 12.

Multielement

cf. Drepanoistodus? cf. venustus (Stauffer). LOFGREN, 1978, pp. 56, 57, Pl. 1, figs. 7, 8.

REMARKS

This single element occurs in a sample with Periodon aculeatus Hadding and Protopanderodus sp. aff. P. varicostatus (Sweet and Bergström). The oral margin of the cusp and the aboral margin of the base meet at the anterior, forming a U-shaped margin like that in Oistodus venustus s.f. This differs from the sharp V-shaped margin found in Oistodus forceps Lindström s.f., the r element of Drepanoistodus forceps. The element is corroded, but appears to have a medial costa on the cusp; this feature is also found in the r element of D. venustus.

TYPE: Figured specimen, ADM 20176.

Genus Eocarniodus Orchard, 1980

Type species: Prioniodus gracilis Rhodes, 1955.

REMARKS

Eocarniodus consists of minute elements that have a wide central denticle and denticulated anterior and posterior processes. The form and hindeodellid denticulation are suggestive of posterior process fragments of a-d elements in Amorphognathus species. Elements of Eocarniodus differ in that the bases usually have thickened lateral margins similar to elements of Carniodus. Other differences are discussed below.

Eocarniodus gracilis (Rhodes)

Pl. 7, figs. 23, 28, 30

Carniodus sp. Walliser. WEYANT in PARIS, PELHATE and WEYANT, 1981, p. 20, Pl. 2, fig. 14.

Prioniodus gracilis RHODES, 1955, p. 136, Pl. 8, figs. 5, 6.

Multielement

Eocarniodus gracilis (Rhodes). ORCHARD, 1980, p. 20, Pl. 2, figs. 13?, 14, 15?, 18-21, 24-26, 27?, 28, 30, 31?, 33, 34, 36?, 38 (includes synonymy).

REMARKS

The few elements from the Peel River section have translucent bases. The denticles are entirely composed of white matter; the boundary between this and the hyaline matter is straight and distinct, and delineated by the raised margin of the base. The basal cavity extends throughout the length of the element and there is a small and low cavity tip beneath each denticle. The cavity beneath the cusp is deeper than beneath the denticles and extends to the level of the other denticles. All accessory denticles are of a comparable size. The denticles and cusp are longitudinally striated.

Most of the elements are slightly arched, the point of arching being beneath the cusp. The anterior process is slightly flexed toward the inner side and the cusp is slightly flexed to the outer side in some elements. The inner face of the cusp is flat; the outer face is convex. All of the above are not characteristic of posterior process fragments of *Amorphognathus* elements.

Elements from the Blackstone River section are not as translucent as those from the Peel River. Comparison of these elements and fragments of the *a-d* elements of *A. ordovicicus* Branson and Mehl shows that the white matter level is at the base of the denticles in *Eocarniodus* and above the base of the denticles in *Amorphognathus*. All elements of this study are referred to as *a-b* elements. No *e*, *f* or *g* elements are identified in Yukon material.

TYPES: Hypotypes, ADM 20177-20179.

Genus *Eoplacognathus* Hamar, 1966

Type species: *Ambalodus lindstroemi* Hamar, 1964.

Eoplacognathus? sp. A

Pl. 1, figs. 10, 11, 14, 15

REMARKS

Four incomplete specimens are present. The most complete fragment (herein referred to as element 1) has a short narrow anterior process and a long, platform-like posterior process (Pl. 1, fig. 15). An adenticulate lobe diverges posteriorly from one side of the posterior process. The anterolaterally directed process is broken. The cusp is posterior to the junction of the anterolateral and anterior processes. The other three fragments consist of one anterior and two posterior processes. All elements have a "honeycomb" ornamentation along the margins. This pattern is also on the denticles of element 1. The basal cavity is widest beneath the central part of this specimen. The cavity under the processes is narrow.

Due to the fragmentary nature, a specific name is not applied, and I also query the generic identification. There are a few taxa that have platform elements with processes similar to these fragments. The Llanvirn Amorphognathus kielcensis Dzik has a posterolateral process that is not bifurcated as in younger species. Element 1 of Eoplacognathus? sp. A differs in that the posterolateral process is adenticulate, and the anterolateral process is anteriorly, not laterally directed as in the g element of A. kielcensis. The Whiterockian Cahabagnathus friendvillensis (Bergström) has a posterolateral process that differs from element 1 of this study in that the process is denticulated and diverges at a greater angle, and there is a break in the denticulation from the main row of denticles to those of the antero- and posterolateral processes.

The divergence and form of the processes on the most complete specimen are most like those of q elements of Eoplacognathus. The "honeycomb" ornamentation is not diagnostic since it is found on elements of both E. foliaceus (Fahraeus) and E. suecicus Bergström. The posterolateral process of E. suecicus is directed towards the posterior whereas it is perpendicular to the main denticle row in E. foliaceus. Element 1 has a posterolateral process or lobe that diverges like that of E. suecicus but differs in that the lobe is adenticulate. The wide posterior platform and restricted basal cavity are, however, characteristic of E. foliaceus (Löfgren, 1978).

Löfgren (1978) states that E. suecicus ranges from early to middle Llanvirn, and E. foliaceus is middle Llanvirn in age.

TYPES: Figured specimens, ADM 20180-20183.

Genus Gamachignathus McCracken, Nowlan and Barnes, 1980

Type species: G. ensifer McCracken, Nowlan and Barnes, 1980.

REMARKS

Gamachignathus and Birksfeldia are Late Ordovician genera that were established in 1980 and may be synonyms (Nowlan, 1983a). The apparatus of Gamachignathus contains the following elements (with the homologous elements of Birksfeldia in parentheses): a-1 or cordylodontiform (not recognized in Birksfeldia), a-2 or gothodontiform (=Sb elements), b (=asymmetrical Sa elements), c (=symmetrical Sa elements), e-1 (=Sc elements), e-2 (=M elements), f (=Pb elements), g (=Pa elements).

If not synonyms, both genera must be closely related to each other, and to other North Atlantic Province genera such as Amorphognathus and Prioniodus (see also Nowlan, 1983a). I suggest that the diagnosis for Birksfeldia is in need of revision to make the apparatus plan conform to those of Amorphognathus, Gamachignathus and Prioniodus. A comparison of Gamachignathus and the Silurian Pterospathodus is found under the remarks of the latter taxon.

Gamachignathus has now been identified from Québec (McCracken et al., 1980, and others), northwestern and western New Brunswick (Nowlan, 1983a; personal communication, 1984), Nevada and California (Ross, et al., 1979, p. C11) and northern Yukon (Lenz and McCracken, 1982). An unpublished fauna from the Cape Philips Formation, Cornwallis Island, N.W.T. contains typical Late Ordovician species and includes rare e-2 and f elements of G. ensifer. B. wufengensis Ni and Li has been identified from the Diplograptus bohemicus Zone (Wufeng Stage - Upper Ordovician) of the eastern Yangtze gorges in China (Ni and Li in Wang, et al., 1983).

Gamachignathus ensifer McCracken, Nowlan and Barnes

Pl. 7, fig. 25

Distomodiform elements ROSS, NOLAN and HARRIS, 1979, Fig. 7 (h, i) (=*a*, *e*-1 elements).

Exochognathus keislognathoides Pollock, Rexroad and Nicoll. ROSS, NOLAN and HARRIS, 1979, Fig. 7(l) (=*b* element).

Multielement

Aphelognathus n. sp. ROSS, NOLAN and HARRIS, 1979, Fig. 7 (a, b, e, f) (=*g*, *g*, *f*, *f* elements; non Fig. 7c, d, g = *Aphelognathus* elements).

Gamachignathus ensifer McCRACKEN, NOWLAN and BARNES, 1980, pp. 105-110, Pl. 10.1, figs. 1-17; NOWLAN and BARNES, 1981, p. 13, Pl. 3, figs. 13, 14, 17-21; McCRACKEN and BARNES, 1981a, p. 77, Pl. 5, figs. 1-27; NOWLAN, 1981b, Pl. 2, figs. 1-8, 21-23, 25-27; LENZ and McCRACKEN, 1982, Pl. 1, figs. 11, 12, 17; NOWLAN, 1983a, Pl. 3, figs. 1, 2, 5, 6, 9, 10.

REMARKS

Elements from Nevada identified by Ross, *et al.* (1979) represent the first published record of *Gamachignathus*. These elements occur in strata of the Hanson Creek Formation that is regarded as latest Ordovician and (or) earliest Silurian in age. Ordovician species from the Hanson Creek Formation also include *Drepanoistodus suberectus* (Branson and Mehl) and *Plegagnathus nelsoni* Ethington and Furnish. s.f. Ross, *et al.* (1979) suggested that their distomodiform elements and *Exochognathus keislognathoides* Pollock, *et al.* s.f. probably belong with their *Aphelognathus*? species. Four elements of *A.*? n. sp. Ross, *et al.* are herein equated with *G. ensifer* but others of the same species are probably part of an unknown species of *Aphelognathus*. A mixed Ordovician - Silurian fauna was inferred by the presence of *Ozarkodina* elements.

Ross, *et al*. (1979, p. C11) reported that unpublished material from the Ely Spring Dolomite, California has a similar mixed fauna with abundant *Aphelognathus*? n. sp. (=?*Gamachignathus* sp.) elements.

TYPE: Hypotype, ADM 20184.

Genus *Icriodella* Rhodes, 1953

Type species: I. super*ba* Rhodes, 1953.

Icriodella superba Rhodes?

Pl. 7, fig. 31

b element

?*Rhynchognathus typica* ETHINGTON, 1959, p. 286, Pl. 41,
figs. 3, 4.

c element

?*Rhynchognathus divaricatus* RHODES, 1953, p. 313, Pl. 21,
figs. 145, 146; GLOBENSKY and JAUFFRED, 1971, p. 58,
Pl. 3, fig. 15.

e element

?*Saggitodontus dentatus* ETHINGTON, 1959, p. 287, Pl. 39,
fig. 13; GLOBENSKY and JAUFFRED, 1971, p. 58, Pl. 3,
fig. 9.

f element

?*Saggitodontus robustus* RHODES, 1953, p. 311, Pl. 21, figs.

141, 142; GLOBENSKY and JAUFFRED, 1971, p. 58, Pl. 3, fig. 11.

g element

?Icriodella superba RHODES 1953, p. 288, Pl. 20, figs. 54, 58, 62, 63, 65, 78; GLOBENSKY and JAUFFRED, 1971, p. 55, Pl. 3, fig. 14.

Multielement

?Icriodella superba Rhodes. BERGSTROM and SWEET, 1966, pp. 337-340, Pl. 29, figs. 1-11, (includes synonymy); SWEET and BERGSTROM, 1970, p. 169, Pl. 6, figs. 6K-O; SWEET, ETHINGTON and BARNES, 1971, Pl. 2, figs. 2, 11; UYENO, 1974, p. 14, Pl. 1, figs. 14-19; SWEET, THOMPSON, and SATTERFIELD, 1975, p. 58, Pl. 3, figs. 1-5; ORCHARD, 1980, p. 21, Pl. 1, figs. 14, 17, 18, 23, 24, 26 (includes synonymy); NOWLAN, 1981b, Pl. 3, figs. 6-8; WEYANT in PARIS, PELHATE and WEYANT, 1981, p. 20, Pl. 2, figs. 9?, Pl. 3, fig. 10; DZIK, 1983, Fig. 10(H-J).

REMARKS

Only one f element is present in the Yukon collection. It is similar to Saggitodontus robustus Rhodes s.f. but since the g element is the most diagnostic element of the Ordovician species, the trivial identification is queried.

TYPE: Figured specimen, ADM 20185.

Icriodella sp. A

Pl. 13, figs. 31, 32

REMARKS

This species consists of a fragmentary *b* (rhynchongnathodontiform) element (Pl. 13, fig. 32) and two platform fragments. The *b* element is similar to *Rhynchognathodus typicus* Ethington s.f. (cf. Schopf, 1966, Pl. 3, fig. 18), forms of which are found in the Ordovician *I. superba* Rhodes and the the Silurian *I. deflecta* Aldridge and *I. discreta* Pollock, Rexroad and Nicoll (cf. McCracken and Barnes, 1981a, Pl. 7, fig. 31).

The platform fragments are slender and have two rows of denticles nodes (Pl. 13, fig. 31). These are not diagnostic for either Ordovician (cf. Bergström and Sweet, 1966, Pl. 29, fig. 2) or Silurian (cf. Thompson and Satterfield, 1975, Fig. 5A-C) species.

The sample in which these elements occur is from a debris flow within Silurian strata are dated by graptolites (this sample is from strata 4m above *Atavograptus atavus* - *Lagarograptus acinaces* Zone, 10m above *Pacificograptus pacificus* Zone graptolites). The conodont fauna is predominantly Ordovician, with the Silurian being represented by *Dapsilodus obliquicostatus* (Branson and Mehl) and *Walliserodus curvatus* (Branson and Branson).

The species, and thus age of these fragments, cannot be determined because of their fragmentary nature and their occurrence in a debris flow material.

TYPES: Figured specimens, ADM 20186, 20187.

Icriodella sp. B

Pl. 13, fig. 23

REMARKS

Three corroded fragments of g elements have been recovered from Silurian strata of Pat Lake. They co-occur with indeterminate species of Ozarkodina, Panderodus and Walliserodus. The trivial identity of these robust fragments cannot be determined.

TYPES: Figured specimen, ADM 20188.

Genus Kockelella Walliser, 1957

Type species: K. variabilis Walliser, 1957.

REMARKS

Aldridge (1972) proposed an evolutionary lineage from Spathognathodus abruptus Aldridge s.f. (=Ozarkodina manitoulinensis Pollock, Rexroad and Nicoll, in Cooper 1980), through S. cf. S. abruptus to S. ranuliformis s.f. (=O. ranuliformis, sensu Cooper, 1980). McCracken and Barnes (1981a, pp. 84, 90) suggested that S. manitoulinensis s.f. may be a rare g element in O. oldhamensis (Rexroad), which could therefore be the multielement ancestor of K. ranuliformis.

Kockelella ranuliformis (Walliser)

Pl. 12, fig. 34

g element

Spathognathodus ranuliformis WALLISER, 1964, p. 82, Pl. 6, fig. 9, Pl. 22, figs. 5-7.

Multielement

Kockelella ranuliformis (Walliser). BARRICK and KLAPPER, 1976, p. 76, Pl. 2, figs. 1-11 (includes synonymy).

Ozarkodina ranuliformis (Walliser). COOPER, 1976, p. 216, Pl.2, fig. 9; JEPPSSON, 1979, pp. 241, 242, 244, Fig. 72 (1-3; only).

REMARKS

Only a few a, e, f and g elements are known from Yukon. The a element (not illustrated) has a long, slender biconvex cusp. The processes are both broken but the anterolateral process is long, and directed downward and towards the anterior. In oral view, the processes and cusp form a smooth arch. The base of the anterolateral process is slightly higher than that of the posterior. These features compare with those of the a element of Kockelella ranuliformis. The biconvexity of the cusp is asymmetrical: the outer face is weakly convex whereas the inner face is strongly convex. The denticles are subcircular in cross-section and those on the anterolateral process are erect. On the a element of K. ranuliformis sensu Barrick and Klapper, the denticles are more laterally compressed and those on the anterolateral process are slightly proclined.

Two forms that are regarded as e elements of Kockelella are found in the sample containing both K. ranuliformis and K. walliseri (Helfrich)? The single e element (not illustrated) assigned to K. ranuliformis is incomplete: one process is broken at the cusp. The other rare e elements in this sample are assigned to K. walliseri (below).

The preserved process of the e element of K. ranuliformis is straight and directed downward without arching, and is only slightly flexed to the inner side. The cusp is laterally compressed, erect with respect to the processes, and is slightly twisted to the side. The denticles are erect and confluent for most of their length. The base beneath the cusp is not flared on the outer face; a narrow flare is present on the inner side beneath the cusp. The e element described by Barrick and Klapper (1976) differs significantly in that the denticles are discrete. However, the other e elements assigned below to K. walliseri? are even less similar.

The f element (not illustrated) has an inwardly bowed anterior process that is about the same length as the posterior process. The base of the denticles of the anterior process is high compared with that of the posterior process. Both processes form an even, downwardly directed arch. The cusp and denticles are compressed, and the denticles are basally confluent. The denticles on the anterior process are erect at the anterior end and reclined near the cusp. The base on the outer face beneath the cusp has a subdued, cone-shaped flare; the inner face is not flared. These characters are comparable to those of the f elements described by Barrick and Klapper (1976).

The g element (Pl. 12, fig. 34) has a straight blade-like anterior process with six denticles (including the cusp), a short inwardly curved posterior process with two denticles and an expanded basal flare. The cusp and denticles are partially fused and laterally compressed. Denticles on the anterior process and the cusp are about the same width; the denticles on the posterior process are smaller, the distal one is the smallest. Denticles on the anterior process are erect; those on the other are slightly reclined. The denticles of the posterior process do not extend to the edge of the basal flare. This element conforms with small g elements of K. ranuliformis.

TYPE: Hypotype, ADM 20189.

Kockelella walliseri (Helfrich)?

g element

Spathognathodus walliseri HELFRICH, 1975, Appendix 1, pp. 69-71, Pl. 1, figs. 1, 9, 10, 19, 21.

Spathognathodus n. sp. WALLISER, 1964, p. 88, Pl. 22, fig. 8.

Multielement

Kockelella walliseri (Helfrich). BARRICK and KLAPPER, 1976, p. 78, Pl. 2, figs. 24, 25.

Ozarkodina sp. nov. (Walliser). ALDRIDGE, 1975, Pl. 3, fig.2.

REMARKS

Rare elements (unfigured) found in association with a few elements of <u>Kockelella</u> <u>ranuliformis</u> (Walliser) are tentatively assigned to <u>K</u>. <u>walliseri</u>. The <u>g</u> element has the characteristics of the elements described previously as <u>K</u>. <u>walliseri</u>, but the <u>e</u> and <u>f</u> elements have not been documented, hence the queried tivial name. Helfrich (1975) does not assign his form species to a multielement group, and Barrick and Klapper (1976) recognize only the <u>g</u> element. Barrick and Klapper, however, do note that a single Pb (<u>f</u>) element in their collection has compressed denticles and may be part of <u>K</u>. <u>walliseri</u>.

The <u>e</u> element has a long, downwardly curved posterior process and a short, laterally flexed anterior process. The anterior process has 1 to 3 short and discrete denticles. The denticles of the posterior process are long, discrete, slightly proclined and closely spaced. The denticles and cusp are only slightly compressed. The inner face beneath the cusp has a strongly developed, narrow and posteriorly directed asymmetrical flare.

The <u>e</u> element differs from the same element that Barrick and Klapper (1976) assign to <u>K</u>. <u>ranuliformis</u>, especially in that the anterior process does not form an anticusp. The relatively narrow cusp with its sub-circular basal cross section is similar to that of the <u>f</u> element (below).

The _f_ element has an anterior process that is more inwardly curved than it is in the _f_ element of _K._ _ranuliformis_. The outer face beneath the cusp has a distinct and narrow basal flare that is directed downward. This flare is more developed than the subdued and relatively wider flare on the _f_ element of _K._ _ranuliformis_.

The _g_ element has the characteristic asymmetrical basal cavity and flare, and outer, denticulated lateral process. This process is nearly perpendicular to the long anterior process, and bears up to 3 denticles. The short posterior process has 1 to 2 denticles and is curved to the inner side.

Spathognathodus n. sp. s.f. and _S._ _walliseri_ s.f. are from strata equivalent to the upper Wenlock _S._ _sagitta_ Zone. _O._ sp. nov. of Aldridge (1975) is from the Sheinwoodian (lower Wenlock) of Great Britain. Barrick and Klapper (1976) report _K._ _walliseri_ from the middle to upper Wenlock of Oklahoma.

Genus _Noixodontus_ McCracken and Barnes, 1982

Type species: _Prioniodus_ _girardeauensis_ Satterfield, 1971.

REMARKS

The definition of _Noixodontus_ is based on topotype material from strata originally described by Thompson and Satterfield (1975). The _f_ and _g_ elements were assigned by

Satterfield (1971) to Prioniodus ferrarius Knüpfer s.f. and P. girardeauensis s.f. respectively, and the b-c elements to Trichonodella asymmetrcia (Knüpfer) s.f. by Thompson and Satterfield. McCracken and Barnes (1982) chose P. girardeauensis s.f. as the senior synonym since they believed that P. ferrarius s.f. and T. asymmetrica s.f. of Satterfield (1971) and Thompson and Satterfield (1975) were misidentified and were originally diagnosed from Llanyirn to Landeilo strata. This is only partially correct: P. ferrarius s.f was defined by Knüpfer (1967, p. 52) from the "unteres Lager des Oberen Erzhorizontes" (Llanvirn - Llandeilo) of Thuringia. The type material of T. asymmetrica s.f. is from the "hangende Kalkbank des Oberen Erzlagers" (Caradoc - Ashgill; Knüpfer, 1967, pp. 42, 43).

Bergström (1983, p. 46, Fig. 4A-G) briefly discusses the multielement species Saggittodontina bifurcata Knüpfer. It is based on the Upper Ordovician form species of Knüpfer and possibly includes Strachanognathus thuringensis s.f. (?a element), T. asymmetrica s.f. (?b element), T. n. sp. s.f. (?c element), Tripodontus compactus s.f. (?e element), T. muelleri s.f. (?d element) as well as S. bifurcata s.f (?g element). The older P. ferrarius s.f. is probably not part of S. bifurcata.

Most elements of N. girardeauensis and S. bifurcata are indistinguishable, especially the a-d elements. The g elements, however, appear different: in Saggittodontina it is platform-like, in Noixodontus it is blade-like. The lack of a platform element in Noixodontus may be the product of preservation or low abundance of elements in the known collections from United States. Until both genera are better known, it is best to avoid regarding Noixodontus as a junior subjective synonym of Saggittodontina: it may be a provincial equivalent to the European genus Saggittodontina.

Elements described in Paris, et al. (1981) are queried in the synonymy of N. girardeauensis (below) since they may instead be part of Saggittodontina.

Noixodontus girardeauensis (Satterfield)

f element

Prioniodus girardeauensis SATTERFIELD, 1971, p. 271, Pl. 34, figs. 1, 6, 15, 18, 19, text-fig. 3.

?Saggittondontina robusta Knüpfer. WEYANT in PARIS, PELHATE and WEYANT, 1981, pp. 21, 22, Pl. 2, fig. 11, Pl. 3, figs. 1-3, 5, Pl. 4, figs. 1, 2, 4, 6.

g element

?Saggitondontina? sp. WEYANT in PARIS, PELHATE and WEYANT, 1981, p. 22, Pl. 2, figs. 12, 13, Pl. 4, figs. 3, 5, 7, 8.

Multielement

Noixodontus girardeauensis (Satterfield). McCRACKEN and BARNES, 1982, pp. 1480, 1481, Pl. 2, figs. 5-12, text-fig. 3 (includes synonymy).

Prioniodus? girardeauensis Satterfield. LENZ and McCRACKEN, 1982, Pl. 1, figs. 6-8.

Genus Oulodus Branson and Mehl, 1933

Type species: Cordylodus serratus Stauffer, 1930 (=senior subjective synonym of O. mediocris Branson and Mehl, 1933).

Oulodus fluegeli (Walliser)

REMARKS

Sweet and Schönlaub (1975) reconstructed the apparatus of Ozarkodina plana (Walliser) based on 146 elements from the Karawanken Alps of Austria. The a, b, c, e and f elements of their species may be assignable to Oulodus fluegeli (Walliser) s.l. of the Yukon study. They (1975) assigned their species to Ozarkodina because of a few associated spathognathodontiform elements. Aldridge (1979) believed that the Sc and Pb (a and g) elements of Sweet and Schönlaub's species possibly belonged to Ozarkodina excavata (Branson and Mehl) or its ancestor.

Mirza (1976), in an unpublished dissertation on conodonts from the Canadian Arctic Archipelago, reconstructed an incomplete apparatus that also included Neoprioniodus planus Walliser s.f. With over 500 elements, Mirza recognized an Ozarkodina apparatus that contained N elements and a five-part symmetry transition series (apparatus was reconstructed using terminology of Klapper and Philip, 1971). The f and g elements were not identified but they are present in the elements of Mirza's symmetry series.

Aldridge (1979) assigned 62 elements from the upper Llandovery of Greenland to Oulodus? fluegeli. He (ibid., p. 15) tentatively included "ligonodiniform" elements in the apparatus but noted that the discrete peg-like nature of the denticles of the ligonodiniform element did not compare closely to the denticulation of the other elements. I suggest that these eoligonodiniform (not ligonodiniform) elements do not belong with this species.

Aldridge (1979) and Uyeno and Barnes (1983) tentatively assigned the species to Oulodus because the denticulation departed from the generic diagnosis of Sweet and Schönlaub (1975). The Yukon interpretations are based on very abundant specimens although the majority of the specimens of O. f. fluegeli have closely spaced denticles, some do conform to the diagnosis, and in the other subspecies, O. f. petilus (Nicoll and Rexroad), the discrete denticulation is a diagnostic character. I have therefore unequivocally assigned these subspecies to the genus Oulodus. As an alternative to a subspecies interpretation, the differences may represent sexual dimorphism.

Uyeno and Barnes (1983) noted that O. petila in Cooper (1980) and Oulodus petilus in Uyeno and Barnes (1981) are probably the same taxa as their (1983) O.? f. subsp. A.

Oulodus fluegeli fluegeli (Walliser)

Pl. 9, figs. 5, 6, 10, 13, 14, 17, 19-24, 26, 27, 31, 32

Pl. 10, figs. 3, 4, 7, 8, 10, 11, 13-15, 17-25, 29, 32 *a* element

?*Hindeodella* sp. WALLISER, 1964, p. 36, Pl. 32, fig. 29.

?*Ligonodina variabilis* Nicoll and Rexroad. MILLER, 1978, Pl. 2, fig. 1 (only).

b element

Trichonodella asymmetrica Nicoll and Rexroad. MILLER, 1978, Pl. 2, fig. 9.

c element

Diadelognathus nicolli Aldridge. MILLER, 1978, Pl. 3, fig. 17 (only; fig. 16 is tentatively included under *O. f. petilus* (Nicoll and Rexroad) below).

Hibbardella trichonodelloides (Walliser). ALDRIDGE, 1972, p. 182, Pl. 6, figs. 17, 18; MILLER, 1978, Pl. 3, figs. 12-14.

(?)*Roundya trichonodelloides* WALLISER, 1964, p. 72, Pl. 6, fig. 2, Pl. 31, figs. 22-25.

Trichonodella trichonodelloides (Walliser). LINK and DRUCE, 1972, pp. 101, 102, Pl. 11, figs. 7-10, text-fig. 66.

?*Triconodella* cf. *trichonodelloides* Walliser. LEE, 1982, p. 107, Pl. 3, fig. 21.

e element

Neoprioniodus planus WALLISER, 1964, p. 51, Pl. 4, fig. 10, Pl. 6, fig. 3, Pl. 29, figs. 12, 13, 15; ?REXROAD, 1967, p. 39, Pl. 3, fig. 11; IGO and KOIKE, 1968, p. 12, Pl. 1, figs. 15, 18, Pl. 3, fig. 21; MILLER, 1978, Pl. 2, fig. 13.

f element

Lonchodina fluegeli WALLISER, 1964, p. 44, Pl. 6, fig. 4, Pl. 32, figs. 22-24; ALDRIDGE, 1972, pp. 190, 191, Pl. 8, fig. 6; ?MILLER, 1978, Pl. 3, fig. 22.

Plectospathodus sp. A IGO and KOIKE, 1968, p. 16, Pl. 1, figs. 13, 16, 19, 22.

g element

?*Lonchodina detorta* WALLISER, 1964, pp. 43, 44, Pl. 9, fig. 20, Pl. 30, figs. 34-37.

Lonchodina detorta Walliser. ALDRIDGE, 1972, p.190, Pl. 8, fig. 6.

Multielement

Oulodus? *fluegeli* (Walliser). ALDRIDGE, 1979, pp. 14, 15, Pl. 2, figs. 6-10 (non fig. 11, may be *a* element of unknown *Oulodus* species); ALDRIDGE and MOMAMED, 1982, Pl. 2, figs. 26, 27; MABILLARD and ALDRIDGE, 1983, Pl. 2, figs. 15, 16.

Oulodus? cf. *O.*? *fluegeli* (Walliser). UYENO *in* UYENO and BARNES, 1983, p. 19, Pl. 1, figs. 1-5 (non fig. 6, may be element of *Ozarkodina* species).

?*Ozarkodina plana* (Walliser). SWEET and SCHONLAUB, 1975, p. 52, Pl. 1, figs. 1,4 (non fig. 2 = *g* element of *Ozarkodina* species; figs. 3, 5, 6 may = *b*, *a* and *e* elements of *O. f. petilus*, herein).

DESCRIPTION

All elements have a boundary between white and hyaline matter that is indistinct. White matter occurs in cusp, denticles and denticle bases. Basal cavity on all elements is shallow and continues beneath processes as a narrow excavation that tapers distally.

The a (ligonodiniform) element has a long, narrow cusp that is only slightly compressed laterally. Cusp is slightly reclined, straight and has sharp anterior and posterior edges. Anterior process is slightly deflected to inner lateral side and is slightly directed downward. Inner face of anterior process is concave. / Posterior process is variable, may be either only slightly bowed and straight (a-1 element; cf. Pl. 9, fig. 22), or have distal part that is moderately bowed to inner side and moderately deflected downward (a-2 element; cf. Pl. 9, fig. 21). Denticles are broad and laterally compressed with sharp anterior and posterior edges. They are confluent for about half their length forming processes that are high and blade-like. Proximal denticles are smaller, narrower than distal denticles.

Denticles on anterior process of a element are slightly curved toward cusp. Those on posterior process are reclined at an angle greater than that of cusp. Denticles number up to about 6 on anterior and 9 on posterior processes. On anterior process, interspaces between denticle tips are V-shaped. On small elements, these denticles are less fused basally and thus have U-shaped interspaces. Interspaces between denticles of posterior process are either V- or U-shaped. In general, the fifth through seventh denticle on this process are wider than others but shorter than cusp. Basal cavity is deepest beneath cusp. Basal flare is slight.

The *b* (zygognathiform) element (cf. Pl. 9, figs. 26, 27) has a cusp that is shorter than that of *c* element. In other respects, cusps of both elements are similar. Basal cavity and posterior process are like those of *c* element. Base of cusp is not as posteriorly extensive as it is on *c* element. Cusp and base are slightly to markedly deflected towards inner lateral process. Processes arise from anterolateral margins of cusp, arch downwards and are laterally directed. Inner lateral process is only slightly shorter than outer lateral process.

Denticles on inner process of *b* element are anteroposteriorly compressed. These are wider than those of outer process, thus there are fewer (about 4 or 5 versus 8). These denticles are inclined towards distal part of process and are basally confluent with V-shaped interspaces between tips. Some elements have a large distal denticle on inner process that rivals cusp in size and width. Denticles on outer lateral process are narrow and inclined towards proximal part of process. These denticles vary from being either basally confluent with V-shaped interspaces between tips, or are discrete. The discrete denticles are slightly curved, have U-shaped interspaces and are more peg-like than other denticles.

The *c* (modified trichonodelliform) element (cf. Pl. 10, figs. 20-23) is characterized by a broad, reclined cusp and lateral processes that are directed anterolaterally and slightly downward and form a V-shape when viewed from the oral and aboral sides. Cusp is laterally compressed at base to level of white matter and is confluent with "posterior process". White matter boundary is at same level as processes. Both anterolateral margins of cusp have a costa that extends from lateral processes to apex. The costae bound an anterior margin that is proximally concave, nearly planar at level of white matter and convex from this point to apex. Above level of white matter, anterior margin of cusp is slightly broader than below level of white matter. Posterior margin of cusp is sharp for proximal third of length, producing a subtriangular cross section, and convex for remainder.

"Posterior process" of c element is not posteriorly extended but instead cusp and base are confluent. Angle between proximal posterior margin of cusp and aboral margin varies from about 85 to 135 degrees. Lateral processes arch inward and are of equal length. Processes are directed aborally only slightly and diverge anteriorly at angle of about 90 degrees or less from anterolateral margins of cusp.

Denticles of c element are slightly compressed anterolaterally and number about 5 to 8 on each process. Most elements have denticles that are closely packed and basally confluent proximally, and are discrete distally. Denticles on some elements are all discrete. Discrete denticles have U-shaped interspaces. Basal cavity is deepest beneath anterior part of cusp. Basal excavations beneath anterolateral processes are more narrow than those beneath "posterior process", but none is flared.

The *e* (neoprioniodiniform) element has a long, wide cusp and a long posterior process. Cusp and denticles are laterally compressed with sharp anterior and posterior margins. Outer face of cusp varies from planar to concave; inner face is convex. Process may have up to 15 long, closely packed denticles. The denticles are confluent for most of length and have V-shaped interspaces between tips. Denticles are largest and widest in central region of process. Submorphotypes of *e* elements are defined on cusp attitude and type of margin found at anterior corner of base. The *e*-1 submorphotype is common; *e*-2 is a very rare variant of the *e*-1 element; *e*-3 differs from both and is rare.

The *e*-1 element (cf. Pl. 9, fig. 6) has a straight posterior process that is only slightly bowed to inner side. Base of cusp is deflected laterally to inner side so that cusp is not in plane of posterior process. Base of cusp may be either horizontal, or slightly to moderately deflected downwards below level of aboral margin of posterior process. Cusp is reclined and has inner basal flare that is widest beneath posterior part of cusp. Denticles are reclined; degree of inclination increases towards posterior. Anterior and aboral margins of cusp varies. It may be straight, producing a sharp angle at their juncture; slightly convex, resulting in a more rounded angle; or anteriorly extended as a short adenticulate process. The *e*-2 element (cf. Pl. 9, fig. 10) has a short anterior process bears at least two short, discrete denticles. Cusp on e-2 element is nearly erect.

The e-3 element (Pl. 9, fig. 14) has a base of cusp that is not deflected downward and is not as laterally deflected as in e-1 element. With anterior part of element horizontal, cusp and proximal denticle are proclined, remaining denticles pass through an arch from erect to reclined towards posterior. Distal part of posterior process is deflected downwards and degree of bowing of this part of process to inner lateral side is greater than in e-1 element. Rounded angle between anterior and aboral margin of cusp is about 90 degrees. Basal flare on inner face is more sharply convex than in e-1 element.

The f (prioniodiniform) element has a cusp that is within the plane of anterior process and a posterolateral process that is deflected and twisted. Cusp is laterally compressed, wide and long with sharp anterior and posterior edges and convex lateral faces. Cusp and denticles on anterior process are reclined towards proximal part of posterolateral process, Denticles on both processes are similar: compressed, wide, long, basally confluent and with V-shaped interspaces between tips. They are smaller and narrower toward each extremity of processes. On average-sized specimens, they number about 5 on anterior and 6 on posterolateral processes. Denticles on posterolateral process are inclined towards distal end of process.

Torsion of posterolateral process of f element is as follows: deflected in an inner posterolateral direction so that angle between this and anterior process is about 100 to 140 degrees (cf. Pl. 10, figs. 15, 19); no downward deflection; and twisted so that it is nearly horizontal (thus denticles are directed towards posterior, not posterolateral; cf. Pl. 10, fig. 17). Basal cavity is deepest and basal flare widest beneath cusp. Flare on outer face is narrow; on inner face, flare is broad.

The g (oulodontiform) element is described using the following orientation definitions: posterior -- basal cavity beneath cusp is flared on posterior side only, cusp is slightly recurved in this direction; processes are lateral -- inner lateral process is bowed so that concave side is towards posterior, outer lateral process is deflected towards anterior. Cusp is nearly erect, wide, long with sharp lateral edges. Base of inner process and cusp is only slightly arched. Denticles of inner process and cusp are anteroposteriorly compressed and slightly inclined or curved towards outer lateral process. Outer process is directed anteriorly and arched downward slightly. Some long outer processes have a sinuous lateral bowing. Viewed from aboral or oral sides, apparent angle between aboral margins of processes is 90 degrees or greater (cf. Pl. 10, figs. 3, 11).

Inner lateral process of g element has up to 9 long, wide denticles that are basally confluent and with V-shaped interspaces between tips. Denticles are anterposteriorly compressed with sharp lateral edges. Proximal two or three, and distal two denticles are more narrow and shorter than central denticles. On complete specimens, outer lateral process is about as long as inner. Denticles on outer process are narrower and thus more numerous than those on inner process (in some small elements, 7 denticles on outer, 5 on inner lateral processes). Denticles of outer process are inclined or slightly curved towards posterior, basally confluent, with V-shaped interspaces between tips in proximal region of process. Distal denticles are discrete with U-shaped interspaces. Some elements have small discrete proximal denticles that also have U-shaped interspaces. Proximal and distal denticles on outer process are smaller, less wide than central denticles. Basal cavity is deepest beneath cusp but basal flare is widest beneath proximal denticle of outer process.

REMARKS

Aldridge (1979, pp. 14, 15) briefly summarized the characters of the elements of <u>Oulodus</u>? <u>fluegeli</u>. I do not include his "ligonodiniform" element within this subspecies. It is an eoligonodiniform (<u>a</u>) element and may belong to another species of <u>Oulodus</u>. It was reported in his (<u>ibid</u>., p. 14) study that the cusp of the <u>c</u> element may develop into a "denticulated posterior bar". Some elements of ?<u>Roundya trichonodelloides</u> s.f. also have a narrow cusp and a short denticulated posterior process (cf. Walliser, 1964, Pl.

31, figs. 22, 25). The "posterior process" of all *c* elements in the Yukon study is adenticulate. Aldridge further noted that the lateral processes of the *c* element are directed downward. In Yukon elements, the processes do diverge downward, but only slightly. The peculiar anterior divergence is what differentiates the *c* element of *O. f. fluegeli* from the *c* element of other species of *Oulodus*. Aldridge (1979) did not find *e* elements with anterior denticulation; these very rare *e*-2 elements may be homologous to the *e*-2 elements of Ordovician species of *Oulodus*. Elements of the younger *Neoprioniodus multiformis* Walliser s.f. are variable, with either an adenticulate or denticulate anterior margin (cf. Walliser, 1964, Pl. 29, figs. 15, 19) and thus are similar to the the *e*-1 and *e*-2 elements of *O. f. fluegeli* in Yukon.

Ozarkodina plana (Walliser) of Sweet and Schönlaub (1975) includes a *c* element with a V-shaped divergence of processes, and a *f* element with confluent denticles and a twisted posterior process. These *c* and *f* elements are comparable to the same elements of *O. f. fluegeli*. The *a*, *b* and *e* elements of *O. plana* have a denticulation that is more similar to *Oulodus f. petilus* (Nicoll and Rexroad) than it is to *O. f. fluegeli*.

Miller (1978) suggested that some of his form species represent *O. plana* sensu Sweet and Schönlaub (1975). Six of his form species are included herein under *O. f. fluegeli*. The *f* element from Miller (1978) is queried because it has denticles that are not closely packed. It may be more correct to assign Miller's form species to O. f. petilus (below).

Uyeno and Barnes (1983) described the rare O.? cf. O.? fluegeli as an apparatus composed of elements with V-shaped denticle interspaces. They noted that this feature is more characteristic of the genus Ozarkodina than Oulodus. Their (1983) apparatus also includes a c element that has downwardly directed lateral processes and therefore unlike reconstructions of the Yukon Oulodus fluegeli s.l. The b, f and g elements of Uyeno and Barnes (1983) are comparable to the O. f. fluegeli of this present study.

The two subspecies of O. fluegeli are compared below under the discussion of O. f. petilus.

TYPES: Hypotypes, ADM 20190-20225.

Oulodus fluegeli petilus (Nicoll and Rexroad)

Pl. 9, figs. 1-4, 7-9, 11, 12, 15, 16, 18, 25, 28-30

Pl. 10, figs. 1, 2, 5, 6, 12, 16, 26-28, 30, 31

a element

Ligonodina petila NICOLL and REXROAD, 1969, pp. 38, 39, Pl. 5, figs. 20-22.

?Ligonodina silurica Branson and Mehl. MILLER, 1978, Pl. 2, figs. 2, 3.

b element

?Diadelognathus nicolli Aldridge. MILLER, 1978, Pl. 3, fig. 16 (only; fig. 17 is included under O. fluegeli

fluegeli (Walliser) above).

?*Trichonodella* sp. NICOLL and REXROAD, 1969, p. 65, Pl. 4, fig. 15.

c element

Trichonodella n. sp. LEE, 1982, pp. 107, 108, Pl. 3, figs. 23, 24.

e element

Neoprioniodus planus Walliser. NICOLL and REXROAD, 1969, p. 41, Pl. 5, figs. 11, 12.

f element

?*Lonchodina fluegeli* Walliser. MILLER, 1982, Pl. 3, fig. 22.

g element

Diadelognathus excertus Nicoll and Rexroad. MILLER, 1978, Pl. 3, fig. 15.

Diadelognathus n. sp. A NICOLL and REXROAD, 1969, p. 30, Pl. 6, figs. 9, 10.

Multielement

?*Delotaxis petila* (Nicoll and Rexroad). BARRICK and KLAPPER, 1976, pp. 69, 70, Pl. 4, figs. 29, 33 (= *g*, *a* elements, only; figs. 32, 34-36 may be part of *Delotaxis* species).

Oulodus? *fluegeli* subsp. A UYENO *in* UYENO and BARNES, 1983, pp. 18, 19, Pl. 7, figs. 11-22 (*g* elements; fig. 19 has unusually long posterior process and may be aberrant *b* or *c* element).

?*Oulodus petila* (Nicoll and Rexroad). ALDRIDGE and MOHAMED, 1982, Pl. 2, fig. 34 (*a* element).

?*Ozarkodina plana* (Walliser). SWEET and SCHONLAUB, 1975,

p. 52, Pl. 1, figs. 3, 5, 6 (non fig. 2: may = *g* element of *Ozark[illegible]a* sp.; non figs. 1, 4: may = *f*, *c* elements of *O. f. fluegeli*, herein).

DESCRIPTION

Elements share many of characters found on equivalent elements of *O. f. fluegeli*. Differences are outlined below.

The *a* element has a cusp that is oval in cross section. ~~The~~ *a*-1 element (cf. Pl. 9, fig. 7) has an inner lateral process that is slightly deflected downward and a posterior process that is only slightly bowed laterally and aborally. The *a*-2 element (cf. Pl. 9, fig. 8) has an inner anterolateral process, and a posterior process, with distal parts being moderately bowed to inner side and moderately deflected downward. Denticles are discrete; proximal and extreme distal denticles are smaller, narrower than other denticles. Denticles on anterolateral or lateral processes are slightly recurved posteriorly and toward cusp. Denticles number up to about 7 on posterior process and about 5 on other. Interspaces between denticles of all processes are U-shaped. Denticles near distal end of posterior process are longer than others.

The *b* element (cf. Pl. 9, fig. 25) is similar to *c* element. Denticles on outer lateral process are more narrow and peg-like than those of inner process. There are fewer denticles on inner (about 3 or 4) compared to outer process (about 5 or 6). Inner process denticles are nearly erect and separated by V- to U-shaped interspaces. Central to distal denticles on inner process are larger than other denticles on inner process. Denticles on outer process are nearly erect, slightly curved, and have U-shaped interspaces.

The c element is characterized by lateral processes that are bowed towards posterior forming a W-shape (or more accurately, the form of the Greek letter omega) when viewed from the oral and aboral sides (cf. Pl. 10, fig. 30). Cusp is laterally compressed at base to level of white matter. Costae on anterolateral margins of cusp bound a convex anterior margin to tip of cusp. Anterior margin of cusp is not proximally narrow. On some elements, posterior aboral margin is convex; these elements have a cusp that has a convex posterior margin. Other elements that have a sharp posterior edge on cusp have a tapered aboral margin. Cusp and its base are slightly to markedly deflected towards inner lateral process. Angle of posterior corner is about 90 degrees. A slight posterior flare of base reduces this angle.

Processes of c element diverge anteriorly at angle of about 90 degrees or more from anterolateral margins of cusp. Denticles are discrete, peg-like, subcircular in cross section, have costate lateral margins, and number about 5 or 6 on each process. Most elements have denticles that are smaller proximally and larger distally. Denticles have U-shaped interspaces. Basal cavity is deepest beneath anterior part of cusp. The posterior process has a slightly flared basal excavation in some elements.

The *e* element has a posterior process with between 5 to 7 long denticles. Denticles are discrete and have V- or U-shaped interspaces between them. Two submorphotypes of *e* elements are present and follow definitions of *e*-1 and *e*-2 elements (cf. Pl. 9, figs. 2, 3, respectively) described above for *O. f. fluegeli* (Walliser).

The *f* element has a cusp that is subcircular in cross section and has sharp anterior and posterior edges. Denticles on both processes are separated with V- or U-shaped interspaces. Those of posterolateral process are longer and wider than those on anterior process. Some elements have denticles on posterolateral process that are basally confluent. On average, they number about 4 on anterior and 6 on posterolateral processes. Torsion of posterolateral process on *f* element is similar to that on *f* element of *O. f. fluegeli* (cf. Pl. 10, fig. 5): angle between this and anterior process is about 100 degrees (cf. Pl. 10, figs. 1, 2). One *f* element (Pl. 10, fig. 6) has a short broken and denticulated outer lateral process (?aberrant form).

The *g* element has a cusp that is slightly recurved. Base of inner lateral process and cusp is straight. In aboral or oral view, angle between plane of processes is 90 degrees or less (Pl. 10, figs. 12, 16). Inner process has up to about 7 long, and relatively wide, discrete denticles that have V- or U-shaped interspaces. Outer process of g element is about same length or longer than inner and has up to about 10 denticles. These denticles are inclined or slightly curved towards posterior, discrete, with V- or U-shaped interspaces. Basal cavity flare is widest beneath cusp.

REMARKS

The reconstructions of the subspecies O. f. fluegeli (Walliser) and O. f. petilus follow those of Aldridge (1979) and Uyeno and Barnes (1983), respectively and are supported by abundant material from Yukon. The form of the elements is quite similar, and there is some mophological gradation between elements of the two subspecies. However, most elements are distinguishable. All element differ in denticulation; the a postion of each subspecies is represented by different morphotypes; and the c, f and g elements of each subspecies have a distintive divergence of processes.

The denticles on elements of O. f. fluegeli are generally more closely packed, wider and more numerous than those of O. f. petilus. These features result in denticles that are slightly to moderately confluent with V-shaped interspaces between them on elements of O. f. fluegeli, and discrete with U-shaped interspaces in O. f. petilus. There are exceptions to this generalization: U-shaped interspaces occur on some elements of *O. f. fluegeli*, and some denticles in *O. f. petilus* are basally fused and thus have V-shaped interspaces. Denticles of *O. f. fluegeli* are more compressed than those of *O. f. petilus*, which tend to be more peg-like.

The base of elements in *O. f. fluegeli* is less excavated and thinner than in *O. f. petilus*. This results in elements of *O. f. petilus* being more opaque basally than elements of a similar size in the other subspecies. The flare of the basal cavity is commonly more developed in *O. f. petilus* than in *O. f. fluegeli*, particularly on the *b*, *c*, f and *g* elements.

The *a* elements of *O. f. fluegeli* and *O. f. petilus* are ligonodiniform and eoligonodiniform, respectively. The anterior process of the former is more anteriorly directed; on the latter it is more laterally directed. Both subspecies have two submorphotypes in the *a* position. These may be homologous to the subdivision of position found in Ordovician species of *Oulodus* (cf. McCracken and Barnes, 1981a).

The *b* and *c* elements differ in the angle between the aboral and posterior margins of the cusp. With the aboral margin horizontal, this angle is less in the elements of *O. f. petilus* than in *O. f. fluegeli*. This difference is due to the common occurrence of a posteriorly directed basal flare on elements of *O. f. petilus*. The cusp of these elements in

O. f. fluegeli is distinctively subtriangular due to prominent lateral costae, and subcircular with subdued costae in O. f. petilus.

The denticulated processes of the c elements in O. f. fluegeli are characteristically directed towards the anterior forming a V-shape. The processes on this element of O. f. petilus are directed more downward and laterally, and bowed posteriorly. This divergence results in an omega- or W-outline when viewed from either the oral or aboral direction. Trichonodella n. sp. Lee s.f. has the omega-type of aboral outline seen on the c element of O. f. petilus.

The e-1 (adenticulate anterior corner) and very rare e-2 (denticulate anterior corner) elements occur in both subspecies. These submorphotypes are homologous to the e-1 and e-2 elements of Ordovician genera such as Oulodus (McCracken and Barnes, 1981a) and Gamachignathus (McCracken, et al., 1980). The rare e-3 element was identified only in O. f. fluegeli. The unique occurrence may be due a greater abundance of elements of this subspecies, or it may be incorrectly assigned to this taxon (cf. Ozarkodina sp. aff. O. polinclinata (Nicoll and Rexroad), herein). Both e-1 and e-2 elements of each subspecies can be distinguished by their denticulation.

The f and g elements on average, differ in degree and direction of process divergence, although an overlap in the range of divergence angle is noted. From an aboral or oral view, the processes diverge at apparent angles of greater than 90 degrees in O. f. fluegeli and less than 90 degrees in O. f. petilus. The one f element of O. f. petilus with an additional process may be an aberrant form.

Elements of O.? fluegeli subsp. A Uyeno and Barnes (1983) has a discrete style of denticulation similar to that of O. f. petilus. Their (ibid., Pl. 7, fig. 12) b element is comparable to one of the two varieties of b elements in this taxon. It has an aboral margin that is flared and posteriorly convex, and a cusp that has a convex posterior margin. One of their g elements (ibid., Pl. 7, fig. 19) has processes that diverge in the fashion of a g element, but it also has a long base beneath the cusp. This element could be an aberrant form of an a, b or c element.

The g element of Miller (1978) is comparable to the same element of Uyeno and Barnes (1983, Pl. 7, fig. 12). Miller suggested that it may be part of O. jeannae Schönlaub.

TYPES: Hypotypes, ADM 20226-20253.

Oulodus rohneri Ethington and Furnish

Plate 7, fig. 35

g element

Oulodus rohneri ETHINGTON and FURNISH, 1959, p. 544, Pl. 73, figs. 17, 18.

Multielement

Oulodus rohneri Ethington and Furnish. LENZ and McCRACKEN, 1982, Pl. 1, fig. 13; NOWLAN and McCRACKEN <u>in</u> NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 4 figs. 4-9 (Appendix A, herein; text includes synonmy).

TYPE: Hypotype, ADM 20650.

<u>Oulodus</u> <u>ulrichi</u> (Stone and Furnish)

Pl. 7, figs. 27, 33

<u>a</u> element

<u>Eoligonodina</u> <u>ulrichi</u> STONE and FURNISH, 1959, p. 222, Pl. 32, figs. 16-18.

Multielement

<u>Oulodus</u> <u>ulrichi</u> (Stone and Furnish). NOWLAN and McCRACKEN <u>in</u> NOWLAN, McCRACKEN and BARNES, MS, Pl. 4, Figs. 10-15 (Appendix A, herein; text includes synonymy).

TYPES: Hypotypes, ADM 20254, 20255.

<u>Oulodus</u> n. sp. A

Pl. 11, figs. 13-20

Multielement

cf. <u>Oulodus?</u> sp. B MANNIK, 1983, Fig. 5S (only: Figs. 5T, W, X are comparable to <u>g</u>, <u>b</u>, <u>a</u> elements respectively, of <u>O.</u> <u>jeannae</u> Schönlaub).

DESCRIPTION

All elements have a long narrow cusp and denticles that are circular to slightly compressed in cross section. Denticles are separated by U-shaped interspaces. Basal cavity is small and shallow, widest beneath cusp. Aboral surfaces beneath processes are flat.

The a (eoligonodiniform) element (Pl. 11, figs. 13, 16) has a long downwardly directed inner lateral process that is also directed slightly to posterior. Proximal part of cusp is erect; denticles on posterior process are slightly reclined. Proximal one or two denticles on posterior process are small.

The c element (Pl. 11, figs. 14, 15) has a short convex and adenticulate posterior process or basal flare. Cusp and denticles are slightly recurved. Cross sections of cusp and denticles are oval (laterally compressed) and circular, respectively. Lateral processes diverge at about 70-80 degrees. Intersection of processes is curved, not angular.

The e (neoprioniodiniform) element (Pl. 11, fig. 19) has a curved, slightly proclined cusp and a basal cavity that is markedly flared on inner side. Anterior margin of cusp is gently convex and does not form a process or anticusp. Posterior process may have up to 6 small denticles. Basal flare on inner side is asymmetric; maximum width occurs posterior to cusp. Cavity extends under process as narrow and shallow groove.

The f (prioniodiniform) element (Pl. 11, figs. 17, 20) has a small flare on inner face of base beneath cusp. The g element (Pl. 11, fig. 18) has one straight lateral process and another that is directed downwards and curved only slightly toward the anterior. A small basal flare is beneath cusp on posterior face of base.

REMARKS

The elements have cusp and denticle cross sections and aboral surfaces that suggest *Oulodus jeannae* Schönlaub (*in* Sweet and Schönlaub, 1975). The *a* element of both this and *O. jeannae* have a similarly directed lateral process. A *b* element is not known from Yukon material. The *c* elements of both species have a similar cusp and denticle attitude but the *c* element of *O. jeannae* has a cusp that is characteristically offset from the denticles, and the processes diverge at an angle that is slightly greater than on the Yukon *c* elements.

The *e* elements of both species have well developed basal flares. The *e* element of *O. jeannae* differs in that it has a short adenticulate to denticulate (i.e. euprioniodiniform) anterior process. Only the *e* element of *Oulodus* sp. B Mannik is comparable to the apparatus of *O.* n. sp. A; the other elements of Mannik's (1983) species are comparable with *O. jeannae*.

The cusp of the *e*, *f* and *g* elements of *O. jeannae* all are posteriorly offset from the denticles. This feature is not found in *O.* n. sp. A. The angle between the processes of the *g* element of *O.* n. sp. A is greater than that in *O. jeannae*.

The aboral surfaces, especially on the f and g elements of O. n. sp. A are less expansive than those of O. jeannae, and not everted as in element of Oulodus? n. sp. B (below). All three species may be closely related.

TYPES: Figured specimens, ADM 20256-20263.

Oulodus? n. sp. B

Pl. 11, figs. 1-12

f element

aff. Lonchodina detorta Walliser?. MILLER, 1978, Pl. 3, fig. 21.

aff. Lonchodina walliseri Zeigler. MILLER, 1978, Pl. 3, fig. 23.

Multielement

aff. Oulodus jeannae SCHONLAUB in SWEET and SCHONLAUB, 1975, pp. 49-51, Pl. 1, figs. 13-24.

aff. (?)Oulodus jeannae Schönlaub. MAYR, UYENO, TIPNIS and BARNES, 1980, Pl. 32.1, fig. 14 (c element).

DESCRIPTION

All four (a,c,e,f) known elements are robust and have discrete, stout and peg-like denticles. Most denticles are widely spaced with U-shaped interspaces. Cross sections of cusp and denticles are circular. Basal cavity is small and relatively shallow; it extends as a narrow groove beneath processes. Aboral margin of processes are strongly everted.

The a (eoligonodiniform) element (Pl. 11, figs. 1-3) has a long posterior process with 7 denticles. A relatively long adenticulate interval is present between cusp and first denticle. Denticles are long, straight, sharp and reclined. Fourth and fifth denticles are about as wide as cusp. Inner lateral process is directed slightly downward and to posterior and bears 5 small peg-like denticles that are closely spaced.

The c (trichonodelliform) element (Pl. 11, figs. 5-7) has long denticulated lateral processes and lacks a posterior process. With element oriented so that posterior oral margin of base horizontal, processes are directed to posterior and only slightly downward; cusp and denticles recurve slightly. Processes diverge at low angle forming U-shape with aboral surfaces facing each other. Denticles are long; a complete process has 5 denticles. Proximal denticle on each side of cusp is small; other denticles are about same size as cusp.

The e (euprioniodiniform) element (Pl. 11, figs. 8, 12) has a short anterior process with a small incipient denticle and that is almost completely confluent with cusp. Long, straight cusp is slightly inclined and inwardly directed. Cusp has a basal cross section that is circular but towards tip it is slightly compressed laterally giving it an oval cross section with sharp anterior and posterior edges. Five denticles are present on long posterior process. Proximal denticles are short and subtriangular;

distal denticles are longer and wider but not as large as cusp.

The f (prioniodiniform) element (Pl. 11, figs. 9-11) has an anterior process that is slightly longer than posterior process. Cusp is long, straight and reclined. Denticles on anterior process are slightly compressed laterally, and in large specimens, are confluent or overgrown for most of their length and have triangular tips. Denticles on posterior process are discrete and more subcircular in cross section and longer than those of other process. There are about 6 and 4 denticles on anterior and posterior process, respectively. Denticles of both processes are erect with respect to their bases.

REMARKS

The apparatus of Oulodus? n. sp. B is incomplete: b and g elements are not present in the Yukon collection. The latter element is one of the more diagnostic elements in the apparatus of Oulodus, hence the tentative generic assignment.

The distinguishing features of elements in O. n. sp. B are their robust nature and everted aboral surfaces. These features are not unique to this taxon but are found on elements described by Walliser (1964) and other writers (see below).

O.? *kentuckyensis* (Branson and Branson) sensu McCracken and Barnes (1981a) is a Silurian species that is characterized by elements having widely flared and shallowly excavated aboral surfaces. *O.*? *kentuckyensis* of the above writers, *O.* *kentuckyensis* (sensu Aldridge and Mohamed, 1982) and *O.*? cf. *O.* *kentuckyensis* (of Mannick, 1983) all differ from the Yukon species in that the aboral surfaces are not markedly everted and their *c* elements have processes that are much more widely divergent.

Oulodus sp. nov. A Aldridge and Mohamed (1982) has *e-g* elements that have flared bases like that of the Yukon species, but the *e* element of *O.* sp. nov. A is a neoprioniodiniform not euprioniodiniform.

Mannik (1983) illustrated *a*, *b* and *c* elements of *O.*? sp. C from the Ludlow of October Revolution Island, Estonian S.S.R. The *a* and *c* elements of *O.*? sp. C differ from their counterparts in *O.*? n. sp. B in the degree of process divergence. However, *b* elements of *O.*? sp. C (Mannik, *ibid.*, Fig. 5 H, L, ?M) have an divergence angle similar to that found in the *c* element of *O.*? n. sp. B. The principal differences are that the *b* elements of *O.*? sp.C have denticles that are less inwardly recurved and more inclined outward and anteriorly.

The (*f*) elements of Miller (1978) have cusps that are slightly displaced relative to the processes. Miller suggested that his *L.* *walliseri* s.f. and *L.* *fluegeli* s.f., along with other elements, represent Ozarkodina plana (Walliser) of Sweet and Schönlaub (1975).

Elements of O.? n. sp. B share some similarities with those of O. jeannae from the Pterospathodus celloni Zone of Austria, including the shallow basal cavity, aboral groove and peg-like denticles. The a elements of both species have inclined denticles and a lateral process that is oriented in a similar direction. The c elements of both lack a posterior process but differ in that the cusp is offset in O. jeannae. The processes of the c element in O. jeannae diverge at a greater angle and are more laterally and less posteriorly directed than in O.? n. sp. B.

The e elements of both O. jeannae and O.? n. sp. B are euprioniodoniform and have similar aboral surfaces. The f elements of both species are prioniodiniform and have a cusp slightly displaced relative to the processes, short processes, and a flared base beneath the cusp. The basal cavity of the f element of O. jeannae is deeper than in this element of O.? n. sp. B.

The more robust nature of the elements and more everted aboral surfaces are the primary reasons for not equating the Yukon taxon and O. jeannae, although they may be closely related.

TYPES: Figured specimens, ADM 20264-20273.

Genus Ozarkodina Branson and Mehl, 1933

Emended Lindström, 1970

Type species: O. typica Branson and Mehl, 1933 (=junior synonym of O. confluens Branson and Mehl, 1933).

Ozarkodina excavata (Branson and Mehl)

REMARKS

Jeppsson (1969) formally reconstructed Hindeodella excavata (Branson and Mehl), selecting Prioniodus excavatus s.f. (an e element) as the senior synonym. He (1972) later named Trichognathus excavata Branson and Mehl s.f. as the senior synonym for Ligonodina excavata. Klapper and Murphy (1975) and Barrick and Klapper (1976) included both form species and H. excavata in the reconstruction of O. excavata excavata.

Ligonodina excavata excavata sensu Jeppsson (1972, p. 58, Pl. 1, figs. 25-29) includes "walliseriform" and cristagalliform" elements (after Ziegler's, 1960, form species). These are f and g elements, and are alternatively referred to as prioniodiniform and oulodontiform elements. Jeppsson (1979, p. 239) observed a similarity between the apparatus of his L. excavata and Oulodus oregonia (Branson, Mehl and Branson) sensu Sweet and Schönlaub (1975) and suggested that "they may well be congeneric", and noted that the senior generic name is Ligonodina.

I prefer to regard the apparatus of "L. excavata" as being different from that of Ozarkodina excavata. The f and g elements in Ozarkodina excavata are blade-like and therefore the generic assignment is valid. Elements in the same positions in "L. excavata", if Jeppsson's (1972) reconstruction is correct, are comparable to the f and g elements of Oulodus.

The g elements of Oulodus? kentuckyensis (Branson and Branson) sensu McCracken and Barnes (1981a) and "L. excavata" are even more comparable to each other than to oulodontiform elements of Oulodus s.s. McCracken and Barnes (ibid., pp. 78, 79) recognized that the g element of O.? kentuckyensis and O.? nathani McCracken and Barnes were different, and therefore queried the generic assignent. These two species, and "L. excavata" may represent a genus that is related to Oulodus.

Ozarkodina excavata n. subsp. A

Pl. 12, figs. 11, 15-21

c element

aff. Trichognathus excavata BRANSON and MEHL, 1933, p. 51,
 Pl. 3, figs. 35, 36.

e element

aff. Prioniodus excavatus BRANSON and MEHL, 1933, p. 45,
 Pl. 3, figs. 7, 8.

Multielement

aff. Hindeodella excavata (Branson and Mehl). JEPPSSON,
 1969, pp. 18-20 (includes synonymy).

aff. Hindeodella excavata (Branson and Mehl) sensu Jeppsson.
 JEPPSSON, 1979, p. 240.

non *Ligonodina excavata* (Branson and Mehl) sensu Jeppsson.
JEPPSSON, 1979, pp. 238, 239.

aff. *Ozarkodina excavata* (Branson and Mehl). COOPER, 1976, pp. 215, 216, Pl. 2, figs. 1-4, 6, 7 (includes synonymy); COOPER, 1977a, p. 188, Pl. 16, figs. 8-15; HELFRICH, 1978, Pl. 2, figs. 1-7; HELFRICH, 1980, Pl. 2, figs. 31-38; ALDRIDGE and MOHAMED, 1982, Pl. 1, figs. 16, 17; MABILLARD and ALDRIDGE, 1983, Pl. 3, figs. 1-6.

aff. *Ozarkodina excavata excavata* (Branson and Mehl). BARRICK and KLAPPER, 1976, pp. 78, 79, Pl. 4, figs. 13-23, 26 (includes synonymy); KUWANO, 1976, Pl. 2, figs. 7-10, 12-19; REXROAD, NOLAND and POLLOCK, 1978, pp. 9, 10, Pl. 1, figs. 17-22 (includes synonymy); MAYR, UYENO, TIPNIS and BARNES, 1980, Pl. 32.1, figs. 28, 32; NOWLAN, 1981b, Pl. 6, figs. 10-16, 18; HARRIS, HATCH and DUTRO, 1983, Pl. 1, figs. D-H; NOWLAN, 1983b, Fig. 3(N, Q, U).

DESCRIPTION

Apparatus is like that of *Ozarkodina eexcavata excavata* but has a slightly different *g* element (discussed below) and the denticulation of all elements is compressed. Some *a*, *b* and *f* elements have denticles that are closely spaced with straight proximal edges and long triangular tips.

REMARKS

Barrick and Klapper (1976) found a range in the attitude of the anterolateral process of the *a* element of *Ozarkodina excavata excavata*. It varies from being in the horizontal plane of the posterior process to more commonly arched downward. Both end members are present in the Yukon subspecies (Pl. 12, fig. 11). Some *a* elements herein have the distinctive denticulation mentioned above; otherwise the *a* element is comparable with those in both Klapper and Murphy (1975) and Barrick and Klapper (1976).

The *b* element (Pl. 12, fig. 16) has asymmetrical lateral processes that diverge horizontally at 180 degrees or less and thus are within the range displayed by *b* elements of taxa in both Klapper and Murphy (1975) and Barrick and Klapper (1976). The basally narrow cusp and close spacing of denticles are similar to these features in *b* elements in Klapper and Murphy. The number of denticles and the distal denticles on the inner lateral process are similar to *O. e. excavata* sensu Barrick and Klapper.

The *c* element (Pl. 12, fig. 15) has processes that diverge near the horizontal, thus are like *c* elements in Klapper and Murphy (1975). The *c* element of Barrick and Klapper's (1976) subspecies has processes that are more arched.

The *e* element (Pl. 12, figs. 17, 18) has long, closely spaced denticles, and differ from the elements of Klapper and Murphy's subspecies in that they are wider.

The f element (Pl. 12, fig. 21) has a process angle that varies from being sharply arched as shown in elements of Klapper and Murphy (1975, Pl. 6, fig. 11) to more gently arched and thus within the range of the f element in Barrick and Klapper (1976). The cusp is compressed and the anterior process denticles are partly fused; these features are present in f elements of Klapper and Murphy but not in those of Barrick and Klapper.

The g element (Pl. 12, figs. 19, 20) has a straight aboral margin, relatively few and wide triangular denticles, a long cusp, and the absence of ledges at the base of the denticles. The g element in Klapper and Murphy (1975) has a straight aboral margin, numerous denticles that are partially fused, a short cusp and lateral ledges. The g elements illustrated by Barrick and Klapper (1976) are gently arched, have short, wide cusp and denticles. Barrick and Klapper (1976) found that older forms (cf. Ozarkodina simplex Branson and Mehl s.f.) are unledged, younger forms (e.g. Prioniodella inclinata Rhodes s.f.) have ledges.

All but the g element have closer similarities to elements of O. e. excavata sensu Klapper and Murphy (1975) than to the subspecies of Barrick and Klapper (1976). The g element is distinctive and is the primary reason for recognizing this taxon as a new subspecies of O. excavata.

TYPES: Figured specimens, ADM 20274-20281.

Ozarkodina manitoulinensis (Pollock, Rexroad and Nicoll)?

Pl. 12, figs. 4, 5

g element

Spathognathodus manitoulinensis POLLOCK, REXROAD and NICOLL, 1970, pp. 761, 762, Pl. 111, figs. 17-19; McCRACKEN and BARNES, 1981a, p. 90, Pl. 7, fig. 19 (includes synonymy).

DESCRIPTION

The g element is represented by one partially complete fragment that has short, rounded and erect denticles. It is robust with an anterior process that has a high base and seven fused denticles. Proximal two denticles on this process are completely fused.

Posterior process is deflected from cusp to inner side and has a relatively short base and two denticles. A small gap is present between cusp and first denticle of this process. Base beneath cusp is flared; flare is greater on outer than inner side. Flare of base on outer face is capped by a small node-like denticle; both denticle and cusp are joined by a sharp ridge. Aboral margin is not straight, but instead curves upward from flare to posterior.

REMARKS

The peculiar node-like denticle on the basal flare, and the occurrence of this element in a mixed Ordovician - Silurian fauna give reason to query the identification. It has similarities to Ordovician aphelognathiform and Silurian spathognathodontiform elements.

Compared with aphelognathiform elements, the g element lacks the diagnostic gap caused by overgrowth between the cusp and denticles of the anterior process. There is overgrowth of proximal anterior denticles on this specimen but it does not produce an aphelognathiform gap. Instead it is more similar to overgrowths seen on g elements of the Silurian Ozarkodina oldhamensis (Rexroad).

A deflection of one of the processes on the g element is a character of both the Ordovician Aphelognathus (e.g. A. grandis Branson, Mehl and Branson, A. floweri Sweet) and the Silurian Spathognathodus manitoulinensis s.f. The g element from Yukon differs from the above elements in that it has an ancillary denticle on the outer basal flare. However, similar denticulation is present on some Silurian spathognathodontiform elements (see below); it may be a rare or suppressed character of Ozarkodina taxa.

The g element shares the following features with S. manitoulinensis s.f.: denticles of anterior process are higher and more numerous than those posterior process; basal flare is greater on outer than on inner side; and posterior process is strongly deflected laterally.

McCracken and Barnes (1981a) compared this S. manitoulinensis to the g element of O. oldhamensis and they noted that the proximal denticles on the anterior process are commonly and completely fused in both forms. They (*ibid.*, p. 84) found, but did not illustrate, a fragment of an element comparable to *S. comptus* Rexroad s.f. This element was reported to have small denticle on the basal flare but otherwise is similar to the *g* element of *O. oldhamensis*. In spite of some morphological similarity between these *g* elements, McCracken and Barnes felt that the inclusion of *S. comptus* s.f. as a junior subjective synonym of *O. oldhamensis* was not warranted. Instead, the element with the ancillary denticle was regarded as a rare variant of *O. oldhamensis*.

McCracken and Barnes (1981a) suggested that *S. manitoulinensis* s.f. may be a rare variant of *O. oldhamensis* but did not formally consider it as a junior synonym and retained its form species designation. The same trivial name is used herein but it is assigned to the multielement genus *Ozarkodina*.

TYPE: Figured specimen, ADM 20282,

Ozarkodina sp. aff. *O. polinclinata* (Nicoll and Rexroad)
sensu Aldridge, 1979
Pl. 11, figs. 21-32

g element

aff. *Spathognathodus polinclinata* NICOLL and REXROAD, 1969, p. 60, Pl. 2, figs. 19, 20; MILLER, 1976, Fig. 8(25); MILLER, 1978, Pl. 2, fig. 23, Pl. 3, fig. 25.

Multielement

Ozarkodina aff. O. polinclinata (Nicoll and Rexroad).

ALDRIDGE, 1979, pp. 17, 18, Pl. 2, figs. 1-5.

aff. Ozarkodina polinclinata (Nicoll and Rexroad). COOPER, 1977b, pp. 1058, 1061, 1062, Pl.1, figs. 11, 13-15, 17, 18 (includes synonymy); ALDRIDGE and MOHAMED, 1982, Pl. 2, fig. 35; UYENO in UYENO and BARNES, 1983, p. 22, Pl. 5, figs. 11-16, 19.

REMARKS

Ozarkodina sp. aff. O. polinclinata is a rare species found at the Blackstone River section; elements from the older of the two samples are small and delicate.

The a element (Pl. 11, fig. 21) is ligonodiniform with a downwardly directed anterior process. The attitude of the anterior process does not compare with that of the a element of O. polinclinata sensu Cooper (1977b), which is directed more laterally (thus, eoligonodiniform rather than ligonodiniform). Aldridge (1979) does not illustrate the a element of O. aff. O. polinclinata but notes that fragmentary elements similar to the a elements of Cooper (1977b) may be part of this species. The a element is included herein because the high processes and a wide cusp are features common to other elements of the Yukon species. Its small size and delicate nature are also like the co-occurring b, e, f and g elements.

The b element (Pl. 11, figs. 23-25) has high, smooth processes that diverge at a low angle. Denticles on one process are shorter and less confluent. The b element of Aldridge's (1979) species has a similar angle of process divergence and comparable denticles.

The c element (Pl. 11, figs. 22, 26, 27) is like the b except that it is symmetrical. The cusp of both the b and c elements appear wider than those of this species sensu Aldridge (1979). This may be due to overgrowth of the small erect denticles that flank the cusp.

The e element (Pl. 11, fig. 28) differs from that assigned to O. aff. O. polinclinata by Aldridge (1979). His e element has the form of Neoprioniodus planus Walliser s.f., a form species that is included by Cooper (1977b) in his reconstruction of O.. polinclinata. Aldridge noted a potential problem arising from the assignment of elements like N. planus s.f. to both of his co-occurring O. aff. polinclinata and Oulodus? fluegeli Walliser. In Yukon, O. fluegeli s.l. is extremely common in the samples where O. sp. aff. O. polinclinata occurs. It is possible that the e element of this Ozarkodina species has been mistakenly tabulated with those of O. fluegeli. For example, the rare e-3 element of O. f. fluegeli differs from other e elements assigned to this subspecies; it has an erect cusp like the e element in Cooper's reconstruction of O. polinclinata and may be an alternative to the e element that is described herein. The e elements in both of the above species identified by Aldridge have reclined cusps; this feature is more typical of N. planus. s.f.

The *e* element included in *O.* sp. aff. *O. polinclinata* differs from *N. planus* s.f. in that it has a downwardly directed anterior process with three denticles. The proximal denticle of the *e* element is fused to a wide and slightly inclined cusp; this fusion is a character of other elements of this species.

The *f* (ozarkodiniform) element (Pl. 11, figs. 30, 31) differs slightly from that element in Aldridge's (1979) species; the denticles are longer and more confluent. Otherwise, they share similar short processes, prominent cusp, a twisted posterior process, and basal flare. *Ozarkodina hanoverensis* Nicoll and Rexroad s.f., the *f* element of *O. polinclinata*, is similar except that the processes are longer.

The *g* (spathognathodontiform) element (Pl. 11, figs. 29, 32) conforms well with the same element of *O.* aff. *O. polinclinata* sensu Aldridge (1979). The *g* element of *O. polinclinata* s.s. has a longer anterior process and less conspicuous cusp.

Aldridge (1979) noted the close similarity between this species and *Ozarkodina broenlundi* Aldridge, especially in the elements of the symmetry transition series.

TYPES: Figured specimens, ADM 20283-20294.

Ozarkodina n. sp. A

Pl. 12, figs. 1-3, 7-10

Multielement.

Ozarkodina sp. LENZ and McCRACKEN, 1982, Pl. 1, figs. 18-20.

DESCRIPTION

All known elements are small, delicate and poorly preserved. Base beneath cusp on all elements is not noticeably flared.

The *a* (ligonodiniform) (Pl. 12, fig. 1) element has a long, downwardly directed anterior process that is flexed slightly to inner side. Cusp is long and either erect or slightly reclined. It is wide at base and tapers markedly to tip. Denticles are long and fused for much of their length. Aboral margins of processes are straight and meet at sharp angle beneath cusp. Angle between processes is about 135 degrees.

The *b* (zygognathiform) element (unfigured; cf. Lenz and McCracken, 1982, Pl. 1, [illegible] 19) has a narrow cusp and long, wide diverging processes. Aboral margins of processes are not noticeably curved. The *e* (?synprioniodiniform) element (Pl. 12, fig. 2) has a long posterior process. Denticulation of this process is like that of *a* element. Short(?) anterior process is directed downward.

The *e* element (Pl. 12, fig. 2) is synprioniodiniform and has a short anterior process. The long posterior process is only slightly arched. The laterally compressed cusp is basally wide, and proclined.

The *f* (ozarkodiniform) element (Pl. 12, figs. 3, 7, 8) has a long anterior process and a shorter posterior process. Cusp is long, wide with a nearly erect posterior edge and a reclined anterior edge. Denticles are triangular, inclined towards cusp and number 6-9 on anterior, 3-6 on posterior processes. Anterior edge of cusp and tips of anterior denticles form an almost straight line. Angle between processes is variable. Aboral margin of posterior process at distal end curves upward.

The *g* (spathognathiform) element (Pl. 12, figs. 9, 10) has a straight aboral margin, long anterior process (about 9 denticles) and a short posterior process. Cusp and denticles are long and nearly erect. Denticles of anterior process are longer than those of posterior. Tips of anterior denticles form a line that is inclined upwards towards cusp. First anterior denticle and cusp are fused almost completely. Other denticles are only partially fused and have triangular tips.

REMARKS

The poor preservation of these elements, especially of the denticles, make these elements difficult to compare with known species of *Ozarkodina*.

The *a* element is characterized by its long anterior process. This feature distinguishes it from *a* elements of other Llandovery species of *Ozarkodina*. Late Llandovery - Wenlock species of *Kockelella* illustrated by Barrick and

Klapper (1976) have relatively long anterior processes on the a elements but the denticulation is discrete on both the anterior and posterior processes.

The b and e elements are not diagnostic. Widely diverging processes on the b element are found on elements of species such as O. hassi (Pollock, Rexroad and Nicoll) and O. oldhamensis (Rexroad). Both of these species and O. n. sp. A have synprioniodiniform elements in the e position. The basally wide cusp of the e element is comparable with that of the a, f and g elements. A c element has not been identified from Yukon collections.

The f element is characterized by the denticulation, and the upwardly curved aboral margin on the posterior process. The anterior margin of the cusp and the tips of the anterior denticles form a straight line in both this species and O. hassi. The f element of O. hassi differs in that its processes, particularly the posterior one, are shorter; aboral margin of the posterior process is straight; the angle between the processes is consistently great; and anterior denticles are more confluent. O. n. sp. A Fahraeus and Barnes from the Becscie and Gun River formations, Anticosti Island, Québec has a similar alignment of cusp edge and denticle tips. The posterior process of their element does not have a distally curved aboral margin (Fahraeus and Barnes, 1981a, Pl. 1, fig. 10).

One of the f elements of O. confluens (Branson and Mehl) illustrated by Klapper and Murphy (1975, Pl. 8, fig. 11) has a similar upwardly curved aboral margin of the posterior process. Their element (ibid.) differs in having a longer posterior process, shorter anterior process denticles and a more reclined cusp.

The g element is characterized by anterior denticles that have tips forming an upwardly inclined line toward the cusp. This distinguishes it from the g element of O. oldhamensis, which has a nearly horizontal line of denticle tips. The g element of O. hassi has a wide prominent cusp and short anterior denticles. The f element of the Late Llandovery O. clavula Uyeno (in Uyeno and Barnes, 1981) has a straight aboral margin, long cusp and discrete posterior denticles like one of the g elements herein (Pl. 12, fig. 10) but differs in that the cusp is fused with the proximal denticle on the posterior process. The g element of O. clavula is not comparable to the g element of O. n. sp. A. The g element of O. n. sp. A Fahraeus and Barnes has a similar denticulation on the anterior process. It differs from the g element of O. n. sp. A in that the anterior process is shorter.

O. n. sp. A occurs in strata at the Pat Lake section that are possibly earliest Llandovery, according to Lenz and McCracken (1982). (see Biostratigraphy, herein) The f and g elements are the more diagnostic elements and have some similarities to the same elements of O. hassi and O.

n. sp. A Fahraeus and Barnes. Both of these latter species have been recorded from the Becscie Formation (*Icriodella discreta* - *I. deflecta* Zone) by Fahraeus and Barnes (1981). *O. hassi* is also present in the older *Oulodus*? *nathani* Zone of the Ellis Bay Formation, Anticosti Island (McCracken and Barnes, 1981a, 1981b).

Ozarkodina sp. B

Pl. 12, figs. 22-26, 29

DESCRIPTION

The *a* element is ligonodiniform (Pl. 12, figs. 22, 23) with markedly reclined denticles on posterior process that are wide, laterally compressed and closely spaced. Cusp is wide, compressed, with sharp costate margins. Denticles on anterior process are smaller than those of posterior.

The *b* element (Pl. 12, figs. 24, 25) has high bases on lateral processes and a small posterior flare on base beneath cusp. Inner process has a large, wide, distal denticle. All denticles and cusp are anteroposteriorly compressed with sharp, costate lateral margins. Denticles on outer process are more closely spaced than those of inner. Processes diverge at about 90 degrees. Basal cavity is small, extends under processes as a narrow excavation.

The *c* element (Pl, 12, fig. 29) is like the *b* element except that divergence angle is much less and size of denticles is more even. Figured element is not completely symmetrical; cusp is slightly twisted to one side.

The e? element (Pl. 12, fig. 26) has a denticulated anterior process that is directed downward at nearly 90 degrees to denticulated posterior process. Three denticles on anterior process are long, slightly compressed, discrete and inclined towards cusp. Denticles on posterior process are laterally compressed.

REMARKS

This apparatus lacks f and g elements, two of the more diagnostic elements in Ozarkodina. The a element is ligonodiniform and the b and c elements have high bases; these three elements are not particularly distinctive.

The large denticles on the inner process of the b element are not unique; a similar denticulation is found on other b elements (e.g. O. confluens (Branson and Mehl), O. excavata (Branson and Mehl) and Oulodus fluegeli (Walliser) s.l.).

The b and c elements have some similarities to elements figured as Ozarkodina spp. by Mabillard and Aldridge (1983). One of their better preserved elements (ibid., Pl. 3, fig. 23) has a divergence angle, large and wide inner process denticles, small posterior basal flare, and a cusp cross section with wide costate margins that are similar to elements of O. sp. B. The outer process of their element differs in that its denticles are narrower and less closely spaced. The e element of Mabillard and Aldridge (1983) is synprioniodiniform and is therefore not comparable. These authors found, but did not illustrate, an a element of O. spp. Their O. spp. were found in strata containing Pterospathodus amorphognathoides Walliser.

The e? element is makelliform (pick-shaped), a form that occurs in the e position but not usually in Ozarkodina, hence the queried interpretation. It is included within this taxon because of its co-occurrence with the other rare elements from the Blackstone River sample. The relatively narrow cusp is common to the b and c elements but the denticles on the anterior process are different.

TYPES: Figured specimens, ADM 20302-20307.

Ozarkodina sp. C

Pl. 12, figs. 27, 28, 30-33

cf. Ozarkodina sp. C MABILLARD and ALDRIDGE, 1983, p. 34,
Pl. 3, figs. 9, 10.

DESCRIPTION

The a (ligonodiniform) element (Pl. 12, fig. 27) has wide, discrete denticulation. Denticles and cusp are compressed with sharp edges. The c element (Pl. 12, fig. 28) has a cusp that is subcircular in cross section and has lateral costae. Lateral processes have discrete, compressed denticles and diverge at about 90 degrees. Posterior process is absent; base beneath cusp is posteriorly flared.

The f element (Pl. 12, figs. 30, 31) has short processes, a wide cusp, a high anterior process blade and a nearly straight, unflared aboral margin. Cusp is long, confluent with proximal anterior process denticle and is slightly reclined. Denticles of anterior process on smaller figured element (Pl. 12, fig. 30) are partially confluent with triangular tips. Those of larger figured element (Pl. 12, fig. 31) are more confluent with tips that are more rounded. Denticles and cusp of this element are more fused and confluent than smaller element. Denticles of short posterior process are broken.

The g element (Pl. 12, figs. 32, 33) is characterized by a long, nearly erect, biconvex cusp that has costate anteroposterior margins. Both processes are short although posterior process is much shorter than anterior. Anterior process bears at least 6 denticles. These are peg-like with rounded tips and may be either discrete or partially confluent. Denticles on posterior process are short. Base beneath cusp is slightly flared. Aboral margin is slightly inverted. Margin is convex upwards at anterior corner, straight from this corner to basal flare and slightly concave beneath posterior process.

REMARKS

The association of Ozarkodina elements is from one sample from the Tetlit Creek section. The denticulation on the a and f, and the c and g elements respectively, are similar; these groups may prove to be parts of different species.

The short processes, high anterior blade and nearly straight base are characters found in O. edithae Walliser s.f., the f element of the early Llandovery multielement O. hassi (Pollock, Rexroad and Nicoll).

The g element has a prominent cusp like that found on the g element of O. hassi. Both have a similarly high anterior and low posterior processes. A comparable cusp and process height are also seen on Spathognathodus elibatus Pollock, Rexroad and Nicoll s.f.

The g element of the Llandovery - Wenlock Ozarkodina sp. C Mabillard and Aldridge (1983) has a distinct cusp but it is relatively short and triangular. The anterior process of their element is relatively long compared to that in the O. sp. C herein. The triangular shape of the cusp in their g element is probably due to overgrowth of the proximal denticles (cf. Mabillard and Aldridge, 1983, Pl. 3, fig. 9). Overgrowth of the proximal denticle is seen in the Yukon element with the longer anterior process.

Mabillard and Aldridge (1983) noted a resemblance between the g elements of their O. sp. C and O. gulletensis (Aldridge). The cusp in the latter species is not as distinctly long.

TYPES: Figured specimens, ADM 20308-20313.

Ozarkodina sp. D

Pl. 12, figs. 6, 12-14

DESCRIPTION

The *a* (ligonodiniform) element (Pl. 12, figs. 6, 12) has a wide cusp and short, high anterior process that is directed downward at a low angle. The *f* (ozarkodiniform) element (Pl. 12, figs. 13, 14) has an anterior process with about 4 denticles; posterior process has about 3 denticles. Denticles are partially discrete. Cusp is long and nearly erect. Aboral margins of processes at their distal ends are straight. Aboral angle between processes is large.

REMARKS

These poorly preserved and rare elements are referred to as *Ozarkodina* sp. D since they differ from the species *O.* n. sp. A from the same strata. It is possible that these elements represent more than one species.

The *a* element has an anterior process that is shorter, higher and not as laterally or aborally directed as the same process in *O.* n. sp. A. Also, the aboral angle between processes on the *a* element of *O.* n. sp. A is less than in this element.

The *f* element has some similarities to the *f* element of *O. hassi* (Pollock, Rexroad and Nicoll). The short posterior process and nearly straight aboral margin are shared characters. This element differs from that of *O. hassi* in that the cusp is longer and nearly erect, rather than being short, wide and reclined. The denticles are not as fused, and those of the anterior process are longer than in the f element of O. hassi. The f element of O. oldhamensis (Rexroad) has a longer cusp and partially fused denticles.

The f element differs from the same element of O. n. sp. A in the following features: the cusp is longer, more narrow and less reclined; aboral margins of each process are straight, not curved upward; and the tips of the anterior denticles and anterior edge of the cusp do not form a nearly straight line.

TYPES: Figured specimens, ADM 20314-20317.

Genus Panderodus Ethington, 1959

Type species: Paltodus unicostatus Branson and Mehl, 1933.

Panderodus sp. cf. P. feulneri (Glenister)

Pl. 2, figs. 32, 33, 37

e element

cf. Paltodus feulneri GLENISTER, 1957, p. 728, Pl. 85, fig. 11; NOWLAN in BOLTON and NOWLAN, 1979, p. 18, Pl. 7, figs. 5, 6.

Multielement

cf. Panderodus feulneri Glenister. SWEET, 1979b, p. 64, Fig. 7 (1, 8, 11-14, 17, 18, 22) (includes synonymy); McCRACKEN and BARNES, 1981a, p. 85, Pl. 1, figs. 16-21 (includes synonymy); SWEET, 1983, Pl. 2, figs. 5, 7, 11, 14, 15.

REMARKS

The few elements from Yukon differ from P. feulneri of McCracken and Barnes (1981a) and Sweet (1979b, 1983) in that they are more recurved with the point of curvature being closer to the base. This greater degree of recurvature is found in both small and large forms. The robust character of the small a/b and e elements distinguish them from the equivalent small elements of P. sp. cf. P. gracilis (Branson and Mehl) discussed below.

TYPES: Figured specimens, ADM 20318-20320.

Panderodus? gibber Nowlan and Barnes

Pl. 6, fig. 16

Multielement

Panderodus gibber NOWLAN and BARNES, 1981, p. 16, Pl. 6, figs. 15-19, text-fig. 7H, J.

Panderodus? gibber Nowlan and Barnes. NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 6, figs. 12-20 (Appendix A, herein).

TYPE: Hypotype, ADM 20321.

Panderodus? sp. cf. P. gibber Nowlan and Barnes

Pl. 2, fig. 43

Multielement

cf. Panderodus gibber NOWLAN and BARNES, 1981, p. 85, Pl. 2, figs. 7-10 (includes synonymy; see also P.? gibber, above).

REMARKS

One *a/b* element has the characteristic size and degree of recurvature of the younger *P. gibber*. This specimen differs in that the proximal part of the inner face is markedly striated. These striae are similar in size to the basal wrinkles. The rarity of this form prevents positive species identification.

TYPE: Figured specimen, ADM 20322.

Panderodus gracilis (Branson and Mehl)
Pl. 6, figs. 14, 17

a/b element

Paltodus gracilis BRANSON and MEHL, 1933, p. 108, Pl. 8, figs. 20, 21.

Multielement

Panderodus gracilis (Branson and Mehl). LINDSTROM and ZIEGLER, 1971, Pl. 5, figs. 5, 6, Pl. 6, figs. 1-3; McCRACKEN and BARNES, 1981a, Pl. 1, figs. 3, 4, 7, 8, 11, 12, 15 (only; Pl. 1, figs. 2, 5, 6, 9, 10 = *P. unicostatus* (Branson and Mehl), herein); LENZ and McCRACKEN, 1982, Pl. 2, figs. 2, 5, 12, 15 (only; Pl. 2, figs. 6, 8 = *P.* sp.); NOWLAN and McCRACKEN *in* NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 7, figs. 1-10, 12, 13, 19 (Appendix A, herein; text includes synonymy).

REMARKS

McCracken and Barnes (1981a) were not convinced that the Ordovician P. gracilis and the Silurian P. unicostatus (Branson and Mehl) species were distinguishable. They (1981a) noted some differences but suggested that these reflected environmental conditions and thus were intraspecific rather than interspecific differences. I still agree in principle with these authors but since the two species are entrenched in the literature as "systemic species", I will not add to the confusion. They must however, be convincingly re-diagnosed.

Uyeno and Barnes (1983) included the Ordovician P. serratus Rexroad s.f. of McCracken and Barnes (1981a) in the reconstruction of their Silurian P. unicostatus. It is reasonable to suggest that rare serrated elements are part of multielement species of Panderodus but, if so, the figured element of P. serratus s.f., sensu McCracken and Barnes (1981a) should be equated with the Ordovician P. gracilis, not the Silurian P. unicostatus.

TYPES: Hypotypes, ADM 20323, 20324.

Panderodus sp. cf. P. gracilis (Branson and Mehl)
Pl. 2, figs. 38, 40-42

a/b element

cf. Paltodus gracilis BRANSON and MEHL, 1933, p. 108, Pl. 8, figs. 20, 21.

TYPES: Figured specimens, ADM 20325-20328.

Panderodus unicostatus (Branson and Mehl)

a/b elements

Paltodus unicostatus BRANSON and MEHL, 1933, p. 42, Pl. 3, fig. 3.

Panderodus unicostatus (Branson and Mehl). LINDSTROM and ZIEGLER, 1971, Pl. 3, figs. 4-6, Pl. 5, fig. 1, Pl. 8, figs. 1-4.

e element

Panderodus simplex (Branson and Mehl). LINDSTROM and ZIEGLER, 1971, PL. 2, figs. 1-3, text-fig. 4.

Multielement

Panderodus gracilis (Branson and Mehl). McCRACKEN and BARNES, 1981a, Pl. 1, figs. 1, 2, 5, 6, 9, 10, (only; Pl. 1, figs. 3, 4, 7, 8, 11, 12, 15 = *P. gracilis* (Branson and Mehl) s.s., herein).

Panderodus unicostatus (Branson and Mehl). HELFRICH, 1978, Pl. 1, figs. 1, 2; ALDRIDGE, DORNING and SIVETER, 1981, Pl. 2.2, figs. 1-3; LEE, 1982, pp. 63-69, Pl. 4, figs. 1-11, 13-15 (includes synonymy); UYENO *in* UYENO and BARNES, 1983, pp. 22, 23, Pl. 9, figs. 17-22 (includes synonymy).

"*Panderodus serratus*" apparatus of Cooper, 1975. MILLER, 1978, Pl. 1, figs. 1-5, 7-9.

REMARKS

The question of conspecificity of *P. gracilis* and *P. unicostatus* is discussed under the former species.

Panderodus? sp. A

Pl. 6, fig. 20

REMARKS

Only a few of these fragmentary elements are present. They are slender and acutely recurved immediately above the base. These features can be found in P. liratus Nowlan and Barnes and P. panderi (Stauffer). However, the elements lack costae, and the panderodont groove and furrow found on the outer face of P. liratus. They also lack the basal heel present on the short-based elements of P. panderi.

TYPE: Figured specimen, ADM 20329.

Genus Paroistodus Lindström, 1971

Type species: Oistodus parallelus Pander, 1856.

Paroistodus? sp. A Nowlan and McCracken

Pl. 6, figs. 10, 15, 22

Multielement

Paroistodus sp. A NOWLAN and McCRACKEN, in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 9, figs. 1-22 (Appendix A, herein; text includes synonymy).

REMARKS

Nowlan, et al. (MS) give a detailed account of this taxon.

TYPES: Figured specimens, ADM 20330-20332.

Genus Periodon Hadding, 1913

Emended Bergström and Sweet, 1966

Type species: P. aculeatus Hadding, 1913.

REMARKS

The a, or periodontiform, element of Periodon has been described as comprising a three-part transition series by Barnes, et al. (1979). Kennedy, et al. (1979) expanded this series by identifying four types of elements. These and the corresponding terms used in the genus diagnosis in Robison (1981) are cordylodontiform (dolabrate), ligonodiniform (bipennate), cladognathiform (tertiopedate), and hibbardelliform (alate) elements, or more simply a-1, a-2, b and c elements. To avoid confusion with the a-2 element, the descriptive term tortiliform (sensu Kennedy, et al.) rather than ligonodiniform of Nowlan (1981a) should be used for the f element.

The two types of a elements are homologous to those found in other Ordovician genera such as Aphelognathus, Gamachignathus and Oulodus (described by McCracken and Barnes, 1981a) In these examples, the a elements differ through a modification (via an anterolateral costa or denticulate process) of the anterior region of the element.

Periodon aculeatus Hadding

Emended Bergström and Sweet, 1966

Pl. 1, figs. 13, 20, 22, 25-28

Pl. 2, figs. 24-27, 31, 34, 35

a-d elements

Periodon aculeatus HADDING, 1913, p. 33, Pl. 1, fig. 14.

Multielement

Periodon aculeatus Hadding. REPETSKI and ETHINGTON, 1977, Pl. 1, figs. 16-18, 20, 22, 24; BERGSTROM, 1978, Pl. 79, figs. 3-5; FAHRAEUS and NOWLAN, 1978, p. 482, Pl. 3, figs. 7-10, 13 (only) text-figs. 5(G-L) (includes synonymy); LOFGREN, 1978, pp. 74, 75, Pl. 10, figs. 1(A-B), Pl. 11, figs. 12-26 (includes synonymy); TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 9, figs. 10, 11, 17; NOWLAN, 1981a, p. 12, Pl. 2, figs. 7-10, Pl. 4, figs. 1-9; NI in ZENG, et al., 1983, Pl. 12, figs. 9-17.

Periodon aculeatus aculeatus Hadding. NICOLL, 1980, Figs. 3(A-G).

cf. Periodon aculeatus? Hadding. NOWLAN and THURLOW, 1984, p. 293, Pl. 1, figs. 12-14, 17, 18.

cf. Periodon sp. cf. aculeatus Hadding. SIMES, 1980, Fig. 5.

cf. Periodon cf. P. aculeatus Hadding. TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 8, figs. 13-15; KENNEDY, BARNES and UYENO, 1979, pp. 544-546, Pl. 1, figs. 1-8, 35.

REMARKS

One small e (falodontiform) element (Pl. 2, fig. 35) from the Peel River section has an incipient denticle on the basal anterior margin. Although of a similar size to the e elements of the Belodella species described herein, it differs in that the geniculation angle is greater, the cusp is wider, and the base is more extended posteriorly. All of these characters are found on larger e elements of Periodon aculeatus. The inner face of the cusp on f and g elements has a median longitudinal costa that is paralleled posteriorly by a few striae.

The e elements from the Rock River section differ slightly from those of the Peel River. They have a more erect proximal anterior margin and the aboral margin is not as curved. Kennedy, et al. (1979) discusses some rare forms that co-occur with P. aculeatus but are indistinguishable from e elements of P. grandis Ethington. The elements from Rock River are more similar to those of P. aculeatus than they are to the younger species. Furthermore, the a-d elements do not have the hindeodellid denticulation found in P. grandis, as noted by Bergström and Sweet (1966) and Kennedy, et al. (ibid.).

TYPES: Hypotypes, ADM 20333-20346.

Genus Phragmodus Branson and Mehl, 1933

Type species: P. primus Branson and Mehl, 1933.

Phragmodus sp.

Pl. 1, fig. 24

REMARKS

The single e (oistodontiform) element is comparable to the e element of Phragmodus. The corroded nature makes it difficult to assign a trivial name. The nearly erect cusp is suggestive of P. undatus Branson and Mehl or P. inflexus (Stauffer).

TYPE: Figured specimen, ADM 20602.

Genus Plectodina Stauffer, 1935

Type species: Prioniodus aculeatus Stauffer, 1930.

Plectodina florida Sweet

Pl. 7, fig. 32

Multielement

Plectodina florida SWEET, 1979b, pp. 65, 66, Figs. 8(18, 19, 22-26); NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 10, figs. 16, 19-22 (Appendix A, herein; text includes synonymy).

TYPE: Hypotype, ADM 20346.

Plectodina tenuis (Branson and Mehl)

Pl. 7, figs. 26, 29, 34

q element

Ozarkodina tenuis BRANSON and MEHL, 1933, p. 128, Pl. 10, figs. 19-21, 23.

Multielement

Plectodina tenuis (Branson and Mehl). LENZ and McCRACKEN, 1982, Pl. 1, figs. 9, 10; NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 11, figs. 1-8, 10-12, 14, 15 (Appenidix A, herein; text includes synonymy).

TYPES: Hypotypes, ADM 20598-20600.

Plectodina? sp. A

Pl. 1, figs. 17, 21

REMARKS

Two fragmentary elements are suggestive of a Plectodina species. One of these broken elements is either a cyrtoniodontiform (e) or prioniodiniform (f) element. The blade is probably an ozarkodiniform (g) element.

TYPES: Figured specimens, ADM 20347, 20348.

Genus Polonodus Dzik, 1976

Type species: Ambalodus clivosus Viira, 1974.

Polonodus? sp. A

Pl. 1, fig. 18

DESCRIPTION

Single, incomplete platform has three preserved processes: longest has short denticles that are slightly recurved towards junction of this and two short lateral processes. Cusp is not identifiable, presumably due to fragmentary nature of element but longest process is regarded as anterior. Lateral processes diverge towards anterior. Inner and anterior processes near junction are slightly flexed towards inner side; processes are slightly arched. Ornamentation consists of sharp, concentric ridges with concave upper surfaces and raised edges, and radial rows of short denticles. Denticles are on anterior margin of ridges and are connected with each other by a single sharp costa. Costae and raised edge of concentric ridges merge with denticles. Ornamentation is most distinct on distal part of anterior process. Entire element is basally excavated.

REMARKS

This element is questionably assigned to Polonodus since it lacks (probably due to preservation) the fourth or posterior process. The ornamentation of this element is identical to that of the amorphognathodontiform element of P. clivosus (Viira) as figured by Dzik (1976). The element differs in that the lateral processes diverge anteriorly, not posteriorly. The long process of the Yukon element is also much longer than any process on the ambalodontiform element of P. clivosus.

Polonodus? sp. A Löfgren is much more arched, and has two narrow processes, one of which is anterior. It also has a high main denticle row on the anterior process. Polonodus? sp. B Löfgren differs in that the divergence of the processes is greater. One of the elements of Löfgren (1978, Pl. 16, fig. 8) is similar in that the long processes are laterally flexed.

Polonodus species are known from middle to late Kundan strata (early to middle Llanvirn) in Estonia (Viira, 1967, 1974; Dzik, 1976), middle Kundan in Sweden (Löfgren, 1978), and the Whiterockian (latest Arenig-early Llanvirn) of Newfoundland (Fahraeus, 1970; Nowlan and Thurlow, 1984) and Nevada (Harris, *et al*. 1979).

TYPE: Figured specimen, ADM 20349.

Genus *Prioniodus* (*Oepikodus*) Lindström, 1955
Emended Repetski, 1982

Type species: *Oepikodus smithensis* Lindström, 1955 (cf. Repetski, 1982 for discussion of the type species).

Prioniodus (*Oepikodus*)? sp. A
Pl. 1, fig. 5

REMARKS

The unbowed gothodontiform element of this study has a broken anterior process. The divergence angle of the anterolateral and posterior processes is about 60 degrees. The posterior process lacks the hindeodellid pattern of denticulation and instead has discrete and slightly reclined denticles. The cusp has a sharp costa that continues onto the base as a well developed adenticulate lateral process. Striae are prominent on the cusp posterior to the costae. These extend to the proximal part of the base and beneath the proximal denticles. Faint oblique striae occur on the anterior margin of the element.

The single gothodontiform element is questionably assigned to *Prioniodus* (*Oepikodus*) because of the similarity to *P*. (*O*.) *communis* (Ethington and Clark). It has a similar erect cusp, prominent lateral process and posterior process denticulation (cf. Repetski, 1982, Pl. 11, figs. 5 b, c).

This element can also be compared to elements of two subspecies of Prioniodus (Baltoniodus). P. (B.) prevariabilis medius Dzik and P. (B.) p. norrlandicus Lőfgren have a denticulated anterior process but since this study's element has a broken anterior process, this character cannot be used for comparison. The angle of process-divergence is within the range of P. (B.) p. norrlandicus. The a-2 (gothodontiform) elements of these two subspecies and the Yukon element lack hindeodellid denticulation on the posterior process but there are differences in denticulation. The attitude of the cusp is more like the nearly erect cusp in P. (B.) p. norrlandicus and less like the proclined cusp in P. (B.) p. medius. The a-2 element of P. (B.) p. medius is slightly bowed to the inner side, unlike the element of this study and that of P. (B.) p. norrlandicus. The lateral process is strong and free as in P. (B.) p. norrlandicus and older examples P. (B.) p. medius.

Micro-ornamentation for several taxa of the subgenus P. (Baltoniodus) was described by Lőfgren (1978). On the cusp of all elements, longitudinal striae intertwine forming a rope-like pattern. On the a-2 element, the pattern is restricted to the posterior part of the cusp, while thinner striae occur anterior to the costa. The anterior striae on the element of this study are fainter than in P. (O.) evae and coarser but fainter than in P. (B.) P. norrlandicus.

A similar pattern of striae also occurs in P. (Oepikodus) evae Lindström (Bergström and Cooper, 1973, fig. 4D), P. (P.) elegans Pander (Löfgren, 1978, Pl. 9, fig. 1A) and Gamachignathus ensifer McCracken, Nowlan and Barnes (1980, Pl. 10.1, fig. 14; Pl. 10.2, fig. 14). This pattern, as Löfgren (1978) noted, is not exclusive nor diagnostic of Prioniodontidae. It may be a functional development rather than an evolutionary development. Striae of this type have also been reported in both ramiform (e.g. Hindeodella in Jeppsson, 1974, Pl. 6, figs. 2D, 3D, E; Pl. 7, figs. 10D; Pl. 8, figs. 1, 2A-C) and coniform genera (e.g. Scolopodus, in Löfgren, 1978, Pl. 7, figs. 1A, F).

P. (O.) communis has been found in strata containing Fauna E of Ethington and Clark (1971) and Fauna 1 of Sweet, et al. (1971) by Repetski (1982). P. (B.) p. medius has a reported range of early to middle Llanvirn; P. (B.) p. norrlandicus is late Arenig (Löfgren, 1978).

TYPE: Figured specimen, ADM 20350.

Genus Protopanderodus Lindström, 1971

Type species: Acontiodus rectus Lindström, 1955.

REMARKS

There has been some confusion in the interpretation and the recognition of species of Drepanodus and Protopanderodus and thus a short review of these genera is necessary.

Drepanodus consists of drepanodontiform and pipaform elements. Some authors have further included costate elements. Lindström (1971, p. 41) noted that the cusp of some elements may be costate as in D. robustus Hadding s.f. However, this species was regarded as a species of Protopanderodus by Löfgren (1978), an interpretation that is followed herein. Landing (1976) and Löfgren (1978) have included costate elements in the multielement D. arcuatus Pander, the genotype of Drepanodus.

Protopanderodus was defined to comprise form species of Acontiodus s.f. and Scandodus s.f. Löfgren (1978) expanded this definition to include a symmetry series of costate acontiodontiform elements and acostate to rarely unicostate scandodontiform elements. The asymmetrical acontiodontiform elements of Löfgren's (1978) species of Protopanderodus are very similar in outline to the pipaform elements of Drepanodus.

Lindström's (1970, 1971) suprageneric classification implied that Drepanodus and Protopanderodus were more closely allied to Paroistodus (sensu stricto) and Panderodus, respectively, than to each other. The characteristic feature of Protopanderodus and its relatives is the symmetry series; it is absent in Drepanodus and related genera (Lindström, 1970). Robison (1981) revised this classification with both Drepanodus and Protopanderodus being within a family that includes some genera with, some without, symmetry-transition elements. The interpretations

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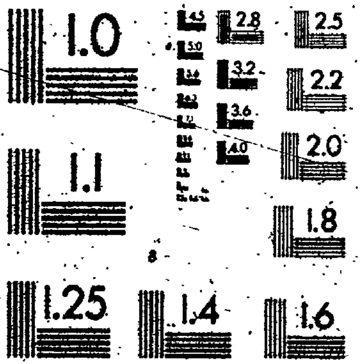

by Barnes, *et al*. (1979) follow Lindström's (1970, 1971) view that the apparatus of *Drepanodus* is fundamentally different from that of *Protopanderodus* (Type III: *q*,*r* versus Type IV: *a*,*b*,*c*).

The acontiodontiform element in *P. insculptus* (Branson and Mehl) that has a posterior denticle is regarded herein as an *a* element. The acostate acontiodontiform element of the *P.* sp. A of this study represents the *a* position. Other species of *Protopanderodus* may have an equivalent element masked in the subtle variations found in the acontiodontiform elements.

The scandodontiform elements are more laterally twisted compared to the acontiodontiform elements. This suggests that it is not part of the first transition series but rather part of the second (i.e. the *e* element).

Multicostate forms with a short base, referred to as *Scolopodus giganteus* Sweet and Bergström s.f., are long ranging and probably are part of different species of *Protopanderodus* (cf. *P. liripipus* Kennedy, *et al*., *P.* sp. aff. *P. varicostatus* (Sweet and Bergström), herein). The position of "gigantiform" elements within an apparatus is not clear.

Costae are of lesser significance in the interpretation of the *Drepanodus* apparatus used herein. Instead, the apparatus of *Drepanodus* is based on the degree of cusp inclination and thus includes *p* and *q* (drepanodontiform and pipaform respectively) elements. In this regard, *Drepanodus* has closer affinities to *Drepanoistodus* than to *Protopanderodus*. The elements of *Drepanodus* may be further differentiated following van Wamel's (1974) example.

In this study, the pipaform element of *Drepanodus* is not considered homologous to the scandodontiform element of *Protopanderodus*, but rather is compared with the homocurvatiform element of *Drepanoistodus*. Unlike *Drepanoistodus*, *Drepanodus* lacks the *r* or oistodontiform element. No attempt will be made to draw homologies between the other elements of *Drepanodus* and *Protopanderodus*.

The elements used in the reconstruction of *D. arcuatus* by Landing (1976, p. 632) raises some questions concerning its generic affinity. Its apparatus includes asymmetrically acostate to costate "*D.arcuatus*-type", symmetrically costate "*Acontiodus arcuatus*-type" and unicostate asymmetrical acontiodontiform ("pipaform") elements. Clearly, the costate elements in his reconstruction of *D. arcuatus* comprise as much a symmetry transition as do those of *Protopanderodus*. Löfgren (1978) noted the great abundance of costate elements of Landing's work and suggested that this may be an example of geographic variation within the *D. arcuatus* species. The elements of Landing's study, and the similar Yukon elements represent a symmetry transition series and thus should be referred to *Protopanderodus* rather than *Drepanodus*. As interpreted herein, *D. arcuatus*, sensu Löfgren (1978) and Landing (1976) are not conspecific; the latter species should be referred to *Protopanderodus*.

Protopanderodus insculptus (Branson and Mehl)

Pl. 5, figs. 9-14, 17, 19

b-c elements

Phragmodus insculptus BRANSON and MEHL, 1933, p. 124, Pl. 10, figs. 32-34.

Scolopodus insculptus (Branson and Mehl). BERGSTROM and SWEET, 1966, pp. 398-400, Pl. 34, figs. 26, 27, text-fig. 13B; WINDER, 1966, pp. 60, 61, Pl. 9, fig. 21, text-fig. 3(21); SERPAGLI, 1967, pp. 97-99, Pl. 28, figs. 1a-6b.

Scolopus (sic) *insculptus* (Branson and Mehl). BARNES, 1974, Pl. 1, fig. 19.

e element

Acodus sp. cf. *A. dissimilaris* (Branson and Mehl). WINDER, 1966, pp. 51, 52, Pl. 9, fig. 3, text-fig. 3(3).

Phragmodus dissimilaris BRANSON and MEHL, 1933, pp. 123, 124, Pl. 10, fig. 29 (this syntype was designated as lectotype of *Scandodus dissimilaris* and the unfigured syntype was described as an asymmetrical element of *Scolopodus insculptus* s.f. (i.e. *b* element) by Bergström and Sweet, 1966).

Scandodus sp. cf. *S. dissimilaris* (Branson and Mehl). BERGSTROM and SWEET, 1966, pp. 396, 397, Pl. 34, figs. 24, 25.

Scandodus? *dissimilaris* (Branson and Mehl). BERGSTROM and SWEET, 1966, text-fig. 13D.

Multielement

Protopanderodus insculptus (Branson and Mehl). SWEET, THOMPSON and SATTERFIELD, 1975, Pl. 1, figs. 19, 20 (element of fig. 19 has a posterior process denticle, thus the *a* element as defined herein); HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 4, fig. 2 (*a* element); ROSS, NOLAN and HARRIS, 1979, Fig. 6(a-c); AN, 1981, Pl. 3, fig. 28 (*a* element); LENZ and McCRACKEN, 1982, Pl. 1, figs, 14-16, 21.

Protopanderodus? *insculptus* (Branson and Mehl). NI *in* ZENG, *et al*., 1983, Pl. 12, fig. 37 (*a* element).

?*Protopanderodus* n. sp. aff. *P. insculptus* (Branson and Mehl). HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 5, fig. 4.

REMARKS

Two *a* elements that have a posterior denticle are present from Peel River material, one of which is figured in Lenz and McCracken (1982). The *e* elements have a keeled posterior oral margin and prominent inner lateral costae bounding a deep medial groove and thus differ from the same element of *Protopanderodus liripipus* Kennedy, *et al*. One *e* element has longitudinal striae along the inner anterior margin.

TYPES: Hypotypes, ADM 20351-20358.

Protopanderodus liripipus Kennedy, Barnes and Uyeno

Pl. 5, figs. 15, 16, 18, 20-25

Multielement

Protopanderodus liripipus KENNEDY, BARNES and UYENO, 1979, pp. 546-550, Pl. 1, figs. 9-19 (includes synonymy); NI and LI in WANG, et al., 1983, pp. 154, 155, Pl. 8, fig. 11; NI in ZENG, et al., 1983, Pl. 12, fig. 34; NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 11, figs. 18, 20 (Appendix A, herein; text includes synonymy).

Protopanderodus Liripipus (sic) Kennedy, Barnes and Uyeno. AN, 1981, Pl. 3, fig. 29.

REMARKS

An element equivalent to the denticulated a element of Protopanderodus insculptus (Sweet and Bergström is not recognized in P. liripipus. The a element may be masked within the b varieties noted by Kennedy, et al. (1979)..The b element is slightly asymmetrical with weak costae. Small c elements have only one prominent costa on each lateral face.

Acontiodontiform elements of this taxon, P. insculptus and P. varicostatus (Branson and Mehl) are quite similar, and incomplete specimens are indistinguishable. A problem arises due to the slight stratigraphic overlap of P. liripipus with the older P. varicostatus and younger P. insculptus.

Acontiodontiform elements of P. liripipus differ from those of P. insculptus in that the latter have a denticle on the base, a feature that is unfortunately not always preserved. Some elements of P. liripipus have long, pointed bases, others have short bases that are not keeled. These features are not seen in P. insculptus, which has elements possessing posterior basal keels. The antero-aboral notch on most elements of P. insculptus is fully developed compared to that in P. liripipus. These characters are used herein to distinguish these elements of P. liripipus and P. insculptus in samples where the species co-occur.

Some acontiodontiform elements of P. aff. P. varicostatus (herein) have bases that are short and not keeled like those found in P. liripipus. The antero-aboral notch on these elements is not strong. The weak notch on the short-based elements and the posterior keel on the long-based elements are used to differentiate P. aff. P. varicostatus from P. liripipus.

The e or scandodontiform element of both species are different. The groove on the inner lateral face of the e element of P. liripipus (Pl. 5, fig. 25) is near the anterior and is bounded by rounded margins. On the e element of P. insculptus (Pl. 5, fig. 13), this groove is more medial and has sharp, costate edges.

Included within P. liripipus is an element referred to as "gigantiform" (Pl. 5, fig. 16; cf. generic discussion, above).

Zeng, et al. (1983, p. 43) report P. cf. P. liripipus from the P.? insculptus Zone of the eastern Yangtze gorges region of China. Both P. liripipus and P. insculptus co-occur in Yukon samples.

TYPES: Hypotypes, ADM 20359-20367.

Protopanderodus parvibasis Löfgren

Pl. 3, figs. 25, 26, 28, 29

Multielement

Protopanderodus parvibasis LOFGREN, 1978, p. 93, Pl. 3, figs. 11-18, text-figs. 31(D-F).

REMARKS.

The b and c elements of P. parvibasis resemble those of P. rectus (Lindström) and P. robustus (Hadding). The e element is diagnostic of this species.

The c element (Pl. 3, figs. 25, 26) differs from that of P. robustus in that it has a more shallow basal cavity, a shorter oral margin and is more laterally compressed. The two small c elements herein are referred to P. parvibasis because of their short base. They differ from those of P. parvibasis illustrated by Löfgren (1978) in that their cusps are erect rather than slightly recurved.

The single laterally compressed e element (Pl. 3, figs. 28, 29) has a short base and a slight expansion of the basal cavity on the inner anterior side. The median carina and groove on the cusp's inner face described by Löfgren (1978) was not noted on this specimen. In other respects, the e element of this study is similar to that of Löfgren (1978) and is most similar to one of four illustrated by her (ibid., Pl. 3, fig. 16).

Löfgren (1978) reported that the range of this species may be from middle Kundan to earliest Aserian (early Llanvirn) in Sweden, and possibly in Estonia (Viira, 1974). The present study is the first report of P. parvibasis occurring outside of Europe.

TYPES: Hypotypes, ADM 20368-20370.

Protopanderodus robustus (Hadding)

Pl. 3, figs. 1-10

a-b elements

Acontiodus robustus (Hadding). LANDING, 1976, pp. 629, 630, Pl. 1, fig. 8.

Drepanodus robustus HADDING, 1913, p. 31, Pl. 1, fig. 5.

c element

?Acontiodus cooperi SWEET and BERGSTROM, 1962, pp. 1221, 1222, Pl. 168, figs. 2, 3, text-fig. 1G.

e element

Scandodus sp. SWEET and BERGSTROM, 1962, p. 1246, Pl. 168, figs. 13, 16.

Multielement

Protopanderodus cooperi (Sweet and Bergström). BARNES and POPLAWSKI, 1973, p. 782, Pl. 4, figs. 8, 15 (only; = b, c elements; Pl. 3, figs. 1, 4, 5 = e elements of P. sp. A, herein); non LANDING, 1976, pp. 638, 639, Pl. 4, fig. 6 (= a? or b element of P. gradatus (Serpagli) or

P. strigatus Barnes and Poplawski), fig. 7 (= e element of P. sp. A, herein).

Protopanderodus reclinatus (Lindström). BARNES and POPLAWSKI, 1973, pp. 782, 784, Pl. 3, fig. 3 (only; fig. 2 = e element of P. sp. A, herein).

Protopanderodus robustus (Hadding). LOFGREN, 1978, pp. 94, 95, Pl. 3, figs. 32-35, text-figs. 31(G-J), (includes synonymy); NOWLAN and THURLOW, 1984, p. 293, Pl. 2, figs. 7, 13, 14.

REMARKS

Löfgren (1978, p. 95) noted that the younger Protopanderodus robustus and the older P. rectus (Lindström) were morphologically very similar and that the asymmetrical acontiodontiform (b) elements were virtually indistinguishable.

The lateral costa of the b element (Pl. 3, figs. 2, 4) is more medial than that of the c element. The inner face has a narrow carina that is strongest in the proximal region of the cusp and the base. The b element of P. parvibasis Löfgren is similar to this element of P. robustus. The b element of P. robustus differs in that the oral margin is usually longer, the base is wider and commonly square, and the cusp is broader (Löfgren, 1978). On the b element illustrated herein, the oral margin differs little from that of Löfgren's figured specimens of P. parvibasis or P. robustus.

The base of the Yukon *b* element is not laterally compressed and the cusp is relatively broad. These features suggest assignment to *P. robustus*. *P. robustus* sensu Löfgren (1978, text-fig. 31J) has a *b* element with a base that is rectangular in profile, with a straight aboral margin. The elements of Löfgren's plate figures (*ibid*., Pl. 3, figs. 32, 34) and the *b* elements of Yukon have a convex aboral margin and a slight antero-aboral hook. Since this hook is moderately developed on the *b* elements of *P. robustus* but poorly developed in *P. parvibasis*, I use this hook as a further distinguishing character.

The *c* elements in both *P. rectus* and *P. robustus* have an indentation or hook on the antero-aboral margin and strong lateral costae that extend from the tip of the cusp to the basal margin. The *c* element of *P. robustus* differs from that of *P. rectus* in that it has a slightly longer base and a cusp that is slightly more recurved. Also, in long-based elements (Pl. 3, fig. 6), the anterior margin from the antero-aboral corner to the level of recurvature is longer and straighter than in the equivalent element of *P. rectus*. Other elements (Pl. 3, fig. 1) have a shorter base but maintain a straight anterior margin.

Löfgren illustrates (1978, text-fig. 31G) a *c* element of *P. robustus* that lacks the antero-aboral hook. All of the *c* elements of this study have this hook. Her element is similar to elements placed herein with *P.* sp. A. except that the costae extend to the aboral margin.

Löfgren (1978, p. 94) recognized the similarity between the symmetrical elements of *P. robustus* and *Acontiodus cooperi* s.f. but noted that the posterior keel of *A. cooperi* s.f. is fluted. I concur with this observation but the association of this form species and *A. robustus* s.f. in Sweet and Bergström (1962) and their morphological similarities tentatively suggests the inclusion of *A. cooperi* s.f. within the synonymy of *P. robustus*.

The *e* element of *P. robustus* (Pl. 3, figs. 3, 5, 7-10) has a base that is longer than that of the same element of *P. rectus*. The length of the base of *Scandodus* sp. s.f. is variable (Sweet and Bergström, 1962). The *e* elements of this present study and Löfgren's have bases that are within this range.

Löfgren (1978, p. 52) suggested that the *A. robustus* of Landing (1976) could be associated with his *Drepanodus arcuatus* (Pander). I disagree, and instead, equate his *D. arcuatus* and *A. robustus* s.f. with *P.* sp. A and *P. robustus*, respectively. *A. robustus*, sensu Landing (*ibid.*) is included within *P. robustus* because its lateral costae are basally strong compared to the basally weak costae of the *c* elements of *P.* sp. A (cf. *A. robustus* s.f. of Bradshaw, 1969).

The element of Barnes and Poplawski (1973, Pl. 3, fig. 3) called *P. reclinatus* (Lindström) is similar to the symmetrical acontiodontiform elements figured by Löfgren (1978, Pl. 3, fig. 32) and herein (Pl. 3, fig. 6). Landing

(1976) included the other illustrated element of *P. reclinatus*, sensu Barnes and Poplawski (1973, Pl. 3, fig. 2) within his *P. cooperi*. Both this element of Barnes and Poplawski and one element of Landing's *P. cooperi* (*ibid.*, Pl. 4, fig. 7) are regarded herein as *e* elements of *P.* sp. A (cf. synonymy for *P. robustus* and *P.* sp. A).

Löfgren (1978) found this species in early Llanvirn and younger strata of Sweden. She also reported that its range could extend to the late Llandeilo, and possibly into the Caradoc. *A. cooperi* s.f. was defined from upper Llandeilo strata in Alabama. *P. cooperi*, sensu Barnes and Poplawski is from the lower Llanvirn of Québec.

TYPES: Hypotypes, ADM 20371-20377.

Protopanderodus varicostatus (Sweet and Bergström)

b-c elements

Scolopodus varicostatus SWEET and BERGSTROM, 1962, p. 1247, Pl. 168, figs. 4-9, text-figs. 1A, C, K; BERGSTROM and SWEET, 1966, text-fig. 13A.

e element

Scandodus unistriatus SWEET and BERGSTROM, 1962, p. 1245, Pl. 168, fig. 12, text-fig. 1E; BERGSTROM and SWEET, 1966, text-fig. 13C; non HAMAR, 1966, p. 74, Pl. 3, figs. 1, 7 (= *P. liripipus* Kennedy, *et al.*, 1979).

Multielement

Protopanderodus varicostatus (Sweet and Bergström).

LINDSTROM and ZIEGLER, 1971, Pl. 7, figs. 3-6;

BERGSTROM, RIVA and KAY, 1974, Pl. 1, figs. 9, 10; GASTILE and MILLER, 1981, Fig. 2(J, K).

Protopanderodus varicostatus (Sweet and Bergström)?. NOWLAN, 1981a, p. 15, Pl. 1, fig. 5, Pl. 3, fig. 15 (includes synonymy); NOWLAN and THURLOW, 1984, p. 293, 294, Pl. 2, figs. 1-3, 8.

Protoprioniodus varicostatus (Sweet and Bergström) (sic). BERGSTROM, 1978, Pl. 79, fig. 6.

REMARKS

The Peel River collection contains elements that have similarities to Protopanderodus varicostatus s.l. In comparing these elements, I have distinguished three associations, which are discussed herein. P. varicostatus (cf. above synonymy) is restricted to include elements that are similar to the form species illustrated by Sweet and Bergström (1962). The fauna of Sweet and Bergström (1962) occurs in upper Llandeilo strata of Alabama. P. cf. P. varicostatus is based on Löfgren's (1978) upper Arenig species P. cf. varicostatus (below). The third association, P. aff. P. varicostatus is the species found in upper Peel River material (upper Llanvirn).

Protopanderodus sp. cf. P. varicostatus
(Sweet and Bergström) sensu Löfgren

cf. Scolopodus varicostatus SWEET AND BERGSTROM, 1962, p. 1247, Pl. 168, figs. 4-9, text-figs. 1A, C, K.

Multielement

Protopanderodus cf. varicostatus (Sweet and Bergström).

LOFGREN, 1978, pp. 91, 92, Pl. 3, figs. 26-31 (includes synonymy); NI in ZENG, et al., 1983, Pl. 12, figs. 27-29.

REMARKS

This species differs from Protopanderodus varicostatus s.s. in the following characters. The acontiodontiform elements have variably developed antero-aboral corners, which may be angular, rounded or indented. The indentation is never as deep as in the same elements of P. varicostatus. The scandodontiform element is like Scandodus unistriatus Sweet and Bergström s.f. but the groove is more anterior.

Most of Löfgren's (1978) acontiodontiform elements are asymmetrical whereas about 25 percent of the Scolopodus varicostatus s.f. elements reported by Sweet and Bergström (1962) are symmetrical. Both studies contained a similar abundance of elements and thus Löfgren's observation is probably not biased. She found that the absence of symmetrical forms was anomalous, considering the close morphological similarities.

Löfgren (1978) noted that P. gradatus Serpagli, a species with a similar ornamentation from the Arenig of Argentina also has few symmetrical elements and that the scandodontiform elements of both her P. cf. varicostatus and P. gradatus were virtually indistinguishable. She further suggested that their differences are due to geographic, rather than stratigraphic, separation.

The elements illustrated by Bergström, et al. (1974) are included here because of their poorly developed antero-aboral indentation. The differences between P. cf. P. varicostatus and P. aff. P. varicostatus are discussed below.

Löfgren (1978) reported that her species ranged from the late Arenig to late Llanvirn of Sweden. The species of Bergström, et al. (1974) occurs within the Pygodus serrus Zone in Newfoundland.

Protopanderodus sp. aff. P. varicostatus
(Sweet and Bergström)
Pl. 5, figs. 1-8

b-c elements

aff. Scolopodus varicostatus SWEET AND BERGSTROM, 1962, pp. 1248, Pl. 168, figs. 4-9, text-figs. 1(A, C, K).

Multielement

?Protopanderodus varicostatus (Sweet and Bergström).
BERGSTROM, RIVA and KAY, 1974, Pl. 1, figs. 9, 10 (fig.9 = e? element); TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 8, figs. 8, 12 (= e, a-c elements); SIMES, 1980, Fig. 6.

REMARKS

The nature of the antero-aboral margin of the acontiodontiform (b-c) elements is similar to that illustrated by Löfgren (1978). This margin lacks the deep indentation as found in *Protopanderodus varicostatus* and may be rounded (Pl. 5, figs. 1, 26), as in the *b* elements, or angular (Pl. 5, fig. 3), as in the *c* elements. In the latter form, an anterior keel is strongly developed. A similar variation is found in *P.* cf. *P. varicostatus* sensu Löfgren. In this taxon, these elements have at least two costae on both lateral faces. This differs from Löfgren's species; most of her elements are bicostate on one side and unicostate on the other. In respect to the number of costae, the *b*-*c* elements compare with those of *P. insculptus* (Branson and Mehl) and *P. liripipus* Kennedy, *et al.* but it lacks the flange-like keel on the posterior margin of the base found in *P. insculptus* and the extended and tapered base found in *P. liripipus*.

The cusp cross-section of the *e* element of *P.* sp. aff. *P. varicostatus* differs from the equivalent elements of *P. liripipus*, *P.* cf. *P. varicostatus* (sensu Löfgren, 1978) and *P. varicostatus* s.s. In these species, the cusp of the *e* element has an inner face with a longitudinal groove; the outer face is acostate. The *e* element of *P.* cf. *P. varicostatus* differs from the same element of *P. varicostatus* in that the groove on the inner face is more anteriorly situated. The outer face of *S. unistriatus* s.f. was further described by Sweet and Bergström (1962) as having a broad longitudinal median carina. The *e* elements in the species of Löfgren, and Kennedy, *et al.* have an outer face that is smoothly convex.

The e element of the Peel River species has a well developed costa that is posterior to the groove on the inner lateral face (Pl. 5, fig. 7). This may be homologous to a weakly developed feature visible on the illustrated holotype of S. unistriatus s.f. (Sweet and Bergström, 1962, Pl. 168, fig. 12). It is the outer face that is the most diagnostic for this element of P. aff. P. varicostatus. The outer face has a prominent median costa and a planar face between this costa and the sharp anterior margin (Pl. 5, fig. 8). The antero-aboral margin of this element is more angular than that of the e element of P. cf. P. varicostatus.

The outer face of the slightly reclined short-based "gigantiform" element (Pl. 5, figs. 4, 5) has a posterolateral costa, and the planar face between this costa and the sharp anterior margin is bisected by a narrow longitudinal groove. The inner lateral face has a median groove and an anterolateral costa on the cusp. This element may be homologous to the element referred to as Scolopodus giganteus Sweet and Bergström s.f. found in other apparatuses.

TYPES: Figured specimens, ADM 20378-20384.

Protopanderodus sp. A

Pl. 3, figs. 11-24, 27

a element

?Scandodus dubius BRADSHAW, 1969, p. 1161, Pl. 134, figs. 19-21.

b element

?Scandodus cf. S. pipa Lindström. BRADSHAW, 1969, p. 1161, Pl. 135, figs. 3, 4.

c element

Acontiodus robustus (Hadding). BRADSHAW, 1969, p. 1148, Pl. 131, figs. 8, 10, 13, 14.

e element

?Distacodus sp. BRADSHAW, 1969, p. 1149, Pl. 131, figs. 3, 4.

Multielement

?Drepanodus arcuatus Pander. LANDING, 1976, p. 632, Pl. 1, figs. 16?, 17-19, 21-23 (= ?,a,c,a,b,b,b elements).

?Drepanodus cf. arcuatus Pander. LOFGREN, 1978, Pl. 2, fig. 2 (e element).

?Drepanoistodus sp. B. TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 8, fig. 17 (?b element).

Protopanderodus arcuatus (Lindström). TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 8, fig. 11 (c element).

Protopanderodus cooperi (Sweet and Bergström). LANDING, 1976, pp. 638, 639, Pl. 4, fig. 7 (only; = e element; fig. 6 = a? or b element of P. gradatus (Serpagli) or P. strigatus Barnes and Poplawski).

Protopanderodus reclinatus (Lindström). BARNES and POPLAWSKI, 1973, pp. 782, 784, Pl. 3, fig. 2 (only; = e element; fig. 3 = P. robustus (Hadding) herein).

non Drepanodus arcuatus Pander. LOFGREN, 1978, pp. 51-53, Pl. 2, figs. 1-8.

REMARKS

This species contains acostate elements and a symmetry transition series of costate elements. The transition series is based on the number and position of costae. A fused cluster of elements is used to associate the c and e elements as part of the same apparatus.

The a (scandodontiform) element is not found in Yukon material but is interpreted to be similar to an element of Drepanodus arcuatus which was illustrated by Landing (1976, Pl. 1, fig. 17). His element has a long, laterally twisted and nearly erect cusp with sharp anterior and posterior edges. The outer (anterolateral) face of the cusp is convex, the inner (posterolateral) face is narrowly carinate.

The b (asymmetrical acontiodontiform) element has sharp anterior and posterior cusp margins. It is similar in outline to S. pipa s.f. but differs in that one cusp face has a posterior costa (Pl. 3, fig. 11). The other face is carinate, as in S. pipa s.f. (Pl. 3, figs. 14, 18). S. cf. Scolopodus pipa of Bradshaw (1969) is similar to the b element in that it has a costa on the outer posterolateral margin and its other face is carinate. Drepanoistodus sp. B of Tipnis, et al. (1978) has a similar outline but no comment can be made concerning its cusp ornamentation because the type material is not readily available.

The c (symmetrical acontiodontiform) element (Pl. 3, figs. 12, 13, 19, 20, 24) is bicostate, strongly recurved and has a long base. The cusp is more recurved and the costae are not as strong basally as in the c element of Protopanderodus robustus (Hadding). The posterior margin of the cusp and proximal region of the base is strongly keeled. The posterior basal margin lacks the indentation found on this element of P. robustus. Acontiodus robustus s.f. sensu Bradshaw (1969) and A. arcuatus Lindström s.f. are similar in that they also have basally weak costae and no basal indentation.

The markedly asymmetrical scandodontiform (e) element (Pl. 3, figs. 15, 21, 22, 27) corresponds closely to the Drepanodus cf. D. arcuatus Lindström s.f. described by Löfgren (1978, Pl. 2, fig. 2). This element has a short base that is strongly flexed to the inner side and has an anteriorly arched outer aboral margin. Its cusp has a faint costa on the outer posterior face. Distacodus sp. s.f. of Bradshaw (1969) has this same arched margin but differs in that both faces of the cusp are costate. The anterior edge of the base is keeled and flexed inward.

One element of P. cooperi sensu Landing (1976) and P. reclinatus sensu Barnes and Poplawski (1973) are herein regarded as e elements of P. sp. A.

The fused cluster (Pl. 3, figs. 16, 17, 22, 23, 27) is composed of two c elements on the obverse side and one e element on the reverse side. Fragments contained in this cluster include the cusp of two elements and the base of an e element.

TYPES: Figured specimens, ADM 20385-20394.

Protopanderodus sp.

Pl. 5, figs. 26, 27

REMARKS

The few elements are associated with Periodon aculeatus Hadding, Phragmodus sp. and Plectodina? sp. The illustrated multicostate element (Pl. 5, fig. 27) is comparable to elements of Protopanderodus insculptus or P. sp. aff. P. varicostatus (Sweet and Bergström). The other illustrated element is more like acontiodontiform elements of P. liripipus Kennedy, et al.

TYPES: Figured specimens, ADM 20395, 20396.

TYPES: Figured specimens, ADM 20452-20471.

Genus Pseudobelodina Sweet, 1979b

Type species: Belodina kirki Stone and Furnish, 1959.

Pseudobelodina? dispansa (Glenister)

Pl. 7, figs. 6-12, 14

Belodus dispansus GLENISTER, 1957, pp. 729, 730, Pl. 88, figs. 14, 15.

Multielement

Pseudobelodina dispansa (Glenister). LENZ and McCRACKEN, 1982, Pl. 2, figs. 11, 14.

Pseudobelodina? dispansa (Glenister). NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 12, figs. 8-26 (Appendix A, herein; text includes synonymy).

REMARKS

Nowlan, et al. (MS) queried the generic name since their interpretation of the apparatus of this species differs from the generic diagnosis. The same interpretation is followed herein.

TYPES: Hypotypes, ADM 20397-20400.

Pseudobelodina sp. cf. P. quadrata Sweet

Pl. 7, fig. 5

Multielement

cf. Pseudobelodina quadrata SWEET, 1979b, p. 70, Fig. 5(15); NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 14, figs. 7-11 (Appendix A, herein; text includes synonymy).

REMARKS

The single element of P. sp. cf. P. quadrata differs from the type material in that the heel is over half the length of the element and the anterior margin of the base is straight. Elements of both species are characterized by subrectangular denticulation. The element is bowed to the furrowed side and thus is equivalent to the P? element of Sweet (1979b).

TYPES: Figured specimen, ADM 20401.

Pseudobelodina vulgaris vulgaris Sweet

Multielement

Pseudobelodina vulgaris vulgaris SWEET, 1979b, p. 71, fig. 5 (2-4) (includes synonymy); LENZ and McCRACKEN, 1982, Pl. 2, fig. 19; NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 15, figs. 1-12 (Appendix A, herein; text includes synonymy).

TYPES: Hypotypes, GSC

Genus Pseudooneotodus Drygant, 1974

Emended Barrick, 1977

Type species: Oneotodus? beckmanni Bischoff and Sannemann, 1958.

REMARKS

Barrick (1977) emended the genus Pseudooneotodus to include both "squat" elements, and small slender conical elements. He recognized two species, the older (P. amorphognathoides Zone) as P. tricornis Drygant, the younger (Kockelella ranuliformis, and younger zones) as P. bicornis. Only the "squat" forms are recognized from the Yukon material. These two species co-occur in the Chicotte Formation (I. inconstans - P. amorphognathoides zones), Anticosti Island, Québec (Uyeno and Barnes, 1983).

Lower Devonian occurrences of one-denticle forms were thought by Barrick (1977) to represent a third species.

Nowlan, et al. (MS) report the occurrence of two Ordovician species at Avalanche Lake, N.W.T.

Pseudooneotodus bicornis Drygant

Pl. 13, fig. 25

Pseudooneotodus bicornis DRYGANT, 1974, p. 67, Pl. 2, figs. 40-48.

Multielement

?Pseudooneotodus beckmanni bicornis Drygant. JEPPSSON, 1979, p. 231 (no illustrations).

Pseudooneotodus bicornis Drygant. ALDRIDGE, DORNING and SIVETER, 1981, Pl. 2.1, figs. 1, 2; UYENO in UYENO and BARNES, 1983, p. 23, Pl. 3, figs. ?25, ?26, 27, 28 (includes synonymy); MABILLARD and ALDRIDGE, 1985, text-fig. 7e.

?Pseudooneotodus sp. MABILLARD and ALDRIDGE, 1983, Pl. 3, figs. 24-26 (figs. 24 = one denticle form; figs. 25, 26 = form with one denticle that extends into ridge).

REMARKS

Only two elements are known from Yukon material; both are squat forms with two denticles.

TYPE: Hypotype, ADM 20402.

Pseudooneotodus tricornis Drygant

Pl. 13, fig. 24

Pseudooneotodus tricornis DRYGANT, 1974, pp. 67, 68, Pl. 2, figs. 49, 50.

Multielement

Pseudooneotodus tricornis Drygant. UYENO in UYENO and BARNES, 1983, p. 23, Pl. 6, figs. 18-20 (includes synonymy); MABILLARD and ALDRIDGE, 1985, text-fig. 7f.

TYPE: Hypotype, ADM 20403.

Genus Pterospathodus Walliser, 1964

Type species: P. amorphognathoides Walliser, 1964.

REMARKS

The genus Llandoverygnathus is regarded by Klapper and Murphy (1975) and later workers as a junior synonym of Pterospathodus. Cooper (1977b) however, preferred to restrict the latter genus to those taxa that contained (g) elements with distinct lateral processes. In this study, I follow the interpretation of Klapper and Murphy.

Uyeno and Barnes (1983) established a new species of the Silurian genus Pterospathodus that features elements having similarities to those of the Ordovician Gamachignathus. P. posteritenuis Uyeno (in Uyeno and Barnes, 1983) was described as having an apparatus of transition series elements (Sa, Sb-Sa, Sb, Sc-Sb, Sc) and M, Pa and Pb elements. The Sa, Sb-Sa and Sb elements, in Sweet's (1979b, p. 56) terminology are Sa, Sba, Sbb elements. The degree of symmetry or asymmetry in these elements (Uyeno and Barnes, 1983, Pl. 2, figs. 14=Sa, 18=Sba, 16=Sbb elements) is comparable to that of Gamachignathus (McCracken, et al., 1980, Pl. 10.1, figs. 5=*c*, 4=Sba or slightly asymmetrical *b*, 3=Sbb or markedly asymmetrical *b* elements). The Sc-Sb element of *P. posteritenuis* does not have a direct counter-part in Ordovician apparatuses; it may be homologous to the *a*-1 and *a*-2 submorphotypes of genera such as *Gamachignathus* and *Oulodus*.

The symmetry series elements of both *P. posteritenuis* and *Gamachignathus* spp. have long cusps and hindeodellid-type denticulation on the posterior process. The M element of *P. posteritenuis* is falodontiform (comparable to the *e*-2 element of *Gamachignathus*); in other species, such as *P. celloni* (Walliser) it is cyrtoniodontiform (cf. *e*-1 element of *Gamachignathus*). The Pb and Pa elements of *P. posteritenuis* are prioniodontiform and blade-like prioniodontiform elements, as are the *f* and *g* elements of *Gamachignathus*. Most *g* elements of *Gamachignathus* spp. have the lateral process broken, but one illustrated element from Anticosti Island, Québec, has a preserved lateral process that is as long as each of the other two processes (cf. McCracken and Barnes, 1981a, Pl. 5, fig. 27).

P. posteritenuis may be a descendant of the Ordovician *Gamachignathus* species, possibly via the older *P. siluricus* (Pollock, Rexroad and Nicoll) found in the *Icriodella discreta - I. deflecta* Zone by Uyeno and Barnes (1983).

The apparatus of P. posteritenuis differs from the younger species P. amorphognathoides Walliser and P. celloni (Walliser), both sensu Barrick and Klapper (1976, pp. 82, 83) and P. pennatus angulatus (Walliser) of Aldridge and Mohamed (1982). The latter three species have elements of the form genus Neoprioniodus s.f. in both the "S" and e positions. The e element, as mentioned above, can be regarded as cyrtoniodontiform and thus not an unusual element for this position. The "S" element is triangular with a denticulated anticusp and posterior process and an undenticulated lateral costa (cf. Barrick and Klapper, 1976; Aldridge and Mohamed, 1982). This form is markedly different from the symmetry transition elements of P. posteritenuis.

These younger species may have a reduced and different first transition series, or the missing elements may be incorrectly assigned to other species (see generic discussion of Carniodus). Llandoverygnathus sp. (=junior synomym of Pterospathodus) of Aldridge (1979) may represent some of these "missing" elements. If the apparatus of these younger species are complete, and thus different from that of P. posteritenuis, then this species of Uyeno may represent a new, related genus.

In this present study, I will follow the previous reconstructions of P. celloni and P. pennatus s.l. and use the "S" designation to distinguish this type of element from a-c elements discussed under Pterospathodus? Indeterminate

Elements. This latter grouping includes e elements and a-c elements that follow a prioniodid plan, as do those of P. posteritenuis.

The generic name assigned to the Indeterminate Elements is queried since the a-c elements have been regarded as part of Carniodus by previous writers. Other workers may disagree with these proposed reconstructions but I find that a complete apparatus for Carniodus can be formed without using these a-c elements. If so, then the a-c elements could be regarded as part of the apparatuses of Pterospathodus species (see further discussion under Carniodus, above and P.? Indeterminate Elements, below).

The three types of e elements from the sample containing three species of Pterospathodus are included together under P.? Indeterminate Elements since I cannot confidently assign them to specific taxa.

Pterospathodus celloni (Walliser)

Pl. 16, figs. 5-10, 16-19, 26-28, 31, 37

f element

Ozarkodina adiutricis WALLISER, 1964, p. 54, Pl. 4, fig. 14, Pl. 27, figs. 1-10, text-figs. 1a, 7h-1 (non text-fig. 7m; element has a carinate or costate cusp; may be part of P. pennatus angulatus (Walliser), s.l., herein); ?MILLER, 1976, Fig. 8 (18, 19, 33); LIEBE and REXROAD, 1977, Pl. 1, fig. 10.

?Ozarkodina adiutricis? Walliser. MILLER, 1976, Fig. 8 (43).

g element

Spathognathodus celloni WALLISER, 1964, pp. 73, 74, Pl. 4, fig. 13, Pl. 14, figs. 3-16, text-figs. 7b-f; IGO and KOIKE, 1968, p. 18, Pl. 2, figs. 1-4; ?MILLER, 1976, Fig. 8 (26, 27, 31).

"S" element

?*Neoprioniodus costatus costatus* WALLISER, 1964, pp. 48, 49, Pl. 6, fig. 14, Pl. 28, figs. 37-40 (only; Pl. 28, figs. 36, 41 are probably "S" elements of *P. amorphognathoides* Walliser); ALDRIDGE, 1975, Pl. 3, fig. 17.

?*Neoprioniodus costatus pacidentatus* WALLISER, 1964, pp. 48, 49, Pl. 4, fig. 23, Pl. 28, figs. 31-35, text-fig. 6(i-k).

?*Neoprioniodus costatus paucidentatus* Walliser. ALDRIDGE, 1972, pp. 193, 194, Pl. 5, figs. 20, 21.

Multielement

?*Llandoverygnathus* sp. ALDRIDGE, 1979, Pl. 1, figs. 12-15 (= *f*, *b*?, S?, *e* elements, respectively).

Pterospathodus celloni (Walliser). ALDRIDGE and MOHAMED, 1982, Pl. 2, fig. 7; LEE, 1982, pp. 59-63, Pl. 1, figs. 1-12; UYENO *in* UYENO and BARNES, 1983, p. 24, Pl. 5, figs. 17, 28, 20-24 (includes synonymy); MABILLARD and ALDRIDGE, 1985, text-fig. 7a.

?*Pterospathodus celloni* (Walliser)? ALDRIDGE, 1980, Fig.1.

?*Pterospathodus* cf. *P. celloni* (Walliser). NOWLAN, 1983b, Figs. 4(v, x, y).

REMARKS

In Yukon material, co-occurrence of species of Pterospathodus is common, hence it is difficult to identify with confidence the e elements even though differences can be noted. These are grouped together with a, b and c elements under Pterospathodus? Indeterminate Elements.

The f elements (Pl. 16, figs. 16-19, 26-28, 37) assigned to P. celloni lack platform ledges and have two weakly developed, undenticulated and offset lateral lobes (Barrick and Klapper, 1976, p. 83). These lobes, or narrow basal flares, characterize the f element in Yukon material. Walliser (1964) illustrated a fair degree of variability in the length of processes, especially the posterior, on Ozarkodina adiutricis s.f. A similar variability is noted herein (cf. Pl. 16, figs. 17, 27). Elements of Walliser (1964) also show a range in the degree of arching of the processes (cf. ibid., Pl. 27, figs. 1, 9). A similar variation is shown herein (Plate 16, figs. 17, 26, 37). O. adiutricis s.f. of Liebe and Rexroad (1977) has a relatively small angle between the two processes when compared with Walliser's material. Comparisons of the f elements of P. celloni and other species of Pterospathodus are made below.

The g (spathognathodontiform) elements (Pl. 16, figs. 5-10) have more subdued basal flares than do the type material. The anterior process may be either straight or arched downward and from either the point of junction with the posterior process, or at its distal end.

N. costatus costatus s.f. of Aldridge (1975, Pl. 3, fig. 7) differs from the "S" element of P. amorphognathoides Walliser sensu Barrick and Klapper (1976) in that the base of the cusp is wider, and the anterior edge of the cusp and the denticle tips form a straighter line. The "S" element in Barrick and Klapper is like that of Walliser's N. c. costatus s.f. (1964, Pl. 28, figs. 36, 41). Elements assigned by Aldridge (1972) to N. c. paucidentatus s.f. are similar to those of N. c. costatus of Walliser (ibid., Pl. 6, fig. 14, Pl. 28, figs. 37-39) and the "S" element herein (Pl. 16, fig. 31).

Llandoverygnathus sp. Aldridge is tentatively included in the synonymy because the f element is comparable with the same element of P. celloni and because this species greatly outnumbers P. pennatus (Walliser) in the study by Aldridge (1979).

The element of P. celloni? sensu Aldridge (1980) was interpreted as a M (e?) element. It is similar in form to the disarticulated cones of Distomodus cf. D. kentuckyensis Branson and Branson (herein) or some of the simple cone elements of "group c" of Uyeno and Barnes (1983; cf. Pl. 8, figs. 9, 10).

P. cf. P. celloni of Nowlan (1983b) differs slightly in that its f element is not arched. The basal flare on the g element is subdued like that on the Yukon form. Nowlan

(1983b) figured an e or cyrtoniodontiform element of D. kentuckyensis. It has a carinate cusp like the e element assigned to P. celloni, but differs in the orientation of its anticusp.

The g elements of all other species of Pterospathodus studied herein are readily distinguishable from the g element of P. celloni.

TYPES: Hypotypes, ADM 20404-20418.

Pterospathodus pennatus angulatus (Walliser)
Pl. 14, figs. 24, 25; Pl. 15, figs. 16, 18
Pl. 16, figs. 1-4, 21, 25

f element

Ozarkodina adiutricis WALLISER, 1964, p. 54, text-fig. 7m (only; Pl. 4, fig. 14, Pl. 27, figs. 1-10, text-fig. 7h-l are equated to P. celloni (Walliser), herein).

g element

?Neospathognathodus pennatus (Walliser). PICKETT, 1978, Pl. 1, figs. 24, 25 (small illustration; no basal flare on side without lateral process).

Spathognathodus pennatus angulatus WALLISER, 1964, Pl. 14, figs. 19-22, text-fig. 1c.

Multielement

Pterospathodus pennatus (Walliser). MILLER, 1978, Pl. 4, figs. 12, 13? (fig. 13 has a flare on side without lateral process).

Pterospathodus pennatus angulatus (Walliser). ALDRIDGE and MOHAMED, 1982, Pl. 2, figs. 8-11.

REMARKS

The f element (Pl. 16, figs. 21, 25) is ozarkodiniform like that of P. celloni (Walliser) but differs in that the outer lateral face of the base beneath the cusp has a more prominent, downwardly directed flare. A sharp costa is present on this flare and extends toward the tip of the cusp. The f elements of both P. celloni and P. p. angulatus show a similar variation in the relative length of the processes. The strong flare and costa are homologous to the better developed lateral process on the f element of P. p. angulatus. In both f and g elements of P. celloni, these features are subdued or absent.

Most anteroposterior blades of the g (spathognathodontiform) element (Pl. 14, figs. 24, 25; Pl. 5, figs. 16, 18; Pl. 16, figs. 1-4) are straight; only a few elements have one process slightly flexed to one side, whereas the posterior process on most g elements in other species of Pterospathodus are bowed toward the inner side. The cusp and denticles on one process are reclined, thus this is the posterior process. The denticles of the anterior process are erect. Since some elements have an inwardly bowed posterior process, the lateral process is therefore outer and it joins the anteroposterior blade at the cusp.

The angle at which the anteriorly directed lateral process joins the blade in the g element is variable; the process may be either nearly perpendicular or anteriorly oblique to the blade. The form of the distal end of this process may be curved with a concave anterior face, or it may be sinusoidal. The lateral process is rarely bifurcated with a short posterior lobe that has a single denticle (herein, Pl. 16, figs. 3, 4, and Walliser, 1964, Pl. 14, fig. 21). This form may be confused with small g elements of P. amorphognathoides Walliser (Aldridge, 1972, Pl. 3, fig. 18) or P. posteritenuis Uyeno.

The g element of P. pennatus pennatus (Walliser) differs in that it has an strongly flared base on the side without a lateral process, although this feature is not noticeable in all of Walliser's specimens (cf. Walliser, 1964, Pl. 14, figs. 23, 25). The denticles on the posterior process of the g element of P. p. pennatus are longer than in this subspecies. The distal end of the posterior process in P. p. angulatus is directed downward slightly. This does not appear to be a character of the g element of P. p. pennatus.

Some g elements found in association with P. p. procerus (Walliser) have an outer lateral process that meets the anteroposterior blade at right angles. These differ in that this process has platform-like margins rather than being blade-like as in P. p. angulatus.

Other possible elements of this subspecies are found under Pterospathodus? Indeterminate elements.

TYPES: Hypotypes, ADM 20419-20428.

Pterospathodus pennatus procerus (Walliser)

Pl. 14, figs. 33, 34; Pl. 15, figs. 15, 17, 19-21, 24
Pl. 16, figs. 22-24; Pl. 17, figs. 6, 11, 12

g element

Spathognathodus pennatus procerus WALLISER, 1964, p. 80, Pl. 15, figs. 2-8, text-fig. le; IGO and KOIKE, 1968, pp. 18, 19, Pl. 2, figs. 8-11.

Multielement

Llandoverygnathus pennatus (Walliser). ALDRIDGE, 1979, Pl. 1, fig. 11.

Pterospathodus pennatus (Walliser). NOWLAN, 1983b, Fig. 4S (g element).

Pterospathodus pennatus procerus (Walliser). JEPPSSON, 1979, pp. 235-238, Fig. 71(1-8); SAVAGE, POTTER and GILBERT, 1983, Fig. 2(A-F); UYENO in UYENO and BARNES, 1983, p. 24, Pl. 8, figs. 1-3 (= g, g and f elements, respectively; includes synonymy).

DESCRIPTION

The e element (Pl. 17, figs. 6, 11, 12) is cyrtoniodontiform and has a cusp with sharp anterior, posterior and inner lateral edges. Inner face is angular with a relatively well developed process.

The f element (Pl. 16, figs. 22-24) is ozarkodiniform with a long reclined cusp, short posterior and long anterior processes. Element is aborally ached, bowed toward inner side and has about 4-6 and 3-5 denticles on anterior and posterior processes, respectively. Denticles on anterior process are longer and wider than those of other process. Denticles and cusp are laterally compressed. Denticles of anterior process are confluent for part of their length and have triangular tips. Proximal denticle of this process is partly confluent with cusp. Denticles of posterior process are discrete and triangular. Margins of processes have a narrow platform-like ledge that forms thickened basal margin. On outer face opposite cusp is a short triangular and adenticulate process that is directed slightly downward. This process is also platform-like. Other face lacks either a process or basal flare. Basal cavity is small and extends as narrow groove under processes. Thickened basal margins of processes angle toward this groove.

REMARKS

The e element is similar to the type 1 e element described below under Pterospathodus? Indeterminate Elements except that the base of the inner face is more laterally extended.

The f element is characterized by its thickened basal margins and adenticulate lateral process. The f element of P. pennatus angulatus (Walliser) lacks this type of margin and has a downwardly directed basal flare rather than a process. It also has a cusp with an outer lateral costa. The f element illustrated by Uyeno and Barnes (1983, Pl. 8, fig. 3) is more similar to the f element of P. p. angulatus herein. The f element of Savage, et al. (1983) has an even weaker basal flare. The f elements of P. amorphognathoides Walliser (i.e. Ozarkodina gaertneri Walliser s.f.) and P. n. sp. A (herein) are similar. O. gaertneri s.f. has an adenticulate lateral process but most forms have longer processes with more denticles.

The cusp of the f element of P. p. procerus is longer and narrower than in P. amorphognathoides. The f element of P. n. sp. A differs from the same element in P. p. procerus in that it has more denticles, a longer anterior process and a short denticulated lateral process. Some forms of f elements of P. amorphognathoides (e.g. O. neogaertneri Nicoll and Rexroad s.f.) and all f elements of P. n. sp. A have a flared base or short process on the inner side as well as the outer. This is not a feature of this element of P. p. procerus.

The g element (Pl. 14, figs. 33, 34; Pl. 15, figs. 15, 17, 19-21, 24) has well developed platform margins on the posterior and outer lateral processes. This platform margin forms the upper surface of a thickened margin similar to that seen in lateral view of P. amorphognathoides Walliser (1964, Pl. 15, fig. 9) and is comparable with that of the f elements. The posterior process is curved distally toward the inner side. Small g elements included under P. p. procerus have a lateral process that is proximally perpendicular to the anteroposterior plane and distally directed towards the anterior. This feature is suggestive of P. p. angulatus (Walliser) or P. p. pennatus (Walliser) but is retained under this taxon because of the platform-like posterior and lateral processes.

TYPES: Hypotypes, ADM 20429-20442.

Pterospathodus n. sp. A

Pl. 14, fig. 27; Pl. 15, figs. 12-14
Pl. 16, figs. 11, 13-15

DIAGNOSIS

Only f and g elements are recognized; apparatus is probably incomplete. The f element is an arched ozarkodiniform with platform-like anterior, posterior and outer lateral processes. These are denticulate; denticles on anterior and posterior processes form a blade. Cusp is distinct on f element only. Denticles on outer process are low, forming a ridge connected to cusp with a costa. Inner lateral process is short and adenticulate. Lateral processes are directed downward. Outer process is commonly directed towards posterior.

The g element is an unarched platform that has a denticulated anterior, and a posterior and outer bifurcated lateral process. Outer posterolateral process is longer than outer anterolateral. Posterior and outer processes are platform-like; anterior is blade-like. Element lacks an inner lateral process, or has only slight adenticulate flare. Denticles on anterior process form a blade; those of posterior and outer lateral processes are short, peg-like.

DESCRIPTION

The f element (Pl. 16, figs. 11, 13-15) is an arched ozarkodiniform element that has a long anterior process and a shorter posterior process. Direction of bowing of these processes is variable. Both may be bowed to inner side; or if only posterior is bowed to this side, anterior process is either straight or slightly bowed to outer side. Outer lateral process is shorter than posterior process; on most elements outer lateral process is posteriorly directed; on some it is directed slightly to anterior. Lateral process has platform-like margins, and is distally tapered although some elements have a lateral process that has a rounded distal end. Side opposite to lateral process either lacks a process or has a short downwardly directed lobe. This lobe is slightly anterior to lateral process. Element is not arched: only lateral process (and adenticulate lobe) and distal end of posterior process are directed downward.

Anterior and posterior processes of f element have a blade-like ridge of denticles. Cusp is wide, long and is at junction of outer lateral and anteroposterior processes. Denticles and cusp contain white matter, are laterally compressed, slightly reclined, confluent and possess triangular tips. Denticles on distal end of posterior process are short, discrete and triangular. Denticles number about 9 on posterior, 13 on anterior processes. A low ridge of two or three denticles on outer process is connected to anterolateral face of cusp base by a sharp costa. Base is completely inverted and has a narrow groove along each process.

The g element (Pl. 14, fig. 27,; Pl. 15, figs. 12-14) is an unarched platform with a denticulated anterior, posterior and bifurcated outer lateral process. Distal end of posterior process is curved inward and downward slightly; other processes are straight. Listing these processes in increasing length: outer anterolateral, outer posterolateral, posterior, and anterior processes. Posterior and outer processes are platform-like. Anterior process is blade-like except in large elements where there is a narrow platform margin. Inner platform edge of posterior process continues anteriorly past cusp to point opposite outer process. At this point this platform margin is either straight or a short adenticulate lobe.

Denticles on anterior process of g element are relatively long, thin, laterally compressed, confluent for most of their length and with triangular tips. They number about 16; longest denticles are situated about two-thirds length from cusp. Denticles on posterior process are short, peg-like, triangular in profile and confluent only at their bases; about 9 in number. Denticles on lateral processes are like those of posterior; anterolateral process has about 4, posterolateral about 7 denticles. Both rows intersect near cusp; denticles at intersection are immediately adjacent to antero-posterior plane. Cusp is indistinguishable (presumably it is at junction of processes). Aboral surface is a shallow excavation under platform processes and is narrowly excavated under anterior process. White matter is present in denticles.

REMARKS

Symmetry transition ("S" or a-c) and e elements have not been recognized. An e element of P.? Indeterminate Elements may be part of this new species.

The f element is similar to Ozarkodina gaertneri Walliser s.f., the f element of P. amorphognathoides Walliser. Both elements have anterior and posterior platforms with blade-like denticle rows and a prominent cusp. The f element of P. n. sp. A differ in that the denticles are more numerous, processes are longer, and the lateral process is denticulated, longer and less downwardly directed.

The f element also differs from that of Astropentagnathus irregularis Mostler. The f element of A. irregularis has a longer lateral process that is perpendicular, not oblique, to the anteroposterior plane.

The *g* element is similar to the same element of *P. amorphognathoides*. The distinguishing characters are: the outer anterolateral process in *P.* n. sp. A is shorter than the posterolateral process, whereas in *P. amorphognathoides*, these lengths are reversed; and the anterior process in *P.* n. sp. A is more blade-like even in large specimens, while in *P. amorphognathoides* it is blade-like only in small specimens.

The *g* element of *P.* n. sp. A is also similar to the *g* element of *A. irregularis*. Both have long outer posterolateral and short anterolateral processes. They differ in that the *g* element of *P.* n. sp. A lacks a well-developed inner lateral process and is not arched.

TYPES: Figured specimens, ADM 20443-2050.

Pterospathodus? Indeterminate Elements

Pl. 16, figs. 20, 29, 30, 32-36, 38-40

Pl. 17, figs. 1-3, 5, 7-10, 13, 14

DESCRIPTION

The *a* element (Pl. 17, figs. 1, 3, 10) is gothodontiform with a relatively long anticusp and hindeodellid-type denticulation on posterior process. Cusp is long with sharp anterior and posterior edges. Cusp and denticles are slightly compressed laterally. Outer face of base has short, downwardly directed adenticulate "process"; inner face is slightly concave. Base at and below level of denticles is smooth and weakly carniodontiform.

The b (Pl. 17, figs. 2, 8, 9, 13, 14) and c (Pl. 17, fig. 7) elements (type 1) are keislognathiform and hibbardelliform, respectively. Cusp has a rounded anterior face and a sharp to costate posterior face. Each lateral face of cusp has a costa that extends to lateral processes. Proximal denticle on each process is long and close to edge of cusp. Other denticles are smaller. Denticles of posterior process are triangular, partially confluent and are relatively large proximally and become smaller towards distal end. Cusp and denticles have faint longitudinal striae; base is smooth. Asymmetry of b element is due to position of lateral process and number and size of denticles on lateral processes. The b and c elements, type 2 are like those of type 1 except that denticulation on posterior process is distinctly hindeodellid.

Three forms of e (cyrtoniodontiform) elements are: type 1 (Pl. 16, figs. 30, 33, 40) -- base has an angular inner face with a sharp edge that extends to tip of cusp as a costa; denticles on posterior process are laterally compressed, short, discrete and triangular; cusp and denticles have fine longitudinal striae that do not extend onto base; Type 2 (Pl. 16, fig. 34; Pl. 17, fig. 5) -- has a distinct rounded carina on inner face of base and cusp; striae are more faint than on type 1 but otherwise both types are similar; Type 3 (Pl. 16, fig. 36) -- has a faint to nonexistent carina on inner face. In other respects, element is similar to types 1 and 2. The fragmentary e-2 element is discussed below.

The d? element (Pl. 16, figs. 20, 29) has four denticulated processes and a long straight cusp that is triangular in cross section. Cusp has a sharp and erect posterior margin; a sharp anterior margin bifurcates at one-third length from tip and continues towards base as a sharp edge of anterior and inner? anterolateral processes. These processes are directed downward slightly. Sharp outer? anterolateral edge of cusp extends basally to end of another process. This process is only slightly directed aborally and towards anterior.

Posterior process of the d? element is broken but has at least one denticle. Denticulation on other processes is subdued; denticles are small and triangular. Faces of element between anterior and outer? and inner? anterolateral processes are gently and angularly concave, respectively. All faces of cusp have well developed fine longitudinal striae that do not extend onto bases of processes. Aboral margin of element is not flared.

The triangular element (Pl. 16, figs. 35, 38, 39) has a long wide and straight cusp and a posterior and two shorter anterolaterally directed processes, all of which are denticulated. Posterior process is slightly twisted and bowed to inner side. Anterolateral processes diverge subsymmetrically from anterior of cusp and are directed slightly downward.

Denticles on this element are triangular and partially fused. Largest denticles on posterior process are proximal; size decreases uniformly toward distal end. Cusp and denticles of posterior process are only slightly reclined. Denticles on anterolateral processes are inclined towards cusp. Anterolateral processes extend along cusp as sharp costate margins. Posterior margin of cusp is sharp. Base is not flared and has a carniodontid-type of ledge. On larger illustrated element, ledge forms a narrow platform on posterior process. Base is relatively wide beneath cusp and proximal parts of processes; excavation diminishes toward distal ends of processes. Cusp and denticles have fine longitudinal striae; base is smooth.

REMARKS

This grouping of Pterospathodus? elements comprise those that previously may have been included under Carniodus (a-c elements); e elements that co-occur with three species of Pterospathodus but cannot be differentiated; and elements (d?, triangular) that have unusual forms and cannot be assigned with confidence to any of the species of Pterospathodus.

The type 1 b and c elements, type 1-3 e elements and the singular d? element co-occur in a sample from the Blackstone River section. This sample also contains Pterospathodus celloni (Walliser), P. pennatus angulatus

(Walliser) and *P.* n. sp. A. This last taxon has similarities to *P. amorphognathoides* Walliser. *Carniodus carnulus* Walliser is absent from this Blackstone River sample.

The illustrated *a* and type 2 *b-c* elements are from a sample from the Tetlit Creek section, which also contains *C. carnulus* and *P. p. procerus* (Walliser). Elements similar to the *a-c* elements have been assigned to *C. carnulus* by Barrick and Klapper (1976) and others, and to *P. posteritenuis* Uyeno in Uyeno and Barnes (1983). I recognize a symmetry transition series in *C. carnulus* based on the form species *C. carnulus* s.f. and use the apparatus of *P. posteritenuis* as a template to suggest alternate reconstruction of other *Pterospathodus* species. This is further discussed under the generic remarks of *Carniodus* and *Pterospathodus*.

The *a* element differs from the *a* element assigned above to *C. carnulus*. That element lacks the strong anticusp, outer lateral process and hindeodellid denticulation. Furthermore, the denticles are approximately the same size, and the posterior process is relatively short. The ornamentation of the *a* elements in both *C. carnulus* and the elements described here is similar. The *a* element of *P.*? spp. co-occurs with elements of *C. carnulus* and *P. p. procerus*.

The *b-c* elements (type 1) are similar to *Roundya latialata* Walliser s.f. and *R. brevialata* Walliser s.f. The former is assigned to C. carnulus by Barrick and Klapper (1976). I have questioned this asignment in the discussion of that taxon. These elements from the Blackstone River section do not co-occur with elements of C. carnulus. Their co-occurrence with three species of Pterospathodus prompts the inclusion of the b-c elements within P.? Indeterminate Elements.

The b and c elements, type 2, are similar to those elements of genera that follow the prioniodid plan, especially with regard to the hindeodellid-type of denticulation. These elements are from strata containing C. carnulus and P. p. procerus.

Only one d? element is present in the Blackstone River sample. It is tentatively referred to as a d? element because of the four processes but it differs from a typical tetraprioniodontiform element in that the processes are not aborally and posteriorly directed.

Except for the extra processes, the d? element can be compared in lateral view to e or cyrtoniodontiform elements such as those described herein. It also has similarities to "S" elements of the Pterospathodus species discussed above. Thus its position is not clear: it may be part of a symmetry series that includes "S" elements, or it may be an e-2 element.

The sharp inner edge of the type 1 e element is comparable to that of the e element of P. p. procerus from younger strata of the Tetlit Creek section and *Neoprioniodus triangularis triangularis* Walliser s.f., the *e* element of *P. amorphognathoides* sensu Barrick and Klapper (1976) and Aldridge and Mohamed (1982). The type 1 element could be part of *P.* n. sp. A because of its close morphology to *P. amorphognathoides*, or it could be included within *P. p. angulatus* (Walliser), a subspecies that is the probable ancestor of *P. p. procerus*.

The *e*-2 element (Pl. 16, fig. 32) has the form of the *e*-2 element of *Carniodus carnulus* Walliser (cf. Pl. 17, fig. 31, herein). It differs in that the cusp is much wider, and the short ?anterior process is medial with respect to the cusp, rather than on one side of the axis. The process continues along the cusp as a costa which is bordered by a medial groove. This broken element is, in this respect, comparable with *Neoprioniodus costatus* Walliser s.f. of Liebe and Rexroad (1977).

P. p. angulatus sensu Aldridge and Mohamed has an *e* element with a rounded inner carina similar to that of the type 2 element. I could follow their precedent and assign the type 2 element to *P. p. angulatus*, leaving the type 1 to be included within *P.* n. sp. A. However, without supporting stratigraphic data, I cannot be confident about the proper assignment. The "*Distomodus kentuckyensis*" of Cooper, 1975 in Miller (1978, Pl. 3, figs. 3, 10) has elements similar to the *e* element type 2 (other elements of his species are tentatively included above under *D. kentuckyensis* Branson and Branson?).

The type 3 element is similar to N. tenuirameus tenuirameus Walliser s.f. of the P. celloni Zone. This form species is regarded as a junior synonym of P. celloni by Barrick and Klapper (1976) and perhaps this third Yukon form should be assigned to that taxon.

The triangular element is from the Tetlit Creek section and co-occurs with C. carnulus and P. p. procerus. The denticulation, striae and carniodontid-type base are characters of both species and therefore not diagnostic. Sharp or costate cusp margins are found on e elements of P. p. procerus. The triangular element may be an e-2 element of this taxon. Alternatively, it may be an element of the first symmetry transition series: the form is suggestive of "S" elements of Pterospathodus species and the d? element described herein.

Genus Pygodus Lamont and Lindström, 1957

Type species: P. anserinus Lamont and Lindström, 1957.

REMARKS

The multielement apparatus of Pygodus consists of f (haddingodontiform) and g (platform) elements. Bergström (1971) and others suspected that the apparatus of P. anserinus also contains hindeodelliform and tetraprioniodontiform (i.e. c and d) elements. These elements were found in the study collection along with b (keislognathiform) and a possible *a* (cordylodontiform) element.

The *a-d* elements belong to one multielement assemblage, although it may not be part of *Pygodus*. There has been a hesitancy to formally equate *Pygodus* with these elements since they tend to occur in low numbers relative to pygodontiform elements of *Pygodus*. Tipnis (1978) suggested that the older *P. serrus* (Hadding) may have lacked these elements for at least part of its stratigraphic range. As interpreted herein, the apparatus of both species of *Pygodus* contains *f* and *g* elements and probably *a-d* elements. An element equivalent to the *e* element found in other genera appears to be absent.

The apparatus of *Pygodus* is a Type VB (*f*,*g* elements) or, if it does contain a first transition series, a modified Type IVE (*a*,*b*,*c*,*d*,*f*,*g* elements).

The *f* and *g* elements are diagnostic of *Pygodus* species. The *f* elements of *P. anserinus* and *P. serrus* differ in the angle between the two processes. However, Bergström (1971) noted that in stratigraphically younger elements of *P. serrus*, the difference is less distinguishable.

The *g* element of *P. serrus* differs from that of *P. anserinus* by having three, rather than four, denticle-rows. In specimens I have viewed, the *g* element of *P. anserinus* is narrower and the denticle-rows are higher than the same element of *P. serrus*. However, there are intermediate forms with a rudimentary denticle-row that have been somewhat arbitrarily assigned to one species or the other. The report follows Nowlan's (1981a) example of *P.* cf. *P. serrus* and gives a conferred species assignment to these intermediate forms. Other *q* elements are readily equated with *P. serrus*.

The intermediate forms are of biostratigraphic significance since they have been traditionally used to define the boundary between the older *P. serrus* and younger *P. anserinus* zones. This denticle-row variablity may be evolutionary (cf. Bergström, 1971, 1973, 1983), ecological (cf. Fahraeus, 1982) or it may reflect an intra-specific variability that is not necessarily temporal on a global scale. If the latter is true, the use of "intermediate" forms as indicators of the *P. serrus* – *P. anserinus* zonal boundary must be done with caution. The stratigraphic significance of species of *Pygodus* is further discussed within the section on biostratigraphy.

The following synonymies attempt to separate forms with a rudimentary fourth denticle-row (i.e. "intermediate" forms) from elements with only three rows.

Pygodus serrus (Hadding)

Pl. 2, figs. 4, 6, 7, 9, 11, 12, 14-18, 20-23, 28-30

f element

Arabellites serra HADDING, 1913, p. 33, Pl. 1, figs. 12, 13.

Multielement

Pygodus serrus (Hadding). BERGSTROM, 1971, pp. 149, 150, Pl.

2, figs. 22, 23; BERGSTROM, RIVA and KAY, 1974, Pl. 1, fig. 18; DZIK, 1976, text-fig. 29a,b,e; LOFGREN, 1978, p. 98, text-fig. 32(D-F); HARRIS, BERGSTROM, ETHINGTON and ROSS, 1979, Pl. 2, fig. 18; ?NICOLL, 1980, Fig. 3(H-L); AN, 1981, Pl. 4, figs. 1-3.

REMARKS

The *a*, *b*, *c* and *d* elements described herein are tentatively assigned to *Pygodus* and somewhat arbitrarily included within *P. serrus* rather than *P.* cf. *P. serrus*. The *f* elements of both Peel River taxa cannot be distinguished and thus are also included within *P. serrus*.

The *a* element (Pl. 2, fig. 23) has a denticulated posterior and only one denticulated lateral (inner) process. The opposite side is adenticulate and convex. The same side of the *b* element (Pl. 2, figs. 14, 15, 29) has a sharp adenticulate lateral process that extends for the full length of the element. In other respects, the *a* and *b* elements are similar.

The *c* (Pl. 2, figs. 16, 20, 28, 30) and *d* (Pl. 2, figs. 17, 21, 22) elements are similar to *Roundya pyramidalis* Sweet and Bergström s.f. and *Tetraprioniodus lindstroemi* Sweet and Bergström s.f., respectively. These names are not included in the above synonymy since the holotypes are associated with *P. anserinus* Lamont and Lindström.

The angle between the two denticulated processes of the *f* element (Pl. 2, figs. 7, 9, 11) is near the maximum limit of the range (55-75 degrees) for *P. serrus*, as defined by Bergström (1971).

Only the *q* elements (Pl. 2, figs. 4, 6, 12) without incipient denticles or a rudimentary denticle row are included within this species. All others are presented within *P.* cf. *P. serrus* (below). Two reports of *P. serrus* are queried in the synonymy (above) since it cannot be resolved that the *q* elements lack incipient denticles.

TYPES: Hypotypes, ADM 20474-20491.

Pygodus sp. cf. *P. serrus* (Hadding)

Pl. 2, figs. 1-3, 5, 8, 10, 13, 19

f element

cf. *Arabellites serra* HADDING, 1913, p. 33, Pl. 1, figs. 12, 13.

Multielement

Pygodus serrus (Hadding). TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 9, figs. 2, 4, 7-9.

Pygodus cf. *P. serrus* (Hadding). NOWLAN, 1981a, p. 12, Pl. 2, figs. 14, 16-20.

Pygodus sp. C LOFGREN, 1978, pp. 97, 98, Pl. 16, figs. 4-6, text-fig. 32A-C.

REMARKS

P. cf. *P. serrus* differs from *P. serrus* in having an incipient denticle or rudimentary denticle row between the medial and outer denticle-rows. These incipient denticles have a papillose micro-ornamentation similar to the better developed denticles. On some specimens, only one incipient denticle is present. On others, two or more form a rudimentary fourth row. One element (Pl. 2, fig. 5) has two incipient denticles on the same inter-row ridge. Fully developed and incipient denticles and the perpendicular inter-row ridges have a similar papilose micro-ornamentation.

All other elements of this species are indistinguishable from those of *P. serrus*.

TYPES: Figured specimens, ADM 20492-20499.

Genus *Scabbardella* Orchard, 1980

Type species: *Drepanodus altipes* Henningsmoen, 1948.

Scabbardella altipes subsp. B Orchard, 1980

Pl. 6, figs. 1-9, 11-13

e-1 element

aff. *Drepanodus altipes* HENNINGSMOEN, 1948, p. 420 , Pl.
1948, p. 420, Pl. 25, fig. 14.

Multielement

Scabbardella altipes (Henningsmoen) subsp. B ORCHARD, 1980,
p. 26, Pl. 5, figs., 2, 3, 14, 18, 20, 23, 24, 30, 33
(figs. 2 = *e*-3; figs. 3, 14, 18, 20, 30 = *a*; figs. 23,
24, 33 = *e*-1 elements); NOWLAN and McCRACKEN *in* NOWLAN,

McCRACKEN and CHATTERTON, MS, Pl. 16, figs. 7-20; Pl. 17, figs. 1-3, 5, 6, 8, 9 (Appendix A, herein; text includes synonymy).

TYPES: Figured specimens, ADM 20500-20511.

Genus *Scalpellodus* Dzik, 1976

Emended Löfgren, 1978

Type species: *Protopanderodus latus* van Wamel, 1974.

REMARKS

The apparatus of *Scalpellodus* consists of scandodontiform and drepanodontiform elements. All elements are acostate but have fine striae on lateral surfaces, except near the anterior margin. The drepanodontiform elements are similar in form to the *e* elements of *Walliserodus* (cf. *W. nakholmensis* (Hamar) of Nowlan, 1981a). Ordovician and Silurian species of *Walliserodus* contain this type of *e* element as well as a symmetry transition series (*a*,*b*,*c*,*d*) of costate cones. The surface micro-ornamentation of both *Scalpellodus* and the *e* element of *Walliserodus* (cf. Nowlan, 1981a; Nowlan and Barnes, 1981) is quite similar.

Nowlan (1981a) included an *e* element in *W. nakholmensis* and questionably equated it with the *Scalpellodus cavus* (Webers) of Dzik (1976). He (1981a) further proposed that both of Löfgren's (1978) new species *S. viruensis* and *Paltodus? jemtlandicus* may represent the *e* elements of *W. iniquus* (Viira) and *W. ethingtoni* (Fahraeus), respectively.

Löfgren (1978) also indicated this possibility in her discussion of W. ethingtoni. I concur with Nowlan's suggestion that Middle Ordovician species of Walliserodus probably contain e elements. However, because of the limited material and the absence of first transition series elements assignable to Walliserodus, the elements below are questionably referred to Scalpellodus.

Scalpellodus? viruensis Löfgren

Pl. 4, figs. 32-37

Multielement

Scalpellodus viruensis LOFGREN, 1978, pp. 102, 103, Pl. 5, figs. 1, 2, 7-9.

REMARKS

The short-based drepanodontiform elements (Pl. 4, figs. 34, 35) have the characters described by Löfgren (1978), including the carinate inner face. The scandodontiform elements have the short base, strong basal anterior keel and twisted and inwardly flexed cusp found on this element of S. viruensis. The one difference is that the two illustrated elements from Yukon show some variation in the length of the base (cf. Pl. 4, figs. 33, 36). The micro-ornamentation (striae parallel to axis of cusp) on both elements compares to that ~~found~~ described by Löfgren (1978).

TYPES: Hypotypes, ADM 20512-20514.

Genus Spinodus Dzik, 1976

Type species: Polygnathus spinatus Hadding, 1913.

Spinodus spinatus (Hadding)

Pl. 1, fig. 2

Cordylodus ramosus HADDING, 1913, p. 31, Pl. 1, fig. 6.

Polygnathus spinatus HADDING, 1913, p. 32, Pl. 1, fig. 6.

a-b elements

Cordylodus spinatus (Hadding). UYENO and BARNES, 1970, pp. 106, 107, Pl. 24, figs. 7-11 (includes synonymy); TIPNIS, CHATTERTON AND LUDVIGSEN, 1978, Pl. 8, fig. 16.

Multielement

Cordylodus ramosus Hadding. BARNES and POPLAWSKI, 1973, p. 772, Pl. 4, fig. 6 (includes synonymy); SIMES, 1980, Fig. 7.

aff. Cordylodus sp. aff. C. spinatus (Hadding). LANDING, 1976, p. 631, Pl.1, fig. 14.

Spinodus ramosus (Hadding). NOWLAN, 1981a, pp. 15, 16, Pl. 4, figs. 18, 19.

REMARKS

Lindström (1964) recognized a symmetry transition series of three elements types based on C. ramosus Hadding s.f. and C. spinatus (Hadding) s.f. Uyeno and Barnes (1970) added a fourth element to this series under their C. spinatus. Barnes and Poplawski (1973) recognized all four elements in C. ramosus from the Mystic Formation of Québec. These are a-1 (cordylodontiform), a-2 (ligonodiniform), b (cladognathodontiform) and c (hibbardelliform) elements.

TYPE: Hypotype, ADM 20515.

Genus Strachanognathus Rhodes, 1955

Type species: Strachanognathus parvus Rhodes, 1955.

Strachanognathus parvus Rhodes

Pl. 2, fig. 36

Strachanognathus parva RHODES, 1955, p. 132, Pl. 8, figs. 1-4.

Strachanognathus parva (sic) Rhodes. PALMIERI, 1978, text-fig. 6(8a-c) (only).

Strachanognathus parvus RHODES, 1955, p. 132, Pl. 7, fig. 16, Pl. 8, figs. 1-4; PALMIERI, 1978, p. 27, Pl. 6, figs. 27, 28 (only).

Multielement

Strachanognathus parvus Rhodes. LOFGREN, 1978, pp. 112, 113, Pl. 1, fig. 29 (includes synonymy); KENNEDY, BARNES and UYENO, 1979, p. 550, Pl. 1, fig. 24; ORCHARD, 1980, p. 26, Pl. 4, figs. 34, 35; NOWLAN, 1981a, p. 13, Pl. 3, fig. 18, Pl. 5, fig. 5; LENZ and McCRACKEN, 1982, Pl. 2, fig. 21.

REMARKS

In the diagnosis of the family Strachanognathidae, Bergström (in Robison, 1981) noted that the apex of the basal cavity is beneath the anterior denticle and not the larger posterior cusp. The samples of this study confirm this observation. Contrary to the above interpretation, it is considered herein that the anterior denticle is the cusp, the posterior denticle represents a denticulated process and that the element is homologous to a cordylodontiform element. Barnes, *et al.* (1979) implied this when they suggested that the apparatus was monoelemental, containing only a cordylodontiform element. The variations noted by Bergström (1962) and others represent a subtle modification of this element. *S. parvus* ranges from the Arenig (Löfgren, 1978) to the Ashgill (Serpagli, 1967; Bergström, 1971; Orchard, 1980; Lenz and McCracken, 1982).

Lenz and McCracken (1982) illustrated a younger specimen of *S. parvus* that has oblique striations on the first denticle. Striae such as these were not observed on the present study's illustrated specimen.

TYPE: Hypotype, ADM 20516.

Genus *Walliserodus* Serpagli, 1967

Type species: *Acodus curvatus* Branson and Branson, 1947.

Walliserodus amplissimus (Serpagli)

Pl. 6, figs. 19

a element

?*Acodus curvatus* Branson and Branson, SERPAGLI, 1967, p. 41, Pl. 6, figs. 3a-c.

e element

Drepanodus amplissimus SERPAGLI, 1967, p. 66, Pl. 15, figs. 1a-5b.

Multielement

Walliserodus amplissimus (Serpagli). ORCHARD, 1980, pp. 26, 27, Pl. 3, figs. 3-7, 9, 12, 13, 17, 18, text-fig. 4A; NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 19, figs. 1-15 (Appendix A herein; text includes synonymy).

REMARKS

A detailed comparison of W. amplissimus and the Silurian W. curvatus (Branson and Branson) is given in Nowlan, et al. (MS).

TYPE: Hypotype, ADM 20517.

Walliserodus curvatus (Branson and Branson)

Pl. 19, fig. 12

a element

Acodus curvatus BRANSON and BRANSON, 1947, p. 554, Pl. 81, fig. 20.

Multielement

Walliserodus curvatus (Branson and Branson). COOPER, 1975, pp. 995, 996, Pl. 1, figs. 10, 11, 16-21 (includes synonymy); NOWLAN and McCRACKEN in NOWLAN, McCRACKEN and CHATTERTON, MS, Pl. 19, fig. 16 (Appendix A; herein; text includes synonymy).

TYPE: Hypotype, ADM 20518.

Walliserodus? ethingtoni (Fahraeus)

Pl. 1, figs. 6, 7

Panderodus ethingtoni FAHRAEUS, 1966, p. 26, Pl. 3, figs. 5a, b.

Walliserodus ethingtoni (Fahraeus) s.f. TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 9, fig. 23.

Multielement

Walliserodus ethingtoni (Fahraeus). BERGSTROM, RIVA and KAY, 1974, Pl. 1, fig. 12; DZIK, 1976, text-figs. 14 o, p; REPETSKI and ETHINGTON, 1977, Pl. 1, fig. 9; LOFGREN, 1978, pp. 114-116, Pl. 4, figs. 27-35, text-fig. 33; AN, 1981, Pl. 3, fig. 16; STOUGE *in* STOUGE and BOYCE, 1983, Pl. 7, figs. 12, 13; NOWLAN and THURLOW, 1984, p. 294, Pl. 2, fig. 15.

cf. *Walliserodus* cf. *ethingtoni* (Fahreaus) (sic). LOFGREN, 1978, pp. 113, 114, Pl. 4, figs. 13, 14.

REMARKS

Fahraeus (1966) erected this species on elements that had two costae on one side and three on the other. Löfgren (1978) reported a greater variation: from two to eleven costae in total. The single *c* element from Yukon has two costae on each side that are symmetrically disposed (i.e. Löfgren's group 2-2 elements). Nowlan (1981a) proposed that *Paltodus*? *jemtlandicus* Löfgren may represent the *e* element of Löfgren's *Walliserodus ethingtoni* apparatus. Löfgren also suggested this since both species have approximately the same range in her studied strata, but she preferred to be conservative in her treatment of these taxa. I do not have elements that can be regarded as *e* elements of *Walliserodus*, hence I questionably assign the species to Walliserodus.

W. cf. ethingtoni of Löfgren (1978) is an older taxon that has elements with longer and less expanded bases than those in W. ethingtoni.

Fahraeus (1970) has reported W. ethingtoni from the Table Head Group of Newfoundland and further suggested that Paltodus n. sp. Hamar (1966) s.f. is probably identical.

TYPE: Hypotype, ADM 20519.

Walliserodus sancticlari Cooper

Pl. 19, figs. 3-10, 15

Multielement

Walliserodus sancticlari COOPER, 1976, pp. 214, 215, Pl.1, figs. 8-11, 16, 21; UYENO in UYENO and BARNES, 1983, p. 26, Pl. 7, figs. 1-3, 5, 6 (includes synonymy).

REMARKS

The a (curvatiform) element (Pl. 19, figs. 6, 9) of Walliserodus sancticlari lacks the costate inner face found on the same element of W. curvatus (Branson and Branson). Cooper (1976) added that this element is straighter in lateral view (except for the sharply curved cusp) than the a element of W. curvatus. Barrick (1977) suggested that Cooper's illustrated form represented an extreme end-member of a series that also includes relatively low, robust forms that are curved near mid-height (cf. Barrick, 1977, Pl. 1, fig. 18; Uyeno and Barnes, 1983, Pl. 7, fig. 2). Barrick further reported that some of these elements have a weak costa on the posterior margin of the inner face. He (1977) noted a gradual loss of the robust forms in younger strata. Yukon elements are comparable to the short, robust elements of Barrick (1977) and Uyeno and Barnes (1983); their base is short and subcircular with only a slight lateral compression.

The *b* (deboltiform) element (Pl. 19, figs. 3-5) of *W. sancticlari* is comparable to the *b* element of *W. curvatus* except that some lack a costa on the outer face (Cooper, 1976). This difference is more common in younger strata (Barrick, 1977).

The *c* elements of *W. sancticlari* (Pl. 19, fig. 10) and *W. curvatus* differ only in the arrangement of costae about the posterior margin. The *c* element from Yukon has a sharp costate posterior margin that becomes lateral at mid-point and is paralleled on the opposite face by a costa, giving the cusp a square cross section. In this sense it may differ from the previously described forms.

The *d* (multicostatiform; Pl. 19, fig. 7) and *e* (unicostatiform; Pl. 19, figs. 8, 15) elements of *W. sancticlari* are comparable to the same elements of *W. curvatus* except that the latter may lack the distinctive costa on one face. The *d* element also varies stratigraphically. Barrick (1977) found that the lateral costae are medial on older and more anterior on younger forms. He stated that the stratigraphic variation in elements of W. sancticlari was so gradual that it was difficult to distinguish with confidence younger from older forms.

W. sancticlari is compared to W. n. sp. A (below) under the remarks to the latter species.

TYPES: Hypotypes, ADM 20520-20528.

Walliserodus n. sp. A

Pl. 18, figs. 1-42

DESCRIPTION

All elements have white matter in cusp, keels and costae. Basal cavity is deep in all elements, extending to point of cusp recurvature.

The a (curvatiform) element (Pl. 18, Figs. 1-9) lacks lateral costae and has a short, triangular and wide base. Cusp is wide, straight, long, compressed and erect to slightly recurved. Recurvature is at two-thirds length of element. Cusp is bowed to inner side and twisted so that inner face is toward posterolateral direction. Anterior and posterior edges are sharp; edges on base are keeled. Anterior keel may curve inward producing a concave inner face. Rarely, edge of keel faces toward posterior. Inner face of base is planar. Outer face is convex; some elements have a wide, low median carina. Aboral margins are straight.

Two forms of b (deboltiform) elements differ according to number of costae. The b-1 element (Pl. 18, figs. 10-12, 18) is similar to a element except for following differences: element is less inwardly bowed; base is slightly longer and not as wide basally; keels are not deflected laterally; and inner face is planar with a weak medial depression. This medial depression is reflected in inner aboral outline; outer outline is convex. Outer face has sharp medial costa. In some specimens, this costa is keel-like and nearly perpendicular to anteroposterior plane. Face that is anterior to costa is slightly concave to slightly convex; face that is posterior to costa is slightly concave.

The b-2 element (Pl. 18, figs. 13-17, 23) is similar to b-1 element, except that base is higher and cusp is proclined. Costa on outer face is keel-like and may be medial or near keeled anterior margin. Some elements develop a second sharp costa between anterior margin and other costa. Inner face has a costa near anterior margin that extends from base to point of cusp recurvature where it merges with anterior keel.

The c (dyscritiform) element (Pl. 18, figs. 19-22, 24-27) has a long base like that b-2 element and a proclined cusp, concave anterior face and keeled anterolateral margins. Aboral outline is triangular. Two varieties are: symmetrical and slightly asymmetrical elements. Symmetrical element (Pl. 18, fig. 21) is unbowed and has a keeled posterior margin on base. Posterior magin of cusp is convex with sharp posterolateral costae. These continue towards base where they merge at mid-height to form posterior keel. Keeled anterolateral costae on base extend anteriorly beyond anterior face. Each costa is immediately paralleled by a sharp costa that is slightly directed to posterior. These lateral costae extend to tip of cusp, bounding a slightly convex anterior margin. Anterolateral costae do not extend beyond point of recurvature. Lateral faces are planar or slightly concave. Oral and aboral margins are straight.

Slightly asymmetrical c element (Pl. 18, fig. 22) has a cusp that is directed toward inner side. Distal part of posterior margin on base, may be straight or may also be directed inward. Inner and outer lateral costae near anterior margin are like those of symmetrical c element. Anterolateral costae may be subdued or as prominent as on symmetrical element. Inner side lacks posterolateral costa. Posterior keel is deflected to inner side and extends to tip of cusp as sharp costa. Cusp has cross section like that of symmetrical element: costae are present at each corner.

The d (multicostatiform) element (Pl. 18, figs. 29, 32, 34-37, 39-42) varies in length of base and number of costae. Element has keeled anterior and posterior margins, proclined cusp, and a nearly straight or slightly concave oral margin. Unbowed elements have a sharp lateral costa near anterior margin on one side that extends for length of element. Immediately anterior to this is a shorter costa. This face may have a costa near posterior margin that extends from tip of cusp to about mid-length. Other face has at least two sharp costae: one near anterior, other near posterior margins. Secondary costa may develop slightly posterior to more anterior costa.

The _e_ (unicostatiform) element (Pl. 18, figs. 28, 30, 31, 33, 38) has a proclined cusp, sharp anterior and posterior margins, and lacks lateral costae. Straight unbowed element has a relatively low wide base. Cusp is laterally compressed and only slightly twisted to inner side. Base on both sides is nearly flat with shallow and wide medial depression. Anterior margin is keeled in some elements. Aboral outline is asymmetric, subrectangular with rounded edges. Other elements (Pl. 18, figs. 30, 31) are similar except that bases are longer and less wide, and cusp is more twisted and inclined in posterolateral direction.

REMARKS

All element positions and morphotypes are readily comparable to those of _Walliserodus_ _curvatus_ (Branson and Branson) and other species of _Walliserodus_. The _e_ element is termed "unicostatiform" even though it is acostate to conform to the descriptive terminology of _W._ _curvatus_. Both this _e_ and that of _W._ _amplissimus_ (Serpagli), another species with an acostate _e_ element, have the outline of _A._ _unicostatus_ Branson and Branson s.f. All elements have a degree of variability, particularly the _b_ through _d_ elements.

The *a* element differs from the a element of *W. curvatus* in lacking lateral costae. In this regard, it is comparable to the *a* element of *W. sancticlari* Cooper (above). It differs in that the base is shorter and wider, and the cusp is more recurved. The robust elements of *W. sancticlari* in Barrick (1977) and Uyeno and Barnes (1983) are more robust than Cooper's type material but still do not approach the extremes found in the *a* elements of *W.* n. sp. A.

The *b*-1 element is comparable to the *b* element of both *W. curvatus* and *W. sancticlari* in the sense that only the outer side has a costa. This element, however, has a wider and shorter base. The *b*-2 element may have comparable elements in both of the above species. It is essentially a *c* element that is markedly asymmetrical. It also differs from *b* elements in other species in its basal proportions.

The *c* element is characterized by its anteriorly directed anterolateral keels and concave anterior face. The *c* elements of *W. curvatus* and *W. sancticlari* are similar to each other in that their anterolateral costae do not extend beyond the anterior face. Also, the anterior face in these *c* elements is more convex. The costae of the *c* element in this new species are better developed than in the other named species.

The morphology of the *d* element in *W. curvatus*, *W. sancticlari* and this new species is variable. In

W. n. sp. A, the *d* element is characterized by a relatively wide base. The *d* element may be even more variable with regards to ornamentation than is recorded herein.

The *e* element lacks a lateral costa as is found in *W. curvatus*. Its short wide base distinguishes it from the *e* element of *W. sancticlari*.

TYPES: Figured specimens, ADM 20529-20570.

Walliserodus? n. sp. B

Pl. 19, figs. 1, 2

REMARKS

The rare geniculated elements share the wide base and cusp of *a* elements of *Walliserodus* n. sp. A described above. They are not included under *W*. n. sp. A because oistodontiform elements are unknown in species of *Walliserodus* and because they occur in a sample that lacks *W*. n. sp. A but contains *W. sancticlari* Cooper. The elements may simply be a rare aberration of the much more abundant form of *a* element of *W*. n. sp. A, or less likely, *W. sancticlari*.

TYPES: Figured specimens, ADM 20571, 20572.

N. gen. A

DIAGNOSIS

Apparatus includes symmetrical c rastrate elements that are unbowed and have a well defined heel and two or three denticles. Symmetry is expressed in a keeled costa and panderodont cusp groove and basal furrow on each lateral face, and a lack of bowing or torsion.

REMARKS

This genus is characterized by its symmetrical, bifurrowed and bicostate rastrate c elements. An a element is tentatively assigned to this genus. If the a elements are not associated with the c element, then the apparatus is either monoelemental, or incompletely known.

N. gen. A n. sp. A

Pl. 7, figs. 13, 15-22, 24

DIAGNOSIS

As for the genus.

DESCRIPTION

All elements are rastrate with basal heels. Proclined denticles are confluent, wide, long and laterally compressed with convex faces. Costae extend from cusp to basal wrinkles. A small planar-faced keel is present between heel and first denticle. Heel is short and about or less than half width of base. Heel is planar except has convex, thickened basal portion. Faint basal wrinkles are present on heel and base of cusp. Upper margin of heel is rounded.

Panderodont furrow and groove are present on one side in *a*, and both sides in *c* elements, and parallel region of denticles. Furrow on base is slightly deflected away from heel. Faint longitudinal striae are present on both sides of groove, and in same position on opposite face. Anterior margin of cusp has a sharp costa on *a* element; on *c* element it is weakly convex.

The *a* element (Pl. 7, figs. 17-20) is unbowed and has an anterior face that is narrowly convex. A weak costa is present on each face of one element, just anterior to mid-line; other element has a weak costa close to preserved part of anterior margin. Heel is about one-third length of base; convex basal portion of heel is about one-half width of heel. Upper and aboral (or posterior) margin of heel form an angle of less than 90 degrees. Five denticles are proclined at less than 20 degrees relative to aboral margin of heel. Base is longer, lower than on *c* elements. Lateral faces of elements are slightly convex except for one element, which has slightly concave faces on proximal part of cusp between denticles and costa. One element does not have a groove; only a basal furrow is present.

The *c* elements (Pl. 7, figs. 13, 15, 16, 21, 22, 24) have two or three denticles and a well defined heel and a slightly convex, wide anterior face on base. Base between furrow and anterior face is widely expanded laterally. One keeled costa bounds each side of this face. Element is symmetrical: unbowed, a costa on each anterior corner, and a groove and furrow on each lateral face.

REMARKS

This new taxon co-occurs with elements of *Belodina confluens* Sweet and *Pseudobelodina*? *dispansa* (Glenister). A bifurrowed *c* element is not known to occur in other rastrate genera such as *Belodina*, *Culumbodina*, *Parabelodina* and *Pseudobelodina*.

TYPES: Figured specimens, ADM 20573-20576.

N. gen. B

DIAGNOSIS

Apparatus of N. gen. B comprises *a*-1, *a*-2?, *b*, *c*, *e*?, *f*, *g* (eoligonodiniform, modified eoligonodiniform, zygognathiform, tri[illegible]odelliform, falcodontiform, prioniodiniform, oulod[illegible]orm) elements. All elements have long processes that have long, closely packed denticles. Cusp is long and compressed. One face of elements has a basal thickening or carniodontiform ledge.

REMARKS

The *a*-1 element is "pick-shaped" and has long posterior and anticusp processes, both of which are denticulated. The *a*-2? is like the *a*-1 except that it also has a long denticulated outer lateral process. The *b* and *c* elements have long denticulated lateral processes that diverge at a small angle. Posterior process may be short and adenticulate or non-existent. The e? element has an erect cusp and an "anticusp", or anterior process, that is directed downward and forms a right angle with the base of the cusp. The posterior process is distally arched downward. Both processes are long and denticulated.

The b, c, f and g elements have forms found in genera such as Oulodus, Ozarkodina of the American Province. The form of the b and c elements suggest Ozarkodina (cf. Ozarkodina broenlundi Aldridge) and the Late Devonian Apatognathus varians klapperi Druce; the f and g elements are similar to the same elements in Oulodus. However, the a-1 and a-2? are not typical of these genera. The e? element has a form that is not readily comparable with known multielement genera. In form, it is like Falcodus s.f., a younger genus with an unknown apparatus.

It is quite likely that some of the elements illustrated by Schönlaub (1971) are synonyms of this new reconstruction. Schönlaub's form taxa are assigned to Falcodus? and Synprioniodina. These two generic names are not regarded as senior synonyms of N. gen. B since the apparatuses of both genera are unknown, and the type material is much younger. The trivial name of S. typica Schönlaub s.f. is available for the species name. The distinctiveness of the a and e elements prevents assignment to any known genera.

N. gen. B n. sp. A

Pl. 13, figs. 1-21

a-1 element

?Synprioniodina typica SCHONLAUB, 1971, p. 49, Pl. 3, fig. 5 (only; Pl. 3, fig. 4 may = b element, herein).

b element

?Falcodus? n. sp. SCHONLAUB, 1971, p. 47, Pl.3, fig.2 (only; Pl. 3, figs. 1, 3 may = e? element, herein).

?Synprioniodina typica SCHONLAUB, 1971, p. 49, Pl. 3, fig. 4 (only; Pl. 3, fig. 5 may = a-1 element, herein).

e? element

?Falcodus? n. sp. SCHONLAUB, 1971, p. 47, Pl. 3, figs. 1, 3 (only; Pl. 3, fig. 2 may = b element, herein); LEE, 1982, p. 81, Pl. 2, fig. 5.

DIAGNOSIS

As for the genus.

DESCRIPTION

The a-1 (eoligonodiniform) element (Pl. 13, figs. 1, 2, 6, 7) is "pick-shaped" with a long denticulated posterior process and an equally long denticulated "anticusp" or aborally directed anterior process. Cusp is long, straight, proclined, relatively wide, and laterally compressed with sharp anterior and posterior edges. Cusp and processes are curved inward slightly. Posterior process is straight or turned upwards distally. It has long, straight, reclind denticles that are confluent for most of their length and number up to at least fourteen. Distal denticles are smaller and shorter than proximal denticles. Proximal denticle is confluent with cusp. "Anticusp" process may have up to at least 21 denticles. These are slightly recurved inward and toward cusp, and are confluent only at their bases. Distal denticles are short, small and nearly erect with respect to process. Inner face has small basal flare beneath cusp; processes have a narrow basal thickening or carniodontiform ledge. Outer face is smooth. Basal cavity is small, extends under processes as narrow excavation.

The a-2? (modified eoligonodiniform) element (Pl. 13, figs. 3, 11) is like the a-1 element except that the cusp is more proclined, and the outer lateral face bears a long aborally and posterolaterally directed process. This process bears up to at least 20 partially confluent denticles that are inclined towards the cusp.

The b position is occupied by slightly to markedly asymmetrical elements (zygognathiform; Pl. 13, figs. 4, 5, 9, 12, 13) that compare well with c elements. Processes diverge asymmetrically and may be straight, slightly arched or distally flexed toward anterior. Denticulation is similar to that of c element. Posterior process is either reduced or replaced with small basal flare. Cavity extends under processes as narrow excavation.

The c (trichonodelliform) element (Pl. 13, figs. 8, 10) has long denticulated lateral processes that are directed downwards. Angle of divergence is small. Cusp, denticles and process ledge are like those of other elements. Posterior process is short and adenticulate with a rounded posterior margin. Cusp is recurved slightly. Aboral surface is like that on other elements.

The e? (falcodontiform) element (Pl. 13, figs. 14-16) has a cusp that is less distinct than on a-c and f elements. It is narrower, less compressed, shorter and tapers rapidly to a point. Cusp is slightly proclined; anterior process is directed downward at an angle of about 90 degrees. Denticles number at least 11 on this process and are slightly recurved inward and toward cusp. They are basally confluent. Posterior process is arched downward and bears up to at least 18 long and partially confluent denticles. Denticles are erect to slightly inclined towards cusp. Basal excavation is like that of other elements.

The f element (Pl. 13, figs. 17, 18, 21) is prioniodiniform with a cusp that is inclined out of the plane of processes. Cusp is long and distinct. Denticles are reclined, and partially confluent for part of their length near cusp, and smaller, more discrete, and erect at distal ends of processes. Processes are about same length with about 10 denticles on each. Inner face has subdued basal ledge; outer face is smooth.

The g element (Pl. 13, figs. 19, 20) is oulodontiform with erect cusp and two long denticluated processes. One lateral process is directed downward, other is directed towards posterior and its distal part is flexed outward. Denticles are long, partially confluent.

REMARKS

The a elements of genera with the American Plan of apparatus have the anterior edge of the cusp extended into a denticulated process that is either directed to the anterior (i.e. ligonodiniform in Ozarkodina) or anterolaterally (i.e. eoligonodiniform in Oulodus). In either form, it may also be directed aborally, but not to the extreme as found herein. Apparatuses wtih the European Plan, such as Amorphognathus, Prioniodus, and probably Astropentagnathus, have a elements that have posterolaterally directed processes. The a elements of the first two genera differ in that the posterior process commonly carries a hindeodellid style of denticulation. One of the elements of S. typica Schönlaub s.f. may represent this element (cf. synonymy).

The a-2? element is tentatively assigned to this position because of its similarity to the a-1 element. Alternatively, it may be viewed as the b element, except that asymmetrical elements similar to the c element are also included within this appartus and are regarded as b elements. This element may also be regarded as ambalodontiform since it has three processes, but again this interpretation is not favoured since the apparatus has an f position that is already occupied by a prioniodiniform element.

One of the elements of Falcodus? n. sp. Schönlaub (1971, Pl. 3, fig. 2) and S. typica (ibid., fig. 4) both have processes and cusp that are oriented like the b elements of this taxon.

The e? element most closely resembles Falcodus? n. sp. Schönlaub s.f. (especially Schönlaub's (1971) element of Pl. 3, fig. 1). The form of the e? element is quite distinct from e elements found in apparatuses of other genera.

The f and g elements are similar to the f and g elements of Oulodus. The affinity of this new genus to Oulodus is discussed under the generic remarks.

Elements of N. gen. B are found associated with elements of Astropentagnathus and it is tempting to suggest that they are all part of the same apparatus. However, I have followed the suggestion of writers such as Schönlaub (1971) and have regarded rhynchognathodontiform elements as representing part of the first symmetry transition series of Astropentagnathus. In Yukon material, a?, b, c, e, f and g elements of Astropentagnathus species are recognized. Furthermore, Astropentagnathus? Indeterminate Elements from the same horizon, comprises b, c, d (tetraprioniodiniform) and holodontiform elements and these elements probably complete the apparatuses of the Astropentagnathus species. The argument for suggesting its association with the other species of Astropentagnathus are given under the remarks to that taxon.

The total number of morphotypes of the co-occurring N. gen B n. sp. A and Astropentagnathus are too numerous, and different, to include all within the two species of Astropentagnathus. Hence I prefer to regard the elements described herein as being part of a taxon that is significantly different from Astropentagnathus.

These elements are common in one sample from the Blackstone River section. However, the stratigraphic occurrence is limited and thus cannot be used to verify the proposed reconstruction.

TYPES: Figured specimens, ADM 20577-20597.

Indeterminate Cruciform Element

Pl. 13, fig. 30

REMARKS

The single cruciform element could well represent Astrognathus tetractis Walliser s.f., the f element of Apsidognathus tuberculatus Walliser, as suggested by Helfrich (1980) and Uyeno and Barnes (1983). The Yukon element has not been equated to these form and multielement species because of some differences described below.

A. tetractis s.f., as illustrated by Walliser (1964), Schönlaub (1971), Aldridge (1972, 1975), Helfrich (1980), and Uyeno and Barnes (1983), has distinct, low, and partially confluent denticles. Most denticles of the Yukon element are fused entirely, forming a sharp, straight ridge; only a few denticles are partially discrete.

A pair of opposing denticles in the elements of Schönlaub (1971), Aldridge (1972, 1975) and Helfrich (1980) are either arched downward, or the oral margin is convex. The processes of Indeterminate Cruciform Element are not arched; the element of Uyeno and Barnes (1983) seems similar to the Yukon element in this respect.

The opposing processes are not offset in the elements of Walliser (1964), Schönlaub (1971) and Aldridge (1972, 1975) (element of Helfrich, 1980, is illustrated in lateral view). The element shown by Uyeno and Barnes (1983) and the Yukon element are similar in that one process is offset relative to the opposing process.

Indeterminate Cruciform Element differs from the elements of the above writers in one notable feature: one process is bifurcated at about the mid-length of the process (the offset process of element in Uyeno and Barnes, 1983, is broken and thus cannot be compared in this respect).

Amorphognathus tenuis Aldridge (1972) s.f. has an offset, bifurcated process (two?) but it differs from the Yukon element because the bifurcation occurs at the junction of this process and the perpendicular processes, and the opposing process is curved, not straight as in Indeterminate Cruciform element.

TYPE: Figured specimen, ADM 20603.

Indeterminate Distacodontiform Element

Pl. 6, figs. 21, 28

REMARKS

The element occurs with Late Ordovician elements from the upper Peel River section. A medial costa occurs on both lateral faces, and on one of the faces, the medial region has fine striae that parallel the axis of the cusp. The element is quite similar in these respects, and in outline, to the acodontiform element of *Acodus*? *mutatus* (Branson and Mehl) sensu Löfgren (1978) from older strata. Löfgren's acodontiform element (*ibid.*, Pl. 2, fig. 16) differs in that only one side is costate; the other is either smooth or carinate. The symmetrical acontiodontiform elements of Löfgren's *A.*? *mutatus* have costae on both lateral faces but differ from the Yukon taxon in that they have a long base. In this respect, the short-based Yukon element is more similar to the acodontiform elements of *A.*? *mutatus*.

One of the illustrated distacodontiform elements of *Dapsilodus*? sp. C (Pl. 4, fig. 1) from older Yukon strata has micro-ornamentation on one face. It differs in that the micro-ornamentation are fine costae rather than striae; these costae are basally divergent and more laterally extensive than the striae of Indeterminate Distacodontiform Element. Also, the base of the element of *Dapsilodus*? sp. C is relatively long in comparison to the base of this element.

TYPE: Figured specimen, ADM 20604.

Indeterminate Oistodontiform Element

Pl. 2, fig. 39

DESCRIPTION

Small oistodontiform element is geniculated but with smooth rather than sharp geniculation angle. Base is posteriorly extended; antero-aboral angle is sharp but not very acute. Oral edge is sharp and nearly straight, sharp anterobasal edge continues along cusp. Aboral margin is convex; outline is slightly biconvex. Basal cavity occupies whole base with only tip extending above oral margin of base. Basal cavity tip is perpendicular to aboral margin. Cusp is slightly flxed to inner side and has sharp posterior edge. Cusp lacks micro-ornamentation and has only sight carina on inner face near point of geniculation.

REMARKS

The single element differs from all other *e* or *r* elements of the Yukon study. Löfgren (1978, p. 118, Pl. 4, fig. 12) described a similar indeterminate oistodontiform element that shares some characters with the same element in *Paltodus? semisymmetricus* (Hamar) (sensu Dzik, 1976). The Yukon specimen differs from both in that it is not as geniculated and has a cusp that is less broad.

The degree of reclination of the cusp is similar to that of the e element of Phragmodus polonicus Dzik, a species that ranges from the Llanvirn to Llandeilo in Poland (Dzik, 1978). One difference is that the e element of P. polonicus has a sharp geniculation angle.

TYPE: Figured specimen, ADM 20605.

Indeterminate Zygognathiform Element

Pl. 13, fig. 22

REMARKS

The single b element occurs with elements of N. gen. B n. sp. A. It has a denticulation that is similar to the elements of this new genus, but is not included in the apparatus due to the following differences: lateral processes are not strongly directed downward; cusp is not as laterally compressed; base of processes is not thickened; and the posterior process is not as short.

One c element (Pl. 13, fig. 8) of N. gen. B n. sp. A has a short posterior process but differs in that the lateral processes are strongly directed downwards, and the posterior faces of the lateral processes have a carniodontid ledge.

TYPE: Figured specimen, ADM 20610.

MIDDLE ORDOVICIAN TO SILURIAN (WENLOCK) CONODONT TAXONOMY AND BIOSTRATIGRAPHY FROM BASINAL STRATA OF THE ROAD RIVER FORMATION IN THE RICHARDSON MOUNTAINS, NORTHERN YUKON TERRITORY

VOLUME II

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LIST OF FIGURES

REFERENCES

ALDRIDGE, R.J.

1972: Llandovery conodonts from the Welsh Borderland. British Museum of Natural History (Geology), Bulletin, v. 22, no. 2, pp. 125-231.

1974: An <u>amorphognathoides</u> Zone conodont fauna from the Silurian of the Ringerike area, south Norway. Norsk Geologisk Tidsskrift, v. 54, pp. 295-303.

1975: The stratigraphic distribution of conodonts in the British Silurian. Journal of the Geological Society of London, v. 131, pp. 607-618.

1976: Comparison of macrofossil communities and conodont distribution in the British Silurian. <u>In</u> Conodont Paleoecology. <u>Edited by</u> C.R. Barnes. Geological Association of Canada, Special Paper 15, pp. 91-104.

1979: An upper Llandovery conodont fauna from Peary Land, eastern North Greenland. Grønlands Geologiske Undersøgelse, Rapport no. 91, pp. 7-23.

1980: Notes on some Silurian conodonts from Ireland. Journal of Earth Sciences, Royal Dublin Society, v. 3, pp. 127-132.

1982: A fused cluster of coniform elements from the late Ordovician of Washington Land, western north Greenland. Palaeontology, v. 25, pp. 425-430.

ALDRIDGE, R.J., DORNING, K.J., HILL, P.J., RICHARDSON, J.B., and SIVETER, D.J.

1979: Microfossil distribution in the Silurian of Britain and Ireland; The Caledonides of the British Isles - reviewed. Geological Society of London, pp. 433-438.

ALDRIDGE, R.J., DORNING, K.J., and SIVETER, D.J.

1981: Microfossil distribution across the Welsh Wenlock Shelf. *In* Microfossils from Recent and Fossil Shelf Seas. *Edited by* J.W. Neale and M.D. Brasier. Ellis Horwood Limited, Chinchester, England, pp. 18-30.

ALDRIDGE, R.J. and MABILLARD, J.E.

1981: Local variations in the distribution of Silurian conodonts; and example from the *amorphognathoides* interval of the Welsh Basin. *In* Microfossils from Recent and Fossil Shelf Seas. *Edited by* J.W. Neale and M.D. Brasier. Ellis Horwood Limited, Chichester, England, pp. 10-17.

ALDRIDGE, R.J., and MOHAMED, I.

1982: Conodont biostratigaraphy of the early Silurian of the Oslo Region. *In* Field Meeting, Oslo Region, 1982. *Edited by* D. Worsley. International Union of Geological Sciences. Subcommission on Silurian Stratigraphy. Paleontological Contributions from the University of Oslo, no. 278, pp. 109-120.

AN TAI-XIANG

1981: Recent progress in Cambrian and Ordovician conodont biostratigraphy of China. Geological Society of America, Special Paper 187, pp. 209-224.

BARNES, C.R.

1974: Ordovician conodont biostratigraphy of the Canadian Arctic. In Proceedings of the Symposium on Canadian Arctic Geology. Edited by J.D. Aitken and J.D. Glass. Geological Association of Canada - Canadian Society of Petroleum Geologists, pp. 221-240 (Imprinted 1973).

1977: Ordovician conodonts from the Ship Point and Bad Cache Rapids Formations, Melville Peninsula, south-eastern District of Franklin; Geological Survey of Canada, Bulletin 269, pp. 99-119.

BARNES, C.R. and FAHRAEUS, L.E.

1975: Provinces, communities, and the proposed nektobenthic habit of Ordovician conodontophorids. Lethaia, v. 8, pp. 133-149.

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 sections. In The Ordovician System. Proceedings of a Palaeontological Association symposium, Birmingham, September, 1974. Edited by M.G. Bassett. University of Wales Press and National Museum of Wales, Cardiff, pp. 209-226.

BARNES, C.R., KENNEDY, D.J., McCRACKEN, A.D., NOWLAN, G.S., and TARRANT, G.T.

1979: The structure and evolution of Ordovician conodont apparatuses. Lethaia, v. 12, pp. 125-151.

BARNES, C.R., and McCRACKEN, A.D.

1981: Early Silurian chronostratigraphy and a proposed Ordovician - Silurian boundary stratotype, Anticosti Island, Québec. *In* Field Meeting, Anticosti - Gaspé, Québec, 1981, v. II: Statigraphy and Paleontology. *Edited by* P.J. Lespérance. Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 71-79.

BARNES, C.R., NORFORD, B.S., and SKEVINGTON, D.

1981: The Ordovician System in Canada: correlation chart and explanatory notes. International Union of Geological Sciences, Publication No. 8, 27 pp.

BARNES, C.R., and POPLAWSKI, M.L.S.

1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada. Journal of Paleontology, v. 47, pp. 760-790.

BARNES, C.R., REXROAD, C.B., and MILLER, J.F.

1973: Lower Paleozoic conodont provincialism. Geological Society of America, Special Paper 141, pp. 157-190.

BARRICK, J.E.

1977: Multielement simple-cone conodonts from the

Clarita Formation (Silurian), Arbuckle Mountains, Oklahoma. Geologica et Palaeontologica, v. 11, pp. 47-68.

1981: Wenlockian (Silurian) conodont biostratigraphy and biofacies, Wayne Formation, central Tennessee. Geological Society of America, Abstracts with Programs, v. 13, no. 6, p. 270 (abstract).

BARRICK, J.E., and KLAPPER, G.

1976: Multielement Silurian (late Llandoverian - Wenlockian) conodonts of the Clarita Formation, Arbuckle Mountains, Oklahoma, and phylogeny of <u>Kockelella</u>. Geologica et Palaeontologica, v. 10, pp. 59-100.

BASSETT, M.G.

1976: A critique of diachronism, community distribution and correlation at the Wenlock - Ludlow boundary. Lethaia, v. 9, pp. 207-218.

BERGSTROM, S.M.

1962: Conodonts from the Ludibundus Limestone (Middle Ordovician) of the Tvaeren area (S.E. Sweden). Arkiv for Mineralogi och Geologi, v. 3, pp. 1-61 (preprints dated 1961).

1971: Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. <u>In</u> Symposium on conodont biostratigraphy. <u>Edited by</u> W.C. Sweet and S.M. Bergström. Geological Society of America, Memoir 127, pp. 83-161.

1973: Biostratigraphy and facies relations in the lower Middle Ordovician of easternmost Tennessee. American Journal of Science, v. 273-A, pp. 261-293.

1978: Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas graptolite zone reference standard. Palaeontology, v. 21, pp. 723-758.

1979a: Whiterockian (Ordovician) conodonts from the Holonda Limestone of the Trondheim region, Norwegian Caledonides. Norsk Geologisk Tiddskrift, v. 59, pp. 295-307.

1979b: First report of the enigmatic microfossil Konyrium in North America. Journal of Paleontology, v. 53, pp. 320-327.

1983: Biostratigraphy, evolutionary relationships, and stratigraphic significance of Ordovician platform conodonts. Fossils and Strata, No. 15, pp. 35-58.

BERGSTROM, S.M., and COOPER, R.A.

1973: Didymograptus bifidus and the trans - Atlantic correlation of the Lower Ordovician. Lethaia, v. 6, pp. 313-340.

BERGSTROM, S.M., RIVA, J., and KAY, M.

1974: Significance of conodonts, graptolites, and shelly faunas from the Ordovician of western and north-central Newfoundland. Canadian Journal of Earth Sciences, v. 11, pp. 1625-1660.

BERGSTROM, S.M. and SWEET, W.C.

1966: Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. Bulletins of American Paleontology, v. 50, no. 229, pp. 271-424.

BERRY, W.B.N.

1976: Aspects of correlation of North American shelly and graptolite faunas. In The Ordovician System. Proceedings of a Palaeontological Association symposium, Birmingham, September, 1974. Edited by M.G. Bassett. University of Wales Press and National Museum of Wales, Cardiff, pp. 153-169.

BISCHOFF, G. and SANNEMANN, D.

1958: Unterdevonische Conodonten aus dem Frankenwald. Notizblatt des Hessischen Landesamt fur Bodenforschung, v. 86, pp. 87-110.

BOLTON, T.E., and NOWLAN, G.S.

1979: A late Ordovician fossil assemblage from an outlier north of Aberdeen Lake, District of Keewatin. Geological Survey of Canada, Bulletin 321, pp. 1-26.

BRADSHAW, L.E.

1969: Conodonts from the Fort Pena Formation (Middle Ordovician), Marathon Basin, Texas. Journal of Paleontology, v. 43, pp. 1137-1168.

BRANSON, E.B., and BRANSON, C.C.

1947: Lower Silurian conodonts from Kentucky. Journal of Paleontology, v. 21, pp. 549-556.

BRANSON, E.B., and MEHL, M.G.

1933: Conodont studies. University of Missouri Studies, v. 8, pp. 1-349.

BRENCHLEY, P.J., and NEWALL, G.

1980: A facies analysis of Upper Ordovician regressive sequences in the Oslo Region, Norway - a record of glacio-eustatic changes. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 31, pp. 1-38.

CARTER, C., TREXLER, J.H., Jr., and CHURKIN, M., Jr.

1980: Dating of graptolite zones by sedimentation rates: implications for rates of evolution. Lethaia, v. 13, pp. 279-287.

CECILE, M.P.

1978: Report on Road River stratigraphy and the Misty Creek Embayment, Bonnet Plume (106B) and surrounding map-areas, N.W.T. In Current Research, Part A. Geological Survey of Canada, Paper 78-1A, pp. 371-377.

1982: The lower Paleozoic Misty Creek Embayment, Selwyn Basin, Yukon and Northwest Territories. Geological Survey of Canada, Bulletin 335, 78 pp. (with paleontological appendix by W.H. Fritz, B.S. Norford, and R.S. Tipnis).

CECILE, M.P., and NORFORD, B.S.

1979: Basin to platform transition, lower Paleozoic strata of Ware and Trutch map-areas, northeastern British Columbia. In Current Research, Part A.

Geological Survey of Canada, Paper 79-1A, pp. 219-226.

CHEN XU, and LENZ, A.C.

1984: Ordovician graptolite zonation and correlation with special reference to the pacific faunal realm. Neues Jahrbuch fur Geologie und Paleontologie, Mh., 1984, Heft 4, pp. 212-222.

CHURKIN, M., Jr., and BRABB, E.E.

1965: Ordovician, Silurian, Devonian biostratigraphy of east-central Alaska. American Association of Petroleum Geologists, Bulletin, v. 49, pp. 172-285.

CHURKIN, M., Jr., CARTER, C., and JOHNSON, B.R.

1977: Subdivision of Ordovician and Silurian time scale using accumulation rates of graptolitic shale. Geology, v. 5, pp. 452-456.

COCKS, L.R.M., HOLLAND, C.H., RICKARDS, R.B., and STRACHAN, I.

1971: A correlation of Silurian rocks in the British Isles. Journal of the Geological Society, Special Report No. 1, 136 pp.

COCKS, L.R.M., LANE, P.D., RICKARDS, R.B., TEMPLE, J.T., and WOODCOCK, N.H.

1983a: The Llandovery area as the type for the first series of the Silurian System. A submission to the Subcommission on Silurian Stratigraphy, April, 1983. International Commission on Stratigraphy, Subcommission on Silurian

Stratigraphy, 30 pp.

1983b: Additional information on the Llandovery Series of the type area. In Two supplementary submissions to the Subcommission on Silurian Stratigraphy, December, 1983. International Commission on Stratigraphy, Subcommission on Silurian Stratigraphy, 7 pp.

COOPER, B.J.

1975: Multielement conodonts from the Brassfield Limestone (Silurian) of southern Ohio. Journal of Paleontology, v. 49, pp. 984-1008.

1976: Multielement conodonts from the St. Clair Limestone (Silurian) of southern Illinois. Journal of Paleontology, v. 50, p. 205-217.

1977a: Upper Silurian conodonts from the Yarrangobilly Limestone, southeastern New South Wales. Proceedings of the Royal Society of Victoria, v. 89, pp. 183-194.

1977b: Toward a familial classification of Silurian conodonts. Journal of Paleontology, v. 51, pp. 1057-1071.

1980: Toward an improved Silurian conodont biostratigraphy. Lethaia, v. 13, pp. 209-227.

COPELAND, M.J.

1981: Latest Ordovician and Silurian ostracode faunas from Anticosti Island, Quebec. In Field Meeting, Anticosti - Gaspe, Quebec, 1981, v. II: Stratigraphy and Paleontology. Edited by P.J.

Lesperance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Departement de geologie, Universite de Montreal, pp. 185-195.

DENNISON, J.M.

1976: Appalachian Queenston delta related to eustatic sea-level drop accompaning Late Ordovician glaciation centered in Africa. In The Orodovician System. Proceedings of a Palaeontological Association symposium, Birmingham, September, 1974. Edited by M.G. Bassett. University of Wales Press and National Museum of Wales, Cardiff, pp. 107-120.

DRYGANT, D.M.

1974: Simple conodonts from the Silurian and lowermost Devonian of the Volyno - Podolian area. Paleontologicheskiy Sbornik, v. 10, pp. 64-70 (English summary).

DZIK, J.

1976: Remarks on the evolution of Ordovician conodonts. Acta Palaeontologica Polonica, v. 21, no. 4, pp. 395-455.

1978: Conodont biostratigraphy and paleogeographical relations of the Ordovician Mojcza Limestone (Holy Cross Mts, Poland). Acta Palaeontologica Polonica, v. 23, pp. 51-72.

1983: Relationships between Ordovician Baltic and North

American Midcontinent conodont faunas. Fossils and Strata, No. 15, pp. 59-85.

EPSTEIN, A.G., EPSTEIN, J.B., and HARRIS, L.D.

1977: Conodont color alteration - an index to organic metamorphism. United States Geological Survey, Professional Paper 995, 27 pp.

ETHINGTON, R.L.

1959: Conodonts of the Ordovician Galena Formation. Journal of Paleontology, v. 33, pp. 257-292.

ETHINGTON, R.L., and CLARK, D.L.

1971: Lower Ordovician conodonts in North America. Geological Society of America, Memoir 127, pp. 63-82.

ETHINGTON, R.L., and FURNISH, W.M.

1959: Ordovician conodonts from northern Manitoba. Journal of Paleontology, v. 33, pp. 540-546.

ETHINGTON, R.L., and SCHUMACHER, D.

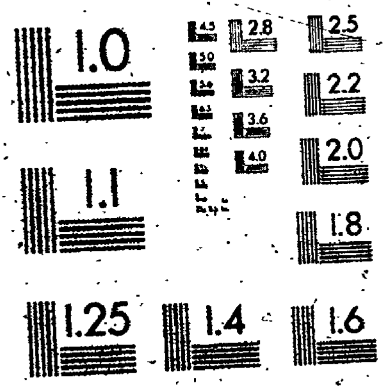
1969: Conodonts of the Copenhagen Formation (Middle Ordovician) in central Nevada. Journal of Paleontology, v. 43, pp. 440-484.

FAHRAEUS, L.E.

1966: Lower Viruan (Middle Ordovician) conodonts from the Gullhogen quarry, southern central Sweden. Sveriges geologiska undersökning, Avhandlingar och uppsater, Serie C, No. 610, Arsbok, No. 5, 40 pp.

1970: Conodont-based correlations of Lower and Middle Ordovician strata in western Newfoundland.

5



Geological Society of America Bulletin, v. 81, pp. 2061-2076.

1971: Lower Devonian conodonts from the Michelle and Prongs Creek formations, Yukon Territory. Journal of Paleontology, v. 45, pp. 665-583.

1982: Allopatric speciation and lineage zonation exemplified by the <u>Pygodus</u> <u>serrus</u> - <u>P.</u> <u>anserinus</u> transition (Conodontophorida, Ordovician). Newsletters on Stratigraphy, v. 11, no. 1, pp. 1-7.

FAHRAEUS, L.E., and BARNES, C.R.

1981: Conodonts from the Becscie and Gun River formations (Lower Silurian) of Anticosti Island, Quëbec. <u>In</u> Field Meeting, Anticosti - Gaspê, Quêbec, 1981, v.II: Stratigraphy and Paleontology. <u>Edited</u> <u>by</u> P.J. Lespèrance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Dêpartement de gêologie, Universitê de Montrêal, pp. 165-172.

FAHRAEUS, L.E., and HUNTER, D.R.

1981: Paleoecology of selected conodontophorid species from the Cobbs Arm Formation (middle Ordovician), New World Island, north-central Newfoundland. Canadian Journal of Earth Sciences, v. 21, pp. 1653-1665.

FAHRAEUS, L.E. and NOWLAN, G.S.

1978: Franconian (Late Cambrian) to early Champlainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland. Journal of Paleontology, v. 52, pp. 444-471.

GABRIELSE, H.

1967: Tectonic evolution of the northern Canadian Cordillera. Canadian Journal of Earth Sciences, v. 4, pp. 271-298.

GABRIELSE, H., BLUSSON, S.L., and RODDICK, J.A.

1973: Geology of the Flat River, Glacier Lake, and Wrigley Lake map-areas, District of Mackenzie and the Yukon Territory (95E, L, M). Geological Survey of Canada, Memoir 366.

GASTIL, R.G., and MILLER, R.H.

1981: Lower Paleozoic strata on the Pacific plate of North America. Nature, v. 292, pp. 828-830.

GLENISTER, A.T.

1957: The conodonts of the Ordovician Maquoketa Formation in Iowa. Journal of Paleontology, v. 31, pp. 715-736.

GLOBENSKY, Y., and JAUFFRED, J.C.

1971: Stratigraphic distribution of conodonts in the Middle Ordovician Neuville section of Quebec. Proceedings of the Geological Association of Canada, v.23, pp. 43-68.

HADDING, A.

1913: Undre Dicellograptusskiffern i Skane jämte nagra darmed ekvwalenta bildningar. Lunds Universitets

Arsskrift, N.F. v. 2, pp. 1-90.

HAMAR, G.

1964: Conodonts from the lower Middle Ordovician of Ringerike. Norsk Geologisk Tidsskrift, v. 44, pp. 243-292.

1966: The Middle Ordovician of the Oslo Region, Norway. 22. Preliminary report on conodonts from the Oslo - Asker and Ringerike districts. Norsk Geologisk Tidsskrift, v. 46, pp. 27-83.

HARRIS, A.G., BERGSTROM, S.M., ETHINGTON, R.L., and ROSS, R.J., JR.

1979: Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions. Brigham Young University Geology Studies, No. 26, Part 3, pp. 7-44.

HARRIS, A.G., HATCH, N.L., and DUTRO, J.T.

1983: Late Silurian conodonts update the metamorphosed Fitch Formation, Litteton area, New Hampshire. American Journal of Science, v. 283, pp. 722-738.

HARRIS, R.W.

1962: New conodonts from Joins (Ordovician) Formation of Oklahoma. Oklahoma Geology Notes, v. 22, pp. 199-211.

HEDBERG, H.D. (editor)

1976: International Guide. A Guide to Stratigraphic Classification Terminology, and Procedure. International Subcommission on Stratigraphic

Classification of IUGS Commissin on Stratigraphy. John Wiley and Sons, New York, New York, 200 pp.

HELFRICH, C.T.

1975: Silurian conodonts from Wills Mountain Anticline, Virginia, West Virginia, and Maryland. Geological Society of America, Special Paper 161, 82 pp.

1978: A conodont fauna from the Keyser Limestone of Virginia and West Virginia. Journal of Paleontology, v. 52, pp. 1133-1142.

1980: Late Llandovery - early Wenlock conodonts from the upper part of the Rose Hill and the basal part of the Mifflintown Formations, Virginia, West Virginia, and Maryland. Journal of Paleontology, v. 54, pp. 557-569.

HENNINGSMOEN, G.

1948: The Tretaspis of the Kullatorp core. Geological Institution of the University of Upsala, Bulletin, v. 32, pp. 374-432.

HILLS, L.V., SANGSTER, E.V., and SUNEBY, L.B. (editors)

1981: Lexicon of Canadian Stratigraphy, Volume 2, Yukon and District of Mackenzie. Canadian Society of Petroleum Geologists, Calgary, Alberta, 240 pp.

HURST, J.M.

1975: The diachronism of the Wenlock Limestone. Lethaia, v. 8, pp. 301-314.

IGO, H., and KOIKE, T.

1968: Ordovician and Silurian conodonts from the Langkawi Islands, Malaya, Part II. Geology and

Palaeontology of Southeast Asia, v. 4, pp. 1-21.

INNIS, J.W.

1980: Sedimentology and stratigraphy of the Ordovician - Silurian Road River Formation, southern Richardson Mountains, Yukon Territory. Unpublished Masters of Science thesis, University of Western Ontario, London, Ontario, i-xii, 195 pp.

JACKSON, D.E., and LENZ, A.C.

1962: Zonation of Ordovician and Silurian graptolites of northern Yukon. American Association of Petroleum Geologists, Bulletin, v. 46, pp. 30-45.

JACKSON, D.E., LENZ, A.C., and PEDDER, A.E.H.

1978: Late Silurian and Early Devonian graptolite, brachiopod and coral faunas from northwestern and Arctic Canada. Geological Association of Canada, Special Paper No. 17, 159 pp.

JELETZKY, J.A.

1962: Pre-Cretaceous Richardson Mountains Trough: its place in the tectonic framework of Arctic Canada and its bearing on some geosynclinal concepts. Transactions of the Royal Society of Canada, v. LVI, Series III, Section III, pp. 55-84.

JEPPSSON, L.

1969: Notes on some Upper Silurian multielement conodonts. Geologiska Föreningens i Stockholm Förhandlingar, v. 91, pp. 12-24.

1972: Some Silurian conodont apparatuses and possible conodont dimorphism. Geologica et Palaeontologica, v. 6, pp. 51-69.

1974: Aspects of Late Silurian conodonts. Fossils and Strata, No. 6, 54 pp.

1979: Conodonts. In Lower Wenlock faunal and floral dynamics - Vattenfallet section, Gotland. Edited by V. Jaanusson, S. Laufeld and R. Skoglund. Sveriges Geologiska Undersokning, C 762, pp. 225-248.

KENNEDY, D.J.

1980: A restudy of conodonts described by Branson and Mehl, 1933, from the Jefferson City Formation, Lower Ordovician, Missouri. Geologica et Palaeontologica, v. 14, pp. 45-76.

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. Canadian Journal of Earth Sciences, v. 16, pp. 540-551.

KLAPPER, G., and BARRICK, J.E.

1983: Middle Devonian (Eifelian) conodonts from the Spillville Formation in northern Iowa and southern Minnesota. Journal of Paleontology, v. 57, pp. 1212-1243.

KLAPPER, G. and MURPHY, M.A.

1975: Silurian - Lower Devonian conodont sequence in the Roberts Mountains Formation of central Nevada. University of California Publications in

Geological Sciences, v. III, 87 pp. (imprint 1974).

KLAPPER, G. and PHILIP, G.M.

1971: Devonian conodont apparatuses and their vicarious skeletal elements. Lethaia, v. 4, pp. 429-452.

KNUPFER, J.

1967: Zur fauna und biostratigraphie des Ordovizuims (Gräfenthaler Schichten) in Thuringen. Freiberger Forschungshefte, C220 (Pälaontologie), 119 pp.

KOHUT, J.J., and SWEET, W.C.

1968: The American Upper Ordovician standard. X. Upper Maysville and Richmond conodonts from the Cincinnati region of Ohio, Kentucky and Indiana. Journal of Paleontology, v. 42, pp. 1456-1477.

KUWANO, Y.

1976: Finding of Silurian conodont assemblages from the Kurosegawa tectonic zone in Shikoku, Japan. Memoirs of the National Science Museum, Tokyo, Japan, No. 9, pp. 17-23.

LAMONT, A., and LINDSTROM, L.

1957: Arenigian and Llandeilian cherts identifed in the Southern Uplands of Scotland by means of conodonts, etc. Edinburgh Geological Society Transactions, v. 17, pp. 60-70.

LANDING, E.

1976: Early Ordovician (Arenigian) conodont and graptolite biostratigraphy of the Taconic Allochthon, eastern New York. Journal of

Paleontology, v. 50, pp. 614-646.

LEE, HA-YOUNG

1982: Conodonts from the Hoedongri Formation (Silurian) western Jeongseon area, Kangweon-do, South Korea. Journal of the National Academy of Sciences, Republic of Korea, Natural Science Series, v. 21, pp. 45-131.

LE FEVRE, J., BARNES, C.R., and TIXIER, M.

1976: Paleoecology of Late Ordovician and Early Silurian conodontophorids, Hudson Bay Basin. In Conodont Paleoecology. Edited by C.R. Barnes. Geological Association of Canada, Special Paper No. 15, pp. 69-89.

LENZ, A.C.

1972: Ordovician to Devonian history of northern Yukon and adjacent District of Mackenzie. Bulletin of Canadian Petroleum Geology, v. 20, pp. 321-361.

1976: Late Ordovician - Early Silurian glaciation and the Ordovician - Silurian boundary in the northern Canadian Cordillera. Geology, v. 4, pp. 313-317.

1978: Llandoverian and Wenlockian Cyrtograptus, and some other Wenlockian graptolites from northern and arctic Canada. Geobios, v. 11, no. 5, pp. 623-653.

1979: Llandoverian graptolite zonation in the northern Canadian Cordillera. Acta Palaeontologica Polonica, v. 24, pp. 137-153.

1980: Wenlockian graptolite reference section, Clearwater Creek, Nahanni National Park, Northwest Territories, Canada. Canadian Journal of Earth Sciences, v. 17, pp. 1075-1086.

1982a: Llandoverian graptolites of the northern Canadian Cordillera: Petalograptus, Cephalograptus, Rhaphidograptus, Dimorphograptus, Retiolitidae, and Monograptidae. Royal Ontario Museum, Life Sciences Contributions, No. 130, 154 pp.

1982b: Ordovician to Devonian sea-level changes in western and northern Canada. Canadian Journal of Earth Sciences, v. 19, pp. 1919-1932.

LENZ, A.C., and CHEN XU

1985: Middle to Upper Ordovician graptolite biostratigraphy of Peel River, and other areas of the northern Canadian Cordillera. Canadian Journal of Earth Sciences, v. 22, pp. 227-239.

LENZ, A.C., and JACKSON, D.E.

in press: Arenigian and Llanvirnian graptolite biostratigraphy, Canadian Cordillera. Journal of the Geological Society of London.

LENZ, A.C., and McCRACKEN, A.D.

1982: The Ordovician - Silurian boundary, northern Canadian Cordillera: graptolite and conodont correlation. Canadian Journal of Earth Sciences, v. 19, pp. 1308-1322.

LENZ, A.C., and PEDDER, A.E.H.

1972: Lower and Middle Paleozoic sediments and paleontology of Royal Creek and Peel River, Yukon, and Powell Creek, N.W.T. Twenty - fourth International Geological Congress, Montreal, 1972, Field Excursion A14, Guidebook, 43 pp.

LIEBE, R.M. and REXROAD, C.B.

1977: Conodonts from Alexandrian and early Niagaran rocks in the Joliet, Illinois area. Journal of Paleontology, v. 51, pp. 844-857.

LINDSTROM, M.

1955: Conodonts from the lowermost Ordovician strata of south-central Sweden. Geologiska Föreningens i Stockholm Förhandlingar, v.76, pp. 517-604.

1964: Conodonts. Elsevier, New York, New York, 196 pp.

1970: A suprageneric taxonomy of the conodonts. Lethaia, v. 3, pp. 427-445.

1971: Lower Ordovician conodonts of Europe. In Symposium on conodont biostratigraphy. Edited by W.C. Sweet and S.M. Bergström. Geological Society of America, Memoir 127, pp. 21-61.

LINDSTROM, M., and ZIEGLER, W.

1971: Feinstrukturelle Untersuchungen an Conodonten 1. Die Uberfamilie Panderodontacea. Geologica et Palaeontologica, v. 5, pp. 9-33.

LINK, A.G., and DRUCE, E.C.

1972: Ludlovian and Gedinnian conodont stratigraphy of the Yass Basin, New South Wales. Bureau of Mineral Resources of Australia, Bulletin, v. 134, pp. 1-136.

LIN YAO-KUN and CHEN XU

1983: Glyptograptus persculptus Zone - the earliest graptolite zone from Yangzi gorges, China. In Stratigraphy and Paleoecology of Systemic Boundaries in China: Ordovician - Silurian Boundary (1), pp. 203-225, 6 pl.

LOFGREN, A.

1978: Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. Fossils and Strata, No. 13, 129 pp.

MABILLARD, J.E., and ALDRIDGE, R.J.

1983: Conodonts from the Coralliferous Group (Silurian) of Marloes Bay, South-West Dyfed, Wales. Geologica et Palaeontologica, v. 17, pp. 29-43.

1985: Microfossil distribution across the base of the Wenlock Series in the type area. Palaeontology, v. 28, pp. 89-100.

MANARA, C., and VAI, G.B.

1970: La sezione e i conodonti del costone sud del M. Rauchkofel (Paleozoico), Alpi Carniche. Giornale di Geologia, v. 36, pp. 441-514.

MANNIK, P.

1983: Silurian conodonts from Severnaya zemlya. Fossils and Strata, No. 15, pp. 111-119.

MAYR, U., UYENO, T.T., and BARNES, C.R.

1978: Subsurface stratigraphy, conodont zonation, and organic metamorphism of the Lower Paleozoic succession, Bjorne Peninsula, Ellesmere Island, District of Franklin. *In* Current Research, Part A. Geological Survey of Canada, Paper 78-1A, pp. 393-398.

MAYR, U., UYENO., T.T., TIPNIS, R.S., and BARNES, C.R.

1980: Subsurface straigraphy and conodont zonation of the Lower Paleozoic succession, Arctic Platform, southern Arctic Archipelago. *In* Current Research, Part A. Geological Survey of Canada, Paper 80-1A, pp. 209-215.

McCRACKEN, A.D., and BARNES, C.R.

1981a: Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Québec, with special reference to the Late Ordovician - Early Silurian chronostratigraphy and the systemic boundary. Geological Survey of Canada, Bulletin 329, Part 2, pp. 51-134.

1981b: Conodont biostratigraphy across the Ordovician - Silurian boundary, Ellis Bay Formation, Anticosti Island, Québec. *In* Field Meeting, Anticosti - Gaspé, Québec, 1981, v.II: Stratigraphy and Paleontology. *Edited by* P.J. Lespérance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 61-69.

1982: Restudy of conodonts (Late Ordovician - Early Silurian) from the Edgewood Group, Clarksville, Missouri. Canadian Journal of Earth Sciences, v. 19, pp. 1474-1485.

McCRACKEN, A.D., and LENZ, A.C.

1980: Ordovician - Silurian conodonts and graptolites: Road River Formation, Peel and Blackstone rivers, northern Yukon. Program with Abstracts, Geological Association of Canada, Mineralogical Association of Canada, Joint Annual Meeting, v. 5, p. 69 (abstract).

1981: Ordovician - Silurian conodonts and graptolites: Road River Formation, Pat Lake, Lower Peel and Rock rivers, northern Yukon. Geological Association of Canada, Mineralogcial Association of Canada, Joint Annual Meeting, v. 6, p. A-38 (abstract).

1985: Conodont paleontology and conodont-graptolite biostratigraphy from the Ordovician-Silurian of the Road River Fm., Richardson Mountains, northern Yukon, Canada. Geological Society of America, Abstracts with Programs, v. 17, no. 2, p. 123 (abstract).

McCRACKEN, A.D., and NOWLAN, G.S.

1984: Conodonts from Ordovician - Silurian boundary strata, Whittaker Formation, Avalanche Lake, Mackenzie Mountains, Northwest Territories, Canada. Geological Society of America, Abstracts with Programs, v. 16, no. 3, p. 179 (abstract).

McCRACKEN, A.D., NOWLAN, G.S., and BARNES, C.R.

1980: Gamachignathus, a new multielement conodont genus from the latest Ordovician, Anticosti Island, Québec. In Current Research, Part C. Geological Survey of Canada, Paper 80-C, pp. 103-112.

McLAREN, D.J.

1970: Presidential address: time, life and boundaries. Journal of Paleontology, v. 44, pp. 801-813.

MERRILL, G.K.

1980: Ordovician conodonts from the Aland Islands, Finland. Geologiska Föreningens i Stockholm Förhandlingar, v. 101, pp. 329-341 (imprint 1979).

MILLER, J.F.

1980: Taxonomic revisions of some Upper Cambrian and Lower Ordovician conodonts with comments on their evolution. The University of Kansas Paleontological Contributions, Paper 99, 39 pp.

MILLER, R.H.

1975: Late Ordovician - Early Silurian conodont biostratigraphy, Inyo Mountains, California. Geological Society of America, Bulletin, v. 86, pp. 159-162.

1976: Revision of Upper Ordovician, Silurian, and Lower Devonian stratigraphy, southwestern Great Basin. Geological Society of America, Bulletin, v. 87, pp. 961-968.

1978: Early Silurian to Early Devonian conodont biostratigraphy and depositional environments of the Hidden Valley Dolomite, southeastern California. Journal of Paleontology, v. 52, pp.323-344.

MIRZA, K.

1976: Late Ordovician to Late Silurian stratigraphy and conodont biostratigraphy of the eastern Canadian Arctic Islands. Unpublished Masters of Science thesis, University of Waterloo, Waterloo, Ontario, i-xiii, 302 pp.

MOSTLER, H.

1967: Conodonten aus dem tieferen Silur der Kitzbühler Alpen (Tirol). Annalen des Naturhistorischen Museums in Wien, v. 71, pp. 295-303.

MURPHY, M.A., DUNHAM, J.B., BERRY, W.B.N., and MATTI, J.C.

1979: Late Llandovery unconformity in central Nevada. Brigham Young University Geological Studies, v. 26, Part 1, pp. 21-36.

NICOLL, R.S.

1980: Middle Ordovician conodonts from the Pittman Formation, Canberra, ACT. Bureau of Mineral Resources of Australia, Journal of Australian Geology and Geophysics, v. 5, pp. 150-153.

NICOLL, R.S., and REXROAD, C.B.

1969: Stratigraphy and conodont paleontology of the Salamonie Dolomite and the Lee Creek Member of the Brassfield Limestone (Silurian) in southeastern Indiana and adjacent Kentucky. Indiana Geological Survey, Bulletin 40, 73 pp., 7 pl. (imprint 1968).

NORFORD, B.S.

1964: Reconnaissance of the Ordovician and Silurian rocks of northern Yukon Territory. Geological Survey of Canada, Paper 63-39, 139 pp.

1976: Faunas and correlation of the uppermost Lower Silurian Tegart Formation, southeastern British Columbia. Geological Association of Canada, Mineralogical Association of Canada, Annual Meetings, Program with Abstracts, v. 1, p. 39 (abstract).

1979: Lower Devonian graptolites in the Road River Formation, northern British Columbia. In Current Research, Part A. Geological Association of Canada, Paper 79-1A, pp. 383, 384.

NORFORD, B.S., BARSS, M.S., BRIDEAUX, W.W., CHAMNEY, T.P., FRITZ, W.H., HOPKINS, W.S., Jr., JELETZKY, J.A., PEDDER, A.E.H., and UYENO, T.T.

1971: Biostratigraphic determinations of fossils from the subsurface of the Yukon Territory and District of Mackenzie. Geological Survey of Canada, Paper 71-15, 25 pp.

NORFORD, B.S., BRAUN, W.K., CHAMNEY, T.P., FRITZ, W.H., McGREGOR, D.C., NORRIS, A.W., PEDDER, A.E.H., and UYENO, T.T.

1970: Biostratigraphic determinations of fossils from the subsurface of the Yukon Territory and the districts of Mackenzie and Franklin. Geological

Survey of Canada, Paper 70-15, 19 pp.

NORFORD, B.S., BRIDEAUX, W.W., CHAMNEY, T.P., COPELAND, M.J., FREBOLD, H., HOPKINS., W.S., Jr., JELETZKY, J.A., JOHNSON, B., McGREGOR, D.C., NORRIS, A.W., PEDDER, A.E.H., TOZER, E.T., and UYENO, T.T.

1973: Biostratigraphic determinations of fossils from the subsurface of the Yukon Territory and districts of Franklin, Keewatin and Mackenzie. Geological Survey of Canada, Paper 72-38, 29 pp.

NOWLAN, G.S.

1981a: Some Ordovician conodont faunules from the Miramichi Anticlinorium, New Brunswick. Geological Survey of Canada, Bulletin 345, 35 pp.

1981b: Late Ordovician - Early Silurian conodont biostratigraphy of the Gaspé Peninsula - a preliminary report. In Field Meeting, Anticosti - Gaspé, Québec, 1981, v.II: Stratigraphy and Paleontology. Edited by P.J. Lespérance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 257-291.

1983a: Biostratigraphic, paleogeographic and tectonic implications of late Ordovician conodonts from the Grog Brook Group, northwestern New Brunswick. Canadian Journal of Earth Sciences, v. 20, pp. 651-671.

1983b: Early Silurian stratigraphy of eastern Canada. Fossils and Strata, No. 15, pp. 95-110.

NOWLAN, G.S., and BARNES, C.R.

1981: Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Québec. Geological Survey of Canada, Bulletin 329, Part 1, pp. 1-49.

NOWLAN, G.S., McCRACKEN, A.D., and CHATTERTON, B.D.E.

1984: Late Ordovician - early Silurian conodont biostratigraphy and provincialism in the northern Canadian Cordillera. Geological Association of Canada, Mineralogical Association of Canada, Joint Annual Meetings, Program with Abstaracts, v. 9, p. 94 (abstract).

NOWLAN, G.S., McCRACKEN, A.D., and CHATTERTON, B.D.E.

Conodonts from Ordovician-Silurian boundary strata, Whittaker Mountains, Northwest Territories, Canada. (193 pp., 22 pl. manuscript submitted to Geological Survey of Canada Bulletin)

NOWLAN, G.S., and THURLOW, J.G.

1984: Middle Ordovician conodonts from the Buchans Group, central Newfoundland, and their significance for regional stratigraphy of the Central Volcanic Belt. Canadian Journal of Earth Sciences, v. 21, pp. 284-296.

ORCHARD, M.J.

1980: Upper Ordovician conodonts from England and Wales. Geologica et Palaeontologica, v. 14, pp.

9-44.

1984: A preliminary account of the conodont record at the western edge of the Mackenzie Platform (Nahanni Map Area), northwestern Canada. Geological Society of America, Abstracts with Programs, v. 16, no. 3, p. 185 (abstract).

OVER, D.J.

1985: Some Silurian conodonts from the southern Mackenzie Mountains, Northwest Territories. Unpublished Master of Science thesis, University of Alberta, Edmonton, Alberta, Spring, 1985, 239 p.

PALMIERI, V.

1978: Late Ordovician conodonts from the Fork Lagoons Beds, Emerald area, central Queensland. Geological Survey of Queensland, Publication 369, Palaeontological Paper 43, 55 pp.

PANDER, C.H.

1856: Monographie der fossilen Fische des Silurischen Systems der russisch - baltischen Gouverments. Akademie der Wissenschaften, St. Petersburg, pp. 1-91.

PARIS, F., PELHATE, A., and WEYANT, M.

1981: Conodontes ashgilliens dans la Formation de Rosan, coupe de Lostmarc'h (Finistère, Massif armoricain). Conséquences paléogéographiques. Bulletin Société geologique et minéralogique de Bretgene, 1981(c), XIII, v. 2, pp. 15-35.

PERRY, D.G., KLAPPER, G., and LENZ, A.C.

1974: Age of the Ogilvie Formation (Devonian), northern Yukon: based primarily on the occurrence of brachiopods and conodonts. Canadian Journal of Earth Sciences, v. 11, pp. 1055-1097.

PETRYK, A.A.

1981a: Stratigraphy, sedimentology and paleogeography of the Upper Ordovician - Lower Silurian of Anticosti Island, Québec. <u>In</u> Field Meeting, Anticosti - Gaspé, Québec, 1981, v. II: Stratigraphy and Paleontology. <u>Edited</u> <u>by</u> P.J. Lespérance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 11-39.

1981b: Upper Ordovician glaciation: Effects of eustatic sea-level fluctuations on the Anticosti Platform Succession, Québec. <u>In</u> Field Meeting, Anticosti - Gaspé, Québec, 1981, v. II: Stratigraphy and Paleontology. <u>Edited</u> <u>by</u> P.J. Lespérance. International Union of Geolgical Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 81-85.

PICKETT, J.

1978: Silurian conodonts from Blowclear and Liscombe

Pools, New South Wales. Journal and Proceedings, Royal Society of New South Wales, v. 111, pp. 35-39.

POLLOCK, C.A., REXROAD, C.B., and NICOLL, R.S.

1970: Lower Silurian conodonts from northern Michigan and Ontario. Journal of Paleontology, v. 44, pp. 743-764.

PRICE, D.

1984: The Pusgillian Stage in Wales. Geological Magazine, v. 121, pp. 99-105.

PUGH, D.C.

1983: Pre-Mesozoic geology in the subsurface of Peel River Map area, Yukon Territory and District of Mackenzie. Geological Survey of Canada, Memoir 401, 61 pp. (also includes microfiche of paleontology, mineralogy, well data; isopach, lithofacies maps, stratigraphic cross sections).

REPETSKI, J.E.

1982: Conodonts from El Paso Group (Lower Ordovician) of westernmost Texas and southern New Mexico. New Mexico Bureau of Mines and Mineral Resources, Memoir 40, 121 pp.

REPETSKI, J.E., and ETHINGTON, R.L.

1977: Conodonts from graptolitic facies in the Ouachita Mountains, Arkansas and Oklahoma. <u>In</u> Symposium on the Geology of the Ouachita Mountains, v. 1: Stratigraphy, Sedimentology, Petrography, Tectonics, and Paleontology. Edited by C.G.

Stone. Arkansas Geological Commission, pp. 92-106.

REXROAD, C.B.

1967: Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area. Indiana Geological Survey, Bulletin 38, 64 pp., 4 pl.

1980: Stratigraphy and conodont paleontology of the Cataract Formation and the Salamonie Dolomite (Silurian) in northeastern Indiana. Indiana Geological Survey, Bulletin 58, 83 pp.

REXROAD, C.B., and NICOLL, R.S.

1971: Summary of conodont biostratigraphy of the Silurian System of North America. In Symposium on Conodont Biostratigraphy. Edited by W.C. Sweet and S.M. Bergström. Geological Society of America, Memoir 127, pp. 207-225.

REXROAD, C.B., NOLAND, A.V., and POLLOCK, C.A.

1978: Conodonts from the Louisville Limestone and the Wabash Formation (Silurian) in Clark County, Kentucky. Indiana Geological Survey, Special Report 16, 19 pp.

RHODES, F.H.T.

1953: Some British Lower Paleozoic conodont faunas. Philosophical Transactions of the Royal Society of London, Series B, v. 237, no. 647, pp. 261-334.

1955: The conodont fauna of the Keisley Limestone.

Quarterly Journal of the Geological Society, v. 111, pp. 117-142.

RICKARDS, R.B.

1976: The sequence of Silurian graptolite zones in the British Isles. Geological Journal, v. 11, pp. 153-188.

ROBISON, R.A. (editor)

1981: Conodonta. In Treatise on Invertebrate Paleontology, Part W, Miscellanea, Supplement 2. Geological Society of America and University of Kansas Press, Boulder, Colorado, and Lawrence, Kansas, xxviii, 202 pp.

ROSS, R.J., Jr., ADLER, F.J., AMSDEN, T.W., BERGSTROM, D., BERGSTROM, S.M., CARTER, C., CHURKIN, M., CRESSMAN, E.A., DERBY, J.R., DUTRO, J.T., Jr., ETHINGTON, R.L., FINNEY, S.C., FISHER, D.W., FISHER, J.H., HARRIS, A.G., HINTZE, L.F., KETNER, K.B., KOLATA, D.L., LANDING, E., NEUMAN, R.B., SWEET, W.C., POJETA, J., Jr., POTTER, A.W., RADER, E.K., REPETSKI, J.R., SHAVER, R.H., THOMPSON, T.L., and WEBERS, G.F.

1982a: The Ordovician System in the United States: correlation chart and explanitory notes. International Union of Geological Sciences, Publication No. 12, 73 pp.

ROSS, R.J., Jr., NAESER, C.W., IZETT, G.A., OBRADOVICH, J.B., BASSETT, M.G., HUGHES, C.P., COCKS, L.R.M., DEAN, W.T., INGHAM, J.K., JENKINS, C.J., RICKARDS, R.B., SHELDON, P.R., TOGHILL, P., WHITTINGTON, H.B., and ZALASIEWICZ, J.

1982b: Fission - track dating of British Ordovician and Silurian stratotypes. Geological Magazine, v. 119, pp. 135-153.

ROSS, R.J., Jr., NOLAN, T.B., and HARRIS, A.G.

1979: The Upper Ordovician and Silurian Hanson Creek Formation of central Nevada. United States Geological Survey, Professional Paper 1126-C, pp. C1-C22.

SATTERFIELD, I.R.

1971: Conodonts and stratigraphy of the Girardeau Limestone (Ordovician) of southeast Missouri and southwest Illinois. Journal of Paleontology, v. 45, pp. 265-273.

SAVAGE, N.M., POTTER, A.W., and GILBERT, W.G.

1983: Silurian and Silurian to early Devonian conodonts from west-central Alaska. Journal of Paleontology, v. 57, pp. 873-875.

SCHONLAUB, H.P.

1971: Zur Problematik der Conodonten - Chronologie an der Wende Ordoviz/Silur mit besonderer Berücksichtigung der Verhältnisse im Llandovery. Geologica et Palaeontologica, v. 5, pp. 35-57.

1975: Conodonten aus dem Llandovery der Westkarawanken (Osterreich). Verhandlungen der Geologischen Bundesanstalt, v. 2-3, pp. 45-65.

SCHOPF, T.J.M.

1966: Conodonts of the Trenton Group (Orodvician) in New York, southern Ontario and Québec. New York

State Museum and Science Service, Bulletin 405, 105 pp.

SERGEEVA, S.P.

1963: Conodonts from the Lower Ordovician in the Leningrad region. Akademia Nauka USSR, Paleontologischeskiy, Zhurnal, 1963, pp. 93-108 (in Russian).

SERPAGLI, E.

1967: I conodonti dell'Ordoviciano superiore (Ashgilliano) delle Alpi Carniche. Bolletino della Società Paleontologica Italiana, v. 6, pp. 30-111.

SIMES, J.E.

1980: Age of the Arthur Marble: conodont evidence from Mount Owen, northwest Nelson. New Zealand Journal of Geology and Geophysics, v. 23, pp. 529-532.

STAUFFER, C.R.

1930: Conodonts from the Decorah Shale. Journal of Paleontology, v. 4, pp. 121-128.

1935: Conodonts of the Glenwood Beds. Geological Society of America, Bulletin, v. 46, pp. 125-168.

1940: Conodonts from the Devonian and associated clays of Minnesota. Journal of Paleontology, v. 14, pp. 417-435.

STONE, G.L., and FURNISH, W.M.

1959: Bighorn conodonts from Wyoming. Journal of Paleontology, v. 33, pp. 211-228.

STOUGE, S., and BOYCE, W.D.

1983: Fossils of northwestern Newfoundland and southeastern Labrador: conodonts and trilobites. Mineral Development Division, Department of Mines and Energy, Government of Newfoundland and Labrador, Report 83-3, 55 pp.

SWEET, W.C.

1979a: Conodonts and conodont biostratigraphy of post - Tyrone Ordovician rocks of the Cincinnati Region. United States Geological Survey, Professional Paper 1066G, pp. G1-G26.

1979b: Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province. Brigham Young University Geological Studies, v. 26, Part 3, pp. 45-86.

1982: Conodonts from the Winnipeg Formation (Middle Ordovician) of the Black Hills, South Dakota. Journal of Paleontology, v. 56, pp. 1029-1049.

1983: Conodont biostratigraphy of Fite Formation and Viola Group. Oklahoma Geological Survey, Bulletin 132, Part II, pp. 23-51.

1984: Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A. *In* Aspects of the Ordovician System. *Edited by* D.L. Brunton. Palaeontological Contributions from the University of Oslo, No. 295, Universitetsforlaget, pp. 23-35.

SWEET, W.C., and BERGSTROM, S.M.

1962: Conodonts from the Pratt Ferry Formation (Middle

Ordovician) of Alabama. Journal of Paleontology, v. 36, pp. 1214-1252.

1970: The generic concept in conodont taxonomy. Proceedings of the North American Paleontological Convention, September, 1969, Part C, pp. 157-173.

1971: The American Upper Ordovician standard. XIII: A reivsed time - stratigraphic classification of North American Upper Middle and Upper Ordovician rocks. Geological Society of America, Bulletin, v. 82, pp. 613-627.

1972: Multielement taxonomy and Ordovician conodonts. Geologica et Palaeontologica, SB1, pp. 29-42.

1976: Conodont biostratigraphy of the Middle and Upper Ordovician of the United States midcontinent. *In* The Ordovician System: Proceedings of a Palaeontological Association Symposium, Birmingham, September, 1974. *Edited by* M.G. Bassett. University of Wales Press and National Museum of Wales, Cardiff, pp. 121-151.

SWEET, W.C., ETHINGTON, R.L., and BARNES, C.R.

1971: North American Middle and Upper Ordovician conodont faunas. *In* Symposium on Conodont Biostratigraphy. *Edited by* W.C. Sweet and S.M. Bergström. Geological Society of America, Memoir 127, pp. 163-193.

SWEET, W.C., and SCHONLAUB, H.P.

1975: Conodonts of the genus *Oulodus* Branson and Mehl, 1933. Geologica et Palaeontologica, v. 9, pp. 41-59.

SWEET, W.C., THOMPSON, T.L., and SATTERFIELD, I.R.

1975: Conodont biostratigraphy of the Cape Limestone (Maysvillian) of eastern Missouri. Missouri Geological Survey, Report of Investigations 57, Part 1, pp. 1-59.

TIPNIS, R.S.

1978: Early Middle Ordovician conodonts of North Atlantic Province from northeastern Ellesmere Island. In Current Research, Part C, Geological Survey of Canada, Paper 78-1C, pp. 75-78.

TIPNIS, R.S., CHATTERTON, B.D.E., and LUDVIGSEN, R.

1978: Ordovician conodont biostratigraphy of the southern District of Mackenzie, Canada. In Western and Arctic Canadian Biostratigraphy. Edited by C.R. Stelck and B.D.E. Chatterton. Geological Association of Canada, Special Paper No. 18, pp. 39-91.

THOMPSON, T.L., and SATTERFIELD, I.R.

1975: Stratigraphy and conodont biostratigraphy of strata contiguous to the Ordovician - Silurian boundary in eastern Missouri. Missouri Geological Survey, Report of Investigations 57, Part 2, pp. 61-108.

UYENO, T.T.

1974: Conodonts of the Hull Formation, Ottawa Group (Middle Ordovician) of the Ottawa - Hull area, Ontario and Quebec. Geological Survey of Canada, Bulletin 248, 31 pp.

UYENO, T.T., and BARNES, C.R.

1970: Conodonts from the Lèvis Formation (Zone D1) (Middle Ordovician), Lèvis, Quebec. Geological Survey of Canada, Bulletin 187, pp. 99-123.

1981: A summary of Lower Silurian conodont biostratigraphy of the Jupiter and Chicotte formations, Anticosti Island, Québec. In Field Meeting, Anticosti - Gaspè, Québec, 1981, v.II: Stratigraphy and Paleontology. Edited by P.J. Lespèrance. Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Dèpartement de gèologie, Universitè of Montrèal, pp. 173-184.

1983: Conodonts of the Jupiter and Chicotte Formations (Lower Silurian), Anticosti Island, Quebec. Geological Survey of Canada, Bulletin 355, 49 pp.

VAN WAMEL, W.A.

1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of northwestern Oland, southeastern Sweden. Utrecht Micropaleontological Bulletins, No. 10, 126 pp.

VIIRA, V.

1967: Ordovician conodont succession in the Ohesaare core. Eesti NSV Teaduste Akadeemia Toimetised, Keemia Geoloogia, v. 16, pp. 319-329 (in Russian with English abstract).

1974: Ordovician conodonts of the East Baltic. Eesti

NSV Teaduste Akadeemia Geoloogia Instituut, Tallinn, 142pp. (in Russian with English summary).

WALLISER, O.H.

1957: Conodonten aus dem oberen Gotlandium Deutschlands und der Karnischen Alpen. Notizblatt des Hessischen Landesamtes für Bodenforschung zu Wiesbaden, v. 85, pp. 28-52.

1964: Conodonten des Silurs. Abhandlungen des Hessischen Landesamtes für Bodenforschung, Heft 41, 106 pp.

1971: Conodont biostratigraphy of the Silurian of Europe. In Symposium on Conodont Biostratigraphy. Edited by W.C. Sweet and S.M. Bergström. Geological Society of America, Memoir 127, pp. 195-206.

WANG XAOFENG, ZENG QINGLUAN, ZHOU TIANMEI, NI SHIZHAO, XU GUANGHONG, SUN QUANYING, LI ZHIHONG, XIANG LIWEN, and LAI CAIGEN

1983: Latest Ordovician and earliest Silurian faunas from the eastern Yangtze Gorges, China with comments on Orodovician - Silurian boundary. Bulletin of the Yichang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences, No. 6, pp. 129-163.

WEBERS, G.F.

1966: The Middle and Upper Ordovician conodont faunas of Minnesota. Minnesota Geological Survey, Special Publication 4, 123 pp.

WEBBY, B.D., VANDENBERG, A.H.M., COOPER, R.A., BANKS, M.R., BURRETT, C.F., HENDERSON, R.A., CLARKSON, P.D., HUGES, C.P., LAURIE, J. STAIT, B., THOMPSON, M.R.A., and WEBERS, G.F.

1981: The Ordovician System in Australia, New Zealand and Antarctica. Correlation Chart and Explanitory Notes. <u>Compiled and edited by</u> B.D. Webby. International Union of Geological Sciences, Publication No. 6, 69 pp.

WILLIAMS, A., STRACHAN, I., BASSETT, D.A., DEAN, W.T., INGHAM, J.K., WRIGHT, A.D., and WHITTINGTON, H.B.

1972: A correlation of Silurian rocks in the British Isles. Journal of the Geological Society, Special Report No. 3, 74 pp.

WILLIAMS, S.H.

1983: The Ordovician - Silurian boundary graptolite fauna of Dob's Linn, southern Scotland. Palaeontology, v. 26, pp. 605-639.

WINDER, C.G.

1966: Conodonts from the Upper Cobourg Formation (late Middle Ordovician) at Colbourne, Ontario. Journal of Paleontology, v. 40, pp. 46-63.

WORKUM, R.H., BOLTON, T.E., and BARNES, C.R.

1976: Ordovician geology of Akpatok Island, Ungava Bay, District of Franklin. Canadian Journal of Earth Sciences, v. 13, pp. 157-178.

WORSLEY, D., ALDRIDGE, R.J., BAARLI, B.G., HOWE, M.P.A., and JOHNSON, M.E.

1983a: The Llandovery Series of the Oslo Region. A Submission to the Subcommission on Silurian Stratigraphy, April, 1983. International Commission on Stratigraphy, Subcommission on Silurian Stratigraphy, Palaeontological Contributions from the University of Oslo, No. 287, 38 pp.

WORSLEY, D., BASSET, M.G., ALDRIDGE, R.J., and HOWE, M.P.A.

1983b: Stages in the Llandovery Series of the Ordovician of the Oslo Region: an amended submission. In Two supplementary submissions to the Subcommission on Silurian Stratigraphy, December, 1983. International Commission on Stratigraphy, Subcommission on Silurian Stratigraphy, 11 pp.

ZENG QINGLUAN, NI SHIZHAO, XU GUANGHONG, ZHOU TIANMEI, WANG XIAOFENG, LI ZHIHONG, LAI CAIGEN, and XIANG LIWEN

1983: Subdivision and correlation on the Ordovician in the eastern Yantze Gorges, China. Bulletin of the Yichang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences, No. 6, pp. 22-68.

ZIEGLER, A.M., RICKARDS, R.B., and McKERROW, W.S.

1974: Correlation of the Silurian rocks of the British Isles. Edited by W.B.N. Berry and A.J. Boucot. Geological Society of America, Special Paper 154, 154 pp.

ZIEGLER, P.A.

1969: The development of sedimentary basins in Western and Arctic Canada. Alberta Society of Petroleum Geologists, 89 pp. (plus stratigraphic diagrams).

ZIEGLER, W.

1960: Conodonten aus dem Rheinischen Unterdevon (Gedinnium) des Remscheider Sattels (Rheinisches Schiefergbirge). Paläontologische Zeitschrift, v. 34, pp. 169-201.

PLATE 1

All are lateral views and from RR78-13m, except where noted.

FIGURE 1.

"Cordylodus" horridus BARNES and POPLAWSKI

Lateral view, X (ADM 20097).

FIGURE 2.

Spinodus spinatus (HADDING)

Cordylodontiform (a-1) element, X (ADM 20515).

FIGURES 3, 4, 8, 9, 12, 19.

Diaphorodus? sp. A

FIGS. 3, 4: cordylodontiform element, outer and inner lateral views, X, X (ADM 20129).

FIGS. 8, 9: cordylodontiform element, outer and inner lateral views, X, X (ADM 20130).

FIGS. 12, 19: oistodontiform elements, ?inner and inner lateral views, X (ADM 20131), X (ADM 20132).

FIGURE 5.

Prioniodus (Oepikodus)? sp. A

Gothodontiform (a) element, outer lateral view, X (ADM 20350).

FIGURES 6, 7.

Walliserodus? ethingtoni (FAHRAEUS)

Symmetrical (c) element, X, X (ADM 20519).

FIGURES 10, 11, 14, 15.

Eoplacognathus? sp. A

Platform (*g*?) elements, oral views. FIG. 10: X (ADM 20180); FIG. 11: X (ADM 20181); FIG. 14: X (ADM 20182); FIG. 15: X (Element 1; ADM 20183).

FIGURES 13, 20, 22, 25-28.

Periodon aculeatus HADDING

FIG. 13: *a* element, X (ADM 20333).

FIG. 20: *b* element, X (ADM 20334).

FIGS. 22, 26-28: *e* elements. FIG. 22: X (ADM 20335); FIG. 26: X (ADM 20336); FIG. 27: X (ADM 20337); FIG. 28: X (ADM 20338). All are from TC78-139m.

FIG. 25: *e* element, X (PR77:1175-90'; ADM 20339).

FIGURE 16.

Coelocerodontus? sp.

Trigoniform (*s*?) element, posterior view, X (TC78-139m; ADM 20601).

FIGURES 17, 21.

Plectodina? sp. A

FIG. 17: *e* or *f* element, inner lateral view, X (ADM 20347); FIG. 21: *g* element, X (ADM 20348). Both are from TC78-139m.

FIGURE 18.

Polonodus? sp. A

Platform fragment, oral view, X (ADM 20349).

FIGURE 23.

Dapsilodus? sp. C

Acodontiform element, X (ADM 20122).

FIGURE 24.

Phragmodus sp.

Oistodontiform (*e*) element, X (TC78-139m; ADM 20602).


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PLATE 2

All are lateral views; all are from PR77:1175-90', except where noted.

FIGURES 1-3, 5, 8, 10, 13, 19.

Pygodus sp. cf. *P. serrus* (HADDING)

Platform (*g*) elements, oral views. FIG. 1: X (ADM 20492); FIG. 2: X (ADM 20493); FIG. 3: X (ADM 20494); FIG. 5: X (ADM 20495); FIG. 8: X (ADM 20496); FIG. 10: X (ADM 20497); FIG. 13: X (ADM 20498); FIG. 19: X (ADM 20499).

FIGURES 4, 6, 7, 9, 11, 12, 14-18, 20-23, 28-30.

Pygodus serrus (HADDING)

FIGS. 4, 6, 12: *g* elements. FIG. 4: oral view, X (ADM 20474); FIG. 6: aboral view, X (ADM 20475); FIG. 12: oral view, X (ADM 20479).

FIGS. 7, 9, 11: *f* elements, outer, inner and outer lateral views. FIG. 7: X (ADM 20476); FIG. 9: X (ADM 20477); FIG. 11: X (ADM 20478).

FIGS. 14, 15, 18, 29: *b* elements. FIG. 14: X (ADM 20480); FIG. 15: X (ADM 20481); FIG. 18: postero-oral view, X (ADM 20484); FIG. 29: posterior view, X (ADM 20490).

FIGS. 16, 28: *c* elements, posterior views, X (ADM 20482), X (ADM 20489).

FIGS. 17, 21, 22: *d* elements. FIG. 17: X (ADM 20483); FIG. 21: X (ADM 20486); FIG. 22: X (ADM 20487).

FIGS. 20, 30: *c* elements. X (ADM 20485), X (ADM 20491).

FIG. 23: *a* element, X (ADM 20488).

FIGURES 24-27, 31, 34, 35.

Periodon aculeatus HADDING

FIGS. 24, 35: *e* elements, X (ADM 20340), X (ADM 20346).

FIGS. 25-27, 34: FIG. 25: *c* (hibbardelliform) element, X (ADM 20341); FIG. 26: *b* (cladognathiform), X (ADM 20342); FIG. 27: *f* (tortiliform) element, X (ADM 20343); FIG. 31: *b* element, X (ADM 20344); FIG. 34: *a* (cordylodontiform) element, outer lateral view, X (ADM 20345).

FIGURES 32, 33, 37.

Panderodus sp. cf. *P. feulneri* (GLENISTER)

FIG. 32: *e* element, X (ADM 20318).

FIGS. 33, 37: *a/b* elements; outer lateral view, X (ADM 20319), inner lateral view, X (ADM 20320).

FIGURE 36.

Strachanognathus parvus RHODES

Cordylodontiform element, X (ADM 20516).

FIGURES 38, 40-42.

Panderodus sp. cf. *P. gracilis* (BRANSON and MEHL)

FIG. 38: *a/b* element, outer lateral view, X (ADM 20325).

FIG. 40: *e* element, X (ADM 20326).

FIGS. 41, 42: *a/b* elements, inner lateral views, X (ADM 20327), X (ADM 20328).

FIGURE 39.

Indeterminate Oistodontiform Element

Lateral view, *e* or *r* element, X (ADM 20605).

FIGURE 43.

<u>Panderodus</u>? sp. cf. <u>P</u>.? <u>gibber</u> NOWLAN and BARNES

Inner lateral view, <u>a</u>/<u>b</u> element, X (ADM 20322).


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PLATE 3

All are lateral views except where noted; all are from PR77:1175-90'.

FIGURES 1-10.

Protopanderodus robustus (HADDING)

FIGS. 1, 6: c (symmetrical acontiodontiform) elements, X (short-based element; ADM 20371), X (long-based element; ADM 20374).

FIGS. 2, 4: b (asymmetrical acontiodontiform) element, outer and inner lateral views, X, X (ADM 20372).

FIGS. 3, 5, 7-10: e (scandodontiform) elements. FIGS. 3, 5: outer and inner lateral views, X, X (ADM 20373); FIGS. 7, 8: outer and inner lateral views, X, X (ADM 20375); FIGS. 9, 10: inner lateral views, X (ADM 20376), X (20377).

FIGURES 11-24, 27.

Protopanderodus sp. A

FIGS. 11, 14, 18: b (asymmetrical acontiodontiform) elements. FIG. 11: costate, outer lateral view, X (ADM 20385); FIGS. 14, 18: acostate, inner lateral view, X, (ADM 20388), X (ADM 20391).

FIGS. 12, 13, 19, 20, 24: c (symmetrical acontiodontiform) elements. FIG. 12: X (ADM 20386); FIG. 13: X (ADM 20387); FIG. 19: X (ADM 20392); FIG. 20: X (ADM 20393); FIG. 24: X (ADM 20394).

FIGS. 15, 21: e (scandodontiform) element, outer and inner lateral views, X, X (ADM 20389).

FIGS. 16, 17, 27: fused cluster, obverse side, X, X, X (ADM 20390).

FIGS. 22, 23: fused cluster, reverse side (showing e element), X, X (ADM 20390).

FIGURES 25, 26, 28, 29.

Protopanderodus parvibasis LOFGREN

FIGS. 25, 26: c (symmetrical acontiodontiform) elements, X (ADM 20368), X (ADM 20369); FIGS. 28, 29: e (scandodontiform) element, outer and inner lateral views, X, X (ADM 20370).

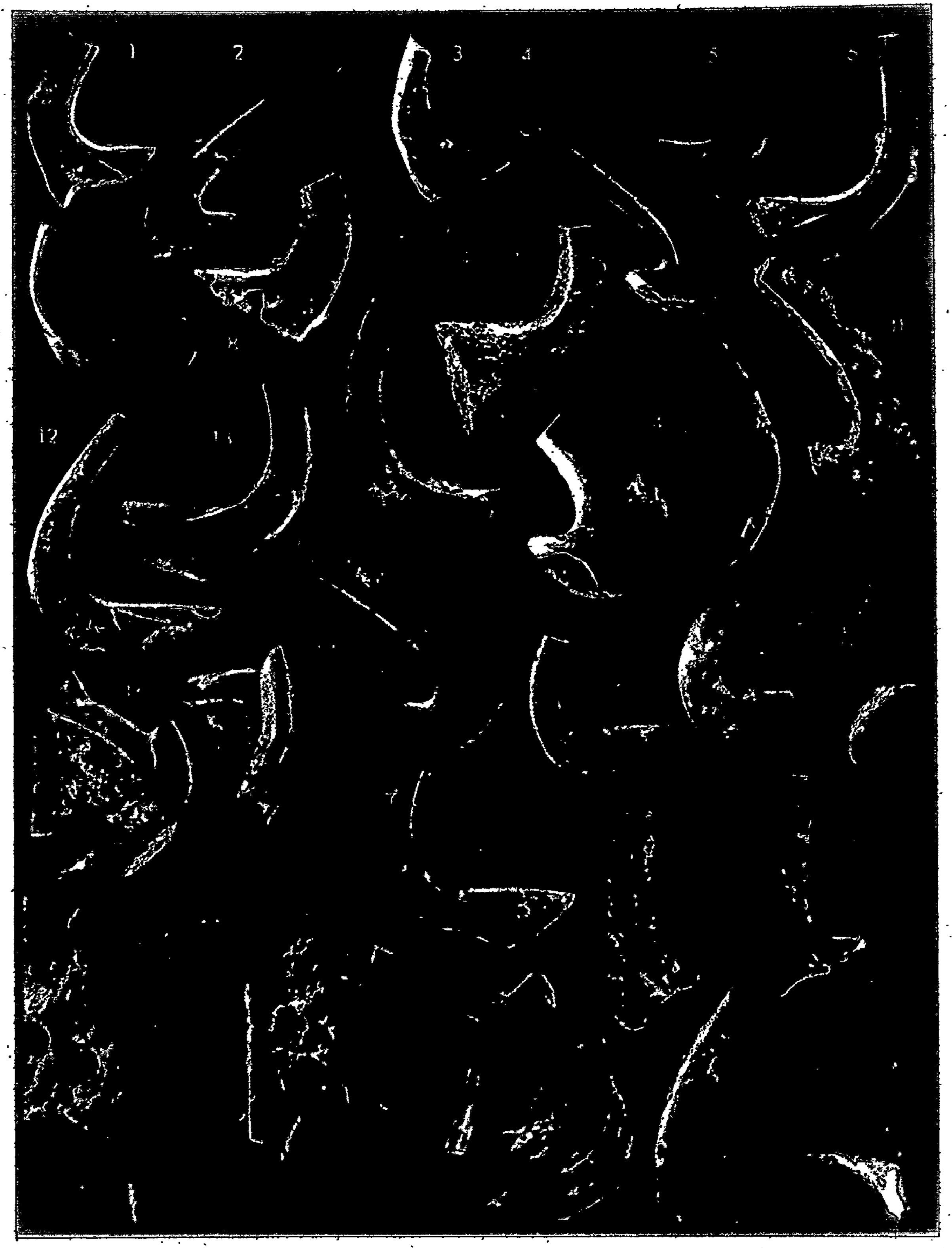
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PLATE 4

All are lateral views except where noted; all are from PR77:1175-90'.

FIGURES 1, 2, 5, 6.

Dapsilodus? sp. C

FIG. 1: *b* (distacodontiform) element, inner lateral view, X, (ADM 20123); FIG. 2: acostate *a*? element, X (ADM 20124); FIG. 5: short-based *b* element, X (ADM 20125); FIG. 6: long-based *b* element, X (ADM 20126).

FIGURES 3, 4, 8, 9, 13, 14, 19-31.

Belodella? sp. aff. *B*.? *nevadensis* ETHINGTON and SCHUMACHER

FIGS. 3, 4: *b* element, outer and inner lateral views, X, X (ADM 20054).

FIGS. 8, 9, 31: *a* element, outer, inner and outer lateral views, X, X, X (ADM 20055).

FIGS. 13, 14, 19, 20: *f*-1 element: FIGS. 13, 14: outer and inner lateral views, X, X (ADM 20056); FIGS. 19, 20: outer and inner lateral views, X, X (ADM 20057).

FIGS. 21, 22: *f*-2 element, inner and outer lateral views, X, X (ADM 20058).

FIGS. 23, 24: *b* element, outer and inner lateral views, X, X (ADM 20059).

FIGS. 25, 27: *c* elements, X (ADM 20060), X (ADM 20062).

FIGS. 26, 28-30: *c* elements. FIGS. 26, 28: posterior and lateral views, X, X (ADM 20061); FIGS. 29, 30: posterior and lateral views, X, X (ADM 20063).

FIGURES 10-12, 15-18.

Drepanoistodus sp. cf. D. basiovalis (SERGEEVA)

FIGS. 10, 15-18: q (homocurvatiform) elements, FIG. 10: X ((ADM 20170); FIG. 15: X (ADM 20172); FIG. 16: X (ADM 20173); FIG. 17: X (ADM 20174); FIG. 18: X (ADM 20175).

FIGS. 11, 12: r (oistodontiform) element, inner and outer lateral views, X, X (ADM 20171).

FIGURES 32-37.

Scalpellodus? viruensis LOFGREN

FIGS. 32, 33, 36, 37: scandodontiform elements. FIGS. 32, 33: inner and outer lateral views, X, X (ADM 20512); FIGS. 36, 37: inner and outer lateral views, X, X (ADM 20514).

FIGS. 34, 35: drepanodontiform element, outer and inner lateral views, X, X (ADM 20513).

FIGURE 7.

Drepanoistodus sp. cf. D. venustus (Stauffer) sensu LOFGREN

Oistodontiform (r) element, X (TC78-139m; ADM 20176).

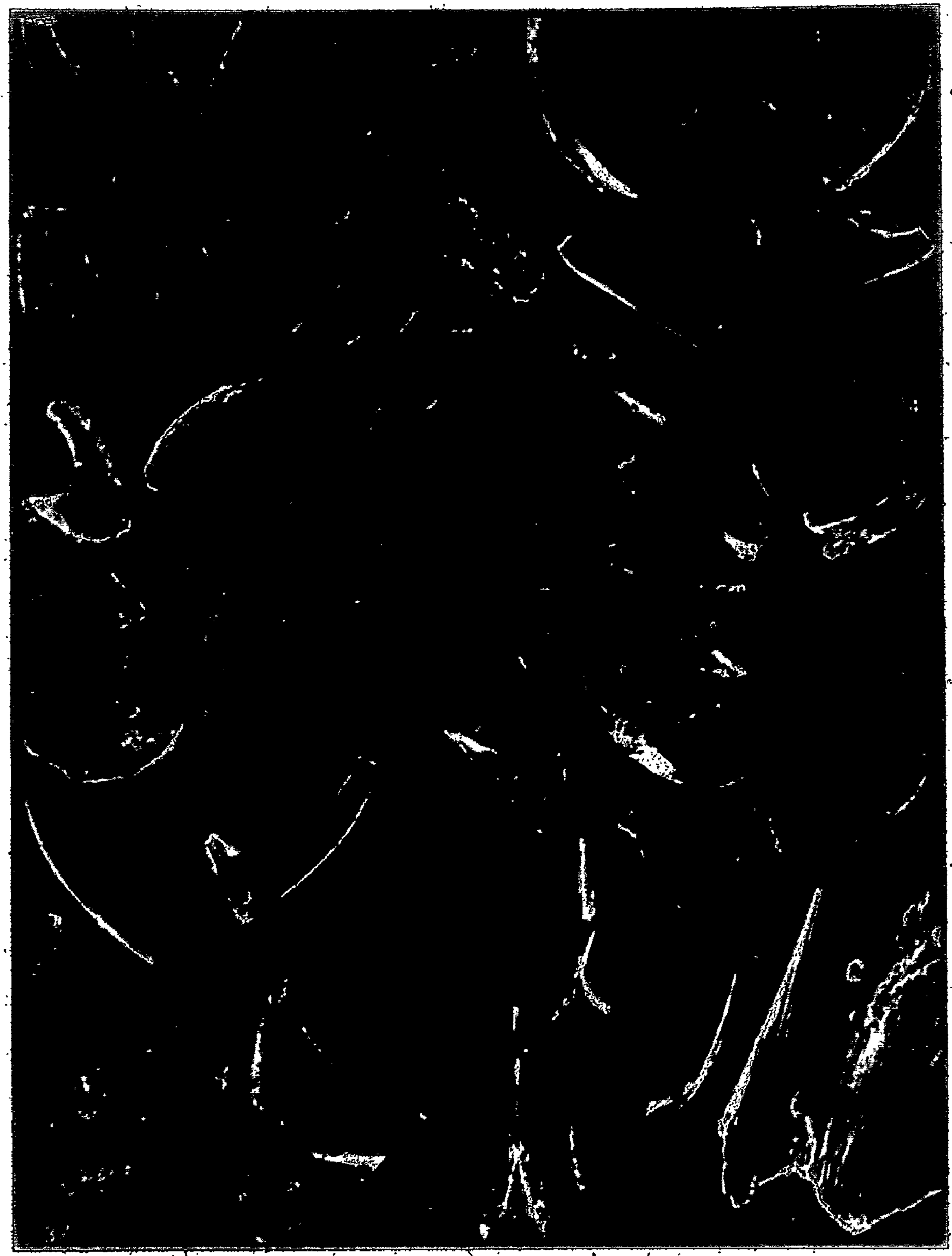

PLATE 5

All are lateral views and from PR77:1485', except where noted.

FIGURES 1-8.

Protopanderodus sp. aff. *P. varicostatus* (SWEET and BERGSTROM)

FIGS. 1, 2: *b* (asymmetrical acontiodontiform) elements, X (ADM 20378), X (ADM 20379); FIG. 3: *c* (symmetrical acontiodontiform) element, X (ADM 20380); FIGS. 4, 5: "gigantiform" element, inner and outer lateral views, X, X (ADM 20381); FIG. 6: *b* element, X (ADM 20382); FIGS. 7, 8: *e* (scandodontiform) element, inner and outer lateral views, X, X (ADM 20384). All are from PR77:1175-90'.

FIGURES 9-14, 17, 19.

Protopanderodus insculptus (BRANSON and MEHL)

FIGS. 9, 11, 14, 17: *b* (asymmetrical acontiodontiform) elements. FIG. 9: X (ADM 20351); FIG. 11: X (ADM 20353); FIG. 14: X (ADM 20356); FIG. 17: X (ADM 20357).

FIGS. 10, 12: *c* (symmetrical acontiodontiform) elements, X (ADM 20352), X (20354).

FIG. 13, 19: *e* (scandodontiform) elements, X (ADM 20355), X (20358).

FIGURES 15, 16, 18, 20-25.

Protopanderodus liripipus KENNEDY, BARNES and UYENO

FIGS. 15, 18, 24: *b*? (asymmetrical acontiodontiform) elements. FIG. 15: X (ADM 20359); FIG. 18: X (ADM 20361);

FIG. 24: X (ADM 20366).

FIG. 16: "gigantiform" element, X (ADM 20360).

FIGS. 20-23: c (symmetrical acontiodontiform) elements. FIG. 20: X (ADM 20362); FIG. 21: X (ADM 20363); FIG. 22: X (ADM 20364); FIG. 23: X (ADM 20365).

FIG. 25: e (scandodontiform) element, X (BR77-1:165'; ADM 20367).

FIGURES 26, 27.

Protopanderodus sp.

Acontiodontiform (b-c) elements, X (ADM 20395), X (ADM 20396). Both are from TC78-139m.

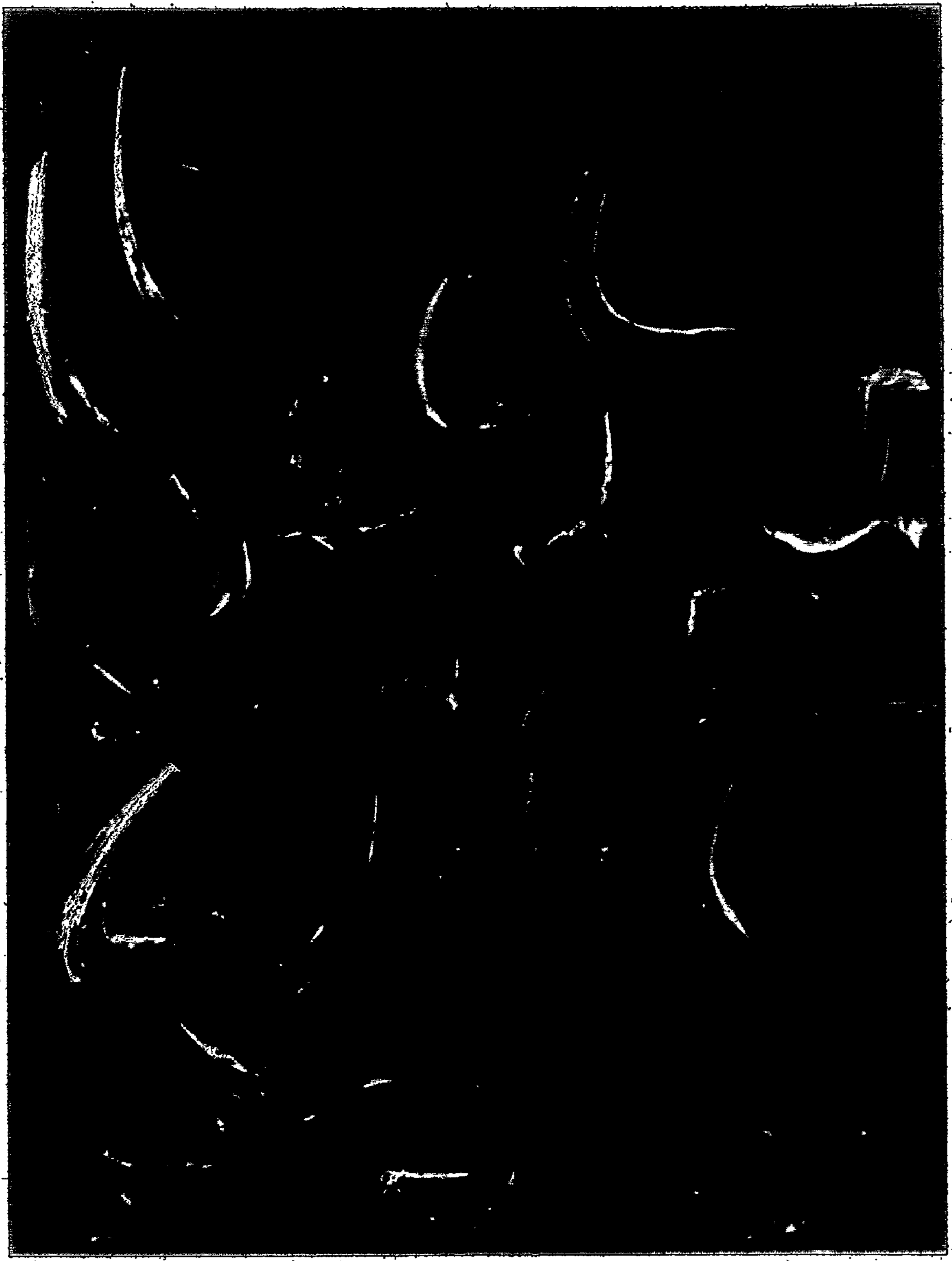

PLATE 6

All are lateral views; all are from PR77-1485', except where noted.

FIGURES 1-9, 11-13.

Scabbardella altipes subsp. B ORCHARD

FIGS. 1-6, 8: *e* elements. FIG. 1: X (ADM 20500); FIG. 2: X (ADM 20501); FIG. 3: X (ADM 20502); FIG. 4: X (ADM 20503); FIG. 5: X (ADM 20504); FIG. 6: X (ADM 20505); FIG. 8: X (ADM 20507).

FIG. 9: *b* element, X (ADM 20508).

FIGS. 7, 11, 12: *a* elements. FIG. 7: X (ADM 20506); FIG. 11: X (ADM 20509); FIG. 12: X (ADM 20510).

FIG. 13: *c* element, X (BR77-1:165'; ADM 20511).

FIGURES 10, 15, 22

Paroistodus? sp. A NOWLAN and McCRACKEN

FIG. 10: *e* element, X (BR77-1:165'; ADM 20330); FIG. 15: *a* element, X (ADM 20331); FIG. 22: *b* element, X (BR77-1:165'; ADM 20332).

FIGURES 14, 17.

Panderodus gracilis (BRANSON and MEHL)

Compressiform (*e*) element, X (ADM 20323), *a*/*b* (graciliform) element, X (ADM 20324).

FIGURE 16.

Panderodus? *gibber* NOWLAN and BARNES

Inner lateral view, *a*/*b* element, X (BR77-1:165'; ADM 20321).

FIGURES 18, 23-27, 29-32.

Besselodus borealis n. sp. NOWLAN and McCRACKEN

FIG. 18: c element, X (BR77-1:165'; ADM 20068).

FIGS. 23, 29: b elements, inner lateral views, X, (ADM 20069).

FIG. 23: e element, X (ADM 20070).

FIGS. 25, 26, 27: a element, inner, outer and inner lateral views. FIG. 25: X (ADM 20071; FIGS. 26, 27: X (ADM 20072).

FIGS. 30, 31: a element, outer and inner lateral views, X, X (BR77-1:165'; ADM 20073).

FIG. 32: b element, inner lateral view, X (ADM 20074).

FIGURE 19.

Walliserodus amplissimus (SERPAGLI)

Multicostatiform (d) element, X (ADM 20517).

FIGURE 20.

Panderodus? sp. A

Inner lateral view, a/b element, X (ADM 20329).

FIGURES 21, 28.

Indeterminate Distacodontiform Elements

Outer and inner lateral views, X (ADM 20604).


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PLATE 7

All are lateral views and from BR77-1:165', except where noted.

FIGURES 1-4.

Belodina confluens SWEET

FIG. 1: *p* element, X (ADM 20064); FIG. 2: *q* element, X (ADM 20065); FIG. 3: *p* element, X (ADM 20066); FIG. 4: *r* element, X (ADM 20067). All are from PR77-1485'.

FIGURE 5. *Pseudobelodina* sp. cf. *P. quadrata* SWEET

Long-heeled element, X (PR77-1485'; ADM 20401).

FIGURES 6-12, 14.

Pseudobelodina? *dispansa* (GLENISTER)

FIGS. 6, 7: outer and inner lateral views, X, X (ADM 20397).

FIGS. 8, 9: outer and inner lateral views, X, X (ADM 20398).

FIGS. 10, 11: X, X (ADM 20399).

FIGS. 12, 14: inner and outer lateral views, X, X (ADM 20400).

FIGURES 13, 15-22, 24.

N. gen. A n. sp. A

FIGS. 13, 15, 24: *c* element, lateral, postero-aboral, anterolateral views, X, X, X (ADM 20573).

FIGS. 16, 21, 22: *c* element, postero-aboral and anterolateral views, X, X, X (ADM 20574).

FIGS. 17, 18: *a* element, X, X (ADM 20575).

FIGS. 19, 20: *a* element, X, X (ADM 20576).

FIGURES 23, 28, 30.

Eocarniodus gracilis (RHODES)

All are *a-b* elements. FIG. 23: X (ADM 20177); FIG. 28: X (ADM 20178); FIG. 30: X (ADM 20179). All are from PR77-1485'.

FIGURE 25.

Gamachignathus ensifer McCRACKEN, NOWLAN and BARNES

Outer lateral view, *f* element, X (PR77-1485'; ADM 20184).

FIGURES 26, 29, 34.

Plectodina tenuis (BRANSON and MEHL)

FIG. 26: *g* element, X (PR77-1485'; ADM 20598); FIG. 29: *e* element, X (ADM 20599); FIG. 34: *f* element, outer lateral view, X (PR77-1485'; ADM 20600).

FIGURES 27, 33.

Oulodus ulrichi (STONE and FURNISH)

Inner lateral views, *e* elements, X (ADM 20254), X (ADM 20255). Both are from PR77-1485'.

FIGURE 31.

Icriodella superba RHODES?

Saggitodontiform (f) element, anterior view , X (ADM 20185).

FIGURE 32.

Plectodina florida SWEET

Posterior view, b element, X (ADM 20346).

FIGURE 35.

Oulodus rohneri ETHINGTON and FURNISH

Inner lateral view, e element, X (PR77-1485; ADM 20650).

FIGURE 36.

Amorphognathus ordovicicus BRANSON and MEHL

Oral view, g element, X (ADM 20001).

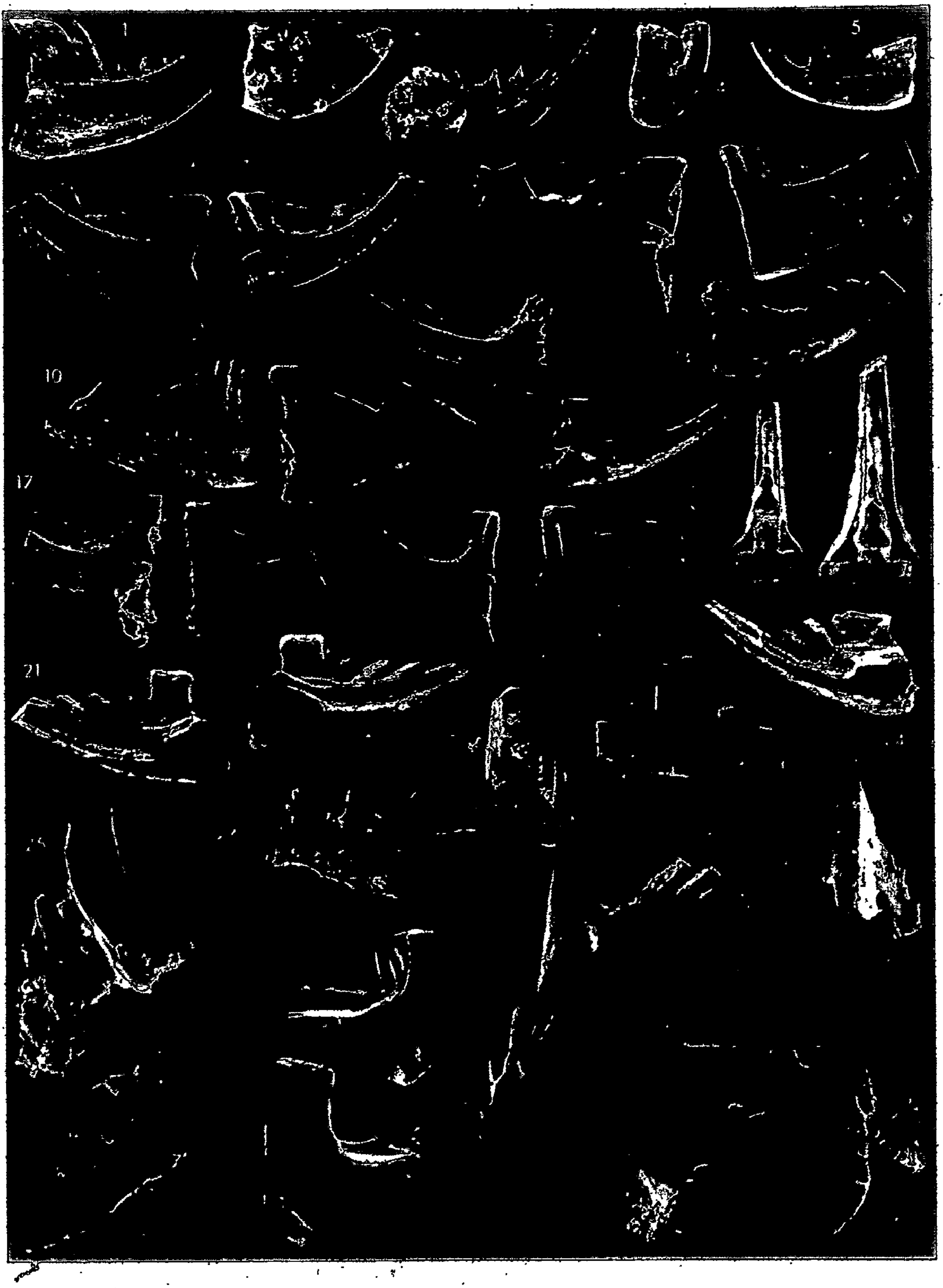
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PLATE 8

All are lateral views and from BR77-1:323', except where noted.

FIGURES 1-11, 13, 15, 16.

Distomodus staurognathoides (WALLISER)

FIG. 1: *e*-2 (falodontiform) element, postero-aboral view, X (ADM 20156); FIG. 2: *a* element, X (ADM 20157); FIGS. 3, 4: *e*-1 (cyrtoniodontiform) elements, X (ADM 20158), X (20159); FIG. 5: *g* element, oral view, X (ADM 20160); FIG. 6: *c* element, posterolateral view, X (ADM 20161); FIGS. 7, 8: *f* elements, oral and anterolateral views, X (RR78-316m; ADM 20162), X (ADM 20163).

FIGS. 9-11: *g* elements, oral views. FIG. 9: X (RR78-316m; ADM 20164); FIG. 10: X (ADM 20165); FIG. 11: X (TC78-218m; ADM 20166).

FIG. 13: *b* element, X (ADM 20167).

FIGS. 15, 16: *g* elements, oral views, X (ADM 20168), X (RR78-316m; ADM 20169). All are from RR78-285m, except where noted

FIGURES 12, 14, 17-20, 22-28, 31, 32, 37, 38.

Distomodus kentuckyensis (BRANSON and BRANSON)?

FIGS. 12, 14, 25: *e*-2 elements, lateral, anterolateral and postero-aboral views. FIG. 12: X (ADM 20133); FIG. 14: X (ADM 20134); FIG. 25: X (ADM 20142).

FIGS. 17, 24: *e*-1 elements, X (ADM 20135), X (ADM 20141).

FIGS. 18, 20: *c* elements, X (ADM 20136), X (ADM 20138).

FIGS. 19, 23, 28, 32, 37: *a* elements. FIG. 19: X (ADM 20137); FIG. 23: X (ADM 20140); FIG. 28: X (ADM 20145); FIG. 32: X (ADM 20147); FIG. 37: X (ADM 20148).

FIGS. 26, 27, 38: *b* elements. FIG. 26: X (ADM 20143); FIG. 27: X (ADM 20144); FIG. 38: X (ADM 20149).

FIG. 22: *f*? element, anterior view, X (ADM 20139).

FIG. 31: *g* element, X (ADM 20146).

FIGURES 21, 29, 30, 34-36.

Distomodus sp. cf. *D. kentuckyensis* (Branson and Branson) sensu COOPER

FIG. 21: *e*-2 element, anterior view, X (ADM 20150).

FIGS. 29, 34: *f*? elements, anterior views, X (RR78-285m; ADM 20151), X (ADM 20153).

FIGS. 30, 36: *a*-*c* elements, X (ADM 20152), X (ADM 20155).

FIG. 35: fragment of process of *f*? or *g*? element, X (ADM 20154).

FIGURES 33, 39, 40.

Aulacognathus bullatus (NICOLL and REXROAD)

FIG. 33: *f* element, outer lateral view, X (ADM 20051);

FIGS. 39, 40: *g* elements, oral views, X (ADM 20052), X (ADM 20053).

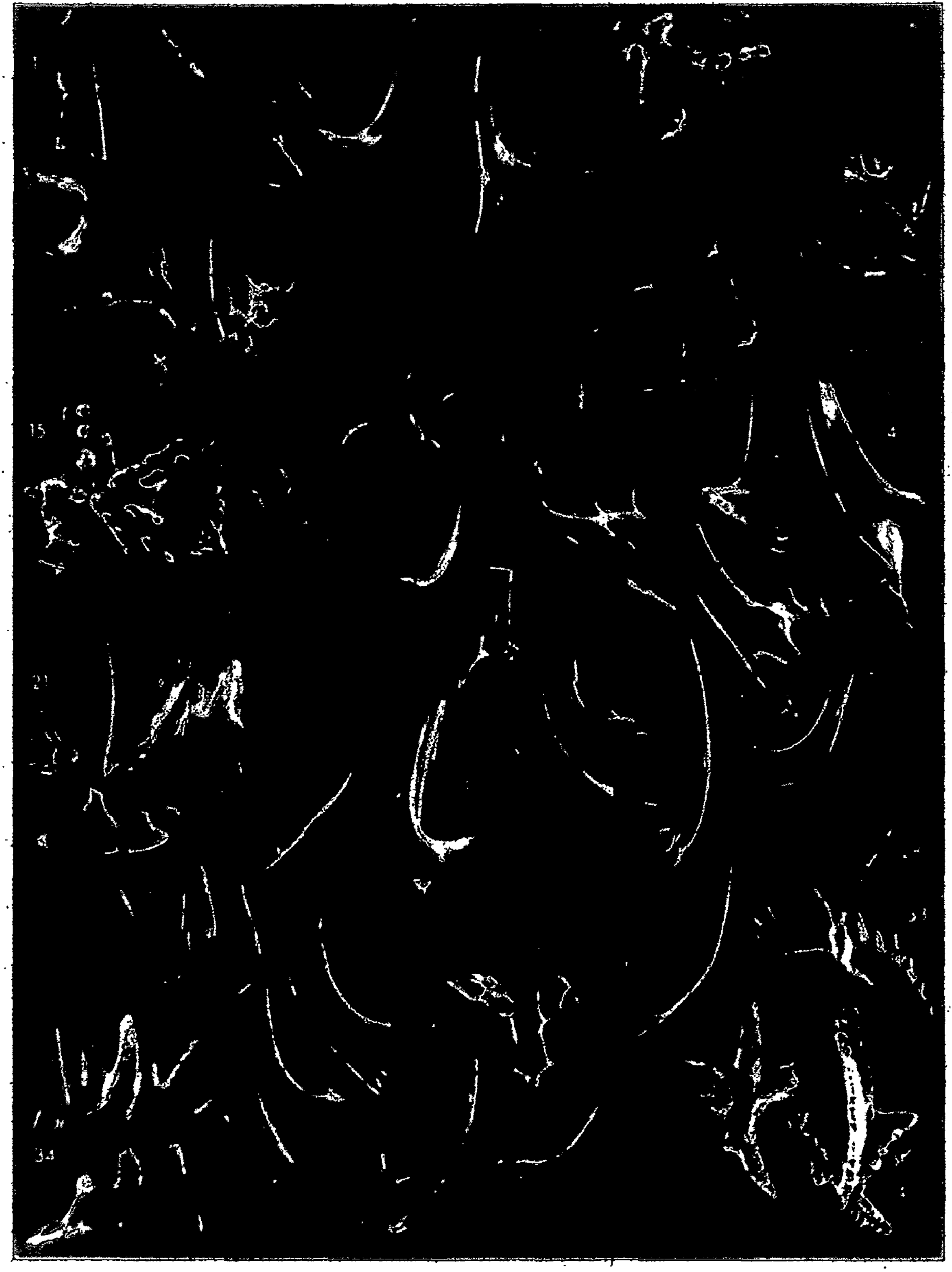
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PLATE 9

All are lateral views and from from BR77-1:296', except where noted.

FIGURES 1-4, 7-9, 11, 12, 15, 16, 18, 25, 28-30.

Oulodus fluegeli petilus (NICOLL and REXROAD)

FIGS. 1, 7, 11, 16: a-1 elements, inner lateral views. FIG. 1: X (ADM 20226); FIG. 7: X (BR77-1:323'; ADM 20230); FIG. 11: X (ADM 20233); FIG. 16 (ADM 20236).

FIGS. 2, 9, 15, 18: e-1 elements. FIG. 2: X (ADM 20227); FIG. 9: X (ADM 20232); FIG. 15: X (ADM 20235); FIG. 18: X (ADM 20237).

FIG. 3: e-2 element, X (ADM 20228).

FIGS. 4, 8, 12: a-2 elements, inner lateral views. FIG. 4: X (ADM 20229); FIG. 8: X (ADM 20231); FIG. 12: X (ADM 20234).

FIGS. 25, 28-30: b elements, posterior views. FIG. 25: X (ADM 20238); FIG. 28: X (ADM 20239); FIG. 29: X (ADM 20240); FIG. 30: X (ADM 20241).

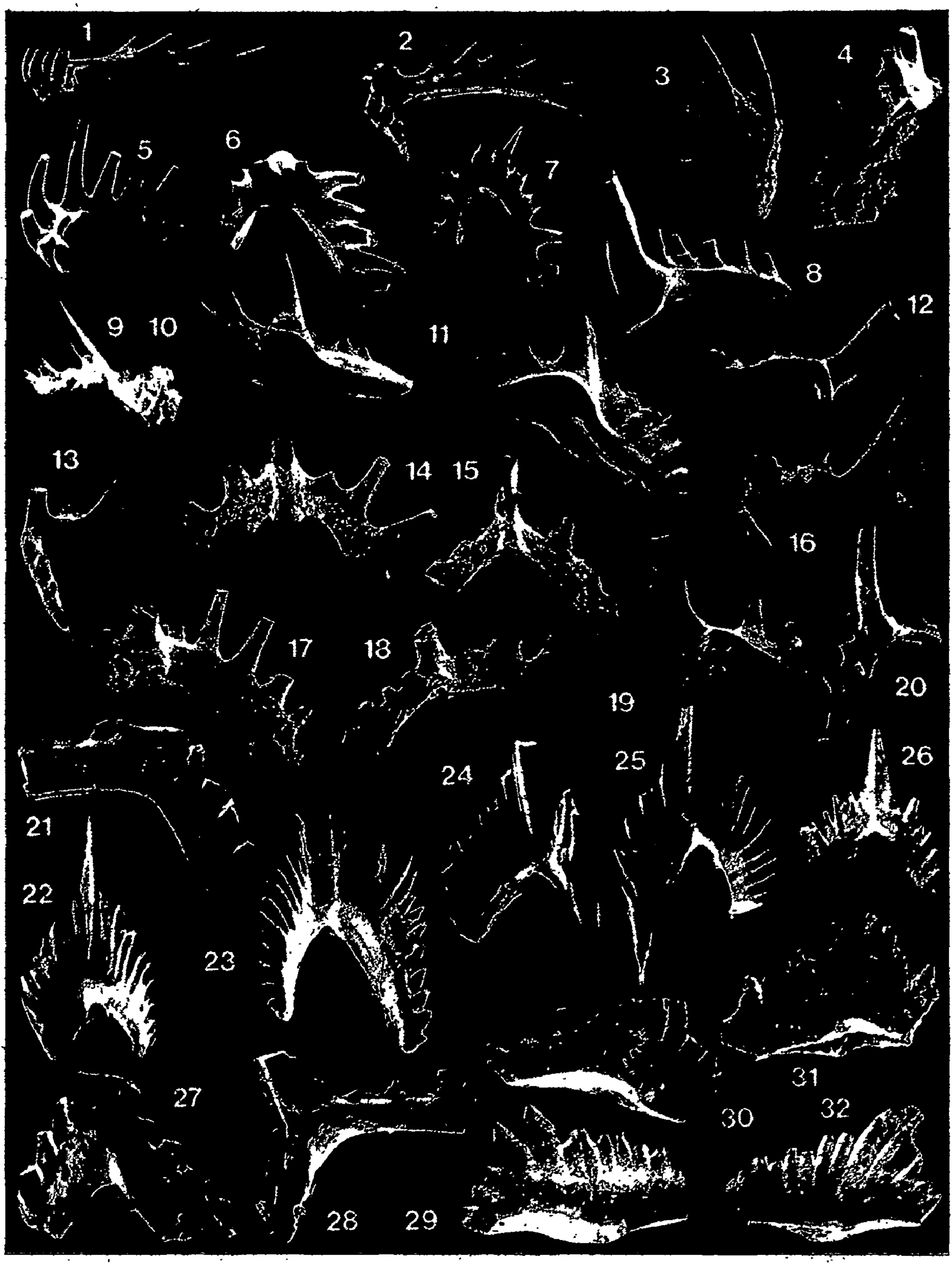
FIGURES 5, 6, 10, 13, 14, 17, 19-24, 26, 27, 31, 32.

Oulodus fluegeli fluegeli (WALLISER)

FIGS. 5, 6, 19, 24: e-1 elements. FIG. 5: X (ADM 20190); FIG. 6: X (ADM 20191); FIG. 19: X (ADM 20196); FIG. 24: X (ADM 20201).

FIG. 10: e-2 element, X (ADM 20192).

FIGS. 13, 17, 20, 21: a-2 element, inner lateral views. FIG. 13: X (ADM 20193); FIG. 17: X (ADM 20195); FIG. 20: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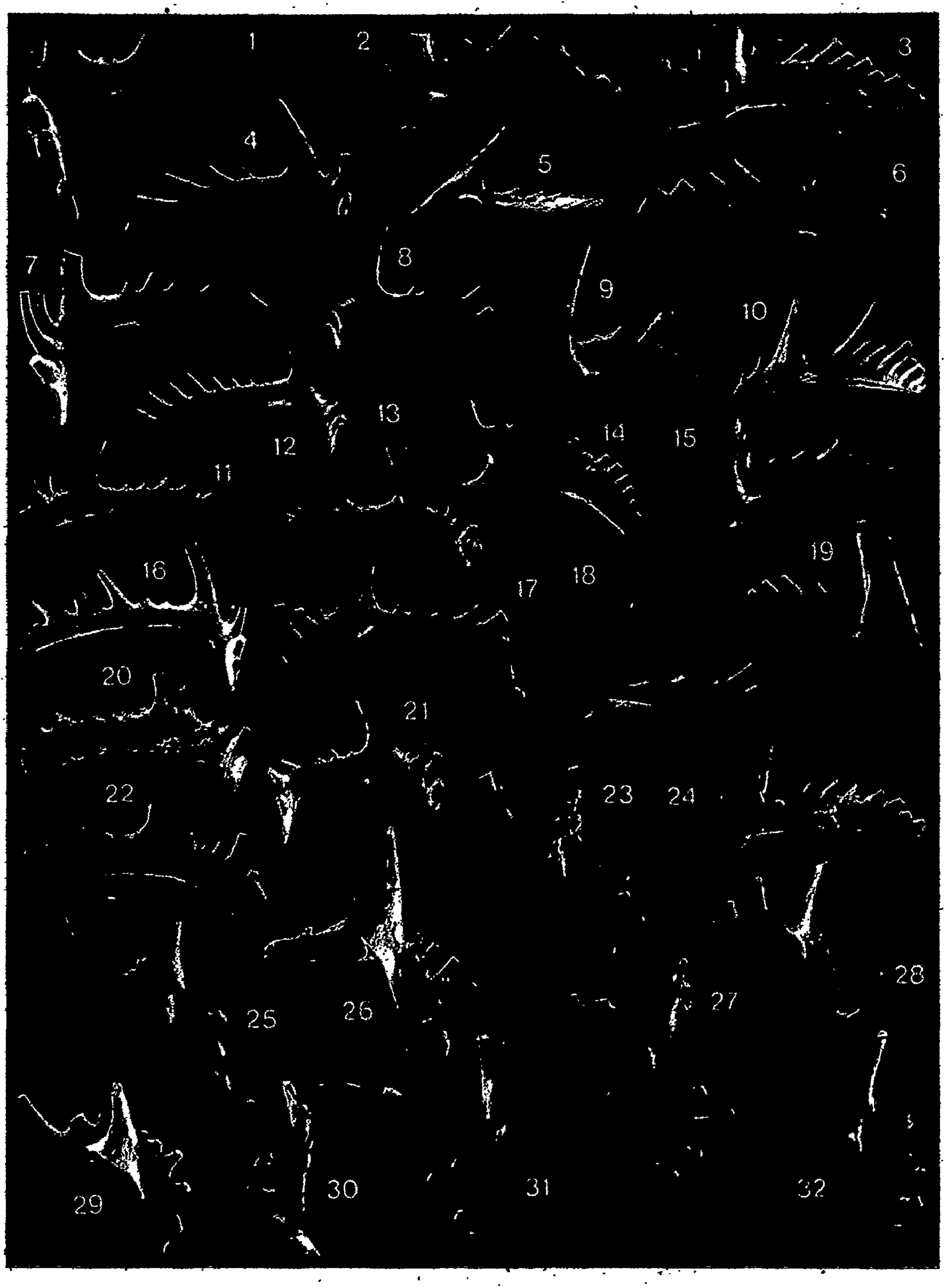
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PLATE 10

All are lateral views except where noted; all are from BR77-1:296'.

FIGURES 1, 2, 5, 6, 9, 12, 16, 26-28, 30, 31.

Oulodus fluegeli petilus (NICOLL and REXROAD)

FIGS. 1, 2, 5: *f* elements. FIGS. 1, 2: inner-oral views, X (ADM 20242), X (ADM 20243); FIG. 5: inner-aboral view, X (ADM 20244).

FIG. 6: *f* element, ?aberrant form, inner-oral view, X (ADM 20245).

FIG. 9: *f* element, inner lateral-aboral view, X (ADM 20246).

FIGS. 12, 16: *g* elements, posterior and anterior views, X (ADM 20247), X (ADM 20248).

FIGS. 26-28, 30, 31: *c* elements. FIGS. 26, 28: antero-lateral views, X (ADM 20249), X (ADM 20250); FIGS. 27, 30, 31: postero-lateral views. FIG. 27: X (ADM 20251); FIG. 30: X (ADM 20252); FIG. 31: X (20253).

FIGURES 3, 4, 7, 8, 10, 11, 13-15, 17-25, 29, 32.

Oulodus fluegeli fluegeli (WALLISER)

FIGS. 3, 4, 10, 11: *g* elements, antero-oral views. FIG. 3: X (ADM 20206); FIG. 4: X (ADM 20207); FIG. 10: X (ADM 20210); FIG. 11: X (ADM 20211).

FIGS. 7, 8, 13, 14: *g* elements. FIGS. 7, 8: anterior views, X (ADM 20208), X (ADM 20209); FIGS. 13, 14: posterior views, X (ADM 20212), X (ADM 20213).

FIGS. 15, 17, 19, 22, 24: *f* elements. FIGS. 15, 19: inner lateral-oral views, X (ADM 20214), X (ADM 20217); FIGS. 17, 24: inner lateral-aboral views, X (ADM 20215), X (ADM 20222); FIG. 22: X (ADM 20220).

FIGS. 18, 20, 21, 23, 25, 29, 32: *c* elements. FIGS. 18, 25, 29, 32: antero-oral views. FIG. 18: X (ADM 20216); FIG. 20: antero-lateral view, X (ADM 20218); FIGS. 21, 23: lateral-oral view, X (ADM 20219), X (ADM 20221); FIG. 25: X (ADM 20223); FIG. 29: X (ADM 20224); FIG. 32: X (ADM 20225).


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PLATE 11

All are lateral views and from B77-1:323', except where noted.

FIGURES 1-12.

<u>Oulodus</u>? n. sp. B

FIGS. 1-3: <u>a</u> elements. FIGS. 1, 2: inner and oral-lateral views, X, X (ADM 20264); FIG. 3: outer lateral view, X (ADM 20265).

FIG. 4: <u>b</u>? element, posterior view, X (ADM 20266).

FIGS. 5-7: <u>c</u> elements. FIGS. 5, 6: lateral and postero-oral views, X, X (ADM 20267); FIG. 7: postero-oral view, X (ADM 20268).

FIGS. 8, 12: <u>e</u> element, inner lateral views, X (ADM 20269), X (ADM 20273).

FIGS. 9-11: <u>f</u> elements, outer, inner and outer lateral views. FIG. 9: X (ADM 20270); FIG. 10: X (ADM 20271); FIG. 11: X (ADM 20272).

FIGURES 13-20.

<u>Oulodus</u> n. sp. A

FIGS. 13, 16: <u>a</u> elements, inner lateral views, X (ADM 20256), X (ADM 20259).

FIGS. 14, 15: <u>c</u> elements, posterior views, X (ADM 20257), X (ADM 20258).

FIGS. 17, 20: <u>f</u> elements, inner lateral views, X (ADM 20260), X (ADM 20263).

FIG. 18: <u>c</u> element, posterior view, X (ADM 20261).

FIG. 19: *e* element, inner lateral-aboral view, X (ADM 20262). All are from TC78-212m.

FIGURES 21-32.

Ozarkodina sp. aff. *O.* *polinclinata* (Nicoll and Rexroad) sensu ALDRIDGE

FIG. 21: *a* element, inner lateral view, X (ADM 20283).

FIGS. 22, 26, 27: *c* elements, posterior views. FIG. 22: X (ADM 20284); FIG. 26: X (BR78-296'; ADM 20288); FIG. 27: X (BR78-296'; ADM 20289).

FIGS. 23-25: *b* elements, posterior views. FIG. 23: X (ADM 20285); FIG. 24: X (ADM 20286); FIG. 25: X (ADM 20287).

FIG. 28: *e* element, X (BR78-296'; ADM 20290).

FIGS. 29, 32: *g* elements, X (ADM 20291), X (BR78-296'; ADM 20294).

FIGS. 30, 31: *f* elements, X (ADM 20292), X (BR78-296'; ADM 20293).


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PLATE 12

All are lateral views, except where noted.

FIGURES 1-3, 7-10.

Ozarkodina n. sp. A

FIG. 1: *a* element, inner lateral view, X (ADM 20295).

FIG. 2: *e* element, inner lateral view, X (ADM 20296);

FIGS. 3, 7, 8: *f* elements. FIG. 3: X (ADM 20297); FIG. 7: X (ADM 20298); FIG. 8: X (ADM 20299).

FIGS. 9, 10: *g* elements, X (ADM 20300), X (ADM 20301).

All are from PT-718, except ADM 20301 (PL79-70.5m).

FIGURES 4, 5.

Ozarkodina manitoulinensis (POLLOCK, REXROAD and NICOLL)

Inner and outer lateral views, X, X (RR78-245m; ADM 20282).

FIGURES 6, 12-14.

Ozarkodina sp. D

FIGS. 6, 12: *a* elements, inner lateral views, X (PL79-70.5m; ADM 20314), X (PT-720; ADM 20315).

FIGS. 13, 14: *f* elements, X (PL79-70.5m; ADM 20316), X (PT-720; ADM 20317).

FIGURE 34.

Kockelella ranuliformis (WALLISER)

Oral View, *g* element, X (TC78-230m; ADM 20189).

FIGURES 11, 15-21.

Ozarkodina excavata n. subsp. A

FIG. 11: *a* element, inner lateral views, X (ADM 20274).

FIG. 15: *c* element, posterior view, X (ADM 20275).

FIG. 16: *b* element, postero-aboral view, X (ADM 20276).

FIGS. 17, 18: *e* elements, inner lateral views, X (ADM 20277), X (ADM 20278).

FIGS. 19, 20: *g* elements, X (ADM 20279), X (ADM 20280).

FIG. 21: *f* element, X (ADM 20281). All are from TC78-286m.

FIGURES 22-26, 29.

Ozarkodina sp. B

FIGURES 22, 23: *a* elements, inner lateral views, X (ADM 20302), X (ADM 20303); both are from BR77-1:323'; FIGS. 24, 25: *b* elements, posterior views, X (ADM 20304), X (ADM 20305); FIG. 26: *e*? element, inner lateral view, X (ADM 20306); FIG. 29: *c* element, posterior view, X (ADM 20307). All are from BR77-1-296', except where noted.

FIGURES 27, 28, 30-33.

Ozarkodina sp. C

FIG. 27: *a* element, inner lateral view, X (ADM 20308); FIG. 28: *c* element, posterior view, X (ADM 20309); FIGS. 30, 31: *f* elements, X (ADM 20310), X (ADM 20311); FIGS. 32, 33: *g* elements, X (ADM 20312), X (ADM 20313). All are from TC78-212m.

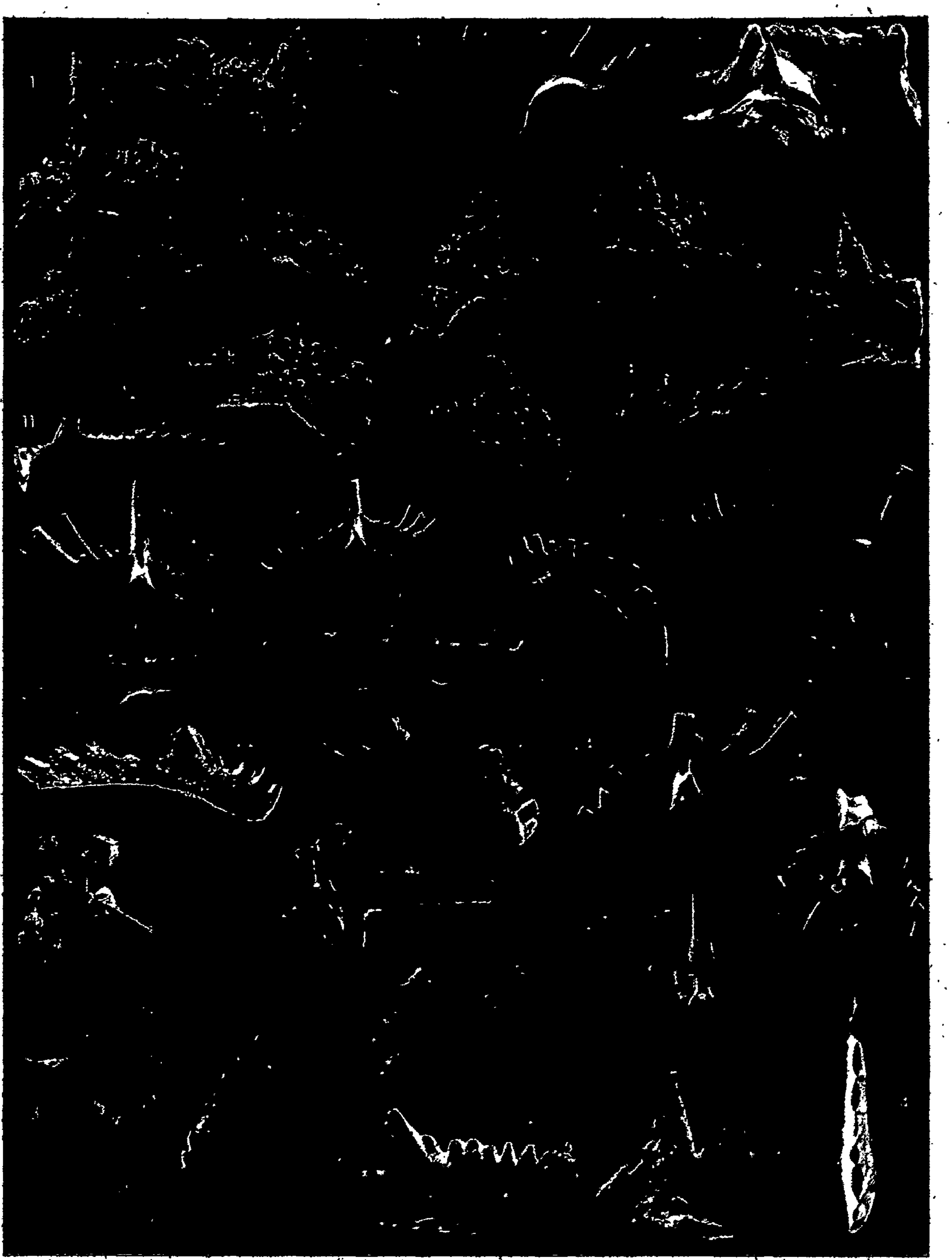

PLATE 13

All are lateral views and from BR78-1-323', except where noted.

FIGURES 1-21.

N. gen. B n. sp. A

FIGS. 1, 2, 6, 7: a-1 elements, inner lateral views. FIG. 1: X (ADM 20577); FIG. 2: X (ADM 20578); FIG. 6: X (ADM 20582); FIG. 7: (ADM 20583).

FIGS. 3, 11: a-2 elements, inner posterolateral and posterior views, X (ADM 20579), X (ADM 20587).

FIGS. 4, 5, 9, 12, 13: b elements, posterior views. FIG. 4: X (ADM 20580); FIG. 5: X (ADM 20581); FIG. 9: X (ADM 20585); FIG. 12: X (ADM 20588); FIG. 13: X (ADM 20589).

FIGS. 8, 10: c elements, posterior views, X (ADM 20584), X (ADM 20586).

FIGS. 14-16: e? elements. FIG. 14: X (ADM 20590); FIG. 15: X (ADM 20591); FIG. 16: X (ADM 20592).

FIGS. 17, 18, 21: f elements, outer, inner and inner lateral views. FIG. 17 X (ADM 20593); FIG. 18: X (ADM 20594); FIG. 21: X (ADM 20597).

FIGS. 19, 20: g elements, posterior views, X (ADM 20595), X (ADM 20596).

FIGURE 22.

Indeterminate Zygognathiform Element

Posterior view, X (ADM 20610).

FIGURE 23.

Icriodella sp. B

Oral view, fragment of g element, X (PL79-70.5; ADM 20188).

FIGURE 24.

Pseudooneotodus tricornis DRYGANT

"Squat three-denticle" element, X (TC78-212m; ADM 20403).

FIGURE 25.

Pseudooneotodus bicornis DRYGANT

"Squat two-denticle" element, X (TC78-230; ADM 20402).

FIGURES 26-29.

Apsidognathus tuberculatus Walliser

FIGS. 26, 28: e (ambalodontiform) elements, X (TC78-218m; ADM 20002), X (TC78-192m; ADM 20003).

FIG. 27, c (pygodontiform) element, oral view, X (TC78-192m; ADM 20004); FIG. 29: g-1 element, oral views, X (TC78-192m; ADM 20005).

FIGURE 30.

Indeterminate Cruciform Element

Oral view, X (TC78-192m; ADM 20603).

FIGURES 31, 32.

Icriodella sp. A

FIG. 31: g element fragment, oral view, X (ADM 20186); FIG. 32: b element, X (ADM 20187). Both are from RR78-245m).

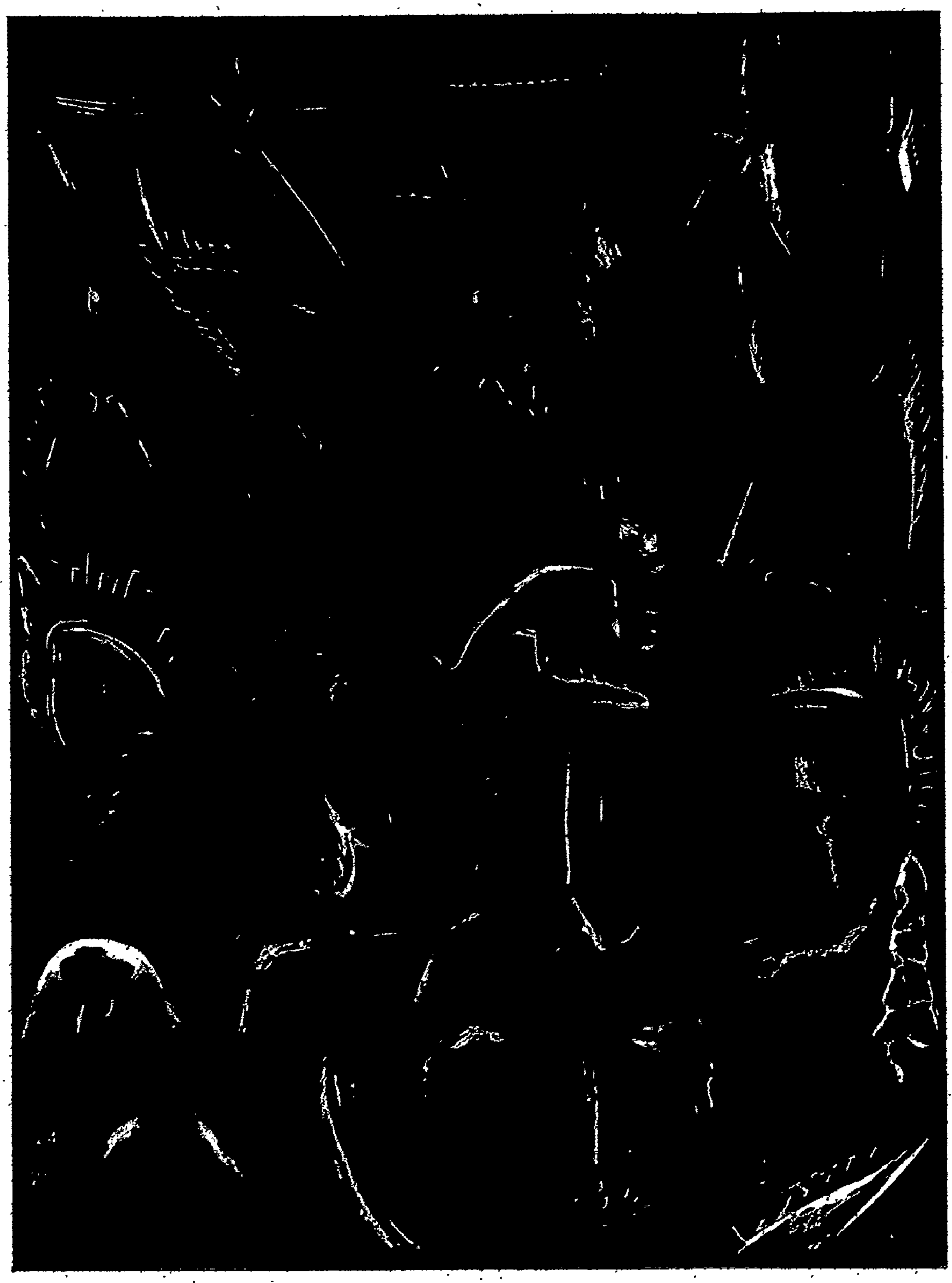

PLATE 14

All are lateral views and from BR77-1-323m, except where noted.

FIGURES 1-9, 11

Astropentagnathus n. sp. A

FIGS. 1, 2: *a*? element, outer lateral views, X (ADM 20023), X (ADM 20024).

FIG. 3: *a/b* element, X (ADM 20025).

FIGS. 4, 8, 11: *e* elements. FIGS. 4, 8: outer and inner lateral views, X, X (ADM 20026); FIG. 11: inner lateral view, X (ADM 20030).

FIGS. 5, 6: *f* elements, oral views, X (ADM 20027), X (ADM 20028).

FIG. 7: *g* element, oral view of micro-ornamentation on basal sheath (same element as in Pl. 15, fig. 27; outer anterolateral process is in upper part of figure), X (ADM 20035).

FIG. 9: *b* element, posterior view, X (ADM 20029).

FIGURES 10, 12-16, 26, 31, 32.

Astropentagnathus irregularis MOSTLER

FIGS. 10, 12: *a*? element, outer and inner lateral views, X, X (ADM 20007).

FIGS. 13-16: FIG. 13; *c* element, oral-lateral view, X (ADM 20008); FIG. 14: *b* element (sensu Uyeno and Barnes, 1983), X (ADM 20009); FIG. 15: *f* element, oral view, X (ADM 20010); FIG. 16: *b* element, posterior view, X (ADM 20011).

FIGS. 26, 31, 32: *f* elements, oral views. FIG. 26: X (ADM 20606); FIG. 31: X (ADM 20607); FIG. 32: X (ADM 20608).

FIGURES 17-23, 28-30.

Astropentagnathus? Indeterminate Elements

FIGS. 17, 21, 29: *d* (tetraprioniodiniform) elements. FIGS. 17, 29: outer posterolateral and anterior views, X, X (ADM 20042); FIG. 29: outer posterolateral view, X (ADM 20049).

FIGS. 18, 30: *b* elements, posterior views, X (ADM 20050, X (ADM 20043).

FIG. 19: *c* element, posterior view, X (ADM 20044).

FIGS. 20, 20, 23, 28: modified "holodontiform" elements. FIG. 20, anterior view, X (ADM 20045); FIGS. 22, 23: posterior views, X (ADM 20046), X (ADM 20047); FIG. 28: posterolateral views, X (ADM 20048).

FIGURE 27.

Pterospathodus n. sp. A

Oral view, *g* element, X (ADM 20443).

FIGURES 24, 25.

Pterospathodus pennatus angulatus (WALLISER)

Oral views, *g* elements, X (ADM 20419), X (ADM 20420).

FIGURES 33, 34.

Pterospathodus pennatus procerus (WALLISER)

Oral views, q elements, X (TC78-212m; ADM 20429), X (TC78-218; ADM 20430).

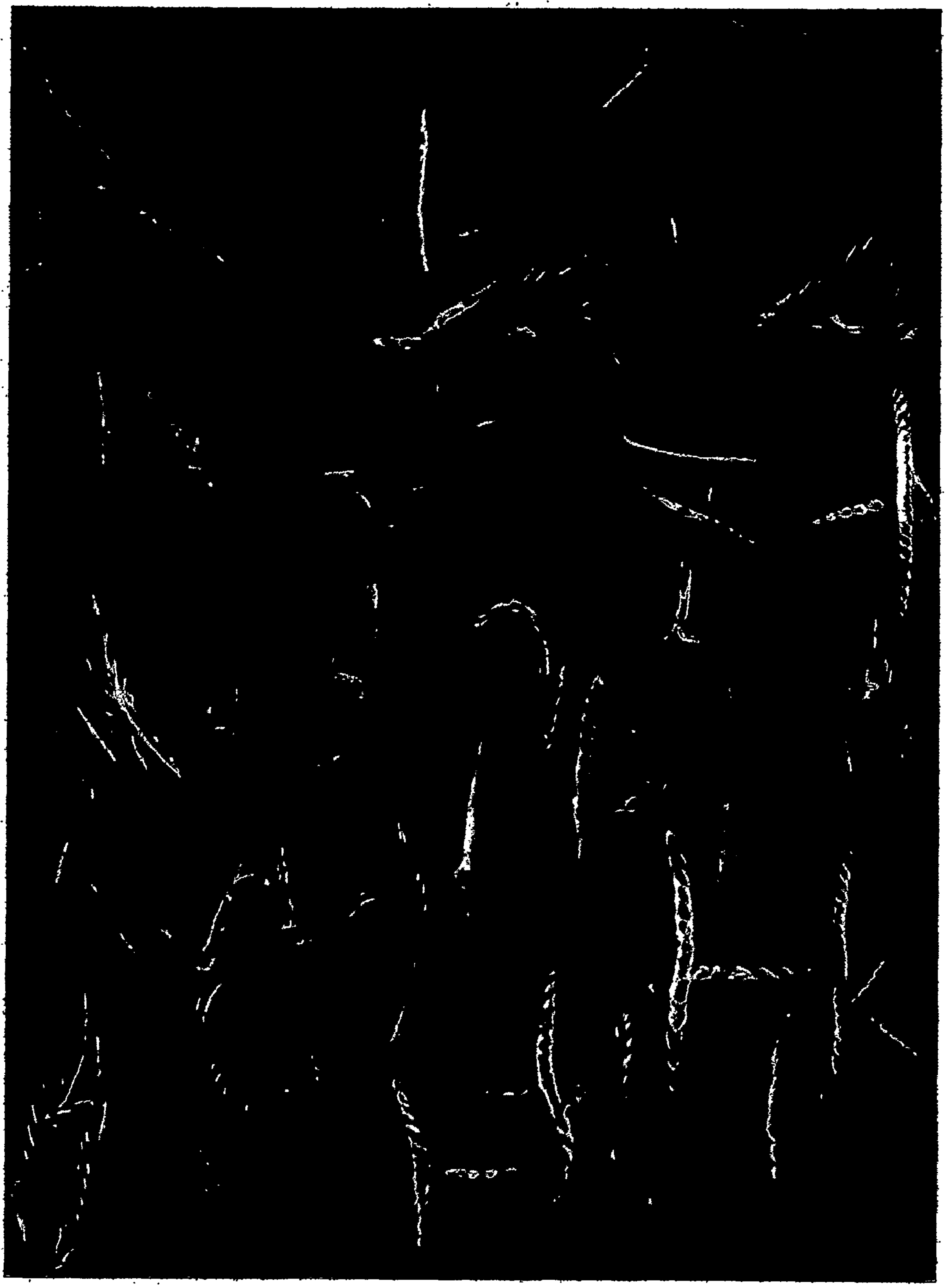

PLATE 15

All are oral views of *g* elements; all are from BR77-1:323', except where noted.

FIGURES 1-11.

Astropentagnathus irregularis MOSTLER

FIG. 1: X (ADM 20012); FIG. 2: X (ADM 20013); FIG. 3: X (ADM 20014); FIG. 4: X (ADM 20015); FIG. 5: X (ADM 20016); FIG. 6: X (ADM 20017); FIG. 7: X (ADM 20018); FIG. 8: X (ADM 20019); FIG. 9: X (ADM 20020); FIG. 10: X (ADM 20021); FIG. 11: X (ADM 20022).

FIGURES 12-14.

Pterospathodus n. sp. A

FIG. 12: X (ADM 20444); FIG. 13: X (ADM 20445); FIG. 14: X (ADM 20446).

FIGURES 15, 17, 19-21, 24.

Pterospathodus pennatus procerus (WALLISER)

FIG. 15: X (TC78-212m; ADM 20431); FIG. 17: X (TC78-212m; ADM 20432); FIG. 19: X (TC78-218m; ADM 20433); FIG. 20: X (TC78-212m; ADM 20434); FIG. 21: X (TC78-212m; ADM 20435); FIG. 24: X (TC78-192m; ADM 20436).

FIGURES 16, 18.

Pterospathodus pennatus angulatus (WALLISER)

FIGS. 16, 18: X (ADM 20421), X (ADM 20422).

FIGURES 22, 23, 25-32.

Astropentagnathus n. sp. A

FIG. 22: X (ADM 20031); FIG. 23: X (ADM 20032); FIG. 25: X (ADM 20033); FIG. 26: X (ADM 20034); FIG. 27: X (ADM 20035); FIG. 28: X (ADM 20036); FIG. 29: X (ADM 20037); FIG. 30: X (ADM 20038); FIG. 31: X (ADM 20039); FIG. 32: X (ADM 20040).

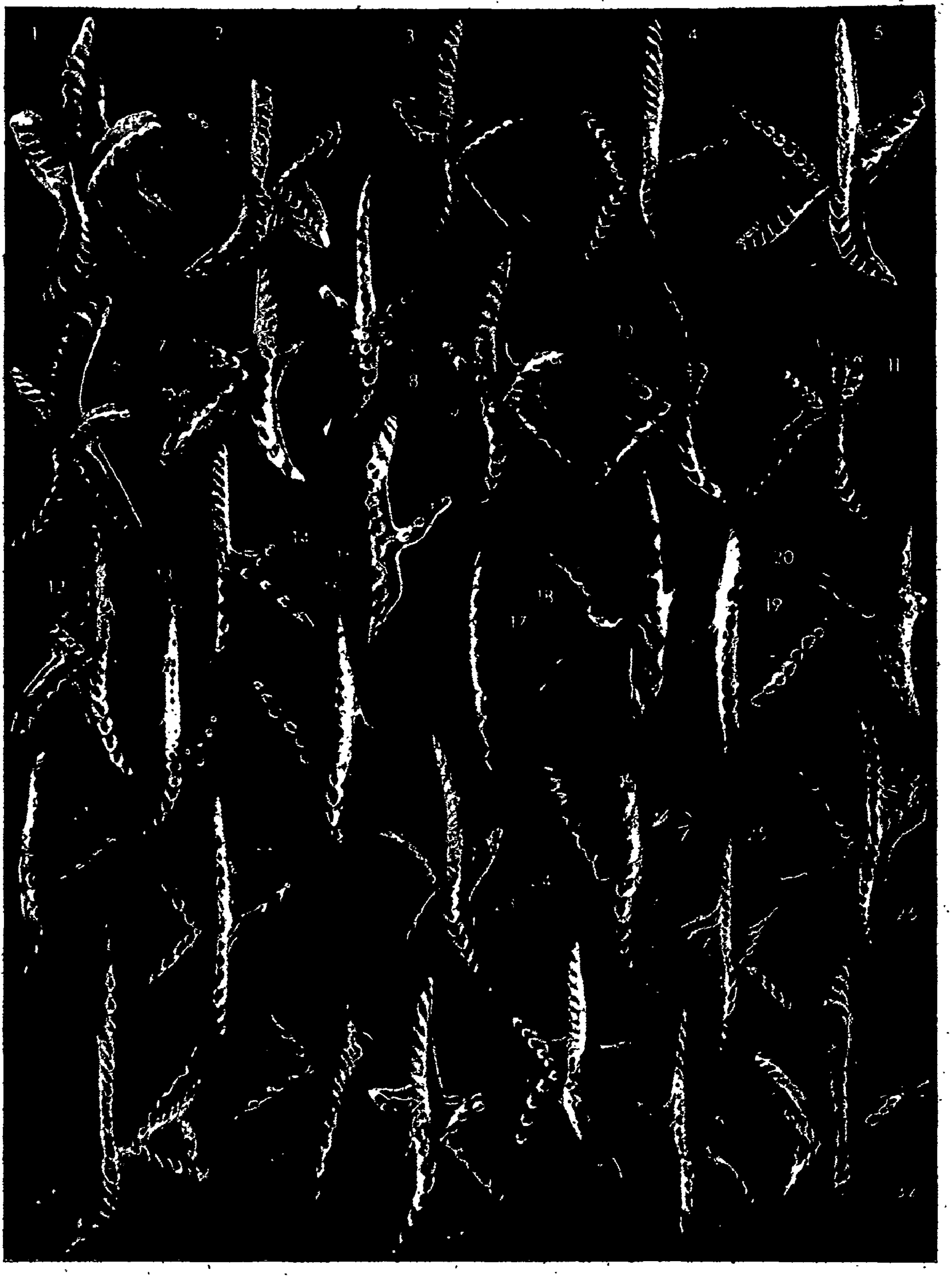
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PLATE 16

All are lateral views and from BR77-1:323', except where noted.

FIGURES 1-4, 21, 25.

Pterospathodus pennatus angularis (WALLISER)

FIGS. 1, 2: *g* elements, X (ADM 20423), X (ADM 20424);

FIGS. 3, 4: *g* elements, with bifurcated lateral process, oral and aboral-latral views, X (ADM 20425), X (ADM 20426).

FIGS. 21, 25: *f* elements, outer lateral views, X (ADM 20427), X (ADM 20428).

FIGURES 5-10, 16-19, 26-28, 31, 37.

Pterospathodus celloni (WALLISER)

FIGS. 5-10: *g* elements. FIG. 5: X (ADM 20404); FIG. 6: X (ADM 20405); FIG. 7: X (ADM 20406); FIG. 8: X (ADM 20407); FIG. 9: X (ADM 20408); FIG. 10: X (ADM 20409).

FIGS. 16-19, 26-28, 37: *f* elements. FIG. 16: X (ADM 20410); FIG. 17: X (ADM 20411); FIG. 18: X (ADM 20412); FIG. 19: X (ADM 20413); FIG. 26: X (ADM 20414); FIG. 27: X (ADM 20415); FIG. 28: X (ADM 20416); FIG. 37: X (ADM 20418).

FIG. 31: "S" element, outer lateral view, X (ADM 20417).

FIGURE 12.

Astropentagnathus irregularis MOSTLER

Oral-lateral view, *f* element, X (ADM 20609).

FIGURES 11, 13-15.

Pterospathodus n. sp. A

Lateral views, *f* elements. FIG. 11: X (ADM 20447); FIG. 13: X (ADM 20448); FIG. 14: X (ADM 20449); FIG. 15: X (ADM 20450).

FIGURES 22-24.

Pterospathodus *pennatus* *procerus* (WAL[illegible]SER)

Outer, inner and inner lateral views, *f* elements. FIG. 22: X (ADM 20437); FIG. 23: X (ADM 20438); FIG. 24: X (ADM 20439). All are from TC78-212m.

FIGURES 20, 29, 30, 32-36, 38-40.

Pterospathodus? Indeterminate Elements

FIGS. 20, 29: *d*? element, posterolateral and lateral views, X, X (ADM 20453).

FIGS. 30, 33, 40: *e*-1 elements, type 1, inner lateral views. FIG. 30: X (ADM 20454); FIG. 33: X (ADM 20455); FIG. 40: X (ADM 20461).

FIG. 32: *e*-2 element, X (ADM 20452).

FIG. 34: *e*-1 element, type 2, inner lateral view, X (ADM 20456).

FIGS. 35, 39: triangular elements, lateral and anterolateral views, X (TC78-212m; ADM 20457), X (TC78-212m; ADM 20460).

FIG. 36: *e*-1 element, type 3, inner lateral view, X (ADM 20458).

FIG. 38: triangular element, X (TC78-212m; ADM 20459).


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PLATE 17

All are lateral views and from TC78-212m, except where noted.

FIGURES 1-3, 5, 7-10, 13, 14.

Pterospathodus? Indeterminate Elements

FIGS. 1, 3, 10: *a* elements. FIG. 1: X (BR77-1:323'; ADM 20462); FIG. 3: (BR77-1:323'; ADM 20464); FIG. 10: X (ADM 20469).

FIGS. 2, 8, 9, 13, 14: *b* elements. FIG. 2: X (BR77-1:323'; ADM 20463); FIG. 8: posterior view, X (ADM 20467); FIG. 9: X (ADM 20468); FIG. 13: X (ADM 20470); FIG. 14: posterior view, X (BR77-1:323'; ADM 20471).

FIG. 5: *e*-1 element, type 2, inner lateral view, X (BR77-1:323'; ADM 20465).

FIG. 7: *c* element, posterior view, X (ADM 20466).

FIGURES 6, 11, 12.

Pterospathodus pennatus procerus (WALLISER)

Inner, outer and anterior views, *e*-1 elements. FIG. 6: X (ADM 20440); FIG. 11: X (ADM 20441); FIG. 12: X (ADM 20442).

FIGURES 4, 15-35.

Carniodus carnulus WALLISER

FIG. 4: *e*-1 element, X (ADM 20075).

FIGS. 15-17: *a* elements, outer, outer and inner lateral views. FIG. 15: X (ADM 20076); FIG. 16: X (ADM 20077); FIG. 17: X (ADM 20078).

FIGS. 18-20: b elements, outer anterolateral views. FIG. 18: X (ADM 20079); FIG. 19: X (ADM 20080); FIG. 20: X (ADM 20081); FIG. 21: X (ADM 20082).

FIGS. 22-25: c elements. FIGS. 22, 24: anterior views, X (ADM 20083), X (ADM 20084); FIGS. 23, 25: posterior views, X (ADM 20085), X (ADM 20086).

FIGS. 26-29, 33: asymmetrical g elements. FIG. 26: X (ADM 20087); FIG. 27: X (ADM 20088); FIG. 28: X (ADM 20089); FIG. 29: X (ADM 20090); FIG. 33: X (ADM 20094).

FIGS. 30, 31: e-2 elements, anterior views, X (ADM 20091), X (ADM 20092).

FIG. 32; symmetrical g element, X (ADM 20093).

FIGS. 34, 35: f elements, outer lateral views, X (ADM 20095), X (ADM 20096).

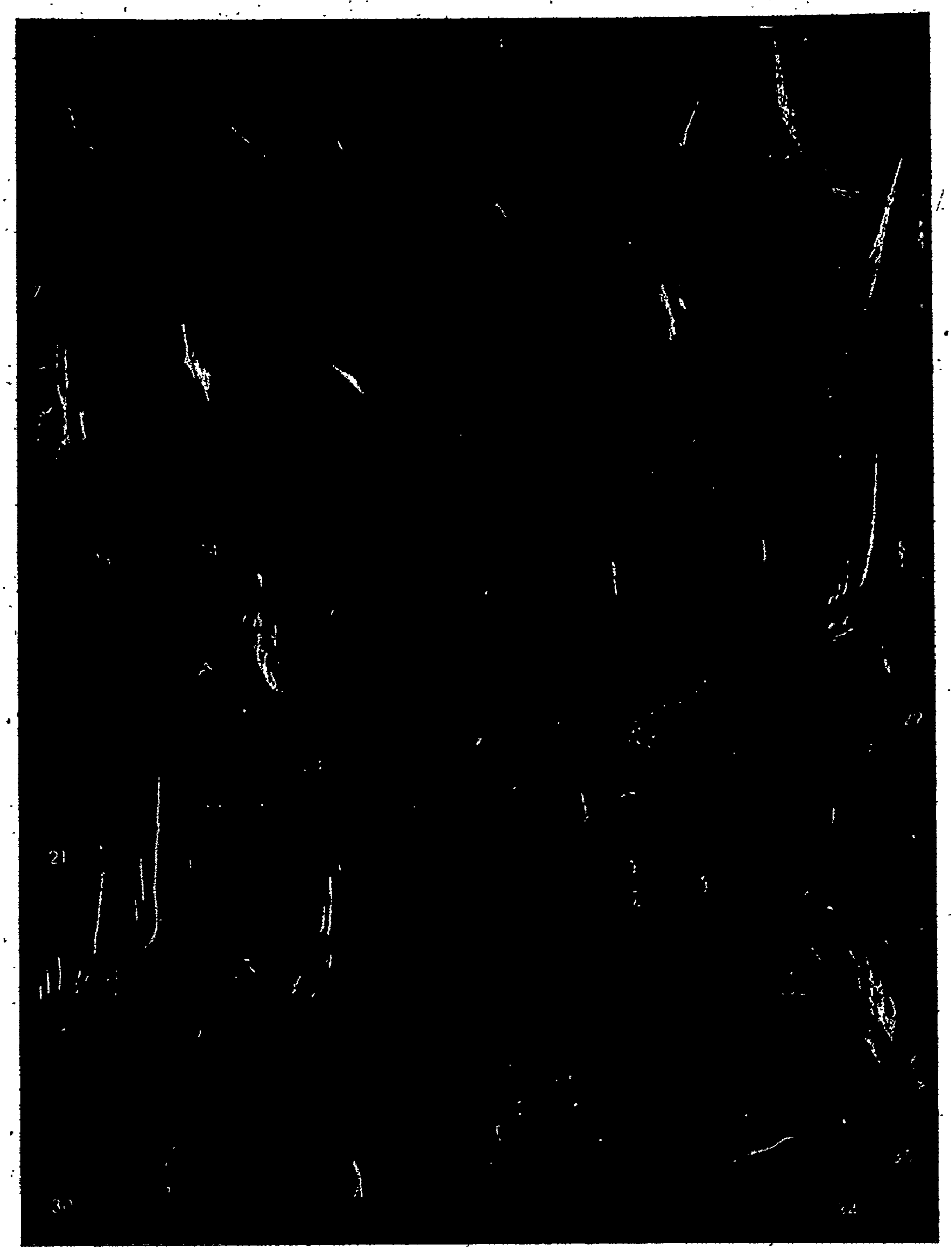
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PLATE 18

All are lateral views, except where noted; all are from BR77-1:296'.

FIGURES 1-42.

<u>Walliserodus</u> n. sp. A

FIGS. 1, 3, 6: <u>a</u> elements, inner lateral views. FIG. 1: X (ADM 20529); FIG. 3: X (ADM 20531); FIG. 6: X (ADM 20534).

FIGS. 2, 4, 5, 7-9: <u>a</u> elements, outer lateral views. FIG. 2: X (ADM 20530); FIG. 4: X (ADM 20532); FIG. 5: X (ADM 20533); FIG. 7: X (ADM 20535); FIG. 8: X (ADM 20536); FIG. 9: X (ADM 20537).

FIGS. 10, 11, 18: <u>b</u>-1 elements, outer lateral view. FIG. 10: X (ADM 20538); FIG. 11: X (ADM 20539); FIG. 18: X (ADM 20546).

FIG. 12: <u>b</u>-1 element, inner lateral view, X (ADM 20540).

FIGS. 13, 16, 17: <u>b</u>-2 elements, inner lateral views. FIG. 13: X (ADM 20541); FIG. 16: X (ADM 20544); FIG. 17: X (ADM 20545).

FIGS. 14, 15: <u>b</u>-2 elements, outer lateral views, X (ADM 20542), X (ADM 20543).

FIGS. 19, 20, 24-27: <u>c</u> elements. FIG. 19: X (ADM 20547); FIG. 20: X (ADM 20548); FIG. 24: X (ADM 20552); FIG. 25: X (ADM 20553); FIG. 26: X (ADM 20554); FIG. 27: X (ADM 20555).

FIGS. 21, 22: <u>c</u> elements, posterior views, X (ADM 20549), X (ADM 20550).

FIG. 23: <u>b</u> element, posterior view, X (ADM 20551).

FIGS. 28, 30, 31, 33, 38: e elements. FIG. 28: X (ADM 20556); FIG. 30: X (ADM 20558); FIG. 31: X (ADM 20559); FIG. 33: X (ADM 20561); FIG. 38: X (ADM 20566).

FIGS. 29, 32, 34-37, 39-42: d elements. FIG. 29: X (ADM 20557); FIG. 32: X (ADM 20560); FIG. 34: X (ADM 20562); FIG. 35: X (ADM 20563); FIG. 36: X (ADM 20564); FIG. 37: X (ADM 20565); FIG. 39: X (ADM 20567); FIG. 40: X (ADM 20568); FIG. 41: X (ADM 20569); FIG. 42: X (ADM 20570).

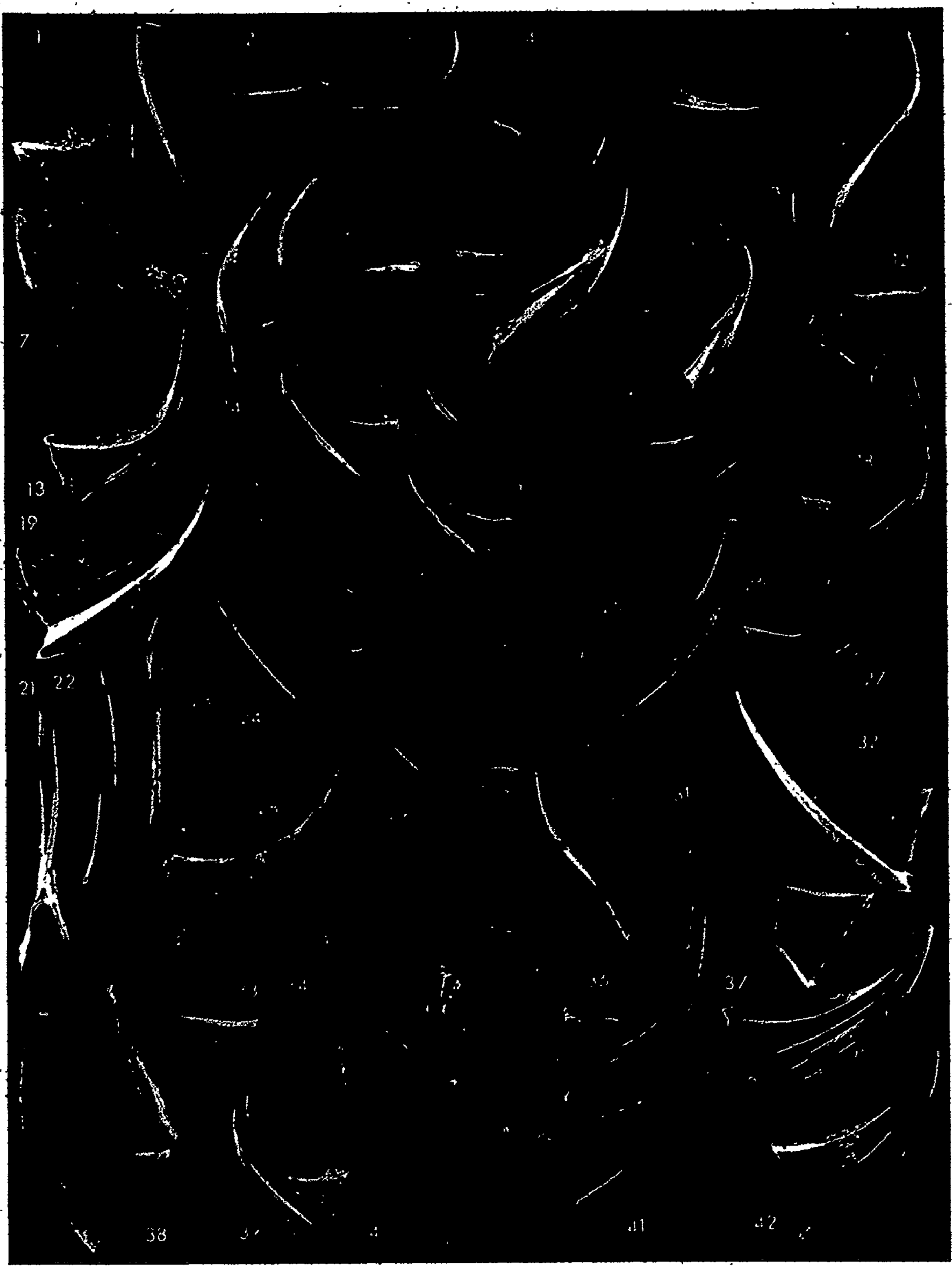

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PLATE 19

All are lateral views and from BR77-1:296', except where noted.

FIGURES 1, 2.

Walliserodus? n. sp. B

outer and inner lateral views, a? (oistodontiform) elements, X (ADM 20571), X (ADM 20572). Both are from TC78-212m.

FIGURES 3-10, 15.

Walliserodus sancticlari COOPER

FIGS. 3, 5: b elements, inner lateral views, X (ADM 20520), X (ADM 20522).

FIG. 4: b element, outer lateral view, X (ADM 20521).

FIGS. 6, 9: a elements, inner lateral views, X (ADM 20523), X (ADM 20526).

FIG. 7: d element, X (ADM 20524).

FIGS. 8, 15: e elements, X (ADM 20525), X (ADM 20528).

FIG. 10: c element, X (ADM 20527).

FIGURE 12.

Walliserodus curvatus (BRANSON and BRANSON)

Lateral view, e element, X (ADM 20518).

FIGURES 11, 13, 14, 16-28, 30-32, 35, 40.

Dapsilodus obliquicostatus (BRANSON and MEHL)

FIG. 11: a element, X (ADM 20098).

FIGS. 13, 28, 32: c elements. FIG. 13: X (ADM 20099);

FIG. 28: X (ADM 20111); FIG. 32: X (ADM 20114).

FIGS. 14, 16, 19-27, 30, 31, 35, 40: b elements. FIGS. 14, 24: X (ADM 20100); FIG. 16: X (ADM 20101); FIG. 19: X (ADM 20104); FIG. 20: X (ADM 20105); FIG. 21: X (ADM 20106); FIGS. 22, 23: X, X (20107); FIG. 25: X (ADM 20108); FIG. 26: X (ADM 20109); FIG. 27: X (ADM 20110); FIG. 30: X (ADM 20112); FIG. 31: X (ADM 20113); FIG. 35: X (ADM 20115); FIG. 40: X (ADM 20116).

FIGS. 17, 18: e elements, outer and inner lateral views, X (ADM 20102), X (ADM 20103).

FIGS. 11, 26, 27, 30-32, 40 are from TC78-212m; FIG. 35 is from RR78-245m.

FIGURES 33, 39.

Decoriconus fragilis (BRANSON and MEHL)

FIG. 33: b element, X (ADM 20127); FIG. 39: c element, X (ADM 20128).

FIGURES 29, 34, 36-38.

Dapsilodus? sp. B

FIGS. 29, 34: e element, inner and outer lateral views, X (ADM 20117), X (ADM 20118).

FIGS. 36-38: a-b elements, outer, inner and inner lateral views. FIG. 36: X (ADM 20119); FIG. 37: X (ADM 20120); FIG. 38: X (ADM 20121). All are from RR78-285m.


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APPENDIX A

PHOTOGRAPHIC PLATES OF CONODONTS FROM AVALANCHE LAKE, SOUTHWESTERN N.W.T.

The following 22 plates illustrate conodonts from Avalanche Lake in the southern Mackenzie Mountains of southwestern Northwest Territories. The plates are part of a recently completed manuscript by G.S. Nowlan, A.D. McCracken and B.D.E. Chatterton, which reports on the Avalanche Lake conodont fauna. These are included herein because a number of taxa are common to both the basinal strata of the Yukon (Road River Formation) and the shallower water carbonate facies of the Whittaker Formation in the N.W.T.

PLATE 1

FIGURE 1.

Amorphognathus? sp. NOWLAN and McCRACKEN

Figured specimen. Oral view, g element, X90, GSC 80180, from AV1-20m.

FIGURES 2-4, 7.

Aphelognathus floweri SWEET?

Figured specimens. (2) Posterior view, b element, X85, GSC 80181. (3) Inner lateral view, e element, X85, GSC 80182. (4) Inner lateral view, f element, X54, GSC 80183. (7) Lateral view, g element, X50, GSC 80184. All specimens are from AV1-20m.

FIGURES 5, 6, 8-15.

Aphelognathus politus (HINDE)

Hypotypes. (5) Lateral view. a-1 element, X90, GSC 80185. (6) Inner lateral view, a-2 element, X80, GSC 80186. (8) Posterior view, b element, X105, GSC 80187. (9) Posterior view, c element, X95, GSC 80188. (10) Lateral view, e element, X100, GSC 80189. (11) Lateral view, g element, X72, GSC 80190. (12, 13) Lateral views, g element, X65, GSC 80191. (14) Inner lateral view, f element, X120, GSC 80192. (15) Lateral view, g element, X85, GSC 80193. All specimens are from AV1-10m except GSC 80189, 80190, (FIGS. 10, 11), which are from AV1-4m.


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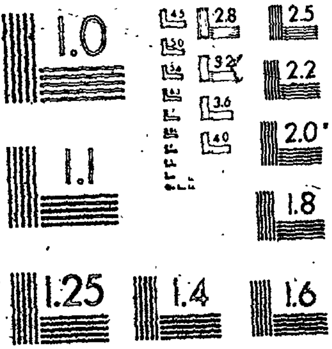

PLATE 2

FIGURES 1-17.

Besselodus borealis NOWLAN and McCRACKEN n. sp.

(1, 2) Inner and outer views, a element, X150, paratype, GSC 80197. (3, 4) Outer and inner lateral views, b-2 element, X180, paratype, GSC 80198. (5, 6) Outer and inner lateral views, b-1 element, X140, paratype, GSC 80199. (7, 8) Lateral views, c element, X240, paratype, GSC 80200. (9, 10) Lateral views, f? element, X165, paratype GSC 80201. (11, 12) Outer and inner lateral views, e element, X260, paratype, GSC 80202. (13-15) Posterolateral, posterior and lateral views, c element, X205, paratype, GSC 80203. (16, 17) Inner and outer lateral views, e element, X235, holotype, GSC 80204. All specimens are from AV1-46m except GSC 80202 (FIGS. 11, 12), which is from AV1-73m.


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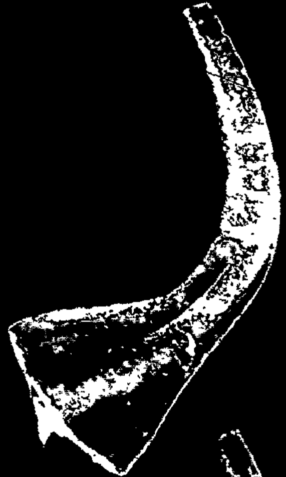
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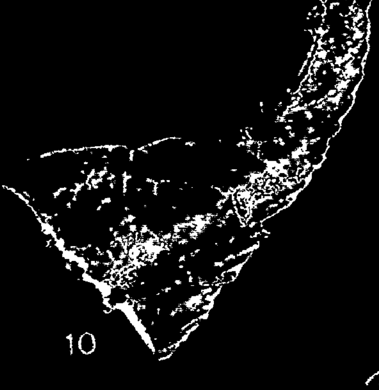
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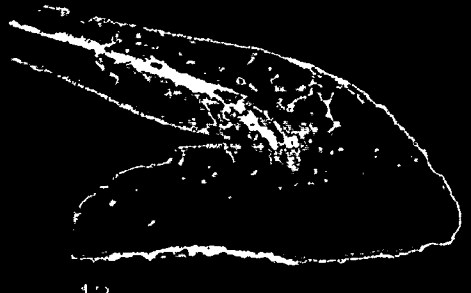
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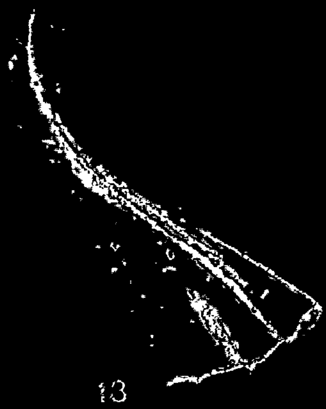
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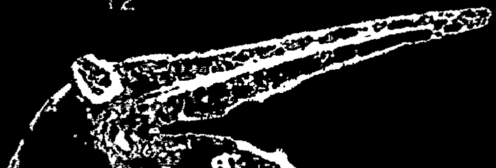
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PLATE 3

FIGURES 1-5, 8-10.

Coelocerodontus trigonius ETHINGTON

Hypotypes. (1) Posterior view, asymmetrical tetragoniform, X115, GSC 80205, from AV1-73m. (2) Posterior view, basal funnel, X 165, GSC 80206, from AV1-46m. (3) Lateral view, basal funnel, X200, GSC 80207, from AV1-46m. (4) Posterior view, symmetrical trigoniform element, X115, GSC 80208, from AV1-73m (see FIG. 10). (5) Lateral view of basal funnel *in situ* with densely packed lamellae, X285, GSC 80209, from AV1-73m (see FIG. 8). (8, 9) Inner and outer lateral views, slightly asymmetrical trigoniform element, X100, GSC 80209 (see FIG. 5). (10) Apical view of tip of symmetrical trigoniform element showing cross section of basal cavity, X890, GSC 80208 (see FIG. 4).

FIGURES 6, 7, 11-13.

Dapsilodus? sp. A NOWLAN and McCRACKEN

Figured specimens. (6, 7) Inner and outer lateral views, *a* element, X150, GSC 80210, from AV4B-111.6m. (11, 12) Outer and inner lateral views, *b* element, X135, GSC 80211, from AV1-84.5m. (13) Outer view, *b* element, X150, GSC 80212, from AV1-84.5m.

FIGURES 14-18, 23.

Decoriconus costulatus (REXROAD)

Hypotypes. (14) Inner lateral view, paltodiform element, X205, GSC 80213. (15) Inner lateral view, paltodiform element, X175, GSC 80214. (16) Inner lateral view, acontiodiform element, X230, GSC 80215. (17) Inner lateral view, paltodiform element, X230, GSC 80216. (18, 23) Inner and outer lateral views, acontiodiform element, X230, GSC 80217. Specimens GSC 80213-80215 (FIGS. 14-16) are from AV1-46m of Ordovician age; GSC 80216, 80217 (FIGS. 17, 18, 23) are from AV4B-111.6m of Silurian age.

FIGURES 19-22.

Depanoistodus *suberectus* (BRANSON and MEHL)

Hypotypes. (19) Lateral view *p* element, X70, GSC 80218. (20) Lateral view, *p* element, X80, GSC 80219. (21) Lateral view, *q* element, X75, GSC 80220. (22) Inner lateral view, *r* element, X130, GSC 80221. All specimens are from AV-10m, except GSC 80218, which is from AV1-4m.


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PLATE 4

FIGURES 1-3.

Juanognathus n. sp. A NOWLAN and McCRACKEN

Figured specimens. (1) Posterior view, slightly asymmetrical *t* element, X130, GSC 80222. (2) Posterior view, markedly asymmetrical element, X140, GSC 80223. (3) Lateral view, *s* element, X105, GSC 80224. All specimens are from AV1-(-30m).

FIGURES 4-9.

Oulodus rohneri ETHINGTON and FURNISH

Hypotypes. (4) Posterior view, *b* element, X110, GSC 80225. (5) Posterior view, *c* element, X110, GSC 80226. (6) Inner lateral view, *a* element, X145, GSC 80227. (7) Inner lateral view, *e* element, X135, GSC 80228. (8) Posterior view, *g* element, X110, GSC 80229. (9) Inner lateral view, *f* element, X145, GSC 80230. All specimens are from AV1-46m.

FIGURES 10-15.

Oulodus ulrichi (STONE and FURNISH)

Hypotypes. (10) Posterior view, *g* element, X55, GSC 80231. (11) Posterior view, *c* element, X75, GSC 80232. (12) Posterior view, *b* element, X75, GSC 80233. (13) Inner lateral view, *a* element, X75, GSC 80234. (14) Inner lateral view, *e* element, X60, GSC 80235. (15) Inner lateral view, *f* element, X75, GSC 80236. All specimens are from AV1-15m.

FIGURES 16-20.

Ozarkodina hassi (POLLOCK, REXROAD and NICOLL)

Hypotypes. (16) Inner lateral view, *a* element, X85, GSC

80238. (18) Posterior view, c element, X95, GSC 80239. (19) Posterior view, e element, X150, GSC 80240. (20) Fused cluster, b or c element beneath g element, X100, GSC80241. All specimens are from AV4B-111.6m.

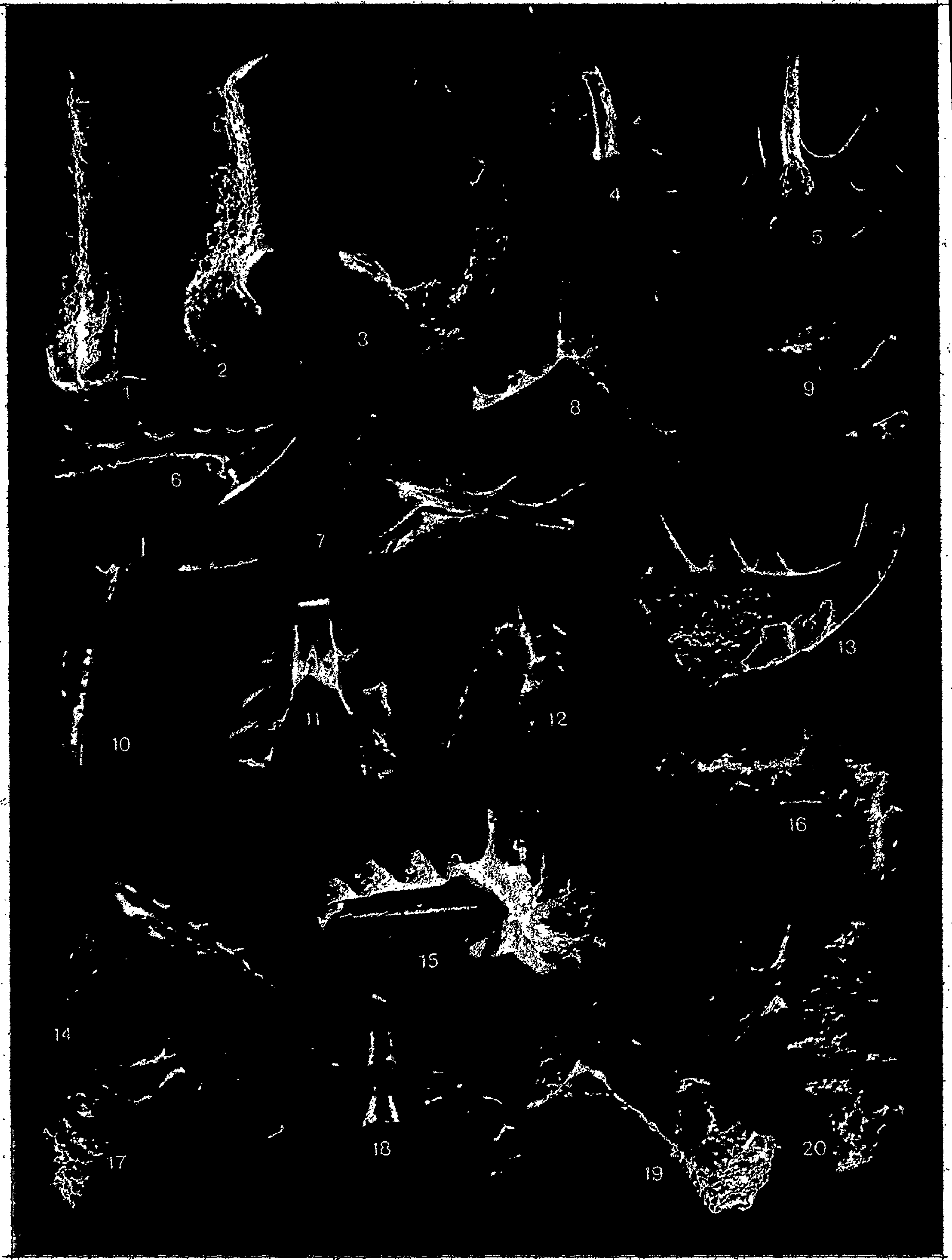
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PLATE 5

FIGURES 1-15.

Ozarkodina sesquipedalis NOWLAN and McCRACKEN n. sp.

(1) Inner lateral view, *a*-2 element, paratype, X105, GSC 80248. (2) inner lateral view, *a*-1 element, paratype, X130, GSC 80249. (3) Outer lateral view, *a*-2 element, paratype, X130, GSC 80250. (4) Posterior view, fragmentary *c*? element, paratype, X85, GSC 80251. (5) Posterolateral view, *b* element, paratype, X115, GSC 80252. (6) Posterior view, *b* element, paratype, X100, GSC 80253. (7, 8) Outer and inner lateral views, *f* element, paratype, X105, GSC 80254. (9, 11) Outer and inner lateral views, *e*-1 element, holotype, X105, GSC 80255 (see FIG. 14). (10) Inner lateral view, *e*-2 element, paratype, X150, GSC 80256. (12) Inner lateral view, *f* element, paratype, X90, GSC 80257. (13) Lateral view, *g* element, paratype, X80, GSC 80258. (14) Close-up view of posterior portion of cusp (left) and proximal denticles, *e*-1 element, holotype, X320, GSC 80255 (see FIGS. 9, 10). (15) Lateral view, *g* element, paratype, X95, GSC 80259. All specimens are from AV1-20m.

FIGURES 16-21.

Ozarkodina hassi (POLLOCK, REXROAD and NICOLL)

Hypotypes. (16) Inner lateral view, *f* element, X115, GSC 80242. (17) Lateral view, *g* element, X80, GSC 80243. (18) Lateral view, *g* element with needle-like denticles in medial portion, X115, GSC 80244. (19) Lateral view, *g* element, X115, GSC 80245. (20) Lateral view, *g* element, X90, GSC

80246. (21) Lateral view, f element with long posterior process, X155, GSC 80247. All specimens are from AV4B-111.6m, except GSC 80243 (FIG. 17), which is from AV1-84.5m.

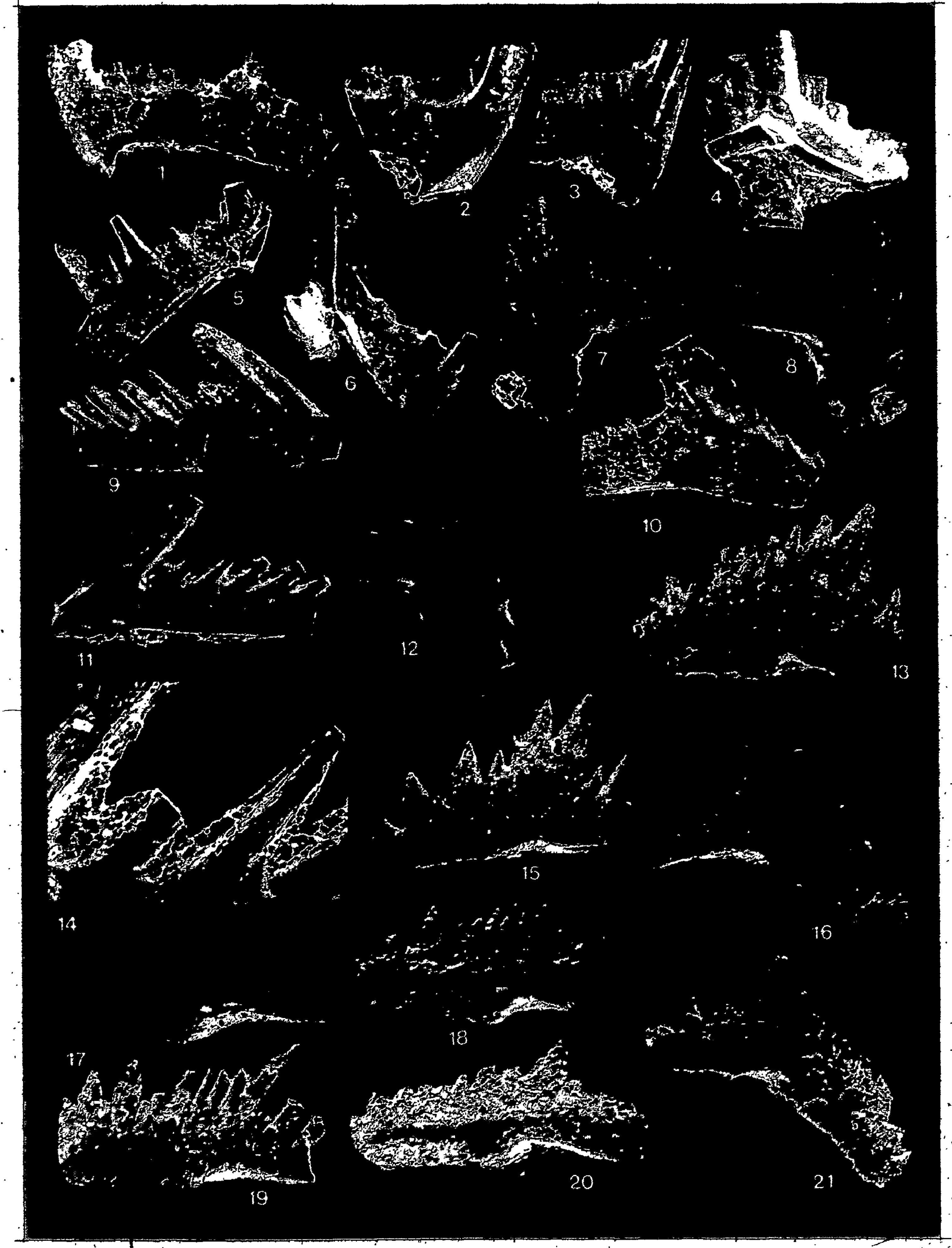
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PLATE 6

FIGURES 1-5.

Panderodus aff. P. bergstroemi SWEET

Figured specimens. (1, 2) Lateral views, c element, X125, GSC 80260. (3) Lateral view, b element, X95, GSC 80261. (4, 5) Lateral views, b element, X95, GSC 80262. All specimens are from AV1-(-30m).

FIGURES 6-11.

Panderodus? clinatus McCRACKEN and BARNES

Hypotypes. (6, 7) Lateral views, weakly compressed e element, X110, GSC 80263, from AV1-6m. (8, 9) Lateral views, e element, X120, GSC 80264, from AV1-4m. (10, 11) Lateral views, a/b element, X80, GSC 80265, from AV1-20m.

FIGURES 12-20.

Panderodus? gibber NOWLAN and BARNES

Hypotypes. (12, 13) Lateral views, c elements, X180, GSC 80266, from AV1-46m. (14, 15) Inner and outer lateral views, a element, X180, GSC 80267, from AV1-46m. (16, 17) Inner and outer lateral views, a element, X170 GSC 80268, from AV1-46m. (18, 19) Outer and inner lateral views, b element, X120, GSC 80269, from AV48-62m. (20) Outer lateral view, b element, X130, GSC 80270, from AV1-20m.

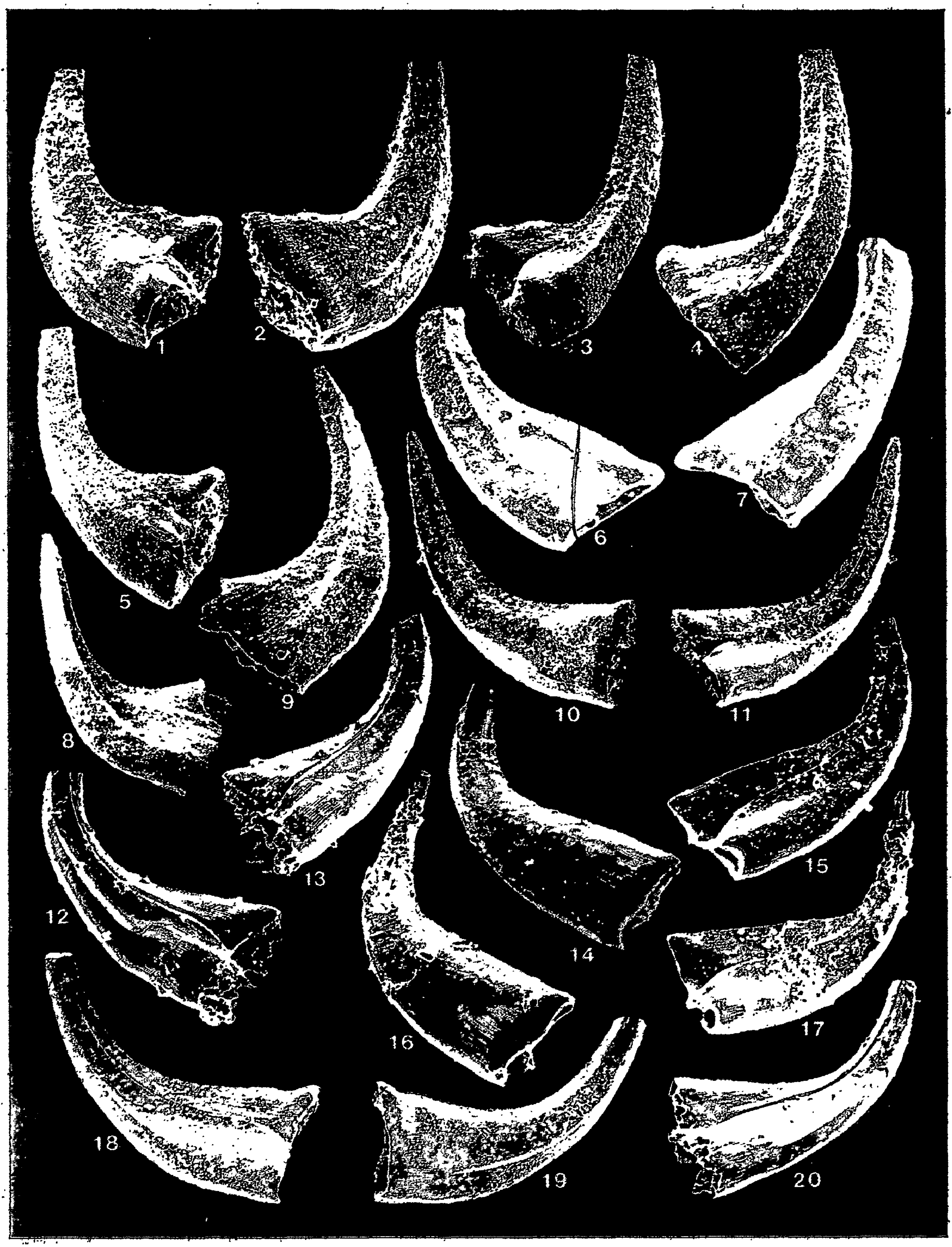
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PLATE 7

FIGURES 1-10, 12, 13, 19.

Panderodus gracilis (BRANSON and MEHL)

Hypotypes. (1) Lateral view, *c* element, X95, GSC 80271, from AV1-73m. (2, 3) Lateral views, *c* element, X95, GSC 80272, from AV1-10m. (4, 5) Inner and outer lateral views, *a* element, X135, GSC 80273, from AV1-46m. (6, 19) Lateral views, *e* element, X95, GSC 80274, from AV1-10m. (7, 8) Outer and inner lateral views, *b* element, X90, GSC 80275, from AV1-73m. (9, 10) Outer and inner lateral views, *a/b* element, X95, GSC 80276, from AV1-10m. (12, 13) Lateral views, *e* element, X110, GSC 80277, from AV1-73m.

FIGURES 11, 15-18, 22.

Panderodus? liratus NOWLAN and BARNES

Hypotypes. (11, 22) Inner and outer lateral views, slender *a/b*? element, X80, GSC 80278, from AV1-20m. (15, 16) Outer and inner lateral views, slender *a/b*? element, X85, GSC 80279, from AV1-20m. (17, 18) Inner and outer lateral views, slender *c*? element, X85, GSC 80280, from AV1-10m.

FIGURES 14, 20, 21, 23-25.

Panderodus panderi (STAUFFER)?

Figured specimens. (14, 25) Inner and outer lateral views, slightly bowed slender element, X150, GSC 80281, from AV1-46m. (20, 21) Inner and outer lateral views, slightly bowed broader element, X135, GSC 80282, from AV1-4m. (23, 24) Lateral views, element with furrow on both sides and basal thickening, X120, GSC 80283, from AV1-20m.

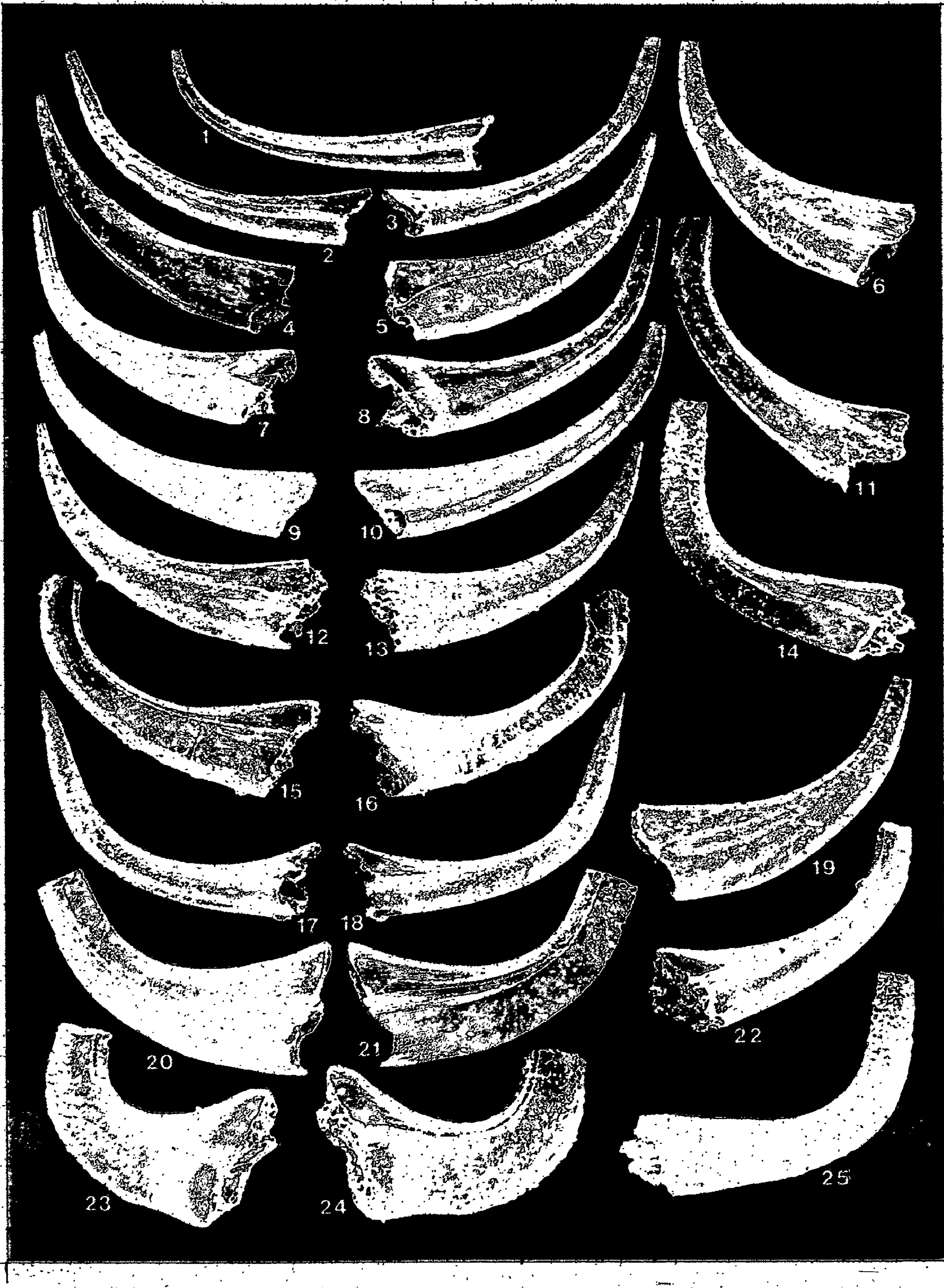
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PLATE 8

FIGURES 1-4, 8-15, 20, 21, 26.

Panderodus rhamphoides NOWLAN and McCRACKEN n. sp.

(1, 2) Outer and inner lateral views, *a* element, paratype, X130, GSC 80284, from AV1-46m. (3, 4) Inner and outer lateral views, *b* element, paratype, X120, GSC 80285, from AV1-10m. (8, 9) Inner and outer lateral views, *b* element, holotype, X80 GSC 80286, from AV1-10m. (10, 11) Inner and outer lateral views, *b* element, paratype, X110, GSC 80287, from AV1-6m. (12, 13) Inner and outer lateral views, *c* element, paratype, X110, GSC 80288, from AV1-4m. (14, 15) Outer and inner lateral views, *e* element, paratype, X210, GSC 80289, from AV1-46m. (20, 21) Inner and outer lateral views, *e* element, paratype, X200, GSC 80290, from AV1-46. (26) Outer lateral view, *e* element, paratype, X180, GSC 80291, from AV1-46m.

FIGURES 5-7.

Panderodus serratus REXROAD s.f.

Hypotype. (5, 7) Outer and inner lateral views, X155, GSC 80292. (6) Inner lateral view, X115, GSC 80293. Both specimens are from AV4B-62m.

FIGURES 16-19, 22-25.

Panderodus? n. sp. A. NOWLAN and McCRACKEN

Figured specimens. (16, 17) Outer and inner lateral views, *a* element, X165, GSC 80294. (18, 19) Outer and inner lateral views, *a* element with medial outer costa, X200, GSC 80295.

(22, 23) Outer and inner lateral views, a element, X220, GSC 80296. (24, 25) Outer and inner lateral views, b element, X220, GSC 80297. All specimens are from AV1-15m, except GSC 80294 (FIGS. 16, 17), which is from AV1-10m.


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PLATE 9

FIGURES 1-22.

Paroistodus? sp. A NOWLAN and McCRACKEN

(1, 3) Outer and inner lateral views, *a*-1 element, X255, GSC 80298. (2, 11) Outer and inner lateral views, *b*-1 element, X160, GSC 80299. (4) Outer lateral view, *e* element, X280, GSC 80300. (5, 6) Outer and inner lateral views, *a*-1 element, X170, GSC 80301. (7, 12) Inner and outer lateral views, *b*-1 element, X170, GSC 80302. (8, 13) Inner and outer lateral views, *b*-2 element, X195, GSC 80303. (9, 10) Outer and inner views, *a*-1 element, X155, GSC 80304. (14, 15) Outer and inner lateral views, *a*-2 element, X170, GSC 80305. (16-19) Lateral, anterolateral, lateral and anterior views, *c* element, X155, GSC 80306. (20) Inner lateral view, *e* element, X145, GSC 80307. (21, 22) Inner and outer lateral views, *e* element, X180, GSC 80308. All specimens are from AV1-46m, except GSC 80298, 80300 and 80301 (FIGS. 1, 3, 4-6) which are from AV1-73m.

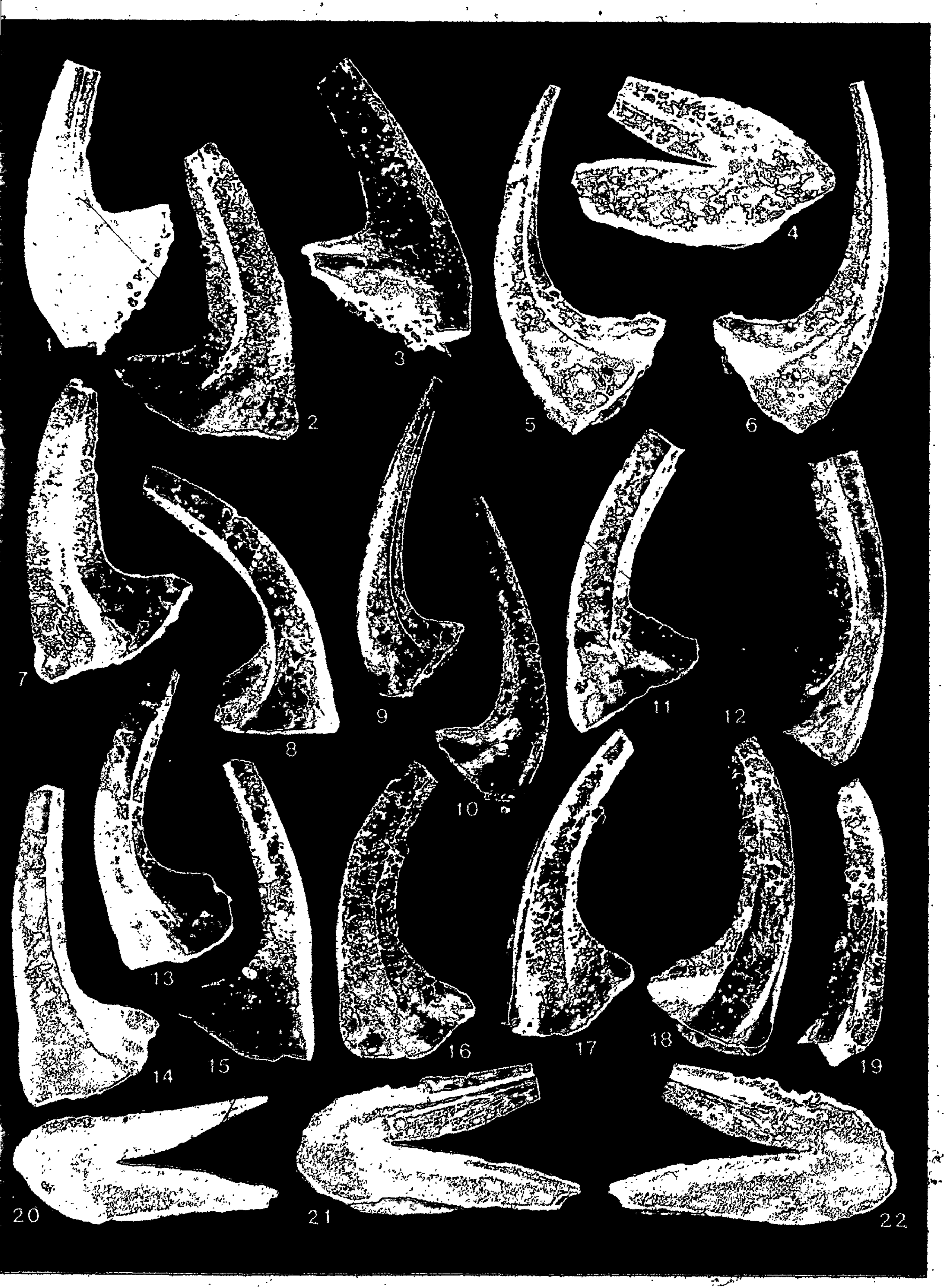
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PLATE 10

FIGURES 1-3, 6, 7.

Phragmodus undatus BRANSON and MEHL

Hypotypes. (1) Lateral view, *b* element, X100, GSC 80309. (2) Lateral view, *c* element, X140, GSC 80310. (3) Outer lateral view, *g* element, X150, GSC 80311. (6) Inner lateral view, *e* element, X140, GSC 80312. (7) Outer lateral element, *f* element, X150, GSC 80313. All species are from AV4B-62m, except GSC 80309 and 80312 (FIGS. 1, 6) which are from AV1-33.5m.

FIGURES 4, 5.

Phragmodus? sp. A. NOWLAN and McCRACKEN

Figured specimens. (4) Lateral view, *c*? element, X95, GSC 80314. (5) Posterolateral view, *b*? element, X95, GSC 80315. Both specimens are from AV1-(-30m).

FIGURES 8-15, 17, 18.

Plectodina aculeatoides SWEET?

Figured specimens. (8) Inner lateral view, *a* element, X105, GSC 80316. (9) Posterior view, *b* element, X90, GSC 80317. (10, 11) Outer and inner lateral views, *f* element, X85, GSC 80317. (12) Inner lateral view, *e* element, X105, GSC 80319. (13) Inner lateral view, *e* element, X75, GSC 80320. (14) Posterior view, *c* element, X100, GSC 80321. (15) Inner lateral view, *f* element, X90, GSC80322. (17) Inner lateral view, *g* element, X65, GSC 80323. (18) Inner lateral view, *g* element, X80, GSC 80324. All specimens are from AV1-10m except GSC 80323 (FIG. 17) which is from AV1-4m.

FIGURES 16, 19-22.

Plectodina florida SWEET

Hypotype. (16) Posterior view, *b* element, X70, GSC 80325. (19) Inner lateral view, *a* element, X70, GSC 80326. (20) Inner lateral view, *e* element, X70, GSC 80327. (21) Inner lateral view, *f* element, X60, GSC 80328. (22) Lateral view, *g* element, X50, GS 80329. All specimens are from AV1-15m.


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Plate 11

FIGURES 1-8, 10-12, 14, 15.

Plectodina tenuis (BRANSON and MEHL)

Hypotypes. (1) Posterior view, *b* element, X110, GSC 80330, from AV1-46m. (2) Posterior view, *b* element, X100, GSC 80331, from AV1-46m. (3) Posterior view, *c* element, X75, GSC 80332, from AV1-4m. (4) Posterior view, *c* element, X105, GSC 80333, from AV1-46m. (5) Lateral view, *e* element, X100 GSC 80334, from AV1-46m. (6, 7) Lateral views, *a* element, X65 and X130 respectively, GSC 80335, from AV1-46m. (8) Inner lateral view, *e* element, X95, GSC 80336, from AV1-73m. (10) Outer lateral view, *f* element, X110, GSC 80337, from AV1-73m. (11) Lateral view, *g* element, X75, GSC 80338, from AV1-46m. (12) Lateral view, *g* element, X100, GSC 80339, from AV1-73m. (14) Inner lateral view, *f* element, X110, GSC 80340, from AV1-46m. (15) Lateral view, *g* element, X110, GSC 80341, from AV1-73m.

FIGURES 9, 13, 16, 17, 19.

Plegagnathus nelsoni ETHINGTON and FURNISH

Hypotype. (9) Lateral view, unfurrowed side, plegagnathiform element, X250, GSC 80342, from AV1-73m. (13) Lateral view, furrowed side, plegagnathiform element with unusually short cusp, X190, GSC 80343, from AV1-10m. (16) Lateral view, *b?* element, X135, GSC 80344, from AV1-73m. (17) Lateral view, *b?* element, X160, GSC 80345, from AV1-72m. (19) Lateral view, furrowed side, plegagnathiform element, X160, GSC 80346, from AV1-72m.

FIGURES 18, 20.

Protopanderodus liripipus KENNEDY, BARNES and UYENO

Hypotypes. (18) Lateral view, protopanderodiform *c* element, X125, GSC 80347, from AV1-72m. (20) Lateral view, protopanderodiform *b* element, X95, GSC 80348, from AV1-75m.


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PLATE 12

FIGURES 1-7.

Pseudobelodina cf. *P. adentata* SWEET

Figured specimens. Outer and inner lateral views, *a* element, X165, GSC 80349, from AV-10m. (3) Inner lateral view, *a* element, X110, GSC 80350, from AV1-(-30m). (4) Outer lateral view, fragmentary *b*? element, X165, GSC 80351, from AV1-6m. (5, 6) Lateral views, *c* element, X165, GSC 80352, from AV1-10m. (7) Inner lateral view, *a* element, X130, GSC 80353, from AV1-10m.

FIGURES 8-26.

Pseudobelodina? dispansa (GLENISTER)

Hypotypes. (8, 9) Outer and inner lateral views, bicostate element bowed to the unfurrowed side, X140, GSC 80354. (10, 19) Lateral views, unbowed bicostate element, X120, GSC 80355. (11, 12) Inner and outer lateral views, bicostate element bowed to the unfurrowed side, X115, GSC 80356. (13, 22) Lateral views, unbowed unicostate element (costa on unfurrowed side), X150, GSC 80357. (14, 15) Outer and inner lateral views, bicostate, slender element bowed to the unfurrowed side, X150, GSC 80358. (16, 26) Inner and outer lateral views, unicostate element bowed to the furrowed side (costa is on inner, furrowed side), X120, GSC 80359. (17, 18) Outer and inner lateral views, bicostate element bowed to the furrowed side, X160, GSC 80360. (20, 21) Outer and inner lateral views, unicostate element bowed to the furrowed side (costa is on outer, unfurrowed side), X140, GSC 80361. (23, 24) Outer and inner lateral views, unicostate element bowed to the furrowed side (costa is on outer, unfurrowed side), X160, GSC 80362. (25) Posterior view, bicostate element bowed to furrowed side, X130, GSC 80363. All specimens are from AV1-46m, except GSC 80360 (FIGS. 17, 18), which is from AV1-73m.

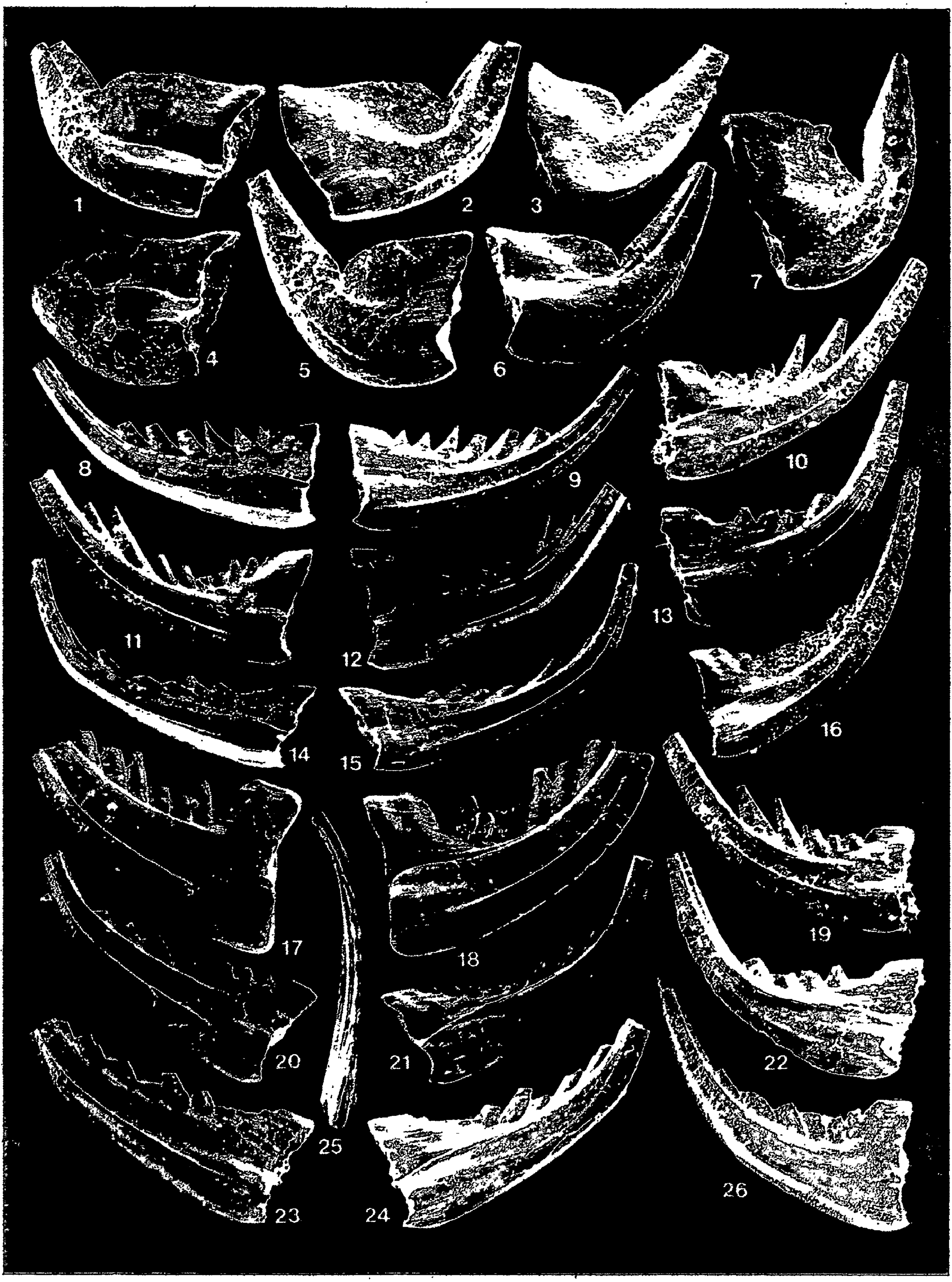
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PLATE 13

FIGURES 1-4.

Pseudobelodina? cf. P.? dispansa (GLENISTER)

Figured specimens. (1, 2) Lateral views, X190, GSC 80364. (3, 4) Lateral views, X220, GSC 80365. Both specimens are from AV1-46m.

FIGURES 5-20.

Pseudobeloodina inclinata (BRANSON and MEHL)

Hypotypes. (5) Close-up of basal filling (see FIGS. 6, 11), X225. (6, 11) Outer and inner lateral views, a element, X100, GSC 80366, from AV1-33.5m (see FIG. 5). (7, 8) Inner and outer lateral views, b element, X100, GSC 80367, from AV1-15m. (9, 10) Inner and outer lateral views, b element, X85, GSC 80368, from AV1-15m. (12, 13) Outer and inner lateral views, b element, X150, GSC 80369, from AV1-4m. (14, 17) Outer and inner lateral views, a element, X85, GSC 80370, from AV1-15m. (15, 16) Inner? and outer? lateral views, c element, X100, GSC 80372, from AV1-15m. (18, 19) Inner and outer lateral views, c element, X200, GSC 80371, from AV 1-33.5m. (20) Outer lateral view, b element, X100, GSC 80373, from AV1-33.5m.

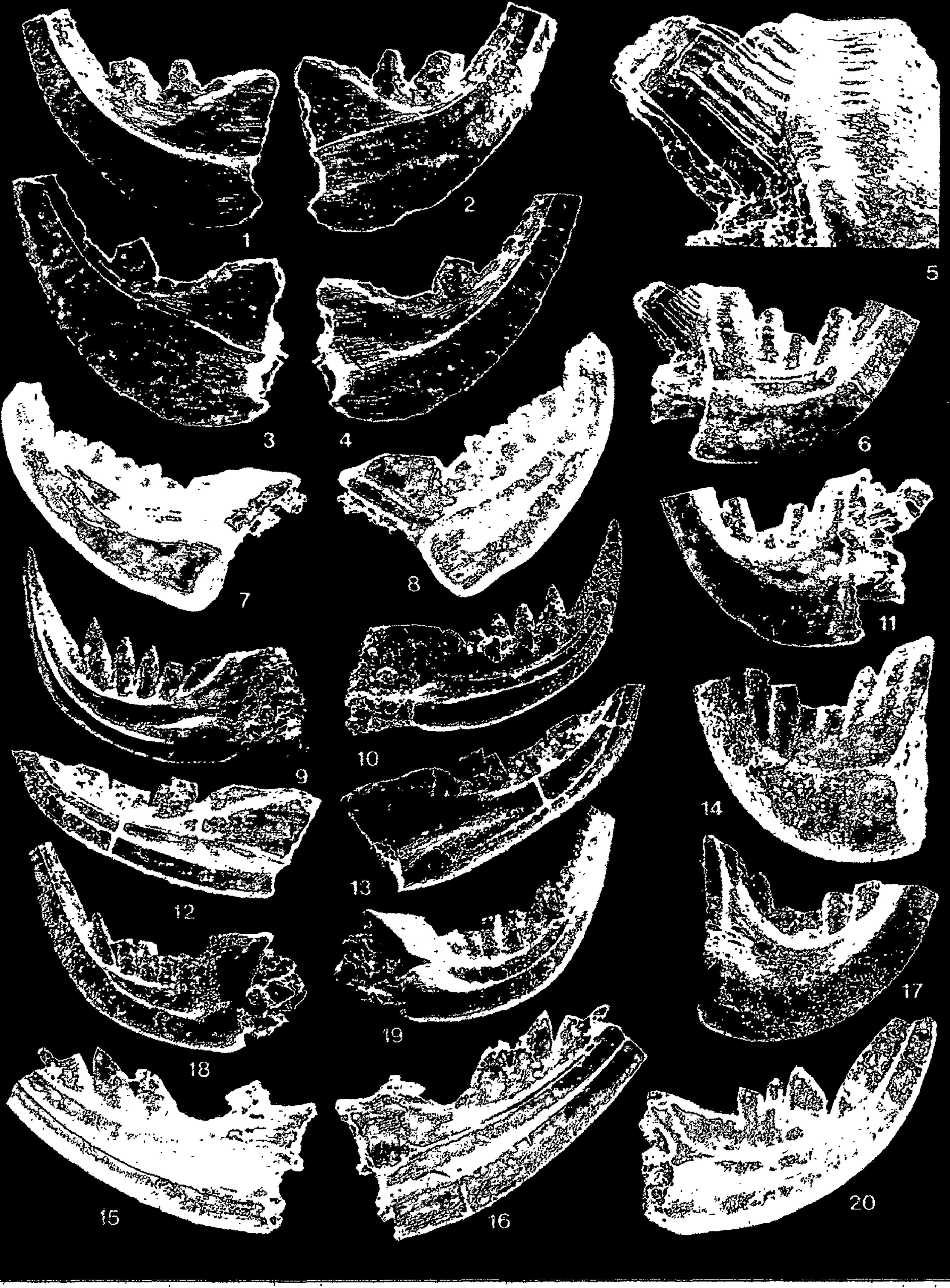
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PLATE 14

FIGURES 1-6.

Pseudobelodina inclinata (BRANSON and MEHL)

Hypotypes. (1, 2) Inner and outer lateral views, *e?* element, X135, GSC 80374, from AV1-33.5m. (3, 4) Outer and inner lateral views, *e?* element, X120 GSC 80375, from AV1-15m. (5, 6) Lateral views of typically fragmented element, X150, GSC 80376, from AV1-10m.

FIGURES 7-11.

Pseudobelodina quadrata SWEET

Hypotypes. (7, 8) Lateral views, element, X100, GSC 80377, from AV1-6m. (9, 10) Lateral views, *a?* element, X170, GSC 80378, from AV1-4m. (11) Outer lateral view, *b* element, X120, GSC 80379, from AV1-6m.

FIGURES 14-24.

Pseudobelodina? obtusa SWEET

Hypotypes. (12, 13) Inner and outer lateral views, X180, GSC 80380. (14, 15) Inner and outer lateral views, X175, GSC 80381. (16, 17) Inner and outer lateral views, X180, GSC 80382. (18, 19) Outer and inner lateral views, X185, GSC 80383. (20, 21) Inner and outer lateral views, X200, GSC 80384 (see FIG. 24). (22, 23) Outer and inner lateral views, X185, GSC 80385. (24) Inner lateral view showing coarse striae and low node-like denticles, X425, GSC 80384 (see FIGS. 20, 21). All specimens are from AV1-10m.

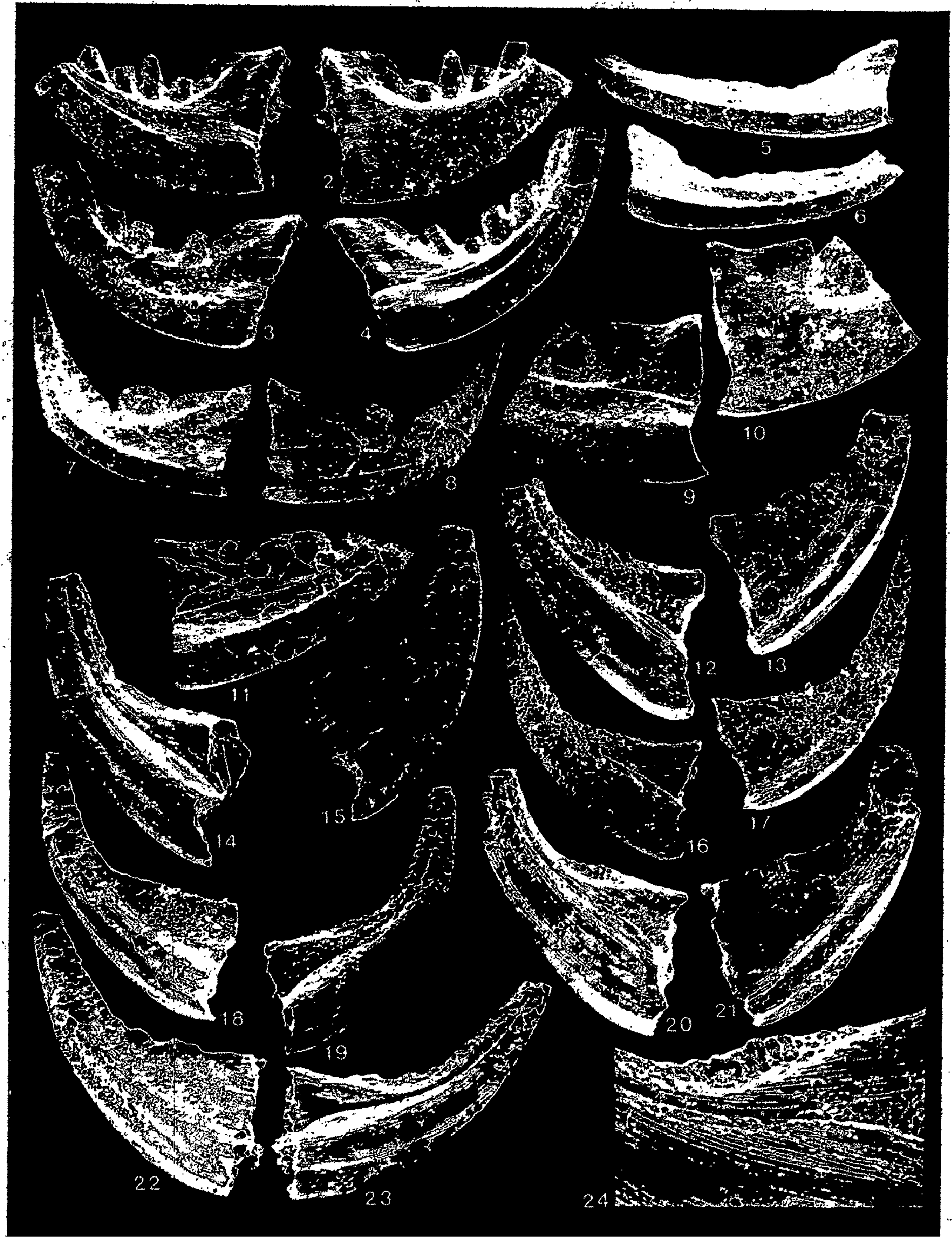
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PLATE 15

FIGURES 1-12.

Pseudobelodina vulgaris vulgaris SWEET

Hypotypes. (1, 4) Outer and inner lateral views, *a* element, X225, GSC 80386. (2, 5) Inner and outer lateral views, *b* element, X220, GSC 80387. (3, 11) Inner and outer lateral views, *e*? element, X200, GSC 80388. (6, 10) Outer and inner lateral views, *e*? element, X240, GSC 80389. (7) Inner lateral view, *a* element, X220, GSC 80390. (8) Lateral view, furrowed side, *c* element, X245, GSC 80391. (9, 12) Lateral views, *c* element, X250, GSC 80392. All specimens are from AV1-46m.

FIGURES 13-18.

Pseudobelodina cf. *P. vulgaris* SWEET

Figured specimens. (13, 14) Outer and inner lateral views, *b* element, X225, GSC 80393, from AV1-73m. (15, 18) Outer and inner lateral views, *b*? element, X220, GSC 80394, from AV1-46m. (16, 17) Lateral views, *c*? element, X290, GSC 80395, from AV1-46m.

FIGURES 19-21.

Pseudobelodina? n. sp. A NOWLAN and McCRACKEN

Figured specimens. (19, 20) Outer and inner lateral views, X130, GSC 80396. (21) Lateral view, furrowed side, X130, GSC 80397. Both specimens are from AV1-10m.

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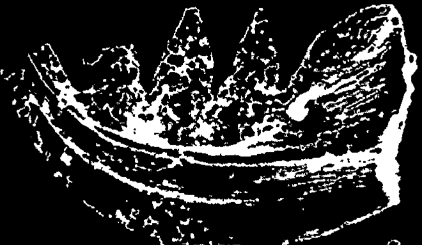

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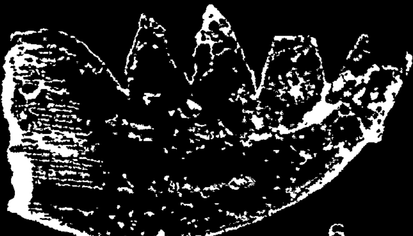

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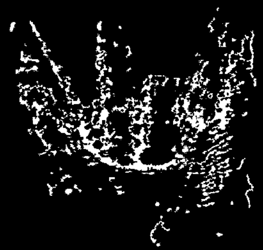

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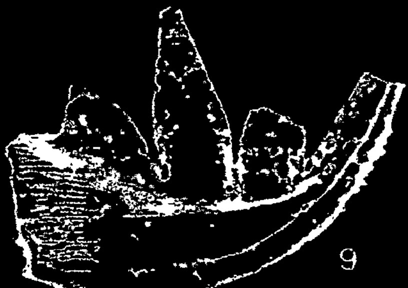

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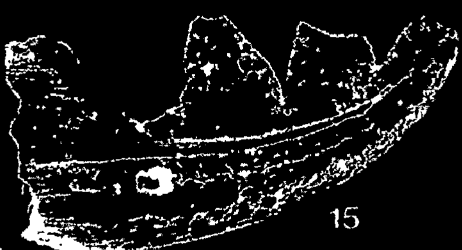

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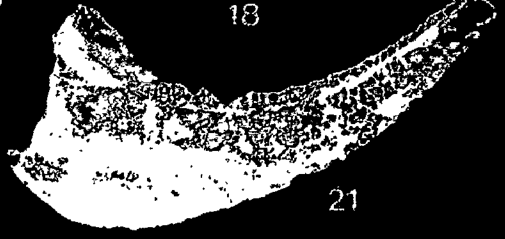

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PLATE 16

FIGURE 1.

Pseudooneotodus aff. P. beckmanni (BISCHOFF and SANNEMANN) Figured specimen. Lateral view, X240, GSC 80398, from AV1-72m.

FIGURES 2-6.

Pseudooneotodus mitratus (MOSKALENKO).

Hypotypes. (2) Lateral view, X170, GSC 80399. (3, 6) Lateral and oral views, X95, GSC 80400. (4) Oral view, X85, GSC 80401. (5) Oral view, slightly nodose specimen, X120, GSC 80402. All specimens are from AV4B-62m except GSC 80402 (FIG. 5), which is from AV1-33.5m.

FIGURES 7-20.

Scabbardella altipes subsp. B ORCHARD

Hypotypes. (7, 8) Inner and outer lateral views, a element, X85, GSC 80403, from AV1-73m. (9, 10) Outer and inner lateral views, with posteriorly extended base, X135, GSC 80404, from AV1-73m. (11) Inner lateral view, a element, X150, GSC 80405, from AV1-46m. (12) Inner lateral view, a element with posterior extended base, X200, GSC 80406, from AV1-73m. (13, 14) Outer and inner lateral views, b element, X135, GSC 80407, from AV1-46m. (15, 16) Outer and inner lateral views, b element with posteriorly extended base, X105, GSC 80408, from AV1-72m. (17, 18) Lateral views, c element, X145, GSC 80409, from AV1-46m. (19, 20) Lateral views, c element, X180, GSC 80410, from AV1-46m (see also

Plate 17).

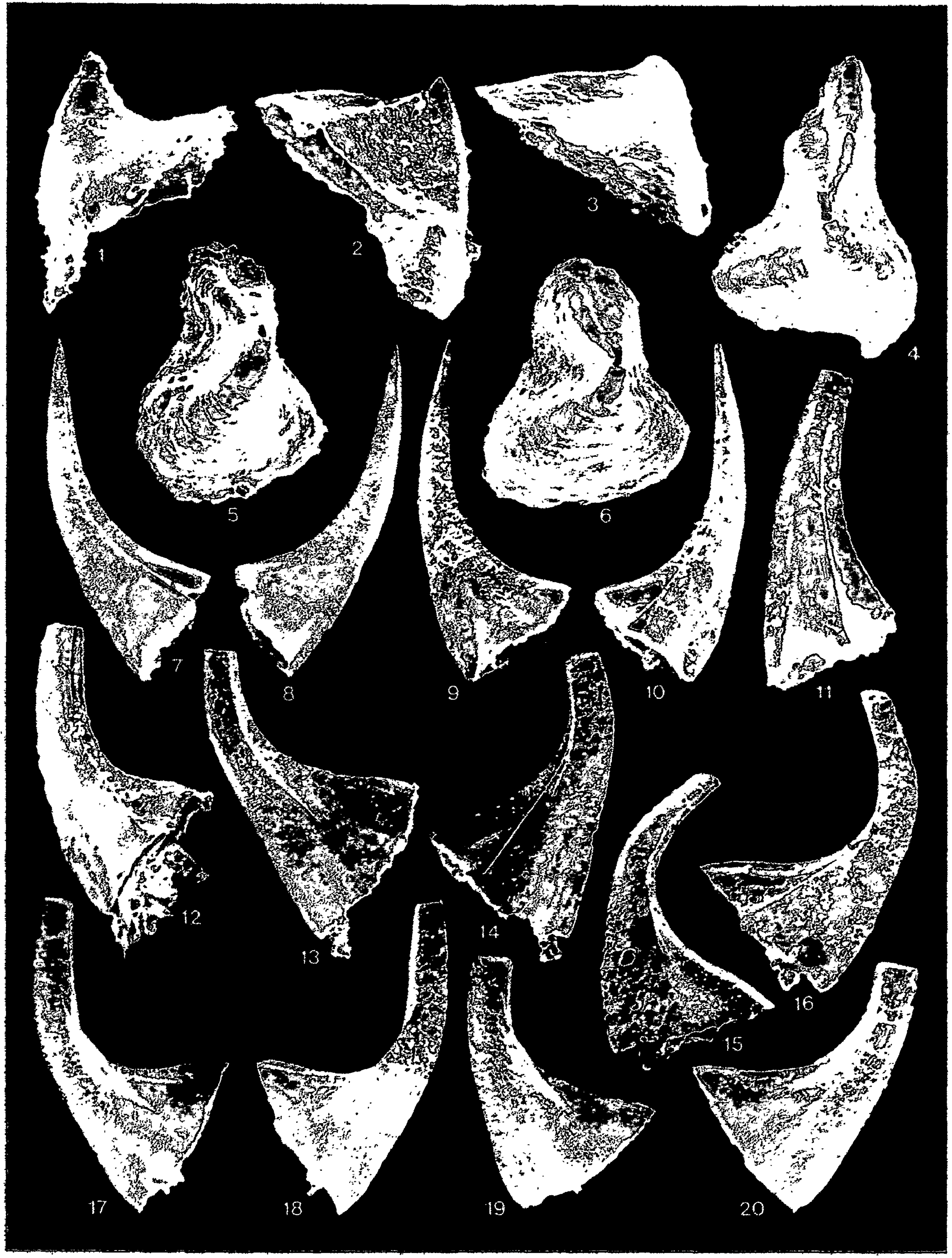
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PLATE 17

FIGURES 1-3, 5, 6, 8, 9.

Scabbardella altipes subsp. B ORCHARD

Hypotypes. (1. 2) Lateral views, e-1 element, X95, GSC 80411, from AV1-73m. (3) Lateral view, acostate side, e-2 element, X125, GSC 80412, from AV1-46m. (5, 6) Lateral views, e-2 element, X110, GSC 80413, from AV1-46m. (8, 9) Lateral views, e-3 element, X125, GSC 80414, from AV1-46m (see also Plate 16).

FIGURES 4, 7, 10-16.

Scabbardella n. sp. A NOWLAN and McCRACKEN

Figured specimens. (4, 7) Inner and outer views, a? element, X170, GSC 80415, from AV1-46m. (10, 11) Outer and inner lateral views, b-1 element, X180, GSC 80416, from AV1-72m. (12, 13) Inner and outer lateral views, b-2 element, X180, GSC 80417, from AV1-73m. (14, 15) Lateral views, c element, X210, GSC 80418, from AV1-72m. (16) Outer lateral view, b-2 element, X200, GSC 80419, from AV1-46m.

FIGURES 17-22.

Spinodus? n. sp. A NOWLAN and McCRACKEN

Figured specimens. (17) Lateral view, X100, GSC 80420. (18) Lateral view, X90, GSC 80421. (19) Lateral view, X85, GSC 80422. (20, 21) Oral and lateral views, X80, GSC 80423. (22) Lateral view, X80, GSC 80424. All specimens are from AV1-20m.

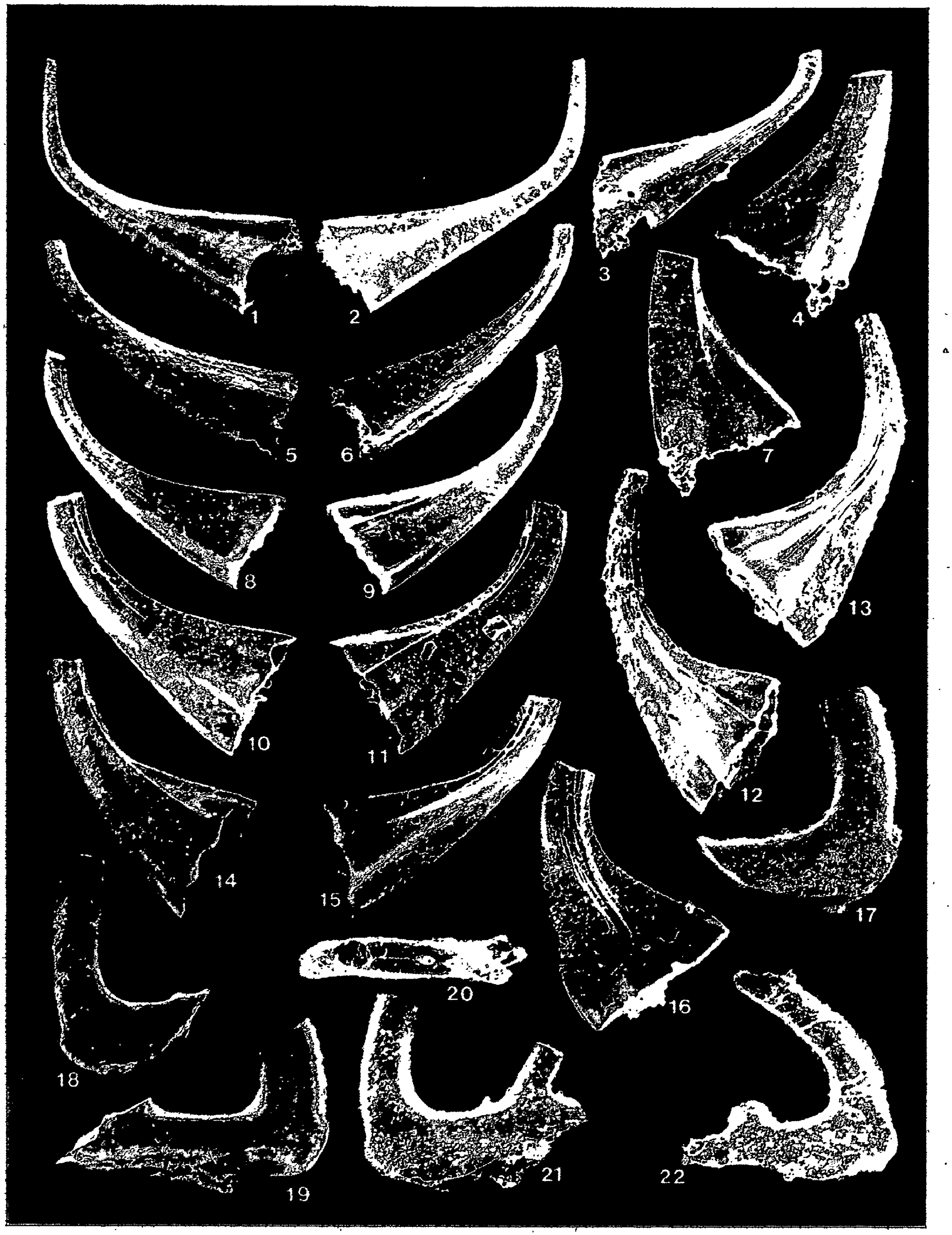
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PLATE 18

FIGURES 1-23.

Staufferella divisa SWEET

Hypotypes. (1, 2) Inner and outer lateral views, *a* element, X160, GSC 80425, from AV1-10m. (3) Inner lateral view, *a* element, X180, GSC 80426, from AV1-46m. (4) Outer lateral view, *a* element, X210, GSC 80427, from AV1-46m. (5, 6) Outer and inner lateral views, *b* element, X160, GSC 80428, from AV1-10m. (7) Outer lateral view, *e*-3 element, X135, GSC 80429, from AV1-10m. (8) Inner lateral view, short-based *a*? element, X120, GSC 80430, from AV1-4m. (9, 10) Lateral and posterior views, *c* element, X160, GSC 80431, from AV1-46m. (11, 12) Inner and outer lateral views, *b*? element, X260, GSC 80432, from AV1-46m. (13) Posterior view, *c* element, X160, GSC 80433, from AV1-10m. (14) Lateral view, *c* element, X265, GSC 80434, from AV1-46m. (15, 16) Outer and inner lateral views, *e*-2 element, X160, GSC 80435, from AV1-10m. (17, 18) Outer and inner lateral views, *e*-1 element, X140, GSC 80436, from AV1-46m. (19) Posterior view, *c* element, X80, GSC 80437, from AV1-4m. (20) Posterior view, *c* element, X185, GSC 80438, from AV1-10m. (21, 22, 23) Posterior, inner and outer lateral views, *e*-3 element, X175, GSC 80439, from AV1-46m.

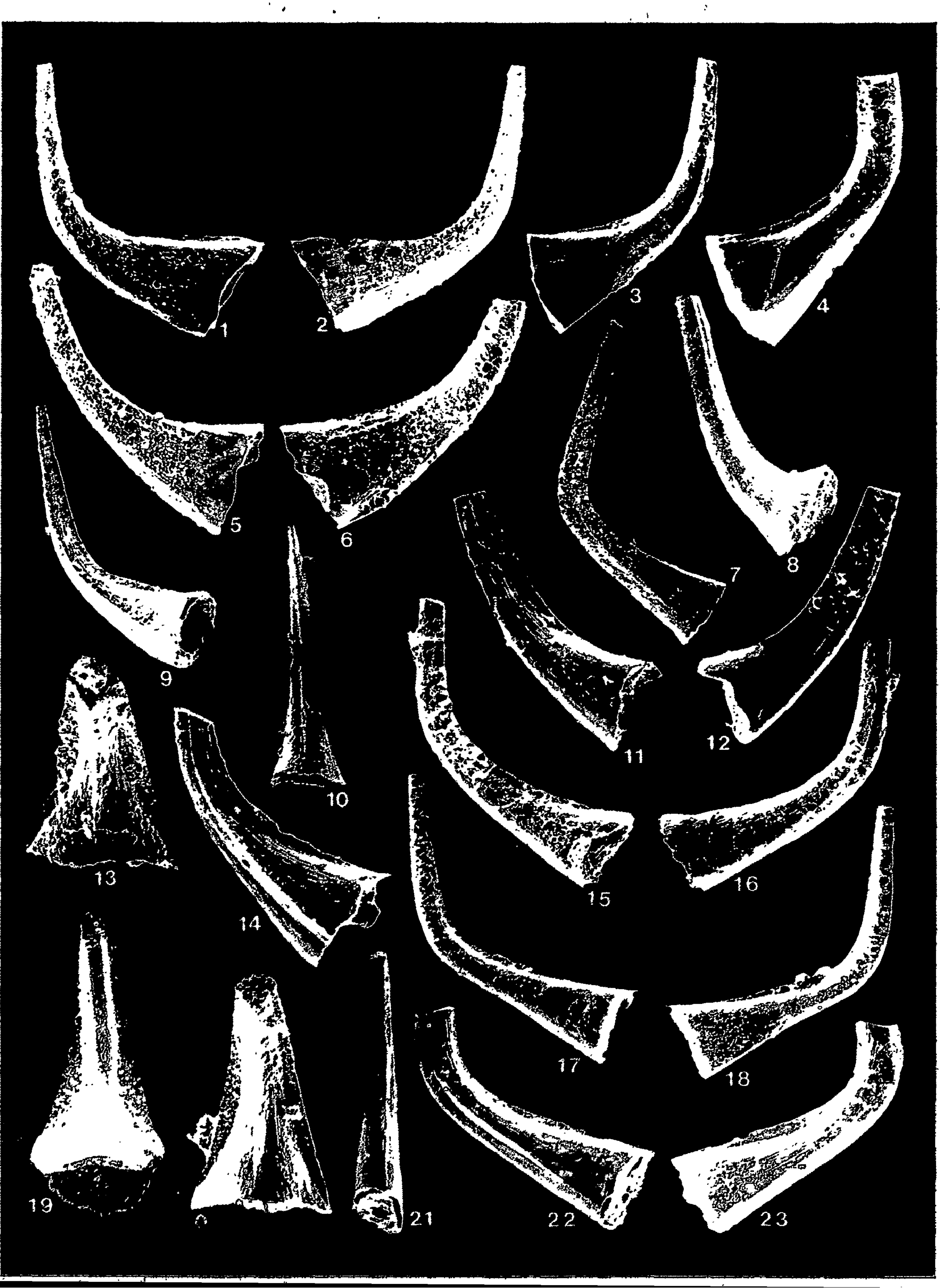
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PLATE 19

FIGURES 1-15.

Walliserodus amplissimus (SERPAGLI)

Hypotypes. (1) Inner lateral view, a element, X165, GSC 80440. (2, 3) Inner and outer lateral views, multicostate a element, X160, GSC 80441. (4) Lateral view, c element, X150, GSC 80442. (5, 6) Lateral views, d element, X135, GSC 80443. (7, 8) Inner and outer lateral views, b element, X115, GSC 80444. (9) Lateral view, basally broken e element, X115, GSC 80445. (10, 12) Lateral views, short-based e element, X150 and X170, GSC 80446. (11) Lateral view, slender e element, X135, GSC 80447. (13) Lateral view, slender e element, X110, GSC80448. (14, 15) Lateral and posterior views, c element, X150, GSC 80449. All specimens are from AV1-10m except GSC 80447 and 80448 (FIGS. 11, 13), which are from AV1-4m.

FIGURES 16.

Walliserodus curvatus (BRANSON and BRANSON)

Hypotypes. Lateral view, fragmentary e element, X145, GSC 80450, from AV4B-111.5m.

FIGURES 17-23.

Walliserodus? rallus NOWLAN and McCRACKEN n. sp.

(17, 18) Outer and inner lateral views, a element, X165, paratype, GSC 80451. (19, 20) Inner and outer lateral views, ~~b=1~~ element, X155, paratype, GSC 80452. (21, 22) Inner and outer lateral views, b-2 element, X150, paratype, GSC 80453. (23) Outer lateral view, b-1 element, X175, paratype, GSC

80454. All specimens are from AV1-73m (see also Plate 20).


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PLATE 20

FIGURES 1-3, 5-8.

Walliserodus? rallus NOWLAN and McCRACKEN n. sp.

(1-3) Outer and inner lateral and anterolateral views, c element, X155, holotype, GSC 80455, from AV1-73m. (5, 6) Lateral views, d element, X145, paratype, GSC 80456, from AV1-46m. (7, 8) Lateral views, e element, X150, paratype, GSC 80457, from AV1-46m (see also Plate 19).

FIGURES 4, 9-24.

Zanclodus levigatus NOWLAN and McCRACKEN n. gen. n. sp.

Paratypes. Group 1 elements: (those bowed to the unfurrowed side). (4, 10) Inner and outer lateral views, low-based element, X175, GSC 80458. (9, 13) Outer and inner lateral views, element with intermediate base-height, X115, GSC 80459. (11, 12) Outer and inner lateral views, slender, high-based element, X110, GSC 80460. (14, 15) Inner and outer lateral views, slender, high-based element, X80, GSC 80461. (16,20) Inner and outer lateral views, element with intermediate base-height, X185, GSC 80462. (17, 18) Outer and inner lateral views, low-based element, X155, GSC 80463. (19, 24) Posterior and lateral views, slender, high-based element, X160, GSC 80464. (21-23) Outer anterolateral, outer lateral and inner lateral views, slender, high-based element with outer anterolateral carina, X160, GSC 80465. All specimens are from AV4B-62m (see also Plates 21, 22).

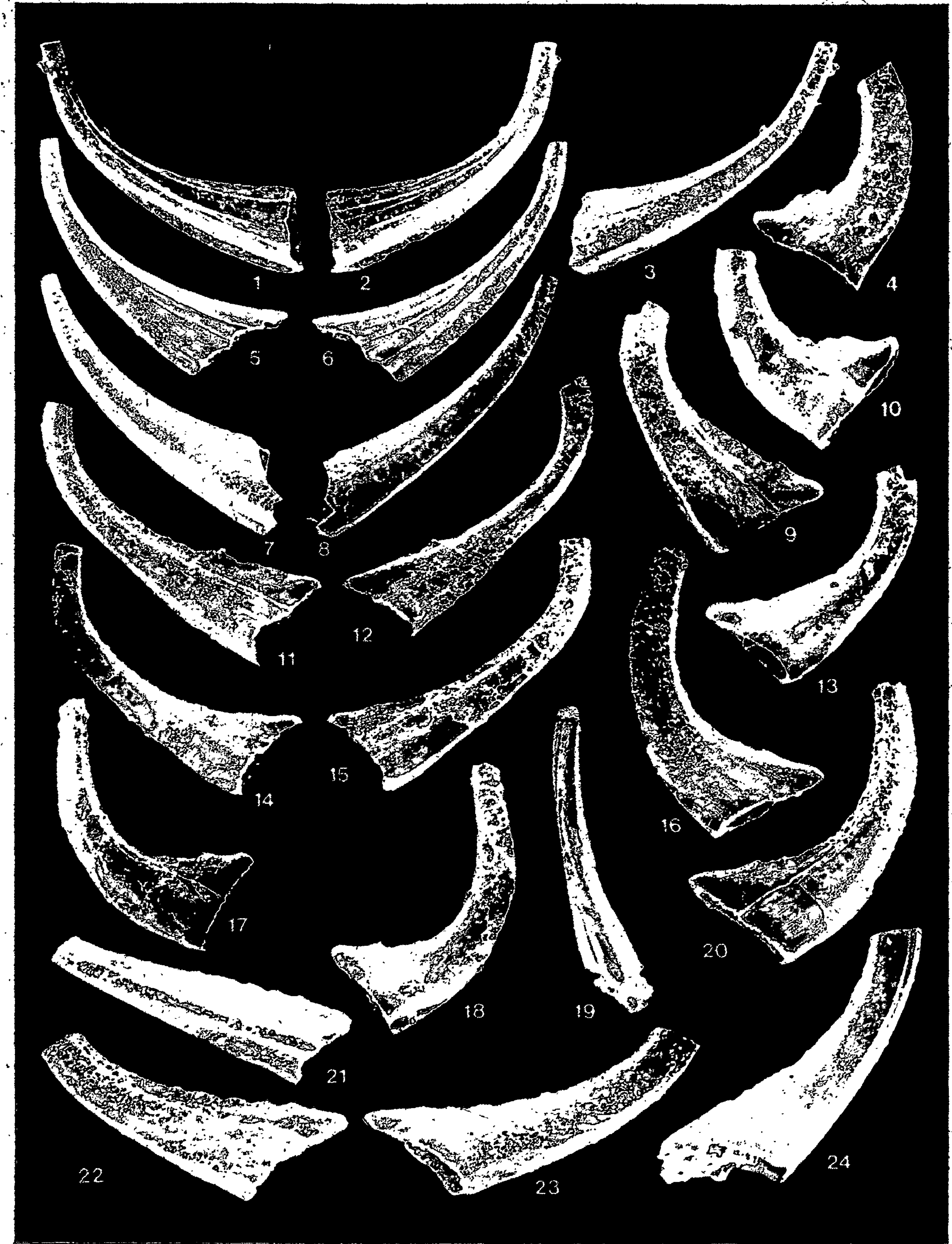
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PLATE 21

FIGURES 1-21

Zanclodus levigatus NOWLAN and McCRACKEN n. gen. n. sp. Holotype (FIGS. 11, 12) and paratypes. Group 2 elements (those bowed to the furrowed side): FIGURES 1-12, 15, 20, 21. Group 3 elements (unbowed): FIGURES 13-14, 16-19. (1, 2) Inner and outer lateral views, slender, high-based element, X130, GSC 80466. (3, 4) Outer and inner lateral views, element with intermediate base-height, X115, GSC 80467. (5, 6) Inner and outer lateral views, low-based element, X125, GSC80468. (7, 8) Inner and outer lateral views, slender, high-based element, X120, GSC 80469. (9, 10 15) Inner lateral, outer lateral and outer anterolateral views, element with intermediate base-height, X165, GSC 80470. (11, 12) Outer and inner lateral views, low-based element, X115, GSC 80471. (13, 14) Lateral views, element with pronounced heel, X195, GSC 80472. (16, 17) Lateral views, X190, GSC 80473. (18, 19) Lateral views, X185, GSC 80474. (20, 21) Inner and outer lateral views, eXtremely low-based element, X170, GSC 80475. All specimens are from AV4B-62m (see also Plates 20, 22).

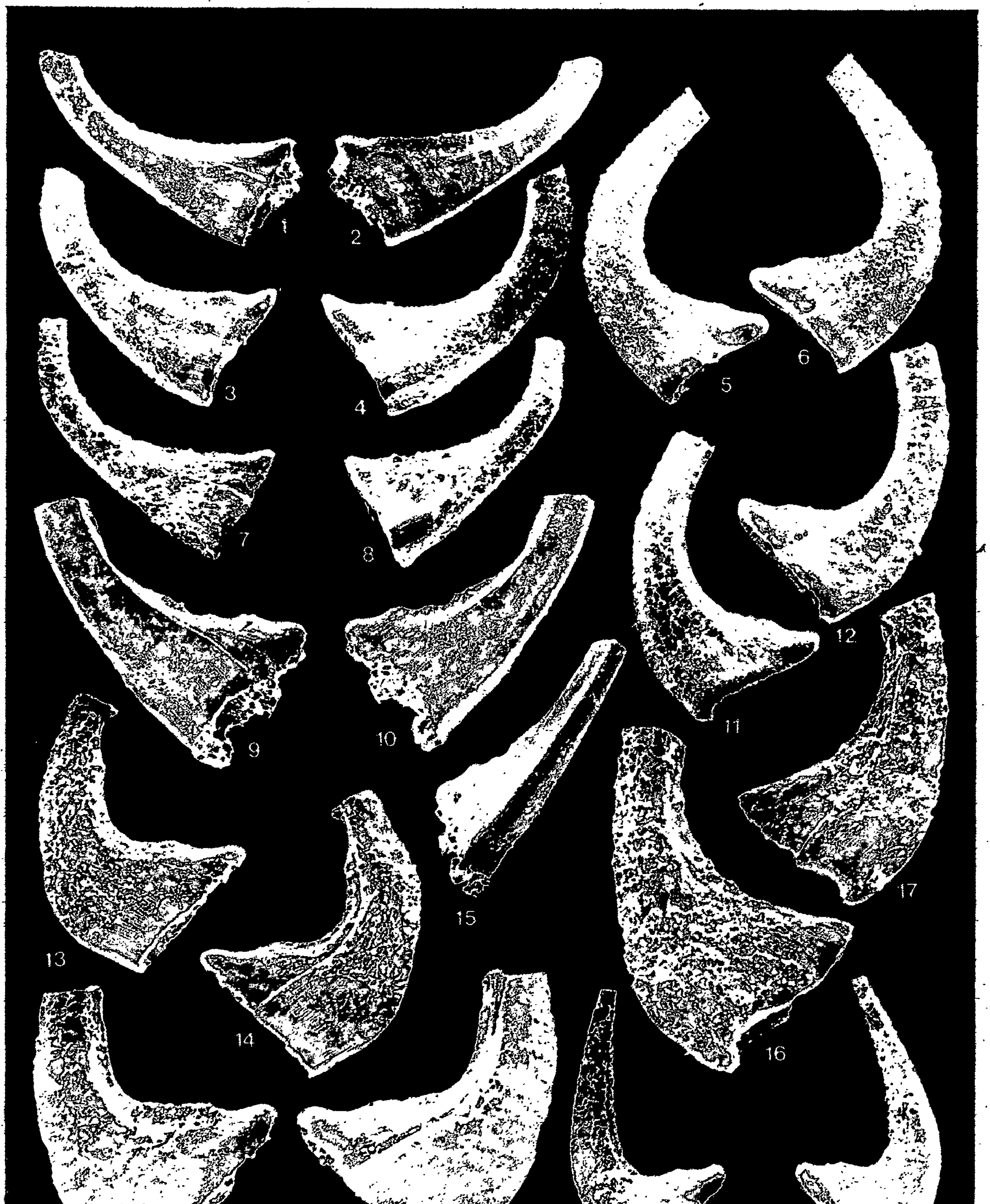
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PLATE 22

FIGURES 1, 2, 4, 5.

Zanclodus levigatus NOWLAN and McCRACKEN n. gen. n. sp.

Paratypes. Group 3 (unbowed) elements. (1, 2) Lateral views, X140, GSC 80476. (4, 5) Lateral views, element lacking heel, X160, GSC 80477. Both specimens are from AV4B-62m (see also Plates 20, 21).

FIGURE 3.

Oistodiform element indet.

Lateral view, X105, GSC 80478, from AV1-6m.

FIGURES 6, 7.

Belodiniform element indet.

Inner and outer lateral views, X120, GSC 80479, from AV1-10m.

FIGURES 8, 9, 12-15.

Milaculum aff. *M. ethinclarki* MULLER

Figured specimens. (8, 9) Lateral and upper views, form with expanded end, X220, GSC 80480, from AV1-10m. (12, 14) Lateral and upper views, gently tapering specimens, X145, GSC 80481, from AV1-10m. (13, 15) Upper and lower views, form with flattened and smooth expanded end, X145, GSC 80482, from AV1-4m.

FIGURES 10, 11.

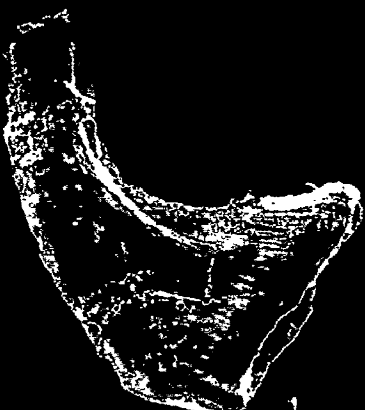
Panderodiform element indet.

Inner and outer lateral views, X95, GSC 80483, from AV1-4m.

FIGURE 16.

Phosphannulus universalis MULLER, NOGAMI and LENZ

Hypotype. Upper view, X235, GSC 80484, from AV1-10m.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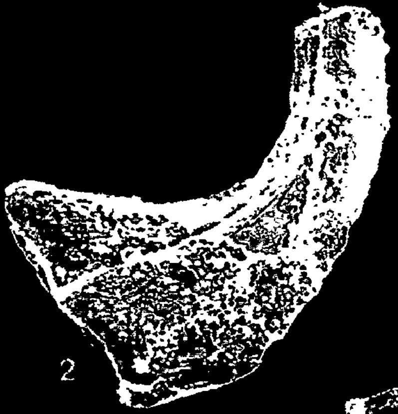
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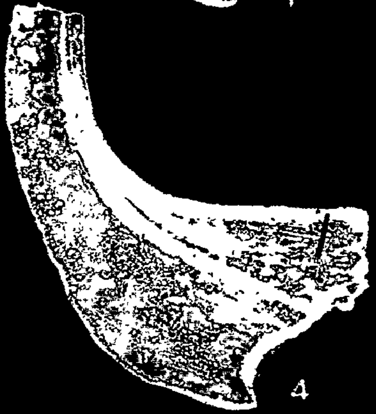
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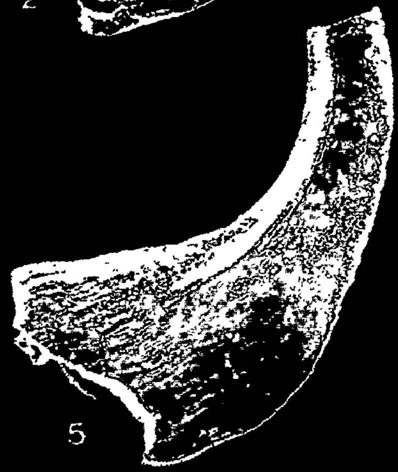
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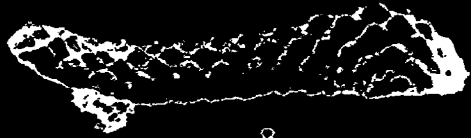
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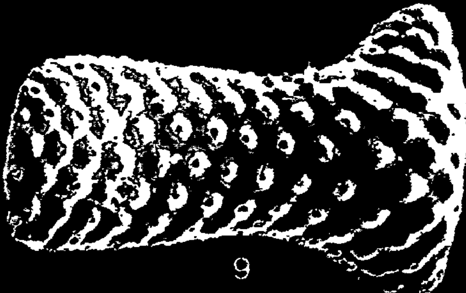
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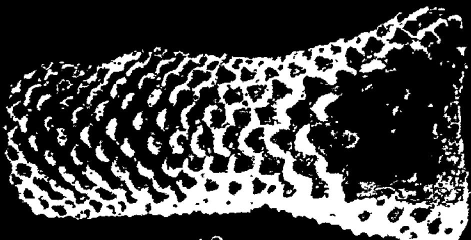
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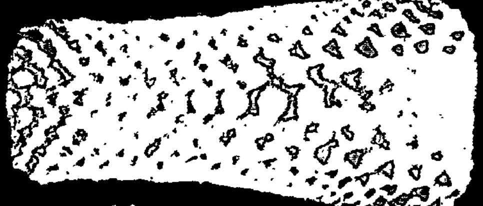
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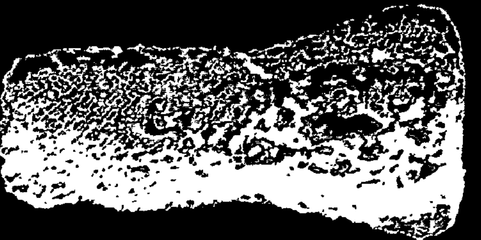
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APPENDIX B

REVISION OF THE ORDOVICIAN-SILURIAN SYSTEMIC BOUNDARY BIOSTRATIGRAPHY ON ANTICOSTI ISLAND, QUEBEC

B.1 Introduction

Few writers have elsewhere recognized the Gamachian Fauna 13 and the earliest Llandovery *Oulodus*? *nathani* Zone of Anticosti Island, Québec since they were proposed by McCracken and Barnes in 1981. There is no doubt that this is due to the limited new discoveries of the definitive taxa. In fact, *O*.? *nathani* McCracken and Barnes has not been positively identified in spite of some recent reports to the contrary (e.g. *O*. cf. *nathani* of Aldridge and Mohamed, 1982; *O*.? cf. *O*.? *nathani* of McCracken and Barnes, 1982; *O*.? *nathani* of Nowlan, 1983b; *O*.? *nathani* in an unpublished thesis by Over, 1985).

In retrospect, some confusion may be inadvertently due to the original definitions of these biozones. What follows is an attempt to add some clarification and improvements to these biostratigraphic units. Since this is an attempt to clarify, I may be risking further complication by trying to relate the systemic boundary of McCracken and Barnes (1981) to the new, internationally proposed level. This new level is discussed further in the section on glaciation and the Ordovician - Silurian boundary (Chapter 6).

B.2 Fauna 13

Fauna 13, as proposed by McCracken and Barnes (1981, p. 64) is

> "characterized by the presence of Gamachignathus ensifer and G. hastatus." (both are species erected by McCracken; Nowlan and Barnes, 1980) "It is uncertain whether the absence of species of Plectodina within the Ellis Bay fauna is also diagnostic of Fauna 13 elsewhere. Although Gamachignathus first appears in the upper Vauréal Formation, the base of Fauna 13 is taken at the level where this genus becomes a dominant component of the fauna. This level is at the base of the Ellis Bay Formation and Fauna 13 ranges into the base of Member 6 of this formation."

It is critical to note that Fauna 13 is characterized by the two Gamachian species of Gamachignathus. McCracken and Barnes (1981) referred to the taxa at the generic level in the remainder of their paragraph, but it is implicit that the fauna is defined at the specific, not generic level. This must be strongly emphasized: any future discovery of the genus in much older (or younger) strata will not indicate that Fauna 13 has an extensive range and is thus not a practical biozone. It may even be expected in older, cooler-water strata. A discovery of this nature will extend the generic range, but would not remove the biostratigraphic significance of the species and of Fauna 13.

I am stressing the significance of the Gamachignathus species in the definition of Fauna 13 because this biozone has already been mis-interpreted. The Ordovician correlation chart for the United States (Ross, et al., 1982, Sheet 1) names the Gamachian conodont fauna "Gamachignathus". This is incorrect; if the biozone is to be named formally, it must be after the species.

Most of the other Ordovician taxa of Fauna 13 range upward from Fauna 12 although two other new species, Aphelognathus aff. A. grandis Branson, Mehl and Branson, and Staufferella inaligera McCracken and Barnes are present. A. aff. A. grandis may represent a new Gamachian taxon, but its known elements are small and delicate, making comparisons with other species difficult. S. inaligera is rare; only 7 of the diagnostic c elements are known. The most abundant and reliable new taxa then, in the Ellis Bay Formation are the two Gamachignathus species; the new biostratigraphic unit therefore was defined on the basis of these species.

A unit based on the first occurrence of the species was unacceptable since G. ensifer first occurs in the Vauréal Formation and is present rarely throughout the upper part of the same strata (Nowlan and Barnes, 1981, table 1). G. hastatus, although not recorded in Nowlan and Barnes (ibid.)

has a singular occurrence in the Vauréal Formation (McCracken, et al., 1980, p. 108). Fauna 13 therefore can not be defined as a range-zone in the sense of Hedberg (1976, pp. 53-57). It should be noted that the study by Nowlan and Barnes (1981) and its companion paper by McCracken and Barnes (1981) were approved for publication on February 18, 1980, whereas that by McCracken, et al. (1980) was conceived later, but published earlier; thus the lack of G. hastatus in the Vauréal Formation as recorded by Nowlan and Barnes (1981) was subsequently revised by McCracken (1981).

In noting the occurrence of Gamachignathus in the upper part of the Vauréal Formation and defining the base of Fauna 13 where "this genus" (i.e. as represented by G. ensifer and G. hastatus) dominates the fauna, McCracken and Barnes (1981, p. 64) were describing an informal acme-type of biostratigraphic unit (sensu acme-zone of Hedberg, 1976, pp. 59, 60). They (ibid.) did not actually define the top of the unit, stating that "Fauna 13 ranges into the base of Member 6 ... " of the Ellis Bay Formation; but clearly, it must occur near the systemic boundary on Anticosti Island. (member designations used herein are sensu McCracken and Barnes, 1981, rather than Petryk, 1981a, 1981b)

This proximity to the systemic boundary is stressed, since on Anticosti, two of the three sections containing boundary strata have transitional zones in which Ordovician and Silurian taxa co-occur.

The rationale used by McCracken and Barnes (1981) to chose the exact position is as follows. At the type section, G. ensifer co-occurs with the Silurian Ozarkodina hassi (Pollock, Rexroad and Nicoll) in three samples through 1m of strata (McCracken and Barnes, 1981, pp. 66, 121, table 3). The top of Fauna 13, if chosen to be the last appearance of G. ensifer, would be above the first occurrence of Ozarkodina. The choice for the upper limit of Fauna 13 for this section was either at the last occurrence of G. ensifer or first occurrence of recognizable Silurian taxa.

Since it is the Ordovician Oulodus rohneri Ethington and Furnish and not G. ensifer that co-occurs with typical Silurian species in a 1.5m transitional zone at the Salmon River section, it was preferable to define the top of Fauna 13 as being at the base of the Silurian rather than at the last occurrence of Ordovician species. (it is accepted practice to allow the base of one stratigraphic unit to define the top of the underlying unit)

B.3 Limits of Fauna 13

The Fauna 13 acme-type unit is based on an increase in proportion of G. ensifer and G. hastatus elements in comparison with other components. The other components may comprise elements of all other taxa, or be exclusive of the panderodonts. If the term "Fauna 13" is not adequate to describe this biostratigraphic interval and a more formal name is required, it must be called the G. ensifer acme-zone, not *Gamachignathus* zone, sensu Ross, *et al.* (1982). I prefer to retain the informal sense of the term "Fauna 13" rather than proposing a formal biozone, but with the clear implication that it represents an acme-type unit.

Hedberg (1976, p. 60) admits to the problem of defining what constitutes a "maximum of development" for delimiting an acme-zone. It is probably inappropriate or premature to formally describe the increase of *Gamachignathus* spp. in Fauna 13 as a percentile, especially when calculations are based on low-yielding samples; such percentiles are statistically invalid. The nature of an acme-zone, however, encourages an attempt at numerical comparison. I will identify below those interpretations that are based on limited data.

In the Ellis Bay area, *G. ensifer* represents about 0.17 percent of the total Vauréal Formation elements, or about 0.3 percent of the elements exclusive of panderodont elements. If divided into lower (samples 1-68) and upper (69-102) parts, *G. ensifer* represents about 0.06 and 1.3 percent of the faunas, respectively (derived from data of Nowlan and Barnes, 1981, table 1) (boundary between lower and upper members is about level of sample 43).

The section at Ellis Bay continues from the upper Vauréal Formation into the Ellis Bay Formation where *G. ensifer* and *G. hastatus* comprise 45.2 percent of the total fauna, or 77.9 percent of the non- panderodont fauna

(McCracken and Barnes, 1981; calculated from tables 2, 3). For the entire Ellis Bay fauna, from all sections, these figures average about 31 and 60 percent (ibid., tables 1-6). The same calculations from the other two sections of Ellis Bay strata are: Vauréal River, 6.8 and 19.4 percent; Salmon River, 33.8 and 53.8 percent. The relatively low values for the Vauréal River section are likely due to the fact that most of member 4, and all of members 5 and 6 were not sampled. Abundance of these taxa in Ellis Bay strata is discussed in greater detail below (see Chapter B.6.1).

The same calculations for the fauna of the Matapedia Group Gaspé, Québec are 21 and 26 percent; and for unit 4 of the White Head Formation, 8 and 11 percent (recalculated from Nowlan, 1981, pp. 261, 266). Nowlan (1983a) reported G. ensifer from the the Grog Brook Group of New Brunswick. The same calculations for these strata are 4.0 and 5.8 percent.

G. ensifer has been reported from carbonates of the Hanson Creek Formation, Nevada by Ross, et al. (1979, p. C11, table 2). Calculations based on the one low-yielding sample (60 elements in total) that contains G. ensifer (as reconstructed by McCracken, et al., 1980) give ratios of about 67 and 78 percent.

In Yukon, the Upper Peel River occurrence of G. ensifer is minor (0.7 and 0.9 percent); At Blackstone River, the few elements of G. ensifer represent about 2 percent of the total fauna and about 3 percent of the fauna exclusive of panderodonts. The percentage calculations for the Blackstone River sample approaches the lower values determined for samples from Ellis Bay strata (Chapter B.6.1) but are not of the same magnitude as the overall values cited above. They can readily be compared to the values noted above for the upper Vauréal Formation.

Birksfeldia, which may be synonymous with Gamachignathus (Nowlan, 1983a), is recorded from Cautleyan and Rawtheyan strata in the British Isles (Orchard, 1980). Birksfeldia comprise 2.0 and 3.4 percent of the total and non-panderodont faunas respectively, Cautleyan zones 2-4 of Orchard (1980, fig. 3). The same calculations for his Rawtheyan zones are: zone 5 -- 4.3 and 4.8 percent; zone 6 -- 1.6 and 1.7 percent; zone 7 -- 3.9 and 4.0 percent. Only zone 7 has abundant elements; the calculations for the others are based on much smaller totals (e.g. for zone 5 : 9 elements of Birksfeldia sp., 139 elements in total). (calculations are based on Orchard's fig. 1 and should be regarded as maximum values for zone 7 since he denotes only partial totals for Amorphognathus and Eocarniodus in two samples).

Wang, et al. (1983) report Birksfeldia wufengensis Ni and Li from the fine clastic strata of the Wufeng Formation, Yangtze Gorges, China; this species is associated with the Diplograptus bohemicus Zone (=Climacograptus? extraordinarius Zone of Williams, 1983). Distributional data were not provided by Wang, et al.

B.4 Biohorizons

As noted above, Fauna 13 is an acme type of biostratigraphic unit that is preceded by the first occurrence of one of its diagnostic species, G. ensifer, in lower strata.

The first occurrence of G. ensifer in the Vauréal Formation (1 element in sample 24 of Nowlan and Barnes, 1981, table 1) is herein regarded as a formal first appearance biohorizon and is suggested to be indicative of late Richmondian time. (Hedberg, 1976, p. 49, convincingly argues for the term biohorizon rather than datum or datum planes, as used by Cooper, 1980)

The last occurrence of Plectodina species in the Vauréal Formation may be regarded as a last appearance or extinction biohorizon and may also be indicative of the late Richmondian. This was cautiously suggested by McCracken and Barnes (1981, p. 64) and the presence of Plectodina, along with the absence of G. ensifer, was used to support a late Richmondian rather than a Gamachian age for the Noix Limestone at Clarksville, Missouri (McCracken and Barnes, 1982).

The presence of Plectodina and rarity of G. ensifer in the Yukon conodont fauna, and absence of the Climacograptus extraordinarius Zone prompted Lenz and McCracken (1982) to assign a late Fauna 12 age to the Blackstone River conodont fauna.

Plectodina does not occur above the middle Vauréal Formation (sample 63, Nowlan and Barnes, 1981, table 1), does not extend to the top of the Richmondian in the western Midcontinent (Sweet, 1979, fig. 3; 1984, Appendix), and is absent in post-middle Cautleyan strata of Orchard (1980, fig. 3). Unless Noixodontus, which co-occurs with Plectodina in Missouri, is shown to be a strictly latest Ordovician genus, then Plectodina does not appear to range into the Gamachian.

The absence of species of Plectodina from the upper part of the Vauréal and the Ordovician part of the Ellis Bay formations is striking: not one element occurs in more than 14,000 elements (approximately 6072, from Nowlan and Barnes, 1981, table 1; 8438 from McCracken and Barnes, 1981, tables 2-6). Nowlan and Barnes, however, have shown that the distribution of Plectodina may be environmentally controlled and this may be an alternate reason for its absence.

As a final remark on Plectodina, it should be noted that the study of the three sections of the Ellis Bay Formation involved strata representing environments that differed spatially, temporally, and possibly climatically. Environments ranged from relatively near- to off-shore, shallow to deep subtidal due to the paleogeography and glacially-induced eustatic changes in sea-level, and possibly warm to cool via a global cooling. A Plectodina community, if present during late Richmondian and Gamachian time in the Anticosti Basin has remained undiscovered.

Pseudobelodina vulgaris ultima Sweet is a latest Richmondian to post-Richmondian subspecies, which occurs in the Bighorn Group of Wyoming, and on Anticosti. Sweet's (1984, Appendix) list of species ranges shows that the last occurrence of Plectodina species is below the first occurrence of P. v. ultima. The range of this subspecies in the Vauréal Formation is unknown, but one element figured as Belodina profunda (Branson and Mehl) by Nowlan and Barnes (1981, Pl. 7, fig. 12) is likely P. v. ultima, and occurs in the upper part of the Vauréal Formation. This one known Anticosti occurrence suggests that the upper part of this formation is latest Richmondian, if not younger Ordovician. "B. profunda" is a rare consituent of the overlying Ellis Bay Formation; without further study, it is not known if this taxon includes elements of P. v. ultima.

B.5 Early Llandovery biostratigraphic units

The lowest Silurian (sensu McCracken and Barnes, 1981) Oulodus? nathani Zone was recognized as representing strata below that of the Distomodus kentuckyensis Assemblage Zone. They (ibid., p. 66) stated that the "... base of this zone is defined by the first occurrence of O.? nathani and the zone extends up to the base of the D. kentuckyensis Zone. Characterisitic species of this zone" (i.e. O.? nathani) "include O.? nathani and D. kentuckyensis;" (this should have read D. aff. D. kentuckyensis).

McCracken and Barnes (1981, p. 72) inadvertently complicated the systemic biostratigraphy with their statement "The Ordovician - Silurian boundary is herein placed at the first occurrence of species of Ozarkodina in the transitional zones (i.e. O. hassi and/or O. oldhamensis)." The O.? nathani Zone as defined, is a normal successive appearance zone (cf. Cooper, 1980, fig. 2): its base is at the first occurrence of O.? nathani McCracken and Barnes, its top is at first occurrence of D. kentuckyensis Branson and Branson.

The base of the O.? nathani Zone and the systemic boundary thus defined are not at exactly the same level since Ozarkodina species occur at a level that is slightly lower than the first occurrence of O.? nathani (McCracken and Barnes, 1981, pp. 66, 72). As defined, the O.? nathani Zone is preceded by a post- Ordovician interval that has biostratigraphically undiagnostic Silurian taxa (i.e. a biointerval zone sensu Hedberg, 1976, pp. 60, 61). McCracken and Barnes (1981, p. 66) noted the low yields of conodonts in their lowest Silurian samples and predicted that further sampling might show "the first appearance of O.? nathani to be associated with the Ozarkodina species in the two samples below, ... " (i.e. base of O.? nathani Zone may prove to coincide with base of Silurian as defined on Anticosti).

A formal name for this interval should take its name from a taxon typical of the zone though not necessarily confined to it (Hedberg, 1976, p. 61). Ozarkodina hassi (Pollock, Rexroad and Nicoll) is an appropriate choice since it is easily distinguishable (unlike species of Panderodus), and ranges upwards past the lower limit of the O.? nathani Zone; the interval is herein termed the O. hassi Biointerval-zone.

B.6 Fauna 13: Diachronous or Isochronous?

B.6.1 Distributional Evidence

Elements of Gamachignathus species are most dominant in Ellis Bay strata on north-western Anticosti Island. These strata represent a subtidal environment interpreted to be farthest offshore. McCracken and Barnes (1981, p. 70) noted that in the more nearshore environments (within Anticosti Basin), these species did not become a force until later, probably through a migration from offshore areas.

As implied above, interpretations based on sparse samples must be made with caution, but the distribution charts and stratigraphic notes of McCracken and Barnes (1981) deserve a review in an attempt to determine environmental influence over species distribution.

At the Vauréal River section of the Ellis Bay Formation, three consecutive samples (V10-V12) contain an abundance of elements, including those of *Gamachignathus* spp.; these samples are within undifferentiated members 1? and 2?. Percentages of *Gamachignathus* species versus total, and non-panderodont total are (in stratigraphic order): 1.4, 11.0, 41.9, and 6.9, 34.5, 79.9, respectively.

Below these strata, only three the of nine samples yielded a total of more than 50 elements of all taxa (V03-236 elements; V06-284; V08-85). The same calculations yield percentage ranges from 0.7 (V06)-4.2 (V03) percent and 1.8 (V06)-8.1 (V03) percent, respectively. The other 6 samples have three elements of *Gamachignathus*; the total number of elements in these 6 samples is 128.

It is interesting to note that samples V01-V04 were identified as being from Vauréal Formation strata (McCracken and Barnes, 1981, pp. 121, 122). Sample V03 is from strata about 2.5m below the base of the Ellis Bay Formation. Excluding this sample, elements of *Gamachignathus* do not become a major component until about mid-level in members 1?-2? of the Ellis Bay Formation at Vauréal River. They are a lesser component through member 3, and into the base of member 4, where the section ends with small bioherms.

The conodont distribution chart of McCracken and Barnes (1981, fig. 13) for the Salmon River section may be unintentionally misleading since it is a composite: samples S01-S10 (members 1?, 2?, 3?) are from section SIIIA, samples S11-S27 (members 2?, 3?, 4?, 4, 5, 6) are from section SIIIB

-- these sections are partially equivalent.

All of the samples from the Salmon River section SIIIA have a low yield of conodonts; the average number per sample is fifteen. Sample S10 (member 3?), however, is relatively rich (52 elements); only a single element of <u>Gamachignathus</u> is present in all of these samples.

Samples S11-S14 from the Salmon River section SIIIB, members 2?-3?, also have low yields (about 11 per sample) but more than half are elements of <u>Gamachignathus</u> species. It was from this section that McCracken and Barnes (1981) noted an increase in the proportion of <u>Gamachignathus</u>. The numbers are so low that they cannot be used to prove this empirical observation; however, species of <u>Gamachignathus</u> appear to dominate the faunas beginning at a level from at least within member 2? on Salmon River.

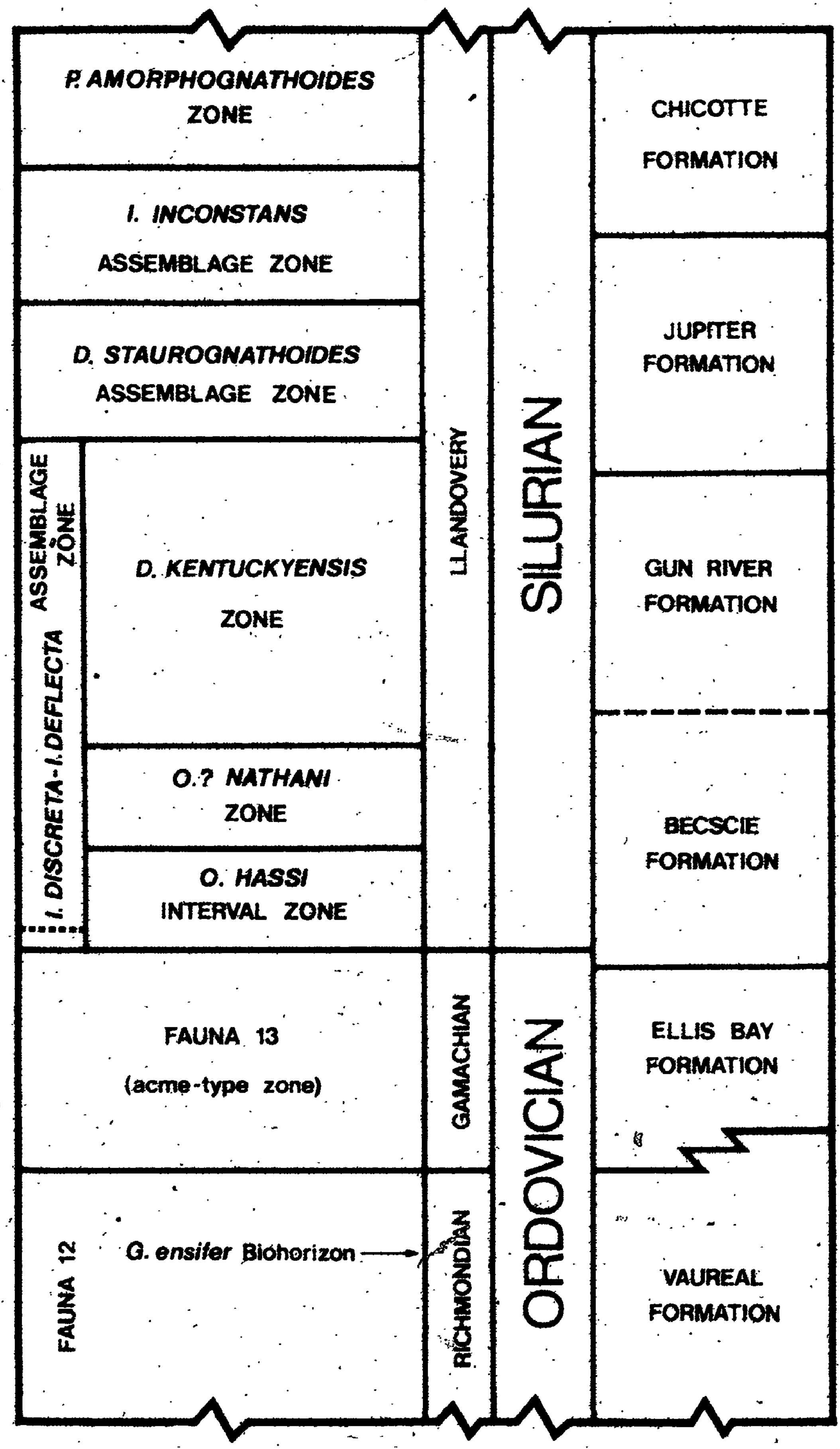
In Ellis Bay strata of the Anticosti sections, Fauna 13 occurs at the base of member 1 of the type area, and within members 1?-2?, and member 2? of the more near-shore sections at Vauréal and Salmon rivers, respectively. The members are not as distinct in these latter two sections hence the queried member designations. If the lithostratigraphic correlation is correct, and isochronous, then the lower boundary of Fauna 13 may be regarded as slightly diachronous (but see conclusions below).

B.6.2 Paleoecology of Gamachignathus and Fauna 13

Much of Fauna 13 has recently been suggested to be an offshore equivalent to the younger part of the midcontinent Fauna 12 (see Sweet, 1983, fig. 2). Fauna 13 is found in an area that is peripheral to the North American craton, and all presently known occurrences of G. ensifer are also in marginal areas. The apparatus type and element morphology of this genus suggests a North Atlantic (European) Province ancestry, and thus possibly a preference of the animal for cooler and deeper waters.

These observations support the suggestion that Fauna 13 is an offshore fauna, but do not necessarily make it coeval with Fauna 12. McCracken and Barnes (1981) implied that Fauna 13 was absent in the midcontinent due primarily to the Ordovician - Silurian boundary hiatus. They also suggested some environmental control to explain the "delayed" domination by species of Gamachignathus in the more nearshore section. This is the apparent diachronous lower boundary as discussed above in the preceding Chapter B.6.1.

The question whether G. ensifer and G. hastatus, and thus Fauna 13 were environmentally controlled must be explored; it may or may not affect the biostratigraphic utility of Fauna 13. The answer is somewhat limited by the fact that, except for the study of the Ellis Bay Formation, there are no studies of strata bearing Gamachignathus species that singularly involve a lateral variation in


P. AMORPHOGNATHOIDES ZONE
I. INCONSTANS ASSEMBLAGE ZONE
D. STAUROGNATHOIDES ASSEMBLAGE ZONE
I. DISCRETA-I. DEFLECTA ASSEMBLAGE ZONE
D. KENTUCKYENSIS ZONE
O.? NATHANI ZONE
O. HASSI INTERVAL ZONE
FAUNA 13 (acme-type zone)
FAUNA 12
G. ensifer Biohorizon
LLANDOVERY
GAMACHIAN
RICHMONDIAN
SILURIAN
ORDOVICIAN
CHICOTTE FORMATION
JUPITER FORMATION
GUN RIVER FORMATION
BECSCIE FORMATION
ELLIS BAY FORMATION
VAUREAL FORMATION

From nearshore (Salmon River) to offshore (Ellis Bay) shallow marine environments, there is an increase in relative abundance of Gamachignathus species, and a slight decrease in faunal diversity. At Salmon River, the elements of Gamachignathus represent 33.8 percent of the total fauna (28 taxa); at Ellis Bay, 45.2 percent of elements from 21 taxa. Strata of both this and the Vauréal formations represent a variety of environments in a relatively shallow carbonate sea. The few samples from around bioherms yielded few elements of Gamachignathus.

G. ensifer also occurs very rarely in fine clastic and carbonate strata representing a trough near a carbonate- and fine clastic-rich slope or platform edge in Yukon (Lenz and McCracken, 1982; and herein). Further to the south in N.W.T., Gamachignathus is absent in the Whittaker Formation that is lithologically transitional between typical, carbonate platform Whittaker strata to the east, and fine clastics of the Road River Formation to the west (Nowlan, et al., MS).

The two Yukon beds from which these elements of G. ensifer were recovered show no sedimentary evidence of mass-flow from platform margins. However, given the nature of a trough environment, there is no argument against a suggestion that such evidence may be cryptic. It is interesting though, that the platform margin facies of the Whittaker Formation in N.W.T. does not contain Gamachignathus.

The clastics and lesser amounts of limestones of the Grog Brook and Matapedia groups are believed to represent deposition by turbidites into a bathyal or abyssal trough. The conodont faunas are concentrated in calcarenites which may represent distal debris flows (Nowlan, 1983a).

The proliferation of *Gamachignathus* species, and thus the occurrence of Fauna 13, may be environmentally controlled; it is perhaps unrealistic to suggest that any taxon is truly insensitive to its environment. To use *Aphelognathus* as an example, Nowlan and Barnes (1981, pp. 5-7) recognized an *Oulodus* - *Aphelognathus* ecozone, which succeeded a deeper water *Phragmodus* ecozone in Vauréal Formation strata. In the higher strata of the Ellis Bay Formation, a more nearshore community is characterized by *A. pyramidalis* (Branson, Mehl and Branson) and panderodonts. A slightly more offshore community has a ramiform component that includes *A.* aff. *A. grandis* Branson, Mehl and Branson (McCracken and Barnes, 1981). Tarrant (1977) noted a similar pattern in the distribution of *A. pyramidalis* and *A. grandis*; the former being found in more nearshore environments than *A. grandis*.

A. grandis is one of several chronozones of Sweet (1984) that are based on the successive appearance of taxa. Since these are chronozones, it is critical that their limits are isochronous, representing the total maximum time span of their diagnostic taxa, regardless of the presence or absence due to migration of the definitive species. The Late

Ordovician species of Gamachignathus were probably no more sensitive to environmental changes than were species of Aphelognathus.

The conclusion is clear: the Late Ordovician Gamachignathus does not appear to be a taxon that was extremely sensitive to its environment.

B.6.3 Diachronism

To summarize the distribution of Fauna 13, it occurs in Ellis Bay strata at the base of member 1, which represents a more offshore subtidal environment, and within members 1? to 2? of more nearshore strata. This difference in level of proliferation may partly be a relict of low-yielding samples but if not, it could be argued that diachronism may not be of great significance. It is noteworthy that the initial proliferation of Gamachignathus species at the Vauréal River section is 2.5m below the base of member 1 of the Ellis Bay Formation; this could be used to argue against the suggestion that the base of Fauna 13 is increasingly diachronous towards the nearshore environments.

A final argument regarding a diachronous base to Fauna 13: the difference in stratigraphic occurrence is based on the assumption that the lithic boundaries are datum planes. Conversely, it is quite reasonable to suggest that the base of Fauna 13 is isochronous and it is the lithic boundaries that are diachronous.

B.7 Summary

1) Fauna 13 was originally defined as being characterized by Gamachignathus ensifer and G. hastatus. Discovery of the genus in lower strata does not necessarily indicate Fauna 13.

2) If Fauna 13 is to be regarded as a formal biozone, the name of this biozone must stress the definitive species.

3) Fauna 13 is an acme-type of biozone. It is pre-mature to formally define the limits of the "acme", but abundance calculations are listed for comparative purposes: Gamachignathus spp. versus total fauna is 31 percent for the Ellis Bay Formation; 21, Matapedia Group; 8, White Head Formation; 4, Grog Brook Group; and 2, Road River Formation. A possible lower limit may be in the range of 5-10 percent.

4) The first occurrence of G. ensifer below Fauna 13 is defined as a first appearance biohorizon and is suggested to be indicative of latest Richmondian, not Gamachian, time.

5) The notable absence of species of Plectodina in strata of the upper part of the Vauréal, and the Ellis Bay formations may represent a last appearance or extinction biohorizon.

6) Pseudobelodina vulgaris ultima, a latest Richmondian to post-Richmondian Ordovician subspecies, occurs in the upper part of the Vauréal Formation, suggesting that these

strata are latest Richmondian. The lack of co-occurrence of this subspecies and *Plectodina* in the midcontinent suggests a late but not latest Richmondian age for the upper limit of *Plectodina*.

7) The Silurian *Oulodus? nathani* Zone is a successive appearance biozone; its base is defined by the first appearance of the nominal species, the upper limit by the the base of the succeeding zone.

8) The undiagnostic interval between Fauna 13 and the *O.? nathani* Zone is the bases of the *Ozarkodina hassi* Biointerval Zone. More detailed study may extend the range of *O.? nathani* downwards so that the *O.? nathani* and *O. hassi* zones coincide.

9) Calculations of relative abundance of species of *Gamachignathus* versus total and non-panderodont total elements from Ellis Bay strata show an increase of *Gamachignathus* species from nearshore to offshore shallow marine environments. The level of significant increase varies; at the base of member 1 in the section representing the most offshore environment, immediately below the Ellis Bay Formation and within members 1?-2? at the intermediate section, and within member 2? in strata representing the most nearshore environment. Differences in relative abundance may be due to sparse collections or the tentative nature of interpretations of the more nearshore lithostratigraphic units.

10) Gamachignathus species are found in a variety of upper Ordovician carbonate environments, and in carbonate beds within clastic troughs (possibly transported from platform margins). These occurrences and the lack of a direct relationship with lithofacies changes suggest that these taxa are no more sensitive to environmental changes than are species of Aphelognathus.

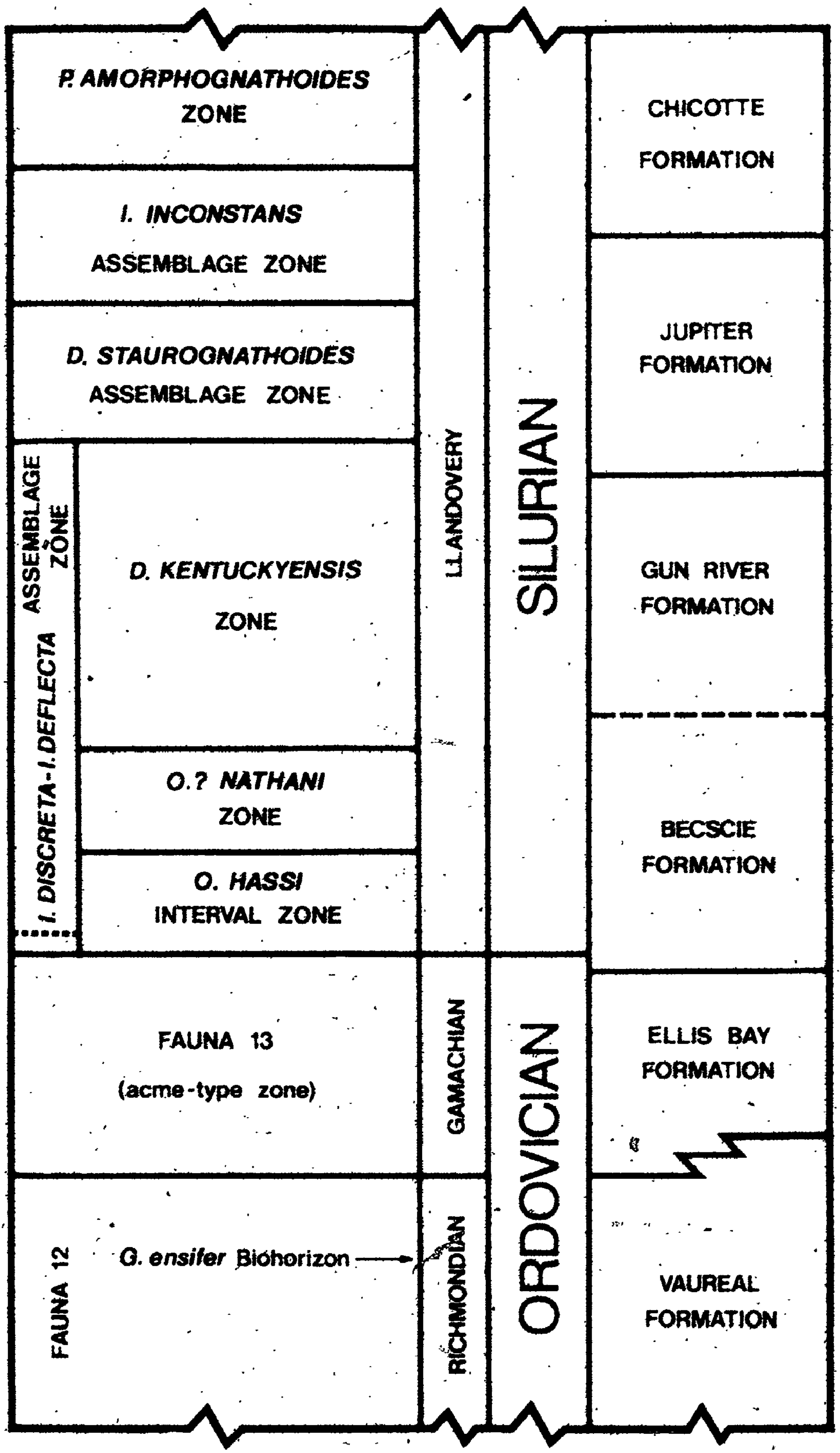
11) It is probable that it is the lithofacies boundaries of the Ellis Bay Formation members, not the base of Fauna 13, that are diachronous.

B.8 Conclusions

I can only partially agree with the implications of Sweet (1983), that strata of Anticosti Basin are in part, an offshore faunal correlative of the upper part of midcontinent Fauna 12. There is, however, an equivalent fauna; it is that which occurs in the upper part of the Vauréal Formation at and above the G. ensifer Biohorizon. Fauna 13 is recognized in this present report as being entirely younger than Fauna 12 of the Vauréal Formation.

The apparent diachronism of the base of Fauna 13, shown between the sections of Ellis Bay strata may be: 1) a relict of small collections; or 2) insignificant on a temporal scale. Furthermore, if the base of the fauna is extended downward at the Vauréal River section to include a sample of relatively high abundance of Gamachignathus species, the base of Fauna 13 would be at a level 2.5m below the base of member 1. A more plausible alternative is that the lithostratigraphic boundaries are diachronous.

FIGURE B1. ANTICOSTI ISLAND LITHO- AND BIOSTRATIGRAPHY. Conodont biostratigraphic units are from Fahraeus and Barnes (1981), McCracken and Barnes (1981), Nowlan and Barnes (1981), Uyeno and Barnes (1981, 1983), and herein. The position of the Ellis Bay - Becscie formational boundary is from Petryk (1981a, 1981b). This is immediately above the Member 7 bioherms (which were previously assigned to Member 6). The nominal taxa of the <u>Icriodella</u> <u>discreta</u>-<u>I</u>. <u>deflecta</u> Asemblage Zone have their first appearance below the <u>O</u>.? <u>nathani</u> Zone.


P. AMORPHOGNATHOIDES ZONE
I. INCONSTANS ASSEMBLAGE ZONE
D. STAUROGNATHOIDES ASSEMBLAGE ZONE
I. DISCRETA - I. DEFLECTA ASSEMBLAGE ZONE
D. KENTUCKYENSIS ZONE
O.? NATHANI ZONE
O. HASSI INTERVAL ZONE
FAUNA 13 (acme-type zone)
FAUNA 12
G. ensifer Biohorizon
LLANDOVERY
GAMACHIAN
RICHMONDIAN
SILURIAN
ORDOVICIAN
CHICOTTE FORMATION
JUPITER FORMATION
GUN RIVER FORMATION
BECSCIE FORMATION
ELLIS BAY FORMATION
VAUREAL FORMATION

REFERENCES

ALDRIDGE, R.J., and MOHAMED, I.

1982: Conodont biostratigaraphy of the early Silurian of the Oslo Region. In Field Meeting, Oslo Region, 1982. Edited by D. Worsley. International Union of Geological Sciences. Subcommission on Silurian Stratigraphy. Palaeontological Contributions from the University of Oslo, no. 278, pp. 109-120.

COOPER, B.J.

1980: Toward an improved Silurian conodont biostratigraphy. Lethaia, v. 13, pp. 209-227.

HEDBERG, H.D. (editor)

1976: International Guide. A Guide to Stratigraphic Classification Terminology, and Procedure. International Subcommission on Stratigraphic Classification of I.U.G.S. Commission on Stratigraphy. John Wiley and Sons, New York, New York, 200 pp.

LENZ, A.C., and McCRACKEN, A.D.

1982: The Ordovician - Silurian boundary, northern Canadian Cordillera: graptolite and conodont correlation. Canadian Journal of Earth Sciences, v. 19, pp. 1308-1322.

McCRACKEN, A.D., and BARNES, C.R.

1981: Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Québec, with special reference to the Late Ordovician -

Early Silurian chronostratigraphy and the systemic boundary. Geological Survey of Canada, Bulletin 329, Part 2, pp. 51-134.

1982: Restudy of conodonts (Late Ordovician - Early Silurian) from the Edgewood Group, Clarksville, Missouri. Canadian Journal of Earth Sciences, v. 19, pp. 1474-1485.

McCRACKEN, A.D., NOWLAN, G.S., and BARNES, C.R.

1980: *Gamachignathus*, a new multielement conodont genus from the latest Ordovician, Anticosti Island, Québec. *In* Current Research, Part C. Geological Survey of Canada, Paper 80-C, pp. 103-112.

NOWLAN, G.S.

1981: Late Ordovician - Early Silurian conodont biostratigraphy of the Gaspé Peninsula - a preliminary report. *In* Field Meeting, Anticosti - Gaspé, Québec, 1981, v.II: Stratigraphy and Paleontology. *Edited by* P.J. Lespérance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 257-291.

1983a: Biostratigraphic, paleogeographic and tectonic implications of late Ordovician conodonts from the Grog Brook Group, northwestern New Brunswick. Canadian Journal of Earth Sciences, v. 20, pp. 651-671.

1983b: Early Silurian stratigraphy of eastern Canada. Fossils and Strata, No. 15, pp. 95-110.

NOWLAN, G.S., and BARNES, C.R.

1981: Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Québec. Geological Survey of Canada, Bulletin 329, Part 1, pp. 1-49.

NOWLAN, G.S., McCRACKEN, A.D., and CHATTERTON, B.D.E.

Conodonts from Ordovician-Silurian boundary strata, Whittaker Mountains, Northwest Territories, Canada. (193 pp., 22 pl. manuscript submitted to Geological Survey of Canada Bulletin)

ORCHARD, M.J.

1980: Upper Ordovician conodonts from England and Wales. Geologica et Palaeontologica, v. 14, pp. 9-44.

OVER, D.J.

1985: Some Silurian conodonts from the southern Mackenzie Mountains, Northwest Territories. Unpublished Master of Science thesis, University of Alberta, Edmonton, Alberta, Spring, 1985, 239 p.

PETRYK, A.A.

1981a: Stratigraphy, sedimentology and paleogeography of the Upper Ordovician - Lower Silurian of Anticosti Island, Québec. In Field Meeting, Anticosti - Gaspé, Québec, 1981, v. II: Stratigraphy and Paleontology. Edited by P.J.

Lespérance. International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Département de géologie, Université de Montréal, pp. 11-39.

1981b: Upper Ordovician glaciation: Effects of eustatic sea-level fluctuations on the Anticosti Platform succession, Québec. <u>In</u> Field Meeting, Anticosti - Gaspé, Québec, 1981, v. II: Stratigraphy and Paleontology. <u>Edited</u> <u>by</u> P.J. Lespérance. International Union of Geolgical Sciences, Subcommission on Silurian Stratigraphy, Ordovician - Silurian Boundary Working Group, Départment de géologie, Université de Montréal, pp. 81-85.

ROSS, R.J., Jr., ADLER, F.J., AMSDEN, T.W., BERGSTROM, D., BERGSTROM, S.M., CARTER, C., CHURKIN, M., CRESSMAN, E.A., DERBY, J.R., DUTRO, J.T., Jr., ETHINGTON, R.L., FINNEY, S.C., FISHER, D.W., FISHER, J.H., HARRIS, A.G., HINTZE, L.F., KETNER, K.B., KOLATA, D.L., LANDING, E., NEUMAN, R.B., SWEET, W.C., POJETA, J., Jr., POTTER, A.W., RADER, E.K., REPETSKI, J.E., SHAVER, R.H., THOMPSON, T.L., and WEBERS, G.F.

1982: The Ordovician System in the United States: correlation chart and explanitory notes. International Union of Geological Sciences, Publication No. 12, 73 pp.

ROSS, R.J., Jr., NOLAN, T.B., and HARRIS, A.G.

1979: The Upper Ordovician and Silurian Hanson Creek Formation of central Nevada. United States Geological Survey, Professional Paper 1126-C, pp. C1-C22.

SWEET, W.C.

1984: Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A. In Aspects of the Ordovician System. Edited by D.L. Brunton. Palaeontological Contributions from the University of Oslo, No. 295, Universitetsforlaget, pp. 23-35.

TARRANT, G.A.

1977: Taxonomy, biostratigraphy and paleoecology of Late Ordovician conodonts from southern Ontario. Unpublished Master of Science thesis, University of Waterloo, Waterloo, Ontario, May, 1977, 240 pp.

WANG XAOFENG, ZENG QINGLUAN, ZHOU TIANMEI, NI SHIZHAO, XU GUANGHONG, SUN QUANYING, LI ZHIHONG, XIANG LIWEN, and LAI CAIGEN

1983: Latest Ordovician and earliest Silurian faunas from the eastern Yangtze Gorges, China with comments on Orodovician - Silurian boundary. Bulletin of the Yichang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences, No. 6, pp. 129-182.

WILLIAMS, S.H.

1983: The Ordovician - Silurian boundary graptolite fauna of Dob's Linn, southern Scotland. Palaeontology, v. 26, pp. 605-639.

APPENDIX C

YUKON CONODONT DISTRIBUTION TABLES

TABLE 1. Ordovician species, samples, abundance.

TABLE 2. Silurian species, samples, abundance.

The total number of elements are listed for each multielement species. Some taxa are not identified to the trivial level; these are noted by "sp." after the generic name. In samples where there are probably more than one species of the same genus, the abbreviation "spp." is used.

A number of elements are un-assignable at the generic level. These are referred to as indeterminate elements. Forms that are illustrated in the plates have been given descriptive terms based on either shape or form-genus name. All others are listed under "Misc. Indet. El."; these totals do not include fragmentary material.

Most rock samples are identified by their field collection numbers since field notes, and rock, acid-digestion and conodont samples all bear the original numbers. Samples from the Blackstone and Peel River sections, however, were collected using measurements in feet; these have been converted to SI units (numbers in parentheses below are the original field measurements). The sample number symbolizes the section, year collected, outcrop number (for Blackstone River samples), and level of collection.

ORDOVICIAN SPECIES	TOTAL	BR77-J:50a	PR77-358a	PR77-408a	PR77-452a	RR78-13a	RR78-167a
AMORPHOGNATHUS							
A. ORDOVICICUS	23	13	0	0	5	0	0
BELODELLA?							
B.? aff. NEVADENSIS	10	0	10	0	0	0	0
BELODINA CONFLUENS	18	6	0	0	6	0	0
BESSELODUS BOREALIS	21	10	0	0	10	0	0
COELOCERODONTUS? sp.	1	0	0	0	0	0	0
"CORDYLODUS" HORRIDUS	1	0	0	0	0	1	0
DAPSILODUS? sp. A	5	0	4	0	0	1	0
DIAPHORODUS? sp. A	4	0	0	0	0	4	0
DREPANOISTODUS							
D. cf. BASIOVALIS	20	0	7	1	0	12	0
D. SUBERECTUS	32	8	0	0	12	0	0
D. cf. VENUSTUS	4	0	0	0	0	3	0
EOCARNIODUS GRACILIS	33	19	0	0	14	0	0
EOPLACOGNATHUS? sp. A	4	0	0	0	0	4	0
GAMACHIGNATHUS							
G. ENSIFER	4	3	0	0	1	0	0
ICRIODELLA SUPERBA?	1	1	0	0	0	0	0
NOIXODONTUS							
N. GIRARDEAUENSIS	3	3	0	0	0	0	0
OULODUS ROHNERI	2	2	0	0	0	0	0
O. ULRICHI	3	1	0	0	2	0	0
PANDERODUS							
P. cf. FUELNERI	3	0	3	0	0	0	0
P.? GIBBER	5	4	0	0	0	0	0
P. cf. GIBBER	1	0	1	0	0	0	0
P. GRACILIS	130	60	0	0	33	0	1
P. cf. GRACILIS	8	0	8	0	0	0	0
PANDERODUS sp. A	3	1	0	0	2	0	0
PAROISTODUS? sp. A	19	7	0	1	4	0	1
PERIODON ACULEATUS	207	0	49	0	0	30	0
PHRAGMODUS sp. A	1	0	0	0	0	0	0
PLECTODINA FLORIDA	2	2	0	0	0	0	0
P. TENUIS	9	7	0	0	2	0	0
PLECTODINA? sp. A	2	0	0	0	0	0	0
POLONODUS? sp. A	1	0	0	0	0	1	0
PRIONIODUS							
P. (OEPIKODUS)? sp. A	1	0	0	0	0	1	0
PROTOPANDERODUS							
P. INSCULPTUS	26	8	0	0	14	0	0
P. LIRIPIPUS	14	2	0	0	9	0	0
P. PARVIBASIS	3	0	3	0	0	0	0
P. ROBUSTUS	34	0	15	0	0	14	0
P. aff. VARICOSTATUS	14	0	10	0	0	3	0
PROTOPANDERODUS sp. A	10	0	10	0	0	0	0
PROTOPANDERODUS spp.	5	0	0	0	0	3	0

ORDOVICIAN SPECIES		BR77-1:50m	PR77-358m	PR77-408m	PR77-452m	RR78-13m	RR78-167m
PSEUDOBELODINA							
P.? DISPANSA	12	7	0	0	2	0	1
P. aff. QUADRATA	1	0	0	0	1	0	0
P. V. VULGARIS	1	0	0	0	1	0	0
PYGODUS SERRUS s.l.	90	0	90	0	0	0	0
SCABARDELLA ALTIPES ssp.	68	25	0	0	30	0	9
SCALPELODUS? VIRUENSIS	3	0	3	0	0	0	0
SPINODUS SPINATUS	2	0	0	0	0	2	0
STRACHANOGNATHUS PARVUS	14	0	8	0	2	0	0
WALLISERODUS							
W. AMPLISSIMUS	10	1	0	0	2	0	0
W.? ETHINGTONI	5	0	0	0	0	1	0
WALLISERODUS? sp.	4	0	0	0	0	0	0
N. GEN. A n. sp. A	5	5	0	0	0	0	0
INDET. DISTACODONT. EL.	1	0	0	0	1	0	0
INDET. OISTODONTIFORM EL.	1	0	1	0	0	0	0
MISC. INDETERMINATE EL.	23	0	1	0	1	3	0
	927	195	223	2	154	83	12

RR78-207a	RR78-225a	RR78-228a	RR78-235a	RR78-245a	TC78-139aa	TOTAL	ORDOVICIAN SPECIES
							AMORPHOGNATHUS
0	0	0	0	5	0	23	A. ORDOVICICUS
							BELODELLA?
0	0	0	0	0	0	10	B.? aff. NEVADENSIS
0	0	3	2	1	0	18	BELODINA CONFLUENS
0	0	0	1	0	0	81	BESSELODUS BOREALIS
0	0	0	0	0	1	1	COELOCERODONTUS? sp.
0	0	0	0	0	0	1	"CORDYLODUS" HORRIDUS
0	0	0	0	0	0	5	DAPSILODUS? sp. A
0	0	0	0	0	0	4	DIAPHORODUS? sp. A
							DREPANOISTODUS
0	0	0	0	0	0	20	D. cf. BASIOVALIS
0	1	1	0	0	10	32	D. SUBERECTUS
0	0	0	0	0	1	4	D. cf. VENUSTUS
0	0	0	0	0	0	33	EOCARNIODUS GRACILIS
0	0	0	0	0	0	4	EOPLACOGNATHUS? sp. A
							GAMACHIGNATHUS
0	0	0	0	0	0	4	G. ENSIFER
0	0	0	0	0	0	1	ICRIODELLA SUPERBA?
							NOIXODONTUS
0	0	0	0	0	0	3	N. GIRARDEAUENSIS
0	0	0	0	0	0	2	OULODUS ROHNERI
0	0	0	0	0	0	3	O. ULRICHI
							PANDERODUS
0	0	0	0	0	0	3	P. cf. FUELNERI
0	0	0	0	1	0	5	P.? GIBBER
0	0	0	0	0	0	1	P. cf. GIBBER
0	0	0	0	17	19	130	P. GRACILIS
0	0	0	0	0	0	8	P. cf. GRACILIS
0	0	0	0	0	0	3	PANDERODUS sp. A
0	0	3	0	1	2	19	PAROISTODUS? sp. A
0	0	0	0	0	128	207	PERIODON ACULEATUS
0	0	0	0	0	1	1	PHRAGMODUS sp. A
0	0	0	0	0	0	2	PLECTODINA FLORIDA
0	0	0	0	0	0	9	P. TENUIS
0	0	0	0	0	2	2	PLECTODINA? sp. A
0	0	0	0	0	0	1	POLONODUS? sp. A
							PRIONIODUS
0	0	0	0	0	0	1	P. (OEPIKODUS)? sp. A
							PROTOPANDERODUS
1	2	0	0	1	0	26	P. INSCULPTUS
0	0	0	0	2	1	14	P. LIRIPIPUS
0	0	0	0	0	0	3	P. PARVIBASIS
0	0	0	0	0	5	34	P. ROBUSTUS
0	0	0	0	0	1	14	P. aff. VARICOSTATUS
0	0	0	0	0	0	10	PROTOPANDERODUS sp. A
0	0	0	0	0	2	5	PROTOPANDERODUS spp.

RR78-207a	RR78-225a	RR78-228a	RR78-235a	RR78-245a	TC78-139a		ORDOVICIAN SPECIES
							PSEUDOBELODINA
0	0	2	0	0	0	12	P.? DISPANSA
0	0	0	0	0	0	1	P. aff. QUADRATA
0	0	0	0	0	0	1	P. V. VULGARIS
0	0	0	0	0	0	90	PYGODUS SERRUS s.l.
0	0	1	0	3	0	68	SCABARDELLA ALTIPES ssp.
0	0	0	0	0	0	3	SCALPELODUS? VIRUENSIS
0	0	0	0	0	0	2	SPINODUS SPINATUS
0	0	1	0	0	3	14	STRACHANOGNATHUS PARVUS
							WALLISERODUS
0	0	2	0	5	0	10	W. AMPLISSIMUS
0	0	0	0	0	4	5	W.? ETHINGTONI
0	0	0	0	0	4	4	WALLISERODUS? sp.
0	0	0	0	0	0	10	N. GEN. n. sp. A
0	0	0	0	0	0	1	INDET. DISTACODONT. EL.
0	0	0	0	0	0	1	INDET. DISTODONTIFORM EL.
0	0	0	0	0	18	23	MISC. INDETERMINATE EL.
1	3	13	3	36	202	927	

SILURIAN SPECIES	PL79-80.0m	PR79-1695'	RR78-245m	RR78-247m	RR78-250m	RR78-275m	RR78-281m	RR78-285m	RR78-308m
ASTROPENTAGNATHUS	0	0	0	0	0	0	0	0	0
A. IRREGULARIS	0	0	0	0	0	0	0	48	0
A. n. sp. A	0	0	0	0	0	0	0	1	0
A.? INDET. ELEMENTS	0	0	0	0	0	0	0	0	0
APSIDOGNATHUS									
A. TUBERCULATUS	0	0	0	0	0	0	0	0	0
AULACOGNATHUS BULLATUS	0	0	0	0	0	0	0	11	0
BELODELLA SILURICA	0	0	0	0	0	0	0	0	0
CARNIODUS CARNULUS	0	0	0	0	0	0	0	0	0
D. OBLIQUICOSTATUS	0	0	4	5	13	1	54	0	0
DAPSILODUS? sp. B	0	0	0	0	2	0	0	49	0
DAPSILODUS spp.	0	0	0	0	0	0	0	0	0
DECORICONUS FRAGILIS	0	0	0	0	2	0	0	0	0
DISTOMODUS									
D. KENTUCKYENSIS?	0	0	0	0	0	0	0	0	0
D. cf. KENTUCKYENSIS	0	0	0	0	0	0	0	16	0
D. STAUROGNATHOIDES	0	0	0	0	0	0	0	9	0
DISTOMODUS spp.	0	0	0	0	0	0	2	0	0
ICRIODELLA sp. A	0	0	3	0	0	0	0	0	0
ICRIODELLA sp. B	0	0	0	0	0	0	0	0	0
JUANOGNATHUS? sp.	0	0	0	0	0	0	0	0	0
KOCKELELLA									
K. RANULIFORMIS	0	0	0	0	0	0	0	0	0
K. WALLISERI?	0	0	0	0	0	0	0	0	0
KOCKELELLA spp.	0	0	0	0	0	0	0	0	0
OULODUS FLUEGELI s.l.	0	0	0	0	0	4	23	20	0
OULODUS n. sp. A	0	0	0	0	0	0	0	7	0
OULODUS? n. sp. B	0	0	0	0	0	0	0	1	0
OULODUS spp.	0	0	0	0	0	0	0	0	0
OZARKODINA									
O. EXCAVATA n. ssp. A	0	0	0	0	0	0	0	3	0
O. MANITOULINENSIS?	0	0	3	0	0	0	0	0	0
O. aff. POLINCLINATA	0	0	0	0	0	0	0	0	0
OZARKODINA n. sp. A	1	0	0	0	0	0	0	0	0
OZARKODINA sp. B	0	0	0	0	0	0	0	0	0
OZARKODINA sp. C	0	0	0	0	0	0	0	0	0
OZARKODINA sp. D	0	0	0	0	0	0	0	0	0
OZARKODINA sp.	0	0	0	0	0	0	0	0	0
OZARKODINA spp.	0	0	0	0	0	0	0	0	0
PANDERODUS GIBBER	0	0	0	0	0	0	0	0	0
P. RECURVATUS	0	0	0	0	0	0	0	0	0
P. UNICOSTATUS	0	0	0	0	0	0	20	0	0
PANDERODUS sp.	6	0	0	0	0	0	0	0	2
PANDERODUS spp.	0	0	0	0	0	0	0	44	0
PSEUDOONEOTODUS									
P. BICORNIS	0	0	0	0	0	0	0	0	0
P. TRICORNIS	0	0	0	0	0	0	0	0	0

SILURIAN SPECIES	PL79-80.0m	PR79-1695	RR78-245m	RR78-247m	RR78-250m	RR78-275m	RR78-281m	RR78-285m	RR78-308m
PTEROSPATHODUS CELLONI	0	0	0	0	0	0	0	7	0
P. PENNATUS ANGLUATUS	0	0	0	0	0	0	0	0	0
P. P. PROCERUS	0	0	0	0	0	0	0	5	0
P. n. sp. A	0	0	0	0	0	0	0	11	0
P.? INDET. ELEMENTS	0	0	0	0	0	0	0	0	0
WALLISERODUS CURVATUS	0	1	1	1	1	0	4	0	0
W. SANCTICLARI	0	0	0	0	0	0	7	0	0
WALLISERODUS n. sp. A	0	0	0	0	0	0	5	2	0
W.? n. sp. B	0	0	0	0	0	0	0	0	0
WALLISERODUS sp.	2	0	0	0	0	0	0	0	0
WALLISERODUS spp.	0	0	0	0	0	2	0	0	0
N. GEN. B. n. sp. A	0	0	0	0	0	0	0	8	0
INDET. CRUCIFORM EL.	0	0	0	0	0	0	0	0	0
INDET. ZYGOGNATH. EL.	0	0	0	0	0	0	0	0	0
MISC. INDET. EL.	0	0	0	0	3	0	0	1	0
	9	1	11	6	21	7	115	243	2

SILURIAN SPECIES	TOTAL	BR77-1:90m	BR77-1:98m	PL79-70.5m	PL79-72.7m	PL79-74.2m	PL79-75.9m	PL79-79.5m
ASTROPENTAGNATHUS					0	0	0	0
A. IRREGULARIS	189	0	137	0	0	0	0	0
A. n. sp. A	65	0	64	0	0	0	0	0
A.? INDET. ELEMENTS	11	0	11	0	0	0	0	0
APSIDOGNATHUS								
A. TUBERCULATUS	14	0	0	0	0	0	0	0
AULACOGNATHUS BULLATUS	13	0	0	0	0	0	0	0
BELODELLA SILURICA	3	0	0	0	0	0	0	0
CARNIODUS CARNULUS	175	0	0	0	0	0	0	0
D. OBLIQUICOSTATUS	887	684	4	0	0	0	0	0
DAPSILODUS? sp. B	51	0	0	0	0	0	0	0
DAPSILODUS spp.	4	0	0	0	0	0	0	0
DECORICONUS FRAGILIS	6	4	0	0	0	0	0	0
DISTOMODUS								
D. KENTUCKYENSIS?	37	0	24	7	0	0	0	0
D. cf. KENTUCKYENSIS	50	9	13	8	0	0	0	0
D. STAUROGNATHOIDES	30	0	0	0	0	0	0	0
DISTOMODUS spp.	10	0	0	0	0	0	0	0
ICRIODELLA sp. A	3	0	0	0	0	0	0	0
ICRIODELLA sp. B	3	0	0	3	0	0	0	0
JUANOGNATHUS? sp.	2	0	0	0	0	0	0	0
KOCKELELLA								
K. RANULIFORMIS	11	0	0	0	0	0	0	0
K. WALLISERI?	11	0	0	0	0	0	0	0
KOCKELELLA spp.	9	0	0	0	0	0	0	0
OULODUS FLUEGELI s.l.	1,285	986	199	0	0	0	0	0
OULODUS n. sp. A	232	0	5	0	0	0	0	0
OULODUS? n. sp. B	13	0	12	0	0	0	0	0
OULODUS spp.	7	0	0	0	0	0	0	0
OZARKODINA								
O. EXCAVATA n. ssp. A	286	0	0	0	0	0	0	0
O. MANITOULINENSIS?	3	0	0	0	0	0	0	0
O. aff. POLINCLINATA	12	5	7	0	0	0	0	0
OZARKODINA n. sp. A	55	0	0	4	40	6	4	0
OZARKODINA sp. B	6	4	2	0	0	0	0	0
OZARKODINA sp. C	90	0	0	0	0	0	0	0
OZARKODINA sp. D	4	0	0	2	0	0	2	0
OZARKODINA sp.	5	0	0	0	0	0	0	0
OZARKODINA spp.	12	0	0	0	0	0	0	0
PANDERODUS GIBBER	4	0	0	3	0	0	1	0
P. RECURVATUS	7	0	0	0	0	0	0	0
P. UNICOSTATUS	419	0	0	0	0	0	0	0
PANDERODUS sp.	131	0	0	31	2	26	46	10
PANDERODUS spp.	817	90	128	0	0	0	0	0
PSEUDOONEOTODUS								
P. BICORNIS	9	0	0	0	0	0	0	0
P. TRICORNIS	1	0	0	0	0	0	0	0

SILURIAN SPECIES		BR77-1:90m	BR77-1:98m	PL79-70.5m	PL79-72.7m	PL79-74.2m	PL79-75.9m	PL79-79.5m
PTEROSPATHODUS CELLONI	81	0	74	0	0	0	0	0
P. PENNATUS ANGLUATUS	41	0	41	0	0	0	0	0
P. P. PROCERUS	229	0	0	0	0	0	0	0
P. n. sp. A	55	0	44	0	0	0	0	0
P.? INDET. ELEMENTS	96	0	20	0	0	0	0	0
WALLISERODUS CURVATUS	64	32	15	0	0	0	0	0
W. SANCTICLARI	152	56	0	0	0	0	0	0
WALLISERODUS n. sp. A	1,592	1,583	0	0	0	0	0	0
W.? n. sp. B	10	8	0	0	0	0	0	0
WALLISERODUS sp.	77	0	0	25	24	8	9	9
WALLISERODUS spp.	1,023	1,021	0	0	0	0	0	0
N. GEN. B. n. sp. A	82	0	74	0	0	0	0	0
INDET. CRUCIFORM EL.	1	0	0	0	0	0	0	0
INDET. ZYGOGNATH. EL.	1	0	1	0	0	0	0	0
MISC. INDET. EL.	21	0	0	0	0	0	0	0
	8,507	4,482	875	83	66	40	62	19

SILURIAN SPECIES	RR78-316*	RR78-2/14*	RR78-2/15*	RR78-2/86*	TC78-144*	TC78-192*	TC78-200*	TC78-212*	TC78-218*
ASTROPENTAGNATHUS	0	0	0	0	0	0	0	0	0
A. IRREGULARIS	3	0	0	0	0	1	0	0	0
A. n. sp. A	0	0	0	0	0	0	0	0	0
A.? INDET. ELEMENTS	0	0	0	0	0	0	0	0	0
APSIDOGNATHUS									
A. TUBERCULATUS	0	0	0	0	0	9	4	0	1
AULACOGNATHUS BULLATUS	0	0	0	0	2	0	0	0	0
BELODELLA SILURICA	0	0	0	0	0	0	0	3	0
CARNIODUS CARNULUS	0	0	0	0	0	7	36	128	2
D. OBLIQUICOSTATUS	0	0	0	0	2	0	0	7	0
DAPSILODUS? sp. B	0	0	0	0	0	0	0	0	0
DAPSILODUS spp.	0	0	0	0	0	0	1	0	0
DECORICONUS FRAGILIS	0	0	0	0	0	0	0	0	0
DISTOMODUS									
D. KENTUCKYENSIS?	0	0	0	0	6	0	0	0	0
D. cf. KENTUCKYENSIS	1	0	0	0	1	1	1	0	0
D. STAUROGNATHOIDES	15	0	0	0	0	0	0	0	6
DISTOMODUS spp.	0	0	1	0	0	6	0	1	0
ICRIODELLA sp. A	0	0	0	0	0	0	0	0	0
ICRIODELLA sp. B	0	0	0	0	0	0	0	0	0
JUANOGNATHUS? sp.	0	0	0	0	0	0	1	0	1
KOCKELELLA									
K. RANULIFORMIS	0	0	0	0	0	0	0	0	0
K. WALLISERI?	0	0	0	0	0	0	0	0	0
KOCKELELLA spp.	0	0	0	0	0	0	0	0	0
OULODUS FLUEGELI s.l.	0	0	0	0	15	2	21	9	6
OULODUS n. sp. A	0	0	0	0	0	0	192	25	3
OULODUS? n. sp. B	0	0	0	0	0	0	0	0	0
OULODUS spp.	0	0	0	0	0	0	0	0	0
OZARKODINA									
O. EXCAVATA n. ssp. A	0	0	0	62	0	0	0	0	0
O. MANITOULINENSIS?	0	0	0	0	0	0	0	0	0
O. aff. POLINCLINATA	0	0	0	0	0	0	0	0	0
OZARKODINA n. sp. A	0	0	0	0	0	0	0	0	0
OZARKODINA sp. B	0	0	0	0	0	0	0	0	0
OZARKODINA sp. C	0	0	0	0	0	0	33	45	3
OZARKODINA sp. D	0	0	0	0	0	0	0	0	0
OZARKODINA sp.	2	0	0	0	1	2	0	0	0
OZARKODINA spp.	0	0	0	0	0	0	0	0	0
PANDERODUS GIBBER	0	0	0	0	0	0	0	0	0
P. RECURVATUS	0	0	0	0	0	0	0	0	7
P. UNICOSTATUS	0	0	4	18	0	0	0	0	8
PANDERODUS sp.	0	0	0	0	3	0	0	0	0
PANDERODUS spp.	34	0	0	0	0	12	400	109	0
PSEUDOONEOTODUS									
P. BICORNIS	0	0	2	0	0	0	0	0	0
P. TRICORNIS	0	0	0	0	0	0	0	0	0

SILURIAN SPECIES	RR78-316a	RR78-2/14a	RR78-2/15a	RR78-2/86a	TC78-144a	TC78-192a	TC79-200a	TC78-212a	TC78-218a
PTEROSPATHODUS CELLONI	0	0	0	0	0	0	0	0	0
P. PENNATUS ANGLUATUS	0	0	0	0	0	0	0	0	0
P. P. PROCERUS	8	0	0	0	0	16	46	128	18
P. n. sp. A	0	0	0	0	0	0	0	0	0
P.? INDET. ELEMENTS	0	0	0	0	0	0	17	58	1
WALLISERODUS CURVATUS	0	0	0	0	8	0	0	0	0
W. SANCTICLARI	0	0	0	0	0	1	25	62	1
WALLISERODUS n. sp. A	0	0	0	0	0	2	0	0	0
W.? n. sp. B	0	0	0	0	0	0	0	2	0
WALLISERODUS sp.	0	0	0	0	0	0	0	0	0
WALLISERODUS spp.	0	0	0	0	0	0	0	0	0
N. GEN. B. n. sp. A	0	0	0	0	0	0	0	0	0
INDET. CRUCIFORM EL.	0	0	0	0	0	1	0	0	0
INDET. ZYGOGNATH. EL.	0	0	0	0	0	0	0	0	0
MISC. INDET. EL.	0	1	0	0	0	0	12	0	3
	63	1	7	80	38	60	789	577	60

TC78-222m	TC78-230m	TC78-236m	TC78-270m	TC78-281m	TC78-286m	TC78-319m	TOTAL	SILURIAN SPECIES
0	0	0	0	0	0			ASTROPENTAGNATHUS
0	0	0	0	0	0	0	189	A. IRREGULARIS
0	0	0	0	0	0	0	65	A. n. sp. A
0	0	0	0	0	0	0	11	A.? INDET. ELEMENTS
								APSIDOGNATHUS
0	0	0	0	0	0	0	14	A. TUBERCULATUS
0	0	0	0	0	0	0	13	AULACOGNATHUS BULLATUS
0	0	0	0	0	0	0	3	BELODELLA SILURICA
2	0	0	0	0	0	0	175	CARNIODUS CARNULUS
0	24	0	0	0	89	0	887	D. OBLIQUICOSTATUS
0	0	0	0	0	0	0	51	DAPSILODUS? sp. B
0	0	3	0	0	0	0	4	DAPSILODUS spp.
0	0	0	0	0	0	0	6	DECORICONUS FRAGILIS
								DISTOMODUS
0	0	0	0	0	0	0	37	D. KENTUCKYENSIS?
0	0	0	0	0	0	0	50	D. cf. KENTUCKYENSIS
0	0	0	0	0	0	0	30	D. STAUROGNATHOIDES
0	0	0	0	0	0	0	10	DISTOMODUS spp.
0	0	0	0	0	0	0	3	ICRIODELLA sp. A
0	0	0	0	0	0	0	3	ICRIODELLA sp. B
0	0	0	0	0	0	0	2	JUANOGNATHUS? sp.
								KOCKELELLA
0	11	0	0	0	0	0	11	K. RANULIFORMIS
0	11	0	0	0	0	0	11	K. WALLISERI?
0	0	0	0	0	5	4	9	KOCKELELLA spp.
0	0	0	0	0	0	0	1,285	OULODUS FLUEGELI s.l.
0	0	0	0	0	0	0	232	OULODUS n. sp. A
0	0	0	0	0	0	0	13	OULODUS? n. sp. B
2	0	1	3	1	0	0	7	OULODUS spp.
								OZARKODINA
0	46	0	0	2	139	34	286	O. EXCAVATA n. ssp. A
0	0	0	0	0	0	0	3	O. MANITOULINENSIS?
0	0	0	0	0	0	0	12	O. aff. POLINCLINATA
0	0	0	0	0	0	0	55	OZARKODINA n. sp. A
0	0	0	0	0	0	0	6	OZARKODINA sp. B
3	6	0	0	0	0	0	90	OZARKODINA sp. C
0	0	0	0	0	0	0	4	OZARKODINA sp. D
0	0	0	0	0	0	0	5	OZARKODINA sp.
0	2	3	0	0	0	7	12	OZARKODINA spp.
0	0	0	0	0	0	0	4	PANDERODUS GIBBER
0	0	0	0	0	0	0	7	P. RECURVATUS
31	146	0	0	0	160	32	419	P. UNICOSTATUS
0	0	2	3	0	0	0	131	PANDERODUS sp.
0	0	0	0	0	0	0	817	PANDERODUS spp.
							0	PSEUDOONEOTODUS
0	7	0	0	0	0	0	9	P. BICORNIS
0	1	0	0	0	0	0	1	P. TRICORNIS

TC78-222m	TC78-230m	TC78-236m	TC78-270m	TC78-281m	TC78-286m	TC78-319m		SILURIAN SPECIES
0	0	0	0	0	0	0	81	PTEROSPATHODUS CELLONI
0	0	0	0	0	0	0	41	P. PENNATUS ANGLUATUS
5	3	0	0	0	0	0	229	P. P. PROCERUS
0	0	0	0	0	0	0	55	P. n. sp. A
0	0	0	0	0	0	0	96	P.? INDET. ELEMENTS
1	0	0	0	0	0	0	64	WALLISERODUS CURVATUS
0	0	0	0	0	0	0	152	W. SANCTICLARI
0	0	0	0	0	0	0	1,592	WALLISERODUS n. sp. A
0	0	0	0	0	0	0	10	W.? n. sp. B
0	0	0	0	0	0	0	77	WALLISERODUS sp.
0	0	0	0	0	0	0	1,023	WALLISERODUS spp.
0	0	0	0	0	0	0	82	N. GEN. B. n. sp. A
0	0	0	0	0	0	0	1	INDET. CRUCIFORM EL.
0	0	0	0	0	0	0	1	INDET. ZYGOGNATH. EL.
0	1	0	0	0	0	0	21	MISC. INDET. EL.
44	258	9	6	3	393	77	8,507	

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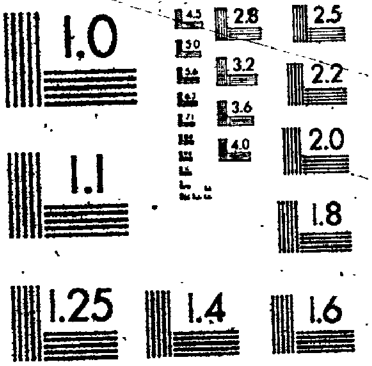

Each conodont sample represents at least 2kg of rock, although not all rock samples were completely disintegrated by acid. Additional material (also 2kg) of some samples were processed; these are denoted below with an "*". Samples that were barren of conodonts (either no conodonts recovered, or the rock was too resistant to acid), and the levels of conodont collections and graptolite zones are listed below. Not all graptolite collections are listed, only the maximum known ranges are necessary for comparison to the conodont samples. Graptolite identifications were provided by A.C. Lenz.

BLACKSTONE RIVER (Section 1)

Barren Conodont Samples: BR77-2:32m (105'), -2:48.8m (160'); BR77-1:6.1m (20'), -1:13.7m (45'), -1:21.3m (70'), -1:29m (95'), -1:36.6m (120'), -1:42.7m (140'), -1:60.7m (199')

Conodont / Graptolite Levels and Zones

BR77-2:6.1m (20') - _D._ _ornatus_ Zone

BR77-2:49.7m (163') - _D._ _ornatus_ Zone

BR77-2:51.8m (170') - _D._ _ornatus_ Zone

BR77-2:54.9m (180') - _D._ _ornatus_ Zone

BR77-1 (immediately overlies section BR77-2)

BR77-1:6.1m (20') - _D._ _ornatus_ Zone

BR77-1:33.5m (110') - _P._ _pacificus_ Zone

BR77-1:36.6m (120') - _P._ _pacificus_ Zone

BR77-1:50.3m (165') - CONODONTS

BR77-1:53.3m (175') - *G. persculptus* Zone?

BR77-1:58.8m (193') - *P. acuminatus* Zone?

BR77-1:61.3m (201') - *P. acuminatus* Zone?

BR77-1:61.9m (203') - *A. atavus* Zone?

BR77-1:62.2m (204') - *A. atavus* Zone?

BR77-1:62.5m (205') - *L. acinaces* Zone

BR77-1:65.5m (215') - *M. argenteus* Zone

BR77-1:66.4m (218') - *M. convolutus* Zone

BR77-1:70.4m (231') - *M. convolutus* Zone

BR77-1:72.2m (237') - *M. sedgwicki* Zone

BR77-1:77.2m (255') - *M. sedgwicki* Zone

BR77-1:80.2m (263') - *M. turriculatus* Zone

BR77-1:90.2m (296') - CONODONTS

BR77-1:98.5m (323') - CONODONTS

BR77-1:99m (325') - *M. turriculatus* Zone

BR77-1:103.6m (340') - *M. spiralis* Zone

PAT LAKE (Section 2)

Barren Conodont Samples: PL79-10m*, -20m*, -30m*

Conodont / Graptolite Levels and Zones

PL79-22m - *D. ornatus* Zone?

PL79-32m - *D. ornatus* Zone?

PL79-40m - *D. ornatus* Zone?

PL79-65m - *P. pacificus* Zone

PL79-69.5m - *P. pacificus* Zone

PL79-70.5m - CONODONTS

PL79-72.7m - CONODONTS

PL79-74.2m* - CONODONTS

PL79-75.9m* - CONODONTS

PL79-79.5m* - CONODONTS

PL79-80.0m - CONODONTS

PL79-86m - *G. persculptus* Zone?

PL79-89m - *G. persculptus* Zone?

PL79-94m - *G. persculptus* Zone?

PL79-97m - *P. acuminatus* Zone

PL79-100m - *A. atavus* or *L. acinaces* Zone

UPPER PEEL RIVER (Section 3)

Barren Conodont Samples: PR77-509m (1670'), -516.6m (1695')**, -544.1m (1785')

Conodont / Graptolite Levels and Zones

PR77-298.9m (980') - lower *P. tentaculatus* Zone

PR77-354.1m (1161') - upper P. tentaculatus Zone

PR77-358.4-362.9m (1175-1190') - CONODONTS

PR77-381.2m (1250') - D. decoratus Zone

PR77-396.5m (1300') - G. teretiusculus Zone

PR77-408.4m (1340') - CONODONTS

PR77-410.2m (1345') - N. gracilis Zone

PR77-452.6m (1481') - P. pacificus Zone

PR77-452.6m (1485')* - CONODONTS

PR77-453.6m (1488') - P. pacificus Zone

PR77-454.2m (1490') - P. pacificus Zone

PR77-454.5m (1491') - P. acuminatus Zone

PR77-456.9m (1499') - P. acuminatus Zone

PR77-457.8m (1502') - A. atavus Zone?

PR77-459m (1506') - A. atavus Zone

PR77-459.6m (1508') - A. atavus Zone

PR77-460.6m (1511') - L. acinaces Zone

PR77-463m (1519') - L. acinaces Zone

PR77-469.4m (1540') - C. gregarius Zone

PR77-472.7m (1551') - C. gregarius Zone

PR77-475.5m (1560') - C. gregarius or M. triangulatus zones

PR77-482.5m (1583') - M. triangulatus Zone

PR77-487.4m (1599') - M. triangulatus Zone

PR77-489.2m (1605') - M. triangulatus or D. magnus? zones

PR77-490.7m (1610') - M. argenteus Zone

PR77-495.9m (1627') - M. convolutus Zone

PR77-508.4m (1668') - M. convolutus Zone

PR77-513.6m (1685') - M. sedgwicki Zone

PR77-515.1m (1690') - M. sedgwicki Zone

PR77-516.3m (1694') - M. turriculatus Zone

PR77-516.6m (1695') - CONODONTS

PR77-559.3m (1835') - M. turriculatus Zone

PR77-570.9m (1873') - M. spiralis Zone

PR77-629.4m (2065') - M. spiralis Zone

PR77-630.9m (2070') - M. spiralis or C. sakmaricus - C. laqueus zones

PR77-635.5m (2085') - C. sakmaricus - C. laqueus Zone

PR77-642.5m (2108') - C. sakmaricus - C. laqueus Zone

ROCK RIVER (Section 4)

Barren Conodont Samples: RR78-69m, -167m*, -207m*, -226m**, -316m*; -2/144m, -2/177m, -2/336m

Conodont / Graptolite Levels and Zones

RR78-13m - Glossograptids

RR78-13m* - CONODONTS

RR78-69m - late Llandeilo or Caradoc Graptolites

RR78-167m - CONODONTS

RR78-207m - CONODONTS

RR78-220m - D. ornatus Zone

RR78-225m - CONODONTS

RR78-228m - CONODONTS

RR78-232m - P. pacificus Zone

RR78-235m - CONODONTS

RR78-235m - P. pacificus Zone

RR78-241m - A. atavus or L. acinaces Zone

RR78-243m - L. acinaces Zone

RR78-244m - C. gregarius Zone

RR78-245m* - CONODONTS

RR78-247m - CONODONTS

RR78-250m* - CONODONTS

RR78-255m - C. gregarius Zone

RR78-275m - CONODONTS

RR78-281m* - CONODONTS

RR78-282m - M. turriculatus Zone

RR78-285m - CONODONTS

RR78-302m - M. turriculatus Zone

RR78-306m - M. spiralis Zone

RR78-308m - CONODONTS

RR78-316m - CONODONTS

RR78-345m - M. spiralis Zone

RR78-2/15m - CONODONTS

RR78-2/86m - CONODONTS

TETLIT CREEK (Section 7)

Barren Conodont Samples: TC78-222m*, -270m*, -388m*

Conodont / Graptolite Levels and Zones

TC78-1m - Arenig-Llanvirn Graptolites

TC78-75m - *N. gracilis* Zone

TC78-133m - *L. acinaces* Zone

TC78-136m - *C. gregarius* Zone

TC78-138m - *M. triangularis* or *D. magnus*? Zone

TC78-139m* - CONODONTS

TC78-139m - *M. argenteus* Zone

TC78-142m - *M. convolutus* Zone

TC78-144m* - CONODONTS

TC78-144m - *M. turriculatus* Zone

TC78-148m - *M. turriculatus* Zone

TC78-168m - *M. spiralis* Zone

TC78-192m - CONODONTS

TC78-192m - *M. spiralis* Zone

TC78-200m - CONODONTS

TC78-212m - CONODONTS

TC78-213m - *C. sakmaricus* - *C. laqueus* Zone

TC78-218m - CONODONTS

TC78-222m - CONODONTS

TC78-228m - *C. sakmaricus* - *C. laqueus* Zone

TC78-230m - CONODONTS

TC78-232m - Wenlock Indeterminate Graptolites

TC78-233m - Wenlock Indeterminate Graptolites

TC78-236m - CONODONTS

TC78-270m - CONODONTS

TC78-273m - *M. ludngreni* Zone

TC78-281m - CONODONTS

TC78-286m - CONODONTS

TC78-319m - CONODONTS

TC78-320m - *N. nilssoni* Zone

TC78-406m - *M. formosus* Zone

END

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