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BULLETIN 373

CONODONTS FROM ORDOVICIAN-SILURIAN BOUNDARY STRATA, WHITTAKER FORMATION, MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES

G.S. NOWLAN
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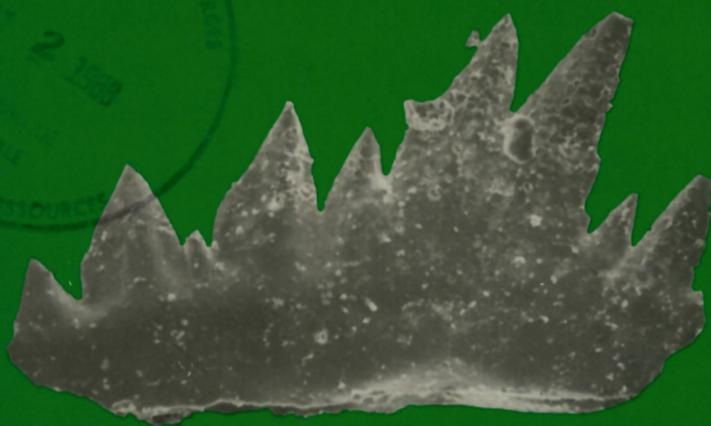

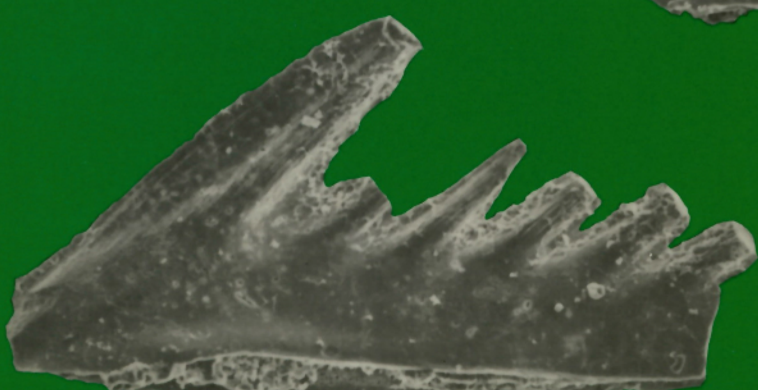

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Preface

The conodont fauna from part of the Whittaker Formation exposed near Avalanche Lake, Northwest Territories is described in this bulletin. The strata are of Late Ordovician and Early Silurian age. Abundant conodonts occur in several samples taken from two sections and they are used to define the Ordovician — Silurian boundary in both sections.

The taxonomic work provides detailed descriptions and illustrations of almost fifty species belonging to twenty-three genera. One new genus and five new species are erected. The resulting taxonomic framework is used to provide a correlation with strata of this age in other sedimentary basins in Canada and elsewhere. Relative abundance data are used to indicate biofacies changes within the section. The difficulty of correlating faunas of this age from northwestern Canada with those from eastern Canada (e.g., Anticosti Basin) is discussed in terms of restricted oceanic circulation.

Detailed paleontological work of the type presented here provides the taxonomic basis for studies of conodonts of this age from other parts of Canada and the world. Precise correlation and paleoecological studies can only be effected with well identified fossils, and taxonomic works such as this one provide the necessary background for further examination of strata of this age. This work is part of an ongoing study of the detailed correlation of Upper Ordovician and Lower Silurian strata in Canada, and provides an important framework for hydrocarbon and mineral exploration.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

Préface

Le présent bulletin décrit les conodontes provenant d'une partie de la formation de Whittaker qui affleure près du lac Avalanche, dans les Territoires du Nord-Ouest. Les couches datent de l'Ordovicien supérieur et du Silurien inférieur. Plusieurs échantillons prélevés dans deux sections contiennent de nombreux conodontes qui servent à définir la limite entre l'Ordovicien et le Silurien dans les deux sections.

Les travaux taxonomiques ont permis de décrire en détail et d'illustrer quelque 50 espèces appartenant à 23 genres. Un nouveau genre et cinq nouvelles espèces ont été établies. Il en résulte un cadre taxonomique qui permet d'établir une corrélation avec les couches contemporaines d'autres bassins sédimentaires au Canada et ailleurs. Les données sur l'abondance relative servent à indiquer les changements de biofaciès à l'intérieur d'une section. Les difficultés que soulèvent la mise en corrélation des faunes du même âge du nord-ouest du Canada et celles de l'est du Canada (p. ex., le bassin d'Anticosti) sont examinées en fonction d'une circulation océanique restreinte.

Les travaux paléontologiques détaillés de ce genre permettent d'établir une base taxonomique aux fins de l'étude des conodontes du même âge trouvés ailleurs au Canada et à l'étranger. L'établissement d'une corrélation précise et la mise en œuvre de travaux paléoécologiques peuvent se faire uniquement au moyen de fossiles correctement identifiés; de tels travaux taxonomiques fournissent donc les données de base nécessaires pour l'examen plus poussé des couches de cet âge. Les présents travaux font partie d'une étude permanente de la corrélation détaillée des couches de l'Ordovicien supérieur et du Silurien inférieur au Canada, et ils servent de base aux activités d'exploration entreprises afin de découvrir de nouvelles sources d'hydrocarbures et de minéraux.

R.A. Price, sous-ministre adjoint
Commission géologique du Canada

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Abstract

Two sections within the middle part of the Whittaker Formation, exposed near Avalanche Lake, Mackenzie Mountains, Northwest Territories (62°23'N; 127°02'W) comprise well bedded, black, argillaceous limestone and shale. The Ordovician-Silurian boundary at section AV1 (116 m; 17 conodont samples) lies within a covered interval. Section AV4B (50 m; 10 samples) was collected at closely spaced intervals around the systemic boundary, which has been located within a 0.6 m interval.

The samples yielded over 9000 conodont elements that are moderately well preserved and have a colour alteration index (CAI) of 5. The Upper Ordovician fauna is diverse, with almost fifty species of twenty-three genera. It is dominated numerically by elements of panderodont species that represent 50 per cent of the specimens. Plectodina tenuis *is the most abundant denticulate species with specimens comprising 14 per cent of the fauna. Other significant species are:* Aphelognathus politus, Coelocerodontus trigonius, Decoriconus costulatus, Oulodus rohneri, O. ulrichi, Plectodina aculeatoides?, P. florida, Pseudobelodina? dispansa, P. inclinata, P. vulgaris vulgaris, Scabbardella altipes, Staufferella divisa *and* Walliserodus amplissimus. *One new genus and new species is recognized:* Zanclodus levigatus, *a panderodont species with similarities to some species of* Pseudobelodina. *Four other new species are erected:* Besselodus borealis, Ozarkodina sesquipedalis, Panderodus rhamphoides *and* Walliserodus? rallus.

No elements of Gamachian Fauna 13 have been recognized, and specimens of North Atlantic Province species are very sparse. This is attributed to the restriction of the Selwyn Basin during the Late Ordovician and Early Silurian. The systemic hiatus in the Canadian Cordillera may be, in part, a result of the restriction of circulation.

Early Silurian conodonts are sparse, generally poorly preserved and include: Decoriconus costulatus, Ozarkodina hassi, Panderodus gracilis *and* Dapsilodus? sp. A.

Résumé

Deux sections dans la partie centrale de la formation de Whittaker, qui affleure près du lac Avalanche, dans les monts Mackenzie, Territoires du Nord-Ouest (62°23' de latitude N et 127°02' de longitude 0), se composent de calcaire et de schiste argileux noirs bien lités. La limite entre l'Ordovicien et le Silurien à la section AV1 (116 m; 17 échantillons de conodontes) se trouve au sein d'un intervalle couvert. Les échantillons de la section AV4B (50 m; 10 échantillons) ont été prélevés à des intervalles étroitement espacés autour de la limite systémique, qui se situe dans un intervalle du 0,6 m.

Les échantillons ont donné plus de 9 000 éléments de conodontes plus ou moins bien conservés, dont l'indice d'altération de la couleur est de 5. La faune très variée de l'Ordovicien supérieur contient près de 50 espèces appartenant à 23 genres. Les espèces pandérodontes sont les plus nombreuses, leurs éléments représentant 50 % des échantillons. Plectodina tenuis *l'espèce denticulée la plus abondante, représente 14 % des organismes. On y trouve également d'autres espèces importantes:* Aphelognathus politus, Coelocerodontus trigonius, Decoriconus costulatus, Oulodus rohneri, O. ulrichi, Plectodina aculeatoides?, P. florida, Pseudobelodina? dispansa, P. inclinata, P. vulgaris vulgaris, Scabbardella altipes, Staufferella divisa *et* Walliserodus amplissimus. *Un nouveau genre et une nouvelle espèce ont été reconnus:* Zanclodus levigatus, *une espèce pandérodonte qui ressemble à certaines espèces de* Pseudobelodina. *Quatre autres nouvelles espèces ont été établies:* Besselodus borealis, Ozarkodina sesquipedalis, Panderodus rhamphoides *et* Walliserodus? rallus.

Aucun élément de la faune 13 du Gamachien n'a été reconnu, et les échantillons d'espèces de la province du nord de l'Atlantique sont très rares. On attribue cette situation à la circulation restreinte dans le bassin de Selwyn au cours de l'Ordovicien supérieur et du Silurien inférieur. Il se peut que la lacune systémique observée dans la Cordillère canadienne soit due en partie à cette même restriction de la circulation.

Les conodontes du Silurien ancien, rares et généralement mal conservés, comprennent: Decoriconus costulatus, Ozarkodina hassi, Panderodus gracilis *et* Dapsilodus? esp. A.

INTRODUCTION

Conodonts from Upper Ordovician and Lower Silurian strata have been the subject of several recent papers, many of which have dealt specifically with the Ordovician-Silurian boundary interval. Interest in the systemic boundary has been spurred on by the activities of the Subcommission on Silurian Stratigraphy and the Ordovician-Silurian Boundary Working Group, in their search for a base for the Silurian system. These recent studies of conodonts have dealt with several different areas, including the North American craton (Sweet, 1979a, b) and its marginal basins, notably the Anticosti Basin in Quebec (Nowlan and Barnes, 1981; McCracken and Barnes, 1981), the Matapedia Basin in Quebec and New Brunswick (Nowlan, 1981b) and the Blackstone and Richardson troughs of the northern Canadian Cordillera (Lenz and McCracken, 1982). Conodonts are abundant in the Anticosti Basin, where the strata represent a shallow water facies, but are rare in truly basinal rocks. No conodonts were recovered from lowest Silurian strata in the Matapedia Basin (Nowlan, 1981b) and conodonts are generally sparse in basinal sections in the northern Canadian Cordillera. Thus it was of interest to us to locate and sample a section spanning the Ordovician-Silurian boundary that represented a basin margin facies near the platform edge. Such a section was available east of Avalanche Lake, Northwest Territories.

During the summers of 1978 and 1979, one of us (BDEC) and the late David G. Perry measured several sections through Upper Ordovician and Silurian strata in the central Mackenzie Mountains. These sections are readily accessible only by means of helicopter and are most easily reached from Tungsten in the Northwest Territories or Watson Lake in Yukon Territory. One of these sections (AV1), about 10 km east-southeast of Avalanche Lake, was recognized as having Ordovician-Silurian boundary strata (see Figures 1-3). BDEC returned to the same area in 1983 with graduate student J. Over and field assistant G. Brandley. During this later trip, an attempt was made to collect in detail through the boundary interval that had been identified on the basis of conodonts and trilobites. Trenching through the 7 m covered interval at the boundary (see Figure 3) proved unsuccessful because of the deep and unconsolidated nature of the overburden and the location of the section in a comparatively steep-sided valley (Fig. 2); the covered interval was reduced by only 2 m. Strata of the boundary interval were traced, however, to a section that is perfectly exposed on both sides of the next small valley to the southeast, section AV4B (see Figures 1-3). The purpose of this paper is to describe in detail the conodonts recovered in samples from each of these sections (Fig. 3) and to examine their biostratigraphic and paleoecological significance. The samples are referred to by section number, followed by stratigraphic level in metres (e.g., AV4B-111.0 m). The conodont data are intermeshed with trilobite data from the same sections and a report on the ostracode faunas from these sections is currently being prepared by M.J. Copeland (Geological Survey of Canada). A report on Bryozoa from the Upper Ordovician strata of these sections has recently been published (Bolton and Ross, 1985).

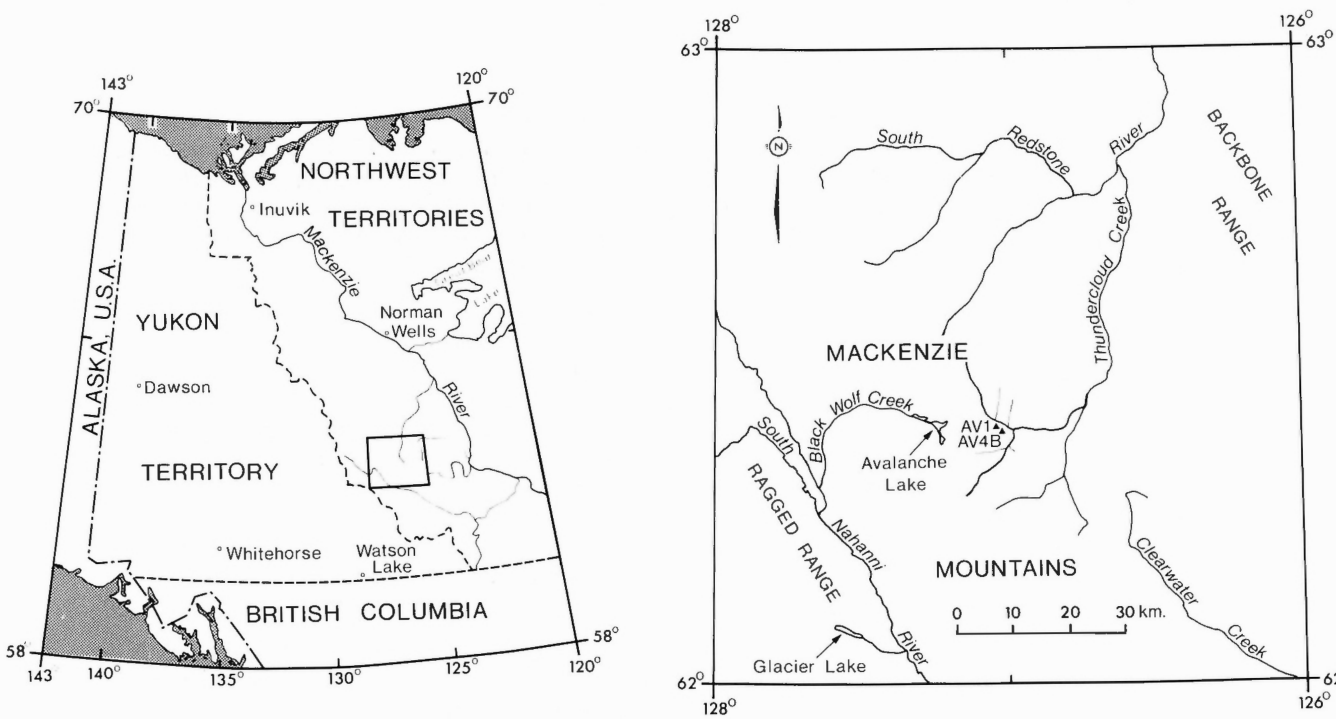

Figure 1. Location map for Avalanche Lake sections (latitude 62°23'N, longitude 127°02'W). Area in box on the left is shown in more detail on the right. Sections AV1 and AV4B indicated by triangles.

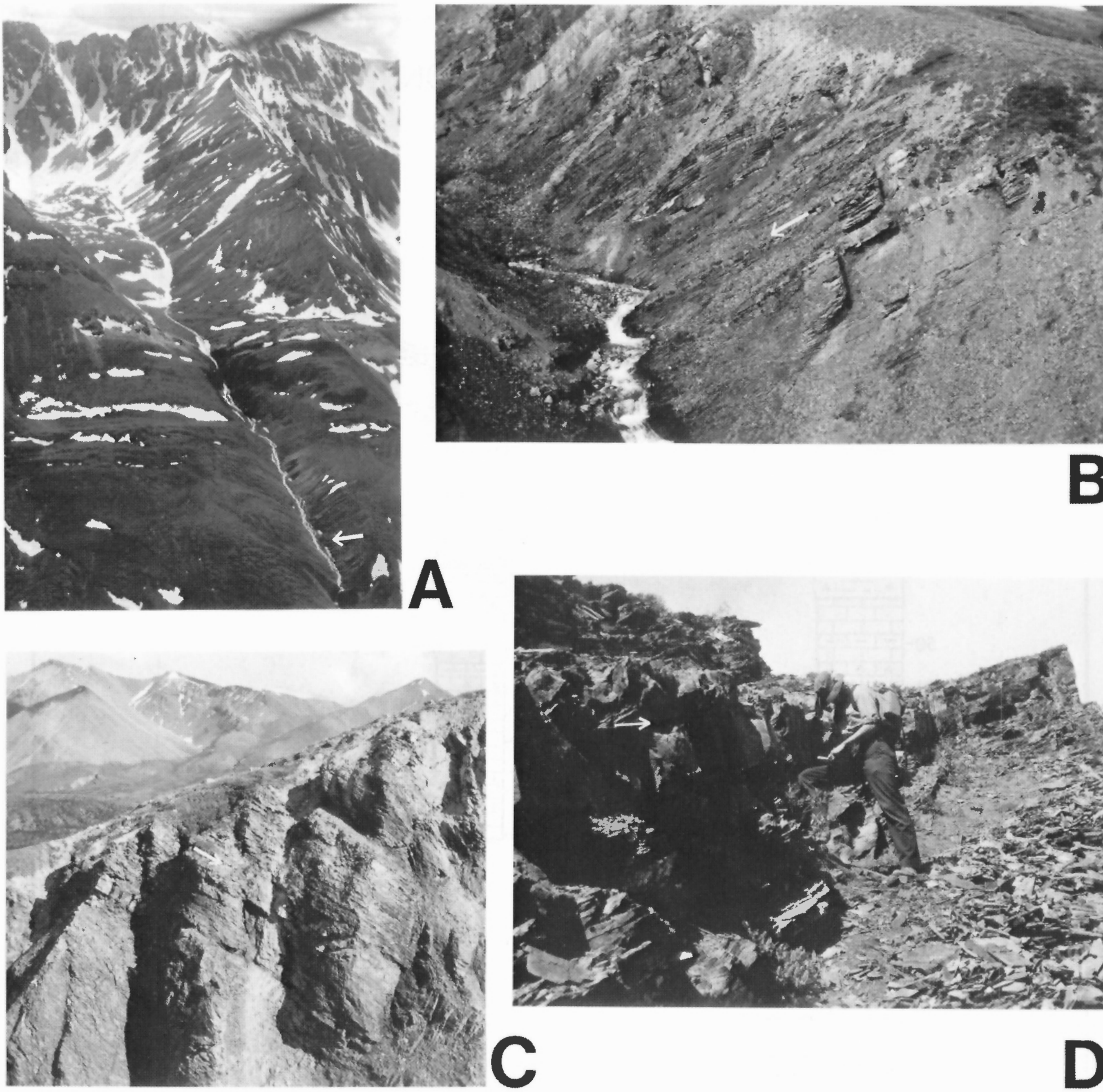

Figure 2. Views of sections sampled. A. (GSC photo no. 203467-P) Section AV1 (and AV2) viewed toward the south from a helicopter. AV1-0 m is at the top of a small waterfall in the creek just above the bottom of the photograph. The approximate position of the Ordovician-Silurian boundary is shown by the white arrow. The upper part of section AV1 (AV1-320 m to AV1-600 m) is on the slope to the east of the creek (left side in photograph); section AV2 was measured in equivalent strata on the west side of the valley (to the right in the photograph). B. (GSC photo no. 203467-R) Section AV4B: Ordovician-Silurian boundary interval, viewed from the top of the cliff on the southeast side of the valley toward west-northwest. Position of boundary is shown by the white arrow; samples were collected on this side for conodonts and trilobites. C. (GSC photo no. 203467-Q) Section AV4B: southeast side of valley; level of Ordovician-Silurian boundary shown by the white arrow. D. (GSC photo no. 203467-O) Section AV4B: detail of Ordovician-Silurian boundary interval, viewed from south. White arrow shows AV4B-111.5 m level.

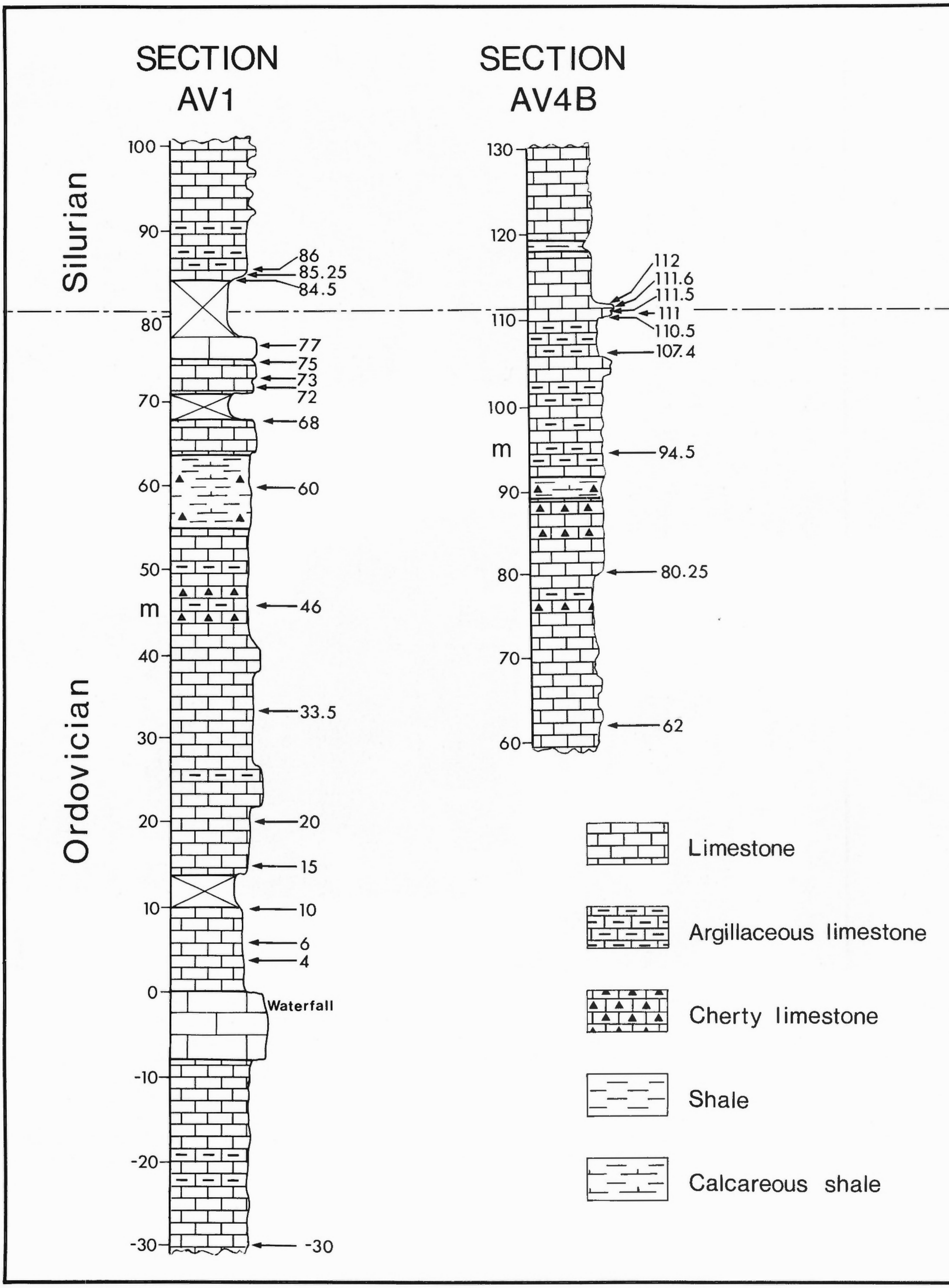

Figure 3. Diagram showing sections sampled. Numbered arrows indicate sample levels yielding conodonts. Dashed line is Ordovician-Silurian boundary. Waterfall indicated in section AV1 is shown in Figure 2A.

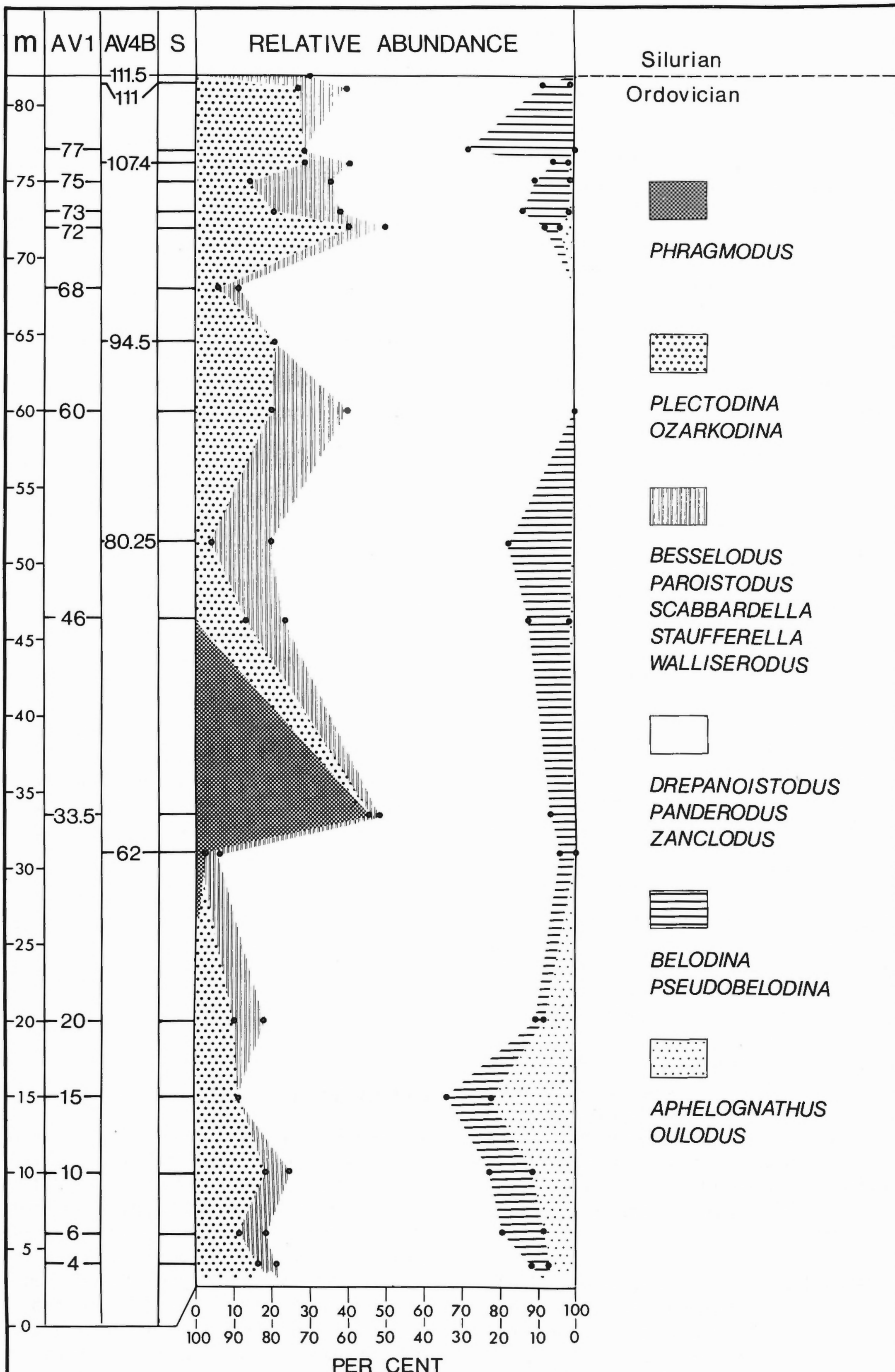

Figure 4. Relative abundance diagram for Ordovician conodont genera recovered from sections AV1 and AV4B. The sections are shown as a composite, based on the level of the Ordovician-Silurian boundary in each section; relative sample levels are shown in column 'S'. Data for Silurian samples are not shown; numerical data for both Ordovician and Silurian samples are provided in Table 1.

STRATIGRAPHY AND SAMPLES

The Ordovician-Silurian boundary occurs within a sequence of interbedded argillaceous limestone, cherty limestone and calcareous shale. In the central Mackenzie Mountains, strata of this age have been assigned either to the Whittaker Formation or to the Road River Formation (Douglas and Norris, 1961; Gabrielse et al., 1973). The type section of the Whittaker Formation on the east flank of the Whittaker Range consists of limestone, dolostone and shale (Douglas and Norris, 1961) and the unit is regarded as a sequence of platform carbonates and interbedded clastic rocks. Conversely, the Road River Formation is a unit composed predominantly of clastic rocks (Jackson and Lenz, 1962) and is regarded as being basinal in origin. Some workers, however, have included intervals of thin bedded, argillaceous limestone in the Road River Formation (Gabrielse et al., 1973). Strata in sections AV1 and AV4B near the Ordovician-Silurian boundary interval represent a facies that is transitional in lithology between these two formations. The sections are located at the transition from the platform facies to the outer detrital basinal facies (see Glacier Lake map sheet *in* Gabrielse et al., 1973). As the rocks in these two sections consist predominantly of limestone, they are included in the Whittaker Formation in this study. The sections represent a level approximately in the middle of the formation. Figure 3 is a diagrammatic representation of the two sections and the levels sampled for conodonts.

In the field, the Ordovician-Silurian boundary was approximately located on the basis of the stratigraphic distribution of trilobite faunas. In section AV1, strata below the boundary (0-77 m) contain specimens of a comparatively deep water trilobite fauna consisting of species of *Anataphrus, Ampyxina, Cryptolithus* and *Robergiella* (Chatterton and Perry, 1983). Strata above the boundary in section AV1 (84.5-97.5 m) are characterized by specimens of *Primaspis mackenziensis* Chatterton and Perry and *Leonaspis jaanussoni* Chatterton and Perry. A pygidium that can be assigned to the Silurian trilobite genus *Acernaspis* has been obtained from AV1-124.5 m. This genus first occurs on Anticosti Island about 45-50 m above the Ordovician-Silurian boundary that was determined from conodont evidence (Chatterton et al., 1983). Thus Chatterton and Perry (1983) placed the Ordovician-Silurian boundary between 77 m and 84.5 m above the base of section AV1 and not at the 95.5 m level as implied by their statement (*ibid.*, p. 5, 6) that the systemic boundary was "defined by the appearance of the conodont *Distomodus kentuckyensis* and a distinctive new trilobite fauna". An unfortunate misprint near the end of the same sentence (78.5 instead of 98.5) confused the situation further by suggesting that the level of 78.5 m was just above the systemic boundary.

In section AV4B (Figs. 2, 3) the Ordovician trilobite genera *Anataphrus* and *Cryptolithus* occur up to the 110.65 m level. This is within 20 cm of a thick bed (110.85 m-111.3 m) that lies immediately beneath the boundary (Fig. 3). The bed consists of 30-45 cm of resistant micritic limestone, the base of which is slightly irregular, with topographic relief up to 5 cm. In the field, this presumed disconformity was thought to represent the systemic boundary, but Ordovician conodonts were later recovered from a sample at 111.0 m. This bed is overlain conformably by an equally resistant bed of biostromal limestone (111.3 m-111.5 m) containing abundant silicified tabulate corals as well as gastropods, brachiopods, rostroconchs and trilobites. The field placement of the systemic boundary at 110.85 m was reinforced by the recovery of trilobite specimens of Silurian aspect from the biostromal bed, including a species of *Ascetopeltis* and one of *Encrinuroides*, with characters intermediate between *Encrinurus* and *Encrinuroides*. These trilobite species are common in strata of Early Silurian age in section AV1 and occur together with specimens of *Distomodus kentuckyensis* Branson and Branson; they were not recovered from the Ordovician part of AV1. At a slightly higher level in section AV4B, about 8.5 m-17 m above the boundary, several beds contain abundant silicified specimens of the trilobite *Leonaspis jaanussoni*, which is a common species at the same level in section AV1 (see above).

Conodonts from the Silurian part of the sequence have been described in detail in a recently completed thesis (Over, 1985). We discuss only the lowermost Silurian samples. In this study, conodonts are described from strata mainly below the systemic boundary. At section AV1, samples through 107 m of strata (-30 m to 77 m) have been taken at widely spaced intervals up to a level near the boundary and then at more closely spaced intervals across the boundary. Only three samples have been processed from the lowermost Silurian strata of section AV1 for this study. Unfortunately, at section AV1 the systemic boundary lies within a covered interval and cannot be located precisely.

In section AV4B, samples have been taken through 50 m of strata (62 m-112 m) that enclose the Ordovician-Silurian boundary. Samples are widely spaced below the boundary, but closely spaced samples were taken in the boundary interval (see Fig. 3). Altogether, 26 samples yielded conodonts and these are plotted on the sections presented in Figure 3. An additional three samples (AV1-53.5, AV1-54 and AV4B-110.8) were barren. The weight of sample dissolved varied considerably (0.8 kg to 12.3 kg), but averaged just over 3 kg. The samples from section AV1 were processed at the University of Alberta, those from section AV4B at the Geological Survey of Canada, Ottawa. A total of about 90 kg of rock was dissolved.

CONODONT BIOSTRATIGRAPHY

The two sections, AV1 and AV4B, are correlated on the basis of the location of the Ordovician-Silurian boundary in each section as determined by conodont distribution (Figs. 2, 3; Table 1). Based on this datum, a composite section has been constructed in Figure 4. The description of formal assemblage zones has not been undertaken because of the relatively narrow stratigraphic interval examined and the wide spacing of samples through most of the section. The main focus of this paper is the nature of the conodont fauna at the boundary between the Ordovician and the Silurian. For the purposes of general biostratigraphic discussion, however, it is possible to organize the taxa into informal assemblages based on the nature and extent of their distribution in the section. The order of samples from the two sections indicated in the composite section in Figure 4 is assumed to be in stratigraphic sequence.

Assemblage 1. Taxa assigned to this assemblage occur only in the lowest sample of the sequence in section AV1 (-30 m). This sample was collected 30 m below the lip of the waterfall that marks the base of measurement of section AV1 (Figs. 2A, 3). The specimens recovered from this sample are assigned to five taxa, two of which, *Pseudobelodina* cf. *P. adentata Sweet* and *Panderodus gracilis* (Branson and Mehl), are long-ranging. The other three taxa are restricted to the -30 m level and are considered as assemblage 1 taxa: *Juanognathus* n. sp. A, *Panderodus* aff. *P. bergstroemi Sweet* and *Phragmodus*? sp. A. None of these taxa is biostrati-graphically significant. Typical *P. adentata* is known elsewhere from strata as old as mid-Maysvillian, suggesting that the lowest strata sampled in this study may be as old as Maysvillian. The evidence is weak, however, and the base of the section may well be of Richmondian age.

Assemblage 2. This division includes those taxa that are restricted to the lower part of the sequence (AV1-4 m to AV1-33.5 m, including AV4B-62 m). At AV1-4 m several taxa make their first appearance; most range upward through the sequence but some are restricted to the lower part of the section. Of the latter group, several occur only in section AV1, suggesting that the correlation shown on the composite section is correct (Fig. 4).

Those taxa with a range restricted to the lower part of section AV1 (4 m to 20 m level) are: *Aphelognathus politus* (Hinde), *Plectodina aculeatoides* Sweet?, *P. florida* Sweet, *Pseudobelodina* cf. *P. adentata, P.*? *obtusa* Sweet, *P. quadrata* Sweet, *P.*? n. sp. A, and *Spinodus*? n. sp. A. In this interval, three additional taxa are known only from single samples: *Amorphognathus*? sp. (AV1-20 m), *Aphelognathus floweri* Sweet? (AV1-20 m) and *Oulodus ulrichi* (Stone and Furnish) (AV1-15 m).

Four additional taxa have a slightly longer range. *Ozarkodina sesquipedalis* n. sp. ranges from AV1-4 m to AV4B-62 m; *Panderodus serratus* Rexroad ranges from AV1-20 m to AV1-33.5 m; *Phragmodus undatus* Branson and Mehl ranges from AV1-10 m to AV1-33.5 m, but is only abundant at the 33.5 m level (see discussion under Paleoecology); and *Pseudobelodina inclinata* (Branson and Mehl) is common from AV1-4 m to AV1-33.5 m. The significance of these restricted ranges is uncertain, but it is likely to be a paleoecological or paleogeographic restriction because of the greater known range of these taxa elsewhere (e.g., Sweet, 1979b; Nowlan and Barnes, 1981).

Assemblage 3. This assemblage includes those taxa with a range restricted to the upper part of the composite sequence that is of certain Ordovician age (AV4B-62 m to AV4B-111 m). This assemblage has a stratigraphic range that overlaps slightly with the upper range of assemblage 2. Taxa that are restricted to this interval are: *Besselodus borealis* n. sp., *Paroistodus*? sp. A, *Protopanderodus liripipus* Kennedy, Barnes and Uyeno, *Pseudobelodina*? cf. *P.*? *dispansa* (Glenister), *Pseudooneotodus mitratus* (Moskalenko), *Scabbardella* n. sp. A, and *Walliserodus*? *rallus* n. sp. None of these taxa is biostratigraphically significant, but *Decoriconus costulatus* (Rexroad) is also present in this part of the sequence and it is known only from latest Ordovician to Silurian strata elsewhere (McCracken and Barnes, 1981). *Scabbardella altipes* (Henningsmoen) is common in the upper part of the section, but first occurs at AV1-20 m, below the stratigraphic limit of assemblage 3.

Assemblage 4. This grouping includes all the long-ranging taxa; most make their first appearance at AV1-4 m, but *Panderodus gracilis* first occurs in AV1 (-30 m). The other taxa assigned to this assemblage (and their individual stratigraphic ranges are: *Belodina confluens* Sweet (AV1-4 m to AV1-75 m); *Coelocerodontus trigonius* Ethington (AV1-4 m to AV4B-111 m); *Drepanoistodus suberectus* (Branson and Mehl) (AV1-4 m to AV4B-111 m); *Oulodus rohneri* Ethington and Furnish (AV1-10 m to AV4B-111 m); *Plectodina tenuis* (Branson and Mehl) (AV1-4 m to AV4B-111m); *Pseudobelodina? dispansa* (Glenister) (AV1-6 m to AV4B-111 m); *P. vulgaris vulgaris* Sweet (AV1-4 m to AV1-72 m); *Staufferella divisa* Sweet (AV1-4 m to AV4B-111 m); *Walliserodus amplissimus* (Serpagli) (AV1-4 m to AV1-73 m); *Zanclodus levigatus* n. gen. n. sp. (AV1-4 m to AV4B-111 m); and several species of *Panderodus*.

The presence of *Oulodus rohneri* confirms the Richmondian age of this part of the sequence.

The highest unequivocal Ordovician conodont assemblage occurs in AV4B-111 m and, as can be seen from the above discussion and Table 1, the fauna is quite diverse. A sample at the AV4B-111.5 m level contains a very sparse and undiagnostic assemblage comprising only representatives of *P. gracilis* and *Walliserodus curvatus* (Branson and Mehl).

Assemblage 5. This assemblage includes those specimens assigned to taxa considered to be of Silurian age. These occur in samples AV1-84.5 m, -85.25 m and -86 m and in section AV4B-111.6 m and -112 m. The taxa represented are *Dapsilodus*? sp. A, *Decoriconus costulatus, Ozarkodina hassi* (Pollock, Rexroad and Nicoll) and *Panderodus gracilis.* This impoverished Early Silurian fauna characterizes earliest Silurian strata in both sections. *Distomodus kentuckyensis* Branson and Mehl first occurs at AV1-95.5 m (Chatterton and Perry, 1983).

ORDOVICIAN-SILURIAN BOUNDARY

The most complete section across the Ordovician-Silurian boundary in North America that has been studied in detail is exposed on Anticosti Island, Quebec. Conodont faunas are well known from this sequence (Nowlan and Barnes, 1981; McCracken and Barnes, 1981; Fåhraeus and Barnes, 1981; Uyeno and Barnes, 1983). The sequence is extremely fossiliferous and recent reports on the study of several other fossil groups from Anticosti Island are provided in Lespérance (1981). Upper Ordovician and Lower Silurian strata in the Anticosti Basin mainly represent carbonate deposition in shallow subtidal conditions. Conodont faunas are abundant across the systemic boundary and change dramatically through a thin transitional zone, above which most Ordovician species are extinguished (McCracken and Barnes, 1981). Sections across the Ordovician-Silurian boundary in the Matapedia Basin of Gaspé Peninsula have also been studied in detail for conodonts (Nowlan, 1981b) and other fossil groups (Lespérance, 1981). The Upper Ordovician conodont faunas of the Gaspé correlate readily with those from Anticosti Island, but conodonts are virtually absent from the lowest Silurian part of the Matapedia sequence. As strata representing shallow subtidal conditions dominate the Anticosti Island sequence, with no deep basinal deposits preserved, and because conodonts are lacking in basinal Silurian strata of the Matapedia Basin, it became expedient to look for a section where outer shelf and basinal sediments interdigitate. The sections east of Avalanche Lake represent strata deposited on the eastern margin of the Selwyn Basin, and were therefore considered suitable. Unfortunately, correlation with other Upper Ordovician sections has proved difficult because of the unusual nature of the Selwyn Basin (see below).

In the sections at Avalanche Lake there is a dramatic extinction of conodont species, much like that recorded from the systemic boundary on Anticosti Island. However, the expected latest Ordovician fauna (Fauna 13 of McCracken and Barnes, 1981) has not been recovered. The highest occurrences of conodont taxa considered as Ordovician are at AV1-77 m and AV4B-111 m in the two sections, respectively (see Table 1). In section AV1, a 7.5 m covered interval follows the last occurrence of Ordovician conodonts; the first Silurian conodonts, including *Ozarkodina hassi*, occur at AV1-84.5 m. The conodont-based Ordovician-Silurian boundary thus lies somewhere between the 77 m and 84.5 m level in section AV1; as noted above, trenching reduced the covered interval by less than 2 m. In section AV4B at the 111.5 m level (0.5 m above the highest occurrence of Ordovician conodonts), a sample produced a sparse fauna comprising specimens of the undiagnostic species, *Panderodus gracilis* and *Walliserodus curvatus*, and is thus of ambiguous biostratigraphic position. The first undeniably Silurian fauna, including abundant specimens of *O. hassi*, has been recovered from AV4B-111.6 m. Thus the boundary based on conodonts is restricted to a 0.6 m interval in section AV4B (111 m to 111.6 m); its exact placement is uncertain but it may lie at the top of the resistant bed that includes sample AV4B-111.5 m.

One of the most striking features of the Ordovician conodont fauna reported here is the virtual absence of representatives of North Atlantic Province genera, such as *Amorphognathus*. This is particularly unusual because taxa of North Atlantic Province affinity are common elsewhere in Upper Ordovician strata of the Midcontinent Province. The migration of *Amorphognathus* and other North Atlantic Province ("European") faunal elements onto the North American craton has been recognized for a long time (e.g., Sweet et al., 1971, Fig. 3). Conodonts of the North Atlantic Province are usually considered to be normal, open ocean faunas, in contrast to the craton-restricted Midcontinent Province faunas. It is thus surprising that North Atlantic Province conodont faunas are so poorly represented in the Avalanche Lake sections that are in the platform margin facies. *Amorphognathus*, possibly represented by a single fragment of a platform element and portions of two processes in the Avalanche Lake sections, is known from basinal strata near the top of the Ordovician sequence in the Blackstone and Richardson troughs of northern Yukon (Lenz and McCracken, 1982). In eastern Canada, *Amorphognathus* is present in Richmondian and Gamachian strata of the Anticosti Basin (Nowlan and Barnes, 1981; McCracken and Barnes, 1981) although it does not extend to the top of the Gamachian. It is also known from the Matapedia Basin (Nowlan, 1981b), from strata of the Michigan Basin (Barnes et al., 1978; Schopf, 1966) and from the Hudson Bay Lowlands (Le Fèvre et al., 1976). These occurrences, with the exception of those in the Michigan Basin, are of Richmondian age. *Amorphognathus* has been reported from Richmondian strata in miogeoclinal strata of the Arctic Islands (Barnes, 1974) and is now known from several additional localities in the region (Nowlan, unpublished data). In western North America, the genus occurs sparsely in Upper Ordovician sections of the western Midcontinent Province in Wyoming, New Mexico and the subsurface of Kansas (Sweet, 1979b) as well as in sections in Nevada and California (Harris et al., 1979). The above listing of occurrences is not exhaustive but it serves to show that *Amorphognathus* occurred almost ubiquitously around the margins and well onto the craton of North America in Late Ordovician time. The Selwyn Basin in our study area is thus exceptional in its virtual lack of North Atlantic Province conodont species in Upper Ordovician strata.

The trilobites occurring in the Ordovician part of the Avalanche Lake sections consist overwhelmingly of taxa regarded as deep, cool and/or quiet water forms, including species of *Cryptolithus* and *Anataphrus*, with some specimens of *Robergiella* and *Ampyxina* (see Ludvigsen, 1979). Rare elements of the Upper Ordovician fauna are taxa that are believed to have preferred shallower and more platformal biofacies, such as *Cybeloides, Sceptaspis, Holia, Harpidella* and *Ceraurus*. The relatively shallower and more platformal trilobite biofacies that occur in the Gamachian immediately below the Ordovician-Silurian boundary on Anticosti Island contain a very different trilobite fauna (Chatterton et al., 1983).

The fact that conodonts of North Atlantic Province affinity are sparse to absent in the Avalanche Lake sections and that trilobites of deeper, quiet water aspect occur in the samples may suggest that the basin was cut off from open oceanic circulation. Recently, Goodfellow and Jonasson (1984) studied sulphur isotopes in strata of the Selwyn Basin. They concluded that the basin fluctuated from being open and well ventilated to closed and stratified during the Paleozoic. One of the times of maximum restriction was at the Ordovician-Silurian boundary where $\delta^{34}S$ values from pyrite suggest that the Selwyn Basin had become increasingly isolated from open ocean water. According to Goodfellow and Jonasson (1984), well ventilated, open ocean conditions did not return until late Llandovery time. This is the level at which conodonts (Chatterton and Perry, 1983) become more abundant, diverse and well preserved. The same is true for the ostracode faunas (M.J. Copeland, pers. comm., 1984).

The fact that the Selwyn Basin may have been restricted around the time of the systemic boundary has important implications for correlation. It is probable that, if North

Atlantic Province genera such as *Amorphognathus* were excluded from the basin, then the index species of Fauna 13, *Gamachignathus ensifer* McCracken, Nowlan and Barnes, would also have had little chance of entering the basin. The genus *Gamachignathus* is considered to have a greater affinity with North Atlantic Province taxa and to have originated in cooler, open ocean waters. Its domination in strata of the Gamachian Stage (Ellis Bay Formation, Anticosti Island) was taken to reflect a cooling of the marine environment as a result of Late Ordovician glaciation (McCracken et al., 1980).

This raises the possibility that the absence of Gamachian faunas from the Selwyn Basin may be the result of environmental and circulatory restriction rather than a stratigraphic hiatus. This is an appealing conclusion because there is little physical evidence of a break in the sequence at Avalanche Lake. The genus *Gamachignathus* does occur in the Blackstone Trough in northern Yukon, but there it is too sparse to be considered part of Fauna 13 (Lenz and McCracken, 1982). It is conceivable that the apparent break in conodont and graptolite faunas (absence of conodont Fauna 13, *Climacograptus extraordinarius* Zone and, in some sections, *Glyptograptus persculptus*? Zone) noted in the northern Cordillera may be a result of oceanic circulation restrictions rather than a hiatus. Lenz and McCracken (1982) have pointed out that a lowering of the sea level related to glaciation may have caused sufficient restriction of basinal areas to hamper migration into the region from other areas. Thus, the oceanic restriction in the Selwyn Basin may have been the result of sea level fluctuations near the Ordovician- Silurian boundary, which caused a hiatus in cratonic areas. The sections on Anticosti Island show no evidence of a restriction of the Anticosti Basin or of a hiatus at the Ordovician-Silurian boundary, but lithological alternations and reef development do suggest repetitive shallowing episodes (see McCracken and Barnes, 1981). This restriction of the Selwyn Basin may account for the differences in conodont faunas from continental margin basins in northwestern and eastern Canada. The faunal break at the systemic boundary and the massive extinction of conodont species, however, is probably the result of a glacially induced regression.

Earliest Silurian conodont faunas at Avalanche Lake are of low diversity and *Ozarkodina hassi* is the only blade-bearing species present. The remainder are simple cone taxa. The absence of species of *Distomodus, Icriodella* and *Oulodus*? may suggest that strong oceanic restrictions were still in effect, although these genera are present in slightly younger strata (D.J. Over, pers. comm., 1984). The trilobite faunas in the lowest Silurian horizons, although quite different in the relative abundances of taxa, are very similar in overall taxonomic composition to those occurring in strata of the same age on Anticosti Island. Most of the same genera and several of the same species occur in both regions (Chatterton and Ludvigsen, 1983). Less is known about Silurian trilobite biofacies and so it is impossible to determine whether these trilobites represent shallower or deeper environments than those of the Upper Ordovician. The sedimentological evidence suggests, however, that the Lower Silurian platform margin facies of the Mackenzie Mountains may be deeper than those of Anticosti Island because they consist of argillaceous micrite and cherty micrite grading upwards into graptolitic shale and dolomitic chert.

As is the case on Anticosti Island, there is disagreement on the positioning of the Ordovician-Silurian boundary based on ostracode and conodont faunas (Copeland, 1981, 1983). On Anticosti Island, the base of the Silurian, as defined by conodonts, is placed near the top of a bioherm development (McCracken and Barnes, 1981) at the base of the Becscie Formation of Petryk (1981). However, ostracodes considered to be of Ordovician aspect range higher (Nowlan, 1982; Copeland, 1983) with a tetradellid species ranging up to 25 m above the conodont-based boundary (Copeland, 1973). A similar situation exists in the Avalanche Lake sections. In section AV1, the known upper limit of the Ordovician *Platybolbina (Reticulobolbina) lenzi* ostracode assemblage is at AV1-99 m, some 14.5 m above the first occurrence of Silurian conodonts (M.J. Copeland, pers. comm., 1984).

In the trilobite faunas, it is interesting to note that in addition to the change coincident with the conodont-based Ordovician-Silurian boundary a second event occurs at a higher level, namely the appearance of the genus *Acernaspis*. Approximately 30-40 m above the boundary in section AV4B, a talus block (apparently close to being in place) was found that contains a species of *Acernaspis*. This genus has also been found in place in AV1-124.5 m, 40-47.5 m above the systemic boundary, and a similar species occurs first on Anticosti Island 45-50 m above the conodont-based Ordovician-Silurian boundary (Chatterton et al., 1983; Lespérance, 1985). This genus is known only from Silurian strata elsewhere.

This staggered faunal changeover noted in both areas may be the result of greater tolerance of ostracodes to the ecologic shifts induced by glaciation, particularly the pronounced regressive events. Thus, the question of placement of a mutually acceptable Ordovician-Silurian boundary is more complex than originally assumed. The IUGS decision (Cocks, 1985) to place the boundary in a faulted, poorly exposed, almost exclusively graptolitic sequence at Dob's Linn, Scotland, should be reconsidered and attention paid to the possibility of finding a more suitable location, bearing in mind the transitional nature of the faunal turnover at the boundary. A more precisely defined level may be available if the specific ranges and extinction levels of more than one group are considered.

CONODONT PALEOECOLOGY

The relatively limited stratigraphic coverage afforded by the samples from the Avalanche Lake sections does not permit detailed analysis of faunal distribution. Nevertheless, relative abundance data for six taxa or groups of taxa have been calculated and are graphically presented in the composite section in Figure 4. As far as possible these groups correspond to the groups of taxa plotted by Sweet (1979b, Fig. 4). The groups are: (1) *Phragmodus*; (2) *Plectodina* and *Ozarkodina*; (3) *Besselodus, Scabbardella, Staufferella, Paroistodus?* and *Walliserodus* s.l.; (4) *Panderodus* s.l., *Drepanoistodus* and *Zanclodus*; (5) *Belodina* and *Pseudobelodina* s.l.; and (6) *Aphelognathus* and *Oulodus*. The main differences between these and Sweet's (1979b) groupings are: the inclusion of *Ozarkodina* with *Plectodina*, the addition of the third group, and the inclusion of *Drepanoistodus* and *Zanclodus* with *Panderodus*. These changes are made in an attempt to accommodate as close to 100 per cent of the fauna as possible. *Ozarkodina* is grouped with *Plectodina* because of their general similarity. Similarly, the taxa listed in the third category are all simple cone apparatuses that include 'extra' elements beyond the *a, b, c* transition series (Barnes et al., 1979). *Zanclodus* is grouped with *Panderodus* s.l. because it is a panderodont, but it is probably more similar to some species of *Pseudobelodina* (see under Systematic Paleontology).

One of the most striking features shown in Figure 4 is the marked increase in the relative abundance of *Phragmodus* in the middle part of the section. The genus represents 47 per cent of the total fauna in sample AV1-33.5 m and about 3 per cent in sample AV4B-62 m, which is subjacent in the composite section. Marked fluctuations in the abundance of *Phragmodus* are shown by Sweet (1979b) for several sections, particularly in the eastern Midcontinent. Nowlan and Barnes (1981, Figs. 2, 3) also noted major increases in the relative abundance of *Phragmodus* in the Vauréal Formation of Anticosti Island. From a study of thin sections, they showed that high relative abundance values for *Phragmodus* corresponded to intervals interpreted as representing quieter, deeper water facies. It is therefore suggested that the surge in relative abundance of *Phragmodus* at this level in the Avalanche Lake sections corresponds to a deepening event in the basin. At this level, species of *Plectodina* are absent, whereas above and below, the genus maintains a fairly steady proportion of 10-20 per cent of the total fauna. It should be noted that McCracken and Barnes (1981) recovered *P. undatus* from shale within a reef of the Ellis Bay Formation on Anticosti Island. This represents an exception to the pattern noted by Nowlan and Barnes (1981), but the specimens may have been derived, due to storm activity.

The grouping of 'complex' simple cones (*Besselodus*, etc.) shows little fluctuation but it does become less abundant with peaks of *Belodina* and *Pseudobelodina* s.l., suggesting a possible antipathetic relationship. A related 'complex' simple cone genus, *Dapsilodus*, has been recognized as being characteristic of offshore to oceanic conditions in Silurian strata (Aldridge and Mabillard, 1981; Barrick, 1983). Such a preference cannot be proven for the similar Ordovician genera *Besselodus* and *Paroistodus*?.

Perhaps the most marked feature of the Avalanche Lake faunas is the overwhelming abundance of species of *Panderodus* s.l., and this is readily apparent in Figure 4. Specimens assigned to *Panderodus* s.l. and *Zanclodus* constitute 50 per cent of the total fauna and *Drepanoistodus* accounts for an additional 10 per cent. The relative abundance of this group ranges between 30 and 90 per cent of individual samples. Barnes and Fåhraeus (1975) concluded that taxa such as *Panderodus* and *Drepanoistodus* were so widely distributed that they must be pelagic. If this is the case, then specimens of these taxa would be preserved despite anoxic bottom conditions that might reduce the numbers of nektobenthic taxa. It is possible that the abundance of these supposed pelagic taxa reflects the poor ventilation and restriction of the Selwyn Basin proposed by Goodfellow and Jonasson (1984).

The distribution of *Aphelognathus* and *Oulodus* does not seem to follow any particular pattern. These genera are only common near the base of section AV1 and are only sporadic in occurrence throughout the rest of the sequence. It is interesting to note, however, that the *Aphelognathus*-*Oulodus* association commonly constitutes a large proportion of the uppermost Ordovician faunas in North America (see Sweet 1979b; Nowlan and Barnes, 1981).

SYSTEMATIC PALEONTOLOGY

Over 9000 identifiable conodont elements have been recovered from the 26 productive samples. Their distribution is recorded in Table 1.* The fauna is diverse in the Ordovician, with 47 species belonging to 23 genera, only three of which persist into the Silurian. Only 108 specimens (representing four genera) are from samples considered to be Silurian, the remainder are of Ordovician age. The specimens are thermally altered to a Colour Alteration Index (CAI) of 5 (Epstein et al., 1977). Preservation varies from poor, particularly in Silurian samples, to good. The taxonomy presented here is the responsibility of two of us (GSN and ADM).

Multielement taxonomy has been employed throughout, except for a few rare specimens. Locational notation is after Barnes et al. (1979). Illustrated material is stored at the Geological Survey of Canada (GSC) in the National Type Fossil Collection in Ottawa. As far as possible, both sides of critical elements have been illustrated.

Phylum CONODONTA Pander, 1856

Class CONODONTATA Pander, 1856

Order CONODONTOPHORIDA Eichenberg, 1930

Genus *Amorphognathus* Branson and Mehl, 1933

Type species. *Amorphognathus ordovicicus* Branson and Mehl, 1933.

Amorphognathus? sp. Nowlan and McCracken

Plate 1, figure 1

Remarks. A single fragment of a platform element is tentatively assigned to this genus. It shows nodose denticulation on the upper surface typical of platform elements of *Amorphognathus*. Parts of two processes, possibly representing lateral processes, are preserved.

Types. Figured specimen, GSC 80180.

* See page 50

Genus *Aphelognathus* Branson, Mehl and Branson, 1951

Type species. *Aphelognathus grandis* Branson, Mehl and Branson, 1951.

Aphelognathus floweri Sweet?

Plate 1, figures 2-4, 7

Multielement

?*Aphelognathus floweri* SWEET, 1979b, p. 56, Fig. 10 (2, 6, 10-12, 16, 17).

Remarks. A few elements probably referable to this species have been recovered but the sparsity of material and some morphological differences preclude certain identification. Only *b, e, f* and *g* elements have been recovered from a single sample (see Table 1). These are generally similar to homologous elements of *A. floweri* but significant differences can be noted.

Two *b* elements equivalent to Sweet's (1979b) Sbb element have been recovered and these both have a short downwardly tapering posterior process characteristic of the species. The cusp appears to be proclined, although it is not completely preserved in either specimen. No other elements of the ramiform complex have been recovered.

Two *e* (prioniodiniform) elements are similar but not identical to the M element of Sweet (1979b). The anterior process is longer than that described for the species and the proximal portion of the posterior process is either adenticulate or bears only low denticles. The two processes are not at 90 degrees, as in *A. shatzeri* Sweet, nor are they of subequal length, as in *A. pyramidalis* (Branson, Mehl and Branson). The large, inward-flaring basal sheath typical of *A. floweri* is present.

Three *f* (prioniodiniform) elements are very similar to the Pa element illustrated by Sweet (1979b) and differ only in having an anterior process that is slightly longer, rather than equal in length, to the posterior process.

The *g* (aphelognathiform) elements recovered here have a typically spatulate anterior process, but differ from those of *A. floweri* in having a longer posterior process and in having two, rather than four, low denticles on the proximal part of the anterior process.

The specimens assigned tentatively to this taxon are slightly different from those of typical *A. floweri*, but they resemble that species most closely. The even nature of the denticulation on all elements and more proclined to erect cusps of *b* and *e* elements exclude these specimens from the closely related species *A. shatzeri* and *A. pyramidalis.*

Types. Figured specimens, GSC 80181-80184.

Aphelognathus politus (Hinde)

Plate 1, figures 5, 6, 8-15

a element

?*Prioniodus elegans* Pander. HINDE, 1879, p. 358, Pl. 15, fig. 10.

?*Cordylodus elegans* Hinde (sic). BRANSON and MEHL, 1933, p. 153, Pl. 12, fig. 17.

f element

Prioniodus furcatus HINDE, 1879, p. 358, Pl. 15, fig. 13; PARKS and FRITZ, 1923, p. 37, Pl. 6, fig. 25.

Euprioniodina? furcata (Hinde). HOLMES, 1928, p. 10, Pl. 5, fig. 23.

Dichognathus furcata (Hinde). BRANSON and MEHL, 1933, p. 155, Pl. 12, fig. 15.

g element

Prioniodus? politus HINDE, 1879, p. 358, Pl. 15, figs. 11, 12; PARKS and FRITZ, 1923, p. 37, Pl. 6, figs. 26,27.

Bryantodus politus (Hinde). HOLMES, 1928, p. 7, Pl. 5, fig. 16.

Ozarkodina(?) polita (Hinde). BRANSON and MEHL, 1933, p. 155,156, Pl. 12, fig. 16.

?*Ozarkodina(?) equilatera* BRANSON and MEHL, 1933, p. 118, Pl. 10, fig. 7.

Aphelognathus irregularis PULSE and SWEET, 1960, p. 249,250, Pl. 36, figs. 15,17.

Ozarkodina polita (Hinde). BERGSTRÖM and SWEET, 1966, p. 351, Pl. 31, figs. 6-11.

?*Aphelognathus politus* (Hinde). SWEET, ETHINGTON and BARNES, 1971, p. 182, Pl. 2, fig. 23.

Aphelognathus politus (Hinde). HARRIS, BERGSTRÖM, ETHINGTON and ROSS, 1979, Pl. 5, fig. 14.

Multielement

Aphelognathus politus (Hinde). NOWLAN, 1981b, p. 265, Pl. 1, figs. 1-4.

non *Aphelognathus furcatus* (Hinde)? ORCHARD, 1980, p. 17, Pl. 1, figs. 3, 4, 6-8, 11, 16.

Remarks. It is apparent that *A. politus* and *Plectodina tenuis* (Branson and Mehl) had apparatuses comprising closely similar elements that differ most in the morphology of the *g* element. Only those elements closely identified with *A. politus* are included in the synonymy; some elements of the *a-f* positions of *A. politus* may be included within previous synonymies provided for *P. tenuis* (e.g., Nowlan and Barnes, 1981). Thus the synonymy provided above may be incomplete.

In an unpublished thesis, Tarrant (1977) showed that *Prioniodus furcatus* Hinde s.f. is associated with *Prioniodus? politus* Hinde s.f. in material collected from the Don Valley Brickyard, Toronto, a locality only about 800 m from Hinde's (1879) original Garrison Common locality. The illustrations of Hinde's material (Hinde, 1879; Parks and Fritz, 1923; Holmes, 1928; Branson and Mehl, 1933) all show a prioniodiniform element (*P. furcatus*) with a downward extension of the base below the cusp. None of our specimens has this downward extension but Tarrant (1977) indicates that such elements are associated with *A. politus,* so his interpretation (based on abundant faunas) is followed here.

Sweet (1979a, p. G15) noted that in the distinction of *P. tenuis* and *A. politus,* it is "difficult or impossible to determine which ramiform and prioniodiniform elements should be assigned to which species". We concur with this view. In this study, the problem is compounded by the relatively sparse representation of elements of *A. politus* and their consistent occurrence together with elements of *P. tenuis.*

Sweet (1979a) reported that in samples containing only *A. politus*-type *g* elements, the associated ramiform and prioniodiniform elements are more robust that those of *P. tenuis*. He also noted a tendency for the development of lateral flanges and for the anterobasal corner of the *a* and *e* elements to become denticulate. In our collections we have few robust elements, but some of the features noted by Sweet (1979a) can be recognized.

In samples containing elements of both *P. tenuis* and *A. politus, a* elements that have an inwardly flexed anterior margin of the base are rare, and there are equally few with a downwardly and inwardly directed denticulate anterior process. Although these *a* elements are not robust, it is suggested that they belong to *A. politus*. Such elements are, however, severely underrepresented (Table 1) and it must be assumed that *a* elements more closely similar to those of *P. tenuis* were also present in the apparatus of *A. politus*.

The few *b* elements included in *A. politus* are markedly different from those of *P. tenuis*. The shorter of the two lateral processes is much longer than the equivalent process in the *b* element of *P. tenuis*. In addition, the longer process is not flexed posteriorly as in *b* elements of *P. tenuis,* but rather the aboral outline is convex downward. The denticles are more discrete and less compressed and the posterior extension of the base beneath the cusp is more pronounced than in typical *b* elements of *P. tenuis*.

Some *c* elements are similar to those of *P. tenuis,* except that the cusp and denticles are less compressed and they have a short, denticulate posterior process. These *c* elements are included within *A. politus*.

As noted under *P. tenuis,* a few *e* elements in samples containing both *A. politus* and *P. tenuis* bear an anterior denticle. According to Sweet's (1979a) observation, these probably belong to *A. politus*. They are no more robust than *e* elements assigned to *A. politus* and are extremely rare in our collections.

The *f* element assigned to *A. politus* differs somewhat from that assigned to *P. tenuis*. The anterior and posterior processes diverge at about 90 degrees, smaller than the angle of divergence in *f* elements of *P. tenuis*. The denticles of the posterior process are approximately in a plane with the cusp rather than inclined to the outer side. Nowlan (1981b, Pl. 1, fig. 3) illustrated a similar element from the White Head Formation, Gaspé Peninsula, Quebec.

The *g* element of *A. politus* is by far the most characteristic element of the species and has been described in detail by Pulse and Sweet (1960) and commented upon by Bergström and Sweet (1966).

The overall close similarity of elements in *A. politus* and *P. tenuis* suggests that the generic distinction may be inappropriate. It will require a redefinition of *Aphelognathus* to permit removal of *A. politus* from the genus, because the gap in denticulation anterior of the main cusp exhibited by *g* elements is one of the characteristics of the genus.

Types. Hypotypes, GSC 80185-80193.

Genus *Belodina* Ethington, 1959

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

Belodina confluens Sweet

Plate 1, figures 16-21

Multielement

Belodina compressa (Branson and Mehl). LENZ and McCRACKEN, 1982, Pl. 2, figs. 3, 4, 7.
Belodina confluens SWEET, 1979b, p. 59, 60, Fig. 5 (10, 17), Fig. 6 (9), (includes synonymy to 1978); NOWLAN, 1983, p. 662, 664, Pl. 3, figs. 3, 4 (includes synonymy to 1982).

Remarks. All the *q* (compressiform) elements recovered have a smoothly rounded anterior margin typical of *B. confluens*. The micro-ornament on elements of this species differs from that of elements assigned to species of *Pseudobelodina*. Striae are present over most of the surface of *p* (grandiform) and *q* elements except the upper part of the heel and distal portion of the denticles; striae near the anterior margin are oblique to the anterior edge on the most convex portion of the margin and subparallel distally and proximally. In elements of *Pseudobelodina,* striae tend to be restricted to the basal region (as in the basal wrinkles of *Panderodus*), to the areas immediately adjacent to the groove, particularly beneath the denticles, and to the cusp; other areas of *Pseudobelodina* elements are usually smooth, although Nowlan and Barnes (1981, Pl. 8, figs. 6, 7) have illustrated specimens of *P. dispansa* (Glenister) with oblique anterior striae. The distribution of striae may be of value for separating taxa at the generic level.

Types. Hypotypes, GSC 80194-80196.

Genus *Besselodus* Aldridge, 1982 emended Nowlan and McCracken, herein

Type species. *Besselodus arcticus* Aldridge, 1982.

Diagnosis. Apparatus consists of distacodiform (*a, b, c, f*?) and oistodiform (*e*) elements. All are laterally compressed, bicostate and have sharp anterior edges. Posterior edge on *a, b, e* and *f*? elements is sharp. Most elements have prominent oblique striae on anterolateral margins. Posterior face of *c* element is concave; basal cross-section is triangular. The *a, b* and *c* elements comprise a symmetry transition series.

Remarks. The genus *Besselodus* was originally diagnosed as containing at least two element-types, distacodiform and oistodiform. Unlike *Acodus? mutatus* (Branson and Mehl) (sensu Löfgren, 1978) and *Paroistodus? mutatus* (sensu Nowlan and Barnes, 1981), *Besselodus* lacks an acodiform element. We distinguish four types of distacodiform elements in the apparatus of our new species of *Besselodus*.

A distacodiform element with two posterolateral costae and sharp anterior edge is regarded as the *c* element. The position of the costa and anterior edge are such that the cross-section is triangular. This element may be equivalent to the one element Aldridge (1982, p. 426) referred to as *Coelocerodontus trigonius* Ethington.

The *f?* element differs slightly from the other distacodiform elements in ornamentation (costae, striae) and the shape of the base. The position is in question because it may alternatively represent a further subdivision of the *b* elements.

The oistodiform and distacodiform elements of *Besselodus* and *Paroistodus* are not closely similar even though they have been equated in the past (see synonymy below). In this present study, cursory sorting grouped small elements of both genera. Small distacodiform elements of *Scabbardella* may also be confused with those of *Besselodus* and *Paroistodus*.

A discussion of *Besselodus, Dapsilodus* and *Paroistodus* is found under the generic remarks of *Paroistodus*.

Besselodus borealis Nowlan and McCracken n. sp.

Plate 2, figures 1-17

Multielement

Paroistodus? mutatus (Branson and Mehl)? NOWLAN and BARNES, 1981, p. 20, Pl. 1, figs. 18, 19 (only); LENZ and McCRACKEN, 1982, Pl. 2, figs.?9, 13, 18 (only).

cf. *Dapsilodus mutatus* (Branson and Mehl)? ORCHARD, 1980, p. 20, Pl. 5, figs. 6, 15,?16, 21.

Diagnosis. Apparatus consists of distacodiform (*a, b, c, f?*) and oistodiform (*e*) elements. The *a* and *b* elements have relatively long anterobasal heels. Fine anterior striae are present on *a, b, e* and *f?* elements. Anterior margin of *e* element forms continuous curve from tip of cusp to aboral margin. Strong costae on cusp of *e* element are medial and erect. The *f?* element lacks heel found on *a* and *b* elements, thus has more triangular base. Tips of anterior striae may be discrete, forming serrated edge.

Description. All elements, except *e* elements, are distacodiform and all are bicostate and laterally compressed. Costae are directed posteriorly and their length, prominence and position are variable. Distacodiform elements have a long triangular base and a recurved erect cusp. All elements are straight, not bowed. Cusp is flexed slightly to inner side in some *b* and *e* elements. Inner side of base on *a, b* and *f?* elements is nearly planar; outer face is gently convex. Cusp of all elements is laterally compressed and has sharp anterior and posterior edges. These edges extend to basal margin on all but *c* element. Posterior face of *c* element at mid-length is concave, bounded by posterolateral costae and has a sharp cusp margin and a flared base. Proximal part of base is unornamented and on *a* and *b* elements has a straight and short posterior basal heel.

All elements, except *c*, have oblique striae on lateral faces of anterior margin of base. Parallel striae are faint to well developed and are strongest from base to about point of cusp recurvature. Angle of striae with respect to basal anterior margin is about 5, 15 and 25 degrees in *a* and *b*, *e* and *f?* elements, respectively. Striae of *f?* element are more coarse and longitudinally more extensive than striae of *a* and *b* elements. They also have slight upward concavity and, towards the anterior, have discrete tips producing a serrated anterior and lower margin.

The *a* element (Pl. 2, figs. 1, 2) has a short costa on both faces. These are immediately posterior of element axis and only in middle third of element. Costa on inner face is slightly more medial than costa on outer face.

The *b* elements vary in morphology but are similar to the *a* element, except that costae are longer and more posteriorly situated. Costa of outer face of *b-1* element (Pl. 2, figs. 5, 6) is only slightly more posterior than other costa. Costae of *b-2* (Pl. 2, figs. 3, 4) element are more asymmetrically positioned than on *b-1* element, with costa of outer face near posterior edge of cusp. Costae on outer face of both *b* elements extend basally into carina. The *b-2* element has a longer base than the *b-1* element.

Base of *c* element is relatively long. Anterior margin of *c* element is sharp for full length of element. Posterolateral costae on each face of cusp bound a concave posterior face. Basal quarter of posterior margin has narrowly flared heel or carina. Costae extend to near basal margin as carinae or rounded costae. Cusp has a sharp posterior margin and a diamond-shaped cross-section from tip to point of recurvature. It has a few faint longitudinal striae on posterolateral faces. Lateral faces of element are unornamented and flat. Lateral face of one side of base is broadly sinuous and shallow.

The *e* element has a long straight cusp with a strong medial costa on each face. Cusp is flexed only slightly to inner side. Base is about half as long as cusp, has a nearly straight aboral margin and rounded antero- and postero-aboral margins. Anterior margin forms broad arch from aboral margin to apex. Geniculation angle is small. Costae do not extend to geniculation level. Striae on anterior margin extend from or slightly below geniculation angle to proximal third of cusp. Posterolateral face of cusp on one element has faint longitudinal striae.

The *f?* element differs from *a* and *b* elements in basal outline and ornamentation. Base is more triangular since it lacks a basal heel and, instead, posterior margin is continuously concave from tip to aboral margin. Both faces have strong posterolateral costa from tip to mid-length as well as fainter costae between these and posterior margin. Striae on anterior margin are at greater angle than in *a* and *b* elements, extend farther apically and basally, and some are discrete, forming a finely denticulated or serrated margin.

Remarks. The *a* and *b* elements are distinguished by subtle differences, particularly with regard to the costae. Two varieties of *b* elements are noted, representing variably asymmetrical distacodiform elements. An alternative interpretation is that the *b-2* element represents the *d* position. In ornamentation it is more similar to the *b-1* element, but in outline it has the geometry of the *c* element. We are aware that the *c* element lacks the characteristic striae found on all other elements, but are confident that its other characters justify its inclusion in this apparatus.

The nearly bilaterally symmetrical distacodiform elements of *Besselodus arcticus* Aldridge may be homologous to the *b-1* elements of *B. borealis* n. sp. Most distacodiform elements of Aldridge (1982) have a short posterior heel like those of the *a* and *b* elements. The heel of elements recovered here is, however, longer. The angle of the anterior striae of *b* elements of *B. arcticus* is larger and the striae are shorter and coarser compared with this species.

One of Aldridge's (1982, p. 428, Pl. 44, figs. 5, 6) distacodiform elements lacks "the geniculation of the anterior edge, producing a more triangular outline for the basal postion of the unit". This character compares to that described herein for the *f*? element. All elements of *B. arcticus* differ in that none has a serrated anterior margin. Unpublished material available to one of us (ADM) from Yukon Territory also contains serrated distacodiform elements.

The *e* element of both *B. arcticus* and *B. borealis* is the most diagnostic. The *e* element of the former species has an anterobasal margin in which the cusp and base meet at the level of geniculation, producing a rounded "V"-shape. In this respect the element is similar to *Oistodus venustus* Stauffer s.f. The costa on the *e* element of *B. arcticus* is posteriorly directed, unlike the erect costae of both *O. venustus* s.f. and the *e* element of *B. borealis*. The *e* element of *B. borealis* has an anterior margin that forms a continuous curve from cusp tip to aboral margin. The costae of this element of *B. borealis* are medial, whereas those of *B. arcticus* are post-medial (only one side is known, cf. Aldridge, 1982, p. 428). The cusp of the *e* elements of *B. arcticus* is curved; that of the same element of *B. borealis* is straight. As in other elements of *B. arcticus*, the striae are coarser than those of this species.

Derivation of name. From the Latin *borealis*, meaning northern. This is chosen in reference to the northern location of this study area (Northwest Territories), and the occurrence of elements of this species in Yukon Territory.

Types. Holotype, GSC 80204; paratypes, GSC 80197-80203.

Genus *Coelocerodontus* Ethington, 1959

Type species. *Coelocerodontus trigonius* Ethington, 1959.

Remarks. Sweet and Bergström (1972) reconstructed the apparatus of *Coelocerodontus* to include at least two elements showing symmetry transition. The apparatus may be a Type IB (Barnes et al., 1979) or Type IA, as suggested below (i.e., *s*, *t* or *s*, *t*, *u* elements).

Coelocerodontus trigonius Ethington

Plate 3, figures 1-5, 8-10

Tetragoniform element

Coelocerodontus tetragonius ETHINGTON, 1959, p. 273, Pl. 39, fig. 14; HAMAR, 1964, p. 261, Pl. 2, fig. 14, Textfig. 4(9); SCHOPF, 1966, p. 45, Pl. 5, fig. 8; WINDER, 1966, Pl. 9, fig. 4; WEYANT, 1968, p. 41, Pl. 6, fig. 4.

Trigoniform element

Coelocerodontus trigonius ETHINGTON, 1959, p. 273, Pl. 39, fig. 4; HAMAR, 1964, p. 261, Pl. 2, fig. 15, Textfig. 4(10); SCHOPF, 1966, p. 45, Pl. 5, fig. 9; WINDER, 1966, Pl. 9, fig. 4; WEYANT, 1968, p. 41, Pl. 6, figs. 3, 5.

Multielement

Coelocerodontus trigonius Ethington. WEBERS, 1966, p. 25, Pl. 2, figs. 12, 13a, b, 14; ORCHARD, 1980, p. 19, Pl. 2, figs. 17, 22, 23, 29.

Description. Hyaline elements have keeled anterolateral margins, a wide base and are evenly curved to apex of long proclined cusp. Posterior margin is either keeled or sharp with a costa. All keels extend from aboral margin, diminish toward apex, where they become costae.

Symmetrical (Pl. 3, fig. 4) trigoniform element has an evenly convex anterior face; posterolateral faces are gently convex on base, planar or slightly concave near apex.

Slightly asymmetrical (Pl. 3, figs. 8, 9) trigoniform element is similar except for a faint, medial, outer lateral costa that is strongest on base. Costa does not extend to aboral margin; at mid-length of element the costa becomes a carina, which diminishes apically.

Posterior edge of asymmetrical (Pl. 3, fig. 1) tetragoniform element is sharp with costa. Outer lateral face has a faint posterolateral costa that extends from aboral margin to about one third of length of element. All faces are gently concave or nearly planar. Basal cross-section is asymmetrically subtriangular. Apical cross-section of one specimen (Pl. 3, fig. 10) has small aperture, reflecting depth of basal cavity.

Basal funnels have a subtriangular outline and are proportionally similar in length and width. Posterior and anterolateral margins are rounded. Parallel growth lamellae are either densely packed (Pl. 3, fig. 5) or more widely spaced (Pl. 3, figs. 2, 3). Edges of lamellae are straight but irregular. Surface of lamellae is finely granular with some small, low nodes. One element (Pl. 3, fig. 10) has faint lines on its exterior surface that may reflect the underlying lamellae of the basal funnel.

Remarks. These elements are similar in form to the *c* elements of *Walliserodus*, but the thin walls and exceptionally deep basal cavity are characteristic of *Coelocerodontus*.

From the material of this study and a review of the few reports of *Coelocerodontus trigonius*, we note a subtle variation in trigoniform and tetragoniform elements. Weyant (1968, Pl. 6, figs. 3, 5a, b) illustrated trigoniform elements, one of which has an additional costa on a concave anterolateral face; his tetragoniform element has four costa, all of which appear to be lateral. The costae of the poorly preserved tetragoniform element illustrated by Orchard (1980) appear to be oriented laterally, and to anterior and posterior. The *e* element of *W.*? *rallus* n. sp. has this type of cross-section but it is more laterally compressed, its tip contains white matter, and it has basal wrinkles, unlike the elements of *C. trigonius.*

Coelocerodontus trigonius may have a Type IA apparatus (sensu Barnes et al., 1979) with the tetragoniform element (sensu Orchard, 1980) and symmetrical trigoniform element being the *s* and *u* elements, respectively. Elements such as the asymmetrical trigoniform (of this study and Weyant, 1968) and asymmetrical tetragoniform (this study) may represent *t* elements that are transitional in symmetry between the *s* and *u* elements.

Types. Hypotypes, GSC 80205-80209.

Genus *Dapsilodus* Cooper, 1976

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

Remarks. The Silurian genus *Dapsilodus* is composed of *a*, *b* (asymmetrical distacodiform), *c* (symmetrical distacodiform) and *e* (acodiform) elements. The distacodiform elements are morphologically similar to the same elements of the Ordovician genus, *Besselodus.* The apparatuses differ in that the *a* element of *Dapsilodus* is twisted, whereas it is straight in *Besselodus.* Also, the *e* element in *Dapsilodus* is acodiform; in *Besselodus* it is oistodiform. There may be some similarities between *Dapsilodus* and the Ordovician *Paroistodus* (see remarks under the latter genus).

Dapsilodus? sp. A Nowlan and McCracken

Plate 3, figures 6, 7, 11-13

Description. All known elements are distacodiform with a slightly reclined cusp. Elements are laterally compressed with sharp anterior and posterior margins and subtriangular bases. Posterior margin of base forms a short heel; anterior margin of base curves toward posterior. Costae are situated posteromedially and vary in position and prominence. Oblique longitudinal striae extend along anterior margin from base to proximal part of cusp.

The cusp of the *a* element (Pl. 3, figs. 6, 7) is twisted inward to the side that has the more distinct costa. This inner costa extends from the aboral margin to about one- third the length of element. Costa on outer face is visible only on distal third of cusp. Posterior heel is shortest of all elements.

The *b* element has a base and basal heel that are longer than those in the *a* element. Both lateral costae are in approximately the same position, although in one element (Pl. 3, figs. 11, 12) the inner costa is more posterior than the outer. The inner costa extends farther toward the base than does the outer costa. On one element, weak longitudinal striae are present between outer costa and posterior margin and its outer face has faint basal wrinkles.

Remarks. As only *a* and *b* elements are present in our sparse Silurian collections, we can make only a partial comparison with other species. Since these few elements are morphologically similar to elements of both *Dapsilodus* and the Ordovician *Besselodus* we question the generic identification. The genus *Dapsilodus* is preferred over *Besselodus* because of the twisted nature of the elements, and their stratigraphic age.

The distacodiform elements of *Dapsilodus obliquicostatus* described by both Cooper (1976) and Barrick (1977) have nearly erect cusps; the cusps are slightly reclined in elements of *D.*? sp. A. These elements of *D. obliquicostatus* have a straight anterior margin that forms an acute angle with the aboral margin. This is in contrast to the nearly perpendicular margins in *D.*? sp. A. The striae of the anterior margin of both species are nearly perpendicular to the aboral margin. Since the antero-aboral angle is smaller in *D. obliquicostatus* than in *D* .? sp. A, these striae are more oblique relative to the anterior margin. The anterior margin striae on elements of *D.*? sp. A are longer than those of *D. obliquicostatus.* Elements of *D. obliquicostatus* lack the short posterior heel found in *D.*? sp. A.

Barrick's (1977) species *D. praecipuus, D. sparsus* and *D.*? sp. all differ from *D.* ? sp. A in that their distacodiform elements have short bases.

These distacodiform elements are morphologically similar to elements of *Besselodus borealis* n. sp. found in the Ordovician part of the Avalanche Lake sections. They have similar outlines, short basal heels on their posterior margin, striae, costae, cusp recurvature and short heels on the posterior basal margin. The striae on the anterior margin of elements of *D.*? sp. A are stronger than those of the elements of *B. borealis.* Elements of *D.* ? sp. A are twisted; those of *B. borealis* are straight. A comparison of element morphotypes follows.

The base of the *a* element has a straight anterior margin that is nearly perpendicular to the aboral margin. The same element of *B. borealis* has a base that in lateral view approaches an equilateral triangle.

The *b* element is similar to the *b-2* element of *B. borealis.* Both have long bases and subsymmetrically positioned costae. The costa on the inner face of the *b* element of *D*? sp. A extends closer to the base than does the same costa of the *b-2* element of *B. borealis.* These rare elements are difficult to distinguish from those of *B. borealis.*

The close morphological similarity of the known elements suggests that the Ordovician *B. borealis* and the Silurian *D.*? sp. A are related.

Types. Figured specimens, GSC 80210-80212.

Genus *Decoriconus* Cooper, 1975

Type species. *Paltodus costulatus* Rexroad, 1967.

Remarks. The apparatus consists of striated *p* and *q* (acontiodiform and paltodiform) elements. Some species such as *D. fragilis* (Branson and Mehl) (sensu Cooper, 1976) may have an *r* (drepanodiform) element that is more recurved than the other elements. The Silurian type species, as defined, apparently lacks this third element. However, McCracken and Barnes (1981) found an *r* element in the Ordovician species, *D. costulatus,* and suggested that the element may also be present in the same Silurian species.

Decoriconus costulatus (Rexroad)

Plate 3, figures 14-18, 23

Paltodiform element

Paltodus costulatus REXROAD, 1967, p. 40, 41, Pl. 4, figs. 27, 28 (only).

Multielement synonymy

Decoriconus costulatus (Rexroad). McCRACKEN and BARNES, 1981, p. 75, 76, Pl. 2, figs. 24-27 (includes synonymy to 1978); NOWLAN, 1981b, Pl. 4, fig. 7, Pl. 5, fig. 25.

Remarks. This species has been found in the Upper Ordovician of Anticosti Island, Québec by McCracken and Barnes (1981) and is also reported from the Lower Silurian of the Gaspé region, Québec (Nowlan, 1981b) and Ohio (Cooper, 1975). In this study it occurs in both Ordovician and Silurian strata. Both acontiodiform and paltodiform elements are present in the Avalanche Lake material. A drepanodiform element like that described by McCracken and Barnes (1981) was not found. McCracken and Barnes (1981) tentatively included *Acontiodus minutus* Serpagli s.f. within the synonymy of this species. *Paltodus costulatus* s.f. has priority over *A. minutus* s.f. Thus, if both form species are conspecific, *A. minutus* s.f. should be considered as a junior subjective synonym.

Types. Hypotypes, GSC 80213-80217.

Genus *Drepanoistodus* Lindström, 1971

Type species. *Oistodus forceps* Lindström, 1955.

Drepanoistodus suberectus (Branson and Mehl)

Plate 3, figures 19-22

p element

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

Multielement

Drepanodus suberectus (Branson and Mehl). SWEET and BERGSTRÖM, 1966, p. 330-333, Pl. 35, figs. 22-27 (includes synonymy through 1966).

Drepanoistodus suberectus (Branson and Mehl). UYENO, 1974, p. 14, Pl. 1, figs. 5-9 (includes synonymy through 1973); TIPNIS, CHATTERTON and LUDVIGSEN, 1978, Pl. 1, figs. 25-27; BOLTON and NOWLAN, 1979, p. 18, Pl. 7, figs. 11, 15, 16; SWEET, 1979a, p. G16; SWEET, 1979b, p. 54, fig. 7 (21, 23, 30); MERRILL, 1980, p. 337, fig. 5(1-4); ORCHARD, 1980, p. 20, Pl. 5, figs. 10, 11, 26, 27, 31; ? COOPER, 1981, p. 164, Pl. 26, figs. 1, 2, 6; NOWLAN and BARNES, 1981, p. 12, 13, Pl. 4, figs. 17-19; McCRACKEN and BARNES, 1981, p. 77, Pl. 3, figs. 1-6 (includes synonymy through 1978); LENZ and McCRACKEN, 1982, Pl. 2, fig. 22; SWEET, 1982, p. 1034, Pl. 1, figs. 7, 8, 11, 18, 19; NOWLAN, 1983, p. 660, Pl. 3, figs. 22, 23.

Remarks. This species is one of the most common recovered from the Avalanche Lake sections. Of the several new additions to the synonymy list, only the specimens reported by Cooper (1981) are in doubt. Despite the fact that he recovered almost five hundred specimens, none was oistodiform. The specimens he reported are all minute and may represent juveniles of *D. pitjanti* Cooper, 1981.

Types. Hypotypes, GSC 80218-80221.

Genus *Juanognathus* Serpagli, 1974

Type species. *Juanognathus variabilis* Serpagli, 1974.

Juanognathus n. sp. A Nowlan and McCracken

Plate 4, figures 1-3

Description. Apparatus comprises *s* (scandodiform) and *t* (asymmetrical acontiodiform) elements; a completely symmetrical acontiodiform (*u*) element has not been recovered.

The *s* element is a broad, short, laterally compressed, recurved simple cone element. Anterior and posterior edges are sharp; anterobasal corner is flexed to inner side. Posterior portion of base is extended posteriorly; oral edge is sharply rounded. Base is low and broad and curves evenly into cusp. Cusp is short, broad proximally and tapers abruptly at point of maximum curvature; it is slightly flexed to inner side. Element is unornamented.

The *t* element is anteroposteriorly compressed and bears a posterior carina. Anterior face is smoothly convex, terminating in sharp lateral edges that are directed posterolaterally. Posterior carina is subcentral and sharply rounded in subsymmetrical elements; it is broadly rounded and markedly offset in more asymmetrical elements. On base, posterior carina is laterally compressed, flanked by grooves and may be extended posteriorly as an oral margin in more asymmetrical elements. Posterolateral faces are flat to concave and contrast with high relief of posterior carina; they may be subequally broad in subsymmetrical elements, or one may be twice as broad as the other in markedly asymmetrical elements. Striae are present on the base near aboral margin.

Remarks. This group of elements is assigned to *Juanognathus* because of their similarity to the type species *J. variabilis* Serpagli. They differ from the type species in lacking any downward extension of the posterolateral edges and in the more compressed nature of the *s* element.

This is the first report of the genus from Upper Ordovician strata. Nowlan (1983) assigned a group of Late Ordovician simple cones to *Staufferella*? n. sp. A and noted that they were similar to *Juanognathus*. *Staufferella*? n. sp. A differs markedly from the elements assigned to *Juanognathus* herein, particularly in the presence of anterior costae on *t* elements.

No truly symmetrical acontiodiform (*u*) element has been recovered but one of the *t* elements is subsymmetrical (Pl. 4, fig. 1). Only six specimens of this species have been recovered and more material is required for a more complete description of the species. The black, opaque nature of the specimens precludes observation of the basal cavity.

Types. Figured specimens, GSC 80222-80224.

Genus *Oulodus* Branson and Mehl, 1933

Type species. *Cordylodus serratus* Stauffer, 1930.

Oulodus rohneri Ethington and Furnish

Plate 4, figures 4-9

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

Multielement

Oulodus rohneri Ethington and Furnish. SWEET, 1979b, p. 62, Fig. 9 (2, 3, 7?, 8, 11, 12); NOWLAN and BARNES, 1981, p. 13, 14, Pl. 2, figs. 8-16; McCRACKEN and BARNES, 1981, p. 79, 80, Pl. 4, figs. 7-22; NOWLAN, 1981b, p. 278, Pl. 1, figs. 5-7, 11, 15; LENZ and McCRACKEN, 1982, Pl. 1, fig. 13; NOWLAN, 1983, p. 660, Pl. 2, fig. 14.

Oulodus sp. MILLER and ZILINSKY, 1981, Fig. 3 (14?, 15?, 16, 17, 18).

Remarks. The multielement reconstruction of Nowlan and Barnes (1981) is followed herein. Sweet (1979b) described *O. rohneri* as a septimembrate apparatus but listed and illustrated only six elements. Nowlan and Barnes (1981) recognized six element types but noted a dimorphism of eoligonodiniform and cordylodiform elements in the *a* position. The same dimorphism is noted in our material.

The element Sweet (1979b) assigned to the M (*e*) position of this species is quite unlike that recognized by Nowlan and Barnes (1981) and McCracken and Barnes (1981); its anterobasal corner is extended anteriorly and the denti- culation is very irregular. Typically the *e* element has a convex anterior outline in lateral view and the denticles are of more even size.

The material figured by Miller and Zilinsky (1981) is probably all assignable to *O. rohneri,* but their illustrations of the cyrtoniodiform(?) element (Fig. 3.14) and trichonodelliform element (Fig. 3.15) are too poor to permit positive identification. One specimen illustrated by Miller and Zilinsky (1981, Fig. 3.16) is an *e* element of *O. rohneri,* not an Sc element (*a*) as indicated by those authors.

Types. Hypotypes, GSC 80225-80230.

Oulodus ulrichi (Stone and Furnish)

Plate 4, figures 10-15

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

Multielement

Oulodus ulrichi (Stone and Furnish). SWEET, 1979b, p. 62, Fig. 9 (20-27); NOWLAN and BARNES, 1981, p. 14, 15, Pl. 2, figs. 1-7; McCRACKEN and BARNES, 1981, p. 80, Pl. 4, figs. 23-33; NOWLAN, 1981b, p. 278, Pl. 1, figs. 9,10.

Remarks. Sweet (1979b) and Nowlan and Barnes (1981) independently reconstructed this apparatus and came to identical conclusions. Their reconstructions are followed in this paper.

Types. Hypotypes, GSC 80231-80236.

Genus *Ozarkodina* Branson and Mehl, 1933

Type species. *Ozarkodina typica* Branson and Mehl, 1933 (= junior synonym of *O. confluens* Branson and Mehl, 1933).

Ozarkodina hassi (Pollock, Rexroad and Nicoll)

Plate 4, figures 16-20, Plate 5, figures 16-21

g element

Spathognathodus hassi POLLOCK, REXROAD and NICOLL, 1970, p. 760, 761, Pl. 111, figs. 8-12.

Multielement

Ozarkodina hassi (Pollock, Rexroad and Nicoll). COOPER, 1975, p. 1005, Pl. 3, figs. 7-12; McCRACKEN and BARNES, 1981, p. 83, Pl. 7, figs. 1, 2, 4, 6-13 (includes synonymy to 1980); FÅHRAEUS and BARNES, 1981, Pl. 1, fig. 8; NOWLAN, 1981b, Pl. 4, fig. 13, Pl. 5, figs. 1, 2, 5, 6; ALDRIDGE and MOHAMED, 1982, p. 116, Pl. 1, fig. 21.

Remarks. The apparatus of this common Early Silurian species has been described and discussed in detail most recently by McCracken and Barnes (1981) and their interpretation is followed herein. Most of the Avalanche Lake specimens conform well with elements of *O. hassi,* however a few *f* and *g* elements are somewhat atypical. Some *f* elements differ from the *f* element of *O. hassi* in having a longer and higher posterior process that is only slightly lower than the anterior process (Pl. 5, fig. 21). Some *g* elements appear to lack a main cusp; instead the denticles of that region are thin and needle-like (Pl. 5, fig. 18).

A single fused cluster composed of a *g* element fused to the posterior surface of an *a, b* or *c* element has been recovered (Pl. 4, fig. 20); it is assumed that this is a post- transport diagenetic effect rather than a natural fused cluster.

Types. Hypotypes, GSC 80237-80247.

Ozarkodina sesquipedalis Nowlan and McCracken n. sp.

Plate 5, figures 1-15

Diagnosis. A species characterized by highly compressed elements with low denticles. Elements of the *a* and *e* positions are of two types based on the presence or absence of anterior denticles. Apparatus comprises cordylodiform (*a-1*), eoligonodiniform (*a-2*), plectospathodiform (*b*), neoprion-iodiform (*e-1*), falodiform (*e-2*), arched ozarkodiniform (*f*) and unarched ozarkodiniform (*g*) elements. A symmetrical (*c*) element has not been recovered but is assumed to have been present in the apparatus.

Description. The *a-1* element is a strongly laterally compressed cordylodiform element. Cusp laterally compressed and proclined; anterior and posterior edges are sharp and thin. Inner lateral face of cusp bears a broad, rounded and prominently striated carina that extends onto upper part of base but not below a line marking base of denticles. Outer lateral face of cusp convex, but bears a shallow median groove. Denticles begin on proximal part of cusp confluent with sharp posterior edge. Denticulation of posterior process is irregular and hindeodellid in style. Denticles are low, comprising only about one-fifth of the total height of the posterior process. Larger denticles bear a lateral, sharply rounded carina on each side such that cross-section is diamond-shaped. Smaller denticles are laterally compressed with lenticular cross-section. Anterobasal corner is thin and slightly flexed to inner side. Basal cavity is shallow, restricted to anterior portion of base and extends as a shallow groove beneath posterior process.

The *a-2* element is similar to the *a-1* element, but it differs in having a long, slender denticle anterior to the cusp. Anterior denticle is longitudinally striated and lies in a plane with the cusp; posterior process is straight but forms an angle of about 150 degrees with the plane of the cusp. Inner lateral face is weakly carinate and outer face is smoothly convex. Anterobasal corner is flexed to outer side. Otherwise the element is identical to the *a-1* element.

The *b* element is plectospathodiform. Cusp is twisted and recurved posteriorly; lateral edges are sharp. Posterior face of cusp is broadly rounded and curves evenly into postero-oral margin, which is sharply curved beneath the cusp. Posterior process is absent. Anterior face of cusp is flat to weakly convex. Lateral processes form an angle of about 90 degrees with one another. One is laterally directed and the other is posteriorly directed; both are straight. Posteriorly directed process lies close and almost parallel to postero-oral edge; it is separated from it by a groove. Posteriorly directed process slightly larger than laterally directed process; both are denticulate. Denticles are anteroposteriorly compressed and of irregular size; larger ones are posteriorly carinate and striated and form up to one half of height of process. One or two small denticles are between each of the larger denticles. Anterior face of element is smoothly convex with maximum convexity at proximal denticle of posteriorly directed process. Basal cavity is shallow with apex beneath cusp; it shallows and narrows markedly toward distal end of process.

No complete *c* element has been recovered, but some fragments, particularly those with an anteriorly flat cusp, may represent fragments of a symmetrical *c* element.

The *e-1* element is neoprioniodiform with cusp and denticles that are strongly reclined posteriorly. Cusp is broad and straight with prominent inner, striated carina situated posteriorly of mid-line. Denticles of posterior process are sharp-edged, reclined in cusp plane and bear similar, inner lateral carinae that are medially situated. Outer faces of cusp and denticles are smoothly convex. Anterior margin of element is sharp and extended anteriorly and aborally. Anterobasal extension is slightly flexed to outer side. Basal cavity is shallow and narrow with widest portion beneath posterior edge of cusp; it narrows abruptly to the anterior end and more gently along the posterior process.

The *e-2* element is similar to the *e-1* element, but bears at least two slender denticles on anterior margin that are reclined posteriorly in a plane with the cusp and posterior process. The inner lateral carina on the cusp is less pronounced and the whole surface is more prominently striated.

The *f* element is an arched ozarkodiniform element. Cusp is long, slender and proclined with sharp anterior and posterior edges. Lateral faces are biconvex. In lateral view, posterior margin is straight and may be keeled, whereas anterior margin is convex. Anterior and posterior processes form an angle of 110-120 degrees with one another in lateral view. Anterior process bears five to six denticles similar in outline to cusp. An inner lateral carina with subdued striae is present on anterior denticles. Proximal anterior denticle is high and fused with cusp for most of its length. Anterior process is about twice as high as posterior process. A weak basal flare is present at the junction of the two processes; it is more pronounced on the inner side. Posterior process is straight, slightly longer than anterior process, and bears at least six erect denticles, which are shorter than those on anterior process.

The *g* element is ozarkodiniform, but the base is straight or weakly arched in lateral view. Cusp is laterally compressed with sharp edges; lateral faces are weakly convex. Anterior process is longer than posterior process and bears six to nine denticles of varying size. In lateral view, anterior edges of cusp and anterior denticles are strongly convex, whereas posterior edge is straight or weakly convex. Larger denticles have weakly convex, striated carinae on both sides. Striae are much more subdued than on *a* and *e* elements. Posterior process is short with three or four denticles that are more discrete than those of the anterior process; small and large denticles alternate. In lateral view, posterior outline of denticles is convex, whereas anterior outline is straight to weakly convex. Lateral faces of element are flat with an extremely weak basal flare situated beneath proximal denticle of anterior process. In lateral view, anterior and posterior extremities are inclined toward the centre of the base.

Remarks. This species has not been reported previously, but somewhat similar elements are known from Upper Ordovician strata elsewhere. Nowlan and Barnes (1981, p. 15) reported *Ozarkodina* sp. s.f. from the upper part of the Vauréal Formation, Anticosti Island, Québec. This form resembles the *g* element of *O. sesquipedalis,* but its denticles are more slender and the posterior process is lower. Serpagli (1967) described the form taxon *O. alpina*, s.f. from the Upper Ordovician of the Carnic Alps which, although similar in overall shape, is distinguished by lateral costae rather than striated carinae. Furthermore, none of the other elements assigned to *O. sesquipedalis* is reported by Serpagli (1967).

The only other taxon occurring in the Ordovician possibly referable to *Ozarkodina* is that illustrated by Orchard (1980) as *Ozarkodina? pseudofissilis* (Lindström). The component *f* and *g* elements were interpreted as *O. pseudotypica* Lindström s.f. and *Ctenognathus pseudofissilis* Lindström s.f., respectively, by Orchard (1980). A similar association was illustrated by Nowlan (1981b) from the Matapedia Group in Québec. Orchard (1980) noted, but did not illustrate rare ramiform elements of the species. *Ozarkodina? pseudofissilis* differs from *O. sesquipedalis* in having a more typical spathognathodiform *g* element.

Ozarkodina sesquipedalis may provide an evolutionary link between Ordovician species of *Plectodina* and Silurian species of *Ozarkodina.* The species superficially resembles *P. florida* Sweet but can be assigned to *Ozarkodina* for the following reasons: (1) the *b* element is plectospathodiform rather than zygognathiform; (2) the *e-1* element is not cyrtoniodiform, but more akin to neoprioniodiform elements; (3) the very shallow basal cavity of all elements; and (4) the highly irregular denticulation, particularly in *a* elements. In fact, this species resembles some Early Silurian species of *Ozarkodina* such as *O. hassi* (Pollock, Rexroad and Nicoll) and *O.* sp. B of Nowlan (1981b), which have unarched ozarko- diniform *g* elements. However, all Silurian species have ligonodiniform *a* elements.

Types. Holotype, GSC 80255; paratypes GSC 80248-80254, 80256-80259.

Derivation of name. From *sesquipedalian* (Latin, *sesquipedalis*) — given to the use of long words. In honour of all those paleontologists who have a propensity for the utilization of tortuously long words when short ones would suffice.

Genus *Panderodus* Ethington, 1959

Type species. *Paltodus unicostatus* Branson and Mehl, 1933.

Remarks. Nowlan and Barnes (1981) made an attempt to rationalize the broad diversity of elements and apparatuses referred to this genus. They erected three informal groups that they believed might serve as a basis for the subdivision of the genus. In this study we have placed some panderodontacean elements within a new genus *Zanclodus,* however, this type of apparatus was not considered in the *Panderodus* groupings of Nowlan and Barnes (1981). *Zanclodus* differs from Panderodus in having three variable types of element, in being laterally acostate and in having elements that are bowed to the furrowed side (see discussion under *Zanclodus*). Other panderodont elements recovered in this study can be referred to taxa belonging to one or another of the groupings of Nowlan and Barnes (1981). However, some modifications are required.

Group I apparatuses of Nowlan and Barnes (1981) are those similar to the apparatus of the type species *P. unicostatus* Branson and Mehl, which may be a synonym of *P. gracilis* (see McCracken and Barnes, 1981). These apparatuses are characterized by a symmetry transition series of slender costate elements. An intergradational series of asymmetrical arcuatiform and graciliform elements can be referred to as *a/b* elements; subsymmetrical graciliform elements are referred to the *c* position. Broad, laterally compressed compressiform or simplexiform elements are referred to the *e* position. In Sweet's (1979b) terminology, *a/b* elements are arcuatiform, asimiliform and tortiform(?), *c* elements are similiform, and *e* elements are falciform. This type of apparatus is displayed by *P. gracilis* and *P. rhamphoides* n. sp. in our collections and is also apparently displayed by *P. bergstroemi* Sweet, *P. breviusculus* Barnes and *P. feulneri* (Glenister), (see Sweet, 1979b). *Panderodus unicostatus* sensu Cooper (1976) and *P. serratus* Rexroad sensu Cooper (1975) are Silurian representatives of this type of panderodontacean apparatus.

Nowlan and Barnes (1981) defined Group II apparatuses as bi-elemental and cited *P.? gibber* Nowlan and Barnes as a representative. In this paper, *P.? gibber* is revised to include a third element (see discussion under *P.? gibber*). The asymmetrical element of Nowlan and Barnes (1981) is herein interpreted as an *a* element and the symmetrical element is interpreted as a *c* element. A bicostate element similar to the *a* element is interpreted as the *b* element. As *P.? gibber* is considered representative of Group II apparatuses, Group II is revised here to include apparatuses that possess *a* (asymmetrical unicostate), *b* (asymmetrical bicostate) and *c* (symmetrical) elements. Group II apparatuses lack the *e* element present in Group I apparatuses.

Group III apparatuses were defined by Nowlan and Barnes (1981) as bielemental, comprising laterally compressed, broad, low-based elements and long, slender elements. *Panderodus panderi* (Stauffer) and *P. liratus* Nowlan and Barnes were considered as representatives of this group (Nowlan and Barnes, 1981); these species are similar, but their apparatuses, particularly that of *P.? panderi,* are not fully understood (see, for example, Sweet 1979b).

Some species do not fall within any of these three groups. *Panderodus? clinatus* McCracken and Barnes was defined as being composed only of arcuatiform and compressiform elements. These elements presumably occupy the *a/b* (arcuatiform) and *e* (compressiform) positions and thus the apparatus lacks a *c* element. *Panderodus?* n. sp. A as interpreted here comprises only *a* and *b* elements (see description below).

We can conclude that a variety of apparatus types are referred to *Panderodus* s.l. Only those species with an apparatus similar to that of *P. gracilis* or *P. unicostatus* can be referred to the genus with confidence. Hence we question the generic assignment of all species that do not have a Group I apparatus. New genera are probably required for the other species, but progress in this direction should be undertaken with caution because of the subtle complexity of panderodontacean apparatuses.

Panderodus aff. *P. bergstroemi* Sweet

Plate 6, figures 1-5

Multielement

aff. *Panderodus bergstroemi* SWEET, 1979b, p. 63, Fig. 7 (7, 9, 15, 16, 20).

Remarks. A few panderodont specimens resemble *P. bergstroemi* except that the heel and posterior extension of the base are less pronounced. Asymmetrical (*b*, asimiliform) elements have a shorter and broader base than typical *P. bergstroemi.* A single symmetrically bicostate (*c*, similiform) element differs from typical *P. bergstroemi* in having a sharp, rather than rounded anterior margin, and in lacking twin posterior costae. All elements are bilaterally costate and are either straight or bowed gently toward the unfurrowed side. No acostate falciform (*e*) elements, identified by Sweet (1979b) as *M* or *P* elements, were recovered.

Types. Figured specimens, GSC 80260-80262.

Panderodus? *clinatus* McCracken and Barnes

Plate 6, figures 6-11

Multielement

Panderodus clinatus McCRACKEN and BARNES, 1981, p. 84, 85, Pl. 2, figs. 1-6.
Panderodus sp. C NOWLAN and BARNES, 1981, p. 20, Pl. 5, figs. 18-22, Textfig. 7F,G.

Remarks. McCracken and Barnes (1981) erected this species for a bielement apparatus consisting of arcuatiform (*a*/*b*) and compressiform (*e*) elements. Nowlan and Barnes (1981) noted variation in the position of the inner ridge (=costa) and outer groove of their graciliform (herein arcuatiform) elements.

Comparison with the type material of *P. clinatus* permits the following observations. The rare arcuatiform (*a*/*b*) elements in this study have the same abrupt recurvature, short base, low heel, straight cusp and weakly excavated outer basal furrow as typical specimens of *P. clinatus.* In addition, the outer groove is in the same position in specimens of both collections. One notable difference in the *a*/*b* elements is that the inner anterolateral costa is more pronounced on specimens from the Avalanche Lake sections.

One of the *e* elements recovered differs from those typical of *P. clinatus* in being bicostate, less compressed and bowed slightly to the furrowed side (Pl. 6, figs. 6, 7).

The generic identification is queried because a *c* element has not been identified. Otherwise the apparatus is similar to that of *P. gracilis* (Branson and Mehl) and other species with a Group I apparatus (sensu Nowlan and Barnes, 1981). The apparatus of *P.*? *clinatus* differs from that of *P.*? *gibber* Nowlan and Barnes (Group II apparatus) in having an *e* element.

Types. Hypotypes, GSC 80263-80265.

Panderodus? *gibber* Nowlan and Barnes

Plate 6, figures 12-20

Multielement

Panderodus gibber NOWLAN and BARNES, 1981, p. 16, Pl. 6, figs. 15-19, Textfig. 7H, J; McCRACKEN and BARNES, 1981, p. 85, Pl. 2, figs. 7-10 (includes synonymy through 1978); NOWLAN, 1981b, Pl. 2, figs. 18, 20; LENZ and McCRACKEN, 1982, Pl. 2, fig. 1.

Remarks. This species was originally diagnosed as having a bielement apparatus: an asymmetrical element with a sharp, inwardly directed anterior edge and an outer groove and basal furrow; a symmetrical element with sharp anterolateral edges and posterolateral grooves on both faces. Nowlan and Barnes (1981) observed little or no gradation between these two element types.

Basing our study on the material from Avalanche Lake, we recognize variation in ornamentation and degree of torsion within the asymmetrical elements. The markedly asymmetrical (*a*) element (Pl. 6, figs. 14-17) follows the original diagnosis, in that it has a sharp inner anterior edge and an acostate outer face. The slightly asymmetrical (*b*) element (Pl. 6, figs. 18-20) differs in having sharp, asymmetrically opposed, posteriorly directed lateral edges; these are antero- and postero-laterally situated on the grooved and ungrooved faces, respectively. Some *b* elements (Pl. 6, figs. 18, 19) have sharp anterolateral edges that are subsymmetrically opposed.

The *a* element has a cusp that is twisted out of the anteroposterior plane toward the grooved side and a base that has its posterior part deflected toward the ungrooved side. In *b* elements, only the cusp is twisted. Some *a* and *b* elements have faint longitudinal striae on both sides of the groove. More rarely there are faint striae on the smooth, inner posterolateral face.

The symmetrical *c* element (Pl. 6, figs. 12, 13) in the Avalanche Lake material conforms with the original diagnosis. It also has longitudinal striae between the grooves and posterior margin of the cusp.

We herein revise the diagnosis of *P.*? *gibber* to include both markedly (*a*), and slightly (*b*), asymmetrical elements as well as symmetrical (*c*) elements. The equivalent terminology of Sweet (1979b) is arcuatiform (*a*), asimiliform (*b*) and similiform (*c*) elements. Despite this revision, the apparatus of *P.*? *gibber* remains markedly different from that of *P. gracilis* in that elements are less morphologically intergradational, there is no *e* (compressiform) element, and the *c* element has grooves on both sides. These significant differences lead us to question the generic assignment and to speculate that this species belongs to a separate genus.

Panderodus cf. *P. staufferi* (Branson, Mehl and Branson) of McCracken and Barnes (1981) may have a similar apparatus. We have re-examined the type material and found elements homologous to the *a*, *b* and *c* elements of *P.*? *gibber.* The compressiform elements of *P.* cf. *P. staufferi* sensu McCracken and Barnes (1981) are herein interpreted as *b* and *c* elements (ibid. , Pl. 2, figs. 14, 16, 18 = *b* elements; fig. 17 = *c* element). The arcuatiform element of McCracken and Barnes (1981) is interpreted as the *a* element and it differs from homologous elements of *P.*? *gibber* in that it is less abruptly recurved and has a sharp edge immediately anterior of the groove.

Types. Hypotypes, GSC 80266-80270.

Panderodus gracilis (Branson and Mehl)

Plate 7, figures 1-10, 12, 13, 19

a/b element

Paltodus arcuatus STAUFFER, 1935b, p. 612, Pl. 74, figs. 6, 8, 9.
Paltodus gracilis BRANSON and MEHL, 1933, p. 108, Pl. 8, figs. 20, 21.

b/c element

Paltodus equicostatus RHODES, 1953, p. 297, Pl. 21, figs. 106-109, Pl. 22, figs. 162, 165.

a-c element

Panderodus unicostatus (Branson and Mehl); PALMIERI, 1978, p. 23, Pl. 1, Figs. 4-7, Textfig. 3 (3a-3d).

e element

Paltodus compressus BRANSON and MEHL, 1933, p. 109, Pl. 8, fig. 19.
Drepanodus similaris RHODES, 1953, p. 292, 293, Pl. 21, figs. 98, 99 only.

Multielement

Panderodus gracilis (Branson and Mehl). NOWLAN and BARNES, 1981, p. 16, Pl. 6, figs. 20, 23, 27 (contains synonymy to 1977); MOSKALENKO, 1977, Pl. 11, fig. 7; LEE, 1977, p. 137, 138, Pl. 1, fig. 5; PALMIERI, 1978, p. 21, 22, Pl. 1, figs. 1-3, 17-23, Textfig. 3 (1a-2d); HARRIS, BERGSTRÖM, ETHINGTON and ROSS, 1979, Pl. 5, figs. 1-3; NOWLAN in BOLTON and NOWLAN, 1979, p. 20, Pl. 7, figs. 19, 21-23; STOUGE and PEEL, 1979, p. 107, Fig. 2A; ORCHARD, 1980, p. 23, Pl. 3, figs. 1, 2, 8, 10, 11, 14, 15, 19, 22, 23, 26, 32; Textfig. 4B; McCRACKEN and BARNES, 1981, p. 85, 86, Pl. 1, figs. 1-12, 15; NOWLAN, 1981b, p. 280, Pl. 2, figs. 13, 14;?AN, 1981, Pl. 3, figs. 23, 27; LENZ and McCRACKEN, 1982, Pl. 2, figs. 2, 5, 6, 8, 12, 15.

Remarks. Orchard (1980) identified four morphotypes in the apparatus of this species: an intergradational series of three elements (similiform, arcuatiform and asimiliform) tentatively assigned to Sa, Sb and Sc, respectively, and a falciform element tentatively regarded as the M element. McCracken and Barnes (1981) identified three main element types: graciliform, arcuatiform and compressiform; in terms of Orchard's (1980) reconstruction these correspond to asimiliform, similiform/arcuatiform and falciform, respectively.

In this study we concur with Orchard's (1980) tentative assignment of the various morphotypes to specific element positions. We regard elements described as *Paltodus gracilis* s.f. by Branson and Mehl (1933) and *Paltodus arcuatus* s.f. by Stauffer (1935b) to occupy the *a* position. They are asymmetrical elements characterized by a broad, smooth inner face, inwardly directed anterior edge, and an outer grooved face. Elements of the *a* position are intergradational through *b* elements to the subsymmetrical *c* element that is typified by slender elements with an anterolateral costa on each face (e.g., *Paltodus equicostatus* Rhodes, 1953 s.f.). The laterally compressed, subsymmetrical element described as *Paltodus compressus* Branson and Mehl, 1933 is interpreted herein as the *e* element.

A few elements of *P. gracilis* have been recovered from lowest Silurian strata in Section AV4B.

Types. Hypotypes, GSC 80271-80277.

Panderodus? *liratus* Nowlan and Barnes

Plate 7, figures 11, 15-18, 22

Panderodus arcuatus (Stauffer). BARNES, 1977, p. 106, Pl. 3, figs. 23-25.
Panderodus panderi (Stauffer).?ETHINGTON and FURNISH, 1959, Pl. 73, fig. 9;? STONE and FURNISH, 1959, p. 226, Pl. 31, fig. 4.
Panderodus n. sp. C s.f. NOWLAN in BOLTON and NOWLAN, 1979, Pl. 7, figs. 17, 18.

Multielement

Panderodus liratus NOWLAN and BARNES, 1981, p. 17, Pl. 6, figs. 21, 22, 24, 28, 29, Textfig. 7D; McCRACKEN and BARNES, 1981, p. 86, Pl. 2, figs. 19-21; NOWLAN, 1981b, p. 280, Pl. 2, figs. 12, 19.
Panderodus panderi (Stauffer). BARNES, 1977, p. 107, Pl. 3, fig. 22 (only); SWEET, 1979b, p. 64, Fig. 7 (5, only).

Remarks. As noted by Nowlan and Barnes (1981), *P. liratus* is distinguished from *P. panderi* by its distinctive slender element and by the less posteriorly extended base and less prominent flange on broad (*e*?) elements. Only rare, slender *a/b* elements have been recovered in this study. Sweet (1979b) has illustrated and described one of these as *P. panderi* from New Mexico.

Types. Hypotypes, GSC 80278-80280.

Panderodus? *panderi* (Stauffer)?

Plate 7, figures 14, 20, 21, 23-25

?*Paltodus panderi* STAUFFER, 1940, p. 427, Pl. 60, figs. 8, 9; GLENISTER 1957, p. 728, 729, Pl. 85, figs. 8, 9.

Multielement

?*Panderodus panderi* (Stauffer). SWEET, THOMPSON and SATTERFIELD, 1975, p. 33, 34, Pl. 1, fig. 12 (includes synonymy to 1975); BARNES, 1977, p. 107, Pl. 3, fig. 21 only; NOWLAN in BOLTON and NOWLAN, 1979, p. 20, Pl. 7, figs. 3, 4, 7; SWEET, 1979b, p. 64, fig. 7 (1-4, 6, 10) only; ORCHARD, 1980, p. 23, Pl. 3, fig. 24; NOWLAN and BARNES, 1981, p. 17, Pl. 6, figs. 3, 4, 14; McCRACKEN and BARNES, 1981, p. 86, Pl. 2, figs. 11-13.

Remarks. The types of *P. panderi* are from a mixed collection of Ordovician and Devonian conodonts and as such the apparatus from which they came may never be clearly known. Sweet (1979b) has pointed out the difficulty of delimiting the variation of *P. panderi* and he treated the species in a broad sense.

A few specimens recovered in this study are questionably referred to *P. panderi*. All are bicostate with costae approximately medially situated as in similiform elements of Sweet (1979b). The elements are straight or slightly bowed to the unfurrowed side. Four unbowed elements bear conspicuous panderodont grooves and furrows on both sides (see Pl. 7, figs. 23, 24), a condition not reported in *Panderodus*, except in *P.*? *gibber* Nowlan and Barnes, which is considered here as a doubtful member of the genus. These elements are referred to as *b/c* elements. Only a few specimens show basal thickening and equally few bear a posterior extension of the base, both being characteristics of the species. Thus, these symmetrical, bicostate and, in some cases, bi-furrowed elements are tentatively referred to *P. panderi*. The fact that they are all approximately symmetrical is puzzling, because more variability is to be expected in the apparatus, as shown by Sweet (1979b). These elements are not readily placed in any of the other panderodont species reported in this paper.

Types. Figured specimens, GSC 80281-80283.

Panderodus rhamphoides Nowlan and McCracken n. sp.

Plate 8, figures 1-4, 8-15, 20, 21, 26

Diagnosis. Apparatus consists of a symmetry transition series (*a, b, c*) and compressiform (*e*) elements. Elements are strongly compressed laterally, wide, and have proclined and lanceolate cusps. Posterior margin is sharp; anterior margin of base is narrowly rounded. Aboral margin is perpendicular to the nearly straight and subparallel sides of the base. White and hyaline matter boundary is nearly parallel to axis of element. Posterior margin within white matter is thin and weakly translucent. The *a-c* elements are bowed. They differ in that the anterior portion of the outer face has a narrow and weak carina on the *a* element and has a more prominent carina on the *b* and *c* elements. The *b* element has a more sharply inclined cusp than the *a* element. The *c* element is subsymmetrical, in that it has a costa on the anterior part of the inner face directly opposite the carina on the outer face. Outer face of these and *e* elements has a panderodont furrow. The *e* element is acostate, not bowed and has a sharp anterior margin.

Description. Strongly laterally compressed elements have a wide base that does not taper greatly. Cusp is proclined, relatively short and is wide proximally. Posterior edge of element is sharp down to basal wrinkles. Anterior edge of cusp is sharp. This sharp edge continues to near the basal wrinkles in some elements; others have a rounded anterior margin of the base. Aboral margin is nearly perpendicular to posterior margin of the base. Panderodont furrow is present on base and extends to tip of cusp as groove or notch. Notch is deeply and asymmetrically excavated and expanded aborally. Anterior outline of base is straight to weakly convex with part nearest base inclined toward furrow. Micro-ornamentation consists of faint longitudinal striae and relatively long and faint basal wrinkles. White and hyaline matter boundary nearly parallel to axis of element. White matter extends from cusp to above basal wrinkles on posterior margin and to about mid-length of element on anterior margin. White matter in larger elements has less distinct margins. Basal cavity extends to less than mid-length. Incipient denticles appear to be present within weakly translucent white matter along posterior margin. The *a-c* elements are bowed; *e* element is nearly straight.

The *a-c* elements are bowed to inner, unfurrowed side. They are represented by a variety of arcuatiform elements that exhibit degrees of cusp recurvature and attitude of inner lateral face. Anterior and posterior margins are slightly oblique to this plane. These elements are flexed so that their cusp tip is directed posterolaterally.

The *a* element has a wide cusp and base (Pl. 8, figs. 1, 2) and is characterized by a smooth arch of anterior and posterior margins, from the base to tip of cusp; there is no inflection point at junction of base and cusp. Posterior margin is sharp. Anterior margin of cusp is sharp, becomes costate on proximal part of base and narrowly rounded and acostate on distal portion. Outer face has a narrow, medial and weak carina extending from base to tip. Similar carina is on inner face of base, bounded by low depression on each side.

The *b* element (Pl. 8, figs. 3, 4) has a narrower lanceolate cusp that exhibits a sharper inflection in the arch of cusp and base than the *a* element. Anterior edge is like that of *a* element, except that costa is more prominent and longer on some *b* elements.

The *c* element is like the *b* element except that it has an inner costa near the anterior margin that extends along the cusp to the basal wrinkles. Costa is directly opposite carina on outer face.

The *e* (compressiform) elements are nearly straight, although some rare elements are bowed slightly to the furrowed side. All have acostate lateral faces and sharp anterior and posterior edges. Anterior margin near the aboral margin is rounded and inclined toward the furrow. Longitudinal striae on ungrooved face are present on cusp and become faint toward anterior edge and tip of cusp. Striae on grooved outer face are in same region as on inner face, but are less prominent and longitudinally more extensive between furrow and posterior margin. Small elements (Pl. 8, figs. 14, 15) have a short, wide, nearly erect cusp, and are not visibly ornamented. Margins of base are nearly straight and parallel. Low, median carina on outer face extends from base to point of cusp recurvature. Larger elements (Pl. 8, fig. 26) have a longer, more tapered and more proclined cusp. Anterior and posterior cusp margins curve evenly onto base. A weak and low median carina is present on both faces.

Remarks. The elements of *P. rhamphoides* n. sp. can be confused with those of *P. gracilis* (Branson and Mehl). The *a-c* elements have an inner face that is nearly in the anteroposterior plane, whereas the *a/b* elements of *P. gracilis* have an inner face that is noticeably oblique to this plane. The cusp of the *a-c* elements is more laterally directed in this new species than in the *a/b* elements of *P. gracilis*. The *a/b* elements of *P. gracilis* differ further in that they have shorter bases and less pronounced and excavated basal notches. Some arcuatiform elements of *P. gracilis* (cf. McCracken and Barnes, 1981, Pl. 1, figs. 5, 8) lack an anterolateral costa and instead have a sharp margin. Although similar in this respect to the *a/b* elements of *P. rhamphoides*, they differ in lateral outline.

Both the *c* element of *P. rhamphoides* and the arcuatiform (*a*) element of *P. gracilis* have a broad, flat, inner face. They differ in that the *c* element of this new species has a sharp anterior margin and an inner costa, whereas the *a* element of *P. gracilis* has an inwardly deflected, costate, anterolateral margin and a smooth, convex, anterior face. The *c* element of *P. rhamphoides* differs further in that the outer face has a carina that is symmetrically opposed to the inner costa. The outer face of the *a* element of *P. gracilis* is acostate.

The *e* element of *P. rhamphoides* is characterized by its subparallel-sided base and a wide cusp that is less proclined than that of the *e* element of *P. gracilis*. White matter distribution also distinguishes these *e* elements of *P. rhamphoides* from those of *P. gracilis*.

Panderodus serratus Rexroad s.f. has a posterior margin that is noticeably denticulate. In this regard it differs from the *a-c* elements of *P. rhamphoides*, which may have incipient denticulation. The geometry of *P. serratus* s.f. is like that of the *a* and *b* elements of *P. gracilis*.

Panderodus rhamphoides has an apparatus consisting of *a, b, c,* and *e* elements. Hence, we do not question its affiliation to *P. gracilis* and other species, such as *P. feulneri* (Glenister), that have a similar apparatus. The apparatus of these three species differs from other coniform species assigned here to *Panderodus*? and *Zanclodus* n. gen.

Derivation of name. From the Greek *rhamphodes*, meaning beak-like.

Types. Holotype, GSC 80286; paratypes, GSC 80284, 80285, 80287-80291.

Panderodus serratus Rexroad s.f.

Plate 8, figures 5-7

Panderodus serratus Rexroad. ALDRIDGE, 1972, p. 204, Pl. 9, fig. 7; COOPER, 1975, p. 993, 994, Pl. 1, figs. 5, 7 only;?HELFRICH, 1980 Pl. 2, fig. 14 only; McCRACKEN and BARNES, 1981, p. 86, 87, Pl. 2, fig. 28.

Panderodus cf. *P. serratus* Rexroad. NOWLAN and BARNES, 1981, p. 17, 18, Pl. 6, figs. 9, 11, Textfig. 7A.

Panderodus unicostatus serratus Rexroad, 1967, p. 47, Pl. 4, Figs. 3, 4.

Remarks. Posteriorly serrated elements assigned to *P. serratus* by various authors, whether in form or multielement taxonomy, are all closely similar. They have a smooth inner face with an anterolateral costa that varies in prominence, and a grooved outer face. As such they are very similar to asymmetrical (*b*, Sb) elements of *P. gracilis* (Branson and Mehl), except for the serrated posterior margin. Cooper (1975) and Helfrich (1980) have recognized *P. serratus* as a multielement species with apparatus composition very similar to *P. gracilis*; in both these studies, serrated elements are rare. McCracken and Barnes (1981) regarded *P. serratus* as a form taxon but speculated that it might be a variant of the arcuatiform element of *P. gracilis*. Nowlan and Barnes (1981) considered the same speculation but noted that the distribution of elements that they referred to *P.* cf. P. serratus s.f. and *P. gracilis* was different. *Panderodus* cf. *P. serratus* of Nowlan and Barnes (1981), distinguished from typical material by having a shorter cusp and less prominent inner costa, is considered here to be *P. serratus* s.f.

In view of the uncertainty concerning the apparatus of *P. serratus*, the few elements recovered for this study are considered in form taxonomy, although recognizing the possibility that they may be rare (ecophenotypic?) variants within *P. gracilis*.

Types. Hypotypes, GSC 80292, 80293.

Panderodus? n. sp. A Nowlan and McCracken

Plate 8, figures 16-19, 22-25

Description. Apparatus composed of *a* and *b* elements; both have short proclined cusps and long bases with straight anterior and posterior margins. Panderodont groove and basal furrow are located on inner side. Furrow is deeply excavated; longitudinal striae are near groove on cusp and proximal part of base. Outer face has well developed and posteriorly directed costa. Both this costa and groove on outer face are either medially or post-medially situated. Basal wrinkles are present on distal part of base.

The *a* element has a wide base that is laterally compressed and a cusp that is strongly directed toward the inner side. Anterior and posterior edges of base are sharp from basal wrinkles to tip of cusp. Cusp is subcircular in cross-section. Groove and furrow on inner face is near posterior margin; furrow in base is subsymmetrically excavated. Faces of base on both sides of groove are nearly flat. Some variation is noted on outer face. On some elements (Pl. 8, figs. 16, 22), costa is near posterior margin, extending through region of basal wrinkles to aboral margin as a strong carina. On other elements (Pl. 8, figs. 18, 19), costa is not as sharp and does not extend past basal wrinkles.

The *b* element (Pl. 8, figs. 24, 25) has a base that is narrower than that of *a* element. Anterior margin is convex; posterior margin is sharp. Cusp and inner lateral face are oblique relative to anteroposterior plane. Inner face has a sharp, posteriorly directed costa near posterior margin. Postion of this costa is variable; it does not extend aborally past basal wrinkles. Costa on outer face is medial and extends from cusp to basal wrinkles, where it becomes a weak carina. Basal groove is asymmetrically excavated.

Remarks. Panderodus? n. sp. A co-occurs in two samples with *P. rhamphoides,* but they are not regarded as part of the same apparatus since this co-occurrence is not consistent in younger samples from Avalanche Lake.

The *a* and *b* elements of *P.*? n. sp. A have a laterally compressed and long base like those of *P. rhamphoides* n. sp., but differ in that the cusp is narrow and subcircular, not broad and compressed. The base of the *b* element is more narrow in *P.*? n. sp. A than it is in the same element of *P. rhamphoides.* The *c* element of *P. rhamphoides* has a costa on the inner face like the *b* element of *P.*? n. sp. A, but it lacks a strong costa on the outer face.

The most distinguishing feature between these species is the panderodont groove and furrow. On elements of this taxon, it is on the inner face; in *P. rhamphoides,* it is on the outer face.

A long base and a grooved inner face are characters of elements of *Zanclodus levigatus* n. gen. n. sp. Elements of *P.*? n. sp. A differ in that they are costate and have a less recurved cusp.

We query the generic name since the apparatus may be incomplete and may not be like that of *Panderodus* sensu stricto (see generic discussion of *Panderodus*).

Types. Figured specimens, GSC 80294-80297.

Genus *Paroistodus* Lindström, 1971

Type species. *Oistodus parallelus* Pander, 1856.

Remarks. Lindström (1971) defined the apparatus based on Lower Ordovician material, as consisting of drepanodiform and oistodiform elements. Since his work, Middle and Late Ordovician species reconstructions have been variously interpreted as *Acodus* (Löfgren, 1978), *Dapsilodus* (Bergström, 1978) and *Paroistodus*? (Sweet, 1979b). The form species that has been pivotal to this confusion is *Belodus*? *mutatus* Branson and Mehl, which has a trivial name that is fitting, considering the generic fluctuations. *Belodus*? *mutatus* s.f. is comparable in some respects with the *a* element of *Scabbardella altipes* (Henningsmoen) sensu Orchard and the *e* element of *Dapsilodus obliquicostatus* (Branson and Mehl).

Oistodus venustus Stauffer s.f., a distinctive and long ranging form species has either been excluded (Löfgren, 1978; Orchard, 1980) or included (Sweet, 1979b; Nowlan and Barnes, 1981) in an apparatus with *B.*? *mutatus* s.f.

In this study we include an oistodiform element within *Paroistodus*? sp. A, although we realize that it greatly outnumbers the other elements in the apparatus. This superabundance of oistodiform elements may indicate that either the apparatus is unusually rich in *e* elements or that the oistodiform elements are not part of the species. If the oistodiform element is considered as a separate species and not part of *Paroistodus*? sp. A, then the *a-1* element, which is similar to *B.*? *mutatus* s.f., could be considered as the *e* element. This alternative reconstruction would result in an apparatus that is more similar to that of *D. obliquicostatus* than that of *S. altipes.* If this alternative is adopted, the markedly bowed *a-2* and *b-2* elements could be considered either as part of the first symmetry transition series, which would then comprise the *a-2, b-1* and *b-2* elements, or they could represent *f* and *g* elements.

Dapsilodus obliquicostatus, may have been derived from *Besselodus,* but differs in that its *e* element is acodiform rather than oistodiform. If an acodiform element rather than an oistodiform element is considered as the *e* element of *Paroistodus*? sp. A, then both *Besselodus* and *Dapsilodus* may have *P.*? sp. A as a common ancestor.

Paroistodus? sp. A Nowlan and McCracken

Plate 9, figures 1-22

a element

?*Acodus inornatus* Ethington. HAMAR, 1966, p. 48, Pl. 2, figs. 1, 2, 10, Textfig. 4(1-3) (Middle Ordovician).
Acodus mutatus (Branson and Mehl). ?IGO and KOIKE, 1967, p. 12, 13, Pl. 1, figs. 21, 22, Textfig. 4(c); non SERPAGLI, 1967, p. 41, 42, Pl. 6, figs. 1, 6 (similar to *a* element in *Dapsilodus mutatus* of Orchard, 1980); ?MANARA and VAI, 1970, p. 476; cf. PALMIERI, 1978, Textfig. 4(4a-c).
Acodus sp. 1 WEYANT, 1968, p. 28, Pl. 5, fig. 8.
?*Belodus*? *mutatus* BRANSON and MEHL, 1933, p. 126, Pl. 10, fig. 17.

b element

Acontiodus procerus Ethington. non SERPAGLI, 1967, p. 46, 47, Pl. 9, figs. 6-11 (similar to *b* and *c* elements in *Dapsilodus mutatus* of Orchard, 1980); cf. PALMIERI, 1978, Textfig. 4(5a-c); ?MANARA and VAI, 1970, p. 477.
?*Acontiodus semisymmetricus* HAMAR, 1966, p. 51, Pl. 7, figs. 5, 6, Textfig. 3(6) (Middle Ordovician).
?*Distacodus bygdoeyensis* HAMAR, 1966, p. 57, Pl. 1, figs. 12-14, Textfig. 3(1) (Middle Ordovician).
non *Distacodus procerus* ETHINGTON, 1959, p. 268, Pl. 38, fig. 8; WEYANT, 1968, p. 45, Pl. 5, fig. 12.
cf. *Distacodus* sp. cf. *D. procerus* Ethington. WINDER, 1966, p. 55, 56, Pl. 9, fig. 8, Textfig. 3(8).
Distacodus sp. 1 WEYANT, 1968, p. 46, Pl. 5, figs. 9, 11.

d element

cf. *Distacodus mucrus* WINDER, 1966, p. 55, Pl. 9, fig. 7, Textfig. 3(7); WEYANT, 1968, p. 45, Pl. 5, fig. 10.

e element

Oistodus venustus Stauffer. WEYANT, 1968, p. 53, Pl. 2, fig. 9; non UYENO and BARNES, 1970, p. 110, Pl. 21, figs. 6, 7 (hypotypes viewed, have carinae rather than costae).
cf. *Oistodus venustus* STAUFFER, 1935a, p. 147, Pl. 12, fig. 12; HAMAR, 1966, Pl. 1, fig. 20 (Middle Ordovician); WINDER, 1966, Pl. 9, fig. 12, Textfig. 3(12).
?"*Oistodus*" spp. PALMIERI, 1978, p. 21, Pl. 5, fig. 9 (only).

Multielement

Acodus mutatus (Branson and Mehl). ?SWEET and BERGSTRÖM, 1966, p. 303-305, Pl. 35, figs. 7-9 (Middle Ordovician, includes synonymy to 1966); cf. PALMIERI, 1978, p. 6, 7, Pl. 2, figs. 17-19.

?"*Acodus*" *mutatus* (Branson and Mehl). SWEET, THOMPSON and SATTERFIELD, 1975, Pl. 1, fig. 14.

?*Acodus*? *mutatus* (Branson and Mehl). LÖFGREN, 1978, p. 44-46, Pl. 2, figs. 9-21, Textfig. 23 (Middle Ordovician, includes synonymy to 1976).

non *Dapsilodus mutatus* (Branson and Mehl). BERGSTRÖM, 1978, Pl. 80, figs. 21-23 (longitudinal striae = *Scabbardella*); ORCHARD, 1980, p. 20, Pl. 5, figs. 6, 15, 16, 21 (oblique striae = ?*Dapsilodus*).

cf. *Drepanoistodus*? *venustus* (Stauffer)?. ORCHARD, 1980, p. 20, Pl. 5, figs. 1, ?29, 34.

?*Drepanoistodus* cf. *venustus* (Stauffer). WANG et al., 1983, p. 153, Pl. 8, figs. 12, 13.

?*Oistodus venustus* Stauffer. BERGSTRÖM and SWEET, 1966, p. 341, 342, Pl. 35, figs. 20, 21 (Middle Ordovician, includes synonymy to 1966).

cf. "*Oistodus*" *venustus* Stauffer. SWEET, THOMPSON and SATTERFIELD, 1975, Pl. 1, fig. 9.

?*Panderodus (Dapsilodus) mutatus* (Branson and Mehl); DZIK, 1976, p. 435, Textfig. 15g-i (Middle Ordovician).

Paroistodus? *mutatus* (Branson and Mehl). ?SWEET, 1979a, p. 18 (no illustrations); NOWLAN and BARNES, 1981, p. 20, Pl. 1, figs. 15-17, 20, 21, 24 (only) (hypotypes viewed: figs. 15, 24 = *e*, 16, 17 = *a*, 20, 21 = *b* elements, respectively; figs. 18, 19 = *Besselodus* (herein); figs. 22, 23 unknown; includes synonymy to 1977); McCRACKEN and BARNES, 1981, p. 88, Pl. 3, figs. 7-9; LENZ and McCRACKEN, 1982, Pl. 2, fig. 10 (only) (= *e* element; figs. 9, 13, 18 herein = *Besselodus*).

cf. *Scabbardella*? *bygdoeyensis* (Hamar). ORCHARD, 1980, p. 26, Pl. 5, figs. 32, 37.

Diagnosis. Apparatus consists of *a, b, c* and *e* (acodiform, distacodiform, and oistodiform) elements. First transition series elements are either uni- or bi-costate and are characterized by a short, laterally flared and posteriorly extended base and broad, laterally compressed cusp. Medial or slightly postmedial costae are prominent and terminate abruptly about mid-base. In proximal region they are sharp, but distal portion of costae on cusp of some elements is rounded. Strongly bicostate *e* element has a long cusp and base that are about the same length. Anterior part of base characteristically curves upward. Element curvature varies from slightly reclined to recurved (*a, b, c* elements) and geniculate (*e* element).

Micro-ornamentation consists of oblique striae centered about costae of *e* element and faint longitudinal striae on distal portion of cusp of *b* element. Lateral faces of other elements and all bases are smooth.

Element morphotypes are further subdivided into: *a-1*, *a-2* (acodiform elements slightly and markedly bowed to acostate side, respectively), and *b-1*, *b-2* (distacodiform elements slightly and markedly bowed, respectively) elements.

Description. All elements have a broad, laterally compressed cusp and a short base that is posteriorly extended. Elements are either uni- or bi-costate. Prominent costae extend from near apex to about mid-base, where they terminate abruptly. Costae are proximally sharp and apically either sharp or rounded. Bases of all elements are smooth, lacking wrinkles or striae. Sharp, posterior edge of cusp extends to aboral margin. Anterior edge is similar on all except *e* elements. Submorphotypes of *a* and *b* elements may represent end members of series of variably bowed elements.

First transition series (*a, b, c*) elements have bases that are laterally flared. Cusp costae are sharp for most of the length in *a-1* and *c* elements and distally rounded in *a-2* and *b* elements. Sharp portion of costae on all elements is directed posteriorly. Cusps of *a-1* and *c* elements lack micro- ornamentation. Faint longitudinal striae are present between costa (or carina) of each face of cusp and posterior margin on *a-2* and *b* elements.

Unicostate *a-1* element is slightly bowed to inner, acostate side and, although it varies in degree of recurvature, it is more recurved than all but the *e* element. Inner face is evenly convex or only slightly carinate. Carina is well developed on elements that have weaker costa. Base is not as flared as in *a-2* element.

Unicostate *a-2* element is markedly bowed to inner, acostate side and is slightly reclined. Costa in distal extremity of cusp is rounded.

Bicostate *b-1* element is slightly reclined and bowed. Rounded costa of each side succeeds sharp costa at about mid-length.

Unicostate *b-2* element is similar to *a-2* element except that it has one costa on each face.

Bicostate *c* element is slightly recurved but not as much as *a-1* element. Costae appear to be sharp for all their length. Sharp distal edge of cusp bifurcates, producing sharp anterolateral edge that extends to basal alae, bounding sharply concave anterior face. Face has subdued costa near inner anterolateral ala.

Bicostate *e* element has cusp and base of about equal length. Anterior part of base curves upward intersecting anterior margin of cusp at about same level as geniculation point. Proximal part of cusp's anterior margin is either gently or strongly curved. Cusp is bowed slightly to inner side. Cusp of some elements is bowed slightly upward. Rounded and erect costae are bounded by striae that are slightly oblique to axis of cusp. Costae do not extend to base and are more subdued and carina-like at either end of cusp.

Remarks. In our collection we did not find elements referable to *Distacodus procerus* Ethington s.s., hence we query all references to this form species and its multielement associates (i.e. the Middle Ordovician reconstruction of *A. mutatus* (Branson and Mehl) in Bergström and Sweet, 1966 and Löfgren, 1978). The illustrated form species (late Middle to Late Ordovician) of Palmieri (1978) is an exception, because its even recurvature is more similar to that of the elements in this study.

Löfgren (1978) illustrated one acontiodiform element that has anterior striae like that found in the Silurian *Dapsilodus obliquicostatus* (Branson and Mehl). None of the elements of *Paroistodus*? sp. is similarly striated. She found no relationship between her Llanvirn *B.*? *mutatus* s.f. and *Oistodus venustus* Stauffer s.f. These two form species were suggested by Barnes and Poplawski (1973) to be part of the same apparatus. Some of Löfgren's (1978) acodiform and acontiodiform elements have numerous longitudinal lateral costae similar to some *b* elements of *Scabbardella* species illustrated herein. The bases of the oistodiform elements illustrated by Bergström and Sweet (1966) and Löfgren (1978), *O. venustus* and *Drepanoistodus*? *venustus*, respectively, are relatively short compared with the cusps. Many of the *e* elements in this study have a cusp and base that are subequal in length.

The Maysvillian-Richmondian *"A." mutatus* of Sweet et al. (1975) is more similar to some *a* elements of this study's *Scabbardella* subspecies than it is to the same element of *A. mutatus* (sensu Bergström and Sweet, 1966) or *P.*? sp. A, particularly in having a base that is not extended posteriorly. Their (1975) *"O." venustus* element, however, has a long base, like the *e* elements described here.

The distacodiform element of the Llanvirn *Panderodus (Dapsilodus) mutatus* of Dzik (1976) is similar to *D. procerus* s.f., except that the base is shorter. The acodiform element (ibid. , Textfig. 15i) is similar to the *a* element described in this study.

The elements of Orchard's (1980) *Dapsilodus mutatus* have oblique striae on the basal margin and thus are not equated with *P.*? sp. A. His generic assignment may be correct as the Silurian type species of *Dapsilodus* also has obliquely striated acodiform and distacodiform (*a, b, c*) elements and is not associated with *e* (oistodiform) elements. Orchard's (1980) *Drepanoistodus*? *venustus*? includes a scandodiform element that he tentatively referred to *Scandodus brevibasis* Serpagli s.f. This scandodiform element is similar to an acodiform element recovered herein. Wang et al. (1983) concur with Orchard's (1980) reconstruction of *D.*? *venustus*?. *Scabardella*? *bygdoeyensis* (Hamar) of Orchard (1980), comparable to the *b* elements described in this paper, occurred in only one sample, that also contained a few elements of *D.*? *venustus*?. The outlines of *Distacodus bygdoeyensis* s.f. and *Acodus inornatus* Ethington s.f. from the Middle Ordovician material described by Hamar (1966) are comparable with those *b* and *a* elements, respectively, in this study. In both of Hamar's (1966) forms, one costa extends from the apex to the aboral margin, a characteristic more similar to *Scabbardella* than to *Paroistodus*? (both genera sensu this study). *Acontiodus semisymmetricus* Hamar s.f. has costae that are similar to *Paroistodus*?.

Weyant's (1968) *Distacodus mucrus* Winder s.f., *D.* sp. 1 s.f., and *Acodus* sp. 1 s.f. are similar to *Paroistodus*? sp. A elements, especially with regard to the flared, short and posteriorly extended base and wide, suberect to recurved cusp. We have viewed the type material of Winder (1966) and found his *D.* sp. cf. *D. procerus* s.f. and *D. mucrus* s.f. comparable to this study's *b* and *c* elements.

Winder's (1966) *D.* sp. cf. *D. procerus* s.f. has an erect cusp like a few of the *b* elements of *P.*? sp. A. Other *b* elements from Avalanche Lake are more recurved. *D. mucrus* s.f. is slightly more recurved than this study's *c* element, but both have short, posteriorly extended bases, strong costae and basal anterior alae.

We do not assign a trivial name to this species even though there are elements with similarities to *Distacodus mucrus* s.f. and *D. bygdoeyensis* s.f. Both are Middle Ordovician and, more importantly, not all of the other elements are present in the original studies. If *P.*? sp. A is not conspecific with Sweet's (1979a) reconstruction of *P.*? *mutatus* then Winder's (1966) trivial name is a possible senior synonym.

Our interpretation of the apparatuses of *P.*? sp. A and those elements discussed above is summarized below. *Paroistodus*? sp. A is composed of *a, b, c* and *e* elements. The combined assemblage of Bergström and Sweet (1966), *A. mutatus* and *O. venustus* (i.e. *P.*? *mutatus* of Sweet, 1979b), has some similarities. A *c* element has not been identified in this latter association, but it may be represented by a symmetrical distacodiform element. *Acodus*? *mutatus* of Löfgren (1978) may be combined with *Drepanoistodus*? *venustus*, but their numerical relationship in her study does not support this suggestion. The acontiodiform elements of *A.*? *mutatus* are composed of both asymmetrical and symmetrical elements, thus the apparatus consists of *a, b* and *c* elements. The combined *Scabbardella*? *bygdoeyensis* and *Drepanoistodus*? *venustus*? of Orchard (1980) may be equivalent to *P.*? sp. A of this study. *Dapsilodus mutatus* of Bergström (1978) and Orchard (1980) are probably *Scabbardella altipes* (Henningsmoen) (*a, b, c, e* elements) and a species of *Dapsilodus* (*a, b, c* elements), respectively. *Paroistodus*? *mutatus* of Sweet (1979a) and *P.*? sp. A of this study may belong to the same genus (possibly unnamed) but are clearly not conspecific.

Löfgren (1978) suggested a relation between her *A.*? *mutatus* and *Protopanderodus*. We believe that there is a greater alliance between the genera *Acodus*? (sensu Löfgren, 1978), *Besselodus* (herein), *Dapsilodus* and *Paroistodus*? than with genera such as *Protopanderodus*, *Scabbardella* and *Staufferella* (see also generic remarks).

Types. Figured specimens, GSC 80298-80308.

Genus *Phragmodus* Branson and Mehl, 1933

Type species. *Phragmodus primus* Branson and Mehl, 1933.

Phragmodus undatus Branson and Mehl

Plate 10, figures 1-3, 6, 7

Phragmodus undatus BRANSON and MEHL, 1933, p. 115, 116, Pl. 8, figs. 22-26.

Multielement

Phragmodus undatus Branson and Mehl. NOWLAN and BARNES, 1981, p. 21, Pl. 4, figs. 1-11, 13 (contains complete synonymy to 1977); PALMIERI, 1978, p. 24, Pl. 4, figs. 18-23, Pl. 6, figs. 2-5, 7-12, 15, 16, Pl. 7, figs. 1-8, 11, 12; McCRACKEN and BARNES, 1981, p. 88, Pl. 3, figs. 29-33; NOWLAN, 1981b, p. 278, 282, Pl. 1, figs. 18, 20-24, Pl. 3, fig. 4.

Remarks. Nowlan and Barnes (1981) have reviewed the nature of this species recently and their concept is followed herein.

Types. Hypotypes, GSC 80309-80313.

Phragmodus? sp. A Nowlan and McCracken

Plate 10, figures 4, 5

?*Phragmodus* n. sp. Barnes, 1974, p. 237, Pl. 1, fig. 20.

?*Phragmodus undatus* Branson and Mehl. PULSE and SWEET, 1960, p. 257, 258, Pl. 37, figs. 18, 19 only.

Description. Two specimens are assigned to this taxon. *Phragmodiform* (*c*?) element has a rounded anterior margin with weak posterolateral costae present on base at the level at which posterior process originates. Costae become less distinct on cusp and disappear toward aboral margin. Cusp is slender and subrounded; reclined posteriorly. Base is extended downward into an anticusp. Posterior process is arched and bears one laterally compressed denticle, which is much larger than the cusp, flanked by a small, compressed denticle on each side. Process is low near junction with base. Basal cavity is shallow to slit-like beneath process and not visible in cusp due to black colour of specimens.

Asymmetrical (*b*? or *e*?) element is similar in size and preservation to *c*? element. Cusp is laterally compressed, reclined and bowed markedly to inner side so that its inner face forms an angle of just over 90 degrees with inner face of base. Posterior edge curves smoothly into oral edge, which bears a single, small, laterally compressed denticle. Anterior edge of base is sharp and extended downward as an anticusp. Oral edge is also directed downward, but does not extend as far as anterior edge. Inner face of base is flared; outer face is smoothly convex. Basal cavity is shallow beneath anterior and posterior extensions, not visible within base.

Remarks. These two unusual elements are grouped together because of their co-occurrence, size, style of preservation and similar basal geometry. The *c*? element is most like *a-d* elements of *Phragmodus*, but cusp and denticles are more rounded and the aboral surface is much wider. The *b*? or *e*? element is atypical of *b* or *e* elements of *Phragmodus*, which are normally phragmodiform and oistodiform, respectively. The generic assignment is thus questionable.

The dense black preservation of these elements and the nature of the basal cavity suggests that they may be fibrous conodonts, although this cannot be confirmed.

The phragmodiform (*c*) element is similar in some respects to that illustrated by Barnes (1974) as *Phragmodus* n. sp. from the Thumb Mountain Formation of Bathurst Island in the Canadian Arctic Archipelago. His specimen has two, more compressed denticles between the cusp and major denticle, rather than one, and the denticles are more compressed than on the specimen from Avalanche Lake. It is similar in having lateral costae and a broad aboral surface.

Two elements illustrated as 'robust growth stages' of *P. undatus* by Pulse and Sweet (1960, p. 264) are also similar to *Phragmodus*? sp. A in being rounded and having few denticles between the cusp and major denticle.

Types. Figured specimens, GSC 80314-80315.

Genus *Plectodina* Stauffer, 1935a

Type species. *Prioniodus aculeatus* Stauffer, 1930.

Plectodina aculeatoides Sweet?

Plate 10, figures 8-15, 17, 18

?*Plectodina aculeatoides* SWEET, 1979b, p. 65, Fig. 8 (18, 19, 22-26).

Remarks. Sweet (1979b) erected this taxon for elements comprising an apparatus that he considered very similar to *P. aculeata* (Stauffer). *Plectodina aculeatoides* is distinguished from *P. aculeata* by the presence of a cyrtoniodiform rather than a prioniodiniform *e* element. Unfortunately, the type material is rather poorly preserved and a detailed description was not provided. Our collections contain sparse but relatively well preserved specimens that may be assignable to *P. aculeatoides*.

Recovery of dichognathiform elements in two samples that lack elements of *Phragmodus* prompted a search for possible associated elements. The samples also contain abundant elements of *P. tenuis* (Branson and Mehl) and *Aphelognathus politus* (Hinde), which made the search difficult. Identification of distinctive *b* and *c* elements proved impossible, but subtly different *a* (cordylodiform) and *e* (cyrtoniodiform) and distinctive *g* elements are recognized as probable associates of the dichognathiform *f* elements.

The *a* and *e* elements assigned herein differ from those of *P. tenuis*, and its closely similar associate *A. politus*, in having a narrower angle (about 90 degrees) between the aboral margin of the posterior process and the posterior margin of the downwardly extended portion of the base. This distinction is more consistent among the *e* than the *a* elements. In other respects these elements of *P. aculeatoides*? are indistinguishable from those in *P. tenuis*.

Dichognathiform (*f*) elements are quite distinctive. They are strongly arched, with a long posterior process that bears up to seven posteriorly reclined, compressed denticles. Anterolateral process is only slightly inwardly directed so that it forms an angle of about 160° with the posterior process. It bears up to four denticles that are more discrete than those of the posterior process. Cusp is reclined and laterally compressed, with sharp posterior and anterior edges. The element is more strongly arched and denticles are more discrete than dichognathiform elements of *P. undatus*.

Ozarkodiniform (*g*) elements are distinguished from those of *P. tenuis* in having a much longer, and inwardly deflected posterior process, a longer, more slender cusp and a more arched aboral outline. In these respects it closely resembles elements that Webers (1966) assigned to *Ozarkodina obliqua* (Stauffer), a component of *P. aculeata*. The type material (Stauffer, 1930) and most subsequent reports of *P. aculeata* are based on poorly preserved material.

The elements described and discussed above are tentatively included in *P. aculeatoides* because of the similarity of components within the apparatus. Certainty of identification is precluded because of the lack of an original description and because of the fragmentary nature of the type material.

Since no distinctive *b* or *c* elements are identified for this apparatus, it is presumed that some of those listed in Table 1 as *P. tenuis* may belong to *P. aculeatoides*. This is reflected in the anomalously large number of *b* and *c* elements of *P. tenuis* shown for the 10 m sample from Section AV1 (see Table 1).

Types. Figured specimens, GSC 80316-80324.

Plectodina florida Sweet

Plate 10, figures 16, 19-22

Multielement

Plectodina bidentata NOWLAN and BARNES, 1981, p. 21, 22, Pl. 3, figs. 1-8.
Plectodina florida SWEET, 1979b, p. 65, 66, fig. 8 (18, 19, 22-26); McCRACKEN and BARNES, 1982, p. 1482, Pl. 1, figs. 7, 11-14, 16-18.

Remarks. The elements of this species have been described in detail by Sweet (1979b) and Nowlan and Barnes (1981). Only a few specimens have been recovered, but representatives of all except the *c* element are present.

Types. Hypotypes, GSC 80325-80329.

Plectodina tenuis (Branson and Mehl)

Plate 11, figures 1-8, 10-12, 14, 15

g element

Ozarkodina tenuis BRANSON and MEHL, 1933, p. 128, Pl. 10, figs. 19-21, 23.

Multielement

Plectodina tenuis (Branson and Mehl). SWEET, 1979b, p. 66, fig. 8 (1-5, 7); NOWLAN and BARNES, 1981, p. 22, Pl. 4, figs. 12, 14-16, 20, 21 (contains synonymy through 1978); LENZ and McCRACKEN, 1982, Pl. 1, figs. 9, 10; McCRACKEN and BARNES, 1982, p. 1482, Pl. 1, figs. 1-6, 8-10; SWEET, 1983, Pl. 3, figs. 10, 14-16, 18, 19.

Remarks. As noted in Nowlan and Barnes (1981), it has been shown by Tarrant (1977) that *Prioniodus furcatus* Hinde s.f. is part of the apparatus of *Aphelognathus politus* and not part of a species of *Plectodina*. Furthermore, it is not an element of an *Oulodus* species, as suggested by Sweet (1979b). Thus, elemental components of *P. tenuis* are those on which Sweet et al. (1975) based their discussion of *P. furcata tenuis*. Sweet (1979b) renamed the assemblage *P. tenuis tenuis* and distinguished it from *P. tenuis inclinata*. A detailed synonymy of the components of the apparatus of *P. tenuis* has been provided by Nowlan and Barnes (1981).

A large number of elements assignable to *P. tenuis* have been recovered in this study and this permits some discussion of the variability within individual elements. In the lower part of its range in the Avalanche Lake sections, this species co-occurs with *Aphelognathus politus* and *Plectodina aculeatoides*?; the difficulty of distinguishing some elements of these apparatuses is discussed in the remarks under those taxa.

Some *a* elements of *P. tenuis* are well preserved, so the posterior process is complete. There are up to seventeen denticles on the posterior process, which can be up to 1.3 mm in length. The downwardly projecting lip of the basal margin flanking the basal cavity is variably developed on *a* elements; some have a pronounced basal extension, whereas in others the basal outline curves more or less evenly from the anterobasal corner into the posterior process.

The *b* element is characterized by one short and one long lateral process. The longer process is recurved posteriorly and the degree of recurvature is highly variable. The short process is usually straight but may also be recurved anteriorly. Thus, the degree of asymmetry is highly variable.

As noted by McCracken and Barnes (1982) the *e* element has an anterior margin that is either anteriorly extended and acute or more rounded. In this study, most specimens have a concave anterior outline of the base and an anteriorly extended, acute anterobasal corner.

The remaining elements are comparable to those previously described.

Types. Hypotypes, GSC 80330-80341.

Genus *Plegagnathus* Ethington and Furnish, 1959

Type species. *Plegagnathus nelsoni* Ethington and Furnish, 1959.

Plegagnathus nelsoni Ethington and Furnish

Plate 11, figures 9, 13, 16, 17, 19

Costate (*a-c*) elements

''*Cordylodus*'' *robustus* Ethington and Furnish. NOWLAN and BARNES, 1981, p. 12, Pl. 7, figs. 16-19 (contains synonymy to 1980); McCRACKEN and BARNES, 1981, p. 75, Pl. 3, fig. 22; NOWLAN, 1981b, Pl. 1, Fig. 25.

Acostate plegagnathiform elements

Plegagnathus dartoni (Stone and Furnish). NOWLAN in BOLTON and NOWLAN, 1979, p. 21, Pl. 8, figs. 2?, 3; McCRACKEN and BARNES, 1981, p. 89, Pl. 3, Fig. 24.

Plegagnathus nelsoni ETHINGTON and FURNISH, 1959, p. 544, 545, Pl. 73, figs. 2, 3; ?HARRIS, BERGSTRÖM, ETHINGTON, and ROSS, 1979, Pl. 5, Fig. 5; ?NOWLAN in BOLTON and NOWLAN, 1979, p. 21, Pl. 8, Fig. 1; McCRACKEN and BARNES, 1981, p. 89, Pl. 3, fig. 24.

Multielement

Plegagnathus dartoni (Stone and Furnish); NOWLAN and BARNES, 1981, p. 12, Pl. 7, figs. 16-19.

Plegagnathus nelsoni Ethington and Furnish; SWEET, 1979b, p. 67, Fig. 7 (19, 26, 27, 32, 33), (includes synonymy through 1978).

Remarks. Sweet (1979b) revised the genus *Plegagnathus* to include two species, each with an apparatus comprising five elements. In his study, *Plegagnathus dartoni* is characterized by a costate plegagnathiform element with needle-like denticles, that is bowed to the furrowed side and that has its anterobasal corner situated beneath the proximal one-third of the posterior process. As a result, all previous reports of *P. dartoni,* except the original type, were included by Sweet (1979b) in his revised account of *P. nelsoni.* The main distinguishing character of *P. nelsoni* is that the plegagnathiform element that is bowed to the furrowed side has the anterobasal corner beneath, or posterior to, the midpoint of the posterior process.

Re-examination of all samples from the Vauréal Formation, Anticosti Island, reported by Nowlan and Barnes (1981) shows that all specimens fall within *P. nelsoni,* as defined by Sweet (1979b). Nowlan and Barnes (1981) considered *P. nelsoni* s.f. and *P. dartoni* s.f. as synonyms. Re-examination of the figured types of McCracken and Barnes (1981) from the Ellis Bay Formation, Anticosti Island reveals that they also fall within *P. nelsoni.*

All specimens of *Plegagnathus* reported by Bolton and Nowlan (1979) have also been examined. The element referred to *P. nelsoni* s.f. (ibid. , Pl. 8, fig. 1) bears fine needle-like denticles typical of Sweet's (1979b) revised *P. dartoni,* but it is bowed to the unfurrowed side and is, therefore, not diagnostic. One of the elements referred to *P. dartoni* s.f. (ibid., Pl. 8, fig. 2) is bowed to the furrowed side and may represent an element of revised *P. dartoni,* but the anterobasal corner is broken so that its full extent is not known. The other specimen referred by Bolton and Nowlan (1979) to *P. dartoni* s.f. and another unfigured specimen from the same Aberdeen Lake outlier are both referable to *P. nelsoni* as revised by Sweet (1979b). It is therefore possible that a mixture of the two species is represented by the four Aberdeen Lake specimens.

The form species *Cordylodus robustus* was considered by Sweet (1979b) as the ramiform complex of *Plegagnathus.* This possibility was also put forward independently by Nowlan and Barnes (1981) and that reconstruction is followed herein.

The element figured as *P. nelsoni* by Harris et al. (1979) is broken, but may be a representative of *Pseudobelodina vulgaris ultima* Sweet.

The validity of species separation using only plegagnathiform elements bowed to the unfurrowed side may be questioned. All ramiform elements (= *C. robustus* s.f.) of the two species are identical and plegagnathiform elements that are bowed to the unfurrowed side may have anteriorly situated anterobasal corners in both species. The element that is bowed to the furrowed side and has an anteriorly situated anterobasal corner may simply be a rare component of the apparatus of a single species. Unfortunately, specimens of *Plegagnathus* are always rare.

Denticle width, although cited in the diagnoses for the species, is also considered by Sweet (1979b, p. 67) to be a criterion that "must be used with caution in separating the species". Re-examination of collections cited above has shown that denticle width is indeed an uncertain criterion for species separation.

Types. Hypotypes, GSC 80342-80346.

Genus *Protopanderodus* Lindström, 1971

Type species. *Acontiodus rectus* Lindström, 1955.

Protopanderodus liripipus Kennedy, Barnes and Uyeno

Plate 11, figures 18, 20

Multielement

Protopanderodus liripipus KENNEDY, BARNES and UYENO, 1979, p. 546-550, Pl. 1, figs. 9-19 (includes synonymy through 1979); AN, 1981, Pl. 3, fig. 29; NOWLAN, 1981b, p. 14, Pl. 5, figs. 6-8; WANG and WANG, 1981, Pl. 1, fig. 4.

cf. *Protopanderodus* cf. *liripipus* Kennedy, Barnes and Uyeno. ORCHARD, 1980, p. 24, Pl. 4, figs. 27, 33.

cf. *Protopanderodus* cf. *P. liripipus* Kennedy, Barnes and Uyeno. NOWLAN, 1981a, Pl. 3, fig. 23; NOWLAN, 1983, p. 667, Pl. 3, figs. 12, 15.

Remarks. Only a few elements of this species were found and all are asymmetrical to symmetrical protopanderodiform (*b* and *c*) elements. One of these (Pl. 11, fig. 18) appears to have a broken cusp that has been healed by subsequent phosphate deposition. No scandodiform elements have been recovered.

Types. Hypotypes, GSC 80347-80348.

Genus *Pseudobelodina* Sweet, 1979b

Type species. *Belodina kirki* Stone and Furnish.

Remarks. Sweet (1979b) indicated the presence of four different element types in species of this genus. He regarded those bowed to the unfurrowed side as a symmetry transition series (Sa, Sb, Sc) and those bowed to the furrowed side as P? elements. Herein, we refer the elements of the transition series to the *a* (usually unicostate), *b* (asymmetrical bicostate) and *c* (symmetrical bicostate) positions and the element bowed to the furrowed side as *e*? elements. We prefer to regard the latter as *e*? elements because there are several simple cone genera that are composed of *a, b, c* and *e* elements and none as yet known that is composed of *a, b, c* and *f* or *g* (=P) elements.

Some species are only tentatively assigned to this genus: *P.* ? *dispansa, P.* ? *obstusa* and *P.*? n. sp. A. The reason for questioning the assignment of *P.*? *obstusa* and *P.*? n. sp. A is that they are represented by a single type of element only. The doubt concerning the assignment of *P.* ? *dispansa* is based on the fact that more than four types of element are present in the apparatus. *Pseudobelodina*? *dispansa* may represent a separate genus (see discussion under species and the generic discussion for *Zanclodus* n. gen.).

Pseudobelodina cf. *P. adentata* Sweet

Plate 12, figures 1-7

cf. *Eobelodina* sp. BARNES, 1977, p. 106, Pl. 4, fig. 13.
cf. *Eobelodina* n. sp. B McCRACKEN and BARNES, 1981, p. 77, Pl. 3, fig. 28.

<u>Multielement</u>

cf. *Pseudobelodina adentata* SWEET, 1979b, p. 68, Fig. 5(23), Fig. 6 (2, 4, 10, 14).

Remarks. Relatively few specimens have been recovered and these differ slightly, yet consistently, from the type material. The elements that Sweet (1979b) referred to the Sc position (*a* position of this paper) have smooth inner faces and a rounded outer lateral costa. None of the elements recovered herein has a completely smooth inner face, most have an inwardly flexed anterior margin (or a weak anterolateral costa) and a convex outer furrowed face. Elements of this morphology are referred to the *a* position herein because *b* elements have relatively pronounced costae according to the original definition. Our *a* elements also differ from those of the type material in that the heel lacks a markedly concave upper edge.

A single *b* element has been recovered and it is the only specimen with a well developed outer anterolateral costa. In this regard, the specimens reported as *Eobelodina* sp. s.f. by Barnes (1977) and *Eobelodina* n. sp. by McCracken and Barnes (1981) have been examined and they are closely similar to the *b* elements described by Sweet (1979b).

A single symmetrical (*c*) element has been recovered that conforms closely with Sweet's (1979b) Sa element, except that the furrow is located farther from the posterior margin of the cusp. A similar condition is noted in *a* elements where the furrow may be subcentrally situated. None of Sweet's (1979b) illustrated specimens showing the furrowed side (except his P? element) have a preserved cusp. The elements illustrated by Barnes (1977) and McCracken and Barnes (1981), which are considered comparable with *P. adentata,* have a more posteriorly situated furrow on the cusp than do specimens from Avalanche Lake.

Our collections lack specimens that are bowed to the furrowed side, which Sweet (1979b) assigned tentatively to the P position.

Sweet (1979b, p. 68) included the presence of narrow, vertical trains of white matter in the "anterior" (presumably distal) portion of the heel in the diagnosis of this species. All our specimens are dark (CAI 4 1/2) and thus do not reveal the presence of white matter trains. Recognition of this species with certainty in rocks with a high degree of thermal alteration is impossible.

Types. Figured specimens, GSC 80349-80353.

Pseudobelodina? *dispansa* (Glenister)

Plate 12, figures 8-26

Belodus dispansus GLENISTER, 1957, p. 729, 730, Pl. 88, figs. 14, 15.

<u>Multielement</u>

Belodina dispansa (Glenister). HARRIS, BERGSTRÖM, ETHINGTON, and ROSS, 1979, Pl. 5, fig. 8; NOWLAN and BARNES, 1981, p. 12, Pl. 8, figs. 6, 7, 10, 11; McCRACKEN and BARNES, 1981, p. 75, Pl. 3, figs. 19-21; NOWLAN, 1981b, p. 278, Pl. 1, fig. 26.
Pseudobelodina dispansa (Glenister). SWEET, 1979b, p. 68, 69, Fig. 5 (6, 18), Fig. 6 (1, 6, 7, 8) (includes synonymy through 1978); LENZ and McCRACKEN, 1982, Pl. 2, figs. 11, 14; NOWLAN, 1983, p. 660, Pl. 3, figs. 7, 8.

Remarks. Sweet (1979b) assigned elements previously identified by several authors as *Belodina dispansa* to his new genus *Pseudobelodina.* He argued that these elements should be placed in *Pseudobelodina* because the four different element types characteristic of the genus were recognizable. Sweet (1979b) provided a diagnosis and a brief discussion, but no description. In his discussion (*ibid.*, p. 68) he stated that the three elements of the symmetry transition series (Sa, Sb, Sc) are "bowed, commonly very markedly, to the furrowed side". This statement contradicts the generic diagnosis of *Pseudobelodina,* which states that the three elements should be bowed to the unfurrowed side. Sweet (1979b) considered that elements bowed to the furrowed side might represent P elements.

In our collections there are six different types of element present in the apparatus. These are assignable to three major groups based on type of bowing: (1) elements bowed to the unfurrowed side (Pl. 12, figs. 8, 9, 11, 12, 14, 15); (2) elements bowed to the furrowed side Pl. 12, figs. 16-18, 20, 21, 23-26; and (3) unbowed elements Pl. 12, figs. 10, 13, 19, 22.

(1) Elements that are bowed to the unfurrowed side are bicostate. On strongly bowed elements, the costa on the inner face is subdued and extends only a short distance on to the base, whereas the costa on the outer, furrowed side is more prominent. In less strongly bowed elements, the inner and outer costae are of about equal prominence. The costae may be symmetrically or asymmetrically situated with respect to one another. There is a tendency for the heel to be more prominent on less strongly bowed elements (Pl. 12, fig. 11).

(2) Elements that are bowed to the furrowed side are either unicostate or bicostate. Unicostate elements usually have a prominent costa on the outer, unfurrowed face but, more rarely, the costa is on the inner, furrowed face. Bicostate elements have a costa on both inner and outer faces. In less strongly bowed elements, the costa on the outer, unfurrowed face is less prominent and the heel is better defined.

(3) Unbowed elements tend to be broader, shorter and have a well defined heel. Two types of unbowed elements occur: those with a smooth, furrowed side and a weak anterolateral costa on the other side; and those with an anterolateral costa on each side that are subsymmetrically to symmetrically situated with respect to one another. A few unbowed elements that have a smooth furrowed side, a median costa on the other side, and only two denticles are referred to *P.* ? cf. *P.* ? *dispansa* (see below).

The recognition of at least six element types in the apparatus of this species casts doubt on the generic assignment. Another conflict with the generic diagnosis arises from the variability of denticle number from 4 to 9 per specimen. In his discussion of the original diagnosis (Sweet, 1979b, p. 68), Sweet noted that elements of *Pseudobelodina* "show a rather remarkable constancy in denticle number, which is more or less independent of size." The variability noted herein for the element of *P.* ? *dispansa* can be observed in Sweet's (1979b) illustrations of the taxon.

We have refrained from assigning an element position to the six or more different element types because of the obvious complexity of the apparatus. Although the elements have been grouped on the basis of bowing direction, there are some other generalizations that can be made that transcend these groups. In general, it can be observed that the less bowed an element is, the broader it is and the more pronounced its heel is. Bowed elements tend to be slender and lack a pronounced heel. In addition, both left-and right-handed element types are present.

Some speculation can be made about the position of element types. An unbowed unicostate element may be considered as the *a* element, because all elements bowed to the unfurrowed side are bicostate, and presumably *b* elements. Unbowed bicostate elements are the most symmetrical elements and probably occupy the *c* position. This interpretation of unbowed elements and those bowed to the unfurrowed side is similar to Sweet's (1979b), except that he notes that Sc (*a*) elements are bowed. It is noted that the elements suggested here as being in the *b* position are by far the most common elements.

In addition there are three different types of element bowed to the furrowed side: unicostate elements with costa on inner side (*e*?), unicostate elements with costa on outer side (*f*?) and bicostate, usually symmetrical elements (*g*?). All these elements are rare in our collections. These assignments are speculative because the significance of bowing direction is not well understood in terms of the geometry of conodont apparatuses.

It may well be that *P.* ? *dispansa* belongs to a separate genus (see discussion under *Zanclodus levigatus* n. gen. n. sp.).

Types. Figured specimens, GSC 80354-80363.

Pseudobelodina? cf. *P.* ? *dispansa* (Glenister)

Plate 13, figures 1-4

Multielement

cf. *Pseudobelodina dispansa* (Glenister). SWEET, 1979b, p. 68, 69, Fig. 5, (6, 18), Fig. 6 (1, 6-8).

Remarks. A few small, broad elements that are unbowed and bear only two denticles are assigned to this taxon. The furrowed side is smooth and the opposite side bears a prominent costa that originates near the aboral margin and is located subcentrally on the anterior portion of the base. It curves evenly across the base to occupy a central or slightly posterior position on the cusp. Cusp is broad and sharp-edged. The denticles are unequally proclined and of unequal size; the one next to the cusp is broader and more proclined, that next to the heel is narrower and less proclined.

These elements are similar to unbowed unicostate (*a*?) elements of *P.* ? *dispansa* but the costa is more centrally situated and the denticles are fewer. They share a similar striation pattern with *P.* ? *dispansa* in that striae are concentrated on the cusp, around the furrow and beneath the denticles on the unfurrowed side. They are small and may represent early growth stages of unbowed elements of *P.* ? *dispansa,* however, they are sufficiently distinctive to warrant separation from that species. They are also similar to similiform elements of *Parabelodina denticulata* Sweet but the presence of a costa on the outer side excludes them from that species. Furthermore, none of the other elements of *P. denticulata* have been recovered.

Types. Figured specimens, GSC 80364-80365.

Pseudobelodina inclinata (Branson and Mehl)

Plate 13, figures 5-20, Plate 14, figures 1-6

Belodus inclinatus BRANSON and MEHL, 1933, p. 125, 126, Pl. 10, fig. 24.

Multielement

Pseudobelodina inclinata (Branson and Mehl). SWEET, 1979b, p. 69, Fig. 6 (11, 15, 16, 22), (includes synonymy through 1979).

Remarks. Sweet (1979b) noted that *P. inclinata* and *P. kirki* (Stone and Furnish) are closely related and that isolated elements may be difficult to assign to species. The distinguishing features for the above species are the number of denticles and the prominence of costae. Elements of *P. inclinata* generally have fewer denticles and weaker costae than the equivalent elements of *P. kirki.* Fully developed elements have only three or four, and at least five denticles in *P. inclinata* and *P. kirki,* respectively. There may be an overlap in denticle number since Sweet (1979b, p. 69) noted that none of the Sb and Sa (=*b* and *c*) elements of *P. inclinata* has more than five denticles.

The *a* elements differ from those of *P. inclinata* of Sweet (1979b) in that they lack a faint, rounded inner costa on the inner face of the cusp. One element (Pl. 13, fig. 6) has a short faint carina on the outer face of the base, the other element (Pl. 13, fig. 17) has a faint carina on the inner face of the cusp. These differences are not regarded as significant. All *a* elements are bowed and most have three or four denticles. The one exception (Pl. 13, fig. 17) has five denticles, which is suggestive of *P. kirki* since Sweet (1979b, p. 69) stated that none of these elements of *P. inclinata* have more than four denticles. As the number of denticles on some elements of *P. kirki* can vary depending on size (Sweet, 1979b p. 69) we accept a similar variability in *P. inclinata* and regard this five-denticled form as a large, rare element of *P. inclinata.* Furthermore, the faint inner carina found on one element may be equivalent to the faint rounded costa of this element of *P. inclinata;* the equivalent element of *P. kirki* is acostate.

The *b* elements vary in that they have an outer anterolateral costa that is relatively faint or prominent on slightly (Pl. 13, fig. 8) and markedly bowed (Pl. 13, fig. 10) elements, respectively. In both varieties, the costa is not as well developed as that of the inner face. Both costae on this element of *P. kirki* are more prominent. One of the elements (Pl. 13, figs. 7, 8) has five denticles, the maximum number according to Sweet (1979b); another has two denticles that are fused. Small elements (Pl. 13, figs. 12, 13) have relatively long heels and denticles that are spatulate and rounded, characters that are found on elements of *P. quadrata* Sweet. This latter species differs in that its elements have a maximum of two denticles (as defined by Sweet, 1979b) and anterolateral costae that are not as close to the anterior margin as they are in these small specimens.

Small *c* elements have three proclined denticles, larger ones have four. The anterolateral costae are equidistant from the anterior margin and are equally developed. The costae are not as well developed as they are in the same element of *P. kirki*. Most *c* elements are only slightly bowed to the unfurrowed side. One large element (Pl. 13, figs. 18, 19), with five denticles, is nearly straight but has a lateral twist that is suggestive of *P. torta* Sweet. The *c* elements of *P. torta* differ in that they have three denticles.

Elements that are bowed to the costate, furrowed side that Sweet (1979b) considered as P? elements, have three or four denticles; these are assigned to the *e*? position herein. The outer side of this element is smooth. The costa is not as well developed as it is in the same element of *P. kirki*.

All elements have fine basal wrinkles or striae and longitudinal striae between the furrow and the base of the denticles. One *a* element (Pl. 13, figs. 5, 6) has a curious basal infilling. This material is clear, rather than dark like the rest of the element, and is striated with some of the striae overlapping the aboral margin.

Types. Hypotypes, GSC 80366-80376.

Pseudobelodina? *obtusa* Sweet

Plate 14, figures 12-24

Pseudobelodina? *obtusa* SWEET, 1979b, p. 70, Fig. 6(2); SWEET, 1983, Pl. 3, Fig. 13.

Remarks. Sweet (1979b) erected this species for a single type of element that is bowed to the furrowed side. The Avalanche Lake specimens permit a few additional comments to Sweet's (1979b) description. On several of our specimens, a weak costa is present on the outer, unfurrowed side (e.g., Pl. 14, figs. 13, 21). The costa is most prominent at the basal margin; it is situated near the anterior margin and parallels it to the point of recurvature, where it converges with the anterior margin and disappears. In some specimens the costa is replaced by a weak carina; in others neither a costa nor a carina is present.

All specimens are strongly striated longitudinally. The low node-like denticles on the posterior margin noted by Sweet (1979b) are present on most specimens, but in some they are reflected merely as an irregular posterior margin. White matter trains, a character of the species, are not visible on our black specimens.

Sweet (1979b), p. 70) noted that the only possible associated element in *P.*? *obtusa* may be a "group of smooth- sided simple cones, bowed to the unfurrowed side, which have in their posterior margins trains of white matter that may indicate incipient denticulation," but he did not illustrate them. We have referred a few elements to *Pseudobelodina*? n. sp. A that may be a part of the apparatus of *P.*? *obtusa* (see remarks under *P.*? n. sp. A).

Types. Hypotypes, GSC 80380-80385.

Pseudobelodina quadrata Sweet

Plate 14, figures 7-11

Belodina sp. 1 WEYANT, 1968, p. 39, Pl. 2, figs. 4a,b.
Belodina n. sp. 1 BARNES, 1977, p. 105, 106, Pl. 3, fig. 12.

Multielement

Pseudobelodina quadrata SWEET, 1979b, p. 70, Fig. 5 (15).

Remarks. Elements of this species are characterized by one or two distinctive, subrectangular denticles. Sweet (1979b) placed the element illustrated as *Belodina* n. sp. 1 by Barnes (1977) in synonymy; restudy of the specimen shows that it is a *b* element with two denticles. Barnes' (1977) description includes elements with two to four denticles, but by Sweet's (1979b) definition, elements with more than two denticles should be excluded from *P. quadrata*.

The rare elements recovered in this study all have one denticle. A single fragmentary element that may occupy the *a* position has been recovered; only the heel and proximal portion of a denticle are preserved (Pl. 14, figs. 9, 10). Costae are absent from the lateral faces of this specimen and its fragmentary nature does not allow recognition of bowing direction. The *b* element (Pl. 14, fig. 11) is bowed to the unfurrowed side. It has an inner costa that is more prominent and is situated closer to the anterior margin than the outer costa. The *b* element differs from that of Sweet (1979b) in that the cusp is nearly erect rather than proclined. The elements illustrated by Weyant (1968) and Barnes (1977) are also nearly erect. The *c* element (Pl. 14, Figs. 7, 8) is unbowed and has costae that are equally developed and symmetrically placed.

Elements recovered herein also differ from Sweet's (1979b) holotype in having denticles that are more distinctly separated from the heel.

Types. Hypotypes, GSC 80377-80379.

Pseudobelodina vulgaris vulgaris Sweet

Plate 15, figures 1-12

Multielement

Belodina profunda (Branson and Mehl). HARRIS, BERGSTRÖM, ETHINGTON, and ROSS, 1979, Pl. 5, fig. 6; NOWLAN *in* BOLTON and NOWLAN, 1979, p. 18, Pl. 8, figs. 8, 9; NOWLAN and BARNES, 1981, p. 12, Pl. 7, figs. 1?, 2-5, 7-9 (only), (Pl. 7, figs. 6, 12 = *P. vulgaris ultima* Sweet); McCRACKEN and BARNES, 1981, p. 75, Pl. 3, figs. 13-15.

"*Belodina*" *profunda* (Branson and Mehl). NOWLAN, 1981b, p. 278, Pl. 1, fig. 27.

Pseudobelodina vulgaris vulgaris SWEET, 1979b, p. 71, Fig. 5 (2-4), (includes synonymy through 1978); LENZ and McCRACKEN, 1982, Pl. 2, fig. 19.

Remarks. Most elements assigned to this species are closely similar to those described and illustrated by Sweet (1979b). However, some minor differences can be noted. In some *a* and *b* elements, the heel is slightly broader and the radius of curvature is slightly larger than in typical elements of the species. Elements showing these differences also have costae that are more subdued than on the type material. Similar elements have been illustrated by Nowlan (1981b) and Nowlan and Barnes (1981). One of the elements illustrated by Nowlan and Barnes (1981, Pl. 7, fig. 1) is a *b* element with only one denticle; otherwise it is identical to other *b* elements of *P. vulgaris vulgaris* that have a broader heel. The specimen is not assignable to *P. quadrata* because the denticle is clearly spatulate rather than quadrate in outline. We have viewed all hypotypes reported in the synonymy except those of Harris et al. (1979) and Sweet (1979b).

Other elements that are morphologically similar to *P. vulgaris vulgaris* are present in the same sample. They have a much larger radius of curvature and much broader heels. They tend to be small and may represent juveniles of the species, but at present are referred to *P.* cf. *P. vulgaris vulgaris* (see below).

Types. Hypotypes, GSC 80386-80392.

Pseudobelodina cf. *P. vulgaris vulgaris* Sweet

Plate 15, figures 13-18

Multielement

cf. *Pseudobelodina vulgaris vulgaris* SWEET, 1979b, p. 71, Fig. 5 (2-4).

Remarks. Elements assigned here are similar to *P. vulgaris vulgaris* but differ in several important respects. The heel is broader and lower and the outline of the distal portion of the heel forms a much shallower angle with respect to the anterior margin of the base. Two denticles are present on the anterior margin and they are spatulate in outline but more discrete than on typical specimens. Most of the elements have a costa on each side that are asymmetrically situated with respect to one another, and can be referred to the *b* position. A few specimens have a smooth outer furrowed face and a prominent costa on the inner face. Most can be referred to the *b* position.

Elements similar to the *a* element of *P. vulgaris vulgaris* have not been recovered. None of the elements has three denticles and all are bowed to the furrowed side, therefore no *e*? elements (= P? of Sweet, 1979b) have been recognized. Some of the bicostate elements have subsymmetrically placed costae and could be interpreted as *c* elements.

These elements co-occur in samples with *P.* ? *dispansa* (Glenister) and *P. vulgaris vulgaris* or with *P.* ? *dispansa* alone. Their small size and discrete denticles suggest that they may be juvenile specimens of *P. vulgaris vulgaris* but the radius of curvature is too great for their inclusion in that species as it is presently defined. They may represent a separate species or subspecies in which only the *b* elements differ from *P. vulgaris vulgaris.* A shortage of *b* elements typical of *P. vulgaris vulgaris* suggests that the juvenile hypothesis is more likely, but relatively few elements have been recovered.

A re-examination of the collections of Nowlan and Barnes (1981) from the Vauréal Formation, Anticosti Island, which yielded over 500 specimens assignable to *P. vulgaris* s.l., revealed the presence of rare elements of this type.

Types. Figured specimens, GSC 80393-80395.

Pseudobelodina? n. sp. A Nowlan and McCracken

Plate 15, figures 19-21

Description. Laterally compressed, acostate, broad simple cones with a panderodont furrow on one side. Elements are either unbowed or bowed slightly to the unfurrowed side. Base is low and broad with basal wrinkles. Anterobasal angle is obtuse so that base expands rapidly to maximum width at a low level on the base; above this the element tapers gently to the distal end of the cusp. Panderodont furrow forms a V-shaped notch on the outer lateral face of the base. Above the notch, the furrow is narrow and flanked by striae. The furrow is restricted to the posterior half of the base and runs parallel and close to the posterior margin of the cusp. The posterior margin of the base is produced as an indistinct heel. Anterior and posterior margins are sharp, except near the aboral margin where they are narrowly rounded. Posterior edge is very thin and appears to be serrated on some specimens. Unfurrowed side may show a constriction immediately anterior of posterior edge. Cusp is broad, sharp-edged and proclined.

Remarks. This element, although rare, co-occurs with elements of *P.*? *obtusa* Sweet. *Pseudobelodina*? n. sp. A may be an element similar to that mentioned as a possible associate in the apparatus of *P.*? *obtusa* by Sweet (1979b). It is similar to *P.*? *obtusa* in geometry and outline, but it lacks prominent striae and well defined nodose posterior denticles. Larger collections will be required in order to assess whether *P.*? *obtusa* and *P.*? n. sp. A are indeed elements of the same species.

Types. Figured specimens, GSC 80396-80397.

Genus *Pseudooneotodus* Drygant, 1974

Type species. *Oneotodus? beckmanni* Bischoff and Sannemann.

Pseudooneotodus aff. *P. beckmanni* (Bischoff and Sannemann)

Plate 16, figure 1

Oneotodus? beckmanni BISCHOFF and SANNEMANN, 1958, p. 98, Pl. 15, figs. 22, 23?, 24 (only).
aff. *Oneotodus? beckmanni* BISCHOFF and SANNEMANN, 1958, p. 98, Pl. 15, fig. 25 (holotype).
Pseudooneotodus beckmanni (Bischoff and Sannemann). DRYGANT, 1974, p. 67, Pl. 2, figs. 34-39.

Indeterminate element

Form C. WEYANT, 1968, p. 64, Pl. 6, figs. 13, 15 only.

Multielement

Pseudooneotodus beckmanni (Bischoff and Sannemann). COOPER, 1977, p. 1068, 1069, Pl. 2, figs. 14, 17 (includes synonymy through 1977); NOWLAN and BARNES, 1981, p. 23, Pl. 2, figs. 20, 21; McCRACKEN and BARNES, 1981, p. 89, Pl. 2, figs. 30, 31.
Pseudooneotodus aff. *beckmanni* (Bischoff and Sannemann). ORCHARD, 1980, p. 24, Pl. 3, figs. 30, 34.

Remarks. Orchard (1980) noted that the holotype of *O.? beckmanni* appears to be marginally serrate although most forms ascribed to *P. beckmanni* have a smooth basal margin. In addition, it appears that the holotype may have more than one, possibly two or three, apices; this feature is more typical of *P. bicornis* Drygant and *P. tricornis* Drygant.

Pending study of the type material, we prefer to follow Orchard (1980) and tentatively link our material to *P. beckmanni.* If the type material of *O. ? beckmanni* is truly serrate and bi- or tri-cuspate, then a new name is required for all unicuspate, non-serrate elements previously referred to the species.

The paratype figured by Bischoff and Sannemann (1958, Pl. 15, fig. 23) appears to have the indented basal outline more typical of *P. mitratus* (Moskalenko).

Types. Figured specimen, GSC 80398.

Pseudooneotodus mitratus (Moskalenko)

Plate 16, figures 2-6

Ambalodus mitratus mitratus MOSKALENKO, 1973, p. 86, Pl. 17, figs. 9-11.
Ambalodus mitratus Moskalenko. MOSKALENKO, 1977, Pl. 9, fig. 14; Pl. 11, fig. 19.
Oneotodus mitratus (Moskalenko). DZIK, 1976, Fig. 12e, f.
?*Oneotodus beckmanni* BISCHOFF and SANNEMANN, 1958, p. 98, Pl. 15, fig. 23 (only).

Multielement

"*Pseudooneotodus*" *mitratus* (Moskalenko). ORCHARD, 1980, p. 25, Pl. 3, figs. 35, 42.
Pseudooneotodus mitratus (Moskalenko). NOWLAN and BARNES, 1981, p. 23, Pl. 2, figs. 17-19 (contains synonymy through 1978); McCRACKEN and BARNES, 1981, p. 89, Pl. 2, fig. 32; NOWLAN, 1981b, p. 280, Pl. 2, fig. 15; NOWLAN, 1983, p. 667, Pl. 3, figs. 17, 21.

Remarks. As noted under *P.* aff. *P. beckmanni,* one of the paratypes figured by Bischoff and Sannemann (1958) may possibly be a representative of *P. mitratus.*

Nowlan (1983) has pointed out that some specimens of *P. mitratus* bear rounded nodes on the flanks of the posterior ridge. The specimens from Avalanche Lake bear a few isolated nodes, but are not as prominently nodose as elements illustrated by Nowlan (1981b) from the White Head Formation near Percé, Québec and Nowlan (1983) from the Grog Brook Group of northwestern New Brunswick.

Types. Hypotypes, GSC 80399-80402.

Genus *Scabbardella* Orchard, 1981

Type species. *Drepanodus altipes* Henningsmoen, 1948.

Remarks. Orchard (1980) established this genus for acodiform, drepanodiform and distacodiform elements that are laterally compressed with sharp anterior and posterior edges. Nowlan (1983) revised the diagnosis to include drepanodiform elements with longitudinal striae. Collections of *S. altipes* from northwestern Canada (this study, and Lenz and McCracken, 1982) show that long-based acodiform elements may be striated as well. All elements in this study are variably striated (either faintly or prominently) longitudinally and all have short basal wrinkles. In addition to the above elements, a symmetrical distacodiform element is present.

The revised apparatus based on several Late Ordovician collections (published and unpublished) from Canada consists of short-based acodiform, asymmetrical distacodiform, symmetrical distacodiform, and long-based drepanodiform, acodiform and distacodiform (=*a, b, c, e-1, e-2, e-3*) elements. This is a complete first and incomplete second transition series (sensu Barnes et al., 1979) based on costae number and position. Intermediate forms are also present in the first transition series (*a-c*). The apparatus is similar to that of *Staufferella* (sensu this report).

Orchard (1980, Textfigs. 1, 4c) recognized a complex apparatus for *Scabbardella,* but did not apply the elemental terminology of Sweet and Schonlaub (1975) to his description or illustrated specimens. His (1980) interpretation is, however, similar to that in this study, by being based on costae number and position and has an acostate element in the M (=*e*) position.

The constituent form species of *S. altipes* have been recorded from strata ranging in age from Early to Late Ordovician. The annotated synonymies below are an attempt to clarify the occurrence of species of this genus. The synonymy for *S. altipes* s.l. includes all occurrences of the form species that cannot be related with confidence to *S. altipes* subsp. B Orchard. The synonymy for this subspecies includes sources that reported the characteristic *a* element; we also include those for which we have viewed type specimens.

Most Middle Ordovician occurrences of form taxa listed in the synonymy below are queried. These may be part of other species of *Scabbardella.* Nowlan (1983) suggested that *S. lacrimosus* (Kennedy et al.) could be reconstructed to comprise " A ." *similaris* Rhodes s.f. (*a* element) and *Coelocerodontus lacrimosus* s.f., both of Kennedy et al. (1979), and the *b* element *Dapsilodus*? *similaris* (Rhodes) sensu Nowlan (1981a). An element with an outline similar to this last species was referred to *A. similaris* Rhodes sensu Hamar (1966) by Repetski and Ethington (1977). This may also be part of *S. lacrimosus.*

Acodus similaris s.f. of Schopf (1966) and an acostate striated drepanodiform element, *A. numaltipes* Schopf s.f. (= *Drepanodus ? altipes ?*, sensu Sweet et al., 1959), may be *a* and *e* elements of another Middle Ordovician species.

The two forms (*c*? and *a*? elements) of *Drepanodus ? altipes ?* described by Serpagli (1967) and Palmieri (1978) respectively, may be aberrant forms of *Scabbardella* or some other unknown genus.

The distacodiform (*b*) element *Scabbardella ? bygdoeyensis* (Hamar)? sensu Orchard (1980) may be part of *Paroistodus ?* sp. A as noted herein.

Scabbardella altipes (Henningsmoen, 1948)

Acodus similaris Rhodes. LINDSTRÖM, 1959, p. 435, Pl. 3, figs. 6-9 (figs. 6, 7 = *e*; 8, 9 = *a* elements); BERGSTRÖM, 1964, p. 8, 9, Textfig. 1 (= *a* element); ?HAMAR, 1964, p. 256, Pl. 1, fig. 3 (*a* element, Middle Ordovician); ?HAMAR, 1966, p. 48, 49, Pl. 2, figs. 3-6, 9, 13, Textfig. 4 (6-10, 12 only) (figs. 3, 5, 9 = *a*; figs. 4, 6 = *e* elements; figs. 7, 8 similar to *Dapsilodus similaris* of Nowlan (1981a), Middle Ordovician); non SCHOPF, 1966, p. 33, Pl. 5, fig. 29 (may be *a* element of *Scabbardella* apparatus that includes striated drepanodiform element, *A. numaltipes* Schopf s.f., Middle Ordovician); ?VIIRA, 1967, Textfig. 5 (8a, b) (*b* element, middle Caradoc); ?KNUPFER, 1967, p. 19, Pl. 3, figs. 11, 12 (*e* element, Middle Ordovician); SERPAGLI, 1967, p. 42, Pl. 7, figs. 1a-4c, 7a-c (only) (figs. 1a-c, 7a-c = *a*; figs. 2a-c = *e-3* ; figs. 3a-4c = *b* elements; figs. 5a-6c, 8a-10d = *S. altipes* subsp. B Orchard, herein); MANARA and VAI, 1970, p. 476, Pl. 62, figs. 1, 2 (*a* element); VIIRA, 1974, p. 43, Pl. 11, figs. 23, 24, Pl. 12, figs. 14, 15, Textfigs. 19, 20 (=? *b* elements); FLAJS and SCHONLAUB, 1976, Pl. 1, fig. 30 (= *a* element), Pl. 2, figs. 16, 23 (fig. 16 = *e*; fig. 23 = *a* elements); ?MOSKALENKO, 1980, p. 173, Pl. 55, fig. 1, Textfig. 59 (1, 2) (= *a* element); PARIS, PELHATE and WEYANT, 1981, p. 19, Pl. 2, fig. 3 (*a* element).

Acodus cf. *A. similaris* Rhodes. SERPAGLI and GRECO, 1964, p. 196, Pl. 34, figs. 1a, b (= *a* element).

non *Acodus similaris* Rhodes sensu HAMAR, 1966. REPETSKI and ETHINGTON, 1977, Pl. 1, fig. 15 (similar to *Dapsilodus ? similaris,* sensu Nowlan, 1981a, Lower-Middle Ordovician).

non " *Acodus*" *similaris* Rhodes. KENNEDY, BARNES and UYENO, 1979, Pl. 1, figs. 21, 22 (= *a* element of another species?, see generic remarks).

?*Acordus similaris* Rhodes (sic). MERRILL, 1980, Fig. 5 (12) (*a* element, Caradoc).

Drepanodus altipes HENNINGSMOEN *in* WAERN et al., 1948, p. 420, Pl. 25, fig. 14 (*e-1* element); RHODES, 1953, p. 292, Pl. 21, figs. 102-105 (fig. 102 = *e-3* element; figs. 103-105 = *e-1* elements); RHODES, 1955, p. 125, 126, Pl. 10, figs. 6, 8, 29 (= *e-1* element); SERPAGLI and GRECO, 1964, p. 199, Pl. 35, fig. 1 (= *e-1* element); IGO and KOIKE, 1967, p. 17, 18, Pl. 2, fig. 8, Textfig. 4 (M) (= *e-1* element); ?KNUPFER, 1967, p. 25, Pl. 2, figs. 9, 10, 15 (Middle Ordovician); non LEE, 1970, p. 318, Pl. 17, fig. 20; ?LEE, 1977, p. 164, Pl. 1, fig. 7, Textfig. 2(G) (Middle Ordovician); ?LEE, 1980, Pl. 2, fig. 3 (same specimen illustrated in Lee, 1977).

"*Drepanodus*" *altipes* Henningsmoen. FLAJS and SCHÖNLAUB, 1976, Pl. 1, figs. 28, 29 (costate, may be *e-2* and *a* elements, respectively).

Drepanodus ? altipes Henningsmoen. BERGSTRÖM, 1964, p. 22, 23, Textfig. 8 (= *e-1* element; re-illustration of holotype); SERPAGLI, 1967, p. 65, Pl. 15, figs. 8a-9c (= *e-1* element); ?MANARA and VAI, 1970, p. 481.

Drepanodus ? altipes Henningsmoen?. BERGSTRÖM, 1964, p. 22, 23, Textfig. 9 (= *e-1* element).

?*Drepanodus ? cf. D. altipes* Henningsmoen. PALMIERI, 1978, p. 19, 20, Pl. 2, figs. 22-23, Textfig. 4 (2a-c), (Late Ordovician).

non *Drepanodus ? altipes* Henningsmoen?. SWEET, TURCO, WARNER and WILKIE, 1959, p. 1048, 1049, Pl. 130, fig. 1 (= *a* element); SERPAGLI, 1967, Pl. 29, figs. 6a-c (?aberrant form, anteroposteriorly compressed); PALMIERI, 1978, p. 19, Pl. 2, figs. 24, 25, Textfig. 4 (3a-c), (?aberrant form; like Serpagli's (1967) but laterally compressed).

Drepanodus arcuatus Pander. RHODES, 1953, p. 292, Pl. 21, fig. 110 (*a* element; = *Acodus similaris* Rhodes s.f., Bergström, 1964, p. 8, 9); RHODES, 1955, p. 126, Pl. 10, fig. 24 (apical fragment).

Drepanodus cf. *D. arcuatus* Pander. RHODES, 1955, Pl. 10, fig. 21 (apical fragment).

Drepanodus similaris RHODES, 1953, p. 292, 293, Pl. 21, fig. 97 only, (= *e-1* element; RHODES, 1955, p. 126, Pl. 10, figs. 4, 5 (= *e-1* element).

?*Panderodus similaris* (Rhodes). HAMAR, 1966, p. 67, Pl. 2, figs. 11, 12, Textfig. 5(3) (= *e-1* element; Middle Ordovician).

Panderodus ? similaris (Rhodes). SERPAGLI, 1967, p. 87, Pl. 6, figs. 2a-c (= *e-1* element).

Multielement

Dapsilodus mutatus Branson and Mehl). BERGSTROM, 1978, Pl. 80, figs. 21-23 (longitudinally striated *e*, and *a* or *b* elements, respectively; lower Maysvillian-Richmondian).

non *Dapsilodus similaris* Rhodes). NOWLAN, 1981a, p. 13, Pl. 5, figs. 1-4 (= *a* and *b* elements, see generic remarks).

Scabbardella altipes (Henningsmoen). ORCHARD, 1980, p. 25, 26, Pl. 5, figs. 2-5, 7, 8, 12, 14, 18, 20, 23, 24, 28, 30, 33, 35, Textfig. 4(C).

Scabbardella altipes subsp. B Orchard, 1980

Plate 16, figures 7-20, Plate 17, figures 1-3, 5, 6, 8, 9

a element

Acodus similaris RHODES, 1955, p. 124, 125, Pl. 10, figs. 7, 10, 14, 16, 18, 23, 26-28, 30; SERPAGLI, 1967, p. 42, Pl. 7, figs. 5a-6c, 8a-10d (only); IGO and KOIKE, 1967, p. 13, Pl. 1, figs. 16-18, Textfig. 4(E); PALMIERI, 1978, p. 7, Pl. 2, figs. ?14, 20, 21, Textfig. 4 (6a-c).

a-e elements

?*Acodus* cf. *A. mutatus* Branson and Mehl. SERPAGLI and GRECO, 1964, p. 196, Pl. 34, figs. 2a, b (co-occurs with *A.* cf. *similaris* Rhodes s.f. and *Drepanodus altipes* Henningsmoen s.f.); (*a* and *e-1* elements).

Multielement

Coelocerodontus ? sp. LENZ and McCRACKEN, 1982, Pl. 2, figs. 20, 23-28 (figs. 20, 24 = *a*; fig. 23 = *e-2*; figs. 25-28 = *e-1* elements).

Scabbardella altipes (Henningsmoen) subsp. B. ORCHARD, 1980, p. 26, Pl. 5, figs. 2, 3, 14, 18, 20, 23, 24, 30, 33 (fig. 2 = *e-3*; figs. 3, 14, 18, 20, 30 = *a*; figs. 23, 24, 33 = *e-1* elements).

Scabbardella altipes (Henningsmoen). NOWLAN, 1983, p. 668, Pl. 1, figs. 6, 7, 11-14 (fig. 6 = *a*; figs. 7, 12-14 = *e-1*; fig. 11 = *e-2* elements).

Description. All elements are straight, not bowed and have a long proclined cusp that is laterally compressed. Base length is variable; base is laterally compressed and has an elliptical basal cross-section. Anterior and posterior edges are sharp and form short keels on base. Upper basal edge has low heel. Ornamentation consists of strong posterolateral costae, faint longitudinal striae and basal wrinkles.

Base length and posterior extension of *a* element are variable; elements with a short base are either abbreviated (Pl. 16, figs. 7, 8, 11) or extended (Pl. 16, figs. 9, 10, 12) posteriorly. Strong posteriorly directed costa on inner face does not extend to apex; basally, it extends to, or terminates immediately above, the aboral margin. Faint longitudinal striae and basal wrinkles are present in some specimens.

The *b* element (Pl. 16, figs. 13-16) has a strong costa on inner face, terminating just above aboral margin. Costa on outer face is more anteriorly situated and ends well above aboral margin. Inner face has an additional short costa close to, but anterior of longer costa. Striae are present on both faces between costae and posterior margin. Cusp of some elements is flexed slightly to inner side. Base of some elements is more posteriorly extended than that of others.

The *c* element is characterized by symmetrically disposed posterolateral costae restricted to middle third of element and bound a concave posterior surface in the area of recurvature. Remaining parts of posterior margin are sharp, that of base is keel-like.

The *e* element is straight and its base is longer than that of other elements. Both faces are finely and longitudinally striated. All have a nearly flat, narrow anterolateral face on one side. The *e-1, e-2* and *e-3* elements are acostate (drepanodiform), unicostate (acodiform), and bicostate (distacodiform), respectively. Costa on *e-2* element is short, extending from near apex to point of recurvature. Outer costa of *e-3* element is similar to that of *e-2* element; inner costa is more prominent and extends for entire length of element.

Remarks. Orchard (1980) noted that this subspecies from North Wales included acodiform (*a* elements) that are more strongly recurved than those of his *S. altipes* subsp. A from northern England. Many of these Welsh elements also have bases that are extended posteriorly and antero-aborally. Unillustrated elements of *Coelocerodontus* sp. with similar characters, although not as exaggerated as in Orchard's illustration (1980, Pl. 5, fig. 18) occur in samples from the Blackstone River, Yukon Territory (Lenz and McCracken, 1982). In that study, illustrations show that a wide, posteriorly extended base is present not only on *a* elements, but also on *e-2* and *e-1* elements (*ibid.*, Pl. 2, figs. 20, 23, 25, respectively). Unfortunately, Orchard (1980) did not illustrate drepanodiform (*e-1*) elements of this subspecies. Most elements illustrated here share this character and this may be diagnostic of the subspecies.

We do not formally establish this subspecies, since some of Rhodes (1955) *a* elements from northern England are similar to those of subspecies B, although only one of his three illustrated *e* elements has an expanded base. The Welsh *e* elements illustrated in Rhodes (1953) are more slender than those of subspecies B. If the extended wide base is a distinguishing character, it is clearly not simply a matter of geographic isolation.

Orchard's (1980, Pl. 5, fig. 18) *a* element of *S. altipes* subsp. B is similar to the *a* elements of his (*ibid.*, Pl. 5, fig. 16) *Dapsilodus mutatus* (Branson and Mehl) and our *Paroistodus?* sp. A. Small *a* elements of all the above species may be difficult to distinguish. The *a* element of *D. mutatus* (sensu Orchard, 1980) has oblique striae that are characteristic of *Dapsilodus* and are not found in either *Scabbardella* or *Paroistodus?*. The costa on the *a* element of *P.?* p. A terminates well above the aboral margin, whereas on the *a* element of *S. altipes* s.l. it either extends to the aboral margin or nearly so. In this respect, the lectotype of *Belodus? mutatus* s.f. illustrated by Bergström (1964, Textfig. 2) is more similar to the *a* element of *Scabbardella*, than to that of *Paroistodus*?, because the costa extends to the aboral margin. The presence of basal wrinkles in large *a* elements of *Scabbardella* may serve to distinguish them from *a* elements of *Paroistodus?*. However, the largest elements of *Paroistodus*? are much smaller than those of *Scabbardella* and it may be that the presence of basal wrinkles is a function of size. Other than the costa length, basal striae and size, we can offer no other distinguishing characters for *a* elements of *Scabbardella* and *Paroistodus*?.

Types. Hypotypes, GSC 80403-80414.

Scabbardella n. sp. A Nowlan and McCracken

Plate 17, figures 4, 7, 10-16

Description. Apparatus is incompletely known (*a*?, *b-1*, *b-2*, *c* elements). All elements have a laterally compressed base and cusp. Except for *a* element, all are straight. Cusp is proclined and has sharp anterior and posterior edges that extend to aboral margin of base. Upper basal edge has short, low heel. Central part of posterior edge is keel-like. Ornamentation consists of posteriorly directed posterolateral coste on all elements, shorter secondary costae on *b* elements, longitudinal striae on *a*? elements and weak basal wrinkles on lateral faces of *b-2* and *c* elements.

The *a*? element (Pl. 17, figs. 4, 7) is weakly costate; inner costa is stronger than outer. Costae extend along cusp and terminate at proximal part of base. Elements are bowed slightly to inner side. Longitudinal striae are strongest posterior to costae.

The *b-1* element (Pl. 17, figs. 10, 11) is strongly costate. Primary costa on inner face extends from aboral margin to distal region of cusp; other costae on this face are shorter. Outer face has few short costae on cusp and is less convex than inner face. Base is relatively long and not posteriorly extended, as is base of *b-2* element.

The *b-2* element (Pl. 17, figs. 12, 13, 16) has a base that is shorter and more posteriorly extended than that of *b-1* element. Inner face has a costa that extends from aboral margin to distal region of cusp. Fainter and shorter costae occur on both sides of this costa. Outer face is multicostate with distinct primary costa. Area of costae extends from proximal part of base to distal part of cusp and from mid-line to posterior edge. Not all costae extend for the full length of this area. Lateral face of base on multicostate, outer side is narrowly carinate with nearly flat anterior and posterior regions. Inner face is gently convex.

The *c* element is strongly bicostate. Costae originate near aboral margin and extend along cusp. Element is nearly symmetrical with posterior edge slightly flexed to one side. Base is relatively long and narrow, as in *b-1* element.

Remarks. The elements of this species differ from those of *S. altipes* (Henningsmoen) subsp. B Orchard, particularly in the *b* and *c* elements. They lack the posteriorly extended base and distinct basal heel found on the above subspecies. The *b* elements bear more costae and those of the *c* element are more prominent. The base of the *c* element is longer than that of the same element of *S. altipes* subsp. B.

The *a*? element is queried because it is distacodiform rather than acodiform as in *S. altipes* subsp. B. Neither of its costae extend below the cusp.

One of the *b-2* elements has a basal heel that is more similar to *b* elements of *S. altipes* subsp. B; it is included here because it is multicostate.

Elements of both species of *Scabbardella* co-occur, hence we prefer not to designate this as a subspecies. The *e* elements are either unknown or indistinguishable from those included in *S. altipes* subsp. B.

Only the *b* elements can be compared with those of *S. altipes* subsp. A Orchard; the *a* elements are dissimilar and the *c* and *e* elements are not recognized in the material described by Orchard (1980) and in this study, respectively. The *b* element of Orchard (*ibid.*, Pl. 5, fig. 28) has a longer base and more recurved cusp than the *b-2* element of this study, and is more recurved than the *b-1* element.

This species is not formally named because it is rare and the apparatus is incompletely known.

Types. Figured specimens, GSC 80415-80419.

Genus *Spinodus* Dzik, 1976

Type species. *Polygnathus spinatus* Hadding, 1913.

Remarks. Dzik (1976, p. 424) erected this genus for elements "with strongly elongated branches and long denticles circular in cross-section". He suggested that the apparatus resembled that of "primitive Prioniodontidae", but provided only a brief diagnosis of the genus and supplied no synonymy for the single species *S. spinatus*. It is not clear whether Dzik (1976) intended to exclude *Cordylodus ramosus* Hadding s.f. from the apparatus. As Nowlan (1981a) pointed out, the co-occurrence of *C. ramosus* and *C. spinatus* (Hadding) s.f. is common. Lindström (1964) grouped these two form taxa under *C. spinatus*. Barnes and Poplawski (1973) and Nowlan (1981a) referred to the species as *C. ramosus* and *S. ramosus*, respectively. R.L. Ethington (pers. comm., 1981) has pointed out that *Spinodus spinatus* is the correct name for the type species because the designation of Lindström (1964), who first revised the species, cannot be reversed. According to Article 24a of the Code of Zoological Nomenclature, further page reference is not necessary after the first revision. Thus, the citation of *S. ramosus* by Nowlan (1981a) is incorrect, and the type species is therefore *Polygnathus spinatus* Hadding s.f.

Spinodus? n. sp. A Nowlan and McCracken

Plate 17, figures 17-22

?*Plectodina breviramea* (Walliser). MANARA and VAI, 1970, p. 492, Pl. 62, fig. 5 (only).

Description. Cusp is long, slender and recurved posteriorly; lateral faces are convex, anterior and posterior edges are costate. Anterobasal corner is strongly compressed and slightly deflected laterally; some rudimentary denticles occur rarely on the anterior edge above the maximum compression. In lateral view the anterobasal corner is slightly extended anteriorly just above the anterior termination of basal cavity.

Posterior margin of cusp curves evenly into oral edge of posterior process. A thin posterior costa continues from cusp onto oral surface of process. A large, posteriorly directed denticle is developed on most specimens. Denticle is in plane of cusp or only slightly deflected to one side. Edges of denticle are weakly costate and a small nodose denticle may occur posteriorly of the large denticle along the line of the costa. Another small nodose denticle may be developed between the cusp and large denticle.

Lateral faces of element are smooth and no striae are visible. Elements are opaque, thus basal cavity is not visible laterally but appears to be shallow and groove-like from the aboral view. Cavity begins posteriorly of anterobasal corner and expands evenly to a point of maximum width about midway between cusp and large posterior denticle; it is shallow beneath posterior process and bears a median groove. Specimens appear to be hyaline because of their opaque, black colour.

Remarks. This group of elements is assigned tentatively to *Spinodus,* but with several reservations. Firstly, only one element type has been recovered: that with a posterior process. No lateral processes are visible on any of the specimens recovered, suggesting that they are *a* elements. Nowlan (1981a) made rough estimates of the ratio of *a, b* and *c* elements in *S. spinatus* (Hadding) and concluded that the ratio was about 20 *a* elements without anticusp: 3 *a* elements with anticusp: 3 *b* elements: 1 *c* element. If the specimens from Avalanche Lake are indeed members of the same genus then it is possible that the collection is too small to reveal *b* or *c* elements. Secondly, the cusp and denticles are somewhat laterally compressed, whereas those of *S. spinatus* are rounded; and thirdly, the inverted basal cavity of typical *S. spinatus* is not visible on the specimens from Avalanche Lake.

Apart from these significant reservations, the elements most closely resemble *Spinodus.* They are also similar in general outline to *Protopanderodus insculptus* (Branson and Mehl), but they lack lateral grooves or costae. Some elements referred to *Plectodina breviramea* (Walliser) s.f., the *a* element of *Hamarodus europaeus* (Serpagli), are similar to *Spinodus*? n. sp. A particularly one illustrated by Manara and Vai (1970). No other elements assignable to *Hamarodus* have been recovered from these samples.

Types. Figured specimens, GSC 80420-80424.

Genus *Staufferella* Sweet, Thompson and Satterfield, 1975

Type species. *Distacodus falcatus* Stauffer, 1935a.

Remarks. Several new species have been described since this genus was established. In these, the basally depressed *c* (symmetrical acontiodiform) elements do not have the diagnostic basally alate lateral costae. This element has the most interspecific variability: the lateral costae may be subdued, with no alae (*S. inaligerae* McCracken and Barnes), prominent and basally notched or alate (*S. falcata* (Stauffer) and *S. lindstroemi* Ethington and Schumacher, respectively), prominent but only slightly notched (*S. divisa* Sweet) or serrated (*S. brevispinata* Nowlan and Barnes). The differences between the remaining elements of *Staufferella* species are quite subdued, especially those between *S. brevispinata* and *S. divisa.*

The apparatus reconstruction used in this paper recognizes a symmetry transition series of costate simple cones, as does the work of Barnes et al. (1979) and Sweet (1982). Barnes et al. (1979) considered *Staufferella* to have a Type I apparatus (i.e., *s, t, u* elements), but noted (*ibid.*, p. 137) a homology between this type and their Type IIB aparatuses (i.e., *s, t, u* = *a, b, c* elements). The latter element designation is followed in this paper. In addition to the elements of the symmetry transition series, there are other markedly different elements. These are slender costate coniform elements that have a long base and a long proclined to nearly erect cusp. Sweet (1982) recognized the uniqueness of these elements by excluding them from the symmetry series and by regarding them as Pa and Pb elements. In this study, these elements are referred to as *e* elements (i.e., M of Sweet and Schönlaub, 1975) rather than *f* or *g* elements. The three varieties of *e* element found in this study could alternatively be homologous to the complete second transition series of more complex apparatuses (i.e., *e-1, e-2, e-3* = *e, f, g* elements), but we prefer to draw homologies to other simple cone genera rather than ramiform genera. Several simple cone genera (e.g., *Protopanderodus, Scabbardella, Walliserodus*) are similar in that they have a symmetry transition series as well as a more unique element or group of elements. We view the above genera as having modified Type IVE apparatuses (i.e., a first transition series and an incomplete second transition series).

In *Staufferella,* the *a* (scandodiform) element is laterally compressed with sharp antero- and postero-lateral edges. The *b* element has asymmetrically disposed lateral costae or sharp edges. The *c* (acontiodiform) element has lateral costae and a base that is anteroposteriorly depressed in large specimens. The *e* element is a long and slender coniform element that may be acostate or have one or two costae. The base of the *e-1, e-2* and *e-3* elements is longer than that of elements of the transition series.

Staufferella divisa Sweet

Plate 18, figures 1-23

Multielement

Staufferella divisa SWEET, 1982, p. 1045-1047, Pl. 1, figs. 1-5.

Description. The *a* element (Pl. 18, figs. 1-4, 8) is laterally compressed with a proclined cusp that is as long as, or longer than the base. Element is twisted and bowed so that anterior and posterior costae of base become anterolateral and posterolateral along cusp. Posterior costa is keel-like at mid-length. Two forms of *a* element are present. The more common form (Pl. 18, figs. 3, 4) is only slightly twisted. Posterior keel-like costa is prominent when viewed from either side. This costa on the more asymmetrical element (Pl. 18, figs. 1, 2) is noticeable only on inner side. Outer lateral face of this element is smoothly convex from posterior to anterior margins; anterior and anterolateral faces are narrowly convex. One *a*? element with a short base (Pl. 18, fig. 8) has a shallow groove on inner face that extends from tip of cusp to point of recurvature. Groove is prominently striated and the whole surface of the *a* element has faint longitudinal striae. Base on most elements is unornamented, but basal wrinkles are present on large forms.

The *b* element (Pl. 18, figs. 5, 6, 11, 12) is similar to the *a* element, except that it is less compressed laterally and has a strong costa on the inner lateral face that is close to the posterolateral costa. This lateral costa extends from the point of recurvature to the proximal part of the base. Ornamentation and basal wrinkles on large element are similar to that of large *a* element. One *b*? element (Pl. 18, figs. 11, 12) lacks visible lateral costa and instead has a distinct axial line along the cusp. Cusp is smooth anterior of this line, and striated posteriorly. Basal cross-section of this element is subcircular.

The *c* element (Pl. 18, figs. 9, 10, 13, 14, 19, 20) has a proclined cusp that is longer than the base. Posterior and lateral costae are keel-like at the point of recurvature and all extend along the length of cusp in larger elements. Posterior costa does not extend to aboral margin of the base. Lateral costae extend to aboral margin, but are weak. Anterior face of element is smoothly convex. Posterolateral faces are convex but nearly planar. Small elements (Pl. 18, figs. 9, 10, 14) have lateral costae that are weak in proximal part of the cusp. Toward the apex, costae (Pl. 18, fig. 14) define a boundary between unornamented anterior face and striated posterolateral faces; this is similar to the situation in small *b*? elements (Pl. 18, figs. 11, 12). Base of small elements is circular in cross-section, and in posterior view is evenly tapered to the apex. Anterior face of small elements is more convex than that of large elements. Base of large elements (Pl. 18, figs. 13, 19, 20) is anteroposteriorly compressed with inflated lateral margins. The *c* element has longitudinal striae on both faces posterior to lateral costae.

The *e* elements are long and slender with a proclined to rarely erect cusp; base is approximately equal in length to cusp. Elements are abruptly bent at point of recurvature. All elements have a posterior costa that is keel-like at mid-length and slightly offset to outer lateral side. This costa does not extend to aboral margin but continues along posterior edge of lanceolate cusp. Costa on anterior margin of cusp does not extend basally beyond point of recurvature. Base is laterally compressed with convex margins. The number of lateral costae is variable. Surface is covered with fine longitudinal striations between posterior costa and lateral costa, or in elements without lateral costae, posteriorly of mid-lines.

The *e-1* element (Pl. 18, figs. 17, 18) has no lateral costae. The *e-2* element (Pl. 18, figs. 15, 16) has a weak costa on inner lateral face that is basally anterolateral but is at mid-width on cusp. The *e-3* element (Pl. 18, figs. 7, 21-23) is symmetrically bicostate. Twist of cusp and offset of posterior costa gives this element slight asymmetry. Lateral costae are strong in distal region of base; they do not extend beyond point of cusp recurvature nor to proximal part of base.

Remarks. Two variants are noted in the sample from 46 m in Section AV1. The *a*? element is unique because it has a shorter more laterally compressed base and a groove with striae on the inner lateral face. The small *b*? element lacks a lateral costa on its base and instead has striae on the cusp. All striae are of equal prominence but the one most anterior on both faces may be homologous to the lateral costae of the *e-3* element. This element, however, lacks the relatively long base found on typical *e* elements. A small *c* element (Pl. 18, fig. 14) from the same sample has similar cusp ornamentation. In this element, the anterior-most striae extend toward the base as prominent costae. The above differences, at least in the small *b*? and *c* elements may be one of scale, or intra-specific variation.

Most *a* and *b* elements, and the *e-2* and *e-3* elements are indistinguishable from the Sc, Sb, Pa and Pb elements, respectively, of Sweet (1982). Elements similar to the grooved *a*? element, *b*? and *e-1* elements are not noted in Sweet's (1982) description of the Kirkfieldian occurrence of *S. divisa.* The cusp attitude of the *e* elements of this study may be more variable, since Sweet (1982) does not report nearly erect P elements. The *c* element of the species described here, from the Upper Ordovician, has a more pronounced posterior costa and more subdued anterolateral costae than does the same element of *S. divisa* of Sweet (1982). Large *c* elements have a more laterally expanded base; small *c* elements also have a more circular basal cross-section.

The diagnostic *c* element of *S. divisa* lacks the basal alae found on the same elements of the Middle Ordovician *S. falcata* (Stauffer) and early Late Ordovician *S. lindstroemi* (Ethington and Schumacher) and does not have the serrated or denticulated lateral costae of the *c* element of the Late Ordovician *S. brevispinata* Nowlan and Barnes (= *S.* n. sp. Sweet, 1979b). The *c* elements of both *S. divisa* and the Gamachian *S. inaligerae* McCracken and Barnes are both "wingless", but the *c* element of this latter species is more laterally compressed, pinched at the point of cusp recurvature, and its lateral costae do not extend to the aboral margin. The *e* element of *S. inaligerae* (= markedly asymmetrical element of McCracken and Barnes, 1981) has much more subdued costae and a broader cusp than the same element of *S. divisa.*

Types. Hypotypes, GSC 80425-80439.

Genus *Walliserodus* Serpagli, 1967

Type species. *Acodus curvatus* Branson and Branson, 1947.

Remarks. The apparatus of *Walliserodus* consists of a symmetry transition series of multicostate *a, b, c* and *d* elements and a carinate or unicostate *e* element. These constitute a complete first and incomplete second transition series (sensu Barnes et al., 1979). Other simple cone genera (*Panderodus, Paroistodus, Protopanderodus, Scabbardella* and *Staufferella*) have a similar apparatus, except that they lack a *d* element. All of the above genera have a first symmetry transition series based on position of costae and have an additional unique element that is laterally compressed (cf. *Panderodus, Scabbardella, Walliserodus*) or morpho- logically distinct (e.g., oistodiform element in *Paroistodus*, scandodiform element in *Protopanderodus*).

The interpretation of *Walliserodus* is based upon Barrick's (1977) and McCracken and Barnes' (1981) reconstructions of *W. sancticlari* Cooper and *W. curvatus*, respectively. Cooper's (1975, 1976) reconstruction of these species, and Orchard's (1980) interpretation of *W. amplissimus* (Serpagli) differ slightly.

Walliserodus amplissimus (Serpagli)

Plate 19, figures 1-15

a element

?*Acodus curvatus* Branson and Branson. SERPAGLI, 1967, p. 41, Pl. 6, figs. 3a-c.
Scandodus zermulaensis SERPAGLI, 1967, p. 96, 97, Pl. 27, figs. 4a-6d.

b-d elements

Walliserodus debolti (Rexroad). SERPAGLI, 1967, p. 104, 105, Pl. 31, figs. 1a-4c (= *d* elements), 5a-8d (= *b* elements), 9a-11c (= *c* elements), 12a-c (=? *c* elements), 13a-c (=? *b* elements).

e element

Drepanodus amplissimus SERPAGLI, 1967, p. 66, Pl. 15, figs. 1a-5b; ?MANARA and VAI, 1970, p. 481.

Multielement

Walliserodus amplissimus (Serpagli). ORCHARD, 1980, p. 26, 27, Pl. 3, figs. 3-7, 9, 12, 13, 17, 18, Textfig. 4A.
Walliserodus cf. *W. curvatus* (Branson and Branson). NOWLAN *in* BOLTON and NOWLAN, 1979, p. 21, Pl. 8, figs. 19-32; NOWLAN and BARNES, 1981, p. 24, 25, Pl. 8, figs. 17-24; McCRACKEN and BARNES, 1981, p. 91, Pl. 1, figs. 22-25.

Remarks. As *W. amplissimus* and the Silurian species *W. curvatus* (Branson and Branson) are quite similar, a detailed comparison is necessary.

Most specimens of *A. curvatus* s.f., the *a* element of *W. curvatus*, were reported by Rexroad (1967) to have only a single costa on the inner lateral face. Both he and Cooper (1975) noted that some elements have additional costae on the inner face and one on the outer. The equivalent elements of the Ordovician *W. amplissimus* are also quite variable. Most reported elements, and most of those herein are unicostate on the inner face and acostate on the outer. Only one element (Pl. 19, figs. 2, 3) has more than one costa on the inner side. The Ordovician *a* elements differ from those of the Silurian in that they are generally less costate. Otherwise, the elements are indistinguishable.

The *b* element of *W. amplissimus* is homologous with *Paltodus debolti* Rexroad s.f. found in *W. curvatus*. Rexroad (1967) noted that secondary posterior costae are present in most specimens of his form species. Serpagli (1967) illustrated a variety of this form species, showing a great degree of intraspecific variation. This variety has not been confirmed in either the Upper Ordovician or Lower Silurian multielement species. Cooper (1975) concluded that Serpagli's (1967) specimens probably belonged to a species that was more primitive than *W. curvatus*. The illustrated *b* element of *W. amplissimus* (Pl. 19, figs. 7, 8) has an outer posterolateral costa, in addition to a posterior and an inner anterolateral costae (cf. *W. debolti*, sensu Serpagli, 1967, Pl. 31, figs. 5a-c, only). As in the *a* element, *b* elements of *W. curvatus* maybe more costate than their Ordovician counterparts.

Paltodus dyscritus Rexroad s.f., the *c* element of *W. curvatus* has a posterolateral costa on each face. All *c*elements in our *W. amplissimus* have a posterolateral costa on the outer side only. The equivalent element of *W.* cf. *W. curvatus* sensu Nowlan and Barnes (1981) has the same ornamentation. Bolton and Nowlan (1979) and Nowlan and Barnes (1981) reported that the anterior face of this element is flatter than that of *P. dyscritus* s.f.

The *d* elements of *W. amplissimus* and *W. curvatus* both have costate or sharp anterior and posterior edges. The *d* element of *W. curvatus* (*P. migratus* Rexroad s.f. and *P. multicostatus* Branson and Mehl s.f.) also has two costae on each lateral face, some of these are rarely bifurcated (Rexroad, 1967). The *d* element of the Ordovician species differs in that it commonly has four, rather than six, primary costae (cf. Sc element of *W. amplissimus* sensu Orchard, 1980, distacodiform element of *W.* cf. *W. curvatus* sensu Nowlan and Barnes, 1981). Some of the *d* elements of Nowlan and Barnes' (1981) species have a single secondary costa. The *d* element of *W. amplissimus* illustrated herein has an outer face with one posterolateral costa; the inner face has a bifurcating primary costa, and an anteriorly situated costa that becomes the anterior margin on the base.

The *e* element of *W. amplissimus* differs from that of *W. curvatus* in that it lacks a posterolateral costa on one face and instead is carinate. The *e* element *D. amplissimus* s.f., is similar in outline to *A. unicostatus* Branson and Branson s.f. in that both are broad and gently recurved. The equivalent element of *W. curvatus* as illustrated by Cooper (1975) differs in that its base is wider relative to the rest of the element. Some *e* elements (Pl. 19, figs. 10, 12) have a relatively short base, similar to those illustrated by Nowlan in Bolton and Nowlan (1979, Pl. 8, fig. 28) and by Nowlan and Barnes (1981, Pl. 8, fig. 22).

Micro-ornamentation has been noted in previous reports: Nowlan and Barnes (1981) noted that all elements may be striated; Cooper (1975) noted that longitudinal striations were present on the *a* element of *W. curvatus*, and to a lesser degree on all the other elements. In this study, longitudinal striations were found on most elements along the anterior margin, and along the posterior face of the cusp of the *c* element. McCracken and Barnes (1981) stated that the ornamentation of *W.* cf. *W. curvatus* was not as well developed as in the Silurian *W. curvatus*, but did not give details regarding the individual elements.

As noted above, the most diagnostic elements of *W. amplissimus* are the *d* and *e* elements. There are subtle differences between the *a* and *c* elements of this species and *W. curvatus*. The *b* elements of both species may be difficult to distinguish.

No distinction is made regarding the two informal subspecies of Orchard (1980). These subspecies were recognized by the relative prominence of costae. The *d* element of this study is most like that of *W. amplissimus* subspecies B Orchard. The other costate elements cannot be compared, since they are not illustrated by Orchard (1980).

Types. GSC 80440-80449.

Walliserodus curvatus (Branson and Branson)

Plate 19, figure 16

a element

Acodus curvatus BRANSON and BRANSON, 1947, p. 554, Pl. 81, fig. 20; NEUBAUER, 1979, Pl. 4, figs. 9a,b.

c element

Paltodus cf. P. *dyscritus* Rexroad. LEE, 1982, p. 95, 96, Pl. 4, figs. 19-22, 25.

e element

Acodus unicostatus BRANSON and MEHL. LEE, 1982, p. 69, 70, Pl. 4, figs. 16, 17.

Multielement

Walliserodus curvatus (Branson and Branson). COOPER, 1975, p. 995, 996, Pl. 1, figs. 10, 11, 16-21 (includes synonymy to 1975); REXROAD, NOLAND and POLLOCK, 1978, p. 12, Pl. 1, figs. 1-5; HELFRICH, 1980, Pl. 2, figs. 20, 25; McCRACKEN and BARNES, 1981, p. 90, 91, Pl. 1, figs. 26-30 (includes synonymy to 1981).

Remarks. Only fragmentary elements of this Silurian species are present in our collections. A multicostate apical fragment may be either a b or *c* element. The *e* element is acostate on its nearly planar faces and has a prominent rounded medial costa on the other, convex face.

This species is compared above with the Ordovician species *W. amplissimus* (Serpagli).

Types. Hypotype, GSC 80450.

Walliserodus? rallus Nowlan and McCracken n. sp.

Plate 19, figures 17-23, Plate 20, figures 1-3, 5-8

Diagnosis. Apparatus comprises slender, laterally compressed and evenly curved bicostate (*a*), multicostate (*a, b, c, d*) and unicostate (*e*) elements. Multicostate elements have up to 10 costae of varying length and prominence. Posterior margin is costate in all elements; anterior margin on all except c element is keel-like.

The *a* element is bicostate and has outer medial and inner posterolateral costae. The *b-1, b-2, c* and *d* elements have posterolateral costae on both faces and may be distinguished as follows: the *b-1* element has an inner anterolateral costa; *b-2* element differs in that this costa is more anterior and more subdued; the *c* element has a concave anterior face between two anterolateral costae; the *d* element has a medial costa on one face.

All elements are straight or only slightly bowed and have basal wrinkles and faint longitudinal (*a, b-2, c, d* elements) or more prominent oblique (*b-1, e* elements) striae.

Description. Elements are slender, laterally compressed and evenly curved. Lateral faces and posterior margin are costate. Anterior face is concave on *c* elements, keel-like on others. Most costae do not extend to apex or aboral margin. Cusp and basal cross-sections are sub-oval; base is more laterally compressed than cusp. Basal wrinkles and faint longitudinal or oblique striae are present. Outer face of *a* element is narrowly convex and has subdued costa. Outer face of *b, c* and *d* elements has fewer costae than inner face.

Slightly bowed *a* element (Pl. 19, figs. 17, 18) has sharp anterior and posterior margins that extend for length of element. Lateral faces are asymmetrically bicostate. Outer face has a strong medial costa extending from anterior margin of basal wrinkles to apex. Antero- and posterolateral faces are slightly concave or nearly planar. No micro-ornamentation is visible on this face. Inner side has a posterolateral costa that extends from basal wrinkles to about mid-length of element. Posterolateral face has faint longitudinal striations and is slightly concave. Inner face is narrowly convex at mid-width and is concave toward anterior, producing keel-like anterior margin. Keel is widest near basal wrinkles and diminishes in width toward tip of cusp.

The *b-1* element (Pl. 19, figs. 19, 20, 23) has a prominent costa on anterior, posterior and inner anterolateral faces and posterolateral costae on both faces. Posterolateral costae are in same position on both faces. Posterolateral costae on inner face do not extend for full length of element. One extends posteriorly, the other anteriorly. Both parallel each other for short distance at mid-length. Faint, short costae lie between anterolateral and posterior costae. Outer face has short costa between posterolateral and posterior costa. Posterolateral costa extends for full length of element. Outer face is acostate between posterolateral and anterior costae, but has faint striae that are slightly oblique to axis of element. Element is straight or only slightly bowed to inner, more costate face.

The *b-2* element (Pl. 19, figs. 21-22) is similar to the *b-1* element except that its inner anterolateral costa is more subdued and parallels the anterior margin. Inner posterolateral costa extends for full length of element. Element is unbowed but asymmetrical due to posterior costa being flexed toward inner side at mid-length.

The *c* element (Pl. 20, figs. 1-3) has a posterior costa that extends for full length of element. Costa is strong basally and diminishes toward point of recurvature. Prominent medial costae of both faces do not extend to apex. Anterolateral faces are acostate between medial and anterolateral costae. Outer face (Pl. 20, fig. 1) has posterolateral costa that extends from mid-cusp to near aboral margin. On inner face (Pl. 20, fig. 2) a secondary, posterolateral costa bifurcates from medial costa near point of recurvature. Another secondary costa in middle region of element parallels posterior costa. A tertiary costa is present on inner face in basal part of element between medial and posterolateral costae. Element is neither bowed nor flexed; asymmetry is due to number and position of costae.

The *d* element has prominent costae on both faces, on posterior and strong keel-like anterior costa. One face has a strong medial costa with about two secondary and several tertiary costae between medial and posterior costae. Other face has a strong posterolateral costa and only few tertiary costae. This face has fewer costae than other. Element is slightly bowed.

The *e* element has a faint anterolateral costa on one face. This face is broadly convex, other face is narrowly convex. Anterior margin is keel-like. Posterolateral faces have striae that are slightly oblique to axis of element. Element is slightly bowed.

Remarks. The atypical form of the *a* element and the slender and multicostate nature of all the elements are reasons for questioning the generic assignment. *Walliserodus curvatus* (Branson and Branson), the type species of *Walliserodus,* has a short-based and recurved acodiform element in the *a* position. The *a* element of *W. ? rallus* n. sp. is slender and proclined. *Walliserodus ? rallus* differs further from *W. curvatus* in that its *a, b, c* and *d* elements are more slender, proclined and have more costae. The *c* elements of the above species are similar in that they are unbowed, but have a slight asymmetry due to the number and position of the costae. The narrowly convex inner face of the *e* element of *W. ? rallus* is equivalent to the carinate and costate face of the same element of *W. amplissimus* and *W. curvatus*, respectively.

The multicostate nature of elements of *W ? rallus* is more comparable to *W. ethingtoni* (Fåhraeus) sensu Löfgren (1978) than it is to *W. amplissimus* and *W. curvatus.* However, *W. ethingtoni* differs from *W. ? rallus* in that its elements have a short, wide base and nearly erect cusp.

Species of *Dvorakia* Klapper and Barrick have slender, multicostate elements that are similar in some respects to those of *W. ? rallus* and *Walliserodus* species. They differ, however, in apparatus plan and some morphological details. The most fundamental difference is that *Dvorakia* lacks a *c* element, which is present in the symmetry transition series of both *W. ? rallus* and species of *Walliserodus.* The *a* element of *Dvorakia* species (= Sc element of Klapper and Barrick, 1983) has an outline that is more similar to the homologous elements of *Walliserodus* species than to those of *W. ? rallus.* The costae are stronger and more distinct in all elements of *Dvorakia* species than they are in elements of *W. ? rallus*, but not as well developed as in elements of *Walliserodus* species.

Klapper and Barrick (1983) have suggested that the uppermost Ludlow-Eifelian genus *Dvorakia* is a probable descendant of the Upper Ludlow representatives of *Walliserodus.* They postulated that the evolutionary transition occurred during the Late Silurian and that the absence of a *c* element in *Dvorakia* represents a reduction in the number of apparatus positions. The recovery of elements of *W. ? rallus* from Upper Ordovician strata that are similar in many respects to those of *Dvorakia* may suggest that the start of the evolutionary transition from *Walliserodus* to *Dvorakia* occurred earlier than Klapper and Barrick (1983) suggested. Alternatively, *W. ? rallus* may represent an earlier speciation event that was unsuccessful and not part of a lineage from *Walliserodus* to *Dvorakia.*

Types. Holotype, GSC 80455; paratypes, 80451-80454, 80456, 80457.

Derivation of name. The trivial name is after a genus of long-legged wading bird, *Rallus*, and refers to the slender nature of the elements.

Genus *Zanclodus* Nowlan and McCracken n. gen.

Type species. *Zanclodus levigatus* Nowlan and McCracken n. sp.

Diagnosis. Panderodontacean conodonts with a skeletal apparatus comprising laterally acostate, deeply excavated, adenticulate, simple cone elements, each with a panderodont furrow on one lateral face and a weakly developed posterior heel. Three, internally variable groups of elements char- acterize the apparatus: those bowed to the unfurrowed side, those bowed to the furrowed side and unbowed elements. Each group shows a variation in the degree of recurvature of the cusp and the width of the base. Bowed elements are variable in the degree of bowing and the inward flexure of the anterior margin of the base.

Remarks. Representatives of *Zanclodus* n. gen. have previously been regarded as elements of unnamed species of *Panderodus.* However, the apparatus recognized is quite different from that of *Panderodus.* Barrick (1977) recognized four elements in the apparatus of *Panderodus:* a laterally compressed M element and three elements forming a transition series. Sweet (1979b) recognized an additional (tortiform) element in the transition series that does not materially change the apparatus. *Zanclodus* differs from *Panderodus* in having only three basic, but variable, types of element, in being laterally acostate and also in having elements that are bowed to the furrowed side.

Zanclodus is distinguished from *Pseudobelodina,* an apparatus with four element types, by being laterally acostate and adenticulate. It is, however, similar in apparatus style to *Pseudobelodina? dispansa* (Glenister), which is discussed in some detail above, and which we believe may not be a representative of *Pseudobelodina. Pseudobelodina? dispansa* has the same three basic groups of elements as *Z. levigatus* and it is weakly heeled, but elements of *P.? dispansa* are laterally costate and denticulate. *Pseudobelodina? dispansa* may belong to a separate genus that is more closely related to *Zanclodus* than to *Pseudobelodina*.

The distribution of white matter is unknown because of the high level of thermal alteration; white matter is visible only in cusp tips of small specimens.

Derivation of name. From the Greek, *zanklos*, meaning sickle, combined with *-odus*, a suffix meaning tooth.

Zanclodus levigatus Nowlan and McCracken n. sp.

Plate 20, figures 4, 9-24, Plate 21, figures 1-21, Plate 22, figures 1, 2, 4, 5

?*Panderodus* n. sp. B NOWLAN and BARNES, 1981, p. 19, Pl. 6, figs. 8, 12, 13, Textfig. 7E.

Diagnosis. As for genus.

Description. Apparatus consists of three, internally variable groups of elements: (1) those bowed to the unfurrowed side (Pl. 20, figs. 4, 9-24); (2) those bowed to the furrowed side (Pl. 21, figs. 1-12, 15, 20, 21); and (3) unbowed elements (Pl. 21, figs. 13, 14, 16-19; Pl. 22, figs. 1, 2, 4, 5).

(1) Elements bowed to the unfurrowed side are extremely variable in height of base and degree of recurvature of cusp. Outer lateral face bears a narrow furrow that is close and parallel to the posterior margin of cusp and confined to the posterior half of the base. Typically the furrow ends just above the aboral margin (Pl. 20, fig. 11), but in some specimens it intersects the margin (Pl. 20, fig. 20). A thin, posteriorly directed costa bounds the anterior margin of the furrow. In most specimens the furrow is flanked by prominent striae on the cusp and upper portion of the base.

Inner lateral face is smooth except for striae that are most prominent and abundant near the point of recurvature. Anterior margin is sharp for full length of high-based, slender elements (Pl. 20, figs. 14, 15). However, in more strongly reclined, low-based elements (e.g., Pl. 20, figs. 4, 10, 17, 18) the anterior margin of the base is narrowly rounded. In some elements, the anterior margin is slightly flexed inwards (Pl. 20, fig. 18) in the region of recurvature. In others, the anterior margin is more strongly flexed inwards and a broad carina is developed anterolaterally on the outer face (Pl. 20, figs. 21, 22). In such elements, the anterior margin is flat to concave.

Posterobasal corner is extended posteriorly and the distal portion of the posterior margin is narrowly rounded and thickened at, and below, the level of the basal wrinkles. These features combine to produce a narrow, poorly defined heel with a concave upper margin. The heel is most prominent on short-based elements and may be virtually absent on slender high-based elements. Above the basal wrinkles, the posterior margin is sharp and curves evenly into the thin, keel-like posterior margin of the cusp. The thin, posterior margin of the cusp is bounded anteriorly by the groove on the outer side and by the longitudinal striations on the inner side.

The cusp is laterally compressed, with sharp anterior and posterior edges. In slender elements with a high base (Pl. 20, figs. 11, 12, 14, 15), an abrupt recurvature of the cusp is present above the intersection of the cusp and base. In broad, low-based elements, the cusp is straight beyond the point of recurvature.

The basal cavity is deep, with the apex near the anterior margin. Anterior outline of basal cavity is convex, whereas posterior outline of basal cavity is gently concave. Aboral outline is straight to gently concave. Both left- and right-hand forms are present in the apparatus.

(2) Elements bowed to the furrowed side exhibit a similar variability of base height and cusp recurvature. They are also similar in most morphological aspects, except for the direction of bowing. A shallow, inner furrow is situated close and parallel to the posterior margin of the cusp. At the point of recurvature, the furrow diverges from the posterior margin and crosses the posterior portion of the base to intersect the aboral margin posterior to the mid-line of the base. In most specimens, the furrow terminates just above the basal margin. The posterior margin of the base has a weak heel developed in the thickened basal portion. The posterior margin of the upper part of the base and of the cusp is thin. The thin posterior margin is bounded anteriorly by the furrow on the inner side and by a striated area on the outer side.

Anterior margin is flexed inwards to varying degrees; it is sharp for the full length of the high-based elements (Pl. 21, figs. 1, 2, 7, 8), but narrowly rounded in the basal part of the low-based elements (e.g., Pl. 21, figs. 11, 12). A flattened anterior margin is developed in a few elements that have an outer, anterolateral carina and inwardly flexed anterior margin (Pl. 21, figs. 9, 10, 15).

In other respects, elements of Group 2 are identical to those of Group 1 described above. Both right- and left-hand forms are present.

(3) Unbowed elements have a short and broad base, like the most reclined bowed elements. Posterior portion of the base is weakly to markedly heeled, but a few specimens appear to lack a heel (Pl. 22, figs. 4, 5). In lateral view, the anterior margin of the base is strongly convex; maximum convexity is below the cusp/base interface. A gentle concavity in the anterior outline is present below the maximum convexity, producing a slightly sinuous anterior basal outline.

The furrowed side bears striae both anteriorly and posteriorly of furrow; they are most prominent on upper base and lower cusp. The furrow is close to the posterior margin of the cusp and extends onto the posterior margin of the cusp and onto the posterior portion of the base; it does not intersect the aboral margin, but may be represented by a shallow depression, which produces a downward extension of the aboral outline.

Unfurrowed side is smooth, except for longitudinal striae concentrated near the posterior margin. These striae form the anterior limit of a thin, sharp posterior margin on the cusp and upper base.

Cusp is broad, erect to slightly proclined and unbowed. Anterior and posterior margins are sharp.

Remarks. Nowlan and Barnes (1981) reported elements similar to *Z. levigatus* n. gen. n. sp. from the Vauréal Formation, Anticosti Island. Re-examination of the collections has confirmed a similar suite of elements. Only slender, bowed elements were illustrated (ibid .), but some low-based, unbowed elements are also present in the collections. *Panderodus* n. sp. B Nowlan and Barnes is undoubtedly a representative of *Zanclodus,* but some of its features are different from those of *Z. levigatus*. None of the elements assigned to *P.* n. sp. B exhibits a heel, and the posterior edge is not thin as in *Z. levigatus.* In addition, no bowed elements with a flattened anterior margin have been noted in the Anticosti collections.

Panderodus recurvatus (Rhodes) and *P. spasovi* Drygant?, both sensu Barrick (1977), are like *Z. levigatus* in that they include elements that have grooves on either the inner or outer face and also have a similar, sickle-like outline. *Panderodus recurvatus* and *P. spasovi* differ in that the basal heel is not as well developed and the elements are laterally costate. These species may be upper Llandovery representatives of the genus.

For additional comments see "Remarks" under the genus.

Derivation of name. From the latin, *levigatus,* meaning smooth, in reference to the lack of lateral costae.

Types. Holotype, GSC 80471; paratypes, GSC 80458-80470, 80472-80477.

Belodiniform element indet.

Plate 22, figures 6, 7

Description. A long, narrow, strongly bowed belodiniform element. Heel is narrow and basal cavity is shallow. Element is bowed strongly to unfurrowed side, which bears an anterolateral costa extending from top of heel to about two thirds of cusp length. Postero-oral margin bears ten low rectangular denticles with rounded apices. Denticles are more fused near heel and distal part of cusp, becoming more discrete near centre of element. Cusp, heel and denticles form an even, posteriorly concave curve; denticles do not project above level of heel or posterior margin of cusp. Medial portion of inner face between anterolateral costa and denticles is convex. Outer face is smoothly convex and bears a panderodont furrow, which originates at about mid-height of heel and extends to mid-point beneath eighth denticle. Anterior margin is evenly convex in lateral view, except for a small concavity beneath heel.

Remarks. This element is highly distinctive and has not been reported previously in the literature. One of us (GSN) has recognized similar elements in the Irene Bay Formation on Ellesmere Island in the Canadian Arctic Archipelago.

These elements may possibly belong to a species of *Culumbodina* Moskalenko as reconstructed by Sweet (1979b) because he noted that denticles are present on almost all of the posterior margin in juvenile representatives of the genus. The absence of associated elements precludes a generic assignment.

Types. Figured specimen, GSC 80479.

Oistodiform element indet.

Plate 22, figure 3

Remarks. Two oistodiform elements, both with broken cusps, are similar to the *e* element in species of *Periodon.* They have a sinuous basal outline and a long, posteriorly extended base. Lack of denticles on the anterior basal margin precludes positive generic identification. It is probable that these specimens are part of a *Periodon* apparatus, possibly *P. grandis* (Ethington).

Types. Figured specimen, GSC 80478.

Panderodiform element indet.

Plate 22, figures 10, 11

Description. A slender, bicostate, unbowed panderodiform element. Panderodontacean groove is restricted to posterior part of element, being coincident with the posterior margin on the cusp and close to the posterior margin on the base. A prominent furrow is developed around the groove on the distal part of the base. Grooved side bears an anterolateral costa that is pronounced at point of recurvature, less prominent on upper part of base and absent on distal part of base. Ungrooved side bears an anterolateral costa that extends to cusp tip, but is absent on most distal part of base. Base is parallel-sided in lateral view and tapering starts only near junction with cusp. Posterior margin is sharp; anterior margin is sharply rounded. Cusp is short and proclined.

Remarks. This element bears some resemblance to *c* (symmetrical) elements of *Panderodus gracilis,* but the parallel-sided base and short cusp distinguish it from that species. It is much more slender than *c* elements of *Panderodus rhamphoides*.

Types. Figured specimen, GSC 80483.

Associated microfossils

Genus *Milaculum* Müller, 1973

Type species. *Milaculum ruttneri* Müller, 1973

Milaculum aff. *M. ethinclarki* Müller

Plate 22, figures 8, 9, 12-15

aff. *Milaculum ethinclarki* MÜLLER, 1973, p. 223, Pl. 34, figs. 5, 6, 8.

Remarks. Milaculum ethinclarki was originally described from the Middle Ordovician Kirkfield Formation at Healey Falls in southern Ontario (Müller, 1973). The original synonymy also included forms from the Lower Ordovician illustrated by Ethington and Clark (1965). Recently, Ethington and Clark (1982) discussed *M. ethinclarki* and removed the Lower Ordovician specimens from synonymy, citing some consistent and significant differences in morpho- logy. Our Upper Ordovician material from the Avalanche Lake sections, although generally resembling *M. ethinclarki*, is also significantly different from the type material in a number of ways.

The material from the Avalanche Lake sections is morphologically variable, containing some specimens quite similar to *M. ethinclarki* (e.g., Pl. 22, figs. 8, 9), but they are more slender, and have more regularly arranged and less densely packed nodes on the upper surface. These specimens are smaller than the specimens illustrated by Müller (1973) and may be juveniles. Other specimens differ more markedly from *M. ethinclarki.* These are slender and taper evenly along the longitudinal axis, lacking the median construction of *M. ethinclarki.* The broad end of these specimens is also the highest part and the transverse face may be smooth (e.g., Pl. 22, fig. 13) or only weakly nodose (Pl. 22, fig. 14). Such smooth areas are not reported for the upper surface of *M. ethinclarki.* On most Avalanche Lake specimens, the nodes are more regularly arranged than in typical *M. ethinclarki,* being set in rows diagonal to the longitudinal axis on each side of the mid-line such that a crescentic pattern is produced (e.g., narrow end of specimen illustrated in Pl. 22, fig. 14). These characters serve to distinguish the Avalanche Lake specimens from typical *M. ethinclarki.* The differences noted by Ethington and Clark (1982) for Lower Ordovician material and herein for Upper Ordovician material may point to a future biostratigraphic use for the genus *Milaculum* in the Ordovician, or to the fact that a wide variety of elements were present in the animal that bore plates assigned to the genus.

Types. Figured specimens, GSC 80480-80482.

Genus *Phosphannulus* Müller, Nogami and Lenz

Type species. *Phosphannulus universalis* Müller, Nogami and Lenz.

Phosphannulus universalis Müller, Nogami and Lenz

Plate 22, figure 16

Phosphannulus universalis MÜLLER, NOGAMI and LENZ, 1974, p. 89, Pl. 18, figs. 1-12, Pl. 19, figs. 1-13, Pl. 20, figs. 1-7, Pl. 21, figs. 1-9. NOWLAN in BOLTON and NOWLAN, 1979, Pl. 8, fig. 33.

Remarks. A single specimen, lacking the tube-like projection of more complete specimens, has been recovered. It is identical to the more regular, symmetrical forms illustrated by Müller et al. (1974).

Types. Hypotype, GSC 80484.

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Table 1. Numerical distribution of conodont elements in samples from sections AV1 and AV4B. Genera and species are listed alphabetically; samples are listed in ascending stratigraphic order from left to right for each section. The locational notation of Barnes et al. (1979) is used for elements of most species, but other abbreviations are required for *Coelocerodontus trigonius* (TRI = trigoniform; TET = tetragoniform; B. C. = basal cone), *Pseudobelodina? dispansa* and *Zanclodus levigatus* (GP. 1, GP. 2, GP. 3 = groups 1, 2 and 3, respectively; uni = unicostate; bi = bicostate).

		AV1 m																
		-30	4	6	10	15	20	33.5	46	60	68	72	73	75	77	84.5	85.25	86
Amorphognathus? sp.	*g*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Aphelognathus floweri ?	*a*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
	g	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
A. politus	*a*	-	1	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	4	9	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	3	3	11	-	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	2	2	23	-	-	-	-	-	-	-	-	-	-	-	-	-
	g	-	20	7	90	-	-	-	-	-	-	-	-	-	-	-	-	-
Belodina confluens	*p*	-	3	3	19	1	-	-	1	-	-	-	-	-	-	-	-	-
	q	-	2	5	36	4	-	-	5	-	-	-	3	1	-	-	-	-
	r	-	4	-	10	-	-	-	4	-	-	-	-	-	-	-	-	-
Besselodus borealis	*a*	-	-	-	-	-	-	-	11	-	-	-	3	-	-	-	-	-
	b-1	-	-		-	-	-	-	6	1	-	1	3	1	-	-	-	-
	b-2	-	-	-	-	-	-	-	11	1	-	-	2	-	-	-	-	-
	c	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-
	e	-	-	-	-	-	-	-	10	-	-	-	2	-	-	-	-	-
	f?	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-
Coelocerodontus trigonius	TRI	-	-	-	-	-	-	-	4	-	-	-	4	-	-	-	-	-
	TET	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-
	B.C.	-	1	-	-	-	-	-	5	-	-	1	1	3	-	-	-	-
Dapsilodus ? sp. A	*a*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1
Decoriconus costulatus	AT	-	-	-	-	-	-	-	4	-	-	-	1	-	-	-	-	-
	PA	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Drepanoistodus suberectus	*p*	-	3	2	9	2	14	2	10	-	-	4	9	3	-	-	-	-
	q	-	16	11	121	33	112	21	66	1	5	19	24	9	-	-	-	-
	r	-	4	2	4	4	45	2	4	-	1	1	1	1	-	-	-	-
Juanognathus n. sp. A	*s*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	t	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oulodus rohneri	*a*	-	-	-	2	-	11	-	7	-	-	2	3	-	-	-	-	-
	b	-	-	-	-	-	1	-	2	-	-	1	1	-	-	-	-	-
	c	-	-	-	-	-	3	-	2	-	-	3	2	1	-	-	-	-
	e	-	-	-	1	-	4	-	11	-	-	1	1	-	-	-	-	-
	f	-	-	-	1	-	5	-	8	-	-	2	2	-	-	-	-	-
	g	-	-	-	2	-	1	-	4	-	-	3	3	2	-	-	-	-
O. ulrichi	*a*	-	-	-	-	24	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-
	g	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
Ozarkodina hassi	*a*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2
O. sesquipedalis	*a*	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	-	1?	-	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-
	g	-	1	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-
Panderodus aff. *P. bergstroemi*	*b*	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.? clinatus	*a/b*	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	e	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
P.? gibber	*a*	-	5	7	8	4	-	-	20	-	-	2	8	3	-	-	-	-
	b	-	1	1	4	1	1	-	4	-	-	-	2	-	-	-	-	-
	c	-	3	2	2	-	1	-	5	1	-	1	2	-	-	-	-	-

AV4B m 62	80.25	94.5	107.4	110.5	111	111.5	111.6	112	TOTAL	
–	–	–	–	–	–	–	–	–	1	*Amorphognathus? sp.*
–	–	–	–	–	–	–	–	–	0	*Aphelognathus floweri ?*
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	0	
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	3	
–	–	–	–	–	–	–	–	–	6	
–	–	–	–	–	–	–	–	–	8	*A. politus*
–	–	–	–	–	–	–	–	–	13	
–	–	–	–	–	–	–	–	–	17	
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	27	
–	–	–	–	–	–	–	–	–	117	
3	4	–	–	–	–	–	–	–	34	*Belodina confluens*
2	4	–	1	–	–	–	–	–	63	
1	1	–	1	–	–	–	–	–	21	
3	3	–	1	–	1	–	–	–	22	*Besselodus borealis*
2	2	–	2	–	3	–	–	–	21	
1	–	–	–	–	2	–	–	–	17	
–	–	–	–	–	–	–	–	–	4	
–	–	–	–	–	2	–	–	–	14	
–	–	–	–	–	–	–	–	–	3	
–	–	–	–	–	7	–	–	–	15	*Coelocerodontus trigonius*
–	–	–	–	–	2	–	–	–	5	
–	–	–	–	–	–	–	–	–	11	
–	–	–	–	–	–	–	1	–	2	*Dapsilodus ? sp. A*
–	–	–	–	–	–	–	2	2	9	
1	–	–	–	–	–	–	2	–	8	*Decoriconus costulatus*
3	–	–	–	–	1	–	2	1	10	
15	–	–	1	–	5	–	–	–	79	*Drepanoistodus suberectus*
232	4	1	4	–	27	–	–	–	706	
64	–	–	1	–	6	–	–	–	140	
–	–	–	–	–	–	–	–	–	2	*Juanognathus n. sp. A*
–	–	–	–	–	–	–	–	–	4	
–	–	–	–	–	–	–	–	–	0	
–	–	–	–	–	–	–	–	–	25	*Oulodus rohneri*
–	–	–	–	–	–	–	–	–	5	
–	–	–	–	–	–	–	–	–	11	
–	–	–	1	–	2	–	–	–	21	
–	–	–	–	–	4	–	–	–	22	
–	–	–	1	–	2	–	–	–	18	
–	–	–	–	–	–	–	–	–	24	*O. ulrichi*
–	–	–	–	–	–	–	–	–	9	
–	–	–	–	–	–	–	–	–	9	
–	–	–	–	–	–	–	–	–	13	
–	–	–	–	–	–	–	–	–	13	
–	–	–	–	–	–	–	–	–	7	
–	–	–	–	–	–	–	12	2	16	*Ozarkodina hassi*
–	–	–	–	–	–	–	13	2	15	
–	–	–	–	–	–	–	9	3	12	
–	–	–	–	–	–	–	3	2	5	
–	–	–	–	–	–	–	15	–	15	
–	–	–	–	–	–	–	20	2	27	
–	–	–	–	–	–	–	–	–	8	*O. sesquipedalis*
–	–	–	–	–	–	–	–	–	5	
–	–	–	–	–	–	–	–	–	1?	
–	–	–	–	–	–	–	–	–	11	
1	–	–	–	–	–	–	–	–	12	
–	–	–	–	–	–	–	–	–	19	
–	–	–	–	–	–	–	–	–	6	*Panderodus aff. P. bergstroemi*
–	–	–	–	–	–	–	–	–	1	
–	–	–	–	–	–	–	–	–	3	*P.? clinatus*
–	–	–	–	–	–	–	–	–	3	
12	–	–	2	–	17	–	–	–	88	*P.? gibber*
7	–	–	–	–	4	–	–	–	25	
3	–	–	–	–	5	–	–	–	25	

Table 1 (cont.)

		AV1 m																
		−30	4	6	10	15	20	33.5	46	60	68	72	73	75	77	84.5	85.25	86
P. gracilis	*a-c*	15	154	83	331	78	158	25	773	12	34	73	173	92	1	-	-	-
	e	3	54	22	145	17	38	3	213	3	4	19	50	19	2	-	-	-
P.? liratus	*a/b*	-	-	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-
P.? panderi ?	*a/b*	-	6	-	2	3	4	1	1	-	-	-	-	-	-	-	-	-
	b/c	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
P. rhamphoides	*a-b*	-	2	-	24	6	2	-	101	-	1	4	52	6	-	-	-	-
	c	-	1	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-
	e	-	5	2	9	2	1	-	70	-	1	3	32	3	-	-	-	-
***P. serratus* s.f.**		-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
***P.?* n.sp. A**	*a*	-	-	-	4	6	-	-	6	-	-	-	-	-	-	-	-	-
	b	-	-	-	1	4	-	-	4	-	-	-	-	-	-	-	-	-
***Paroistodus?* sp. A**	*a*-1	-	-	-	-	-	-	-	7	-	-	2	4	3	-	-	-	-
	a-2	-	-	-	-	-	-	-	5	1	-	-	1	2	-	-	-	-
	b-1	-	-	-	-	-	-	-	21	1	-	2	7	3	-	-	-	-
	b-2	-	-	-	-	-	-	-	8	-	-	-	3	1	-	-	-	-
	c	-	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-
	e	-	1	-	-	-	-	2	109	2	-	9	40	28	-	-	-	-
Phragmodus undatus	*a-d*	-	-	-	1	-	1	20	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	-	1	21	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-
	g	-	-	-	1	-	-	14	-	-	-	-	-	-	-	-	-	-
***P.?* sp.A**	*c?*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	b,e?	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectodina aculeatoides?	*a*	-	6	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	2	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	3	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-
	g	-	3	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-
P. florida	*a*	-	-	-	1	12	1	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	e	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
	g	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
P. tenuis	*a*	-	16	7	42	-	-	-	85	3	-	37	44	7	1	-	-	-
	b	-	4	4	27	-		-	18	-	-	13	11	2	-	-	-	-
	c	-	6	3	34	-	-	-	24	-	1	14	19	3	-	-	-	-
	e	-	10	3	31	-	-	-	67	-	2	23	32	8	-	-	-	-
	f	-	5	2	11	-	-	-	41	1	-	15	17	5	1	-	-	-
	g	-	8	4	22	-	-	-	56	3	-	26	27	12	-	-	-	-
Plegagnathus nelsoni	*a-c*	-	-	-	-	-	-	-	2	-	-	1	3	-	-	-	-	-
		-	-	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-
Protopanderodus liripipus	*b*	-	-	-	-	-	-	-	3	1	1	-	1	1	-	-	-	-
	c	-	-	-	-	-	-	-	-	1	-	2	1	2	-	-	-	-
Pseudobelodina* cf. *P. adentata	*a*	5	2	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
P.? dispansa	GP. 1	-	-	-	2	1	-	-	115	-	-	5	40	10	1	-	-	-
	GP. 2 uni	-	-	-	2	-	-	-	19	-	-	1	5	2	-	-	-	-
	GP. 2 bi	-	-	-	1	-	-	-	22	-	-	2	6	1	-	-	-	-
	GP. 3 uni	-	-	1	2	1	-	-	23	-	-	1	9	4	-	-	-	-
	GP. 3 bi	-	-	-	3	1	2	-	57	-	-	2	17	6	-	-	-	-
P.?* cf. *P.? dispansa		-	-	-	-	-	-	-	11	-	-	-	4	3	1	-	-	-
P. inclinata	*a*	-	2	-	2	4	1	1	-	-	-	-	-	-	-	-	-	-
	b	-	2	6	4	9	3	4	-	-	-	-	-	-	-	-	-	-
	c	-	-	-	-	3	1	1	-	-	-	-	-	-	-	-	-	-
	e?	-	-	1	-	2	-	4	-	-	-	-	-	-	-	-	-	-
P.? obtusa		-	-	-	25	5	-	-	-	-	-	-	-	-	-	-	-	-
P. quadrata	*a?*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	b	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	c	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

AV4B m										
62	80.25	94.5	107.4	110.5	111	111.5	111.6	112	TOTAL	
332	28	5	32	1	255	5	2	–	2662	***P. gracilis***
102	2	2	7	–	68	1	–	–	774	
–	–	–	–	–	1	–	–	–	7	***P.? liratus***
–	1	–	–	–	–	–	–	–	18	***P.? panderi ?***
–	–	–	–	–	–	–	–	–	4	
10	5	–	4	–	14	–	–	–	231	***P. rhamphoides***
–	–	–	–	–	1	–	–	–	5	
15	4	–	1	–	25	–	–	–	173	
8	–	–	–	–	–	–	–	–	10	***P. serratus* s.f.**
–	–	–	–	–	2	–	–	–	18	***P.?* n.sp. A**
–	–	–	–	–	4	–	–	–	13	
1	–	–	–	–	1	–	–	–	18	***Paroistodus?* sp. A**
1	–	–	–	–	2	–	–	–	12	
–	–	–	–	–	5	–	–	–	39	
1	–	–	–	–	4	–	–	–	17	
1	–	–	–	–	1	–	–	–	5	
18	–	–	9	–	64	–	–	–	282	
21	–	–	–	–	–	–	–	–	43	***Phragmodus undatus***
8	–	–	–	–	–	–	–	–	30	
2	–	–	–	–	–	–	–	–	18	
4	–	–	–	–	–	–	–	–	19	
–	–	–	–	–	–	–	–	–	1	***P.?* sp.A**
–	–	–	–	–	–	–	–	–	1	
–	–	–	–	–	–	–	–	–	21	***Plectodina aculeatoides?***
–	–	–	–	–	–	–	–	–	6	
–	–	–	–	–	–	–	–	–	6	
–	–	–	–	–	–	–	–	–	15	
–	–	–	–	–	–	–	–	–	19	
–	–	–	–	–	–	–	–	–	18	
–	–	–	–	–	–	–	–	–	14	***P. florida***
–	–	–	–	–	–	–	–	–	6	
–	–	–	–	–	–	–	–	–	0	
–	–	–	–	–	–	–	–	–	5	
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	10	
–	1	–	15	–	106	–	–	–	364	***P. tenuis***
–	1	1	3	–	28	–	–	–	112	
–	–	–	4	–	16	–	–	–	124	
–	1	–	4	–	35	–	–	–	216	
–	–	1	3	–	22	–	–	–	124	
–	–	1	3	–	32	–	–	–	194	
–	–	–	–	–	–	–	–	–	6	***Plegagnathus nelsoni***
–	–	–	–	–	–	–	–	–	3	
4	–	–	–	–	2	–	–	–	13	***Protopanderodus liripipus***
1	–	–	–	–	1	–	–	–	8	
–	–	–	–	–	–	–	–	–	13	***Pseudobelodina* cf. *P. adentata***
–	–	–	–	–	–	–	–	–	1	
–	–	–	–	–	–	–	–	–	1	
7	3	–	3	–	41	–	–	–	228	***P.? dispansa***
1	–	–	–	–	4	–	–	–	34	
–	–	–	–	–	3	–	–	–	35	
3	–	–	–	–	6	–	–	–	50	
7	–	–	1	–	12	–	–	–	108	
1	–	–	–	–	1	–	–	–	21	***P.?* cf. *P.? dispansa***
9	–	–	–	–	–	–	–	–	19	***P. inclinata***
25	–	–	–	–	–	–	–	–	53	
8	–	–	–	–	–	–	–	–	13	
8	–	–	–	–	–	–	–	–	15	
–	–	–	–	–	–	–	–	–	30	***P.? obtusa***
–	–	–	–	–	–	–	–	–	1	***P. quadrata***
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	1	

Table 1 (cont.)

		AV1 m																
		−30	4	6	10	15	20	33.5	46	60	68	72	73	75	77	84.5	85.25	86
P. vulgaris vulgaris	*a*	–	1	–	3	–	–	–	8	–	–	–	–	–	–	–	–	–
	b	–	–	–	–	–	–	–	5	–	–	1	–	–	–	–	–	–
	c	–	–	–	1	–	–	–	6	–	–	–	–	–	–	–	–	–
	e?	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–	–
P.* cf. *P. vulgaris vulgaris	*a*	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
	b	–	–	–	–	–	–	–	10	–	–	–	3	–	–	–	–	–
	c	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
***P.?* n.sp. A**		–	–	1	5	–	–	–	–	–	–	–	–	–	–	–	–	–
Pseudooneotodus* aff. *P. beckmanni		–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
P. mitratus		–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–
Scabbardella altipes	*a*	–	–	–	–	–	–	–	13	–	–	1	7	1	–	–	–	–
	b	–	–	–	–	–	2	–	10	–	1	1	4	1	–	–	–	–
	c	–	–	–	–	–	1	–	4	–	–	1	1	1	–	–	–	–
	e−1	–	–	–	–	–	1	–	3	–	–	2	2	1	–	–	–	–
	e−2	–	–	–	–	–	–	–	2	–	–	–	3	–	–	–	–	–
	e−3	–	–	–	–	–	1	–	5	–	–	2	5	2	–	–	–	–
***S.* n.sp. A**	*a?*	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–
	b−1	–	–	–	–	–	–	–	1	–	–	1	–	1	–	–	–	–
	b−2	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
	c	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
***Spinodus?* n.sp. A**		–	–	–	2	–	12	–	–	–	–	–	–	–	–	–	–	–
Staufferella divisa	*a*	–	3	4	3	–	–	–	14	–	–	–	5	–	–	–	–	–
	b	–	–	–	4	–	–	–	6	–	–	–	–	–	–	–	–	–
	c	–	1	–	4	–	–	–	8	–	1	–	–	–	–	–	–	–
	e−1	–	1	–	–	–	–	–	18	–	–	–	1	1	–	–	–	–
	e−2	–	2	1	9	–	1	–	16	–	–	1	5	2	–	–	–	–
	e−3	–	–	2	11	–	–	–	3	–	–	–	1	–	–	–	–	–
Walliserodus amplissimus	*a*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
	b	–	–	–	2	–	–	–	–	–	–	1	1	–	–	–	–	–
	c	–	–	–	5	–	–	–	–	–	–	–	4	–	–	–	–	–
	d	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
	e	–	2	–	5	–	–	–	3	–	–	–	1	–	–	–	–	–
W. curvatus	*a*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	b	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	d	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	e	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
W.? rallus	*a*	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
	b−1	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
	b−2	–	–	–	–	–	–	–	2	–	–	–	1	–	–	–	–	–
	c	–	–	–	–	–	–	–	5	–	–	–	1	–	–	–	–	–
	d	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
	e	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–
Zanclodus levigatus	GP. 1	–	1	2	4	10	14	6	1	1	2	–	–	–	–	–	–	–
	GP. 2	–	–	–	1	3	2	2	–	–	–	–	–	–	–	–	–	–
	GP. 3	–	–	–	1	3	9	4	–	1	1	–	–	–	–	–	–	–
belodiniform element indet.		–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
oistodiform element indet.		–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–
panderodiform element indet.		–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Totals:	38	380	205	1235	315	529	152	2240	35	55	310	736	258	7	6	2	5

AV4B m 62	80.25	94.5	107.4	110.5	111	111.5	111.6	112	TOTAL	
2	–	–	–	–	–	–	–	–	14	*P. vulgaris vulgaris*
3	–	–	–	–	–	–	–	–	9	
–	–	–	–	–	–	–	–	–	7	
1	–	–	–	–	–	–	–	–	10	
–	–	–	–	–	–	–	–	–	1	*P.* cf. *P. vulgaris vulgaris*
–	–	–	–	–	–	–	–	–	13	
–	–	–	–	–	–	–	–	–	2	
–	–	–	–	–	–	–	–	–	6	*P.*? n.sp. A
–	–	–	–	–	3	–	–	–	4	*Pseudooneotodus* aff. *P. beckmanni*
14	–	–	–	–	–	–	–	–	16	*P. mitratus*
2	1	–	1	–	4	–	–	–	30	*Scabbardella altipes*
5	1	–	–	–	4	–	–	–	29	
–	1	–	–	–	2	–	–	–	11	
2	1	–	–	–	4	–	–	–	16	
–	1	–	–	–	3	–	–	–	9	
1	–	–	1	–	5	–	–	–	22	
–	–	–	–	–	–	–	–	–	2	*S.* n.sp. A
–	–	–	–	–	–	–	–	–	3	
1	–	–	–	–	–	–	–	–	4	
–	–	–	–	–	–	–	–	–	1	
–	–	–	–	–	–	–	–	–	14	*Spinodus*? n.sp. A
5	–	–	–	–	3	–	–	–	37	*Staufferella divisa*
7	–	–	–	–	1	–	–	–	18	
4	–	–	–	–	1	–	–	–	19	
1	–	–	–	1	1	–	–	–	24	
2	–	–	–	–	1	–	–	–	40	
4	–	–	–	–	–	–	–	–	21	
–	–	–	–	–	–	–	–	–	3	*Walliserodus amplissimus*
–	–	–	–	–	–	–	–	–	4	
–	–	–	–	–	–	–	–	–	9	
–	–	–	–	–	–	–	–	–	2	
–	1	–	–	–	–	–	–	–	12	
–	–	–	–	–	–	–	–	–	0	*W. curvatus*
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–	–	–	–	–	–	–	–	–	0	
–	–	–	–	–	–	2	–	–	2	
–	–	–	–	–	–	–	–	–	3	*W.*? *rallus*
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–	–	–	–	–	1	–	–	–	4	
–	–	–	–	–	1	–	–	–	3	
230	2	1	2	–	–	–	–	–	276	*Zanclodus levigatus*
119	–	–	–	–	1	–	–	–	128	
113	1	2	2	–	–	–	–	–	137	
–	–	–	–	–	–	–	–	–	2	belodiniform element indet.
–	–	–	–	–	–	–	–	–	2	oistodiform element indet.
–	–	–	–	–	–	–	–	–	1	panderodiform element indet.
1464	73	14	110	2	883	9	81	14	9158	

PLATE 1

Figure 1. *Amorphognathus*? sp.

Oral view, *g* element, × 90, GSC 80180 from AV1-20 m.

Figures 2-4, 7. *Aphelognathus floweri* Sweet?

2. Posterior view, *b* element, × 85, GSC 80181.
3. Inner lateral view, *e* element, × 85, GSC 80182.
4. Inner lateral view, *f* element, × 54, GSC 80183.
7. Lateral view, *g* element, × 50, GSC 80184.

All specimens from AV1-20 m.

Figures 5, 6, 8-15. *Aphelognathus politus* (Hinde). Hypotypes.

5. Lateral view, *a-1* element, × 90, GSC 80185, from AV1-10 m.
6. Inner lateral view, *a-2* element, × 80, GSC 80186, from AV1-10 m.
8. Posterior view, *b* element, × 105, GSC 80187, from AV1-10 m.
9. Posterior view, *c* element, × 95, GSC 80188, from AV1-10 m.
10. Lateral view, *e* element, × 100, GSC 80189, from AV1-4 m.
11. Lateral view, *g* element, × 72, GSC 80190, from AV1-4 m.

12, 13. Lateral views, *g* element, × 65, GSC 80191, from AV1-10 m.

14. Inner lateral view, *f* element, × 120, GSC 80192, from AV1-10 m.
15. Lateral view, *g* element, × 85, GSC 80193, from AV1-10 m.

Figures 16-21. *Belodina confluens* Sweet. Hypotypes.

16, 17. Lateral views, *p* element, × 116, GSC 80194.
18, 19. Lateral views, *q* element, × 116, GSC 80195.
20, 21. Lateral views, *r* element, × 133, GSC 80196.

All specimens from AV1-10 m.

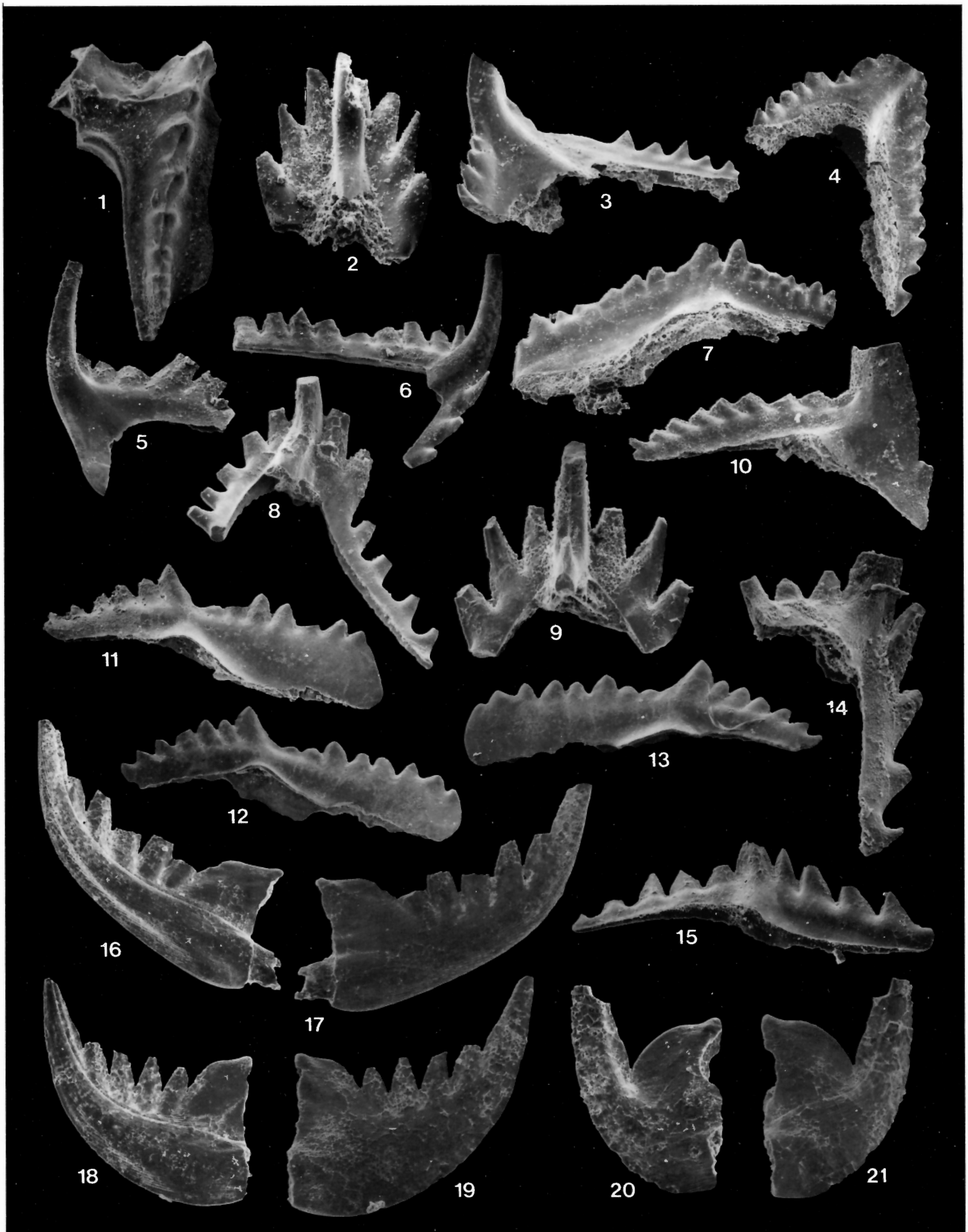
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PLATE 2

Figures 1-17. *Besselodus borealis* Nowlan and McCracken n. sp.

1, 2. Inner and outer views, *a* element, × 150, paratype, GSC 80197.
3, 4. Outer and inner lateral views, *b-2* element, × 180, paratype, GSC 80198.
5, 6. Outer and inner lateral views, *b-1* element, × 140, paratype, GSC 80199.
7, 8. Lateral views, *c* element, × 240, paratype, GSC 80200.
9, 10. Lateral views, *f*? element, × 165, paratype, GSC 80201.
11, 12. Outer and inner lateral views, *e* element, × 260, paratype, GSC 80202.
13-15. Posterolateral, posterior and lateral views, *c* element, × 205, paratype, GSC 80203.
16, 17. Inner and outer lateral views, *e* element, × 235, holotype, GSC 80204.

All specimens from AV1-46 m, except GSC 80202 (figs. 11, 12), which is from AV1-73 m.


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PLATE 3

Figures 1-5, 8-10. *Coelocerodontus trigonius* Ethington. Hypotypes.

1. Posterior view, asymmetrical tetragoniform, × 115, GSC 80205, from AV1-73 m.
2. Posterior view, basal funnel, × 165, GSC 80206, from AV1-46 m.
3. Lateral view, basal funnel, × 200, GSC 80207, from AV1-46 m.
4. Posterior view, symmetrical trigoniform element, × 115, GSC 80208, from AV1-73 m (see fig. 10).
5. Lateral view of basal funnel in situ with densely packed lamellae, × 285, GSC 80209, from AV1-73 m (see fig. 8).

8, 9. Inner and outer lateral views, slightly asymmetrical trigoniform element, × 100, GSC 80209 (see fig. 5).

10. Apical view of tip of symmetrical trigoniform element showing cross-section of basal cavity, × 890, GSC 80208 (see fig. 4).

Figures 6, 7, 11-13. *Dapsilodus*? sp. A Nowlan and McCracken.

6, 7. Inner and outer lateral views, *a* element, × 150, GSC 80210, from AV4B-111.6 m.

11, 12. Outer and inner lateral views, *b* element, × 135, GSC 80211, from AV1-84.5 m.

13. Outer view, *b* element, × 150, GSC 80212, from AV1-84.5 m.

Figures 14-18, 23. *Decoriconus costulatus* (Rexroad). Hypotypes.

14. Inner lateral view, paltodiform element, × 205, GSC 80213.
15. Inner lateral view, paltodiform element, × 175, GSC 80214.
16. Inner lateral view, acontiodiform element, × 230, GSC 80215.
17. Inner lateral view, paltodiform element, × 230, GSC 80216.

18, 23. Inner and outer lateral views, acontiodiform element, × 230, GSC 80217.

Specimens GSC 80213-80215 (figs. 14-16) are from AV1-46 m of Ordovician age; GSC 80216, 80217 (figs. 17, 18, 23) are from AV4B-111.6 m of Silurian age.

Figures 19-22. *Drepanoistodus suberectus* (Branson and Mehl). Hypotypes.

19. Lateral view, *p* element, × 70, GSC 80218.
20. Lateral view, *p* element, × 80, GSC 80219.
21. Lateral view, *q* element, × 75, GSC 80220.
22. Inner lateral view, *r* element, × 130, GSC 80221.

All specimens from AV1-10 m, except GSC 80218 (fig. 19), which is from AV1-4 m.


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PLATE 4

Figures 1-3. *Juanognathus* n. sp. A Nowlan and McCracken.

1. Posterior view, slightly asymmetrical *t* element, × 130, GSC 80222.
2. Posterior view, markedly asymmetrical *t* element, × 140, GSC 80223.
3. Lateral view, *s* element, × 105, GSC 80224.

All specimens from AV1-(-30 m).

Figures 4-9. *Oulodus rohneri* Ethington and Furnish. Hypotypes.

4. Posterior view, *b* element, × 110, GSC 80225.
5. Posterior view, *c* element, × 110, GSC 80226.
6. Inner lateral view, *a* element, × 145, GSC 80227.
7. Inner lateral view, *e* element, × 135, GSC 80228.
8. Posterior view, *g* element, × 110, GSC 80229.
9. Inner lateral view, *f* element, × 145, GSC 80230.

All specimens from AV1-46 m.

Figures 10-15. *Oulodus ulrichi* (Stone and Furnish). Hypotypes.

10. Posterior view, *g* element, × 55, GSC 80231.
11. Posterior view, *c* element, × 75, GSC 80232.
12. Posterior view, *b* element, × 75, GSC 80233.
13. Inner lateral view, *a* element, × 75, GSC 80234.
14. Inner lateral view, *e* element, × 60, GSC 80235.
15. Inner lateral view, *f* element, × 75, GSC 80236.

All specimens from AV1-15 m.

Figures 16-20. *Ozarkodina hassi* (Pollock, Rexroad and Nicoll). Hypotypes.

16. Inner lateral view, *a* element, × 100, GSC 80237.
17. Posterior view, *b* element, × 85, GSC 80238.
18. Posterior view, *c* element, × 95, GSC 80239.
19. Posterior view, *e* element, × 150, GSC 80240.
20. Fused cluster, *b* or *c* element beneath *g* element, × 100, GSC 80241.

All specimens from AV4B-111.6 m. More elements of O. *hassi* are illustrated in Plate 5.

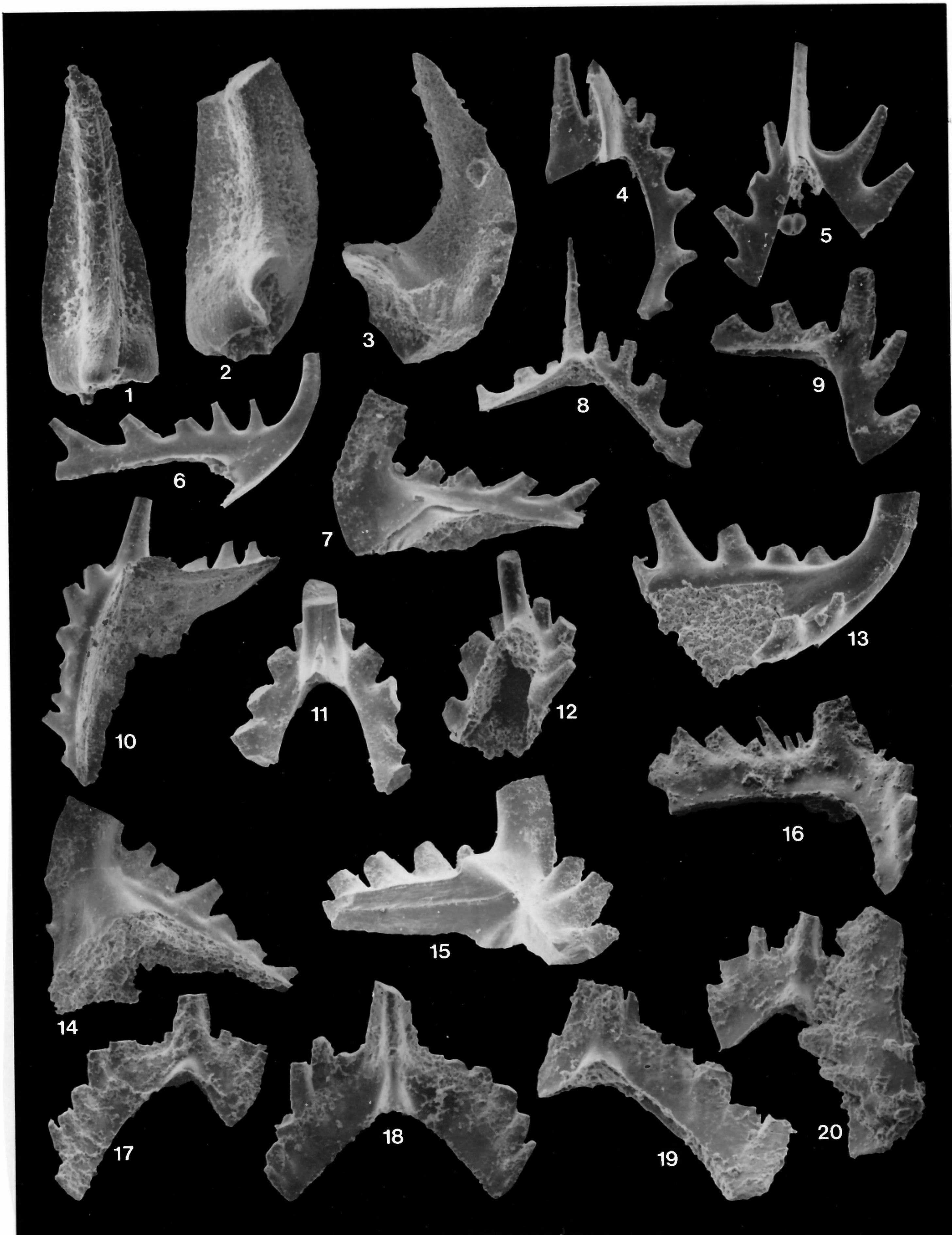

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PLATE 5

Figures 1-15. *Ozarkodina sesquipedalis* Nowlan and McCracken n. sp.

1. Inner lateral view, *a-2* element, paratype, × 105, GSC 80248.
2. Inner lateral view, *a-1* element, paratype, × 130, GSC 80249.
3. Outer lateral view, *a-2* element, paratype, × 130, GSC 80250.
4. Posterior view, fragmentary *c*? element, paratype, × 85, GSC 80251.
5. Posterolateral view, *b* element, paratype, × 115, GSC 80252.
6. Posterior view, *b* element, paratype, × 100, GSC 80253.

7, 8. Outer and inner lateral views, *f* element, paratype, × 105, GSC 80254.

9, 11. Outer and inner lateral views, *e-1* element, holotype, × 105, GSC 80255 (see fig. 14).

10. Inner lateral view, *e-2* element, paratype, × 150, GSC 80256.

12. Inner lateral view, *f* element, paratype, × 90, GSC 80257.

13. Lateral view, *g* element, paratype, × 80, GSC 80258.

14. Close-up view of posterior portion of cusp (left) and proximal denticles, *e-1* element, holotype, × 320, GSC 80255 (see figs. 9, 11).

15. Lateral view, *g* element, paratype, × 95, GSC 80259.

All specimens from AV1-20 m.

Figures 16-21. *Ozarkodina hassi* (Pollock, Rexroad and Nicoll). Hypotypes.

16. Inner lateral view, *f* element, × 115, GSC 80242.
17. Lateral view, *g* element, × 80, GSC 80243.
18. Lateral view, *g* element with needle-like denticles in medial portion, × 115, GSC 80244.
19. Lateral view, *g* element, × 115, GSC 80245.
20. Lateral view, *g* element, × 90, GSC 80246.
21. Lateral view, *f* element with long posterior process, × 155, GSC 80247.

All specimens from AV4B-111.6 m, except GSC 80243 (fig. 17), which is from AV1-84.5 m.

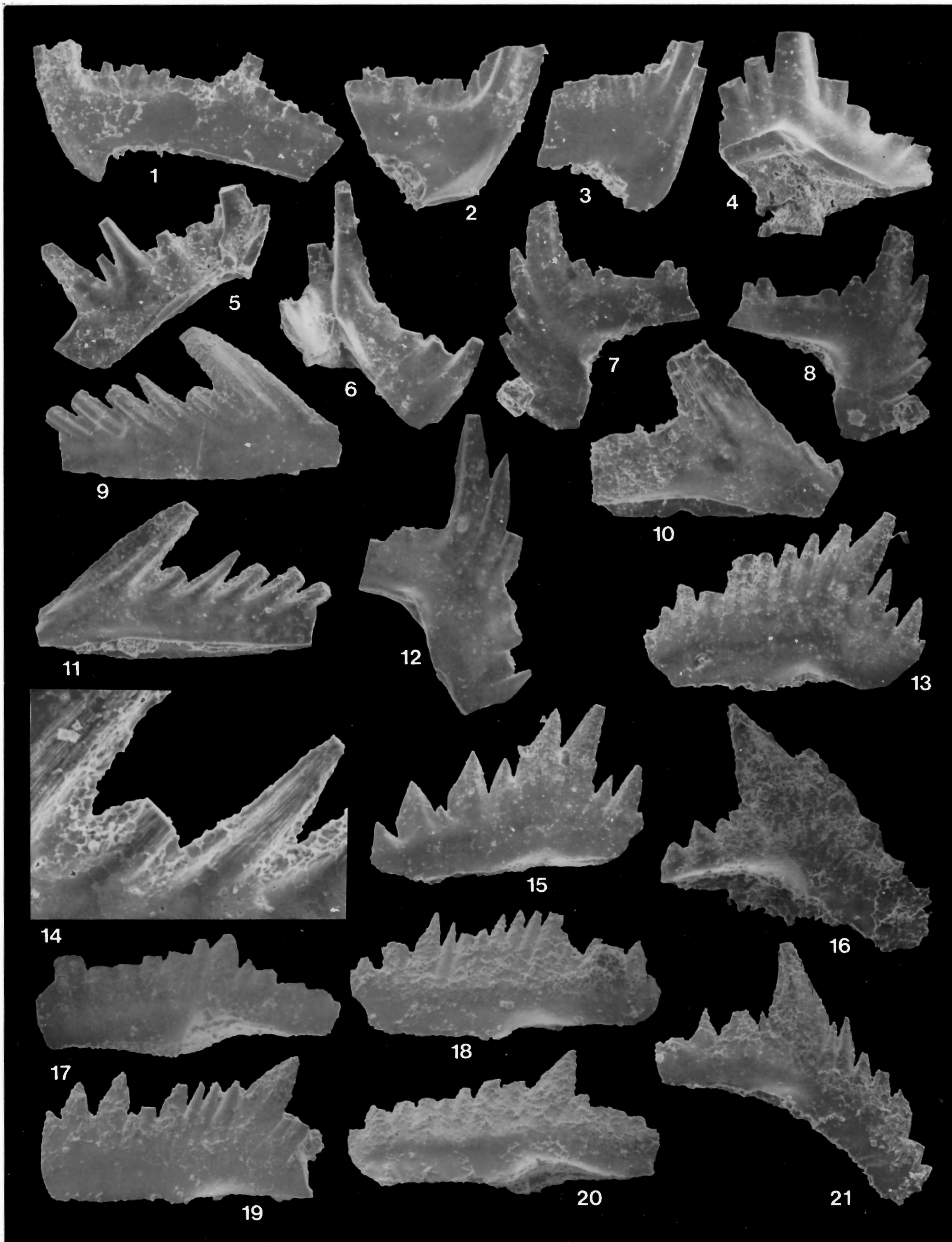
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PLATE 6

Figures 1-5. *Panderodus* aff. *P. bergstroemi* Sweet.

1, 2. Lateral views, *c* element, × 125, GSC 80260.
3. Lateral view, *b* element, × 95, GSC 80261.
4, 5. Lateral views, *b* element, × 95, GSC 80262.

All specimens from AV1-(-30 m).

Figures 6-11. *Panderodus*? *clinatus* McCracken and Barnes. Hypotypes.

6, 7. Lateral views, weakly compressed *e* element, × 110, GSC 80263, from AV1-6 m.
8, 9. Lateral views, *e* element, × 120, GSC 80264, from AV1-4 m.
10, 11. Lateral views, *a/b* element, × 80, GSC 80265, from AV1-20 m.

Figures 12-20. *Panderodus*? *gibber* Nowlan and Barnes.

12, 13. Lateral views, *c* element, × 180, GSC 80266, from AV1-46 m.
14, 15. Inner and outer lateral views, *a* element, × 180, GSC 80267, from AV1-46 m.
16, 17. Inner and outer lateral views, *a* element, × 170, GSC 80268, from AV1-46 m.
18, 19. Outer and inner lateral views, *b* element, × 120, GSC 80269, from AV4B-62 m.
20. Outer lateral view, *b* element, × 130, GSC 80270, from AV1-20 m.


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PLATE 7

Figures 1-10, 12, 13, 19. *Panderodus gracilis* (Branson and Mehl). Hypotypes.

1. Lateral view, *c* element, × 95, GSC 80271, from AV1-73 m.
2, 3. Lateral views, *c* element, × 95, GSC 80272, from AV1-10 m.
4, 5. Inner and outer lateral views, *a* element, × 135, GSC 80273, from AV1-46 m.
6, 19. Lateral views, *e* element, × 95, GSC 80274, from AV1-10 m.
7, 8. Outer and inner lateral views, *b* element, × 90, GSC 80275, from AV1-73 m.
9, 10. Outer and inner lateral views, *a-b* element, × 95, GSC 80276, from AV1-10 m.
12, 13. Lateral views, *e* element, × 110, GSC 80277, from AV1-73 m.

Figures 11, 15-18, 22. *Panderodus*? *liratus* Nowlan and Barnes. Hypotypes.

11, 22. Inner and outer lateral views, slender *a/b* element, × 80, GSC 80278, from AV1-20 m.
15, 16. Outer and inner lateral views, slender *a/b* element, × 85, GSC 80279, from AV1-20 m.
17, 18. Inner and outer lateral views, slender *a/b* element, × 85, GSC 80280, from AV1-10 m.

Figures 14, 20, 21, 23-25. *Panderodus*? *panderi* (Stauffer)?

14, 25. Inner and outer lateral views, slightly bowed, slender *a/b* element, × 150, GSC 80281, from AV1-46 m.
20, 21. Inner and outer lateral views, slightly bowed, broader *a/b* element, × 135, GSC 80282, from AV1-4 m.
23, 24. Lateral views, *b/c* element with furrow on both sides and basal thickening, × 120, GSC 80283, from AV1-20 m.

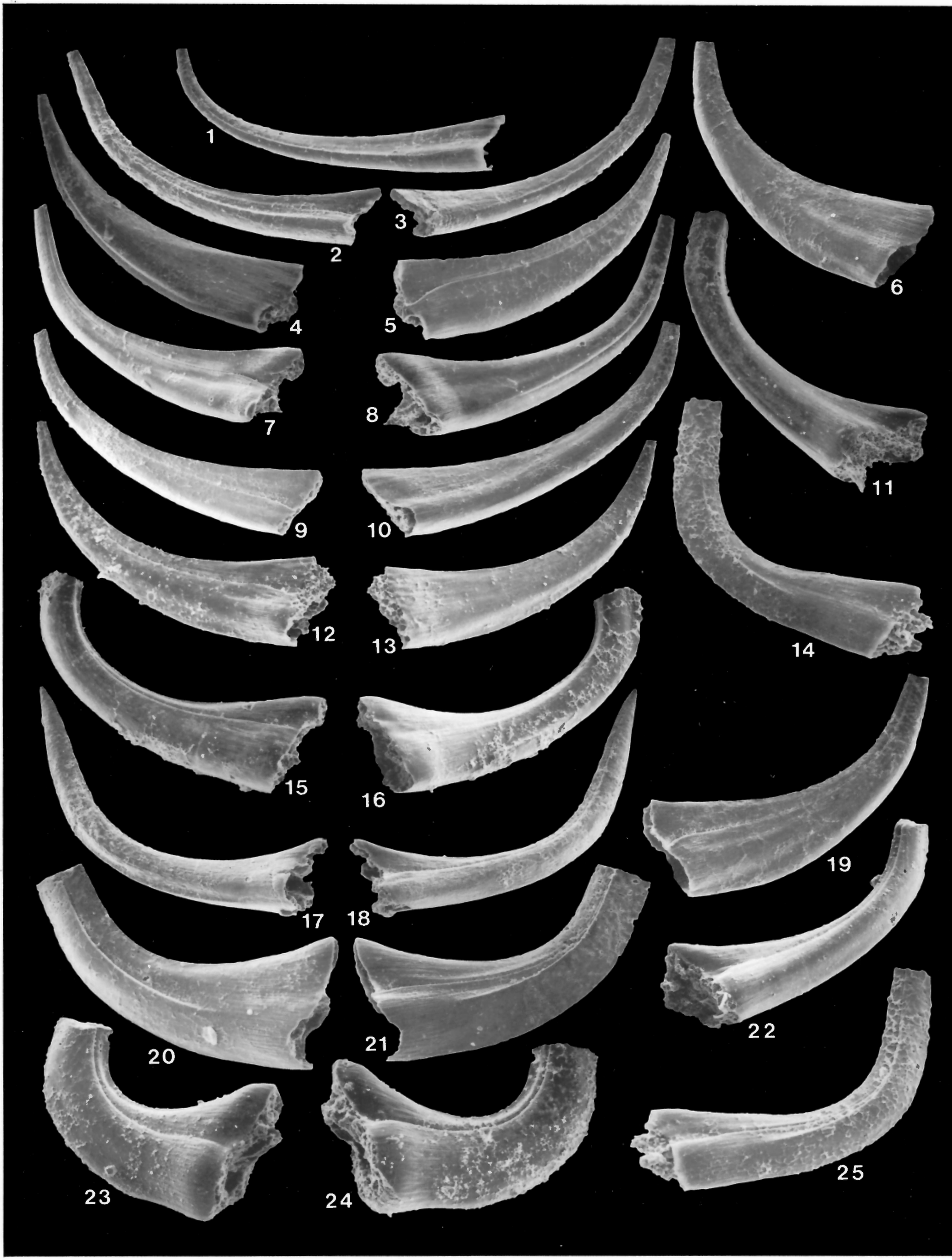
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PLATE 8

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, × 130, GSC 80284, from AV1-46 m.
3, 4. Inner and outer lateral views, *b* element, paratype, × 120, GSC 80285, from AV1-10 m.
8, 9. Inner and outer lateral views, *b* element, holotype, × 80, GSC 80286, from AV1-10 m.
10, 11. Inner and outer lateral views, *b* element, paratype, × 110, GSC 80287, from AV1-6 m.
12, 13. Inner and outer lateral views, *c* element, paratype, × 110, GSC 80288, from AV1-4 m.
14, 15. Outer and inner lateral views, *e* element, paratype, × 210, GSC 80289, from AV1-46 m.
20, 21. Inner and outer lateral views, *e* element, paratype, × 200, GSC 80290, from AV1-46 m.
26. Outer lateral view, *e* element, paratype, × 180, GSC 80291, from AV1-46 m.

Figures 5-7. *Panderodus serratus* Rexroad s.f. Hypotypes.

5, 7. Outer and inner lateral views, × 155, GSC 80292.
6. Inner lateral view, × 115, GSC 80293.

Both specimens from AV4B-62 m.

Figures 16-19, 22-25. *Panderodus*? n. sp. A Nowlan and McCracken.

16, 17. Outer and inner lateral views, *a* element, × 165, GSC 80294.
18, 19. Outer and inner lateral views, *a* element with medial outer costa, × 200, GSC 80295.
22, 23. Outer and inner lateral views, *a* element, × 220, GSC 80296.
24, 25. Outer and inner lateral views, *b* element, × 220, GSC 80297.

All specimens from AV1-15 m, except GSC 80294 (figs. 16, 17), which is from AV1-10 m.

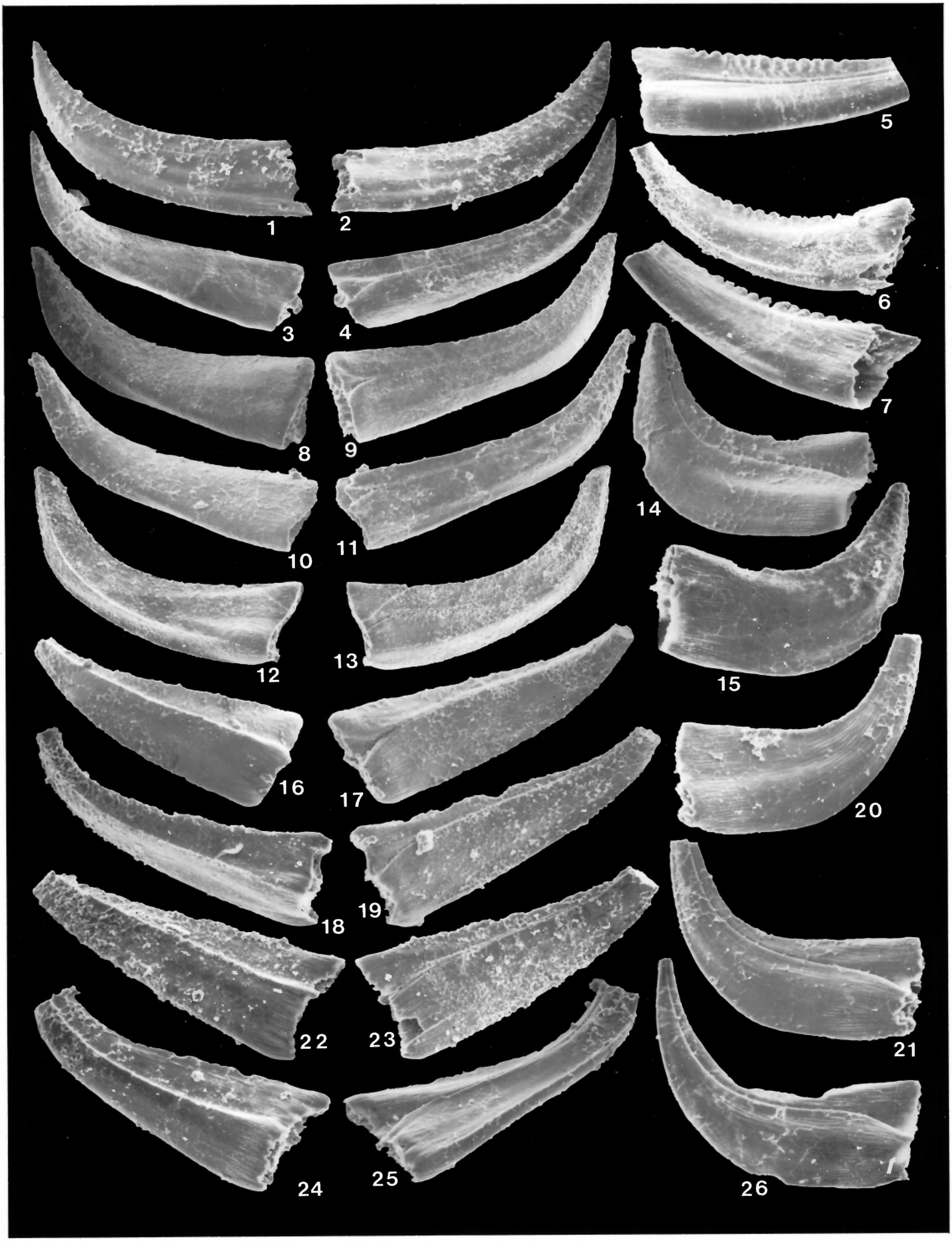
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PLATE 9

Figures 1-22. *Paroistodus*? sp. A Nowlan and McCracken.

1, 3.	Outer and inner lateral views, *a-1* element, × 255, GSC 80298.
2, 11.	Outer and inner lateral views, *b-1* element, × 160, GSC 80299.
4.	Outer lateral view, *e* element, × 280, GSC 80300.
5, 6.	Outer and inner lateral views, *a-1* element, × 170, GSC 80301.
7, 12.	Inner and outer lateral views, *b-1* element, × 170, GSC 80302.
8, 13.	Inner and outer lateral views, *b-2* element, × 195, GSC 80303.
9, 10.	Outer and inner lateral views, *a-1* element, × 155, GSC 80304.
14, 15.	Outer and inner lateral views, *a-2* element, × 170, GSC 80305.
16-19.	Lateral, anterolateral, lateral and anterior views, *c* element, × 155, GSC 80306.
20.	Inner lateral view, *e* element, × 145, GSC 80307.
21, 22.	Inner and outer lateral views, *e* element, × 180, GSC 80308.

All specimens from AV1-46 m, except GSC 80298, 80300 and 80301 (figs. 1, 3, 4-6), which are from AV1-73 m.

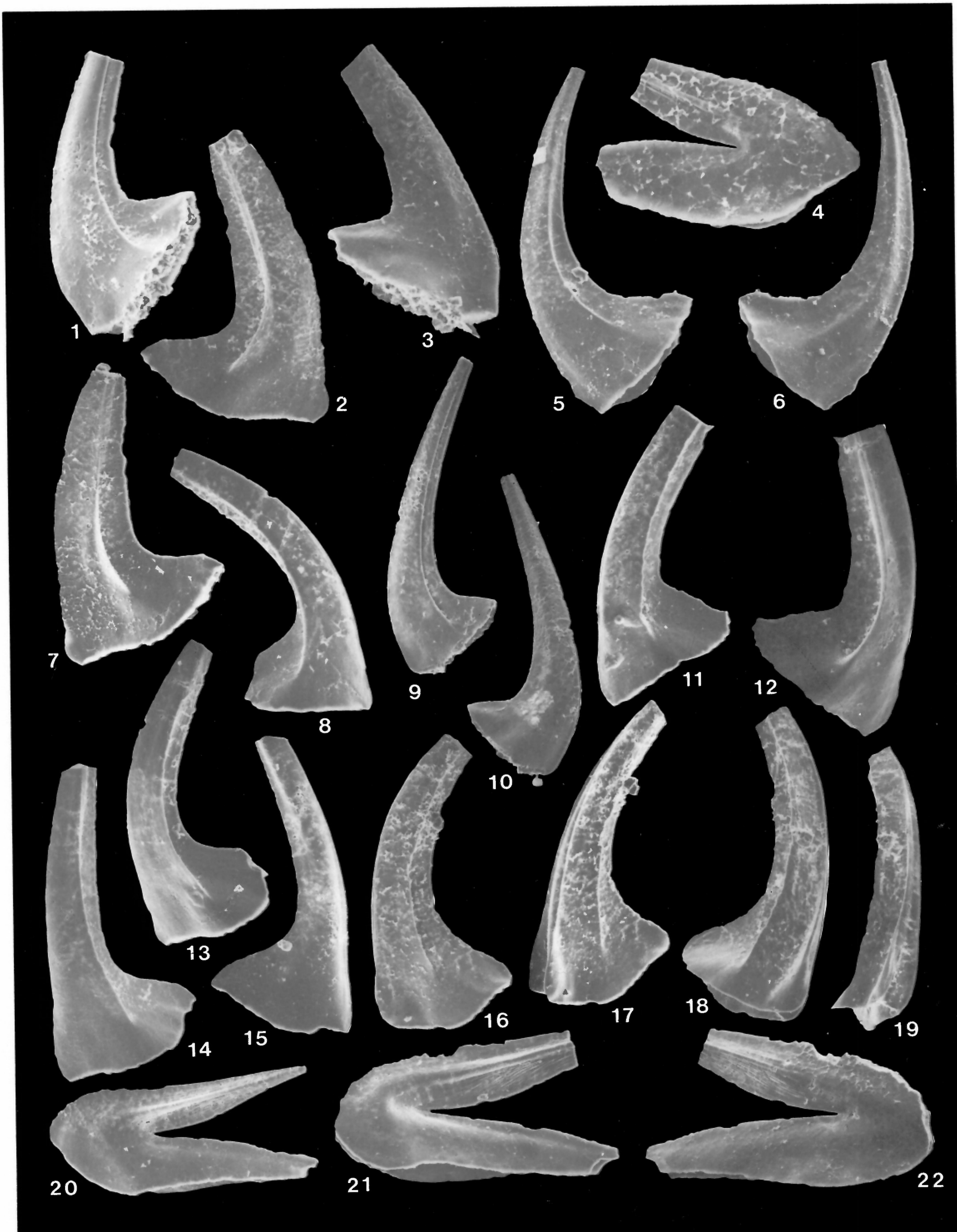
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PLATE 10

Figures 1-3, 6, 7. *Phragmodus undatus* Branson and Mehl. Hypotypes.

1. Lateral view, *b* element, × 160, GSC 80309.
2. Lateral view, *c* element, × 140, GSC 80310.
3. Outer lateral view, *g* element, × 150, GSC 80311.
6. Inner lateral view, *e* element, × 140, GSC 80312.
7. Outer lateral view, *f* element, × 150, GSC 80313.

Specimens from AV4B-62 m, except GSC 80309 and 80312 (figs. 1, 6), which are from AV1-33.5 m.

Figures 4, 5. *Phragmodus*? sp. A Nowlan and McCracken.

4. Lateral view, *c*? element, × 95, GSC 80314.
5. Posterolateral view, *b*? or *e*? element, × 95, GSC 80315.

Both specimens from AV1-(-30 m).

Figures 8-15, 17, 18. *Plectodina aculeatoides* Sweet?

8. Inner lateral view, *a* element, × 105, GSC 80316.
9. Posterior view, *b* element, × 90, GSC 80317.

10, 11. Outer and inner lateral views, *f* element, × 85, GSC 80318.

12. Inner lateral view, *e* element, × 105, GSC 80319.
13. Inner lateral view, *e* element, × 75, GSC 80320.
14. Posterior view, *c* element, × 100, GSC 80321.
15. Inner lateral view, *f* element, × 90, GSC 80322.
17. Inner lateral view, *g* element, × 65, GSC 80323.
18. Inner lateral view, *g* element, × 80, GSC 80324.

All specimens from AV1-10 m, except GSC 80323 (fig. 17), which is from AV1-4 m.

Figures 16, 19-22. *Plectodina florida* Sweet. Hypotypes.

16. Posterior view, *b* element, × 70, GSC 80325.
19. Inner lateral view, *a* element, × 70, GSC 80326.
20. Inner lateral view, *e* element, × 70, GSC 80327.
21. Inner lateral view, *f* element, × 60, GSC 80328.
22. Lateral view, *g* element, × 50, GSC 80329.

All specimens from AV1-15 m.


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PLATE 11

Figures 1-8, 10-12, 14, 15. *Plectodina tenuis* (Branson and Mehl). Hypotypes.

1. Posterior view, *b* element, × 110, GSC 80330, from AV1-46 m.
2. Posterior view, *b* element, × 100, GSC 80331, from AV1-46 m.
3. Posterior view, *c* element, × 75, GSC 80332, from AV1-4 m.
4. Posterior view, *c* element, × 105, GSC 80333, from AV1-46 m.
5. Lateral view, *e* element, × 100, GSC 80334, from AV1-46 m.

6, 7. Lateral views, *a* element, × 65 and × 130, respectively, GSC 80335, from AV1-46 m.

8. Inner lateral view, *e* element, × 95, GSC 80336, from AV1-73 m.
10. Outer lateral view, *f* element, × 110, GSC 80337, from AV1-73 m.
11. Lateral view, *g* element, × 75, GSC 80338, from AV1-46 m.
12. Lateral view, *g* element, × 100, GSC 80339, from AV1-73 m.
14. Inner lateral view, *f* element, × 110, GSC 80340, from AV1-46 m.
15. Lateral view, *g* element, × 110, GSC 80341, from AV1-73 m.

Figures 9, 13, 16, 17, 19. *Plegagnathus nelsoni* Ethington and Furnish. Hypotypes.

9. Lateral view, unfurrowed side, plegagnathiform element, × 250, GSC 80342, from AV1-73 m.
13. Lateral view, furrowed side, plegagnathiform element with unusually short cusp, × 190, GSC 80343, from AV1-10 m.
16. Lateral view, *b*? element, × 135, GSC 80344, from AV1-73 m.
17. Lateral view, *b*? element, × 160, GSC 80345, from AV1-72 m.
19. Lateral view, furrowed side, plegagnathiform element, × 160, GSC 80346, from AV1-72 m.

Figures 18, 20. *Protopanderodus liripipus* Kennedy, Barnes and Uyeno. Hypotypes.

18. Lateral view, protopanderodiform *c* element, × 125, GSC 80347, from AV1-72 m.
20. Lateral view, protopanderodiform *b* element, × 95, GSC 80348, from AV1-75 m.

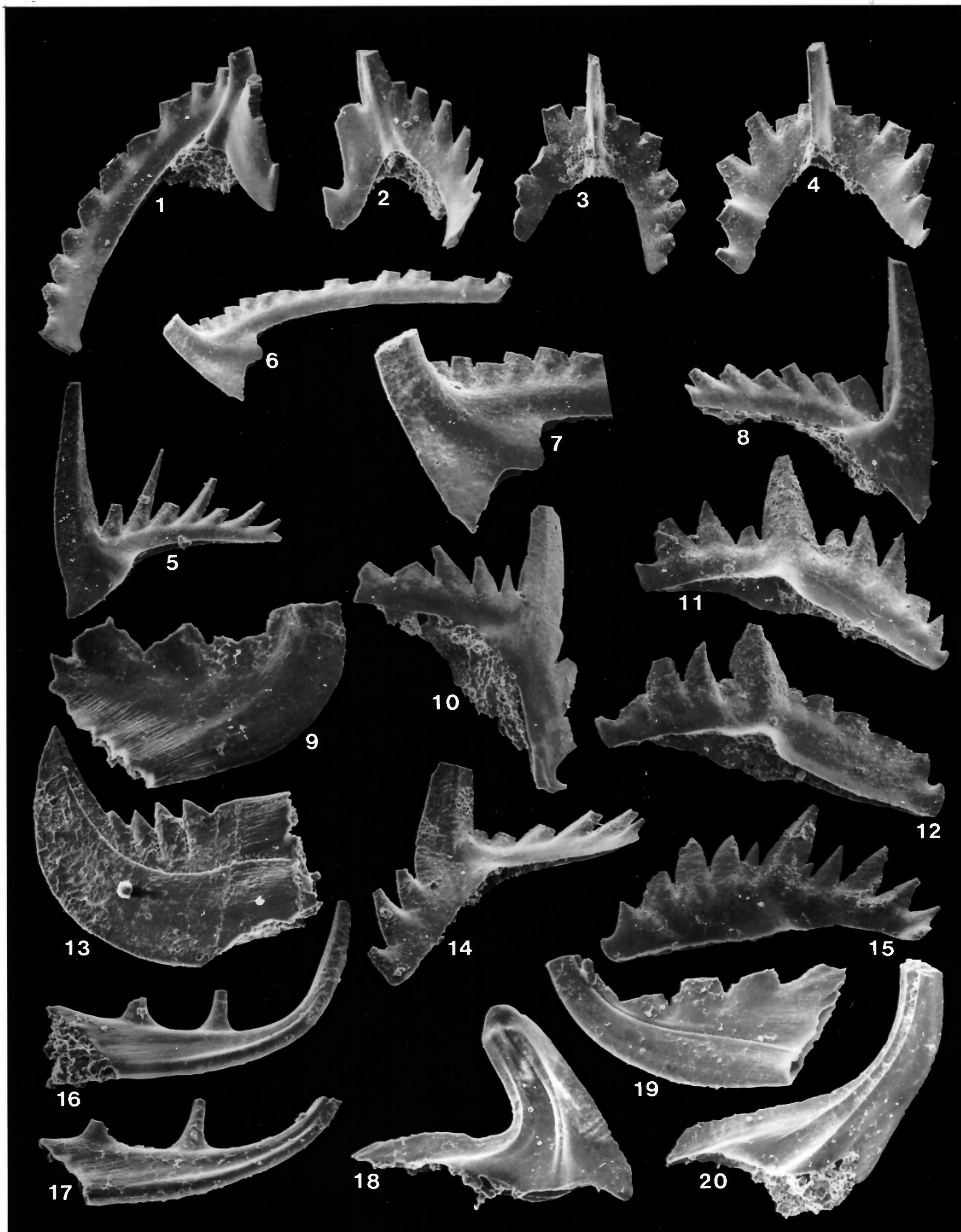
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PLATE 12

Figures 1-7. *Pseudobelodina* cf. P. *adentata* Sweet.

1, 2. Outer and inner lateral views, *a* element, × 165, GSC 80349, from AV-10 m.
3. Inner lateral view, *a* element, × 110, GSC 80350, from AV1-(-30 m).
4. Outer lateral view, fragmentary *b*? element, × 165, GSC 80351, from AV1-6 m.
5, 6. Lateral views, *c* element, × 165, GSC 80352, from AV1-10 m.
7. Inner lateral view, *a* element, × 130, GSC 80353, from AV1-10 m.

Figures 8-26. *Pseudobelodina*? *dispansa* (Glenister). Hypotypes.

8, 9. Outer and inner lateral views, bicostate element bowed to the unfurrowed side, × 140, GSC 80354.
10, 19. Lateral views, unbowed bicostate element, × 120, GSC 80355.
11, 12. Inner and outer lateral views, bicostate element bowed to the unfurrowed side, × 115, GSC 80356.
13, 22. Lateral views, unbowed unicostate element (costa on unfurrowed side), × 150, GSC 80357.
14, 15. Outer and inner lateral views, bicostate, slender element bowed to the unfurrowed side, × 150, GSC 80358.
16, 26. Inner and outer lateral views, unicostate element bowed to the furrowed side (costa is on inner, furrowed side), × 120, GSC 80359.
17, 18. Outer and inner lateral views, bicostate element bowed to the furrowed side, × 160, GSC 80360.
20, 21. Outer and inner lateral views, unicostate element bowed the furrowed side (costa is on outer, unfurrowed side), × 140, GSC 80361.
23, 24. Outer and inner lateral views, unicostate element bowed to the furrowed side (costa is on outer, unfurrowed side), × 160, GSC 80362.
25. Posterior view, bicostate element bowed to furrowed side, × 130, GSC 80363.

All specimens from AV1-46 m, except GSC 80360 (figs. 17, 18), which is from AV1-73 m.

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PLATE 13

Figures 1-4. *Pseudobelodina*? cf. *P.*? *dispansa* (Glenister).

1, 2. Lateral views, × 190, GSC 80364.
3, 4. Lateral views, × 220, GSC 80365. Both specimens from AV1-46 m.

Figures 5-20. *Pseudobelodina inclinata* (Branson and Mehl). Hypotypes.

5. Close up of basal filling of specimen illustrated in figures 6, 11, × 225.
6, 11. Outer and inner lateral views, *a* element, × 100, GSC 80366, from AV1-33.5 m (see fig. 5).
7, 8. Inner and outer lateral views, *b* element, × 100, GSC 80367, from AV1-15 m.
9, 10. Inner and outer lateral views, *b* element, × 85, GSC 80368, from AV1-15 m.
12, 13. Outer and inner lateral views, *b* element, × 150, GSC 80369, from AV1-4 m.
14, 17. Outer and inner lateral views, *a* element, × 85, GSC 80370, from AV1-15 m.
15, 16. Inner? and outer? lateral views, *c* element, × 100, GSC 80371, from AV1-15 m.
18, 19. Inner and outer lateral views, *c* element, × 200, GSC 80372, from AV1-33.5 m.
20. Outer lateral view, *b* element, × 100, GSC 80373, from AV1-33.5 m. More specimens of *P. inclinata* are illustrated in Plate 14.

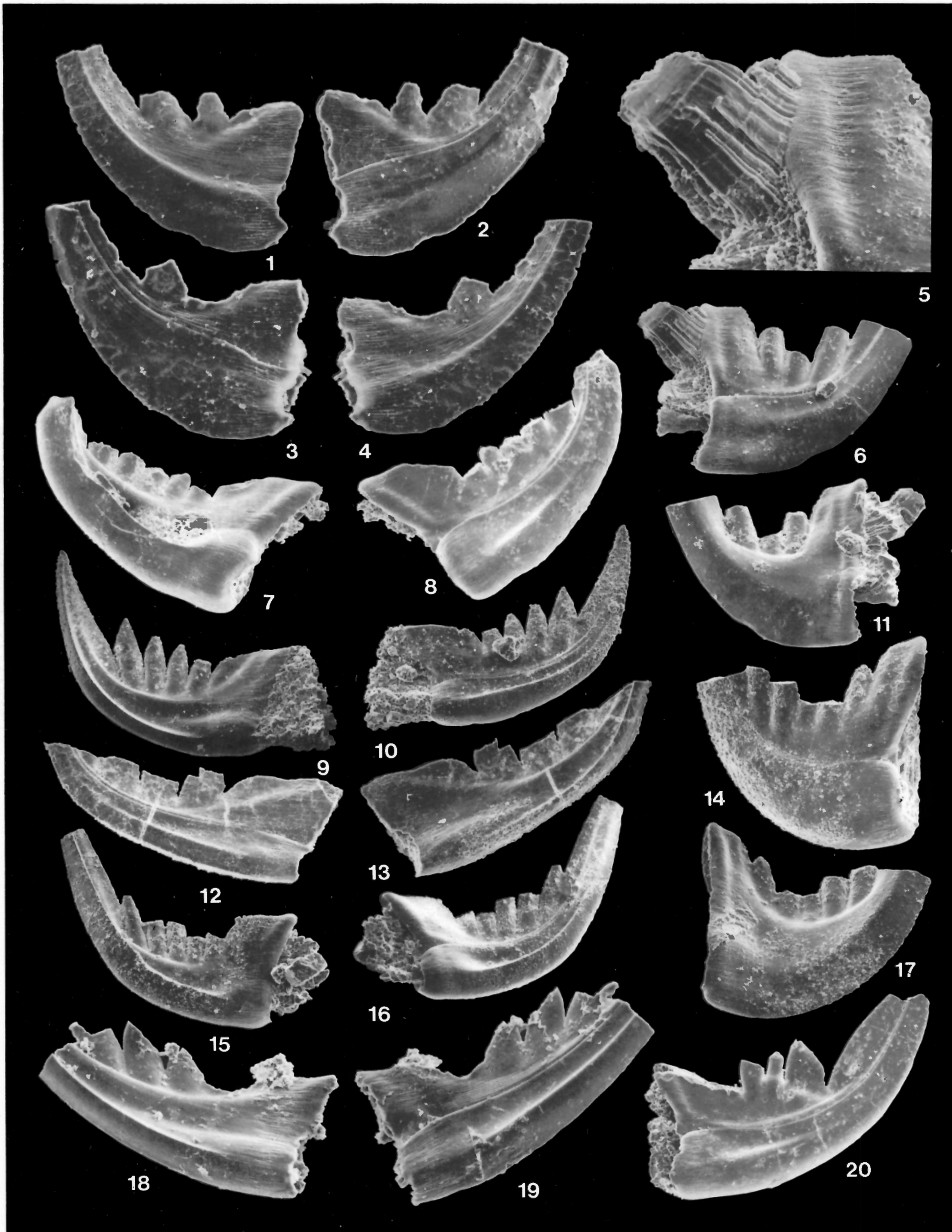
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PLATE 14

Figures 1-6. *Pseudobelodina inclinata* (Branson and Mehl). Hypotypes.

1, 2. Inner and outer lateral views, *e*? element, × 135, GSC 80374, from AV1-33.5 m.
3, 4. Outer and inner lateral views, *e*? element, × 120, GSC 80375, from AV1-15 m.
5, 6. Lateral views of typically fragmented element, × 150, GSC 80376, from AV1-10 m.

Figures 7-11. *Pseudobelodina quadrata* Sweet. Hypotypes.

7, 8. Lateral views, *c* element, × 100, GSC 80377, from AV1-6 m.
9, 10. Lateral views, *a*? element, × 170, GSC 80378, from AV1-4 m.
11. Outer lateral view, *b* element, × 120, GSC 80379, from AV1-6 m.

Figures 12-24. *Pseudobelodina*? *obtusa* Sweet. Hypotypes.

12, 13. Inner and outer lateral views, × 180, GSC 80380.
14, 15. Inner and outer lateral views, × 175, GSC 80381.
16, 17. Inner and outer lateral views, × 180, GSC 80382.
18, 19. Outer and inner lateral views, × 185, GSC 80383.
20, 21. Inner and outer lateral views, × 200, GSC 80384 (see fig. 24).
22, 23. Outer and inner lateral views, × 185, GSC 80385.
24. Inner lateral view showing coarse striae and low node-like denticles, × 425, GSC 80384 (see figs. 20, 21).

All specimens from AV1-10 m.


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PLATE 15

Figures 1-12. *Pseudobelodina vulgaris vulgaris* Sweet. Hypotypes.

1, 4. Outer and inner lateral views, *a* element, × 225, GSC 80386.
2, 5. Inner and outer lateral views, *b* element, × 220, GSC 80387.
3, 11. Inner and outer lateral views, *e*? element, × 200, GSC 80388.
6, 10. Outer and inner lateral views, *e*? element, × 240, GSC 80389.
7. Inner lateral view, *a* element, × 220, GSC 80390.
8. Lateral view, furrowed side, *c* element, × 245, GSC 80391.
9, 12. Lateral views, *c* element, × 250, GSC 80392.

All specimens from AV1-46 m.

Figures 13-18. *Pseudobelodina* cf. *P. vulgaris vulgaris* Sweet.

13, 14. Outer and inner lateral views, *b* element, × 225, GSC 80393, from AV1-73 m.
15, 18. Outer and inner lateral views, *b*? element, × 220, GSC 80394, from AV1-46 m.
16, 17. Lateral views, *c*? element, × 290, GSC 80395, from AV1-46 m.

Figures 19-21. *Pseudobelodina*? n. sp. A Nowlan and McCracken.

19, 20. Outer and inner lateral views, × 130, GSC 80396.
21. Lateral view, furrowed side, × 130, GSC 80397.

Both specimens from AV1-10 m.

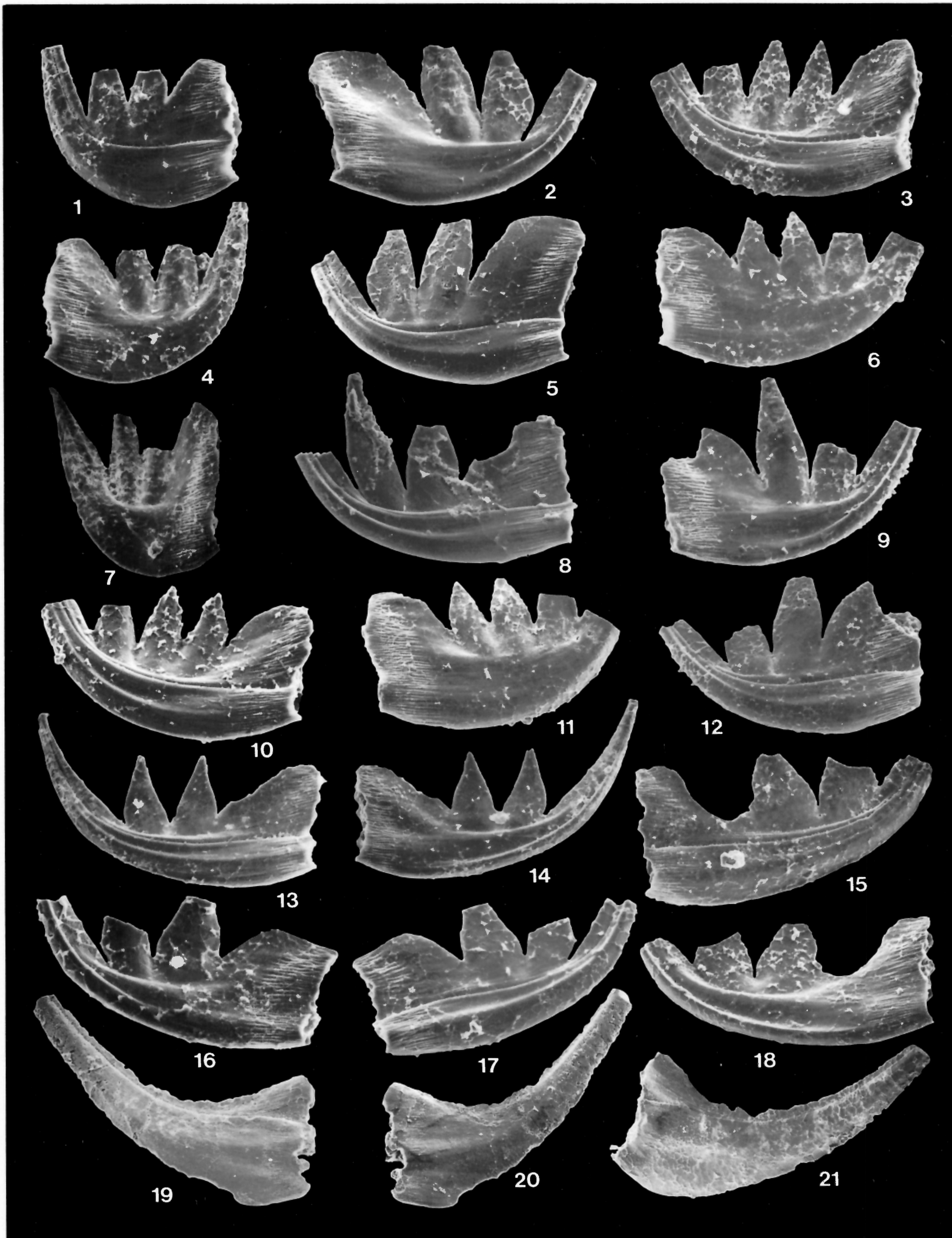
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PLATE 16

Figure 1. *Pseudooneotodus* aff. *P. beckmanni* (Bischoff and Sannemann).

1. Lateral view, × 240, GSC 80398, from AV1-72 m.

Figures 2-6. *Pseudooneotodus mitratus* (Moskalenko). Hypotypes.

2. Lateral view, × 170, GSC 80399.
3, 6. Lateral and oral views, × 95, GSC 80400.
4. Oral view, × 85, GSC 80401.
5. Oral view, slightly nodose specimen, × 120, GSC 80402.

All specimens from AV4B-62 m, except GSC 80402 (fig. 5), which is from AV1-33.5 m.

Figures 7-20. *Scabbardella altipes* subsp. B Orchard. Hypotypes.

7, 8. Inner and outer lateral views, *a* element, × 85, GSC 80403, from AV1-73 m.
9, 10. Outer and inner lateral views, *a* element with posteriorly extended base, × 135, GSC 80404, from AV1-73 m.
11. Inner lateral view, *a* element, × 150, GSC 80405, from AV1-46 m.
12. Inner lateral view, *a* element with posteriorly extended base, × 200, GSC 80406, from AV1-73 m.
13, 14. Outer and inner lateral views, *b* element, × 135, GSC 80407, from AV1-46 m.
15, 16. Outer and inner lateral views, *b* element with posteriorly extended base, × 105, GSC 80408, from AV1-72 m.
17, 18. Lateral views, *c* element, × 145, GSC 80409, from AV1-46 m.
19, 20. Lateral views, *c* element, × 180, GSC 80410, from AV1-46 m. More specimens of *S. altipes* are illustrated in 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, × 95, GSC 80411, from AV1-73 m.
3. Lateral view, acostate side, *e-2* element, × 125, GSC 80412, from AV1-46 m.
5, 6. Lateral views, *e-2* element, × 110, GSC 80413, from AV1-46 m.
8, 9. Lateral views, *e-3* element, × 125, GSC 80414, from AV1-46 m.

Figures 4, 7, 10-16. *Scabbardella* n. sp. A Nowlan and McCracken.

4, 7. Inner and outer lateral views, *a*? element, × 170, GSC 80415, from AV1-46 m.
10, 11. Outer and inner lateral views, *b-1* element, × 180, GSC 80416, from AV1-72 m.
12, 13. Inner and outer views, *b-2* element, × 180, GSC 80417, from AV1-73 m.
14, 15. Lateral views, *c* element, × 210, GSC 80418, from AV1-72 m.
16. Outer lateral view, *b-2* element, × 200, GSC 80419, from AV1-46 m.

Figures 17-22. *Spinodus*? n. sp. A Nowlan and McCracken.

17. Lateral view, × 100, GSC 80420.
18. Lateral view, × 90, GSC 80421.
19. Lateral view, × 85, GSC 80422.
20, 21. Oral and lateral views, × 80, GSC 80423.
22. Lateral view, × 80, GSC 80424.

All specimens from AV1-20 m.


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PLATE 18

Figures 1-23. *Staufferella divisa* Sweet. Hypotypes.

1, 2. Inner and outer lateral views, *a* element, × 160, GSC 80425, from AV1-10 m.
3. Inner lateral view, *a* element, × 180, GSC 80426, from AV1-46 m.
4. Outer lateral view, *a* element, × 210, GSC 80427, from AV1-46 m.
5, 6. Outer and inner lateral views, *b* element, × 160, GSC 80428, from AV1-10 m.
7. Outer lateral view, *e-3* element, × 135, GSC 80429, from AV1-10 m.
8. Inner lateral view, short-based *a*? element, × 120, GSC 80430, from AV1-4 m.
9, 10. Lateral and posterior views, *c* element, × 160, GSC 80431, from AV1-46 m.
11, 12. Inner and outer lateral views, *b*? element, × 260, GSC 80432, from AV1-46 m.
13. Posterior view, *c* element, × 160, GSC 80433, from AV1-10 m.
14. Lateral view, *c* element, × 265, GSC 80434, from AV1-46 m.
15, 16. Outer and inner lateral views, *e-2* element, × 160, GSC 80435, from AV1-10 m.
17, 18. Outer and inner lateral views, *e-1* element, × 140, GSC 80436, from AV1-46 m.
19. Posterior view, *c* element, × 80, GSC 80437, from AV1-4 m.
20. Posterior view, *c* element, × 185, GSC 80438, from AV1-10 m.
21, 22, 23. Posterior, inner and outer lateral views, *e-3* element, × 175, GSC 80439, from AV1-46 m.

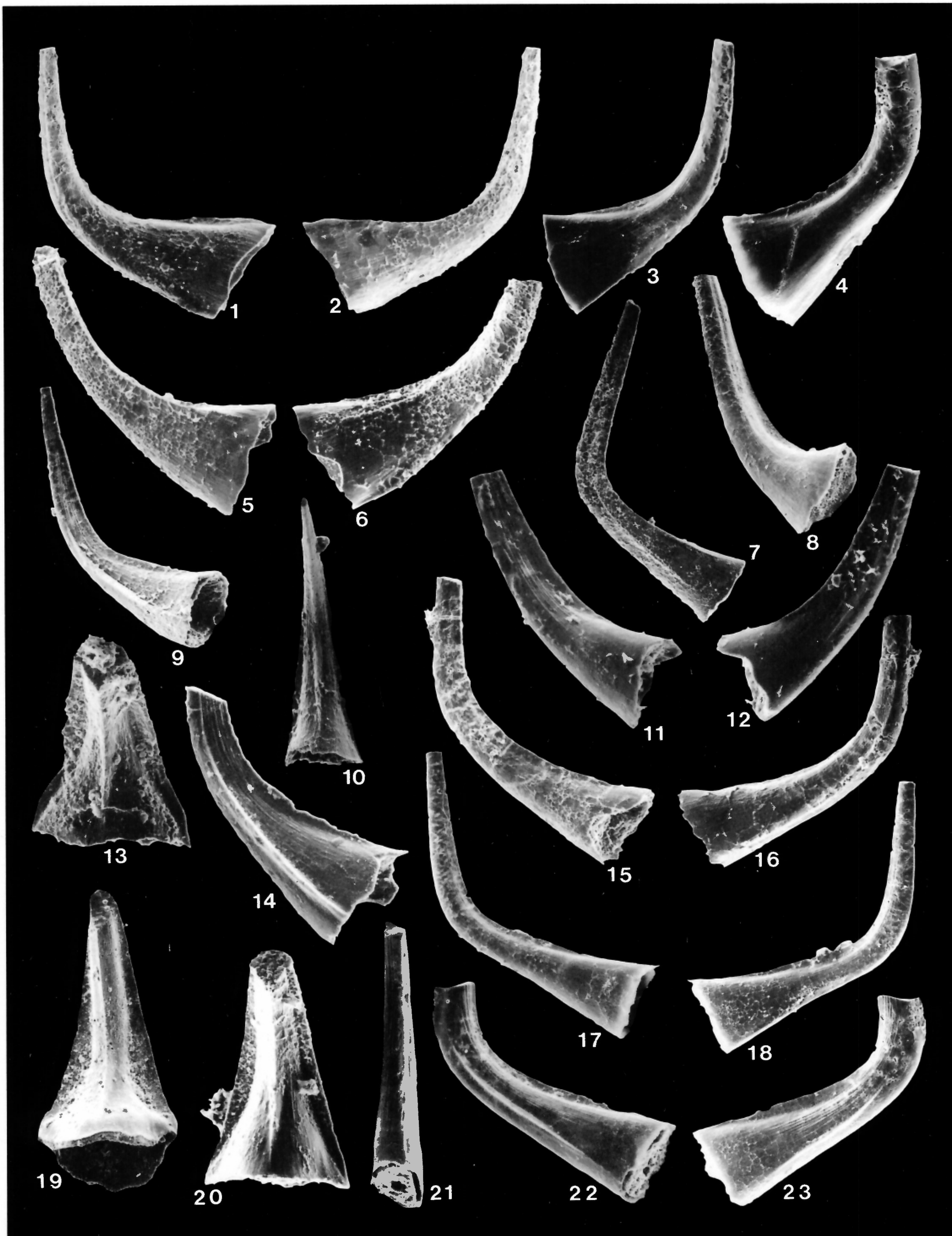
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PLATE 19

Figures 1-15. *Walliserodus amplissimus* (Serpagli). Hypotypes.

1. Inner lateral view, *a* element, × 165, GSC 80440.
2, 3. Inner and outer lateral views, multicostate *a* element, × 160, GSC 80441.
4. Lateral view, *c* element, × 150, GSC 80442.
5, 6. Lateral views, *d* element, × 135, GSC 80443.
7, 8. Inner and outer lateral views, *b* element, × 115, GSC 80444.
9. Lateral view, *e* element broken at base, × 115, GSC 80445.
10, 12. Lateral views, short-based *e* element, × 150 and x 170, GSC 80446.
11. Lateral view, slender *e* element, × 135, GSC 80447.
13. Lateral view, slender *e* element, × 110, GSC 80448.
14, 15. Lateral and posterior views, *c* element, × 150, GSC 80449.

All specimens from AV1-10 m, except GSC 80447 and 80448 (figs. 11, 13), which are from AV1-4 m.

Figure 16. *Walliserodus curvatus* (Branson and Branson). Hypotype.

16. Lateral view, fragmentary *e* element, × 145, GSC 80450, from AV4B-111.5 m.

Figures 17-23. *Walliserodus*? *rallus* Nowlan and McCracken n. sp.

17, 18. Outer and inner lateral views, *a* element, × 165, paratype, GSC 80451.
19, 20. Inner and outer lateral views, *b-1* element, × 155, paratype, GSC 80452.
21, 22. Inner and outer lateral views, *b-2* element, × 150, paratype, GSC 80453.
23. Outer lateral view, *b-1* element, × 175, paratype, GSC 80454.

All specimens from AV1-73 m. More specimens of *W.*? *rallus* are illustrated in 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, × 155, holotype, GSC 80455, from AV1-73 m.

5, 6. Lateral views, *d* element × 145, paratype, GSC 80456, from AV1-46 m.

7, 8. Lateral views, *e* element, × 150, paratype, GSC 80457, from AV1-46 m.

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, × 175, GSC 80458.

9, 13. Outer and inner lateral views, element with intermediate base height, × 115, GSC 80459.

11, 12. Outer and inner lateral views, slender, high-based element, × 110, GSC 80460.

14, 15. Inner and outer lateral views, slender, high-based element, × 80, GSC 80461.

16, 20. Inner and outer lateral views, element with intermediate base height, × 185, GSC 80462.

17, 18. Outer and inner lateral views, low-based element, × 155, GSC 80463.

19, 24. Posterior and inner lateral views, slender, high-based element, × 160, GSC 80464.

21-23. Outer anterolateral, outer lateral and inner lateral views, slender, high-based element with outer anterolateral carina, × 160, GSC 80465.

All specimens from AV4B-62 m. More specimens of *Z. levigatus* are illustrated in Plates 21 and 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, × 130, GSC 80466.
3, 4. Outer and inner lateral views, element with intermediate base height, × 115, GSC 80467.
5, 6. Inner and outer lateral views, low-based element, × 125, GSC 80468.
7, 8. Inner and outer lateral views, slender, high-based element, × 120, GSC 80469.
9, 10, 15. Inner lateral, outer lateral and outer anterolateral views, element with intermediate base height, × 165, GSC 80470.
11, 12. Outer and inner lateral views, low-based element, × 115, GSC 80471.
13, 14. Lateral views, element with pronounced heel, × 195, GSC 80472.
16, 17. Lateral views, × 190, GSC 80473.
18, 19. Lateral views, × 185, GSC 80474.
20, 21. Inner and outer lateral views, extremely low-based element, × 170, GSC 80475.

All specimens from AV4B-62 m. More specimens of *Z. levigatus* are illustrated in Plates 20 and 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, × 140, GSC 80476.
4, 5. Lateral views, element lacking heel, × 160, GSC 80477.

Both specimens from AV4B-62 m.

Figure 3. Oistodiform element indet.

3. Lateral view, × 105, GSC 80478, from AV1-6 m.

Figures 6, 7. Belodiniform element indet.

6, 7. Inner and outer lateral views, × 120, GSC 80479, from AV1-10 m.

Figures 8, 9, 12-15. *Milaculum* aff. *M. ethinclarki* Müller.

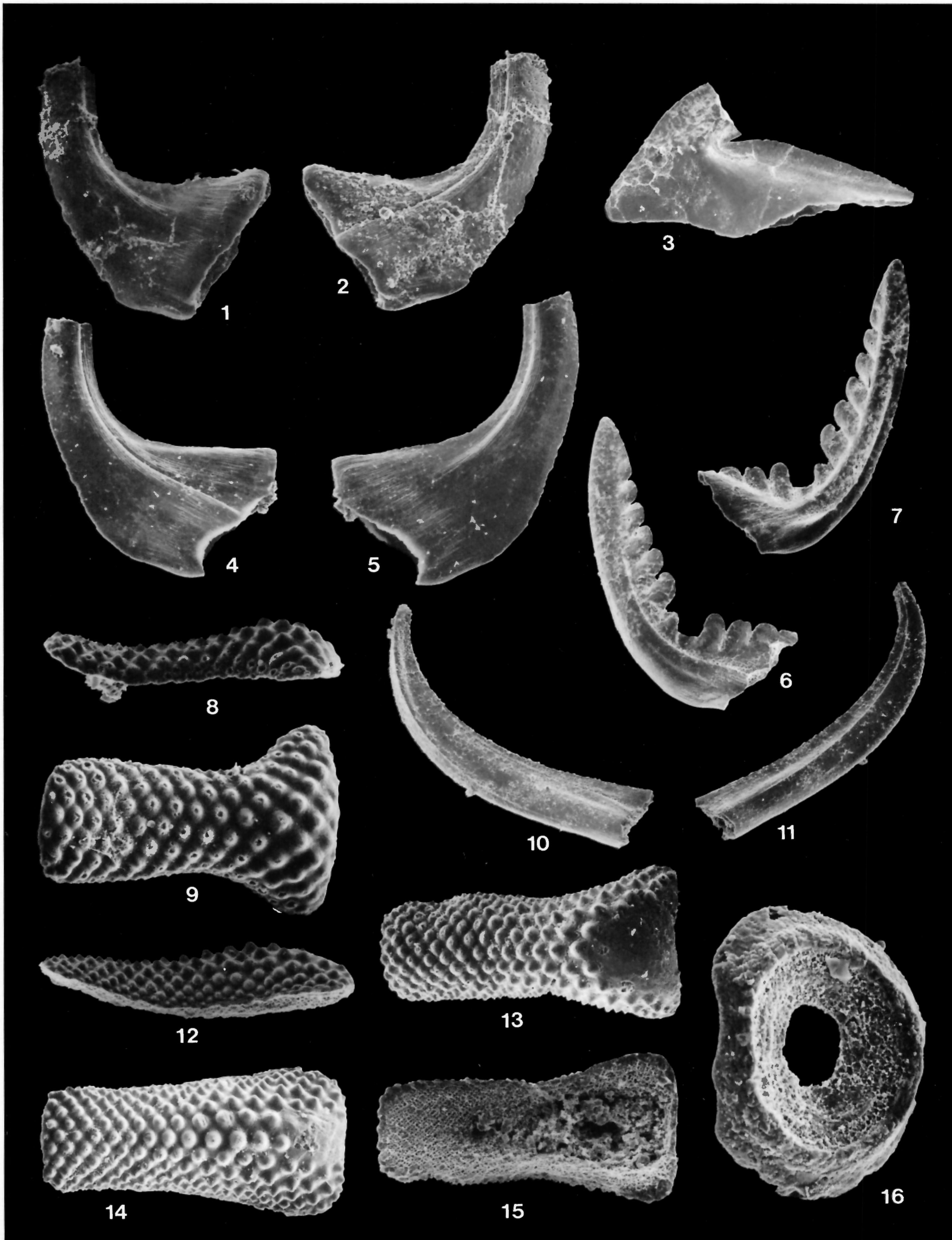
8, 9. Lateral and upper views, form with expanded end, × 220, GSC 80480, from AV1-10 m.
12, 14. Lateral and upper views, gently tapered specimen, × 145, GSC 80481, from AV1-10 m.
13, 15. Upper and lower views, form with flattened and smooth expanded end, × 145, GSC 80482, from AV1-4 m.

Figures 10, 11. Panderodiform element indet.

10, 11. Inner and outer lateral views, × 95, GSC 80483, from AV1-4 m.

Figure 16. *Phosphannulus universalis* Müller, Nogami and Lenz. Hypotype.

16. Upper view, × 235, GSC 80484, from AV1-10 m.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