Upper Ordovician conodonts from the Malongulli Formation, Cliefden Caves area, central New South Wales

J. A. Trotter[1] & B. D. Webby[2]

Thirty-seven spicule-dominated clasts from limestone breccia in the lower part of the Upper Ordovician Malongulli Formation of the Cliefden Caves area, central New South Wales, have yielded a collection of 2657 conodonts. These have been assigned to 48 species, dominated by *Belodina confluens* Sweet, *Besselodus* sp., *Dapsilodus mutatus* (Branson & Mehl)?, *Drepanoistodus suberectus* (Branson & Mehl), *'Oistodus'* cf. *venustus* Stauffer, *Panderodus gracilis* (Branson & Mehl), *Paroistodus*? sp. A Nowlan & McCracken, *Scabbardella altipes* subsp. B Orchard and *Walliserodus amplissimus* (Serpagli). Two new species are described, *Pseudobelodina*? *anceps* and *Taoqupognathus tumidus*. This allochthonous assemblage is a mixture of North American Midcontinent and North Atlantic-type pelagic elements, reflecting derivation from warm shallow and cooler deeper zones of the low-latitude, offshore Malongulli site. These spicule-dominated clasts probably formed initially as periplatform-ooze deposits at the outer margins of an island platform, then were incorporated in debris flows and transported basinward to become associated with the basal, *in situ*, graptolitic siltstone–shale Malongulli succession. The graptolite horizons are late Eastonian in age (Zone of *Dicranograptus hians kirki*). There is little evidence of reworking of the conodonts from older horizons. Twelve species have close North American Midcontinent affinities and may be correlated, using graphic methods, with the lower half of the Zone of *Oulodus velicuspis*, i.e. within the North American mid-upper Edenian Stage. This establishes upper limits for the age of the underlying pre-Malongulli carbonate succession, and confirms the Malongulli Formation as distinctive and much younger than the Darriwilian–early Gisbornian Malongulli-type succession to the east of Cliefden Caves.

Introduction

The acid-etched residues of allochthonous limestone from breccias in the lower part of the Ordovician Malongulli Formation, in the Cliefden Caves area of central New South Wales, contain a rich and varied conodont fauna. These are the same clasts that produced diverse assemblages of siliceous sponges (mainly demosponges and hexactinellids), discrete sponge spicules and radiolarians, described, respectively, by Rigby & Webby (1988), Webby & Trotter (1993) and Webby & Blom (1986). Altogether, 2657 conodont specimens have been recovered from the spicule-rich clasts, and these are assigned to 48 species (24 genera) (Table 1). Each clast from the three main breccia localities has been individually processed: specifically, 23 clasts (CM1–23) from Coppermine Creek (Fig. 1, locality 1), 11 (GC1–11) from Gleesons Creek (Fig. 1, locality 2), and 3 (AB1–3) from the small breccia on the Angullong side of the Belubula River (Fig. 1, locality 3). All are from similar stratigraphic levels in the lower part of the Malongulli Formation (Fig. 2). Separate upper and lower Gleesons Creek limestone breccias were previously mapped (Rigby & Webby 1988), but are now regarded as representing one very thick graded unit, repeated by thrust faulting. The most common elements of the Malongulli spicule-rich fauna are *Belodina confluens* Sweet (126 specimens), *Besselodus* sp. (140 specimens), *Dapsilodus mutatus* (Branson & Mehl)? (108 specimens), *Drepanoistodus suberectus* (Branson & Mehl) (225 specimens), *'Oistodus'* cf. *venustus* Stauffer (356 specimens), *Panderodus gracilis* (Branson & Mehl) (409 specimens), *Paroistodus*? sp. A Nowlan & McCracken (229 specimens), *Scabbardella altipes* subsp. B Orchard (131 specimens), and *Walliserodus amplissimus* (Serpagli) (152 specimens).

Little descriptive work on the Middle–Upper Ordovician conodont faunas of central New South Wales (and the Australian Capital Territory) has previously been published. Savage (1990) documented the assemblage (many of

them new taxa) from the lower part of the Cliefden Caves Limestone Group (Fossil Hill Limestone), in the same area as this study, but from a stratigraphically much lower level (Fig. 2). Other papers have only provided brief reports of conodont occurrences and their age significance; for example, those from Ordovician limestone–volcanic associations west of Parkes and near Sofala (Packham 1967; Pickett 1978; Pickett & Ingpen 1990), and from the more widely distributed Ordovician quartz-rich greywacke–slate–chert associations of the Lachlan Fold Belt, specifically from the slates and cherts (Nicoll 1980; Stewart & Glen 1986; Pickett 1991).

The Malongulli Formation of the Cliefden Caves area has two stratigraphically distinct graptolite assemblages, which establish the age range for the succession and, by inference, that of the limestone breccia in the lower part of the unit (Fig. 2). The graptolite association from near the base of the Malongulli Formation (Moors 1970), which directly underlies the main breccia, contains *Dicranograptus* cf. *hians kirki*, *Leptograptus eastonensis*, *Dicellograptus elegans*, and *Normalograptus tubuliferus*. This assemblage has been assigned to the Eastonian Zone of *Dicranograptus hians kirki* (Ea3), which probably corrrelates with the British *Pleurograptus linearis* Zone (VandenBerg *in* Webby & Nicoll 1989; VandenBerg & Cooper 1992), i.e. at or close to the Caradoc–Ashgill boundary. Alternatively, the assemblage may, following Williams (1982), equate with a slightly lower level, spanning an interval from the upper part of the *Dicranograptus clingani* Zone to the lower part of the *Pleurograptus linearis* Zone, that is, late Caradoc age (Fig. 3). The upper part of the Malongulli Formation has been referred to the early Bolindian Zone of *Climacograptus uncinatus* (Bo1) (Percival 1976; Jenkins 1978), which represents a level in the early-mid Ashgill. In terms of North American stages, the Malongulli Formation probably spans an interval from Edenian through Maysvillian to early Richmondian age (Fig. 3).

Two types of limestone clasts are found in the lower Malongulli Formation breccia—a coral-dominated biofacies, which probably derived from the nearby contemporaneous island-shelf carbonate succession (middle-upper Cargo Creek Limestone and equivalents to the west—see Webby & Packham 1982, fig. 6), and a distinctive

[1] CSIRO Division of Petroleum Resources, North Ryde Laboratories, PO Box 136, North Ryde, NSW 2113
[2] Department of Geology & Geophysics, University of Sydney, NSW, 2006, and Centre for Ecostratigraphy & Palaeobiology, School of Earth Sciences, Macquarie University, NSW 2109

Table 1. Distribution of conodont specimens in clasts of limestone breccia at Coppermine Creek, Gleesons Creek and on the Angullong side of the Belubula River, lower part of the Malongulli Formation, Cliefden Caves area.

| SPECIES (LOCALITY & CLAST)	COPPERMINE CREEK																						ANGULLONG SIDE OF BELUBULA			GLEESONS CREEK											TOTAL
	CM1	CM2	CM3	CM4	CM5	CM6	CM8	CM9	CM10	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM18	CM19	CM20	CM21	CM22	CM23	AB1	AB2	AB3	GC1	GC2	GC3	GC4	GC5	GC6	GC7	GC8	GC9	GC10	GC11	
Ansella sp.	5	1								3	5	1	3		1	1	2																	1			23
Belodina confluens Sweet	2	2	1	8	7	2	6	4		12	11	2	4	6	7	2	18		4		15		1		1		2	6		3							126
Belodina sp.A	1	1	1	1	1			1			2				1		4		2		1																16
Belodina sp.B		1			1				1								1				4																8
Belodina sp.C				1	1														2		7																10
Belodina sp.D										2							1												1								3
Belodina sp.E		2																																			2
Belodina sp.F											1						1																				2
Belodina sp.G				1																1																	2
Besselodus sp.	13	8			27	2	1	12	1	1	1	2	9	16	6		10				16						1	3		1	2				7	1	140
Chirognathus duodactylus Branson & Mehl?															1		1																				2
Culumbodina? sp.			2		1	1	1						1				1									1											8
Dapsilodus mutatus (Branson & Mehl)?	16	5		11	5	3	3	6	1	4	1	8	8	1	3		7			1	17						4			1					1	2	108
Drepanoistodus suberectus (Branson & Mehl)	23	3		5	9	16	1	9	2	38	6	4	6	5	12	5	14	1		2	39			1	4		5	1		3		1	3		7		225
Istorinus? sp.	5						3			10	2	1		3		1	1																	1		3	30
"Oistodus" cf. venustus Stauffer	50	4		2	28	9	9	4		37	35	10	17	20	27	9	21	3	1	1	45			2	1	1				1		5	5		6	3	356
Oulodus cf. oregonia (Branson, Mehl & Branson)																	1																				1
Ozarkodina sesquipedalis Nowlan & McCracken	2				1		4			4		1	2		1		11				7		4											2			39
Panderodus gracilis (Branson & Mehl)	58	15		33	15	26	14	14	8	17	12	23	18	36	17	11	21	4	4	4					5	7	8	9		14	1	1	1	3	7	3	409
Panderodus sp.A	27			1					2	4	3	7	8	13	4	2	3			1													1				76
Panderodus sp.B											2					1	1																				4
Panderodus sp.C				3									1		1	1																					6
Panderodus sp.D	4	1		3	1					10			5		7	1	7		2		8				1	3		1		1				1			56
Panderodus? liratus Nowlan & McCracken															1										1												2
Paroistodus sp.	5				7			2		10	4	1	4	2	2		4				7						1			3						1	53
Paroistodus? sp. A Nowlan & McCracken	52			10	1	7	11			13	23	19	15	32	11	6	7	4			10			2									3	2		1	229
Periodon grandis Ethington	2										2				1										1												6
Periodon? sp.																	1																				1
Phragmodus undatus Branson & Mehl	4				1			2		24	7	3	5	1	1	1		1									2			1			1	1		5	60
Protopanderodus insculptus (Branson & Mehl)					1	10		2		4	6								1	3	18										1					1	47
Protopanderodus liripipus Kennedy, Barnes & Uyeno	1					11											5																				17
Pseudobelodina dispansa (Glenister)	11	1		5	7		7			1	2	4	3	6	2	2	27			1	16		1				2					1	2				101
Pseudobelodina inclinata (Branson & Mehl)	4	1		5		1		1								1														1							14
Pseudobelodina sp.A								1																													1
Pseudobelodina sp.B										1																											1
Pseudobelodina? anceps sp. nov.	26			2		2			1	2		17	14	19	2	3					3	1														1	93
Pseudooneotodus beckmanni (Bischoff & Sannemann)				1							1																			1							3
Pseudooneotodus mitratus (Moskalenko)				1	2					1	1						2																				7
Scabbardella altipes subsp.B Orchard	11	2		2	3	20	3	5	1	11	6	5	4	8	1	1	20			1	15		1	1	1		1			3	3	1			1		131
Strachanognathus parvus Rhodes	1			1	3												1				1																7
Taoqupognathus tumidus sp. nov.	3	1		3	4	1	2	2		3	3	1	2				6				6		1														38
Walliserodus amplissimus (Serpagli)	19	1		3	8	2	1	6		25	7	4	4	9	7	1	5	1	1		28		1		2	1		4		3		5	1	1	2		152
Yaoxianognathus? tunguskaensis (Moskalenko)																	2																	2			4
Zanclodus levigatus Nowlan & McCracken				2							2				1		2													1							8
Gen. et sp. indet.A																	1																				1
Gen. et sp. indet.B																											1										1
Gen. et sp. indet.C	8			1	2	2		1		1			4		7																						26
Gen. et sp. indet.D	1																																				1
																																					2657
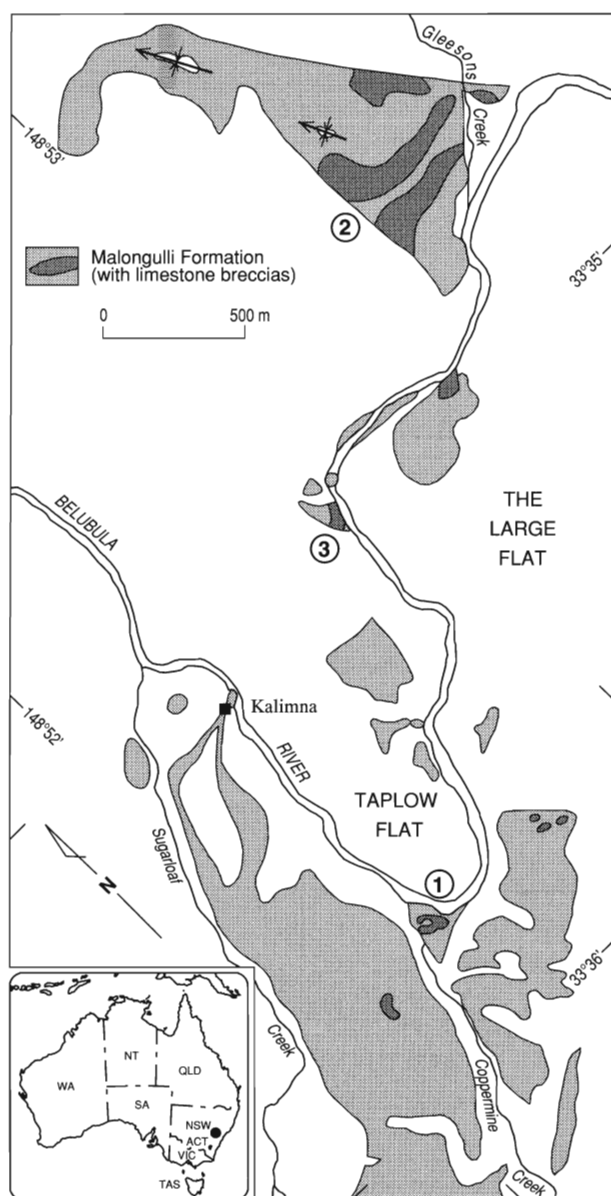
Figure 1. Location of the Cliefden Caves area and outcrop of the Malongulli Formation with associated limestone breccia, central New South Wales. Note the location of the conodont-bearing breccia at Coppermine Creek (1), Gleesons Creek (2), and on the Angullong side of the Belubula River (3).

sponge-dominated 'periplatform ooze' biofacies (tabular blocks, distinctively laminated and containing abundant siliceous spicules). The 'periplatform ooze' biofacies is not known from the associated *in situ* island-shelf carbonate sequence (see Webby 1992, fig. 6). The tabular, spicule-rich clasts were probably eroded from the outer island-shelf or upper slope by debris flows moving basinward from the island shelf (Rigby & Webby 1988; Webby 1992). The conodont faunas described herein come exclusively from the spicule-rich, 'periplatform ooze'-derived breccia clasts.

It has previously been noted (Rigby & Webby 1988; Webby 1992) that the shallow-water carbonates of the underlying Cliefden Caves Limestone Group (Fossil Hill to Vandon Limestones inclusive; see Fig. 2) with their warm-water coral and stromatoporoid associations formed on volcanic highs at low-latitudes off the Gondwana

continental margin. The high concentrations of siliceous organisms (sponges and radiolarians) in the tabular clasts of the Malongulli breccias suggest that a favourable slope environment may have existed, possibly because of a ready supply of nutrients associated with upwelling at the equatorial convergence (Rigby & Webby 1988; Webby 1992).

There is little evidence to suggest that the clasts of the Malongulli breccia were reworked from significantly older horizons. The compound cerioid rugose coral *Favistina*, specifically *F. floweri*, occurs in the island-shelf deposits to the west, notably in the upper parts of the Cargo Creek and Canomodine Limestones (Webby 1988) and is not known from older stratigraphic levels of the island-shelf
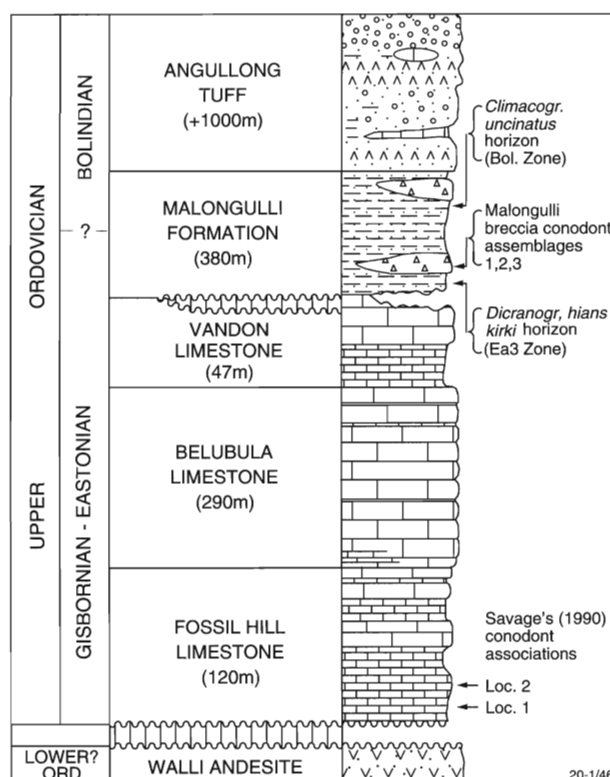
Figure 2. Generalised stratigraphic column of the upper Ordovician sequence in the Cliefden Caves area, showing horizons with Savage's (1990) conodont associations in the lower part of the Fossil Hill Limestone, and the lower Malongulli breccia with the Coppermine Creek (1), Gleesons Creek (2) and Angullong side of the Belubula River (3) conodont assemblages. The graptolite zonal indicators in the basal and upper parts of the Malongulli Formation are also shown. The Fossil Hill, Belubula Limestone and Vandon Limestone are the component formations of the Cliefden Caves Limestone Group.

successions; indeed, it is a diagnostic representative of the biostratigraphically distinct coral–stromatoporoid fauna IIIb (Webby *in* Webby et al. 1981; *in* Webby & Nicoll 1989). This same species of *Favistina* is present in clasts of the lower Malongulli breccias, establishing that it was reworked from contemporaneous, not older, deposits.

The spicule-rich clasts, derived from environmental settings further offshore, also show little indication of being reworked from older deposits of ages. Of the 2657 conodonts processed, only the occurrences of *Ansella* sp. (23 specimens) and *Chirognathus duodactylus* (two speci-

BRITISH SERIES	NORTH AMERICAN SERIES & STAGES		AUSTRALIAN STAGES & ZONES	CONODONT ZONES	
				NORTH ATLANTIC	MID CONTINENT
Ashgill	Cincinnatian	Gamachian	Bo5 / Bolindian	Am. ordovicicus	A. shatzeri
		?			A. divergens
		Richmondian	Bo1		A. grandis
(base of linearis)		? Maysvillian	Ea4	Am. superbus	O. robustus
		Edenian	Ea3		O. velicuspis
			Eastonian		B. confluens
Caradoc	Mohawkian "Wilderness" "Porterfield" "Trenton"	Shermanian	Ea2		Pl. tenuis
		Kirkfieldian		Am. tvaerensis	Ph. undatus
		Rocklandian	Ea1		
		Blackriveran	Gi2 / Gisbornian		B. compressa
					E. quadridactylus
					P. aculeata
(base of gracilis)			Gi1		

20-1/47

Figure 3. Middle–Upper Ordovician correlation chart showing inferred relationships between series, stage and conodont zonal schemes (based on Bergström 1990; Fortey et al. 1991; VandenBerg & Cooper 1992; MacKenzie & Bergström 1993). Note that the Australian column is based on graptolite zones (Gi1-2, Ea1-4 & Bo1-5), and that in the British column the levels at the base of *Nemagraptus gracilis* Zone and the base of *Pleurograptus linearis* Zone are shown (the base of the *linearis* Zone is equivalent to the top of the *Dicranograptus clingani* Zone).

mens) suggest reworking from older (?Middle Ordovician) horizons; but they represent less than one per cent of the total fauna.

Palaeoenvironments

The conodonts from the spicule-rich clasts comprise a diverse fauna dominated by cosmopolitan species (taxa occurring in both North Atlantic and North American Midcontinent 'provinces' of Sweet & Bergström 1984) as well as species of characteristic North American Midcontinent-type. The cosmopolitan species appear mainly to have been derived from North Atlantic forms, and are represented by *Dapsilodus mutatus* (Branson & Mehl)?, *Protopanderodus insculptus* (Branson & Mehl), *Protopanderodus liripipus* Kennedy, Barnes & Uyeno, *Strachanognathus parvus* Rhodes, and *Periodon grandis* Ethington. Other taxa of more restricted North Atlantic affinity are primarily represented by *Scabbardella altipes* Subsp. B Orchard and *Walliserodus amplissimus* (Serpagli). *W. amplissimus* is known from the Carnic Alps (Serpagli 1967) and England and Wales (Orchard 1980), but has also been reported from Canada by Nowlan et al. (1988). Elements characteristic of Chinese and Siberian faunal 'provinces' are rare, being represented by *Taoqupognathus tumidus* sp. nov., *Yaoxianognathus? tunguskaensis* (Moskalenko), and *Culumbodina?* sp.

Species characteristic of the North American Midcontinent fauna include *Panderodus gracilis* (Branson & Mehl), *Belodina confluens* Sweet, *Pseudobelodina dispansa* (Glenister), *Paroistodus?* sp. A Nowlan & McCracken, and *Phragmodus undatus* Branson & Mehl. Rare specimens of *Oulodus* cf. *oregonia* (Branson, Mehl & Branson), *Chirognathus duodactylus* Branson & Mehl?, and *Zanclodus levigatus* Nowlan & McCracken were also recovered. *Phragmodus undatus* (Branson & Mehl) is characteristic of the North American Midcontinent 'province', though it also occurs rarely in North Atlantic faunas,

while *Drepanoistodus suberectus* (Branson & Mehl) is truly cosmopolitan, being equally represented in both faunal provinces (Sweet & Bergström 1984).

In terms of overall percentages, the cosmopolitan species in the fauna constitute 34.5% of the total, elements characteristic of the North American Midcontinent make up 37%, and elements of the North Atlantic, almost 11% of the total. Minor additions are the Siberian–Chinese (1.9%) and a proportion of undiagnostic elements (15.6%).

Individually, the most common taxa are *Panderodus gracilis* (15.5% of the total), '*Oistodus*' cf. *venustus* (13.5%), *Paroistodus?* sp. A Nowlan & McCracken (9.0%), and *Drepanoistodus suberectus* (8.5%). The belodinans comprise 14% of the fauna, of which *Belodina confluens* and *Pseudobelodina dispansa* alone make up 8.5%. *B. confluens* and *P. dispansa* probably represent a part of the same apparatus (S.M. Bergström pers. comm. 1994). Bergström (1990) has recorded *B. confluens* as an important constituent of the North American Midcontinent fauna and present in Scottish, Polish, and Swedish successions. In contrast, the most dominant North Atlantic species are *Walliserodus amplissimus* (6%) and *Scabbardella altipes* subsp. B (5% of the total).

There is a strong association between some elements of the Malongulli spicule-clast fauna and the D1–4 species clusters of Sweet & Bergström's (1984) Late Ordovician *Oulodus velicuspis* 'Chronozone' (late Edenian–early Maysvillian). Species present in both faunas are *Belodina confluens, Drepanoistodus suberectus, Phragmodus undatus, Periodon grandis, Pseudobelodina inclinata, Panderodus gracilis, Protopanderodus liripipus,* and *Dapsilodus mutatus* (the latter being only tentatively identified in the Malongulli fauna). Sweet & Bergström (1984), using cluster analysis of conodont data across the equatorially disposed North American Platform during the *O. velicuspis* zonal interval, were able to differentiate species into site clusters A–D. Many with wide distributions were grouped in clusters D1–4. As Sweet & Bergström (1984) further noted, the species in the D1–4 clusters, also had extra-North American, essentially cosmopolitan, distributions in Late Ordovician seas. The Malongulli (D1–4) species constitute 36% (40% if *Pseudobelodina dispansa* is regarded as belonging to the *Belodina confluens* apparatus) of the total New South Wales fauna.

Additionally, Sweet & Bergström (1984) recognised a number of specific environmental differences between the D-clustered North American occurrences. *Drepanoistodus suberectus* was regarded as a eurythermal, cosmopolitan species with equal representation in cold and warm-water faunas; *Panderodus gracilis, Dapsilodus mutatus* and *Protopanderodus liripipus* as stenothermal, inhabiting the deeper, cold-water (or North Atlantic) realm of low latitudes; and *Belodina confluens* and *Phragmodus undatus* as characteristic of the warm-water realm.

The presence of stenothermal *Panderodus gracilis, Dapsilodus mutatus?* and *Protopanderodus liripipus*, as well as *Drepanoistodus suberectus* and *Periodon grandis*, in the Malongulli fauna confirms the existence of a relatively deeper and cooler water mass. Together, these components of the Malongulli fauna constitute 31% of the total. Significantly, Sweet & Bergström (1984) have also noted that on the North American Platform the deepest *O. velicuspis* 'Chronozone' conodont biofacies is typified by

an abundant association of *Periodon grandis* and *Dapsilodus mutatus*. *Scabbardella altipes* subsp. B and *Walliserodus amplissimus* are additional restricted North Atlantic (cooler water) elements in the Malongulli fauna.

Phragmodus undatus is recognised as a warm-water indicator and, in the North American Upper Ordovician, as characterising a comparatively shallow, offshore biofacies, above the deep-water association with *Dapsilodus mutatus*? and *Periodon grandis* (Sweet & Bergström 1984). In the Cincinnati region, Sweet (1988) showed *P. undatus* as the chief representative of an oxygenated and well-lit water mass above the deep bottom waters and offshore from the shallow shelf environments. Nowlan & Barnes (1981) have noted in the Vauréal Formation (Richmondian) of Anticosti Island that increased abundance of *P. undatus* in the succession reflects a phase of the deeper subtidal conditions. In the spicule-bearing clasts of the Malongulli breccia, this species represents some 2.3% of the total fauna.

The shallowest component of the Malongulli fauna is suggested by typical warm-water, North American Midcontinent-type species, such as *Belodina confluens*, *Pseudobelodina dispansa*, *Oulodus* cf. *oregonia*, *Chirognathus duodactylus?*, *Zanclodus levigatus*, and *Besselodus* sp. However, only *B. confluens* and *P. dispansa* (possibly part of the same apparatus) are present in sufficient numbers (8.5% of the fauna) to suggest that a component of the very shallow, nearshore *Pseudobelodina* biofacies (Sweet & Bergström 1984) may also be represented.

It seems, in conclusion, that the conodont fauna of this particular offshore, deeper water, siliceous sponge-dominated, low-latitude Malongulli site comprised a mixture of pelagic elements—North American Midcontinent types, derived from warm, shallow surface waters, and North Atlantic and cosmopolitan types, which accumulated from cooler, deeper, possibly near-bottom, waters.

Biostratigraphy

The graptolite assemblage in the lower part of the Malongulli Formation has a late Eastonian age (Ea3 Zone) (Moors 1970; VandenBerg *in* Webby et al. 1981), and the contemporaneous, conodont-bearing, spicule-rich clasts of the associated breccia are likely to be of similar age. In the absence of close ties between the graptolite and conodont zonal schemes, it is difficult to precisely relate this late Eastonian (Ea3) zonal level to the well-established North American or European conodont biozonations. It equates with a level in the Early Cincinnatian (Edenian–early Maysvillian) or Late Caradoc to Caradoc–Ashgill boundary (Fig. 3), but the precise correlation to zonal level is difficult.

As already noted, elements of the Malongulli fauna have close ties with components of the North American fauna at the level of the Late Ordovician *O. velicuspis* Zone (late Edenian–early Maysvillian), but a more precise means of correlation is needed. This may be provided by comparing the Malongulli species with the conodont ranges established numerically, using the graphic correlation methods of Sweet (1984) for the upper Middle and Upper Ordovician rocks of the North American Midcontinent 'province'. Based on a composite standard section (CSS), a numerical time-range was allocated to each North American conodont species, and to each zone and stage subdivision.

Twelve Malongulli species have similar occurrences to the North American forms. Five in particular have comparatively short numerical CSS ranges—*Belodina confluens* (1025–1169), *Periodon grandis* (968–1149), *Pseudobelodina inclinata* (1092–1268), *Chirognathus duodactylus* (967–987), and *Oulodus oregonia* (1014–1111). The last two are only tentatively assigned in the Malongulli fauna (*Ch. duodactylus*? and *O.* cf. *oregonia*). The six longer ranging forms and four of the five short-ranging species have common occurrences through the 1092–1111 interval, which equates with the lower part of the *O. velicuspis* Zone, i.e. middle to late Edenian. The fifth, short-ranging species is *Ch. duodactylus*? and is excluded because it is not identical with the North American *Ch. duodactylus* (having lower CSS values 967–987). If *Oulodus* cf. *oregonia* is also excluded, because of its tentative assignment, the remaining three short-ranging species have common occurrences through the 1092–1149 interval, which correlates with almost the entire *O. velicupis* Zone, i.e. from mid-Edenian to early Maysvillian.

A further point of qualification is that, although Sweet (1984, 1988) recognised *B. confluens* as having its last appearance in the mid-Maysvillian, Nowlan et al. (1988) recorded it from a Richmondian fauna in the Northwest Territories of Canada. Bergström (1990) has similarly noted that *B. confluens* may range upwards into the lower part of the North Atlantic *Amorphognathus ordovicicus* Zone (Fig. 3), but has mainly been recorded from the *A. superbus* Zone (i.e. equivalent to ranging through the Shermanian, Edenian to early Maysvillian).

Most North Atlantic elements of the fauna are long-ranging species, of little value for precise correlation. *Walliserodus amplissimus* is a representative of the *Amorphognathus ordovicicus* Zone fauna in the British Isles (Orchard 1980), and occurs in the Ashgill of the Carnic Alps (Serpagli 1967) and Richmondian of the Northwest Territories, Canada (Nowlan et al. 1988). *Protopanderodus insculptus* is also a characteristic species of the *A. ordovicicus* Zone (Bergström 1971; Kennedy et al. 1977), and has been recorded from Ashgill deposits (Viira 1974; Serpagli 1967) as well as from the upper part of the underlying *Amorphognathus superbus* Zone of the late Caradoc (Dzik 1978). *Protopanderodus liripipus* has been reported from the *A. ordovicicus* Zone of Wales (Savage & Bassett, 1985) and the upper part of the *A. tvaerensis* Zone (middle Caradoc) of Tasmania (Burrett et al 1983). *Dapsilodus mutatus* has been recorded as having a similarly long range in Scotland (*A. tvaerensis* to *A. ordovicicus*), while *Scabbardella altipes* occurs in both the *A. superbus* and *A. ordovicicus* Zones of Scotland (Bergström 1990). *Strachanognathus parvus* is considered a characteristic conodont species of the *A. ordovicicus* Zone (Bergström 1971), but is known from much older (Arenig) strata (Löfgren 1978, p.112).

Remarks on other local Ordovician conodont faunas

Conodonts from the Fossil Hill Limestone, Cliefden Caves area

Savage (1990) described the Upper Ordovician conodont faunas (many of them new taxa) from the lower part of the Cliefden Caves Limestone Group, specifically from two horizons (his localities 1 and 2) in the lower part of the Fossil Hill Limestone, some 400 m stratigraphically

below the Malongulli breccia fauna described here (Fig. 2). He recorded new species of *Aphelognathus*, *Belodina*, *Yaoxianognathus*, and *Taoqupognathus*, in addition to reporting *Panderodus gracilis*, *Belodina conflu-ens*, and *Phragmodus? tunguskaensis* in the fauna. Savage claimed, mainly on the basis of the range of *B. confluens* in the North American Midcontinent Province, a middle to late Caradoc (mid-Shermanian to mid-Edenian) age for the lower part of the Fossil Hill succession, in contrast to the earlier view of Webby et al. (1981) and Webby & Packham (1982) of an early to middle Caradoc (late Gisbornian) age for this basal part of the succession.

Unfortunately, the fauna described by Savage (1990) is undiagnostic, and his use of *B. confluens* for defining the lower age limit of his assemblages does not help. According to Sweet (1984) and Bergström (1990), *B. confluens* ranges down into the upper *A. tvaerensis* Zone, which correlates with the middle Caradoc (or a level in the Kirkfieldian or Shermanian). Packham (*in* Webby 1969) and Barnes (*in* Webby & Kruse 1983) suggested, from preliminary determinations of the conodont faunas, that the horizons in the lower part of the Cliefden Caves succession were of late Porterfield? or early Wilderness (i.e. Blackriveran) aspect (Fig. 3). This was an important basis for Webby et al. (1981) suggesting a late Gisbornian (early to middle Caradoc) age.

The basal part of the overlying Malongulli Formation, with its conodont-bearing, spicule-rich clasts, is late Eastonian (Ea3 Zone) and probably correlates with the North American middle to late Edenian. It is at least 400 m higher than the Fossil Hill units containing Savage's conodont fauna (Fig. 2) and, based on studies of other fossil groups, this 400 m represents the stratigraphic equivalent of at least one biozone. The intervening Vandon Limestone, for example, has coral/stromatoporoid, trilo-bite and brachiopod assemblages which are biostrati-graphically distinct from underlying, and laterally equivalent, overlying carbonate sequences (Webby 1974; Webby *in* Webby & Nicoll 1989; Percival 1992) and cannot be younger than middle Eastonian (Ea2). The underlying Fossil Hill Limestone and Belubula Limestone (Fig. 2) must be early to middle Eastonian or older (but probably no older than late Gisbornian). In terms of North American stages, this is about equivalent to the Rock-landian or Kirkfieldian (Fig. 3). Current work by Dr Zhen Yongyi (University of Sydney, personal communication, October 1994) on the conodont assemblages of the Fossil Hill Limestone confirms the presence of important diag-nostic elements additional to those studied by Savage. A species of *Tasmanognathus* occurs in the lower part, then *Phragmodus undatus* appears towards the middle of the Fossil Hill sequence. The lower member of the Benjamin Limestone in Tasmania shows a similar record of appear-ances through assemblages OT12 to 14 of Banks & Burrett (1980), and this part of the Tasmanian sequence is usually equated with the late Gisbornian (Blackriveran) to early Eastonian (Rocklandian–Kirkfieldian) interval (Banks & Burrett 1989; Webby 1991).

Conodonts from the Coombing Formation (formerly 'Smith's Malongulli Formation'), east of Cliefden Caves

The Malongulli Formation was originally defined by Stevens (1952) based on a 'calcareous facies' developed only in the Cliefden Caves area. However, the conception of the formation was widened by Stevens (1957) to include a 'siltstone–arenite' facies in the region to the east, in the mistaken belief that both facies have a similar age. Since the 1970s, the type Malongulli Formation in the Cliefden Caves area (Moors 1970; Percival 1976) has been established as having a late Eastonian to early Bolindian age. The 'siltstone–arenite facies' is now recognised as a distinctly older, Darriwillian (Da3)–early Gisbornian (Gi1) unit. It contains graptolites *Cryptograp-tus tricornis*, *Pseudotrigonograptus ensiformis*, *Loganog-raptus logani*, *Amplexograptus* sp., *Isograptus* sp., and *Tetragraptus* sp. of probable Da3 age (Smith 1966; Packham 1969) and assemblages with *Glyptograptus* sp. (previously referred to *G. teretiusculus*, but possibly *G.* sp.A of VandenBerg & Cooper 1992, p.44), *Dicellograptus* sp., and *Nemagraptus gracilis* (C.J. Jenkins *in* Taylor 1988). A few localised limestone pods have produced conodonts *Periodon aculeatus*, *Belodella jemtlandica*, *Protopanderodus* cf. *robustus*, and platform-element *Eo-placognathus* sp. of broadly similar age range (Taylor 1988; Pickett 1992).

Webby (1973, p. 446; 1974; 1976; *in* Webby et al. 1981, p.30) has consistently referred to this distinctive Darri-willian–early Gisbornian unit as Smith's 'Malongulli Formation'. Taylor (1988) informally renamed it the 'Weemalla Beds', and Wyborn (1992, fig. 1) mapped the area with the fossil occurrences as a part of his 'Coombing Formation', but many other workers have, since the 1970s, failed to distinguish the unit from the type Malongulli Formation.

Systematic descriptions

All the illustrations in Plates 1–7 are SEM photomicro-graphs. Figured specimens bearing the prefix CPC are deposited in the Commonwealth Palaeontological Collec-tion of the Australian Geological Survey Organisation, Canberra. For details of the localities within the Malon-gulli Formation of the Cliefden Caves area, see the Canowindra 1:50 000 topographic maps 8630-I and IV (First edition, 1978). Details of these localities and horizons are given in Rigby & Webby (1988) and Webby & Trotter (1993). The main localities (see Fig. 1) have the following grid references: lower limestone breccia at Coppermine Creek, FC736810 (locality 1); lower (and tectonically repeated) limestone breccia at Gleesons Creek, FC757829 to FC757830 (locality 2); and lower limestone breccia at the Belubula River (Angullong side), FC745823 (locality 3). Numbers of conodont species are listed for each clast in Table 1. Details of clast numbers of all figured specimens are included in brackets in the plate captions.

The Malongulli conodonts are mainly well preserved, especially those from the limestone breccias at Copper-mine Creek. The specimens characteristically have Colour Alternation Index (CAI) values of 4 to 6, suggesting heating of the host rocks to temperatures higher than 200°C (Epstein et al. 1977).

Phylum **Conodonta** Pander, 1856

Class **Conodontata** Pander, 1856

Order **Conodontophorida** Eichenberg, 1930

Genus *Ansella* Fåhraeus & Hunter, 1985

Type species. *Belodella jemtlandica* Löfgren, 1978

Ansella sp.

Pl. 1, figs 1–5; Pl. 2, figs 5 & 6; ?Pl. 5, fig. 32

Remarks. The association assigned to this species comprises mainly denticulate elements (Pl. 1, figs 1–5), a few adenticulate elements (Pl. 2, figs 5 & 6) and a probable geniculate element (Pl. 5, fig. 32). The denticulate elements are characterised by a high sinuous blade-like structure that becomes denticulate orally. The denticles of *A. jemtlandica* (Löfgren) and *A. sinuosa* (Stouge) differ in being fewer, usually coarser, lower and more clearly differentiated basally. Stouge (1984) included a fine, 'hairlike' denticulate form as *A. jemtlandica* (Löfgren) which may be conspecific with *A.* sp., although the geniculate element of the former differs greatly from that tentatively assigned to *A.* sp. (Pl. 5, fig. 32). This latter geniculate element features a truncated anterobasal corner, and has a straight upper basal margin, which is expanded posteriorly. *Ansella nevadensis* (Ethington & Schumacher) is distinctly triangular in basal cross-section and accommodates a strong anterolateral furrow and carina, whereas *A.* sp. features 1 or 2 fine keels along the anterior margin.

Genus *Belodina* Ethington, 1959

Type species. *Belodus compressa* Branson & Mehl, 1933

Belodina confluens Sweet, 1979

Pl. 2, figs 7?, 18–20, 24, 25, 27–30

1979   *Belodina confluens* Sweet 1979, p. 59–60, fig. 5 (10, 17), fig. 6 (9).

1981   *Belodina confluens* Sweet; Sweet *in* Ziegler, p. 73–77, pl. 2, figs 8–14.

1988   *Belodina confluens* Sweet; Nowlan & McCracken, *in* Nowlan et al., p. 12, pl. 1, figs 16–21 (*cum. syn.*)

1989   *Belodina confluens* Sweet; McCracken & Nowlan, p. 1888, pl. 1, figs 19–21; pl. 2, figs 1 & 2.

1990   *Belodina confluens* Sweet; Uyeno, p. 71, pl. 1, figs 8 & 9.

1990   *Belodina confluens* Pickett & Ingpen, p. 6, cover photo, K.

Remarks. The compressiform elements are distinguishable from those of other species by their uniformly curved anterior margin closely paralleled by a thin carina on the concave furrowed side. The element represented by Pl. 2, fig. 7 differs slightly in being more compressed.

Belodina sp. A

Pl. 2, figs 12 & 13

Remarks. These grandiform elements have a roundly terminated cusp apex, which allies them to *Belodina*. However, they differ from *B. confluens* in having an anterior margin that is not uniformly arcuate, and slightly flattened basally. They also exhibit similarities in outline to elements of *Pseudobelodina inclinata*, but lack the flatter, broader denticles.

Belodina sp. B

Pl. 2, fig. 14

Remarks. The large size of this grandiform element and its characteristic broadly rounded cusp readily distinguish this form from other species of the genus.

Belodina sp. C

Pl. 2, fig. 15

?1978   *Belodina* sp. D. Palmieri, p. 15, Pl. 3, figs 16 & 17.

Remarks. This strongly compressiform element closely resembles the elements of *Belodina* sp. D illustrated by Palmieri (1978, pl. 3, figs 16 & 17), although the latter features distinctly discrete denticles.

Belodina sp. D

Pl. 2, figs 16, 17, 22 & 23

Remarks. This species is characterised by the irregular curvature of the anterior margin. A change of near 90 degrees occurs between the anterobasal margin and cusp margin, becoming widely keeled at this point.

Belodina sp. E

Pl. 2, fig. 21

Remarks. The nature of the heel may suggest affinities to *B.* sp. F described below (see Pl. 2, fig. 26).

Belodina sp. F

Pl. 2, fig. 26

Remarks. This large, short and wide eobelodiniform element resembles the stratigraphically older *B. monitorensis* Ethington & Schumacher; this latter is similarly robust, has an exceptionally short wide heel, and is slightly bowed to the unfurrowed side. *B.* sp. F also appears to have affinities with the compressiform elements *Belodina* sp. C and sp. E as they also feature an unusually short, wide heel. However, the latter species differs greatly in size.

Belodina sp. G

Pl. 2, figs 3 & 4

Remarks. Elements are long with a narrow base, and are characterised by 8 to 9 evenly sized spatula-like denticles with well-rounded tips. Blade shape and the nature of denticulation, therefore, distinguish this species.

Genus *Besselodus* Aldridge, 1982

Type species. *Besselodus arcticus* Aldridge, 1982

Besselodus sp.

Pl. 3, fig 7, 12–18

Remarks. Nowlan & McCracken (*in* Nowlan et al. 1988) recognised four types of distacodiform (S) elements and a geniculate oistodiform (M) element as constituting the *Besselodus* apparatus. In the Malongulli collection, Sa (= c), Sb (= b), Sc (= a), and M (= e) elements are recognised, the latter being closer to *B. borealis* Nowlan & McCracken than *B. arcticus* Aldridge with its anterobasal margin extending past the line of geniculation of the cusp and base. The Malongulli form also shares the medial positioning of the costa, though is not as strongly developed. The S elements tend to develop a more distinctive posterobasal 'heel' than that of the Canadian species, causing the triangular base to be a right-angle triangle.

These elements are assigned to *Besselodus* Aldridge in preference to *Dapsilodus* Cooper, as all elements are unbowed and differ in general shape to those assigned to *Dapsilodus*, and because geniculate M elements are also present.

Genus *Chirognathus* Branson & Mehl, 1933

Type species. *Chirognathus duodactylus* Branson & Mehl, 1933

Chirognathus duodactylus Branson & Mehl, 1933?

Pl. 4, fig. 23

?1933 *Chirognathus duodactylus* Branson & Mehl, p. 28, pl. 2, figs 1 & 2

?1982 *Chirognathus duodactylus* Branson & Mehl; Sweet, p. 1038, pl. 1, figs 12–17.

?1991 *Chirodactylus duodactylus* Branson & Mehl; Sweet, *in* Ziegler, p. 47–50, pl. 1, figs 11–16 (*cum syn.*)

Remarks. The two specimens are probably Pb elements of *C. duodactylus* Branson & Mehl, following the reassessment given by Sweet (1982). The Malongulli material shares the distinct antero-posteriorly flaring basal cavity and reclined cusp, the latter twisted distally and being twice as long as the next largest denticle which is accommodated by the longer process. However, well-developed denticles on the shorter lateral process are lacking, yet are shown to be developed in other illustrated forms (Sweet 1982, pl. 1, fig. 12; Webers 1966, pl. 5, fig. 5). As only one specimen is complete and the other fragmentary, and the species is typically recorded elsewhere from Middle Ordovician strata, only a tentative assignment is proposed here.

Genus *Culumbodina* Moskalenko, 1973

Type species. *Culumbodina mangazeica* Moskalenko, 1973

Culumbodina? sp.

Pl. 5, figs 16–18; ?Pl. 2, figs 1 & 2

1978 *Panderodus* sp. B Palmieri, p. 23, Pl. 2, fig. 10, Fig. 3 (7a–d).

?1978 *Panderodus* sp. A Palmieri, p. 23, Pl. 2, figs 1–6; Pl. 9, figs. 1–3; Fig. 4 (1a–1d).

Remarks. The Malongulli forms (Pl. 5, figs 16–18) appear similar to those described by Palmieri (1978, pl. 2, fig. 10) as *Panderodus* sp. B from the Fork Lagoons Beds, central Queensland, principally in regard to the posterior serrations and general outline of the latter. These features are reminiscent of *Culumbodina* Moskalenko, but the serrations of the Malongulli specimens do not develop the denticle overgrowths of typical representatives of the genus *Culumbodina* Moskalenko. Furthermore, the *Culumbodina*? sp. elements are slightly bowed toward the furrowed side, the opposite direction to elements of *Culumbodina* Moskalenko. The much stouter elements represented in Pl. 2, figs 1 and 2 have a similar denticulation and may, therefore, also be included, though tentatively, as a part of the apparatus.

Genus *Dapsilodus* Cooper, 1976

Type species. *Distacodus obliquicostatus* Branson &

Mehl, 1933

Dapsilodus mutatus (Branson & Mehl, 1933)?

Pl. 3, figs 19, 20 & 22

?1933 *Belodus*(?) *mutatus* Branson & Mehl, p. 126, pl. 10, fig. 17.

?1980 *Dapsilodus mutatus* (Branson & Mehl); Orchard, p. 20, pl. 5, figs 6, 15, 16, 21 (*cum syn.*).

Remarks. Acodiform elements only were recovered, each with a long posterolateral costa almost extending to the aboral margin. The smaller elements (Pl. 3, figs 19 & 22), however, seemingly lack the oblique anterobasal striae characteristic of *Dapsilodus* Cooper.

Genus *Drepanoistodus* Lindström, 1971

Type species. *Oistodus forceps* Lindström, 1955

Drepanoistodus suberectus (Branson & Mehl, 1933)

Pl. 5, figs 27–31

1933 *Oistodus suberectus* Branson & Mehl, p. 111, pl. 35, figs 22–27.

1988 *Drepanoistodus suberectus* (Branson & Mehl); Nowlan & McCracken, *in* Nowlan et al., pl. 16, pl. 3, figs 19–22 (*cum syn.*)

1990 *Drepanoistodus suberectus* (Branson & Mehl); Uyeno, p. 76, pl. 1, figs 13, 16–18.

Remarks. Suberectiform Sa elements, drepanodiform Sb elements and very few oistodiform M elements were recovered from the Malongulli collection.

Genus *Istorinus* Knupfer, 1967

Type species. *Istorinus erectus* Knüpfer, 1967

Istorinus? sp.

Pl. 3, figs 29–32

Remarks. Similar elements were previously assigned to '*Carniodus*' Walliser by Serpagli (1967) and Palmieri (1978), who illustrated fragmented forms comprising a flexed, laterally compressed blade with a long, erect cusp flanked by one or two denticles. Sweet & Bergström (1984) revised the taxonomy of the European faunas, reassigning Serpagli's '*Carniodus*' Walliser to *Istorinus erectus* Knüpfer; however, the latter is believed to be composed of more complete elements.

Genus *Oistodus* Pander, 1856

Type species. *Oistodus lanceolatus* Pander, 1856

'*Oistodus*' cf. *venustus* Stauffer 1935

Pl. 3, figs 27 & 28

cf. 1935 *Oistodus venustus* Stauffer, p. 147, pl. 12, fig. 12.

1988 *Paroistodus*? sp. A Nowlan & McCracken; *in* Nowlan et al., p. 24, pl. 9, figs 4, 20–22 (*cum syn.*, 'e' element only).

1989 *Paroidstodus*? sp. A Nowlan & McCracken; McCracken & Nowlan, p. 1889, pl. 3, fig. 6

1990 '*Oistodus*' cf. '*O.*' *venustus* Stauffer; Bergström, p. 22, pl. 3, fig. 13.

Remarks. This geniculate element is variable in its development of costae, being weaker in some specimens, and they may be medially or more posteriorly positioned. The length of the base is usually subequal to the cusp, but may be somewhat shorter. Such variations are typical of the morphological range of this form species.

The affinity of this element is not clear, many similar forms having previously been assigned to or compared with *O. venustus* (e.g. Hamar 1966; Winder 1966; Weyant 1968). Nowlan & McCracken (*in* Nowlan et al. 1988) regarded such forms as 'e' elements of their *Paroistodus?* sp. A apparatus (see also description of *Paroistodus?* sp. A Nowlan & McCracken, herein). The Malongulli representatives of '*Oistodus*' cf. *venustus* differ from *O. venustus* as originally described and illustrated by Stauffer (1935), in that the former features a sharper, almost pointed, anterobasal corner than the latter.

<p align="center">Genus Oulodus Branson & Mehl, 1933</p>

Type species. *Cordylodus serratus* Stauffer, 1930

<p align="center">Oulodus cf. oregonia (Branson, Mehl & Branson, 1951)</p>

<p align="center">Pl. 4, figs 16 & 17</p>

cf. 1951 *Prioniodina oregonia* Branson, Mehl & Branson, p. 15–16, pl. 3, fig. 18, pl. 4, figs 28–32.

cf. 1975 *Oulodus subundulatus* Sweet, Turco, Warner & Wilkie; Sweet & Schönlaub, p. 47, pl. 2, figs 13–18 (Pb element, fig. 14).

non 1975 *Oulodus oregonia* (Branson, Mehl & Branson); Sweet & Schönlaub, p. 48, pl. 2, figs 1–6 [=*O. velicuspis* (Pulse & Sweet, 1960)].

cf. 1981 *Oulodus oregonia* (Branson, Mehl & Branson); Sweet, *in* Ziegler, p. 199–200, pl. 1, fig. 1–6.

Remarks. This specimen is virtually identical to the Pb element of *O. subundulatus* (Sweet, Turco, Warner & Wilkie) as described by Sweet & Schönlaub (1975, pl. 2, fig. 14). Sweet (*in* Ziegler 1981) synonymised this form with *O. oregonia* (Branson, Mehl & Branson) and reassigned the elements of the same name described by Sweet & Schönlaub (1975) to *O. velicuspis* (Pulse & Sweet). Sweet's revised classification is followed here for the Malongulli specimen, the specimen seemingly closest to *O. oregonia*; but without the presence of the diagnostic M element, this assignment must remain tentative. *Oulodus* sp. Barnes figured by An (1985) is also similar to the Malongulli specimen; however, a description is lacking, so preventing further comparison.

<p align="center">Genus Ozarkodina Branson & Mehl, 1933</p>

Type species. *Ozarkodina typica* Branson & Mehl, 1933

<p align="center">Ozarkodina sesquipedalis Nowlan & McCracken, in Nowlan et al., 1988</p>

<p align="center">Pl. 6, figs 13–25</p>

1988 *Ozarkodina sesquipedalis* Nowlan & McCracken, *in* Nowlan et al., p. 18, Pl. 5, figs 1–15.

Remarks. Pa, Pb, M, and Sc elements (equivalent to 'f', 'g', 'e', 'a' elements) of *O. sesquipedalis* Nowlan & McCracken (*in* Nowlan et al., 1988, p. 18) were recovered. Minor variations between these specimens and the Canadian forms include the additional denticles in the P elements of the Malongulli collection. The Pa element may accommodate up to 17 denticles (Pl. 6, fig. 25) while the Pb element may develop up to 8 rather than 6 along its anterior process (Pl. 6, fig. 17). It is also noted that the posterior process of the Pb element accommodates alternating large and small denticles, which are shorter and more discrete than those forming the anterior process.

As noted in the original descriptions of Nowlan & McCracken (*in* Nowlan et al. 1988, p. 19), the Sc element closely resembles *Plectodina florida* Sweet, but can be distinguished by its smaller, irregular, posterior denticles that are fused rather than discrete, and by its proportionately higher base.

The P elements of the Malongulli material are remarkably similar to elements of *Yaoxianognathus yaoxianaensis* An (1985, pl. II, figs 6 & 7) and may well be synonymous. The assignment to *O. sesquipedalis* Nowlan & McCracken is followed, however, as there is a greater range of elements included in this form, and the more distinctive 'zygognathiform' and 'hibbardelliform' elements of the Chinese species are absent from the Malongulli collection.

<p align="center">Genus Panderodus Ethington, 1959</p>

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

<p align="center">Panderodus gracilis (Branson & Mehl, 1933)</p>

<p align="center">Pl. 5, figs 1–4, 9, 10, 12–15</p>

1933 *Paltodus gracilis* Branson & Mehl, p. 108, pl. 8, figs 20 & 21.

1988 *Panderodus gracilis* (Branson & Mehl); Nowlan & McCracken, *in* Nowlan et al., p. 21, pl. 7, figs 1–10, 12–13, 19 (*cum syn.*).

1990 *Panderodus gracilis* (Branson & Mehl); Uyeno, p. 69–70, pl. 1, figs 14, 19–20.

Remarks. Following Orchard's (1980) assessment of element positions M, Sa and Sb, representatives of this species have been recovered: (1) broad, symmetrical, laterally compressed M elements, which were originally described as *Paltodus compressus* Branson & Mehl, 1933; (2) slender, costate, graciliform Sa elements, featuring two anterolateral costae, one each side; and (3) an intermediate Sb element with only one anterolateral costa on the reverse side. A seemingly transitional form between the Sa and Sb elements is also exhibited (see Pl. 5, figs 4 & 9, 1 & 10).

The basal transverse section delineates the typically broad rounded anterior, a strongly pinched centre, and a narrow, laterally compressed, posterior. Hence, they are typical representatives of this species and do not differ from the range illustrated by Orchard (1980), and by Nowlan & McCracken (*in* Nowlan et al. 1988).

<p align="center">Panderodus sp. A</p>

<p align="center">Pl. 1, figs 10–12</p>

Description. Elements small, laterally compressed with two symmetrically disposed anteromedian carinae, one extending the length of each face. Carinae taper apically, become flattened basally, and in one, bounded posteriorly by a fine slit-like groove or furrow. Cusp proclined, margins sharp and keeled, anterobasal corner slightly truncated, and posterobasal corner with rounded lip.

Posterior margin irregularly serrated to almost finely denticulate in some forms. Base may be relatively high and long, with basal wrinkles.

Remarks. These elements show some resemblance to *Pseudobelodina*? *anceps* n. sp., particularly in basal outline and the square-faced lateral carinae, but lack denticles.

Panderodus sp. B

Pl. 5, figs 6 & 11

Remarks. *Panderodus* sp. B differs from the other illustrated forms primarily by the notch-like depression at the posterobasal margin. This basal outline is reminiscent of *P. panderi* Stauffer; however the former is generally acostate. Additionally, the compressiform element is smaller and less blade-like than that of *Panderodus gracilis* (Branson & Mehl), and with a more recurved cusp.

Panderodus sp. C

Pl. 1, figs 15 & 19

Description. Elements small, laterally compressed and scythe-shaped with broadly flattened base and uniformly curved, keeled margins. Basal wrinkles present, cusp twisted in some, and slightly bowed to the furrowed side. Weak posteromedian and anteromedian carina accommodated by the unfurrowed and furrowed faces, respectively; the latter extending to basal margin. Furrow developed as fine slit-like groove that extends the entire exposed length (apex not preserved) of specimens.

Remarks. These small panderodontid elements resemble elements of *Zanclodus* Nowlan & McCracken and could well belong to this apparatus. The former differs in lacking the posteriorly expanded base and the weak 'heel' characteristic of *Zanclodus* Nowlan & McCracken.

Panderodus sp. D

Pl. 5, figs 24–26

?1978   *Panderodus* sp. aff. *P. panderi* (Stauffer); Palmieri, p. 22, pl. 1, figs 9, 13 & 14, text fig. 3(4–5).

Description. Strongly recurved coniform elements compressed laterally; commonly with weakly developed anterior and posterior keels. One or two weak nodes or denticles, typically represented just above mid-height on posterior margin of cusp.

Remarks. Palmieri (1978) described similar forms as *Panderodus* sp. aff. *P. panderi* [pl. 1, figs 9, 13 & 14 and text-figs 3 (4 & 5)]; however, none of these elements show the thickened upturned base characteristic of *P. panderi* (Stauffer). *P.* sp. D is distinguished from *Culumbodina*? sp. by having much smaller and less conspicuous denticles (characteristically positioned above rather than below mid-height) and a greater recurvature of the cusp, and by lacking the posteriorly expanded base. It probably represents a new species of *Panderodus*.

Panderodus? *liratus* Nowlan & Barnes 1981

Pl. 5, figs 5, 7 & 8

1981   *Panderodus liratus* Nowlan & Barnes, p. 17, pl. 6, figs 21, 22, 24, 28 & 29, text-figs 7C & D.

1988   *Panderodus*? *liratus* Nowlan & Barnes; Nowlan & McCracken, *in* Nowlan et al., p. 21, pl. 7, figs 11, 15–18, 22 (*cum syn.*).

Remarks. The Malongulli specimens are referred to *P.*? *liratus* Nowlan & Barnes, a species reported specifically from Late Ordovician successions of Anticosti Island (Nowlan & Barnes 1981) and the Northwest Territories of Canada (Nowlan et al. 1988), because they exhibit a distinctive heel-like extension at the posterobasal corner of the cusp.

Genus *Paroistodus* Lindström, 1971

Type species. *Oistodus parallelus* Pander, 1856

Paroistodus sp.

Pl. 5, figs 19–23

Remarks. These geniculate elements are similar to the oistodiform elements of the stratigraphically older species *Paroistodus parallelus* (Pander). As the diagnostic drepanodiform elements are lacking in this collection, a further species assignment is not possible.

Paroistodus? sp. A Nowlan & McCracken, 1988

Pl. 3, fig. 21

1988   *Paroistodus*? sp. A Nowlan & McCracken, *in* Nowlan et al., p. 24–26, pl. 9, figs 1, 3, 5, 6, 9, 10, 14 & 15 (*cum syn.*, 'a' elements only).

1989   *Paroistodus*? sp. A Nowlan & McCracken; McCracken & Nowlan, p. 1889, pl. 3, fig. 1.

Remarks. The elements assigned to *Paroistodus*? sp. A Nowlan & McCracken are acodiform and lack oblique anterobasal striae. Thus, they closely conform to the Sc (= 'a') elements of Nowlan & McCracken's species. Of the other elements of Nowlan & McCracken's *Paroistodus*? sp. A apparatus, only the 'e' elements are well represented in the Malongulli assemblages. They are here referred to form species '*Oistodus*' cf. *venustus* Stauffer 1935 (see above).

Genus *Periodon* Hadding, 1913

Type species. *Periodon aculeatus* Hadding, 1913

Periodon grandis (Ethington, 1959)

Pl. 4, figs 13, 14, 27 & 28

1959   *Loxognathus grandis* Ethington, p. 281, pl. 40, fig. 6.

1981   *Periodon grandis* (Ethington); Lindström, *in* Ziegler, p. 243–244, pl. 1, figs. 13–18.

1989   *Periodon grandis* (Ethington); McCracken & Nowlan, p. 1889, pl. 3, figs 7–9.

1990   *Periodon grandis* (Ethington); Bergström, p. 11, pl. 3, fig. 7.

Remarks. Ramiform and prioniodiniform elements are represented in this collection, the latter (particularly Pl. 4, fig. 14) being similar to elements described by Ethington (1959, p. 284, pl. 41, fig. 14) and that illustrated by Sweet (1979, fig. 8: 20), but differing slightly from the latter in having a slightly higher and wider flaring base. The Malongulli ramiform elements are nearly identical to those illustrated by Bergström & Sweet (1966, pl. 30, figs 7 & 8).

Periodon? sp.

Pl. 5, fig. 34

Remarks. This incomplete element is probably related to *Periodon* Hadding; it features relatively large denticles. The lateral process, though broken, shows a large denticle apparently exceeding the size of the cusp.

Genus *Phragmodus* Branson & Mehl, 1933

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

Phragmodus undatus Branson & Mehl, 1933

Pl. 6, figs 2–11 (1 & 12)?

1933   *Phragmodus undatus* Branson & Mehl, p. 115–116, pl. 8, figs 22–26.

1966   *Phragmodus undatus* Branson & Mehl; Philip, p. 112, fig. 1–5.

1988   *Phragmodus undatus* Branson & Mehl; Nowlan & McCracken, *in* Nowlan et al., p. 26–27, pl. 10, figs 1–3, 6 & 7 (*cum syn.*).

1989   *Phragmodus undatus* Branson & Mehl; McCracken & Nowlan, p. 1889, pl. 3, figs 10–12.

Remarks. The Malongulli material includes representatives of the Pa, Pb, M, Sa, Sb and Sc elements. One rather 'robust' Sc element (Pl. 6, fig. 1), similar to that illustrated by Pulse & Sweet (1960), may not belong to this species, as was previously suggested by Nowlan & Barnes (1981). The other less-typical specimen is the large Pa element (Pl. 6, fig. 12), which has broad, irregularly developed denticles and the cusp base accommodating a longitudinal ridge.

Genus *Protopanderodus* Lindström, 1971

Type species. *Acontiodus rectus* Lindström, 1955

Protopanderodus insculptus (Branson & Mehl, 1933)

Pl. 4, figs 1, 7–12

1933   *Phragmodus insculptus* Branson & Mehl, p. 124, pl. 10, figs 32–34.

1978   *Protopanderodus insculptus* (Branson & Mehl); Palmieri, p. 25, pl. 2, figs 26–29, text-fig. 4 (10a–10c) (*cum syn.*).

Remarks. According to Kennedy et al. (1979), *Protopanderodus insculptus* is readily distinguished from the very similar *P. liripipus* (see Pl. 4, figs 2–6) by the development of a denticle on its base. Plate 4, figure 1 features a lobate, flange-like basal process with only the basal remnants of its posterior denticle. Palmieri (1978, pl. 2, fig. 26) illustrated a form from central Queensland, which shows the remains of the base of the broken secondary denticle, but none show the prominent anterobasal flange that is apparent in the Malongulli representatives. Most elements are either symmetrical or slightly asymmetrical, the only exception being that in Plate 4, figure 8. The last is markedly asymmetrical, featuring a cusp that is strongly costate on one face with a correspondingly short weak costa on the other.

Protopanderodus liripipus Kennedy, Barnes & Uyeno, 1979

Pl. 4, figs 2–6

1979   *Protopanderodus liripipus* Kennedy, Barnes & Uyeno, p. 546–550, pl. 1, figs 9–19.

1983   *Protopanderodus liripipus* Kennedy, Barnes & Uyeno; Burrett, Stait & Laurie, p. 184, fig. 9A & B.

1985   *Protopanderodus liripipus* Kennedy, Barnes & Uyeno; Savage & Bassett, p. 708, pl. 86, fig. 15.

1988   *Protopanderodus liripipus* Kennedy, Barnes & Uyeno; Nowlan & McCracken, *in* Nowlan et al., p. 29, pl. 11, figs 18, 20 (*cum syn.*).

1989   *Protopanderodus liripipus* Kennedy, Barnes & Uyeno; McCracken & Nowlan, p. 1890, pl. 4, fig. 1.

Remarks. These specimens are recognised as symmetrical, slightly asymmetrical, and markedly asymmetrical protopanderodiform elements of *Protopanderodus liripipus*, in accordance with the description given by Kennedy et al. (1979). They are distinguishable from similar forms by their elongate, pointed base and the absence of a basal denticle. As in *P. insculptus* (Branson & Mehl), the anterobasal flange is variably developed.

Genus *Pseudobelodina* Sweet, 1979

Type species. *Belodina kirki* Stone & Furnish, 1959

Pseudobelodina dispansa (Glenister, 1957)

Pl. 1, figs 21–26, 31–33, (27–29, 34 & 35)?

1957   *Belodus dispansus* Glenister, p. 729–730, pl. 88, figs 14 & 15.

1988   *Pseudobelodina*? *dispansa* (Glenister) Nowlan & McCracken, *in* Nowlan et al., p. 30–31, pl. 12, figs 8–26 (*cum. syn.*).

1978   *Belodina* sp. D Palmieri, p. 15, pl. 3, figs 18, 19 & 22.

1989   *Pseudobelodina*? *dispansa* (Glenister); McCracken & Nowlan, p. 1890, pl. 4, figs 2–4.

1990   *Pseudobelodina dispansa* (Glenister); Uyeno, p. 73, pl. 1, fig. 24, 30.

Remarks. S.M. Bergström (Ohio State University, personal communication, May 1994) regards this taxon as a part of the same apparatus as *Belodina confluens*. The forms here assigned to the group vary in curvature of the anterior margin and in number and size of the denticles. Specimens shown in Plate 1, figures 31–33 compare closely with the original material described by Glenister (1957), though one specimen illustrated has only four denticles. Specimens illustrated in Plate 1, figures 23 and 24 have much enlarged denticles, while the bases of Plate 1, figures 21, 22, and 25 are longer and narrower. The latter are equivalent to forms illustrated by Nowlan & McCracken (*in* Nowlan et al. 1988, pl. 12, figs 8–26), McCracken & Nowlan (1989, pl. 4, fig. 2), and Uyeno (1990, pl. 1, fig. 24, 30). The specimen in Plate 1, figure 29 is tentatively assigned to this taxon as an aberrant form with only three proclined denticles. However, its general morphology shows affinities to elements within this group. Plate 1, figures 27 and 28 may be considered as shorter, broader, compressiform varieties of the forms represented in Plate 1, figures 23 and 24, with a blade of higher, longer denticles compared to those at the other end of the spectrum represented by Plate 1, figures 31–33. Elements with a long cusp, low heel and three to four proclined denticles (Pl. 1, figs 34 & 35) are also tentatively grouped within this apparatus.

Pseudobelodina inclinata (Branson & Mehl, 1933)

Pl. 2, figs 8–11

1933 *Belodus inclinatus* Branson & Mehl, p. 125–126, pl. 10, fig. 24.

1979 *Pseudobelodina inclinata* (Branson & Mehl); Sweet, p. 69, figs 6.11, 6.15, 6.16, & 6.22 (*cum syn.*).

1988 *Pseudobelodina inclinata* (Branson & Mehl); Nowlan & McCracken, *in* Nowlan et al., p. 31, pl. 13, figs 5–20, pl. 14, figs 1–6.

Remarks. The aspect of the posterobasal corner varies in the Malongulli material from being truncated (Pl. 2, figs 8, 10 & 11) to extending basally (Pl. 2, fig. 9). The latter feature is illustrated by the original material from the Maquoketa Shale (Branson & Mehl 1933; Sweet *in* Ziegler 1981; Sweet 1979) and in specimens from the Whittaker Formation, illustrated by Nowlan & McCracken (*in* Nowlan et al. 1988). The present material also differs in featuring a flattened anterobasal corner.

Pseudobelodina sp. A

Pl. 1, fig. 20

Remarks. This species differs from others of this genus in that the heel is almost non-existent. The lateral faces are completely covered with striae and the anterior margin is rounded basally, then straight along much of its length—in other species this margin is uniformly curved.

Pseudobelodina sp. B

Pl. 1, fig. 30

Remarks. *Pseudobelodina* sp. B has a uniformly curved anterior margin as does *P. dispansa* (Glenister), see above, but differs from the latter in denticulation and by developing a more distinct heel.

Pseudobelodina? *anceps* n. sp.

Pl. 1, figs 6–9, 13–14

Material. Ninety-three elements from Coppermine Creek and Gleesons Creek clasts (CM1, 2, 5, 8, 10, 11, 13–17, 22, and GC11). Figured specimens CPC 32987–88 (Form 1), CPC 32983–84 (Form 2) and CPC 32985–86 (Form 3); designated holotype is the form-2 element, CPC32983.

Derivation of name. Latin *anceps*, meaning two-edged, alluding to the doubled ridges on the medially flattened lateral face.

Description. Three forms were recognised, ranging from long and narrowly coniform to shorter, wider-based elements with a variably proclined to recurved cusp. Elements are slightly bowed to the more convex side or straight as in Form 3. Basal cross-section varies from subrounded to ovate. Lateral faces bear a single thin, median costa or ridge along the carina of the more convex side and two—one upper and one lower—bounding the flattened carina of the other face in one element type (Pl. 1, fig. 13–14); the second element type (Pl. 1, figs 6 & 9) repeats the former costate plan, but is slightly laterally compressed with an ovate basal section, a higher heel and, thus, longer basal margin; the third (Pl. 1, figs 7 & 8) has symmetrically disposed costae, two on each

side, a more rounded and restricted basal opening as in Form 1, and a heel that develops as a high blade, extending the basal margin further than the intermediate Form 2.

Remarks. The medially flattened lateral face bounded by prominent doubled ridges distinguishes *P.*? *anceps* n. sp. from other belodinids. Its affinities are likely to be related to *Pseudobelodina* Sweet, as it features strong lateral coastae, a 'wrinkled' base and a 'panderodontid-like' furrow. This furrow is bearly discernible in Plate 1, figure 8, as it is obscured by the upper lateral ridge. *P.*? *anceps* lacks the sinuous blade-like denticulate structure that characterises *Ansella* sp.

Genus *Pseudooneotodus* Drygant, 1974

Type species. *Oneotodus*? *beckmanni* Bischoff & Sannemann, 1958

Pseudooneotodus beckmanni (Bischoff & Sannemann, 1958)

Pl. 4, figs 29 & 30

1958 *Oneotodus*? *beckmanni* Bischoff & Sannemann, p. 98, pl. 15, figs 22–25.

1981 *Pseudooneotodus beckmanni* (Bischoff & Sannemann); Nowlan & Barnes, p. 23, pl. 2, figs 20 & 21 (*cum syn.*)

1990 *Pseudooneotodus beckmanni* (Bischoff & Sannemann); Uyeno, p. 99–100, pl. 1, figs 36 & 37.

Remarks. The Malongulli specimens are identical to the Canadian forms from the Vauréal Formation figured by Nowlan & Barnes (1981) and the laterally compressed ovate representatives of the type material from Germany (Bischoff & Sannemann 1958, pl. 15, fig. 25).

Pseudooneotodus mitratus (Moskalenko, 1973)

Pl. 4, figs 21 & 22

1973 *Ambalodus mitratus mitratus* Moskalenko, p. 86, pl. 17, figs 9–11.

1973 *Ambalodus mitratus nostras* Moskalenko, p. 87, pl. 17, figs 12–14, ?15.

1978 *Pygodus*? sp. Palmieri, p. 25, pl. 4, figs 24, 27–29 only.

1988 *Pseudooneotodus mitratus* (Moskalenko); Nowlan & McCracken, *in* Nowlan et al., p. 34, pl. 16, figs 2–6 (*cum syn.*).

1989 *Pseudooneotodus mitratus* (Moskalenko); McCracken & Nowlan, p. 1890, pl. 4, fig. 8.

Remarks. Two different forms are apparent: (1) an asymmetrical, nodose variety with weak concentric ornamentation (Pl. 4, fig. 21); and (2) a form which lacks nodes (Pl. 4, fig. 22). The elements are equivalent to the type material from the Siberian Platform illustrated by Moskalenko (1973); the nodose variety was originally described as the subspecies *P. mitratus nostras* Moskalenko and the smooth form as *P. mitratus mitratus* Moskalenko. Intermediate forms have often featured in other collections (e.g. Nowlan et al. 1988), but these subspecies have not been recognised here.

Genus *Scabbardella* Orchard, 1980

Type species. *Drepanodus altipes* Henningsmoen, 1948

Scabbardella altipes (Henningsmoen, 1948) subsp.
B Orchard, 1980

Pl. 3, fig. 1–6, 8–11

1948   *Drepanodus altipes* Henningsmoen, p. 420, pl. 25, fig. 14 (*partim?*).

1980   *Scabbardella altipes* (Henningsmoen) subsp. B Orchard, p. 26, pl. 5, figs 2, 3, 14, 18, 20, 23, 24, 30 & 33.

1989   *Scabbardella altipes* (Henningsmoen) subsp. B Orchard; Nowlan & McCracken, *in* Nowlan et al., p. 36, pl. 16, figs 7–20, pl. 17, figs 1–3, 5, 6, 8 & 9 (*cum syn.*).

Remarks. A variety of Sc elements are the predominant representatives of this species. Some (Pl. 3, figs 3 & 4) are equivalent to *Acodus similaris* Rhodes, as illustrated by Serpagli (1967, pl. 7, figs 5 & 6), and to some Canadian representatives of *S. altipes* subsp. B Orchard (Nowlan & McCracken *in* Nowlan et al. 1988, particularly pl. 16, figs 7–10); such elements are strongly laterally compressed and broader than the other elements of this collection. The other Sc elements feature a narrow, recurved cusp and either a long narrow base (Pl. 3, figs 6, 10 & 11) or a short widely triangular base (Pl. 3, figs 2, 5 & 9). The former are closely comparable to those from the Keisley Limestone illustrated by Rhodes (1955, pl. X, figs 10 & 26) as *Acodus similaris* Rhodes. The latter are similar, in general outline, to the M (= 'e-3') elements figured by Nowlan & McCracken (*in* Nowlan et al. 1988), but lack the second costa. Plate 3, figure 2 is also unusually ornamented with relatively strong closely spaced longitudinal striae.

The Sa (= 'c') element has the same form as those from the Whittaker Formation, Canada (Nowlan & McCracken *in* Nowlan et al. 1988, pl. 16, figs 17–20) and features finer striae and ridges associated with the primary posterolateral costae (Pl. 3, fig. 8).

Genus *Strachanognathus* Rhodes, 1955

Type species. *Strachanognathus parvus* Rhodes, 1955.

Strachanognathus parvus Rhodes, 1955

Pl. 4, figs 24–26

1955   *Strachanognathus parvus* Rhodes, p. 132, pl. 7, fig. 16, pl. 8, figs 1–4.

1978   *Strachanognathus parvus* Rhodes; Löfgren, p. 112, pl. 1, fig. 29 (*cum syn.*).

1978   *Strachanognathus parvus* Rhodes; Palmieri, p. 27, pl. 6, figs 27 & 28, text-fig. 6 (8a–8c).

1980   *Strachanognathus parvus* Rhodes; Orchard, p. 26, pl. 14, figs 34 & 35.

1990   *Strachanognathus parvus* Rhodes; Bergström, pl. 1, fig. 10.

Remarks. The Malongulli specimens are fairly typical representatives of this species, thus being closely comparable to the type material from the Keisley Limestone (Rhodes 1955).

Genus *Taoqupognathus* An, 1985

Type species. *Taoqupognathus blandus* An, 1985.

Taoqupognathus tumidus n. sp.

Pl. 7, figs 10–24

1978   *Drepanodus? altipes?* Henningsmoen; Palmieri, p. 19, pl. 2, figs 24 & 25, Fig. 4 (3a–c).

?1978   *Drepanodus?* cf. *altipes* Henningsmoen; Palmieri, p. 19, pl. 2, figs 22 & 23.

Material. Thirty-eight elements from 14 clasts in the breccia at Coppermine Creek (CM1–2, 4–9, 11–14, 18, 22, & 23); 13 figured specimens CPC 33162–74; holotype designated Sc? type 'c' element CPC 33171.

Derivation of name. From Latin *tumidus*, swollen, alluding to the portly, penguin-like outline.

Description. Blade-like coniform panderodontid elements, featuring basal wrinkles and a medial furrow on outer face, from base to cusp tip. Characteristic flange-like posterior process is exhibited in all but one element, and a variably developed ledge marks the base and cusp junction. Posterobasal corner of all elements is extended posteriorly and an anterobasal protruberance marks the height of basal ledge. Four groups of elements are recognised, with the Sb? and Sc? elements further subdivided into two and three types, respectively:

(1) **M? elements** (Pl. 7, figs 21 & 22) are symmetrical or slightly asymmetrical, slender and coniform; they lack costae and posterior process, have a convex anterior margin, concave posterior margin, recurved cusp and reduced lateral basal ledge; the unfurrowed side is smooth.

(2) **Sb? elements** are asymmetrical unicostate and with posterior process; and they are subdivided into:

- **type 'a'** (Pl. 7, figs 17 & 18) is composed of short, stout asymmetrical elements exhibiting an almost straight anterior margin, with cusp tip slightly higher than flange-like posterior process; posterior process almost extends full length of margin; furrowed side convex; unfurrowed side concave and accommodating prominent anteromedial costa developed as lateral process;

- **type 'b'** (Pl. 7, figs 14 & 15) comprises flattened and more elongate coniform elements (in comparison to Sb? type 'a' forms), with proclined cusp, prominent basal ledge and small nodular or lobe-like process developed along posterior margin near mid-length; furrowed side convex; unfurrowed side concave and accommodating posterior costa, developed as short lateral process, bounding posterior flange and extending to cusp tip.

(3) **Sc? elements** asymmetrical, and may feature short medial ridge with expanded posterior flange-like process, with cusp in transverse section sinusoidally bowed; subdivided into:

- **type 'a'** (Pl. 7, figs 10 & 11), which consists of forms with cusp sub-erect and anterior margin gently arcuate, posterior margin featuring distinct but narrow, lobe-like process (larger than the Sb? type 'b' element) near mid-height; basal ledge prominent; furrowed side convex; unfurrowed side concave, featuring median ridge on upper half between process and cusp tip;

- **type 'b'** (Pl. 7, figs 12–13), which has a convex anterior margin, posterior margin showing high flange-like process and prominent basal ledge; posterior

process extends from base for three-fifths of length of element; furrowed side convex; unfurrowed side concave with short, weak median ridge towards cusp tip;

- **type 'c'** (Pl. 7, figs 19 & 20), which exhibits an almost straight anterior margin, and posterior margin with high flange-like process (greater than Sc? type 'b' element); posterior process extends from base for three-quarters of element length; basal ledge prominent; furrowed side convex; unfurrowed side concave and smooth.

(4) **P? elements** (Pl. 7, figs 16, 23 & 24) asymmetrical and showing lateral twisting of cusp tip; anterior margin convex; posterior margin concave; basal ledge reduced; furrowed side convex; unfurrowed side convex, smooth and strongly bowed with cusp twisted laterally, becoming displaced toward the unfurrowed side at junction of posterior process; flange-like posterior process high (greater than that of the Sc? type 'b' element), extending along much of posterior margin.

Remarks. The genus was first illustrated by An (1985 pl. II, figs 18 & 19) based on *Taoqupognathus blandus* An, and featuring elements equivalent to those described above as occupying the Sb? type 'b' position. Savage (1990) described and illustrated a new species, *Taoqupognathus philipi* Savage from the lower part of Cliefden Caves Limestone Group (Fossil Hill Limestone), naming six different element types, using Greek numerals, from a smallest 'alpha' element to a largest 'zeta' element. This size gradation is not apparent in the Malongulli material, though three elements are very similar to forms identified in the Cliefden Caves succession. The M? (=Savage's 'delta') and the Sb? type 'b' (='beta') elements are quite similar, though the latter is a more elongate element in the Malongulli fauna, tending towards the shape of Savage's 'gamma' element. Neither costae nor posterolateral processes are mentioned in Savage's descriptions, although a prominent costa or ridge is shown in his illustration of the 'beta' element (see Savage 1990, fig. 8-4). Savage's 'gamma' element apparently lacks this feature. The Sc? type 'c' elements of *T. tumidus* (equivalent to the 'zeta' elements of Savage's *T. philipi*) are much broader, with the posterior process being wider and terminating orally almost at right-angles to the cusp. P?, Sb? type 'a', Sc? type 'a' and Sc? type 'b' elements are difficult to identify in Savage's species, and close comparisons are limited without essential descriptive details such as presence or absence of lateral costae or processes.

The specimens Palmieri (1978) described previously from the Late Ordovician Fork Lagoons Beds of central Queensland, which he referred tentatively to *Drepanodus* Pander, should now be interpreted as P? and M? elements of *T. tumidus*.

Genus **Walliserodus** Serpagli, 1967

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

Walliserodus amplissimus (Serpagli, 1967)

Pl. 7, figs 1–9

1967   *Drepanodus amplissimus* Serpagli, p. 66, pl. 15, figs. 1–5.

1978   *Drepanodus* sp. aff. *D. amplissimus* (Serpagli); Palmieri, p. 20, pl. 2, figs 15 & 16, text-fig. 4 (8a–c).

1988   *Walliserodus amplissimus* (Serpagli); Nowlan & McCracken *in* Nowlan et al., p. 40, pl. 19, figs 1–15 (*cum syn.*).

1989   *Walliserodus amplissimus*? (Serpagli); McCracken & Nowlan, p. 1892, pl. 4, fig. 11.

Remarks. Sa, Sb?, and M elements ('c', 'b', and 'e', types, respectively, following the nomenclature of Nowlan & McCracken *in* Nowlan et al. 1988) are recognised from the Malongulli collection. They are fairly typical representatives, comparing closely with those from the Carnic Alps (Serpagli 1967), and from the Whittaker Formation, Canada (Nowlan et al. 1988).

The Sa elements (Pl. 7, figs 1, 3–4) are distinctly triangular in basal transverse section, developing an anterior face with each edge defined by a single sharp anterolateral costa. The posterior margin is thinly keeled and a posterolateral costa is developed on one side only. These elements are equivalent to those in Serpagli (1967, pl. 31, figs 8 & 11) and Nowlan & McCracken (*in* Nowlan et al. 1988, pl. 19, figs 4, 14 & 15). The M elements (Pl. 7, figs 6–9) are equivalent to the carinate forms illustrated in Nowlan et al. (1988, pl. 19, figs 12 & 13), Serpagli (1967, pl. 15, fig. 2), and Palmieri (1978, pl. 2, figs 15 & 16). They are characterised by a strong posterior taper, creating a sharp widely keeled margin, a broader cusp, and the smooth curvature of the anterior and posterior margins, in contrast to the abrupt recurvature of the cusp in other elements.

The Sb? elements (Pl. 7, figs 2 & 5) have a sharp anterolateral costa on the flatter side and a posterolateral costa on the convex side. Plate 7, figure 5 features an additional keel or costa along the posterior margin. The cusps of both specimens are bowed to the convex side. The obvious difference between these two forms is the shorter base in one (see Pl. 7, fig. 5) in contrast to the much higher base in the other (see Pl. 7, fig. 2). The positioning of the costae equates these elements to those of Serpagli (1967, pl. 31, fig. 5).

Genus **Yaoxianognathus** An, 1985

Type species. *Yaoxianognathus yaoxianensis* An, 1985.

Yaoxianognathus? tunguskaensis (Moskalenko, 1973)

Pl. 4, figs 18–20

1973   *Phragmodus? tunguskaensis* Moskalenko, 1973, p. 74, Pl. XII, figs 1–3.

1983   *Phragmodus? (Spinodus?) tunguskaensis* Moskalenko; Moskalenko, Fig. 4.Z.

1985   *Oulodus? tunguskaensis* (Moskalenko); An, p. 108, pl. II, fig. 9.

1988   *Spinodus?* n. sp. A Nowlan & McCracken, *in* Nowlan et al., p. 38, pl. 17, figs 17–22.

1990   *Phragmodus? tunguskaensis* Moskalenko; Savage, p. 830, figs 10.7 & 10.8.

Remarks. The species has previously been assigned tentatively to various genera, including *Phragmodus*, *Oulodus* and *Spinodus* (Moskalenko 1973, 1983; An 1985; Nowlan & McCracken *in* Nowlan et al. 1988; Savage 1990). Savage (1990) described the species from the underlying Fossil Hill Limestone of the Cliefden Caves area (Fig. 2) and, following Moskalenko's (1973) original assignment, placed it tentatively in the genus *Phragmodus*.

However, the material seems better tentatively grouped in *Yaoxianognathus* An, especially given the similarities to the 'cordylodiform form' (Sc) elements of that genus. The Siberian elements that feature a prominent anterior denticle (e.g. Moskalenko 1973, pl. XII, fig. 1) resemble *Yaoxianognathus* sp. A of An (1985), and the latter also features a prominent denticle near mid-length of the posterior process.

The specimens from the present collection are closely similar to the type material from the Siberian Platform, and, in particular, to the holotype (Moskalenko 1973, pl. XII, fig. 3) with a much reduced anterior process, rather than to the paratypes of Moskalenko, which have developed a true denticle. The material illustrated by Nowlan & McCracken (*in* Nowlan et al. 1988) as *Spinodus*? n. sp. A is conspecific and also features the reduced anterior process.

Genus ***Zanclodus*** Nowlan & McCracken, *in* Nowlan et al., 1988

Type species. *Zanclodus levigatus* Nowlan & McCracken, *in* Nowlan et al., 1988

Zanclodus levigatus Nowlan & McCracken, *in* Nowlan et al., 1988

Pl.3, figs 23–26

1988   *Zanclodus levigatus* Nowlan & McCracken, *in* Nowlan et al., p. 43–44, pl. 19, figs 1–15.

Remarks. Nowlan & McCracken (*in* Nowlan et al. 1988) erected the genus *Zanclodus* to accommodate pandero-dontacean conodonts with a distinct, but weakly developed, posterior heel, and often truncated anterobasal margin. Elements of the type species show greater variation in flexure, being bowed to the unfurrowed side (group 1), bowed to the furrowed side (group 2), or unbowed (group 3).

The Malongulli collection features elements from groups 1 and 3, and is typical of the type material from the Whittaker Formation. The elements assigned to group 3 show the typical square-shaped base in profile, owing to the short, broad base, distinct posterior heel and truncated anterior margin (Pl. 3, figs 24–26). The group 1 representative (Pl. 3, fig. 23) is bowed to the unfurrowed side by definition, slightly more laterally compressed, features a very weakly developed posterior heel, and the truncation of the anterobasal margin is less abrupt compared to the group 3 elements. However, the 'characteristic' *Zanclodus* Nowlan & McCracken base is still distinguishable.

Gen. et sp. indet. A.

Pl. 5, fig. 33

Remarks. This small and incomplete element features an anterior, posterior and lateral process. The anterior process accommodates one small denticle, the lateral process is irregularly denticulate with four small and one large denticle, and the posterior process develops from the posterior costa of the cusp into a small flaring aboral lip.

Gen. et sp. indet. B

Pl. 5, fig. 35

Remarks. This large robust blade accommodates ten stout denticles. The denticles are uniformly short, rounded and erect, but become proclined anteriorly. Narrow lips flank a very shallow basal cavity, which is truncated posteriorly. Another distinguishing feature is the lateral deflection of the anterior end of the blade, which terminates with a larger (broken) denticle.

Gen. et sp. indet. C

Pl. 1, figs 16–18

?1978   *Acodus mutatus* (Branson & Mehl); Palmieri, p. 6–7, pl. 2, fig. 17 & 18, text-fig. 4(a–c).

Remarks. This small, blade-like element with a broadly sub-triangular profile has similarities to forms assigned to the genus *Acodus* Pander by Palmieri (1978, Pl. 2, figs 17 & 18) and Stouge (1984, pl. 14, figs 20 & 22). Those assigned by Palmieri are essentially the same as the Malongulli elements, although it seems to develop a slightly convex, rather than flat to concave, furrowed side. Those assigned by Stouge from Newfoundland have the same general outline. However, in the Malongulli material, the costa does not appear to be as prominent, as it is almost developed as a lateral process. The opposite face is not described by Stouge and is assumed to be featureless.

Gen. et sp.indet. D

Pl. 4, fig. 15

Remarks. Specific assignment is prevented by the lack of diagnostic elements, although this zygognathiform element shows similarities with the Sb element of *Plectodina florida* Sweet (1979, fig. 8:17).

Acknowledgements

References

Aldridge, R.J., 1982. A fused cluster of coniform conodont elements from the Late Ordovician of Washington Land, western North Greenland. *Palaeontology*, 25, 425–430.

An, T., 1985. Ordovician conodonts from Yaoxian and Fuping, Shaanxi Province, and their stratigraphic significance. *Acta Geologica Sinica,* 59, 97–108 (in Chinese).

Banks, M.R. & Burrett, C.F., 1980. A preliminary Ordovician biostratigraphy of Tasmania. *Journal of the Geological Society of Australia*, 26, 363–376.

Banks M.R. & Burrett, C.F., 1989. The Gordon Group (Early Ordovician to Early Silurian)— mainly platform carbonates. *In* Burrett, C.F. & Martin, E.L. (editors), Geology and mineral resources of Tasmania. *Geological Society of Australia, Special Publication*, 15, 201–224.

Bergström, S.M., 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. *Geological Society of America, Memoir,*
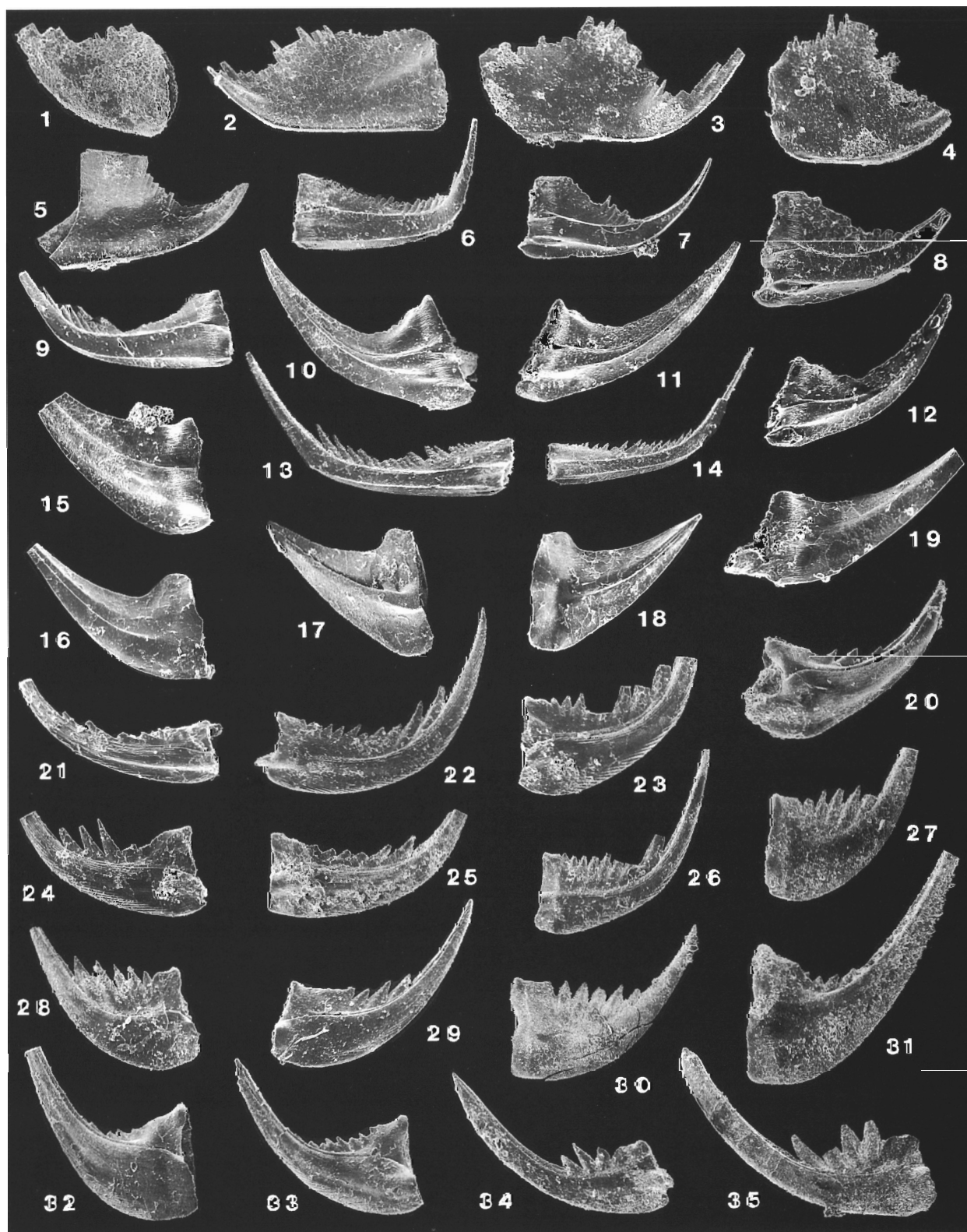
Plate 1. Figs 1–5, *Ansella* sp.; respectively CPC 32978 (CM12), x72; CPC 32979 (CM18) x72; CPC 32980 (CM1), x72; SUP CPC 32981 (CM13), x90; CPC 32982 (GC8), x90. Figs 6–9, 13 & 14, *Pseudobelodina? anceps* sp.nov.; 6, 9, Form 2, respectively holotype CPC 32983 (CM15), x90;   CPC 32984 (CM15), x90; 7–8, Form 3, respectively CPC 32985 (CM23), x108; CPC 32986 (CM10), x99; 13–14, Form 1, respectively CPC 32987 (CM13), x90; CPC 32988 (CM13), x90. Figs 10–12, *Panderodus* sp. A; respectively CPC 32989 (CM15), x90;   CPC 32990 (CM17), x90; CPC 32991 (CM11), x90. Figs 15, 19, *Panderodus* sp. C; respectively CPC 32992 (CM4), x90; CPC 32993 (CM4), x90. Figs 16–18, Gen. et sp. indet. C; 16, CPC 32994 (CM1), x117; 17–18, CPC 32995 (CM6), x90. Fig. 20, *Pseudobelodina* sp. A, CPC 32996 (CM9), x72. Figs 21–26, 31–33, *Pseudobelodina dispansa* (Glenister, 1957); 21–26, respectively CPC 32997 (CM8), x99; CPC 32998 (CM18), x72; CPC 32999 (CM18), x90; CPC 33000 (CM1), x108; CPC 33001 (CM8), x72; CPC 33002 (CM18), x72; 31–33, respectively CPC 33003 (CM22), x72; CPC 33004 (CM4), x72; CPC 33005 (CM4), x72. Figs 27–29, 34 & 35, *Pseudobelodina dispansa* (Glenister, 1957)?; 27–29, respectively CPC 33006 (CM18), x81; CPC 33007 (CM18), x72; CPC 33008 (CM13), x72; 34–35, respectively CPC 33010 (CM18), x72; CPC 33011 (GC6), x45. Fig. 30, *Pseudobelodina* sp. B; CPC 33009 (CM11), x45.
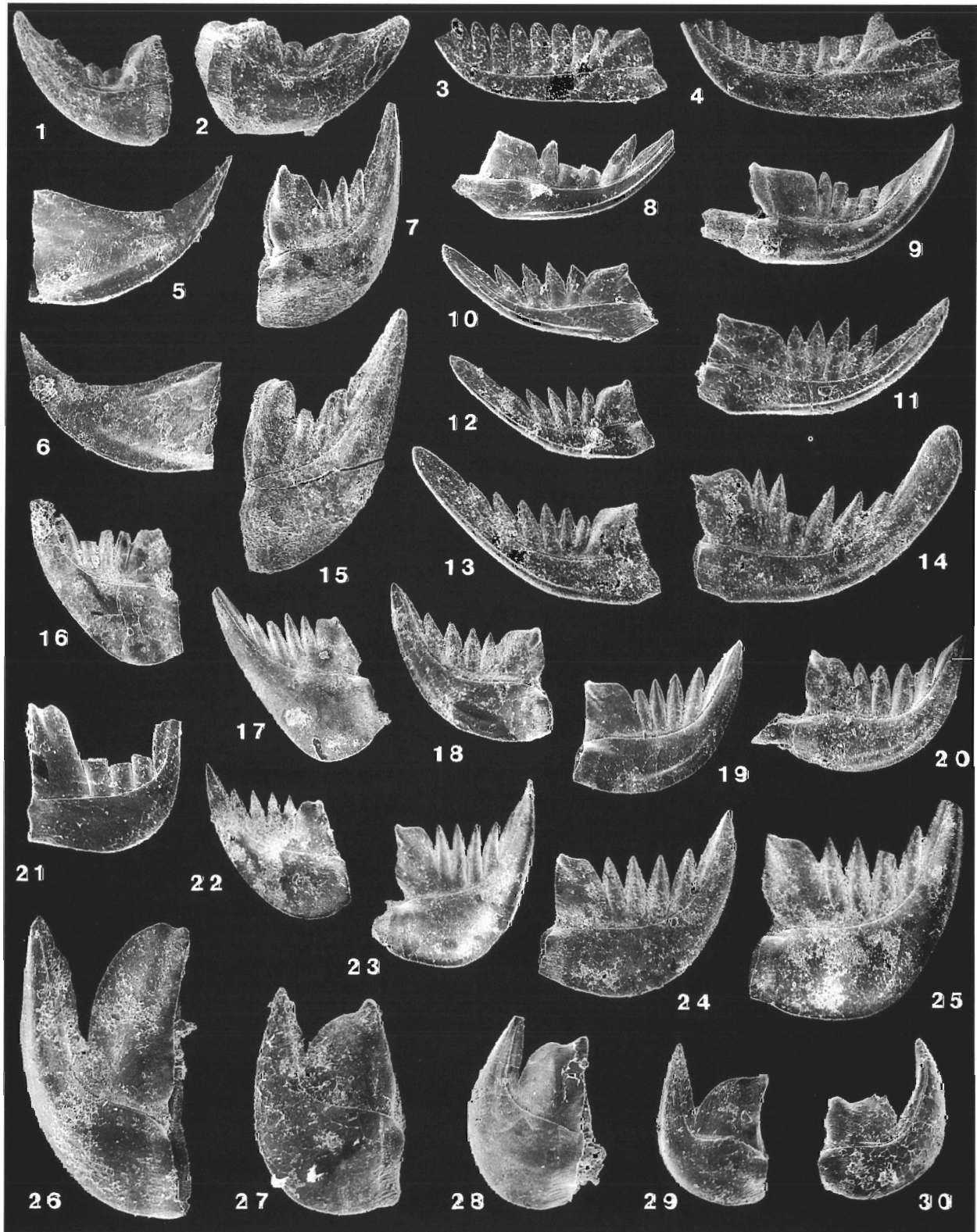
Plate 2. Figs 1 & 2, *Culumbodina*? sp.?; respectively CPC 33012 (CM4), x90; CPC 33013 (CM14), x72. Figs 3 & 4, *Belodina* sp. G; respectively CPC 33014 (CM20), x72; CPC 33015 (CM4), x72. Figs 5 & 6, *Ansella* sp.; CPC 33016 (CM11), x63. Fig. 7, *Belodina confluens* Sweet 1979?; CPC 33017 (CM4), x54. Figs 8–11, *Pseudobelodina inclinata* (Branson & Mehl, 1933); respectively CPC 33018 (CM8), x99; CPC 33019 (GC5), x36; CPC 33020 (CM1), x108; CPC 33021 (CM4), x81. Figs 12 & 13, *Belodina* sp. A; respectively CPC 33022 (CM22), x54; CPC 33023 (CM9), x54. Fig. 14, *Belodina* sp. B; CPC 33024 (CM18), x54. Fig. 15, *Belodina* sp. C; CPC 33025 (CM22), x54. Figs 16, 17, 22 & 23, *Belodina* sp. D; respectively CPC 33026 (GC4), x45; CPC 33027 (CM11), x36; CPC33028 (CM11), x54; CPC 33039 (CM18), x36. Figs 18–20, 24, 25, 27–30, *Belodina confluens* Sweet, 1979; 18–20, 24–25, compressiform elements, respectively CPC33029 (CM11), x54; CPC33030 (CM6), x54; CPC 33031 (CM3), x54; CPC33032 (CM18), x54; CPC 33033 (CM22), x54; 27–30, eobelodiniform elements, respectively CPC 33034 (CM11), x90; CPC 33035 (GC3), x90; CPC 33036 (CM1), x90; CPC 33037 (CM20), x90. Fig. 21, *Belodina* sp. E; CPC 33038 (CM2), x108. Fig. 26, *Belodina* sp. F, CPC33040 (CM22), x72.
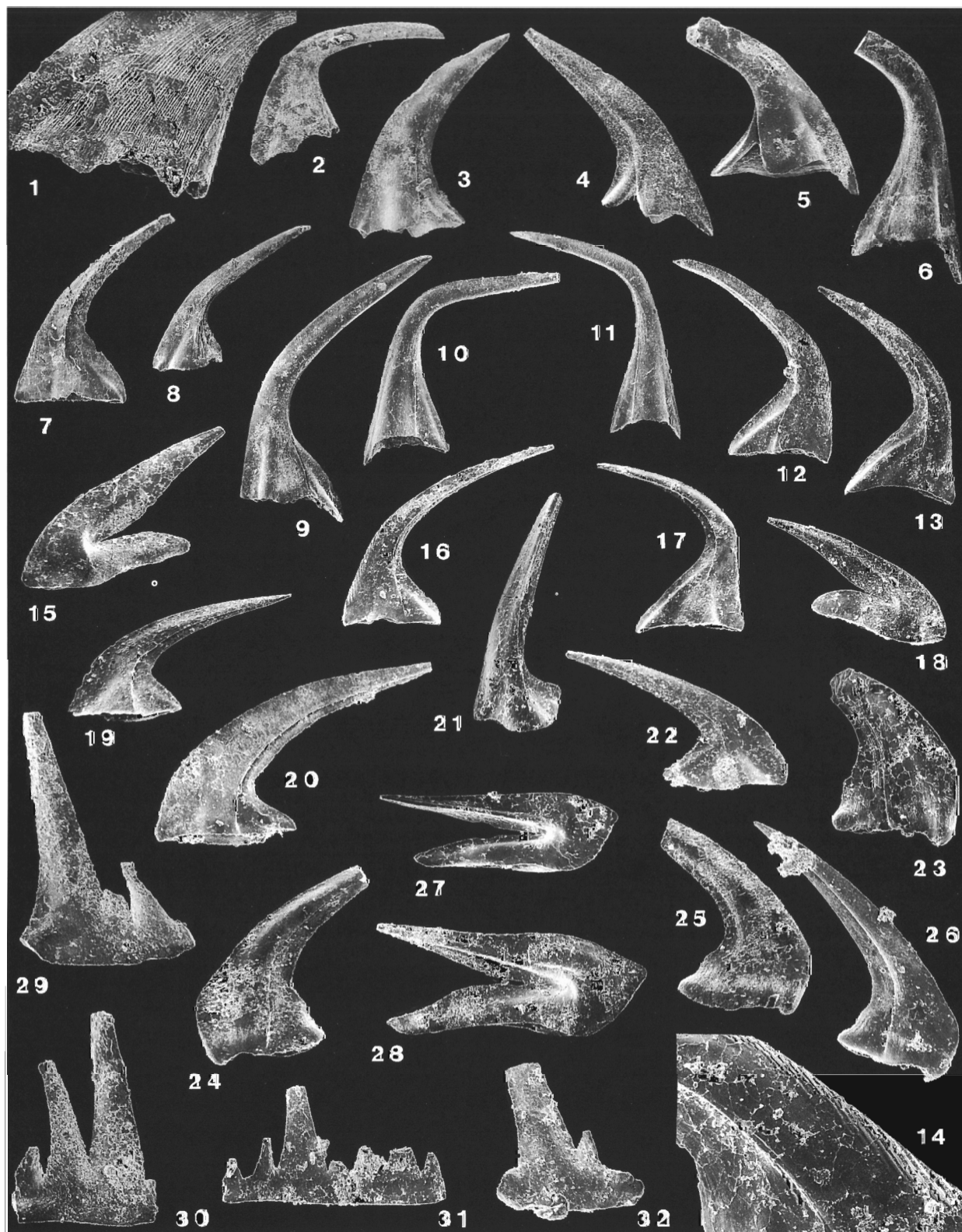
Plate 3. Figs 1–6, 8–11, *Scabbardella altipes* subsp. B Orchard, 1980; 1–6, 9–11, Sc elements, respectively CPC 33041 (GC6), x90 & x36; CPC 33042 (CM18), x22.5; CPC 33043 (CM18), x22.5; CPC 33044 (CM18), x27; CPC33045 (CM11), x27; CPC 33046 (CM6), x18; CPC 33047 (CM18), x36; CPC33048 (CM23), x36; 8, Sa element, CPC 33049 (CM18), x27. Figs 7, 12–18, *Besselodus* sp.; 7, 13–14, Sc elements, respectively CPC 33050 (GC10), x63; CPC 33051 (CM5), x54 & x324; 12, 16–17, Sb elements, respectively CPC 33052 (GC10), x54; CPC 33053 (CM5), x54; CPC 33054 (CM13), x54; 15, 18, M elements, respectively CPC 33055 (CM6), x72; CPC 33056 (CM13), x72. Figs 19–20, 22, *Dapsilodus mutatus* (Branson & Mehl, 1933)?; Sc elements, respectively CPC 33057 (CM13), x72; CPC 33058 (GC2), x63; CPC 33059 (CM1), x72. Fig. 21, *Paroistodus*? sp. A Nowlan & McCracken, 1988; Sc element, CPC33060 (CM19), x72. Figs 23–26, *Zanclodus levigatus* Nowlan & McCracken, 1988; 23, Group 1 element, CPC 33061 (CM18), x108; 24–26, Group 3 elements, respectively CPC 33062 (CM18), x90; CPC 33063 (CM15), x90; CPC 33064 (GC3), x90. Figs 27–28, *'Oistodus'* cf. *venustus* Stauffer 1935; respectively CPC 33065 (CM6), x72; CPC 33066 (CM11), x72. Figs 29–32, *Istorinus*? sp.; respectively CPC 33067 (CM11), x90; CPC 33068 (CM11), x90; CPC 33069 (CM1), x90; CPC 33070 (CM9), x90.
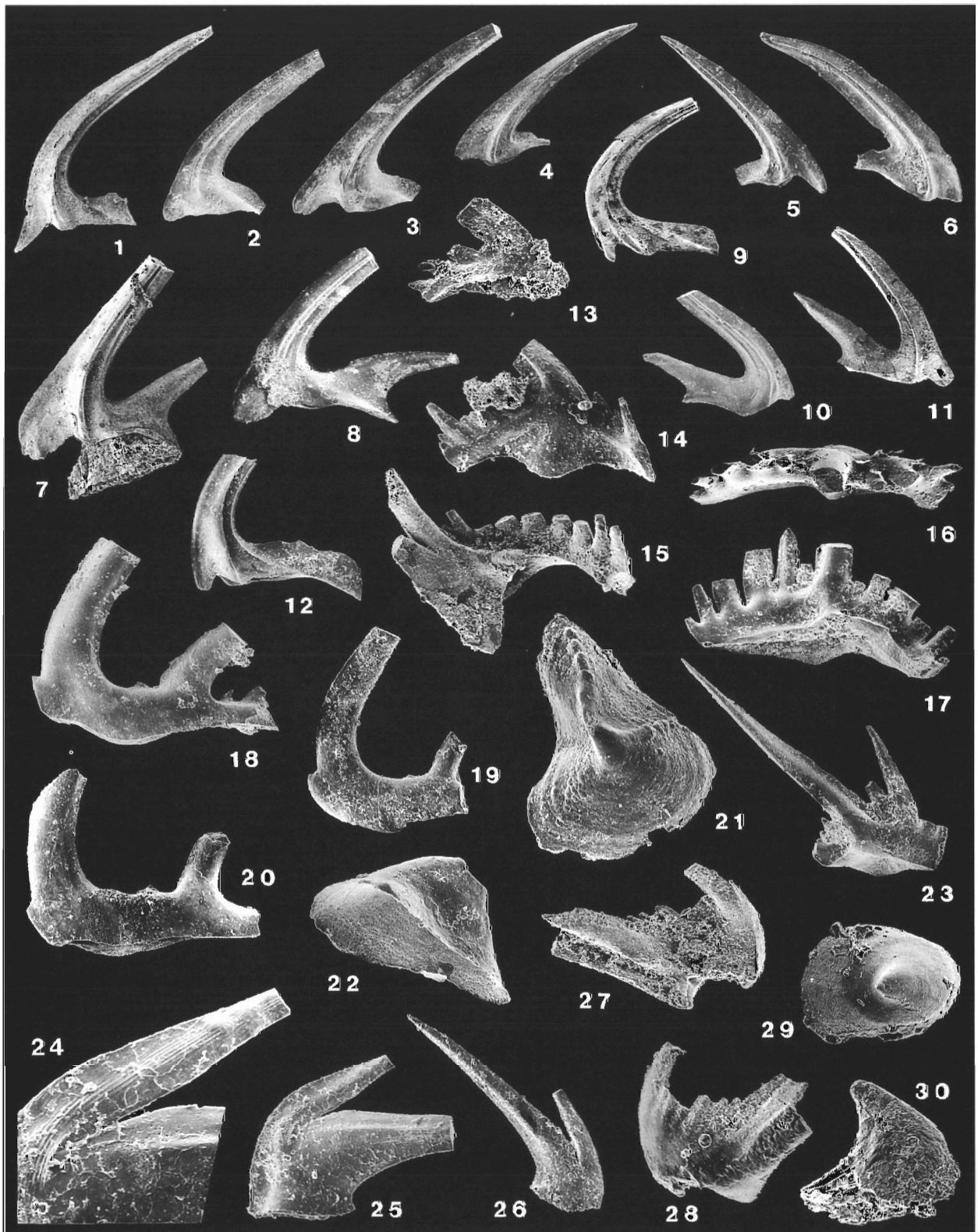
Plate 4. Figs 1, 7–12, *Protopanderodus insculptus* (Branson & Mehl, 1933); respectively CPC 33071 (GC6), x27; CPC 33072 (CM6), x27; CPC 33073 (CM22), x27; CPC 33074 (CM6), x36; CPC 33075 (CM22), x27; CPC 33076 (GC11), x27; CPC 33077 (CM6), x36. Figs 2–6, *Protopanderodus liripipus* Kennedy, Barnes & Uyeno, 1979; respectively CPC 33078 (CM6), x27; CPC 33079 (CM18), x27; CPC 33080 (CM6), x27; CPC 33081 (CM6), x27; CPC 33082 (CM6), x27. Figs 13, 14, 27–28 *Periodon grandis* (Ethington 1959). 13–14 P (prioniodiniform) elements, respectively CPC 33083 (CM1), x90; CPC 33084 (CM1), x90; 27–28, S (periodontiform) element, CPC 33085 (CM16), (inner & outer views), x90. Fig. 15, Gen. et sp. indet. D; CPC 33086 (CM1), x63. Figs 16 & 17, *Oulodus* cf. *oregonia* (Branson, Mehl & Branson, 1951); Pb element, CPC 33087 (CM18), (oral & lateral views), x63. Figs 18–20, *Yaoxianognathus? tunguskaensis* (Moskalenko, 1973), respectively CPC 33088 (CM18), x54; CPC 33089 (GC9), x54; CPC 33090 (GC9), x54. Figs 21 & 22, *Pseudooneotodus mitratus* (Moskalenko, 1973); 21, nodose element, CPC 33091 (CM6), x63; 22, element lacking nodes, CPC 33092 (CM5), x117. Fig. 23, *Chirognathus duodactylus* Branson & Mehl, 1933?; Pb element, CPC 33093 (CM18), x72. Figs 24–26, *Strachanognathus parvus* Rhodes, 1955; 24 & 25, CPC 33095 (CM6), x205 & x90; 26, CPC 33096 (CM6), x72. Figs 29 & 30, *Pseudooneotodus beckmanni* (Bischoff & Sannemann, 1958); respectively CPC 33097 (GC3), x135; CPC 33098 (CM12), x135.
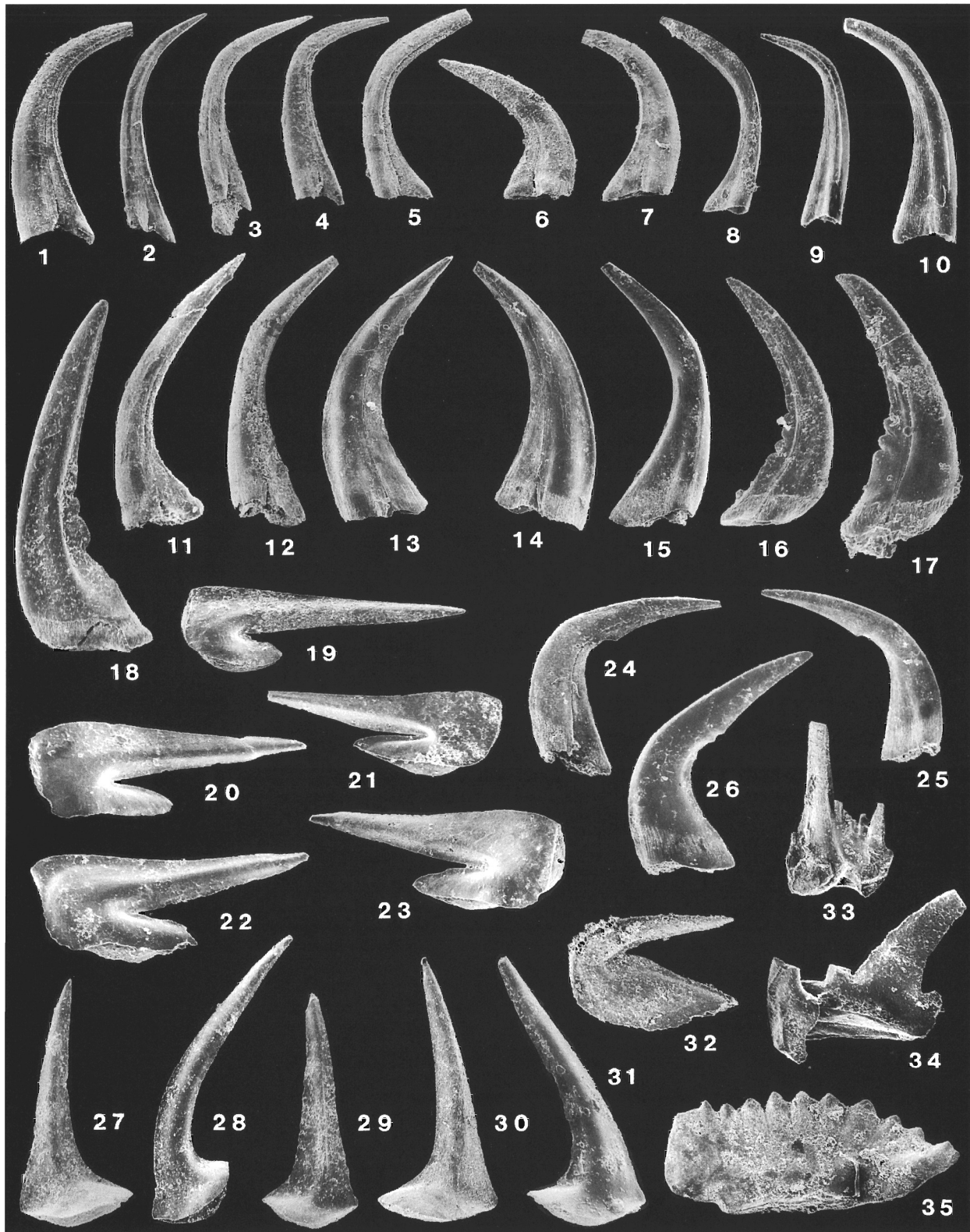
Plate 5. Figs 1–4, 9 & 10, 12–15, *Panderodus gracilis* (Branson & Mehl, 1933); 1, 4, 9, 10, Sa–Sb elements, 1, 10, CPC 33099 (GC10), x72; 4, 9, CPC 33100 (GC10), x72; 2–3, Sa elements, respectively CPC 33101 (GC3), x45; CPC 33102 (CM13), x54; 12, 15, Sb element, CPC 33103 (CM9), x45; 13 & 14, M elements, respectively CPC 33104 (CM6), x45; CPC 33105 (CM6), x45. Figs 5, 7 & 8, *Panderodus? liratus* Nowlan & Barnes 1981; 5, 8, CPC 33106 (AB3), x54; 7, CPC 33107 (CM15), x72. Figs 6, 11, *Panderodus* sp. B, respectively CPC 33108 (CM17), x72; CPC 33109 (CM18), x90. Figs 16–18, *Culumbodina?* sp.; respectively CPC 33110 (CM4), x81; CPC 33111 (CM9), x72; CPC 33112 (CM6), x72. Figs 19–23, *Paroistodus* sp.; respectively CPC 33113 (CM11), x72; CPC 33114 (CM9), x72; CPC 33115 (GC5), x72; CPC 33116 (CM6), x72; CPC 33117 (GC2), x72. Figs 24–26, *Panderodus* sp. D, 24–25, CPC 33118 (GC3), x72 & x72; 26, CPC 33119 (CM22), x72. Figs 27–31, *Drepanoistodus suberectus* (Branson & Mehl, 1933); 27, 29–31, oistodiform elements, respectively CPC 33120 (CM11), x63; CPC 33121 (AB3), x63; CPC 33122 (CM11), x63; CPC 33123 (CM22), x63; 28, drepanodiform element, CPC 33124 (CM9), x45. Fig. 32, *Ansella* sp.?; CPC 33125 (CM1), x90. Fig. 33, Gen. et sp. indet. A, CPC 33126 (CM18), x72. Fig. 34, *Periodon?* sp.; CPC 33127 (CM18), x72. Fig. 35, Gen. et sp. indet. B; CPC 33128 (GC1), x45.
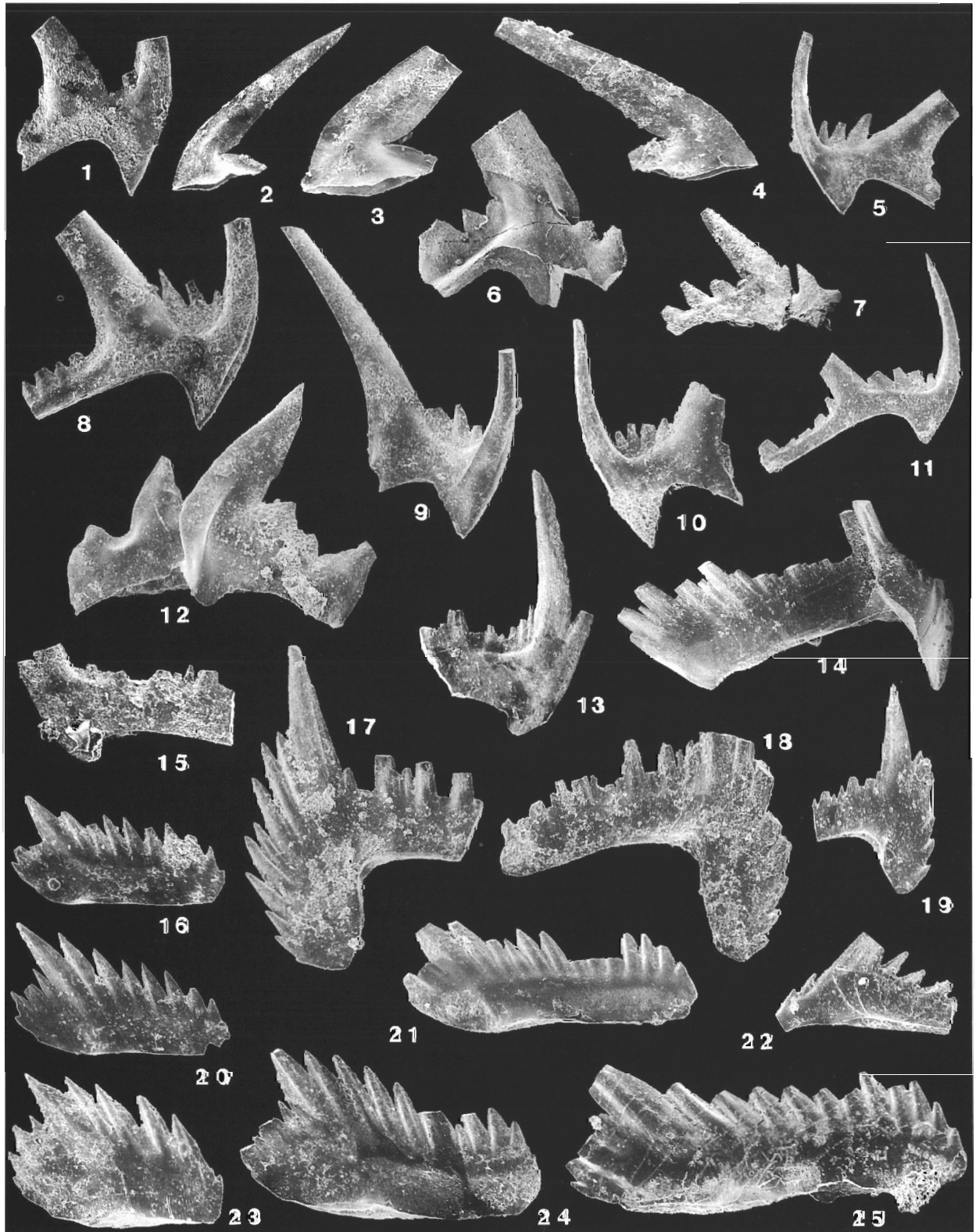
Plate 6. Figs 2–11, *Phragmodus undatus* Branson & Mehl, 1933; 5, 8, 11, Sc elements, respectively CPC 33129 (CM1), x63; CPC 33130 (CM11), x63; CPC 33131 (CM1), x63; 2–4, M elements, respectively CPC 33132 (CM13), x63; CPC 33133 (CM11), x63; CPC 33134 (CM14), x63; 6, Pb element, CPC 33135 (CM11), x63; 7, Pa element, respectively CPC 33138 (GC1), x63; 9, Sa element, CPC 33136 (CM11), x63; 10, Sb element, CPC 33137 (CM11), x63. Figs 1 & 12. *Phragmodus undatus* Branson & Mehl, 1933?; 1, Sc element, CPC 33140 (CM11), x63; 12 Pa element CPC 33139 (CM11), x63. Figs 13–25, *Ozarkodina sesquipedalis* Nowlan & McCracken, 1988; 13, 15, Sc elements, respectively CPC 33152 (GC1), x72; CPC 33153 (CM8), x90; 14, Sb element, CPC 33141(CM18), x54; 16, 20-21, 23-25, Pa elements, respectively CPC 33146 (CM5), x72; CPC33147 (CM18), x72; CPC 33148 (CM22), x72; CPC 33149 (CM18), x72; CPC 33150 (GC1), x72; CPC 33151 (GC9), x72; 17-19, Pb elements, respectively CPC 33142 (CM18), x72; CPC 33143 (CM18), x72; CPC33144 (CM1), x72; 22, M element, CPC 33145 (CM18), x72.

127, 83–157.

Bergström, S.M., 1990. Biostratigraphic and bio-geographic significance of Middle and Upper Ordovician conodonts in the Girvan succession, south-west Scotland. *Courier Forschungsinstitut Senckenberg*, 118, 1–43.

Bergström, S.M. & Sweet, W.C., 1966. Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana.

Bulletin of American Paleontology, 50(229), 271–441.

Bischoff, G. & Sannemann, D., 1958. Unterdevonische Conodonten aus dem Frankenwald. *Notizblatt hessisches Landesamt für Bodenforschung*, 86, 87–110.

Branson, E.B. & Branson, C.C., 1947. Lower Silurian conodonts from Kentucky. *Journal of Paleontology*, 21, 549–556.

Branson, E.B. & Mehl, M.G., 1933. Conodont studies. *University of Missouri Studies*, 8 (1–4), 1–343.
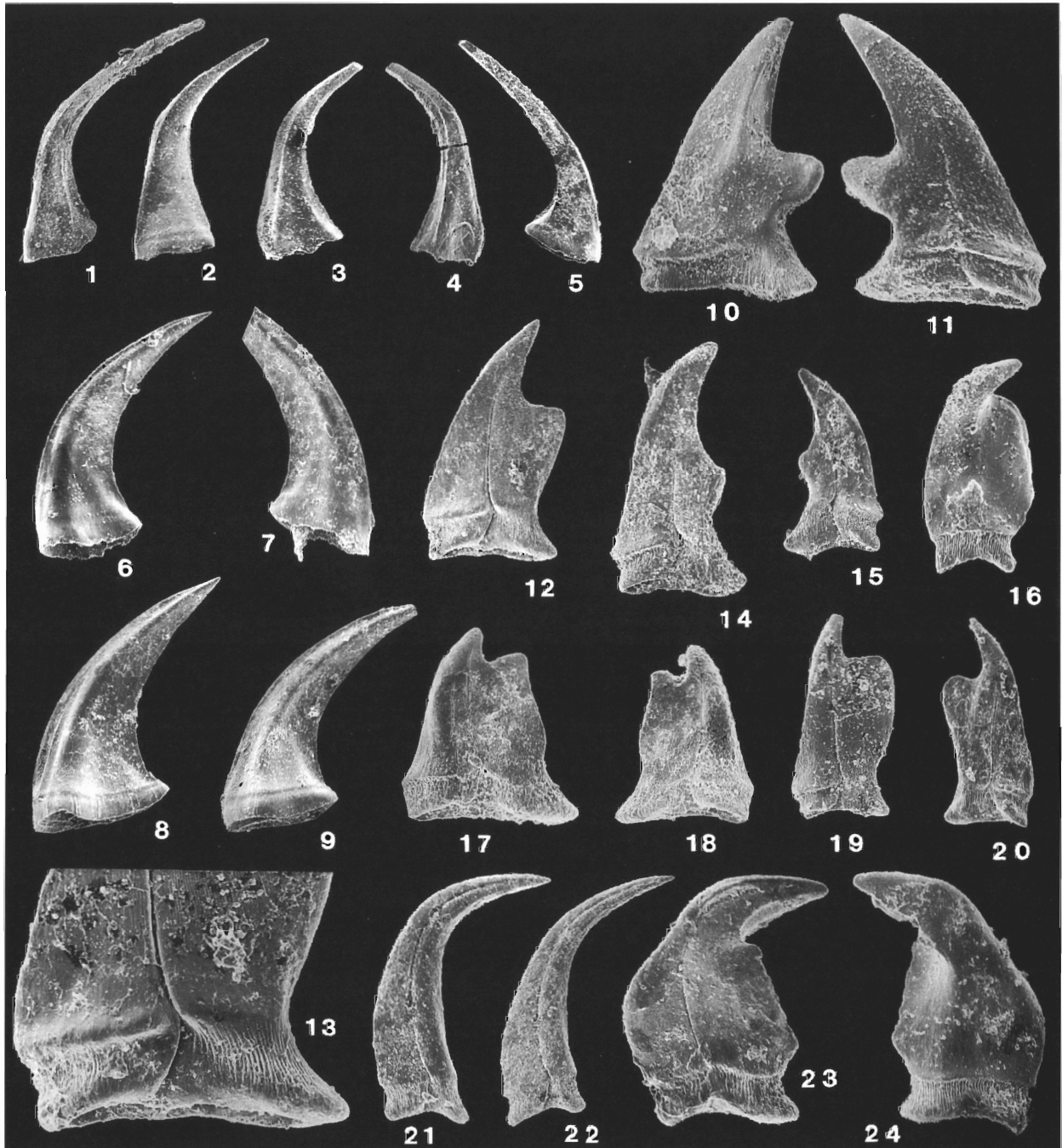

Plate 7. Figs 1–9, *Walliserodus amplissimus* (Serpagli, 1967); 1, 3 & 4, Sa elements, 1, CPC 33156 (CM11), x72; 3 & 4, CPC 33157 (GC10), x72; 2, 5, Sb? elements, respectively CPC 33154 (CM13), x72; CPC 33155 (CM11), x63; 6–9, M elements, respectively CPC 33158 (GC3), x63; CPC 33160 (AB3), x72; CPC 33161 (CM6), x54; CPC 33159 (GC7), x63. Figs 10–24, *Taoqupognathus tumidus* sp.nov.; 10 & 11, Sc? type 'a' elements, respectively CPC 33162(CM18), x108; CPC 33163 (CM18), x108; 12 & 13, Sc? type 'b' element, CPC 33164 (CM5), x108 & x225; 14 & 15, Sb? type 'b' elements, respectively CPC 33165 (CM11), x90; CPC 33166 (CM18), x90; 16, 23 & 24, P? elements, 16, CPC 33167 (CM4), x108; 23 & 24, CPC 33168 (CM6), x108; 17 & 18, Sb? type 'a' elements, respectively CPC 33169 (CM5), x108; CPC 33170 (CM12), x108; 19 & 20, Sc? type 'c' elements, respectively CPC 33172 (CM2), x108; holotype CPC 33171 (CM23), x108; 21 & 22, M? elements, respectively CPC 33173 (CM8), x108; CPC 33174 (CM4), x90.

Branson, E.B., Mehl, M.G. & Branson, C.C., 1951. Richmond conodonts of Kentucky and Indiana. *Journal of Paleontology*, 25, 1–17.

Burrett, C., Stait, B. & Laurie J., 1983. Trilobites and microfossils from the Middle Ordovician of Surprise Bay, southern Tasmania, Australia. *Memoir of the Association of Australasian Palaeontologists*, 1, 177–193.

Cooper, B. J., 1976. Multielement conodonts from the St. Clair Limestone (Silurian) of Southern Illinois. *Journal of Paleontology*, 50, 205–217.

Drygant, D.M., 1974. Prostye Konodonty Silura i nizhov Devona Volyno-Podolya [Simple conodonts from the Silurian and lowermost Devonian]. *Paleontologicheskiy Sbornik*, 10, 64–69.

Dzik, J., 1976. Remarks on the evolution of Ordovician conodonts. *Acta Palaeontologica Polonica*, 21, 395–455.

Eichenberg, W., 1930. Conodonten aus dem Culm des Harzes. *Paläontologisches Zeitschrift*, 12, 177–182.

Epstein, A.G., Epstein, J.B. & Harris, L.D., 1977. Conodont color alteration—an index to organic metamorphism. *U.S. Geological Survey Professional Paper*, 995, 1–20.

Ethington, R.L., 1959. Conodonts of the Ordovician Galena Formation. *Journal of Paleontology*, 33, 257–292.

Fåhraeus, L.E. & Hunter, D.R., 1985. Simple-cone conodont taxa from the Cobbs Arm Limestone (Middle Ordovician), New World Island, Newfoundland. *Canadian Journal of Earth Sciences*, 22, 1171–1182.

Fortey, R.A., Bassett, M.G. Harper, D.A.T., Hughes R.A., Ingham, J.K., Molyneux, S.G. Owen, A.W., Owens, R.M., Rushton, A.W.A., & Sheldon, P.R., 1991. Progress and problems in the selection of stratotypes for the bases of series in the Ordovician System of the historical type area in the U.K. *In* Barnes C.R. & Williams, S.H. (Editors). Advances in Ordovician Geology, *Geological Survey of Canada Paper*, 90-9, 5–25.

Glenister, A. T., 1957. The conodonts of the Ordovician Maquoketa Formation in Iowa. *Journal of Paleontology*, 31, 715–736.

Hadding, A., 1913. Undre dicellograptusskiffern i Skåne jämte några därmed ekvivalenta bildningar. *Lunds Universitets Årsskrift, Avd.*, 2, 9, 1–90.

Hamar, G., 1966. The Middle Ordovician of the Oslo region, Norway 22. Preliminary report on conodonts from the Oslo-Asker and Ringerike districts. *Norsk Geologisk Tidsskrift*, 46, 27–83.

Henningsmoen, G., 1948. The *Tretaspis* Series of the Kullatorp Core. *The Bulletin of the Geological Institutions, University of Uppsala* 32, 374–432.

Jenkins, C.J., 1978. Llandovery and Wenlock stratigraphy of the Panuara area, central New South Wales. *Proceedings of the Linnean Society of New South Wales*, 102, 109–130.

Kennedy, D.J., Barnes, C.R. & Uyeno, T.T., 1979. A Middle Ordovician conodont faunule from the Tetagouche Group, Camel Back Mountain, New Brunswick. *Canadian Journal of Earth Sciences*, 16, 540–551.

Knüpfer, J., 1967. Zur Fauna und Biostratigraphie des Ordoviziums (Gräfenthaler Schichten) in Thüringen. *Freiberger Forschungshefte*, C220, 1–81.

Lindström, M., 1955. Conodonts from the lowermost Ordovician strata of south-central Sweden. *Geologiska Föreningens i Stockholm Förhandlingar*, 76, 517–604.

Lindström, M., 1971. Lower Ordovician conodonts of Europe. *In* Sweet, W.C. & Bergström, S.M. (Editors). Symposium on Conodont Biostratigraphy. *Geological Society of America, Memoir*, 127, 21–61.

Löfgren, A., 1978. Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. *Fossils and Strata*, 13, 1–129.

MacKenzie, P. & Bergström, S.M., 1993. Discovery of the zonal index conodont *Amorphognathus ordovicicus* in the Richmondian of Indiana: Implications for the regional correlation of the North American Upper Ordovician Standard. *Geological Society of America, Abstracts with Programs*, 25, 472.

McCracken, A.D. & Nowlan, G.S., 1989. Conodont paleontology and biostratigraphy of Ordovician carbonates and petroliferous carbonates on Southampton, Baffin, and Akpatok islands in the eastern Canadian Arctic. *Canadian Journal of Earth Sciences*, 26, 1880–1903.

Moors, H.T., 1970. Ordovician graptolites from the Cliefden Caves area, Mandurama, N.S.W., with a re-appraisal of their stratigraphic significance. *Proceedings of the Royal Society of Victoria*, 83, 253–287.

Moskalenko, T.A., 1973. Conodonts of the Middle and Upper Ordovician on the Siberian Platform. *Akademiy Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki* 137, 1–143, Novosibirsk (in Russian).

Moskalenko T.A., 1983. Conodonts and biostratigraphy in the Ordovician of the Siberian Platform. *Fossils and Strata*, 15, 87–94.

Nicoll, R.S., 1980. Middle Ordovician conodonts from the Pitman Formation, Canberra, A.C.T. *BMR Journal of Australian Geology & Geophysics*, 5, 150–153.

Nowlan, G.S. & Barnes, C.R., 1981. Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Quebec. *Geological Survey of Canada, Bulletin*, 329, Part I, 1–49.

Nowlan, G.S., McCracken, A.D. & Chatterton, B.D.E., 1988. Conodonts from Ordovician-Silurian boundary strata, Whittaker Formation, MacKenzie Mountains, Northwest Territories. *Geological Survey of Canada, Bulletin* 373, 1–99.

Orchard, M.J., 1980. Upper Ordovician conodonts from England and Wales. *Geologica et Palaeontologica*, 14, 9–44.

Packham, G.H., 1967. The occurrence of shelly Ordovician strata near Forbes, New South Wales. *The Australian Journal of Science*, 30, 106–107.

Packham, G.H., 1969. The geology of New South Wales. *Geological Society of Australia, Journal*, 16, 1–654.

Palmieri, V., 1978. Late Ordovician conodonts from the Fork Lagoons Beds, Emerald area, central Queensland. *Geological Survey of Queensland, Publication* 369, *Palaeontological Paper*, 43, 1–55.

Pander, C.H., 1856. Monographie der fossilen Fische des Silurischen Systems der russisch-baltischen Gouvernements. *Akademie der Wissenschaften, St. Petersburg*, 1–91.

Percival, I.G., 1976. The geology of the Licking Hole Creek area, near Walli, central-western New South Wales. *Journal and Proceedings of the Royal Society of New South Wales*, 109, 7–23.

Percival, I.G., 1992. Ordovician brachiopod biostratigraphy of central-western New South Wales. *In* Webby, B.D. & Laurie, J.R. (editors), *Global perspectives on Ordovician geology*, 215–229. Balkema, Rotterdam.

Philip, G.M., 1966. The occurrence and palaeogeographic significance of Ordovician strata in northern New South Wales. *The Australian Journal of Science*, 29, 112–113.

Pickett, J.W., 1978. Further evidence for the age of the Sofala Volcanics. *Quarterly Notes of the Geological Survey of New South Wales*, 31, 1–4.

Pickett, J.W., 1991. Conodonts from cherts of the Ordovician 'Foxlow Formation' west of Numerella. Geological Survey of New South Wales, Unpublished Palaeontological Report 1991/2 (GS 1991/130).

Pickett, J.W., 1992. Conodont assemblages from limestones north of 'Millamolong', via Mandurama. Geological Survey of New South Wales, Unpublished Palaeontological Report 1992/11 (GS 1992/356).

Pickett J.W. & Ingpen, I.A., 1990. Ordovician and Silurian strata south of Trundle, New South Wales. *Quarterly Notes of the Geological Survey of New South Wales*, 78, 1–14.

Pulse, R.R. & Sweet, W.C., 1960. The American Upper Ordovician Standard. III. Conodonts from the Fairview and McMillan Formations of Ohio, Kentucky and Indiana. *Journal of Paleontology*, 34, 237–264.

Rigby J.K. & Webby, B.D., 1988. Late Ordovician sponges from the Malongulli Formation of central New South Wales, Australia. *Palaeontographica Americana*, 56, 1–147.

Rhodes, F.H.T., 1955. The conodont fauna of the Keisley Limestone. *Quarterly Journal of the Geological Society of London,* 11, 117–142.

Savage, N.M., 1990. Conodonts of Caradocian (Late Ordovician) age from the Cliefden Caves Limestone, southeastern Australia. *Journal of Paleontology*, 64, 821–831.

Savage, N. & Bassett M.G., 1985. Caradoc-Ashgill conodont faunas from Wales and the Welsh Borderland. *Palaeontology*, 28, 679–713.

Serpagli, T.J.M., 1967. I conodonti dell'Ordoviciano Superiore (Ashgilliano) delle Alpi Carniche. *Bolletino della Società Paleontologica Italiana,* 6, 30–111.

Smith, R.E., 1966. The geology of Mandurama-Panuara. *Journal and Proceedings of the Royal Society of New South Wales*, 98, 239–262.

Stauffer, C.R., 1930. Conodonts from the Decorah Shale. *Journal of Paleontology*, 4, 121–128.

Stauffer, C.R., 1935. Conodonts of the Glenwood Beds. *Geological Society of America, Bulletin*, 46, 125–168.

Stevens, N.C., 1952. Ordovician stratigraphy at Cliefden Caves, near Mandurama, New South Wales. *Proceedings of the Linnean Society of New South Wales*, 77, 114–120.

Stevens, N.C., 1957. Further notes on Ordovician formations of central New South Wales. *Journal and Proceedings of the Royal Society of New South Wales,* 90, 44–50.

Stewart, I.R. & Glen, R.A., 1986. An Ordovician age for part of the Girilambone Group at Yanda Creek, east of Cobar. *Geological Survey of New South Wales, Quarterly Notes* 64, 23–25.

Stone, G.L. & Furnish, W.M., 1959. Bighorn conodonts from Wyoming. *Journal of Paleontology*, 33, 211–228.

Stouge, S., 1984. Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. *Fossils and Strata*, 16, 1–145.

Sweet, W.C., 1979. Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province. *Brigham Young University Geology Studies*, 26, 45–86.

Sweet, W.C., 1982. Conodonts from the Winnipeg Formation (Middle Ordovician) of the northern Black Hills, South Dakota. *Journal of Paleontology*, 56, 1029–1049.

Sweet, W.C., 1984. Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcon-

tinent Province, U.S.A., *In* Bruton, D.L. (editor). Aspects of the Ordovician System. *Palaeontological Contributions from the University of Oslo*, 295, 23–35.

Sweet, W.C., 1988. *The Conodonta: morphology, taxonomy, paleoecology, and evolutionary history of a long-extinct animal phylum*. Clarendon Press, Oxford, x + 212 pp.

Sweet, W.C. & Bergström, S.M., 1984. Conodont provinces and biofacies of the Late Ordovician. *Geological Society of America, Special Paper* 196, 69–87.

Sweet, W.C. & Schönlaub, H.P., 1975. Conodonts of the genus *Oulodus* Branson & Mehl, 1933. *Geologica et Palaeontologica*, 9, 41–59.

Taylor, J.M. 1988. The geology of 'Weemalla' and 'Narambon' near Panuara, central western New South Wales. Unpublished B.Sc. thesis, University of Sydney, 1-138 pp.

Uyeno, T.T., 1990. Biostratigraphy and conodont fauna of Upper Ordovician through Middle Devonian rocks, eastern Arctic Archipelago. *Geological Survey of Canada, Bulletin*, 401, 1–211.

VandenBerg, A.H.M. & Cooper, R.A., 1992. The Ordovician graptolite sequence of Australasia. *Alcheringa* 16, 33–85.

Viira, V., 1974. Konodonty ordovika Pribaltiki. *Eesti NSV Teaduste Akadeemia Geoloogia Instituutt,* 1–142, Valgus, Tallinn (In Russian).

Webers, G.F., 1966. The Middle and Upper Ordovician conodont faunas of Minnesota. *Minnesota Geological Survey, Special Publication*, 4, 1–123.

Webby, B.D., 1969. Ordovician stromatoporoids from New South Wales. *Palaeontology*, 12, 637–662.

Webby, B.D., 1973. *Remopleurides* and other Upper Ordovician trilobites from New South Wales. *Palaeontology*, 16, 445–475.

Webby, B.D., 1974. Upper Ordovician trilobites from central New South Wales. *Palaeontology*, 17, 203–252.

Webby, B.D., 1976. The Ordovician System in south eastern Australia. *In* Bassett, M.G. (editor). *The Ordovician System*. University of Wales Press & National Museum of Wales, Cardiff, 417–446.

Webby, B.D., 1991. Ordovician stromatoporoids from Tasmania. *Alcheringa*, 15, 191–227. Webby, B.D., 1992. Ordovician island biotas: New South Wales record and global implications. *Journal and Proceedings of the Royal Society of New South Wales*, 125, 51–77.

Webby, B.D. & Blom, W., 1986. The first well-preserved radiolarians from the Ordovician of Australia. *Journal of Paleontology*, 60, 145–167.

Webby, B.D. & Kruse, P.D., 1983. The earliest heliolitines: a diverse fauna from the Ordovician of New South Wales. *Palaeontographica Americana*, 54, 164–168.

Webby, B.D. & Nicoll, R.S., 1989. Australian Phanerozoic Timescales 2: Ordovician. *Bureau of Mineral Resources, Australia, Record* 1989/32, 1–42, 1 chart.

Webby, B.D. & Packham, G.H., 1982. Stratigraphy and regional setting of the Cliefden Caves Limestone Group (Late Ordovician), central-western New South Wales. *Journal of the Geological Society of Australia*, 29, 297–317.

Webby, B.D. & Trotter, J., 1993. Ordovician sponge spicules from New South Wales, Australia. *Journal of Paleontology,* 67, 28–41.

Webby, B.D., VandenBerg, A.H.M., Cooper, R.A., Banks, M.R., Burrett, C.F., Henderson, R.A., Clarkson, P.D, Hughes, C.P., Laurie, J., Stait B., Thomson, M.R.A. & Webers, G.F., 1981. The Ordovician System in Australia, New Zealand and Antarctica. Correlation

Chart and Explanatory Notes. *International Union of Geological Sciences Publication*, 6, 1–69.

Weyant, M., 1968. Conodontes ordoviciens de I'lle Hoved (Archipel Arctique Canadien). *Bulletin de la Société Linnéenne de Normandie, 10 série,* 9, 20–66.

Williams, S.H., 1982. Upper Ordovician graptolites from the top Lower Hartfell Shale Formation (*D. clingani* and *P. linearis* zones) near Moffat, southern Scotland. *Transactions of the Royal Society of Edinburgh, Earth Sciences,* 72, 229–255.

Winder, C.G., 1966. Conodonts from the upper Cobourg Formation (late Middle Ordovician) at Colbourne, Ontario. *Journal of Paleontology,* 40, 46–63.

Wyborn, D., 1992. Stratigraphy and geochemistry of Ordovician volcanics from the Lachlan Fold Belt in central New South Wales. *In* Webby, B.D. & Laurie, J.R. (editors), *Global perspectives on Ordovician geology.* Balkema, Rotterdam, 495–497.

Ziegler, W. (editor), 1981. *Catalogue of Conodonts,* Vol.4. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. v + 445 pp.

Ziegler, W. (editor), 1991. *Catalogue of Conodonts,* Vol.5. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. iv + 212 pp.