Conodont faunas from sequences on or marginal to the Anakie Inlier (Central Queensland, Australia) in relation to Devonian transgressions

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Abstract. Sedimentary intervals with limestones reflecting transgressive/regressive (T/R) events of various ages on or marginal to the Anakie Inlier in east-central Queensland are displayed in the Ukalunda Beds at Mary Creek, Douglas Creek Limestone at Copperfield, Greybank Volcanics near Fletchers Awl, the Glendarriwell Beds near Anakie, and the Sedgewick Formation south of Alpha. Conodonts from these and other occurrences enable the ages of these events to be specified:

• Conodonts from the Douglas Creek Limestone, resting unconformably on Proterozoic Bathampton Metamorphics, demonstrate that this transgressive event commenced sometime late in the *perbonus/gronbergi/nothoperbonus* interval, with marine conditions persisting through until at least well into the *inversus* Zone. The transgression was therefore coeval with a deepening event well displayed in the Buchan-Murrindal area of eastern Victoria.

• Conodonts from the Ukalunda Beds show that at least part of that sequence accumulated during the *perbonus/gronbergi/nothoperbonus* and *inversus* zones coeval with accumulation of the Douglas Creek Limestone.

• Conodonts from the allochthonous limestone occurrences in the Dunstable Beds at "Telemon" document carbonate sedimentation, at least in that area, through much or all of the interval from at least *inversus* Zone (but possibly *perbonus/gronbergi/nothoperbonus* interval as well) through to late Eifelian *australis* and *kockelianus* zones or even earliest Givetian.

• Conodonts from the exposures of Sedgeford Formation indicate an age within the interval late Eifelian (*australis* Zone) to earliest Givetian (*hemiansatus* Zone). These provide an age for what were arguably nearshore regressive environments, broadly coeval with the youngest limestones of a "now lost carbonate platform" or fringing reefs, the source of the allochthonous limestone clasts in the primarily volcaniclastic Dunstable Beds.

• Conodonts from a marine transgression at the base of the Greybank Volcanics near Fletcher's Awl date the transgression as Late and/or Latest *crepida* Zone (Late Devonian; mid-early Famennian). This corresponds precisely with a global transgression event within interval IIe of the Johnson et al. (1985) T-R scheme inferred from Euramerican sequences. In an appendix, the previously imprecisely calibrated transgression event in the Coffee Hill Member at the base of the Columbine Sandstone in east-central New South Wales is argued to represent the same event.

• Conodonts from the Glendarriwell Limestone on the southern flank of the Anakie Inlier document a marine incursion at the base of the middle Famennian *marginifera* Zone. This transgression, identified from many areas around the world and widespread in the Burdekin Basin (Mawson and Talent 1997), is here named the Myrtlevale Transgression.

• Viewed ensemble, the seven localities considered here may be viewed as tiny remnant areas of outcrop (the substantial tract of Ukalunda Beds aside) of formerly appreciable transgressions – now evidenced only along the northwestern flank – of a major basinal feature extending eastwards beneath the Permian-Triassic Bowen Basin to the ur-Pacific Ocean, and conceivably westwards beneath the Drummond and Galilee basins to have joined, perhaps intermittently, with the Adavale Basin.

How these last two transgressions into the Adavale-Emerald Basin, may relate chronologically to the base of the Drummond Group, a widespread clastic sequence outcropping over several thousand sq. km around the Anakie Inlier, is speculative, though the base of the Drummond Group is generally assumed to be Famennian in age.

No new taxa are proposed, but taxonomic style in relation to speciation and possible generic discrimination within the long-standing genus *Polygnathus* Hinde, 1879, are considered. *Costapolygnathus* Bardashev et al. 2002, being based on *Polygnathus dubia* Hinde, 1879, the type species of *Polygnathus* Hinde, 1879, is a junior objective synonym of the latter.

Key words: Conodonts, Devonian, Emsian, Eifelian, Famennian, transgressions, Queensland, Australia

Introduction

Over several years we have focused, intermittently, on the transgression–regression (T–R) pattern and diachronism in the Middle Palaeozoic of Australia (Talent and Yolkin 1987, Talent 1988, 1989, Mawson and Talent 1989, 1997, 2000, Mawson et al. 1992, Talent et al. 2000, 2003, Talent and Mawson 1999). In these studies we have been basing stratigraphic alignment of the T–R events primarily on conodont biostratigraphy, preferentially selecting as "type sequences" those where there are palaeontologic and lithologic evidence of gradual deepening up-section and, preferably, unequivocal onlap onto substantially older, even folded sequences. Shallowest facies, at the end of such cycles, are regarded as belonging to the regressive cycle rather than to the succeeding cycle (= lowstand systems tract of

sequence stratigraphers). In this regard we follow Johnson et al. (1996). The late Ivo Chlupáč, to whom we dedicate this contribution, focused intensively and perceptively on the transgression–regression pattern and diachronism displayed by the Devonian sequences of the Czech Republic, endeavouring to discern global patterns in these events. It is therefore appropriate that a contribution in his honour should focus on the same topics, though on a neglected region from which few data were available.

Devonian stratigraphic units in central Queensland (cf. Withnall et al. 1995a, 1995b) are not well known, largely because areas of outcrop are generally small, disconnected, and exposures are rare and generally poor; Silurian sequences are not known from this region (cf. Talent et al. 2003). The few occurrences of Devonian rocks in central Queensland are scattered around a core area of Ordovician

and older (including Proterozoic) rocks, the Anakie Inlier, and are assumed to have connected eastwards – beneath the Late Palaeozoics (Carboniferous and Permian) of the Bowen Basin – with the Yarrol Province of the New England Foldbelt of eastern Queensland. They possibly connected westwards with the subsurface Adavale Basin of southwestern Queensland (cf. McKellar and Hoffmann 2003, *q.v.* for earlier literature), a petroleum-producing province with a substantial Devonian sequence. The Adavale Group of the Adavale Basin has produced sparse conodonts (present whereabouts unknown; R. S. Nicoll and J. J. Draper pers. comm.) of uncertain chronologic implications, though palynological data indicate ages from Emsian to Frasnian (Hashemi 1997, 2002, Hashemi and Playford in press).

We here attempt to improve precision as regards ages of seven limestone-bearing central Queensland Devonian sequences, and to briefly consider how Devonian marine transgressions in this region may align with transgressions reported from elsewhere.

The largest area of limestone-bearing marine Devonian rocks of central Queensland, the primarily clastic Ukalunda Beds, outcrops generally poorly over about 5000 sq. km northeast of the Anakie Inlier; it has produced conodonts of early Emsian age (Brock and Talent 1993). The overlying Drummond Group – mostly Early Carboniferous in age but including the broadly Late Devonian Mt Wyatt Formation in the northeast – extends in a broad tract around and to the west and southwest of the Anakie Inlier where thrusting has brought to the surface a few sq. km of a generally arenaceous sequence with rather rare calcareous horizons of broadly Eifelian to earliest Givetian age (Mawson in Henderson et al. 1995), the Sedgeford Formation (1100+ m). Relationships of the Sedgeford Formation to the Ukalunda Beds are speculative, though continuity is possible beneath the Drummond Basin, as are continuity with the Dunstable Beds (or Dunstable Volcanics) about 90 km to the east-southeast, as well as with the Glendarriwell Beds (Withnall et al. 1995b) about 100 km to the east-northeast (Fig. 1A), and with the subsurface Adavale Basin (90,000+ sq. km) to the west and southwest.

Occurrences of Devonian limestones

Excluding the subsurface Adavale Group (McKellar and Hoffmann 2003, *q.v.* for earlier literature), and the widespread Drummond Group (Early Carboniferous and ?latest Devonian) there are seven areas in central Queensland with Devonian strata, from six of which conodonts have been obtained by acid-leaching of carbonates. This report documents conodonts from four of the six cono-

dont-bearing areas and discusses the ages and transgression-regression implications of all seven occurrences. They all occur lapping onto (or in proximity to) the Proterozoic–Early Palaeozoic Anakie Inlier. The Early Palaeozoics include the Ordovician Theresa Creek Volcanics, formerly thought to be Devonian (Withnall et al. 1995b, cf. Anderson et al. in print), and the Fork Lagoon Beds (Palmieri 1978). The limestone-bearing Devonian occurrences are:

1. Douglas Creek Limestone, Copperfield, south of Clermont

The Douglas Creek Limestone (Veevers et al. 1964, Jell and Hill 1970, Withnall et al. 1995a, b), assumed to be at least 100 m in thickness, crops out in an area of generally poor exposures on the left flank of Douglas Creek about 8.5 km SSW of Clermont (Fig. 1B). It is underlain in the north by quartz-veined quartzites of the Bathampton Metamorphics (Proterozoic); the boundary is not exposed but is presumed to be an unconformity. If previous interpretations are correct, this may equate in some way with Unit A of the Ukalunda Beds, possibly but not certainly the oldest unit of the Ukalunda Beds, but there is great uncertainty regarding the stratigraphic position of the various units within the Ukalunda Beds (Dickins and Malone 1973). Clastics outcropping on the right flank of Douglas Creek (including macrofossil locality CL 172 of Veevers et al. 1964) about 2–2.5 km downstream, are assumed to overlie the Douglas Creek Limestone; they are perhaps best regarded as Ukalunda Beds *sensu stricto*.

2. Ukalunda Beds, Mary Creek, "Old Hidden Valley"

The Ukalunda Beds, extending over about 5000 sq. km northeast of the Anakie Inlier (cf. Brock and Talent 1993, and literature therein) and outcropping from beneath ?latest Devonian–Early Carboniferous clastics (Mt Wyatt Formation) and Carboniferous volcanics, are thought (Malone et al. 1964, 1966) to exceed 1300 m in thickness, but outcrops are generally poor, and the regional structure is not well understood. Emsian (*perbonus/gronbergi/nothoperbonus* Conodont Zone) coral and brachiopod faunas have been described and conodonts illustrated from two sections in Mary Creek on "Old Hidden Valley" station (Jell and Hill 1969, Brock and Talent 1993) and brachiopods from beds of approximately the same age in Boundary Creek, ca 60 km to the southeast (Parfrey 1989), as well as from imprecisely known localities near "Ukalunda" (now "Pyramid" station – for composite list of brachiopods see Talent et al. 2001). The Mary Creek sections are presented here (Fig. 2, HID, S-HID) as background to the conodonts documented herein (Tab 1, Plate I, figs 15–20).

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Fig. 1. Locations of Devonian limestone occurrences (mentioned in the text) adjacent to and on the Anakie Inlier, central Queensland, and enlargements of the three areas from which the principal data – sampled sections and spot samples – have been obtained, based on mapping by Malone et al. (1966) and Paine and Cameron (1972) for Mary Creek ("Old Hidden Valley"), Withnall et al. (1995a) for Douglas Creek ("Lillyvale"), Copperfield, and Hayward (1993) for the "Mooramin"–Fletcher's Awl areas.
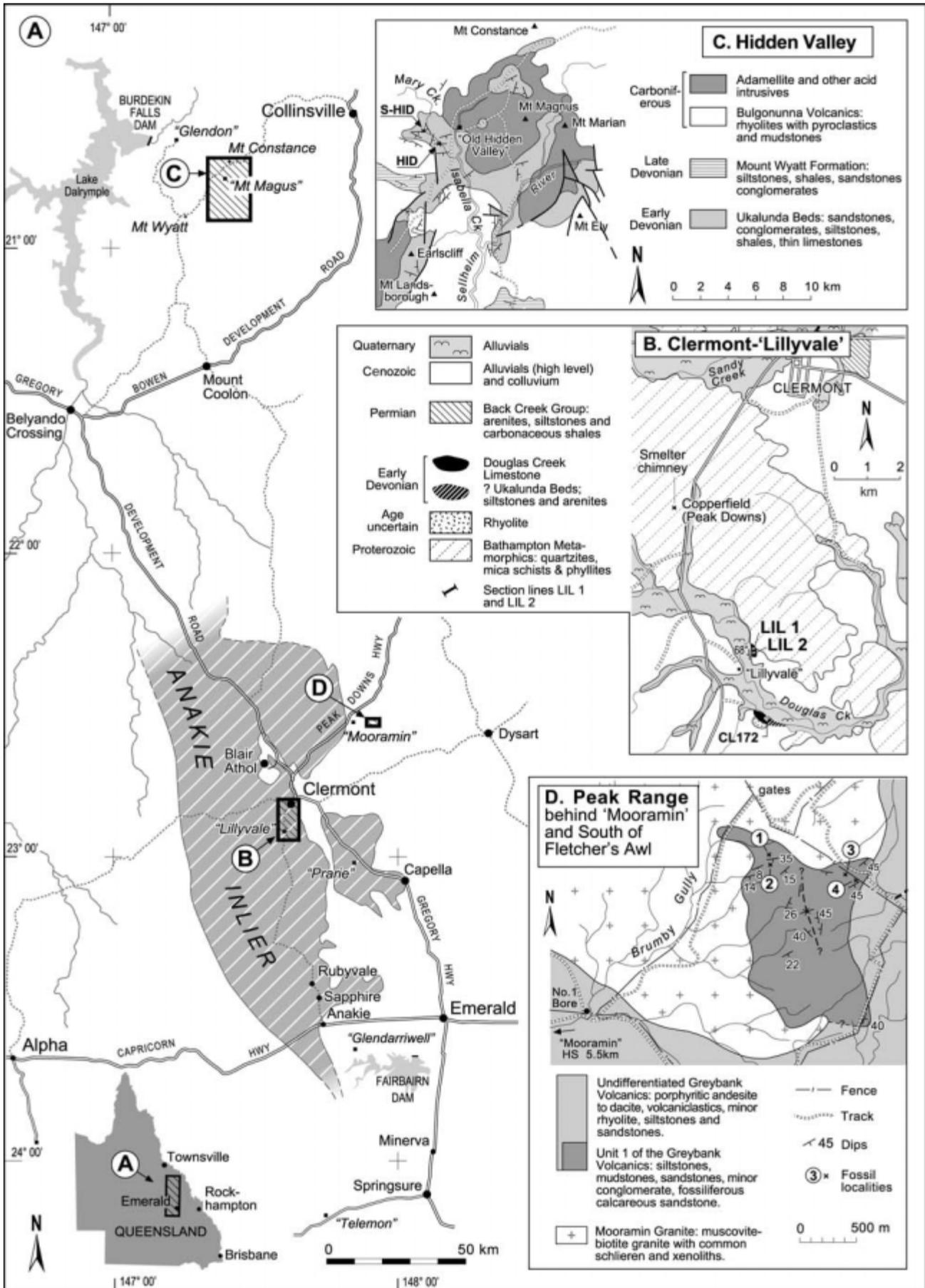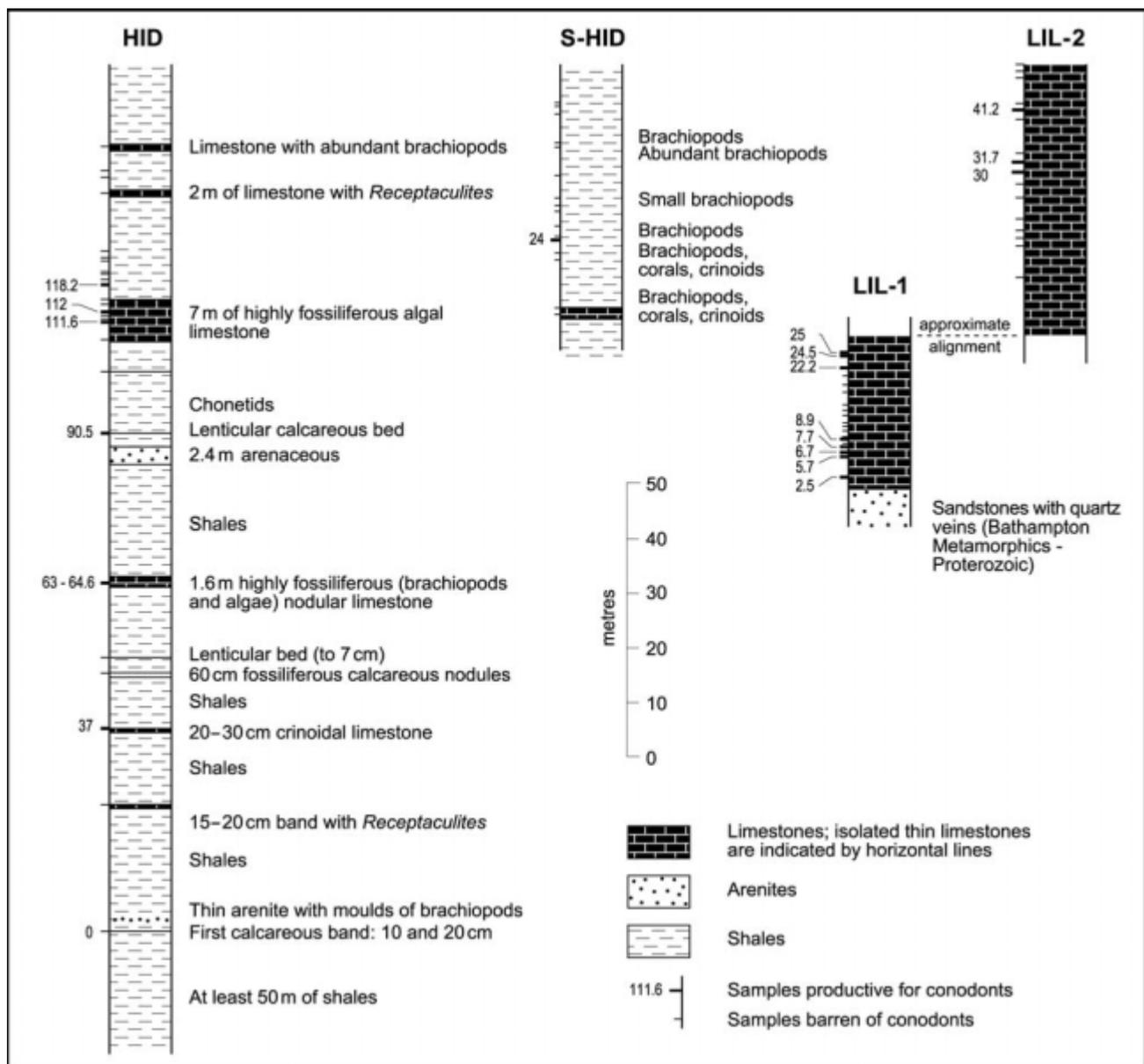
Fig. 2. Sampled stratigraphic sections: A and B. Douglas Creek Limestone on "Lillyvale", Copperfield (sections LIL 1 and LIL 2); C and D. Ukalunda Beds in Mary Creek, "Old Hidden Valley" (sections HID and S-HID).

3. "Prairie" (west of Capella district)

Massive limestones on the left flank of Sandy Ck 9.5 km, about south of "Prairie" station were provisionally referred to the Douglas Creek Limestone by Withnall et al. (1995a). Outcrops of sandstones and conglomerates flanking Retro Ck about 4 km south of "Prairie" station were also provisionally referred to the Douglas Creek Limestone by Withnall et al. (1995b, p. 67).

4. Dunstable Beds ("Telemon")

The Dunstable Beds, an andesitic sequence consisting predominantly of volcanics and pyroclastics outcrops on the Nogoa Anticline on "Telemon" station (formerly "Dunstable" station; location on Fig. 1A) about 38 km west of

Springsure (Mollan et al. 1969, Dickins and Malone 1973, Fordham 1976). Small occurrences of limestones were mapped, and corals and conodonts from these limestones were illustrated by Fordham (1976). Analysis of the conodont faunas (Mawson et al. 1985) indicated anomalous associations of Emsian as well as Eifelian polygnathids and the possibility of an instructive sequence spanning the Emsian–Eifelian boundary, but this proved not to be so. The faunas illustrated by Fordham were re-evaluated by us (Mawson et al. 1985) and shown to include *Polygnathus perbonus, P. inversus, P. serotinus, P. costatus partitus* (identified by Fordham as *P.* aff. *decorosus*), *P. parawebbi* and *P. linguiformis linguiformis* beta morph.

Forms identified by Fordham (1976, Pl. 5, figs 9–12, 19–22, 24, 25, 31, 32) variously as *P. foveolatus foveolatus*, *P. foveolatus* n. subsp. and *P. linguiformis*

Tab. 1. Distribution of conodonts on stratigraphic sections through the Douglas Creek Limestone on "Lillyvale" at Copperfield, and the Ukalunda Beds in Mary Creek, "Old Hidden Valley", and a spot sample PB-061 from a small outcrop of Douglas Creek Limestone among alluvials on the Anakie Inlier, central Queensland

		Douglas Creek Limestone																			Ukalunda Beds								
		PB-048							LIL-1									LIL-2			PB-061	HID								SHID 24
Taxon	El.	O48/A	O48/B	O48/E	O48/F	O48/G	O48/H	O48/J	2,5	5,7	6,7	7,7	8,9	22,2	24,5	25	30	31,7	41,2	PB-061	0	37	63,64,6	90,5	108–111,5	111,6	112	118,6	SHID 24
Belodella sp. cf. B. paucidentata						1	1																						
Bel. resima		1																											
Dvorakia chattertoni		3																											
Dvorakia sp.		1																											
Neopanderodus aequabilis																	1			1									
Oulodus murrindalensis	Sa																			1									
Oulodus murrindalensis	Sb				1																				2				
Ozarkodina buchanensis	Pa																					1			1				
O. linearis	Pa								1																				
Panderodus unicostatus				2											1		2	1								2	1		
Pandorinellina exigua exigua	Pa				1															3									
Pandorinellina exigua exigua	Pb																			1									
Pand. e. philipi	Pa																								1			1	
Pand. sp. indet.			1																										
Polygnathus inversus	Pa													1			1	1											1
P. nothoperbonus	Pa					2	1				2	1		1	2	2	4	3			4	1			3				
P. perbonus	Pa					3	1			1		1	1	1	1	1	1	1		1	3	1			3				
Polygnathus sp.	Pa	2		2				1			2		3			1	1			5		1		2	1	2			
Unassigned elements	Pb													1			1	1			1	1	2		1				
Unassigned elements	Sb																	1			1				1		1		
Unassigned elements	Sc																		1							2			

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linguiformis are in fact the chronologically important *P. linguiformis bultyncki*; this was pointed out by Klapper and Johnson (1980).

5. Sedgeford Formation (Alpha district)

The Sedgeford Formation (1,100+ m) outcrops from beneath the Late Carboniferous–Early Permian Joe Joe Formation about 50 km southwest of Alpha. Limestone samples from about 240–280 m above the faulted base of the exposed sequence produced (Mawson in Henderson et al. 1995, p. 441–442, Fig. 4) the conodonts *Bipennatus bipennatus bipennatus* alpha morph and *Icriodus "expansus"*. Though the former appears first in the *costatus* Zone and extends through to the Early *varcus* Zone (Mawson 1993), *I. "expansus"* is not known from horizons earlier than *australis* Zone and is not known to extend beyond the *ensensis* Zone (as formerly understood). The association thus indicates an age in the range Eifelian (but not early Eifelian *partitus* and *costatus* zones) to possibly earliest Givetian.

Identifications of associated taxonomically diverse but undocumented macrofaunas accord with a broad Emsian–Eifelian age, but the conodonts indicate that if Emsian horizons are indeed present, they are likely to be lower in the sequence than the interval from which the conodont samples were derived.

6. Greybank Volcanics (Fletcher's Awl)

The Greybank Volcanics, developed in the vicinity of Fletcher's Awl, 37–45 km northeast of Clermont, east-central Queensland, consists typically of coarsely porphyritic andesitic and subordinate dacitic lavas with minor volcaniclastic breccias, pebble to boulder polymictic conglomerates, siltstones and mudstones, with a basal sedimentary sequence of quartzose sandstones and, locally, fossiliferous siltstones, mudstones, and a thin interval of limestone on a ridge crest at grid reference $950_{43}067_{40}$, about 15 m above its nonconformable contact with the underlying Mooramin Granite (Fig. 1D). The brachiopod-dominated faunas from this basal unit are sparse but are relatively diverse and, in finer lithologies, well preserved. It was from the above limestone interval that Mark Hayward, formerly of the Queensland Department of Minerals and Energy, sent us a sample which produced a juvenile specimen of the conodont *Palmatolepis subperlobata* indicating a Late Devonian (early Famennian) age for the marine transgression in that area (Mawson in Withnall et al. 1995b, p. 74). Subsequently, we located the *in situ* source of the limestone boulders, and sampled the limestone interval in quest of a conodont fauna that might be more chronologically constraining. Hayward's (1993) careful mapping of the area about Fletcher's Awl was incorporated in the 1 : 100,000 map of the southern part of the Anakie Inlier, east-central Queensland (Withnall et al. 1995a); a shortened description was included in the monograph on the geology of the southern Anakie Inlier (Withnall et al. 1995b, 71–75).

7. Glendarriwell Beds (southeast of Anakie township)

Limestones of the Glendarriwell Beds occur as low but substantial outcrops in and adjacent to the bed of Skeleton Creek approximately 3.5 km east of "Glendarriwell" homestead, about 15 km southeast of Anakie (Fig. 1). A small conodont faunule obtained previously from these outcrops seemed indicative of an Emsian age (Withnall et al. 1995b, p. 69) and thus approximately the same age as the Douglas Creek Limestone, but it is shown herein to be Late Devonian in age.

Conodont data and implications

Five stratigraphic sections were sampled through two Emsian units on and near the Anakie Inlier, the Douglas Creek Limestone and the Ukalunda Beds. They span an interval from seemingly low in *perbonus/gronbergi/nothoperbonus* interval to high in the *inversus* Zone.

1. Douglas Creek Limestone

Three stratigraphic sections were sampled for conodonts: LIL-1, LIL-2, sampled by the authors, and PB-048, sampled by Paul Blake of the Geological Survey of Queensland. LIL-1 (24 samples) commencing at 639_0672_8, crossed a small gully at approximately 25 m and terminated with the last outcrops of limestone at 28.4 m. LIL-2 (16 samples), extending to higher horizons, commenced at 639_3671_3 and extended through 49.6 m of scattered limestone outcrops (Fig. 2). Precise alignment of these two sections is uncertain, but they seem to align as shown in Fig. 2. Section PB-048 commenced at the eastern limit of outcrop and was sampled at 10 m intervals (11 samples). A spot sample, PB-061, from an isolated outcrop among alluvials at $628_{56}657_{79}$, about 180 m southwest of LIL-1, was also productive (Tab. 1).

PB-048 section: Polygnathids from this 100 m section include specimens of *Polygnathus perbonus, P. nothoperbonus*, and *P. inversus* (early and late forms). One of the specimens of *P. perbonus* suggests a transitional form from *P. dehiscens* thus indicating the section commenced very low in the *perbonus/gronbergi/nothoperbonus* Zone. Spot sample PB-061 produced *P. perbonus* and *Pandorinellina exigua exigua*; this accords with an age within the *perbonus/gronbergi/nothoperbonus* Zone.

LIL-1 section: This section appears to span both the *perbonus/gronbergi/nothoperbonus* and *inversus* zones. Specimens of *P. inversus* that have a protuberance or lip forming on the outer margin of the basal pit (e.g., Pl. 1, figs 8, 10) indicate a form transitional to *P. serotinus* and is therefore regarded as a late form of *P. inversus*.

3. LIL-2 section. Only three produced conodonts. These indicate that part of the section from LIL-2/30 to LIL-2/41.2 can be dated as *inversus* Zone.

2. Ukalunda Beds

HID section: Because of co-occurrence of *Polygnathus perbonus, P. nothoperbonus, Pandorinellina exigua philipi* and *Ozarkodina buchanensis*, this can be dated as *perbonus/gronbergi/nothoperbonus* Zone. It is generally accepted that *Pand. e. philipi* does not occur in horizons younger than the *perbonus/gronbergi/nothoperbonus* Zone (e.g. Klapper and Johnson 1980). At Buchan, southeastern Australia, *O. buchanensis* has a similar upper range (Mawson 1987).

S-HID section: Only one polygnathid was obtained: *P. inversus* (Plate I, fig. 15, upper view only) from sample S-HID-24. The specimen appears to be the late form of the species because of development of a lip on the outer edge of the basal pit.

It is not clear if the two limestone-bearing sequences of Ukalunda Beds sampled in Mary Creek, "Old Hidden Valley" (Fig. 2, HID and S-HID sections) are basal or near-basal and therefore in some way reflect transgressive events, but the two sampled sections from the Douglas Creek Limestone at "Lillyvale" (Fig. 1B, LIL-1 and LIL-2, interpreted as resting unconformably on Proterozoics of the Anakie Inlier, are interpreted as reflecting a transgressive event. Conodont data (Tab. 1) indicate the inception of this transgression took place in the *perbonus/gronbergi/nothoperbonus* Zone.

3. "Prairie"

The "Prairie" occurrence was extensively sampled in the vicinity of grid reference 880447, but no conodonts were obtained. The presence of massive stromatoporoids and favositids recall the forms present in the Douglas Creek Limestone to which this occurrence was provisionally referred by Withnall et al. (1995a).

4. Dunstable Beds ("Telemon")

Examination of the Dunstable Beds limestone occurrences mapped by Fordham (1976) and examination of additional limestone occurrences in that unit has shown all of them to be allochthonous. Their allochthonous nature is well displayed, for example, at grid reference $711_{50}259_{75}$. Further documentation of the conodont faunas of the Dunstable Beds has therefore not been undertaken. Because these occurrences are allochthonous, they do not provide compelling evidence regarding transgressive or regressive events. As noted earlier in this paper, the spread of ages indicated by the conodonts illustrated by Fordham (1976) is consistent with carbonate accumulation – whether as a carbonate platform or fringing reefs is speculative – over much of the Emsian and through all, or almost all, Eifelian time: from at least *inversus* Zone but probably *perbonus/gronbergi/nothoperbonus* Zone (where *Polygnathus perbonus* is most common), through early Eifelian *partitus* and *costatus* zones (indicated by presence of *P. costatus partitus* and *P. linguiformis bul-*

Tab. 2. Conodonts from locality 1, Greybank Volcanics, 'Mooramin', and from the Glendarriwell Beds

		Glendarriwell Beds	Greybank Volcs loc. 1
Belodella resima		3	
Icriodus iowaensis iowaensis	I		10
Mehlina strigosa	Pa		2
Palmatolepis crepida	Pa		2
Pal. minuta minuta	Pa		1
Pal. subperlobata	Pa		3
Palmatolepis sp.	Pa		2
Polygnathus busmakovi	Pa		1
P. hieroglyphica	Pa	1	
P. kuradjalis	Pa	3	
P. sp. cf. P. procerus	Pa		2
P. porrectus	Pa		1
P. webbi	Pa		3
Polygnathus sp. indet.	Pa		2
Unassigned elements	Pb		9
	M		1
	Sb		5
	Sc		13

tyncki) to late Eifelian or *australis* and *kockelianus* zones or even earliest Givetian (indicated by the presence of *P. parawebbi*, a form known to range from *australis* to Early *varcus* zones).

5. Sedgeford Formation (Alpha)

We have nothing to add to our former conclusion (Mawson in Henderson et al. 1995) that the horizon producing conodonts falls within the interval late Eifelian (*australis* Zone) to earliest Givetian (*hemiansatus* Zone). These provide an age for what were arguably nearshore regressive environments, broadly coeval with the youngest limestones of a "lost carbonate platform" or fringing reefs, the source of the allochthonous limestone clasts in the primarily volcaniclastic Dunstable Beds. The Sedgeford Formation may thus be construed as possibly a lateral facies equivalent of the latter.

6. Greybank Volcanics (Fletcher's Awl)

Acid-leaching of *in situ* limestone on the hillcrest at locality 1, above Brumby Gully, "Mooramin" (Fig. 1D), as well as limestone float from Hayward's original locality (Fig. 1D, loc. 2), and limestone float between the two localities, produced a small but diverse and well-preserved conodont fauna (Tab. 2; Plate II). On the basis of the age-range of the species recovered, a general *crepida* Zone age is indicated. *Palmatolepis crepida*, and *Polygnathus buzmakovi* make their first appearance at the base of the Early *crepida* Zone. The uppermost range of *Icriodus io-*

waensis iowaensis, Pal. subperlobata, P. busmakovi and *P. sp.* cf. *P. procerus* is at the top of the Latest *crepida* Zone. *Pal. minuta minuta* and *P. webbi* are long-ranging forms. The identification of *Polygnathus porrectus* and *Mehlina strigosus,* however, indicates that the age of the limestone interval can be further constrained to the Late and Latest *crepida* zones. The age corresponds to one of the transgressive pulses documented by Johnson et al. (1985) for Euramerica (see above) and is here named the Greybank Transgression. The same transgression is inferred to occur elsewhere in eastern Australia, notably in the basal member of the Columbine Sandstone in New South Wales (see Appendix).

7. Glendarriwell Beds

The assumption that the Glendarriwell Beds represented another Emsian interval analogous to the Douglas Creek Limestone, Ukalunda Beds and the poorly constrained "Prairie" limestone is now modified by identification of a faunule (Tab. 2) with *Polygnathus karadjalis* Vorontsova and Kuz'min and *P. hieroglyphica* Mawson and Talent, forms occurring in abundance in the Myrtlevale Formation throughout the Burdekin Basin (Mawson and Talent 1997). These forms, from a sample acid-leached and picked by Paul Blake of the Geological Survey of Queensland, from a sample (PBAN001) from Anakie topographic sheet $915_{32}882_{32}$, are indicators of a global transgression commencing at the base of the Early *marginifera* Zone, here named the Myrtlevale Transgression. Additional sampling of Skeleton Creek outcrops (surmised to be up-sequence) at $914_{51}875_{57}$ at the head of small gully, at $913_{60}875_{35}$, and at $912_{88}876_{23}$ failed to produce additional conodonts.

Overview of palaeogeography

There is no preserved record around or on the Anakie Inlier of sequences post-dating the Late Ordovician (Fork Lagoon Beds and Theresa Creek Volcanics) and pre-dating the Douglas Creek Limestone. The Anakie Inlier is therefore presumed to have been positive throughout Silurian and Early Devonian (until Emsian) times.

The shallow-water Douglas Creek and "Prairie" limestones cropping out more or less along the eastern flank of the Anakie Inlier, despite some uncertainty regarding the precise age of the Prairie limestone, accords with a substantial part of that region around the Anakie Inlier having been a shallow marine carbonate platform (not necessarily continuous) during a substantial part of Emsian time. This tract may have connected with the deeper water context represented by the Dunstable Beds of the "Telemon" area.

Conodont data demonstrate that inception of the transgression (represented by the Douglas Creek Limestone) commenced sometime late in the *perbonus/gronbergi/nothoperbonus* interval, with marine conditions persisting through until at least well into the *inversus* Zone. The transgression therefore corresponded in time with the deepening displayed in the Buchan–Murrindal area of eastern Victoria – by swift transition from shallow marine Murrindal Limestone to pelagic Taravale Formation late in the *perbonus/gronbergi/nothoperbonus* interval (Talent and Yolkin 1987, Talent 1989, Talent et al. 1993). Interestingly, the Ukalunda Beds sections sampled in Mary Creek, "Old Hidden Valley", also produced conodonts indicative of the *perbonus/ gronbergi/nothoperbonus* and *inversus* zones, the latter represented by only a single sample from the S-HID section. These limestones are thus approximately coeval with the Douglas Creek Limestone, with the HID outcrops being not far above the base of the Ukalunda Beds; the S-HID section appears to be stratigraphically higher.

No evidence is available from mid-Devonian sequences outcropping in the vicinity of the Anakie Inlier for the succession of T–R events displayed by the Burdekin Basin or Broken River sequences (Mawson and Talent 1997, Talent et al. 2002, cf. Fig. 3), but conodont data from the allochthonous limestone occurrences in the Dunstable Formation at "Telemon" document carbonate sedimentation, at least in that area, through much or all of the interval from at least *inversus* Zone (but possibly *perbonus/gronbergi/nothoperbonus* Zone as well) through to late Eifelian *australis* and *kockelianus* zones or even earliest Givetian (see earlier). Marine connection with the Adavale Basin is possible for some or all of that interval, the seaway possibly including the Sedgeford area.

The association of early Famennian palmatolepids and polygnathids low in the Greybank Volcanics accords with an open-shelf/carbonate platform environment. This transgressive event is here shown to have occurred during the Late and Latest *crepida* zones, and was coeval with one of the important transgressive pulses documented as having occurred in Euramerica within interval IIe of the Johnson et al. (1985) T-R scheme. In an appendix, the previously imprecisely calibrated transgression event in the Coffee Hill Member at the base of the Columbine Sandstone in east-central New South Wales is argued to represent the same event. This event is here named the **Greybank Transgression**.

Another Devonian transgressive event is documented from the Glendarriwell Limestone. Sparse but compelling conodont data shows this incursion on the southern flank of the Anakie Inlier to have occurred at the beginning of the middle Famennian, in the *marginifera* Zone. This transgression, identified from many areas around the world and widespread in the Burdekin Basin (Mawson and Talent 1997), is here named the **Myrtlevale Transgression**.

Viewed ensemble, the seven localities considered here may be regarded as tiny remnant outcrop-tracts (the substantial tract of Ukalunda Beds aside) of formerly appreciable transgressions – exposed now only along the northwestern flank – of a major basinal feature extending eastwards beneath the Permian-Triassic Bowen Basin to the ur-Pacific Ocean. Conceivably, the basin also extended westwards beneath the Drummond and Galilee basins to join, presumably intermittently, with the Adavale Basin, in which case it might appropriately be referred to as the Adavale–Emerald Basin.
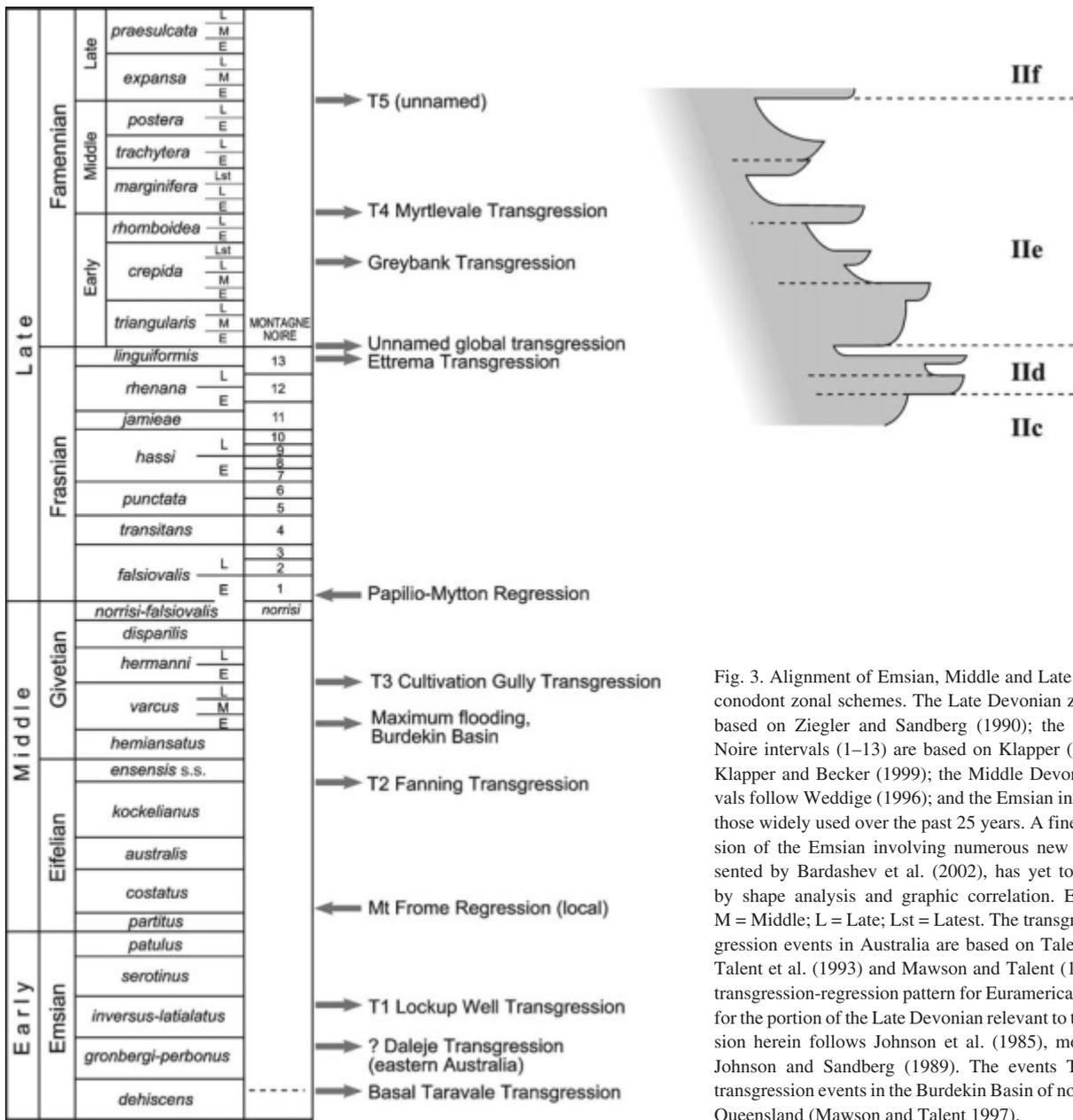
Fig. 3. Alignment of Emsian, Middle and Late Devonian conodont zonal schemes. The Late Devonian zonation is based on Ziegler and Sandberg (1990); the Montagne Noire intervals (1–13) are based on Klapper (1989) and Klapper and Becker (1999); the Middle Devonian intervals follow Weddige (1996); and the Emsian intervals are those widely used over the past 25 years. A finer subdivision of the Emsian involving numerous new taxa, presented by Bardashev et al. (2002), has yet to be tested by shape analysis and graphic correlation. E = Early; M = Middle; L = Late; Lst = Latest. The transgression-regression events in Australia are based on Talent (1989), Talent et al. (1993) and Mawson and Talent (1997). The transgression-regression pattern for Euramerica (far right) for the portion of the Late Devonian relevant to the discussion herein follows Johnson et al. (1985), modified by Johnson and Sandberg (1989). The events T1–T5 are transgression events in the Burdekin Basin of northeastern Queensland (Mawson and Talent 1997).

How the last two transgressions within this basin, the Greybank and Myrtlevale transgressions, relate chronologically to the base of the Drummond Group is speculative, though the base of the Drummond Group is generally assumed to extend down into the Famennian (Olgers 1972).

Conodont Colour Alteration Indices (CAI)

Despite the small number of conodont-producing localities, the conodont CAI values (Tab. 3) are interesting. The Famennian units – Glendarriwell Beds and Greybank Volcanics – represent annealing temperatures (if annealed for 1 Ma) of about 100 and 150 °C respectively (cf. Epstein et al. 1977, Rejebian et al. 1987); they would be viewed as falling, broadly, within the wet gas "window". Values of around 4 for the Douglas Creek Limestone and Ukalunda

Tab. 3. Colour alteration indices (CAI) of conodonts from localities around the Anakie Inlier, central Queensland.

Locality or Section	Colour Alteration Indices
Glendarriwell Beds	2–2.5
Greybank Volcanics	3–3.5
Ukalunda Beds	
HID section	4
Douglas Creek Limestone	
PB-061	3.5–4
PB-048 section	4
LIL-1 section	4
LIL-2 section	3.5–4

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Beds in Mary Creek suggest annealing temperatures (if annealed for 1 Ma) around 220°C, equating with the dry gas "window" (cf. Merriman and Kemp 1997). Illite crystallinity measurements (Kübler Indices), acting as proxies for CAI values, may provide a modicum of additional thermal information, especially for the tract of Ukalunda Beds (cf. Brime et al. 2003).

Taxonomic notes

Figured specimens are in the palaeontological collections of the Australian Museum prefixed by AMF or in the University of Queensland Geology Museum prefixed by QMF.

A. Emsian taxa

Family Belodellidae Khodalevich and Tschernich, 1973

Genus *Belodella* Ethington, 1959
Type species: *Belodus devonicus* Stauffer, 1940

Belodella resima (Philip, 1965)
Plate I, fig. 13

1965 *Belodus resimus* sp. nov. Philip, p. 98, Pl. 8, Figs 15–17.
1995 *Belodella resima* (Philip), Mawson et al., p. 424–427, Pl. 4, Figs 1–9 (see for further synonymy).

Comments: In reconstructing belodellid apparatuses occurring commonly in Australian sequences, Mawson et al. (1995), following Klapper and Barrick (1983), pointed out that elements of the apparatus of *B. resima* lack the longitutidinal costae or striations that typify elements of *B. devonica*. Typical of the belodellid specimens from the area, the specimen illustrated on Plate I, fig. 13 shows no sign of striations or costae.

Belodella sp. cf. *B. paucidentata* Moskalenko and Chegodaev, 1988
Plate II, figs 12, 15

1988 *Belodella paucidentata* n. sp. Moskalenko and Chegodaev, p. 137–138, Pl. 18, Figs 12–18.
1992 *Belodella*? *paucidentata* Moskalenko and Chegodaev; Barrick and Klapper, p. 43, Pl. 1, Fig. 13.

Comments: The widely spaced, tiny, peg-like denticles suggest these central Queensland belodellids should be referred to *Belodella paucidentata*. We do this hesitantly because these specimens are from an Emsian fauna whereas those previously described are no younger than Lochkovian.

Genus *Dvorakia* Klapper and Barrick, 1983
Type species: *Dvorakia chattertoni* Klapper and Barrick, 1983

Dvorakia chattertoni Klapper and Barrick, 1983
Plate II, figs 13, 14

1983 *Dvorakia chattertoni* n. sp. Klapper and Barrick, p. 1127, 1229, Figs 8H, I, L, M, O–S.

Comments: Specimens herein of *D. chattertoni* (Plate II, figs 13, 14) closely resemble those from the Middle Devonian, Spillville Formation, northern Iowa and southern Minnesota illustrated by Klapper and Barrick (1983, Figs 8H, P) as Sd and Sb elements respectively. It appears that this species occurs in horizons ranging in age from the Emsian (*perbonus/gronbergi/nothperbonus* Zone) to the Eifelian (*kockelianus* Zone).

Family Panderodontidae Lindström, 1970

Genus *Panderodus* Ethington, 1959
Type species: *Paltodus unicostatus* Branson and Mehl, 1933.

Panderodus unicostatus (Branson and Mehl, 1933)
Plate I, figs 11, 12

1933 *Paltodus unicostatus* n. sp. Branson and Mehl, p. 42, Pl. 3, Fig. 3.
1995 *Panderodus unicostatus* (Branson and Mehl); Simpson and Talent, p. 118–121, Pl. 2, Figs 1–32 (see for further synonymy).

Comments: Simpson and Talent (1995) prepared an extensive synonymy for this globally distributed species. Although a little more slender than many representatives of the species, specimens from the Douglas Creek Limestone appear to fit within the range of variation in *Panderodus unicostatus*.

Genus *Neopanderodus* Ziegler and Lindström, 1971
Type species: *Neopanderodus perlineatus* Ziegler and Lindström, 1971

Neopanderodus aequabilis Telford, 1975
Plate I, fig. 14

1975 *Neopanderodus aequabilis* n. sp. Telford, p. 30–31, Pl. 2, Figs 5–9, 11, 12.
1995 *Neopanderodus aequabilis* Telford; Mawson et al., p. 428, Pl. 4, Figs 10–17 (see for further synonymy).

Comments: It appears that *N. aequabilis* occurs in Early and Middle Devonian horizons and thus is stratigraphically more useful than species of long-ranging *Panderodus*.

Family Polygnathidae Bassler 1925

Genus *Polygnathus* Hinde, 1879
Type species: *Polygnathus dubius* Hinde, 1879

1879 *Polygnathus* nov. gen. Hinde, p. 361.

1925 *Hindeodella* n. gen. Bassler, p. 219.

1957 *Ctenopolygnathus* n. gen. Müller and Müller, p. 1084.

2002 *Eoctenoplygnathus* gen. nov. Bardashev et al., p. 398.

2002 *Eocostapolygnathus* gen. nov. Bardashev et al., p. 401.

2002 *Eolinguipolygnathus* gen. nov. Bardashev et al., p. 407.

2002 *Ctenopolygnathus* Müller and Müller; Bardashev et al., p. 412.

2002 *Costapolygnathus* gen. nov. Bardashev et al., p. 414 [= objective synonym of *Polygnathus* Hinde, 1879].

2002 *Linguipolygnathus* gen. nov. Bardashev et al., p. 418.

Comments: Numerous supposedly new polygnathid conodont taxa have been proposed by long-time friends, Bardashev et al. (2002), based primarily on re-allocation of illustrations of Early Devonian species, most formerly referred to the genus *Polygnathus*. This major work, entailing an exhausting survey of publications globally, is illustrated by small but elegant drawings arranged in hypothesised lineages, but lacks photo-illustrations of any taxa, takes no account of intraspecific variation (documentation of large intergrading populations is pivotal for this) and, unhappily, the proposed genus *Costapolygnathus*, to which five new and four previously described species are referred, has, as designated type species, *Polygnathus dubia* Hinde, 1879, the type species of *Polygnathus s. s.* The complicated nomenclatorial history of *P. dubia* (including designation of a neotype) was carefully spelled out by Huddle (1970; see also Klapper in Ziegler, 1973, p. 353–4). *Costapolygnathus* is thus a junior objective synonym of *Polygnathus*! We are concerned that no account seems to have been taken of the variation displayed by large populations of Pa elements of polygnathids. Authors who have presented illustrations of a scatter of individuals from such populations may be dismayed to find that illustrated specimens they knew to be parts of a continuum have been allocated to a scatter of new species and different lineages – some with incongruous ages. We have reservations too regarding the weight accorded characters of the upper surface versus characters of the lower surface of the Pa elements of *Polygnathus*, and the hierarchical level accorded the hypothesised lineages (genera?, subgenera? or informal), but these are matters of personal opinion.

If uncritically accepted, the taxonomy presented by Bardashev et al. (2002) would signify a remarkably high level of provinciality for polygnathids globally during Early Devonian times, followed abruptly by decreased provinciality during the Eifelian and the remainder of the Devonian where no comparable exercise has been undertaken, though we understand that a similar exercise for the Frasnian was nearing completion several years ago (I. Bardashev, pers. comm. 1998), likewise involving a plethora of forms viewed as being new species. As far as we know, this monograph has yet to be published. If the taxonomic fragmentation proposed by Bardashev et al. (2002) is accepted, a similar exercise needs to be carried out on polygnathids for the remaining stages of the Devonian before meaningful numerical analysis can be undertaken. And perhaps such an exercise should be extended to other Devonian conodont genera as well. As was stated in an earlier work (Talent et al. 2001, p. 3), "Without consistency of taxonomy, any attempt at numerical analysis would reflect only areas of intense taxonomic study (especially the work of taxonomic 'splitters'), and areas of neglect or dearth of data. Such patterns of apparent endemism and provincialism have little if anything to do with true patterns of provinciality."

Many of our colleagues display a penchant for taxonomic lumping, others for taxonomic splitting when confronted by an abundance of superbly preserved material. For the latter, it becomes a challenge! Others, with a more cautious approach to taxonomy are inclined to synonymise previously proposed genera and species. The trend to lumping, usually argued to be on the basis of "biological reality", may be exemplified by the work involving one of us (Talent et al. 2001) on the Early and Middle Devonian brachiopods of the Asia-Australia hemisphere. The opposite tendency to taxonomic splitting may be exemplified by the works of Gatinaud (1949, cf. Pitrat 1965, p. H699–H700), Sidyachenko (1962) and Lyashenko (especially 1973) on Late Devonian cyrtospiriferid brachiopods. Exemplification of taxonomic "de-fragmentation" with respect to the latter two works has been presented by Talent and Gratsianova (1986, 1988).

More serious is the dramatic increase in the number of zones proposed by Bardashev et al. (2002) for the Pragian and Emsian stages without indication of sequences in which the boundaries of the proposed zones might be specified and, if so desired, be available for further study. The Bardashev et al. zonal scheme needs to be tested by graphic analysis, globally. The elegant results of such an approach have already been presented for the Frasnian (Klapper 1989, 1997, Klapper et al. 1995, 1996, Gouwy and Bultynck 2000), the Eifelian (Belka et al. 1997) and, increasingly, for other major slices of the geologic record, e.g. Sweet (1995) for the Ordovician.

Examples of excessive taxonomic splitting and lumping are scattered across all phyla, plant and animal, but huge numbers of species accommodated with a single genus need not imply oversplitting. Witness the scleractinian genus *Acropora* with 100 or so living species (Veron and Wallace 1984, Wallace 1999), the orchid genus *Dendrobium* with at least 850 species (Lavarack et al. 2000), and, two Australian examples, the plant genera *Eucalyptus* (Chippendale 1988), and *Grevillea* (Makinson 2000) – the first with at least 513 species, and the second in excess of 452 species – have defied generic grouping despite many attempts to do so, mounted by the most knowledgeable workers on the respective groups.

Likewise at the generic-level. Witness the great morphological diversity in the echinoid family Clypeasteridae Agassiz, 1835. By the mid 1960s, 27 nominal genera, exclusive of objective synonyms, had been proposed; Durham (1966) placed all of them in synonymy of a single ge-

nus, the generally large and striking *Clypeaster* Lamarck, 1801. No one has insisted on undoing Durham's generic lumping. Taxonomic lumping and splitting may be referred to as taxonomic style.

Our views regarding the proposed slicing of new taxa from the genus *Polygnathus* are summarised in the generic synonymy above. The reality and/or relevance of these proposed taxa needs testing by shape analysis comparable to the exercises already undertaken by workers on Late Devonian and a selection of Early Devonian conodont taxa (Klapper and Foster 1986, 1993, Sloan in press). Unfortunately these exercises have not included species referred to *Polygnathus*.

Some authors as they grow older become taxonomic splitters – exemplified by the great malacologist Paul Bartsch who, in old age, discriminated a whole galaxy of intertidal mollusc taxa which had "escaped notice" by 200 years of workers on east-coast USA intertidal communities – others, perhaps including ourselves (working mostly with brachiopods and conodonts) tend to be conservative. We hope that, taxonomic quibbles aside, we as well as our esteemed colleagues, Bardashev et al. (2002), may be proved to have retained balance as regards taxonomic style.

Polygnathus inversus Klapper and Johnson, 1975
Plate I, figs 8–10, 15; Plate II, figs 8–11

1975 *Polygnathus inversus* n. sp. Klapper and Johnson, p. 73, Pl. 3, Figs 34, 35.
1977 *Polygnathus inversus* Klapper and Johnson; Klapper (in Ziegler), p. 451–453, Polygnathus Pl. 9, Fig. 1 (see for further synonymy).
1980 *Polygnathus inversus* Klapper and Johnson; Klapper and Johnson, p. 453 (see for further synonymy).
1987 *Polygnathus inversus* Klapper and Johnson; Mawson, p. 274, Pl. 33, Figs 3–8, Pl. 36, Figs 8, 9.
1990 *Polygnathus inversus* Klapper and Johnson; Uyeno, p. 83, Pl. 7, Figs 6, 7, 39–44, Pl. 9, Figs 7–12, 15, 16, 36, 37, Pl. 13, Figs 1–4, Pl. 17, Figs 35–38 (see for further synonymy.
1991 *Polygnathus inversus* Klapper and Johnson; Uyeno, Pl. 2, Figs 11, 12.
2002 *Costapolygnathus inversus* alpha morph (Klapper and Johnson), Bardashev et al., p. 415, Text-figs 9, 14.25.
2002 *Costapolygnathus inversus* beta morph (Klapper and Johnson), Bardashev et al., p. 415, Text-figs 9, 14.24.

Comments: Specimens of *P. inversus* from central Queensland show a range of variation comparable to that displayed by the Nevada material (Klapper and Johnson 1975). Included in the species are specimens in which an incipient bulge and/or lip is developed on the outer side of the basal pit. It is presumed that such forms are best considered as late forms of *P. inversus*, intermediate to *P. serotinus*, having a shelf-like protuberance on the outer side of the basal pit.

Polygnathus nothoperbonus Mawson, 1987
Plate I, figs 1–4; Plate II, figs 4, 5

1975 *Polygnathus* aff. *P. perbonus* (Philip), Klapper and Johnson, p. 74, Pl. 2, Figs 1–10.
1987 *Polygnathus nothoperbonus* Mawson, p. 276, Pl. 32, Figs 11–15, Pl. 33, Figs 1, 2, Pl. 6, Fig. 7 (see for further synonymy).
1990 *Polygnathus nothoperbonus* Mawson; Uyeno, p. 85, Pl. 7, Figs 4, 5, Pl. 9, Figs 5, 6, 13, 14 (see for further synonymy).
2002 *Eolinguipolygnathus nothoperbonus* (Mawson, 1987), Bardashev et al., p. 411, Text-figs 10, 15.18.

Comments: This form was first identified from the Baratine Member of McColley Canyon Formation at Lone Mountain, Nevada by Klapper and Johnson (1975) as *Polygnathus* aff. *P. perbonus*. Mawson (1987) erected the species *P. nothoperbonus* on the basis of abundant material from the Buchan–Murrindal area of southeastern Australia, considering it to be clearly part of a lineage from *P. dehiscens* to *P. nothoperbonus-inversus-serotinus*; this lineage has been recognised almost globally with occurrences, *inter alia*, in the Canadian Arctic Islands (Uyeno 1990), Nevada (Klapper and Johnson 1975), east-central Alaska (Lane and Ormiston 1979), Australia (Mawson 1987), and southeast Siberia and central Asia (Apekina and Mashkova 1978).

Polygnathus perbonus (Philip, 1966)
Plate I, figs 5, 16–18; Plate II, figs 1–3, 6, 6

1966 *Roundya perbona* n. sp. Philip, p. 448–449, Pl. 2, Figs 29–40, Pl. 4, Figs 7, 8.
1977 *Polygnathus perbonus* (Philip); Klapper (in Ziegler), p. 487–489, Polygnathus Pl. 1, Figs 3, 4 (see for further synonymy).
1980 *Polygnathus perbonus* (Philip); Klapper and Johnson, p. 454 (see for further synonymy).
1987 *Polygnathus perbonus* (Philip); Mawson, p. 276–277, Pl. 34, Figs 8–13, Pl. 36, Fig. 2.
1991 *Polygnathus perbonus* (Philip); Bardashev, p. 243, Pl. 109, Figs 23–27.
1993 *Polygnathus perbonus* (Philip); Brock and Talent, p. 233, Fig. 9A–H.
2002 *Eolinguipolygnathus foveolatus* alpha morph (Philip and Jackson); Bardashev et al., p. 409, Text-figs 10, 15.10, 15.11.
2002 *Eolinguipolygnathus foveolatus* beta morph (Philip and Jackson); Bardashev et al., p. 409, Text-figs 10, 15.12.

Comments: In recognising the complete apparatus for this species, Klapper and Philip (1971), according to the rules of priority, referred the species to *P. perbonus* because the Sc element of the apparatus had been previously named as *Roundya perbona* by Philip (1966). Both morphs of *Eolinguipolygnathus foveolatus* are synonymised by us.

Originally described from the Buchan area, southeastern Australia (Philip 1966), *P. perbonus* has been discriminated widely in eastern Australia (e.g., Pedder et al. 1970, Telford 1975, Philip and Pedder 1967, Mawson 1987, Brock and Talent 1993) as well as in other parts of the world, for example, in the Barrandian of the Czech Republic (Klapper et al. 1978), east-central Alaska (Lane and Ormiston 1979), South China (Wang and Ziegler, 1983) and Central Asia (Apekina and Mashkova 1978, Kim et al. 1984, Bardashev 1991). As its distribution parallels that of *P. nothoperbonus* (Mawson 1987), it is recognised as a zonal form for the *perbonus/nothoperbonus/gronbergi* Zone.

Genus *Ozarkodina* Branson and Mehl, 1933
Type species: *Ozarkodina typica* Branson and Mehl, 1933
Ozarkodina buchanensis (Philip, 1966)
Plate I, fig. 20.

1966 *Spathognathodus steinhornensis buchanensis* n. subsp. Philip, p. 450–451, Pl. 2, Figs 1–15 (non Figs 16–28).
1987 *Ozarkodina buchanensis* (Philip, 1966); Mawson, p. 282–286, Pl. 37, Figs 1–20 (see for further synonymy).

Comments: This species is known from many localities in eastern Australia: Buchan and Bindi, Victoria (Philip 1966, Klapper and Philip 1971, Mawson 1987), Loyola, Victoria (Cooper 1973), and the Cavan Limestone, New South Wales (Pedder et al. 1970). It has been found also in east-central Alaska (Lane and Ormiston, 1979).

Ozarkodina linearis (Philip, 1966)

1966 *Eognathodus linearis* n. sp. Philip, p. 444–445, Pl. 4 Figs 34–36, Text-fig. 3.
1973 *Ozarkodina linearis* (Philip); Klapper (in Ziegler, ed.), p. 237, *Ozarkodina* Pl. 2, Fig. 2 (see for further synonymy).
1987 *Ozarkodina linearis* (Philip); Mawson, p. 288, 290, Pl.38, Figs 1–17 (see for further synonymy).
2002 *Amydrotaxis linearis* (Philip); Bardashev et al., p. 392, Text-figs 7, 11.1.

Comments: Only one specimen of this species was recovered in this study: from the lowest horizon of the Douglas Creek Limestone in LIL-1 section (Table 1). *O. linearis* was first described from Buchan, eastern Victoria, by Philip (1966). The range is from *dehiscens* Zone to *inversus* Zone (Klapper and Johnson 1980). Elements of the apparatus have been discriminated in material from numerous horizons at Buchan and Wee Jasper, southeastern Australia (Mawson 1987, Pedder et al. 1970, Philip 1966). The elements assigned to the *O. linearis* apparatus are not related to those of the *Amydrotaxis* apparatus described and illustrated by Klapper and Murphy (1980), Murphy and Matti (1982) or Mawson (1986). The species is accordingly referred back to *Ozarkodina*.

Genus *Pandorinellina* Müller and Müller, 1957
Type species: *Pandora insita* Stauffer, 1940
Pandorinellina exigua exigua (Philip, 1966)

1966 *Spathognathodus exiguus* n. sp. Philip, p. 449–450, Pl. 3, Figs 26–37, Text-fig. 7.
1973 *Pandorinellina exigua exigua* (Philip); Klapper (in Ziegler, ed.), p. 319, *Ozarkodina* Pl. 2, Fig. 10 (see for further synonymy)
1990 *Pandorinellina exigua exigua* Klapper; Uyeno, p. 96, Pl. 6, Fig. 12 (see for further synonymy).

Comments: *Pand. exigua exigua s.s.* has an age-range of at least from *dehiscens* Zone through to the top of *serotinus* Zone (Klapper and Johnson 1980) whereas *Pand. e. philipi* has been reported from horizons dated as *sulcatus* Zone to *perbonus/gronbergi/nothperbonus* Zone.

Pandorinellina exigua philipi (Klapper, 1969)
Plate I, fig. 19

1969 *Spathognathodus exiguus philipi* n. subsp. Klapper, p. 16–18, Pl. 4, Figs 30–38.
1973 *Pandorinellina exigua philipi* Klapper; Klapper (in Ziegler, ed.), p. 321, 322, Ozarkodina Pl. 2, Fig. 11 (see for further synonymy)
1990 *Pandorinellina exigua philipi* Klapper; Uyeno, p. 96, Pl. 6, Figs 1–6, 41 (see for further synonymy).

Comments: *Pand. exigua philipi* is easily discriminated from *Pand. exigua exigua* by its more restricted basal cavity. It has been reported from horizons dated as *sulcatus* Zone in the Yukon (Fåhraeus 1971), east-central Alaska (Lane and Ormiston 1979), southeast Alaska (Savage 1977, Savage et al. 1977) to *perbonus/gronbergi/nothperbonus* Zone in east-central Alaska (Lane and Ormiston 1979, Wee Jasper, southeastern Australia (Pedder et al. 1970), and possibly in Central Asia (Apekina and Mashkova 1978).

B. Famennian taxa

Family Icriodontidae Müller and Müller, 1957

Genus *Icriodus* Branson and Mehl, 1934
Type species: *Icriodus expansus* Branson and Mehl, 1934

Icriodus iowaensis iowaensis Youngquist and Peterson, 1947
Plate III, figs 10–12

1947 *Icriodus iowaensis* n. sp. Youngquist and Peterson, p. 247, Pl. 37, Figs 22–24, 27–29.
1966 *Icriodus iowaensis* Youngquist and Peterson; Anderson, p. 406, Pl. 52, Figs 8, 9, 13, 17–21.
1975 *Icriodus iowaensis iowaensis* Youngquist and Peterson; Klapper (in Ziegler), p. 125–126, *Icriodus* Pl. 1, Fig. 5 (see for further synonymy).

1984 *Icriodus iowaensis iowaensis* Youngquist and Peterson; Sandberg and Dreesen, p. 159–160, Pl. 1, Figs 7–11.

1993 *Icriodus iowaensis iowaensis* Youngquist and Peterson; Ji and Ziegler, p. 56, Text-fig. 6, Fig. 8.

2001 *Icriodus iowaensis* Youngquist and Peterson; Johnston and Chatterton, p. 18, Pl. 1, Figs 20–28.

Comments: The platforms of all specimens of *I. i. iowaensis* from the Greybank Volcanics are consistently of moderate width, thus representing the narrow morphotype referred to by Sandberg and Dreesen (1984, p. 160). The arrangement of the denticles confirm the identification with conspicuous ridges connecting the 3 rows of denticles, and the longitudinal ridge on the cusp continuing as a medial ridge on the platform. Note cell imprints on the upper surface of the denticles on the left-hand side of the juvenile specimen illustrated on Plate III, fig. 12. Sandberg and Dreesen (1984) give the range of *I. i. iowaensis* as from the base of the Middle *triangularis* Zone into the Early *rhomboidea* Zone.

Genus *Palmatolepis* Ulrich and Bassler, 1926
Type species: *Palmatolepis perlobata* Ulrich and Bassler

Palmatolepis crepida Sannemann, 1955
Plate III, figs 4, 5

1955 *Palmatolepis crepida* n. sp. Sannemann, p. 134, Pl. 6, Fig. 21.

1973 *Palmatolepis crepida* Sannemann; Klapper (*in* Ziegler), p. 125–126, *Palmatolepis* Pl. 3, Figs 5, 6 (see for further synonymy).

1989 *Palmatolepis crepida* Sannemann; Ji, Pl. 3, Fig. 26.

1993 *Palmatolepis crepida* Sannemann; Ji and Ziegler, p. 59, Pl. 22, Figs 1–7, Text-fig. 3, Fig. 4.

1995 *Palmatolepis crepida* Sannemann; Schülke, p. 32, Pl. 9, Figs 14–16, Figs 28.2, 28.4, 28.6–28.8 (see for further synonymy).

2001 *Palmatolepis crepida* Sannemann; Johnston and Chatterton, p. 30, Pl. 13, Fig. 12.

Comments: Ji and Ziegler (1993) have identified *Pal. crepida* in horizons of the Lali Formation, South China dated as Early *crepida* Zone extending into the Early *rhomboidea* Zone – the same range as given by Matyja (1993) for occurrences of the species in western Pomerania.

Palmatolepis minuta minuta Branson and Mehl, 1934
Plate III, fig. 2

1934 *Palmatolepis minuta* n. sp. Branson and Mehl, p. 134, Pl. 18, Figs 1–5.

1977 *Palmatolepis minuta minuta* Branson and Mehl; Klapper (*in* Ziegler), p. 335–338, *Palmatolepis* Pl. 9, Figs 1–5 (see for further synonymy).

1989 *Palmatolepis minuta minuta* Branson and Mehl; Ji, Pl. 2, Figs 15, 16.

1990 *Palmatolepis minuta minuta* Branson and Mehl; Ziegler and Sandberg, p. 69 (see for further synonymy).

1993 *Palmatolepis minuta minuta* Branson and Mehl; Ji and Ziegler, p. 65, Pl. 7, Figs 1–19, Pl. 9, Figs 8–18, Text-fig. 13, Figs 9, 15, 16.

2001 *Palmatolepis minuta minuta* Branson and Mehl; Johnston and Chatterton, p. 28, Pl. 11, Figs 8–21.

Comments: Ji and Ziegler (1993) recognised 3 morphotypes of *Pal. m. minuta.* The specimen illustrated here appears to represent morphotype 3, characterised by a gently curved carina and without the development of an inner lobe. Ziegler and Sandberg (1990, p. 69) gave the range of *Pal. m. minuta* as from the base of the Late *triangularis* Zone into the *trachytera* Zone. In the Palliser Formation and Wabamun Group, Canada, Johnston and Chatterton (2001, p. 28) have found *Pal. m. minuta* to range from Early to Middle *crepida* zones to the Late *marginifera* Zone.

Palmatolepis subperlobata Branson and Mehl, 1934
Plate III, figs 1, 3

1934 *Palmatolepis subperlobata* n. sp. Branson and Mehl, p. 235, Pl. 18, Figs 11–21.

1971 *Palmatolepis subperlobata* Branson and Mehl; Szulczewski, p. 40–41, Pl. 13, Fig. 12.

1989 *Palmatolepis subperlobata* Branson and Mehl; Ji, Pl. 2, Figs 15, 16.

1989 *Palmatolepis shongshanensis* n. sp. Wang, p. 85, Pl. 20, Figs 5–7.

1993 *Palmatolepis subperlobata* Branson and Mehl; Ji and Ziegler, p. 72 , Pl. 20, Figs 3–9, Pl. 21, Figs 11, 12, Text-fig. 16, Figs 5, 6, 8 (see for further synonymy).

Comments: From the Lali Section, South China, Ji and Ziegler (1993) have identified *Pal. crepida* in horizons dated as Middle *triangularis* Zone to Early *marginifera* Zone. Ziegler and Sandberg (1990, p. 23) indicate that *Pal. subperlobata* first appeared in the Late *triangularis* Zone.

Genus *Polygnathus* Hinde, 1879
Type species: *Polygnathus dubius,* Hinde, 1879

Comments: The genus *Polygnathus* is readily identified globally by its distinctive platform and free blade continuing as a carina onto the platform. Klapper and Philip (1971) recognised the elements making up the apparatus structure. The plethora of genera erected by Bardashev et al. (2002) does little to elucidate the taxonomy of this cohesive group. Until the species clustered within the new genera are shown to have common, discrete characteristics enabling unequivocal discrimination of each apparatus and that their evolutionary pathways can be tested by graphic correlation, its seems best that they be synonymised.

Pa elements belonging to the *communis* Group of *Polygnathus* have a depression behind the basal pit on the lower

surface. This feature has been used by Vorontsova (in Barskov et al. 1991) to erect a separate genus, *Neopolygnathus*.

Polygnathus buzmakovi Kuz'min, 1990
Plate III, fig. 9

1990 *Polygnathus buzmakovi* n. sp. Kuz'min, p. 70, Pl. 4, Figs 1–4.
1997 *Polygnathus buzmakovi* Kuz'min; Molloy et al, Pl. 6, Figs 3–5.

Comments: Whereas Kuz'min (1990) and Barskov et al. (1991) give a *crepida* Zone age for this species, Molloy et al. (1997) report the occurrence of *P. buzmakovi* from both *crepida* Zone and Early *marginifera* Zone horizons in a limestone–shale–sandstone sequence west of Misri Khel, Khyber area, northwest Pakistan.

Polygnathus hieroglyphica Mawson and Talent, 1997
Plate III, fig. 18

1974 *Polygnathus* sp. Matyja and Zbikowska, p. 684, 692, Pl. 7, Fig. 7.
1987 *Polygnathus orientalis* Gagiev et al., Pl. 26, Figs 10, 11a-b, 12.
1991 *Polygnathus orientalis* Gagiev et al.; Barskov et al., p. 60, Pl. 14, Fig. 15.
1997 *Polygnathus hieroglyphica* n. sp. Mawson and Talent, p. 214, 216, Fig. 14.1–10 (see for taxonomic comment).

Comment: The fragment of platform illustrated by us (Pl. 3, Fig. 18) shows the distinctive ornament of *P. hieroglyphica* first described from Early *marginifera* sequences in the Myrtlevale Formation at Mt. Podge, NE Queensland; the new species was based on 293 specimens. At the posterior of the broad, lanceolate platform, a faint trace of the carina is visible with ornament resembling hieroglyphs on either side.

Polygnathus karadjalis Vorontsova and Kuz'min, 1984
Plate III, figs 15–17, 19

1984 *Polygnathus karadjalis* n. sp. Vorontsova and Kuz'min, p. 61–62, Pl. 1, Figs 1–5.
1991 *Polygnathus karadjalis* Vorontsova and Kuz'min; Barskov et al., p. 23, Pl. 4, Figs 1–2.
1997 *Polygnathus karadjalis* Vorontsova and Kuz'min; Mawson and Talent, p. 216, 218, Fig. 15.15–24.

Comments: Although having a serotiniform platform, this species is distinguished by the arrow-like structure developed on the lower surface anterior of the basal pit (cf. Plate III, figs 16, 17). *P. karadjalis* was first described from central Kazakhstan (Vorontsova and Kuz'min 1984) and according to Vorontsova (1993) occurs in horizons dated from Late *marginifera* Zone to Late *trachytera* Zone.

Mawson and Talent (1997) obtained 1430 specimens of *P. karadjalis* from horizons at Mt Podge in the Myrtlevale Formation, northeastern Queensland dated as Early *marginifera* Zone. To date, *P. karadjalis* is known only from Australia and Kazakhstan.

Polygnathus sp. cf. *P. procerus* Sannemann, 1955
Plate III, fig. 6

cf. 1955 *Polygnathus procera* n. sp. Sannemann, p. 150, Pl. 1, Fig. 11.
cf. 1993 *Palmatolepis procerus* Sannemann; Ji and Ziegler, Pl. 38, Figs 4–8, Text-fig. 21, Fig. 1 (see for further synonymy).
cf. 1993 *Palmatolepis procerus* Sannemann; Matyja, Pl. 26, Fig. 1.

Comments: Ji and Ziegler (1993) indicate that in the Lali Section, South China, the range for this species is from Middle *falsiovalis* Zone into the Late *crepida* Zone. Matyja (1993) gives the range for this species – as found in western Pomerania – as Early *triangularis* Zone to Latest *crepida* Zone.

Polygnathus porrectus Vorontzova and Kuz'min, 1984
Plate III, fig. 8

1974 *Polygnathus semicostatus* morph trend 8 Dreesen and Orchard, p. 5, Pl. 1, Figs 8a., 8b
1984 *Polygnathus porrectus* Vorontzova and Kuz'min n. sp., p. 63–63, Pl. 1, Figs 17, 18.

Comments: Although Vorontzova and Kuz'min (1984, p. 64) give the age for their new species described from central Kazakhstan as *marginifera–trachytera* zones, Barskov et al. (1991) suggest a Late *crepida* Zone–Early *marginifera* Zone for the range of *P. porrectus.*

Polygnathus webbi Stauffer, 1938
Plate 3, Fig. 7

1938 *Polygnathus webbi* n. sp. Stauffer, p. 439, Pl. 53, Figs 25, 26, 28, 29.
1973 *Polygnathus webbi* Stauffer; Klapper (in Ziegler, ed.), p. 393–394, *Polygnathus* Pl. 2, Fig. 7 (see for further synonymy).

Comments: *Polygnathus webbi* and *P. normalis* are right- and left-hand forms of the one species (Klapper in Ziegler 1973). They are an example of Class IIIb symmetry described by Lane (1968). The range for the species is Latest *falsiovalis* Zone to Latest *trachytera* Zone.

Mehlina strigosa (Branson and Mehl, 1934)
Plate III, fig. 14

1934 *Spathodus strigosus* n. sp. Branson and Mehl, p. 187, Pl. 17, Fig. 17.

2001 *Mehlina strigosa (*Branson and Mehl); Johnston and Chatterton, p. 49–50, Pl. 32, Figs 16–20, Pl. 33, Figs 1–4 (see for further synonymy).

Comment: The specimen from the Greybank Volcanics near Fletcher's Awl, illustrated on Plate III, fig. 14, falls within the range of variation of the specimens from the Palliser Formation and Wabamun Group, Canada (Johnston and Chatterton 2001, Pl. 32, Figs 16–20, Pl. 33, Figs 1–4) in the arrangement of denticles, and width of the unit and basal cavity. Johnston and Chatterton have found *M. strigosa* to occur in horizons ranging from Late *crepida* Zone to *expansa* Zone. They also note that whereas Ziegler and Sandberg (1984) reported the lower limit of *M. strigosa* to be Early *marginifera* Zone, Druce (1976) has also reported older occurrences of the species.

Appendix

Age of the Coffee Hill Member of the Columbine Sandstone, Gap Creek, east-central New South Wales, reconsidered.

Fordham (in Jones and Turner 2000, p. 526–528) identified and illustrated conodonts from a phosphatic shell horizon, locally known as the "*Lingula* limestone", in the Late Devonian Coffee Hill Member of the Columbine Sandstone at Gap Creek, west of Orange, NSW. Associates included lingulid brachiopods in abundance, rare articulate brachiopods, vertebrate microliths (including dipnoans), scolecodonts, bryozoans and phyllocarids; many of these have been referred to or documented by other authors (see Jones and Turner 2000). Though the conodont fauna was substantial (328 conodonts from 20 kg), Fordham was unable to be more specific regarding the age than "late *falsiovalis* to latest *marginifera* zones", i.e. occurring somewhere within a span of 21 zones or subzones, amounting to about two-thirds of Late Devonian time (cf. Fig. 3). Because these conodonts are important for dating the important associated fish microlith fauna of the Coffee Hill Member of the Columbine Sandstone, and because they date a marine transgression of regional or even global extent, we re-evaluate their taxonomy and age-implications. The following comments refer to the identifications presented by Fordham (in Jones and Turner 2000, Fig. 4):

A–E. *Icriodus cornutus* Sannemann. The Coffee Hill specimens identified by Fordham as *I. chojnicensis* differ from the type material of this species from Chojnice 2 borehole, western Pomerania (Matyja 1972) in having more regularly arranged denticles; the lateral denticles are not aligned or alternating with the median row of denticles. Also diagnostic of *I. chojnicensis* according to Matyja (1972, p. 745) is always having fewer denticles in the lateral rows than in the median row. Subsequent amended diagnoses by Dreesen and Houllebergs (1980, p. 120) and Sandberg and Dreesen (1984, p. 163) emphasise these features. In her range-chart of Famennian conodonts from

western Pomerania, Matyja (1993, Fig. 7) shows the range of *I. cornutus* as from within the Middle *triangularis* Zone to Late *marginifera* Zone: the same range given by Sandberg and Dreesen (1984, p. 163).

F–H, J–L. *Polygnathus communis* Branson and Mehl group. Fordham (in Jones and Turner, p. 526, Fig. 4 explanation and Fig. 4.H, L) indicates that all polygnathids from Coffee Hill have a distinctive depression behind the basal pit on the lower surface of the Pa element. This feature is common to polygnathids belonging to the *communis* Group. Using this feature to erect a new genus, *Neopolygnathus*, Vorontsova (in Barskov et al. 1991) separated the group from other polygnathids. Representatives of the *communis* group are not known to occur in faunas older than *crepida* Zone (Dreesen and Dusar 1974, Barskov et al. 1991, Matyja 1993). Sandberg and Ziegler (1979, p. 188) indicate that *P. c. communis* first appears in the Middle *crepida* Zone.

M. Unassigned Pb element possibly from a polygnathid apparatus.

N, Q. *Pelekysgnathus inclinatus* Thomas. I element fragment and Cd (oistodiform) element, respectively. According to Sandberg and Dreesen (1984 p. 162) the oldest known occurrence of *Pel. inclinatus* is Early *crepida* Zone.

O. Unassigned Pb element possibly from a palmatolepid apparatus.

P. *Mehlina strigosa* (Branson and Mehl). The specimen illustrated is remarkably similar to material from the Palliser Formation and Wabamun Group, Canada, illustrated by Johnston and Chatterton (2001, Pl. 32, Figs 16–20; Pl. 33, Figs 1–4); it is reported from Late *crepida* to Early to Middle *expansa* zones.

In view of the above, the fauna illustrated by Fordham (1976) cannot be older than *crepida* Zone. On presently available information it is almost certainly Late and/or Latest *crepida* Zone. This accords with indications from associated phyllocarids (e.g. Jones and Turner 2000, Figs 3.4, 6R) and vertebrate micro-remains e.g. *Phoebodus* teeth documented by Jones and Turner (2000, p. 531, 534, Figs 8.1–4). It is thus believed to correlate with the marine transgression (here named the Greybank Transgression, Fig. 3) near the base of the Greybank Volcanics on "Mooramin" in the vicinity of Fletcher's Awl (Fig. 1D, specifically fossil locality 1), and aligns with a pronounced transgressive event of Late and/or Latest *crepida* Zone in Euramerica (Johnson et al. 1985, Johnson and Sandberg 1989). In other words, it is a global rather than local event.

We suggest that this event, now discriminated in Australia as a marine interval in two localities more than 1,000 km apart, may be represented by marine incursions in other prevailingly non-marine Late Devonian sequences in eastern Australia, perhaps on occasion confused with the prominent latest Frasnian *linguiformis* Zone (Ettrema Transgression of Fig. 3) of the "Lambian facies" of the Late Devonian of eastern Australia, or the early mid-Famennian Myrtlevale Transgression (*marginifera* Zone), well expressed in the Burdekin Basin of northeastern Queensland (Mawson and Talent 1997). The Ettrema,

Greybank and Myrtlevale transgressions may have correlates among the shallow marine horizons of the Bulgeri Formation of the Broken River region (Lang *in* Withnall and Lang 1993, p. 139, 146), characterised by chronologically inconsequential but indubitably nearshore marine faunas – with, for example, rare linguloid brachiopods, and moulds of crinoid ossicles, corals or mollusks, as, for instance, in the Rockfields Member and at the base of the Stopem Blockem Conglomerate Member.

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Plate I

1–4 – *Polygnathus nothoperbonus* Mawson, 1987.

1, 2 – upper and lower views respectively of AMF 125372 from LIL-2/31.7, × 40; 3 – upper view of AMF 125373 from LIL-1/24.5, × 40; 4 – lower view of AMF 125374 from LIL-2/30, × 40.

5, 16–18 – *Polygnathus perbonus* (Philip, 1966).

5 – lower view of AMF 125375 from LIL-1/22.2, × 50; 16 – lower view of QMF 25656 from HID/0, × 70; 17, 18 – upper and lower views respectively of QMF 25655 from HID/108–111.5; *Note:* Figs 16–18 re-illustrated from Brock and Talent (1993, Fig. 9 A, B, and D).

8–10, 15 – *Polygnathus inversus* (Klapper and Johnson, 1975).

8 – lower view of AMF 125376 from LIL-2/30, × 40. Note the development of the lip on the outer margin of the basal pit. 9, 10 – upper and lower views respectively of AMF 125377 from LIL-1/7.7, × 30. 15 – upper view of AMF 12582 from S-HID/24, × 40.

11, 12 – *Panderodus unicostatus* (Branson and Mehl, 1933).

11 – lateral view of ?Sb element, AMF 125378 from LIL-2/31.7, × 50; 12 – lateral view of ?Sa element, AMF 125379 from LIL-2/31.7, × 40;

13 – *Belodella resima* (Philip, 1965).

Lateral view of ?Sb element, AMF 125380 from LIL-1/6.7, × 30.

14 – *Neopanderodus aequabilis* Telford, 1975.

Lateral view of AMF 125381 from LIL-2/30, × 30.

19 – *Pandorinellina exigua philipi* (Klapper, 1969).

Lateral view of AMF 125383 from HID/108–111.5, × 80.

20 – *Ozarkodina buchanensis* (Philip, 1966).

Lateral view of AMF 125384 from HID/37, × 60.
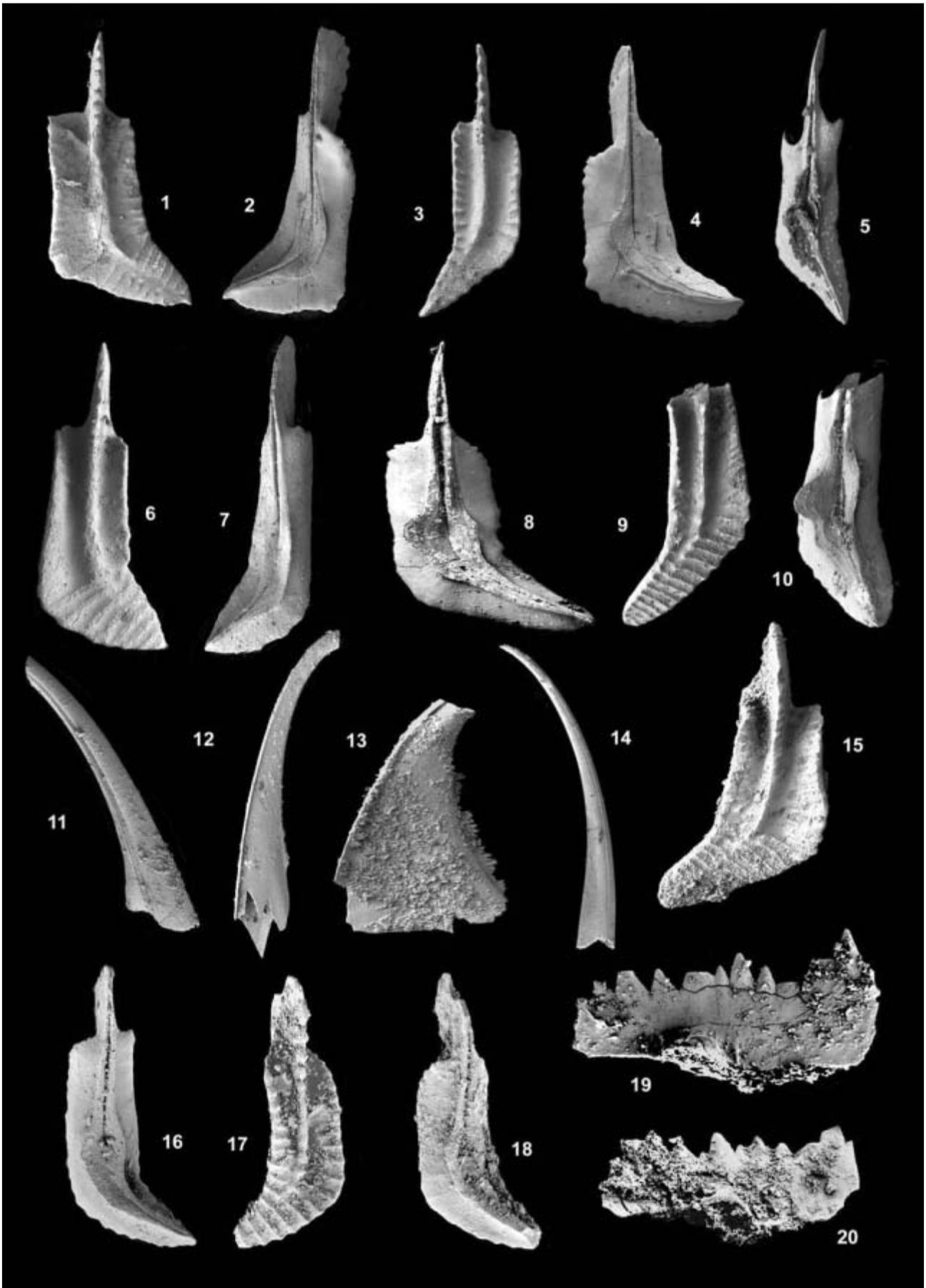
Plate I

Plate II

1–3, 6, 7 – *Polygnathus perbonus* (Philip, 1966).

1, 2 – upper and lower views respectively of AMF 125385 from PB-048/G, × 40; 3 – upper view of AMF 125386 from PB-048/A, × 40; 6 – upper and lower views respectively of AMF 125388 from PB-028/H, × 70.

4–5 – *Polygnathus nothoperbonus* Mawson, 1987.

Upper and lower views respectively of AMF 125387 from PB-061, × 40.

8–11 – *Polygnathus inversus* (Klapper and Johnson, 1975).

8 – lower view of AMF 125389 from PB-048/G, × 45; 9, 10 – upper and lower views respectively of AMF 125390 from PB-048/G, × 30; 11 – upper view of AMF 125391 from PB-048/J, x 50. Note abraded nature of the specimen.

12, 15 – *Belodella* sp. cf. *B. paucidentata* Moskalenko and Chegodaev, 1988.

12 – lateral view of AMF 125392 from PB-048/A, × 70; 15 – lateral view of AMF 125395 from PB-061, × 70.

13, 14 – *Dvorakia chattertoni* Klapper and Barrick, 1983.

13 – lateral view of Sd element, AMF 125396 from PB-048/A, × 60; 14 – lateral view of Sb element, AMF 125397 from PB-048/A, × 70; 15 – upper view of AMF 125426, × 60.

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Plate III

Note: Figures 1–14 are from the Greybanks Volcanics, Loc. 1; Figures 13–19 are from the Glendarriwell Beds, sample PBAN-100.

1, 3 – *Palmatolepis subperlobata* Branson and Mehl, 1934.

1 – upper view of AMF 125398, × 70; 3 – upper view of AMF 125400, × 70.

2 – *Palmatolepis minuta minuta* Branson and Mehl, 1934.

Upper view of AMF 125399, × 60.

4, 5 – *Palmatolepis crepida* Sannemann, 1955.

4 – upper view of AMF 125401, × 60; 5 – upper view of AMF 125402, × 70.

6 – *Polygnathus* sp. cf. *P. procerus* Sannemann, 1955.

Upper view of AMF 125403, × 120.

7 – *Polygnathus webbi* Stauffer, 1938.

Upper view of AMF 125404, × 40.

8 – *Polygnathus porrectus* Vorontzova and Kuz'min, 1984.

Upper view of AMF 125405, × 60.

9 – *Polygnathus buzmakova* Kuz'min, 1990.

Upper view of AMF 125406, × 60.

10–12 – *Icriodus iowaensis iowaensis* Youngquist and Peterson, 1947.

10 – upper view of AMF 125407, × 70. 11 – upper view of AMF 125408, × 60; 12 – upper view of AMF 125409, × 110. Note cell pattern developed on the upper surface of the left-hand side denticles.

13 – Unassigned Pb element.

Lateral view of AMF 125410, × 60.

14 – *Mehlina strigosa* (Branson and Mehl, 1934).

Lateral view of AMF 125411, × 60.

15–17, 19 – *Polygnathus karadjalis* Vorontsova and Kuz'min, 1984.

15, 16, upper and lower views respectively of AMF 125425, × 45; 17, enlargement of lower surface of anterior portion of the platform of AMF 125425, × 80, showing distinctive arrow-shaped structure; 19, upper view of AMF 125426, × 60.

18 – *Polygnathus hieroglyphica* Mawson and Talent, 1997.

Upper view of the posterior portion of platform of AMF 125427, × 40.

Plate III