Conodonts, Corals and Stromatoporoids from Late Ordovician and Latest Silurian Allochthonous Limestones in the Cuga Burga Volcanics of Central Western New South Wales

Yong Yi Zhen

Geological Survey of New South Wales, WB Clarke Geoscience Centre, 947-953 Londonderry Road, Londonderry, NSW 2753, Australia

Published on 5 October 2018 at https://openjournals.library.sydney.edu.au/index.php/LIN/index

Zhen, Y.Y. (2018). Conodonts, corals and stromatoporoids from Late Ordovician and latest Silurian allochthonous limestones in the Cuga Burga Volcanics of central western New South Wales. *Proceedings of the Linnean Society of New South Wales* **140**, 265-294.

Conodont faunas of two disparate ages were recovered from allochthonous limestone clasts within the Cuga Burga Volcanics of the Wellington region in central western New South Wales. A Late Ordovician conodont fauna comprising 12 species is confidently assigned to the *Taoqupognathus blandus* Biozone of early Katian age. Four other samples yielded latest Silurian conodonts including *Belodella resima*, *Belodella* sp., *Delotaxis detorta*?, *Dvorakia* sp., *Lanea*? *planilingua*, *Panderodus unicostatus*, *Pseudooneotodus beckmanni*, *Pseudooneotodus* sp., *Wurmiella excavata* and *Zieglerodina remscheidensis*. Rugose and tabulate corals found in association with the latest Silurian conodont samples include *Aphyllum lonsdalei*, *Aphyllum pachystele*, *Cystiphyllum* sp., *Tryplasma derrengullenense*, *Entelophyllum patulum yassense*?, *Pseudoplasmopora follis*, *Pseudoplasmopora* sp. cf. *P. heliolitoides*, *Striatopora* sp. A, *Striatopora* sp. B, *Syringopora* sp., and Favositidae gen. et sp. indet. Associated late Silurian stromatoporoids include *Amphipora* sp., *Clavidictyon*? sp., *Schistodictyon webbyi* sp. nov. and *Syringostromella* sp. *Tryplasma derrengullenense* Etheridge, 1907 is revised based on thin sections prepared from the lectotype and a topotype and re-examination of the other type specimens.

Manuscript received 10 July 2018, accepted for publication 16 September 2018

KEYWORDS: biostratigraphy, conodonts, corals, Cuga Burga Volcanics, Lachlan Orogen, Ordovician, Silurian, stromatoporoids.

INTRODUCTION

The Early Devonian (Lochkovian) age of the Cuga Burga Volcanics on the northern Molong High in central western New South Wales is based on its stratigraphic position, variously overlying the Barnby Hills Shale and Hanover Formation of late Silurian age (Rickards et al. 2005), and in other places sitting conformably on the Camelford Limestone that spans the Silurian – Devonian boundary. Stratigraphic units conformably overlying the Cuga Burga Volcanics include the Garra Formation (Lochkovian to Pragian age) and the Tolga Member of the Cunningham Formation (Mawson and Talent 2000; Talent and Mawson 1999). Internal evidence for the age of the Cuga Burga Volcanics is not as precise, as fossils are only present in allochthonous limestones and have not been extensively studied. Conodonts and macrofossils from these allochthonous limestones were previously reported briefly in publications by Strusz (1960, 1961), Bischoff (1981), Meakin and Morgan (1999), Cherns et al. (2004) and Farrell (2004a), in several unpublished honours theses (Kemežys 1959; Bunny 1962; Vandyke1970; Morton 1974) and in an internal report of the Geological Survey of NSW [GSNSW] (Percival 1998). Documented herein are conodonts and associated macrofossils (corals and stromatoporoids) collected from allochthonous limestones within the Cuga Burga Volcanics in the area immediately south and east of Wellington (Fig. 1) during the GSNSW mapping program of the Dubbo 1:250,000 Sheet (2nd edition) in 1997-1998

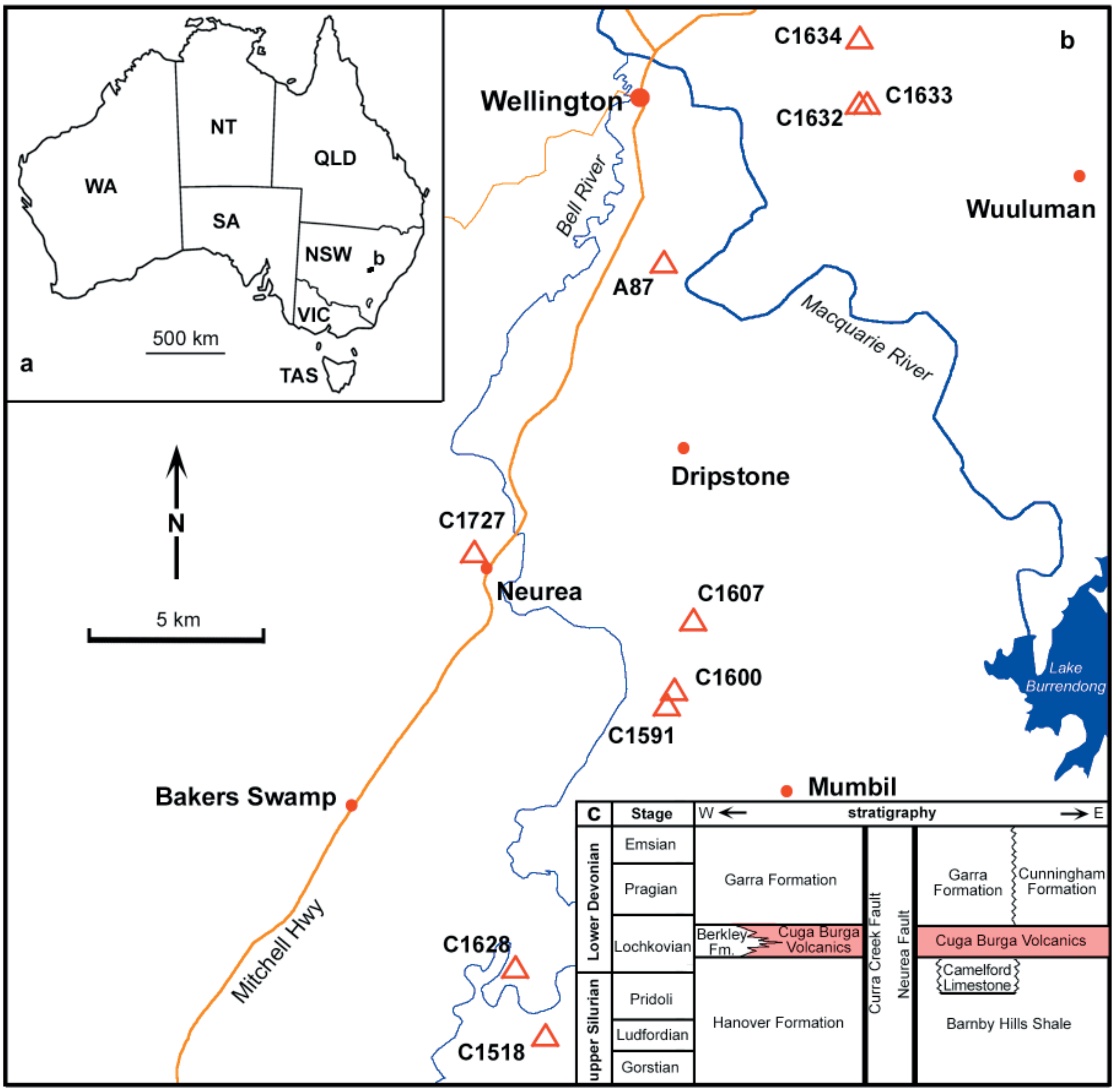

Figure 1. Location maps and stratigraphy of the study area; a, map of Australia showing the location of the study area (Fig. 1b) in central western New South Wales; b, map showing the study area immediately south and east of Wellington and the sample locations from allochthonous limestones in the Cuga Burga Volcanics (base map based on Google Earth); c, Stratigraphy of the Cuga Burga Volcanics (modified after Meakin and Morgan 1999, fig. 1; Fergusson 2010 fig. 4; Mawson and Talent 2000).

and an additional conodont sample (A87) obtained by G. Bischoff. This contribution represents the first palaeontological study focussed on the fossils from the Cuga Burga Volcanics, and provides new data to confirm the allochthonous origin and possible sources of the limestone clasts in this volcanic unit. The study will enable a better understanding of the regional palaeogeography and tectonostratigraphic implications of tectonic events affecting the northern Lachlan Orogen preceding the Early Devonian.

REGIONAL GEOLOGY AND DISTRIBUTION OF THE CUGA BURGA VOLCANICS

The Cuga Burga Volcanics was formally named by Strusz (1960, fig. 2) for the volcanic succession of lava flows, tuffs, breccias, and associated sandstones, siltstones and limestones exposed on both sides of the Oakdale Anticline, immediately south of Wellington (Fig. 1). The nomenclatural history of the unit and its current definition and distribution mainly in the

Dubbo and Bathurst 1:250,000 map sheet areas were reviewed by Meakin and Morgan (1999). The Cuga Burga Volcanics is dominated by shoshonitic latitic volcanic and volcaniclastic rocks with minor lithological components identified as three unnamed members, namely detrital limestone horizons, trachyte and latite intrusions, and trachyte and rhyolite units (Morton 1974; Meakin and Morgan 1999). Although it generally forms easily recognizable rocky hills or walls in the area due to stronger resistance to erosion, no continuous section of the formation is available and the type section is yet to be established. Therefore the lithofacies distribution, internal stratigraphy and detailed correlation of this volcanic unit are still poorly understood.

The thickness of the Cuga Burga Volcanics is highly variable, ranging from a maximum thickness of approximately 1300 m estimated from the outcrops exposed southwest of Stuart Town (Kemežys 1959; Packham 1969; Morton 1974, p. 9; Mawson and Talent 2000; Talent and Mawson 1999), 640 m thick in the Mumbil area (Strusz 1960), about 400 m thick to the north of the Wuuluman Granite, to only 50 m thick in the Four Mile Creek area which represents its most southern exposure (Meakin and Morgan 1999). At a location west of Stuart Town, the Cuga Burga Volcanics was reported missing, with Cunningham Formation directly resting on the Barnby Hills Shale (Packham 1969, p. 140).

Strusz (1960, p. 132) indicated that around the Oakdale Anticline the Cuga Burga Volcanics directly overlay the Barnby Hills Shale and was overlain by the Tolga Member (a calcarenite unit) of the Cunningham Formation (also see Morton 1976). Meakin and Morgan (1999, fig. 1; Fig. 1c) provided a more comprehensive overview of contact relationships of the Cuga Burga Volcanics with underlying and overlying stratigraphic units in the Dubbo 1:250,000 map sheet area. The Lochkovian age (*eurekaensis* conodont Biozone to lower *pesavis* conodont Biozone) now accepted for the Cuga Burga Volcanics relies on these regional stratigraphic contact relationships, specifically derived from conodont biozonation of overlying and underlying stratigraphic units (Talent and Mawson 1999; Meakin and Morgan 1999; Fig. 1c). A Přidoli (*eosteinhornensis* conodont Biozone) to Lochkovian (*eurekaensis* conodont Biozone or possibly early *delta* conodont Biozone) age for the Camelford Limestone was based on the conodont faunas recovered from several measured sections of this unit exposed in the Gap and Camelford Park areas, south of Wellington (Farrell 2004a, 2004b). Intensive studies of conodonts from the Garra Formation that overlies the Cuga Burga Volcanics demonstrated that its base was diachronous, varying from the *delta* conodont Biozone to the *pesavis* conodont Biozone of the upper Lochkovian (Wilson 1987; Mawson et al. 1988; Talent and Mawson 1999; Farrell 2004a). Packham et al. (2001) indicated that the base of the Cunningham Formation was also diachronous from late Lochkovian (*delta* conodont Biozone) on the west flank of the Hill End Trough to late Pragian in the east.

Meakin and Morgan (1999, fig. 9) presented a palaeogeographic model demonstrating the development during the Lochkovian of various stratigraphic units on the Molong Arch (referred to as Molong High, Molong Platform or Mumbil Shelf by various authors) and on the Cowra Trough to the west and Hill End Trough to the east in central NSW. They identified at least five eruptive centres in the region, which generated the material for the deposition of the Cuga Burga Volcanics. Widespread volcanic activity in the late Silurian and Early Devonian reflected thermal instability in the region and acted as a prelude (with alternating episodes of contraction and extension) of the Tabberabberan Orogeny in the Middle Devonian (Fergusson 2010).

METHODS AND REPOSITORY

All the limestone samples were cut for preparation of coral and stromatoporoid thin sections before they were dissolved in 10% acetic acid. The resulting insoluble residues were separated using sodium polytungstate solution to reduce the residue volume for picking. Illustrated specimens were gold coated and photographed by SEM using a mix of secondary and backscattered electrons. Figures 2-6 are SEM photomicrographs of conodonts captured digitally (numbers with the prefix IY are the file names of the digital images). 70 conodont specimens are figured and bearing the prefix MMMC (MMMC5242 to MMMC5311 inclusive). They are deposited in the microfossil collection, and corals (Figs 7-11) and stromatoporoids (Fig. 12) in the macrofossil collection (prefix MMF), of the Geological Survey of New South Wales, housed at the WB Clarke Geoscience Centre at Londonderry in outer western Sydney. For the corals and stromatoporoids illustrated in Figures 7-12, each MMF number represents one rock sample, from which one or more thin sections were prepared (each with a suffix a, b, c etc, following the MMF number). On each thin section, if multiple taxa occur, they are annotated with a suffix -1, -2 -3 etc after the thin section catalogue number, such as MMF34020b-1 (*Tryplasma derrengullenense*) and MMF34020b-2 (*Entelophyllum patulum yassense*?).

Locations	allochthonous limestones	Ordovician	latest Silurian									
	Species / Sample numbers	A87	C1600	C1591	C1607	C1628	C1518	C1627	C1632	C1633	C1634	Total
Conodonts	*Belodina confluens* Sweet, 1979	27										27
	Besselodus fusus Zhen in Zhen et al., 2015	1										1
	Chirognathus cliefdenensis Zhen and Webby, 1995	18										18
	Drepanoistodus suberectus (Branson and Mehl, 1933)	4										4
	Panderodus gracilis (Branson and Mehl, 1933)	114										114
	Panderodus sp. Zhen, Webby and Barnes, 1999	11										11
	Periodon grandis (Ethington, 1959)	16										16
	Pseudooneotodus mitratus (Moskalenko, 1973)	1										1
	Taoqupognathus blandus An in An et al., 1985	10										10
	Venoistodus sp.	1										1
	Yaoxianognathus? tunguskaensis (Moskalenko, 1973)	38										38
	Yaoxianognathus sp. cf. *Y. yaoxianensis* An in An et al., 1985	2										2
	Belodella resima (Philip, 1965)		3	3								6
	Belodella sp.			1								1
	Delotaxis detorta? (Walliser, 1964)		1		2							3
	Dvorakia sp.		7									7
	Lanea? planilingua (Murphy and Valenzuela-Rios, 1999)		1		2	1?						4
	Panderodus unicostatus (Branson and Mehl, 1934)		36	15		5						56
	Panderodus sp.								5	10		15
	Pseudooneotodus beckmanni (Bischoff and Sannemann, 1958)		1									1
	Pseudooneotodus sp.				1							1
	Wurmiella excavata (Branson and Mehl, 1933)		8	1								9
	Zieglerodina remscheidensis (Ziegler, 1960)		10	4	11	3						28
	Total conodont specimens yielded	243	67	24	16	9	0	0	5	10	0	359
Rugose corals	*Aphyllum lonsdalei* (Etheridge, 1890)			X			X	X				
	Aphyllum pachystele Munson and Jell, 2016		X				X				X	
	Cystiphyllum sp.			X			X					
	Tryplasma derrengullenense Etheridge, 1907							X				
	Entelophyllum patulum yassense? (Etheridge, 1892)			X				X				
Tabulate corals	*Striatopora* sp. A			X				X				
	Striatopora sp. B		X	X			X				X	
	Favositid gen. et sp. indet.		X									
	Pseudoplasmopora follis (Milne-Edwards and Haime, 1851)										X	
	Pseudoplasmopora sp. cf. *P. heliolitoides* (Lindstrom, 1899)							X	X			
	Syringopora sp.							X				
Stromatoporoids	*Amphipora* sp.							X				
	Clavidictyon? sp.							X				
	Schistodictyon webbyi sp. nov.							X				
	Syringostromella sp.		X	X			X	X				

Table 1. Distribution of conodont species from five limestone samples, and corals and stromatoporoids in six limestone samples (X marking occurrence of species in each sample) of the Cuga Burga Volcanics.

Type material of *Tryplasma derrengullenense* Etheridge, 1907, including the Lectotype (AM F.9789, FT.15449 and FT.15450), paralectotypes (AM F.9707 and AM F.50623), and two topotypes (AM F.9793, AM F.9794, FT.15451 cut from AM F9794) are housed at the Australian Museum, Sydney.

NOTE: FIGURES 2-12 ARE LOCATED FOLLOWING THE REFERNCES

MATERIAL AND SAMPLE LOCALITIES

A total of 359 identifiable conodont specimens (Table 1) were recovered from seven limestone samples, including 243 specimens from the Upper Ordovician sample (A87) and 116 specimens from the remaining six samples of Silurian age (mostly latest Silurian). The CAI of the conodonts from these samples is about 3.5 to 4. The limestones are moderately recrystallized with microstructure details of corals and stromatoporoids altered and generally poorly preserved. However, alteration seems variable among specimens allowing some better-preserved specimens to be studied and illustrated in this contribution.

Sample A87 was collected and processed by the late Dr Günther Bischoff from a limestone megaclast (about 3 m in length) in the Cuga Burga Volcanics, exposed immediately north of the road from Red Hill to Apsley about 400 m E of Apsley (about 400 m E of Railway crossing; grid ref. 32.592222°S, 148.951111°E, see Bischoff 1981, p. 176), 4.5 km SSE of Wellington (Fig. 1). This sample produced a well preserved and diverse Late Ordovician (early Katian) conodont fauna including *Belodina confluens* Sweet, 1979 (Fig. 2a-g), *Besselodus fusus* Zhen in Zhen et al., 2015 (Fig. 2h-i), *Chirognathus cliefdenensis* Zhen and Webby, 1995 (Fig. 2j-n), *Drepanoistodus suberectus* (Branson and Mehl, 1933) (Fig. 2o-p), *Panderodus gracilis* (Branson and Mehl, 1933) (Fig. 3f-k), *Panderodus* sp. Zhen, Webby and Barnes, 1999 (Fig. 3l-o), *Periodon grandis* (Ethington, 1959) (Fig. 3a-e), *Pseudooneotodus mitratus* (Moskalenko, 1973) (Fig. 4h), *Taoqupognathus blandus* An in An et al., 1985 (Fig. 4a-g), *Venoistodus* sp. (Fig. 2q), *Yaoxianognathus*? *tunguskaensis* (Moskalenko, 1973) (Fig. 4i-j) and *Yaoxianognathus* sp. cf. *Y. yaoxianensis* An in An et al., 1985 (Fig. 4k). Bischoff (1981, p. 189) reported recovery of eight valves from this sample (A87) assignable to *Cobcrephora silurica* Bischoff, a problematic taxon originally considered to be a primitive chiton.

Aphyllum lonsdalei			
MMF	Sample No	Dc (mm)	Td (mm)
MMF33963a	C1591	10	1.5-3
MMF33963b	C1591	11x14	
MMF33979a-1	C1591	7	0.8
MMF33979b-1	C1591	8.5	
MMF33980	C1591	6	1
MMF34018a-1	C1627	6	
MMF34019-1	C1627	5	0.8-1
MMF34024a	C1627	7x9	
MMF34024b	C1627	7	1-2
MMF34024c	C1627	7	1-2
MMF 34026	C1627	6	
MMF34006a	C1518	8	2-3
MMF34006b	C1518	8	1-2
MMF 34006c	C1518	9	
MMF34011a	C1518	15	1.8-4
MMF34011b	C1518	12x15	
MMF34012a	C1518	16	2-4
MMF34012b	C1518	16	
MMF34012c	C1518	15	1.5-3
Aphyllum pachystele			
MMF34061a	C1600	19	5
MMF34061b	C1600	10	5
MMF34063a	C1600	16	
MMF34063b	C1600	11	3-5
MMF34008a	C1518	13-19	5
MMF34008c	C1518	13x15	4
MMF34008d	C1518	14	4-5
MMF34085a	C1634	7-19	2-4
MMF34085b	C1634	21	2-9

Table 2. Measurements of the corallite diameter (Dc) and vertical distance between tabulae (Td) of *Aphyllum lonsdalei* (Etheridge, 1890) and *Aphyllum pachystele* Munson and Jell, 2016 from five limestone samples of the Cuga Burga Volcanics.

Sample C1600 (8 kg; grid ref. 32.707499°S, 149.011609°E; Fig. 1) was collected from a light grey-pink, birds-eye limestone clast associated with corals and stromatoporoids from "Tolga", east of Tabletop Hill. Sample C1591 (7.9 kg; grid ref. 32.711902°S, 149.011167°E; Fig. 1) was collected from a fine-grained, pink-grey, birds-eye limestone clast of similar lithology in the same vicinity. These two samples yielded a similar conodont fauna (Tables 1-3) including *Belodella resima* (Philip, 1965) (Fig. 5a-e), *Belodella* sp. (Fig. 5f), *Delotaxis detorta*? (Walliser, 1964), *Dvorakia* sp. (Fig. 5g), *Lanea*? *planilingua* (Murphy and Valenzuela-Rios, 1999) (Fig. 6a), *Panderodus unicostatus* (Branson and Mehl, 1933) (Fig. 5l-n), *Pseudooneotodus beckmanni*

MMF34010a	MMF34008d	MMF34008c	MMF34008b	MMF34008a	MMF34007b	MMF34007a	MMF34006c	MMF34006b	MMF34006a	MMF33980	MMF33979b	MMF33979a	MMF33978	MMF33977	MMF33976	MMF33975	MMF33963b	MMF33963a	MMF33962b	MMF33962a	MMF33960b	MMF33960a	MMF33959c	MMF33959b	MMF33959a	MMF34063b	MMF34063a	MMF34062b	MMF34062a	MMF34061b	MMF34061a	**MMF numbers**
C1518	C1518	C1518	C1518	C1518	C1518	C1518	C1518	C1518	C1518	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1591	C1600	C1600	C1600	C1600	C1600	C1600	**Localities**
							X	X	X	X	X	X					X	X														*Aphyllum lonsdalei* (Etheridge, 1890)
	X	X	X	X																					X	X	X			X	X	*Aphyllum pachystele* Munson and Jell, 2016
X					X																											*Cystiphyllum* sp.
																																Tryplasma derrengullenense Etheridge, 1907
																																Entelophyllum patulum yassense? (Etheridge, 1892)
														X	X																	*Striatopora* sp. A
					X	X					X	X	X			X			X	X	X	X	X	X	X			X	X			*Striatopora* sp. B
																												X				Favositidae gen. et sp. indet.
																																Pseudoplasmopora follis (Milne-Edwards and Haime, 1851)
																																Pseudoplasmopora sp. cf. *P. heliolitoides* (Lindstrom, 1899)
																																Syringopora sp.
																																Amphipora sp.
																																Clavidictyon? sp.
																																Schistodictyon webbyi sp. nov.
																																Syringostromella sp.

MMF34088c	MMF34088b	MMF34088a	MMF34085b	MMF34085a	MMF34028	MMF34027	MMF34026	MMF34024d	MMF34024c	MMF34024b	MMF34024a	MMF34023b	MMF34023a	MMF34022c	MMF34022b	MMF34022a	MMF34021a	MMF34020c	MMF34020b	MMF34020a	MMF34019	MMF34018a	MMF34017b	MMF34017a	MMF34012c	MMF34012b	MMF34012a	MMF34011b	MMF34011a	MMF34010b	**MMF numbers**
C1634	C1634	C1634	C1634	C1634	C1632	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1627	C1518	C1518	C1518	C1518	C1518	C1518	**Localities**
							X		X	X	X										X	X			X	X	X	X	X		*Aphyllum lonsdalei* (Etheridge, 1890)
			X	X																											*Aphyllum pachystele* Munson and Jell, 2016
																									X	X				X	*Cystiphyllum* sp.
																			X	X											*Tryplasma derrengullenense* Etheridge, 1907
																		X	X												*Entelophyllum patulum yassense*? (Etheridge, 1892)
												X	X																		*Striatopora* sp. A
																															Striatopora sp. B
																															Favositidae gen. et sp. indet.
X	X	X																													*Pseudoplasmopora follis* (Milne-Edwards and Haime, 1851)
					X												X					X									*Pseudoplasmopora* sp. cf. *P. heliolitoides* (Lindstrom, 1899)
												X	X	X																	*Syringopora* sp.
												X	X																		*Amphipora* sp.
																						X									*Clavidictyon*? sp.
						X									X	X							X	X							*Schistodictyon webbyi* sp. nov.
								X																							*Syringostromella* sp.

Table 3. List of rugose and tabulate coral and stromatoporoid species recovered from six limestone samples in the Cuga Burga Volcanics (X marking occurrence of species in each thin section).

(Bischoff and Sannemann, 1958) (Fig. 5k), *Wurmiella excavata* (Branson and Mehl, 1933) (Fig. 6c-e) and *Zieglerodina remscheidensis* (Ziegler, 1960) (Figs 5i, 6f, h-k, n-o). Associated in the limestone samples are abundant rugose and tabulate corals (Tables 1-3), including *Aphyllum lonsdalei* (Etheridge, 1890) (Fig. 7b-c, j-k), *Aphyllum pachystele* Munson and Jell, 2016 (Fig. 8a-b, e), *Cystiphyllum* sp., *Entelophyllum* *patulum yassense*? (Etheridge, 1892), *Striatopora* sp. A, *Striatopora* sp. B (Fig. 10e), Favositid gen. et sp. indet. (Fig. 11e), and the stromatoporoid *Syringostromella* sp.

Sample C1607 (7.8 kg; grid ref. 32.689087°S, 149.011082°E; Fig. 1, Table 1) was from a grey-green limestone clast exposed on "Catombal Park" property; it yielded *Delotaxis detorta*? (Fig. 5h), *Lanea*? *planilingua* (Fig. 6b), *Pseudooneotodus* sp. (Fig. 5j) and *Zieglerodina remscheidensis* (Fig. 6g, l-m).

Sample C1628 (8 kg, grid ref. 32.784373°S, 148.990911°E; Fig. 1, Table 1) was from a dark grey, sandy limestone clast exposed near the Bell River. It produced *Panderodus unicostatus*, *Zieglerodina remscheidensis* and a doubtful Pa specimen of *Lanea*? *planilingua*.

Sample C1633 (7.5 kg, grid ref. 32.541400°S, 149.014383°E; Fig. 1, Table 1) from a light to medium grey, sheared limestone exposed on "Brookfield" property, Burrendong, yielded only a few specimens of *Panderodus* sp. Sample C1632 (7.7 kg, grid ref. 32.541428°S, 149.012681°E; Fig. 1, Table 1) from same property also yielded *Panderodus* sp. and a poorly preserved tabulate coral specimen assigned to *Pseudoplasmopora* sp. cf. *P. heliolitoides* (Lindström, 1899).

Conodonts were absent from the following three samples, but they yielded corals and stromatoporoids. Sample C1634 (8.2 kg, grid ref. 32.522597°S, 149.005873°E; Fig. 1) from a pink-red limestone clast exposed on "Hillingdale" property, Burrendong, produced several corals (Tables 1-3) including *Aphyllum pachystele* (Fig. 8c-d), *Striatopora* sp. B and *Pseudoplasmopora follis* (Milne-Edwards and Haime, 1851) (Fig. 11a-b). Sample C1627 (8.4 kg, grid ref. 32.687594°S, 148.939809°E; Fig. 1, Tables 1-3) from a dark grey brecciated limestone exposed at Bells Mine, Wellington, yielded a diverse coral and stromatoporoid fauna including *Aphyllum lonsdalei* (Fig. 7a, d-f), *Tryplasma derrengullenense* Etheridge, 1907 (Fig. 9a-b), a phaceloid rugose coral (strongly recrystallized and indeterminate), *Striatopora* sp. A (Fig. 10a-b), *Pseudoplasmopora* sp. cf. *P. heliolitoides* (Fig. 11c-d), *Syringopora* sp. (Fig. 10a-b), *Amphipora* sp. (Fig. 10a-b), *Clavidictyon*? sp. (Fig. 12h), *Schistodictyon webbyi* sp. nov. (Fig. 12a-f) and *Syringostromella* sp. (Fig. 12g). Sample C1518 (7.5kg, grid ref. 32.797783°S, 149.005419°E; Fig. 1, Tables 1-3) from limestone clasts exposed SE of Bell River yielded several corals including *Aphyllum lonsdalei* (Fig. 7g-i, l), *Aphyllum pachystele* (Fig. 8f-g), *Cystiphyllum* sp. (Fig. 9e-h), *Striatopora* sp. B (Fig. 10c-d) and poorly preserved *Syringostromella* sp.

LATE ORDOVICIAN CONODONT FAUNA AND BIOSTRATIGRAPHIC CORRELATION

The Late Ordovician conodont fauna (Figs 2-4, Table 1) recovered from sample A87 is typical of the *Taoqupognathus blandus* conodont Biozone defined by Zhen (2001) and widely recognized in eastern Australia (Zhen and Webby 1995; Zhen et al. 1999, 2003; Zhen and Percival 2017). Apart from the nominal species, another 11 species were recovered from this limestone. All of them were previously reported from the *T. blandus* conodont Biozone in NSW. Zhen and Percival (2017, fig. 2) suggested an early Katian age (late Ka1) for the *T. blandus* Biozone and correlated it with the *Diplacanthgraptus spiniferus* Biozone (Eastonian 2) and basal part of the overlying *Dicranograptus kirki* Biozone (Eastonian 3) of the Australian graptolite succession.

A conodont fauna of the *T. blandus* Biozone was also reported from allochthonous limestones in the underlying late Silurian Barnby Hills Shale exposed between two major parallel faults (Eurimbla Fault and Curra Creek Thrust Fault) in the area (Zhen et al. 2003, fig. 1). The Bowan Park Limestone Subgroup or a contemporary unit might be the original source of these Late Ordovician limestone clasts.

LATEST SILURIAN CONODONT FAUNA

A late Silurian (mostly likely late Přidoli) conodont fauna (Figs 5-6) was recovered from six productive samples collected from allochthonous limestones in the Cuga Burga Volcanics, represented by 10 species (Fig. 1, Table 1). Among the named species, *Panderodus unicostatus* and *Pseudooneotodus beckmanni* had relatively long stratigraphic ranges extending though the entire Silurian to Lower Devonian, and *Wurmiella excavata* was common from the lower Silurian to Lower Devonian (Corradini and Corriga 2010). *Belodella resima* was reported from the Ludlow to Upper Devonian (Druce 1975; Boogaard 1983; Corriga et al. 2009; Corriga and Corradini 2009; Corradini and Corriga 2012). Despite widespread taxonomic disagreement among Silurian conodont workers and lack of a full multi-element revision of this species originally proposed by Walliser (1964) as a form species from the famous Cellon section, near the Austria/Italy border, *Delotaxis detorta* is the nominal species of the conodont Biozone recognized in the upper part of the Přidoli in Europe. It has a stratigraphic range restricted to the upper Přidoli or possibly extending into the basal Lochkovian (Jeppsson 1988; Corradini and Corriga

2012; Corradini et al. 2017). Jeppsson (1974, p. 22) indicated that at the Cellon section, the population represented by the holotype had a small denticle between some of the large ones. This distinctive character has also been observed in some of the specimens recovered from the Cuga Burga Volcanics (Fig. 5h). However, Carls et al. (2007, pp. 150-151, figs 3, 8) argued that this feature was not unique to *D. detorta* and the alternating small denticles were seen only in some of the specimens that they illustrated as *D. detorta* from the GSSP for the Přidoli Series in the Prague Synform. Both *Lanea*? *planilingua* and *Zieglerodina remscheidensis* in the fauna from the Cuga Burga Volcanics are also characteristic of late Přidoli faunas and useful for age determination. They both have a stratigraphic range constrained to the Přidoli and Lochkovian (Corriga et al. 2009; Corradini and Corriga 2012; Peavey 2013; Zhen et al. 2017). Particularly the former, *Lanea*? *Planilingua,* is restricted to a stratigraphical interval from the uppermost Přidoli to middle Lochkovian, recorded in North America (Peavey 2013), Europe (Murphy and Valenzuela-Rios, 1999; Drygant and Szaniawski 2012; Slavík et al. 2012; Corriga et al. 2014), and in the Camelford Limestone (Farrell 2004a) and the Amphitheatre Group (Zhen et al. 2017) of NSW. However, lack of icriodontids and other definite Devonian forms (e.g. *Lanea* and *Ancyrodelloides*) in the current fauna together with the co-occurrence of *Delotaxis detorta*?, *Lanea*? *planilingua* and *Zieglerodina remscheidensis* supports a latest Silurian (late Přidoli) age for the fauna documented herein.

A conodont fauna of Přidoli age was reported from the Barnby Hills Shale (Farrell 2006) and the basal part of the Camelford Limestone (Farrell 2001, 2004a, 2004b, 2006), which directly beneath the Cuga Burga Volcanics in the study area, south of Wellington. Farrell (2006) interpreted isolated limestone outcrops that yielded the Přidoli conodont fauna as mostly likely “grounded” remnants of the Camelford Limestone along the fault line.

CORAL FAUNAS AND THEIR AGE

Four coral assemblages were recognized in the Silurian System in Australia, mainly based on studies from NSW (Strusz 1989, 1995; Strusz and Munson 1997; Munson et al. 2001). The upper Silurian (Ludlow and probably Přidoli) coral faunas referred to as the Hatton’s Corner Assemblage were reported from the Hattons Corner Group at Yass, the upper Yarrangobilly Limestone, Cooleman Limestone, and Quidong Limestone of southern NSW, and the Narragal Limestone, Bungonia Group, Barnby Hills Shale and Mirrabooka Formation in central NSW (Etheridge 1907; Jones 1932, 1936, 1937, 1944; Hill 1940, 1954; Strusz 1961, 1995; Sherwin 1971; McLean 1974, 1975, 1976; Munson et al. 2001). This assemblage is also known from Victoria (see Strusz 1995, p. 20) and the Jack Hills Member of the Jack Formation of northern Queensland (Hill et al. 1969; Munson and Jell 2016). Corals of late Silurian to Lochkovian age were reported from the Cookeys Plains Formation of central NSW (Földvary 2000) and from a dredged sample on the continental slope off southern NSW (Packham et al. 2006). The most distinctive features of the upper Silurian coral faunas are the dramatic decline to disappearance of halysitids and the appearance of several rugose coral species including *Yassia enormis* (Etheridge, 1913), *Toquimaphyllum spongophylloides* (Foerste, 1888), *T.*? *shearsbii* (Chapman, 1925), *Idiophyllum patulum* (Foerste, 1888), *Zelolasma*? *praecox* (Hill, 1940), and *Palaeocyathus australis* Foerste, 1888 (see Strusz 1995, fig. 3) and a number of tabulate corals (see Munson et al. 2001, figs 4-8).

The five rugose coral species in the Cuga Burga Volcanics samples, *Aphyllum lonsdalei*, *Aphyllum pachystele*, *Cystiphyllum* sp., *Tryplasma derrengullenense*, and *Entelophyllum patulum yassense*?, have been widely reported from the upper Wenlock and upper Silurian in New South Wales and Queensland. The type material of *Aphyllum lonsdalei* is from Hatton’s Corner near Yass, and it has also been reported from the various localities in the Yass, Bowning, Jenolan, Wellington and Molong areas (Etheridge 1907; Hill 1940; Strusz 1961; Pickett 2010) in central NSW. It has also been reported from reworked clasts in the Sharpeningstone Conglomerate (Lochkovian) in the Burrinjuck area of southeastern NSW (Percival and Zhen 2017). The type specimens of *Entelophyllum patulum yassense* are from the Ludlow of the Yass area (Jones 1936; Hill 1940; McLean 1976; Strusz and Munson 1997; Pickett 2010, p. 98), and it has also been reported from the upper Silurian of north Queensland (Ludlow, see Munson and Jell 2016) and possibly Inner Mongolia (Guo 1978). The type material of *Tryplasma derrengullenense* is from the upper Silurian exposed near Limestone Creek at Bowning in central NSW, and it has also been reported from the Cuga Burga Volcanics (Strusz 1961) in central western NSW and the Wenlock to Ludlow of the Broken River Province in north Queensland (Hill et al. 1969; Munson and Jell 2016). Both *Aphyllum pachystele* and *Cystiphyllum* sp. were previously only recorded from the Jack Formation of the Broken River Province with the former, *Aphyllum pachystele*, extending from upmost Wenlock to Ludfordian and the latter restricted to the Ludfordian (Munson and Jell 2016, fig. 4).

Among the six species of tabulate corals occurring in the current samples from the Cuga Burga Volcanics, only *Pseudoplasmopora follis* (Milne-Edwards and Haime, 1851) is identified to species level. It was widely distributed in the late Silurian and has been reported from Baltica (Gotland and eastern Europe), Eastern Laurentia (Michigan, Tennessee) and New South Wales (see Földvary 2006, fig. 1).

STROMATOPOROID FAUNA

In Australia, stromatoporoid faunas of late Silurian age were previously reported from the Mirrabooka Formation (Wenlock to Ludlow), Molong Limestone (Wenlock to Ludlow), the Hume Limestone and Bowspring Limestone members of the Silverdale Formation (Ludlow), and the Elmside Formation (Přidoli to Lochkovian) in the Yass region (Birkhead 1975, 1978) and from the Jack Formation (Wenlock to Přidoli) of north Queensland (Webby and Zhen 1997). The fauna from the Jack Formation is characterized by the occurrence of several distinctive clathrodictyids including *Ecclimadictyon*, *Plexodictyon*, *Schistodictyon* and *Simplexodictyon*. Among them, *Schistodictyon* with some 24 species recognized worldwide made its first appearance in the Ludlow (Nestor 2015; Webby et al. 2015). Morphological relationships between *Schistodictyon webbyi* sp. nov. from Sample C1627 in the Cuga Burga Volcanics and several previously known species of *Schistodictyon* in Australia are discussed in the following taxonomic section.

TAXONOMY OF SELECTED CORALS AND STROMATOPOROIDS

Five rugose coral species, two tabulate coral species and one new species of stromatoporoids are documented systematically in this section. Others including *Pseudoplasmopora* sp. cf. *P. heliolitoides* (Lindström, 1899) (Fig. 11c-d), *Syringopora* sp. (Fig. 10a-b), Favositidae gen. et sp. indet. (Fig. 11e), *Amphipora* sp. (Fig. 10a-b), *Clavidictyon*? sp. (Fig. 12h) and *Syringostromella* sp. (Fig. 12g) are illustrated only, as the available material is either insufficient or too poorly preserved to warrant formal taxonomic treatment.

Phylum COELENTERATA Frey and Leuckart, 1847
Subphylum CNIDARIA Hatschek, 1888
Class ANTHOZA Ehrenberg, 1834
Subclass RUGOSA Milne-Edwards and Haime, 1850
Family TRYPLASMATIDAE Etheridge, 1907
Genus *Aphyllum* Soshkina, 1937

Type species

Aphyllum sociale Soshkina, 1937.

Discussion

Hill (1981, p. F100) defined *Aphyllum* as including fasciculate species with lateral or peripheral and pseudoaxial increases. *Aphyllum lonsdalei* (Etheridge, 1890) and *Aphyllum pachystele* Munson and Jell, 2016 from the upper Silurian of Australia had parricidal peripheral increase. For *A. pachystele*, Munson and Jell (2016) reported six offsets from a parent corallite, while in *A. lonsdalei* Etheridge (1907, p. 78) recorded two offsets. In the current material four offsets are observed in a parent corallite (Fig. 7a).

Aphyllum lonsdalei (Etheridge, 1890)
Fig. 7a-l

Synonymy

Tryplasma lonsdalei Etheridge 1890, p. 15, pl. 1, figs 1-6; Etheridge, 1907, pp. 77-80, pl. 10, figs 1-3, pl. 11, figs 2-4, pl. 12, fig. 1, pl. 19, fig. 4, pl. 25, fig. 5, pl. 26, figs 1-7; Hill, 1940, pp. 406-407, pl. 12, figs 13, 14 (*cum syn*.); Strusz, 1961, pp. 343-344, pl. 42, figs 12, 13, text-fig. 4; Pickett, 2010, p. 76.

Tryplasma lonsdalei var. *scalariformis* Etheridge, 1907, pp. 80-81, pl. 12, figs 2, 3, pl. 14, fig. 4, pl. 24, figs 7, 8, 8 a, pl. 25, figs 1-4, pl. 26, figs 8-10.

Tryplasma lonsdalei var. *minor* Etheridge, 1907, pp. 81-2, pl. 16, figs 3, 4, pl. 24, fig. 9, pl. 25, figs 6, 7, pl. 26, fig. 11.

Material

19 thin sections associated with conodont samples C1591 (MMF33963a, MMF33963b, MMF33979a-1, MMF33979b-1, MMF33980), C1627 (MMF34018a-1, MMF34019-1, MMF34024a, MMF34024b, MMF34024c, MMF34026), and C1518 (MMF34006a, MMF34006b, MMF34006c, MMF34011a, MMF34011b, MMF3412a, MMF34012b, MMF34012c).

Diagnosis

Species of *Aphyllum* with loosely phaceloid coralla of parricidal peripheral increase; dimeter of corallites 6 mm in average with connecting tubules; short septal spines in two orders forming a thin peripheral stereozone; tabulae thin, commonly complete and horizontal (modified from Hill 1940, p. 406; Strusz 1961, p. 343).

Description

All available specimens are cylindrical or sub-cylindrical discrete corallites with a diameter (Dc) varying from 5-16 mm (Table 2), more commonly 5-10 mm; parricidal peripheral increase, with two or four offsets observed from parent corallites (Fig. 7a, h), suggesting loosely phaceloid coralla, but connecting tubules not observed; specimens moderately to strongly recrystallized with microstructure altered and obscured; septal spines short, formed of holacanths, in most specimens only just extending out of the peripheral stereozone (probably resulting from recrystallization, see Fig. 7g), whereas in better preserved specimens (Fig. 7a, j) two orders of septa are differentiated, major septa 1-1.5 mm long (one-third to half of the radius), minor septa also extending out of the peripheral stereozone, about one-third as long as the major; septal spines organized in rows on the corallite walls; peripheral stereozone composed of lamellar sclerenchyme tissue, 0.3-0.4 mm in thickness; tabulae thin, complete, commonly horizontal, or slightly concave in some specimens, widely spaced, inequidistant, 0.8-4 mm apart (Table 2, Fig. 7b, e-f, h-i, k-l); dissepiments absent.

Discussion

Hill (1940, p. 406) defined *T. lonsdalei* as a phaceloid species of *Tryplasma* with a mean corallite dimeter (Dc) of 6 mm and with connecting tubules. She selected the lectotype (AM F.35512) from the upper Silurian exposed at Hatton's Corner, Yass. Considering the wide Dc variation observed among the specimens from the Yass-Bowning area, she treated the two subspecies proposed by Etheridge (1907) (*T. lonsdalei* var. *scalariformis* with a mean Dc of 8 mm and *Tryplasma lonsdalei* var. *minor* with a Dc of 4-5 mm) as junior synonyms. Hill (1967, 1981) restricted *Tryplasma* to solitary species and transferred the fasciculate species that were previously referred to *Tryplasma* into *Aphyllum* Soshkina 1937. Ivanovskiy (1969) considered *Tryplasma lonsdalei* as a species of *Rhabdacanthia*, which was subsequently treated as a subjective synonym of *Aphyllum* (see Hill 1981, p. F100). These views are followed herein. Etheridge (1907, p. 80) noted that the diameter of corallites in *T. lonsdalei* var. *scalariformis* varied from 8 to 10 mm and reached a maximum of 15 mm. In the specimens from the allochthonous limestones in the Cuga Burga Volcanics, diameters of corallites (Dc) vary from 5 to 16 mm (Table 2), and are generally larger than the types illustrated from Hatton's Corner near Yass, but are more comparable with the variety originally referred to as *T. lonsdalei* var. *scalariformis* by Etheridge (1907). Same variation in corallite sizes of this species was also reported from the Narragal Limestone and Barnby Hills Shale (Strusz 1961) and from the Burrawong Limestone (Zhen 2018) in central western NSW. However, some specimens in the current material are even larger in diameter (reaching 21 mm) and the distance between tabulae is also highly variable (Fig. 8). Considering the average larger size of the corallites in these specimens, they are assigned to *Aphyllum pachystele* Munson and Jell, 2016 (see discussion below).

Aphyllum newfarmeri (Merriam, 1973) from the Roberts Mountains Formation (Fauna C, Ludlow) of the Great Basin, USA differs from *A. lonsdalei* in having a smaller size of corallites (Dc 4-5 mm) and more widely spaced tabulae, and lacks connecting tubules (Merriam 1973, 1976).

Aphyllum pachystele Munson and Jell, 2016
Fig. 8a-g

Synonymy

Aphyllum pachystele Munson and Jell, 2016, pp. 289-291, fig. 9A-M.

Material

Eleven thin sections associated with conodont samples C1600 (MMF34061a, MMF34061b, MMF34063a, MMF34063b), C1591 (MMF33959a-1), C1634 (MMF34085a, MMF34085b) and C1518 (MMF34008a, MMF34008b, MMF34008c, MMF34008d).

Diagnosis

See Munson and Jell (2016, p. 289).

Description

Specimens discrete cylindrical or sub-cylindrical discrete corallites with a diameter (Dc) varying from 7-21 mm (Table 2); parricidal peripheral increase (Fig. 8b), connecting tubules uncommon, and observed only in a few specimens (Fig. 8e); specimens moderately to strongly recrystallized with microstructure altered and obscured; septal spines short and numerous, composed of holacanths, and in most specimens only just extending out of the peripheral stereozone; the latter is composed of lamellar sclerenchyme tissue up to 1 mm in thickness; tabulae thin, mostly complete, commonly horizontal to gently concave with a central sag in some specimens (Fig. 8d), widely spaced, inequidistant, 2-9 mm apart (Table 2, Fig. 8b-e, g), peripherally rarely supported by inclined tabellae; dissepiments absent.

Discussion

Aphyllum pachystele differs from *A. lonsdalei* by having a larger size of corallites (maximum diameter 25-30 mm), numerous septa (110-120 septa in adult) and more widely spaced tabulae (4-5/10 mm), which are flat or gently sagging and rarely supplemented with declined peripheral tabellae. The type material from the Jack Formation (upper Wenlock to Ludfordian) of the Broken River Province in northeast Queensland shows the distinctive parricidal increase with six offsets, common appearance of connecting tubules and rhabdacanthine septa (Munson and Jell, 2016). Although specimens from the Cuga Burga Volcanics are rather poorly preserved due to recrystallization, they are comparable with the types from northeast Queensland in respect of the size of corallites and the general features of septa, tabulae and peripheral stereozone.

Genus *Tryplasma* Lonsdale, 1845

Type species

Tryplasma aequabile Lonsdale, 1845.

Tryplasma derrengullenense Etheridge, 1907
Figs 8h-r, 9a-b

Synonymy

Tryplasma derrengullenensis Etheridge, 1907, pp. 88, pl. 22, figs 5-8..

Tryplasma derrengullenensis? Etheridge; Strusz, 1961, pp. 345-346, pl.42, fig. 14, pl. 43, fig. 12.

Tryplasma derrengullenense Etheridge; Munson and Jell, 2016, pp. 287-288, fig. 6A-F.

Material

Lectotype (AM F.9789, FT.15449, FT.15450), paralectotypes (AM F.9707, AM F.50623), and topotypes (AM F.9793 and AM F.9794 illustrated by Hill 1940; and FT.15451 newly prepared from AM F.9794) from the upper Silurian exposed in the vicinity of Limestone Creek (more precisely in Derrengullen Creek just above its confluence with Limestone Creek) near Bowning, west of Yass, NSW. One specimen figured herein associated with conodont sample C1627 (MMF34020a, MMF34020b-1).

Diagnosis

Small ceratoid to turbinate *Tryplasma*, diameter 5-18 mm, with irregular rejuvenescence, a deep calice and often trabeculae on distal surfaces of tabulae; rhabdacanthine septa (up to 78-86 in largest specimens) in two orders forming a prominent peripheral stereozone of variable width (0.23-2 mm); tabulae mostly complete, flat or concave and commonly spaced at 8-12 per 10 mm (modified from Hill 1940, p. 407 and Munson and Jell 2016, p. 287).

Description

External

Small solitary coralla, ceratoid, trochoid or turbinate, erect or slightly curved with irregular rejuvenescence and with the maximum diameter in adults ranging from 11 to 16 mm; lectotype (AM F.9789) is a solitary corallum with a maximum diameter (Dc) of 13.14 mm and a total length of 44.10 mm, consisting of the trochoid mother corallum with deep calice and successive daughter offsets by irregular rejuvenescence with growth directions changed several times (Fig. 8h); one of the paralectotypes (AM F.9707) is trochoid with a maximum diameter of 13.98 mm and a length of 22.43 mm with four daughter offsets developed in the calice (Fig. 8i-j); paralectoype AM F.50623 is turbinate with a wider apical angle (about 70°), maximum diameter of 11.15 mm and length of 11.19 mm (Fig. 8k); two topotype specimens illustrated by Hill (1940, pl. 12, fig. 16), both ceratoid; one (AM F.9793) with a maximum diameter of 12.74 mm and a measured length of 28.07 mm and with irregular rejuvenescence, outer surface of corallum wall showing longitudinal double ridges (Fig. 8n); and the other (AM F.9794) is oval in cross section, with a maximum diameter of 13.60x15.61 mm and a preserved length of 27.11 mm (Fig. 8o-q).

Internal

Septa in two orders consisting of large rhabdacanthine trabeculae; major septa reaching up to 3 mm long and varying from specimen to specimen, and only slightly longer and wider than minor, in the lectotype estimated to number 72 (specimen incomplete, Fig. 8l); trabeculae directed upwards and inwards at an angle approximately 30° from the horizontal (Fig. 8m), and distally discontinuous in transverse sections (Fig. 8l, p); septa forming a thin peripheral stereozone 0.25 mm wide, whereas in topotype specimen AM F.9794 (Fig. 8o-p), 80 septa form a thicker peripheral stereozone 1-1.5 mm wide (Dc= 13.60x15.61 mm); tabulae mostly complete, rarely irregularly concave or convex, and variably spaced, in the lectotype at 7-8 per 10 mm (Fig. 8m), while in topotype specimen AM F.9793 (tangential section, Fig. 8n), spaced at 12 per 10 mm in the middle of the specimen, but more closely spaced in the initial part of the corallum (21-25 per 10 mm); short trabeculae as tooth-like spines often borne on the upper surface of tabulae (Fig. 8m). In both sectioned specimens (AM F.9789, and AM F.9794), thin epitheca only partially preserved as dark compact tissue (Fig. 8q).

Discussion

Etheridge (1907) illustrated drawings of three specimens collected by A.J. Shearsby in 1904 from Limestone Creek, near Bowning in the Yass area, NSW. Recently Strusz (pers. comm., 2018) visited the type area of this species, and from comparison of the lithology and silicified preservation he believed that the type locality was in the Derrengullen Creek just above its confluence with Limestone Creek, between Yass and Bowning. Hill (1940) designated one of the syntypes as the lectotype (AM F.9789), and defined the species based on two topotype specimens (Hill 1940, p. 407, pl. 12, fig. 16) represented by a polished transverse section (AM F.9793) and a polished tangential section (AM F.9794). In this study, two thin sections (a TS, FT.15449, and a LS, FT.15450) have been prepared from the lectotype (Fig. 8l-m), and a transverse thin section (FT.15451 prepared from AM F.9794, Fig. 8p) has also been prepared from one of the topotypes illustrated by Hill (1940). The revised diagnosis and description of this species provided herein are based on the study of these five specimens including three originally illustrated by Etheridge (1907) and two by Hill (1940).

The only specimen (Fig. 9a-b) available from the Cuga Burga Volcanics samples is a solitary trochoid corallum 18 mm in diameter, with two orders of short septa consisting of rhabdacanthine trabeculae directed upwards and inwards at about 30° from the horizontal shown in the longitudinal section (Fig. 9a), and mostly complete tabulae spaced 1-3 mm apart. In comparison with the types, it is relatively larger in size, but falls within the definition of *Tryplasma derrengullenense* that was recently given by Munson and Jell (2016, p. 287, fig. 7). Distinction from other Australian species of *Tryplasma*, such as *T. columnare* Etheridge, 1907 with larger cylindrical corallites, has been discussed by Munson and Jell (2016).

Family CYSTIPHYLLIDAE Milne-Edwards and Haime, 1850
Genus *Cystiphyllum* Lonsdale, 1839

Type species

Cystiphyllum siluriense Lonsdale, 1839.

Cystiphyllum sp.
Fig. 9e-h

Synonymy

Cystiphyllum? (*Cystiphyllum*) sp.; Munson and Jell, 2016, pp. 292-293, fig. 10A-B.

Material

Four specimens associated with conodont samples C1591 (MMF33960a-3) and C1518 (MMF34008b, MMF34010a, MMF34010b, MMF34012b-2, MMF34012c-2).

Description

Three fragmentary specimens suggesting subcylindrical solitary coralla, with a diameter of 14-17 mm; thin peripheral stereozone of sclerenchyme 0.5-1 mm in thickness within which are confined very weakly developed septal spines (Fig. 9e, g), septal crusts absent; in transverse lumen filled by concentrically-arranged vesicular plates, larger in the centre and smaller near the periphery; in longitudinal sections (Fig. 9f, h), dissepimentarium narrow, consisting of one or two rows of adaxially inclined, hemispherical to slightly elongated dissepiments; tabularium wide, about two-thirds of corallum radius, consisting of incomplete tabulae with a horizontally floored and convex axial series, often supplemented with inclined peri-plates, tabellae spaced at 8-12 per 10 mm vertically.

Discussion

Specimens from the Cuga Burga Volcanics are comparable with that described by Munson and Jell (2016) from the upper Jack Formation (Ludlow) of the Broken River Province, north Queensland, but the latter is a corallum of a smaller size (12 mm Dc) and less complete tabularium with more convex central tabellae.

Family ENTELOPHYLLIDAE Hill, 1940
Genus *Entelophyllum* Wedekind, 1927

Type species

Madreporites articulatus Wahlenberg, 1821.

Entelophyllum patulum yassense? (Etheridge, 1892)
Fig. 9c-d

Synonymy

Heliophyllum yassense Etheridge, 1892, p. 170, pl. 11, fig. 8, pl. 12, figs 1-3.

Entelophyllum yassense (Etheridge); Hill, 1940, p. 412, pl. 13, figs 11-12.

Entelophyllum patulum yassense (Etheridge); Munson and Jell, 2016, pp. 303-306, figs 10C-E, 16A-F (*cum syn.*).

Material

Two specimens associated with conodont samples C1627 (MMF34020b-2, MMF34020c) and C1591 (MMF33975a, MMF33975b).

Discussion

Only two fragmentary specimens are available. The figured specimen (Fig. 9c-d) has a diameter of 17 mm with two orders of septa that are dilated with prominent carinae in the wide dissepimentarium consisting of small globose dissepiments and a tabularium consisting of incomplete tabellae. It is comparable with *Entelophyllum patulum yassense*, widely reported from the upper Silurian of eastern Australia (Etheridge 1892; Hill 1940; Munson and Jell 2016). However, due to only incomplete transverse sections and an oblique longitudinal section being available, this assignment is regarded as tentative.

Subclass TABULATA Milne-Edwards and Haime, 1850

Family PACHYPORIDAE Gerth, 1921

Genus *Striatopora* Hall, 1851

Type species

Striatopora flexuosa Hall, 1851.

Striatopora sp. A

Fig. 10a-b

Material

Four thin sections associated with conodont samples C1591 (MMF33976, MMF33977) and C1627 (MMF34023a, MMF34023b).

Description

Coralla ramose, preserved as cylindrical branches 7-10 mm in diameter; corallites curving away from axial longitudinal direction and opening perpendicular to surface, with thin walls of compact tissue in the axial region and strong thickening peripherally to form a stereozone 0.5-2 mm wide in longitudinal sections (Fig. 10a-b); stereozone consisting of fine lamellar tissue; corallites polygonal in transverse sections, adult corallites 1-1.4 mm in diameter in axial region and 1.5-1.8 mm on the surface of the coralla; mural pores common, 0.1-0.2 mm wide; tabulae thin and complete, horizontal or slightly concave, 0.8-2 mm apart (commonly 1.5 mm); no septal spines.

Discussion

Striatopora sp. A is characterized by having thin corallite walls in the axial region of the coralla and a thickened stereozone of 0.5-2 mm wide on the surface of the coralla.

Striatopora sp. B

Fig. 10c-e

Material

Fifteen thin sections associated with conodont samples C1591 (MMF33959a-2, MMF33959b, MMF33959c, MMF33960a-1, MMF33960a-2, MMF33960a, MMF33962a, MMF33962b, MMF33975, MMF33978, MMF33979a-2, MMF33979b-2), C1600 (MMF34062a-2, MMF34062b-2) and C1518 (MMF34007a, MMF34007b).

Description

Coralla ramose, preserved as cylindrical branches 4-8 mm in diameter; corallites curving away from axial longitudinal direction and opening obliquely to surface at an angle of about 30°; corallites polygonal in transverse sections, adult corallites 0.8-1 mm in diameter in axial region and up to 1.8 mm on the surface; thin compact walls thickened on both sides in the axial region with secondary lamellar tissue to form a thick wall 0.2 mm wide in transverse sections, thickening gradually and more strongly towards surface of coralla (Fig. 10c-e); mural pores common, about 0.1mm wide; tabulae thin, complete and horizontal, 0.5-1.5 mm apart (typically spaced 7-8 in 5 mm); no septal spines.

Discussion

Striatopora sp. B differs from *Striatopora* sp. A by having thickened corallite walls in the axial region, corallites extending obliquely from axis to the surface of coralla, and closer spaced tabulae.

Family PSEUDOPLASMOPORIDAE Bondarenko, 1963

Genus *Pseudoplasmopora* Bondarenko, 1963

Type species

Pseudoplasmopora conspecta Bondarenko, 1963.

Pseudoplasmopora follis (Milne-Edwards and Haime, 1851)
Fig. 11a-b

Synonymy

Plasmopora follis Milne-Edwards and Haime, 1851, p. 223, pl. 16, figs. 3, 3a.

Pseudoplasmopora follis (Milne-Edwards and Haime); Földvary, 2006, p. 180, figs 4A-F, 8E-F (*cum syn.*).

Material

One specimen associated with conodont sample C1634 (MMF34088a, MMF34088b, MMF34088c).

Diagnosis

See Földvary (2006, p. 180).

Discussion

The only specimen is poorly preserved with tabularia averaging 1 mm in diameter and spaced 21-25 per cm² in transverse sections and in the longitudinal section 11-12 tabulae in 5 mm. It is identical with those documented from the Přidoli rocks in the Trundle region of central NSW (Földvary, 2006) and from the Perry Creek Formation of northern Queensland (Hill et al. 1969), except that in the current specimen spacing of the tabularia is rather variable and less closely spaced.

Two other specimens represented only by transverse sections (MMF34018a, MMF34021a) from C1627 and a poorly preserved specimen from C1632 (longitudinal section, MMF34028) have a larger diameter of tabularia (1.5-2 mm), well-developed septal spines and more widely spaced tabularia (7-9/cm²). Septal spines are variable in length and thickened towards the base. They show some resemblance to *P. heliolitoides* (Lindström, 1899) and are herein assigned to *Pseudoplasmopora* sp. cf. *P. heliolitoides* (Fig. 11c-d).

Phylum PORIFERA Grant, 1836
Class STROMATOPOROIDEA Nicholson and Murie, 1878
Order CLATHRODICTYIDA Bogoyavlenskaya, 1969
Family ANOSTYLOSTROMATIDAE Nestor, 2011
Genus *Schistodictyon* Lessovaya in Lessovaya and Zakharova, 1970

Type species

Schistodictyon posterium Lessovaya in Lessovaya and Zakharova, 1970.

Schistodictyon webbyi sp. nov.
Fig. 12a-f

Material

Three specimens associated with conodont sample C1627 including holotype (MMF34017a, MMF34017b), and two unfigured paratypes (MMF34022a, MMF34022b, MMF34027).

Derivation of name

In honour of Dr Barry Webby, who has made an outstanding contribution to the study of the Palaeozoic stromatoporoids.

Diagnosis

A species of *Schistodictyon* with closely spaced pillars (9-11 per 2 mm) that expand upward in Y-shapes and form a regular network immediately beneath thin and widely-spaced laminae (6-7 per 2 mm).

Description

Skeleton domical and massive with unknown external dimensions; neither mamelons nor astrorhizae observed; microstructure obscured by recrystallization.

Pillars confined to single interlaminar spaces (not superposed) in vertical sections, column-like in the lower part, extending upward into a Y-shaped funnel structure, closely spaced with gallery width narrower than gallery height, 9-11 pillars per 2 mm (Fig. 12c-d, f). In tangential sections, basal part of the pillars appearing as discrete rounded dots (0.035-0.045 mm in diameter), upper part as irregular bars or vermiform, at the top forming a regular network joining tops of surrounding pillars (Fig. 12a-b, e); discrete ring pillars rare (Fig. 12a-b).

Laminae continuous, gently undulating and rarely broken up by small pores in vertical sections, thin, compact and thickened by expanded tops of pillars, thickness varying from 0.07 to 0.08 mm, irregularly spaced 0.2-0.5 mm (average 0.3 mm) apart, typically 6-7 laminae per 2 mm; dissepiments common, variable in size, gently domed upward, thin and compact.

Discussion

As discussed by Webby and Zhen (1997, p. 31), *Schistodictyon* differs from *Anostylostroma* Parks, 1936 mainly by having expanded top parts of the pillars, which show as ring pillars or regular network in tangential sections. In the new species, pillars are funnel-shaped at the top, joining together to form a regular network immediately underneath the laminae (Fig. 12a-b, e), but isolated ring pillars are rare in tangential sections (Fig. 12a). It can be easily differentiated from *Schistodictyon jackense* Webby and Zhen, 1997 from the middle part of the Jack Formation (Ludlow) of the Broken River Province, North Queensland, and *Schistodictyon conjugatum* Lesovaya, 1970 reported from the Hume Limestone Member (Birkhead 1975) and the Bowspring Limestone Member (Birkhead 1978) of the Silverdale Formation (Ludlow) of the Yass district, central NSW, by pillars forming a regular network immediately beneath laminae and by the rare occurrence of isolated ring pillars in tangential sections. It also has wider interlaminar spaces (7-10/2 mm in *S. jackense* and 9-10/2 mm in *S. conjugatum*). Furthermore, multiple splitting of the pillars at the top is common in both *S. jackense* and *S. conjugatum*, but is lacking in the new species. *Schistodictyon*? *cylindriferum* (Ripper, 1933) from the Lilydale Limestone (Pragian) of Victoria has more closely spaced laminae (9-12 per 2 mm) and well-developed large astrorhizal canals (Webby et al. 1993).

DISCUSSION AND CONCLUSIONS

The allochthonous limestone clasts in the Cuga Burga Volcanics were apparently derived from various sources ranging from the Upper Ordovician to uppermost Silurian or possibly lowest Devonian. The Late Ordovician limestone clast (comparable to those from the Barnby Hills Shale) may have originated from the Bowan Park Limestone Subgroup or its correlatives in the area, while the late Silurian limestone clasts that produced conodonts, corals and stromatoporoids documented herein were likely to have come from the Camelford Limestone that directly underlies the Cuga Burga Volcanics.

The Cuga Burga Volcanics accumulated rapidly during a relative short time interval (confined to the Lochkovian Stage), locally reaching a thickness of about 1300 m. Strong variation in thickness within a short distance and diachronous relationships with underlying and overlying stratigraphic units demonstrate that the Volcanics were developed primarily in relatively deeper water as an assembly of sedimentary packages (or pedestals) associated with volcanic centres scattered on the Cowra Trough, Molong Arch and Hill End Trough during the middle Lochkovian (Meakin and Morgan 1999, fig. 9).

The disparate ages of these Ordovician and Silurian limestone clasts support the view that they were ripped up from underlying strata by the local volcanic eruptions. Active volcanism probably also trigged gravitational collapse of the sea-floor scarps and/or hard grounds formed by older rocks (topographic features inherited from uplift during the Benambran Orogeny or caused by syndepositional listric faulting). The collapsed material was then redeposited in surrounding submarine volcanic pedestals and associated sedimentary packages now referred to as the Cuga Burga Volcanics.

ACKNOWLEDGMENTS

The late Dr Günther Bischoff (previously with Macquarie University) is acknowledged for collecting and processing the sample (A87) that yielded the Late Ordovician fauna. Scanning electron microscope photographs were prepared in the Electron Microscope Unit at Macquarie University. Dr Michael Bruce prepared some of the coral thin sections, and David Barnes assisted with photography of corals and stromatoporoids. Drs Matthew McCurry and Patrick Smith of the Australian Museum facilitated the loan of the type specimens of *Tryplasma derrengullenense*. Drs Ian Percival and Des Strusz are thanked for their careful and constructive reviews of the manuscript. The author publishes with permission of the Executive Director, Geological Survey of New South Wales.

REFERENCES

An, T.X., Zhang, A.T. and Xu, J.M., (1985). Ordovician conodonts from Yaoxian and Fuping, Shaanxi Province, and their stratigraphic significance. *Acta Geologica Sinica* **59**, 97–108. (in Chinese with English abstract)

Birkhead, P.K. (1975). Silurian stromatoporoids from Cheesemans Creek, with a survey of some stromatoporoids from the Hume Limestone Member, Yass, New South Wales. *Records of the Geological Survey of New South Wales* **17** (2), 87–122.

Birkhead, P.K. (1978). Some stromatoporoids from the Bowspring Limestone Member (Ludlovian) and Elmside Formation (Gedinnian), Yass area, New South Wales. *Records of the Geological Survey of New South Wales* **18** (2), 155–168.

Bischoff, G.C.O. (1981). *Cobcrephora* n. g., representative of a new Polyplacophoran order phosphatoloricata, with calciumphosphatic shells. *Senckenbergiana Lethaea* **61** (3/6), 173-215

Bischoff, G.C.O. and Sannemann, D. (1958). Unterdevonische Conodonten aus dem Frankenwald. *Notizblatt des Hessischen Landesamtes für Bodenforschung zu Wiesbaden* **86**, 87–110.

Bogoyavlenskaya, O.V. (1969). K postroeniya klassificatsii stromatoporoidei [On constructing the classification of the Stromatoporoidea]. *Paleontologicheskii Zhurnal* **1969 (4)**, 12–27.

Boogaard, V.D. (1983). Conodont faunas from Portugal and southwestern Spain. Part 7. A Frasnian conodont fauna near the Estação de Cabrela (Portugal). *Scripta Geologica* **69**, 1–17.

Branson, E.B. and Mehl, M.G. (1933). Conodont studies No. 1: Conodonts from the Harding Sandstone of Colorado; Bainbridge (Silurian) of Missouri; Jefferson City (Lower Ordovician) of Missouri. *University of Missouri Studies* **8** (1), 5–72.

Bunny, M.R. (1962). The geology of the Parishes of Nanima, Wellington and Galwadgere, Wellington, NSW. B.Sc. Hons thesis, University of Sydney (unpublished).

Carls, P., Slavík, L. and Valenzuela-Ríos, J.I. (2007). Revisions of conodont biostratigraphy across the Silurian-Devonian boundary. *Bulletin of Geosciences* **82** (2), 145–164.

Chapman, F. (1925). New or little-known fossils in the National Museum. Part 28. Some Silurian rugose corals. *Proceedings of the Royal Society of Victoria* **37**, 104–118.

Cherns, L., Rohr, D.M. and Frýda, J. (2004). Polyplacophoran and symmetrical univalve mollusks. In B.D. Webby, F. Paris, M.L. Droser and I.G. Percival (eds), The Great Ordovician biodiversification event. Pp.179–183, Columbia University Press, New York.

Corradini, C. and Corriga, M.G. (2010). Silurian and lowermost Devonian conodonts from the Passo Volaia area (Carnic Alps, Italy). *Bollettino della Società Paleontologica Italiana* **49** (3), 237–253.

Corradini, C. and Corriga, M.G. (2012). A Přídolí–Lochkovian conodont zonation in Sardinia and the Carnic Alps: implications for a global zonation scheme. *Bulletin of Geosciences* **87** (4), 635–650.

Corradini, C., Corriga, M.G., Ferretti, A. and Schönlaub, H.P. (2017). The Cellon section. *Berichte des Institutes für Erdwissenschaften, Karl-Franzens-Universität Graz* **23**, 262–270.

Corriga, M.G. and Corradini, C. (2009). Upper Silurian and Lower Devonian conodonts from the Monte Cocco II Section (Carnic Alps, Italy). *Bulletin of Geosciences* **84** (1), 155–168.

Corriga, M.G., Corradini, C. and Ferretti, A. (2009). Silurian conodonts from Sardinia: an overview. *Rendiconti della Società Paleontologica Italiana* **3** (1), 95–107.

Corriga, M.G., Corradini, C. and Walliser, O.H. (2014). Upper Silurian and Lower Devonian conodonts from Tafilalt, southeastern Morocco. *Bulletin of Geosciences*, **89** (1), 183–200.

Bondarenko, O.B. (1963). Reviziya roda. *Plasmopora*. *Paleontologicheskiy Zhurnal* **1**, 42–52. (in Russian)

Druce, E.C. (1975). Conodont biostratigraphy of the Upper Devonian reef complexes of the Canning Basin, Western Australia. *Bulletin of the Australian Bureau of Mineral Resources, Geology and Geophysics* **158**, 1–303.

Drygant, D. and Szaniawski, H. (2012). Lochkovian conodonts from Podolia, Ukraine, and their stratigraphic significance. *Acta Palaeontologica Polonica* **57** (4), 833–861.

Ehrenberg, C.G. (1834). Beiträge zur physiologischen Kenntniss der Corallenthiere im allgemeinen und besonders des Rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben. *Physiologische Abhandlungen der Königlichen Akademie der Wissenschaft, Berlin* (**1832**), p. 225–380.

Etheridge, R. Jr. (1890). On the occurrence of the genus *Tryplasma* Lonsdale (*Pholidophyllum* Lindström), and another coral apparently referable to *Diphyphyllum* Lonsdale, in the Upper Silurian and Devonian rocks respectively of New South Wales. *Records of the Geological Survey of New South Wales* **2**, 15–21.

Etheridge, R. Jr. (1892). Description of four Madreporaria Rugosa - species of the genera *Phillipsastrea*, *Heliophyllum* and *Cyathophyllum* - from the Palaeozoic rocks of New South Wales. *Records of the Geological Survey of New South Wales* **2**, 165–174.

Etheridge, R. Jr. (1907). A monograph of the Silurian and Devonian Corals of New South Wales, Vol. 2: With Illustrations from Other Parts of Australia; The Genus *Tryplasma.* Memoirs of the Geological Survey of New South Wales, Palaeontology **13**, 41–102.

Etheridge, R. Jr. (1913). A very remarkable species of *Spongophyllum* from the Upper Silurian rocks of New South Wales. *Records of the Australian Museum* **10**, 35–37.

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

Farrell, J.R. (2001). Conodont faunas (Late Ordovician, Silurian and Early Devonian) from the Larras Lee and Wellington districts, central western NSW. PhD thesis, Macquarie University (unpublished).

Farrell, J.R. (2004a). Late Přidoli, Lochkovian, and early Pragian conodonts from the Gap area between Larras Lee and Eurimbla, central western NSW, Australia. *Courier Forschungsinstitut Senckenberg* **245**, 107–181.

Farrell, J.R. (2004b). Siluro-Devonian conodonts from the Camelford Limestone, Wellington, New South Wales, Australia. *Palaeontology* **47**, 937–982.

Farrell, J.R. (2006). Pridoli conodont fauna from tectonically emplaced limestone blocks within the Barnby Hills Shale, central western New South Wales. *Alcheringa* **30** (2), 233–249.

Fergusson, C.L. (2010). Plate-driven extension and convergence along the East Gondwana active margin: Late Silurian–Middle Devonian tectonics of the Lachlan Fold Belt, southeastern Australia. *Australian Journal of Earth Sciences* **57** (5), 627–649.

Földvary, G.Z. (2000). Siluro-Devonian invertebrate faunas from the Bogan Gate-Trundle-Mineral Hill area of central New South Wales. *Records of the Western Australian Museum (Supplement)* **58**, 81–102.
Földvary, G.Z. (2006). *Pseudoplasmopora* (Cnidaria, Tabulata) in the Siluro-Devonian of eastern Australia with comments on its global biogeography. *Proceedings of the Linnean Society of New South Wales* **127**, 175-189.
Foerste, A.F. (1888). Notes on Palaeozoic fossils. *Bulletin of the scientific laboratories of Denison University* **3**, 117–136.
Frey, H. and Leuckart, C.G.F.R. (1847). Beiträge zur Kenntniss wirbelloser Thiere mit besonderer Berücksichtigung der Fauna des Norddeutschen Meeres. viii+170p., 2pls, Verlag von Friedrich Vieweg und Sohn (Braunschweig).
Gerth, H. (1921). Die Anthozoën der Dyas von Timor. *Paläontologie von Timor* **9** (16), 65–147.
Guo, S.Z. (1978). Late Silurian tetracorals from northern Beilingmiao of the Inner Mongolia Autonomous Region. *Professional Papers of Stratigraphy and Palaeontology* **6**, 50–68.
Grant, R.E. (1836). Animal Kingdom. Pp. 107-118. In R.B. Todd (ed.), The Cyclopaedia of Anatomy and Physiology. Volume 1. (Sherwood, Gilbert, and Piper: London): 1–813.
Hall, J. (1851). New genera of fossil corals from the report by James Hall, on the palaeontology of New York. *American Journal of Science, Series 2* **11**, 398–401.
Hatschek, B. (1888–1891). Lehrbuch der Zoologie, eine morphologische Übersicht des Thierreiches zur Einführung in das Studium dieser Wissenschaft: Lief. 1–3, iv + 432p., 407 text-fig., Gustav Fischer (Jena).
Hill, D. (1940). The Silurian Rugosa of the Yass-Bowning district, N.S.W. *Proceedings of the Linnean Society of New South Wales* **65** (3-4), 388–420.
Hill, D. (1954). Coral faunas from the Silurian of New South Wales and the Devonian of Western Australia. *Bulletin of the Australian Bureau of Mineral Resources, Geology and Geophysics* **23**, 6–61.
Hill, D. (1967). The sequence and distribution of Ludlovian, Lower Devonian, and Couvinian coral faunas in the Union of Soviet Socialist Republics. *Palaeontology* **10** (4), 660–693.
Hill, D. (1981). Treatise on Invertebrate Paleontology, Part F, Coelenterata, supplement I, Rugosa and Tabulata (R.C. Moore, ed.). Vols 1-2. The Geological Society of America, Inc. and the University of Kansas, Boulder, Colorado, and Lawrence, Kansas.
Hill, D., Playford, G. and Woods, J.T. (Eds) (1969). Ordovician and Silurian fossils of Queensland. Queensland Palaeontographical Society, Brisbane.
Ivanovskiy, A.B. (1969). Korally semeystv Tryplasmatidae i Cyathophylloididae (rugozy). 112 pp., Akademiya Nauk SSSR, Sibirskoe otdelenie, Instituta geologii i geofiziki, Nauka (Moscow) (in Russian).
Jeppsson, L. (1974). Aspects of Late Silurian conodonts. *Fossils and Strata* **6**, 1–54.
Jeppsson, L. (1988). Conodont biostratigraphy of the Silurian-Devonian boundary stratotype at Klonk, Czechoslovakia. *Geologica et Palaeontologica* **22**, 21–31.
Jones, O.A. (1932). A revision of the Australian species of the coral genera *Spongophyllum* E. & H. and *Endophyllum* E. & H. with a note on *Aphrophyllum* Smith. *Proceedings of the Royal Society of Queensland* **44**, 50–63.
Jones, O.A. (1936). The controlling effect of the environment upon the corallum in *Favosites*; with a revision of some massive species on this basis. *Annals and Magazine of Natural History, (Series 10)* **17**, 1–24.
Jones, O.A. (1937). The Australian massive species of the coral genus *Favosites*. *Records of the Australian Museum* **20**, 79–102.
Jones, O.A. (1944). Tabulata and Heliolitida from the Wellington district, New South Wales. *Journal and Proceedings of the Royal Society of New South Wales* **77**, 33–39.
Kemežys, K.J. (1959). Geology around Bakers Swamp. B.Sc. Hons thesis, University of Sydney (unpublished).
Lesovaya, A.I. and Zakharova, V.M. (1970). Novye stromatoporoidei iz verkhnego silura Turkestanskogo khrebta. *Paleontologicheskii Zhurnal* **1970** (2), 41–51.
Lindström, G. (1899). Remarks on the Heliolitidae. *Handlingar Kongliga Svenska Vetenskaps-Akademiens* **32** (1), 1–140.
Lonsdale, Wm. (1839). Corals, graptolites, and nondescripts. In R.I. Murchison, The Silurian System, part I, II, pp. 675-698, pl. 15, 15 bis, 16, 16 bis, John Murray (London).
Lonsdale, Wm. (1845). Description of some characteristic Paleozoic corals of Russia. In R.I. Murchison, E.de Verneuil and A. von Keyserling, The Geology of Russia in Europe and the Ural Mountains, vol. 1, pp. 591–634, John Murray (London).
Mawson, R. and Talent, J.A. (2000). The Devonian of eastern Australia: stratigraphic alignments, stage and series boundaries, and the transgression - regression pattern re-considered. *Courier Forschungsinstitut Senckenberg* **225**, 243–270.
Mawson, R., Talent, I.A., Bear, V.C., Benson, D.S., Brock, G.A., Farrell, l.R., Hyland, K.A., Pyemont, B.D., Sloan, T.R., Sorentino, L., Stewart, M.L, Trotter, JA, Wilson, G.A. and Simpson, A.J. (1988). Conodont data in relation to resolution of stage and zonal boundaries for the Devonian

of Australia. *Canadian Society of Petroleum Geologists Memoir* **14** (3), 485–527.

Meakin, N.S. and Morgan, E.J. (compilers) (1999). Dubbo 1:250,000 Geological Sheet SI/55-4, 2nd edition. Explanatory Notes. Geological Survey of New South Wales, xvi +504 pp.

McLean, R.A. (1974). Chonophyllinid corals from the Silurian of New South Wales. *Palaeontology* **17**, 655–668.

McLean, R.A. (1975). Silurian rugose corals from the Mumbil area, central New South Wales. *Proceedings of the Linnean Society of New South Wales* **99**, 181–196.

McLean, R.A. (1976). Aspects of the Silurian rugose coral fauna of the Yass region, New South Wales. *Proceedings of the Linnean Society of New South Wales* **100**, 179–194.

Merriam, C.W. (1973). Silurian rugose corals of the central and southwest Great Basin. *Geological Survey Professional Paper* **777**, 1–66, pls 1–16.

Merriam, C.W. (1976). The Roberts Mountains Formation, a regional stratigraphic study with emphasis on rugose coral distribution. *Geological Survey Professional Paper* **973**, 1–51, pls 1–12.

Milne-Edwards, H. and Haime, J. (1850–1855). A monograph of the British fossil corals: p. 1–299, pls 1–72. Palaeontographical Society Monograph (London).

Morton, D.J. (1974). A palaeoenvironmental analysis of the Cuga Burga Volcanics near Wellington, NSW. B.A. Hons (Earth Science) thesis, Macquarie University, Sydney (unpublished).

Morton, D.J. (1976). The Cuga Burga Volcanics – a Lower Devonian volcanic pile. *The Bulletin of the Australian Society of Exploration Geophysicists* **7** (1), 22–22.

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

Munson, T.J., Pickett, J.W. and Strusz, D.L. (2001). Biostratigraphic review of the Silurian tabulate corals and chaetetids of Australia. *Historical Biology* **15** (1-2), 41–60.

Munson, T.J. and Jell, J.S. (2016). Wenlock and Ludlow (Silurian) rugose corals from the type section of the Jack Formation, Broken River Province, northeast Queensland. *Memoirs of the Queensland Museum – Nature* **59**, 273–320.

Murphy, M.A. and Valenzuela-Ríos, J.I. (1999). *Lanea* new genus, lineage of Early Devonian conodonts. *Bollettino della Società Paleontologica Italiana* **37**, 321–334.

Nestor, H.A. (2011). Part E, Revised, Volume 4, Chapter 16C: Clathrodictyida. *Treatise Online* **26**, 1–15.

Nestor, H.A. (2015). Clathrodictyida: Systematic descriptions. In B.D. Webby (coordinating author), Treatise Part E, Porifera, Revised Hypercalcified Porifera, Volume 5, 755–768. The Geological Society of America, Inc. and the University of Kansas, Boulder, Colorado and Lawrence, Kansas.

Nicholson, H.E. and Murie, J. (1878). On the minute structure of *Stromatopora* and its allies. *Journal of the Linnean Society of London, Zoology* **14**, 187–246.

Packham, G.H. (ed.) (1969). The Geology of New South Wales. *Journal of the Geological Society of Australia* **16** (1), 1–654.

Packham, G.H., Percival, I.G., Rickards, R.B. and Wright, A.J. (2001). Late Silurian and Early Devonian biostratigraphy in the Hill End Trough and the Limekilns area, New South Wales. *Alcheringa* **25**, 251–261.

Packham, G.H., Philip, G.M. and Hubble, T.C.T. (2006). Late Silurian or Early Devonian corals from the continental slope off southern New South Wales. *Alcheringa* **30**, 33–42.

Parks, W.A. (1936). Devonian stromatoporoids of North America, Part 1. *University of Toronto Studies Geological Series* **39**, 1–125.

Peavey, F.N.R. (2013). Review, Revision, and Paleobiogeography of Ludlow (Silurian) to Lochkovian (Devonian) Spathognathodontid Conodont Taxa. Ph.D. thesis (Geosciences), Texas Tech University, Texas (unpublished).

Percival, I.G. (1998). Palaeontological age-dating of the Cuga Burga Volcanics, Garra Limestone, and correlative formations. Geological Survey of New South Wales, Report GS1998/347 (unpublished).

Percival, I.G. and Zhen, Y.Y. (2017). Précis of Palaeozoic Palaeontology in the Southern Tablelands Region of New South Wales. *Proceedings of the Linnean Society of New South Wales* **139**, 9–56.

Philip, G.M. (1965). Lower Devonian conodonts from the Tyers area, Gippsland, Victoria. *Proceedings of the Royal Society of Victoria* **79**, 95–117.

Pickett, J.W. (2010). Fossil corals of Australia, New Zealand, New Guinea and Antarctica: bibliography and index. *Memoirs of the Association of Australasian Palaeontologists* **40**, 1–189.

Rickards, R.B., Farrell, J.R., Wright, A.J. and Morgan, E.J. (2005). Silurian graptolites from the Barnby Hills Shale and Hanover Formation, New South Wales. *Proceedings of the Linnean Society of New South Wales* **126**, 153–169.

Ripper, E.A. (1933). The stromatoporoids of the Lilydale Limestone. Part I. *Actinostroma* and *Clathrodictyon*. *Proceedings of the Royal Society of Victoria* **45**, 152–164.

Sherwin, L. (1971). Stratigraphy of the Cheesemans Creek district, New South Wales. *Geological Survey of New South Wales, Records* **13**, 199–237.

Slavík, L., Carls, P., Hladil, J. and Koptíková, L. (2012). Subdivision of the Lochkovian Stage based on conodont faunas from the stratotype area (Prague Synform, Czech Republic). *Geological Journal* **47** (6), 616–631.

Soshkina, E.D. (1937). Korally verkhnego Silura i nizhnego Devona vostochnogo i zapadnogo

sklonov Urala [Corals of the Upper Silurian and Lower Devonian of the eastern and western slopes of the Urals]. *Trudy Paleontologischeskogo Instituta, Akademiya Nauk SSSR* **6** (4), 1–112 [in Russian; English summary).
Strusz, D.L. (1960). The geology of the Parish of Mumbil, near Wellington, N.S.W. *Journal and Proceedings of the Royal Society of New South Wales* **93**, 127–136.
Strusz, D.L. (1961). Lower Palaeozoic corals from New South Wales. *Palaeontology* **4**, 334–361.
Strusz, D.L. (1989). Australian Phanerozoic Timescales: 3. Silurian Biostratigraphic chart and explanatory notes. *Bureau of Mineral Resources, Geology and Geophysics, Record* **1989/33**, 1–28.
Strusz, D.L. (1995). Timescales 3 -Silurian. Australian Phanerozoic Timescales, biostratigraphic charts and explanatory notes second series. *Australian Geological Survey Organisation, Record* **1995/32**, 1–29.
Strusz, D.L. and Munson, T.J. (1997). Coral assemblages in the Silurian of Eastern Australia, a rugosan perspective. In Proceedings of the 7th International Symposium on Fossil Cnidaria including Archaeocyatha and Spongiomorphs, Madrid, Spain, September 12th-15th, 1995, edited by A Perejón and M. J. Comas-Rengifo. *Boletin de la Real Sociedad Espanola de Historia Natural (Sección Geológica)* **92**, 311–323.
Sweet, W.C. (1979). Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province. *Brigham Young University Geology Studies* **26**, 45–86.
Talent, J.A. and Mawson, R. (1999). Eastern Molong Platform and adjacent Hill End Trough, New South Wales: Mid-Palaeozoic conodont data, age-inferences, and implications regarding platform exposure and carbonate sedimentation offshore. *Abhandlungen der Geologisches Bundesanstalt, Wien* **54**, 49–l05.
Vandyke, A. (1970). Geology and palaeontology of the Mumbil-Dripstone area, NSW. B.Sc. Hons thesis, University of Sydney (unpublished).
Wahlenberg, G. (1821). Petrificata telluris Svecanae examinata. *Nova Acta regiae Societatis Scientiarum Upsaliensis* **8**, 1–116.
Walliser, O.H. (1964). Conodonten des Silurs. *Abhandlungen des Hessischen Landesamtes für Bodenforschung zu Wiesbaden* **41**, 1–106.
Webby, B.D. and Zhen, Y.Y. (1997). Silurian and Devonian clathrodictyids and other stromatoporoids from the Broken River region, north Queensland. *Alcheringa* **21**, 1–56.
Webby, B.D., Stearn, C.W. and Zhen, Y.Y. (1993). Lower Devonian (Pragian-Emsian) Stromatoporoids from Victoria. *Proceedings of the Royal Society of Victoria* **105** (2), 113–185.
Webby, B.D., Stearn, C.W. and Nestor, H.A. (2015). Biostratigraphy of the Paleozoic Stromatoporoidea. In B.D. Webby (coordinating author), Treatise on Invertebrate Paleontology Part E, Porifera, Revised. Hypercalcified Porifera, Volume 5, 611–630. The Geological Society of America, Inc. and the University of Kansas, Boulder, Colorado, and Lawrence, Kansas.
Wedekind, R. (1927). Die Zoantharia von Gotland (bes. Nordgotland). Nebst bemerkungen zur Biostratigraphie des Gotlandium. *Sveriges Geologiska Undersokning, series Ca* **19**, 1–94.
Wilson, G.A. (1989). Documentation of conodont assemblages across the Lochkovian-Pragian (Early Devonian) boundary at Wellington, central New South Wales, Australia. *Courier Forschungsinstitut Senckenberg* **117**, 117–171.
Zhen, Y.Y. (2001). Distribution of the Late Ordovician conodont genus *Taoqupognathus* in eastern Australia and China. *Acta Palaeontologica Sinica* **40**, 351–361.
Zhen, Y.Y. (2018). Fossil fauna and inferred age of limestones displayed in the Chinese Garden of Friendship at Darling Harbour, Sydney. Geological Survey of New South Wales, Report GS2018/0629. (unpublished).
Zhen, Y.Y. and Webby, B.D. (1995). Upper Ordovician conodonts from the Cliefden Caves Limestone Group, central New South Wales, Australia. *Courier Forschungsinstitut Senckenberg* **182**, 265–305.
Zhen, Y.Y. and Percival, I.G. (2017). Late Ordovician conodont biozonation of Australia – current status and regional biostratigraphic correlations. *Alcheringa* **41** (3), 285–305.
Zhen, Y.Y., Webby, B.D. and Barnes, C.R. (1999). Upper Ordovician conodonts from the Bowan Park succession, central New South Wales, Australia. *Geobios* **32**, 73–104.
Zhen, Y. Y., Percival, I.G. and Farrell, J. (2003). Late Ordovician allochthonous limestones in Late Silurian Barnby Hills Shale, central western New South Wales. *Proceedings of the Linnean Society of New South Wales* **124**, 41–63.
Zhen, Y.Y., Percival, I.G. and Molloy, P.D. (2015). Late Ordovician conodonts and brachiopods from near Greenvale in the Broken River Province, north Queensland. *Proceedings of the Linnean Society of New South Wales* **137**, 57–105.
Zhen, Y.Y., Hegarty, R., Percival, I.G. and Pickett, J.W. (2017). Early Devonian conodonts from the southern Thomson Orogen and northern Lachlan Orogen in north-western New South Wales. *Proceedings of the Linnean Society of New South Wales* **139**, 69–83.
Ziegler, W. (1960). Conodonten aus dem Rheinischen Unterdevon (Gedinnium) des Remscheider Sattels (Rheinisches Schiefergebirge). *Paläontologische Zeitschrift* **34**, 169–201.

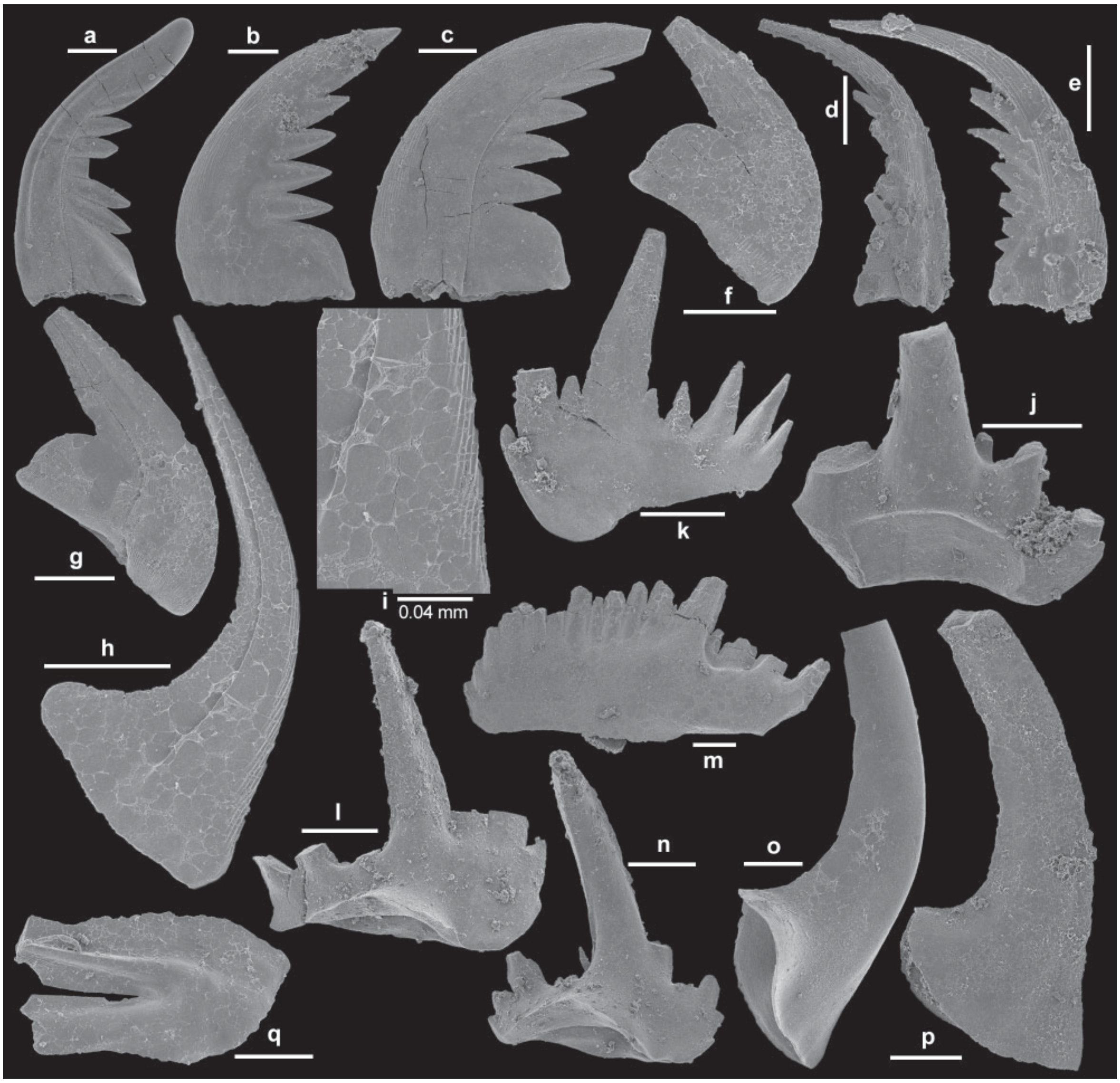

Figure 2. Conodonts recovered from an allochthonous Late Ordovician limestone clast (sample A87) in the Cuga Burga Volcanics. a-g, *Belodina confluens* Sweet, 1979. a, S2 (grandiform) element, MMMC5242, view of furrowed side (IY345-010); b-c, S1 (compressiform) element; b, MMMC5243, view of unfurrowed side (IY345-011); c, MMMC5244, view of furrowed side (IY345-012); d-e, S3 (dispansiform) element; d, MMMC5245, view of furrowed side (IY345-013); e, MMMC5246, view of unfurrowed side (IY345-014); f-g, M (eobelodiniform) element; f, MMMC5247, view of unfurrowed side (IY345-016), g, MMMC5248, view of furrowed side (IY345-015). h-i, *Besselodus fusus* Zhen in Zhen et al., 2015. Sb element, MMMC5249, h, outer-lateral view (IY346-010), i, enlargement showing striation along outer-lateral margin (IY346-011). j-n, *Chirognathus cliefdenensis* Zhen and Webby, 1995. j, Sb element, MMMC5250, posterior view (IY346-013); k, M element, MMMC5251, posterior view (IY346-004); l, Sc element, MMMC5252, inner-lateral view (IY346-005); m, Pa element, MMMC5253, inner-lateral view (IY345-017); n, Sc element, MMMC5254, inner-lateral view (IY346-003). o-p, *Drepanoistodus suberectus* (Branson and Mehl, 1933). o, Pa element, MMMC5255, outer-lateral view (IY346-008); p, Pb element, MMMC5256, inner-lateral view (IY346-009). q, *Venoistodus* sp. M element, MMMC5257, posterior view (IY345-024). Scale bar 100 µm unless otherwise indicated.

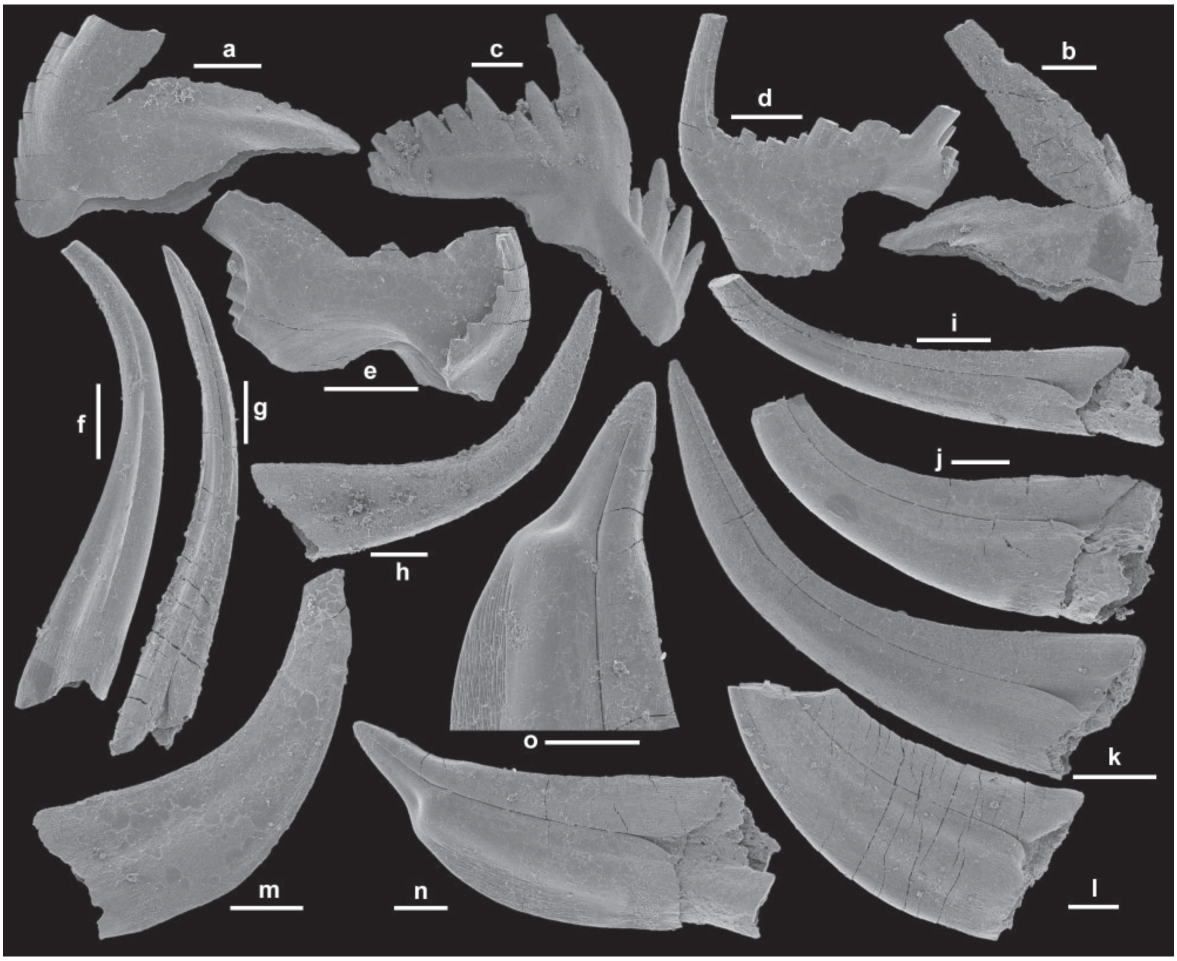

Figure 3. Conodonts recovered from allochthonous Late Ordovician limestone clast (sample A87) in the Cuga Burga Volcanics. a-e, *Periodon grandis* (Ethington, 1959). a-b, M element, a, MMMC5258, anterior view (IY345-025); b, MMMC5259, anterior view (IY345-019); c, Pa element, MMMC5260, outer-lateral view (IY346-001); d, Sc element, MMMC5261, outer-lateral view (IY346-007); e, Sb element, MMMC5262, outer-lateral view (IY346-002). f-k, *Panderodus gracilis* (Branson and Mehl, 1933). f-g, similiform element; f, MMMC5263, inner-lateral view (IY345-028); g, MMMC5264, outer-lateral view (IY345-026); h-i, arcuatiform element; h, MMMC5265, inner-lateral view (IY345-031); i, MMMC5266, outer-lateral view (IY345-027); j-k, falciform element; j, MMMC5267, outer-lateral view (IY345-032); k, MMMC5268, outer-lateral view (IY345-029). l-o, *Panderodus* sp. Zhen, Webby and Barnes, 1999. l, MMMC5269, outer-lateral view (IY345-033); m, MMMC5270, inner-lateral view (IY346-015); n-o, MMMC5271, n, outer-lateral view (IY345-021), o, close up showing wearing of the distal cusp (IY345-022). Scale bar 100 µm.

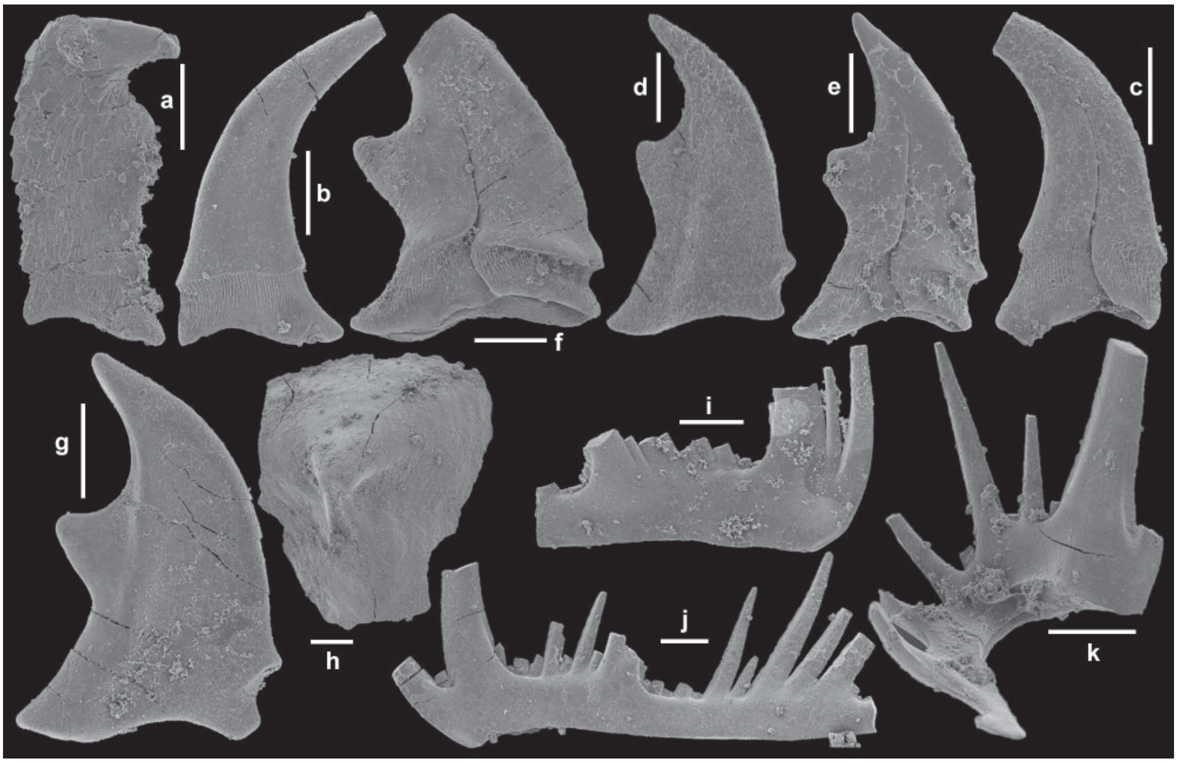

Figure 4. Conodonts recovered from allochthonous Late Ordovician limestone clast (sample A87) in the Cuga Burga Volcanics. a-g, *Taoqupognathus blandus* An in An et al., 1985. a, P element, MMMC5272, inner-lateral view (IY345-003); b-c, M-2 element; b, MMMC5273, inner-lateral view (IY345-009); c, MMMC5274, outer-lateral view (IY345-008); d-e, Sc-5 element; d, MMMC5275, inner-lateral view (IY345-005); e, MMMC5276, outer-lateral view (IY345-004); f-g, Sc-3 element; f, MMMC5277, outer-lateral view (IY345-006); g, MMMC5278, inner-lateral view (IY345-007). h, *Pseudooneotodus mitratus* (Moskalenko, 1973). MMMC5279, upper view (IY345-023). i-j, *Yaoxianognathus? tunguskaensis* (Moskalenko, 1973). Sc element; i, MMMC5280, inner-lateral view (IY346-012); j, MMMC5281, inner-lateral view (IY345-001). k, *Yaoxianognathus* sp. cf. *Y. yaoxianensis* An in An et al., 1985. Sb element, MMMC5282, posterior view (IY346-006). Scale bar 100 µm.

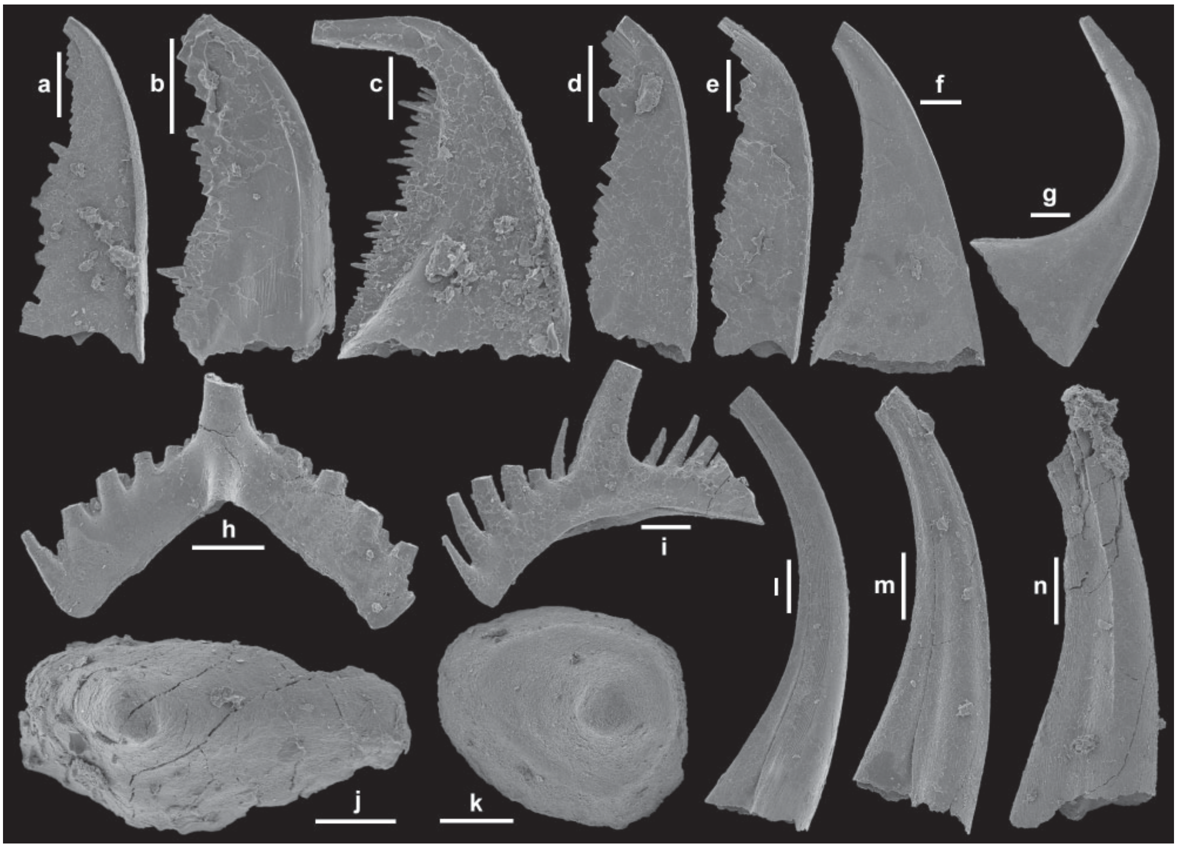

Figure 5. Conodonts recovered from allochthonous latest Silurian limestone clasts in the Cuga Burga Volcanics. a-e, *Belodella resima* (Philip, 1965). a, Sa element, MMMC5283, sample C1591, lateral view (IY346-025); b-c, Sb element; b, MMMC5284, sample C1591, outer-lateral view (IY346-026); c, MMMC5285, sample C1600, inner-lateral view (IY347-010); d-e, Sc element; d, MMMC5286, sample C1600, inner-lateral view (IY347-011); e, MMMC5287, sample C1591, inn-lateral view (IY346-027). f, *Belodella* sp., element with minute denticles along posterior edge, MMMC5288, sample C1591, inner-lateral view (IY346-028). g, *Dvorakia* sp., coniform element, MMMC5289, sample C1600, inner-lateral view (IY347-012). h, *Delotaxis detorta*? (Walliser, 1964). Sa element, MMMC5290, sample C1607, posterior view (IY347-014); i, *Zieglerodina remscheidensis* (Ziegler, 1960). Sc element, MMMC5291, sample C1600, inner-lateral view (IY347-020). j, *Pseudooneotodus* sp. MMMC5292, sample C1607, upper view (IY347-017); k, *Pseudooneotodus beckmanni* (Bischoff and Sannemann, 1958). MMMC5293, sample C1600, upper view (IY347-018). l-n, *Panderodus unicostatus* (Branson and Mehl, 1933). l-m, aequaliform (ae) element; l, MMMC5294, sample C1591, lateral view (IY347-001); m, MMMC5295, sample C1591, lateral view (IY347-003); n, graciliform (qg) element, MMMC5296, sample C1591, inner-lateral view (IY347-004). Scale bar 100 µm.

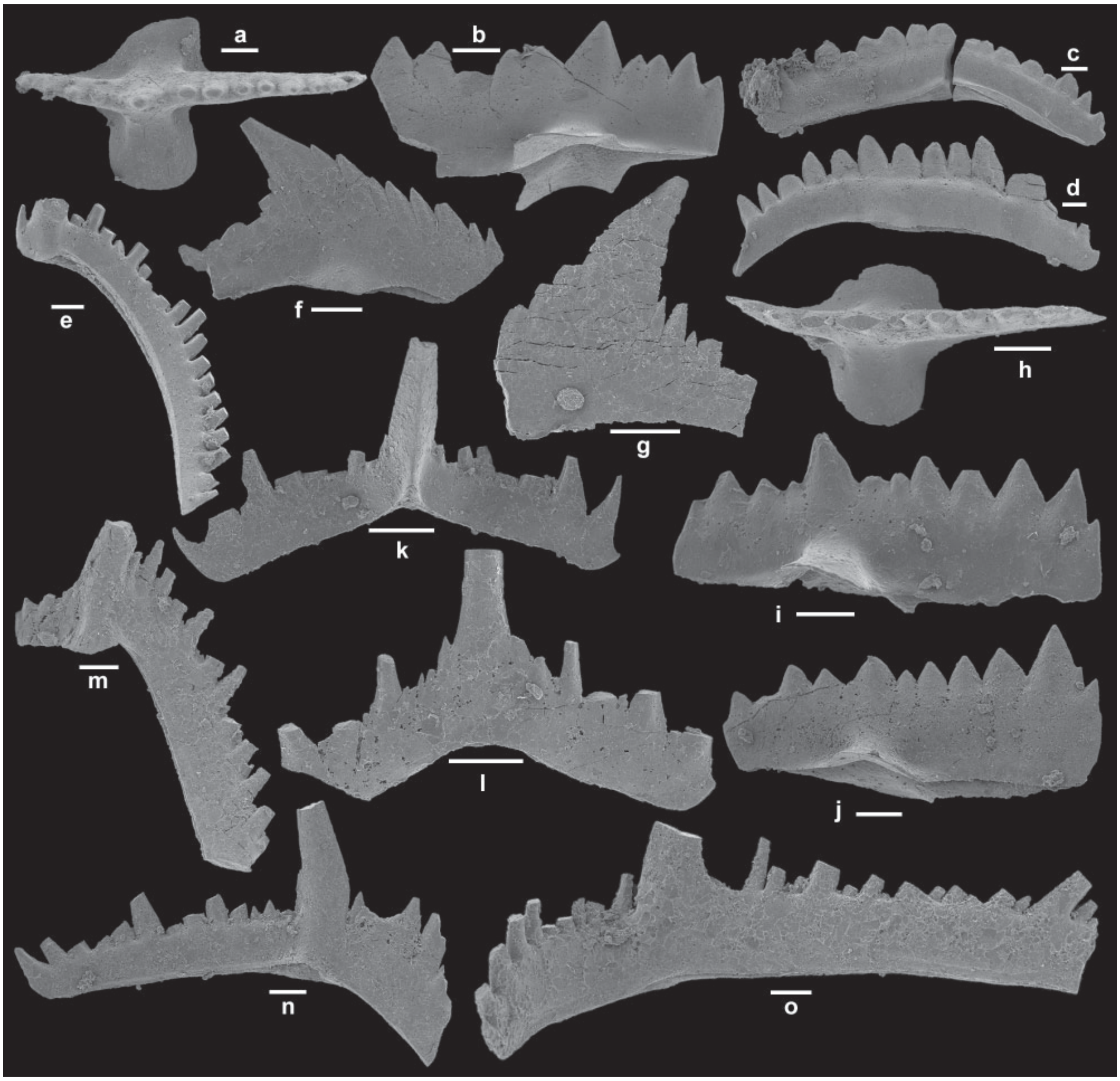

Figure 6. Conodonts recovered from allochthonous latest Silurian limestone clasts in the Cuga Burga Volcanics. a-b, *Lanea*? *planilingua* Murphy and Valenzuela-Rios, 1999. Pa element; a, MMMC5297, sample C1600, upper view (IY346-022); b, MMMC5298, sample C1607, inner-lateral view (IY346-024). c-e, *Wurmiella excavata* (Branson and Mehl, 1933). c-d, Pa element; c, MMMC5299, sample C1591, outer-lateral view (IY346-016); d, MMMC5300, sample C1600, outer-lateral view (IY346-021); e, M element, MMMC?5301, sample C1600, posterior view (IY347-008). f-o, *Zieglerodina remscheidensis* (Ziegler, 1960). f-g, Pb element; f, MMMC5302, sample C1591, outer-lateral view (IY346-017); g, MMMC5303, sample C1607, inner-lateral view (IY347-013); h-j, Pa element; h, MMMC5304, sample C1591, upper view (IY346-019); i, MMMC5305, sample C1600, outer-lateral view (IY346-023); j, MMMC5306, sample C1591, outer-lateral view (IY346-018); k-l, Sa element; k, MMMC5307, sample C1600, posterior view (IY347-005); l, MMMC5308, sample C1607, anterior view (IY347-015); m, M element, MMMC5309, sample C1607, posterior view (IY347-016); n-o, Sc element; n, MMMC5310, sample C1600, inner-lateral view (IY347-006); o, MMMC5311, sample C1600, inner-lateral view (IY347-007). Scale bar 100 µm.

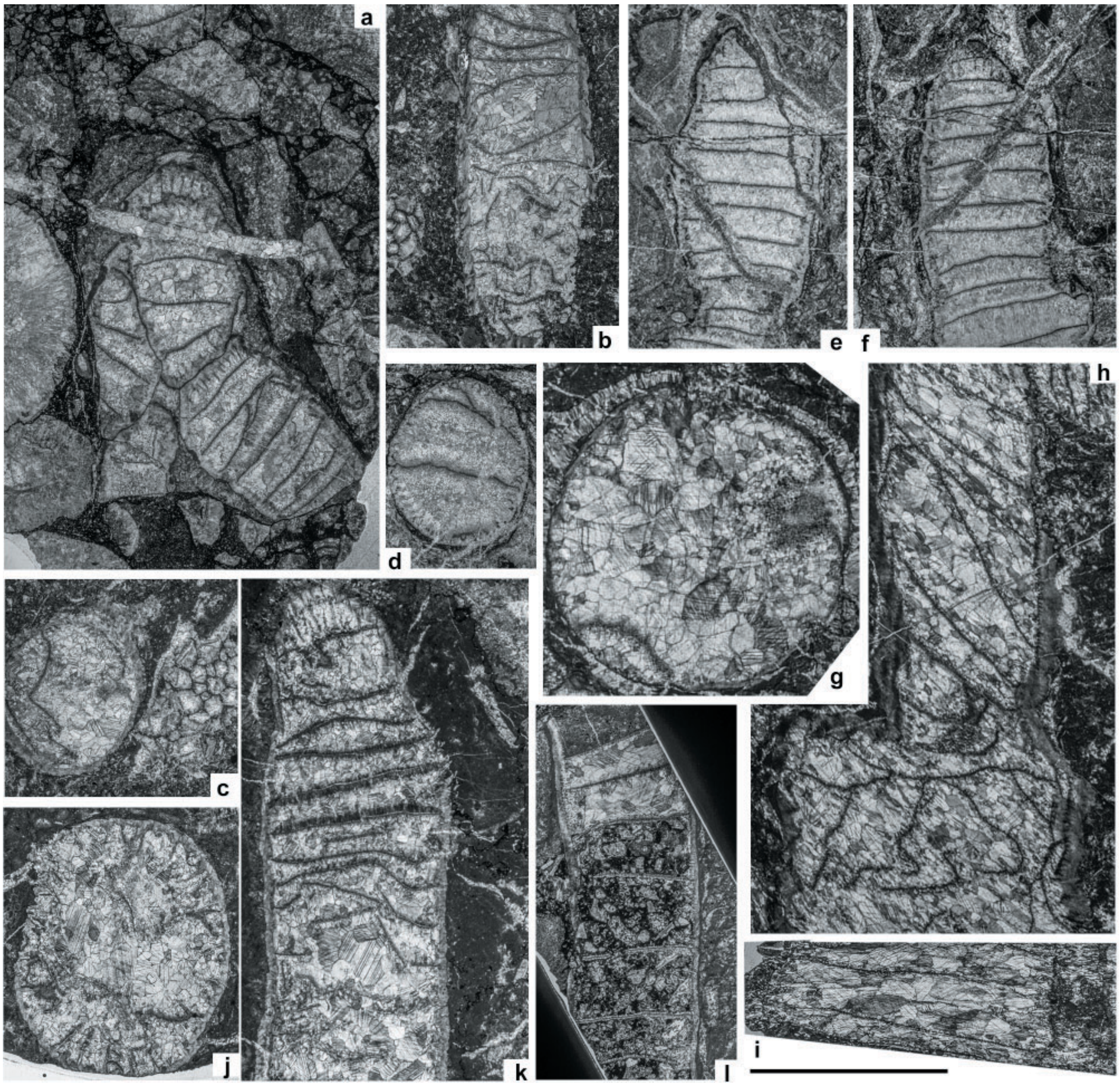

Figure 7. ***Aphyllum lonsdalei*** **(Etheridge, 1890). a, MMF34019, TS, showing parricidal peripheral increase; b, MMF33979a, LS; c, MMF33979b, TS; d, MMF34024a, TS; e, MMF34024b, LS; f, MMF34024c, LS; g, MMF34012b-1, TS; h, MMF34012a-1, LS, showing parricidal peripheral increase; i, MMF34012c-1, LS; j, MMF33963b, TS; k, MMF33963a, LS; l, MMF34006a, LS. TS = Transverse section, LS = Longitudinal section; a, d-f from C1627, b-c, j-k from C1591, g-i, l from C1518; all at same magnification, scale bar = 10 mm.**

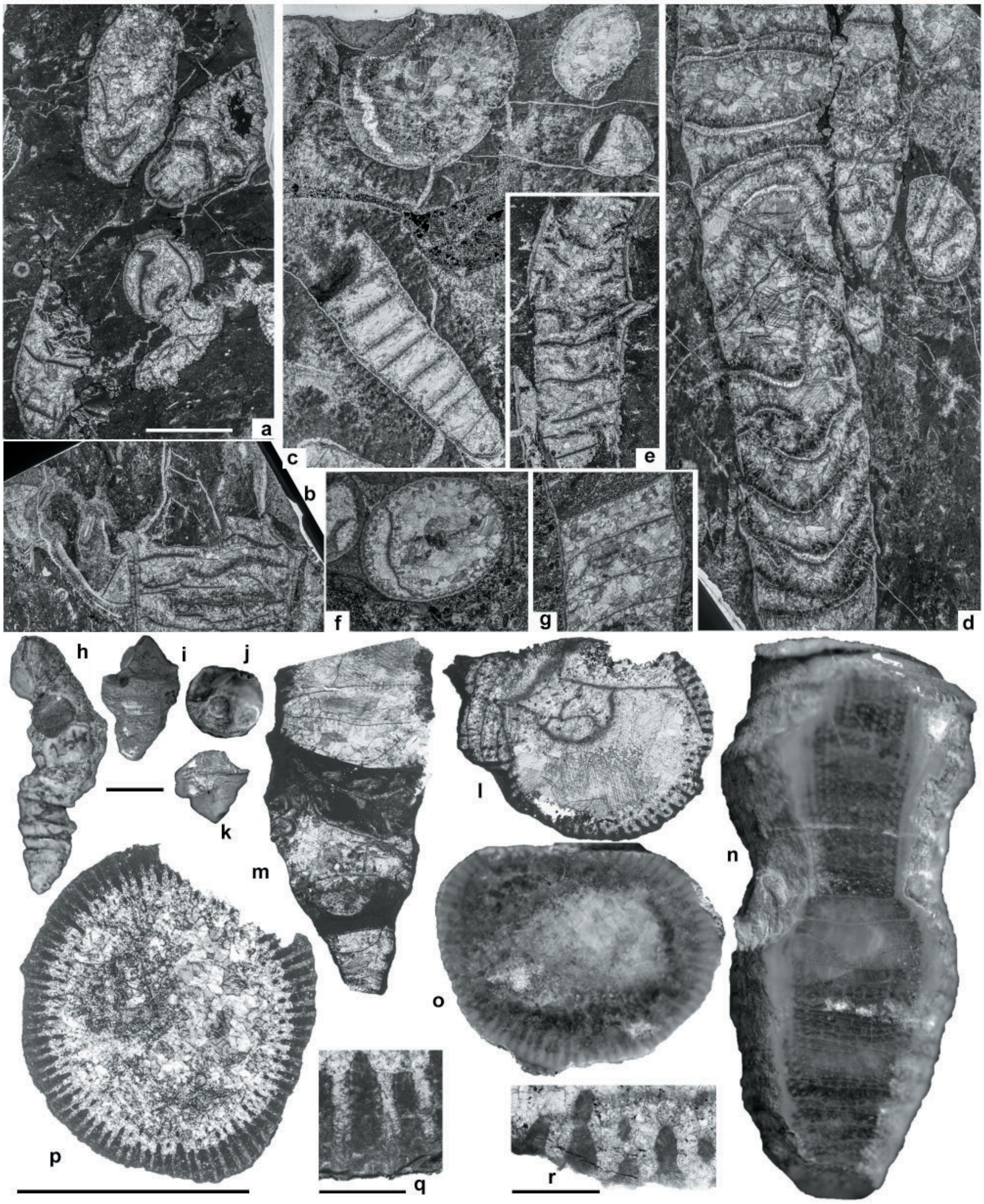

Figure 8. a-g, *Aphyllum pachystele* Munson and Jell, 2016. a, MMF34061b, TS; b, MMF34061a, LS; c, MMF34085b, TS; d, MMF34085a, LS; e, MMF34063b, LS, showing connecting tubule; f, MMF34008c, TS; g, MMF34008d, LS., a-b, e from C1600, c-d from C1634, f-g from C1518. h-r, *Tryplasma derrengullenense* Etheridge, 1907. h, l-m, r, AM F.9789, lectotype, h, external lateral view (also figured by Etheridge, 1907, pl. 22, fig. 8), l, TS (FT.15449), m, LS (FT.15450), r, closing up showing rhabdacanthine septal microstructure (FT.15449); i-j, AM F.9707, paralectotype, i, lateral view (also figured by Etheridge, 1907, pl. 22, fig. 6), j, calical view showing offsets; k, AM F.50623, paralectotype, lateral view (also figured by Etheridge, 1907, pl. 22, fig. 5); n, AM F.9793, topotype, polished tangential surface (also figured by Hill, 1940, pl. 12, fig. 16 right),; o-q, AM F.9794, topotype, o, polished transverse surface (also figured by Hill, 1940, pl. 12, fig. 16 left), p, TS (FT.15451), q, closing up showing rhabdacanthine septal microstructure (FT.15451). Abbreviations referring to Figure 7 caption. Scale bars = 10 mm (a-g, h-k and l-p at same magnification respectively except = 1 mm for q, r).

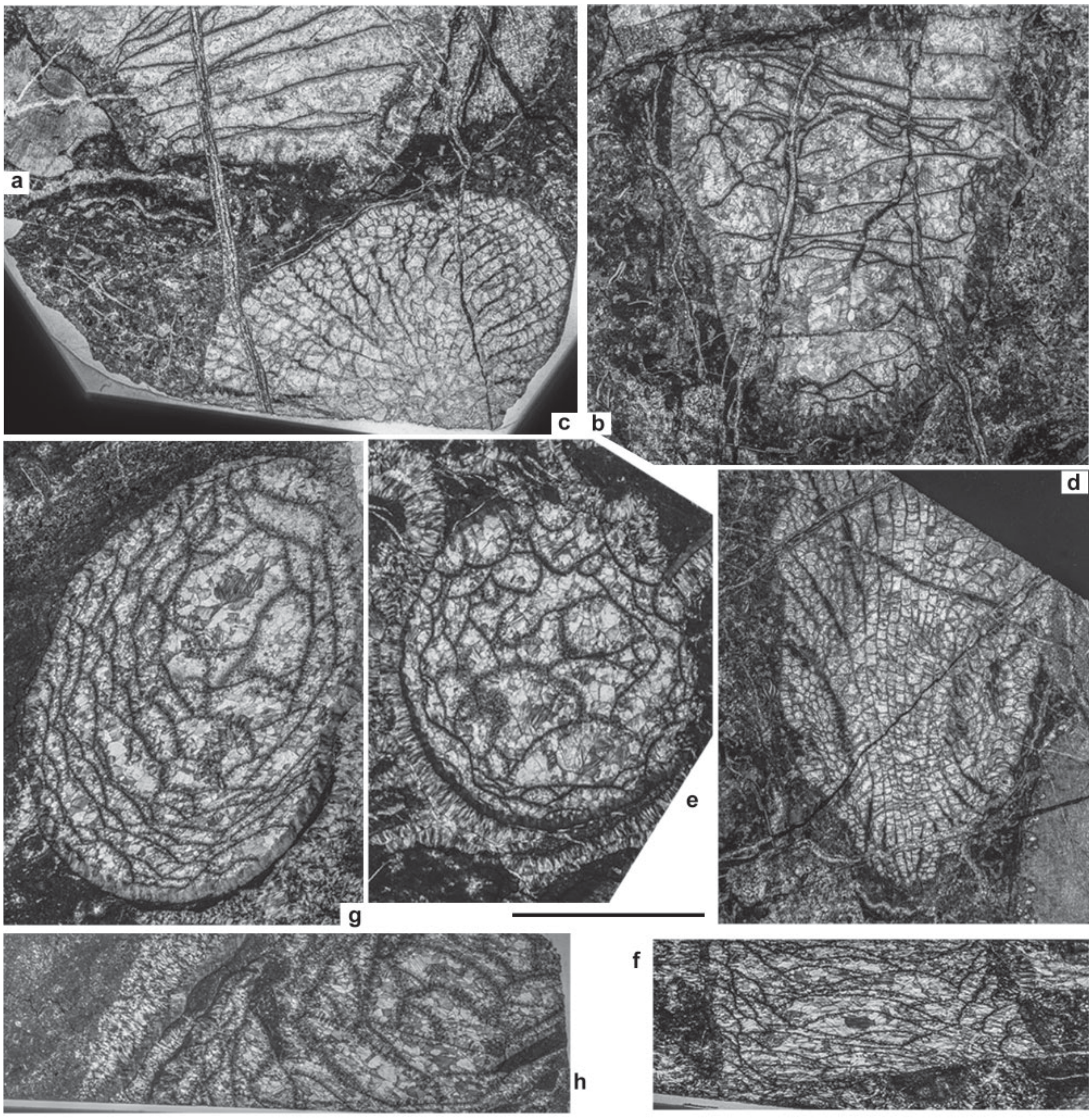

Figure 9. a-b, *Tryplasma derrengullenense* Etheridge, 1907. a, MMF34020b-1, LS; b, MMF34020a, oblique TS. c-d, *Entelophyllum patulum yassense*? (Etheridge, 1892). c, MMF34020b-2, TS; d, MMF34020c, oblique LS. e-h, *Cystiphyllum* sp. e, MMF34012b-2, TS; f, MMF34012c-2, TS; g, MMF34010a, TS; h, MMF34010b, LS. Abbreviations referring to Figure 7 caption; a-d from C1627 and e-h from C1518, all at same magnification, scale bar = 10 mm.

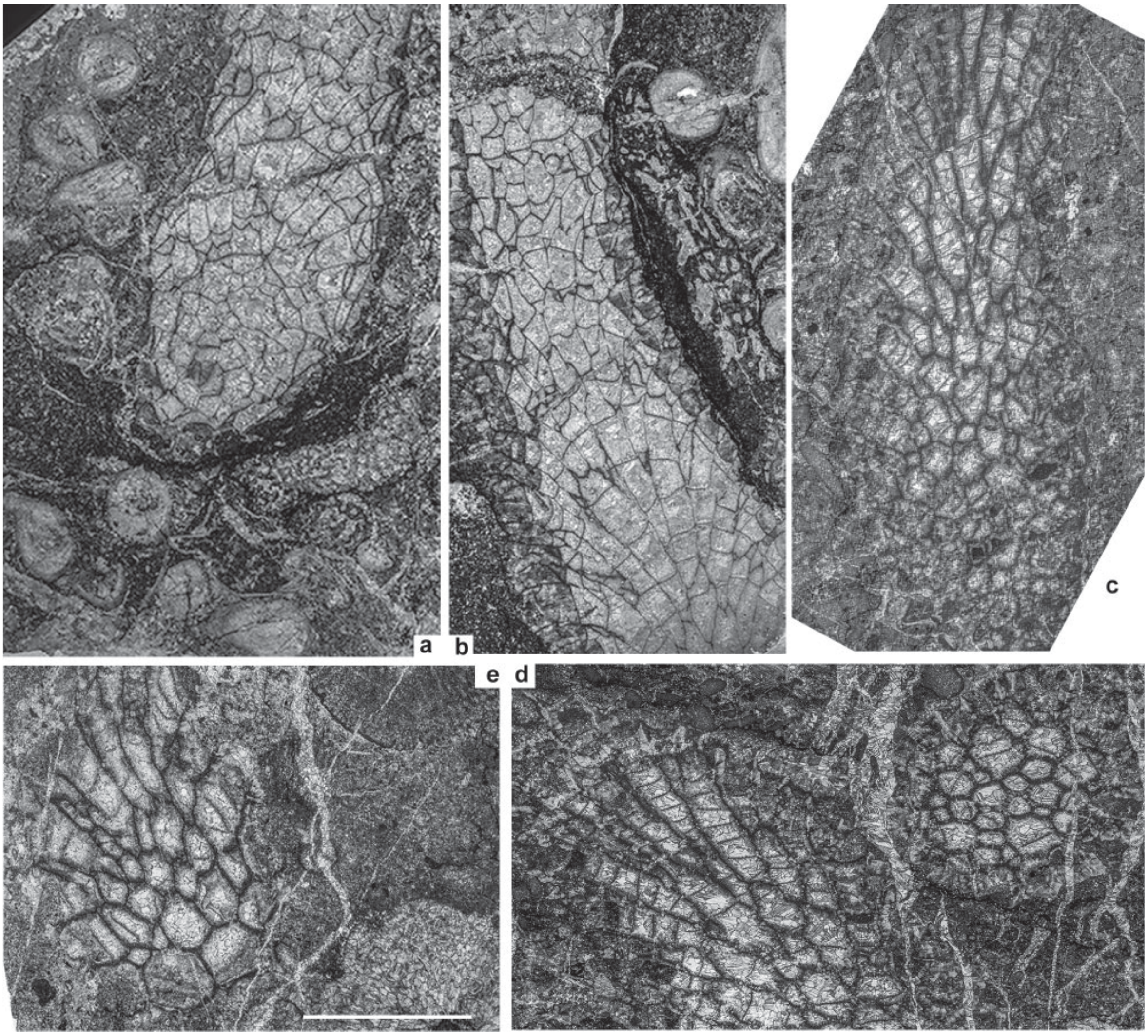

Figure 10. a-b, *Striatopora* sp. A. a, MMF34023a, oblique TS, in association with *Syringopora* sp. and *Amphipora* sp.; b, MMF34023b, oblique LS, in association with *Syringopora* sp. and *Amphipora* sp. c-e, *Striatopora* sp. B.; c, MMF34007b, oblique LS; d, MMF34007a, TS + oblique LS; e, MMF33962a, TS. Abbreviations referring to Figure 7 caption; a-b from C1627, c-d from C1518, e from C1591; all at same magnification, scale bar = 5 mm.

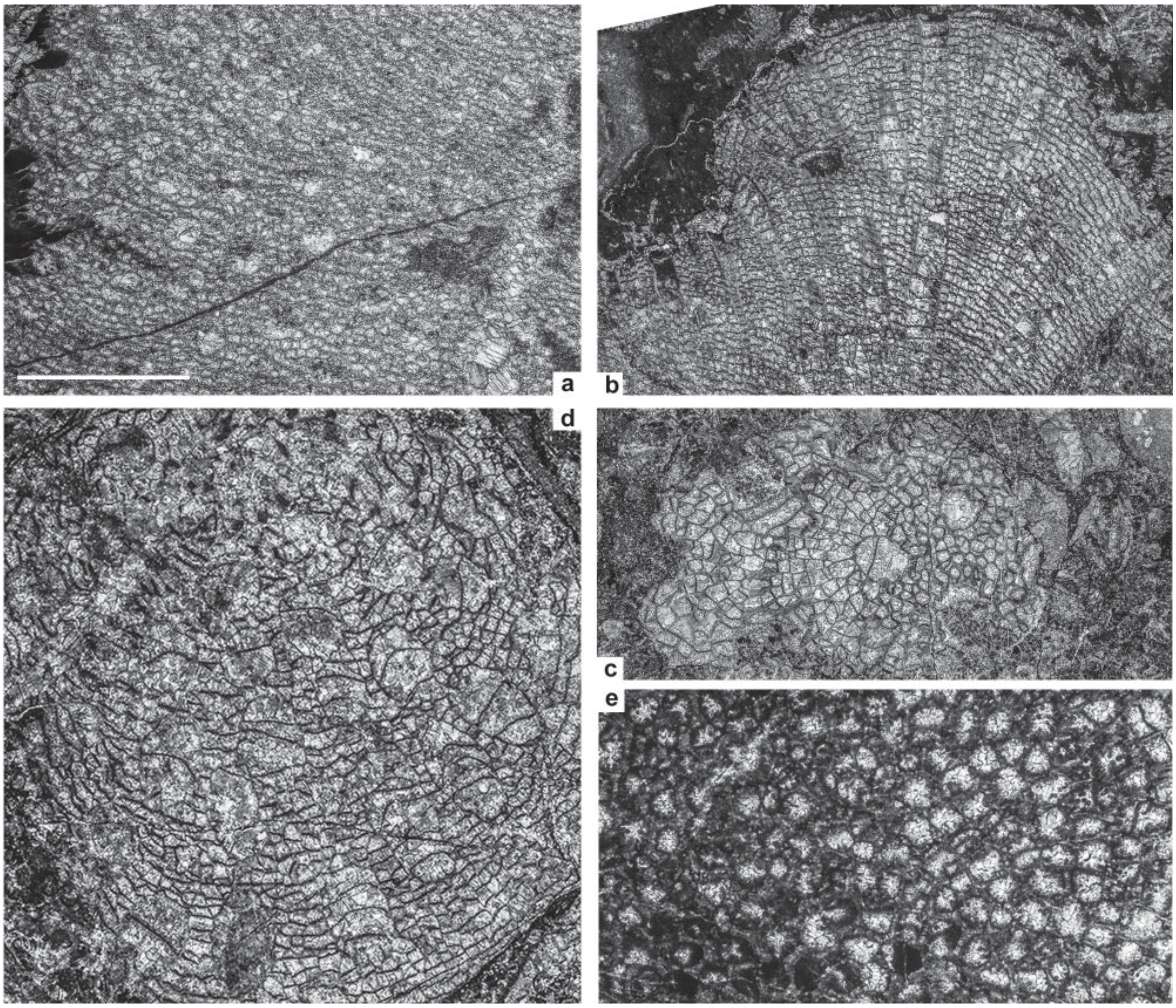

Figure 11. a-b, *Pseudoplasmopora follis* (Milne-Edwards and Haime, 1851). a, MMF34088c, TS; b, MMF34088a, LS. c-d, *Pseudoplasmopora* sp. cf. *P. heliolitoides* (Lindström, 1899). c, MMF34018a, TS; d, MMF34021a, TS. e, Favositidae gen. et sp. indet. MMF34062b, TS. Abbreviations referring to Figure 7 caption; a-b from C1634, c-d from C1627, e from C1600; all at same magnification, scale bar = 5 mm.

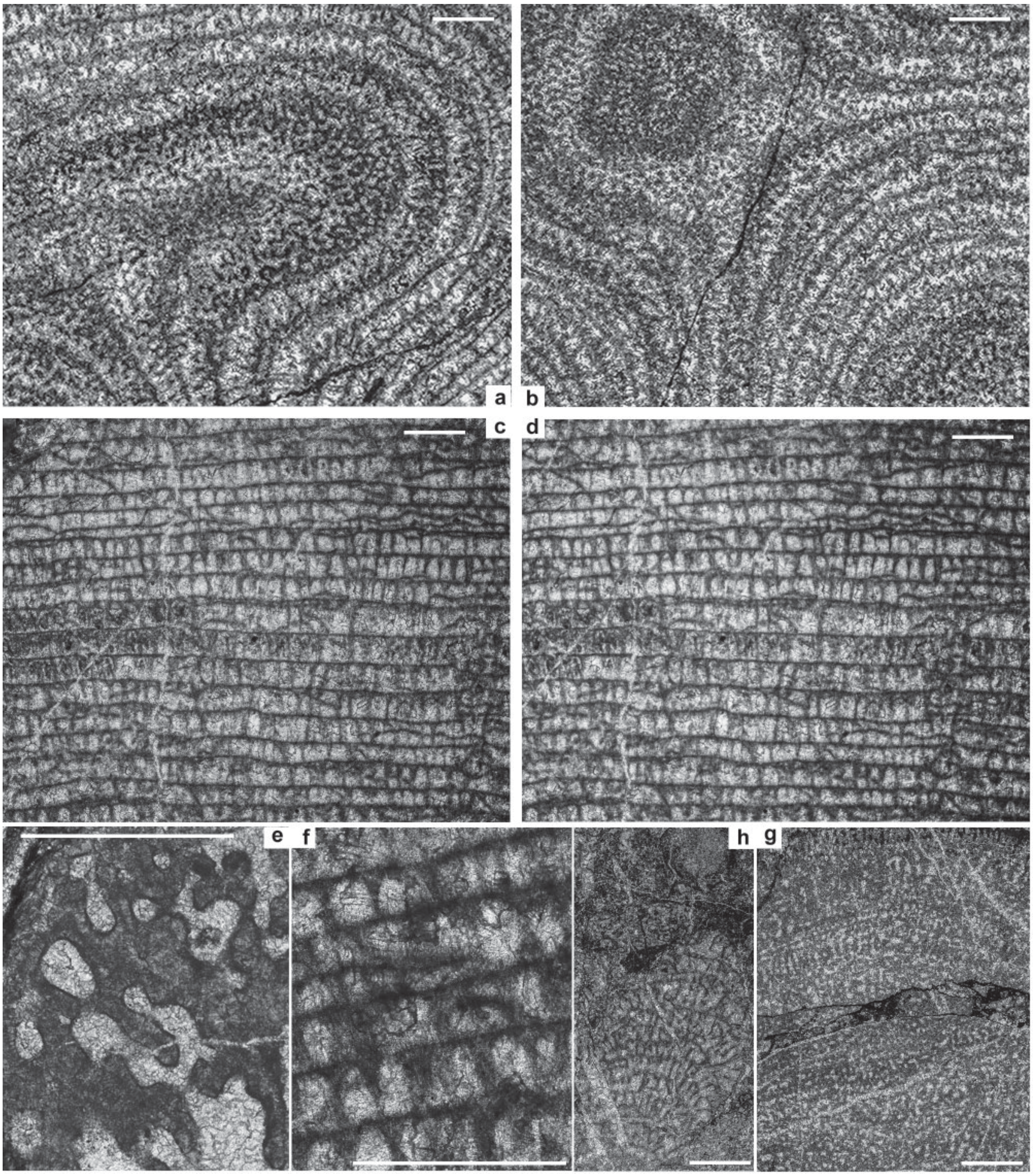

Figure 12. a-f, *Schistodictyon webbyi* sp. nov. Holotype, a-b, e, MMF34017b, tangential sections; c-d, f, MMF34017a, longitudinal sections. g, *Syringostromella* sp. MMF34024d, longitudinal section. h, *Clavidictyon*? sp. MMF34018a, longitudinal section; all from C1627; scale bars = 1 mm.