

Lower Permian (Sakmarian) palynoflora from the Woolaga Limestone Member of the Holmwood Shale, northern Perth Basin, Western Australia

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Abstract

The Woolaga Limestone Member—a thin, muddy, calcareous unit of the Holmwood Shale in the northern Perth Basin of Western Australia—contains a diverse and exceptionally well preserved palynoflora associated with a varied marine invertebrate fauna indicative of a Sakmarian (Early Permian/Cisuralian) age. Spores and pollen grains are overwhelmingly predominant in this palynomorph assemblage, with the identified taxa suggesting its assignment to either the *Convurrencosporites confluens* Zone or the succeeding *Pseudoreticulatispora pseudoreticulata* Zone of the currently recognized Western Australian Permian palynozonation. The spore-pollen content reveals substantial allochthonous contributions from the pteridophytic and gymnospermous (notably glossopterid) land vegetation into the marine depositional environment. Autochthonous or near-autochthonous components consist of algal microfossils (marine, fresh water, or brackish water) and rare scolecodonts (wholly marine).

Keywords: palynology, Lower Permian, Perth Basin, Western Australia

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INTRODUCTION

The past century has witnessed progressive and substantial developments in palynological studies, particularly, but by no means exclusively, in a range of geological and palaeobotanical enterprises, and applications. Whereas marine invertebrate faunas are prime requisites for the precise dating of stratal successions in terms of the international timescale, palynological microfossils (palynomorphs) are typically crucial in establishing correlations between non-marine and marine facies.

The Permian system is represented in Australia by both fossiliferous marine and palyniferous terrestrial successions. Many of the latter are coal-bearing such as in Western Australia's Perth and Collie basins, and in the Sydney and Bowen basins of eastern Australia. The highly weathered nature of the Australian terrain tends to militate against establishing marine to non-marine stratigraphic/chronological correlations because palynomorphs have proven highly susceptible to destruction by the oxidative weathering in the Cenozoic. Hence Australian palynologists necessarily rely almost entirely on samples from boreholes (e.g. Jones & Truswell 1992) or from strata exposed below the level of lateritization (e.g. Playford 2019). In that regard, the present study is a conspicuous and fortuitous exception: the samples hosting the palynoflora recorded herein are from outcrop—seemingly, timely cementation of the hosting sediment effectively militated against subsequent deleterious weathering.

GEOLOGICAL SETTING

The Woolaga Creek area is situated in the northern Perth Basin, specifically within the Irwin Sub-basin (aka Irwin Basin or Irwin Terrace) between the Darling and Urella faults (Fig. 1), and represents a southerly extension of the Permian succession exposed along the Irwin River (Playford 1959; Playford *et al.* 1976; Cockbain 1990; Mory *et al.* 2005; Mory & Haig 2011). In both areas, the Permian strata comprise the following essentially conformable lithostratigraphic units (Fig. 2): in ascending order, Nangetty Formation (glacigene, marine and continental), Holmwood Shale (cold- to warm-water marine), High Cliff Sandstone (marginal marine), Irwin River Coal Measures (non-marine, fluviodeltaic-paralic), Carynginia Formation (shallow marine, restricted circulation) and Wagina Sandstone (non-marine, fluvial).

The Holmwood Shale, as exposed in the western part of the Woolaga Creek area, consists predominantly of grey siltstone and mudstone with intercalations of thin lenticular bioclastic calcarenites. The age of the formation is well established as Cisuralian, specifically Sakmarian, on the basis of its invertebrate fauna. The formation's thickness, as reported by Playford (1959) at Woolaga Creek, is at least 132.6 m, its contact with the underlying Nangetty Formation being unexposed. Farther north, in the Irwin River area, limestone beds are fairly common within the Holmwood Shale (e.g. Beckett and Fossil Cliff members, of the lower and uppermost Holmwood Shale, respectively), but these are somewhat lesser developed in the less complete Woolaga Creek section. There the most conspicuous and fossiliferous calcareous unit forms a bouldery exposure—approximately 1 m thick and about 55 m below the top of the Holmwood Shale—termed the Woolaga Limestone Member (Playford 1959).

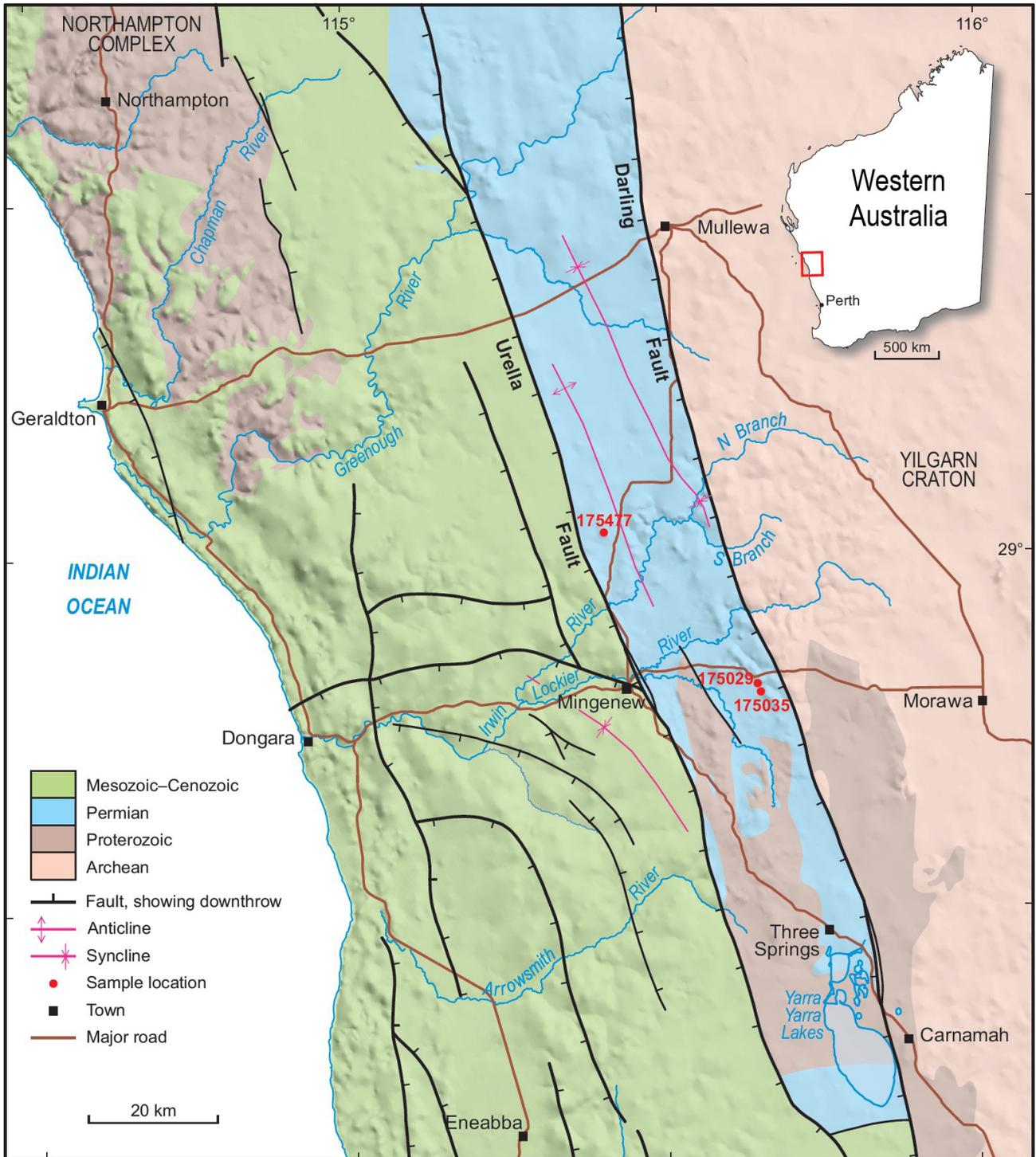


Figure 1. Locality map, northern Perth Basin, including locations of samples studied (UWA 175029, 175035, 175477).

The varied marine invertebrate fauna of the Woolaga Limestone Member includes foraminifers, scyphozoans, bryozoans, brachiopods, bivalves, gastropods, nautiloids, ammonoids, conulariids, annelids, ostracods, sponge spicules and serpulids (Playford 1959, Playford *et al.* 1976, Skwarko 1993, D.W. Haig, email comm., 2 June 2021). Of these, the ammonoid species *Juresanites jacksoni* (Etheridge Jr 1907), *J. campbelli* (Teichert & Glenister 1952) and *Svetlanoceras irwinense* (Teichert & Glenister

1952; previously known as *Uraloceras irwinense*) have been regarded as signifying a Sterlitamakian (late Sakmarian) age (Glenister & Furnish 1961; Glenister *et al.* 1990). Note that in a paper written five years prior to Glenister *et al.* (1990)—but not published until eight years later—Glenister *et al.* (1993, p. 55–56) indicated the likelihood of a Tastubian (early Sakmarian) age for the Woolaga Limestone Member. They further surmised that the Fossil Cliff Member could be late Tastubian but

PERMIAN (part)	GUADALUPIAN (part)			Wagina Sandstone
	CISURALIAN	Kungurian	274.4 ± 0.4 Ma	Carynginia Formation
		Artinskian	283.3 ± 0.4 Ma	Irwin River Coal Measures
		Sakmarian	290.5 ± 0.4 Ma	High Cliff Sandstone
				Holmwood Shale
		Asselian	293.5 ± 0.4 Ma	Nangetty Formation
PENNSYLVANIAN (part)		298.9 ± 0.4 Ma		

Figure 2. Permian stratigraphic succession, Irwin Sub-basin, northern Perth Basin. Ages of stage boundaries (in Ma) after Gradstein *et al.* (2020).

that ‘for practical purposes the Tastubian–Sterlitamakian boundary is considered to lie at the base of the Fossil Cliff Member.’ However, such suggestions were evidently negated by the 1990 publication in which Glenister and his colleagues reverted to a Sterlitamakian age for the Woolaga Limestone Member (and for the Callythara Formation in the Southern Carnarvon Basin).

Leonova (1998, 2011) indicated a generalized (undivided) Sakmarian age for the Western Australian Permian faunas that include *Juresanites jacksoni* and *Svetlanoceras (Uraloceras) irwinense*, which she equated with the Urals species *J. kazachorum* and *U. simense*, respectively (Leonova 2011, table 2.1.3). More recently, Leonova (2018) concluded that globally beyond the South Urals region ‘it is impossible to recognize separate Early Sakmarian and Late Sakmarian [ammonoid] assemblages.’

A recent proposal of an older Permian (Asselian) dating for the Holmwood Shale (Backhouse & Mory 2020) is evidently based on tenuous extrapolation of palynological information and absolute age determination from northern Australia. This is discussed further in the correlation section of the present paper. From the above ammonoid evidence, a Sakmarian (likely Sterlitamakian) age is accepted for the Woolaga Limestone Member.

MATERIAL AND METHODS

This paper reports the palynofloral composition of two Woolaga Limestone Member samples collected on 5 September 2016 by D.W. Haig and A.J. Mory from the unit’s type locality, at 29°12′12.7″S 115°39′17.7″E (sample UWA175029) and 29°11′53.5″S 115°39′13.7″E (sample UWA175035). Both samples are recorded as well-cemented, dark grey, fossiliferous, calcareous mudstone (D.W. Haig, email comm., 5 April 2021). A third sample (UWA175477; a muddy limestone), collected subsequently (2 May 2019) by D.W. Haig and A. Dillinger farther north (Macaroni Hill bioherm at 28°58′17.8″S 115°24′25.56″E) proved essentially non-palyniferous.

As noted previously, the two palyniferous surface samples (UWA175029, UWA175035), are unusual in an Australian context, particularly in yielding palynofloras with such fine and advantageous preservation. The following is a summary of the laboratory procedures (D.J. Mantle, email comm., 9 April 2021) employed by MGPalaeo in extracting and concentrating the palynomorphs: ‘Just over 100 g of each sample were processed using acid-digestion palynological processing techniques as outlined by Phipps & Playford (1984), Wood *et al.* (1996) and Brown (2008). Following washing and crushing of the samples, 100 ml of 32% hydrochloric acid were added, for two hours, to remove carbonates. The resultant residues were then neutralized before the addition of 100 ml of 48% hydrofluoric acid, for 48 hours, to digest silicate minerals. The remaining residues were again neutralized, and then sieved using both 10 µm and 100 µm nylon sieves to remove the fine and coarse components, respectively. The residual organic material was then subjected to heavy-liquid separation using lithium heteropolytungstate (specific gravity 2.1), prior to mounting part of these kerogen fractions on glass microscope slides using Petropoxy-154. The remaining kerogen fractions were then subjected to 40 seconds’ oxidation with nitric acid (69%), with further microscope slides being mounted of these oxidized assemblages. The UWA175035 sample initially yielded a very sparse but well-preserved assemblage; it was thus reprocessed to obtain improved spore-pollen specimens for study. For this repeat processing, the hydrofluoric (HF) acid digestion was increased to five days, with the HF acid refreshed daily. This long-digestion HF treatment resulted in significantly improved spore-pollen yields from this sample.’

The palynomorphs illustrated in Figures 3–9 were captured as high-resolution (TIFF) images with an Olympus BH2 binocular microscope, using either a 40× or a 60× oil-immersion objective, with attached Olympus DP26 digital camera. The images were acquired using Olympus cellSens® software and the plates were assembled via CorelDRAW graphics suite.

Table 1. Composition of palynoflora from the Woolaga Limestone Member arranged in major groups showing relative abundances (based on systematic counting of 250 specimens), figure numbers, and previously recorded occurrences from the Holmwood Shale.

Taxa		Figure nos	
Spores			
<i>Apiculiretusispora</i> sp. 1	•	4A/B	
<i>Apiculiretusispora</i> sp. 2	r	4C/D	
<i>Brevitriletes cornutus</i> (Balme & Hennelly 1956) Backhouse 1991	c	3S, T	* ✓
<i>Calamospora</i> sp.	r	3D	
<i>Convruccosporites confluens</i> (Archangelsky & Gamarro 1979) Playford & Dino 2002	u	3I/J–L	* ✓
<i>Convruccosporites micronodosus</i> (Balme & Hennelly 1956) Playford & Dino 2002	u	3G/H	* ✓
<i>Convruccosporites naumoviae</i> (Hart 1963) Backhouse 1991	r	3M	* ✓
<i>Densoisporites solidus</i> Segroves 1970	c	4K/L	* ✓
<i>Diatomozonotriletes townrowii</i> Segroves 1970	r	4E, F/G	* ✓
<i>Diatomozonotriletes</i> sp. cf. <i>D. saetosus</i> (Hacquebard & Barss 1957) Hughes & Playford 1961	•	4H	
<i>Diatomozonotriletes</i> sp.	r	4I/J	
<i>Gondisporites bharadwajii</i> Foster 1979	•	4N	*
<i>Gondisporites ewingtonensis</i> Backhouse 1988	u	4Q, R	
<i>Gondisporites wilsonii</i> Backhouse 1988	r	4O/P	✓
<i>Granulatisporites austroamericanus</i> Archangelsky & Gamarro 1979	u	3N	
<i>Horriditriletes curvibaculosus</i> Bharadwaj & Salujha 1964	u	3P	
<i>Horriditriletes ramosus</i> (Balme & Hennelly 1956) Bharadwaj & Salujha 1964	u	3Q, R	* ✓
<i>Indotriradites niger</i> (Segroves 1970) Backhouse 1991	u	4M	
<i>Kendosporites striatus</i> (Salujha 1965) Surange & Chandra 1974	•	5P	
<i>Laevigatosporites</i> sp.	r	8A	
<i>Leiotriletes badamensis</i> (Venkatachala & Kar 1965) Foster 1975	r	3C	*
<i>Leiotriletes directus</i> Balme & Hennelly 1956	a	3B	* ✓
<i>Microbaculispora tentula</i> Tiwari 1965	u	3O	* ✓
<i>Punctatisporites gretensis</i> Balme & Hennelly 1956	r	3A	* ✓
<i>Secarisporites lacunatus</i> (Tiwari 1965) Backhouse 1988	u	4S/T, 5A	
<i>Waltzisporea</i> sp.	•	3E, F	
Pollen grains			
<i>Alisporites</i> sp.	r	7F	
<i>Barakarites rotatus</i> (Balme & Hennelly 1956) Bharadwaj & Tiwari 1964	r	5B	*
<i>Barakarites</i> sp.	•	5C	
<i>Caheniasaccites ovatus</i> (Bose & Kar 1966) Gutiérrez 1993	r	7B, C	
<i>Caheniasaccites</i> sp.	r	6G, H	*
<i>Cannanoropollis janakii</i> Potonié & Sah 1960	u	5G, H	*
<i>Cannanoropollis mehtae</i> (Lele 1964) Bose & Maheshwari 1968	r	5D, E	*
<i>Cannanoropollis perfectus</i> (Bose & Maheshwari 1968) Dias-Fabrácio 1981	•	5F	
<i>Cannanoropollis</i> sp.	•	5O	
<i>Cycadopites cymbatus</i> (Balme & Hennelly 1956) Hart 1965	c	8E–H	* ✓
<i>Cycadopites</i> sp.	•	8I	
<i>Limitisporites rectus</i> Leschik 1956	u	6K–N	* ✓
<i>Limitisporites</i> sp. 1	r	6N, O	
<i>Limitisporites</i> sp. 2	r	7A	
<i>Marsupipollenites striatus</i> (Balme & Hennelly 1956) Hart 1965	•	8B	* ✓
cf. <i>Marsupipollenites striatus</i> (Balme & Hennelly 1956) Hart 1965	r	8C/D	
<i>Plicatipollenites densus</i> Srivastava 1970	r	5I	
<i>Plicatipollenites gondwanensis</i> (Balme & Hennelly 1956) Lele 1964	r	5J	*
<i>Plicatipollenites malabarensis</i> (Potonié & Sah 1960) Foster 1975	r	5K, L	*
<i>Plicatipollenites</i> sp. cf. <i>P. triangularis</i> Lele 1964	•	5M	
<i>Plicatipollenites</i> sp.	r	5N	
<i>Potonieisporites brasiliensis</i> (Nahuys, Alpern & Ybert 1968) emend. Archangelsky & Gamarro 1979	r	6F	
<i>Potonieisporites novicus</i> Bharadwaj 1954	u	6A–C	✓

<i>Potonieisporites</i> sp. cf. <i>P. methoris</i> (Hart 1960) Foster 1975	r	6I, J	
<i>Potonieisporites</i> sp.	•	6D, E	
<i>Protohaploxyypinus amplus</i> (Balme & Hennelly 1955) Hart 1964	u	7H	✓
<i>Protohaploxyypinus goraiensis</i> (Potonié & Lele 1961) Hart 1964	u	7G, K	
<i>Protohaploxyypinus limpidus</i> (Balme & Hennelly 1955) Balme & Playford 1967	u	7P, Q	* ✓
<i>Pteruchipollenites gracilis</i> (Segroves 1969) Foster 1979	r	7D	* ✓
<i>Pteruchipollenites</i> sp. cf. <i>P. gracilis</i> (Segroves 1969) Foster 1979	r	7E	
<i>Striatoabieites multistriatus</i> (Balme & Hennelly 1955) Hart 1964	u	7L–N/O	* ✓
<i>Striatopodocarpites</i> sp. 1	•	7I	
<i>Striatopodocarpites</i> sp. 2	•	7J	
<i>Triadispora</i> sp. 1	•	5Q	
<i>Triadispora</i> sp. 2	r	5R, S	
<i>Vittatina fasciolata</i> (Balme & Hennelly 1956) Bharadwaj 1962	r	7R, S	
<i>Vittatina scutata</i> (Balme & Hennelly 1956) Bharadwaj 1962	u	7T–V	✓

Algal microfossils

<i>Cymatiosphaera</i> sp. cf. <i>C. gondwanensis</i> (Tiwari 1965) Backhouse 1991	r	9E/F	
<i>Leiosphaeridia</i> sp.	r	9A	
<i>Maculatasporites</i> sp. cf. <i>M. indicus</i> Tiwari 1964	r	9D	
<i>Maculatasporites</i> sp. 1	r	9G	
<i>Maculatasporites</i> sp. 2	r	9H	
<i>Quadrifurcites horridus</i> Hennelly 1958 emend. Potonié & Lele 1961	r	9I	* ✓
<i>Spongocystia eraduica</i> Segroves 1967	r	9B/C	* ✓
<i>Tetraporina</i> sp.	u	8J–M	

Foraminifera

Microforaminiferal test linings	r	9L, M	
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Disarticulated polychaete annelid jaws

Scolecodonts	•	9J, K	
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a – abundant (>15%); c – common (>5 – 15%); u – uncommon (1–5%); r – rare (<1%); • – present, but not in count traverse.

* reported by Foster (in Foster *et al.* 1985, fig. 3, column 1; sample WA17).

✓ reported by Backhouse (1993, fig. 9).

All 109 figured specimens are preserved in strew slides housed permanently in the Paleontological Type Collection maintained by the Geological Survey of Western Australia, 37 Harris Street, Carlisle, Western Australia 6101. Curatorial information is provided in Appendix 1.

COMPOSITION OF PALYNOFLORA

The spore component comprises 17 genera (15 trilete, 2 monolete) and pollen grains comprise 15 genera (3 bisaccate non-taeniate, 3 bisaccate taeniate, 6 monosaccate, and one each of monocolpate, praecolpate, and polylicate genera). Algal palynomorphs are represented by six genera and polychaete annelids by infrequent, unnamed scolecodonts (Table 1).

Land-derived spores and pollen grains dominate this characteristically Eastern Gondwanan Permian palynoflora, both quantitatively and qualitatively (Table 1), and are accompanied by sparse representation of aquatic algal palynomorphs, and rare scolecodonts and

microforaminiferal test linings (aka palynoforaminifera: Arai & Koutsoukos 1998). The most common spores are *Leiotriletes directus* Balme & Hennelly 1956, *Densoisporites solidus* Segroves 1970 and *Brevitriletes cornutus* (Balme & Hennelly 1956) Backhouse 1991. Pollen species are diversely, if somewhat less commonly represented; the monocolpate *Cycadopites cymbatus* (Balme & Hennelly 1956) Hart 1965 is the most frequently encountered species. Of the palynoflora's minor but clearly autochthonous or near-autochthonous elements, an unnamed species of *Tetraporina* Naumova 1939 emend. Lindgren 1980 is the most common.

TAXONOMIC COMMENTARY

Aptly and aphoristically termed 'the backbone of palynology' (Gravendyck *et al.* 2021), taxonomy is the prime basis for establishing a practical and reliable spore-pollen stratigraphic zonation. As essential prerequisites, taxa selected to define a particular palynozone should have morphological integrity (as represented foremost

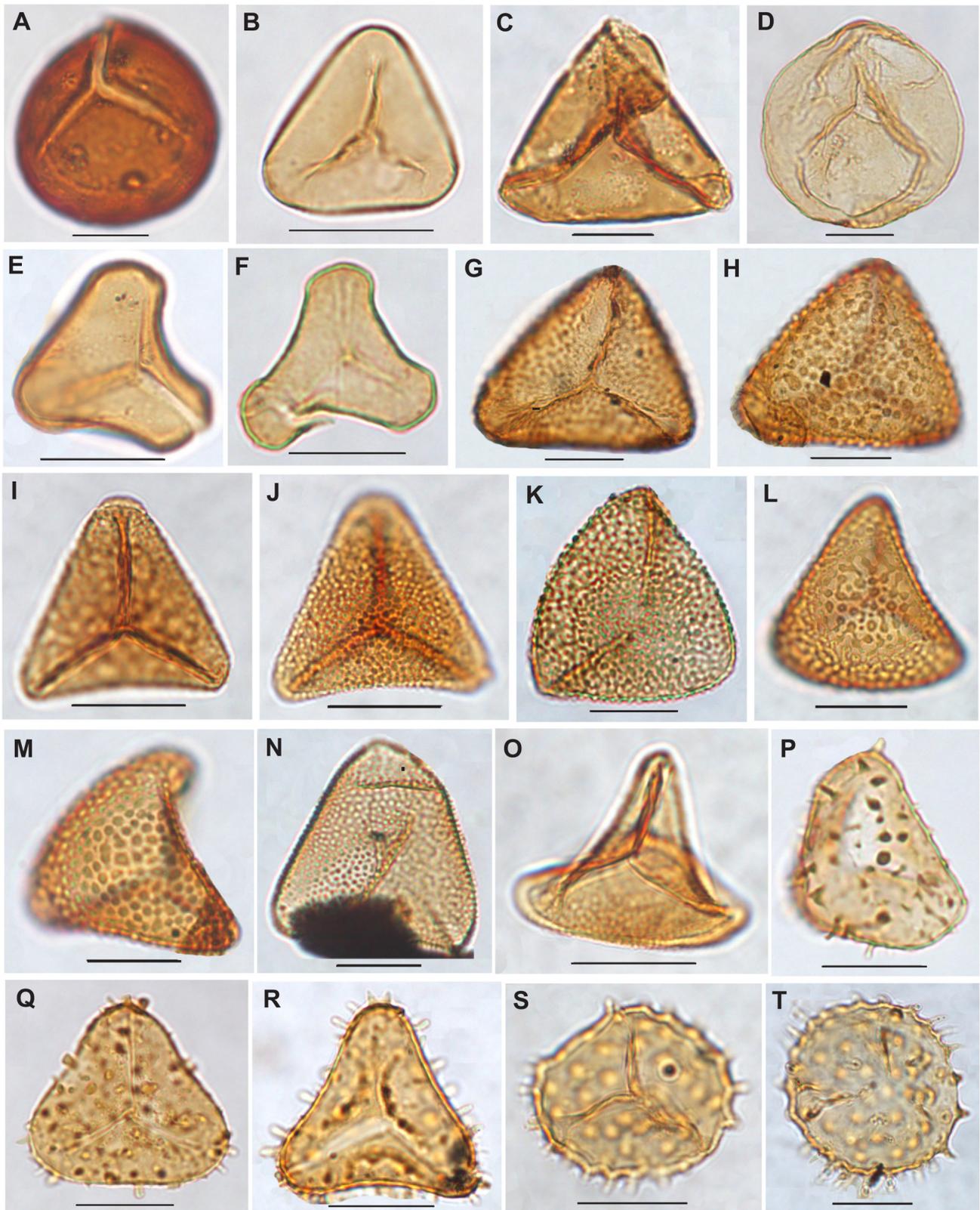


Figure 3. A, *Punctatisporites gretensis*, proximal focus. B, *Leiotriletes directus*, medial focus. C, *Leiotriletes badamensis*, proximal focus. D, *Calamospora* sp., proximal focus. E, F, *Waltzisporea* sp., medial and proximal foci. G/H, *Converrucosporites micronodosus*, proximal/distal foci. I/J–L, *Converrucosporites confluens*, proximal/distal foci. M, *Converrucosporites naumoviae*, distal focus. N, *Granulatisporites austroamericanus*, distal focus. O, *Microbaculispora tentula*, proximal focus. P, *Horriditriletes curvibaculosus*, distal focus. Q, R, *Horriditriletes ramosus*, proximal foci. S–T, *Brevitriletes cornutus*, proximal and medial foci. Scale bars = 20 µm. See Appendix 1 for curatorial details.

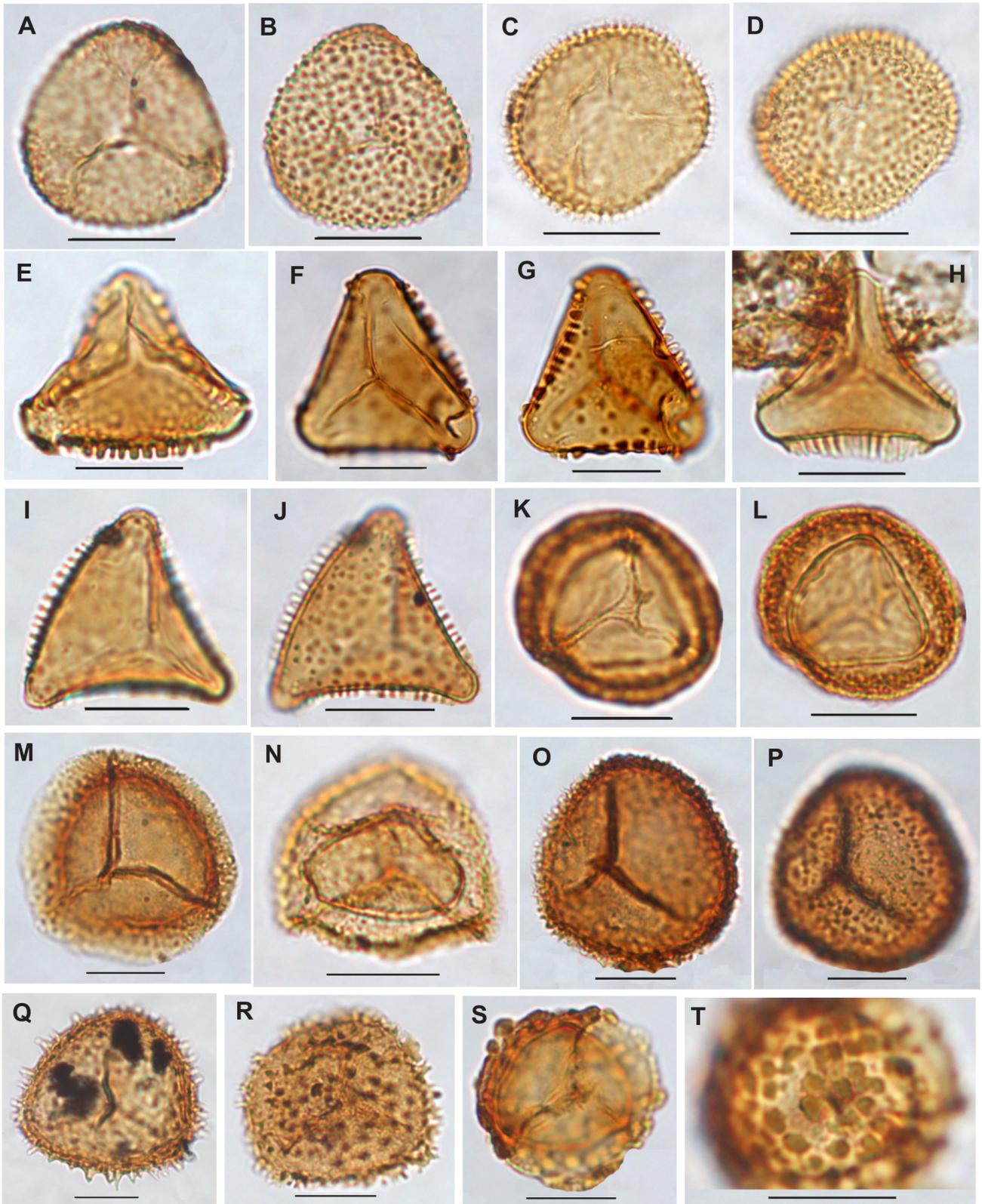


Figure 4. A/B, *Apiculiretusispora* sp. 1, proximal/distal foci. C/D, *Apiculiretusispora* sp. 2, proximal/distal foci. E, F/G, *Diatomozonotriletes townrowii*, near-proximal focus and proximal/medial foci. H, *Diatomozonotriletes* sp. cf. *D. saetosus*, medial focus. I/J, *Diatomozonotriletes* sp., proximal/medial foci. K/L, *Densoisporites solidus*, proximal/medial foci. M, *Indotriletes niger*, proximal focus. N, *Gondisporites bharadwajii*, medial focus. O/P, *Gondisporites wilsonii*, proximal/distal foci. Q, R, *Gondisporites ewingtonensis*, medial and distal foci. S/T, *Secarisporites lacunatus*, proximal/distal foci. Scale bars = 20 μ m. See Appendix 1 for curatorial details.

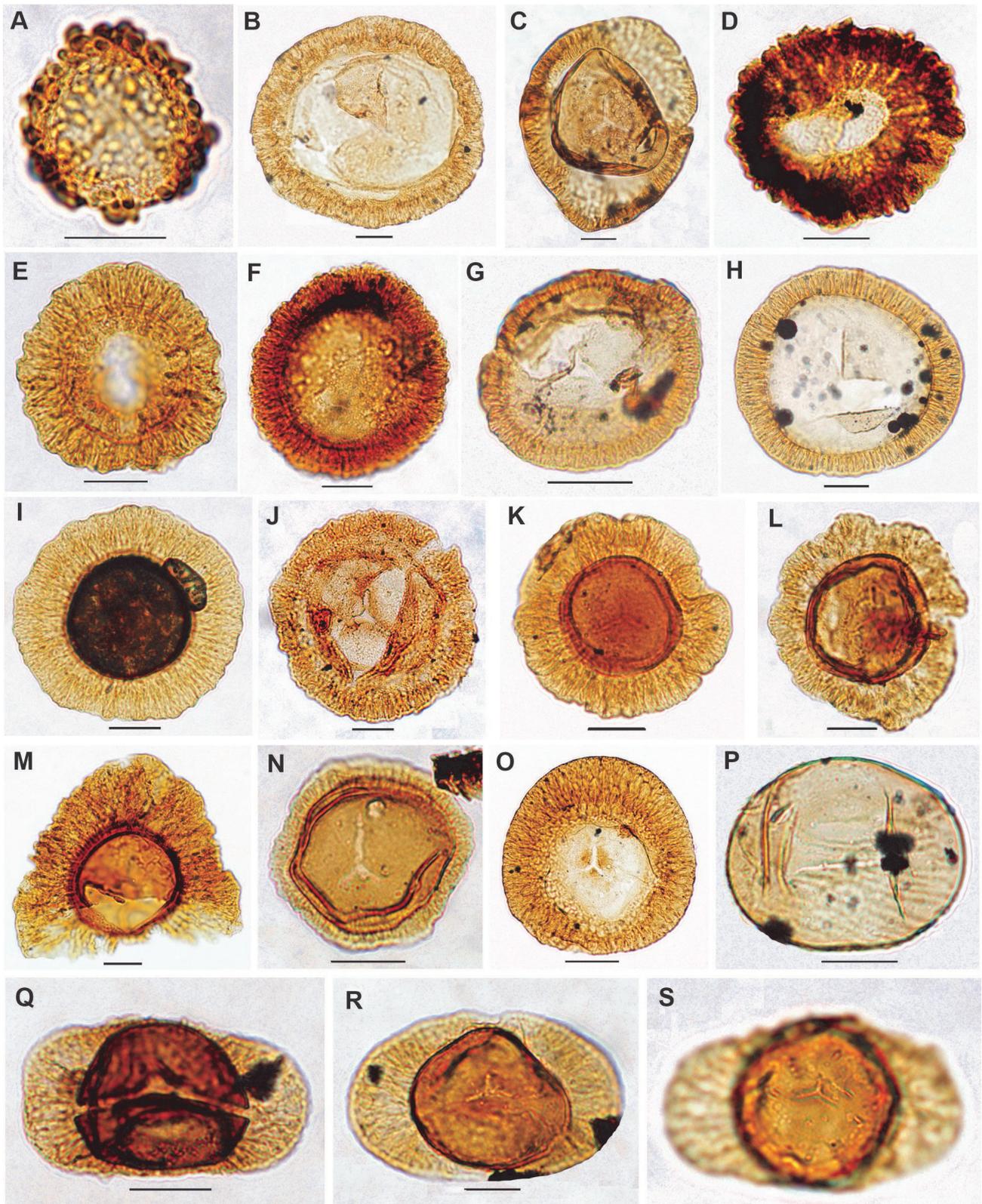


Figure 5. A, *Secarisporites lacunatus*, medial focus. B, *Barakarites rotatus*, medial focus. C, *Barakarites* sp., medial focus. D, E, *Cannanoropollis mehtae*, medial foci. F, *Cannanoropollis perfectus*, proximal focus. G, H, *Cannanoropollis janakii*, proximal foci. I, *Plicatipollenites densus*, medial focus. J, *Plicatipollenites gondwanensis*, proximal focus. K, L, *Plicatipollenites malabarensis*, proximal foci. M, *Plicatipollenites* sp. cf. *P. triangularis*, medial focus. N, *Plicatipollenites* sp., proximal focus. O, *Cannanoropollis* sp., proximal focus. P, *Kendosporites striatus*, medial focus. Q, *Triadispora* sp. 1, medial focus. R, S, *Triadispora* sp. 2, proximal foci. Scale bars = 20 μm , except O (= 50 μm). See Appendix 1 for curatorial details.

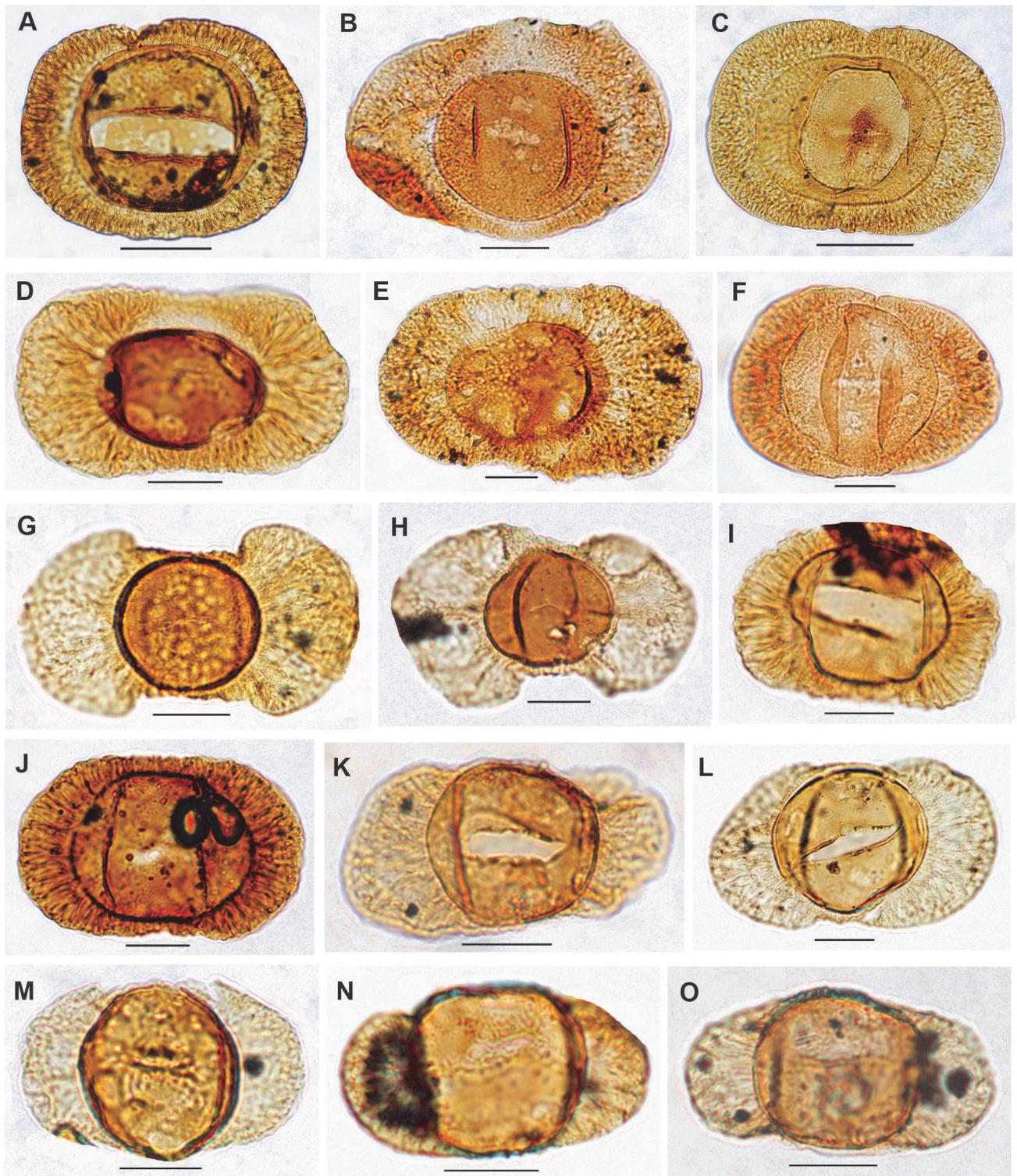


Figure 6. A–C, *Potonieisporites novicus*, medial foci. D, E, *Potonieisporites* sp., medial foci. F, *Potonieisporites brasiliensis*, proximal focus. G, H, *Caheniasaccites* sp., medial and proximal foci. I, J, *Potonieisporites* sp. cf. *P. methoris*, proximal and medial foci. K–M, *Limitisporites rectus*, proximal foci (K, L), medial focus (M). N, O, *Limitisporites* sp. 1, medial foci. Scale bars = 20 μm , except A (= 50 μm). See Appendix 1 for curatorial details.

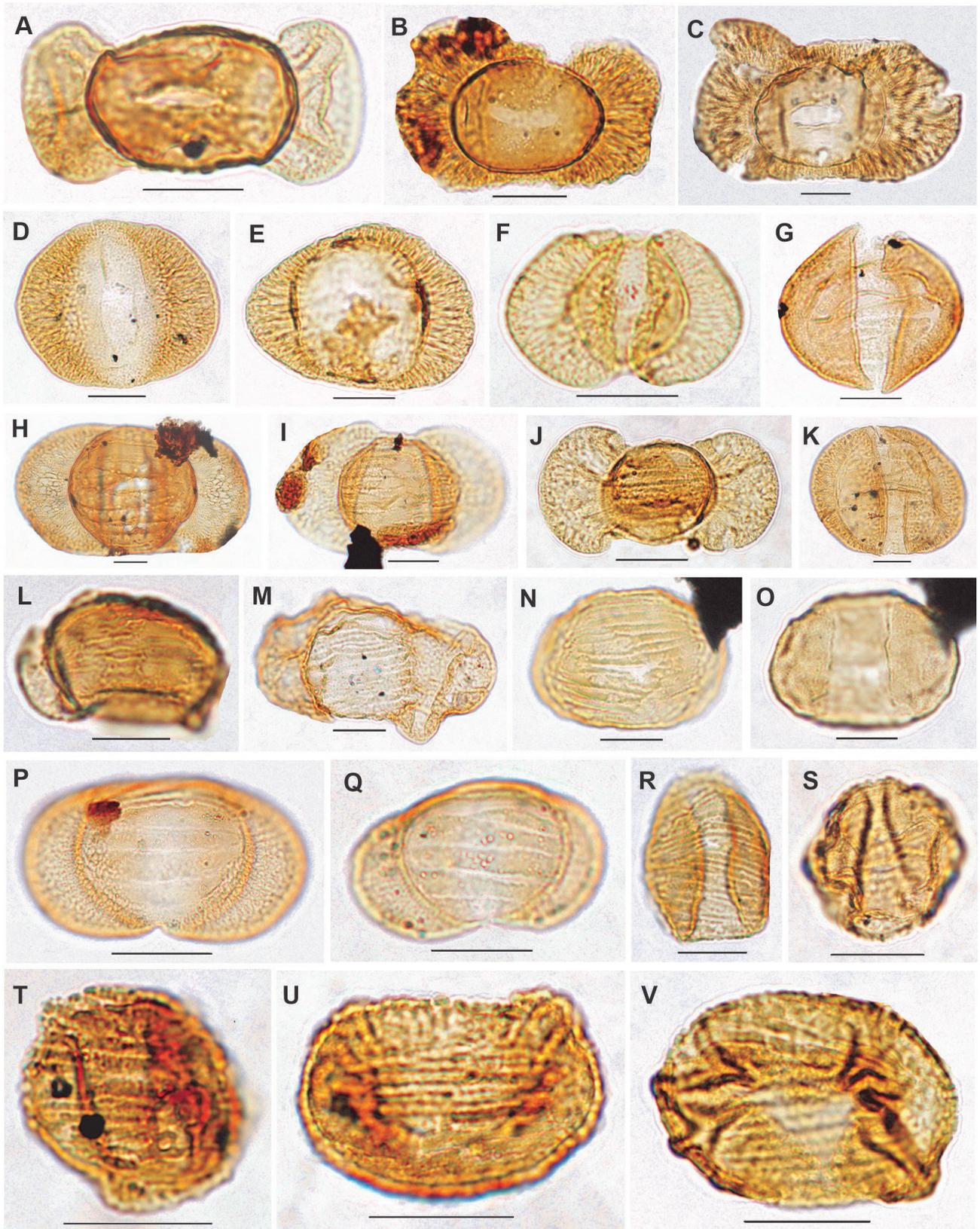


Figure 7. A, *Limitisporites* sp. 2, medial focus. B, C, *Caheniasaccites ovatus*, medial and proximal foci. D, *Pteruchipollenites gracilis*, medial focus. E, *Pteruchipollenites* sp. cf. *P. gracilis*, medial focus. F, *Alisporites* sp., distal focus. G, K, *Protohaploxypinus goraiensis*, medial foci. H, *Protohaploxypinus amplus*, proximal focus. I, *Striatopodocarpites* sp. 1, near-proximal focus. J, *Striatopodocarpites* sp. 2, medial focus. L–N/O, *Striatoabieites multistriatus*, proximal foci (L, M), proximal/distal foci (N/O). P, Q, *Protohaploxypinus limpidus*, medial and proximal foci. R, S, *Vittatina fasciolata*, medial foci. T–V, *Vittatina scutata*, medial foci. Scale bars = 20 µm. See Appendix 1 for curatorial details.

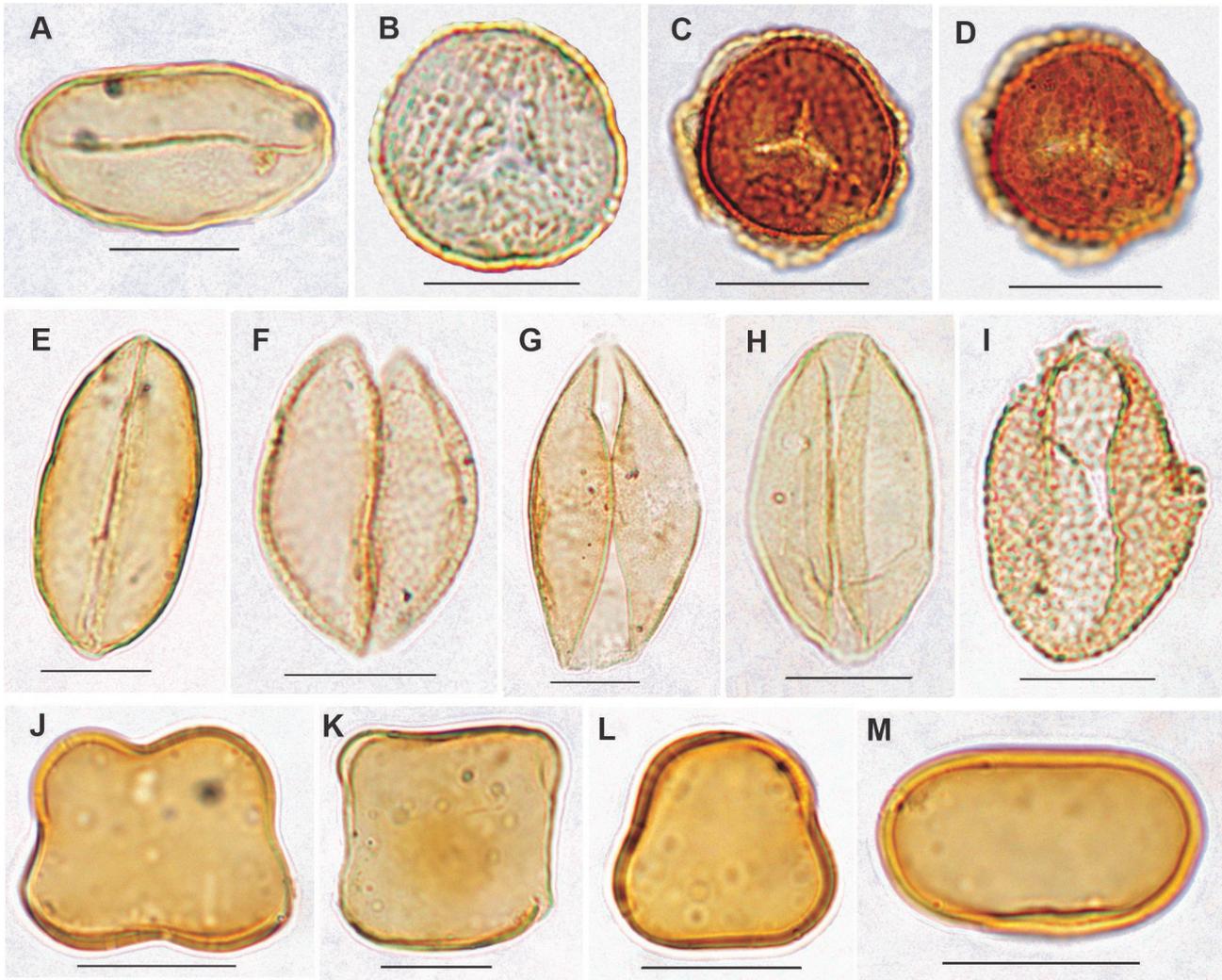


Figure 8. A, *Laevigatosporites* sp., medial focus. B, *Marsupipollenites striatus*, medial focus. C/D, cf. *Marsupipollenites striatus*, proximal/distal foci. E–H, *Cycadopites cymbatus*, medial foci. I, *Cycadopites* sp., medial focus. J–M, *Tetraporina* sp., medial foci. Scale bars = 20 µm. See Appendix 1 for curatorial details.

by their published type material), together with well-defined stratigraphic ranges (first- and/or last-appearance datums) or, less commonly and less definitively, prominent and consistent quantitative acmes or minima.

With many refinements in preparatory techniques, microscopy and photomicrography over the last half-century or so, it is inevitable that some palynomorph species instituted decades ago are difficult to identify with certainty or to be clearly differentiable from other morphologically similar species. This especially applies when the palynoflora being studied, as here, is much better preserved than in many relevant prior publications. Some taxonomic uncertainties encountered during the present study are discussed below and their future resolution would facilitate improved palynostratigraphic precision. No attempt was made at systematic identifications of the few, mostly in situ scolecodonts in view of the taxonomic instability associated with these largely disarticulated polychaete jaw apparatuses.

The zonal eponym *Converrucosisporites confluens* (Archangelsky & Gamero 1979) Playford & Dino 2002

(p. 246, 248; pl. 2, figs 3–8) has, since its institution >40 years ago, become a confused or ‘balloon’ taxon, with some putative identifications straying appreciably beyond Archangelsky & Gamero’s (1979, p. 422–423, pl. 1, figs 5, 6) original definition based on Argentine material (e.g. Césari *et al.* 1995, pl. 1, fig. 12). Cognizant of this taxonomic dilemma, Césari *et al.* (2013) pointed to the possibility or likelihood of morphological intergradation linking *C. confluens* with such species as *Granulatisporites austroamericanus* Archangelsky & Gamero 1979 and *Converrucosisporites micronodosus* (Balme & Hennelly 1956) Playford & Dino 2002. Moreover, Playford & Dino (2002), *inter alia*, have alluded to the possibility that *G. austroamericanus* and *Microbaculispora tentula* Tiwari 1965 are conspecific. However, each of these three species is recorded discretely herein pending provision of more definitive information on the latter’s type material (Tiwari 1965, p. 175–176; pl. 2, figs 35–37; text-fig. 2e). Backhouse & Mory (2020, p. 51) commented that *C. confluens* is with ‘little doubt ... a morphologic development from *M. tentula*.’ Resolution of this taxonomic conundrum is outside the scope of the present account; however, it is relevant to point out that:

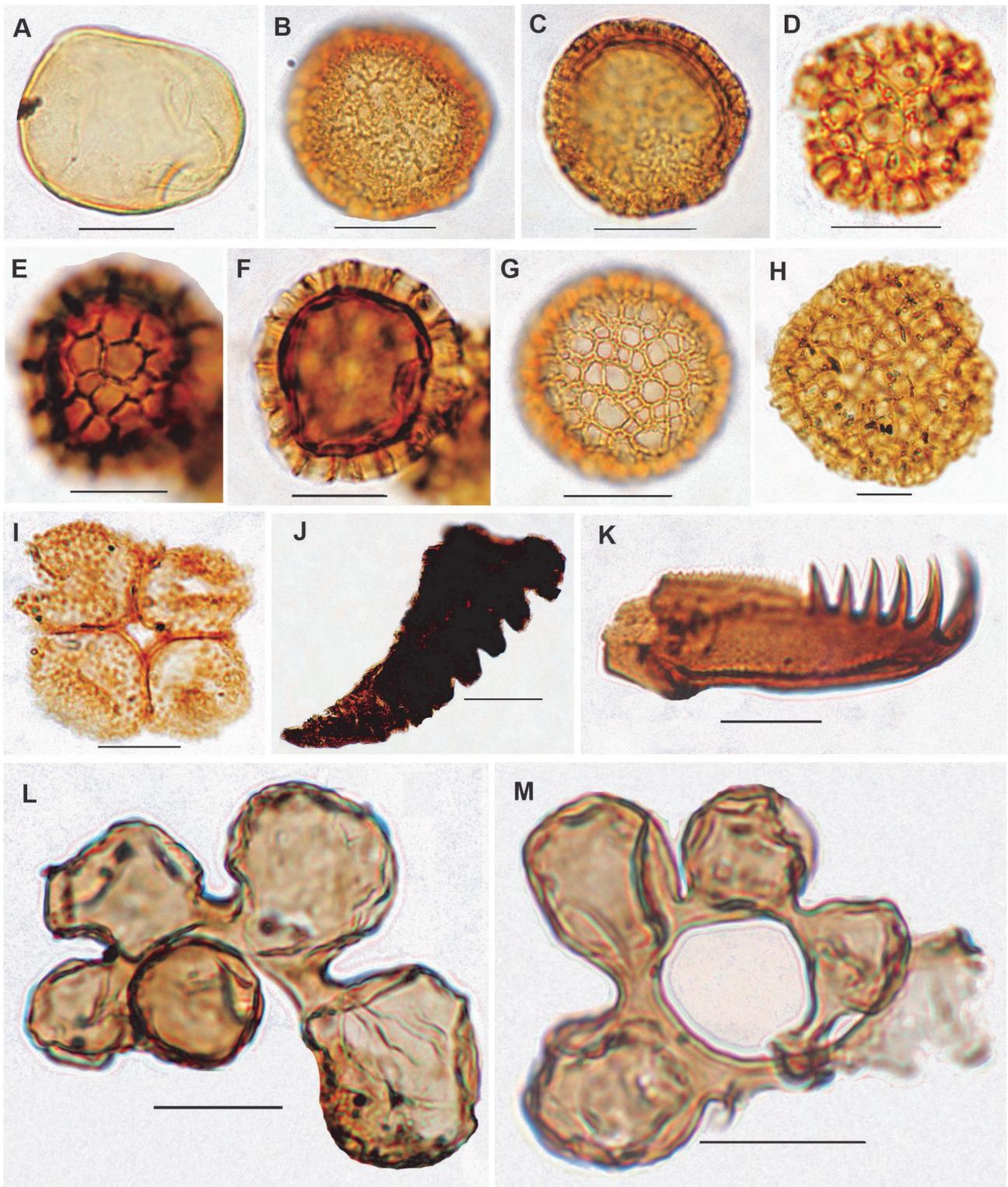


Figure 9. A, *Leiosphaeridia* sp., medial focus. B/C, *Spongocystia eraduica*, high/medial foci. D, *Maculatasporites* sp. cf. *M. indicus*, low focus. E/F, *Cymatiosphaera* sp. cf. *C. gondwanensis*, high/medial foci. G, *Maculatasporites* sp. 1, high focus. H, *Maculatasporites* sp. 2, medial focus. I, *Quadrisporites horridus*, medial focus. J, K, scolecodonts. L, M, microforaminiferal test linings. Scale bars = 20 μ m. See Appendix 1 for curatorial details.

(a) Australian identifications of *Converrucosporites confluens* by Backhouse (1991, pl. VI, figs 1–4) and Foster (in Foster & Waterhouse 1988, fig. 5f, i; albeit doubtfully fig. 4a–c) are consonant with Archangelsky & Gamero's (1979) species diagnosis, as are those recorded herein (Fig. 3I/J–L) and by, inter alia, Vergel (1998) and Playford & Dino (2002, from Argentina) Stephenson (1998, from Oman), Stephenson (2009, from Namibia) and Kavali *et al.* (2021, from India). These and other reports connote the widespread dissemination of *C. confluens* through Eastern, Western and Northern Gondwana during the Cisuralian.

(b) *Pseudoreticulispora pseudoreticulata* (Balme & Hennelly 1956) Bharadwaj & Salujha 1969 (not recorded in the Woolaga assemblage) is distinguishable from *C. confluens* à propos of its mainly larger size and coarser sculpture (e.g. Price 1983, pl. 5, figs 1–9; Backhouse 1991, pl. VI, figs 1–4 vs. figs 5–9; Stephenson & McLean 1999, fig. 4a, b). Backhouse & Mory (2020, p. 14) cautioned that, in some reports, *C. confluens* has been misidentified as *P. pseudoreticulata*, with ensuing doubtful or incorrect palynozonal assignments.

Two trilete apiculate species—*Horriditriletes tereteangulatus* (Balme & Hennelly 1956) Backhouse 1991 and *H. ramosus* (Balme & Hennelly 1956) Backhouse 1991 (the latter recorded herein)—have been differently interpreted, and variously reported, by later authors (e.g. Rigby & Hekel 1977). This is chiefly because the diagnoses and photomicrographs furnished by the original authors (Balme & Hennelly 1956b, p. 247, pl. 2, figs 27–29 and p. 249, pl. 3, figs 39–41, respectively) are insufficiently definitive for the two species to be recognized conclusively and individually. In the present account, identification of *H. ramosus*, as distinct from *H. tereteangulatus*, accords with Foster (1979, p. 39, pl. 7, figs 9–12), Playford & Rigby (2008, p. 18–19, pl. 3, figs 1, 2) and Backhouse (1991, pl. II, figs 14, 15a, b vs. figs 6–9). This applies likewise to the separate recognition, in the two last-named papers, of *H. filiformis* (Balme & Hennelly 1956b, p. 247, pl. 2, figs 22, 23) Backhouse 1991. Note that a specimen figured by Peyrot *et al.* (2019, fig. 3O) as *H. tereteangulatus* is clearly representative of *H. ramosus*. *Horriditriletes uruguayensis* (Marques-Toigo 1974) Archangelsky & Gamero 1979 (p. 424–426; pl. II, figs 2–4) differs little from, and could well be synonymous with, *H. ramosus*; see also Kavali *et al.* (2021, fig. 4.14, 4.16).

The stratigraphically important species *Diatomozonotriletes townrowii*, as defined by Segroves (1970, p. 54–55, pl. 3, figs D–G) and recorded herein (Fig. 4E, F/G), has been identified authentically in many reports (e.g. Backhouse 1991; Balme & Backhouse 1993; Stephenson & McLean 1999; Backhouse & Mory 2020). However, Rigby & Hekel's (1977, p. 9, pl. 2, figs 7, 8) comparative (cf.) identification of *D. townrowii* from the Permian of central Queensland differs conspicuously from the species as originally defined, not simply 'only in having shorter laesurae.' Foster in Foster *et al.* (1985) suggested assignment of those specimens to *Interradispora* Price 1979.

Most of the pollen grains could be identified at specific level with reasonable confidence. However, some uncertainties arise at generic level. For instance, the distinction between *Cannanoropollis* Potonié & Sah 1960

and *Plicatipollenites* Lele 1964 is not always clear cut; and the same evidently applies for *Alisporites* Daugherty 1941 and *Pteruchipollenites* Couper 1958. The recent affirmation (di Pasquo *et al.* 2021) that *Faunipollenites* Bharadwaj 1962 and *Protohaploxypinus* Samoilovich 1953 emend. Morbey 1975 are congeneric confirms the present assignments to the latter of the three species recorded herein.

The pollen grains here identified as cf. *Marsupipollenites striatus* (Balme & Hennelly 1956) Hart 1965 (Fig. 8C/D) are morphologically close to those reported as Balme & Hennelly's (1956a, p. 61, pl. 2, figs 36, 37) species by Foster (1979) and Backhouse (1991), but differ in possessing a relatively narrow equatorial zone. This disparity could possibly be a consequence of more complete preservation seen in the Woolaga Limestone material. Additionally, a single specimen encountered in the present study (Fig. 8B) is identified as *M. striatus*.

Two monosulcate species—*Vittatina fasciolata* (Balme & Hennelly 1956a, p. 62, pl. 3, figs 42–45) Bharadwaj 1962 and *V. sulcata* (Balme & Hennelly 1956a, p. 62, pl. 3, figs 38–41) Bharadwaj 1962—are similar morphologically and thus prone to be differentiated on somewhat nuanced criteria by different authors (e.g. Rigby & Hekel 1977; Backhouse 1991; Balme & Backhouse 1993). The identifications herein (Figs 7R, S and T–V, respectively) are essentially consonant with the two last-cited publications.

The relatively common, inaperturate specimens of the algal genus *Tetraporina*, as reported here, form a morphological, non-speciated near-continuum, with outline varying among square, rectangular, subcircular and elliptical (Fig. 8J–M; see also Segroves 1967, pl. 3, fig. 22; Foster in Foster *et al.* 1985, pl. 1, figs 16, 22). Of the representatives of the genus *Maculatasporites* Tiwari 1964 recorded herein, that labelled informally as *M. sp. 1* (Fig. 9G) appears similar to pollen of *Tribulus terrestris* Linné 1753 of the angiosperm family Zygophyllaceae (Sanchez Botero 2021, pl. 1, fig. 12). However, in detail (Nasri-Ayachi & Nabli 2009), the resemblance is superficial.

PALYNOSTRATIGRAPHIC CORRELATION AND DATING

Systematic documentation of palynomorphs from the Perth Basin's Permian strata—inaugurated in a series of publications (Balme & Segroves 1966; Segroves 1967, 1969, 1970)—was based on samples from boreholes distributed through the basin's northern sector, including the Woolaga Creek area (Segroves 1970, figs 1–3). Stratigraphic ranges of the spores and non-saccate pollen grains within the Permian succession were charted initially by Segroves (1970, fig. 4) and subsequently, and taxonomically more comprehensively, by Segroves (1972, fig. 4). In the latter paper, four stratigraphically successive palynological assemblages were proposed. Of these, the *Quadriflorites* Assemblage was shown as occupying the bulk of the Holmwood Shale including the uppermost Fossil Cliff Member, then known as a separate formation (Segroves 1972, p. 514; figs 1, 4; pls II, III). Not unexpectedly, the samples of the present study are generally compatible with the *Quadriflorites* Assemblage. Foster (in Foster *et al.* 1985) reported an abundant and varied palynoflora from a sample collected from the

type section of the Fossil Cliff Member in the Irwin River area. Mirroring to some extent the case with the Woolaga Limestone samples of the present study, Foster expressed surprise that his outcrop sample proved palyniferous. As indicated in Table 1, a large number of the species listed in Foster *et al.* (1985, fig. 3) are common to the Woolaga Limestone palynoflora.

The vertical ranges of certain species recorded herein were modified or instituted by later studies of Western Australian Permian palynofloras, most notably by John Backhouse; viz. Backhouse (1988, 1991) for the Collie Basin; Backhouse (1993), Perth, Collie and Officer basins; Backhouse (1998), all basins; Mory & Backhouse (1997), Carnarvon Basin; and Backhouse & Mory (2020), Canning Basin. Backhouse (1991, fig. 10) established a palynostratigraphic (spore-pollen) zonal scheme designed to be applicable to Permian successions of Western Australian basins. In particular, Backhouse (1991, fig. 11) provided a comprehensive chart detailing the vertical ranges of palynomorph species, characterized zonally, through Permian strata of the Collie Basin. Subsequently, and of particular relevance here, Backhouse (1993, p. 118–120, fig. 9) documented the vertical distribution of species in the Nangetty Formation and overlying Holmwood Shale in the northern Perth Basin. The palyniferous samples were from six named boreholes in the Irwin River and Woolaga Creek areas, with depth intervals juxtaposed successively (Backhouse 1993, figs 4, 9) and embracing, in ascending order, the following palynostratigraphic units: Stage 2, *Pseudoreticulatispora confluens* (reassigned to *Converrucosporites*) and *Pseudoreticulatispora pseudoreticulata*.

Twenty-one of the species documented by Backhouse (1993, fig. 9) are positively identified in the present material, including the following considered of particular stratigraphic relevance: *Converrucosporites confluens*, *Densoisporites solidus*, *Diatomozonotriletes townrowii*, *Potoniisporites novicus* Bhardwaj 1954, *Spongocystia eraduica* Segroves 1967, *Striatoabieites multistriatus* (Balme & Hennelly 1955) Hart 1964 and *Vittatina scutata*. Collectively, these species would suggest assignment of the Woolaga Limestone Member to either the *C. confluens* Zone or the *P. pseudoreticulata* Zone. The presence of *Diatomozonotriletes*—*D. townrowii* in particular, cited by Backhouse & Mory 2020 (p. 60) as ‘an index species for the base of the *P. pseudoreticulata* Zone’—would tend to favour the second option, notwithstanding the seeming absence of the eponymous *P. pseudoreticulata*. Alternatively, *C. confluens* would suggest the first option. Thus the Woolaga Limestone Member’s palynoflora, as hosted by the two study samples, is here considered assignable to either the *P. pseudoreticulata* Zone or the upper or uppermost *C. confluens* Zone. The Fossil Cliff Member in the Irwin River area, containing both *D. townrowii* and *P. pseudoreticulata* (Foster in Foster *et al.* 1985), is obviously representative of the *P. pseudoreticulata* Zone.

In 1976, Kemp *et al.* discussed uncertainties in the age-dating of many Australian Carboniferous–Permian palynostratigraphic units and the situation has not changed appreciably since then. However, as noted previously, the Woolaga Limestone Member’s ammonoid content in particular is regarded as indicative of a Sakmarian age, which is moreover considered applicable

to the bulk of the Holmwood Shale (e.g. Mory *et al.* 2005; Mory & Haig 2011; Haig *et al.* 2014); this provides a useful age constraint to the palynological content.

However, more recently Backhouse & Mory (2020, p. 14, figs 3, 5) proposed an Asselian age for the Holmwood Shale, and its constituent *C. confluens* and lower *P. pseudoreticulata* spore-pollen zones. They stated that ‘Volcanic ash beds identified by Gorter *et al.* (2005) from the Ditji Formation in the Bonaparte Basin have yielded preliminary zircon dates of about 295 Ma, i.e. within the Asselian, for the *P. confluens* – *P. pseudoreticulata* Zone boundary.’ However, in evaluating that statement, the following should be taken into account:

(a) The above reference to Gorter *et al.* (2005), which dealt exclusively with Carboniferous stratigraphy of the Petrel Sub-basin, was incorrect, the relevant paper being Gorter *et al.* (2008)¹.

(b) The palynozonal attributions, and putative correlation with the Holmwood Shale, should be viewed reservedly insofar as any detail concerning the palynological contents of the Ditji Formation or equivalent strata in the basin are apparently unavailable, at least publicly².

(c) The absolute-age determination, of 293±3 Ma (Bradshaw *et al.* 1990; Gorter *et al.* 2008), did not derive from the Ditji Formation. It was based on a 1984 K–Ar analysis of ‘a dolerite dyke [the so-called Kulka Dolerite] intersected [within a presumed Permian section] 15 m below the Mesozoic unconformity’ in Kulka-1 (Bradshaw *et al.* 1990, p. 117) drilled in the Goulburn Graben of the Arafura Basin. Nevertheless, these data were extrapolated by Gorter *et al.* (2008, p. 102) as applicable to a ‘high gamma ray interval in the Ditji Formation interpreted to be an ash fall.’

Although Backhouse & Mory (2020, p. 38) alluded to ‘preliminary dates from the Bonaparte [Basin]’ indicative of late Asselian cessation of glacial influence in Western Australia, there appear to be no substantive grounds for endorsing an Asselian dating of the Holmwood Shale, which is here reaffirmed as Sakmarian.

PALAEOENVIRONMENTAL SIGNIFICANCE

The predominant spore and pollen components of the palynoflora, and their excellent preservation, indicate substantial input from a range of terrestrial vascular vegetation that evidently flourished near the marine depositional site. Parental sources were spore-producing plants (pteridophytes: sphenophytes, lycophytes, ferns) and the polleniferous gymnosperms (particularly members of the *Glossopteris* Flora); e.g. Rigby (1993), McLoughlin (1993), Balme (1995), Peyrot *et al.* (2019) and McLoughlin & Prevec (2021).

¹ Editor’s comment: The omission in Backhouse & Mory (2020) has been corrected. The revised version can be downloaded from DMIRS eBookshop via www.dmirs.wa.gov.au.

² Editor’s comment: These open-file reports can be downloaded from the DMIRS WAPIMS database, but typically lack taxonomic discussions or illustrations.

The algal (green-algal) elements—qualitatively and quantitatively much subordinate to the spore-pollen component (Table 1)—are assuredly aquatic. Of these, *Maculatasporites* spp., *Quadrisporites horridus* Hennelly 1958 emend. Potonié & Lele 1961, *Spongocystia eraduica* and *Tetraporina* sp. are regarded as essentially non-marine (freshwater or brackish), whereas *Leiosphaeridia* sp. and *Cymatiosphaera gondwanensis* (Tiwari 1965) Backhouse 1991 could be either marine or non-marine (Brenner & Foster 1994; Grenfell 1995; Mays *et al.* 2021). The few scolecodonts and microformaminiferal test linings signify a normal marine environment. However, one of the figured scolecodonts (Fig. 7J), which is less well preserved and much darker than the other (Fig. 7K), could well be remanié. Given the marine depositional environment of the Woolaga Limestone Member, its palynoflora contains both allochthonous (spores and pollen grains) and autochthonous or near-autochthonous (other groups) components.

CONCLUSIONS

(1) Because surface exposures of Australian sedimentary rocks are normally devoid of palynological microfossils due to intensive Cenozoic weathering, the diverse and well-preserved palynoflora from the Woolaga Limestone Member is highly unusual. This has likely resulted from being protected from oxidative desiccation, and flattening by overburden pressure, by early calcareous cementation.

(2) The palynoflora—overwhelmingly dominated, quantitatively and qualitatively, by terrestrial spores and pollen grains—testifies to prolific pteridophytes and gymnosperms (notably glossopterids) flourishing close to the marine depositional site, and with essentially minor contributions from in situ, or close to in situ, green algae, microforaminifers and polychaete annelids completing the palyno-biocenosis.

(3) In palynostratigraphic terms, the spore-pollen component, characteristically early Permian in composition, is referable to either the *Converrucosisporites confluens* Zone or the succeeding *Pseudoreticulatispora pseudoreticulata* Zone as currently recognized in Western Australian Permian strata.

(4) The potential for *C. confluens* and *P. pseudoreticulata* to be confused is unfortunate given their current status as eponymous indices of successive palynozones.

(5) Notwithstanding a recent suggestion of an earlier Permian (Asselian) age for the *C. confluens* Zone and lower *P. pseudoreticulata* Zone (lower part), a Sakmarian age, as signified primarily by the ammonoid fauna, is here reaffirmed for the Woolaga Limestone Member.

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APPENDIX 1

Inventory of palynomorphs illustrated in Figures 3–9. Precise locations of individual specimens on numbered slides are specified by EF coordinates secured via a standard England Finder™ gridded slide. Specimen catalogue numbers (GSWA F55040–F55147, F55165) are those of the permanent repository: Geological Survey of Western Australia, Paleontological Type Collection, 37 Harris Street, Carlisle, WA 6101, Australia.

Palynomorphs	Figure no.	Sample no.	Slide no.	EF coords	Photo no.	GSWA no.
<i>Punctatisporites gretensis</i>	3A	175035	1	P19/1	WL09	F55040
<i>Leiotriletes directus</i>	3B	175035	3	P23	WL684	F55041
<i>Leiotriletes badamensis</i>	3C	175035	3	X36/2	WL1005	F55042
<i>Calamospora</i> sp.	3D	175035	3	R34/1	WL750	F55043
<i>Waltzispota</i> sp.	3E	175035	1	J20/4	WL13	F55044
<i>Waltzispota</i> sp.	3F	175035	3	J41/4	WL823	F55045
<i>Converrucosisp. micronodosus</i>	3G/H	175029	5	D24/3	WL947/48	F55046
<i>Converrucosisp. confluens</i>	3I/J	175035	2	W30/1	WL447/48	F55047
<i>Converrucosisp. confluens</i>	3K	175035	12	G11/3	WL1150	F55048
<i>Converrucosisp. confluens</i>	3L	175035	3	K41	WL824	F55049
<i>Converrucosisp. naumoviae</i>	3M	175035	3	N34/4	WL755	F55050
<i>Granulatisp. austroamericanus</i>	3N	175035	3	K45	WL876	F55051
<i>Microbaculispora tentula</i>	3O	175035	3	K49	WL908	F55052
<i>Horriditriletes curvibaculosus</i>	3P	175035	2	U17	WL338	F55053
<i>Horriditriletes ramosus</i>	3Q	175035	3	R36	WL768	F55054
<i>Horriditriletes ramosus</i>	3R	175035	1	S30/3	WL56	F55055
<i>Brevitriletes cornutus</i>	3S	175035	3	K40/1	WL817	F55056
<i>Brevitriletes cornutus</i>	3T	175035	2	D32	WL456	F55057
<i>Apiculiretusispora</i> sp. 1	4A/B	175035	3	L17/1	WL625/26	F55058
<i>Apiculiretusispora</i> sp. 2	4C/D	175035	3	P18/3	WL629/30	F55059
<i>Diatomozonotriletes townrowii</i>	4E	175035	2	O26/1	WL416	F55060
<i>Diatomozonotriletes townrowii</i>	4F/G	175035	3	Q47/3	WL884/86	F55061
<i>Diatomozonotriletes</i> cf. <i>saetosus</i>	4H	175035	2	K13	WL264	F55062
<i>Diatomozonotriletes</i> sp.	4I/J	175035	2	N46/2	WL547/48	F55063
<i>Densoisporites solidus</i>	4K/L	175035	3	S21	WL669/70	F55064
<i>Indotriradites niger</i>	4M	175035	3	H17/1	WL615	F55065
<i>Gondisporites bharadwajii</i>	4N	175035	3	S42/4	WL844	F55066
<i>Gondisporites wilsonii</i>	4O/P	175029	14	X22/3	WL1240/41	F55067
<i>Gondisporites ewingtonensis</i>	4Q	175029	4	G27/1	WL913	F55068
<i>Gondisporites ewingtonensis</i>	4R	175029	9	M24/2	WL172	F55069
<i>Secarisporites lacunatus</i>	4S/T	175035	3	J21	WL674/76	F55070
<i>Secarisporites lacunatus</i>	5A	175035	2	H40/4	WL517	F55071
<i>Barakarites rotatus</i>	5B	175029	6	R14/4	WL964	F55072
<i>Barakarites</i> sp.	5C	175029	5	R23/2	WL82	F55073
<i>Cannanoropollis mehtae</i>	5D	175035	1	C35	WL62	F55074
<i>Cannanoropollis mehtae</i>	5E	175029	9	M28/3	WL183	F55075
<i>Cannanoropollis perfectus</i>	5F	175035	1	E19/4	WL11	F55076
<i>Cannanoropollis janakii</i>	5G	175029	5	J19	WL942	F55077
<i>Cannanoropollis janakii</i>	5H	175029	4	E36	WL925	F55078
<i>Plicatipollenites densus</i>	5I	175035	1	N19	WL10	F55079
<i>Plicatipollenites gondwanensis</i>	5J	175029	9	U31/2	WL189	F55080
<i>Plicatipollenites malabarensis</i>	5K	175029	5	M20	WL78	F55081
<i>Plicatipollenites malabarensis</i>	5L	175035	1	E35/1	WL61	F55082
<i>Plicatipollenites</i> cf. <i>triangularis</i>	5M	175035	1	T18/1	WL03	F55083
<i>Plicatipollenites</i> sp.	5N	175029	19	W9	WL1356	F55084
<i>Cannanoropollis</i> sp.	5O	175029	8	S30/3	WL138	F55085
<i>Kendosporites striatus</i>	5P	175029	6	S36	WL979	F55086
<i>Triadispora</i> sp. 1	5Q	175035	1	M24/1	WL35	F55087
<i>Triadispora</i> sp. 2	5R	175029	9	R25/2	WL178	F55088
<i>Triadispora</i> sp. 2	5S	175035	2	X22	WL378	F55089
<i>Potonieisporites novicus</i>	6A	175029	17	Q13/2	WL1322	F55090
<i>Potonieisporites novicus</i>	6B	175029	9	G35	WL194	F55091
<i>Potonieisporites novicus</i>	6C	175029	14	D32/2	WL1250	F55092
<i>Potonieisporites</i> sp.	6D	175029	8	L17/4	WL109	F55093

G. Playford: Lower Permian (Sakmarian) palynoflora, Woolaga Limestone Member, Holmwood Shale, Perth Basin

<i>Potonieisporites</i> sp.	6E	175029	8	F12/3	WL104	F55094
<i>Potonieisporites brasiliensis</i>	6F	175029	8	O38/1	WL158	F55095
<i>Caheniasaccites</i> sp.	6G	175035	2	D13	WL262	F55096
<i>Caheniasaccites</i> sp.	6H	175029	6	Q30/3	WL974	F55097
<i>Potonieisporites</i> cf. <i>methoris</i>	6I	175035	1	E33/1	WL58	F55098
<i>Potonieisporites</i> cf. <i>methoris</i>	6J	175029	8	D32/2	WL145	F55099
<i>Limitisporites rectus</i>	6K	175029	9	R22	WL175	F55100
<i>Limitisporites rectus</i>	6L	175029	5	S18	WL77	F55101
<i>Limitisporites rectus</i>	6M	175035	2	R40	WL507	F55102
<i>Limitisporites</i> sp. 1	6N	175029	9	F21	WL171	F55103
<i>Limitisporites</i> sp. 1	6O	175029	6	D32/1	WL977	F55104
<i>Limitisporites</i> sp. 2	7A	175035	3	P24	WL697	F55105
<i>Caheniasaccites ovatus</i>	7B	175035	2	J23/4	WL387	F55106
<i>Caheniasaccites ovatus</i>	7C	175029	6	T24/3	WL970	F55107
<i>Pteruchipollenites gracilis</i>	7D	175029	8	K24/1	WL125	F55108
<i>Pteruchipollenites</i> cf. <i>gracilis</i>	7E	175035	2	C19/3	WL355	F55109
<i>Alisporites</i> sp.	7F	175035	2	W14/4	WL287	F55110
<i>Protohaploxylinus goraiensis</i>	7G	175035	2	K13	WL265	F55111
<i>Protohaploxylinus goraiensis</i>	7K	175029	5	K45/2	WL961	F55112
<i>Protohaploxylinus amplus</i>	7H	175029	9	Q34	WL193	F55113
<i>Striatopodocarpites</i> sp. 1	7I	175035	2	R17	WL341	F55114
<i>Striatopodocarpites</i> sp. 2	7J	175035	2	G29/4	WL728	F55115
<i>Striatoabieites multistriatus</i>	7L	175035	3	D20/1	WL648	F55116
<i>Striatoabieites multistriatus</i>	7M	175029	8	V29	WL137	F55117
<i>Striatoabieites multistriatus</i>	7N/O	175035	3	U37	WL772/73	F55118
<i>Protohaploxylinus limpidus</i>	7P	175035	3	O36/1	WL766	F55119
<i>Protohaploxylinus limpidus</i>	7Q	175035	2	N21/3	WL375	F55120
<i>Vittatina fasciolata</i>	7R	175035	3	K18/3	WL631	F55121
<i>Vittatina fasciolata</i>	7S	175035	3	T30/4	WL732	F55122
<i>Vittatina scutata</i>	7T	175029	8	T31/4	WL141	F55123
<i>Vittatina scutata</i>	7U	175029	9	T27/4	WL179	F55124
<i>Vittatina scutata</i>	7V	175035	2	T41/2	WL524	F55125
<i>Laevigatosporites</i> sp.	8A	175035	2	S48/2	WL567	F55126
<i>Marsupipollenites striatus</i>	8B	175035	10	M20	WL1052	F55127
cf. <i>Marsupipollenites striatus</i>	8C/D	175035	3	M37/4	WL784/85	F55128
<i>Cycadopites cymbatus</i>	8E	175035	2	C18/1	WL344	F55129
<i>Cycadopites cymbatus</i>	8F	175035	3	H39	WL808	F55130
<i>Cycadopites cymbatus</i>	8G	175035	2	D15/4	WL325	F55131
<i>Cycadopites cymbatus</i>	8H	175035	3	O42/1	WL838	F55132
<i>Cycadopites</i> sp.	8I	175029	8	J36/1	WL154	F55133
<i>Tetraporina</i> sp.	8J	175035	2	M14	WL277	F55134
<i>Tetraporina</i> sp.	8K	175035	2	N43/3	WL540	F55135
<i>Tetraporina</i> sp.	8L	175035	2	O26/4	WL417	F55136
<i>Tetraporina</i> sp.	8M	175035	3	J42	WL852	F55137
<i>Leiosphaeridia</i> sp.	9A	175035	3	V44/2	WL872	F55138
<i>Spongocystia eraduica</i>	9B/C	175035	3	S34	WL747/48	F55139
<i>Maculatasporites</i> cf. <i>indicus</i>	9D	175035	2	R10/2	WL210	F55140
<i>Cymatiosph.</i> cf. <i>gondwanensis</i>	9E/F	175035	2	C25/3	WL393/94	F55141
<i>Maculatasporites</i> sp. 1	9G	175035	3	N28/4	WL724	F55142
<i>Maculatasporites</i> sp. 2	9H	175035	1	J29/4	WL54	F55143
<i>Quadrisporites horridus</i>	9I	175029	8	K36/1	WL153	F55144
microforaminiferal test lining	9L	175029	4	O32	WL1019	F55145
microforaminiferal test lining	9M	175035	10	N17/1	WL1046	F55146
scolecodont	9J	175029	9	E39	WL205	F55147
scolecodont	9K	175035	3	T37/3	WL774	F55165