



Launceston's Tamar Graben: Weighing the biostratigraphic evidence

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Geological Consultant's Report 24_01: Launceston's Tamar Graben: Weighing the biostratigraphic evidence

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Cover: View looking northwards along the River Tamar valley from Bradys Lookout, Rosevears.

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Abstract

Plant fossils preserved in sediments in the Tamar Graben are a natural archive of past environments in the Tamar Valley at, and to the north of, Launceston over the past 70 million years (Ma) – a period of geologic time during which Tasmania evolved from a promontory of mainland Australia separated from Antarctica by rift valleys (Southern Margin Rift System), into an island over 2500 km north of the ‘ice’ continent. Like most Late Cretaceous–Neogene sites in inland central, southern, and western Tasmania, the geohistory of this graben is based on a combination of isotopically dated basalts and/or the stratigraphic distribution of fossil pollen and spores (miospores) preserved in fluvio-lacustrine sediments. The biostratigraphic age control for such sites however, assumes that the age range of these miospores in geologic time is the more or less the same as in the offshore Gippsland and Bass basins in Bass Strait.

In this bulletin, we test this assumption for the Tamar Graben by comparing the age ranges of the fossil pollen and spore species (morphospecies) preserved in nine coreholes with their age ranges in the offshore Gippsland and Bass basins. We conclude that the pollen and spore-based biostratigraphies developed for these basins do provide a reliable framework for dating sediments in the Tamar Graben at the geological epoch and sub-epoch scale i.e., over time scales usually greater than c. 3-10 Ma. However, a significant number of the inferred palynostratigraphic ages in the Tamar Graben involved selective ‘weighting’ of the biostratigraphic evidence. How applicable this approach is to dating sediments elsewhere in Tasmania is less certain. Improving the age and correlation of strata of particular interest within the graben will likely require detailed seismic surveys or enhanced isotopic dating of interbedded basalts.

Primary reasons for ancillary dating include: (i) mixing of different age fossil pollen and spore assemblages (microfloras) due to the narrow 5 km width of the graben and endemic reworking of older deposits; (ii) uncertain impact of Paleogene volcanic eruptions on plant communities growing within the graben; (iii) absence of many of the key fossil species (zone index species) whose age range is used to define biostratigraphic zones in the Gippsland and Bass Basins; (iv) apparent differences in the age-range of other less biostratigraphically-reliable morphospecies (zone accessory species) between the Gippsland and Bass basins and the Tamar Graben; (v) significant numbers of morphospecies that potentially represent different plant species to those whose closely related pollen were first formally described in the Gippsland Basin (geographic variants); and (vi) significant numbers of pollen and spore morphotypes that are undescribed or only have informal fossil species names in Industry reports for the Gippsland and Bass basins (manuscript or ms species).

A number of these caveats are unlikely to be resolved without improved independent age control and the development of regional biostratigraphies for Tasmania. The latter will be best achieved by palynostratigraphic analysis of cores from inland basins where deposition of sediments during the Paleogene-Neogene has been less subject to fluvial reworking (e.g., the Longford Basin for northern Tasmania, and Macquarie Harbour Graben for western Tasmania).

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1.0 INTRODUCTION

One of the main tools for determining the age of non-marine sediments deposited during the last 100 million years (Ma) in southern Australia is the biostratigraphic zonation developed between 1971 and 1999 for the Gippsland Basin in eastern Bass Strait (Figure 1). In this zonation, the age ranges of selected fossil pollen and spore species (morphospecies) are used to subdivide geologic time into zones and subzones, which vary in duration from less than 2 to over 9 million years (Ma) but overall encompass Late Cretaceous (*c.* 100–66 Ma), Paleogene (*c.* 66–23 Ma) and Neogene (*c.* 23–2.5 Ma) geologic time (Stover and Evans, 1973; Stover and Partridge, 1973 and 1982; Partridge, 1999 and 2006). Many of the age-diagnostic morphospecies recorded in the Gippsland Basin also occur in correlative sediments in the offshore Bass Basin in central Bass Strait (Figure 1), and onshore extensions of that basin in northern Tasmania such as the Tamar Graben. This graben, now occupied by the Tamar Valley (Figure 2), has drained much of central and northern Tasmania into Bass Strait over the past *c.* 70 Ma and now links Tasmania's second largest city of Launceston to the open ocean (references in Corbett, 2021). This has led to unconsolidated sediments deposited on the sides of the Tamar Graben during the Paleogene (*c.* 66–23 Ma) being prone to landslips (Mazengarb and Stevenson, 2010; Calver, 2011; Mazengarb et al., 2014).

Earlier biostratigraphic data for the Tamar Graben have been reviewed by Sutherland et al. (2006), Forsyth et al. (2014) and Corbett (2021). In most cases, the age control is based on earlier versions of the Gippsland zonation revised by Partridge (1999, 2006). With few exceptions (e.g., Wells (1985) and Bigwood et al. (1988)), information on the stratigraphic distribution of age-diagnostic taxa that underpin the earlier age determinations is available only in unpublished reports or in the Explanatory Reports to geological maps, such as Harris (1988) and Forsyth (1996).

In this paper we revise the biostratigraphic evidence for the age, depositional environments, and palaeovegetation of the forming Tamar Graben via palynostratigraphic analyses of newly-acquired core chips from nine coreholes drilled along the Tamar Graben in the late 1970s to early 2000s. In south to north order these coreholes are: WHDH1 White Hills, AH-2 Abels Hill, LV_1BH1_2005 Lawrence Vale, Englewood Riverside 1, BH1 Windermere, BH3 Windermere, BH2 Rowella, Kelso-1 and BB-BH1 Bell Bay (Figure 3). Our biostratigraphic revision is centred on comparison of the stratigraphic distributions of fossil pollen and spores in the Tamar Graben to their published and unpublished age ranges (time distributions) in the Gippsland and Bass basins, and is complemented with analyses of leaf cuticle fragments preserved in the same samples.



Figure 1. Location of sedimentary basins mentioned in the text (after Boreham et al., 2003).



Figure 2. View looking northwards along the Tamar Valley (photo by Nick Roberts).

Corelog data, confirmed by visual inspections, indicate that large intervals of the drill cores are unsuitable for biostratigraphic analysis or isotopic dating and, given the coarse sampling intervals, it is unclear to what extent the sampled units are separated by unconformities representing prolonged periods of non-deposition or erosion. Accordingly, it is likely that the fossil record encompasses only part of the Maastrichtian (*c.* 70–66 Ma) and Paleogene. The study does not consider sediments deposited during in the Neogene and Quaternary (2.5 Ma–Present) due to endemic reworking of older deposits (Colhoun et al., 2014; M.K. Macphail, pers. obs.).

2.0 PHYSICAL SETTING

The tectonic history of the Tamar Graben closely mirrors those of the Gippsland and Bass basins, whose geology and geohistory have been reviewed in numerous publications (Partridge, 1999; Duddy, 2003; Blevin, 2003; Holdgate and Gallagher, 2003; Bernecker and Partridge, 2005). The Gippsland Basin is not discussed here except to note that the spore, and pollen-based biozones established for this basin have become *de facto* Stage names for the Late Cretaceous to Neogene in southern Australia (Partridge, 2006).

The less intensively-drilled Bass Basin (Figure 4) is a Cretaceous to Cenozoic intracratonic rift basin underlying the shallow (average water depth 60 m) seafloor in present-day Bass Strait. The basin has two major depocentres (Figure 4): (1) the Durroon Sub-basin, which

began developing in the Turonian to mid-Campanian (*c.* 94–75 Ma) near Flinders Island and (2) the main Bass Basin (Cape Wickham Basin), which began developing adjacent to King Island in central Bass Strait *c.* 70 Ma (Stacey and Berry, 2004; Quilty, 2014; Corbett, 2021). The latter basin has three onshore structural extensions in northern Tasmania: the Paleocene–Eocene (*c.* 65–34 Ma) Scottsdale sub-basin on the northeast coast; the Paleocene–Late Oligocene (*c.* 65–23 Ma) Devonport-Port Sorell sub-basin on the northwest coast; and the centrally located, Maastrichtian–Oligocene (*c.* 70–23 Ma) Tamar Graben, which links the wholly onshore Paleocene–Early Neogene (*c.* 65–3.6 Ma) Longford Basin to Bass Strait.

Fluvial, fluvio-deltaic, and lacustrine sediments comprising lithologies eroded from the Ben Lomond Plateau, eastern Central Plateau, and lowland plains in the northern Midlands (Figure 4) have been deposited in Bass Basin following their transport through the Tamar Graben during the Late Cretaceous and Cenozoic. Some of this alluvium accumulated in and around two large freshwater lakes (Figures 5 and 6) in the centre of the Bass Basin during the Late Maastrichtian–Paleocene (Paleolake Koorkah) and Middle Eocene (Paleolake Toolka) (Partridge, 2002; Blevin, 2003). That terrigenous material was subsequently overlain by shoreline (paralic) sediments in the Late Eocene to Early Oligocene (*c.* 34–28 Ma), shallow marine sediments in the Oligocene–Early Miocene (*c.* 28–16 Ma), and open marine carbonates from the Middle Miocene (after *c.*

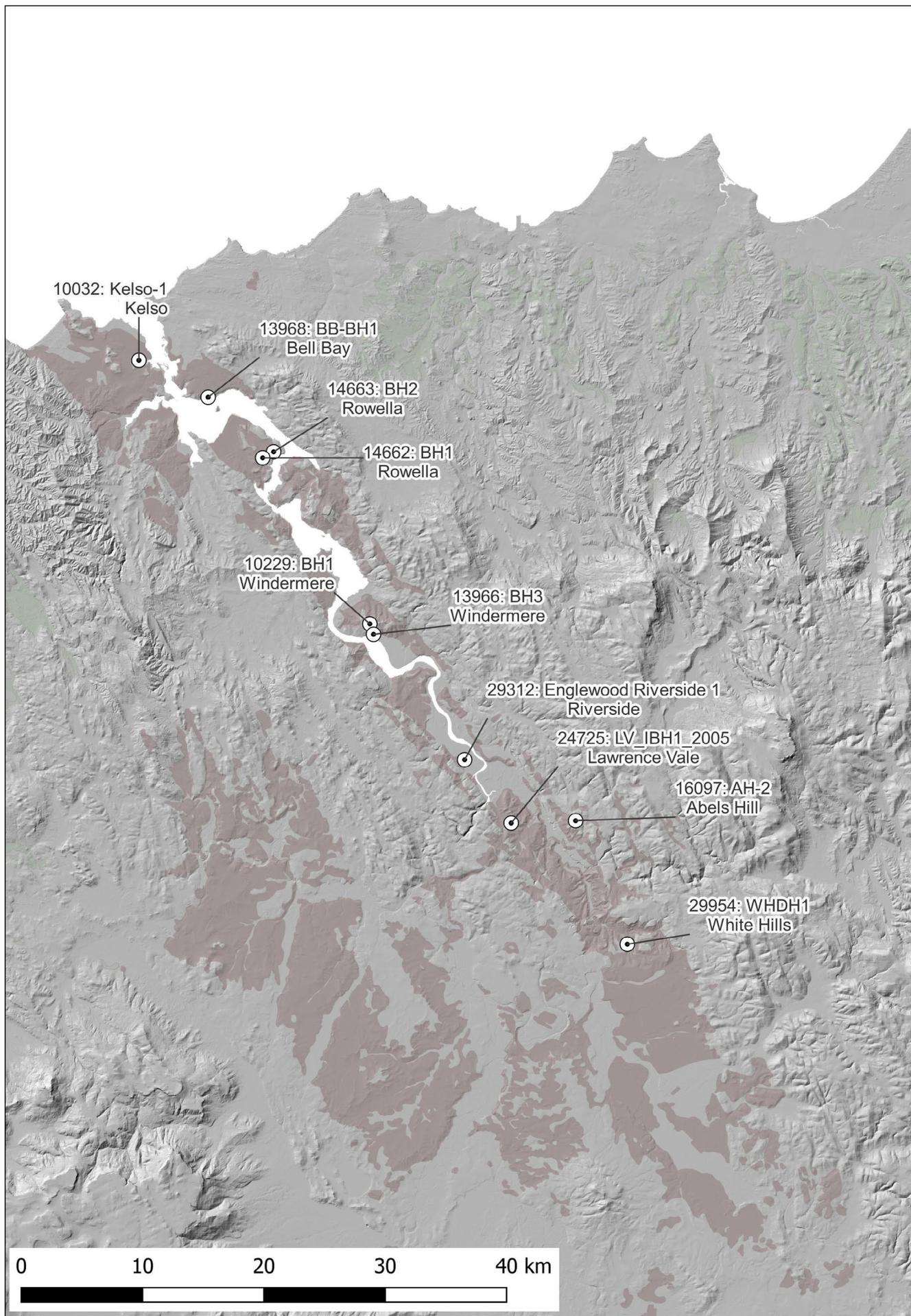


Figure 3. Location of corehole sites. Shaded areas indicate the extent of Paleogene and Neogene basin fills in the Tamar Graben.

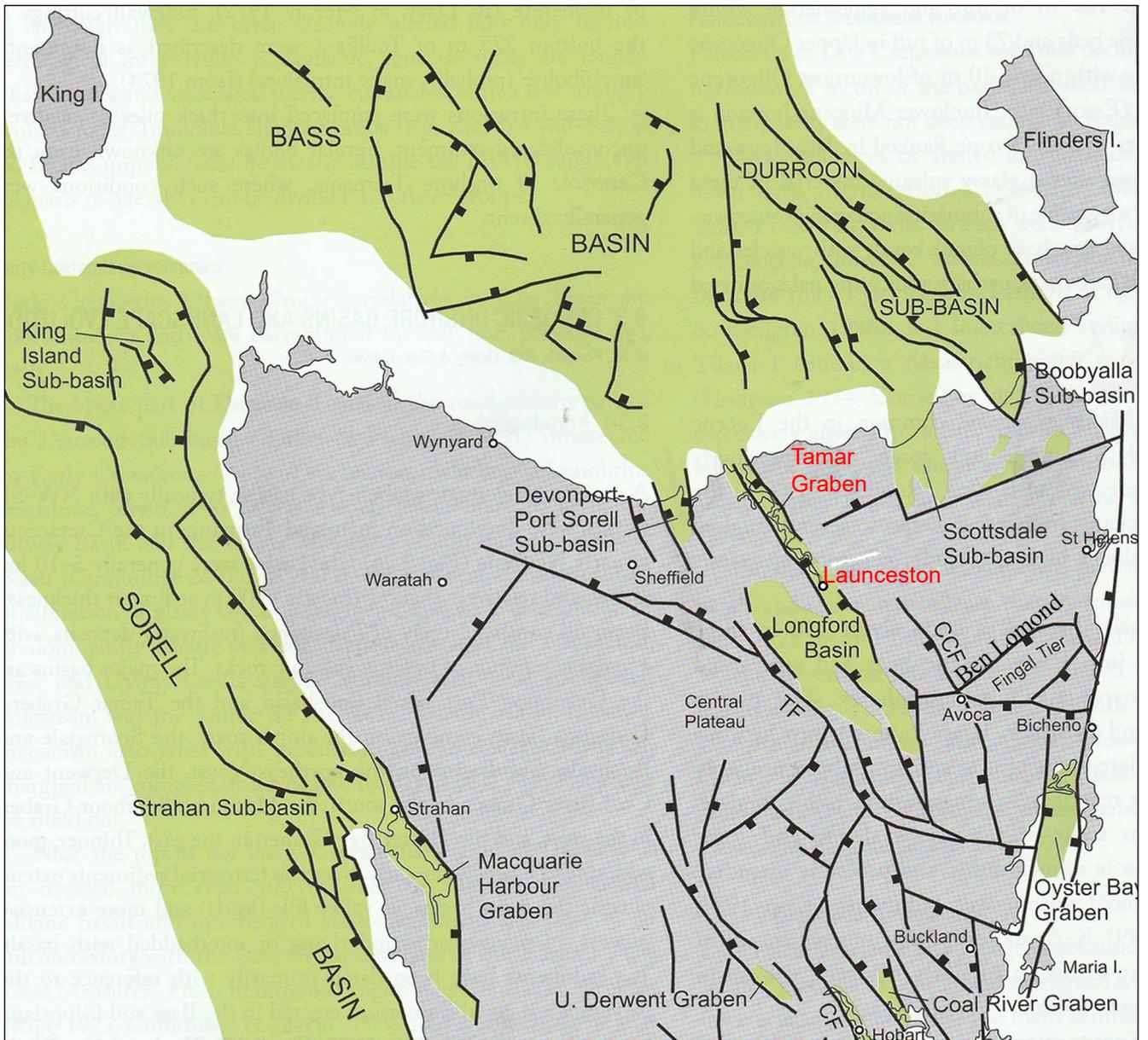


Figure 4. Map of the offshore and onshore extensions of the Bass Basin and other sedimentary basins in northern Tasmania (after Forsyth et al., 2014).

16 Ma). Owing to marked changes in relative sea level, terrestrial shales accumulating between the two major intervals of lacustrine deposition in these paleolakes also preserve marine microfossils (e.g. dinoflagellate cysts and pollen of the mangrove palm genus *Nypa* that now is restricted to tropical estuaries) (Partridge, 1976; Macphail et al., 2014). The first major influx of marine algae (dinoflagellate cysts) into the Bass Basin correlates with high sea levels (marine highstands) and global warming events characterizing the late Paleocene and early Eocene (c. 56–48 Ma).

2.1 Tamar Graben

The Tamar Graben is a narrow trough 5 km wide and up to 4 km deep, that is defined by a series of parallel, NW-trending faults whose formation is closely associated with episodes of rifting, faulting, and subsidence that created the Bass and Gippsland basins during the separation of Australia from Antarctica (Stacey and Berry, 2004; Calver, 2011; Baillie and Quilty, 2014; Corbett, 2021). For example, the dolerite ridges (horsts)

bordering the Tamar River, which rise to 180 m above sea level, are the result of faulting during the Late Cretaceous–Paleogene. Small basalt plateaus and outcrops along the south, upper middle and lower reaches of the Tamar Valley are remnants of middle-Eocene to late-Oligocene (c. 46.7–24.7 Ma) effusive eruptions.

Basement rocks underlying the Tamar Graben infill consist of Permo-Triassic (c. 299–199 Ma) mudstones and sandstones (Parmeener Supergroup) and Jurassic (c. 199–145 Ma) dolerite, both of which were intensely weathered during the Cretaceous and again in the early Eocene. These rocks are overlain by ~ 400 m of fluviolacustrine sediments deposited during the late Cretaceous (Eastern View Coal Measures) and Paleogene (Launceston Group). The sedimentary architecture in the graben reflects the complex interplay between episodic uplift along growth faults, northward tilting of the graben, fluvial sedimentation and channel erosion, and volcanic dislocations leading to out-of-trough diversions of the ancestral Tamar River (Moore et al., 1984; Sutherland et al., 2006; Forsyth et al., 2014).

Dinoflagellate cysts were not recorded in this study but rare occurrences are cited by Forsyth et al. (2014). River terraces bordering the Tamar Valley developed during periods of higher global sea levels during warm periods in the Pliocene (c. 5.33–2.58 Ma) and Pleistocene (2.59–0.11 Ma) but, unlike the current (postglacial) period, it is unclear how far these geologically recent marine highstands extended into the Tamar Valley. These cyst-bearing units most likely are correlative with marine incursions into the Bass Basin during the early- to early-middle Eocene (cf. Partridge, 2002).

3.0 METHODS

3.1 Samples

Forty-eight core-chip samples of weakly-to-highly-carbonaceous sediments were collected from nine of the numerous coreholes drilled in the Tamar Valley by Mineral Resources Tasmania (formerly Mines Department of Tasmania) in the 1970s to 2000s (Table 1). Depths are given in metres below ground surface (mbgs). All samples were processed by Morgan Goodall Paleo Pty. Ltd. (Perth) using standard palynological techniques (Wood et al., 1996) to concentrate the plant microfossil content, chiefly fossil angiosperm and gymnosperm pollen and cryptogam (fern, fern ally, liverwort) and fungal spores. These techniques involve: (i) crushing and washing in distilled water of approximately 5-15 g of sediment; (ii) removal of any carbonates by adding 34% Hydrochloric acid; (iii) further washing, with the addition of 25 ml of 48% hydrofluoric acid to digest silicate minerals; (iv) sieving of the residue through 100 µm and 5 µm mesh filters to remove the coarse and very fine organic components, respectively; and (v) separation out of the residual organic fraction using lithium heterometatungstate, mixed with a polyvinyl alcohol solution (heavy liquid separation). The organic residues were mounted in Petropoxy 154 under glass coverslips in microscope slides for pollen analysis using

a Zeiss™ Photomicroscope fitted with top-of-the-range Plan-Neofluar™ and Planapo™ objectives capable of providing up to 2000x magnification. Coarse organic fractions were retained for plant macrofossil analysis.

3.2 Age control

Two forms of age control are available for the Tamar Graben: biostratigraphic age/age limits for fluvio-lacustrine sediments, inferred using age-range criteria developed for the Gippsland and Bass basins; and isotopic dates for basalts interbedded with the fluvio-lacustrine sediments.

3.2.1 Gippsland Basin zonation

Based on the geomagnetic polarity timescale of Gradstein et al. (2020), the Maastrichtian Epoch and Paleogene Period are dated to 72.17–66.04 Ma and 66.04–23.04 Ma, respectively. In the Gippsland zonation, these intervals are subdivided into longer intervals (zones) and shorter intervals (subzones) of geologic time defined by the first (FAD) and last (LAD) occurrences of selected morphospecies (Table 2). Independent age control is provided by marine microfossils and augmented by detailed seismic correlation of the sampled intervals in offshore hydrocarbon exploration wells. An underlying but mostly untested assumption is that the age-range of morphospecies shared with the Bass Basin and the Tamar Graben are approximately the same as in the Gippsland Basin despite the marked differences in the palaeoenvironmental settings over the past 70 Ma (cf. Macphail and Hill, 1994; Macphail, 1999; Macphail and Gibson, 2014). Whether the geologic ages assigned to the zone and subzone boundaries in the Gippsland Basin by Partridge (2006) are approximately the same as in northern Tasmania is being investigated using isotopic dating of associated basalts by Mineral Resources Tasmania (N. Roberts, MRT, in prep.).

Table 1. Sample data with depths in metres below ground surface (mbgs). The TIGER ID refers to the number assigned to the corehole in the Tasmanian Information on Geoscience and Exploration Resources (TIGER) system. RL height in metres above present-day mean sea level.

DRILL SITE	TIGER ID	Distance to Launceston	RL	SAMPLES			Total depth
			drillsite	number	highest	lowest	
‘southern’ Tamar Graben							
AH-2 Abels Hill	16097	7.7 km (SE)	+ 227.2 m	2	28.16 mbgs	82.35 mbgs	88 m
LV-1BH1 Lawrence Vale	24725	2.5 km (E)	+ 81.0 m	7	7.25 mbgs	55.0 mbgs	64.5 m
WHDH1 White Hills	29954	12 km (SE)	+ 134.7 m	3	14.27 mbgs	43.94 mbgs	48 m
‘central’ Tamar Graben							
Englewood Riverside 1	29312	3.5 km (W)	+ 2.1 m	11	59.64 mbgs	154.80 mbgs	200.0 m
BH-1 Windermere	10229	17 km (NW)	+ 146.1 m	8	27.5 mbgs	175.2 mbgs	177.6 m
BH-3 Windermere	13966	18 km (NW)	+16.4 m	7	31.05 mbgs	90.52 mbgs	114.7 m
‘northern’ Tamar Graben							
BB-BH1 Bell Bay	13968	40 km (NW)	+39.5 m	9	52.55 mbgs	291.84 mbgs	340.6 m
BH-1 Rowella	14663	35 km (NW)	+ 23.0 m	1	8.50 mbgs		39 m
Kelso-1	10032	48 km (NW)	+8.0 m	1	55.0	55.0	250.07 m

Table 2. Biostratigraphic zonation of Paleogene–Neogene geologic time in the offshore Gippsland Basin. First (FAD) and Last (LAD) appearances of zone and zone accessory morphospecies are indicated by ‘^’ and ‘v’, respectively (after Partridge, 2006).

TIMESCALE	ZONE	SUBZONE	Abbrev.	BIOSTRATIGRAPHIC DATUMS
PLEISTOCENE	<i>Tubulifloridites pleistocenicus</i> (2.5–0.01 Ma)	<i>Tubulifloridites pleistocenicus</i> (2.5–0.01)	<i>Tp</i>	^ <i>Tubulifloridites pleistocenicus</i> ; ^ <i>Acaciapollenites octosporites</i>
EARLY to LATE PLIOCENE	<i>Myrtaceidites lipsis</i> (5.3–2.5 Ma)	<i>Myrtaceidites lipsis</i> (5.3–2.5 Ma)	<i>Ml</i>	^ <i>Myrtaceidites lipsis</i> ; v <i>Cyatheacidites annulatus</i>
LATE MIOCENE	<i>Cingulatisporites bifurcatus</i> (7.3–5.3 Ma)	<i>Cingulatisporites bifurcatus</i> (7.3–5.3 Ma)	<i>Cb</i>	^ <i>Monotocidites galeatus</i> ; v common <i>Nothofagidites</i> spp. within zone ^ <i>Cingulatisporites</i> (al. <i>Foraminisporis</i>) <i>bifurcatus</i>
MIDDLE to LATE MIOCENE	<i>Triporopollenites bellus</i> (al. <i>Canthiumidites bellus</i>)	Upper <i>Triporopollenites bellus</i> (11.6–7.3 Ma)	<i>U Tl</i>	^ <i>Haloragacidites amolus</i> ; v abundant <i>Nothofagidites</i> spp.
		Lower <i>Triporopollenites bellus</i> (16.0–11.6 Ma)	<i>L Tl</i>	^ <i>Tubulifloridites</i> spp. within zone ^ <i>Triporopollenites bellus</i> ; v <i>Proteacidites rectomarginis</i>
EARLY OLIGOCENE to EARLY MIOCENE	<i>Proteacidites tuberculatus</i> (31.5–16.0 Ma)	Upper <i>Proteacidites tuberculatus</i> (19.0–16.0 Ma)	<i>U Na</i>	^ <i>Acaciapollenites myriosporites</i>
		Middle <i>Proteacidites tuberculatus</i> (28.4–19.0 Ma)	<i>M Pt</i>	^ <i>Cyathidites subtilis</i> , ^ <i>Ophioglossisporites lacunosus</i> v <i>Granodiporites nebulosus</i>
		Lower <i>Proteacidites tuberculatus</i> (31.5–28.4 Ma)	<i>L. Pt</i>	v <i>Stereisporites</i> (<i>Tripunctisporis</i>) <i>maastrichtiensis</i> within zone ^ <i>Cyatheacidites annulatus</i> ;
MIDDLE EOCENE to EARLY OLIGOCENE	<i>Nothofagidites asperus</i> (45.0–31.5 Ma)	Upper <i>Nothofagidites asperus</i> (33.9–31.5 Ma)	<i>U Na</i>	^ <i>Proteacidites rectomarginis</i> within zone v <i>Triorites magnificus</i>
		Middle <i>Nothofagidites asperus</i> (38.4–33.9 Ma)	<i>M Na</i>	^ <i>Triorites magnificus</i> ; v <i>Anacolosidites luteoides</i>
		Lower <i>Nothofagidites asperus</i> (45.0–38.4 Ma)	<i>L Na</i>	(^ <i>Plicodiporites crescentis</i>) ^ <i>Nothofagidites falcatus</i> above base of zone
		Not subdivided		^ Abundant <i>Nothofagidites</i> spp.
late EARLY to mid-MIDDLE EOCENE	<i>Proteacidites asperopolus</i> (50.6–45.0 Ma)	Not subdivided	<i>Pa</i>	v <i>Myrtaceidites tenuis</i> ; v <i>Intratriporopollenites notabilis</i> ^ <i>Proteacidites asperopolus</i>
EARLY EOCENE to mid MIDDLE EOCENE	<i>Malvacipollis diversus</i> (55.8–50.5 Ma)	Upper <i>Malvacipollis diversus</i> (53.2–50.5 Ma)	<i>U Md</i>	^ <i>Santalumidites cainozoicus</i> within zone ^ <i>Myrtaceidites tenuis</i>
		Middle <i>Malvacipollis diversus</i> (54.3–53.2 Ma)	<i>M Md</i>	^ <i>Proteacidites tuberculiformis</i>
		Lower <i>Malvacipollis diversus</i> (55.8–54.3 Ma)	<i>L Md</i>	^ <i>Spinizonocolpites prominatus</i> ; ^ <i>Intratriporopollenites notabilis</i>
LATE PALEOCENE	<i>Lygistepollenites balmei</i> (65.5–55.8 Ma)	Upper <i>Lygistepollenites balmei</i> (c 57.0–55.8 Ma)	<i>U Lb</i>	^ <i>Matonisporites gigantis</i> within zone ^ <i>Propylipollis annularis</i> ; ^ <i>Proteacidites grandis</i> ;
EARLY to LATE PALEOCENE		Lower <i>Lygistepollenites balmei</i> (65.5–57.0 Ma)	<i>L Lb</i>	v <i>Proteacidites angulatus</i> ^ <i>Polycolpites langstonii</i> within zone ^ <i>Haloragacidites harrisii</i> ; v <i>Battenipollis sectilis</i> v <i>Forcipites longus</i> , <i>Quadrplanus brossus</i> , <i>Tricolporites lilliei</i>

Table 2 cont.

TIMESCALE	ZONE	SUB-ZONE	Code (Table 3)	BIOSTRATIGRAPHIC DATUMS
MAASTRICHTIAN to LATE CAMPANIAN	<i>Forcipites longus</i> (75.5–65.5 Ma)	Upper <i>Forcipites longus</i> (67.0–65.5 Ma)	U Fl	∨ <i>Battenipollis sectilis</i> , <i>F. longus</i> , <i>Quadra. brossus</i> , <i>Tricolporites lilliei</i> ∧ <i>Stereisporites (Tripunctisporis) maastrichtiensis</i> ms
		Lower <i>Forcipites longus</i> (75.5–67.0 Ma)	L Fl	∧ <i>Grapnelispora evansii</i> ; ∨ <i>Forcipites sabulosus</i> ∧ <i>Forcipites sabulosus</i> ; ∧ <i>Tetracolporites verrucosus</i>
MIDDLE CAMPANIAN	<i>Tricolporites lilliei</i> (80.6–75.5 Ma)	(not subdivided)	Tl	∧ <i>Tricolporites lilliei</i> ; ∧ <i>Battenipollis sectilis</i>
LOWER CAMPANIAN	<i>Nothofagidites senectus</i> (83.5–80.6 Ma)	Upper <i>Nothofagidites senectus</i> (82.0–80.6 Ma)	U Ns	∧ <i>Gambierina rudata</i>
		Lower <i>Nothofagidites senectus</i> (83.4–82.0 Ma)	L Ns	∧ <i>Nothofagidites senectus</i> ; ∧ <i>Forcipites sabulosus</i>
SANTONIAN	<i>Tricolporites apoxyexinus</i> (85.8–83.4 Ma)	(not subdivided)	T apx	∧ <i>Tricolporites apoxyexinus</i> ; ∨ <i>Appendicisporites distocarinus</i>
TURONIAN- CONIACIAN	<i>Phyllocladidites mawsonii</i> (93.5–85.8 Ma)	(three subzones)	Pm	∧ <i>Phyllocladidites mawsonii</i>
CENOMANIAN	<i>Hoegisporis uniforma</i> (99.6–93.5 Ma)	(not subdivided)	Hu	∨ <i>Hoegisporis uniforma</i> ∧ <i>Appendicisporites distocarinus</i>

3.2.2 Biostratigraphic age determinations

The age and age limits of each sample were determined using published and unpublished time distributions of age-diagnostic (zone index, zone accessory) morphospecies in Gippsland and Bass basins (Plates 1-4; Table 3; Appendix 1). Unpublished age-range data from the Bass Basin were then compared with the stratigraphic distribution of the same morphospecies in the Tamar Graben core holes to identify probable downhole caved and reworked specimens (Table 4; Appendix 2). Notably, many of the fossil angiosperm and gymnosperm pollen types, and some fern spore types, in the Paleogene are geographic variants of morphospecies first described in the Gippsland and Bass basins. Additionally, a significant number of the less commonly-recorded miospores only have manuscript (ms) names but nonetheless have unpublished but moderately well constrained age ranges in the Bass and/or Gippsland basins. Examples include an apiculate trilete spore (*Conbaculites apiculatus* ms) and two tetracolporate pollen types ornamented with rugulae (*Tetracolporites multistrixus* ms) or a fine reticulum (*T. textus* ms). A selection of the formally described and undescribed age-diagnostic and environmentally informative mor-

phospecies are illustrated in Plates 1-5. Illustrations of other taxa are available in Stover and Partridge (1973), Macphail et al. (1994), and Macphail (1999). A selection of the commonly occurring and rare or previously unrecorded pollen and spore morphotypes is presented in Appendix 3.

3.2.3 Isotopic dates

Potassium-argon (K/Ar) and argon-argon (Ar/Ar) dates for Paleogene-Neogene basalts in Tasmania have been reviewed by Sutherland et al. (2006) and Calver (2011). Modelling (Sutherland et al., 2006) suggests eruptive events occurred in three discrete pulses – at *c.* 46-47 Ma (Middle Eocene), *c.* 34-37 Ma (Late Eocene) and *c.* 24-25 Ma (Late Oligocene). These time intervals correlate with the *Proteacidites asperopolus* Zone, Middle *Nothofagidites asperus* Zone, and Middle *Proteacidites tuberculatus* Zone, respectively, in the Gippsland Basin. The only independently dated interval in this study comes from an early Middle Eocene basalt underlain and overlain by Early- to-early Middle Eocene sediments at 25–134 mbgs in in BH-1 Rowella (Sutherland et al., 2006). The youngest known lava flow within the graben is latest Oligocene (*c.* 25 Ma).

Plate 1.

- a. *Aglaoreidia qualumis*
- b. *Anacolosidites acutullus*
- c. *Australopollis obscurus* (var.)
- d. *Battenipollis sabrinae*
- e. *Battenipollis sabrinae*
- f. *Battenipollis sectilis*
- g. *Camarozonosporites eyrensis* ms
- h. *Clavifera triplex*
- i. *Conbaculites apiculatus* ms
- j. *Dryptopollenites semilunatus*
- k. *Forcipites longus*
- l. *Forcipites sabulosus* (var.)
- m. *Gambierina edwardsii* (var.)
- n. *Gambierina edwardsii* (var.)
- o. *Gambierina rudata* (var.)

Plate 3.

- a. *Propylipollis annularis*
- b. *Propylipollis biporus*
- c. *Proteacidites asperopolus*
- d. *Proteacidites adenanthoides*
- e. *Proteacidites angulatus* (var.)
- f. *Proteacidites incurvatus*
- g. *Proteacidites nasus* (var.)
- h. *Proteacidites grandis* (var.)
- i. *Proteacidites leightonii* (var.)
- j. *Proteacidites ornatus* (var.)
- k. *Proteacidites pachypolus* (polar view)
- l. *Proteacidites pachypolus* (equatorial view)
- m. *Proteacidites lapis* ms
- n. *Stereisporites* (al. *Tripunctisporis*)
maastrichtiensis ms
- o. *Stereisporites regium*

Plate 5.

- a. *Botryococcus*
- b. *Circulisporis parvus* (*Zygnemataceae*)
- c. unidentified operculate cyst
- d-e. *Saeptodinium gravattensis* complex
- f. cf. *Saeptodinium gravattensis* complex (coarse scabrate ornamentation)
- g. cf. *Deflandrea pachyceros*
- h-i. *Morkallacysta pyramidalis* var.
- j-k. indeterminate deflandroid cysts
- l. cf. *Rimosicysta*

Plate 2.

- a. *Granodiporites nebulosus*
- b. *Haloragacidites harrisii*
- c. *Intratropollenites prominatus*
- d. *Lygistepollenites balmei* (polar view)
- e. *Lygistepollenites balmei* (equatorial view)
- f. *Malvacipollis diversus*
- g. *Nothofagidites asperus*
- h. *Nothofagidites deminutus* (var.)
- i. *Nothofagidites endurus*
- j. *Nothofagidites falcatus*
- k. *Nothofagidites goniatus*
- l. *Peninsulapollis gillii* (var.)
- m. *Polycolpites langstonii*
- n. *Pseudowinterapollis wahooensis* ms

Plate 4.

- a. *Tetradopollis securus* ms (var.)
- b. *Tetracolporites multistrixus* ms (polar view)
- c. *Tetracolporites multistrixus* ms (equatorial view)
- d. *Tetracolporites textus* ms (polar view)
- e. *Tetracolporites textus* ms (equatorial view)
- f. *Tetracolporites verrucosus*
- g. *Tricolpites phillipsii* (var.)
- h. *Tricolpites phillipsii* (var.)
- i. *Tricolporites adelaidensis*
- j. *Tricolporites* (al. *Tensucolpites*) *lilliei*
- k. *Tricolpites* sp. A
- l. *Tricolpites* sp. A (var.)
- m. *Tricolporites* sp. A (polar view)
- n. *Tricolporites* sp. A (equatorial view)
- o. *Triporepollenites ambiguus*

Plate 1.

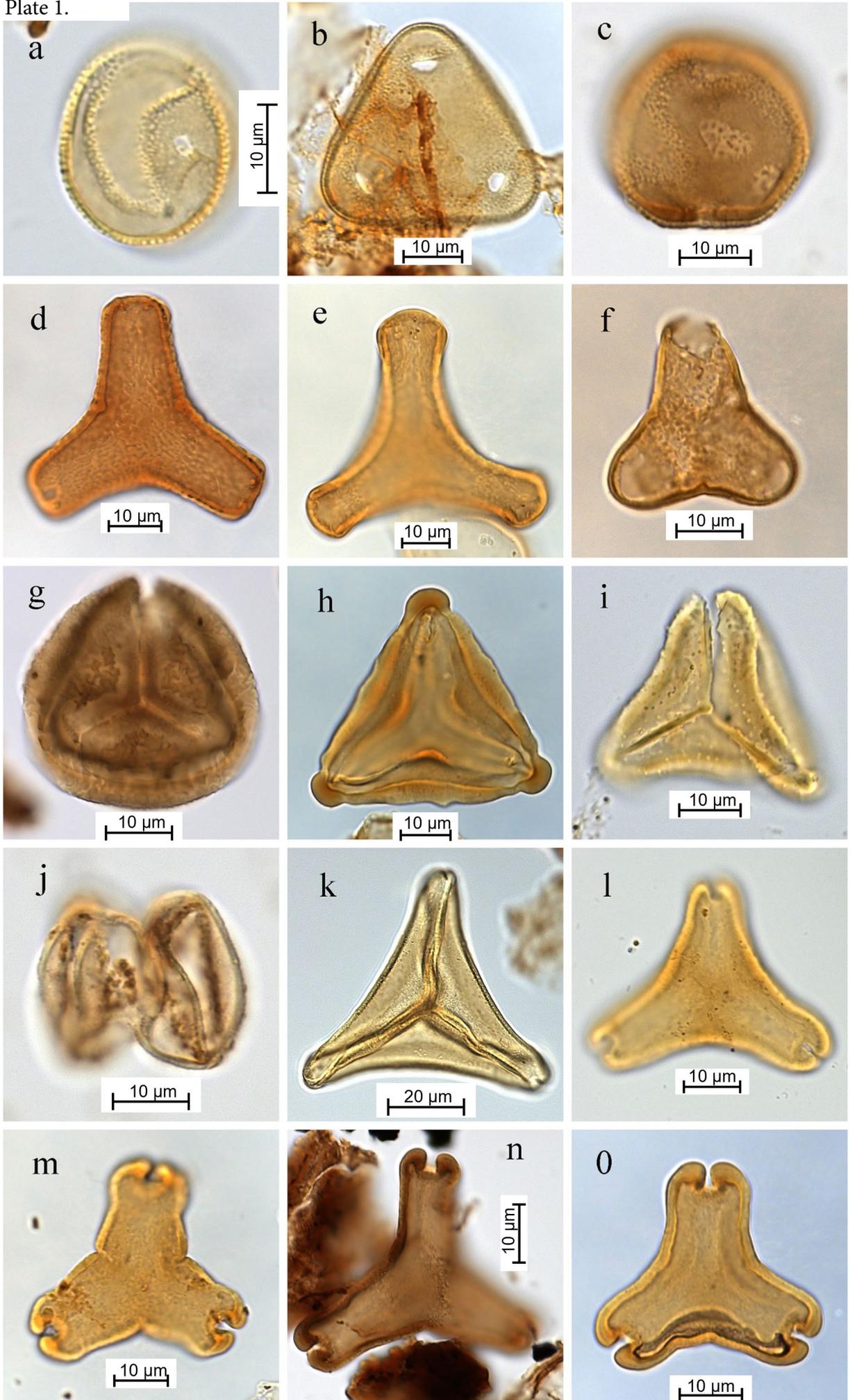


Plate 2.

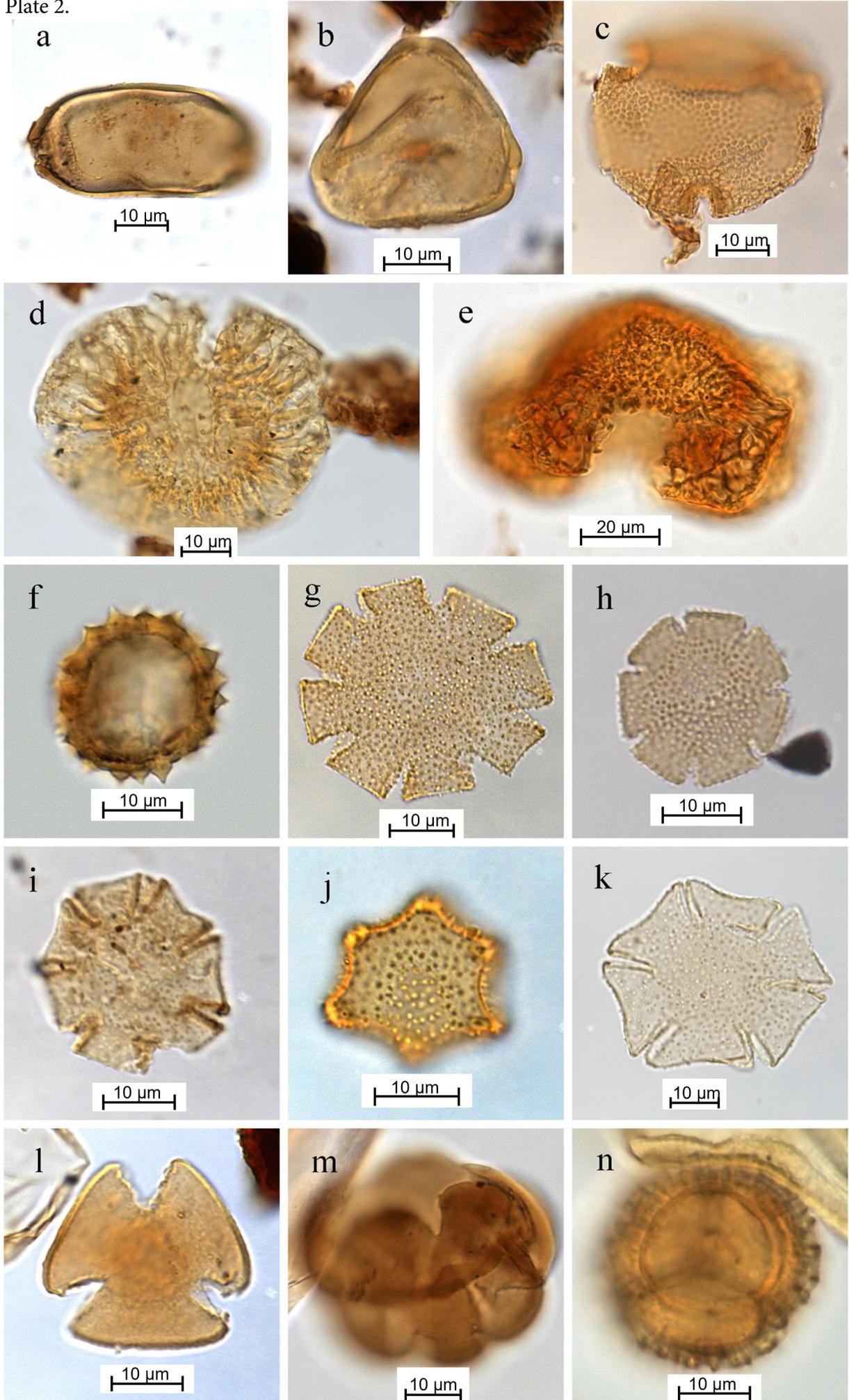


Plate 3.

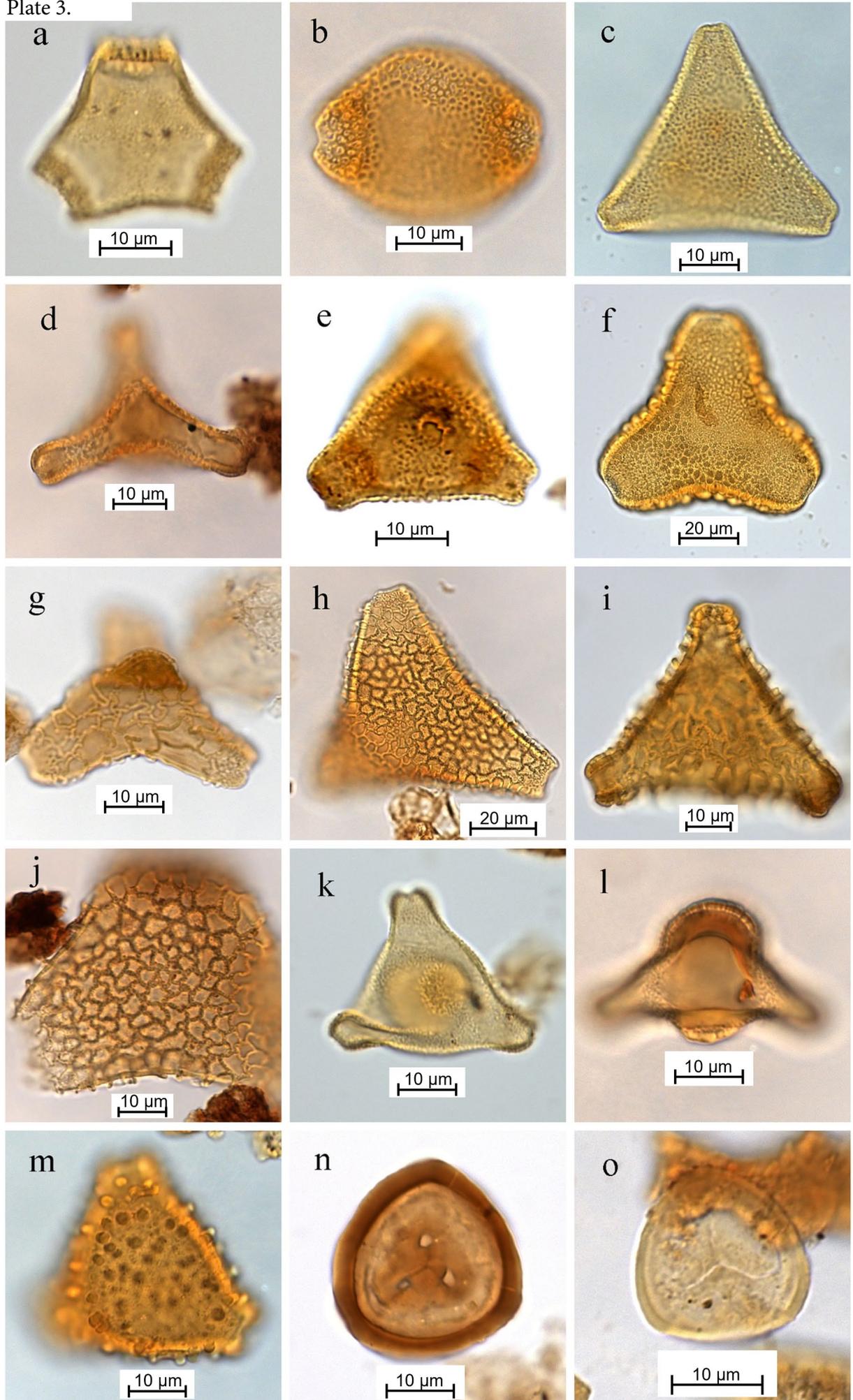
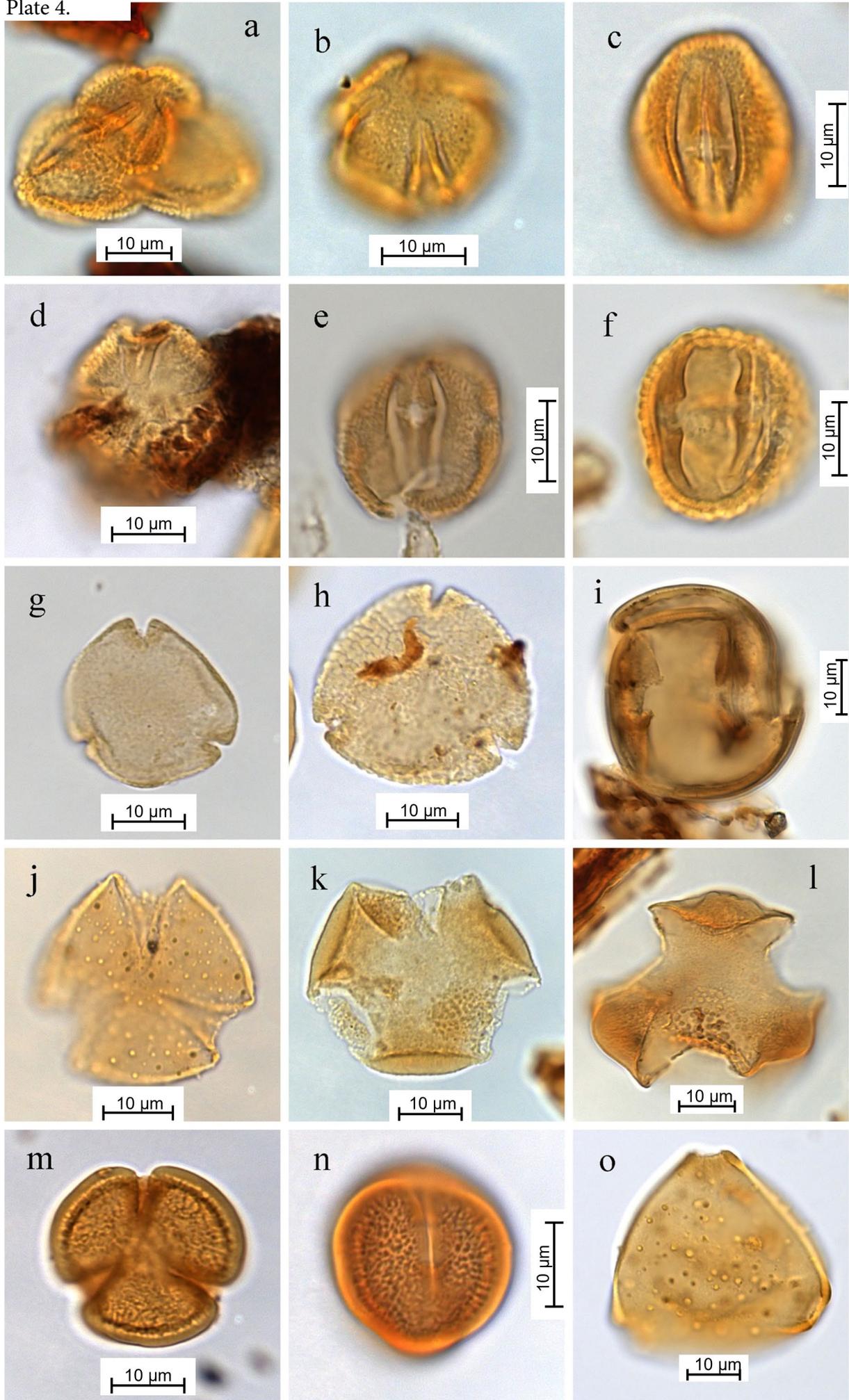
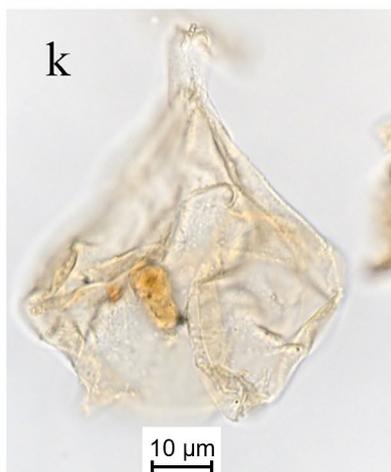
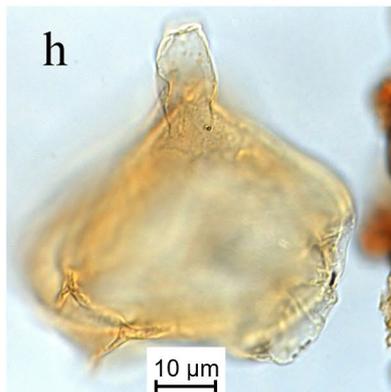
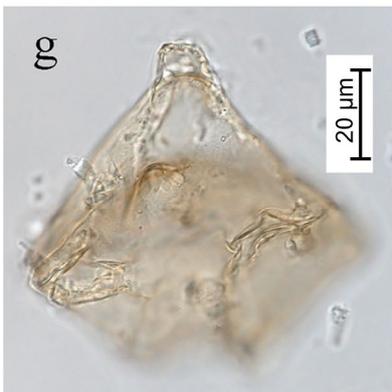
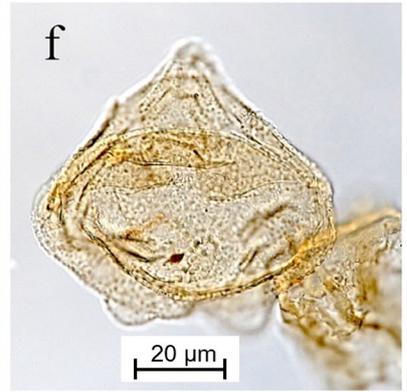
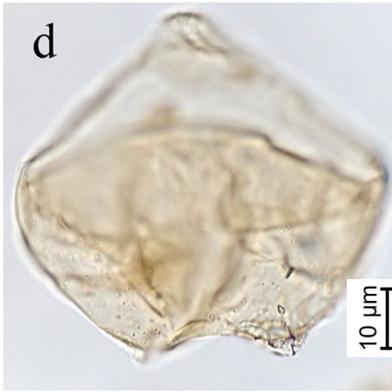
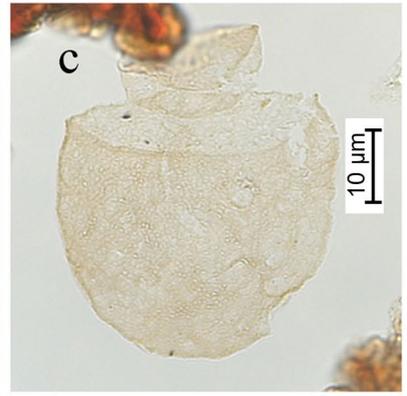
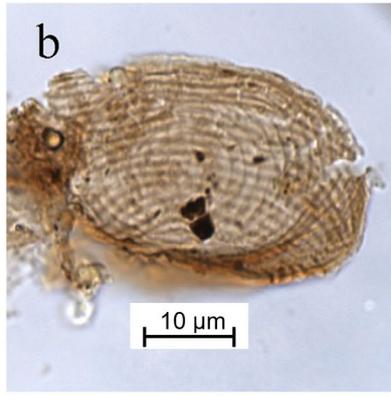
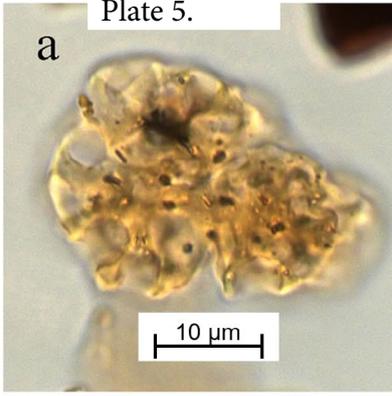


Plate 4.





4.0 RESULTS

Lithostratigraphic details and the individual age of each sample or sampled interval are outlined and explained below following a trend from south to north (toward depocentres in modern-day Bass Strait) along the Tamar Valley. The stratigraphic distribution and estimates of relative abundance of miospores in each sample are given in Appendix 4. The implications of the associated plant macrofossils are discussed in further detail in Appendix 5.

Where possible, the age determinations are based on the FADs or LADs of zone index or reliable zone accessory morphospecies. The age of samples that lack any of these morphospecies are based on negative (absence) evidence and are of very low confidence. Some of the microfloras are ‘mixed age’ and in these instances, the age determinations are based on subjective weighting of the biostratigraphic evidence. For this reason, we also give the maximum and minimum age limits for each sample or sampled interval. Most samples yielded the minimum number (>150 specimens) of fossil pollen and spores (excluding fungal spores) needed to calculate statistically reliable estimates of the relative abundance of those microfossils able to be identified to a fossil genus (morphogenus) or morphospecies. Rare morphospecies (<1%) and those recorded outside the pollen count are indicated by ‘+’ and ‘x’, respectively.

Yields, dominance, diversity

Yields of miospores varied from low to abundant, although concentrations were low due to the much higher yields of finely-disseminated plant detritus. Preservation was equally variable and ranged from poor to good, with preservation typically being poorest in the low-yielding samples or samples close to basalts. Diversity was low compared to correlative fossil pollen and spore assemblages (microfloras) in the Bass and Gippsland basins. With few exceptions, the individual microfloras are dominated by long-ranging morphospecies, chiefly those presumed to represent ancestral species in the gymnosperm families Araucariaceae and Podocarpaceae and the angiosperm Antarctic beech family Nothofagaceae.

A significant number of the typically rare to uncommon morphospecies, including most of the zone index morphospecies found in the Gippsland and Bass basins, were not recorded in the Tamar Graben samples or if present, found only as reworked or downhole-caved specimens. An example of the latter is the late Early Miocene zone index species *Triporopollenites bellus* in Middle Eocene (*Proteacidites asperopolus* Zone) sediments in BH1 Windermere. Permo-Triassic, Mesozoic and early Cenozoic pollen and spores have been widely reworked into younger deposits in the graben over the past c. 70 Ma (this study; Macphail, pers. obs.).

A. ‘southern’ Tamar Graben

Three drillholes are located in the southern sector of the Tamar Graben: AH-2 Abels Hill, LV_1BH1_2005

Lawrence Vale and WHDH-1 White Hills. Based on the biostratigraphic data, all samples represent the Launceston Group.

1. AH-2 Abels Hill (ID 16097)

[517995E, 5410858N, RL 227.2]

The stratigraphic corehole was drilled on the eastern slopes of Abels Hill (~ 230 m AHD) located ~ 1.2 km east of the Launceston suburb of St. Leonards on the banks of the North Esk River. Lithostratigraphic data are unavailable. The total depth reached was 88 mbgs. Age determinations are of low confidence due to apparent mixing of different-age microfloras and absence of age-diagnostic morphospecies (Macphail, 2015a). Undifferentiated *Malvacipollis diversus* Zone microfloras were recovered from sandstones and siltstones overlying a bauxite developed on tilted dolerite basement rocks at ~ RL 87 m (140 mbgs) by Forsyth et al. (2014: 442).

28.16-28.19 mbgs: The microflora is co-dominated by long-ranging gymnosperms (37%) and is given a very low confidence Middle *Nothofagidites asperus* Zone age (Late Eocene) based on the assumption that *Aglaoreidia qualumis* and *Proteacidites rectomarginis* are *in situ*. Other *Proteacidites* spp. are more typically found in Early to early Middle Eocene sediments e.g., *Proteacidites adenanthoides* and *P. incurvatus* (LAD *Proteacidites asperus* Zone). The minimum age limit is (lower) *Proteacidites tuberculatus* Zone based on *Stereisporites (Tripunctisporis) punctatus* (al. *S. maasrichtiensis*). Based on FAD/LAD data, the maximum age limit could be anywhere from Early to Late Eocene. However, an Early to Middle *Nothofagidites asperus* Zone maximum age is supported by the abundance of *Nothofagidites* spp. (24%) relative to *Haloragacidites harrisii* (trace). Nevertheless, despite *Nothofagidites* making up much of this component, the microflora is atypical in that it includes 13% *N. flemingii* rather than the typically more abundant *N. emarcidus-heterus* species complex (2%). Taxa such as *Podosporites microsaccatus* (2%), *Dicotetradites clavatus* and frequent (7%) *Stereisporites* spp. indicate the depositional environment was a wetland or fen surrounded by conifer forest.

82.30-82.35 mbgs: The microflora is a mixture of reworked Permian taxa (25%) and morphospecies that (i) last occur in the Late Cretaceous to Paleocene (*Cranwellia palisadus*, *Peninsulapollis askinae*, *Lygistepollenites balmei*), (ii) first occur in Early Eocene (*Milfordia hypolaenoides*, *Nothofagidites goniatus*), (iii) first or last occur in the Late Eocene (*Proteacidites adenanthoides*), or (iv) are typical of an undifferentiated *Nothofagidites asperus* Zone age e.g., *Nothofagidites* spp. (21%) including *N. asperus* (5%). The *Proteacidites* component includes *P. obscurus* and a variant of the long-ranging morphospecies *P. tenuixinus*. The sample is provisionally assigned (very low confidence)

undifferentiated Middle–Late Eocene age limits, based on the rarity of *Haloragacidites harrisii* relative to *Nothofagidites* spp. and the absence of morphospecies that last occur in the *Malvacipollis diversus*–*Proteacidites asperopolus* Zone. Trace specimens of *Cranwellipollis palisadus* and *Peninsulapollis askinae* hint at the presence of Late Cretaceous facies upstream in the catchment.

2. LV_1BH1_2005 Lawrence Vale (ID 24725)

[512685E, 5410664N, RL 81 m]

LV_1BH1_2005 Lawrence Vale was drilled in the Lawrence Vale ‘land slip zone’ located ~ 2.5 km southwest of the junction of the Tamar and North Esk rivers in Launceston. The total depth reached was 64.5 mbgs. Lithostratigraphic data indicate the seven core chips at ~ 43–55 mbgs come from an interval of black, carbonaceous, fine to medium sands underlain by interbedded yellow brown silt and fine to coarse, poorly to well sorted sands with carbonaceous laminations (Macphail 2014, 2015b). A coarse conglomerate occurs below ~ 58 mbgs. The highest sample (7.5 mbgs) was extensively contaminated during processing. A reprocessed duplicate was found to be devoid of plant microfossils and the sample is omitted from this study. Other samples are provisionally assigned to the Danian Lower *Lygistepollenites balmei* Zone albeit with varying degrees of confidence due to the occurrence of caved and reworked taxa. The freshwater dinocysts assigned to the *Saeptodinium gravattensis* complex occur in all samples, with relative abundances reaching 14% in the sample at 53.4 mbgs.

43.1–46.5 mbgs: Alternative age determinations for this interval are (1) Paleocene *Lygistepollenites balmei* Zone if the usually rare morphospecies *Polycolpites langstonii* at 43.1 mbgs and *Beaupreaidites orbiculatus* are *in situ* or (2) *Proteacidites asperopolus* Zone to Lower *Nothofagidites asperus* Zone if *Conbaculites apiculatus* ms at 43.1 mbgs is *in situ*. Other zone accessory morphospecies first occur in the Lower *L. balmei* Zone but also range into the Early Eocene, e.g., *Peninsulapollis gillii*, *Tetracolporites multistrixus* ms and *Tricolpites phillipsii*.

The provisional (preferred) age determination is Lower *Lygistepollenites balmei* Zone (low confidence). If other evidence is found to show *Conbaculites apiculatus* is *in situ*, then the age defaults to late Early to basal Middle Eocene *Proteacidites asperopolus* Zone.

The interval includes the highest records of morphospecies that typically occur in the *Lygistepollenites balmei* Zone e.g., *Gambierina rudata*, and *Nothofagidites endurus* (2% each) at 43.1 mbgs, and *Stereisporites regium* at 43.1 mbgs, and *Latrobosporites amplius* at 46.5 mbgs. Rare or previously unrecorded distinctive

morphotypes include *Tetracolporites multistrixus* ms and an oblate tricolpate pollen characterized by heavily thickened exine in the mesocolpial regions (*Tricolpites* sp. A this study) at 43.1 mbgs. The latter species, *Evanispora senonica*, and *Tetracolporites* cf. *T. palynius*, together with an undescribed *Proteacidites* morphotype ornamented with thorn-like echini (*Proteacidites* sp. A), and a four-porate var. of *P. crassus* (cf. *P. polymorphus*) occur at 46.5 mbgs. Reworked Late Cretaceous morphospecies include *Battenipollis sectilis* (43.1 mbgs) and *B. sabriniae* (46.5 mbgs).

51.25–55.0 mbgs: The interval is assigned minimum and maximum age limits of Early Danian Lower *Lygistepollenites balmei* Zone (high confidence) based on *Beaupreaidites orbiculatus* and multiple specimens of *Polycolpites langstonii* at 51.25 mbgs, *Haloragacidites harrisii*, at 51.25–53.4 mbgs, and *Proteacidites angulatus* at 55.0 mbgs. *Tricolpites* sp. A occurs at 51.25 mbgs (1%) and 55.0 mbgs.

Morphospecies reworked from Late Cretaceous facies elsewhere in the graben are *Battenipollis sabriniae*, *B. sectilis*, *Peninsulapollis askinae* and *Proteacidites reticuloconcavus* at 53.4 mbgs and less certain, undescribed triporate proteaceous morphotypes resembling *Cranwellipollis palisadus*, *Proteacidites confragosus*, *P. cooksoniae* and *Lewalanipollis* spp. in other samples. Previously unrecorded but distinctive morphotypes include an undescribed *Battenipollis*-like morphospecies with horizontally-aligned colpi bordered by granules, *Neoraistrickia truncata* and a monolete spore densely ornamented with stout baculae (*Baculatisporites* sp.).

3. WHDH-1 White Hills (ID 29954)

[522225E, 5400602N, RL 134.7 m]

White Hills is located ~ 7 km southwest of St. Leonards and about the same distance north of the South Esk River at Evandale near Launceston Airport. Lithostratigraphic data are not available. The total depth reached was 48 mbgs. Three samples were analysed – at 14.31–14.37 mbgs, 31.0–31.03 mbgs and 43.9–43.94 mbgs – from thin siltstone beds preserving minor carbonaceous material within thick fluvial sandstones which are capped by a coarse conglomerate above 10 mbgs. (Macphail, 2015b).

Microfossil yields were very sparse, with the majority of miospores recovered being modern pollen of native and exotic plants e.g., *Acacia* (Fabaceae), *Allocasuarina/Casuarina* (Casuarinaceae), *Eucalyptus* (Myrtaceae) and *Pinus* (Pinaceae). Multiple specimens of *Phyllocladidites mawsonii* occur in all samples; trace numbers of *Lygistepollenites balmei* occur at 31.0–31.03 mbgs and 43.9–43.94 mbgs. If these are *in situ*, Late Cretaceous and/or Paleocene sediments are preserved at depth or upstream of the core site.

Table 3. Summary of the ‘southern’ Tamar Graben core holes.

DRILL HOLE	DEPTH (mbgs)	INFERRED ZONE (Bass Basin criteria)	AGE LIMITS		DEPOSITIONAL ENVIRONMENT
			Maximum	Minimum	
AH-2 Abels Hill	28.16-28.19	Middle <i>Nothofagidites asperus</i>	Early Eocene	Early Oligocene	freshwater fen
	82.30-82.35	undiff. <i>Nothofagidites asperus</i>	Middle Eocene	Late Eocene?	freshwater fen
LV_1BH1_2005 Lawrence Vale	43.1-46.5	Lower <i>Lygistepollenites balmei</i> ?	Paleocene	Early Eocene	freshwater fen
	51.25-55.0	Lower <i>Lygistepollenites balmei</i>	Early Paleocene	Early Paleocene	freshwater fen
WHDH1 White Hills	14.37–14.31	indeterminate	indeterminate	indeterminate	fluvial?
	31.0–31.03	indeterminate	indeterminate	indeterminate	fluvial?
	43.9–43.94	indeterminate	indeterminate	indeterminate	fluvial?

B. ‘central’ Tamar Graben

Launceston Group sediments were sampled in three coreholes in the ‘central’ sector of the graben: Englewood Riverside 1, BH1 Windermere and BH3 Windermere. The only other biostratigraphic data available for the area comes from Legana Cliffs (Bigwood et al., 1988).

1. Englewood Riverside 1 (ID 29312)

[508850E, 5415913N, RL 2.1 m]

The drillsite is located on the flood-prone river terrace lining the western side of the Tamar River close to the Riverside Golf course ~ 3.5 km north of Launceston. Total depth reached was 200.1 mbgs. Ten samples were analysed (lithology in parentheses): at 59.64–59.67 mbgs, 93.95–93.96 mbgs; 103.95–104.00 mbgs (grey-black siltstone); 109.4 mbgs and 115.6 mbgs (carbonaceous laminations in a grey fine sand); 140.5 mbgs, 146.5 mbgs; 148.6 mbgs (fine sandstone); 152.1–152.1 mbgs; and 154.77–154.80 mbgs (brown sandstone).

These were assigned to four biostratigraphic units based on a combination of presence/absence and quantitative data. The interval at 140.5 mbgs is considered transitional between the Cretaceous and Cenozoic, based on the relative abundance of fern spores in an assemblage lacking Paleocene and Maastrichtian indicators. Some samples have been contaminated by modern pollen of native and exotic plants e.g., pines (*Pinus*), cereal grasses and a dock (*Polygonum aviculare*-type), introduced into the sample following drilling (cf. Macphail 2014, 2015c).

54.64–115.6 mbgs: *Haloragacidites harrisii* at 59.64–59.67 mbgs indicates the sample is no older than Lower *Lygistepollenites balmei* Zone and it is provisionally assigned to this Zone (moderate confidence) based on the absence of morphospecies that first occur in the Upper *Lygistepollenites balmei* Zone. Supporting a mini-

imum Paleocene age are: occurrences of *Proteacidites angulatus* at 93.95–93.96 to 115.6 mbgs, the consistent presence of *Australopollis obscurus* and *Peninsulapollis gillii* and based on Gippsland Basin data, and frequent (3%) *Nothofagidites flemingii*.

Tricolpites phillipsii, which first appears in the Lower *Lygistepollenites balmei* Zone, occurs at 109.4 mbgs. The sample at 115.6 mbgs is assigned to the same zone based on the negative evidence, viz. the absence of Late Cretaceous morphospecies, although the relative abundances of *Gambierina rudata* in this sample (16%) and up to 37% at 103.95–104.0 mbgs are more typical of a Late Maastrichtian age in the Gippsland Basin.

Tricolpites sp. A occurs in three of the five samples and an undescribed but equally distinctive tricolporate morphospecies (*Tricolporites* sp. A) occurs at 103.96–104.00 mbgs and 115.6 mbgs. The *Nothofagidites* component includes multiple specimens of a morphotype that resembles *N. asperus* [FAD Lower *Lygistepollenites balmei* Zone] except for the unusually coarse apiculate ornamentation. Other undescribed morphotypes include (i) the proteaceous morphotype ornamented with thorn-like echini, previously only recorded at 43.1–46.5 mbgs in LV_1BH1_2005 Lawrence Vale (*Proteacidites* sp. A, this study) and (ii) several di- and triporate grains ornamented with apiculae.

140.5–146.5 mbgs: The sample at 140.5 mbgs preserved a single specimen of *Battenipollis sectilis* but lacked *Forcipites longus* and other Maastrichtian indicators (see below) whilst differing from the overlying Paleocene microfloras in that *Proteacidites* (19%) and fern spores (22%) are moderately common. Assuming *Forcipites longus*, *Battenipollis sabrinae*, *Nothofagidites senectus* and *Tensuolpites* (al. *Tricolporites*) *lillieii* at 146.5 mbgs are *in situ*, then the minimum age of this sample is Late Maastrichtian, Upper *Forcipites longus* Zone. Other morphospecies with Late Maastrichtian FADs are *Proteacidites cooksoniae*, and *P. crotonoides*.

Stereisporites (*Tripunctisporis*) *maastrichtiensis* ms were not recorded and the maximum age is (undifferentiated) Maastrichtian *Forcipites longus* Zone.

Unusual records at 140.5 mbgs, or at 146.5 mbgs include an undescribed apiculate *Triporopollenites* species, a previously unrecorded (?) member of the peat-moss family Sphagnaceae (*Stereisporites* sp. A, this study) characterized by irregular rugulae on the distal surface (14%) and a probable liverwort (?) found elsewhere in Early Cretaceous and Late Jurassic sediments (*Nevesisporites* spp.). Otherwise, the interval (unit?) is characterized by morphotypes that first occur in the Late Cretaceous e.g., *Beaupreaidites*, *Propylipollis* and *Proteacidites* species complexes centred on *Lewalanipollis* cf. *senectus*, *Proteacidites adenanthoides* and *P. crassus* (see Dettmann and Jarzen, 1996). Gymnosperm relative abundances at 146.5 mbgs are the lowest (5%) recorded in the study. Microcharcoal particles occur in trace numbers.

148.6–154.80 mbgs: Dominance of microfloras in this interval varies between cryptogams (up to 45% at 148.6 mbgs), gymnosperms (up to 42% at 154.77-154 mbgs), and angiosperms (up to 74% at 152.1 mbgs). Morphospecies confirming a Late Maastrichtian minimum age include *Battenipollis sectilis* (2-3%) and *B. sabriniae* (3-8%). However, definite specimens of *Stereisporites* (*Tripunctisporis*) *maastrichtiensis* ms whose FAD defines the lower boundary of the Upper *F. longus* Zone, were not recorded and the age limits of the interval are undifferentiated *Forcipites longus* Zone. If the single specimens of *Forcipites sabulosus* (LAD Lower *F. longus* Zone) at 146.5 mbgs and 154.77-154.80 mbgs are *in situ*, then this interval and possibly underlying sediments down to basement will be Early Maastrichtian Lower *Forcipites longus* Zone. Circumstantial evidence supporting an Early Maastrichtian age is the comparatively low relative abundance of confirmed *Gambierina rudata* specimens (trace to 6%) compared to the higher values recorded at and above 140.6 mbgs.

Unusual or anomalous records in the interval include *Rosannia manika* (Lactoridaceae), *Tricolpites* sp. A. and *Tricolporites* sp. A. at 148.6 mbgs. 16% of an undescribed *Gambierina* morphotype (*G. tenuis* ms) at 152.1 mbgs, *Jaxtacolpus* sp. (148.6 mbgs) and the typically Early Cretaceous species *Aequitriradites spinulosus* (152.1 mbgs) and *Echimonocolpites* sp. (154.80 mbgs).

2. Legana Cliffs

[502789E, 5424238N, RL 6 m]

Legana is a mixed rural and residential area on the west bank of the Tamar River c. 12 km north of Launceston. Microfossil data for this locality come from carbonaceous siltstones and sandstones outcropping in cliffs (Browns Cliffs) lining the river. These deposits

have been assigned Middle to Upper *Malvacipollis diversus* Zone age by Bigwood et al. (1988). Published data indicate the maximum and minimum age limits for these deposits are Upper *Lygistepollenites balmei*–*Malvacipollis diversus* Zone to *Proteacidites asperopolus* Zone, based on *Peninsulapollis gillii* and *Proteacidites grandis*, and *P. incurvatus*, respectively.

3. BH-1 and BH-3 Windermere (ID 10229 and 13966)

Windermere is a rural hamlet located on the eastern side of the Tamar River ~ 23 km northeast of Launceston. BH-3 Windermere (RL 16.4 m) was drilled on the northern side of Windermere Road on a Pleistocene (?) river terrace adjacent to the river whilst BH1 Windermere (RL 146.1 m) was drilled close to the summit of a low ridge east of Gaunt Hill (RL 155 m) ~ 0.9 km north-northwest of BH-3. The total depths reached were 114.7 mbgs and 177.6 mbgs, respectively. Lithostratigraphic data are available only for BH1 Windermere. Samples of Launceston Group sediments from these coreholes were analysed by Wells (1988) but confusion over sample numbering has compromised the data. Two other coreholes in the vicinity, BH-4 Windermere at RL 8 m and BH-2 Windermere at RL ~ 90 m were not sampled.

BH-1 Windermere (ID 10229)

[501042E, 5427196N, RL 146.6 m]

Eight core chips (lithology in parentheses) were analysed at 27.5 mbgs (grey carbonaceous siltstone), 32.5 mbgs (grey carbonaceous siltstone), 45.65 mbgs (black carbonaceous siltstone), 48.3 mbgs (brown siltstone overlying cemented ferruginous siltstone), 76.2 mbgs (yellow-brown siltstone), 100.0 mbgs (brown siltstone), 152.5 mbgs (brown siltstone with plant fragments) and 175.2 mbgs (carbonaceous siltstone) (Macphail, 2015d). Most could be confidently dated using zone index and accessory species.

27.5–48.3 mbgs: The highest microflora, at 27.5 mbgs, is provisionally assigned to the *Proteacidites asperopolus* Zone based on *Concolpites apiculatus*, and geographical variants of *Proteacidites ornatus*, one of which is characterized by delicate rather than robust reticulum. The interval between 32.5 mbgs and 48.3 mbgs can be confidently dated to the same zone, based on *Concolpites apiculatus* ms, *Clavastephanocolporites meleosus*, and *Proteacidites ornatus* at 32.5 mbgs, *Proteacidites asperopolus*, *P. ornatus* and *Intratripollenites notabilis* at 45.65 mbgs, and *Concolpites apiculatus* and *Proteacidites ornatus* at 48.3 mbgs.

The abundance of gymnosperms in the four samples in this interval shows a marked decline up sequence from 80% to 9%. Unusual or anomalous records that appear to be *in situ* include multiple specimens of *Gambier-*

ina rudata (27.5–45.65 mbgs) and a variant of *Proteacidites pachypolus* characterized by protruberances (bosses) on both poles. Pollen of the tropical arum family Araceae (*Proxapertites operculatus*) and an undescribed apiculate tricolpate pollen with gaping apertures occur at 45.65 mbgs and 48.3 mbgs, respectively. Caved specimens of *Triporopollenites bellus* (FAD *Triporopollenites* (*Canthiumidites*) *bellus* Zone) and possibly *Tricolpites incisus* (FAD *Proteacidites asperopolus* Zone) occur at 45.65 mbgs and 48.3 mbgs, respectively.

76.2–152.5 mbgs: The three samples in this interval are dominated by gymnosperms but, like samples at 27.5–48.3 mbgs, are characterized by the high diversity of angiosperms most of whose pollen occur in low to trace numbers.

The interval is dated as Middle to Upper *Malvacipollis diversus* Zone (low confidence) based on *Proteacidites nasus* [FAD uppermost Lower *Malvacipollis diversus* Zone in the Gippsland Basin] and the absence of morphospecies that first occur in the *Proteacidites asperopolus* Zone. The maximum and minimum age limits are most likely to be Middle *Malvacipollis diversus* Zone and *Proteacidites asperopolus* Zone respectively, based on this morphospecies and *Proteacidites incurvatus*. Other age-diagnostic morphospecies in the interval either first appear in the Lower *Malvacipollis diversus* Zone or last occur in the *Proteacidites asperopolus* Zone e.g., *Intratriporopollenites notabilis* and *Proteacidites kopiensis* at 76.2 mbgs, *Dryptopollenites semilunatus* at 100.0 mbgs, and *Proteacidites pachypolus* (all samples).

Rare records include a palm (*Dicolpopollis*) and a fossil representative of the ebony tree family *Ebenaceae* (*Tricolporites valvatus*) at 76.2 mbgs and *Tricolporites moultonii* ms both at 76.2 mbgs and 100.0 mbgs. Freshwater algae are frequent and include *Botryococcus*, *Saepodinium* and a probable subsaline dinoflagellate cyst resembling *Deflandrea pachyceros*.

175.2 mbgs: The basal sample lacks *Proteacidites nasus* and is provisionally assigned to the Lower *Malvacipollis diversus* Zone based on species whose first occurrences defines the base of this zone e.g., *Nothofagidites goniatus*, *Intratriporopollenites notabilis*, and (marginal marine sediments in the Gippsland Basin) *Proteacidites pachypolus*. Rare occurrences include *Gambierina rudata*, *Tetracolporites multistrixus* ms and a caved specimen of *Aglaoreidia qualumis*. The algal component includes *Saepodinium gravattensis*.

BH-3 Windermere (ID 13966)

[501345E, 5426332N, RL 16.4 m]

Six core chips were analysed, at 31.05 mbgs, 33.75 mbgs, 46.05 mbgs, 53.85 mbgs, 73.10 mbgs and 90.52 m. These are assigned to three zones (Macphail, 2016).

31.05–46.05 mbgs: Samples within this interval are dominated by gymnosperms (59–81%) and include *Peninsulapollis gillii* (LAD basal Upper *Malvacipollis diversus* Zone in the Bass Basin vs Lower *Malvacipollis diversus* Zone in the Gippsland Basin), often in multiple numbers. Otherwise, the microfloras comprise a mix of *Nothofagidites asperus* Zone and *Malvacipollis diversus* Zone microfloras.

The two highest samples (31.05 mbgs, 33.75 mbgs) and the lowest sample (73.1 mbgs) include morphospecies which first or last occur in the Middle *Nothofagidites asperus* Zone (*Aglaoreidia qualumis*, *Proteacidites recavus*) or Lower *N. asperus* Zone (*Nothofagidites falcatus*) as well as morphospecies that are restricted to the *Malvacipollis diversus* to *Proteacidites asperopolus* Zones e.g., *Proteacidites tuberculiformis* at 73.10 mbgs. Assuming the former (*Nothofagidites asperus* Zone component) is caved, then the maximum age limit of the interval is Middle *Malvacipollis diversus* to *Proteacidites asperopolus* Zone. However, the minimum age could be as young as Late Eocene/Early Oligocene based on *Proteacidites nasus* and *Stereisporites* (*Tripunctisporis maastrichtiensis* ms), respectively.

Anomalous and unusual records include *Tricolpites* sp. A at 62.95 mbgs and 73.10 mbgs, miospores of the coral fern family *Gleicheniaceae* ornamented with foveae (*Foveogleicheniidites*) and dispersed gemmae (undescribed *Gleicheniidites* sp.), palms (*Dicolpopollis* sp.) and apiculate triporate spp. All samples preserved pollen of the putative wetland herb *Dicotetradites clavatus* (trace to 3%) and freshwater dinoflagellate cysts *Morkallacysta pyramidalis* and *Saepodinium gravattensis* (trace to 7%).

90.52 mbgs: This gymnosperm-dominated microflora, from a sample located ~ 10 m above the total depth of the corehole, differs markedly from microfloras upsection in the corehole in that it includes multiple specimens of species that typically last occur in the Upper *Lygistepollenites balmei* Zone e.g., *Lygistepollenites balmei*, *Gambierina rudata*, *Nothofagidites endurus* and variants of *Proteacidites angulatus*.

Morphospecies such as *Propylipollis annularis* whose FAD defines the Lower/Upper *L. balmei* Zone boundary are absent. The maximum and probable minimum age limits are Lower and Upper *Lygistepollenites balmei*, based on *Lygistepollenites balmei*, *Nothofagidites asperus* and *Nothofagidites endurus*, and the absence of morphospecies that first occur in the *Malvacipollis diversus* Zone apart from one presumed caved specimen of *Nothofagidites goniatus* (FAD Lower *Malvacipollis diversus* Zone).

Table 4. Summary of the ‘central’ Tamar Graben core holes.

DRILL HOLE	DEPTH (mbgs)	INFERRED ZONE (Bass Basin criteria)	AGE LIMITS		DEPOSITIONAL ENVIRONMENT
			Maximum	Minimum	
Englewood Riverside-1	59.64-115.6	Lower <i>Lygistepollenites balmei</i>	Early Paleocene	Early Paleocene	conifer swamp
	140.6-146.5	Cretaceous/Paleocene transition	Latest Maastrichtian	early Paleocene	conifer swamp
	148.6-158.6	undifferentiated <i>Forcipites longus</i>	Late Maastrichtian	Early Maastrichtian	conifer swamp
Legana Cliffs	c 6	<i>Malvacipollis diversus</i>	Paleocene	mid Middle Eocene	conifer swamp?
BH-1 Windermere	27.5-48.3	<i>Proteacidites asperopolus</i>	Late Early Eocene	early Mid. Eocene	freshwater lake
	76.2-152.5	Middle to Upper <i>M. diversus</i>	mid Early Eocene	mid Early Eocene	freshwater lake
	175.2	Lower <i>Malvacipollis diversus</i>	early Early Eocene	mid Early Eocene	freshwater lake
BH-3 Windermere	31.05-73.10	Middle <i>Nothofagidites asperus</i> + Middle <i>Malvacipollis. diversus</i>	Late Eocene	mid Early Eocene	freshwater lake
	90.52	undiff. <i>Lygistepollenites balmei</i>	Early Paleocene	Late Paleocene	conifer swamp

C. ‘northern’ Tamar Graben

Launceston Group sediments were sampled in three core-holes from the ‘northern’ portion of the Tamar Graben: Kelso-1, BB-BH1 Bell Bay and BH1 Rowella situated ~ 8 km, ~ 10 km and 17 km respectively, from Low Head at the mouth of the Tamar River. Total depths reached were 250.1 mbgs, 340.6 mbgs and 39 mbgs, respectively. Lithostratigraphic data are available for all core holes.

1. BB-BH1 Bell Bay (ID 13968)

[487718E, 5446018N, RL 39.5 m]

The corehole intersected a complex sequence of thin to thick silts and sands, with lignitic and carbonaceous facies, capped by slightly to highly weathered basalts at depths of above ~ 20.5 mbgs and underlain by dolerite below 292.6 mbgs. Thin ironstone horizons (weathering surfaces) occur within the sand and silt units, at 46.6 mbgs, 135.2 mbgs, 205.0 mbgs, 225.0 mbgs, 2467.0 mbgs, 257.0–258.2 mbgs and 277.2–277.6 mbgs. Thick conglomerates occur between 95.4–109.6 mbgs and 291.4–292.6 mbgs at the base of the coarse clastic strata. Nine core chips from five intervals of carbonaceous silts were analysed, the majority of which came from the lower 75 m of the core. The highest sample at 52.55–52.60 mbgs preserved the youngest (and only) Oligocene microflora recorded in the study (see below). Correlative deposits are recorded in drill core elsewhere on the north coast e.g., in the Penguin-Howth district, and a basalt dating to the late Chattian (24.72 ± 0.53 Ma) overlies Oligocene sediments elsewhere in Bell Bay area (Forsyth et al., 2014: 443).

52.55–52.60 mbgs: The gymnosperm-*Nothofagus* dominated microflora is dated as earliest Oligocene Upper *Nothofagidites asperus* Zone Equivalent based on *Granodiporites nebulosus* in a microflora lacking

Cyatheacidites annulatus. Supporting the determination are multiple specimens of *Aglaoreidia qualumis*, which becomes rare above the Upper *Nothofagidites asperus*, and *Proteacidites stipplatus* whose maximum relative abundance occur in this zone in the Gippsland Basin. The maximum and minimum age limits are earliest Oligocene (Upper *Nothofagidites asperus* Zone Equivalent) and Early Oligocene (lower *Proteacidites tuberculatus* Zone Equivalent based on the total age-range of *Granodiporites nebulosus*).

One of the twelve conifers present (*Podosporites erugatus*) is represented by unusually large numbers of pollen (6%), indicating an ancestor of the present-day celery-top pine *Phyllocladus aspleniifolius* was growing in the vicinity or upstream of the core site in the Early Oligocene. Other trees and shrubs include members of the sclerophyll heath (*Ericipites*) and eucalypt (*Myrtaceidites eucalyptoides*) families, as well as a protea (*Beaupreaidites elegansiformis*) now endemic to New Caledonia. Other proteas (*Proteacidites* spp.), *Tricolpites* and *Tricolorites* appear to be undescribed morphotypes.

113.77-113.82 mbgs: The sample is dated as *Proteacidites asperopolus* Zone (moderate confidence rating) based on morphospecies that first (*Concolpites apiculatus* ms) and last (*Intratropipollenites notabilis*, *Proteacidites ornatus*) occur in this zone. Supporting a late Early to early Middle Eocene age is the high abundance of *Haloragacidites harrisii* relative to *Nothofagidites* spp. (41% vs 13%) in the microflora at 113.77–113.82 mbgs. Maximum and minimum age limits are *Proteacidites asperopolus* Zone.

Other age-diagnostic taxa, mostly either first occur within the Early Eocene *Malvacipollis diversus* Zone or range into the Middle or Upper *Nothofagidites as-*

perus Zone e.g., *Anacolosidites acutullus*, *Dryptopollenites semilunatus*, *Polycolporopollenites esobalteus*, *Proteacidites leightonii*, *P. pachypolus* (7%) and *P. nasus*. *Aglaoreida qualumis*, and *Nothofagidites falcatus*, and *Polycolpites langstonii* are assumed to be caved or reworked from the Middle-Late Eocene and Paleocene, respectively.

179.20–245.35 mbgs: The two samples in this interval are assigned to the undifferentiated *Malvacipollis diversus* Zone based on species that first occur in the Lower *Malvacipollis diversus* Zone e.g., *Dryptopollenites semilunatus* and *Intratropopollenites notabilis*, and the absence of morphospecies that first occur in the *Proteacidites asperopolus* Zone. *Malvacipollis subtilis* is frequent (5%) at 179.20–179.30 mbgs. *Tropopollenites ambiguus* at 179.20–179.30 mbgs and *Peninsulapollis gillii* at 245.30–245.35 mbgs hint that the minimum age of the interval is Middle *Malvacipollis diversus*. The abundance of gymnosperms relative to angiosperms (chiefly undescribed morphospecies) increases down hole. Fossil arum pollen (*Proxapertites operculatus*) occur in both samples and *Tetracolporites multistrixus* ms at 245.30–245.35 mbgs. *Dicotetradites clavatus* (6–7%) indicates that the depositional environments were wetlands (fens).

285.8–287.0 mbgs: Two samples are assigned to the Thanetian Upper *Lygistepollenites balmei* Zone (moderate confidence) based on *Propylipollis annularis* and *Proteacidites incurvatus*, which first occur, and *Nothofagidites endurus*, *Proteacidites angulatus* and *Latrobosporites amplus* which last occur, in this zone. The minimum Thanetian age limits are supported by the absence of morphospecies, which first occur in the Early Eocene Lower *Malvacipollis diversus*. *Tetracolporites multistrixus* ms and *T. textus* ms occur at 285.8 mbgs and the latter morphospecies also occurs at 287.0 mbgs. Palm pollen (*Dicolpopollis*) occur in both samples.

288.4–291.84 mbgs: The three microfloras in this interval are dominated by gymnosperms. All are assigned to the Lower *Lygistepollenites balmei* Zone (moderate confidence) based on (i) *Beaupreaidites orbiculatus* at 289.25–289.30 mbgs and 291.90–291.84 mbgs, (ii) morphospecies that first (*Haloragacidites harrisii*, *Nothofagidites asperus*) or last (*Polycolpites langstonii*) occur in the *Lygistepollenites balmei* Zone, and (iii) the absence of morphospecies that first appear in the Upper *L. balmei* Zone (*Propylipollis annularis*, *Proteacidites incurvatus*).

Long-ranging but uncommon to rare morphospecies of an undescribed variant of *Camarozonosporites australiensis* (*C. eyrensis* ms), *Lygistepollenites balmei*, *Australopollis obscurus*, *Gambierina edwardsii*, *G.*

rudata, *Peninsulapollis gillii*, *Proteacidites tenuiexinus*, *Pseudowinterapollis cranwellae*, *Tetracolporites multistrixus* ms, *Tricolpites phillipsii* and *Tricolporites adelaidensis*. The only miospore evidence for wet conditions is trace numbers of *Dicotetradites clavatus*, suggesting that depositional environments were drier than in Upper *Lygistepollenites balmei* Zone time and, by extrapolation, the microfloras are more likely to represent conifer forest than a swamp.

2. BH-1 Rowella (ID 14663)

[492213E, 5440984N, RL 23 m]

Rowella is a rural locality on the west bank of the Tamar River ~ 46 km northwest of Launceston. The corehole is located on a high level (Pleistocene?) river terrace developed across basalt flows underlain by dolerite. Forsyth (1989) has reported undifferentiated Upper *Malvacipollis diversus*–*Proteacidites asperopolus* sediments (depths unspecified) underlying and overlying basalts below 24.6 mbgs in BH-1 Rowella and BH-2 Rowella. The BH1 sample analysed comes from the 0.2-m-thick carbonaceous silt at 8.5 mbgs within a thin (~ 25 m) unit of Launceston Group silts and sands deposited over a >10 m thick basalt. Owing to core loss, the top of the underlying dolerite in both coreholes is uncertain but is likely to be at *c.* 82 mbgs. Unusually, the Permian shale basement rocks at 134 mbgs were separated from the overlying dolerite by a 0.2-m-thick basalt.

8.5 mbgs: Despite the shallow depth, the one sample submitted for analysis yielded a diverse, well preserved ‘transitional’ Middle Eocene microflora dominated by angiosperms (52%) with *Haloragacidites harrisii* (12%), *Nothofagidites* spp. (20%) and *Malvacipollis* (2%).

The sample is no older than Upper *Malvacipollis diversus* based on *Santalumidites cainozoicus* and is assigned to the *Proteacidites asperopolus* Zone based on the Potassium/Argon date of 47 ± 0.1 Ma for the underlying ~ 100-m-thick basalt (cf. Partridge, 2006). Nevertheless, the sample lacks age-diagnostic morphospecies that first occur in *Proteacidites asperopolus* Zone e.g., *Conbaculites apiculatus*, *P. asperopolus*, *P. recavus* or *Sapotaceoidaepollenites rotundus*. The minimum age is no younger than this zone based on *Intratropopollenites notabilis*. Other potentially age-diagnostic morphospecies in the microflora either appear earlier, e.g., *Proteacidites nasus* (uppermost Lower *Malvacipollis diversus* Zone), or later e.g., *Aglaoreidia qualumis* (Middle *Nothofagidites asperus* Zone) in the Bass and Gippsland basins. *Morkallacysta pyramidalis*, *Dicotetradites clavatus* (6%) and unidentified algae (4%) indicate the sediment accumulated in a freshwater depression (pond?) or channel.

Table 5. Summary of the ‘northern’ Tamar Graben core holes.

DRILL HOLE	DEPTH (mbgs)	INFERRED ZONE (Bass Basin criteria)	AGE LIMITS		DEPOSITIONAL ENVIRONMENT
			Maximum	Minimum	
BB BH1 Bell Bay	52.55-52.60	Upper <i>Nothofagidites asperus</i>	earliest Oligocene	Early Oligocene	coastal plain
	113.77-113.82	<i>Proteacidites asperopolus</i> Zone	mid Early Eocene	early Middle Eocene	fen
	179.20-245.35	undiff. <i>Malvacipollis diversus</i>	early Early Eocene	mid Early Eocene	fen
	285.8-287.0	Upper <i>Lygistepollenites balmei</i>	Late Thanetian	Late Thanetian	conifer forest
	288.4-291.84	Lower <i>Lygistepollenites balmei</i>	Danian	Thanetian	conifer forest
BH1 Rowella	8.5	<i>P. asperopolus</i>	mid Early Eocene	mid Middle Eocene	Freshwater pond?
	c 125-1134	(Potassium/Argon date)	c 47 Ma	c 47 Ma	(basalt flow)
Kelso-1	55.0	indeterminate	indeterminate	indeterminate	(intrabasaltic lignite)

3. Kelso-1 Kelso (ID 10032)

[482013E, 5449084N, RL 8 m]

Kelso is a small rural locality at Kelso Bay on the west banks of the Tamar River ~ 3 km upriver from its mouth at Low Head. The sample comes from a ~ 4 m thick interval of a strongly indurated carbonaceous mudstone at 54.6–58.2 m between undated basalts at c. 24–54 mbgs, and tuffaceous sands and claystones at c. 59–61 mbgs overlying decomposed dolerite at 61.6 mbgs. A sample from 55.0 mbgs yielded carbonized (TAI >4) wood fragments only.

5.0 DISCUSSION

Despite the coarse sampling intervals and biostratigraphic caveats, the data are adequate to correlate the individual coreholes (Figure 7) as well as help improve the broad-brush tectonic and sedimentary history for the Tamar Graben. However, the chronostratigraphy depends on the assumptions that the overwhelming majority of morphospecies recorded in the Tamar Graben cores represent the same species or genera as in the Bass and Gippsland basin floras and, with minor exceptions (see Table 3), the age ranges in the two offshore basins and Tamar Graben align at the zone and, where applicable, subzone scale. Furthermore, we have assumed any serious discrepancies are likely to reflect differences in the number of drillholes for which palynostratigraphic data are available or unrecognized reworking or down-hole caving of morphospecies. For example, age-range data for the Gippsland Basin is based on ~ 300 wells (last reviewed in 1999 and 2006) whereas those for the Bass Basin (this study) primarily are based on ~ 30 mostly 1970s-vintage wells (Partridge, 1973). Other discrepancies in morphospecies age ranges between the Bass Basin and the Tamar Graben (Table 4) are likely to reflect differences in the local environment and source vegetation over geological time, compounded

by higher rates of fluvial erosion and redeposition of sediments within the narrow graben. One example is the tropical mangrove palm (*Nypa*), which grew on the Bassian plain during the Early Eocene hyperthermals but, on the evidence available, never migrated into the Tamar Graben (cf. Partridge, 1976). Nevertheless, paleoenvironmental differences almost certainly has allowed some parent plants to appear earlier or survive later as relict populations within the Tamar Graben. Examples of morphospecies with probable extended age ranges compared to the Bass and Gippsland basins are *Aglaoreida qualumis*, *Peninsulapollis gillii*, *Triporepollenites ambiguus* and the manuscript morphospecies *Tetracolporites multistrixus* and *T. textus*.

Early to? Late Maastrichtian

The only confirmed Late Cretaceous samples in this study are undifferentiated Maastrichtian *Forcipites longus* Zone sediments at RL -146.5 to -152.7 m (148.6–154.8 mbgs) in Englewood Riverside 1, located in the central sector of the Tamar Graben. These either occupied a depression in the basement rocks or were part of an unsampled, laterally extensive unit dipping northwards (down-to-basin) along the axis of the graben. Otherwise, the only evidence for more widespread Late Cretaceous deposits in the Tamar Graben is reworked specimens of *Battenipollis sabriniae* and *B. sectilis* spp. in Paleocene sediments in the LV_1BH1_2005 Lawrence Vale corehole, and *Cranwellipollis palisadus* and *Peninsulapollis askinae* in probable Middle-Late Eocene sediments in AH-2 Abels Hill.

The age and thickness of the Maastrichtian section in Englewood Riverside-1 are equivocal for several reasons: (i) *Battenipollis sectilis* at 140.6 mbgs and *Forcipites longus*, *F. sabriniae* and *Tensucolpites lillieii* at 146.5 mbgs may be reworked; (ii) It is unknown if samples dated by Forsyth et al. (2014: 442) as ‘latest Cretaceous’ from the Maastrichtian unit preserved the

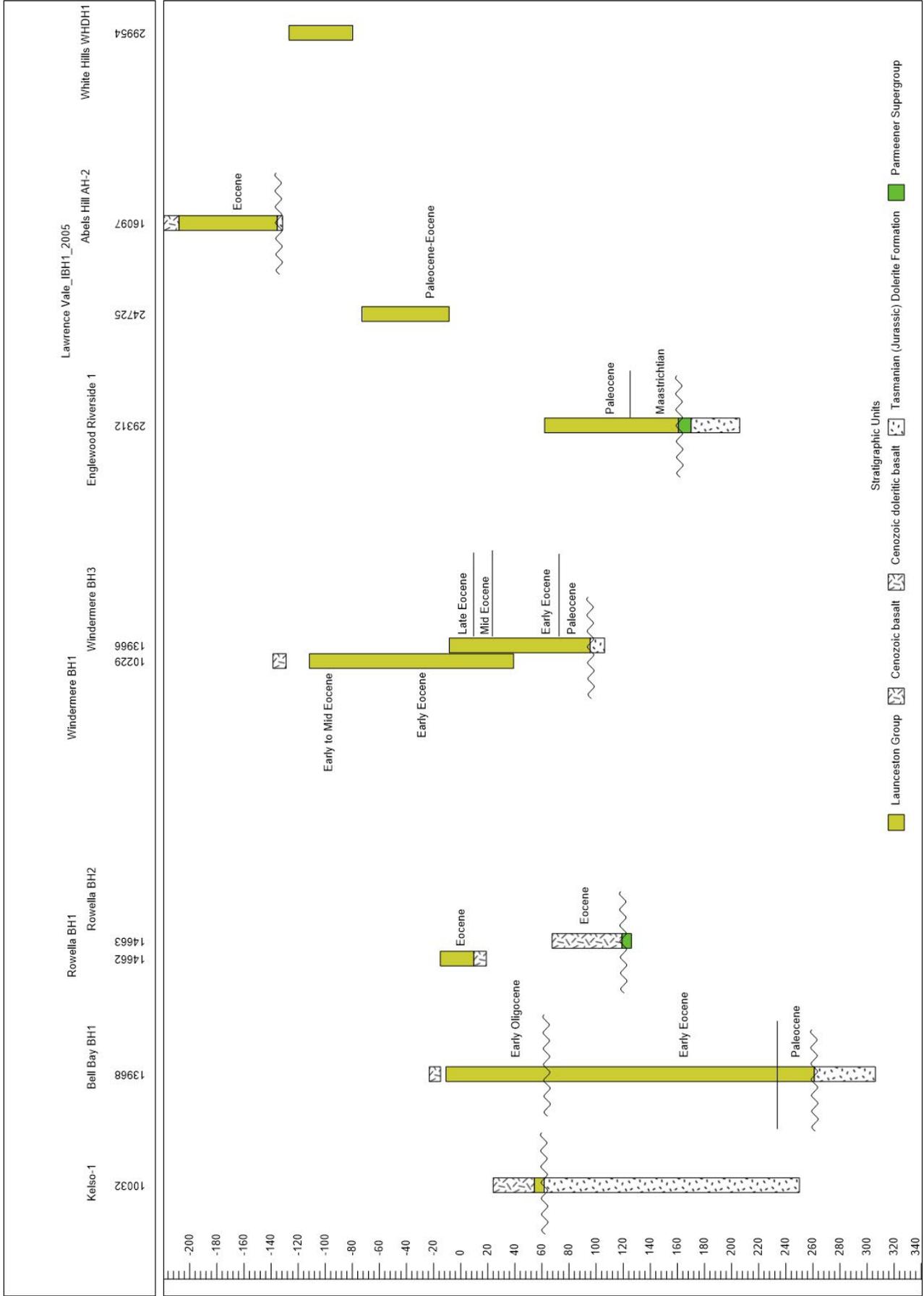


Figure 7. Graphic correlation of coreholes.

key Late Maastrichtian morphospecies *Stereisporites maastrichtiensis*; (iii) On the data available, the top of the Maastrichtian unit could be as high as RL -138.5 m (140.5 mbgs); (iv) If *Forcipites sabulosus* at 146.5 mbgs and 154.77-154.80 mbgs are *in situ*, then sediments at and below 146.5 mbgs date to the Early Maastrichtian (Lower *F. longus* Zone).

The provisional interpretations adopted in this study are (a) the section at and below 148.6 mbgs is Early Maastrichtian, a proposal that is in good agreement with the *c.* 70 Ma date for the formation of the Tamar Graben (cf. Partridge, 2006; Corbett, 2019), and (b) the overlying fluvial sandstone at 140.6-146.5 mbgs is a ‘transitional unit’ encompassing the Cretaceous Tertiary boundary. Whether high relative abundances of cryptogam spores in the four samples reflect local deposition in a riparian fern swamp or, as in New Zealand, the transient expansion of cryptogams at 140.6-146.5 mbgs reflects the impact of the bolide defining the Cretaceous-Paleocene boundary (K/T Event) (cf. Vajda et al., 2001; Vajda and Raine, 2003) is uncertain. This will be investigated by closer sampling of the section between 115.6-152.1 mbgs (M.K. Macphail, in prep.). However, we note that none of the Tamar Graben samples preserve significant amounts of micro-charcoal i.e., particles that are likely to be present if northern Tasmania experienced the catastrophic wildfires predicted to have accompanied the K/T bolide impact elsewhere (Kring, 2007). Otherwise, available data demonstrate this fernland community had been largely replaced by ancestral Podocarpaceae (see below), including the now extinct probable shrub conifer *Podosporites microsaccatus* by the time represented by the sample at 140.5 mbgs.

Paleocene (Danian to late Thanetian)

Microfloras assigned to the Early Danian to early Late Thanetian Lower *Lygistepollenites balmei* Zone are recorded with varying degrees of confidence in all three sectors of the Tamar Graben (BB-BH1 Bell Bay, Englewood Riverside 1, BH3 Windermere, and possibly in or upstream of WHDH1 White Hills). The shallowest occurrences are in the ‘southern’ Tamar Graben, at RL 34.5 to 37.9 m (43.1–46.5 mbgs) in LV_1BH1_2005 Lawrence Vale. The undifferentiated *Lygistepollenites balmei* Zone sample at 90.52 mbgs in BH3 Windermere lacks morphospecies that first occur in the Upper *L. balmei* Zone and to that extent is circumstantial evidence that Lower *L. balmei* Zone facies also occur at RL -74.12 m (90.52 mbgs) in the central part of the graben. The top of the unit in the northern Tamar Graben at RL -248.9 m (288.4 mbgs) in BB-BH1 Bell Bay indicates northward dipping (or tilting of) sediments infilling graben in the Early Danian. Minimum thicknesses range from ~ 12 m in the southern part of the graben to ~ 34 m in the central part of the graben although it remains uncertain if the Paleocene unit thickens northwards in the graben.

All microfloras are dominated by the gymnosperms (63-92%), in particular *Phyllocladidites mawsonii* whose nearest living relative (NLR) is the shrub to tall tree *Lagarostrobos franklinii* (Huon Pine), now endemic to cool to cold perhumid climates in Tasmania, and *Podocarpidites*, whose NLRs *Podocarpus* and *Prumnopitys* are more widely distributed across the Southern Hemisphere (Enright et al., 1995). Co-dominants in Englewood Riverside 1 include *Microcachryidites antarcticus* whose NLR is the alpine mat conifer *Microcachrys tetragona* in Tasmania, and the *Podocarpidites/Trichotomosulcites* complex, which appears to represent a clade of now extinct shrub conifers colonizing the banks of streams and lakes. The consistent presence of *Gambierina* (up to 16% at 93.95–93.96 mbgs in Englewood Riverside 1) confirms the clade survived into Paleocene time irrespective of the varying impact the K/T event might have had on insect-pollinated vs wind-pollinated taxa in northern Tasmania (Macphail, 1994).

Paleocene (latest Thanetian)

The Thanetian Stage encompasses the last *c.* 1.2 Ma years of Paleocene time (Upper *Lygistepollenites balmei* Zone). The only probable microfloras of this age recorded in the study occur in the ‘northern’ Tamar Graben in BB-BH1 Bell Bay at 285-287.0 mbgs (RL -246.3–247.5 m). The age limits however, are based on a single specimen of *Propylipollis annularis* (FAD Upper *L. balmei* Zone) in an interval lacking Early Eocene and Danian (Lower *L. balmei* Zone) index species. Whether the minimal (~ 3.5 m) thickness of this unit reflects the brief period of geologic time assigned to the zone in the Gippsland Basin by Partridge (2006) is unknown. As for correlative microfloras in the Gippsland Basin, cryptogams are frequent but otherwise the graben vegetation remained dominated by gymnosperms, in particular *Phyllocladidites mawsonii* (79-84%).

Early Eocene (Ypresian)

‘Lower’ *Proteacidites asperopolus-Malvacipollis diversus* Zone sediments either were not deposited or else have been eroded from the ‘southern’ Tamar Graben even though correlative sediments are preserved within the ‘central’ and ‘northern’ Tamar Graben during the early to mid-Early Eocene (Ypresian). Bigwood et al. (1988) have reported Eocene sediments from unspecified localities elsewhere in the Launceston area dating to the Middle to Upper *Malvacipollis diversus* Zones. Whether deposition was episodic or continuous cannot be confirmed because many of the correlative (?) samples analysed in this study are difficult to assign to a particular subzone of the *Malvacipollis diversus* Zone. For example, a ~ 66-m-thick unit of undifferentiated *Malvacipollis diversus* Zone sediments occurs at RL -139.7 to -205.85 m (179.2-245.35 mbgs) in BB-BH1 Bell Bay and a thinner, ~ 41-m-thick but potentially

continuous sequence of *M. diversus* Zone deposits occur at RL +69.9 to -29.1 m (76.2-175.2 mbgs) in BH1 Windermere. Whether the lacustrine sediments at the latter site accumulated in a depression at 146 m elevation at the (back-tilted) rear of a previously uplifted fault block, or whether uplift along growth faults continued into Middle Eocene time is uncertain due to contamination of Middle *M. diversus* assemblages at -14.7 to -56.7 m (31.05-73.10 mbgs) in Windermere BH3 by downhole caved Late Eocene sediment. The correlative section in BB-BH1 Bell Bay seems to indicate northward (down to basin) tilting of the graben continued into Early Eocene time.

Despite the chronostratigraphic limitations, the microfossil data confirm the palaeovegetation in northern Tasmania does reflect, albeit indistinctly, one or more global hyperthermal events characterizing the Early Eocene. For example, thermophilous taxa such as *Dryopteridites semilunatus* (*Pandanus*?) and *Intratropollenites notabilis* (Tiliaceae) remained uncommon in the conifer-dominated vegetation within the graben during this period. Otherwise, local conditions remained sufficiently cool to support diverse Podocarpaceae and *Nothofagus* (*Nothofagidites brachyspinulosus*, *N. flemingii*) communities. By this time *Dacrydiumites florinii* (*Dacrydium*), *Dilwynites* spp. (*Agathis-Wollemia*) and *Podocarpidites* (*Podocarpus-Prumnopitys*) had replaced *Phyllocladidites mawsonii* as the dominant gymnosperms although the reason for this is unknown.

Mid Early to early Middle Eocene (late Ypresian–early Lutetian)

The ‘upper’ *Proteacidites asperopolus* Zone ranges from the Early Eocene (late Ypresian) into early Middle Eocene (Lutetian) time and microfloras assigned to this zone potentially date to either or both periods of geologic time. The oldest basalt evidence of volcanic eruptions within the graben dates to *c.* 47 Ma (earliest Lutetian).

The only sediments able to be assigned with moderate confidence to the mid Early to early Middle Eocene *Proteacidites asperopolus* Zone are recorded in the ‘northern’ Tamar Graben at RLs +14.5 m (8.5 mbgs) in BH1 Rowella and -74.27 to -74.32 m (113.77-113.82) in BB-BH1 Bell Bay. The maximum age of the BH-1 Rowella sample is Lutetian. Whether the BB-BH1 Bell Bay interval dates to this period or is Ypresian is unknown due to downhole caving of Late Eocene (*Aglaoreidia qualumis*) and reworking of Paleocene (*Polycolpites langstonii*) sediments, respectively. Both microfloras are characterized by frequent to common *Haloragacidites harrisii* samples but are unlikely to be coeval given marked difference in elevation of the sampled intervals and differences in depositional environments at Rowella (lacustrine) and Bell Bay (wetland

surrounded by rainforest). The apparent lack of mid Early to early Middle Eocene deposits in the ‘central’ and ‘southern’ Tamar Graben could be due to limited sampling or erosion following ‘out-of-trough’ diversion of the ancestral Tamar River by lava blocking the graben (Sutherland et al., 2006).

As in the Ypresian, taxa with thermophilous NLRs are rare but include *Intratropollenites notabilis*, *Dryopteridites semilunatus* and (BB-BH1 Bell Bay) distinctively-ornamented *Proteacidites* spp. such as *P. grandis*, *P. nasus* and *P. pachypolus*. The marked increase in the relative abundance of *Nothofagidites* pollen (20% vs 13%) and cryptogam spores (12% vs 2%) at BH1 Rowella compared to BB-BH1 Bell Bay is ecologically consistent with regional cooling recorded elsewhere in the Early to Middle Eocene (cf. Zachos et al., 2001; Bijl et al., 2013; Macphail et al., 2014).

Middle to Late Eocene (mid Lutetian to Priabonian)

Samples able to be assigned (low confidence) to the Lower to Middle *Nothofagidites asperus* Zone occur at RL -14.65 to -17.35 m (31.05–33.75 mbgs) in BH-3 Windermere in the central sector and RL 199.04 m (28.16 mbgs) in AH2 Abels Hill in the southern sector of the Tamar Graben. The ~ 215 m decrease in elevation between the top of the *Nothofagidites asperus* Zone supports ongoing northward tilting of the graben into the Late Eocene but may have a more local tectonic explanation. The microfloras are atypical for this period in that the Windermere microfloras are dominated by gymnosperms (59-69%) and the AH2 Abels Hill microflora by *Nothofagus* subgenera *Fuscospora* and *Nothofagus* (total 21%) and Proteaceae (25%), not *Nothofagus* subgenus *Brassospora* spp. (<4%) as was the case in the Gippsland and Bass basins at this time (Macphail et al., 1994; 2014). The significance of this is unclear but may be related to volcanism after *c.* 47 Ma. The only potential thermophilous taxa recorded during this period occur in the ‘mixed age’ sample at 31.03 mbgs in BH3 Windermere, viz. *Beaupreaidites verrucosus* whose NLR is endemic to New Caledonia, and an unidentified palm (*Dicolpopollis*).

Early Oligocene (Rupelian)

One sample at RL -13.05 m (52.55 mbgs) in BB-BH1 Bell Bay is dated to the earliest Oligocene (Upper *N. asperus* Zone). Assuming, as appears to be the case, the zone index species *Granodiporites nebulosus* and *Aglaoreidia qualumis* are *in situ*, this may be the youngest age determination recorded for any corehole within the graben. The age of the overlying sediments (or volcanoclastics) is unknown. By this time, gymnosperms, appear to have replaced angiosperms as the dominant trees and (*Podosporites microsaccatus*) shrubs in the local vegetation.

6.0 CONCLUSIONS

The study confirms that biostratigraphic criteria used to subdivide Late Cretaceous and Paleogene time in the Gippsland and Bass basins provide a valid biostratigraphic framework for reconstructing the geohistory of the Tamar Graben at the geological epoch and sub-epoch scale i.e., over time scales usually greater than *c.* 3-10 Ma. However, the absence of zone index and more reliable zone accessory morphospecies in many samples means that many of the sampled intervals could only be assigned to one or more of the broad biostratigraphic subdivisions of geologic time recognized by in the Gippsland and Bass basins. Despite this limitation, trends in the mostly conifer-dominated paleofloras and vegetation broadly mirror changes recorded on the Bassian coastal plain except for the Early Eocene where apparently cooler local conditions prevented the establishment of thermophilous plants such as *Nypa*. Several undescribed pollen morphotypes are not known to occur elsewhere and may represent plants that were restricted to the graben due to differing environmental constraints. Nevertheless, the combined spore- and pollen-based age determinations and isotopic dates support previous studies in that:

1. The oldest sediments are Maastrichtian *Forcipites longus* Zone (Englewood Riverside-1). As yet, there is no published biostratigraphic evidence to confirm the “latest Cretaceous” (presumably Late Maastrichtian Upper *F. longus* Zone) age proposed by Forsyth et al. (2014). We note deposition within the Early Maastrichtian (late Early *F. longus* Zone) is consistent with currently accepted *c.* 70 Ma age for the faulting events leading to the formation of the graben. Significant relative abundances of pollen produced by *Nothofagus* and the extinct clade represented by *Gambierina* shows the palaeovegetation was part of the extinct temperate vegetation colonizing the developing rift valleys between East Antarctica and southern Australia (see Dettmann 1989, Dettmann 1994). Leaf cuticles confirm the local presence of Proteaceae and conifers, including Podocarpaceae, in Danian sediments at ~ 103.9 mbgs in Englewood-Riverside-1. This macrofossil evidence is consistent with a nutrient-deficient, open-structured conifer swamp setting inferred from the microflora, a conclusion that is supported by absence of Lauraceae, whose diverse cuticles become prevalent in closed-rainforest assemblages from the Paleogene onwards in mainland Australia (see Greenwood and Christophel, 2005). Maastrichtian vegetation here also has a diverse proteaceous pollen component, which in Central Australia is confirmed by the cuticular remains of open-habitat morphogenera (Carpenter et al.,

2012). It is possible that the Maastrichtian–Paleocene interval in Englewood Riverside 1 preserves sediments deposited close to the time (*c.* 65.5 Ma) of Cretaceous–Tertiary (K/T) bolide impact.

2. Paleocene (Danian–Thanetian) sediments are present in northern (BB BH1 Bell Bay), central (Englewood Riverside 1, Windermere BH3) and southern (LV-1BH1_2005 Lawrence Vale) sectors of the graben. Because of tilting and channeling, it is probable that these sedimentary sequences only provide discontinuous record of events occurring during this *c.* 10-Ma-long period. What is apparent is that that swamp forests dominated by temperate conifers such as ancestral *Lagarostrobos* (Huon Pine) but not *Nothofagus*, had colonized the banks of, and valley slopes above the ancestral Tamar River during this epoch. We note the only prominent cuticle taxa so far recovered from Paleocene sediments in the LV_1BH1 Lawrence Vale (52.8 mbgs) and BB-BH1 Bell Bay (285.8 mbgs) cores are from conifers and Proteaceae.
3. Early Eocene deposits are preserved only in the ‘central’ (BH1 Windermere) and ‘northern’ Tamar Graben sectors (BB-BH1 Bell Bay, BH1 Rowella). Bauxite fragments in Early Eocene deposits in the AH2 Abels Hill core, imply intense weathering of the dolerite basement rocks in the ‘southern’ Tamar Graben (Forsyth et al., 2014). For the same reason, it is unlikely deposition was continuous during the period even if Early Eocene deposits accumulating in this sector subsequently were destroyed through fluvial erosion. Trace specimens of *Deflandrea pachyceros* (*Deflandrea cf. pachyceros*) in BH1 Windermere indicate subsaline conditions but are unlikely to be evidence for a marine connection. For example, this dinoflagellate (i) is associated with much larger numbers of a freshwater algae in the Tamar Graben and (ii) also occurs in Paleogene lacustrine facies in the Alice Springs region, Central Australia (cf. Macphail, 1997; Macphail et al., 2014). Unlike the Macquarie Harbour graben on the West Coast and the Bass Basin, local conditions did not support the tropical mangrove palm *Nypa* (Partridge, 1976; Pole and Macphail, 1996; Carpenter et al., 2012) and the only apparent hints of warmer conditions during hyperthermals characterizing the Paleocene-Eocene transition are trace occurrences of presumed thermophile members of the euphorbia (Euphorbiaceae), palm (Arecaceae), pandanus (?) (Pandanaeae) and lime (Malvaceae subfamily Tilioideae) families. One possible reason for the maintenance of relatively cool, wet environments favouring temperate *Nothofagus* spp. within the graben is cold air drainage down the topograph-

ically confined valley. It is uncertain whether cold-air drainage or other forcing factors explain the observed expansion of *Dacrydium* and Casuarinaceae (*Gymnostoma*?) populations in this sub-epoch.

4. The Middle to possibly Late Eocene period is characterized by the apparent preservation of *in situ* deposits only in the ‘southern’ Tamar Graben (AH2 Abels Hill) although mixing of Middle and Early Eocene microfloras in BH3 Windermere below RL +16.4 m is circumstantial evidence for former deposition of correlative sediments in the ‘central’ Tamar Graben even if these since have been destroyed by fluvial processes. It is uncertain whether freshwater lacustrine sediments in the higher Windermere corehole (BH1) is evidence of uplift along growth faults that persisted into Middle Eocene time or deposition occurred on possible already back-tilted fault block uplifted in the Early Eocene. No compelling evidence for an impact of volcanic eruptions on the early Middle Eocene vegetation was found, either because of the selective sampling of organic-rich (not volcanoclastic) deposits, or because of rapid regeneration of plant communities on nutrient-rich volcanic regolith following eruptions. The relative abundance of *Nothofagus* (37–63%) at the AH2 Abels Hill core site is evidence that climates were overall cooler than during the earlier Early Eocene in the southern sector of the graben even though podocarp gymnosperms remained the dominant tree taxa. There is no specific evidence that extensive freshwater swamps lined the ancestral Tamar River although soil moisture levels were sufficiently high to support ancestral species of the Huon Pine during the Paleogene.
5. The presence of *c.* 31.5–34 Ma (Early Oligocene) terrestrial sediments at RL –13 m in the northern sector of the graben (BB-BH1 Bell Bay) is significant in that deposits of this age coincide with onset of major Antarctic glaciation between *c.* 38–28 Ma (late Middle Eocene–Early Oligocene) and the associated marked drop of up to 50–60 m in global sea levels (references in Houben et al., 2012). Apart from trace *Beauprea*, species with warm-temperate to tropical NLRs were absent. Regional cooling almost certainly was responsible for the expansion of *Nothofagus* (*Brassospora*) spp., a subgenus that was previously uncommon in the Tamar Graben but which had become a dominant in temperate rainforest in mainland southeastern Australia during the mid-Middle Eocene (cf. Stover and Partridge, 1973; Macphail, 1999; Partridge, 1999). The sample pre-dates the *c.* 25 Ma basalt at George Town and any potential damming or diversion of the ancestral Tamar River that this volcanic eruption might have caused (cf. Sutherland et al., 2006).

To what extent our age-range data for the Tamar Graben can be used to infer or revise age determinations for other onshore sites in Tasmania is less certain. Primary reasons are taxonomic, depositional, and geographic. (1) A significant number of the described and undescribed (ms) zone accessory species are geographic variants of morphospecies found in the Gippsland and Bass basins and for the same reason may have differing age-ranges and paleoecologies whether or not their stratigraphic distribution has been ‘blurred’ by local fluvial reworking of older deposits in the Tamar Graben. (2) More generally, the mountainous topography and location of Tasmania at middle to high paleolatitudes has led to strong environmental gradients west to east and upslope across Tasmania during the Paleogene–Neogene. An example is warm water gyres within the partially-occluded Austro-Antarctic Gulf between southern Australia and Antarctica allowed *Nypa* and other thermophiles to colonize coastal plains in Macquarie Harbour and on the Bassian coastal plain during the Early Eocene hyperthermals whereas *Nothofagus*-dominated cool temperate rainforest occupied sites that were exposed to the open ocean on the East Coast of Tasmania (references in Macphail et al., 2014).

For this reason, we consider it unlikely that a *fine resolution* biostratigraphy can be developed that is applicable to all of onshore Tasmania. Nonetheless assuming adequate to good preservation of miospores, projects that potentially will improve the chronostratigraphic resolution in northern Tasmania are (i) palynostratigraphic analyses of sediments interbedded with isotopically-dated basalt (cf. Macphail 2022; N. Roberts, in prep.) and (ii) detailed palynostratigraphic analysis of drill core from onshore basins such as the Longford Basin where fluvial reworking and erosion are less of a constraint (Figure 4). Similarly, combining the palynostratigraphic data from coreholes drilled in the Macquarie Harbour Graben and the Sorell Basin (Cape Sorell-1) potentially provides a regional biostratigraphy for western Tasmania (references in Forsyth et al., 2014; Hill et al., 2014). The biostratigraphic and chronostratigraphic potential of Paleogene–Neogene lacustrine and paleochannel sediments (and associated basalts) in paleolakes in the Derwent and Coal River grabens, near Glenora, in southern Midlands, are mostly untested (cf. Everard et al., 2014; Forsyth et al., 2014).

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APPENDIX 1

Comparison of the age range (time distributions) of fossil pollen and spores in the Gippsland and Bass basins, Bass Strait, during the Campanian to Oligocene periods.

Zone names spelled out in the text. Records in parentheses indicate inconsistent occurrences. Zone index and zone accessory morphospecies are highlighted in bold type. Primary data from Partridge (1973, 1999).

A # indicates data includes unpublished records of M.K. Macphail.

FOSSIL MORPHOSPECIES	GIPPSLAND BASIN (Partridge 1999 #)		BASS BASIN (Partridge 1973*)	
	FAD	LAD	FAD *	LAD *
<i>Acaciapollenites myriosporites</i>	Upper <i>P. tuberculatus</i>	<i>T. pleistocenicus</i>	no data	
<i>Acaciapollenites octosporites</i>	<i>T. pleistocenicus</i>	<i>T. pleistocenicus</i>	no data	
<i>Aequitriradites spimulosus</i>	no data		no data	
<i>Aglaoreidia qualumis</i>	Middle <i>N. asperus</i>	Lower <i>T. bellus</i>	Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Ailanthipites paenestriatus</i>	mid Upper <i>L. balmei</i>	<i>T. bellus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Anacolosidites acutullus</i>	(U. Lb) Lower <i>M. diversus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>A. luteoides</i>	Middle <i>M. diversus</i>	Lower <i>N. asperus</i>	Middle <i>M. diversus</i>	Lower <i>N. asperus</i>
<i>A. sectus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>Australopollis obscurus</i>	(<i>A. dist.</i>) <i>P. mawsonii</i>	Upper <i>L. balmei</i> (<i>L. Md.</i>)	Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
<i>Banksiaeaeites arcuatus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>B. elongatus</i>	Upper <i>L. balmei</i>	<i>T. bellus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Battenipollis sabriniae</i>	(U Ns) <i>T. lilliei</i>	Upper <i>F. longus</i>	no data	
<i>B. sectilis</i>	(mid) <i>T. lilliei</i>	Upper <i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>Beaupreaidites elegansiformis</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>B. orbiculatus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i> (<i>L. Lb</i>)	Upper <i>F. longus</i>	Lower <i>L. balmei</i> ?
<i>B. verrucosus</i>	Lower <i>L. balmei</i>	<i>T. bellus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Bluffopollis scabratus</i>	Upper <i>M. diversus</i>	<i>T. bellus</i> (<i>Pt</i>)	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Camazonosporites bullatus</i>	mid <i>T. apoxyxinus</i>	Lower <i>M. diversus</i>	Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
<i>Camazonosporites eyrensis</i> ms	<i>F. longus</i>	<i>L. balmei</i> ?	no data	
<i>Cingulatisporites bifurcatus</i>	<i>C. bifurcatus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Chenopodipollis chenopodiaceoides</i>	(<i>L Pt</i>) <i>C. bifurcatus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Clavastephanocolporites meleosus</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i> (<i>L Na</i>)	<i>P. asperopolus</i>	(basal) Lower <i>N. asperus</i>
<i>Clavatiipollenites glarius</i>	<i>P. asperopolus</i>	<i>T. bellus</i>	no data	
<i>Clavifera triplex</i>	(<i>P. m</i>) <i>T. apoxyxinus</i>	Upper <i>L. balmei</i> ?	no data	
<i>Conbaculites apiculatus</i> ms	<i>P. asperopolus</i>	Lower <i>N. asperus</i>	<i>P. asperopolus</i>	basal Middle <i>N. asperus</i>
<i>Cranwellipollis palisadus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>Crassiretiriletes vanraadshoovenii</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	Upper <i>N. asperus</i>
<i>Cupanieidites orthoteichus</i>	Upper <i>L. balmei</i>	<i>C. bifurcatus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Cyathacidites annulatus</i>	Lower <i>P. tuberculatus</i>	<i>M. lipsis</i>	<i>P. tuberculatus</i>	<i>P. tuberculatus</i>
<i>Cyathidites splendens</i>	<i>T. lilliei</i>	<i>C. bifurcatus</i>	Lower <i>F. longus</i>	basal Upper <i>N. asperus</i>
<i>Cyathidites subtilis</i>	Middle <i>P. tuberculatus</i>	<i>M. lipsis</i>	no data	
<i>Dacrycarpites australiensis</i>	Lower <i>N. senectus</i>	<i>M. lipsis</i>	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>Dacrydiumites florinii</i>	(<i>P. m</i>) <i>T. apoxyxinus</i>	<i>M. lipsis</i>	Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>Densoisporites implexus/simplex</i>	<i>M. lipsis</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Dicotradites clavatus</i>	<i>T. lilliei</i>	Middle <i>N. asperus</i>	<i>T. lilliei</i>	Middle <i>N. asperus</i>
<i>Dicolpopollis</i> spp.	no data		no data	
<i>Dilwynites granulatus</i>	<i>N. senectus</i> ?	<i>T. pleistocenicus</i>	no data	
<i>D. tuberculatus</i>	<i>T. lilliei</i>	<i>M. lipsis</i>	<i>T. lilliei</i>	<i>P. tuberculatus</i>
<i>Dodonaea sphaerica</i>	<i>T. bellus</i>	<i>T. pleistocenicus</i>	no data	
<i>Dryadopollis retequetrus</i>	mid Middle <i>N. asperus</i>	Lower <i>P. tuberculatus</i>	no data	
<i>Drytopollenites semilunatus</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i> (<i>M Na</i>)	Lower <i>M. diversus</i>	(basal) Upper <i>N. asperus</i>
<i>Echimonocolpites</i> sp.	no data		no data	
<i>Ephredipites notenis</i>	no data		Lower <i>F. longus</i>	Middle <i>N. asperus</i>
<i>Fenestrites</i> sp.	<i>T. pleistocenicus</i>	<i>T. pleistocenicus</i>	(outside recorded period)	
<i>Foveotrilites balteus</i>	Lower <i>N. senectus</i>	<i>M. lipsis</i>	Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>F. crater</i>	Upper <i>N. asperus</i>	<i>T. bellus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>F. palaequetrus</i>	mid Middle <i>N. asperus</i>	Upper <i>P. tuberculatus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Forcipites longus</i>	Lower <i>F. longus</i>	Upper <i>F. longus</i>	Lower <i>F. longus</i>	Upper <i>F. longus</i>
<i>Forcipites sabulosus</i>	Upper <i>N. senectus</i>	Lower <i>F. longus</i>	<i>N. senectus</i>	(basal) Upper <i>F. longus</i>
<i>F. crater</i>	Upper <i>N. asperus</i>	<i>T. bellus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Gambierina askinae</i>	(U Ns) <i>T. lilliei</i>	Upper <i>F. longus</i>	no data	
<i>G. edwardsii</i>	<i>T. lilliei</i>	Lower <i>L. balmei</i> (<i>U Lb</i>)	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>G. rudata</i>	Upper <i>N. senectus</i>	Lower <i>L. balmei</i> (<i>U Lb</i>)	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>Graminidites</i> spp.	(<i>L Pt</i>) <i>C. bifurcatus</i>	<i>T. pleistocenicus</i>	(outside record)	
<i>Gothanipollis bassensis</i>	upper <i>P. asperopolus</i>	Upper <i>N. asperus</i> (<i>Pt</i>)	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Grandiporites nebulosus</i>	Upper <i>N. asperus</i>	Lower <i>P. tuberculatus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>Grapnelispora evansii</i>	mid Lower <i>F. longus</i>	Upper <i>F. longus</i>	no data	
<i>Gyropollis psilatus</i>	<i>M. lipsis</i>	<i>T. pleistocenicus</i>	(outside recorded period)	
<i>Hakeaidites australis</i>	<i>M. lipsis</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Haloragacidites haloragoides</i>	<i>T. bellus</i>	<i>T. pleistocenicus</i>	(outside recorded period)	
<i>Haloragacidites harrisii</i>	Lower <i>L. balmei</i>	<i>T. pleistocenicus</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Herkosporites elliotii</i>	(<i>Pm</i>) <i>T. apoxyxinus</i>	Upper. <i>L. balmei</i> (<i>L Md</i>)	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>Ilxpollenites</i> spp.	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Integricarpus</i> spp.	Lower <i>L. balmei</i>	Middle <i>M. diversus</i>	Lower <i>M. diversus</i>	Middle <i>M. diversus</i>
<i>Interulobites intraverrucatus</i>	(Albian)	(lower) <i>P. mawsonii</i>	no data	
<i>Intratraporopollenites notabilis</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	lower Lower <i>N. asperus</i>
<i>Ischyosporites gremius</i>	(<i>U Lb</i>) Lower <i>M. diversus</i>	Upper <i>N. asperus</i>	Middle <i>M. diversus</i>	Upper <i>N. asperus</i>

FOSSIL MORPHOSPECIES	GIPPSLAND BASIN (Partridge 1999 #)		BASS BASIN (Partridge 1973*)	
	FAD (ZONE)	LAD (ZONE)	FAD (ZONE) *	LAD (ZONE) *
<i>Jaxtacolpus</i> sp.	Upper <i>F. longus</i>	Upper <i>L. balmei</i>	Upper <i>F. longus</i>	Lower <i>L. balmei</i>
Kuylisporites waterbolkkii	mid Upper <i>M. diversus</i>	<i>C. bifurcatus</i>	(Lb?) Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Latrosporites amplus</i>	<i>T. apoxyxinus</i>	Lower <i>L. balmei</i> (U Lb)	<i>N. senectus</i>	Upper <i>L. balmei</i>
<i>L. marginis</i>	Lower <i>N. asperus</i> ?	<i>M. lipsis</i>		no data
<i>Lewalanipollis senectus</i>		no data		no data
<i>Lygistepollenites balmei</i>	mid <i>T. apoxyxinus</i>	Lower <i>M. diversus</i>	Upper <i>F. longus</i>	Upper <i>L. balmei</i>
<i>Malvacipollis diversus</i>	upper Lower <i>L. balmei</i>	<i>P. asperopolus</i> (L Na)	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>M. subtilis</i>	mid Lower <i>L. balmei</i>	<i>M. lipsis</i>	(L Lb) Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
Matonisporites gigantis	mid Upper <i>L. balmei</i>	mid Lower <i>M. diversus</i>	Upper <i>L. balmei</i>	Lower <i>M. diversus</i>
<i>M. ornamentalis</i>	Upper <i>L. balmei</i>	<i>T. pleistocenicus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Microalattidites palaeogenicus</i>	no data	<i>M. lipsis</i>		no data
<i>Milfordia homeopuncta</i>	(Pa) Lower <i>N. asperus</i>	<i>M. galeatus</i>	(Pa) Lower <i>N. asperus</i>	Upper <i>N. asperus</i> (Pt)
<i>M. hypolaenoides</i>	(Pa) Lower <i>N. asperus</i>	<i>T. pleistocenicus</i>	(Pa) Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
Monotocidites galeatus	<i>M. lipsis</i>	<i>T. pleistocenicus</i>		(outside recorded period)
Myrtaceipollenites australis	Lower <i>M. diversus</i>	Upper <i>M. diversus</i> (Pa)	Lower <i>M. diversus</i>	Upper <i>M. diversus</i> (Pa)
<i>Myrtaceidites eucalyptoides</i>	Lower <i>P. tuberculatus</i>	<i>T. pleistocenicus</i>		no data
M. lipsis	<i>M. lipsis</i>	lower <i>T. pleistocenicus</i>		(outside period of record period)
<i>M. parvus-mesonesus</i>	mid Upper <i>L. balmei</i>	<i>T. pleistocenicus</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
M. tenuis	Upper <i>M. diversus</i>	<i>P. asperopolus</i>	Upper <i>M. diversus</i>	<i>P. asperopolus</i>
<i>M. verrucosus</i>	(U Md) <i>P. asperopolus</i>	<i>T. pleistocenicus</i>	upper Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
Myrtaceipollenites australis	Lower <i>M. diversus</i>	Upper <i>M. diversus</i> (Pa)	Lower <i>M. diversus</i>	Upper <i>M. diversus</i> (Pa)
<i>Nothofagidites asperus</i>	(L Lb) Upper <i>L. balmei</i>	<i>T. pleistocenicus</i>	<i>P. asperopolus</i>	<i>P. tuberculatus</i>
<i>N. brachyspinulosus</i>	(L Fl.) Lower <i>L. balmei</i>	<i>M. lipsis</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
<i>N. deminutus-vansteenisii</i>	Upper <i>M. diversus</i>	<i>C. bifurcatus</i>	Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
N. emarcidus-heterus complex	(L Lb) Upper <i>L. balmei</i>	<i>M. lipsis</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>N. endurus</i>	Upper <i>N. senectus</i>	Upper <i>L. balmei</i>	<i>N. senectus</i>	Upper <i>L. balmei</i>
<i>N. falcatus</i>	Lower <i>N. asperus</i>	<i>M. lipsis</i>	mid Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
N. flemingii	(L Lb) Upper <i>L. balmei</i>	<i>M. lipsis</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
N. goniatus	(L Lb) <i>P. asperopolus</i>	Lower <i>P. tuberculatus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
N. senectus	Lower <i>N. senectus</i>	Upper <i>F. longus</i>	<i>N. senectus</i>	Upper <i>F. longus</i> (L Lb)
<i>Nuxpollenites</i> sp.	Upper <i>N. asperus</i>	<i>T. pleistocenicus</i>		no data
<i>Ophioglossisporites lacunosus</i>	Middle <i>P. tuberculatus</i>	<i>T. pleistocenicus</i>		(outside period of record)
<i>Ornamentifera sentosa</i>	<i>T. apoxyxinus</i>	Upper <i>F. longus</i>	<i>T. lilliei</i>	Lower <i>F. longus</i>
<i>Parvisaccites catastus</i>	Lower <i>L. balmei</i>	Lower <i>P. tuberculatus</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Peninsulapollis gillii</i>	(T apx.) Lower <i>L. balmei</i>	Upper <i>L. balmei</i> (L Md.)	<i>N. senectus</i>	basal Upper <i>M. diversus</i>
<i>P. truswelliae</i>		no data		no data
<i>Periporopollenites demarcatus</i>	Upper <i>F. longus</i>	Lower <i>T. bellus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>P. vesicus</i>	Lower <i>N. asperus</i>	Lower <i>T. bellus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. polyoratus</i>	<i>T. lilliei</i>	<i>P. tuberculatus</i>	Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>Peromonolites densus</i>	Lower <i>F. longus</i>	<i>T. bellus</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
<i>P. vellosus</i>	Upper <i>F. longus</i>	<i>T. bellus</i>	mid Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Phyllocladidites mawsonii</i>	<i>P. mawsonii</i>	<i>T. pleistocenicus</i>	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>P. reticulosaccatus</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>	<i>T. lilliei</i>	basal Upper <i>L. balmei</i>
<i>P. verrucosus</i>	Upper? <i>N. senectus</i>	Upper <i>L. balmei</i>	<i>N. senectus</i>	Upper <i>L. balmei</i>
<i>Podosporites erugatus</i>		no data		no data
Polycolpites langstonii	mid Lower <i>L. balmei</i>	Upper <i>L. balmei</i>	(mid) Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
Polycolporopollenites esobalteus	(mid) Lower <i>M. diversus</i>	<i>T. bellus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
P. tumulatus	<i>T. bellus</i>	<i>M. lipsis</i>		no data
<i>P. varus</i> ms	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
P. tumulatus	<i>T. bellus</i>	<i>M. lipsis</i>		no data
Polyporina granulata	<i>M. lipsis</i>	<i>T. pleistocenicus</i>		no data
Propylipollis annularis	(L Lb) Upper <i>L. balmei</i>	mid Lower <i>M. diversus</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Propylipollis crotonoides</i>	Lower <i>N. senectus</i>	Upper <i>F. longus</i>	Lower <i>F. longus</i>	Lower <i>F. longus</i>
<i>Proteacidites adenanthoides</i> complex	mid Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>
<i>P. alveolatus</i> complex	Middle <i>M. diversus</i>	Lower <i>N. asperus</i>	Middle <i>M. diversus</i>	Lower <i>N. asperus</i>
<i>P. amolosexinus</i>	Lower <i>N. senectus</i>	<i>T. lilliei</i>	<i>N. senectus</i>	basal Lower <i>L. balmei</i>
P. angulatus	(L Fl) Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	Lower <i>F. longus</i>	Lower <i>L. balmei</i>
P. asperopolus	<i>P. asperopolus</i>	Lower <i>N. asperus</i>	<i>P. asperopolus</i>	basal Middle <i>N. asperus</i>
<i>P. confragosus</i>	(vars. In Late Cretaceous)	Middle <i>N. asperus</i>		no data
<i>P. crassus</i> complex	(vars. In Late Cretaceous)	Middle <i>N. asperus</i>	Upper <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>P. differentipolis</i>	Lower <i>M. diversus</i>	Lower <i>N. asperus</i>	Lower <i>M. diversus</i>	Lower <i>N. asperus</i>
P. grandis	Upper <i>L. balmei</i>	<i>P. asperopolus</i>	Upper <i>L. balmei</i>	Lower <i>N. asperus</i>
P. incurvatus	Upper <i>L. balmei</i>	<i>P. asperopolus</i>	Upper <i>L. balmei</i>	Middle <i>N. asperus</i>
P. kopiensis	Middle <i>M. diversus</i>	lower Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	lower Middle <i>N. asperus</i>
<i>P. latrobensis</i>	(L Md) Middle <i>M. diversus</i>	Middle <i>N. asperus</i> (U Na)	Upper <i>M. diversus</i>	basal Middle <i>N. asperus</i>
P. leightonii	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
P. nasus	Middle <i>M. diversus</i>	Lower <i>N. asperus</i> (M Na)	Upper <i>M. diversus</i>	<i>P. asperopolus</i>

FOSSIL MORPHOSPECIES	GIPPSLAND BASIN (Partridge 1999 #)		BASS BASIN (Partridge 1973*)	
	FAD (ZONE)	LAD (ZONE)	FAD (ZONE) *	LAD (ZONE) *
<i>P. pachypolus</i>	Lower <i>M. diversus</i>	Lower <i>N. asperus</i> (<i>M. Na</i>)	Upper <i>M. diversus</i>	Upper <i>N. asperus</i>
<i>P. recavus</i>	mid <i>P. asperopolus</i>	Lower <i>N. asperus</i>	(<i>Pa</i>) Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>P. rectomarginis</i>	mid Middle <i>N. asperus</i>	Upper <i>P. tuberculatus</i>	Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. reflexus</i>	Lower <i>N. asperus</i>	Lower <i>N. asperus</i>	mid Lower <i>N. asperus</i>	Lower <i>N. asperus</i>
<i>P. reticulatus</i>	upper Lower <i>N. asperus</i>	Middle <i>N. asperus</i>	upper Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>P. reticuloconcavus</i> ms	Lower <i>F. longus</i>	Upper <i>F. longus</i>	Lower <i>F. longus</i>	lower Upper <i>F. longus</i>
<i>P. reticuloscabratus</i>	(<i>FP?</i>) Lower? <i>L. balmei</i>	Upper <i>N. asperus</i>	Upper <i>L. balmei</i>	basal Upper <i>N. asperus</i>
<i>P. rugulatus</i>	not recorded?		mid <i>P. asperopolus</i>	lower Middle <i>N. asperus</i>
<i>Proteacidites stipplatus</i>	(late) Middle <i>N. asperus</i>	Middle <i>P. tuberculatus</i>	mid Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. symphonemoides</i>	<i>T. bellus</i>	<i>M. lipsis</i>	(outside period of record)	
<i>Proteacidites tenuixinus</i>	Upper <i>L. balmei?</i>	Lower <i>N. asperus</i>	<i>N. senectus</i>	Upper <i>N. asperus</i>
<i>P. tuberculatus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	(mid) <i>T. bellus</i>	Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. tuberculiformis</i>	Middle <i>M. diversus</i>	(early) Lower <i>N. asperus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>
<i>Proxapertites operculatus</i>	not recorded		no data	
<i>Pseudowinterapollis cranwellae</i>	<i>T. lilliei</i>	Middle <i>N. asperus</i>	<i>T. lilliei</i>	Upper <i>N. asperus</i>
<i>P. wahoensis</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>	Upper <i>Forcipites longus</i>	Lower <i>L. balmei</i>
<i>P. sp. A (thomy)</i>	no data		no data	
<i>Psilastephanocolporites micus</i>	Upper <i>P. tuberculatus</i>	<i>M. lipsis</i>	(outside period of record)	
<i>Quadraplans brossus</i>	Lower <i>F. longus</i>	Upper <i>F. longus</i>	Lower <i>F. longus</i>	Upper <i>F. longus</i>
<i>Rhoipites ampereaformis</i>	<i>M. lipsis</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Rosannia</i> (al. <i>Lactipollis</i>) <i>manika</i>	undiff. <i>F. longus</i>	undiff. <i>M. diversus</i>	no data	
<i>Rudolphisporis rudolphi</i>	upper <i>C. bifurcatus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Rugulatisporites cowrensis</i>	<i>T. bellus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>R. mallatus</i>	(<i>U Fl</i>) Lower <i>L. balmei</i>	<i>T. bellus</i>	mid Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>R. trophus</i>	Lower <i>N. asperus</i>	<i>T. bellus</i>	Lower <i>N. asperus</i>	Middle <i>N. asperus</i> (<i>Pt</i>)
<i>Santalumidites cainozoicus</i>	mid Upper <i>M. diversus</i>	Middle <i>N. asperus</i>	upper Upper <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Sapotaceoidapollenites rotundus</i>	<i>P. asperopolus</i>	Upper <i>N. asperus</i> (<i>Tb</i>)	mid <i>P. asperopolus</i>	<i>P. tuberculatus</i>
<i>Spinizonocolpites prominatus</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>
<i>Stephanocolpites oblatum</i>	Upper <i>N. asperus</i>	<i>T. pleistocenicus</i>	no data	
<i>Stereisporites regium</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>Stereisporites maastrichtiensis</i>	Upper <i>Forcipites longus</i>	Lower <i>P. tuberculatus</i>	Upper <i>F. longus</i>	lower <i>P. tuberculatus</i>
<i>Stereisporites regium</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>Stereisporites sp. A (this paper)</i>	no data		no data	
<i>Symplocoipollenites austellus</i>	<i>T. bellus</i>	<i>M. lipsis</i>	(outside period of record)	
<i>Tetracolporites multistrixis</i> ms	(<i>U Fl</i>) Lower <i>L. balmei</i>	<i>P. asperopolus</i> (<i>L Na</i>)	Lower <i>L. balmei</i>	Upper <i>L. balmei</i> (<i>L Md</i>)
<i>T. textus</i> ms	Upper <i>L. balmei</i>	Upper <i>L. balmei?</i>	Upper <i>L. balmei?</i>	Upper <i>L. balmei?</i>
<i>T. verrucosus</i>	Lower <i>F. longus</i>	Lower <i>L. balmei</i> (<i>U Lb</i>)	Upper <i>F. longus</i>	Upper <i>L. balmei</i>
<i>Tetradopollis securus</i> ms	Upper <i>F. longus</i>	Lower <i>L. balmei</i>	Upper <i>F. longus</i>	Lower <i>L. balmei</i>
<i>Thymelopollis</i> sp.	<i>T. pleistocenicus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Tricolpites asperus</i>	no data		no data	
<i>T. confessus</i>	<i>T. apoxyxinus</i>	Upper <i>F. longus</i>	<i>N. senectus</i>	Upper <i>F. longus</i>
<i>T. phillipsii</i>	Lower <i>L. balmei</i>	Lower <i>M. diversus</i> (<i>U Md</i>)	Lower <i>L. balmei</i>	Lower <i>N. asperus</i> (<i>U Na</i>)
<i>T. simatus</i>	Lower <i>N. asperus</i>	Lower <i>P. tuberculatus</i>	Lower <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>T. thomasii</i>	upper Lower <i>N. asperus</i>	Middle <i>N. asperus</i>	mid Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>T. waiparaensis</i>	<i>T. lilliei</i>	Upper <i>F. longus</i> (<i>L Lb</i>)	Upper <i>F. longus</i>	Upper <i>F. longus</i>
<i>T. sp A (this paper)</i>	not recorded		not recorded	
<i>Tricolporites adelaidensis</i>	(<i>U Lb</i>) Lower <i>M. diversus</i>	<i>T. bellus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>T. (al. Tensucolpites) lilliei</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>T. leuros</i>	Lower <i>N. asperus</i>	mid <i>T. bellus</i>	mid <i>P. asperopolus</i>	Upper <i>N. asperus</i> (<i>Pt</i>)
<i>T. sp. A (this paper)</i>	not recorded		not recorded	
<i>Triorites magnificus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>Triporetetes reticulatus</i>				
<i>Triporepollenites ambiguus</i>	(<i>L Md</i>) Middle <i>M. diversus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>T. (Canthiumidites) bellus</i>	<i>T. bellus</i>	<i>M. lipsis</i> (<i>Tp</i>)	(outside period of record)	
<i>Tubulifloridites antipoda/simplis</i>	<i>T. bellus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>T. pleistocenicus</i>	(<i>M. lip</i>) <i>T. pleistocenicus</i>	<i>T. pleistocenicus</i>	(outside period of record)	
<i>Verrucatosporites attinatus</i>	Middle <i>N. asperus</i>	<i>M. lipsis</i>	(<i>L Na</i>) Middle <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>Verrucosisporites cristatus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	<i>T. bellus</i>	(<i>M Na</i>) Upper <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Verrucosisporites kopukuensis</i>	mid Lower <i>L. balmei</i>	<i>M. lipsis</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>

APPENDIX 2

Comparison of age range in the Bass Basin and Tamar Graben drillholes for morphospecies recorded in the *N. senectus* to *Proteacidites tuberculatus* Zone (Bass Basin) and *Forcipites longus* Zone to Upper *Nothofagidites asperus* Zone in the Tamar Graben).

Morphospecies with significantly different FADs or LADs are shaded. Zone index and zone accessory morphospecies are in bold type; caved and reworked specimens are indicated by 'C' and 'R' respectively.

FOSSIL MORPHOSPECIES	TAMAR GRABEN (this paper)		BASS BASIN (Partridge 1973)	
	Lowest record	Highest record	FAD *	LAD *
<i>Aequitriradites spinulosus</i>	Not recorded		<i>F. longus</i>	<i>F. longus</i>
<i>Aglaoreidia qualumis</i>	<i>P. asperopolus</i>	Upper <i>N. asperus</i>	Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Ailanthipites paenestriatus</i>	Upper <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Anacolosidites acutullus</i>	<i>P. asperopolus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>A. luteoides</i>	undiff. <i>M. diversus</i> Zone		Middle <i>M. diversus</i>	Lower <i>N. asperus</i>
<i>A. sectus</i>	Not recorded		Middle <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>Australopollis obscurus</i>	<i>F. longus</i>	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
<i>Banksiaeisites arcuatus</i>	Early to Mid. <i>M. diversus</i>	Upper <i>M. diversus</i>	Middle <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>B. elongatus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Battenipollis sabriniae</i>	<i>F. longus</i>	<i>F. longus</i>	no data	
<i>B. sectilis</i>	<i>F. longus</i>	<i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>Beaupreaidites elegansiformis</i>	Early <i>M. diversus</i>	Upper <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>B. orbiculatus</i>	Lower <i>L. balmei</i>	Upper <i>N. asperus</i> (R)	Upper <i>F. longus</i>	Lower <i>L. balmei</i> ?
<i>B. verrucosus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Bluffopollis scabratus</i>	not recorded		Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Camazonosporites bullatus</i>	not recorded		Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
<i>Camazonosporites eyrensis</i> ms	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	no data	
<i>Clavastephanocolporites meleosus</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	(basal) Lower <i>N. asperus</i>
<i>Clavatipollenites glarius</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	no data	
<i>Clavifera triplex</i>	Upper <i>L. balmei</i>	Middle <i>N. asperus</i>	no data	
<i>Conbaculites apiculatus</i> ms	<i>P. asperopolus</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	basal Middle <i>N. asperus</i>
<i>Cranwellipollis palisadus</i>	<i>F. longus</i>	<i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>Crassiretiriletes vanraadshoovenii</i>	not recorded (Lower <i>M. diversus</i> Zone West Coast)		Lower <i>M. diversus</i>	Upper <i>N. asperus</i>
<i>Cupanieidites orthoteichus</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Cyatheacidites annulatus</i>	not recorded (Lower <i>P. tuberculatus</i> NW Tas.)		<i>P. tuberculatus</i>	<i>P. tuberculatus</i>
<i>Cyathidites splendens</i>	<i>F. longus</i>	Upper <i>M. diversus</i>	Lower <i>F. longus</i>	basal Upper <i>N. asperus</i>
<i>Cyathidites subtilis</i>	undiff. <i>N. asperus</i> Zone		no data	
<i>Dacrycarpites australiensis</i>	<i>F. longus</i>	Upper <i>N. asperus</i>	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>Dacrydiumites florinii</i>	<i>F. longus</i>	Upper <i>N. asperus</i>	Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>Dicotetradites clavatus</i>	<i>F. longus</i>	Upper <i>N. asperus</i>	<i>T. lilliei</i>	Middle <i>N. asperus</i>
<i>Dicolpopollis</i> spp.	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	no data	
<i>Dilwynites granulatus</i>	<i>F. longus</i>	Middle <i>N. asperus</i>	<i>N. senectus</i> ?	<i>P. tuberculatus</i>
<i>D. tuberculatus</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	<i>T. lilliei</i>	<i>P. tuberculatus</i>
<i>Dryadopollis retequetrus</i>	not recorded		no data	
<i>Dryptollenites semilunatus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	(basal) Upper <i>N. asperus</i>
<i>Echimonocolpites</i> sp.	<i>F. longus</i>	<i>F. longus</i>	no data	
<i>Ephredipites notensis</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>	Lower <i>F. longus</i>	Middle <i>N. asperus</i>
<i>Forcipites longus</i>	<i>F. longus</i>	<i>F. longus</i>	Lower <i>F. longus</i>	Upper <i>F. longus</i>
<i>Forcipites sabulosus</i>	<i>F. longus</i>	<i>F. longus</i>	<i>N. senectus</i>	(basal) Upper <i>F. longus</i>
<i>Foveotrilletes balteus</i>	undiff. <i>N. asperus</i> Zone		Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>F. crater</i>	not recorded		(M Na) Upper <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>F. palaequetrus</i>	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>G. edwardsii</i>	<i>F. longus</i>	Upper <i>L. balmei</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>G. rudata</i>	<i>F. longus</i>	<i>P. asperopolus</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>Gothanipollis bassensis</i>	undiff. <i>N. asperus</i> Zone		Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Granodiporites nebulosus</i>	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	(M Na) Upper <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>Haloragacidites harrisii</i>	Lower <i>L. balmei</i>	Upper <i>N. asperus</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Herkosporites elliotii</i>	<i>F. longus</i>	<i>P. asperopolus</i>	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>Ilexpollenites</i> spp.	<i>F. longus</i>	Upper <i>N. asperus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Integricorpus</i> spp.	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	Lower <i>M. diversus</i>	Middle <i>M. diversus</i>
<i>Interulobites intraverrucatus</i>	<i>F. longus</i> (R)	<i>F. longus</i> (R)	no data	
<i>Intratrirporopollenites notabilis</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	lower Lower <i>N. asperus</i>
<i>Ischyosporites gremius</i>	not recorded		Middle <i>M. diversus</i>	Upper <i>N. asperus</i>
<i>Jaxtacolpus</i> sp.	<i>F. longus</i>	<i>F. longus</i>	Upper <i>F. longus</i>	Lower <i>L. balmei</i>
<i>Kuylisporites waterbolkkii</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	(Lb?) Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Latrobosporites amplus</i>	<i>F. longus</i>	Upper <i>L. balmei</i>	<i>N. senectus</i>	Upper <i>L. balmei</i>
<i>L. marginis</i>	Lower <i>N. asperus</i>	Middle <i>N. asperus</i>	no data	
<i>Lewalanipollis senectus</i>	<i>F. longus</i> (R?)	<i>F. longus</i> (R?)	no data	
<i>Lygistepollenites balmei</i>	<i>F. longus</i>	Upper <i>L. balmei</i>	Upper <i>F. longus</i>	Upper <i>L. balmei</i>

FOSSIL MORPHOSPECIES	TAMAR GRABEN (this paper)		BASS BASIN (Partridge 1973)	
	Lowest record	Highest record	FAD (ZONE) *	LAD (ZONE) *
<i>Malvacipollis diversus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>M. subtilis</i>	Upper <i>L. balmei</i>	Middle <i>N. asperus</i>	(L Lb) Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
Matonisporites gigantis	not recorded		Upper <i>L. balmei</i>	Lower <i>M. diversus</i>
<i>M. ornamentalis</i>	Lower <i>N. asperus</i>	Middle <i>N. asperus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Microalaidites palaeogenicus</i>	<i>F. longus</i>	Middle <i>N. asperus</i>	no data	
<i>Milfordia homeopuncta</i>	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	(Pa) Lower <i>N. asperus</i>	Upper <i>N. asperus</i> (Pt)
<i>M. hypolaenoides</i>	Lower <i>N. asperus</i>	Middle <i>N. asperus</i>	(Pa) Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
Myrtaceipollenites australis	Not recorded (Lower <i>M. diversus</i> Zone West Coast)		Lower <i>M. diversus</i>	Upper <i>M. diversus</i> (Pa)
<i>Myrtaceidites parvus-mesonesus</i>	Middle <i>M. diversus</i>	Undiff. <i>N. asperus</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
M. tenuis	Upper <i>M. diversus</i>	Upper <i>M. diversus</i>	Upper <i>M. diversus</i>	<i>P. asperopolus</i>
<i>M. verrucosus</i>	undiff. <i>N. asperus</i> Zone		upper Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>Nothofagidites asperus</i>	Lower <i>L. balmei</i>	Upper <i>N. asperus</i>	<i>P. asperopolus</i>	<i>P. tuberculatus</i>
<i>N. brachyspinulosus</i>	<i>F. longus</i>	Upper <i>N. asperus</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
<i>N. deminutus-vansteenisii</i>	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	Upper <i>M. diversus</i>	<i>P. tuberculatus</i>
N. emarcidus-heterus complex	Lower <i>L. balmei</i>	Upper <i>N. asperus</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>N. endurus</i>	<i>F. longus</i>	Upper <i>L. balmei</i>	<i>N. senectus</i>	Upper <i>F. longus</i> (<i>L. balmei</i>)
<i>N. falcatus</i>	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	mid Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
N. flemingii	<i>F. longus</i>	Upper <i>N. asperus</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
N. goniatus	Undiff. <i>L. balmei</i> (R)	Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
N. senectus	<i>F. longus</i>	<i>F. longus</i>	<i>N. senectus</i>	Upper <i>F. longus</i> (<i>L. balmei</i>)
<i>Ornamentifera sentosa</i>	not recorded		<i>T. lilliei</i>	Lower <i>F. longus</i>
<i>Parvisaccites catastus</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Peninsulapollis gillii</i>	<i>N. senectus</i>	basal Upper <i>M. diversus</i>	<i>F. longus</i> (C?)	Middle <i>N. asperus</i> (R)
<i>Periporipollenites demarcatus</i>	<i>F. longus</i>	Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>P. vesicus</i>	<i>P. asperopolus</i>	Upper <i>N. asperus</i>	Lower <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. polyoratus</i>	<i>F. longus</i>	Middle <i>N. asperus</i>	Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>Peromonolites densus</i>	Lower <i>L. balmei</i>	Upper <i>N. asperus</i>	Lower <i>F. longus</i>	<i>P. tuberculatus</i>
<i>P. vellosus</i>	<i>P. vellosus</i>	<i>P. vellosus</i>	mid Lower <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Phyllocladites mawsonii</i>	<i>F. longus</i>	Upper <i>N. asperus</i>	<i>N. senectus</i>	<i>P. tuberculatus</i>
<i>P. reticulosaccatus</i>	<i>F. longus</i>	Upper <i>N. asperus</i> (R?)	<i>T. lilliei</i>	basal Upper <i>L. balmei</i>
<i>P. verrucosus</i>	<i>F. longus</i>	<i>F. longus</i>	<i>N. senectus</i>	Upper <i>L. balmei</i>
<i>Podosporites erugatus</i>	Middle <i>N. asperus</i>	Upper <i>N. asperus</i>	no data	
Polycopites langstonii	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	(mid) Lower <i>L. balmei</i>	Upper <i>L. balmei</i>
Polycoporipollenites esobalteus	Upper <i>M. diversus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>P. varus</i> ms	not recorded (Lower <i>M. diversus</i> Zone West Coast)		Lower <i>M. diversus</i>	Middle <i>N. asperus</i>
Propylipollis annularis	Upper <i>L. balmei</i>	Upper <i>N. asperus</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>
<i>Propylipollis crotonoides</i>	<i>F. longus</i>	<i>F. longus</i>	Lower <i>F. longus</i>	Lower <i>F. longus</i>
<i>Proteacidites adenanthoides</i> complex	<i>F. longus</i>	Middle <i>N. asperus</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>
<i>P. alveolatus</i> complex	<i>P. asperopolus</i>	Middle <i>N. asperus</i>	Middle <i>M. diversus</i>	Lower <i>N. asperus</i>
<i>P. amoloxinus</i>	<i>F. longus</i>	<i>F. longus</i>	<i>N. senectus</i>	basal Lower <i>L. balmei</i>
P. angulatus	Lower <i>L. balmei</i>	Upper <i>L. balmei</i>	Lower <i>F. longus</i>	Lower <i>L. balmei</i>
P. asperopolus	<i>P. asperopolus</i>	<i>P. asperopolus</i>	<i>P. asperopolus</i>	basal Middle <i>N. asperus</i>
<i>P. cooksoniae</i>	<i>F. longus</i> (R?)	<i>F. longus</i> (R?)	no data	
<i>P. crassus</i> complex	<i>F. longus</i>	Middle <i>N. asperus</i>	Upper <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>P. differentipolis</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	Lower <i>N. asperus</i>
P. grandis	Lower <i>M. diversus</i>	Middle <i>N. asperus</i> (R?)	Upper <i>L. balmei</i>	Lower <i>N. asperus</i>
P. incurvatus	Upper <i>L. balmei</i>	Middle <i>N. asperus</i>	Upper <i>L. balmei</i>	Middle <i>N. asperus</i>
P. kopiensis	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>	Lower <i>M. diversus</i>	lower Middle <i>N. asperus</i>
<i>P. latrobensis</i>	Middle <i>M. diversus</i>	Upper <i>M. diversus</i>	Upper <i>M. diversus</i>	basal Middle <i>N. asperus</i>
P. leightonii	Upper <i>M. diversus</i>	<i>P. asperopolus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
P. nasus	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>	Upper <i>M. diversus</i>	<i>P. asperopolus</i>
P. obscurus	<i>P. asperopolus</i>	<i>P. asperopolus</i>	Lower <i>M. diversus</i>	<i>T. bellus</i>
P. ornatus	<i>P. asperopolus</i>	<i>P. asperopolus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>
P. pachypolus	Lower <i>M. diversus</i>	<i>P. asperopolus</i>	Upper <i>M. diversus</i>	Upper <i>N. asperus</i>
P. recavus	Middle <i>M. diversus</i>	<i>P. asperopolus</i>	(Pa) Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
P. rectomarginis	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>P. reflexus</i>	not recorded		mid Lower <i>N. asperus</i>	Lower <i>N. asperus</i>
<i>P. reticulatus</i>	Upper <i>M. diversus</i>	Upper <i>M. diversus</i>	upper Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
P. reticuloconcavus ms	not recorded		Lower <i>F. longus</i>	lower Upper <i>F. longus</i>
<i>P. reticulosabratus</i>	Lower <i>L. balmei</i>	Undiff. <i>M. diversus</i>	Upper <i>L. balmei</i>	basal Upper <i>N. asperus</i>
<i>P. rugulatus</i>	Not recorded		mid <i>P. asperopolus</i>	lower Middle <i>N. asperus</i>
Proteacidites stipplatus	Upper <i>N. asperus</i>	Upper <i>N. asperus</i>	mid Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Proteacidites tenuiximus</i>	Lower <i>L. balmei</i>	Undiff. <i>M. diversus</i>	<i>N. senectus</i>	Upper <i>N. asperus</i>
P. tuberculatus	not recorded		Middle <i>N. asperus</i>	<i>P. tuberculatus</i>
P. tuberculiformis	undiff. <i>M. diversus</i>	<i>P. asperopolus</i>	Middle <i>M. diversus</i>	<i>P. asperopolus</i>

FOSSIL MORPHOSPECIES	TAMAR GRABEN (this paper)		BASS BASIN (Partridge 1973)	
	Lowest record	Highest record	FAD (ZONE) *	LAD (ZONE) *
<i>Proxaperites operculatus</i>	Undiff. <i>M. diversus</i>	<i>P. asperopolus</i>	no data	
<i>Pseudowinterpollis cranwellae</i>	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	<i>T. lilliei</i>	Upper <i>N. asperus</i>
<i>P. wahoensis</i>	not recorded		Upper <i>Forcipites longus</i>	Lower <i>L. balmei</i>
<i>P. sp. A (thorny)</i>	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	no data	
<i>Quadruplanus brossus</i>	not recorded		Lower <i>F. longus</i>	Upper <i>F. longus</i>
<i>Rosannia</i> (al. <i>Lactipollis</i>) <i>manika</i>	<i>F. longus</i>	<i>F. longus</i>	no data	
<i>Rugulatisporites mallatus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	mid Upper <i>F. longus</i>	<i>P. tuberculatus</i>
<i>R. trophus</i>	not recorded		Lower <i>N. asperus</i>	Middle <i>N. asperus</i> (Pt)
<i>Santalumidites cainozoicus</i>	Upper <i>M. diversus</i>	Upper <i>M. diversus</i>	upper Upper <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>Sapotaceoidaepollenites rotundus</i>	not recorded		mid <i>P. asperopolus</i>	<i>P. tuberculatus</i>
<i>Spinizonocolpites prominatus</i>	not recorded		Lower <i>M. diversus</i>	<i>P. asperopolus</i>
<i>Stereisporites regium</i>	<i>F. longus</i>	Lower <i>L. balmei</i>	<i>T. lilliei</i>	Upper <i>L. balmei</i>
<i>Stereisporites</i> sp. A (this paper)	<i>F. longus</i>	<i>F. longus</i>	no data	
<i>Stereisporites maastrichtiensis</i>	Lower <i>L. balmei</i>	Middle <i>N. asperus</i>	Upper <i>F. longus</i>	lower <i>P. tuberculatus</i>
<i>Tetracolpites multistrixis</i> ms	Lower <i>L. balmei</i>	Middle <i>N. asperus</i> (R)	Lower <i>L. balmei</i>	Upper <i>L. balmei</i> (L Md)
<i>T. textus</i> ms	Upper <i>L. balmei</i>	Upper <i>L. balmei</i>	Upper <i>L. balmei</i> ?	Upper <i>L. balmei</i> ?
<i>T. verrucosus</i>	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	Upper <i>F. longus</i>	Upper <i>L. balmei</i>
<i>Tetradopollis securus</i> ms	not recorded		Upper <i>F. longus</i>	Lower <i>L. balmei</i>
<i>Tricolpites asperus</i>	Lower <i>L. balmei</i>	Lower <i>L. balmei</i>	no data	
<i>T. confessus</i>	not recorded		<i>N. senectus</i>	Upper <i>F. longus</i>
<i>T. phillipsii</i>	Lower <i>L. balmei</i>	<i>P. asperopolus</i>	Lower <i>L. balmei</i>	Lower <i>N. asperus</i> (U Na)
<i>T. simatus</i>	undiff. <i>N. asperus</i> Zone		Lower <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>T. thomasii</i>	not recorded		mid Lower <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>T. waiparaensis</i>	<i>F. longus</i>	<i>F. longus</i>	Upper <i>F. longus</i>	Upper <i>F. longus</i>
<i>T. sp A</i> (this paper)	<i>F. longus</i>	Lower <i>L. balmei</i>		
<i>Tricolpites adelaidensis</i>	Lower <i>L. balmei</i> (R)	Upper <i>N. asperus</i>	Lower <i>M. diversus</i>	<i>P. tuberculatus</i>
<i>T. (al. Tensucolpites) lilliei</i>	<i>F. longus</i>	<i>F. longus</i>	<i>T. lilliei</i>	Upper <i>F. longus</i>
<i>T. leuros</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	mid <i>P. asperopolus</i>	Upper <i>N. asperus</i> (Pt)
<i>T. sp. A</i> (this paper)	<i>F. longus</i>	Lower <i>L. balmei</i>	not recorded	
<i>Triorites magnificus</i>	not recorded		Middle <i>N. asperus</i>	Middle <i>N. asperus</i>
<i>Tripoporipollenites ambiguus</i>	Early-Middle <i>M. diversus</i>	<i>P. asperopolus</i>	Middle <i>M. diversus</i>	Middle <i>N. asperus</i>
<i>T. (Canthiumidites) bellus</i>	<i>P. asperopolus</i> Zone (C)		(outside period of record)	
<i>Verrucatosporites attinatus</i>	Middle <i>N. asperus</i>	Middle <i>N. asperus</i>	(L Na) Middle <i>N. asperus</i>	Upper <i>N. asperus</i>
<i>Verrucosiporites cristatus</i>	<i>P. tuberculatus</i> Zone (NE Tasmania)		(M Na) Upper <i>N. asperus</i>	<i>P. tuberculatus</i>
<i>Verrucosiporites kopukuensis</i>	<i>P. asperopolus</i>	Middle <i>N. asperus</i>	Upper <i>L. balmei</i>	<i>P. tuberculatus</i>

APPENDIX 3

Commonly occurring and rare or previously unrecorded pollen and spore morphotypes.

[Included to show the diversity of plants represented by fossil pollen or spores and provide a *de facto* 'pollen atlas' for future work.]

A. FIGS 1–12: CRYPTOGAM SPORES

1. *Aequitriradites spinulosus* [Late Cretaceous]
2. *Gleicheniidites ancorus* ms [Late Cretaceous]
3. *Gleicheniidites bulbosus* ms [Mesozoic]
4. *Gleicheniidites apiculatus* ms [Mesozoic–Cenozoic?]
5. *Foveogleicheniidites* sp. [Mesozoic]
6. *Selagosporis* [Mesozoic–Cenozoic?]
7. unidentified spore ornamented with three proximal verrucae [Cenozoic?]
8. *Peromonolites baculatus* ms [Mesozoic–Cenozoic]
9. *Nevesisporites lacunosus* [Mesozoic]
10. *Peromonolites linearis* [Mesozoic]
11. *Evansispora?* sp. [Mesozoic]
12. *Verrucatosporites* sp. [Cenozoic]

B. FIGS. 13–31: GYMNOSPERM POLLEN

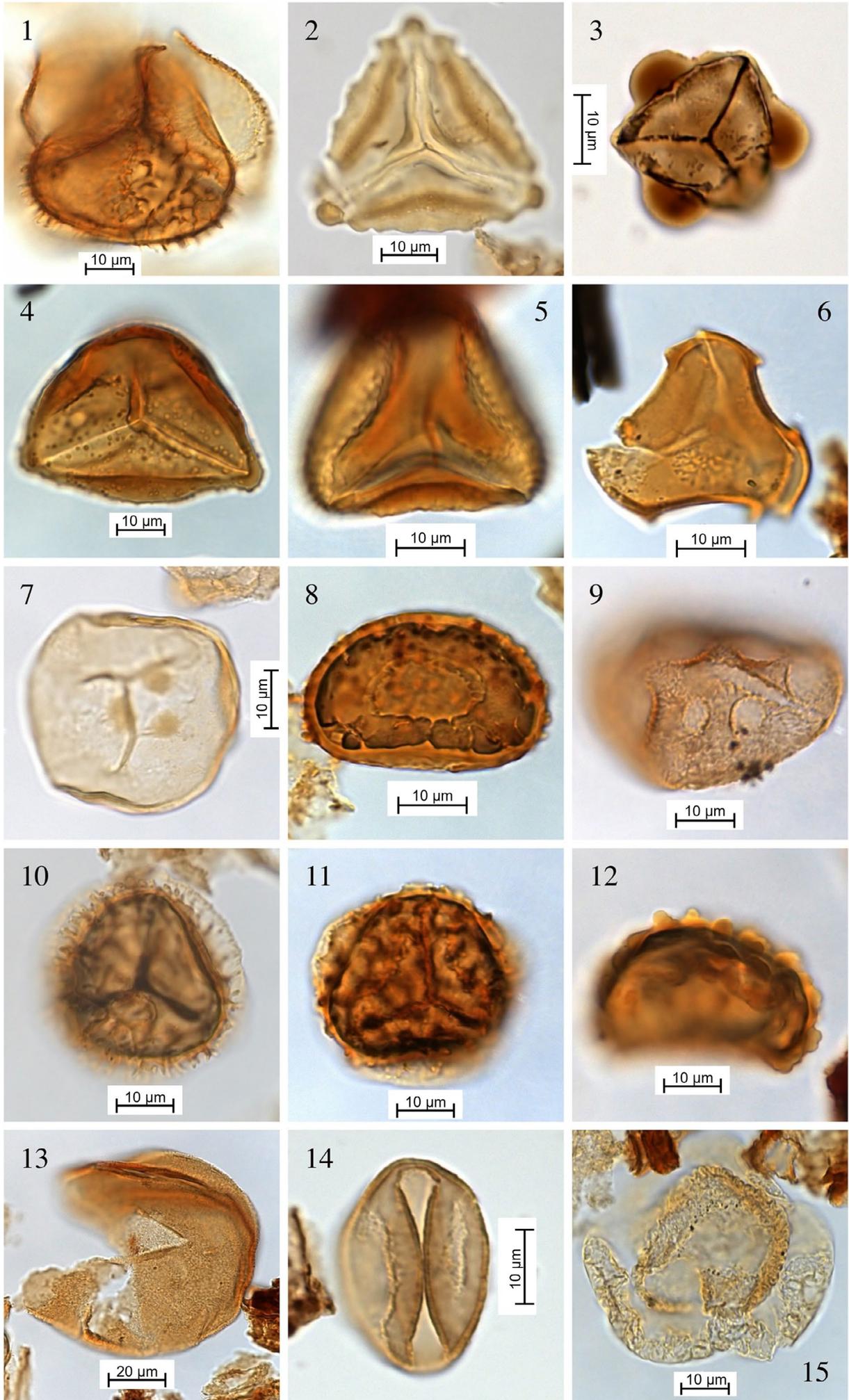
13. *Araucariacites australis* [Mesozoic–Cenozoic]
14. *Cycadopites* sp. [Mesozoic–Cenozoic]
15. *Dacrycarpidites australiensis* [Late Cretaceous–Cenozoic]
16. *Dilwynites granulatus* [Late Cretaceous–Cenozoic]
17. *Dilwynites* cf. *D. pusillus* ms [Late Cretaceous]
18. *Dilwynites tuberculatus* [Cenozoic]
19. *Parvisaccites catastus* [Cenozoic]
- 20-21. *Phyllocladidites mawsonii* vars. [Late Cretaceous–Cenozoic]
- 22-23. *Podocarpidites* sp. cf. *P. ellipticus* [Late Cretaceous–Cenozoic]
- 24-25. *Podocarpidites* aff. *P. torquatus* [Cenozoic]
26. *Ephredipites notenis* [Mesozoic–Cenozoic]
27. *Microalatidites palaeogenicus* [Late Cretaceous–Cenozoic]
28. *Microcachryidites antarcticus* [Mesozoic–Cenozoic]
- 29-30. *Podosporites parvus-microsaccatus* complex [Cretaceous–Cenozoic]
31. *Trichotomosulcites subgranulosus* [Cretaceous–Cenozoic]

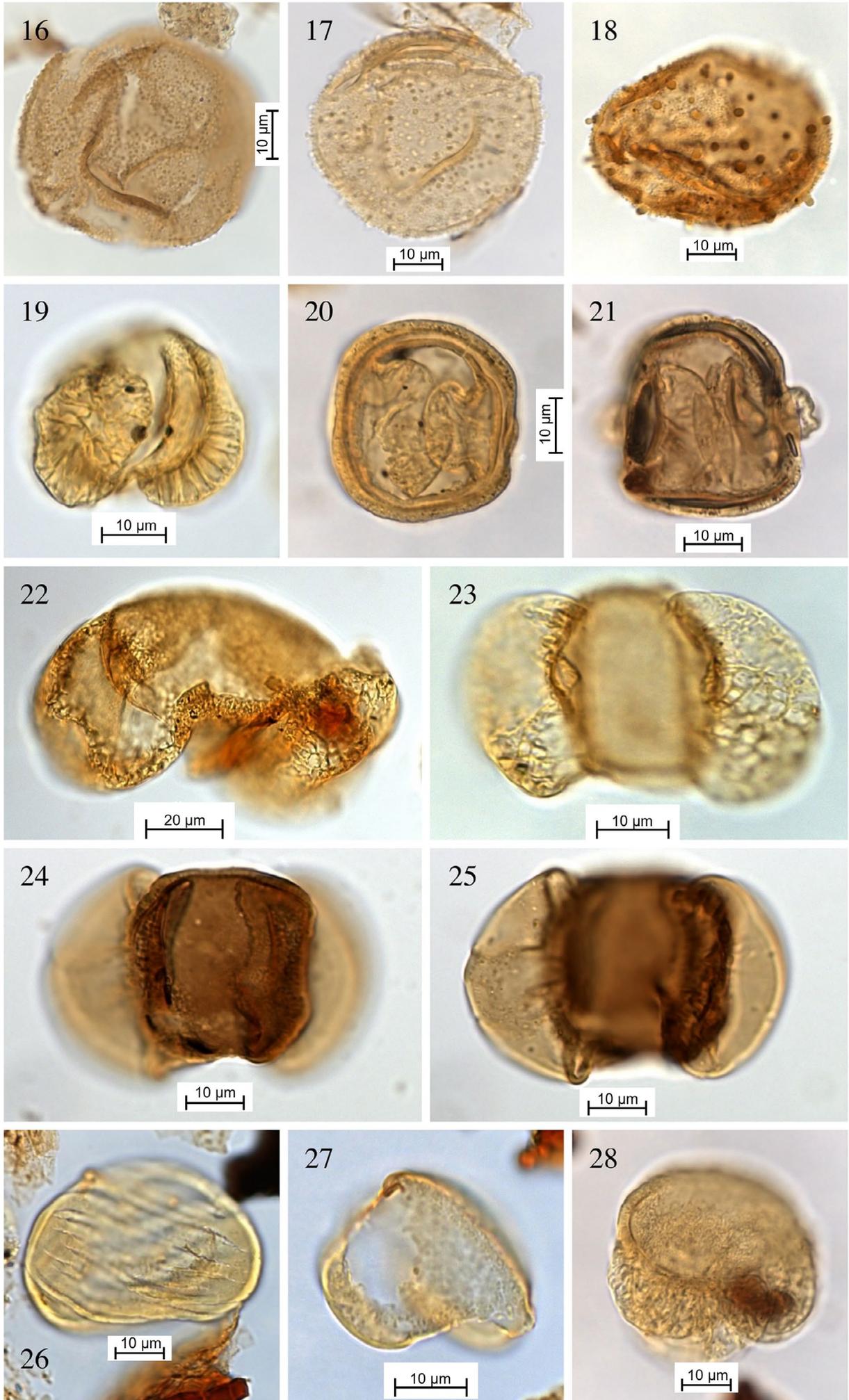
C. FIGS. 32–125: ANGIOSPERM POLLEN

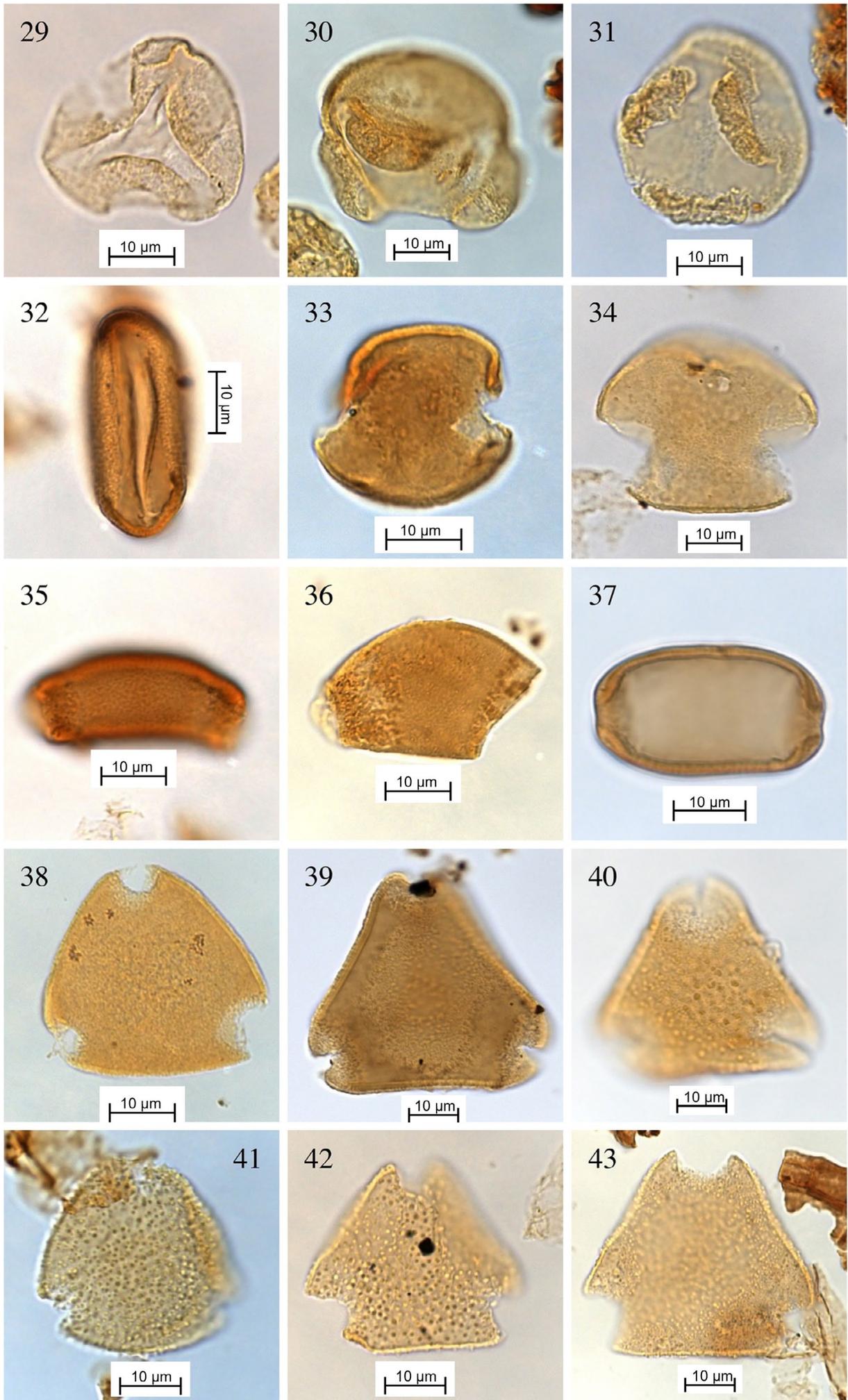
32. *Arecipites* sp. [Cenozoic]
- 33-34. *Dicolpopollis* spp. [Late Cretaceous–Cenozoic]
34. *Banksiaeidites* sp. cf. *Banksia serrata* [Cenozoic]
35. *Banksiaeidites* sp. aff. *B. arcuatus* [Cenozoic]
36. *Banksiaeidites elongatus* complex [Cenozoic]
37. *Beaupreaidites* sp. (scabrate ornamentation) [Cenozoic]
38. *Beaupreaidites elegansiformis* var. [Late Cretaceous–Cenozoic]
- 39-40. *Beaupreaidites verrucosus* [Late Cretaceous–Cenozoic]
- 41-43. *Beaupreaidites/Proteacidites* sp. (apiculate ornamentation) [Cenozoic]
44. *Clavatipollenites* sp. [Late Cretaceous–Cenozoic]

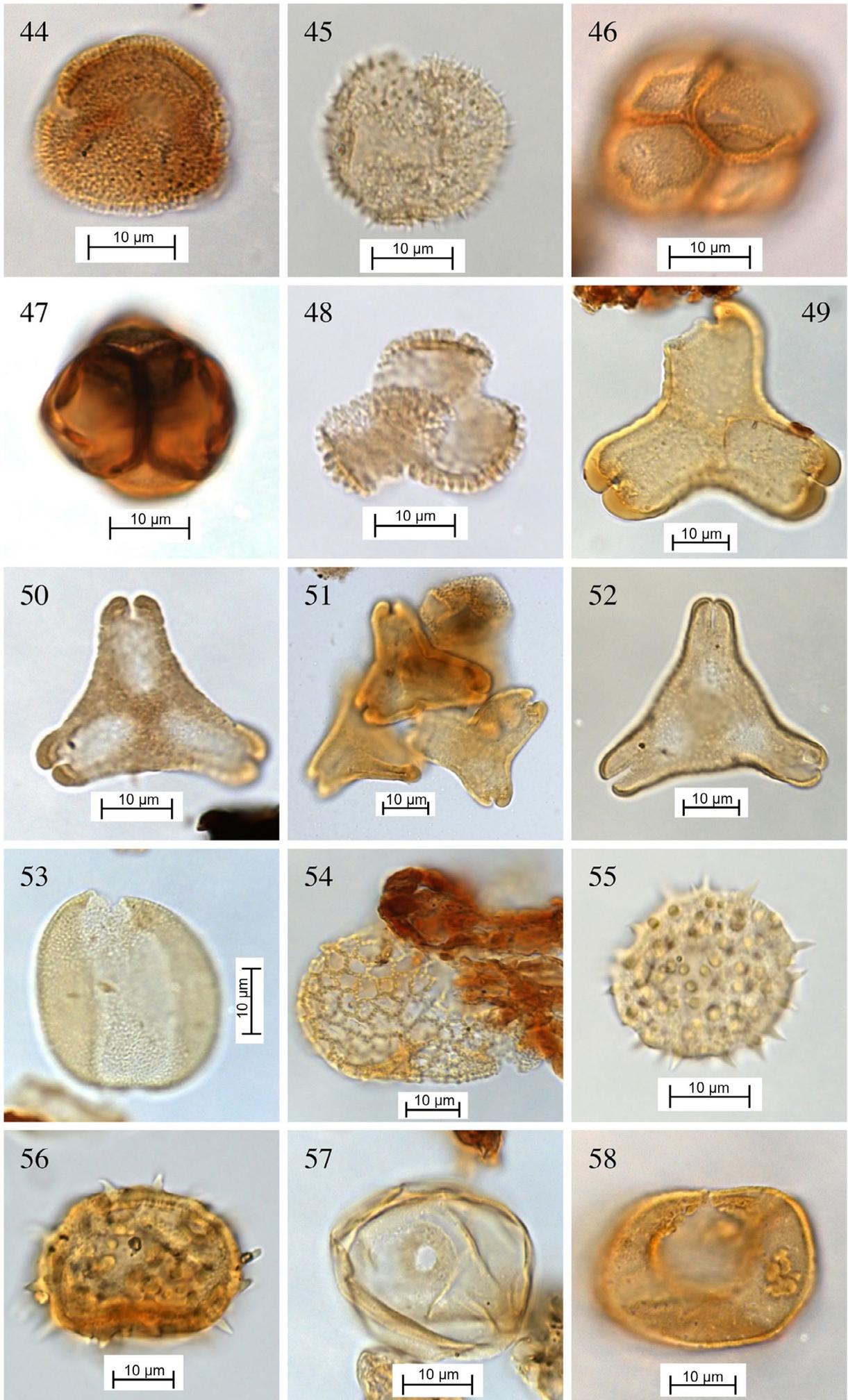
45. *Compositoipollenites* sp. [Cenozoic]
46. *Dicotetradites meridianus* [Late Cretaceous–Cenozoic]
47. *Ericipites* sp. [Late Cretaceous–Cenozoic]
48. *Ilexpollenites anguloclavatus* complex [Late Cretaceous–Cenozoic]
49. *Gambierina edwardsii* var. [Late Cretaceous–early Cenozoic]
50. *Gambierina rudata* var. [Late Cretaceous–early Cenozoic]
51. *Gambierina rudata* pollen tetrad [Late Cretaceous–early Cenozoic]
52. *Forcipites* sp. [Late Cretaceous]
53. *Liliacidites* sp cf. *L. bainii* [Cenozoic]
54. *Liliacidites* sp, cf. *Agave/Lilium* [Late Cretaceous–Cenozoic]
55. *Malvacipollis diversus* [Cenozoic]
56. *Malvacipollis robustus* ms [Cenozoic]
57. *Milfordia homeopuncta* [Cenozoic]
58. *Milfordia hypolaenoides* [late Cenozoic]
59. ‘*Monolites*’ sp. (scabrate ornamentation) [Cenozoic]
60. pentacolp(or?)ate sp [Cenozoic]
61. pentacolporate sp. [Cenozoic]
- 62-63. *Polycolpites reticulatus* ms [Cenozoic]
64. *Proxapertites operculatus* [Cenozoic]
65. *Periporipollenites polyoratus* [Late Cretaceous?–Cenozoic]
66. *Rhoipites* sp. [Cenozoic]
67. *Rosannia manika* [Late Cretaceous–Cenozoic]
68. *Tetradopollis* sp. [Late Cretaceous–Cenozoic]
69. *Tetracolpites* cf. *sphericus* [Cenozoic]
70. *Tricolpites* cf. *asperus* [Cenozoic]
- 71-73. *Tricolpites* sp. (scabrate ornamentation) [Cenozoic]
- Figs. 74–88. Nothofagidites spp.**
74. *N. emarcidus* complex [Cenozoic]
75. *N. brachyspinulosus-incrassata* complex [Late Cretaceous–Cenozoic]
76. *N. deminutus-vansteenisii* complex [Cenozoic]
- 77-79. *N. flemingii* complex [Late Cretaceous–Cenozoic]
- 80-81. *N. goniatus* complex [Cenozoic]
82. *N. senectus* complex [Late Cretaceous]
- 83-85. *N.* cf. *cranwelliae* [Cenozoic NZ]
- 86-88. *N. endurus* complex [early Cenozoic]
- Figs. 89-125. Proteacidites and related genera**
89. *Cranwellipollis* sp. cf. *C. palisadus* [Late Cretaceous]
90. *Diporites* sp. (scattered apiculae) [Cenozoic]
91. *Diporites* sp. (reticulate) [Cenozoic]
92. *Lewalanipollis* cf. *L. senectus* [Late Cretaceous]

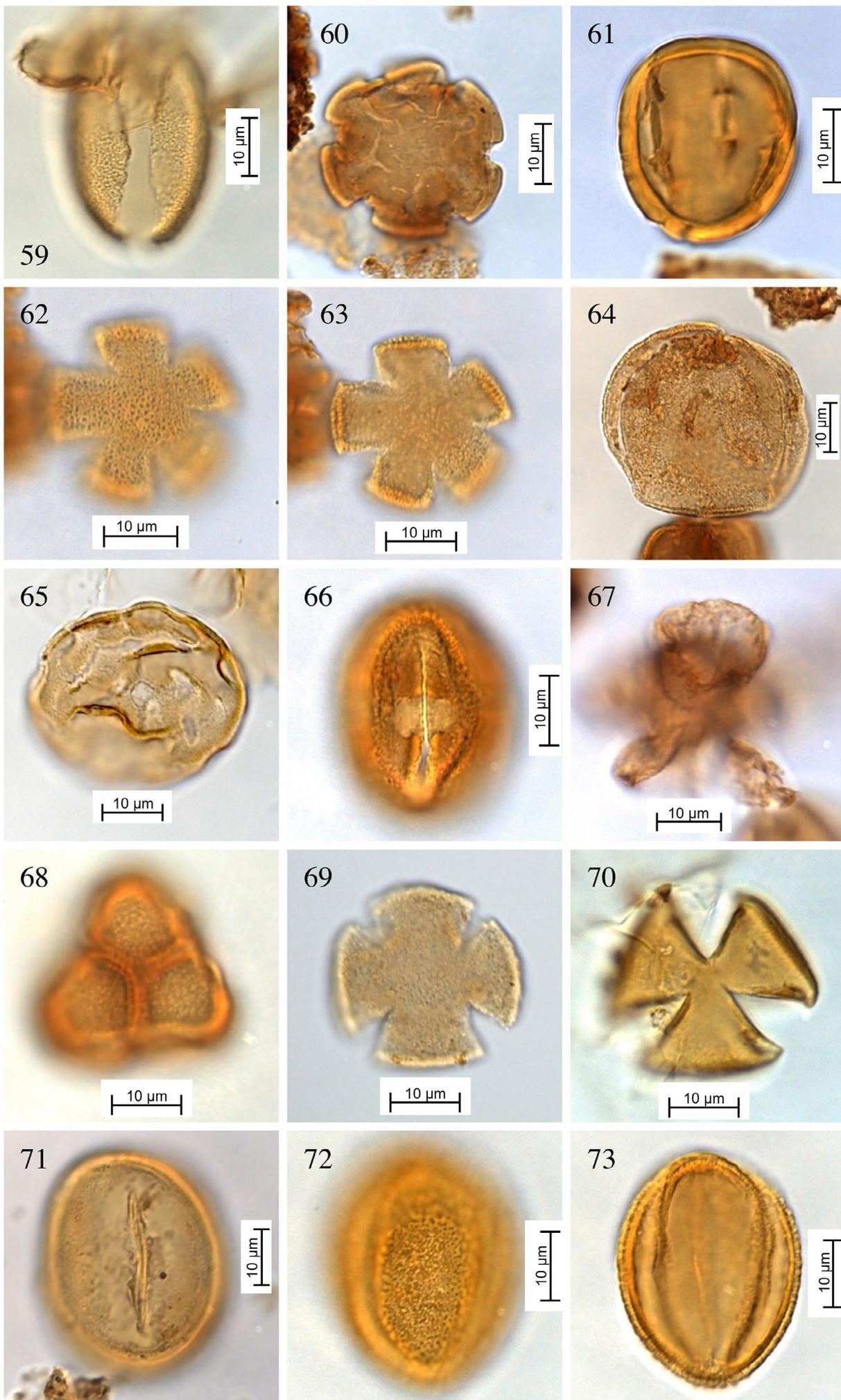
93. *Lewalanipollis* cf. *L. trycheros* [Late Cretaceous]
94. *Proteacidites* aff. *tenuixinus* [Late Cretaceous–Cenozoic]
95. *Proteacidites* cf. *obscurus* (scattered apiculae) [Cenozoic]
96. *Proteacidites obscurus* [Cenozoic]
97. *Proteacidites* sp. cf. *P. sinulatus* [Cenozoic]
- 98-100. *Proteacidites adenanthoides* complex [Cenozoic]
- 101-103. *Proteacidites scrobiculatus* ms [Cenozoic]
- 104-106. *Proteacidites* cf. *alveolatus* [Cenozoic]
- 107-109. *Proteacidites reticulosabratus* complex [Late Cretaceous–Cenozoic]
- 110-112. *Proteacidites crassus* complex [Late Cretaceous–Cenozoic]
113. *Proteacidites* cf. *P. polymorphus* [Late Cretaceous]
- 114-115. *Proteacidites* cf. *Cranwellipollis confragosus* [Late Cretaceous–Cenozoic]
- 116-118. *Proteacidites* aff. *P. angulatus* [Cenozoic]
119. *Triporopollenites* sp. [Cenozoic]
- 120-124. *Proteacidites* sp. A (micro-echinate) [Cenozoic]
- D. FIGS. 126-139: MESOZOIC–PALAEOZOIC SPORES**
- 125-130 *Antulsporites* spp. [Jurassic?]
- 131-132. *Foveotriletes* sp.
133. unidentified baculate trilete spore
134. *Cadargasporites*?
135. *Horriditriletes ramosus* [Permian]
136. *Microbaculispora micronodosa* [Late Permian]
137. *Corollinia torosa* [Jurassic–Early Cretaceous]
138. *Plicatipollenites* sp. [Permian]
139. carbonized xylem
- E. FIGS. 141-148: ALGAL CYSTS**
140. *Botryococcus*
141. *Circulisporis parvus* (Zygnemataceae)
142. *Tetraporina* sp. (Zygnemataceae)
143. unidentified operculate algal cyst
144. dinoflagellate cyst cf. *Deflandrea pachyceros* [Cenozoic]
145. *Morkallacysta pyramidalis* [Cenozoic]
- 146-147. *Saeptodinium gravattensis* complex [Cenozoic]
148. *Saeptodinium tasmaniensis* complex [Cenozoic]

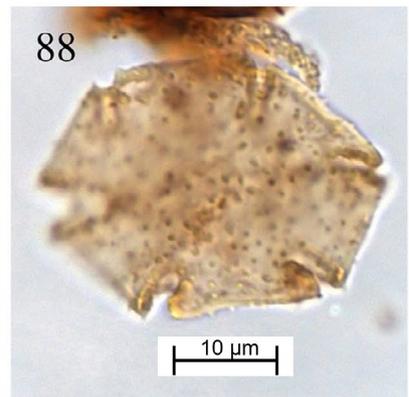
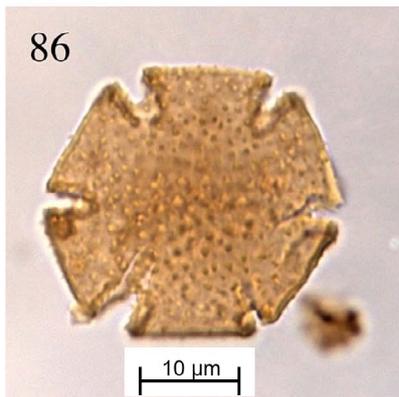
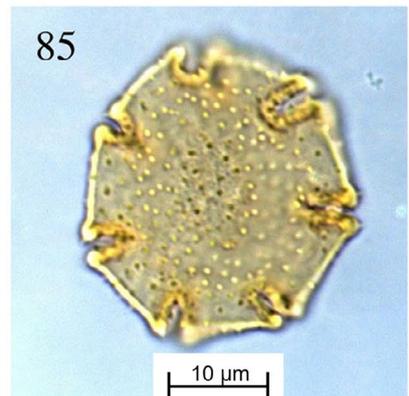
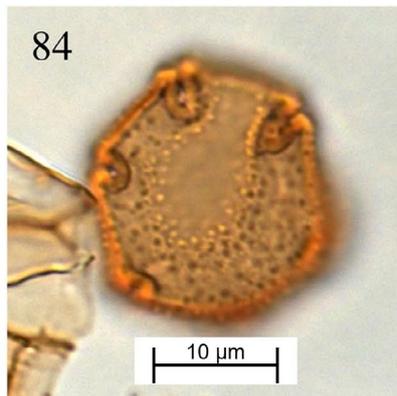
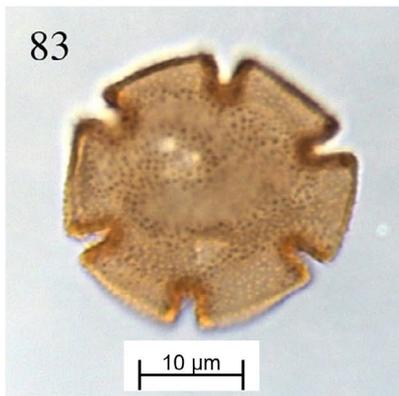
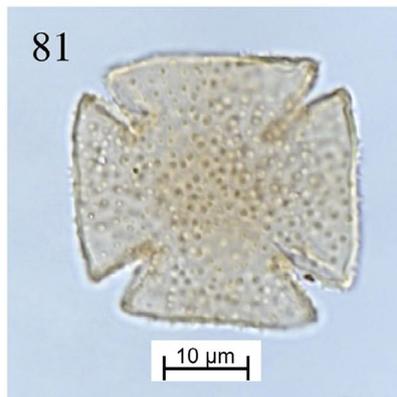
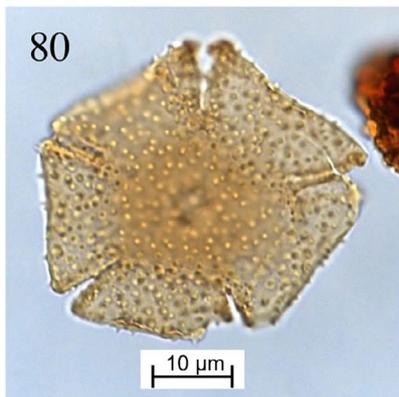
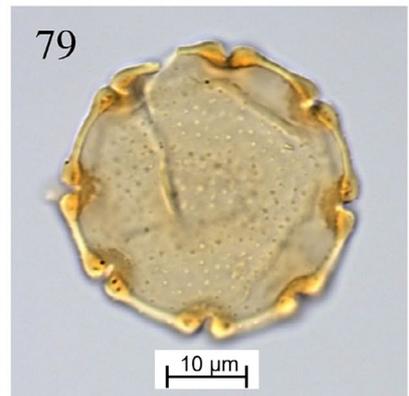
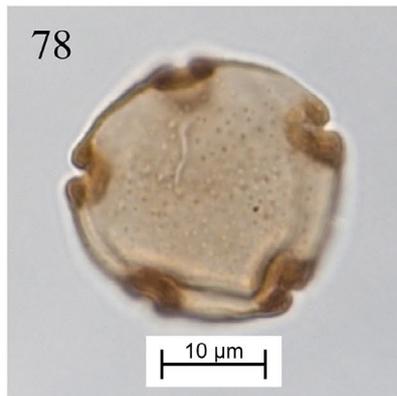
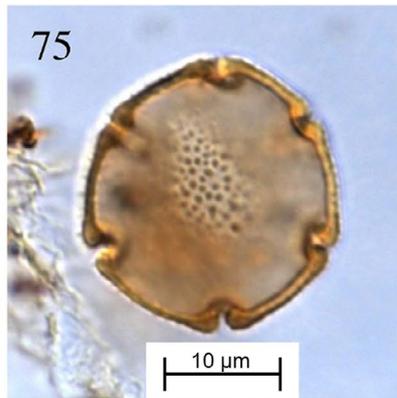
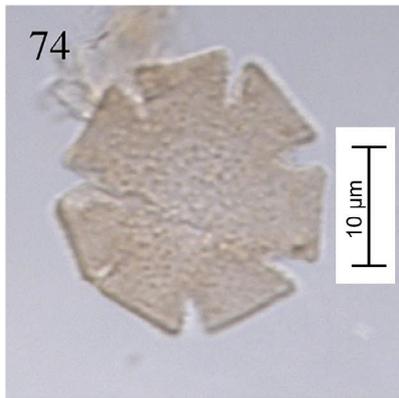


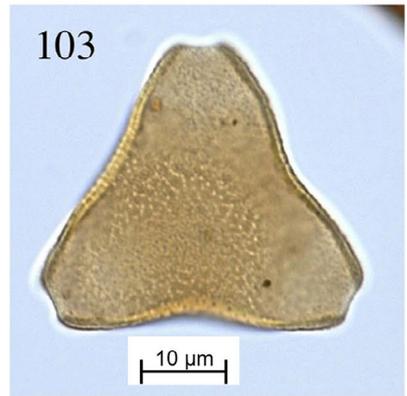
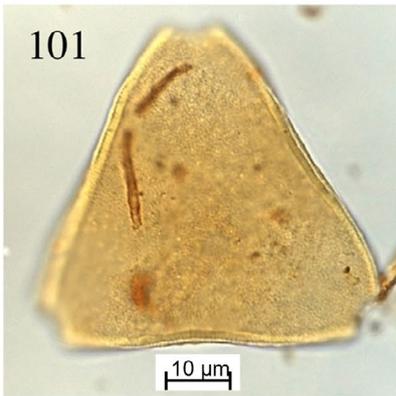
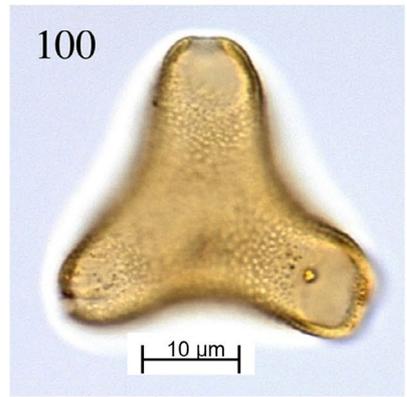
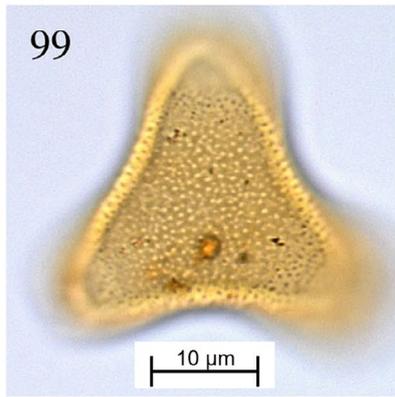
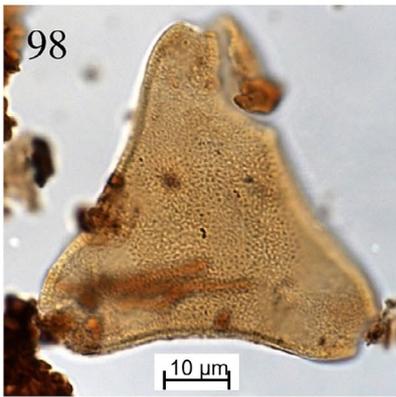
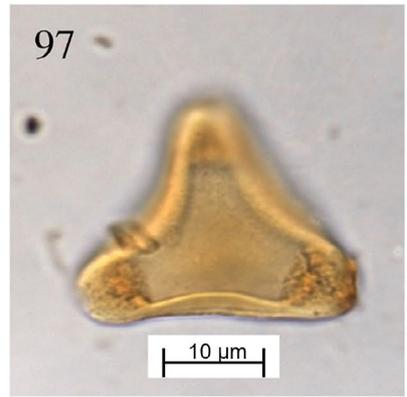
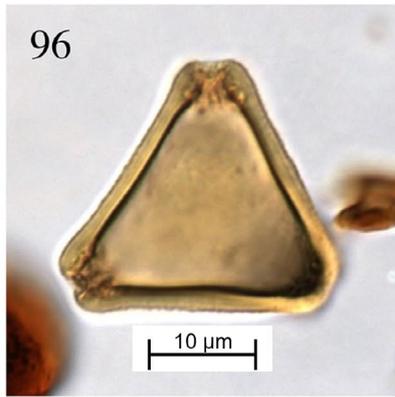
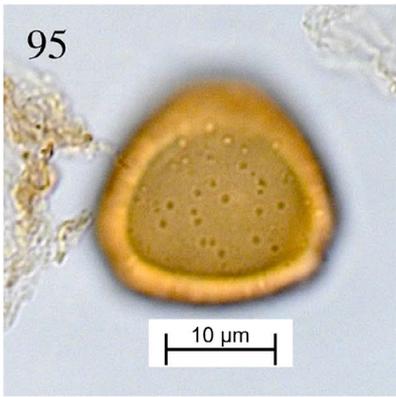
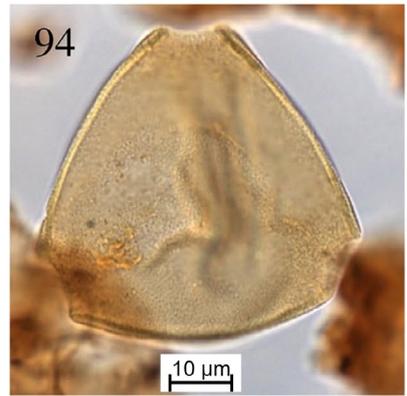
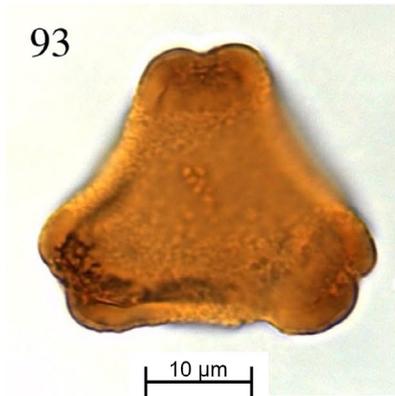
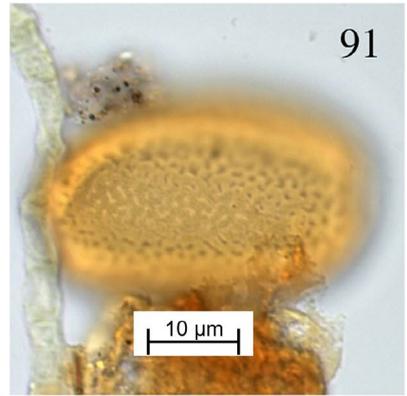
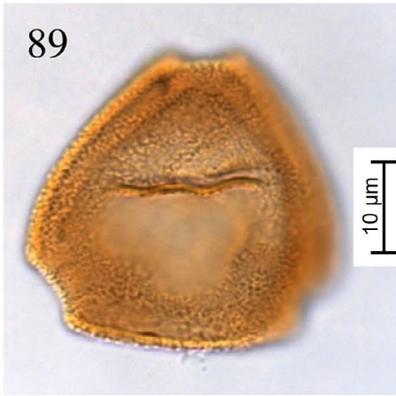


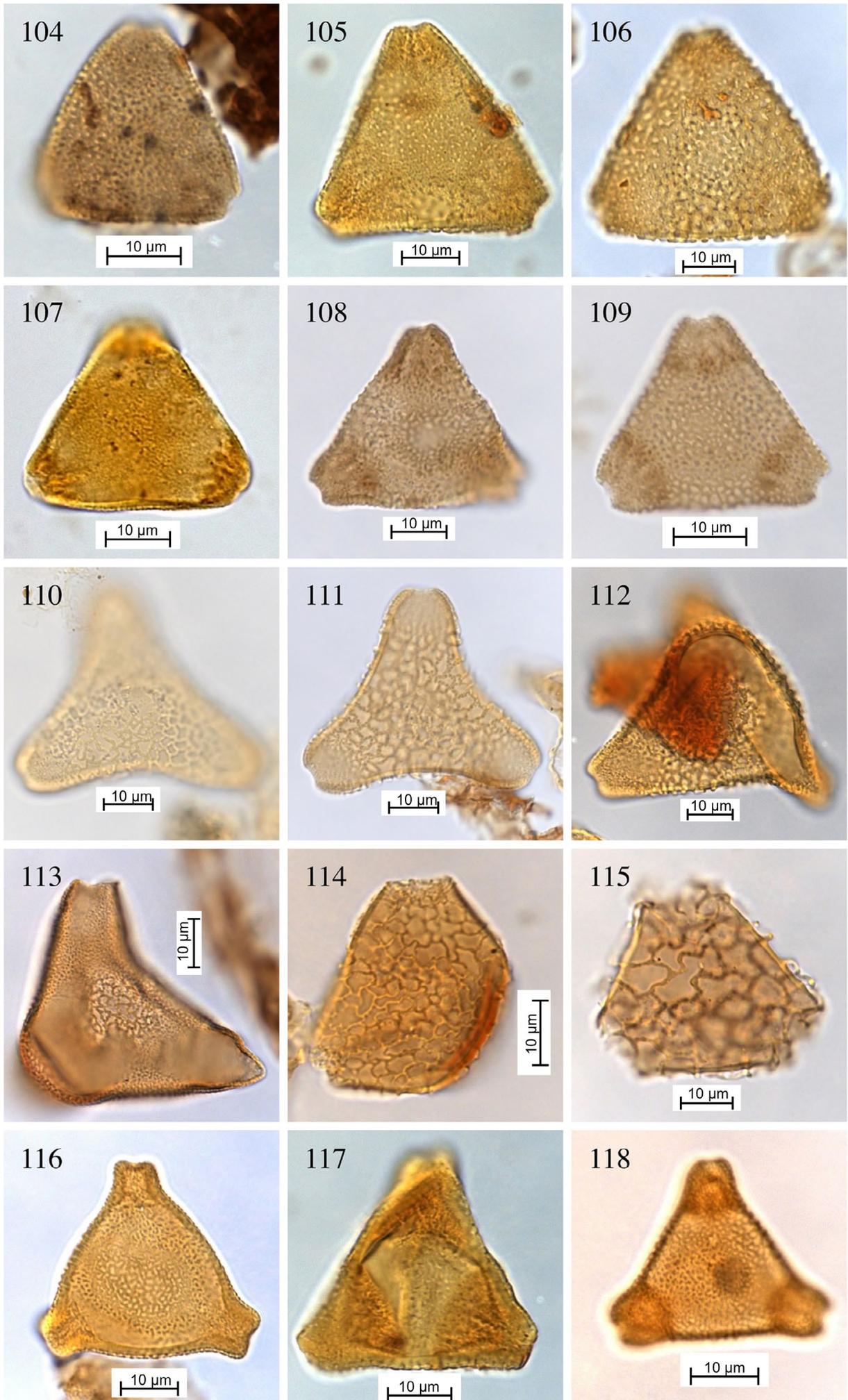


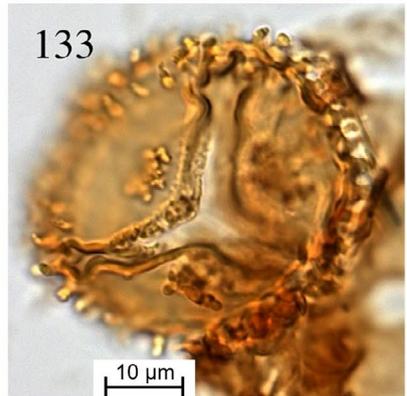
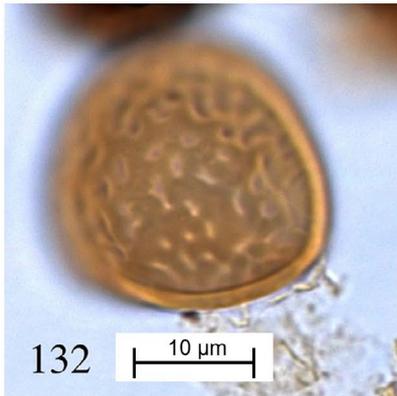
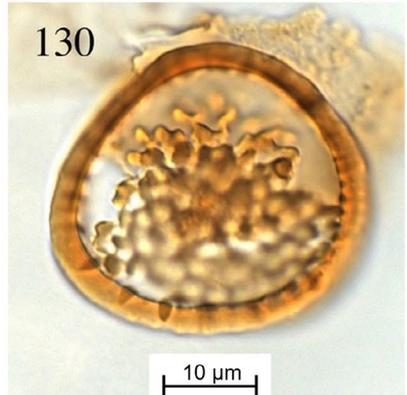
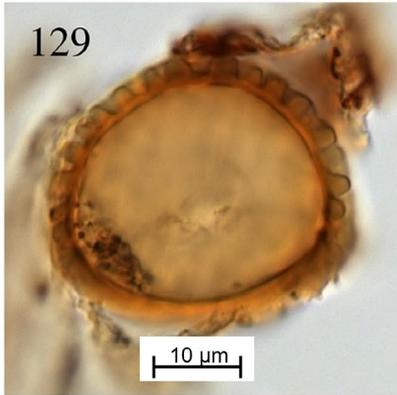
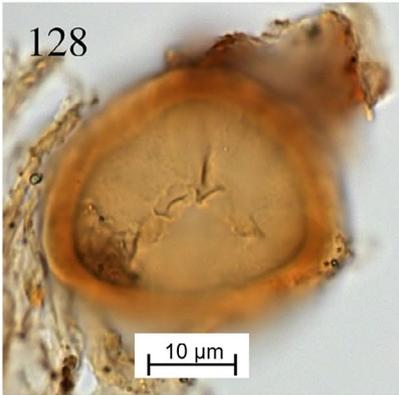
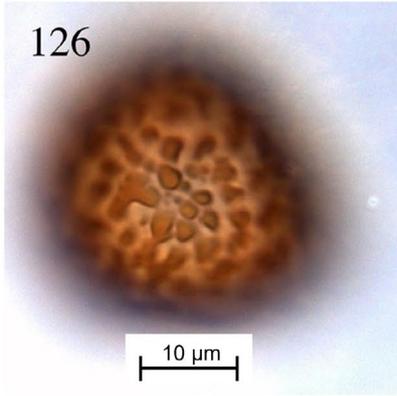
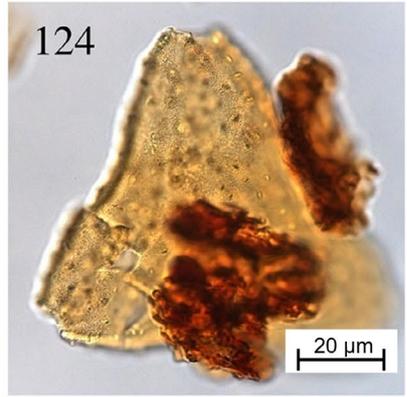
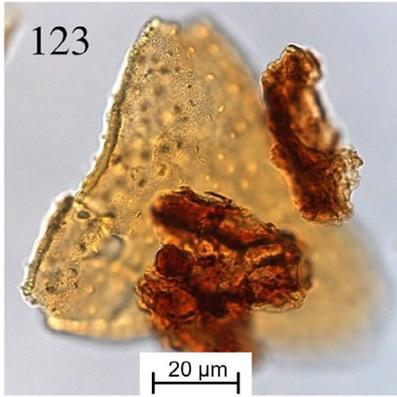
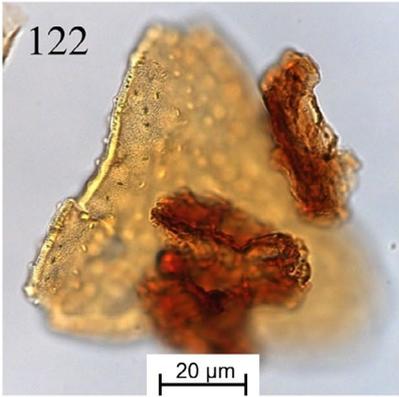
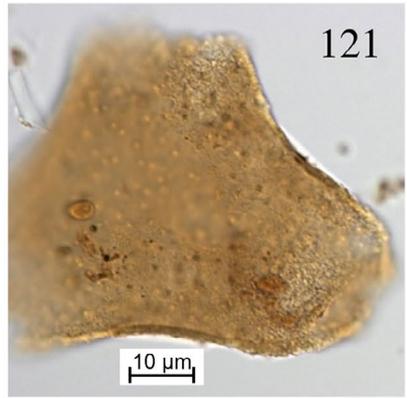
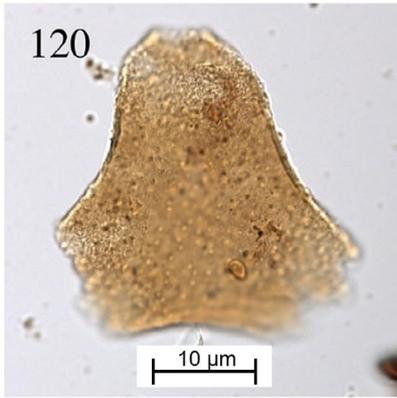
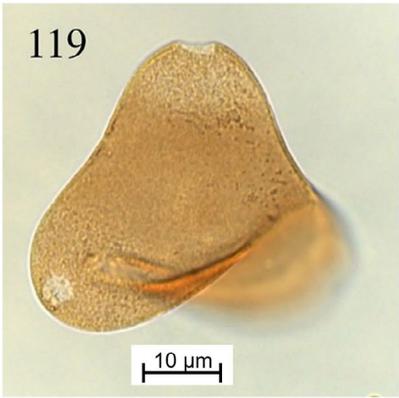


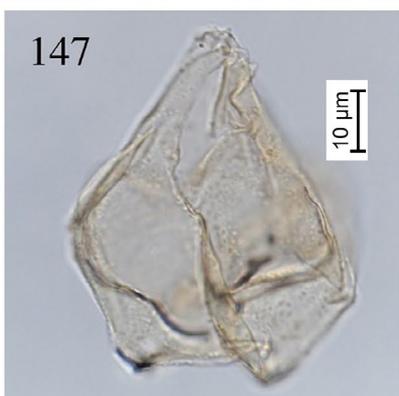
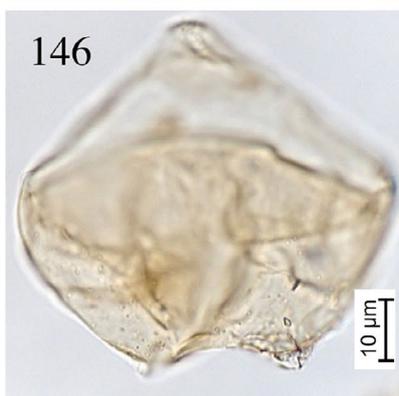
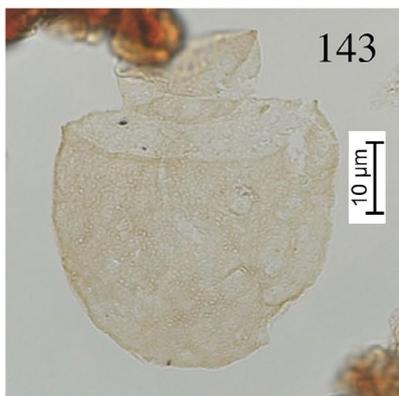
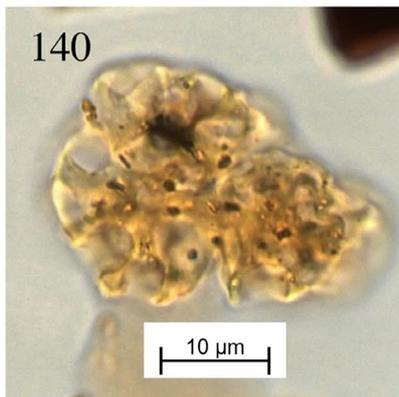
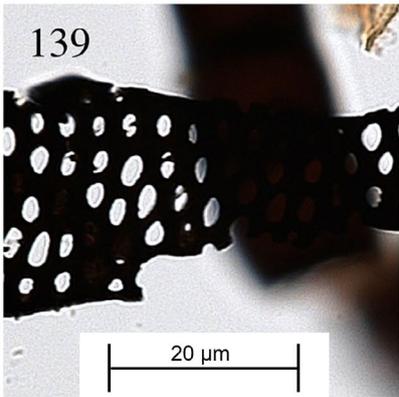
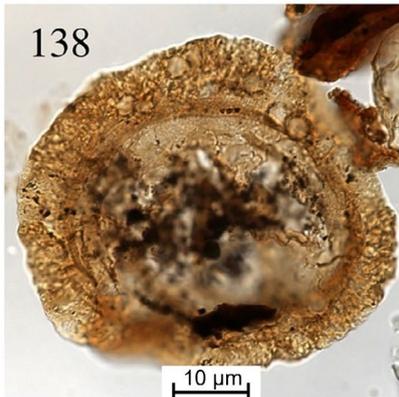
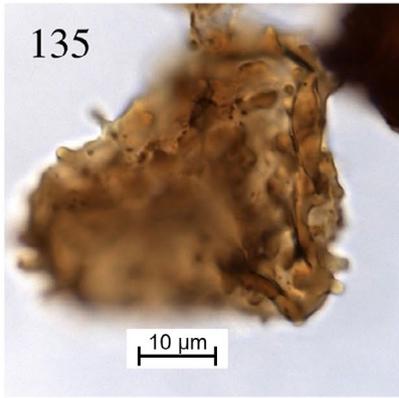
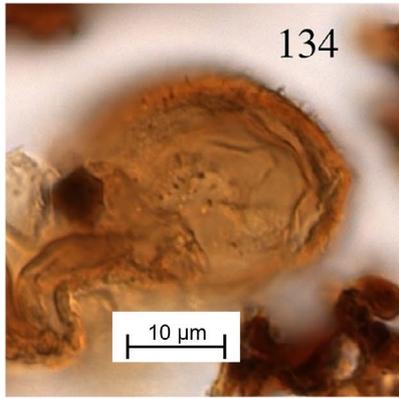












APPENDIX 4

Stratigraphic distribution and relative abundance data for identifiable morphospecies in the Tamar Graben coreholes.

Relative abundances calculated as a percentage of the total terrestrial pollen and spore count:
'+' indicates percentages less than 1%; 'x' indicates morphospecies recorded outside the pollen sum.

A: 'Southern' Tamar Graben core holes

Morphospecies	Abels Hill-2		LV 1BH1 Lawrence Vale						White Hills WHD1		
	28.16-28.19	82.30-82.35	43.1	46.5	51.25	52.6	53.4	55.0	14.27-14.31	31.00-31.03	43.90-43.94
Age/Age range	Middle-Late Eocene		Paleocene			Paleocene (Danian)			indeterminate		
Gymnosperms											
<i>Araucariacites australis</i>		4%	3%	9%	6%	+	1%	1%			(1)
<i>Dacrycarpites australiensis</i>	+	+	x	+			x	x		(1)	
<i>Dacrydiumites florinii</i>	6%	2%	2%	1%	1%	+	+	+			
<i>Dilwynites granulatus</i>		2%	3%	1%	3%	+	+	2%		(2)	
<i>Dilwynites tuberculatus</i>						x		x			
<i>Lygistepollenites balmei</i>		+	+	x	+	+	+	+		(1)	(1)
<i>Microalatiidites palaeogenicus</i>	x	+			x	+	+	1%			
<i>Microcachrydites antarcticus</i>	+	4%	2%	19%	7%	10%	5%	3%		(2)	(1)
<i>Parvisaccites catastus</i>		+		+	+		x				
<i>Phyllocladites mawsonii</i>	8%	14%	16%	9%	24%	11%	22%	36%	(5)	(5)	(2)
<i>Phyllocladites reticulosaccatus</i>			x	+	2%	x	x	+			
<i>Phyllocladites verrucosus</i>							+				
<i>Podocarpidites cf. torquatus</i>		+	x	x	1%	+	x	x			
<i>Podocarpidites spp.</i>	19%	30%	41%	33%	31%	25%	34%	38%		(4)	(1)
<i>Podosporites erugatus</i>		+									
<i>Podosporites/Trichotomosulcites</i>	2%	5%	13%	11%	6%	37%	14%	9%		(1)	
<i>Trisaccites spp.</i>			x	x			x	x			
TOTAL:	37%	63%	79%	84%	81%	85%	82%	92%	(5)	(16)	(6)
Angiosperms											
<i>Aglaoreidia qualumis</i>	+										
<i>Australopollis obscurus</i>							x	+			
<i>Battenipollis sabriniae</i>				x			x				
<i>Battenipollis sectilis</i>							x				
<i>Beaupreaidites orbiculatus</i>				+	x						
<i>Beaupreaidites verrucosus</i>	+										
<i>Conbaculites apiculatus</i>			+								
<i>Cranwellipollis palisadus</i>		+			cf.		x	x			
<i>Dicotradites clavatus</i>	1%	+	+	x							
<i>Gambierina edwardsii</i>			x		x		x	x			
<i>Gambierina rudata</i>			2%	+	+	2%	2%	+			
<i>Gambierina tenuis ms</i>			x				x				
<i>Haloragacidites harrisii</i>	+	+	+	+	x	x	x		(1)	(1)	
<i>Ilexpollenites spp.</i>			+				x				
<i>Lewalanipollis senectus</i>			cf.								
<i>Liliacidites spp.</i>			x								
<i>Malvacipollis subtilis</i>	+	+									
<i>Milfordia hypolaenoides</i>		+									
<i>Nothofagidites asperus</i>	+	5%	+	+	2%	+	+	+		(1)	
<i>Nothofagidites brachyspinulosus complex</i>	9%	6%	+	+	2%	2%	1%	x			
<i>Nothofagidites deminutus-vansteenisii</i>	cf.										
<i>Nothofagidites emarcidus complex</i>	2%	2%	1%		2%		x				
<i>Nothofagidites endurus complex</i>			2%		+	+	2%	x			
<i>Nothofagidites endurus f. goniatus</i>			+				x				
<i>Nothofagidites flemingii</i>	13%	6%	3%	1%	+	2%	2%	+			
<i>Nothofagidites goniatus</i>		2%		+							
unassigned <i>Nothofagidites</i>	+	+	1%	2%	+	+	1%	2%			
Total <i>Nothofagidites</i>	24%	21%	7%		7%	7%					

Morphospecies	Abels Hill-2		LV 1BH1 Lawrence Vale						White Hills WHDH1		
	28.16-28.19	82.30-82.35	43.1	46.5	51.25	52.6	53.4	55.0	14.27-14.31	31.00-31.03	43.90-43.94
Age/Age range	Middle-Late Eocene		Paleocene		Paleocene (Danian)				indeterminate		
Angiosperms (cont.)											
<i>Peninsulapollis askiniae</i>		+					x				
<i>Peninsulapollis gillii</i>			2%	2%	2%	2%	2%	+			
<i>Periporopollenites demarcatus</i>		+					x				
<i>Periporopollenites polyoratus</i>			+	+	x		x	x			
<i>Polycolpites langstonii</i>		?	x		x						
<i>Propylipollis annularis</i>				cf.							
<i>Propylipollis biporus</i>							cf.				
<i>Proteacidites adenanthoides</i> complex	7%	+		x	x.			cf.			
<i>Proteacidites alveolatus</i> complex	+										
<i>Proteacidites amolosexinus</i>							cf.	cf.			
<i>Proteacidites angulatus</i>			cf.	x				x			
<i>Proteacidites cooksoniae</i>			x				cf.	cf.			
<i>Proteacidites crassus</i>			x	+			x	x			
<i>Proteacidites incurvatus</i>	5%										
<i>Proteacidites obscurus</i>	+	+	x								
<i>Proteacidites reticulosabratus</i>				+	cf.		x				
<i>Proteacidites rectomarginis</i>	x										
<i>Proteacidites scaboratus</i>			x		x						
<i>Proteacidites tenuiexinus</i>				x							
<i>Proteacidites</i> sp. A				x							
<i>Proteacidites</i> cf. <i>amolosexinus</i>				x			x				
<i>Proteacidites</i> cf. <i>angulatus</i>			x								
<i>Proteacidites</i> cf. <i>polymorphus</i>							x	cf.			
<i>Proteacidites</i> cf. <i>tenuiexinus</i>							x				
<i>Proteacidites</i> cf. <i>tripartitus</i>			x								
unassigned <i>Proteacidites</i> spp.	13%	3%	4%	+	5%	1%	3%	2%	(1)		
Total <i>Proteacidites</i> spp.	25%	3%		+							
unassigned <i>Rhoipites</i> spp.		+			x						
<i>Tetracolporites multistrixis</i> ms			x				?				
<i>Tetracolporites palynius</i>			x								
<i>Tricolpites phillipsii</i>			x								
<i>Tricolpites</i> sp. A			x	x			+				
unassigned <i>Tricolpites</i> spp.		+	x	x	1%		+				
<i>Tricolporites adelaidensis</i>	+										
unassigned <i>Tricolporites</i> spp.			x	x							
<i>Tricolporites</i> sp. A			x	x			x				
<i>Tripoporopollenites ambiguus</i>					x			x			
unassigned angiosperm pollen			+	+	x	+	+				
Total angiosperms	53%	27%									
TOTAL		27%	15%	7%	16%	12%	15%	4%	(2)	(2)	(0)

Morphospecies	Abels Hill-2		LV 1BH1 Lawrence Vale						White Hills WHDH1		
	28.16-28.19	82.30-82.35	43.1	46.5	51.25	52.6	53.4	55.0	14.27-14.31	31.00-31.03	43.90-43.94
Age/Age range	Middle-Late Eocene		Paleocene		Paleocene (Danian)				indeterminate		
Cryptogams											
<i>Baculatisporites</i> spp.		3%	+	+							
<i>Cingutriletes</i> spp.			x	x	x			x	x		
<i>Clavifera triplex</i>									cf.		
<i>Conbaculites apiculatus</i>			cf.								
<i>Cyathidites australis/minor</i>	1%	2%	+	6%	1%	+	+	1%	(1)		
<i>Cyathidites splendens</i>								x			
<i>Dictyophyllidites</i>								+			
<i>Evansispora senonica</i>			x	?							
<i>Gleicheniidites</i> spp.	3%	+	+	+	1%			+		(1)	
<i>Herkosporites elliotii</i>			x	+	+	x	x				
<i>Kuylisporites waterbolkii</i>											
<i>Laevigatosporites ovatus/ major</i>	1%	1%	+	1%	1%	+					
<i>Latrobosporites amplus</i>				x	x			+			
<i>Latrobosporites crassus</i>	+			x							
<i>Latrobosporites marginis</i>		+		x				x.			
<i>Matonisporites ornamentalis</i>	+	+									
<i>Neoraistrickia equalis</i>								x	x		
<i>Neoraistrickia truncata</i> var.				x				x	x		
<i>Peromonolites densus</i>								x			
<i>Peromonolites</i> spp.								x	x		
<i>Perotriletes</i> cf. <i>linearis</i>		+						x	x		
<i>Polypodiisporites</i> spp.	+	+	+		x	x	+	x			
<i>Retitriletes australoclavatidites</i> complex		+	+	+	x	+	+	+	(1)		
<i>Retitriletes semimuris</i>				x				x			
<i>Rugulatisporites mallatus</i>			cf.								
<i>Sellaspora asperata</i>								x			
<i>Stereisporites antiquisporites/australis</i>	7%	+	2%	9%+		+	1%	1%			
<i>Stereisporites maastrichtiensis</i>	+		x		+		x	x			
<i>Stereisporites regium</i>			x	x	x	x	x	x			
<i>Trilites tuberculiformis</i>	+	+									
<i>Verrucosisporites kopukuensis</i>		+									
unassigned trilete spores			1%		x	x	x	+			
TOTAL	9%	10%	6%	9%	4%	2%	3%	4%	(2)	(1)	(0)
POLLEN SUM	298	411	370	462	387	362	408	427	9	20	6
Fungal spores											
<i>Mediaverrunites</i>					+						
<i>Pesavis</i>		+	+		+						
indet. fungal spores			4%	+	7%	2%	4%	+			
Algae & fungi											
<i>Botryococcus</i>		+			1%	+				(1)	(1)
<i>Saepodinium</i> complex			?	+	7%	2%	14%	+			
Modern pollen contaminants								x	(8)		(8)
Reworked Permo-Triassic spores		13%									
Reworked Permo-Triassic gymnosperms		12%	x	x	x	x	x	x			
Reworked Permo-Triassic algae		2%	x								

B: 'Central' Tamar Graben

1. Englewood Riverside 1

Morphospecies Englewood Riverside 1	59.64- 59.67	93.95- 93.96	103.9-5 104.00	109.4	115.6	140.5	146.5	148.6	152.1	154.77 154.80
Age/Age range	• Paleocene (Danian)					K/T transition		Maastrichtian		
Gymnosperms										
<i>Araucariacites australis</i>	+		+	3%	1%	+	+	+	+	+
<i>Cupressacites</i>	+	+								
<i>Dacrycarpites australiensis</i>	1%	+	+							x
<i>Dacrydiumites florinii</i>	1%	x	+	2%	+	+		+		+
<i>Dilwynites granulatus</i>	3%		+	4%	1%	+		+		+
<i>Dilwynites tuberculatus</i>	x		x	+	+					x
<i>Lygistepollenites balmei</i>	+	x	x	+				+		
<i>Microalatiidites palaeogenicus</i>	+							+		
<i>Microcachryidites antarcticus</i>	22%	9%	6%	4%	2%	1%	+	1%	4%	31%
<i>Parvisaccites catastus</i>	x				x					
<i>Phyllocladidites mawsonii</i>	13%	37%	15%	7%	12%	12%	+	6%	5%	4%
<i>Phyllocladidites reticulosaccatus</i>	3%	3%	1%	+	+	+		+	+	
<i>Phyllocladidites verrucosus</i>		+	2%	+	+	+		+		
<i>Podocarpidites cf. torquatus</i>		x		x				x		
<i>Podocarpidites spp.</i>	27%	10%	18%	30%	23%	12%	3%	7%	7%	7%
<i>Podosporites microsaccatus complex</i>	6%	2%	1%	10%	13%	12%		11%	2%	+
Total gymnosperms	79%	63%	44%	61%	53%	39%	5%	27%	19%	42%
Angiosperms										
<i>Aglaoreidia qualumis</i>						x				
<i>Australopollis obscurus</i>	+	1%	+	x	+	+	x		x	
<i>Arecipites sp.</i>									+	
<i>Battenipollis sabriniae</i>							x	5%	8%	3%
<i>Battenipollis sectilis</i>						+	+	2%	2%	3%
<i>Beaupreaidites elegansiformis</i>				cf.						x
<i>Beaupreaidites verrucosus</i>	x			x						
' <i>Beaupreaidites apiculatus</i> ms				2%	x				2%	x
<i>Beaupreaidites orbiculatus</i>					x					3%
<i>Cranwellipollis palisadus</i>							+			+
<i>Dicolpopollis spp.</i>				x	x				x	
<i>Dicotradites clavatus</i>	+	+						1%		+
<i>Echimonocolpites sp.</i>									+	7%
<i>Ericipites spp.</i>							x		x	x
<i>Forcipites longus</i>							x	+	+	x
<i>Forcipites sabulosus</i>							x			x
<i>Forcipites spp.</i>										x
<i>Gambierina edwardsii</i>	x	cf.	x	+	x		x		x	c.
<i>Gambierina rudata</i>	1%	16%	37%	7%	16%	9%	+	3%	2%	6%
<i>Gambierina tenuis</i> ms					x		+		16%	
<i>Gambierina sp (micro-apiculate)</i>				x						
<i>Haloragacidites harrisii</i>	+									
<i>Illexpollenites sp.</i>					x					x
<i>Jaxtacolpus</i>								x		

Morphospecies Englewood Riverside 1	59.64- 59.67	93.95- 93.96	103.9-5 104.00	109.4	115.6	140.5	146.5	148.6	152.1	154.77 154.80
Age/Age range	Paleocene (Danian)				K/T transition			Maastrichtian		
Angiosperms (cont.)										
<i>Lewalanipollis</i> cf. <i>senectus</i>				x	x					x
<i>Liliacidites</i> (epireticulate ornamentation)									+	
<i>Liliacidites</i> spp.	+		+		+	+	+	+	+	+
<i>Milfordia homeopuncta</i>								x		
<i>Nothofagidites asperus</i>	+		3%	x						
<i>Nothofagidites brachyspinulosus</i>	+	+	x	x	+	+			x	+
<i>Nothofagidites emarcidus-heterus</i>	+				x					
<i>Nothofagidites endurus</i>	+	10%	1%	7%	7%	2%	2%			8%
<i>Nothofagidites flemingii</i>	3%			x		+		x	x	
<i>Nothofagidites kaitangata</i>										x
<i>Nothofagidites senectus</i> complex		cf.				+	+	+	12%	7%
unassigned <i>Nothofagidites</i> spp.	+	+	3%	+					3%	+
<i>Peninsulapollis gillii</i>	2%	3%	+	2%	5%	7%	5%	8%	4%	1%
<i>Periporopollenites polyoratus</i>	+	x	x	x	1%	+			x	x
<i>Periporopollenites demarcatus</i>						x				
<i>Polycolpites</i> sp. (reticulate)										x
<i>Propylipollis annularis</i>				cf.						
<i>Proteacidites adenantoides</i> complex			x	x	x	+				x
<i>Proteacidites angulatus</i>		x	x	x	x					cf.
<i>Proteacidites cooksoniae</i>					cf.		x			
<i>Proteacidites crassus</i> complex	x		x	x	x	+			x	
<i>Proteacidites crotonoides</i>							x			
<i>Proteacidites reticuloconcavus</i>										cf.
<i>Proteacidites reticulosabratus</i>			x	x		x			x	
<i>Proteacidites tenuixinus</i>		x	+	x	x	x			x	+
<i>Proteacidites</i> cf. <i>alveolatus</i>	x			x	cf.			x		
<i>Proteacidites</i> sp. A	x									
unassigned <i>Proteacidites</i> spp.	5%	4%	8%	7%	10%	19%	6%	7%	10%	8%
<i>Pseudowinterapollis cranwellae</i>				+						x
<i>Pseudowinterapollis wahooensis</i> ms										x
unassigned <i>Rhoipites</i> spp.		+								x
<i>Rosannia manika</i>							x			
<i>Tensuolpites lilliei</i>							x		+	2%
<i>Tetradopollis</i> sp.							+		x	
<i>Tetracolporites verrucosus</i>				x						
<i>Tricolpites asperus</i>	x	x	+							
<i>Tricolpites phillipsii</i>				x						
<i>Tricolpites waiparaensis</i>								+	+	x
<i>Tricolpites</i> sp. A	x		x	x	+	+	+		x	+
unassigned <i>Tricolpites</i> spp.	+									+
<i>Tricolporites</i> sp. A		x	x		x		x			+
unassigned <i>Tricolporites</i> spp.	+	+		2%	+	2%			5%	+
<i>Triporopollenites</i> sp. (apiculate)					x	x			2%	
unassigned <i>Triporopollenites</i> spp.		+			+	+	2%	+	x	2%
unassigned angiosperms	+		+	+	+	2%	+	+	3%	+
Total angiosperms	17%	35%	53%	37%	41%	40%	22%	28%	74%	52%

Morphospecies Englewood Riverside 1	59.64- 59.67	93.95- 93.96	103.9-5 104.00	109.4	115.6	140.5	146.5	148.6	152.1	154.77 154.80
Age/Age range	Paleocene (Danian)				K/T transition			Maastrichtian		
Cryptogams										
<i>Aequitriradites spinulosus</i>									+	
<i>Baculatisporites</i> spp.	+		+		+	4%	1%	2%	3%	+
<i>Balmeisporites glenelgensis</i>							x			
<i>Cingutritiles</i> spp.	x		x	x	x					
<i>Cyathidites australis/minor</i>	+	+	+	+	1%	3%	2%	1%	+	+
<i>Cyathidites splendens</i>	+	x				x				x
<i>Densoisporites</i> sp			x							
<i>Dictyophyllidites</i> sp.				+						
<i>Evansispora senonica</i>							x			
<i>Gleicheniidites</i> spp.			x							
<i>Herkosporites elliotii</i>	x			x	+	+	x	+		x
<i>Laevigatosporites major/ovatus</i>	1%		1%	+	1%	6%	29%	20%	+	3%
<i>Latrobosporites amplus</i>				x.		cf.	x			
<i>Latrobosporites</i> cf. <i>crassus</i>		+					x			
<i>Leptolepidites</i> cf. <i>verrucosus</i>						+			+	+
<i>Matonisporites cooksoniae</i>						+		+		
<i>Neoraistrickia equalis</i>	+		x	x	x		3%			
<i>Neveisporites</i> spp.							4%			
<i>Peromonolites densus</i>	x				x					
<i>Peromonolites</i> spp.	+	+			x	x				+
<i>Perotritiles linearis</i>						+	x		x	x
<i>Perotritiles</i> spp.							1%			x
<i>Polypodiisporites</i> spp.		x				+				
<i>Retitritiles australoclavatidites</i>	+		x		+		3%	4%		+
<i>Retitritiles circolumenus</i>				x						
<i>Retitritiles semimuris</i>							x			
<i>Rugulatisporites mallatus</i>	cf.			x						
<i>Stereisporites antiquisporites/australis</i>	+	1%	+	1%	1%	+		+	+	+
<i>Stereisporites regium</i>	x	x	x	x	+	x			x	x
<i>Stereisporites maastrichtiensis</i>	x	+	+	x	x					
<i>Stereisporites</i> sp. A							14%	13%	x	x
<i>Triporoletes reticulatus</i>					x		+		2%	x
unassigned trilete spores	+			x		3%	14%	2%	1%	1%
Total cryptogams	4%	3%	3%	2%	5%	22%	73%	45%	7%	6%
POLLEN SUM	443	310	435	347	429	366	587	413	474	411
FUNGAL SPORES										
<i>Pesavis</i>	x			x	x					
unassigned morphotypes				18%	4%	20%		12%		
ALGAL CYSTS										
Amorphous types	10%									
<i>Botryococcus</i>		+	1%		1%	+	+	1%	2%	1%
<i>Saepodinium</i> cf. <i>gravattensis</i> (scabrate)					x					
Caved Cenozoic morphospecies										
<i>Aglaoreidia qualumis</i>	x									
Modern pollen contaminants	x					8%		11%	x	
Reworked Permo-Triassic spores			x	x				x		
Reworked Permo-Triassic gymnosperms	x							x		

2. Windermere coreholes

Morphospecies BH1 Windermere	27.5	32.5	45.65	48.3	76.2	100.0	152.5	175.2
Age/Age range	Early Eocene							
Gymnosperms								
<i>Araucariacites australis</i>	+		1%	1%	2%	2%	2%	3%
<i>Dacrycarpites australiensis</i>	+		+			x	+	x
<i>Dacrydiumites florinii</i>	+	x	4%	8%	6%	7%	5%	3%
<i>Dilwynites granulatus</i>	2%	5%	4%	19%	12%	7%	15%	13%
<i>Dilwynites tuberculatus</i>	x	+	1%	6%	5%	4%	4%	1%
<i>Ephredipites notensis</i>	+	2%	x	x	x	x	x	x
<i>Microalacidites palaeogenicus</i>				x			x	1%
<i>Microcachryidites antarcticus</i>	x	+	+	5%	2%	2%	2%	1%
<i>Parvisaccites catastus</i>				+	x	x	+	+
<i>Phyllocladidites mawsonii</i>	+	5%	+	11%	3%	4%	2%	4%
<i>Phyllocladidites reticulosaccatus</i>							x	
<i>Podocarpidites cf. torquatus</i>		x		x	x		x	x
<i>Podocarpidites spp.</i>	5%	24%	16%	24%	28%	27%	22%	27%
<i>Podosporites microsaccatus complex</i>	x	4%	6%	7%	5%	10%	20%	15%
Total gymnosperms	9%	47%	34%	80%	63%	60%	72%	71%
Angiosperms								
<i>Ailanthipites paenestriatus</i>	+			+	x	+		
<i>Arecipites</i>	+				+			x
<i>Banksiaeidites arcuatus</i>						+		
<i>Banksiaeidites elongatus</i>	+		+			+		
<i>Banksiaeidites spp.</i>			x	+	x			x
<i>Beaupreaidites elegansiformis</i>						x		
<i>Beaupreaidites verrucosus</i>					x	x	x	+
<i>Beaupreaidites sp. (scabrata)</i>					x			
<i>Bluffopollis scabratus</i>			x					
<i>Clavatipollenites glarius</i>		x		+				
<i>Clavastephanocolporites meleosus</i>		+						
<i>Cupanieidites orthoteichus</i>	+	x	+		x	x		x
<i>Dicolpopollis spp.</i>					x		x	x
<i>Dicottradites clavatus</i>	3%	2%	3%	2%	x	+	1%	+
<i>Drytopollenites semilunatus</i>			+	+		+	x	
<i>Ericipites spp.</i>								x
<i>Haloragacidites harrisii</i>	62%	8%	10%	2%	2%	+	+	x
<i>Gambierina rudata</i>	x	x	x		x	x		x
<i>Ilexpollenites sp.</i>			x	x				x
<i>Intratrirporopollenites notabilis</i>			x		x			x
<i>Liliacidites spp.</i>	1%		2%	+	+	+		
<i>Malvacipollis diversus</i>	x					+		
<i>Malvacipollis subtilis</i>	4%	3%	4%	2%	2%	+	+	x
<i>Milfordia homeopuncta</i>	+		x	x	+	x	2%	x
<i>Milfordia hypolaenoides</i>								x
<i>Myrtaceidites parvus-mesonesus</i>	3%	5%	2%			+		+

Morphospecies BH1 Windermere	27.5	32.5	45.65	48.3	76.2	100.0	152.5	175.2
Age/Age range	Early Eocene							
Angiosperms (cont.)								
<i>Nothofagidites asperus</i>	+	+	1%	1%	+	x	1%	3%
<i>Nothofagidites brachyspinulosus</i>	+	6%	8%	+	6%	9%	5%	5%
<i>Nothofagidites deminutus-vansteenisii</i>	2%	+	+	x	+		+	+
<i>Nothofagidites emarcidus</i> complex	+	11%	x	+		3%	1%	2%
<i>Nothofagidites flemingii</i>	+		1%	3%	6%	8%	6%	9%
<i>Nothofagidites goniatus</i>	+	+	+	x	x	+	1%	+
unassigned <i>Nothofagidites</i>				+	2%	3%	1%	+
<i>Peninsulapollis gillii</i>					x	x	+	x
<i>Periporopollenites demarcatus</i>	x	x	x	x	x	x		x
<i>Periporopollenites polyoratus</i>					x		x	x
<i>Periporopollenites vesicus</i>	x	x	x					
<i>Periporopollenites</i> spp.	1%		2%	+	1%	2%	3%	2%
<i>Polycolporopollenites esobalteus</i>	x		x					
<i>Propylipollis annularis</i>				x	x	x	x	x
<i>Proteacidites adenanthoides</i> complex	x		x	x		x	x	x
<i>Proteacidites alveolatus</i> complex	x	x	x	x	x	x	x	x
<i>Proteacidites angulatus</i>					x			
<i>Proteacidites asperopolus</i>			x					
<i>Proteacidites biporus</i>	cf.						x	
<i>Proteacidites beddoesii</i>			x					
<i>Proteacidites crassus</i> complex			x	x	x		x	x
<i>Proteacidites differentipolis</i>	x	x	x	x				
<i>Proteacidites grandis</i>	x	x		+	x	x		x
<i>Proteacidites incurvatus</i>		x	x	+			x	x
<i>Proteacidites kopiensis</i>				x	x			
<i>Proteacidites latrobensis</i>					x			
<i>Proteacidites leightonii</i>		1%	x	x				
<i>Proteacidites nasus</i>	x	x	x	+	x	x	x	
<i>Proteacidites obscurus</i>	x	x					x	
<i>Proteacidites ornatus</i>	cf.	x	x	x				
<i>Proteacidites pachypolus</i>	2%	2%	2%	+	x	x		x
<i>Proteacidites pseudomoides</i>	x							x
<i>Proteacidites recavus</i>			cf.			x		
<i>Proteacidites rectus</i>					x		x	x
<i>Proteacidites reticulosabratus</i> D&J							x	
<i>Proteacidites tenuixinus</i>	cf.							
<i>Proteacidites</i> sp. A								x
unassigned <i>Proteacidites</i> spp.	3%	6%	7%	2%	3%	3%	2%	3%
<i>Proxapertites operculatus</i>			x					
<i>Pseudowinterapollis wahooensis</i>								cf.
unassigned <i>Rhoipites</i> spp.	+	+	1%	x	+		+	x

Morphospecies BH1 Windermere	27.5	32.5	45.65	48.3	76.2	100.0	152.5	175.2
Age/Age range	Early Eocene							
Angiosperms								
<i>Striatotricolporites</i> sp.							x	
<i>Tetracolpites spherica</i>			x	x	x			
<i>Tetracolporites multistrixus</i> ms							x	x
<i>Tricolpites phillipsii</i>				x	x		x	x
<i>Tricolpites moultonii</i> ms			x		x	x		x
<i>Tricolpites trilobatus</i>		x	x	x	x	x	x	
<i>Tricolporites valvatus</i>				cf.	x	x	x	x
<i>Tricolpites</i> (apiculate)			x	x	+	x		
unassigned <i>Tricolpites</i> spp.	+		+	2%	2%	1%	2%	+
unassigned <i>Tricolporites</i> spp.	+	x	1%	+		2%	+	
<i>Tripoporollenites ambiguus</i>			x					
<i>Tripoporollenites</i> sp. (apiculate)						x	x	x
unassigned <i>Tripoporollenites</i> spp.			x	x			x	
unassigned angiosperm pollen	3%	1%	1%	+	2%	2%	+	1%
Total angiosperms	88%	49%	57%	18%	33%	37%	26%	28%
Cryptogams								
<i>Baculatisporites</i> spp.	+		+	+	+			
<i>Clavifera triplex</i>							x	
<i>Conbaculites apiculatus</i> ms	x	x	1%	x				
<i>Cyathidites australis/minor</i>	2%	+	+	+	3%	2%	+	1%
<i>Cyathidites splendens</i>		x			x			
<i>Dictyophyllidites arcuatus</i>		+	9%	+	x		+	
<i>Evansispora cenozoica</i>	cf.							
<i>Gleicheniidites</i> spp.	x	1%	1%	x	x	x	+	x
<i>Herkosporites elliotii</i>						x		x
<i>Kuylisporites waterbolkii</i>				x				
<i>Laevigatosporites major/ovatus</i>		+	+		+	+	+	+
<i>Peromonolites baculatus</i> ms								x
<i>Peromonolites</i> spp.				x	x			x
<i>Perotrilletes linearis</i>	cf.				x		x	
<i>Polypodiisporites</i> spp.	+	+			x	x	x	x
<i>Retitrilletes australoclavatidites</i> complex					x		+	
<i>Rugulatisporites mallatus</i>	x	+						
<i>Selagosporis</i> sp.					+			
<i>Stereisporites antiquisporites/australis</i>		+					x	x
<i>Stereisporites maastrichtiensis</i>				x	x	x		x
<i>Trilites tuberculiformis</i>		x					x	
<i>Triporoletes reticulatus</i>							x	
<i>Verrucosisorites kopukuensis</i>		x		x	x		x	
unassigned trilete spores	+	+					+	
Total spores	3%	4%	13%	1%	4%	3%	2%	1%
SPORE-POLLEN SUM	416	297	365	446	389	333	421	401

Morphospecies BH1 Windermere	27.5	32.5	45.65	48.3	76.2	100.0	152.5	175.2
Age/Age range	Early Eocene							
Caved spp. (Cenozoic)								
<i>Aglaoreidia qualumis</i>								x
<i>Tricolpites incisus</i>				x				
<i>Triporopollenites bellus</i>			x					
Reworked spp. Cenozoic								
<i>Gambierina rudata</i>	x	x	x		x			
<i>Gambierina tenuis</i> ms								x
Modern pollen contaminants	x							
Reworked Permo-Triassic spores				x		x	x	x
Reworked Permo-Triassic gymnosperms		+				x	x	x
Algal cysts (incl. dinocysts)								
<i>Botryococcus</i>		1%	2%	9%	3%	140%	+	1%
<i>Deflandrea pachyceros</i>				x	x	x		
<i>Saeptodinium</i> complex		2%	27%	16%	12%	23%	8%	1%
unassigned algal cysts	9%	+	19%	97%	43%	42%	10%	9%
Fungal spores								
unassigned morphotypes	14%	14%	10%	4%	10%	9%	3%	3%

Morphospecies BH 3 Windermere	31.05	33.75	46.05	53.85	62.95	73.10	90.52
Age/Age range	Middle Eocene						Paleocene
Gymnosperms							
<i>Araucariacites australis</i>	3%	4%	1%	+	+	2%	
<i>Dacrycarpites australiensis</i>	+			+		+	+
<i>Dacrydiumites florinii</i>	8%	4%	1%	+	5%	2%	2%
<i>Dilwynites granulatus</i>	12%	8%	1%	x	+	12%	+
<i>Dilwynites tuberculatus</i>	2%	2%	x	x	+	3%	+
<i>Ephredipites notensis</i>			x		x		
<i>Lygistepollenites balmei</i>	x						x
<i>Microalaticites palaeogenicus</i>	+	x	x	x	+	+	
<i>Microcachrydites antarcticus</i>	3%	1%	2%	2%	+	4%	3%
<i>Parvisaccites catastus</i>	+	x		x	+	+	+
<i>Phyllocladidites mawsonii</i>	2%	4%	2%	2%	4%	1%	22%
<i>Phyllocladidites verrucosus</i>							+
<i>Phyllocladidites reticulosaccatus</i>							x
<i>Podocarpidites cf. torquatus</i>	+	1%	x	x	x	x	x
<i>Podocarpidites spp.</i>	25%	29%	19%	76%	22%	35%	26%
<i>Podosporites microsaccatus complex</i>	8%	8%	46%	12%	48%	20%	27%
Total gymnosperms	69%	59%	73%	93%	81%	81%	83%
Angiosperms							
<i>Aglaoreidia qualumis</i>	+	cf.			1%		
<i>Anacolosidites acutullus</i>			x				
<i>Banksiaeidites elongatus</i>	+			x			
<i>Beaupreaidites elegansiformis</i>					x		
<i>Beaupreaidites verrucosus</i>	x	x	x	x	+		
<i>Dicolpopollis spp.</i>	x	x			x		
<i>Dicotradites clavatus</i>	1%	2%	2%	+	3%	2%	+
<i>Gambierina edwardsii</i>							x
<i>Gambierina rudata</i>							x
<i>Haloragacidites harrisii</i>	2%	4%	x	x	2%	1%	
<i>Ilexpollenites sp.</i>	x	x			+	x	
<i>Liliacidites spp.</i>	+	+	+			x	+
<i>Malvacipollis subtilis</i>	+	x			x	x	x
<i>Milfordia homeopuncta</i>	+		+	x	2%		
<i>Nothofagidites asperus</i>	5%	5%	+		+	+	+
<i>Nothofagidites brachyspinulosus</i>	6%	5%	+	+	+	+	+
<i>Nothofagidites deminutus-vansteenisii</i>			+				+
<i>Nothofagidites emarcidus complex</i>	4%	4%	2%	2%	+	2%	+
<i>Nothofagidites endurus</i>							+
<i>Nothofagidites falcatus</i>	+	x					
<i>Nothofagidites flemingii</i>	6%	7%	3%	x	2%	5%	4%
<i>Nothofagidites goniatus</i>	+	+	2%	x		1%	+
unassigned Nothofagaceae	2%	3%	+	+	+	+	1%

Morphospecies BH 3 Windermere	31.05	33.75	46.05	53.85	62.95	73.10	90.52
Age/Age range	Middle Eocene						Paleocene
Angiosperms (cont.)							
<i>Peninsulapollis gillii</i>	+	1%	x	+	+	2%	+
<i>Periporopollenites demarcatus</i>	x	x	x	x	x	x	x
<i>Periporopollenites polyoratus</i>	1%	3%	2%	x		2%	1%
<i>Periporopollenites vesicus</i>	x	x	x	x	x	x	
<i>Propylipollis annularis</i>	x		x	x		x	
<i>Proteacidites adenantoides</i> complex	x		x	x	x	x	
<i>Proteacidites alveolatus</i> complex		x	5%	x	3%		
<i>Proteacidites angulatus</i>	cf.					cf.	
<i>Proteacidites beddoesii</i>	x						
<i>Proteacidites crassus</i> complex	x	x		x	x	x	
<i>Proteacidites differentipolis</i>			x				
<i>Proteacidites incurvatus</i>	x	x	x	x	+	x	
<i>Proteacidites kopiensis</i>		x					
<i>Proteacidites leightonii</i>	cf.						
<i>Proteacidites nasus</i>			x				
<i>Proteacidites obscurus</i>	x						
<i>Proteacidites pseudomoides</i>					x		
<i>Proteacidites recavus</i>	x	x				x	
<i>Proteacidites rectus</i>			cf.				
<i>Proteacidites simulatus</i>	x	x					
<i>Proteacidites stipplatus</i>	cf.						
<i>Proteacidites tuberculiformis</i>						x	
<i>Proteacidites cf. angulatus</i>						x	x
unassigned <i>Proteacidites</i> spp.	2%	5%	8%	2%	2%	3%	6%
<i>Pseudowinterapollis cranwellae</i>	x						
unassigned <i>Rhoipites</i> spp.			x				
<i>Tetracolporites multistriatus</i> ms	x	x		x		x	
<i>Tricolpites phillipsii</i>						cf.	
<i>Tricolpites asperus</i>							x
<i>Tricolpites trilobatus</i>	x	+	+	x			
<i>Tricolpites</i> sp. A					x	x	
<i>Tricolpites</i> sp. (apiculate)	x						
unassigned <i>Tricolpites</i> spp.	+					x	+
<i>Tricolporites adelaidensis</i>					x		
<i>Tricolporites leuros</i>	x						
unassigned <i>Tricolporites</i> spp.	+	+	x	+	+	x	
unassigned angiosperm pollen	+	2%		+	+		+
Total angiosperms	30%	40%	26%	7%	18%	18%	16%

Morphospecies BH 3 Windermere	31.05x	33.75	46.05	53.85	62.95	73.10	90.52
Age/Age range	Middle Eocene						Paleocene
Cryptogams							
<i>Baculatisporites</i> spp.	x	+					
<i>Cingutritetes</i> spp.							
<i>Clavifera triplex</i>	x		+	x	+	x	
<i>Cyathidites australis/minor</i>	+	+	+	+	x	+	+
<i>Cyathidites splendens</i>		+					
<i>Dictyophyllidites arcuatus</i>	x						
<i>Evansispora senonica</i>	x						
<i>Gleicheniidites</i> spp.	x	x	x	x	+	x	x
<i>Herkosporites elliotii</i>	x				x	x	+
<i>Laevigatosporites major/ovatus</i>	+	+	x	x	+		+
<i>Latrobosporites marginis</i>			x				
<i>Peromonolites baculatus</i> ms						x	
<i>Peromonolites densus</i>							x
<i>Peromonolites vellosus</i>							x
<i>Polypodiisporites</i> spp.		x					x
<i>Retitritetes australoclavatidites</i> complex	+						x
<i>Rugulatisporites trophus</i>	x						
<i>Selagosporis</i> sp.						x	x
<i>Stereisporites antiquisporites/australis</i>	x			x	x		
<i>Stereisporites maastrichtiensis</i>	x	x		x		x	x
<i>Triporoletes reticulatus</i>				x			
<i>Verrucatosporites attinatus</i>	x						
<i>Verrucosporites kopukuensis</i>						x	
unassigned trilete spores		+				+	
Total cryptogams	+	2%	+	+	+	+	1%
SPORE-POLLEN SUM	402	278	315	303	440	293	397
Modern pollen contaminants			x				
Reworked Permo-Triassic spores		2%					
Reworked Permo-Triassic gymnosperms	1%	x					x
Algal cysts (incl. dinocysts)							
<i>Botryococcus</i>	+		+		2%		
<i>Morkallacysta pyramidalis</i>	x						
<i>Saepodinium</i> complex	15%	13%	2%	2%	5%	+	
Fungal spores							
<i>Pesavis</i>	x						
unassigned morphotypes	4%	7%	2%	3%	+	x	+

C. 'Northern' Tamar Graben

1. BB BH1 Bell Bay & BH1 Rowella

Morphospecies BB-BH1 Bell Bay	52.55- 52.60	113.77- 113.82	179.20- 179.30	245.30- 245.35	285.8-	287.0	288.4	289.25- 289.30	291.80- 291.84	BH1 Rowella 8.5
Age/Age range	Oligocene	Early Eocene			Paleocene (Thanetian)		Paleocene (Danian)			late Early Eocene
Gymnosperms										
<i>Araucariacites australis</i>	+	+	+	1%			+	+	+	
<i>Cupressacites</i>										
<i>Dacrycarpites australiensis</i>	+	+	+	+					1%	
<i>Dacrydiumites florinii</i>	3%	3%	11%	4%	x	+	+	2%	4%	3%
<i>Dilwynites granulatus</i>	+	1%	4%	2%	x	+		+	3%	+
<i>Dilwynites tuberculatus</i>		x	x	+				+	+	
<i>Ephrediptes noiensis</i>		+	x							3%
<i>Lygistepollenites balmei</i>					x	+	+	2%	3%	
<i>Microalatiidites palaeogenicus</i>	+				x	+	1%	2%	2%	
<i>Microcachryidites antarcticus</i>	7%	1%	5%	3%	x	x	2%	9%	8%	1%
<i>Parvisaccites catastus</i>	+	x		+			x	x	x	
<i>Phyllocladidites mawsonii</i>	12%	2%	2%	2%	79%	59%	58%	20%	26%	+
<i>Phyllocladidites reticulosaccatus</i>	+	x	+	x		x	+	x	x	
<i>Phyllocladidites verrucosus</i>										
<i>Podocarpidites cf. torquatus</i>		x	x	x		x	x	x	x	
<i>Podocarpidites</i> spp.	12%	11%	17%	39%	4%	14%	14%	26%	8%	10%
<i>Podosporites erugatus</i>	6%								cf.	
<i>Podosporites microsaccatus</i> complex	18%	3%	5%	25%	+	4%	3%	12%	8%	2%
Total gymnosperms	60%	21%	44%	78%	84%	79%	79%	74%	63%	20%
Angiosperms										
<i>Aglaoreidia qualumis</i>	+	x								+
<i>Ailanthipites paenestriatus</i>		x								+
<i>Anacolosidites acutullus</i>		x								
<i>Australopollis obscurus</i>					+		+	x	+	
<i>Banksiaeaidites arcuatus</i>		.	+							+
<i>Banksiaeaidites elongatus</i>				cf.						
<i>Banksiaeaidites</i> spp.		x								
<i>Beaupreaidites elegansiformis</i>	x		+	x						
<i>Beaupreaidites orbiculatus</i>								x	x	
<i>Beaupreaidites verrucosus</i>			x	x						
<i>Beaupreaidites</i> spp.	x								x	
<i>Cranwellipollis palisadus</i>									x.	
<i>Cupanieidites orthoteichus</i>		x								
<i>Dicolpopollis cf. metroxylonoides</i>				x						
<i>Dicolpopollis</i> spp.					x	x				
<i>Dicotetradites clavatus</i>	+	4%	6%	7%	x	x	x	2%	4%	6%
<i>Dryptopollenites semilunatus</i>		x		x						
<i>Ericipites</i> spp.	x	x								
<i>Gambierina edwardsii</i>							x			
<i>Gambierina rudata</i>					x	x	+	+	x	
<i>Gambierina tenuis</i>							x			
<i>Granodiporites nebulosus</i>	x									
<i>Haloragacidites harrisii</i>	2%	41%	3%	x		x	x	+	+	12%
<i>Illexpollenites</i> sp.	x	+						x	x	

Morphospecies BB-BH1 Bell Bay	52.55- 52.60	113.77- 113.82	179.20- 179.30	245.30- 245.35	285.8	287.0	288.4	289.25- 289.30	291.80- 291.84	BH1 Rowella 8.5
Age/Age range	Oligocene	Early Eocene			Paleocene (Thanetian)		Paleocene (Danian)			late Early Eocene
Angiosperms (cont.)										
<i>Intratropipollenites notabilis</i>		x	+							+
<i>Liliacidites</i> spp.			+					x		2%
<i>Malvacipollis diversus</i>		x	x							
<i>Malvacipollis subtilis</i>		2%	5%	x						2%
<i>Milfordia homeopuncta</i>		+	2%							
<i>Myrtaceidites eucalyptoides</i>	x									
<i>Myrtaceidites parvus-mesonesus</i>			x							1%
<i>Nothofagidites asperus</i>	1%		x	+	x	+	x	x	+	+
<i>Nothofagidites brachyspinulosus</i>	3%	6%	6%	2%	x	+	+	2%	2%	13%
<i>Nothofagidites deminutus-vansteenisii</i>	x									
<i>Nothofagidites emarcidus</i> complex	17%	5%	3%	x	+	2%	1%			5%
<i>Nothofagidites endurus</i> complex			x		x	+	2%	+	+	
<i>Nothofagidites falcatus</i>	+									
<i>Nothofagidites flemingii</i>	+	2%	5%	2%	+	2%	2%	1%	2%	1%
<i>Nothofagidites goniatus</i>		x	+	+						+
<i>Nothofagidites vansteenisii</i> complex										1%
unassigned Nothofagaceae	x	x	x		x				+	
Total <i>Nothofagidites</i>	21%	13%	14%	6%	+	5%	6%	2%	4%	20%
<i>Peninsulapollis gillii</i> vars.				x	+	1%	2%	x	x	
<i>Periporopollenites demarcatus</i>		x	x	x						1%
<i>Periporopollenites polyoratus</i>	x	x	x	x	x	x	+	+	+	
<i>Periporopollenites vesicus</i>	x	x								
<i>Periporopollenites</i> spp.	2%	2%	+	2%				+	2%	
<i>Poluspissusites ramus</i>	x									
<i>Polycolpites langstonii</i>								x		
<i>Polycolporopollenites esobalteus</i>		x								
<i>Propylipollis annularis</i>	x		x	x		+	x			
<i>Proteacidites adenanthoides</i> complex		x				x	x.	x	x	+
<i>Proteacidites alveolatus</i> complex		x	x							
<i>Proteacidites angulatus</i>			x			x	cf.	cf.		
<i>Proteacidites crassus</i> complex		x				x		x		x
<i>Proteacidites grandis</i>		x								
<i>Proteacidites incurvatus</i>		+	2%			x				
<i>Proteacidites leightonii</i>										x
<i>Proteacidites nasus</i>		1%								x
<i>Proteacidites obscurus</i>			x.							
<i>Proteacidites ornatus</i>		x								
<i>Proteacidites pachypolus</i>		7%								
<i>Proteacidites pseudomoides</i>			+			x				
<i>Proteacidites scaboratus</i>	x	x	x	x				x	x	
<i>Proteacidites stipplatus</i>	x	cf.								
<i>Proteacidites tenuixinus</i>						x	x			
<i>Proteacidites</i> cf. <i>alveolatus</i>		x	x	x				x	x	
<i>Proteacidites</i> (apiculate)										
unassigned <i>Proteacidites</i> spp.	+	8%	8%	4%	5%	5%	4%	4%	6%	1%
<i>Proxapertites operculata</i>			2%							
<i>Pseudowinterapollis cranwellae</i>								x		

Morphospecies BB-BH1 Bell Bay	52.55- 52.60	113.77- 113.82	179.20- 179.30	245.30- 245.35	285.8	287.0	288.4	289.25- 289.30	291.80- 291.84	BH1 Rowella 8.5
Age/Age range	Oligocene	Early Eocene			Paleocene (Thanctian)		Palaeocene (Danian)			late Early Eocene
Angiosperms (cont.)										
<i>Rhoipites scabratus</i>	x	x								
unassigned <i>Rhoipites</i> spp.										2%
<i>Santalumidites cainozoicus</i>										x
<i>Striatotricolporites</i> sp.				x						
<i>Tetracolpites</i> spp.	x	+						x		
<i>Tetracolporites multistrixus</i> ms				x	x		x		x	
<i>Tetracolporites textus</i> ms					x	x				
<i>Tetracolporites palynius</i>		x								
<i>Tetracolporites verrucosus</i>							cf.			
<i>Tetracolporites</i> sp.							+			
<i>Tricolpites asperus</i>		x	x						x	
<i>Tricolpites trilobatus</i>		x								
<i>Tricolpites confessus</i>								cf.	cf.	
<i>Tricolpites phillipsii</i>					x	x		x	+	
<i>Tricolpites waiparaensis</i>										
<i>Tricolpites</i> sp. A								x	x	
<i>Tricolporites leuros</i>	4%									
<i>Tricolporites adelaidensis</i>	x						x	x	x	
<i>Tricolporites moultonii</i> ms			+							
<i>Tricolporites</i> sp. nov.									x	
unassigned <i>Tricolpites</i> spp.	4%	x	2%	+	x	+	1%	+	1%	
unassigned <i>Tricolporites</i> spp.	3%	+	6%	+		x	+	+		
<i>Triporopollenites ambiguus</i>	x	x	x							cf.
unassigned <i>Triporopollenites</i> spp.	+	+					x			
unassigned angiosperm pollen	2%	x	2%	x				1%	+	
Total angiosperms	38%	78%	49%	20%	6%	11%	15%	14%	19%	67%
Cryptogams										
<i>Baculatisporites</i> spp.	+	+		x	+	x		+	+	+
<i>Camarozonosporites eyrensis</i> ms								x	x	
<i>Cingutriteles</i> spp.					x	x	x			
<i>Clavifera triplex</i>				x		x	x		x	
<i>Conbaculites apiculatus</i> ms		x			?					
<i>Cyathidites australis/minor</i>	+	+	x	x			x	+	x	4%
<i>Cyathidites splendens</i>		x	x					x	+	
<i>Foveotriteles palaequetrus</i>	x									
<i>Gleicheniidites</i> spp.		x	x	+	+	7%	x	6%	10%	
<i>Herkosporites elliotii</i>		x					x	x	x	
<i>Laevigatosporites ovatus/major</i>	+	x	x	+	+	+	1%	2%	4%	6%
<i>Latrobosporites amplus</i>						x		x	x	
<i>Latrobosporites crassus</i>	x					+	+	+		+
<i>Neoraistrickia equalis</i>							x			
<i>Peromonolites densus</i>									x	
<i>Peromonolites</i> sp.	x							+		
<i>Perotriteles linearis</i>								+		
<i>Perotriteles senonica</i>										
<i>Polypodiisporites</i> spp.		x						x	x	
<i>Retitriteles australoclavatidites</i> complex	+					x	x	x	+	
<i>Retitriteles circolumenus</i>					x				x	
<i>Rugulatisporites mallatus</i>							x			

Morphospecies BB-BH1 Bell Bay	52.55- 52.60	113.77- 113.82	179.20- 179.30	245.30- 245.35	285.8	287.0	288.4	289.25- 289.30	291.80- 291.84	BH1 Rowella 8.5
Age/Age range	Oligocene	Early Eocene			Paleocene (Thanetian)		Paleocene (Danian)			late Early Eocene
Cryptogams (cont.)										
<i>Stereisporites antiquisporites/australis</i>	x			+	9%	3%	4%	3%	2%	
<i>Stereisporites maastrichtiensis</i>		x	x		+	x	+	x	x	
<i>Stereisporites regium</i>								x		
<i>Triporoletes reticulatus</i>										
unassigned trilete spores				+						+
Total cryptogams	2%	2%	8%	2%	10%	11%	6%	12%	17%	12%
POLLEN SUM	373	328	387	393	316	400	370	398	421	366
Caved Cenozoic pollen										
<i>Granodiporites nebulosus</i>			x							
Modern pollen contaminants										
Reworked Permo-Triassic spores	x									
Reworked Permo-Triassic gymnosperms	x	x	x					x	x	
Algae										
acritarch							+			
<i>Botryococcus</i>	+				+	+		+		
<i>Saeptodinium</i>			2%	1%				1%		
Fungal spores										
<i>Pesavis</i>	x									
indet. fungal spores	+	2%	4%	9%	+	+	+	1%	2%	

APPENDIX 5

Macrofossil analyses.

Samples of Bell Bay-1, Lawrence Vale-1 and Englewood-1 core sediment from various depths were examined for plant remains. Approximately 5g of sediment per sample was gently macerated in warm water containing about 5% hydrogen peroxide, followed by sieving through a 300 µm sieve. The sieved residue was then soaked in household bleach (sodium hypochlorite 42 g/L) for ~ 1 hr to clear mesophyll from cuticles, and the cuticles were rinsed, stained with safranin O, placed in a petri-dish with water and further searched. Cuticular fragments were picked out using fine forceps and mounted on glass slides in glycerine jelly for light microscopy and photography (Nikon E200 microscope with Tucsen 5.0 megapixel digital camera).

Samples that have so far yielded cuticular remains are all from intervals that have been determined palynologically to belong to the Lower *L. balmei* Zone equivalent (Paleocene: ~Early Thanetian to 'mid' Danian): i.e. Bell Bay-1, 285.8 m, 287 m, 288.4 m; Lawrence Vale-1, 52.8 m; Englewood-1, 103.9 m, 109.4 m.

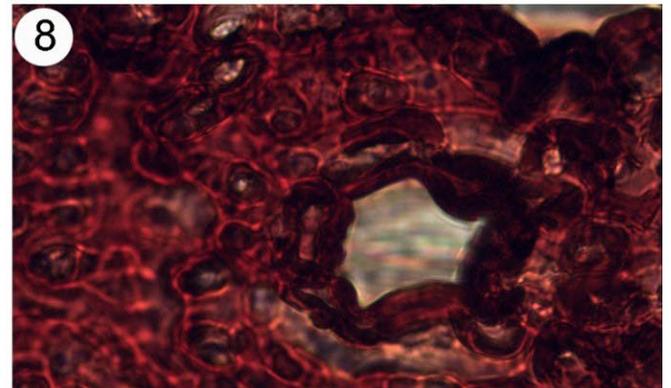
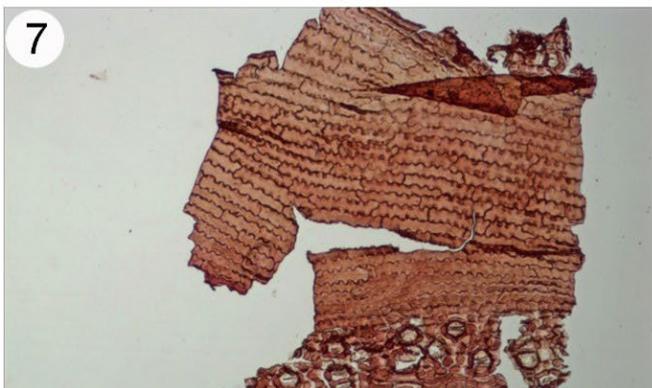
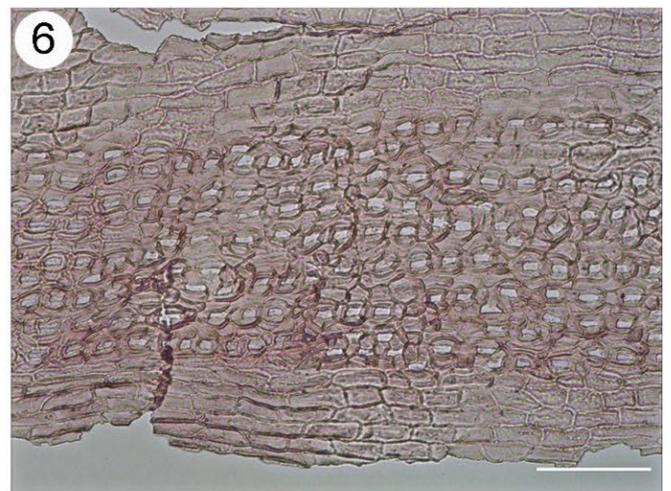
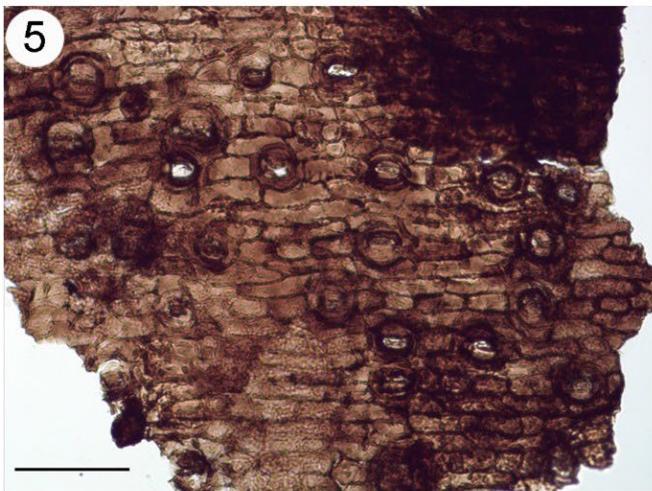
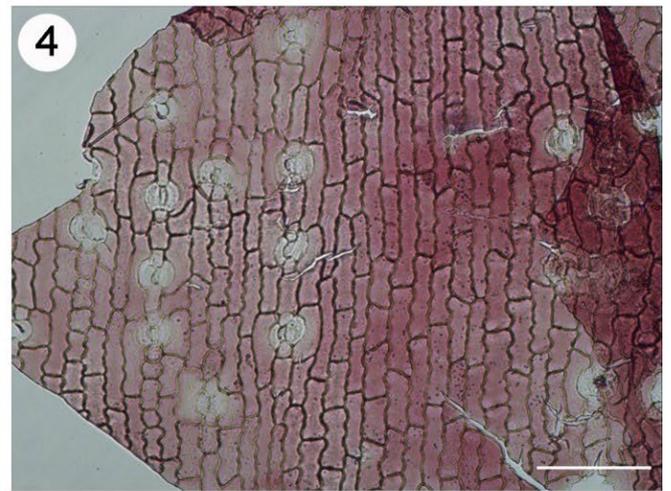
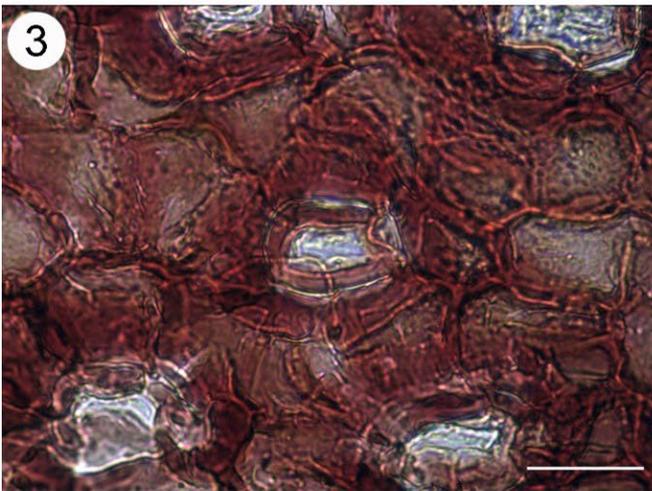
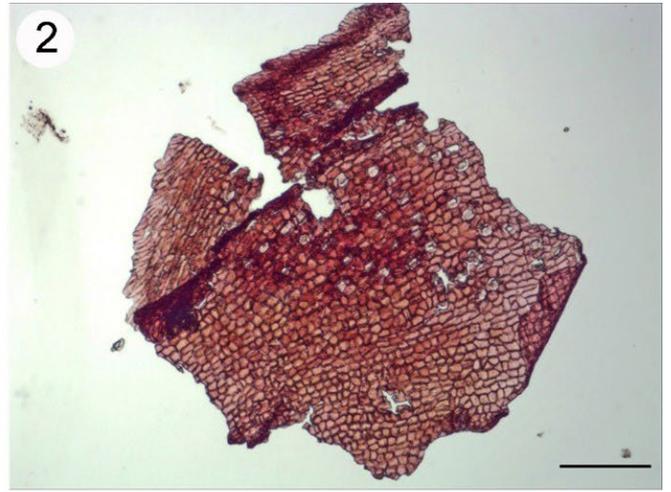
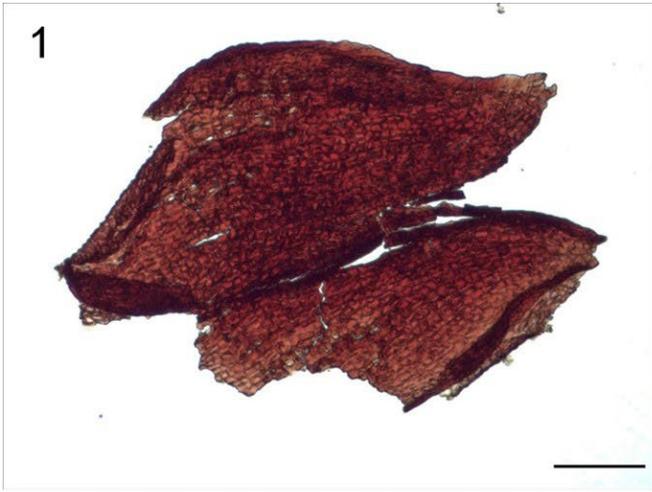
Collectively, the samples show evidence of the presence of abundant conifers, notably including certain frill-margined, scale-leaved Podocarpaceae (Figs 1–3, 17, 18) and some extinct taxa (Figs 7–9, 15). Angiosperms were not diverse, but included several Proteaceae (Figs 11, 12, 21). Absence of Lauraceae and any evidence of Myrtaceae (especially 'syzygioid' cuticles) and Cunoniaceae/Elaeocarpaceae suggests local absence of closed rainforest vegetation. A single type of monocot cuticle was recovered (Fig. 13). Clumped pollen was noted (Fig. 20), indicating low energy input from *in situ* sources. Overall, the foliar remains do not contradict the palynological evidence that the Tamar Graben sediments mostly accumulated within regional swampy conditions that supported open forest or coniferous heathy vegetation. The nearest living relatives of the scale-leaved podocarps are now mostly restricted to cool to cold and wet regions at high latitudes in Tasmania, New Zealand and Patagonia. So far, the palynologically dated latest Cretaceous intervals in Englewood-1 have not yielded useful macrofossil remains (R. Carpenter, in prep.)

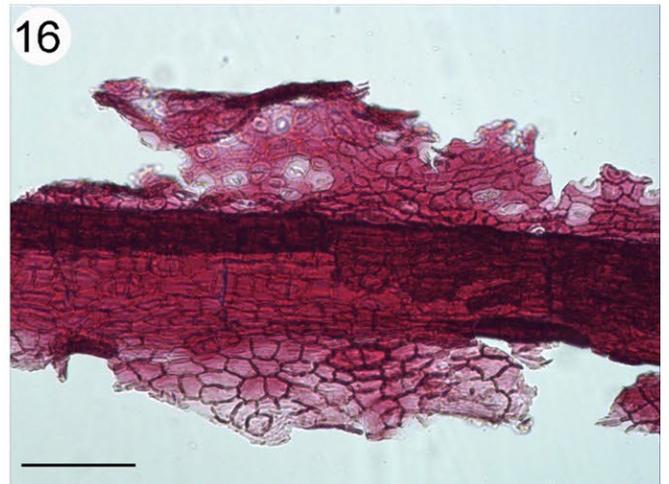
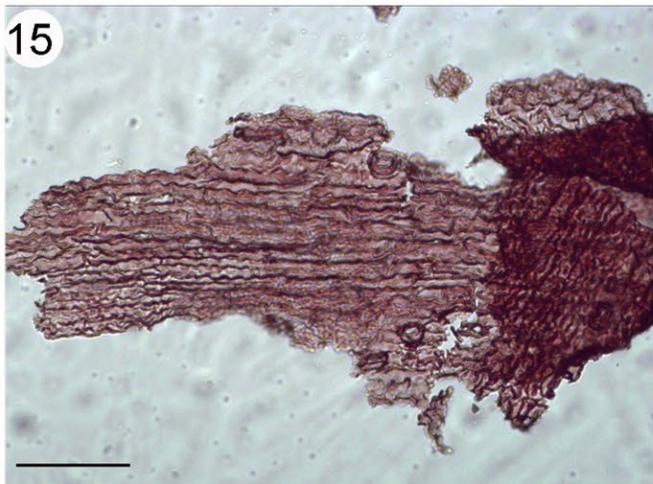
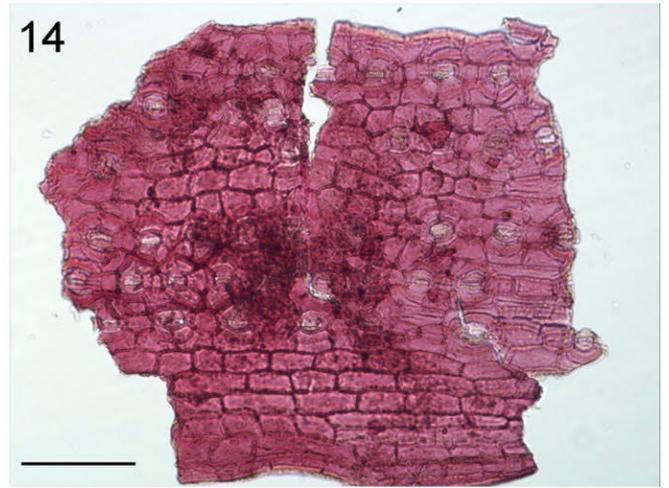
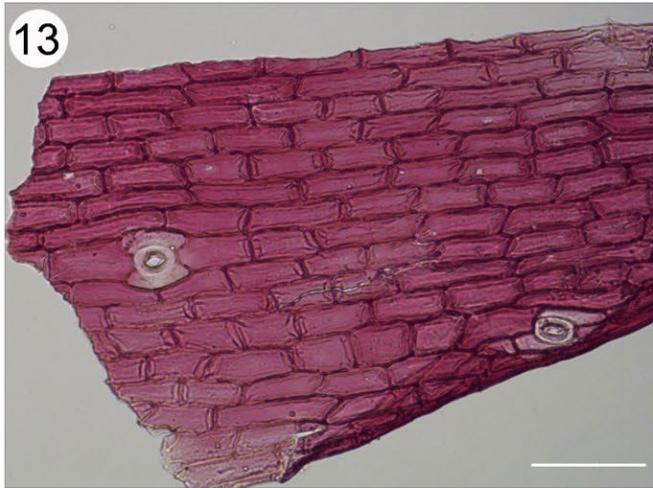
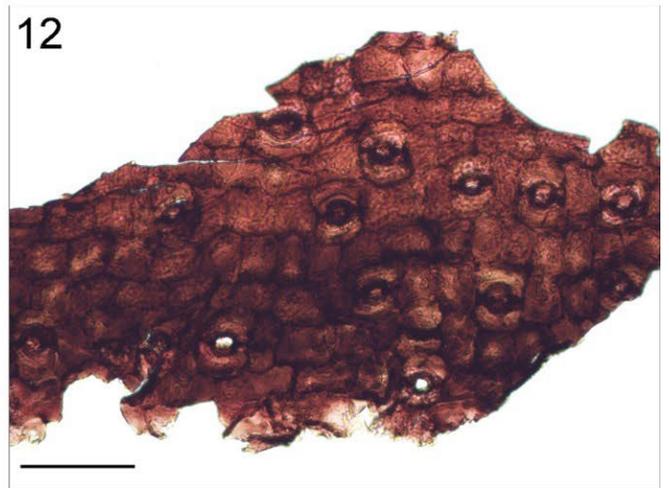
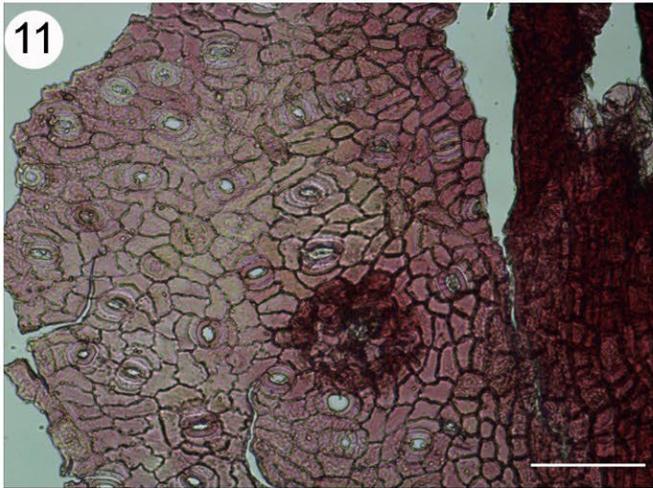
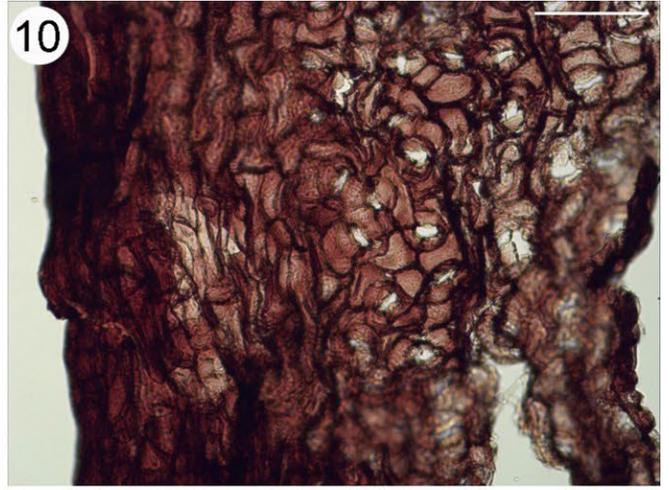
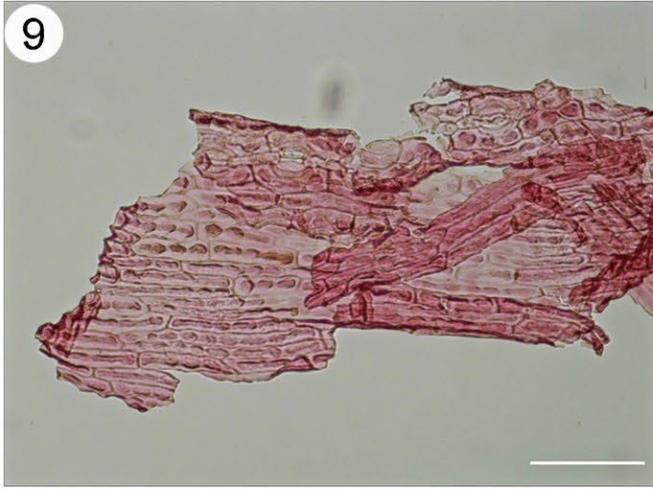
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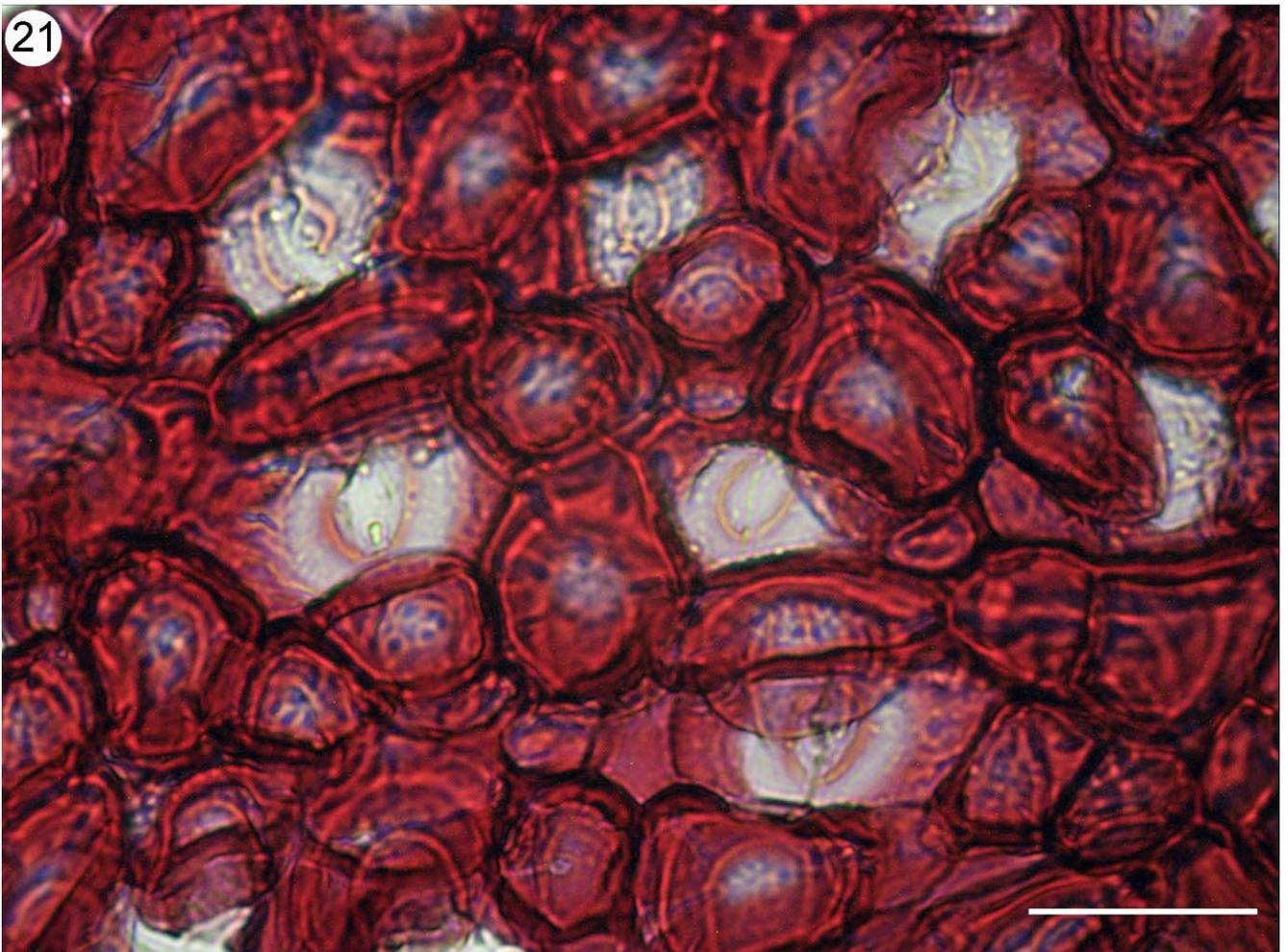
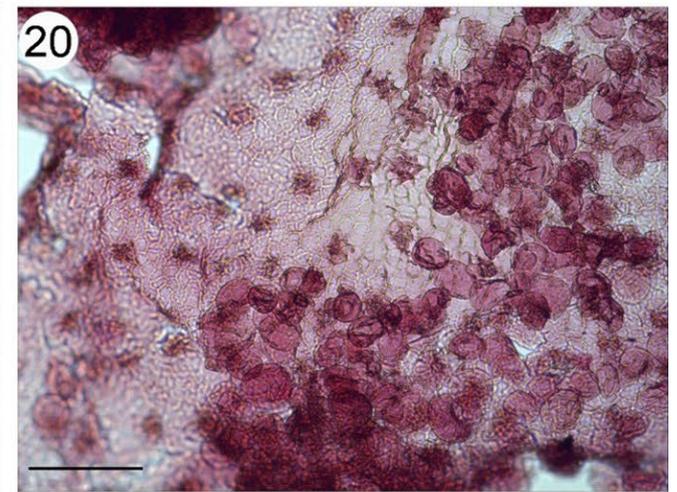
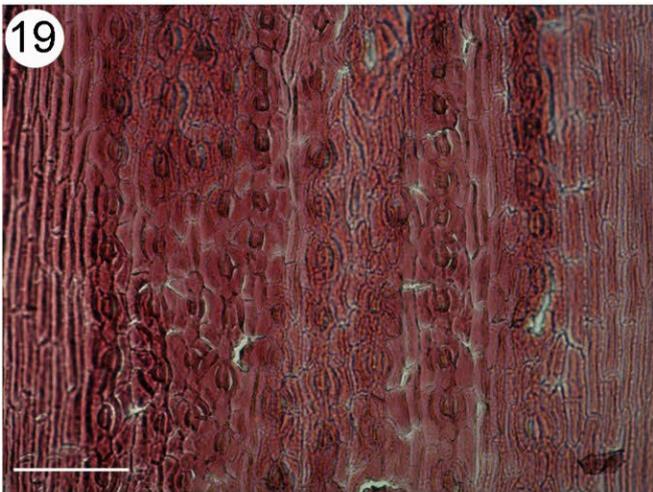
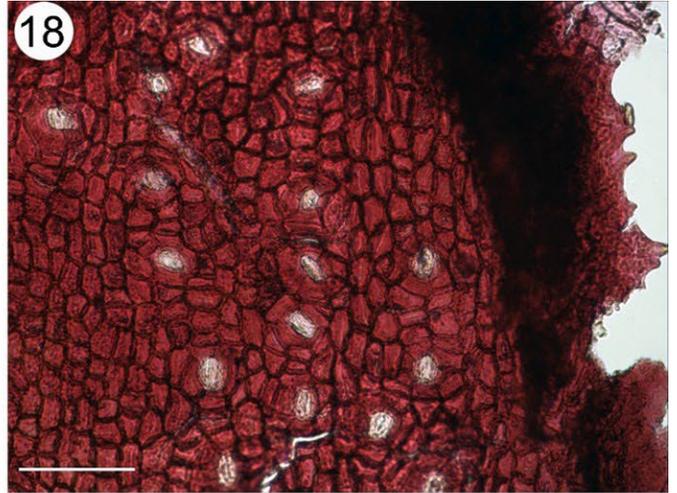
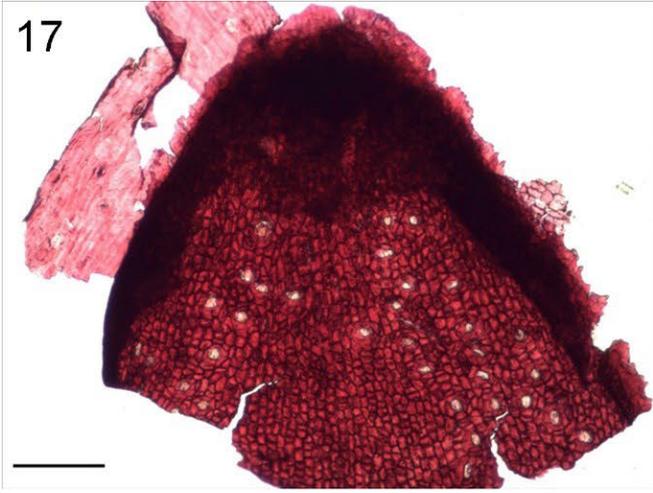
Figs 1–8. Coniferous cuticles from Bell Bay-1. **1.** Frill-margined, scale-leaved Podocarpaceae (podocarp taxon 1) with parallel-aligned stomata (287 m). **2, 3.** Frill-margined, scale-leaved Podocarpaceae (podocarp taxon 2) with parallel-aligned stomata with Florin rings (287 m). **4.** Podocarp taxon 3 (287 m). **5.** Podocarp taxon 4 (288.4 m). **6.** Podocarp taxon 5 (287 m). **7, 8.** Extinct conifer showing tightly sinuous epidermal walls, stomatal zone with papillae, and sunken guard cells (287 m, 285.8 m). Scale bars = 200 µm for 1, 2; 100 µm for 4–7; 25 µm for 3, 8.

Figs 9–16. Cuticles from Bell Bay-1 (**9–13**) and Englewood-1 (**14–16**). **9.** ?podocarp with surface papillae (285.8 m). **10.** ?Araucariaceae (288.4 m). **11.** Proteaceae, probably subfamily Grevilleoideae (287 m). **12.** ?Proteaceae (similar to subfamily Persoonioideae, tribe Persoonieae) (287 m). **13.** Monocot (287 m). **14.** Podocarpaceae (103.9 m). **15.** ? extinct podocarp (109.4 m). **16.** Proteaceae with very small stomata (103.9 m). Scale bars = 100 µm.

Figs 17–21. Cuticles from Lawrence Vale-1 (52.8 m). **17, 18.** Frill-margined, scale-leaved podocarp with randomly oriented stomata. **19.** Podocarp. **20.** Note pollen mass adhered to cuticle. **21.** Proteaceae with stomata shielded by large surface papillae. Scale bars = 200 µm for 17; 100 µm for 18–20; 25 µm for 21.









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