Early Oligocene age for top of Latrobe reservoirs in Tommyruff-1 and Wyrallah-1, southwest Gippsland Basin.

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INTERPRETATIVE DATA

Summary

Palynological analysis of new cuttings samples from across the top of Latrobe Group in the offshore Tommyruff-1 and Wyrallah-1 wells has found the *Fromea leos* microplankton Zone at the base of the marine carbonates in both wells and the Upper *Nothofagidites asperus* Zone from the shallowest coal seam within the Latrobe Group in Wyrallah-1. Unfortunately, the sample at the equivalent stratigraphic level in Tommyruff-1 was too badly contaminated by downhole cavings to provide a reliable zone determination. Comparison of these results with the nearby Kyarra-1A well and those onshore wells in which there are comparable palynological analyses indicates that in Wyrallah-1 and probably Tommyruff-1 the youngest Latrobe Group reservoirs are basal Early Oligocene in age. As the sandstones of this age apparently pinch out seaward into the basal marls and calcareous claystones of the Seaspray Group they potentially create a stratigraphic component to any top-of-Latrobe structures in the most western part of the offshore Gippsland Basin.

Introduction

The study was performed at the initiative of Dr Tom Bernecker for the Minerals & Petroleum Division of the Department of Primary Industries as part of their review of open exploration acreage. The primary objective was to investigate the age of uppermost Latrobe Group because the available palynological reports suggested that the reservoir sandstones could extend into the Early Oligocene. Unfortunately, the analyses had to be performed on cuttings because neither the original palynological slides nor any remaining sidewall core material could be located in time for this review. Cutting samples were also collected and analysed from the base of the overlying Seaspray Group to gain some control on the assemblages that were likely to be caving from the overlying carbonates. Results from the samples analysed are provided in Table 1, while the key identification criteria and calibration between the spore-pollen and microplankton zonal schemes are summarised in Figure 1.

The materials analysed consist of two new cuttings samples from each well collected from the Department of Primary Industries Minerals & Petroleum Core Library at Werribee, on Friday 29th November 2002. Laboratory processing of the new cuttings samples and preparation of new slides from the residues was performed by Laola Pty Ltd in Perth. Between 13 and 15 grams of the cuttings were processed to give mostly low organic residue yields containing moderate to high palynomorph concentrations (Tables 2 & 3). Palynomorph preservation varied from poor to good, and the samples contained an average diversity of 29+ spore-pollen species, and 12+ species of microplankton per sample. The species recorded during the microscope examination are listed in Tables 4 and 5. Author citations for spore-pollen species can be sourced from Stover & Partridge (1973, 1982), and for the microplankton from indexes compiled by Fensome *et al.* (1990) and Williams *et al.* (1998). Manuscript species are indicated by either “ms” or “†” after their binomial.

In the following sections the assemblages recovered from the new samples are discussed first and this is followed by a comparison between the new results and the previous palynological studies and a discussion of how both relate to the interpretation of the stratigraphy encountered in the wells.

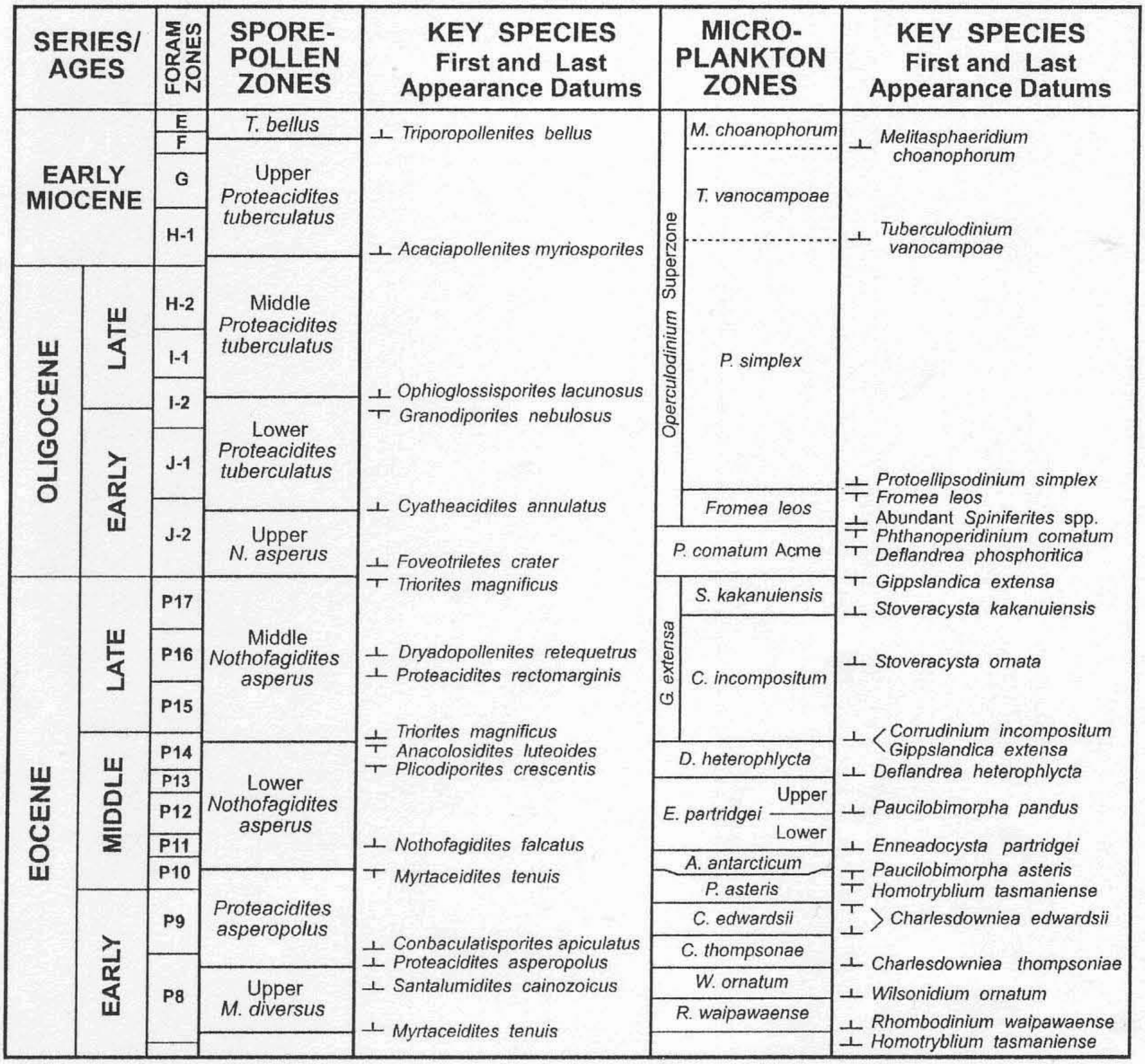

Figure 1. Spore-pollen and microplankton zones and their key defining species events relative to Gippsland Basin and international planktonic foraminiferal zonal schemes and standard ages. Note that vertical scale on diagram is not proportional to any chronometric scale.

Discussion of Assemblages

Fromea leos Zone of the *Operculodinium* microplankton Superzone, and *Proteacidites tuberculatus* spore-pollen Zone
Tommyruff-1 at 898 metres and caved to 928 metres, and Wyrallah-1 at 872-75 metres
Age: Early Oligocene.

The samples analysed from the basal Seaspray Group gave assemblages dominated by dinocysts (total MP estimated to be >70%) typical of the *Operculodinium* Superzone. Species of the genus *Spiniferites* overwhelmingly dominate the microplankton, with *Operculodinium centrocarpum* the next most commonest form. Although all other dinocyst species were rare to only occasionally frequent the presence of the acritarch species *Fromea leos* sp. nov. is diagnostic of the lowest zone recognised within the Superzone (Figure 1). The associated spore-pollen assemblages are assigned to the *P. tuberculatus* Zone based on presence of *Cyatheacidites annulatus*. This spore could be caved however because where there is detailed sidewall core sampling other wells the FAD[1] of *C. annulatus* occurs within the *F. leos* Zone (Figure 1). None of the other spore-pollen species recorded are restricted to the zone.

The deeper cuttings sample in Tommyruff-1 at 928m, which on the electric logs should be below the top of the Latrobe Group, unfortunately contained an essentially identical assemblage and is therefore interpreted to be substantially caved. Macphail (1990) encountered similar problems of downhole contamination (described as bioturbation) and uphole reworking in his examination of the sidewall cores from Tommyruff-1. Examples are his anomalous deep record of *Cyatheacidites annulatus* in the sidewall core at 922.4m, and the unusually shallow record of the Late Eocene species *Triorites magnificus* in the sidewall core at 897m and *Gippslandica extensa* even shallower in the sidewall core at 852m. The former species does not overlap with the latter two species in the standard zonation schemes illustrated in Figure 1. A number of other typical Late Eocene index species were also recorded in sidewall cores above the top-of-Latrobe by Macphail (1990). However, as equivalent species overlaps were not found in this study, the earlier results from the sidewall cores must be considered suspect until the original palynological samples can be checked.

Upper *Nothofagidites asperus* spore-pollen Zone
Wyrallah-1 at 884-87 metres
Age: basal Early Oligocene.

The deeper sample examined in Wyrallah-1 contains a spore-pollen dominated assemblage with abundant *Nothofagidites* pollen (>50%), and the common occurrence of *Phyllocladidites mawsonii* and *Haloragacidites harrisii* (both >10%). When combined with the frequent occurrence of *Proteacidites stipplatus* and presence of *Aglaoreidia qualumis*, without associated older or younger index species, the overall character of the assemblage is considered typical of the Upper *N. asperus* Zone as originally defined by Stover & Partridge (1973; p.243). The associated microplankton are rare (est. <5% of total SP + MP), dominated by *Spiniferites* spp. and are all considered to be caved from the Seaspray Group. The gross composition of the spore-pollen assemblage is also consistent with the sample being a coal and coming from shallowest and thickest coal in Wyrallah-1, which is identified between 877.5 and 887.5m on the electric logs.

Geological Discussion

The wells Tommyruff-1 and Wyrallah-1, located in the westernmost offshore Gippsland Basin, are unusual in that they lack any clear manifestation of the Middle to Late Eocene Gurnard Formation at the top of the Latrobe Group. Instead, the palynological assemblages reported in the previous studies by Martin (1984a) and Macphail (1990) suggest the shallowest reservoir sandstones of the Latrobe Group were either younger or equivalent in age to the Gurnard Formation. A similar relationship is known to occur in the onshore Gippsland Basin in the St Margaret Island-1 well to the west, and the Burong-1 and Darriman-1 wells to the north. In these wells the age of the youngest Latrobe Group is Early Oligocene (= Upper *N. asperus* Zone) and there is no obvious Gurnard Formation developed (Partridge & Stover, 1971; Partridge, 1978; Partridge & Macphail, 1996). In this study of new cuttings samples, the evidence from the Tommyruff-1 well proved to be equivocal, but a confident Early Oligocene Upper *N. asperus* Zone age was obtained for the shallowest coal penetrated in Wyrallah-1. A review of the previous palynological studies from Kyarra-1A, and log correlations to this well, are interpreted to show how the shallowest coal and associated sandstones in Wyrallah-1 pinch out and are a lateral facies of the basal carbonate sediments in Kyarra-1A (Figure 2).

[1] FAD = First Appearance Datum

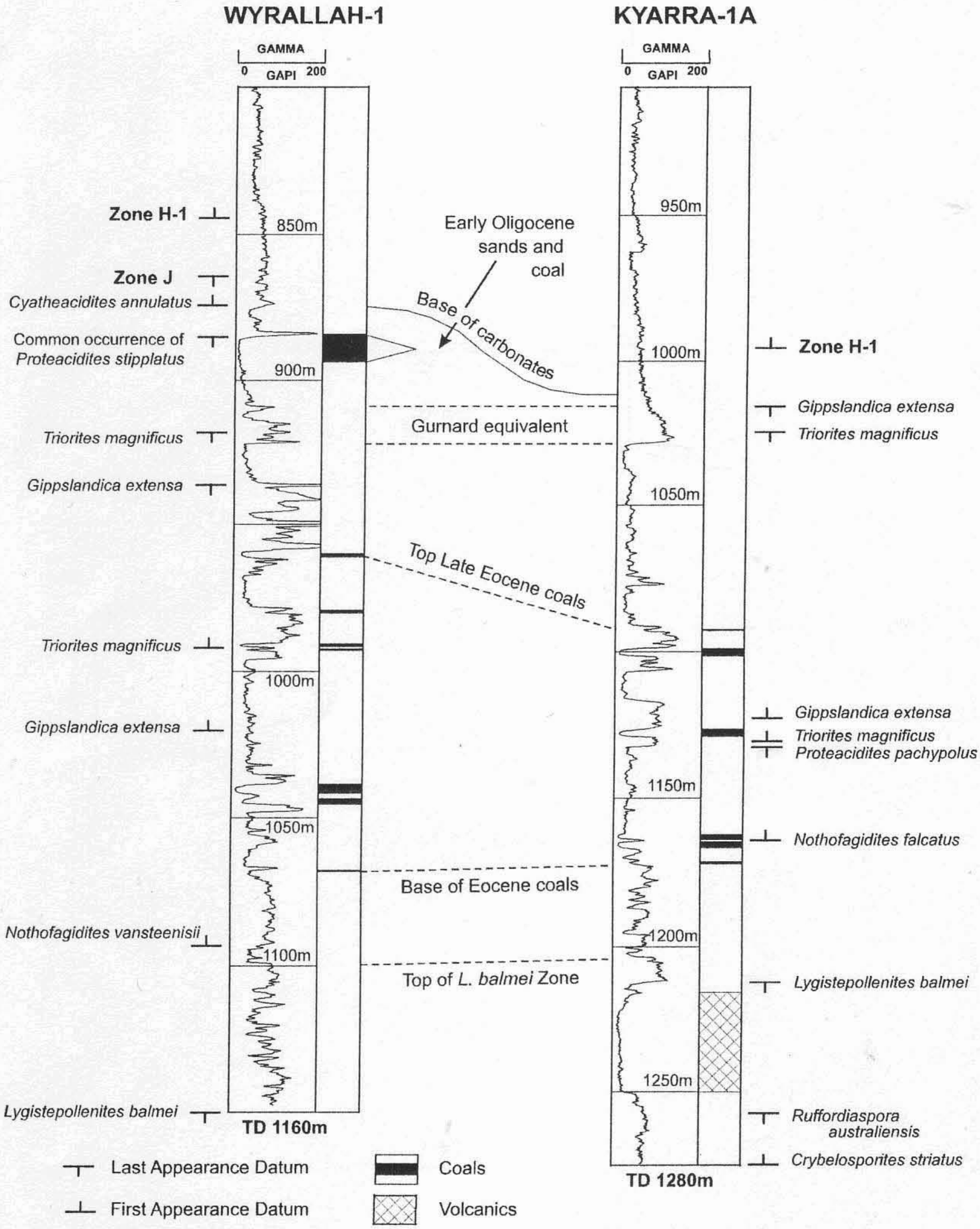

Figure 2. Key palynological First and Last Appearance Datums and suggested gamma ray log correlations between Wyrallah-1 and Kyarra-1 in the offshore Gippsland Basin.

Tommyruff-1.

In Tommyruff-1 the top of the Latrobe Group is placed at 900mMDKB on the well completion log, where on the cuttings descriptions dark grey to olive green marl with only a **trace** of glauconite is recorded as overlying white to translucent quartz sandstones with some grains showing orange-brown staining. A slightly elevated gamma ray response does occur from 896 to 900m, but SWC 49 at 897m is described as a olive grey **marl** with common pelletoidal glauconite, which the author would place in the basal Seaspray Group because of the high carbonate content. The Gurnard Formation in contrast is typically either not calcareous or only slightly calcareous (Partridge, 1999). The overlying SWCs 50 to 53 are also marls, but with only minor to trace amounts of glauconite, while the next deeper sample SWC 48 at 900m lies on the lithological boundary. This samples is described as composed of dark brown claystone, white translucent sandstone and dark green pelletoidal glauconite. Unfortunately, the proportions between these three lithological components was not specified. In the authors opinion only this sample is lithologically similar to the Gurnard Formation. The next group of sidewall cores between 902 and 917.1m are all described as sandstones without any recorded glauconite.

Macphail (1990) provisionally assigned the sidewall cores at 897m and 900m in Tommyruff-1 to the Upper *N. asperus* Zone based on the higher proportion of spore-pollen to microplankton, but also noted the presence of anomalous species due to either uphole reworking or downhole contamination (bioturbation). He placed the top of the older Middle *N. asperus* Zone in SWC 42 at 922.4m based on the presence of *Triorites magnificus* in a spore-pollen dominated microflora. The intervening sidewall cores between 902 and 917.1m were not analysed for palynology because of their unfavourable lithologies.

The two new cuttings analysed from Tommyruff-1 are dominated by microplankton and therefore relative to the spore-pollen dominated assemblages reported from the equivalent sidewall cores by Macphail (1990), they are probably substantially caved. The assemblages do however confirm that the Early Oligocene *Fromea leos* microplankton Zone lies near the base of the Seaspray Group in the well (Figure 1). Notably absence from the cuttings was any evidence of mixing of species ranges or reworking of Late Eocene fossils into the basal Seaspray Group as was apparent in the sidewall cores. Amalgamating the data from both palynological studies the author’s preferred interpretation is that the interval 896 to 900m belongs to the Upper *N. asperus* Zone as might the uppermost sandstone unit between 900 and 921m. In contrast, the typical Gurnard Formation of Middle *N. asperus* Zone age is not present, but is instead represented by the age equivalent sandstones and underlying interbedded shales between 921 and 1062m.

Wyrallah-1.

The top of the Latrobe Group in Wyrallah-1 is placed at 874m on the well completion log, where on the cuttings descriptions light to medium grey **calcareous claystone** with very common glauconite overlies first, a 10 metre thick medium grey to light brown sandstone bed, and then, a 10 metre thick lignitic coal seam. Although the interval 838 to 874m shows an elevated gamma ray response it cannot be assigned to the Gurnard Formation because it is highly calcareous and also contains Early Oligocene and Early Miocene foraminiferal faunas (Taylor, 1984).

In the original palynological study by Martin (1984a) the age of the youngest Latrobe Group is poorly constrained as the shallowest four sidewall cores analysed at 870m, 878m, 880m and 887m contain very limited assemblages that cannot be reliably assigned to any zone. However, the next deepest sidewall core analysed at 918m can be confidently assigned to the Late Eocene Middle

N. asperus Zone based on the LAD[2] of *Triorites magnificus*. The two new cuttings analysed from Wyrallah-1 yielded good assemblages which provide a *Fromea leos* Zone assignment for the base of the carbonates and an Upper *N. asperus* Zone assignment for the shallowest coal, and thus clearly place the top of the Latrobe Group within the Early Oligocene (Figure 1).

The significance of the above zone assignments is illustrated by palynological and log correlations between Wyrallah-1 and Kyarra-1A located 9 km due east (Figure 2). In the latter well the Gurnard Formation is clearly represented between 1013 and 1028m by a high gamma ray signature and the glauconitic-rich lithologies described from both the cuttings and sidewall cores. The identification is confirmed by the recovery of good Late Eocene palynomorph assemblages belonging to both the Middle *N. asperus* and *G. extensa* Zones (Harris, 1983; Martin 1984b). These two zones also extend through ~100 metres of the underlying coarse clastic facies of the Latrobe Group down to at least 1122m (Figure 2). The palynological equivalent interval in Wyrallah-1 is identified in sidewall cores between 918 and 1020m but is entirely within the Latrobe Group. This is supported by the log correlations suggested in Figure 2. As a consequence of these latter correlations the thick coal and sandstone between 874 and 914m at the top of the Latrobe Group in Wyrallah-1 is interpreted to correlate with just the interval 1006 to 1013m in Kyarra-1A. The thinning of the interval from 40 metres to <8 metres between the two wells is constrained below by the palynology and above by micropalaeontology (Taylor, 1983). In Taylor's report Early Miocene foram zone H-1 was confidently identified 995.5m based on the planktonic forams, but was interpreted to extends down to 1005.5m based on the benthic forams. Unfortunately the palynological analysis from the base of the Seaspray Group in Kyarra-1A is unhelpful as Harris (1983) did not record the index species of either the *P. comatum* Acme Zone or younger *F. leos* Zone.

Conclusion

The analysis of new samples and review of previous palynological studies has identified reservoir sandstones of Early Oligocene age at the top of the Latrobe Group in Wyrallah-1, and their probable presence in Tommyruff-1. As these sandstone can also be shown to thin and pinch out into the basal marls and calcareous claystones of the Seaspray Group in a seaward direction they create a stratigraphic component to any top-of-Latrobe structures in the most western part of the offshore Gippsland Basin.

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[2] LAD = Last Appearance Datum

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INTERPRETATIVE DATA

Table 1: Interpretative data for Tommyruff-1 and Wyrallah-1, offshore Gippsland Basin.

Sample Type	Depth	Palynology Zones STAGE/AGE	CR*	Comments and Key Species Present
Tommyruff-1				
Cuttings	898m	*P. tuberculatus* SP Zone & *Operculodinium* Superzone and *F. leos* MP Zone **Early Oligocene**	D2 D2	Microplankton est. >70% dominated by dinocysts belonging to *Spiniferites* spp. but including FADs of acritarch *Fromea leos* ms and spore *Cyatheacidites annulatus.*
Cuttings	928m	*P. tuberculatus* SP Zone & *Operculodinium* Superzone **Early Oligocene**	D2 D2	Assemblage is considered to be largely CAVED as it is dominated by dinocysts est. >50% and lacks any spore-pollen diagnostic of older zones.
Wyrallah-1				
Cuttings	872-875m	*P. tuberculatus* SP Zone & *Operculodinium* Superzone and *F. leos* MP Zone **Early Oligocene**	D2 D2	Microplankton est. >70% overwhelmingly dominated by *Spiniferites* spp. but including FADs of acritarch *Fromea leos* ms and spore *Cyatheacidites annulatus.*
Cuttings	884-887m	Upper *N. asperus* SP Zone **Early Oligocene**	D2	Diverse SP flora dominated by *Nothofagidites* pollen with frequent *Proteacidites stipplatus* but notably lacking index species of Middle *N. asperus* Zone.

FAD & LAD = First & Last Appearance Datums
ms = manuscript species
MP = Microplankton
SP = Spore-pollen

***CR = Confidence Ratings used in STRATDAT database and applied to Table 1.**

Alpha codes: Linked to sample		**Numeric codes:** Linked to fossil assemblage		
A	Core	**1**	**Excellent confidence:**	High diversity assemblage recorded with key zone species.
B	Sidewall core	**2**	**Good confidence:**	Moderately diverse assemblage with key zone species.
C	Coal cuttings	**3**	**Fair confidence:**	Low diversity assemblage recorded with key zone species.
D	Ditch cuttings	**4**	**Poor confidence:**	Moderate to high diversity assemblage without key zone species.
E	Junk basket	**5**	**Very low confidence:**	Low diversity assemblage without key zone species.

BASIC DATA

Table 2: Basic sample data for Tommyruff-1 and Wyrallah-1, offshore Gippsland Basin.

Sample Type	Depth	Lithology	Wt. (grams)	VOM (cc)	O/Yield
Tommyruff-1					
Cuttings	898m	Light-medium grey marl (clumped)	15.0	1.2	0.080
Cuttings	928m	80% medium grey mudstone/marl; 20% medium-coarse quartz sand	15.2	0.4	0.026
Wyrallah-1					
Cuttings	872-875m	100% light grey marl?	13.0	0.2	0.015
Cuttings	884-887m	55% black-dark grey carbonaceous shale; 40% quartz sand; 5% marl	15.2	2.5	0.164
		Average:	**14.6**		

Wt = Weight of sample processed in grams.
VOM = Volume of wet organic residues in cubic centimetres recovered from sample.
O/Yield = Organic Yield (VOM divided by Wt.)

Table 3: Basic assemblage data for Tommyruff-1 and Wyrallah-1, Gippsland Basin.

Sample Type	Depth	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species*	No. MP Species*
Tommyruff-1						
Cuttings	898m	Low	Moderate	Poor-Fair	28+	16+
Cuttings	928m	Low	High	Fair-Good	35+	15+
Wyrallah-1						
Cuttings	872-875m	Low	Very low to High	Poor-Fair	22+	16+
Cuttings	884-887m	High	High	Good	34+	4+
				Averages:	**29+**	**12+**

Table 4: Species occurrences for Tommyruff-1 and Wyrallah-1, offshore Gippsland Basin.

	Tommyruff-1		Wyrallah-1	
	898m	928m	872-75m	884-87m
	Cuttings	Cuttings	Cuttings	Cuttings
Spore-Pollen				
Aglaoreidia qualumis			X	X
Araucariacites australis		X	X	X
Bluffopollis scabratus		X		
Camarozonosporites heskermensis				X
Cupressacites sp.		X		
Cyatheacidites annulatus			X	
Cyathidites paleospora	X	X	X	
Cyathidites splendens		X		
Dacrycarpites australiensis		X		X
Dictyophyllidites sp.			X	X
Dilwynites granulatus	X	X	X	X
Ericipites crassiexinus			X	
Gleicheniidites circinidites		X	X	X
Haloragacidites harrisii	X	C	X	X
Herkosporites elliottii		X	X	
Ischyosporites irregularis ms		X		
Laevigatosporites major		X		
Laevigatosporites ovatus		X		X
Latrobosporites marginatus		X		X
Lygistepollenites florinii	X	X	X	X
Malvacipollis subtilis				X
Microalatidites paleogenicus				X
Microcachryidites antarcticus				X
Nothofagidites asperus		X		
Nothofagidites brachyspinulosus		X	X	X
Nothofagidites deminutus	X	C	X	C
Nothofagidites emarcidus/heterus	A	A	C	A
Nothofagidites falcatus	X	X	X	X
Nothofagidites flemingii	X	X		X
Nothofagidites goniatus				X
Nothofagidites vansteenisii		X	X	X
Periporopollenites demarcatus		X		X
Phyllocladidites mawsonii	X	C	X	C
Podocarpidites spp.	X	X	X	F
Polypodiidites spp.		X		X
Proteacidites spp.		X	X	X
Proteacidites annularis		X	X	X
Proteacidites carobelindiae/marginatus		X		
Proteacidites obscurus				X
Proteacidites stipplatus		X		F

Table 4: Species occurrences for Tommyruff-1 and Wyrallah-1, offshore Gippsland Basin.

	Tommyruff-1		**Wyrallah-1**	
	898m	**928m**	**872-75m**	**884-87m**
	Cuttings	**Cuttings**	**Cuttings**	**Cuttings**
Spore-Pollen				
Reticuloidosporites escharus ms	X			
Stereisporites antiquisporites		X		
Trichotomosulcites subgranulatus				X
Tricolporites spp.	X	X	X	X
Tricolporites adelaidensis		X		X
Tricolporites leuros				X
Tricolporites paenestriatus		X		X
Verrucosisporites kopukuensis		X		X
Microplankton				
Apteodinium australiense	X	X	X	
Cooksonidium capricornum	X	X	X	
Cyclopsiella vieta	X	X	X	
Dapsilidinium pseudocolligerum	X	X	F	X
Deflandrea phosphoritica		X		
Fromea leos ms	X		X	
Hystrichokolpoma rigaudiae	X	X	X	
Impagidinium spp.	X	X		
Lingulodinium machaerophorum	X	X	X	X
Lingulodinium solarum			X	
Operculodinium centrocarpum	C	C	C	X
Paralecaniella indentata	X	X		
Pentadinium laticinctum	X	X		
Protoellipsodinium mamilatus ms	X			
Protoellipsodinium simplex ms	X	X	X	
Reticulatosphaera stellata	X			
Schematophora speciosus			X	
Spiniferites spp.	A	A	A	X
Systematophora placacanthum	X		X	
Tectatodinium pellitum		X	cf.	
Other Palynomorphs				
Microforaminiferal liners	X		X	
Scolecodonts		X		
Fungal spores & hyphae	X	X	X	X

Abbreviations:
X = Present
F = Frequent
C = Common
A = Abundant
CV = Caved
cf. = Compare with