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PETROFINA EXPLORATION AUSTRALIA S.A.

ANGLER - 1

1989

WELL COMPLETION REPORT

APPENDIX 2

PALYNOLOGY

PETROLEUM DIVISION

PALYNOLOGY OF PETROFINA ANGLER-1

VIC/P20, GIPPSLAND BASIN

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for

PETROFINA EXPLORATION AUSTRALIA S.A.

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INTERPRETATIVE

PALYNOLOGY OF PETROFINA ANGLER-1

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INTERPRETATIVE

I SUMMARY

2710-2760m (cutts) : mixed P. tuberculatus Zone (Oligocene) with middle Eocene reworking : nearshore marine : immature

2770m (cutts) - lower N.asperus Zone : Middle Eocene : nearshore marine : immature

hiatus corresponding to major episode of canyon formation

2780m (cutts)-2820m (cutts) : lower P.asperopolus - upper M.diversus Zone : Early Eocene : nearshore marine : immature

lower M. diversus Zone (early Eocene) may be present in this unsampled interval

Hiatus apparently corresponding to the entire Paleocene

2925m (cutts)-2952m (swc) : upper T.longus Zone : Late Maastrichtian : marginally marine (I.druggii dinoflagellate Zone) : immature

2980m (cutts)-3050m (swc) middle T.longus Zone : Late Maastrichtian : non-marine : immature

3083m (swc)-3525m (cutts): lower T.longus Zone : Early Maastrichtian : non-marine to brackish : immature

3587m (swc)-4181m : T.lillei Zone : Early to Late Campanian : marginally marine 3587m (I.korojonense dinoflagellate Zone) : non-marine 3689-3956m, nearshore marine 4055 - 4132.5m (I.korojonense dinoflagellate Zone), non-marine 4181m (swc) : immature to marginally mature

4208m (swc) - 4334m (swc) : upper N.senectus Zone : Early Campanian : nearshore marine (I.korojonense dinoflagellate Zone) at 4208m, slightly brackish at 4279.5m, non-marine at 4334m : marginally mature

II INTRODUCTION

Thirty four samples were submitted by Mark Tringham of Petrofina for palynology. Three cuttings samples (3250, 3445, 3500m) were submitted on an urgent basis during drilling to check progress ahead of the logs and were reported by Fax. After well completion, eighteen swcs were initially submitted from the Cretaceous section and were reported by Fax on 16.6.89. Six Cretaceous infill samples (2 swcs, 4 cutts) and seven Tertiary cuttings samples were then processed to complete the breakdown. All this sampling is reported in detail herein. Raw data is presented in Appendix I.

The palynostratigraphic framework for the Cretaceous is most recently reviewed by Helby, Morgan and Partridge (1987), but detailed modifications to this scheme were discussed by Morgan (1988), and detailed taxonomic study of Campanian dinoflagellates of the region is available in Marshall (1988). In the Tertiary, the zonal scheme was most recently published by Partridge (1976), but significant new data exists in privately circulated studies, in Harris (1985), Morgan (1988), and in Marshall and Partridge (1988). The zonal scheme used here is shown in Fig. 1 and is a combination of Helby, Morgan and Partridge (1987) and Partridge (1976). The new data is easily discussed against this framework.

Organic maturity data was generated in the form of the Spore Colour Index and plotted on Fig. 2. The oil and gas windows follow the general consensus of geochemical literature. The oil window corresponds to spore colours of light-mid brown (2.7) to dark brown (3.6). This would correspond to Vitrinte Reflectance values of 0.6% to 1.3%. However, factors such as detailed kerogen type, basin type, basin history and heating curves all affect precise interpretation, and analytical machine-based maturity parameters are probably more reliable.

	AGE	SPORE - POLLEN ZONES	DINOFLAGELLATE ZONES
Early Tertiary	Early Oligocene	P. tuberculatus	
	Late Eocene	upper N. asperus	P. comatum
		middle N. asperus	V. extensa
	Middle Eocene	lower N. asperus	D. heterophlycta
			W. echinosuturata
		P. asperopolus	W. edwardsii
			W. thompsonae
	Early Eocene	upper M. diversus	W. ornata
			W. waipawaensis
		middle M. diversus	
		lower M. diversus	W. hyperacantha
	Paleocene	upper L. balmei	A. homomorpha
		lower L. balmei	E. crassitabulata
			T. evittii
Late Cretaceous	Maastrichtian	T. longus	M. druggii
	Campanian	T. lillei	I.korojonense
		N. senectus	X. australis
	Santonian	T. pachyexinus	N. aceras
			I. cretaceum
			O. porifera
	Coniacian	C. triplex	
	Turonian		C. striatoconus
			P. infusorioides
	Cenomanian	A. distocarinatus	
Early Cretaceous	Albian Late	P. pannosus	
	Albian Middle	upper C. paradoxa	
		lower C. paradoxa	
	Albian Early	C. striatus	
	Aptian	upper C. hughesi	
		lower C. hughesi	
	Barremian	F. wonthaggiensis	
	Hauterivian		
	Valanginian	upper C. australiensis	
	Berriasian	lower C. australiensis	
Juras.	Tithonian	R. watherooensis	

FIGURE 1 ZONATION FRAMEWORK

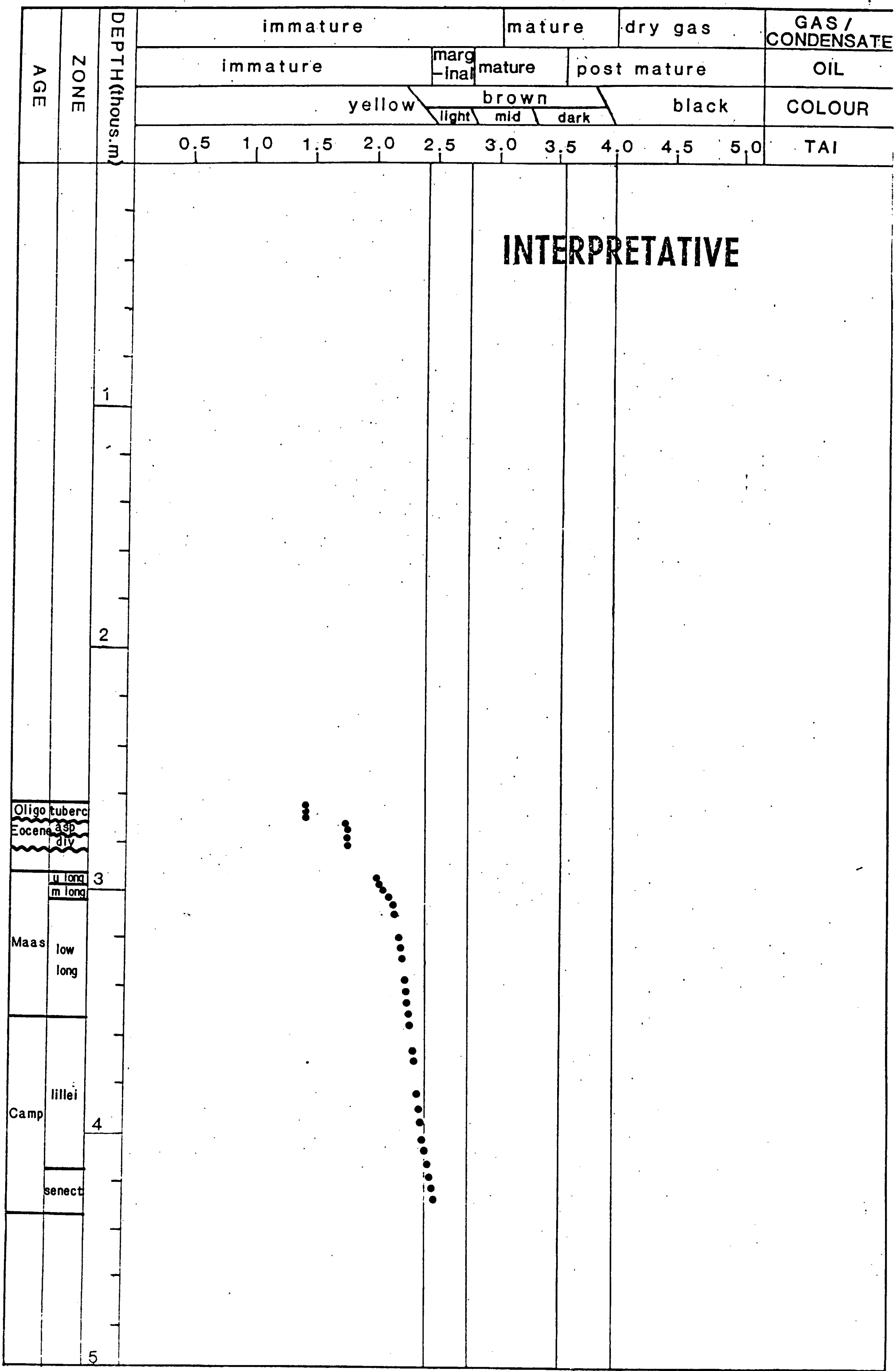

FIGURE 2 MATURITY PROFILE, ANGLER-1

III PALYNOSTRATIGRAPHY **INTERPRETATIVE**

A. 2710m (cutts) - 2760m (cutts) : probably P. tuberculatus Zone

These very lean samples contain mixed assemblages. Spores and pollen are scarce and of low diversity, with Nothofagidites spp. and Proteacidites spp. the dominant forms. At 2710m (cutts), Cyatheacidites annulatus is seen, indicating an Oligocene P.tuberculatus Zone assignment. At 2730m, Gambierina rudata implies a Paleocene or older age, but is presumed reworked.

Dinoflagellates are dominant with Operculodinium spp. and Spiniferites spp. the most common, suggesting an Oligocene age. However, Schematophora speciosa is a rare but consistent component of all three samples and suggests a Middle Eocene lower N.asperus (to basal middle N.asperus) Zone assignment. It is presumed to be reworked.

Nearshore marine environments are indicated by the low diversity dinoflagellates and spore-pollen. The Lakes Entrance Formation is normally of Oligocene age, while the Middle Eocene is normally represented by the topmost Latrobe Group and the correlative Turrum and Gurnard Formations.

Colourless palynomorphs indicate immaturity for hydrocarbon generation, although some oxidation may have occurred at the time of deposition.

B. 2770m (cutts) : lower N.asperus Zone
This lean assemblage is assigned on the basis of the dinoflagellates. The spores and pollen are very scarce, of low diversity and long-ranging.

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Dinoflagellates dominate with Areosphaeridium dictyoplokus and A.arcuatum (s.l.) the most common. This indicates assignment to the W.echinosuturata or D.heterophlycta Dinoflagellate Zones, with assignment to the upper W.echinosuturata Zone the most likely. The presence of Wetzeliella spp. (W.coleothrypta and W.articulata) is consistent with the assignment, while D.phosphoritica may be slightly caved, and W.edwardsii is considered slightly reworked. This dinoflagellate interval occurs in the lower N.asperus spore-pollen Zone.

Nearshore marine environments are indicated by the low diversity dinoflagellates and spores and pollen. Low yields of well preserved palynomorphs are common in greensands. These features are normally seen in the Gurnard Formation or its correlatives the topmost Latrobe Group, Turrum Formation or Flounder Formation. This acme occurs in Helios-1 at 2608m. An unconformity is therefore likely between 2770 and 2780m, corresponding to the major phase of Marlin channel and canyon formation.

Yellow spore colours indicate immaturity for hydrocarbon generation.

C 2780m (cutts) - 2820m (cutts) : lower P.asperopolus - upper M.diversus Zones.

Assignment to the lower Proteacidites asperopolus to upper Malvacipollis diversus Zones is based primarily on the dinoflagellate evidence, but supported by the spores and pollen. The caved or in situ nature of taxa cannot be established from the cuttings, but oldest P.asperopolus (2780m), P.pachypolus (2820m), Myrtaceidites tenuis (2800m) and youngest Proteacidites grandis (2780m), M.tenuis (2800m) and M.diversus (2820m) combine to support the assignment. However, the assemblage could be caved for part of this interval as it is cuttings based.

Dinoflagellates dominate the assemblage, with Homotriblium tasmaniense abundant. Other common elements include the Areosphaeridium spp. discussed above, but these are presumed caved, as they do not normally co-occur. H.tasmaniense normally dominates assemblages from the W.waiparaensis to W.edwardsii Zones. Wetzeliella spp. were seen only at 2820m where W.glabra and W.edwardsii are probably caved. Other obviously caved elements include Phthanoperidinium eocenicum and Schematophora speciosa. No older elements were seen reworked.

Nearshore marine environments are indicated by the low diversity dinoflagellates and spore-pollen. These features are normally seen in the topmost Latrobe Group or correlative Flounder Formation.

Yellow spore colours indicate immaturity for hydrocarbon generation.

D. lower M.diversus Zone

The lower Malvacipollis diversus Zone of Early Eocene age may be present in the well, but its depth is uncertain. The dinoflagellate Hafniasphaera septata occurs as caving at 2925m in the late Cretaceous, but is usually restricted to the lower M.diversus and upper L.balmei Zones in the Gippsland Basin. This interval might be present in the gap 2820 to 2850m where some shales appear to be present on the wireline logs. The interval would therefore be marine and equivalent to the topmost Latrobe Group or Flounder Formation.

E. 2925m (cutts) - 2950m (swc) : upper T.longus Zone

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This sample is assigned to the upper Tricolpites longus Zone as defined by Morgan (1988) at the top on youngest Quadraplanus brossus, Tricolpites longus, T.waiparaensis, Tricolporites lillei and Triporopollenites sectilis, all of which are restricted to Maastrichtian and older strata. At the base, oldest common Gambierina rudata with rare Nothofagidites spp. indicates the assignment. Proteacidites spp. dominate the palynomorph assemblage, with frequent Cyathidites spp., Gambierina rudata, Phyllocladidites mawsonii and prominent T.sectilis. In the residue, inertinite is very common, with frequent spores and pollen and minor plant debris (cuticle and tracheid). The cuttings at 2925m are heavily contaminated by Eocene caving.

Dinoflagellates are very scarce and fragmentary, but the presence of Manumiella conorata indicates assignment to the M.druggii dinoflagellate Zone.

Marginally marine environments are indicated by the very scarce dinoflagellates (about 1% of palynomorphs) and their low diversity, and the common and diverse spores and pollen. The absence of sapropel and vast cuticle seen below suggests slower deposition and oxidation in a wave reworked situation.

Yellow spore colours indicate immaturity for oil and gas/condensate.

These features are usually seen in the massive sand unit of the Latrobe Group and its correlatives in Vic P20.

F. 2980m (cutts) - 3050m (swc) : middle T.longus Zone

INTERPRETATIVE

These samples are assigned to the middle T.longus Zone in the sense of Morgan (1988) by exclusion from the section above having frequent G.rudata and the section below having frequent N.endurus. Within the interval, Proteacidites spp. are dominant, with N.endurus and G.rudata both equally prominent. In this well, T.waiparaensis and T.sectilis are both frequent at 3050m, and their twin acme may have correlative potential.

Dinoflagellates are absent at 3050m and very scarce (perhaps caved) at 2980m. The residues are dominanted by cuticle fragments and amorphous sapropel, suggesting very rapid deposition in non-marine or slightly brackish environments. The assemblage is not highly diverse due to dilution of palynomorphs by this plant debris.

Dark yellow spore colours indicate immaturity for hydrocarbon generation.

These features are usually associated with the interbedded silt/sand sequence of the Latrobe Group and its part correlative, the upper massive sand in Vic P20.

G. 3083m (swc)-3525m (cutts) lower T.longus Zone

This interval is assigned to the lower T.longus Zone at the top on youngest frequent N.endurus, and at the base on oldest Tricolpites longus (3525m cutts, 3485m swc)and Tetracolporites verrucosus (3485m swc). Within the zone, Proteacidites spp. are consistently common, with Cyathidites, P.mawsonii, Dilwynites spp. and N.endurus frequent. Tricolpites confessus is consistent to frequent in the interval 3204m (swc) to 3276m (swc), but especially at 3276m, and this acme correlates with 3214-66m in Selene-1 and 3352.8m (11,000ft.) in Hapuku-1. T.longus at 3500m and 3525m is in cuttings and could be caved slightly. Oldest T.longus in swc is therefore at 3485m.

The residues are dominated by cuticle fragments and amorphous sapropel, suggesting very rapid deposition in a stagnant environment. Trace dinoflagellates were seen at the top and base of the interval at 3130m (Isabelidinium spp.) and at 3397m (Isabelidinium and Cyclopsiella), 3445m (Heterosphaeridium spp.), 3485m (Trithyrodinium and Cyclopsiella) 3500m (Isabelidinium, O.operculata and O.subtilis) and 3525m (Odontochitina subtilis, Cyclopsiella) and indicate brackish marine conditons at these levels.

Dark yellow to light brown spore colours indicate immaturity, but approaching marginal maturity for oil, and immaturity for gas/condensate.

These features are usually seen associated with coaly facies above the Selene Sandstone in Vic P20.

H. 3587m (swc) - 4181m (swc) : T.lillei Zone

Assignment to the Tricolporites lillei Zone is shown at the top by the absence of younger indicators, and at the base by oldest T.lillei in swcs. Within the zone, Proteacidites, Cyathidites, Dilwynites, P.mawsonii and N.endurus are frequent.

The residues are mostly dominated by cuticle fragments and amorphous sapropel with scarce spores and pollen. This is consistent with rapid deposition in a non-marine stagnant environment. At the top and base of the interval, there is less amorphous material and dinoflagellates occur. At 3587m (swc), scarce dinoflagellates include Odontochitina subtilis (less spiny than O.indigena, more robust and shorter horned than O.spinosa), Isabelidinium pellucidum (cf. I.greenense Marshall unpubl.) and I.cretaceum. These indicate assignment to the I.korojonense dinoflagellate Zone in marginally marine environments. At 4055m (swc), 4132m (swc) and 4208m (swc), a more diverse dinoflagellate assemblage is dominated by I.pellucidum (cf. I.greenense) with Cribroperidinium spp., I.cretaceum, H. glabra and Odontochitina subtilis and O."prolata" Marshall unpubl. This also indicates the I.korojonense dinoflagellate Zone, but in nearshore marine environments. At 4181m (swc) dinoflagellates are absent, indicating non-marine environmenrts.

Dark yellow to light brown spore colours above 4000m indicate immaturity, but light brown spore colours below 4000m indicate marginal maturity for oil, but immaturity for gas/condensate.

These features are usually associated with the coaly section below the Selene Sandstone in Vic P20.

I. 4208m (swc)-4334m (swc) : upper N.senectus Zone

Assignment to the upper Nothofagidites senectus Zone is indicated at the top by the absence of younger indicators and at the base by oldest Gambierina rudata and N.senectus. Proteacidites spp. dominate most assemblages, with Dilwynites , Cyathidites and Nothofagidites intermittently frequent. T.confessus and T.sabulosus occur to the base of the interval.

Dinoflagellates are frequent at 4208m, as discussed above, and indicate nearshore marine environments

IV CONCLUSIONS

INTERPRETATIVE

A. GEOLOGY

The studied section appears to consist of Oligocene Lakes Entrance Formation, thin and incomplete Middle and Early Eocene nearshore marine Gurnard Formation and Latrobe Group, a Paleocene hiatus, and a thick Maastrichtrian to Campanian Latrobe Group. The Latrobe Group is not as coaly as elsewhere in the block, and contains significantly marine intervals in the Campanian. Marine Campanian has not previously been seen in the basin except at Pisces-1 and some drag ocean floor samples to the east. This well therefore marks the new westward extent of Campanian marine influence in the Gippsland Basin.

B. PALYNOLOGY

These marine intervals provide a useful means of subdividing the previously indivisible T.lillei Zone into three, as well as providing possible tie points for sequence stratigraphic analysis. These marine episodes would be expected to correlate into nearby wells.

C. MATURITY

Maturity data are disappointing, showing that the section is still not mature at T.D. Considerable potential for mature section therefore exists below this point.

INTERPRETATIVE

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