THE FORAMINIFERAL SEQUENCE
and
BIOSTRATIGRAPHIC and BIOFACIES SYNTHESIS
of
ATHENE # 1,
GIPPSLAND BASIN.

for: PHILLIPS AUSTRALIAN OIL COMPANY.

August 25, 1983.

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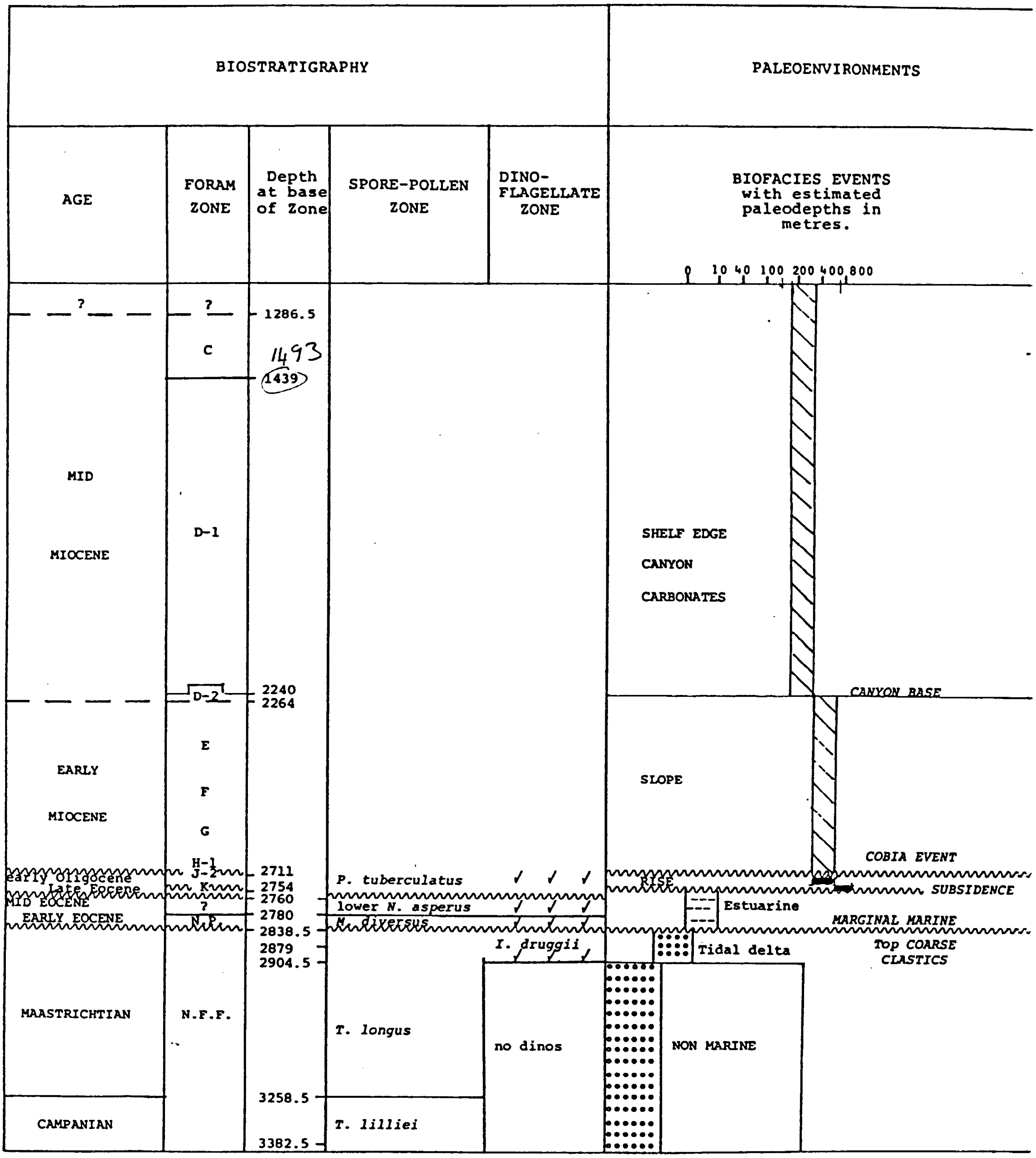

BIOSTRATIGRAPHY					PALEOENVIRONMENTS
AGE	FORAM ZONE	Depth at base of Zone	SPORE-POLLEN ZONE	DINO-FLAGELLATE ZONE	BIOFACIES EVENTS with estimated paleodepths in metres.
?	?	1286.5			
MID MIOCENE	C	1493 1439			SHELF EDGE CANYON CARBONATES
	D-1	2240			
	D-2	2264			CANYON BASE
EARLY MIOCENE	E F G H-1				SLOPE COBIA EVENT
early Oligocene	J-2	2711	*P. tuberculatus*	✓ ✓ ✓	RISE
Late Eocene	K	2754			SUBSIDENCE
MID EOCENE	?	2760	lower *N. asperus*	✓ ✓ ✓	Estuarine
EARLY EOCENE	N.P.	2780	*M. diversus*	✓ ✓ ✓	MARGINAL MARINE
		2838.5			
		2879		*I. druggii* ✓ ✓ ✓	Tidal delta Top COARSE CLASTICS
		2904.5			
MAASTRICHTIAN	N.F.F.	3258.5	*T. longus*	no dinos	NON MARINE
CAMPANIAN		3382.5	*T. lilliei*		

TABLE 1: INTERPRETED BIOSTRATIGRAPHIC and FACIES SEQUENCE for ATHENE # 1.
(An integration of the stratigraphic palynology and foraminiferal sequence reports).

by: David Taylor & Helene A Martin,
August 24th, 1983.

KEY:

∿∿∿ = hiatus
✓ ✓ ✓ = dinoflagellates present but unable to nominate Zone.
N.P. = no planktonic foraminifera
N.F.F. = no foraminifera found

INTRODUCTION.

Forty seven sidewall cores and one rotary cutting sample were submitted for examination from ATHENE # 1 between 3382.5 and 1286.5 metres. The sidewall cores between 3382.5 to 2838.5m were barren of foraminifera, although the rotary cutting sample labelled 3110m contained Mid Eocene planktonics, which proved to be contaminants (see below). Sidewall cores at 2754 and 2752m could not be adequately cleaned before preparation and heavy contamination is reported (see Table 2); no doubt due to mud cake.

The following Tables accompany this report:-

TABLE 1:	INTERPRETED BIOSTRATIGRAPHIC and FACIES SEQUENCE: an integration of the palynology and this report: on Page 1.
TABLE 2:	Factual data: PLANKTONIC FORAMINIFERAL DISTRIBUTION: at back of text.
TABLE 3:	Factual data: BENTHONIC FORAMINIFERAL DISTRIBUTION and SEDIMENT GRAIN ANALYSIS: at back of text.
TABLE 4:	Factual data: RESIDUE LITHOLOGY of BARREN FORAMINIFERAL INTERVAL between 2835.5 and 3382.5m: at back of text.
TABLE 5:	Interpretative: FORAMINIFERAL BIOSTRATIGRAPHIC DATA with reliability of Zonal Picks: at back of text.

The ATHENE # 1 sequence is discussed briefly in ascending order (i.e. uphole). The palynology has been integrated with the foraminiferal results: see Table 1, and report by Helene A Martin.

LATE CRETACEOUS - 3382.5 to 2879m.

Age determined by palynology as this interval was found to be barren of foraminifera, although limonitic stained Mid Eocene planktonics were present in the rotary cutting sample from 3110m. As this assemblage was identical to that from the limonitic rich sidewall core at 2780m, it was apparent that the cuttings from 3110m were downhole contaminants. Moreover, Dr. Martin found Eocene microfloras in these cuttings, whilst the sidewall core above and below, were of Late Cretaceous age.

The top of the Late Cretaceous interval (at 2879.5m) is marked by the occurrence of the *Isabelidinium druggii* Dinoflagellate Zone, with an unnamed dinoflagellate assemblage immediately below it (at 2904.5m). However, neither sidewall cores contained foraminifera, although across the Tasman, in New Zealand, *I. druggii* is associated with late Maastrichtian planktonic foraminifera (Strong, 1977 and Wilson, 1977). One can only conclude that the late Maastrichtian marine transgression in the Tasman Sea region only marginally affected the Gippsland deltas, so that the salinity threshold did not approach the 35°/₀₀ required to substain planktonic foraminifera. Some species of modern dinoflagellates can withstand salinities far below that of normal seawater (= 35°/₀₀). For instance, Smayda (1983, p.80-81) cites a figure of <5°/₀₀ for occurrences of *Gonyaulax* sp. in the Gulf of Finland.

The occurrence of *I. druggii* is near the top of the *COARSE CLASTICS*. Despite the sample gap between the latest Cretaceous at 2879m and the Early Eocene at 2838.5m, a major hiatus is apparent at 2850m (on E-logs). The time span of this hiatus was in the order of 14 million years.

EARLY EOCENE 2838.5 to 2786.5m.

Age determined by palynology as this interval was barren of planktonic foraminifera. A few specimens of the arenaceous benthonic foraminifera *Haplophragmoides* confirm the assessment of marginal marine environments proposed by Dr. Martin on palynological grounds. In modern estuarine systems, ecologists apply the form *gradient* to such backwater, low salinity, areas that are embraced within the paleoecologist's term *marginal marine* (Smayda, 1983, fig. 4.1).

Both the age and biofacies of this unit indicate that it can be equated with the, lower *Member III*, of the *FLOUNDER FORMATION*. A hiatus occurred between the top of this Early Eocene unit and the overlying Mid Eocene *GURNARD FORMATION*. It is difficult to estimate the length of this hiatus which could have been as much as 10 million years but certainly no less than 5 m.y.

MID EOCENE - 2780 to 2765m.

In this oxidised "greensand" interval, planktonic foraminifera were sporadic and specific diversity very low, with *Globigerina angiporoides minima* being the only species listed which was restricted to the Mid

Eocene (Jenkins, 1974). The palynological evidence, presented by Dr. Martin, is far more convincing regarding a Mid Eocene age determination.

The Mid Eocene planktonic assemblages may be better developed in horizons not sampled by sidewall cores, as Mid Eocene, limonitic stained specimens were abundant as mud contaminants in ditch cuttings from the non-marine Late Cretaceous sequence (for example, at 3110m).

The common occurrence of the arenaceous benthonic, *Haplophragmoides,* together with the episodic occurrence of planktonics (refer Table 3) supports a paleoenvironmental designation of marginal marine. In the classification of modern estuarine systems, this Mid Eocene unit would be within the *tidal* zone (Smayda, 1983, fig. 4.1). The presence of wind blown quartz sand and laterised glauconitic clay suggests proximity to a sand dune barrier to the open sea, with occasional breaches in this barrier allowing influx of planktonic foraminifera. A modern local analogue is the Gippsland Lakes/Ninety Mile Beach System (Apthorpe, 1980).

This unit has the biofacies characteristics and is within the age range of the *GURNARD FORMATION.* The hiatus between it and the overlying Latest Eocene *COLQUHOUN FORMATION* was of some 3 million years in extent.

LATEST EOCENE - ZONE K - 2760 to 2756m.

The association of the Oligocene species *Globigerina brevis* with the Eocene species *G. linaperta* and *Globigerinatheka index* is evidence of a position right on the Eocene/Oligocene boundary (Jenkins, 1974), but by local convention, the interval is designated late Eocene. However, from the presence of the angiosperm pollen *Proteacidites tuberculatus,* palynologists designate this unit as no older than earliest Oligocene. This quibble can be dismissed as being semantic, as neither planktonic foraminiferal workers, nor palynologists would dispute a geochronological age approximating 37 m.y. What should be emphasised is that the latest Eocene, Zone K foraminiferal assemblages are distinct and thus distinguishable from the Early Oligocene Zone J-2 assemblages.

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entity of the sidewall cores at 2754 and 2752m was due obviously to an inability to remove mud cake prior to processing, rather than to reworking of Early Oligocene assemblages into the Miocene sediments.

The dominance of deep oceanic, benthonic foraminifera (refer Table 3 and Hayward & Buzas, 1979) suggests a continental rise sedimentation site, with an estimated paleodepth of some 800m. Towards the top of the unit, species appear which indicate proximity to the base of the continental slope, coinciding with increased purity of the biogenic carbonates.

This unit is obviously a *deep water equivalent* of the *LAKES ENTRANCE MARL.*

THE *COBIA EVENT* at 2713m (E-logs).

The change in planktonic assemblages from the Early Oligocene, J-2 at 2720m to the Early Miocene H-1 at 2711m is indicative of the effects of this hiatus with a time span of some 12 million years. It is noted that there was no expression of gross environmental change on either side of the unconformity, with both lithofacies and biofacies being very similar. However, the Early Miocene micrites display a greater degree of carbonate diagenesis than the Early Oligocene ones below (refer Table 3).

EARLY to MID MIOCENE - Zones H-1, G, F, E & D-2 - 2711 to 2264.5m.

Zone H-1 assemblages are well represented at the base of the unit and the assemblage at the top is typical of Zone D-2. But, because of inadequate sampling, it can only be assumed that Zones G, F, E-2 and E-1 are present. This assumption is substantiated partly by the abundance of elements of these assemblages (without *Orbulina universa*) within the Early Oligocene assemblages (refer Table 2).

Sedimentation occurred on the continental slope with the presence of upper slope/shelf edge species being evidence of shelf edge progradation up sequence. The unit is designated *TASMAN SEA CARBONATES.*

MID MIOCENE *CANYON FILL* - Zones D-1 to C - 2240 to 1493 to ?1286.5m.

The base of turbo-carbonate, canyon fill sequence is at 2264m (E-logs), yet there is not recognisable biostratigraphic break between the rich D-2 assemblage at 2264.5m and the sparse D-1 assemblages at and above 2240m.

The rapid accumulation rate of the canyon fill unit can be appreciated from the scaled Table 1; in that more than 900m of canyon fill accumulated in less than 5 million years, whilst the underlying 1150m of the Athene sequence represents some 60 million years of geological time.

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SIDEWALL CORES Depth in metres	PLANKTONIC FORAMINIFERA																																				PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY		
	MID EOCENE			LATE EOCENE to EARLY OLIGOCENE									EARLY to MID MIOCENE																								ZONE	Depth at Base	AGE
	G'ina senni	*G'ina linaperta*	*G'ina angiporoides minima*	*G'ina brevis*	*G'ina angiporoides* (SS)	*G'alia nana*	*G'theka index*	*G'ina euapertura*	*G'ina praebulloides*	*G'ina tripartita*	*G'alia munda*	*G'alia gemma*	*G'alia continuosa*	*G'ina woodi connecta*	*G'ina woodi woodi*	*G'ina bulloides*	*G'oides parawoodi*	*G'alia siakensis/mayeri*	*G'alia zealandica* (SS)	*G'quad dehiscens* (SS)	*G'quad advena*	*Cat. dissimilis*	*G'alia kugleri*	*G'alia bella*	*G'oides trilobus*	*Orb. universa*	*Praeorb. glomerosa*	*G'oides bispherica*	*G'alia miozea miozea*	*G'alia miozea conoidea*	*G'alia praescitula*	*G'alia praemenardii*	*G'alia peripheronda*	*G'alia conica*	*G'ina ciperoensis*	*G'ina & G'alia* indet (<.2mm)			
1286.5																•										•											C		MID MIOCENE
1493.0															x	x		x								•										D		1493	
1733.5	indet																																						
1985.0															x	x		•							•	•				•				•			D-1		
2240.0															x	x		x							•	•				•								2240	
2264.5															x	x		x							x	x	•	•	x	x	x	x	•	x	x		D-2	2264.5	
2472.5														x	x	x	•	•	•	•					?												G	2472	EARLY MIOCENE
2671.0	indet																																				?	2671	
2692.5													•	x	x	x	x			•		x																	
2707.5													x	x	x	x	x	x	x	x	•	x	•	•												D	H-1		
2711.0													•	x	x	x	•	•	•	•	•	•														D		2711	
∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿		∿
2720.0				x	x				x	x																										D			EARLY OLIGOCENE
2726.5				x	x			x		x	•																									D			
2733.5				x	x			x	x	x	•	•	•																							D			
2737.5				x	x				x	•	•	x																								D			
2744.0	indet																																				J-2		
2746.0				x	x			x	x	x	?	?	?																							D			
2748.0				?	x			x		?																										D			
2750.0				x	x	x		x	x	x	x	x	x																							D			
2752.0				•	x			x	x	•		?		ζ	ζ	ζ			ζ	ζ				ζ	ζ		ζ	ζ	ζ		ζ								
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2765.0		•	•																																				MID EOCENE
2770.0	No planks																																						
2773.5	•	•	•																																				
2775.5	No planks																																				?		
2778.5			•																																				
2780.0	•	•	•																																			2780	
2786.5	No planks																																						
2788.5	No planks																																						

KEY:
• = <20 specimens
x = >20 specimens
D = Dominant >60% specimens
ζ = mud cake contaminants

N.F.F. = no foraminifera found
∿∿∿∿∿∿∿∿ = hiatus
∿∿∿ ? ∿∿∿ = probable hiatus

TABLE 2: PLANKTONIC FORAMINIFERAL DISTRIBUTION - ATHENE # 1.

David Taylor, August 23, 1983.

SIDEWALL CORES Depth in metres	ESTUAR-INE					CONTINENTAL RISE																	CONTINENTAL SLOPE											RESIDUE GRAIN LITHOLOGY													
																																		MAJOR COMPONENTS	MINOR COMPONENTS												
	Haplophragmoides spp.	*Bathysiphon angelseaensis*	*Nodosaria* spp.	*Ammodiscus parri*	*Cibicides perforatus*	*Ammobaculites calcarcus*	*Ammoglobigerina globigeriformis*	*Hyperammina subnodosum*	*Rhabdammina abyssorum*	*Vulvulina* spp.	*Melonis barleeanum*	*Oridorsalis tenera*	*Osangularia bengalensis*	*Stilostomella antillea*	*Karreriella bradyi*	*Discammina compressa*	*Lagena* spp.	*Martinotiella communis*	*Pleurostomella tenera*	*Alveolophragmium* spp.	*Cibicides karreriformis*	*Ammodiscus incertus*	*Siphonina australis*	*Cassidulina leavigata*	*Cibicides wuellerstorfi*	*Gyroidina* spp.	*Sphaeroidina bulloides*	*Cibicides mediocris*	*Oridorsalis umbonifer*	*Cibicides molestus*	*Siphouvigerina proboscidea*	*Cibicides subhaidingeri*	*Euuvigerina pygmea*	Y: recrystallised biomicrite f: planktonic foraminifera m: biomicrite .‡: qtz sandy marls & calc siltst. G: pellet glauc .o: polymodal qtz sdst. ∇Δ: frosted & fractured qtz.	pyrite	mica	limonitic clay	glauconite	f-m ang qtz	c ang-subrd qtz	fish fragments	echinoid spines	ostracodes	brachiopods	sponge spicules	foram count	Plank foram %
1286.5	indet																																	YYYYYYYYYYYYYYYYYYYY									r			?	?
1493.0																	•							x			•				•	•	x	YYYYYYYYYYYYYYYYYYYY			C								r	200	60
1733.5	indet																																	YYYYYYYYYYYYYYYYYYYY												?	?
1985.0																	•						•	•		•				•				YYYYYYYYYYYYYYYYYYYY			r	r								?	?
2240.0																	x						•	•						•		•		YYYYYYYYYYYYYYYYYYYY			C								r	?	?
2264.5																														•	x			YYYYYYYYYYYYYYYY fff	C		C									2000	99
2472.5																•													•					YYYYYYYYYYYYYYYYYYYY			C		C							200	95
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2775.5	•																																	Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ			C	A								10	nil
2778.5																																		∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇	r	r	r	C								10	100
2780.0	•																																	Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ	C		A	A								20	50
2786.5	•																																	∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ GG		A										10	nil
2788.5	•																																	Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇Δ∇ GG	r											10	nil

KEY: • = <20 specimens ∿∿∿∿∿ = hiatus
x = >20 specimens ∿∿?∿∿? = probable hiatus
indet = indeterminate due to preservation

TABLE 3: BENTHONIC FORAMINIFERAL DISTRIBUTION and SEDIMENT GRAIN ANALYSIS - ATHENE # 1.

David Taylor, August 24, 1983.

TABLE 4.

RESIDUE LITHOLOGIES of BARREN FORAMINIFERAL INTERVAL between 2835.5 and 3382.5m in ATHENE # 1.

Prepared by: *David Taylor*,
August 22, 1983.

Depth in metres	SWC	Residue Lithology (grains >.075mm)
2838.5	#19	m-c, ang-subrd qtz with Abundant limonite, pellet glauc & rare pyrite.
2879.5	#17	f-m, ang frosted qtz with pyrite common.
2904.5	#16	f-c, ang frosted qtz with abundant limonitic clay, common mica & rare pyrite.
2940.0	#15	*ibid*
3084.0	#14	*ibid*
3103.0	#13	f ang qtz, clayey sdst, with mica & limonite common.
3108.0	#12	f ang qtz, clayey sdst with glauc common & mica rare.
3113.5	#11	*ibid*
3237.0	#10	f ang qtz, clayey sdst, with rare limonitic clay.
3258.0	# 9	*ibid*
3302.5	# 6	f ang qtz, clayey sdst.
3315.0	# 5	f ang qtz, clayey sdst, limonite & mica rare.
3328.0	# 4	f ang qtz, sandy siltst with pyrite common.
3363.5	# 3	f-m ang qtz, clayey sdst with pyrite & limonite common.
3375.0	# 2	*ibid*
3382.5	# 1	f ang qtz, clayey sdst with abundant limonitic clay & common pyrite, glauc & mica.

TABLE 5.

MICROPALEONTOLOGICAL DATA SHEET

BASIN: GIPPSLAND ELEVATION: KB: _____ GL: _____

WELL NAME: ATHENE # 1 TOTAL DEPTH: _____

AGE		FORAM. ZONULES	HIGHEST DATA					LOWEST DATA				
			Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time	Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time
PLEISTOCENE		A_1										
		A_2										
PLIOCENE		A_3										
		A_4										
		B_1										
MIOCENE	LATE	B_2										
		C	1493	2				1493	2			
	MIDDLE	D_1	1985	1				2240	2			
		D_2	2264.5	0				2264.5	0			
		E_1	¶									
		E_2	¶									
	EARLY	F	¶									
		G	2472.5	2				2472.5	2			
		H_1	2692.5	1				2711	1	2707.5	0	
OLIGOCENE	LATE	H_2										
		I_1										
		I_2										
	EARLY	J_1										
		J_2	2720	1				2754*	1	2750	0	
EOCENE		K	2756	1				2760	2			
		Pre-K	2765	2				2780	2			

COMMENTS Pre K interval between 2765 & 2780m contains sporadic low diversity assemblages of mid Eocene planktonic foraminifera.

* SWCs at 2754 & 2752m were part mud cake & could be adequately cleaned. They contained Zone F to E-1 species and contaminants.

¶ Zones not found, due to sample gap; probably present on observation above.

CONFIDENCE RATING:

O: SWC or Core - Complete assemblage (very high confidence).
1: SWC or Core - Almost complete assemblage (high confidence).
2: SWC or Core - Close to zonule change but able to interpret (low confidence).
3: Cuttings - Complete assemblage (low confidence).
4: Cuttings - Incomplete assemblage, next to uninterpretable or SWC with depth suspicion (very low confidence).

NOTE: If an entry is given a 3 or 4 confidence rating, an alternative depth with a better confidence rating should be entered, if possible. If a sample cannot be assigned to one particular zone, then no entry should be made, unless a range of zones is given where the highest possible limit will appear in one zone and the lowest possible limit in another.

DATA RECORDED BY: David Taylor DATE: August 23, 1983.

DATA REVISED BY: _____ DATE: _____