APPENDIX-1

PALYNOLOGICAL ANALYSIS OF REMORA-1
GIPPSLAND BASIN

by

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INTERPRETED DATA

INTRODUCTION

Thirty-five sidewall core and four cuttings samples were examined for spore-pollen and dinoflagellates. Selected samples were also examined for kerogen type and thermal alteration index. Oxidized organic yields are mostly moderate to high while preservation is generally poor. Recorded spore-pollen diversity is mostly moderate. Dinoflagellate diversity is moderate to high in the Turrum Formation and overlying Seaspray Group, while only one sample from the underlying undifferentiated Latrobe Group contained dinoflagellates.

Lithological units and palynological zones from the base of the Seaspray Group to T.D. are summarized below. Interpretative data with zone identifications and confidence ratings are recorded in Table-1 and basic data on residue yields, preservation and diversity are recorded in Table-2. The occurrences and relative frequencies of spore-pollen and dinoflagellate species are tabulated on the accompanying range chart. Kerogen data for 30 samples are recorded in Table-3.

SUMMARY

AGE	UNIT/FACIES	ZONE	DEPTH (mKB)
Oligocene-Miocene	Seaspray Group	P. tuberculatus	2065.0-2080.0
UNCONFORMITY	2084.0m		
Late Eocene Middle Eocene	Turrum Formation	Middle N. asperus Lower N. asperus	2088.0-2115.0 2119.0-2182.0
UNCONFORMITY	2185.0m		
Paleocene Maastrichtian Maastrichtian Campanian Campanian	Latrobe Group (undifferentiated sands, shales coals and volcanics)	Lower L. balmei Upper T. longus Lower T. longus T. lilliei N. senectus	2194.5-2338.8 2369.0-2572.5 2581.0-2756.0 2790.0-2859.0 2947.0-2958.5
	T.D. 2961.0m		

GEOLOGICAL COMMENTS

1. The Turrum Formation in Remora-1 is bounded by significant unconformities. The top of the formation has probable Miocene Lakes Entrance Formation unconformably overlying Late Eocene, while at the base Middle Eocene overlies Paleocene.

2. The Turrum Formation displays increasing marine influence from the bottom to the top of the formation. The indicators are the increase in glauconite and carbonate in the sidewall cores and the increase in the abundance and diversity of dinoflagellates (Table-2). The exception to this trend are the sidewall cores at 2101m and 2119m which exhibit low dinoflagellate diversity a result of low palynomorph recoveries. The increase in marine indicators is a result of either or both a combination of decreasing sedimentation rates or increasing water depth during deposition of the Turrum Formation.

3. The Lower and Middle N. asperus Zones in Remora-1 are represented in the Turrum Formation by different average shale response on the gamma ray log and are separated by a distinct log break at 2116.5m. A log break separating these zones in the Gurnard Formation is usually found in other wells where palynological control is adequate. This log break probably represents the 39.5 million year sequence boundary (see Haq et al., 1987) and has the potential to give a more detailed correlation between the Turrum and Gurnard Formations. Other log breaks in the Turrum Formation in Remora-1 are noted at 2142m and 2172.5m, however these cannot be related confidently to palynomorph assemblage changes or sequence boundaries.

4. Erosion by the Marlin Channel at the Remora-1 location has removed approximately 300m of Late Paleocene to Early Eocene undifferentiated Latrobe Group sediments prior to deposition of the Turrum Formation. This estimate of missing section is based on a comparison to the thickness of this interval in Sunfish-1 and 2.

5. The datum approximating the Cretaceous/Tertiary boundary recognized on log character in other wells from more marine environments in the Gippsland Basin cannot be located in the coastal plain facies found in Remora-1.

6. The volcanics intersected between 2885 to 2946m separate the T. lilliei and N. senectus Zones and are time equivalent with volcanics located in other parts of the northeastern Gippsland Basin. It is not possible to demonstrate with the poor palynological data available from this part of Remora-1 whether any section is missing related to erosion associated with the breakup unconformity proposed by Lowry (1987).

BIOSTRATIGRAPHY

The zone boundaries have been established using the criteria of Stover & Partridge (1973) and Helby et al. (1987). The author citations for most of the spore-pollen species recorded can be sourced from either these publications or references cited therein. The exception are species followed by "ms" indicating manuscript names. Author citations for dinoflagellates can be found in Lentin & Williams (1985).

Nothofagidites senectus Zone: 2947.0-2958.5 metres.

The two samples assigned to this zone gave very limited, poorly preserved assemblages. The presence of N. senectus confirms an age no older than this zone, however given the poor assemblages from these samples the section could belong to the younger T. lilliei Zone. The sidewall core at 2954.0m identified as a possible altered volcanic rock gave a moderate yield of organic material and rare spores and pollen, indicating the lithology is a tuff or a reworked volcanic sandstone.

Tricolporites lilliei Zone: 2790-2859 metres.

The sidewall core at 2859m is assigned to the T. lilliei Zone on the presence of Triporopollenites sectilis, frequent Gambierina rudata and a single poorly preserved and tentatively identified specimen of Tricolporites lilliei. The three cuttings samples between 2790 to 2822m were only given a cursory examination to confirm their age as N. senectus Zone or younger.

Lower Tricolpites longus Zone: 2581-2756 metres.

The base of the Lower T. longus Zone is picked on the oldest occurrence of T. longus and Tetracolporites verrucosus following the revised zone definition for the T. longus Zone given by Helby et al. (1987). Both species first occur at 2756m. The samples from this zone are dominated by Gambierina rudata, Nothofagidites senectus, Phyllocladidites mawsonii and Latrobosporites spp. The eponymous zone species and other characteristic T. longus Zone species are rare.

Upper Tricolpites longus Zone: 2369-2572.8 metres.

The base of the Upper T. longus Zone is picked on the oldest occurrence of Stereisporites (Tripunctisporis) sp. found at 2572.5m. In general this species is rare. The samples from this zone also display frequent to abundant Gambierina spp. and more frequent occurrence and greater diversity of accessory species typical of the T. longus Zone. From amongst these latter species the youngest occurrences of Proteacidites clinei ms, P. otwayensis ms and Quadraplanus brossus are used to pick the top of the zone at 2369m. This last sample also contains the only occurrence of dinoflagellates below the base of the Turrum Formation.

Lower Lygistepollenites balmei Zone: 2194.5-2338.8 metres

Although most samples from this zone gave reasonable yields of organic residue the concentration and diversity of the spore-pollen assemblages were low and preservation is poor. The base of the zone is picked at 2338.8m in an assemblage of moderate diversity which lacks T. longus Zone indicator species. The top of the zone, picked at 2194.5m on the common occurrence of Lygistepollenites balmei, is readily distinguished from the overlying Turrum Formation assemblages on the absence of dinoflagellates.

Lower Nothofagidies asperus Zone: 2119-2182 metres.

The base of this zone is readily picked by the oldest occurrence of Middle Eocene dinoflagellates and the marked change in the spore-pollen assemblage across the unconformity at the base of the Turrum Formation. Key spore-pollen species supporting this zone assignment are limited but include Nothofagidites falcatus at 2173.8m and 2139m, plus Proteacidites recavus and Tricolpites simatus both at 2139m. The dinoflagellates in general are more definitive and based on the occurrence of the nominate species enable the recognition of the following zones:

Deflandrea heterophlycta Zone: 2119m
Areosphaeridium diktyoplokus Zone: 2133.9-2182m

Middle Nothofagidites asperus Zone: 2088-2115 metres.

Each of the three samples in this zone gave poor assemblages of spores and pollen. The zone is thus identified with poor confidence on the presence of the dinoflagellate species Alisocysta ornatum at 2088m and Schematophora speciosus at 2115m. Elsewhere these dinoflagellates are characteristic of the Middle N. asperus Zone.

Proteacidites tuberculatus Zone: 2065-2080 metres.

The frequent occurrence of the spore Cyatheacidites annulatus in two low yield samples enable a good confidence zone pick. Although there is no supporting foraminiferal analysis the frequent occurrence of C. annulatus and the associated dinoflagellates overall suggest a Miocene rather than an Oligocene age for the base of the Seaspray Group.

REFERENCES

HAQ, B.U., HARDENBOL, J. & VAIL, P., 1987. Chronology of fluctuating sea levels since the Triassic. Science 235, 1156-1167.

HELBY, R., MORGAN, R. & PARTRIDGE, A.D., 1987. A palynological zonation of the Australian Mesozoic. Mem. Ass. Australas. Palaeontols 4, 1-94.

LENTIN, J.K. & WILLIAMS, G.L., 1985. Fossil dinoflagellates: Index to genera and species, 1985 Edition. Canadian Tech. Rep. Hydrog. Ocean Sci. 60, 1-451.

LOWRY, D.C., 1987. A new play in the Gippsland Basin. APEA J. 27(1), 164-172.

STOVER, L.E. & PARTRIDGE, A.D., 1973. Tertiary and Late Cretaceous spores and pollen from the Gippsland Basin, southeastern Australia. Proc. R. Soc. Vict. 85, 237-286.

TABLE 1: SUMMARY OF INTERPRETATIVE DATA FOR REMORA-1

SAMPLE TYPE	DEPTH	SPORE-POLLEN ZONE	DINOFLAGELLATE ZONE (OR ASSOCIATION)	CONF. RATING	COMMENTS
SWC 60	2065.0m	*P. tuberculatus*		0	Frequent *Cyatheacidites annulatus*
SWC 59	2080.0m	*P. tuberculatus*		0	Frequent *Cyatheacidites annulatus*
SWC 58	2088.0m	Middle *N. asperus*		2	
SWC 57	2101.0m	Indeterminate			Insufficient yield for determination
SWC 56	2115.0m	Middle *N. asperus*		2	
SWC 55	2119.0m	Lower *N. asperus*	*D. heterophlycta*	1	
SWC 54	2133.9m	Lower *N. asperus*	*A. diktyoplokus*	1	
SWC 53	2139.0m	Lower *N. asperus*	*A. diktyoplokus*	1	Common *O. centrocarpum*
SWC 52	2152.0m	Lower *N. asperus*	*A. diktyoplokus*	1	Dominated by *A. diktyoplokus*
SWC 51	2173.8m	Lower *N. asperus*	*A. diktyoplokus*	1	
SWC 50	2182.0m	Lower *N. asperus*	*A. diktyoplokus*	1	Palynomorph concentration low.
SWC 49	2194.5m	Lower *L. balmei*		1	Common *L. balmei*
SWC 48	2200.2m	Lower L. *balmei*		2	
SWC 47	2202.2m	Lower *L. balmei*		2	Common *L. balmei*.
SWC 46	2204.4m	Indeterminate			
SWC 44	2245.5m	Lower *L. balmei*		1	
SWC 42	2308.0m	Indeterminate			
SWC 40	2338.8m	Lower *L. balmei*		1	
SWC 39	2369.0m	Upper *T. longus*		1	*Trichodinium hirsutum* only dino.
SWC 37	2396.5m	Indeterminate			

TABLE 1: SUMMARY OF INTERPRETATIVE DATA FOR REMORA-1

SAMPLE TYPE	DEPTH	SPORE-POLLEN ZONE	DINOFLAGELLATE ZONE (OR ASSOCIATION)	CONF. RATING	COMMENTS
SWC 36	2426.3m	Upper T. longus		1	Abundant Gambierina
SWC 35	2460.0m	Upper T. longus		1	Common Gambierina
SWC 34	2464.0m	Indeterminate			
SWC 33	2483.5m	Upper T. longus		1	Frequent Gambierina
SWC 31	2557.0m	Upper T. longus		1	Frequent Gambierina
SWC 29	2572.5m	Upper T. longus		1	Common Gambierina
SWC 28	2581.0m	Lower T. longus		2	Common Gambierina
SWC 26	2612.8m	Lower T. longus		2	Common Gambierina
SWC 24	2641.0m	Indeterminate			
SWC 21	2716.0m	Lower T. longus		1	Abundant N. senectus
SWC 19	2749.5m	Indeterminate			Barren of fossils
SWC 18	2756.0m	Lower T. longus		1	
Cuttings	2790-95m	T. lilliei		3	
Cuttings	2805-10m	T. lilliei		3	
Cuttings	2820-22m	T. lilliei		3	
SWC 10	2859.0m	T. lilliei		2	Common N. senectus
SWC 4	2947.0m	N. senectus		2	Abundant N. senectus
SWC 2	2954.0m	Indeterminate			Fossils confirm SWC not volcanic
SWC 1	2958.5m	N. senectus		2	

P A L Y N O L O G Y   D A T A   S H E E T

B A S I N: GIPPSLAND ELEVATION: KB: 22.0m GL: -57.4m

WELL NAME: REMORA-1 TOTAL DEPTH: 2916.0 (Schl.)

AGE	PALYNOLOGICAL ZONES	HIGHEST DATA					LOWEST DATA				
		Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time	Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time
NEOGENE	*T. pleistocenicus*										
	M. lipsis										
	C. bifurcatus										
	T. bellus										
PALEOGENE	*P. tuberculatus*	2065	0				2080	0			
	Upper *N. asperus*										
	Mid *N. asperus*	2088	2				2115	2			
	Lower *N. asperus*	2119	1				2182	1			
	P. asperopolus										
	Upper *M. diversus*										
	Mid *M. diversus*										
	Lower *M. diversus*										
	Upper *L. balmei*										
	Lower *L. balmei*	2194.5	1				2338.8	1			
LATE CRETACEOUS	Upper *T. longus*	2369	1				2572.5	1			
	Lower *T. longus*	2581	2				2756	1			
	T. lilliei	2790	3				2859	2			
	N. senectus	2947	2				2958.5	2			
	T. apoxyexinus										
	P. mawsonii										
	A. distocarinatus										
EARLY CRET.	*P. pannosus*										
	C. paradoxa										
	C. striatus										
	C. hughesi										
	F. wonthaggiensis										
	C. australiensis										

COMMENTS: Depths in metres.
D. heterophylycta Dino. Zone 2119m (Rtg 1)
A. diktyoplokus Dino. Zone 2133.9-2182m (Rtgs 2)

CONFIDENCE RATING:
- 0: SWC or Core, Excellent Confidence, assemblage with zone species of spores, pollen and microplankton.
- 1: SWC or Core, Good Confidence, assemblage with zone species of spores and pollen or microplankton.
- 2: SWC or Core, Poor Confidence, assemblage with non-diagnostic spores, pollen and/or microplankton.
- 3: Cuttings, Fair Confidence, assemblage with zone species of either spores and pollen or microplankton, or both.
- 4: Cuttings, No Confidence, assemblage with non-diagnostic spores, pollen and/or microplankton.

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: A.D. Partridge DATE: July 1987

DATA REVISED BY: DATE:

BASIC DATA

TABLE-2: BASIC DATA

KEROGEN SUMMARY

TABLE-3: KEROGEN DATA

TABLE-2: SUMMARY OF BASIC PALYNOLOGY DATA FOR REMORA-1

SAMPLE TYPE	DEPTH	LITHOLOGY	RESIDUE YIELD	PRESERVATION	SPORE-POLLEN DIVERSITY	DINOFLAGELLATES ABUNDANCE	NO. SPECIES
SWC 60	2065.0m	Calc. claystone	Low	Fair	Moderate	Common	9+
SWC 59	2080.0m	Calc. claystone	Low	Poor	Moderate	Common	5+
SWC 58	2088.0m	Glauc. silty sst.	Moderate	Poor-fair	Moderate	Common	10+
SWC 57	2101.0m	Glauc. sdy siltst.	Very low	Poor-fair	Low	Rare	4+
SWC 56	2115.0m	Glauc. slty sst.	Low	Poor-fair	Moderate	Common	14+
SWC 55	2119.0m	Glauc. sdy slst.	Very low	Fair-good	Moderate	Frequent	8+
SWC 54	2133.9m	Glauc. slty sst.	Low	Fair	Moderate	Frequent	10+
SWC 53	2139.0m	Silty glauc. sst.	High	Fair-good	High	Frequent	11+
SWC 52	2152.0m	Silty carb. sst.	Moderate	Poor	Low	Common	4+
SWC 51	2173.8m	Mica. siltst.	High	Poor-fair	Moderate	Frequent	5+
SWC 50	2182.0m	V. fine mica. sst.	Moderate	Poor	Low	Rare	4
SWC 49	2194.5m	V. fine carb. sst.	Moderate	Poor	Moderate		
SWC 48	2200.2m	Mica. siltst.	High	Poor	Low		
SWC 47	2202.2m	Qtz sst.	Low	Very poor	Low		
SWC 46	2204.4m	Pyr. qtz. sst.	Very low	Poor	Low		
SWC 44	2245.5m	Mica. sltst.	High	Poor	Moderate		
SWC 42	2308.0m	Mica. qtz sst.	Moderate	Poor	Low		
SWC 40	2338.8m	Mica. qtz slst.	High	Fair	Moderate		
SWC 39	2369.0m	Mica. shale	High	Fair	High	Very rare	1
SWC 37	2396.5m	Mica. shale	Low	Poor	Very low		
SWC 36	2426.3m	Mica. shale	High	Poor	Moderate		
SWC 35	2460.0m	Carb. slst.	Moderate	Poor-fair	Moderate		

TABLE-2: SUMMARY OF BASIC PALYNOLOGY DATA FOR REMORA-1

SAMPLE TYPE	DEPTH	LITHOLOGY	RESIDUE YIELD	PRESERVATION	SPORE-POLLEN DIVERSITY	DINOFLAGELLATES ABUNDANCE	NO. SPECIES
SWC 34	2464.0m	Grey slst.	Low	Very poor	Very low		
SWC 33	2483.5m	Sdy slst.	High	Fair	Moderate		
SWC 31	2557.0m	Mica. shale	High	Poor-fair	Moderate		
SWC 29	2572.5m	Shale	High	Fair	Moderate		
SWC 28	2581.0m	Shale	Moderate	Poor	Moderate		
SWC 26	2612.8m	Sdy slst.	Moderate	Poor	Moderate		
SWC 24	2641.0m	Carb. shale	Moderate	Poor-fair	Low		
SWC 21	2716.0m	Sdy carb. slst	High	Poor	Moderate		
SWC 19	2749.5m	Carb. sst.	Moderate	Poor	Barren		
SWC 18	2756.0m	Siltstone	Moderate	Poor-fair	Moderate		
Cuttings	2790-95m		Moderate	Poor	Low		
Cuttings	2805-10m		High	Poor	Moderate		
Cuttings	2820-22m		High	Poor	Moderate		
SWC 10	2859.0m	Carb. sltst.	Moderate	Poor	Moderate		
SWC 4	2947.0m	Carb. sltst.	Moderate	Poor	Moderate		
SWC 2	2954.0m	Volcanic tuff?	Moderate	Poor	Low		
SWC 1	2958.5m	Slty sst.	Moderate	Poor	Low		

DIVERSITY

Low = less than 10 species

Moderate = 10 to 30 species

High = more than 30 species

KEROGEN SUMMARY

The results of kerogen analysis of 30 samples to assist geochemical analysis of maturation and source potential are presented in Table-3.

The thermal maturation indicies follow the scheme of F.L. Staplin (1977: Interpretation of maturation history from colour of particulate organic matter - A review. Palynology vol. 1, p. 9-18). The kerogen classification scheme is a slightly modified version of the scheme proposed by Th. C. Masran & S.A.J. Pocock (1981: The classification of plant-derived particulate organic matter in sedimentary rocks. In Organic Maturation Studies and Fossil Fuel Exploration, J. Brooks (editor), Academic Press Inc. (London) Ltd. p. 145-175).

LEGEND TO TABLE-3

TAI = Thermal Alteration Index

KEROGEN (Particulate organic matter types) expressed as percentages

Amorphous	= 1.1	(undifferentiated) + 1.2 (grey amorphous)
Structured aqueous	= 2.1	(algae) + 2.2 (dinoflagellates/acritarchs)
Biodegraded terrestrial	= 3.0	
Spore-pollen	= 4.0	
Structured terrestrial	= 5.1	(laminar) + 5.2 (cellular) + 5.3 (semi opaque)
Inert	= 6.1	(opaque) + 6.2 (meta-opaque)
Indeterminate organic fines	= 7.0	(expressed as decimal fraction of total organic matter but excluded from percentage count)

OIL PRONE = sum of categories 1.0 to 4.0

TABLE 3: KEROGEN ANALYSIS REMORA-1, GIPPSLAND BASIN

SAMPLE	DEPTH (m)	TAI	1.1	2.2	3.0	4.0	5.1	5.2	5.3	6.1	7.0	% OIL PRONE
SWC 60	2065.0	1.9	10	3	10	2			25	50	0.10	25
SWC 59	2080.0	2.0	15	5	20				20	40	0.05	40
SWC 58	2088.0	2.1	56	2	20	2			10	10	0.05	80
SWC 56	2115.0	2.1	40		30	tr			20	10	0.10	70
SWC 55	2119.0	2.1	10		10	2			73	5	0.05	22
SWC 54	2133.9	2.0	80		10				8	2	0.05	90
SWC 52	2152.0	2.0	5	2	22	1			60	10	0.05	30
SWC 51	2173.8	2.0	20		60				15	5	0.25	80
SWC 50	2182.0	2.0	20		68	tr			10	2	0.20	88
SWC 49	2194.5	2.0	5		15	tr			60	20	0.10	20
SWC 48	2200.5	1.9	5		43	2			30	20	0.10	50
SWC 47	2202.5	2.1				1			69	30	0.01	1
SWC 44	2245.5	2.0	10		60		5		15	10	0.20	70
SWC 42	2308.0	2.0	3		25			22	25	25	0.02	28
SWC 40	2338.8	2.0	40		30	tr			15	15	0.20	70
SWC 39	2369.0	2.0	15		60	tr			20	5	0.25	75
SWC 37	2396.5	2.1	15		5				60	40	0.10	20
SWC 36	2426.3	2.1			20	5			55	20	0.10	25
SWC 33	2483.5	2.0	20		65				5	10	0.25	85
SWC 29	2572.5	2.1	30		37	3	5		5	20	0.20	70
SWC 28	2581.0	2.0	35		40	5			15	5	0.25	80
SWC 26	2612.8	2.0			20	5			50	25	0.05	25
SWC 24	2641.0	2.1	10		50	tr			13	27	0.20	60
SWC 21	2716.0	2.1	5		40	5	25		10	15	0.20	50
SWC 19	2749.5		2		10				80	8	0.10	12
SWC 18	2756.0	2.1	5		80	tr			10	5	0.25	85
SWC 10	2859.0	2.1	5		73	2			15	5	0.20	80
SWC 4	2947.0	2.1	22		65	1		5	5	2	0.20	88
SWC 2	2954.0	2.2	15		60	tr			20	5	0.25	75
SWC 1	2958.5	2.3	50		28	2			15	5	0.20	80