New palynological analysis of the Gurnard Formation in Whale–1, Gippsland Basin.

by

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Biostrata Report 2000/25

28th November 2000

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INTERPRETATIVE DATA

Summary

Four new cuttings samples and a review of relinquished palynological slides from nine sidewall core samples have been analysed from the Gurnard Formation in Whale–1 over a 25 metre interval from 440 to 465m. All samples were very low yielding, but whereas the single palynological slides recovered from the cuttings contained high diversity spore-pollen assemblages which could readily be assigned to the Lower and Middle *Nothofagidites asperus* Zones, the palynological slides from the sidewall cores contained very low numbers of palynomorphs and low diversity assemblages that could only be assigned to the undifferentiated *N. asperus* Zone. Microplankton recorded from the cuttings were substantially caved, but the Late Eocene *C. incompositum* Zone was recorded from 440m at the top of the sequence and the late Middle Eocene *D. heterophlycta* Zone from the deepest cuttings at 465m. Microplankton from the other cuttings samples were not zone diagnostic, but the top of the latter zone ranges as shallow as the sidewall core at 457m based on the presence of a single specimen of *Deflandrea heterophlycta*. The stratigraphic succession in the well is summarised in Table 1, and the zone assignments of the individual samples provided in Table 2.

Table 1: Palynological Summary for Whale–1.

AGE	UNIT/FACIES	SPORE-POLLEN ZONES (MICROPLANKTON ZONES)	DEPTHS mKB
RECENT to OLIGOCENE	SEASPRAY GROUP Seafloor to 438m	No palynology dating.	
Late EOCENE to late Middle EOCENE	LATROBE GROUP Gurnard Formation 438 to 465.5m	Middle *N. asperus* *(C. incompositum)* Lower *N. asperus* *(D. heterophlycta)*	440 to 445m (440 to 442†m) 455 to 465m (457† to 465m)
EOCENE?	LATROBE GROUP Undiff. coarse clastics 465.5 to 472m	Barren samples	467 to 472m†
ALBIAN	STRZELECKI GROUP 472 to 810mTD	*C. striatus* †	475 to 502m†

† Zone picks after Harris (1982).

Introduction

The new palynological analyses of Whale–1 were undertaken as part of a larger review project for Basin Oil Pty Ltd, revising the age dating and correlation of the Gurnard Formation in the wells Baleen–1, Flathead–1, Judith–1, Patricia–1, and Sperm Whale–1, located on the Northern Strzelecki Terrace in the offshore Gippsland Basin. The samples were collected by the author from the Victorian Department of Natural Resources & Environment on 13th September 2000, and submitted to Laola Pty Ltd in Perth for palynological processing. The prepared palynological slides were returned during the next two weeks and Provisional Reports on the analyses were submitted on the 4th and 23rd October.

An average of 17.5 grams of washed and dried cuttings were processed for each sample, and although recovery of the organic residue was mostly low the palynomorph concentrations on the slides was high allowing high diversity spore-pollen assemblages and moderate diversity microplankton assemblages to be recorded. Details of zone assignments, confidence ratings and key comments are given in Table 2, while the basic sample data is provided in Table 3, and the visual residues yields, preservation of palynomorphs and recorded species diversity are provided in Table 4. Results of the assemblage counts are provided in Table 5, and a listing of all known spore-pollen and microplankton identified are provided in Table 6. Author citations for spore-pollen species can mostly be sourced from Stover & Partridge (1973, 1982), and for the microplankton species from the indexes of Williams *et al.* (1998) and Fensome *et al.* (1990). Species names followed by “ms” or “†” are unpublished manuscript names.

Geological Discussion

The initial palynological study of Whale–1 by Harris (1982) recorded very low diversity spore-pollen assemblages (range 0 to 13 and average <6 species per sample) and even lower diversity microplankton assemblages (range 0 to 5 and average <1 species per sample) from the sidewall cores analysed from the Gurnard Formation. Overall these assemblages do not allow confident zone identification. The new examination of relinquished palynological slides from the sidewall core for this study, although documenting greater diversity still recorded few zone index species from the sidewall cores (Table 4). In contrast the new cuttings samples analysed contained high diversity spore-pollen assemblages (average 50 species per sample) and moderate diversity microplankton assemblages (average 20 species per sample).

The improvement in results from the cuttings is believed to be a combination of larger sized samples and a modified laboratory processing sequence. In the latter, the preparation of kerogen slides was skipped and the samples were given a mild oxidation to remove pyrite prior to the density separation step. The net result was better yields and high concentration of palynomorphs in the organic extracts and on the palynological slides.

Notwithstanding the high diversities, key index species are still comparatively rare in the cuttings samples. The highest sample at 440m is clearly no younger than the Middle *N. asperus* and *C. incompositum* Zones, while the deepest sample at 465m can be confidently assigned to the *D. heterophlycta* Zone in the upper part of the Lower *N. asperus* Zone. Assignment of the two middle cuttings samples is less clear, but the marked change in both yield and kerogen character between the two top and two bottom samples suggests the Middle/Lower *N. asperus* Zone boundary falls between 445m and 455m. However, inspection of the electric logs reveals a distinct log break at 444m on the bulk density/neutron porosity logs, which would perhaps be a better choice for the zone boundary, provided a limited amount of caving of the cuttings assemblages is accepted. The poor results from the sidewall cores lend support to this interpretation with the possible occurrence of the Late Eocene index species *Gippslandica extensa* at 442m and the youngest occurrence of *Deflandrea heterophlycta* at 457m.

In conclusion, the Gurnard Formation in Whale–1 clearly contains parts of both the Middle and Late Eocene represented by the Lower and Middle *N. asperus* spore-pollen Zones and corresponding *D. heterophlycta* and *C. incompositum* microplankton Zones, but no evidence was encountered to confirm the presence of either the older *E. partridgei* microplankton Zone or younger *P. comatum* Acme Zones, but a thin section of the *F. leos* microplankton Zone may be present.

Discussion of Assemblages

***Nothofagidites asperus* spore-pollen Zone.**
Interval: 440 to 465 metres.
Age: Middle to Late Eocene.

Although all samples analysed belong to the broad *N. asperus* Zone based on the prominence of *Nothofagidites* pollen (average 55% in cuttings samples), key index species for finer subdivision are sporadic in the cuttings samples and extremely rare in the sidewall cores. The interval analysed is no older than Lower *N. asperus*

Zone based on the oldest occurrences of *Nothofagidites falcatus, Tricolpites simatus* and *Tricolporites leuros* in the deepest cuttings at 465m, and no younger than the Middle *N. asperus* Zone based on the youngest occurrences of *Proteacidites recavus, P. nasus* and *Santalumidites cainozoicus* in the shallowest cuttings at 440m. Subdivision of the section between these two subzones is based on the occurrence of *Anacolosidites sectus* in the cuttings at 445m as this species is not known to range below the Middle *N. asperus* Zone.

***Corrudinium incompositum* microplankton Zone.**
Interval: 440 to 445 metres.
Age: Middle Eocene.
The *C. incompositum* Zone is recorded from the shallowest cuttings sample based on the presence of both the eponymous species and *Gippslandica extensa*. Other species recorded that are consistent with this assignment are *Schematophora speciosus, Stoveracysta ornata* and *Phthanoperidinium comatum*. The zone may extends as least as deep as the sidewall core at 442 and cuttings at 445m based on the present of poor specimens of *Gippslandica extensa*.

In the shallowest cuttings most of the microplankton assemblage is interpreted as caved from the overlying Seaspray Group based on the overwhelming dominance of *Spiniferites* cysts (71% of MP count). The presence of the distinctive acritarch *Fromea leos* ms amongst the caved component suggests the possible presence of section equivalent to the "Early Oligocene Wedge" found in Patricia–1 and Baleen–1 (Partridge, 2000a-b), but this is not supported by any clear expression on the electric logs.

***Deflandrea heterophlycta* microplankton Zone.**
Interval: 457 to 465 metres.
Age: Middle Eocene.
This zone is identified in the deepest cuttings sample based on the presence of the eponymous species together with *Enneadocysta partridgei* Stover & Williams 1995 (formerly referred to by the manuscript name *Areosphaeridium australicum*), and *Paucilobimorpha inaequalis* (= *Tritonites inaequalis* Marshall & Partridge, 1988), which range no younger. The presence of *Rhombodinium glabrum* and the moderate abundance of *Vozzhennikovia apertura/rotunda* (9% of MP count) are consistent with the zone, but the dominance of *Spiniferites* spp. in the assemblage (48% of MP count) is thought to be largely caved. The zone may extended as

shallow as 457m based on the identification of a single specimen of *Deflandrea heterophlycta* in that sidewall core. The other sidewall cores in the interval lack diagnostic species.

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***Confidence Ratings used in STRATDAT database and applied to Table 2.**

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 recorded 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 recorded without key zone species.
E	Junk basket	**5**	**Very low confidence:**	Low diversity assemblage recorded without key zone species.

Table 2: Interpretative data from Whale–1 well.

Sample Type	Depth	Spore-Pollen Zone (Microplankton Zone)	CR*	Comments and Key Species Present
SWC	440m	*N. asperus* undiff.	B5	Partly desiccated slides containing less than 30 palynomorphs, none of which are age diagnostic.
Cuttings	440m	Middle *N. asperus* (*C. incompositum*)	D4 D2	MP 38%; *Nothofagidites* pollen 56%. *Spiniferites* dinocysts 71% of MP count. LADs of *Corrudinium incompositum*, *Proteacidites recavus* and *Santalumidites cainozoicus*.
SWC	442m	*N. asperus* undiff. (*C. incompositum*)	B5 B3	Partly desiccated slides containing less than 30 palynomorphs. Presence of single specimens of *Schematophora speciosus* and *Gipplsandica extensa* are consistent with the MP zone age.
SWC 12	445m	*N. asperus* undiff.	B5	Poor slides containing <50 specimens. *Nothofagidites* > *H. harrisii*
Cuttings	445m	Middle *N. asperus*	D2	MP <7% (mostly caved). FAD of *Anacolosidites sectus* confirms subzone.
SWC 19	450m	*N. asperus* undiff.	B5	Very lean slides with <20 specimens.
SWC 18	453.5m	*N. asperus* undiff.	B5	Very lean slides with <20 specimens.
Cuttings	455m	Lower *N. asperus*	D4	MP 13% (mostly caved). Although sample displays marked change in kerogen character compared to shallower cuttings there are no zone diagnostic microplankton.
SWC 17	457m	*N. asperus* undiff. (*D. heterophlycta*)	B5 B3	Lean slides with about 40 palynomorphs including single specimen of *Deflandrea heterophlycta*.
SWC 16	460m	*N. asperus* undiff.	B5	Lean slides with <30 specimens.
SWC 14	462m	*N. asperus* undiff.	B4	Lean slides with <30 specimens.
SWC 13	463.5m	*N. asperus* undiff.	B4	Lean slides with <30 specimens.
Cuttings	465m	Lower *N. asperus* (*D. heterophlycta*)	D4 D2	MP 12% (mostly caved). FADs of *Deflandrea heterophlycta*, *Paucilobimorpha inaequalis* and *Rhombodinium glabrum* confirm zone.

MP %= microplankton expressed as % of combined SP & MP count.
Nothofagidites % = abundance expressed as % of SP count only.
FAD & LAD = First & Last Appearance Datums.
*CR = Confidence Ratings

BASIC DATA

Table 3: Basic sample data on new samples processed from Whale–1.

Sample Type	Depth	Lithology	Weight (grams)
Cuttings	440m	Unconsolidated greenish-brown glauconitic sandstone	18.1
Cuttings	445m	Unconsolidated brown glauconitic sandstone	17.2
Cuttings	455m	Unconsolidated greenish-brown glauconitic sandstone (sand to powder)	17.2
Cuttings	465m	Unconsolidated greenish-brown glauconitic mudstone (mostly powder)	17.4
		Average:	**17.5**

Table 4: Basic assemblage data on samples examined in Whale–1.

Sample Type	Depths	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species	No. MP Species
SWC	440m	Low	Low	Fair	14+	2+
Cuttings	440m	Low	High	Poor-good	43+	22+
SWC	442m	Low	Very low	Fair	5+	8+
SWC 12	445m	Low	Very low	Fair-good	5+	4+
Cuttings	445m	Very low	High	Good	44+	17+
SWC 19	450m	Very low	Very low	Fair	9+	NR
SWC 18	453.5m	Low	Very low	Fair	10+	NR
Cuttings	455m	High	Low	Fair	53+	20+
SWC 17	457m	Low	Very low	Fair	19+	1+
SWC 16	460m	Low	Very low	Fair	12+	4+
SWC 14	462m	Low	Low	Good	25+	1+
SWC 13	463.5m	Low	Low	Fair	16+	1+
Cuttings	465m	High	High	Poor-good	62+	20+
				Averages:	**24+**	**7+**

Table 5. Whale–1 BASIC DATA Palynomorph Assemblage Counts.

Sample Type:	Cuttings	Cuttings	Cuttings	Cuttings
Depth (m):	**440**	**445**	**455**	**465**
SPORE-POLLEN SPECIES				
Baculatisporites spp.	0.8%		0.6%	
Cyathidites spp. small <40µm	4.1%	0.5%	2.5%	0.8%
Gleicheniidites circinidites	1.6%			0.8%
Laevigatosporites spp.			3.8%	1.5%
Stereisporites spp.	0.8%	0.5%	1.3%	
Trilete spores undiff.	0.8%		1.9%	0.8%
TOTAL SPORES:	**8%**	**1%**	**10%**	**4%**
GYMNOSPERMS				
Araucariacites australis	4.9%		0.6%	0.8%
Dilwynites spp.	3.3%	0.5%	3.1%	0.8%
Lygistepollenites florinii	0.8%	3.7%	1.3%	3.0%
Microcachyridites antarticus	0.8%	0.5%	0.6%	
Parvisaccites catastus		0.5%		
Phyllocladidites mawsonii	6.6%	7.0%	5.7%	9.0%
Podocarpidites spp.	6.6%	1.6%	5.7%	3.0%
Trichotomosulcites subgranulatus	1.6%			
TOTAL GYMNOSPERM POLLEN:	**25%**	**14%**	**17%**	**17%**
ANGIOSPERM pollen undiff.		1.1%	1.9%	2.3%
Haloragacidites harrisii	6.6%	9.6%	10.7%	14.3%
Cupanieidites orthoteichus			0.6%	
Dicotetradites clavatus		1.1%		
Liliacidites spp.		0.5%		
Malvacipollis spp.		1.6%	0.6%	2.3%
Myrtaceidites spp.	0.8%		2.5%	
Nothofagidites asperus	0.8%	0.5%		
Nothofagidites brachyspinulosus		2.7%	0.6%	1.5%
Nothofagidites deminutus	4.1%	5.3%	5.7%	2.3%
Nothofagidites emarcidus/heterus	43.4%	47.6%	37.1%	43.6%
Nothofagidites flemingii	3.3%	2.7%	0.6%	3.0%
Nothofagidites goniatus		0.5%	0.6%	
Nothofagidites vansteenisii	4.1%	4.3%	3.1%	1.5%
Periporopollenites spp.		1.1%		
Polycolpites esobalteus				1.5%
Proteacidites annularis			1.3%	
Proteacidites obscurus			0.6%	
Proteacidites pachypolus		0.5%		
Proteacidites spp.	3.3%	4.3%	3.8%	2.3%
Santalumidites cainozoicus				0.8%
Tricolporites paenestriatus				0.8%
Tricolp(or)ates spp.	0.8%	1.6%	3.1%	3.8%
TOTAL ANGIOSPERM POLLEN:	**67%**	**85%**	**73%**	**80%**
TOTAL SPORE-POLLEN COUNT:	**122**	**187**	**159**	**133**
Initial MICROPLANKTON COUNT:	76	13	23	18
TOTAL initial SP & MP COUNT:	198	200	182	151
Microplankton as % SP + MP:	38.4%	6.5%	12.6%	11.9%
MICROPLANKTON				
Dinoflagellates undiff:	11%	38%	34%	22%
Dapsilidinium pseudocolligerum	1%		3%	2%
Deflandrea spp.				2%
Cerebrosphaera zigzag†	4%	23%		11%
Enneadocysta partridgei				2%
Fromea spp.		8%		
Gippslandica extensa	1%			
Histiocysta variata†			3%	
Impagidinium spp.	1%			
Lingulodinium macharophorum		8%		
Operculodinium centrocarpum	5%		2%	2%
Paralecaniella indentata			2%	
Paucilobimorpha spp.				2%
Protoellipsodinium simplex ms	5%	8%		
Spinidinium/Vozzhennikovia spp.		15%	3%	9%
Spiniferites spp.	71%		53%	48%
TOTAL MICROPLANKTON COUNT:	**76**	**13**	**64**	**46**
OTHER PALYNOMORPHS				
Fungal spores and hyphae	2.9%	3.8%	5.2%	9.6%
TOTAL COUNT ALL PALYNOMORPHS:	**204**	**208**	**192**	**167**

† Manuscript species

Table 6. Whale–1 BASIC DATA Palynomorph Species List.

Sample Type:	SWC	Cts	SWC	SWC	Cts	SWC	SWC	Cts	SWC	SWC	SWC	SWC	Cts
Depth (m):	440	440	442	445	445	450	453.2	455	457	460	462	463.5	465
SPORE-POLLEN SPECIES													
Anacolosidites sectus					X								
Araucariacites australis	X	5%		X				X	X	X	X		X
Baculatisporites spp.		X		X				X				X	X
Beaupreaidites elegansiformis								X					
Beaupreaidites trigonalis†		X											
Beaupreaidites verrucosus						X							
Bluffopollis scabratus		X											
Camarozonosporites heskermensis								X					X
Clavastephanocolporites meleosus													X
Cupanieidites orthoteichus								X		X			X
Cyatheacidites annulatus					CV								
Cyathidites palaeospora	X	4%		X	X	X		3%	X	X	X	X	X
Cyathidites splendens			X	X			X	X	X				
Dacrycarpites australiensis	X							X					X
Dicotetradites clavatus					X						X		X
Dictyophyllidites arcuatus					X			X					
Dilwynites granulatus	X	3%		X	X			3%	X		X	X	X
Dilwynites tuberculatus								X			X	X	X
Ericipites crassiexinus											X		X
Ericipites scabratus		X					X	X			X		
Foveotriletes balteus		X			X				X				X
Gleicheniidites circinidites		2%			X			X	X	X			X
Haloragacidites canacomyricoides					X								
Haloragacidites harrisii	X	7%	X	X	10%	X	X	11%	X	X	X		14%
Haloragacidites trioratus					X			X					X
Herkosporites elliottii	X	X											X
Ilexpollenites spp.								X					
Ischyosporites gremius													X
Ischyosporites irregularis†		X		X							X		
Kuylisporites waterbolkii		X						X					X
Laevigatosporites major		X				X							
Laevigatosporites ovatus	X	X		X	X			4%		X	X	X	2%
Latrobosporites marginatus		X											X
Liliacidites spp.					X								
Lygistepollenites florinii	X	X		X	4%	X	X	X	X		X	X	3%
Malvacipollis robustus†					X							X	X
Malvacipollis subtilis					2%		X	X					2%
Matonisporites ornamentalis	X	X			X				X				
Microcachyridites antarticus		X		X	X			X					
Myrtaceidites mesonesus/parvus		X						3%			X		
Myrtaceidites verrucosus				X									
Nothofagidites asperus		X			X			X					X
Nothofagidites brachyspinulosus					3%						X	X	2%
Nothofagidites deminutus		4%			5%	X		6%	X		X	X	2%
Nothofagidites emarcidus/heterus	X	43%	X	X	48%	X	X	37%	X	X	X	X	44%
Nothofagidites falcatus	X	X		X	X			X					X
Nothofagidites flemingii		3%			3%			X	X		X		3%
Nothofagidites goniatus					X			X					X
Nothofagidites vansteenisii	X	4%	X	X	4%			3%	X				2%
Parvisaccites catastus					X								
Periporopollenites demarcatus		X					X						X
Periporopollenites polyoratus					X								
Peromonolites densus								X					
Phyllocladidites mawsonii		7%	X	X	7%		X	6%			X		9%
Podocarpidites spp.		7%		X	2%	X		6%	X	X	X	X	3%
Polycolpites esobalteus								X					2%
Polypodiidites perverrucatus				X	X			X			X		X
Proteacidites adenanthoides													X
Proteacidites annularis		X			X			X		X			
Proteacidites crassus								X					X
Proteacidites latrobensis											X		
Proteacidites nasus		X											
Proteacidites obscurus					X			X			X	X	
Proteacidites pachypolus					X			X					
Proteacidites pseudomoides								X					

Table 6. Whale–1 BASIC DATA Palynomorph Species List.

Sample Type:	SWC	Cts	SWC	SWC	Cts	SWC	SWC	Cts	SWC	SWC	SWC	SWC	Cts
Depth (m):	440	440	442	445	445	450	453.2	455	457	460	462	463.5	465
Proteacidites recavus		X						X					X
Proteacidites reticuloscabratus								X					
Proteacidites stipplatus	X												
Proteacidites tuberculiformis					X								
Proteacidites spp.	X	3%		X	4%	X		4%	X		X		2%
Retitriletes spp.						X				X			X
Rugulatisporites mallatus		X			X			X					X
Santalumidites cainozoicus		X											X
Sapotaceoidaepollenites rotundus					X								
Stereisporites antiquisporites		X		X	X			X			X		
Trichotomosulcites subgranulatus		2%											
Tricolpites simatus								X					X
Tricolporites adelaidensis				X	X			X					X
Tricolporites leuros					X			X					X
Tricolporites paenestriatus		X											X
Tricolporites scabratus													X
Tricolporites sphaerica								X					X
Tricolp(or)ates spp.		X		X	2%			3%	X			X	4%
Tripunctisporis maastrichtiensis								X	X				X
Verrucatosporites alienus												X	
Verrucatosporites attinatus								X					X
Verrucosisporites cristatus		X									X		
Verrucosisporites kopukensis		X			X			X			X	X	X
MICROPLANKTON													
Cerebrosphaera zigzag†		4%			X			X					11%
Corrudinium incompositum		X											
Cooksonidium capricornum					cf.								
Cyclopsiella vieta					X								
Dapsilidinium pseudocolligerum		1%						3%					2%
Deflandrea heterophlycta									X				X
Deflandrea phosphoritica													X
Deflandrea spp.								X			X		2%
Distatodinium ellipticum								cf.					
Enneadocysta partridgei													2%
Eocladopyxis peniculata		X											
Fromea leos†		X			X								
Fromea spp.		X	X		X								
Gippslandica extensa		X	cf.		cf.								
Histiocysta variata†					X			3%					
Hystrichokolpoma rigaudiae		X						X					
Impagidinium spp.		X			X								
Lingulodinium macharophorum	X	X			X			X					
Membranosphaera adnata†					X								X
Nematosphaeropsis rhizoma†		CV						CV					CV
Operculodinium centrocarpum	X	5%			X			2%					2%
Paralecaniella indentata		X			X	X		2%		X			X
Paucilobimorpha inaequalis													2%
Pentadinium laticinctum		CV			CV								CV
Phthanoperidinium comatum		X						X					
Phthanoperidinium delicatum†								X					
Protoellipsodinium simplex ms		5%			CV			CV					CV
Pyxidinopsis pontus†		CV			CV			CV					CV
Rhombodinium glabrum													X
Schematophora speciosus		X	X										
Spiniferites spp.		71%			X			53%					48%
Stoveracysta ornata		X											
Systematophora placacanthum		X			X			X					
Tectatodinium pellitum		CV			CV								
Tectatodinium scabroellipticum†		X											
Thalassiphora pelagica													X
Vozzhennikova apertura/rotunda					X			3%					9%

† Manuscript species
X = Present (1% or less)
CV = Caved
RW = Reworked
cf. = Compare with