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APPENDIX-4

PALYNOLOGICAL ANALYSIS OF HAPUKU-1, GIPPSLAND BASIN.

by

ALAN PARTRIDGE

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INTRODUCTION

The zones recognised in Hapuku-1 are summarized below. The determinations are based on the examination of 14 cutting samples and 44 core and sidewall core samples. At total depth (T.D.) the well was still within the Late Cretaceous *T. lilliei* Zone.

As expected the section penetrated by Hapuku-1 contained some surprises. The section contained an exceptionally thick *T. lilliei* Zone overlain by condensed *T.longus* and *L. balmei* Zones. On top of this is 36 feet of glauconitic siltstone which can be divided into 10 to 15 feet of probable early Eocene at the base, overlain by 20-25 feet of Late Eocene to basal Oligocene Upper *N.asperus* Zone which represents the thickest and only unequivocal occurrence of this zone as yet found in any of the wells in the offshore portion of the Gippsland Basin.

All productive samples above the *T.lilliei* Zone contain dinoflagellates and the Paleocene dinoflagellate zones contain the most diverse and abundant dinoflagellate assemblages of this age found in the basin. The basic frequency information on spore-pollen and dinoflagellates is summarized on the chart accompanying this report for the youngest part of the Latrobe Group. The high percentage of dinoflagellates and of gymnosperms relative to other spore-pollen illustrated suggests that the depositional enviornment is marine and well distant from the shoreline. Consideration of the sharpness of the dinoflagellate zone boundaries, depositional rates and lithology suggests the presence of a number of disconformities.

SUMMARY

AGE	ZONES (Spore-pollen&Dinoflagellates)	DATA & RATING (depth in feet) Highest	Lowest
Miocene	*P. tuberculatus*	9160 (3)	9182 (0)
	UNCONFORMITY		
Late Eocene - basal Oligocene	Upper *N.asperus*	9200 (0)	9221 (0)
	DISCONFORMITY		
Eocene	Zone undifferentiated	9227 (2)	9227 (2)
	UNCONFORMITY		
Late Paleocene	Upper *L.balmei*/ *W. homomorpha*	9236 (0)	9265 (0)
	DISCONFORMITY		
middle Paleocene	Lower *L.balmei*/ *E.crassitabulata*	9290 (0)	9346 (0)
	DISCONFORMITY		
Early Paleocene (Danian)	Lower *L.balmei* *T.evittii*	9358 (0)	9400 (0)
	? UNCONFORMITY		

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Summary cont'd

AGE	ZONES (Spore-pollen&Dinoflagellates)	DATA & RATING Highest	(depth in feet) Lowest
Late Cretaceous (Maastrichtian)	*T.longus/D.druggii*	9700 (1)	9810 (1)
DISCONFORMITY			
Late Cretaceous (Maastrichtian to Campanian)	*T. lilliei*	9875 (2)	11,930 (1)

ANALYSIS OF ZONES

Tricolporites lilliei Zone [Top 9875' (2) alternate 10,022' (1) to Base 11,930 (1)]. The consistant occurrence of the zone species *T.lilliei* plus *Triporopollenites sectilis* and sporadic occurrence of *Gephrapollenites wahooensis, Tricolpites waiparaensis, Gambierina rudata, G. edwardsii* and *Stereisporites regium* indicate that the section can be no older than the *T. lilliei* Zone. In general the spore-pollen are in low concentration with respect to other organic material in the preparations and as a consequence diversity is also low. The preservation in general is poor owing to pyrite pitting of the fossil exines.

Acritarchs, algae and dinoflagellates are present in samples at 9875; 10,022; 10,068 and 10,450 feet. However they are not well preserved and except for *Deflandrea pachyceros* at 9875 feet, and the algae *Palambages spp.* (9875 & 10,068 feet) and *Botryococcus sp.* (10,068 feet) they can only be identified as *Baltisphaeridium spp (sensu lato)*. These occurrences are significant however as it is the first time possible marine indicators have been identified from the *T. lilliei* Zone in the Gippsland Basin. Nevertheless a fresh water lacustrine environment cannot be excluded for this limited assemblage.

Tricolpites longus Spore/Pollen Zone and *Deflandrea druggii* Dinoflagellate Zone [9700' (1) to 9810' (1)].

The three samples referred to these zones contain very limited assemblages, which is not unexpected considering the sandy lithologies of the sidewall cores. The age dating is based on fragmented speciments of the dinoflagellates *Deflandrea druggii* and *D. conorata* and the presence of the pollen *Triporopollenites sectilis* and *Tricolporites lilliei* (at 9750 feet and 9810 feet). The pollen indicated that the section is no younger than the *T. longus* Zone.

Some difficulty is experienced in picking the *T.longus/T.lilliei* boundary in this well as one of the usual criteria has broken down. Normally there is a marked change in the ratios of *Nothofagidites spp* to *Gambierina spp.* across this boundary with high values of *Nothofagidites spp.* in the *T.lilliei* Zone but virtual absence from the *T. longus* where there is a corresponding increase in *Gambierina spp.* Applying this criteria (see frequency) distribution chart) the sample at 9750 feet is obviously in the *T.longus*

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Zone while those at 10,022 and 10,068feet belong to the *T. lilliei* Zone. The two intervening samples could be placed in either zone so the boundary is taken at the base of the occurrence of genuine marine dinoflagellates.

Lygistepollenites balmei Zone [Upper 9236' (0) to 9265' (0) Lower 9290' (0) to 9400' (0)]

This zone is readily recognised on its spore-pollen content which also substantiates the separation between the Lower and Upper subzones. However, most assemblages are composed of over 50% dinoflagellates (see Palynological frequency chart). They are the richest dinoflagellate assemblages found so far in the Paleocene of the Gippsland Basin and allow further subdivision of the *L.balmei* Zone into three subzones which have been recognised elsewhere in the basin. Although most samples contained dinoflagellates which was suprising considering the coarse grained lithology not all productive samples contained enough material for confident zone identification or counting.

Dinoflagellate Zones in *L.balmei* Zone.

Wetzeliella homomorpha Zone [9236' (1) to 9265' (1)]

This zone containing the lowest dinoflagellate percentages and diversity is recognised on occurrence of the zone species *W. homomorpha*. Other dinoflagellates present include *Adnatosphaeridium retiintextum*, *Achomosphaera septatum*, *Svalbardella australina* and *Deflandrea medcalfi*.

Eisenackia crassitabulata Zone [9290' (1) to 9346' (1)]

This zone is characterised by abundant *Adnatosphaeridium retiintextum* and lesser abundances of *Eisenackia crassitabulata* and *E. sp cf. circumtabulata*. Other dinoflagellates present include *Cladopyxidium septatum*, *Cyclonephelium vitilare*, *Deflandrea bakeri*, *D. dilwynensis* and *Svalbardella australina*

Trithyrodinium evittii [9358' (1) to 9400 (1)]

In this zone *Palaeoperidinium pyrophorum Deflandrea spp* and *Adnatosphaeridium reiintextum* are the most dominent forms. Other species present are *Deflandrea speciosa*, *D.palaeocenicus n.sp D.bakeri*, *D.dilwynensis*, rare *Eisenackia crassitabulata*, *Hystrichokolpoma mentitum*, *Gonyaulacysta sp.*, *Palaeostomocystis laevigata*, *Spinidinium spp.*, *Svalbardella australina* and *Trichodinium hirsutum*.

The sidewall core at 9638 feet contains a high dinoflagellate percentage (see Palynological Frequency chart) and is thus most similar to samples from the overlying *L. balmei* zone. However the assemblage contains only long ranging spore-pollen and dinoflagellates, plus a few undescribed dinoflagellates which have not previously been recorded and therefore the sample cannot be confidently referred to either the underlying or overlying zones.

Eocene (Zone undifferentiated) [9227' (2)]

The probable presence of Early Eocene is suggested by the recovery of a very limited dinoflagellate assemblage from a single sidewall core. The few spore-pollen observed in the preparation were not of age significant. Cuttings from this level upon preparation were found to be dominated by

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material caved from overlying Miocene, so it is unlikely that this determination can be improved on.

The dinoflagellate assemblage consists of:

Achomosphaera septatum

Adnatosphaeridium retiintextum

Cordosphaeridium bipolare

? *Diphyes colligerum*

Operculodinium centrocarpum

Thalassiphora pelagica

Wetzeliella homomorpha

? *W. hyperacantha*

The most likely age for this assemblage is certainly Lower *M.diversus* Zone but since none of the species are actually restricted to that zone and considering the possibility that there may be some reworking the assemblage is best left as undifferentiate Eocene. The maximum thickness for this unit can only be 15 feet.

Upper *Nothofagidites asperus* Zone [9200' (0) to 9221 (0)]

This zone was originally defined on negative evidence, being the interval following the extinction of many typical Eocene species and prior to the first appearance of the spore *Cyatheacidites annulatus* (Stover & Partridge, 1973).

It has not previously been confidently identified in the offshore portion of the Gippsland Basin. However the samples from Hapuku-1 placed in this zone conform to the original definition and although there is still not a single fossil known which is restricted to this zone the assemblages obtained were diverse and in terms of a combination of characters quite distinctive. The total assemblages show good agreement with others recorded from onshore.

Gippsland Basin and from the Bass Basin
Important spore-pollen identified include:

Aglaoreidia qualumis	9200'
Foveotriletes palaeoquetrus	9200'
Kuylisporites waterbolkii	9200', 9221'
Nothofagidites falcatus	9200', 9209', 9218'
Proteacidites rectomarginis	9200', 9209'
P. stipplatus	9200'
Tricolpites leuros	9209'
Triporopollenites chnosus	9200'

The dinoflagellate component of the assemblages is more diverse than other Upper *N.asperus* Zone samples examined and includes:

Cordosphaeridium inodes	9200', 9221'
Deflandrea heterophlycta	9218'
Homotryblium sp.cf. H.tasmaniense	9200', 9209', 9218'
Hystrichokolpoma rigandae	9200'
Hystrichosphaeridium capricornum	9218', 9221'
Nematosphaeropsis balcombiana	9200, 9209'
Phthanoperidinium coreoides	9221'
P. delicatum	9221'
Systematophora placacantha	9200', 9221'

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Proteacidites tuberculatus [9160' (3) to 9182' (0)]

The presence of the spore *Cyathcacidites annulatus* in the sidewall core at 9182 feet indicates an age no older than the above zone. The foraminifera extracted from this sidewall core were indeterminate because of partial dissolution and or diagenesis however the spore-pollen and dinoflagellate assemblage obtained is not inconsistant with the Zone F (late Early Miocene) age obtained from the lowest sidewall core containing datable foraminifera at 9150 feet.

DISCUSSION OF UNCONFORMITIES

A number of unconformities and/or disconformities are postulated in the Latrobe Group section penetrated in this well. The higher ones between the *P.tuberculatus* Zone (Miocene) and the Upper *N. asperus* Zone (late Eocene - basal Oligocene) and between the Eocene and the *L. balmei* Zone (Paleocene) are obvious because of the marked age differences.

The other breaks are more subtle and correspond to section missing across zone boundaries. Thus a complete sequence of zones is still present.

The two lowest breaks between the *T.longus/T.lilliei* and *L.balmei/T.longus* Zones are partially inferred from seismic and electric log correlation. Because the breaks are at zone boundaries it is uncertain how much section or time is missing. On the basis of environments interpreted from the palynological examination however there are distinct increases in percentages of dinoflagellates across both boundaries concurrent with decreases in depositional rate (see Palynological Frequency chart).

Likewise the two ther disconformities postulated between the three dinoflagellate zones recognised by within the *L. balmei* Zone are characterised by distinct zone changes and overall slow depositional rates. For these zones, assuming that there was continuous deposition, would give depositional rates between 0.3 cm/1000 years and 2.5 cm/1000 years. And these are the maximum rates!

They are anomalous depositional rates because they are less than what is considered as average rates for pelagic sedimentation in the ocean determined from the Deep Sea Drilling Project (D.S.D.P) and which has a range of between 1 to 5 cm/1000 years.

Considering that the *T.longus* and *L.balmei* Zones are dominated by coarse to often pebbly sands it would be difficult to rationalize the slow depositional rates with the lithology without the recognition of disconformities.

In addition the presence of a disconformity between the *E. crassitabulata* and *W. homomorpha* Zones could be an explanation for the origin of the dolomite cementation of the sandstones in the *E. crassitabulata* Zone.

Understanding the environmental setting of these sands in the *T.longus* and *L.balmei* Zones is more difficult however. Any explanation must consider a) absense of foraminifera or other marine fossils aside from dinoflagellates; b) the presence of disconformities;c) the very coarse lithologies recorded ; d) the lack of any obvious reworking of spore-pollen or dinoflagellates between zones.

The high percentage of dinoflagellates to spore-pollen particularly in *T.evittii* and *E. crassitabulata* Zones as well as high ratio of gymnosperm pollen to angiosperm pollen and spores suggest an offshore environment a considerable distance from the shore line. These features are consistant with one of the few environmental trends recognised in studies of distribution of spore-pollen

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and microplankton in present day marine sediments. (See Cross, et.al. 1966; Traverse & Ginsburg 1966). The trends are that the ratio of dinoflagellates to spore-pollen increase offshore and that among the spore-pollen, gymnosperm pollen increases preferentially with respect to the rest of the taxa because the gymnosperm pollen float more readily and longer as a consequence of their morphology and therefore can be transported further offshore.

Even though it appears to be an offshore marine environment the lack of any other marine fossils is difficult to explain. Especially the lack of foraminifera although their absence may be related to the coarse grained lithology which is ± implying a high energy environment. However the latter interpretation is inconsistant with the presence in the sands of dinoflagellates and spore-pollen which would be expected to be winnowed out in a high energy environment.

The possibility that the sands were emplaced by turbidity currents or a grain flow or represent slump deposits is also considered unlikely as they lack the coarser derived terrestrial plant fragments and recycled palynomorphs which are typical of palynological preparations from such deposits. Further, such an explanation is not helped by the presence of a complete sequence of zones even though they may be separated by disconformities.

Overall the sequence in the Paleocene in Hapuku-1 shows more similarity with the wells on, as with Dart-1, or adjacent to, as with Moray-1 the stable north and south platforms rather than the closer wells to the north east such as Albacore-1 and Mackerel-1. This suggests that we may have a different provenance for these units in Hapuku-1 and related to this may be that the sands from these areas are only available as specific times.

REFERENCES

Cross, A.T., Thompson, G.G. & Zaitzeff, J.B., (1966). Sources and distribution of palynomorphs in bottom sediments, southern part of Gulf of California. Marine Geology vol. 4. pp 467-524.

Stover, L.E. & Partridge, A.D. (1973). Tertiary and Late Cretaceous spores and pollen from the Gippsland Basin, Southeastern Australia. Proc. Roy. Soc. Vict. vol. 85 pt. 2: 237-286.

Traverse, A. & Ginsburg, R.N., (1966). Palynology of the surface sediments of Great Bahama Banks as related to water movement and sedimentation. Marine Geology 4 (6): 417-459

SAMPLES ANALYSED

SAMPLE	DEPTH IN FEET	ZONE
Cuttings	9110 - 20	Barren, mineral charcoal only.
Cuttings	9160 - 70	*P. tuberculatus* Zone
SWC 55	9182	*P. tuberculatus* Zone
SWC 53	9200, K,B.	Upper *N. asperus* Zone
SWC 52	9209	Upper *N. asperus* Zone
SWC 51	9218	Upper *N. asperus* Zone
SWC 50	9221 P,	Upper *N. asperus* Zone
Cuttings	9220 - 30	Indeterminate, dominated by material caved from *P. tuberculatus* Zone
SWC 49	9227	Eocene, undifferentiated but pre - Upper *N. asperus*
Cuttings	9230 - 40	Indeterminate, dominated by material caved from *P. tuberculatus* Zone.
SWC 48	9236	Upper *L. balmei/W. homomorpha* Zones
Core - 1	9250	Upper *L. balmei/W. homomorpha* Zones
Core - 1	9265	Upper *L. balmei/W. homomorpha* Zones
Core - 1	9274½	Indeterminate, very low yield.
Core - 2	9290	Lower *L. balmei/E. crassitabulata* Zones.
Core - 2	9309	Barren, mineral charcoal and woody material only.
Core - 2	9321	Lower *L. balmei/E. crassitabulata* Zones.
Core - 2	9329	Lower *L. balmei/E. crassitabulata* Zones
Core - 3	9346	Lower *L. balmei/E. crassitabulata* Zones
Core - 3	9358	Lower *L. balmei/T. evittii* Zones
Core - 3	9364 ½	Lower *L. balmei/T. evittii* Zones
Core - 3	9369	Lower *L. balmei/T. evittii* Zones
SWC 47	9400	Lower *L. balmei/T. evittii* Zones
SWC 46	9460	SWC contaminated.
SWC 45	9524	Barren
SWC 42	9638	Very low yield, zone indeterminate.

Samples Analysed cont'd

SAMPLE	DEPTH IN FEET	ZONE
SWC 40	9700	*T.longus/D.druggii* Zones
SWC 39	9750	*T.longus/D.druggii* Zones
SWC 38	9810	*T.longus/D.druggii* Zones
Cuttings	9870 - 80	Indeterminate, preparation dominated by drilling mud contamination
SWC 37	9875	*T.lilliei* Zone
SWC 36	9918	Indeterminate, SWC contaminated.
SWC 34	9968	Barren
SWC 33	10,022	*T.lilliei* Zone
Cuttings	10,030 - 40	*T.lilliei* Zone
SWC 32	10,031	SWC contaminated with Oligocene-Miocene fossils.
SWC 31	10,068	*T.lilliei* Zone
Junk Basket return	from trip to 10,115	*T.lilliei* Zone
SWC 119	10,200	*T.lilliei* Zone
SWC 116	10,385	*T.lilliei* Zone
SWC 115	10,450	*T.lilliei* Zone
Coal Cuttings	10,520 - 30	*T.lilliei* Zone
SWC 112	10,643	*T.lilliei* Zone
SWC 110	10,766	*T.lilliei* Zone
Coal Cuttings	10,980 - 90	*T.lilliei* Zone
SWC 106	11,033	*T.lilliei* Zone
SWC 105	11,100	*T.lilliei* Zone
SWC 104	11,175	*T.lilliei* Zone
Coal Cuttings	11,320 - 30	*T.lilliei* Zone
SWC 102	11,334 P	*T.lilliei* Zone
SWC 101	11,400	*T.lilliei* Zone
Cuttings	11,500 - 10	*T.lilliei* Zone
SWC 97	11,648	Barren, mineral charcoal only.
Cuttings	11,660 - 70	*T.lilliei* Zone
SWC 95	11,743	*T.lilliei* Zone
Coal Cuttings	11,820 - 30	*T.lilliei* Zone
SWC 91	11,930	*T.lilliei* Zone
Cuttings	11,940 - 50	*T.lilliei* Zone

Samples analysed cont'd

SAMPLE	DEPTH IN FEET	ZONE
Cuttings	11,970 - 74	*T.lilliei* Zone

Recycled spore-pollen are indicated by

K: Early Cretaceous

B: *L.balmei* Zone species

P: Permian

BASIN GIPPSLAND BASIN DATE September 25, 1975

WELL NAME HAPUKU-1 ELEVATION K.B. +28'

AGE	PALYNOLOGIC ZONES	HIGHEST DATA Preferred Depth	Rtg.	Alternate Depth	Rtg.	2 way time	LOWEST DATA Preferred Depth	Rtg	Alternate Depth	Rtg.	2 way time
OLIG-MIO.	P. tuberculatus	9160	3	9182	0		9182	0			
EOCENE	U. N. asperus	9200	0				9221	0			
	M. N. asperus										
	L. N. asperus										
	P. asperopolus										
	U. M. diversus										
	M. M. diversus										
	L. M. diversus										
PALEO-CENE	U. L. balmei	9236	0				9265	0			
	L. L. balmei	9290	0				9400	0			
LATE CRETACEOUS	T. longus	9700	1				9810	1			
	T. lilliei	9875	1				11,743	1	11,970	3	
	N. senectus										
	C. trip./T.pach.										
	C. distocarin.										
	T. pannosus										
EARLY CRETACEOUS											
PRE-CRETACEOUS											

COMMENTS: Wetzeliella homomorpha Dinoflagellate Zones 9236' (1) to 9265'(1)

Eisenackia crassitabulata Dino. Zone 9290' (1) to 9346'(1)

Trithyrodinium evittii Din. Zone 9358' (1) to 9400'(1)

Deflandrea druggii Dino. Zone 9700' (1) to 9810'(1)

Undifferentiated Eocene occurs in SWC at 9227'

RATINGS:
- 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 spore and pollen or microplankton, or both.
- 4; CUTTINGS, NO CONFIDENCE, assemblage with non-diagnostic spores, pollen and/or microplankton.

NOTE: If a sample cannot be assigned to one particular zone, then no entry should be made. Also, if an entry is given a 3 or 4 confidence rating, an alternate depth with a better confidence rating should be entered, if possible.

DATA RECORDED BY: ALAN PARTRIDGE DATE September 25, 1975

DATA REVISED BY: DATE