FORAMINIFERAL SEQUENCE

HAPUKU # 1

by DAVID TAYLOR

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SUMMARY

The HAPUKU # 1 well intersected a thick section of prograding Plio/Pleistocene carbonates (drilled thickness of + 5055'). This is the thickest section of Pliocene known in the Gippsland Basin; and for that matter, in southern Australia. The Plio/Pleistocene biostratigraphic sequence present in FLOUNDER # 5 (Taylor, 1975) was repeated in HAPUKU and the adopted zonation was found to be valid, though correlation with the European stratotype needs reconsideration with the availability of the detailed discussion of Stainforth et al (1975).

The Miocene section is severely abbreviated and the base of progradation between 7650 and 7900 is marked by the absence of Zone C and dramatic change in the benthonic components. In many other Gippsland sections the massive progradation took place during the mid Miocene in Zones C and/or D-1. The basal zones of the Miocene and most, if not all, of the Oligocene zones are absent in Hapuku.

The biostratigraphic sequence in HAPUKU # 1 is summarized below:-

AGE	Minimal Depth Zone	Multi Association Zones	Depth in Hapuku # 1 Top	Base
PLEISTOCENE				
--?--?--?--		A-2	?	2110
	A	A-3	2150 to	3700
PLIOCENE		A-4	3800 to	6250
		B-1	6450 to	7050
--?--?--?--	B			
LATE MIOCENE		B-2	7450 to	7650
		D-1	7900 to	8270
MID MIOCENE	D	D-2	8400 to	8800
————	E	?	9030 to	9060
EARLY MIOCENE	F		9150 to	?9182
? EARLY OLIGOCENE or ? LATE EOCENE	? J-2 or K		9200 to	9209

INTRODUCTION

Sixty-two side wall cores were examined between 1995 and 9875. Side wall cores at 9218, 9221, 9236 and 9875 were barren of fauna, as were samples from conventional cores # 1, # 2 and # 3 and a junk basket sample from 10115. Side wall cores from 9172, 9182, 9200 and 9209 contained non-diagnostic faunas. During drilling rotary cutting samples were examined but are not discussed in this report.

All depths cited in this report and listed on charts are in feet as labelled on samples submitted. The depths are below datum of + 28' M.S.L. and the water depth of 1260' is included in the measurement.

Three sheets of Distribution Charts accompany this report.

Sheet 1 shows the distribution of planktonic foraminifera with the basis of biostratigraphic breakdown.

Sheet 2 gives the distribution of benthonic species.

Sheet 3 summarizes the environmental analysis and presents an interpretative model.

Symbols on the charts are as follows:-

°	=	1 - 20 specimens
I	=	over 20 specimens
D	=	dominant (over 40%)
[°] or [I]	=	reworked planktonics or reworked or misplaced benthonics
?	=	dubious identification
cf	=	similar but not identical

BIOSTRATIGRAPHY

LATE EOCENE to EARLY OLIGOCENE:- Side wall cores at 9200 and 9209 contained only arenaceous foraminifera without planktonics. The fauna and lithology are reminiscent of the LAKES ENTRANCE GREENSAND. If this inference is correct and synchronuity of the rock unit maintained seawards, then the samples represent the earlymost Oligocene (J-2) or the latest Eocene (K).

OLIGOCENE to EARLY MIOCENE HIATUS:- Most, if not all, of the Oligocene and the base of the early Miocene are not represented in the biostratigraphic sequence, unless the poorly preserved planktonic faunas at 9172 and 9182 are older than Zone F.

EARLY MIOCENE - ? 9182 - 9150 - ? 9060:- Partial dissolution and/or diagensis have obliterated most taxonomic features on specimens from samples at 9182 and 9172. The side wall core at 9150 contains a slightly better preserved fauna and *Globigerinoides bisphericus* can be positively identified in association with *G. trilobus*. The association is characteristic of the minimal layer Zone F. Preservation is still poor at 9060, but moulds of *Praeorbulina glomerosa* were present without the ultimate *Orbulina* forms. Despite the inability to achieve identification of the *curvus* morphotype, a basal Zone E designation is applied and the early Miocene boundary is placed tentatively at 9060.

MID MIOCENE - ? 9030 - 8800 - 7900:- The side wall core at 9030 is zonally indeterminate, but probably represents the top of Zone E. The next side wall core at 8800 contains a characteristic Zone D-2 fauna with an association of *Orbulina universa* and *Globorotalia peripheroronda*.

The probable base of Zone D-1, at 8270, is faunally indistinct, but at 8100 there is an association of the various morphotypes of *G. mayeri* without *G. peripheroronda*. *G. lenguaensis* occurs at the top of the Zone with *G. mayeri* (S.L.).

As the fauna at 7900 is quite distinct from that in the next highest sample, at 7650, and as 7650 contains *G. acostaensis*, the side wall core at 7900 is regarded as representing the top of the mid Miocene in Hapuku, in accordance with the opinions of Stainforth et al (1975). Previously the mid and late Miocene have not been split in offshore Gippsland, because of lack of definition, but here it is both practical and convenient to distinguish between mid and late Miocene.

MISSING SECTION:- Zone C appears to be absent, as *G. mayeri mayeri* and *G. lenguaensis* are not present in association with *G. miotumida miotumida*. However, there is a 250 foot unsampled interval between the top of D and the base of B. But there is a dramatic change in benthonic components between 7900 and 7650, which suggests that the former represented a deepwater ooze, whilst the latter was at or near the base of a prograding sequence (see below).

Therefore, the supposition of a disconformity is not inconsistent with the environmental interpretation based on benthonic foraminifera.

LATE MIOCENE - 7650 - 7450:- A fairly nondescript fauna, devoid of most globorotalids apart from *G. miotumida miotumida* and *G. miotumida conoidea*. This lack of faunal definition is, in fact, the characteristic of Zone B-2 which is a vague, transitional interval between the diverse Miocene and Pliocene faunas.

PLIOCENE - ? 7050 - 1995 - ? :- As in Flounder # 5, the base of the Pliocene is placed at the initial appearance of *G. miozea conmiozea* and not at the appearance of *G. puncticulata*. This placement is consistent with that related to the Italian stratotype by Stainforth et al (1975) but not with the "traditional New Zealand Pliocene" of Kennett & Watkins (1974).

Between 7050 and 6450 there is a globorotalid fauna dominated by *G. miozea* (S.L.) (including *G. miozea conomiozea*), without the evolutionary descendant forms *G. puncticulata* (S.L.) (Kennett & Watkins, 1974) or elements of the *G. crassaformis* lineage of Lamb & Beard (1972). The evolutionary positions of the sequences place this interval within Zone B-1.

Distinct *G. puncticulata* (S.L.) first appears at 6250 with rare forms reminiscent of *G. aemiliana*. *G. crassaformis* is apparent at and above 5850 with sporadic occurrences of a rather thick shelled form referred to as *G. margaritae*. These ranges are consistent with the definition of Zone A-4 in Flounder # 5 (Taylor, 1975).

Zone A-3 is between 3700 and 2150; the base being marked by the dominant occurrence of *G. inflata*. *G. acostaensis* is replaced by *Neogloboquadrina humerosa* within the zone. *Globorotalia margaritae* was not reported within the interval.

The fauna at 2110 is dominated by *G. inflata* and *Globigerina bulloides*, but contains *Neogloboquadrina dutertrei*, *N. humerosa* and *Globorotalia tosaensis tenuitheca* which indicates the base of Zone A-2 as in Flounder # 5. The highest Hapuku sample at 1995 is still within A-2, so that the Quaternary Zone A-1 was not sampled, though it is no doubt present, above the highest side wall core.

ENVIRONMENT

Data relating to this environmental interpretation is shown on Distribution Chart - Sheet 3, whilst benthonic foraminiferal distribution is given on Sheet 2.

The totally arenaceous fauna in the "greensand", of possible late Eocene and/or early Oligocene age, suggests an anaerobic, lagoonal environment with the probability of reduced salinity waters. Such assumptions are identical for the onshore Lakes Entrance Greensand.

A definite environmental trend during the Mio/Pliocene is clearly shown by the pattern of benthonic foraminiferal distribution on the chart - Sheet 2. This trend, in ascending order, is:-

1) A concentration of deepwater species between 9182 and 7970. These species include *Sigmoidopsis schlumbergi, Gyroidina broekiana, Discammina compressa* and morphologically simple arenaceous forms. Specimen frequency fluctuates but is relatively high and planktonics always comprise over 98% of total fauna. The two deepest samples at 9182 and 9172 contain poorly preserved planktonic faunas which suggest that they had been subjected to partial or, for some species, total dissolution. Both of these samples contain *Cibicides mundulus* which, off Gippsland today, shows preference for depths approaching that of calcium carbonate compensation. Sedimentation evidently took place on the outer continental rise in the early Miocene and on the shallower inner continental rise during the mid Miocene.

2) The interval between 7050 and 3500 is dominated by the lens-shaped *Cassidulina carinata* in relatively poor and small specimen sized benthonic and planktonic faunas. The faunas give the impression that they were size and shape sorted by strong currents. A position on the lower continental slope is assumed.

3) From 3300 to 3196 the dominant species is *Epistominella exigua*, which is common on the present day continental slope.

4) *Virgulina rotundata* and *V. schrebersiana* are usually the common forms between 3096 and 2110, although *Bolivinita quadrilatera* is abundant at 2996 and *Euuvigerina bassensis* and *E. pigmea* dominate at 2110 and 2203.

Although all these species are present in the Jemmys Point Formation at Lakes Entrance (Parr, 1939 and Nicholls, 1968), they are by no means as abundant there as they are in Hapuku or on the modern Gippsland continental slope. Thus a slope position is indicated, which became shallower as is evident by the dominance of *Euuvigerina bassensis* and *E. pigmea* higher in the section.

The trend is from deepwater sedimentation in the early and mid Miocene to a prograded slope sequence in the Pliocene. The fact that Zone C is missing may be due to removal by high energy conditions which are evident at the base of the prograded sequence.

REFERENCES

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Form R 193 3/71

BASIN GIPPSLAND BY David Taylor

WELL NAME HAPUKU-1 DATE Sept. 24, 1975 ELEV. +28'

Foram Zonules

		Highest Data	Quality	2 Way Time	Lowest Data	Quality	2 Way Time
PLEIST.	A_1						
	Alternate						
	A_2	1995	0		2110	0	
	Alternate						
PLIOCENE	A_3	2150	0		3700	0	
	Alternate						
	A_4	3800	0		6250	0	
	Alternate						
	B_1	6450	0		7050	0	
	Alternate						
MIOCENE	B_2	7450	0		7650	1	
	Alternate						
	C						
	Alternate						
	D_1	7900	1		8270	1	
	Alternate	7970	0				
	D_2	8400	0		8800	0	
	Alternate						
	E	9030	2		9060	0	
	Alternate	9060	0				
	F	9150	1		9150	1	
	Alternate						
	G						
	Alternate						
	H_1						
	Alternate						
	H_2						
	Alternate						
OLIGOCENE	I_1						
	Alternate						
	I_2						
	Alternate						
	J_1						
	Alternate						
	J_2						
	Alternate						

COMMENTS:

Zone C missing. SWC at 7650' above foot of progradation. SWC's at 9170', 9182' contain indeterminant planktonic faunas due to partial dissolution and or diagenesis.

Samples at and below 9200' contain no planktonic faunas.

Note: If highest or lowest data is a 3 or 4, then an alternate 0, 1, 2 highest or lowest data will be filled in if control is available.

If a sample cannot be interpreted to be one zonule, as apart from the other, no entry should be made.

0 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).

Date Revised _____

HAPUKU # 1 **HAPUKU-1** **SPECIES LIST.** SHEET 1 of 3 SHEETS

DEPTH of SIDE WALL CORES in feet

PLANKTONICS	1995	2110	2150	2203	2297	2400	2505	2600	2700	2800	2900	2996	3096	3196	3268	3300	3400	3500	3590	3700	3800	3900	4005	4090	4200	4280	4350	4500	4700	4900	5100	5300	5530	5650	5850	6050	6250	6450	6650	6850	7050	7450	7650	7900	7970	8100	8270	8400	8600	8800	9030	9060	9150	9172	9182	9200	9209	9218	9221	9227	9236
																																																														N N N N F F F F F F F F
1. *Globigerina bulloides*	I	D	D	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	•	•	•	•	•	I	•	•			•	•		•	•		•	•	•						I	I												
2. *G. decoraperta*	I	I		•	•		•		•		I																	•			•	•		•	•	•	•	•	•			I	I	I	•	•		D		D														
3. *Globorotalia obesa*	•																																												•		•																				
4. *G. inflata*	D	D	D	D	D	D	D	D	D	D	D	I	D	D	D	D	D	D	D	I	•		•		•		?									cf																																
5. *Globigerinella aequalateralis*	I	I		•	•		I	•	•		I		I	I				•	•	•		I	I	I				•	•																																									
6. *Globorotalia miotumida conomiozea*		[•]																			-				•	I		I											I	I		•																												
7. *G. crassaformis*		•	•	•	•	•	•	•	•	•	•	•	I	I	•	I	•	I	I	I	I	I	I	I	I	I	D	I	I	•		•	I	I	I																																
8. *G. scitula*		•	•			•	I	•	•	•	•	•	•		•											•	I	•	•				•								•																											
9. *G. tosaensis tenuitheca*		•																																																																								
10. *Neogloboquadrina dutertrei*		•																																																																							
11. *N. humerosa*		•	•	•	•							•	•	•																																																										
12. *Globigerinoides rubra*		•																																																																							
13. *G. obliquus*		•																																																																							
14. *Orbulina universa*		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	•	I		•	•	I	•	•	•	I			D	D	I	I	•	•	•	I	I	I																				
15. *Globigerina falconensis*			I	I		•	I	•	•	I			•		•		•		•		I		I																										•																								
16. *Globorotalia miotumida conoidea*												cf		cf			cf	cf	cf						•								•		I	I	I	D	D	•		•	D	D	•	•	•																						
17. *G. cf scitula*												•	•	I																																																													
18. *G. acostaensis*													cf		•								•		I	•	•	•								•				•																														
19. *G. puncticulata*																	I	I	I	I	D	D	I	I	I	I	I	D	D	•	•	•	D	D	D	D	I	cf				?																														
20. *Globoquadrina altispira*																				•																																																					
21. *Globigerinoides trilobus trilobus*																						•	•	•										•								•	•		•		•	I	I			I																		
22. *G. trilobus sacculifera*																						•	•	•	•																																																
23. *Globorotalia miotumida miotumida*																							[•]*											?														•		•																								
24. *G. puncticulata sphericomiozea*																							I	I	•	•	•	•	•	•			I	•																																								
25. *Neogloboquadrina pachyderma*																											•																																																	
26. *Globoquadrina dehiscens* (S.S.)																											•																						?			•			D	D																		
27. *Globorotalia margaritae*																													•	•				•																																							
28. *G. siakensis*																																		?																																									
29. *G. cf semiliana*																																					•	•																																							
30. *G. premenardii*																																						•																																							
31. *G. miozea* (S.S.)																																							•																																						
32. *G. continuosa*																																																																															
33. *Globigerina nepenthes*																																																																														
34. *G. venezuelana*																																																																														
35. *Globorotalia praescitula*																																																																													
36. *G. conica*																																																																													
37. *G. mayeri barisanensis*																																																																													
38. *G. lenguaensis*																																																																													
39. *G. mayeri mayeri*																																																																													
40. *G. mayeri nympha*																																																																													
41. *Globigerina foliata*																																																																													
42. *G. woodi woodi*																																																																													
43. *Globigerinoides bisphericus*																																																																													
44. *Globorotalia peripheroronda*																																																																													
45. *Globoquadrina larmeui*																																																																													
46. *Globigerinoides trilobus* (elongate form)																																																																													
47. *Globoquadrina advena*																																																																													
48. *Praeorbulina glomerosa* (S.L.)																																																																													
49. *Globigerina apertura*																																																																													
50. indeterminate globigerinids (poor preservation)																																																																													

SYMBOLS:

o	= 1 - 20 specimens
I	= over 20 specimens
D	= dominant (over 40%)
[o] or [I]	= reworked planktonics or reworked or misplacedbethonics
?	= dubious identification
cf	= similar but not identical
NFF	= no foraminiferal fauna

Depth in feet to base of ZONE	2110	3700	6250	7050	7650	8270	8800	9060	9150	9182	no planktonics
	A-2	A-3	A-4	B-1	B-2	D-1	D-2	E	F	?	

HAPUKU 61 **HAPUKU-1** SPECIES LIST

DEPTH of SIDE WALL CORES in feet

1995 2110 2150 2203 2287 2400 2505 2600 2700 2800 2900 2996 3096 3196 3268 3300 3400 3500 3590 3700 3800 3900 4005 4090 4200 4280 4350 4500 4700 4900 5100 5300 5530 5650 5850 6050 6250 6450 6650 6850 7050 7450 7650 7900 7970 8100 8270 8400 8600 8800 9030 9060 9150 9172 9182 9200 9209 9218 9221 9227 9236

BENTHONICS

51. *Sphaeroidina bulloides*
52. *Brizalina nobilis*
53. *Fuuvigerina bassensis*
54. *F. pigmea*
55. *Lenticulina* spp.
56. *Rodosaria* spp.
57. *Notorotalia clathrata*
58. *Brizalina earlandi*
59. *Bolivinita pliocea*
60. *Discorotalia aranea*
61. *Globobulimina pacifica*
62. *Melonis pompiliodes*
63. *Pyrgo* sp. (large)
64. *Textularia semicarinata*
65. *Virgulina rotundata*
66. *V. schreibersiana*
67. *Brizalina pseudobeyrichi*
68. *Bolivinita quadrilatera*
69. *Globobulimina ovata*
70. *Martinottiella communis*
71. *Cassidulinoides* sp.
72. *Epistominella exigua*
73. *Karreriella bradyi*
74. *'Planulina' wuellerstorfi*
75. *Bolivina* sp? (striate)
76. *Bulimina submarginata*
77. *Siphouvigerina proboscidea*
78. *Bolivina robusta*
79. *Glandulina* sp.
80. *Hoeglundina elegans*
81. *Triloculina* spp.
82. *Osangularia bengalensis*
83. *Heronallenia* cf. *polita*
84. *Ancmalina tasmanica*
85. *Cibicides opacus*
86. *Astrononion* sp. carter
87. *Ancmalina colligera*
88. *Fissurina* sp.
89. *Florilus* cf. *parri*
90. *Cassidulina carinata*
91. *Ancmalina bassensis*
92. *Lagena* spp.
93. *Trifarina bradyi*
94. *Cibicides subhaidingeri*
95. *Fuuvigerina miocea*
96. *Notorotalia* cf. *taranakia*
97. *Pullenia bulloides*
98. *Cassidulina subglobosa*
99. *Cibicides thiara*
100. *C. mediocris*
101. *Gyroidina soldani*
102. *Fuuvigerina mioschwageri*
103. *Sigmoidopsis schlumbergeri*
104. *Eponides subhaidingeri*
105. *Melonis* sp?
106. *Rosalina* sp?
107. *Ammodiscus* sp (smooth)
108. *Bathysiphon* sp B
109. *Glomospira* spp.
110. *Gyroidina broekiana*
111. *Haplophragmoides* cf *paupera*
112. *Anomalina macroglabra*
113. *Rhabdammina* sp.
114. *Discammina compressa*
115. *Spiroloculina pusillum*
116. *Cibicides mundulus*
117. *Bathysiphon* sp A
118. *Haplophragmoides* cf *incisa*
119. *H. rotundata*
120. *Ammodiscus parri*

SYMBOLS:

o = 1 - 20 specimens

I = over 20 specimens

D = dominant (over 40%)

[O] or [I] = reworked planktonics or reworked or misplaced bethonics

? = dubious identification

cf = similar but not identical

NFF = no foraminiferal fauna

HAPUKU-1 SPECIES LIST

DEPTH of SIDE WALL CORES in feet	1995	2110	2150	2203	2297	2400	2505	2600	2700	2800	2900	2996	3096	3196	3268	3300	3400	3500	3590	3700	3800	3900	4005	4090	4200	4280	4350	4500	4700	4900	5100	5300	5530	5650	5850	6050	6250	6450	6650	6850	7050	7450	7650	7900	7970	8100	8270	8400	8600	8800	9030	9060	9150	9172	9182	9200	9209	9218	9221	9227	9236
OTHER FAUNA																																																																	
Echinoid spines	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•							•	•	•	•	•		•	•	•	•	•										•																		
Mollusca frags	•	•	•																																									•																					
Ostracods	•	•	•	•	•	•	•	•	•	I	•		•		•	•	•	•	•	•			•	•					•																																				
Sponge spicules		•				I	I	I			I	I		I	I																				I		I	I	I						I				I															
Fish teeth															•																																																		
INORGANIC MATERIALS																																																																		
Limonite	•	•	I	I	•	•								•	I	•	•					•	•	•	•	•																																									
Pyrite	•	•												•	I	•	•					•	•	•	•	•																																							
Angular quartz													•	I	•	I		I	I				I		I	I	I				I	•				•	I		I	I			I	I		•	I		I	•	I		I	I	I	D	D	D	I	D	D
Glauconite																	•																																					I		I	I	I	D	D	D				
Mica																																																													I				
Coarse rounded quartz + gravel																																																																D			

SYMBOLS:

o = 1 - 20 specimens

I = over 20 specimens

D = dominant (over 40%)

PERCENTAGE PLANKTONIC FORAMINIFERA

100%
50%
0%

RELATIVE SPECIMEN COUNT = •-•-•
and
BENTHONIC DIVERSITY = x-x-x

3000 15
2000 10
1000 5
0 0

DOMINANT BENTHONIC GROUP

EUUVIGERINA
VIRGULINA
EPISTOMINELLA
CASSIDULINA
ARENACEOUS

ENVIRONMENTAL INTERPRETATION	PROGRADING SLOPE	HIGH ENERGY PROGRADING SLOPE	BASE of SLOPE	CONTINENTAL RISE	LAGOONAL	
Depth in feet to base of ZONE	2110 / A-2	3700 / A-3	6250 / A-4	7050 / B-1	7650 / B-2	8270 / D-1	8800 / D-2	9150 / F	?	?