PE990629

APPENDIX 6.2

THE FORAMINIFERAL SEQUENCE IN VOLADOR-1

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FOR: SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

R 4688

VOLADOR # 1.

SUMMARY OF FORAMINIFERAL SEQUENCE

†Sample Depth (m)	ZONE*	AGE*	PALEOENVIRONMENT¶	E-Log Pick
1325	A-4	Early Pliocene	Shelf Edge (≈250m)	
1475 to 1785	B-2 to C	Late to Mid Miocene	Upper Slope carbonates (400-250m)	
1925 to 2555	D-1	Mid Miocene	Slumping of carbonate down slope with canyon fills	
~~ (2 m.y.) ~~~				2563
2564 to 2650	E-1 to E-2	Mid to Early Miocene	Carbonates at base of continental slope (≈1000m)	
				2659
2671 to 2828	F to G	Early Miocene	Deep oceanic basin carbonate with sporadic corrosion due to proximity of C.C.D. (2000-1000m).	
~~ (12-14 m.y.) ~~~				2840
2850 to 2935	J-2	Early Oligocene	Carbonates from rapid transgression & eustatic sea level rise onto shelf platform (40m-<200m).	
				2938
2941	J/K	Eo/Oligocene Boundary	Commencement of early Oligocene Transgression coincidental with tectonic adjustment (<40m)	
?	?	?	?	?—2945
2949 to 3010	No planktonics	"Early Tertiary" arenaceous forams.	Barrier barred estuary/ lagoonal system; anoxic & polyhaline (<10m).	
?	?	?	?	?
2947 to 3030	? No microfauna found	?	?	

† Summary of results of examination of fiftyfive sidewall cores as tabulated on Tables 2, 3 & 4.

* Based solely on planktonic foraminifera. Detailed planktonic foraminiferal distributions on Table 2, with reliability of zonal boundary picks given on Table 1.

¶ Interpretations based on benthonic foraminifera (see Table 3); total microfauna and other sediment grains (see Table 4). Paleo-depth estimates given in parentheses.

—?—?— Unable to interpret contact relationship

~~~(2 m.y.)~~~ Hiatus with time span in parentheses.
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BIOSTRATIGRAPHY.

This discussion is based on the distribution of Tertiary planktonic foraminifera in the Gippsland sector of the Tasman Sea Provence. The biostratigraphic letter scheme is in accordance with those for other sectors of the Provence, as outlined by Jenkins (1974), and Srinivasan & Kennett (1981).

EARLY TERTIARY - 3010 to 2949: No planktonic foraminifera found, but the arenaceous benthonic foraminiferal assemblages were similar to arenaceous assemblages, which were common in early Tertiary sediments in all three Bass Strait Basins (Taylor, 1965).

EO/OLIGOCENE BOUNDARY - 2841m: Only planktonic foraminifera present were two specimens of *Globigerina angiporoides angiporoides* which ranged from latest Eocene into the basal Oligocene.

BASAL OLIGOCENE - ZONE J-2 - 2935 to 2850m: Contains planktonic assemblages typical of the basal Oligocene (Zone J-2) of the Tasman Sea region; especially *Globigerina brevis* and *Globorotalia gemma* (? syn. or ≡ *G. postcretacea*).

EARLY MIOCENE - ZONES G at 2828m and the OLIGO/MIOCENE HIATUS at 2840m (E-log): At 2828m, the presence of *Globigerinoides trilobus* with the Tasman Sea early/mid Miocene *Globorotalia* suite of *G. miozea miozea*, *G. praescitula* and *G. zealandica* indicates a biostratigraphic position some distance above the base of the Miocene; that is Zone G, rather than the basal Miocene Zone H-1. Such a biostratigraphic placement of the sidewall core at 2828m automatically implies a hiatus existed between the early Oligocene at 2850m and the early Miocene. The E-log pick for this event in Volador # 1 is at 2840m. This event was an ubiquitous one in deep water Oligo/Miocene sequences in the Gippsland Basin as well as in the whole Tasman Sea Provence (refer Loutit & Kennett, 1981a). In Volador, the time span of the Hiatus was some 12 to 14 million years in length, compared with a maxima of 20 million years recorded in Hapuku # 1. However, in marginal, shallow water, Gippsland sequences, sedimentation was accumulating during this interval (e.g. at Lakes Entrance - refer Jenkins, 1974, Table 3). The causes of this hiatus will be discussed in the Paleoenvironment section of this report.

<u>EARLY/MID MIOCENE - ZONES G,F.E-2 & E-1 - 2828m to 2564m</u>: A deep water sequence of early Miocene carbonate extends from Zone G, through Zone F (with *Globigerinoides bisphericus* ≡ *G. sicanus*), to Zone E-2 at the top of the early Miocene with members of the *Praeorbulina glomerosa* Group. Sediment accumulation was also evident at the very base of the mid Miocene (Zone E-1 with *Orbulina suturalis*); before the sequence was abruptly truncated by mid Miocene slumping and submarine canyon cutting.

<u>MID MIOCENE - BASE of CANYON FILL SEQUENCE - ZONE D-1 at 2555m</u>: Probably all the mid Miocene Zone D-2 sediment was removed by slope slumping and/or the initiation of canyon cutting. A hiatus, with a time span of some 2 million years was evident in the Volador sequence, with an E-log pick at 2563m.

<u>MID MIOCENE - ZONE D-1 - CANYON FILL SEQUENCE 2555 to 1925m</u>: A thick sequence of Zone D-1 assemblages, which fluctuate in the quality of preservation. The degree of diagenesis was proportional to the ability to specifically identify specimens and thus positively identify a Zone D-1 assemblage in each sample. This is demonstrated by the tabulation below and in several columns on Table 4.

Depth (m)	Sidewall Core	ZONE	Reliability Rating (refer Table 1) &	Preservation Quality
1925	# 43	indeterminate		poor
2001	# 42	D-1	(1)	moderate
2144	# 40	indeterminate		poor
2300	# 37	indeterminate		poor
2350	# 36	D-1	(2)	poor
2426	# 34	D-1	(1)	moderate
2452	# 33	indeterminate		poor
2500	# 31	D-1	(O)	moderate
2525	# 30	D-1	(O)	moderate
2555	# 29	D-1	(1)	moderate

Samples with a high confidence rating of zero (O), contained the *Globorotalia peripheroacuta* morphotype of the *G.foshi* Group; whilst those with a moderate rating of one (1) contained members of the Tasman Sea Provence *Globorotalia* suite, including the highest appearance of *G. conica* at 1925m.

MID to LATE MIOCENE to EARLY PLIOCENE - ZONES C.B-2 and A-4 - 1785 to 1325m:

Because of poor sidewall core recovery, the upper part of the Gippsland sequence was poorly represented in Volador # 1. Zone B-1 was not designated but was probably present in the unsampled interval between 1475 and 1325m. The sample at 1325m contained an almost complete list of species for a Zone A-4 planktonic assemblage, bearing witness of the early Pliocene transgression onto the southern Australian Margin.

PALEOENVIRONMENT.

These interpretations are based on the analysis of the benthonic foraminiferal faunas, as well as all faunal elements (including planktonic foraminifera) and other sediment grains in the prepared residues (size >.075mm). Paleo-depths and other physico-chemical parameters are deduced from the benthonic assemblage by a combination of both comparison with faunal distribution in sediments of similar age and by using present day distribution of species analogues.

3010 to 2949m "EARLY TERTIARY" ESTUARINE: These arenaceous benthonic foraminiferal assemblages were, as elsewhere in the Bass Strait region, indicative of poorly oxygenated water with severe salinity fluctuations (Taylor, 1965). Distinctly biogenic pyrite and indications of sediment bioturbation were associated with these faunas, as were pyritized discs and spheres which could be attributed to diatoms. Such fossil features are characteristics of the carbon-rich, mudstones and micaceous quartz sandy siltstones of the Flounder Formation of the Gippsland, the Demons Bluff Formation of the Bass Basin and the Johanna River Sand and Dilwyn Formation of the Otway Basin. The facies similarities suggest the development of a series of barrier-barred estuarine/lagoonal systems. However, the facies was extremely diachronous, ranging in age from latest Paleocene to Eocene across the three Bass Strait Basins.

By this comparative reasoning, I regard the Flounder Formation to fill a series of estuarine scours rather than deeply incised channels.

2941 to 2850m - EO/OLIGOCENE - RAPID TRANSGRESSION: The four assemblages within this interval demonstrate rapid environmental change; from the initiation of the marine transgression onto an exposed surface at 2941m to total inundation by shelfal seas and establishment of a biogenic carbonate, sedimentary regime. Both the planktonic and benthonic foraminiferal assemblages indicate that this transgression was isochronous with and resulted in similar environmental responses as the Whaingaroan Stage in New Zealand (Loutit & Kennett, 1981b).

The "*Vail Coastal On-lap Curve*" (e.g. Loutit & Kennett, l.c., p.1596) expresses this Whaingaroan transgressive event in terms of eustatic sea level rise. However, the increase in paleo-water depth in the Gippsland Basin Deep was too exaggerated in vertical scale, to have resulted purely from eustatic sea level rise. Vulcanism and tectonic uplift occurred in the East Gippsland Highlands in latest Eocene Times (Wellman, 1974), so that compensatory subsidence could explain the rapidity of basin deepening (refer below for further discussion).

<u>OLIGOCENE/EARLY MIOCENE HIATUS - 2840m (E-log)</u>: The sidewall cores above this hiatus contained an extremely deep water benthonic foraminiferal assemblage associated with Zones G & F (early Miocene) planktonic faunas. The benthonic faunas were often dominated by morphologically primitive agglutinated foraminifera; especially the branching tubed form *Rhabdammina abyssorum*. These benthonic assemblages closely resemble those recorded in sediments of the same age from DSDP Site 206 in the Tasman Sea by Hayward & Buzas (1979). By analogy, these Volador faunas are typical of modern assemblages inhabiting the continental rise between 2000-4000m. This depth is confirmed by comparative methods, in that the interpreted depths are "consistent with inferred little change in water depth (3000m) at DSDP 206 between the early Miocene and now" (Hayward & Buzas, l.c., p.24). A higher depth estimation of between 2000 and 1000m is given for the Volador # 1 early Miocene as faunal modification may have occurred due to upwelling of carbonate deplete water, thus raising the C.C.D. at the base of the continental rise.

Effects of the corrosion due to differential dissolution of $CaCO_3$ are noted in the Volador early Miocene with the degree of corrosion fluctuating sporadically (see Table 4). Thus carbonate sedimentation was in the proximity of the C.C.D. throughout the early Miocene.

However, Loutit & Kennett (1981a, fig. 1-4) show that the C.C.D. was deeper during the late Oligocene to early Miocene than it was during the early Oligocene and Eocene, or during the mid to late Miocene. Loutit & Kennett (1981a & b and Kennett references therein) account for the hiatus in terms of paleoceanographic changes associated with the opening of the Southern Ocean, causing northern movement of high velocity deep currents to penetrate into the Tasman Sea. The non-accumulation of sediment was thus explained for in terms of non-deposition or erosion. But the time span of the hiatus is by no means uniform throughout the Gippsland Basin. This inconsistency is even apparent in wells within the same structure. Instances of the time span variation are:-

Zero along Basin Margins (e.g. Lakes Entrance)
8-10 million years in Kingfish, Fortesque, Cobia Wells
12-14 million years in Volador # 1
17 million years in Flounder # 1
and 20 million years in Hapuku # 1.

This data supports the contention that upwelling of the C.C.D. was responsible for the absence of some if not all Oligo/Miocene carbonate sedimentation. The extent of the upwelling would have been a function of the submarine topography in the proximity of any one site.

<u>2828 to 2564m - EARLY to MID MIOCENE BASIN DEEP CARBONATES</u>: The deep water environmental interpretation for the Zone G & F interval (2828 to 2671m) is discussed above. Gradual shallowing of the depositional surface occurred and is most marked at and above 2650m, during the early/mid Miocene transition of Zones E-2 and E-1. A situation at the base of the continental slope (≈1000m) is envisaged.

<u>2555 to 1925m - MID MIOCENE CANYON FILL CARBONATES</u>: High energy sedimentation is evident at and above 2555m, compared with generally low energy regimes of the continental rise below 2564m. Recycling of shallow shelf benthonics and size and shape sorting of planktonics are features of assemblages at and above 2555m. This 2555m sample was just above the truncation of the biostratigraphic sequence during the mid Miocene (at 2563m on E-log). All these features are typical of submarine cutting and subsequent carbonate filling in Gippsland offshore sequences. The time span for this Zone D-1 fill with a thickness of at least 600m was less than 1.5 million years. This accumulation rate was remarkably high. No doubt much of the accumulation was slumped material from an unstable shelf edge and upper slope.

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Table 1

MICROPALEONTOLOGICAL DATA SHEET

BASIN: GIPPSLAND ELEVATION: KB: +25.3 GL: -260

WELL NAME: VOLADOR # 1 TOTAL DEPTH:

AGE	FORAM. ZONULES	HIGHEST DATA Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time	LOWEST DATA Preferred Depth	Rtg	Alternate Depth	Rtg	Two Way Time
PLEISTOCENE	A_1										
PLEISTOCENE	A_2										
PLIOCENE	A_3										
PLIOCENE	A_4	1325	0				1325	0			
PLIOCENE	B_1										
MIOCENE LATE	B_2	1475	2				1475	2			
MIOCENE LATE	C	1700	0				1785	1			
MIOCENE MIDDLE	D_1	2001	1				2555	1	2525	0	
MIOCENE MIDDLE	D_2										
MIOCENE MIDDLE	E_1	2570	0				2570	0			
MIOCENE MIDDLE	E_2	2590	0				2650	0			
MIOCENE EARLY	F	2671	1				2750	1			
MIOCENE EARLY	G	2760	1				2828	0			
MIOCENE EARLY	H_1										
OLIGOCENE LATE	H_2										
OLIGOCENE LATE	I_1										
OLIGOCENE LATE	I_2										
OLIGOCENE EARLY	J_1										
OLIGOCENE EARLY	J_2	2850	1				2941	2	2935	0	
EOCENE	K	2941	2				2941	2			
EOCENE	Pre-K	2947	2				3010	2			

COMMENTS: Pre-K interval does not contain planktonic foraminiferal; but arenaceous fauna & diatoms were present and together with lithofacies suggest Flounder Formation.

N.B. Hiatus between J-2 & G (time span ≈12-14m.y.) and between E-1 & D-1 (time span ≈2 m.y.). Absence of B-1 was probably an artifact of sampling.

CONFIDENCE RATING:

- 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).

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.

ENVIRONMENT: Barred Estuary /lagoon

SIDEWALL CORES Depth in metres	Ammodiscus parri	Bathysiphon angleseaensis	Haplophragmoides incisa	H. paupera	Trochammina depressa	Discs & spheres ? Diatoms
1325.0						
1475.0						
1700.0						
1785.0						
1925.0	indet					
2001.0						
2144.0						
2300.0	indet					
2350.0	indet					
2426.0						
2452.0	indet					
2500.0						
2525.0						
2555.0						
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2564.0						
2570.0						
2580.0						
2590.0						
2599.0						
2610.0						
2620.0						
2631.0						
2640.0						
2650.0						
2659.0						
2671.0						
2680.0						
2690.0						
2700.0						
2710.0						
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2730.0						
2740.0						
2750.0						
2760.0						
2770.0						
2780.0						
2790.0						
2800.0						
2810.0						
2820.0						
2825.0						
2828.0	R					R
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2850.0						
2890.0						
2935.0						
2941.0						
—?—		?				
2949.0		x	•	•		•
2970.0		•				x
2990.0		•				•
3000.0		•				x
3010.0	•	x	•	•	•	
3019.3						
3019.5	N.F.F.					
3030.0						

ENVIRONMENT: Transgressive onto shelf platform

SIDEWALL CORES Depth in metres	Bolivina finlayi	B. anastomosa	Bulimina truncana	Plectofrondicularia whaingaroica	Cibicides thiara	Textularia "trochus"	Bathysiphon sp(porcelaineous)
1325.0					x		
1475.0							
1700.0							
1785.0							
1925.0							
2001.0							
2144.0							
2300.0							
2350.0							
2426.0					•		
2452.0							
2500.0	x	•	•				
2525.0							
2555.0			•				
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2564.0							
2570.0							
2580.0							
2590.0							
2599.0							
2610.0							
2620.0							
2631.0							
2640.0							
2650.0							
2659.0							
2671.0							
2680.0							
2690.0							
2700.0							
2710.0							
2720.0							
2730.0							
2740.0							
2750.0							
2760.0							
2770.0							
2780.0							
2790.0							
2800.0							
2810.0							
2820.0							
2825.0							
2828.0							
〰〰〰							
2850.0							•
2890.0				•	•	•	•
2935.0	•	•	•	•	•	•	
2941.0	indet						
—?—		?					
2949.0							
2970.0							
2990.0							
3000.0							
3010.0							
3019.3							
3019.5							
3030.0							

ENVIRONMENT: OCEANIC BASIN DEEP

SIDEWALL CORES Depth in metres	Rhabdammina abyssorum	Ammodiscus incertus	Stilostomella antillea	Globobulimina pacifica	Sigmoilopsis schlumbergi	Gyroidina zealandica	Oridorsalis tenera	Vulvulina pennatula	Epistominella exigua	Discammina compressa	"Cyclammina" spp.	Ammoglobigerina sp.	Hyperammina subnodosum	Karreriella bradyi	Eggerella bradyi	Textularia goesii	Cibicides mundulus	C. wuellerstorfi	Pleurostomella tenuis	Cibicides karreriformis	Hyperammina cylindrica
1325.0																					
1475.0																					
1700.0																					
1785.0																					
1925.0																					
2001.0											•										
2144.0																					
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2426.0				•										•							
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2500.0				•																	
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2564.0																					
2570.0																					
2580.0																					
2590.0								•													x
2599.0																					
2610.0									•												
2620.0		x	•			•							x								x
2631.0	x		•									•	x								
2640.0			•						•	•	•	•		•	•						•
2650.0			•							•	x		x		•						
2659.0													•								•
2671.0											•										x
2680.0	x	•					•				•	•	x								x
2690.0	D								•					•							
2700.0	x	•								•			x								x
2710.0	D		x			•				•	•					•	•	•		•	
2720.0	D		•					•		•	•	x		•	•	•	x	•	•		
2730.0	x			•					•	•			x	•							
2740.0	x											•									
2750.0	D									•											
2760.0	x			•			x		•	•	•										
2770.0	x			x																	
2780.0	x									•											
2790.0	•					•															
2800.0	•								•												
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3019.5																					
3030.0																					

ENVIRONMENT: BASE of RISE and SLOPE

SIDEWALL CORES Depth in metres	Recurvoides spp.	Melonis barleeanus	Osangularia bengalensis	Fissurina spp & Lagena spp	Hopkinsina mioindex	Cibicides temperatus	Rhabdammina algaeformis	Brachysiphon corbiformis	Bulimina marginata	Saccammina sp.	Lenticulina spp.	Oridorsalis umbonatus	Cassidulina subglobosa	Cassidulina leavigata	Euuvigerina maynii	Trifarina bradyi	Cibicides opacus	Siphouvigerina proboscidae
1325.0									•				•	x		•	•	•
1475.0														x	•			
1700.0														x			x	
1785.0				•					•									
1925.0																		
2001.0														x			x	
2144.0											x							
2300.0																		
2350.0																		
2426.0				x							•			x		•	x	x
2452.0																		
2500.0									•		x	•	•	•	•	•	x	
2525.0				•	•	•				•	•	•	•					
2555.0									•	•	•							
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2564.0				•			x	•										
2570.0				•			•	•										
2580.0							D	x										
2590.0					•	x												
2599.0				x														
2610.0																		
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3030.0																		

ENVIRONMENT: SHELF

SIDEWALL CORES Depth in metres	Cibicides vortex	Cibicides lobatulus	Anomalina macroglabra	Pseudoclavulina rudis	Textularia carinata	Bolivinita quadrilatera	Virgulina spp.	PLANKT FORA ZON
1325.0		x		•	•	•	•	A-
1475.0								B-
1700.0								
1785.0								C
1925.0								
2001.0								
2144.0								
2300.0								
2350.0								
2426.0								D-
2452.0								
2500.0		R	R	R	R			
2525.0								
2555.0								
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2564.0								E-
2570.0								
2580.0								
2590.0								
2599.0								
2610.0								
2620.0								E-
2631.0								
2640.0								
2650.0								
2659.0								
2671.0								
2680.0								
2690.0								
2700.0								F
2710.0								
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2760.0								
2770.0								
2780.0								
2790.0								
2800.0								G
2810.0								
2820.0								
2825.0								
2828.0								
〰〰〰								
2850.0								
2890.0								J-
2935.0								
2941.0								K/
—?—			?					?
2949.0								
2970.0								
2990.0								
3000.0								
3010.0								
3019.3								
3019.5								
3030.0								

KEY: • = <20 specimens
x = >20 specimens
D = Dominant >60% specimens
? = determination queried

R = Recycled specimens
N.F.F. = no foraminifera found
〰〰〰 = definite hiatus
—?—? = hiatus - uncertain

indet = specifically indeterminate because of poor preservation due to solution effects and/or diagenesis.

TABLE 3: DISTRIBUTION of BENTHONIC FORAMINIFERA in Valador – 1
(with environmental assessment based on both analogy & comparison; refer Table 4).

David Taylor, April 12, 1983.

SIDEWALL CORES Depth in metres	GROSS FORAMINIFERAL ASSEMBLAGE CHARACTERS: Total foram count	% Arenaceous benthonic forams	% calcareous benthonic forams	% planktonic forams	$CaCO_3$ PRESERVATION Quality	$CaCO_3$ PRESERVATION - Factor	ENERGY & O_2 REGIME	MINOR GRAIN COMPONENTS – BIOGENIC (exclud.-forams): ? Diatom-disc & spheres	Biogenic pyrite	Bioturbation-faecal pellets, tubes	Fish fragments	Ostracods	Bryozoa fragments	Echinoid spines	Sponge spicules	INORGANIC: Mica	Limonitic clay	c-m ang. qtz.	glauc pellets	? siderite nodules	GROSS LITHO-GRAIN COMPONENTS m: calc silt, marl & biomicrite ▼: recrystall. biomicrite & calc.siltst. P: pyrite & limonite ..: f qtz sdst ∇Δ: m-c pitted & fractured qtz oo: m-c ang. subrd qtz. --: clayst. & siltst. 0% 50% 100%	¶PALEO-ENVIRONMENTAL ASSESSMENT - refer also Table 3. ESTUARINE/LAGOONAL (<10m) INNER SHELF (<40m) MID SHELF (<100m) OUTER SHELF (<200m) SHELF EDGE (≈250m) UPPER SLOPE (400m-250m) CANYON in SLOPE (1000m-400m) CONTINENTAL RISE (≈1000m) OCEANIC BASIN (2000m-1000m)	E-LOG CHARACTER CHANGE
1325.0	2000	<1	5	95	EX							A		A	A						mmmmmmmmmmmmmmm		
1475.0	?	?	?	?	P	REX	SORT								C						▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
1700.0	250		20	80	M	REX	SORT								A						mmmmmmmmmmmmmmm		
1785.0	100		10	90	M	?	?														▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
1925.0	?	?	?	?	P	REX	HIGH											A			▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2001.0	500	1	4	95	M	REX	SORT				C										▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2144.0	?	?	?	?	P	REX	HIGH														▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2300.0	?	?	?	?	P	REX	HIGH								C						▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2350.0	100	?	?	?99	P	REX	SORT											A			▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2426.0	1000	<1	5	95	M	REX	SORT					A						A			▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2452.0	5	0	0	100	P	REX	HIGH		R												▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2500.0	2000	<1	5	95	M	REX	RCY		R					r					R		▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2525.0	2000	<1	2	98	M	REX	SORT										A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2555.0	500	5	5	90	M	REX	?										A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
∿∿∿∿	∿∿∿∿							∿∿∿∿								∿∿∿∿					∿∿∿∿	∿∿∿∿	2563
2564.0	100	10	5	85	P	REX	LOW										A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2570.0	500	4	1	95	M	REX	LOW														▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2580.0	500	20	0	80	P	REX	LOW														▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2590.0	500	2	3	95	M	REX	SORT														▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2599.0	100	0	2	98	P	REX	?		r		r										▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2610.0	2000	<1	<1	99	G		SORT		D	A				C							mmmmmmmmmmm PPPP		
2620.0	1000	3	2	95	M	REX	?		A								A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2631.0	200	1	1	98	P	REX	LOW		r								A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2640.0	2000	5	5	90	G		SORT							r							mmmmmmmmmmmmmmm		
2650.0	1000	20	<1	80	G		LOW										r				mmmmmmmmmmmmmmm		
2659.0	?	?	0	?	VP	COR	?										A				mmmmmmmmmmmmmmm		2659
2671.0	500	4	<1	95	M	COR	?					r									mmmmmmmmmmmmmmm		
2680.0	500	20	5	75	M	COR	LOW		A								A				mmmmmmmmmmmmmmm		
2690.0	1000	5	<1	95	G		SORT		A								A	C			mmmmmmmmmmmmmmm		
2700.0	250	75	5	10	P	COR	LOW		A								A				mmmmmmmmmmmmmmm		
2710.0	500	15	5	80	M	COR	?		A												mmmmmmmmmmmmmmm		
2720.0	1000	15	5	80	G		SORT		A				R								mmmmmmmmmmmmmmm		
2730.0	1000	20	<1	80	G		SORT		A				R								mmmmmmmmmmmmmmm		
2740.0	50	40	0	60	P	COR	?		C				R								mmmmmmmmmmmmmmm		
2750.0	500	2	0	98	M	COR	LOW		A												mmmmmmmmmmmmmmm		
2760.0	1000	5	5	90	G		?		C			r									mmmmmmmmmmmmmmm		
2770.0	2000	1	1	98	G		SORT		A								A				mmmmmmmmmmmmmmm		
2780.0	500	10	0	90	M	COR	LOW		A								A				mmmmmmmmmmmmmmm		
2790.0	100	10	<1	90	P	COR	?		A								A				mmmmmmmmmmmmmmm		
2800.0	50	10	<1	90	P	COR	?														mmmmmmmmmmmmmmm		
2810.0	500	5	0	95	M/P	COR	LOW		C		r	r									mmmmmmmmmmmmmmm		
2820.0	1500	4	<1	95	M/P	COR	LOW		r		r										mmmmmmmmmmmmmmm		
2825.0	500	1	1	98	M/P	COR	LOW		r		r						A		r		mmmmmmmmmmmmmmm		
2828.0	500	1	1	98	M/P	COR	RCY		A								A				mmmmmmmmmmmmmmm		
∿∿∿∿	∿∿∿∿							∿∿∿∿								∿∿∿∿					∿∿∿∿	∿∿∿∿	2840
2850.0	?200	?		?95	P	REX	HIGH		A								A				▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2890.0	500	<1	<1	?99	P	REX	HIGH		r												▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2935.0	2000	<1	<2	98	P	REX	SORT		r	r									r		▼▼▼▼▼▼▼▼▼▼▼▼▼▼▼		
2941.0	2	0	0	100	M		HIGH			r									r		.... ∇Δ∇Δ∇Δ		2938
		?		?		?		?					?					?			? ?	? ?	?2945
2949.0	20	100	0	0			BAR	r	A	A									C		----- .... oooo		
2970.0	10	100	0	0			BAR	A		A						A			A	A	----- .... oooo		
2990.0	10	100	0	0			BAR	r	A	A						C			C		----- .... oooo		
3000.0	10	100	0	0			BAR	A	A	r						A		A	r		----------		
3010.0	20	100	0	0			BAR		A	r						A		C	r		----------		
3019.3	-	-	-	-												A	A				----- .... ∇Δ∇Δ		
3019.5	-	-	-	-												A					----- .... Δ∇Δ∇	?	
3030.0	-	-	-	-												A					....		

PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY

ZONE	Depth at Base	AGE
A-4	1325	PLIOCENE
B-2	1475	LATE MIOCENE
C	1785	to
D-1	2555	MID MIOCENE
E-1	2570	MID MIOCENE
E-2	2650	EARLY MIOCENE
F	2750	
G	2828	
J-2	2935	EARLY OLIGOCENE
K/J	2941	EO/OLIGOCENE
?		?

EX= Excellent
G= Good Texture & Shape
M= Moderate Texture & Shape
P= Poor-texture obliterated
VP= Very Poor-only "Ghosts"
M/P= planktonics moderate but benthonics poor.

REX= diagenetic recrystallisation
COR= corrosion at or near C.C.D.
HIGH = energy, seafloor currents
SORT= size & shape sorted
RCY= recycled shallow water forms
LOW= energy, seafloor currents, poor oxygenation

BAR= to ocean - low energy oxygenation & salinity.
A= 1-5% of grains
C= >20 grains
r= <20 grains
R= Recycled

¶Paleowater depth in parentheses

TABLE 4: PALEOENVIRONMENTAL ANALYSIS - VOLADOR # 1.

David Taylor, April 19, 1983.