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FORAMINIFERAL SEQUENCE ON MARLIN PROSPECT

GIPPSLAND SHELF

By

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SUMMARY OF SEQUENCE

Marlin A-1 Depth in ft. El = +31 ft.	Biostrat. Unit	Age	Marlin B-1 Depth in ft. El = +31 ft.
- 850	A	UPPER MIOCENE)	First returns at 2320'
850-1200	B	" "))	
1200-1800	C	MIDDLE MIOCENE	-
1800-2300	D	" "	? -2500
2300-2700	E	" "	2500-2900
2700-3000	F	LOWER MIOCENE)	2900-3900
3000-3700	G	" "))	
3700-4300	H	" "	3900-4470
4300-4510	I	OLIGOCENE	4470-4710
4510-4800	J	LOWER OLIGOCENE	4710-4900
4800 (approx.)	K	to uppermost EOCENE	4900 (approx.)
			N.F.F.*
N.F.F.*	S-T	upper to middle PALEOCENE	5105-5160(cores)
			N.F.F.*
7237-7267 (core 12)	Z	uppermost CRETACEOUS	? 7920 (side wall)
N.F.F.* to 8485 (T.D.)			N.F.F.* to 9995(last sample)

* N.F.F. = No fresh fauna.

INTRODUCTION:

The Marlin Prospect is a Tertiary structure some 27 miles south-east of Lakes Entrance. In this area the sea floor is approx 200 feet below the sea level surface. Two wells have been drilled by Esso Exploration (Aust.) Inc. on this structure : namely Marlin A-1 (formerly designated as E.G.S.4) and Marlin B-1.

I have already reported on the Marlin A-1 sequence (Taylor, 1966a), but in this report I am ammending my opinion on the section below the upper Eocene. The two sequences, with depth ranges of biostratigraphic units, are summarized in tabular form on page 1 of this report. The down sequence biostratigraphic scheme was initiated for the Barracouta A-1 well (then E.G.S.1 - see Taylor, 1966b) and I have subsequently extended it down to include the lower Tertiary and Upper Cretaceous.

SAMPLE DETAIL:

Detail regarding Marlin A-1 is given by Taylor (1966a, p.1). The pertinent data regarding Marlin B-1 is as follows. Cutting samples were examined between first return at 2320 feet and the final sample at 9995 feet (T.D. is given as 10005 feet - the final core was not recovered). Thirteen cores were recovered and examined. The first core was cut between 4790 and 4820 feet; the final core between 9876 and 9903 feet. Five side wall cores were submitted from the interval 7560 to 8640 feet. The 13 3/8" casing shoe was set at 2251 feet; the 9 5/8" casing shoe at 5346 feet. Despite this, contamination was sporadically heavy below the 9 5/8" shoe. This contamination was mainly of Zonule I faunas (i.e. between 4300-4510 feet). This fauna is in a marl just above the sand contact and no doubt caves readily in open hole, thus is incorporated in the mud and recirculates even when the section is cased-off.

The datum for both wells is +31 feet M.S.L. (= rotary table elevation on drilling vessel). All depths in this report are sample depths.

THE BIOSTRATIGRAPHIC SEQUENCE:

Both wells intersected an uninterrupted sequence of Miocene and Oligocene sediments. The presence of uppermost Eocene sediments are indicated in both sections. There is then an interval apparently barren of foraminifera. In the B-1 well, probable upper-middle Paleocene species were found in core. In the A-1 well probable uppermost Cretaceous species were found in a core. In B-1 the uppermost Cretaceous cannot be confirmed because of heavy contamination.

I. MID TERTIARY

In the case of Marlin B-1, no samples were taken above 2320 feet, so that the presence of Zonules A and B (upper Miocene) and Zonule C (middle Miocene) cannot be established, but from the example of other Gippsland Shelf wells one would not doubt their presence. For the same reason the thickness of Zonule D cannot be established.

Zonules E to I (middle Miocene to Oligocene) are consistent between both sections, in both thickness and faunal character (refer Taylor, 1966a and b). The 200 foot depth displacement between sections is purely due to the fact that A-1 is on the culmination of the Marlin Structure, whilst B-1 is on the flank.

The base of Zonule I is rich in arenaceous species including *Haplophragmoides* spp., *Karreriella* spp, *Bolivinopsis cubensis* and *Vulvulina granulosa*. These species comprise a dominant element of the fauna below 4680 feet in B-1 but are not so apparent in A-1. It is noted that these species comprise most of the cutting contaminants below the 9 5/8" casing shoe.

At 4710 feet, in B-1, the first appearance of *Globorotalia testarugosa* marks the top of Zonule J. At this level *G. opima opima* and *Anomalinoides vitranoda* are common. The basal part of Zonule I and the top of Zonule J are within the marl, although the sand and glauconite content is increasing. Fragments of a pyrite-cemented glauconitic sand were noted below 4710 feet. Such sediment bears Zonule J faunas in the onshore Lakes Entrance area. *Globigerina linaperta*, *G. angiporoides* and *Guembelitra* sp. appear first 4890 feet indicating Zonule K. *G. linaperta* is regarded as the index of the top of the upper Eocene in sub-surface section. It is noted that no fauna was found in the 3 cores cut between 4790 feet and 5043 feet. These three cores consisted of coarse sands with minor coals.

II. LOWER TERTIARY

Normally upper Eocene is placed within the Lower Tertiary. However in Victoria the Upper Eocene faunas have closer affinities to the post Eocene ~~affinities to the~~ post Eocene faunas than to the pre-Upper Eocene faunas. In fact there is a sharp faunal break in that two distinct faunal groups can be recognised. This faunal change affects all faunal elements (arenaceous, calcareous benthonic and planktonic) at both specific and generic level. There are gaps in all evolutionary lineages. For this reason, I exclude the Upper Eocene from the Lower Tertiary.

No lower Tertiary species were recognised in the A-1 section. In B-1, the bottom foot of core 1 (5105 feet) and throughout core 6 (down to 5160 feet) contained arenaceous species. These species comprise a fauna which was unknown from the Gippsland Basin and completely different from the Paleocene and Upper Cretaceous arenaceous faunas of the Otway Basin. Species present are:

Trochammina sp. - a compressed form with a flattened umbilical side, stellate pattern around the umbilicus and an acute periphery (especially in later chambers). The Recent species group, Trochammina squatmata Parker and Jones, could well be a convergent or closely related species. If it were not for the fine grained arenaceous test wall, one would regard this species as a Cibicidina sp. This species comprise 70% of the fauna at 5106 feet and is the only species present in other samples.

Rzehakina epigona (Rzehak) - mainly the "delta group" as illustrated by Scott (1961) but including some of Scott's "alpha group". This species comprise 15% of sample at 5106 feet.

?Controchammina depressa Finlay - specimens compare with topotype material from New Zealand. But apertural detail is not apparent in the B-1 specimens, nor in the topotype material.

Bolivinopsis compta Finlay - compares closely with New Zealand topotypes, but the B-1 material has coarser walls and the initial coils of some specimens are larger than the topotypes.

Haplophragmoides sp. - ? H. paupera (Chapman). These specimens have the typical acute periphery of H. paupera but the umbilical features are too obscured for definite identification.

The age of this fauna will firstly be considered at the generic level. Rzehakina is recognised as an uppermost Cretaceous (Senonian) to upper Paleocene form. Its presence in the Eocene is not substantiated. Scott (1961, pp.38-40) discusses its range in New Zealand, as well as in the Caribbean and Europe. It is noted that Rzehakina has not been reported from Australia. Controchammina is an endemic New Zealand genus restricted to the Paleocene (sensu McGowran, 1966). Controchammina spp. is often associated with Rzehakina epigona.

At the specific level, Scott (1961) divides R. epigona into "generational forms". As already stated, most of the B-1 specimens appear to fall into the "delta group", although the limited number of specimens did not allow testing by Scott's statistical procedures. The presence of alpha and delta forms and absence of beta and gamma forms is recorded from the basal Waipawan Stage by Scott. Controchammina depressa is restricted to the Waipawan stage, whilst Bolivinopsis compta ranges from the Waipawan to the Porangan Stage (middle Eocene). Haplophragmoides paupera (s.s.) ranges from the Senonian to the upper Paleocene in the Otway Basin. Although the Trochammina sp. is a most distinctive species, no age connotation can be placed on it, especially as the form could be chronologically homologous. However this Trochammina sp. may be very useful in local correlation.

One immediately concludes that this fauna contains striking New Zealand elements and that the specific content is similar to that of the arenaceous faunas of the basal Waipawan Stage (see Scott, l.c., p.26). The range overlap of three species, confirms a Waipawan Stage comparison, but as will be discussed later, this fauna was in a restricted, marginal-marine environment, therefore could be a relict fauna, younger than similar faunas of the Waipawan Stage. Yet the coincidence of specific content, and the worldwide range of Rzehakina does favour a Waipawan correlation.

From Scott's (1961) discussion it is assumed that Rzehakina epigona does not range above the basal Waipawan, which according to McGowran's (1966) and Jenkins (1965) findings, straddles the middle/upper Paleocene boundary, Jenkins (l.c.) has shown that the upper part of the Waipawan must be considered as lower Eocene. On the planktonic fauna, the basal Waipawan can be correlated, via the Caribbean, with McGowran's (1966) A. mckannai and possibly the higher G. Simplex zonules of the Carnarvon Basin (Western Australia). In turn the A. mckannai zonule can be correlated with my Zonule T and G. simplex with my Zonule S and probably R of the Otway Basin. (Zonule Q is the top of the Paleocene in the Otway Basin and Zonule U = the "Pebble Point Shell Bed").

On the above evidence, the cored interval 5105 to 5160 feet is considered to represent Zonule T or S with a possibility of R. A middle to upper Paleocene age is considered.

III. UPPER CRETACEOUS

Taylor (1966a) reported Upper Cretaceous foraminifera in core 12 (7237-7267 feet) in Marlin A-1. Cuttings above this core were thought to contain similar arenaceous species up to 6500 feet. Re-examination confirmed the presence of Cretaceous arenaceous species in core 12, but identifications above this core are now not considered to be conclusive.

The fauna in core 12 or Marlin A-1, as listed by Taylor (l.c., p.4), is almost identical in specific content to that in core 3 (4126-34 feet) and core 4 (4309-16 feet) in Frome-Broken Hill's Flaxman's No.1 Well, Otway Basin. Core 4 contained a small species of the Mesozoic pelecypod Inoceramus, which does not extend into the Tertiary. Both cores 3 and 4 contained a microflora, which included Triorites edwardsii and at the time considered as lower Tertiary. On the molluscan evidence, core 4 must be considered as Cretaceous, whilst the foraminifera are the same in both cores 3 and 4. Taylor (1964) placed these two cores within the top of his Victorian Upper Cretaceous Zonule A, to which he assigned a Senonian age. On reconsidering this work, I now feel that the top of Zonule A could be high in the Senonian (i.e. Campanian) as the first Santonian species (i.e. mid-Senonian) did not appear until 4974 feet in Flaxman's. For this reason I have now split the Upper Cretaceous Zonule A into two Zonules. Namely: the top of Zonule XA = the highest appearance of the Santonian species, whilst Zonule Z = the highest appearance of Upper Cretaceous species as in Flaxman's. The top of Zonule Z therefore corresponds with the top of my original Zonule A. From the above discussion it is evident that Triorites edwardsii extends down into the Upper Cretaceous, but not below Zonule Z. Harris (1965) established a T. edwardsii Zone in the Paleocene of the Otway Basin. The top of this micro-floral zone is within my Zonule U, and T. edwardsii extends upwards to Zonule R.

Core 12 in Marlin A-1 is still regarded as Upper Cretaceous and the fauna suggests Zonule Z, thus is high in the Senonian. The Upper Cretaceous could well extend above 7237, but the cuttings are too heavily contaminated and possible Upper Cretaceous arenaceous species too rare for a thorough taxonomic examination.

There is no clear evidence of Upper Cretaceous in Marlin B-1. Cutting sample below 7500 feet did contain some arenaceous species of Upper Cretaceous affinities, but these were very rare and were swamped out by heavy contamin-ation so that positive identification was impossible. Side wall core was taken in the suspected Upper Cretaceous interval, but 4 of the 5 cores submitted were barren of fauna. The side wall core at 7920 feet, contained pyritic foraminiferal moulds, which could not be further identified.

DEPOSITIONAL HISTORY

No further conclusion can be made on Upper Cretaceous deposition on the Marlin Structure, apart from that already inferred by Taylor (1966a).

The designated Paleocene fauna in Marlin B-1 (5105-5160 feet) is of considerable interest. In the sample at 5105 feet, the sediment contained about 50 specimens per 100 gms. of material. The fauna was dominated by Trochammina sp. (70%) and with 15% Rzehakina epigona. The low faunal count and the dominance of Trochammina suggests a marginal marine environment (lagoon, marsh and/or estuary). Phleger (1960, p.158) states that the Recent species T. squamata Parker and Jones (morphologically similar to T. sp. in Marlin B-1) is a lc euryhaline species occurring in open-ocean as well as lagoonal and marsh estuaries faunas. If Rzehakina inhabited similar situations to the living morphological equivalent Miliammina, then the Trochammina - Rzehakina association would indicate salt marsh and estuary conditions working on analogy from Phelger's (l.c., p.153 and pl.8) data. Similar conclusions are gained from other publications. Certainly the conditions would have been brackish water. The amount of carbonaceous material and coarse sand in the sediment confirms a salt marsh and estuary environment.

In New Zealand, the facies preference of Rzehakina appears erratic (Scott, 1961), although it tends to inhabit restricted environments at the top of its range in the Waipawan Stage. It is interesting that the base of the Lizard Springs Formation (Paleocene-Lower Eocene of Trinidad) contains an exclusively arenaceous fauna which Bolli (1957) designated as the Rzehakina epigona Zonule, which is directly above the Cretaceous/Tertiary unconformity. The top of this zonule is marked by the incoming of planktonic species in abundance, although R. epigona does continue to the Upper Paleocene. Evidently the R. epigona Zonule marks the initiation of a transgression, before open marine conditions were established.

The Trochammina-Rzehakina faunas are thus taken to indicate ingressions of marine conditions into brackish or fresh water environments. Close sampling of the B-1 section, showed the fauna to be sporadic over the interval 5105 to 5160 feet. This suggests that the fauna was never properly established and that dilution pressures were greater than the marine influence. Thus the environment is towards the non-marine end of the marine to non-marine environmental series.

The uppermost Eocene to lower Oligocene environmental interpretation is difficult. The sediments are mainly sands and silty sands with some coal. In neither of the Marlin wells, was fauna found in core. Zonules J and K are recognised only from cuttings. It could be argued that they are contamination from the overlying marl sequence. Yet the species always appear in the established sequence. In Barracouta A-1, Taylor (1966b) pointed out that these uppermost Eocene and lower Oligocene faunas consisted predominantly of small sized planktonic specimens. Taylor (l.c.) considered that the faunas were "displaced" being washed into an alien environment by periodic marine flooding. The same statement appears true for the Marlin sections. This can be demonstrated in core from the Wurruk Wurruk No.1 bore (Sale - Gippsland) where there are thin marine ingressions amongst non-marine lignitic sands. The faunal constituents in these ingressions are identical with those from the Barracouta and Marlin sections.

Marlin B-1 has provided new information regarding the uppermost Eocene/lower Oligocene environment. Core 1 showed evidence of organic activity (burrowing ect.) in the sediment. The outstanding example is a piece of coal at 4796 feet, which is riddled by tubes containing medium to coarse quartz sand. This piece of core is illustrated on Fig. 1. The tubes are horizontal and not vertical to the bedding. In transverse section, they are ovate and the outer surfaces smooth. These tubes are reminiscent of crustacean burrows, especially with the terminal expansion of some tubes (fig. 1-a) in the form "living chambers". If these are in fact animal burrows, then the coal would have to have formed before activity took place. Some crustacea could burrow into this coal, even if it were as indurated (? sub-bituminous rank) as it is at present. The consideration is, how did the animals gain access to the coal in the sequence? The range of possible circumstances could be:

(i) Immediately after coal deposition, there was an intensity of animal life in deltaic conditions. The coarse sand suggests deltaic sedimentation, so that the coal surface would have been soft and easily channeled.

(ii) Sedimentation of the coal sequence; exposure and rapid erosion; then marginal-marine sedimentation on the deeply channeled surface, allowing the animals horizontal entry to the coal beds.

(iii) Erosion of the coal sequence and deposition of detrital coal blocks.

Any one of these circumstances could be associated with sporadic marine faunal ingressions as described for the Marlin sequences.

In the upper Oligocene and Miocene, the environment in the calcareous sequence is identical in both Marlin A-1 and B-1 (refer Taylor, 1966a).

GEOLOGICAL SETTING:

Taylor's (1966a) statement that the Barracouta and Marlin structure are structurally unrelated is confirmed by the B-1 section. The Marlin structure shows continuous sedimentation during the Miocene, whilst a hiatus is shown for the Barracouta structure (Taylor 1966b).

The presence of uppermost Eocene at 4900 feet and the appearance of probable upper Paleocene, only 200 feet below this (at 5106 feet), without any intervening faunas, strongly suggests a hiatus in Marlin B-1. Paleocene faunas were suspected at an equivalent level in A-1. Evidently after this hiatus marine ingressions began in uppermost Eocene times. The fact that some coal is riddled with supposed animal burrows, suggests that the ingressions were onto an unevenly eroded surface. These ingressions become a major transgression in the Oligocene (at top of Zonule J) and sediment type changes from sand to marl.

The mechanisms of this transgression appears to be structural as it is heralded by the ingressions. Although the only evidence of this "channel-fill" sedimentation is in Marlin B-1, it is inferred for Marlin A-1 and the Barracouta sections, as all contain sporadic ingressions. This channel cutting and filling is probably more effective on the structural highs. The Cod A-1 section (E.G.S.-3) is structurally lower; the uppermost Eocene/lower Oligocene is above, not within the sand/coal sequence. In Cod A-1, the transgression is of the "Lakes Entrance type" with an initial marine invasion, then a restricted environment (poor faunas and glauconite formation) followed by a resumption of open marine conditions. The Cod sequence does not exhibit an ingressive pattern. If the Cod depositional surface was just below the level of channel floors (i.e. valleys), the transgression would be fully operative on Cod but may only periodically penetrate into the marginal marine sedimentation operative in the valleys.

The Marlin structure is the only locality to yield Paleocene faunas in the Gippsland Basin. However these faunas are so sporadic, that their recognition is probably dictated by the chance factor of coring. The marginal marine nature of the fauna in Marlin B-1 must indicate that there are better developed Paleocene faunas in structurally lower situations in the vicinity.

The correlation, of the Marlin B-1 Paleocene fauna with the Otway Basin, is an extremely involved one, requiring correlation to New Zealand, thence to Western Australia by way of Trinidad. The actual distance is less than two hundred miles. There was evidently no direct seaway communication between the Gippsland and Otway Basins during Paleocene times. The B-1 fauna is an endemic New Zealand one, so direct seaway communication with New Zealand is inferred.

ACKNOWLEDGEMENTS:

As in other investigations, I am particularly grateful for the assistance given by Mrs. J.G. Knight (Geol. Surv. Vict.). Some of my interpretations in this report are illustrated and supported by her painstaking line drawings on figure 1. The nature of the surface of the specimen did not permit clear photography.

Discussion with Dr. Brian McGowran (University of Adelaide) enabled me to sort out the complex Paleocene correlation expounded in this report. Dr. McGowran kindly gave me permission to use information which is still in press. Long discussions with Mr. John Elliott (Esso Exploration) have been of considerable benefit and the co-operation of Mr. Brian Hopkins (Haematite) was appreciable.

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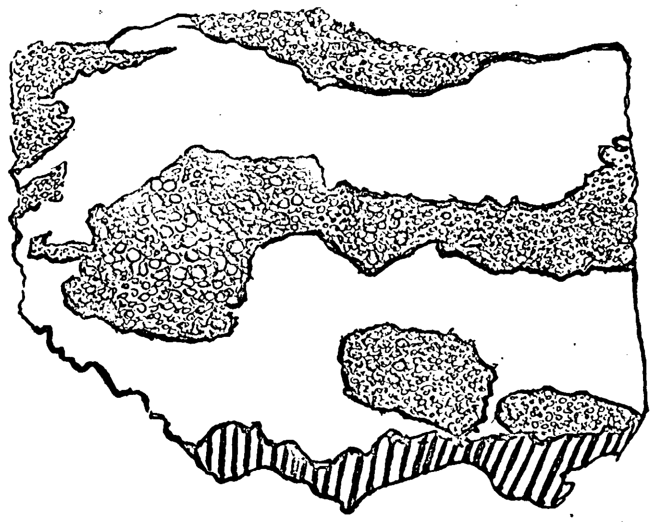
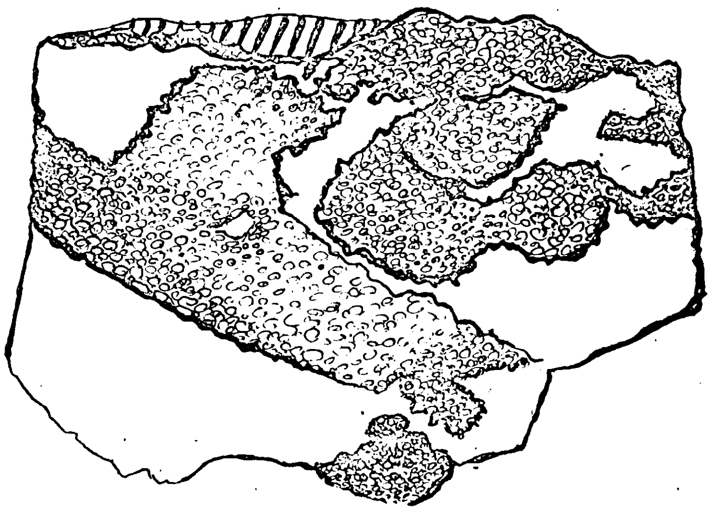


a



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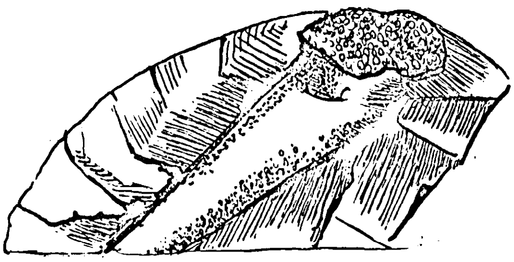

c

Fig. 1 Core sample from 4796 feet (Core 1) showing sand filled tubes in coal. a = flat side; b = rounded side; c = base of sample. Natural size