APPENDIX - 1

SOLE-1

PALAEONTOLOGICAL REPORT

by

M. Apthorpe

Melbourne May 1973

INTERPRETATIVE

Introduction.

This report presents an analysis based on foraminifera of the upper part of the Sole-1 well, in the Gippsland Basin, Southern Australia. The interval 1015 feet to 2657 feet was sampled by 41 sidewall cores, of which 32 were used in this analysis. Some samples were not examined because of severe diagenesis.

Acknowledgements.

The writer is indebted to David J. Taylor, consultant to Esso Exploration Ltd., for biostratigraphic advice and guidance on the environmental interpretation of the fauna, based on his work on the Gippsland Basin.

The Foraminiferal Sequence.

Summary.

Sole-1 intersected 1660 feet + of the Gippsland Limestone Formation before reaching the unfossiliferous Latrobe Group. In this well the Gippsland Limestone is entirely of Middle Miocene age, in the sense of Shell. (The same interval is referred to the Upper Miocene by Taylor and Esso, who use only a two-fold division of the Miocene). The biostratigraphic units intersected are zonules C, D-1 and D-2 of Taylor (1966, and unpublished).

The depositional environment of that part of the Gippsland Limestone intersected in this well is of an upward and outward building slope and shelf with progressive shallowing. Initial continental slope deposits are followed by thick deposits of a migrating submarine canyon, passing up into outer neritic and then middle neritic carbonate shelf sediments. The nature of the top of the sequence is concealed by the casing.

Biostratigraphy.

Zonule C (+1015' - approximately 1750').

The zonule is identified in this well on the presence of Globorotalia lenguaensis, which is sporadically abundant, together with Globorotalia miotumida. Longer ranging planktonic species occurring in the zonule include the Globorotalia miozea group, Globorotalia acostaensis, G. menardii, G. mayeri, G. panda, G. siakensis, G. bella, and Orbulina universa. Globigerinoides glomerosus circularis ranges up into this zonule; it has previously been reported only as high as Zonule D. The occurrence of Globorotalia siakensis in Zonules C and D-1 extends the known range of the species in Southern Australia considerably upwards. Globorotalia lenguaensis disappears about 150 feet above the base of the zonule (lowest occurrence at 1582 feet).

Zonule D-1 (approximately 1750' - 2150').

The top of the zonule is placed at the highest occurrence of Globorotalia conica. Specimens referable to Jenkin's species Globorotalia "mayeri barisanensis" occur just above this, at 1705', so that the top of D-1 could possibly be placed as high as 1705'. Other species present apart from those listed above are Globorotalia acostaensis (in the upper part of the zonule only) and occasional occurrences of Globorotalia peripheroacuta. Globorotalia miotumida and G. panda both disappear close to the base of the zonule.

Zonule D-2 (2150' - approximately 2650')

The top of the zonule is defined by the highest occurrence of Globorotalia peripheroronda in the sample at 2160'. Specimens close to Globorotalia peripheroacuta appear higher in the sequence, within D-1, but abundant specimens corresponding to the type of G. peripheroacuta occur only near the base of D-2.

Orbulina universa and O. suturalis disappear at 2538'. Older members of the Orbulina lineage, Globigerinoides transitorius and Globigerinoides sicanus (=bisphericus), do not appear until 2623', so that there appears to be a gap in the lineage. Since G. sicanus is the indicator species for the top of Zonule E, the interval between 2623' and 2657' is referred to the Zonule D - Zonule E boundary. Some workers may prefer to place the interval within Zonule E, but the numbers of Globigerinoides sicanus are not great, and Globigerinoides glomerosus glomerosus is conspicuously absent, so that a determination on the boundary is preferred here. Taylor (pers. comm.) has suggested that the disappearance of Orbulina above the base of D-2 may be due to environmental factors. He has indicated that changing water mass characteristics may have temporarily removed the Orbulina population from the Sole area at the time when O. universa was evolving.

Rare specimens of Globorotalia zealandica, which is normally found in Zonules F to H, may indicate reworking of older sediments into the Sole sequence. Reworking is supported by the presence of Oligocene microplankton species within the Miocene carbonate sequence. Cassigerinella chipolensis occurs in abundance at 2632'. Its presence may be due either to reworking, or may be an extension of the local range of the species.

The form recorded here as Globigerina tripartita is the same as that referred to by Jenkins, and by Taylor, as Globoquadrina dehiscens advena.

All sidewall cores examined below 2660' were barren of foraminifera.

Environment of Deposition.

A. Comment on the faunas.

Neritic (shelf) faunas have been recognised by the abundance of the calcareous benthonic group, the Cibicidae, which make up 23% of the total fauna in the middle neritic samples. The species Cibicides cygnorum and Rosalina mitchelli, which are abundant, are confined to the shelf. The percentage of planktonic species rises from 50% in the middle neritic interval to 63% in the outer neritic.

Canyon faunas in general have a much lower diversity, particularly in the group of calcareous benthonic species, than either shelf or slope faunas. Two types of canyon fill are recognised here:
i) The upper part of the canyon sequence (1485' - 1918') is characterized by moderate planktonic percentages, and by high percentages of individual calcareous benthonic species which are spasmodically important, and then rapidly become insignificant in number. Cassidulina neocarinata is consistently abundant; Taylor regards it as indicative of high energy conditions. Shape and size sorting by currents or slumping appears to be an important factor contributing to the abundance of some species.
ii) The lower part of the canyon sequence is extremely impoverished in all calcareous benthonic species, and the planktonic percentage rises to over 88% below 2400'. Arenaceous species are relatively more important than in the upper part of the canyon. The calcareous benthos includes small numbers of the most common slope species, presumably washed in. Conditions within the canyon appear to have been unsuitable for the survival of an in situ calcareous benthonic fauna. The only abundant

calcareous benthonic is Nonionella bradii. In the upper canyon this species is abundant only where Cassidulina neocarinata, the high energy indicator, is also at a peak. It is therefore possible that Nonionella bradii may be indicative of extremely unstable, turbulent, or high energy conditions within the canyon environment. The lower part of the canyon appears to have been a more extreme environment for fauna than the upper part, and there is a much greater ratio of sediment to fauna than elsewhere.

Slope faunas are recognized on a planktonic percentage over 60%, and a rich and extremely diverse benthonic fauna which includes deep water species. Some of the latter include: Melonis pompilioides, Planulina wuellerstorfi, Gavelinopsis lobatulus, Bucella cf. frigida, Euuvigerina picki (in a smoother slope morphology), Ramulina globulifera (one sample only), Reophax scorpiurius, Karreriella bradyi, Sigmoilopsis schlumbergeri, Vulvulina pennatula and Cyclammina spp. "Canyon" species such as Cassidulina neocarinata may also be abundant in slope samples. Some samples with transitional characteristics may represent the low energy edge of a migrating canyon, transitional to the slope.

B. The sequence of environments.

Slope (2651' - 2510').

At the base of the Gippsland Limestone carbonate sedimentation commenced on the upper continental slope. A flourishing deep-water fauna developed, but the presence of shallow water species (Carpenteria rotaliformis, Elphidium macellum), quartz and lithic fragments suggest transportation of material from the shelf. Reworking of older parts of the Gippsland Limestone is suggested by some of the planktonics and microplankton (see Biostratigraphy - Zonule D-2).

Lower "canyon and slope" interval (2500' - 1950').

The alternation of slope, canyon and transitional faunas suggests that one or more canyons migrated laterally across the continental slope in the Sole area during this interval. As already noted, environmental conditions within the canyon(s) appear to have been extreme, and the quantity of high-energy indicators within the intervening slope intervals suggests that the slope was also subjected to strong current activity, perhaps as a "spillover" from adjacent canyons.

Severe diagenesis has affected some sediments within the canyons. Channeling of solutions through the more porous parts of the canyon fill has resulted in heavy calcite cementation of some samples.

Upper canyon interval (1950' - 1450').

The later infilling of the canyon occurred under conditions more favourable to the development of an indigenous bottom living fauna. The abundance of Cassidulina neocarinata is interpreted by Taylor as indicating fairly high energy conditions throughout this interval. There are periodic population explosions of other forms - Bulimina costata and B. marginata, Epistominella exigua, Gavelinopsis lobatulus. Current activity may have strengthened at around 1705', where a percentage rise occurs in Cassidulina neocarinata and Nonionella bradii. (The latter is conspicuous in the more "hostile" lower canyon sequence). Sponge spicules are abundant in this interval.

Neritic (shelf) interval (1450' - 1015').

The canyon faunas pass upwards into deep outer neritic faunas below 1400'. High productivity at the shelf edge produces a planktonic percentage over 60%, and a rich and diverse benthos in which no single species is dominant. The dominant group of the deeper water faunas, the Cassidulinids, are gradually replaced on the shelf by the Cibicidae. Sponge spicules are extremely abundant, particularly in the outer neritic environment.

No detailed analysis of the shelf faunas has been made, but the depth of

INTERPRETATIVE

water is seen to gradually shallow to middle neritic at the highest sample at 1015'. The foraminiferal populations show a gradual change, suggesting fairly stable conditions, in contrast to the violent fluctuations in populations observed in the lower part of the sequence.

Correlation of the local zonation with the Shell standard zonation.

Zonule C is correlated with the Globigerinoides subquadratus zone, based on the overlap of the ranges of Globorotalia mayeri and Globorotalia lenguaensis. The highest occurrence of Globorotalia mayeri defines the top of Zonule C in Victoria, and marks the top of Jenkins' G. mayeri mayeri zone in New Zealand. There appears to be some inconsistency between time ranges in temperate and tropical regions obvious here, as both Globorotalia acostaensis and Hastigerinella aequilateralis are present in Zonule C. Neither is reported by Postuma to range downwards so far.

Zonule D-1 is approximately equivalent to part or all of the Globorotalia fohsi (s.l.) zone, the G. lobata, and G. peripheroacuta zones of Postuma (1971). The top of the zonule cannot be precisely correlated with the standard zones because the top is defined on the appearance (=extinction) of two local species, Globorotalia conica and Globorotalia "mayeri barisanensis" (after Jenkins).

Zonule D-2 can be firmly equated with the Globorotalia peripheroronda zone of the standard zonation. D-2 is defined on the highest appearance of G. peripheroronda, and its base is defined on the highest appearance of Globigerinoides sicanus (=bisphericus).

Note on the distribution chart (Enclosure 2)

Because the washed residues of the sidewall cores consisted of thousands of foraminifera, conventional frequency symbols are not employed on the chart as they would generally be meaningless. A cross (x) on the chart indicates that the species was common to abundant (ie. tens to thousands of specimens present in the sample); a dot (.) indicates that the species was rarely seen during counting. A total of 200 to 1000 specimens were counted for each of the 24 cores quantitatively analysed.

References.

Jenkins, D.G. (1960) Planktonic foraminifera from the Lakes Entrance oil shaft, Victoria, Australia. Micropal. v.6, no.4.

Jenkins, D.G. (1971) New Zealand Cenozoic Planktonic Foraminifera. New Zealand Geological Survey, Paleontological Bulletin 42.

Postuma, J.A. (1971) Manual of Planktonic Foraminifera. Elsevier, Amsterdam.

Taylor, D.J. (1966) Esso Gippsland Shelf No.1: The Mid-Tertiary Foraminiferal Sequence. Australia: Petroleum Search Subsidy Act; Publication no. 76.