Attachment to WCR.

Appendix 9 of WCR

Ingleby-1

(W1038)

APPENDIX-9

PALNOLOGY

PALYNOLOGICAL ANALYSIS, INGLEBY-1

PEP 100, OTWAY BASIN

by

M.K. MACPHAIL

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Consultant Palynologist, 20 Abbey St., Gladesville, NSW 2111

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INTRODUCTION

Nine sidewall cores, representing the interval 75.0m to 313.0m in Ingleby-1 were processed and examined for spore-pollen and dinoflagellates.

Yields and preservation are adequate to high, allowing most samples to be dated with confidence. The exception is the interval between 240.0-244.0m where either or both downhole caving and reworking has resulted in mixed Eocene and Mesozoic palynofloras.

Palynological determinations and interpreted lithological units are summarized below. Interpretative and basic data are given in Tables 1 and 2 respectively. Estimated TAI values of and dominant kerogen types present in each sample are given in Table 3. The stratigraphic distribution of all species is recorded in the attached range chart. Electric log data were unavailable.

SUMMARY

AGE	UNIT	ZONE	DEPTH RANGE (m)	ENVIRONMENT
Oligocene - Early Miocene	HEYTESBURY GP	P. tuberculatus	75.0 - 150.0	restricted marine
Late Eocene	NIRRANDA GP	Middle N. asperus	164.0	marginal marine
Middle Eocene?	NIRRANDA GP?	Lower N. asperus?	244.0	flŭvio-lacustrine?
- - - - - -	- - - - -	- - UNCONFORMITY	- - - - - -	- - - - - -
Middle Albian	EUMERALLA FM	C. paradoxa	248.0	lacustrine
Lower Albian	"	C. striatus	313.0	lacustrine

TD 331.2m

GEOLOGICAL COMMENTS

1. Middle? Albian, C. paradoxa Zone sediments which locally form the top of the Eumeralla Formation in Ingleby-1 are overlain sequentially by (a) Middle Eocene, marginal marine facies provisionally assigned to the Nirranda Group and (b) Late Oligocene-Early Miocene, restricted marine facies provisionally assigned to the Heytesbury Group. There is no definite evidence that the well intersected Late Cretaceous or Paleocene sediments. The sample spacing is too coarse to verify the existence or not of any unconformity between the Nirranda and Heytesbury Group facies.

2. As at Nalangil-1 (Macphail, 1991), the composition of the Tertiary palynofloras more closely resembles those found in the central west Murray Basin than in basins to the south-east. Based on time-range data from the Murray Basin, it is possible that the Middle N. asperus Zone sample at 202.0m may be as young as latest Eocene-Early Oligocene, Upper N. asperus Zone.

3. Because of difficulties in establishing whether Early Cretaceous palynomorphs are in situ or reworked in mixed palynofloras, it is uncertain whether the top of the Eumeralla Formation occurs at or below 244.0m.

   The latter hypothesis is considered to be more likely for two reasons:

   (a) Both the Tertiary and Early Cretaceous palynomorphs at 244.0m [and at 240.0m] show the same degree of thermal maturity [3- to 3]. Conversely spore-pollen above 240.0m have TAI values within the immature range, making it unlikely that the Tertiary component at 244.0m is caved.

   (b) Sediments at 244.0m are overlain by essentially barren strata - a claystones at 240.om interpreted as a decomposed tuff and, at 224.5-230.0m, decomposed basalts (hand-written SWC descriptions).

4. The observation (Table 3) that TAI values both uphole and downhole of the interval 240.0-244.0m is consistent with localized heating. On present indications, the basalt sampled at 230.0m will be Middle - Late Eocene and, less certain, extruded onto a landscape developed on Eumeralla Formation.

5. The Middle Albian, C. paradoxa Zone date for the SWC at 248.0m is unusually young for the top of the Eumeralla Formation in the onshore Otway Basin. It is noted that C. paradoxa Zone sediments occur in Snail-1, offshore Torquay Sub-basin.

5. TAI values of 2+ to 3- indicate that sediments below 240.0m are within the mature phase of liquid hydrocarbon generation. Whilst these estimates need to be verified using vitrinite reflectance, it is certain that TAI values at TD do not reach the over-mature values [3+ to 4] found at similar depths [910 ft.] in e.g. Hindhaugh Creek-1. Kerogen extracts are dominated by biodegraded structured and unstructured terrestrial material except at 313.0m which yielded very well preserved plant material, primarily derived from woody plants.

6. The well terminated within the Eumeralla Formation (C. striatus Zone sediments).

PALAEOENVIRONMENTS

1. The relative abundance of marine dinoflagellates and spore-pollen indicate a progressive strengthening of the marine influence at Ingleby-1 from the Late Eocene to the Early Miocene. At this time restricted marine conditions prevailed at the wellsite.

2. There is no definite evidence of any marine influence during the deposition of the claystone unit at 244.0m.

3. Low numbers of the algal cyst Spheripollenites psilatus demonstrate that the depositional environment during the C. paradoxa Zone was lacustrine. The excellent state of preservation of plant macerals at 313.0m indicate that this claystone accumulated under anaerobic conditions, eg. within a deep freshwater lake basin.

BIOSTRATIGRAPHY

Zone and age-determinations have been made using criteria proposed by Stover & Partridge (1973), Helby et al. (1987), Macphail & Truswell (1989) and unpublished observations made on Gippsland, Bass and Otway Basin wells. Zone names have not been altered to take account of nomenclatural changes to nominate species such as Triporopollenites bellus [now Canthiumidites bellus: see Mildenhall & Pocknall, 1989].

It is noted that spore-pollen criteria used to define the Late Eocene-Early Miocene Middle N. asperus, P. tuberculatus and T. bellus Zones are not always reliable away from the Gippsland Basin. The need for caution is emphasized by the occurrence in Ingleby-1 of a number of spore-pollen species previously recorded outside of the Murray Basin only in Nalangil-1.

For example, Anacolosidites sectus and Tricolpites thomasii are diagnostic of Middle N. asperus Zone sediments in the Gippsland Basin but range upwards into Early Oligocene, Upper N. asperus Zone strata in central west Murray Basin boreholes (see Macphail & Truswell, ibid). It is possible that the extended time distributions apply to wells in the northwestern sector of PEP 100.

Dinoflagellates may provide an alternative method (see Partridge, 1976) but to date the relevant, independently dated formations in the Gippsland Basin have not closely sampled or all the species systematically recorded.

Again some distributions appear to be time-transgressive. For example, Corrudinium incompositum, which in the Gippsland Basin is an index species for the Middle N. asperus Zone, ranges into the Upper N. asperus Zone in the Murray Basin. An apparently in situ specimen occurs in P. tuberculatus Zone sediments at 150.0m.

Crybelosporites striatus Zone 313.0m Early Albian

The lowest sample available for analysis [SWC 3 at 313.0m] yielded a rich palynoflora dominated by several long-ranging Mesozoic spores and gymnosperm species, in particular Cyathidites spp., Cicatricosisporites australiensis, Baculatisporites comaumensis and Stereisporites spp.

These are associated with low numbers of the lacustrine algal cyst *Spheripollenites psilatus* and the sample is distinguished from those upsection by the near perfect state of preservation of the spore-pollen and woody plant remains.

Crybelosporites striatus and *Trilobosporites trioreticulosus* are frequent-common, demonstrating that the sample is no older han *C. striatus* Zone. The assemblage includes the rare species, *Crybelosporites punctatus*.

The sample at 291.0m yield a very sparse assemblage of long-ranging Mesozoic species and caved Eocene pollen.

Coptospora paradoxa Zone 248.0m Middle? Albian

The palynoflora at 248.0m resembles that at 313.0m with two important exceptions: the palynoflora includes (i) large numbers of the nominate and index species of the *C. paradoxa* Zone, *Coptospora paradoxa*, and (ii) a very early occurrence of *Clavifera triplex*. This specimen appears to be *in situ*.

Although *C. triplex* first appears within the *C. paradoxa* Zone in northern Australia, it is not known to range lower than the *A. distocarinatus* Zone in southern Australia. A Middle rather than Albian age is implied. The absence of angiosperm pollen indicates that the palynoflora is older than Upper Albian, *P. pannosus* Zone. The relative abundance of *Triporoletes simplex*, *Foraminisporis* spp. and *Crybelosporites striatus* support an Early Cretaceous age.

Lower *N. asperus* Zone 244.0m Middle Eocene

The sparse palynofloras at 244.0m consists of long-ranging, Cretaceous spores, chiefly *Cicatricosisporites* and *Cyathidites* spp. These occur mixed with Tertiary pollen types, chiefly *Nothofagidites* (frequent-common) and *Proteacidites* and include one specimen of the Middle *N. asperus* Zone indicator, *P. reticulatus*. Several Tertiary marine dinocysts are present.

Although *P. reticulatus* is good evidence for minor caving, it noted that most Tertiary palynomorphs have the same TAI values [3- to 3] as the Mesozoic gymnosperms.

The sample is provisionally assigned to the Lower *N. asperus* Zone, based on *Rhoipites alveolatus* (see also Geological Comments). The sample is no older than *C. striatus* Zone, based on *Trilobosporites trioreticulosus*.

The SWC at 240.0m yielded very low amounts of semi-opaque and opaque organic matter. Two specimens of Nothofagidites in this extract have TAI values within the range 3 to 3-.

Middle Nothofagidites asperus Zone 164.0m Late Eocene

One sample is assigned to this zone, based on the association of Aglaoreidia qualumis, Anacolosidites sectus, Tricolpites thomasii, Proteacidites nasus, P. pachypolus (frequent) and P. reticulatus at 236.0m. Dinoflagellates present in the assemblage include Corrudinium incompositum, Cordosphaeridium inodes, and an undescribed? species resembling Glaphyracysta retiintexta. The zone index species Triorites magnificus is absent.

An Early Oligocene, Upper N. asperus Zone age is possible but unlikely since the assemblage lacks definite Oligocene-Miocene indicators such as Acaciapollenites miocenicus and Corsinipollenites.

The palynoflora is extremely diverse and includes a number of rare species or uncommon records for this zone, e.g. Dicolpopollis cf metroxylonoides, Gyropollis psilatus, Margocolporites vanwijhi, Ricciaesporites kawaraensis and Tricolpites trioblatus. Also present and apparently in situ is a Phimopollenites sp. resembling the Late Cretaceous sp. P. pannosus. Reworked Early Cretaceous spp. are rare.

Proteacidites tuberculatus Zone 75.0-100.0m Oligocene - late Early Miocene

The three palynofloras assigned to this zone are dominated by Nothofagidites emarcidus-heterus, Araucariacites australis and Haloragacidites harrisii. Marine dinoflagellates are frequent-abundant with the relative abundance reaching a maximum at 100.0m. All samples yielded low numbers of Early Cretaceous spores.

The lower boundary is picked at the first appearance of the zone index species Cyatheacidites annulatus at 150.0m. This is associated with Foveotriletes crater and the very rare species Diporites aspis. The assemblage includes an unexplained specimen of the Middle [-Upper] N. asperus Zone dinoflagellate Corrudinium incompositum. This is the youngest record to date of this species (cf Macphail & Truswell, 1989)

The palynoflora at 100.0m includes Cyathidites subtilis and Foveotriletes lacunosus.

The upper boundary is placed at 75.0m, a palynoflora that includes significant numbers of Cyatheacidites annulatus in addition to the rare species Perisyncolporites pokornyi (see also Nalangil-1: Macphail, 1991) and Reevesiapollenites reticulatus. Granodiporites nebulosus indicates that the sample is unlikely to be younger than P. tuberculatus Zone. Indicator species of the T. bellus Zone are absent.

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TABLE 1: SUMMARY OF INTERPRETATIVE PALYNOLOGICAL DATA

SWC	DEPTH (m)	ZONE S-P	ZONE DINO	CONF. RTG.	COMMENT
24	75.0	P. tub.	-	1	G. nebulosus, C. annulatus
23	100.0	P. tub.	-	1	C. annulatus
19	150.0	P. tub.	-	1	C. annulatus
17	164.0	M. N. asp.	C. incom.	2	C. incompositum
11	240.0	Indet.	-	-	Negl. yield
09	244.0	Indet.	-	-	Mixed palynoflora
07	248.0	C. paradoxa	-	0	angiosperm spp. absent
04	291.0	Indet.	-	-	Very low yield
03	313.0	C. striatus	-	-	C. striatus

TABLE 2: **BASIC DATA**

SWC	DEPTH (m)	YIELD S-P	YIELD DINO	DIVERSITY S-P	DIVERSITY DINO	PRES.	LITH.*
24	75.0	low	low	high	med.	good	slst./clyst.
23	100.0	low	low	med.	med.	good	slst./clyst.
19	150.0	v. high	low	high	med.	good	shelly clyst trace glau.
17	164.0	v. high	low	high	med.	good	clyst.
11	240.0	negl.	-	low.	-	mod.	decomposed volcanics?
09	244.0	low.	low	med.	low	poor	clyst., slty
07	248.0	v. high	-	med.	-	good	clyst.
04	291.0	v. low	-	low	-	mod.	slst./clyst.
03	313.0	high	-	med.	-	good	carb. clyst.

* Lithological descriptions [main rock type.qualifier] taken from hand-written sidewall core sample description sheets

TABLE 3: BRIEF KEROGEN DESCRIPTIONS

SWC	DEPTH (m)	EST. TAI*	DOMINANT KEROGEN TYPE(S)#
24	75.0	2+ to 3-	unstructured amorphous
23	100.0	2+ to 3-	unstructured amorphous, fines
19	150.0	2	struct. & unstruct. amorphous
17	164.0	2	struct. & unstruct. amorphous
11	240.0	3- to 3	unstruct. amorphous (opaques)
09	244.0	3- to 3	structured amorphous
07	248.0	2+ to 3-	structured amorphous
04	291.0	2+ to 3-	structured amorphous
03	313.0	2+ to 3-	well-preserved struct. (woody)

* TAI estimates based on the chart of "Spore-pollen exine coloration with geothermal maturation" published as Colour Plate 1 in Traverse A. (1988) "Palaeo-palynology", Unwin Hyman, Boston. In this (standard) scale, TAI values of 1 to 2 are immature, TAI values of 2+ to 3 represent the mature phase of liquid hydrocarbon generation and TAI values of 3+ to 5 represent dry gas or barren.

\# Kerogen types are based on the classification of organic matter in clastic systems published by Hart, G.F. (1986) Palynology **10**: 1-23. The majority of samples yielded low to significant amounts of fines of indeterminate origin.