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PALYNOLOGICAL ANALYSIS, BOGGY CREEK-1

PEP 104, OTWAY BASIN

by

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INTRODUCTION

Nine sidewall cores, representing the interval 939.5m to 1836.0m in Boggy Creek-1 were processed and examined for spore-pollen and dinoflagellates.

Yields and diversity reflect the low amounts of material available for analysis but in most cases the recovery was adequate to allow the sample to be dated with moderate confidence. The exception is the basal sample (SWC 3: 1836.0m) where mud contamination and possible reworking makes it uncertain whether the indicator species are in situ. The majority of samples are contaminated with low numbers of caved pollen or dinoflagellates.

Palynological determinations and interpreted lithological units are summarized below. Interpretative and basic data are given in Tables 1 and 2 respectively. TAI values are given in Table 3. The stratigraphic distribution of all species is recorded in the attached range chart. Electric log data were made available as a control on the palynology.

SUMMARY

AGE	UNIT	ZONE	DEPTH RANGE (m)	ENVIRONMENT
Paleocene	WANGERRIP GP.	Upper L. balmei	939.5	marine
- - - - - - - - - - -		- unconformity -	- - - - -	- - - - -
Maastrichtian	SHERBROOK GP.	Upper T. longus	981.5	marginal marine
Campanian	"	N. senectus	1487.0	marginal marine
Santonian	"	T. apoxyexinus	1579.0	marginal marine
Cenomanian - Turonian	"	P. mawsonii - A. distocarinatus	16~~8~~68.0-1715.0	marginal marine
"	"	"	1722.0	fluvio-deltaic
- - - - - - - - - - -		- unconformity -	- - - - -	- - - - -
Middle - Late Albian?	EUMERALLA FORMATION	P. pannosus?	1836.0	fluvio-lacustrine

GEOLOGICAL COMMENTS

1. The palynological data confirm that Boggy Creek-1 intersected at least 800m of Wangerrip and Sherbrook sediments. The age breakdown confirms log analysis that the unconformity separating these formations occurs between 939.5m and 981.5m.

2. The Upper *L. balmei* Zone date and location within a ca. 36m thick sandstone indicates the sample at 939.5m represents the Pebble Point Formation. It is noted that Tabassi has recorded sandstone units within the Pember Mudstone (Laig *et al.*, 1989).

3. Dinoflagellates and spore-pollen provide conflicting dates for SWC 19 (981.5m) - basal Danian, lowermost *L. balmei* Zone and Maastrichtian, Upper *T. longus* Zone respectively.

   The position of the SWC within a ca. 25m thick claystone near the top of a major (500m thick) interval of interbedded sandstones, siltstones and shales, strongly indicates that the sample is (Maastrichtian) Paaratte Formation.

4. The SWC at 1487.0m yielded a marine dinoflagellate that is restricted to the Campanian, *X. australis* Zone. This date is supported by a pollen type which first appears in the co-eval spore-pollen zone (*N. senectus* Zone). Accordingly the sample is considered to represent Paaratte Formation.

   Electric log data indicate that this sample (a claystone) occurs within an upward coarsening sandy unit at the top of a ca. 160m thick shale interval (interpreted as Belfast Mudstone). Based on the palynology, the boundary between the Paaratte Formation and the Belfast Mudstone occurs at the top of this shale (1498m), rather than at the base of the first thick sand at 1482m.

5. The *I. cretaceum/T. apoxyexinus* Zone date for SWC 13 (1579.0m) is consistent with the identification of the interval between ca. 1498-1658m (characterized by a consistently high gamma ray signature) as Belfast Mudstone.

6. SWCs at 1668m, 1715.0m and 1722.5m yielded pollen indicators of the Turonian-earliest Santonian *P. mawsonii* Zone. In contrast, the electric log data indicate that the interval between 1658-1742m comprises relatively thick beds of sandstone, siltstone and shale, a sequence that is typical of the Waarre Sandstone (widely dated as Cenomanian, *A. distocarinatus*

Zone).

In this instance, there are several reasons why a *P. mawsonii* Zone age should not be seen as inconsistent with the interval being Waarre Sandstone:

(a) The indicator species are extremely rare and time-consuming to locate. A more cursory examination would have indicated that the sample was *A. distocarinatus* Zone. This almost certainly will have been the case with many Otway wells which intersect the Waarre Sandstone.

(b) It is possible that the *P. mawsonii* Zone indicators are mud contaminants (considered unlikely).

(c) Recent analyses of wells in the Gippsland and Otway Basin (M.K. Macphail, A.D. Partridge, unpubl.), e.g. Copa-1 in EPP 23, have shown that published palynological criteria used to distinguish the *A. distocarinatus* and *P. mawsonii* Zones are not always reliable. For this reason the interval is shown in the Summary as *P. mawsonii-A. distocarinatus* Zone.

(d) Deposition of the Waarre Sandstone may have extended into Turonian times in some areas of the Otway Basin, i.e the formation is time-transgressive. This is a distinct possibility.

Irrespective of the above qualifications, there is no reason to believe that the interval is any older than Cenomanian, *A. distocarinatus* Zone.

7. Because of difficulties in establishing whether the key spore-pollen species in SWC 3 (1836.0m) are in situ, the age of this sample is uncertain. Alternative picks are *P. pannosus* Zone and *C. hughesii* Zone. Both are consistent with the sample being Eumeralla Formation.

8. TAI values demonstrate that the sediments at and above 1836.0m are not the source of the CO_2 reservoired at ca. 1662-1673m.

PALAEOENVIRONMENTS

1. There is no definite evidence of any marine influence during the deposition of the carbonaceous claystone at 1836.0m.

2. Marine dinoflagellates at 1722.5m are assumed to be caved. The rich gymnosperm and fern palynoflora is characteristic of peat swamp/fluvio-deltaic conditions.

3. Massive pyrite scarring of palynomorphs indicate anoxic conditions during the deposition of the sediment at 1715.0m. The dominant dinoflagellate in this sample is abundant in open marine sediments accumulating in the Timor Sea region during the Middle-Late Albian (R.J. Helby, pers. comm.). The significance of this is unknown but, as at 1668.0m, the abundance of dinocysts relative to spore-pollen and calcareous nature of the sediment is suggestive of a locally intense marine influence at the Boggy Creek-1 wellsite prior to the Santonian.

   The existence of marine conditions here during the Cenomanian-Turonian is in good agreement with rifting along the southern margin although, as noted above, the species are more typical of Early Cretaceous dinocyst floras (relicts of the marine connection between the Otway Basin and epicontinental seas in central and northern Australia? See Frakes *et al.*, 1987)

4. Abundant dinoflagellates confirm that marine conditions persisted at Boggy Creek-1 from the Santonian until at least the Late Paleocene.

BIOSTRATIGRAPHY

Zone and age-determinations have been made using criteria proposed by Stover & Partridge (1973), Helby et al. (1987), and unpublished observations made on Otway and Gippsland Basin wells (Macphail & Hos, 1989; Macphail & Partridge, unpubl.).

It is noted that published spore-pollen criteria used to separate the Cenomanian, *Appendicisporites distocarinatus* Zone and Turonian 'lower' *P. mawsonii* Zone have been found to be unreliable in both the Otway Basin (Copa-1) and Gippsland Basin (e.g. Admiral-1, Judith-1, Shark-1). A number of alternative index species have been identified and are used in this report.

The informal subdivision of the *Tricolpites longus* Zone proposed by Macphail (1984: see Helby *et al.*, 1987 p.58) is followed in this report. The name of the zone is retained in spite of nomenclatural changes to the nominate species, now *Forcipites longus*.

Phimopollenites pannosus Zone? 1836.0m Middle-Late Albian?

The lowest SWC available for analysis [SWC 3 at 1836.0m] yielded a very sparse palynoflora dominated by long-ranging Mesozoic spores and gymnosperm species, in particular *Cyathidites* spp., *Cicatricosisporites australiensis*, *Foraminisporis asymmetricus* and *Triporoletes* spp., and mud contaminants, in particular *Eucalyptus* and species derived from the *O. porifera/I. cretaceum* Zones, e.g. *Odontochitona porifera* and *Proteacidites amolosexinus*.

The sample is provisionally assigned to the *Phimopollenites pannosus* Zone based on two specimens of the nominate species *Phimopollenites pannosus*. It is no older than this zone if these pollen grains are in situ. There is no compelling evidence that the sample is as young as *A. distocarinatus* Zone. Indicator species of the *P. mawsonii* Zone are absent.

If the *P. pannosus* specimens are mud contaminants, then the sample is suggested to be no older than Aptian, *C. hughesii* Zone based on multiple specimens of *F. asymmetricus*. The absolute maximum age will be Neocomian *C. australiensis* Zone based on the relative abundance of *Cicatricosisporites australiensis*.

Phyllocladidites mawsonii Zone 1668.0-1722.5m Turonian-Early Santonian

Three samples, at 1722.5m, 1715.0m and 1668.0m, are assigned to this zone with varying degrees of confidence. It is strongly emphasized that in all cases the dating depends on very rare occurrences of the index species *Phyllocladidites mawsonii*. This pollen is easily overlooked in early Late Cretaceous palynofloras and a caved origin cannot be ruled out. However the other pollen data are compelling that the interval is no older than *A. distocarinatus* Zone or younger than *P. mawsonii* Zone.

(1) The lower boundary is placed at 1722.5m, based on very rare occurrences of the nominate species *Phyllocladidites mawsonii* and *Interulobites intraverrucatus* and more frequent occurrences an undescribed spore that appears to be restricted to *P. mawsonii* Zone sediments in the Otway and Gippsland Basins: *Laevigatosporites musca* ms.

It is emphasized that *Phyllocladidites mawsonii* is extremely rare [1 specimen in two strew mounts each containing upward of 10,000 palynomorphs], suggesting that the sample lies close to the lower boundary of the zone. It is considered unlikely that the pollen grain has been caved. *Interulobites intraverrucatus* confirms that the sample is no older than *A. distocarinatus* Zone (see Helby *et al.*, 1987 p.55).

These spp. are associated with *Appendicisporites distocarinatus* and frequent *Clavifera triplex*, both of which support a general *P. mawsonii/A. distocarinatus* Zone attribution.

The palynoflora is an exceptionally rich one, dominated by long-ranging spores [*Baculatisporites*, *Cyathidites*, *Gleicheniidites*, *Osmundacites* spp., *Stereisporites australis* f. *crassa*] and gymnosperm pollen [chiefly *Podocarpidites*]. Significant numbers of an undescribed freshwater cyst are present. Rare specimens of the marine dinocysts, *Cribroperidinium edwardsii/ muderongensis*, *Odontochitona operculata* and *O. striatoperforata*, are considered to be caved.

(2) The SWC sample at 1715.0m is clearly marine: approximately 30% of the recovery are marine dinocysts and the overwhelming majority of palynomorphs show massive pyrite scarring. These include the most common taxon present, *Palaeoperidinium cretaceum*. Otherwise, the dinoflagellate flora includes *Amosopollis cruciformis*, *Cribroperidinium ewdardsii Cyclonephelium compactum*, a *Diconodinium* sp. within the *D. pusillum* complex, *Heterosphaeridium heterocanthum*, frequent *Odonotochitona operculata*, *Oligosphaeridium pulcherrimum* and *Spiniferites furcatus/ramosus*. It is noted that at least two of these, *Palaeoperidinium cretaceum* and *Diconodinium* cf *pusillum*, are more typical of Middle-Late Albian than Cenomanian-Turonian assemblages.

Spore-pollen spp. present include (very rare) specimens of *Phyllocladidites mawsonii*, *Hoegisporis uniforma* and *Laevigatosporites musca*, associated with more frequent numbers of *Appendicisporites distocarinatus* and *Australopollis obscurus*. Specimens of *Proteacidites* are present although at least one species, *P. amolosexinus*, almost certainly is caved. As with the sample at 1722.5m, the spore-pollen confirm that the maximum and minimum age limits for the sample are *A. distocarinatus* Zone and *P. mawsonii* Zone respectively.

(3) The upper boundary of the zone is placed provisionally at 1668.0m, a sample yielding a sparse palynoflora dominated by long-ranging Cretaceous dinoflagellates including frequent-common *Amosopollis cruciformis*, *Cyclonephelium compactum*, *Heterosphaeridium heterocanthum* and *Valensiella griphus* Norvick & Burger 1975 (a species similar to but larger than *Cassiculosphaeridia reticulata*). None are age-diagnostic but, a date younger than Santonian is unlikely based on the association of *Canningia* sp., *Chlamydophorella* cf *ambigua*, *Cribroperidinium edwardsii*, *Odontochitona operculata*, *O. striatoperforata*, *Oligosphaeridium pulcherrimum* and *Spiniferites furcatus/ramosus*.

If in situ, *Phyllocladidites mawsonii* and undescribed spp. of *Forcipites* and *Proteacidites* confirm that the sample is no older than *P. mawsonii* Zone.

Tricolpites apoxyexinus/Isabelidinium cretaceum Zone
1579.0m Santonian

One sample is assigned to this zone with a high degree of confidence based on the association of *Tricolpites apoxyexinus*, *Forcipites sabulosus*, *Latrobosporites amplus* and *Proteacidites otwayensis* with *Isabelidinium cretaceum* and frequent *Odontochitona porifera* and *Heterosphaeridium* spp.

The sample includes reworked *Appendicisporites distocarinatus* as well as Permian and Early Cretaceous spp.

Nothofagidites senectus/Xenikoon australis Zone 1487.0m
Lower Campanian

The occurrence of multiple specimens of *Xenikoon australis* confirm a *N. senectus/X. australis* Zone age for the SWC sample at 1487.0m. The date is supported by occurrences of *Nothofagidites* cf *kaitangata*, associated with *Tricolporites apoxyexinus*. The palynoflora includes a diverse range of *Forcipites* spp., including *F. renmarkensis*, and *Proteacidites* spp., including *P. amolosexinus*, *P. dierama*, *P. otwayensis* and *P. retiformis*. *Heterosphaeridium heterocanthum* dominates the dinocyst flora.

The single record of *Tetracolporites verrucosus* is not considered to be evidence for a younger (Maastrichtian) age (compare Helby *et al.*, 1987) since the species is known to occur in the *N. senectus* Zone in the Gippsland Basin.

Upper *Forcipites* (*Tricolpites*) *longus* Zone 981.5m Maastrichtian

One sample, at 981.5m, is provisionally assigned to this zone based on the relative abundance of *Stereisporites* (*Tripunctisporis*) sp. in an assemblage including a diverse range of typically Late Cretaceous (ms) species including *Beaupreaidites orbiculatus*, **Proteacidites ademonosus**, *P. cleinei*, *P. protograndis*, *P. otwayensis* ms, *P.* sp. cf *P. wahoonesis* and *Tetradopollis securus*.

The palynoflora is however unusual for this zone in that (a) the dinoflagellate flora includes significant numbers of *Glaphyracysta*, some of which fall within the morphological range of the Paleocene species *G. retiintexta* and (b) the relative abundance of *Gambierina rudata* is very low.

Geological data indicate that a Maastrichtian age is the more probable, implying that *G. retiintexta* has an extended range or that it has been caved. The data are emphatic that the sample is no younger than basal Danian, Lower *L. balmei* Zone or older than upper Maastrichtian Upper *T. longus* Zone.

Upper *Lygistepollenites balmei* Zone 939.5m Paleocene

The SWC at 939.5m is dated as Upper *L. balmei* Zone, based on the frequent specimens of the dinoflagellates *Deflandrea medcalfii* and a variant of *Senegalium dilwynense*, in an assemblage including *Amosopollis cruciformis*, *Australopollis obscurus*, *Bysmapollis emaciatus*, *Latrobosporites amplus*, *Lygistepollenites balmei* and *Phyllocladidites reticulosaccatus*.

Species first appearing in the Eocene are absent except for rare, unexplained specimen of the typically Late Eocene dinoflagellate *Gippslandica extensa*. The palynoflora includes significant numbers of reworked palynomorphs, in particular *Cribroperidinium edwardsii* and *Apteodinium granulosum*.

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TABLE 1: SUMMARY OF INTERPRETATIVE PALYNOLOGICAL DATA

SWC	DEPTH (m)	ZONE S-P	ZONE DINO	CONF. RTG.	COMMENT
20	939.5	U. L.b.	Indet.	2	No younger than this Zone
19	981.5	U. T.l.	Indet.	2	No younger than basal Danian
14	1487.0	N. sen.	X. aus.	0	Xenikoon australis
13	1579.0	T. apx.	I. cret.	1	Isabelidinium cretaceum
12	1668.0	P. maw.	Indet.	2	No older than this zone
08	1715.0	P. maw.	Indet.	1	No younger than this Zone.
07	1722.5	P. maw.	-	1	No older than *A. dist.* Zone
06	1772.0	Indet.	-	-	Mainly mud contaminants
03	1836.0	P. pann.	-	2	No older than C. hughesii Zone?

U. L.b. = Upper *L. balmei* Zone
U. T.l. = Upper *T. longus* Zone
N. sen. = *N. senectus* Zone
X. aus. = *X. australis* Zone
T. apx. = *T. apoxyexinus* Zone
I. cret. = *I. cretaceum* Zone
P. maw. = *P. mawsonii* Zone
A. dist. = *A. distocarinatus* Zone
P. pann. = *P. pannosus* Zone

TABLE 2: **BASIC DATA**

SWC	DEPTH (m)	YIELD S-P	YIELD DINO	DIVERSITY S-P	DIVERSITY DINO	PRES.	LITH.*
20	939.5	low	low	low	med.	mod.	sst.
19	981.5	low	low	med.	low	mod.	clyst.
14	1487.0	low	low	med.	low	poor	clyst.
13	1579.0	low	med.	med.	med.	good	glau. clyst.
12	1668.0	v. low	low	low	med.	mod.	calc. sst.
08	1715.0	med.	med.	med.	med.	poor	dol. sltst.
07	1722.5	high	caved	med.	low	mod.	slst./coal
06	1772.0	negl.	caved	-	-	mod.	slst.
03	1836.0	low	-	low	-	mod.	carb. clyst.

* Lithological descriptions [main rock type/qualifier] taken from typed sidewall core sample description sheets

TABLE 3: **TAI ESTIMATES**

SWC	DEPTH (m)	EST. TAI*	MATURITY	DOMINANT KEROGEN
20	939.5	2.00	Immature	S>V>I>>E
19	981.5	2.00+	Immature	S>V>I>>E
14	1487.0	2.00+	Immature	S>V>I>E
13	1579.0	2.00+	Immature	I>S>V>E
12	1668.0	2.25-	Immature	V>I>E>S
08	1715.0	2.25-	Immature	S>I>V>E
07	1722.5	2.25-	Immature	V>S>I>E
06	1772.0	2.25	Very early oil	S>I>V>E
03	1836.0	2.25	Very early oil	S>I>V>E

E = Exinite & Alginite

I = Inertinite

S = Sapropel (granular)

V = Vitrinite

Palynomorphs with TAI values of 3 to 5, representing the dry gas phase, were not recorded.

* TAI estimates made using fluorescence miscroscopy techniques by International Stratigraphic Consultants P/L. Cottesloe, W.A. 6011. See Appendix 1.