Palynological analysis of the Cretaceous section penetrated in Wombat-2, onshore Gippsland Basin.

by

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INTERPRETATIVE DATA

Summary

Palynological analysis has been performed on four cuttings and three core sample over the interval 1356 to 1500.6m in Wombat-2. All samples examined are assigned a Cretaceous age. The Late Maastrichtian Upper *Forcipites longus* spore-pollen Zone is identified at 1356-59m at the top of the interval, while the remaining productive assemblages between 1365 and 1500.6m are interpreted to belong to the Early Cretaceous, although only the shallowest core sample at 1497.7m could be confidently assigned to the mid Albian *Coptospora paradoxa* Zone. No spore-pollen characteristic of the Turonian age *Phyllocladidites mawsonii* Zone were found in Wombat-2, in contrast to their occurrence in the adjacent Wombat-1.

Based on the palynological assemblages recorded the stratigraphic succession in Wombat-2 is interpreted to consist of Late Maastrichtian age sediments belonging to either the basal Barracouta, or Yarram formations of the Latrobe Group, unconformably overlying Early Cretaceous Strzelecki Group sediments, without the presence of any intervening section belonging to either the Golden Beach or Emperor Subgroups.

Introduction

The four cuttings and three core sample analysed from the Wombat-2 well drilled by Lakes Oil N.L. were submitted for a mixture of urgent and routine analysis between the 15th and 21st April 2004, with the objective of confirming initially the presence or absence of the "Golden Beach Group" (as used in the sense of Lowry & Longley, 1991), and to confirm the penetration and location of the top of the underlying Strzelecki Group. All samples were forwarded directly to the palynological processing facilities of Core Laboratories Australia Pty Ltd (formerly operated by Laola Pty Ltd) in Perth, for laboratory processing and slide preparation. The latter slides were returned to the author for microscope analysis on the 19th and 30th April 2004, and two Provisional Reports giving the initial zone and age determinations were issued on the same days.

The final zones and ages assigned to the samples, zone confidence ratings, and zone identification criteria for each of the samples are summarised on Table 1. The organic residues yields from the samples varies from low to high, but the palynomorph concentrations were mainly low and preservation is mostly poor to fair (Table 2). The recorded spore-pollen diversity varies from very low to high averaging 21+ species per sample, whereas the recorded microplankton diversity is very low diversity averaging only one species per sample. The distribution of the palynomorphs identified in the samples are displayed on the accompanying StrataBugs™ range chart. Author citations for most of the recorded spore-pollen species can be sourced from the papers by Dettmann (1963), Helby *et al.* (1987) or Stover & Partridge (1973), while the author citations for the microplankton species can be sourced from the indexes for dinocysts and other organic-walled microplankton prepared by Fensome *et al.* (1990) and Williams *et al.* (1998). Manuscript species names and combinations are indicated by "sp. nov." or "comb. nov." on the range chart and "ms" after their binomials names in the text and tables.

Discussion of Results

The shallowest cuttings sample analysed in Wombat-2 at 1356-59m contains a good spore-pollen assemblage that can confidently be assigned to the Upper *Forcipites longus* Zone. The assemblage recorded is virtually identical to the assemblage previously recorded at 1329-32m in Wombat-1 (Partridge, 2004). Both samples provide reliable Late Maastrichtian ages for the base of the upper Latrobe Group, and in terms of the traditional onshore stratigraphy they would lie within either the Barracouta or Yarram formations (Hocking, 1976, 1988). These two formation have recently been included in the Halibut Subgroup by Partridge (1999) and Bernecker & Partridge (2001). It should be noted however that both these Maastrichtian age assemblages were collected from immediately below the top of the "Golden Beach Formation" identified by the well site geologist on the formation evaluation or rock log. In Wombat-1 the top of the "Golden Beach Formation" is identified at 1327m on the rock log, while in Wombat-2 the formation is picked at 1353m. The coincidence of finding Late Maastrichtian age sediments below a lithological break in the two wells suggests the presence of another Upper Cretaceous lithological unit (or sequence) in the onshore basin that has not been adequately analysed. Sediments belonging to the Upper *F. longus* Zone are recorded from Wonga Binda-1, Emperor-1 and Golden Beach West-1 in addition to the two Wombat wells. However, the unit appear to be absence from other nearby wells, only slightly further inshore, where there is sufficient palynological age control (eg. Burong-1, Colliers Hill-1, Dutson Downs-1, North Seaspray-1, Macalister-1 and probably McCreesh-1). In all other onshore wells it is impossible, on the limited samples available, to determine whether a thin Late Maastrichtian section is present or absent.

The next group of cuttings analysed between 1365-68m and 1419m (which lie below the 9-5/8 inch casing set at 1359m), are unfortunately badly contaminated by extraneous organic matter that is interpreted to have been derived from a new drilling mud additive. This modern organic material dilutes and masks the low numbers of *in situ* spores and pollen recovered. Most of the fossils recorded on the palynological slides have long ranges that are known to extend throughout the Cretaceous and many through most of Tertiary. The presence however, of multiple specimens of *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis*, and common *Cyathidites* spores favours an Early Cretaceous age and hence Strzelecki Group assignment. In marked contrast to Wombat-1 these cuttings lack the common *Dilwynites* and *Cupressacites* pollen that are a feature of the *Phyllocladidites mawsonii* Zone found in the Wombat-1 well. Based on the absence of any species diagnostic of the latter zone the stratigraphic section analysed in Wombat-2 is interpreted to consists of the Barracouta Formation (or Yarram Formation) directly overlying the Strzelecki Group.

The final three core samples between 1497.7 and 1500.6m gave a mixture of very good, moderate and extremely poor assemblages. The shallowest sample contained a high diversity assemblage that could confidently be assigned to the mid Albian *Coptospora paradoxa* Zone, and is considered typical of the Strzelecki Group. The middle sample at 1499.75m gave a moderate diversity, yet still typical, Early Cretaceous assemblage which could not be assigned to a zone because it lacked key zone index species. The deepest sample gave a very low diversity assemblage that was not independently age diagnostic, but is entirely consistent with a Early Cretaceous age. The three samples illustrate the variation in results that can be obtained from different lithologies in the Strzelecki Group and highlight the need to analyse a variety of lithologies to obtain the best results. Based on comparison with other nearly wells penetrating the onshore Seaspray Depression the >140 metres of Strzelecki Group penetrated in Wombat-2 is likely to all belong to the *C. paradoxa* Zone.

In summary, all palynological assemblages recorded in Wombat-2 belong to the Cretaceous. The succession encountered consists of Late Maastrichtian age non-marine sediments of the Halibut

Subgroup unconformably overlying non-marine sediments of the Strzelecki Group. There is no evidence in the palynological assemblages of any section belonging to the Santonian to Campanian age Golden Beach Subgroup or the Turonian to Coniacian Emperor Subgroup, which combined represent the former "Golden Beach Group" of Lowry & Longley (1991).

Palynological Assemblages and Zones

Upper *Forcipites longus* spore-pollen Zone
Cuttings at: 1356-59 metres
Age: Late Maastrichtian.

The shallowest cuttings sample analysed is assigned to the Upper *F. longus* Zone (formerly Upper *Tricolpites longus* Zone) based on the joint occurrence of *Proteacidites clinei* ms, *Proteacidites (Propylipollis) crotonoides*, *Proteacidites (Cranwellipollis) palisadus* and *Proteacidites reticuloconcavus* ms which all range no younger than the Cretaceous, associated with the presence of the spore *Tripunctisporis maastrichtiensis* and the common occurrence of the angiosperm pollen *Gambierina rudata* (16%), which range no older than this zone according to the updated definition of Partridge (1999). The assemblage is dominated by angiosperm pollen (45%) with species of *Proteacidites* most abundant (sum total of all *Proteacidites* species 23%). Surprisingly, relatively few palynomorphs caved from the overlying Tertiary were recorded in this assemblage.

***Coptospora paradoxa* spore-pollen Zone**
Core sample at: 1497.7 metres
Age: mid Albian.

The shallowest core sample at 1497.7m gave the best Early Cretaceous age Strzelecki Group assemblage with a diverse spore-pollen assemblage containing rare specimens of the index species *Coptospora paradox*a and *Perotrilites majus.* Both these species have their oldest stratigraphic occurrences within this zone according to the ranges documented in Dettmann & Playford (1969; table 9.4). The assemblage is dominated by spores (68%), mainly *Cyathidites* spp. (average 22%) and *Baculatisporites/Osmundacidites* spp. (average 19%), although bisaccate gymnosperm pollen lumped under *Podocarpidite*s spp. represent the most abundant individual category (average 26%). Other species in the assemblage considered characteristic of the Strzelecki Group include the frequent occurrence of *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis* (~3%), and presence of *Aequitriradites spinulosus, A. verrucosus, Crybelosporites striatus* and *Foraminisporis asymmetricus*. This sample also contains the presence of the algae *Sigmopollis carbonis* and acritarch *Micrhystridium* sp. A, which are consistent with the zone and age determination.

The cuttings samples between 1365 and 1419m and the other two core samples at 1499.75 and 1500.6m are also assigned to the Early Cretaceous even though they contain much poorer assemblages. The most distinctive species in the samples is the spore *Ruffordiaspora australiensis* which has a fairly consistent range from the base of the Cretaceous into the basal Cenomanian (*R. australiensis* to *P. pannosus* Zones), but is in comparison relatively rare and inconsistent in the Late Cretaceous of the succeeding Emperor and Golden Beach subgroups. With the exception of the core sample at 1499.75m, which is overwhelmingly dominated by *Podocarpidites* pollen (>80%), all these other samples contain relatively few palynomorphs, such that the species abundances in the assemblages are not considered reliable.

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INTERPRETATIVE DATA

Table 1: Interpretative palynological data for Wombat-2, onshore Gippsland Basin.

Sample Type	Depth metres	Spore-Pollen Zone Age/Stage	CR*	Comments and Key Species Present
Cuttings*	1356-1359m	Upper *F. longus* Zone **Late Maastrichtian**	D1	LADs of *Proteacidites reticuloconcavus* ms and *P. clinei* ms with FAD of spore *Tripunctisporis maastrichtiensis* in angiosperm dominated (45%) assemblage in which *Gambierina rudata* is common (16%). Assemblage surprisingly contains very few caved Tertiary spore-pollen.
Cuttings*	1365-1368m	Zone indeterminate but probably **Early Cretaceous**		LAD of spore *Ruffordiaspora australiensis* in very low palynomorph yielding sample favours Early Cretaceous age assignment.
Cuttings*	1387-1390m	Zone indeterminate but probably **Early Cretaceous**		Sample yielded a few long ranging spore-pollen species. An Early Cretaceous age is favoured in absence of any distinctive Late Cretaceous species.
Cuttings	1419m	Zone indeterminate but clearly **Early Cretaceous**		Presence of spore *Ruffordiaspora australiensis* in low palynomorph yielding sample favours Early Cretaceous age and Strzelecki Group assignment.
Core 1	1497.7m	*C. paradoxa* SP Zone **Mid-Late Albian**	A1	Presence of *Coptospora paradoxa* and *Perotrilites majus* confirm zone assignment in spore dominated assemblage. Confident top of Strzelecki Group
Core 1	1499.75m	Zone indeterminate but clearly **Early Cretaceous**		Assemblage dominated by bisaccate gymnosperm pollen assigned to *Podocarpidites* (>80%), without any associated diagnostic index species.
Core 1	1500.6m	Zone indeterminate but probably **Early Cretaceous**		Small 2g sample gave very low yield with <20 specimens on slides. Species recorded not age diagnostic but consistent with other core samples.

*Rush preparation.

FAD & LAD = First & Last Appearance Datums
MP = Microplankton
SP = Spore-pollen

***Confidence Ratings used in STRATDAT database and applied to Table 1.**

Alpha codes: Linked to sample		**Numeric codes:** Linked to fossil assemblage		
A	Core	**1**	**Excellent confidence:**	High diversity assemblage recorded with key zone species.
B	Sidewall core	**2**	**Good confidence:**	Moderately diverse assemblage with key zone species.
C	Coal cuttings	**3**	**Fair confidence:**	Low diversity assemblage recorded with key zone species.
D	Ditch cuttings	**4**	**Poor confidence:**	Moderate to high diversity assemblage without key zone species.
E	Junk basket	**5**	**Very low confidence:**	Low diversity assemblage without key zone species.

BASIC DATA

Table 2: Basic assemblage data for Wombat-2, onshore Gippsland Basin.

Sample Type	Depth	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species	No. MP Species
Cuttings*	1356-1359m	Moderate	Low	Fair	38+	4+
Cuttings*	1365-1368m	Low	Very low	Poor	11+	
Cuttings*	1387-1390m	Low	Very low	Poor	7+	
Cuttings	1419m	High	Low	Poor-good	35+	
Core 1	1497.7m	Moderate	High	Fair-good	39+	3+
Core 1	1499.75m	Moderate	Moderate	Poor	13+	
Core 1	1500.6m	Very low	Very low	Poor	7+	
* Rush preparation.				**Averages:**	**21+**	**<1**

Description of Range Chart.

The range chart accompanying this report was prepared using the StrataBugs™ program and displays the palynomorph species in the samples proportional to their depth in the well. The palynomorphs recorded are split into different categories, with the spores, gymnosperm pollen and angiosperm pollen plotted in separate panels with the abundance of individual species calculated as a percentage of the total Spore-Pollen sum. This is followed by the panel labelled Caved which records the abundance of Tertiary palynomorphs as a percentage of total Tertiary and Cretaceous palynomorphs. The Microplankton and Other palynomorphs are next plotted as separate panels, with abundances expressed as a percentage of the total Spore-Pollen plus Microplankton sum or Spore-Pollen plus Others sum. Finally, Permian and Triassic species in the assemblages a plotted in panel labelled Reworked. Within the panels the species are plotted according to their highest or youngest occurrence or alphabetical. The following codes or abbreviations apply to the individual species occurrences and abundances on the range chart:

Numbers	=	Abundance expressed as percentage
+	=	Species outside of count
C	=	Caved species
R	=	Reworked species
?	=	Questionable identification of species.

Well Name : Wombat-2

Operator : Lakes Oil NL
Completed: 24 April 2004
Interval : 1300m - 1600m
Scale : 1:2000
Chart date: 01 June 2004

Spudded : 30 March 2004

Cretaceous Palynological Range Chart
Sample Interval 1356-59 to 1500.6m
Microscope analysis by Alan D. Partridge

Wombat-2

Biostrata Pty Ltd
AUSTRALIA

Attachment to Biostrata Report 2004/07

Depth | Lithostratigraphy: Formation | Casing | Lithology | Spore-Pollen: Zone | Samples (metres)

1300m
1350m
1400m
1450m
1500m
TD 1550
1550m
1600m

Barracouta Formation
Strzelecki Group
9 5/8
1359.00m
Upper F. longus
Early Cretaceous (including C. paradoxa Zone)

1359
1368
1390
1419
1497.70
1499.75
1500.60

Spores

% of KT = S + G + A (30mm=100%)

Ariadnaesporites sp. (threads)
Baculatisporites spp.
Cyathidites spp. (large species)
Cyathidites spp. (small species)
Dictyophyllidites spp.
Gleicheniidites circinidites
Laevigatosporites major
Laevigatosporites ovatus
Latrobosporites amplus
Reticulosporis (Schizaea) albertonensis
Retitriletes spp.
Stereisporites antiquasporites
Tripunctisporis maastrichtiensis
Verrucosisporites kopukuensis
Cyathidites australis
Klukisporites scaberis
Osmundacidites wellmanii
Ruffordiaspora australiensis
Ceratosporites equalis
Foraminisporis asymmetricus
Stereisporites regium
Trilete spores undiff.
Triporoletes reticulatus
Triporoletes simplex
Aequitriradites spinulosus
Aequitriradites verrucosus
Cicatricosisporites hughesii
Cicatricosisporites & Ruffordiaspora spp.
Cingutriletes congruens
Coptospora paradoxa
Crybelosporites striatus
Leptolepidites verrucatus
Neoraistrickia truncatus
Perotrilites majus
Retitrilletes austroclavatidites
Retitrilletes facetus
Retitrilletes nodosus
Velosporites triquetrus
Dictyotosporites speciosus

Gymnosperms

% of KT = S + G + A (30mm=100%)

Araucariacites australis
Dilwynites granulatus
Lygistepollenites balmei
Lygistepollenites florinii
Microcachyridites antarcticus
Phyllocladidites mawsonii
Podocarpidites exiguus
Podocarpidites spp.
Trichotomosulcites subgranulatus
Corollina torosa

Angiosperms

% of KT = S + G + A (30mm=100%)

Dicotetradites clavatus
Gambierina rudata
Haloragacidites harrisii
Nothofagidites deminutus
Nothofagidites emarcidus/heterus
Nothofagidites senectus
Peninsulapollis gillii
Proteacidites clinei sp. nov.
Proteacidites (Propylipollis) crotonoides
Proteacidites (Cranwellipollis) palisadus
Proteacidites reticuloconcavus sp. nov.
Proteacidites spp.
Tricolpites waiparaensis
Tricolporites adelaidensis
Nothofagidites endurus
Australopollis obscurus
Ericipites crassiexinus
Malvacipollis subtilis
Periporopollenites demarcatus
Proteacidites (Propylipollis) annularis
Tricolporites (Ailanthipites) paenestriatus

Caved

% of Caved + In_Situ: Caved
100

Microplankton

*1
Apteodinium australiense
Botryococcus braunii
Gippslandica extensa
Spiniferites spp.
Circulisporites parvus
Micrhystridium sp. A
Sigmopollis carbonis

Other

*2
Fungal spores & hyphae
Indeterminate palynomorphs
Reworked palynomorphs

Reworked

*3
Annulispora folliculosa
Aratrisporites spp.
Callialasporites segmentatus
Dulhuntyispora dulhuntyi
Foveosporites moretonensis
Horriditriletes ramosus
Plicatipollenites spp.
Protohaploxypinus spp.