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Palynological review of Upper Cretaceous section penetrated in Chat-1, Bass Basin.

by

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INTERPRETATIVE DATA

Summary

Palynological analysis has been performed on five new cuttings samples and the relinquished palynological slides from an additional ten samples over the interval 2490 to 3104mTD penetrated in Chat-1 in the Durroon Sub-Basin. The section analysed is interpreted to comprise at least 400 metres of Maastrichtian to Campanian age strata (*Forcipites longus* to *Nothofagidites senectus* Zones), unconformably overlying approximately 80 metres of Turonian age strata (*Phyllocladidites mawsonii* Zone). The latter also contains lacustrine algal cysts of the *Rimosicysta* microplankton Superzone and can be correlated with the Durroon Formation. These Late Cretaceous sediments in turn unconformably overlie 92 metres of basic igneous rocks at the base of the well, which have been determined to have a Middle Jurassic age (Bathonian) on recent radiometric dating, and are correlated with the dolerites in Tasmania.

Introduction

This study was undertaken for Minerals Resources Tasmania to review the age dating of the Upper Cretaceous portion of the Eastern View Group penetrated in the Chat-1 well drilled in 1986 by Bridge Oil Limited. Located on the northwestern margin of the Durroon Sub-basin Chat-1 is the second most easterly well in the Bass Basin after Durroon-1. The only previous palynological study of the well is a report by Morgan (1986) included in the Well Completion Report.

The materials analysed consist of five new cuttings and the relinquished palynological slides from three sidewall cores and seven cuttings samples provided by Minerals Resources Tasmania. Unfortunately, no additional sidewall core material was available for study other than the prepared palynological slides in the relinquishment set, and no conventional cores were cut in the well. The laboratory processing of the five new palynological samples was performed by Laola Pty Ltd in Perth. Initial results of the microscope analysis were provided in a Provisional Report submitted on 21st December 2003, and the final determinations are summarised in Table 1.

From the new samples approximately 15 grams of cuttings were processed to give high organic residue yields containing low to moderate concentrations of palynomorphs (Tables 2 & 3). Judging from the relinquished slides the organic residue yields and palynomorph concentrations in the original samples was more variable ranging from very low to high. Overall the palynomorph preservation in both sets of samples was fair. The distribution of the palynomorphs identified in the samples are shown on the accompanying StrataBugs™ range chart.

Author citations for spore-pollen species can be mostly sourced from Dettmann (1963), Stover & Partridge (1973) and Helby *et al.* (1987), while those for the few microplankton recorded can be sourced from the indexes compiled 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" or "†" after their binomials names in the text and tables.

Previous Studies and Objectives

The original palynological report on Chat-1 by Morgan (1986) provided results on 33 cuttings samples prepared and analysed on an urgent or quick turnaround basis while the well was drilling, and three sidewall cores from near the base of the well prepared and analysed after the well reached total depth. As explained by Morgan (1986), because of the emphasis on fast turnaround, many of his cuttings samples were not given the ideal laboratory treatment. This is reflected in the more variable concentration of palynomorphs on the relinquished slides, and the fact that the glycerine jelly mounting medium in many of the original slides examined has not been properly cured. Some slides have subsequently partly desiccated while in others the mounting medium is still fluid. Notwithstanding these difficulties comparable assemblages were recorded from both the original slides and new cuttings samples analysed.

Over the interval investigated in this report Morgan (1986) identified the *Forcipites* (al. *Tricolpites*) *longus* Zone between 2370 and 2805m, the *Tricolporites lilliei* Zone from 2899.93 to 3033m and regarded the deepest cuttings at 3104m as no older than the *Nothofagidites senectus* Zone. In addition the Maturity Profile provided by Morgan (1986; figure 1) indicates that the 10 samples re-examined are a mid-brown colour with a TAI (Thermal Alteration Index) reading of 2.75 to 3.25 which Morgan considered to fall into the mature maturation window for oil generation.

Based on the above palynological results the traditionally accepted interpretation of Chat-1 has been that at total depth the well was still within the Upper Cretaceous (no older than Campanian), and that the basic igneous rocks penetrated below 3012m were equivalent to the Tertiary intrusive volcanics found in many other wells in the Bass Basin. The latter interpretation was supported by the brown colour of the palynomorphs which were interpreted to have been partly carbonised by the Tertiary intrusion.

In contrast, more recent regional geological and seismic mapping of the Bass Basin for the *Western Tasmanian Regional Minerals Program* (Blevin, 2003), has revealed that the Chat-1 well is located over a major basin dividing structure named the Chat Accommodation Zone (CAZ), and is further interpreted to have actually reached basement in a mid-Jurassic age dolerite (Blevin, 2003; fig.3.6). Subsequently, radiometric dating of cuttings from this unit has confirmed a Middle Jurassic age (167 Ma or Bathonian) for the igneous rocks below 3012m (Dance *et al.*, in press). The Cretaceous sediments overlying this basement were in turn interpreted to include portions of both the Durroon and Bass Megasequences (Blevin, 2003; p.47-52), but it was unclear as to the precise ages of the sediments and the positions of the unconformities between the megasequences. The objectives of this new study were therefore to improve the palynological age dating and identify if possible the best positions for the sequence bounding unconformities.

Discussion of Results

The new palynological analysis has made the important discovery of the *Phyllocladidites mawsonii* spore-pollen Zone and the associated *Rimosicysta* microplankton Superzone directly overlying the dolerite basement. These zones identified between 2949 and 3006m, and found caved into deeper cuttings, confirm the presence of Turonian age strata in Chat-1 that correlate with the Durroon Formation in Durroon-1 (Smith, 1986; Partridge 2002a-b). Based on comparison of the gamma ray logs between the two wells the Durroon Formation is identified between 2930 and 3012m in Chat-1. The record of *Rimosicysta* sp. in the slightly shallower cuttings at 2928m is best interpreted to represent reworking.

The overlying 440 metres of section examined up to 2490m is comprised of younger Campanian to Maastrichtian age sediments. This interval contains good assemblages that can be confidently assigned to the Maastrichtian *Forcipites longus* Zone, and other poorer assemblages that are more characteristic of the older Campanian *Nothofagidites senectus* and/or *Tricolporites lilliei* Zones. Unfortunately, the location of the boundaries between, and therefore the thickness of these zones is not clearly defined. On face value the cuttings assemblages suggest the *F. longus* Zone is over 360 metres thick extending as deep as 2850m. This would leave less than 80 metres of section above the Durroon Formation for the two older zones. However, examination of possible electric logs correlations with Durroon-1 would suggest that a more logical position for a major sequence boundary and associated zone change would be at the prominent sandstone located at 2734 to 2754m. On the accompanying range chart this sandstone is taken as the boundary between the informal Chat and Boobyalla units which are identified in Durroon-1 (see Partridge, 2002b, fig.6; and also reproduction of this illustration in Blevin, 2003; fig.4.6). If indeed this position is accepted as the most logical position of a lithological or sequence boundary it would require that there is significant caving of *F. longus* Zone assemblages in Chat-1. Unfortunately, it is unlikely this interpretation can be resolved with any certainty by the analysis of additional cuttings samples because of the masking effects of the down-hole cavings.

The new study also refutes the mid-brown colour and TAI values of 2.75 to 3.25 recorded from the palynological assemblages below 2400m by Morgan (1986; fig.1). Determinations of the colour of the palynomorphs using reference slides calibrated against the colour standards for the scheme of Staplin (1969, 1977) are tabulated below. The readings were made on kerogen slides from the five new cuttings samples and a single labelled kerogen slide in the relinquishment set studied by Morgan (1986). Although none of the relinquished slides from the other nine original samples were labelled as kerogen slides the available oxidised slides did not contain palynomorph with higher TAI values aside from the occasional reworked Permian or Triassic specimen.

Sample	Depth	TAI value
Cuttings	2625m	1.6 to 2.0
Cuttings	2751m	1.8 to 2.0
*Cuttings	2799m	1.8 to 2.0
Cuttings	2850m	1.5 to 2.2
Cuttings	2928m	1.8 to 2.2
Cuttings	3006m	2.0 to 2.2

*Kerogen slide from relinquishment collection studied by Morgan (1986).

The range of recorded values from 1.5 to 2.2 (pale yellow to light brown) reflects the presence of caved palynomorphs in the kerogen slides, but is not higher than 2.2 on the TAI scale of Staplin (1969; 1977). This would place the organic matter (kerogen) in either the **immature** or **transition to mature** organic-facies on the empirical scale for hydrocarbon maturation shown on the summary chart in Staplin (1977; text-fig.10), and contradicts the prior **mature** organic-facies assignment of Morgan (1986).

Palynological Zones

Overall, the interval analysed contains diverse spore-pollen assemblages that can be confidently assigned to the Upper Cretaceous zonation schemes developed in the Otway and Gippsland Basins (Dettmann & Playford, 1969; Stover & Partridge, 1973; Helby *et al.*, 1987; Partridge, 1999). But although good confidence can be expressed in presence of the zones discussed there is much less certainty about the precise depth limits of the zones due to the presence of significant cavings in the cuttings. The most obvious cavings are in the samples below 3012m, as this section is now known to consist largely of mid-Jurassic age basalt and is considered to represents basement. Therefore, all the spore-pollen characteristic of the *N. senectus* to *T. lilliei* Zones and the *P. mawsonii* Zone recorded from the two deepest cuttings clearly have to be caved from higher in the well. Similarly, the samples assigned to the *P. mawsonii* Zone contain many species known only from *N. senectus* and younger zones. It is also suspected, but with much less confidence, that the assemblages from the *F. longus* Zone may be significantly caved masking the true thickness of the immediately older *T. lilliei* and *N. senectus* Zones.

***Forcipites longus* spore-pollen Zone**
Interval: 2490 to 2805 metres, and caved to 2850 metres
Age: Maastrichtian.

The seven shallowest cuttings samples analysed contain assemblages assigned to the *Forcipites* (al. *Tricolpites*) *longus* Zone. According the stratigraphic ranges in Helby *et al.* (1987; fig.33) the interval can be no younger than this zone based on the LADs (Last Appearance Datums) of *Battenipollis sectilis* and *Tricolporites lilliei* in the shallowest cuttings sample, and is unlikely to be older than the zone based on the FADs (First Appearance Datums) of *Tetracolporites verrucosus* at 2850m, and *Forcipites longus* at 2805m. Supporting these datums are the occurrences of the manuscript species *Proteacidites reticuloconcavus* ms and *Battenipollis croccodilus* ms which have ranges restricted to this zone.

The shallowest two samples can be further assigned to the Upper subzone of the *F. longus* Zone based on the common occurrence of *Gambierina rudata* (7 to 10%) and a reduced or equal abundance of *Nothofagidites* pollen. In contrast the five deeper samples, containing assemblages where *Nothofagidites* pollen is of greater abundance than *G. rudata*, are assigned to the Lower subzone. The spore *Tripunctisporis maastrichtiensis*, whose FAD is also used to mark the base of the Upper subzone was only recorded from the shallowest sample.

***Nothofagidites senectus* to *Tricolporites lilliei* spore-pollen Zones**
Sidewall core at 2899.93 metres and caved in deeper samples,
Age: Campanian.

The sidewall cores at 2899.93m and 2967.03m are both white sandstones which normally would be considered unfavourable for palynology. However, in the relinquishment slide collection both samples are represented by slides containing very low organic yields and very low numbers of palynomorphs. The fact that anything at all was recovered is surprising to the author, and it is considered likely that the assemblages recorded represent mud contamination. Notwithstanding this caveat the moderate diversity spore-pollen assemblages recorded contain common *Nothofagidites senectus* and the rare specimens of *Gambierina rudata*. Based on recent studies in the adjacent Gippsland and Otway Basin this association would indicate a Upper *N. senectus* Zone or younger age, although Morgan (1986) favoured a *T. lilliei* Zone assignment. Similar assemblages with common *N. senectus* and lack of younger index species are also recorded as caved components in the samples from the underlying *P. mawsonii* Zone and through the basement interval.

The only species found that can be considered to have a useful LAD in the samples is *Forcipites sabulosus*, which is typically common in the *N. senectus* Zone, frequent in the *T. lilliei* Zone and extremely rare in the basal Lower *F. longus* Zone. For example, it varies from present to common (<1% to 7%) in the sidewall cores assigned to the two older zones in Durroon-1, but was recorded from only one of three sidewall cores from the Lower *F. longus* Zone (Partridge, 2002a). However, in Chat-1 this species has only been recorded as isolated specimens in the cuttings at 2928m, 3006m and 3033m. As these occurrences are from the older *P. mawsonii* Zone and basement intervals they are not particularly helpful. Although they suggest that the *N. senectus* and/or *T. lilliei* Zones are indeed present in Chat-1, they do not help with defining the location of those zones. It is therefore concluded that although there is sufficient evidence in the recorded assemblages to suggest that both the *N. senectus* and *T. lilliei* Zone are present in Chat-1 it is not possible to specify the precise stratigraphic intervals over which these zones occur.

***Phyllocladidites mawsonii* spore-pollen Zone, and**
***Rimosicysta* microplankton Superzone**
Interval: 2949 to 3006 metres
Age: Turonian.

The *P. mawsonii* Zone is identified in the cuttings by a change from mainly angiosperm dominated assemblages to gymnosperm dominated assemblages. The change is best expressed by the increased abundance of *Dilwynites* and *Cupressacites* pollen which are highly characteristic of the Durroon Formation in Durroon-1. This change is graphically illustrated in Durroon-1 by the diagram in Partridge (2002b; fig.6), which is reproduced in Blevin (2003; figure 4.6). The cuttings at 3006m and 3104m contain the most representative assemblages, but the change can be identified as shallow as 2949m. Aside from *Dilwynites echinatus* ms and *D. pusillus* ms none of the spore-pollen considered most characteristic of the *P. mawsonii* Zone were recorded. This is not particularly unusual as these key species were also extremely rare in the Durroon Formation in Durroon-1 (Partridge, 2002a).

Supporting the spore-pollen evidence are the presence of rare algal cysts belonging to *Rimosicysta* and the same undescribed species of the non-marine dinocyst *Morkallacysta* as found in Durroon-1 by Partridge (1973, 2002). These forms are considered typical of the *Rimosicysta* Superzone proposed by Partridge (1999), as it is expressed in the Bass Basin. It is also noteworthy that there is a marked increase in the diversity of reworked Permian and Triassic spore-pollen in assemblages assigned to the *P. mawsonii* Zone. As such reworking is also a feature of the *P. mawsonii* Zone in the Gippsland Basin it cannot be directly linked to the basement rocks underlying this zone in Chat-1.

In conclusion, evidence from both spore-pollen and microplankton supports the presence of a Turonian age interval equivalent to the Durroon Formation in Chat-1. Examination of the electric logs suggests that the formation most likely corresponds to the mostly shaly section between 2930 and 3012m. However, the identification of poor specimens of *Rimosicysta* in the cuttings at 2928m suggests the unit could either extend slightly shallower, or alternatively there is reworking across an unconformity into the younger Campanian to Maastrichtian strata.

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Description of Range Chart.

The range chart accompanying this report was prepared using the StrataBugs™ program and displays the palynomorph species in the cuttings proportional to their depth in the well, and against selected electric logs which were supplied to Mineral Resources Tasmania through the courtesy of Wiltshire Geological Services Pty Ltd. 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. 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 Other sum. Finally, Permian, Triassic and Early Cretaceous species considered to be reworked in the assemblages are plotted in panel labelled Reworking. Within the panels the species are either plotted alphabetically or according to their highest or youngest occurrence. 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.

INTERPRETATIVE DATA

Table 1: Interpretative palynological data for Chat-1, Bass Basin.

Sample Type	Depth metres	Spore-Pollen Zones Age/Stage	CR*	Comments and Key Species Present
Cuttings	2490	Upper *F. longus* **Late Maastrichtian**	D2	LAD of *Proteacidites reticuloconcavus* ms associated with *Gambierina rudata* 7% ≈ *Nothofagidites* spp. 8%
Cuttings*	2625	Upper *F. longus* **Late Maastrichtian**	D2	Several Cretaceous species including *Battenipollis sectilis*; with *Gambierina rudata* 10% ≈ *Nothofagidites* spp. 11%
Cuttings	2697	Lower *F. longus* **Early-mid Maastrichtian**	D4	Change in composition of assemblage where *Nothofagidites* spp. 14% > *Gambierina rudata* 6%
Cuttings*	2751	Lower *F. longus* **Early-mid Maastrichtian**	D4	Assemblage dominated by *Stereisporites* spp. >35%; with *Nothofagidites* spp. 5% > *Gambierina rudata* <2%
Cuttings	2799	Lower *F. longus* **Early-mid Maastrichtian**	D2	*Forcipites longus* and *Tricolporites lilliei* both recorded; with *Gambierina rudata* 5% & *Nothofagidites* spp. 2% both low.
Cuttings	2805	Lower *F. longus* **Early-mid Maastrichtian**	D2	FAD of *Forcipites longus* in assemblage where *Nothofagidites* spp. 18% >> *Gambierina rudata* 0.6%
Cuttings*	2850	Lower *F. longus* **Early-mid Maastrichtian**	D5	Assemblage badly caved possibly masking older *N. senectus* Zone age
SWC 6	2899.93	*N. senectus* Zone or younger	B3	Contaminated? assemblage containing <50 palynomorphs, with *Nothofagidites senectus* dominant species
Cuttings*	2928	Indeterminate		Possible highest occurrence of algal cyst *Rimosicysta*
Cuttings	2949	*P. mawsonii* Zone **Turonian**	D4	Highest occurrence of increased abundance of *Dilwynites* pollen which is characteristic of Durroon Formation.
SWC 5	2967.03	*N. senectus* Zone or younger	B3	Contaminated? assemblage containing <100 palynomorphs, with *Nothofagidites senectus* dominant species
Cuttings*	3006	*P. mawsonii* Zone **Turonian**	D4	*Dilwynites* pollen abundant 21%, *Cupressacites* sp. 9%, associated with algae *Rimosicysta* and *Morkallacysta*.
Cuttings	3033	Mixed assemblage of *F. longus*, *N. senectus* and *P. mawsonii* Zones		Cuttings from volcanic interval containing a highly mixed and interpreted caved assemblage.
SWC 1	3099.77	Barren		SWC originally described as a basalt
Cuttings	3104	Caved assemblage from *P. mawsonii* Zone		Cuttings from volcanic interval containing a mixed and interpreted caved assemblage.

*New

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 sample data for Chat-1, Bass Basin.

Sample Type	Depth metres	Lithology	Wt. (grams)
Cuttings	2490		
Cuttings*	2625	Medium grey & brown grey mudstone >60%, off-white fine-medium grained sandstone <40%, trace coal (loose)	15.0
Cuttings	2697		
Cuttings*	2751	Dark grey to black carbonaceous mudstone >70%, medium grey mudstone ~20%, off-white sandstone <10% (loose)	13.1
Cuttings	2799		
Cuttings	2805		
Cuttings*	2850	Medium & light grey mudstone 60%, light grey sandstone 30%, dark grey carbonaceous shale	15.8
SWC 6	2899.93	Sandstone, friable, white, fine-grained, poorly sorted angular quartz, and clay to silt matrix; approx 20% dark grains or biotite mica.	
Cuttings*	2928	Medium grey mudstone 90%, sandstone & carbonaceous shale <10%	14.8
Cuttings	2949		
SWC 5	2967.03	Sandstone, firm, white, fine-grained, poorly sorted with angular quartz and lithic fragments, and argillaceous, calcareous matrix	
Cuttings*	3006	Medium grey mudstone	15.3
Cuttings	3033		
SWC 1	3099.77	Basalt, dark grey-brown, mixture of crushed and hard parts	
Cuttings	3104		
*New		**Average:**	**14.8**

Table 3: Basic assemblage data for Chat-1, Bass Basin.

Sample Type	Depth	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species	No. MP Species
Cuttings	2490	Moderate	High	Fair-Good	36+	
Cuttings*	2625	High	Moderate	Poor	26+	
Cuttings	2697	Moderate	High	Fair-Good	30+	
Cuttings*	2751	High	Moderate	Fair	28+	
Cuttings	2799	Moderate	Moderate	Fair-Good	45+	
Cuttings	2805	High	High	Fair-Good	40+	
Cuttings*	2850	High	Low	Poor-Fair	30+	
SWC 6	2899.93	Very low	Very low	Fair	20+	
Cuttings*	2928	High	Low	Poor	29+	2+
Cuttings	2949	Low	Low	Fair	41+	2+
SWC 5	2967.03	Very Low	Low	Fair	22+	1+
Cuttings*	3006	High	Moderate	Fair	31+	4+
Cuttings	3033	High	High	Fair	33+	7+
SWC 1	3099.77	Very low	Barren			
Cuttings	3104	Moderate	Moderate	Fair	29+	1+
*New				**Averages:**	**31+**	**2+**

Well Name : Chat-1

Operator : Bridge Oil Ltd
Spudded : 15 January 1986
Completed: 06 February 1986
Lat/Long : 40°10' 53.43"S 146°41' 54.95"E
Interval : 2450m - 3125m
Palynomorph Range Chart for Cretaceous
Scale : 1:2400
Sample Interval 2490 to 3104m
Chart date: 06 February 2004
Microscope analysis by Alan D. Partridge

Chat-1

Biostrata Pty Ltd
AUSTRALIA

Attachment to Biostrata Report 2004/02