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INTERPRETATIVE DATA.
Palynological analysis of cuttings samples from Glenaire-1 and Sidetrack, onshore Otway Basin.

by

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Summary

Quantitative palynological analyses have been performed on twenty-six (26) cuttings samples over the composite interval of 1956 to 3701mMD in the Glenaire-1 and ST1 holes. The stratigraphic succession analysed commences in the basal part of the Eumeralla Formation, penetrates a thick Laira Formation and terminates in the Pretty Hill Formation. The spore-pollen succession in descending order comprises the bottom 100 metres of the Lower *Pilosisporites notensis* Zone, overlying at least 850 metres assigned to the Upper *Foraminisporis wonthaggiensis* Zone. Below 2900m the quality of the assemblages declines in response to increasing thermal maturation of the section, characterised by increasing carbonisation of the spore-pollen specimens and a corresponding decline in the preservation, abundance and diversity of the assemblages. This basal section can only be assigned to a composite zone interval representing the broad *F. wonthaggiensis* Zone and Upper part of the *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis* Zone. Relative to other wells in the Penola Trough the Glenaire-1 & ST1 well is interpreted to have penetrated an exceptionally thick Laira Formation which may be partly a facies equivalent of the Katnook Sandstone. Thermal Alteration Index (TAI) values determined through the section analysed range from 2.1 at the top to 3+ at base of the section analysed and indicates that the bottom ~700 metres in the well is probably thermally mature for the generation of liquid hydrocarbons.

Table 1. Stratigraphic and Palynological Summary of Glenaire-1 & ST1.

<table>
<tr><th>AGE</th><th>STRATIGRAPHY</th><th>SPORE-POLLEN ZONES</th><th>DEPTHS (mKB)</th></tr>
<tr><td>Aptian to
latest Barremian</td><td>Eumeralla Formation
~600 to 2025m</td><td>Lower Pilosisporites notensis Zone</td><td>1956 to 2037m</td></tr>
<tr><td>Barremian to
latest Hauterivian</td><td rowspan="2">Laira Formation
2025 to 3507m</td><td>Upper Foraminisporis wonthaggiensis Zone
(Laevigatosporites belfordii Subzone)</td><td>2142 to 2904m
(2307 to 2706m)</td></tr>
<tr><td rowspan="2">Hauterivian
to Valanginian</td><td rowspan="2">undiff. Foraminisporis wonthaggiensis to
Upper Ruffordiaspora australiensis Zones</td><td rowspan="2">3054 to 3651m</td></tr>
<tr><td>Pretty Hill Formation
3507 to 3701mTD</td></tr>
</table>

Introduction

Twenty-six cuttings samples have been analysed for palynology from the Glenaire-1 & ST1 well to investigate the Early Cretaceous succession penetrated in the eastern Penola Trough. The well was drilled by operator Beach Petroleum Ltd in 2006, within permit PEP 160 located in the Victorian portion of the onshore Otway Basin. Twelve of the samples analysed are from the original hole between 1956 and 3054mMD, while the remaining 14 samples are from the sidetrack (ST1) hole between 3135 and 3701mMD. The objective of the study was to provide age subdivision of the succession penetrated using palynology.

Materials and Methods: Selected washed and dried cuttings bags were initially supplied by Bronwyn Camac of Beach Petroleum Ltd and from these ~20 gram sample splits were taken and forwarded by the author to Core Laboratories Australia Pty Ltd in Perth for processing on 13th November 2007. Fourteen of the samples were processed using the industry standard procedure whereby the density separation the organic-matter (kerogen) from any undissolved mineral matter is undertaken using zinc bromide heavy liquid solution prior to any oxidation of the organic matter. For the remaining 12 samples the reverse procedure was requested and the mixed residues of organic and undissolved mineral matter from the initial acid dissolution steps were oxidised **before** the density separation. The latter technique was employed on selected samples to determine if the choice of processing procedures was likely to have an observable effect on the composition of the assemblages recorded. Although minor differences in the quality of the final slides were observed between adjacent samples no systematic bias could be established in the recorded assemblages. The prepared palynological slides were received on 27th November 2007, and the initial results of the microscope analysis were provided in two Provisional Reports issued between 21st December 2007 and 3rd January 2008.

Results: A summary of the palynological zones and stratigraphic units identified in Glenaire-1 & ST1 is provided in Table 1, while the final zones and ages assigned to individual samples, zone confidence ratings, and zone identification criteria for each of the samples are provided in Table 2. Basic sample data comprising the lithologies and weights of samples processed are provided in Table 3, while basic assemblage data comprising the visual organic residues yields, palynomorph concentrations on the slides and palynomorph preservation, and the number of species of spore-pollen and microplankton recorded from individual samples are provided in Table 4. The palynological slides prepared and examined are listed in Table 5.

Overall, an average of 16 grams of the cuttings were processed to give mostly moderate organic yields. Unfortunately, the preservation of the palynomorphs and their concentrations on the slides declined markedly with increasing depth, and this is accompanied by a parallel decline in the overall diversity of the assemblages (Figure 1).

Description of Range Chart: The palynomorphs identified in the two separate holes are combined on a single StrataBugs™ range chart as the samples analysed do not overlap in depth. The species recorded in the samples are displayed proportional to their depth in the well and in terms of their relative abundance (as a percentage). The species recorded are also split into different categories. The terrestrial spore-pollen are divided between spores and gymnosperm pollen, which are plotted in separate panels as percentages of just the spore-pollen count. Individual microplankton species are then plotted in the panel labelled MP, with abundances expressed as a percentage relative to the sum of the combined spore-pollen and microplankton count. The next panel labelled Orts is for the counts on all remaining palynomorph categories in the assemblages, and these are expressed as a percentage of the sum of the total spore-pollen plus all Other palynomorphs counted, excluding the microplankton. Species interpreted as reworked are then plotted in the panel labelled RW. The final data panel provides Thermal Alteration Index (TAI) values according to the empirical scale of Staplin (1969, 1977), based on the colour (or carbonization) of the spore-pollen. Within the panels the species are plotted in order of their youngest occurrences or alternatively in alphabetical order. Extra panels on the left-hand side of the chart provide the interpreted age, stratigraphy, and zones identified, as well as the electric logs and a percentage summary of the principal lithologies

The following codes or abbreviations apply to the individual species occurrences and abundances on the range chart:

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

Author citations for most of the recorded spore-pollen species can be sourced from the papers by Backhouse (1988), Dettmann (1963, 1986) and Helby *et al.* (1987), while the author citations for the microplankton species can be sourced from the index of miscellaneous organic-walled microplankton prepared by Fensome *et al.* (1990). Manuscript species names and combinations are indicated by "sp. nov." or "comb. nov." on the range chart.

Geological Discussion.

The stratigraphic section analysed in Glenaire-1 & ST1 consists of 1745 metres of Early Cretaceous sediments between 1956 and 3701mMDKB which belong to the Otway Supergroup and Crayfish Group. Based on the TAI (Thermal Alteration Index) or colour of the un-oxidised spore-pollen in the palynological assemblages these Cretaceous sediments range from **transitional to mature** at the top of the section to thermally **mature** at the base of the section according to the "hydrocarbon metamorphic facies" scale of Staplin (1977; text-fig.10). The TAI values assigned to the samples are plotted on Figure 1, while their correlation against other maturation criteria is summarised in Figures 2 and 3. Consequent upon this increasing thermal maturity the preservation of the palynomorphs declines with depth and the assemblages over the bottom 800 metres in the well cannot be confidently assigned to a single spore-pollen zone, although there is sufficient evidence to say the well is unlikely to have penetrated sediments any older than Early Cretaceous.

Figure 1 also plots the decline, with increasing depth, in both the concentration of the palynomorphs on the palynological slides and the number of species recorded in the samples. In the Glenaire-1 hole above 3100m the palynological slides contain an average of 200 specimens per cm^2 (range 57 to 580 specimens per cm^2). In contrast, in the samples from the Glenaire-ST1 hole below 3100m the palynological slides average only 7 specimens per cm^2 (range <1 to 22 specimens per cm^2). This change in concentration of palynomorphs on the slides is reflected in the decline in the diversity from an average of 38 species per sample in the Glenaire-1 hole to an average of only 11 species per sample in the ST1 hole. The numbers of indeterminate palynomorph specimens recorded are also higher in the original hole relative to the sidetrack hole, but when expressed as a percentage of the total count, the relative abundance of indeterminate specimens increases markedly in the thermally mature samples from the ST1 hole (eg. Orts column on the accompanying StrataBugs™ chart). Although all palynological slides prepared from the samples in the sidetrack hole were scanned the lower concentration of specimens in the deeper samples has meant that the rarer zone index species were not consistently found and therefore confident age dating of this deeper section has not been achieved.

The palynological succession analysed commences with a 80 to 150 metre thick section of Aptian (to possibly latest Barremian) age belonging to the Lower *Pilosisporites notensis* Zone, overlying a minimum 850 metre thick section of the Upper *Foraminisporis wonthaggiensis* Zone of Hauterivian to latest Barremian age. The bottom 850 metres penetrated, including all of the ST1 hole can only be assigned to the composite zone interval representing the broad undifferentiated *Foraminisporis wonthaggiensis* Zone and Upper *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis* Zone.

According to the latest stratigraphic summary by Morton & Drexel (1995; fig 5.2) the Lower *P. notensis* Zone does not extend below the base of the Eumeralla Formation, or the base of the Windermere Sandstone Member. Applying this criterion to the palynological results and gamma ray log character in Glenaire-1 the best pick for the base of the Eumeralla Formation would either be at 2025m or slightly shallower at 1975m. The choice hinges on a subjective judgement about the sample at 2037m, which lies below both picks, and is badly contaminated by down-hole cavings from the Eumeralla Formation. Based on the prominence of the younger zone species *Pilosisporites notensis* in this sample the author favours the deeper pick for the base of the Eumeralla Formation.

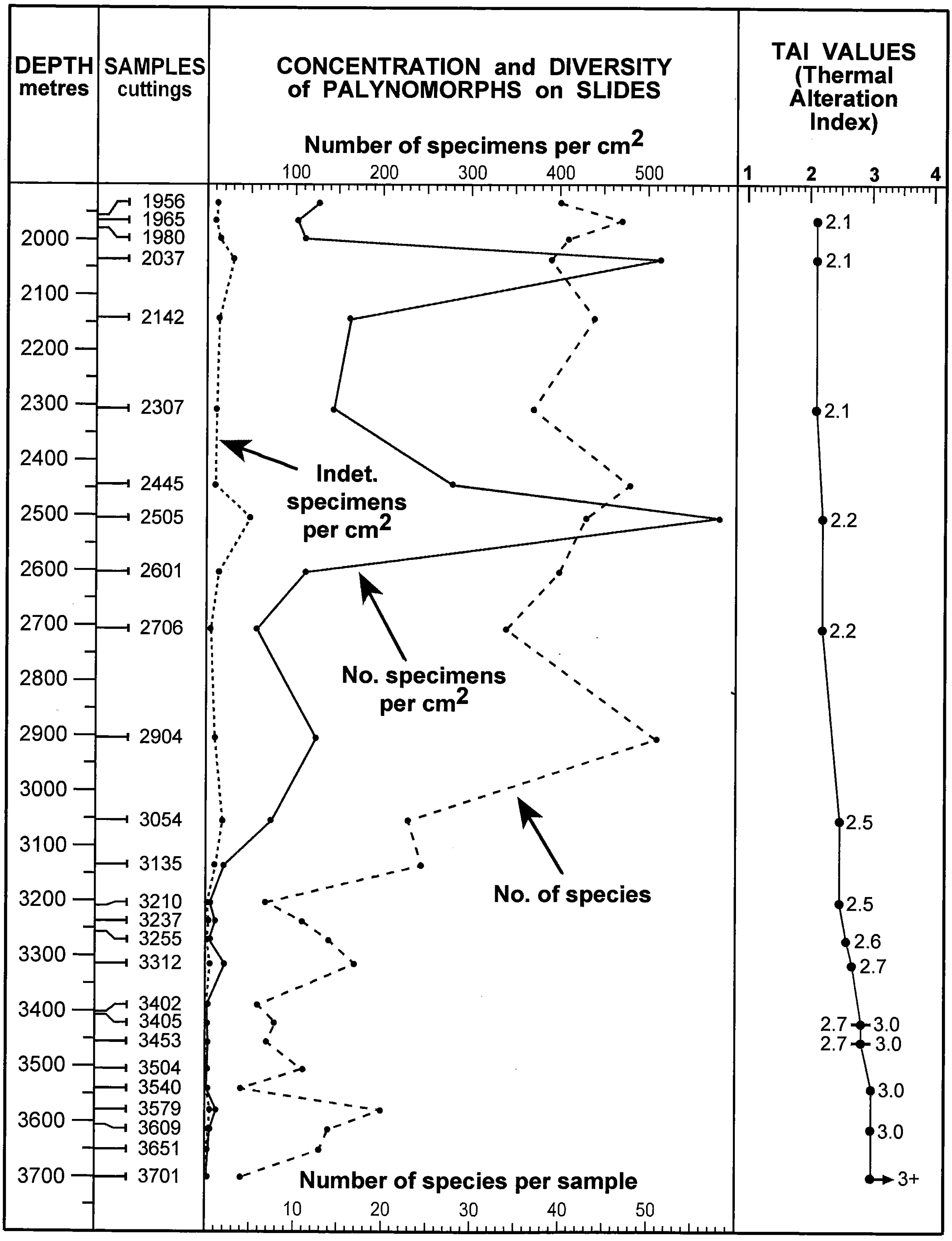

Figure 1. Graphical representation of palynomorph distribution in samples plotted against depth.

The older *F. wonthaggiensis* and Upper *R. australiensis* Zones are in turn representative of the Crayfish Group following established correlation of the spore-pollen zones to the lithostratigraphy in Morton & Drexel (1995; fig 5.2). The section in the Glenaire-1 & ST1 well representing these zones consists of a 1482 metres thick shaly succession between 2025 and 3507m, overlying a 194 metre thick interbedded sand and shale section between 3507 and 3701mTD. Based on the gamma ray log character and lithological description of the cuttings these two units are best correlated with the Laira and Pretty Hill formations within the Crayfish Group. What is exceptional about this interpretation is that the Laira Formation is 65% thicker than the previously recorded maximum thickness of 888 metres drilled in the Katnook-3 well, and that no section equivalent to the Katnook Sandstone has been penetrated in Glenaire-1 & ST1. And based on the lithologies described in the cuttings descriptions there is also no evidence of the thin Windermere Sandstone Member which occurs at the base of the Eumeralla Formation.

The above aspects of the palynological assemblages impinge on broader questions about the Early Cretaceous succession in Penola Trough concerning the nature of the "Crayfish Unconformity" and how this is expressed in the palynological succession. According to Kopsen & Scholefield (1990; p.266) a major erosional unconformity occurs at the top of their Crayfish Group and they suggest that over 2500 metres of section has been stripped from the group prior to the deposition of the overlying Eumeralla Formation. Such a large amount of erosion ought to represent a significant time interval to account for both the deposition of the missing sediments and their subsequent removal. Unfortunately, there has been no clear understanding of how this missing section is expressed in the palynological succession other than to acknowledge that it appears to lie at the boundary between the Upper *F. wonthaggiensis* and Lower *P. notensis* zones.

The palynological results from the Glenaire-1 & ST1 well potentially makes a new contribution to understanding this missing section, based on the following observations:

1. The confirmed 762 metres of Upper *F. wonthaggiensis* Zone penetrated in Glenaire-1 & ST1 (to probably more than 880 metres if the zone is extended to top of Laira Formation at 2025m) is significantly greater than found in other nearby wells in the Penola Trough. The total thickness could even be greater if part of the Laira Formation within the Glenaire-ST1 hole belongs to this zone. Unfortunately, the mature maturation of the deeper part of the well precludes the confident identification of the upper subzone below 2904m.
2. The recognition of the new *Laevigatosporites belfordii* Subzone in Glenaire-1 & ST1 based on the LADs (Last Appearance Datums) of several rare but distinctive species may provide a means to further subdivide the Upper *F. wonthaggiensis* Zone, and help evaluate the extend of any missing section in other wells.
3. Within the Glenaire-1 & ST1 succession there is an additional potential subzone between the LAD of *Laevigatosporites belfordii* and the base of the Lower *P. notensis* Zone. This section, which is of the order of 270 metres thick, is only represented by the one good assemblage at 2142m which can potentially be characterised by the presence of the spore *Perotrilites linearis*. (The next shallower sample 2037m, which contains the LAD of *P. linearis* in the well, may also fall in this interval but unfortunately the assemblage is interpreted to be heavily contaminated by down-hole cavings and is assigned to the overlying zone). A similar section to this subzone has previously been recognised in the Megascolides-2 well in the Gippsland Basin where it has a similar thickness (Partridge, 2007).
4. The three shallowest samples, between 1956 and 1980m, can all be characterised by a possible new variety of the spore *Crybelosporites punctatus* which may represent a useful marker species for the base of the Lower *P. notensis* Zone. Unfortunately, this species does not appear to have been recorded in the open file palynological reports from the nearest adjacent wells, so its true potential cannot be fully evaluated.

The identification of both **(A)** an exception thick section the Laira Formation in Glenaire-1 & ST, and **(B)** new characteristics to the palynological assemblages which do not appear to be documented in other nearby wells, suggests that the Glenaire-1 & ST well may have penetrated extra section compared to other wells in the Penola Trough. This interpretation is strongly supported by a review of thickness of the comparable interval in other wells in the Penola Trough in Text-table-1.

	Crankshaft-1	Banyula-1	Laira-1	Katnook-3	Ladbroke Grove-1	Glenaire-1 & ST1
Eumeralla	1078m	1158m	1123m	1262m	1120m	1425m
Windermere	5m	5m	16m	4m		
Katnook	683m*			77m		
Laira	181m	356m	750m	888m*	711m	1482m
Pretty Hill	81m+	439m+	321m+	247m+	740m+	194m+
T.D.	2535m	2789m	3003m	3105m	3422m	3701m

* Thickest known sections prior to drilling Glenaire-1 &ST1

Text-table-1. Thickness of Early Cretaceous formations penetrated in selected wells in the Penola Trough according to Appendix 5.2 in Morton & Drexel (1995), compared to thickness of formations identified in Glenaire-1 & ST1.

The wells included in Text-figure-1 form a northwest to southeast line of section along the axis of the Penola Trough extending to the Glenaire-1 & ST1 well in the southeast. The five wells selected for comparison are representative of all other well in the trough and include the thickest known section of the Katnook Formation in Crankshaft-1, and the previously thickest known section of the Laira Formation in Katnook-3. The striking feature of the five comparison wells is that the Katnook and Laira formations has an average combined thickness of 729 metres, which is less that half the 1482 metres thickness of the Laira Formation in the Glenaire-1 & ST1 well. Assuming that the base of the Eumeralla Formation and top of the Pretty Hill Formations represent approximate timelines there are three issues or questions that require further investigation. These are:

1. Does the greater thickness of the Laira Formation in Glenaire-1 & ST1 represent extra section not represented in the other five well?
2. Alternatively, is the greater thickness of the Laira Formation a consequence of a doubling of the depositional rate?
3. Is the Katnook Formation everywhere younger than the Laira Formation, or does the former represent a facies time-equivalent to the latter?

Unfortunately, a brief review of the available palynological reports from other wells in the Penola Trough has not been able to resolve these questions, as the potential new palynological subdivisions within the Laira Formation documented in Glenaire-1 & ST1 cannot be identified in any other well. As a consequence, neither question one nor three can be answered by the available palynology. In contrast, it is noted that the Eumeralla Formation in the Glenaire-1 hole is 25% thicker than the average thickness of this formation in the other five wells in Text-figure-1. This suggests that the Glenaire-1 & ST1 well is situated where there was greater accommodation in the Penola Trough during the Early Cretaceous, which resulted in the accumulation of a thicker section. It would therefore seem that at least part of the reason for a thicker Laira Formation in Glenaire-1 & ST1 could be due to higher depositional rates.

Kerogen Maturation

The potential of sedimentary successions to generate liquid hydrocarbons relates to their thermal maturity, which can be determined from the colour (= level of carbonization) of dispersed organic matter (= kerogen) recovered in palynological preparations. Various empirical scales have been proposed for this change in the colour of palynomorphs and other microfossils, but the one used herein is the original organic metamorphism scale of Staplin (1969, 1977) based on the changes in colour of the exinite of spores and pollen. This scheme is neither better nor worse than the alternative colour scales applied to spore-pollen, but rather has been chosen because the author holds reference palynological slides which have been calibrated to the original "colour standards" developed at Imperial Oil Ltd by Frank Staplin and his co-workers (Figure 2). Calibration of the TAI (Thermal Maturation Index) values to other maturation scales is displayed on Figure 3.

The TAI values determined from the non-oxidised kerogen slides in Glenaire-1 & ST1 are tabulated below. The samples between 1965 and 3210m have TAI values of 2.1 to 2.5, which would place them in the transition zone between the **Immature** and **Mature** organic facies. In contrast, the deeper samples between 3255 and 3701m have an overall TAI range of 2.6 to 3.0+ which would place them in the **Mature** organic facies. These results suggest the shaly bottom 500 metres in Glenaire-ST1 has sufficient maturation to be generating liquid hydrocarbons.

Hole	Sample Type	Depth metres	TAI values
Glenaire-1	Cuttings	1965m	2.1
Glenaire-1	Cuttings	2037m	2.1
Glenaire-1	Cuttings	2307m	2.1
Glenaire-1	Cuttings	2505m	2.2
Glenaire-1	Cuttings	2706m	2.2
Glenaire-1	Cuttings	3054m	2.5
Glenaire-ST1	Cuttings	3210m	2.5
Glenaire-ST1	Cuttings	3255m	2.6
Glenaire-ST1	Cuttings	3312m	2.7
Glenaire-ST1	Cuttings	3405m	2.7 to 3.0
Glenaire-ST1	Cuttings	3453m	2.7 to 3.0
Glenaire-ST1	Cuttings	3540m	3.0
Glenaire-ST1	Cuttings	3609m	3.0
Glenaire-ST1	Cuttings	3701m	3.0+

Text-table-2. Thermal Maturation Index (TAI) values in Glenaire-1 & ST1.

TAI number	Thermal Alteration	Colour of Organic Matter	Associated Reservoired Hydrocarbons
1.0	None	Fresh, yellow-green	Oil and/or Gas
2.0	Slight	Brownish-yellow or orange	Oil and/or Gas
3.0	Moderate	Brown	Oil and/or Gas
4.0	Strong	Brownish-black	Dry Gas
5.0*	Severe	Black	Barren

* Determination of highest rank requires additional petrographic evidence of metamorphism.

Figure 2. Original scale proposed in Staplin (1969) associating colour of spore-pollen exinite, expressed as Thermal Alteration Index number with observed reservoired hydrocarbons.

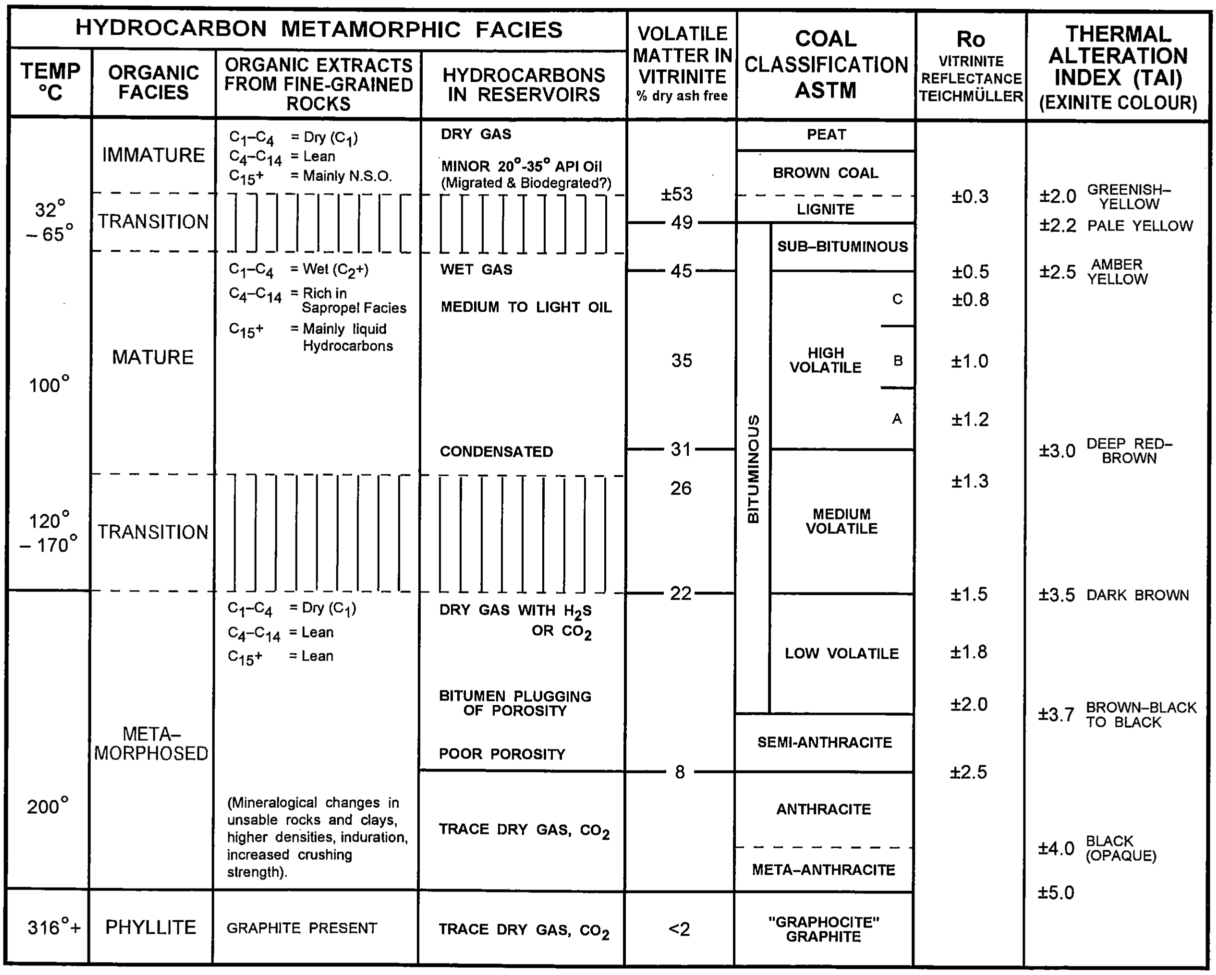

Figure 3. Comparison of Hydrocarbon Metamorphic Facies, with calibrations of coal rank, and Vitrinite Reflectance and the kerogen Thermal Alteration Index, adapted from Staplin (1977).

Biostratigraphy.

The samples analysed in Glenaire-1 & ST1 are classified according to the spore-pollen zonation scheme which was original developed by Dettmann & Playford (1969) and subsequently modified by Helby *et al.* (1987) and Morgan *et al.* (1995). A recently published comparison of the different terminology used by these authors can be found in the contribution by Partridge & Dettmann (2003) to the latest edition of the *Geology of Victoria.*

Lower *Pilosisporites notensis* spore-pollen Zone of Morgan *et al.* (1995)
(= *Cyclosporites hughesii* Zone of Helby *et al.*, 1987)
Cuttings interval: 1956 to 2037 metres
Age: Early Aptian to possibly latest Barremian.

The *P. notensis* Zone was defined by Morgan *et al.* (1995; appendix 6.1) as the interval from the FAD (First Appearance Datum) of *Pilosisporites notensis* to the FAD of *Crybelosporites striatus.* The FAD of *Foraminisporis asymmetricus,* which is the marker for the base of the modified *C. hughesii* Zone of Helby *et al.* (1987; p.35), was considered by Morgan *et al.* (1995; fig.6.1) to occur later than the FAD of *P. notensis,* while the LAD (Last Appearance Datum) of *Cooksonites variabilis* was used to defined the top of the Lower subzone. Within the Glenaire-1 original hole the two principal index species *P. notensis* and *F. asymmetricus* are considered to have concurrent first appearances at 2037m, with the deeper occurrence of both species interpreted to be caved. The interval is no younger than the Lower subzone based on the occurrence of *Cooksonites variabilis* in the shallower sample at 1956m, while the presence of *Pilosisporites parvispinosus* also in this sample suggests a position close to the top of the Lower subzone, assuming of course that the latter species is not caved.

Potential secondary index species within the assemblages consist of the distinctive presence of *Crybelosporites punctatus* in the three samples between 1956 and 1980m and the shallowest occurrence of *Perotrilites linearis* in the deepest sample at 2037m. Both of these species may be potential markers for further subdivision of this zone. Overall, the assemblages are dominated by *Cyathidites* spores (range 47 to 60%, average 54%), and bisaccate gymnosperm pollen lumped together under *Podocarpidites* (range 11 to 19%, average 16%). All other species recorded average less than 5% within these assemblages.

The only organic-walled microplankton recorded in the interval is *Schizosporis reticulatus* which is recorded as less than 1% in the assemblage counts, but is often more conspicuous in the scanned portion of the slides because of its large size and distinctive ornament.

Upper *Foraminisporis wonthaggiensis* spore-pollen Zone
Cuttings interval: 2142 to 2904 metres
Age: Barremian to late Hauterivian.

The parent *F. wonthaggiensis* Zone can traditionally be defined as the interval from the FAD of the eponymous species *Foraminisporis wonthaggiensis* to the FADs of *Pilosisporites notensis* and/or *Foraminisporis asymmetricus* (Helby *et al.*, 1987; Morgan *et al.*, 1995). The zone is subdivided into Upper and Lower subzones by the FAD of *Triporoletes* (al. *Rouseisporites*) *reticulatus* which defines the base of the Upper subzone. In the Glenaire-1 original hole the seven samples between 2142 and 2904m conform to this strict definition of the zone with *F. wonthaggiensis* recorded in all samples and *T. reticulatus* recorded in 5 of the 7 samples. Supporting the zone assignment is the only occurrence recorded in the well of the acritarch *Microfasta evansii* (at 2142m) as this microplankton species is most typically of the broad *F. wonthaggiensis* Zone.

Assemblages from this zone interval continue to be dominated by spores of *Cyathidites* (range 26 to 53%, average 32%), and the bisaccate gymnosperm pollen *Podocarpidites* (range 10 to 25%, average 17%), accompanied by a rise in the abundance of the *Osmundacidites/Baculatisporites* spore plexus (range 22 to 46%, average 35%). All other species recorded average less than 5% within these assemblages. Aside from *Microfasta evansii* Morgan 1975 the only organic-walled microplankton recorded in the zone interval is *Schizosporis reticulatus* which is recorded as less than 1% in the assemblage counts. The latter species is however often more conspicuous in the scanned portion of the slides because of its large size and distinctive ornament.

Within the assemblages the occurrence of several distinctive secondary index species enables the recognition of the following new subzone which has the potential to provide an additional division within and better correlation of the *F. wonthaggiensis* Zone:

***Laevigatosporites belfordii* spore-pollen Subzone new**
Cuttings interval: 2307 to 2706 metres
Age: Barremian to late Hauterivian.

The top of the *L. belfordii* Subzone is herein defined as the LAD of the monolete spore species *Laevigatosporites belfordii,* while the base of the subzone is tentatively defined as the FAD of this eponymous species and/or the FAD of *Triporoletes reticulatus*. Essentially, the subzone represents an upper disjunct range zone of the eponymous species. In the basins along the Southern Margin it is suggested that the spore *L. belfordii* does not occur in the Lower *F. wonthaggiensis* Zone, and perhaps not in any of the older zones. However, a lower disjunct range for the species is well established in the *Biretisporites eneabbaensis* Zone found through the Parmelia Formation in the Perth Basin (Backhouse, 1988), and through the Barrow Group on the Exmouth Plateau (eg. Partridge, 1996). The upper disjunct range of the species has previously been documented in the Jerboa-1 well in the Eyre Sub-basin (Powis & Partridge, 1980), and recently in the Megascolides-1 well in the Gippsland Basin (Partridge, 2007).

In the Glenaire-1 original hole the spore *Laevigatosporites belfordii* is recorded from all five samples assigned to the subzone. Other species characteristic of the subzone are *Murospora florida* (only at 2445m), *Concavissimisporites variverrucatus* (at 2445m and 2601m), and *Retitriletes watherooensis* (at 2445m, 2505m and 2601m). There are also questionable identification of the species *Aequitriradites hispidus* (at 2700m) and *Crybelosporites stylosus* (at 2445 and 2601m) from the subzone which may be significant.

***Foraminisporis wonthaggiensis* to Upper *Ruffordiaspora australiensis* spore-pollen Zones**
Cuttings interval: 3054 to 3651 metres, and probably extending to TD at 3701 metres.
Age: Valanginian to Hauterivian.

The deepest sample from the original Glenaire-1 hole and all fourteen samples from the sidetrack hole unfortunately only yielded low to moderate diversity assemblages which can only be assigned with very low confidence to a composite zone interval representing the undifferentiated broad *F. wonthaggiensis* Zone and the older Upper *R. australiensis* Zone. The most significant zone species in these assemblages are *Cyclosporites hughesii* which was recorded in 5 of the 15 samples, and *Dictyotosporites speciosus* which is only recorded in the two shallowest samples. The two eponymous species *Foraminisporis wonthaggiensis* and *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis* were only recorded as single specimens in the sample at 3579m, and it is highly likely that both could be caved. Other species in the assemblage supportive of a broad Early Cretaceous age are *Aequitriradites spinulosus* (in 5 of the 15 samples) *Ceratosporites equalis* (in 6 of the 15 samples), and *Retitriletes nodosus* (in 5 of the 15 samples). The remainder of the species in the assemblages are not considered diagnostic as they can be equally as common in older rocks. Overall the assemblages are dominated by spores of the *Osmundacidites/Baculatisporites*, *Cyathidites* and

Retitriletes species complexes, and bisaccate gymnosperm pollen lumped together under *Podocarpidites* spp.

According to the most recent synthesis of the Early Cretaceous palynological succession in the Otway Basin by Morgan *et al.* (1995) the FADs of *Cyclosporites hughesii* and *Ruffordiaspora* (al. *Cicatricosisporites*) spp. mark the base of the Upper *R. australiensis* Zone, while the FAD of *Dictyotosporites speciosus* is younger and marks the base of the Lower *F. wonthaggiensis* Zone. In contrast, the FAD of the eponymous species *Foraminisporis wonthaggiensis* is considered to occur slightly above the base of the revised Lower *F. wonthaggiensis* Zone concept of Morgan *et al.* (1995; fig.6.1). It is clear from these defining criteria that these deeper assemblages from Glenaire-1 and ST1 belong to a time interval encompassing both the broad *F. wonthaggiensis* to Upper *R. australiensis* Zones, but unfortunately the assemblages are too poor to be any more precise. For example it would be wrong to place any significance on the FAD of *Dictyotosporites speciosus* at the relatively shallow 3125m as being indicative of the base of the Lower *F. wonthaggiensis* as the absence of this species from the underlying assemblages is most likely a consequence of the extremely poor preservation and low diversity of the assemblages rather than a consequence of any real age difference.

In summary, both the species content and the abundances of species in the deeper assemblages are not markedly different from the composition of the shallower and younger assemblages in the well, and therefore it is reasonable to conclude that there is no gross change in the assemblages from the Glenaire-ST1 hole to suggest that either (1) a much older section has been penetrated, or (2) an otherwise anomalous stratigraphic section has been encountered. Instead, the decline in the quality of the palynological assemblages and the ability to zone and age date those assemblages is interpreted to be directly a consequence of the increasing thermal maturation through the deepest 700 metres penetrated in the well.

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Table 2a. Interpretative data for Glenaire-1, onshore Otway Basin.

Sample Type	Depths	Spore-Pollen Zones STAGE/AGE	CR	Comments and Key Species Present
Cuttings	1956m	Lower *P. notensis* Zone **latest Barremian to Aptian**	D1	LAD of *Cooksonites variabilis* and FAD of *Pilosisporites parvispinosus*
Cuttings	1965m	Lower *P. notensis* Zone **latest Barremian to Aptian**	D1	Index species common, including *Cyclosporites hughesii* and *Foraminisporis asymmetricus.*
Cuttings	1980m	Lower *P. notensis* Zone **latest Barremian to Aptian**	D1	FAD of common *Crybelosporites punctatus*, with index species *P. notensis* and *F. asymmetricus*
Cuttings	2037m	Lower *P. notensis* Zone **latest Barremian to Aptian**	D1	FADs of *P. notensis* and *F. asymmetricus* in association with LAD of *Perotrilites linearis*
Cuttings	2142m	Upper *F. wonthaggiensis* Zone **latest Hauterivian to Barremian**	D4	LAD and only occurrence of microplankton *Microfasta evansii*
Cuttings	2307m	Upper *F. wonthaggiensis* Zone (*L. belfordii* Subzone) **latest Hauterivian to Barremian**	D1	LAD of rare *Laevigatosporites belfordii* associated with younger index species *P. notensis* which is interpreted to be caved.
Cuttings	2445m	Upper *F. wonthaggiensis* Zone (*L. belfordii* Subzone) **latest Hauterivian to Barremian**	D1	LADs of *Murospora florida*, *Concavissimisporites variverrucatus* and *Retitriletes watherooensis* and FAD of *Perotrilites linearis*
Cuttings	2505m	Upper *F. wonthaggiensis* Zone (*L. belfordii* Subzone) **latest Hauterivian to Barremian**	D1	Presence of *Laevigatosporites belfordii* and *Retitriletes watherooensis*
Cuttings	2601m	Upper *F. wonthaggiensis* Zone (*L. belfordii* Subzone) **latest Hauterivian to Barremian**	D1	Presence of *Laevigatosporites belfordii* and *Concavissimisporites variverrucatus*
Cuttings	2706m	Upper *F. wonthaggiensis* Zone (*L. belfordii* Subzone) **latest Hauterivian to Barremian**	D1	LAD and only occurrence of probable *Aequitriradites hispidus* associated with oldest confident in situ *Triporoletes reticulatus.*
Cuttings	2904m	Upper *F. wonthaggiensis* Zone and CAVED *P. notensis* Zone **latest Hauterivian to Barremian**	D5	FAD of *Triporoletes reticulatus* but specimen could possibly be CAVED, as is rare *Pilosisporites notensis.*
Cuttings	3054m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D2	Frequent *Cyclosporites hughesii* associated with rare *Dictyotosporites speciosus* in moderate diversity assemblage.

FAD and LAD = First and Last Appearance Datums

Table 2b. Interpretative data for Glenaire-ST1, onshore Otway Basin.

Sample Type	Depths	Spore-Pollen Zones STAGE/AGE	CR	Comments and Key Species Present
Cuttings	3135m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D2	*Cyclosporites hughesii* and *Dictyotosporites speciosus* present in moderate diversity assemblage.
Cuttings	3210m	Zone indeterminate **undiff. Early Cretaceous**		Very low yield with <50 recorded from single slide recovered.
Cuttings	3237m	Zone indeterminate **undiff. Early Cretaceous**		Low diversity, very poorly preserved assemblage dominated by bisaccate pollen lumped together under *Podocarpidites* spp.
Cuttings	3255m	Zone indeterminate **undiff. Early Cretaceous**		Low fossil yield with <40 identifiable specimens per slide. No zone diagnostic species recorded.
Cuttings	3312m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D2	*Cyclosporites hughesii* present in low diversity, very poorly preserved assemblage dominated by *Osmundacidites wellmanii.*
Cuttings	3402m	Zone indeterminate **undiff. Early Cretaceous**		Very low fossil yield with <10 identifiable specimens per slide.
Cuttings	3405m	Zone indeterminate **undiff. Early Cretaceous**		Very low fossil yield with <20 identifiable specimens per slide.
Cuttings	3453m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D5	*Cyclosporites hughesii* present in very low fossil yield with <30 identifiable palynomorphs per slide.
Cuttings	3504m	Zone indeterminate **undiff. Early Cretaceous**		Very low fossil yield with <20 identifiable specimens per slide.
Cuttings	3540m	Essentially BARREN		Less than 20 specimens found on 3 slides scanned & counted.
Cuttings	3579m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D5	FADs of spores *Foraminisporis wonthaggiensis* and *Ruffordiaspora australiensis* in well but single specimens recorded could be CAVED.
Cuttings	3609m	Zone indeterminate **undiff. Early Cretaceous**		Very low yield of very poorly preserved palynomorphs without any index species.
Cuttings	3651m	undiff. *F. wonthaggiensis* to Upper *R. australiensis* Zones **Valanginian to Hauterivian**	D5	FAD of *Cyclosporites hughesii* in very low fossil yield with <30 identifiable specimens per slide.
Cuttings	3701m	Essentially BARREN		Less than 10 specimens found on 2 slides scanned & counted.

CR = Confidence Ratings used in STRATDAT database and applied to Table 2.

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.

Table 3. Basic sample data for Glenaire-1 & ST1-2, onshore Otway Basin.

Sample Type	Depth metres	Lithology (abbreviated from well-site cuttings descriptions)	Wt grams
Cuttings	1956	100% silty claystone, trace coal	16.3
Cuttings	1965	90% silty claystone, 10% sandstone, trace coal	16.4
Cuttings	1980	90% silty claystone, 10% sandstone	16.8
Cuttings	2037	90% silty claystone, 10% sandstone	15.6
Cuttings	2142	100% silty claystone	15.3
Cuttings	2307	90% silty claystone, 10% sandstone	15.9
Cuttings	2445	100% silty claystone	15.8
Cuttings	2505	100% silty claystone	17.1
Cuttings	2601	100% silty claystone	15.5
Cuttings	2706	100% silty claystone	15.4
Cuttings	2904	100% silty claystone	15.6
Cuttings	3054	100% silty claystone	15.4
Cuttings†	3135	100% silty claystone	15.2
Cuttings†	3210	>70% coarse quartz sandstone, <30% silty claystone	15.6
Cuttings†	3237	60% silty claystone, 10% sandstone, 30% coal	15.2
Cuttings†	3255	100% silty claystone	15.9
Cuttings†	3312	100% silty claystone	15.4
Cuttings†	3402	70% silty claystone, 10% sandstone, 20% coal	15.2
Cuttings†	3405	80% silty claystone, 10% sandstone, 10% coal	16.1
Cuttings†	3453	90% silty claystone, 10% sandstone	15.9
Cuttings†	3504	100% silty claystone	15.2
Cuttings†	3540	90% silty claystone, 10% sandstone	15.4
Cuttings†	3579	90% silty claystone, 10% sandstone	15.3
Cuttings†	3609	80% silty claystone, 20% sandstone	15.0
Cuttings†	3651	100% silty claystone	15.6
Cuttings†	3701	90% silty claystone, 10% sandstone	16.7
		Average:	**15.7**

† = Cuttings from sidetrack ST1 hole

Wt = Weight of sample processed in grams.

Table 4. Basic assemblage data for Glenaire-1 & ST1-2, onshore Otway Basin.

Sample Type	Depth metres	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species	No. MP Species
Cuttings	1956	Moderate-High	High	Poor-Fair	39+	1
Cuttings	1965	High	Moderate-High	Poor-Fair	46+	1
Cuttings	1980	High	High	Fair	40+	1
Cuttings	2037	High	High	Poor-Fair	38+	1
Cuttings	2142	Moderate	High	Poor	42+	2
Cuttings	2307	Moderate-High	High-Low	Fair	37+	1
Cuttings	2445	High	High	Poor-Fair	46+	2
Cuttings	2505	High	Moderate-High	Poor-Fair	42+	1
Cuttings	2601	Moderate-High	Moderate	Poor	39+	1
Cuttings	2706	Moderate-High	Moderate	Poor-Fair	34+	NR
Cuttings	2904	Moderate-High	Moderate	Poor-Very poor	40+	1
Cuttings	3054	Moderate	Moderate	Very Poor	23+	NR
Cuttings†	3135	Moderate-Low	Low	Very Poor	24+	NR
Cuttings†	3210	Very Low	Very Low	Poor	7+	NR
Cuttings†	3237	Moderate	Moderate	Very Poor	11+	NR
Cuttings†	3255	Moderate	Low	Very Poor	14+	NR
Cuttings†	3312	Moderate	Moderate	Very Poor	17+	NR
Cuttings†	3402	Moderate	Negligible	Very Poor	6+	NR
Cuttings†	3405	Moderate	Very Low	Very Poor	8+	NR
Cuttings†	3453	Moderate	Very Low	Very Poor	7+	NR
Cuttings†	3504	Low	Very Low	Very Poor	11+	NR
Cuttings†	3540	Low	Negligible	Poor	4+	NR
Cuttings†	3579	Moderate	Moderate	Poor-Very poor	20+	NR
Cuttings†	3609	Moderate	Low	Very Poor	14+	NR
Cuttings†	3651	Low-Moderate	Very Low	Very Poor	13+	NR
Cuttings†	3701	Low-Moderate	Negligible	Very Poor	4+	NR
				Average:	**24+**	**<1**

† = Cuttings from sidetrack ST1 hole

NR = Not Recorded

Table 5. Palynological slides from Glenaire-1 & ST-1, onshore Otway Basin.

No.	Sample Type	Depth Metres	Catalogue Number	Core Lab Prep. No.	Description
1	Cuttings	1956m		6675	Oxidised slide 1
2	Cuttings	1956m		6675	Oxidised slide 2
3	Cuttings	1956m		6675	Oxidised slide 3
4	Cuttings	1965m		6661	Kerogen slide 1
5	Cuttings	1965m		6661	Oxidised slide 2
6	Cuttings	1965m		6661	Oxidised slide 3
7	Cuttings	1980m		6676	Oxidised slide 1
8	Cuttings	1980m		6676	Oxidised slide 2
9	Cuttings	1980m		6676	Oxidised slide 3
10	Cuttings	2037m		6662	Kerogen slide 1
11	Cuttings	2037m		6662	Oxidised slide 2
12	Cuttings	2037m		6662	Oxidised slide 3
13	Cuttings	2142m		6677	Oxidised slide 1
14	Cuttings	2142m		6677	Oxidised slide 2
15	Cuttings	2142m		6677	Oxidised slide 3
16	Cuttings	2307m		6663	Kerogen slide 1
17	Cuttings	2307m		6663	Oxidised slide 2
18	Cuttings	2307m		6663	Oxidised slide 3
19	Cuttings	2445m		6678	Oxidised slide 1
20	Cuttings	2445m		6678	Oxidised slide 2
21	Cuttings	2445m		6678	Oxidised slide 3
22	Cuttings	2505m		6664	Kerogen slide 1
23	Cuttings	2505m		6664	Oxidised slide 2
24	Cuttings	2505m		6664	Oxidised slide 3
25	Cuttings	2601m		6679	Oxidised slide 1
26	Cuttings	2601m		6679	Oxidised slide 2
27	Cuttings	2601m		6679	Oxidised slide 3
28	Cuttings	2706m		6665	Kerogen slide 1
29	Cuttings	2706m		6665	Oxidised slide 2
30	Cuttings	2706m		6665	Oxidised slide 3
31	Cuttings	2904m		6680	Oxidised slide 1
32	Cuttings	2904m		6680	Oxidised slide 2
33	Cuttings	2904m		6680	Oxidised slide 3
34	Cuttings	3054m		6666	Kerogen slide 1
35	Cuttings	3054m		6666	Oxidised slide 2
36	Cuttings	3054m		6666	Oxidised slide 3
37	Cuttings†	3135m		6681	Oxidised slide 1
38	Cuttings†	3135m		6681	Oxidised slide 2
39	Cuttings†	3135m		6681	Oxidised slide 3
40	Cuttings†	3210m		6667	Kerogen slide 1

† = Cuttings from sidetrack ST1 hole

Table 5. Palynological slides from Glenaire-1 & ST-1, onshore Otway Basin.

No.	Sample Type	Depth Metres	Catalogue Number	Core Lab Prep. No.	Description
41	Cuttings†	3237m		6682	Oxidised slide 1
42	Cuttings†	3237m		6682	Oxidised slide 2
43	Cuttings†	3237m		6682	Oxidised slide 3
44	Cuttings†	3255m		6668	Kerogen slide 1
45	Cuttings†	3255m		6668	Oxidised slide 2
46	Cuttings†	3255m		6668	Oxidised slide 3
47	Cuttings†	3312m		6669	Kerogen slide 1
48	Cuttings†	3312m		6669	Oxidised slide 2
49	Cuttings†	3312m		6669	Oxidised slide 3
50	Cuttings†	3402m		6683	Oxidised slide 1
51	Cuttings†	3402m		6683	Oxidised slide 2
52	Cuttings†	3402m		6683	Oxidised slide 3
53	Cuttings†	3405m		6670	Kerogen slide 1
54	Cuttings†	3405m		6670	Oxidised slide 2
55	Cuttings†	3405m		6670	Oxidised slide 3
56	Cuttings†	3453m		6671	Kerogen slide 1
57	Cuttings†	3453m		6671	Oxidised slide 2
58	Cuttings†	3453m		6671	Oxidised slide 3
59	Cuttings†	3504m		6684	Oxidised slide 1
60	Cuttings†	3504m		6684	Oxidised slide 2
61	Cuttings†	3504m		6684	Oxidised slide 3
62	Cuttings†	3540m		6672	Kerogen slide 1
63	Cuttings†	3540m		6672	Oxidised slide 2
64	Cuttings†	3540m		6672	Oxidised slide 3
65	Cuttings†	3579m		6685	Oxidised slide 1
66	Cuttings†	3579m		6685	Oxidised slide 2
67	Cuttings†	3579m		6685	Oxidised slide 3
68	Cuttings†	3609m		6673	Kerogen slide 1
69	Cuttings†	3609m		6673	Oxidised slide 2
70	Cuttings†	3609m		6673	Oxidised slide 3
71	Cuttings†	3651m		6686	Oxidised slide 1
72	Cuttings†	3651m		6686	Oxidised slide 2
73	Cuttings†	3651m		6686	Oxidised slide 3
74	Cuttings†	3701m		6674	Kerogen slide 1
75	Cuttings†	3701m		6674	Oxidised slide 2

† = Cuttings from sidetrack ST1 hole

Well Name : Glenaire-1 & ST1

Operator : Beach Petroleum (BPT) Spudded : 08 September 2006
Well Code : GLENAIRE-1ST1 Completed : 04 November 2006
Lat/Long : 37°34' 47.03"S 140°59' 52.25"E
Interval : 1925m - 3725m INTERPRETATIVE Palynological Range Chart
Scale : 1:6000 Sample Interval 1956 to 3701m
Chart date: 28 May 2008 Microscope analysis by Alan D. Partridge

Glenaire-1 & ST1

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Attachment to Biostrata Report 2008/02A