INTERPRETATIVE DATA
Palynological analysis of cuttings samples from Pritchard-1, onshore Otway Basin.

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Summary

Palynological analyses have been performed on twenty-two cuttings samples between 960 and 2541m from the Pritchard-1 exploration well and the final results are summarised in Table 1. The recovered spore-pollen assemblages form an incomplete succession from the uppermost *Phyllocladidites mawsonii* Zone to lowermost *Malvacipollis diversus* Zone representing an age range from possible latest Turonian to Early Eocene. The low diversity and moderately abundant microplankton in the assemblages are even more incomplete with only selected Late Cretaceous and Early Paleogene zones represented in the succession.

Table 1. Palynological and Stratigraphic Summary of Pritchard–1.

Age	Spore-Pollen Zones/Subzones (Microplankton Zones/Subzones)	Depths	Stratigraphic Equivalence
Early Eocene	*Malvacipollis diversus* Zone *Proteacidites grandis* Subzone *Spinizonocolpites prominatus* Subzone (*Apectodinium homomorphum* Zone) (*Apectodinium hyperacanthum* Zone)	960 to 1263m 960 to 1071m 1263m (960 to 1071m) (1263m)	Pember Mudstone
Paleocene	Mixed *M. diversus* and *L. balmei* Zones (*Apectodinium hyperacanthum* Zone)	1305m (1305m)	Pember Mudstone
Late Maastrichtian	Undifferentiated *Forcipites longus* Zone (*Manumiella druggii* Zone)	1326m (1326m)	Massacre Shale
Early Maastrichtian to Late Campanian	Lower *Forcipes longus* Zone (*Isabelidinium pellucidum* Zone)	1348 to 1401m (1348 to 1401m)	Timboon Sandstone
Early Campanian	*Nothofagidites senectus* Zone (*Xenikoon australis* Zone)	1530m (1530m)	Paaratte Formation
Santonian	*Tricolporites apoxyexinus* Zone (*Isabelidinium cretaceum* Zone) (*Isabelidinium rotundatum* Subzone)	1713 to 1986m 1713 to 1986m (1713m)	Mount Salt Formation (= Belfast Unit C to Nullawarre Greensand)
Santonian	*Tricolporites apoxyexinus* Zone (*Isabelidinium cretaceum* Zone)	2025 to 2094m (2025 to 2094m)	Mount Salt Formation (= Belfast Unit C)
Santonian	*Tricolporites apoxyexinus* Zone (*Odontochitina porifera* Zone)	2250m (2250m)	Mount Salt Formation (= Belfast Unit B)
Coniacian	*Phyllocladidites mawsonii* Zone *Clavifera vultuosus* Subzone (*Conosphaeridium striatoconum* Subzone)	2358m 2358m (2358m)	Mount Salt Formation (= Belfast Unit A and Morum Formation)
Coniacian to ?Late Turonian	*Phyllocladidites mawsonii* Zone *Gleicheniidites ancorus* Subzone or younger (*Trithyrodinium* Subzone)	2460 to 2541m 2460 to 2541m (2460 to 2541m)	Mount Salt Formation (= Belfast Unit A and Morum Formation)

Introduction

This palynological study of the onshore Prichard-1 well was undertaken for Essential Petroleum Resources Limited as part of the post-drill analysis for the Well Completion Report. Prichard-1 is located in the north-western portion of the Portland Trough and was drilled during March and April 2006 to a TD of 2543m. The nearest adjacent well is Henke-1 which was drilled in 1987 to the significantly shallower TD of 1435m.

Twenty-two cuttings samples are analysed (plus two samples given repeat preparations which confirmed that one of the original samples was out-of-place) over a 1581m thick interval between 960 and 2541m. The samples were received in two separate batches by the author in April and sent to Core Laboratories Australia Pty Ltd for chemical processing. Palynological slides were returned on 26th April and 11th May 2006. Initial results of the microscope analysis of the samples were provided in four Provisional Reports issued between 1st and 23rd May.

Final interpretative results of the palynological analysis of the individual samples are provided in Table 2. Basic sample and palynological assemblage data is provided in Table 3. An average of 15 grams from each sample was processed to give mainly moderate to high organic residue yields, which contained mostly moderate to high concentrations of palynomorphs. Preservation of the palynomorphs was generally poor to very poor, and only occasionally fair. Spore-pollen diversity was moderate to high averaging 38+ species per sample while microplankton diversity ranged from low to moderate with one to fourteen species per sample (average 7+ species per sample).

The distribution of the palynomorphs identified in the samples are displayed on the accompanying StrataBugs™ range chart. The palynomorphs are displayed proportional to their depth in the well and in terms of their relative abundance (as a percentage). They are also split between different categories. The terrestrial spores and pollen are divided between spores, gymnosperm pollen and angiosperm pollen, which are plotted in separate panels. The next panel labelled Neves Effect represents the percentage sum of all species of the gymnosperm pollen genera *Araucariacites* and *Dilwynites* in the spore-pollen count. The following panel shows the abundance of marine microplankton (mainly dinocysts) and the colonial algae *Amosopollis cruciformis* as a percentage relative to the combined spore-pollen and microplankton counts. Next the percentage abundance of individual species in the microplankton count are displayed in the panel labelled Microplankton. Then plotted are Other palynomorphs, with abundances expressed as a percentage of the sum of the total Spore-Pollen plus Other palynomorphs counted. The final panel labelled Reworking records those palynomorphs considered reworked from Permian, Triassic and Early Cretaceous strata. The species are plotted within the panels according to their shallowest or youngest occurrences, or in alphabetical order. 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.

Author citations for the recorded spore-pollen species can be sourced from papers by Dettmann (1963), Dettmann & Playford (1968), Helby *et al.* (1987) and 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.

Geological Discussion

The suite of cuttings samples analysed from Pritchard-1 extend approximately from the middle of the Sherbrook Group to the middle of the Wangerrip Group. The formations identified in these two groups, based on recorded lithologies and electric log character, and their relationship to the spore-pollen and microplankton zones identified in the samples is discussed below in descending order:

Pember Formation (935 to 1315 metres): Six samples were analysed from this formation, with the shallower five between 960 and 1263m containing good Lower *M. diversus* Zone assemblages, whereas the deepest sample at 1305m contains a problematic assemblage which could represent either the Lower *M. diversus* Zone or older *L. balmei* Zone. It is noteworthy however that the occurrence of the *Apectodinium hyperacanthum* microplankton Zone in association with the *Spinizonocolpites prominatus* spore-pollen Subzone is recorded from the next shallowest sample at 1235m. These last two zones are diagnostic of the Rivernook Member which is identified within the Pember Mudstone in the Port Campbell Embayment (Abele *et al.*, 1976; p.206). The Rivernook Member also divides the Pember Mudstone into a "lower" Paleocene (Upper *L. balmei* Zone) portion, and a "upper" Early Eocene (Lower *M. diversus* Zone) portion. It is therefore suggested that the sharp log break on both the gamma ray and sonic logs at 1269m in Pritchard-1 could approximate this upper/lower boundary of the formation in the Port Campbell Embayment, as well as the Paleocene/Eocene boundary. At the top of the Pember Mudstone there are currently no identified palynological criteria that can be used to distinguish the Pember from the overlying undifferentiated Dilwyn Formation. Unfortunately, the cuttings samples analysed in Pritchard-1 provide no additional information on this last problem.

Pebble Point Formation (1315 to ?1322 metres): Less than ten metres of this formation is believed to be present in Pritchard-1. The formation is identified by a sharp break to higher velocities on the sonic log opposite a shaly signature on the gamma ray log which is indistinguishable from the overlying Pember Mudstone. No palynological samples were analysed from this interval, but some of the palynomorphs recorded in the deeper sample at 1326m are compatible with having come from Pebble Point microfloras and could easily have been derived from the formation.

Massacre Shale (?1322 to 1333 metres): The thin shale on the gamma ray log sandwiched between two higher velocity spikes on the sonic log is confirmed to be the Massacre Shale based on the occurrence of dinocysts diagnostic of the *Manumiella druggii* Zone in the cuttings at 1326m. The Massacre Shale was identified by Partridge (2001) as a thin but widespread transgressive event within the Otway Basin which straddles the Cretaceous/Tertiary boundary. The mixed assemblage obtained from the cuttings sample suggests that both latest Maastrichtian and basal Danian portions of the formation may be present in Pritchard-1.

Timboon Sandstone (1333 to 1495 metres): This interval, down to the next most obvious electric log break at 1495m, is predominantly sandstone on gamma log (>60%), and is assigned to the Timboon Sandstone based on the identification of the Lower *F. longus* and *I. pellucidum* Zones in the three cuttings between 1348 and 1401m. These palynological results are somewhat atypical in that the *T. lilliei* Zone was not recorded (although it may be present in the unsampled interval from 1401 to 1495m), and that the dinocyst *Isabelidinium pellucidum* was recorded as ranging to near the top of the formation. This stratigraphic range for the latter dinocyst in Pritchard-1 suggests there may be section missing at the top of the formation (refer to position of zone on Figure 1).

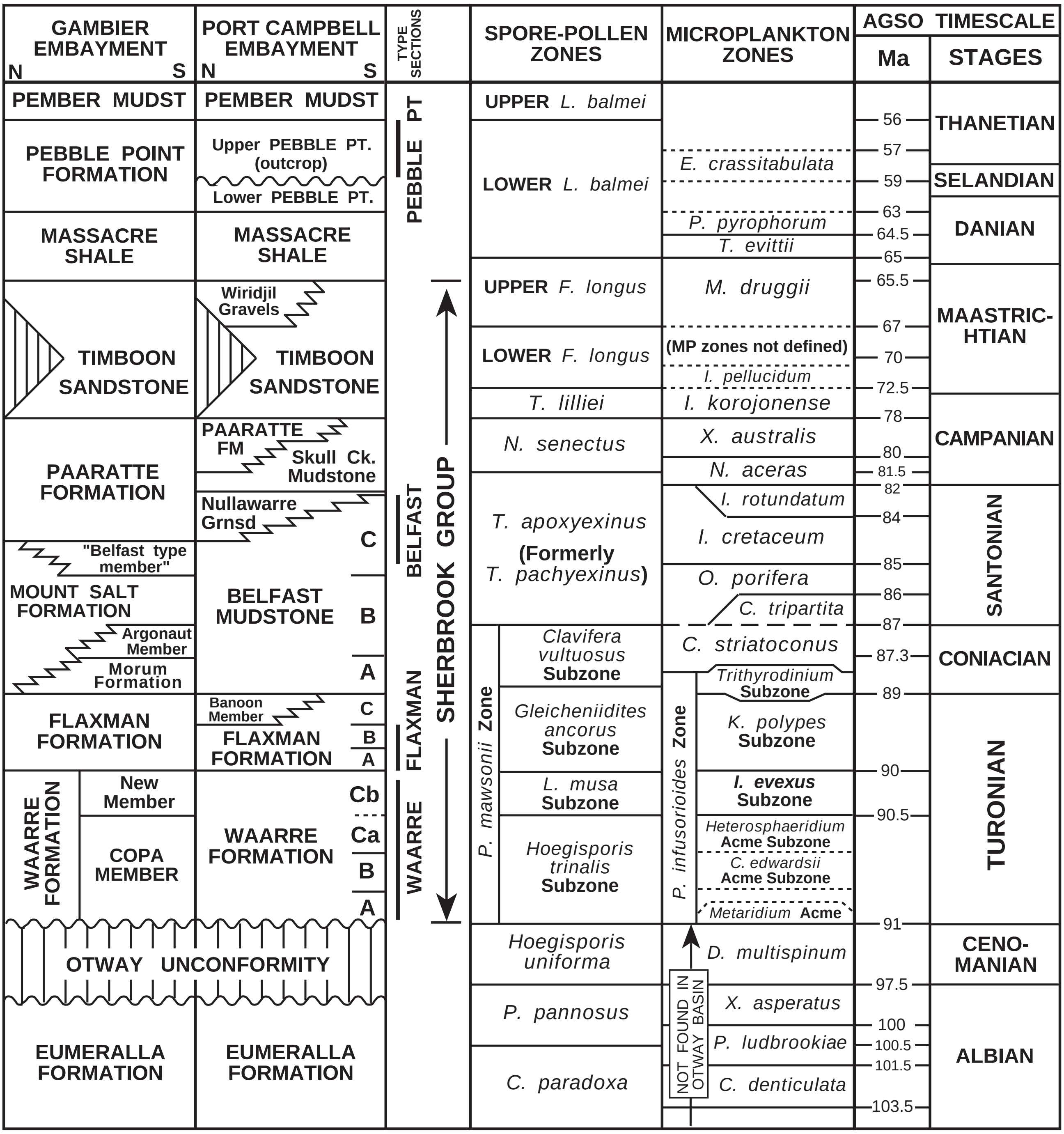

Figure 1. Revised stratigraphy, palynological zonation and ages for Sherbrook Group originally proposed by Partridge (2001) with suggested correlations to international stages and the AGSO chronometric time scale (Young & Laurie, 1996). The *Trithyrodinium*, *Heterosphaeridium* Acme and *Metaridium* Acme subzones are new additions to the microplankton succession.

Paaratte Formation (1495 to 1709 metres): The restricted usage of this formation name advocated by Partridge (2001) is as a time-rock unit essentially equivalent to the *N. senectus* spore-pollen Zone and *N. aceras* to *X. australis* microplankton Zones, although it may possibly extend into the very uppermost *T. apoxyexinus* Zone and *I. rotundatum* Subzone (see Figure 1). In Pritchard-1, the section which would be best equivalent is the thinly interbedded and mostly shaly interval between 1495 and 1709m. The only sample analysed from this interval at 1530m, contains the both the *N. senectus* and *X. australis* Zones thereby confirming the formation assignment. The formation perhaps could be extended deeper through the slightly more sandy, but still thinly interbedded section down to 1871m. Counting against this latter interpretation are the older palynological ages obtained from this deeper section, which is herein referred to Mount Salt Formation.

Mount Salt Formation (1709 to 2510+ metres): In Pritchard-1 the >800 metre thick and mostly sandy section (average 50% sandstone) from 1709m to the base of electric log data at ~2510m, and possibly extending to TD at 2543m is broadly referred to the Mount Salt Formation. This name was originally proposed by Reynolds *et al.* (1966) but subsequently fell in to disuse, and has only recently been revived by Partridge (2001) as a better stratigraphic term to describe the more sandy sections found in the western Otway Basin, that are time equivalent to the classical sections of the Belfast Mudstone in the Port Campbell Embayment. The eleven palynological samples analysed correlate this Mount Salt interval with the uppermost *P. mawsonii* to *T. apoxyexinus* spore-pollen Zones and the *C. striatoconum, O. porifera, I. cretaceum* microplankton Zones and *Trithyrodinium* and *I. rotundatum* Subzones (Figure 1). Suggested age range is Santonian to Coniacian possibly extending into the uppermost Turonian.

The characteristic feature of the electric logs are thick and thin shales with “bottoms” that are sharp and flat and “tops” that gradually coarsening-up into blocky sandstones typically 10 to 20 metres thick. Based on these log characteristics the shales are interpreted to represent cyclical marine flooding events, most likely at a parasequence scale. The two most prominent shale beds at 1992 to 2030m and 2060 to 2100m contain palynological assemblages equivalent to the *I. cretaceum* Zone, and are therefore interpreted to represent marine interbeds or “tongues” equivalent to Unit C of the Belfast Mudstone (Figure 1). Deeper in the well the shale bed at 2310 to 2362m, which contains the important *C. striatoconum* Zone is similarly interpreted to represent a marine “tongue” of the Morum Formation, or the equivalent of Unit A of the Belfast Mudstone. The still deeper shale beds at 2435 to 2471m and possibly 2510 to 2543mTD can also be interpreted as additional marine “tongues” of the Morum Formation. The available palynology data suggest it is unlikely that Pritchard-1 has penetrated any section older than the Morum Formation.

Between the above thicker shale beds are five thin shale beds (with “bottoms” at 2298m, 2280m, 2250m, 2224m and 2199m). Based on the assemblage recovered at 2250m these thin shales probably all belong to the *O. porifera* Zone and are therefore equivalent to Unit B of the Belfast Mudstone. In the eastern Otway Basin the Shipwreck Unconformity or sequence boundary has been shown to lie between the *O. porifera* and overlying *I. cretaceum* Zone in the Minerva field. The equivalent stratigraphic position for this unconformity in Pritchard-1 is within the thick sandstone between 2100 and 2192m. In contrast, from western offshore Otway Basin the distal wedge of the Argonaut Member has been documented to occur at or near the palynological boundary between the *C. striatoconum* and *O. porifera* Zones. In Pritchard-1 it appears likely that equivalent sediments to the Argonaut Member are missing at an unconformity or sequence boundary at about 2300m.

Above the two thick *I. cretaceum* Zone shales there is an overall coarsening up section between 1991 and 1870m, which is in turn overlain by a section comprised of thinly interbedded sands and shales up to 1709m. The palynological data suggests this 182 metre thick interval is broadly equivalent to the Nullawarre Greensand in the Port Campbell Embayment. Although the overall thickness is comparable the electric log character suggests different depositional environments in the two areas.

Palaeoenvironments

All recovered palynomorph assemblages contain at least some marine dinocysts, whereas none display any palynological characteristics considered diagnostic of non-marine environments of deposition (eg. abundant fungal microfossils, and/or assemblages skewed to selected spores). It can therefore reasonably be concluded that the shaly sediments sampled for palynology are mostly, if not entirely, representative of marine depositional environments. In contrast, none of the sandstones were specifically sampled for palynology, so the only thing that can be said about these is that they are interbedded with the marine shales.

The marine microplankton (excluding the colonial algae *Amosopollis cruciformis*) recorded in the assemblages display low to moderate abundances (range <1% to 44%, average 7%) and generally low diversity with a range of 1 to 11 species, and average of 6 species per sample (excluding obvious caved forms). The highest abundance of microplankton was recorded in the sample at 1326m from the Massacre Shale, while the highest diversity assemblage was recorded from the shale between 2060 and 2100m, corresponding to the flooding event at the base of *I. cretaceum* Zone (Table 2). The most abundant microplankton in the Cretaceous section is the colonial algae *Amosopollis cruciformis*, which has an average abundance of 22% (of combined SP + MP count) in the deepest seven samples, while the most abundant microplankton in the Tertiary section are the dinocyst *Apectodinium* spp., and the acanthomorph acritarch *Impletosphaeridium*, recorded in the sample at 1326m. Overall the moderate abundance and diversity of marine microplankton would tend to favour nearshore marine environments of deposition for all of the samples analysed. The only possible caveat to this conclusion is that high depositional rates, caused by high input of terrestrially derived clastic sediments could be diluting both abundance and diversity of the marine microplankton.

Independent of the evidence from the microplankton the occurrence of **Neves effects** in the terrestrially derived spore-pollen assemblages can provide supporting evidence on the depositional environment. Neves effects are defined as the tendency for certain fossil gymnosperm pollen to occur in greater abundance in distal marine environments. In the Australian Late Cretaceous and Cenozoic palynological succession Neves effects have empirically been found to be displayed by the species *Araucariacites australis* and the various species of the genus *Dilwynites*. When the combined abundance of these two pollen types exceeds 20% of the total count of the terrestrial spores and pollen a strong Neves effect is indicated, suggesting a distal offshore environment of deposition in both marine and lacustrine settings. The low to moderate Neves effects recorded in Pritchard-1 of between <2% to 24% (average 9%) would tend to favour a proximal rather than distal environment of deposition.

The notable exception to the above general observations is the high abundances of *Amosopollis cruciformis* recorded over the bottom 450 metres penetrated in Pritchard-1. This species is a colonial algae that is known to occur in non-marine and brackish as well as marine environments. The consistently recorded high abundances of *A. cruciformis* in both proximal and distal offshore environments throughout part of the lower Sherbrook Group, is interpreted to be related to the incomplete connection between the Otway Basin and fully marine open-ocean environments along the Southern Margin rift during the time interval middle Turonian to early Santonian. Unfortunately, this algal species is not considered to be a good indicator for determining proximal versus distal marine depositional environments within the Otway Basin.

Biostratigraphy

The samples analysed in Pritchard-1 are broadly classified according to the Australian standard palynological zonation schemes established by Stover & Partridge (1973) and Helby *et al.* (1987). Additional finer resolution spore-pollen and microplankton zones and subzones are according to Partridge (1999, 2001). A recent summary of these zonation schemes can also be found in the latest edition of the *Geology of Victoria* (Partridge & Dettmann, 2003).

Lower *Malvacipollis diversus* spore-pollen Zone
Interval: 960 to 1263 metres, possibly extending down to 1305 metres
Age: Early Eocene.

The shallowest five samples analysed are confidently assigned to this zone, while a large part of the assemblage recorded from the next deepest sample at 1305m is probably caved from this zone. The assemblages are considered typical of the zone based on the common occurrence of the species *Malvacipollis diversus/subtilis* (average 7%) and *Haloragacidites harrisii* (average 6%). However, somewhat atypically for the Lower *M. diversus* Zone the assemblages are dominated by gymnosperm pollen (range 25 to 53%, average 45%), largely due to moderate Neves effects (average 16%).

Two subzones are recognised within the interval. The older *S. prominatus* Subzone recorded at 1263m is identified by the presence of the eponymous species and putative mangrove pollen *Spinizonocolpites prominatus*, in association with the spore *Crassoretitriletes vanraadshooveni* and angiosperm pollen *Proteacidites pachypolus*. All three species are found together at the base of the parent *M. diversus* Zone and then drop out of the palynological assemblages, only to reappear in the younger Upper *M. diversus* and/or *P. asperopolus* Zones. This short, disjunct initial stratigraphic appearance of these species within the *S. prominatus* Subzone has been documented in all three Bass Strait basins and is correlated with the brief global warming event known as the PETM (Palaeocene-Eocene Thermal Maximum) which occurs just above the Paleocene/Eocene boundary (Gradstein *et al*., 2004; p.402).

The shallower samples belong to the younger *P. grandis* Subzone named after the often frequent to common occurrence of the eponymous species *Proteacidites grandis* in this subzone. In Pritchard-1 this species occurs in 3 of the 4 shallowest samples in but with low abundances of <1%. The subzone is therefore identified by the absence of *S. prominatus* and other indicator species for the older subzone, and the absence of *Proteacidites tuberculiformis* and *Myrtaceidites tenuis* which respectively mark the base of the next younger *P. tuberculiformis* and *M. tenuis* Subzones (and the equivalent Middle and Upper *M. diversus* Zone boundaries). *Integricorpus antipodus* ms found at 1005m is the only index recorded not known to range above the *P. grandis* Subzone. Species with unexpected or unusually early appearances in the assemblages are *Bysmapollis emarciatus* found at 960m, 1005m and 1071m, and *Proteacidites pachypolus* recorded at 960m. The latter species is tentatively interpreted to be caved, but alternatively could have a longer stratigraphic range in the western Otway Basin in response to the known east to west warming climatic gradient along the Southern Margin, that operated during the Paleogene.

***Apectodinium homomorphum* microplankton Zone**
Interval: 960 to 1071 metres, questionable to 1164 metres
Age: Early Eocene.

The *A. homomorphum* Zone in SE Australia was redefined by Partridge (1999) as the interval from the youngest occurrence of *Apectodinium hyperacanthum* to the oldest occurrence of *Homotryblium tasmaniense*. The zone is named after the species most consistently found in the low diversity assemblages that characterise this zone in the three Bass Strait basins. In Pritchard-1 the four shallower samples analysed, which contain low diversities and low abundances of microplankton, are considered to belong to this zone based on the presence of either the eponymous species or *Deflandrea pachyceros*. It needs to be pointed out that these are the "long-spined varieties" of *Apectodinium* that are morphologically closest to the type specimens of *A. homomorphum*, and not the "short-spined varieties" of *Apectodinium* which were the basis of the old *A.* (al. *Wetzeliella*) *homomorphum* Zone of Partridge (1976). The latter morphotypes were re-assigned to the new *Apectodinium reburrus* manuscript species and Acme zone by Partridge (1999).

***Apectodinium hyperacanthum* microplankton Zone**
Sample at: 1263 metres, caving down to 1305 and 1326 metre
Age: Latest Paleocene to Early Eocene.

The *A. hyperacanthum* Zone is defined by the total range of the eponymous species in SE Australia and is always found associated with the lowermost part of the Lower *M. diversus* and uppermost part of the *L. balmei* spore-pollen zones. In Pritchard-1 the zone is confidently identified at 1263m, based on the highest but rare occurrence of the eponymous species. The zone may possibly be represented in the next deepest sample at 1305m where the eponymous species is actually more abundant. However, the similar common occurrence of the eponymous species at 1326m has to represent cavings as that sample is clearly older.

***Lygistepollenites balmei* spore-pollen Zone**
Age: Paleocene.

The highest occurrence of the *L. balmei* Zone is tentatively identified at 1305m based on the very rare occurrence of *Australopollis obscurus* and *Tetracolporites verrucosus* which do not generally range above this zone. However, the assemblage notably lacks the other more typical index species for the zone such as *Lygistepollenites balmei*, *Gambierina rudata* and *Polycolpites langstonii,* and instead contain frequent *Malvacipollis diversus* (5%) and *Haloragacidites harrisii* (7%), which are more typical of the younger Lower *M. diversus* Zone. Because it is possible that the few *L. balmei* Zone index species recorded could be reworked the preferred interpretation of the assemblage from 1305m is that it contains a mixed assemblage from both the *L. balmei* and *M. diversus* Zones.

***Manumiella druggii* microplankton Zone and**
Undifferentiated *Forcipites longus* spore-pollen Zone
Sample at: 1326 metre
Age: Late Maastrichtian

Finding the dinocyst *Manumiella conorata* in the cuttings at 1326m is interpreted to indicate the presence of the *M. druggii* Zone within the shale between 1321 and 1330m on the gamma ray log. The associated record of the distinctive spore *Grapnelispora evansii*, and threads off the megaspore *Ariadnaesporites*, in the assemblage is also taken as evidence for the presence of the top of the *F. longus* Zone and the top of the Cretaceous within this shale, which is therefore correlated with the Massacre Shale of Partridge (2001). The assemblage also contains a significant number of species that are undoubtedly caved from the much younger Lower *M. diversus* Zone. Unfortunately, no index species restricted to the Upper *F. longus* subzone where recorded in this sample.

Lower *Forcipites longus* spore-pollen Zone
Isabelidinium pellucidum microplankton Zone
Interval: 1348 to 1401 metres
Age: Late Campanian to Early Maastrichtian

The three samples analysed from the upper part of the Timboon Sandstone contain assemblages dominated by angiosperm pollen (average 39%), especially *Proteacidites* spp. (average 25%). They are assigned to the Lower *F. longus* Zone based on the joint occurrence of the eponymous species *Forcipites longus* with *Tetracolporites verrucosus* and *Proteacidites reticuloconcavus* ms in the deepest sample at 1401m, and the absence, in this or the two shallower samples, of any evidence of *Forcipites sabulosus* which marks the top of the underlying *T. lilliei* Zone. The latter zone is typically found in the lower part of the Timboon Sandstone and if present in Pritchard-1 would have to lie in the unsampled interval from 1401 to 1495m.

The associated low diversity microplankton assemblages are assigned to the *I. pellucidum* Zone based on the consistent presence of good specimens of *Isabelidinium pellucidum* in all samples. Typically this zone occurs through the lower part of the Timboon (Figure 1) so its occurrence only ~20 metres below the Massacre Shale suggests the possibility of missing section at the top of the Timboon Sandstone.

Nothofagidites senectus spore-pollen Zone
Xenikoon australis microplankton Zone
Sample at: 1530 metres
Age: Early Campanian

The sample is confidently assigned to the *N. senectus* Zone based on the frequent occurrences of *Forcipites sabulosus* (5%) and *Nothofagidites senectus* (4%), and to the *X. australis* Zone based on the infrequent occurrence of the eponymous dinocyst *Xenikoon australis* (<2% of SP + MP count). The commonest categories amongst the moderate to high diversity spore-pollen are *Podocarpidites* spp. (17%) and *Proteacidites* spp. (13%), in an assemblage which notably lacks any single dominant species. In contrast, the associated microplankton are represented by an essentially monotypic assemblage of the eponymous species.

Tricolporites apoxyexinus spore-pollen Zone
Interval: 1713 to 2250 metres
Age: Santonian

The *T. apoxyexinus* Zone is strictly defined as the interval from the FADs of *Tricolporites apoxyexinus* and/or *Ornamentifera sentosa* to the FAD of *Nothofagidites senectus* (Helby *et al*. 1987). Unfortunately, these principal index species can be very rare and inconsistent and therefore identification of the zone often relies on the oldest occurrences of weaker secondary index species like *Latrobosporites amplus* and *L. ohaiensis*. In the six samples (and one repeat sample) between 1713 and 2250m the two principal index species only occur in the shallowest two samples, while the secondary index species *Latrobosporites amplus* occurs in these and the deepest sample at 2250m. However, the latter species also occurs deeper again at 2358m, while *Latrobosporites ohaiensis* is recorded still deeper in the repeat preparation at 2520mB. As a consequence of the rarity of the index species the confidence in the zone identification is low.

Overall the assemblages are dominated by gymnosperm pollen (average 54%), with secondary spores (average 43%) and minor angiosperm pollen (average ~3%). Amongst the last *Proteacidites* pollen is frequent (average 1.4%) between 2025 to 2250m, but becomes common (average 5.5%) between 1713 and 1986m providing a weak Lower/Upper subdivision of the *T. apoxyexinus* Zone.

***Isabelidinium cretaceum* microplankton Zone**
Interval: 1713 to 2094 metres
Age: Santonian

The five samples in the interval contain microplankton assemblages which are of low abundance (average ~10%) and low diversity (average <10 species per sample), but can be assigned to the *I. cretaceum* Zone based on the sporadic occurrence of the eponymous species at 1813m 1986m and 2094m, and the additional presence of the eponymous species for the *Isabelidinium rotundatum* Subzone in the shallowest sample at 1713m. The shallowest significant abundance of the colonial algae *Amosopollis cruciformis* is recorded within this zone in the deepest sample at 2094m where it represents 18% of the combined SP + MP count, and >50% of the MP count. In the shallower samples the abundance of this algae averages <3%.

The initial preparation of the A sample from the deeper cuttings at 2520m also yielded the index species *Isabelidinium cretaceum* associated with the spore-pollen index species *Ornamentifera sentosa* and an anomalously low abundance of *Amosopollis cruciformis* (<2% of combined SP + MP count) and therefore was interpreted to be out-of-sequence (Table 1). Initially it was thought that this sample at 2520m had been switched with the sample at 2250m, but upon repeat processing of both cuttings samples it has be concluded that the original A sample at 2520m has somehow been mislabelled and is actually representative of a depth higher in the well. The list of species recorded from the out-of-place original sample is provided separately in Appendix 1, and only data from the B sample at 2520m is included on the main range chart.

***Odontochitina porifera* microplankton Zone**
Sample at: 2250 metres
Age: Santonian

The repeat B sample processed from 2250m contained rare specimens of both *Odontochitina porifera* and *O. cribropoda* in a low diversity microplankton assemblage which is assigned to the *O. porifera* Zone with low confidence. The dominant microplankton is *Amosopollis cruciformis* at 6 to 10% of combined SP and MP count.

***Phyllocladidites mawsonii* spore-pollen Zone**
Interval: 2358 to 2541 metres
Age: Latest Turonian to Coniacian.

The deepest five samples analysed in Pritchard-1 are best assigned to the uppermost *P. mawsonii* Zone based on the consistent presence of the eponymous species and the former zone species *Clavifera triplex*, without the consistent occurrence of any of the index species for the next younger *T. apoxyexinus* Zone. The assemblages are dominated by bisaccate gymnosperm pollen assigned to *Podocarpidites* (average 39%), the spores *Cyathidites* spp. (average 16%) and *Gleicheniidites* spp. (9%), and display weak Neves effects (average <10%). The rare but consistent presence of *Gleicheniidites ancorus* ms in the four deepest samples between 2460 and 2541mTD mean those samples can be not older than *G. ancorus* Subzone, while *Clavifera vultuosus* ms the index species for the next younger *C. vultuosus* Subzone was only recorded in the shallowest sample at 2358m. Also supporting assignment to these subzones is the common occurrence of *Cupressacites* sp. (average 5%), and consistent but rare presence of *Australopollis obscurus* (average 2%). In contrast, species more typical of the lower parts of the *P. mawsonii* Zone such as *Appendicisporites distocarinatus*, *Laevigatosporites musa* ms and *Verrucosisporites admirabilis* ms are either absent or extremely rare. Within the assemblages there are also rare index species interpreted as caved from higher in the well, which are recorded as caved on the range chart.

Conosphaeridium striatoconum microplankton Zone
Sample at: 2358 metres, possibly extending down to 2541m
Age: Coniacian

Two good specimens of the eponymous species *Conosphaeridium striatoconum* were recorded in the third and final slide examined from the cuttings at 2358m, which emphasises the often hit-or-miss nature in finding this important index species. In the initial Provisional Report the sample had not been, and could not be, assigned to this zone based on the assemblage recorded from the counts and scans of the first two slides examined. The fact that the key species is typically rare, yet two specimens were recorded, makes it extremely unlikely that the species is either caved or reworked in Pritchard-1. Finding of this species provides a crucial tie-point to the traditional stratigraphy as the *C. striatoconum* Zone is characteristic of the base of the Belfast Mudstone in the Port Campbell Embayment, and of the Morum Formation in the Gambier Embayment (Partridge, 2001). The presence of the zone confirms that the basal sandy section in Pritchard-1 is time equivalent to shaly facies over the remainder of the basin. Accepting this leads to the likely conclusion that is that most of the deeper section in Pritchard-1 down to TD could also be equivalent to this zone, notwithstanding the absence of the index species.

Trithyrodinium microplankton Subzone
Interval: 2460 to 2541 metres
Age: Coniacian to Late Turonian

The deepest four samples analysed in Pritchard-1 all contain rare specimens of *Trithyrodinium* spp., but lack convincing specimens of either *Kiokansium polypes* and *Valensiella griphus* whose LADs mark both the top of the *K. polypes* Subzone, and the top of the Flaxman Formation as redefined in Partridge (2001). The interval from the LADs of these two species to the FAD of *Conosphaeridium striatoconum* constitutes the *Trithyrodinium* Subzone shown on Figure 1. In some wells the latter subzone is represented by a significant thickness of sediments, whereas in other wells there is little or no gap between the LAD of *K. polypes* and the FAD of *C. striatoconum*. Consequently, it is highly likely that the *Trithyrodinium* Subzone is wholly or partly an artefact of the difficulty of finding *C. striatoconum*. Because of these problems it is uncertain whether Pritchard-1 had penetrated the equivalent of the Flaxman Formation by the time the well reached TD.

Extremely rare, poorly preserved and highly questionable specimens *Kiokansium polypes* and *Valensiella griphus* were recorded at 2094m and 2517m, and these are included on the range chart for completeness. In consideration of all the other assemblage data these anomalous occurrences are treated by the author as either unreliable identifications or reworking.

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Table 2. Interpretative palynological data for Pritchard–1

No.	Depth Metres	Sample Type	Spore-Pollen Zone or Subzone	CR	Microplankton Zone or Subzone	CR	Key Species & Comments	Age/Stage	MMP%	AC%	NE%
1	960	Cuttings	*P. grandis* Subzone	D1	*A. homomorphum*	D5	*Proteacidites grandis* frequent *Proteacidites pachypolus* rare	Early Eocene	<2%		11%
2	1005	Cuttings	*P. grandis* Subzone	D2	Indetermninate		*Integricorpus antipodus* ms present	Early Eocene	<1%		16%
3	1071	Cuttings	*P. grandis* Subzone	D2	*A. homomorphum*	D5	FAD of *Bysmapollis emarciatus*	Early Eocene	4%		11%
4	1164	Cuttings	Lower *M. diversus*	D4	Indetermninate		Lower diversity assemblage	Early Eocene	<1%		24%
5	1263	Cuttings	*S. prominatus* Subzone	D1	*A. hyperacanthum*	D3	FADs of *Spinizonocolpites prominatus* and *Crassiretitriletes*	Early Eocene	13%		18%
6	1305	Cuttings	Mixed Lower *M. diversus and L. balmei*	D4	*A. hyperacanthum*	D5	FAD of *Hafniasphaera septata*	Early Eocene to Paleocene	17%		13%
7	1326	Cuttings	Mixed *L. balmei* and *F. longus* Zones	D4	*M. druggii*	D3	LADs of *Manumiella coronata* and *Grapnelispora evansii*	Late Maastrichtian	44%	0.5%	16%
8	1348	Cuttings	Lower *F. longus*	D1	*I. pellucidum*	D3	LAD of *Proteacidites reticuloconcavus* ms and LAD of	Early Maastrichtian to Late Campanian	<2%	0.6%	<2%
9	1362	Cuttings	Lower *F. longus*	D4	*I. pellucidum*	D3	*Isabelidinium pellucidum* present	Early Maastrichtian to Late Campanian	9%		6%
10	1401	Cuttings	Lower *F. longus*	D1	*I. pellucidum*	D3	FADs of *Forcipites longus* and *Tetracolporties verrucosus*	Early Maastrichtian to Late Campanian	<2%		3%
11	1530	Cuttings	*N. senectus*	D1	*X. australis*	D3	LADs of *Xenikoon australis* and *Forcipites sabulosus* (5%)	Early Campanian	6%		6%
12	1713	Cuttings	Upper *T. apoxyexinus*	D2	*I. rotundatum* Subzone	D3	FAD of common *Proteacidites* (13%) and LAD of *Isabelidinium*	Late Santonian	4%		5%
13	1833	Cuttings	*T. apoxyexinus*	D2	*I. cretaceum*	D5	FAD of *Tricolporites apoxyexinus*	Santonian	4%	0.7%	6%
14	1986	Cuttings	*T. apoxyexinus*	D4	*I. cretaceum*	D5	Frequent *Proteacidites* spp. (~4%)	Santonian	8%	3%	3%
15	2025	Cuttings	*T. apoxyexinus*	D4	*O. porifera* or younger	D5	Younger Campanian cavings suspected	Santonian	4%	2.5%	4%
16	2094	Cuttings	*T. apoxyexinus*	D4	*I. cretaceum*	D3	FAD of *Isabelidinium cretaceum eongatum* of Marshall 1984	Santonian	12%	18%	3%
17	2250A	Cuttings	*T. apoxyexinus*	D4	Indeterminate		LAD of *Coptospora pileolus* ms	Santonian	<1%	6%	5%

Table 2. Interpretative palynological data for Pritchard–1

No.	Depth Metres	Sample Type	Spore-Pollen Zone or Subzone	CR	Microplankton Zone or Subzone	CR	Key Species & Comments	Age/Stage	MMP%	AC%	NE%
18	2250B	Cuttings	*T. apoxyexinus*	D2	*O. porifera*	D3	FADs of *Odontochitina porifera* and *Odontochitina cribropoda*	Santonian	5%	10%	<2%
19	2358	Cuttings	*T. apoxyexinus* to uppermost *P. mawsonii*	D4	*C. striatoconum*	D3	LAD of *Consosphaeridium striatoconum* and FAD of	Santonian to Coniacian	4%	20%	17%
20	2460	Cuttings	*T. apoxyexinus* to uppermost *P. mawsonii*	D4	*Tirthyrodinium* Subzone or younger	D3	Colonial algae *Amosopollis cruciformis* dominates assemblage	Santonian to Coniacian	8%	30%	<1%
21	2517	Cuttings	*T. apoxyexinus* to uppermost *P. mawsonii*	D4	Indeterminate		*Nothofagidites senectus* and *Forcipites sabulosus* very rare	Santonian to Coniacian	4%	14%	15%
22	2520A	Cuttings	*T. apoxyexinus*	D2	*I. cretaceum*	D3	OUT-OF-PLACE sample with FAD of *Isabelidinium cretaceum*	Santonian to Coniacian	5%	1.5%	9%
23	2520B	Cuttings	*T. apoxyexinus* to uppermost *P. mawsonii*	D3	*Tirthyrodinium* Subzone or younger	D3	FAD of *Latrobosporites ohaiensis*	Santonian to Coniacian	8%	42%	11%
24	2541	Cuttings	*T. apoxyexinus* to uppermost *P. mawsonii*	D4	*Tirthyrodinium* Subzone or younger	D3	FADs of *Trithyrodinium* spp. and *Gleicheniidites ancorus* ms	Santonian to Coniacian	<5%	18%	6%

Sample A = Original sample processed
Sample B = Repeat sample processed
CR = Confidence Ratings
SP and MP = Spore-Pollen and Microplankton
FADs and LADs = First and Last Appearance Datums
MMP% = Percentage abundance of marine microplankton (mainly dinocysts) in combined SP + MP count
AC% = Percentage abundance of colonial algae *Amosopollis cruciformis* in combined SP + MP count
NE% = Neves effect determined by percentage abundance of all *Araucariacites* and *Dilwynites* pollen in SP count

CONFIDENCE RATINGS (CR)

Alpha Code Linked to Sample	Numeric Code Linked to Palynomorph Assemblage
A = Core	1 = Excellent confidence: High diversity assemblage **plus** key zone species.
B = Sidewall core	2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
C = Coal cuttings	3 = Fair confidence: Low diversity assemblage **plus** key zone species.
D = Ditch cuttings	4 = Poor confidence: Moderate to high diversity **minus** key zone species.
J = Junk basket	5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 3. Basic sample and palynological assemblage data for Pritchard-1

No.	Depth Metres	Sample Type	Lithology (Hand-specimen descriptions)	Weight grams	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP* Species	No. MP* Species
1	960	Cuttings	Medium brown-grey siltstone	14.9	High	High	Very poor	54+ (1+)	4+
2	1005	Cuttings	Dark brown grey muddy sandstone	15.2	High	Moderate	Poor-fair	39+	2+
3	1071	Cuttings	Medium grey mudstone	15.0	High	Low	Poor	31+	3+
4	1164	Cuttings	Medium grey muddy sandstone	14.8	High	Low	Poor	22+ (2+)	1+
5	1263	Cuttings	Medium grey mudstone	15.1	High	High	Very poor	44+ (4+)	9+
6	1305	Cuttings	Medium chocolate grey hard mudstone	15.0	High	Moderate	Very poor	34+	11+
7	1326	Cuttings	Medium grey muddy sandstone	15.1	High	Moderate	Very poor	28+ (4+)	9+ (3+)
8	1348	Cuttings	Medium grey sandy mudstone	15.0	High	High	Poor-fair	59+ (3+)	5+ (1+)
9	1362	Cuttings	Medium grey muddy sandstone	15.0	High	Moderate	Poor-fair	38+ (1+)	3+ (2+)
10	1401	Cuttings	Medium greenish grey mudstone	15.0	High	High	Fair	37+ (6+)	7+ (1+)
11	1530	Cuttings	Medium grey muddy sandstone	14.9	High	Moderate	Very poor	35+ (5+)	4+
12	1713	Cuttings	Medium grey sandy mudstone	15.1	High	Moderate	Poor	32+ (5+)	7+
13	1833	Cuttings	Medium grey mudstone	14.8	Moderate	Low	Poor-fair	34+ (3+)	9+ (1+)
14	1986	Cuttings	Medium grey silty mudstone	15.0	Moderate	Moderate	Poor	27+ (3+)	6+
15	2025	Cuttings	Medium-dark grey hard mudstone	15.0	Moderate	Moderate	Poor	39+ (2+)	7+ (1+)
16	2094	Cuttings	Dark grey soft mudstone	14.8	High	Moderate	Very poor	25+ (3+)	12+ (2+)
17	2250A	Cuttings	Medium grey mudstone	15.1	Moderate	Moderate	Very poor	32+ (5+)	4+
18	2250B	Cuttings	Medium grey mudstone	15.0	High	Moderate	Poor	31+ (5+)	6+
19	2358	Cuttings	Dark grey soft mudstone	14.9	High	Moderate	Very poor	26+ (2+)	8+
20	2460	Cuttings	Dark grey soft mudstone	15.0	High	High	Very poor	27+ (2+)	7+
21	2517	Cuttings	Medium grey mudstone	15.0	Moderate	Moderate	Very poor	29+ (6+)	8+ (1+)
22	2520A	Cuttings	Medium grey muddy sandstone	15.0	High	Moderate	Poor-very poor	32+ (2+)	4+ (1+)
23	2520B	Cuttings	Medium to dark grey mudstone	18.9	High	Low	Very poor	24+ (3+)	6+ (1+)
24	2541	Cuttings	Medium grey muddy sandstone	15.1	Moderate	Moderate	Very poor	30+ (2+)	5+ (1+)

* SP and MP species numbers in brackets refer to number of reworked and/or caved species identified.

Appendix. List of species recorded from out-of-place sample A at 2520m in Pritchard-1.

Spore-Pollen	
Araucariacites australis	X
Ariadnaesporites sp. (threads)	0.8%
Australopollis obscurus	3.1%
Baculatisporites spp.	2.4%
Cicatricosisporites & *Ruffordiaspora* spp.	0.8%
Clavifera triplex	1.6%
Clavifera vultuosus sp. nov.	1.6%
Cupressacites sp.	6.3%
Cyathidites spp. (large species)	1.6%
Cyathidites spp. (small species)	12.6%
Dictyophyllidites spp.	2.4%
Dilwynites echinatus sp. nov.	0.8%
Dilwynites granulatus	2.4%
Gleicheniidites ancorus sp. nov.	0.8%
Gleicheniidites circinidites	9.4%
Herkosporites elliottii	2.4%
Laevigatosporites ovatus	0.8%
Latrobosporites amplus	X
Lygistepollenites florinii	2.4%
Microcachryidites antarcticus	3.9%
Ornamentifera sentosa	0.8%
Osmundacidites wellmanii	1.6%
Peninsulapollis gillii	X
Perotrilites majus	0.8%
Phyllocladidites mawsonii	0.8%
Plicatipollenites spp.	Reworked
Podocarpidites spp.	25.2%
Proteacidites spp.	2.4%
Protohaploxypinus spp.	Reworked
Rugulatisporites spp.	0.8%
Stereisporites antiquasporites	0.8%
Trichotomosulcites subgranulatus	7.1%
Trilete spores undiff.	2.4%
Vitreisporites signatus	1.6%
Count:	127
Microplankton	
Amosopollis cruciformis	X
Apectodinium homomorphum	Caved
Dinogymnium acuminatum	X
Heterosphaeridium spp.	X
Isabelidinium cretaceum	X
SP + MP Count:	136
Amosopollis cruciformis (in SP count):	1.5%
Marine microplankton (in SP count):	5.1%

X = Present outside of count.

Well Name : Pritchard-1

Operator : Essential Petroleum Resou

Well Code : PRITCHARD-1

Lat/Long : 38° 0' 26.25"S 141°12' 35.40"E

Interval : 940m - 2560m

Scale : 1:2500

Chart date : 03 July 2006

INTERPRETATIVE Palynomorph Range Chart

Sample interval 960 to 2541m

Microscope analysis by Alan D. Partridge

Pritchard-1

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