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APPENDIX 9B

PALYNOLOGICAL ANALYSIS

(by Alan Partridge)

HOWMAINS-1

Palynological analysis of Howmains-1, Port Campbell Embayment, Otway Basin.

by

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INTERPRETATIVE DATA

Introduction

Twenty sidewall cores samples between 1036.0-2098.0m were analysed in Howmains-1. The author cleaned and split the samples then forwarded them to Laola Pty Ltd in Perth for processing to prepare the palynological slides.

Between 8.2 to 14.4 grams (average 11.3 g) of the sidewall cores were processed for palynological analysis. High residue yields were extracted from most samples. Kerogen slides were prepared with filtered and unfiltered fractions, whilst separate oxidised slides were prepared from fractions concentrated from the residues using 8 and 15 micron filters. Palynomorph concentrations on the palynological slides were mostly low to moderate, while palynomorph preservation was poor to fair and only very occasionally good. The interaction of poor preservation and low palynomorph concentration made most palynological slides slow and difficult to examine.

Excluding the two nearly barren samples at 1907m and 1997m the overall spore-pollen diversity was high averaging 26+ species per sample. Microplankton diversity was low to very low in the Tertiary and Early Cretaceous but moderate in the Late Cretaceous Sherbrook Group where the average diversity was 12+ species per sample. The microplankton abundance data presented in Table-2 was obtained from counts made on slides prepared using 8 microns filter cloth.

Geological ages, formations and palynological zones for the interval sampled in Howmains-1 are given in Table-1. Additional interpretative data with zone identification and Confidence Ratings are recorded in Table-3, whilst basic data on sidewall core lithologies, residue yields, preservation and diversity are recorded on Tables-4 and 5. All species which have been identified with binomial names are tabulated on separate range charts for spore-pollen and microplankton which present the recorded assemblages in order of lowest appearances.

Table-1: Palynological Summary Howmains-1

<table>
<tr><th>AGE</th><th>UNIT</th><th>SPORE-POLLEN ZONES</th><th>MICROPLANKTON ZONES (SUBZONES)</th></tr>
<tr><td>EOCENE</td><td rowspan="2">PEMBER MUDSTONE
1017-1082m</td><td rowspan="2">Lower M. diversus
1036m
L. balmei
1072m</td><td rowspan="2">INDETERMINATE</td></tr>
<tr><td rowspan="3">PALEOCENE</td></tr>
<tr><td>PEBBLE POINT FORMATION
1082-1138m</td><td rowspan="5">NOT SAMPLED</td><td rowspan="5">NOT SAMPLED</td></tr>
<tr><td rowspan="2">K/T BOUNDARY SHALE
1138-1163m</td></tr>
<tr><td rowspan="2">MAASTRICHTIAN</td></tr>
<tr><td rowspan="2">PAARATTE FORMATION
1163-1473m</td></tr>
<tr><td rowspan="3">CAMPANIAN</td></tr>
<tr><td rowspan="3">SKULL CREEK MUDSTONE
1473-1637m</td><td rowspan="5">N. senectus
to
T. apoxyexinus
1483-1815m</td><td>X. australis
1483m</td></tr>
<tr><td>N. aceras
1558m</td></tr>
<tr><td rowspan="3">SANTONIAN</td><td rowspan="2">I. cretaceum
1632-1807m</td></tr>
<tr><td rowspan="3">BELFAST MUDSTONE
1637-1840m</td></tr>
<tr><td>O. porifera
1815m</td></tr>
<tr><td>CONIACIAN</td><td rowspan="4">P. mawsonii
1828-1887.5m</td><td>C. striatoconus
1828-1838m</td></tr>
<tr><td rowspan="3">TURONIAN</td><td>WAARRE D
1840-1856m</td><td>P. infusorioides
1847-1854m</td></tr>
<tr><td>WAARRE B
1856-1888.5m</td><td rowspan="2">P. infusorioides
(C. edwardsii)
1860-1904m</td></tr>
<tr><td>WAARRE A
1888.5-1902m</td></tr>
<tr><td>LATE ALBIAN</td><td>EUMERALLA FORMATION
1902-2150m (T.D.)</td><td>P. pannosus
1936-2098m</td><td></td></tr>
</table>

Geological Comments

1. The sequence sampled in Howmains-1 spans the time interval of Late Albian to Early Eocene. With some minor modifications most samples can be readily assigned to the Mesozoic spore-pollen and microplankton zones defined by Helby, Morgan & Partridge (1987) or the Tertiary spore-pollen zones of Stover & Partridge (1973).

2. A number of the spore-pollen zones used or discussed herein represent modifications or name changes by Helby *et al.* (1987) of zones originally erected by Dettmann & Playford (1969) upon wells from the Port Campbell Embayment. As these zones are ~~is~~ still widely used in reports and publications on the Otway Basin it is appropriate to provide a summary of the equivalence between the two zonation schemes. Explanations of the reasons for the zone name changes can be found in Helby *et al.* (1987). The zones referred to in this report are:

Dettmann & Playford (1969)		**Helby *et al.* (1987)**
Nothofagidites Microflora (in part only)	=	*N. senectus* Zone
T. pachyexinus Zone	=	*T. apoxyexinus* Zone
C. triplex Zone	=	*P. mawsonii* Zone
A. distocarinatus Zone	=	*A. distocarinatus* Zone
P. pannosus Zone	=	*P. pannosus* Zone

3. The spore-pollen succession commences with the *P. pannosus* Zone identified in the Eumeralla Formation. In the overlying Waarre Formation the *P. mawsonii* Zone was found to extend to the base of the unit and the Cenomanian *A. distocarinatus* Zone as redefined by Helby *et al.* (1987) is considered to be absent at the unconformity between the Waarre and Eumeralla Formations. This relationship confirms results previously obtained from Iona-2 and Langley-1 (Partridge 1994a,b). Assemblages from the succeeding Belfast and Skull Creek Mudstones proved to be disappointing as the boundaries between the *P. mawsonii* and overlying *T. apoxyexinus* Zone and between the *T. apoxyexinus* and *N. senectus* Zones could not be confidently identified. The two shallowest samples from the Tertiary were also disappointing, for although displaying high diversity they contained few key species.

4. Marine microplankton were recorded in all samples analysed from the Late Cretaceous Sherbrook Group and both samples from the Early Tertiary Pember Mudstone. Abundant marine microplankton comprising 90% of the assemblage count were also recorded from the sidewall core at 1904m, which is below the most logical log pick for the top of the Eumeralla Formation at 1902m. This sample consisted of two lithologies, a friable sandstone and a greenish grey claystone which is most similar to the underlying Eumeralla samples (Table-4). The sample could not be adequately cleaned and is therefore possibly contaminated. It is suspected the dinoflagellates are coming from sandstone lithology which has been introduced as a clastic dike into the Eumeralla Formation. Such clastic dikes are a typical features of the better exposures of the unconformity between the Eumeralla and Pebble Point Formations which outcrop at Point Margaret and Buckleys Point (see Keating 1993). The two other good assemblages from the Eumeralla Formation contained only the single non-marine algae species *Circulosporites parvus* (De Jersey 1962).

5. Six microplankton zones are recorded from the Sherbrook Group between the basal Turonian to Early Campanian and they conform to the normal sequence documented by Helby *et al.* (1987). As well the new *C. edwardsii* Subzone previously recorded in Iona-2 and Langley-1 was identified in the lower half of the *P. infusorioides* Zone. The microplankton recorded from the two Tertiary samples could not be assigned to any of the established zones.

6. The oldest unit penetrated in Howmains-1 is the Eumeralla Formation between 1902-2150m (T.D.). The lithology is a variable greenish-grey to medium grey claystone to sandstone (Table-4). Although the Late Albian *P. pannosus* Zone identified form this section conforms to the youngest age known from this formation, there are compositional differences in both the spore-pollen and non-marine microplankton in the unit which indicate there is no direct correlation to the *P. pannosus* Zone sections in Iona-2 and Langley-1. This is not considered surprising as the *P. pannosus* Zone represents a time interval of between 4 to 5 million years and the wells may well be sampling different parts of the zone below the top of Eumeralla unconformity.

7. In the Waarre Formation identified between 1840-1902m palynological correlation with the more detailed sampled Langley-1 well suggests that the Howmains-1 section contains parts of Units A, B and D of the Waarre (*sensus* Buffin 1989) and that Unit C is missing at an unconformity at 1856m.

8. Palynological assemblages characteristic of the Waarre Units A and B were recorded from the three sidewall cores between 1860-1887.5m as well as the sample at 1904m whose problematical location is discussed above. The spore-pollen assemblages are characterised by the pollen *Hoegisporis trinalis* ms and spore *Appendicisporites distocarinatus* while the microplankton assemblages are characterised by the association of *Cribroperidinium edwardsii, Palaeoperidinium cretaceum* and *Cyclonephelium compactum.* The association of these three species does not occur above Unit B in Langley-1. The two overlying samples at 1847m and 1854m are in turn best correlated with palynological assemblages in the Waarre Unit D in Langley-1 between 1712.5-1729.5m based on the characteristic increase in abundance of *Heterosphaeridium* spp and *Amosopollis cruciformis*.

9. The above correlation is also strongly supported by the identification of the *Conosphaeridium striatoconus* Zone at 1828m and 1838m. This zone provides a critical tie point to Langley-1 at 1701m (Partridge 1994b) and Iona-1 at 1276.5m (Morgan 1988). The zone was also recorded from the nearby Flaxmans-1 well in core-21 at 6832ft (= 2082m) by Stacy (1981). Unfortunately this record is unreliable as the well completion report records core-21 as no recovery. It is therefore uncertain where Stacy obtained his sample although it may have come from the lower part of core-22 between 6632-6635ft (= 2021-2022m) as recently suggested by Partridge (letter to GFE Resources Ltd on 7 September 1994). Following the arguments given in the Langley-1 palynological report the base of the Belfast Mudstone is picked below the *C. striatoconus* Zone at 1840m where there is a sharp increase in separation between the bulk density and neutron porosity logs.

10. The Belfast Mudstone in Howmains-1 contains the *C. striatoconus, O. porifera* and *I. cretaceum* microplankton Zones as was also found in Langley-1. The presence of the *Isabelidinium rotundatum* ms (Marshall 1984) at 1632m and 1663m suggests that the log pick for the top of the Belfast at 1637m is actually the characteristic log break for the base of the Skull Creek Mudstone in Langley-1 (at 1517m) and Iona-2 (at 1163m). This means that the Nullawarre Greensand Member in the latter two wells is a facies of the uppermost part of the Belfast Mudstone in Howmains-1.

11. The Cretaceous/Tertiary (K/T) boundary shale identified in Langley-1 between 892-917.5m is correlated using the gamma log to the shale between 1138-1163m in Howmains-1. This would make the overlying sand between 1082-1138m the Pebble Point Formation and place the two

shallowest samples analysed in the Pember Mudstone Member. These suggested correlations could be tested by palynological analysis of cuttings sample from the interpreted K/T boundary shale which in Langley-1 and Iona-1 contains distinctive dinoflagellate assemblages.

12. Howmains-1 is similar to Langley-1 in that all samples analysed from the Sherbrook Group are considered to be marine based on the abundance and diversity of microplankton (Tables 2 & 5). Whilst superficially the microplankton abundance appears greater in Howmains-1 relatively to Langley-1 this cannot yet be demonstrated as significance because of difference in palynomorph preservation and concentrations resulting from slightly different sample preparations between the two wells. What is clear is that the palynological analysis has not identified any non-marine fluviatile to coastal plain environments within the Sherbrook Group. Instead all the palynological samples examined are representative of offshore marine environments.

13. In contrast to both Langley-1 and Iona-2 only the non-marine algal cyst *Circulosporites parvus* (De Jersey 1962) was recorded in the samples from the Eumeralla Formation in Howmains-1. Because there are also differences between these three wells in the composition of the associated spore-pollen assemblages it is considered more likely that the assemblage differences reflect time differences within the *P. pannosus* Zone rather than being due to lateral facies changes. This suggests there is potential for future subdivision of the *P. pannosus* Zone.

14. Reworked palynomorphs were recorded from virtually all samples analysed. Because of age and preservation differences Permian and Triassic spore-pollen are the most obvious reworked palynomorphs. Reworked Early Cretaceous spores and pollen from the Otway Group are found throughout the Sherbrook Group, but the full extent of this reworking is impossible to estimate as many Early Cretaceous species are considered to range into the Late Cretaceous.

Table-2: Microplankton Abundance for Selected Samples.

Sample Type	Depth (m)	Microplankton Zone or Subzone	Microplankton Abundance as % Relative to total Spore-pollen and Microplankton	Most abundant microplankton species as % of total microplankton
SWC-30	1036.0		8%	*Paralecaniella indentata* >75%.
SWC-29	1072.0		6%	*Paralecaniella indentata* >35%.
SWC-28	1483.0	*X. australis*	40%	*Heterosphaeridium* spp. >75%.
SWC-27	1558.0	*N. aceras*	36%	*Heterosphaeridium* spp. >65%.
SWC-26	1632.0	*I. cretaceum*	28%	*Heterosphaeridium* spp. >35%.
SWC-25	1663.0	*I. cretaceum*	12%	*Heterosphaeridium* spp. >30%.
SWC-24	1807.0	*I. cretaceum*	19%	*Amosopollis cruciformis* >30%.
SWC-23	1815.0	*O. porifera*	33%	*Heterosphaeridium* spp. 35%. *Amosopollis cruciformis* 35%.
SWC-22	1828.0	*C. striatoconus*	42%	*Heterosphaeridium* spp. >25%. *Amosopollis cruciformis* >30%.
SWC-21	1838.0	*C. striatoconus*	66%	*Amosopollis cruciformis* >50%.
SWC-20	1847.0	*P. infusorioides*	52%	*Heterosphaeridium* spp. 30%. *Amosopollis cruciformis* 30%.
SWC-19	1854.0	*P. infusorioides*	43%	*Heterosphaeridium* spp. 21%. *Amosopollis cruciformis* 35%.
SWC-18	1860.0	*C. edwardsii*	35%	*Cribroperidinium edwardsii* >15%.
SWC-15	1882.0	*C. edwardsii*	15%	*Cyclonephelium* spp. >35%.
SWC-13	1887.5	*C. edwardsii*	10%	*Cyclonephelium* spp. >40%.
SWC-10	1904.0	*C. edwardsii*	90%	*Palaeoperidinium cretaceum* >60%.
SWC- 7	1936.0		2%	*Circulisporites parvus* 100%.
SWC- 1	2098.0		<1%	*Circulisporites parvus* 100%.

Biostratigraphy

The zone and age determinations for the Cretaceous samples are based on the Australia wide Mesozoic spore-pollen and microplankton zonation schemes described by Helby, Morgan & Partridge (1987). For the Tertiary zone and age determinations are based on the spore-pollen zonation scheme of Stover & Partridge (1973) with subsequent unpublished modifications.

Author citations for most spore-pollen species can be sourced from Helby, Morgan & Partridge (1987), Dettmann (1963), Dettmann & Jarzen (1988), Stover & Partridge (1973) or other references cited herein. Author citations for dinoflagellates can be found in the indexes of Lentin & Williams (1985, 1989) or other references cited herein. Species names followed by "ms" are unpublished manuscript names.

Spore-Pollen Zones

Lower *Malvacipollis diversus* Zone.
Interval: 1036.0 metres.
Age: Early Eocene.

The shallowest sample is assigned to this zone on the presence of *Proteacidites grandis* and *P. nasus* Truswell & Owens 1988 and absence of *Lygistepollenites balmei*. Although the assemblage is of high diversity (31+ species) it lacks certain species which would be considered typical of the zone (eg. *Malvacipollis diversus* and *Intratriporopollenites notabilis*) and contains other species whose occurrence would be considered anomalous such as *Proteacidites confragosus*. It is possible the sample could belong to the Middle *M. diversus* Zone on the presence of a questionable specimen of *Proteacidites xestoformis* ms. The few specimens of *Australopollis obscurus* recorded were interpreted as reworked, although this species is known to range higher in the Otway Basin compared to the Gippsland Basin. The assemblage is dominated by *Podocarpidites* spp. 20%, *Cyathidites* spp. 16%, *Proteacidites* spp. 14%, *Dilwynites* spp. 13%, and *Gleicheniidites circinidites* 10%. The associated microplankton are not zone diagnostic but do indicate a marine environment of deposition.

***Lygistepollenites balmei* Zone.**
Interval: 1072.0 metres.
Age: Paleocene.

The dominance of *Dilwynites* spp. and *Proteacidites* spp. both at 23% in association with frequent *Lygistepollentites balmei* at 3.5% is typical of the gross assemblage character of this zone. Even though of high diversity (29+ species) the sample could not be assigned with confidence to either the Upper or Lower *L. balmei* Subzones although the presence of *Anacolosidites acutullus* and *Proteacidites adenanthoides* would favour assignment to the Upper subzone. The few microplankton recorded were not diagnostic but confirm a marine environment of deposition.

The sample also contained a single specimen of the interesting and unusual primitive angiosperm *Lactoripollenites africanus* Zavada & Benson 1987.

***Nothofagidites senectus* to *Tricolporites apoxyexinus* Zones.**
Interval: 1483.0-1815.0 metres (368+ metres).
Age: Lower Campanian to Santonian.

The six samples over this interval contained moderate to high diversity spore-pollen assemblages with a total diversity of 55+ species. Unfortunately the assemblages were dominated by long ranging species and the FADs (First Appearance Datums) for the key index species which define the zone boundaries were significantly younger than the established relationships of their FADs to the parallel microplankton zones. Thus, the two shallowest and two deepest samples to be honest with the recorded data had to be bracketed with their adjacent zones (Table-3). Examples of delayed FADs are the index species *Nothofagidites senectus* and *Forcipites sabulosus* diagnostic of the base of the *N. senectus* Zone which could not be found in the two shallowest samples at 1483m and 1558m. It is well established that these species range as old as the *N. aceras* Zone (Helby *et al.* 1987) and this was recently confirmed in the palynological analysis of Iona-2 (Partridge 1994a). Similarly, the possible index species for the base of the *T. apoxyexinus* Zone were either not recorded (eg. *Forcipites stipulatus* and *Ornamentifera sentosa*) or are recorded later than expected as for example *Tricolporites apoxyexinus* and *Peninsulapollis gillii* which were not confidently recorded until 1632m. However, on abundance data the *T. apoxyexinus* Zone clearly to extend as deep as 1663m based on the frequent to common occurrence of *Proteacidites* spp. and *Australopollis obscurus*, while the established relationships between the spore-pollen and microplankton zones suggests it should extend as deep as 1815m. Overall the assemblages in this interval are dominated by *Podocardipites* spp. with a significant increase in angiosperm pollen from 1663m.

***Phyllocladidites mawsonii* Zone** (formerly the *Clavifera triplex* Zone).
Interval: 1828.0-1887.5 metres (60+ metres).
Age: Turonian-Coniacian.

The seven samples assigned to the *P. mawsonii* Zone can be subdivided into two subzones based mainly on the range of *Hoegisporis trinalis* ms.

The lower subzone represented by the three samples between 1860-1887.5m (and probably the spore-pollen poor sample at 1904m) is characterised by the consistent and often frequent occurrence of *H. trinalis* ms, *Appendicisporites distocarinatus*, *Rugulatisporites admirabilis* ms and *Cicatricoisisporites pseudotripartitus* with only the very rare occurrence of the eponymous species *P. mawsonii* (only at 1887.5m). Other rare species from this lower interval include *Densoisporites muratus* ms, *Stoverisporites microverrucatus* Burger 1976 and a single specimen of *Hoegisporis uniforma*. These samples correlate well with assemblages documented from the Waarre Units A and B in Langley-1 (Partridge 1994b).

The upper subzone represented by the four samples between 1828-1854m is characterised by the consistent occurrence of *P. mawsonii* and the first appearance and increasing presence of *Clavifera triplex*. The overall character of the assemblages also changes with the incoming of abundances of the dinoflagellate *Heterosphaeridium* spp. and the enigmatic algal cyst *Amosopollis cruciformis*. The more abundant microplankton combined with lower yields and lower palynomorph concentrations means that the full spore-pollen diversity probably has not been adequately recorded from this upper subzone. Important LADs (Last Appearance Datums) include *Appendicisporites distocarinatus* at 1854m and *Rugulatisporites admirabilis* ms at 1828m. This upper subzone correlates moderately well with similar assemblages from the Waarre Unit D and basal Belfast Mudstone in Langley-1 (Partridge 1994b).

***Appendicisporites distocarinatus* Zone.**
Interval: Not recorded in Howmains-1.
Age: Cenomanian.

The results from Howmains-1 confirms the observations in Langley-1 and Iona-2 that the *A. distocarinatus* Zone in terms of the modified concept of Helby *et al.* (1987) is not present in the Waarre Formation.

***Phimopollenites pannosus* Zone.**
Interval: 1936.0-2098.0 metres (162+ metres).
Age: Late Albian.

Only two of the four samples analysed from the Eumeralla Formation gave datable assemblages which are assigned to the zone on the presence of the eponymous species *P. pannosus*. The presence of *Trilobosporites trioreticulosus* in both samples could be considered an important accessory indicator in line with the range for this species given by Dettmann & Playford (1969, table 9.4) but not its range given by Helby *et al.* (1987, fig.33). This species has not been recovered *insitu* from the Waarre Formation in the other wells recently analysed. In overall composition the assemblages in Howmains-1 differ from those in Langley-1 and Iona-2 by their significant abundances of *Cicatricosisporites* spp. (5% to 9%) and limited abundance of *Corallina* spp. (<3%).

Microplankton Zones

***Xenikoon australis* Zone**
Interval: 1483.0 metres
Age: Early Campanian.

The shallowest sample from the Late Cretaceous is assigned to the *X. australis* Zone on the presence of the eponymous species. The assemblage is dominated by *Heterosphaeridium heteracanthum* and the only other diagnostic species are *Nelsoniella tuberculata* and *Isabelidinium thomasii*.

***Nelsoniella aceras* Zone.**
Interval: 1558.0 metres.
Age: Early Campanian.

The single sample is assigned to the zone on presence of eponymous species *N. aceras* (>6%) and lack of next zone index *X. australis*. The sample is dominated by *Heterosphaeridium* spp. (>55%) and contains common *Palaeohystrichophora infusorioides* (15%) and *Gillianía hymenophora* (4.5%), whilst *Amosopollis cruciformis* is rare (<1%).

***Isabelidinium cretaceum* Zone.**
Interval: 1632.0-1807.0 metres (175+ metres).
Age: Santonian.

The three samples assigned to the zone lack *Isabelidinium cretaceum* s.s. but contain the accessory indicator species *Isabelidinium belfastense* (at 1807m) and *Amphidiadema denticulata* (at 1663m) which were considered by Helby *et al.*

(1987, fig.40) to have their FADs in the upper part of the zone. The two shallower samples also contain *Isabelidinium rotundatum* ms Marshall 1984. This species is the variety of *I. cretaceum* recorded by Cookson & Eisenack (1961, p.11, figs 1,2) from the Belfast No. 4 bore. It is characteristically circumcavate rather than simply cavate at the apices like the holotype and most of the paratypes of *I. cretaceum*. This species was also found in the Nullawarre Greensand and basal part of Skull Creek Mudstone in Iona-2 and Langley-1 (Partridge 1994 a,b) and is undoubtedly a useful form for future formal subdivision of the *I. cretaceum* Zone.

***Odontochitina porifera* Zone.**
Interval: 1815.0 metres (<21 metres).
Age: Santonian.

The sample lacks *Odontochitina porifera* but is assigned to the zone on presence of *Chatangiella victoriensis* and absence of eponymous and other index species for underlying and overlying zones. The sample is equated with the upper part of the principal reference section for the *O. porifera* Zone in Morum-1 (Helby *et al.* 1987, p.64) which contains *C. victoriensis*. *Odontochitina porifera* was recorded in only 3 of the 9 sidewall core samples over this upper interval and only in one of the samples containing *C. victoriensis* (Partridge 1975). The sample is dominated equally by *Heterosphaeridium* spp. and *Amosopollis cruciformis* both at 35%.

***Conosphaeridium striatoconus* Zone.**
Interval: 1828.0-1838.0 metres (10+ metres).
Age: Coniacian.

Of the two samples assigned to the zone the shallower contains frequent *C. striatoconus* (5%) whilst from the deeper only a single detached operculum with a distinctive central process characteristic of *C. striatoconus* was recorded. None of the other species recorded can be considered diagnostic of the zone. The microplankton assemblages from both samples are dominated by *Heterosphaeridium heteracanthum* and *Amosopollis cruciformis* (Table-2).

***Palaeohystrichophora infusorioides* Zone.**
Interval: 1847.0-1904.0 metres (55+ metres).
Age: Turonian.

The samples are assigned to the *P. infusorioides* Zone based on the absence of index species *Pseudoceratium ludbrookiae* and significant accessory species *Litosphaeridium siphoniphorum* and *Canninginopsis denticulata* diagnostic of the underlying *D. multispinum* Zone and absence of *Conosphaeridium striatoconus* whose FAD defines the base of the overlying zone. The zone is therefore recognised on negative evidence identical to the way it was originally defined (Helby *et al.* 1987, p.62). As with other wells in the Otway Basin the assemblages are depauperate compared to equivalent age assemblages from the North West Shelf. The zone has an average microplankton diversity of 12+ species/sample and a total diversity of 32+ species. Only the oldest of three subzones established in Langley-1 could be recognised in Howmains-1.

***Cribroperidinium edwardsii* Subzone.**
Interval: 1860.0-1904.0 metres (42+ metres).
Age: Turonian.

This zone was originally defined in Iona-2 and Langley-1 palynological reports (Partridge 1994a, b). In Howmains-1 it is best characterised by the consistent presence of *Cribroperidinium edwardsii, Palaeoperidinium cretaceum* and *Cyclonephelium compactum.* The samples also contain fairly consistent *Odontochitina costata/operculata* and *Oligosphaeridium complex/pulcherrimum* and inconsistent *P. infusorioides.* The consistent presence of *Kiokansium polypes* in the shallowest three samples supports the assignment of the shaley section between 1856-1888.5m to the the Waarre Unit B based on a weak subdivision of this subzone seen in Langley-1.

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Table-3: Interpretative Palynological Data for Howmains-1, Otway Basin

Sample Type	Depth (m)	Spore-pollen Zone	CR*	Microplankton Zones	CR*	Comments and Key Species
SWC-30	1036.0	Lower *M. diversus*	B1	Indeterminate		*Proteacidites grandis* present.
SWC-29	1072.0	*L. balmei*	B1	Indeterminate		Frequent *L. balmei* with *Tricolpites phillipsii*.
SWC-28	1483.0	*N. senectus* to *T. apoxyexinus*		*X. australis*	B3	FAD of *Xenikoon australis* with *Nelsoniella tuberculata*.
SWC-27	1558.0	*N. senectus* to *T. apoxyexinus*		*N. aceras*	B2	FAD of *Nelsoniella aceras*.
SWC-26	1632.0	*T. apoxyexinus*	B4	*I. cretaceum*	B3	*Isabelidinium rotundatum* ms present.
SWC-25	1663.0	*T. apoxyexinus*	B4	*I. cretaceum*	B2	FADs for *I. rotundatum* ms, *Aphidiadema denticulata* and *Heterosphaeridium evansii* ms.
SWC-24	1807.0	*T. apoxyexinus* to *P. mawsonii*		*I. cretaceum*	B4	Zone pick based on *Isabelidinium belfastense*.
SWC-23	1815.0	*T. apoxyexinus* to *P. mawsonii*		*O. porifera*	B5	Zone pick based on presence of *Chatangiella victoriensis* and absence of *C. striatoconus*.
SWC-22	1828.0	*P. mawsonii*	B4	*C. striatoconus*	B2	*Conosphaeridium striatoconus* common.
SWC-21	1838.0	*P. mawsonii*	B2	*C. striatoconus*	B2	Dominated by *Amosopollis cruciformis* comprising 35% of total count. *C. striatoconus* identified on single detached opercula.
SWC-20	1847.0	*P. mawsonii*	B2	*P. infusorioides*	B2	LAD *Rugulatisporites admirabilis* ms.
SWC-19	1854.0	*P. mawsonii*	B2	*P. infusorioides*	B2	FAD of *Clavifera triplex* and common *Amosopollis cruciformis* with LAD of *Appendicisporites distocarinatus*.
SWC-18	1860.0	*P. mawsonii*	B1	*P. infusorioides* (*C. edwardsii*)	B2	LAD *Hoegisporis trinalis* ms and LAD of consistent *C. edwardsii*.
SWC-15	1882.0	*P. mawsonii*	B1	*P. infusorioides* (*C. edwardsii*)	B2	Single specimen of *Hoegisporis trinalis* ms recorded.
SWC-13	1887.5	*P. mawsonii*	B1	*P. infusorioides* (*C. edwardsii*)	B2	FADs *Phyllocladidites mawsonii* and *Hoegisporis trinalis* ms.
SWC-10	1904.0	Indeterminate		*P. infusorioides* (*C. edwardsii*)	B3	Microplankton >85% at base of marine transgression with FAD *Cribroperidinium edwardsii*.
SWC- 9	1907.0	Indeterminate				Sample virtually barren.
SWC- 7	1936.0	*P. pannosus*	B1			LAD *Trilobosporites trioreticulosus*. with *Cicatricosisporties* spp. 9%.
SWC- 4	1997.0	Indeterminate				Sample virtually barren.
SWC- 1	2098.0	*P. pannosus*	B1			FAD *Phimopollenites pannosus*.

*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum

Confidence Ratings

The Confidence Ratings assigned to the zone identifications on Table-4 are quality codes used in the STRATDAT relational database being developed by the Australian Geological Survey Organisation (AGSO) as a National Database for interpretive biostratigraphic data. Their purpose is to provide a simple relative comparison of the quality of the zone assignments. The alpha and numeric components of the codes have been assigned the following meanings:

Alpha codes: Linked to sample type

- **A** Core
- **B** Sidewall core
- **C** Coal cuttings
- **D** Ditch cuttings
- **E** Junk basket
- **F** Miscellaneous/unknown
- **G** Outcrop

Numeric codes: Linked to fossil assemblage

1	**Excellent confidence:**	High diversity assemblage recorded with key zone species.
2	**Good confidence:**	Moderately diverse assemblage recorded with key zone species.
3	**Fair confidence:**	Low diversity assemblage recorded with key zone species.
4	**Poor confidence:**	Moderate to high diversity assemblage recorded without key zone species.
5	**Very low confidence:**	Low diversity assemblage recorded without key zone species.

BASIC DATA

Table 4: Basic Sample Data - Howmains-1, Otway Basin

Table-5: Basic Palynomorph Data for Howmains-1, Otway Basin

Palynomorph Range Charts for Howmains-1, Otway Basin

Range Chart 1: Spore-pollen by Lowest Appearance

Range Chart 2: Microplankton by Lowest Appearance

Table 4: Basic Sample Data - Howmains-1, Otway Basin.

SAMPLE TYPE	DEPTH (metres)	REC (cm)	LITHOLOGY	SAMPLE WT (g)	RESIDUE YIELD
SWC-30	1036.0	5.0	Dark grey brown bioturbated silty claystone (well cleaned).	11.4	High
SWC-29	1072.0	5.5	Dk grey brown silty claystone with coarse sandstone burrows and occasional quartz pebbles up to 4mm (well cleaned).	11.3	High
SWC-28	1483.0	3.0	Interlaminated med grey brown claystone and off-white fine grn sandstone. Laminations <1-4mm with crosscutting burrows 2mm diam. (well cleaned).	11.6	High
SWC-27	1558.0	3.0	Med. grey firm silty claystone (sample well cleaned).	11.3	High
SWC-26	1632.0	3.8	Dk gry bioturbated silty claystone (well cleaned).	11.3	High
SWC-25	1663.0	2.8	Med. grey non-calcareous claystone (well cleaned).	11.0	High
SWC-24	1807.0	2.5	Med-dk grey slightly calcareous claystone with pyritised fossils, but no obvious glauconite (well cleaned).	9.3	Moderate
SWC-23	1815.0	3.0	Med-dk grey calcareous claystone; glauconite not obvious (well cleaned).	12.9	High
SWC-22	1828.0	4.5	Dk gry claystone with very fine glauconite and with common slickensides through core (well cleaned).	10.5	Moderate
SWC-21	1838.0	4.0	Dk greenish grey pelletised to pebbly claystone with brown (limonitic?) cement between pellets. Qtz pebbles up to 3mm; but no obvious glauconite (well cleaned).	14.4	Low
SWC-20	1847.0	3.8	Med. brn grey mottled silty claystone.	12.3	Moderate
SWC-19	1854.0	3.5	Med. grey sandy claystone with pyrite nodules and calcareous fragments (well cleaned).	9.3	Moderate
SWC-18	1860.0	4.0	Med. grey silty claystone faintly laminated, with carbonaceous flecks and bioturbated (well cleaned).	11.0	Moderate
SWC-16	1874.0	<1.0	Light grey f. to crs grn quartz sandstone with blk coal partings which may be suitable for palynological analysis.		
SWC-15	1882.0	3.5	Med. gry sandy claystone with lt gry sandstone laminae (6mm) which are pyritic or micaceous (well cleaned).	8.2	Moderate
SWC-14	1884.0	<1.0	Off white argillaceous sandstone with kaolinitic matrix with med. brn-gry laminated claystone whose relationship to sandstone is not clear. Not analysed by palynology.		

Table 4: Basic Sample Data - Howmains-1, Otway Basin. Cont...

SAMPLE TYPE	DEPTH (metres)	REC (cm)	LITHOLOGY	SAMPLE WT (g)	RESIDUE YIELD
SWC-13	1887.5	3.7	Med. gry, faintly laminated hard claystone with carbonaceous flecks. Slickensided fractures cut across core (well cleaned).	11.6	High
SWC-10	1904.0	3.0	Med. greenish-grey calc. claystone mixed with green grey sandstone. Sample friable, poorly cleaned, possibly contaminated.	13.5	Low
SWC- 9	1907.0	3.4	Lt greenish-grey non-calcareous brittle claystone (well cleaned/no contamination).	11.3	Very low
SWC- 8	1912.5	<2.0	Lt greenish-grey argillaceous lithic sandstone (not sampled for palynology).		
SWC- 7	1936.0	4.8	Lt and dk grey mottled claystone with carbonaceous flecks (well cleaned)	10.1	High
SWC- 4	1997.0	3.0	Lt greenish grey non-calc. claystone. Fairly brittle, well cleaned sample.	10.9	Very low
SWC- 3	2027.5	<3.0	Lt greenish grey homogeneous clayey siltstone. (Not sampled for palynology, well cleaned.		
SWC- 1	2098.0	<3.0	Med grey homogenous brittle claystone (well cleaned).	11.1	Moderate

Table-5: Basic Palynomorph Data for Howmains-1, Otway Basin.

SAMPLE TYPE	DEPTH (metres)	Palynomorph Concentration	Palynomorph Preservation	No. S-P spp*	Microplankton Abundance	No MP Species*
SWC-30	1036.0	Moderate	Poor	31+	Frequent	2+
SWC-29	1072.0	Moderate	Poor	29+	Rare	6+
SWC-28	1483.0	Very low	Poor	23+	Abundant	10+
SWC-27	1558.0	Moderate	Poor	25+	Abundant	12+
SWC-26	1632.0	Moderate	Poor	30+	Abundant	9+
SWC-25	1663.0	Low	Poor	23+	Frequent	11+
SWC-24	1807.0	Moderate	Poor	24+	Common	11+
SWC-23	1815.0	Moderate	Poor	34+	Abundant	10+
SWC-22	1828.0	Low	Poor	27+	Abundant	15+
SWC-21	1838.0	Moderate	Poor	25+	Very abundant	17+
SWC-20	1847.0	Very low	Poor	18+	Very abundant	17+
SWC-19	1854.0	Low	Poor-fair	23+	Abundant	19+
SWC-18	1860.0	Low	Poor	25+	Common	12+
SWC-15	1882.0	Moderate	Poor-fair	31+	Common	10+
SWC-13	1887.5	Moderate	Poor-fair	35+	Common	11+
SWC-10	1904.0	Moderate	Poor	10+	Very abundant	7+
SWC- 9	1907.0	Very low	Poor	2+		
SWC- 7	1936.0	Moderate	Fair-good	27+	Very rare	1
SWC- 4	1997.0	Very low	Poor	3+		
SWC- 1	2098.0	High	Poor-fair	33+	Very rare	1

*Diversity:				
	Very low	=	1-5	species
	Low	=	6-10	species
	Moderate	=	11-25	species
	High	=	26-74	species
	Very high	=	75+	species