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# Palynological Analysis of Dunbar-1, Port Campbell Embayment, Otway Basin.

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# INTERPRETATIVE DATA

## Introduction

Fourteen sidewall cores samples were analysed in Dunbar-1 with the focus of the palynological investigation concentrated on the Waarre Formation and basal Belfast Mudstone. Age dating is provided for only a short 167 metres interval of the well extending from 1401.0m within the Belfast Mudstone to 1568.0m within the Eumeralla Formation. The palynological zones and ages identified and their correlations to formations or units identified in the well are summarised in Table 1 below. Additional interpretative data with zone identification and Confidence Ratings are recorded in Table 3, whilst basic data on sidewall core lithologies, sample quality and quantities, residue yields, preservation and diversity are recorded on Tables 4 and 5. All species which have been identified with binomial names are tabulated on a composite range chart for both spore-pollen and microplankton which presents the recorded assemblages in order of lowest appearances.

**Table 1: Palynological Summary Dunbar-1.**

| AGE | UNIT | SPORE-POLLEN ZONES | MICROPLANKTON ZONES (SUBZONES) |
|---|---|---|---|
| SANTONIAN | BELFAST MUDSTONE 1349*-1476m | *T. apoxyexinus* 1401.0m | *I. cretaceum* 1401.0m |
| CONIACIAN | | *P. mawsonii* 1467.2-1472.3m | *C. striatoconus* 1467.2-1472.3m |
| TURONIAN | WAARRE FORMATION UNIT D 1476-1482m | *P. mawsonii* 1477.0-1480.2m | *P. infusorioides* 1477.0-1480.2m |
| | WAARRE FORMATION UNIT C 1482-1520m | *P. mawsonii* 1501.2-1505.8m | *P. infusorioides* 1501.2-1505.8m (*C. edwardsii*) 1505.8m |
| | WAARRE FORMATION UNITS A/B 1520-1548m | *P. mawsonii* 1520.6-1544.4m | *P. infusorioides* 1520.6-1544.4m |
| ALBIAN | EUMERALLA FORMATION 1548-1758m (T.D.) | *C. paradoxa* or younger 1552.7-1568.0m | NO ZONES PRESENT |

* Top of Belfast Mudstone in Dunbar-1 is a fault contact.

Between 3.8 to 12.4 grams (average 8 g) of the sidewall cores were cleaned and split by the author then forwarded them to Laola Pty Ltd in Perth for processing. Moderated to high residue yields were extracted from most samples. Kerogen slides were prepared with filtered and unfiltered fractions, and where sufficient

residue was recovered 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.

Overall spore-pollen diversity was high averaging 26+ species per sample (Table 5). Microplankton diversity was moderate averaging 13+ species per sample in the Belfast Mudstone and Unit D of the Waarre Formation between 1401-1480.2m. But diversity was low from the rest of the Waarre and underlying Eumeralla Formation where it ranged from zero to 12 species per sample with an average of less than 5 species per sample. The microplankton abundance data presented in Table 2 was obtained from counts made on slides prepared using 8 micron filter cloth.

## Geological Comments

1. The short sequence analysed from Dunbar-1 spans the time interval of Late Albian to Santonian, and except for some minor modifications most samples can be readily assigned to the Mesozoic spore-pollen and microplankton zones defined by Helby, Morgan & Partridge (1987).

2. The spore-pollen succession analysed commences with two assemblages from the Eumeralla Formation which are no older than the *C. paradoxa* Zone and no younger than the *P. pannosus* Zone. These assemblages are overlain by the *P. mawsonii* Zone which includes all samples from Waarre Formation and basal Belfast Mudstone between 1544.4m and 1467.2m. As has been found in the recently analysed Iona-2, Langley-1, Howmains-1 and the nearby Vaughan-1 wells (Partridge 1994a, b, c, 1995) the Cenomanian *A. distocarinatus* Zone as redefined by Helby Morgan & Partridge (1987) is considered to be absent in Dunbar-1 at the unconformity between the Waarre and Eumeralla Formations. Above the *P. mawsonii* Zone there is a 66-metre gap to the shallowest sample analysed from the middle of the Belfast Mudstone which is assigned to the *T. apoxyexinus* Zone.

3. Marine microplankton were recorded in all but one of the twelve samples from the Waarre Formation and overlying Belfast Mudstone (Table 5). However, as observed in the nearby Vaughan-1 well,the microplankton abundances in Units A to C of the Waarre are notably less than found in either Langley-1 or Howmains-1 suggesting that Dunbar-1, like Vaughan-1, is located closer to the palaeoshoreline. The abundances and diversity of microplankton from the overlying Unit D of the Waarre and the Belfast

Mudstone are, in contrast, interpreted to represent open marine environments.

**Table-2: Microplankton Abundance in Selected Samples in Dunbar-1**

| SAMPLE TYPE | DEPTH (Metres) | Microplankton Zone and (Subzone) | Microplankton Abundance as % Relative to total Spore-pollen and Microplankton Count | Most abundant microplankton species as % of total Microplankton Count |
|---|---|---|---|---|
| SWC 24 | 1401.0 | *I. cretaceum* | 11% | *Heterosphaeridium* spp. >60%. |
| SWC 23 | 1467.2 | *C. striatoconus* | 12% | *Amosopollis cruciformis* ~20%. |
| SWC 22 | 1472.3 | *C. striatoconus* | 12% | *Heterosphaeridium* spp. >50%. |
| SWC 20 | 1477.0 | *P. infusorioides* | 22% | *Heterosphaeridium* spp. >25%.<br>*Cribroperidinium* spp. >25%.<br>*Amosopollis cruciformis* >20%. |
| SWC 19 | 1480.2 | *P. infusorioides* | 12% | *Amosopollis cruciformis* ~40%. |
| SWC 15 | 1505.8 | (*C. edwardsii*) | 10% | No species dominant in low count. |
| SWC 14 | 1520.6 | Indeterminate | «1% | Microplankton too rare to count. |
| SWC 12 | 1531.5 | *P. infusorioides* | <3% | No species dominant in low count. |
| SWC 4 | 1544.4 | *P. infusorioides* | 29% | *Exochosphaeridium* sp. ~35%.<br>*Cyclonephelium* spp. ~20%. |

4. Subdivision of the Waarre Formation into the units proposed by Buffin (1989) is provisionally suggested as follows:

| | |
|---|---|
| Waarre Unit D: | 1476-1482m |
| Waarre Unit C: | 1482-1520m |
| Waarre Unit B: | 1520-1534m |
| Waarre Unit A: | 1534-1548m |

These picks are consistent with palynomorph ranges recorded and units picked in Langley-1 and Vaughan-1. Like in Vaughan-1, the sidewall cores at 1501.5m and 1505.8m are considered to be no younger than the sample from core 1 at 1750m in Langley-1.

5. In Dunbar-1 the Waarre Unit D is taken as the interval below the lowest occurrence of the *C. striatoconus* Zone (or younger zones if the former is missing) to the top of the first clean sand of Unit C. On the electric logs in Dunbar-1 the top is picked at 1476m at the point of increase in the resistivity and sonic logs and at what is considered the best log break above the sample at 1477m. On the gamma ray log the top could be picked slightly lower at 1478m to correspond to a decline in the gamma ray readings. On either pick Unit D is very thin being represented by only 4 to

6 metres of section in contrast to a thickness 15 metres in Langley-1 (Partridge, 1994b) and 20 metres in Iona-2. In the nearby Vaughan-1 well a thickness of 9.5 metres was assigned to Unit D based on the comparison of the distinct spike on the sonic log at 1594m, which was correlated to a similar spike at 1479m in Dunbar-1. Unfortunately, the top of Unit D in Vaughan-1 could not be confirmed by the palynology because the most likely position for the *C. striatoconus* Zone could not be sampled by sidewall cores owing to severe caving problems at the base of the Belfast Mudstone.

6. The oldest unit penetrated in Dunbar-1 is the Eumeralla Formation between 1548-1758m (T.D.). Of the three sidewall cores over this interval only the deeper two were considered suitable to process (Table 4), but the spore-pollen assemblages extracted were poor and provide only an age range from the *C. paradoxa* to the *P. pannosus* Zones.

## Biostratigraphy

The zone and age determinations are based on the Australia wide Mesozoic spore-pollen and microplankton zonation schemes described by Helby, Morgan & Partridge (1987). Author citations for most spore-pollen species can be sourced from Helby, Morgan & Partridge (1987), Dettmann (1963), Stover & Partridge (1973) or other references cited herein, whilst author citations for dinoflagellates can be found in the index of Lentin & Williams (1993). Species names followed by "ms" are unpublished manuscript names.

***Tricolporites apoxyexinus* spore-pollen Zone**
**and**
***Isabelidinium cretaceum* microplankton Zone.**
**Interval: 1401.0 metres.**
**Age: Santonian.**

The shallowest sample analysed is assigned to this zone on the presence of the eponymous species *Tricolporites apoxyexinus* and the associated secondary index species *Latrobosporites amplus* and *L. ohaiensis*. In composition the sample is characterised by the incoming of significant angiosperm pollen comprising >19% of the spore-pollen count. The most abundant angiosperms are small varieties of *Proteacidites* spp. at 9% and *Australopollis obscurus* at 5%. The sample also contains common microplankton which are assigned to the *I. cretaceum* Zone on the presence of frequent specimens of both *Amphidiadema denticulata* and *Isabelidinium rotundatum* ms and rare specimens of *Isabelidinium thomasii* in an assemblage dominated by *Heterosphaeridium* spp.

***Phyllocladidites mawsonii* spore-pollen Zone**

(formerly the *Clavifera triplex* Zone).

**Interval: 1467.2-1544.4 metres** (77+ metres).

**Age: Turonian-Coniacian.**

The eleven 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 is represented by the six samples between 1505.8-1544.4m and probably should also include the sample at 1501.2m, which gave a high residue yield with unfortunately only a very low concentration of palynomorphs. The subzone is characterised by the consistent and occasionally frequent occurrence of *Hoegisporis trinalis* ms and *Appendicisporites distocarinatus* associated with rare *Stoverisporites microverrucatus*. Other species considered diagnostic of this lower subzone were either rare or not recorded in Dunbar-1. Although the eponymous species *Phyllocladidites mawsonii* was not recorded to overlap with *H. trinalis* ms this is not of concern as the occurrence of *P. mawsonii* near the base of its range is both very rare and variable. The same comments are true for the base range of *Clavifera triplex* in the Otway Basin which in this well was found as deep as 1535.9m before the deepest occurrence of *P. mawsonii* at 1477m. As this is the reverse of the situation in the other wells recently analysed it would surely be refuted if additional slides were prepared and examined.

The upper subzone is characterised by the extension of the ranges of *Rugulatisporites admirabilis* ms and *Laevigatosporites musa* ms above the last occurrence of *H. trinalis* ms and an increase in abundance of the gymnosperm pollen *Cupressacites* sp. and *Dilwynites* spp. The occurrence of the distinctive spore *Clavifera vultuosus* ms at the top of the zone in the two samples containing the dinoflagellate *Conosphaeridium striatoconus* suggests that a further subdivision of the *P. mawsonii* Zone may be possible.

Overall the *P. mawsonii* Zone assemblages are very similar those recorded in other recent wells examined (*loc. cit.*). A character which distinguishes all assemblages from the *P. mawsonii* Zone from those in the underlying Eumeralla Formation is the consistent and common occurrence of *Gleicheniidites circinidites* in nearly all samples.

***Conosphaeridium striatoconus* microplankton Zone.**
**Interval: 1467.2-1472.3 metres** (5+ metres).
**Age: Coniacian.**

Two samples are assigned to this zone on the occurrence of the eponymous species *C. striatoconus* and absence of both *Kiokansium polypes*, characteristic of the underlying *P. infusorioides* Zone, and species of *Odontochitina* and *Isabelidinium* diagnostic of the immediately younger zones. The moderate diversity assemblages recorded from the two samples are dominated by *Heterosphaeridium* spp. and *Amosopollis cruciformis* and lack other species considered diagnostic of the zone.

***Palaeohystrichophora infusorioides* microplankton Zone.**
**Interval: 1477.0-1544.4 metres** (67+ metres).
**Age: Turonian.**

The samples identified as belonging to the *P. infusorioides* Zone, like others recently analysed from the Port Campbell Embayment (Partridge, 1994a, b, c; 1995), are assigned to the zone on negative evidence. All lack the key index species of the underlying *D. multispinum* Zone, yet lie below the FAD (First Appearance Datum) for *Conosphaeridium striatoconus* which defines the next youngest zone. In Dunbar-1 the total assemblage recorded from the zone is comprised of 25+ dinoflagellate and 6+ algal or acritarch species, all of which are known to have long ranges extending into both older and younger zones. Confidence in the zone assignment is therefore dependant, firstly, on the fact that the composite assemblage from the zone can be considered to have a high diversity yet still lack older or younger index species and, secondly, because it reproduces similar results obtained the other recently analysed wells.

***Cribroperidinium edwardsii* Subzone.**
**Interval: 1505.8.0 metres**
**Age: Turonian.**

The *Cribroperidinium edwardsii* Subzone was originally recognised and defined with the concept of an acme zone in the Iona-2 and Langley-1 wells (Partridge 1994a, b). However, in Dunbar-1 the zone is not clearly identified. Although *C. edwardsii* occurs as the most prominent *Cribroperidinium* species at 1505.8m, it is not the dominant or even the most conspicuous species in the sample. Nevertheless, this sample is the best candidate for the zone. Other occurrences include only a tentative identification of *C. edwardsii* at 1531.5m and its presence as rare specimens amongst a similar but non-verrucate *Cribroperidinium*

species at 1477m. This latter sample is not typical of concept the *C. edwardsii* acme in Iona-2 and Langley-1 as it contains abundances of both *Heterosphaeridium* spp. and *Amosopollis cruciformis*, which in other wells occur above the *C. edwardsii* acme. Similar difficulties with identification of the subzone were reported from the nearby Vaughan-1 (Partridge, 1995). It would appear the difficulty with identifying the subzone is related to the overall reduction in abundance of microplankton through the lower part of the Waarre Formation in these two wells.

***Coptospora paradoxa* spore-pollen Zone or younger.**
**Interval: 1552.7?-1568.0 metres.**
**Age: Late Albian.**

The two samples analysed from the Eumeralla Formation are no older than the *C. paradoxa* Zone on presence of the eponymous species in the deeper sample, but could just as easily belong to the younger *P. pannosus* Zone as both assemblages are poor. The lithological character supports the assignment along with the frequent occurrence of *Corallina torosa* in the shallower sample, as this is a typical character of Eumeralla assemblages analysed from the *P. pannosus* Zone.

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## Table-3: Interpretative Palynological Data for Dunbar-1, Otway Basin.

| Sample | Depth Metres | Spore-Pollen Zone | *CR | Microplankton Zones and (Subzone) | *CR | Comments and Key Species |
|---|---|---|---|---|---|---|
| SWC 24 | 1401.0 | *T. apoxyexinus* | B4 | *I. cretaceum* | B3 | FADs for *Isabelidinium rotundatum* ms and *Amphidiadema denticulata*. |
| SWC 23 | 1467.2 | *P. mawsonii* | B2 | *C. striatoconus* | B3 | LAD of *C. striatoconus* with *Clavifera vulluosus* ms |
| SWC 22 | 1472.3 | *P. mawsonii* | B2 | *C. striatoconus* | B2 | FADs for *Conosphaeridium striatoconus* & *C. vulluosus* ms. |
| SWC 20 | 1477.0 | *P. mawsonii* | B4 | *P. infusorioides* | B3 | LADs of *Klokansium polypes* and *Rugulatisporites admirabilis* ms. Assemblage contains common *Cribroperidinium* sp. |
| SWC 19 | 1480.2 | *P. mawsonii* | B2 | *P. infusorioides* | B4 | LAD of *Laevigatisporites musa* ms. |
| SWC 16 | 1501.2 | *P. mawsonii* | B4 | | | LAD of *Appendicisporites distocarinatus* in sample with low fossil concentration. |
| SWC 15 | 1505.8 | *P. mawsonii (H. trinalis)* | B2 | *P. infusorioides (C. edwardsii)* | B3 | LAD of *Hoegisporis trinalis* ms |
| SWC 14 | 1520.6 | *P. mawsonii (H. trinalis)* | B3 | | | Similar to overlying sample, but lacking key microplankton. |
| SWC 12 | 1531.5 | *P. mawsonii (H. trinalis)* | B2 | *P. infusorioides* | B4 | *Cribroperidinium edwardsii* possibly present. |
| SWC 9 | 1535.9 | *P. mawsonii (H. trinalis)* | B3 | | | Very low yield with *H. trinalis* present. |
| SWC 8 | 1538.3 | *P. mawsonii* | B5 | | | Low yield sample lacking key index species. |
| SWC 4 | 1544.4 | *P. mawsonii (H. trinalis)* | B2 | *P. infusorioides* | B2 | Typical basal Waarre microplankton assemblage. FAD *H. trinalis* ms and *R. admirabilis* ms. |
| SWC 2 | 1552.7 | Indeterminate | | | | Frequent *Corallina torosa* and marked jump in maturation suggests sample is from Eumeralla Formation |
| SWC 1 | 1568.0 | *C. paradoxa* or younger. | | | | *Coptospora paradoxa* frequent without younger index species. |

*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 - Dunbar-1, Otway Basin.

| SAMPLE TYPE | DEPTH (Metres) | REC (cm) | LITHOLOGY | SAMPLE WT (g) | RESIDUE YIELD |
|---|---|---|---|---|---|
| SWC 24 | 1401.0 | 4.1 | Dark brown-grey mainly homogeneous claystone. Well cleaned | 11.1 | High |
| SWC 23 | 1467.2 | 4.0 | Dark brown homogeneous claystone. No obvious glauconite. Well cleaned | 10.2 | High |
| SWC 22 | 1472.3 | 4.2 | Dark brown grey homogeneous claystone. No obvious glauconite. Well cleaned | 11.8 | High |
| SWC 20 | 1477.0 | 3.4 | Dark brown grey claystone, trace glauconite and pyrite, very fine. Small shark tooth observed on broken surface. Well cleaned. | 12.4 | Moderate |
| SWC 19 | 1480.2 | 2.3 | Medium grey to brown pyritic claystone. Pyrite nodule 7mm diam. and shelly fossil fragments present. Well cleaned. | 6.9 | Moderate |
| SWC 16 | 1501.3 | 3.4 | Light grey very coarse sandstone with 2mm thick carbonaceous laminae. Moderately well cleaned. | 7.6 | High |
| SWC 15 | 1505.8 | 2.3 | Medium grey claystone. Sample soft, mud penetrated. Poorly cleaned. | 7.1 | High |
| SWC 14 | 1520.6 | 3.0 | Dark grey claystone with minor <2mm white sandstone laminae. Moderately well cleaned, some mud penetration. | 8.4 | High |
| SWC 12 | 1531.5 | <2.0 | Medium brown soft claystone badly mud contaminated. Not cleaned. | 5.4 | High |
| SWC 9 | 1535.9 | 3.0 | Light brown grey fine grained sandstone with argillaceous matrix and lithic grains. Sample very soft but well cleaned. | 7.6 | Low |
| SWC 8 | 1538.3 | 2.6 | Light brown grey very fine sandstone. Similar to SWC 9. Sample soft but well cleaned. | 7.0 | Low |
| SWC 4 | 1544.4 | 2.5 | Dark brown grey homogeneous claystone with 3mm laminae of medium grey sandstone. Well cleaned. | 8.4 | Moderate |
| SWC 3 | 1548.2 | 3.0 | Light grey fine grained sandstone with white argillaceous matrix. Not processed. | | |
| SWC 2 | 1552.7 | 2.0 | Medium grey fine grained sandstone with argillaceous matrix with irregular clasts of medium grey claystone. Moderately well cleaned. | 3.8 | Low |
| SWC 1 | 1568.0 | <1.5 | Medium grey brown subfissil claystone. Mud penetrated. Poorly cleaned. | 4.3 | High |

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

| SAMPLE TYPE | DEPTH (Metres) | Palynomorph Concentration | Palynomorph Preservation | Number S-P Species* | Microplankton Abundance | Number MP Species* |
|---|---|---|---|---|---|---|
| SWC 24 | 1401.0 | Moderate | Fair | 32+ | Common | 11+ |
| SWC 23 | 1467.2 | Moderate | Fair | 33+ | Common | 9+ |
| SWC 22 | 1472.3 | Moderate | Poor-fair | 40+ | Common | 16+ |
| SWC 20 | 1477.0 | Moderate | Fair | 34+ | Abundant | 20+ |
| SWC 19 | 1480.2 | Low | Poor-fair | 29+ | Common | 11+ |
| SWC 16 | 1501.3 | Very low | Fair | 11+ | NR | |
| SWC 15 | 1505.8 | Low | Fair | 31+ | Common | 10+ |
| SWC 14 | 1520.6 | Moderate | Fair-good | 34+ | Very rare | 2+ |
| SWC 12 | 1531.5 | Moderate | Fair-good | 32+ | Frequent | 6+ |
| SWC 9 | 1535.9 | Low | Poor-good | 16+ | Very rare | 1+ |
| SWC 8 | 1538.3 | Low | Poor | 19+ | Very rare | 1+ |
| SWC 4 | 1544.4 | High | Poor | 31+ | Abundant | 12+ |
| SWC 2 | 1552.7 | Low | Very poor | 11+ | NR | |
| SWC 1 | 1568.0 | Moderate | Very poor | 15+ | Frequent | 2+ |

***Diversity:**

| | | |
|---|---|---|
| Very low | = | 1-5 species |
| Low | = | 6-10 species |
| Moderate | = | 11-25 species |
| High | = | 26-74 species |
| Very high | = | 75+ species |
| NR | = | Not recorded in sample |