# Palynological analysis of the interval 837 to 1359 metres in Loch Ard–1, Otway Basin.

by

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**Biostrata Report 2000/3**

**12 March 2000**

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## Summary

In this report relinquished palynological slides from 15 samples (12 sidewall cores and 3 cuttings) are analysed from Loch Ard–1, over a ~520 metre interval between 837 and 1344–59 metres. The section analysed extends from the upper part of the Eumeralla Formation into the lower Sherbrook Group, and a summary of the identified palynological zones, their ages, and the suggested correlation of the section to the revised stratigraphy of the Sherbrook Group is provide below:

**Table–1: Palynological summary for Loch Ard–1.**

| AGE | EQUIVALENT LITHOLOGICAL UNIT | SPORE–POLLEN ZONES & Subzones | MICROPLANKTON ZONES & Subzones |
|---|---|---|---|
| CONIACIAN | BELFAST MUDSTONE unit A equivalent ?828–908m | *P. mawsonii* Zone and *C. vultuosus* Subzone 837m | *C. striatoconum* Zone 837m |
| TURONIAN | FLAXMAN FORMATION equivalent ?908–1017m | *P. mawsonii* Zone and *G. ancorus* Subzone 915†–954m | *P. infusorioides* Zone and *K. polypes* Subzone 915†–954m |
| TURONIAN | WAARRE FORMATION ?1017m–1326m<br>Subdivided into Unit C ?1017m–1179m Unit B ?1179m–1210m Unit A ?1210–1326m | *P. mawsonii* Zone 1022m–1200m<br>*L. musa* Subzone 1022m<br>*H. trinalis* Subzone 1107–1200m | *P. infusorioides* Zone 1022m–1200m<br>*C. edwardsii* Subzone 1188m–1200m |
| LATE ALBIAN | EUMERALLA FORMATION ?1326–1397m T.D. | *C. paradoxa* Zone 1344–59†m | Not zoned. |

† Depths from cuttings samples

Detailed interpretative data on all samples, including zone identifications and Confidence Ratings and environmental interpretation are recorded in Table 2, whilst basic data on sidewall core lithologies, number of palynological slides, visual residue yields, preservation and species diversity are presented on Table 3. Counts of selected samples are recorded on Table 4 and distribution of selected palynomorphs are presented on Table 5.

## Materials and Methods

The study is based on relinquished palynological slides were borrowed from the Department of Natural Resources and Environment. The interval analysed from 837–1359m is equivalent to the lower part of the Belfast Mudstone to the upper part of the Eumeralla Formation, based on the latest understanding of the relationship between the palynological zones and formations derived from recent studies in the Port Campbell Embayment (Fig.1; Partridge, 1994, 1997, 1999).

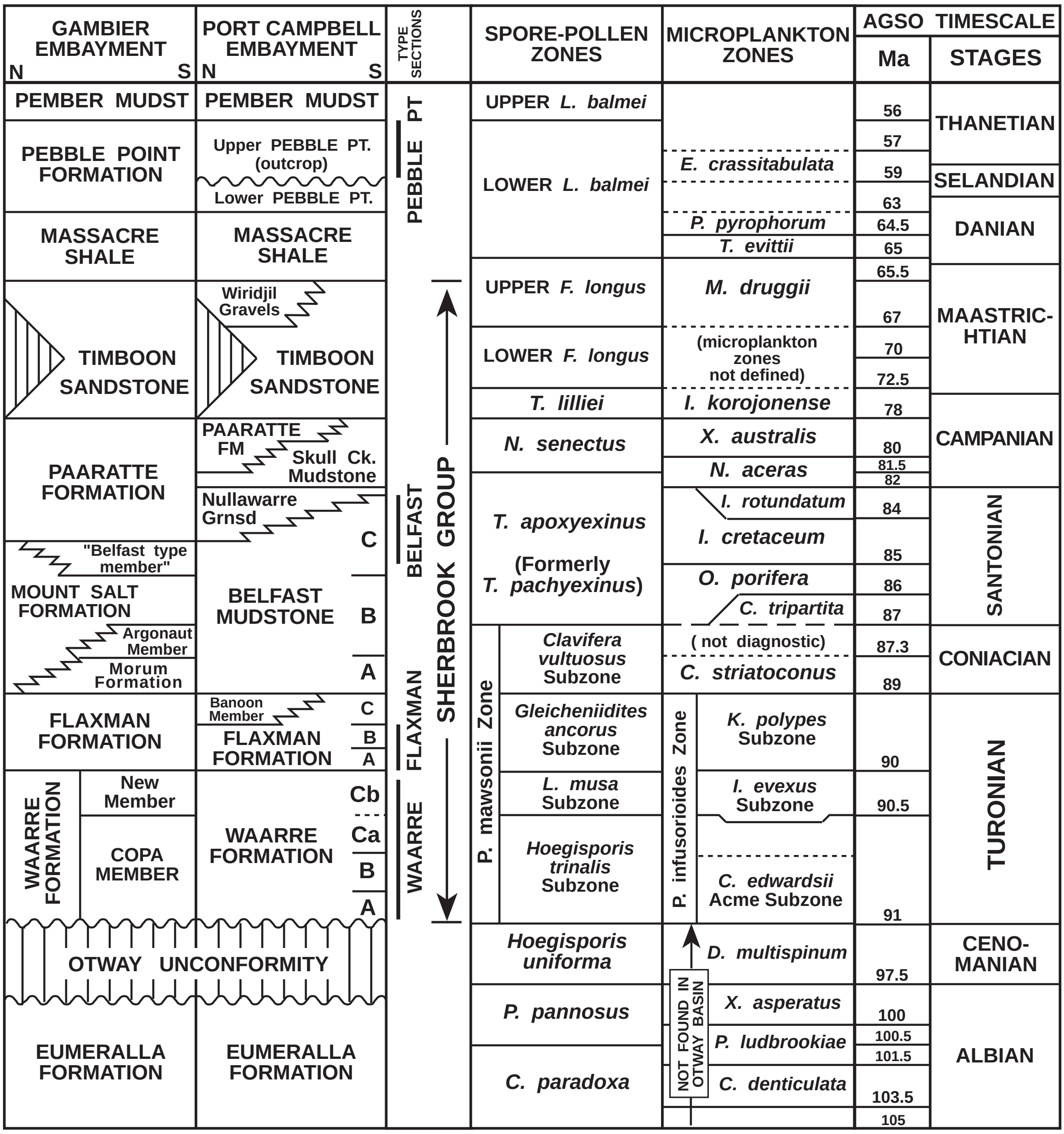


Figure 1. Revised Sherbrook Group stratigraphy, palynological biostratigraphy and proposed correlation to international stages and AGSO chronometric timescale (Young & Laurie, 1996).

Additional relinquished palynological slides from Loch Ard–1 were also available for another 8 sidewall cores and one cuttings sample from the upper Sherbrook Group between 402.5 and 820m, but these slides were not reviewed as part of this study. The Basic Data range chart prepared by Dr Roger Morgan in April 1994, and included in the Well Completion Report was available during the study, but not the final interpretative written report.

Based on the number of palynological slides in the relinquishment collection, eleven samples gave moderate to high yields, while the remaining four samples gave very low yields and are effectively barren (Table 3). Concentration of palynomorphs on the slides from the productive samples is moderate to high, with spore-pollen diversity also mainly moderate to high. In contrast, micro-plankton diversity is low in the Eumeralla and Waarre Formation, but moderate in the overlying Flaxman Formation and Belfast Mudstone. Preservation of the palynomorph is mainly fair to good. The few poorly preserved samples are the result of over-oxidation of the palynomorphs during sample preparation.

The assemblage abundances given on Table 4 were counted under a x40 objective (usually on slides sieved at 10μm), and although providing a good approximation of the abundance of the major species groups they cannot be considered accurate to better than about ±1%. On tables and in text the abundance of spore-pollen species is always expressed as a percentage of the spore-pollen count. In contrast, the microplankton abundances are generally expressed as percentage of combined spore-pollen and microplankton count (eg. Table 2), but abundance of individual genera/species are given as percentages of just the microplankton count on Table 4. Because of the mostly low numbers of microplankton counted in the samples (between 1 and 58 specimens) the relative abundance of individual species is not particularly reliable. Larger counts of the microplankton was not practical under the designated scope of this study.

## Palaeoenvironments

The palaeoenvironments assigned to the samples on Table 2 is based on consideration of 1) abundance, diversity and type of microplankton in the palynological assemblage, 2) the way the spore-pollen composition is skewed by changes in abundance of different species, and 3) the lithology of the samples. The various environmental categories distinguished and their corresponding lithological and palynological characteristics are summarised on Figure 2.

| ENVIRONMENT | TYPICAL LITHOLOGIES | CHARACTERISTICS OF PALYNOLOGICAL ASSEMBLAGES |
|---|---|---|
| **NON-MARINE** — including marsh, overbank, fluviatile and alluvial environments | **Coals** and **carbonaceous mudstones** | **Microplankton** absent to extremely rare, all non-marine species. **Spore-pollen** assemblages skewed with high abundances of certain species. Diagnostic species include gymnosperm pollen: *Phyllocladidites mawsonii, P. eunuchus, Trichotomosulcites subgranulatus* and spores: *Gleicheniidites* spp., *Cyathidites* spp. *Cicatricosisporites* spp., and *Ruffordiaspora* spp. |
| **LACUSTRINE** — mostly moderately long-standing fresh-water lakes on coastal plain. Ephemeral lakes mostly lack microplankton. | **Mudstones** to **siltstones** — massive or laminated | **Microplankton** diversity low (1 to 3 species), abundance usually low, but if high normally dominated by single species. Characteristic species: *Amosopollis cruciformis, Sigmopollis carbonis* and *Micrhystridium* sp. A. **Spore-pollen** assemblages less skewed but in large palaeolakes can show Neves effect characterised by abundance of *Dilwynites* spp. |
| **PARALIC** — marine incursions extending landward of palaeoshoreline. Includes coastal lagoons, estuaries and interdistributary bays. But only lagoons have unique microplankton and algae. | **Mudstones** to **sandstones** — laminated, mottled (burrowed), carbonaceous, pyritic. | **Microplankton** diversity low to moderate (3 to ~8 species), abundance low to moderate (1% to ~10%). Characterised by marine, brackish and cosmopolitan forms. Typical species include: *Amosopollis cruciformis, Heterosphaeridium* spp., *Cribroperidinium edwardsii* and algae *Botryococcus braunii*. **Spore-pollen** assemblages typically homogenous. |
| **NEARSHORE MARINE** — or proximal marine immediately offshore from palaeoshoreline. | **Mudstones** to **sandstones** — laminated, pyritic, burrowed, slightly calcareous, rare glauconite, but still carbonaceous. | **Microplankton** diversity low to moderate (>3 to <12 species), abundance moderate (>5% to <30%). Contains most marine species often associated with an abundance of forms washed out of the paralic environments. **Spore-pollen** assemblages typically homogenous. |
| **OFFSHORE MARINE** — or distal marine equivalent to middle and outer neritic environments. | **Mudstones** to **sandstones** — glauconitic, pyritic, calcareous, sparsely carbonaceous. | **Microplankton** diversity increases to >10 species and abundance >10%, with abundances of species often variable between samples. **Spore-pollen** assemblages generally show distinct Neves effect with abundance of *Dilwynites* pollen. |
| **OCEANIC MARINE** — outer shelf to slope environments. | **Mudstones** — often glauconitic, calcareous, pyritic. | **Microplankton** diversity >15 or 20 species and abundance >30%, with abundances of species often variable between samples. **Spore-pollen** often poorly preserved, with consequent increased prominence of more robust spores. Neves effect still present in better preserved assemblages. |

**Figure 2.** Empirical model for palaeoenvironments in Sherbrook Group.

## Biostratigraphy

The zone and age determinations are based on the Australia wide Mesozoic spore-pollen and microplankton zonation schemes described by Helby *et al.* (1987), with finer resolution provided by new subzones (Fig.1). The latter are based on extensive unpublished work in the onshore Port Campbell Embayment (eg. Partridge, 1994, 1997, 1999). Identification of zones is determined from the presence/absence of key species recorded in Table 5, supported by the changes in assemblage composition recorded by the abundance data (Table 4). Preparation of a comprehensive range chart showing distribution of all species recorded was not commissioned as part of this review study, and is likely to be deferred until completion of re-examination of the shallower samples in well.

Author citations for most spore-pollen species can be sourced from Helby *et al.* (1987), Dettmann (1963), Stover & Partridge (1973) or other references cited herein, whilst author citations for dinoflagellates can be found in the index of Williams *et al.* (1998). Species names followed by “ms” or are unpublished manuscript names.

***Phyllocladidites mawsonii*** **spore–pollen Zone**
**Interval: 837 to 1200 metres.**
**Age: Turonian–Coniacian.**
This zone was identified in ten samples over approximately 160 metres, with the eponymous species *Phyllocladidites mawsonii*, and the former index species *Clavifera triplex* recorded from 7 out of the 10 samples. The absence of both species from the three samples from 1186 to 1200m is not age significant, but rather reflects limited time/effort expended on these samples for this project. The deepest 5 samples in the interval are assigned to the *H. trinalis* Subzone, the *L. musa* Subzone is recorded from a single sample, the *G. ancorus* Subzone is recorded in two samples, and the *C. vultuosus* Subzone is recorded from the shallowest sample. Most samples show some marine influence. Further details of the assemblages from the *P. mawsonii* Zone are provided under the discussion of the subzones.

***Clavifera vultuosus*** **spore-pollen Subzone**
**and**
***Conosphaeridium striatoconum*** **microplankton Zone**
**Sample at: 837 metres.**
**Age: Coniacian.**
The sidewall core at 837m contains a high diversity spore-pollen assemblage and moderate diversity microplankton assemblage, which are assigned to the respective zones on the presence of the eponymous species. Accessory microplankton present confirming the age are *Isabelidinium balmei*, *Trithyrodinium* spp. and *Xenascus australis*. The spore-pollen assemblages are dominated by bisaccate pollen referred to *Podocarpidites* (27%) and the spores *Gleicheniidites circinidites* (10%) and *Cyathidites* (10%), while the microplankton assemblage is dominated by the colonial algae *Amosopollis cruciformis* (19% of combined SP and

MP count[1]) and marine dinoflagellate cysts of *Heterosphaeridium* spp. (4% of combined count). The overall abundance (31%) and diversity (12 species) of the microplankton combined with the moderate abundance of *Dilwynites* (12%) and *Cupressacites* (8.5%) pollen, which are diagnostic of a mild Neves effect (Traverse, 1988), is suggestive of an offshore environment of deposition.

The underlying cuttings at 875-90m could belong to these zones based on the similarities of the count data, but as the sample clearly contains a significant caved component from the shallower *T. apoxyexinus* SP Zone and *C. tripartita* MP Subzone (present in sidewall core at 820m) it is best either left as indeterminate or referred to the broader *P. mawsonii* Zone with low confidence.

***Palaeohystrichophora infusorioides* microplankton Zone.**
**Interval: 915 to 1200 metres.**
**Age: Turonian.**
Although microplankton are recorded from most of the underlying *P. mawsonii* SP Zone, none of the samples individually contain sufficiently diverse assemblages to provide confident assignment to the *P. infusorioides* Zone. Combined however, the amalgamated assemblage from all samples is entirely consistent with this zone identified in other wells in the Otway Basin. The identification of the *K. polypes*, and *C. edwardsii* Acme Subzones is based solely on a few key species.

***Gleicheniidites ancorus* spore-pollen Subzone**
**and**
***Kiokansium polypes* microplankton Subzone.**
**Interval: 915 to 954 metres.**
**Age: Late Turonian to Coniacian?**
The two samples are assigned to these subzones on the presence of the eponymous species *Gleicheniidites ancorus* ms and *Kiokansium polypes*, in association with the dinoflagellate cyst *Valensiella griphus*, which is restricted to the *K. polypes* Subzone in the Otway Basin. The LADs[2] for the spores *Appendicisporites distocarinatus, Laevigatosporites musa* ms and *Verrucosisporites admirabilis* ms in the sidewall core at 954m is consistent with the zone assignment. The spore-pollen assemblages are dominated by *Podocarpidites* and the microplankton assemblage by *Amosopollis cruciformis*. Moderate microplankton diversity and abundance favours a marine environment of deposition, with sample at 954m the more distal based on the abundance of *Dilwynites* pollen (20%).

[1] SP = Spore-pollen; MP = Microplankton
[2] LAD = Last Appearance Datum

***Laevigatosporites musa* spore–pollen Subzone**
**Sample at: 1022 metres.**
**Age: Mid? Turonian.**

The *L. musa* Subzone was originally defined as the interval between the LAD for *Hoegisporis trinalis* ms, and the youngest consistent/prominent occurrence of *Laevigatosporites musa* ms, which usually occurs before the FAD[3] for *Gleicheniidites ancorus* ms. However, recent analyses of samples from the top of the Waarre Formation in the Iona and Mylor fields in the onshore Port Campbell Embayment, and from the adjacent Eric the Red–1, have extended the range of *Hoegisporis trinalis* ms to nearer the top of the Waarre Formation and potentially through the entire *L. musa* Subzone. As a consequence of these findings the base of the *L. musa* Subzone is identified on alternative criteria, consisting of the FAD of *Tricolporites variverrucatus* ms, and the oldest occurrence of significant abundances of the colonial algae *Amosopollis cruciformis*, which at 1022m represents 7% of total SP and MP count. Although the dinoflagellate *Isabelidinium evexus* ms, could be expected to occur in this assemblage it was not found.

The spore-pollen assemblage at 1022m is dominated by gymnosperm pollen (72%), with the alete pollen *Dilwynites* spp. (21%) and *Araucariacites australis* (11%) the most prominent suggesting a Neves effect. However, the microplankton are not particularly diverse (7 species) nor abundant (12%), and therefore a nearshore marine or paralic environment of deposition is considered more likely.

***Hoegisporis trinalis* spore–pollen Subzone**
**Interval: 1107 to 1200 metres.**
**Age: Early? Turonian.**

The *H. trinalis* Subzone is here identified as the interval from the LAD of Cenomanian species *Hoegisporis uniforma* to the FAD of *Tricolporites variverrucatus* ms. The eponymous species is recorded from three out five samples, and the spores *Appendicisporites distocarinatus* from four out of five samples. Other index species are sporadic, largely reflecting limited searching of the palynological slides. The assemblages at 1150m and 1186m are non-marine and dominated by the spores of *Gleicheniidites circinidites* (average 44%), while the other samples are dominated by gymnosperm pollen (average 50%) and spores of *Cyathidites* (average 27%), and represent paralic or near-shore marine environments. The assemblage from 1107m with 22% *Dilwynites* pollen probably represents the most distal marine environment. The assemblage at 1188m is unusual as it contains over 10% reworked Early Cretaceous and Permian palynomorphs.

[3] FAD = First Appearance Datum

***Cribroperidinium edwardsii* microplankton Acme Subzone.**
**Interval: 1188 to 1200 metres.**
**Age: Early? Turonian.**
Similar to the situation found in the adjacent Eric the Red–1 well (Partridge, 2000), both samples contain a low diversity and abundance of microplankton, making it difficult to assess the relative abundance of species. Consequently, the samples are assigned to the subzone solely on the total range of *Cribroperidinium edwardsii* observed in Loch Ard–1.

***Coptospora paradoxa* spore-pollen Zone**
**Cuttings at: 1344–59 metres**
**Age: Late Albian.**

The age of the bottom ~190 metres in Loch Ard–1 is poorly constrained. The sidewall cores at 1208m and 1329m gave low yields with the species recorded either long ranging or obvious caved contaminants, making the age of both samples indeterminate. The cuttings at 1344–59m also contained a mixed assemblage, but the presence of multiple specimens of *Coptospora paradoxa, Crybelosporites striatus* and *C. megastriatus* ms provide sufficient evidence for a confident assignment to the *C. paradoxa* Zone. Environment of deposition is non-marine although the lacustrine microplankton *Micrhystridium* sp. A and *Circulisporites parvus* were recorded.

## Conclusions and Recommendations

This new palynological study of Loch Ard–1 has confirmed the presence of the Albian *C. paradoxa* Zone in the Eumeralla Formation, and established that the lower Sherbrook Group samples all belong to the Turonian to Coniacian *P. mawsonii* Zone. This zone can be further subdivided into the *H. trinalis* and *L. musa* Subzones which are stratigraphically equivalent to the Waarre Formation, the *G. ancorus* Zone equivalent to the Flaxman Formation, and the *C. vultuosus* Subzone considered equivalent to unit A of the Belfast Mudstone (Fig.1). Associated microplankton in the Sherbrook Group are assigned to the *C. edwardsii* and *K. polypes* Subzones of the *P. infusorioides* Zone, and the succeeding *C. striatoconum* Zone. However, relative to age equivalent sections in wells examined from the onshore Port Campbell Embayment the lower Sherbrook Group sequence in Loch Ard–1 is clearly less marine, and many diagnostic spore-pollen and microplankton species were either not recorded or are difficult to find in these more non-marine assemblages.

Based on the identification of the palynological subzones, combined with the electric logs and sidewall core lithologies, a provisional subdivision of the

Sherbrook Group, according to the traditional formations erected in the Port Campbell Embayment, is proposed in Table 1.

Unfortunately, picking the precise location of the formation boundaries is still difficult because the interval studied is poorly sampled for palynology, with an effective sample spacing of >50 metres. However, substantial improvement could be achieved with additional palynological analysis of the following samples:

| Sample Type | Depth | Lithology |
|---|---|---|
| Cuttings | 900–05m | Shale on gamma log |
| SWC 59 | 970m | Claystone |
| SWC 58 | 988m | Claystone |
| SWC 57 | 1003m | Argillaceous sandstone |
| SWC 55 | 1027m | Interlaminated siltstone/claystone |
| SWC 49 | 1137m | Argillaceous siltstone |
| SWC 47 | 1154m | Interlaminated sandstone/claystone |
| SWC 46 | 1155.5m | Silty claystone |
| SWC 42 | 1194m | Coal |
| SWC 40 | 1205m | Interlaminated coal/claystone |
| SWC 36 | 1278m | Interlaminated sandstone/claystone |
| SWC 32 | 1326m | Argillaceous sandstone and coal |

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## Confidence Ratings

The Confidence Ratings assigned to the zone identifications on Table 2 are quality codes used in the STRATDAT relational database 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. |

## Species Diversity

The use of relative diversity terms equate to the following number of species. Both spore-pollen and microplankton diversity excludes reworked or caved species in the samples.

| | | | |
|---|---|---|---|
| Low | = | 1–10 | species |
| Moderate | = | 11–25 | species |
| High | = | 26–74 | species |
| Very high | = | 75+ | species |

## Table 2: Interpretative Palynological Data for Loch Ard–1

| Sample Type | Depth (m) | Spore-Pollen Zone (or Subzone) | CR | Microplankton Zone (or Subzone) | CR | Marine MP% | Ac% | Total MP% | Environment from palynology | Comments & Key Species Present |
|---|---|---|---|---|---|---|---|---|---|---|
| SWC 10 | 837 | *C. vultuosus* | B1 | *C. striatoconum* | B2 | 12% | 19% | 31% | Marine/offshore | FADs of *Conosphaeridium striatoconum* and *Clavifera vultuosus* ms. |
| Cuttings | 875–90 | *P. mawsonii* | D5 | | | 7% | 7% | 14% | Marine/offshore | Sample contains significant caved component from overlying *T. apoxyexinus* and *C. tripartitus* Zones. |
| Cuttings | 915–25 | *G. ancorus* | D1 | *K. polypes* | D2 | 6% | 6% | 12% | Marine/nearshore | LADs for *Kiokansium polypes* and *Valensiella griphus* . |
| SWC 1 | 927 | Indeterminate | | | | | | | Indeterminate | Essentially BARREN slides contain mainly angular opaques and modern pollen contaminants. |
| SWC 60 | 954 | *G. ancorus* | B1 | *K. polypes* | B2 | 4% | 6% | 10% | Marine/offshore | FADs for *Gleicheniidites ancorus* ms and *V. griphus.* |
| SWC 56 | 1022 | *L. musa* | B1 | | | 5% | 7% | 12% | Marine/nearshore to Paralic | LAD of Hoegisporis trinalis ms and<br>FAD of Tricolporites variverrucatus ms |
| SWC 54 | 1048 | Indeterminate | | | | | | | Indeterminate | Essentially BARREN. Slides dominated by mineral matter with only rare palynomorphs. |
| SWC 51 | 1107 | *H. trinalis* | B4 | | | <1% | X | <1% | Paralic to nearshore marine | *Dilwynites* spp. 22%, *Cyathidites* spp. 27% |
| SWC 48 | 1150 | *H. trinalis* | B1 | | | X | | | Non-marine | LAD of frequent *Appendicisporites distocarinatus* in assemblage with abundant *Gleicheniidites* 54%. |
| SWC 44 | 1186 | *H. trinalis* | B4 | | | | | | Non-marine | LAD of *Laevigatosporites musa* ms with *Gleicheniidites* 35%. |
| SWC 43 | 1188 | *H. trinalis* | B4 | *C. edwardsii* | B3 | 3% | | 3% | Paralic to nearshore marine | Permo-Triassic and Early Cretaceous reworking conspicuous. |
| SWC 41 | 1200 | *H. trinalis* | B1 | *C. edwardsii* | B3 | 6% | <1% | 6% | Paralic to nearshore marine | FADs of *Hoegisporis trinalis* ms and *Cribroperidinium edwardsii.* |
| SWC 39 | 1208 | Indeterminate | | | | | | | Non-marine | BARREN slides contain angular opaque kerogen and mineral matter. |
| SWC 31 | 1329 | Indeterminate | | | | | | | Non-marine | Essentially BARREN. Most palynomorphs appear to be caved. |
| Cuttings | 1344–59 | *C. paradoxa* | D1 | | | | | 2% | Non-marine | LAD *Coptospora paradoxa* in spore dominated assemblage. |

CR = Confidence Rating
NR = Not recorded

MP% = Microplankton
Ac% = *Amosopollis cruciformis* %
X = Present in sample but not in count.

## Table 3: Basic Sample and Palynomorph Data for Loch Ard–1

| Sample Type | Depth (m) | Lithology | Kerogen slides | Oxidised slides | Visual Yield | Palynomorph Concentration | Preservation | No. SP Species | No. MP Species |
|---|---|---|---|---|---|---|---|---|---|
| SWC 10 | 837 | CLAYSTONE arenaceous dark grey-black with coarse quartz floaters. | | 4 | Moderate | Moderate | Fair-good | 38 | 12 |
| Cuttings | 875–90 | | | 3 | Moderate | Moderate | Fair-good | 40 | 11 |
| Cuttings | 915–25 | | | 2 | Moderate | Low | Fair | 36 | 11 |
| SWC 1 | 927 | CLAYSTONE arenaceous, light-medium grey. | 1 | B | Very low | Extremely low | Poor | 2 | |
| SWC 60 | 954 | CLAYSTONE medium-olive grey, with carbonaceous laminae and coaly fragments. | | 4 | High | High | Fair | 48 | 12 |
| SWC 56 | 1022 | CLAYSTONE medium-olive grey, with common carbonaceous laminae. | | 4 | High | High | Fair (over oxid.) | 40 | 7 |
| SWC 54 | 1048 | SANDSTONE argillaceous, light-medium grey with coaly fragments. | 1 | B | Very low | Exceptionally rare | Poor | 8 | |
| SWC 51 | 1107 | SILTY-CLAYSTONE medium-dark grey with common carbonaceous flecks. | | 4 | High | High | Poor (over oxidised) | 37 | 5 |
| SWC 48 | 1150 | CLAYSTONE medium-dark grey, with carbonaceous laminae and coaly fragments. | | 4 | High | High | Fair | 38 | 2 |
| SWC 44 | 1186 | COAL and CLAYSTONE carbonaceous, sample crumbly. | | 4 | High | High | Poor (over oxidised) | 24 | |
| SWC 43 | 1188 | CLAYSTONE medium-olive grey to greenish grey. | | 3 | Moderate | Moderate | Poor-good | 34 | 3 |
| SWC 41 | 1200 | CLAYSTONE light olive grey to greenish grey, slightly bioturbated. | | 4 | High | Moderate | Fair | 42 | 5 |
| SWC 39 | 1208 | CLAYSTONE light olive grey to beige, trace feldspar. | | 1 + B | Very low | Essentially barren | Poor | 1 | |
| SWC 31 | 1329 | CLAYSTONE medium greenish grey to green, trace feldspar. | | 1 + B | Very low | Essentially barren | Poor | 8 | |
| Cuttings | 1344–59 | | | 2 | Moderate | Moderate | Poor-good | 38 | 1 |
| | | **Total slides:** | **2** | **40** | | | **Averages:** | **28.9** | **6.9** |

B = Blank slide included in relinquishment set.

## Table 4: Loch Ard–1 — Assemblage abundance data for selected palynomorphs.

| **Sample Type:** | **SWC** | **CTS** | **CTS** | **SWC 60** | **SWC 56** | **SWC 51** | **SWC 48** | **SWC 44** | **SWC 43** | **SWC 41** | **CTS** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (m):** | **837.0** | **875–90** | **915–25** | **954.0** | **1022.0** | **1107.0** | **1150.0** | **1186.0** | **1188.0** | **1200.0** | **1344–59** |
| **SPORES** | | | | | | | | | | | |
| *Aequitriradites* spp. | | | | | | | | | | 0.6% | 0.7% |
| *Appendicisporites* spp. | | | | | | | | 2.6% | | 1.9% | |
| *Baculatisporites* spp. | | 0.6% | 0.7% | | 0.7% | 1.3% | 0.7% | | 1.3% | 1.3% | 2.6% |
| *Cicatricosisporites* spp. | | 0.6% | 0.7% | 0.5% | | | | | | 7.1% | 3.3% |
| *Clavifera* spp. | 2.3% | | | 0.5% | | | 0.7% | | | | |
| *Coptospora paradoxa* | | | | | | | | | | | 0.7% |
| *Crybellosporites* spp. | | | | | | | | | | | 1.3% |
| *Cyathidites* (large) >40µm | 0.8% | 1.3% | 3.0% | 0.5% | 0.7% | 2.0% | 0.7% | | 14.5% | 1.9% | 2.6% |
| *Cyathidites* (small) <40µm | 10.0% | 12.3% | 8.2% | 15.1% | 17.2% | 24.5% | 7.2% | 6.5% | 20.8% | 16.0% | 29.6% |
| *Dictyophyllidites* spp. | 4.6% | 1.9% | 5.2% | 0.5% | | 4.0% | 2.6% | 0.7% | 1.3% | 2.6% | 1.3% |
| *Gleicheniidites* spp. | 10.0% | 3.2% | 3.7% | 4.3% | 4.1% | 4.6% | 53.9% | 35.3% | 3.8% | 6.4% | 4.6% |
| *Herkosporites/Ceratosporites* spp. | | 0.6% | 1.5% | 3.2% | 0.7% | 0.7% | 0.7% | 1.3% | 1.9% | 0.6% | 1.3% |
| *Laevigatosporites ovatus* | 1.5% | 0.6% | 2.2% | 0.5% | | 2.0% | 5.9% | 2.6% | 1.3% | 3.2% | 0.7% |
| *Laevigatosporites musa* ms | | | | 0.5% | | 0.7% | | | | 0.6% | |
| *Marratisporites scabratus* | | | | | | | | | | 0.6% | |
| *Osmundacidites* spp. | 0.8% | 1.3% | 1.5% | 1.1% | | | 2.6% | 10.5% | 0.6% | | 0.7% |
| *Peromonolites* spp. | | | | | | | 1.3% | | | 0.6% | |
| *Perotrilites* spp. | | 0.6% | 0.7% | | | | | | | | |
| *Retitriletes* spp. | 0.8% | 4.5% | 0.7% | 3.2% | | | 1.3% | | 5.0% | 3.2% | 3.3% |
| *Rugulatisporites* spp. | | | | | 0.7% | 1.3% | | | | | |
| *Stereisporites* spp. | | 0.6% | | | | 0.7% | 1.3% | | | 0.6% | |
| Triletes undiff. | 3.1% | 3.2% | 5.2% | 4.3% | 2.1% | 1.3% | 1.3% | 0.7% | 2.5% | 5.1% | 3.3% |
| *Triporoletes reticulatus* | | | | | | | | | | 0.6% | 2.0% |
| **Total Spores:** | **33.8%** | **31.8%** | **33.6%** | **34.4%** | **26.2%** | **43.0%** | **80.3%** | **60.1%** | **52.8%** | **53.2%** | **57.9%** |
| **GYMNOSPERMS undiff.** | | 1.9% | | | | | | | | | |
| *Araucariacites australis* | 3.1% | 0.6% | 1.5% | 2.7% | 11.0% | 6.0% | 2.0% | 0.7% | | 4.5% | 1.3% |
| *Corollina* spp. | | 1.3% | 3.0% | 2.7% | | | | 0.7% | 1.3% | 0.6% | 2.0% |
| *Cupressacites* sp. | 8.5% | 9.7% | 2.2% | 1.1% | 1.4% | 0.7% | 0.7% | 0.7% | | 0.6% | 1.3% |
| *Dilwynites pusillus* ms | 11.5% | 3.9% | 6.7% | 11.8% | 16.6% | 21.2% | 3.3% | | | 6.4% | |
| *Dilwynites* spp. | | 1.3% | 2.2% | 8.6% | 4.8% | 0.7% | | 3.9% | 0.6% | 2.6% | |
| *Hoegisporis trinalis* ms | | | | | | 0.7% | | | | 0.6% | |
| *Microcachryidites antarcticus* | 10.0% | 9.1% | 9.0% | 3.8% | 15.2% | 4.0% | 2.0% | 2.6% | 3.1% | 5.8% | 17.8% |
| *Phyllocladidites eunuchus* ms | | | 0.7% | | | 0.7% | 1.3% | | | | |
| *Phyllocladidites mawsonii* | 1.5% | 4.5% | 2.2% | 3.8% | 0.7% | | | | | | |
| *Podocarpidites* spp. | 26.9% | 26.6% | 32.8% | 22.0% | 15.9% | 17.2% | 7.2% | 26.1% | 40.3% | 19.9% | 18.4% |
| *Trichotomosulcites subgranulatus* | 3.1% | 3.9% | 2.2% | 6.5% | 6.2% | 4.6% | 3.3% | 3.3% | 1.9% | 5.8% | 1.3% |
| **Total Gymnosperms:** | **64.6%** | **63.0%** | **62.7%** | **62.9%** | **71.7%** | **55.6%** | **19.7%** | **37.9%** | **47.2%** | **46.8%** | **42.1%** |
| **ANGIOSPERMS undiff.** | | 3.2% | 0.7% | | | | | | | | |
| *Asteropollis asteroides* | | 0.6% | 0.7% | | 0.7% | | | | | | |
| *Australopollis obscurus* | 0.8% | | | 2.2% | | | | | | | |
| *Liliacidites* spp. | | | | | 0.7% | 0.7% | | 2.0% | | | |
| *Proteacidites/Triporopollenites* spp. | | 1.3% | 0.7% | | | | | | | | |
| *Tricolpites/Tricolporites* spp. | 0.8% | | 1.5% | 0.5% | 0.7% | 0.7% | | | | | |
| **Total Angiosperms:** | **1.5%** | **5.2%** | **3.7%** | **2.7%** | **2.1%** | **1.3%** | | **2.0%** | | | |
| **Total Spore-Pollen:** | **130** | **154** | **134** | **186** | **145** | **151** | **152** | **153** | **159** | **156** | **152** |
| | | | | | | | | | | | |
| **MICROPLANKTON % of MP COUNT** | | | | | | | | | | | |
| Microplankton undiff. | 5% | 15% | 16% | 16% | 35% | 100% | | | | 50% | 67% |
| *Amosopollis cruciformis* | 62% | 50% | 53% | 49% | 60% | | | | | 10% | |
| *Chatangiella* spp. | | 4% | 5% | | | | | | | | |
| *Cribroperidinium edwardsii* | | | | | | | | | 20% | 30% | |
| *Cyclophelium* spp. | 3% | | | | | | | | | | |
| *Heterosphaeridium* spp. | 14% | 15% | 16% | 13% | | | | | | | |
| *Isabelidinium* spp. | 7% | | | | | | | | | | |
| *Kiokansium polypes* | | | 5% | 4% | | | | | 20% | | |
| *Micrhystridium* spp. | | | | 4% | | | | | 60% | | 33% |
| *Odontochitina* spp. | | | | 2% | | | | | | | |
| *Palaeohystrichophora infusorioides* | 2% | | | 2% | | | | | | | |
| *Spiniferites* spp. | 2% | 12% | | | 5% | | | | | 10% | |
| *Trithyrodinium* spp. | 5% | 4% | 5% | | | | | | | | |
| *Valensiella griphus* | | | | 9% | | | | | | | |
| **Total Microplankton Count** | **58** | **26** | **19** | **45** | **20** | **1** | | | **5** | **10** | **3** |
| **Microplankton % of total SP & MP:** | 44.6% | 16.9% | 14.2% | 24.2% | 13.8% | 0.7% | | | 3.1% | 6.4% | 2.0% |
| ***A. cruciformis* as % of total SP & MP:** | 19.1% | 7.2% | 6.5% | 9.5% | 7.3% | | | | | 0.6% | |
| **Total SP and MP count:** | **188** | **180** | **153** | **231** | **165** | **152** | **152** | **153** | **164** | **166** | **155** |
| **Other Palynomorphs Count** | | | | | | | | | | | |
| *Botryococcus braunii* | | | | 0.4% | | | | 1% | 1% | 2% | |
| Fungal fruiting bodies | | | 1% | | 1% | | | | | | |
| Fungal spores | | | | | | | | | | | |
| Fungal hyphae | | | | | | 3% | | 1% | 1% | | |
| Reworked Fossils | | 1% | 2% | | | 1% | | | 10% | 1% | |
| **Total other count:** | | **1** | **4** | **1** | **1** | **5** | | **2** | **20** | **5** | |
| **TOTAL COUNT** | **188** | **181** | **157** | **232** | **166** | **157** | **152** | **155** | **184** | **171** | **155** |

## Table 5: Stratigraphic distribution of key index palynomorphs in Loch Ard–1.

| Sample Type | Depth (metres) | 1 Crybelosporites megastriatus ms | 2 Coptospora paradoxa | 3 Crybelosporites striatus | 4 Cicatricosisporites cuneformis | 5 Hoegisporis trinalis ms | 6 Appendicisporites distocarinatus | 7 Dilwynites spp. | 8 Cupressacties sp. | 9 Laevigatosporites musa ms | 10 Interulobites intraverrucatus | 11 Phyllocladidites eunuchus ms | 12 Clavifera triplex | 13 Phyllocladidites mawsonii | 14 Verrucosisporites admirabilis ms | 15 Tricolporites variverrucatus ms | 16 Cyatheacidites tectifera | 17 Gleicheniidites ancorus ms | 18 Proteacidites spp. | 19 Clavifera vultuosus ms |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SWC 10 | 837 | | | W | | | | 12% | 9% | | | | 2% | 2% | ? | | X | X | | X |
| Cuttings | 875–90 | | | | | | | 5% | 10% | | | | X | 5% | | | • | X | 1% | |
| Cuttings | 915–25 | | | | | | | 9% | 2% | | X | 1% | X | 2% | | | • | X | 1% | |
| SWC 1 | 927 | | | | | | | • | • | | • | • | • | • | | | • | • | | |
| SWC 60 | 954 | | | | | | X | 21% | 1% | 1% | • | X | 1% | 4% | X | | X | X | | |
| SWC 56 | 1022 | | | | | X | X | 21% | 1% | X | • | • | X | 1% | 1% | X | | | | |
| SWC 54 | 1048 | | | | | • | • | • | • | • | • | • | • | X | • | | | | | |
| SWC 51 | 1107 | | | | | 1% | X | 22% | X | 1% | • | 1% | • | X | 1% | | | | | |
| SWC 48 | 1150 | | | | | X | X | 3% | 1% | X | • | 1% | 1% | X | | | | | | |
| SWC 44 | 1186 | | | | | • | 2% | 4% | 1% | X | X | | | | | | | | | |
| SWC 43 | 1188 | | W | | | • | • | 1% | • | | | | | | | | | | | |
| SWC 41 | 1200 | | | | X | 1% | 2% | 3% | 1% | ? | | | | | | | | | | |
| SWC 39 | 1208 | | | | | | | | | | | | | | | | | | | |
| SWC 31 | 1329 | | | | | | | | | | | | | | | | | | V | |
| Cuttings | 1344–59 | X | 1% | 1% | | | | | V | | | | | | | | | | | |

| Sample Type | Depth (metres) | 20 Micrhystridium sp. A | 21 Cribroperidinium edwardsii | 22 Cyclonephelium compactum | 23 Heterosphaeridium spp. | 24 Amosopollis cruciformis | 25 Kiokansium polypes | 26 Oligosphaeridium spp. | 27 Palaeohystrichophora infusorioides | 28 Odontochitina operculata/costatae | 29 Valensiella griphus | 30 Trithyrodinium spp. | 31 Isabelidinium balmei | 32 Conosphaeridium striatoconum | 33 Chatangiella tripartitus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SWC 10 | 837 | | | | 4% | 19% | | | 1% | | | X | X | X | |
| Cuttings | 875–90 | | | | 2% | 7% | | | • | | | 1% | | | V |
| Cuttings | 915–25 | | | | 2% | 7% | X | | • | | X | V | | | V |
| SWC 1 | 927 | | | | • | • | • | | • | | • | | | | |
| SWC 60 | 954 | 1% | | | 3% | 10% | 1% | | X | X | 2% | | | | |
| SWC 56 | 1022 | • | | | X | 7% | • | X | X | | | | | | |
| SWC 54 | 1048 | • | | | • | • | • | | | | | | | | |
| SWC 51 | 1107 | • | | | X | X | • | | | | | | | | |
| SWC 48 | 1150 | • | | X | • | • | • | | | | | | | | |
| SWC 44 | 1186 | • | | • | • | • | • | | | | | | | | |
| SWC 43 | 1188 | 2% | 1% | • | • | • | X | | | | | | | | |
| SWC 41 | 1200 | • | 2% | X | X | 1% | | | | | | | | | |
| SWC 39 | 1208 | • | | | | | | | | | | | | | |
| SWC 31 | 1329 | • | | | | | | | | | | | | | |
| Cuttings | 1344–59 | 1% | | | | | | | | V | | | | | |

Numbers 1 to 19 are spore-pollen
Numbers 20 to 33 are microplankton

**LEGEND**

- 1% = Percentage abundance
- X = Present but <1% of count
- ? = Questionable identification or occurrence
- W = Reworked species occurrence
- V = Caved species occurrence
- • = Not recorded in sample within species range