Palynological Analysis of Vaughan-1, Port Campbell Embayment, Otway Basin

by

Alan D. Partridge

Biostrata Pty Ltd
A.C.N. 053 800 945

Biostrata Report 1995/5

31 May 1995

CONTENTS

INTERPRETATIVE DATA

BASIC DATA

INTERPRETATIVE DATA

Introduction

Seventeen sidewall cores samples between 803.0m to 1899.0m were analysed in Vaughan-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 2.7 to 12 grams (average 7.7 g) of the sidewall cores were processed for palynological analysis. 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. Recorded microplankton diversity was usually low to very low in most samples with only two samples showing a moderate diversity. 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 Vaughan 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 Vaughan-1

AGE	UNIT	SPORE-POLLEN ZONES	MICROPLANKTON ZONES (SUBZONES)
EOCENE	PEMBER MUDSTONE 742-813m	NOT SAMPLED	NOT SAMPLED
PALEOCENE		Upper *L. balmei* 803.0m	Indeterminate
	PEBBLE POINT FORMATION 813-870m	NOT SAMPLED	NOT SAMPLED
	K/T BOUNDARY SHALE 870-898m	Lower *L. balmei* 874.0-883.0m Upper *T. longus* 889.0-895.0m	Indeterminate *M. druggii* 895.0m
MAASTRICHTIAN	PAARATTE FORMATION 898-1157m	NOT SAMPLED	NOT SAMPLED
CAMPANIAN	SKULL CREEK MUDSTONE 1157-1316m	*N. senectus* 1164.0m	*N. aceras* 1558m 1164.0
SANTONIAN	NULLAWARRE 1316-1407m	NOT SAMPLED	NOT SAMPLED
CONIACIAN	BELFAST MUDSTONE 1407-1588m		
TURONIAN	WAARRE FORMATION 1588-1692m	*P. mawsonii* 1595.5-1692.5m	*P. infusorioides* 1595.5-1674.0m *(C. edwardsii)* 1650.0m
LATE ALBIAN	EUMERALLA FORMATION 1692-2014m (T.D.)	*P. pannosus* 1797.0-1899.0m	NO ZONES PRESENT

Geological Comments

1. The sequence sampled in Vaughan-1 spans the time interval of Late Albian to Late Paleocene. 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, Langley-1 and Howmains-1 (Partridge 1994a, b, c). The *P. mawsonii* Zone includes all samples from Waarre Formation up to 1595.5m, after which there is a 431-metre gap to the next Late Cretaceous sample from the Skull Creek Mudstone, followed by a further sampling gap of 269 metres to a suite of samples from the K/T boundary shale, which approximates the boundary between the Sherbrook Group and overlying Pebble Point Formation. These four samples were disappointing, for although displaying high diversity they contained few key species. The shallowest sample was from near the base of the Pember Mudstone.

4. Marine microplankton were recorded from seven of the nine samples in the Waarre Formation (Table 2). Except in those samples containing abundant cysts of *Amosopollis cruciformis*, the microplankton abundances were notably less than found in either Langley-1 or Howmains-1, suggesting that Vaughan 1 was located closer to the palaeoshoreline. In the deeper of the two samples lacking microplankton (SWC 7 at 1689m) the spore-pollen assemblage is similar to adjacent samples and the microplankton were probably not recorded due to the overall low palynomorph concentration. In the shallower sample at 1599.5m the assemblage has a distinct spore-pollen composition which needs extended discussion.

Table-2: Microplankton Abundances in Selected Samples in Vaughan-1

Sample Type	Depth (m)	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	803.0	Indeterminate	6%	No species dominant in low count.
SWC 23	874.0	Indeterminate	3%	*Paralecaniella indentata* 50%.
SWC 21	889.0	Indeterminate	<2%	No species dominant in low count.
SWC 20	895.0	*M. druggii*	6%	*Micrhystridium* spp. >50%.
SWC 19	1164.0	*N. aceras*	9%	*Heterosphaeridium* spp. >50%.
SWC 18	1595.5	*P. infusorioides*	26%	*Amosopollis cruciformis* >25% *Heterosphaeridium* spp. >20%.
SWC 17	1599.5	No zone possible.	<<1%	Only single specimen recorded
SWC 15	1609.0	*P. infusorioides*	19%	*Amosopollis cruciformis* >90%.
SWC 13	1622.0	*P. infusorioides*	3%	No species dominant in low count.
SWC 11	1650.0	(*C. edwardsii*)	10%	*Amosopollis cruciformis* 50%.
SWC 9	1674.0	*P. infusorioides*	<3%	No species dominant in low count.
SWC 4	1797.0	Indeterminate	0.7%	*Micrhystridium* sp. 100%.

5. The sidewall core at 1599.5m from a high gamma ray spike above the highest sand in the Waarre Formation contained an unusual and very distinctive spore-pollen assemblage dominated by *Gleichenitidites* spp. (45%), *Podosporites microsaccatus* (18%), *Podocarpidites* spp. (14%) and *Cyathidites minor* (sensus lato) with an abundance of 9%. The rest of the assemblage was of low diversity and, except for a single acritarch, the sample lacked microplankton. Because the four most abundant species represent 86% of the assemblage the sample is considered to be providing a snapshot of the local vegetation. The exceptional abundance of *Gleichenitidites* spp. which is mostly the species *Gleichenitidites circinidites* suggests the components of the

assemblage cannot have been transported far to the depositional site or otherwise the assemblage would have displayed spore-pollen abundances more similar to the other samples. The environment of deposition is envisaged to be essentially non-marine, perhaps representing an overbank deposit. Relative to the Waarre Formation in the Langley-1 well, where all the analysed samples contained marine microplankton (Partridge, 1994b), this sample in Vaughan-1 would represent a proximal non-marine equivalent, perhaps representing part of a highstand system tract. This latter interpretation is reinforced by the overlying sample at 1595.5m in Vaughan-1, which is interpreted as relatively deep or open marine, as it contains a microplankton abundance of 26% and a diversity of >12 microplankton species. The abrupt change from a non-marine assemblage to an open marine assemblage is typical of a "downward shift" in facies, which is diagnostic of a sequence boundary. It is therefore proposed that in Vaughan 1 a major sequence boundary occurs at the top of Unit C of the Waarre Formation which is picked from the gamma and sonic logs to lie at 1597.5m.

6. The sample at 1692.5m was comprised of two lithologies, a light grey feldspathic sandstone and a medium grey claystone, of which only the latter was submitted for processing. The presence of mixed lithologies makes the reliability of this sample questionable, particularly as the character of the extracted assemblage is similar to the sample recovered at 1904m in Howmains-1. This latter sample was below the log break for top of the Eumeralla Formation and was interpreted as possibly from a clastic dyke. A similar interpretation is possible for the sample in Vaughan-1. Such clastic dykes 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).

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

Waarre Unit D:	1588-1597.5m
Waarre Unit C:	1597.5-1642m
Waarre Unit B:	1642-1656m
Waarre Unit A:	1656-1692m

These picks are consistent with palynomorph ranges recorded and units picked in Langley-1. The assemblages in Vaughan-1 suggest that the SWC at 1650m can be no younger than Waarre B whilst the SWC at 1622m is no younger than the sample from core-1 at 1750m in Langley-1. The shallowest sample from the Waarre in Vaughan-1 at 1595.5m is interpreted

to lie within Unit D based on current understanding of microplankton ranges.

8. The oldest unit penetrated in Vaughan-1 is the Eumeralla Formation between 1692-2014m (T.D.). The lithology of the five sidewall cores over this interval comprised blue-grey feldspathic sandstone and medium grey claystone or siltstone (Table 4). The sandstone lithologies were considered unlikely to yield diagnostic assemblages so only the two sidewall cores with finer grained lithologies were analysed to give a Late Albian *P. pannosus* Zone age. The spore-pollen composition and abundance show most similarity to assemblages from the *P. pannosus* Zone sections in Langley-1 and are significantly different from assemblages in Howmains-1.

9. The Cretaceous/Tertiary (K/T) boundary shale Vaughan 1 between 870-898m was sampled with four sidewall cores. Although the recorded assemblages contained moderate to diverse spore-pollen they lacked key index species, and unfortunately the associated microplankton were rare and/or of low diversity. Consequently the resulting age assignments are given only low confidence ratings and the observations whilst consistent with results from the K/T boundary shale in other wells do not provide any new insights to understanding the age and correlation potential of this unit.

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) Stover & Partridge (1973) or other references cited herein. Author citations for dinoflagellates can be found in the indexes of Lentin & Williams (1993) or other references cited herein. Species names followed by "ms" are unpublished manuscript names.

***Lygistepollenites balmei* Zone.**
Interval: 803.0 - 883.0 metres.
Age: Paleocene.
The three samples assigned to the *L. balmei* Zone contain high diversity assemblages of spore-pollen but comparatively few index species. The total

diversity was 53+ species, but of this 15% were distinctive reworked species mainly derived from the Early Cretaceous or Permian.

The shallowest sample at 803m can be no older than Upper *L. balmei* Zone on presence of *Proteacidites grandis* and *Banksieaidites elongatus* and no younger on presence of eponymous species and *Australopollis obscurus*.

The samples at 874m and 883m are no older than the Lower *L. balmei* Zone on presence of *Haloragacidites harrisii* and no younger on presence of *Proteacidites angulatus* at 874m. The presence of *Beaupreaidites orbiculatus* Dettmann & Jarzen 1988 suggests a position low in the zone.

The associated microplankton in the three samples are of low diversity and whilst supporting a Paleocene age do not allow finer age dating.

Upper *Tricolporites longus* Zone.
Interval: 889.0 - 895.0 metres.
Age: Late Maastrichtian.

The two samples assigned to the zone although of moderate to high diversity contain very few index species. The shallowest sample is assigned to the zone primarily on several specimens of *Proteacidites otwayensis* ms. The lack of other restricted species means the zone assignment has low confidence. The deeper sample contains the extra index species *Proteacidites wahooensis* ms and *Tricolporites lilliei* neither of which range above this zone. An age no older than the Upper subzone is firmly constrained by the consistent presence of *Stereisporites* (*Tripunctisporis*) spp. Both samples are dominated by small nondescript *Proteacidites* pollen.

***Manumiella druggii* Zone.**
Interval: 895.0 metres.
Age: Late Maastrichtian.

Although both samples assigned to Upper *T. longus* Zone contain rare microplankton only the deeper sample can be assigned to *M. druggii* Zone on presence of *Manumiella conorata* and a possible apical fragment of *M. seelandica*.

***Nothofagidites senectus* Spore-pollen Zone**
and *Nelsoniella aceras* Microplankton Zone.
Interval: 1164.0 metres.
Age: Early Campanian.

The sample is assigned to the *N. senectus* Zone on the occurrence of a single recorded specimen of the eponymous species. The rest of the spore-pollen

assemblage is dominated by *Proteacidites* spp. (20%) and *Podocarpidites* spp. (17%) and whilst consistent with this assignment contains no other diagnostic taxa.

The microplankton assemblage is much more diagnostic with the present of *Nelsoniella aceras*, *N. tuberculata* and *Amphidiadema nucula* (represented by transitional morphology to *Xenikoon australis*) all supporting the zone assignment.

***Phyllocladidites mawsonii* Zone** (formerly the *Clavifera triplex* Zone).
Interval: 1828.0-1887.5 metres (60+ metres). 1595.5 - 1692.5
Age: Turonian-Coniacian.
The nine 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 six samples between 1622-1692.5m is characterised by the consistent and often frequent occurrence of *H. trinalis* ms, *Appendicisporites distocarinatus*, *Rugulatisporites admirabilis* ms and *Laevigatosporites musa* ms with only the very rare occurrence of the eponymous species *P. mawsonii* (at 1674m and 1631m). Other rare species from this lower interval include angiosperms *Striatopollis paraneus* and *Australopollis obscurus*. These samples correlate well with assemblages documented from the Waarre Units A and B in Langley 1 and Howmains 1 (Partridge 1994b, c).

The upper subzone represented by the three samples between 1595.5-1609m is characterised by higher abundances of *Gleicheniidites circinidites* but otherwise is rather non descript. The overall character of the assemblages does however change with the incoming of abundances of the enigmatic algal cyst *Amosopollis cruciformis*. Important LADs (Last Appearance Datums) include *Rugulatisporites admirabilis* ms and *Laevigatosporites musa* both at 1599.5m.

***Palaeohystrichophora infusorioides* Zone.**
Interval: 1595.5-1692.5 metres (97+ metres).
Age: Turonian.
As with other wells recently analysed from the Otway Basin the *P. infusorioides* Zone is identified on the absence of index species *Pseudoceratium ludbrookiae* and the 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 as originally defined by Helby *et al.* (1987, p.62). In Vaughan-1 the zone has an average microplankton diversity of 7+ species/sample and a total diversity of 25+ species

in the seven marine samples. Only the oldest of three subzones established in Langley-1 could be recognised in Vaughan-1.

***Cribroperidinium edwardsii* Subzone.**
Interval: 1650.0 metres
Age: Turonian.
This zone was originally defined in Iona-2 and Langley-1 palynological reports (Partridge 1994a, b). In Vaughan-1 it was only confidently recorded in the sample with the highest microplankton abundance in the lower part of the Waarre Formation based on the presence of rare and fragmented specimens of *Cribroperidinium edwardsii*. The other species recorded in the sample are all long ranging forms previously recorded from the zone. The possible record of the species on the range chart at 1674m is based on opercula only and must be treated with caution.

***Phimopollenites pannosus* Zone.**
Interval: 1797.0-1899.0 metres.
Age: Late Albian.
The two samples analysed from the Eumeralla Formation are assigned to the zone on the presence of the eponymous species *P. pannosus* at 1797m and other tricolpate pollen at 1899m. The assemblages are dominated by *Podocarpidites* spp. *Cyathidites* spp. and *Baculatisporites* spp. which together with frequent to common *Corollina torosa* makes them compositionally distinct from the over lying Waarre Formation assemblages. Although the deep sidewall core sample was apparently well cleaned it did contained some obvious down-hole contaminants.

References

BUFFIN, A.J., 1989. Waarre Sandstone development within the Port Campbell Embayment. *APEA J. 29* (1), 299-311.

DETTMANN, M.E., 1963. Upper Mesozoic microfloras from southeastern Australia. *Proc. R. Soc. Vict. 77*, 1-148.

DETTMANN, M.E. & JARZEN, D.M., 1988. Angiosperm pollen from uppermost Cretaceous strata of southeastern Australia and the Antarctic Peninsula. *Mem. Ass. Australas. Palaeontols 5*, 217-237.

DETTMANN, M.E. & PLAYFORD, G., 1969. Palynology of the Australian Cretaceous: a review. In *Stratigraphy and palaeontology. Essays in honour of Dorothy Hill*, K.S.W. Campbell, ed., A.N.U. Press Canberra, 174-210.

HELBY, R., MORGAN, R. & PARTRIDGE, A.D., 1987. A palynological zonation of the Australian Mesozoic. *Mem. Ass. Australas. Palaeontols 4*, 1-94.

KEATING, K., 1993. The lithostratigraphy, palynology and sequence stratigraphy of the Pebble Point Formation. BSc Honours thesis, La Trobe University (unpubl.).

LENTIN, J.K. & WILLIAMS, G.L., 1993. Fossil Dinoflagellates: Index to genera and species, 1993 Edition. *AASP Contribution Series No. 28*, 1-856.

PARTRIDGE, A.D., 1994a. Palynological analysis of Iona-2 in Port Campbell Embayment, Otway Basin. *Biostrata Report 1994/4*, 1-25.

PARTRIDGE, A.D., 1994b. Palynological analysis of Langley-1, Port Campbell Embayment, Otway Basin. *Biostrata Report 1994/11*, 1-28.

PARTRIDGE, A.D., 1994c. Palynological analysis of Howmains-1, Port Campbell Embayment, Otway Basin. *Biostrata Report 1994/13*, 1-22.

STOVER, L.E. & PARTRIDGE, A.D., 1973. Tertiary and late Cretaceous spores and pollen from the Gippsland Basin, southeastern Australia. *Proc. R. Soc. Vict. 85*, 237-286.

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

Sample Type	Depth (m)	Spore-pollen Zone	*CR	Microplankton Zones and (Subzones)	*CR	Comments and Key Species
SWC 24	803.0	Upper *L. balmei*	B3			FAD *Proteacidites grandis*.
SWC 23	874.0	Lower *L. balmei*	B3			LAD *Proteacidites angulatus*. Microplankton rare only *Deflandrea speciosus* significant.
SWC 22	883.0	Lower *L. balmei*	B5			Age dating weak as key index species were not recorded. Microplankton extremely rare and not diagnostic.
SWC 21	889.0	Upper *T. longus*	B5			Concentration of palynomorphs very low with high diversity of reworked species. Zone pick of low confidence based on multiple specimens of *Proteacidites otwayensis* ms.
SWC 20	895.0	Upper *T. longus*	B3	*M. druggii*	B3	*Proteacidites* spp. dominant at >40%. *Manumiella conorata* present. FAD *Stereisporites (Tripunctisporis)* spp.
SWC 19	1164.0	*N. senectus*	B3	*N. aceras*	B3	*Nelsoniella aceras* and *N. tuberculata* present.
SWC 18	1595.5	*P. mawsonii*	B5	*P. infusorioides*	B3	LAD *Kiokansium polypes*.
SWC 17	1599.5	*P. mawsonii*	B3			LAD *Rugulatisporites admirabilis* ms. Deltaic or coastal plain environment dominated by *Gleicheniidites* spp. <45%.
SWC 15	1609.0	*P. mawsonii*	B4	*P. infusorioides*	B5	*Amosopollis cruciformis* >18%.
SWC 13	1622.0	*P. mawsonii*	B2	*P. infusoroides*	B5	LAD *Hoegisporis trinalis* ms. and *Appendicisporites distocarinatus*.
SWC 12	1631.0	*P. mawsonii*	B1	*P. infusorioides*	B5	FADs for good *Phyllocladidites mawsonii*, *Clavifera triplex* and *Laevigatosporites nusa* ms.
SWC 11	1650.0	*P. mawsonii*	B2	*P. infusorioides* (*C. edwardsii*)	B3	*Cribroperidinium edwardsii* Acme.
SWC 9	1674.0	*P. mawsonii*	B2	*P. infusorioides*	B5	FAD of poor *P. mawsonii*.
SWC 7	1689.0	*P. mawsonii*	B3			Moderate diversity assemblage with *H. trinalis* ms and *Appendicisporites distocarinatus*. No microplankton recorded from this sample.
SWC 6	1692.5	*P. mawsonii*	B2	*P. infusorioides*	B5	Reliable Waarre assemblage from claystone fraction of SWC.
SWC 4	1797.0	*P. pannosus*	B2			*Phimopollenites pannosus* present in spore dominated assemblage with *Classopollis* spp. common at 9%.
SWC 2	1899.0	*P. pannosus*	B4			*Tricolpites* sp. and *Perotrilites majus* present. Some downhole contamination present.

*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 - Vaughan-1, Otway Basin.

SAMPLE TYPE	DEPTH (Metres)	REC (cm)	LITHOLOGY	SAMPLE WT (g)	RESIDUE YIELD
SWC 24	803.0	4.5	Blk glauconitic? claystone. Firm sample well cleaned.	12.0	Moderate
SWC 23	874.0	4.3	Blk pyritic very fine sandstone. Minor burrowing possibly glauconitic. Firm sample well cleaned.	9.3	Moderate
SWC 22	883.0	4.3	Brown-dk grey coarse grained sandstone with dk grey clay matrix. Sample firm but may be mud penetrated. Poorly cleaned.	9.7	Moderate
SWC 21	889.0	4.0	Dk gry-blk homogeneous siltstone. No structure or obvious accessories. Firm sample well cleaned. With floating sand grains of quartz up to 2mm - sample more a sandstone.	9.4	High
SWC 20	895.0	4.0	Dk gry-bk homogeneous sandstone. No obvious structure. Well cleaned firm. Floating quartz grains up to 1.5mm.	10.1	High
SWC 19	1164.0	3.5	Mixed lithologies. Lt grey fine grained sst and dk-med grey claystone. Contact irregular. Sample soft but well cleaned.	6.7	Moderate
SWC 18	1595.5	3.0	Medium grey mottled sandstone with patchy clay matrix. Firm sample well cleaned.	10.5	Moderate
SWC 17	1599.5	<1.0	Med grey-dk grey claystone with carbonaceous lenses. Firm, well cleaned.	2.7	High
SWC 15	1609.0	1.8	Dk grey fillile (irregular) claystone. Well cleaned/firm.	5.4	High
SWC 13	1622.0	2.5	Dk brown grey claystone with thin <1mm light grey siltstone laminae. Firm, well cleaned.	7.8	High
SWC 12	1631.0	2.5	Med grey claystone with thin <1mm light grey silstone laminae. Firm, well cleaned.	7.9	High
SWC 11	1650.0	3.0	Med grey mottled sandstone, possibly glauconitic.	8.2	High
SWC 9	1674.0	<1.5	Dark grey soft claystone. Not cleaned.	3.7	High
SWC 7	1689.0	2.5	Med grey claystone with light grey fine grained sandstone laminae up to 1.5mm. Firm sample well cleaned.	7.3	High
SWC 6	1692.5	2.7	Mostly 60% light grey feldspathic sandstone with med grey claystone. Only latter processed - well cleaned.	5.3	Moderate
SWC 4	1797.0	3.0	Medium grey clayey siltstone. Well cleaned/firm.	8.6	Moderate
SWC 2	1899.0	1.8	Med grey - blue grey homogeneous claystone. Firm, well cleaned.	6.4	Moderate

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

SAMPLE TYPE	DEPTH (metres)	Palynomorph Concentration	Palynomorph Preservation	No. S-P spp*	Microplankton Abundance	No MP Species*
SWC 24	803.0	Moderate	Good	39+	Frequent	6+
SWC 23	874.0	Moderate	Good	42+	Rare	5+
SWC 22	883.0	Low	Good	30+	Rare	2+
SWC 21	889.0	Very low	Fair-good	21+	Rare	3+
SWC 20	895.0	Low	Poor-good	31+	Frequent	7+
SWC 19	1164.0	Moderate	Low	33+	Common	8+
SWC 18	1595.5	Moderate	Poor-fair	21+	Abundant	12+
SWC 17	1599.5	Moderate	Poor-fair	16+	Very rare	1
SWC 15	1609.0	Moderate	Fair-good	17+	Common	5+
SWC 13	1622.0	Moderate	Poor-fair	33+	Rare	4+
SWC 12	1631.0	Moderate	Poor-fair	21+	Frequent	6+
SWC 11	1650.0	Low	Poor-fair	23+	Frequent	11+
SWC 9	1674.0	Low	Fair	27+	Rare	6+
SWC 7	1689.0	Low	Fair	25+	NR	
SWC 6	1692.5	Moderate	Poor	25+	Frequent	5+
SWC 4	1797.0	Moderate	Fair	22+	Very rare	1
SWC 2	1899.0	High	High	21+	Rare	3+

***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