PALYNOLOGICAL ZONATION OF LOWER CRETACEOUS SEDIMENTS OF THE OTWAY BASIN, VICTORIA

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SUMMARY

Subsurface and outcrops of the pre-Upper Cretaceous Mesozoic sequence in the Victorian section of the Otway Basin are biostratigraphically subdivided in terms of the palynologically-based zonation scheme outlined by Dettmann (1968d). The oldest Mesozoic sediments encountered are considered to be of Middle-Upper Jurassic age. These are overlain by a sequence, dominantly non-marine in origin, in which the following biostratigraphic units are recognized (from the base upwards): the Crybelosporites stylosus Zone; the Cyclosporites hughesi Subzone (comprising the Murospora florida , the Rouseisporites reticulatus, and the Foraminisporis asymmetricus Units); the Crybelosporites striatus Subzone; the Coptospora paradoxa Zone (comprising the Dictyotosporites filosus Unit and a succeeding unnamed unit);and the Tricolpites pannosus Zone.

The ages of the biostratigraphic units are briefly discussed and it is shown that they span the Lower Cretaceous with possible extensions into the uppermost Jurassic and Cenomanian.

The oldest zone of the Lower Cretaceous sequence, the Crybelosporites stylosus Zone appears to be of limited areal distribution. Succeeding subdivisions of the Cyclosporites hughesi and Crybelosporites striatus Subzones occur over progressively wider areal extents. Several localised depositional breaks are detectable within the C. hughesi and C. striatus Subzones. The Coptospora paradoxa Zone appears to have been deposited over much of the onshore areas of the basin, but is notably absent in the north-western region of the Port Campbell Embayment. The Tricolpites pannosus Zone is of decreased areal extent; within this zone dinoflagellates appear suggesting the onset of marine conditions which persisted throughout the Upper Cretaceous.

The occurrence of remanié (reworked) spores and pollen grains within the Cretaceous sequence of the Otway Basin is briefly discussed, and

it is shown that they are of value in assessing the age and location of source material. Within the Cretaceous sequence Permian, Triassic, and early Cretaceous reworked spores and pollen grains are recognized. The Permian and Triassic derivatives occur spasmodically throughout the sequence; those of Cretaceous age are found near the top of the Lower Cretaceous development and persist throughout the Upper Cretaceous sequence where they are particularly abundant at horizons immediately above a hiatus.

INTRODUCTION

Palynological studies of the non-marine Mesozoic sequence developed in the Otway Basin were initiated by Cookson (1953) who presented a taxonomic account of several of the enclosed spore-pollen types. She later (1954) recognized the stratigraphic value of one of these species, Cicatricosisporites australiensis, which is now used, with certain reservations, as a Cretaceous index throughout Australia. Basic taxonomic accounts of the spore-pollen contents were published by Cookson and Dettmann (1958a,b; 1959) and by Dettmann (1963a), who demonstrated that the enclosing sediments are mainly, if not all, of Lower Cretaceous age. The latter author also recognized a sequence of three distinct microfloral assemblages, each of stratigraphic significance within the Lower Cretaceous. In order of decreasing age, the assemblages delineated by Dettmann are the Stylosus Assemblage, the Speciosus Assemblage (comprising an older and a younger category) and the Paradoxa Assembl During the period 1963 - 1965 Dettmann studied numerous Lower Cretaceous s ubsurface sequences intersected by oil exploratory wells and government water bores at the joint request of Frome-Broken Hill Company Pty. Ltd. and Haematite Explorations Pty. Ltd. Subdivision of the sequences examined was based upon the distribution of her (1963a) microfloral assemblages.

Concurrently Evans (1961 and later), Hodgson (1964), and Harris (1964) examined numerous sections studied by Dettmann, presenting their results in unpublished records or appendices to subsidized well completion reports. In 1966 (1966b) Evans summarised all available palynological data on the Cretaceous of the Otway Basin, and subdivided the Lower Cretaceous sequence in terms of his palynological units K1a-d, K2a-b.

The relationships of Evans's palynological units to Dettmann's micro floral assemblages have been discussed by Dettmann and Playford (1969) who introduced and defined a sequence of Cretaceous spore-pollen zones in eastern Australia. The Lower Cretaceous zones, which are based primarily upon the vertical distribution of Dettmann's microfloral assemblages, comprise from the base upwards: the *Crybelosporites stylosus* Zone, the *Dictyotosporites speciosus* Zone (comprising the *Cyclosporites hughesi* Subzone and the *Crybelosporites striatus* Subzone), the *Coptospora paradoxa* Zone, and the *Tricolpites pannosus* Zone.

After examining three closely sampled Lower Cretaceous sections penetrated by wells recently drilled in the Otway Basin, Dettmann (1968d) proposed a way by which the *Cyclosporites hughesi* Subzone and the *Coptospora paradoxa* Zone can be subdivided on spore-pollen criteria. The sequence of biostratigraphic divisions thus far delineated in the Lower Cretaceous of the Otway Basin is tabulated in Table 1. Diagnostic criteria of the various zonal divisions are documented in Dettmann and Playford (1969) and Dettmann (1968d) and are summarized in Table 1 which also indicates age relationships of the zones (see also Evans and Hawkins 1967, Dettmann and Playford 1969). From this it is evident that the zones span the Lower Cretaceous , with possible extensions into the Upper Jurassic and Cenomanian.

An assessment of the palynological data obtained from available Lower Cretaceous material from the Otway Basin indicates that the zonal scheme outlined in Table 1 is applicable on a basin-wide basis. The purpose of the present account is to summarize the palynological data and to document the distribution of the spore-pollen zones within numerous Lower Cretaceous sequences in the Victorian section of the basin. The distribution of dinoflagellates of presumed marine to brackish water origin within the sequence is also indicated. In addition some consideration is given to the age of sediments immediately underlying and overlying the Lower Cretaceous sequence. The occurrence and age of recycled spores and pollen grains detected in Lower Cretaceous sediments are discussed in terms of their potential usefulness in the determination of source material and in the detection of erosional surfaces within the Lower Cretaceous sequence.

ZONAL ATTRIBUTION OF MATERIAL STUDIED

In the following pages, all samples studied are listed under headings of the sequence from which they were obtained. Zonal attribution of the Lower Cretaceous sediments is based entirely upon the writers examination of the contained microfloras. No attempt has been made to zone palynologically several well sections, material of which has been studied by other workers but not by the writer.

As noted above, the spore-pollen zones considered here span the Lower Cretaceous with possible extensions into the Upper Jurassic and Cenomanian. Older Mesozoic sediments were intersected beneath the Lower Cretaceous sequence in Casterton No.1 well; these are believed to be of Middle - Upper Jurassic age and palynological data obtained from them are considered below. Moreover, where applicable and where information exists, horizons immediately above each of the Lower Cretaceous sections examined are attributed to one of the Upper Cretaceous or Lower Tertiary spore-pollen zones of Dettmann and Playford (1969) and Harris (1965) respectively. This information is included to illustrate the age relationships of overlying strata.

The majority of the samples herein evaluated were examined during the period 1963-1968 at the request of several oil companies viz: Frome-Broken Hill Company Pty. Ltd., Haematite Exploration Company Pty. Ltd., Shell Development (Australia) Pty. Ltd., and Planet Exploration Company Pty. Ltd. These companies hold palynological reports on the relevant material and reference to the reports is made under the appropriate heading. The reports should, if necessary, be referred to for additional microfloral details.

Reports submitted prior to 1967 contain references to the Lower Cretaceous microfloral assemblages of Dettmann (1963a) and to two mid-late Cretaceous spore-pollen assemblages delineated by her during 1964 (1964a).

These microfloral assemblages have since been shown to be diagnostic of the Cretaceous spore-pollen zones of Dettmann and Playford (1969) as follows (from oldest to youngest):

The Stylosus Assemblage is diagnostic of the Crybelosporites stylosus Zone.

The Speciosus Assemblage (older category) diagnoses the Cyclosporites hughesi Subzone of the Dictyotosporites speciosus Zone.

The Speciosus Assemblage (younger category) diagnoses the Crybelosporites striatus Subzone of the Dictyotosporites speciosus Zone.

The Paradoxa Assemblage is represented in sediments of the Coptospora paradoxa Zone.

The Paradoxa/II Assemblage occurs in sediments of the Tricolpites pannosus Zone.

Assemblage II occurs within the Appendicisporites distocarinatus Zone.

Assemblage III is known from the Clavifera triplex and Tricolpites pachyexinus Zones and from the sequence containing the Nothofagidites Microflora.

The majority of the palynological determinations documented in the original reports have been checked during the course of the present study. Moreover, samples from which microfloras were recorded as indeterminate or doubtful, have in most cases been subjected to further investigation using additional palynological residues. Data obtained from these studies have been assessed and where appropriate, the original determinations have been modified. Thus, the results are believed to express with as much precision as sampling has enabled, the microfloral sequence that occurs in the Lower Cretaceous of the Otway Basin.

In several instances the results presented herein appear to be anomalous to those obtained from the same well sections by other workers. Some of the discrepancies can be explained in terms of slightly different connotations relating to the equivalence of the palynological zonal schemes that have been formulated for the Otway Basin Lower Cretaceous sequence. Others, however, are not so readily explicable and may require further investigation, with especial emphasis on checking sampling horizon of material and identification of contained species, Consideration should also be given to the possibility that a particular microflora contains recycled forms and/or contaminants from younger horizons.

In several sections recycled spores and pollen grains of Permian, Triassic and Lower Cretaceous age are represented. The sampling horizons in which the secondarily deposited forms have been detected and the ages of the recycled forms are specified for each sequence examined.

Dinoflagellates believed to be marine or brackish water dwellers make their appearance within the Tricolpites pannosus Zone, near the top of the Lower Cretaceous sequence in several well sections. The Lower Cretaceous occurrence of such organisms is noted. Reference should be made to Evans (1966b, pp. 31-2) who has also documented the early Cretaceous distribution of a distinct group of microplankton referred to the Acritarcha. The forms recorded by him are mostly of unknown affinity although some may be related to the Chlorophyceae; the enviormental significance of these forms is speculative and is discussed by Evans (loc. cit.).

Oil Exploration Wells

Planet Tullich No.1

SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	
core 3	1051-53	Coptospora paradoxa (Unnamed unit)	Eumeralla Fm "Unit 1"
" 4	1540-41	" "	
" 5	2051-61	" "	
" 6	2556-66	" "	
" 12	4500-05	Cyclosporites hughesi	Eumeralla Fm "Unit 2"
" 14,15	~~5300-63~~ 5360-63	" "	"Basal Unit"

Reference: Dettmann 1965d.

Comments: Cores 12 and 14,15 are now known to be within the Cyclosporites hughesi Subzone. Despite the absence of diagnostic species core 12 is thought to be near the boundary between the Rouseisporites reticulatus and Murospora florida Units. The example from core 12 attributed by Dettmann (1965d) to Foraminisporis asymmetricus is specifically distinct from the species.

Planet Heathfield No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
?erbrook Gp	core 2	1378-93	Nothofagidites or T. pachyexinus	Permian, L. Cret.
	" 3	1858-63	?Tricolpites pannosus	
	" 4	1863-73	not determinable	
	" 5	2365-73	Coptospora paradoxa (unnamed unit)	
	" 6	2373-81	" "	
	" 7	2874-84	" "	
Eumeralla Fm "Unit 1"	" 8	3377-87	?Coptospora paradoxa	
	" 9	3754-64	Crybelosporites striatus	
	" 10	4144-54	" " (base)	
	" 12	4620-26	Foraminisporis asymmetricus	
	" 13	5026-36	" "	
	" 14	5406-16	Rouseisporites reticulatus	
	" 15	5693-703	" "	
	" 16	5990-6000	" "	
Eumeralla Fm "Unit 2"	" 17	6380-90	" "	
	" 18	6890-7000	?Murospora florida	
	" 19	7487-500	" "	

Reference: Dettmann 1965b,d.

Comments: Core 3 is either within the Coptospora paradoxa or Tricolpites pannosus Zones; the sample studied is heavily contaminated, containing large numbers of Upper Cretaceous and Lower Tertiary species. Core 8 is not certainly referable to the Coptospora paradoxa Zone; core 10 probably represents a basal horizon of the Crybelosporites striatus Subzone. Cores

18 and 19 are tentatively referred to the Murospora florida Unit.

Planet Casterton No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
Eumeralla Fm Unit 1 / top Unit 2	core 1	2016-27	Foraminisporis asymmetricus (base)
	" 2	2420-90	Rouseisporites reticulatus
Eumeralla Fm "Unit 2"	" 4	3596-606	" "
	" 7,8	4497-512	?Murospora florida
	" 11	5270-80	not determinable
Pretty Hill Sst	" 12	5609-18	Murospora florida (?base)
	" 14	6396-406	not determinable
	" 15	6763-69	" "
Basal Unit	" 18	7385-95	Middle-Upper Jurassic
	" 19	7739-49	not determinable

Reference: Dettmann 1965d.

Comments: Cores 7,8 are not certainly referable to the Murospora florida Unit and core 11 did not yield plant microfossils. Core 12 is within the M. florida Unit and probably represents a basal horizon of this unit. Cores 14,15 yielded sparse microfloras that may be of lowermost Cretaceous or uppermost Jurassic age. A distinctly older assemblage was extracted from core 18; this poorly preserved microflora contains several undescribed forms and abundant Tsugaepollenites, a feature characteristic of Australian Middle-Upper Jurassic assemblages (see Balme 1957/ 1964). The microflora contained in core 19 is badly preserved and few forms are identifiable.

F.B.H. Pretty Hill No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Belfast Mdst	core 6	2726-39	Tricolpites pachyexinus	Permian, L. Cret.
	" 7	2928-40	Tricolpites pannosus	Permian, D. speciosus Zone derivatives
	" 8	3340-60	Coptospora paradoxa (unnamed unit)	
Eumeralla Fm "Unit 1"	" 9	3810-30	" "	
	" 10	4315-28	" "	
	" 11	4625-40	" "	
	" 12	4640-55	" "	

umeralla Fm "Unit 1"	" 13	4940-60	Coptospora paradoxa (?Dictyotosporites filosus)
umeralla Fm "Unit 2"	" 14	5400-20	not determinable
	" 15	5420-24	Dictyotosporites speciosus (subzone not determined)
	" 16	5935-47	Foraminisporis asymmetricus
tty Hill Set	" 17	6070-80	Cyclosporites hughesi (unit not determined)
	" 18	6576-88	" "
	" 19	6690-702	?Crybelosporites stylosus
	" 20	7200-14	" "
	" 21	7585-97	not determinable

unable to resample JP June 1970

Reference: Dettmann 1963b; 1964i; 1968d.

Comments: Dinoflagellates first appear in core 6 of this well, ie. within the Upper Cretaceous Tricolpites pachyexinus Zone.

F.B.H. Eumeralla No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Paaratte Fm	core 4	2835-49	Tricolpites pachyexinus	
Eumeralla Fm "Unit 1"	" 5	3311-21	Tricolpites pannosus	
	" 6	3800-12	Coptospora paradoxa (unnamed unit)	Permian, D. speciosus Zone derivatives
	" 7	4285-300	" "	Permian, Triassic
	" 8	4812-14	" "	
	" 9	5297-309	" "	Permian, Triassic
Eumeralla Fm base Unit 1/top Unit 2	" 10	5799-816	" "	
	" 11	6034-54	Crybelosporites striatus	
Eumeralla Fm "Unit 2"	" 12	6242-52	" "	
	" 13	6252-57	" "	Permian
	" 15	6704-20	" "	
	" 16	7225-40	Foraminisporis asymmetricus	
	" 17	7697-712	" "	
	" 18	7712-17	" "	
	" 19	8143-56	Rouseisporites reticulatus	
	" 20	8459-65	" "	Permian, Triassic
	" 21	8914-24	" "	
	" 22	9373-85	" "	

Eumeralla Fm "Unit 2"	core 23	9767-74	<u>Rouseisporites</u> <u>reticulatus</u>
	" 24	9881-90	" "
	" 25	10,300-08	not determinable

new data June 1970 indicates [illegible] the "undescribed unit between Rouseisporites and [illegible] florida

<u>Reference:</u> Dettmann 1963b; 1964i; 1968d.

<u>Comments:</u> The first appearance of dinoflagellates is within the Upper Cretaceous <u>Tricolpites</u> <u>pachyexinus</u> Zone (core 4).

<u>F.B.H. Flaxmans No.1</u>

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre Fm	core 27	7200-20	<u>Appendicisporites</u> <u>disto-carinatus</u>	Permian, L. Cret.
Eumeralla Fm "Unit 1"	" 28	7473-93	<u>Tricolpites</u> <u>pannosus</u>	Permian, <u>D.</u> speciosus Zone derivatives
	" 29	7648-66	not determinable	
	" 30	7864-70	" "	
	" 31	7966-78	" "	
	" 32	8139-50	<u>Coptospora</u> <u>paradoxa</u> (unnamed unit)	
	" 33	8150-61	" "	Permian, Triassic
	" 34	8470-86	" "	
	" 35	8884-96	" "	
	" 36	9123-35	" "	
	" 37	9499-520	not determinable	
Eumeralla Fm "Unit 2"	" 38	9772-85	" "	
	" 39	10,122-34	" "	Permian, Triassic
	" 40	10,492-502	<u>C.</u> <u>paradoxa</u> (<u>D.</u> <u>filosus</u>) or <u>Crybelosporites</u> <u>striatus</u>	
	" 41	10,801-17	<u>Crybelosporites</u> <u>striatus</u>	
	" 42	11,087-92	" "	
	" 43	11,225-35	" "	
	" 44	11,517-28	" "	

<u>Reference:</u> Dettmann 1964b.

<u>Comments:</u> Dinoflagellates occur initially in the <u>Tricolpites</u> <u>pannosus</u> Zone (core 28). Stratigraphically lower horizons (cores 29-31) yielded sparse microfloras in which diagnostic species are lacking. Similarly cores 37 - 39 lack diagnostic assemblages, and core 40 is either within the <u>Dictyotosporites</u> <u>filosus</u> Unit or the <u>Crybelosporites</u> <u>striatus</u> Subzone.

F.B.H. Port Campbell No.1

Lower Cretaceous sediments were not intersected; the lowest horizons examined (cores 23, 24 between 5700 - 5934 feet) are within the Appendicisporites distocarinatus Zone and contain dinoflagellates (see Dettmann 1964a).

Waarre Fm

F.B.H. Port Campbell No.2

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre Fm	core 15	8409-18	Appendicisporites distocarinatus	Permian, Triassic
	" 16	8556-70	Tricolpites pannosus	
	" 17	8605-24	" "	
Eumeralla Fm "Unit 1"	" 18	8826-46	not determinable	

Reference: Dettmann 1964a.

Comments: Core 18 did not yield spores or pollen grains. Dinoflagellates were recovered from samples of the Tricolpites pannosus Zone and from successive Upper Cretaceous zones.

F.B.H. Port Campbell No.3

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre Fm	core 3	4781-801	Appendicisporites distocarinatus	Permian, D. speciosus Zone derivatives
Eumeralla Fm "Unit 1"	" 4	5155-65	not determinable	Permian, Triassic
	" 5	5526-30	Coptospora paradoxa (unnamed unit)	" "

Reference: Dettmann 1964a.

Comments: Dinoflagellates were not observed in the samples listed above; they appear in core 2 (4676-95 feet) which is within the Appendicisporites distocarinatus Zone.

F.B.H. Port Campbell No.4

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre Fm	core 15	5152-67	Appendicisporites distocarinatus	C. paradoxa Zone derivatives
Eumeralla Fm "Unit 1"	" 16	5426-76	not determinable	
	" 17	5754-70	Tricolpites pannosus	

	core 18	6070-84	Coptospora paradoxa (unnamed unit)
	" 19	6355-67	
Eumeralla Fm "Unit 1"	" 20	6663-83	" "
	" 22	7183-91	" "
	" 23	7690-710	" "
	" 24	7889-907	C. paradoxa (Dictyotosporites filosus)
Eumeralla Fm "Unit 2"	" 25	7907-10	" "
	" 26	8279-99	Crybelosporites striatus
	" 27	8500-20	" "

Reference: Dettmann 1964h.

Comments: During the course of this investigation Coptospora paradoxa and Dictyotosporites filosus have been recovered from cores 24 and 25; thus, the horizons are believed to be within the Dictyotosporites filosus Unit. Dinoflagellates first appear in core 15 (Appendicisporites distocarinatus Zone).

F.B.H. Sherbrook No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre Fm	core 11	3825-26	Appendicisporites distocarinatus	Permian
	" 13	4049-51	Coptospora paradoxa (unnamed unit)	
	" 14	4064-69	" "	
	" 17	4316-18	" "	
	" 18	4321-27	" "	
Eumeralla Fm "Unit 1"	" 19	4598-601	" "	
	" 20	4865-77	" "	
	" 23	4896-904	" "	
	" 24	4913-29	" "	Triassic
	" 25	5216-36	" "	Permian
	" 26	5414-24	" "	Triassic

Reference: Dettmann 1964d.

Comments: The Tricolpites pannosus Zone was not recognized in the sequence. Dinoflagellates first appear in the Appendicisporites distocarinatus Zone (core 11).

F.B.H. Fergusons Hill No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Waarre	core 6	2437-49	Appendicisporites distocarinatus	Permian, D. speciosus Zone derivatives
	" 7	2741-60	not determinable	
	" 8	3085-105	" "	
	" 9	3105-11	?Tricolpites pannosus	Permian, Triassic, D. speciosus Zone derivatives
	" 10	3419-30	Coptospora paradoxa (unnamed unit)	Triassic
Eumeralla Fm "Unit 1"	" 11	3732-52	" "	
	" 12	4092-112	" "	
	" 13	4514-34	" "	
	" 14	5077-97	" "	
	" 15	5554-69	C. paradoxa (?Dictyotosporites filosus)	Triassic
	" 16	5934-50	" "	
	" 17	6403-23	" "	Triassic
	" 18	6555-67	" "	Permian
	" 19	7037-47	Crybelosporites striatus	
	" 20	7220-30	" "	
	" 21	7330-45	" "	
	" 22	7818-32	Foraminisporis asymmetricus	Permian
	" 23	8247-60	" "	
	" 24	8758-73	" "	
	" 25	9195-211	" "	
Eumeralla Fm "Unit 2"	" 26	9626-31	" "	
	" 27	10,092-96	Cyclosporites hughesi (unit not determined)	
	" 28	10,574-88	" "	
	" 29	10,660-68	" "	
	" 30	11,080-94	" "	
	" 31	11,419-32	" "	
	sidewall core	11,438	" "	
	sidewall cores	11,450-95	not determinable	

<u>Reference:</u> Dettmann 1964d,e.

<u>Comments:</u> Core 9 is probably within the <u>Tricolpites pannosus</u> Zone

although only doubtful specimens of *T. pannosus* were recovered. The microflora contained in core 15 includes *Coptospora paradoxa* and a specimen of *Dictyotosporites speciosus*. Thus, if the latter species has not been recycled, the horizon is referable to the *Dictyotosporites filosus* Unit Core 16 contains *Coptospora paradoxa* but lacks other diagnostic components of the *D. filosus* Unit. Cores 17 and 18 are believed to be from within the unit because of their content of *Coptospora paradoxa*, *C. striata*, *Dictyotosporites speciosus*, and *D. filosus*. Horizons between 10,092 - 11,438 feet are within the *Cyclosporites hughesi* Subzone, but diagnostic species of the units of this subzone were not encountered in the poorly preserved microfloras. Plant microfossils obtained from samples at 11,450-95 are strongly carbonized, but species suggestive of a Lower Cretaceous age have been recorded.

Dinoflagellates make their initial appearance in core 6 (*Appendicisporites distocarinatus* Zone).

Interstate Woolsthorpe No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
Eumeralla Fm "Unit 2"	sidewall core	4300	*Foraminisporis asymmetricus*
	" "	4515	*Rouseisporites reticulatus*
	" "	4750	not determined
Pretty Hill Sst	" "	4841	" "
	" "	5005	*Murospora florida*
	" "	5178	" "
	" "	5275	" "
	" "	5495	" "
	" "	5900	" "
"Basal Unit"	" "	6090	" "
	" "	6230	" "
	" "	6380	?*Crybelosporites stylosus*

Reference and Comments: Palynological data obtained from this well is discussed fully by Dettmann (1968a,d).

Interstate Garvoc No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Eumeralla Fm "Unit 1"	sidewall core	3076	not determinable	
	" "	3262	" "	
	" "	3334	Coptospora paradoxa (Dictyotosporites filosus)	Permian, Triassic
Eumeralla Fm "Unit 2"	" "	3549	Foraminisporis asymmetricus	
	" "	3642	Rouseisporites reticulatus	
	" "	3763	" "	
	" "	3940	" "	Permian
	" "	4078	" "	
	" "	4184	" "	
	" "	4272	" "	
	" "	4394	" "	
Pretty Hill Sst	" "	4489	" "	
	core 1	4532½	not determinable	
	sidewall core	4637	" "	
	" "	4705	" "	
	" "	4798	" "	
	" "	4878	Murospora florida	
	" "	4940	" "	
	" "	4964	" "	

Reference and Comments: Microfloral contents and zonal attribution of the sediments are discussed by Dettmann (1963 b,d).

Interstate Purrumbete No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Eumeralla Fm "Unit 1"	sidewall core	1602	Coptospora paradoxa (Dictyotosporites filosus)	
	" "	2100	?Crybelosporites striatus	Triassic
	" "	2300	" "	
	" "	2600	Crybelosporites striatus	
	" "	2800	" "	
Eumeralla Fm "Unit 2"	" "	2908	" "	
	" "	2995	" "	
	" "	3300	" "	
	" "	3510	" "	Triassic
	" "	3710	" "	
	" "	3830	?Foraminisporis asymmetricus	
	" "	4008	" "	

Eumeralla Fm "Unit 2"	sidewall core	4220	Foraminisporis asymmetricus
	" "	4490	" "
	" "	4722	" "
	" "	5070	" "
	" "	5300	Rouseisporites reticulatus
	" "	5695	" "
	" "	5925	?Rouseisporites reticulatus

Reference and Comments: Spore-pollen evidence obtained from the sediments is documented and discussed by Dettmann (1968c,d).

Shell Pecten 1-A

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
(arre Fm	sidewall core	5327	Appendicisporites distocarinatus
Eumeralla Fm "Unit 1"	" "	5920	Tricolpites pannosus
	" "	5977	?Coptospora paradoxa
	" "	6013	" "
	" "	6155	" "
	" "	7204	Coptospora paradoxa
	" "	7276	" "
	" "	7399	" "
	" "	7490	" "
	" "	7552	" "
Eumeralla Fm "Unit 2"	" "	7715	" "
	" "	7920	" "
	" "	8120	Coptospora paradoxa or Crybelosporites striatus
	" "	8206	" "
	" "	8333	" "
	" "	8546	" "
	" "	8630	" "
	" "	8670	" "
	" "	8743	" "
	" "	8873	" "
	" "	8962	" "
	" "	9132	?Crybelosporites striatus
	" "	9210	not determinable
	" "	9305	" "

Reference and Comments: The determinations cited above are quoted in

Dettmann (1967a). Data on the distribution of dinoflagellates and of reworked plant microfossils within the sequence is included within the latter report which has not been available during this study, since it was not brought to Canada. Samples between 5920 feet and 6155 feet warrant further investigation to determine if reworked microfossils of Lower Cretaceous age are represented in the microfloras.

Shell Nerita No. 1

SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
sidewall core	4782	Nothofagidites or Tricolpites pachyexinus
" "	4804	not determinable
" "	4944	Crybelosporites striatus
" "	5287	" "
" "	5561	" "
" "	5900	" "
" "	6068	" "
" "	6456	not determinable

Eumeralla Fm "Unit 2"

Reference and Comments: Microfloral details are documented by Dettmann (1967b), but this account has not been accessible during the present study.

Oil Development Anglesea No. 1

SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
core 6	1778-98	?Nothofagidites
" 7	1931-51	Coptospora paradoxa or Crybelosporites striatus
" 8	2225-45	" "
" 9	2286-96	" "
" 10	2557-67	Crybelosporites striatus
" 11	2860-70	" "
" 12	3158-68	" "
" 13	3460-70	Foraminisporis asymmetricus
" 14	3724-34	" "
" 16	4011-21	" "
" 17	4223-34	" "
" 18	4517-27	" "
" 19	4819-29	" "
cores 20 - 33	5161 - 10,065	not determinable

Eumeralla Fm "Unit 1"

Reference: Dettmann 1965c.

Comments: Microfloras obtained from the Lower Cretaceous sequence are poorly to badly preserved (carbonized). Few spore-pollen types were identified in the lower part of the section between 5161 feet and 10,065 feet; in the upper intervals it was not possible to identify all forms present. Dinoflagellates were not observed in the material examined.

Government Water Bores

V.D.M. Timboon No.5

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
Eumeralla Fm "Unit 1"	core BA	3407-10	Appendicisporites distocarinatus
	" BB	3500-04	Tricolpites pannosus
	" BC	3562-69	Coptospora paradoxa (unnamed unit)
	" BD	3680-91	" "

Reference: Dettmann (1964c).

Comments: Dinoflagellates appear initially within the Appendicisporites distocarinatus Zone (core BA).

V.D.M. Wangoom No.2

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
Eumeralla Fm "Unit 1"	core AM	3136-53	?Appendicisporites distocarinatus
	" AN	3225-45	?Tricolpites pannosus
	" AO	3347-49	Tricolpites pannosus
	" AP	3437-43	" "
	" AQ	3670-72	not determinable
	" AR	3968-72	Coptospora paradoxa (unnamed unit)
	" AS	4224-46	?Coptospora paradoxa

Reference: Dettmann (1964f).

Comments: Dinoflagellates make their first appearance within the Tricolpites pachyexinus Zone (core AL, 3016-35 feet). Cores AM and AN contain extremely sparse microfloras that may be in part recycled.

V.D.M. Wangoom No.6

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Belfast Mdst	core AX	3252-56	Tricolpites pachyexinus	

Eumeralla Fm "Unit 1"	core AY	3314-21	?Coptospora paradoxa (unnamed unit)	D. speciosus Zone derivatives
	" AZ	3411-15	" "	
	" BA	3715-17	not determinable	
	" BB	3717-19	" "	

Reference: Dettmann (1964f).

Comments: Cores AY and AZ are probably within the Coptospora paradoxa Zone although they may be as young as the Tricolpites pannosus Zone. The earliest occurrences of dinoflagellates are within the Tricolpites pachyexinus Zone (core AX).

V.D.M. Terang No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
	core AL	1617-37	Tertiary	
Eumeralla Fm "Unit 1"	" AN	1741-47	Dictyotosporites speciosus (unit not determined)	Permian
	" AO	1840-50	Rouseisporites reticulatus	
	" AP	1934-42	" "	
	" AQ	2127-35	" "	

Reference: Dettmann (1964j).

V.D.M. Carpendeit No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
	core AL	1077-95	Tertiary	
Eumeralla Fm "Unit 1"	" AM	1166-76	?Crybelosporites striatus	
	" AN	1258-63	" "	
	" AO	1474-78	Crybelosporites striatus	
	" AP	1620-25	" "	
	" AQ	1689-702	" "	Permian

Reference: Dettmann (1964j).

Comments: Cores AO - AQ appear to be at the base of the Crybelosporites striatus Subzone. Cores AM and AN contain sparse microfloras and are probably within the C. striatus Subzone.

Not on Chart V.D.M. Tandarook No.1

SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
core AT	1923-29	not determined
" AU	2015-28	Crybelosporites striatus

Reference: Dettmann (1964j)

Comments: Only two samples from this sequence have been studied.

V.D.M. Mepunga No.7

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Pebble Point Fm	core AT	3413-28	Tricolpites pachyexinus	C. paradoxa Zone derivatives
Eumeralla Fm "Unit 1"	" AU	3623-43	Tricolpites pannosus	
	" AV	3858-75	Coptospora paradoxa (unnamed unit)	

Reference: Dettmann (1964j).

Comments: Dinoflagellates were observed in core AT, Tricolpites pachyexinus Zone.

If no value V.D.M. Cobriejong No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
? Sherbrook Gp	core K	1535-54	Nothofagidites or Triorites edwardsii
Eumeralla Fm "Unit 1"	" L	1658-63	not determinable
	" O	1871-77	" "
	" P	2022-36	" "

Reference: Dettmann (1964j).

Comments: Core O provided a sparse assemblage suggestive of a Lower Cretaceous age. Cores L and P did not yield plant microfossils. Dinoflagellates occur in core K (uppermost Cretaceous or Paleocene).

If no value V.D.M. Panmure No.2

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
Dilwyn Fm: Pebble Point Mbr	core AQ	2593-601	?Tricolpites pachyexinus
Eumeralla Fm "Unit 1"	" AR	2715-28	not determinable
	" AS	2865-80	" "

Reference: Dettmann (1964j).

Comments: Core AQ is of Upper Cretaceous age and is probably from within the Tricolpites pachyexinus Zone; dinoflagellates occur in this sample. Cores AR and AS provided sparse microfloras of probable Lower Cretaceous age.

V.D.M. Yangery No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Belfast Mdst	core AQ	2863-67	Clavifera triplex	C. paradoxa Zone derivatives
Eumeralla Fm "Unit 1"	" AR	3016-31	Coptospora paradoxa (Dictyotosporites filosus)	
	" AS	3193-208	not determinable	
	" AT	3379-88	Crybelosporites striatus	Triassic
	" AU	4320-30	" "	

Reference: Dettmann (1965a).

Comments: Core AR yielded Coptospora paradoxa and C. striata suggesting that the sediments are within the Dictyotosporites filosus Unit. Dinoflagellates occur within core AQ (Clavifera triplex Zone).

V.D.M. Laang No.1

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Paaratte Fm	core AT	3532-46	Nothofagidites	
Eumeralla Fm "Unit 1"	" AV	3869-74	Tricolpites pannosus	
	" AW	4081-94	Coptospora paradoxa (unnamed unit)	Permian

Reference: Dettmann (1965a).

V.D.M. Belfast No.4

	SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE	REMANIÉ FOSSILS
Curdies Fm	core AO	3561-65	?Nothofagidites	
Eumeralla Fm "Unit 1"	" AU	5065-73	not determinable	
	" AW	5344-54	Coptospora paradoxa (?Dictyotosporites filosus)	Permian, Triassic
	" AX	5501-21	not determinable	Permian, Triassic

Reference: Dettmann (1965a).

Comments: The sample of core AU did not yield stratigraphically significant plant microfossils. Core AW contains a sparse microflora in which a single specimen of Dictyotosporites speciosus was recorded together with species of the Coptospora paradoxa Zone. This would imply the presence of the Dictyotosporites filosus Unit, but it is possible that D. speciosus has been reworked from older sediments. The sparse assemblage extracted from core AX is suggestive of a Lower Cretaceous age.

Dinoflagellates occur in core AO of late Cretaceous age; they are also present in stratigraphically lower horizons referable to the Tricolpites pachyexinus Zone and occurring at 4492-4655 feet. Samples from within this interval have been studied by Cookson and Eisenack (1961) and Douglas (1962).

V.D.M. Ecklin No.3

SAMPLE	DEPTH (ft.)	SPORE-POLLEN ZONE
core AO	2142-44	Tertiary (Eocene)
" AR	2474-99	Cyclosporites hughesi (unit not determined)
" AS	2561-68	not determinable

imaralla Fm "Unit 1"

Reference: Dettmann (1965a).

Comments: Core AS is devoid of plant microfossils; core AR appears to be within the Cyclosporites hughesi Subzone but lacks diagnostic species of the units of this subzone.

ot 2 Chart

V.D.M. Birregurra No.1

Cookson (1954) and Cookson and Dettmann (1958a) examined horizons from between 1089 feet and 1102 feet. These sediments contain Coptospora paradoxa and are clearly within the Coptospora paradoxa Zone. Other species present suggest that the sediments are within the upper part of the zone. Overlying sediments at 1006 -1022 feet are of Paleocene age (Triorites edwardsii Zone).

Outcrop Material

More than 40 outcrop samples from the Otway Group were examined palynologically by Dettmann (1964g). Only three of the samples yielded sufficiently diverse and well preserved microfloras for zonal attribution of the sediments viz:

P35	*Dictyotosporites speciosus* Zone (no older than *Foraminisporis asymmetricus* Unit) or *Dictyotosporites filosus* Unit.
P53	*Crybelosporites striatus* Subzone or *Coptospora paradoxa* Zone.
Blanket Bay	*Crybelosporites striatus* Subzone

Several outcrop samples from the Otway Basin were studied by Dettmann (1963a). These include:

Barongarook Creek, 3m. SE Colac	*Coptospora paradoxa* Zone (unnamed unit)
Devil's Kitchen, $5\frac{1}{2}$m. SE mouth of Gellibrand River	" "
Bellarine Peninsula	" "
Barrabool Hills	*Crybelosporites striatus* Subzone

DISTRIBUTION OF THE SPORE-POLLEN ZONES

The following notes include brief reference to the known distribution of the spore-pollen zones in the Victorian section of the Otway Basin, and to the sequences in which the individual zones are most completely represented. They are intended to supplement the information tabulated on the preceding pages. Evaluation of the relationships existing between the spore-pollen zones and the lithological units of the basin has not been attempted since the writer does not have detailed information on the precise extent of the rock units in each section.

Jurassic

Sediments at 7385-95 feet in Casterton No.1 well are believed to be of Jurassic age and occur beneath a Lower Cretaceous sequence. As discussed previously, the palynological evidence indicates an age no older than the Middle Jurassic and possibly no younger than the Oxfordian-Kimeridgian. From the same well, Evans (1966c/ p.116)reports the occurrence of "two dolerite sills (7850-79 ft and 7895-947 ft) of Jurassic (153 m.y.) or Lower Cretaceous (120 m.y.) age".

Crybelosporites stylosus Zone

The zone has been identified only in several subsurface sections and is best known from Penola No.1 well, 4766-76 feet in South Australia. In Victoria, horizons in Pretty Hill No.1 at 6690-7214 feet and in Woolsthorpe No.1 at 6380 feet are possibly referable to the zone; these overlie pre?mesozoic basement. The zone was not identified in Casterton No.1 but may be represented in sediments at 6396-406 feet which unconformably overlie Middle-Upper Jurassic strata.

Murospora florida Unit

Sediments comprising this unit are of greater proven areal extent than the *Crybelosporites stylosus* Zone. The unit has been encountered in numerous subsurface sections, but has not been recognized in outcrop.

In Woolsthorpe No.1 well the unit comprises 1200 feet of sediments, overlying strata tentatively referred to the *Crybelosporites stylosus* Zone. In Casterton No.1 well a similar thickness of the unit appears to be developed. In Garvoc No.1 well, the unit is approximately 100 feet thick and rests on pre-Mesozoic metamorphics. The *Murospora florida* Unit may also be represented in Tullich No.1 well (4500-5863 feet), Heathfield No.1 well (6890-7500 feet), Pretty Hill No.1 well (within the interval 6070-6388 feet), and Eumeralla No.1 well (10,300-08 feet).

Rouseisporites reticulatus Unit

The unit has been recognized over wider areas of the basin than the *Murospora florida* Unit. It appears to be represented in its entirety in Heathfield No.1, Casterton No.1, and Eumeralla No.1 wells, attaining a thickness of 1000 - 1600 feet. In Pretty Hill No.1 well, the unit is absent or of considerably thinner development. It has been recognized at the base of the Purrumbete No.1 well and within the Lower Cretaceous sequences in Woolsthorpe No.1 and Garvoc No.1 wells. In Terang No.1 bore, horizons of the unit occur at the top of the Lower Cretaceous section and beneath Tertiary sediments.

Foraminisporis asymmetricus Unit

The unit appears to have extensive areal distribution within the Otway Basin, but shows considerable variation in thickness from one locality to another. Although its base was not determined in Fergusons Hill No.1 and Anglesea No.1 wells, it includes from at least 1400 - 1800 feet of sediment. The unit appears to be represented in its entirely and is 1300 feet thick in Purrumbete No.1 well. It is probably incompletely developed in Garvoc No.1 and Pretty Hill No.1 wells. In Eumeralla No.1 and Heathfield No.1 wells apparently complete developments of the unit are at least 500 feet in thickness. The unit is represented in Casterton No.1 and Woolsthorpe No.1 wells, but its vertical extent is unknown due to insufficient sampling.

Crybelosporites striatus Subzone

The subzone has been intersected in many of the subsurface sections examined and is known from at least two outcrop sections (Blanket Bay; Barrabool Hills). It is probably represented in its entirety in Eumeralla and Purrumbete No.1 wells where it attains thicknesses of 700 feet and 1100 feet repsectively. Thinner (ca.300 feet) developments of the subzone occur in Fergusons Hill No.1 and Heathfield No.1 wells, and the subzone appears to be absent from the Garvoc No.1 sequence. Numerous wells ceased drilling within the subzone (Flaxmans No.1 and Port Campbell No.4 wells; Carpendeit No.1, Tandarook No.1, and Yangery No.1 bores); the Tandarook and Carpendeit No.1 horizons referred to the subzone occur at or near the top of the Lower Cretaceous sequence. In Nerita No.1 well, the uppermost 1100 feet of the Lower Cretaceous sequence is referable to the Crybelosporites striatus Subzone; in Anglesea No.1 well, the subzone occurs at shallower depths within the upper portion of the Lower Cretaceous. The subzone possibly occurs in Pretty Hill No.1 and Pecten No.1 wells, but its precise extent in these sequences has not been ascertained.

Dictyotosporites filosus Unit

Developments of this unit generally comprise a thin sequence of sediments that occur in both the South Australian and Victorian sections of the basin. In Fergusons Hill No.1 well the unit may be as much as 1000 feet thick, whereas in Port Campbell No.4 a considerably thinner (less than 500 feet) development was recognized. The unit occurs in Flaxmans No.1, Garvoc No.1, and Pretty Hill No.1 wells but its precise vertical extent has not been ascertained. It is also present beneath the unconformity at the top of the Lower Cretaceous in Purrumbete No.1 well, Yangery No.1 bore and possibly Belfast No.4 bore. Its presence has not been established, possibly due to lack of sampling in Eumeralla No.1, Tullich No.1, and Heathfield No. 1 wells.

Coptospora paradoxa Zone (unnamed unit)

This the major portion of the Coptospora paradoxa Zone includes up to 2000 feet of sediments Fergusons Hill No.1, Flaxmans No.1, Port Campbell No.4, Sherbrook No.1, Eumeralla No.1, Pretty Hill No.1, Heathfield No.1, and Tullich No.1 wells. The unit also occurs in Port Campbell No.3 well and in Timboon No.5, Wangoom Nos.2 and 6, Mepunga No.7, Laang No.1, Yangery No.1 and Birregurra No.1 bores. Pecten No.1 and possibly Anglesea No.1 contain developments of the unit which was also identified in outcrop at Barongarook Creek, Devil's Kitchen, and on the Bellarine Peninsula.

Tricolpites pannosus Zone

The zone is of more limited areal distribution than the Coptospora paradoxa Zone. It includes a thin sequence of sediments in Pretty Hill No.1, Eumeralla No.1, Flaxmans No.1, Port Campbell Nos 2 and 4, and Pecten No.1 wells. It has also been recognized in Timboon No.5, Wangoom No.2, Mepunga No.7, and Laang No.1 bores and may be represented in Fergusons Hill No.1 and Heathfield No.1 wells. The zone has not been recognized in outcrop; it contains the first occurrences of dinoflagellates in the Upper Mesozoic of the Otway Basin.

Upper Cretaceous and Tertiary

Upper Cretaceous and Lower Tertiary spore-pollen and microplankton zones of Harris (1965), Evans (1966b), and Dettmann and Playford (1969) have not been considered in detail in this report. However, reference has been made to the age and zonal attribution of sediments immediately succeeding the Lower Cretaceous sequence in the majority of the subsurface sections examined.

The oldest Upper Cretaceous spore-pollen zone delineated by Dettmann and Playford (1969) is the Appendicisporites distocarinatus Zone; the zone is of ?Cenomanian-Turonian age and is within Evans's (1966b) Ascodinium parvum Zone. It has been recognized in several wells within the Port Campbell Embayment viz: Port Campbell Nos. 1, 2, 3, and 4; Flaxmans No.1; Fergusons Hill No.1; Sherbrook No.1; and Pecten -1 wells and Timboon No.5 and Wangoom No.2 bores. From available evidence it appears that the zone includes horizons of the Waarre Formation which Taylor (1964) and Leslie (1966) place within the Otway Group. Microfloras of the Waarre Formation contain several species not known from the Tricolpites pannosus and older zones. The microfloras, are however, sometimes sparse containing significant proportions of spore-pollen types thought to have been reworked from the Lower Cretaceous sequence; further detailed investigation of these microfloras is warranted.

The succeeding Clavifera triplex Zone appears to be of more limited areal distribution than the Appendicisporites distocarinatus Zone.within the Port Campbell Embayment with known representation in Port Campbell Nos. 2 and 4, Flaxmans No.1, Fergusons Hill No.1 and Pecten -1 wells. It is also known from the Tyrendarra Embayment in Yangery No.1 bore. Upper portions of the zone equate with Taylor's (1964) Zonule B and with Evans's (1966b) "unclassified gap"; the basal horizons are equivalent to the upper part of the Ascodinium parvum Zone. Foraminiferal evidence indicates that the zone is mostly of Turonian age.

Senonian - early Tertiary sediments are of more widespread distribution within the Otway Basin. In southern areas of the Port Campbell Embayment Senonian and younger horizons overlie the Clavifera triplex and Appendicisporites distocarinatus Zones; to the north the late Cretaceous-early Tertiary sequence succeeds progressively older horizons of the Lower Cretaceous development.

DISTRIBUTION OF DINOFLAGELLATES IN THE LOWER AND EARLY UPPER CRETACEOUS OF THE OTWAY BASIN

Acid resitant microfossils exhibiting features consistent with dinoflagellate morphology appear within the Otway Basin in sediments of late Albian or Cenomanian age and persist throughout the Upper Cretaceous sequence. The assemblages recorded from the Otway Basin show a remarkable similarity, both in specific content and in stratigraphical distribution, to the ones recorded from marine sequences of the Great Artesian and Carnarvon Basins (see Cookson and Eisenack 1958, 1960, 1961, 1962; Douglas 1962; Evans 1966b). These data possibly suggest that the Otway Basin dinoflagellates existed in marine or marginal marine envicrments despite the fact that modern dinoflagellates are not restricted to marine habitats. Evidence for a marine origin of much of the Otway Basin Upper Cretaceous sequence has been brought forward by Taylor (1964), but dinoflagellates also occur in horizons for which a marine origin is less certain. This is particularly the case for sediments deposited during late Albian and early Upper Cretaceous (pre-Turonian) times when dinoflagellates appeared and became established within the Otway Basin.

As documented in preceding sections of this article, dinoflagellates make their initial appearances within the Tricolpites pannosus Zone. Their distribution within this zone in the area studied is clearly not ubiquitous, either in a lateral or vertical sense. In fact dinoflagellates appear to be confined to southerly developments of the zone within the Port Campbell Embayment, with known representation in Flaxmans No.1 and Port Campbell No.2 wells. Within these sections the dinoflagellates are minor components of the microfloras (less than 2%) and are not particularly diverse. Species represented include Gonyaulacysta spp. (including G. edwardsii), Odontochitina operculata, and Ascodinium parvum. Assemblages containing these species occur over wider areal extents of the Port Campbell Embayment within the Appendicisporites distocarinatus Zone, with documented occurrences from Port Campbell Nos. 1,2,3, and 4; Flaxmans No.1; Sherbrook No.1; and Fergusons Hill No.1 wells and Timboon No.5 bore. Similar but more diverse assemblages occur within the basal portion of the Clavifera triplex Zone as developed within the Port Campbell Embayment (Port Campbell Nos. 2 and 4, Flaxmans No.1, and Fergusons Hill No.1 wells) and also within the Tyrendarra Embayment (Yangery No.1 bore). Succeeding horizons of the Clavifera triplex Zone contain continued appearances of Odontochitina operculata together with the introduction of several types not known from underlying strata; in places these assemblages are associated with Foraminifera indicative of Taylor's (1964) Zonule B of Turonian age.

The Turonian and later Upper Cretaceous occurrences have not been documented in detail in the present account, but from records presented by Cookson and Eisenack (1961), Douglas (1962), Evans (1966b), and Dettmann (1964a and later) it appears that dinoflagellates attain maximum diversity and areal distribution during the Senonian in strata attributable to Taylor's (1964) Zonule A.

A morphologically distinct group of microplankton referred to the heterogenous group, the Acritarcha, are sometimes associated with dinoflagellates in the Otway Basin late Albian - uppermost Cretaceous sequence and also occassionally occur in Lower Cretaceous horizons that lack dinoflagellates. Evans (1966b) has discussed the stratigraphical distribution of such forms within pre Upper Albian strata, suggesting that certain types made provide ephemeral evidence for marine incursions during this time period. Whilst several of the forms recorded by him are of algal and possibly chlorophycean affinity, and hence probably of aquatic origin, there is as yet no firm evidence to postulate their precise enviormental significance.

REWORKED SPORES AND POLLEN GRAINS IN LOWER CRETACEOUS SEDIMENTS OF THE OTWAY BASIN

Numerous records have been made of the presence of reworked spores and pollen grains within the Otway Basin Lower Cretaceous sequence (Evans 1961; Dettmann 1963b and later; present study). Types identified by these authors are of Permian, Triassic, and early Cretaceous age. The reworked fossils are rarely common (forming less than 1% of total microflora) and occur spasmodically in many of the well sequences studied. Their presence illustrates that Permian, Triassic, and/or early Cretaceous sediments provided, at least in part, the source material of the enclosing horizons.

Fossil spores and pollen grains are not particularly durable to prolonged oxidisation processes and hence to survive a second cycle of deposition need to be transported and buried under non-oxidising conditions (Muir 1967). The importance of detecting reworked spores and pollen grains is stressed by several workers (eg. Muller 1959, Muir 1967) for if undetected, false stratigraphical and phytogeographical conclusions may be drawn. Spores and pollen are usually easy to recognise as having been recycled when the microfloras with which they are associated are of considerably younger aspect. However, reworking is more difficult to detect when there has been a brief time lapse between primary and secondary deposition. Certainly in the present study, representation of reworked Lower Cretaceous fossils in slightly younger Lower Cretaceous microfloras was not always immediately apparent, whereas Permian and Triassic forms were readily recognized as having been recycled.

From present records, Permian and Triassic spores and pollen appear to be widely dispersed within the Otway Basin Lower Cretaceous sequence. They are more persistent within the upper portions of the <u>Dictyotosporites</u>

speciosus Zone and in the succeeding Coptospora paradoxa and Tricolpites pannosus Zones, and are as yet unknown from the Crybelosporites stylosus Zone and Murospora florida Unit. Permian forms are also well represented in the Upper Cretaceous - Lower Tertiary sequence (detailed records not given here, but refer Cookson 1956, Evans 1962, Dettmann 1967a). However, little evidence has been brought forward as to possible areas from which the reworked types were derived during Cretaceous and early Tertiary times.

Spores and pollen reworked from the Dictyotosporites speciosus Zone are also widely distributed in the Tricolpites pannosus Zone and are occassionally represented in uppermost horizons of the Coptospora paradoxa Zone. These data suggest erosion of the D. speciosus Zone during late Albian times. This trend continued throughout the Upper Cretaceous and early Tertiary as evidenced by the widespread distribution of D. speciosus Zone derivatives, together with reworked types from the Coptospora paradoxa and Tricolpites pannosus Zones, in the Upper Cretaceous - Lower Tertiary sequence. Within the Port Campbell Embayment, Lower Cretaceous reworked types are especially prevalent (up to 10% of total microflora) in horizons immediately above a suspected hiatus in the Upper Cretaceous sequence. Leslie (1966) refers to a change in source material of the Waarre Formation indicating that the unit includes reworked Otway Group sediments, and both Leslie and Taylor (1964) indicate that widespread faulting affected the Lower Cretaceous sequence during the Upper Cretaceous. Moreover, the marine Upper Cretaceous sediments accumulated on a sloping surface (of the Otway Group) trending northwest - southeast (Taylor 1964). Significantly horizons of the Otway Group forming this sloping surface and which were exposed during the Upper Cretaceous, occur in the northern and western portions of the embayment and are referable to the D. speciosus - T. pannosus Zones. Lower Cretaceous sediments comprising the Otway Ranges were also apparently exposed during the Upper Cretaceous (Taylor 1964) and although palynological data from this area are meagre, some horizons are referable to the D. speciosus and C. paradoxa Zones.

CONCLUSIONS

Palynological data reviewed in this report serve to illustrate the time-stratigraphical relationships within, and the structural configuration of, the Otway and Merino Groups as developed within the Victorian section of the basin. In Figure 1 the palynological evidence has been used to express these features within subsurface developments in the Port Campbell Embayment and eastern Tyrendarra Embayment. Few sections have been available for study in other areas of the Victorian section of the basin, but a number of conclusions may be surmised from the data obtained from them.

Basal horizons of the Mesozoic sequence developed within the Victorian section of the basin are clearly not everywhere of the same age. The base of the sequence as encountered in Casterton No.1 well is of probable Middle-Upper Jurassic age and is distinctly older than sediments assigned tentatively to the Crybelosporites stylosus Zone and which overlie pre-Mesozoic basement in Pretty Hill No.1 and Woolsthorpe No.1 wells. To the east, in Garvoc No.1 well, the base of the Mesozoic sequence is younger and belongs to the Murospora florida Unit; in Fergusons Hill No.1 well, basal horizons are within the Cyclosporites hughesi Subzone and may be as young as the Foraminisporis asymmetricus Unit of this subzone.

Palynological evidence supports the presence of an unconformity between Middle-Upper Jurassic and Lower Cretaceous sediments in Casterton No.1 well. Several other unconformities appear to exist within the Lower Cretaceous sequence at certain localities. In Garvoc No.1 well the Crybelosporites striatus Subzone is not represented and the Foraminisporis asymmetricus Unit appears to be incompletely developed between horizons of the Rouseisporites reticulatus and Dictyotosporites filosus Units. The R. reticulatus - F. asymmetricus Units and/or C. striatus Subzone may be incompletely represented in Pretty Hill No.1 well, and in Woolsthorpe No.1 well the R. reticulatus Unit may be only partially developed. Leslie (1966) suggests the possible existence of an unconformity within Fergusons Hill No.1 well and this may account for the thin development of the C. striatus Subzone within this well.

Palynological data also illustrate that the top of the Otway Group and its equivalents does not form a time concordant surface. This is most clearly evident in the Port Campbell Embayment where more reference sections have been available for study (see Fig. 1). Within this area, the upper surface of the Otway Group (excluding Waarre Formation) is youngest along the coastal strip between Port Campbell and Warrnambool to as far north as Timboon. Here the top of the Otway Group is comprised of strata belonging to the Tricolpites pannosus Zone (as in Fergusons Hill No.1, Port Campbell Nos. 2 and 4, Flaxmans No.1, Mepunga No.7, Wangoom No.2, and Timboon No.5). At other localities (Wangoom No.6 and Sherbrook No.1) uppermost horizons of the Otway Group are probably older and are referable to the Coptospora paradoxa Zone (unnamed unit). Farther to the north and west successively older biostratigraphic subdivisions form the top of the Otway Group as encountered in Purrumbete No.1 (Dictyotosporites filosus Unit), Carpendeit No.1 (Crybelosporites striatus Subzone) and Terang No.1 (Rouseisporites reticulatus Unit).

A similar situation appears to exist in the Tyrendarra Embayment to the west of Warrnambool. Here data are scarce, but in Belfast No.4 and Yangery No.1 the Dictyotosporites filosus Unit comprises the top of the Lower Cretaceous sequence, whereas in Eumeralla No.1 and Pretty Hill No.1 horizons of the Tricolpites pannosus Zone occur beneath Upper Cretaceous sediments. Few data are available from other areas. In the Anglesea Embayment, uppermost horizons of the Otway Group are possibly comparable in age in Anglesea No.1 (Crybelosporites striatus Subzone or Coptospora paradoxa Zone) and Nerita No.1 (C. striatus Subzone); outcrops in the Cape Otway - Colac area are within the upper part of the Dictyotosporites speciosus Zone and the Coptospora paradoxa Zone. Uppermost horizons of the Lower Cretaceous sequence in Heathfield No.1 are within the Tricolpites pannosus Zone, but were not sampled in Casterton No.1 and Tullich No.1.

Marine influences testified by the presence of dinoflagellates occurred during deposition of the Tricolpites pannosus Zone in Flaxmans No.1 and Port Campbell No.2 wells. The remainder of the Lower Cretaceous samples studied lack palynological evidence that unequivocably suggest deposition under marine conditions.

Source material of the Lower Cretaceous sediments appears to have been partly derived from Permian and Triassic sediments. Developments of the sequence were in places eroded contemporaneously with deposition of late Albian - Lower Tertiary strata.

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25th July, 1969.

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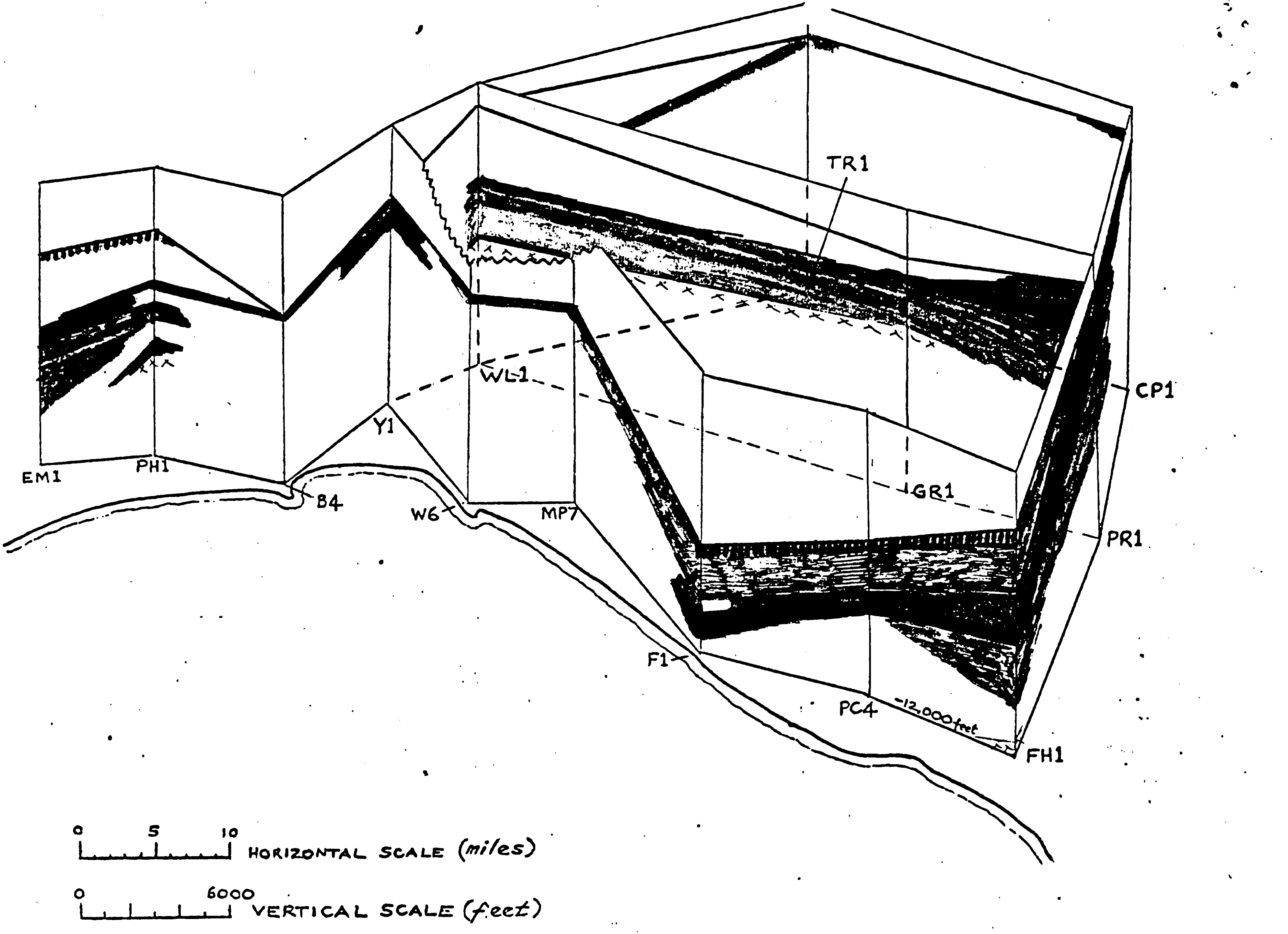


TR1
CP1
WL-1
Y1
EM1
PH1
B4
W6
MP7
GR1
PR1
F1
PC4
-12,000 feet
FH1
0 5 10 HORIZONTAL SCALE (miles)
0 6000 VERTICAL SCALE (feet)

EXPLANATION OF FIGURE 1

Panel diagram showing distribution of spore-pollen zones in Lower Cretaceous sediments of Port Campbell and Tyrendarra embayments.

Legend to biostratigraphic units (see Table 1 for hierarchial system):

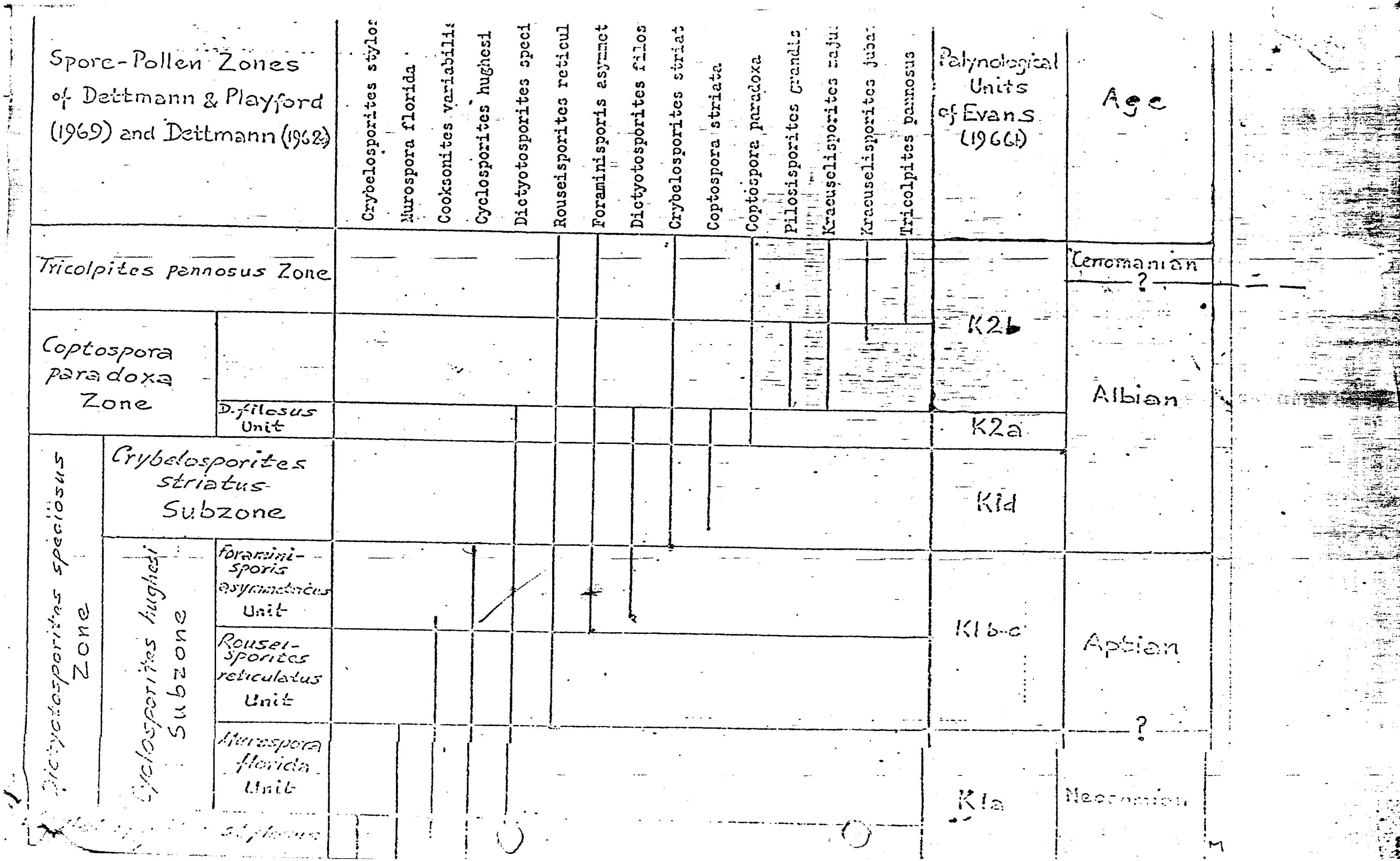
- *Tricolpites pannosus* Zone
- *Coptospora paradoxa* Zone (unnamed Unit)
- *Dictyotosporites filosus* Unit
- *Crybelosporites striatus* Subzone
- *Foraminisporis asymmetricus* Unit
- *Rouseisporites reticulatus* Unit
- *Murospora florida* Unit
- *Crybelosporites stylosus* Zone

Well symbols:

EM1 - Eumeralla No. 1 well
PH1 - Pretty Hill No. 1 well
B4 - Belfast No. 4 bore
Y1 - Yangery No. 1 bore
W6 - Wangoom No. 6 bore
MP7 - Mepunga No. 7 bore
F1 - Flaxmans No. 1 well
PC4 - Port Campbell No. 4 well
FH1 - Fergusons Hill No. 1 well
PR1 - Purrumbete No. 1 well
CP1 - Carpendeit No. 1 bore
TR1 - Terang No. 1 bore
GR1 - Garvoc No. 1 well
WL1 - Woolsthorpe No. 1 well

Heavy black lines connecting well sections represent top of Lower Cretaceous Otway Group.

Black crosses denote (pre-Mesozoic) basement.



Spore-Pollen Zones of Dettmann & Playford (1969) and Dettmann (1962)
Crybelosporites stylos
Murospora florida
Cooksonites variabilis
Cyclosporites hughesi
Dictyotosporites speci
Rouseisporites reticul
Foraminisporis asymmet
Dictyotosporites filos
Crybelosporites striat
Coptospora striata
Coptospora paradoxa
Pilosisporites grandis
Kraeuselisporites majus
Kraeuselisporites jubat
Tricolpites pannosus
Palynological Units of Evans (1966)
Age
Tricolpites pannosus Zone
Coptospora paradoxa Zone
D. filosus Unit
Crybelosporites striatus Subzone
Foraminisporis asymmetricus Unit
Rouseisporites reticulatus Unit
Murospora florida Unit
Cyclosporites hughesi Subzone
Dictyotosporites speciosus Zone
K2b
K2a
K1d
K1b-c
K1a
Cenomanian
?
Albian
Aptian
?
Neocomian