PALYNOLOGICAL EXAMINATION

OF ARDONACHIE NO. 2 BORE

872 - 3105 FEET

OTWAY BASIN

BY

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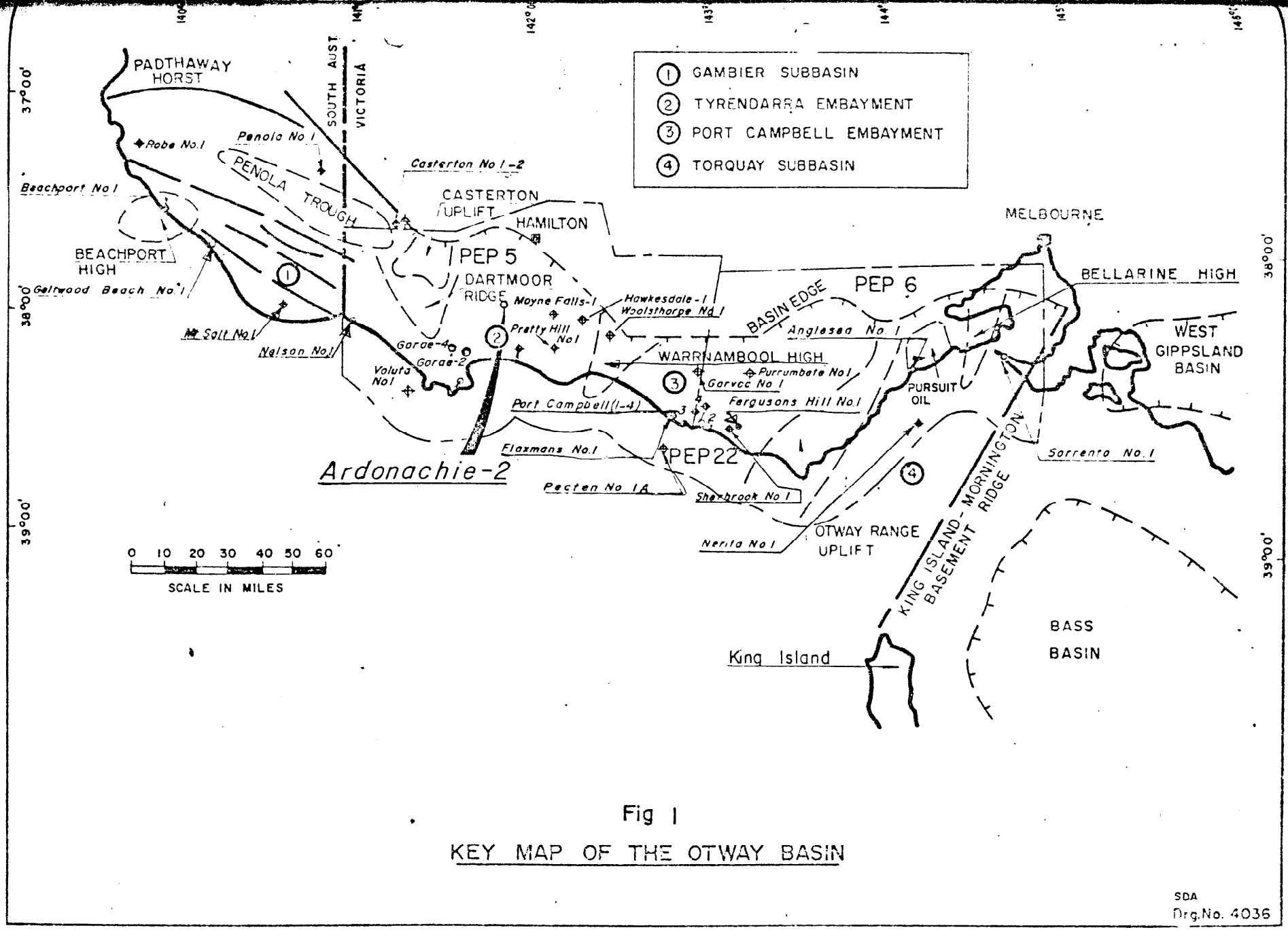

Fig 1

KEY MAP OF THE OTWAY BASIN

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PALYNOLOGICAL EXAMINATION OF ARDONACHIE No.2 BORE,
872 - 3105 FEET

I INTRODUCTION

Ten samples of cores from between 872 and 3105 feet in Ardonachie No.2 bore were submitted by Shell Development (Australia) Pty. Ltd. for palynological examination and age determination. The bore was sunk in the Otway Basin, Victoria by the Mines Department of Victoria and the cored section examined is considered (refer Sample list; E&P:MA:33.21; 6th August, 1970) to include horizons of the Wangerrip Group (872-2444 feet), possible developments of the Sherbrook Group (2623-37 feet), and probable horizons of the Otway Group (2864-3105 feet).

All samples were processed for palynological examination by a method involving the use of hydrofluoric acid, zinc bromide and ultrasonic vibration (see Dettmann 1968). After this treatment the residues were examined for plant microfossils, the preservation quality of which was ascertained (see Table 1). Specific analyses of the plant microfossil assemblages was carried out after the residues were subjected to further treatment with Schulze solution (2-3 minutes) and weak alkali (ca. 1% ammonium hydroxide), followed by thorough washing in distilled water.

Plant material including spores, pollen grains, and fragments of wood and cuticle was obtained from all samples; dinoflagellate cysts and/or acritarchs are also represented in minor proportions in the majority of samples. Evidence provided by the plant microfossils indicates that the section examined includes horizons of Upper (872-2067 feet) and Middle (2441-2837 feet) Paleocene age overlying a thin Senonian (2864-2902 feet) sequence which rests on Middle - Upper Albian (3101 - 05 feet) strata. These age estimations are based upon the presence of Harris' (1965, 1970)

Gambierina edwardsii and Cupanieidites orthoteichus Zonules and of Dettmann and Playford's (1969) Tricolpites pachyexinus and Contospora paradoxa Zones.

II MICROFLORAL ASSEMBLAGES AND AGE DETERMINATIONS

The microfloras extracted from the samples are documented below in terms of their qualitative and quantitative content. The quantitative estimates are denoted as floows: Ab (abundant) - numerical representation of a particular species totals at least 5% of total microflora; C (common) - numerical representation of a species forms 1-5% of total microflora; and R (rare) - numerical representation of a species is less than 1% of total microflora.

A. 872 - 2067 feet

core 5, 872-94 feet

Prob *M. diversus*

An abundant well preserved microflora was obtained from the sample. The following types were observed:

Spores	Baculatisporites comaumensis (Cookson)	C
	Cyathidites australis Couper	C
	C. minor Couper	C
	Gleicheniidites circinidites (Cookson)	C
	Laevigatosporites ovatus Wilson & Webster	C
	L. major (Cookson)	C
	Trilites tuberculiformis Cookson	R
	Verrucosisporites kopkuensis (Couper)	R
Pollen	* Alisporites grandis (Cookson)	R
	* Cupanieidites orthoteichus Cookson & Pike	R
	Dacrydiumites florinii Cookson & Pike	R
	Dilwynites granulatus Harris	Ab
	Malvacipollis diversus Harris	R
	* Myrtaceidites eugenioides Cookson & Pike	C
	Microcachryidites antarcticus Cookson	C
	Nothofagidites emarcidus (Cookson)	C
	N. brachyspinulosus (Cookson)	R
	Phyllocladidites mawsonii Cookson	C
	Podocarpidites ellipticus Cookson	Ab
	P. exiguus Harris	R
	Proteacidites annularis Cookson	R
	P. crassus Cookson	R
	* P. dilwynensis Harris	C
	P. incurvatus Cookson	R

	*P. reticuloscabratus Harris	R
	P. subscabratus Couper	Ab
	Tricolporites prolata Cookson	C
	Tricolpites sp.	C
	Tiliaepollenites notabilis Harris	R
	Triorites harrisii Couper	Ab
Microplankton:	Cordosphaeridium sp.	R
Remanié:	Arcellites reticulatus (Cookson & Dettmann) - Lower or early Upper Cretaceous	

core 7, 1114-33 feet

Abundant, well preserved spores and pollen grains were extracted from the sample as follows:

Spores:	Baculatisporites comaumensis (Cookson)	Ab
	Cyathidites australis Couper	R
	C. minor Couper	C
	C. gigantis (Cookson)	R
	Clavifera sp.	R
	Gleicheniidites circinidites (Cookson)	C
	Foveotriletes sp.	R
	Lycopodiumsporites austroclavatidites (Cookson)	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
	Verrucosisporites kopukuensis (Couper)	R
Pollen:	Araucariacites australis Cookson	R
	Banksieaeidites sp.	R
	*Cupanieidites orthoteichus Cookson & Pike	R
	Dilwynites granulatus Harris	Ab
	Microcachryidites antarcticus Cookson	R
	Myrtaceidites eugeniioides Cookson & Pike	C
	Malvacipollis diversus Harris	C
	Nothofagidites emarcidus (Cookson)	C
	N. cf. brachyspinulosus (Cookson)	R
	Podocarpidites ellipticus Cookson	Ab
	P. exiguus Harris	R
	* Polyporina fragilis Harris	C
	Proteacidites adenanthoides Cookson	R
	P. crassus Cookson	C
	P. crassipora Harris	R
	* P. dilwynensis Harris	R
	*P. reticuloscabratus Harris	R
	P. subscabratus Couper	Ab
	P. tuberculiformis Harris	R
	Triorites harrisii Couper	Ab
	Tricolpites sp.	R
	Tetracolpites sp. Tetracolporites sp ?	R

core 10, 1446-48 feet

An abundant well preserved assemblage of spores and pollen grains

as extracted from the sample. Microplankton were also recovered in minor

roportions. The following types were identified:

pores:	Cyathidites australis Couper	C
	C. minor Couper	Ab
	Gleicheniidites circinidites (Cookson)	C
	G. sp.	R
	Laevigatosporites ovatus Wilson & Webster	C
	L. major (Cookson)	C
ollen:	Cycadopites sp.	R
	Dilwynites granulatus Harris	Ab
	Dacrydiumites florinii Cookson & Pike	Ab
	Malvacipollis diversus Harris	Ab
	Myrtaceidites eugeniioides Cookson & Pike	C
	Nothofagidites emarcidus (Cookson)	R
	N. cf. brachyspinulosus (Cookson)	R
	Microcachryidites antarcticus Cookson	Ab
	*Polyporina fragilis Harris	R
	Podocarpidites ellipticus Cookson	Ab
	Proteacidites annularis Cookson	C
	P. crassus Cookson	R
	*P. scaboratus Couper	C
	P. subscabratus Couper	Ab
	*P. reticuloscabratus Harris	R
	Tricolpites sp.	R
icroplankton:	Baltisphaeridium sp.	R
	Deflandrea cf. obliquipes Deflandre & Cookson	R

ore 12, 1719-39 feet

Well preserved spores and pollen grains occur in the

esidue in abundant proportions. Species identified include:

pores:	Baculatisporites comaumensis (Cookson)	C
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	C. splendens Harris	R
	Gleicheniidites circinidites (Cookson)	C
	Laevigatosporites ovatus Wilson & Webster	Ab
	*Latrobosporites crassus Harris	R
	Verrucatosporites speciosus Harris	R
ollen:	Araucariacites australis Cookson	R
	*Cupanieidites orthoteichus Cookson & Pike	R
	Dacrycarpites australiensis Cookson & Pike	R
	Dacrydiumites florinii Cookson & Pike	Ab
	Dilwynites granulatus Harris	Ab
	Microcachryidites antarcticus Cookson	C
	Malvacipollis diversus Harris	C
	Myrtaceidites eugeniioides Cookson & Pike	C
	Phyllocladidites mawsonii Cookson	R
	Podocarpidites ellipticus Cookson	C
	P. exiguus Harris	C

	Proteacidites annularis Cookson	R
	P. adenanthoides Cookson	C
	P. crassus Cookson	C
	*P. dilwynensis Harris	R
	P. incurvatus Cookson	R
	P. subscabratus Couper	Ab
	Triorites harrisii Couper	C
	Tricolporites prolata Cookson	C
	Tiliaepollenites notabilis Harris	R
	Tricolpites sp.	R
Remanié:	Nuskoisporites sp. - Permian	

core 15, 2063-67 feet

The following species of well preserved spores and pollen grains were observed in the residue which contains abundant plant microfossils:

ores:	Baculatisporites comaumensis (Cookson)	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	C. splendens Harris	R
	Gleicheniidites circinidites (Cookson)	Ab
	Laevigatosporites ovatus Wilson & Webster	C
	*Latrobosporites crassus Harris	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	Stereisporites antiquasporites (Wilson & Webster)	C
Pollen:	Dacrydiumites florinii Cookson & Pike	R
	Dilwynites granulatus Harris	Ab
	Microcachryidites antarcticus Cookson	C
	Nothofagidites cf. brachyspinulosus (Cookson)	R
	Podocarpidites ellipticus Cookson	Ab
	P. microsaccatus (Couper)	C
	Myrtaceidites eugeniioides Cookson & Pike	R
	Proteacidites crassus Cookson	C
	*P. dilwynensis Harris	R
	*P. reticuloscabratus Harris	C
	P. subscabratus Couper	Ab
	P. tuberculiformis Harris	R
	*Stephanoporopollenites obscurus Harris	R
	Tricolpites sp.	R
[illegible]:	Triorites harrisii Couper	C
Remanié:	Nuskoisporites sp. - Permian	
	Murospora florida (Balme))	
	Pilosisporites notensis Cookson & Dettmann)	- Lower Cretaceous

The abundant well preserved microfloras obtained from sediments between 872 and 2067 feet are characterized by an abundance and diversity of proteaceous forms, abundant Podocarpidites, Dilwynites, and infrequent Nothofagidites. Pteridophyte elements are frequent but display little diversity.

Specifically, the microfloras are characterized by Cupanieidites orthoteichus, Proteacidites reticuloscabratus, P. dilwynensis, Myrtaceidites eugeniioides, and Tiliaepollenites notabilis, which are absent from lower horizons in the well. The microfloras thus suggest reference of the sediments between 872 and 2067 feet to Harris' (1965, 1970) Cupanieidites orthoteichus Zonule of Upper Paleocene age.

Rare microplankton occur in two of the samples here referred to the Cupanieidites orthoteichus Zonule; types identified provide some support for a Lower Tertiary age (Cookson and Eisenack 1967).

Plant microfossils of Permian and Lower Cretaceous age occur infrequently in the residues and demonstrate that Permian and Lower Cretaceous horizons provided, at least in part, source material of the enclosing sediments.

The abundance of land derived forms and the intermittent and rare occurrence of microplankton suggests that the sediments accumulated in a continental to near-shore marine environment.

B. 2441 - 2637 feet

core 18, 2441-44 feet

Reasonably well preserved spores and pollen grains occur frequently in the sample which also yielded minor proportions of microplankton as follows:

Spores:	Baculatisporites comaumensis (Cookson)	Ab
	Cyathidites australis Couper	Ab
	C. minor Couper	C
	Gleicheniidites circinidites (Cookson)	C
	Laevigatosporites ovatus Wilson & Webster	C
	Lycopodiumsporites austroclavatidites (Cookson)	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
Pollen:	Dacrydiumites florinii Cookson & Pike	R
	D. balmei Cookson	R
	Dilwynites granulatus Harris	C
	D. tuberculatus Harris	Ab
	Araucariacites australis Cookson	C

	Microcachryidites antarcticus Cookson	C
	Phyllocladidites mawsonii Cookson	Ab
*	P. reticulosaccatus Harris	R
	Podocarpidites ellipticus Cookson	C
	P. exiguus Harris	C
	Proteacidites crassus Cookson	C
	P. subscabratus Couper	Ab
	Tricolporites sp.	R
Microplankton:	Deflandrea dartmooriaCookson & Eisenack	R
	Epicephalopyxsis indentata Deflandre & Cookson	C
	Hystrichosphaeridium sp.	R
Remanié:	Nuskoisporites sp. - Permian	

core 19, 2625-37 feet

A small residue in which one to several examples of the following types was obtained from the sample:

Spores:	Ceratosporites sp.	
	Cyathidites australis Couper	
	Laevigatosporites ovatus Wilson & Webster	
Pollen:	Cycadopites sp.	
*	Dacrydiumites ellipticus Harris	
	D. balmei Cookson	
	Microcachryidites antarcticus Cookson	
	Phyllocladidites mawsonii Cookson	
	Proteacidites subscabratus Couper	
Incertae Sedis:	Amosopollis sp.	
Microplankton:	Epicephalopyxsis indentata Deflandre & Cookson	

Assemblages extracted from samples between 2441 and 2637 feet are well preserved but are restricted in both a qualitative and quantitative sense; in particular, angiosperms exhibit a marked decrease in abundance and diversity in comparison with stratigraphically higher assemblages. The two assemblages recovered from 2441-2637 feet contain Dacrydiumites balmei which appears on present knowledge to be restricted to Harris' (1965, 1970) Gambierina edwardsii Zonule, with possible representation in undifferentiated lowermost Tertiary - uppermost Cretaceous strata (i.e. in horizons immediately above those containing the Nothofagidites Microflora of Dettmann and Playford 1969). The Gambierina edwardsii Zonule is dated as Middle Paleocene although it is possible that its lower age limit may be

within the early Paleocene (see Harris 1970; McGowran, Lindsay, and Harris 1970).

Microplankton recorded from the samples are frequent components of Paleocene strata elsewhere in the Otway Basin (Deflandre and Cookson 1955; Cookson and Eisenack 1965, 1967).

The sediments appear to have accumulated in a near-shore marine environment as evidence by the persistent, but infrequent microplankton content.

C. 2864 - 2902 feet

Core 20, 2864-75 feet

A sparse assemblage of fairly preserved spores and pollen grains occurs in the sample. Other microfossils identified include dinoflagellate cysts and chitinous foraminiferal remains. Species identified include:

Spores: Clavifera triplex (Bolkhovitina)
Laevigatosporites ovatus Wilson & Webster
Lycopodiumsporites austroclavatidites (Cookson)
Pollen: Microcachryidites antarcticus Cookson
Phyllocladidites mawsonii Cookson
Proteacidites subscabratus Couper
Microplankton: *'Gymnodinium' nelsonense Cookson
Hexagonifera glabra Cookson & Eisenack

core 21, 2895-902 feet

Plant microfossils occur frequently in the residue and include the following forms of spores, pollen grains, and microplankton:

Spores:	Camarozonosporites amplus (Stanley)	R
	Baculatisporites comaumensis (Cookson)	Ab
	Clavifera triplex (Bolkhovitina)	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	Gleicheniidites circinidites (Cookson)	Ab
	Laevigatosporites ovatus Wilson & Webster	Ab
	Stereisporites antiquasporites (Wilson & Webster)	C
Pollen:	Asteropollis sp.	C
	Cycadopites sp.	C
	Araucariacites australis Cookson	C
	Microcachryidites antarcticus Cookson	R
	Podocarpidites ellipticus Cookson	Ab
	P. sp.	R

	Phyllocladidites mawsonii Cookson	C
	Proteacidites subscabratus Couper	C
	P. spp.	R
*	Tricolpites pachyexinus Couper	R
	T. spp.	C
	Tricolporites spp.	C
Incertae Sedis:	Amosopollis cruciformis Cookson & Balme	R
Microplankton:	'Hystrichosphaeridium' heteracanthum Deflandre & Cookson	R
	Odontochitina porifera Deflandre & Cookson	R

The two samples from between 2864 and 2902 feet provided reasonably well preserved plant microfossils. The assemblage from 2864-75 feet is sparse in spores, pollen grains, and microplankton. Stratigraphically significant species include Hexagonifera glabra and 'Gymnodinium' nelsonense, components of Evans' (1966) Deflandrea cretacea Zone which is equivalent to the basal portion of the Tricolpites pachyexinus Zone of Dettmann and Playford (1969). The age of the horizon is thus within the Senonian.

The lower sample yielded more frequent spores and pollen grains including Camarozonosporites amplus, Tricolpites pachyexinus, and various undesribed forms together with the microplankton Odontochitina porifera. On this basis the deposit is also included within the Tricolpites pachyexinus Zone.

On the basis of the occurrence of dinoflagellate cysts in a dominantly land-derived microflora, the sediments are considered to have accumulated in a near-shore marine to brackish water situation.

D. 3101 - 05 feet

core22, 3101-05 feet

Fairly preserved spores and pollen grains occur abundantly in the residue together with rare examples of probable acritarchs. The following species were identified:

C paradoxa (prob. unnamed C paradoxa)

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	R
	A. verrucosus (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	C

	Balmeisporites holodictyus Cookson & Dettmann	C
	B. tridictyus Cookson & Dettmann	R
	Cicatricosisporites australiensis (Cookson	C
	C. pseudotripartitus (Bolkhovitina)	R
	Coptospora paradoxa (Cookson & Dettmann)	C
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	C. punctatus (Delcourt & Sprumont)	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	R
	F. dailyi (Cookson & Dettmann)	R
	Rouseisporites reticulatus Pocock	R
	R. simplex (Cookson & Dettmann)	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
	Trilobosporites trioreticulosus Cookson & Dettmann	R
Pollen:	Araucariacites australis Cookson	C
	Alisporites grandis (Cookson)	R
	A. similis (Balme)	R
	Cycadopites nitidus (Balme)	C
	Classopollis cf. classoides Pflug	R
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites ellipticus Cookson	Ab
	Podosporites microsaccatus (Couper)	C
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	R

The sample provided abundant, reasonably well preserved spores and pollen grains. Gymnosperms and pteridophytes are diversely represented in the assemblage which lacks undoubted angiosperms. The presence of Coptospora paradoxa, Trilobosporites trioreticulosus, and Balmeisporites holodictyus leaves little doubt that the horizons are within the Coptospora paradoxa Zone of Middle-Upper Albian age (See Dettmann and Playford 1969; Evans and Hawkins 1967).

The preponderance of land-derived plant microfossils and the apparent absence of dinoflagellate cysts suggests that the sediments accumulated in a continental environment.

III CONCLUDING REMARKS

As outlined above the following spore-pollen biostratigraphic units occur in Ardonachie No.1 bore:- the Cupanieidites orthoteichus Zonule between 872 and 2067 feet; the Gambierina edwardsii Zonule between 2441 and 2637 feet; the Tricolpites pachyexinus Zonule between 2864 and 2902

feet; and the Coptospora paradoxa Zone at 3101-05 feet.

Nearby sequences in which these spore-pollen biostratigraphic units have been identified include Eumeralla No.1 well and Branxholme No.1, Gorae No.2, and No.4 bores. Thus the following correlations may be proposed:-

1) Ardonachie No.1 between 872 and 2067 feet is equivalent to at least part of the sequence between 2933 and 5432 feet in Gorae No.2; between 2895 and 6084 feet in Gorae No.4; and possibly to horizons between 2108-21 in Eumeralla No.1 (see Dettmann 1970a,b).

2) Ardonachie No.1 between 2441 and 2637 feet and Branxholme No.1 between 370 and 430 feet are probable equivalents and are referable to the Gambierina edwardsii Zonule (see Dettmann 1969).

3) Ardonachie No.1 at 2864-902 feet and Eumeralla No.1 at 2835-49 are probable correlatives within the Tricolpites pachyexinus Zone (see Dettmann 1970a).

4) Ardonachie No.1 at 3101-05 feet, which is within the Coptospora paradoxa Zone, may be correlated with at least portion of the sequences between 602 and 1497 feet in Branxholme No.1 and between 5800 and 5816 feet in Eumeralla No.1 (see Dettmann 1969).

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EXPLANATION OF TABLE 1

Preservation and zonal attribution of plant microfossil assemblages in cores of Ardonachie No.2 bore, 872-3105 feet.

Abbreviations:
Yield expresses frequency of plant microfossils in the palynological residues as follows:-

- Ab = abundant
- C = common
- Sp = sparse

Colour and Preservation. Spores, pollen, microplankton, wood, and cuticle present in the residues are denoted by their colour (col.) and quality of preservation (pres.) thus:-

- Y = yellow
- Br = brown
- Bl = black
- good = well preserved
- fair = fairly preserved

Spore-pollen zones are those defined by Harris (1965, 1970) and Dettmann and Playford (1969).

TABLE 1

Group	Depth (feet)	Yield	Spore-Pollen Col.	Spore-Pollen Pres.	Microplankton Col.	Microplankton Pres.	Wood Col.	Wood Pres.	Cuticle Col.	Cuticle Pres.	Spore-Pollen Zone
WANGERRIP GP	872-894	Ab	Y	good	Y	good	Br-Bl	fair	Y	good	Cupanieidites orthoteichus
	1114-1133		"	"	–	—	"	"	"	"	"
	1446-1448		"	"	Y	good	"	"	"	"	"
	1719-1739		"	"	—	—	"	"	"	"	"
	2063-2067		"	"	–	—	"	"	"	"	"
	2441-2444	C	Y-Br	"	Y	good	"	"	Y-Br	"	Gambierina edwardsii
	2623-2637	Sp	"	"	"	"	"	"	"	"	"
	2864-2875	"	"	"	"	"	"	"	"	fair	Tricolpites pachyexinus
Spier-Brook	2895-2902	C	"	"	"	"	"	"	"	"	"
Otway	3101-3105	Ab	"	fair	—	—	"	"	"	"	Coptospora paradoxa