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PALYNOLOGY OF LOWER TERTIARY SEDIMENTS, SOUTHEASTERN AUSTRALIA

by

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Geological Survey of South Australia

Submitted for the degree of M.Sc. through the Department of Botany University of Adelaide

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This thesis contains no material which has been accepted for the award of any other degree or diploma in any university and the thesis contains, to the best of my knowledge, no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signed ....

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SUMMARY

From a biostratigraphic study of the distribution of dispersed fossil spores and pollen in the Lower Tertiary sediments of southern Australia, six zonules have been recognised. These have been correlated with the succession of foraminiferal zones in the marine sequence and thus their relative stratigraphic position is well known. The zonules can be correlated over wide areas of southern Australia and are therefore of more than local correlative value. They provide the criteria for the recognition and correlation of both geological and palaeobotanical events.

In the section on stratigraphy and correlation the nomenclature of the lower Tertiary sediments in South Australia has been reviewed and revised where necessary. In addition several un-named units have received formal stratigraphic names. These are the Poelpena, Wanilla and Wilkatana Formations, the Renmark Beds and the Burrungle Member of the Knight Formation.

The study has highlighted two important time stratigraphic boundaries. One, that between the Upper Cretaceous and Lower Tertiary, can be defined arbitrarily on microfloral assemblages occurring in essentially a non-marine or marginal marine sequence.

The beginning of Tertiary sedimentation in southern Australia is marked by the appearance of spores and pollen characteristic of the *Gambierina edwardsii* Zonule and younger sediments. These include pollen from the genera *Beaupreaidites*, *Echiperiporites*

and *Proteacidites*. The Tertiary microfloras are distinct from those of the Upper Cretaceous and the boundary between the two approximates closely a disconformity recognised on geophysical evidence.

The other boundary, between the Paleocene and Eocene, is represented by a hiatus. The change from Paleocene to Middle Eocene sediments is accompanied by a major floral change. Particularly striking is the appearance in large numbers of several new *Nothofagidites* species together with an increase of more than 40% new species. At this time too, more than 30% of the species present in the youngest Paleocene (or perhaps earliest Eocene) became extinct. Neither faunas nor microfloras characteristic of the Lower Eocene have been recognised.

In the systematic section two new genera, *Gambierina* and *Lakulangipollis* have been proposed and about sixty-six new species described. Of these new types, more than twenty-five are members of the genus *Proteacidites* and it is during the lower Tertiary that this genus reaches its maximum diversity.

The final section briefly highlights the differences between the Australasian fossil floras and those of the rest of the world during this time. A broad correlation exists between the microfloras of Australia and New Zealand. Both of these regions show similar development of the *Nothofagus* group over a similar time interval. The genus *Proteacidites* in New Zealand microfloras apparently does not reach the diversity as it does in southern Australia.

INTRODUCTION

The immediate task of this project is to provide a timescale (or a biostratigraphic series) in southeastern Australia for the definition and correlation of geological events relating to the deposition of both marine and non-marine sediments in the early Tertiary Period. Major floral modifications (evolution and migration) during this time can then be accurately correlated and dated by reference to standard sequences established by fossil groups other than spores or pollen. Thus on the one hand we have a biostratigraphic tool (palynology) to correlate rocks containing plant microfossils from one region to another, and on the other we have a means of tracing, both temporally and spacially, the evolution and migration of some of the more significant elements of the Australian flora during this time.

Both aspects of this study are closely integrated and it is emphasized that a discussion of plant biogeography or evolution is neither complete nor accurate without adequate geological control.

The co-ordination of plant macro- and micro-fossil evidence is a distant but highly desirable aim and few microfloral entities can be convincingly related to floras established on macrofossil evidence. Moreover, the precise dating of the majority of plant macrofossil-bearing sediments is far from clear.

Another important part of this thesis is the taxonomic treatment (description, nomenclature and classification) of the dispersed pollen and spores. These are named in accordance with the International Code of Botanical Nomenclature and receive Form

Generic and Specific names. In the systematic section the botanical affinities, where known, are also indicated.

Thus a palynological study of the Lower Tertiary sediments in southern Australia is a most valuable objective at this time.

Locally and regionally the study has contributed to the basic understanding of the evolution of the Australian flora and its relationships to that of the rest of the world.

Non-marine sediments of Lower Tertiary age are widely distributed throughout southeastern Australia and in certain instances are intercalated with marine limestones, marls and glauconitic sandstones. To appreciate fully the biostratigraphy of these sediments, their relationship to the marine sequence is of utmost importance and is an integral part of this study. Keeping this in mind, the analyses of palynological data from non-marine or brackish water sediments have been closely compared with those from favourable sediments intercalated in the marine sequence or with the marine sediments directly. Sections of importance in this respect are those of the Princetown-Casterton areas of Paleocene age; the Upper Eocene sections of the Castle Cove - Browns Creek area, the Buccleuch Group in the Murray Basin and the Blanche Point Marls of the St. Vincent Basin; and the Middle Eocene Burrungle Member of the Knight Formation in the Gambier Embayment.

A biostratigraphic sequence has been established in the Murray, Otway and St. Vincent Basins and serves as a reference for all the other sequences in southeastern Australia. That in the central part of the Murray Basin appears to be the most complete. The Company Bore drilled in 1910 near Loxton has provided nearly 1,000 feet of Lower Tertiary sediments adequately sampled. Six or more microfloral zonules are recognised in a continuous sequence. Assemblages in the Paleocene, Middle and Upper Eocene can be correlated with type marine sequences elsewhere and moreover the zonules can be recognised throughout the Lower Tertiary of south-eastern Australia and are therefore of strong correlative value.

Using this timescale a correlation table has been produced of Lower Tertiary sediments in southeastern Australia for the comparison and demarcation of both palaeobotanical and geological events. Microfloras from Tasmania are not treated in this study.

By the nature of their small size (10 to 200 microns) and low density, pollen and spores are particularly suited to wide dispersal by both wind and water. Indeed, many plant species rely on these characteristics for pollination. However, even in insect- or self-pollinated species, dispersal by wind or water can result in considerable numbers being preserved in sedimentary deposits. The result is that pollen and spores are not restricted to any particular depositional environment and are therefore disseminated, often in great abundance, in genetically dissimilar sediments.

The methods of preparation in palynology are dependent on the nature of the membranes surrounding the protoplasm and gametes. Recent chemical studies (Shaw and Yeadon 1964), indicate that these are extremely complex consisting of cellulose (10-15%), a xylan fraction (10%), a lipid fraction (55-60%) and a lignin fraction (10-15%). The exine, the outermost layer, is only preserved in the fossil state and is to a certain degree resistant to oxidization.

Because of their small size and abundance, sufficient numbers of microfossils can usually be obtained from a sample of about 5 grams weight. Other acid resistant fossils occurring together with spores and pollen include, fungal spores, filaments and fruiting bodies; leaf cuticles, tracheidal fragments, "microforaminifera", acritarchs and dinoflagellate cysts. None of these groups are dealt with in this thesis.

The application of palynology is limited, however, to the nature of the sediments and conditions imposed during and after deposition. Spores and pollen will only be preserved in a reducing environment; lithologies such as limestones and sandstones usually are barren. Post depositional effects of metamorphism, deep burial (greater than about 10,000 feet), high coal rank and surface weathering often result in the destruction of the exine and therefore restrict the application of this method.

PREVIOUS INVESTIGATIONS

Australian Tertiary palaeobotany was considerably revived by Dr. I.C. Cookson, in collaboration with K.M. Pike, S.L. Duigan, M.E. Dettmann, G. Deflandre and A. Eisenack, and a series of papers dealing primarily with identification and classification of spores, pollen and microplankton were produced. Three papers of stratigraphic significance (Cookson 1953, 1954; Cookson and Dettmann 1959) indicated that pollen and spores had biostratigraphic value particularly in non-marine sediments. Probably the most important paper to appear (Cookson & Pike 1954), described seventeen species of dicotyledonous pollens from Australia and New Guinea. Since 1959, Cookson and her co-workers have concentrated almost entirely on the description of microplankton.

Other authors, Balme & Churchill (1959) and Pike (1949, 1950), have contributed observations of less importance and no species were formally described by them. Harris (1965) has monographed microfloras from Paleocene sediments in southwestern Victoria.

ACKNOWLEDGEMENTS

To my supervisor, Dr. R.T. Lange, I owe much in the way of developing a critical and objective approach to the subject of my thesis. In the initial stages he contributed much to my understanding of the problems that have developed between neo-botanical and palaeobotanical thought. Dr. N.H. Ludbrook, formerly Senior Palaeontologist, Geological Survey of South Australia, has been an invaluable source of information and encouragement throughout the project. My numerous colleagues, especially Dr. B. McGowran, who also read and criticised a draft, and J. Murray Lindsay, have contributed materially and in many hours of discussion and I am most appreciative. Their discussions with me on correlation of the zonules with planktonic foraminiferal zones were quite critical to this study. For guidance on excursions into Victoria and much constructive criticism and ready provision of samples I thank Mr. David J. Taylor, formerly of the Department of Mines, Victoria.

Without the ready co-operation of both the South Australian and Victorian Mines Departments this investigation would not have been possible.

METHODS

Source of Samples

All relevant stratigraphic, lithological and locality data of samples studied are summarised in Appendix A; the samples are grouped in their respective sedimentary basins. Figs. 4-6 indicate the approximate position of the localities.

As samples are taken by one or more methods of drilling in connection with oil exploration or water resources, it is of importance in this study to discuss the applicability of each type of sample used.

1. Core samples: These are the most useful subsurface source of material in that they are uncontaminated by drilling muds (unless sandy and therefore susceptible to mud penetration) and are accurately located in the subsurface stratigraphic sequence. They are of two types: those taken by rotary drilling methods and those taken by percussion or wire line drilling techniques--tube samples. The former is very expensive to cut and the interval between cores is usually of the order of 300 feet. Tube samples obtained during

percussion drilling are simpler and relatively cheaper to obtain. In several wells almost the entire sequence has been cored and a satisfactory sampling interval achieved. The depth from which tube core samples can be taken is dependant on the type of rig operating but is usually less than 1,500 feet.

2. Cuttings obtained during rotary drilling are generally unsatisfactory for palynological analysis. They are often heavily contaminated with drilling mud and cavings from sediments higher in the section. Only the "tops" of the ranges of species can be used reliably in any stratigraphic interpretation.

3. Sludges are obtained during percussion drilling and are of considerable value where cores are not available. They do not suffer the defects of cuttings as generally no drilling fluid other than the formation water is used and secondly the casing may follow very closely behind or may be driven ahead of the drilling bit, reducing the possibility of contamination from cavings.

4. Outcrop samples provide the most reliable source of material. When carefully collected they are uncontaminated and their stratigraphic and geographic position can be accurately determined. However in South Australia most outcrop samples of favourable lithologies, except those from a few Pleistocene or later deposits, have failed to yield pollen or spores. This is believed to be due to the development of deep weathering profiles during the Pleistocene and the lack of subsequent rejuvenation to remove these to expose fresh sediments. Victorian outcrop samples generally have yielded

excellent microfloras and the effect of weathering appears to be less severe, particularly in the south-west of that state.

All well samples are stored at the Core Laboratory of the South Australian Department of Mines, Thebarton. Outcrop samples collected from several field trips in Victoria are retained in the Palaeontological Collection.

Preparation, Examination and Storage of Residues.

To ensure consistent results for all types of sediments a standard procedure was followed. The method is basically similar to those described by earlier authors and in particular that of Balme and Hassell (1962). The method adopted was chosen after considerable experimentation and gives consistently good results for all types of sediments.

Initially if carbonates were present they were removed from the crushed sediment with dilute hydrochloric acid. The basic procedure is then as follows:

1. Boil about 5g. of the crushed (> 2mm) carbonate free sediment with 50 ml. 60% Hydrofluoric acid until only a sludge remains. Wash by centrifuging twice with water. This step is carried out in 250 ml. nickel or copper beakers.

2. Transfer residue to beaker and add 40 ml. of 10% Hydrochloric acid. Boil for one or two minutes. Centrifuge and wash twice.

3. Add 60 ml. of Schultze solution (1 part concentrated Potassium chlorate solution: 2 parts concentrated nitric acid) to the moist residue, transfer to a beaker and heat gently for about one minute. Centrifuge and wash three times. This is a critical step in the procedure as too much oxidation will destroy all spores and pollen. In some samples better results were obtained by allowing the residue to stand in the Schultze solution for 10-20 minutes before boiling.

4. Transfer residue to a beaker, add 40 ml. of 10% potassium carbonate solution and heat to boiling point. Centrifuge and wash until supernatant liquid is clear.

5. Add 30 ml. of concentrated nitric acid, stir for 10 to 20 seconds then wash immediately three or four times.

6. Add 30 ml. of 10% potassium carbonate solution for 20 seconds. Centrifuge and wash residue until solution is clear.

The residue is stored in glass phials to which has been added an aliquot of glycerine and a few drops of 1% phenol solution.

Four strew slides are made up using glycerine jelly, two of which are stained with safranin. The glycerine jelly is made by the following method:

1. 20 gms. gelatin (bacterial culture quality) are dissolved in 120 ccs. of distilled water on a water bath.

2. When dissolved add 140 ccs. pure glycerine and 0.5 gms. phenol. Allow to set.

A drop of melted glycerine jelly with or without safranin is mixed thoroughly with a small quantity of residue on a microscope slide and the coverslip lowered. The slides are immediately inverted to permit the microfossils to settle closer to the coverslip. These are allowed to stand for at least three days before being cleaned of excess glycerine jelly and ringed with goldsize varnish or nail lacquer. Strew-slides were initially surveyed at X100 magnification; identification and morphological analyses made at magnifications X450, X630 and X1000. In addition several hundred single grain mounts of individual specimens were prepared. A Leitz Laborlux Microscope No. 579756 of the Palynological Laboratory was used during the investigation and E-W, N-S vernier readings are from this instrument. Photomicrographs were taken on Adox KB14 film (developed in Adox E10 and printed on Kodak No. 3 and No. 4 papers) using a Leica M1 camera with Mikas attachment.

Slide and sample numbers mentioned in the text are denoted by the prefix S and are stored in the Palynological Laboratory. Registered specimens housed in the Palaeontological Collection, Geological Survey of South Australia, are denoted by the prefix Py. Holotypes of newly described species are retained in this repository, where possible, as single grain mounts. The rare occurrence of some species precludes this general practice and holotypes in these cases are carefully chosen from strew-slides. Delicate species may fracture or become distorted when prepared as single grain mounts, and to ensure that morphological characters are not misinterpreted, two photomicrographs of the species are included--one of the single grain preparation and the other from a strew-slide preparation.

STRATIGRAPHIC PALYNOLOGY

Six distinct, successive microfloral assemblages are distinguishable in Paleocene and Eocene sediments. Each is characterised by one or more distinctive pollen or spore species of restricted stratigraphic range. On this basis they will be used to demonstrate their important correlative value, both locally and regionally. The age of these assemblages will be discussed with reference to the standard marine sequences of southeastern Australia. Their relationships to planktonic foraminiferal zones are indicated in Tables 1 and 2.

It is acknowledged that the distribution of many species is not known, but those that have been chosen to characterise particular assemblages are believed to be reliable index species. Furthermore, the assemblages have time-stratigraphic value and can be shown empirically to occur essentially as units over sufficiently wide geographic areas to warrant their use.

The nomenclature of palynological units in Australia has been inconsistent. Dettmann (1963) has referred to her units as "Assemblages" prefixed by the specific epithet of the index species; Balme (1964) has used "Assemblage" and "Microflora" in combination with a generic name; Cookson (1954) has used "Microflora" in combination with a letter classification system; Evans (1963) used simply a letter classification and Harris (1965a) used the binomial of an index species combined with the term "Zone" which was further qualified in conformity with the American Code of Stratigraphic Nomenclature.

In this present text it is proposed that the "Zone Concept" of Teichert (1958) be applied to the assemblages. If this is accepted, then the term "zonule" in combination with the name of the index species, which need not necessarily be confined to the zonule, is applicable to these units. Teichert (*op. cit.* p. 115) described a zonule as a minor biostratigraphic unit recognisable in geographically restricted areas. This definition needs some clarification as used in this context. The word "minor" implies that the zonule does not have intercontinental or world-wide application. This does not imply that the unit is of minor importance intra-continentally. Teichert (*op. cit.*p. 113) considers that a zonule "is recognisable in a sedimentary basin or similar restricted area of sedimentation." It is proposed not to restrict the use of the term in this sense but to apply it to sedimentary basins within southeastern Australia. At first this would appear to be an amplification of Teichert's definition, but it is important to realise that this study is based on organic remains principally from terrestrial plants growing around the areas of sedimentation.

The Australian Code of Stratigraphic Nomenclature (1964 Ed.), however, provides for the use of the term "zone" in conjunction with the name of the fossil or fossils or symbol denoting a fossil assemblage. The American Code of Stratigraphic Nomenclature, however, amplifies considerably the term such that a large number of terms are available to describe an assemblage. This author is in agreement with Teichert that this multiplicity of names and definitions is unnecessary. The fundamental approach of Teichert, based on the original concepts of Arkell, Oppel, Kleinpell, Fenton and Fenton and others leaves little to be desired.

Essentially biostratigraphic units are rocks indentified by a distinct fauna or flora and are defined solely by the fossils they contain. They should be identified with a type section or locality.

The two main factors determining the differentiation of microfloras are evolution and migration.

Kuyl *et. al.* (1955) defined three types of zones:

a. by species which occur only in one particular zone, or whose stratigraphic highest or lowest occurrence is to be found at the boundaries of that zone. Causation - evolution. Essentially qualitative.

b. by species which occur most numerously in one particular zone, or whose main distribution ends or begins at the boundaries of that zone. This is essentially a quantitative approach. Causation - migration and edaphic changes.

c. by a fairly constant association of species, the lowest and highest occurrences of which are usually found elsewhere in the stratigraphic sequence.

The first type (a), is that used in this text and is essentially based on the evolution of new taxa and the extinction of others.

Before attempting to define any zonules several *a priori* considerations need to be observed:

a. The only INSTANT that the fossil can supply is either the beginning or end of its stratigraphic range. (Teichert *op. cit.*) These are the only true "time plans" observable.

b. A zone or zonule can be refined only by omitting species whose ranges do not conform to the original definition. These smaller units will be primarily only of local correlative value.

c. Ignoring negative factors, e.g. poorly preserved or low yield samples, the assemblages of each unit are to a certain degree distinct.

d. Boundaries between units need not necessarily coincide with those of the current geological time scale nor with those of any other fossil group.

e. The relative ages, with respect to accepted palaeontological time scale, can only be determined by reference to other fossil groups on which this scale is erected.

f. The boundaries between lithologic and biostratigraphic units may be coincident, lie at quite different stratigraphic horizons, or may even cross each other.

Delineation and age of the microfloral assemblages

Cookson (1954) described two Tertiary microfloras, ("B") and ("C") from the Birregurra No. 1 Bore in southwestern Victoria and based the identification of these on the two species, *Triorites edwardsii* and *Proteacidites pachypolus* respectively. Evans (1966) has recorded the former or a closely allied species from Upper Cretaceous sediments in Victoria.

The author has been unable to examine the Birregurra material and is therefore not in a position to comment in detail on these two microfloras. Microflora "B" of Cookson was also based on the vertical distribution of *Podosporites microsaccatus*, a long ranging form, occurring in the Cretaceous sediments of the Otway Basin and the middle Paleocene sediments of the Pebble Point Formation and the Dilwyn Clay. Thus it is necessary to closely define assemblages in which these species occur.

Microflora "C" has been characterised by the index species, *Proteacidites pachypolus*, which ranges from the Upper Paleocene in Victoria and Western Australia to the Upper Eocene in southern Australia. For correlations in southern Australia the vertical distribution of this species is limited to very broad use.

Comparing the assemblage from the Birregurra Bore (760-790 feet), it is clear that a Microflora "C" assemblage is not present in the Princetown Member of the Dilwyn Clay.

Paleocene Zonules

The type sections for the Paleocene zonules are located in the Princetown to Dilwyn Bay sequence.

The stratigraphy of the area has been the subject of a number of papers by Baker (1943, 1944, 1950 and 1953) and for the purpose of this study the stratigraphic relationships and thicknesses of the sediments indicated by Baker (1953) are accepted. Fig. 1 shows the generalised stratigraphic succession of the Wangerrip Group in the Princetown area, the stratigraphic position of the samples examined, and the distribution of selected species.

The Pebble Point Formation unconformably overlies Lower Cretaceous sediments of the Otway Group. The base of the formation is typically a ferruginous unfossiliferous conglomeratic grit with minor lenses of sandy and gritty carbonaceous clays. Towards the top of the formation at Pebble Point, the sediments become more sandy and glauconitic with the final development of a shelly horizon, fifteen feet thick. This is succeeded by a gritty phase and the conformable Dilwyn Formation.

The Dilwyn Formation consists of gritty and sandy clays and silts with three minor marine ingressions, the "*Turritella* bed", the "*Trochocyathus* bed" and the Rivernook Member. It is generally

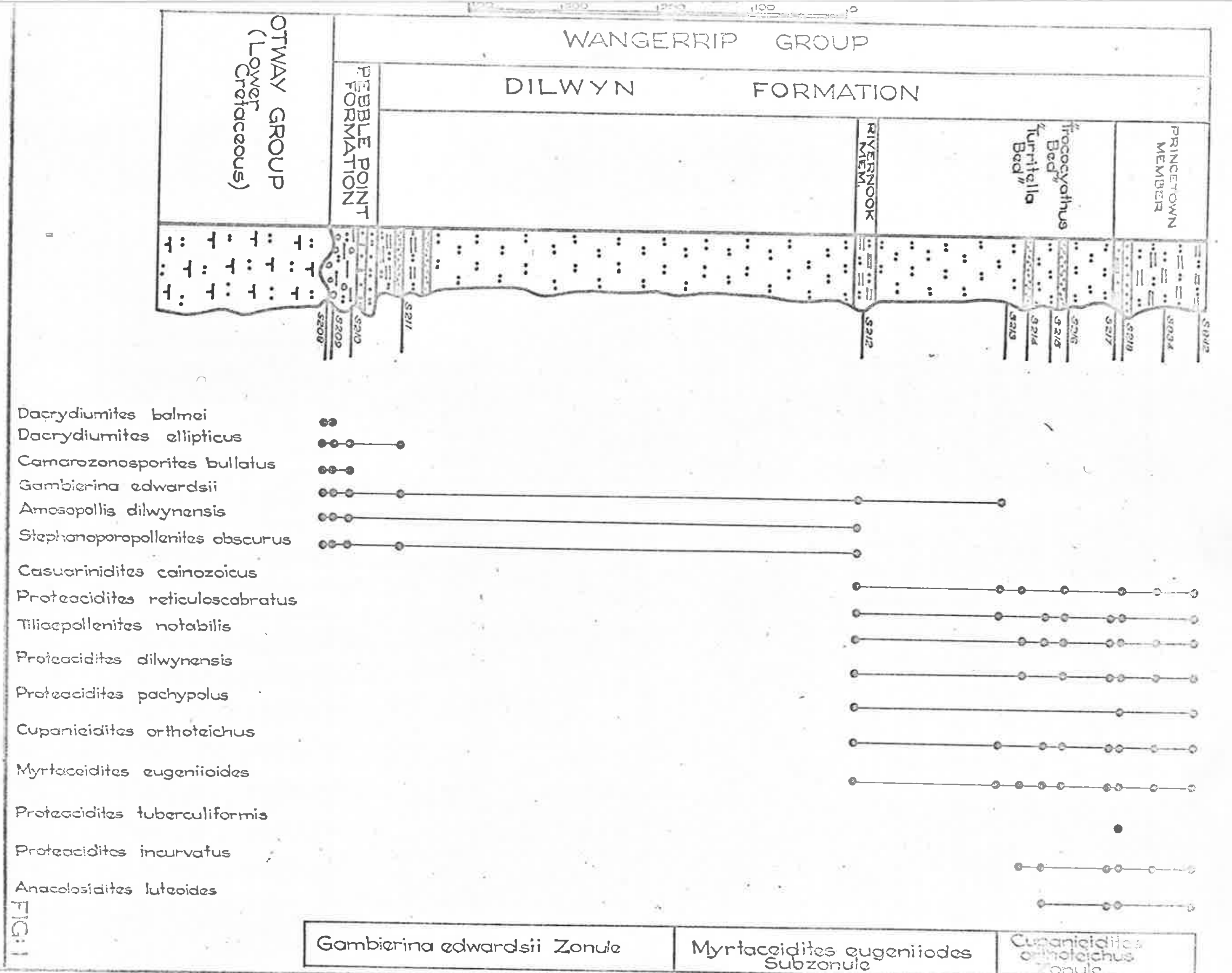


FIG: 1

STRATIGRAPHIC SECTION AND DISTRIBUTION OF SELECTED SPECIES WANGERRIP GROUP, VICTORIA

(STRATIGRAPHY AFTER BAKER)

poorly fossiliferous. Mineralogically the sandy and gritty phases of the Pebble Point Formation are essentially similar to the fossiliferous beds of the Dilwyn Formation (Baker 1953). Baker (*op. cit.* p. 131) states with reference to the Dilwyn Formation: "Lithologically and mineralogically there is virtually no significant difference....throughout the Dilwyn Clay itself." All sediments of the Wangerrip Group in the area are conformable and have a shallow dip (5^{o}) to the north-west.

The *Gambierina edwardsii* Zonule

This zonule has been defined and described by Harris (1965a) in samples S208-S211 and includes the Pebble Point Formation and the lower portion of the Dilwyn Formation. The assemblage is characterised by the distinctive species *Gambierina edwardsii*, *Camarozonosporites bullatus* and *Dacrydiumites ellipticus*.

Dacrydiumites balmei appears to be restricted in this section to the basal beds of the Pebble Point Formation. *Amosopollis dilwynensis* occurs consistently in this zonule.

The most commonly occurring forms include: *Dilwynites granulatus*, *Stephanopollenites obscurus*, *Proteacidites parvus*, *P. subscabratus*, *Cyathidites australis*, *Laevigatosporites ovatus* and *Podosporites microsaccatus* with an abundance of gymnospermous pollen including *Dacrydiumdites florinii*, *Phyllodadidites mawsonii*, *Microcachyridites antarcticus* and *Podocarpidites ellipticus*.

Species of rare occurrence include *Dacrydiumites balmei, Cyathidites splendens, Proteacidites adenanthoides, P. crassus, Anacolosidites acutullus* and *Nothofagidites* spp.

This microflora appears to be equivalent in part to Microflora "B" of Cookson (1954).

The *Cupanieidites orthoteichus* Zonule

This zonule has been defined and described in samples S212 to S218 and includes the upper section of the Dilwyn Formation. The upper limit of this assemblage is unknown. It includes the *Duplopollis orthoteichus* Assemblage Zone and the *Triorites edwardsii - D. orthoteichus* Concurrent Range Zone of Harris (1965a), now referred to as the *Myrtaceidites eugeniioides* Subzonule.

The zonule is characterised by the presence of *C. orthoteichus, Myrtaceidites eugeniioides* together with *Proteacidites incurvatus, P. pachypolus, Anacolosidites luteoides, Banksieaeidites* sp. and *Beaupreaidites elegansiformis*. *Gambierina edwardsii* is absent from the upper part.

Several species are particularly abundant in the zonule and they include *Tricolporites prolata, Dilwynites granulatus* and *Proteacidites subscabratus*. Commonly occurring species include *Dacrydiumites florinii, Podocarpidites ellipticus, Laevigatosporites major, Dilwynites tuberculatus, Proteacidites* spp., *Casuarinidites cainozoicus, Polyporina fragilis, Echiperiporites diversus,* *Nothofagidites* spp. and *Tricolporites microreticulatus*.

Species of rare occurrence include *Cyathidites splendens*, *Alisporites grandis*, *Peromonolites densus* and *Latrobosporites crassus*.

On the basis of the distribution of *M. eugeniioides* this zonule can be subdivided into a lower sub-zonule, the *Myrtaceidites eugeniioides*. The base is recognised by the appearance, generally in some abundance, of the nominate species together with *Tiliaepollenites notabilis*, *Proteacidites dilwynensis* and *P. reticuloscabratus*. *Phyllocladidites reticulosaccatus* and *T. edwardsii* appear to extend up into this unit.

The zonule is not equivalent to Cookson's Microflora "C" which is distinctly younger than the microflora described here. In particular, several distinctive species listed from the Birregurra Bore are not present; e.g. *Beaupreaidites verrucosus*, Cookson, *Cupanieidites majus*, *C. reticularis*, *Santalumidites cainozoicus*, *Tricolpites thomasii*, *Triorites magnificus*, *Nothofagidites aspera* and *N. diminuta*.

Age and Correlation

Singleton (1943) on the basis of a molluscan fauna assigned a Danian to Lower Eocene age for the Pebble Point Formation. Glaessner and Parr (in Baker 1943) noted that there was no disagreement as to the age of the Formation when both molluscan and foraminiferal evidence were considered. Parr (in Baker 1944, pp. 86 and 87) concluded that the foraminiferal assemblages of the Pebble Point Formation, the Rivernook Member and the "*Turritella* bed" were essentially similar.

On the basis of planktonic foraminifera occurring in the Pebble Point Formation and the Rivernook Member, the age of the *Gambierina edwardsii* Zonule in the type section can be dated as middle to upper Paleocene. McGowran (1965) notes that two distinct foraminiferal assemblages are known from the outcropping Paleocene sequence at Pebble Point. The planktonic competent, while not so diverse as in the Tethyan region or in the Carnarvon Basin of Western Australia, nevertheless is developed sufficiently to correlate the older (Pebble Point Formation) fauna with the *Globorotalia pusilla pusilla* Zone of Bolli (1957); and the younger (Rivernook Member) fauna with either the upper part of the *Globorotalia membranacea* Zone or the *Globorotalia velascoensis* Zone in the same sequence. Thus the Pebble Point Formation is middle Paleocene and the Rivernook Member, middle to upper Paleocene in age.

Further to this, Dr. B. McGowran has supplied the following communication. "Of the five foraminiferal-biostratigraphic units distinguished in the Princetown section (Taylor in Singleton 1967) attempts have been made to correlate and thus date three. The significance of *Planorotalites chapmani ehrenbergi* in the Pebble Point Formation probably is less than has been indicated by McGowran (1965, 1968) but there is no good reason for changing the Middle Paleocene age. In a new study (McGowran, unpubl. report, Geol. Surv. S. Aust.) the age of the Rivernook Member and a new fauna from below it ("Rivernook A"; *Truncorotaloides* aff. *acutus* of Table 2 herein = *Globorotalia angulata* → *G. aequa* of Taylor, *op. cit.*) are discussed in terms of new data on Upper Paleocene correlations and the position of the Paleocene/Eocene Boundary. It is concluded that the Rivernook Member should still be regarded as Upper Paleocene in age. That the Princetown Member can be taken also as Paleocene by superposition (Harris 1965a, McGowran 1965) is now somewhat doubtful, but a possible Lower Eocene age (Taylor *op. cit.*) cannot be proved or disproved without more facts. With some reservations about the highest part, the entire section outcropping at Princetown can be regarded as of Paleocene age."

The lower age limit of the oldest microfloral unit is somewhat in doubt and requires further study, particularly where there appears to be continuous sedimentation from the Upper Cretaceous (see Taylor 1965a) to the Lower Tertiary. There is some evidence (author's unpublished data; also Evans, 1966) that *G. edwardsii* or a closely allied form extends into the Upper Cretaceous but the other components of the assemblage such as *Anacolosidites* spp. and numerous *Proteacidites* spp. including *P. dilwynensis* and *P. ornatus* appear to be restricted to Paleocene and younger sediments. Thus the age of the *Gambierina edwardsii* Zonule is Middle Paleocene but could be as old as Lower Paleocene. There is no direct evidence for this however.

<table>
<tr><th colspan="2">Planktonic foraminiferal Zones</th><th>Palynological zonules</th></tr>
<tr><td rowspan="8">UPPER</td><td>Q.
Planorotalites cf. *P. pseudomenardii*</td><td rowspan="4">*Cupanieidites orthoteichus*</td></tr>
<tr><td></td></tr>
<tr><td>R.
Planorotalites chapmani chapmani</td></tr>
<tr><td></td></tr>
<tr><td>S.
Truncorotaloides aequa
Lamarckina rugulosa</td><td rowspan="4">*Myrtaceidites eugeniioides*</td></tr>
<tr><td></td></tr>
<tr><td>T.
Truncorotaloides aff. *T. acuta*</td></tr>
<tr><td></td></tr>
<tr><td rowspan="2">MIDDLE</td><td>U.
Planorotalites chapmani ehrenbergi, *Baggatella* sp. nov.</td><td rowspan="2">*Gambierina edwardsii*</td></tr>
<tr><td></td></tr>
</table>

Table 1

Relationships between foraminiferal and palynological zones in the Paleocene

Note: Foraminiferal data and ages from Taylor (in Singleton 1967) and McGowran (pers. comm).

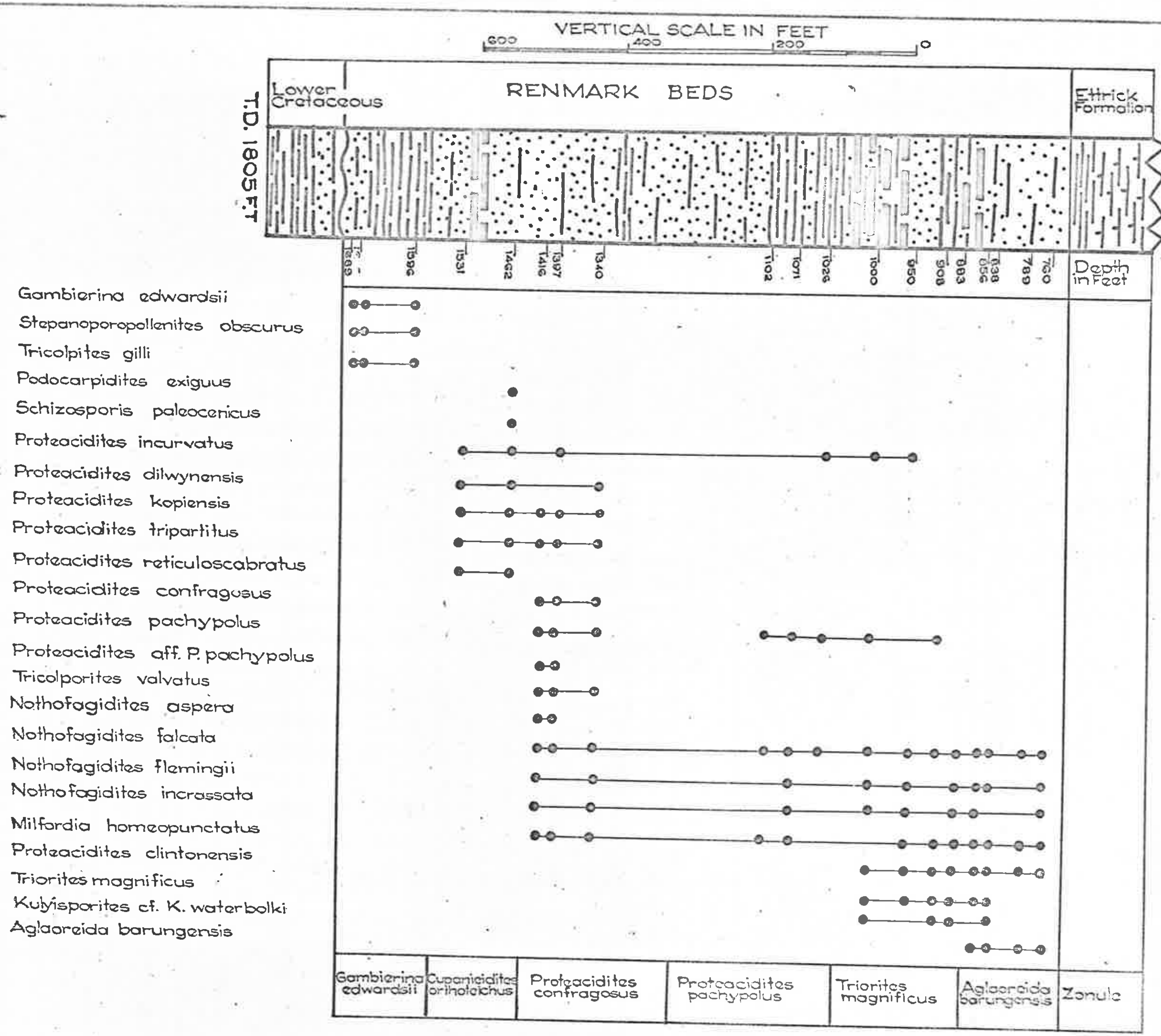
The Princetown Member of the Dilwyn Formation has been regarded by Baker (1953) and Raggatt and Crespin (1952) as Eocene. The sediments carry *Cyclammina* spp. which are of limited stratigraphic value. Taylor (1966) offers further support of a Paleocene age for the unit on the basis of his *Haplophragmoides* faunas.

Palynological evidence (Harris 1965a) confirms the view that deposition from the Rivernook Member to the end of the Princetown Member was continuous, there being no major microfloral breaks or significant changes in frequences. On the basis of this evidence the *Cupanieidites orthoteichus* Zonule present in the Princetown Member is Upper Paleocene in age, although as already noted by McGowran, a possible Lower Eocene age can neither be proved nor disproved.

Table 1 indicates the relationships between Paleocene foraminiferal and palynological zones in the Princetown-Dilwyn Bay sequence.

Eocene Zonules

While it was most appropriate and convenient to choose an outcrop sequence for the type sections of the Paleocene zonules, no such sequence exists for those of the Eocene. Moreover there are no known subsurface sequences that have both a complete zonal sequence and associated marine faunas. Therefore a subsurface



Note: Zonule boundaries drawn between sampling interval.

FIG: 2.

STRATIGRAPHIC SECTION AND DISTRIBUTION OF SELECTED SPECIES IN THE RENMARK BEDS, COMPANY BORE 'LOXTON'

(GENERALIZED LITHOLOGY AFTER LUDBROOK 1961) section in the centre of the Murray Basin with an Eocene sequence as well as Paleocene zonules in superposition has been chosen for typification. Age relationships are determined for the Eocene zonules by correlation to marine sequences elsewhere in southern Australia. (See Table 2.)

The "Company" Bore drilled 15 miles northeast of Loxton provides a complete zonule sequence in the Renmark Beds between 740 (base of the Ettrick Formation) and 1698 feet, the top of the Cretaceous. The lower boundary has been placed stratigraphically lower than that shown by Ludbrook (1961 fig. 1) on lithological and palynological evidence. The boundary between Paleocene and Eocene sediments lies between 1416 and 1462 feet. Fig. 2 indicates the distribution of selected species and the limits of the zonules.

The *Proteacidites confragosus* Zonule

This zonule between 1340 and 1416 feet in "Company Bore", is characterised by the consistent occurrence of *Proteacidites pachypolus P.* aff. *P. pachypolus* together with *Triporopollenites gemmatus*, *Proteacidites confragosus*, *P. kopiensis* and *P. tripartitus*.

The most commonly occurring species include *Nothofagidites* spp., *Dacrydiumites florinii*, *Podocarpidites ellipticus*, *Proteacidites tortuosus*, *P. wilkatanaensis*, "*Triorites*" *psilatus* and *Caryophyllidites* spp.

Species of rare occurrence include *Dacrycarpites australiensis*, *Alisporites varius* and *Milfordia* spp.

The zonule is a "total range zone" of the two species *P.* aff. *P. pachypolus* and *P. confragosus*.

The *Proteacidites pachypolus* Zonule

This zonule, between 1026 and 1102 feet in "Company Bore", is considered to be transitional between the *P. confragosus* and the succeeding zonules. It is characterised by the very common occurrence of the nominate species and negatively by the lack of *P.* aff. *P. pachypolus* and *Triorites magnificus*. Characteristically it is rich in *Nothofagidites* spp. and *Proteacidites* spp., in particular *P. kopiensis*, *P. reticulatus* and *P. symphyonemoides*.

Trilites tuberculiformis and *T. ornamentalis* are rare or absent.

The base of the zonule is marked by the last occurrence of *P.* aff. *P. pachypolus* and *P. confragosus*.

The *Triorites magnificus* Zonule

This zonule, between 883 and 1000 feet in the type locality, is characterised by the distinctive species, *Triorites magnificus*, readily identified even when poorly preserved, together with *P. pachypolus* and *P. incurvatus* Cookson. Characteristic also of this assemblage, particularly towards the upper limit, is an increase in the frequency of the pteriodphyte component represented by

Trilites tuberculiformis Cookson, *T. ornamentalis Laevigatosporites major* (Cookson), *Kuylisporites* cf. *K. waterbolki* and *Verrucosisporites kopkuensis* (Couper).

Commonly occurring species include *Podocarpidites ellipticus, Alisporites varius, Dacrydiumites florinii, Alisporites similis, Echiperiporites diversus, Ericipites crassiexinous,* and *Sapotaceoipollenites rotundus*

Species of rare occurrence include *Tricolpites thomasii,* Cookson and Pike, *Proteacidites tripartitus* and *P. dilwynensis.*

The base of the zonule is marked by the first appearance of *T. magnificus.*

The *Aglaoreida barungensis* Zonule

This unit, between 760 and 856 feet in the "Company Bore", is characterised by the presence of the distinctive species after which it is named, together with a characteristic associated assemblage with few stratigraphically restricted forms. Species present in the underlying units but rare or absent in this Zonule include *Anacolosidites acutullus, Beaupreaidites elegansiformis, Proteacidites truncatus, P. adenanthoides, P. reticulatus, P. pachypolus* and *Tricolpites thomasii.* Associated species with *A. barungensis* include *Milfordia* spp., *Kuylisporites,* cf. *K. waterbolki, Proteacidites clintonensis, Ceratosporites striatomarginatus, C. fimbriomarginatus, Nothofagidites aspera,* and *N. brachyspinulosa* and *Triorites magnificus.*

The base of the zonule is marked by the first appearance of the nominate species and the top by the first appearance of *Cyatheacidites annulata* Cookson and/or several undescribed taxa (see following discussion).

Age and Correlation

The recent advances in planktonic foraminiferal zonation and correlation in southern Australia, particularly in Eocene and younger sediments, by Lindsay (1967, 1969), Ludbrook and Lindsay (1969), McGowran and Lindsay (1969) and McGowran, Harris and Lindsay (MS unpubl.) have provided a firm basis on which to correlate and date the palynological zonules of the Eocene in this region. Their relationships to the planktonic foraminiferal zones are indicated on Table 2. Ludbrook and Lindsay's Table 1 correlates the South Australian zones with zones in Trinidad, Venezuela and East Africa. McGowran and Lindsay's (*op. cit.*) fig. 1 records the ranges of relevant Middle to Upper Eocene species and morphotypes in South Australia, New Zealand and Trinidad.

The *Proteacidites confragosus* Zonule

The type assemblage of this zonule can be correlated directly, and quite precisely, with the microflora in the Burrungule Member of the Knight Formation. The assemblages are very similar in total composition and in particular have *P. pachypolus*, *P.* aff. *P. pachypolus* and *P. confragosus* in common.

Planktonic foraminifera in the Burrungle Member include *Planorotalites australiformis* (Jenkins), *Truncorotaloides collactea* (Finlay), *"Globigerina"* cf. *G. higginsi* (Bolli) and *Guembelitria* aff. *G. columbiana* (Howe) and this assemblage occurs in the *"Globorotalia" australiformis* zone of Ludbrook and Lindsay (1969) (*Planorotalites australiformis* zone in McGowran, Lindsay, 1969). McGowran, Harris and Lindsay conclude that the Burrungle Member is not younger than earliest Lutetian, i.e. earliest Middle Eocene. These authors, however, point out that this is a minimum age. No marine Lower Eocene nor any Eocene spore-pollen assemblages below and distinct from the *Proteacidites confragosus* zonule have been recognised, so both biostratigraphic units could conceivably extend into the Lower Eocene. Against this however there are several species, in particular *Verrucosisporites kopukuensis* (Couper) and *"Triorites" scabratus* Couper (?=*"T." psilatus* Harris sp. nov.), that would seem to indicate a Middle-Upper Eocene age with reference to the New Zealand succession (1960), although correlations are not precise.

This zonule does not appear to extend to the level of the next highest foraminiferal zone, that of *Truncorotaloides primitivus*.

The *Proteacidites pachypolus* Zonule

In all basins, except the Gambier Embayment, the zonule is associated only with non-marine sediments. In the Gambier Embayment it succeeds the *Proteacidites confragosus* Zonule being present in the Kongorong Sand and basal Lacepede Formation. The latter Ludbrook (1969) and Ludbrook & Lindsay (1969) place in the *Truncorotaloides primitivus* Zone. The base therefore appears to correspond with the change from Burrungle Member (or Knight Formation) to Kongorong Sand and Lacepede Formation. The Kongorong Sand does not contain useful planktonic faunas.

The upper limit however is quite indefinite. In the Eucla Basin the zonule is in Pidinga Sands which underlie the Wilson Bluff Limestone in Nullarbor No. 6 Bore. In Nullarbor No. 8 and Albala Karoo Bores McGowran and Lindsay (1969) place the base of the Wilson Bluff Limestone within the *Globigerapsis index index* zone. But tertiary sediments below this formation in these bores have not yielded any microfloras. Moreover it is apparent from an examination of Ludbrook's cross-section of the Eucla Basin (in Parkin 1969, Fig. 97) that the base of the Wilson Bluff Limestone cannot be assumed to be time concordant. Therefore the upper boundary could on present evidence be anywhere from within the *"Turborotalia" aculeata* zone to the *Truncorotaloides primitivus* zone.

The *Triorites magnificus* Zonule

For the reasons discussed above, the position of the lower boundary of this zonule remains in doubt. There is evidence to suggest that it lies below the *"Turborotalia" aculeata* zone. In the St. Vincent Basin the *Triorites magnificus* zonule extends well below the *"Turborotalia" aculeata* zone where Lindsay (1969) has identified the latter in several sections and notes that no older zones beyond this have been identified. But this is because planktonic foraminifera disappear downsection. The evidence points to a lower boundary perhaps within the *Globigerapsis index index* zone. The upper boundary seems to be somewhere within the *"Turborotalia" aculeata* zone. The zonule is commonly present in the Adelaide Plains Sub-Basin in correlatives of a Blanche Point Marls--Tortachilla Limestone sequence.

The zonule has been identified in Morphett Street and Victoria Bridges foundation test bore 14, at 56 feet. Lindsay (1969) has outlined the subsurface stratigraphy at this locality, and has supplied the following personal communication.

"Open tube core from bore 14 in marly correlatives and equivalents of Blanche Point Transitional Marls--Tortachilla Limestone at 57-58 feet contains a well-preserved and quite varied planktonic microfauna including rare *Turborotalia aculeata, Globigerapsis index* (Finlay) and *Subbotina linaperta* (Finlay), together with common small *Hantkenina alabamensis compressa* Parr, but no *Truncorotaloides primitivus*. This sample is therefore in both the *Hantkenina alabamensis compressa* zone and the *T. aculeata* zone of Upper Eocene age (Ludbrook and Lindsay, 1969).

The *Hantkenina alabamensis compressa* zone can be traced through bore 11 (82-89 feet), bore 12 (66-73 feet) and bore 14 (56-?63 feet), all in the same stratigraphic unit. Where it is present, this zone occurs within the *T. aculeata* zone in the St. Vincent and Otway Basins (Ludbrook and Lindsay, 1969; Lindsay, 1969).

By comparison with sequences elsewhere in the St. Vincent Basin it is inferred that the succession of Blanche Point Marls--Tortachilla Limestone and its correlatives and equivalents are all contemporaneous with the *T. aculeata* zone, although the zonal species may be rare and sporadic in occurrence.

Because of poor microfaunas, no planktonic foraminiferal zonation is possible at present for the underlying correlatives and equivalents of South Maslin Sands at the bottom of bores 11, 12 and 14."

Further evidence on the position of the upper boundary has been obtained from the classic Browns Creek section. J.M. Lindsay has provided the following personal communication regarding the age of this unit.

"Sample WKH 5, collected by W.K. Harris, is from 30 feet below the greensand at the measured section of Browns Creek Clay (Cookson and Eisenack, 1965, Fig. 1), that is, near sample 2 used by Cookson and Eisenack. Planktonic foraminifera are well-preserved and rather varied. *Turborotalia aculeata* (Jenkins) is abundant, but despite suitable facies *Truncorotaloides primitivus* (Finlay) is not present. The sample is therefore assigned to the *Turborotalia aculeata* zone of Upper Eocene age (Ludbrook and Lindsay, 1969).

Sample WKH 4 is from 10 feet below the greensand, that is, near sample 4 used by Cookson and Eisenack. Planktonic foraminifera are again well-preserved and quite varied, but *T. primitivus* is not present, and in this case *T. aculeata* is very rare. However the sample is also assigned to *T. aculeata* zone.

A sample from near the top of Browns Creek Clay, 5 feet below Castle Cove Limestone, was collected by N.H. Ludbrook in 1955. In a good planktonic microfauna this sample contains common *T. aculeata* but no *T. primitivus*, and is therefore also in *T. aculeata* zone.

A sample of Castle Cove Limestone, collected and presented by D.J. Taylor, contains very rare *T. aculeata* but despite suitable facies, no *T. primitivus*, and is in *T. aculeata* zone.

A sample of "Lower Glen Aire Clays" (now Glen Aire Clay) collected from Aire Coast by N.H. Ludbrook, 1955, contains common *T. aculeata* but no *T. primitivus* and is similarly from the *T. aculeata* zone."

Thus the entire section, at Browns Creek in particular, lies within the *"Turborotalia" aculeata* zone. This dating is not in conflict with Taylor's biostratigraphic scheme (in Singleton 1967). Both the *Triorites magnificus* and *Aglaoreida barungensis* zonules occur here although the unfavourable nature of the sediments for palynological analysis precludes precise location of the boundary.

The *Aglaoreida barungensis* Zonule

The lower datum of this zonule has been established in the previous discussion. Further to this the zonule has been identified in core between 458 and 470 feet in S.A.D.M. Light No. 1 Bore in the Adelaide Plains Sub-Basin. Lindsay (1969 p. 25) has discussed the importance of this core in that both the *Subbotina linaperta* zone and the *"Turborotalia" aculeata* zone are present, the former at least as low as 467 feet, three feet above the latest occurrence of *"Turborotalia" aculeata*. Lindsay concluded that the sequence was probably Eocene below 460 feet. This is then further evidence that the lower boundary of this zonule lies below the *Subbotina linaperta* zone.

The upper boundary is another problematical one. In E. & W.S. Keith Bore 1 at 224-225 feet the Zonule is associated with *Subbotina linaperta* (Finlay) and J.M. Lindsay has provided the following personal communication on this sample.

"An open-tube core from E. and W.S. Department Keith Bore 1 at 224-225 feet consists of thinly-interbedded black carbonaceous silty clay and pale grey silty very fine-grained quartz sand. Parts are finely shelly. This lithology compares best with Buccleuch Group bed "B" (Ludbrook, 1969, p. 16).

Benthonic foraminifera include *Cyclammina* sp. aff. *C. incisa* (Stache) (abundant), *Bulimina pupoides* d'Orbigny (abundant), and *Reusella finlayi* Dorreen (very rare).

Planktonic species include rare *Subbotina linaperta* (Finlay) (which also occurs with *Globigerina ampliapertura* Bolli at 220-224 feet), and frequent *Chiloguembelina cubensis* (Palmer). Despite suitable facies, neither *Turborotalia aculeata* (Jenkins) nor *Guembelitria stavensis* Bandy are present.

The sample is therefore assigned to the *Subbotina linaperta* zone, of late Eocene age (Lindsay, 1967; Ludbrook and Lindsay, 1969)."

From this and the previous evidence of S.A.D.M. Light No. 1 Bore the zonule clearly extends up into rocks containing the *Subbotina linaperta* zone. Lindsay (1969, p. 25) approximates the position of the Eocene-Oligocene boundary at the extinction of *S. linaperta*.

From the meagre assemblages obtained from a very few Janjukian sediments there seem to be no criteria at present whereby one can distinguish between microfloras of the Eocene (Aldingan) and those of the Oligocene (Janjukian). Thus the *Aglaoreida barungensis* zonule is Upper Eocene in age and probably extends into the Oligocene. Unpublished data of this author indicates a significant change in microfloras at about Longfordian (Lower Miocene) time and in particular this is marked by the appearance of *Cyatheacidites annulata* Cookson.

	Planktonic Foraminiferal Zone	Palynological zonules
UPPER	*Subbotina linaperta*	*Aglaoreida barungensis*
	"Turborotalia" aculeata	
MIDDLE	*Globigerapsis index index*	*Triorites magnificus*
	Truncorotaloides primitivus	*Proteacidites pachypolus*
	Planorotalites australiformis	*Proteacidites confragosus*
LOWER	No Faunas or Microfloras known	

Table 2

Relationships between foraminiferal and palynological zones in the Eocene

Note: Foraminiferal data and ages from Ludbrook & Lindsay (1969), McGowran & Lindsay (1969 and pers. comm.), McGowran, Harris & Lindsay (M.S.).

TIME STRATIGRAPHIC BOUNDARY PROBLEMS

Although Tertiary spore-pollen assemblages cannot be equated directly with any precision to standard sequences in Europe and central America, they nevertheless can be related indirectly through accompanying foraminiferal faunas (see Tables 1 & 2 and previous discussion) and can therefore contribute much to the solution of boundary problems within rock sequences.

Two boundaries of considerable importance, the Cretaceous-Tertiary and the Paleocene-Eocene, can be recognised, albeit arbitrarily, by spore-pollen assemblages. The first lies within an interval of sediments with no marine faunas. The latter probably represents a widespread interval of non-deposition.

The Eocene-Oligocene boundary is represented by a continuity of microfloras and cannot at present be recognised by the presence or absence of spore or pollen species.

The Cretaceous-Tertiary Boundary

Few palynological facts are available on this subject and Evans (1966) has briefly discussed the problem related to the boundary in the Otway Basin and concluded that the nominate species of the *Triorites edwardsii* Assemblage Zone was not a suitable marker of basal Tertiary sediments and that the boundary between the Mesozoic and Tertiary "be at the unconformity between the

'Curdies Beds' and the Pebble Point Formation." No biostratigraphic evidence for placing the boundary here is given but it should be noted that at this level a regional unconformity recognised on geophysical evidence is indicated (Leslie 1966, White 1968). This boundary does approximate very closely the "boundary" discussed herein. However as a "time boundary" this is unsatisfactory from a biostratigraphic point of view. Firstly, it is based on lithological changes which may be diachronous and for this reason alone it should be determined by faunal or floral changes. Bock and Glenie (1965) suggest that the Timboon Sand Member of the Paaratte Formation *in places* is transitional lithologically with the Pebble Point Formation. Secondly, there is a significant microfloral "break" occurring in sediments below the Bahgallah Formation (e.g. Mt. Salt No. 1 Well) and the typical *Gambierina edwardsii* Zonule microfloras present in both the Bahgallah and Pebble Point Formations extend into sediments preceding these units in both the Gambier and Port Campbell Embayments.

Certainly the boundary problem exists because of the lack of marine faunas between Taylor's Senonian Zonule A (1964), other marine Upper Cretaceous fossils (Glaessner 1964) and McGowran's (1965) Middle Paleocene Pebble Point fauna, the oldest marine Tertiary fauna known from Australia. Taylor (*op. cit.*) records up to 2,000 feet of sediment between these as being barren of fauna. Thus an arbitrary definition of a biostratigraphic boundary in south eastern Australia based on palynological assemblages is most useful.

Dettmann and Playford's (1968, 1969) description of new Cretaceous taxa and a zonal scheme for the Upper Cretaceous in particular is timely. Their youngest Cretaceous unit is the *Nothofagidites* Microflora characterised by the presence of *N. senectus* Dettmann and Playford, *Cámarozonosporites bullatus*, *Dacrydiumites florinii*, *Tricolpites gillii*, *T. sabulosus* Dettmann and Playford, *Proteacidites amolosexinus* Dettmann and Playford and aff. *Triorites edwardsii*. Of these species most, except *P. amolosexinus* and *T. sabulosus* extend into microfloras of the Tertiary. In Geltwood Beach No. 1 Well this assemblage is present in core 1 at 2,000 feet, together with several species not described by Dettmann and Playford including members of the *Proteacidites* group, *N.* cf. *N. emarcida* and *Ericipites* sp.

The *Nothofagidites* Microflora contrasts quite markedly with assemblages from the Middle Paleocene and is not an impoverished *G. edwardsii* Zonule microflora. By the Middle Paleocene strongly sculptured forms of *Proteacidites* had become well established. These include *P. incurvatus*, *P. dilwynensis*, *P. reticuloscabratus* and *P. ornatus*. Other species which make their first appearance include:

Verrucatosporites speciosus	*Podocarpidites exiguus*
Peromonolites densus	*Latrobosporites crassus*
Dilwynites granulatus	*P. adenanthoides*
Malvacipollis diversus	*P. symphyonemoides*
Triporopollenites harrisii	*P. annularis*
Dacrydiumites balmei	*Dacrydiumites ellipticus*

Thus it is quite apparent that a major floral change takes place after the *Nothofagidites* Microflora and before the deposition of the Pebble Point or Bahgallah Formations. Dettmann and Playford (*op. cit.*) have already indicated a Santonian-uppermost Cretaceous for the *Nothofagidites* Microflora which extends from near the top of Taylor's Zonule A. Nevertheless there is no firm palaeontological dating of Cretaceous sediments in this region beyond Taylor's Zonule A. Dettmann and Playford (1969) note that age equivalents of the Upper Cretaceous southeastern Australian assemblages are quite distinct morphologically from those of Europe, North America, Eurasia and Africa but show some similarity to those of New Zealand. In particular *Tricolpites pachyexinus* is restricted in New Zealand to Senonian-Maastrichtian sediments (Couper 1960).

It is not unreasonable then to recognise the beginning of Tertiary sedimentation in southeastern Australia as the evolution of the flora that follows the *Nothofagidites* Microflora and continues into the Pebble Point Formation. Thus the arbitrary base of the Tertiary-sequence here may be defined as the base of the *Gambierina edwardsii* Zonule. Species that are present in the Cretaceous unit and absent in the *G. edwardsii* Zonule include *P. amolosexinus*, *Ornamentifera sentosa*, *Stereisporites viriosus*, aff. *T. edwardsii*, *Tricolpites pachyexinus* and *T. sabulosus*.

In marginal areas of the basin the boundary is an unconformity with the transgressive Pebble Point Formation (or Bahgallah Formation) marking the base of the Tertiary as it is in the sequence at Dilwyn Bay. McGowran (1968 Table 1) indicates an increasing hiatus towards marginal areas.

The Paleocene-Eocene Boundary

Within the Otway Basin Paleocene microfloras are succeeded by those of the Eocene with varying degrees of palynological disconformity. For example in the Anglesea district the *G. edwardsii* Zonule is succeeded by the *P. pachypolus* Zonule and in the western Gambier Embayment the *P. confragosus* Zonule succeeds the *C. orthoteichus* Zonule. Thus the boundary between the Paleocene and Eocene is represented by a palynological disconformity and it only remains now to enlarge on the relationship between the lowest recognised Eocene assemblage, the *P. confragosus* Zonule and the highest Paleocene, the *C. orthoteichus* Zonule.

It has been shown (Harris 1965) that there is continuity in the Dilwyn Clay Formation microfloras through to the end of the Princetown Member and there is no evidence to suggest that this unit is younger than Upper Paleocene. (See previous discussion.)

The age of the *P. confragosus* Zonule has been discussed elsewhere and determined as Middle Eocene. In the Otway Basin the unit is only represented, as far as is known, in the Gambier Embayment where it is associated with sporadically occurring marine foraminiferal faunas of Middle Eocene age. It would appear therefore that this zone does not go below the Middle Eocene but this is an open question (McGowran, Harris & Lindsay MS unpubl., and previous discussion). It should also be noted that no marine faunas or floras of Lower Eocene age have been recognised in southeastern Australia.

A comparison between assemblages from the Burrungule and Princetown Members reveals some startling differences that substantiate the presence of a hiatus. The assemblages are contrasted in Table 3.

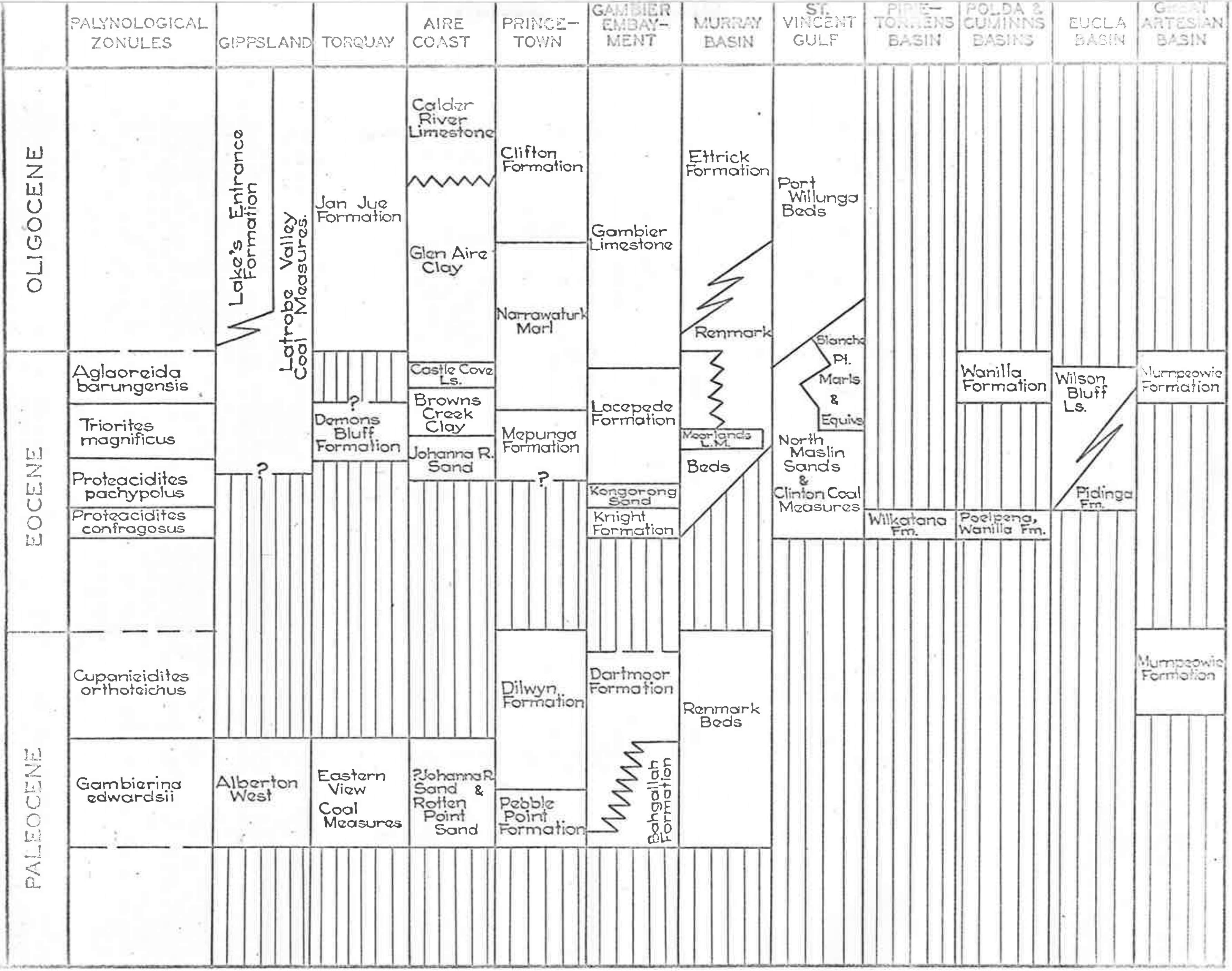
TABLE 3

Princetown Member	Burrungle Member	Species in Common
Podocarpidites exiguus	*Milfordia* sp.	*Araucariacites australis*
Microfoveolatosporites fromensis	*Graminidites* sp.	*Dacrydiumites florinii*
Verrucatosporites speciosus	*Proteacidites kopiensis*	*Phyllocladidites mawsonii*
Peromonolites densus	*P. confragosus*	*Podosporites microsaccatus*
Cyathidites gigantis	*P. concretus*	*Dacrycarpites australiensis*
C. splendens	*P. reticulatus*	*Microcachryidites antarcticus*
Triplanosporites pseudoreticulatus	*P.* aff. *P. pachypolus*	*Podocarpidites ellipticus*
Latrobosporites crassus	*?Haloragacidites* sp.	*Laevigatosporites ovatus*
Tiliaepollenites notabilis	*Ilexipollenites* sp.	*L. major*
Proteacidites dilwynensis	*?Fuschia* sp.	*Cyathidites australis*
P. tuberculiformis	*Triletes kopukuensis*	*C. minor*
P. reticuloscabratus	*Tiliaepollenites* sp.	*Stereisporites antiquasporites*
Stephanopollenites obscurus	*Tricolpites thomasii*	*Proteacidites ornatus*
Krauselisporites papillatus	*Tricolporites valvatus*	*P. pachypolus*
	Polycolporites sp.	*Cupanieidites orthoteichus*
	Nothofagidites diminuta	*Beaupreaidites eleganisformis*
	N. cincta	*Echiperiporites diversus*
	N. hetera	*Lycopodiumsporites austroclavatidites*
	"Triorites" scaboratus	*Trilites tuberculiformis*
	Tricolporites spp.	*Gleicheniidites circinidites*
		Casuarinidites cainozoicus
		P. incurvatus
		P. annularis
		Caryophyllidites sp.

From this list it is clear that about 35% of the species present in the Paleocene become extinct, and the Burrungle Member represents an evolutionary burst of about 45% new species. A number of species in the Burrungle Member are undescribed and the list does not take these into account. These would further increase this percentage. This then is further evidence of a time break between "Princetown Member time" and "Burrungle Member time." All evidence then points to a hiatus during the Lower Eocene in this basin. The hiatus is variable in degree in that not only part or all Lower Eocene sediments may be absent but also parts of the Paleocene and Middle Eocene in the marginal areas. Thus for the present we can accept the base of the *P. confragosus* Zonule as the base of the Eocene sequence in southeastern Australia.

Further to this, it is interesting to note that petroleum companies operating in the Otway Basin recognise an unconformity at about this level (White 1968, p. 81, Leslie 1966, Table 1). The recognition of this is presumably based on geophysical evidence and gross lithological changes.

It can therefore be inferred that the Paleocene-Eocene relationship over southeastern Australia, at least in the onshore sequences, is an unconformable one.



CORRELATION TABLE OF SOME LOWER TERTIARY SEDIMENTS SOUTH-EASTERN AUSTRALIA

Fig. 3

STRATIGRAPHY AND CORRELATION

The following account describes relevant data pertaining to the sediments studied, such as lithology, palaeontology, age and relationships. For convenience the sedimentary units are listed according to their geographic dispositions in their respective sedimentary basins. In addition, previously unnamed formations are described and type sequences designated.

Figure 3 is a correlation table of lower Tertiary sediments in southeastern Australia.

Figure 4 indicates the distribution of the Tertiary sedimentary basin in South Australia.

A few comments concerning definition and correlation of these sediments are appropriate at this time. Striking similarities have been observed in comparing sediment lithologies, in particular those of non-marine or marginal marine environments, from numerous sequences such that Eocene silts from the Gippsland Basin are very closely comparable with those of the Eucla Basin. This similarity can be taken a step further into the vertical (or time) extrapolation such that Paleocene silts closely resemble those of the Eocene and these are in fact, in some cases, not separable by gross lithologic criteria. Paucity of good marker beds, except those of the marine Paleocene and Eocene, and the rapid lensing of sands and lignites within individual basins, influences the degree of precision of


FIG.4
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
NEW SOUTH WALES
VICTORIA
SOUTH AUSTRALIA
SHOWING
TERTIARY SEDIMENTARY BASINS
& BOREHOLE LOCALITIES
Basin limits
Borehole location
SCALE
MILES 20 10 0 20 40 60 MILES
GREAT AUSTRALIAN BIGHT
SOUTHERN OCEAN
Approximate limit of THE GREAT ARTESIAN BASIN
Approximate Limit of THE GREAT ARTESIAN BASIN
Oodnadatta
Patchawarra Bore
LAKE EYRE North
Lake Eyre Bore
Cannuwaukaninna
LAKE EYRE South
Marree
Crombies Well
Mulcowurtina Nº2
Cootabarlow Nº1
Curtowarra Bore
LAKE FROME
Leigh Creek
PIRIE - TORRENS BASIN
LAKE TORRENS
Lake Torrens Bore 3A
Cook
EUCLA BASIN
Pidinga R.H.
Nullarbor Nº6
Lake Tolonkootra
Nullarbor H.Sn
Nullarbor Nº5
Tarcoola
Malbooma
EVERARD
LAKE GAIRDNER
WILLOCHRA BASIN
WALLOWAY BASIN
Wilkatana Nº1
Pt. Augusta
Wilmington
Orroroo
Streaky Bay
Whyalla
Pt. Pirie
Warramboo
Kopi K.R.9
POLDA BASIN
Polda Nº1
Lock
Canopus Nº1
ULEY-WANILLA BASIN
Cummins
Bore
Pt. Lincoln Bore 18
Pt. Lincoln
SPENCER GULF
Clinton
GULF ST VINCENT
ADELAIDE
Morgan
MURRAY BASIN
Wm. Renmark Nº1
Company Bore
Loxton Nº2
Tailem Bend
Moorlands
Cooks Plain Bore
Coomandook Bore
Coonalpyn
For enlargement see Figure 5
KANGAROO Is
Keith Nº1
E&W.S. Keith A
Bordertown
Kingston
Naracoorte
F. Tate Bore
Comaum Bore 1A
Penola
GAMBIER EMBAYMENT
Geltwood Beach Nº1
County Grey Bore 8
Mt. Gambier
Mt. Salt Nº1
G.M.

lithological correlations. Consequently the recognition and correlation of units both laterally and vertically without refined studies such as palaeontology and clay mineralogy can be in error.

Eucla Basin

The Eucla Basin covering over 68,000 square miles is shared by Western Australia and South Australia, approximately one-third lying within the South Australian border (Ward 1946). The Basin developed in mid-Tertiary times as a deep embayment of the southern coastline of Australia. In the deeper sections Cretaceous and Lower Permian sediments are developed (Ludbrook in Glaessner and Parkin 1958 p. 129, Harris and Ludbrook 1966).Nullabor No. 8 Bore penetrated 530 feet of marine Tertiary limestone, 600 feet of Lower Cretaceous shales, sand and conglomerate and 250 feet of Lower Permian shales. To the east and marginal to the basin, non-marine sands, silts and lignites are developed as continental facies of the lower units of the Eocene Wilson Bluff Limestone and the Hampton Sandstone. These sediments approach the surface at Lake Pidinga.

Pidinga Sands: This name has been used informally (Ludbrook in Glaessner and Parkin 1958) for sands, clays and lignites beneath marine limestones of the Eucla Basin. Non-marine and paralic sands, lignites and carbonaceous clays underlie with apparent disconformity the Wilson Bluff Limestone in the Nullabor No. 6 Bore (Ludbrook in Glaessner and Parkin 1958). The extent of these sediments is now known but equivalent lithologies occur in the Lake Tallacootra and Malbooma areas (King 1951 and Ludbrook *op. cit.* p. 130) where they overlie gneissic bedrock at shallow depths of about 90 feet. In the Pidinga area the lignitic series is overlain by unfossiliferous mottled alunitic and gypseous clays and sands capped by the Nullabor Limestone. King (*op. cit.* p. 32) has presented a general stratigraphic column for the sequence and summarised the geology and physiography. The type sequences are as follows:

1) Bore P15 Lake Pidinga - (for locality see Mining Review Adelaide No. 90, p. 6).

Between 2'6" and 48'0" - Grey to brown lignitic and pyritic sands, clays and silts. A detailed log is published in Mining Review Adelaide, No. 90, p. 7. The bore bottomed in lignitic sands. The unit is overlain by the Nullabor Limestone.

2) Mullarbor No. 6 Bore, 50 miles southwest of Lake Pidinga (for locality see Ludbrook Fig. 26 in Glaessner & Parkin 1958). The Pidinga sands are represented by the unit between 344 and 450 feet, and comprise carbonaceous and lignitic sands and clays in part alunitic, glauconitic clays and ferruginous sands.

The unit is overlain by the Wilson Bluff Limestone and underlain by Lower Cretaceous shales and conglomerates.

In both Mullarbor No. 6 and Lake Pidinga Bores the microfloral assemblages are identified as the *Proteacidites pachypolus* Zonule. In particular they have the nominate species but lack *P.* aff. *P. pachypolus*, *P. confragosus* and the related assemblage of the lowest Eocene zonule. The microflora is dominated by *Nothofagidites* spp. including *N. falcata*, *N. brachyspinulosa*, *N. matauraensis* and

N. hetera. *P. clintonensis*, *T. magnificus* and *K.* cf. *K. waterbolki* have not been recorded in the assemblages.

The Pidinga Sands are therefore of Middle Eocene age and correlate with the *Proteacidites pachypolus* Zonule.

Polda Basin

The basin in the Hundreds of Squire, Tinline and Talia was first named by J.I. Miller, then District Engineer of the E. & W.S. Department in 1928. Primarily the basin was defined hydrologically; the best quality water occurring in wide spread calcareous dune sands at relatively shallow depths. More recent drilling has revealed an extensive sequence of Tertiary clays, silts, sands and lignites unconformably overlying upper Jurassic sands, silts and low grade lignites (Harris 1964). The lateral extent of the Tertiary and Jurassic sediments is unknown and the margins of the sedimentary basin remain undefined. The basin is bounded in the west near Elliston by ?Precambrian conglomerates and sands, resting on older granites. To the east of Lock and north of Polda the basin is encompassed by Precambrian metamorphic and plutonic rocks.

Poelpena Formation (Harris 1966). Non-marine sands, lignites, carbonaceous silts and clays have recently been discovered in the Polda Basin. They overlie Upper Jurassic sands, clays and silts, and are overlain in turn by Quaternary sediments. The type section as indicated by the Polda No. 1 Stratigraphic Hole is as follows:

Locality: 1 mile south of the Lock-Elliston Road on the boundary of the Hundreds of Tinline and Squire. The type section between 55 and 224 feet consists of sands, carbonaceous silts and clays and lignites.

The supplementary section is taken from KR9 Bore 5½ miles east-south-east of Kopi, Section 25, Hundred of Ulyerra. The formation between 120 and 220 feet consists of lignite, lignitic clays and sands and white to green-grey clays. It is overlain by grey to red-brown clayey sands and underlain by weathered Precambrian metasediments.

From 118 to 190 feet in Polda No. 1 Stratigraphic Hole the microfloral assemblages clearly indicate a correlation with the *Proteacidites confragosus* Zonule. In particular the assemblages contain both *P. pachypolus* and *P.* aff. *P. pachypolus* together with *P. kopiensis*, *P. tripartitus* and common *Triporopollenites gemmatus*. Comparable microfloras have been recovered from KR9 Bore near Kopi.

Whilst the nominate species has not been identified from these sequences, the overall similarity of the microfloras with the *Proteacidites confragosus* Zonule is sufficient to indicate the identification and correlation of this zonule.

Thus the age of the Poelpena Formation is Middle Eocene and correlates with the *Proteacidites confragosus* Zonule.

Cummins Basin

This basin extends as a sedimentary unit from south of Wanilla in a narrow trough-like series of complex bedrock depressions to just south of Tooligie. In the Cummins School Bore, a maximum thickness of 445 feet of clays, sands, lignites and gravel was intersected. Johns (1961) mentions gneisses outcropping in the basin, while drilling has shown that the basement floor topography is irregular and undulating. Carbonaceous clays and silts from the basin have yielded small planktonic foraminifera similar to those occurring in the Upper Eocene elsewhere in South Australia and indicate paralic conditions of sedimentation (Johns *op. cit.* p. 26). The sequence however, is dominantly non-marine. The southern extensions of the basin are considered in this text to include the Uley-Wanilla and Lincoln Basins of Hillwood (1960).

Wanilla Formation (Harris 1966) Non-marine and paralic sediments occur in a narrow sedimentary trough extending approximately north-south from west of Port Lincoln to Karkoo. The sediments consist of lignites, sands, carbonaceous clays and silts. Ludbrook (1963, p. 7) reported the occurrence of pauperate planktonic foraminifera in the Cummins, Wanilla and Lincoln Basins but did not comment further on their Eocene age. These sediments are approximately 250 feet thick in the Cummins area but their full lateral extent is unknown.

The type and supplementary sequence of the formation are in the Cummins School Drainage Bore, between 115 and 400 feet and Cummins Police Drainage Bore, between 142 and 234 feet. The top and bottom of the formation are not known from this bore.

Microfloras from the Wanilla Formation in the Cummins School Drainage Bore can be clearly divided into two units: an upper one between 87 and 149 feet and a lower between 150 and 382 feet. The upper unit is characteristically dominated by *Milfordia* spp. together with *Aglaoreida barungensis* and abundant *Nothofagidites* spp. There is no evidence that either *T. magnificus* or *P. pachypolus* are present. Thus the assemblage is assigned to the *Aglaoreida barungensis* Zonule and is most probably of Upper Eocene age.

On the other hand however, the lower assemblage is comparative with that from the Poelpena Formation. Thus this is of Middle Eocene age and a correlative of the *Proteacidites confragosus* Zonule. Therefore within the Wanilla Formation, at least in the deeper sections of the basin, there is an obvious palynological disconformity. That is both the *Proteacidites pachypolus* and *Triorites magnificus* are absent.

In Observation Bore 18 at Port Lincoln the lower Zonule is present at 70-80 feet.

Pirie-Torrens Basin

This basin is bounded in the east by the fault system which marks the western limit of the Flinders Ranges and in the west by a major structural discontinuity which marks the western margin of

Spencers Gulf and extends northward for about 150 miles to the northern extremity of Lake Torrens (Ward 1944, Chebotarev 1958).

An exploration programme for evaporites and brine resulted in the drilling of several bores in the bed of Lake Torrens. One of these, Lake Torrens Bore 3A penetrated 830 feet of sediments comprising recent lake sediments, dolomitic mudstones, gravels and carbonaceous mudstones. Further to the south the Santos-Wilkatana Bores penetrated an abbreviated Cainozoic sequence and finally bottomed in Upper Proterozoic sediments after passing through Cambrian shales and limestones. There are no marine Tertiary sediments recorded from the basin.

Wilkatana Formation (New name): Non-marine sands, silts and lignites occur at depth throughout much of the Pirie-Torrens Basin. Their full lateral extent and their possible connection with the St. Vincent Basin is unknown. The type sections of the formation are designated in the Santos Ltd. Wilkatana Bore 1 between 316 and 462 feet and Bore 2, between 276 and 468 feet.

S.A.D.M. Lake Torrens Bore 3A yielded very-well preserved microfloras between 603 and 887 feet, the total depth. Similarly the samples from Santos Wilkatana Bore 1 (325'3" and 351'4") yielded well-preserved assemblages. In particular the microfloras are characterised by abundant *Proteacidites* spp., *P. pachypolus*, *P.* aff. *P. pachypolus*, *P. confragosus*, *P. incurvatus*, *P. subscabratus* and *P. adenanthoides*. Notably the assemblages are characterised by a low diversity, and frequency, of *Nothofagidites* spp. (*N. mateauraensis*, *N. falcata* and *N. brachyspinulosa*). Also *T. harrisii* is comparatively uncommon.

The available evidence indicates clearly an identification with the *Proteacidites confragosus* Zonule and the Wilkatana Formation is therefore Middle Eocene in age.

Great Artesian Basin

The largest single geological unit in Australia, the Great Artesian Basin occupies more than one-third of the area of South Australia. The structure and history of the Basin has been adequately dealt with by Sprigg (in Glaessner and Parkin 1958) and will not be reiterated in this text. Suffice it to say that Tertiary sediments are widespread throughout the basin but are generally thin and of non-marine origin.

Murnpeowie Formation: Forbes (1966) described this non-marine formation from the Reedy Springs area on the MARREE Sheet. The lowermost unit is a quartz pebble conglomerate in a ferruginous sandstone matrix. This is followed by gravels, gritty, coarse and medium grained sands and sandstone. Grey and dark grey sandstones with carbonaceous matter occur above this and are followed in turn by partly calcareous and silicified (duricrust) sandstones. These sediments appear to be widespread throughout the basin. In their subsurface correlatives the grain size is generally finer and principally silt size. There is a high proportion of carbonaceous material such that lignitic horizons are developed in many instances. The formation is disconformably overlain by the dolomitic Etadunna Formation (?Miocene) and the base rests disconformably on Lower or Middle Cretaceous sediments.

Microfloral assemblages in correlatives of this formation from quite widespread localities within the Great Artesian Basin (e.g. Lake Eyre - Lake Cootabarlow - Patchewarra) indicate that there were two phases of deposition--one in the Paleocene, the other in the Upper Eocene. The two units have been only identified in superposition in two bores, Lake Eyre Bore 20 and Cootabarlow Bore 2. In the other bores (Patchewarra, Currawarra, Muloowurtna No. 2 and Cannuwaukaninna) the assemblages that have been studied are of Paleocene age. One sample in East of Lake Frome Bore 1 (290-293 feet) yielded an Upper Eocene assemblage.

The Paleocene microfloras show closest similarities with those of the Murray Basin and much less so than those of the Otway Basin.

Stephanoporollenites obscurus, *Myrtaceidites eugeniioides* and *Cupanieidites orthoteichus* are ubiquitous and characterise the assemblage at 240 feet in Lake Eyre Bore 20 and below 536 feet in Cootabarlow Bore 2. *Proteacidites fromensis* is characteristically present in all of the Paleocene assemblages and is a most distinctive form. As might be expected, *Nothofagidites* spp. are either absent or very rare.

The evidence from the species present and the absence of forms such as *G. edwardsii*, *D. balmei* and *C. bullatus* would indicate an identification with the *Cupanieidites orthoteichus* Zonule. The common occurrence of *S. obscurus* may indicate a correlation low in this zonule, i.e. in the *Myrtaceidites eugeniioides* subzonule.

The typically Eocene assemblages from Lake Eyre Bore 20 (156-164 feet) and Lake Cootabarlow Bore 2 (515-536 feet) are characterised in particular by the presence of *Milfordia* spp., *Aglaoreida barungensis* and few *Proteacidites* sp. *P. pachypolus* and *T. magnificus* are notably absent. *Nothofagidites* spp. are most common and dominate the assemblages. Thus these microfloras are of Upper Eocene Age (or ?Oligocene) and are identified with the *Aglaoreida barungensis* Zonule.

Again in a sequence of non-marine sediments, sands, silts and lignites, we have an obvious palynological disconformity (between Upper Paleocene and Upper Eocene rocks) that is not immediately apparent in their lithological character. Thus there are two phases of deposition of the Murnpeowie Formation equivalents in the Great Artesian Basin.

Willochra Basin

This basin, about 600 square miles in area, is present in a large complex bedrock depression extending from Booleroo in the south to Willochra in the north (Ward 1946). Sediments in the basin are fluviatile sands, gravels and clays, with minor lignitic sands developed at the base of the sequence.

"Booleroo sands:" Non-marine sands, silts and clays, carbonaceous in part occur in the subsurface throughout this small basin. Insufficient boring and sampling data do not permit formal definition of this unit.

Three samples from the Willochra Test Bore No. 2 have yielded assemblages containing *P. pachypolus*, *Caryophyllidites* spp., *Nothofagidites matauraensis*, *N. falcata*, *Milfordia* spp. and *Tricolporites* spp. The notable absence of forms such as *Proteacidites confragosus*, *P.* aff. *P. pachypolus*, *Triorites magnificus* and *Aglaoreida barungensis* would indicate a correlation with the *Proteacidites pachypolus* Zonule. Thus the age of the "Booleroo sands" is middle Eocene.

Walloway Basin

This small basin is beneath the broad plain which extends northwards through the Hundreds of Black Rock Plain, Walloway, and Oladdie. The town of Orroroo lies on its western margin in the Hundred of Walloway.

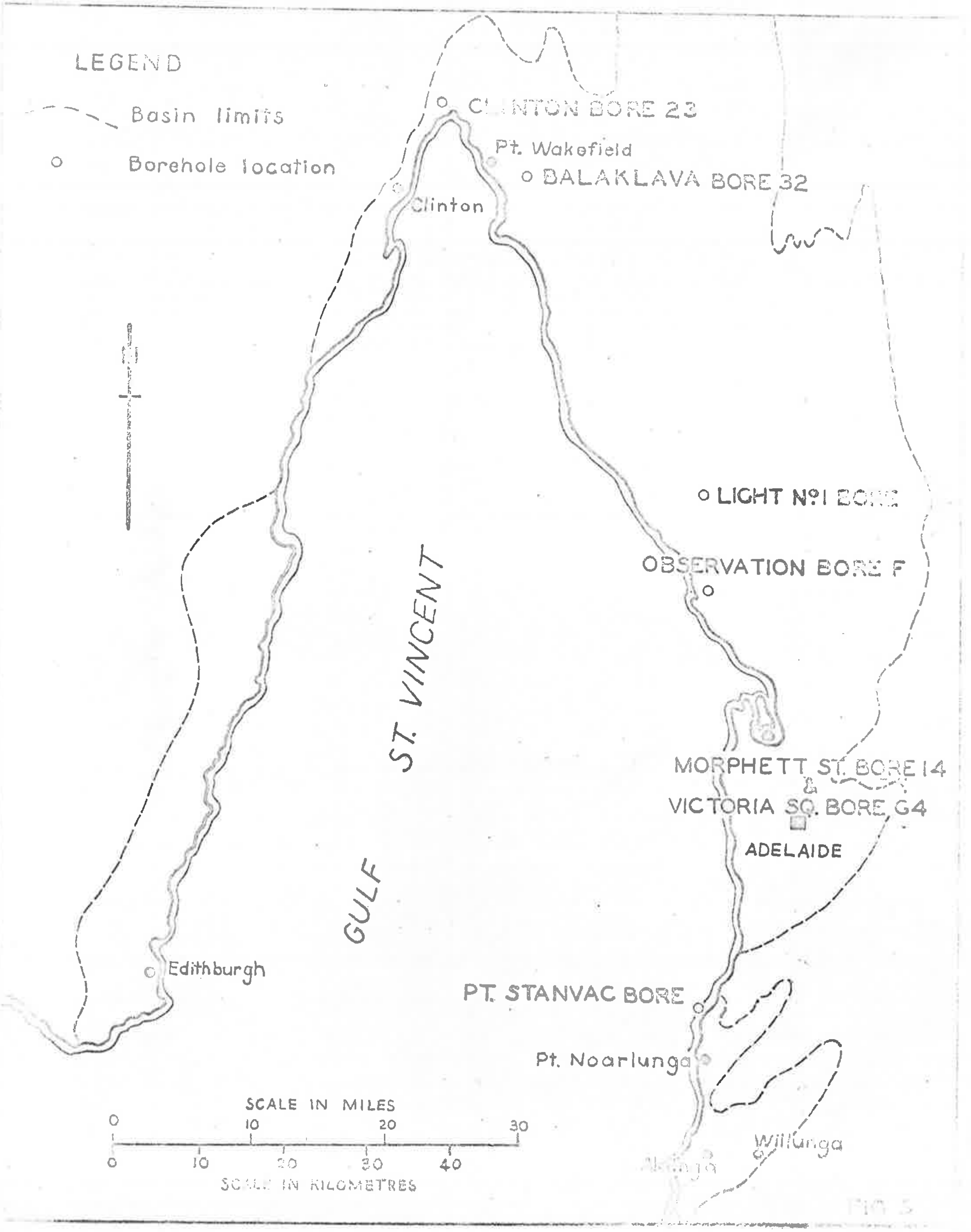
The basin is flanked by Upper Proterozoic sediments, tillites and slates, of the Adelaide system (Ward 1946). The stratigraphy of this basin is also poorly known. The sediments are fluviatile sands, clays and some minor lignites. The depth to basement in parts is known to exceed 600 feet.

"Walloway sands:" Non-marine sands, silts and clays in part carbonaceous are present in the subsurface of the Walloway Basin in the Orroroo area. Insufficient boring data and samples do not permit formal definition of this unit.

Only two samples from the Orroroo Bore (at 567 and 568 feet) provided any indication of the age of this formation. However the assemblages are well preserved and are dominated by *Nothofagidites* spp. (in particular *N. matauraensis* and *N. falcata*) and *Triporopollenites harrisii*. *Proteacidites pachypolus*, *Echiperiporites diversus* and *Podocarpidites ellipticus* are also commonly present. The assemblage is very similar to those in the "Booleroo sands" and a correlation with *Proteacidites pachypolus* Zonule, and therefore a middle Eocene age, is inferred.

St. Vincent Basin

The St. Vincent Basin comprises the areas surrounding the St. Vincent Gulf and can be subdivided into several Tertiary sub-basins. The stratigraphy has been treated by a number of workers, notably



AND BOREHOLE LOCATIONS

Reynolds (1953) and Glaessner and Wade (in Glaessner & Parkin 1958). Lindsay (1969) has recently studied the stratigraphy of the Adelaide Plains Sub-Basin. Glaessner and Woodward (in Cochrane 1956) studied sediments from the Willunga Bore and correlated them with the type outcrop section and Lindsay (1967) studied the foraminifera and stratigraphy of the type section of the Port Willunga Beds. Recent drilling by the South Australian Department of Mines in the northern portions of the basin has revealed extensive lignitic sequences (Hillwood 1961, Johnson 1964). Permian sediments outcrop near Maslin Bay, at Hallett Cove, Cape Jervis and Yorke Peninsula.

The Tertiary units described by Reynolds (*op. cit.*) in the Willunga sub-basin can be readily correlated with most sub-surface sequences elsewhere in the basin (e.g. Lindsay 1969). The units of importance in this study are as follows:

North Maslin Sands: The type section of the North Maslin Sands comprises sands, clays and silts but in the subsurface where the effect of weathering is less noticeable, the sediments are generally carbonaceous and lignites are of common occurrence. They are succeeded in most instances by a marine Upper Eocene sequence.

The important discovery in 1967 of carbonaceous leaf beds of the type section in A.B.M."s Noarlunga quarry provided the first real evidence for the age of the North Maslin Sands. As might be expected from the very fine preservation of the macroscopic flora, the spore-pollen assemblages are likewise well preserved and very diverse. The microflora is dominated by species of *Nothofagidites* --*N. mataur aensis*, *N. falcata*, *N. flemingii*, *N. hetera* and *Proteacidites* spp.--*P. confragosus*, *P.* aff. *P. pachypolus*, *P. pachypolus*, *P. kopiensis* and *P. annularis*. Other elements in the microflora include *Santalumidites cainozoicus*, *Tricolpites thomasii*, *Clavatipollenites* sp., *Equisetosporites* sp. and *Casuarinidites cainozoicus*.

The presence of *P. confragosus* and *P.* aff. *P. pachypolus* indicates a correlation with the *Proteacidites confragosus* Zonule of Middle Eocene age. This correlation and age determination is the subject of a paper by McGowran, Harris and Lindsay at present in manuscript form.

Elsewhere within the Basin the age of the unit, or its lithological correlatives, does not appear to be as old as in the type section. In Observation Bore F, Port Gawler, North Maslin Sands (or Clinton Coal Measures) at 1050 and 1065 feet yielded rich and very well preserved microfloras that are identified as belonging to the *Proteacidites pachypolus* Zonule. The assemblages are dominated by *Nothofagidites* spp. and *Proteacidites* spp. In particular *P. clintonensis* and *P. pachypolus* are present with *Beaupreaidites verrucosus* and abundant *Tricolporites adelaidensis*.

Samples higher in the sequence (734 to 875 feet) in Blanche Point Marl Equivalents yielded very poor microfloras.

In the Willunga township bore assemblages from 634-644 feet and 664-670 feet in the North Maslin Sands are identified as the *Triorites magnificus* Zonule. In particular they contain the nominate species together with *Tricolporites adelaideusis, Beaupreaidites verrucosus* and *Proteacidites clintonensis* and abundant *Nothofagidites* spp.

Thus the age of the North Maslin Sands ranges from low in the Middle Eocene in the type section through to middle-upper Eocene in the Willunga Bore a few miles to the south east of Maslin Bay.

Blanche Point Marls: Dark grey to grey marls and limestones overlain by mid-Tertiary limestones outcrop in the area of Blanche Point near Willunga and have been correlated by Glaessner and Woodard (in Cochrane 1956) in sub-surface sections of the Willunga sub-basin. An Upper Eocene age was first assigned to these sediments on the evidence of the occurrence of *Hantkenina alabamensis compressa* Parr (Glaessner 1951). Correlatives of this unit in the Adelaide Plains sub-basin represent a more restricted environment particularly towards the top of the sequence where a regressive phase is inferred. This unit is less calcareous and can be described as a carbonaceous silt. They are preceded by a transgressive phase, the Tortachilla Limestone.

Palynological information on the Blanche Point Marls and their equivalents is derived mainly from the Adelaide Plains Sub-Basin and the Willunga Bore in the Willunga Sub-Basin. No assemblages have been recovered from the outcropping type section.

Morphett Street and Victoria Bridges Foundation Bore 14 intersected between 50 and 89 feet sequence of "Blanche Pt. Marl--Tortachilla Limestone--South Maslin Sands" equivalents (Lindsay 1969). Four samples from this bore yielded very similar microfloras dominated by species of *Nothofagus--N. hetera, N. vansteenisi, N. brachyspinulosa, N. falcata* and *N. matauraensis,* together with *Proteacidites pachypolus, P. clintonensis, P. incurvatus, Triorites magnificus,* and *Trilites tuberculiformis.*

Thus in this area the sediments of this complex are identified with the *Triorites magnificus* Zonule. In S.A.D.M. Light No. 1 Bore the *Triorites magnificus* Zonule extends as high as 562 feet and is succeeded at 470 feet (no core samples between these depths) by the *Aglaoreida barungensis* Zonule and the significance of this has been discussed elsewhere.

Two samples from the Willunga Township Bore (420-426 feet, 574-578 feet) in the Blanche Point Marls have yielded an identical terrestrial microflora as that from the North Maslin Sands in the well and discussed previously. Also the unit referred to as the "Chinaman's Gully Beds" (396-409 feet) has yielded a comparable microfloral assemblage with the lower units. Lithologically this unit could well be placed in the lithological facies of the North Maslin Sands or the Clinton Coal Measures.

The Blanche Point Marls and equivalent sequences in the Adelaide Plains Sub-Basin are almost entirely within the *Triorites magnificus* Zonule. The *Aglaoreida barungensis* Zonule is only present in the deeper sections of this sub-basin where the "Blanche Point Marl facies" extends high into the Eocene.

Clinton Coal Measures: This name was used informally by Ludbrook (1963 fig. 1). Non-marine sands, silts and lignites achieve maximum development towards the north of the basin in the Inkerman - Balaklava and Clinton areas. In the former area the lignitic series is overlain by correlatives of the Blanche Point Marls. North of Clinton on the western margin of the basin, the series extends into the mid-Tertiary with an obvious palynologic disconformity between the Eocene and ?L. Miocene units. Type sections of the Clinton Coal Measures are designated by Bore C23 between 150 and 318 feet and Bore C20 between 190 and 301 feet in the Hundred of Clinton. The locality of the bores and lithological logs are given by Johnson (1964). Several bores bottomed in Precambrian slates, dolomites and sandstones.

The extensive development of lignites and highly carbonaceous lithofacies at the head of the Gulf of St. Vincent, and therefore near to the northernmost extension of the St. Vincent Basin have yielded excellently preserved and very diverse microfloral assemblages. The Port Clinton No. 23 Stratigraphic bore section of the Clinton Coal Measures can be divided into two zonules. The upper one (150-198 feet), identified with the *Aglaoreida barungensis* Zonule is dominated by *Milfordia* spp. and very common *A. barungensis*. *Triorites magnificus* and *Proteacidites pachypolus* occur, possibly as remanie fossils as evidenced by their darker colouring and corrosion. The lower assemblage is typical of the *Triorites magnificus* Zonule. Besides the nominate species, *Proteacidites clintonensis*, *Tricolporites adelaidensis* and *Nothofagidites* spp. are the most common elements. *Proteacidites pachypolus* is also present in these assemblages.

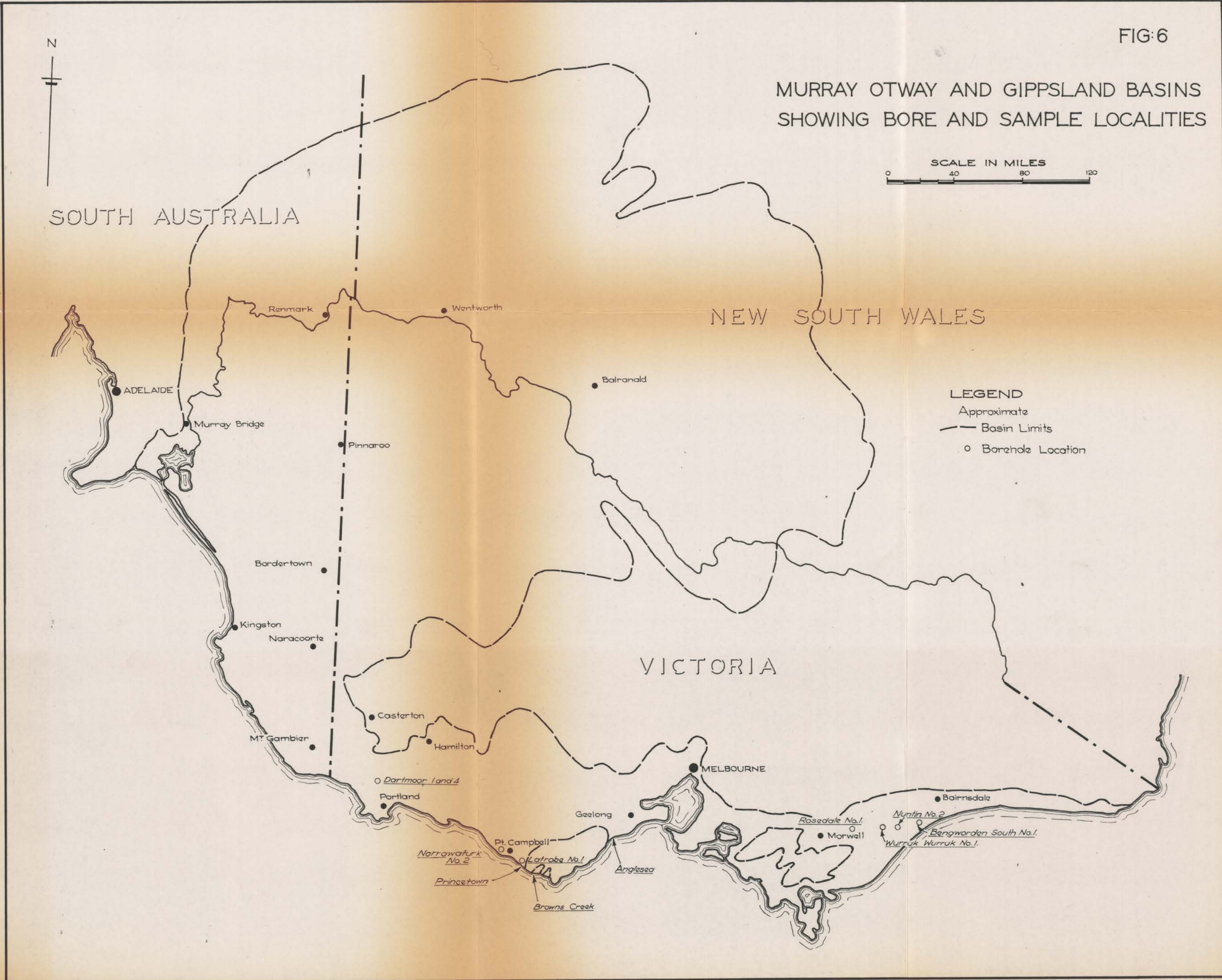
In Barunga Bore 4 the *Triorites magnificus* Zonule (244-249 feet) is succeeded by a unit regarded as of ?early Miocene. It is quite distinct from the *Aglaoreida barungensis* Zonule which has not been identified in this bore.

Across the other side of the Gulf from Port Clinton the Inkerman-Balaklava Coalfield Bore 32 intersected a highly carbonaceous sequence between 125 and 291 feet. This entire thickness is identified with the *Triorites magnificus* Zonule.

Murray Basin

The Murray Basin is a large structural unit, its present configuration being defined by the distribution of marine Tertiary sediments. It extends into both New South Wales and Victoria and

FIG:6


MURRAY OTWAY AND GIPPSLAND BASINS
SHOWING BORE AND SAMPLE LOCALITIES
SCALE IN MILES
0
40
80
120
N
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
LEGEND
Approximate
Basin Limits
Borehole Location
Renmark
Wentworth
Balranald
ADELAIDE
Murray Bridge
Pinnaroo
Bordertown
Kingston
Naracoorte
Casterton
Hamilton
MT Gambier
Dartmoor 1 and 4
Portland
MELBOURNE
Geelong
Pt. Campbell
Narrawaturk No. 2
Latrobe No. 1
Princetown
Browns Creek
Anglesea
Rosedale No. 1.
Morwell
Bairnsdale
Nuntin No. 2
Bengworden South No. 1.
Wurruk Wurruk No. 1.

in South Australia occupies approximately 28,000 square miles, about one-quarter of its total area (Ward 1944). The depositional history of the basin is reviewed briefly by Ward (1946) but recent drilling by oil companies in the more central parts of the basin have indicated the presence of Lower Cretaceous and Permian sediments (Ludbrook 1958, 1961). The Tertiary stratigraphy has been detailed more recently by Ludbrook (1961). The basin is bounded in the north and the west by folded Upper Proterozoic and Lower Palaeozoic sedimentary metamorphic and plutonic rocks. The southern margin of the basin in South Australia is marked by the Padthaway Horst (of Sprigg 1952) lying between Bordertown and Naracoorte and separates the Murray Basin from the Otway Basin. (Gambier Sunklands of Sprigg *op. cit.* p. 19). Sprigg discussed the evidence for this separation and concluded that the southern margin of the Murray Basin extended, in South Australia, in an arc from Cape Jaffa near Kingston to south of Naracoorte (Sprigg *op. cit.* Fig. 3 p. 20). O'Driscoll (1960 Fig. 6) using geophysical and all available bore data relating to the basement-Tertiary interface constructed a contour map on this surface which supports the division of the two basins as does the section drawn by Ludbrook in Glaessner & Parkin (1958 Fig. 21).

Renmark Beds (Harris 1966): Non-marine and paralic sediments of wide areal extent within the Murray Basin, previously referred to as the Knight Group, are herein defined as the Renmark Beds.

For reasons, which are outlined in the discussion on the Otway Basin immediately succeeding this section, the term "Knight Group" or Wangerrip Group is not applicable to initial Tertiary sedimentary units in the Murray Basin. Group names should not be applied outside the area in which the constituent bounding formations occur. The formations of the Wangerrip Group cannot be recognised in the Murray Basin.

The type sections of the Renmark Formation are designated between 635 and 1320 feet in AOG Loxton Bore and between 740 and 1698 feet in Company Bore Loxton, as described by Ludbrook (1961 p. 9). It should be noted that the formation in Company Bore has been extended to 1698 feet on both lithological and palynological evidence.

The Renmark Beds are dominantly non-marine thoughout the basin except where they are transitional into "Buccleuch Group" sediments. Here a restricted marine fauna persists. This facies certainly should have at least "Member" status but until more is known of its lateral and vertical limits, it will be treated as undifferentiated Renmark Beds. The occasional presence of dinoflagellates and acritarchs in the Paleocene and middle Eocene sediments would suggest a paralic or marginal marine environment.

Lack of samples and inadequate deep borehole control of sections prohibits lithological subdivision of the formation at this time. Accordingly, the term "Beds" is used.

The lignites occurring in the Moorlands district which are, however, well documented are here treated as having "member" status within the Renmark Beds and are therefore referred to as the Moorlands Lignite Member.

The distribution of spores and pollen and the limits of the Eocene Zonules in the Loxton Company Bore has been discussed in a previous section and will not be repeated here. Within the basin these zonules are the most widespread except for the lowest, the *Proteacidites confragosus* Zonule, which occurs only in the deeper sections, that in the centre of the Murray Basin. It occurs in AOC Renmark No. 1 Well in core 4 (1210-1224 feet). Towards the margins of the basin, e.g. Keith and Coonalpyn in the south and Canopus in the north, this zonule is not present. In these marginal areas the youngest Eocene is the *Proteacidites pachypolus* Zonule. In the M.B.O.S. Keith Bore 1 this is present core between 775 and 815 feet. The assemblage is characterised by the common occurrence of the nominate species together with *Proteacidites clintonensis*, *Tricolporites adelaidensis*, abundant *Nothofagidites* spp.
It is succeeded at 755-765 feet by the *Triorites magnificus* Zonule and the *Aglaoreida barungensis* Zonule between 553 and 491 feet. In the E. & W.S. Keith Township Bore A a very similar succession of these three zonules has been identified. The *Aglaoreida barungensis* Zonule in this bore is in Buccleuch Beds (see previous discussion) (unit "B"). Similarly the sediments in M.B.O.S. Keith No. 1 Bore

above 695 feet would also be more appropriately identified with the Buccleuch Beds.

Shaft samples of Moorlands Lignite Member have yielded rich and very well preserved fossils including *Triorites magnificus, Proteacidites incurvatus, P. adenanthoides* and abundant *Nothofagidites* spp. indicating an identification with the *Triorites magnificus* Zonule.

Paleocene sediments in the basin are similarly restricted to the central part. In Loxton Company Bore they are present between 1698 and 1462 feet. The *Gambierina edwardsii* Zonule is present between 1596 and 1698 feet and is characterised by the presence of the nominate species together with *Stephanopollenites obscurus, Krauselisporites papillatus, Podocarpidites exiguus* and *Anacolosidites acutullus*. The *Cupanieidites orthoteichus* Zonule is present in samples between 1462 and 1531 feet and is characterised by the absence of *G. edwardsii* and the presence of *Dilwynites granulatus, Trilites gigantis, Proteacidites incurvatus, Myrtaceidites eugeniioides* and the nominate species of the Zonule.

Thus the age of the Renmark Beds ranges from Middle Paleocene to Upper Eocene.

Buccleuch Beds:: The "Buccleuch Group" was established by Ludbrook in 1957 and later reaffirmed in 1961, for a group of sediments in the southwestern extremity of the Murray Basin.

representing an Eocene transgression equivalent to that in the St. Vincent Basin and on the Aire Coast.

However the erection of a "Group" without valid formation units and without valid names is contrary to Article IV(23) of the Australian Code of Stratigraphic Nomenclature. It is therefore more appropriate and correct to refer to the sequence as the Buccleuch Beds (see (IV)27 of the above Code) until the individual beds are formally named.

No attempt will be made at this time to enlarge upon or formalise the various units described by Ludbrook (1961). Suffice it to say that both in a northerly and an easterly direction away from the type area the limestones and shelly sands thin rapidly and the environment becomes estuarine grading to non-marine in the Renmark-Loxton area.

Within the type area for this unit two formations are particularly suitable for palynological examination. The first precedes the limestone of "Buccleuch A" of Ludbrook and has been referred to the Renmark Beds in the previous discussion. It is partly correlated with the Moorlands Lignite Member. Typically at this level the most notable feature of the microfloras is the abundance of trilete and monolete spores, in particular *Trilites ornamentalis*, *T. tuberculiformis*, *Laevigatosporites major* and *Kulysporites* cf. *K. waterbolki*. This assemblage occurs high in the *Triorites magnificus* Zonule. The other unit of interest is "Buccleuch B." Microfloras high in this unit are identified as the *Aglaoreida barungensis* Zonule and are present in E. & W.S. Keith Bore A (see preceding section on Eocene zonules), Cosden Bore (220-303 feet), Ki-Ki Bore (340-381 feet), Coonalpyn Cold and Wet Bore (190-224 feet) and Coomandook Bore (221-241 feet). Thus the age of the Buccleuch Beds is Middle to Upper Eocene.

Otway Basin

This is the negative tectonic element corresponding to the depositional surface of all Mesozoic and Tertiary rocks from Lacepede Bay in South Australia to Port Phillip Bay in Victoria and is comprised of several embayments. Lower Cretaceous sediments outcrop in the vicinity of Casterton in the Dundas High and in the Otway Ranges. Upper Cretaceous sediments have been revealed in the Gambier, Portland and Port Campbell Embayments by petroleum exploration companies and the Victorian Department of Mines (McQueen 1961, White 1968). The sedimentation and biostratigraphy of the Upper Cretaceous has been discussed by Taylor (1964 a, b). Tertiary sediments have received detailed attention by a number of workers, in particular Kenley (1951), Ludbrook (1961), Carter (1958), Boutakoff (1963), Raggatt and Crespin (1955) and McGowran (1965).

Gambier Embayment

Lower Tertiary sediments of the Gambier Embayment and indeed of much of the Otway Basin are principally non-marine to marginal marine sands, silts, clays and lignites. To cover a large thickness of sediments the term "Knight sands and clays" was used by Sprigg (1952), subsequently the Knight Group of Sprigg and Boutakoff (1953), to name the sediments. The only outcrop of these in South Australia is at Knights Quarry about 8 miles northwest of Mt. Gambier.

These early Tertiary clastic sediments have been the subject of some nomenclatural confusion in recent years and in 1966 Harris made certain suggestions in order to clarify the stratigraphy of the units involved. The present status and relationships are summarised in the following table.

Table 4

Age		Gambier Embayment		Pt. Campbell Embayment
M. Eocene		Knight Formation		?
Paleocene	Wangerrip Group	Dartmoor Formation	Wangerrip Group	Dilwyn Formation
		Bahgallah Formation		Pebble Pt. Formation

The term "Knight Group" has been used loosely by many authors to include most non-marine and paralic sediments throughout the Embayment and those of the Murray Basin (e.g. Ludbrook 1961, 1969). Sprigg and Boutakoff (1953) included the Bahgallah and Dartmoor Formations of western Victoria in their definition of the "Group." In outcrop sections both of these units are of Paleocene age and moreover palaeontological, palynological and lithological evidence indicates that they are equivalent to and therefore synonymous with the Pebble Point and Dilwyn Formations respectively. Clearly then these two formations should be included within the definition of the Wangerrip Group. Thus "Knight Group" is reduced to Knight Formation, an Eocene unit lying disconformably above the Dartmoor Formation.

Leslie (1966 p. 208) and McGowran (1968 Table 1) have already indicated these correlations and Bock and Glenie (1965) go so far as to reduce the rank of the Dartmoor to "member" status differing from the Dilwyn Formation "by an excess of quartz sands over shales".

At this stage there is no point in introducing new nomenclature for the unit exposed in Knights quarry, originally named "Knight Sands and Clays" by Sprigg (1952) as Ludbrook (in Parkin 1969) has done. The Tartwaup Formation is synonymous with the Knight Formation.

Apart from distinct palynological differences between the Dartmoor and Knight Formations there are lithologically characters which can be used to separate the two units. The Eocene Knight Formation consists mainly of unconsolidated poorly sorted coarse sand grit and minor conglomerates with interbeds of lignitic clay (Burrungle Member). The Paleocene Dartmoor Formation on the other hand is mainly a fine to medium grained quartz and micaceous carbonaceous siltstone. Whilst quartz is the predominant mineral in the latter, the coarse grains of the Knight Formation are chert, feldspar and fragments of metamorphic rocks.

The type sequence of the Knight Formation is at Knight's Quarry, section 718, Hundred of Blanche, 8 miles north-west of Mt. Gambier. This sequence is disconformably overlain by the Compton Conglomerate followed by the Gambier Limestone. In the type area the age of the Knight Sands is inferred as Middle Eocene from extrapolation of bore data in County Grey.

Immediately overlying coarse sands of the Knight Formation in County Grey is a shallow water estuarine or deltaic deposit carrying a small fauna of foraminifera indicating a Middle Eocene age and occasional molluscan fragments. This is described as the Burrungle Member of the Knight Formation (Harris 1966). It is typically a laminated silty clay with a few sand intercalations, slightly calcareous and very carbonaceous. The lower boundary of the member is transitional with undifferentiated Knight Formation.

The type sequence is in bores C.G. 8 (72-115 feet) and C.G. 9 (80-114 feet) in County Grey, Hundred of Young.

The assemblages from the Burrungle Member have been discussed elsewhere under the section on Eocene zonules and identified with the *Proteacidites confragosus* Zonule.

The Kongorong Sand and Lacepede Formation: Overlying the Knight Formation is a sequence of increasingly marine sediments, the Kongorong Sand is a brown to yellow brown limonitic stained quartz grit with a carbonaceous clay matrix. The Lacepede Formation is a brown to black carbonaceous silt rich in glauconite near the base and grades into a greenish grey marl (Ludbrook 1969). Very few samples of either formation are available for palynological examination. In F. Jose Bore, Hundred of Spence an assemblage in the Kongorong Sand at 250-260 feet is identified as the *Proteacidites pachypolus* Zonule. A similar age has been determined for the lower part of the Lacepede Formation (200-218 feet) in E. & W.S. Kingston Bore 1.

Bahgallah Formation: Glauconitic sands and grits outcropping in the cliffs of the Glenelg River at Killara and Bahgallah Bluffs overlie the Lower Cretaceous Runnymede Formation with slight angular disconformity. At Killara Bluff the formation consists of about thirty feet of yellow brown ferruginous sands and minor silty and gravelly layers. These are poorly fossiliferous and are overlain by 22 feet of dark red brown and yellow clays, silts and sands, which contain an assemblage of Paleocene fossils. Kenley (1951) recorded several mollusca from these sediments and compared them with those of the Pebble Point Formation. Fresh outcrops of the Formation are exposed in the bed of the Glenelg River 1-3 miles downstream from Killara Bridge. Here they are dark green glauconitic quartz sands and oolitic greensands carrying relatively well-preserved fossils.

Little is known of the distribution of the formation in South Australia but it appears to be present at 2494-2504 feet in ODNL Mt. Salt No. 1 Well. It is not present in either Beach Petroleum NL Geltwood Beach No. 1 Well or ODNL Penola No. 1 Well.

At present no good microfloral assemblages have been recovered from this formation in South Australia. However in the Comaum No. 2 Bore Harris and Cookson (1965) reported a microfloral characterised by *G. edwardsii*, *Triorites clavatus* and *Trilites gigantis*. This assemblage occurs in a lignite and is identified with the *Gambierina edwardsii* Zonule and is probably a non-marine correlative of the Bahgallah Formation.

Dartmoor Formation: The Dartmoor Formation locally overlaps the Bahgallah Formation but in the Glenelg Valley downstream from Killara Bridge the formation grades downwards through a zone of interdigitation into the Bahgallah Formation.

The formation comprises purple and black laminated micaceous silts, occasionally containing *Haplophragmoides* spp., quartz sands, carbonaceous clays and minor brown coals. Palynological and independent micro-palaeontological evidence indicates a Paleocene age.

Very good microfloras have been obtained from both surface and subsurface sediments of this formation. The outcropping section near Dartmoor, the Dartmoor Nos. 1 (68-350 feet) and 4 (134-206) bores and the McEwens Settlement or Drajurk Bore (104-580 feet) indicate that the Dartmoor Formation is entirely Paleocene in age. Moreover it appears to be within the *Cupanieidites orthoteichus* Zonule. Species present include abundant *Proteacidites renmarkensis*, *Stephanopollenites obscurus*, *Cupanieidites orthoteichus*, *Cyathidites splendens* and *Todisporites* sp.

Port Campbell Embayment

Lower Tertiary sediments of the Port Campbell Embayment are Pebble Point, the Dilwyn and Mepunga Formations. The stratigraphic, palaeontological and lithological data of the first two have been summarised by Harris (1965) and McGowran (1965) and herein.

The stratigraphic palynology of the type sections of these formations has been described under a previous section.

Two bores in the Port Campbell Embayment have been examined --V.D.M. LaTrobe No. 1 and Narrawaturk No. 2 bores. In LaTrobe Bore the Paleocene-Eocene boundary lies between 515 and 588 feet and the Tertiary-Cretaceous boundary between 1524 and 1627 feet. The Paleocene microfloral sequence can be readily correlated with that of the outcropping section along the coast. The *Duplopollis orthoteichus* Zonule was identified between 588 and ?1002 feet. Because of poor yields and preservation between 1002 and 1415, the lower limit of this zonule is indeterminate. At 1509 feet definite *Gambierina edwardsii* Zonule is present. D.J. Taylor (pers. comm.) does not record a fauna below 1130 feet.

In Narrawaturk No. 2 bore the Paleocene-Eocene boundary lies between 2332 and 2439 feet and the Tertiary-Cretaceous boundary between 3035 and 3380 feet. The *Cupanieidites orthoeichus* Zonule has been identified at 2441 and 2584 feet. At 2855 and 3035 a Paleocene microfloral assemblage was identified but because of poor yields and preservation a more precise zonation is not possible.

Mepunga Formation: Non-marine Middle-Upper Eocene carbonaceous silts and clays are known only from the sub-surface and are correlated palynologically with the Anglesea Member and the Eocene portion of the Johanna River Sands (*sensu lato*). They overlie disconformably Paleocene sediments and are in turn overlain by the Narrawaturk Marl (Bock and Glenie 1965).

Five samples from the LaTrobe No. 1 Bore between 199 and 515 feet in this formation and one from Narrawaturk No. 2 Bore at 2332 feet have been examined but because of low yields a precise identification with a zonule is not possible. The assemblages are suggestive, however, of a correlation with the *Triorites magnificus* Zonule or even younger. They do not resemble the microfloras from the Johanna River Sands below the Browns Creek Clays.

Aire Coast

Two small, but biostratigraphically important, Tertiary embayments occur east of Moonlight Head and west of Cape Otway in the vicinity of the mouth of the Johanna River. Formations comprise in ascending order the Rotten Point Sands (overlying with unconformity Lower Cretaceous sediments), the Johanna River Sands and the Browns Creek Clays. The Rotten Point Sands have not yielded any pollen or spores.

Browns Creek Clays and Johanna River Sands: Sediments comprising this formation consist principally of fossiliferous sandy clays, greensands, glauconitic clays and bryozoal marls. The basal part of the sequence exposed in Browns Creek consists of twenty or thirty feet of dark purple to black carbonaceous silts, sands and clays with several interposed ferruginous bands. These sediments should perhaps be regarded as a separate unit from the Browns Creek Clays, which in contrast are richly fossiliferous and calcareous. They can be referred to as Johanna River Sands. The carbonaceous sediments occasionally carry *Cyclamina* spp. The stratigraphic sequence just west of Browns Creek measured by B. Hocking, B. McGowran and D.J. Taylor (in Cookson & Eisenack 1965 fig. 1) is as follows. Both the top and the bottom of the section are obscured by drift sand. The bottom unit from the Browns Creek gully has been added by this author.

Thickness in feet	Lithology
4	Dark grey carbonaceous clay.
48	Grey clayey marl, bryozoal towards base.
2	Grey marl with glauconite decreasing upwards.
4	Glauconitic sand with *Notostrea* basal 6" of brown clayey sand.
22	Dark grey fossiliferous clay - *Turritella* common.

Thickness in feet	Lithology
17	Brown grey fossiliferous sandy clay ironstained quartz sand - *Turritella* common.
4	Brown sandy clay - coarse to fine, round to angular sand.
approx. 30' (in Brown's Creek)	Dark purple to black carbonaceous, micaceous silts, sands and clays with several ferruginised horizons. Top of unit grades into a mottled zone.

The importance of this section in this study has been noted previously. The *Aglaoreida barungensis* Zonule has been identified in the highest sample, a dark grey carbonaceous clay, and the *Triorites magnificus* Zonule in the brown and grey fossiliferous clay with common *Turritella* below the glauconitic sand with Notostrea. Below this sequence in the Browns Creek gully dark purple to black carbonaceous silts, sands and clays have yielded a rich microfloral identified with the *Proteacidites pachypolus* Zonule. In particular it contains the nominate species together with *Tricolpites thomasii*, *Proteacidites symphyonemoides*, *P. incurvatus* and abundant *Nothofagidites* spp. Of interest in this assemblage is the presence of abundant reworked Paleocene species such *Stephanopollenites obscurus* and *Proteacidites reticuloscabratus* indicating an erosional break either in the Johanna River Sands or between this unit and the Rotten Point Sands. Taylor (1965 p. 157) concludes that the upper part of the Johanna River Sands is of Upper Eocene age and the lower, Paleocene.

Torquay Embayment

Eastern View Coal Measures: Basal Tertiary non-marine sediments (Paleocene) crop out in Coalmine Creek, Spout Creek and coastal cliffs southwest of Airys Inlet. The unit, described by Raggatt and Crespin (1955) consists of sands, carbonaceous shales and lignites and overlies unconformably Lower Cretaceous sediments. The coal measures are apparently overlain conformably by the Boonah Sandstone (Raggatt & Crespin *op. cit.* p. 113).

Cookson (1953) and Cookson and Pike (1953 a and b, 1954b) described several species from this unit at Coalmine Creek: *Cupanieidites orthoteichus*, *Phyllocladidites mawsonii*, *Podosporites microsaceatus*, *Dacrycarpites australiensis* and *Gambierina edwardsii*. Later Cookson (1956) described *Tricolpites gillii* from the same locality. Thus from the presence of *G. edwardsii* and *T. gillii* in this small assemblage it is possible to indicate that the unit in its type section is no younger than Palaeocene. Further significant species which have been isolated in this study from both outcrop and subsurface sections include *Dacrydiumites balmei*, *Phyllocladidites verrucosus*, *P. reticulosaccatus*, *Proteacidites tuberculiformis*, *P. parvus*, *Dilwynites granulatus*, *Stephanopollenites obscurus*, *Cyathidites splendens* and *Peromonolites densus*. Thus the assemblages recovered from the type sections of the unit indicate clearly that it is Paleocene, and by comparison with the Pebble Point Formation it is of middle-upper Paleocene age. The presence of *G. edwardsii* and *D. balmei*, which appears to be restricted to the base of the *Gambierina edwardsii* Zonule, are evidence in support of this conclusion. However, the notable apparent lack of heavily reticulated forms of the genus *Proteacidites (P. dilwynensis, P. grandis* and *P. ornatus)*, common in the Pebble Point sequence, suggest that the Eastern View Coal Measures may be a little older, alternatively there may be some environmental control in the distribution of this group. In subsurface sequences the biostratigraphic correlatives of the Eastern View Coal Measures are readily identifiable and are of similar age to the type section. There is no palynological evidence to suggest a correlation with the Upper Cretaceous Curdies Formation in the western part of the Otway Basin as indicated by Leslie (1966, fig. 5).

Demons Bluff Formation: Carbonaceous sands, silts, greywackes and interbedded volcanics named by Raggatt and Crespin (1955) outcrop in the cliffs and creek sections near Anglesea. They are predominantly dark brown to purple with abundant ?algal remains, infilled worm burrows and a brackish water microfauna characterised by "*Cyclammina* spp."

Microfloras from the outcropping type section at Anglesea have yielded *Triorites magnificus, Anacolosidites luteoides, A. acutullus, Proteacidites pachypolus, P. clintonensis* and *P. reticulatus*. Both *T. magnificus* and *P. clintonensis* are rare in the assemblages indicating a correlation low in the *Triorites magnificus* Zonule. Inland from the type section lignitic sequences containing this Zonule overlie correlatives of the Eastern View Coal Measures and thus it is most difficult to separate the two units lithologically. The situation is essentially the same as that reported by Cookson (1954) for the Birregurra Bore. Here what appears to be the *Triorites magnificus* Zonule between 760 and 960 feet overlies probable *Gambierina edwardsii* Zonule between 1006 and 1022 feet.

Gippsland Basin

The Gippsland Basin in south-eastern Victoria is bounded on the south-west by Wilson's Promontory Granite; on the west by the Mesozoic non-marine sediments of the Narracan and Balook Blocks; and on the north and east by Palaeozoic sediments, metamorphics, volcanics and granites (Hocking & Taylor 1964).

Up to 1800 feet of non-marine sands, clays, coal seams and basalts underlie a marine sequence in the eastern portion of the basin (Carter 1964). Thomas and Baragwanath (1949) described a similar sequence from the western portion of the basin not overlain by marine Tertiary sediments. The Latrobe Valley Coal Measures on the western margin of the basin have been the subject of extensive investigations by Thomas & Baragwanath (1948, 1949, 1950 and 1951) and by Gloe (1960). Hocking & Taylor (*op. cit.* p. 127) have summarised the stratigraphy of the Basin with respect to the marine formations. The following table (after Thomas & Baragwanath 1948 p. 43 and Gloe *op. cit.* p. 62) summarises the stratigraphic succession in the Latrobe Valley Coal Measures. Mr. C.S. Gloe in a written communication to the author (dated 11.6.65) indicated that he considered the Yinnar Group to be the stratigraphic equivalent of the Traralgon Group.

Yallourn Group	(Yallourn Seam ((Yallourn Clay	
Morwell Group	(Morwell No. 10 Seam ((Morwell No. 1A Seam) ( ) (Morwell No. 1B Seam) ((Morwell No. 2 Seam	Morwell No. 1 Seam)) Latrobe Seam)
Traralgon Group = Yinnar Group	(Clays with interbedded ((thin coal seams.	
Narracan Group	(Thorpdale Volcanic Suite with ((interbedded clays and coals ((((Childers Formation - sub-basaltic ((conglomerates, coal, clays.	

On the basis of the superposition of sediments of Janjukian age above the coal measures, Carter (*op. cit.*) regarded the age of these as Eocene with some possible extension into the Oligocene.

Carter (*op. cit.* p. 21) indicates that there is no evidence of marine interdigitation and that the "Latrobe Valley Coal Measures everywhere antedate the Marine Tertiary sequence." The "Coal Measures" rest unconformably on Mesozoic sediments.

West of the marine mid-Tertiary developments, however, the upper limit to the age is quite uncertain, and in fact, the sequence possibly extends well into the Miocene. Cookson and Dettmann (1959) reported from the Alberton West District the occurrence of *Gambierina edwardsii*.

The startling change in facies between bores in the Latrobe Valley, e.g. Rosedale No. 1 and those of the Gippsland Basin proper e.g. Wurruk Wurruk No. 1 over a distance of twenty miles is imediately apparent on Figure 7. Here the Baragwanath Anticline has evidently controlled the deposition of non-marine coal measures on the one hand and post Upper Eocene marine sediments on the other. A palynological examination of representative samples of the Latrobe Valley Coal Measures (*sensu lato*) collected by C.S. Gloe and M.A. George of the S.E.C., Victoria, clearly indicates that the coal measures extend in age at least into the Lower Miocene. Although the detailed palynology of this interesting group of sediments cannot be presented here, it is sufficient to note that all units above the Traralgon Group are younger than the *Aglaoreida barungensis* Zonule and therefore Lower Miocene or younger. This change is marked in particular by the appearance of *Cyatheacidites annulata*.

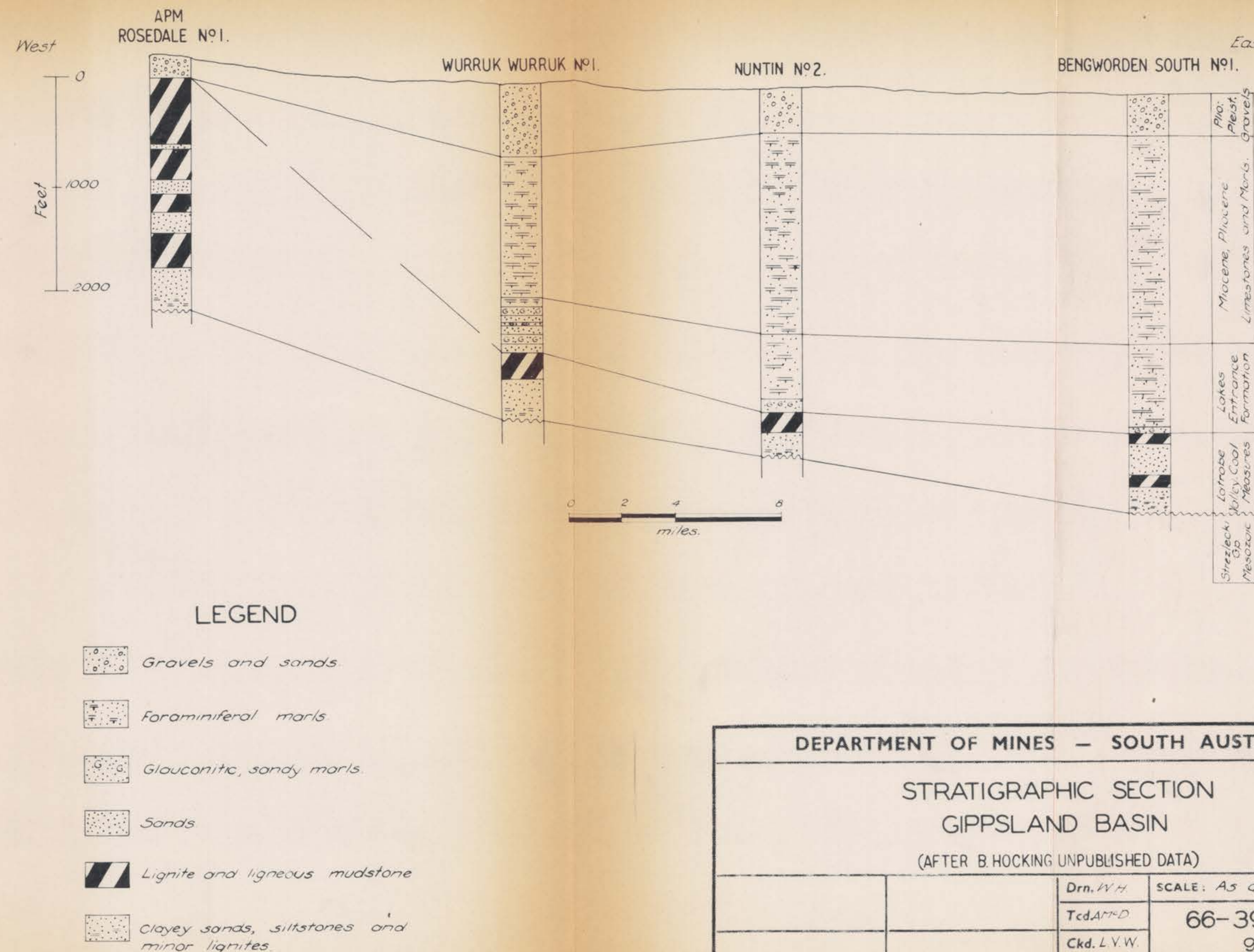


FIG: 7

DEPARTMENT OF MINES — SOUTH AUSTRALIA

STRATIGRAPHIC SECTION
GIPPSLAND BASIN

(AFTER B. HOCKING UNPUBLISHED DATA)

		Drn. W.H.	SCALE: As above.
		Tcd. A.McD.	66–394
		Ckd. L.V.W.	994·5
Director of Mines		Exd.	DATE: 6-6-66

The sediments of the Traralgon and Narracan Groups are, at least in the samples examined, of Eocene age and correlated with the *Triorites magnificus* and *Aglaoreida barungensis* Zonules. In particular *Triorites magnificus, Proteacidites clintonensis* and *P. pachypolus* occur together in the Traralgon No. 2 Seam (Tong Bore Bore 146 at 530 feet) and *Triorites magnificus* and *Aglaoreida barungensis* in the Traralgon No. 1 seam (Tong Bong Bore 150 at 280 feet, and Tong Bong Bore 147 at 130 feet).

In the Rosedale bore *C. annulata* is first recorded at 1278-1280 feet. Thus the sequence above this level is younger than the *Aglaoreida barungensis* Zonule.

The sedimentary sequence below about 1400 feet in this and the other three wells in the basin proper are of Eocene age and most probably Upper Eocene. Because of poor preservation in all of these wells a further refinement of this dating is not possible at this stage. No Paleocene sediments have been identified in the samples examined.

Thus from the evidence of *Gambierina edwardsii* with *Tricolpites gillii* and *Dacrydiumites balmei* (Cookson and Dettmann 1959) in the Alberton West district, the Latrobe Valley Coal Measures range in age from Paleocene (?Middle) to at least Lower Miocene. There is a probable hiatus between the Paleocene and Eocene sediments.

SYSTEMATIC PALYNOLOGY

Nomenclature and Classification

Considerable nomenclatural confusion exists in spore and pollen taxonomy since the application of palynology to the stratigraphy of Tertiary sediments. Three lines of approach have been used.

The first is the natural system whereby a fossil taxon receives the binomial or more simply the generic name of an extant taxon. Traverse (1955 and 1957) advocated that fossil taxa should, wherever possible, be placed in extant genera. This approach depends very heavily on the confidence that a particular author places on his identification. Except in a very few cases, most Lower Tertiary fossils cannot be related with any confidence to a particular genus and much less so to a species. There seems to be little justification for the identification of these on spore morphology alone. Misidentification and parallel or convergent evolution of these organs can lead to false interpretations. Thus a Linnaean generic or specific name on a fossil spore or pollen can give misleading information.

The second approach is based purely on the morphology of the fossils and they in turn receive form generic and specific binomials that do not necessarily indicate close natural relationships. Form genera, because they are based on morphological criteria, tend to be more or less artificial. Nevertheless they can in many instances indicate probable genetic relationships. The genera *Anacolosidites*, *Myrtaceidites* and *Beaupreaidites* illustrate this point. Thus an attempt can be made in many instances to confine the circumscription of new form genera to limits that could indicate possible phylogenetic relationships. It is not to be implied by this statement that extant generic and specific names should be used for fossil taxa. The contrary is true. Natural relationships if known can be indicated elsewhere other than in the binomial of the species.

The third approach is a "hybrid" between the first two. If a fossil taxon can be assigned to an extant genus it receives that generic name and a form specific name. This system is most confusing and should be avoided.

The nomenclature of spores and pollen described in this study is based on the rules of priority and typification as laid down in the International Code of Botanical Nomenclature.

All formally named species and genera described herein are form taxa.

The morphographical classification of Potonié (1956, 1958, 1960) for the sporal dispersal is adopted, together with the revised classification of "Sporites" by Dettmann (1963).

The botanical affinities are indicated where known. Only genera or species considered as new are fully described.

The species are depicted in Plates 1-12. They are referred to by the preparation and slide number followed by the "E-W" and "N-S" microscope vernier readings.

Glossary of Descriptive Terms

The morphological criteria and descriptive terms used in this section are those adopted by a number of workers--Erdtmann (1952, 1957, 1958), Harris (1955), Erdtman and Vishnu-Mittre (1958) with minor additions from the glossary of Dettmann 1963. The definitions have been extracted from the glossaries of these workers with little or no modification.

AMB: outline of a spore viewed with one of the poles exactly uppermost, i.e. with the polar axis directed straightly towards the observer.

APERTURE: any weak, preformed part of the general surface of a spore which may be engaged in forming an opening in connection with the normal exit of intra-exinous substance.

AURICULAE: radially situated extensions of the equitorial exine (or exoexine).

BACULA: endosexinous rods supporting any ectosexinous elements. Also isolated sexinous rods.

BROCHI: the meshes of a reticulum. A brochus consists of a lumen and the adjoining half of the muri which separate that particular lumen from other lumina.

CINGULUM: a comprehensive thickening of the equatorial exine (or exoexine).

COLPI: equatorial, usually longitudinal apertures (length: breadth > 2.

COLPORATE: with oriferous colpi.

CORONA: extensions of the equatorial exine (or exoexine) in the interradial regions. The extensions may be dissected and composed to fimbriate-like elements.

DISTAL FACE: that part of a spore surface which is directed outwards in its tetrad.

ECTOSEXINE: the upper (outer, distal) part of the sexine. To the ectosexine belong e.g. pila heads, tegilla, tecta (at least partially) etc.

ENDOSEXINE: the basal (lower, inner, proximal) part of the sexine (what remains if the upper part of the sexine, the ectosexine, is removed).

EQUATOR: the border line between the two faces (the proximal and the distal) of a polar spore.

EXINE: the main, outer, usually resistant layer of a sporoderm.

FORAMINA: (global (q.v.), ± circular apertures.

GLOBAL: said of apertures ± uniformly spread over the surface of a spore.

GRANULA: granules, often very small and ± rounded sexinous excrescences.

HETERPOLAR: in heteropolar spores the distal and proximal faces are ± distinctly different as regards apertures, etc.

INTERRADIAL CRASSITUDES: thickenings of the equatorial exine (or exoexine in the interradial regions.

INTERRADIAL REGION: the region that includes the proximal area adjacent to the tetrad mark and the corresponding distal area.

ISOPOLAR: in isopolar spores there are no differences between the proximal and the distal faces.

LAESURA: the proximal aperture of trilete and monolete spores. Trilete spores possess three laesurae which radiate from the proximal pole, and monolete spores possess one laesura which has its centre at the proximal pole.

LIPS: thickening and/or upturned extensions of the exine (or exoexine) about the laesurate margins.

LO; LO-PATTERN: any pattern which at high adjustment of the microscope appears as 'bright islands' separated by 'dark channels' and on lower adjustment presents the reverse picture, viz. 'dark islands' separated by 'bright channels'.

LUMINA: the spaces between the muri of a reticulum.

MURI: ridges separating the lumina of an ordinary reticulum.

NEXINE: the inner, non-sculptured part of the exine.

OBLATE: distinctly flattened. This term is used exclusively in descriptions of radiosymmetric, isopolar spores where the ratio between polar axis and equatorial diameter is 0.75-0.50.

OBLATE SPHEROIDAL: this term is used excluisvely in descriptions of radiosymmetric, isopolar spores, where the ratio between polar axis and equatorial diameter is 1.00-0.88.

OPERCULUM: a thickening of measureable bulk and clearly defined of an aperture membrane (± circular in pori, elongate in colpi, etc.).

OS: the inner part of a composite aperture.

PERINE: the outermost, extra-exinous sporoderm layer in some spores.

PEROBLATE: very flattened. The term is used exclusively in describing radiosymmetric, isopolar spores where the ratio between polar axis and equatorial diameter is < 0.50.

PERPROLATE: this term denotes exclusively the shape of radiosymmetric, isopolar spores where the ratio between polar axis and equatorial diameter is > 2.

PILA: sculptural elements consisting of a ± swollen apex (caput) and a rod-like neck (collum).

POLAR AXIS: a perpendicular line connecting the poles of a spore.

POLE: polar spores have two poles, one (the proximal) directed towards the centre of the tetrad, the other (the distal) facing in the opposite direction.

PORI: equatorial, ± isodiametric apertures. The limit between porus and colpus is defined by the length-breadth ratio of 2:1.

PROLATE: this term denotes exclusively the shape of radiosymmetric, isopolar spores where the ratio between polar axis and equatorial diameter is 2--1.33.

PROLATE SPHEROIDAL: this term denotes exclusively the shape of radiosymmetric, isopolar spores where the ratio between polar axis and equatorial diameter is 1.14--1.00.

PROXIMAL FACE: that part of a spore surface which is directed inwards in its tetrad.

PSILATE: smooth, without adornments.

PUNCTITEGILLATE: with a tegillum with minute perforations (puncta).

RADIOSYMMETRIC(AL): radiosymmetric spores have more than two vertical planes of symmetry, or, if provided with two such planes, always with equilong axes.

RETICULUM: sculptural pattern consisting of brochi (i.e., of muri separated by lumina).

RUGAE: global, ± regularly arranged apertures with length-breadth ratio > 2:1.

RUGULAE: elevations which are elongated and irregular in basal outline (maximum basal diameter at least twice minimum basal diameter); sides parallel, converging, or diverging; crests flat, rounded, or pointed.

SACCUS: airsac (sexine loosened from nexine; bacula or ± baculoid elements usually sticking to the under surface of the tegillum).

SEXINE: the outer, sculptured part of the exine.

SPHEROIDAL: in spheroidal spores the ratio between polar axis and equatorial diameter is 0.88-1.14.

SPINES: long, conspicuous, and generally sharp, pointed excrescences; length exceeding 3 μ.

SPINULES: small spines, not exceeding about 3μ in length.

SPORODERM: the wall of a spore.

STRIAE: narrow grooves (± parallel; length at least twice the breadth), separated by ridges (lirae).

SUBISOPOLAR: in subisopolar spores there are certain, ± slight differences between the distal and the proximal face (one may, e.g., be very convex, the other less convex, plane, or even concave). If there are other differences, e.g. in number and arrangement of apertures, the spores are heteropolar.

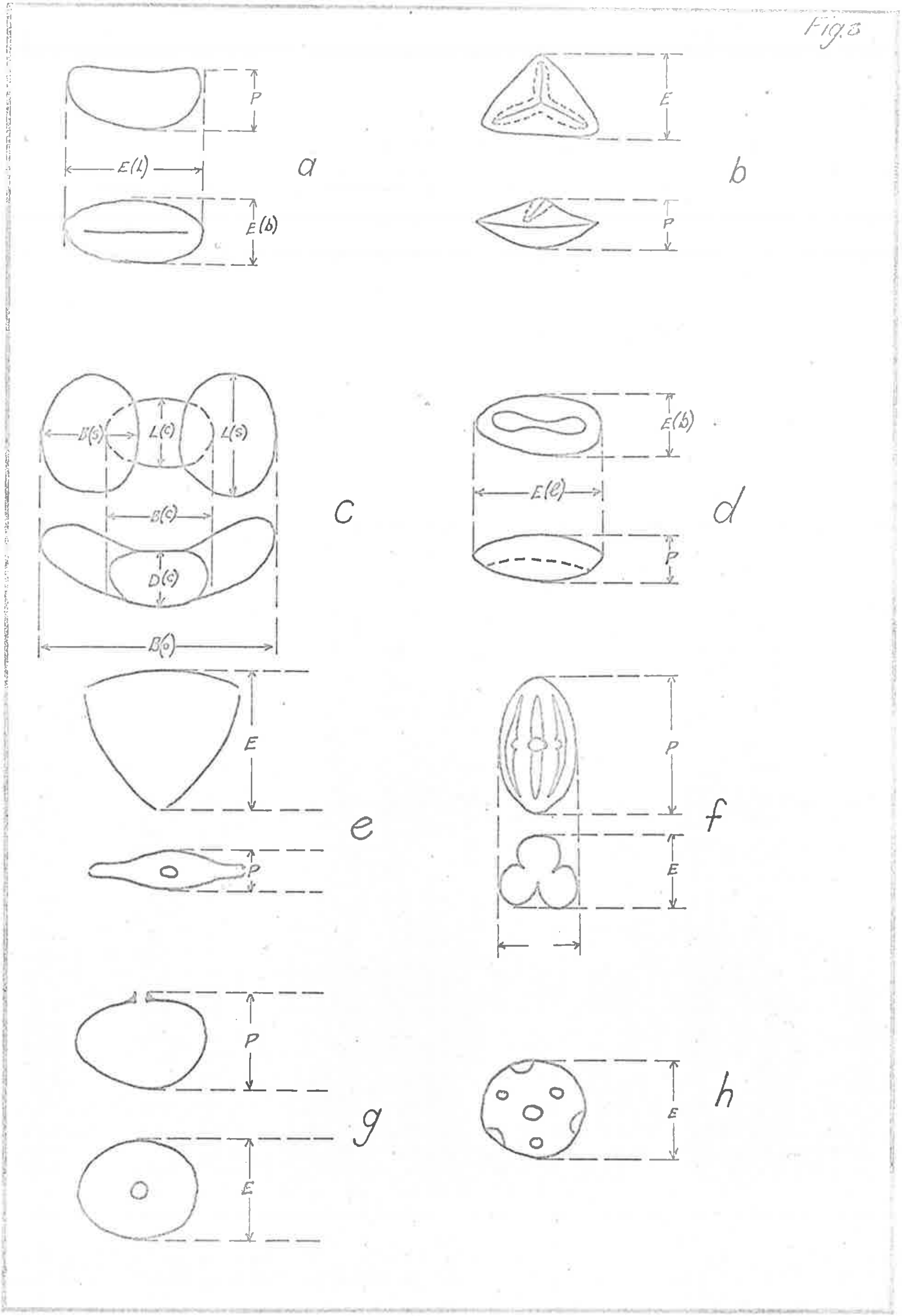


Fig. 8
P
E(l)
E(b)
a
E
P
b
B(s)
L(c)
L(s)
B(c)
D(c)
B(o)
c
E(b)
E(l)
P
d
E
P
e
P
E
f
P
E
g
E
h

SUBOBLATE: term used exclusively in describing radiosymmetric, isopolar spores with the ratio polar axis: equatorial diameter 0.75-0.80.

SULCUS: aperture in the distal face of a spore (and usually with the distal pole in its centre) with the ratio length: breadth > 2.

SYNCOLPATE: with colpi anastomosing at the poles.

TEGILLUM: an ectosexinous, ± homogeneous layer usually distinctly separated from the nexine by a baculate zone (endosexine).

TETRADS: spores united in fours.

ULCUS: a single, ± pore-like aperture, usually situated at the distal pole or ± near it.

VALVAE: thickenings of the equatorial exine (or exoexine) in the radial regions.

VERRUCAE: wartlike sculptinous projections (basal diameter as a rule longer than any other tangential diameter).

ZONA: a comprehensive extension of the equatorial exine (or exoexine).

The bracketed figure given in the description of the species is the mode of the dimension. Measurements unless otherwise specified are based on at least fifteen specimens.

Figure 8 - Showing dimensions measured on spores and pollen

a. Monolete spore

E(l) - equatorial length

E(b) - equatorial breadth

P - polar diameter

b. Trilete spore

E - equatorial diameter

P - polar diameter

c. bisaccate pollen

L(c) - corpus length

B(c) - corpus breadth

D(c) - corpus depth

B(s) - saccus breadth

L (s)- saccus length

B(o) - overall length

d. Monosulcate pollen

E(b) - equatorial breadth

E(l) - equatorial length

P - polar diameter

e. Triporate pollen

E - equatorial diameter

P - polar diameter

f. tricolporate pollen

P - polar diameter

E - equatorial diameter

g. Monorporate pollen

E - equatorial diameter

P - polar diameter

h. Periporate pollen

E - equatorial diameter

Anteturma	SPORITES
Turma	TRILETES
Suprasubturma	ACAVATITRILETES
Subturma	AZONOTRILETES
Infraturma	LAEVIGATI
Genus	CYATHIDITES Couper, 1953

Cyathidites gigantis (Cookson) Harris

(Plate 2, figure 16)

1953 *Triletes gigantis* Cookson, p. 466, PI. 1, figs. 8,9.

Remarks : This species is not common in the samples studied and is restricted to Paleocene sediments. It differs from *Cyathidites splendens* in the smaller size, the thicker exine and the prominently thickened angles, and coarser nature of the sculpture. It is doubtful whether this species should be included in this genus. The laesurae reach the equator or nearly so. The natural affinities of the species are unknown.

Cyathidites splendens Harris

(Plate 2, figures 12,13,15)

Description: Microspores trilete, elliptical to biconvex in lateral view; amb triangular with straight to concavely angular sides with broadly rounded angles. Laesurae straight, length 3/4 spore radius; in compressed specimens laesurae accompanied by wide "lips" (7-10μ wide) which narrow at the equatorial extremities. Exine 3-4μ thick, psilate to undulating with a distinct OL pattern in surface view.

Dimensions: Equatorial diameter 88 (96) 103*u* (10 specimens)

Holotype: Preparation S209; Py 156, 35.8 : 106.2 Pl. 2, fig. 13.

Type locality: Dilwyn Bay, Pebble Point Formation

Comparison and affinity: *Cyathidites splendens* is readily distinguished from *Cyathidites punctatus* (Delcourt & Sprumont) by its larger size and thicker exine. Spores of similar morphology occur in Lygodium Swartz.

Distribution: The species is distinctive but not common. It does not occur in sediments younger than Paleocene.

Genus TODISPORITES Couper 1958

Todisporites gambierensis Harris sp. nov.

(Plate 1, figure 21)

Diagnosis: Microspores trilete more or less circular in lateral view; amb circular; laesurae straight, almost reaching to the equator, with narrow (1-2μ wide), prominent elevated lips (2μ high). Exine 1-2μ thick, psilate, often much folded.

Dimensions: Equatorial diameter 48 (50) 57 μ.

Holotype: Preparation S716, slide S716/1 25.2 : 109.4. Py 375. Pl. 1, fig. 21.

Type locality: Cannuwaukaninna Bore at 176 feet. Paleocene, Murpeowie Formation.

Comparison and affinity: *T. gambierensis* differs from both *T. major* Couper and *T. minor* Couper by the nature of the upturned lips. Its dimensions are smaller than that of *T. major.* Couper (1958) provisionally places the genus in the family Osmundaceae.

Distribution: The species is often very common in Paleocene sediments, particularly in the Gambier Embayment (e.g. McEwens Settlement Bore).

Todisporites brevilaesuratus Harris sp. nov.

(Plate 2, figure 19)

Diagnosis: Microspores trilete, biconvex to elliptical in lateral view; amb circular; l-esurae simple straight < 2/3 the radial diameter. Exine 2-2.5μ thick, psilate.

Dimensions: Equatorial diameter 45 (52) 60μ.

Holotype: Preparation S298. Slide S298/1, 23.7 : 98.4. Py 376 Pl. 2, fig. 19.

Type locality: Canopus Bore 742-749 feet. Renmark Formation, Middle-Upper Eocene.

Comparison and Affinity: This species is distinct from *T. gambierensis* in the shorter laesurae, thicker exine and general shape of the spore. The length of the laesurae separate it from *T. minor* Couper.

Genus DICTYOPHYLLIDITES Couper emend. Dettmann 1963

Dictyophyllidites concavus Harris

(Plate 2, Figure 2)

Description: Microspores trilete, biconvex; amb triangular with straight sides and rounded angles. Laesurae straight extending almost to amb; enclosed with low membranous lips and bordered by a convex thickening of the exine, 5-7μ wide, exine 1.5-2μ thick, psilate.

Dimensions: Equatorial diameter 28 (35) 42μ (10 specimens)

Holotype: Preparation S209 Py 017 39.5 : 103.8 Pl. 1 fig. 19 of Harris (1965a).

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinities: *Dictyophyllidites concavus* is closely comparable with *Toroisporis (Toroisporis) pessinensis* Krutzsch (1962) but differs from this species in the nature of the slightly raised laesurae.

The species differs from *D. harrisii* in being smaller. Couper (1958) relates the genus to spores of the Jurassic fern *Dictyophyllum*.

Distribution: Spores of this type are widely distributed in European Tertiary sediments (Krutzsch 1959). They occur rarely in basal Tertiary sediments of southern Australia.

Dictyophyllidites rotundus Harris sp. nov.

(Plate 2, figure 3)

Diagnosis: Microspores trilete, biconvex; amb rounded triangular. Laesurae straight with slightly raised lips, length almost equal to spore radius and bordered by a slight convex thickening 7-10μ wide. Exine 1.5-2μ thick, slightly thicker at the angles.

Dimensions: Equatorial diameter 49 (55) 60μ.

Holotype: Preparation S726, Slide S726/1 20.2 : 108.9, Py 377, Pl. 2 fig. 3.

Type Locality: Cooks Plains Bore 126-158 feet, Buccleuch Beds.

Remarks: This species differs from *D. concavus* in its larger size and shape.

Distribution: It occurs commonly in Upper Eocene and younger sediments.

Infraturma APICULATI

Genus CERATOSPORITES Cookson & Dettmann 1958

?*Ceratosporites fimbriomarginatus* Harris sp. nov.

(Plate 3, figures 9, 11)

Diagnosis: Microspores trilete, tetrahedral; distal surface strongly convex, proximal surface pyramidal. Amb circular to convexly sub-triangular. Laesurae straight, extending almost to the amb and with membranous elevated lips 1.5-3μ high. Exine 1.5-2μ thick, finely sabrate. Distal surface sculptured with slender setulate elements 5-6μ apart, 3-4μ high with bases c.1μ wide. Proximal surface scabrate and margins of the lips ornamented with one row of spinulate elements which occasionally fuse to form a "fimbriate" margin to the lips.

Dimensions: Equatorial diameter 38 (40) 45μ.

Holotype: Slide ST502/8, Py 277, 39.3 : 99.7

Type locality: Comaum Bore 1A at 374 feet, Bahgallah Formation equivalent, Paleocene.

Distribution: Appears to be typically a Paleocene form.

Remarks: Because of the unusual sculpturing features of the proximal surface, it is doubtful whether this species and the following should be placed in the genus *Ceratosporites* which is characterised by having an unornamented proximal surface.

The natural affinities of the species are unknown.

?*Ceratosporites striatomarginatus* Harris sp. nov.

(Plate 3, figure 10)

Diagnosis: Microspores trilete, tetrahedral; distal surface strongly convex, proximal surface pyramidal. Amb convexly sub-triangular. Laesurae straight, extending almost to the amb and with membranous elevated lips 1.5-3μ high. Exine 1.5-2μ thick, psilate to finely scabrate. Distal surface sculptured with slender spinulate and setulate elements 3-4μ apart, 2-3μ high with bases 1-2μ wide. Proximal surface smooth to scabrate except around the interradial regions bordering the lips. Sculpture here is of spinules 3-5μ long and lying with their long axes parallel to the proximal surface giving a "striated" effect.

Dimensions: Equatorial diameter 35 (37) 42μ.

Holotype: Sample S21, Slide S21/1, 102.1 : 47.3 Py. 378

Type locality: Lake Eyre Bore 20, 156 feet. Murnpeowie Formation equivalent.

Distribution: an uncommon form found occasionally in Eocene sediments.

Genus VERRUCOSISPORITES (Ibrahim) Potonié & Kremp 1954

Verrucosisporites kopukuensis (Couper) comb. nov.

(Plate 3, figures 15, 16)

Synonomy: 1960 *Trilites kopukuensis* Couper p. 42, Pl. 3 figs. 1, 2.

Remarks: The Australian forms of this species agree very well with description and figures of the type. Characteristically the specimens are much folded and fractured. Couper gives a Bortonian to Runangan (Upper Eocene) range. In southern Australia the species ranges from the *Proteacidites confragosus* Zonule into the Lower Miocene.

Infraturma MURORNATI

Genus LATROBOSPORITES Harris

Type species: *Latrobosporites crassus* Harris, Princetown Victoria.

Diagnosis: Microspores trilete; spheroidal; laesurae simple narrow lips; exine thick and usually very dense; proximal and distal sculptural elements similar, consisting of rugulae.

Latrobosporites crassus Harris

(Plate 2, figure 1)

Description: Microspores large spheroidal trilete; amb circular or nearly so. Laesurae straight, length 2/3 spore radius, bordered by narrow straight lips. Exine 2.5μ thick. Distal and proximal ornamentation consisting of low interlocking rugulae approximately 7.5μ long and 1-2μ wide. Intervening lumina of similar size and shape.

Dimensions: 58 (80.7) 100μ (10 specimens).

Holotype: Preparation S217 Py 058 37.1 : 103.0 Pl. 2 Fig. 8 of Harris (1965a)

Type locality: Princetown Member of the Dilwyn Clay, Princetown.

Genus TRIPLANOSPORITES Pflug 1952

Triplanosporites pseudoreticulatus Harris

(Plate 2, figure 4)

Description: Microspores trilete, very strongly biconvex to elliptical in lateral view. Equatorial region strongly concave. Polar diameter more than twice equatorial diameter. Laesurae straight with prominently raised lips. Exine 2-2.5μ thick reticulate to pseudoreticulate, lumina 2μ wide, mesh 2-3μ wide. The species has not been observed in proximal aspect.

Dimensions: (6 specimens) Polar diameter 55 (62) 68μ.

Holotype: Preparation S209; Py 029 38.4 : 104.0 Pl. 2 fig. 7 of Harris (1965a)

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinity: The species differs from *T. tertiarius* Pflug 1953, having prominently raised lips and a coarser sculpture. Natural affinities unknown.

Distribution: An infrequent species throughout the sequence at Dilwyn Bay. Appears to be restricted to Paleocene sediments.

Genus RUGULATISPORITES Pflug 1953

Rugulatisporites minor Harris sp. nov.

(Plate 3 figure 13,
Plate 14, figures 7, 17)

Diagnosis: Microspores trilete, biconvex; amb rounded triangular to sub-circular. Laesurae straight and simple reaching almost to amb. Exine 2μ thick, closely ragulate both proximally and distally. Elements closely spaced, more or less uniform in size, shape and distribution, 1-2μ high and 2-4μ long and sinuous. Lumina of similar shape but narrower. Elements flattened in optical section.

Dimensions: Equatorial diameter 32 (38) 49μ.

Holotype: Plate 4 fig. 7, Preparation S705, slide S705/1 18.5 : 96.8; Py 379.

Type locality: Poyntz Bore Hd. Ettrick at 310 feet, Buccleuch Beds.

Remarks: The species is a common component of the *Triorites magnificus* Zonule. Natural affinities are unknown.

Rugulatisporites rotundus Harris sp. nov.

(Plate 4 figure 15)

Description: Microspores trilete, biconvex; amb rounded triangular. Laesurae simple and straight, teaching to the amb. Exine 2-3μ thick, rugulate both proximally and distally. Elements flattened in optical section of varying shapes and sizes, 2-3μ high, 3-7μ long. Lumina sinuous 2-5μ wide.

Dimensions: Equatorial diameter 47 (52) 60μ.

Holotype: Plate 4 figure 15. Preparation S209, Slide S209/1, 47.6 : 113.8.

Type locality: Pebble Point Formation, Dilwyn Bay Victoria. Paleocene.

Comparison and distribution: This species is clearly separated from the preceding by its larger size and the shape and distribution of the sculptural elements.

Subturma ZONOTRILETES

Infraturma AURICULATI

Genus TRILITES Erdtman ex Couper emend. Dettmann 1963.

Trilites concavus Harris sp. nov.

(Plate 4, figures 11, 12, 13)

Diagnosis: Microspores trilete, tetrahedral, proximal surface convex, distal surface pyramidal. Polar diameter occasionally greater than equatorial. Laesurae straight reaching the amb, and with membranous elevated lips 1-2μ high. Exine 2-3μ thick and slightly thicker in the equatorial radial regions. Proximal surface smooth, distal surface and equatorial regions ornamented with verrucae and rugulae. Elements closely spaced and rounded, 3-4μ high and up to 6μ long. Valvae with slightly larger elements.

Dimensions: Equatorial diameter 35 (37) 45μ.

Holotype: Plate 4 figure 13, Preparation S705 Slide S705/1, 39.7 : 103.5.

Type locality: Poyntz Bore Hd. Ettrick at 310 feet, Buccleuch Beds.

Distribution and remarks: Commonly occurs in Buccleuch Beds and equivalents in the Murray Basin.

It is quite distinct from all other *Trilites* spp. Natural affinities are unknown.

Infraturma CINGULATI

Genus CINGUTRILETES Pierce emend. Dettmann 1963

Cingutriletes comaumensis Harris sp. nov.

(Plate 1 figure 24)

Diagnosis: Microspores trilete, biconvex, amb subcircular to rounded sub-triangular. Laesurae straight extending to amb of spore cavity and enclosed with low membranous lips. Exine 1-2μ thick, cingulate; cingulum 7-9μ wide and very faintly radially striated.

Dimensions: Equatorial diameter (including cingulum) 47 (53) 59μ.

Holotype: Plate 4 fig. 24. Preparation S502. Slide ST502/18, 33.4 : 102.9 Py. 286.

Type locality: Comaum Bore 1A at 374 feet. Bahgallah Formation equivalent, Paleocene.

Comparison and distribution: The species is common in the Comaum samples but rare in Paleocene sediments elsewhere. It differs from *C. clavus* (Balme) in its larger size and lack of distal ornament.

Genus KRAEUSELISPORITES Leschik emend. Jansonius 1962

Kraeuselisporites papillatus Harris

(Plate 4, figure 1)

Description: Microspores trilete, zonata, biconvex in lateral view; amb circular to sub-triangular. Spore body triangular with almost straight sides and rounded angles. Laesurae straight, length 3/4 of spore body radius. Exine, 1.5-2μ thick. Proximal surface scabrate, distal surface ornamental with granulae and verrucae. Zona scabrate to granulate, 3-5μ wide.

Dimensions: Equatorial diameter 26 (33) 39μ. (7 specimens)

Holotype: Preparation S209; Py 018, 40.2 : 100.7; Pl. 2 fig. 15 of Harris (1965a)

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinity: The species is distinct from those described by Cookson and Dettmann (1958) in having a smaller size and smaller sculptural elements.

The spores of the genus *Selaginella* Beauv. are comparable.

Distribution: The species occurs sporadically throughout the sequence at Dilwyn Bay and elsewhere in Paleocene sediments.

Genus POLYPODIACEOISPORITES Potonie 1951

Polypodiaceoisporites obscurus Harris

(Plate 2, figure 6)

Description: Microspore trilete cingulate biconvex; amb triangular with straight sides with rounded often irregular angles. Laesurae obscure, straight reaching to the inner margin of the cingulum. Exine 2μ thick, proximal surface granulate to psilate, distal surface irregularly thickened with rugulae. Cingulum 3-5μ wide, indistinct at the angles.

Dimensions: Equatorial diameter, 42 (45) 52μ (Five specimens)

Holotype: Preparation S218, Py 080 37.3 : 102.3; Pl. 3 fig. 5 of Harris (1965a)

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparison and affinity: The species is similar to those described by Krutzsch (1959a & b) but differs from these in the structure of the cingulum at the angles. The spores are similar to those found in the genus *Pteris* Linn (Harris 1955).

Distribution: The species is found only rarely in the Princetown Member. It has been noted in Eocene sediments in South Australia.

Infraturma TRICRASSATI

Genus CAMAROZONOSPORITES Pant ex Potonie

Camarozonosporites bullatus Harris

(Plate 3, figures 1, 2)

Description: Microspores trilete, zonate, biconvex, amb circular or nearly so. Spore body sub-triangular in polar view with straight to convex sides and rounded angles. Laesurae straight with slightly raised lips (1-2μ), length 3/4 of spore body radius. Exine 2-3μ thick, sub-scabrate to psilate.

Dimensions: Equatorial diameter 47 (51) 60μ (six specimens).

Holotype: Preparation S208; Py 006 40.5 : 101.5; Pl. 3 fig. 3.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparisons and Affinity: The species is similar to *C. semilevis* Krutzsch but is larger and has a wider zone. It has affinities with the genus *Lycopodium* Linn.

Distribution: The species is found sporadically in the lower portion of the sequence at Dilwyn Bay. It is common in Comaum Bore. Dettmann & Playford (1968) record the species from the Upper Cretaceous. It does not occur in sediments younger than Paleocene.

Camarozonosporites sherlockensis Harris sp. nov.

(Plate 3, figures 4, 5;
Plate 4, figures 20, 21, 22)

Diagnosis: Microspores trilete, biconvex; amb convexly triangular. Laesurae straight reaching almost to the amb, with slightly raised lips thickened 4-5μ wide. Exine 4-5μ thick, tricrassate at the equator; crassitudes 7-12μ wide in interradial regions narrowing to 3-4μ at the radii. Distal exine covered with low anastomosing muri (2-3μ wide) forming a reticulum, lumina 3-10μ in diameter; muri on proximal surface lower and wider and do not anastomose to form a reticulum.

Dimensions: Equatorial diameter 58 (68) 75μ.

Holotype: Plate 4, fig. 21. Preparation and slide number ST161/2; 36.4 : 107.1. Py 144.

Type locality: Geltwood Beach No. 1 Well, core 1 at 2000 feet. Paleocene.

Remarks and comparison: The species is quite distinct from *C. bullatus*, *C. amplus* (Stanley) and *C. ohaiensis* (Couper). It shows some similarity to *C. helenensis* Krutzsch, but has much longer laesurae.

Affinity: *Lycopodium* spores (Harris 1955) display similar sculptural and equatorial features.

Distribution: The species ranges from the Paleocene through to the middle to upper Eocene.

Camarozonosporites paleocenicus Harris sp. nov.

(Plate 3 figures 6, 7)

Diagnosis: Microspores trilete, biconvex; amb sub-circular to rounded sub-triangular. Laesurae straight, length 1/2 - 2/3 spore radius. Exine 2-3μ thick, thicker in interradial regions where crassitudes 3-5μ wide are developed. Distal and equatorial sculpture consisting of low (c. 1μ high) sinuous rugulae 3-7μ in length and 1-3μ wide, enclosing lumina of similar dimensions. Proximal sculpture smooth to faintly scabrate.

Dimensions: Equatorial diameter 31 (35) 40μ.

Holotype: Plate 3 fig. 7. Preparation and sample number S751/2, 35.2 : 100.4; Py 385.

Type locality: Cook 1A bore (Eucla Basin) 362 feet. Pidinga Formation. Eocene.

Comparison: This species is very similar to *C. heskemensis* Krutzsch and it may be conspecific.

Affinity: The spores of *Lycopodium cernuum* L. are comparable.

Distribution: The species occurs sporadically in Paleocene and Eocene sediments.

Camarozonosporites buccleuchensis Harris sp. nov.

(Plate 3, figure 8)

Diagnosis: Microspores trilete, biconvex, amb sub-circular. Laesurae straight, length 1/2 spore radius. Exine 2-3μ thick, thicker in interradial regions where crassitudes 3-4μ wide are developed. Distal and equatorial sculpture consisting of low (c. 1μ high) sinuous rugulae 2-4μ in length and 1-2μ wide, enclosing lumina of similar dimensions. Proximal sculpture smooth to faintly scabrate.

Dimensions: Equatorial diameter 30 (34) 39μ.

Holotype: Preparation and slide number S730/1; 36.9 : 98.7, Py 386.

Type locality: Cold & Wet Bore 350-360 feet. Buccleuch Beds. Eocene.

Comparison and affinity: This species is quite similar to *C. paleocenicus* but is distinguished by the smaller ornament. The spores of the *Lycopodium cernuum* Morphotype (Krutzsch 1963) are comparable.

Distribution: Common in middle to upper Eocene sediments, particularly in the *Triorites magnificus* Zonule.

Turma MONOLETES

Suprasubturma ACAVATOMONOLETES

Subturma AZONOMONOLETES

Infraturma SCULPTATOMONOLETI

Genus VERRUCATOSPORITES Thomson & Pflug 1953

Verrucatosporites speciosus Harris

(Plate 1, figures 8-10)

Description: Spores free; anisopolar, bilateral monolete; laesura two lipped about 2/3 the length of the greater equatorial axis; shape elliptical in polar view, approximately plano-convex in lateral view. Exine 2-3μ thick, verrucate; verrucae 2-7μ wide at base, 1.5-2μ high.

Dimensions: (15 specimens) Equatorial diameter; length 35 (47) 50μ, breadth 20 (26) 32μ.

Holotype: Preparation S217; Py 066, 40.0 : 103.5; Pl. 1 fig. 8.

Type locality: Princetown Member of the Dilwyn Clay, Princetown.

Comparisons and affinity: The species differs from *Polypodiidites perverrucatus* Couper in the more even distribution of the sculptural elements. The species has affinities with the genus *Microsorium* Link.

Distribution: The species is of common occurrence in the sediments studied and in the lower Tertiary of southern Australia.

Verrucatosporites confragosus Harris sp. nov.

(Plate 1, figures 4, 6, 7)

Diagnosis: Microspores monolete, bilateral; plano-convex in full equatorial view; amb more or less elliptical. Laesura straight, simple, length 2/3 that of the major amb axis. Exine 2-3μ thick, with low verrucae evenly distributed and more or less equidimensional, 3-5μ in diameter. Lumina narrow 1-1.5μ wide.

Dimensions: Equatorial diameter 54 (60) 68μ, polar length 38 (45) 50μ.

Holotype: Plate 1 fig. 4. Preparation and slide number S298/1 16.7 : 108.2. Py 380.

Type locality: Canopus Bore at 742-749 feet. Renmark Formation. Eocene.

Comparison and affinity: It is distinguished from *V. speciosus* Harris by the shape and size of the sculpture and the greater ratio between the length of the laesura and the longer equatorial diameter. The species has affinities with spores of the genus *Microsorium* Link.

Distribution: A common species in the middle to upper Eocene.

Verrucatosporites tuberosus Harris sp. nov.

(Plate 1, figure 11)

Diagnosis: Monolete spores, bilateral; concavo-convex in full equatorial view; amb sub-elliptical. Laesura straight < 1/2 length of the longer equatorial axis. Exine 2-2.5μ thick with few large rounded verrucae 3-6μ high and 2-4μ in base diameter.

Dimensions: Equatorial diameter: length 38 (40) 43μ, polar length 20 (25) 29μ.

Holotype: Plate 1, fig. 11. Preparation and slide number S310/1 20.4 : 92.2, Py 381.

Type locality: Hd. Carcuma Bore 405-410 feet. Buccleuch Beds, middle - upper Eocene.

Comparison and affinity: This species is clearly distinguished from other members of the genus by the few and large verrucae. It has possible affinities with spores of *Microsorium*.

Distribution: Sporadic in middle - upper Eocene and younger sediments.

Genus MICROFOVEOLATOSPORIS Krutzsch 1959

Microfoveolatosporis fromensis (Cookson) Harris

(Plate 1, figure 12)

Synonomy: 1956 *Schizaea fromensis* Cookson, p. 43 pl. 8, fig. 3.

Remarks: This species is very rare and is present in the Princetown Member. Cookson (1956) records the species from the Paleocene of the Great Artesian Basin.

The spores of the genus *Schizaea* Sm. are comparable.

Microfoveolatosporites albertonensis (Cookson) comb. nov.

(Plate 1, figure 13)

Synonomy: 1956 *Schizaea albertonensis* Cookson, p. 43 pl. 8, fig. 4.

Remarks: As with the former, this species is also rare and appears to be restricted to Paleocene sediments. The figured specimen is from the Renmark Beds (AOC North Renmark No. 1 Well 1761-1771 feet). Cookson (1956) suggests that this species is closely similar to *Schizaea pusilla* Pursh.

Microfoveolatosporis validus Harris sp. nov.

(Plate 1, figures 5, 14)

Diagnosis: Microspores monolete, bilateral; plano-convex in full equatorial view; amb more or less elliptical. Laesura straight, simple, length 3/5 that of the major equatorial axis. Exine 2-2.5μ thick, foveolate to foveo-reticulate; with circular and more or less regularly disposed foveolae, 1-2μ in diameter and 0.5-1μ deep.

Dimensions: Equatorial diameter; length 37 (40) 46μ, polar length 24 (27) 29μ.

Holotype: Plate 1 fig. 5. Preparation and slide number S710/1, 27.6 : 204.4, Py 382.

Type locality: Cannuwaukaninna Bore at 127 feet, Murnpeowie Formation equivalent, Paleocene.

Comparison and affinity: The size of the species and distribution of the foveolae separate it from *M. albertonensis* and *M. fromensis*. It closely resembles *M. canaliculatus* Dettmann but is distinctly larger and has a different distribution of foveolae. The species is similar to deviating spores of *Schizaea pectinata* (Selling 1944).

Distribution: An uncommon species in the lower Tertiary sediments.

Supra subturma PERINOMONOLITES

Genus PEROMONOLITES (Erdtman 1947) ex Couper 1953

Peromonolites densus Harris

(Plate 1, figure 17)

Description: Spores free; anisopolar, bilateral, monolete; laesura extending just over 1/2 the length of the greater equatorial axis; shape elliptical in polar view, biconvex in lateral view; exine 1.5-2μ thick sub-verrucata to scabrate, surrounded by a dense hyaline perispore 2-5μ thick, regulate.

Dimensions: Equatorial diameter: (15 specimens) length 33 (40) 45μ, breadth 25 (30) 33μ, Polar diameter 34 (32) 33μ.

Holotype: Preparation S209; Py 046, 36.9 : 103.0; Pl. 1 fig. 5.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparisons and affinity: The species is similar to *P. bowenii* Couper, but differs from this species in the nature of the sculpture of the perine. It differs from *P. problematicus* Couper, in shape and sculptural elements.

Distribution: The species occurs commonly throughout the Paleocene.

Peromonolites concretus Harris sp. nov.

(Plate 1, figures 8, 18)

Diagnosis: Microspores bilateral, monolete, plano-convex in full equatorial view; amb more or less elliptical. Laesura straight, simple, length 2/3 that of the major amb axis. Exine 1.5-2μ thick unsculptured, surrounded by a dense spongy perine 2-3μ thick.

Dimensions: Equatorial diameter: length 48 (53) 57μ, polar length 27 (30) 38μ.

Holotype: Plate 1, fig. 8. Preparation and slide number S716/1, 25.9 : 107.8. Py 383.

Type locality: Cannuwaukaninna Bore at 150 feet. Murnpeowie Formation equivalents. Paleocene.

Remarks: The closest affinity of this species is with *P. densus* Harris but is readily distinguished by the shape of the spore and the nature of the perine. The species is uncommon in Paleocene and Eocene sediments. The natural affinities of the species are unknown.

Peromonolites vellatus Harris sp. nov.

(Plate 1 figure 15)

Diagnosis: Microspores monolete bilateral, biconvex in full equatorial view; amb elliptical. Laesura straight, simple, length 2/3 that of the major amb axis. Exine 1.5-2μ thick finely scabrate, surrounded by a thin hilate perispore (c. 1μ thick) with a scabrate sculpture.

Holotype: Preparation and sample number S727/1, 26.4 : 100.9, Py 384.

Dimensions: Equatorial diameter 35 (38) 47μ, polar diameter 10 (13) 15μ.

Type locality: Cooks Plains Bore 168-214 feet. Buccleuch Beds. Eocene.

Remarks: The nature of the hilate perine makes this a distinctive spore. It is reminiscent of spores of the genus *Blechnum*. The species is uncommon and is present in Eocene and younger sediments.

Anteturma POLLENITES

Turma SACCITES

Subturma DISACCITES

Genus PODOCARPIDITES Cookson ex Couper 1953

Podocarpidites exiguus Harris

(Plate 5, figure 19)

Description: Pollen free, anisopolar, bisaccate, bilateral. Body of grain sub-circular to elliptical in polar view. Proximal cap psilate to finely scabrate exine 1-1.5μ thick, sulcus broad well defined, psilate. Bladders large, strongly inclined distally, breadth greater than the depth of the corpus, reticulum wide, indistinct and incomplete.

Dimensions: (7 specimens) Depth of body 18 (22) 25μ; total breadth 42 (45) 48μ; breadth of body 26 (28) 32μ; breadth of sacci 24 (25) 28μ.

Holotype: Preparation S209; Py 154 28.2 : 105.9; Pl. 3 fig. 12.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparisons and affinity: The species is similar to *P. marwickii* Couper, but is much smaller. The nature of the reticulum of the sacci is distinct from *P. ellipticus* Cookson, and *P. similis* Balme. Similar pollens are found in the genera *Podocarpus* L'Herit and *Dacrydium* Soland.

Distribution: Appears to be confined to Paleocene sediments.

Podocarpidites magnificus Harris sp. nov.

(Plate 5, figure 10)

Diagnosis: Bisaccate pollen, anisopolar, bilateral. Body of grain sub-circular in polar view. Proximal cap finely punctate with a distinct OL pattern. Exine 1-2.5μ thick. Bladders large, attached distally. Bladder length greater than body length. Body breadth a little greater than bladder breadth. Attachment zone 3-7μ wide. Sculpture of bladders reticulate and complete. Lumina 3-7μ wide.

Dimensions: (5 specimens) Overall breadth 82 (85) 87μ; Saccus breadth 35 (38) 40μ, length 47 (50) 51μ; Body length 45 (47) 48μ.

Holotype: Preparation and sample number ST547/13, 35.1 : 103.7, Py 323.

Type locality: Lake Cootabarlow Bore at 536 feet. Murnpeowie Formation equivalents. U. Eocene.

Comparison and affinity: Because of its large size and strongly reticulate bladders, this species cannot be confused with any other in the genus. It is clearly related to the genus *Podocarpus*.

Distribution: A rare form in middle - upper Eocene assemblages.

Genus PHYLLOCLADIDITES Cookson ex Couper

Remarks: Cookson (1947) proposed the sporotype genus *Phyllocladidites* later erected to generic level by Couper (1953) for form species which resembled pollen of the genus *Phyllocladus*. Later (1953) Cookson transferred forms assigned to *Phyllocladites* to *Dacrydriumites* because of their closer similarity to pollen of *Dacrydium franklinii*. There was no type selected for the genus *Dacrydiumites*.

Under Article 62 of the International Code of Botanical Nomenclature this procedure is illegitimate. A legitimate name must not be rejected because it is inappropriate. The genus *Phyllocladidites* is here retained.

Phyllocladidites verrucosus (Cookson) comb. nov.

(Plate 5, figure 8; Plate 6, figure 3)

Synonomy: 1965 *Phyllocladites mawsonii* Cookson; Harris 1965a p. 86, Pl. 26 fig. 15.

Remarks: The very prominent sculpture consisting of verrucae on the proximal surface separates this species from all others in the genus. It is confined apparently to Paleocene sediments.

Phyllocladidites reticulosaccatus Harris

(Plate 6, figure 2)

Description: Pollen free, bisaccate, anispolar, bilateral. Body of grain sub-circular in polar view. Proximal cap psilate. Exine 3-5μ thick. Bladders small, usually infolded onto the sulcus, finely but distinctly reticulate with a prominent basal tubercle at the proximal root of each bladder.

Dimensions: (7 specimens unexpanded) Body breadth 37 (40) 45μ, body depth 42 (45) 50μ; Sacci breadth 22 (28) 30μ.

Holotype: Preparation S209; Py 038 42.4 : 101.5; Pl. 3 fig. 16.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparisons: The species is very similar to *P. mawsonii* Cookson but differs in the thicker exine and the dense reticulum of the sacci. It is similar to the pollen of *Dacrydium franklinii*.

Distribution: The species occurs sporadically throughout the section.

Genus DACRYDIUMITES Cookson ex Harris 1965

Type Species designated: *Dacrydiumites florinii* Cookson & Pike.

Diagnosis: Pollen bisaccate occasionally trisaccate. Sacci free or united around the region of the sulcus. Venation of sacci prominently radial, becoming reticulate near the periphery.

Remarks: Cookson (1953) as noted previously recommended referring pollens of the *Dacrydium franklinii* type to the genus *Dacrydiumites*. Later Cookson and Pike (1953) and Cookson (1957) described two new species as belonging to this genus. Fossil pollen grains of the *Dacrydium franklinii* type are not included in this genus, and are morphologically distinct from those of *Dacrydiumites* here diagnosed.

Dacrydiumites ellipticus Harris

(Plate 5, figure 15)

Description: Pollen free, anisopolar, bilateral, bisaccate. Body of grain spherical, circular in polar view. Proximal cap granulate to psilate. Sulcus, indistinct without a rim, with scattered granulae. Exine 1.5-2μ thick. Bladders more or less confluent, projecting more than half the body diameter from the body, with coarse radially arranged thickenings becoming reticulate near the periphery.

Dimensions: (15 specimens) Polar diameter of body 17 (21) 30μ. Overall breadth 38 (43) 50μ, depth 29 (32) 45μ.

Holotypes: Preparation S209; Py 037 37.7 : 103.5, Pl. 3 fig. 20.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparisons and affinity: In general morphology this species is similar to *D. balmei* but is readily distinguished by its smaller size. It is distinguished from *D. florinii* by the smaller body size and the extent of the bladders.

Distribution: The species appears to be restricted to the Pebble Point Formation and the lower portion of the Dilwyn Clay.

Genus ALISPORITES Daugherty 1941

Alisporites varius Harris sp. nov.

(Plate 5, figures 4, 6, 7, 12)

Description: Pollen, bisaccate, an isopolar bilateral. Body of grain more or less circular in polar view. Exine 1.5-2μ thick, proximal cap faintly scabrate, sulcus psilate. Bladders attached distally and distinctly smaller than body and a little longer than broad. Bladders distinctly and evenly reticulate, lumina 2-3μ in diameter.

Dimensions: Overall breadth 28 (43) 56μ, body length 22 (28) 42μ, breadth 21 (26) 36μ, saccus length 18 (23) 28μ, breadth 12 (15) 22μ.

Holotype: Plate 5 figure 4. Preparation and slide number S705/1, 38.6 : 100.2. Py 324.

Type locality: Poyntz Bore at 310 feet. Buccleuch Beds; middle - upper Eocene.

Comparison and affinity: This species differs from *A. similis* (Balme) in the shape of the body and size and shape of the bladders relative to the body size. The reticulate ornament on the bladders is also distinct.

Distribution: Occasionally a very common form in middle-upper Eocene assemblages.

Subturma POLYSACCITES

Genus PODOSPORITES Rao 1943 emend.

Emended diagnosis: Rao's diagnosis is here emended to include pollen with 2-3 small sacci.

Podosporites microsaccatus (Couper) Dettmann

(Plate 6, figure 7, 8)

Selected Synonomy: 1953 *Dacrydium microsaccatum* Couper, p. 35; Pl. 4, fig. 38.

1954 *Trisaccites micropteris* Cookson & Pike, p. 64; Pl. 2, fig. 21-29.

1954 *Phyllocladus palaeogenicus* Cookson & Pike, p. 63; Pl. 2, figs. 1-6.

1963 *Podosporites microsaccatus* (Couper), Dettmann p. 104; Pl. 26, fig. 6,7.

1965 *Phyllocladidites palaeogenicus* (Cookson), Harris 1965a, p. 86; Pl. 26, fig. 19.

Remarks: Both the bi and tri saccate forms now regarded as the one species show identical characters so far as bladder shape and ornament, and body ornament are concerned. There seems little point therefore in separating the two forms on bladder numbers alone. However both Dettmann (1963) and Cookson and Pike (1954) have recorded only the trisaccate form from Lower Cretaceous sediments. The species ranges therefore from the Lower Cretaceous to the Miocene. Cookson and Pike related the species to the genus *Phyllocladus*.

Podosporites rotundus Harris sp. nov.

(Plate 6, figure 9)

Diagnosis: Pollen, bisaccate, free, anisopolar, bilateral. Body of grain more or less circular in polar view. Exine 1-2μ thick, proximal cup finely scabrate. Bladders very small, unornamented, attached distally and separated by a wide (20μ) tenuites. Bladder length smaller than body length.

Dimensions: Body length 20 (25) 28μ, overall diameter 19 (25) 30μ, saccus breadth 3-5μ.

Holotype: Preparation and slide number S546/1, 35.7 : 105.4; Py 325.

Type locality: Lake Cootabarlow Bore at 515 feet. Murnpeowie Formation equivalents. Upper Eocene.

Comparison and distribution: This species is readily distinguished from *P. microsaccatus* by the wide tenuites and the very small bladders which do not reach the length of the body. The affinities of the species are unknown. It is often a common component in Upper Eocene assemblages.

Turma ALETES

Subturma AZONALETES

Infraturma SUBPILONAPITI

Genus DILWYNITES Harris 1965

Diagnosis: Pollen nonaperturate, spheroidal. Exine sculpture consisting of verrucae, granulae or spinules.

Type species: *Dilwynites granulatus* Harris, new species.

Discussion: This genus is similar to *Araucariacites* but is readily distinguished by the thicker exine and the coarse and varied nature of the sculptural elements. Comparable pollen is found in many widely separated taxonomic genera, e.g. *Cinnamonum, Amborella, Callitris, Diselma* and *Neocallitropsis*.

Dilwynites granulatus Harris

(Plate 6, figure 10)

Description: Pollen non-aperturate, spherical, often folded. Exine 1.5 - 2.5μ thick, ornamented with granulae 0.5 - 1μ high.

Dimensions: Diameter 32 (36.5) 40μ (15 specimens).

Holotype: Preparation S209; Py 039, 38.3 : 103.7; Pl. 4 fig. 6.

Type locality: Dilwyn Bay, Pebble Point Formation.

Distribution: The species is very common throughout the sequence. Its frequency distribution pattern follows that of the angiosperms in the Princetown sequence.

Dilwynites tuberculatus Harris 1965

(Plate 6, figure 11)

Description: Pollen non-aperturate, spherical, often folded. Exine 2-2.5μ thick ornamented with verrucae and granulae up to 2μ high and 2-4μ apart. Area between verrucae, psilate to granulate.

Dimensions: (10 specimens) Diameter 35 (39) 45μ.

Holotype: Preparation S218; Py 099, 37.4 : 102.9; Pl. 4 fig. 9.

Type locality: Princetown; Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The species differs from *D. granulatus* in having a coarser and more irregular ornamentation.

Distribution: a consistently occurring form throughout the Paleocene.

Turma PLICATES

Subturma POLYPLICATES

Genus EQUISETOSPORITES Daugherty emend. Sing 1964

Equisetosporites notensis (Cookson) comb. nov.

(Plate 5, figure 14)

Synonomy: 1957 *Ephedra notensis* Cookson p. 45, Pl. 9 figs. 6-10.

1960 *Ephedra notensis* Anderson p. 17, Pl. 10 fig. 6.

Remarks: The species occurs occasionally in both Paleocene and Eocene sediments but is never common. Cookson (1957) records the species also from widely separated localities. Cookson compared the species with pollen of *Ephedra nana* Dusen.

Subturma MONOCOLPATES

Genus LILIACIDITES Couper 1953

Liliacidites varius Harris sp. nov.

(Plate 6, figure 15)

Diagnosis: Pollen, bilateral, monosulcate, amb elliptical. Sulcus extends the full length of the grain. Exine 1.5μ thick, sexine reticulate, lumina 1-1.5μ in diameter, becoming narrower towards the extremities of the sulcus.

Dimensions: Longest axis 26 (33) 38μ, breadth 16 (20) 25μ.

Holotype: Preparation and slide number S730/1, 30.4 : 102.1; Py 3.

Type locality: Cannuwaukaninna Bore at 150 feet, Murnpeowie Formation equivalents, middle - upper Eocene.

Comparison and remarks: This species differs from *L. variegatus* Couper in the pattern of the ornament. It is distinguished from *L. aviemorensis* McIntyre by not having as strong a sculptural pattern. The pollen of various members of the Liliaceae are comparable.

Distribution: A form commonly met with in Eocene and younger assemblages.

Genus RECTOSULCITES Anderson 1960

Rectosulcites microreticulatus Harris sp. nov.

(Plate 6, figures 12, 13, 23)

Diagnosis: Pollen bilateral, monosulcate, amb elliptical with rounded ends. Sulcus 2-3μ wide, reaches to within 2-3μ of the greatest equatorial length and slightly constricted in the middle. Exine 1.5-2μ thick, sculpture consisting of evenly disposed and very fine (< 0.5μ) punctae.

Dimensions: Longest diameter 31 (34) 40μ, breadth 20 (25) 27μ.

Holotype: Plate 6 fig. 12. Preparation and sample number S546/1, 14.5 : 109:6, Py 3.

Type locality: Lake Cootabarlow Bore at 515 feet. Murnpeowie Formation equivalent, Upper Eocene.

Comparison and affinity: This species differs from *R. latus* Anderson in the nature of the ornament. *R. latus* is psilate to finely scabrate. Natural affinities unknown.

Distribution: The species is rare in middle - upper Eocene sediments.

Subturma TRIPTYCHES

Genus TRICOLPITES (Erdtman) Couper 1953

Tricolpites renmarkensis Harris sp. nov.

(Plate 6, figures 34, 35)

Diagnosis: Pollen peroblate, radiosymmetric, tricolpate angulaperturate. Amb triangular, sides deeply concave. Colpi short (2.5-3μ). Exine 2-2.5μ thick, very finely and evenly scrobiculate.

Dimensions: Radial diameter 25 (28) 39μ.

Holotype: Plate 6 fig. 34. Preparation and sample number ST25/11 37.9 : 100.2; Py 353.

Type locality: AOC North Renmark No. 1 Well, 1761-1771 feet. Renmark Beds, Paleocene.

Comparisons and affinity: This species is quite distinct from any other in the genus. Its affinities are unknown.

Distribution: Appears to be restricted to the lowest Paleocene horizons in the centre of the Murray Basin.

Tricolpites voraginosus Harris sp. nov.

(Plate 7, figures 19, 20)

Diagnosis: Pollen prolate, radiosymmetric, tricolpate. Amb in equatorial view ellipsoidal. Colpi extend almost to the entire length (polar axis) of the grain, narrow and slightly constricted in the equatorial regions. Exine 2.5-3μ thick, sexine twice as thick as nexine, baculate. Bacula < 1μ in diameter and evenly distributed over the grain. Lumina between bacula < 1μ in diameter. The capita appear to fuse together. Both OL and LO patterns of similar dimensions are obtainable.

Dimensions: Polar diameter 37 (42) 48μ, equatorial diameter 16 (18) 27μ.

Holotype: Plate 7, fig. 19; Preparation and sample number S741/2 30.0 : 105.2; Py 389.

Type locality: Cummins School Bore 115-128 feet, Wanilla Formation, Middle Eocene.

Comparison and remarks: The fine sculptural pattern and size of the pollen separat this species clearly from those described by Couper (1953, 1960) and McIntyre (1965, 1968). Natural affinities unknown.

Distribution: The species occurs throughout the middle and upper Eocene.

Subturma PTYCHOTRIPORINES

Infraturma PROLATI

Genus TRICOLPORITES Cookson 1947

Tricolporites valvatus Harris sp. nov.

(Plate 7, figures 49, 50)

Diagnosis: Pollen radiosymmetric, prolate tricolporate. Amb in equatorial view ellipsoidal. Apertures compound, colpi reading to with 3 or 4μ of the poles, margins strongly invaginated to about 8μ. Equatorial aperture orate, 5-8μ in diameter. Exine 2-3μ thick unornamented.

Dimensions: Polar diameter 45 (52) 55μ, equatorial diameter 30 (35) 39μ.

Holotype: Plate 7 fig. 49. Preparation and sample number ST241/12, 35.7 : 98.5. Py 176.

Type locality: Lake Torrens Bore 3A 813-814 feet, Wilkatana Formation, Middle Eocene.

Comparison and affinity: The strongly invaginated colpi and psilate exine make this a very distinctive species. Its natural affinities are unknown.

Distribution: Common in the Wilkatana Formation but less common in other Middle Eocene (*Proteacidites confragosus* Zonule) assemblages.

Tricolporites adelaidensis Harris sp. nov.

(Plate 8, figures 3, 4)

Diagnosis: Pollen, subsphaeroidal, tricolporate; amb in polar and equatorial view more or less circular. Apertures compound, colpi of varying length and often indistinct. Equatorial aperture circular indistinct, up to 16μ in diameter. Exine two layered, nexine twice as thick as sexine. Sexine unsculptured, dense.

Dimensions: Equatorial diameter 49 (60) 72μ.

Holotype: Plate 8 fig. 3. Preparation and sample number ST228/14, 39.5 : 103.0; Py 130.

Type locality Observation Bore F 1055 feet. North Maslin Sands Equivalent; middle - upper Eocene.

Comparison and affinity: The rather thick nature of the exine, the shape and the unsculptured sexine make this species distinctive. The natural affinities are unknown.

Distribution: Ranges from middle Eocene through to the Miocene and is most abundant in the *Triorites magnificus* Zonule.

Tricolporites concinnus Harris sp. nov.

(Plate 8, figures 12, 13, 23)

Diagnosis: Pollen radiosymmetric, prolate, tricolporate. Amb in equatorial view ellipsoidal. Apertures compound, colpi reaching almost to the poles 1-2μ wide and slightly invaginated.

Equatorial apertures 2-3μ in diameter and slightly elongated equatorially and rimmed by thickening of the exine. Exine conspicuously two layered. Sexine twice as thick as nexine and thickens at the poles, minutely punctate (< 1μ in diameter).

Dimensions: Polar diameter 28 (30) 34μ, equatorial diameter 19 (22) 24μ.

Holotype: Plate 8, fig. 13. Preparation and slide number S560/1, 30.7 : 107.0, Py 390.

Type locality: Polda No. 1 Bore 118 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: The species is distinguished from *T. microreticulatus* by its smaller size and finer ornament. Natural affinities unknown.

Distribution: A commonly occurring form in middle - upper Eocene assemblages.

Tricolporites delicatus Harris sp. nov.

(Plate 8 figures 20, 21, 22)

Diagnosis: Pollen radiosymmetric sub-prolate to oblate sphaeroidal, tricolporate. Apertures compound colpi extending almost to the poles and strongly invaginated. Colpi surfaces free of ornament. Equatorial apertures more or less circular, rimmed by exine thickening and sometimes protruding. Exine distinctly two layered, sexine twice as thick as nexine. Sexine ornament evenly spread over the surface, reticulate, lumina circular 1μ wide.

Dimensions: Polar diameter 25 (30) 34μ, equatorial diameter 28 (32) 37μ.

Holotype: Plate 8, fig. 22. Preparation and sample number S559/1, 28.7 : 104.1; Py 391.

Comparison and affinity: The species appears quite similar to *Tricolporopollenites rhomboidaliformis* McIntyre but lacks the typically "rhomboid" shape and sub-triangular amb of this species.

Distribution: This species is very common in certain Eocene sediments particularly the Burrungle Member.

Tricolporites microreticulatus Harris

(Plate 8 figure 11)

Description: Pollen free, prolate to perprolate, tricolporate. Amb in lateral view elliptical. Apertures complex; colpus less than 1μ wide and extending about 3/4 the length of the solar diameter, bordered by prominently thickened lips 2μ wide, spreading around the pore. Pore diameter 4-6μ. Exine 2μ thick finely reticulate, lumina and mesh 1μ wide.

Dimensions: (10 specimens) Equatorial diameter 23 (24) 27μ. Polar diameter 32 (37) 40μ.

Holotype: Preparation S218; Py 070, 39.4 : 100.9; Pl. 4 fig. 18.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The morphology of the species is consistent with many dicotyledonous genera. The natural affinities are unknown.

Distribution: The species occurs frequently throughout the Paleocene and Eocene sediments of southern Australia.

Tricolporites scabratus Harris, new species

(Plate 8, figure 5)

Description: Pollen free subspheroidal to oblate, tricolporate. Amb in lateral view sub-circular. Apertures complex. Colpus 1-2µ wide usually less than 3/4 the length of the polar diameter, bordered by thickened lips 2-4µ wide and spreading around the pore, pore diameter 5-7µ. Exine 2-3µ thick scabrate to very finely reticulate.

Dimensions: (7 specimens) Polar diameter 39 (91) 45µ; Equatorial diameter 32 (36) 40µ.

Holotype: Preparation S218; Py 073, 34.4 : 105.1; Pl. 4 Fig. 17.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparison and affinity: The species is readily distinguished from *T. microreticulatus* in being larger and more spherical and in the finer nature of the ornament.

Distribution: The species occurs infrequently in Paleocene sediments.

Genus ILEXPOLLENITES Thiergart 1937

Ilexpollenites ornatus Harris sp. nov.

(Plate 7 figure 46)

Diagnosis: Pollen radiosymmetric, prolate, tricolporate. Amb in equatorial view ellipsoidal. Apertures indistinctly compound. Colpi reach almost to the poles. Equatorial apertures indistinct, 4-5μ in diameter. Exine 2-4μ thick, distinctly two layered, sexine twice as thick as nexine, ornamented with clavae 1-2μ in diameter and 2-2.5μ high, and scattered over the entire surface. Lumina less than 2μ in diameter.

Dimensions: Polar diameter 31 (36) 42μ, equatorial diameter 20 (25) 27μ.

Holotype: Preparation and slide number S289/1, 18.9 : 104.1; Py 392.

Type locality: Moorlands. Moorlands Lignite Member, middle-upper Eocene.

Comparison and affinity: This species resembles closely *I. clifdenensis* McIntyre from the New Zealand Miocene. This species however is tricolpate. *I. ornatus* is possibly the pollen of a member of the Aquifoliaceae.

Distribution: A rare form occurring only in Eocene and younger sediments.

Subturma PTYCHOPOLYPORINES

Genus SAPOTACEOIDAEPOLLENITES Pot., Thoms., & Thierg. 1950

Sapotaceoidaepollenites rotundus Harris sp. nov.

(Plate 7, figures 41, 41)

Diagnosis: Pollen radiosymmetric, subsphaeroidal to sub-prolate, four and less frequently three aperturate. Apertures compound. Colpi 2/3 length of polar axis 2-3μ wide. Equatorial aperture more or less circular 5-6μ in diameter and slightly elongate in an equatorial direction. Apertural margin prominently rimmed and thickened. Exine 2-2.5μ thick, nexine about as thick as sexine. Sexine psilate to finely scabrate.

Dimensions: Polar diameter 30 (36) 39μ, equatorial diameter 28 (33) 35μ.

Holotype: Plate 7 fig. 42. Preparation and slide number ST241/3 46. 3 : 103.3. Py 167.

Type locality: Lake Torrens Bore 3A 813 feet, Wilkatana Formation, Middle Eocene.

Comparison and affinity: The closest resemblance of this species is with *Tricolporopollenites latizonatus* McIntyre, but this species is most commonly 3-aperturate, has a longer polar/equatorial axis ratio and has a broad thickened zone of the exine in the equatorial region. The species is very similar to pollen of the Sapotaceae.

Distribution: The species first appears in the Middle Eocene and continues on often sporadically into the mid-Tertiary.

Subturma PTYCHOPOLYPORINES

Genus LAKULANGIPOLLIS gen. nov.

Diagnosis: Pollen prolate-sphaeroidal to subsphaeroidal, 9-11 aperturate. Apertures compound, with colpi and equatorial rugae which coalesce about the equator. Exine psilate.

Type species: *Lakulangipollis torrensensis* Harris sp. nov.

Remarks: This genus differs from *Psila stephanocolporites* Leidelmeyer 1966 in having a subsphaeroidal shape and shorter colpi.

Lakulangipollis torrensensis Harris sp. nov.

(Plate 7 figures 44, 45)

Diagnosis: As for generic diagnosis and in addition, colpi 1-2μ wide and less than 1/2 the length of the polar axis. Equatorial furrow 3-4μ wide. Sexine as thick as nexine, psilate.

Dimensions: Polar diameter 20 (24) 32μ, equatorial diameter 21 (28) 34μ.

Holotype: Plate 7 fig. 44. Preparation and slide number ST241/14, 32.7 : 106.8 Py 178.

Type locality: Lake Torrens Bore 3A at 813 feet. Wilkatana Formation, Middle Eocene.

Comparison and affinity: *L. torrensensis* is closely similar to

Polycolpites esobaltens McIntyre, but has more than eight colpi that are shorter than 1/2 the polar diameter. Grains of this type occur in the Polygalaceae.

Distribution: Appears consistently in most middle-upper Eocene assemblages.

Turma POROSES

Subturma MONOPORINES

Genus AGLAOREIDA Erdtman 1960

Aglaoreida barungensis Harris sp. nov.

(Plate 7 figure 18)

Diagnosis: Pollen monoporate, sphaeroidal to slightly bilateral. Pore circular (3-4μ in diameter) with incrassate margin 1-1.5μ wide. Exine 2μ thick, sexine as thick as nexine, reticulate. Reticulum undifferentiated over the grain, lumina 1-1.5μ in diameter.

Dimensions: Equatorial diameter 18 (22) 25μ.

Holotype: Preparation and slide number ST325/15, 42.1 : 110.8. Py 195.

Type locality: Hd. Barunga Bore 4, 215 feet. Clinton Coal Measures, ?Lower Miocene.

Comparison and affinity: The pollen figured by Couper (1960 pl. 9 figs. 21, 22) as *Typha* sp. appear to be very similar to

A. barungensis. *A. barungensis* differs from *A. cyclops* Erdtman in not having a differentiated reticulum. *"Monoporites" subreticulata* Cookson has a wider rim to the pore. *A. barungensis* is very similar to pollen of *Typha* and *Sparganium*.

Distribution: This species first occurs in the Upper Eocene and continues through to the Upper Tertiary.

Genus MILFORDIA Erdtman 1960 emend.

Emended diagnosis: Pollen grains monoporate, ulcerate or monocolpate. Exine psilate, its outer layer (sexine) provided with small densely spaced scrobiculi.

Synonomy: 1966 MONULCIPOLLENITES: Fairchild in Stover *et. al.* p. 2.

Remarks: It is considered here that to distinguish different genera on apertural types alone in this group is not justified. The combination of a monopored-ulcerate or-colpate pollen with a scrobiculate exine is a more "natural generic group." Pollen of these types occur in the Restionaceae and the Flagellariaceae.

Milfordia homeopunctatus (McIntyre) comb. nov.

(Plate 6, figures 19, 20)

Synonomy: 1965 *Monoporopollenites homeopunctatus* McIntyre p. 206 figs. 4, 5.

Remarks: The specimens from the Southern Australian Eocene assemblages appear to be identical with *M. homeopunctatus* from the New Zealand Miocene.

Genus GRAMINIDITES Cookson 1947

Graminidites psilatus Harris sp. nov.

(Plate 6, figures 22, 25)

Diagnosis: Pollen monoporate, sphaeroidal but often intensely folded. Pore 3μ in diameter with a prominent bordering rim 2-2.5μ wide. Exine 1.5-2μ thick, psilate.

Dimensions: Equatorial diameter 32 (35) 42μ.

Holotype: Plate 6 fig. 22. Preparation and slide number S710/1, 47.6 : 112.0. Py 394.

Type locality: Cannuwaukaninna Bore at 127 feet. Murnpeowie Formation equivalents. Upper Eocene.

Comparison and affinity: *G. psilatus* differs from *G. media* Cookson in having a psilate exine as against a granulate or scabrate exine. As Cookson (1947 p. 134) has pointed out, monoporate grains with a distinct poral rim are characteristic of the Graminae but are not confined to that family.

Distribution: Commonly occurs in Upper Eocene and younger sediments but is also known from the Middle Eocene.

Subturma TRIPORINES

Genus MYRTACEIDITES Cookson & Pike emend. Potonie

Myrtaceidites tenuis Harris

(Plate 7, figure 22)

Description: Pollen isopolar, oblate, angulaperturate, tricolporoid, amb triangular to sub-triangular with convex sides. Arci indistinct, no polar islands. Exine psilate, 1-2μ thick.

Dimensions: (7 specimens) Equatorial diameter 21 (24) 27μ.

Holotype: Preparation S217, Py 152. 37.3 : 107.2; Pl. 4 fig. 31.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The species differs from the upper Tertiary form, *Myrtaceidites eucalyptoides* forma *convexus* Cookson and Pike, in having indistinct arci and no polar islands. Cookson and Pike (1954) related similar forms to the genus *Eucalyptus*.

Distribution: A very rare form present in the Princetown Member.

Genus MYRTACEOIPOLLENITES R. Potonie 1951

Myrtaceoipollenites australis Harris

(Plate 8, figure 28)

Description: Pollen, isopolar, oblate, angulaperturate, tricolporoid. Amb triangular to sub-triangular, side straight to convex. Exine 2μ thick, psilate to scabrate thickening to about 5μ around the apertures.

Dimensions: (5 specimens) Equatorial diameter 24 (27) 29μ.

Holotype: Preparation S218; Py 105 49.4 : 105.5; Pl. 5 fig. 19.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparison and affinity: The species differs from *M. thiergarti* R. Pot. in having a thicker exine around the apertures. The affinities of the species are unknown.

Distribution: The species occurs rarely in the Princetown Member and in the Eocene. McIntyre (1968) records the species from the Bortonian-Kaiatan.

Genus TILIAEPOLLENITES (R. Potonie) Pot. & Ven. 1934

Tiliaepollenites notabilis Harris

(Plate 8, figure 2)

Description: Pollen, isopolar, oblate to peroblate, angulaperturate, tricolporoid, amb in polar view subcircular. Exine 2μ thick, reticulate, lumina about 1μ wide. Exine prominently thickened around the apertures.

Dimensions: (7 specimens) Equatorial diameter 43 (48) 52μ.

Holotype: Preparation S218; Py 082 37.1 : 104.0; Pl. 5 fig. 2.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The species is similar to *T. reticulatus* Groot and Groot but has a smaller reticulum. Pollen of the genus *Tilia* is comparable with this species.

Distribution: Restricted to the upper portion of the Dilwyn Clay and correlatives.

Genus ANACOLOSIDITES (Cookson & Pike) Potonie 1960

Anacolosidites comaumensis Harris sp. nov.

(Plate 6, figure 40)

Diagnosis: Pollen isopolar, oblate 6-forate, amb triangular to rounded triangular with slightly concave sides. Pores indistinct, 5 x 2.5μ in diameter and close to the angles. Exine distinctly two layered 2-2.5μ, sexine about as thick as nexine but thins over the angles, ornament scabrate.

Dimensions: Equatorial diameter (5 specimens) 27 (28) 30μ.

Holotype: Preparation and slide number ST502/8, 40.0 : 112.8, Py 275.

Type locality: Comaum Bore 1A at 374 feet. Bahgallah Formation equivalent. Middle Paleocene.

Comparison and affinity: The species is quite distinct from both *A. acutullus* and *A. luteoides*, especially in the nature of the indistinct pores and the scabrate sculpture.

Distribution: A very rare species only recorded from the Comaum Bore.

Genus BEAUPREAIDITES (Cookson) Couper 1953

Beaupreaidites trigonalis Harris sp. nov.

(Plate 8, figures 30, 33)

Diagnosis: Pollen isopolar, oblate, angulaperturate. Amb triangular with straight sides but exine curves in noticeably in the apertural regions. Apertures simple pores 1-2μ in diameter. Exine two layered 2-2.5μ thick, sexine slightly thinner than nexine, sculpture evenly distributed over grain except near the angles, finely reticulate. Lumina c. 1μ wide. Sexine thinner in the region of the angles.

Dimensions: Equatorial diameter 22 (28) 32μ.

Holotype: Plate 8, fig. 30. Preparation and sample number S561/1 27.2 : 93.1; Py 395.

Type locality: Polda No. 1 at 161 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: The small side and fine, evenly distributed reticulate sculpture separates this species from *B. verrucosus* and *B. elegansiformis*. It has close similarities with pollen of the genus *Beauprea*.

Distribution: An uncommon species most frequent in Middle Eocene sediments. Rare or absent in the Upper Eocene.

Beaupreaidites reticulatus Harris sp. nov.

(Plate 12, figures 14, 15)

Diagnosis: Pollen isopolar, oblate angulaperturate. Amb triangular with straight sides that curve in towards the apertures at the angles. Apertures simple, colpi. Exine 2-3μ thick. Sexine a little thicker than nexine. Sculpture prominent reticulum, lumina irregular in shape up to 7μ in diameter, smaller at the poles and towards the angles. Muri 2µ wide.

Dimensions: Equatorial diameter (5 specimens) 35 (38) 40µ.

Holotype: Plate 12 fig. 15. Preparation and slide number S166/1 34.6 : 99.7. Py 396.

Type locality: Geltwood Beach No. 1 Well at 2328 feet. Paleocene.

Comparison and affinity: The heavy reticulate sculpture of this species separates it from all other *Beaupreaidites* spp. It is suggested that it has some affinity with the genus *Beauprea*.

Distribution: A very rare species noted only from the Paleocene in the Gambier Embayment.

Genus PROTEACIDITES Cookson 1950

Proteacidites tuberculiformis Harris

(Plate 8, figure 31)

Description: Pollen large, sub-isopolar, oblate to peroblate, angulaperturate, triorate. Amb triangular with straight to concave sides. Ora circular 5-7µ wide. Exine 2-3µ thick, not thinning towards the apertures, granulate to scabrate with verrucae 2-4µ wide at base and 2µ high, regularly distributed.

Dimensions: (5 specimens) Equatorial diameter 88 (95) 100µ.

Holotype: Preparation S218; Py 083, 39.0 : 105.2, Pl. 6 fig. 5.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: No comparable pollens of this type are known.

Distribution: Occurs rarely in the Princetown Member.

Proteacidites ornatus Harris

(Plate 12, figure 8)

Description: Pollen sub-isopolar, peroblate, angulaperturate. Amb triangular with straight sides. Triorite, ora circular 5μ in diameter. Exine 2-3μ thick ornamented with a dense reticulum. Lumina 4-8μ wide reducing to 1μ at the apertures. Mesh of reticulum convolute, 1.5-2.5μ wide, 3-5μ high.

Dimensions: (7 specimens) Equatorial diameter 67 (70) 75μ.

Holotype: Preparation S217; Py 060 39.8 : 105.8; Pl. 5 fig. 26.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The species is readily distinguished from *P. grandis* Cookson and *P. crassus* Cookson by its characteristic reticulum and shape of the amb in polar view.

Distribution: Sporadic distribution throughout Paleocene and Middle Paleocene sediments.

Proteacidites reticuloscabratus Harris

(Plate 10, figure 14)

Description: Pollen, sub-isopolar, oblate, angulaperturate. Amb triangular with straight sides. Triorite, ora 3μ in diameter. Exine 2-2.5μ thick, thickening prominently around the apertures; reticulate, lumina 1-1.5μ wide, mesh 1-2μ wide.

Dimensions: (10 specimens) Equatorial diameter 24 (29) 35μ.

Holotype: Preparation S218; Py 070 39.4 : 100.9; Pl. 5 fig. 21.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: The species differs notably from *P. annular annularis* in the coarse nature of the reticulum and *P. symphyonemoides* in the thickening of exine around the apertures.

Distribution: Uncommon throughout the Paleocene.

Proteacidites dilwynensis Harris

(Plate 12, figures 2, 3, 4, 5)

Description: Pollen isopolar to sub-isopolar, peroblate, triorite, angulaperturate. Amb triangular with deeply concave sides. Ora 5-7.5μ in diameter. Exine 2-3μ thick, thickening slightly about 10μ from the aperture, reticulate, lumina 2-4μ wide in polar area, 1μ wide near the apertures, mesh 1.5μ high, 1μ wide.

Dimensions: (7 specimens) Equatorial diameter 65 (70) 72μ.

Holotype: Preparation S218; Py 076 39.3 : 100.3; Pl. 5 fig. 27.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparisons and affinity: This species is closely similar to *P. grandis* Cookson but is distinguished from this species by the smaller lumina, the thickening of the exine around the apertures.

Distribution and remarks: This species appears to represent a complex of morphotypes which begin their range in the Paleocene and continue through to the middle - upper Eocene.

Proteacidites latrobensis Harris

(Plate 9, figure 33)

Description: Pollen sub-isopolar, oblate, angulaperturate. Sub triangular, sides straight to slightly convex or concave. Triorite, ora 1.5μ in diameter. Exine 1-1.5μ thick, prominently thickened around the aperature, scrobiculate.

Dimensions: (15 specimens) Equatorial diameter 18 (25) 33μ.

Holotype: Preparation S218; Py 107 32.0 : 101.6; Pl. 5, fig. 24.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparison and affinity: The species is readily distinguished from *P. callosus* and *P. obscurus* by the psilate nature of the exine and the prominent thickening of this around the aperture. Natural affinities unknown.

Distribution: Commonly occurring throughout the Paleocene and into the Middle Eocene.

Proteacidites similis Harris

(Plate 9, figure 39)

Description: Pollen sub-isopolar, oblate, angulaperturate, triorite, sub-triangular with deeply convex sides. Ora circular 2μ in diameter. Exine 1.5-2μ thick scabrate appearing minutely reticulate.

Dimensions: (10 specimens) Equatorial diameter 22 (26) 30μ.

Holotype: Preparation S209; Py 153 38.7 : 100.9; Pl. 6 fig. 12.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinity: This species differs from *P. granoratus* in its smaller size and from *P. adenanthoides* in having finer sculptural elements and more concave sides.

Distribution: Sporadic distribution in Paleocene sediments.

Proteacidites echinatus Harris sp. nov.

(Plate 8, figures 34, 35, 36, 40)

Diagnosis: Pollen subisopolar, peroblate angulaperturate. Amb triangular with straight, slightly convex or concave sides. Apertures, three, circular 2-3μ in diameter. Exine 2μ thick, thickening near the apertures. Ornament consisting of sparsely distributed spinulae 1.5μ high with base 1μ wide. Sexine scabrate between spinulae.

Dimensions: Equatorial diameter (7 specimens) 30 (35) 42μ.

Holotype: Plate ,, fig. 36. Preparation and slide number S172/1 46.9 : 96.5 Py 397.

Type locality: Lake Tallacoota Shaft. Pidinga Formation, middle - upper Eocene.

Comparison and affinity: Pollen of this type are not represented in the recent flora although pollen of *Telopea* has some similarities.

Distribution: This species is rare and is known only from middle-upper Eocene sediments in Eyre Peninsular and in the Eucla Basin.

Proteacidites lepidus Harris sp. nov.

(Plate 9, figure 2)

Diagnosis: Pollen small, sub-isopolar, oblate, angulaperturate. Amb rounded triangular, sides slightly convex. 3-aperturate, apertures 2.5-3μ in diameter. Exine 3μ thick uniform in thickness. Sexine about as thick as nexine ornamented with a dense reticulum, lumina 1.5-3μ in diameter, slightly smaller in the polar regions, muri c. 1μ wide.

Dimensions: Equatorial diameter 21 (25) 31μ.

Holotype: Preparation and slide number S561/1 35.2 : 108.6, Py 398.

Type locality: Polda No. 1 Bore at 161 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: This species is quite characteristic and cannot be confused with any other known form. It is suggested that it has affinities with the Proteacene.

Distribution: This species is often common in Middle Eocene sediments particularly those of the Polda Basin.

Proteacidites varius Harris sp. nov.

(Plate 9, figures 3, 4, 5)

Diagnosis: Pollen small, sub-isopolar, peroblate, angulaperturate. Amb triangular with straight or slightly concave sides. Apertural pores, three, 2.5μ in diameter. Exine 2-2.5μ thick, Sexine much thinner than nexine and thins markedly near the apertures. Ornament 0.5μ high consisting of fused groups of bacula c. 1μ in diameter. Groups becoming smaller to absent near apertures.

Dimensions: Equatorial diameter 20 (25) 37μ.

Holotype: Plate 9 fig. 3. Preparation and slide number S716/1, 46.7 : 112.4. Py 399.

Type locality: Cannuwaukaninna Bore at 150 feet. Murpeowie Formation. Eocene.

Comparison and affinity: *P. varius* is distinguished from *P. lepidus* by its shape and the nature of the ornament. The nature of the ornament distinguishes the species from *P. reticulatus* Cookson and *P. symphyonemoides* Cookson. It is most likely the pollen of a member of the Proteaceae.

Distribution: A common species in middle and upper Eocene assemblages in the Murnpeowie and Poelpena Formations in particular.

Proteacidites paleocenicus Harris sp. nov.

(Plate 9, figure 12, Plate 10, figure 10)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, sides straight. Pores simple 4-5μ wide. Exine 2-3μ thick, sexine about as thick as nexine but extends past nexine which thins markedly in the apertural regions. Ornament reticulate. Lumina in the centre of the pollen and about the poles up to 2.5μ in diameter but diameter decreases rapidly towards the angles.

Dimensions: Equatorial diameter (7 specimens) 26 (30) 32μ.

Holotype: Plate 9 fig. 12. Preparation and slide number S211/1, 42.8 : 108.7. Py 400.

Type locality: Dilwyn Clay, Dilwyn Bay, Victoria.

Comparison and affinity: The characteristic ornament pattern distinguishes this species from others in the genus *Proteacidites*.

Distribution: A rare species apparently confined to Paleocene sediments in the Otway Basin.

Proteacidites vulgaris Harris sp. nov.

(Plate 9, figures 14, 16, 28)

Diagnosis: Pollen sub-isopolar, oblate angulaperturate, three pored. Amb triangular with straight to slightly convex sides. Apertures ?compound 2μ in diameter. Exine 2μ thick. Sexine as thick as nexine, faintly and sparsely scabrate. Nexine appears to separate from sexine 7μ from the aperture to form an attrium.

Dimensions: Equatorial diameter 20 (25) 32μ.

Holotype: Plate 9 fig. 28. Preparation and slide number S650/1 39.6 : 107.3. Py 401.

Type locality: Hd. Cummins Bore at 374 feet. Wanilla Formation, Middle Eocene.

Comparison and affinity: *P. concretus* closely resembles this species but the two can be separated by the characters of the nexine near the apertures. *P. concretus* shows no separation of nexine and sexine as does *P. vulgaris*.

Distribution: The species is a very common component of the assemblages in the Poelpena Formation. It ranges from Middle to Upper Eocene.

Proteacidites lautus Harris sp. nov.

(Plate 9, figures 23, 24)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triorate. Amb triangular with straight sides except where exine bulges out around the aperture. Apertures 11-15μ wide externally and 7-9μ internally. Exine 4-5μ thick scabrate becoming thicker towards the apertures but then thinning to 2.5-3μ. Sexine much thinner than nexine and extends out beyond the nexine in the apertural region. Apertures 7.5μ diameter in the nexine, 15μ in the sexine.

Dimensions: Equatorial diameter 34 (37) 42μ

Holotype: Plate 9 fig. 23. Preparation and slide number S289/1, 40.0 : 94.2. Py 402.

Type locality: Moorlands Lignite Member, Moorlands; middle-upper Eocene.

Comparison and affinity: The rather thick nexine and much thinner nexine are distinctive features of the species. It shows some similarity to *Triorites magnificus* but differs from this species in aperture construction and sexine ornament.

Distribution: Most commonly occurs in Middle Eocene sediments and is rare or absent in the *Aglaoreida barungensis* Zonule and does not extend down into the Paleocene.

Proteacidites unicus Harris sp. nov.

(Plate 9, figures 25, 26)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triorate. Amb more or less triangular. Sides straight in the inter-apertural regionals. Exine 2-2.5µ in the inter-apertural regions but the nexine thickens at about 15µ from the aperture to form a distinct "collar" 5µ thick and 7µ wide. The nexine is slightly "pinched" in at this point thereafter it bulges out and thins rapidly. Sexine about as thick as nexine in the interradial regions and retains a constant thickness, with a distinct OL pattern. Lumina c. 1µ in diameter.

Dimensions: Equatorial diameter (5 specimens) 38 (50) 56µ.

Holotype: Plate 9 fig. 25. Preparation and sample number S648/1, 25.4 : 104.5. Py 403.

Type locality: Wilkatana Bore 1 at 351 feet. Wilkatana Formation. Middle Eocene.

Comparison and affinity: *P. unicus* is a most distinctive pollen and cannot be confused with any other described species. It shows some similarities to the pollen of *Hakea* and *Grevillea* (Erdtman 1952).

Distribution: A very rare species known only from the Pirie-Torrens Basin.

Proteacidites concretus Harris sp. nov.

(Plate 9, figures 31, 32)

Diagnosis: Pollen subisopolar, oblate, angulaperturate, triporate. Amb triangular with straight sides. Apertures circular 1.5μ in diameter. Exine 2μ thick but thickens in the region of the aperture to 4μ and forms a pore "canal" 5μ long. Exine faintly and evenly scabrate. LO pattern.

Dimensions: Equatorial diameter 25 (28) 32μ.

Holotype: Plate 9 figure 32; Preparation and slide number S360/2, 36.4 : 105.8. Py 404.

Type locality: Kopi Bore 222-202 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: This species is most closely similar to *P. latrobensis* Harris, particularly in the nature of the aperture. It however differs from this species by the nature of the ornament. (*P. latrobensis* has a scrobiculate pattern.)

Distribution: A common species in most Eocene sediments. Not known from the Paleocene.

Proteacidites ligneolus Harris sp. nov.

(Plate 9, figures 34, 41)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate. Amb triangular with straight sides. Exine 2μ thick, sexine as thick as nexine, ornamented with low (< 1μ high) coalesced group of bacula (1μ wide). These become smaller towards the apertures where the sexine thins slightly.

Dimensions: Equatorial diameter 34 (38) 40μ.

Holotype: Plate 9 fig. 42. Preparation and slide number ST218/16 38.7 : 102.8. Py 085

Type locality: Princetown Member, Princetown, Victoria. Upper Paleocene.

Comparison and affinity: This species is similar to *P. rectomarginus* Cookson but is much smaller. It is distinguished from *P. parvus* Cookson by not having exine that thins markedly near the apertures. *P. subscabratus* Couper is smaller and has a scabrate sculpture.

Distribution: The species is present in the Princetown Member of the Dilwyn Clay and ranges into the middle - upper Eocene but is uncommon.

Proteacidites clintonensis Harris sp. nov.

(Plate 10, fig. 1,
Plate 11, figs. 5, 6, 11)

Diagnosis: Pollen sub-isopolar, oblate angulaperturate, tri-porate. Amb more or less triangular with concave sides. Pores circular 20-35μ in diameter. Exine 3μ thick, sexine slightly thinner than nexine. Capita of bacula coalesce to form groups up to 7μ wide and show an LO pattern. Elements rounded in optical section. Nexine in region of pores, alternately thick and thin. The sexine is readily lost by corrosion.

Dimensions: Equatorial diameter 62 (75) 98μ.

Holotype: Plate 11, fig. 11. Preparation and slide number S705/1, 49.1 : 103.4. Py 405.

Type locality: Poyntz Bore, Hd. Ettrick at 310 feet. Buccleuch Beds, middle - upper Eocene.

Comparison and affinity: Plate 10 fig. 1 and Plate 11 fig. 7 possibly can be separated as another species. These two specimens are similar to *P. rectomarginus* Cookson but have much larger apertures. The species is distinguished from *P. incurvatus* by the nature of the sculpture and the characteristic aperture. The exine does not thin markedly near the apertures as it does in *P. incurvatus*.

Distribution: The species is almost ubiquitous in Eocene sediments and is particularly common in the *Triorites magnificus* Zonule. It ranges from Middle Eocene to at least Lower Miocene.

Proteacidites comaumensis Harris sp. nov.

(Plate 10, figures 2, 3)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with straight to slightly concave sides. Pores simple sub-circular, 7μ in diameter. Exine 2.5μ thick, sexine as thick as nexine, ornamented with sparse low (1.5μ high) verrucae 2-3μ in diameter. Between these elements the sexine is evenly punctate (< 1μ in diameter) giving a clear OL pattern.

Dimensions: Equatorial diameter (5 specimens) 50 (53) 59μ.

Holotype: Plate 10 fig. 3. Preparation and sample number ST502/19, 38.3 : 105.7. Py 296.

Type locality: Comaum Bore 1A at 374 feet. Bahgallah Formation equivalent. Middle Paleocene.

Comparison and affinity: *P. comaumensis* shows some similarity to *P. clintonensis* but can be readily distinguished by the ornament, apertures and shape of the amb.

Distribution: This species is a rare type and has only been noted from the Comaum Bore.

Proteacidites kopiensis Harris sp. nov.

(Plate 10, figures 7, 8)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, sides straight or nearly so. Apertures sub-circular simple 7-8μ in diameter. Exine 2μ thick and slightly thicker in the equatorial inter-aperturate regions. Sexine about half as thick as nexine, ornamented with a reticulum. Muri 1-1.5μ wide. Lumina 2μ in diameter at the equator and decrease gradually to 1μ towards the apertures and polar regions.

Dimensions: Equatorial diameter 36 (40) 47μ.

Holotype: Plate 10 fig. 7. Preparation and sample number S560/1 26.7 : 107.3. Py 393.

Type locality: Polda No. 1 hole at 123 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: This species is readily distinguished from other *Proteacidites* spp. by the characteristic ornament pattern.

Distribution : This species is present in the uppermost section of the Princetown Member of the Dilwyn Formation and continues in all basins into the middle - upper Eocene. It does not appear to range higher than the *Triorites magnificus* Zonule.

Proteacidites tripartitus Harris sp. nov.

(Plate 10, figures 11, 12, 13)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with more or less straight sides. Apertures sub-circular, simple but obscure 2-2.5μ wide. Exine 2.5-3μ thick. Sexine half as thick as nexine, foveolate. Lumina c. 1μ in diameter slightly smaller at the poles and towards the apertures. Muri 2-3μ wide. Nexine thickens to 5μ at 10μ from the diameter. Pore "canal" 7-8μ long.

Dimensions: Equatorial diameter 27 (30) 34μ.

Holotype: Plate 10, fig. 11. Preparation and slide number S650/1, 47.3 : 103.4. Py 406.

Type locality: Hd. Cummins Bore at 374 feet. Wanilla Formation, Middle Eocene.

Comparison and affinity: The detail of the apertures closely resembles that found in *P. latrobensis* and *P. concretus* but is distinguished by the characteristic ornament.

Distribution: The species first appears very high in the Princetown Member of the Dilwyn Formation but does not become common with the Middle Eocene.

Proteacidites collaroides Harris sp. nov.

(Plate 10, figures 17, 18)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with slightly convex sides. Aperture sub-circular simple 5μ wide. Exine 2μ thick. Sexine about as thick as nexine except near the apertures where the sexine is scabrate. Nexine thickens to 3-4μ near aperture.

Dimensions: Equatorial diameter 37 (40) 44μ.

Holotype: Plate 10, fig. 17. Preparation and slide number S241/1, 33.3 : 111.0. Py 407.

Type locality: Lake Torrens Bore 3A at 813 feet. Wilkatana Formation, Middle Eocene.

Comparisons and affinity: The foveolate sculpturing of the exine combined with the "collared" effect about the apertures clearly separate this species from others in the genus.

Distribution: Appears to be confined to Middle Eocene sediments from Eyre Peninsular and the Pirie-Torrens Basin.

Proteacidites fromensis Harris sp. nov.

(Plate 10, figure 19)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, sides strongly concave. Pores simple, circular, 5μ in diameter. Exine 2.5-3μ thick. Sexine slightly thinner than nexine in the inter-angles and thins towards the angles, evenly granulate to scabrate. Nexine thickest in the inter-angles.

Dimensions: Equatorial diameter 61 (65) 70μ.

Holotype: Preparation and sample number S17/2, 36.1 : 101.6. Py 408.

Type locality: Lake Eyre Bore 20 at 210 feet. Murnpeowie Formation equivalent, Paleocene.

Comparison and affinity: The strongly concave sides of the amb size and the scabrate ornament separate this species from others in the genus. It differs from *P. granoratus* Couper in that the ornament does not become coarser around the apertural region.

Distribution: *P. fromensis* is restricted to and characteristic of Paleocene sediments and is most common in the Murray and Great Artesian Basins.

Proteacidites voraginosus Harris sp. nov.

(Plate 11, figures 1, 2, 3)

Diagnosis: Pollen sub-isopolar, angulaperturate, oblate, triporate. Amb triangular, side straight to slightly concave or convex. Pores simple, circular 4-5μ in diameter. Exine uniform and 3-4μ thick. Sexine as thick as nexine, ornamented evenly over the surface with large fovealae. Lumina and muri 2-3μ wide becoming slightly smaller and more circular at the poles. Lumina near the angles elongated 1½ - 2 times as long as broad.

Dimensions: Equatorial diameter (8 specimens) 46 (50) 53μ.

Holotype: Plate 11, fig. 1 Preparation and slide number ST547/33, 41.4 : 103.5 Py 342.

Type locality: Lake Cootabarlow Bore at 536 feet. Murnpeowie Formation equivalent. Paleocene.

Comparison and affinity: The thick exine and dense fovecolate sculpture without modification in the region of the apertures separates this species from *P. collaroides*.

Distribution: *P. voraginosus* is a rare form restricted to Paleocene sediments in the Great Artesian and Murray Basins and the Gambier Embayment.

Proteacidites confragosus Harris sp. nov.

(Plate 11, figures 7, 8)

Diagnosis: Pollen sub-isopolar, angulaperturate, oblate, triporate. Amb triangular with slightly convex sides. Pores simple sub-circular 6-7μ in diameter, obscure. Exine 4-5μ thick. Sexine three times as thick as nexine, heavily ornamented with a dense reticulum, lumina 3-4μ in diameter polygonal, and made up of distinct bacula 1-1.5μ in diameter.

Dimensions: Equatorial diameter 54 (60) 69μ.

Holotype: Plate 11, fig. 8. Preparation and slide number, ST241/9, 42.0 : 106.1. Py 173.

Type locality: Lake Torrens Bore 3A at 813 feet. Wilkatana Formation, Middle Eocene.

Comparison and affinity: This is a most handsome species and is clearly distinct from any other known in the genus.

Distribution: An index form for Middle Eocene sediments; *P. confragosus* has been recorded from the North Maslin Sands, the Renmark, Poelpena and Wanilla Formations and the Burrungle Member.

Proteacidites tortuosus Harris sp. nov.

(Plate 11, figures 13, 16;
Plate 12, figure 1)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb rounded triangular, sides convex. Pores simple 13-15μ wide. Exine 5μ thick. Nexine thicker than sexine. Sexine ornamented scattered verrucae, 2μ wide and up to 6μ long, rounded in optical section and 2μ high. Areas between these elements psilate.

Dimensions: Equatorial diameter 53 (55) 58μ.

Holotype: Plate 11, fig. 13. Preparation and slide number S563/2, 31.8 : 100.4 Py 409.

Type locality: Polda Bore 1 at 181 feet; Poelpena Formation, Middle Eocene.

Comparison and affinity: The large distinctive verrucae thick exine and rounded sub-triangular shape separate this species from those described here. *P. tortuosus* differs from *P. tuberculatus* Cookson in being smaller. The verrucae are not arranged in a reticuloid pattern and are not confined to spherical shape.

Distribution: This species has been recorded only from Middle Eocene sediments on Eyre Peninsula, Poelpena and Wanilla Formations.

Proteacidites pidingaensis Harris sp. nov.

(Plate 12, figure 10)

Diagnosis: Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb sub-triangular, side convex. Pores simple 9-11μ in diameter. Exine 2.5-3μ thick. Sexine a little thicker than nexine, pseudoreticulate densely ornamental with low verrucae (1μ high) up to 2μ in diameter near the poles and becoming narrower towards the apertures. Verrucae partly coalesce leaving lumina 3-4μ long and c. 1μ wide.

Dimensions: Equatorial diameter 52 (55) 57μ.

Holotype: Preparation and slide number ST188/1, 36.4 : 102.4. Py 151.

Type locality: Observation Bore F at 1050 feet, North Maslin Sands, middle - upper Eocene.

Comparison and affinity: In size and shape this species resembles *P. tortuosus* but is distinguished by the smaller nature of the ornament and its distribution forming narrow lumina.

Distribution: The species has only been recorded from the St. Vincent and Eucla Basins.

Proteacidites perparvulus Harris sp. nov.

(Plate 12, figure 12)

Diagnosis: Pollen small, sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, side slightly concave. Pores simple 1-1.5μ thick. Sexine as thick as nexine except near the apertures where the nexine thins markedly. Sexine ornamented with fine (< 0.5μ in diameter < 0.5μ high) and evenly distributed projections giving a distinct LO pattern.

Dimensions: Equatorial diameter 18 (20) 25μ.

Holotype: Preparation and slide number S705/1, 44.8 : 109.2. Py 410.

Type locality: Poyntz Bore, Hd. Ettrick at 310 feet. Buccleuch Beds, middle-upper Eocene.

Comparison and affinity: *P. perparvulus* is quite similar to *P. varius* but is distinct in having smaller and distinctive ornament and nexine which thins conspicuously near the apertures.

Distribution: The species has been recorded from the Buccleuch Beds and middle - upper Eocene phases of the Renmark Beds.

Genus TRIORITES Cookson ex Couper 1953

Type species (by subsequent designation of Couper, 1953, p. 60):

Triorites magnificus Cookson 1950

Discussion:

Dettmann and Playford recently (1968) summarised the present status of the genus, but chose to continue using the diagnosis of Couper (1953) pending a review by the author.

Potonie (1960) clearly indicated that the two species *T. magnificus* and *T. clavatus* were morphologically comparable and distinct from other forms allocated to the genus. However, Potonie gave no indication as to where these other species should be placed.

It is clear from the present study that *T. magnificus* and *T. clavatus* are very closely related morphologically and perhaps phylogenetically. Indeed Cookson (1957, p. 49) goes so far as to state that "there is little or no doubt that they were produced by closely related plants. Both species have the same shape, type of ora and exine stratification, and structure...." Thus these two species form a natural grouping and all other species previously assigned to the genus are better accommodated elsewhere. Couper's (1953) diagnosis is too broad and is suggestive of suprageneric category.

All other species unless they conform to the diagnosis should be accommodated elsewhere.

"*Triorites*" *psilatus* Harris sp. nov.

(Plate 7, figures 31, 32, 33)

Diagnosis: Pollen radiosymmetric, isopolar, oblate, triorate. Amb sub-triangular, sides straight to slightly convex. Ora sunken, 2-4μ wide, circular. Exine 2μ except around apertures where it thickens to 3 or 4μ. Exine psilate.

Dimensions: Equatorial diameter 24 (32) 40μ.

Holotype: Plate 7, fig. 33. Preparation and slide number S563/1, 43.7 : 94.5. Py 411.

Type locality: Polda No. 1 Hole at 181 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: "*T.*" *psilatus* is very comparable and may be conspecific with "*T.*" *scabratus* Couper. The ornament on the latter is scabrate however.

Distribution: This species is a very common form throughout the Lower Tertiary in southern Australia. It makes its first appearance in the Princetown Member and ranges through to the Lower Miocene. The upper limit has not been determined.

Genus GAMBIERINA gen. nov.

Type species: *Triorites edwardsii* Cookson & Pike pars. p. 214, pl. 2, figs. 101 to 106.

Diagnosis: Pollen radiosymmetric, oblate, lobate, angulaperturate, triorate. Apertures sunken. Sexine thinner than nexine, psilate to scabrate.

Remarks: The characters of the exine, the apertures and general shape distinguish this genus from *Triorites*.

Genus TRIPOROPOLLENITES (Pflug) Thomson & Pflug 1953

Triporopollenites harrisii (Couper) comb. nov.

(Plate 7, figure 36)

Synonomy: 1953 *Triorites harrisii* Couper, N.Z. geol. Surv. paleont. Bull. 22:61 pl. 7, fig. 111.

1953 *Haloragacidites trioratus* Couper, N.Z. geol. Surv. paleont. Bull. 22:41, pl. 5, fig. 50.

1954 *Triorites harrisii*, Cookson & Pike, Aust. J. Bot. 2(2):215, pl. 2, fig. 95-99.

1960 *Triorites harrisii*, Couper, N.Z. geol. Surv. paleont. Bull. 32:67 pl. 12, figs. 2,3.

1965 *Triorites harrisii*, Harris, Palaeontographica B 115:94, pl. 27, fig. 37.

Remarks: *T. harrisii* is clearly not a *Triorites* but is closely similar to pollen in the genus *Triporopollenites.* The pollen of *Corylus, Myrica* and *Canacomyrica* is similar. Cookson and Pike (1954) indicate that the pollen of *C. monticola* and *T. harrisii* are "practically indistinguishable from one another."

Triporopollenites gemmatus Harris sp. nov.

(Plate 7, figures 24, 27, 28)

Diagnosis: Pollen occasionally free but most commonly united in tetrads. Tetrads 34-40μ in overall diameter. Individual pollen radiosymmetric oblate sub-isopolar, triorate. Amb sub-triangular with straight to convex sides. Exine 4-5μ thick (including ornament). Sexine and nexine difficult to separate but nexine appears to be thicker than sexine. Exine covered with verrucae 2-3μ wide, sphaerical and 2μ high. Verrucae separated from each other (2-3μ) by granulate ornament. Apertures obscured by ornament, porate or orate opening 1.5-2.5μ wide.

Dimensions: Individual pollen, equatorial diameter 29 (25) 31μ.

Holotype: Plate 7 fig. 28. Preparation and slide number ST555/9, 39.8 : 101.8. Py 439.

Type locality: Observation Bore 1B, Port Lincoln - Wanilla Formation, Middle Eocene.

Comparison and affinity: *T. gemmatus* is similar to *T. bullis* Gruas-Cavagnetto from the Sparnacian of the Paris Basin but this species is more or less circular and appears to have a thickened rim to the aperture.

Distribution: Appears to be restricted to Middle and middle - upper Eocene sediments from the Pirie Torrens and Great Artesian Basins and Eyre Pensinsula.

Subturma POLYPORINES

Infraturma STEPHANOPORITI

Genus STEPHANOPOROPOLLENITES Pflug 1952

Stephanoporopollenites obscurus Harris

(Plate 6, figure 42)

Description: Pollen free, oblate to subspheroidal zoniporate. Amb circular to subcircular in polar view. Pores 5-7μ indistinct 6-8μ in diameter. Membrane aperture granulate. Exine 1-2μ thick, scabrate to finely granulate.

Dimensions: (15 specimens) Equatorial diameter 31 (36) 40μ.

Holotype: Preparation S208; Py 011 35.8 : 103.4; Pl. 6 fig. 15.

Type locality: Dilwyn Bay, Pebble Point Formation

Comparison and affinity: The natural affinities of the species are unknown.

Distribution: A widely distributed form throughout the Paleocene of southern Australia. Dettmann and Playford record the species from Upper Cretaceous sediments in the Otway Basin.

Genus NOTHOFAGIDITES (Erdtman) Potonie 1960

Remarks: The following species described by Cookson 1959 and Couper 1953 and 1960 are combined into the form genus *Nothofagidites*.

Nothofagidites flemingii (Couper) comb. nov. (= *N. cincta* Cookson)

Nothofagidites mataurensis (Couper) comb. nov. (= *N. emarcida* Cookson).

Nothofagidites aspera (Cookson) comb. nov.

Nothofagidites brachyspinulosa (Cookson) comb. nov.

Nothofagidites deminuta (Cookson) comb. nov.

Nothofagidites falcata (Cookson) comb. nov.

Nothofagidites hetera (Cookson) comb. nov.

Nothofagidites incrassata (Cookson) comb. nov.

Nothofagidites vansteenisi (Cookson) comb. nov.

Infraturma PERIPORITI

Genus ECHIPERIPORITES Hammen & Wymstra 1964

Remarks: The genus *Malvaeipollis* Harris 1965 is a junior synonym of *Echiperiporites*.

Echiperiporites diversus (Harris) comb. nov.

(Plate 7, figure 1)

Description: Pollen free subspheroidal, oblate zoni-porate to zoni-pororate. Amb circular to sub-circular. Pores 4-5, 1.5-2.5μ in diameter, rimmed, rim 1-1.5μ wide. Exine 2.5-3μ thick. Spines and or spinulae 2-3μ long, basal diameter 1-1.5μ.

Dimensions: (15 specimens) Equatorial diameter 22 (27) 32μ.

Holotype: Preparation S218; Py 091, 34.9 : 101.5; Pl. 6 fig. 18.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Comparison and affinity: Pollen of this type agrees well with pollen of the genera *Plagianthus* and *Hoheria* in the family Malvaceae. *E. diversus* differs from *E. multiporosus* in being stephanoporate rather than periporate.

Distribution: A common species from the Paleocene to Miocene sediments in southern Australia.

Echiperiporites multiporosus Harris sp. nov.

(Plate 6, figure 43)

Diagnosis: Pollen free, sphaeroidal, periporate. Amb circular. Pores 12-14, 1.5-2μ in diameter, not rimmed. Exine 3-4μ thick. Sexine ornamented by spines 2-3μ long with base 1.5μ wide. Exine scabrate between spines.

Dimensions: Equatorial diameter: 19 (25) 32μ.

Holotype: Preparation and slide number S559/1, 24.7 : 98.0. Py 412.

Type locality: Polda No. 1 Hole at 118 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: *E. multiporosus* differs from *E. diversus* in the distribution of pores. It shows strong affinities with the Malvaceae.

Distribution: *E. multiporosus* first appears in middle - upper Eocene sediments and continues on into the Miocene at least. It is of widespread distribution but is nowhere common.

Genus CARYOPHYLLIDITES Couper 1960

Caryophyllidites tuberosus Harris sp. nov.

(Plate 7, figures 7, 10, 12, 23)

Diagnosis: Pollen free, sphaeroidal periporate and opereulate. Amb circular. Pores 10-20, 3-5μ in diameter clearly operculate. Opercula 2μ high and appear to arise from the basal sexine layer, ornamented with very fine spinulae, distinct LO pattern. Sexine as thick as nexine, finely and evenly punctate, distinct OL pattern.

Dimensions: Diameter 23 (29) 38μ.

Holotype: Plate 7 fig. 7. Preparation and slide number S559/1, 40.6 : 102.5. Py 413.

Type locality: Polda No. 1 Hole at 118 feet. Poelpena Formation, Middle Eocene.

Comparison and affinity: *C. tuberosus* is distinct from *C. polyoratus* in that it is operculate.

Distribution: A common species varying throughout southern Australia from Middle Eocene to Miocene.

Genus SIMPLICEPOLLIS Harris 1965

Diagnosis: Pollen generally united in tetrads, subspheroidal triporate. Pores simple. Apertural membrane psilate. Exine 1-1.5μ thick psilate to finely scabrate.

Type species: *Simplicepollis meridianus* Harris.

Discussion: Pollens of this genus are particularly simple with regard to aperture shape and structure. The pollen differs from that occurring in the Typhaceae and Sparganiaceae in having three apertures (Erdtman 1952). The natural affinities of the genus are unknown.

Simplicepollis meridianus Harris

(Plate 7, figure 9)

Description: Pollen generally united in tetrads, subsphaeroidal triporate circular to sub-circular in polar view. Pores simple, unrimmed. Apertural membrane psilate. Exine 1.5-2μ thick.

Dimensions: (15 specimens) Equatorial diameter (single pollen) 17 (22) 27μ.

Holotype: Preparation S218; Py 100; 32.9 : 104.6; Pl. 4 Fig. 33 of Harris 1965a.

Type locality: Princetown, Princetown Member of the Dilwyn Clay.

Distribution: A widely distributed and common form throughout the Paleocene.

Comparison: McIntyre's species *S. scabratus* is possibly synonymous with *S. meridianus*.

Simplicepollis minor Harris sp. nov.

(Plate 7, figures 4, 5, 6)

Diagnosis: Pollen united in tetrads, subsphaeroidal, periporate. Pores simple, 3 to 5 in number, 2-3μ in diameter and covered by a psilate tenuitas. Exine 1.5-2μ thick, finely scabrate. Sexine thinner than nexine.

Dimensions: Overall diameter of tetrad 25 (28) 32μ, individual pollen 15 (19) 22μ.

Holotype: Plate 7, fig. 4. Preparation and slide number, S546/1, 46.0 : 95.7. Py 414.

Type locality: Cootabarlow Bore at 515 feet. Murnpeowie Formation equivalent. Upper Eocene.

Comparison and affinity: *S. minor* is smaller than *S. meridianus* and has often more apertures. Natural affinities not known.

Distribution: A common form occurring in middle - upper Eocene sediments but rare or absent in the *Aglaoreida barungensis* Zonule.

Genus POLYPORINA (Naumova) Potonie 1960

Polyporina fragilis Harris

(Plate 7, figure 2)

Description: Pollen free sub-spheroidal, panporate. Amb circular. Number of pores very variable, 15 to 40; diameter 3-4μ. Exine 2μ thick, psilate to finely scabrate.

Dimensions: (15 specimens) Diameter 17 (22) 32μ.

Holotype: Preparation S209; Py. 018, 40.3 : 105.5; Pl. 6, fig. 21.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinity: The species agree very closely to the pollen of the Chenopodiaceae.

Distribution: A common and widely distributed form in the lower Tertiary.

Turma JUGATES

Subturma TETRADITES

Genus ERICIPITES Wodehouse 1933

Ericipites scabratus Harris

(Plate 7, figure 43)

Description: Pollen united in tetrads, sub-spheroidal to oblate, tricolporate. Amb in polar view sub-circular. Apertures complex, colpus extending 3/4 the length of the polar diameter. Colpus 1-2μ wide, pores 2μ wide. Exine 2μ thick finely scabrate.

Dimensions: (7 specimens) Equatorial diameter 17 (21) 25μ.

Holotype: Preparation S209; Py. 155; 43.7 : 112.0; Pl. 6 fig. 22 of Harris 1965.

Type locality: Dilwyn Bay, Pebble Point Formation.

Comparison and affinity: Pollen of this type occur predominantly in the order Ericales. Affinities other than this are unknown.

Distribution: The species is of rare occurrence in the Paleocene.

Ericipites crassiexinous Harris sp. nov.

(Plate 7, figures 39, 40)

Diagnosis: Pollen united in tetrads. Individual grains indistinctly tricolporate, tetrahedral in shape and strongly united in the tetrad. Exine 2.5-3.5µ thick, sexine as thick as nexine psilate. Apertures complex, colpi about 14µ long and 1.5µ wide. Pores indistinct and difficult to detect, 2µ in diameter.

Dimensions: Overall diameter 35 (42) 53µ. Individual grains 24 (30) 35µ in diameter.

Holotype: Plate 7, fig. 39. Preparation and slide number, S660/1 53.4 : 96.5. Py 415.

Type locality: Bore Hd. Cummins at 117 feet. Wanilla Formation. Middle Eocene.

Comparison and affinity: The psilate nature of the exine and the larger size of this species distinguishes it from *E. scabratus*. Pollen of this type characterise the order *Ericales*.

Distribution: Often a very common form in middle and upper Eocene sediments throughout the area.

Ericipites lepidus Harris sp. nov.

(Plate 7, figures 37, 38)

Diagnosis: Pollen united (*in*) tetrads, indistinctly tricolporate. Individual grains circular in polar view and more or less sphaeroidal. Apertures complex. Colpi about 16µ long and 1.5µ wide. Pores indistinct about 1-2μ in diameter. Exine 1.5-2μ thick, psilate. Sexine and nexine not distinguishable.

Dimensions: Overall diameter of tetrad 38 (45) 57μ. Individual grains 21 (30) 38μ.

Holotype: Plate 7, fig. 37. Preparation and slide number ST360/1, 35.7 : 98.9. Py 230.

Type locality: Kopi Anomaly Bore 1 at 200 feet. Poelpena Formation. Middle Eocene.

Comparison and affinity: *E. lepidus* is distinct from *E. crassiexinous* in having a thinner exine and individual grains are less tightly bound together in the tetrad. It is probably representative of a member of the *Ericales*.

Distribution: The species is particularly common in the Eyre Pensinsular Middle Eocene sediments. Its known range is middle to upper Eocene.

INCERTAE SEDIS

Genus SCHIZOSPORIS Cookson & Dettmann 1959

Schizosporis paleocenicus Harris sp. nov.

(Plate 6, figure 14)

Diagnosis: Grain strongly ellipsoidal, length about three times breadth. Grain separates lengthwise along a line of weakness, into two approximately equal parts. Exine 2.5-3μ thick, not differentiated into nexine and sexine, ornamented with crowded anastomosing rugulae 2μ wide and up to 7 or 8μ long and 1-1.5μ high.

Dimensions: (8 specimens) Length 92 (95) 105μ, breadth 30 (35) 42μ.

Holotype: Preparation and slide number S716/1, 20.1 : 96.8, Py 416.

Type locality: Cannuwaukaninna Bore at 150 feet. Murnpeowie Formation equivalent, Paleocene.

Comparison and affinity: *S. paleocenicus* is distinct from any other members of the genus described from Australia but is closely similar to *Ovoidites ligneolus* (Potonie), a Miocene species from Europe. It is separated from this species by its larger size and more dense ornament.

Distribution: This species is rare and has been recorded only from Paleocene sediments. It is present in the Great Artesian and Murray Basins and Harris (1965b) recorded it from sediments of similar age in the Brisbane area, Queensland.

Genus AMOSOPOLLIS Cookson & Balme 1962

Amosopollis dilwynensis Harris sp. nov.

(Plate 12, figure 17)

Synonomy: 1965 *Amosopollis cruciformis*, Harris p. 97, Pl. 29, fig. 26.

Diagnosis: Pollen grains in rhomboidal tetrads. Individual grains prolate to sub-prolate. Exine 2μ thick, psilate to scabrate except near the margins of the aperture where grana 1-1.5μ in diameter are present. Aperture is a long gaping sulcus extending the full length of the grain. Margins of sulcus not ragged.

Dimensions: (10 specimens) Overall diameter of tetrad 50 (60) 68μ. Individual grains 22 (34) 40μ in diameter.

Holotype: Preparation and sample number, ST209/2, 39.3 : 100.7. Py 015.

Comparison and affinity: *A. dilwynensis* is in general larger than the genotype but can also be distinguished by the psilate scabrate sculpture and more importantly by the straight margins of the sulcus.

Distribution: *A. dilwynensis* is a rare species but has been observed in Paleocene sediments from the Murray and Otway Basins, and a similar form has been reported (Harris 1965b) from Queensland in sediments of similar age.

SOME COMMENTS ON VEGETATIONAL HISTORY

The origin of the Australian flora and its relationships to that of the rest of the world has long been a source of interest and argument between biogeographers. However, where these discussions have been supported by palaeobotanical data there has been too little emphasis on the stratigraphy and time relationships of the floras.

Dettmann and Playford (1969) have recently noted that Late Cretaceous microfloras from southeastern Australia are quite distinct from those of the rest of the world except New Zealand. This is also true for the early Tertiary Period and the greatest similarities exist between the Australian and New Zealand microfloras. Thus the evidence strongly points to an Australasian origin for many of the groups present in the flora of Australia today. Indeed, Burbidge (1960) has already indicated the large degree of endemism in the Australian flora and Florin (1940) clearly indicated that the conifers of Australia, New Zealand and South America are a distinct group from those of the northern hemisphere. The work of Couper (1953, 1960) in New Zealand indicates that there is a broad similarity between the floras of the two lands and that certain notable vegetational changes took place at about the same time in both regions. The Paleocene microfloras of the two regions are dominated by *Proteacidites* (more so in southern Australia) and conifers and pollen of *Nothofagus* is relatively uncommon. It is not until the Middle (Bortonian) and Upper Eocene (Kunangan) that

Nothofagus dominates the assemblages. The same can be said for the Australian microfloras; *Nothofagus* pollen rapidly becomes dominant in the middle-upper Eocene sequences.

The microflora described by Cookson (1947) from Kerguelen appears to be younger than Lower Tertiary. The presence of *Cyatheacidites annulata* gives a lower limit of Lower Miocene. The appearance of *Drosera* pollen supports this and suggests an age as young as Pliocene. Thus the absence of *Nothofagus* pollen in these sediments probably is due to their relatively younger age.

The Lower Tertiary also is of interest in that many familiar plant groups first appear at this time. Among the monocotyledons, pollen identified with the Graminae and Restionaceae or Flagellariaceae first appear in the Middle Eocene. Pollen referred to Sparganiaceae or Typhaceae appears later and high in the Upper Eocene. Among dictoyledonous pollen the genus *Proteacidites* assumes many varied and distinctive forms often heavily sculptured but which do not persist into the uppermost Eocene. They are perhaps the most striking elements of the Paleocene and middle to upper Eocene assemblages.

On a more local scale there have been very few studies of changes in pollen frequencies in a stratigraphically controlled section. The Paleocene outcrop sequence at Princetown is ideal for this and the results of a frequency study are presented here. Certainly a study of this type is needed also for the Eocene.

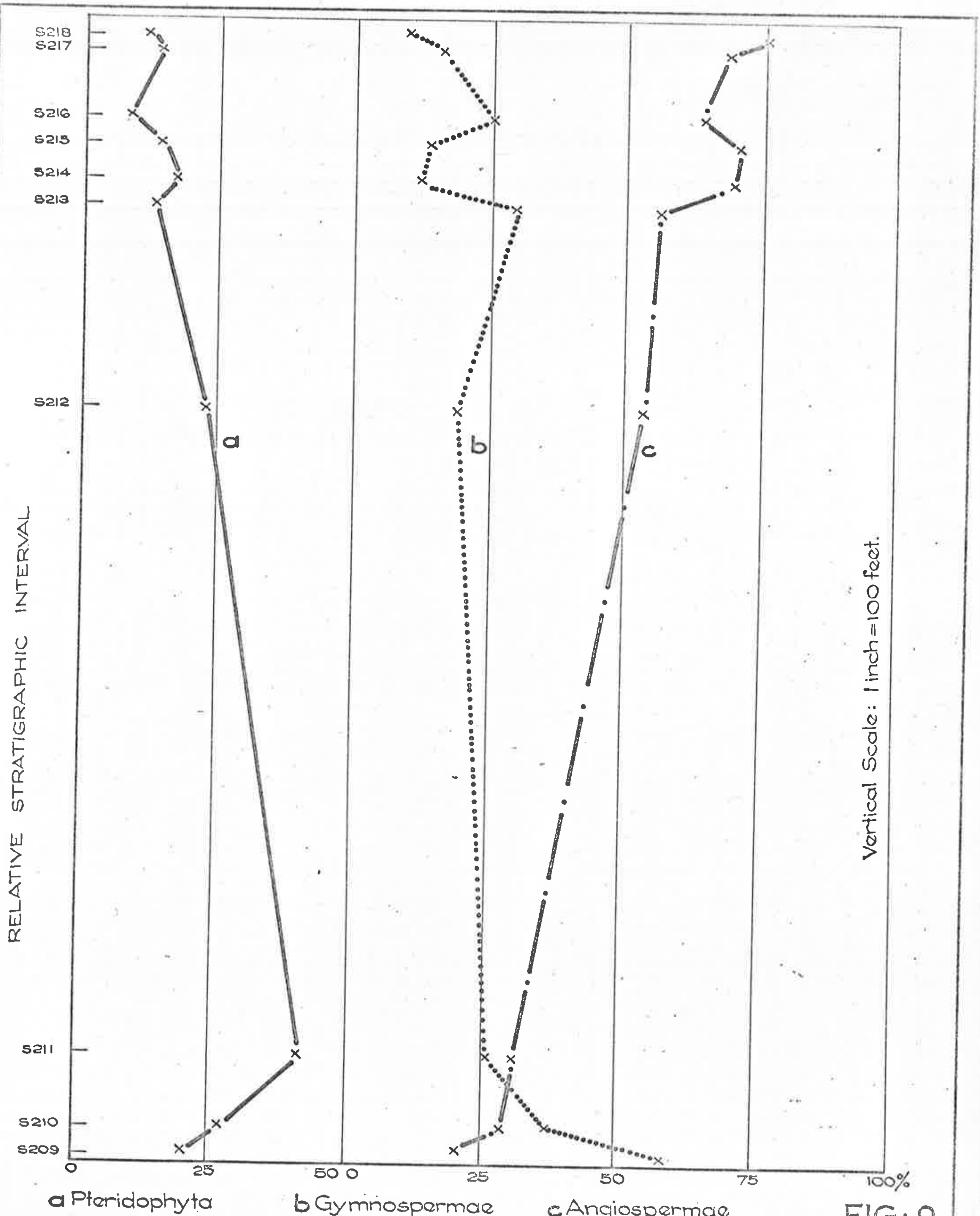


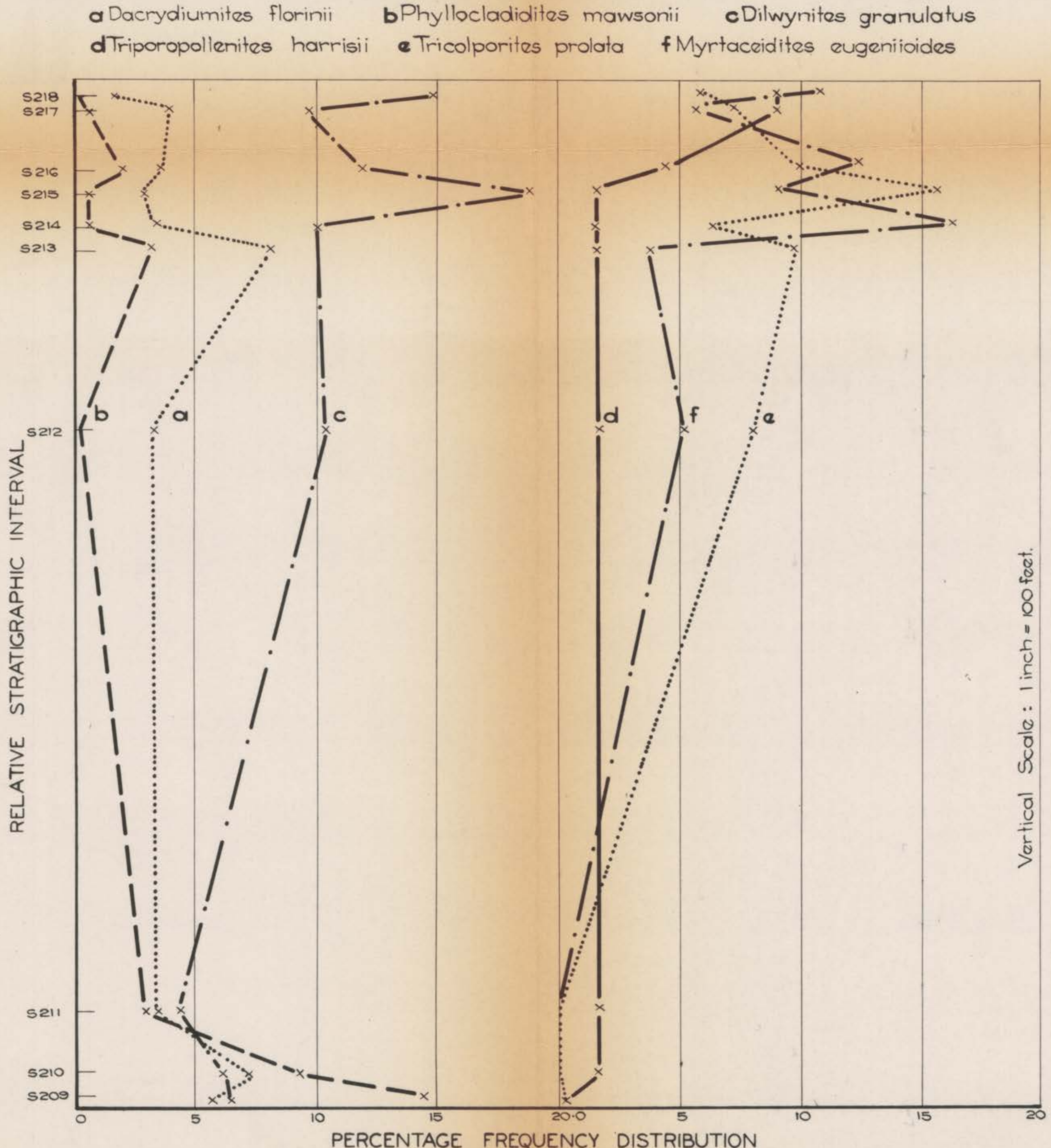
FIG: 9

GRAPH SHOWING PERCENTAGE FREQUENCY OF THE MAJOR PLANT GROUPS IN THE LOWER TERTIARY SECTION PRINCETOWN VICTORIA

The interpretations of floral migrations and fluctuations in relation to climatic conditions prevailing at the time of deposition is dependant firstly on the certainty to which indicative form genera and species can be related to extant genera. Of these only a small proportion exhibit significant changes in frequency in this section. Secondly the relative pollen fall of any of these species is unknown. Thus any conclusions drawn regarding climatic conditions must necessarily therefore be only a hypothesis.

Oxygen isotope palaeotemperature measurements of molluscs from the Pebble Point Formation assayed at 10.6°C and 11.8°C (Dorman and Gill 1959). These authors did not reach any firm conclusions on the evidence available but indicated that the mean temperature was less than in the Eocene of the Brown's Creek Clay, Cape Otway district.

Figure 9 illustrates the frequency changes of the three major plant groups, and Figure 10, frequency changes of six selected species. Due to inaccessibility of much of the area there is a lack of samples between S211 and S213 of the section. Considering fig. 9 it is evident that from the base of the Pebble Point Formation to the top of the Princetown Member there is a substantial increase in angiosperm pollen accompanied by a corresponding decrease in gymnosperm pollen. These curves indicate migration of angiosperms near to the area of deposition and in particular reflect relative increases in mean annual temperature throughout the sequence. Frequencies derived from samples S213 and S216 indicate a particularly



GRAPHS SHOWING PERCENTAGE FREQUENCY DISTRIBUTIONS OF SOME SELECTED SPECIES

FIG: 10

rapid increase and fall in mean temperature conditions and are accompanied by the marine ingressions, the "*Trochocyathus* bed" and the "*Turritella* bed."

The distribution frequency of pteridophyte spores in Fig. 9(a) is difficult to evaluate. The upper portion of the curve follows the trend in the frequency distribution of the angiosperms. The lower section however suggests that there is possibly a significant over-representation of these spores.

The dominance of gymnosperms, particularly those related to the genus *Dacrydium*, in the lower portion of the section suggests that a cool temperature climate prevailed, similar to that of Tasmania today. The increase in dominance of the angiosperm elements of the flora, e.g. Myrtaceae indicate a gradual climatic shift to a warm temperature or sub-tropical climate similar to that existing in the MacPherson - MacLeay Overlap (Burbidge 1960) in eastern Australia. The presence of a relatively high proportion of gymnosperms in this section can possibly be explained by the presence of cooler climatic conditions in topographically higher areas near to the sedimentary environment.

APPENDIX A

DATA ON SAMPLES STUDIED

Outcrop and bore samples are listed and described macroscopically under headings of localities from which they were obtained, together with relevant stratigraphic data. All samples are retained in the South Australian Department of Mines' collection. SADM and VDM indicate South Australian and Victorian Mines Department bores respectively. The data are set out such that the depth (in feet) of the sample is followed by the rock type, the stratigraphic unit and finally the preparation number.

Eucla Basin

1. SADM Pidinga Bore, sludge samples comprise:

Depth (ft.)	Rock Type	Stratigraphic Unit	Preparation
2.5 -13.5	Silt, carbonaceous	Pidinga Formation	S238
13.5 - 25.0	" "	" "	S236
25.0 - 34.5	" "	" "	S237
41.5 - 44.2	" "	" "	S239

2. Nullarbor No. 6 Bore, cuttings samples comprise:

344 - 400	Black mudstone	Pidinga Formation	S623
400 - 430	" "	" "	S622

Polda Basin

1. SADM Polda No. 1 Stratigraphic Hole, Core Samples comprise:

118	Silt, dark brown	Poelpena Formation	S559
123	Sand, carbon-aceous	" "	S560
161	Lignite, dark brown	" "	S561
170	" " "	" "	S562
181	Sand, lignitic	" "	S563
190	Lignite, dark brown	" "	S564

2. SADM Kopi anomaly Bore KR9. Core samples comprise:

140 - 122	Sand, black lignitic	Poelpena Formation	S359
140 - 142	Clay, dark brown	" "	S355
160 - 162	Lignite, dark brown	" "	S356
180 - 182	Clay, grey	" "	S357
200 - 202	Clay, grey	" "	S360

Cummins Basin

1. SADM Observation Bore 113, Hundred of Uley, Co. Flinders;

   Sludge sample from 70 - 80 feet - Wanilla Formation.

   Preparation S87.

2. SADM Bore Hundred of Cummins, Co. Flinders. Sludge samples

   comprise:

87 - 100	Carbonaceous sandy silt	Wanilla Formation	S661
117 - 142	" " "	" "	S660
142 - 149	" " "	" "	S649
149 - 157	" " "	" "	S659
161 - 165	" " "	" "	S658
192 - 206	" " "	" "	S657
225 - 227	" " "	" "	S656
230 - 238.5	" " "	" "	S655
273 - 275	" " "	" "	S654
278 - 280.5	" " "	" "	S653
315.5 - 317.9	" " "	" "	S652
374 - 382	" " "	" "	S650

<u>Pirie - Torrens Basin</u>

1. Santos Wilkatana Bore 1. Core samples comprise:

325.3	Silt, black, carbonaceous	Wilkatana Formation	S647
351.3	" " "	" "	S648

2. SADM Lake Torrens Bore 3A. Core samples comprise:

603 - 605	Silt, carbon-aceous	Wilkatana Formation	S246
813 - 814	" "	" "	S241
885 - 887	" "	" "	S450

Great Artesian Basin

1. Enterprise Exploration Co. Cootabarlow Bore 2. Core samples comprise:

515	Siltstone, carbonaceous	Wilkatana Formation	S546
536	" "	" "	S547
550	Mudstone, carbonaceous	" "	S1084
581	Siltstone, carbonaceous	" "	S1086

2. Patchewarra Bore. Sludge sample from 600 - 620 feet. Black carbonaceous silt. Murnpeowie Formation. Preparation S919.

3. Currawarra Bore. Core sample from 312 feet. Black carbonaceous silt. Preparation S920. Murnpeowie Formation.

4. Muloowurtina Bore 2. Sludge sample from 415 0 445 feet. Black carbonaceous silt. Preparation S914. Murnpeowie Formation.

5. East of Lake Frome Bore 1. Sludge sample from 290 - 293 feet. Black carbonaceous silt. Preparation S917. Murnpeowie Formation.

6. Cannuwaukaninna Bore. Core samples comprise:

109	Brown silt carbonaceous	Murnpeowie Formation	S715
127	" " "	" "	S710
150	" " "	" "	S716
158	" " "	" "	S717

7. SADM Lake Eyre Bore 20. Core camples comprise:

156	Brown siltstone	Murnpeowie Formation	S21
164	" "	" "	S20
240	Grey siltstone	" "	S17

<u>Willochra Basin</u>

1. Willochra Test Bore No. 2. Sludge samples comprise:

78 - 90	Black sandy silt	See Twidale Sands	S742
98 - 102	" " "	" "	S743
102 - 130	" " "	" "	S744

<u>Walloway Basin</u>

1. Ororoo Bore. Core samples comprise:

567	Black, sandy silt	Walloway Sands	S691
568	" " "	" "	S692

St. Vincent Basin

1. SADM Inkerman-Balaklava Coalfield Bore 32. Core samples comprise:

125	Sandy clay,black	Clinton Coal Measures	S220
161	Lignite, dark brown	" " "	S221
175	" " "	" " "	S222
198	Sandy clay, brown	" " "	S223
218	Lignite, clayey	" " "	S224
251	Lignite, dark brown	" " "	S225
263	Silty clay, light brown	" " "	S226
291	Silt, light brown	" " "	S227

2. SADM Clinton Coalfield Bore 23. Core samples comprise:

210	Lignite, clayey	Clinton Coal Measures	S329
235	Lignite	" " "	S330
244	"	" " "	S331
255	"	" " "	S332
270	Silt, lignitic	" " "	S333
275	Sand, lignitic	" " "	S334
285	Lignite	" " "	S335
300	Lignitic silt	" " "	S336
318	" "	" " "	S337

3. SADM Observation Bore F, Port Gawler. Cores comprise:

734	Mudstone, dark grey glauconitic	Blanche Point Marls	S141
735	" " "	" " "	S321
830	Grey, glauconitic marl	" " "	S318
875	Clay, carbonaceous glauconitic	" " "	S320
1050	Lignite, brown	Clinton Coal Measures	S188
1065	Siltstone, carbonaceous	" " "	S229

4. SADM Morphett Street Bridge Bore 14. Cores comprise:

56	Silt, calcareous carbonaceous	Blanche Point Marls	S461
67	" " "	" " "	S462
82	" " "	" " "	S453
89	" " "	" " "	S552

5. SADM Government Offices, Bore 4, Victoria Square.

Core samples comprise:

92	Clayey silt, dark grey	Blanche Point Marl Correlative	S349
96	" " " "	" " " "	S348
97	" " " "	" " " "	S347
112.5	Clayey sand, grey	" " " "	S346
119	Pyritic silt, shelly, grey	" " " "	S345

122	Pyritic silt, shelly, grey	Blanche Point Marl Correlative	S344
125	" " " "	" " " "	S343
130	" " " "	" " " "	S342
145	Silt, glauconitic shelly, brown	" " " "	S339
165	" " " "	" " " "	S338
177	Silty clay, shelly, glaucon-itic	" " " "	S350
198	" " " "	" " " "	S351

6. SADM Willunga Township Bore. Sludge samples comprise:

396 - 400	Silt, dark grey	Chinamans Gully Beds	S81
405 - 409	Sand, silty, grey	" " "	S82
420 - 426	Silt, dark grey	Blanche Point Marls	S83
574 - 578	" " "	" " "	S84
635 - 644	Sand, lignitic	North Maslin Sands	S85
644 - 670	" "	" " "	S86

7. SADM Light No. 1 Stratigraphic Hole. Core samples comprise:

464	Glauconitic silt	Blanche Point Marls	S40
470.5	" "	" " "	S41
562	Glauconitic, lignitic, silt	" " "	S42

8. SADM Hundred of Boucaut Bore 4. Core samples comprise:

172	Brown lignite	Clinton Coal Measures	S323
212	" "	" " "	S322

9. SADM Hundred of Barunga Bore 4. Core samples comprise:

244	Brown lignite	Clinton Coal Measures	S394
249	" "	" " "	S393

9. Geosurveys Pt. Stanvac Bore 8. Core samples from 83 feet. Dark brown carbonaceous silt. North Maslin Sands. Preparation S424.

10. Leaf beds, ABM sand pit, Noarlunga, Maslin Bay. Dark brown carbonaceous clay. S1308.

Murray Basin

1. Murray Basin Oil Syndicate Keith Bore 1. Core samples comprise:

491 - 496	Carbonaceous siltstone	Buccleuch Beds	S291
528 - 532	" "	" "	S293
573 - 583	" "	" "	S290
583 - 600	" "	" "	S292
630 - 640	" "	" "	S295
675 - 695	Oolitic sandstone	" "	S129
714 - 724	Carbonaceous siltstone	Renmark Formation	S294

755 - 765	Carbonaceous siltstone	Renmark Formation	S112
775 - 785	" "	" "	S109
795 - 815	" "	" "	S108

2. SADM Bore 1 Sec. 24 Hd. Carcuma. Sludge samples comprise:

293 - 298	Clay, black, fossiliferous	Buccleuch Beds	S315
313 - 318	" " "	" "	S314
328 - 333	" " "	" "	S313
357 - 362	" " "	" "	S312
382 - 387	" " "	" "	S311
405 - 410	" " "	Renmark Formation	S310
415 - 420	" " "	" "	S309
435 - 440	Clayey sand, dark grey	" "	S308

3. SADM Canopus Bore 1. Sludge samples comprise:

526 - 536	Clay, sand, carbonaceous	Renmark Formation	S301
548 - 572	Clay, grey, gritty	" "	S300
595 - 600	Clay, grey	" "	S299
742 - 749	Sand, carbonaceous	" "	S298
860 - 881	Sand, silty, carbonaceous	" "	S297
881 - 898	" " "	" "	S296

4. Cold and Wet Bore, Coonalpyn. Slude samples comprise:

200 - 224	Silt, grey brown	Buccleuch Beds	S728
334 - 340	Silt, clayey, dark brown	Renmark Formation	S729

350 - 360	Silt, clayey, dark brown	Renmark Formation	S730
389 - 393	Lignite with coarse sand	" "	S731
480 - 485	Clayey silt, dark grey	" "	S732

5. Hd. Cotton Bore. Sludge samples comprise:

537 - 602	Clay, silty, brown	Buccleuch Beds	S733
660 - 664	Silt, dark brown	" "	S734
680 - 682	" " "	" "	S735
712 - 725	Clay, fossiliferous, dark brown	" "	S736
734 - 762	" " " "	" "	S737
762 - 794	" " " "	" "	S738

6. Company Bore, Loxton. Sludge samples comprise:

747	Silt, carbonaceous	Renmark Formation	S900
758	" "	" "	S877
760	" "	" "	S878
789	" "	" "	S879
838	" "	" "	S880
856	" "	" "	S881
883	" "	" "	S882
908	" "	" "	S883
943	" "	" "	S884
950	" "	" "	S865
1000	" "	" "	S911
1026	" "	" "	S889

1071	Silt, carbonaceous	Renmark Formation	S885
1102	" "	" "	S886
1304	" "	" "	S887
1397	" "	" "	S888
1416	" "	" "	S866
1462	" "	" "	S867
1531	" "	" "	S868
1569	" "	" "	S869
1672	" "	" "	S890
1689	" "	" "	S870

7. Australian Oil Corporation North Renmark No. 1 Well. Core samples comprise:

917 - 927	Brown lignite	Renmark Formation	S23
1210 - 1224	Carbonaceous siltstone	" "	S24
1761 - 1771	" "	" "	S25

8. Beach Petroleum Monash No. 1 Well. Core sample at 1543 - 1553 feet. Brown carbonaceous silt. Renmark Formation.

9. Moorlands Lignite, Hd. Sherlock - shaft sample, lignitic silt. Renmark Formation, Moorlands Lignite Member. Preparation S289.

10. SADM Hd. Bower Bore 1. Core sample at 441 feet. Brown lignite. Renmark Formation. Preparation S286.

11. E. & W.S. Keith Bore A (Sects. 374/202) Core samples comprise:

191	Brown carbonaceous silt	Buccleuch Beds	S1491
224'6"	" " "	" "	S1490
225'4	" " "	" "	S1502
335	Black carbonaceous silt	Renmark Beds	S1492
336	" " "	" "	S1493
356	" " "	" "	S1494
375	" " "	" "	S1503
383	" " "	" "	S1500

12. Poyntz Bore, Hundred of Ettrick. Sludge samples comprise:

226	Fossiliferous grey silt	Buccleuch Beds	S703
268'5"	" " "	" "	S704
310	Dark brown carbonaceous silt	" "	S705

Gambier Embayment

1. County Grey lignite investigation Bore C.G. 8. Cores comprise:

95	Brown carbonaceous silt	Burrungle Member	S1087
100	" " "	" "	S1088
112	" " "	" "	S1089
121	" " "	" "	S1090
149	" " "	" "	S1092
156	" " "	" "	S1093
166	" " "	" "	S1094

2. E. & W.S. Kingston Bore 1. Sludge samples comprise:

190 - 200	Black glauconitic silt	Lacepede Formation	S1188
200 - 210	" " "	" "	S1189
210 - 218	Black clayey sand	?Kongorong Sand	S1190

3. F. Jose Bore. Hd. Spence Sec. 28. Sludge samples comprise:

250 - 260	Brown sandy clay	Kongorong Sand	S1178
260 - 270	" " "	" "	S1179
270 - 280	" " "	" "	S1180
280 - 290	" " "	" "	S1181

4. Comaum No. 1A Bore. Core samples comprise:

357	Brown silt	Buccleuch Beds	S6
362	" "	" "	S529
374	Brown lignite	Bahgallah Formation equivalent	S502

5. Beach Petroleum Geltwood Beach No. 1 Well. Core 1 at 2000 - 2015, brown sandy clay. S161.

6. Dartmoor No. 1 Bore. Sludge samples comprise:

68 - 115	Black carbonaceous silt	Dartmoor Formation	S1395
130 - 169	" " "	" "	S1396
234 - 257	" " "	" "	S1397
301 - 302	" " "	" "	S1398
331 - 350	" " "	" "	S1399

7. Dartmoor No. 4 Bore. Sludge samples comprise:

134	Black carbonaceous silt	Dartmoor Formation	S1400
163	" " "	" "	S1401
206	" " "	" "	S1402

8. McEwens Settlement Bore (Drajurk No. 1), Parish of Drajurk. Sludge samplés comprise:

104 - 121	Black carbonaceous silt	Dartmoor Formation	S1403
130	" " "	" "	S1409
180	" " "	" "	S1404
190	" " "	" "	S1385
248	" " "	" "	S1405
300	" " "	" "	S1406
330	" " "	" "	S1410
350	" " "	" "	S1411
370	" " "	" "	S1386
400	" " "	" "	S1412
440	" " "	" "	S1413
460	" " "	" "	S1388
480	" " "	" "	S1414
520	" " "	" "	S1416
560	" " "	" "	S1387
580	" " "	" "	S1417

9. Dartmoor Formation outcrop samples, near Dartmoor.

Dark brown carbonaceous silts, S506, S841, S826.

Port Campbell Embayment

1. V.M.D. Latrobe No. 1 Bore. Core samples comprise:

200	Brown silty clay	Wangerrip Group (undifferentiated)	S509
208	" " "	" " "	S510
312	" " "	" " "	S511
419	" " "	" " "	S512
493	" " "	" " "	S514
591	" " "	" " "	S515
659	" " "	" " "	S516
691	" " "	" " "	S517
750	" " "	" " "	S518
868	" " "	" " "	S519
971	" " "	" " "	S520
1003	" " "	" " "	S521
1094	" " "	" " "	S522
1171	" " "	" " "	S523
1229	" " "	" " "	S524
1280	" " "	" " "	S525
1400	" " "	" " "	S526
1509	" " "	" " "	

2. Princetown to Dilwyn Bay - for samples S208 - 218 see Harris 1965a Appendix. Additional outcrop sample from the Princetown Member comprise S923 - Top of the Member, S834 - Middle of the Member.

Aire Coast

Outcrop samples from the following formations:

1. Johanna River sands, exposed in Brown's Creek. Black carbonaceous silty sands, sample number S818, S819, S823, S824.

2. Brown's Creek Clays, exposed in landslip west of Brown's Creek.

   S485 Brown carbonaceous clay 50 feet above greensand.

   S861 Brown calcareous clay. 30 feet below greensand.

Anglesea Embayment

1. Outcrop samples of the Demons Bluff Formation: Purple to black carbonaceous silts, sample numbers S475, S473, S471.

2. Outcrop samples of the Eastern View Coal Measures exposed in Coalmine Creek, black lignite, samples S469, S467 and S466.

3. V.D.M. Paraparap Bore 1, District of Anglesea. Core samples comprise:

62	Brown lignite	Demons Bluff Formation	S1239
99	" "	" " "	S1240
340	" "	Eastern View Coal Measure	S1235

4. V.D.M. Angahook Bore 61, District of Anglesea. Core samples comprise:

40 - 43	Brown lignitic silt	Demons Bluff Formation	S1245
445 - 446	Brown lignite	" " "	S1246
463 - 467	" "	" " "	S1247
650 - 653	" "	" " "	S1249
1257 -1260	Black lignite	Eastern View Coal Measures	S1250

Gippsland Basin

1. Moolamoona Mine. Childers Formation. Brown lignite. Samples S1115, S1099.

2. S.E.C. Tong Bong No. 146 core at 530 feet. Traralgan No. 2 seam. Carbonaceous clay. S1100.

3. S.E.C. Tong Bong No. 147 core at 130 feet Traralgan No. 1 seam. Lignite. S1102.

4. S.E.C. Tong Bong No. 150 core at 280 feet. Traralgan No. 1 seam. Lignite S1114.

5. S.E.C. Narracan No. 2657. Core samples of the Yinnear Group comprise:

183	Dark brown lignite	S1275
187	" " "	S1276
189	" " "	S1277
194	" " "	S1301
197	" " "	S1278

6. Rosedale No. 1 Bore. Core samples comprise:

237	Brown coal	Latrobe Value Coal Measures	S1047
468	" "	" " " "	S1046
476	" "	" " " "	S1130
878	" "	" " " "	S1045
1072	" "	" " " "	S1044
1278	" "	" " " "	S1043
1665	" "	" " " "	S1041
1882	" "	" " " "	S1131
1989	" "	" " " "	S1040
2191	Grey carbonaceous clay	" " " "	S1039
2277	" " "	" " " "	S1038
2287	" " "	" " " "	S1132

7. Wurruk Wurruk No. 1. Core samples comprise:

2459	Brown sandstone	Latrobe Valley Coal Measures	S1054
2517	Brown Coal	" " " "	S1053
2537	" "	" " " "	S1052
2742	" "	" " " "	S1051
2784	" "	" " " "	S1050
2990	Grey carbonaceous silt	" " " "	S1049
3094	Grey clay	" " " "	S1048

8. Nuntin No. 2. Core samples comprise:

3035	Brown coal	Latrobe Valley Coal Measures	S1057
3134	" "	" " " "	S1129
3206	" "	" " " "	S1056
3227	Grey clay	" " " "	S1055

9. Bengwarden South No. 1. Core samples comprise:

3199	Brown Coal	Latrobe Valley Coal Measures	S1037
3290	Carbonaceous siltstone	" " " "	S1036
3610	Brown coal	" " " "	S1035
3672	" "	" " " "	S1034
3700	Carbonaceous silt-stone	" " " "	S1033
3834	Grey clay	" " " "	S1133
3927	" "	" " " "	S1032

APPENDIX B

Lithological logs of newly described or redefined type formations

The depth in feet is followed by the lithology of the sediments.

PIDINGA SANDS

Nullarbor No. 6 Bore

344 - 400	Dark brown carbonaceous silt.
400 - 430	Brown carbonaceous silt.

POELPENA FORMATION

Polda No. 1 Stratigraphic Bore

55 - 65	Sand, brown, fine, slightly clayey.
65 - 105	Sand, dark brown, medium well rounded quartz grains, slightly clayey.
105 - 110	Sand, dark brown, carbonaceous, fine to medium grained quartz, well rounded, poorly sorted, grains up to 5 mm. in diameter.
110 - 115	Silty sand, micaceous, dark brown, poorly sorted, well rounded quartz grains up to 5 mm. in diameter.

115 - 122	Core - Silt, dark brown, mottled, carbonaceous, pyritic, micaceous with occasional wood fragments.
122 - 123	Core - Silt, sandy, dark brown, carbonaceous and micaceous.
123 - 158	Sand, fine to coarse, predominantly coarse near base of unit, carbonaceous, micaceous.
158 - 160	Lignitic silt, dark brown.
160 - 170	Core - Lignite, dark brown to black.
170 - 172	Core - Lignite, slightly sandy.
172 - 180	Sand, lignitic, medium, subangular to rounded quartz.
180 - 187	Core - Sand, lignitic, coarse to medium quartz grains.
187 - 190	Core - Lignite, dark brown.
190 - 193	Core - Lignite, dark brown, sandy, pyritic.
193 - 194	Core - Sand, black, lignitic, medium grained quartz, rounded.
194 - 224	Sand, brown, coarse to angular to subrounded quartz grains.

Kopi KR9 Bore

120 - 122	Core - Sand, coarse to grit size, grey clayey.
122 - 140	Sand, fine to coarse, dark grey to black, lignitic.
140 - 142	Core - Clay, dark brown, lignitic, minor fine quartz, micaceous.
142 - 160	Clay, lignitic, dark grey to brown slightly sandy.
160 - 162	Core - Lignite, clayey, gritty, dark brown.
162 - 180	Clay, sandy, lignitic, very dark grey.
180 - 182	Core - Clay, grey, gritty, quartz grains rounded.
180 - 200	Clay, grey, gritty, lignitic, dark grey.
200 - 202	Core - Clay, grey, gritty, lignitic.
202 - 210	Clay, lignitic, gritty, dark grey.
210 - 220	Sand, grey, clayey, slightly lignitic.

WANILLA FORMATION

Cummins School drainage Bore

0 - 14.5	Yellowish brown sandy clay.
14.5 - 30	Reddish brown and grey mottled sandy clay.
30 - 85	Light reddish brown mostly medium quartz sand with subangular to subrounded quartz grains and limonite.
85 - 107	Yellow, fine somewhat micaceous sand with fine subrounded to subangular quartz grains.
107 - 115	Creamy white and grey fine to medium sand with subrounded quartz grains.
115 - 117.5	Brown lignite.
117.5- 153	Black earthy lignite.
153 - 195	Dark brown sandy lignitic clay.
195 - 240	Grey carbonaceous sand with mica flakes.
240 - 244	Grey to dark brown micaceous sandy and clayey silt with lignitic matter, resin and plant fibres.
244 - 255	Grey micaceous carbonaceous silty sand with medium to coarse quartz grains.

255 - 275	Grey fine to coarse micaceous sand.
275 - 282	Grey-brown micaceous carbonaceous silty sand.
282 - 330	Grey fine to coarse micaceous clayey sand.
330 - 400	Light grey silty grit and sand.
400 - 429	Light grey quartz schist derivative.
429 - 466	Grey white clayey fine sandstone.
466 - 476.5	Bedrock.

Cummins Police Drainage Bore

0 - 142	No samples.
142 - 169	Grey silty grit with angular medium coarse quartz.
169 - 182	Dark brown micaceous carbonaceous sandy silt.
182 - 205	Dark brown highly carbonaceous.
205 - 214	Grey silty grit and sand.
214 - 228	Brown grey lignitic silt with lignitic matter and resin.
228 - 234	Grey-white medium and coarse sand with lignitic matter.

BURRUNGLE MEMBER of the KNIGHT FORMATION

Bore C.G. 8.

72 - 106	Clay, grey, silty, micaceous and carbonaceous.
106 - 108	Grit and coarse sand, black, clayey.
108 - 115	Clay, brown, micaceous and carbonaceous.

Bore C.G. 9.

80 - 91	Clay, grey, silty, calcareous and carbonaceous.
91 - 102	Silt, grey brown, lignitic.
102 - 106	Silt, grey brown, laminated with brown carbonaceous clay, pyritic.
106 - 114	As for 102 - 106 but slightly gritty.

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Explanations to Plates 1-12

All figures x 750 unless otherwise specified. Plates 1-12 incorporate species that have been identified in this present study. The name of the species is followed by the sample and slide number, and the E-W, N-S co-ordinates.

Fig. 23 *Stereisporites antiquasporites* Wilson & Webster
S310/1 53.7 : 96.4

24 *Cingutriletes comaumensis* sp. nov.
ST502/18 33.4 : 102.9

25 *C. clavus* (Balme) Dettmann
S209/3 53.0 : 108.9

26 *Cyathidites australis* Couper
S209/3 26.7 : 106.0

27 *Concavissimisporites* sp.
S622/1 30.5 : 108.8

PLATE 1

Fig. 1,2 *Laevigatosporites major* (Cookson) Krutzsch
S289/1 26.7 : 96.7; S660/1 37.8 : 104.5

3 *L. ovatus* Wilson & Webster
S209/4 41.9 : 100.8

4,6,7 *Verrucatosporites confragosus* sp. nov.
S298/1 16.7 : 108.2; S360/2 38.1 : 108.2;
S298/1 34.2 : 100.3

8,18 *Perinomonoletes concretus* sp. nov.
S716/1 25.9 : 107.8; S313/1 20.6 : 109.1

9 *Verrucatosporites speciosus* Harris
ST217/12 38.2 : 104.1

10 *V.* sp.
S310/1 44.1 : 104.4

11 *V. tuberosus* sp. nov.
S310/1 20.4 : 92.2

12 *Microreticulatosporis fromensis* (Cookson) Harris
S209/2 32.8 : 96.8

13 *M. albertonensis* (Cookson) comb. nov.
ST25/1 43.8 : 10-.9

5,14 *M. validus* sp. nov.
S710/1 27.6 : 104.4; S289/1 27.2 : 95.8

15 *Peromonolites vellatus* sp. nov.
S727/1 26.2 : 100.9

17 *P. densus* Harris
S209/2 39.5 : 97.6

16,19 ?*Spinososporites* sp.
S562/1 47.1 : 94.1; S209/2 30.7 : 95.0

20 ?*Perinomonoletes* sp.
S310/1 45.9 : 103.2

21 *Todisporites gambierensis* sp. nov.
S716/1 25.2 : 109.4

22 *Cyathidites minor* Couper
S727/1 26.2 : 100.9

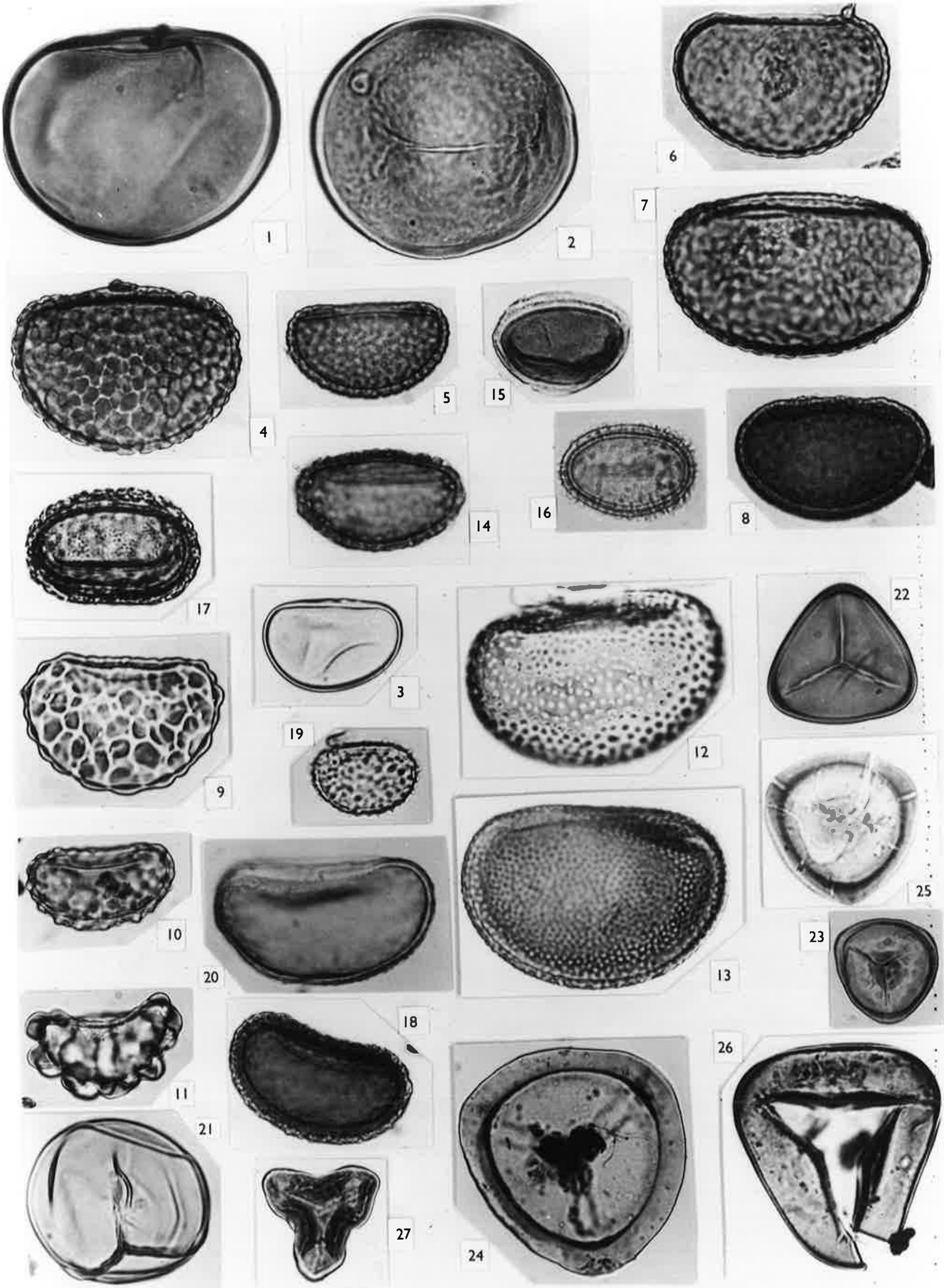

PLATE I

<u>PLATE 2</u>

Fig. 1 *Latrobosporites crassus* Harris
S209/1 41.8 : 112.6

2 *Dictyophyllidites concavus* Harris
S209/1 47.6 : 113.8

3 *D. rotundus* sp. nov.
S726/1 20.2 : 108.9

4 *Triplanosporites pseudoreticulatus* Harris
ST209/17 38.4 : 104.0

5 *Triplanosporites* sp.
ST126/1 43.0 : 98.0

6 *Polypodiaceoisporites obscurus* Harris
ST218/11 37.3 : 102.3

7 *Baculatisporites comaumensis* (Cookson) Potonie
ST208/14 38.2 : 104.8

8 *Osmundacidites* cf. *O. wellmanii* Couper
S298/1 23.9 : 109.5

9 *Gleicheniidites circinidites* (Cookson) Dettmann
S209/3 48.6 : 107.5

10 *Dictophyllidites* sp.
S20/3 36.3 : 96.2

11 *Kuylisporites* cf. *K. waterbolki* Potonie
S728/1 41.4 : 110.2

12,13, 15 *Cyathidites splendens* Harris
S546/1 48.3 : 110.4; S716/1 38.1 : 108.3;
ST209/39 35.8 : 106.2

14 *C.* cf. *C. splendens* Harris
S101/1 30.0 : 108.2

16 *Triletes gigantis* Cookson
S14/3 34.3 : 103.1

17,18 *Stereisporites* cf. *S. antiquasporites* Wilson & Webster
S209/3 49.9 : 107.9; S710/1 43.4 : 109.8

19 *Todisporites brevilaesuratus* sp. nov.
S298/1 23.7 : 98.4

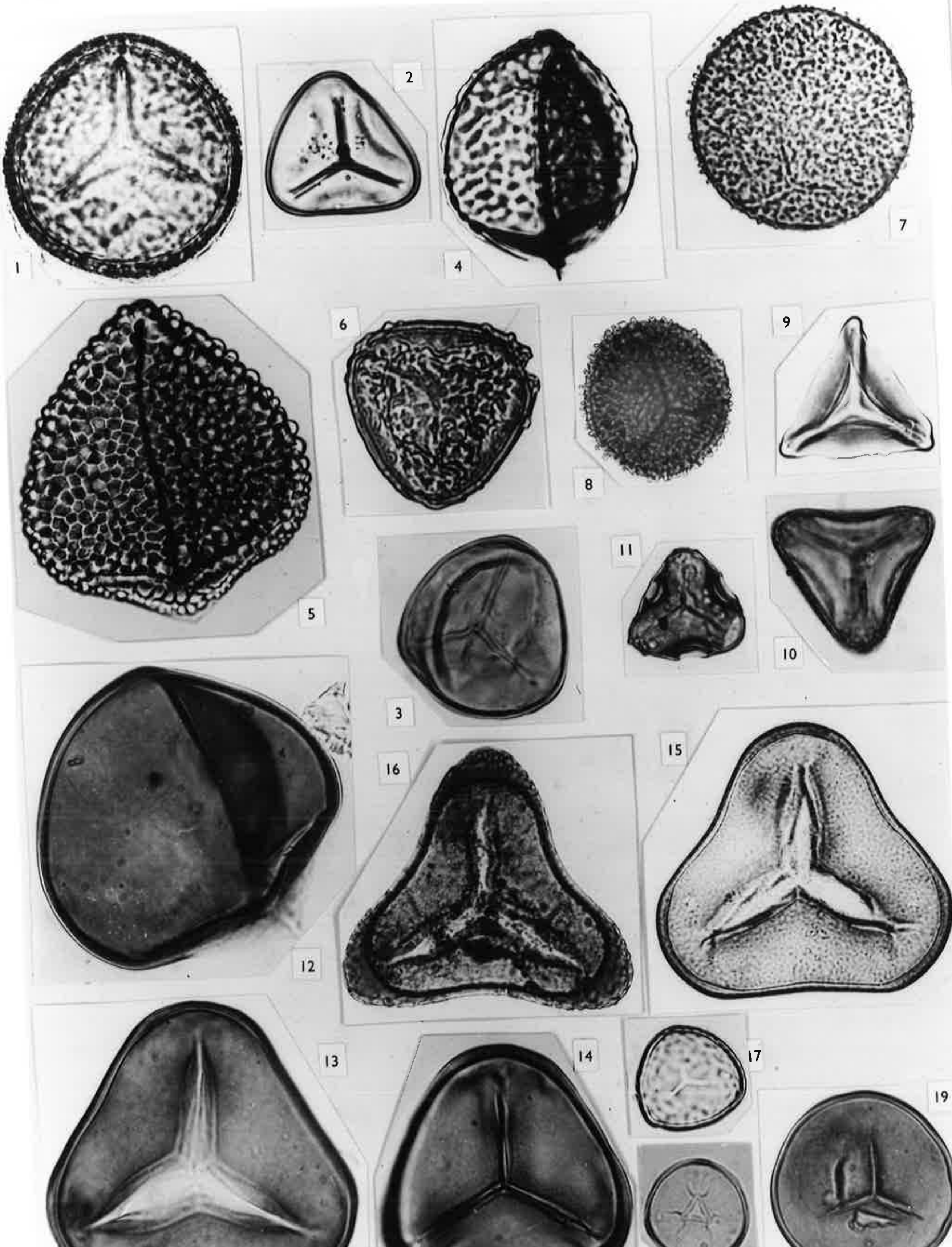

PLATE 2

PLATE 3

Fig.	1,2	*Camarozonosporites bullatus* Harris ST14/6 36.1 : 106.4; ST502/12 38.1 : 103.3
	3	Gen. et. sp. indet. S546/1 27.2 : 103.4
	4,5	*Camarozonosporites sherlockensis* sp. nov. S289/1 43.2 : 104.2; S289/1 27.5 : 101.4
	6,7	*C. paleocenicus* sp. nov. S547/1 24.9 : 98.9; S751/2 35.2 : 100.4
	8	*C. buccleuchensis* sp. nov. S730/1 36.9 : 98.7
	9,11	?*Ceratosporites fimbriomarginatus* sp. nov. ST502/8 39.3 : 99.7; S216/1 30.3 : 102.8
	10	?*C. striatomarginatus* sp. nov. S21/1 102.1 : 47.3
	12	*Trilites tuberculiformis* Cookson S727/1 44.3 : 101.1
	13	*Trilites* sp. S101/3 35.0 : 109.9
	14	?*Leptolepidites* sp. S310/1 49.8 : 94.3
	15,16	*Verrucosisporites kopukuensis* (Couper) comb. nov. S722/1 43.5 : 107.6; S730/1 28.1 : 100.3
	17	*Rugulatisporites minor* sp. nov. S730/1 37.8 : 96.6
	18	*Rugulatisporites* sp. ST502/13 37.8 : 99.4
	19	?*Camarozonosporites* sp. S710/1 48.4 : 110.2

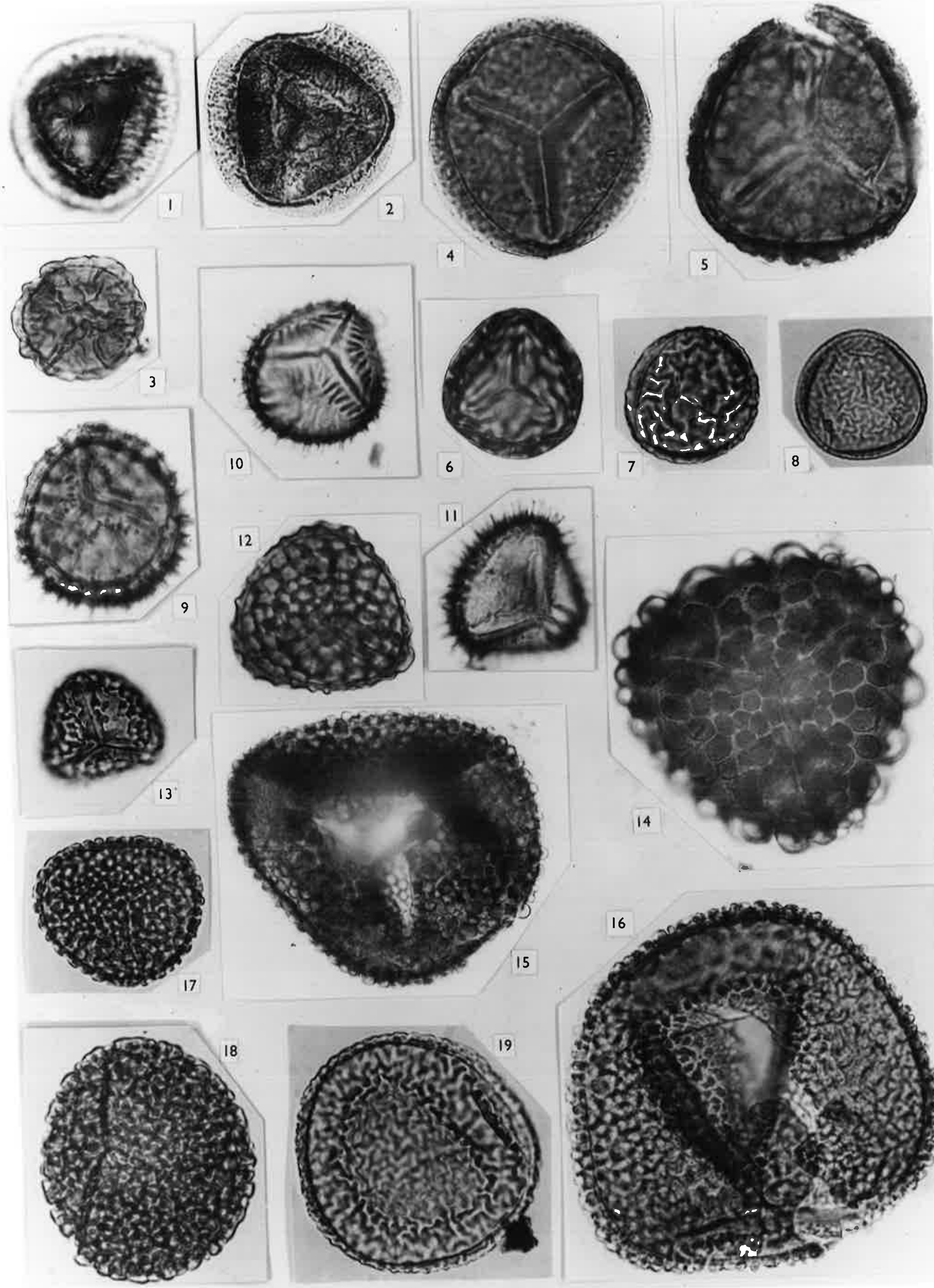

PLATE 3

PLATE 4

Fig. 1 *Kraeuselisporites papillatus* Harris
S209/1 28.6 : 111.4

2 *Camarozonosporites bullatus* Harris
ST208/6 40.5 : 101.5

3 ?*Camarozonosporites* sp.
S705/1 30.7 : 103.5

4,10 *Trilites ornamentalis* Cookson
S310/1 18.5 : 96.8; S705/1 34.9 : 103.6

5,6 *Polypodiaceoisporites cingulatus* sp. nov.
S313/1 32.3 : 108.7; S314/1 26.7 : 97.5

7,17 *Rugulatisporites minor* sp. nov.
S705/1 34.7 : 93.9; S705/1 28.2 : 95.8

8 *Lycopodiumsporites austroclavatidites* (Cookson) Potonie
S727/1 44.2 : 111.5

9 Gen. et. sp. indet.
S209/2 44.2 : 97.6

11,12,13 *Trilites concavus* sp. nov.
S726/1 20.2 : 108.9; S313/1 32.3 : 108.7
S705/1 39.7 : 103.5

14,16 *T. tuberculiformis* Cookson
S722/1 36.2 : 107.6; S730/1 33.6 : 108.2

15 *Rugulatisporites rotundus* sp. nov.
S209/1 47.6 : 113.8

18 *Ceratosporites equalis* Cookson & Dettmann
S209/1 44.2 : 92.6

19 *Januasporites spinulosus* Dettmann
S313/1 18.1 : 97.0 (?Reworked Cretaceous)

20,21,22 *Camarozonosporites sherlockensis* sp. nov.
S547/1 28.9 : 108.7; ST161/2 36.4 : 107.1
S209/1 35.1 : 112.0

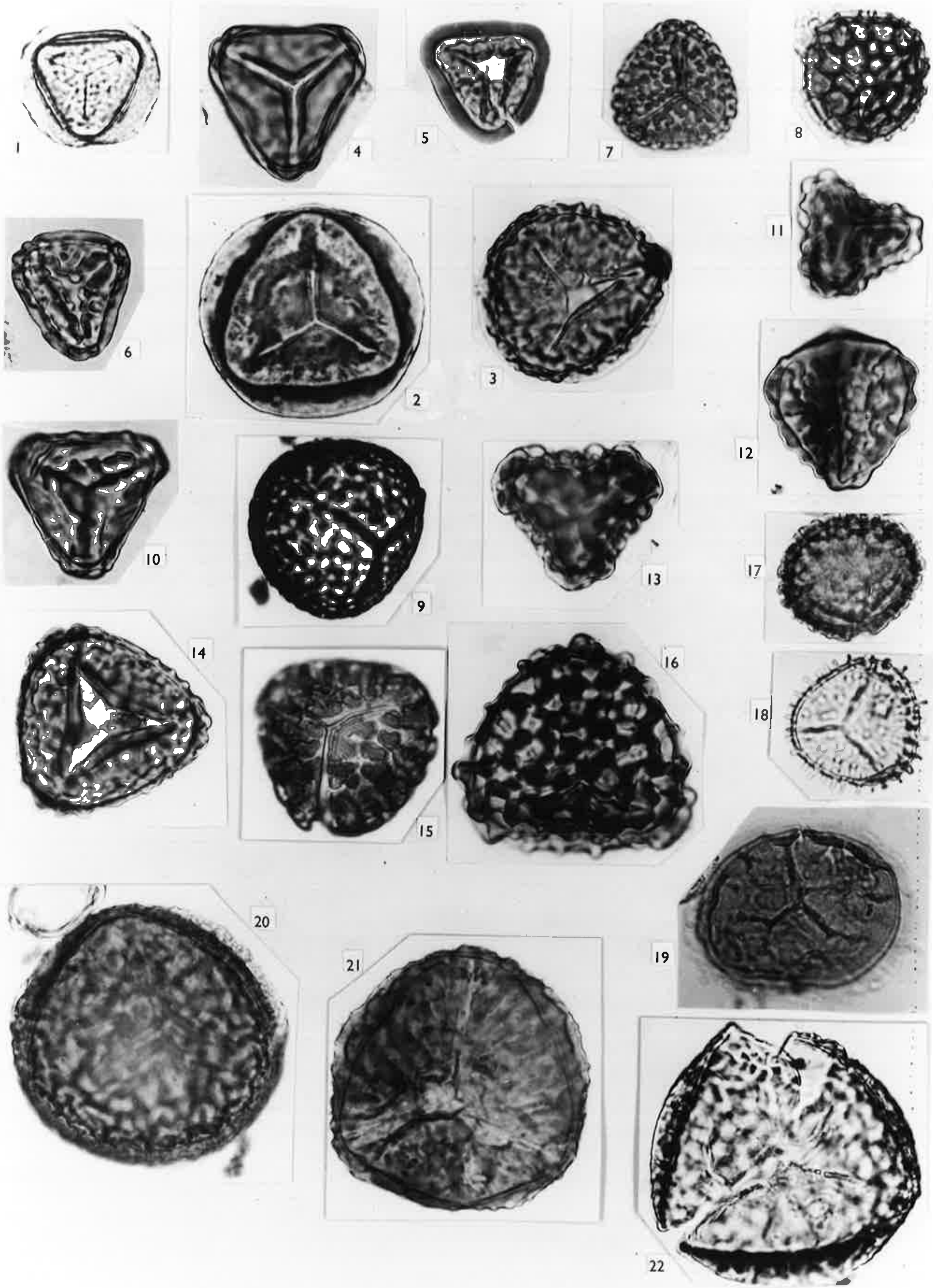

PLATE 4

PLATE 5

Fig. 1,2 *Podocarpidites* sp.
S704/1 23.1 : 104.1

3,5,18 *P. ellipticus* Cookson
S705/1 40.6 : 108.5; S705/1 32.6 : 107.4;
ST502/41 44.2 : 102.2

4,6,7,12 *Alisporites varius* sp. nov.
S705/1 38.6 : 100.2; S730/1 49.3 : 98.5;
S727/1 34.9 : 102.4; S705/1 38.6 : 100.2

8 *Phyllocladidites verrucosus* (Cookson) comb. nov.
ST502/41 44.2 : 102.2

9 *P. mawsonii* Cookson
S705/1 49.3 : 106.4

10 *Podocarpidites magnificus* sp. nov.
ST547/13 35.1 : 103.7

11 *P.* sp.
S298/1 50.7 : 106.4

13 *Alisporites grandis* (Cookson) Dettmann
S730/1 18.8 : 95.3

14 *Equisetosporites notensis* (Cookson) comb. nov.
S561/1 19.6 : 94.5 (x 1000)

15 *Dacrydiumites ellipticus* Harris
S209/3 43.1 : 108.8

16 *D. balmei* Cookson
S209/3 40.8 : 111.8

17 *D. florinii* Cookson
S209/1 37.9 : 114.0

19 *Podocarpidites exiguus* Harris
S728/1 54.5 : 111.3

20 *P. microreticuloidata* Cookson
S728/1 56.4 : 102.8

21,22 *Alisporites similis* (Balme) Dettmann
S546/1 25.5 : 107.7; S564/1 33.1 : 102.8

23 *Araucariacites australis* Cookson
S209/1 18.9 : 112.0

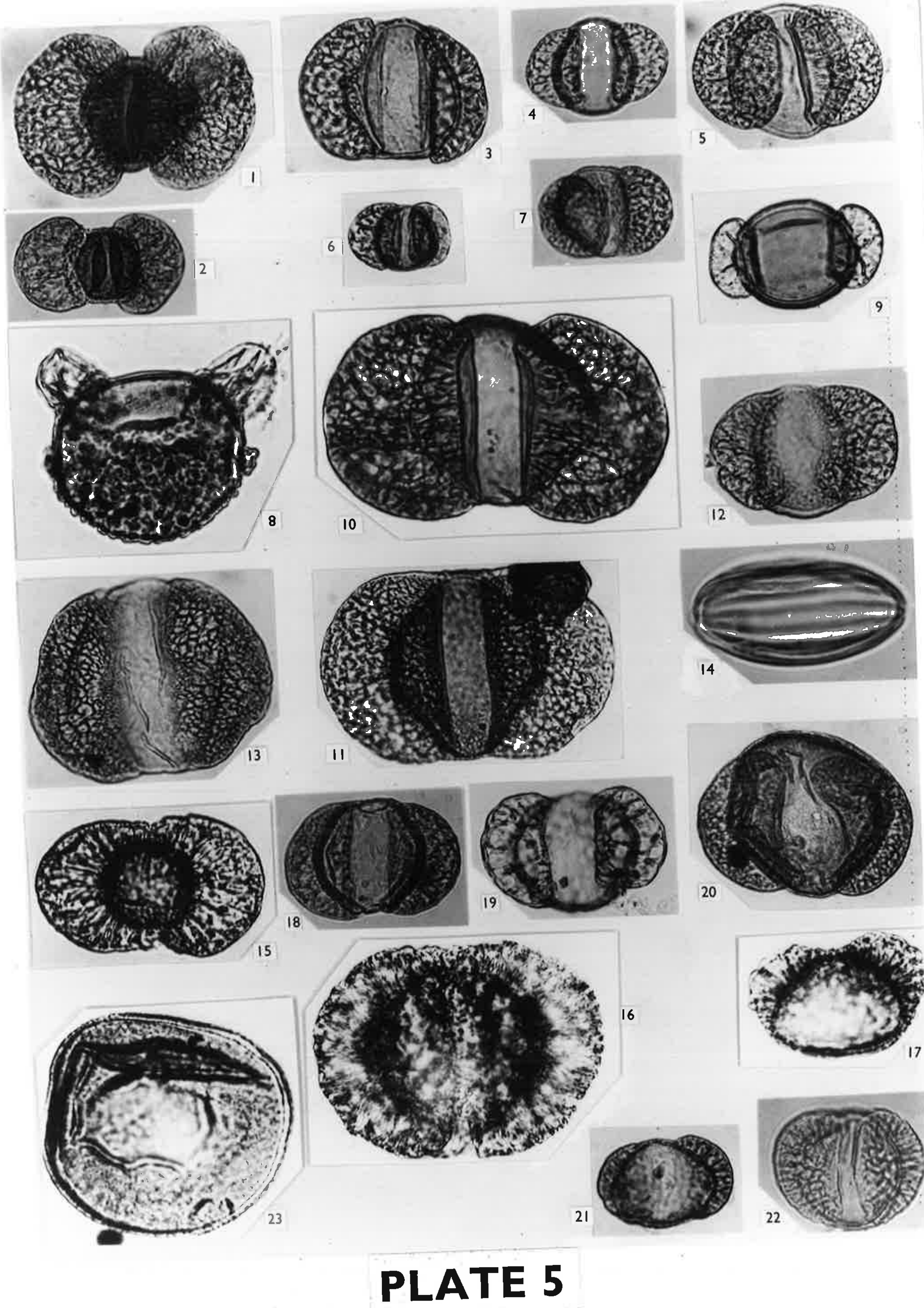

PLATE 5

PLATE 6 (cont.)

Fig. 22,25 *Graminidites psilatus* sp. nov.
S710/1 47.6 : 112.0; S310/1 36.7 : 97.4

24 *Clavatipollenites* sp.
S560/1 26.8 : 95.4

26 *Proteacidites* sp. 2-aperturate form
S289/1 35.6 : 104.2

27 *Banksieaeidites elongatus* Cookson
S210/1 32.1 : 109.6

28 *B. minimus* Cookson
S561/1 32.4 : 104.0

29 *Tricolpites gillii* Cookson
S209/2 47.9 : 103.2

30,31,32,33 *T. thomasii* Cookson & Pike
S727/1 25.8 : 105.5; S272/2 40.0 : 110.4;
S559/1 31.5 : 106.1; S650/1 57.6 : 100.4

34,35 *T. renmarkensis* sp. nov.
ST25/11 37.9 : 100.2; ST25/8 37.7 : 106.0

36 *Santalumidites cainozoicus* Cookson & Pike
S730/1 33.6 : 106.9

37 *Anacolosidites acutullus* Cookson & Pike
S211/1 51.5 : 96.4

38 Triporate sp. indet.
S17/4 38.2 : 106.1

39 ?*Anacolosidites* sp.
S298/1 36.6 : 112.6

40 *Anacolosidites comaumensis* sp. nov.
ST502/6 40.0 : 112.8

41 *A. luteoides* Cookson & Pike
S215/1 23.3 : 94.5

42 *Stephanopollenites obscurus* Harris
S209/3 39.5 : 100.8

43 ?*Echiperiporites multiporosus* sp. nov.
S559/1 24.7 : 98.0

PLATE 6

Fig. 1 *Dacrycarpites australiensis* Cookson & Pike
S209/3 30.7 : 109.6

2 *Phyllocladidites reticulosaccatus* Harris
ST209/26 42.4 : 101.5

3 *P.* cf. *P. verrucosus* (Cookson) comb. nov.
S208/1 45.1 : 99.0

4,5 *Microcachryidites antarcticus* Cookson
S209/3 24.1 : 104.7; S726/1 30.1 : 99.5

6 *Podocarpidites* cf. *P. multesimus* (Bolkovitina) Pocock
S561/1 31.6 : 108.7

7,8 *Podosporites microsaccatus* (Couper) Dettmann
S208/1 46.3 : 109.1; S209/1 31.4 : 110.7

9 *P. rotundus* sp. nov.
S546/1 35.7 : 105.4

10 *Dilwynites granulatus* Harris
S728/1 30.7 : 107.0

11 *D. tuberculatus* Harris
ST218/30 37.4 : 102.9

12,13,23 *Rectosulcites microreticulatus* sp. nov.
S546/1 14.5 : 109.6; S562/1 26.9 : 91.7;
S546/1 40.5 : 109.9

14 *Schizosporis paleocenicus* sp. nov.
S716/1 20.1 : 96.8

15 *Liliacidites varius* sp. nov.
S730/1 30.4 : 102.1

16 *L.* cf. *L. kaitangataensis* Couper
S730/1 52.8 : 107.7

17,18 *L.* cf. *L. aviemorensis* McIntyre
S563/1 27.9 : 109.5; S705/1 45.9 : 112.2

19,20 *Milfordia homeopunctatus* (McIntyre) comb. nov.
S546/1 31.9 : 105.5; S741/2 [illegible] : [illegible]

21 *Graminidites* sp.
S726/1 31.8 : 104.9

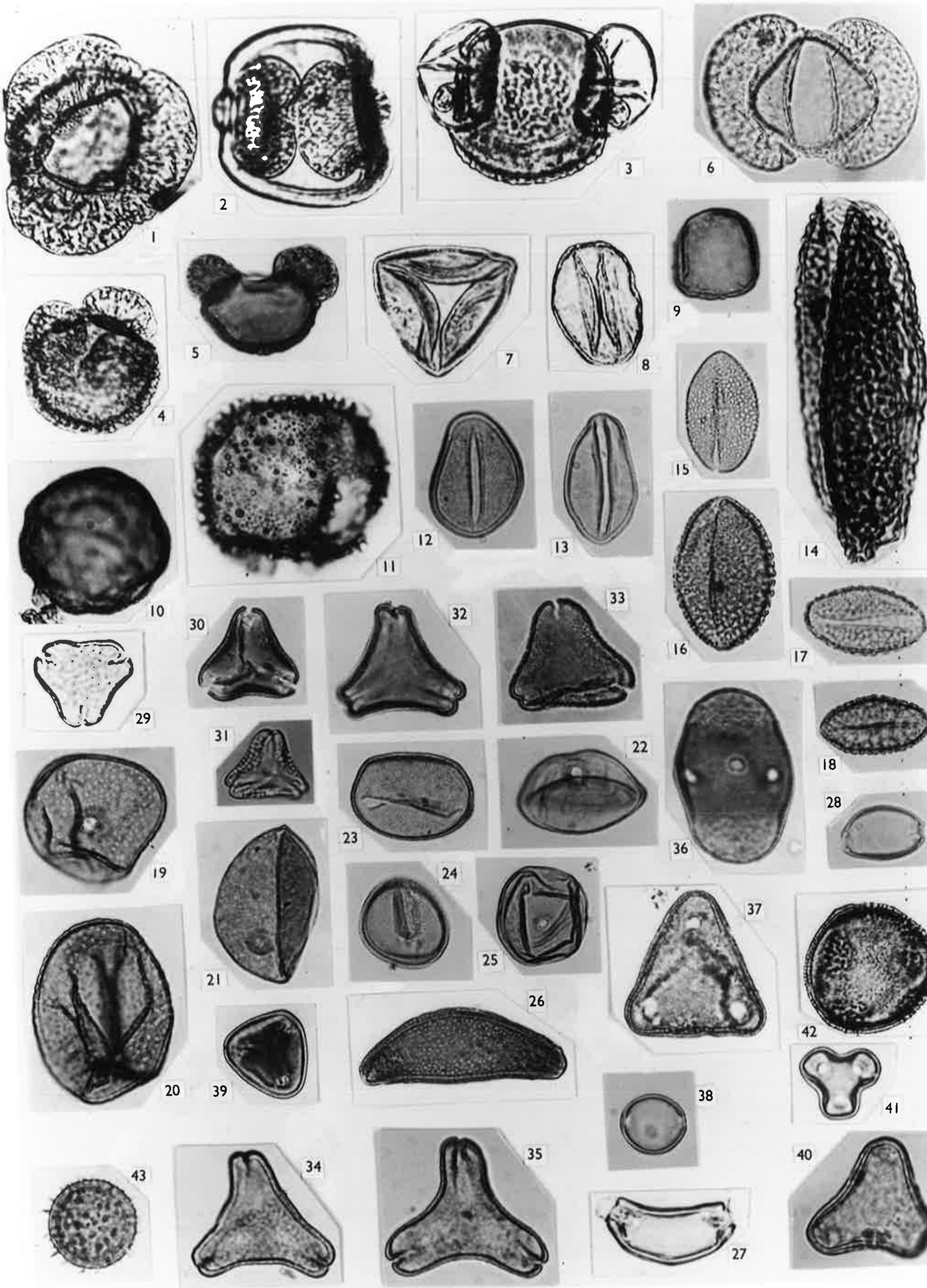
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PLATE 6

PLATE 7 (cont.)

Fig. 31,32,33	*Triorites psilatus* sp. nov.	
	ST360/15 36.9 : 101.1; S393/2 42.8 : 108.8	
	S563 43.7 : 94.5	
34	*Compositoipollenites* sp.	
	S730/1 50.4 : 100.0	
35	*Casuarinidites cainozoicus* Cookson & Pike	
	S217/1 27.6 : 101.5	
36	*Triporopollenites harrisii* (Couper) comb. nov.	
	S603/2 34.4 : 111.7	
37,38	*Ericipites lepidus* sp. nov.	
	ST360/1 35.7 : 98.9; ST90/18 41.6 : 104.6	
39,40	*E. crassiexinous* sp. nov.	
	S660/1 53.4 : 96.5; S560/1 19.8 : 107.6	
41,42	*Sapotaceoidaepollenites rotundus* sp. nov.	
	ST360/20 30.8 : 100.0; ST241/3 46.3 : 103.3	
43	*Ericipites scabratus* Harris	
	S209/2 43.7 : 112.0	
44,45	*Lakulangipollis torrensensis* gen. et. sp. nov.	
	ST241/14 32.7 : 106.8; S647/2 20.4 : 94.4	
46	*Ilexpollenites ornatus* sp. nov.	
	S289/1 18.9 : 104.1	
47,48	*Tricolporites prolata* Cookson	
	S710/1 42.8 : 101.5; S560/1 50.1 : 98.6	
49,50	*Tricolporites valvatus* sp. nov.	
	ST241/12 35.7 : 98.5; ST241/11 39.6 : 98.6	

PLATE 7

Fig. 1	*Echiperiporites diversus* (Harris) comb. nov. S209/1 45.2 : 102.1
2	*Polyporina fragilis* Harris ST209/5 40.3 : 105.5
3	Gen. et. sp. indet. ST717/1 39.6 : 101.3
4,5,6	*Simplicepollis minor* sp. nov. S546/1 46.0 : 95.7; S559/1 24.4 : 107.1; S241/1 36.6 : 103.5.
7,10,12,13	*Caryophyllidites tuberosus*, sp. nov. S559/1 40.6 : 102.5; S648/1 33.3 : 110.8; S560/1 26.6 : 104.0; S560/1 27.7 : 110.0
8,9	*Simplicepollis meridianus* Harris S101/4 38.5 : 112.6; ST218/31 32.9 : 104.6
14,15,16,17	*Tricolpites* spp. S561/1 22.4 : 108.5; S647/2 22.6 : 108.3; S562/1 52.7 : 94.7; S705/1 36.7 : 113.6
18	*Aglaoreida barungensis* sp. nov. ST325/15 43.1 : 110.8
19,20	*Tricolpites voraginosus* sp. nov. S741/2 30.0 : 105.2; S647/2 50.2 : 109.6
21	*Myrtaceidites eugeniioides* Cookson & Pike S212/1 37.9 : 105.4
22	*M. tenuis* Harris S217/1 37.3 : 107.2
23,26	*Cupanieidites orthoteichus* (Cookson & Pike) Krutzsch S560/1 28.1 : 109.1; S727/1 31.2 : 92.6
24,27,28	*Triporopollenites gemmatus* sp. nov. S647/2 39.1 : 107.2; S547/1 32.3 : 98.8 ST555/9 38.8 : 101.8
25	*Myrtaceidites mesonesus* Cookson & Pike S727/1 27.1 : 93.4
29,30	*Triorites* spp. S546/1 46.6 : 95.0; [illegible]

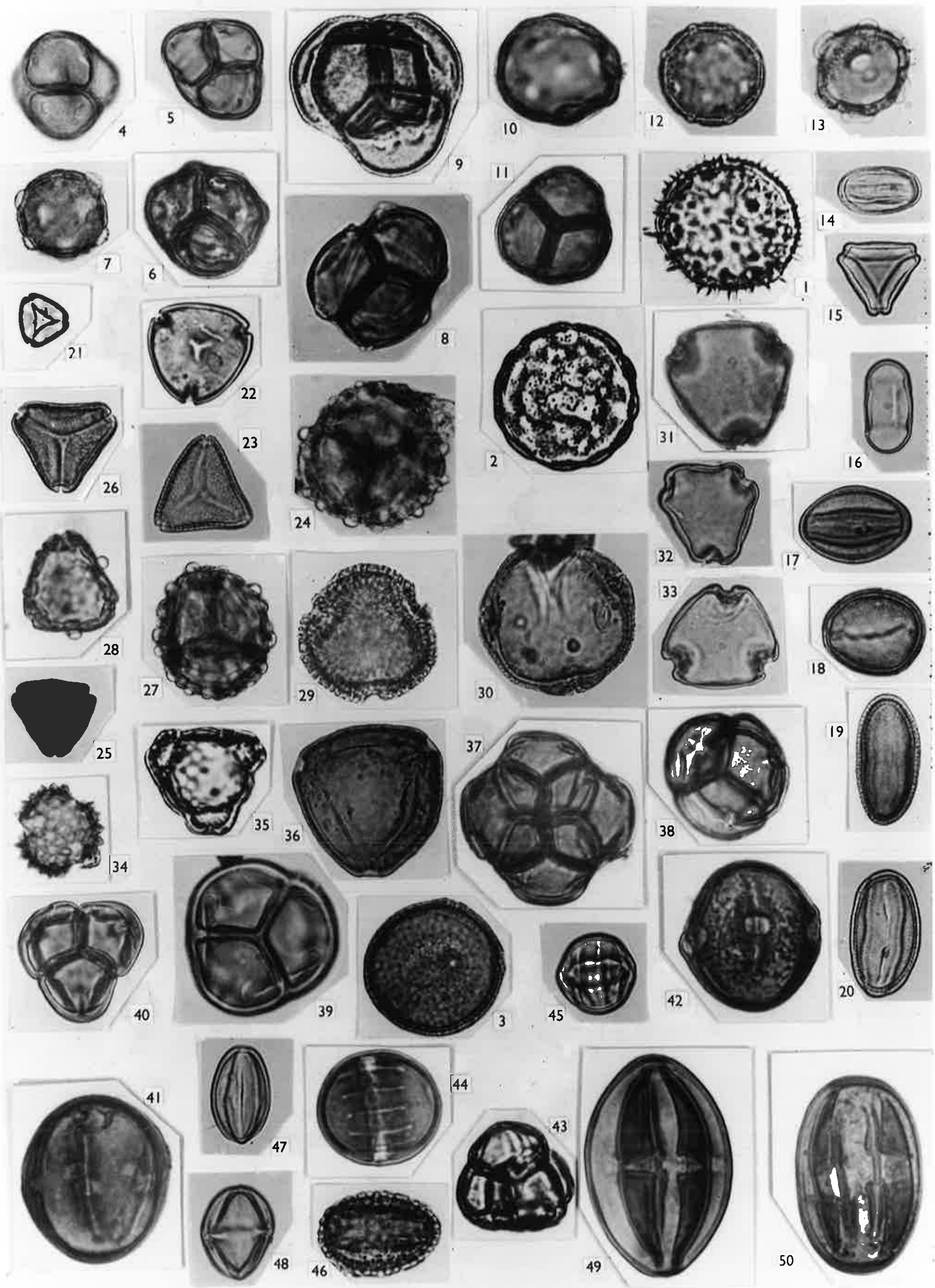
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PLATE 7

PLATE 8 (cont.)

Fig. 27	*Tricolpites* cf. *T. membranus* Couper	
	S731/1 32.0 : 107.8	
28	*Myrtaceoipollenites australis* Harris	
	S214/1 28.8 : 103.4	
29	*Beaupreaidites verrucosus* Cookson	
	S563/1 18.3 : 94.4	
30,33	*Beaupreaidites trigonalis* sp. nov.	
	S561/1 27.2 : 93.1; S561/1 36.0 : 104.3	
31	*Proteacidites tuberculiformis* Harris	
	ST218/14 39.0 : 105.2	
32	*P.* sp.	
	S705/1 27.7 : 99.8	
34,35,36,40	*P. echinatus* sp. nov.	
	S563/2 45.5 : 96.6; S563/1 40.0 : 102.1; S272/1 46.9 : 96.5; S751/2 31.5 : 98.8	
37	*P. latrobensis* Harris	
	S730/1 27.9 : 114.1	
38	*P.* aff. *P. pachypolus* Cookson & Pike	
	S560/1 23.6 : 99.3	
39	*P. obscurus* Cookson	
	S562/1 26.0 : 105.5	
41,42	*P. annularis* Cookson	
	S289/1 40.0 : 100.0; S561/1 22.4 : 104.6	

PLATE 8

Fig. 1 *Gambierina edwardsii* (Cookson & Pike) comb. nov.
ST208/2 32.8 : 104.1

2 *Tiliaepollenites notabilis* Harris
ST218/13 37.1 : 104.0

3,4 *Tricolporites adelaidensis* sp. nov.
ST228/14 39.5 : 103.0; ST555/8 34.8 : 104.6

5 *Tricolporites scabratus* Harris
ST218/4 34.3 : 105.1

6,10,15 *T.* spp.
S647/2 76.2 : 92.7; ST502/1 41.7 : 101.7;
S561/1 53.4 : 100.1

7 *T.* cf. *T. microreticulatus* Harris
ST225/3 38.9 : 105.4

8 *T. sphaerica* Cookson
S705/1 36.7 : 113.6

9 *T. prolata* Cookson
S705/1 47.5 : 100.6

11 *T. microreticulatus* Harris
ST218/1 39.4 : 100.9

12,13,23 *T. concinnus* sp. nov.
S546/1 20.1 : 98.7; S560/1 30.7 : 107.0;
S727/1 43.1 : 112.6

14 *T.* cf. *T. fissilis* Couper
S208/1 37.3 : 101.1

16,17,18 *T.* spp.
S17/4 47.5 : 112.6; S161/1 33.7 : 95.2; S107/1
32.0 : 104.6

19 *Tricolporites* aff. *T. membranus* Couper
S559/1 20.4 : 99.4

20,21,22 *Tricolporites delicatus* sp. nov.
S559/1 31.3 : 104.2; S546/1 24.8 : 97.4;
S559/1 28.7 : 104.1

24,25,26 *T.* spp.
S730/1 56.1 : 100.2; S662/1 39.3 : 109.8;
S17/4 33.4 : 103.7

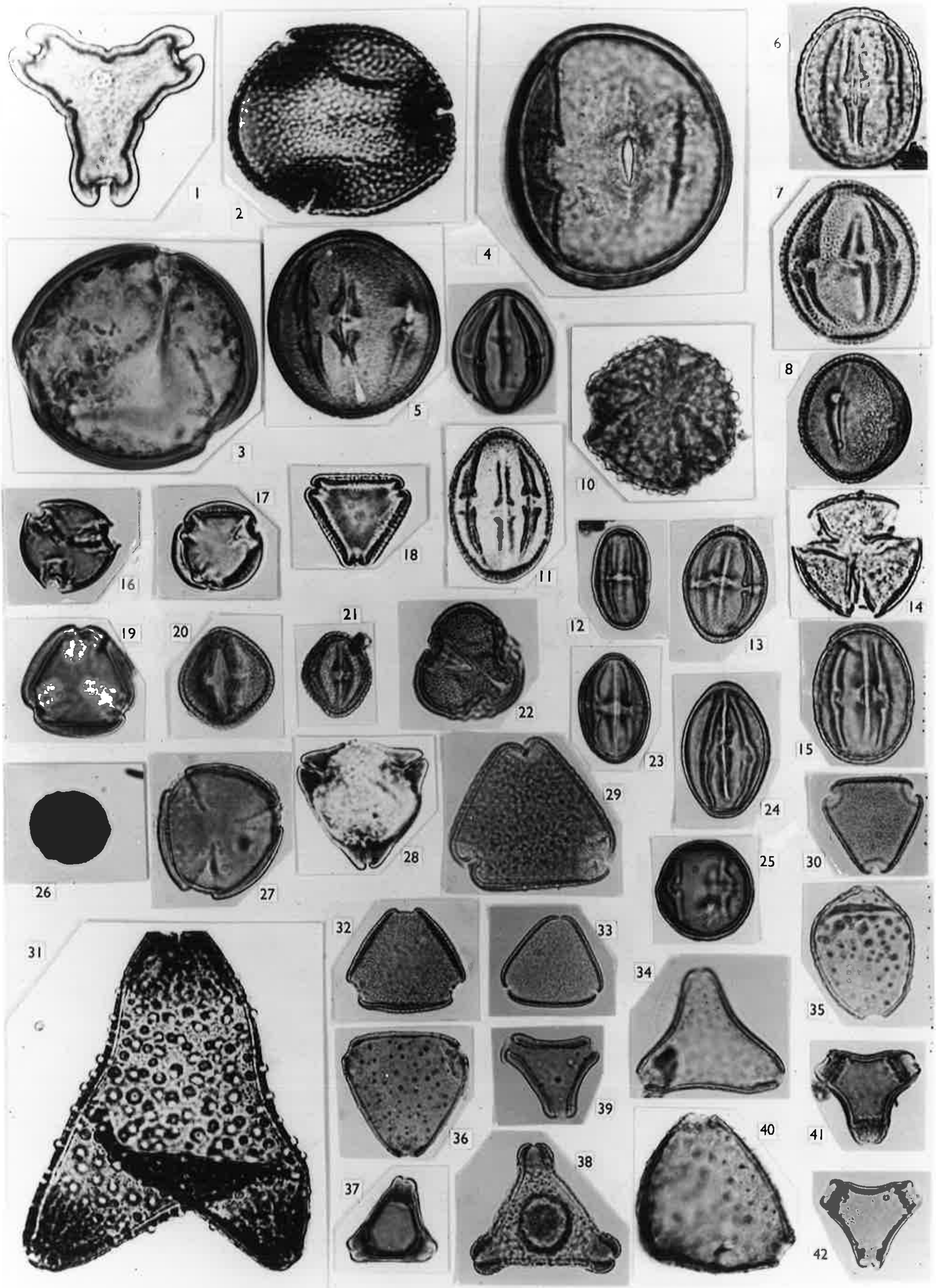
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PLATE 8

PLATE 9 (cont.)

Fig. 23,24	*P. lautus* sp. nov.	
	S289/1 40.0 : 94.2; S561/1 44.7 : 109.4	
25,26	*P. unicus* sp. nov.	
	S648/1 25.4 : 104.5; S623/1 23.6 : 109.6	
27	*P.* cf. *P. collaroides* sp. nov.	
	S716/1 35.4 : 95.5	
29	*P.* sp.	
	S560/1 32.5 : 99.5	
30	*P. obscurus* Cookson	
	S289/1 41.1 : 98.8	
31,32	*P. concretus* sp. nov.	
	S289/1 24.6 : 102.9; S360/2 36.4 : 105.8	
33	*P. latrobensis* Harris	
	ST218/38 32.0 : 101.6	
34,41	*P. ligneolus* sp. nov.	
	S715/1 50.3 : 107.7; ST218/16 38.7 : 102.8	
35	*P.* cf. *P. granoratus* Couper	
	ST208/5 42.1 : 102.8	
36	*P. parvus* Cookson	
	S209/3 45.8 : 104.6	
39	*P. similis* Harris	
	S209/2 38.7 : 100.9	
42	*Triorites clavatus* Cookson	
	ST502/21 101.8 : 35.8	
43	*Proteacidites pachypolus* Cookson & Pike	
	S560/1 46.3 : 104.7	

PLATE 9

Fig.	1	*Proteacidites* aff. *P. crassus* Cookson S730/1 29.8 : 98.5
	2	*P. lepidus* sp. nov. S561/1 35.2 : 108.6
	3,4,5	*P. varius* sp. nov. S716/1 46.7 : 112.4; S547/1 23.3 : 96.4; S562/1 37.7 : 97.5
	6	*P.* sp. S710/1 21.8 : 95.9
	7,11,19	*P. adenanthoides* Cookson S715/1 21.7 : 101.9; S210/1 33.7 : 102.0 S564/1 46.4 : 101.5
	8,9	*P.* cf. *P. asperatus* McIntyre S564/1 37.7 : 110.8; S647/2 30.1 : 95.9
	10	*P. symphyonemoides* Cookson ST217/9 39.3 : 107.9
	12	*P. paleocenicus* sp. nov. S211/2 42.8 : 108.7
	13	*P.* sp. S546/1 48.2 : 106.2
	14,16,28	*P. vulgaris* sp. nov. S710/1 42.1 : 97.4; S560/1 29.5 : 103.4; S650/1 39.6 : 107.3
	15,17	*P.* spp. S730/1 31.8 : 95.2; S705/1 31.9 : 105.6
	18	*Triorites* sp. S663/2 47.8 : 104.6
	20,37,38,40	*P. subscabratus* Couper ST217/1 34.1 : 102.6; S561/1 36.6 : 109.4; S561/1 33.7 : 101.5; S730/1 25.8 : 111.3
	21	*P. scaboratus* Couper ST218/16 38.7 : 102.8
	22	*P. granulatus* Cookson ST208/5 42.1 : 102.8

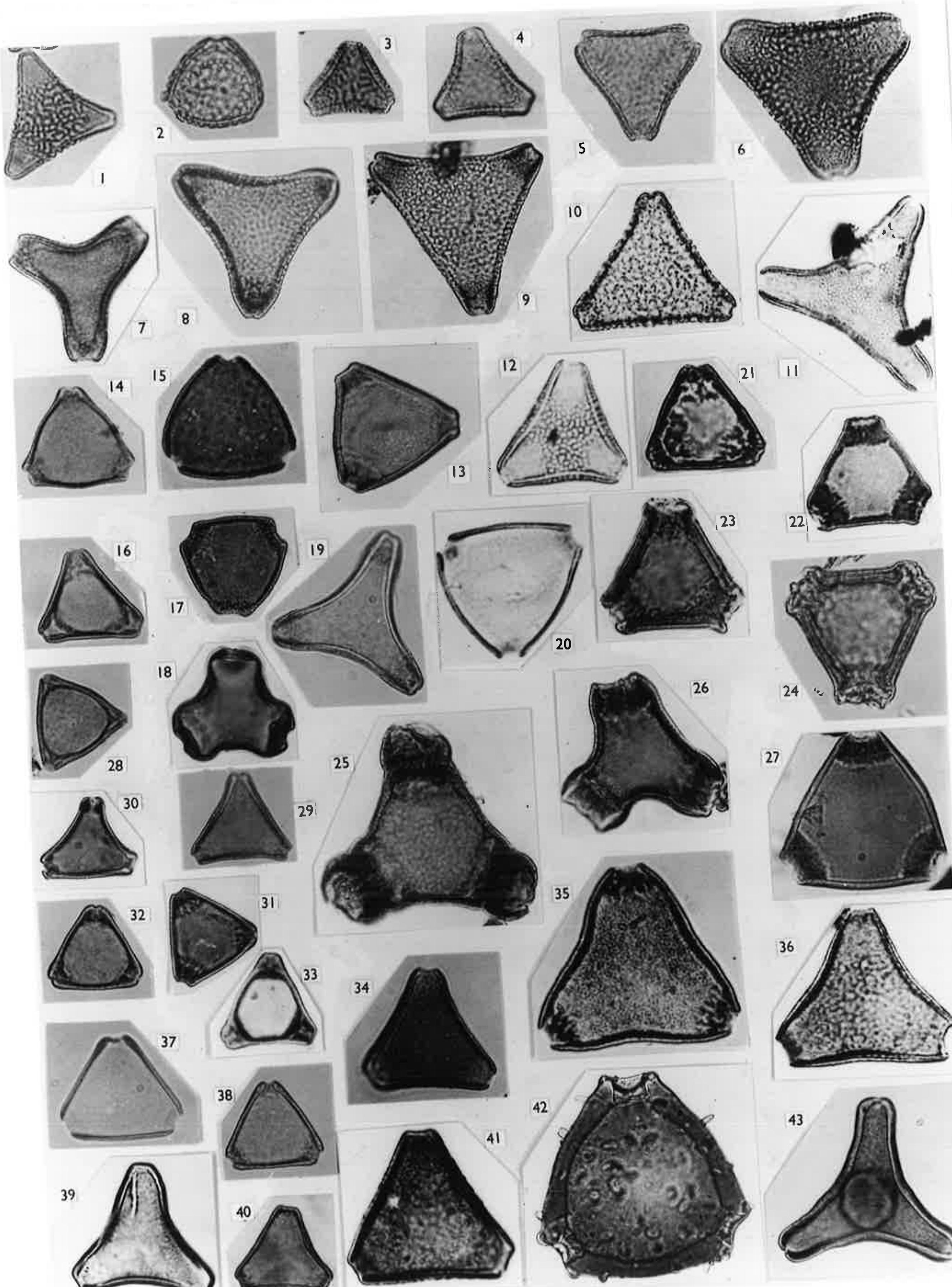
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PLATE 9

PLATE 10

Fig. 1 *Proteacidites clintonensis* sp. nov.
S741/1 18.0 : 110.7

2,3 *P. comaumensis* sp. nov.
ST90/6 40.7 : 101.5; ST502/29 38.3 : 105.7

4,5 *P.* spp.
S104/2 48.0 : 101.4; S289/1 36.9 : 95.5

6 *P. incurvatus* Cookson
S710/1 42.1 :108.8

7,8 *P. kopiensis* sp. nov.
S560/1 26.7 : 107.3; S623/1 17.1 : 109.6

9 *P.* sp.
ST547/29 30.1 : 104.2

10 *P. eyrensis* sp. nov.
S166/2 40.5 : 95.4

11,12,13 *P. tripartitus* sp. nov.
S650/1 47.3 : 103.4; S560/1 28.2 : 101.2;
S560/1 39.5 : 106.3

14 *P. reticuloscabratus* Harris
S218/1 39.4 : 100.9

15 *P. reticulatus* Cookson
S730/1 22.7 : 98.5

16 *P.* sp.
S275/1 47.9 : 114.3

17,18 *P. collaroides* sp. nov.
S241/1 33.3 : 111.0; S241/1 26.8 : 99.7

19 *P. fromensis* sp. nov.
S17/2 36.1 : 101.6

20 *P.* sp.
ST502/30 46.1 : 101.7

21 *P. symphyonemoides* Cookson
S17/2 33.5 : 112.6

22 *P.* sp.
S166/3 39.0 : 101.2

23 *P. crassus* Cookson
ST547/24 36.7 : 97.6

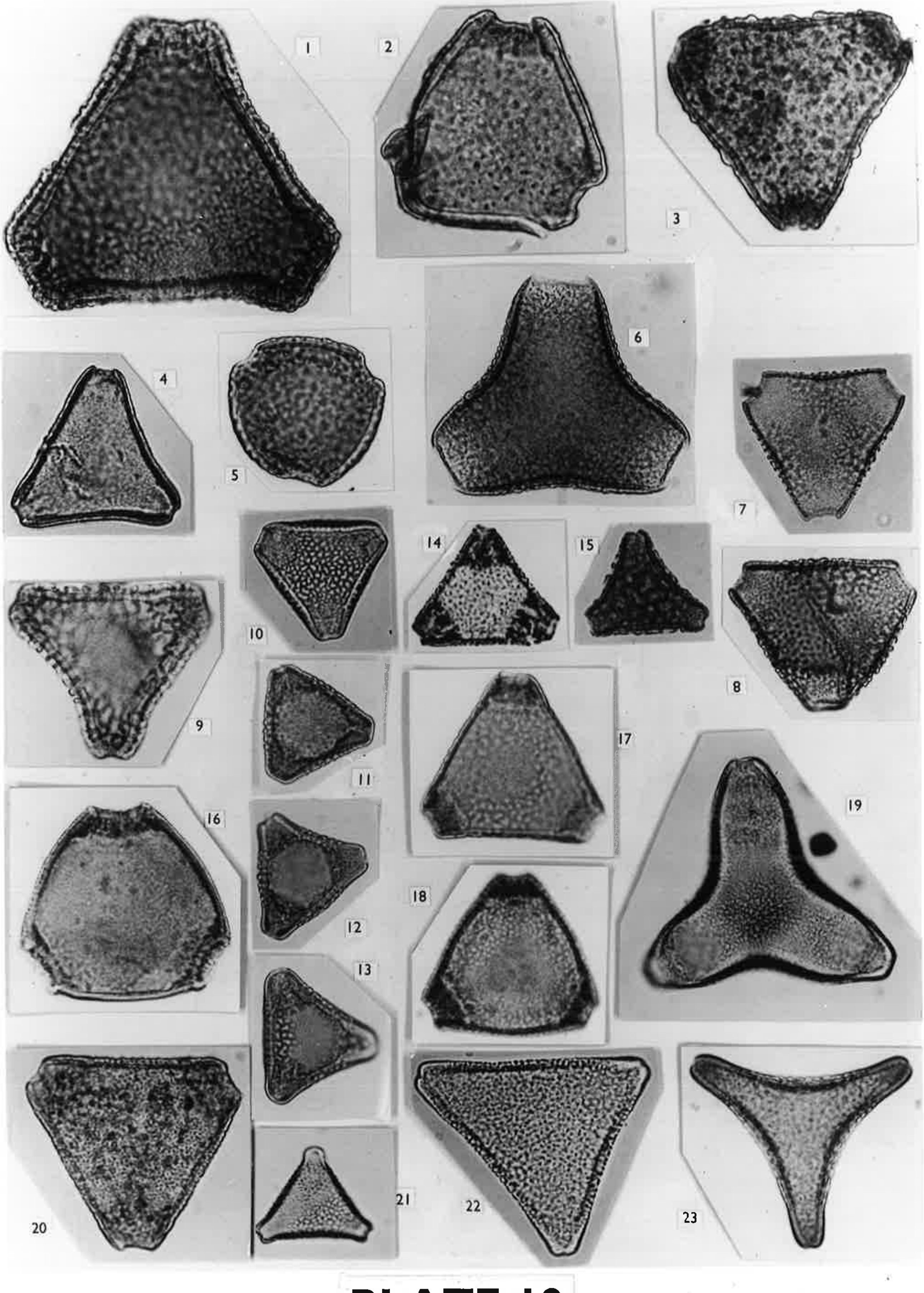

PLATE 10

PLATE 11

Fig. 1,2,3 *Proteacidites voraginosus* sp. nov.
ST547/33 41.4 : 103.5; ST502/46 44.2 : 103.2;
S546/1 42.2 : 95.3

4 *P.* sp.
S728/1 26.8 : 107.1

5,6,11 *P. clintonensis* sp. nov.
S741/2 43.6 : 102.8; S662/1 42.3 : 102.8;
S705/1 49.1 : 103.4

7,8 *P. confragosus* sp. nov.
ST241/4 36.4 : 105.3; ST241/9 42.0 : 106.1

9,10 *P.* sp.
ST502/4 37.1 : 103.2; ST502/15 36.5 : 102.2

12 *P.* sp.
ST228/12 38.7 : 103.9.

13,16 *P. tortuosus* sp. nov.
S563/2 31.8 : 100.4; S741/2 17.3 : 95.4

14,15,18 *Proteacidites* sp.
S751/2 43.2 : 105.9; S705/1 49.4 : 94.3
S751/2 28.3 : 100.8

17 *Beaupreaidites* sp.
ST547/28 30.1 : 104.2

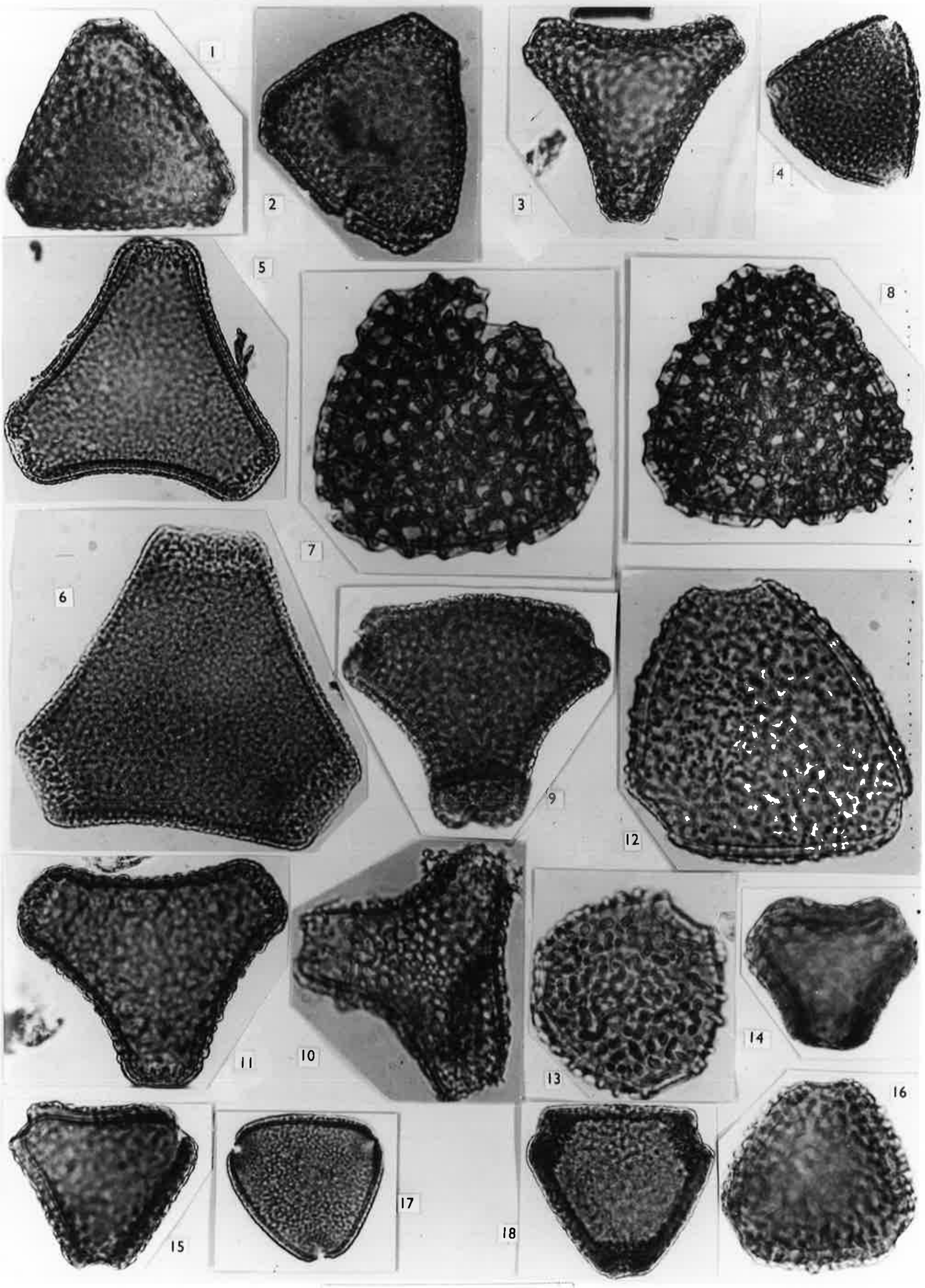

PLATE 11

PLATE 12 (cont.)

Fig. 24,30	*N. incrassata* (Cookson) comb. nov.	
	S726/1 26.2 : 108.7; S722/1 21.3 : 102.6	
26	*N. falcata* (Cookson) comb. nov.	
	S728/1 38.3 : 112.7	
27	*N. brachyspinulosa* (Cookson) comb. nov.	
	S730/1 27.0 : 108.6	
28,29	*N. matauraensis* (Couper) comb. nov.	
	S728/1 41.8 : 107.8; S726/1 21.4 : 103.6	
31	*N. deminuta* (Cookson) comb. nov.	
	S705/1 32.6 : 106.4	
32	*N. hetera* (Cookson) Harris	
	S705/1 49.1 : 110.7	
33	*N. aspera* (Cookson) comb. nov.	
	S705/1 40.7 : 105.3	
34	*Tricolporites* sp.	
	S161/1 33.7 : 95.2	

PLATE 12

Fig. 1 *Proteacidites tortuosus* sp. nov.
S741/2 21.8 : 107.5

2,3,4,5 *P. dilwynensis* Harris
S560/1 53.6 : 101.0; ST218/7 39.3 : 100.3;
S730/1 25.8 : 111.3; S705/1 51.7 : 109.4

6 *P. grandis* Cookson
S212/1 39.6 : 93.9

7 *P.* aff. *P. crassus* Cookson
ST208/1 38.9 : 104.8

8 *P. ornatus* Harris
ST217/1 39.8 : 105.8

9,13 *Triorites magnificus* Cookson
S730/1 32.9 : 94.3; S705/1 32.8 : 112.3

10 *Proteacidites pidingaensis* sp. nov.
ST188/1 36.4 : 102.5

11,21 *Beaupreaidites elegansiformis* Cookson
ST222/8 34.2 : 103.8; S705/1 47.7 : 105.1

12 *Proteacidites perparvulus* sp. nov.
S705/1 44.8 : 109.2

14,15 *Beaupreaidites reticulatus* sp. nov.
S161/1 49.1 : 102.8; S166/1 34.6 : 99.7

16 *Amosopollis cruciformis* Cookson & Balme
S165/1 37.3 : 98.3

17 *A. dilwynensis* sp. nov.
ST209/2 39.3 : 100.7

18 *Tricolporites* sp.
S275/1 34.3 : 112.7

19 *Haloragacidites* cf. *H. haloragoides* Cookson & Pike
S272/1 35.8 : 108.1

20 ?Lactoridaceae
ST717/1 39.6 : 101.3

22,25 *Nothofagidites flemingii* Couper comb. nov.
S722/1 29.8 : 103.9; S705/1 49.1 : 110.7

23 *N. vansteenisi* (Cookson) comb. nov.
S662/1 43.2 : 105.9

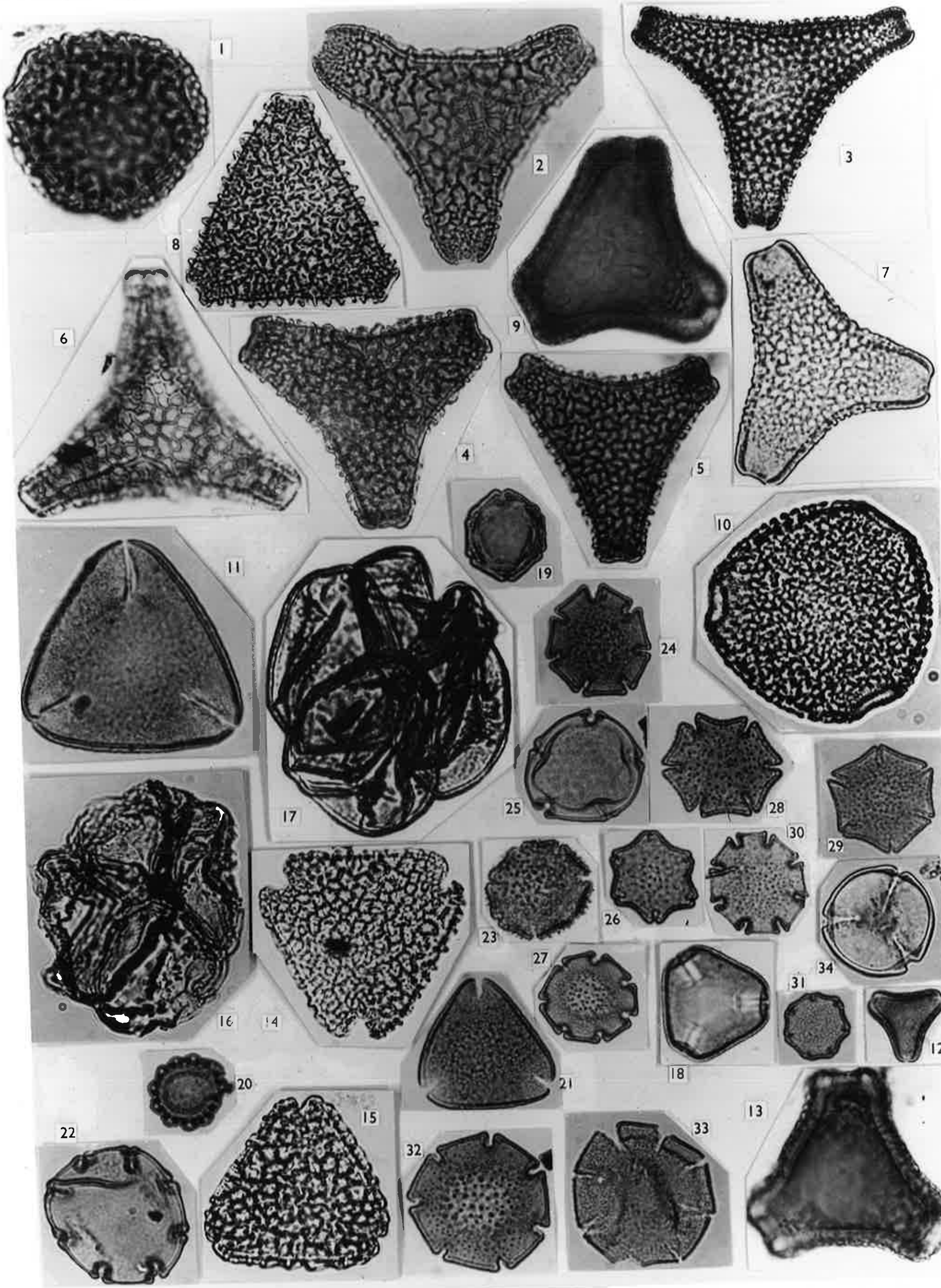
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PLATE 12