PALYNOLOGY OF SOME TERTIARY DEPOSITS FROM NEW SOUTH WALES

by

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ABSTRACT

Microfloras from freshwater sediments from three localities in New South Wales - Nerriga, Kiandra, and Cadia, have been studied and compared with previously described Tertiary assemblages. Samples for palynological study were taken from sections with a K-Ar dated basalt to give independent age control. For two localities, Kiandra and Cadia (dated as early and middle Miocene, respectively) there is good agreement between the microfloral and radiometric ages. At Nerriga, this dating is less precise; the age indicated by the microflora is early Eocene, whereas the K-Ar age on the basalts indicate late Eocene.

All three microfloral suites could be compared to those described from the Gippsland and Otway Basins, and could therefore be related to zones described from these sequences. Many characteristic species from these south coast assemblages (e.g. some species of *Proteacidites*) are absent, however.

Suites from all three localities suggest a rainforest vegetation, and can be considered part of the widespread Tertiary *Cinnamomum* flora. This flora consists of *Nothofagus* of all three types (*brassi*, *menziesii*, and *fusca*), various gymnosperms, and a diversity of angiosperms and pteridophytes. Whether this was a pan-Australian flora remains to be assessed, as data become available from areas outside of southeastern Australia. Elements of this flora are also found in Tertiary deposits of other southern regions - New Zealand, Antarctica, Kerguelen, southern South America, and Ninetyeast Ridge.

Most fossil taxa can be related to living groups with a temperate distribution, although some tropical elements are present. The assemblage indicates a higher rainfall in these areas in the Tertiary than at present. Indications of warmer temperatures are uncertain from the microfloras, although palaeotemperature data indicate warmer temperatures at least in the Paleogene.

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CHAPTER 1. INTRODUCTORY REMARKS

Outline of Project

This work concerns the study of three suites of palynomorphs from Tertiary sub-basaltic freshwater deposits in the Eastern Highlands of New South Wales. Objectives for this study were threefold. First, to investigate palynomorph assemblages from Tertiary sediments found beneath or interbedded with volcanic rocks which had been dated by K-Ar isotopic methods. Second, to relate and compare these assemblages with suites of similar age recently described from coastal basin sequences (e.g. the Gippsland Basin), and to evaluate the applicability of zonal schemes based on these coastal sequences to the terrestrial deposits. Third, to give a clearer picture of the regional vegetational spectrum at that time. Comparisons of contemporaneous assemblages from different depositional environments, terrestrial to marginal marine, will give a better idea of species useful as diagnostic types for demarcating palynostratigraphic units, regardless of facies, and of those that are indicative of a more restricted/localized environment, e.g., peat swamps. Similarities between microfloras from two different environments can be compared: the Eastern Highlands, an upland area throughout the Tertiary period, and the coastal sedimentary basins, which have been subjected to marine transgressions at various times during the Tertiary. At present, the extent of ecological variation between assemblages of the same age is just becoming apparent, as more published reports of reliably dated microfloras become available.

The major impetus for this study was provided by the determination of the ages for numerous Cenozoic volcanic rocks in eastern Australia by potassium-argon (K-Ar) isotopic dating methods (Wellman, 1971; Wellman & McDougall, 1974a; 1974b). These K-Ar dates for the basalts are used to provide an independent age control on the associated sediments and the microfloras contained within them.

Prior to the dating of these basalts by K-Ar methods, it was difficult to give accurate ages both for the volcanic rocks and the associated sediments. Most of this region has been above sea level and subject to erosion throughout the Cenozoic and at least part of the Mesozoic. The basalts were subaerially erupted, and the sediments commonly contained abundant plant remains but lacked other fossil material. Reliance on the plant macrofossils alone proved inadequate to relate these rocks to the geologic time scale with any precision.

The K-Ar dates on the volcanic rocks have given the necessary age control on the associated sediments so that the palynomorph assemblages can be related to the geologic time scale and then compared with other dated assemblages of Tertiary age known from Australia and surrounding regions. Study of a sufficient number of palynomorph assemblages from these dated sections, to cover the entire span of Tertiary time, will thus provide a reference base to accommodate samples from localities with no age control except the fossil pollen and spores.

Absence of evidence of significant erosion between sediments and overlying basalts, the unconsolidated nature of the sediments, and the fact that lavas and sediments are interbedded in some places, has led to the assumption of contemporaneity of volcanic rocks and associated sediments, and this is accepted herein.

Sample localities for this study were restricted to those with a K-Ar dated basalt and polleniferous sediments in the same section. It was initially hoped to get a good spread of samples throughout the Tertiary, but suitable polleniferous material was found in only three localities. The samples from the other seven localities collected proved to be barren. In all, 165 samples were collected, prepared, and examined for palynomorphs, and five sections from three localities were chosen for further study (see Text-figure 1). Samples used were from Kiandra, in the Snowy Mountains; Cadia, south of Orange; and Nerriga, north of Braidwood. Each of the three localities is situated in a different volcanic province.

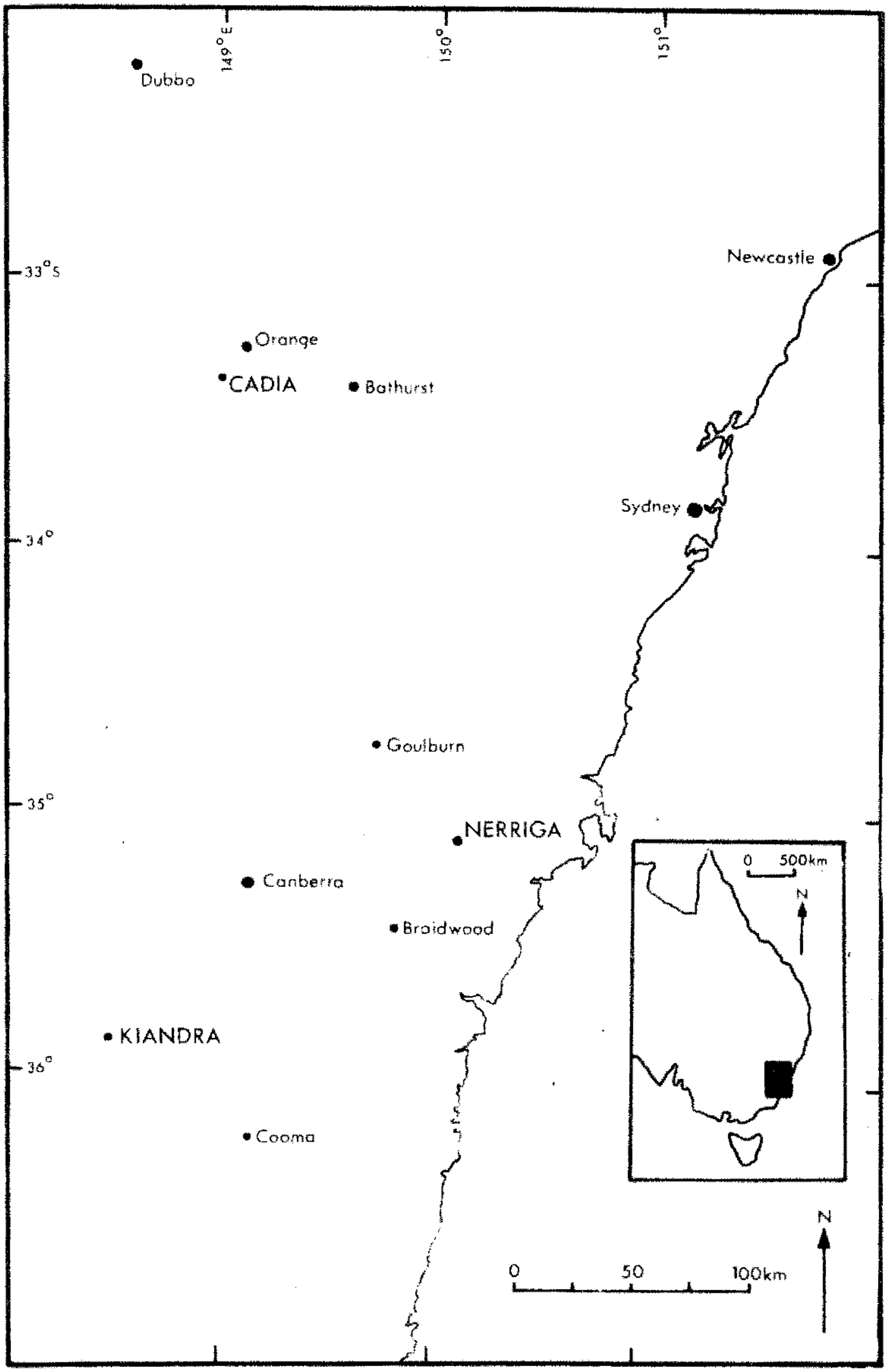
A brief outline of the geology of this region, followed by a more detailed account of the Tertiary rocks and plant fossils, is given in the following sections.

Geological History of Southeastern Australia - Brief Synopsis

The area of concern here forms part of the Tasman Geosyncline, an essentially Palaeozoic feature occupying almost the entire eastern quarter of the Australian continent. The localities studied are included in the Lachlan Fold Belt, which forms the western part of the geosyncline, with sedimentation mainly from Cambrian through Devonian. To the northeast, and separated by the Permo-Triassic Sydney Basin, is the New England Fold Belt, with sedimentation from ?Ordovician through to the end of the Palaeozoic.

The Palaeozoic history of the Tasman Geosyncline in New South Wales has recently been reviewed by Scheibner (1974). A complex series of troughs and highs developed in the early Palaeozoic and were subsequently deformed by several distinct periods of folding accompanied by granitic intrusions. Throughout much of the Mesozoic and the Tertiary, this area was subject to the forces of erosion, and by mid-Cretaceous time a widespread erosional surface had developed.

During the Permian and continuing into the Mesozoic deposition took place in several isolated basins on the southeastern margin of the continent, in Tasmania, in several scattered basins in Victoria, and the Sydney Basin, with sporadic volcanic activity in the north (Brown, Campbell, & Crook, 1968). During the Cretaceous, deposition



Text-figure 1. Map of southeastern New South Wales, showing the three localities mentioned in this study.

of marine and nonmarine sequences was initiated in the Gippsland and Otway Basins, which formed on the eroded surface of the Tasman Geosyncline, and the Murray Basin, which formed as a southward extension of the Great Artesian Basin. Deposition in these basins continued through the Tertiary, with thin sequences of nonmarine and marine deposits, and sedimentation was initiated in two other marginal basins, the St. Vincent and Bass Basins. At the same time, scattered patches of thin terrestrial sediments were deposited in the lakes and river systems of the Eastern Highlands and coastal plain, and also further inland, in the internal drainage systems such as the Lake Eyre Basin.

In the late Mesozoic and into the Tertiary, epeirogenic movement formed the Eastern Highlands, a broad upland area along the eastern margin of the continent. This was accompanied by widespread volcanism throughout the area. Uplift of at least 300 metres in the axial part of the highland occurred between mid-Cretaceous and late Oligocene times, and a lesser uplift (the Kosciusko Uplift) of up to 200 metres occurred in post-middle Miocene times (Wellman & McDougall, 1974b).

The Tertiary Volcanic Rocks and Associated Sediments

Volcanic rocks of Cenozoic age are widespread in eastern Australia. Wellman & McDougall (1974a; 1974b) have recently summarized information on these basalts. They are mainly subaerially erupted alkalic basaltic lavas, with a small proportion of more silicic lavas and related intrusive rocks. The extrusive lavas occur in large volcanic piles up to 1000 metres thick, as thin extensive lava fields, or partly filling valleys, and were erupted onto surfaces of low relief on rocks of pre-Cenozoic age. In many places they overlie and are interbedded with thin sequences of freshwater sediments.

These rocks are grouped into volcanic provinces by Wellman &

McDougall (1974a) on the basis of age and chemical composition. Each province contains basalts of similar composition, generally erupted during the same episode of volcanism (with a duration of up to 5 m.y.), and cover an area of 50-200 km^2. During the past few years, a sufficient number of K-Ar dates on these basalts has become available to assign an age to the volcanic activity in most provinces with confidence.

Prior to this, ages assigned to the basalts were based on data from physiography, erosion levels, and fossil floras contained in the associated sediments. Correlations were made with Victorian sequences which had interbedded fossiliferous marine horizons. The fossil floras were all included in the so-called *Cinnamomum* flora (terminology of Sussmilch, 1937), which was believed to be early to mid-Cenozoic in age, and older than the flora underlying the Newer Volcanic Series in Victoria, of Pliocene-Pleistocene age. Various ages were assigned to the *Cinnamomum* flora by different authors. Surprisingly, these sediments rarely contained fossils other than plants.

Other attempts to date the volcanic rocks resulted in subdividing them into older "monadnock" basalts that formed caps on hills standing above the level of the surrounding areas, and younger "flood" or "plateau" basalts that formed lava fields in relatively low-lying areas. These were also assigned various ages by different authors. The felsic rocks were later separated as a distinct group, but their age relative to other groups was difficult to establish.

In many areas in New South Wales the volcanic rocks overlie thin lake and river deposits, including the so-called deep leads (former watercourses that are now buried under basalt, and are locally auriferous), which are thought to be at the most only slightly older than the basalts. These sediments consist of gravel, sand, silt, clay, and lignite. There is little or no evidence of erosion prior to lava eruption, the sediments are poorly consolidated, and in some places the lavas and sediments are interbedded.

The sediments studied here are found in three different volcanic provinces. The samples from Nerriga are in the Nerriga Province, with basalt dates of 46 to 40 m.y. (in the ~~middle~~ late Eocene); the sites near Kiandra are included in the Snowy Province, with K-Ar dates on the basalts from 22 to 18 m.y. (in the early Miocene); and the material from Cadia is in the Orange Province, with dates for the basalts ranging from 12 to 11 m.y. (middle Miocene). They are all freshwater deposits.

Interest in the deep lead deposits was enhanced by the discovery of alluvial gold and tin in the coarse sands and gravels at some localities. Large collections of plant macrofossils were made and later described, commonly with only sketchy information as to geologic horizon or exact geographic location. Aside from the plant fossils, which are abundant at many localities, these monmarine sediments have also been reported to contain mammal bones (Walcott, 1920), freshwater fish bones (Hills, 1934; 1946), and diatoms (Card & Dun, 1897; Skvortzov, 1937). When one considers the large number of plant macrofossils found, other fossils are sparsely represented. Only the macrofossil plants have been studied in any detail until recently, however, when investigation of the microfloras was undertaken, mainly by Cookson and her co-workers.

The *Cinnamomum* Flora

The most common plant macrofossils in these freshwater deposits are fossil fruits and leaf impressions, which are part of the so-called *Cinnamomum* flora. This flora, also called the "brush forest" flora by Deane (1900a), includes predominantly broad-leaved mesic vegetation of *Laurus*, *Cinnamomum*, *Daphnandra*, *Ficus*, and *Nothofagus*, with a sparse representation of such typical Australian taxa as *Casuarina*, *Eucalyptus*, and several proteaceous genera (Crocker, 1959). It is generally considered to represent vegetation growing under warmer and wetter conditions than now found in the area. Deane compared this flora to the vegetation growing in the patches of coastal rainforest at the present time. When used to date the associated basalts, various ages have been suggested for this flora: early Pliocene (Sussmilch, 1937), Oligocene to early Miocene (Hills, 1938), Oligocene to late Miocene (Singleton, 1941), and Eocene to late Pliocene (Gill, 1952). In many cases ages were suggested by comparison with similar floras from Victoria in rocks correlated with marine sequences. The occurrence of mid-Tertiary volcanic rocks in Victoria and south Queensland similar to those in New South Wales gave additional support to a mid-Tertiary age for these rocks (Wellman, 1971). Wellman & McDougall (1974a) have recently suggested an age for the *Cinnamomum* flora ranging from 45 to 16 m.y., or middle Eocene to middle Miocene, based on the K-Ar dates for associated basalts. Further comment on this age range for the flora will be given below.

It was recognized last century that this flora was markedly different from that growing in these areas at the present time, with the paucity in the fossil deposits of such typical "Australian elements" as *Banksia*, *Eucalyptus*, and *Casuarina*. Deane (1900a) suggested that the change from a dominantly "brush forest" flora to an "open forest" flora (with mainly *Eucalyptus*, *Banksia*, *Casuarina*, and Proteaceae) was caused by a change in climate, probably increased dryness, in southeastern Australia. The "open forest" flora underlies the Newer Volcanic Series of Pliocene-Pleistocene age, and is similar to the flora growing over much of Victoria and New South Wales today.

Information from the plant macrofossils is still too incomplete and in many cases out of date to evaluate the geographic extent and composition of the *Cinnamomum* flora, and to determine whether this was generally a "pan-Australian" flora during at least part of the Tertiary. Adequate data on these aspects of the *Cinnamomum* flora would not be provided from macrofloras alone, because of the difficulties of finding well-preserved material for precise identification, and the small proportion of the total flora that would be preserved in this way. Also, leaf form is a character more responsive to climatic change (hence the usefulness of leaf flora studies in palaeoclimate analyses), and changes in leaf form in typical Australian groups since Tertiary times may make these groups difficult to recognize in older deposits. However, the macrofossils could be useful in supplementing data from microfloral assemblages, which would be more representative of the regional flora, and can generally be placed in a chronostratigraphic framework with more precision.

Several important components of the *Cinnamomum* flora are not represented in the microflora at all. Notable absences are the Lauraceae and *Ficus*. From microfloral assemblages, the *Cinnamomum* flora contains a varied gymnosperm assemblage, together with all three groups of *Nothofagus*, abundant and diverse Proteaceae, and several types now found only in tropical and subtropical regions (e.g. *Anacolosidites*, *Beaupreaidites*). That many of the taxa found in abundance in Tertiary deposits are no longer found on mainland Australia attests to the fact that great changes in the vegetation have taken place since the Tertiary. There appear to be several distinct microfloral assemblages during the range of the *Cinnamomum* flora, as well as several long-ranging taxa that appear from Paleocene through to ?Pliocene times. A fuller discussion of these assemblages will be given in a later section.

There are few records in the palynological literature of the post-*Cinnamomum* flora, which is characterized by many of the typical "Australian elements": abundant Compositae, Gramineae, Myrtaceae, *Casuarina*, *Acacia*, and Proteaceae (different from the earlier Tertiary proteaceous types), and absence or low percentage of *Nothofagus*. This microflora has been tentatively dated as late Pliocene-Pleistocene by Martin (1973b), and similar microfloras have been mentioned by Duigan & Cookson (1957) and Harris (1971).

Previous Work on Australian Tertiary Floras

From last century until Cookson's work in the 1940's, study of Tertiary floras was concerned with plant macrofossils: stems, wood, fruits, and leaves, commonly fragmentary and poorly preserved. In a recent review of palaeobotanical literature from Australia, de Jersey (1968) gives a full discussion of these early studies, so mention of only a few more relevant works will be made here. These early studies were seriously hampered by lack of knowledge of the present Australian vegetation. Fossil fruits from various deep lead deposits were studied by von Mueller (1874; 1876; 1884), who considered them to be Pliocene, and an important monograph on leaves and fruits from some of the deep leads, notably Dalton, Emmaville (Vegetable Creek), and Elsmore, was written by von Ettingshausen (1888). In this work leaves were identified not only with Australian floral elements but also with several prominent Northern Hemisphere genera. Von Ettingshausen advocated the Cosmopolitan Tertiary Flora theory which, stated briefly, infers that there was a greater similarity between the Tertiary flora in a given region and other Tertiary floras throughout the world, than between the Tertiary and present floras in the same area.

Botanists more acquainted with the Australian flora, such as Deane (1900a; 1900b), questioned the validity of such an approach, and asserted that instead of identifying Tertiary plant fossils with Northern Hemisphere groups, one need only investigate the Australian native flora to find similar plants. He also questioned the identifications based on leaf impressions alone, especially with genera found only in Europe and North America, and illustrated the range in leaf form found in several living Australian groups, such as the Lauraceae and *Eucalyptus*, to prove his point.

There have been relatively few studies of the macrofossils in recent years. Mention can be made of studies on the fossil woods by Nobes (1922), Barnard (1927), and Patton (1958); on leaves, cones, and cuticles by Pike (1952) on *Banksia* and *Casuarina*, Cookson & Duigan (1950; 1951) on the Banksieae and the Araucariaceae, and Cookson (1947b) on the Oleaceae. In many of these studies comparisons were made between the fossil material and living plants of related types. Duigan (1950) summarized all the reported occurrences of plant macro- and microfossils known up to that time in her catalogue of the Australian Tertiary flora. Study of a diverse and well-preserved flora from Maslin Bay, of early middle Eocene age, is currently in progress (Lange, 1970). Results from this study will be of great interest when available.

Publication of work on the microfloras commenced with a preliminary report by Cookson (1945) on pollen found in some Victorian brown coals. A series of papers in the next two decades by Cookson and her co-workers covered the morphology of many different pollen types found in these Tertiary deposits: proteaceous grains (Cookson, 1950), various dicotyledonous pollen types (Cookson & Pike, 1954b), *Acacia* (Cookson, 1954a), various gymnosperms (Cookson, 1953a; Cookson & Pike, 1953a; 1953b; 1954a), *Ephedra* (Cookson, 1956), and *Nothofagus* (Cookson, 1946; 1952; 1959; Cookson & Pike, 1955). In an attempt to use pollen assemblages stratigraphically, Cookson (1954b) recognized three different microfloras, which she considered to be Cretaceous, Paleocene-early Eocene, and Eocene in age.

Subsequent studies which have used pollen assemblages for stratigraphic zonation have been made by Harris (1965a; 1971) for Victorian and South Australian coastal sequences in the Otway and St Vincent Basins, Hekel (1972) for sequences from Queensland, and

Stover & Evans (1973) and Stover & Partridge (1973) for the Gippsland Basin, proposing a sequence of zones from Cretaceous to at least middle Miocene.

Martin (1973a; 1973b; 1974) has recently described several pollen assemblages from a series of Tertiary deposits from New South Wales, and Hos (1975) has discussed the pollen from some upper Eocene deposits in Western Australia.

In addition to her work on pollen and spores, Cookson also pioneered Australian studies on microplankton (in a series of papers with Deflandre and Eisenack), fungi (1947c), and algae (1953c), all studied as dispersed remains in palynological preparations. Later work on fungi, mainly epiphyllous and studied *in situ* on leaf cuticles of fossil leaves, has been done by Lange (1969; 1970), Lange & Smith (1971), and Selkirk (1972; 1975).

CHAPTER 2. ELEMENTS OF THREE TERTIARY MICROFLORAS

Composition of the Assemblages

The following three chapters discuss the localities investigated in this study. These three deposits all have the following in common. They are all from upland sites, and consist of predominantly lacustrine sediments (with some fluvial deposits at Kiandra). They are assumed to have been deposited over a relatively short time interval. The lakes in which these sediments were deposited apparently formed as a result of disruption to drainage, caused by tectonic disturbances that characterize much of the Tertiary in the Eastern Highlands. These disturbances also resulted in periods of volcanism and eruption of lavas.

The preservation of the spores and pollen is generally good, indicating rapid burial. The many clusters of grains in all three samples indicate that this site of deposition was fairly close to where the pollen was shed. If transported far, they would be separated into discrete grains. The variety of grain sizes and diversity of anemophilous and entomophilous types in the samples show a flora not transported a great distance. In only a few samples from Kiandra and Cadia was there apparent over-representation of a few taxa.

The microfloras from these samples comprise a rainforest vegetation. They include several species which are considered to be long-ranging through the Tertiary period. Many of the spores and gymnosperms are in this group, along with pollen taxa such as _Haloragacidites_ _harrisii_ and _Myrtaceidites_ spp. Less than a third (49 species) of the total number of taxa listed in Table 1 are found at all three localities. Each locality also includes a number of species not found at the other two, some of which have limited or

TABLE 1. Distribution of Species at the Three Localities Studied

TRILETE SPORES	Nerriga	Kiandra	Cadia
Cyathidites australis	x	x	-
minor	x	-	-
cf. *C. minor*	-	x	x
splendens	x	-	-
subtilis	-	x	x
Biretisporites spp.	x	x	x
Deltoidospora sp.	x	x	x
Stereisporites antiquasporites	x	x	x
(*Tripunctisporis*) sp.	x	-	-
Verrucosisporites kopukuensis	x	x	x
cristatus	-	x	x
cf. *V. cristatus*	x	x	-
Leptolepidites tuberosus sp. nov.	-	x	-
Osmundacidites spp.	-	x	x
Baculatisporites comaumensis	x	x	x
Foveotriletes crater	x	x	-
palaequetrus	x	-	-
Foveosporites lacunosus	-	x	x
Lycopodiumsporites sp. 1	-	x	-
sp. 2	-	x	-
sp. 3	-	x	x
spp. undiff.	x	x	x
Rugulatisporites micraulaxus	-	-	x
mallatus	x	x	-
trophus	-	x	-
Klukisporites reticulatus sp. nov.	-	x	-
Matonisporites ornamentalis	-	x	x
Trilites tuberculiformis	x	-	-
Ischyosporites sp. 1	x	x	x
sp. 2	x	x	x
Gleicheniidites circinidites	x	x	x
Clavifera triplex	x	-	-
Cingutriletes clavus	-	x	x
Cyatheacidites annulatus	-	x	-
MONOLETE SPORES			
Laevigatosporites ovatus	x	x	x
major	x	x	x
Polypodiisporites speciosus	x	-	-
sp. 1	-	x	x
sp. 2	x	-	-
Reticuloidosporites escharus	x	x	x
Microfoveolatosporis sp. 1	-	x	x
sp. 2	x	-	-
Echinosporis sp.	-	x	-
Peromonolites densus	-	x	x
vellosus	-	x	x
Hypolepis spinysporis	-	x	x

SACCITES	Nerriga	Kiandra	Cadia
Podocarpidites ellipticus	x	x	x
marwickii	x	x	x
cf. P. multesimus	-	x	-
sp.	x	x	x
Lygistepollenites florinii	x	x	x
Parvisaccites catastus	x	x	-
Alisporites grandis	-	x	x
Phyllocladidites mawsonii	-	x	x
Phyllocladus palaeogenicus	x	x	x
Dacrycarpites australiensis	-	x	x
Microcachryidites antarcticus	x	x	-
parvus	-	x	-
Podosporites microsaccatus	-	x	x
ALETES			
Araucariacites australis	x	x	x
sp.	-	x	-
Dilwynites granulatus	x	x	x
cf. D. tuberculatus	x	x	-
POLYPLICATES			
Ephedripites notensis	x	-	-
MONOCOLPATES			
Liliacidites lanceolatus	x	x	-
sp.	x	x	x
Arecipites spp.	-	x	x
Monosulcites verrucosus sp. nov.	-	x	x
TRICOLPATES			
Beaupreaidites elegansiformis	-	x	-
verrucosus	-	x	-
Gothanipollis cf. G. gothani	x	x	x
cf. G. bassensis	-	x	-
Tricolpites delicatulus	x	x	x
cf. T. pachyexinus	x	x	-
psilatus	-	x	x
punctaticulus	-	x	x
patulus sp. nov.	x	-	-
cancellatus sp. nov.	-	x	x
PTYCHOTRIPORINES			
Intratriporopollenites notabilis	x	-	-
Gemmatricolporites cf. G. gestus	x	-	-
Tricolporites sphaerica	x	x	x
microreticulatus	x	x	x
paenstriatus	x	-	-
cf. T. angurium	-	x	x
prolata	x	x	x
scabratus	x	-	-
retequetrus	-	x	-
valvatus	x	-	-
cf. T. endobalteus	-	x	x
sp. 1	-	x	x
sp. 2	x	-	-
sp. 3	x	-	-
sp. 4	-	x	x
sp. 5	x	-	-

		Nerriga	Kiandra	Cadia
Cupanieidites	*major/orthoteichus*	x	x	x
Myrtaceidites	*mesonesus*	x	x	x
	parvus	x	x	x
	eugeniioides	x	x	x
	eucalyptoides	-	x	x
	verrucosus	x	x	-
Symplocoipollenites	*austellus*	-	-	x
Sapotaceoidaepollenites	cf. *S. rotundus*	x	x	x
Ilexpollenites	*clifdenensis*	x	x	x
Dodonaea	*sphaerica*	-	x	x
POLYPTYCHES				
Nothofagidites	*asperus*	x	x	x
	goniatus	-	x	x
	flemingii	x	x	x
	brachyspinulosus	x	x	x
	deminutus	-	x	x
	emarcidus	x	x	x
	falcatus	-	x	x
	heterus	x	x	x
	incrassatus	x	x	x
	vansteenisii	x	x	x
Polycolpites	*esobalteus*	x	x	x
	sp.	-	x	x
MONOPORINES				
Sparganiaceaepollenites	cf. *S. barungensis*	-	x	x
Graminidites	*media*	-	-	x
DIPORINES				
Banksieaeidites	*elongatus*	x	x	x
	arcuatus	x	x	x
TRIPORINES				
Triporopollenites	*chnosus*	-	x	-
	ambiguus	x	-	-
	bellus	-	x	x
Santalumidites	*cainozoicus*	x	-	-
Proteacidites	*annularis*	x	x	x
	asperopolus	x	-	-
	pachypolus	x	-	x
	tenuiexinus	x	-	-
	?*callosus*	x	-	-
	concretus	x	-	-
	crassus	x	-	-
	grandis	x	-	-
	ornatus	x	-	-
	kopiensis	x	-	-
	latrobensis	x	-	-
	minimus	x	x	x
	cf. *P. obscurus*	-	x	x
	parvus	x	x	-
	pseudomoides	x	-	-
	?*rectomarginis*	x	-	-
	reticuloscabratus	x	x	-

	Nerriga	Kiandra	Cadia
Proteacidites similis	-	-	x
subpalisadus	-	x	x
subscabratus	-	x	x
symphyonemoides	-	-	x
tuberculiformis	x	-	-
cadiensis sp. nov.	-	-	x
tripartitus	x	-	-
Triorites minisculus	x	x	x
introlimbatus	x	x	-
sp.	-	x	x
Haloragacidites harrisii	x	x	x
trioratus	x	x	x
haloragoides	-	-	x
POLYPORINES			
Anacolosidites acutullus	x	-	-
luteoides	x	-	-
Periporopollenites vesicus	x	x	-
demarcatus	x	x	-
sp. 1	-	x	-
sp. 2	-	x	-
Malvacipollis diversus	x	x	x
subtilis	x	x	x
Polyporina cf. P. chenopodiaceoides	-	x	x
Echiperiporites sp.	-	x	-
Polyorificites sp.	-	x	x
JUGATES			
Ericipites crassiexinus	x	x	-
scabratus	x	x	x
Simplicepollis meridianus	x	-	-
Gephyrapollenites calathus	-	x	x
Polyadopollenites myriosporites	-	-	x
INCERTAE SEDIS			
Schizosporis parvus	x	x	x
rugulatus	x	-	-
Circulisporites spp.	x	-	x

well-known stratigraphic ranges.

A total of 45 spore, 18 gymnosperm, and 106 angiosperm taxa, as well as three of uncertain affinities, have been isolated in samples from these localities (Table 1), as well as an indeterminate number of species of fungal spores, abundant fungal remains, and algae. Many of these, including species of *Nothofagidites* and some of the gymnosperms, are typical elements of the Tertiary floras of several southern regions as a whole, including, in addition to Australia, New Zealand, Antarctica, Kerguelen, and South America.

In Table 2, an attempt has been made to list living botanical families that are represented by the microfloras discussed in this work. In some cases, affinities are tentatively suggested, and the fossil taxon is preceded by a question mark (?). Less than half of the fossil taxa can be related, even tentatively, to living families, but it is interesting to note that both tropical and southern temperate families are represented. Many taxa from these microfloras can be compared with those from the Gippsland Basin and other assemblages, although they lack some species characteristic of these assemblages, e.g. some species of *Proteacidites* and the monoporate species *Milfordia homeopunctata*.

In the following two sections, brief mention is made of the fungi and algae found in these samples, and any possible significance of their presence.

Implications of the Fungi

Fungal remains were found in abundance in samples from all three localities. The fungal spores have been accorded broad taxonomic treatment in the systematic section, and have generally been placed in form-genera. Five species of fungal fructifications have been identified in these deposits, and are also included in the systematic section. The dispersed fungal spores generally can not be identified with living forms, so they can give us little palaeobotanical and

TABLE 2. Botanical Families Represented by Fossil Taxa

Families are arranged in alphabetical order under appropriate headings

---

PTERIDOPHYTES

Cyatheaceae/Dicksoniaceae

Cyathidites australis
C. minor
C. cf. *C. minor*
C. subtilis
?*Matonisporites ornamentalis*
Rugulatisporites mallatus
Trilites tuberculiformis

Dennstaedtiaceae

Hypolepis spinysporis
?*Leptolepidites tuberosus* sp. nov.

Gleicheniaceae

Clavifera triplex
Gleicheniidites circinidites

Lycopodiaceae

Foveotriletes crater
F. palaequetrus
Foveosporites lacunosus
Lycopodiumsporites spp.

Osmundaceae

Baculatisporites comaumensis
Osmundacidites spp.

Polypodiaceae

Polypodiisporites speciosus
Polypodiisporites spp.

Protocyatheaceae

Cyatheacidites annulatus

Schizaeaceae

Cyathidites splendens
?*Laevigatosporites major*
Microfoveolatosporis spp.
Verrucosisporites kopukuensis

BRYOPHYTES

Sphagnaceae

Cingutriletes clavus
Stereisporites antiquasporites
S. (*Tripunctisporis*) sp.

GYMNOSPERMS

Araucariaceae

Araucariacites australis

Araucariaceae (cont.)

A. sp.
?*Dilwynites granulatus*

Ephedraceae

Ephedripites notensis

Podocarpaceae

Dacrycarpites australiensis
Lygistepollenites florinii
Microcachryidites antarcticus
Phyllocladidites mawsonii
Phyllocladus palaeogenicus
Podocarpidites spp.
?*Podosporites microsaccatus*

MONOCOTYLEDONS

Gramineae

Graminidites media

Liliaceae

Liliacidites lanceolatus
L. sp.
?*Monosulcites verrucosus* sp. nov.

Sparganiaceae

Sparganiaceaepollenites
cf. *S. barungensis*

DICOTYLEDONS

Aquifoliaceae

Ilexpollenites clifdenensis

Casuarinaceae

Haloragacidites harrisii
H. trioratus

Epacridaceae

?*Ericipites crassiexinus*
?*E. scabratus*

Euphorbiaceae

Dodonaea sphaerica
?*Echiperiporites* sp.
?*Malvacipollis diversus*
?*M. subtilis*
Tricolporites cf. *T. endobalteus*

Fagaceae

Nothofagidites spp.

Haloragaceae

Haloragacidites haloragoides

Leguminosae

Polyadopollenites myriosporites

Loranthaceae

Gothanipollis cf. *G. gothani*
G. cf. *G. bassensis*

Myrtaceae

Myrtaceidites spp.

Olacaceae

Anacolosidites spp.

Oleaceae

?*Tricolporites sphaerica*

Polygalaceae

Polycolpites esobalteus

Proteaceae

Banksieaeidites spp.
Beaupreaidites elegansiformis
B. verrucosus
?*Proteacidites* spp.
?*Triporopollenites chnosus*

Santalaceae

Santalumidites cainozoicus

Sapindaceae

Cupanieidites major/*orthoteichus*

Sapotaceae

Sapotaceoidaepollenites
cf. *S. rotundus*

Saxifragaceae

?*Polycolpites* sp.

Symplocaceae

Symplocoipollenites austellus

Winteraceae

Gephyrapollenites calathus

palaeoclimatic information apart from indicating the existence of a fungal flora of considerable diversity. The fructifications, however, can be referred to living taxonomic groups with greater accuracy and therefore may be of more value as climatic indicators. Fructifications found in this study can be referred to the family Microthyriaceae. Living members of the family are epiphyllous; although host-specific, at present members of this group are found on both gymnosperm and angiosperm leaves.

The epiphyllous fungi are of special interest here because of recent work done on this group in Australian Tertiary deposits. Selkirk (1969; 1972; 1975) has studied the epiphyllous fungi from Kiandra, and Lange (1969; 1970) and Lange & Smith (1971) have described fungal assemblages from the Middle Eocene Maslin Bay flora, South Australia. Prior to this, the only work on Australian Tertiary fungi was done by Cookson (1947c).

The Microthyriaceae had a generally global distribution during the Tertiary, with records from North America, Europe, Asia, Sumatra, Australia, New Zealand, Kerguelen, Africa, and India (see Dilcher, 1965, and Ramanujam & Rao, 1973, for a more detailed list of occurrences). They appear to have had a modern aspect by Eocene times (Dilcher, 1965). At present, members of the Microthyriaceae are abundant in humid tropical to semitropical areas with high rainfall. Rainfall and humidity appear to be more critical than temperature in controlling their present distribution (Ramanujam & Rao, 1973). Although fossil microthyriaceous fungi have commonly been regarded as indicating warm moist conditions, Selkirk (1975) advocates caution in accepting such climatic interpretations, especially if based on poorly identifiable fossil material assigned to form-genera such as Phragmothyrites. He has noted that in New South Wales, members of _Microthyrium_ (similar to many isolated fossil fructifications) are common in subtropical rainforests in coastal areas, but extend into sub-alpine and low rainfall areas as well.

In general, the fossil fungi found in these samples appear to be of little use as climatic indicators on their own, but may help reinforce evidence indicated by the macro- and microfloras with regard to moisture and temperature requirements. Some fungal species described from Kiandra by Selkirk (1975) can be compared to modern genera or species whose ecological requirements are known. Fossil members of the Trichopeltaceae, _Asterina_ spp., and the Meliolaceae appear to indicate moist conditions, with most hosts for living Australian members of these groups either rainforest species or those confined to moist environment. On the other hand, modern species of _Vizella_ and the Entopeltaceae are found in a wide range of climatic conditions so that fossil species referable to these two groups would not be useful indicators on their own.

Implications of the Algae

Three recognizable types of algal remains were found in these samples: *Pediastrum*, a planktonic colonial alga, found in low frequencies in a few samples at all three localities; *Botryococcus*, a planktonic colonial oil-secreting alga, found in low to moderate frequencies in some samples from all three localities; and acritarchs, here not identified more specifically, found in a few samples from Kiandra. No quantitative or detailed systematic work has been done on the algae found in these samples, but their presence in these deposits is of interest, and consideration must be given to any information they can provide on these floras and their environments.

The occurrence of *Pediastrum* and *Botryococcus* together in the same deposit is indicative of a lacustrine environment. *Botryococcus* has a geologic record which extends back at least to the Ordovician. It is an alga for which vegetative reproduction only is known, and has remained virtually unchanged over a long period of time. The fossil record shows that *Botryococcus* is commonly found in fresh-water deposits, but it has also been reported in brackish and marine deposits (Newman, 1965). Traverse (1955) recorded *Botryococcus* from a sequence of lignite, clay, and organic silt of Oligocene age from Vermont. In the deposit, *Botryococcus* was numerous in the silt, along with *Quercus* pollen (an anemophilous genus); both were absent from the lignite, which contained abundant pollen of a swamp shrub. Traverse interpreted the distribution of *Botryococcus* and *Quercus* pollen to imply deposition in shallow, muddy open water, some distance from standing vegetation. Dulhunty (1944) thought deposits with *Botryococcus* formed in small, isolated lakes, filled by the penetration of backwaters through peat beds or marshes from flowing watercourses some distance away.

He believed that growth of the alga was hampered in peaty swamps with considerable humic matter. In the deposits of concern here, *Botryococcus* is most numerous in a sample from Cadia, which is lignitic; however, it is not found in the lignite samples from Kiandra.

Pediastrum is a planktonic, colonial green alga with an acid-resistant, cellulosic wall, and a fossil record extending back to the Early Cretaceous (Newman, 1965). At present it has a freshwater habitat, and it was probably restricted to freshwater environments in the past, although it has been reported from two marine deposits of Cretaceous age (Evitt, 1963). The colonies found in these deposits differ from those previously described in some morphological details, but are generally similar. *Pediastrum* was found in only a few samples, but was represented at all three localities.

The presence of spinose acritarchs in a few samples from Kiandra is of interest, in that there are few published records of this group from freshwater environments. Only a mention of their occurrence is made here, and they have not been identified more specifically.

The algae found in these deposits are indicative of lacustrine conditions, but appear to provide little other information.

CHAPTER 3. NERRIGA

Regional Setting

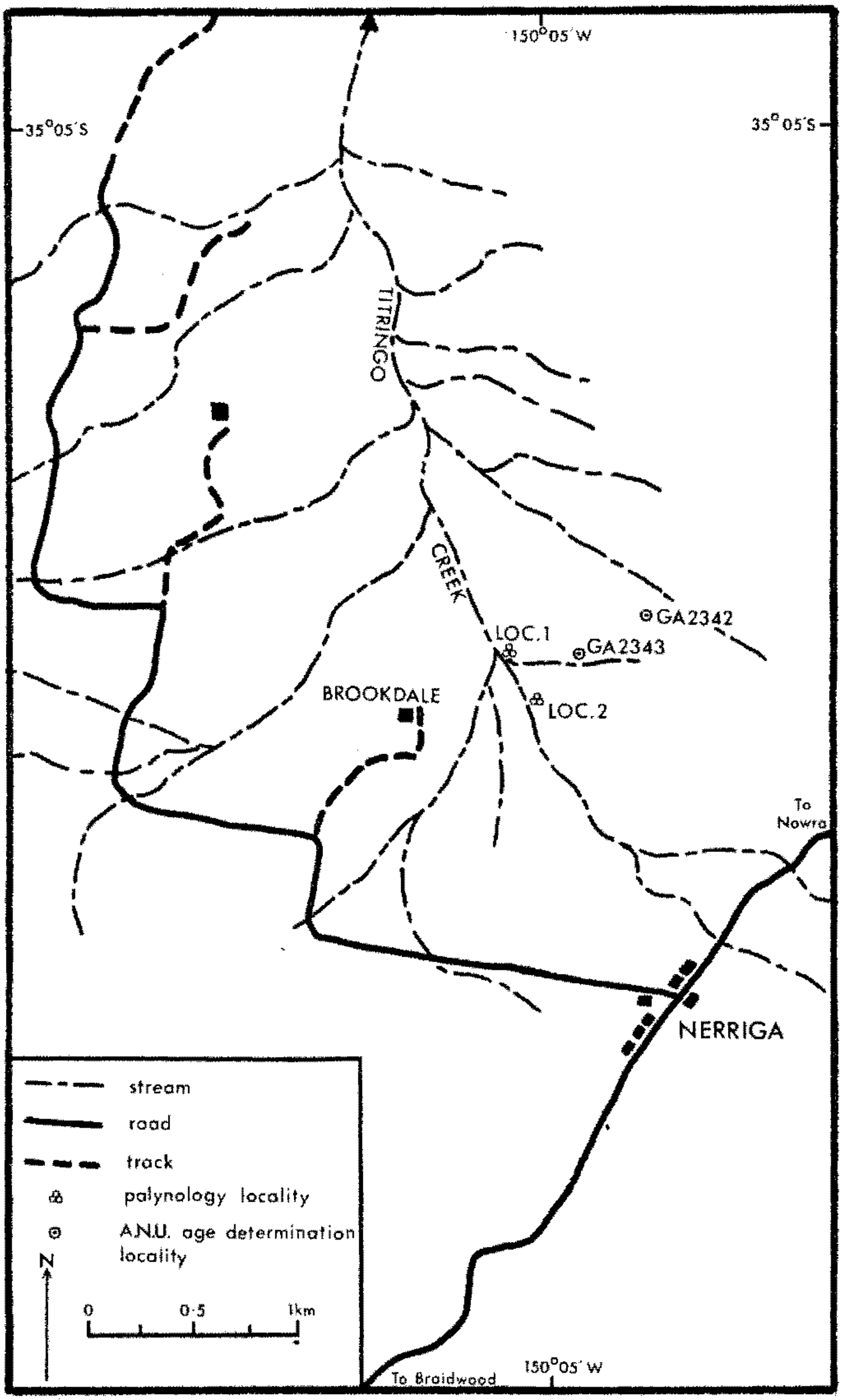
Nerriga is situated approximately 50 km north of Braidwood, in the Southern Tablelands of New South Wales (see Text-figure 1). The Nerriga area forms a wide upland plain at an elevation of 650-730 metres, bordered to the east by the Budawang Range and Sassafras Tableland with elevations of 820-850 metres, and to the west by the valley of the Shoalhaven River which drops down to less than 300 metres. Dry sclerophyll eucalypt forest covers much of this area, with patches of swampy heath and woodland on gentler slopes; some areas have been cleared for grazing.

Craft (1931) has described the physiography of this region, and more recently Raine (1967) mapped and described the geology, and made a preliminary study of the Tertiary microflora. In the area, Tertiary basalts and sediments overlie a Palaeozoic surface of Ordovician, Upper Devonian, and Permian rocks.

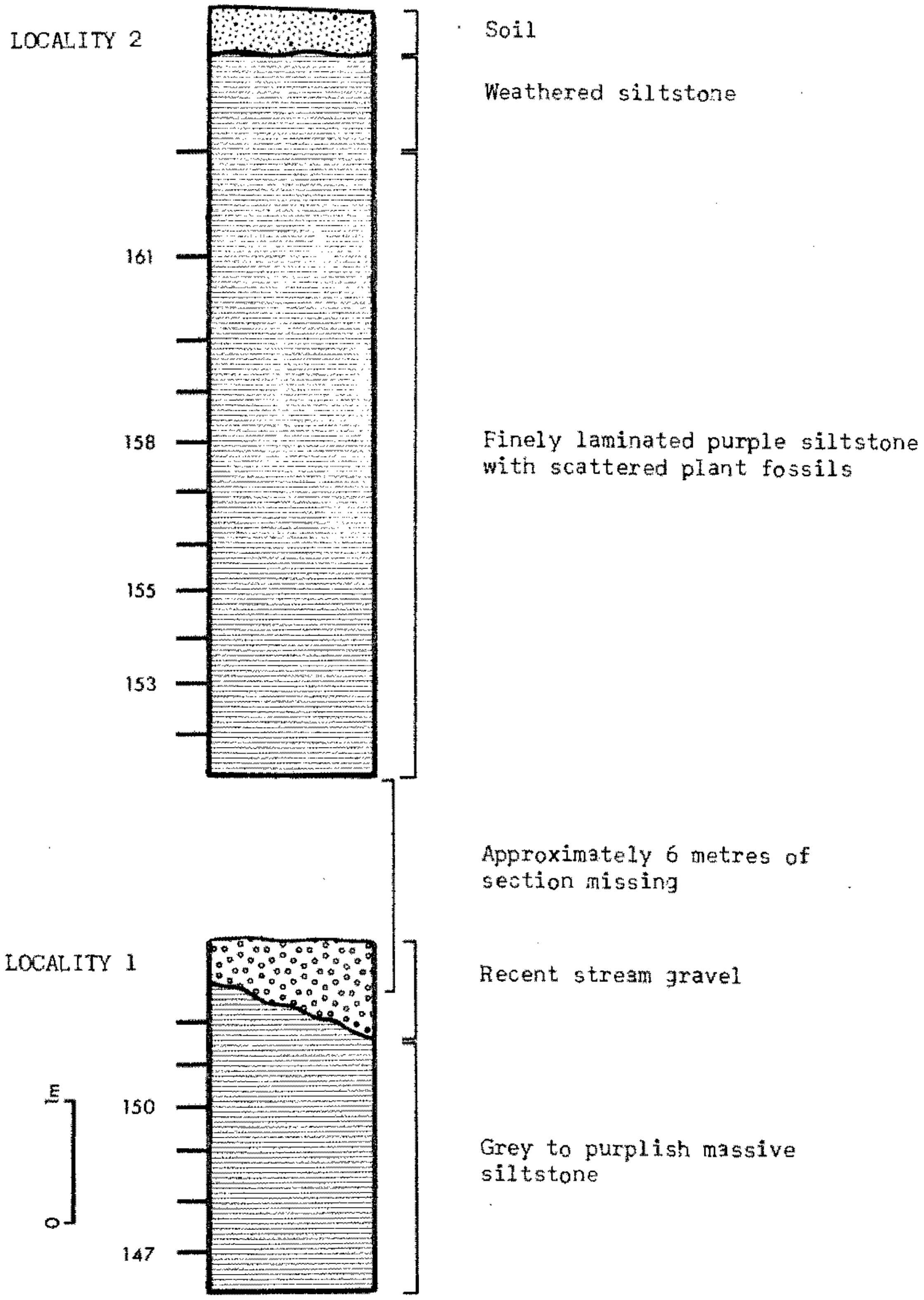
Tertiary Basalts and Associated Sediments

Tertiary basalt flows overlie a sequence of freshwater sediments near Nerriga. These basalts are part of the Nerriga Volcanic Province (Wellman & McDougall, 1974a), with ages ranging from 46 to 40 m.y., i.e. late Eocene. Craft (1931) notes that the basalts have a maximum thickness of more than 106 metres (350 feet) near Titringo Creek. The occurrence of Tertiary silcrete deposits indicates that basalts were formerly more extensive than at present.

Two basalt samples have been dated in this area (see Text-figure 2). Their K-Ar ages do not agree with their relative stratigraphic positions. Wellman & McDougall (1974a, p.255) suggest that the stratigraphically older rock (GA2343, which gave ages of 40.8 and 41.9 m.y.) has lost some argon, so that both



Text-figure 2. Sample localities from the Nerriga area.



Text-figure 3. Stratigraphic sequence at localities 1 and 2, Nerriga area. (See Text-figure 2 for location.) Palynological sampling intervals are indicated at the left of the column, with samples used in this study shown by number.

basalts are at least 45 m.y. old. (The stratigraphically younger rock, GA2342, gave ages of 44.8 and 41.6 m.y.).

Sub-basaltic sediments in the area include sand, gravel, and in some places grey siltstone. Inter-basaltic sediments include sand and gravel (Raine, 1967). The grey siltstone unit, exposed in a stream section along Titringo Creek, consists of horizontally bedded, finely laminated siltstone with rare fine sandstone. The unit has a maximum thickness of 38 metres, and contains abundant leaves, wood, and small circular fruits. Samples for palynological study were collected from this unit. The siltstone is overlain by white clay-rich sand and then by basalt; Raine found evidence of erosion at the top of these sediments at the contact with the basalt.

A total of 20 samples were collected and macerated, and 6 were chosen for detailed study. Sample localities are shown in Text-figures 2 and 3. The siltstone unit is nearly horizontal, with no apparent folding or faulting, so altitudinal differences are assumed to approximate stratigraphic intervals. In agreement with the field evidence of a generally uniform sequence, the microfloral assemblage was similar in all the samples studied.

Composition of the Assemblage

A diverse assemblage of 25 species of spores, 11 species of gymnosperms, 67 species of angiosperms, and 3 species of uncertain affinities were isolated in these samples. Most taxa can be related to previously described species. (These taxa are form species, and no equivalence to extant natural botanical species is implied. A form species may and probably does include more than one living natural botanical species.) Table 3 lists the species found in these samples, and includes quantitative analyses based on counts of 250 grains (on average) per sample. Species are arranged in

TABLE 3. Composition of the Microfloral Assemblage from Nerriga

All figures are in percentages of total grain count.
+, observed in count scans but not included in count.

SPORES	147	150	153	155	158	161
Cyathidites australis	4	3	5.5	5.5	5	6
minor	4.5	4	3	9	3	5.5
splendens	-	-	1	1	-	0.5
Biretisporites spp.	0.5	0.5	1.5	2.5	1	1.5
Deltoidospora sp.	-	-	-	-	-	-
Stereisporites antiquasporites	0.5	1.5	2	0.5	-	-
(*Tripunctisporis*) sp.	-	1	+	1	1	0.5
Verrucosisporites kopukuensis	-	-	-	0.5	-	-
cf. *V. cristatus*	-	-	0.5	-	-	-
Baculatisporites comaumensis	-	-	0.5	0.5	-	0.5
Foveotriletes crater	-	-	-	-	-	-
palaequetrus	-	-	-	0.5	-	-
Rugulatisporites mallatus	-	-	1.5	1.5	-	1
Trilites tuberculiformis	-	3	4	7	3	3
Ischyosporites sp. 1	0.5	-	0.5	0.5	0.5	-
sp. 2	1	0.5	2	3	0.5	1
Lycopodiumsporites spp.	1	-	-	-	-	-
Gleicheniidites circinidites	-	0.5	-	-	-	-
Clavifera triplex	-	-	-	0.5	0.5	-
Laevigatosporites ovatus	3	0.5	1	1.5	1	1.5
major	3.5	0.5	0.5	1	1	1
Polypodiisporites speciosus	0.5	-	0.5	0.5	0.5	-
sp. 2	-	0.5	1	0.5	-	-
Reticuloidosporites escharus	-	-	-	-	-	-
Microfoveolatosporis sp. 2	0.5	-	-	0.5	-	-
TOTAL SPORES	19.5	15.5	25.0	37.5	17.0	22.0
POLLEN						
Podocarpidites spp. undiff.	-	0.5	-	0.5	-	0.5
ellipticus	1	0.5	1.5	2	2	2
marwickii	-	-	-	-	-	-
sp.	-	-	0.5	-	1	1
Lygistepollenites florinii	0.5	-	+	-	0.5	-
Parvisaccites catastus	-	-	0.5	-	-	-
Microcachryidites antarcticus	-	-	-	0.5	0.5	-
Phyllocladus palaeogenicus	-	-	-	-	-	-
Araucariacites australis	0.5	-	+	-	-	-
Dilwynites granulatus	-	0.5	1	0.5	-	1
cf. *D. tuberculatus*	-	-	-	-	-	-
Ephedripites notensis	0.5	0.5	-	-	0.5	1
TOTAL GYMNOSPERMS	2.5	2.0	3.5	3.5	4.5	5.5
Liliacidites lanceolatus	2	-	2	-	0.5	2.5
spp.	2.5	0.5	1.5	1.5	2.5	2.5
Monocolpate spp.						
Tricolpites spp.	3	2	1	0.5	1.5	2
cf. *T. pachyexinus*	1	-	-	0.5	-	-
patulus sp. nov.	-	1	-	0.5	1.5	-

	147	150	153	155	158	161
Intratriporopollenites notabilis	0.5	-	-	-	0.5	0.5
Cupanieidites major/orthoteichus	11	11	6.5	6	9	6
Myrtaceidites mesonesus	1	1	0.5	-	1	1
parvus	6	4.5	1.5	2.5	0.5	5.5
eugeniioides	0.5	0.5	+	-	-	-
verrucosus	-	-	-	-	0.5	-
Gemmatricolporites cf. G. gestus	-	-	1	-	-	-
Tricolporites sphaerica	-	0.5	1	0.5	2	0.5
microreticulatus	1.5	2.5	3	1	2	2.5
paenstriatus	1	3	3.5	1	2	2
prolata	2	3	0.5	2	4.5	5.5
scabratus	1.5	0.5	2	2	3	1.5
valvatus	-	-	-	-	-	-
sp. 2	1.5	-	-	1	-	2
sp. 3	1.5	-	-	1	-	-
sp. 5	-	-	-	-	-	1.5
undiff.	6.5	2	2	1	1.5	-
Sapotaceoidaepollenites						
cf. S. rotundus	-	-	-	-	-	-
Ilexpollenites clifdenensis	-	-	0.5	-	0.5	0.5
Nothofagidites asperus	1	0.5	+	0.5	-	-
flemingii	-	0.5	1	-	0.5	-
brachyspinulosus	-	0.5	1.5	-	-	0.5
emarcidus-heterus	5	7	4	1	7.5	4
incrassatus	-	-	0.5	0.5	-	-
vansteenisii	2.5	2	0.5	0.5	2.5	2
Polycolpites esobalteus	1.5	1.5	1.5	1	1.5	1.5
Sparganiaceaepollenites spp.	-	-	+	-	1	-
Banksieaeidites elongatus	-	1.5	1	0.5	1	1.5
arcuatus	0.5	0.5	-	-	0.5	-
Triporopollenites ambiguus	-	-	-	-	0.5	-
Santalumidites cainozoicus	0.5	1.5	2.5	0.5	2	1
Proteacidites annularis	0.5	-	+	-	-	-
asperopolus	-	0.5	0.5	-	1	2
pachypolus	-	0.5	0.5	1	0.5	-
tenuiexinus	-	-	-	-	-	-
?callosus	-	0.5	1	1	-	-
concretus	1	1	2.5	0.5	-	0.5
grandis	-	0.5	1	1	0.5	-
ornatus	-	0.5	0.5	-	-	0.5
crassus	-	-	-	0.5	-	-
kopiensis	2	-	0.5	0.5	-	0.5
latrobensis	-	-	1.5	1.5	-	-
minimus	3	4	1	3.5	2	3.5
parvus	-	0.5	-	1	-	0.5
pseudomoides	1.5	1	2.5	6	1.5	3.5
reticuloscabratus	-	3.5	0.5	1.5	3.5	0.5
subscabratus	3.5	3.5	4	4	4	1
?rectomarginis	-	-	-	-	-	-
tuberculiformis	-	-	-	-	-	-
tripartitus	0.5	-	3.5	0.5	1	1.5
undiff.	2	-	1	-	-	-

	147	150	153	155	158	161
Triorites miniscululus	1.5	4	3	4.5	4.5	4
introlimbatus	-	7	-	-	2.5	2
Haloragacidites harrisii	2.5	2	3.5	2	3	3
trioratus	-	1.5	1.5	0.5	0.5	-
Anacolosidites acutullus	0.5	-	-	0.5	0.5	-
luteoides	-	-	0.5	0.5	0.5	0.5
Periporopollenites vesicus	-	-	-	-	-	-
demarcatus	1	1	1	0.5	-	0.5
Malvacipollis diversus	1	1	1	0.5	1	1
subtilis	-	-	+	-	-	-
Ericipites crassiexinus	0.5	-	-	-	-	-
scabratus	-	0.5	-	-	-	-
Simplicepollis meridianus	-	2	1	1	2	0.5
TOTAL POLLEN	75.0	82.5	71.0	58.0	78.5	72.0
Schizosporis parvus	3	-	1	1	-	0.5
rugulatus	-	-	-	-	-	-
Circulisporites spp.	0.5	-	1	-	-	-
TOTAL INCERTAE SEDIS	3.5	-	2	1	-	0.5

major taxonomic groups. All samples also contained a diverse array of fungal spores, some fungal fructifications, and algae (Pediastrum, Botryococcus).

The assemblage has been divided into three component groups: spores, gymnosperms, and angiosperms. The gymnosperms include Ephedripites notensis and Dilwynites spp. Although Harris (1965a) considered an angiosperm affinity likely for Dilwynites granulatus and D. tuberculatus, a gymnosperm affinity appears equally possible, and in this study these species have been considered to be of gymnosperm affinity.

The angiosperm group has been further subdivided into the Nothofagidites component, the Myrtaceae-type* component (Myrtaceidites spp.), the Cupanieidites major/orthoteichus component, the Proteaceae-type component (Proteacidites spp. + Banksieaeidites spp.), and the Casuarina-type component (Haloragacidites harrisii + H. trioratus). Relative percentages of component groups for these samples are given in Table 4, and the same data is shown diagramatically in Text-figure 4.

The spore assemblage comprises 15.5 to 37.5% of the total assemblage, and contains pteridophytes, including a tree fern element (Cyathidites spp., and perhaps Trilites tuberculiformis), and some bryophytes (Stereisporites spp.). The tree fern element forms at least 7% of the assemblage, and is therefore a significant part of the assemblage. High percentages for individual species (more than 5% of total grain count) are 5-6% for Cyathidites australis (samples 153, 155, 158, 161), 5.5 and 9% for Cyathidites minor (samples 161 and 155), and 7% for Trilites tuberculiformis (sample 155).

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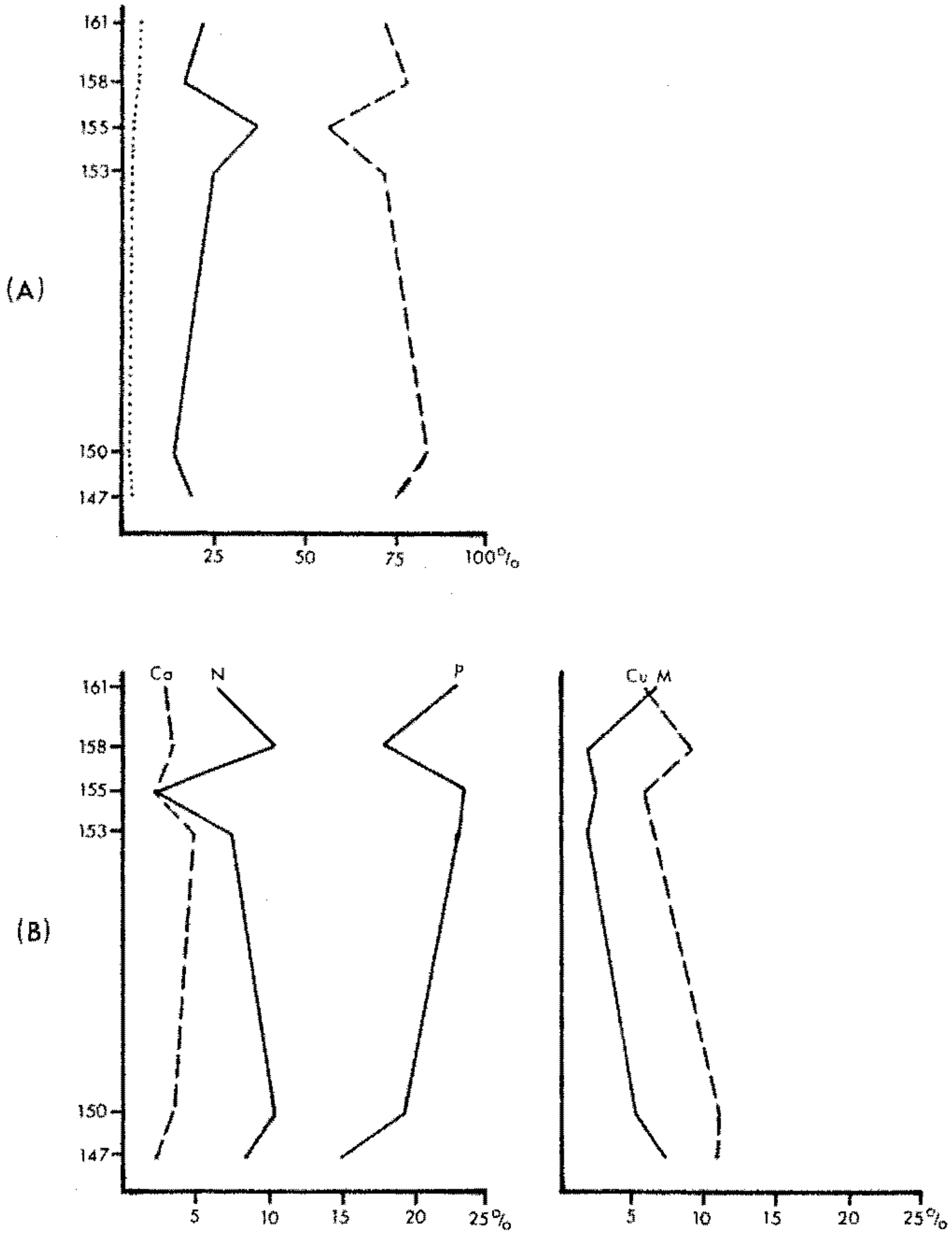
*For ease of discussion, fossil species that can confidently be assigned to a specific living taxon are referred to as ____-type component, e.g. two fossil species (H. harrisii and H. trioratus) that can be assigned to a living taxon (Casuarina) for the purposes of abundance data, etc., are referred to as Casuarina-type component.



Text-figure 4. Percentage frequency distribution of major component groups (A) and some selected angiosperm components (B), Nerriga. For A, solid line = pteridophytes, dotted line = gymnosperms, and dashed line = angiosperms. For B, N = Nothofagidites spp., Ca = Casuarina-type, P = Proteaceae-type, Cu = Cupanieidites orthoteichus, M = Myrtaceae-type.

The gymnosperm component is very small, 2-5.5%, and except for *Podocarpidites* spp., only a few grains of each species were found.

The angiosperm component dominates the assemblage, both in number of species and absolute grain numbers (58-83% of the total number of grains counted). In contrast with assemblages from the two other localities, the *Nothofagidites* component is small, 2.5-10.5%, with pollen of the *brassi* type the most abundant in each sample. Pollen of *menziesii* type, represented by *N. asperus*, is rare, whereas pollen of *fusca* type, represented by *N. flemingii*

TABLE 4. Relative Percentages of Major Component Groups, Nerriga

All figures are in percentages of total grain count

Sample No.	Spores	Gymno.	Total Ang.	*Notho.* (*m*,*f*)	Myrt.	*Cup.*	Prot.	*Cas.*
147	19.5	2.5	75	8.5 (1,-)	7.5	11	15	2.5
150	15.5	2	82.5	10.5 (1,1)	5.5	11	19.5	3.5
153	25	3.5	71	7.5 (-,2.5)	2	6.5	23	5
155	37.5	3.5	58	2.5 (1,-)	2.5	6	23.5	2.5
158	17	4.5	78.5	10.5 (-, 1)	2	9	18	3.5
161	22	5.5	72	6.5 (-, 1)	6.5	6	23	3

Gymnosperm component: Includes *Araucariacites australis*, *Dilwynites* spp., *Ephedripites notensis*, as well as *Podocarpidites* spp., *Lygistepollenites florinii*, *Parvisaccites catastus*, *Microcachryidites antarcticus*, and *Phyllocladus palaeogenicus*.

Nothofagidites component: Total of all three groups, *brassi*+*menziesii*+*fusca*; separate values for *menziesii* and *fusca* types given in parentheses.

Myrtaceae-type component: *Myrtaceidites* spp.

Cupanieidites major/*orthoteichus* component: *Cupanieidites major*/*orthoteichus*.

Proteaceae-type component: *Proteacidites* spp. + *Banksieaeidites* spp.

Casuarina-type component: *Haloragacidites harrisii* + *H. trioratus*.

and *N. brachyspinulosus*, forms up to a third of the total *Nothofagidites* component. The Myrtaceae-type component, 2-7.5%, is composed of *Myrtaceidites parvus* and *M. mesonesus*; only a few grains of *M. eugeniioides* and *M. verrucosus* were seen. The *Cupanieidites major/orthoteichus* group is morphologically diverse in these samples, and reaches abundances of 11% of the total grain count. (The three species types described by Cookson & Pike (1954b) were all found in these samples, as well as many intergrading specimens, so they have been treated here as a species group.) *Proteacidites* spp. were abundant both in numbers of species and relative percentages of the total assemblage, and the Proteaceae-type component (*Proteacidites* spp. + *Banksieaeidites* spp.) was 15-23%. The *Casuarina*-type component was small, 2.5-5%. For this value the percentages of *Haloragacidites harrisii* and *H. trioratus* have been combined, as both species have probable affinities with the Casuarinaceae (see Guppy and others, 1973, p.205).

A different analysis of this assemblage, using the three floristic elements outlined by Burbidge (1960), divides the suite into "Antarctic", "Australian", and "Tropical" elements. The "Antarctic" element contains taxa with a postulated origin in the Southern Hemisphere and a possible Antarctic centre of dispersal. Included in this group are *Nothofagus* (represented by *Nothofagidites* spp.), the Podocarpaceae (*Podocarpidites* spp., *Dacrycarpites*, *Lygistepollenites florinii*), and the Araucariaceae (*Araucariacites* spp.). Together these form a minor part of the assemblage from Nerriga. The "Tropical" element contains taxa related to those now distributed mainly in tropical and subtropical regions from Indo-Malaysia to Australia. Included in this group are *Cupanieidites major/orthoteichus*, *Anacolosidites acutullus*, *A. luteoides*, *Santalumidites cainozoicus*, and possibly *Malvacipollis* spp.

The "Australian" element consists of taxa with extensive development in the Australian region, and is represented by *Banksieaeidites* spp., *Proteacidites* spp., *Casuarina*-type pollen, and *Myrtaceidites* spp. This group comprises a significant part of the assemblage. Further mention of the implications of these elements will be given below.

Age of the Assemblage

Several species found at Nerriga are not found at the other two localities. These species are:

Cyathidites minor
C. splendens
Clavifera triplex
Polypodiisporites speciosus
P. sp. 2
Microfoveolatosporis sp. 2
Ephedripites notensis
Intratriporopollenites notabilis
Gemmatricolporites cf. *G. gestus*
Tricolpites patulus (sp. nov.)
Tricolporites paenstriatus
T. scabratus
T. valvatus
Triporopollenites ambiguus
Santalumidites cainozoicus
Anacolosidites acutullus
A. luteoides
Stereisporites (*Tripunctisporis*) sp.
Foveotriletes palaequetrus
Trilites tuberculiformis
Proteacidites asperopolus
P. tenuiexinus
P. ?*grandis*
P. ornatus
P. crassus
P. kopiensis
P. latrobensis
P. pseudomoides
P. ?*rectomarginis*
P. tuberculiformis
P. tripartitus
P. ?*callosus*
P. concretus
Simplicepollis meridianus

Several of these species have restricted stratigraphic ranges during the Eocene in the Gippsland Basin, and therefore can be of chronostratigraphic use. The following species all occur within the period encompassed from the *Malvacipollis diversus* to the Lower *Nothofagidites asperus* Zones (Stover & Partridge, 1973), of early to middle Eocene age: *Triporopollenites ambiguus*, *Tricolporites scabratus*, *Anacolosidites acutullus*, *A. luteoides*, *Proteacidites asperopolus*, *P. crassus*, *P. kopiensis*, *P. latrobensis*, *P. grandis*, *P. ornatus*, *P. tuberculiformis*, *Intratriporopollenites notabilis*, *Santalumidites cainozoicus*. In addition, *Tricolporites paenstriatus*, *Proteacidites pseudomoides*, *P. tenuiexinus*, and

Simplicepollis meridianus have longer ranges that extend throughout this interval. *Stereisporites* (*Tripunctisporis*) sp. and *Foveotriletes palaequetrus* have ranges confined to or beginning in the Lower *Nothofagidites asperus* Zone.

Cyathidites splendens has been reported as rare in the *Cupanieidites orthoteichus* Zonule of the Otway Basin (Harris, 1971), and occurs with *A. luteoides* and *Intratriporopollenites notabilis*. *Tricolporites valvatus* and *P. kopiensis* have been reported from middle Eocene deposits by Harris (1972).

These data would suggest an age of early to middle Eocene for this assemblage, considerably earlier than the K-Ar date on the basalt would indicate. The closest equivalent zone in the Gippsland Basin is the *Malvacipollis diversus* Zone regarded as early Eocene (Stover & Evans, 1973). Characteristics of assemblages from this zone are: predominance of *Proteacidites* spp., the preponderance of angiosperm pollen (Stover & Evans give a figure of 75% for the angiosperm component at the top of the zone), and a generally subordinate position for *Nothofagidites* spp. pollen, with the *fusca* and *brassi* types represented. Pollen of the *menziesii* type is absent in this zone in the Gippsland Basin, but is found in the overlying zone (the *Proteacidites asperopolus* Zone). Spores and gymnosperms are sparse in this zone; this is not paralleled in the Nerriga assemblage, however, as a diversity of spores are present, although gymnosperms are minor. Species found in the *M. diversus* Zone but not at Nerriga are *Proteacidites leightonii*, *P. reticulatus*, *Schizocolpus marlinensis*, *Spinizonocolpites prominatus*, *Beaupreaidites elegansiformis*, *Kuylisporites waterbolkii*, *Milfordia homeopunctata*, and *Dryptopollenites semilunatus*. *Beaupreaidites elegansiformis* is here considered to be facies-controlled, and characteristic of peat swamp environments; *Milfordia homeopunctata* may be restricted environmentally as well (Machin (1971) correlates abundant Restionaceae with brackish to marine water conditions in a study of Tertiary microfloras from the Isle of Wight.) This zone is considered equivalent in part to the Cupanieidites orthoteichus Zonule of Harris (1971).

In his study of the Nerriga microflora, Raine (1967) considered an age of youngest Paleocene to early Eocene likely, and placed it in the Cupanieidites orthoteichus Zonule of Harris. Table 5 gives a list of the species he recorded from these deposits, and the second column gives the equivalent name used herein, if not the same, or notes that it was not found in the present study.

Comparison with Other Assemblages from Australia

Microfloras of Eocene age have been described from several different parts of Australia. Where continuous and extensive sections through Eocene deposits have been studied, e.g. the Otway and the Gippsland Basins, several different zonal assemblages have been described within that interval, indicating a time of change in the floras represented. Spore-pollen zones in the Otway and Gippsland Basins have been correlated with planktonic foraminiferal zones.

Otway Basin: The Nerriga assemblage does not really show features characteristic of any particular upper Paleocene or Eocene zonule described by Harris (1971) for the Otway Basin. Harris's use of long-ranging gymnosperm and spore species as diagnostic if "common" or "rare" in a particular zonule can be misleading in attempts to correlate on a regional scale, as these species can be assumed to vary in abundance with strictly local conditions within a long period of time. Of more use in the application of zonal schemes outside the Otway Basin area is a listing of the spore and pollen species found within that interval, as well as diagnostic,

Table 5. Species Previously Reported from Nerriga Microfloras

Data from Raine (1967)

Species Reported by Raine	Equivalent Name in this Study
Cyathidites minor	"
C. splendens	"
Deltoidospora sp.	"
Leiotriletes spp.	*Biretisporites* spp.
Neoraistrickia sp.	*Rugulatisporites mallatus*
Ischyosporites sp.	"
Trilites sp.	*Trilites tuberculiformis*
Echinosporis microechinatus Krutzsch	(not found)
Microfoveolatosporis sp.	"
Polypodiisporites sp.	"
Podocarpidites cf. *P. ellipticus*	"
P. cf. *P. marwickii*	"
P. sp.	"
Banksieaeidites cf. *B. minimus*	*B. arcuatus*
Proteacidites annularis	"
P. cf. *P. grandis*	"
P. incurvatus	(not found)
P. ornatus	"
P. pachypolus	"
P. parvus	"
P. reticuloscabratus	*P. tripartitus*
P. scaboratus Couper	(not found)
P. subscabratus	"
P. symphyonemoides	*P. pseudomoides*
P. tuberculiformis	"
P. sp. a	(not found)
P. sp. b, c	*P. tuberculiformis*
P. sp. d	*Triporopollenites ambiguus*
Anacolosidites acutullus	"
A. luteoides	"
Triorites harrisii	*Haloragacidites harrisii*
Malvacipollis sp. a	*M. diversus*
M. sp. b	*M. subtilis*
Tricolpites sp. a	*T. patulus* sp. nov.
T. sp. b	(not found)
Duplopollis orthoteichus	*Cupanieidites orthoteichus*
"*Tricolporites*" *microreticulatus*	"
T. sphaerica	"
T. scabratus	"
Myrtaceidites sp.	*Myrtaceidites mesonesus*
Tiliaepollenites notabilis	*Intratriporopollenites notabilis*
Stephanoporopollenites sp.	(not found)
Periporiti gen. et sp. indet.	(not found)
Nothofagidites brachyspinulosus	"
N. cf. *cincta*	*N. flemingii*
N. hetera	"
Microthyriacites edwardsi	*Callimothallus pertusus*

common, and abundant taxa. (Species that were found to be most useful in relating assemblages from terrestrial deposits to those from the Gippsland Basin zones were generally not abundant or common, but were distinctive and short-ranging. Many of the diagnostic species, e.g. some species of *Proteacidites*, are absent from the terrestrial deposits.

The *Cupanieidites orthoteichus* Zonule (late Paleocene) is characterized by *C. orthoteichus*, *Proteacidites pachypolus*, *Anacolosidites luteoides*, and *Myrtaceidites eugeniioides*, all found at Nerriga, and *Proteacidites incurvatus* and *Beaupreaidites elegansiformis*, absent from Nerriga. All species listed by Harris as abundant or common are also found at Nerriga, except for *Polyporina fragilis*. *Santalumidites cainozoicus* and *Nothofagidites asperus* are absent from the zonule, although both are found in Cookson's Microflora C and at Nerriga.

The *Proteacidites confragosus* Zonule (Eocene) is characterized by consistent occurrence of *Proteacidites pachypolus*, *P. kopiensis*, and *P. tripartitus*, all also found at Nerriga; also by *P. confragosus* and *Triporopollenites gemmatus*, which are absent from Nerriga. Species listed as common and rare, except for the long-ranging gymnosperms and *Nothofagidites* spp., are absent from Nerriga.

The *Proteacidites pachypolus* Zonule, considered by Harris to be equivalent to Cookson's Microflora C, is rich in species of *Nothofagidites* and *Proteacidites*. *P. pachypolus* is common, and *P.* (?)*asperopolus* (listed by Harris as *P.* cf. *pachypolus*, and assumed to be *asperopolus*) and *Triorites magnificus* are absent. The *Triorites magnificus* Zonule (middle to late Eocene) is characterized by *Triorites magnificus* and *Proteacidites incurvatus*, absent from Nerriga, and *P. pachypolus*. In this zonule there is an increase in the pteridophyte component, and most species listed as common or rare are also found at Nerriga, as well as the other two localities (Kiandra and Cadia). The highest zonule recognized in the Eocene is the *Sparganiaceaepollenites barungensis* Zonule, characterized by the nominate species and *Nothofagidites asperus*, *N. brachyspinulosus*, *Proteacidites clintonensis*, and several spore and pollen species not found at Nerriga.

None of these zonules particularly characterize the microflora from Nerriga, although all have some species in common with it.

Gippsland Basin: Mention has already been made of the *M. diversus* Zone, which has many species in common with the Nerriga assemblage. Similarities with the *P. asperopolus* and Lower *Nothofagidites asperus* Zones are also found; however, the high abundances of *P. pachypolus*/*P. asperopolus* and *H. harrisii* over *Nothofagidites* spp., a characteristic of the *P. asperopolus* Zone in the Gippsland Basin (Stover & Evans, 1973) is not found at Nerriga. Also, the sudden dominance of *Nothofagidites* spp. which is diagnostic of the base of the Lower *Nothofagidites asperus* Zone is not paralleled at Nerriga, where *Nothofagidites* spp. is minor. Based on similarities of species and general trends, the closest equivalent zonal assemblage is the *M. diversus*, early Eocene.

Queensland: Unit 1 of the Queensland Tertiary succession appears to cover the entire Lower Tertiary, and is undifferentiated (Hekel, 1972), so that no comparisons with the suite from Nerriga can be made at this time. However, species such as *Anacolosidites* sp., which appear to range only through the Eocene in southern Australia, appear to have a later range in the Queensland sequence, and are found in Units 2 and 3, to early Miocene.

Birregurra: Cookson (1954b) described three microfloras from a borehole at Birregurra, Victoria. The youngest assemblage, Microflora C, is characterized by *Anacolosidites luteoides*, *C. orthoteichus*, *Myrtaceidites eugeniioides*, *Proteacidites pachypolus*, and *Santalumidites cainozoicus*, all found at Nerriga. Of all the other species listed as occurring in this suite, only *P. incurvatus*, *Tricolpites thomasii*, and *Beaupreaidites verrucosus* are not found at Nerriga. Except for the species of *Proteacidites*, however, these taxa are generally long-ranging.

Great Artesian Basin: Harris (in Wopfner, Callen, & Harris, 1974) has discussed some microfloras from the Eyre Formation, in the south-western Great Artesian Basin. He has assigned microfloras from the oldest, most widespread unit to the *Gambierina edwardsii* Zone (although the nominate species is absent), close to the boundary with the *C. orthoteichus* Zone; species in common with the Nerriga microflora are few, but include *Anacolosidites acutullus*, *C. orthoteichus*, *Proteacidites kopiensis*, and *Intratriporopollenites notabilis*. In the Frome Embayment, microfloras assigned to the *Proteacidites confragosus* Zone have been found, characterized by *P. confragosus* and *P. asperopolus*, with a low frequency of *Nothofagidites* spp. and high *Haloragacidites harrisii* and *H. trioratus*. Several assemblages assigned to the *Proteacidites pachypolus* Zone have also been found. No microfloras equivalent to the *C. orthoteichus* Zone (or its equivalent in the Gippsland Basin, the *Malvacipollis diversus* Zone), of early Eocene age, have been identified to date.

Western Australia: Hos (1975) has recently discussed a microflora from the upper Eocene Werillup Formation. This assemblage lacks the large reticulate species of *Proteacidites* found at Nerriga, and appears to be distinctly younger than the Nerriga assemblage. Many species are found in both suites, but they are generally long-ranging.

Maslin Bay: To date little data on the pollen assemblage from the early Middle Eocene deposits at Maslin Bay, South Australia, have been available. The microflora has been assigned to the *Proteacidites confragosus* Zone (McGowran, Harris, & Lindsay, 1970). A preliminary report on the vascular plant content (Lange, 1970) suggests an abundance of angiosperm remains, which Lange thought resembled some leaf litters from Queensland wet forests. Many gymnosperm leaves were assignable to the Podocarpaceae and Araucariaceae, and pteridophyte remains were not observed during the preliminary survey.

Deep Lead Deposits: Partridge (1971) has examined a sample from Vegetable Creek (Emmaville), northern New South Wales. Von Ettingshausen (1888) described the extensive collection of plant macrofossils found in this deposit, and several species of pollen were described in papers by Cookson and Cookson & Pike. Partridge considered this assemblage equivalent to the Lower *Nothofagidites asperus* Zone. There are many species in common with the Nerriga microflora; notable absences at Nerriga are *Beaupreaidites elegansiformis*, *B. verrucosus*, and *Foveotriletes balteus*.

Based on the suite from Nerriga, and published records of microfloras of equivalent age from other parts of Australia, the following general features characterize early and middle Eocene assemblages:

1. Abundance and diversity of *Proteacidites* spp., which appear to be widely represented in southern Australian microfloras. The large, elaborately reticulate types, e.g. *Proteacidites ornatus*, *P. grandis*, *P. leightonii*, are especially distinctive. Many of these species appear to have limited vertical ranges.
2. Generally small proportion of *Northofagidites* spp. in relation to other angiosperm groups. The *N. menziesii* type appears to be absent from microfloras older than middle Eocene. The number of species assigned to the *brassi* group is smaller than in younger assemblages.

3. Abundance and diversity in morphology found in the Cupanieidites major/orthoteichus species group.

4. Presence of several taxa with "tropical" affinities, i.e. Anacolosidites luteoides, A. acutullus, Santalumidites cainozoicus. These appear to extend through middle Eocene deposits in southern Australia, although, on present data, they have a later range in Queensland (Hekel, 1972).

An age of early Eocene for the sediments containing the microflora is not incompatible with evidence from the K-Ar dates on the basalts, assuming that late Eocene is a minimum age for the basalts, and there is evidence for erosion between deposition of the siltstone unit and eruption of the basalts.

Palaeoecology

The finely laminated nature and uniform lithology of this siltstone suggest deposition in a quiet water, lacustrine environment. Raine (1967, p.E27) assumed an environment of slowly moving water, with continual submergence; there is no evidence of dessication cracks or bioturbation, and abundant plant remains have been preserved. The existence of a lake during this time period implies disturbance by uplift or blocking of drainage to the north.

Reconstruction of the floral assemblage and its possible climatic requirements at the time of deposition of the siltstone at Nerriga requires two basic assumptions: first, that reliable correlation of diagnostic form taxa with extant taxa (genera and families) can give useful information on ecological requirements and plant associations that may in turn be related back to the fossil taxa, and second, that ecological tolerances of plants represented in early Tertiary microfloras have not altered subsequently (Burbidge, 1960). Both assumptions, and floral reconstructions based on them, become less reliable with increase in time from the present, and are generally not attempted with pre-Cenozoic deposits. Reconstructing floras and climatic conditions based on isolated taxa is unwise; one must think in terms of plant communities existing together, and base any conclusions on the entire spectrum, if possible.

One must also bear in mind that many factors controlling deposition and preservation of spores or pollen grains are unknown. These include rate of pollen production, efficiency and type of dispersal mechanism, suitability of pollen morphology for preservation (e.g. the abundance of Lauraceae leaves found in deposits at Kiandra is not reflected in the microfloral assemblage, where no pollen assignable to Lauraceae is found), as well as many characteristics relating to the physiographic and depositional parameters of the particular site.

With all these limitations in mind, one may proceed to use whatever data are available from taxa that have been confidently related to living genera and families. There are many fossil taxa in this assemblage that cannot be related to living taxa, either because they are morphologically similar to living taxa found in a number of distantly or unrelated families (many of the tricolpate and tricolporate species would be included in this group), or are species with an obscure botanical affinity, possibly produced by extinct plants (several species assigned to *Proteacidites*, e.g. *P. asperopolus*, *P. pachypolus*, *P. ornatus*, appear to have been produced by plants that are now extinct; whereas *Gemmatricolporites* cf. *G. gestus* has an unknown botanical affinity). The so-called "Antarctic" elements will be considered first. *Nothofagidites* spp. represent pollen of types assigned to all three groups of *Nothofagus* now living, although in the Nerriga suite pollen of *menziesii* type is minor. Relative abundances and number of species of this genus in the Nerriga assemblage are small compared to younger Tertiary assemblages, but the ecological requirements of the living *Nothofagus* group are well-documented in comparison with other living groups. At present, there is no single region where all three types of *Nothofagus* grow together.

The *Nothofagus brassi* group is at present found in lower montane rainforests in New Guinea above 2400 metres, and in New Caledonian forests above 600-900 metres, in areas with moderate to high rainfall. They are evergreen trees which require high and relatively uniform humidity. These rainforest communities are composed of up to three *Nothofagus* species, and are associated with species of *Podocarpus* (section *Dacrycarpus*), *Dacrydium*, and *Phyllocladus*, with Myrtaceae, broad-leaved Lauraceae, and Proteaceae also represented (Duigan, 1966). Martin (1973b) has suggested that for assemblages with *brassi* type pollen, rainfall requirements would be 150-180 cm per year. Moderate temperatures would be indicated.

Trees with *menziesii* and *fusca* type pollen are found in areas with a humid climate and cool temperatures. Trees with *Nothofagus fusca* type pollen are not found in Australia at present except in Tasmania, where the endemic *Nothofagus gunnii* is confined to wet peaks. There it is found in temperate rainforest communities with *N. cunninghamii* (with *menziesii* type pollen), *Phyllocladus*, and *Dacrydium*, developed in areas where rainfall is 100 to 250 cm per year and mean annual temperature is 10^{o}C. (data in Selkirk, 1969). *Nothofagus* with *fusca* type pollen is also found in New Zealand, where it occupies a broader climatic belt than *Nothofagus* with *menziesii* type pollen, which grows only in cooler parts of New Zealand (McQueen, Mildenhall, & Bell, 1968). *Nothofagus menziesii* forms pure stands in predominantly subalpine and other cold sites at low altitudes in wetter parts of New Zealand, with an understorey of shrubs, filmy ferns, and bryophytes. It is also found in upper and lower montane *Nothofagus*-conifer forest, in areas with cool, moist conditions (Wardle, 1967). Cockayne (1926) has characterized the subantarctic beech forest environment as one of frequent cold, with southwest winds accompanied by driving sleet, comparatively low summer temperatures, and conditions in general favorable for development of peat. In the Thames district of New Zealand, podocarp-broadleaf forests are found at lower altitudes and *Nothofagus* forests at higher altitudes; rainfall is 125-200 cm per year, and mean annual temperatures are 13 to 20°C. at sea level. *Dacrydium* and *Phyllocladus* are also present (Cockayne, 1928). Temperature as determined by altitude, rather than precipitation, appears to influence distribution of taxa in New Zealand forests (Wardle, 1964).

Nothofagus with *menziesii* type pollen is also found in temperate rainforest in New South Wales and Queensland, and in disjunct communities in Victoria. In New South Wales rainforest distribution is restricted to areas with high precipitation (at least 150 cm per year), and *Nothofagus* is restricted to higher altitudes with cooler temperatures and higher rainfall (at least 180 cm per year) (Martin, 1973b).

The gymnosperm component, composed of members of the Podocarpaceae and Araucariaceae, is generally minor in this assemblage, but is also indicative of a rainforest environment and moderate to high rainfall. *Podocarpus* with *Podocarpidites ellipticus* type pollen and Araucariaceae grow in coastal districts of northeastern Australia at present. *Dacrydium* (represented by *Lygistepollenites florinii*), *Microcachrys* (represented by *Microcachryidites antarcticus*), and *Phyllocladus* (*P. palaeogenicus*) are not found on the Australian mainland at present. *Podocarpus* is found in a wide range of habitats, from subtropical or tropical montane to subalpine. *Microcachrys* is an endemic genus of Tasmania. *Phyllocladus* is found at present in the Philippines, Borneo, New Guinea, Tasmania, and New Zealand; *Dacrydium* is distributed in Indo-Malaysia, New Caledonia, Fiji, Chile, New Zealand, and Tasmania. *Araucaria* and *Agathis* are trees found only in rainforest communities, commonly on steep slopes to ensure good drainage (Patton, 1958).

These three "Antarctic" elements generally indicate a rainforest vegetation, probably on higher areas, with moderate temperatures and a high rainfall of at least 150-180 cm per year.

Taking the "Tropical" elements next, an important group in this assemblage is the *Cupanieidites major/orthoteichus* species group, which has been related to the Tribe Cupanieae of the Sapindaceae, now found in tropical rainforest communities in northeastern Australia. *Anacolosidites acutullus* and *A. luteoides* have been related to the Olacaceae, a family with predominantly tropical distribution, and *Santalumidites cainozoicus* has been compared with *Santalum*, restricted to warmer rainforest communities in Australia and the Indo-Pacific region. (Although Germeraad, Hopping, & Muller (1968) considered *S. cainozoicus* in part a synonym of *Florschuetzia levipoli*, related to the living mangrove genus *Sonneratia*, Partridge (in Stover & Partridge, 1973) has pointed out that morphological differences exist between the two taxa, and they are here considered to be different.)

Many of the pteridophytes can be included in this group, although this is by no means certain. The tree fern element is consistently represented in these samples, and is indicative of a moist environment. Many of the Cyatheaceae (represented by *Cyathidites* spp.) at present have a mainly tropical and subtropical distribution, and *Cyathea* itself is characteristic of montane rainforest in wet tropics (Willis, 1966). However, several species of *Cyathea* grow under moist, cool temperate environments in southeast

Australia, Tasmania, and New Zealand (Willis, 1970; Cockayne, 1926), and the closely related Dicksoniaceae also has a wide southern temperate range. Other arborescent ferns represented in this assemblage are probably *Trilites tuberculiformis*, *Rugulatisporites mallatus*, and perhaps *Matonisporites ornamentalis*.

Other trilete and monolete genera in this assemblage probably can be related to ferns and epiphytes, and *Stereisporites* spp. have been related to *Sphagnum*, which is characteristic of boggy, swampy areas. *Lygodium* (possibly represented by *Cyathidites splendens*) is a climbing fern of tropical and subtropical association; *Lycopodium*, with tropical and temperate distribution, and the Polypodiaceae, which are cosmopolitan but especially characteristic of wet tropics, are generally epiphytes, with some ferns; and the gleichenaceous ferns (represented by *Gleicheniidites circinidites* and *Clavifera triplex*) are tropical, subtropical, and south temperate in present distribution. The varied nature and abundance of spore taxa in this assemblage also implies a high humidity/abundant rainfall.

The "Australian" element is important in this assemblage, mainly as a result of abundance of species assigned to the genus *Proteacidites*. These comprise up to 23% of the total assemblage in some samples. Although many different species are represented at Nerriga, few can be related to extant taxa, especially the large and elaborate sculptured types, such as *P. ornatus*, and *P. grandis*, and the verrucate *P. tuberculiformis*. The early and middle Eocene appears to have been a period of diversity for this group in southern Australia, as many species do not appear in later Eocene and younger Tertiary assemblages. They are thus useful stratigraphically in lower Tertiary deposits. Although many living species of Proteaceae are sclerophyllous, the family probably originated in rainforest environments in eastern Australia and the southwestern Pacific region in the Late Cretaceous (Muller, 1970), and the diversity of species represented at Nerriga appears to also indicate a rainforest environment. *Banksieaeidites elongatus* and *B. arcuatus* are found consistently in low frequencies in all samples, and have been related to the living genera *Banksia* and *Dryandra*. *Banksia* is usually rare or absent in Australian rainforest communities at present, although it may occur in associations near subtropical rainforest and *Nothofagus* forest (Jones, in Duigan, 1966).

Myrtaceidites spp. forms 2-7.5% of the assemblage. The most common species in almost all samples is *M. parvus*, of uncertain affinities. Small numbers of *Myrtaceidites mesonesus* (with affinities suggested by McWhae (1957) to *Whiteodendron*, one of the *Tristania* complex, from Sarawak, but also with similarities to other groups in the Myrtaceae), *M. eugeniioides*, and *M. verrucosus*, were also found in these samples. *M. mesonesus* and *M. eugeniioides* may have rainforest associations, but they may be sclerophyllous as well.

Haloragacidites harrisii and *H. trioratus* are also found consistently, in low frequencies, in all samples. These two species are considered to be related to *Casuarina*, which at present are trees and shrubs found in a wide range of environments.

The presence of *Ephedripites notensis* would appear out of place in a generally moist environment; *Ephedra* is a xerophytic shrub of rocky or sandy desert habitats, and is distributed in warm temperate regions. The presence of *Sparganium* (*Sparganiaceaepollenites* cf. *barungensis*), which are aquatic herbs, and Epacridaceae (*Ericipites* spp.), small trees and shrubs of heaths and boggy areas, would indicate moist conditions. The occurrence of *Circulisporites* spp. in these samples, as well as in samples from Cadia, is of interest, but any palaeoecological significance of this group is unknown.

The significance of the abundant remains of epiphyllous and other fungi and algae is uncertain. The presence of abundant fructifications that can be assigned to the Microthyriaceae, as well as dispersed fungal spores, is taken as indicative of a moist environment. Fossil microthyriaceous fungi have commonly been regarded as indicating warm moist conditions, although Selkirk (1974) notes that, although common in subtropical rainforest areas in coastal New South Wales, members of the genus also extend into sub-alpine areas and low rainfall areas.

Colonies of *Pediastrum*, a planktonic colonial green alga, and *Botryococcus*, a planktonic colonial oil-secreting alga, are also found in these samples. Occurrence of both algae together in the same deposit indicates lacustrine conditions (Newman, 1965).

In general, a rainforest vegetation, with abundant rainfall (an increase of 100-120 cm per year is indicated) and in some cases a slightly warmer climate than that found in the area at the present, is indicated by most of the palynomorph suite from Nerriga that can be related to extant taxa. Most elements, except for the possible sclerophyllous groups and *Ephedra*, require moist conditions in their present environments. The tropical elements and the predominance of *Nothofagidites* of *brassi* type over the other two types could favor moderate, and possibly slightly warmer temperatures, which would agree with paleotemperature data for the early part of the Eocene (Shackleton & Kennett, 1974). The higher rainfall indicated would probably have been more evenly distributed throughout the year, as taxa such as *Nothofagus* cannot at present tolerate long periods of dryness.

Studies on modern pollen rain from temperate rainforests are not yet available from Australia. A recent study of pollen deposition in a tropical rainforest in northeastern Queensland (Kershaw & Hyland, 1975) gives some interesting comparative data, however. A similar number of taxa (99) were represented in the samples, which were collected from a small lake surrounded by rainforest vegetation in the Atherton Tableland. Sclerophyll pollen (from taxa not considered to be rainforest taxa, e.g. Casuarina, Eucalyptus, Eugenia, Callitris) formed 10-30% of the total; the remainder of the spectrum was composed of pteridophytes and rainforest trees, vines, and epiphytes. The tropical rainforest is described as structurally dense and complex, with a rich variety of species which occur in low frequencies and are mainly entomophilous. There is no single flowering season, little or no annual deciduousness, general lack of strong winds, and either regular rain showers or marked wet and dry seasons. Pollen deposition is extremely low in the lake sampled (90 and 250 grains/cm^2 per year; the only published figures of similar pollen fallout rate were from treeless tundra in northern Canada), and there were marked fluctuations in the relative abundance of the different taxa correlated to wet and dry seasons. However, Kershaw & Hyland found that taxa were consistently represented within each sampling period (extending over two dry and one wet season), and there was evidence of long-distance transport of some taxa, thus giving a true expression of the regional vegetation.

With the limitations imposed by the length of time involved from early Eocene to the present, and the proportion of fossil taxa that cannot be related to living groups, this type of rainforest vegetation may have been structurally similar to that existing at Nerriga in early-middle Eocene times, except that it had a greater proportion of probably wind-dispersed pollen than found at present in the vegetation of the Atherton Tableland. Sclerophyllous communities were probably present along with the rainforest vegetation, in drier areas or poorer soils. In general, a forested vegetation is indicated, with higher, more uniformly distributed rainfall. Paleotemperature data, and the presence of tropical elements farther south than found at present, indicates that temperatures were warmer at this time, although this is not necessarily indicated by the microflora at Nerriga.

CHAPTER 4. KIANDRA

Regional Setting

The old gold mining town of Kiandra is situated in the Snowy Mountains, on a broad undulating upland surface, the Kiandra Tableland. The town itself is at 1400 metres, and the surrounding tableland ranges between 1375 and 1600 metres. The plateau surface is deeply dissected, with valleys at present up to 600 metres deep. Several basalt-capped flat-topped ridges and plateaux are found in the area. Around Kiandra the plant communities are sub-alpine, with extensive treeless frost hollows dominated by various species of snowgrass, especially Poa caespitosa, and swampy areas with sedge (Carex gaudichaudiana) and many other bog species. Slopes are forested by snow gum, Eucalyptus niphophila (Moye, 1959).

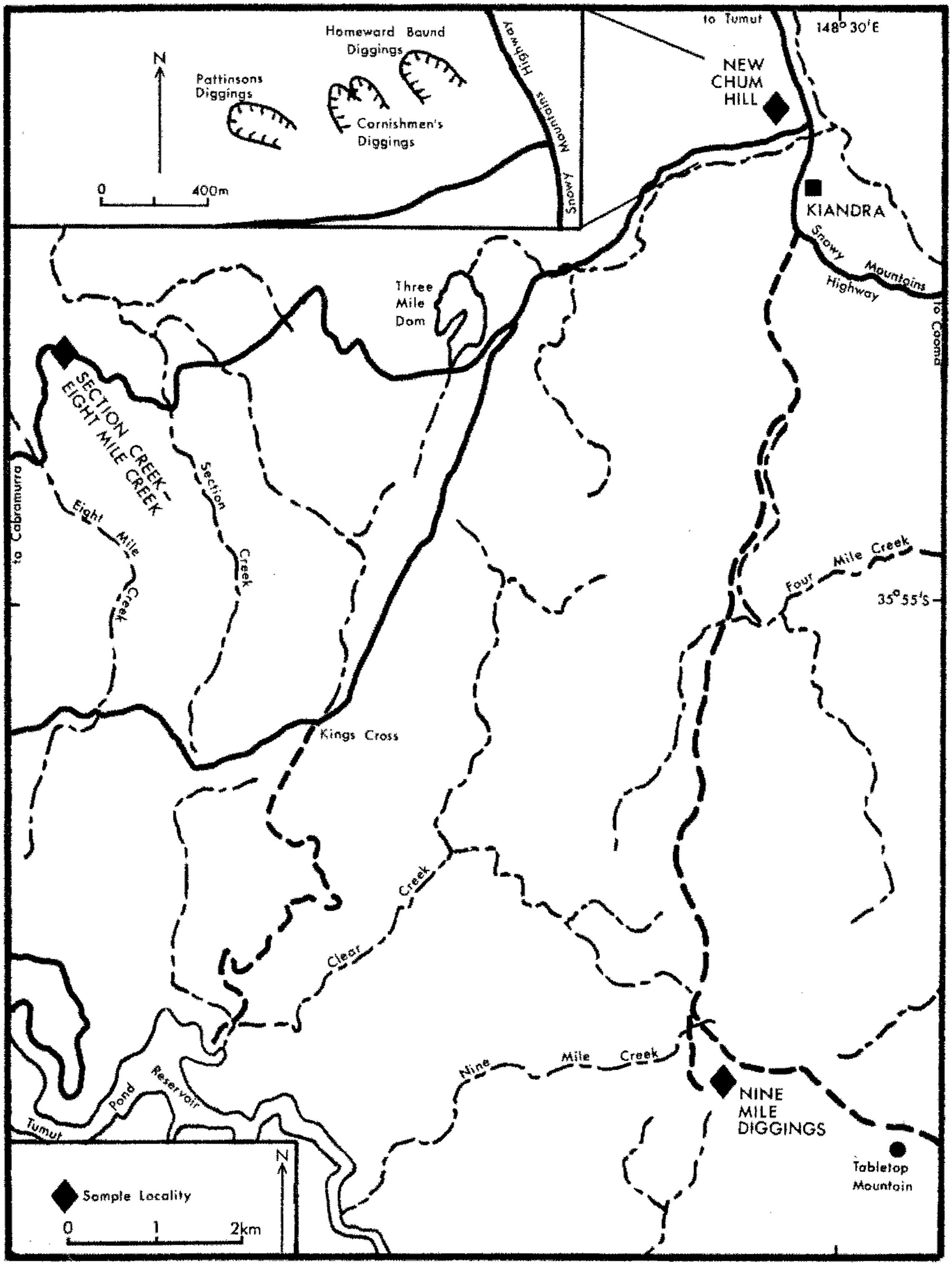
A short-lived gold rush at Kiandra in 1859-1861 resulted from finds of alluvial gold in old river gravels beneath basalt ridges, and extensive sluicing for gold in these sub-basaltic deep lead deposits has exposed several good sequences of sediments. The Tertiary rocks were first studied by Andrews (1901), who interpreted the generally linear arrangement of basalt-capped ridges as the remnants of two former river valley systems, which he termed the Kiandra and the Round Mountain Leads. Subsequent work has suggested that a more complex situation existed (Moye and others, 1969). Since the work by Andrews, the sediments have been studied in detail by Gill & Sharp (1957), and many Tertiary basalts in this region have been dated by K-Ar methods (Wellman, 1971; Wellman & McDougall, 1974a).

Tertiary Basalts and Associated Sediments

The Tertiary basalts and associated sediments were deposited on an eroded surface of probable Cretaceous age, and in the vicinity of Kiandra, overlie the Kiandra Beds, of Late Ordovician age. The basalts are included in the Snowy Province of Wellman & McDougall (1974a), with ages of 22-18 m.y., early Miocene. In this area the basalts partly fill former valleys cut into the plateau surface, forming the so-called deep leads. The fluvio-lacustrine sequence capped by the basalts consists of gravel, sand, clay, and lignite.

The basalts appear to have originated from a number of points, including Round Mountain and Tabletop Mountain, which are probably volcanic plugs, and from several dikes (see Text-figure 5). In places, three continuous cycles of sedimentation can be discerned in the sub-basaltic sediments. This is clearly seen at New Chum Hill, Kiandra, where the three cycles can be followed around the extensive series of exposures: Pattinson's and Winkler's Claim to the west, Cornishman's Claim in the middle, and Homeward Bound Claim to the east. The cyclic nature of these deposits has been attributed to "tectonic ponding" (K.R. Sharp, pers. comm.), or disruption of the drainage systems caused by faulting. These three cycles have been identified over a wide area (Moye, Sharp, & Stapledon, 1963). Greatest development of basaltic lavas in this area is found after the third cycle of sedimentation, but basalts have also been found near the base of the sequence in places, and at least four separate flows have been identified (Moye, Sharp, & Stapledon, 1963).

Gill & Sharp (1957) studied the two linear sequences of basalt-capped Tertiary sediments near Kiandra which had been called the Kiandra and Round Mountain Leads by Andrews (1901). Good sections through these sediments were exposed as a result of sluicing for gold;



Text-figure 5. Sample localities from the Kiandra area.
Inset map shows detailed localities of New Chum Hill.

elsewhere the sediments are covered by extensive basalt talus slopes caused by slumping of the unconsolidated sub-basaltic sediments, and can only be studied in detail with the help of subsurface coring. Many cores were drilled by the S.M.H.E.A. (Snowy Mountains Hydro-Electric Authority) through the Tertiary and underlying Palaeozoic rocks during the course of their work in the area, but this core material was not available to the author as it had been destroyed by the S.M.H.E.A. prior to the start of this project.

Plant remains are abundant in certain horizons in these fresh-water sediments; in places, large pieces of wood and beds of leaves have been found. Previous work on the floras from Kiandra has been done by Cookson (1947c), Cookson & Pike (in Gill & Sharp, 1957), and Selkirk (1969; 1972; 1974; 1975). Further mention of this work and the macrofloras will be made later in this section.

Three sections were selected for study (see Text-figure 5), and a total of 84 samples were collected and macerated. The most extensive section collected was at Cornishman's Claim, New Chum Hill, with a K-Ar date of 21.5 m.y. on the basalt which caps New Chum Hill. Some samples were also collected from a roadcutting between Section Creek and Eight Mile Creek, with a K-Ar date on the basalt of 21.7 m.y. A suite of samples from Nine Mile Diggings was collected for comparative purposes, as the basalt capping the sequence had not been dated radiometrically.

New Chum Hill

Gill & Sharp (1957, pp.29-30) described the section at Cornishman's Claim in detail. The Tertiary sediments at New Chum Hill comprise three sedimentary cycles, each with coarse sands and gravels at the bottom fining upwards to fine sand, silt, clay, and finally lignite/ligneous clay. Total thickness of this sequence is

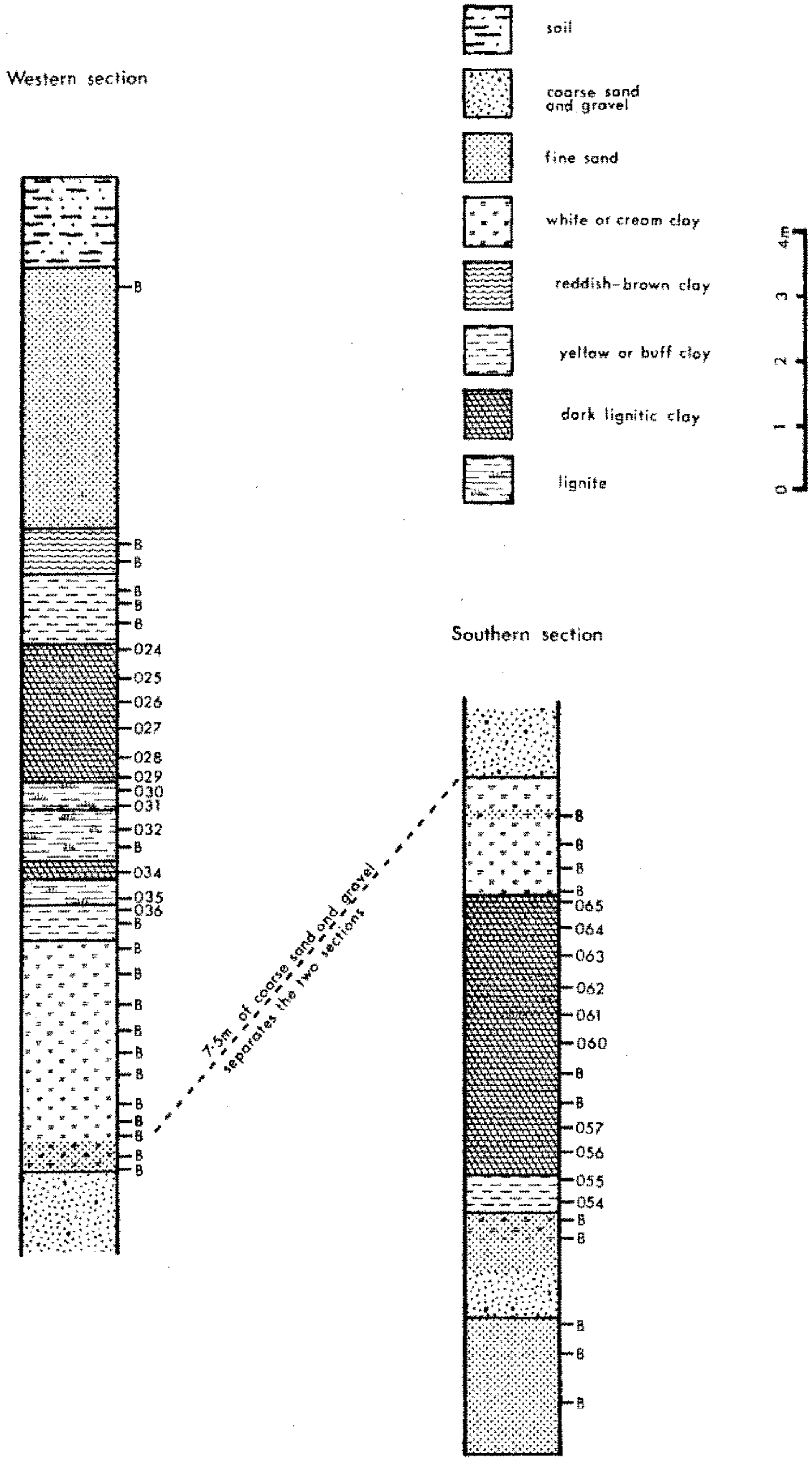
32 metres. Although there is considerable lensing out of beds, and lateral differentiation of the beds is marked, they can still be followed through this extensive exposure without great difficulty. The three cycles of sedimentation are easily picked out. Gill & Sharp found some evidence of inter-cycle erosion at the top of the finer-grained beds (lignites and ligneous clays).

Cornishman's Claim was chosen for sampling as all three cycles could be collected within the one exposure and also because this section was described in detail by Gill & Sharp. Positions of samples collected from the sequence are shown in Text-figure 6.

Fifty samples were collected through this extensive section. All samples collected from the highest cycle (the higher lignite horizon) proved to be barren, although good assemblages were found in the finer-grained sediments in the middle and lower "lignites". (The term "lignite" is used in a broad sense for the dark brown and black sediment layers; only the middle cycle had a true lignite horizon, whereas the lower horizon had carbonaceous or ligneous clays, with many fragments of wood and leaves, rather than beds of true lignite.) The assemblage will be discussed in a following section.

Section Creek-Eight Mile Creek

A sequence of sediments exposed in a roadcutting on the Kiandra-Cabramurra road consists of thinly bedded white, yellow, and buff silt and clay with some thin discontinuous lignitic bands, passing down to a mauve clay overlying a 1-metre thick bed of sandy lignitic clay at the base of the section. The sequence is capped by basalt which shows columnar jointing. Total exposed thickness of this sequence is 3.0 metres.



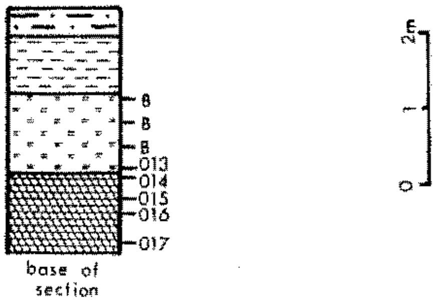
Text-figure 6. Stratigraphic succession at New Chum Hill, Kiandra. For location, see Text-figure 5. Upper lignite horizon not shown on this section. B = sample barren of pollen.

Eight samples were collected and macerated. Positions of productive samples in this sequence are shown in Text-figure 7. All polleniferous samples came from the base of the sequence, and the microflora was similar to, but sparser than, that from New Chum Hill. Because of the sparse nature of the microflora, percentage counts were not made and only distribution of taxa in these samples was recorded.

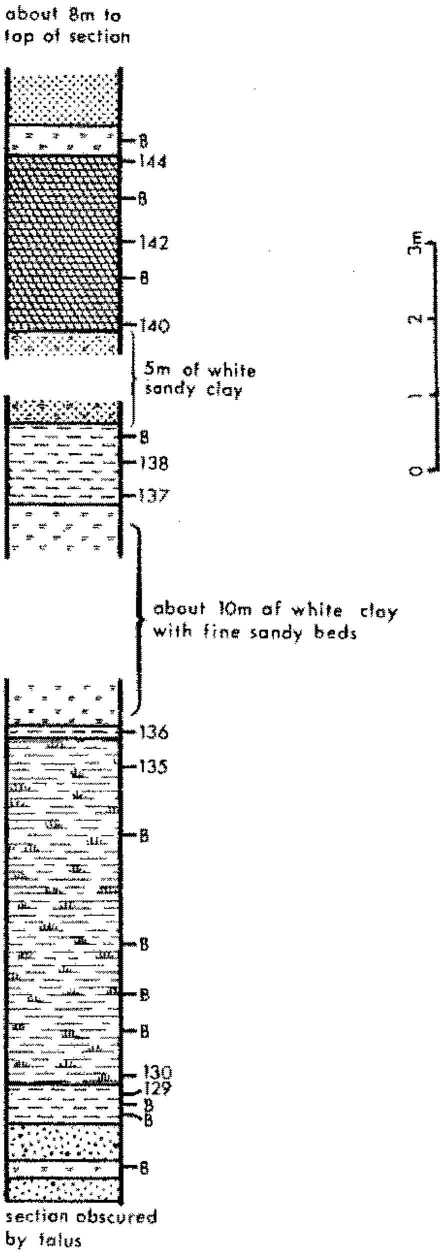
Nine Mile Diggings

Twenty samples were collected from the upper part of a thick sequence of sediments exposed at Nine Mile Diggings. Much of the section is obscured by hillwash; samples were taken from the uppermost 32 metres of the section. A 4.5 metre thick lignite is underlain by white and yellow clay, sand, and gravel, and overlain by white clay, dark ligneous clay and fine sand. Beds were markedly discontinuous laterally, commonly less than 1 metre in lateral extent. The remainder of the section is obscured.

Twenty samples were collected and macerated, to compare with microfloras from the three sedimentary cycles from New Chum Hill (see Text-figure 8). The section collected was thought to correspond to the higher lignite horizon at New Chum Hill. At Nine Mile Diggings large pieces of wood and numerous leaf beds were found, with one horizon appearing to be composed entirely of wood, with a sandy matrix. Comparison of the Nine Mile Diggings flora with that from New Chum Hill was hampered first by the fact that no polleniferous residues were recovered from samples of the higher lignite sequence from New Chum Hill and, second, by the relatively uniform assemblage throughout the remainder of the sequence at New Chum Hill, where except for the samples of true



Text-figure 7. Stratigraphic succession at Section Creek-Eight Mile Creek. For lithological symbols, see Text-figure 6; for locality, see Text-figure 5. B = barren.



Text-figure 8. Stratigraphic succession at Nine Mile Diggings. For lithological symbols, see Text-figure 6; for locality, see Text-figure 5. B = barren.

lignite, no real differences between the lower and middle lignite assemblages were found.

Composition of the Assemblage

Microfloras recovered from samples from Nine Mile Diggings and Section Creek-Eight Mile Creek were less diverse than those from the New Chum Hill section, but contained the same species. All three assemblages are considered to be of the same age. The following remarks will pertain to the taxa in samples from New Chum Hill, as this was the most diverse of the three.

A diverse assemblage of 32 species of spores, 17 species of gymnosperms, and 62 species of angiosperms, with 1 species of uncertain affinity were isolated in these samples. Many taxa could not be assigned to previously described species. Three new species (two spores and one monocolpate type) have been described from these samples, and several possibly new forms have been described but not specifically named. A complete list of the taxa found in New Chum Hill, and relative abundances based on counts of at least 250 grains per sample, are given in Table 6. In addition, fungal spores and fructifications were found in almost all samples. No species assignable to Circulisporites were found, although this genus was represented at Nerriga and Cadia; the possible significance of its presence or absence is unknown.

This assemblage is dominated by the angiosperm component, and contains a greater number of species than the other two microfloras described in this study. Although a large number of species was found in these samples, many were too poorly represented to appear in abundance calculations. Many angiosperm, spore, and gymnosperm species are represented by only a few grains per slide. As can be seen from values for the gymnosperm component (Table 7; Text-figure 9)

TABLE 6. Distributions and Relative Abundances of Species, New Chum Hill, Kiandra

x, less than 1% of sample; +, presence noted after conclusion of count.
All figures are in percentages.

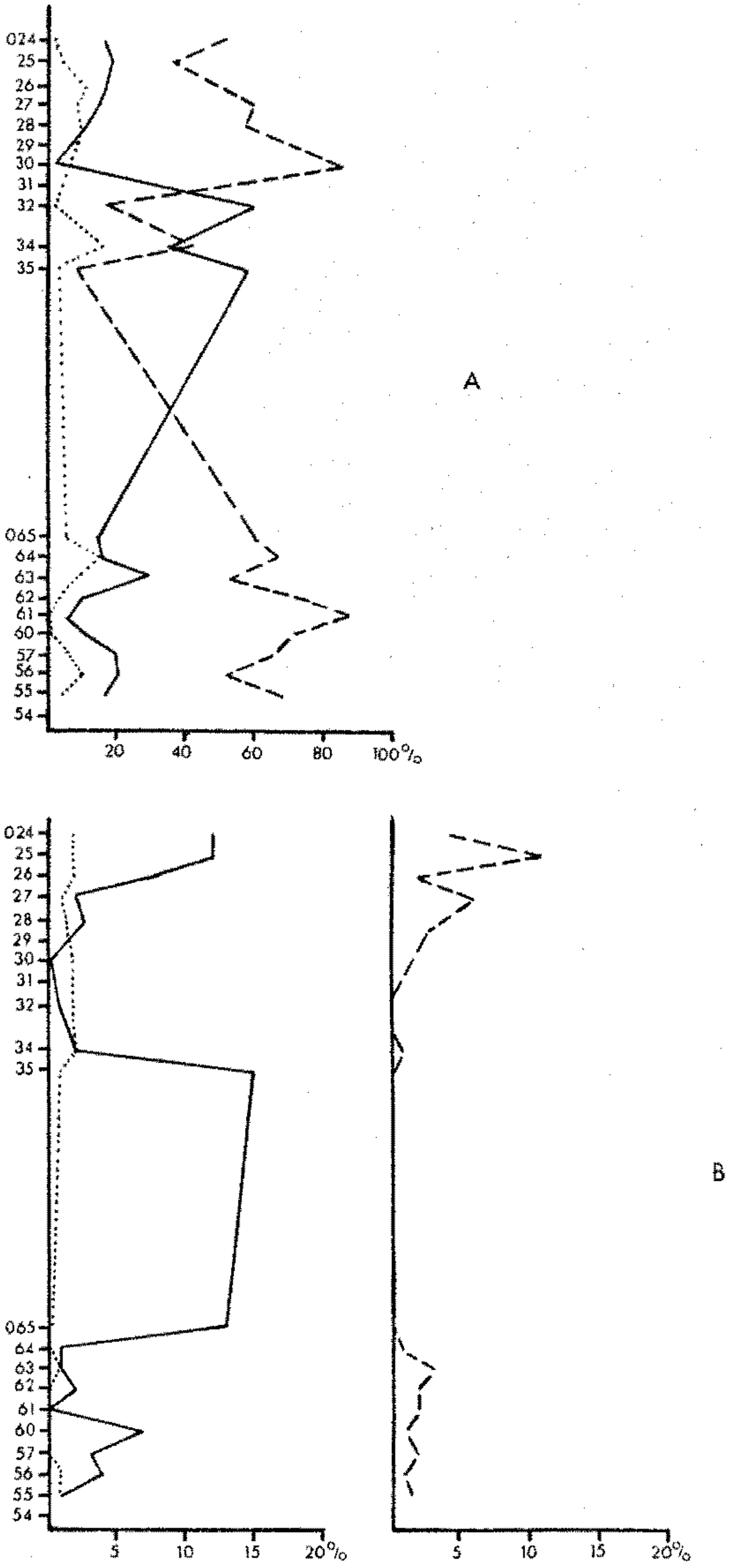
SPORES	055	056	057	060	061	062	063	064	065	035	034	032	030	028	027	026	025	024
Cyathidites cf. *C. minor*	5	6.5	8	2	2	3	16	9	5	6	2	5	-	3	4	3	2	7
subtilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biretisporites spp.	-	+	-	2	-	1	-	+	x	1	4	1	-	-	-	-	-	-
Deltoidospora sp.	2.5	x	1	-	-	-	1	+	x	-	-	2	-	+	-	-	-	-
Osmundacidites spp.	-	x	-	-	-	-	-	-	x	-	2	1	-	1	-	-	1	-
Baculatisporites comaumensis	-	x	-	-	-	+	1	-	x	-	2	-	-	+	1	1	-	1
Leptolepidites tuberosus sp.nov.	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Lycopodiumsporites spp.	1.5	-	-	-	-	-	-	1	x	-	-	-	-	-	-	-	-	-
Klukisporites reticulatus sp.nov.	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Ischyosporites sp. 1	-	+	+	-	-	x	-	-	x	-	1	-	-	-	+	-	-	+
sp. 2	-	1.5	-	-	-	+	-	-	x	-	-	-	-	1.5	-	2	-	-
Stereisporites antiquasporites	-	+	-	1	-	+	1	1	x	-	-	1	-	-	2	-	1	-
Cingutriletes clavus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gleicheniidites circinidites	-	-	-	-	-	-	-	-	-	47	13	46	-	+	-	-	+	-
Matonisporites ornamentalis	5	6.5	7	1	-	2	6	3	4	1	4	-	-	2	2	-	6	3
Cyatheacidites annulatus	-	+	+	-	-	-	-	-	+	-	1	-	-	+	1	-	+	+
Rugulatisporites mallatus	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
trophus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Foveosporites lacunosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Foveotriletes crater	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Verrucosisporites kopukuensis	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-
cristatus	-	+	-	-	-	-	-	-	+	1	-	+	-	-	-	-	-	-
cf.*V.cristatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trilete spp.	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Laevigatosporites ovatus	2.5	2	3	4	2	2	2	2	x	1	2	+	1	2	4	5	5	4
major	-	1.5	1	1		x	1	-	x	-	4	-	1	1	-	4	1	2
Polypodiisporites sp. 1	-	+	-	-	-	-	1	-	+	1	-	+	-	-	1	-	-	-

SPORES (cont.)	055	056	057	060	061	062	063	064	065	035	034	032	030	028	027	026	025	024
Microfoveolatosporis sp. 1	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	1	1	-
Reticuloidosporites escharus	-	x	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+	+
Peromonolites densus	-	+	-	-	-	x	-	-	+	-	+	-	-	+	+	1	+	-
vellosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Echinosporis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypolepis spinysporis	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
TOTAL SPORES	16.5	20	20	11	6	10	29	16	14	58	35	60	2	10.5	15	17	19	17
POLLEN																		
Podocarpidites spp. undiff.	-	1.5	-	-	-	-	-	-	-	-	-	+	-	4	1	-	1	-
ellipticus	1.5	5	4	+	-	1	5	5	3	1	7	1	3	3	3	2	2	2
marwickii	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
cf. *P.multesimus*	-	-	-	-	-	-	-	-	+	-	-	-	1	+	-	-	-	-
sp.	1.5	x	x	-	-	1	1	3	x	1	3	-	3	x	1	1	-	1
Lygistepollenites florinii	1.5	+	x	-	-	x	1	1	1	+	1	2	-	x	+	2	-	+
Dacrycarpites australiensis	-	2	x	-	-	x	1	2	+	-	3	+	-	1	2	4	1	+
Phyllocladidites mawsonii	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1	1	+	-
Phyllocladus palaeogenicus	-	x	-	-	-	-	-	2	x	1	-	-	-	-	-	-	-	+
Alisporites grandis	-	+	-	1	-	-	-	-	-	-	1	-	-	+	-	-	-	-
Microcachryidites antarcticus	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-
parvus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Podosporites microsaccatus	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	1	-
Parvisaccites catastus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Araucariacites australis	-	+	x	-	-	-	+	-	+	-	-	-	-	x	1	1	+	-
sp.	-	+	-	-	-	-	-	-	-	-	1	-	-	-	+	-	-	-
Dilwynites granulatus	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. *D.tuberculatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL GYMNOSPERMS	4.5	10	6	1	-	3	8	13	5	4	16	3	7	10	9	11	5	3

	055	056	057	060	061	062	063	064	065	035	034	032	030	028	027	026	025	024
Monosulcites verrucosus sp. nov.	1.5	+	+	-	-	-	-	-	x	-	-	+	-	2	+	2	+	1
Liliacidites spp.	-	1.5	1	-	-	-	+	-	-	-	+	-	-	1	+	-	+	+
Monocolpate spp.	-	-	-	1	-	-	x	+	x	-	+	2	1	1	-	1	-	1
Tricolpites psilatus	1.5	x	1	-	-	x	-	-	x	1	-	11	-	1	1	2	2	3
punctaticulus	2.5	2	1	-	-	x	-	-	x	-	-	1	1	1	-	-	+	-
delicatulus	-	+	+	-	-	x	1	-	-	-	-	-	-	-	3	2	-	-
spp.	-	2.5	-	-	2	+	1	-	-	-	-	+	-	x	+	-	-	-
Gothanipollis cf. *G. gothani*	-	+	-	-	-	x	-	-	x	-	-	-	-	x	-	-	1	-
cf. *G. bassensis*	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beaupreaidites elegansiformis	-	-	-	-	-	-	-	-	-	+	+	2	-	-	-	-	-	-
verrucosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricolporites prolata	1.5	+	1	1	-	x	-	-	x	6	1	1	-	1	-	1	2	1
sphaerica	-	x	-	-	-	-	-	2	+	-	-	-	1	x	+	-	-	+
retequetrus	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
scabratus	-	+	-	1	-	-	-	-	-	-	-	-	-	x	-	-	1	-
microreticulatus	-	-	+	-	2	x	-	1	x	1	-	-	-	-	-	-	-	-
cf. *T. endobalteus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
spp.	-	x	+	3	-	3	-	-	x	-	-	-	-	x	3	1	3	1
Dodonaea sphaerica	-	-	+	-	-	x	-	-	-	2	-	+	-	-	-	-	-	+
Myrtaceidites parvus	1.5	x	2	4	-	1	1	1	6	9	2	1	-	1.5	1	3	4	9
mesonesus	-	3.5	1	3	-	x	-	-	6	2	-	-	-	1	1	4	4	3
spp.	-	-	-	-	-	-	-	-	x	4	-	-	-	x	-	1	4	1
Cupanieidites orthoteichus	-	-	-	-	-	-	-	-	x	-	+	+	-	x	-	1	1	+
Ilexpollenites clifdenensis	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Sapotaceoidaepollenites cf. *S. rotundus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nothofagidites emarcidus-heterus	52	41	61	58	80	66	49	61	54	8	33	13	77	44	52	40	30	45
deminutus	3	2	-	-	2	x	1	2	x	1	1	2	2	2	1	4	3	+
falcatus	1.5	x	-	-	-	x	-	-	-	-	-	-	-	1	-	-	-	+
incrassatus	1.5	x	+	4	4	-	-	-	1	-	-	1	-	1	-	1	-	-
vansteenisii	4	x	2	1	-	-	1	-	x	-	1	1	1	2	1	1	2	2
brachyspinulosus	2.5	4	-	5	2	5	+	1	2	-	1	-	-	3	4	3	2	4

	055	056	057	060	061	062	063	064	065	035	034	032	030	028	027	026	025	024
Nothofagidites flemingii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
asperus	2.5	2.5	2	1	-	4	2	2	1	-	1	+	5	4	1	3	-	1
goniatus	-	2.5	-	3	-	-	-	1	x	-	-	-	-	1	1	-	-	-
Polycolpites esobalteus	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sparganiceaepollenites cf. S. barungensis	-	-	+	1	-	-	-	-	+	-	+	+	-	-	-	-	+	-
Banksieaeidites elongatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
arcuatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triporopollenites chnosus	-	+	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
bellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proteacidites minimus	1.5	+	2	1	2	x	3	-	+	-	1	-	1	1	4	2	8	3
cf. P. obscurus	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
parvus	-	x	-	-	-	-	-	-	+	-	-	-	-	x	-	-	2	-
subpalisadus	-	-	-	-	-	x	-	1	+	-	-	-	-	x	-	-	1	1
spp.	-	x	-	-	-	1	-	-	-	-	-	-	-	x	2	-	-	-
"Triorites" minisculus	-	x	-	1	-	+	-	-	+	1	1	+	+	1	-	-	-	2
introlimbatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haloragacidites harrisii	1.5	1.5	-	-	-	+	1	-	+	1	2	1	2	1.5	1	2	2	2
trioratus	-	+	-	-	-	-	-	-	+	-	-	1	-	-	-	-	1	-
Malvacipollis spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
Polyporina cf. P. chenopodiaceoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echiperiporites sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyorificites sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Periporopollenites demarcatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
vesicus	-	x	+	-	-	-	-	-	-	1	+	+	-	-	-	-	-	+
sp. 2	-	1.5	+	-	-	+	-	-	+	-	-	+	-	x	-	-	-	-
sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	055	056	057	060	061	062	063	064	065	035	034	032	030	028	027	026	025	024
Ericipites crassiexinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
scabratus	-	x	+	-	-	x	1	-	x	-	+	-	-	-	-	-	-	+
Gephyrapollenites calathus	-	+	-	-	-	-	-	-	x	-	-	-	-	1	-	-	2	+
Schizosporis parvus	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-



Text-figure 9. Percentage frequency distribution of major component groups, New Chum Hill, Kiandra. For A, solid line = pteridophytes, dotted line = gymnosperms, dashed line = *Nothofagidites* spp. For B, solid line = Myrtaceae, dotted line = *Casuarina* type, and dashed line = Proteaceae type.

TABLE 7. Major Component Groups of Microfloras, New Chum Hill

All figures are in percentages. Samples are arranged in stratigraphic order, from base of section (055).

Sample No.	Spores	Gymno.	Noth.(m,f)	Other Angio.	Myrt.	Cas.	Prot.
055	16.5	4.5	67.5 (3,3)	11.5	1	1	1.5
056	20	10	53 (5,4)	17	4	1	1
057	20	6	65 (2,-)	9	3	-	2
060	11	1	72 (4,5)	16	7	-	1
061	6	-	88 (-,2)	6	-	-	2
062	10	3	76 (4,3)	11	2	-	2
063	29	8	53 (2,-)	10	1	1	3
064	16	13	66 (3,1)	5	1	-	1
065	14	5	60 (3,2)	21	13	-	-
035	58	4	9 (-,-)	28	15	1	-
034	35	16	42 (1,1)	7	2	2	1
032	60	3	17 (-,-)	20	1	2	-
030	2	7	85 (5,-)	6	-	2	1
028	10.5	10	58 (5,3)	22	3	1.5	3
027	15	9	60 (2,4)	16	2	1	6
026	17	11	51 (3,3)	21	8	2	2
025	19	5	37 (-,2)	39	12	2	11
024	17	3	52 (1,4)	28	12	2	4

this group forms a generally minor part of the assemblage, with percentages ranging from nil to 16% of the total grain count. In number of species, the spore and gymnosperm assemblages from Kiandra are more diverse than those from Nerriga.

This assemblage is dominated in terms of actual grain numbers by Nothofagidites spp., which, except for three samples from a lignite horizon, comprised 37-88% of the assemblage. Most Nothofagidites pollen could be assigned to the brassi type, with pollen of fusca and menziesii types present but subordinate, forming at the most a sixth of the total. The menziesii and fusca pollen types were found in approximately equal proportions. Numerous other angiosperm species were represented, but only in small numbers.

The spore assemblage is diverse, and ranges from 2 to ~~59%~~ 60, with high values of 35, 58, and 60% (samples 034, 035, and 032), in lignite samples. Sample 034 is from a shaly zone within the lignite (middle lignite horizon), whereas samples 035 and 032 are taken from the lignite itself. A large number of spore species were too sparsely represented to be recorded in abundance counts. Species recorded consistently from most samples are Cyathidites cf. C. minor, Baculatisporites comaumensis, Stereisporites antiquasporites, Matonisporites ornamentalis, Laevigatosporites ovatus, and L. major. Of interest is the abundance of Gleicheniidites circinidites in the three lignite samples mentioned above; this species was numerous in these three samples, but was rarely seen in all other samples. Cyatheacidites annulatus, a distinctive spore found in low frequencies in almost all samples, is considered diagnostic for Oligocene and younger microfloras.

The gymnosperm component is minor, although many species are represented. Podocarpidites spp., Lygistepollenites florinii, and Dacrycarpites australiensis are the most numerous types found. A species assigned to Araucariacites, with a finer sculpture than A. australis, is found in these samples but has not been found at either Nerriga or Cadia. Only a few grains of Phyllocladidites mawsonii were found in all these samples combined, which was unexpected, as this species was recorded by Cookson & Pike (in Gill & Sharp, 1957) from the middle lignite horizon of Cornishman's Claim. It is mentioned with Beaupreaidites elegansiformis, which has only been found in the lignite samples in the present study; however, the few grains of P. mawsonii seen were in clay samples, not lignites. The original slides of this material described by Cookson & Pike could not be located in the National Museum, Melbourne, so the presence of this species in any appreciable numbers at Kiandra is assumed to be a very localized occurrence.

As noted previously, the angiosperm assemblage is dominated by Nothofagidites spp., with brassi type pollen the most numerous. Other angiosperm taxa in these samples are sparsely represented, except for localized maxima of 11% for Tricolpites psilatus (sample 032), 6% for Tricolporites prolata (sample 035), 9% for Myrtaceidites parvus (samples 035 and 024), 6% for M. mesonesus (sample 065), and 8% for Proteacidites minimus (sample 025). Myrtaceidites spp. were consistently found in all samples, as were Proteacidites minimus and Haloragacidites harrisii.

An interesting feature to emerge from this suite of samples is the difference reflected in the microfloras from the two lithologically different sample types. The middle lignite horizon was a true lignite, whereas the lower lignite was a carbonaceous dark brown clay. (No pollen was recovered from the uppermost horizon, which also appeared to be a carbonaceous clay, rather than a lignite.) The series of samples through the middle lignite horizon (032, 034, and 035, with 034 a shaly layer within the lignite) contained microfloras dominated by Gleicheniidites circinidites, which was rarely found in other samples from this locality. G. circinidites composed 47 and 46% of the assemblage in the lignites, and 13% of the intervening sample. The remainder of the assemblage in these lignites was sparse, and contained Cyathidites cf. C. minor and several other spore species, Beaupreaidites elegansiformis, small quantities of Nothofagidites spp., small psilate tricolpate and tricolporate grains, and Myrtaceidites spp. Thus a much reduced and somewhat different spectrum is found in the microfloras taken from these lignite samples.

This is the only real difference found in the microfloras from Kiandra, as otherwise the vertical distribution of taxa through the sequence is generally uniform. The restriction of Beaupreaidites elegansiformis to the lignitic lithology is of interest, considering that it is a widely reported species in Tertiary deposits. B. verrucosus was not found in the lignites, however, but was present in the adjacent clays. It appears that B. elegansiformis is facies-controlled, whereas *G. circinidites* may simply be over-represented in these samples. Both species may have been particularly suited to a swampy, lignite-forming environment, and were abundant in the immediate vicinity of deposition. Alternatively, deposition of pollen from the other taxa may have been restricted for some reason (e.g. representation of anemophilous taxa such as *Nothofagidites* spp. may have been hampered). *Cyatheacidites annulatus* was completely lacking in these three samples, although specimens were found in all other samples. That microfloras above and below this horizon are essentially the same shows that this restricted environment was of short duration.

Similar differences in microfloras from coal and clastic lithologies have been recorded previously. Stover & Partridge (1973, p.243) have recorded percentages of more than 80% for *Phyllocladidites mawsonii* in coals from the Lower *Nothofagidites asperus* Zone. Earlier, Partridge (1971) reported certain taxa as abundant in coals of the onshore part of the Gippsland Basin (e.g. *P. mawsonii*, *B. elegansiformis*, *Ericipites* spp., *Proteacidites annularis*, *P. obscurus*, *Triorites magnificus*, *Milfordia homeopunctata*, *Psilastephanocolporites yallournensis*); others as either rare (*Cyathidites* spp., *Foveosporites lacunosus*, *Cupanieidites orthoteichus*) or absent in coals (*Deltoidospora* sp., *Stereisporites antiquasporites*, *Matonisporites ornamentalis*, *Cyatheacidites annulatus*), although they may be abundant in adjacent clastic samples. Thus, the pollen spectrum for samples from lignites and coals compared with that from adjacent clastics may be markedly different, with several taxa apparently facies-controlled to a "peat swamp" environment.

As mentioned previously, assemblages from the other two sites near Kiandra were not as diverse as that from New Chum Hill. Tables 8 and 9 list species found at these two sites, and Table 10

TABLE 8. Distribution of Species, Section Creek-Eight Mile Creek

Percentages not calculated; only presence noted, as only sample 015 showed sufficient diversity to give abundance data

SPORES	013	014	015	016	017
Cyathidites cf. *C. minor*	x	x	x	x	x
subtilis	x	x	x	x	x
Verrucosisporites cristatus	-	-	x	-	-
Leptolepidites tuberosus sp.nov.	-	-	-	-	x
Osmundacidites spp.	-	x	x	-	x
Baculatisporites spp.	-	x	x	-	x
Ischyosporites spp.	x	x	x	-	x
Matonisporites ornamentalis	x	-	x	x	x
Cyatheacidites annulatus	x	-	-	x	x
Gleicheniidites circinidites	-	-	-	-	x
Lycopodiumsporites spp.	-	x	-	-	-
Laevigatosporites ovatus	x	x	x	-	x
major	x	-	x	-	x
Polypodiisporites sp. 1	x	x	x	-	x
Reticuloidosporites escharus	-	x	-	-	x
Peromonolites densus	-	-	-	-	x
Hypolepis spinysporis	-	-	x	-	-
POLLEN					
Podocarpidites spp. undiff.	-	x	x	x	-
ellipticus	x	x	x	-	x
marwickii	-	-	x	-	-
sp.	x	-	x	x	x
Lygistepollenites florinii	-	-	x	-	-
Dacrycarpites australiensis	x	x	x	-	x
Podosporites microsaccatus	-	-	x	-	-
Phyllocladus palaeogenicus	-	-	-	x	x
Monocolpate spp.	-	-	x	-	-
Monosulcites verrucosus sp. nov.	-	x	-	-	-
Tricolpites psilatus	x	x	-	-	-
punctaticulus	-	-	x	-	-
spp.				x	x
cancellatus sp. nov.	-	-	x	-	x
Cupanieidites orthoteichus	-	-	x	x	x
Myrtaceidites parvus	-	x	x	x	-
mesonesus	-	-	x	-	-
verrucosus	-	-	-	x	-
Tricolporites prolata	-	-	x	x	-
sphaerica	-	-	x	-	-
cf. *T. angurium*	-	-	-	x	-
spp.	-	-	x	-	x
Proteacidites cf. *P. obscurus*	x	x	x	-	-
minimus	-	-	-	-	x
Haloragacidites harrisii	-	x	x	x	x
trioratus	-	-	-	-	x
Periporopollenites demarcatus	x	-	-	-	-
Nothofagidites emarcidus-heterus	x	x	x	x	x
falcatus	-	-	x	-	x
goniatus	-	-	-	-	x
asperus	x	x	x	x	x
brachyspinulosus	-	x	x	-	x
flemingii	x	x	x	x	x
Polycolpites esobalteus	-	-	-	-	x

TABLE 9. Relative Abundances of Species, Nine Mile Diggings, Kiandra

SPORES	129	130	135	136	137	138	140	142	144
Cyathidites cf. *C. minor*	-	2	-	-	3	-	-	-	-
subtilis	-	-	-	-	-	-	-	-	-
Cyatheacidites annulatus	-	-	-	-	2	-	-	-	-
Biretisporites spp.	-	-	-	-	+	-	-	-	-
Stereisporites spp.	-	-	-	-	1	+	-	+	-
Osmundacidites spp.	-	-	-	-	1	1	-	-	-
Baculatisporites comaumensis	-	-	1	-	+	+	-	-	-
Lycopodiumsporites spp.	-	1	-	-	1	-	-	-	2
Gleicheniidites circinidites	-	-	-	-	+	-	-	-	2
Matonisporites ornamentalis	-	1	18	+	-	+	-	+	2
Ischyosporites sp. 1	-	-	-	-	-	1	-	+	-
sp. 2	-	-	1	-	3	+	-	+	-
Foveotriletes crater	-	-	-	-	+	+	-	-	-
Klukisporites reticulatus sp. nov.	-	-	-	-	+	-	-	-	-
Leptolepidites tuberosus sp. nov.	-	-	-	-	+	-	-	-	-
Verrucosisporites kopukuensis	-	-	-	-	+	-	-	-	-
Laevigatosporites ovatus	1	6	36	5	5	1	6	1	6
major	-	3	2	3	-	-	-	-	6
Polypodiisporites sp.1	-	-	-	-	2	+	-	+	8
Reticuloidosporites escharus	-	-	-	-	-	-	-	-	4
Microfoveolatosporis sp. 1	-	-	-	-	1	-	-	-	-
Peromonolites densus	-	-	-	-	-	-	-	+	-
vellosus	-	-	-	-	-	-	-	-	-
Hypolepis spinysporis	-	-	-	-	-	+	-	-	-
POLLEN									
Podocarpidites spp. undiff.	-	1	-	-	-	2	-	-	2
ellipticus	3	4	-	1	+	-	-	+	-
cf. *P. multesimus*	-	+	-	-	-	-	-	-	-
sp.	2	5	+	+	-	-	-	-	-
Lygistepollenites florinii	1	2	-	1	-	+	-	-	-
Alisporites grandis	1	-	-	1	-	-	-	-	-
Dacrycarpites australiensis	+	+	-	-	-	-	-	+	-
Araucariacites australis	-	+	1	-	+	-	-	+	-
sp.	-	-	-	-	+	-	-	-	-
Dilwynites granulatus	-	-	-	-	-	-	-	-	-
Liliacidites spp.	-	-	-	-	+	-	-	-	-
Monocolpate spp.	-	+	-	-	+	+	4	1	5
Monosulcites verrucosus sp. nov.	-	-	-	-	-	-	-	1	-
Sparganiaceaepollenites cf. *S. bargunensis*		-	-	-	-	+	-	-	-
Tricolpites psilatus	-	+	-	-	2	-	-	6	2
punctaticulus	-	-	-	-	1	-	-	-	-
Gothanipollis cf. *G. gothani*	-	-	-	-	-	-	-	+	-
Dodonaea sphaerica	-	-	-	-	+	-	-	1	-
Tricolporites microreticulatus	-	1	-	-	-	1	-	-	-
sphaerica	-	-	-	-	+	-	-	1	-
prolata	-	-	-	-	-	1	-	1	-
cf. *T. endobalteus*	-	-	-	-	-	+	-	-	-
sp. 4	-	-	-	-	-	+	8	1	-

	129	130	135	136	137	138	140	142	144
Myrtaceidites parvus	-	-	-	-	-	-	-	5	-
Proteacidites minimus	-	-	-	-	-	2	-	-	-
parvus	-	-	-	-	-	-	-	+	-
subpalisadus	-	-	-	-	-	1	-	1	-
"*Triorites*" *minisculus*	-	1	-	-	1	-	-	1	-
Haloragacidites harrisii	-	1	1	+	+	-	-	+	-
Nothofagidites emarcidus-heterus	77	42	24	60	73	84	30	76	55
deminutus	-	-	-	-	-	-	-	-	-
falcatus	-	-	-	-	-	-	-	-	-
incrassatus	5	15	8	6	-	1	-	-	-
vansteenisii	2	-	-	1	-	-	-	-	-
brachyspinulosus	-	12	2	5	-	1	-	-	-
flemingii	-	-	3	13	-	-	-	-	-
asperus	8	2	1	4	1	3	-	1	2
goniatus	-	-	2	-	1	1	2	2	-
Polycolpites sp.	-	-	-	-	-	+	-	+	-
Periporopollenites vesicus	-	-	-	-	-	-	-	+	-
sp. 1	-	-	-	-	-	-	-	+	-
sp. 2	-	+	-	-	1	+	-	+	4
Ericipites scabratus	-	1	-	-	-	-	-	-	-
Schizosporis parvus	-	-	-	-	1	+	-	-	-

TABLE 10. Percentages of Major Component Microfloral Groups, Nine Mile Diggings

All figures are in percentages

Sample No.	Spores	Gymno.	Noth. (m,f)	Other Angio.	Cas.	Myrt.	Prot.
129	1	7	92 (8,-)	-	-	-	-
130	13	12	71 (-,-)	4	1	-	-
135	58	1	40 (3,5)	1	1	-	-
136	8	3	89 (2,9)	-	-	-	-
137	19	-	74 (2,-)	6	-	-	-
138	3	2	89 (4,1)	5	-	-	3
140*	6	-	82 (2,-)	12	-	-	-
142	1	-	79 (3,-)	20	-	5	1
144*	30	2	58 (2,-)	10	-	-	-

*Less than 100 grains counted.

gives percentages of the major component groups for samples from Nine Mile Diggings. (Percentages were not calculated for samples from Section Creek-Eight Mile Creek, as assemblages were generally too sparse.)

The entire assemblage from Nine Mile Diggings appears to be dominated by _Nothofagidites_ spp., up to 92% of the total count. Few other angiosperm taxa are represented, compared with samples from New Chum Hill. This includes a greater abundance of pollen of _N. incrassatus_, _N. flemingii_, and _N. brachyspinulosus_, and a lower proportion of the _N. emarcidus-heterus_ group, than found at New Chum Hill. Almost no pollen assignable to _N. deminutus_, _N. vansteenisii_, or _N. falcatus_ were found at Nine Mile Diggings. Spores and gymnosperms were generally minor, with about two-thirds the number of species found at New Chum Hill represented. Two samples, 129 and 140, had no trilete spores recorded in the count; these were, lithologically, from a purplish clay underlying a lignite and a coarse granular horizon (perhaps a fossil soil). Samples 130 and 135 were lignites, but no correlation between sample lithology and microfloras could be made as at New Chum Hill. *Gleicheniidites circinidites* was generally rare throughout the sequence, and *Beaupreaidites* spp. were not found in any samples. Sample 135 had unusually high maxima for two spores: 36% for *Laevigatosporites ovatus*, and 18% for *Matonisporites ornamentalis*. Other significant abundances were 8% for *Tricolporites* sp. 4 (sample 140), and 6% for *Tricolpites psilatus* (sample 142). Possible significance of these high values is not known. In addition to consistent occurrence of *Nothofagidites* spp. of *brassi* type, the most consistently occurring taxon was *Laevigatosporites ovatus*.

Two samples had no angiosperm taxa except for species of *Nothofagidites* (samples 129 and 136) recorded in the count, and the only species present but not included in the count was *Haloragacidites harrisii*.

All taxa found at Nine Mile Diggings were found at New Chum Hill.

The microflora from Section Creek-Eight Mile Creek was much less diverse, although all species represented were also found at the other two sites.

Age of the Assemblage

The following species were found at Kiandra but not at Nerriga or Cadia:

Leptolepidites tuberosus sp. nov.
Lycopodiumsporites sp. 1 and sp. 2
Rugulatisporites trophus
Klukisporites reticulatus sp. nov.
Cyatheacidites annulatus
Echinosporis sp.
Podocarpidites cf. *P. multesimus*
Microcachryidites parvus
Araucariacites sp.
Beaupreaidites elegansiformis
B. verrucosus
Gothanipollis cf. *G. bassensis*
Tricolporites retequetrus
Triporopollenites chnosus
Periporopollenites sp. 1
P. sp. 2
Echiperiporites sp.

The following species were found both at Kiandra and at Cadia:

Cyathidites cf. *C. minor*
C. subtilis
Verrucosisporites cristatus
Osmundacidites spp.
Foveosporites lacunosus
Matonisporites ornamentalis
Cingutriletes clavus
Polypodiisporites sp. 1
Microfoveolatosporis sp. 1
Peromonolites densus
P. vellosus
Hypolepis spinysporis
Podosporites microsaccatus
Dacrycarpites australiensis
Alisporites grandis
Phyllocladidites mawsonii
Arecipites spp.
Monosulcites verrucosus sp. nov.
Sparganiaceaepollenites cf. *S. barungensis*
Triporopollenites bellus
"*Triorites*" sp.
Proteacidites subpalisadus
P. subscabratus
P. cf. *P. obscurus*
Myrtaceidites eucalyptoides
Dodonaea sphaerica
Tricolporites cf. *T. angurium*
T. cf. *T. endobalteus*
T. sp. 1
T. sp. 4
Tricolpites psilatus
T. punctaticulus
T. cancellatus sp. nov.
Polycolpites sp.
Nothofagidites goniatus
N. deminutus
N. falcatus
Polyporina cf. *P. chenopodiaceoides*
Polyorificites sp.
Gephyrapollenites calathus

Some of the species from both groups are useful chronostratigraphicall as they have been reported from well-dated horizons. *Cyatheacidites annulatus* has not been reported from microfloras older than early Oligocene in the Gippsland Basin, and Miocene elsewhere in Australia. *Beaupreaidites elegansiformis* appears to be facies-controlled, and is considered of limited chronostratigraphic use. *B. verrucosus* may be a more useful species for dating, as it has a shorter range in the Gippsland Basin, and does not appear to be a "peat swamp environment" type. Several species found at Kiandra are also reported from the Gippsland Basin assemblages: *Rugulatisporites trophus*, *Foveosporites lacunosus*, *Cyathidites subtilis*, *Cyatheacidites annulatus*, *Tricolporites retequetrus*, *Triporopollenites chnosus*, *Parvisaccites catastus*, *Periporopollenites demarcatus*, *P. vesicus*, and *Gephyrapollenites calathus*. Overlapping ranges of these species in the Gippsland Basin sequences suggest resemblance of the Kiandra microflora to the middle subdivision of the *Proteacidites tuberculatus* Zone, which approximates the Oligocene-Miocene boundary (Stover & Partridge, 1973).

The base of the *P. tuberculatus* Zone is defined by the appearance of *Cyatheacidites annulatus* and *Foveotriletes crater* (the latter species has also been recorded at Nerriga, which extends its range back to the Eocene); the top is marked by the last occurrence of *Tricolporites retequetrus*, found at Kiandra, and two other species not found in this assemblage. Stover & Partridge have recognized three informal subdivisions, based on last occurrences of species. The lower subdivision is characterized by consistent occurrence of two species of *Proteacidites* not found at Kiandra, as well as *Foveotriletes crater* and *Verrucosisporites cristatus*; *Myrtaceidites eucalyptoides* and *Chenopodopollis* sp. (?= *Polyporina* cf. *P. chenopodiaceoides*) appear for the first time. Species found at Kiandra which appear at the top of this lower subdivision are *Rugulatisporites trophus*, *Parvisaccites catastus*, and *Beaupreaidites verrucosus*. The middle subdivision is characterized by the occurrence of *Foveosporites lacunosus* and *Cyathidites subtilis*; species with a last occurrence at the top of this subdivision which are also found at Kiandra are *Nothofagidites flemingii*, *Periporopollenites demarcatus*, and *P. vesicus*. Thus, most similarity to the Kiandra microflora is found with assemblages from the middle subdivision of this zone.

Stover & Partridge correlate the *P. tuberculatus* Zone with the interval extending from the upper part of Taylor's planktonic zonule J to the boundary between zonules E and F (early-late Miocene boundary). The occurrence of *Triporopollenites bellus* at Kiandra is of interest, as Stover & Partridge have used this as the nominate species for their overlying zone in the Gippsland Basin, with a first appearance at the base (approximately mid Miocene). This species appears earlier at Kiandra.

The upper subdivision of the *P. tuberculatus* Zone in the Gippsland Basin is characterized by the occurrence of *Acacia*-type pollen and *Psilastephanocolpites micus*, neither of which is found in the Kiandra assemblage. An age of early Miocene appears reasonable, based on the K-Ar dates and the occurrence of several species characteristic of the *Proteacidites tuberculatus* Zone in Gippsland Basin, especially the middle subdivision, of late Oligocene-early Miocene age.

Comparisons With Other Microfloras from Australia

There are few records of Oligocene and basal Miocene microfloras from Australia. In addition to the assemblage from the Gippsland Basin, comparison can be made with only two other areas, northern Tasmania and Queensland.

Tasmania: Harris (1971) regards the first appearance of *Cyatheacidites annulatus* as indicative of an age of Miocene or younger, and has noted the appearance of this species in Longfordian (basal Miocene) sediments of the Fossil Bluff Sandstone in northern Tasmania. This species is found at least as late as the Grange Burn microflora, regarded as Pliocene (Kalimnan). Harris has defined the base of the *Cyatheacidites annulata* Zonule, which he has not found in the Otway Basin, as the first appearance of *C. annulatus*, and the top as the first appearance of *Acacia*-type pollen. The assemblage is characterized by a high frequency and diverse association of *Nothofagidites* spp., consistent occurrence of Winteraceae pollen (*Gephyrapollenites calathus*), *Sparganiaceaepollenites barungensis*, *Trilites tuberculiformis*, *Matonisporites ornamentalis*, and *Kuylisporites* cf. *K. waterbolkii*. It appears to be very similar to the assemblage from Kiandra, except for the absence of *T. tuberculiformis* (found only at Nerriga in this study) and *Kuylisporites* cf. *K. waterbolkii*.

The earlier occurrence of *Cyatheacidites annulatus* in the Gippsland Basin may reflect sampling bias, as few microfloras from the Oligocene-early Miocene interval are known.

Queensland: No good correlation can be made between assemblages from Kiandra and those from Unit 2 (late Oligocene) or Unit 3 (early Miocene) described by Hekel (1972) in the Queensland Tertiary sequence. Characteristic species of Unit 2 are not found at Kiandra; Unit 3 assemblages contain abundant *Nothofagidites* spp., especially of the *brassi* type, but other typical taxa, *Crassoretitriletes vanraadshooveni* and *Malvacearumpollis estelae*, can be correlated with the pantropical zones of Germeraad, Hopping, & Muller (1968). By this time the assemblages in Queensland were distinctly different from those in southeastern Australia.

Comparison of the Macro- and Microflora

The assemblage from Kiandra is one of the few Australian Tertiary floras with recent work on both macro- and microfossils. Theoretically, this enables comparison of recovery and can expand or reinforce identifications of taxa based on either macro- or microfossils alone. There are few assemblages where both macrofloras and microfloras have been studied recently, although many such studies on overseas deposits have been made (e.g. MacGinitie, 1974, on an early middle Eocene flora from Wyoming; one of numerous studies where both have been studied intensively). Another promising location for such a study is the Maslin Bay flora in South Australia, of middle Eocene age, which appears to have an abundant, diverse, and well-preserved macro- and microflora (Lange, 1970).

It is obvious that the flora represented by macrofossils will tend to be more localized and fragmentary than that from the microfossils; preservation of wood, leaves, and fruits is dependant on these organs falling in or being transported to the site of deposition, and then finding conditions conducive for quick burial and preservation. The microflora, on the other hand, will tend to be more representative of the regional vegetation, and will generally be deposited in much greater quantities. Many taxa too far away or too fragile to be preserved in the macroflora will only be recognized in the microflora, even if optimum conditions for plant preservation prevail. Alternatively, some groups have pollen that is commonly not preserved, e.g. the Lauraceae, and the presence of this group would go unnoticed without macrofossil evidence of its presence.

The plant macrofossils and epiphyllous fungi from Kiandra have been recently studied by Selkirk (1969; 1972; 1974; 1975), who studied the fossil fungi _in situ_ on leaf cuticles from the lower lignite, Homeward Bound Claim, New Chum Hill. Previously, Cookson (1947c) described some fossil fungi found in palynological preparations, and Cookson & Pike (in Gill & Sharp, 1957) listed a few of the micro- and macrofossils found in samples from various localities in the Snowy Mountains (Table 11). Cookson & Pike listed 16 spore and pollen species, which is less than a seventh of the total number of species found herein. Only a few species were identified from macrofossils: ?_Podocarpus_, _Phyllocladus_, and Lauraceae.

Selkirk was concerned mainly with the epiphyllous fungi and their host leaves, which were both gymnospermous and angiospermous. A list of fossils he reported from Kiandra (Table 12) contains few additional records of higher plants; in addition to the fungal flora and an epiphyllous moss, he has described _Podocarpus praecupressinus_, Lauraceae, and Myrtaceae. The bulk of the lignite was formed of Lauraceae leaves, which appeared to belong to a new fossil species (Duigan (1966) previously described three fossil species from Yallourn). Lauraceae pollen is not preserved in sediments, and fossil records of its pollen are unknown (Leopold, in MacGinitie, 1974, p.57). In spite of the diversity of taxa represented in the microflora when compared with the macroflora, a group which must have grown close to the site of deposition was not recorded in the microflora at all.

TABLE 11. Plant Fossils Described From Various Sites Near Kiandra

Data from Cookson & Pike in Gill & Sharp, 1957

Microfossil Remains		Macrofossil Remains
Fungi	*Notothyrites setiferus* Cookson	
	Asterothyrites minutus Cookson	
	Plochmopeltinites masonii Cookson	
Algae*	*Melosira granulata*	
	Navicula viridis	
	Gomphonema intricatum	
	Vanhuerckia rhomboides	
Bryophytes		
	Stereisporites antiquasporites	
Pteridophytes		
	Cyatheacidites annulatus Cookson	fern fronds
	fern spores undifferentiated	
Gymnosperms		
	Dacrycarpites australiensis Cookson & Pike	?*Podocarpus*
	Phyllocladidites mawsonii (Cookson)	*Phyllocladus* leaves
	Lygistepollenites florinii (Cookson)	
	Phyllocladus palaeogenicus Cookson & Pike	
	Microcachryidites antarcticus Cookson	
	Podosporites microsaccatus	
Angiosperms		
	Nothofagus spp. *brassi* type	Lauraceae leaves
	menziesii type	reeds
	fusca type	cuticle
	Myrtaceidites mesonesus Cookson & Pike	unidentified wood
	Cupanieidites ?*major* Cookson & Pike	
	Beaupreaidites elegansiformis Cookson	
	Proteacidites symphyonemoides Cookson	
	Haloragacidites harrisii Couper	

*Diatoms identified by B. Tindale.

TABLE 12. Plant Fossils From Homeward Bound Claim, New Chum Hill

Data from Selkirk (1969; 1972; 1974; 1975)

Fungi	Order Meliolales		
		Family Meliolaceae	*Meliolinites spinksii* Selkirk
			sp.
	Order Dothiorales		
		Family Entopeltaceae	*Vizella discontinua* Selkirk
			Entopeltacites attenuatus Selkirk
			irregularis Selkirk
			cooksoniae Selkirk
	Order Microthyriales		
		Family Microthyriaceae	*Notothyrites kiandrensis* Selkirk
			Asterina kosciuskensis Selkirk
			sp.1
			sp.2
			Euthythyrites morenoinitis Selkirk
			Phragmothyrites kiandrensis Selkirk
			delicatus Selkirk
			cf. *fimbriatus*
			sp.1
			sp.2
			Callimothallus pertusus Dilcher
			Plochmopeltinites masonii Cookson
		Family Trichopeltaceae	*Trichopeltinites kiandrensis* Selk.
		Family Micropeltaceae	*Dictyotopileos* sp.
	Of doubtful affinity		
		?Family Trichthyriaceae (Capnodiales)	
		cf. Trichopelteca	
		Mycelial setae of *Vitalia*	
Mosses	cf. *Ephemeropsis*		
Gymnosperms	*Podocarpus praecupressinus*		
Angiosperms	Lauraceae		
	Myrtaceae		

Several mummified leaves referable to the Myrtaceae were found; Selkirk (1969) thought them similar to those from some genera of the subfamily Myrtoideae (e.g. *Austromyrtus*, *Xanthomyrtus*, *Eugenia*, *Syzygium*, *Ac~~enem~~mena*) and also of some genera of the subfamily Leptospermoideae (e.g. *Backhousia*). The *Podocarpus* leaves were assigned to *Podocarpus* section *Dacrycarpus*, represented in the microflora by *Dacrycarpites australiensis*.

Selkirk did not study wood or leaf fragments; subsequent study of these may enlarge the list of macrofloral elements, but not to the extent where it will reflect the variety of taxa seen in the microflora. The general lack of macrofossils of *Nothofagus* reinforces the conclusion that *Nothofagus* forests probably stood on higher ground at a distance, with broadleaf and gymnosperm forests closer to the shore of the lake at Kiandra.

In summary, relatively few taxa of higher plants are represented in the macroflora compared with the microflora. Of the few families represented in the leaf flora, however, the Lauraceae is the most numerous, and is completely unrepresented in the microflora.

Palaeoecology

A diversity of species is represented in the microflora from Kiandra. Angiosperms dominate the assemblage, with an abundance of *Nothofagidites* pollen, especially of the *brassi* type, in most samples. Ecological requirements and present distributions of the three groups of living *Nothofagus* were discussed in the preceding chapter, and will not be repeated here, except to emphasize that the presence of abundant *Nothofagidites* pollen is probably indicative of high rainfall (at least 150-180 cm per year (Martin, 1973b)) and perhaps moderate temperatures.

Gymnosperms are represented by more species than in the assemblages from Cadia and Nerriga, and are considered indicative of a moist, rainforest environment. *Podocarpus* is now represented in a wide range of climates in temperate and tropical areas. *Podocarpus* section *Dacrycarpus*, represented in both the macro- and microfloras, has its major development in New Guinea, where it grows in rainforest associated with *Nothofagus*. Two taxa now endemic to Tasmania may be represented in the flora at Kiandra: *Dacrydium franklinii* is the only known living conifer with pollen similar to *Phyllocladidites mawsonii*, found rarely at Kiandra and Cadia but more abundant in other Tertiary deposits, and *Microcachrys tetragona*, with pollen similar to *Microcachryidites antarcticus*. *Dacrydium* and *Phyllocladus* are not now found on the Australian mainland, but are represented in cool temperate and montane rainforests in Tasmania, New Zealand, and New Guinea.

The Araucariaceae are also represented in this assemblage (*Araucariacites australis*, *A.* sp., and perhaps *Dilwynites granulatus*). This may indicate the presence of both *Agathis* and *Araucaria*, as the range in size and sculpture of the fossil grains is large. Other probable rainforest trees in this assemblage are *Gephyrapollenites calathus* (*Drimys*), *Cupanieidites orthoteichus*, and *Sapotaceoidaepollenites* cf. *S. rotundus*.

The presence of two fossil species (*Beaupreaidites elegansiformis* and *B. verrucosus*) with suggested affinities to an endemic New Caledonian genus of the Proteaceae (*Beauprea*) is of interest. *Beaupreaidites elegansiformis* and *B. verrucosus*, although rare in this assemblage, are widely distributed in Australian Tertiary deposits.

The diverse spore assemblage consists of pteridophytes, including a tree fern element, and bryophytes. The spores, gymnosperms, and some other pollen types are all indicative of moist conditions, and this is reinforced by the fungi and macrofossils. Selkirk (1975) came to a similar conclusion, based on a study of the fungi, macrofossils, and a limited pollen flora. The presence of plentiful leaves of Lauraceae suggests a broadleaf or mixed broadleaf-gymnosperm forest vegetation around the lake, with Nothofagus forest farther away, probably on higher ground. Although many elements are typical of Tasmanian temperate rainforests, Selkirk (1969) has noted that broad-leafed Lauraceae are not found in these temperate forests at the present time. In New South Wales this group is found mainly in subtropical rainforests, and does not extend into the temperate Nothofagus forests. This may be suggestive of warmer conditions than found in these temperate forests today, although some species of Lauraceae are found in montane temperate forests in New Guinea. The presence of an epiphyllous moss (Selkirk, 1974) with closest affinity to an Indo-Malaysian species may indicate warmer conditions; the other living species of this genus is found in Tasmania and New Zealand.

Layers of mummified leaves and large masses of wood suggest a generally stagnant lake environment. These stagnant lake phases were of short duration, however, as the same flora is represented in the lower two lacustrine phases (lower and middle "lignites"), and would probably be represented in the upper lacustrine phase as well. Gill & Sharp (1957) infer a humid, warm climate and high rainfall, based on the presence of plentiful organic matter and the broad-leaf flora. A humid, high rainfall environment certainly appears to be indicated, with some indication of warmer temperatures than found in the area at present. Most elements of the flora can be compared with those of temperate rainforests of Tasmania, lower montane forests of New Guinea, and New Caledonian forests. Whether temperatures were higher at Kiandra in the early Miocene than found in temperate rainforests at the present time is uncertain. Many taxa now found in tropical-subtropical regions of Australia, such as *Cupanieidites orthoteichus*, *Malvacipollis* spp., and *Tricolporites* cf. *T. endobalteus*, cannot indicate tropical or subtropical conditions in themselves, as a majority of the assemblage that has been related to living taxa have a temperate distribution as well.

Temperatures at Kiandra during early Miocene were probably cooler than those found at Nerriga in the early-middle Eocene, based on both the absence of some of the "Tropical" elements found at Nerriga and recent paleotemperature data (Shackleton & Kennett, 1974). A moist, closed rainforest environment, with precipitation more evenly distributed throughout the year, appears to be indicated, with some altitudinal zonation of forest components.

CHAPTER 5. CADIA

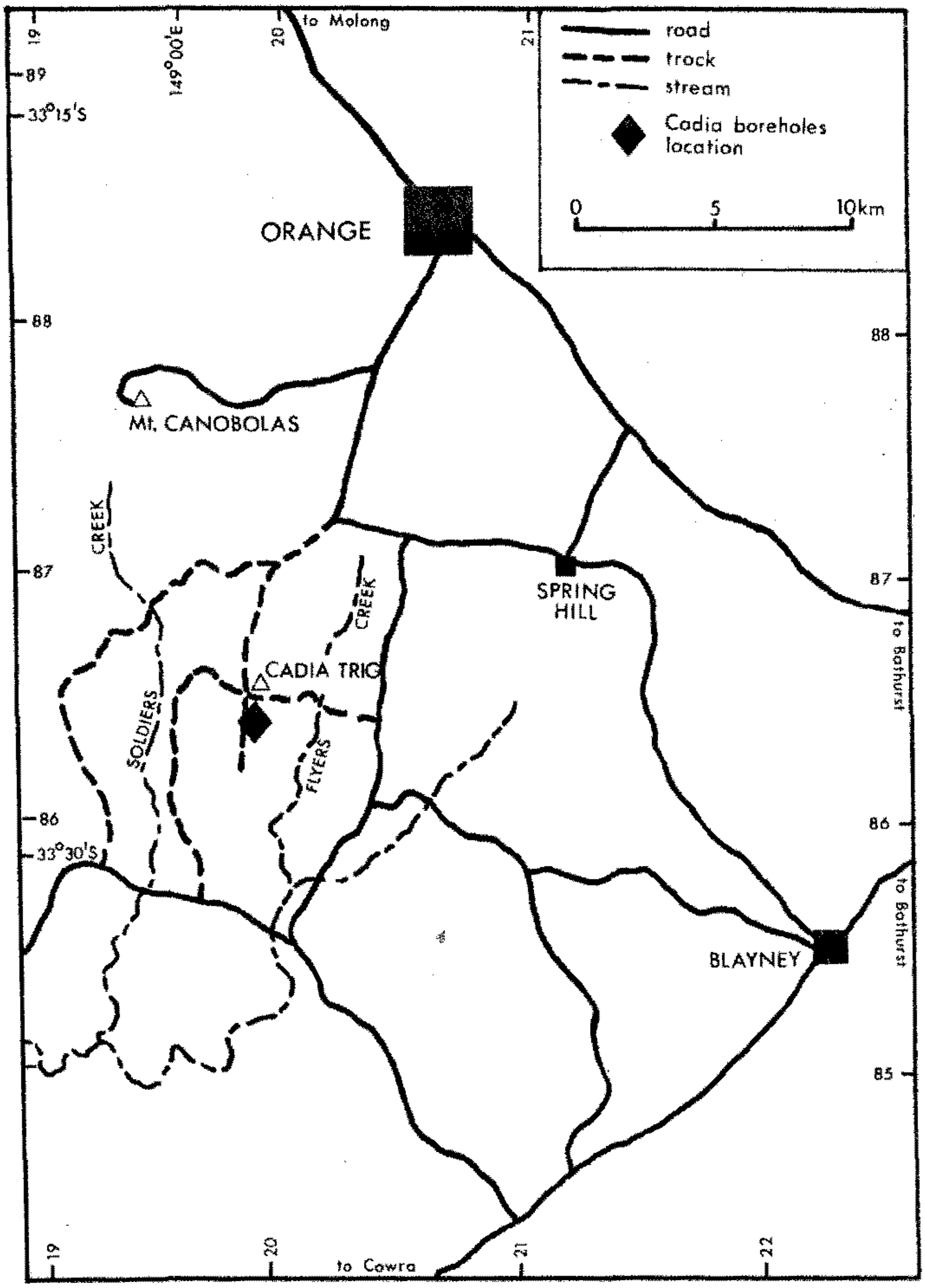
Regional Setting

Cadia is situated 20 km south-southwest of Orange, in the Central Tablelands of New South Wales. Elevations in the area reach a maximum of 1000 metres at Cadia Trig., with maximum relief in the order of 300 metres. This area comprises a number of lava-capped, flat-topped steep-sided ridges, with part of the area cleared for grazing, and the remainder thickly wooded.

The region is near the northern end of the present exposure of the Canberra-Molong High. Sadler (1972) mapped the Palaeozoic rocks of this area in detail, with emphasis on the Ordovician volcanic rocks and the chalcopyrite-pyrite-magnetite mineralization. Pacific Copper Explorations Ltd is at present taking steps to initiate mining in the area, and it is as a result of an extensive drilling program at Big Cadia and Little Cadia that subsurface material from the Tertiary basalts and interbedded sediments was made available for study (see Text-figure 10). Basalt-capped ridges are found to the north, east, and west of Big Cadia, and east of Little Cadia. Boreholes at Little Cadia penetrate up to 100 metres of basalt, tuff, and interbedded sediments.

Tertiary Basalts and Associated Sediments

The Tertiary basalts in this area are included in the Orange Volcanic Province, with ages ranging from 12.9 to 10.9 m.y., or middle Miocene (Wellman & McDougall, 1974a). South of Orange an area of basaltic lavas forms a plateau, and to the north, west, and south are valley flows thought to originate from the plateau. Southwest of Orange is the Canobolas Volcanic Complex, a dissected, conical volcanic centre. Ages on the Canobolas Volcanic Complex



Text-figure 10. Location of boreholes sampled in the Cadia area. Co-ordinates refer to 10,000 yard Transverse Mercator Grid, Zone 8. Co-ordinates of individual boreholes are: PC235, N863516 E198616; PC242, N863466 E198833; PC243, N863570 E198900; PC246, N863516 E198950; PC247, N8635670 E198973.

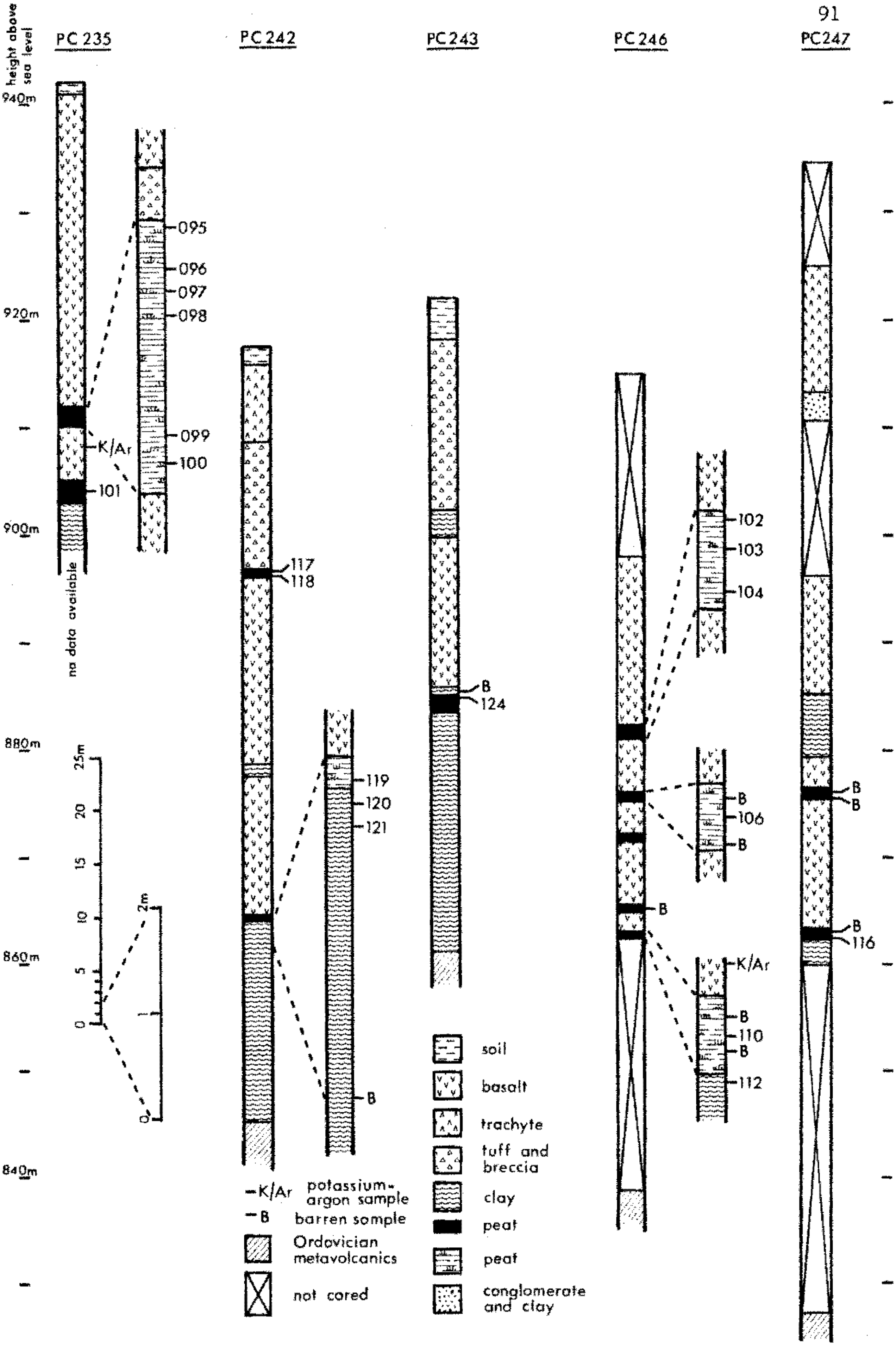
appear to be slightly younger than those of the surrounding lavas.

The basalts were erupted onto a surface of eroded Palaeozoic (Ordovician to Upper Devonian) rocks; the pre-basaltic surface was irregular and sloped in a general southwesterly direction (Stevens & Packham, 1952). No basalts from Cadia had been dated previously, although several in the vicinity of Mount Canobolas were recently dated (Wellman & McDougall, 1974a). Dr I. McDougall arranged for the dating of two basalt samples from the cores at Cadia, and the results gave a mean age of 12 m.y., or middle Miocene. This agrees with other basalt dates from the surrounding region. (Further detailed information on these basalts is given in Appendix 2.)

In all, 30 samples from five boreholes were selected for study. Lithologic sequences in each borehole, with position of samples taken for palynological study and locations of basalt samples dated by K-Ar, are given in Text-figure 11. The five boreholes are closely spaced, with a maximum distance apart of 335 metres (PC 235 and 247), and a minimum distance of 76 metres (PC 243 and 246). Depth to Palaeozoic bedrock varies from 60 to 107 metres.

Despite the close spacing of the sites, considerable variation in lithologies and thicknesses of units was found. Above bedrock, each borehole has a thick clay sequence which passes up into lignite and grey clay, overlain by a basalt flow. A series of flows, with interbedded thin layers of clay and lignite, with clay at the base, reaches a maximum thickness of 107 metres in Borehole 247.

As much of this thick clay sequence was not cored, samples could be taken only from the upper part and from the overlying lignite and grey clay. Because the microfloras in this pre-basaltic sequence are very similar to that of the inter-basaltic layers, the sediments are all considered to be of generally the same age.



Text-figure 11. Stratigraphic sequences in the five boreholes sampled from the Cadia area. For locality, see Text-figure 10.

Most productive samples had similar assemblages of palynomorphs, and differences in relative abundances in each sample did not appear to show any trends that could be related from one borehole to another. Most samples were taken from lignites, diatomites, and grey to brown clays, some with visible plant fragments. Samples were not taken adjacent to contacts with overlying basalts, as the tops of these sediment layers appeared to be baked; samples were selected a few centimetres below this baked zone.

In several of the samples macerated the grains had a strong brownish tinge, indicating that some alteration of the exines had taken place. As these samples were taken close to the contact with an overlying basalt, this alteration appears to be caused by the thermal effect of the overlying basalt, although the sediments did not appear baked. Gray (in Gray & Boucot, 1975, p.1022) noted similar color changes in palynomorphs in late Tertiary sediments within Columbia River basalt. Although she noted color changes over a distance of "a few tens of feet", in the Cadia samples such changes, from dark brown to apparently unaltered grains, were found over only several centimetres vertical distance.

Composition of the Assemblage

In samples from Cadia a total of 24 species of spores, 12 species of gymnosperms, 65 species of angiosperms, and 3 species of uncertain affinities were isolated. Most can be identified with previously described Tertiary species. Colonies of Botryococcus were numerous in some samples, although only a few colonies of Pediastrum were found. Several different species of fungal spores were present, although fructifications were rare.

Angiosperm pollen comprised more than half of every sample (except sample 112). (These counts exclude fungal and algal remains.) A complete list of pollen and spore species found in these samples is given in Table 13, which also shows relative percentage abundances of taxa in each sample. These percentages are based on counts of at least 200 grains, except for sample 103, for which fewer than 100 grains were counted. Several species found in these samples were not found in either of the other two localities. These are *Rugulatisporites micraulaxus*, *Symplocoipollenites austellus*, *Graminidites media* , *Proteacidites cadiensis* (sp. nov.), *P. symphyonemoides*, *P. similis*, *Haloragacidites haloragoides*, and *Polyadopollenites myriosporites*. As will be noted below, all these species, except for *P. similis* and *P. cadiensis*, have been reported from pollen assemblages dated as Miocene or younger. Although the relative numbers of *G. media*, *P. myriosporites*, and *H. haloragoides* are very low in these samples, these three species become increasingly important components of later Miocene and Pliocene microfloras (e.g. Martin, 1973a). Gramineae and *Acacia* (*P. myriosporites*) are important elements in the extant vegetation.

Several species in these samples occur too rarely to be recorded either in the percentage counts or in scans made during counting; these are *Verrucosisporites kopukuensis*, *V. cristatus*, *Banksieaeidites arcuatus* (which has not been reported from Miocene deposits previously), *Triporopollenites bellus*, *Polyorificites* sp., and *Triorites* sp.

The assemblage in general consists of a variety of spores, a somewhat less diverse gymnosperm group, and a diverse angiosperm assemblage. With regard to *Nothofagidites* pollen, species assigned to the *brassi* group are the most numerous both in absolute numbers and in number of species, with appreciable numbers of *menziesii* type in some samples. Pollen assigned to the *fusca* group is minor or absent in all samples. Table 14 shows the assemblage in each sample grouped into four major components: spores, gymnosperms, angiosperm pollen (excluding *Nothofagidites* spp.), and *Nothofagidites* spp. The

TABLE 13. Composition of the Microfloral Assemblage from Cadia

All figures are in percentages, except for sample 103, where less than 100 grains were counted.
–, present in slide but not included in count; seen in scan after conclusion of counting.

SPORES	095	096	097	098	099	100	101	117	118	120	121	124	102	103	112	116
Cyathidites sp. cf. *C. minor*	1.5	-	1	3	1	1	1.5	1	1.5	1	+	1	5.5	1	11	11
subtilis	-	-	-	0.5	0.5	0.5	+	+	+	-	+	-	2	-	4	1
Biretisporites spp.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Deltoidospora sp.	1	1	-	-	-	0.5	1	+	+	0.5	+	-	1	-	6	3
Stereisporites antiquasporites	-	-	-	-	-	-	-	-	-	+	-	3	1	-	-	0.5
Verrucosisporites kopukuensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cristatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmundacidites spp.	-	-	-	-	1	-	0.5	-	+	-	1	0.5	1	-	-	-
Baculatisporites comaumensis	0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodiumsporites spp.	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	28	-
Foveosporites lacunosus	-	-	-	-	0.5	-	-	-	-	0.5	-	-	-	-	-	-
Rugulatisporites micraulaxus	1	1	1	3	+	2.5	-	-	-	+	+	-	-	-	16	1
Ischyosporites spp.	1	2	1	3	1	1.5	+	-	-	-	+	-	1.5	-	4	14.5
Cingutriletes clavus	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Matonisporites ornamentalis	0.5	1	1	-	-	-	-	+	-	-	1	-	1.5	-	-	-
Gleicheniidites circinidites	-	-	-	-	-	-	-	-	-	-	1.5	-	-	-	-	-
Laevigatosporites ovatus	2.5	0.5	1	8	4.5	0.5	2.5	3	2	1	0.5	8	1.5	15	8	6
major	3.5	1.5	2	10	4.5	-	0.5	2	0.5	-	-	4	3.5	5	-	1
Polypodiisporites sp. 1	3.5	3	2	6	1	0.5	-	4	1.5	+	+	-	2	11	1.5	-
Reticuloidosporites escharus	-	-	-	-	2.5	-	1	+	-	-	+	-	-	-	-	-
Microfoveolatisporis sp. 1	+	-	-	1	0.5	0.5	-	+	0.5	-	-	-	-	-	-	-
Peromonolites densus	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
vellosus	-	-	-	-	-	0.5	-	-	-	+	+	-	1	-	-	-
Hypolepis spinysporis	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
TOTAL SPORES	16.0	11.0	9.0	34.5	17.0	8.0	13.0	10.0	6.0	3.0	4.5	16.5	21.5	32.0	78.5	38.0

POLLEN	095	096	097	098	099	100	101	117	118	120	121	124	102	103	112	116
Podocarpidites undiff.	7	8.5	3	5	4	4	3	1	1.5	5	6	7	6	4	1.5	1.5
ellipticus	1.5	2	1	-	-	-	1	-	-	-	-	0.5	-	-	-	-
marwickii	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
sp.	-	1	3	0.5	+	1.5	0.5	+	-	1	1	3	2	1	-	-
Lygistepollenites florinii	1.5	-	1.5	3	1	1	+	+	+	7	6	1.5	0.5	-	-	-
Dacrycarpites australiensis	-	-	1	0.5	0.5	-	+	-	-	+	-	3.5	2.5	1.5	-	-
Phyllocladidites mawsonii	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Phyllocladus palaeogenicus	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Podosporites microsaccatus	0.5	-	-	-	-	-	-	-	-	0.5	1	-	-	-	-	-
Alisporites grandis	1	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Araucariacites australis	-	-	1	0.5	-	0.5	-	-	+	-	+	1	-	1	-	-
Dilwynites granulatus	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL GYMNOSPERMS	11.5	11.5	10.5	10.0	6.0	7.0	4.5	1	1.5	13.5	14.0	16.5	11.0	7.5	1.5	1.5
Graminidites media	1	-	1.5	1.5	1	1.5	1.5	+	-	1.5	1	2	2.5	-	-	-
Sparganiaceaepollenites cf. *S. barungensis*	-	-	-	0.5	+	-	-	1	1	-	+	-	0.5	-	-	-
Liliacidites spp.	-	-	1	-	-	-	3	-	-	1	1.5	-	-	-	1.5	-
Monosulcites verrucosus sp. nov.	-	-	-	-	2	-	-	+	-	-	-	1	-	-	-	-
Monocolpate spp.	-	-	-	1.5	1	-	-	1	-	-	+	2	-	1	-	1.5
Banksieaeidites elongatus	1	-	-	-	-	-	-	-	1	-	+	-	-	-	-	-
arcuatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gothanipollis cf. *G. gothani*	-	-	-	-	-	-	0.5	-	+	-	-	-	-	-	-	-
Tricolpites psilatus	5	9	5	3	2.5	-	2	-	+	-	3	1.5	1	-	-	1.5
delicatulus	1	-	2.5	-	-	-	1	-	-	2.5	1.5	-	-	-	-	-
punctaticulus	2	-	-	6	-	-	-	-	2	-	-	-	-	-	-	-
spp.	4.5	1.5	1.5	-	1	1.5	7	-	-	-	-	-	1	-	-	-

POLLEN (cont.)	095	096	097	098	099	100	101	117	118	120	121	124	102	103	112	116
Cupanieidites orthoteichus	1	-	1.5	-	-	-	+	1.5	+	+	3.5	-	-	-	-	-
Myrtaceidites mesonesus	1.5	1	2	-	1.5	-	1.5	1.5	5	-	-	-	-	-	-	-
parvus	7	7	6.5	1.5	4	1.5	4	3.5	8	1.5	6.5	1.5	4	1	-	-
eucalyptoides	1	-	2	-	1	-	1	1	1	-	-	1.5	-	-	-	-
spp.	1	-	-	-	1	-	2	-	-	-	1	-	-	-	-	-
Symplocoipollenites austellus	-	-	-	-	-	1.5	+	+	1.5	+	1.5	-	-	-	-	-
Tricolporites sphaerica	7	7.5	12.5	-	1	-	1	+	2	1.5	1.5	-	1	5	-	-
microreticulatus	-	-	-	2	4	-	6	+	+	1.5	3.5	-	1	-	-	-
prolata	2.5	1	1.5	3	1	-	3.5	1.5	1	-	1.5	-	-	-	-	-
cf. T. angurium	-	10	7	-	-	-	1	+	-	7	4.5	-	-	-	-	-
sp. 4	-	0.5	1	2	4.5	-	-	1.5	+	2.5	1.5	-	-	-	-	-
spp.	1	1.5	1.5	4	3	-	-	-	-	-	-	-	-	2	-	-
Tricolporopollenites endobalteus	-	1.5	-	-	-	1.5	1.5	-	-	-	+	-	-	-	-	-
Sapotaceoidaepollenites cf. S. rotundus	-	-	-	-	-	-	+	0.5	-	-	0.5	-	0.5	-	-	-
Ilexpollenites clifdenensis	5	0.5	-	-	-	-	+	+	+	+	-	-	-	-	-	-
Dodonaea sphaerica	-	-	1	1.5	1	-	1.5	-	+	+	+	-	-	-	-	-
Triporopollenites bellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proteacidites annularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5
pachypolus	1	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
minimus	1	2.5	-	-	1	1.5	1	0.5	-	-	-	-	-	2	-	-
cf. P. obscurus	-	-	-	0.5	0.5	0.5	+	+	0.5	-	+	-	-	-	-	-
cadiensis sp. nov.	4.5	7.5	2.5	1.5	1	-	+	0.5	1.5	0.5	0.5	1.5	-	5	-	-
subpalisadus	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
subscabratus	2	-	-	-	-	-	+	2.5	-	1.5	-	-	-	-	-	-
symphyonemoides	-	-	-	0.5	-	-	+	+	+	1	-	-	-	-	-	-
similis	0.5	0.5	-	-	-	-	+	+	-	+	0.5	-	-	-	-	1.5
Triorites minisculus	-	-	-	-	-	-	-	+	+	-	0.5	1	-	-	3	-
introlimbatus	0.5	-	-	-	-	-	+	-	-	-	0.5	-	-	-	-	-
sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

POLLEN (cont.)	095	096	097	098	099	100	101	117	118	120	121	124	102	103	112	116
Haloragacidites harrisii	-	1	1.5	10	1	27.5	2	1.5	+	5.5	2.5	2.5	18	9	1.5	18
trioratus	-	0.5	1				+									
haloragoides	+	-	-	-	0.5	+	0.5	+	-	-	+	0.5	-	-	-	0.5
Nothofagidites emarcidus-heterus	11	12	15	21	36.5	40.5	31	71	62.5	52	41.5	45.5	32	19	14	41
deminutus	1	1	-	-	-	-	-	-	-	-	1.5	-	-	-	-	-
falcatus	3.5	5	4	-	-	1.5	-	1.5	1.5	1.5	-	-	-	-	-	1
incrassatus	-	0.5	3	0.5	1	1.5	1.5	1.5	1.5	1.5	-	-	-	-	-	-
vansteenisii	-	1	1	-	-	-	1.5	-	1.5	1.5	-	1	1	-	-	-
brachyspinulosus	0.5	-	-	-	1	-	-	0.5	-	-	0.5	-	-	-	-	-
flemingii	-	-	-	1.5	+	-	1	-	-	0.5	0.5	-	-	-	-	-
asperus	-	-	1	-	1.5	8	3	1.5	1.5	5	5	8	4.5	1	-	0.5
goniatus	4	3	3.5	0.5	-	-	2.5	-	-	-	1.5	1.5	-	-	-	-
Polycolpites esobalteus	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
sp.	-	-	-	-	-	-	-	-	0.5	-	+	-	0.5	-	-	-
Malvacipollis diversus	-	-	-	-	-	1	-	-	+	+	-	-	0.5	-	-	-
subtilis	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-
Polyporina cf. *P. chenopodiaceoides*	-	-	-	-	-	1.5	-	0.5	-	-	0.5	-	-	-	-	-
Polyorificites sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ericipites scabratus	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-	0.5
Gephyrapollenites calathus	+	0.5	-	-	3.5	-	4.5	+	+	+	+	-	-	-	-	-
Polyadopollenites myriosporites	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
TOTAL ANGIOSPERM POLLEN	71.0	75.5	80.0	59.5	77.0	85.0	82.5	89.0	92.5	83.5	81.5	67.0	66.5	60.5	20.0	60.5
Schizosporis parvus	1.5	1.5	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Circulisporites spp.	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-
TOTAL INCERTAE SEDIS	1.5	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 14. Percentage Frequency of Major Floral Components from Cadia

All figures are in percentages

Sample No.	Spores	Gymno.	*Noth*.(*m*,*f*)	Other Angio.	*Cas*.	Myrt.	Gram.	Prot.
095	16	11.5	20 (-, 1)	52	-	10.5	1	10
096	11	11.5	22.5 (3,-)	55	1.5	8	-	10.5
097	9	10.5	27.5 (4.5,-)	53	2.5	10.5	1	2.5
098	34.5	10	22.5 (1, 1)	34	10	1	1	1.5
099	17	6	40 (1.5,1)	34	1.5	6	1	2.5
100	8	7	49.5 (8,-)	36	27.5	1	1.5	2
101	13	4.5	39.5 (5.5,1)	43	2	8,5	1	1
102	21.5	11	37.5 (4.5,-)	30	18	4	2.5	-
103+	32	7.5	20 (1,-)	28	9	1	-	7
112	78.5	1.5	14 (-,-)	5.5	1.5	-	-	3
116	38	1.5	42.5 (1,-)	20	18	-	-	1
117	10	1	74 (1.5, 1)	13	1	5	-	3.5
118	6	1.5	65.5 (1.5, 1)	27	-	14	-	2
120	3	13.5	59 (5.5,-)	25.5	5.5	1	1.5	3
121	4.5	14	50.5 (6.5,1)	33	2.5	7.5	1	1.5
124	16.5	16.5	56 (6.5,1)	12	2.5	2	2	1.5

Gymnosperm component: *Podocarpidites* spp., *Lygistepollenites florinii*, *Dacrycarpites australiensis*, *Podosporites microsaccatus*, *Alisporites grandis*, and *Araucariacites australis*.

Nothofagidites component = species assigned to *brassi* + *menziesii* + *fusca* groups. Individual values for *menziesii* (*m*) and *fusca* (*f*) also given.

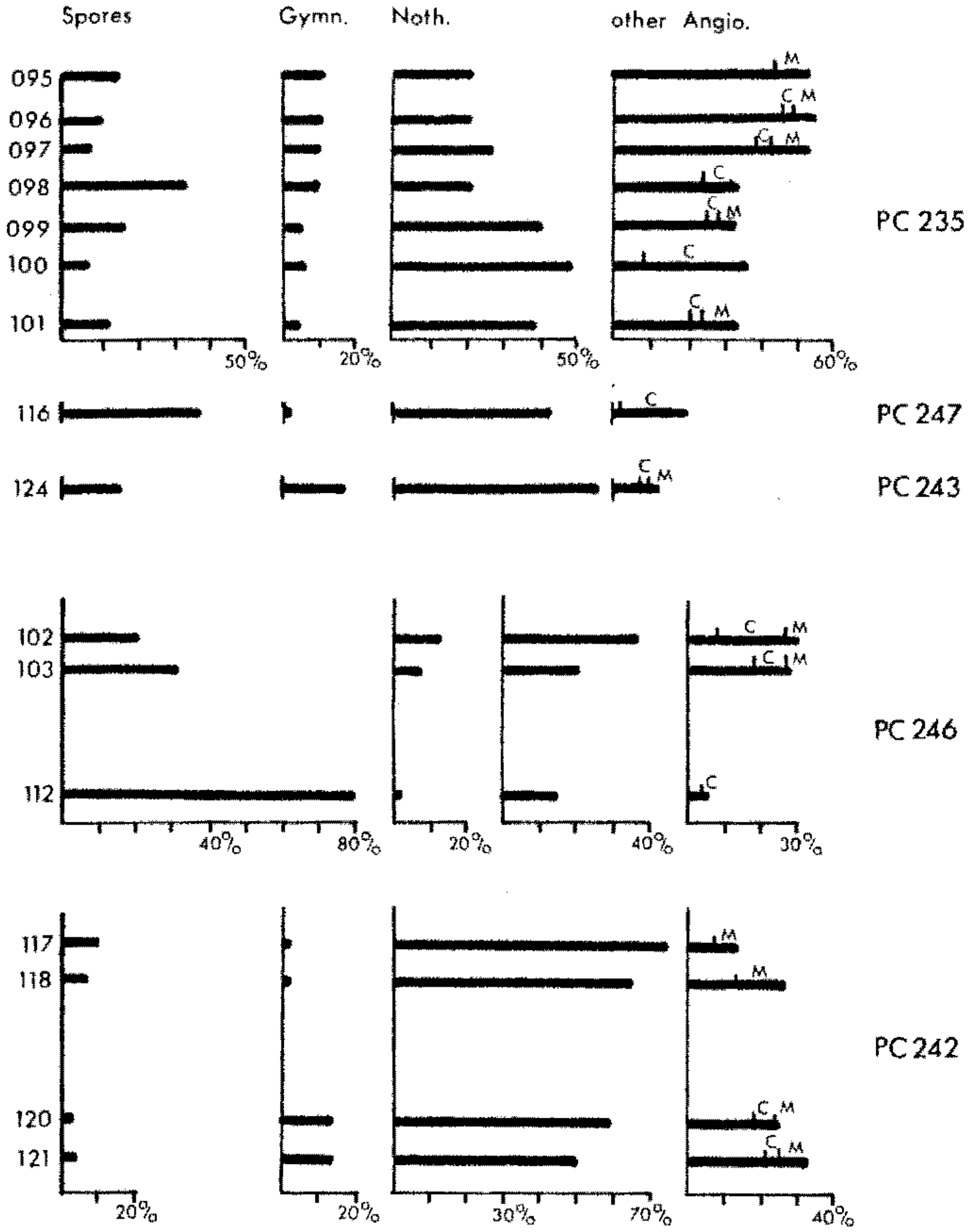
Other Angiosperms: all pollen excluding *Nothofagidites* spp. Includes pollen types in the following four columns: *Casuarina*-type (*H. harrisii* + *H. trioratus*), Myrtaceae-type (*Myrtaceidites* spp.), Gramineae-type (*G. media*), and Proteaceae-type (*Proteacidites* spp. + *Banksieaeidites* spp.)

+ Less than 100 grains counted.

angiosperm assemblage has been subdivided to include separate values for Myrtaceae-type pollen (*Myrtaceidites* spp.), *Casuarina*-type pollen (*Haloragacidites harrisii* + *H. trioratus*), Gramineae-type pollen (*Graminidites media*), and Proteaceae-type pollen (*Proteacidites* spp. + *Banksieaeidites* spp.). The same information is shown by histograms in Text-figure 12. In these histograms the vertical spacing of samples is not to scale, as polleniferous samples were closely spaced in relatively thin sequences of sediment.

Large differences in relative abundances of particular component groups are readily apparent. One sample, 112, was remarkably different as it contained 78.5% spores, more than twice that of any other sample. Few other species were present. As this sample was taken from a buff clay, it probably represents a different depositional environment, with localized over-representation of the ferns growing adjacent to the site of deposition. Large numbers of relatively few species are represented, with few taxa other than spores. The spore assemblage consists of *Cyathidites* cf. *C. minor*, *C. subtilis*, *Deltoidospora* sp., *Lycopodiumsporites* spp., *Rugulatisporites micraulaxus*, *Ischyosporites* spp., *Laevigatosporites ovatus*, and *Polypodiisporites* sp. 1. Such over-representation of one group distorts the relative abundance values of the other component groups, so that in quantitative comparisons of samples, this particular sample is best disregarded.

Only two spore taxa, *Cyathidites* cf. *C. minor* and *Laevigatosporites ovatus*, were consistently recorded in count scans in all samples, and *Rugulatisporites micraulaxus*, *Ischyosporites* spp., *Cyathidites subtilis*, *Laevigatosporites major*, and *Polypodiisporites* sp. 1 were recorded in count scans from most samples. Except for the very high abundance in sample 112, mentioned above, relative percentages of



Text-figure 12. Histograms of Major Component groups, Cadia. Vertical scale exaggerated; for actual vertical intervals, see Text-figure 11.
C, *Casuarina*-type; M, Myrtaceae-type.

the spore component ranged from 3 to 38%, with the higher values generally a result of abundance of a single species. This is probably a reflection of proximity of these spore-producing plants to the site of deposition. Individual high relative percentages were recorded for Laevigatosporites ovatus (8 and 8.5%) in samples 098, 101, and 124; L. major (10%) in sample 098; and Ischyosporites spp. (14.5%) and Cyathidites cf. C. minor (11%) in sample 116.

The gymnosperm component ranges from 1 to 16.5%, and is generally minor in these assemblages. Few species are represented by more than a few grains; Podocarpidites spp. are found consistently, especially the P. ellipticus type. Lygistepollenites florinii has been recorded from most samples, and Dacrycarpites australiensis and Araucariacites australis are found in low frequencies in several samples.

The angiosperm assemblage includes a diversity of species, especially tricolpate and tricolporate pollen types. Several species assigned to Proteacidites are found in low frequencies, although a previously undescribed species, P. cadiensis, comprised 7.5% of the assemblage in one sample. Most species are smooth to faintly reticulate; none of the highly ornamented types assigned to this genus were found in these samples.

Haloragacidites harrisii and H. trioratus, which have been included together under the heading Casuarina-type for abundance calculations (as both fossil taxa have probable affinities with the Casuarinaceae) are found consistently in all samples, and were common to abundant in a few; high counts of 27.5% in sample 100 and 18% in samples 102 and 116 are of special note.

Myrtaceidites spp., especially M. parvus (of uncertain affinities), reached maximum percentages of 10 to 14%, and were present in all samples. Specimens with conspicuously thickened exine at the apertures

(*M. eucalyptoides*) were found in very small numbers. Pollen with tricolpate and tricolporate apertures are common in some samples; *Tricolporites sphaerica* forms 12.5% of the assemblage in sample 097, and *T.* cf. *T. angurium* and *Tricolpites psilatus* represent 10 and 9%, respectively, in sample 096.

It is surprising that no pollen related to the Compositae (e.g. *Tubulifloridites* spp.) has been found in these samples, as pollen of this type has been reported from microfloras of similar age from other localities. This, together with the low representation of Gramineae pollen, could be indicative of closed forest conditions occurring at the site.

The *Nothofagidites* pollen group is represented by ten species, with pollen of the *brassi* type the most numerous in all samples. Disregarding the one sample (112) with an abundance of fern spores, the *Nothofagidites* group comprises 20 to 74% of the pollen assemblages. Pollen of the *fusca* type is found in negligible quantities, whereas pollen of the *menziesii* type comprises up to a sixth of the total number of grains of the genus counted.

Age of the Assemblage

Many of the species found in these samples are known to be long-ranging elsewhere and therefore of little use in fixing an upper and lower age limit for the assemblage. Significant species for age determination are *Rugulatisporites micraulaxus*, *Symplocoipollenites austellus*, *Proteacidites symphyonemoides*, *Triporopollenites bellus*, *Polyadopollenites myriosporites*, and *Haloragacidites haloragoides*, which have all been reported from the Gippsland Basin (Stover & Partridge, 1973). Most of these species are restricted to microfloras from the *Triporopollenites bellus* Zone; two are found in both the *T. bellus* and the underlying *Proteacidites tuberculatus* Zone. The *T. bellus* Zone is thought to correlate with Taylor's planktonic zonules F through B, and possibly A (Stover & Partridge, 1973, p.245). *Haloragacidites haloragoides* is reported to appear first within the *T. bellus* Zone, whereas the other species are found from the base of the zone.

Harris (1971) considers that the first appearance of *Acacia*-type pollen (*Polyadopollenites myriosporites*) coincides with the base of the middle Miocene in the Otway and St Vincent Basins, and the first appearance of this species is used to mark the top of his *Cyatheacidites annulata* Zonule. However, this species appears to occur in basal Miocene deposits in the Gippsland Basin, and its first appearance is later than middle Miocene in Queensland (Hekel, 1972).

Two other species in the Cadia samples are not found at either Kiandra or Nerriga. *Graminidites media* has been reported from few assemblages; it was originally described from middle Miocene deposits in Kerguelen, and has since been reported from Eocene deposits in the Otway Basin (Harris, 1971), and Miocene and younger horizons elsewhere. *Proteacidites similis* has previously only been reported from the Paleocene of Victoria (Harris, 1965a), and appears to be of little chronostratigraphic value.

In general, an age of middle Miocene for this assemblage appears to be reasonable, on the basis of known pollen ranges; this is in good agreement with the K-Ar dating of basalt samples from the cores.

Comparisons With Other Assemblages

Microfloras of middle and late Tertiary age are not well known, and there are few published records of reliably dated Miocene or younger microfloras.

Otway Basin: Microfloras of this age are not well known from the Otway Basin. Harris (1971) remarks that the first appearance of *Acacia*-type pollen (*Polyadopollenites myriosporites* and *P. octosporites*) coincides with the base of the middle Miocene in the Otway and St Vincent Basins. Associated with Acacia he has reported the following species:

- *Cyatheacidites annulatus*
- *Cyathidites minor*
- *Laevigatosporites ovatus*
- *Haloragacidites harrisii*
- *H. trioratus*
- *Nothofagidites* spp.
- *Sparganiaceaepollenites barungensis*
- Chenopodiaceae pollen
- *Proteacidites pachypolus*
- *Sapotaceoipollenites* sp.
- *Araucariacites australis*
- *Lygistepollenites florinii*
- *Dacrycarpites australiensis*
- *Podosporites microsaccatus*
- *Podocarpidites ellipticus*
- *Phyllocladidites mawsonii*
- cf. *Gunnerites reticulatus* Cookson
- *Santalumidites cainozoicus*
- Winteraceae pollen

Most of these are long-ranging Tertiary species except for *C. annulatus*, *P. myriosporites*, Chenopodiaceae pollen, and Winteraceae pollen. Harris also notes that the diversity of *Nothofagidites* spp. is low in the middle Miocene deposits, but the diversity and abundance, especially of the *brassi* type, is higher than in Pliocene assemblages. Of the species listed above, all except *C. annulatus*, Cf. *Gunnerites reticulatus*, and *Santalumidites cainozoicus* are found in samples from Cadia. However, *P. myriosporites* is the only species found at Cadia and not also found at Kiandra.

Gippsland Basin: Microfloras from Cadia show many similarities to those of the *Triporopollenites bellus* Zone, which Stover & Partridge (1973) regard as late Miocene, perhaps extending into Pliocene. Species restricted to this zone, and also found in the Cadia assemblages, are *Triporopollenites bellus* (extremely rare at Cadia, and also found at Kiandra), *Rugulatisporites micraulaxus*, *Proteacidites symphyonemoides*, and *Symplocoipollenites austellus*, which all appear in assemblages from the base of the zone in the Gippsland Basin, and *Haloragacidites haloragoides*, which appears within the zone. They also note the following general trends within the zone: increase in abundance of *Gephyrapollenites calathus* and *Myrtaceidites eucalyptoides*; *Nothofagidites* spp. still abundant in the lower part of the zone, and becomes less abundant and has fewer species towards the top;

lower diversity and abundance of gymnosperm pollen than in underlying Proteacidites tuberculatus Zone; increase in diversity of angiosperm pollen, especially tricolporate types and Myrtaceidites spp.

Species regarded as diagnostic of this zone, which are not found in the Cadia assemblages, are Polypodiaceosporites tumulatus (probably a fern), Tubulifloridites antipodica (affinities with Compositae), and Milfordia homeopunctata (affinities with Restionaceae). Several species of Proteacidites which range into the T. bellus Zone in the Gippsland Basin, e.g. P. rectomarginis and P. tuberculatus, are not found at Cadia.

Lachlan and Murrumbidgee Valleys: Upper Tertiary assemblages described by Martin (1973b) are generally younger than the microflora from Cadia. They are from fluvio-lacustrine sediments of uncertain age correlated with similar deposits elsewhere. She tentatively considers these samples to range from Pliocene to post-Tertiary. The Nothofagidites component consists only of menziesii and fusca types. A few samples from deeper levels at Hay and Narrandera have a predominance of brassi type pollen; frequencies of spores, gymnosperms, and Casuarina-type pollen are low, and Compositae and and Gramineae are absent. The assemblage has some general similarities to the spectrum from Cadia, but as she has given no details of the species represented, detailed comparisons cannot be made at present.

Queensland: Microfloras from Unit 4 of the Tertiary succession in Queensland (Hekel, 1972), ranging from the late early Miocene to late Miocene, have few similarities to the Cadia assemblage. Characteristic of this unit in Queensland are Chenopodipollis sp., Echitricolporites sp., Polyadopollenites sp., Polypodiidites usmensis, and Polypodiisporites sp.; Milfordia sp. is also widely found. Nothofagidites spp. decreases towards the upper part of the unit. Some species in microfloras from this interval have been related to the pantropical zones of Germeraad, Hopping, & Muller (1968).

Central Tablelands: Partridge (1971) examined an assemblage from a subsurface sample of sub-basaltic clays from Cudal, located about 30 km from Orange. This could also be considered part of the Orange Volcanic Province, with basalt dates of middle Miocene. He referred the assemblage to the *T. bellus* Zone, based on occurrence of *Symplocoipollenites austellus*, *Rugulatisporites micraulaxus*, abundant *Nothofagidites* spp., and other Miocene species. He did not record *Haloragacidites haloragoides*, which he assumed would give a late rather than a middle Miocene age. From the scant information on this assemblage (it is part of an Appendix), it appears very similar to that from Cadia, except that he records *Cyatheacidites annulatus*, which has not been found in any samples from Cadia. Partridge considers *C. annulatus*, *Cyathidites subtilis*, and *Polyadopollenites myriosporites*, found in both this sample and marine sediments of the Gippsland Basin, as probably more diagnostic of regional Upper Tertiary vegetation than are some species found in the Latrobe Valley coals (e.g. *Proteacidites tuberculatus*, *Tricolpites estoutus*, and *Beaupreaidites elegansiformis*), which may be facies-controlled.

Yallourn: The microflora from Yallourn, Victoria, is correlated with assemblages from the *T. bellus* Zone by Partridge (1971) and is similar to that from Cadia except for the presence at Yallourn of *Proteacidites tuberculatus*, *Milfordia homeopunctata*, *Foveotriletes balteus*, *Cyatheacidites annulatus*, and *Beaupreaidites elegansiformis*. Several taxa of the macrofossil flora have also been described: cones of *Casuarina* and *Banksia*, and leaves from six species of *Banksia* (Pike, 1952), wood from *Banksia*, *Casuarina*, *Agathis*, *Podocarpus*, and *Phyllocladus* (Patton, 1958), and three species of wood (Nobes, 1922). Duigan (1966) has discussed the brown coal flora represented at Yallourn, and has suggested similarities, based on the total plant assemblage of angiosperm and gymnosperm taxa, to lower montane rainforests of New Guinea.

Although knowledge of Miocene microfloral assemblages is still very scanty, some broad generalizations can be made. *Nothofagidites* spp., especially *brassi* type, is still present in significant numbers but decreases during this time interval. Some significant elements of the microfloras of southeastern Australia at this time are: periporate pollen types assignable to the Chenopodiaceae, *Acacia*-type pollen, *Haloragacidites haloragoides*, Gramineae-type pollen, increase of pollen assignable to the Compositae (*Tubulifloridites*, *Echitricolporites*), increase of *Myrtaceidites* spp., especially *M. eucalyptoides*, and Winteraceae (*Drimys*, *Gephyrapollenites*). There is a general decrease in the gymnosperm spectrum, both in total abundance and in number of species present.

Based on correlations between these Central Tableland localities and the Gippsland Basin, the first appearances of *Triporopollenites bellus*, *Symplocoipollenites austellus*, *Rugulatisporites micraulaxus*, *Haloragacidites haloragoides*, and *Polyadopollenites myriosporites* are useful stratigraphic markers; their presence/absence in similar microfloras from other localities should be investigated to see whether they have a more widespread diagnostic value.

As similarities in pollen taxa and general trends are found between Cadia and the Gippsland Basin assemblages, it is assumed that the suite at Cadia is representative of the regional flora as a whole, rather than just a localized vegetation, and contains species that will be useful chronostratigraphically.

Palaeoecology

The pollen spectrum from Cadia is dominated by angiosperms, which, except for two samples (103 and 112), compose 55 to 92% of the assemblage. The flora, based on the palynomorph content, is generally uniform throughout the sequence, with variations only in relative proportions rather than actual elements in the assemblage. Preservation of grains, except for those showing thermal alteration mentioned previously, was good, indicating rapid deposition under anaerobic conditions, probably with little transport. The presence of intact clusters of Myrtaceae-type and *Casuarina*-type grains suggests that these were deposited very close to the site where the anthers bearing these grains fell into the water.

The high diversity and abundance of angiosperms and diversity of pteridophytes and epiphyllous fungi suggest moist conditions. A tree fern element, represented by *Cyathidites* spp., occurs in low frequencies in almost all samples. This tree fern element, plus a varied fern assemblage, are indicative of high rainfall. The presence of *Stereisporites* spp. and *Cingutriletes clavus*, which have been related to the moss genus *Sphagnum*, suggest presence of boggy conditions.

Abundant *Nothofagidites* spp. are also indicative of high rainfall, as mentioned in previous chapters. In this assemblage, *brassi* type is still the most abundant, although it is generally slightly less abundant than in the samples from Kiandra.

The other "Antarctic" elements present are of relatively minor importance in terms of abundance. The Podocarpaceae and Araucariaceae are represented, in low to moderate frequencies, in all samples. *Podocarpidites* spp., *Lygistepollenites florinii*, *Dacrycarpites australiensis*, *Phyllocladus palaeogenicus*, *Phyllocladidites mawsonii*, *Podosporites microsaccatus*, *Alisporites grandis*, *Araucariacites australis*, and *Dilwynites* spp. suggest that a variety of gymnosperms were found in the vicinity. As all species of gymnosperms found at Cadia were found at Kiandra, remarks on distribution of related modern taxa will not be repeated here, and reference can be made to the preceding chapter.

The "tropical" element of the vegetation is very minor, and includes *Symplocoipollenites austellus*, with possible affinities with *Symplocos*, distributed at present in tropical and subtropical areas of Asia, Australia, Polynesia, and America (Willis, 1966). *Cupanieidites orthoteichus*, related to the Cupanieae of the Sapindaceae, and *Gephyrapollenites calathus*, related to *Drimys*, are considered to be rainforest species, and both are consistently found in low frequencies in samples from Cadia.

The "Australian" element in this assemblage forms 5 to 30%, and includes *Casuarina*-type pollen (*H. harrisii* and *H. trioratus*), *Banksieaeidites* spp., *Proteacidites* spp., *Acacia*-type pollen (*Polyadopollenites myriosporites*), and *Myrtaceidites* spp. The *Casuarina*-type component is found in almost all samples, and is common in a few (27.5% and 18% of the total assemblage). *Banksieaeidites* spp., related to the living *Banksia* and *Dryandra*, is found in very small numbers, whereas species of *Proteacidites* are found consistently in low to moderate frequencies. However, most of these species cannot be related to living taxa; an exception is *P. symphyonemoides*, which Cookson (1950) has compared to living species of *Symphyonema*. The "eucalypt" type of Myrtaceae pollen, here assigned to *M. eucalyptoides*, is found in very small frequencies in these samples. *M. parvus*, of uncertain affinities, and *M. mesonesus*, which has been compared to *Whiteodendron* by McWhae (1957), are much more abundant.

This assemblage has little representation from Gramineae-type pollen, and no pollen that can be referred to the Compositae. This, as pointed out previously, can be taken to indicate closed forest conditions at the site. Pollen referred to the Restionaceae (*Milfordia homeopunctata*), found in other deposits of equivalent age, is absent (and also absent from Nerriga and Kiandra).

The presence of the algae *Botryococcus* and *Pediastrum* indicate a freshwater environment. The lithology and fine grainsize of the sediments (clays, diatomites, and lignites) suggests a generally slow-moving water regime, lacustrine passing up into a more stagnant, swampy environment prior to deposition of the basalts. The time interval over which these sediments were deposited was probably not long, as the floral assemblage is generally similar in composition throughout the sequence in any one borehole. Formation of lakes in which such sediments were deposited was probably a part of the general drainage disruption caused by tectonic disturbance during this period, also reflected by volcanicity. As there is no evidence of fluvial deposits grading up into lacustrine it is possible that these lakes were caused by blockage of drainage channels, perhaps by lavas. Rainfall must have been *ca* 150-180 cm per annum, with rainforest vegetation close to the site of deposition.

The extreme abundance of a few species of spores in sample 112, and local maxima of single spore species in a few other samples (098, 101, 124, 116) suggest some over-representation of local elements growing in proximity to the site of deposition.

As there is no evidence of a marked seasonal climate at the time, and *Nothofagus* does not appear to be able to withstand periods of dryness, marked seasonality is unlikely.

Duigan (1966), in a study of the Yallourn brown coal flora, suggests a vegetation of *Nothofagus* rainforests and gymnosperm or mixed gymnosperm-broadleaf forests, in an area of high rainfall and moderate temperatures. All pollen types that she considered to represent the flora at Yallourn are also present at Cadia, with the exception of *Beaupreaidites elegansiformis* (which appears to be represented mainly in peat swamp environments) and Restionaceae (*Milfordia homeopunctata*). She found that the greatest number of living analogues of the angiosperm and gymnosperm taxa identified together at Yallourn occurred today in lower montane rainforests of New Guinea.

Patton (1958), in a study of woods from Victorian brown coals, believed that the forests that formed the brown coals were almost purely coniferous. The trees grew in a swamp that was subsiding so slowly that the trees were able to reach an age and size equivalent to those growing on dry land. Most of the fossil wood lacked obvious growth rings, which is characteristic of wood of tropical species today, but not restricted to tropical species alone. Woods of *Casuarina* and *Banksia*, found sporadically in these brown coals, were considered to come from higher ground than the coniferous forests. Both genera are considered to be xerophytic today, with distribution controlled by both rainfall and quality of soil.

These prolonged swampy conditions were not found at Cadia; however, *Nothofagus* rainforest and vast expanse of gymnosperm-broadleaf forest appear to have been widely distributed in south-eastern Australia throughout most of the Tertiary. Rainfall still must have been considerable in the middle Miocene at Cadia, but temperatures in this region at the time are unknown, and may have been similar to those existing in the region at the present time.

CHAPTER 6. THE *Cinnamomum* FLORA IN TIME AND SPACE

Introduction

Microfloras from the three localities discussed in this study can all be considered part of the same widespread Tertiary flora (the *Cinnamomum* flora). Although some taxa of this flora are probably found only in Australian Tertiary deposits, many are also found in Tertiary sediments of surrounding regions: New Zealand, Antarctica, Kerguelen, southern South America, and Ninetyeast Ridge.

The term *Cinnamomum* flora, although firmly entrenched in Australian Tertiary literature, is a misnomer from a palynological point of view, as pollen of *Cinnamomum* and associated Lauraceae are not found in the microfloras. Major microfloral elements are species of *Nothofagus*, Myrtaceae, Proteaceae, and a variety of gymnosperms, together with a diversity of angiosperms and pteridophytes. Many of these taxa are no longer found on the Australian mainland, especially many of the gymnosperms and *Nothofagus* of *brassi* and *fusca* types.

Although there is a definite sampling bias towards southeastern Australia for Tertiary microfloras, with few published records from the centre, north, and Western Australia, it is apparent that the rainforest vegetation indicated by the pollen assemblages was widespread. There is evidence of humid forest vegetation at high latitudes during the Paleogene and at least part of the Neogene. Crocker (1959) has suggested a lower habitat diversity for vegetation during the Tertiary, although whether this flora was a true pan-Australian flora, rather than a southern and eastern one, remains to be assessed.

Groups such as the Gramineae, Compositae, and *Acacia*, which form an important part of the present vegetation, are only sparsely represented in the younger assemblages of the *Cinnamomum* flora.

A change from the moist rainforest vegetation to the xeric, more open vegetation so characteristic of many parts of southeastern Australia at the present time, appears to have taken place in later Miocene or Pliocene times.

Pollen of Nothofagus type is a consistent and at times abundant component of this earlier Tertiary microflora. Species with brassi and fusca type pollen are found in Upper Cretaceous deposits, and species with menziesii type pollen first occurs in the middle Eocene. This genus appears to have a definite southern origin and dispersal (Cranwell, 1964); North American occurrences recently described and illustrated by Elsik (1974a) are not convincing. The Podocarpaceae, well-represented in the Tertiary flora, is also assumed to have a southern origin and dispersal. Although Podocarpus and Phyllocladus are now found in tropical regions, the meagre fossil evidence suggests that these genera arrived in the tropics late in the Tertiary (Muller, 1966).

Duration of the Tertiary Flora

Wellman & McDougall (1974a) have suggested an age range for the Cinnamomum flora of middle Eocene to middle Miocene (45 m.y. to 10 m.y.), based on the K-Ar ages of basalts associated with plant-bearing sediments. A sufficient number of pollen assemblages have been studied and published to show that this flora extends from at least basal Tertiary probably through to at least late Miocene, but was not uniform throughout this period. Records of pollen assemblages in deposits younger than mid-Miocene are rare, so that a younger age limit on this flora is difficult to place. Only in southeastern Australia is there a sufficient spread of samples to show several changes in the microflora through this interval of time (Paleocene through Miocene). The floral changes have provided the basis for erection of a series of spore-pollen zonal schemes in the Otway and Gippsland Basins, permitting correlation between sampling sites at least in southeastern Australia. This has been demonstrated in the assemblages discussed in the preceding three chapters.

The following section is an attempt to relate vegetation changes, as shown by the microfloras, to a stratigraphic framework, followed by mention of assemblages that have been described from that particular interval of time.

Upper Cretaceous: In Upper Cretaceous deposits, some elements of this Tertiary flora are already present: species of *Nothofagidites* with *brassi* type pollen, gymnosperms such as *Microcachryidites antarcticus* and *Lygistepollenites florinii*, Proteaceae, and some spores. Dettmann & Playford (1969) note that southeastern Australian and New Zealand Upper Cretaceous microfloras are very similar, with the appearance of *Nothofagus* pollen in Australia, New Zealand, and Antarctica at about the same time.

A sequence of spore-pollen zones have been described by Dettmann & Playford (1969) for the Great Artesian and Otway Basins, and Stover & Evans (1973) for the Gippsland Basin. They will not be discussed herein, except to emphasize that several elements of the Tertiary flora were already present in these assemblages, e.g. *Nothofagidites senectus*, *Gambierina edwardsii*, and some of the gymnosperms.

Paleocene: Most elements of the *Cinnamomum* flora appear to be present in Paleocene assemblages, with the first myrtaceous pollen and *Nothofagus* of *fusca* type, and also the first appearance of *Haloragacidites harrisii*. Many species of Proteaceae have been reported from this interval, including *Banksieaeidites* spp., *Beaupreaidites elegansiformis*, and several species assigned to *Proteacidites*, although the large reticulate and verrucate types (e.g. *P. grandis*, *P. ornatus*, *P. leightonii*, *P. tuberculiformis*) do not appear until the end of the Paleocene, and in places in early Eocene. *Gambierina edwardsii* appears to be confined to the Paleocene, and in both the Gippsland and Otway Basins there are several species with short vertical ranges also confined to this interval. First appearances of *Anacolosidites acutullus* and *Cupanieidites orthoteichus* have been reported from Paleocene deposits in the Otway Basin.

Harris (1971) has described two zonules from Paleocene deposits of the Otway Basin. The *Gambierina edwardsii* Zonule is characterized by *G. edwardsii*, *Camarozonosporites bullatus*, and *Lygistepollenites ellipticus*; *L. balmei* is restricted to the zone; and other species present are *Amosopollenites dilwynensis*, *Australopollis obscurus*, abundant gymnosperm pollen, *Proteacidites parvus*, *P. subscabratus*, *P. adenanthoides*, *P. crassus*, *Anacolosidites acutullus*, and *Nothofagidites* spp. This zonule is correlated in part with the *Lygistepollenites balmei* Zone of Stover & Evans (1973) and Microflora B of Cookson (1954). The other zonule described by Harris, the *Cupanieidites orthoteichus* Zonule, has been discussed in the chapter on Nerriga, and components of the assemblage will not be repeated here.

Stover & Evans (1973) have described two spore-pollen zones from the Gippsland Basin: the *Tricolpites longus* Zone, of early to possibly middle Paleocene age, and the *Lygistepollenites balmei* Zone, middle and late Paleocene, which has been correlated with the *G. edwardsii* Zonule of Harris and Microflora B of Cookson (1954). The *T. longus* Zone is characterized by a virtual absence of *Nothofagidites* spp. at the base, and no specific dominance of any one group, although angiosperm pollen, gymnosperm pollen, and spores are common. The *L. balmei* Zone contains the first records of myrtaceous type and *Nothofagus* of *fusca* type pollen.

Paleocene microfloras have also been described from the Great Artesian Basin (Wopfner, Callen, & Harris, 1974), and from localities near Brisbane, Queensland (Harris, 1965b).

Eocene: The relatively warm, moist conditions of the Eocene, as indicated by paleotemperature data (Shackleton & Kennett, 1974), must have been favorable for the expansion of many "tropical" taxa (e.g. *Bombax*, *Anacolosidites*) to higher latitudes, into southern Australia. During this time there is an increase in diversity and abundance of species assigned to *Proteacidites*, with a variety of morphological types, including highly ornamented and large forms. Pollen of *Nothofagus*, although still found in relatively small numbers, increases in dominance through this interval, and *Nothofagus* of *menziesii* type is found for the first time. The first report of graminaceous pollen is from the Eocene of the Otway Basin. A variety of tricolporate and tricolpate pollen species appear throughout this interval.

The onset of cooler conditions towards the close of the Eocene and into the Oligocene would be assumed to show changes in the vegetation, with the gradual replacement of the "tropical" taxa, and the last appearance of many species of *Proteacidites*, especially the large reticulate and verrucate types.

A number of Eocene assemblages have been reported (see Comparison with Other Assemblages, in the chapter on Nerriga), revealing a diverse assemblage with many species with short vertical ranges. Several Eocene spore-pollen zones have been described from the Otway and Gippsland Basins. Mention of these will be brief here, as they have already been treated in the chapter on Nerriga. Harris (1971) has not recognized any zonules of early Eocene age. Zonules described from middle and upper Eocene deposits are the *Proteacidites confragosus*, *P. pachypolus*, *Triorites magnificus*, and *Sparganiaceaepollenites barungensis* Zonules.

Stover & Evans (1973) and Stover & Partridge (1973) have described three Eocene spore-pollen zones from the Gippsland Basin. The *Malvacipollis diversus* Zone (early Eocene) is correlated in part with the *Cupanieidites orthoteichus* Zonule of Harris (1971); the *Proteacidites asperopolus* Zone (early Eocene) is correlated with the *P. confragosus* Zonule of Harris; and the Lower *Nothofagidites asperus* Zone (middle and late Eocene) is correlated with the *P. pachypolus* and *Triorites magnificus* Zonules of Harris.

The Upper *Nothofagidites asperus* Zone represents a transitional assemblage between typical Eocene and Oligocene microfloras. The zone is characterized by *Proteacidites stipplatus*, and the first appearance of *Granodiporites nebulosus* and *Proteacidites tuberculatus*. The diversity of species is low when compared with microfloras from other zones.

Oligocene: Although records of microfloras from this interval are sparse, there seems to be no evidence of a return to the relatively warm conditions of the Eocene, with the absence of the tropical taxa from southeastern Australia (although they apparently occur for a longer time in Queensland). The abundance and diversity of species of *Nothofagidites*, especially of *brassi* type, attest to the continuation of a moist, rainforest environment. Aside from the predominance of *Nothofagus* pollen, pollen of *Myrtaceidites eucalyptoides* and Chenopodiaceae-type appear for the first time. Both these groups are part of the present flora. It is also possible that *Acacia*-type pollen appears during this interval.

As the major part of the uplift of the Eastern Highlands took place by the late Oligocene (Wellman & McDougall, 1974a), development of moist, elevated habitats would favor expansion of *Nothofagus* rainforest, and the area covered by this type of vegetation was probably extended during this time. This would be shown in the great abundance of pollen assigned to *Nothofagidites* spp. in microfloras from deposits ranging from late Eocene to early Miocene.

There are few reliably dated assemblages of Oligocene age. Mention of the *Proteacidites tuberculatus* Zone microflora from the Gippsland Basin (Stover & Partridge, 1973) has been made previously, in the chapter on Kiandra. Harris (1971) has erected no formal zonal unit within this interval in the Otway Basin. He has described an informal unit, pending further study, characterized by abundant *Nothofagidites* spp., especially *N. emarcidus* and *N. falcatus*, *Haloragacidites harrisii* and *H. trioratus*, gymnosperms, *Sparganiaceaepollenites barungensis*, *Graminidites* sp., *Myrtaceidites* spp., *Proteacidites varius*, *P. annularis*, *P. clintonensis*, *Malvacipollis diversus*, and the nominate species, *Verrucatosporites* sp. nov.

Miocene: During the Miocene, some prominent elements in the present vegetation either appear for the first time or increase in abundance; this includes *Acacia*, Gramineae, Compositae, and several species of Proteaceae. *Myrtaceidites eucalyptoides* becomes more abundant in microfloras. Species of *Nothofagidites* gradually decrease in importance in assemblages during this time, with the complete disappearance of pollen of *brassi* type presumably at the end of the Miocene. There appears to be a diversity of habitats, with the introduction of herbaceous ground cover plants, and apparent restriction of the typical earlier Tertiary rainforest vegetation to smaller areas (probably highland areas) under pressure of decreasing precipitation. More open forest types may be present.

Although several microfloras of early Miocene age have been reported, few reliably dated middle and upper Miocene microfloras have been described. Assemblages of these ages are discussed in the preceding two chapters, Kiandra and Cadia. The *Triporopollenites bellus* Zone assemblage described from the Gippsland Basin

(Stover & Partridge, 1973) is considered to be late Miocene, possibly extending into the Pliocene.

Pliocene: During the Pliocene, the last vestiges of the rainforest vegetation so typical of the earlier Tertiary may have been restricted to small refuge areas, with brief expansions during periods of increased precipitation. Martin (1973b) has described an interesting series of samples from the Lachlan and Murrumbidgee River valleys. A few of the deeper samples, of presumed Miocene age, have typical lower Tertiary microfloras with a predominance of *Nothofagus* of *brassi* type. The gradual disappearance of this vegetation type from the area, presumably in response to decreasing precipitation, left a vegetation of elements (her Myrtaceae-*Casuarina* phase) that were present but minor in the rainforest but which became abundant after the disappearance of the rainforest types. In samples tentatively dated as Pliocene, there is a reappearance of rainforest vegetation, with *Nothofagus* and gymnosperms found as in the older Tertiary assemblages, but without *Nothofagus* of *brassi* type. Martin (1973b, p.49) tentatively regards this return to rainforest vegetation as possibly late Pliocene. These conditions favorable to rainforest development did not persist, and this vegetation disappeared, leaving Myrtaceae and *Casuarina* phase vegetation. Small numbers of Gramineae and Compositae are present.

Harris (1971) has listed the content of the microflora from the Grange Burn Coquina of Kalimnan age. *Nothofagidites* spp. are rare, although pollen of *brassi* type is still present (perhaps the latest record of this pollen type on mainland Australia); *Haloragacidites haloragoides*, "*Grevillea*" type pollen, *Acacia*, *Graminidites* sp., Chenopodiaceae and Winteraceae pollen are "modern" elements in the assemblage, in addition to *Casuarina*, spores, and gymnosperms.

Diversity of the Neogene assemblages appears to be lower than in Paleogene microfloras. The last record of the Cinnamomum flora appears to be in the Pliocene, with gradual disappearance of the brassi type of Nothofagus (?at the end of the Miocene) and gradual replacement of the rainforest elements. Probably beginning in the early Miocene, there is a gradual reduction in the areal extent of this rainforest vegetation. This is presumably a result of decrease in precipitation, with an increase in abundance of vegetation types more tolerant of decreased or less uniformly distributed rainfall. Although most elements of the post-Cinnamomum flora were present in the earlier rainforest vegetation, they are found only in small numbers in the earlier flora.

Instead of an abrupt termination of the rainforest vegetation, there is thus a gradual decrease in and replacement of this Tertiary Cinnamomum flora, with elements of it persisting in more favorable environments through part of the Pliocene. An age of Late Cretaceous/basal Paleocene to Pliocene would thus be indicated for this Cinnamomum Tertiary flora.

Comparison with Areas Outside Australia

Couper (1960a) has noted the peculiar distribution patterns of Tertiary and Upper Cretaceous representatives of the Fagaceae and the Podocarpaceae in the Southern Hemisphere. Although records from some of these regions are sparse, similarities in some elements of the microfloral suites of Tertiary age from Australia, New Zealand, Antarctica, Kerguelen, southern South America, and Ninetyeast Ridge are apparent. Elements of this flora - Nothofagidites of all three types, Proteaceae, Myrtaceae, and Podocarpaceae, all appear to have had a widespread distribution throughout this time interval.

New Guinea: Little is known of Tertiary microfloras from New Guinea, although Couper (1960a) and others have assumed a late arrival for taxa such as Nothofagus of brassi type, generally coinciding with the disappearance of these groups from mainland Australia in the Pliocene perhaps under the influence of deteriorating temperatures. Recent work by Khan (1974) has shown that Nothofagus with pollen of brassi type, as well as Microcachryidites antarcticus and Podocarpus section Dacrycarpus, have a fossil record extending back to at least late Miocene. There is possible correlation between the elevation of wet highland areas and development of suitable habitats for these taxa.

New Zealand: Many species in Upper Cretaceous and Lower Tertiary deposits in Australia are also found in New Zealand, including all three types of Nothofagus, gymnosperms, many taxa assigned to Proteaceae, Myrtaceae, and other angiosperm groups. Several tropical taxa found in Paleogene deposits are also found in Australia (Bombax, Anacolosidites), and some species described by Couper (1953; 1954; 1960) and McIntyre (1965; 1968) from New Zealand are also part of Australian Tertiary assemblages.

Antarctica: Cranwell (1964; 1969) and Kemp (1972a; 1972b; 1975) have indicated evidence of forest cover of temperate aspect at least to Eocene time in both East and West Antarctica, and possibly through late Oligocene in some areas. Nothofagus of brassi and fusca types, Proteaceae, small myrtaceous pollen, gymnosperms, and a variety of angiosperm taxa have been described from this region. Cranwell (1969) described plant assemblages of Senonian to Eocene age which she thought indicative of moist, warm conditions, and inferred warm wet forests with dry coasts and hinterlands. Cranwell, Harrington, & Speden (1960) and McIntyre & Wilson (1966) have also recorded assemblages from close to McMurdo Sound, and the latter infer a temperate, cool to moderately warm climate. Pollen from recent drilling sites in the Ross Sea suggests that vegetation was present in the area until late Oligocene (Kemp & Barrett, in press). A *Nothofagus*-dominated vegetation (mainly *fusca* and *brassi* types), with podocarps, Proteaceae, and Myrtaceae shows little change from the Eocene assemblages, and does not appear to reflect the increasing deterioration of the Antarctic climate.

Kerguelen: A microflora described by Cookson (1947b) from Kerguelen was dominated by gymnosperm pollen, with *Nothofagus* pollen absent. In addition to ferns, fungi, and gymnosperms (both Podocarpaceae and Araucariaceae), the assemblage also included *Graminidites media*, *Tubulifloridites antipodica*, *Tricolpites* (*Gunnerites*) *reticulatus*, and *Cyatheacidites annulatus*. More recent work by Nougier (1970) has fixed the age of the plant-bearing beds as probably middle Miocene (14-15 m.y.), based on a date for an associated basalt. At this time, Kerguelen was already emergent, with a humid temperate climate and a flora of conifers (both Podocarpaceae and Araucariaceae), 5 species of monocotyledons, 3 species of dicotyledons, and 10 species of spores.

Southern South America: There are few records of Tertiary assemblages from southern South America. Cookson & Cranwell (1967) described an assemblage from Chile of Eocene or Oligocene age, with both *brassi* and *fusca* type of *Nothofagus*, *Phyllocladidites mawsonii*, and *Cyatheacidites annulatus*. Subsequent work by Archangelsky (1973) on Paleocene microfloras from Argentina, and Fasola (1969) on middle Tertiary microfloras from Chile, has shown that these floras contained species of Proteaceae, Myrtaceae, and several tricolpate and tricolporate pollen types similar to those from Australian deposits.

Ninetyeast Ridge: Two microfloras have been described from this mid-Indian Ocean ridge. Harris (1974) has described an assemblage of Paleocene age, which he correlated with the *G. edwardsii* Zonule of Harris (1971) and its equivalent in the Gippsland Basin (*L. balmei* Zone).

This microflora contains no species of Proteacidites, but contains other Australian Tertiary elements - Nothofagidites spp., gymnosperms, and Myrtaceidites spp., as well as several short-ranging Paleocene species enabling correlation with the zones mentioned above.

Kemp (1974) has described a microflora which she tentatively considered to be post-Oligocene in age, and possibly contemporaneous with the Kerguelen deposits. The microflora contains many new species, and is therefore difficult to correlate with Australian sequences. It has no pollen assignable to Nothofagidites, but there are some elements of the Tertiary Australian assemblage - Myrtaceidites mesonesus, Proteacidites symphyonemoides, and Cupanieidites orthoteichus.

Implications of the Flora

Previous workers on Tertiary stratigraphy and floras have assumed that a humid, tropical to subtropical climate is indicated by the Cinnamomum flora (Crocker, 1959; Gill, 1952; 1961). This would require subtropical temperatures and moist rainforest vegetation at high latitudes in the Tertiary.

The Antarctic continent (plate) has been essentially fixed in its present latitudinal position for at least the last 40 m.y. (Lowrie & Hayes, 1975), and probably for a much longer period. Thus Australia has moved relative to Antarctica in an essentially northward direction. After initial rifting, possibly beginning as early as Late Cretaceous, Antarctica and Australia separated in the Paleocene, about 55 m.y. BP, and Australia began moving northward about 5 cm/year (Hayes & Frakes, 1975). By the Oligocene, about 35 m.y. BP, Australia had migrated northward nearly 1000 km from Antarctica, and a continuous deep water passage was now opening up between them. Hayes & Frakes (1975) consider that initiation of major continental glaciation in Antarctica began about 25 m.y. BP, in the late Oligocene.

Wellman, McElhinny, & McDougall (1969) have estimated palaeolatitudes of 70-80°S. for southeastern Australia in Middle Cretaceous times, decreasing to 39°S, (for Canberra, which is at present 35°S.) 25 m.y. ago, with a generally uniform rate of movement northward during this interval. There has been little northward movement indicated from the polar wander curve for the last 20 m.y. (Wellman & McDougall, 1974b). This is in disagreement with the seafloor anomaly data, which shows northward movement of about 11° of latitude in the last 20 m.y. (Weissel & Hayes, 1972).

From evidence of Paleogene Antarctic and Australian microfloras, at least a temperate, warm, moist environment is indicated, although temperatures are difficult to estimate. Several recent palaeotemperature determinations have been made by Shackleton & Kennett (1974), based on analyses of benthonic and planktonic foraminifera from sites on the Tasman Rise, collected on Leg 29 of the Deep-Sea Drilling Project. They infer surface ocean temperatures of about 20°C. in the early Eocene (at a site originally at 50°S. latitude), falling to about 13°C. in the middle Eocene, and 11°C. in the late Eocene. Bottom temperatures follow a similar trend to surface temperatures. Warm oceans and resulting high rainfall would favor the southward extension of tropical families (e.g. Olacaceae and Bombaceae) to higher latitudes at this time. Shackleton & Kennett record a further temperature drop in the Oligocene (to about 7°C. surface temperature), a rise in the early Miocene (to 10°C.), followed by a fall and a later rise in middle Miocene time. By this time they believe that there is evidence that the Antarctic ice sheet had reached stability, and was unaffected by subsequent temperature amelioration.

These generally warmer and wetter conditions were present at least through Eocene times, and the presence of many so-called tropical elements in Eocene assemblages of Australia and New Zealand reflect this latitudinal expansion southward (and also northward, in the Northern Hemisphere) of warmer floral groups. Cooler temperatures in the late Eocene and the Oligocene resulted in disappearance of these tropical taxa. A rainforest vegetation was still indicated at least through Miocene time in Australia, and perhaps into Pliocene, although there appears to be a reduction in the area covered by rainforest from early Miocene onwards.

A tropical vegetation has previously been assumed to be indicated by the Cinnamomum flora. However, alternatively, this could be considered to be a warm temperate assemblage with tropical elements. Daley (1972), in a discussion of the climate of the London Clay flora, suggested that a true tropical rainforest climate was not represented in the London Clay, but a climate type not represented at the present day. A seasonal but frostless climate, higher rainfall, and elevated but not necessarily tropical temperatures would allow tropical plants to spread to higher latitudes, so that under conditions of abundant moisture supply, temperatures need not be tropical. Temperate vegetation could grow on higher land under somewhat less humid conditions. Similar conditions could explain the floral elements found in the Tertiary of Australia, where taxa with tropical affinities are found in association with other taxa related to present-day temperate groups. This is found especially in Paleocene and Eocene deposits, with fewer taxa of tropical affinities found in more recent microfloras.

Frakes & Kemp (1972) have attempted to reconstruct global palaeoclimates in the later half of the Eocene (40-48 m.y. ago) and the early half of the Oligocene (30-37 m.y. ago). They noted that great warmth and high precipitation in Eocene high-latitude regions can be partly explained by global temperature distributions during that time. Because of their longer residence time in equatorial regions, surface waters reaching high latitude regions were warmer than at present, and warmed the coastal atmosphere through evaporation and subsequent condensation. Because of ocean circulation patterns and continental configurations at the time, poleward transport of heat by the oceans would have been effective, leading to more efficient atmospheric transfer of heat energy away from the equatorial heat source. In the early part of the Oligocene, in contrast, cooler and drier conditions resulted in part from less effective poleward transport of heat energy.

Northward movement of Australia and the subsequent formation of a deepwater channel between Australia and Antarctica would be expected to have a strong influence on climatic patterns, and hence changes in the vegetation. In the Paleogene, decrease in temperature (and possibly, to a lesser extent, some decrease in precipitation) appears to be the significant influence for changes reflected in the floras. In the Neogene, however, decrease in precipitation appears to be the significant factor effecting floral changes.

CHAPTER 7. CONCLUDING REMARKS

Deposits from the three localities investigated in this study all have similarities. All are fluvio-lacustrine terrestrial deposits, and from upland sites. All occur in the same sequence as basalts which have been radiometrically dated. Basalts have capped and therefore preserved these sediments; otherwise they would be easily eroded. The lakes in which these sediments were deposited probably formed as a result of tilting, faulting, and general tectonic disruption of drainage, also reflected by periods of volcanism. Such tectonic movements characterize the eastern margin of Australia throughout much of the Tertiary. Each sequence has been deposited over a relatively short interval of time, as indicated by the general uniformity of the microflora in the vertical sequence, so that differences within the sequence reflect short-term environmental differences.

Several points emerge from this study and are set out below.

1. Relationship between isotopic (K-Ar) and microfloral dates.

In all three localities, there was generally good agreement between the K-Ar dates and the age that would be indicated by the microfloras alone, when correlated with those described from the Gippsland and Otway Basins. This agreement was best for the two Miocene assemblages from Kiandra and Cadia, but was less precise for that from Nerriga, where an age of late Eocene was indicated by the basalt dating and early Eocene by the microflora in the underlying siltstone. However, Wellman & McDougall (1974a) had assumed some argon loss in the samples from Nerriga, as their K-Ar ages did not agree with the relative stratigraphic positions of the two basalt samples. Late Eocene would therefore be a minimum age only.

Raine (1967) also found evidence of erosion between the deposition of the siltstone unit and eruption of the basalt. In the other two localities, basalts are assumed to be generally contemporaneous with the sediments, as there is no evidence of erosion between basalts and sediments, and they are interbedded in places.

2. Comparison between highland and coastal assemblages.

All the microfloras investigated herein contained taxa that could be related to those from the Gippsland Basin, and in some cases the Otway Basin; these microfloras could therefore be related to zones described from these sequences. Taxa that proved to be most useful for fixing upper and lower age limits on these microfloras were rarely abundant in the assemblages, but were distinctive species with short vertical stratigraphic ranges. A sufficient number of taxa representative of the regional vegetation were found in microfloras from both these environments - highland lakes and coastal basins, so that zonal schemes based on sequences in south coast marginal basins can be applied to these highland terrestrial deposits for purposes of correlation. Many taxa characteristic of these coastal sequences are absent from the highland deposits, however, including several species of *Proteacidites*, *Milfordia* spp., and some spores. The presence of several new species in these terrestrial deposits suggests that these may be restricted to highland habitats.

Data are as yet insufficient to determine whether differences in distributions and abundances reflect major environmental differences, or merely localized absences. For example, *Cyatheacidites annulatus*, a distinctive spore in Oligocene and younger deposits, was not found in the assemblage from Cadia, but was found by Partridge (1971) in a microflora of similar age a short distance away. This appears to be a localized absence from Cadia. Many distinctive and widespread species of *Proteacidites* may be restricted to a lower, more coastal environment, as they are characteristic components of assemblages from the Otway and Gippsland Basins, but are absent in contemporaneous terrestrial deposits.

3. Parent vegetation and palaeoclimates.

The floras represented in these assemblages indicate a rainforest vegetation over much of the Eastern Highlands during the Tertiary. This type of vegetation requires a higher rainfall than is found in these areas at the present time. The presence of taxa that require almost constant humidity (e.g. *Nothofagus* of *brassi* type) suggest that the rainfall was more evenly distributed throughout the year, without long periods of dryness. There is some indication of warmer temperatures, especially in the Paleogene, from recent palaeotemperature data, although the microfloras in themselves do not indicate a substantially warmer climate. In the past, the extensive distribution of this rainforest flora has been assumed to indicate tropical and subtropical conditions during the Tertiary. This is not necessarily indicated by the microfloras, which contain taxa which have both tropical and temperate distribution at present.

This rainforest vegetation, generally termed the *Cinnamomum* flora (a misnomer from a palynological point of view), was distributed over a wide expanse of Australia during the Tertiary, although whether this was a truly pan-Australian flora remains to be assessed. Further detailed study of microfloras from areas outside of south-eastern Australia would be needed to determine this.

Some of the elements of this widespread flora are also found in Tertiary deposits of other southern regions - New Zealand, Antarctica, Kerguelen, southern South America, and Ninetyeast Ridge. This includes species assigned to the Podocarpaceae and Araucariaceae, *Nothofagus*, Proteaceae, and Myrtaceae. Some of these groups (e.g. *Nothofagus*, and perhaps some Podocarpaceae) may have had an Antarctic origin and/or centre for dispersal to other southern regions; others, such as the Proteaceae and Myrtaceae, may have originated in Australia. Some of these taxa are no longer present on mainland Australia, but are found in New Caledonia, New Guinea, Tasmania, and New Zealand, where they are found in temperate rainforest habitats.

4. Suggestions for future research.

Suggested future projects include further work on both macro- and microfloras. For the macrofloras, a two-fold approach would give data on both the flora and palaeoclimates. This would involve critical analysis of the floral content using methods such as cuticle analysis, as well as physiognomic study of leaf floras, following procedures such as those outlined by Wolfe (1971) with emphasis on leaf morphology for palaeoclimatic interpretations. Currently, study of the middle Eocene Maslin Bay flora in South Australia is in progress; other well-preserved material may be available, and collections of plants described last century are possibilities.

For the microfloras, a two-fold approach is again advisable. Investigation of microfloras from reliably dated localities and a range of environments will extend our understanding of the floras of the time, and their extent in time and space. Information is fragmentary at present, except for good sequences of polleniferous sediments in the Gippsland and Otway Basins. Some samples from the Great Artesian Basin have been described, as well as a series of palynological units from Queensland. Otherwise, few well-dated microfloras are known. Those from New South Wales are best represented (the three localities described herein, as well as Vegetable Creek and Cudal), followed by Victoria (Yallourn, Birregurra, and Grange Burn) and South Australia (Moorlands and Maslin Bay). From Tasmania and Western Australia, there are single reports only, and no published records from the centre, although studies are in progress. Neogene assemblages are more poorly known than those from the Paleogene at present, although knowledge of both is still sparse. New radiometric dates are becoming available (e.g. Green & Stevens, 1975, for southeast Queensland), enabling independent age control on associated sediments. Such localities would be of primary interest for palynological study.

This study of microfloras would be coupled with critical comparison and identification of some of the less distinctive but nevertheless abundantly distributed fossil pollen types with modern Australian taxa, following the lines of Martin (1974) on fossil Euphorbiaceae, to enable more precise phytogeographic and palaeoecologic analyses to be made.

SYSTEMATIC PALYNOLOGY

INTRODUCTION

Palynomorph assemblages in Tertiary deposits have posed special problems in classification and nomenclature for palynologists. Microfloras from pre-Tertiary deposits are described under artificial form-generic and form-specific names, and are classified under an artificial suprageneric morphographic scheme. It is assumed that many plants producing these palynomorphs are now extinct, although in some cases relationships with living plants at a higher taxonomic level than genus can be made. In Quaternary and sub-Recent assemblages, identification of the fossils with living plants to at least generic level can usually be made, and a natural botanical system for nomenclature and classification is followed.

When dealing with assemblages of Tertiary age, some compromise between these two approaches must be adopted. In this study, an artificial system for nomenclature and classification is preferred, and any information on affinities with living plants is contained within the section on that species. Other workers on Australian and New Zealand Tertiary microfloras, for example Couper (1953; 1960) and Martin (1973a), follow a natural botanical classification, and place pollen types that they can relate to living genera and families into these living taxa, with a section of *incertae sedis* for pollen types that cannot be accommodated in such a system. These *incertae sedis* are then placed in form genera organized under artificial morphographic suprageneric headings.

An artificial system has been followed here because, firstly, such a system can accommodate all pollen and spore species within a single classification. Also, when dealing only with *sporae dispersae*, caution must be exercised in attempting to assign fossil species to living genera as at present there is still insufficient knowledge of the pollen morphology of many groups in Australasian floras in particular, and Southern Hemisphere floras in general, to be able to make many such assignments with certainty. It is a well-known fact that plants belonging to different families can produce morphologically similar pollen, whereas plants belonging to closely related genera can produce pollen that is morphologically quite different. If a fossil species is assigned to an artificial form genus, any change in its presumed affinities based on subsequent additional information can be accommodated easily. However, if placed in a living genus, or a fossil genus with a name based on affinities with a living genus or family, such a change in implied affinity is less easily made. An example of this is the species *Haloragacidites trioratus* Couper 1953, a common fossil species in Australian Tertiary deposits. When originally described, Couper placed the species in the form genus *Haloragacidites* which he erected for "fossil pollen grains belonging to the family Haloragaceae that cannot be more accurately placed" (Couper, 1953, p.31). Subsequent comparison with living Australian species shows closer affinity with the Casuarinaceae, rather than the Haloragaceae, although the generic name *Haloragacidites* has priority over *Casuariniidites* Cookson & Pike 1954. Although the use of generally "neutral" form-generic names, with no implied affinities, is preferred, the use of names such as *Haloragacidites* is accepted and followed here, as such names fulfil the rules of priority for validly published names.

PREPARATION OF SAMPLES

Procedures for the extraction of pollen and spores followed standard techniques, as outlined by Kummel & Raup (1965). Although several attempts were made to adhere to a standard preparation routine for all samples, most samples had to be treated on an individual basis to get maximum recovery and best preservation. Some samples were prepared according to several different methods, in order to compare recovery and possible effects of corrosion during preparation.

For dark carbonaceous clays and lignites, the general procedure followed was:

a. 10 grams of sample treated without heating for 15 minutes in Schultze solution (30 ml H_2O, 60 ml HNO_3, 3 gm $KClO_3$).
b. sample centrifuged and washed.
c. sample treated with 5% solution of NH_4OH for 5 minutes.
d. sample washed thoroughly.

For less carbonaceous samples, the general procedure was:

a. 10 grams of sample warmed in 7% HCl.
b. sample centrifuged and decanted.
c. sample treated with 30 ml concentrated HF, heated if necessary.
d. after washing well, either heavy liquid separation ($ZnBr_2$ solution), and/or oxidation (cold), followed by alkali treatment (cold) in 5% solution NH_4OH, depending on individual sample requirements.

In general, oxidation and alkali treatment were kept to a bare minimum for all samples.

Very fine organic and inorganic matter was a problem in many samples, and both density separation by decanting and controlled centrifuging, as outlined in Kummel & Raup (1965), were commonly employed in attempts to clean the residues.

Heavy liquid separation, using $ZnBr_2$ solution of specific gravity varying from 1.7 to 2.0, proved to be highly effective in a few samples, but gave disappointing results in others. Incomplete separations appeared to be due to interaction between the organic and inorganic grains, trapping many pollen grains in with the heavier mineral matter and large chunks of organic debris, despite repeated attempts to get a clean separation.

In the early stages of this study, samples were also acetolized after alkali treatment, but this procedure was discontinued because of possible additional corrosion of exines, and doubt as to the value of using this procedure on fossil material. (Acetolization is generally used with Recent pollen to dispose of the cell contents, leaving only the outer resistant exine layer, as in fossil grains.) All these samples were re-prepared using the procedure outlined above.

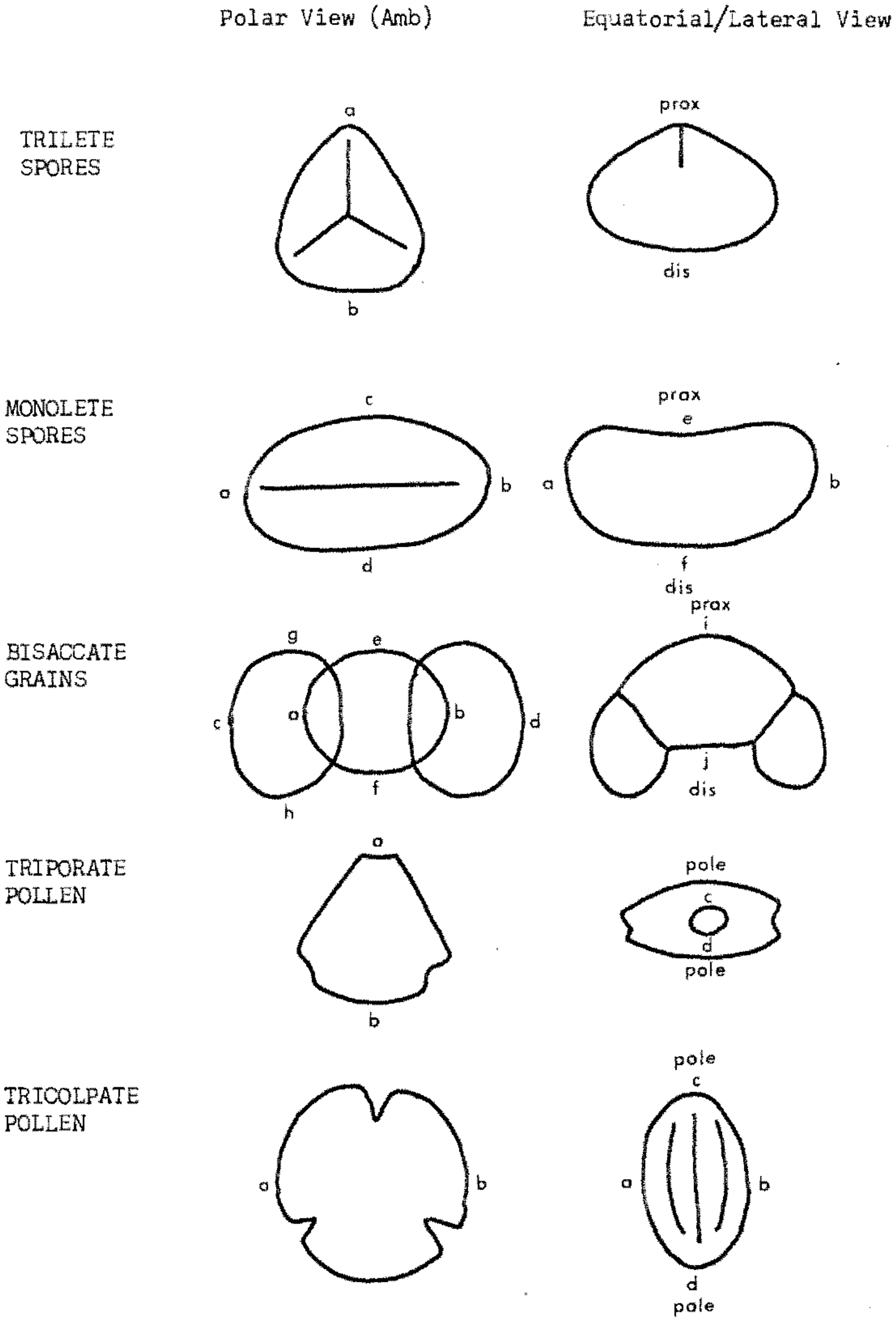
Sample residues were mounted in glycerin jelly, and a few preparations were also mounted in silicone oil, to enable grains to be examined in several orientations. A few preparations were stained with safranin, although preservation in most residues was such that staining was considered to be unnecessary.

SYSTEMATIC DESCRIPTIONS

For convenience, the following section is arranged according to the suprageneric scheme outlined by Potonié (1956; 1958; 1960), with modification of the Turma Sporites as outlined by Dettmann (1963). In the few cases where previously described species have been put into a natural botanical classification this has been retained for convenience, rather than transferring these species to the relevant form genus. These species have been placed at the end of the relevant morphological group. Broad taxonomic treatment has been accorded the dispersed fungal and algal remains which are found in abundance in these samples. They are included at the end of the section of spores and pollen.

In the following descriptions, morphological terminology follows usage given in Harris (1955) and Kremp (1965). The size ranges are based on at least fifteen suitably oriented specimens preserved in polar view (unless otherwise noted), except for prolate grains, which are measured mainly in equatorial view, and polar view if suitably oriented specimens are available. Dimensions given are the two extremes and the mean, and where not otherwise stated, are based on the longest equatorial diameter. Text-figure 13 gives the grain orientations and positions of measurements used in the following descriptions. All measurements are in micromillimetres.

Wherever possible, botanical affinities of the fossil forms are given or suggested. If the affinities have been suggested by other authors, reference to the relevant paper has been made. If no reference is cited, suggested affinities are the opinion of the present author. Early in this study, the computer-assisted method of retrieval for modern pollen identifications (see Guppy and others, 1973), located in the Dept of Biogeography and Geomorphology, School of Pacific Studies, A.N.U., was used to suggested possible



Text-figure 13. Grain orientations and measured dimensions. For trilete spores, ab = equatorial diameter; for monolete spores, ab = length, cd = width, ef = height. For bisaccate grains, ab = corpus width, cd = total width, ef = corpus height, gh = saccus height, ij = corpus depth. For triporate pollen, ab = equatorial diameter, cd = pore diameter. For tricolpate pollen, ab = equatorial diameter, cd = polar diameter. Proximal pole = prox, distal pole = dis.

modern Australian affinities for some taxa. Results at that time were generally not helpful, as most suggested matches were not similar to the unknowns. In a few cases, for example *Haloragacidites harrisii*, with close matches with several species of *Casuarina*, and *Cupanieidites orthoteichus*, with close matches to several species of the Cupanieae, these affinities were already known, and these fossil species were coded to see whether any living species belonging to other genera also had similar pollen. Of more use was the reference slide collection of modern pollen and spores also located in the Dept of Biogeography and Geomorphology. If the relevant material was available in this collection, affinities suggested in the literature were checked and compared with the fossil grains.

Stratigraphic ranges cited in the literature have been included, except for those given in the earlier papers by Cookson and her co-workers, when dating for some of the Tertiary samples was vague. In these cases, more precise ranges for samples from these localities, given by Stover & Partridge (1973), have been included where possible. The Kerguelen material, described by Cookson (1947b), is considered to be of probable middle Miocene age (Nougier, 1970). Extra-Australian records of occurrence have been included where possible.

New species, here designated sp. nov., will be formally validated in later publication. They are based on study of at least fifteen specimens. Previously undescribed species represented by fewer specimens are simply referred to as sp.

Relative abundances are given for each species, and the following percentages have been used (based on an average count of 250 grains per sample): rare (=low frequency), 0 to 4% of total grain count; moderate frequency, 4 to 9% of total grain count; common, 10-20%

of total grain count; abundant, more than 20% of total grain count.

All photographs are x1000, unless otherwise noted. Most were taken on a Zeiss microscope, Serial No. 4752128, located in the Geology Dept, A.N.U. Some photographs, and all interference contrast photographs, were taken on a Leitz Ortholux microscope located in the Palynology Section, Bureau of Mineral Resources. Slides containing holotypes of new species will be deposited in the Palaeontology Collection, Dept of Geology, A.N.U. Slide numbers and co-ordinates referring to the Zeiss microscope mentioned above are given in the captions to the plates, and for holotypes are also given in the section under that particular species.

Anteturma SPORITES H. Potonié 1893

Turma TRILETES Reinsch emend. Dettmann 1963

Subturma AZONOTRILETES Luber emend. Dettmann 1963

Infraturma LAEVIGATI Bennie & Kidston emend. Potonié 1956

Genus *Cyathidites* Couper 1953

Type species (by original designation): *Cyathidites australis* Couper, 1953.

Remarks: Couper erected this genus to include smooth triangular trilete spores with rounded apices and concave sides. Spores generally fitting into this group are common in samples from Kiandra, and are also common, but less so, in samples from Cadia and Nerriga. Several spores of cyatheaceous type were found which could not be accommodated in existing form species, and because of their rare occurrence they have not been treated systematically.

In its present form, the diagnosis for this genus does not accommodate spores with a faintly patterned exine, such as *Cyathidites subtilis* Partridge and some spores included by Martin (1973a) in her species *Cyathea paleospora*. The diagnosis for this genus should therefore be emended to include such spores.

Cyathidites australis Couper 1953

(Plate 1, figures 1,2)

For synonymy to 1963, see Dettmann, 1963, p.22.

1965a *Cyathidites australis* Couper, Harris, p.79, Pl.24, fig.11.

Remarks: Smooth trilete spores with concave to straight sides, rounded apices, a thicker exine and larger size than *C. minor*, have been included within this species. This is one of the most common spores found in samples from Nerriga, and several specimens have been found in samples from Kiandra.

Dimensions: 44 (52) 57 µm

Occurrence: Found in samples from Nerriga and Kiandra, in low to moderate frequencies (up to 6% of total grain count).

Reported Stratigraphic Range: This species is common throughout the Upper Mesozoic of both Australia and New Zealand (Dettmann, 1963; Couper, 1953), and has also been reported from the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Similar spores are found in the Cyatheaceae and the Dicksoniaceae. Couper (1953) has suggested affinities with a Jurassic fern, *Cladophlebis lobifolia* Phill., and a living fern of the Dicksoniaceae, *Thyrsopteris elegans* Kunze.

Cyathidites minor Couper 1953

(Plate 1, figures 3,4)

For synonymy to 1963, see Dettmann, 1963, pp.22-23.
1965a *Cyathidites minor* Harris, p.79, Pl.24, fig.12.

Remarks: Smaller size and a more fragile exine distinguish this species from *C. australis*. These specimens lack the strongly concave sides found typically in *C. minor*, but otherwise agree with previous descriptions. *C. minor* has been found only in samples from Nerriga. Spores of similar size and shape, but with thicker exines, are common in samples from Kiandra and Cadia, and have been described here as *C.* cf. *C. minor*.

Dimensions: 28 (32) 36 µm

Occurrence: Found in samples from Nerriga, in low to moderate frequencies (3 to 9% of total grain count).

Reported Stratigraphic Range: This is a common spore species in Mesozoic deposits in Australia and New Zealand (Dettmann, 1963; Couper, 1953), and is widely distributed in lower Tertiary sediments of southern Australia (Harris, 1965a).

Botanical Affinities: Couper (1953, p.28) compares this species with spores of the living New Zealand ferns *Cyathea smithii*, *C. colensoi*, and *C. novae-zealandiae*, which are figured in Harris (1955).

Cyathidites cf. *C. minor* Couper 1953

(Plate 1, figure 7)

Description: Miospore free, anisopolar, trilete. Amb triangular, with broadly rounded apices and concave to straight sides. Laesurae extend from 2/3 to almost entire radius, distinct, straight, bordered by low lips in some specimens. Proximal surface broadly convex, distal surface more deeply convex. Exine distinctly two-layered, 1.5 µm thick, of uniform thickness, smooth.

Remarks: Although this species is one of the commonest spores seen in this study, it is difficult to place it in any of the previously described species of the genus. These specimens are most similar to *C. minor* but have a thicker exine and therefore lack the fragile, often crumpled appearance of Couper's species. For this reason they have not been placed in synonymy with *C. minor*. *C. australis* is similar in structure but larger. These specimens have more rounded apices, but are otherwise similar to *Cyathea paleospora* Martin 1973, and may be conspecific with her broadly defined species.

This is one of the most common species found in samples from Kiandra, and is also common in some samples from Cadia. Spores similar to this species appear to be widely distributed in Mesozoic and Tertiary deposits in Australia, and Mesozoic deposits of New Zealand.

Dimensions: 27 (36) 41 µm

Occurrence: Found in samples from Kiandra and Cadia. Rare to common (2 to 16% of total grain count).

Botanical Affinities: Similar to many living cyatheaceous and dicksoniaceous fern spores. Martin (1973a, p.7) remarks that her fossil specimens are similar to spores of the living C. leichhardtiana (F. Muell.) Copel. (which has a perispore), and C. novae-caledonae (Metl.) Copel., C. woollsiana (F. Muell.) Domin, and C. cooperi (Hook. ex F. Muell.) Dom. Spores of C. leichhardtiana in the modern pollen collection, Dept of Biogeography and Geomorphology, are similar.

Cyathidites splendens Harris 1965

(Plate 1, figures 5,6)

Synonymy

1965a Cyathidites splendens Harris, p.79, Pl.24, figs 13-15.

Remarks: Only a few spores referable to this species have been found. The large size and thick exine distinguish this from other species of Cyathidites. Although smaller than the specimens described by Harris (88 (96) 103 µm), they are otherwise similar.

Dimensions: 60, 66, and 80 µm (three specimens measured)

Occurrence: Found in samples from Nerriga, in low frequencies (up to 2.5% of total grain count).

Reported Stratigraphic Range: Harris (1965a) reported this species from Paleocene deposits in Victoria.

Botanical Affinities: Harris (1965a) has noted that spores of similar morphology occur in the genus Lygodium Swartz.

Cyathidites subtilis Partridge 1973

(Plate 1, figure 8)

Synonymy

1973 Cyathidites subtilis Partridge in Stover & Partridge, p.247, Pl.13, figs 1, 2.

Remarks: These specimens conform with those described from the Gippsland Basin. In some samples from Kiandra, this species is almost as common as C. cf. minor. In many specimens the granulate ornament can be discerned only under high magnification and oil immersion.

Martin (1973a) included some specimens with a granulate ornament in her species Cyathea paleospora, but the pattern on her figured specimens (Figs 27, 28, 29) appears finer than that found on these specimens.

Dimensions: 30 (36) 48 µm

Occurrence: Found in samples from Kiandra and Cadia, in low frequencies (up to 4% of total grain count).

Reported Stratigraphic Range: Found from the base of the Proteacidites tuberculatus Zone through the Triporopollenites bellus Zone, late Oligocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Harris (1955) describes several species of Cyathea which have a granulate ornament.

Genus *Biretisporites* Delcourt & Sprumont emend. Delcourt, Dettmann, & Hughes 1963

Type species: *Biretisporites potoniaei* Delcourt & Sprumont, 1955.

Biretisporites spp.

(Plate 1, figures 10,12)

Remarks: Several specimens with this rather simple morphology were found in some samples. More than one fossil species is represented, and two extremes of morphology found in spores assigned to this genus are illustrated. Too few specimens were found to enable subdivision into species.

Dimensions: 23 (32) 48 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia, in low frequencies.

Botanical Affinities: Unknown.

Genus *Deltoidospora* Miner emend. Potonié 1956

Type species: *Deltoidospora hallii* Miner, 1935.

Deltoidospora sp.

(Plate 1, figures 9,13)

Description: Miospore free, anisopolar, trilete. Amb triangular, with straight sides and sharply rounded apices. Laesurae straight, distinct, almost reaching equator. Proximal surface broadly pyramidal, distal surface sharply pyramidal to hemispherical. Exine 1.5-2 µm thick, two-layered, smooth to scabrate.

Remarks: These specimens do not conform with any previously described species from Australian Tertiary deposits. *D. granulomargo* Martin 1973 has a granular ornament adjacent to the trilete mark, and *D. inconspicua* Martin 1973 is smaller and has a thinner exine.

Dimensions: 26 (33) 40 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia, in low to moderate frequencies.

Botanical Affinities: Unknown. Possibly with *Cyathea*.

Genus *Stereisporites* Pflug 1953

Type species (by original designation): *Stereisporites stereoides* (Potonié & Venitz 1934) Pflug, 1953.

Stereisporites antiquasporites (Wilson & Webster 1946) Dettmann 1963

(Plate 1, figure 14)

For synonymy to 1963, see Dettmann, 1963, p.25.

1965a *Stereisporites antiquasporites* Wilson & Webster emend. Dettmann, Harris, p.79, Pl.24, fig.20.

1974 *Stereisporites antiquasporites* Wilson & Webster, Harris, Pl.1, fig.11.

Remarks: Considerable morphological variation has been found in published records of this species. Dettmann (1963, p.25) noted slight exinal thickenings in the equatorial radial regions, and a low distal polar thickening, laesurae $\frac{1}{2}$ to $\frac{3}{4}$ of the spore radius, and a generally smooth exine. The specimen illustrated by Harris (1965a) has a more pronounced sculpture, whereas Kemp (1975) has illustrated a specimen as *S. antiquasporites* with a distinct sculpture of low verrucae over the distal surface of the spore.

Specimens seen in this study are smooth, and have a circular darkening *ca* 5 µm in diameter at the distal pole. Slight thickening at the equatorial radial regions is apparent but not marked. The specimen illustrated by Harris (1974) from Ninetyeast Ridge was very similar to these. Considerable variation in length of laesurae, from 1/3 to $\frac{3}{4}$ length of spore radius, was found in these specimens.

This species occurs consistently, but not abundantly, in most samples from Kiandra. Sphagnum sp., figured by Couper (1953, Pl.1, fig.1), is very similar to these specimens. Couper gives a range for this type as Jurassic to Recent.

Dimensions: 23 (27) 30 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia, in low frequencies.

Reported Stratigraphic Range: Reported by Cookson (1947b; 1953b) from Tertiary lignites of middle Miocene age from Kerguelen, and Paleocene coal from Comaum, S.A. Also occurs in various Jurassic and Cretaceous deposits in Australia (Balme, 1957; Dettmann, 1963), and in Paleocene sediments on Ninetyeast Ridge (Harris, 1974).

Botanical Affinities: With spores of the moss Sphagnum (Cookson, 1953b).

Stereisporites (Tripunctisporis) sp.

(Plate 1, figure 11)

Synonymy

1973 Stereisporites (Tripunctisporis) sp., Stover & Evans, Pl.2, fig.12.

1973 Stereisporites (Tripunctisporis) sp., Stover & Partridge, p.251.

Remarks: Several sphagnoid spores with three distal foveolae arranged in a triangle were found in samples from Nerriga. These specimens appear identical with those described from the Gippsland

Basin by Stover & Partridge (1973).

Dimensions: 36 (38) 44 µm (seven specimens measured)

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: From the Tricolpites longus Zone through Upper Nothofagidites asperus Zone, Paleocene to early Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: With the moss genus Sphagnum.

Infraturma APICULATI Bennie & Kidston emend. Potonié 1956

Genus Verrucosisporites Potonié & Kremp 1955

Type species (by original designation): Verrucosisporites verrucosus Potonié & Kremp, 1955.

Verrucosisporites kopukuensis (Couper) Stover 1973

(Plate 2, figures 1,2)

Synonymy

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

1973 Verrucosisporites kopukuensis (Couper) Stover in Stover & Partridge, p.251, Pl.16, figs 2,3.

Remarks: These large spores have an extremely variable and dense ornament consisting mainly of verrucae and grana, with gemmae and baculae also present. These specimens are smaller than Couper's specimens (his size range was 120-138 µm), and are on the smaller end of the range given by Stover & Partridge, but otherwise conform with published descriptions. No specimens were found with ornament arranged in such a regular pattern as Figure 2 of Plate 16 in Stover & Partridge.

Dimensions: 70 (84) 99 µm (five specimens measured)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: *Malvacipollis diversus* Zone through the *Triporopollenites bellus* Zone, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Couper (1960) reported it from Upper Eocene deposits in New Zealand.

Botanical Affinities: Partridge (1971) noted similarities with spores of *Lygodium articulatum* A. Rich., described by Harris (1955).

Verrucosisporites cristatus Partridge 1973

(Plate 2, figure 3)

Synonymy

1973 *Verrucosisporites cristatus* Partridge in Stover & Partridge, p.251, Pl.15, fig.5.

Remarks: Several specimens with the complex ornament of capilli and filiform processes, described by Partridge for *V. cristatus*, were found in samples from Kiandra and Cadia. They agree well with those described from the Gippsland Basin, and their size range is similar (60 (82) 95 µm).

Dimensions: 66 (88) 100 µm (ten specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: From within the Lower *Nothofagidites asperus* Zone through the *Triporopollenites bellus* Zone, late Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Verrucosisporites cf. *V. cristatus* Partridge 1973

(Plate 2, figure 5; Plate 3, figure 1)

Remarks: Five specimens of a large spore similar to *V. cristatus* in type of ornament, but with a higher density and reduced size of ornament, were found in samples from Kiandra and Nerriga. Too few specimens were found to determine whether they are within the range of variation of *V. cristatus*. The ornament on these specimens was *ca* 2 µm high, *ca* 5-2 µm wide, and 1-2 µm apart, and the exine was thick (3 µm).

Dimensions: 62 (74) 88 µm (five specimens measured)

Occurrence: Found in samples from Kiandra and Nerriga. Rare.

Botanical Affinities: Unknown.

Genus *Leptolepidites* Couper 1953

Type species (by original designation): *Leptolepidites verrucatus* Couper, 1953.

Leptolepidites tuberosus sp. nov.

(Plate 2, figure 4; Plate 3, figures 2,3)

Diagnosis: Spore trilete, amb rounded-triangular; exine thick, 2-3 µm, with coarse verrucate sculpture.

Description: Miospore free, anisopolar, trilete. Amb rounded-triangular, with straight to gently convex sides and rounded apices. Proximal surface a broad, low pyramid, distal surface broadly rounded. Rays of trilete mark reach equator, straight, bordered by low (less than 1 µm high) lips. Smooth area with irregular margins adjacent to trilete mark, 2-8 µm wide. Exine 2-3 µm thick, ornamented with verrucae, broadly pointed to truncate in outline, 6-8 µm high, either straight-sided or broadening out at bases, circular to irregular in plan view, coalescing in places to form sinuous thick muri 5-20 µm long. Verrucae lower and more rugulose on proximal surface. In some specimens verrucae are generally larger at equatorial apices than interradially, giving an impression of apical modification (Pl.2, fig.4). However, in most specimens size distribution of verrucae is random. Verrucae are closely spaced, with no intervening area visible. In some cases, verrucae are clavate, with constricted bases (see Text-figure14). Some specimens are ornamented with discrete rounded verrucae, whereas in others the verrucae are discrete in places, but otherwise coalesce to form muri.

Holotype: Specimen on slide 028/1 (1084-037), 52 µm in diameter, illustrated on Pl.3, fig.3. Specimen oriented with distal pole uppermost. Amb rounded-triangular; exine _ca_ 2 µm thick at equator, difficult to see because of sculpture. Laesurae reach equator, _ca_ 22 µm long, straight. Smooth area adjacent to trilete mark; remainder of exine ornamented with densely spaced verrucae 7-10 µm high, pointed to truncate in side view; commonly discrete but a few coalesce towards bases to form rugulae _ca_ 20 µm in length.

Type locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of Name: From tuber, Latin, swelling or bulb; tuberosus, full of protuberances, in reference to the sculpture of the spore.

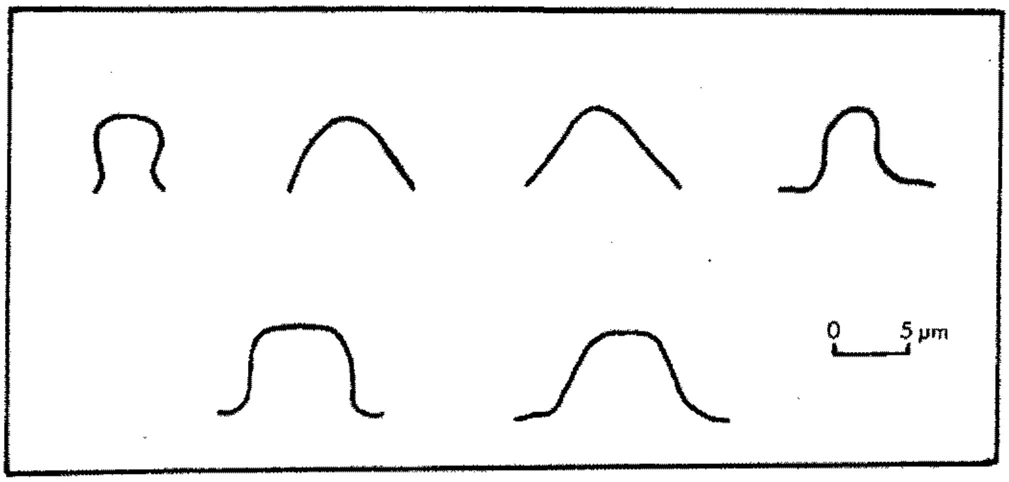
Remarks: _Rugulatisporites_ _mallatus_ Stover 1973 is smaller and has short, discontinuous rugulae with a clavate outline. These specimens have larger, higher verrucate projections that may be clavate in outline but are interspersed with a variety of other types.

Leptolepidites verrucatus Couper 1953 is smaller and has smaller verrucae, and *Trilites verrucatus* Couper 1953 has smaller, lower verrucae. *Leptolepidites baranyaensis* Nagy 1963, described from the Miocene of Hungary, is of similar size and ornament, and has reduced ornament on the proximal surface. The genus *Leptolepidites* appears appropriate for this species. *Trilites* as emended by Dettmann (1963) is restricted to spores with apical modification (sculptured valvae), a feature not found in this species.

Dimensions: 40 (51) 66 µm

Occurrence: Found in samples from Kiandra. Rare.

Botanical Affinities: Spores of the living fern genus *Leptolepia* are similar in shape and ornament (Couper, 1953; Erdtman, 1957).



Text-figure 14. Range in variation seen in outline of projections of *Leptolepidites tuberosus* sp. nov.

Infraturma MURORNATI Potonié & Kremp 1954

Genus Osmundacidites Couper 1953

Type species (by original designation): Osmundacidites wellmanii Couper, 1953.

Osmundacidites sp. 1

(Plate 3, figure 4)

Description: Miospore free, anisopolar, trilete. Amb spherical to subcircular, commonly folded and crumpled. Rays of trilete mark almost reach equator. Exine thin, ca 1.25 µm thick, of uniform thickness, ornamented with grana, spinae, and baculae up to 1.5 µm high, extremely variable, sparser on proximal than on distal surface.

Remarks: The variable granulate-baculate ornament on this species makes inclusion in this genus uncertain. Couper (1953, p.20) proposed the genus Osmundacidites for spores of osmundaceous affinities with granular-papillate sculpture. The genus Baculatisporites Thomson & Pflug 1953 is intended for spores with baculate sculpture. It is similar to O. wellmanii in size, but has a coarser sculpture. Baculatisporites comaumensis (Cookson) has baculate sculpture.

Dimensions: 35 (45) 66 µm (ten specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Botanical Affinities: With spores of the Osmundaceae.

Osmundacidites sp. 2

(Plate 3, figure 6)

Description: Miospore free, anisopolar, trilete. Amb circular, commonly folded. Rays of trilete mark equal $\frac{3}{4}$ radius. Exine thin, less than 1 µm thick, ornamented with low, closely spaced grana, 0.5-1 μm wide, up to 1 μm high. Ornament reduced on proximal surface.

Remarks: This species fits the diagnosis for the genus Osmundacidites, as it has a low, dense ornament of grana. It is found in low frequencies in most samples from Kiandra, and a few from Cadia.

Dimensions: 32 (41) 56 μm (eight specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Botanical Affinities: With spores of the Osmundaceae.

Genus Baculatisporites Thomson & Pflug 1953

Type species: Baculatisporites primarius (Wolff) Thomson & Pflug, 1953.

Baculatisporites comaumensis (Cookson) Potonié 1956

(Plate 3, figures 5,9)

For synonymy to 1963, see Dettmann, 1963, p.35.

1965a Baculatisporites comaumensis (Cookson) Harris, p.80, Pl.25, fig.1.

1974 Baculatisporites comaumensis (Cookson) Harris, Pl.1, fig.6.

Remarks: Although this species has been widely reported from Upper Mesozoic deposits in Australia, there have been few reports of it in Tertiary sediments. These specimens have an ornament consisting of baculae up to 2 μm high, with some gemmae, spinae, and grana. The sculpture elements are 1-3 μm apart, slightly sparser on the proximal surface.

Dimensions: 35 (52) 88 μm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Reported from the Mesozoic of both eastern and Western Australia (Dettmann, 1963; Balme, 1957). Harris (1965a) reported it from Paleocene sediments in Victoria, and noted that it is not a common species in lower Tertiary sediments; he later (1974) reported it from Paleocene sediments from Ninetyeast Ridge.

Botanical Affinities: Cookson (1953b) has compared this species to spores of Todea Willd., and Leptopteris Presl., and also to spores of certain species of Osmunda L.

Genus Foveotriletes van der Hammen ex Potonié 1956

Type species: Foveotriletes scrobiculatus (Ross), designated by Potonié, 1956.

Foveotriletes crater Partridge 1973

(Plate 3, figure 10)

Synonymy

1973 Foveotriletes crater Partridge in Stover & Partridge, p.248, Pl.14, figs 1-3.

Remarks: Although these specimens are slightly larger than those from the Gippsland Basin, the variable size and density of the foveolae distinguish this from other species of the genus. The specimen illustrated has small, closely spaced foveolae, but other specimens seen had larger and fewer foveolae, and were similar to those illustrated by Stover & Partridge (1973).

Dimensions: 25 (36) 40 µm (seven specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: Proteacidites tuberculatus Zone through *Triporopollenites bellus* Zone, early Oligocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown. Possibly with the genus *Lycopodium*.

Foveotriletes palaequetrus Partridge 1973

(Plate 4, figure 1)

Synonymy

1973 *Foveotriletes palaequetrus* Partridge in Stover & Partridge, p.248, Pl.14, figs 4, 5.

Remarks: Although only a few specimens have been seen, they appear to conform in sculptural detail and grain outline with those described from the Gippsland Basin by Stover & Partridge (1973).

Dimensions: 40 and 46 µm (two specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Lower *Nothofagidites asperus* Zone through *Proteacidites tuberculatus* Zone, late Eocene through early Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Harris (1974) reported it from Paleocene sediments on Ninetyeast Ridge.

Botanical Affinities: Specimens of *Lycopodium australianum* and *L. selago* seen by the author are similar in grain outline and sculpture. Partridge (1971, p.119) has compared this species to spores of *Lycopodium australianum* Herter, figured by Harris (1955), although these differ in having a smooth proximal surface. Spores of *Lycopodium fuegianum* Roivainen (in Heusser, 1971) are also similar in shape and sculpture.

Genus Foveosporites Balme 1957

Type species (by original designation): Foveosporites canalis Balme, 1957.

Foveosporites lacunosus (Partridge 1973) comb. nov.

(Plate 3, figure 7)

Synonymy

1973 Foveotriletes lacunosus Partridge in Stover & Partridge, p.248, Pl.14, fig.6.

Remarks: A few specimens were found, and they are similar in size and morphology with those from the Gippsland Basin. The shallow, generally small foveolae, smooth proximal surface, and convex triangular amb distinguish this species. Transfer of this species to Foveosporites Balme, a genus proposed for foveolate circular to rounded triangular spores, appears appropriate. Foveotriletes van der Hammen ex Potonié is generally reserved for foveolate spores with a triangular amb and straight to concave sides.

Dimensions: 31 (36) 45 µm (six specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Proteacidites tuberculatus Zone through Triporopollenites bellus Zone, late Oligocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Spores of Lycopodium squarrosus seen by the author are comparable. Partridge (1971) noted similarities with spores of the Lycopodium billarderi varium group.

Genus Lycopodiumsporites Thiergart ex Delcourt & Sprumont 1955

Type species: Lycopodiumsporites agathoecus (Potonié) Thiergart, 1938.

Remarks: Spores referable to this genus occur rarely but consistently in most samples. The three most common species are described in the following section.

Lycopodiumsporites sp. 1

(Plate 3, figure 8)

Description: Miospore free, anisopolar, trilete. Amb rounded-triangular; proximal surface smooth, pyramidal, laesurae straight, extending to periphery, bordered by low membraneous lips, ca 1 µm high. Distal surface broadly convex, ornamented with a closed, irregular reticulum of high (2-3 µm), narrow (1 µm wide), straight-sided, membraneous muri which enclose polygonal lumina, 4-5 µm in diameter. Muri are raised into a membraneous network, which extends ca 3 µm outwards at equator, giving the appearance of a flange in polar compressions. Exine 1-1.5 µm thick.

Remarks: This species has finer muri and a finer reticulum than L. austroclavatidites (Cookson). L. facetus Dettmann 1963 has similar membraneous muri, but differs by having reticulate sculpture on both the proximal and distal surfaces. It is similar to Lycopodium sp. (fastigatum-volubile group) described by Couper (1953).

Dimensions: 35 (45) 50 µm

Occurrence: Found in samples from Kiandra in low frequencies.

Botanical Affinities: This species resembles spores of Lycopodium fastigatum and L. clavatum. Also resembles Lycopodium Group IV of Harris (1955).

Lycopodiumsporites sp. 2

(Plate 4, figure 2)

Synonymy

1969 Lycopodium sp., Fasola, p.16, Pl.3, figs 6, 7.

Description: Miospore free, anisopolar, trilete. Amb rounded to subtriangular, with apices broadly rounded, sides straight to convex. Laesurae of trilete mark reach equator. Proximal surface smooth, distal surface coarsely reticulate, lumina irregular, polygonal to circular, up to 10 µm wide, enclosed by narrow muri ca 0.5 µm wide, 1 µm high.

Remarks: This species is similar to L. austroclavatidites (Cookson) but the muri are narrower and lower, so that they do not form such a distinct membraneous flange around the equator. The size ranges overlap, although L. austroclavatidites tends to be larger (34 (43) 58 µm).

Dimensions: 25 (35) 45 µm, inclusive of ornament (seven specimens measured).

Occurrence: Found in samples from Kiandra in low frequencies.

Botanical Affinities: Probably with Lycopodium.

Lycopodiumsporites sp. 3

(Plate 4, figures 3,4)

Description: Miospore free, anisopolar, trilete. Amb rounded-triangular, with straight to convex sides and broadly rounded apices. Rays of trilete mark equal $\frac{3}{4}$ radius, bounded by curvaturae, and enclosed by membraneous lips. Exine 1 µm thick. Distal surface and equator ornamented with a fine, closed reticulum; muri 1-2 µm high, less than 1 µm wide, with knobbly projections at the junctions of the muri, enclosing irregularly shaped polygonal lumina, 2-4 µm in diameter.

Remarks: Lycopodiumsporites eminulus Dettmann 1963 has a similar size range and structure, but differs in having lumina that are more rounded. This species has a finer, fainter reticulum than either of the preceding two new species. Most specimens were found as equatorial compressions. Specimens from Kiandra were generally larger (40-48 µm) than those from Cadia (25-38 µm).

Dimensions: 25 (37) 48 µm, including ornament.

Occurrence: Found in samples from Kiandra and Cadia in low frequencies except in one sample from Cadia, where this species formed 28% of total grain count.

Botanical Affinities: Probably with Lycopodium.

Genus Rugulatisporites Thomson & Pflug 1953

Type species: Rugulatisporites quintus Pflug & Thomson in Thomson & Pflug, 1953.

Rugulatisporites micraulaxus Partridge 1973

(Plate 4, figure 5)

Synonymy

1973 Rugulatisporites micraulaxus Partridge in Stover & Partridge, p.250, Pl.15, figs 2,3.

Remarks: This species is very common in some samples from Cadia. Most specimens have both fossulate and foveolate ornament on the distal surface, and grana adjacent to the unsculptured area bordering the trilete mark. They agree well with those described from the Gippsland Basin.

Dimensions: 30 (36) 46 µm

Occurrence: Found in samples from Cadia, generally in low frequencies, except in one sample (112) where it formed 16% of total grain count.

Reported Stratigraphic Range: *Triporopollenites bellus* Zone, late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Rugulatisporites mallatus Stover 1973

(Plate 4, figures 7,8)

Synonymy

1973 *Rugulatisporites mallatus* Stover in Stover & Partridge, p.250, Pl.15, fig.1.

Remarks: An ornament of short, discontinuous rugulae with a clavate ("mushroom-shaped") cross-section distinguishes this species from *R. trophus* Partridge and *R. micraulaxus* Partridge. These specimens are larger than those from the Gippsland Basin (36 (42) 47 µm) but are otherwise similar.

Dimensions: 44 (48) 52 µm

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: *Lygistepollenites balmei* Zone through *Triporopollenites bellus* Zone, middle Paleocene through late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Similar to some spores of living Dicksoniaceae, for example *Culcita dubia*, from Victoria, which have similar clavate projections.

Rugulatisporites trophus Partridge 1973

(Plate 4, figure 6)

Synonymy

1973 Rugulatisporites trophus Partridge in Stover & Partridge, p.250, Pl.15, fig.4.

Remarks: The variable ornament of low, flat-topped rugulae distinguishes this species from R. mallatus, which has clavate and more discontinuous rugulae.

Dimensions: 46 (52) 60 µm (13 specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: Lower Nothofagidites asperus Zone into the lower part of the Proteacidites tuberculatus Zone, middle Eocene into early Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Genus Klukisporites Couper 1958

Type species (by original designation): Klukisporites variegatus Couper, 1958.

Klukisporites reticulatus sp. nov.

(Plate 4, figures 9,10)

Diagnosis: Spore trilete, with triangular amb. Exine 2-3 µm thick, ornamented with a low, irregular reticulum.

Description: Miospore free, anisopolar, trilete. Amb triangular, with straight to concave sides and rounded, protruding apices. Rays of trilete mark almost reach equator; straight, simple, bordered by a slightly raised smooth area up to 5 µm wide. Exine 2-3 µm thick, ornamented with a reticulum of low muri, 1-3 µm high, 1-2 µm wide, enclosing irregular polygonal lumina, up to 8 µm in diameter. The reticulum is slightly reduced on the proximal surface.

Holotype: Specimen on slide 023/5 (1044-117), 47 µm in diameter, on Pl.4, fig.10. Preserved in distal aspect. Amb triangular, with concave sides and broadly rounded apices. Laesurae almost reach equator, straight, 25 µm long, bordered by smooth raised area 7 µm at widest part. Exine 2.5 µm thick. Sculpture of muri, 3 µm high, 2 µm wide (wider in places), which form irregular reticulum. Lumina irregular-polygonal, 7 µm in maximum dimension.

Type Locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of Name: From reticulum, Latin, diminutive for net, in reference to the delicate nature of the sculpture.

Remarks: This species has lower muri and larger lumina than Klukisporites lachlanensis Martin, and is larger and lacks the granular margo of K. granulomargo Martin.

Dimensions: 42 (40) 60 µm

Occurrence: Found in samples from Kiandra. Rare.

Botanical Affinities: Unknown.

Subturma ZONOTRILETES Waltz 1958

Infraturma AURICULATI Schopf emend. Dettmann 1963

Genus Matonisporites Couper emend. Dettmann 1963

Type species (by original designation): Matonisporites phlebopteroides Couper, 1958.

Matonisporites ornamentalis (Cookson 1947) Partridge 1973

(Plate 5, figures 1,4)

Synonymy

1947b Trilites ornamentalis Cookson, pp.136-137, Pl.XVI, figs 63,64.

1947b Trilites cf. ornamentalis Cookson, Pl.XVI, fig.65.

1973 Matonisporites ornamentalis (Cookson) Partridge, Stover & Partridge, pp.249-250, Pl.13, figs 3,4.

Remarks: A wide range of variation in amount and pattern of the distal exinal thickening was found in these specimens. Some showed little thickening distally and low thickened bands adjacent to the trilete mark, whereas other specimens had an elaborate ornament of thickened sinuous bands on the distal surface.

Although this was a common spore species in the present study, it has been reported previously only from Kerguelen and the Gippsland Basin.

Dimensions: 32 (42) 52 µm

Occurrence: Found in samples from Kiandra and Cadia, in moderate frequencies, except in one sample from Nine Mile Diggings near Kiandra, where it formed 18% of the total grain count.

Reported Stratigraphic Range: Tertiary lignites of probable middle Miocene age from Kerguelen (Cookson, 1947b); Lower Nothofagidites asperus Zone through Triporopollenites bellus Zone, late Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: This species has been compared with spores of the tree fern Dicksonia antarctica Labill. by Duigan & Cookson (1957).

Genus Trilites Cookson ex Couper 1953 emend. Dettmann 1963

Type species: Trilites tuberculiformis Cookson 1947, designated by Couper, 1953.

Trilites tuberculiformis Cookson 1947

(Plate 5, figure 3)

Synonymy

1947b Trilites tuberculiformis Cookson, p.136, Pl.XVI, figs 61,62.

1967 Trilites tuberculiformis Cookson, Cookson & Cranwell, pp.208-209, Pl.3, figs 4,5.

Remarks: This species was a common spore in samples from Nerriga. In size and ornament it conforms to the specimens described from Kerguelen.

Dimensions: 40 (44) 52 µm

Occurrence: Found in samples from Nerriga in low to moderate frequencies.

Reported Stratigraphic Ranges: Tertiary lignites of probably middle Miocene age from Kerguelen (Cookson, 1947b). A similar species has been reported from Australian Upper Mesozoic deposits (Dettmann, 1963) and Miocene deposits in New Zealand (Couper, 1953). Also reported from the Lower Tertiary of Chile (Cookson & Cranwell, 1967).

Botanical Affinities: Some species of the Dicksoniaceae have comparable spores, especially Dicksonia squarrosa (Forst.), figured by Harris (1955).

Genus Ischyosporites Balme 1957

Type species (by original designation): Ischyosporites crateris Balme, 1957.

Ischyosporites sp. 1

(Plate 5, figures 2,7,8)

Description: Miospore free, anisopolar, trilete. Amb triangular, with straight sides and broadly rounded apices. Rays of trilete mark almost reach equator, straight, bordered by smooth to scabrate area ca 5-6 µm wide. Exine ca 2-3 µm thick, ornamented with thin muri 2-3 µm high (5 µm at apices), ca 1 µm thick, forming a foveo-reticulate ornament on equatorial and distal surfaces. Muri enclosing polygonal lumina ca 5 µm in diameter. Valvae prominent.

Remarks: This species of Ischyosporites has thinner muri than previously described Australian species. I. punctatus Cookson & Dettmann 1958 and I. gremius Stover 1973 have thicker muri and more rounded lumina, but are similar in size. An aberrant "quadrilete" form is also illustrated.

Dimensions: 44 (59) 70 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies, except in one sample from Cadia (116), where it formed 14% of total grain count.

Botanical Affinities: Unknown.

Ischyosporites sp. 2

(Plate 6, figure 1)

Description: Miospore free, anisopolar, trilete. Amb triangular, with straight sides and rounded apices. Rays of trilete mark almost reach equator, straight, bordered by a smooth to punctate area 2-4 µm wide. Exine ca 3 µm thick, 5 µm thick at apices, ornamented with a reticulum of muri 2-4 µm wide, ca 5 µm high, enclosing irregularly shaped, rounded and rounded-polygonal lumina 2-3 µm wide. Valvae not prominent.

Remarks: This species has a coarser ornament, thicker muri, less prominent valvae, and more rounded and irregular lumina than Ischyosporites sp. 1. The lumina are smaller in relation to thickness of muri than in I. crateris Balme and I. gremius Stover. I. punctatus Cookson & Dettmann has more circular to elliptical lumina than this species.

Dimensions: 49 (58) 66 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Botanical Affinities: Unknown.

Infraturma TRICRASSATI Dettmann 1963

Genus Gleicheniidites Ross ex Delcourt & Sprumont 1955 emend. Dettmann 1963

Type species: Gleicheniidites senonicus Ross 1949, designated by Delcourt & Sprumont, 1955.

Gleicheniidites circinidites (Cookson 1953) Dettmann 1963

(Plate 5, figures 5,6)

Synonymy

1953b Gleichenia cercinidites Cookson, p.464, Pl.1, figs 5,6.

1957 Gleichenia cf. G. cercinidites Cookson, Balme, p.23, Pl.3, figs 42-44.

1963 Gleicheniidites cf. G. cercinidites (Cookson) Dettmann, p.65, Pl.XIII, figs 6-10.

1965a Gleicheniidites circinidites (Cookson) Harris, p.82, Pl.25, fig.17.

1973a Gleichenia circinidites Cookson, Martin, p.6, fig.9.

Remarks: These specimens conform with previous descriptions of the species. It was found consistently but not abundantly in most samples, but comprised more than half the total grain count in a few samples of ligneous clay from Kiandra.

Dimensions: 28 (35) 44 µm

Occurrence: Found in some samples from Nerriga, Kiandra, and Cadia in low frequencies, except for three samples from Kiandra, where this species formed 47, 13, and 46% of the assemblage counted.

Reported Stratigraphic Range: Cookson (1953b) reported this species from various deposits of Tertiary age, and also reported finding pinnules of *Gleichenia circinata* at several levels at Yallourn. Harris (1965a) reported it from Paleocene deposits in Victoria, and Martin (1973a) has found it in ?Upper Pliocene sediments in New South Wales. Also reported from Upper Jurassic and Cretaceous deposits in Australia (Balme, 1957; Dettmann, 1963) and Lower Cretaceous to Recent deposits in New Zealand (Couper, 1953).

Botanical Affinities: With the Gleicheniaceae, especially spores belonging to *Gleichenia circinata* Swartz (Cookson, 1953a).

Genus *Clavifera* Bolkovitina 1966

Type species (by original designation): *Clavifera triplex* (Bolkovitina) Bolkovitina, 1966.

Clavifera triplex (Bolkovitina) Bolkovitina 1966

(Plate 6, figure 4)

For synonymy see Dettmann & Playford, 1968; Kemp, 1970.

1973 *Clavifera triplex* (Bolkovitina) Bolkovitina, Archangelsky, pp.348-350, Pl.II, figs 4-6.

Remarks: This species is reported to intergrade with species of *Gleicheniidites*. However, specimens seen in these samples can be distinguished from *G. circinata* by the thickenings in the equatorial radial region, in addition to the interradial crassitudes, and no forms intermediate with *G. circinata* were seen.

Dimensions: 30 (38) 44 µm (seven specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Reported from various Cretaceous deposits in eastern Australia, USSR, Germany, and Britain (Dettmann & Playford, 1968; Kemp, 1970). Also reported from deposits of Paleocene age from Argentina and Ninetyeast Ridge (Archangelsky, 1973; Harris, 1974).

Botanical Affinities: With the Gleicheniaceae, for example, *Gleichenia microphylla*, which is similar in morphology but psilate.

Infraturma CINGULATI Potonié & Klaus emend. Dettmann 1963

Genus *Cingutriletes* Pierce 1961 emend. Dettmann 1963

Type species: *Cingutriletes congruens* Pierce, 1961.

Cingutriletes clavus (Balme 1957) Dettmann 1963

(Plate 6, figures 2,3)

For synonymy to 1963, see Dettmann, 1963, p.69.

1965a *Cingutriletes clavus* (Balme) Dettmann, Harris, p.82, Pl.25, fig.18.

Remarks: A few cingulate sphagnoid spores were found in samples from Kiandra. These spores have been placed in a species erected by Balme (1957) as *Sphagnites clavus*, later transferred by Dettmann to *Cingutriletes*.

Dimensions: 24 (26) 34 µm (nine specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Reported from Jurassic, Cretaceous, and Tertiary deposits in Australia (Dettmann, 1963).

Botanical Affinities: With the Sphagnaceae.

Genus Cyatheacidites Cookson 1947 emend. Partridge 1973

Type species: Cyatheacidites annulatus Cookson 1947, designated by Potonié, 1956.

Cyatheacidites annulatus Cookson 1947

(Plate 6, figures 5,6)

Synonymy

1947b Trilites (Cyatheacidites) annulata Cookson, p.136, Pl.XV, figs 53-55.

1957 Cyathea annulata (Cookson), Cookson, p.45, Pl.9, figs 4,5.

1967 Cyatheacidites annulatus Cookson, Cookson & Cranwell, p.208, Pl.3, figs 7,8.

1969 Cyatheacidites annulatus Cookson, Fasola, p.12, Pl.2, fig.3.

1973 Cyatheacidites annulatus Cookson, Stover & Partridge, p.247, Pl.13, figs 5,6.

1973b Cyatheacidites annulata Cookson, Martin, p.51, Pl.1, figs 1-3.

Remarks: This very distinctive spore occurs commonly in some samples from Kiandra. Almost all specimens were polar compressions, with smooth to gently undulate margins, and definite verrucate projections, as well as grana, on the proximal surface. These specimens were larger than those from the Gippsland Basin (35 (56) 65 µm).

This is one of the few species with published Tertiary fossil records from South America as well as Australia and Kerguelen.

Dimensions: 53 (65) 87 µm

Occurrence: Found in samples from Kiandra in low frequencies.

Reported Stratigraphic Range: Reported from Tertiary lignites of probable middle Miocene age from Kerguelen and Tertiary deposits of various ages in Australia (Cookson, 1947b; 1957). Proteacidites tuberculatus Zone through Triporopollenites bellus Zone, early

Oligocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Harris (1971) considers the appearance of *C. annulatus* to indicate a Miocene or younger age, and has used it as the nominate species for a zonule extending to middle Miocene, or the first appearance of *Acacia* pollen. Also reported from the Pliocene of Queensland (Cookson, 1957) and New South Wales (Martin, 1973b), Eocene of Chile (Cookson & Cranwell, 1967; Fasola, 1969), and Paleocene of Argentina (Archangelsky, 1973).

Botanical Affinities: This species has been compared with the living Central and South American fern *Lophosoria quadripinnata* (Gmelin) Christensen (Erdtman, 1957; 1958). *Lophosoria* is an isolated relict genus previously included in the Cyatheaceae, but now referred to a special family, the Protocyatheaceae (Erdtman, 1958). The present range extends from Mexico to parts of Patagonia, Chile, and the Juan Fernandos Islands (Skottsberg, in Cookson & Cranwell, 1967).

Turma MONOLETES Ibrahim 1933
Subturma AZONOMONOLETES Luber 1935
Infraturma LAEVIGATOMONOLETI Dybová & Jachowicz 1957

Genus *Laevigatosporites* (Ibrahim) Schopf, Wilson, & Bentall 1944

Type species (by original designation): *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1933.

Remarks: Smooth monolete spores, here referred to the species *L. ovatus* and *L. major*, were abundant in almost all the samples studied. Morphologically these two species are similar, and distinction between them is made on the basis of size ranges. These two form species probably include spores which originally had fragile, thin perispores which have not been preserved, as well as spores that are psilate.

Laevigatosporites ovatus Wilson & Webster 1946

(Plate 6, figure 7)

For synonymy to 1963, see Dettmann, 1963, p.86.

1965a Laevigatosporites ovatus Wilson & Webster, Harris, p.83, Pl.24, fig.2.

1973a Laevigatosporites ovatus Wilson & Webster, Martin, p.13, fig.50.

Remarks: This species is common in some, and present in most samples from all three localities.

Dimensions: 26 (30) 37 µm in length x 15-26 µm in width

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Widely reported from Upper Mesozoic and Tertiary sediments in Australia, and spores similar to this species are known from Devonian to Recent and are common throughout the world.

Botanical Affinities: Probably with the Schizaeaceceae and the Blechnoideae (Harris, 1955). Martin (1973a) notes that this species resembles a number of genera - Thelypteris, Asplenium, Athyrium, Aspidium, and Blechnum, all of which either have smooth spores or shed perispores easily to leave the spore completely smooth.

Laevigatosporites major (Cookson) Krutzsch 1959

(Plate 6, figure 8)

Synonymy

1947b Monolites major Cookson, p.135, Pl.15, fig.56.

1959 Laevigatosporites major (Cookson) Krutzsch, p.195.

1965a Laevigatosporites major (Cookson) Harris, p.83, Pl.24, fig.1.

1968 Laevigatosporites major (Cookson) Dettmann & Playford, p.82, Pl.8, fig.2.

1974 Laevigatosporites major Cookson, Harris, Pl.1, fig.1.

Remarks: The large size distinguishes this species from L. ovatus. To date, this species has been reported only from Upper Cretaceous and Tertiary deposits.

Dimensions: 45 (48) 60 µm in length x 28-42 µm in width.

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Reported from Paleocene deposits in Victoria (Harris, 1965a), and middle Miocene lignites from Kerguelen (Cookson, 1947b). Infrequent in Upper Cretaceous deposits in eastern Australia (Dettmann & Playford, 1968). Harris (1974) has recorded L. major and L. ovatus in Paleocene sediments from Ninetyeast Ridge.

Botanical Affinities: Harris (1965a) has suggested affinities with spores of Schizaea fistulosa Labill.

Infraturma SCULPTATOMONOLETI Dybová & Jachowicz 1957

Genus Polypodiisporites Potonié 1933 emend. Khan & Martin 1971

Type species: Polypodiisporites favus Potonié & Gelletich 1933, designated by Potonié, 1956.

Remarks: The suggestion by Khan & Martin (1971) that the three form genera Polypodiisporites, Polypodiidites, and Verrucatosporites, be combined into the single form genus Polypodiisporites, is accepted here. The variations in ornament of species within each of these genera seem to encompass a wider spectrum than differences between the genera themselves. Therefore, monolete spores with verrucae or similar sculpture, the arrangement of which forms a negative reticulum, have been included within this genus.

Polypodiisporites speciosus (Harris 1965) comb. nov.

(Plate 6, figure 9)

Synonymy

1965a Verrucatosporites speciosus Harris, pp.83-84, Pl.24, figs 8-10.

Remarks: This species has been assigned to the genus Polypodiisporites, following the suggestion of Khan & Martin (1971). Although very few specimens were found, they are similar in size and ornament to those described from the Paleocene of Victoria.

Dimensions: 40 (42) 44 µm in length (five specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Common in lower Tertiary sediments of southern Australia (Harris, 1965a).

Botanical Affinities: Harris (1965a) has compared P. speciosus with spores of the living genus Microsorium Link. Spores of Microsorium diversifolium have similar size and ornament, and Davallia pyxidata also has similar size and coarsely verrucate sculpture.

Polypodiisporites sp. 1

(Plate 7, figure 2)

Description: Miospore free, anisopolar, monolete, bilateral. Concavo-convex to plano-convex in lateral view, elliptical in equatorial view. Margin undulate. Laesura equal to $\frac{1}{2}$ to $\frac{3}{4}$ length of spore, simple and slit-like. Exine 2 µm thick, ornamented with verrucae with incised fossulae, forming a negative reticulum. Verrucae up to 6 µm in diameter, 2 µm high, irregularly polygonal in plan view, flattened at the apices, rarely anastomosing. Size of verrucae generally uniform in any one area, but size diminishes toward laesura, decreasing to grana 1-2 µm in diameter close to suture.

Fossulae narrow (0.5 µm), incised less than 1 µm.

Remarks: Several species of Polypodiisporites have been described from Australian Tertiary sediments. Polypodiidites sp. Martin 1973 has lophae which decrease in size towards the suture, and is similar in size. Polypodiisporites speciosus (Harris) has larger, more widely spaced verrucae. Polypodiisporites sp. Hekel 1972 differs by having a radial arrangement of elongated verrucae towards the suture, whereas this species has a reduction in size of ornament. Of the species described by Krutzsch (1967) in his Atlas, Verrucatosporites rugufavus is most similar to this species. It differs in having verrucae that are more radially elongate, whereas in this species the verrucae are generally more rounded. Polypodiisporites sp. 2 has smaller, more uniform verrucae that only decrease slightly in size towards the suture.

Dimensions: 38 (51) 63 µm in length x 29 (32) 37 µm in width

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies.

Botanical Affinities: With spores of some living species of Polypodium, Microsorium, and Davallia.

Polypodiisporites sp. 2

(Plate 7, figure 1)

Description: Miospore free, anisopolar, monolete, bilateral. Plano-convex in lateral view, elliptical in equatorial view. Exine thick, 3 µm ornamented with circular to elliptical, closely spaced verrucae, forming a negative reticulum. Fossulae incised, ca 1 µm wide. Verrucae 4-6 µm wide, generally of uniform size, becoming slightly smaller towards suture.

Remarks: This species was fairly common in samples from Nerriga. It differs from the preceding two species in having a generally uniform ornament of closely spaced verrucae.

Dimensions: 40 (52) 62 µm in length x 30-50 µm in width

Occurrence: Found in samples from Nerriga in low frequencies.

Botanical Affinities: Probably with the Polypodiaceae.

Genus Reticuloidosporites Pflug 1953

Type species: Reticuloidosporites dentatus (Pflug) Pflug, 1953.

Reticuloidosporites escharus Partridge 1971 (ms name)

(Plate 6, figure 10)

Description: Miospore free, anisopolar, monolete, bilateral. Concavo-convex to plano-convex in lateral view, elliptical in equatorial view. Laesura straight, extending almost the entire length of spore. Exine 2-3 µm thick, ornamented with verrucae, 1-4 µm wide, 2.5-2.8 µm high, in places coalescing to form short sinuous muri.

Remarks: These specimens appear very similar in size and morphology to those described by Partridge from the onshore Gippsland Basin. The unusual ornament and undulating outline distinguish this species from other monolete spores.

Dimensions: 29 (35) 50 µm in length x 23-27 µm in width
(13 specimens measured)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Partridge (1971) reported this species as rare to present in Eocene, rare to common in Oligocene-Miocene deposits in the Gippsland Basin.

Botanical Affinities: Unknown.

Genus Microfoveolatosporis Krutzsch 1959

Type species (by original designation): Microfoveolatosporis pseudodentatus Krutzsch, 1959.

Microfoveolatosporis sp. 1

(Plate 7, figure 4)

Description: Miospore free, anisopolar, monolete, bilateral. Concavo-convex to plano-convex in lateral view, oval to broadly rounded in equatorial view. Laesura equal to ½ length of spore. Exine 2-2.5 µm thick, two-layered, layers of equal thickness, ornamented with small pits ca 1 µm wide, about 1-2 µm apart, forming a foveo-microreticulate ornament.

Remarks: These specimens are not as deeply pitted as Schizaea punctata Cookson (1957), and do not resemble any other previously described species of the genus.

Dimensions: 40 (55) 84 µm x 37-75 µm (12 specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Botanical Affinities: Probably with the Schizaeaceae.

Microfoveolatosporis sp. 2

(Plate 7, figure 3)

Description: Miospore free, anisopolar, monolete, bilateral. Plano-convex in lateral view, elliptical in equatorial view. Laesura equal to ½ length of grain. Exine 1.5 µm thick, with foveo-reticulate ornament, lumina 1-2 µm wide, polygonal, decreasing slightly towards laesura. Intervening muri less than 1 µm wide.

Remarks: This fairly small monolete spore was found in samples from Nerriga. It is much smaller than *M.* sp. 1, and has foveolae that are more irregular in shape.

Dimensions: 26, 27, and 30 µm in length, 23 µm in width (one measurement) (Three specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Botanical Affinities: Probably comparable with spores of *Schizaea*.

Genus *Echinosporis* Krutzsch 1967

Type species (by original designation): *Echinosporis echinatus* Krutzsch, 1967.

Echinosporis sp.

(Plate 7, figure 6)

Description: Miospore free, anisopolar, monolete, bilateral. Concavo-convex to plano-convex in lateral view, round to elliptical in equatorial view. Laesura equal to 2/3 length of spore. Exine thin, 0.5 µm, scabrate, ornamented with scattered conical spines and baculae, 2-4 µm high, *ca* 2 µm wide at base, tapering to a blunt tip.

Remarks: This rare monolete species has a distinctive ornament of blunt conical spines, and is unlike any previously described species from Australian Tertiary deposits.

Dimensions: 23 (26) 36 µm in length, 22-32 µm in width (four specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Botanical Affinities: Unknown.

Genus Peromonolites Couper 1953

Type species (by original designation): Peromonolites bowenii Couper, 1953.

Peromonolites densus Harris 1965

(Plate 7, figures 5,9)

Synonymy

1965a Peromonolites densus Harris, p.84, Pl.24, figs 3-5.

1973 Peromonolites densus Harris, Stover & Evans, Pl.2, fig.7.

1973 Peromonolites densus Harris, Stover & Partridge, p.251 (not illustrated).

Remarks: This species is common in some samples. The thickness of the perispore is variable, and specimens with both thick and thin finely wrinkled perispores are illustrated.

Dimensions: 33 (43) 62 µm in length x 20 (22) 27 µm in width

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Lygistepollenites balmei Zone through Triporopollenites bellus Zone, middle Paleocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Harris (1965a) reported it from the Paleocene of Victoria, and later (1974) from Paleocene sediments on Ninetyeast Ridge.

Botanical Affinities: Unknown.

Peromonolites vellosus Partridge 1973

(Plate 7, figures 7,8)

Synonymy

1973 Peromonolites vellosus Partridge in Stover & Partridge,
pp.251-252, Pl.15, fig.6; Pl.16, fig.1.

Remarks: These specimens are very similar to those described from the Gippsland Basin. At times it was difficult to distinguish a "furry, mat-like" texture of the perispore from specimens of P. densus with a thick, finely wrinkled perispore.

Dimensions: 37 (47) 52 µm in length, 20-42 µm in width (six specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Lygistepollenites balmei Zone through Triporopollenites bellus Zone, middle Paleocene to late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Order FILICALES

Family DENNSTAEDTIACEAE

Genus Hypolepis

Hypolepis spinysporis Martin 1973

(Plate 7, figures 10,11)

Synonymy

1973a Hypolepis spinysporis Martin, p.8, figs 23,24.

Remarks: The spines on this species are variable in both density and dimensions, possibly in some cases as a result of corrosion. Martin (1973a) has noted a similar variability in her specimens.

Dimensions: 27 (31) 39 µm in length x 17 (21) 22 µm in width

Occurrence: Found in samples from Kiandra (rare) and Cadia (rare to common).

Reported Stratigraphic Range: Rare in ?Upper Pliocene deposits in New South Wales (Martin, 1973a).

Botanical Affinities: Martin (1973a) has compared this species with spores of _Hypolepis_ _muelleri_ N.A. Wakef. and _H_. _tenuifolia_ Bernh. Spores of _H_. _tenuifolia_ seen by the author are similar.

Anteturma POLLENITES Potonié 1931

Turma SACCITES Erdtman 1947 ex Potonié 1958

Subturma DISACCITES Cookson 1947 ex Potonié 1958

Genus _Podocarpidites_ Cookson ex Couper 1953 emend.

Type species: _Podocarpidites_ _ellipticus_ Cookson 1947, designated by Couper, 1953.

Remarks: The genus _Podocarpidites_ was proposed by Cookson (1947b, p.131) for fossil pollen grains of podocarpaceous affinities with two air sacs. Couper (1953, p.35) emended Cookson's original diagnosis to include pollen with more than two air sacs. It appears that this genus is in need of revision, with a more precise array of form species to accommodate the diversity of bisaccate grains seen in Tertiary assemblages. In the course of this study, numerous bisaccate grains assignable to this genus were seen, especially in samples from Kiandra, but they were difficult to place in already described species.

As single species of living podocarps can vary considerably in both grain size and relative grain proportions within and between populations of single species (Martin, 1959), a wide range of variation was allowed for in each of the fossil species included here. Statistical analyses may be needed to help place these grains into discrete form taxa. One distinctive type, distinguished generally by size from all other bisaccate podocarpaceous grains in these samples, has been included in this section as *Podocarpidites* sp.; all other bisaccate grains referable to this genus have been treated simply as *Podocarpidites* undifferentiated.

Podocarpidites ellipticus Cookson 1947
(Plate 8, figure 1; Plate 9, figure 2)

For synonymy to 1965, see Harris, 1965a, p.85.

1973a *Podocarpus elliptica* (Cookson), Martin, p.15, figs 59,60.

Remarks: This species was the most common saccate grain found. It occurs in almost all samples from all three localities, and has been widely reported from Mesozoic and Tertiary deposits throughout Australia.

Dimensions: corpus width 24 (29) 34 µm corpus height 22 (29) 38 µm
total width 38 (49) 60 µm total height 23 (32) 49 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Widely reported from Mesozoic and Tertiary deposits in Australia (Balme, 1957; Dettmann, 1963; Harris, 1965a; 1965b; Martin, 1973a; Hos, 1975). Also occurs in Paleocene deposits from Ninetyeast Ridge (Harris, 1974), lignites of middle Miocene age from Kerguelen (Cookson, 1947b), and Mesozoic and Tertiary deposits from New Zealand (Couper, 1953; 1960).

Botanical Affinities: Resembles several species of Podocarpus, and also Dacrydium laxifolium Hook. f., which is described in Cranwell, 1940.

Podocarpidites marwickii Couper 1953

(Plate 8, figures 2,3)

Synonymy

1953 Podocarpidites marwickii Couper, p.36, Pl.4, fig.39.

1960 Podocarpidites marwickii Couper, Couper, p.45, Pl.4, figs 10,11.

Remarks: The large, rather delicate sacci patterned with an incomplete reticulum and the fine pattern on the corpus are similar to Couper's species. The sacci are commonly wrinkled and distorted, and appear fragile. These grains are easily distinguished from other bisaccate grains found in these samples. This species is more abundant in samples from Kiandra than in those from Nerriga and Cadia.

Dimensions:	corpus width 32-44 µm	corpus height 36-39 µm
	total width 50-70 µm	saccus height 25-44 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Occurrence: Couper gives the range of this species in New Zealand as Lower Cretaceous to Lower Oligocene (1953) and later (1960) as Lower Cretaceous to Upper Eocene.

Botanical Affinities: With the Podocarpaceae.

Podocarpidites cf. P. multesimus (Bolkovitina) Pocock 1963

(Plate 8, figure 4)

Synonymy

1963 Podocarpidites cf. P. multesimus (Bolkovitina) Pocock, Dettmann, p.103, Pl.XXV, figs 13-16.

Remarks: Several bisaccate grains with large sacci in relation to corpus size, comparable to P. multesimus, were found in samples from Kiandra. They are smaller but otherwise similar to the specimens described by Dettmann (1963).

Dimensions: corpus width 30 (35) 40 µm corpus height 30 (35) 44 µm
total width 50 (61) 72 µm saccus height 38-52 µm

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: Similar grains are infrequent in Upper Mesozoic deposits of southeastern Australia (Dettmann, 1963).

Botanical Affinities: Probably with the Podocarpaceae.

Podocarpidites sp.

(Plate 8, figure 5; Plate 9, figure 2)

Description: Grain free, anisopolar, bilateral, bisaccate. Corpus subcircular to elliptical in polar view, furrow well-defined, smooth. Rest of corpus finely reticulate, units of reticulum 1-1.5 µm. Exine of corpus two-layered, 2 µm thick, appears spongy, inner layer slightly thicker than outer layer. Sacci large, coarsely reticulate, distally pendant.

Remarks: This large bisaccate grain was fairly common in several samples from Kiandra, and was found in most samples from Kiandra and Cadia. A few grains were found from Nerriga.

Podocarpidites major Couper 1953 is similar in size and outline, but has a finer more delicate reticulum on the sacci, and a coarser sculpture on the proximal cap. It is reported from the Jurassic of New Zealand.

Dimensions: corpus width 30 (40) 50 µm corpus height 32 (44) 55 µm
total width 60 (73) 85 µm corpus depth 38 µm
(one specimen)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Botanical Affinities: Probably with the Podocarpaceae.

Genus Lygistepollenites Stover & Evans 1973

Type species: Lygistepollenites balmei (Cookson), designated by Stover & Evans, 1973.

Remarks: Stover & Evans (1973, pp.63-64) proposed the genus Lygistepollenites for saccate pollen species previously assigned to Dacrydiumites by Cookson (1956) which lack proximal protuberances between the corpus and proximal roots of the sacci. They have retained the generic name Phyllocladidites Cookson ex Couper 1953 emend. for pollen types such as Phyllocladidites mawsonii Cookson which have these localized thickenings (fuller mention of this will be made later). Much confusion has surrounded the nomenclature of this group of species, and Stover & Evans give a full account of the events surrounding this nomenclatural muddle.

Lygistepollenites florinii (Cookson & Pike) Stover & Evans 1973

(Plate 8, figures 6,7; Plate 9, figure 4)

Synonymy

1953b Dacrydiumites florinii Cookson & Pike, p.479, Pl.3, figs 20-35.

1965a Dacrydiumites florinii Cookson & Pike, Harris, p.87, Pl.26, fig.18.

1968 Dacrydiumites florinii Cookson & Pike, Dettmann & Playford, p.83, Pl.8, fig.3.

1973a Dacrydium florinii (Cookson & Pike), Martin, pp.14-15, figs 57,58.

1973 Lygistepollenites florinii (Cookson & Pike), Stover & Partridge, p.252.

Remarks: Specimens of *Lygistepollenites florinii* exhibit considerable morphological variation. Most grains are bisaccate, but in some specimens the sacci may coalesce to form a continuous "frill" and appear monosaccate, and occasionally trisaccate forms are seen. The three types illustrated show the range of variation in this species. Cookson & Pike (1953b) note that the range of variation seen in this fossil species may indicate the presence of more than one natural species of *Dacrydium*, but they also remark that they found a wide range of variation in bladder development in the living species *D. cupressinum*, and a wide range of size in *D. elatum*.

This species was present in almost all samples.

Dimensions: 36-65 µm x 20-32 µm, overall dimensions

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: *Lygistepollenites balmei* Zone through *Triporopollenites bellus* Zone, middle Paleocene through Miocene, in the Gippsland Basin. Uncommon in Upper Cretaceous deposits in south-eastern Australia (Dettmann & Playford, 1968). Also reported from various Tertiary deposits in New South Wales, Victoria, Tasmania, South Australia, and Western Australia (Cookson & Pike, 1953b; Martin, 1973a). Also found in Oligocene deposits in the Ross Sea, Antarctica (Kemp, 1975).

Botanical Affinities: Similar to pollen of living species of *Dacrydium* group B, which includes *D. araucarioides* Brong. & Gris., *D. balansae* Brong. & Gris., *D. beccarii* Parl., *D. cupressinum* Sol., *D. elatum* Wall., *D. gibbsiae* Stapf., *D. lycopodioides* Brong. & Gris., and *D. novoguineese* Gibbs (Cookson & Pike, 1953b). Specimens with the sacci united into a continuous vesiculate frill resemble *D. guillauminii*, found in New Caledonia, and *D. araucarioides*.

Genus Parvisaccites Couper 1958

Type species (by original designation): Parvisaccites radiatus Couper, 1958.

Parvisaccites catastus Partridge 1973

(Plate 8, figures 8,9)

Synonymy

1973 Parvisaccites catastus Partridge in Stover & Partridge, p.252, Pl.16, figs 5,6.

Remarks: This species was more common in samples from Kiandra than in those from Nerriga. The small size of the sacci relative to the corpus, and the slightly radial pattern and rounded outline of the sacci, readily distinguish this from other bisaccate grains in these samples.

Dimensions: 29 and 30 µm total height x 42 and 45 µm total width (two specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: Upper part of Lygistepollenites balmei Zone into basal part of Proteacidites tuberculatus Zone, late Paleocene into early Oligocene, in the Gippsland Basin.

Botanical Affinities: Partridge (1971) suggested affinity with pollen of Dacrydium bidwillii Hook. f.

Genus Alisporites Daugherty 1941 emend. Jansonius 1971

Type species (by original designation): Alisporites opii Daugherty, 1941.

Remarks: Jansonius (1971) has recently emended the generic diagnosis of Alisporites based on study and re-description of the holotype of A. opii Daugherty. As emended, the new generic diagnosis includes the following features: cappa not strongly thickened, but clearly differentiated from sacci; sacci proximally attached in equatorial region, but distally more or less strongly overlapping the central part; distal bases of sacci not clearly marked, enclosing a cappula that reaches towards the equator; on distal side a generally narrow exinal sulcus is reflected by nexinal folds parallel to and approximately underlying the distal bases of the sacci; sacci not strongly distally pendant, with fine reticulation. This emendation has defined the genus with greater precision, a task certainly warranted for most bisaccate genera at the present time.

Alisporites grandis (Cookson) Dettmann 1963

(Plate 9, figure 1)

For synonymy to 1963, see Dettmann, 1963, p.102.

Remarks: Few specimens of this distinctive bisaccate species were found, and they are much smaller than specimens of Alisporites grandis studied by Dettmann (1963) and Cookson (1954b). Dettmann gives overall dimensions of 78 (102) 136 µm x 56 (73) 97 µm, so that these specimens are just within the minima of her size ranges. Except for size, these grains appear similar to those described from Upper Mesozoic deposits in Australia.

This species is clearly distinct from other bisaccate grains found in these samples. The sacci are attached along the full height of the corpus, are not strongly distally pendant, and are finely reticulate. The size of the reticulum becomes finer towards the bases of the sacci. The margins of the corpus are poorly defined, and the surface is finely reticulate-granulate; size of ornament becomes coarser towards the sacci. In most specimens the furrow was clearly defined, although in a few the margins to the sulcus appeared irregular and gradational, rather than distinct.

Dimensions: 36 (43) 55 μm x 37 (46) 80 μm total height x total width

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Upper Mesozoic deposits in both eastern and Western Australia (Dettmann, 1963; Balme, 1957).

Botanical Affinities: Unknown.

Genus Phyllocladidites Cookson ex Couper 1953

Type species: Phyllocladidites mawsonii Cookson 1947, designated by Couper, 1953.

Remarks: For a full synonymy and discussion of the genus, see Stover & Evans (1973, p.63). They have emended the genus to include only bisaccate grains referable to Phyllocladus with proximal exinal thickenings.

Phyllocladidites mawsonii Cookson ex Couper 1953

(Plate 9, figures 5,6)

Synonymy

1947b Phyllocladidites mawsonii Cookson, p.133, Pl.14, figs 22-28.

1953a Dacrydiumites mawsonii Cookson, p.66, Pl.1, figs 9-26.

1953b Dacrydiumites mawsonii Cookson, p.465, Pl.1, fig.10.

1953 Phyllocladidites mawsonii Cookson, Couper, p.38, Pl.9, fig.135.

1957 Dacrydium mawsonii Cookson, p.53 (addendum).

1960 Dacrydiumites mawsonii (Cookson) Couper, p.43, Pl.3, figs 7-8.

1965a Phyllocladidites mawsonii Cookson, Harris, p.86, Pl.26, figs 13-15.

1967 Phyllocladidites mawsonii Cookson, Cookson & Cranwell, p.209, Pl.3, fig.10.

1968 Phyllocladidites mawsonii Cookson, Dettmann & Playford, pp.83-84, Pl.8, fig.4.

1969 Phyllocladidites mawsonii Cookson, Fasola, p.18, Pl.4, figs 1-4.

1973 Phyllocladidites mawsonii Cookson, Stover & Partridge, p.252 (not illustrated).

Remarks: Although this is one of the few species reported by Cookson from Kiandra (in Gill & Sharp, 1957), very few specimens were found in the present study. This is even more surprising when one realizes that she described very few taxa in an extremely rich assemblage. However, repeated searches through strew slides and new preparations still did not produce additional specimens of P. mawsonii. Partridge (1971) noted that this species was very abundant in coals, but less so in the adjacent clastic sediments in the Gippsland Basin, and therefore plants that produced P. mawsonii may have been part of the coal-producing flora. Few good pollen preparations were obtained from the lignitic layers at Kiandra, and these did not contain P. mawsonii.

Therefore, one must assume that either grains of P. mawsonii occurred in very stratigraphically localized assemblages, which is unusual, or the few grains found were transported from some distance, and the plants producing P. mawsonii were not represented in the flora growing in the vicinity of Kiandra at that time.

Dimensions: 30 x 24-27 µm (three specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Nothofagidites senectus through Triporopollenites bellus Zones, Late Cretaceous (Senonian) through

Miocene, in the Gippsland Basin. Also found in Upper Cretaceous deposits in southeastern Australia (Dettmann & Playford, 1968), various Tertiary deposits throughout southern Australia (Cookson, 1953a; Hos, 1975), and also Upper Cretaceous and Tertiary deposits from Antarctica and South America (Cookson & Cranwell, 1967; Cranwell, 1964; Fasola, 1969). Couper (1960) gives its range in New Zealand as Lower Senonian to Upper Eocene.

Botanical Affinities: Similar to pollen of the Tasmanian species *Dacrydium franklinii* Hook. f., which has similar proximal thickenings.

Genus *Phyllocladus* Rich.

(Plate 10, figure 5)

Phyllocladus palaeogenicus Cookson & Pike 1954

Synonymy

1954a *Phyllocladus palaeogenicus* Cookson & Pike, pp.63-64, Pl.2, figs 1-6.

1960 *Phyllocladus* sp. Couper, p.44, Pl.4, fig.5.

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

Remarks: This species cannot be accommodated in the genus *Phyllocladidites* as emended by Stover & Evans 1973, as it lacks the proximal exinal thickenings found in species such as *P. mawsonii*. At the present time there appears to be no form genus to accommodate this species, so it is therefore retained in *Phyllocladus*. There are few reports of this fossil species from Australian Tertiary deposits since the original work of Cookson & Pike (1954a), although it occurs consistently in most samples from Kiandra, and rarely in samples from Cadia and Nerriga.

Both bisaccate and trisaccate grains conformable with *P. palaeogenicus* were found, although Cookson & Pike make no mention of finding trisaccate forms. Cranwell (1940), in describing the pollen of living New Zealand conifers, notes that the pollen of Phyllocladus glauca Carr. is rarely trisaccate, and it is not certain from her descriptions of P. trichomanoides Don. and P. alpinus Hook. f., the other two species of Phyllocladus found in New Zealand, whether these occur with trisaccate as well as bisaccate grains. Most grains found were unexpanded.

Dimensions: 14-34 x 25-48 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Throughout the Tertiary of the Gippsland Basin (Partridge, 1971), Paleocene of Victoria (Harris, 1965a), and various deposits of Tertiary age from southeastern Australia (Cookson & Pike, 1954a). Also Upper Eocene to present in New Zealand (Couper, 1960), and Paleocene of Ninetyeast Ridge (Harris, 1974).

Botanical Affinities: Probably with Phyllocladus. Both Cookson & Pike (1954a) and Couper (1960) have remarked on the great uniformity of grains of all living species of Phyllocladus.

Subturma POLYSACCITES Cookson 1947

Genus Dacrycarpites Cookson & Pike ex Potonié 1958

Type species: Dacrycarpites australiensis Cookson & Pike, designated by Potonié, 1958.

Dacrycarpites australiensis Cookson & Pike 1953

(Plate 9, figure 7; Plate 10, figure 1)

Synonymy

1953b Dacrycarpites australiensis Cookson & Pike, p.78, Pl.2, figs 27-31; Pl.3., figs 46-51.

1953 Podocarpus dacrydioides Rich, Couper, p.34, Pl.4, fig.34.

1965a Dacrycarpites australiensis Cookson & Pike, Harris, p.87, Pl.26, fig.22.

1973a Podocarpus australiensis (Cookson & Pike), Martin, pp.15-16, figs 61,62.

Remarks: These trisaccate grains are found in almost all samples from Kiandra and Cadia, but are never common. Several aberrant forms were found. In some specimens, the three sacs are fully or partially fused, forming a continuous marginal "frill", or the sacci are unequal in size, with one large and two small or two large and two small sacci. Most specimens had three discrete sacci, very similar in size.

Dimensions: 35-48 µm corpus width
42-67 µm total width (maximum diameter measured)

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Found in various deposits of Tertiary age from Queensland, New South Wales, Victoria, South Australia, and Western Australia (Cookson & Pike, 1953b; Cookson, 1954b; Harris, 1965a; Martin, 1973a).

Botanical Affinities: Cookson & Pike (1953b) compared this pollen with living members of the genus Podocarpus section Dacrycarpus. Pollen from Podocarpus dacrydioides A. Rich., described by Cranwell (1940), is very similar, if not identical, to this species.

Genus Microcachryidites Cookson ex Couper 1953

Type species: Microcachryidites antarcticus Cookson 1947, designated by Couper, 1953.

Microcachryidites antarcticus Cookson 1947

(Plate 10, figures 4,6)

Synonymy

1947b Microcachryidites antarctica Cookson, p.132, Pl. XIII, figs 12-15; Pl.XIV, figs 16-19.

1953 Microcachryidites antarcticus Cookson, Couper, pp.37-38, Pl.9, fig.134.

1954a Microcachryidites antarcticus Cookson, Cookson & Pike, pp.66-67, Pl.2, figs 8-20.

1960 Microcachryidites antarcticus Cookson, Couper, pp.43-44, Pl.3, fig.9.

1963 Microcachryidites antarcticus Cookson, Dettmann, p.103, Pl.XXVI, figs 1-5.

1965a Microcachryidites antarcticus Cookson, Harris, p.87, Pl.26, figs 6,7.

1973a Microcachryidites antarcticus Cookson, Martin, p.16, fig.63.

Remarks: Most specimens found were trisaccate, although two bisaccate grains were seen. Cookson (1947b) notes that Microcachrys tetragona Hook. f. commonly has three sacci but may have from two to six. The New Zealand fossil specimens are predominantly trisaccate (Couper, 1953). Although most of the specimens from Kerguelen were bisaccate, those from Australian Tertiary deposits were generally trisaccate. Two- and four-winged forms were also observed (Cookson & Pike, 1954a).

Dimensions: 23-35 µm x 24-47 µm (four specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: Widely distributed in Upper Mesozoic and Tertiary deposits in Australia (Dettmann, 1963; Cookson & Pike, 1954a; Martin, 1973a; Hos, 1975). Also reported from Tertiary lignites of middle Miocene age from Kerguelen (Cookson, 1947b);

Lower Cretaceous to Oligocene deposits in New Zealand (Couper, 1953; 1960), and Paleocene deposits from Ninetyeast Ridge (Harris, 1974).

Botanical Affinities: Cookson (1947b) noted that these grains are morphologically similar to pollen of *Microcachrys tetragona* Hook. f., at present restricted to Tasmania.

Microcachryidites parvus Couper 1960

(Plate 10, figure 2)

Synonymy

1960 *Microcachryidites parvus* Couper, p.44, Pl.4, figs 1-3.

Remarks: A few small, trisaccate grains conformable with this species were found in samples from Kiandra. The sacci are semicircular, not clearly reticulate, and are distinctly different in structure from *Microcachryidites antarcticus*. These specimens are also smaller.

Dimensions: 22 and 26 µm (two specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: Upper Oligocene to Lower Pleistocene in New Zealand (Couper, 1960).

Botanical Affinities: Unknown.

Genus *Podosporites* Rao 1943

Type species: *Podosporites tripakshi* Rao, 1943.

Podosporites microsaccatus (Couper) Dettmann 1963

(Plate 10, figures 3,8)

For synonymy to 1963, see Dettmann, 1963, p.104.

1965a *Podosporites microsaccatus* (Couper), Harris, p.88, Pl.26, fig.23.

Remarks: This trisaccate grain was present in most samples from Kiandra in low frequencies, but was rarely found in samples from Cadia. Partridge (1971) notes that P. microsaccatus is found mostly in Eocene and early Oligocene, and rarely in Miocene sediments in the Gippsland Basin.

Dimensions: 15-25 µm (maximum diameter)

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Upper Mesozoic and Lower Tertiary deposits in eastern Australia (Dettmann, 1963; Cookson, 1954b; Cookson & Pike, 1954a; Partridge, 1971), Bajocian-Aptian of Western Australia (Balme, 1957), and Albian-Maestrichtian of New Zealand (Couper, 1954; 1960). Also reported from Oligocene deposits in the Ross Sea, Antarctica (Kemp, 1975).

Botanical Affinities: Unknown. Perhaps comparable with Phyllocladus (Cookson & Pike, 1954a).

Turma ALETES Ibrahim 1933

Subturma AZONOLETES Luber emend. Potonié & Kremp 1954

Infraturma GRANULONAPITI Cookson emend. Potonié 1958

Genus Araucariacites Cookson ex Couper 1953

Type species: Araucariacites australis Cookson 1947, designated by Couper, 1953.

Araucariacites australis Cookson 1947

(Plate 10, figures 7,10)

Synonymy

1947b Granulonapites (Araucariacites) australis, Cookson, pp.130-131, Pl.XIII, figs 1-4.

1963 Araucariacites australis Cookson, Dettmann, pp.105-106, Pl.XXVI, fig.15.

1965a Araucariacites australis Cookson, Harris, p.88, Pl.26, fig.24.

1973a Araucariacites australis Cookson, Martin, pp.16-17, fig.64.

Remarks: Pollen of A. australis was found consistently in most samples from all three localities. The granular ornament is distinctive but variable in intensity, and the grains are commonly folded. They may represent fossil species of either Agathis or Araucaria.

Duigan (1966) has recorded both Agathis and Araucaria as macroplant fossils from the Yallourn Coal Seam, where they are the dominant macroplant remains in the brown coals. Partridge (1971, p.158) notes that the pollen itself is rare in the coals, but often abundant in the clastic sediment of the area.

Dimensions: 41 (54) 74 µm

Occurrence: Found in most samples from Nerriga, Kiandra, and Cadia. Rare to common.

Reported Stratigraphic Range: This species has been widely reported from Mesozoic and Tertiary deposits from many parts of the world, and is common in Upper Mesozoic and Tertiary deposits of southeastern Australia (Dettmann, 1963; Harris, 1965a; Martin, 1973a; Hekel, 1972). To date there appear to be no Tertiary reports of this species from Western Australia, although it has been found in Cretaceous deposits (Balme, 1957).

In New Zealand, the known range of A. cf. australis is Jurassic to Lower Oligocene (Couper, 1953).

Botanical Affinities: Cookson (1947b) and Cookson & Duigan (1951) compared this species with both fossil and living araucarian species.

Araucariacites sp.

(Plate 10, figure 9; Plate 11, figures 1,2)

Description: Grain free, spherical, commonly folded, alete. Exine thick, 3-4 µm, two-layered, nexine thin, less than 0.75 µm, homogeneous. Sexine 2 µm, appears two-layered, stratification difficult to discern. Exine ornamented with coarse and fine grana, less than 0.5 µm in diameter, giving a "felted" appearance. Although no aperture is discernible, most grains are deeply folded, which may indicate a thinner area of exine.

Remarks: These grains have a much finer granular ornament and a smaller minimum size than specimens of *A. australis*, which they otherwise resemble. This species has been found only in samples from Kiandra. Based on small size of grains, these specimens may represent a species of *Agathis*.

Dimensions: 26 (48) 74 µm

Occurrence: Found in samples from Kiandra in low frequencies.

Botanical Affinities: Perhaps with the Araucariaceae. Some pollen grains from living species of *Araucaria* have a fine granulate ornament.

Genus *Dilwynites* Harris 1965

Type species (by original designation): *Dilwynites granulatus* Harris, 1965.

Remarks: Harris (1965a) proposed this genus for nonaperturate spheroidal grains that have a coarser granular sculpture than grains referable to *Araucariacites*, and a thick exine.

Dilwynites granulatus Harris 1965

(Plate 11, figure 5)

Synonymy

1965a Dilwynites granulatus Harris, p.88, Pl.27, figs 6,7.

1968 Dilwynites granulatus Harris, McIntyre, pp.178-179, figs 1,2.

1972 Dilwynites granulatus Harris, Hekel, p.7, Pl.1, fig.16.

Remarks: These specimens have a much greater size range than those originally described by Harris, which were 32-40 µm. Hekel (1972) notes that he has found considerable variation in size and sculpture within this species.

Dimensions: 28 (50) 88 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: From within the Tricolpites longus Zone through the Triporopollenites bellus Zone, Paleocene through Miocene, in the Gippsland Basin. Also found in the Paleocene of Victoria (Harris, 1965a), Eocene of Western Australia (Hos, 1975), Tertiary of Queensland (Hekel, 1972), and Paleocene of New Zealand (McIntyre, 1968).

Botanical Affinities: Harris (1965a) has assumed an angiosperm origin for this species, although he added that comparable pollen is found in many taxonomically widely separated genera, for example Cinnamomum, Amborella, Callitris, Diselma, and Neocallitropsis. It may also be produced by a member of the Araucariaceae.

Dilwynites cf. D. tuberculatus Harris 1965

(Plate 11, figure 6)

Remarks: Several grains similar to D. tuberculatus Harris, except for size and thickness of exine, were found in this study. They have been found in samples from Kiandra and Nerriga, and have an ornament of spines and baculae, 2-3 µm high, scattered irregularly over the surface, 1-4 µm apart. The exine is thinner (1-1.5 µm) than that given by Harris (2-2.5 µm), and the grains are much larger (Harris gives a range of 35-45 µm).

Dimensions: 48 (56) 84 µm

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: Harris (1965a) records *D. tuberculatus* consistently throughout the Paleocene of Victoria. Also reported from Upper Eocene deposits in Western Australia (Hos, 1975).

Botanical Affinity: Of possible angiosperm origin (Harris, 1965a).

Turma PLICATES Naumova emend. Potonié 1960
Subturma POLYPLICATES Erdtman ex Potonié 1958

Genus *Ephedripites* Bolkovitina 1953

Type species: *Ephedripites mediolobatus* Bolkovitina, 1953.

Ephedripites notensis (Cookson 1957) comb. nov.

(Plate 11, figures 3,4)

Synonymy

1957 *Ephedra notensis* Cookson, p.45, Pl.9, figs 6-10.
1960 *Ephedra notensis* Cookson, Couper, p.46, Pl.5, figs 1,2.
1973a "*Ephedra*" *notensis* Cookson, Martin, p.17, figs 65,66.

Remarks: These specimens are similar to previously reported occurrences of *E. notensis*. This species is found rarely in samples from Nerriga, and a few grains showed the slight polar thickenings noted by Martin (1973a) in her specimens, although in these specimens there appears to be some separation of the exine layers, rather than a thickening.

Dimensions: 22 (35) 40 µm (six specimens measured)

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: Tertiary deposits in Tasmania, Victoria, and South Australia (Cookson, 1956; 1957). Occurs in Eocene-Oligocene deposits in New South Wales (Martin, 1973a), middle and late Eocene deposits in the Gippsland Basin (Partridge, 1971), and Maestrichtian to Upper Pliocene deposits in New Zealand (Couper, 1960).

Botanical Affinities: Probably with Ephedra, a genus now found in North and South America and Eurasia, although Cookson (1957) mentioned that it is found only in South America. Martin (1973a) notes that this pollen type is not restricted to Ephedra, but makes no mention of other possibilities.

Subturma MONOCOLPATES Wodehouse, Iversen, & Troels-Smith 1953

Remarks: Systematic treatment of the monocolpate group is brief and rather broad, as this group is numerically insignificant in almost all samples, and includes a diverse range of taxa, each represented by only a few specimens. With such a small number of specimens available for study, subdivision into species was considered unwarranted for most genera, and they have been cited simply as spp.

Genus *Liliacidites* Couper 1953

Type species (by original designation): *Liliacidites kaitangataensis* Couper, 1953.

Remarks: Several different species of this genus were represented by one or two specimens only, and they have not been included. Only the two most common reticulate monocolpate liliaceous forms are mentioned in the following section.

Liliacidites lanceolatus Stover 1973

(Plate 11, figures 12,13)

Synonymy

1973 *Liliacidites lanceolatus* Stover in Stover & Partridge, p.253, Pl.16, figs 9,10.

Remarks: These specimens are smaller than those from the Gippsland Basin, which are 37 (40) 44 µm long. The sculpture is similar, with the mesh of the reticulum smaller at the poles than at the equator.

Dimensions: 26 (31) 37 µm in length, 18-22 µm in width

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: *Malvacipollis diversus* through *Triporopollenites bellus* Zones, early Eocene through Miocene, in the Gippsland Basin.

Liliacidites sp.

(Plate 11, figure 8)

Description: Grain free, elliptical, monocolpate. Colpus extends the entire length of grain, or nearly so. Exine 1.5 µm thick, stratification not discernible; reticulate, lumina *ca* 1 µm in diameter, polygonal, equidimensional over entire surface of grain.

Remarks: The uniform size of the reticulum over the entire grain distinguishes this species from *L. lanceolatus*, and the uniform mesh, smaller size, and thinner, less clearly structured exine distinguish it from *L. bainii* Stover 1973.

Dimensions: 26 (33) 44 µm in length, 15 (18) 22 µm in width
(12 specimens measured)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Botanical Affinities: Probably with the Liliaceae.

Genus *Arecipites* Wodehouse 1933 emend. Nichols, Ames, & Traverse 1973

Type species: *Arecipites punctatus* Wodehouse 1933, designated by Potonié, 1958.

Arecipites spp.

(Plate 11, figure 7)

Remarks: Several monocolpate grains referable to this genus were found. Because of their extreme rarity, only a mention of their occurrence in these samples is made, and they have not been described to species level. *Arecipites* sp., figured by Hekel (1972, p.7, Pl.3, fig.11) from Tertiary deposits in Queensland, is very similar to the specimen illustrated here.

Dimensions: 40, 41, and 44 µm (three specimens measured)

Occurrence: Rare, in samples from Kiandra and Cadia.

Botanical Affinities: Possibly with the Palmae. Some pollen from living species of the Amaryllidaceae, for example *Calostemma purbureum*, is also similar.

Genus *Monosulcites* Cookson ex Couper 1953

Type species: *Monosulcites minimus* Cookson 1947, designated by Couper, 1953.

Remarks: The genus *Monosulcites* was erected by Cookson (1947b) and later validated by Couper (1953), who designated a type species. The diagnosis of the genus is broad (Couper, 1953, p.65): "Free, anisopolar, monosulcate. Grain elongate to subcircular. Exine variable in thickness and sculpture. Size variable." On the basis of this diagnosis, there would appear to be some overlap with other monocolpate genera, especially *Liliacidites* Couper and *Arecipites* Wodehouse. In their revision of monocolpate genera, Nichols, Ames, and Traverse (1973) have clearly distinguished *Liliacidites* from *Arecipites* on the basis of exine structure; *Liliacidites* is reticulate, with non-tectate exine, whereas *Arecipites* is tectate, with a psilate to finely scrobiculate sculpture. They made no mention of the genus *Monosulcites*, which is here retained as a "neutral" genus, appropriate for this species which is not reticulate and lacks clearly differentiated exine stratification.

Monosulcites verrucosus sp. nov.

(Plate 11, figures 9,10,11)

Description: Grain free, monosulcate, oval to subcircular in polar view. Colpus ½ to 2/3 length of grain, well defined. Exine thin, 0.5-0.75 µm, two-layered, stratification difficult to discern.

Nexine very thin; sexine less than 1 µm, ornamented by scattered grana and apiculae, 0.5-0.75 µm high, 0.5 µm in diameter, up to 3 µm apart. Surface of grain has a scabrate to warty appearance.

Holotype: Specimen on slide 028/1 (987-152), 26 µm in diameter, illustrated on Pl.11, fig.10. The holotype is 26 µm long; preserved in distal aspect. The grain is ovoid; suture is straight, incised, 14 µm long. Exine is two-layered, and less than 1 µm thick. Nexine very thin; sexine thicker, with low ornament of scattered grana and apiculae, up to 0.75 µm high, 0.5-2 µm apart.

Type locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of name: From verruca, Latin, wart; verrucosus, full of warts, for the appearance of the low, coarse sculpture.

Remarks: This small grain shows some similarities to Monosulcites spinosus Martin 1973, but differs by having a sparser and more reduced ornament.

Dimensions: 18 (23) 29 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Botanical Affinities: Unknown. Pollen of Astelia alpina, of the Liliaceae, is comparable in size and general morphology, although the ornament consists of low, more sharply pointed spines and the exine is thicker. Pollen of some species of Lomandra (Xanthorrhoeaeceae) is also comparable, although the pollen seen had thicker exines and a more regularly arranged sculpture.

Subturma TRIPTYCHES Potonié 1960

Genus Beaupreaidites Cookson ex Couper 1953 emend. A.R.H. Martin 1973

Type species: Beaupreaidites elegansiformis Cookson 1950, designated by Couper, 1953.

Remarks: A.R.H. Martin (1973) has emended the generic diagnosis to clarify the nature of the apertures. In both fossil species of Beaupreaidites and in pollen of living Beauprea the apertures are colpoids, with irregular thin margins and thinned exine in this region. Tricolporate and tricolporoidate grains are clearly excluded from this genus as now emended.

Beaupreaidites elegansiformis Cookson ex Couper 1953

(Plate 12, figure 2)

Synonymy

1950 Beaupreaidites elegansiformis Cookson, p.168, Pl.1, figs 2-4.

1965a Beaupreaidites elegansiformis Cookson, Harris, p.91, Pl.28, fig.4.

1969 Beaupreaidites elegansiformis Cookson, Fasola, p.28, Pl.7, fig.8.

1973 Beaupreaidites elegansiformis Cookson, Stover & Partridge, pp.253-254 (not illustrated).

1973 Beaupreaidites elegansiformis Cookson, Stover & Evans, Pl.3, fig.6.

Remarks: Only a few specimens were found in lignite samples from Kiandra. The colpi were commonly torn and gaping, but these specimens appear similar in size and ornament to previous descriptions.

Dimensions: 40, 44, 45, and 48 µm (four specimens measured)

Occurrence: Found in lignite samples from Kiandra. Rare.

Reported Stratigraphic Range: Malvacipollis diversus through Triporopollenites bellus Zones, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also reported from the Paleocene of Victoria (Harris, 1965a), Upper Eocene of Western Australia (Hos, 1975), Upper Cretaceous of New Zealand (Couper, 1953), and middle Tertiary of Chile (Fasola, 1969).

Botanical Affinities: Cookson (1950, p.168) has compared this species with pollen of Beauprea elegans Brongn. & Gris., and these grains are very similar to pollen of that species seen by the author. The genus Beauprea consists of ten species, all at present confined to New Caledonia.

Beaupreaidites verrucosus Cookson 1950

(Plate 12, figure 1)

Synonymy

1950 Beaupreaidites verrucosus Cookson, p.169, Pl.1, figs 6,7.

1973 Beaupreaidites verrucosus Cookson, Stover & Partridge, p.254 (not illustrated).

Remarks: Only a few specimens referable to this species were found in samples from Kiandra. Except for the gemmae and verrucae scattered irregularly over the surface, they are similar in morphology to B. elegansiformis.

Dimensions: 32 µm (one specimen measured)

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: Malvacipollis diversus into the Proteacidites tuberculatus Zone, early Eocene into early Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Cookson (1950) compared this species to pollen of Beauprea spathulaefolia.

Genus *Gothanipollis* Krutzsch 1959

Type species (by original designation): *Gothanipollis gothani* Krutzsch, 1959.

Gothanipollis cf. *G. gothani* Krutzsch 1959

(Plate 12, figures 6,7)

cf. 1959 *Gothanipollis gothani* Krutzsch, p.237, Pl.47, figs 564-569.

Remarks: Several specimens of this small, easily overlooked species were found in samples from Kiandra and Cadia. In outline, the apices are truncated and the sides concave, with the colpi commonly gaping. The exine is thin, less than 1 µm, and stratification is indistinct. The surface of the grain appears smooth. Apical cushions appear to be absent; this feature is well-developed in specimens of *G. gothani*. These specimens are smaller than *G.* cf. *G. bassensis*, and have more truncated, slightly recurved apices.

Dimensions: 12 (16) 18 µm (seven specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: *Gothanipollis gothani* was originally described from Middle Eocene coals from Germany.

Botanical Affinities: Possibly with the Loranthaceae (Krutzsch, 1969). Elsik & Dilcher (1974) note affinities with the genera *Gaiadendron* and *Phrygilanthus* of the Loranthaceae for the genus *Gothanipollis*.

Gothanipollis cf. *G. bassensis* Stover 1973

(Plate 12, figure 9)

cf. 1973 *Gothanipollis bassensis* Stover in Stover & Partridge, p.254, Pl.17, figs 13-16.

Remarks: These grains are larger than *G.* cf. *G. gothani*, and ornamented rather than psilate. They resemble *G. bassensis* but are larger, have a slightly thicker and distinctly stratified exine, and narrower apices. These specimens have slightly raised air cushions bordering the arci; Stover makes no mention of the presence or absence of this feature in *G. bassensis*.

Dimensions: 22 (24) 26 µm (seven specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: *G. bassensis* has a range in the Gippsland Basin from the Lower *Nothofagidites asperus* Zone into the lower part of the *Proteacidites tuberculatus* Zone, middle Eocene through Oligocene (Stover & Partridge, 1973).

Botanical Affinities: Possibly with the Loranthaceae (Krutzsch, 1969). Some pollen of living species of *Loranthus* seen by the author is similar in morphology but much larger, *ca* 40-45 µm.

Genus *Tricolpites* Cookson ex Couper 1953

Type species: *Tricolpites reticulatus* Cookson 1947, designated by Couper, 1953.

Tricolpites delicatulus Couper 1960

(Plate 12, figure 4)

Synonymy

1960 *Tricolpites delicatulus* Couper, p.65, Pl.10, figs 23,24.

1973a *Tricolpites delicatulus* Couper, Martin, p.39, fig.170.

Remarks: These specimens are similar in size and morphology to those described from New Zealand, and are larger but otherwise similar to those described by Martin (1973a) from New South Wales. This species is found in low frequencies in samples from all three localities.

Dimensions: 28 (34) 40 µm polar diameter, 15 (17) 20 µm equatorial diameter (six specimens measured)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Upper Oligocene to Middle Miocene of New Zealand (Couper, 1960), and Eocene-Oligocene of New South Wales (Martin, 1973a).

Botanical Affinities: Unknown.

Tricolpites cf. _T. pachyexinus_ Couper 1953

(Plate 15, figure 2)

cf. 1953 _Tricolpites pachyexinus_ Couper, p.62, Pl.8, figs 120,121.

cf. 1960 _Tricolpites pachyexinus_ Couper, Couper, p.64, Pl.10, fig.22.

cf. 1968 _Tricolpites pachyexinus_ Couper, Dettmann & Playford, p.84, Pl.8, figs 9,10.

Remarks: The thick exine relative to size and the long, smooth colpi distinguish this from other tricolpate species found in these samples. These grains are smaller and have a thinner exine than _T. pachyexinus_ as described by Couper (1953; 1960).

Dimensions: 21 (25) 30 µm equatorial diameter (five specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: Upper Cretaceous deposits from Australia and New Zealand (Dettmann & Playford, 1968; Couper, 1953; 1960).

Botanical Affinities: Unknown.

Tricolpites psilatus Martin 1973

(Plate 12, figure 3)

Synonymy

1973a Tricolpites psilatus Martin, p.40, figs 172,173.

Remarks: These specimens are larger than those described by Martin (her size range is 11 (14) 16 µm) but are otherwise similar. In polar view the grains are nearly circular, in equatorial view prolate to nearly circular. The exine is clearly two-layered and smooth.

Martin (1973a) notes that this species occurs only with Nothofagus.

Dimensions: 13 (17) 24 µm polar diameter
11 (13) 15 µm equatorial diameter
(five specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Rare in Eocene-Oligocene and ?Upper Pliocene deposits in New South Wales (Martin, 1973a).

Botanical Affinities: Unknown.

Tricolpites punctaticulus McIntyre 1968

(Plate 12, figure 5)

Synonymy

1968 Tricolpites punctaticulus McIntyre, pp.187-190, figs 35-37.

Remarks: These grains are slightly larger than those described by McIntyre (1968), but are otherwise similar.

Dimensions: 15 (16) 21 µm polar diameter, 9-12 µm equatorial diameter (seven specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Miocene deposits in New Zealand (McIntyre, 1968).

Botanical Affinities: McIntyre (1968) noted similarities to *Weinmannia* pollen, which, however, has equatorial pores.

Tricolpites patulus sp. nov.

(Plate 12, figures 8,10,12)

Diagnosis: Grain tricolpate, with circular amb. Colpi long, straight, commonly gaping. Sculpture of a uniform, clearly defined reticulum.

Description: Grain free, isopolar, radiosymmetric, tricolpate. Amb circular; oblate in equatorial view. Colpi long, straight, margins smooth and appear slightly thickened; commonly gaping. Exine 1-1.5 µm thick, stratification indistinct. Sexine clavate-reticulate, lumina *ca* 1 µm in diameter, circular to polygonal, elongated in some specimens. Muri 0.5 µm wide, 1 µm high, underlain by single row of columellae. Size of reticulum uniform over grain.

Remarks: This species is similar in size, but more finely and uniformly reticulate than *T. incisus* Stover 1973 described from the Gippsland Basin. It does not resemble any other described Australian Tertiary species.

Dimensions: 22 (27) 31 µm equatorial diameter (seven specimens measured)

Occurrence: Found in samples from Nerriga in low frequencies.

Botanical Affinities: Unknown.

Holotype: Specimen on slide 147/2 (1082-222), 31 μm in diameter, illustrated on Plate 12, figure 8.

Type locality: Nr Nerriga, G.R. 3084 6656, 22.5-30 cm above base of section at Titringo Creek.

Derivation of name: From patulus, Latin, for spread out, open, in reference to the expanded condition of the colpi found in most specimens seen in this study.

Tricolpites cancellatus sp. nov.

(Plate 15, figures 1,3)

Diagnosis: Grain tricolpate, with circular to rounded triangular amb. Exine ornamented with a coarse, clavate-reticulate sculpture.

Description: Grain free, isopolar, tricolpate. Amb circular to rounded triangular, generally circular in equatorial view. Colpi long, about 2/3 length of grain, obscured by ornament. Exine thick, stratification not apparent, clavate-reticulate, lumina irregularly polygonal in shape, varying in diameter from less than 1 μm to 3 μm, most commonly 1.5-2 μm. In places, smaller lumina, less than 1 μm, are interspersed. Muri simplibaculate, ca 0.5 μm in diameter, clavate, up to 2.5 μm high. Size of reticulum smaller at poles than at equator.

Remarks: This species resembles Tricolpites geranioides Couper 1960, described from the Upper Miocene of New Zealand, but is much smaller (Couper's specimens have a polar diameter of 47-66 μm, equatorial diameter of 37-47 µm), and is circular in outline. The size of the mesh is similar. No other species described from Australian or New Zealand Tertiary deposits has such a coarse reticulum.

Dimensions: 23 (25) 27 µm maximum diameter

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Botanical Affinities: Unknown.

Holotype: Specimen on slide 028/4 (972-209), 24 µm polar diameter, illustrated on Pl.15, fig.1. Grain oriented in polar view.

Type locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of name: From cancellus, Latin, for lattice, in reference to the sculpture.

Subturma PTYCHOTRIPORINES Potonié 1960

Genus *Intratriporopollenites* (Thomson & Pflug) emend. Mai 1961

Type species: *Intratriporopollenites* (al. *Tiliaepollenites*) *instructus* (R. Pot.) Thomson & Pflug, 1953.

Intratriporopollenites notabilis (Harris) Stover 1973

(Plate 14, figure 13)

Synonymy

1965a *Tiliaepollenites notabilis* Harris, p.91, Pl.28, figs 2,3.

1968 *Tiliaepollenites notabilis* Harris, McIntyre, p.194, fig.54.

1972 *Tiliaepollenites notabilis* Harris, Hekel, p.15 (not illustrated).

1973 *Intratriporopollenites notabilis* (Harris) Stover, Stover & Partridge, p.257 (not illustrated).

Remarks: Specimens found in these samples conform with previously described occurrences from Victoria and the Gippsland Basin. This large, distinctly ornamented grain has prominent thickening of the exine adjacent to the apertures.

Dimensions: 48 (54) 60 µm (equatorial diameter)

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: *Malvacipollis diversus* and *Proteacidites asperopolus* Zones, early Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria (Harris, 1965a), ?Paleocene to Oligocene of Queensland (Hekel, 1972), and Paleocene of New Zealand (McIntyre, 1968).

Botanical Affinities: Harris (1965a) compares this to pollen of *Tilia*.

Genus *Gemmatricolporites* Leidelmeyer 1966

Type species (by original designation): *Gemmatricolporites berbicensis* Leidelmeyer, 1966.

Gemmatricolporites cf. *G. gestus* Partridge 1973

(Plate 14, figure 11; Plate 15, figure 4)

cf. 1973 *Gemmatricolpites gestus* Partridge in Stover & Partridge, p.257, Pl.19, fig.4.

Remarks: These specimens are smaller than those described from the Gippsland Basin. The sculpture is very irregular, with large scattered verrucae and gemmae. The colpi are short, with thickened margins, and the pores are indistinct. Partridge made no mention of thickening of colpi margins in his description, and his illustrated specimen appears to lack this feature.

Dimensions: 30, 30, and 36 µm (three specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: For G. gestus, Lower Nothofagidites asperus Zone, middle to late Eocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Genus Tricolporites Cookson 1947

Type species: Tricolporites sphaerica Cookson, 1947, monotypic when proposed.

Remarks: The broad diagnosis of the genus as emended by Stover & Partridge (1973) is followed here, to include tricolporate grains with exine variable in thickness and sculpture.

Tricolporites sphaerica Cookson 1947

(Plate 12, figure 11; Plate 15, figure 5)

Synonymy

1947a Tricolporites sphaerica Cookson, p.195, Pl.9, figs 14,15.

1973 Tricolporites sphaerica Cookson, Stover & Partridge, p.259, Pl.18, figs 5-7.

1973a Tricolporopollenites sphaericus (Cookson), Martin, p.43.

Remarks: A large range of variation in exine thickness, size of reticulum, general shape, and variation in exine thickness within a single specimen was noted in these specimens. Stover & Partridge

(1973) noted a similar wide range of variation in their study of topotype material. The shape of the grain in equatorial view varied from oblate to prolate, although most grains were subspherical.

This species was found consistently in almost all samples. There were also several specimens found in samples from Nerriga that were similar to *T. sphaerica* in morphology, but were much larger, *ca* 45 µm in diameter, within the size range of *T. microreticulatus* Harris (see Pl.15, fig.5). Stover & Partridge (1973) have suggested the possibility of *T. sphaerica* and *T. microreticulatus* being conspecific, pending further study. An insufficient number of specimens of this large, somewhat intergradational type were found in these samples, and at present the two separate species have been retained.

Dimensions: 19 (29) 34 µm polar diameter
18 (24) 28 µm equatorial diameter

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Lower *Nothofagidites asperus* Zone to the *Triporopollenites bellus* Zone, late Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Rare in Eocene-Oligocene and upper Pliocene deposits in New South Wales (Martin, 1973a).

Botanical Affinities: Cookson (1947a) suggested possible affinities with the Oleaceae, as pollen of similar morphology is found in *Olea paniculata* (from Queensland), *O. cunninghami* (New Zealand), *O. montana* (New Zealand), and *O. europaea*. Grains of *Olea paniculata* and *O. europaea*, seen by the author, are comparable; some genera of the Rutaceae, for example *Acronychia*, also have similar pollen.

Tricolporites microreticulatus Harris 1965

(Plate 12, figure 14)

Synonymy

1965a *Tricolporites microreticulatus* Harris, p.96, Pl.27, fig.17.

1972 *Tricolporites microreticulatus* Harris, Hekel, p.12, Pl.3, figs 7,8.

Remarks: The specimens from Nerriga are similar in size and morphology to those described by Harris, although the width of the lips bordering the colpi is a feature with a large range of variation.

Specimens with similar morphology but a smaller size range were found at Kiandra and Cadia.

Dimensions: 30 (39) 44 µm at Nerriga; 20 (28) 30 µm at Kiandra and Cadia

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Reported from the Paleocene of Victoria and in lower Tertiary sediments of southern Australia and the Great Artesian Basin (Harris, 1965a), and common in Tertiary deposits from Queensland (Hekel, 1972).

Botanical Affinities: Unknown.

Tricolporites paenestriatus Stover 1973

(Plate 12, figure 15)

Synonymy

1973 *Tricolporites paenestriatus* Stover in Stover & Partridge, pp.259-260, Pl.19, fig.1.

Remarks: These specimens are slightly larger but otherwise similar to those described from the Gippsland Basin. The rugulate to roughly striate pattern formed by the sexine ridges distinguish this from other species of the genus.

Dimensions: 27 (35) 39 µm

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: From within the *Lygistepollenites balmei* Zone through the Lower *Nothofagidites asperus* Zone, early Eocene into late Eocene (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Tricolporites cf. *T. angurium* Partridge 1973

(Plate 12, figure 13)

cf. 1973 *Tricolporites angurium* Partridge in Stover & Partridge, p.259, Pl.18, fig.10.

Remarks: These grains have a wider size range and are generally smaller than those reported from the Gippsland Basin, and in equatorial view are prolate to perprolate, rather than prolate to subprolate, as described by Partridge. The long colpi with indistinct ora and delicate reticulate ornament distinguish this from other tricolporate grains found in these samples.

Dimensions: 25 (29) 40 µm x 15 (17) 20 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: *T. angurium* is reported from the Lower *Nothofagidites asperus* Zone, middle into late Eocene, in the Gippsland Basin.

Botanical Affinities: Unknown.

Tricolporites cf. I. endobalteus (McIntyre 1965)

(Plate 13, figure 3)

cf. 1965 Tricolporopollenites endobalteus McIntyre, p.211, figs 27-29.

Remarks: These small tricolporate and tetracolporate grains are found in greater abundance at Cadia than at Kiandra. Less than half the grains were tetracolporate, a feature also noted by Martin (1974) in her specimens of I. endobalteus, although in his original description McIntyre made no mention of tetracolporate specimens.

The size range of these grains is much larger than in previous reports of I. endobalteus, and in many specimens the transverse colpus appears more like a pore. The specimens found in these samples are not as obviously thickened near the ora as those illustrated by McIntyre.

Dimensions: 12 (18) 25 µm

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Oligocene to Miocene in New Zealand (McIntyre, 1965), middle Eocene through Pliocene in New South Wales (Martin, 1974), and from the Matonisporites ornamentalis Zone into the Triporopollenites bellus Zone, where it is most common, from the onshore part of the Gippsland Basin (Partridge, 1971).

Botanical Affinities: Martin (1974) has reported this species as very similar to living species of Macaranga and Mallotus, of the Euphorbiaceae. Pollen of Macaranga inomoena, M. quadriglandulosa, and Mallotis angustifolium, seen by the author, are comparable.

Tricolporites prolata Cookson 1947

(Plate 13, figure 7)

Synonymy

1947b Tricolporites prolata Cookson, p.134, Pl.XV, fig.46.

1965a Tricolporites prolata Cookson, Harris, p.96, Pl.27, figs 14-16.

1974 Tricolporites prolata Cookson, Harris, Pl.3, figs 9,10.

Remarks: Smooth to scabrate, small tricolporate grains included in this species were common in samples from Kiandra and Cadia, and rarely found in samples from Nerriga. In equatorial view, the grain outline varied from prolate to almost circular, and the pores were distinct.

Dimensions: 13 (17) 22 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Originally described from Tertiary lignites of probable middle Miocene age from Kerguelen (Cookson, 1947b); also reported from the Paleocene of Victoria and Paleocene of Ninetyeast Ridge (Harris, 1965a; 1974).

Botanical Affinities: Unknown.

Tricolporites scabratus Harris 1965

(Plate 13, figure 1)

Synonymy

1965a Tricolporites scabratus Harris, p.97, Pl.27, figs 18,19.

1973 Tricolporites scabratus Harris, Stover & Partridge, p.260, Pl.19, fig.2.

Remarks: In size and morphology these specimens are very similar to those described by Harris (1965a). In a few specimens, the exine is thicker, up to 4 µm, and the two layers appear homogeneous, with no discernible structure. In other grains, a very faint columellar layer is visible.

Dimensions: 36 (45) 52 µm

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: *Malvacipollis diversus* through Lower *Nothofagidites asperus* Zone, early Eocene into late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria, and elsewhere in Eocene sediments of southern Australia (Harris, 1965a). A similar form has been described from the Paleocene of Argentina (Archangelsky, 1973).

Botanical Affinities: Unknown.

Tricolporites retequetrus Partridge 1973

(Plate 13, figures 2,5)

Synonymy

1973 *Tricolporites retequetrus* Partridge, Stover & Partridge, p.260, Pl.19, figs 8,9.

Remarks: The reticulate pattern on the equatorial area between the apertures and the smooth to scabrate polar area distinguish this species readily. Only individual grains were seen, although Partridge notes that this species can be found united in tetrads.

Dimensions: 32 (38) 44 µm (seven specimens measured)

Occurrence: Found only in samples from Kiandra. Rare.

Reported Stratigraphic Range: From within the Lower *Nothofagidites asperus* Zone through the *Proteacidites tuberculatus* Zone, late Eocene to early Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Tricolporites valvatus Harris 1972

(Plate 13, figure 6)

Synonymy

1972 Tricolporites valvatus Harris, p.54, figs 8,9.

Remarks: A few specimens of this distinctive tricolporate species were found in samples from Nerriga. The smooth exine and strongly inturned colpi readily distinguish this from other species of the genus. These specimens are smaller than those described by Harris (his specimens had a polar diameter of 45 (52) 55 μm).

Dimensions: 36 (42) 48 μm

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Middle Eocene (Proteacidites confragosus Zonule) assemblages in southern Australia (Harris, 1972).

Botanical Affinities: Unknown.

Tricolporites sp. 1

(Plate 13, figure 4)

Description: Grain free, radiosymmetric, isopolar, tricolporate. Circular in polar view, no equatorial view seen. Exine thick, 3-4 μm, two-layered and homogeneous. Nexine 1 μm thick, of uniform thickness. Sexine 2-3 μm, thinning towards apertures to 1-2 μm. Colpi smooth, short, index polaris 0.4; pore 4-5 μm in diameter.

Exine very faintly reticulate, lumina less than 1 μm in diameter, muri less than 1 μm in maximum width.

Remarks: This large, tricolporate grain is unlike any previously described species from Australian Tertiary deposits. It occurs rarely in most samples from Kiandra and Cadia.

Dimensions: 36 (55) 66 µm (seven specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Botanical Affinities: Unknown.

Tricolporites sp. 2

(Plate 13, figure 7)

Description: Grain free, radiosymmetric, isopolar, tricolporate. Grain oblate to subspherical. Exine 1.5-2 µm thick, sexine and nexine approximately equal in thickness, in some specimens a faint columellar layer discernible. Colpi short, becoming indistinct towards poles. Cross-colpus 4-6 µm long, edges indistinct in some specimens. Exine ornamented by a fine, uniform reticulum, with lumina ca 1 µm in diameter, and muri ca 1 µm wide.

Remarks: This species resembles Tricolporopollenites ivanhoensis Martin 1973, which is slightly smaller and has a wider cross-colpus.

Dimensions: 24 (26) 30 µm (seven specimens measured)

Occurrence: Found in samples from Nerriga in low frequencies.

Botanical Affinities: Martin (1973a) notes that pollen of similar morphology is found in many dicotyledonous families, for example, Rubiaceae, Rutaceae, Euphorbiaceae, Araliaceae, and Umbelliferae.

Tricolporites sp. 3

(Plate 13, figure 8; Plate 14, figure 1)

Description: Grain free, isopolar, radiosymmetric, tricolporate. Amb circular, equatorial view not seen. Colpi long, straight, almost reaching poles, bordered by prominent, thick margins, 3-4 µm wide. Pore diameter 6 µm (one measurement only). Exine layers clearly visible. Reticulate sexine, up to 2 µm thick in intercolpal areas, thinning to less than 1 µm adjacent to colpi margins. Nexine thin, 0.5 µm thick between colpi. Adjacent to colpus, nexine thickens to 3 µm, forming a rigid, raised margin. Size of mesh of reticulum is smaller towards the poles. Size of lumina and muri less than 1 µm at equator, reduced to less than 0.5 µm at poles.

Remarks: Only six specimens, all in polar orientation, were seen. This species differs from T. sp. 5 in having thickened and raised margins to the colpi, and having a difference in mesh size over the grain surface; the mesh of the reticulum is reduced at the poles. *Tricolpites mataurensis* Couper has similar colpus margins, although the margins are wider in the specimens illustrated by Couper and Martin and are smooth. *T. mataurensis* is tricolpate.

Dimensions: 44 (48) 52 µm (six specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Botanical Affinities: Unknown.

Tricolporites sp. 4

(Plate 13, figure 10)

Description: Grain free, isopolar, radiosymmetric, tricolporate. Amb circular, prolate in equatorial view. Colpi long, not reaching poles, ends pointed to blunt. Ora distinct, large (4-5 µm high, 4-6 µm wide), circular to lalongate. Exine 2-2.5 µm thick, exine thickness constant between poles and equator. Stratification distinct, sexine thicker than nexine, columellae faint, single rows forming a faint reticulum of uniform size, lumina ca 0.5 µm in diameter, a finely pitted ornament in surface view.

Remarks: The large distinct ora, faint ornament, and relatively thick exine distinguish this species from other tricolporate grains found in these samples. No similar tricolporate species has been described from Australian Tertiary deposits.

Dimensions: 20 (26) 29 µm polar diameter
18-21 µm equatorial diameter
(13 specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies. Only a few specimens have been found in samples from Cadia.

Botanical Affinities: Unknown. Similar grains are found in several families, for example, the Rutaceae.

Tricolporites sp. 5

(Plate 14, figure 2)

Description: Grain free, isopolar, radiosymmetric, tricolporate. Amb circular; equatorial view oblate. Colpi long, straight, without thickened margins. Exine 2 µm thick, of uniform thickness, stratification indistinct. Sexine clavate-reticulate, reticulum mesh uniform over surface of grain, size of units ca 0.75 µm. Pore lalongate, 4 µm wide, 3 µm high.

Remarks: This species has shorter colpi without thickened margins and a coarser, more uniform reticulum than Tricolporites sp. 3.

Dimensions: 30 (37) 44 µm (eight specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Botanical Affinities: Unknown.

Genus *Cupanieidites* Cookson & Pike 1954

Type species: *Cupanieidites major* Cookson & Pike 1954, designated by Krutzsch, 1959.

Cupanieidites major/orthoteichus Cookson & Pike 1954

(Plate 14, figures 8,14)

Synonymy

1954b *Cupanieidites orthoteichus* Cookson & Pike, p.213, Pl.2, figs 73-78.

1954b *Cupanieidites major* Cookson & Pike, pp.213-214, Pl.2, figs 83-85.

1954b *Cupanieidites reticularis* Cookson & Pike, p.214, Pl.2, figs 87-89.

1965a *Duplopollis orthoteichus* (Cookson & Pike), Harris, p.89, Pl.27, figs 20,21.

1973 *Cupanieidites major/orthoteichus* Cookson & Pike, Stover & Partridge, p.257 (not illustrated).

1973a *Duplopollis orthoteichus* (Cookson & Pike), Martin, p.19, fig.77.

Remarks: The apparent intergradation of the two species *C. major* and *C. orthoteichus* when a large number of specimens is available was pointed out by Stover & Partridge (1973, p.257). A large number of specimens was available for study in material from Nerriga, and this was found to be the case. Specimens approaching *C. reticularis* were also part of this general series, so they have, at present, all been put into synonymy as a single variable species group. These specimens show an independent range of variation in the following features: outline in polar view; presence/absence of polar islands; prominence and size of polar islands, arci, and pores; prominence and size of reticulate ornament; and thickness and visible structure of exine.

In the younger material, from Kiandra and Cadia, fewer specimens were found, and they all appeared conformable with *C. orthoteichus*.

Dimensions: 21 (26) 30 µm (equatorial diameter)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare to common.

Reported Stratigraphic Range: *Malvacipollis diversus* Zone through *Triporopollenites bellus* Zone, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria (Harris, 1965a), and various Tertiary deposits from Western Australia, South Australia, Victoria, New South Wales, and Queensland (Cookson & Pike, 1954b; Hos, 1975).

Botanical Affinities: Cookson & Pike (1954b) have compared this species group with several living members of the tribe Cupanieae of the Sapindaceae, at present developed mainly in rainforest areas of northeastern Australia. Pollen of the living species *Castanospora alphandi*, *Cupaniopsis anacardioides*, and *Diploglottis australis*, seen by the author, are all with the range of variation observed in this fossil species group.

Genus *Myrtaceidites* Cookson & Pike ex Potonié 1960

Type species: *Myrtaceidites mesonesus* Cookson & Pike, designated by Potonié, 1960.

Remarks: Although fossil grains belonging to this genus are easily recognizable, it is very difficult to assign them reliably and consistently to fossil species. This is because of their relatively simple morphology, and the range of variability observed in these few morphological features. These features include presence or absence of polar island, size of polar island, general outline, pore morphology, and exine thickness and pattern. Pike (1956), in a study of pollen grains belonging to all living tribes of the family Myrtaceae, found that grains of two different living species within the same genus could vary in these features and, conversely, grains of widely separated genera could be virtually indistinguishable.

As noted by Stover & Partridge (1973, p.254), when a large number of specimens is available it is very difficult to maintain the species described by Cookson & Pike (1954b) because of so many intermediate types. Typical forms of these species are described in the following section, and the intermediates have been ignored systematically, but recorded in the percentage counts. In counts of relative abundances, all myrtaceous grains except *M. eucalyptoides* are included together as *Myrtaceidites* spp.

Myrtaceidites mesonesus Cookson & Pike 1954

(Plate 14, figures 7,10)

Synonymy

1954b *Myrtaceidites mesonesus* Cookson & Pike, pp.205-206, Pl.1, figs 32-36.

1973a *Myrtaceidites mesonesus* Cookson & Pike, Martin, p.23, figs 92,93.

Remarks: This was the most common species of *Myrtaceidites* seen in these samples. As in other species of this genus, the range of variability is large, and grains approaching the morphology of *M. eucalyptoides* were seen. Several grains that could be referred to *M. protrudiporens* Martin 1973, with protruding pores and some thickening around the edges of the polar island, were found in samples from Kiandra (see Pl.14, fig.7). They have been included with *M. mesonesus* because they are larger (Martin gives a size range of 12-14 μm), lack the faint exine pattern, and have a weaker pore protrusion than seen on the specimens described by Martin (1973a).

Dimensions: 12 (17) 20 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia, in low to moderate frequencies. More abundant in samples from Kiandra and Cadia; rarely found in samples from Nerriga.

Reported Stratigraphic Range: Eocene to Pliocene (Cookson & Pike, 1954b), and Eocene-Oligocene and ?Upper Pliocene and Pleistocene of New South Wales (Martin, 1973a).

Botanical Affinities: Cookson & Pike (1954b) noted that this grain type is similar to certain eucalypts, for example, _E_. _tessellaris_ F. Muell. McWhae (1957) noted that this species is very similar to the living genus _Whiteodendron_, one of the _Tristania_ complex. Martin (1973a) also compared this grain type to _Metrosideros_. This type, in fact, has similarities to pollen of a wide range of species belonging to the genus _Eucalyptus_.

Myrtaceidites _parvus_ Cookson & Pike 1954

(Plate 14, figure 4)

Synonymy

1954b _Myrtaceidites_ _parvus_ Cookson & Pike, p.206, Pl.2, figs 27-31.

1973a _Myrtaceidites_ _parvus_ Cookson & Pike, Martin, pp.23-24, figs 94,95.

Remarks: This small myrtaceous grain type was found in almost all samples from all three localities. The straight to slightly convex sides and very simple morphology distinguish this from other species of the genus. Most grains seen lacked polar islands; when present, they were very small.

Dimensions: 12 (14) 16 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Eocene to Pliocene (Cookson & Pike, 1954b) and ?Upper Pliocene-Pleistocene of New South Wales (Martin, 1973a).

Botanical Affinities: With the Myrtaceae. Species of *Leptospermum*, *Baeckia*, and *Kunzea*, among others, have similar pollen.

Myrtaceidites eugeniioides Cookson & Pike 1954

(Plate 14, figure 5)

Synonymy

1954b *Myrtaceidites eugeniioides* Cookson & Pike, p.204, Pl.1, figs 21-26.

1965a *Myrtaceidites eugeniioides* Cookson & Pike, Harris, p.90, Pl.27, fig.34.

1973a *Myrtaceidites eugeniioides* Cookson & Pike, Martin, pp.22-23, fig.91.

Remarks: The small size, truncate apices, and straight to concave sides are characteristic of this species. Only a few specimens assignable to this species were seen.

Dimensions: 10-14 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: Eocene to Pliocene (Cookson & Pike, 1954b), Paleocene of Victoria (Harris, 1965a), and Eocene-Oligocene and ?Upper Pliocene of New South Wales (Martin, 1973a).

Botanical Affinities: Resembles pollen of living species of the tribe Eugeniinae, especially *Eugenia* and *Cleistocalyx*, seen by the author.

Myrtaceidites eucalyptoides Cookson & Pike 1954

(Plate 14, figures 6,9)

Synonymy

1954b *Myrtaceidites eucalyptoides* forma *orthus* Cookson & Pike, p.205, Pl.1, figs 38-40.

1954b *Myrtaceidites eucalyptoides* forma *convexus* Cookson & Pike, p.205, Pl.1, figs 41-46.

1973a *Myrtaceidites eucalyptoides* forma *convexus* Cookson & Pike, Martin, p.22, figs 88-89.

1973a *Myrtaceidites eucalyptoides* forma *orthus* Cookson & Pike, Martin, p.22, fig.90.

Remarks: Cookson & Pike proposed this species for myrtaceous grains with a pronounced thickening of exine around the apertures, as found in some species of *Eucalyptus*. Martin (1973a, p.22) emended *M. eucalytoides* forma *convexus* to include grains that are not obviously thickened, but that have smooth exine clearly defined around the pore. As not many specimens of this species were found, and all these had a prominent thickening, no comment on this emendation will be made here. Considering the range of variation found within each species assigned to this genus, retention of the subspecific groups erected by Cookson & Pike appears unwarranted at the present time.

This species was more abundant in samples from Cadia, and was only rarely found in samples from Kiandra.

Dimensions: 12 (16) 19 μm

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Pliocene to Pleistocene (Cookson & Pike, 1954b), ?Upper Pliocene and Pleistocene of New South Wales (Martin, 1973a).

Botanical Affinities: This pollen type resembles that of some species of *Eucalyptus*.

Myrtaceidites verrucosus Partridge 1973

(Plate 14, figure 3)

Synonymy

1973 *Myrtaceidites verrucosus* Partridge in Stover & Partridge, p.254, Pl.17, figs 17-19.

Remarks: Only a few specimens of this distinctive ornamented myrtaceous grain were found. They are similar to the Gippsland Basin specimens in size and morphological features.

Dimensions: 15 (19) 22 µm (four specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra. Rare.

Reported Stratigraphic Range: *Proteacidites asperopolus* through *Triporopollenites bellus* Zones, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Partridge (1971) noted similarities to pollen of the endemic New Zealand genera *Neomyrtus* and *Lophomyrtus*. Pollen of some species of *Austromyrtus* are also faintly patterned.

Genus *Symplocoipollenites* Potonié 1960

Type species: *Symplocoipollenites vestibulum* (Potonié), designated by Potonié, 1960.

Symplocoipollenites austellus Partridge 1973

(Plate 15, figures 9,11)

Synonymy

1973 *Symplocoipollenites austellus* Partridge in Stover & Partridge, p.258, Pl.17, fig.20.

Remarks: These specimens appear to be similar to those described from the Gippsland Basin. Most specimens seen had straight sides; a few were roundly convex.

Dimensions: 20 (24) 30 µm

Occurrence: Found in samples from Cadia in low frequencies.

Reported Stratigraphic Range: *Triporopollenites bellus* Zone, late Miocene, in the Gippsland Basin.

Botanical Affinities: Some members of the Indo-Pacific genus *Symplocos* have similar pollen morphology (van der Meijden, 1970). Pollen of *Symplocos stanelli*, seen by the author, has a similar type of aperture but much coarser ornament.

Genus *Sapotaceoidaepollenites* Potonié, Thomson, & Thiergart 1950

Type species: *Sapotaceoidaepollenites manifestus* (Potonié) 1931.

Sapotaceoidaepollenites cf. *S. rotundus* Harris 1972

(Plate 14, figure 12)

cf. 1972 *Sapotaceoidaepollenites rotundus* Harris, p.56, figs 17,18.

Remarks: These specimens are similar to *S. rotundus* Harris 1972, but are smaller, more prolate, and generally tricolporate rather than tetracolporate. In size, aperture number, and generally prolate outline they show similarities to *Tricolporopollenites latizonatus* McIntyre 1965, but lack the broad thickened zone of exine at the equatorial region.

Specimens seen from Nerriga are all tetracolporate.

Dimensions: 20 - 32 µm X 11 - 25 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Botanical Affinities: Probably with the Sapotaceae. Pollen of *Malacantha alnifolia*, seen by the author, has thicker exine but is otherwise similar.

Genus *Ilexpollenites* Thiergart ex Potonié 1960

Type species: *Ilexpollenites iliacus* (Potonié 1931) Thiergart, 1937.

Ilexpollenites clifdenensis McIntyre 1968

(Plate 15, figure 7)

Synonymy

1968 *Ilexpollenites clifdenensis* McIntyre, p.182, figs 9-11.

Remarks: A wide range of variation in density and size of ornament, and size and shape of grain, has been found in specimens assigned to this species. In some specimens the pores are indistinct.

Dimensions: 22 (35) 46 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Most common in samples from Kiandra.

Reported Stratigraphic Range: Miocene of New Zealand (McIntyre, 1968).

Botanical Affinities: McIntyre (1968) suggested affinities with the Aquifoliaceae. Pollen of several species of *Ilex* are similar.

Section Disciflorae

Order Sapindales

Family Sapindaceae

Genus *Dodonaea* L.

Dodonaea sphaerica Martin 1973

(Plate 15, figure 6)

Synonymy

1973a *Dodonaea sphaerica* Martin, p.18, figs 72-74.

Remarks: In size and morphology these specimens appear identical with those described by Martin (1973a).

Dimensions: 16 (23) 31 µm polar diameter

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Ranges: Eocene-Oligocene and ?Upper Pliocene-Pleistocene of New South Wales (Martin, 1973a).

Botanical Affinities: With the Sapindaceae. Martin (1973a) has noted similarities with *Dodonaea camfieldii* Maiden & Betche and *D. pinnata* Sm. These grains are also similar to other living species of *Dodonaea*, seen by the author, for example, *D. filifolia* Hook., *D. hexandra*, and *D. rudicola*.

Subturma POLYPTYCHES Potonié 1960

Genus *Nothofagidites* Erdtman ex Potonié 1960

Type species: *Nothofagidites flemingii* (Couper), designated by Potonié, 1960.

Remarks: Grains referred to this genus were found in all samples studied, and, although in only low frequencies in samples from Nerriga, formed more than half the total grain count in samples from Kiandra, and were only slightly less numerous in samples from Cadia. Although all three groups of *Nothofagus* pollen were found, pollen of the *brassi* type predominated.

As noted by Stover & Evans (1973, p.64), a high percentage of interspecific and infraspecific variation exists in both living and fossil species assigned to *Nothofagus*. In samples from Kiandra, which had a large number of *brassi* type pollen in each sample, such a great range of variation was apparent. Even following the criteria set out by Cookson (1946; 1959), there were still many grains that could not be satisfactorily placed in an existing species.

For convenience, the following section is subdivided into three parts, according to the three pollen types found in living *Nothofagus* species. This practice has been followed by previous authors.

Nothofagus menziesii Group (Cranwell, 1939)

Remarks: This group is characterized by large size, thin exine, and unrimmed to weakly rimmed apertures or fissure points. Two species belonging to this group have been found in these samples, although grains assigned to this group are very rare in samples from Nerriga.

Living species of *Nothofagus* with pollen assigned to this group are found in New Zealand (*N. menziesii*), Tasmania and Victoria (*N. cunninghamii*), Queensland (*N. moorei*), and South America (*N. obliqua*, *N. glauca*, *N. alpina*) (Cranwell, 1939; Heusser, 1971). This type first appears in Australian deposits during the middle Eocene, and in New Zealand during the Maestrichtian (Fleming, 1962).

Nothofagidites asperus (Cookson) Stover & Evans 1973

(Plate 16, figure 5)

Synonymy

1946 Nothofagus sp. a Cookson, p.53, Pl.1, figs 5-7, fig.2.

1959 Nothofagus aspera Cookson, p.25, Pl.IV, figs 1,2.

1973 Nothofagidites asperus (Cookson) Stover & Evans, p.64, Pl.4, fig.6.

1973a Nothofagus aspera Cookson, Martin, p.34, fig.149.

Remarks: Several unfissured or partly fissured specimens were seen. Specimens had 6 to 8, mostly 7, fissure points. These grains are smaller than those described by Cookson (her size range was 40-60 µm) and Stover & Evans (35-60 µm), but are otherwise similar. Specimens described by Martin (1973a) are similar to these in size.

This species was present in almost all samples from Kiandra and Cadia, in low frequencies, and rarely in samples from Nerriga.

Dimensions: 30 (40) 47 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia.

Reported Stratigraphic Range: Lower Nothofagidites asperus Zone through Triporopollenites bellus Zone, middle Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in Eocene-Oligocene and ?Upper Pliocene deposits in New South Wales (Martin, 1973a), and in various Tertiary localities in New South Wales and Victoria (Cookson, 1946).

Botanical Affinities: Similar to the living species N. cunninghamii (Hook.) Oerst., N. moorei (F. Muell.) Maiden, and N. menziesii Oerst., with closest resemblance to N. moorei (Cookson, 1959).

Nothofagidites goniatus (Cookson) Stover & Evans 1973

(Plate 16, figure 9)

Synonymy

1946 Nothofagus sp. g Cookson, p.58, Pl.II, figs 30-32, fig.8.

1959 Nothofagus goniata Cookson, p.28, Pl.IV, figs 5,6.

1973 Nothofagidites goniatus (Cookson) Stover & Evans, pp.64-65, Pl.4, fig.4.

Remarks: Stover & Evans (1973) assigned N. goniatus to the menziesii group based on similarities of this species to Nothofagidites asperus, although Cookson (1959) had included it in the brassi group. From specimens seen in this study, assignment to the menziesii group appears more appropriate, although the apertures have a more definite margin than specimens of N. asperus.

Specimens with 4 and 5, mostly 5, apertures were seen, and this species was found more frequently in samples from Cadia. These specimens are at the smaller end of the size range given by Cookson (1959), which is 32-59 µm.

Dimensions: 31 (35) 40 µm

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: From within the upper part of the Malvacipollis diversus Zone into the Proteacidites tuberculatus Zone, early Eocene through Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Nothofagus fusca Group (Cranwell, 1939)

Remarks: Pollen of this group is characterized by thickening of the exine around the apertures, and a circular outline in polar view. This type of pollen was found in low frequencies in most samples from all three localities and two species were recognized.

Living species of Nothofagus with pollen of this type are found in New Zealand (N. fusca, N. truncata, N. solandri, and N. cliffortioides), South America (N. pumilio, N. dombeyi, N. antarctica, N. betuloides, and N. alessandrii), and Tasmania (N. gunnii) (Cranwell, 1939; Cookson & Cranwell, 1967). Oldest fossil records of this group are from the Upper Cretaceous of New Zealand and Antarctica (Cookson & Cranwell, 1967), and it first occurs in deposits of middle Paleocene age in Australia.

Nothofagidites flemingii (Couper) Potonié 1960

(Plate 16, figures 7,8)

For synonymy to 1973, see Stover & Evans, 1973, pp.65-66.

1973 Nothofagidites flemingii (Couper) Potonié, Stover & Evans, pp.65-66, Pl.2, fig.1.

Remarks: Stover & Evans (1973) have revised the description of N. flemingii to accommodate specimens previously assigned to Nothofagus cincta Cookson, and consider N. cincta a junior synonym.

These specimens are smaller (Stover & Evans give a size range of 27-54 µm, with an average of 40), but are otherwise similar. Grains had 6 or 7, mostly 6, apertures.

Dimensions: 21 (26) 38 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Lygistepollenites balmei Zone into the Proteacidites tuberculatus Zone, late Paleocene through Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Nothofagidites brachyspinulosus (Cookson) Harris 1965

(Plate 16, figures 4,6)

Synonymy

1946 Nothofagus sp. b Cookson, p.53, Pl.1, figs 8-13, fig.3.

1959 Nothofagus brachyspinulosa Cookson, p.26, Pl.IV, fig.4.

1965a Nothofagidites cf. N. brachyspinulosus (Cookson) Harris, p.96.

1973a Nothofagus brachyspinulosa Cookson, Martin, p.34, fig.150.

Remarks: This species occurs rarely but consistently in most samples. Grains with 5 to 7 apertures were seen, and they conform with previous descriptions, although they are on the small side of the size range.

Dimensions: 20 (24) 27 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Lygistepollenites balmei through Triporopollenites bellus Zones, middle Paleocene through Miocene, in the Gippsland Basin. Also reported from the Paleocene of Victoria (Harris, 1965a).

Nothofagus brassi Group (Cookson & Pike, 1955)

Remarks: Pollen belonging to this group was found in all samples. Grains of brassi type are characterized by a generally angular outline in polar view, small to medium size (10-35 µm), and firm exine with no thickening around the apertures. As noted by Stover & Evans (1973, p.66), this group proved to be the most difficult to subdivide into species groupings because of a vast range of variation in shape, size, aperture number, and sculpture.

Discovery of living species of Nothofagus with this type of pollen occurred quite late, and was reported by Cookson in 1952. Previously, this group was known only from fossil evidence. Living species with brassi type pollen are found only in New Guinea and New Caledonia (Cookson, 1952). Fossil pollen of this type first appears in deposits of Senonian age in both Australia and New Zealand (Dettmann & Playford, 1968; Fleming, 1962), and earliest fossil records from New Guinea date from Upper Miocene deposits (Khan, 1974).

Nothofagidites deminutus (Cookson) Stover & Evans 1973

(Plate 16, figure 10)

Synonymy

1946 Nothofagus sp. d Cookson, pp.55-56, Pl.1, figs 19-21.

1959 Nothofagus deminuta Cookson, p.29, Pl.IV, fig.12.

1973 Nothofagidites deminutus (Cookson) Stover & Evans, p.66, Pl.4, fig.5.

1973a Nothofagus deminuta Cookson, Martin, p.35, fig.151.

Remarks: Stover & Evans (1973) note that this species appears relatively late in the upper part of the Malvacipollis diversus Zone, and is particularly abundant in the Proteacidites asperopolus Zone and less common in the Nothofagidites asperus Zone in the Gippsland Basin.

These specimens had 5 to 8, mostly 6 or 7, apertures, and were more abundant in samples from Kiandra than in those from Cadia.

Dimensions: 20 (23) 27 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: From within the upper part of the Malvacipollis diversus through the Triporopollenites bellus Zones, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in deposits of Eocene-Oligocene age in New South Wales (Martin, 1973a).

Nothofagidites emarcidus (Cookson) Harris 1965

(Plate 16, figure 11)

Synonymy

1946 *Nothofagus* sp. e Cookson, pp.56-57, Pl.II, figs 22-25, fig.6.

1959 *Nothofagus emarcida* Cookson, pp.26-27, Pl.IV, figs 7,8.

1965a *Nothofagidites emarcida* (Cookson) Harris, p.96, Pl.29, fig.25.

Remarks: This is the most common species of *Nothofagidites* found in all samples. It is possible that further study will show that *N. emarcidus* and *N. heterus* are both part of an intergrading series. Study of New Zealand material may show that *N. mataurensis* Couper 1953 fits into this series as well.

These specimens had 5 to 7, mostly 6 or 7, apertures, and were similar to previous descriptions.

Dimensions: 23 (29) 34 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare to abundant.

Reported Stratigraphic Range: *Malvacipollis diversus* through *Triporopollenites bellus* Zones, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also common in the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Similar to pollen of *Nothofagus grandis* Steen. (Cookson, 1959).

Nothofagidites falcatus (Cookson) Stover & Evans 1973

(Plate 16, figure 16)

Synonymy

1946 *Nothofagus* sp. f Cookson, p.57, Pl.II, figs 26-29.

1959 *Nothofagus falcata* Cookson, p.27, Pl.IV, fig.14.

1972 *Nothofagidites falcata* (Cookson) Hekel, p.11, Pl.6, fig.15.

1973 *Nothofagidites falcatus* (Cookson) Stover & Evans, p.66, Pl.4, fig.13.

1973a *Nothofagus falcata* Cookson, Martin, p.35, fig.153.

Remarks: This species is distinguished readily by deeply embayed sides between the apertures and sculpture of large, coarse spinules. Specimens are commonly asymmetric, and have 5 or 6, mostly 6, apertures.

Dimensions: 21 (25) 32 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Lower *Nothofagidites asperus* through *Triporopollenites bellus* Zones, middle Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in upper Oligocene to upper Miocene deposits in Queensland (Hekel, 1972), and Eocene-Oligocene deposits in New South Wales (Martin, 1973a).

Botanical Affinities: Pollen of *Nothofagus codonandra* and *N. balansae* seen by the author have similar concave sides.

Nothofagidites heterus (Cookson) Stover & Evans 1973

(Plate 16, figure 12)

Synonymy

1946 *Nothofagus* sp. h Cookson, p.58, Pl.II, figs 33-35, fig.9.

1959 *Nothofagus hetera* Cookson, p.27, Pl.IV, figs 9,10.

1973 Nothofagidites heterus (Cookson) Stover & Evans, p.66
(not illustrated).

Remarks: This species is distinguished from N. emarcidus by higher aperture number, less angular amb, and slightly coarser sculpture (Cookson, 1959, p.27), and appears to form part of a continuous series with that species. Specimens had 6 to 9, mostly 7 or 8, apertures, and were found in almost all samples from Kiandra and Cadia.

In all percentage abundances, specimens of N. heterus and N. emarcidus have been included together.

Dimensions: 25 (30) 34 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare to abundant.

Reported Stratigraphic Range: From within the upper part of the Malvacipollis diversus Zone through the Triporopollenites bellus Zone, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Nothofagidites incrassatus (Cookson) comb. nov.

(Plate 16, figure 15)

Synonymy

1946 Nothofagus sp. i Cookson, p.59, Pl.II, figs 36-38, fig.10.
1959 Nothofagus incrassata Cookson, p.27, Pl.IV, fig.13.
1973a Nothofagus incrassata Cookson, Martin, p.35 (not illustrated)

Remarks: This species has not been recognized in the Gippsland Basin. These specimens are smaller than the range given by Cookson of 27-48 µm, but are otherwise similar. This species is found in low frequencies in some samples from all three localities.

Specimens had 5 to 7, mostly 6 or 7, apertures.

Dimensions: 21 (24) 28 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Rare, in Eocene-Oligocene deposits from New South Wales (Martin, 1973a).

Nothofagidites vansteenisii (Cookson) Stover & Evans 1973

(Plate 16, figure 14)

Synonymy

1946 Nothofagus sp. j Cookson, pp.59-60, Pl.II, figs 39-45.

1959 Nothofagus vansteenisi Cookson, p.29, Pl.IV, fig.11.

1973 Nothofagidites vansteenisii (Cookson) Stover & Evans, p.66 (not illustrated).

Remarks: These grains are smaller than the size range given by Cookson of 27 (34) 40 µm, but are otherwise similar. Specimens had 5 to 8, mostly 6 or 7, apertures.

Dimensions: 23 (27) 29 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Lower Nothofagidites asperus Zone through Triporopollenites bellus Zone, middle Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Genus Polycolpites Couper 1953

Type species (by original designation): Polycolpites clavatus Couper, 1953.

Polycolpites esobalteus McIntyre 1968

(Plate 16, figures 18,19)

Synonymy

1968 Polycolpites esobalteus McIntyre, p.197, figs 67-69.

1973 Polycolpites esobalteus McIntyre, Stover & Partridge, p.261, Pl.20, figs 10-11.

Remarks: Specimens of P. esobalteus in these samples had six to eleven, mostly six to eight, long colpi, as well as a colpus transversalis. They appear to be identical with the specimens described from the Miocene of New Zealand.

Dimensions: 22 (27) 33 μm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies. This species was more abundant in samples from Nerriga than in those from the other two localities.

Reported Stratigraphic Range: Malvacipollis diversus through Triporopollenites bellus Zones, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Originally described from the Miocene of New Zealand (McIntyre, 1968).

Botanical Affinities: Grains with this morphology are found in the Polygalaceae, and may have been produced by a fossil member of the family (McIntyre, 1968).

Polycolpites sp.

(Plate 16, figure 13)

cf. Quintinia psilatispora Martin, 1973a, pp.20-21, figs 80,81.

Description: Grain free, isopolar, radiosymmetric, polycolpate. Subspherical to prolate, amb circular. Colpi 4 or 5, more commonly

5, long, simple, almost reaching poles. Exine thin, 1-1.5 µm, distinctly two-layered, thinning towards colpi, smooth to scabrate.

Remarks: This species is similar to Quintinia psilatispora Martin 1973, although her specimens are smaller (12-15 µm x 7-12 µm). She has reported this species as infrequent in Eocene-Oligocene and ?Upper Pliocene deposits in New South Wales, and found it only in association with Nothofagus pollen.

Dimensions: 12 (19) 26 µm, polar diameter; 10-17 µm, equatorial diameter

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Botanical Affinities: Martin (1973a) has compared her species Quintinia psilatispora with pollen of living Quintinia of the Saxifragaceae. Some species of Quintinia seen by the author are comparable, although many have prominent pores, a feature not apparent in these fossil grains.

Turma POROSES Naumova emend. Potonié 1960

Subturma MONOPORINES Naumova 1939

Genus Sparganiaceaepollenites Thiergart ex Potonié 1960

Type species: Sparganiaceaepollenites polygonalis Thiergart 1937, monotypic when proposed.

Sparganiaceaepollenites cf. S. barungensis Harris 1972

(Plate 16, figure 1)

cf. Sparganiaceaepollenites barungensis Harris, 1972, pp.53-54, figs 1-3.

Description: Grain free, spherical, monoporate. Pore circular, 2-4 µm in diameter, commonly obscured by folding of the grain. Pore not bordered by an annulus. Exine 1-1.5 µm thick, composed of two layers of equal thickness. Reticulate ornament distinct, complete, with lumina ca 1 µm in diameter.

Remarks: The grains are commonly folded, so that the pore is not visible except in relatively undistorted specimens. These grains are very similar to S. barungensis Harris, although they appear to have a more definite margin to the pore, a fine reticulum, and are larger (his size range was 18 (22) 25 µm).

Couper (1960) has figured a similar form as Typha sp.

Dimensions: 21 (24) 30 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Harris (1972) remarks that S. barungensis first occurs in the Upper Eocene, and continues through the Upper Tertiary. Martin (1973a) has reported it from Eocene-Oligocene and ?Upper Pliocene deposits in New South Wales.

Botanical Affinities: Similar to pollen of the living Typha and Sparganium. Martin (1973a) has compared S. barungensis with Sparganium antipodium Graebn., and notes that it differs from Typha domingensis Pers. in having a complete reticulum.

Genus Graminidites Cookson ex Potonié 1960

Type species: Graminidites media Cookson 1947, designated by Potonié, 1960.

Graminidites media Cookson 1947

(Plate 15, figures 8,10)

Synonymy

1947b Monoporites (Graminidites) media Cookson, p.134, Pl.XV, figs 41,42.

1973a Graminidites media Cookson, Martin, p.38, figs 167,168.

Remarks: These grains are commonly crumpled, although several almost spherical specimens were seen. The exine is thin (0.75-1 µm), smooth to scabrate, and homogeneous. The pore is 2-4 µm in diameter, and is bordered by an annulus. The width and prominence of the annulus is variable; in some specimens it is prominent, ca 1 µm high and 1-3 µm wide, but in others it was barely perceptible and not elevated.

These grains are very similar to those described by Cookson and by Martin, although Martin mentions a fine to coarse reticulate surface pattern, not seen in any specimens here (perhaps due to preservation), and her size range is broader (19 (26) 42 µm).

Dimensions: 25 (36) 41 µm

Occurrence: Found in samples from Cadia. Rare to common.

Reported Stratigraphic Range: There have been few reports of graminaceous type grains from Australian Tertiary deposits. Martin (1973a) has reported this species from deposits of assumed Late Pliocene and Pleistocene age from New South Wales. Also reported from Tertiary lignites of middle Miocene age from Kerguelen (Cookson, 1947b), and in New Zealand from Lower Oligocene to the present (Couper, 1953). Harris (1971) has reported Graminidites sp. as rare in the Proteacidites confragosus Zonule (middle Eocene) of the Otway Basin; this appears to be the earliest report of graminaceous pollen from Australia.

Botanical Affinities: This faintly patterned, monoporate grain type is characteristic of the Gramineae. Other families, the Restionaceae and Flagellariaceae, have some species with similar monoporate apertures, but have a coarser exine pattern (Chanda, 1966).

Subturma DIPORINES Naumova emend. Potonié 1960

Genus Banksieaeidites Cookson ex Couper 1954

Type species: Banksieaeidites elongatus Cookson, designated by Couper, 1954.

Banksieaeidites elongatus Cookson 1950

(Plate 15, figure 12; Plate 16, figure 2)

For synonymy to 1973, see Stover & Partridge, 1973, p.262.

1953b Banksieaeidites minimus Cookson, Cookson, p.466, Pl.1, fig.18.

Remarks: As a continuous range in size of the two forms, B. minimus and B. elongatus, was found in this study, the placement of the two species into synonymy by Stover & Partridge (1973) is accepted here. Intermediates in size are less common in these samples than in the Gippsland Basin material, but they are found, although most specimens tend to fall within the two groups originally proposed by Cookson (1950).

Dimensions: 17 - 45 μm in length, 14 - 24 μm in width

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: From within the Lygistepollenites balmei Zone through the Triporopollenites bellus Zone, late Paleocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also reported from Eocene-Oligocene deposits in New South Wales, Paleocene of Victoria, upper Eocene in Western Australia, and Miocene (Yallourn) in Victoria (Martin, 1973a; Harris, 1965a; Hos, 1975; Cookson, 1953b).

Botanical Affinities: Comparable to pollen of living Banksia and Dryandra (Cookson, 1950).

Banksieaeidites arcuatus Stover 1973

(Plate 16, figure 3)

Synonymy

1973 Banksieaeidites arcuatus Stover in Stover & Partridge, p.262, Pl.21, figs 2-4.

Remarks: The smaller apertures, thicker exine relative to size, and asymmetrical outline due to one strongly convex side distinguish this from the preceding diporate species. The criterion of asymmetric grain outline as a diagnostic feature for specific determination is questioned, however. As this feature does not appear to control grain orientation, in some compressions, the grain would not appear asymmetric. The smaller aperture diameters and thicker exine relative to size were considered of greater importance in distinguishing this species from B. elongatus. These specimens are very similar to those described from the Gippsland Basin.

Dimensions: 20 (24) 26 µm long X 14 (18) 24 µm wide.

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: Malvacipollis diversus Zone through Lower Nothofagidites asperus Zone, early, middle, and late Eocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Probably with *Banksia* and *Dryandra*. Grains of *Austromuellea triversis*, from Queensland, seen by the author, are very similar to this species. Many specimens have one strongly convex side, and thickening of the exine at the pores, as seen in *B. arcuatus*.

Subturma TRIPORINES Potonié 1960

Genus *Triporopollenites* Pflug & Thomson 1953

Type species: *Triporopollenites coryloides* Pflug in Thomson & Pflug, 1953.

Triporopollenites chnosus Partridge 1973

(Plate 16, figure 17)

Synonymy

1973 *Triporopollenites chnosus* Partridge in Stover & Partridge, p.269, Pl.21, fig.6.

Remarks: A few specimens conformable with this species were found in some samples from Kiandra. The thick exine, slight anisopolarity, and lack of apiculae readily distinguish this species from *T. ambiguus*, and the thick, relatively homogeneous exine distinguishes this from other triporate grains found in the same samples. The exine layers of these specimens are homogeneous, whereas the specimen figured by Stover & Partridge appears to have some structuring in the outer sexinal layer (although this is not mentioned in the description).

Dimensions: 42 (45) 50 µm (four specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Reported Stratigraphic Range: From within the Lower *Nothofagidites* asperus Zone through the Triporopollenites bellus Zone, late Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Possibly with the Proteaceae. Pollen of Synephea spp., seen by the author, is similar in size and outline, and has a thick homogeneous exine. The grains are faintly reticulate, however, rather than scabrate.

Triporopollenites ambiguus Stover 1973

(Plate 17, figure 1)

Synonymy

1973 Triporopollenites ambiguus Stover in Stover & Partridge, p.269, Pl.21, fig.7.

Remarks: Several specimens with thin exine and scattered apiculae were found in samples from Nerriga. They appear to be identical with the species described from the Gippsland Basin.

Dimensions: 30 (37) 40 µm (six specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Malvacipollis diversus through Lower Nothofagidites asperus Zones, early Eocene into late Eocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Triporopollenites bellus Partridge 1973

(Plate 17, figures 2,3)

Synonymy

1973 Triporopollenites bellus Partridge in Stover & Partridge, p.269, Pl.27, figs 9,10.

Remarks: These specimens are similar to those described from the Gippsland Basin in circular outline, relatively thick exine, and ornament. However, the apertures were very difficult to see on all specimens. There appear to be two to three pores, which are not annulate, whereas the specimen illustrated from the Gippsland Basin had a definite annular thickening around the pores.

Dimensions: 17 (24) 29 µm (four specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: *Triporopollenites bellus* Zone, late Miocene, in the Gippsland Basin (Stover & Partridge, 1973). This species appears earlier at Kiandra, which has been correlated with the middle subdivision of the *Proteacidites tuberculatus* Zone.

Botanical Affinities: Unknown. Pollen of *Phyllanthus calycinus*, of the Euphorbiaceae, is similar in ornament but tricolporate. The colpi are not distinct, but there is some modification of the reticulum adjacent to the colpus.

Genus *Santalumidites* Cookson & Pike emend. Partridge 1973

Type species: *Santalumidites cainozoicus* Cookson & Pike, 1954, monotypic when proposed.

Remarks: Germeraad, Hopping, & Muller (1968) noted the possibility of some overlap between their genus *Florschuetzia*, with affinities to the living mangrove genus *Sonneratia*, and *Santalumidites* as illustrated by Cookson & Pike (1954b). Partridge (in Stover & Partridge, 1973) has noted that *Santalumidites* differs from *Florschuetzia* in having porate and colporate apertures and in lacking sexine in the polar area.

Santalumidites cainozoicus Cookson & Pike 1954

(Plate 17, figures 5,6)

Synonymy

1954b Santalumidites cainozoicus Cookson & Pike, pp.209-210, Pl.2, figs 67-71.

1972 Santalumidites cainozoicus Cookson & Pike, Hekel, p.17, Pl.5, figs 10-11.

1973 Santalumidites cainozoicus Cookson & Pike, Stover & Partridge, p.258 (not illustrated).

1973 Santalumidites cainozoicus Stover & Evans, Pl.4, fig.3.

Remarks: These specimens are smooth to finely ornamented, and comparable to the specimens described from Queensland. No grains were found with ornament as coarse as that illustrated by Cookson & Pike (1954b).

Dimensions: 30 (37) 44 μm (nine specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Malvacipollis diversus Zone into Nothofagidites asperus Zone, early to late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Tertiary of Queensland (Hekel, 1972), upper Eocene deposits of Western Australia (Hos, 1975), Pliocene of New Guinea, and Tertiary deposits from various localities in Australia (Cookson & Pike, 1954b).

Botanical Affinities: Cookson & Pike (1954b) compared this species with pollen of Santalum. Pollen of S. freycenetianum, seen by the author, is the most similar to this fossil species, and pollen of S. spicatum, S. murrayanum, S. acuminatus, and S. lanceolatum is comparable.

Genus Proteacidites Cookson ex Couper 1953

Type species: Proteacidites adenanthoides Cookson 1950, designated by Couper, 1953.

Remarks: Samples from Nerriga contain a large number of species belonging to this genus, although most are represented by relatively few specimens. In the two other sites, Kiandra and Cadia, small triporate finely reticulate grains predominate, and fewer species of Proteacidites occur.

Revision of the genus is being undertaken by W.K. Harris and A.R.H. Martin. Although not all species assigned to this form genus are definitely assumed to be produced by extinct members of the Proteaceae, all species of Proteacidites have been included in calculations of the Proteaceae-type component in abundance data.

Proteacidites annularis Cookson 1950

(Plate 17, figure 7)

For synonymy to 1973, see Stover & Partridge, 1973, p.264.

Remarks: The specimens found in the present study were on the small side of the size range, and were commonly corroded and torn at the apertural collars. They are otherwise conformable with previous descriptions. Stover & Partridge (1973) have considered P. granulatus Cookson 1953 conspecific with P. annularis, which is accepted here.

Dimensions: 22 (27) 36 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: Lygistepollenites balmei Zone through Triporopollenites bellus Zone, middle Paleocene through

Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria (Harris, 1965a) and from Paleocene to Upper Eocene (?Middle Oligocene) in New Zealand (Couper, 1953; 1960).

Botanical Affinities: Cookson (1950, p.171) compared P. annularis with pollen of Xylomelum angustifolium Kipp. and X. occidentale R. Br., which have similar apertural collars.

However, specimens of X. angustifolium and X. occidentale, seen by the author, are less similar in grain outline to P. annularis, although they have the distinctive "apertural collars".

Proteacidites asperopolus Stover & Evans 1973
(Plate 17, figures 9,10)

Synonymy

1973 Proteacidites asperopolus Stover & Evans, pp.66-67, Pl.4, fig.1.

1973 Proteacidites asperopolus Stover & Evans, Stover & Partridge, p.264, Pl.26, fig.2.

Remarks: Few specimens were found with the sexine intact over the entire grain, although it was generally intact around the apertures. This species is easily distinguished from P. pachypolus, the other strongly heteropolar species of the genus, in having a reticulate ornament on the apertural areas, and a coarser reticulate sculpture on the polar areas.

Dimensions: 30 (35) 37 μm

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Upper part of the Malvacipollis diversus Zone into lower part of the Lower Nothofagidites asperus

Zone, early Eocene into middle Eocene (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Proteacidites pachypolus Cookson & Pike 1954

(Plate 18, figures 1,2)

For synonymy to 1973, see Stover & Partridge, 1973, p.266.

Remarks: The specimens from Nerriga are more prominently heteropolar than those from Cadia, which have only a weak thickening at one pole. The specimens from Cadia are also smaller. No specimens have been found in samples from Kiandra.

Dimensions: 27 (34) 39 µm

Occurrence: Found in samples from Nerriga and Cadia. Rare.

Reported Stratigraphic Range: Upper part of Malvacipollis diversus Zone into Lower Nothofagidites asperus Zone, early Eocene into late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in Paleocene deposits in Victoria (Harris, 1965a), and various Tertiary deposits in southern Australia (Cookson & Pike, 1954b; Cookson, 1954b).

Botanical Affinities: Unknown.

Proteacidites tenuiexinus Stover 1973

(Plate 20, figures 3,4)

Synonymy

1973 Proteacidites tenuiexinus Stover in Stover & Partridge,
pp.268-269, Pl.25, figs 6,7.

Remarks: These grains are similar to those described from the Gippsland Basin. The scabrate to granulate ornament, generally straight-sided triangular outline, and thin exine distinguish this species from similar triporate grains of the genus. Although Stover mentions a convexly triangular amb, his illustrated specimens are nearly straight-sided to slightly convex.

Dimensions: 26 (29) 30 µm

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Upper part of Lygistepollenites balmei Zone into Lower Nothofagidites asperus Zone, late Paleocene to middle Eocene (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Proteacidites ?callosus Cookson 1950

(Plate 18, figure 4)

Synonymy

1950 Proteacidites callosus Cookson, p.175, Pl.3, fig.28.

1973a Proteacidites callosus Cookson, Martin, p.29, fig.124.

Remarks: A few specimens conformable with the rather brief description given by Cookson (1950) have been found in samples from Nerriga. Assignment of these specimens is tentative, pending redescription in more detail of Cookson's specimens.

Dimensions: 40 (43) 45 µm (five specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Originally described by Cookson (1950) from Moorlands, South Australia (late Eocene), and later from deposits of ?Late Pliocene age in New South Wales (Martin, 1973a).

Botanical Affinities: Unknown.

Proteacidites concretus Harris 1972

(Plate 17, figure 8)

Synonymy

1972 *Proteacidites concretus* Harris, p.58, figs 48,49.

Remarks: A few specimens of *P. concretus* have been found in samples from Nerriga. The scabrate exine and distinctive pore structure distinguish this from other species of the genus found in these samples.

Dimensions: 26 and 26 µm (two specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Common in most Eocene sediments (Harris, 1972).

Botanical Affinities: Unknown.

Proteacidites crassus Cookson 1950

(Plate 17, figure 4)

Synonymy

1950 *Proteacidites crassus* Cookson, p.173, Pl.2, fig.22.

1965a *Proteacidites crassus* Cookson, Harris, p.92, Pl.28, fig.8.

1973 *Proteacidites crassus* Cookson, Stover & Partridge, p.265, Pl.22, fig.9.

Remarks: A few specimens referable to *P. crassus* were found in samples from Nerriga. The gradual reduction in mesh size from the poles to the apertural areas and the strong anisopolarity distinguish this species.

Dimensions: 42 µm (one specimen measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Proteacidites asperopolus Zone through Lower Nothofagidites asperus Zone, early to late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Unknown.

Proteacidites ?grandis Cookson 1950

(Plate 19, figures 1,4)

Synonymy

1950 Proteacidites grandis Cookson, p.173, Pl.2, fig.23.

1965a Proteacidites grandis Cookson, Harris, p.92, Pl.29, fig.1.

1973 Proteacidites grandis Cookson, Stover & Partridge, p.265, Pl.23, fig.3.

Remarks: These specimens have a finer meshed reticulum than P. ornatus, with mesh size reduced to punctae at the apertures. These specimens lack the deeply concave sides found in previously illustrated specimens, but are otherwise similar. A diporate form of this species is also illustrated.

Dimensions: 50 (60) 72 µm

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: Malvacipollis diversus and Proteacidites asperopolus Zones, early Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Also found in the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Unknown.

Proteacidites ornatus Harris 1965

(Plate 19, figure 2)

Synonymy

1965a Proteacidites ornatus Harris, p.93, Pl.28, figs 22,23,26.

1973 Proteacidites ornatus Harris, Stover & Partridge, p.266 (not illustrated).

Remarks: Four large, reticulate species have been assigned to Proteacidites. P. grandis Cookson and P. dilwynensis Harris have relatively small-meshed reticulate ornament. P. ornatus has a larger mesh reticulum, which is reduced in size towards the apertures. P. leightonii Stover has the largest mesh reticulum, which does not appear to reduce in size towards the apertures.

In these specimens, the muri of the reticulum are 1.25-1.5 µm wide, 3 µm high, and the lumina are irregular in outline, about 3-6 µm in diameter. Single columellae, rather indistinct, underlie the muri. The size of the mesh is smaller towards the apertures, so these grains are assigned to P. ornatus.

Dimensions: 60 (66) 70 µm

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: Upper part of the Malvacipollis diversus and Proteacidites asperopolus Zones, early Eocene, in the Gippsland Basin (Stover & Partridge, 1973); also reported from the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Unknown.

Proteacidites kopiensis Harris 1972

(Plate 18, figure 6)

Synonymy

1972 *Proteacidites kopiensis* Harris, p.57, figs 26,27.

1973 *Proteacidites kopiensis* Harris, Stover & Partridge, p.265 (not illustrated).

Remarks: A few specimens with the characteristic reticulate ornament of *P. kopiensis* were found in samples from Nerriga. The reduction in mesh size both towards the poles and towards the apertures distinguishes this from other species of *Proteacidites*.

Dimensions: 44, 48, and 48 µm (three specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: *Malvacipollis diversus* into Lower *Nothofagidites asperus* Zones, early Eocene into late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Harris reports (1972) that this species does not occur higher than his *Triorites magnificus* Zonule, basal Tertiary into middle-late Eocene.

Botanical Affinities: Unknown.

Proteacidites latrobensis Harris 1966

(Plate 18, figure 5)

Synonymy

1965a *Proteacidites crassipora* Harris, pp.93-94, Pl.28, figs 24,25.

1966 *Proteacidites latrobensis* Harris, p.332.

1973 *Proteacidites latrobensis* Harris, Stover & Partridge, pp.265-266, Pl.25, fig.5.

Remarks: A few specimens have been found in samples from Nerriga. The distinctive pore structure and scrobiculate exine with scattered apiculae distinguish this from other species of *Proteacidites*.

Dimensions: 26, 30, and 44 µm (three specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: *Malvacipollis diversus* Zone through Lower *Nothofagidites asperus* Zone, early to late Eocene, in the Gippsland Basin (Stover & Partridge, 1973), Reported originally from the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Unknown. Pollen of *Helicia purpuraceus* and *H. sarunagedica* have similar "pore canals".

Proteacidites minimus Couper 1954

(Plate 19, figure 6)

Synonymy

1954 *Proteacidites minimus* Couper, p.479, fig.2.

Remarks: Small, finely reticulate triporate grains referred to this species were found in almost all samples.

Dimensions: 16 (22) 28 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Miocene-Pliocene of New Zealand (Couper, 1954).

Botanical Affinities: Couper (1954) has compared this species with pollen of the living New Zealand species *Knightia excelsa* R. Br., but *P. minimus* is smaller with finer sculpture.

Proteacidites cf. P. obscurus Cookson 1950

(Plate 19, figure 8)

For synonymy for P. obscurus to 1973, see Stover & Partridge, p.266.

Remarks: These specimens are much smaller than those described by Cookson (1950) and Harris (1972) but are otherwise similar in morphology. These grains lack the ornament of fused groups of bacula found in specimens of P. varius Harris 1972, and have a faint reticulate pattern.

Dimensions: 16 (19) 24 µm

Occurrence: Found in samples from Kiandra and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Malvacipollis diversus through Triporopollenites bellus Zones, early Eocene through late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Pollen of some living species of Helicia seen by the author is similar.

Proteacidites parvus Cookson 1950

(Plate 18, figure 9)

Synonymy

1950 Proteacidites parvus Cookson, p.175, Pl.3, fig.29.
1960 Proteacidites parvus Cookson, Couper, p.50, Pl.5, fig.21.
1965a Proteacidites parvus Cookson, Harris, p.92, Pl.28, figs 10,11.

Remarks: This species is the most common species of the genus in samples from Kiandra. These specimens conform in size and morphology with Cookson's rather brief description.

Dimensions: 35 (39) 44 µm

Occurrence: Found in samples from Kiandra and Nerriga in low frequencies.

Reported Stratigraphic Range: Paleocene of Victoria (Harris, 1965a), and Cretaceous through Oligocene in New Zealand (Couper, 1960).

Botanical Affinities: Unknown.

Proteacidites pseudomoides Stover 1973

(Plate 19, figure 5)

Synonymy

1973 *Proteacidites pseudomoides* Stover in Stover & Partridge, pp.266-267, Pl.25, fig.3.

Remarks: In size, morphology, and sculpture these grains conform with those described from the Gippsland Basin. This species is found consistently and in low frequencies in samples from Nerriga.

Dimensions: 26 (27) 30 µm

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: *Malvacipollis diversus* into *Proteacidites tuberculatus* Zone, early Eocene into early Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Proteacidites cf. *P. rectomarginis* Cookson 1950

(Plate 18, figure 8)

Synonymy

1950 *Proteacidites rectomarginis* Cookson, pp.174-175, Pl.2, fig.27.

1965a *Proteacidites* cf. *P. rectomarginis* Cookson, Harris, p.91, Pl.28, figs 14,15.

1972 *Proteacidites clintonensis* Harris, p.57, figs 30-34.

cf. *Proteacidites rectomarginis* Cookson, Stover & Partridge, 1973, p.267, Pl.23, figs 6-8.

Remarks: These specimens appear to resemble some that have been assigned to *P. rectomarginis*. They are most similar to but smaller than specimens described by Harris as *P. clintonensis*, especially Figure 30, which he remarks closely resembles *P. rectomarginis* Cookson but lacks the thickening of the nexine adjacent to the pores. Stover & Partridge (1973) revised the description of *P. rectomarginis* after study of topotype material and put *P. clintonensis* into synonymy with *P. rectomarginis*. According to the revised description, these specimens would be excluded from *P. rectomarginis* as they lack the granulate to verrucate sculpture and thickened nexine adjacent to the pores. The exine thins, rather than thickens, towards the apertures, so that these specimens are more similar to *P. incurvatus* in exine structure. However, *P. incurvatus* is larger (63-102 µm), the exine is much thicker (6 µm interradially, thinning to 4 µm adjacent to the pores), and grains have a coarser ornament of tuberculae or rounded verrucae (which, however, is not apparent on their illustrated specimen (Stover & Partridge, Pl.25, fig.8)).

Dimensions: 40 (48) 56 µm

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: *P. rectomarginis* is found from within the Lower *Nothofagidites asperus* Zone into the *Triporopollenites bellus* Zone, late Eocene into late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Unknown.

Proteacidites reticuloscabratus Harris 1965

(Plate 18, figure 7)

Synonymy

1965a *Proteacidites reticuloscabratus* Harris, p.93, Pl.28, figs 20,21.

1973a *Proteacidites reticuloscabratus* Harris, Martin, p.30, fig.135.

Remarks: Although these specimens are smaller than those originally described by Harris, which were 24 (29) 35 µm, they are otherwise similar.

Dimensions: 19 (23) 27 µm

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: Found in the Paleocene of Victoria (Harris, 1965a) and deposits of Eocene-Oligocene age from New South Wales (1973a).

Botanical Affinities: Probably with the Proteaceae. Pollen of *Lomatia longifolia* seen by the author is similar in size and general morphology.

Proteacidites similis Harris 1965

(Plate 20, figure 1)

Synonymy

1965a *Proteacidites similis* Harris, p.94, Pl.29, figs 11,12.

Remarks: These specimens are similar in size and general morphology to those described by Harris from the Paleocene of Victoria. The broadly concave sides, faintly patterned exine, and apparently diffuse pore edges distinguish this from other triporate grains found in these samples. This species has been found only in samples from Cadia.

Dimensions: 27 (28) 30 µm (seven specimens measured)

Occurrence: Found in samples from Cadia in low frequencies.

Reported Stratigraphic Range: This species has been reported only from the Paleocene Dilwyn Clay (Harris, 1965a).

Botanical Affinities: Unknown.

Proteacidites subpalisadus Couper 1953

(Plate 19, figures 7,10)

Synonymy

1953 *Proteacidites subpalisadus* Couper, p.43, Pl.5, fig.51.

1960 *Proteacidites subpalisadus* Couper, Couper, p.50, Pl.5, fig.20.

1973a *Proteacidites subpalisadus* Couper, Martin, pp.30-31, fig.136.

Remarks: The convex sides between the pores, reticulate thin exine, and large diameter of the apertures distinguish this, from other species. The diameter of the pores is variable, and in some specimens the apertures appear brevicolpate.

Dimensions: 15 (20) 30 µm

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Late Cretaceous to Late Eocene in New Zealand, and ?Late Pliocene of New South Wales (Martin, 1973a).

Botanical Affinities: Unknown.

Proteacidites subscabratus Couper 1960

(Plate 20, figure 2)

Synonymy

1960 Proteacidites subscabratus Couper, p.52, Pl.6, figs 8-10.

1965a Proteacidites subscabratus Couper, Harris, p.92, Pl.29, figs 8-10.

1973a Proteacidites subscabratus Couper, Martin, p.31, fig.137.

Remarks: Small, smooth, scabrate to faintly reticulate triporate grains conformable with this species were found in almost all samples.

Dimensions: 19 (22) 26 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Found in the Paleocene of Victoria (Harris, 1965a), and deposits of Eocene-Oligocene and ?Late Pliocene age of New South Wales (Martin, 1973a). Also reported from middle Oligocene of New Zealand (Couper, 1960).

Botanical Affinities: Unknown.

Proteacidites symphyonemoides Cookson 1950

(Plate 19, figure 9)

Synonymy

1950 Proteacidites symphyonemoides Cookson, p.172, Pl.2, fig.17.

1973 Proteacidites symphyonemoides Cookson, Stover & Partridge, p.268, Pl.25, figs 1,2.

Remarks: Examination of the lectotype has shown that these specimens belong to P. symphyonemoides, which has been redescribed and illustrated by Partridge (in Stover & Partridge, 1973). Partridge has noted the morphological differences between small reticulate grains found in Eocene deposits (here assigned to *P. pseudomoides* Stover 1973) and those found in Miocene deposits (*P. symphyonemoides*). This species has been found in low frequencies in almost all samples from Cadia.

Some specimens that are similar in morphology, but are larger and have a slightly coarser reticulum, have been found in samples from Kiandra. They would belong to a morphologically similar but distinct species, but have not been described because of their relative rarity.

Dimensions: 21 (25) 28 µm

Occurrence: Found in samples from Cadia in low frequencies.

Reported Stratigraphic Range: *Triporopollenites bellus* Zone, late Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Cookson (1950) compared this species with pollen of the living *Symphyonema* R. Br.

Proteacidites tuberculiformis Harris 1965

(Plate 19, figure 3)

Synonymy

1965a *Proteacidites tuberculiformis* Harris, p.92, Pl.29, figs 5-7.

1973 *Proteacidites tuberculiformis* Harris, Stover & Partridge, p.269.

Remarks: Large size and distinctive ornament readily distinguishes this from other species of the genus. Density and distribution of verrucae was variable on these specimens, with verrucae almost absent on some grains. Specimens were commonly torn or folded.

Dimensions: 85 (101) 120 µm

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: From within the Malvacipollis diversus Zone through the Lower Nothofagidites asperus Zone, early Eocene into late Eocene, in the Gippsland Basin (Stover & Partridge, 1973). Originally described from the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Unknown.

Proteacidites cadiensis sp. nov.

(Plate 18, figure 3)

Diagnosis: Grain triporate, angulaperturate, with a straight-sided triangular amb. Surface faintly reticulate. Pores have a weakly developed "pore canal".

Description: Grain free, isopolar, angulaperturate, triporate. Amb triangular, sides straight or nearly so, apices blunt; in equatorial view biconvex. Pore edges diffuse, not clearly defined; pores slightly concave in polar view, 4-5 µm in diameter. Exine 1.5-2 µm thick, nexine and sexine of equal thickness, stratification distinct, with clearly discernible columellae larger. Sexine tectate, surface faintly reticulate, reticulum uniform, size of units 0.5 µm. Sexine thins towards pores to less than 0.75 µm; nexine thickens adjacent to pore to 1.5 µm, forming a "pore canal" ca 5 µm long and generally difficult to discern because of the nature of the sculpture.

Remarks: This species is consistently found in low to moderate frequencies in samples from Cadia. In morphology, these specimens do not resemble any previously described species of the genus. Proteacidites parvus Cookson 1950 is larger, has a wider pore diameter in relation to size, and has a thicker exine. Proteacidites subscrabratus is smaller and has a slight thickening of the exine adjacent to the pore, rather than a pore canal structure.

P. concretus and P. latrobensis have more distinct, better developed "canal" structures.

Holotype: Specimen on slide 095/1 (1238-210), 35 µm in diameter, illustrated on Plate 18, figure 3.

Type locality: Cadia, Pacific Copper Core PC235, depth interval 29.45-29.75 metres. Middle Miocene.

Derivation of name: From Cadia, N.S.W., the locality where this species was found.

Dimensions: 27 (31) 35 µm

Occurrence: Found in samples from Cadia in low to moderate frequencies.

Botanical Affinities: Unknown.

Proteacidites tripartitus Harris 1972

(Plate 20, figures 5,6)

Synonymy

1972 Proteacidites tripartitus Harris, p.56, figs 23-25.

Remarks: Although these specimens are larger than those described by Harris, they are otherwise similar. The size of the mesh is reduced slightly towards the apertures, but any reduction in size towards the poles is imperceptible on these specimens, and very difficult to see on the specimens illustrated by Harris.

Dimensions: 26 (34) 42 µm (12 specimens measured)

Occurrence: Found in samples from Nerriga in low frequencies.

Reported Stratigraphic Range: This species first appears high in the Princetown Member of the Dilwyn Formation, and is common in middle Eocene deposits (Harris, 1972).

Botanical Affinities: Unknown.

Genus "*Triorites*"

Remarks: This generic name is used in an informal sense for simple triporate grains, smooth to sculptured, of variable size and of diverse origin, which are difficult to place in existing genera. A similar usage was employed by Hekel (1972). Harris (1972) and Dettmann & Playford (1968) summarised the state of the genus to that time. Pending a full review of the genus by Harris, use of it here will be informal.

"*Triorites*" *minisculus* McIntyre 1965

(Plate 20, figure 11)

Synonymy

1965 *Triorites minisculus* McIntyre, p.206, figs 6-8.

Remarks: Small triporate grains with simple pore structure and thin exine were found in most samples from all three localities. A wider size range is found in these specimens than was originally described by McIntyre (13-16 μm).

Dimensions: 13 - 22 μm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Paleocene of New Zealand (McIntyre, 1965).

Botanical Affinities: Unknown.

"Triorites" introlimbatus McIntyre 1968

(Plate 20, figure 9)

Synonymy

1968 Triorites introlimbatus McIntyre, pp.196-197, figs 57-61.

1973a Triorites introlimbatus McIntyre, Martin, pp.44-45, figs 193-194.

Remarks: A few specimens referable to this species were found. They are larger than those reported from New Zealand. No diporate forms were seen, although a few tetraporate grains were found.

Dimensions: 14 - 23 µm

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: Originally described from the Miocene of New Zealand, and also reported from Eocene-Oligocene deposits from New South Wales (Martin, 1973a).

Botanical Affinities: Unknown.

"Triorites" sp.

(Plate 20, figure 8)

Description: Grain free, triporate, subcircular in polar view, commonly modified by folding. Pores slightly protruding, circular, having a diameter of 2-3 µm. Exine 2-3 µm thick, two-layered, sexine slightly thicker than nexine, thickens slightly towards apertures. Faint reticulate ornament, lumina and muri less than 0.5 µm in diameter, appears uniform over grain.

Remarks: These spherical triporate grains are unlike any previously described species from Australian Tertiary deposits.

Dimensions: 28 (34) 45 μm (11 specimens measured)

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Boranical Affinities: Unknown.

Genus *Haloragacidites* Couper 1953

Type species (by original designation): *Haloragacidites trioratus* Couper, 1953.

Synonymy

1953 *Haloragacidites* Couper, p.41.
1954 *Casuarinidites* Cookson & Pike, p.200.
1960 *Casuarinidites* Cookson & Pike, Potonié, p.114.
1960 *Haloragacidites* Couper, Potonié, p.125.

Remarks: This fossil genus and its type species have had a confusing history (see Mildenhall & Harris, 1971, for a full discussion). Although Couper (1960, p.67) placed *H. trioratus* (here regarded as synonymous with *Casuarinidites cainozoicus*) and *Triorites harrisii* in synonymy, this has not been followed here. *H. trioratus* is retained for pollen grains with strongly aspidate pores, and *H. harrisii* includes triporate grains of similar morphology but with thinner exine and non-aspidate pores.

Haloragacidites harrisii (Couper) Harris 1971

(Plate 20, figure 7)

For synonymy to 1971, see Mildenhall & Harris, 1971, p.304.

1972 "*Triorites*" *harrisii* Couper, Hekel, p.17, Pl.5, fig.7.

1973 *Haloragacidites harrisii* (Couper) Harris, Stover & Partridge, p.271.

1973a *Casuarina harrisii* (Couper), Martin, p.33, figs 147,148.

Remarks: Although the general morphology of *H. harrisii* and *H. trioratus* is similar, *H. harrisii* has a wider pore opening, less protrusion of the pore itself, a larger size range, and thinner exine with no thickening adjacent to the apertures.

This species is found in almost all samples, and is abundant in some samples from Cadia.

Dimensions: 24 (27) 37 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare to abundant.

Reported Stratigraphic Range: *Lygistepollenites balmei* through *Triporopollenites bellus* Zones, middle Paleocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Widely reported throughout the Tertiary in Australia, and occurs from Late Cretaceous to Late Pliocene in New Zealand (Mildenhall & Harris, 1971).

Botanical Affinities: Probably with *Casuarina*. Cookson & Pike (1954b, p.216) also suggested a close affinity with *Canacomyrica monticola* of the Myricaceae, known only from New Caledonia. Couper (1953) had already suggested similarities with pollen of *Casuarina* and *Geniostoma rupestre*; he later (1960) considered the pollen of Geniostoma distinct, but Casuarina very similar. Kershaw (1970) has discussed the morphological variation found within living species of the Casuarinaceae, which includes the range found both within this species and especially in H. trioratus.

Haloragacidites trioratus Couper 1953

(Plate 20, figure 16)

Synonymy

1953 Haloragacidites trioratus Couper, p.41, Pl.5, fig.50.

1954b Casuarinidites cainozoicus Cookson & Pike, p.200, Pl.1, figs 1-6.

1960 Triorites harrisii Couper, Couper, p.67 (pars), Pl.12, fig.3.

1965a Casuarinidites cainozoicus Cookson & Pike, Harris, p.90, Pl.27, fig.35.

1971 Haloragacidites trioratus Couper, Mildenhall & Harris, pp.301-304, figs 1-5.

1972 Casuarinidites cainozoicus Cookson & Pike, Hekel, p.15, Pl.5, fig.5.

1973a Casuarina cainozoica (Cookson & Pike), Martin, pp.32-33, figs 145-146.

Remarks: This species was found in almost all samples, although it was never as abundant as H. harrisii. Specimens with four aspidate pores were found in samples from Cadia, whereas in samples from Nerriga and Kiandra, all specimens had three pores.

Dimensions: 22 (24) 26 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare to common.

Reported Stratigraphic Range: Widely reported throughout the Tertiary and also Quaternary in Australia, and found from Oligocene to lower Miocene in New Zealand (Mildenhall & Harris, 1971).

Botanical Affinities: Probably with Casuarina. Cookson & Pike (1954b) suggested affinities with Casuarina and also possibly Canacomyrica.

Haloragacidites haloragoides Cookson & Pike 1954

(Plate 20, figure 10)

Synonymy

1954b Haloragacidites haloragoides Cookson & Pike, p.202, Pl.1, figs 7-9.

1973a Haloragis haloragoides (Cookson & Pike), Martin, p.21, figs 85-87.

1973 Haloragacidites haloragoides Cookson & Pike, Stover & Partridge, p.271, Pl.27, figs 4,5.

Remarks: These specimens are very similar to those previously described. Three- to five-pored grains were seen, although those with four pores were most common.

Dimensions: 18 (25) 30 µm (eight specimens measured)

Occurrence: Found in samples from Cadia. Rare.

Reported Stratigraphic Range: Upper part of the Triporopollenites bellus Zone, late Miocene, in the Gippsland Basin (Stover & Partridge, 1973). Pliocene to Quaternary (Cookson & Pike, 1954b; Martin, 1973a).

Botanical Affinities: Similar to living species of Haloragis (Martin, 1973a).

Subturma POLYPORINES Potonié 1960

Genus *Anacolosidites* Cookson & Pike 1954

Type species: *Anacolosidites efflatus* (Potonié) Krutzsch, designated by Krutzsch, 1959.

Anacolosidites acutullus Cookson & Pike 1954

(Plate 20, figures 12,14)

Synonymy

1954b *Anacolosidites acutullus* Cookson & Pike, p.208, Pl.1, figs 62,63.

1965a *Anacolosidites acutullus* Cookson & Pike, Harris, p.94, Pl.27, figs 27,28.

1973 *Anacolosidites acutullus* Cookson & Pike, Stover & Partridge, p.270, Pl.27, fig.1.

Remarks: These specimens conform in size and morphology with previous descriptions. Only three specimens were found in samples from Nerriga. The sexine ornament appears to be uniform in size over the surface of the grain in these specimens, whereas the grain illustrated by Stover & Partridge has sculpture that is coarser near the poles than at the equator.

Dimensions: 37, 42, and 44 µm (three specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: *Malvacipollis diversus* Zone to basal part of Lower *Nothofagidites asperus* Zone, early to middle Eocene, in the Gippsland Basin. Also reported as rare in the Paleocene of Victoria (Harris, 1965a).

Botanical Affinities: Cookson & Pike (1954b) suggested affinities with pollen of *Anacolosa*, of the Olacaceae, or an allied extinct type.

Anacolosidites luteoides Cookson & Pike 1954

(Plate 20, figures 13,17)

Synonymy

1954b Anacolosidites luteoides Cookson & Pike, pp.207-208, Pl.2, fig.50.

1965a Anacolosidites luteoides Cookson & Pike, Harris, p.94, Pl.27 fig.29.

1968 Anacolosidites luteoides Cookson & Pike, McIntyre, p.195, figs 55,56.

1973 Anacolosidites luteoides Cookson & Pike, Stover & Partridge, p.270, Pl.27, fig.6.

Remarks: Several specimens of A. luteoides were found in samples from Nerriga. They are slightly larger than the specimens from the Gippsland Basin, but are otherwise similar. No specimens with slit-like apertures, referable to Anacolosidites sectus Partridge 1973, were found.

Dimensions: 20 (22) 22 µm (four specimens measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: Malvacipollis diversus Zone into Lower Nothofagidites asperus Zone, early and middle Eocene, in the Gippsland Basin. Also found in the Paleocene of Victoria (Harris, 1965a) and in the Eocene of New Zealand (McIntyre, 1968).

Botanical Affinities: Cookson & Pike (1954b) noted the similarity of this species to pollen of the living species Anacolosa lutea Gillespie, found in Fiji, and A. papuana Schellen, found in New Guinea and adjacent islands. The genus Anacolosa has its present main development in the tropical region of the Western Pacific and southern India (Couper, 1960). This distinctive arrangement of six pores is also found in other genera of the Olacaceae (Cathedra, Ptychopetalum). Archangelsky (1973) has described a species similar to A. luteoides from the Paleocene of Artentina, and remarks that the presence of fossil remains of this tropical family in Lower Tertiary deposits in Australia, New Zealand, Argentina, Europe, and the U.S.A. may indicate a major expansion into higher latitudes during that time, under warmer conditions.

Genus Periporopollenites Pflug & Thomson 1953

For synonymy see Stover & Partridge, 1973, p.272.

Type species: Periporopollenites stigmosus Potonié, designated by Pflug & Thomson in Thomson & Pflug, 1953.

Remarks: Stover & Partridge (1973, p.272) have used this form genus for periporate grains with 10 to ca 32 apertures, clearly stratified and comparatively thin exines, and simple pores with or without spanning membranes. This usage is followed herein, reserving Polyporina Naumova ex Potonié 1960 for small, thick-walled polyporate grains of probable chenopodiaceous affinities, and Malvacipollis Harris 1965 for polyporate grains with sculptural protrusions.

Periporopollenites vesicus Partridge 1973

(Plate 20, figure 15; Plate 21, figure 1)

Synonymy

1973 Periporopollenites vesicus Partridge in Stover & Partridge, p.273, Pl.26, fig.12.

Remarks: These specimens have fewer pores than the specimens described from the Gippsland Basin (ranging from 10 to 15 with an average of 13). The columellae are also distinct, but less so than in specimens of P. demarcatus Stover. The annular thickening around the pores and the granular membrane covering the pores distinguishes this from other polyporate grains found in these samples. Although Partridge does not mention any thickening around the rims of the pores, his illustrated specimen appears to have annular thickenings.

Dimensions: 28 (32) 38 µm (eight specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: Lower *Nothofagidites asperus* Zone into the *Proteacidites tuberculatus* Zone, middle Eocene through Oligocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Similar periporate grains are found in species belonging to the Amaranthaceae, Chenopodiaceae, and Alismataceae.

Periporopollenites demarcatus Stover 1973

(Plate 21, figures 2,3)

Synonymy

1973 *Periporopollenites demarcatus* Stover in Stover & Partridge, pp.272-273, Pl.26, figs 10,11.

Remarks: These specimens are smaller than those from the Gippsland Basin, which are 26 (29) 35 µm, but are otherwise similar. The symmetrical arrangement of the twelve pores distinguishes this from the other periporate species found in these samples. This species is more common in samples from Nerriga than in those from Kiandra.

Dimensions: 21 (26) 30 µm (eight specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: From within the Malvacipollis diversus Zone into the Proteacidites tuberculatus Zone, early Eocene into early Miocene, in the Gippsland Basin.

Botanical Affinities: Unknown.

Periporopollenites sp. 1

(Plate 21, figure 4)

Description: Grain free, spherical, periporate. Amb generally circular, commonly modified due to folding of grain. Pores number 11 to 14, irregularly distributed, circular, 4-7 µm in diameter, with low thickened borders 0.5-0.75 µm high. Exine 1.5-2 µm thick, stratification generally apparent, columellae distinct, single, uniformly distributed; sexine slightly thicker than nexine, puncto-reticulate, units 0.5 µm in diameter.

Remarks: This species has lower annuli and lacks the spanning pore membranes found in P. vesicus, has more definite, larger, and fewer pores than P. sp. 2, and has an irregular pore arrangement and is larger than P. demarcatus.

Dimensions: 28 (34) 44 µm (six specimens measured)

Occurrence: Found in samples from Kiandra. Rare.

Botanical Affinities: Unknown.

Periporopollenites sp. 2

(Plate 21, figure 6)

Description: Grain free, spheroidal, periporate. Amb generally circular to ellipsoidal. Pores number 15 to 30, 2-3 µm in diameter, circular, unrimmed, edges diffuse. Exine thin, 1-1.5 µm, stratification generally difficult to discern. Nexine appears very thin. Sexine puncto-reticulate, columellae single, distinct, densely and uniformly distributed. Units of reticulum 0.5 µm in diameter.

Remarks: This species has smaller, more numerous pores than the three previous species of the genus, and is unlike any previously described periporate species from Australian Tertiary deposits. It has been found in most samples from Kiandra.

Dimensions: 28 (34) 40 µm

Occurrence: Found in samples from Kiandra in low to moderate frequencies (up to 4% of total grain count).

Botanical Affinities: Unknown.

Genus *Malvacipollis* Harris 1965

Type species: *Malvacipollis diversus* Harris 1965; monotypic when proposed.

Malvacipollis diversus Harris 1965

(Plate 21, figure 5)

Synonymy

1965a *Malvacipollis diversus* Harris, p.95, Pl.29, fig.18 (non fig.19).

1972 *Malvacipollis diversus* Harris, Hekel, p.18, Pl.6, figs 28,29.

1973 *Malvacipollis diversus* Harris, Stover & Partridge, p.272, Pl.26, fig.6.

1973 *Malvacipollis diversus* Harris, Stover & Evans, Pl.3, fig.3.

Remarks: The pores are difficult to see in most specimens, and number from 4 to 7. A large range of variation was found in intensity of the annular thickening and length and density of the conate spines.

The specimens seen conform in structure to euphorbiaceous, rather than malvaceous, pollen, as outlined by Martin (1974).

Dimensions: 22 (26) 29 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Upper part of the *Lygistepollenites balmei* Zone through the *Proteacidites asperopolus* Zone, late Paleocene through early Eocene, in the Gippsland Basin. Also found from the Paleocene of Victoria (Harris, 1965a), Paleocene through Miocene-Pliocene in Queensland (Hekel, 1972), and middle Eocene through Miocene in New South Wales (Martin, 1974).

Botanical Affinities: Martin (1974) has noted the similarities, based on exine stratification and spine structure, with *Austrobuxus* (*Longetia*) *swainii* and *Dissiliaria halaghioides* of the Euphorbiaceae, and has shown how these differ from malvaceous pollen. Pollen of *Longetia swainii* seen by the author is similar, but has fewer pores; grains had 4 or 5 pores.

Malvacipollis subtilis Stover 1973

(Plate 21, figure 10)

Synonymy

1965a *Malvacipollis diversus* Harris, Pl.29, fig.19.

1973 *Malvacipollis subtilis* Stover in Stover & Partridge, p.272, Pl.26, figs 7-9.

Remarks: Stover & Partridge (1973) have noted that *M. subtilis* differs from *M. diversus* by having spines rather than conate projections, more widely spaced spines, and a slightly larger size. This appears to be a workable method of distinguishing these two types, based on the material seen in the present study. In most specimens of both species, however, the apertures are difficult to see. Some of these specimens have a thinner exine (1 μm max.) than the specimens illustrated by Stover & Partridge, and are larger, but are otherwise similar.

Dimensions: 29 (38) 48 μm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Upper part of Lygistepollenites balmei Zone through Triporopollenites bellus Zone, early Eocene through late Miocene, in the Gippsland Basin.

Botanical Affinities: As with previous species.

Genus Polyporina Naumova ex Potonié 1960

Type species: Polyporina multistigmosa (R. Pot. 1934), designated by Potonié, 1960.

Polyporina cf. P. chenopodiaceoides Martin 1973

(Plate 21, figure 7; Plate 22, figure 1)

cf. P. chenopodiaceoides Martin, 1973a, p.28, figs 118-120.

Description: Grain free, spherical, polyporate. Pores circular, with very low rims or unrimmed, up to 50 in number, 1-2 μm in diameter. Exine smooth to scabrate, thick (2 μm), sexine thicker than nexine, structure and sculpture difficult to discern.

Remarks: Several small, thick-walled polyporate grains which resemble P. chenopodiaceoides Martin 1973 were found in samples from Kiandra and Cadia. The general exine structure and sculpture appear indistinct, perhaps due to chemical corrosion during preparation or preservation. P. chenopodiaceoides differs from these specimens in having a thinner exine, narrow rims around the pores, distinct pores, and a patterned exine.

Dimensions: 10 (16) 23 µm

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Reported Stratigraphic Range: Martin (1973a) has reported P. chenopodiaceoides from ?Upper Pliocene and Pleistocene deposits from New South Wales.

Botanical Affinities: Similar polyporate grains are found in the Chenopodiaceae, Caryophyllaceae, and Amaranthaceae.

Genus Polyorificites Martin 1973

Type species (by original designation): Polyorificites oblatus Martin, 1973.

Polyorificites sp.

(Plate 21, figure 8; Plate 22, figure 9)

Description: Grain free, spherical to oblate, amb circular, zoniporate. Pores small, numbering 5 to 7, 2 µm in diameter, circular to elliptical, with an annulus 0.5 µm wide. Exine thin, less than 1 µm, with a fine reticulate pattern.

Remarks: A few zoniporate grains found differed from P. oblatus Martin 1973 in having a thinner exine and indistinct exine stratification, larger size, and non-aspidate pores with a smaller annulus. This species differs from Helciporites astrus Partridge 1973, a zoniporate species similar to P. oblatus, in lacking the pronounced thickening around the pores, which are prominently aspidate.

Dimensions: 23 (28) 36 μm (seven specimens measured)

Occurrence: Found in samples from Kiandra and Cadia. Rare.

Botanical Affinities: Unknown.

Genus *Echiperiporites* van der Hammen & Wijmstra 1964

Type species (by original designation): *Echiperiporites akanthos* van der Hammen & Wijmstra, 1964.

Echiperiporites sp.

(Plate 21, figures 9,11)

cf. *Micrantheum spinyspora* Martin, 1973a, p.32, figs 141-143.

Remarks: Several echinate periporate grains were found in samples from Kiandra. They are similar to *Micrantheum spinyspora* Martin 1973, but are larger and have fewer pores.

Dimensions: 26, 36, and 36 μm (three specimens measured)

Occurrence: Found in samples from Kiandra.

Reported Stratigraphic Range: ?Upper Pliocene and Pleistocene of New South Wales for *Micrantheum spinyspora* (Martin, 1973a).

Botanical Affinities: Martin (1973a) has suggested that *M. spinyspora* is similar to the pollen of modern *Micrantheum ericoides* Des. f. and *M. hexandrum* Hook. f., and later (1974) also suggested affinities to *Neoroepera*.

Turma JUGATES Erdtman 1943

Subturma TETRADITES Cookson ex Potonié 1960

Genus *Ericipites* Wodehouse 1933

Type species: *Ericipites longisulcatus* Wodehouse 1933.

Ericipites crassiexinus Harris 1972

(Plate 22, figure 11)

Synonymy

1972 *Ericipites crassiexinus* Harris, pp.54-55, figs 15,16.

1973 *Ericipites crassiexinus* Harris, Stover & Partridge, p.273.

1973 *Tetrahedral tetrad*, Stover & Evans, Pl.4, fig.7.

Remarks: Several tetrads of this large smooth species were found in samples from Kiandra. In size and morphology they are similar to specimens previously described.

Dimensions: 36 (44) 52 µm (ten specimens measured)

Occurrence: Found in samples from Nerriga and Kiandra in low frequencies.

Reported Stratigraphic Range: *Malvacipollis diversus* Zone through *Triporopollenites bellus* Zone, early Eocene through Miocene, in the Gippsland Basin (Stover & Partridge, 1973).

Botanical Affinities: Harris (1972) noted similarities of this pollen type with the Order Ericales. Similar grains are found in the Epacridaceae, for example, *Epacris* cf. *calvertiana*.

Ericipites scabratus Harris 1965

(Plate 22, figure 3)

Synonymy

1965a Ericipites scabratus Harris, p.97, Pl.29, figs 22,23.

Remarks: These specimens differ from E. crassiexinus Harris in being scabrate rather than smooth, and having a thinner exine (ca 2 µm). Only the specimens from Cadia are close to the size range given by Harris (17-25 µm); the specimens from Kiandra are much larger, but otherwise similar.

Dimensions: 21 (32) 40 µm

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia in low frequencies.

Reported Stratigraphic Range: Harris (1965a) reported this species as rare in the Paleocene of Victoria.

Botanical Affinities: Harris (1965a) noted similarities with the Order Ericales. Similar grains united in tetrads are found in the Epacridaceae.

Genus Simplicepollis Harris 1965

Type species: Simplicepollis meridianus Harris 1965, monotypic when proposed.

Simplicepollis meridianus Harris 1965

(Plate 22, figures 12,13)

Synonymy

1965a Simplicepollis meridianus Harris, p.95, Pl.27, figs 32,33.

1973 Simplicepollis meridianus Harris, Stover & Partridge, p.275 (not illustrated).

Remarks: A few specimens conformable with this species were found in samples from Nerriga. These tetrads are similar in size and sculpture to those described from the Gippsland Basin.

Dimensions: 30 and 36 µm (two tetrads measured)

Occurrence: Found in samples from Nerriga. Rare.

Reported Stratigraphic Range: From within the Tricolporites lilliei Zone through the Lower Nothofagidites asperus Zone, Late Cretaceous into Late Eocene, in the Gippsland Basin. Common in lower Tertiary sediments of southern Australia (Harris, 1965a).

Botanical Affinities: Unknown.

Genus Gephyrapollenites Stover 1973

Type species (by original designation): Gephyrapollenites cranwellae Stover (in Stover & Partridge, 1973).

Gephyrapollenites calathus Partridge 1973

(Plate 22, figure 5)

Synonymy

1960 (?)Pseudowintera sp., Couper, p.46, Pl.5, fig.4.

1973a Drimys tetradites Martin, pp.17-18, figs 67-69.

1973 Gephyrapollenites calathus Partridge in Stover & Partridge, p.274, Pl.28, fig.3.

Remarks: These specimens were more commonly found united into tetrads, and the pore was difficult to see on many specimens. The pore was not bordered by an annulus. Only a few tetrads were found in samples from Kiandra, but this species was much more numerous in samples from Cadia. The size range is similar to previous descriptions.

Dimensions: 21 (29) 34 µm tetrad diameter; single grains 18-21 µm

Occurrence: Found in samples from Kiandra and Cadia in low frequencies.

Reported Stratigraphic Range: Lower *Nothofagidites asperus* Zone through *Triporopollenites bellus* Zone, late Eocene through Miocene, in the Gippsland Basin, and ?Upper Pliocene deposits in New South Sales (Martin, 1973a). Also reported from middle Oligocene to the present in New Zealand (Couper, 1960).

Botanical Affinities: Similar to grains of the living species *Drimys insipida* (R. Br. ex DC) and *D. lanceolata* (Poir.) Baill. (Martin, 1973a).

Subturma POLYADITES Pant 1954

Genus *Polyadopollenites* Pflug 1953

Type species: *Polyadopollenites multipartitus* Pflug in Thomson & Pflug 1953.

Polyadopollenites myriosporites (Cookson) Partridge 1973

(Plate 22, figure 2)

Synonymy

1954a *Acacia myriosporites* Cookson, p.55, Pl.1, figs 1,5-8.

1972 *Acacia pollenites* cf. *A. myriosporites* (Cookson), Mildenhall, pp.490-492, figs 1-10,13.

1973 *Polyadopollenites myriosporites* (Cookson) Partridge in Stover & Partridge, p.275, Pl.27, fig.11.

1973a *Acacia myriosporites* Cookson, Martin, p.20, fig.79.

Remarks: Only a single complete polyad of sixteen grains, and a half polyad of eight grains, were found in samples from Cadia. However, this species may be more abundant, but easily overlooked, due to the relatively unremarkable appearance and small size of single grains when the polyads have disaggregated.

Martin (1973a) notes that this species occurs in relatively low frequencies and is associated with high Casuarinaceae and Myrtaceae counts in her samples.

Dimensions: 30 and 39 µm diameters of polyads; single grains *ca* 15 µm

Occurrence: Found in two samples from Cadia.

Reported Stratigraphic Range: From within the *Proteacidites tuberculatus* Zone through the *Triporopollenites bellus* Zone, Miocene, in the Gippsland Basin. Also reported from Pliocene deposits in Queensland (Hekel, 1972), Pliocene deposits in Victoria (Cookson, 1954a), ?Upper Pliocene deposits in New South Wales (Martin, 1973a), and Middle Miocene in the Otway and St Vincent Basins (Harris, 1971). Middle Pliocene to Holocene in New Zealand (Mildenhall, 1972; pers. comm.).

Botanical Affinities: Cookson (1954a) compared this with living species of *Acacia*.

INCERTAE SEDIS

Genus *Schizosporis* Cookson & Dettmann 1959

Type species (by original designation): *Schizosporis reticulatus* Cookson & Dettmann, 1959.

Schizosporis parvus Cookson & Dettmann 1959

(Plate 22, figure 8)

Synonymy

1959 Schizosporis parvus Cookson & Dettmann, p.216, Pl.1, figs 15-20.

1963 Schizosporis parvus Cookson & Dettmann, Dettmann, p.108, Pl.XXVI, figs 18,19.

Remarks: Although these specimens are smaller than those described by Cookson & Dettmann (the equatorial diameter of their specimens was 65-90 μm), they are otherwise similar in having an ellipsoidal shape, equatorial furrow, and a relatively thin, faintly patterned exine.

Dimensions: 38 (54) 62 μm (12 specimens measured)

Occurrence: Found in samples from Nerriga, Kiandra, and Cadia. Rare.

Reported Stratigraphic Range: Upper Mesozoic deposits in the Otway and Great Artesian Basins (Cookson & Dettmann, 1959).

Botanical Affinities: Unknown. Cookson & Dettmann (1959) noted some resemblance to zonosulcate pollen of the Rapateaceae, although an angiosperm origin for this group is uncertain.

?Schizosporis rugulatus Cookson & Dettmann 1959

(Plate 22, figure 4)

Synonymy

1959 Schizosporis rugulatus Cookson & Dettmann, p.216, Pl.1, figs 5-9.

Remarks: A single specimen which appears very similar to, if not identical with, S. rugulatus was found in a sample from Nerriga. It is large, and is within the size range given by Cookson & Dettmann (82-112 μm). This specimen resembles ?Schizosporis sp. or Ovoidites sp. illustrated by Harris from lower Tertiary deposits in Queensland (1965b, Pl.1, fig.10).

Dimensions: 88 µm long

Occurrence: Found in a sample from Nerriga.

Reported Stratigraphic Range: Cretaceous (Albian-Cenomanian) deposits in southeastern Australia (Cookson & Dettmann, 1959), and lower Tertiary deposits in Queensland (Harris, 1965b).

Botanical Affinities: Unknown.

Genus *Circulisporites* de Jersey emend. Norris 1965

Type species (by original designation): *Circulisporites parvus* de Jersey, 1962.

Circulisporites spp.

(Plate 22, figures 6,7,10)

Remarks: There are probably two different species of this genus represented in these samples. The specimens from Cadia have thinner, more irregular ridges on each equatorial half, and are very similar to those described from Tertiary deposits in Queensland (Hekel, 1972). Several specimens were split into two equal parts along the equator, suggesting a thinning of the exine. Norris (1965) noted a similar separation into hemispheres in specimens from Antarctica.

The specimens from Nerriga have thicker, more regularly concentric ridges, and appear to have a slight thickening or "rim" at the equator, and no separated hemispheres were seen. These specimens are probably a different species of *Circulisporites*.

No specimens were found in any samples from Kiandra.

Dimensions: 40 (46) 52 µm

Occurrence: Found in samples from Nerriga and Cadia in low to moderate frequencies.

Reported Stratigraphic Range: Similar forms have been seen in Devonian deposits from the Canning Basin (personal observation), and have been reported from Permian of Western Australia, Triassic and Jurassic of Queensland, Triassic of Antarctica, Cretaceous of Africa, and Lower Tertiary deposits of Queensland (references in Hekel, 1972).

Botanical Affinities: Unknown. Possibly algal or fungal.

DISPERSED FUNGAL SPORES AND FRUCTIFICATIONS

Introduction

Fungal remains were common in all samples, and fungal spores comprised 40-60%, on average, of the total spore component (pollen/spores + fungal spores) in each sample. Fructifications, both immature and mature, commonly fragmented, bits of hyphae, and clusters of fungal cells were also abundant. Although considered of little stratigraphic or ecological use by most palynologists, the fungal material in these samples was extremely abundant and diverse, and some mention of it must be made. However, detailed quantitative and qualitative analysis of the fungal remains were considered unwarranted at the present time, and a rather broad taxonomic treatment has been given to them here, to show the wide range of morphological types present in these samples. The dispersed fungal spores, which cannot be identified with living forms, have simply been identified to form-generic level. Special attention has been given to the unusual and ornamented types, which, because of their distinctive appearance, have greater potential, at least initially, as stratigraphic indicators than the psilate and morphologically simpler types. Any stratigraphic or paleoecological uses for dispersed fungal spores are just beginning to be demonstrated (Elsik, 1974), but this usefulness cannot be fully assessed until published records of dated fossil fungal assemblages are both numerous and available for evaluation and comparison.

The fossil record of the fungi is attracting renewed attention, both from workers interested in documenting the stratigraphic occurrences of dispersed fungal remains, in an effort to demonstrate the stratigraphic usefulness of this group, and also from biologists interested in the evolutionary history and ecology of the group. The two main centres of activity have been North America, with studies by Dilcher (1965), Clarke (1965), Elsik (1968a), Sheffy & Dilcher (1971), and Elsik & Dilcher (1974); and also in India, with works by Rao (1958), Venkatachala & Kar (1969), Jain & Gupta (1970), Kar, Singh, & Sah (1972), and Ramanujam & Rao (1973). This list is by no means comprehensive, but gives some of the more significant papers on fossil fungi.

A resurgence of interest in dispersed fungal remains in the past ten years, especially by American palynologists, has resulted in development of a morphological classification for these fossils with no phylogenetic implications. The classification used here is based on characteristics of shape, number of cells and apertures, and type of septation, and is that followed by Clarke (1965), Dilcher (1965), Elsik (1968a; 1968b), Sheffy & Dilcher (1971), and Elsik & Jansonius (1974), among others. The practice of creating form species on single specimens to show the range of variation found in fungal assemblages is not followed here, however, and most forms are identified only to generic level. A completely different approach has been followed by Lange & Smith (1971), who used a pictorial, essentially non-taxonomic method to illustrate the variety of dispersed fungal spores found in the Middle Eocene

Maslin Bay floras. This method avoids the encumbrance of creating numerous form species to accommodate this variety. A compromise between these two approaches would probably create a workable method for handling the range of morphological types found in these samples, and facilitate comparisons with other fungal floras.

In the following section, fungal spores have been subdivided into groups based on number of cells (unicellate, dicellate, multicellate) and are generally identified to form-generic level only. Two new genera have been erected, each including two new species.

The fructifications, which can be related to living families, have been identified with previously described species, and no new species have been proposed.

A few miscellaneous fungal remains unlike anything seen previously by the author in the literature are mentioned in the concluding section.

Remarks: A diverse array of single-celled, thick-walled fungal spores were found in all samples. Many spores showed numerous irregular perforations, probably a result of biological degradation. Most spores have been included in existing form genera; a few unicellate spores could not be placed in an existing genus, so two new genera, Striatisporonites and Ornatisporonites, are proposed herein, for ornamented unicellate, monoporate spores.

Genus Inapertisporites (van der Hammen 1954) emend. Sheffy & Dilcher 1971

Remarks: This genus includes unicellate, inaperturate fungal or algal spores, usually globular to subglobular in shape, with variable sculpture.

Inapertisporites spp.

(Plate 23, figures 1,2,4,5,8,10)

Remarks: Almost all samples contained a diverse assemblage of inaperturate globular, fusiform, and irregularly shaped spores, ranging from 5 µm to almost 50 µm in maximum diameter. Further subdivision of this group has not been attempted at this time. Many of the large, spherical grains showed radial tears due to compression, although one extremely large sphere, 60 µm in diameter, had a distinctive series of folds probably also resulting from compression. The six types illustrated show the range of size and shape seen in this group.

Genus *Monoporisporites* (van der Hammen 1954) emend. Sheffy & Dilcher 1971

Remarks: This genus includes unicellate, monoporate, smooth to finely punctate fungal or algal spores, with spherical to subspherical shape. The aperture can be either a hilum or a pore.

Monoporisporites spp.
(Plate 23, figure 3)

Remarks: Most spores assigned to this genus are small (9 to 20 µm), spherical to elliptical, and smooth. These monoporate, unicellate grains were found in low frequencies in most samples.

Genus *Lacrimasporonites* (Clarke 1965) emend. Elsik 1968

Remarks: As emended, this genus includes unicellate, monoporate, psilate fungal spores, spatulate to elliptical in shape, with the pore apical.

Lacrimasporonites spp.
(Plate 23, figures 7)

Remarks: Specimens assigned to this genus occur in samples from all three localities. The tear-drop shape distinguishes this from other monoporate, unicellate forms, and the thick wall and pore "canal" distinguish it from other previously described species of the genus. A typical specimen of this genus is illustrated; it is large, spherical, and has a short, definite, pore canal. Most other species seen in these samples were smaller and more elongated.

Genus Diporisporites (van der Hammen 1954) emend. Elsik 1968

Remarks: Unicellate, diporate spores, with pores on opposite ends of the grain, shape and sculpture variable, are included in this genus.

Diporisporites spp.

(Plate 23, figure 6)

Remarks: Specimens referred to this genus are found sporadically in some samples from all three localities.

Genus Hypoxylon (Bulliard 1791) Fries 1849

cf. Hypoxylon sp.

(Plate 23, figure 11)

Remarks: Several spores similar to those illustrated by Elsik & Dilcher (1974) were found in samples from Kiandra. The elongate, fusiform spores are characterized by a linear fold, slit, or scar.

Genus Ornatisporonites gen. nov.

Diagnosis: Unicellate spores of fungal or algal origin; nonseptate, with a single pore. Exine thick. Shape spherical or nearly so; ornament of spiny projections.

Type species: Ornatisporonites spectabilis sp. nov.

Remarks: This genus is erected for unicellate, monoporate, spherical spores with an ornament of spiny projections. At present there appears to be no form genus which can accommodate such spores. Monoporisporites (van der Hammen), Lacrimasporonites (Clarke), and Basidiosporites Elsik are restricted to psilate to finely punctate spores (although Elsik & Dilcher, 1974, Pl.27, fig.10, include a spore with verrucate sculpture in the genus Monoporisporites), and Reticulatisporonites Elsik is restricted to spores with reticulate sculpture.

Ornatisporonites spectabilis sp. nov.

(Plate 23, figure 9)

Description: Unicellate, monoporate, spherical spores. Wall thick, 2-3 µm, ornamented with long, thin spines, 8 µm long, sharply pointed and commonly bent. Pore small, 2 µm in diameter, difficult to discern. Maximum diameter of two grains measured, excluding spines, 48 and 48 µm.

Holotype: Specimen on slide 028/4 (1011-032), 48 µm in diameter, illustrated on Plate 23, figure 9.

Type locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of name: From Latin, spectabilis, showy, in reference to the ornament of long, dense spines.

Remarks: These spores are larger and have longer, stouter, more sharply pointed spines than Ornatisporonites spiculus. This species has been found in samples from Kiandra and Cadia.

Ornatisporonites spiculus sp. nov.

(Plate 23, figure 13)

Description: Unicellate, monoporate, spherical spores. Wall thick, 2 µm, ornamented with closely spaced, conical spines, up to 3 µm long, 2 µm apart, commonly broken so that only bases remain. Pore 3-4 µm in diameter. Maximum diameter of five grains measured, 22-31 µm.

Holotype: Specimen on slide 028/5 (936-207) 22 µm in diameter (excluding spines), illustrated on Plate 23, figure 13.

Type locality: New Chum Hill, Kiandra, Cornishman's Claim, 8.8 metres below top of section. Early Miocene.

Derivation of name: From Latin, spica, point, spear, for the ornament of short, sharp spines.

Remarks: These spherical, spiny spores were found in samples from Kiandra. This species differs from _O. spectabilis_ in having spines that are shorter, finer, and more densely spaced.

Striatisporonites gen. nov.

Diagnosis: Unicellate spores of fungal or algal origin; nonseptate, with a single pore. Exine thick. Shape fusiform or elongate. Ornament of longitudinal striations.

Type species: _Striatisporonites clinatus_ sp. nov.

Remarks: This genus is erected for longitudinally striated, unicellate monoporate spores, as at present there appears to be no valid form genus which can accommodate them.

Striatisporonites clinatus sp. nov.

(Plate 23, figure 14)

Description: Unicellate, monoporate, fusiform spores. Pore at apical end, 2 µm in diameter. Wall 1 µm thick, ornamented with slightly sinuous, longitudinal striae 2 µm wide, 2-3 µm apart. Maximum length of four grains measured, 27, 29, 40, and 44 µm.

Holotype: Specimen on slide 147/5 (1103-169), 29 µm in diameter, illustrated on Plate 23, figure 14.

Type locality: Nr Nerriga, G.R. 30846656, 22.5-30 cm above base of section at Titringo Creek. Early Eocene.

Derivation of name: From Latin, clinatus, bend, slant, in reference to the sinuous nature of the ridges.

Remarks: These spores have only been found in samples from Nerriga. Only four specimens have been found to date. The distinctive ornament distinguishes this species from previously described unicellate, monoporate spores. This species is large and has a more robust ornament than S. minutus.

Striatisporonites minutus sp. nov.

(Plate 23, figure 15)

Description: Unicellate, monoporate, tear-drop shaped spore, with pore at apical end, 1.5 µm in diameter. Wall 1 µm thick, ornamented with longitudinal striae. Maximum length of two grains measured, 12 and 14 µm.

Holotype: Specimen on slide 147/3 (1212-187), 12 µm in diameter, illustrated on Plate 23, figure 15.

Type locality: Nr Nerriga, G.R. 30846656, 22.5-30 cm above base of section at Titringo Creek. Early Eocene.

Derivation of name: From Latin, minus, minutus, small, in reference to the diminutive size of these spores.

Remarks: These spores are smaller and more tear-drop shaped than Striatisporonites clinatus, but have a similar ornament of longitudinal striae. They have been found only in samples from Nerriga.

Dicellate Fungal Spores

Dicellaesporites Elsik 1968 emend. Sheffy & Dilcher 1971

Remarks: This genus includes inaperturate fungal spores or algal bodies of two cells, uniseptate, psilate to scabrate, of variable shape.

Dicellaesporites spp.

(Plate 23, figure 16; Plate 24, figure 4)

Remarks: Spores included in this genus were common in samples from all three localities. Two general types were found, and are illustrated; one with a fusiform outline, and a thin septum between the two cells, and the other with a thicker wall, rounder shorter cells and a thick, dark septum between them.

Genus Fusiformisporites (Rouse 1962) emend. Elsik 1968

Fusiformisporites spp.

(Plate 23, figures 12,17)

Remarks: Two separate species referable to this genus were found in samples from Nerriga. Both are longitudinally striate, and are 44 to 52 µm long. One species has rather delicate striae, and is similar to Fusiformisporites sp. described by Kemp (in prep.) from Ninetyeast Ridge, although her specimens appear to have shorter ribs. The other species found in these samples is strongly striate.

Genus Dyadosporonites Elsik 1968

Dyadosporonites sp.

(Plate 23, figure 18)

Remarks: Several spores referable to Dyadosporonites were found in samples from Kiandra. They range in maximum length from 25 to 40 μm and were commonly torn at the edge of the pores, probably due to compression.

Multicellate Fungal Spores

Genus *Diporicellaesporites* Elsik 1968

Remarks: This genus includes diporate, multicellate fungal or algal spores, with pores placed at opposite ends of the spore. The shape and ornament are variable. Several different types referred to this genus were found in these samples. One of the most common types can be identified with a species described by Kemp from Ninetyeast Ridge (in prep.), and one is described as a new species, with a distinctive spinose ornament. A third type, found in samples from Nerriga, is unornamented (Pl.24, fig.8).

Diporicellaesporites endogranulosus Kemp (ms name)
(Plate 24, figures 1,3)

Remarks: These specimens appear to be identical in size and morphology with those described by Kemp from pre-Miocene sediments of Ninetyeast Ridge. These specimens are 52 to 86 μm in length, and have been found in samples from Nerriga and Cadia.

Diporicellaesporites sp. nov.
(Plate 24, figures 6,7)

Description: Four-celled spores, roundly fusiform in outline, consisting of two large, rounded central cells and two smaller cylindrical cells, one at each end, each with a single pore. Spore wall 1 μm thick, that of the central two cells ornamented with bluntly rounded spines up to 4 μm long, 2-3 μm apart.

The wall of the two terminal cells is smooth. Maximum length of two specimens measured, 44 and 52 µm.

Remarks: This species has been found only in samples from Nerriga. It does not resemble any previously described species.

Genus Multicellaesporites Elsik 1968

Multicellaesporites spp.

(Plate 24, figures 5,10)

Remarks: This genus includes inaperturate spores of three or more cells, two or more septa, with shape variable around a long axis. A tetracellate and a linear curved type are illustrated, to show the range found in this genus. Spores referred to this genus are found in samples from all three localities.

Genus Pluricellaesporites (van der Hammen 1954) emend.

Elsik & Jansonius 1974

Pluricellaesporites spp.

(Plate 24, figures 9,11,14)

Remarks: Spores with three or more cells, symmetrical or nearly so around the long axis, with a single aperture at one end, are included in this form genus. This genus has been emended several times. Clarke (1965) restricted it to specimens with five or more cells, with no comment on aperture but mentioned slit-like openings through the septa. Elsik (1968a) emended Pluricellaesporites to smooth spores of three or more cells with a single pore, with no mention of the slit-like aperture between cells. Sheffy & Dilcher (1971) further emended this genus to include spores with psilate to scabrate ornament. Elsik & Jansonius (1974) emended it to include specimens that have a subdued ornament, and have broadened the concept of the aperture to include those with a hilum or exitus. Thus this generic concept of multicellular linear forms is obviously broad, and, as specimens are commonly broken at the ends, and distorted by compression, details of aperture and slits in septa are very difficult to discern. Fractisporonites Clarke 1965 is a useful generic concept for fragments of these linear spores which have no apertural details discernible.

A variety of linear spores referable to this genus have been found in samples from all three localities, although they are most abundant in samples from Kiandra. In some specimens, the cell containing the pore is narrower and more elongate than the rest of the cells forming the spore (see Pl.24, fig.9). Spores with a large gradation in cell diameter from the aperture to the apical end, with smallest diameter at the apertural end, have been referred to Brachysporisporites, reserving Pluricellaesporites for linear spores with little difference in cell width within the spore.

Genus Fractisporonites Clarke 1965

Fractisporonites spp.

(Plate 24, figures 13,15)

Remarks: Numerous fragment of linear spores were found, and two typical specimens are illustrated.

Genus Brachysporisporites Lange & Smith 1971

Brachysporisporites spp.

(Plate 24, figure 12; Plate 25, figure 1)

Remarks: Spores consisting of several cells, forming a sharply graded size series from a large apical cell down to a small, hyaline attachment cell, are included in this genus. Spores referred to this genus occurred sporadically in most samples from Kiandra. Two typical specimens are illustrated.

Genus Involutisporonites (Clarke 1965) emend. Elsik 1968

Involutisporonites spp.

(Plate 24, figure 2; Plate 25, figures 2,4)

Remarks: This genus includes monoporate, psilate, multicellate fungal spores that are coiled. These were found most commonly in samples from Kiandra, and three typical specimens are illustrated. Also, several spores ornamented with punctae and coiled generally in a single plane were found in samples from Nerriga and Cadia. One specimen (Pl.25, fig.2)was large, 44 µm, but most other specimens were composed of smaller cells, with a total diameter of 20-23 µm.

Genus Staphlosporonites Sheffy & Dilcher 1971

Staphlosporonites spp.

(Plate 25, figures 3,5,10)

Remarks: Inaperturate spores of four or more cells in clusters, of variable shape, are included in this genus. A variety of types have been placed in this genus, and several different types are illustrated. Spores referred to Staphlosporonites were found in samples from all three localities.

Fructifications

Fungal fructifications have been found in samples from Nerriga and Kiandra; only one type, Callimothallus pertusus Dilcher, has been found in samples from Cadia. Because of their large size, many were fragmented, but several complete specimens were found. All the fructifications can be referred to the Microthyriaceae and Micropeltaceae of the Order Hemisphaeriales (Ascomycetes), which are epiphyllous in habit. Five types of mature fructifications have been recognized in these samples.

Mature forms of the fructifications have been referred to the organ genera Callimothallus Dilcher, Asterothyrites Cookson, and Plochmopeltinites Cookson. No spores were found in direct association with any of the fructifications. Remains of these epiphyllous fungi are first recorded in the Upper Cretaceous Laramie coal from Colorado (Wilson, in Dilcher, 1965), and are widely reported from Tertiary deposits.

Germlings of Microthyriaceous Fungi

(Plate 25, figure 11)

Remarks: Dilcher (1965) has remarked that, as immature stages of these fruiting bodies are morphologically alike, they can only be identified as belonging to the Microthyriaceae. These immature stages have been called "stigmocysts" by Edwards (1922), and "germlings" by Dilcher (1965), and the latter term is used here. Germlings were found in almost all samples from Kiandra and Nerriga, and all stages in development were represented, from flat round discs with entire margins, to those with slightly invaginated margins and a central hyaline spot, through to almost mature forms with radial wall development apparent.

The fossil record extends from lower-middle Eocene to the present, and these germlings have been reported from Asia (lower Tertiary), Europe (Eocene, Oligocene, Miocene), and North America (Eocene). At present, the Microthyriaceae have a worldwide tropical distribution (Dilcher, 1965).

Genus *Callimothallus* Dilcher 1965

Type species: *Callimothallus pertusus* Dilcher 1965.

Callimothallus pertusus Dilcher 1965

(Plate 25, figure 8; Plate 26, figures 1,2; Plate 27, figure 1)

Synonymy

1965 *Callimothallus pertusus* Dilcher, p.13, Pl.5, figs 37-42; Pl.6, figs 43-46; Pl.7, figs 47-55.

1972 *Callimothallus* sp. cf. *C. pertusus* Dilcher; Kar, Singh, & Sah, p.151, Pl.2, fig.21.

1973 *Callimothallus pertusus* Dilcher; Ramanujam & Rao, p.205, Pl.2, figs 15-18.

1975 *Callimothallus pertusus* Dilcher; Selkirk, pp.83-84, Pl.VI, figs 1,2.

Remarks: In these specimens, the central cells are not proliferated or humped up, and they are not noticeably darker than the remainder of the stroma. Pores are small and difficult to see, and the margin is fimbriate in a few fructifications, a feature noted by Dilcher in some of his specimens. The specimens reported from the Tertiary of Assam are similar, and lack the mound of cells in the central area, a feature only found on some forms reported by Dilcher (1965).

This species has been found in samples from Nerriga, Kiandra, and Cadia, and has also been reported from the Eocene of Tennessee, Tertiary of Assam, and Upper Miocene of Kerala, India. Selkirk (1975) has reported similar fructifications as common on the lower surfaces of leaves of ?Lauraceae at Kiandra, often associated with *Plochmopeltinites masonii*.

Callimothallus assamicus Kar, Singh, & Sah 1972

(Plate 24, figures 3,4,5)

Synonymy

1972 *Callimothallus assamicus* Kar, Singh, & Sah, p.151, Pl.2, figs 19-20.

Remarks: Several fructifications referable to this species were found in samples from Nerriga. The ascomata are generally circular in outline, non-ostiolate, and 40-65 µm in diameter. The pores are clearly visible, and found only in the central cells. Central cells are irregularly polygonal; peripheral cells are radially elongated, slightly thicker, and crenulate.

This species has been reported from the Tertiary of Assam.

Callimothallus sp. cf. *C. assamicus* Kar, Singh, & Sah 1972

(Plate 27, figure 2)

Remarks: A single specimen from Kiandra, 80 µm in diameter, has four series of cells radiating from the centre, each with a distinct pore. The margin is uneven. In other features, it is similar to *C. assamicus*.

Genus *Phragmothyrites* Edwards 1922

Type species: *Phragmothyrites eocenica* Edwards, 1922, monotypic when proposed.

?Phragmothyrites ostiolatus (Cookson 1947)

(Plate 27, figures 3,5)

Remarks: A few large specimens similar to Asterothyrites ostiolatus as described and figured by Cookson (1947c, Pl.XII, fig.11) were found in samples from Kiandra. The margins were uneven and incomplete in places. The stoma is smaller (8 µm) than that on the specimen described from Yallourn by Cookson, and these specimens are larger (130 and 140 µm, compared with 106 µm for the specimen from Yallourn).

Selkirk (1975) has placed the genera Asterothyrites Cookson 1947, Microthyriacites Cookson 1947, and Microthallites Dilcher 1965 in synonymy with Phragmothyrites Edwards, which has also been followed here.

Genus Plochmopeltinites Cookson 1947

Type species: Plochmopeltinites masonii Cookson 1947, designated by Selkirk, 1975.

Plochmopeltinites masonii Cookson 1947 emend. Selkirk 1975

(Plate 27, figure 4; Plate 28, figure 1)

Synonymy

1947c Plochmopeltinites masonii Cookson, p.212, Pl.XIII, figs 14,15.

1973 Plochmopeltinites cooksonii Ramanujam & Rao, p.207, Pl.3, figs 22,23.

1975 Plochmopeltinites masonii Cookson, Selkirk, pp.84-85, Pl.XI, figs 1-4.

Remarks: Two specimens referable to this species were found in samples from Kiandra. They measured 92 and 130 µm in maximum diameter, and had margins that were more irregular than those illustrated by Cookson. Selkirk (1975) noted that margins are entire-sinuate or irregularly lobed in the specimens that he studied from Kiandra. The irregular ostiole and thick-walled cells which form most of the plectenchyma are similar to P. cooksonii Ramanujam & Rao 1973, reported from the Upper Miocene of South India, which appears to be conspecific with P. masonii from description and illustrations.

Cookson (1947c) reported this species from Kerguelen, Kiandra, and Traralgon. Selkirk (1975) has found this species on leaves of ?Lauraceae from Kiandra.

Although Cookson (1947c) included this genus in the family Micropeltaceae, Selkirk (1975) remarks that the radiate nature of the thyriothecium would indicate more appropriate placement in the Microthyriaceae.

Other Fungal Remains

Fungal "Clusters"

(Plate 25, figure 9)

Remarks: Clusters or groups of fungal cells were found sporadically in samples from all three localities. Some showed an orderly pattern of cell arrangement, whereas others appeared to be a random clumping of individual cells. Diameters of total clusters ranged from 20 to 70 µm.

Miscellanea

(Plate 25, figures 6,7)

Remarks: Fragments of hyphae and setae were common in most samples. Also, a few large periporate spheres were found in a few samples from Kiandra, and in one sample, two such spheres were found enclosed in a thin, membraneous covering, with a thin "terminal cell". The spheres had thin annuli around each pore, and were 40-45 µm in diameter. They are of presumed fungal origin.

FOSSIL ALGAL REMAINS

Cf. Pediastrum

(Plate 28, figures 2,3)

Remarks: A few colonies referable to this genus have been found in samples from all three localities. They lack the long, terminal processes found in colonies illustrated by Cookson (1953c), Muller (1968), and Newman (1965). In places, the margins of these colonies have low, irregular bumps, rather than spines.

The fossil record of Pediastrum extends from Lower Cretaceous to Recent, and at present the genus is restricted to a freshwater habitat. Although most reported fossil occurrences are in freshwater environments, Pediastrum has also been reported apparently in situ from two Cretaceous marine deposits (Evitt, 1963).

cf. Botryococcus braunii Kützing

(Plate 28, figures 4,7)

Remarks: Colonies of B. braunii were numerous in a few samples from Cadia, and were found sporadically in some samples from all three localities. The colonies were very irregular in size and outline, varying from less than 50 to more than 200 µm in maximum diameter.

This alga has a fossil record ranging from Ordovician to Recent, and previous Australian Tertiary occurrences have been reported by Cookson (1953c) and Martin (1973a). Botryococcus is commonly found in freshwater deposits, but has also been reported from brackish water and marine environments (Cookson, 1953c; Traverse, 1955).

Acritarchs

(Plate 28, figures 5,6)

Remarks: Several small, thin, spiny acritarchs have been found in samples from Kiandra. Two different types are illustrated. Although extremely rare, mention of their occurrence is made as this appears to be the first report of acritarchs from Australian Tertiary freshwater deposits. The only previous published Australian Cainozoic occurrence of freshwater acritarchs was reported by Churchill & Sarjeant (1963) from Holocene peats from southwestern Australia. A few published occurrences of normarine dinoflagellate assemblages from Australian Tertiary deposits have been given by Cookson (1953c), Harris (1973), and Martin (1973a).

REFERENCES CITED

Andrews, E.C., 1901. Report on the Kiandra Lead. *N.S.W. Min. Res. No.10*, 30 pp.

Archangelsky, S., 1973. Palinologia del Paleocene de Chubut. 1. Descripciones sistematicas. *Ameghiniana*, vol.10, pp.339-399.

Balme, B.E., 1957. Spores and pollen grains from the Mesozoic of Western Australia. *C.S.I.R.O. Coal Res. Sect.*, T.C.25, 48 pp.

Barnard, C., 1927. A note on a dicotyledonous fossil wood from Ulladulla, New South Wales. *Proc. Linn. Soc. N.S.W.*, vol.52, pp.113-121.

Brown, D.A., Campbell, K.S.W., & Crook, K.A.W., 1968. The geological evolution of Australia and New Zealand. *Pergamon Press*, 409 pp.

Burbidge, N.T., 1960. The phytogeography of the Australian region. *Aust. J. Bot.*, vol.8, pp.75-212.

Card, G.W., & Dun, W.S., 1897. The diatomaceous earth deposits of New South Wales. *Rec. Geol. Surv. N.S.W.*, vol.5, pp.128-148.

Chanda, S., 1966. On the pollen morphology of the Centrolepidaceae, Restionaceae, and Flagellariaceae, with special reference to taxonomy. *Grana Palynologica*, vol.6, pp.356-415.

Churchill, D.M., & Sarjeant, W.A.S., 1963. Freshwater microplankton from Flandrian (Holocene) p~~ar~~eats of southwestern Australia. *Grana Palynologica*, vol.3, pp.29-53.

Clarke, R.T., 1965. Fungal spores from Vermejo Formation coal beds (Upper Cretaceous) of central Colorado. *The Mountain Geologist*, vol.2, pp.85-93.

Cockayne, L., 1926. Monograph on the New Zealand beech forests. Part I, the ecology of the forests and taxonomy of the beeches. *N.Z. State Forest Service, Bull. No.4*, 71 pp.

Cockayne, L., 1928. Monograph on the New Zealand beech forests. Part II, the forests from the practical and economic standpoints. N.Z. State Forest Service, Bull. No.4, 59 pp.

Cookson, I.C., 1945. Pollen content of Tertiary deposits. Aust. J. Sci., vol.7, pp.145-150.

Cookson, I.C., 1946. Pollens of *Nothofagus* Blume from Tertiary deposits in Australia. Proc. Linn. Soc. N.S.W., vol.71, pp.49-63.

Cookson, I.C., 1947a. On fossil leaves (Oleaceae) and a new type of fossil pollen grain from Australian brown coal deposits. Proc. Linn. Soc. N.S.W., vol.72, pp.183-197.

Cookson, I.C., 1947b. Plant microfossils from the lignites of the Kerguelen Archipelago. B.A.N.Z. Antarctic Res. Exped., 1929-31, Rep. Ser. A-2, pp.129-142.

Cookson, I.C., 1947c. Fossil fungi from Tertiary deposits in the Southern Hemisphere. Part I. Proc. Linn. Soc. N.S.W., vol.72, pp.207-214.

Cookson, I.C , 1950. Fossil pollen grains of proteaceous type from Tertiary deposits in Australia. Aust. J. Scient. Research, Ser. B.-Biol. Sciences, vol.3, pp.166-177.

Cookson, I.C., 1952. Identification of Tertiary pollen grains with those of New Guinea and New Caledonian beeches. Nature, vol.170, p.127.

Cookson, I.C., 1953a. The identification of the sporomorph *Phyllocladidites* with *Dacrydium* and its distribution in southern Tertiary deposits. Aust. J. Bot., vol.1, pp.64-70.

Cookson, I.C. 1953b. Difference in microspore composition of some samples from a bore at Comaum, South Australia. Aust. J. Bot., vol.1, pp.462-473.

Cookson, I.C., 1953c. Records of the occurrence of *Botryococcus braunii*, *Pediastrum*, and the Hystrichosphaerideae in Cainozoic deposits of Australia. Nat. Mus. Vic. Memoirs, No.18, pp.107-123.

Cookson, I.C., 1954a. The Cainozoic occurrence of Acacia in Australia. Aust. J. Bot., vol.2, pp.52-59.

Cookson, I.C., 1954b. A palynological examination of No.2 Bore, Birregurra, Victoria. Proc. Roy. Soc. Vic., vol.66 (new series), pp.119-128.

Cookson, I.C , 1956. Pollen grains of the Ephedra type in Australian Tertiary deposits. Nature, vol.177, pp.47-48.

Cookson, I.C., 1957. On some Australian Tertiary spores and pollen that extend the geological and geographical distribution of living genera. Proc. Roy. Soc. Vic., vol.69, pp.41-53.

Cookson, I.C , 1959. Fossil pollen grains of Nothofagus from Australia. Proc. Roy. Soc. Vic., vol.171, pp.25-30.

Cookson, I.C., & Cranwell, L.M., 1967. Lower Tertiary microplankton, spores and pollen grains from southernmost Chile. Micropaleontology, vol.13, pp.204-216.

Cookson, I.C., & Dettmann, M.E., 1958. Some trilete spores from Upper Mesozoic deposits in the eastern Australian region. Proc. Roy. Soc. Vic., vol.70, pp.95-128.

Cookson, I.C., & Dettmann, M E., 1959. On Schizosporis, a new form genus from Australian Cretaceous deposits. Micropaleontology, vol.5, pp.213-216.

Cookson, I.C., & Duigan, S.L., 1950. Fossil Banksieae from Yallourn, Victoria, with notes on the morphology and anatomy of living species. Aust. J. Scient. Res., Ser. B, vol. 3, pp.133-165.

Cookson, I.C., & Duigan, S L., 1951. Tertiary Araucariaceae from south-eastern Australia, with notes on living species. Aust. J. Scient. Res., Ser. B, vol.4, pp.415-449.

Cookson, I.C., & Pike, K.M., 1953a. The Tertiary occurrence and distribution of Podocarpus (Section Dacrycarpus) in Australia and Tasmania. Aust. J. Bot., vol.1, pp.71-82.

Cookson, I.C , & Pike, K.M., 1953b. A contribution to the Tertiary occurrence of the genus Dacrydium in the Australian region. Aust. J. Bot., vol.1, pp.474-484.

Cookson, I.C., & Pike, K M., 1954a. The fossil occurrence of Phyllocladus and two other podocarpaceous types in Australia. Aust. J. Bot., vol.2, pp.60-68.

Cookson, I.C., & Pike, K.M., 1954b. Some dicotyledonous pollen types from Cainozoic deposits in the Australian region. Aust. J. Bot., vol.2, pp.197-219.

Cookson, I.C., & Pike, K.M., 1955. The pollen morphology of Nothofagus Bl. subsection Bipartae Steen. Aust. J. Bot., vol.3, pp.197-206.

Couper, R.A., 1953. Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand. N.Z. Geol. Surv. Paleont. Bull.22, 77 pp.

Couper, R.A , 1954. Plant microfossils from New Zealand No. 1. Trans. Roy. Soc. N.Z., vol.81, pt. 4, pp.479-483.

Couper, R.A , 1958. British Mesozoic microspores and pollen grains. A systematic and stratigraphic study. Palaeontographica, Abt. B, vol.103, pp.75-177.

Couper, R.A., 1960. New Zealand Mesozoic and Cainozoic plant microfossils. N.Z. Geol. Surv. Paleont. Bull.32, 87 pp.

Couper, R.A., 1960a. Southern Hemisphere Mesozoic and Tertiary Podocarpaceae and Fagaceae and their palaeogeographic significance, pp.491-500 in Pantin, C.F.A. (Editor), A discussion on the biology of the southern cold temperate zone. Proc. Roy. Soc. (London), Ser. B, vol.152, pp.429-677.

Craft, F.A., 1931. The physiography of the Shoalhaven River Valley IV. Nerriga. Proc. Linn. Soc. N.S.W., vol.56, pp.412-430.

Cranwell, L.M., 1939. Southern-beech pollens. Auckland Inst. Mus. Rec., vol.2, pp.175-196.

Cranwell, L.M., 1940. Pollen grains of the New Zealand conifers. N.Z. J. Science & Technology, Sect. B, vol.22, pp.10B-17B.

Cranwell, L.M , 1964. Antarctica: Cradle or grave for its Nothofagus? pp.87-93 in Cranwell, L M. (Editor), Ancient Pacific Floras, The Pollen Story. Univ. of Hawaii.

Cranwell, L.M., 1969. Palynological intimations of some pre-Oligocene climates, pp.1-19, in van Zinderen Bakker, E.M. (Editor), Palaeoecology of Africa, vol.5, Capetown.

Cranwell, L.M., Harrington, H.J., & Speden, I.G., 1960. Lower Tertiary microfossils from McMurdo Sound, Antarctica. Nature, vol.186, pp.700-702.

Crocker, R.L., 1959. Past climatic fluctuations and their influence upon Australian vegetation, pp.283-290 in Keast, A., Crocker, R.L., & Christian, C.S. (Editors), Biogeography and Ecology of Australia, Junk, The Hague, 640 pp.

Daley, B., 1972. Some problems concerning the early Tertiary climate of southern Britain. Palaeogeog., Palaeoclim., Palaeoecol., vol.11, pp.177-190.

Deane, H., 1900a. Observations on the Tertiary flora of Australia, with special reference to Ettingshausen's theory of the Tertiary cosmopolitan flora. Proc. Linn. Soc. N.S.W., vol.25, pp.463-475.

Deane, H., 1900b. Observations on the Tertiary flora of Australia, with special reference to Ettingshausen's theory of the Tertiary Cosmopolitan Flora. Part II. On the Venation of leaves and its value in the determination of botanical affinities. Proc. Linn. Soc. N.S.W., vol.25, pp.581-590.

De Jersey, N.J., 1968. Palaeobotany and palynology in Australia: A historical review. Rev. Palaeobot. Palynology, vol.6, pp.111-136.

Dettmann, M.E., 1963. Upper Mesozoic microfloras from south-eastern Australia. Proc. Roy. Soc. Vic., vol.77, pp.1-148.

Dettmann, M.E , & Playford, G., 1968. Taxonomy of some Cretaceous spores and pollen grains from Eastern Australia. Proc. Roy. Soc. Vic., vol.81, pp.69-93.

Dettmann, M.E., & Playford, G., 1969. Palynology of the Australian Cretaceous: A review, pp.174-210 in Campbell, K.S.W. (Editor), Stratigraphy and palaeontology: Essays in honour of Dorothy Hill. A.N.U. Press, 390 pp.

Dilcher, D.L., 1965. Epiphyllous fungi from Eocene deposits in western Tennessee, U.S.A. Palaeontographica, Abt. B, pp.1-54.

Duigan, S.L., 1950. A catalogue of the Australian Tertiary flora. Proc. Roy. Soc. Vic., vol.63, pp.41-56.

Duigan, S.L., 1966. The nature and relationships of the Tertiary brown coal flora of the Yallourn area in Victoria, Australia. The Palaeobotanist, vol.14, pp.191-201.

Duigan, S.L., & Cookson, I.C., 1957. The occurrence of Azolla filiculoides L. and associated vascular plants in a Quaternary deposit in Melbourne, Australia. Proc. Roy. Soc. Vic., vol.69, pp.5-13.

Dulhunty, J.A., 1944. Origin of the New South Wales torbanites. Proc. Linn. Soc. N.S.W., vol.69, pp.26-48.

Edwards, W.N., 1922. An Eocene microthyriaceous fungus from Mull, Scotland. Trans. Brit. Mycolog. Soc., vol.VIII, pp.66-72.

Elsik, W.C., 1965a. Palynology of a Paleocene Rockdale lignite, Milam County, Texas. 1. Morphology and taxonomy. Pollen et Spores, vol.X, pp.263-314.

Elsik, W.C., 1968b. Palynology of a Paleocene Rockdale lignite. Milam County, Texas. II. Morphology and taxonomy (end). Pollen et Spores, vol.X, pp.599-664.

Elsik, W.C., 1974. Fossil fungal spores and Cenozoic palynostratigraphy. Xerox handout, 7th Ann. Mtg. A.A.S.P., Oct. 1974, 17 pp.

Elsik, W.C., 1974a. Nothofagus in North America. Pollen et Spores, vol.XVI, pp.285-299.

Elsik, W.C., & Dilcher, D.L., 1974. Palynology and age of clays exposed in Lawrence Clay Pit, Henry County, Tennessee. Palaeontographica, Abt. B, 146, pp.65-87.

Elsik, W.C., & Jansonius, J., 1974. New genera of Paleogene fungal spores. Can. J. Bot., vol.52, pp.953-958.

Erdtman, G., 1957. Pollen and spore morphology/Plant taxonomy. Gymnospermae, Pteridophyta, Bryophyta (Illustrations). (An Introduction to Palynology II). Almquist - Wiksell, 151 pp.

Erdtman, G., 1958. On the risks of overstressing the denomination of fossil spores as illustrated by a paper on the former distribution of Lophosoria ("Cyathea annulata"). Svensk. Bot. Tidskr., vol.51, pp.611-613.

von Ettingshausen, C., 1888. Contributions to the Tertiary flora of Australia. Mem. Geol. Surv. N.S.W., Palaeont. No.2, 192 pp.

Evitt, W.R., 1963. Occurrence of freshwater alga Pediastrum in Cretaceous marine sediments. Am. J. Sci., vol.261, pp.890-893.

Fasola, A., 1969. Estudio palinologico de la Formacion Loreto (Terciario medio), Provincia de Magallanes, Chile. Ameghiniana, pp.3-49.

Fleming, C.A., 1962. New Zealand biogeography. A palaeontologist's approach. Tuatara, vol.10, pp.53-108.

Frakes, L.A., & Kemp, E.M., 1972. Influence of continental positions on early Tertiary climates. Nature, vol.240, pp.97-100.

Germeraad, J.H., Hopping, C.H., & Muller, J., 1968. Palynology of Tertiary sediments from tropical areas. Rev. Palaeobot. Palynology, vol.6, pp.189-348.

Gill, E.D., 1952. Range in time of the Australian Tertiary flora. Aust. J. Sci., vol.15, pp.47-48.

Gill, E.D., 1961. The climates of Gondwanaland in Kainozoic times, pp.332-353 in Nairn, A.E.M. (Editor), Descriptive Climatology. Interscience Pubs. Inc., 380 pp.

Gill, E.D., & Sharp, K.R., 1957. The Tertiary rocks of the Snowy Mountains, Eastern Australia. J. Geol. Soc. Aust., vol.4, pp.21-40.

Gray, J., & Boucot, A.J., 1975. Color changes in pollen and spores: A review. Geol. Soc. America Bull., vol.86, pp.1019-1033.

Green, D.C., & Stevens, N.C., 1975. Age and stratigraphy of Tertiary volcanic and sedimentary rocks of the Ipswich district, southeast Queensland. Qld Govt Mining J., May 1975, pp.1-3.

Guppy, J., Milne, P., Glikson, M., & Moore, H., 1973. Further developments in computer assistance to pollen identification. Geol. Soc. Aust. Spec. Publ. No.4, pp.201-206.

van der Hammen, T., & Wijmstra, T.A., 1964. A palynological study of the Tertiary and Upper Cretaceous of British Guiana. Leidse Geol. Mededel., vol.30, pp.183-241.

Harris, W.F., 1955. A manual of the spores of New Zealand Pteridophyta. N.Z. D.S.I.R. Bull. 116, 186 pp.

Harris, W.K., 1965a. Basal Tertiary microfloras from the Princetown area, Victoria, Australia. Palaeontographica, Abt. B, vol.115, pp.75-106.

Harris, W.K., 1965b. Tertiary microfloras from Brisbane, Queensland. Geol. Surv. Qld. Rep. No. 10, 7 pp.

Harris, W.K., 1966. Proteacidites latrobensis. Taxon, vol.15, pp.332-333.

Harris, W.K., 1971. Tertiary stratigraphic palynology, Otway Basin, pp.67-87 in The Otway Basin of southeastern Australia. Special Bulletin. Geol. Survs. S. Australia and Victoria, 464 pp.

Harris, W.K., 1972. New form species of pollen from southern Australian early Tertiary sediments. Trans. Roy. Soc. S. Aust., vol. 96, pp.53-65.

Harris, W.K., 1973. Tertiary non-marine dinoflagellate cyst assemblages from Australia. Geol. Soc. Aust. Spec. Publ. 4, pp.159-166.

Harris, W.K., 1974. Palynology of Paleocene sediments at Site 214, Ninetyeast Ridge. Initial Repts., Deep Sea Drilling Project, vol.XXVI, pp.503-519.

Hayes, D.E., & Frakes, L.A., 1975. General synthesis, Deep Sea Drilling Project Leg 28, pp.919-942 in Hayes, D.E., Frakes, L.A., and others. Initial Reports of the Deep Sea Drilling Project, Vol.28, U.S. Govt. Printing Office (Washington).

Hekel, H., 1972. Pollen and spore assemblages from Queensland Tertiary sediments. Geol. Surv. Qld. Publ. No. 355, Pal. Papers No.30, 34 pp.

Heusser, C.J., 1971. Pollen and spores of Chile. Modern types of the Pteridophyta, Gymnospermae, and Angiospermae. Univ. of Arizona Press, 167 pp.

Hills, E.S., 1934. Tertiary freshwater fishes from Southern Queensland. Mem. Qld Museum, 10.

Hills, E.S., 1938. The age and physiographic relationships of the Cainozoic volcanic rocks of Victoria. Proc. Roy. Soc. Vic., vol.51, (new series), pp.112-139.

Hills, E.S., 1946. Fossil Murray Cod (*Maccullochella macquariensis*) from diatomaceous earths in New South Wales. Rec. Aust. Mus., vol. 21, pp.380-382.

Hos, D., 1975. Preliminary investigation of the palynology of the Upper Eocene Warillup Formation, Western Australia. J. Roy. Soc. W.A., vol.58, pp.1-14.

Jain, K.P., & Gupta, R.C., 1970. Some fungal remains from the Tertiaries of Kerala coast. The Palaeobotanist, vol.18, pp.177-182.

Jansonius, J., 1971. Emended diagnosis of Alisporites Daugherty 1941. Pollen et Spores, vol.XIII, pp.349-357.

Kar, R.K., Singh, R.Y., & Sah, S.C.D , 1972. On some algal and fungal remains from Tura Formation of Garo Hills, Assam. The Palaeobotanist, vol.19, pp.146-154.

Kemp, E.M., 1970. Aptian and Albian miospores from southern England. Palaeontographica, Abt. B, Bd. 131, pp.73-143.

Kemp, E.M., 1972a. Reworked palynomorphs from the West Ice Shelf area, East Antarctica, and their possible geological and palaeoclimatological significance. Marine Geology, vol.13, pp.145-157.

Kemp, E.M., 1972b. Recycled palynomorphs in continental shelf sediments from Antarctica. Antarctic J., Sept.-Oct.1972, pp.190-191.

Kemp, E.M., 1974. Preliminary palynology of samples from Site 254, Ninetyeast Ridge. Initial Repts, Deep Sea Drilling Project, vol.XXVI, pp.815-823.

Kemp, E.M., 1975. Palynology of Leg 28 Drill Sites, Deep Sea Drilling Project. Initial Repts, Deep Sea Drilling Project, vol. XXVIII, pp.599-623.

Kemp, E.M., in prep. Microfossils of fungal origin from Tertiary sediments on the Ninetyeast Ridge, Indian Ocean. Bur. Min. Res. Bull.

Kemp, E.M., & Barrett, P.J., in press. Antarctic glaciation and early Tertiary vegetation: evidence from Ross Sea Drillsites. Nature.

Kershaw, A.P., 1970. Pollen morphological variation within the Casuarinaceae. Pollen et Spores, vol. XII, pp.145-161.

Kershaw, A.P., & Hyland, B.P.M., 1975. Pollen transfer and periodicity in a rain-forest situation. Rev. Paleobot. Palynology, vol.19, pp.129-138.

Khan, A.M., 1974. Palynology of Neogene sediments from Papua (New Guinea). Stratigraphic boundaries. Pollen et Spores, vol. XVI, pp.265-284.

Khan, A.M., & Martin, A.R.H., 1971. A note on genus *Polypodiisporites* R. Potonié. Pollen et Spores, vol. XIII, no. 3, pp.475-480.

Kremp, G.O.W., 1965. Morphologic encyclopedia of palynology. Univ. of Arizona Press, 263 pp.

Krutzsch, W., 1959. Micropaläontologische (Sporenpaläontologische) Untersuchungen in der Braunkuhle des Geiseltales. Geologie, 8, Beih. 21/22, pp.1-425.

Krutzsch, W., 1967. Atlas der mittel- und jungtertiären dispersen Sporae und Pollen sowie der Mikroplankton Formen des nordlichen Mitteleuropas. Lief IV und V. VEB Gustav Fischer Verlag, Jena, pp.1-232.

Krutzsch, W., 1969. Taxonomie syncolp(or)ater und morphologisch benachbarter pollengattungen and -arten (sporae dispersae) aus der oberkreide und dem Tertiaer. Pollen et Spores, vol.11, pp.397-424.

Kummel, B., & Raup, D., 1965. Handbook of palaeontological techniques. W.H. Freeman, 415 pp.

Lange, R.T., 1969. Recent and fossil epiphyllous fungi of the *Manginula-Shortensis* group. Aust. J. Bot., vol.17, pp.565-574.

Lange, R T., 1970. The Maslin Bay flora, South Australia. 2. The assemblage of fossils. N. Jb. Geol. Paläont. Mh., no. 8, pp.486-490.

Lange, R.T., & Smith, P.H., 1971. The Maslin Bay flora, South Australia. 3. Dispersed fungal spores. N. Jb. Geol. Paläont. Mh., no. 11, pp.663-681.

Lowrie, W., & Hayes, D.E., 1975. Magnetic properties of oceanic basalt samples, pp.860-878 *in* Hayes, D.E., Frakes, L.A., and others, Initial Reports of the Deep Sea Drilling Project, vol.28, U.S Govt. Printing Office (Washington).

MacGinitie, H.D., 1974. An early Middle Eocene flora from the Yellowstone-Absaroka volcanic province, northwestern Wind River Basin, Wyoming. Univ. Calif. Publs. Geol. Sci., vol.108, 103 pp.

McGowran, B., Harris, W.K., & Lindsay, J.M., 1970. The Maslin Bay flora, South Australia. 1. Evidence for an early middle Eocene age. N. Jb. Geol. Paläont. Mh., no.8, pp.481-485.

Machin, J., 1971. Plant microfossils from Tertiary deposits of the Isle of Wight. New Phytologist, vol.70, pp.851-872.

McIntyre, D.J., 1965. Some new pollen species from New Zealand Tertiary deposits. N.Z. J. Bot., vol.3, pp.204-214.

McIntyre, D.J., 1968. Further new pollen species from New Zealand Tertiary and uppermost Cretaceous deposits. N.Z. J. Bot., vol.6, pp.177-204.

McIntyre, D.J., & Wilson, G.J., 1966. Preliminary palynology of some Antarctic Tertiary erratics. N.Z. J. Bot., vol.4, pp.315-321.

McQueen, D.R., Mildenhall, D.C., & Bell, C.J.E., 1968. Palaeobotanical evidence for changes in the Tertiary climates of New Zealand. Tuatara, vol.16, pp.49-56.

McWhae, K.M., 1957. A note on the pollen of Whiteodendron and Kjellbergiodendron. Reinwardtia, vol.4, pp.189-191.

Martin, A.R.H., 1959. South African palynological studies. I. Statistical and morphological variation in the pollen of the South African species of Podocarpus. Grana Palynologica, vol.2, pp.40-68.

Martin, A.R.H., 1973. Reappraisal of some palynomorphs of supposed proteaceous affinity. I. The genus Beaupreaidites Cookson ex Couper and the species Proteacidites hakeoides Couper. Geol. Soc. Aust. Spec. Publ. 4, pp.73-78.

Martin, H.A., 1973a. The palynology of some Tertiary and Pleistocene deposits, Lachlan River Valley, New South Wales. Aust. J. Bot. Suppl. Ser., No.6, 57 pp.

Martin, H.A., 1973b. Upper Tertiary palynology in southern New South Wales. Geol. Soc. Aust. Spec. Publ. No.4, pp.35-54.

Martin, H.A., 1974. The identification of some Tertiary pollen belonging to the family Euphorbiaceae. Aust. J. Bot., vol.22, pp.271-291.

van der Meijden, R., 1970. A survey of the pollen morphology of the Indo-Pacific species of Symplocos (Symplocaceae). Pollen et Spores, vol. XII, pp.513-551.

Mildenhall, D.C., 1972. Fossil pollen of Acacia type from New Zealand. N.Z.J. Bot., vol.10, pp.485-494.

Mildenhall, D.C., & Harris, W.F., 1971. Status of Haloragacidites (al. Triorites) harrisii (Couper) Harris comb. nov. and Haloragacidites trioratus Couper, 1953. N.Z.J. Bot., vol.9, pp.297-306.

Moye, D.G., Editor, 1959. Historic Kiandra. A Guide to the History of the District. Cooma-Monaro Historical Society, 74 pp.

Moye, D.G., Sharp, K.R., & Stapledon, D.H., 1963. Geology of the Snowy Mountains region. Cooma, Snowy Mts Hydro-Electric Auth., 66 pp.

Moye, D.G., Sharp, K.R., Whiting, J.W., & Hall, L.R., 1969. Cainozoic rocks outside the Murray Basin. 1. Snowy Mountains area. J. Geol. Soc. Aust., vol.16, pp.549-551.

Mueller, F. von, 1874. Observations on new vegetable fossils of the auriferous drifts. Geol. Surv. Vic., 1874.

Mueller, F. von., 1876. Fossil plants of the Upper Tertiary leads of New South Wales. Dept Mines N.S.W. Ann. Rept, p.124.

Mueller, F. von., 1884. Observations on new vegetable fossils of the auriferous drifts. Geol. Surv. Vic., 1884.

Muller, J., 1966. Montane pollen from the Tertiary of Borneo. *Blumea*, vol.14, pp.231-235.

Muller, J., 1968. Palynology of the Pedawan and Plateau Sandstone Formations (Cretaceous-Eocene) in Sarawak, Malaysia. *Micropaleontology*, vol.14, pp.1-37.

Muller, J., 1970. Palynological evidence on early differentiation of angiosperms. *Biol. Rev.*, vol.45, pp.417-450.

Nagy, E., 1963. Some new spore and pollen species from the Neogene of the Mecsek Mountain. *Acta Botanica*, Acad. Scient. Hungaricae, vol.9, pp.387-404.

Newman, K.R., 1965. Significance of algae in Waltman Shale Member of Fort Union Formation (Paleocene), Wyoming. *The Mountain Geologist*, vol.2, pp.79-84.

Nichols, D.J., Ames, H.T., & Traverse, A., 1973. On *Arecipites* Wodehouse, *Monocolpopollenites* Thomson & Pflug, and the species "*Monocolpopollenites tranquillus*". *Taxon*, vol.22, pp.241-256.

Nobes, E.D., 1922. A preliminary note on the fossil woods from some Australian Brown Coal Deposits. *Trans. Roy. Soc. S. Aust.*, vol. 56, pp.528-536.

Norris, G., 1965. Triassic and Jurassic miospores and acritarchs from the Beacon and Ferrar Groups, Victoria Land, Antarctica. *N.Z. J. Geol. Geophysics*, vol.8, pp.236-277.

Nougier, J., 1970. Contribution à l'étude géologique et géomorphologique des iles Kerguelen. Vol.1. Comité national français des recherches antarctiques, no.27, 440 pp.

Partridge, A.D., 1971. Stratigraphic palynology of the onshore Tertiary sediments of the Gippsland Basin, Victoria. M.Sc. thesis, Univ. N.S.W., 302 pp.

Patton, R.T., 1958. Fossil wood from Victorian brown coal. *Proc. Roy. Soc. Vic.*, vol.70, pp.129-143.

Pike, K.M., 1952. Fossil fruiting cones of *Casuarina* and *Banksia* from Tertiary deposits in Australia. *Proc. Roy. Soc. Vic*., vol.65, pp.1-8.

Pike, K.M , 1956. Pollen morphology of Myrtaceae from the south-west Pacific area. *Aust. J. Bot*., vol.4, pp.13-53.

Potonié, R., 1956. Synopsis der Gattungen der Sporae dispersae. I. Teil. Sporites. *Beih. geol. Jb*., 23, pp.1-103.

Potonié, R., 1958. Synopsis der Gattungen der Sporae dispersae. II. Teil. *Beih. geol. Jb*., 31, pp.1-114.

Potonié, R., 1960. Synopsis der Gattungen der Sporae dispersae. III. Teil. *Beih. geol. Jb*., 39, pp.1-161.

Raine, J.I., 1967. Geology of the Nerriga area with special reference to Tertiary stratigraphy and palynology. B. Sc. (Hons.) thesis, Australian National University.

Ramanujam, C.G.K., & Rao, K.P., 1973. On some microthyriaceous fungi from a Tertiary lignite of south India. *The Palaeobotanist*, vol.20, pp.203-209.

Rao, A.R., 1958. Fungal remains from some Tertiary deposits of India. *The Palaeobotanist*, vol.7, pp.43-46.

Sadler, D.R , 1972. Geology of Cadia, N.S.W. B. Sc. (Hons.) thesis, Australian National University, 56 pp.

Scheibner, E., 1974. A plate tectonic model of the Palaeozoic tectonic history of New South Wales. *J. Geol. Soc. Aust*., vol.20, pp.405-426.

Selkirk, D.R., 1969. Studies in Australian Tertiary Palaeobotany. An epiphyllous flora from Kiandra, New South Wales. Ph.D. thesis, Univ. Sydney, 108 pp.

Selkirk, D.R., 1972. Fossil *Manginula*-like fungi and their classification. *Proc. Linn. Soc. N.S.W*., vol.97, pp.141-149.

Selkirk, D.R., 1974. A fossil epiphyllous moss from the Australian Miocene. *The Bryologist*, vol.77, pp.249-250.

Selkirk, D.R., 1975. Tertiary fossil fungi from Kiandra, New South Wales. Proc. Linn. Soc. N.S.W., vol.100, pp.70-94.

Shackleton, N.J., & Kennett, J.P., 1974. Paleotemperature history of the Cenozoic and the initiation of Antarctic glaciation: oxygen and carbon isotope analyses in DSDP sites 277, 279, and 281, pp.743-755 in Kennett, J.P., Houtz, R.E., and others, Initial Reports of the Deep Sea Drilling Project, vol.29, U.S. Gov't Printing Office, Washington, 1197 pp.

Sheffy, M.V., & Dilcher, D L., 1971. Morphology and taxonomy of fungal spores. Palaeontographica, Abt. B, pp.34-51.

Singleton, F.A., 1941. The Tertiary geology of Australia. Proc. Roy. Soc. Vic., vol.53, 125 pp.

Skvortzov, B.V., 1937. Notes on fossil diatoms from New South Wales, Australia. 1. Fossil diatoms from diatomaceous earth, Cooma, N.S.W. Proc. Linn. Soc. N.S.W., vol.62, pp.175-180.

Stevens, N.C., & Packham, G.H., 1952. Graptolite zones and associated stratigraphy at Four Mile Creek, south-west of Orange, N.S.W. J. Proc. Roy. Soc. N.S.W, vol. LXXXVI, pp. 94-99.

Stover, L.E., & Evans, P.R., 1973. Upper Cretaceous-Eocene spore-pollen zonation, offshore Gippsland Basin, Australia. Geol. Soc. Aust., Spec. Publs. 4, pp.55-72.

Stover, L.E., & Partridge, A.D., 1973. Tertiary and Late Cretaceous spores and pollen from the Gippsland Basin, southeastern Australia. Proc. Roy. Soc. Vic., vol.85, pp.237-286.

Sussmilch, C.H., 1937. The geological history of the Cainozoic Era in New South Wales. Proc. Linn. Soc. N.S.W, vol. LXII, pp.viii-xxxiii.

Thomson, P.W., & Pflug, H.D., 1953. Pollen and Sporen des mitteleuropäischen Tertiärs. Palaeontographica, Abt. B, vol. 94, pp.1-138.

Traverse, A., 1955. Occurrence of the oil-forming alga Botryococcus in lignites and other Tertiary sediments. Micropaleontology, vol.1, pp.343-350.

Venkatachala, B.S., & Kar, R.K., 1969. Palynology of the Tertiary sediments in Kutch - 2. Epiphyllous fungal remains from the bore-hole no. 14. The Palaeobotanist, vol.17, pp.179-183.

Walcott, R.H., 1920. Evidence of the age of some Australian Gold Drifts, with special reference to those containing mammalian remains. Geol. Surv. N.S.W. Rec., vol.14, pp.66-97.

Wardle, P., 1964. Facets of the distribution of forest vegetation in New Zealand. N.Z. J. Bot., vol.2, pp.352-366.

Wardle, P., 1967. Biological flora of New Zealand. 2. Nothofagus menziesii (Hook.f.) Oerst (Fagaceae) Silver Beech. N.Z. J. Bot., vol.5, pp.276-302.

Weissel, J.K., & Hayes, D.E., 1972. Magnetic anomalies in the southeast Indian Ocean, pp.165-196 in Hayes, D.E. (Editor), Antarctic Oceanology II: the Australian-New Zealand Sector. Antarctic Res. Ser., vol.19, Washington (Am. Geophys. Union).

Wellman, P., 1971. The age and palaeomagnetism of the Australian Cenozoic volcanic rocks. Ph.D. thesis, Australian National University, 388 pp.

Wellman, P., & McDougall, I., 1974a. Potassium-argon ages on the Cainozoic volcanic rocks of New South Wales. J. Geol. Soc. Aust., vol.21, pp.247-272.

Wellman, P., & McDougall, I., 1974b. Cainozoic igneous activity in eastern Australia. Tectonophysics, vol.23, pp.49-65.

Wellman, P., McElhinny, M.W., & McDougall, I., 1969. On the polar-wander path for Australian during the Cenozoic. Geophys. J. Roy. Astr. Soc., vol.18, pp.371-395.

Willis, J.C., 1966. A dictionary of the flowering plants and ferns. (seventh edition, revised by H.K. Airy Shaw). Cambridge Univ. Press, 1214 pp.

Willis, J H., 1970. A handbook to plants in Victoria. Vol.1. Melbourne Univ. Press, 320 pp.

Wolfe, J.A , 1971. Tertiary climatic fluctuations and methods of analysis of Tertiary floras. Palaeogeog., Palaeoclimatol., Palaeoecol., vol. 9, pp.27-57.

Wopfner, H., Callen, R., & Harris, W.K., 1974. The Lower Tertiary Eyre Formation of the southwestern Great Artesian Basin. J. Geol. Soc. Aust., vol.21, pp.17-52.

Appendix 1. Register of Sample Data

Nerriga References for localities 1 and 2, shown on Text-figure 2, are 30846658 and 30856656 on Sheet 8927-IV, Nerriga 1:50,000 series sheet.

Lithology of samples in hand specimen is given below. For localities in stratigraphic section, see Text-figure 3.

147	purplish grey siltstone
150	dark grey siltstone
153	purplish grey siltstone, slightly coarser than other samples
155	dark grey siltstone
158	dark grey siltstone
161	medium grey siltstone

Kiandra New Chum Hill west side of spur, eastern half of Cornishman's Claim.

024	dark brown clay, with abundant leaf and wood fragments visible
025	dark brown clay, with abundant leaf and wood fragments visible
026	dark brown clay
027	dark brown clay, with lignitic layers
028	dark brown clay, with lignitic layers
030	dark brown lignite from band 20 cm thick
032	black lignite
034	grey shaly horizon within a lignite
035	black lignite

New Chum Hill - south of previous section, at edge of western spur, eastern half of Cornishman's Claim.

065	dark grey clay
064	dark grey clay with sandy layers
063	dark grey clay with sandy layers
062	brown lignitic clay with thin sandy layers 1 cm thick
061	brown lignitic clay with thin sandy layers 1 cm thick
060	brown lignitic clay
057	brown lignitic clay
056	brown lignitic clay
055	medium grey clay

Section Creek-Eight Mile Creek. For localities of samples, see Text-figures 5 and 7. Two sections were collected, separated by 5 metres of section which was obscured. The upper twelve samples were barren. The lower five sample lithologies are given herein.

013	purplish buff clay
014	black lignitic bands alternating with coarse sandy layers
015	dark grey clay with lignitic bands
016	dark grey clay with sandy and silty layers, with abundant wood fragments
017	dark grey clay with sandy and silty layers, with abundant wood fragments.

Nine Mile Diggings. For localities of samples, see Text-figures 5 and 8.

129	purplish buff, brown, and red mottled clay
130	black lignite
135	black lignite
136	mauve clay
137	dark mauve and buff clay
138	mauve clay, with abundant fossil wood
140	coarse sandy horizon at base of a mauve clay sequence; perhaps a fossil soil
142	mauve clays with much lignitic material
144	mauve clays with much lignitic material

Cadia Lithology of samples in hand specimen is given below. For localities in borehole successions, see Text-figure 11.

095	dark grey peaty lignite
096	dark grey peaty lignite
097	medium grey siltstone
098	grey peaty lignite, with a few thin vitreous layers 1 mm thick
099	light grey diatomite
100	dark grey peaty lignite
101	dark grey peaty lignite, fissile
102	dark brown peaty lignite
103	grey peaty lignite
112	mottled buff to yellow clay
116	light grey diatomite
117	dark grey peaty lignite
118	dark grey siltstone
120	buff silty clay with abundant plant fragments visible
121	buff silty clay with abundant plant fragments visible
124	medium grey peaty lignite with stems and plant fragments visible

Appendix 2. Potassium-argon ages on basalts from near Cadia, New South Wales

A.N.U. Lab. No.	K wt %	^{40}Ar Radiogenic (10^{-7}ccNTP/g)	$\frac{100.\,^{40}\text{Ar Rad.}}{\text{Total }^{40}\text{Ar}}$	Calculated Age (m.y.) ± 2 s.d.	
73-1186	1.323 1.324	6.619	19.6	12.5±0.4	Pacific Copper Hole 235 Depth 33.8 m Collar altitude 942 m
73-1187	1.448 1.451	6.700	26.5	11.5±0.3	Pacific Copper Hole 246 Depth 51.5 m Collar altitude 914 m

$\lambda_e = 0.585\text{x}10^{-10}\text{yr}^{-1}$ $\lambda_\beta = 4.72\text{x}10^{-10}\text{yr}^{-1}$ $^{40}\text{K/K} = 1.19\text{x}10^{-2}$ atom per cent

Plates and Captions

All figures are X1000 unless otherwise noted. Co-ordinates with the slide numbers apply to a Zeiss microscope, Serial No. 4752128, located in the Geology Dept, A.N.U.

Plate 1

Fig.1. *Cyathidites australis* Couper, proximal focus; specimen on slide 147/1 (1215-058), 42 µm, equatorial diameter. Nerriga.

Fig.2. *Cyathidites australis* Couper, interference contrast; specimen on 147/6 (1035-129), 53 µm, equatorial diameter. Nerriga.

Fig.3. *Cyathidites minor* Couper, interference contrast; specimen on 147/6 (1057-200), 29 µm, equatorial diameter. Nerriga.

Fig.4. *Cyathidites minor* Couper, proximal focus; specimen on 147/6 (964-121), 30 µm, equatorial diameter. Nerriga.

Fig.5. *Cyathidites splendens* Harris, equatorial view; specimen on 150/6 (1055-218), 92 µm, polar diameter. Nerriga. X750.

Fig.6. *Cyathidites splendens* Harris, proximal focus; specimen on 161/2 (1211-082), 88 µm, equatorial diameter. Nerriga. X750.

Fig.7. *Cyathidites* cf. *C. minor*, proximal focus, specimen on 028/1 (1162-112), 33 µm, equatorial diameter. Kiandra.

Fig.8. *Cyathidites subtilis* Partridge, a, equatorial focus, b, distal focus; specimen on slide 028/4 (986-021), 34 µm, equatorial diameter. Kiandra.

Fig.9. *Deltoidospora* sp., proximal focus; specimen on 028/1 (888-057), 29 µm, equatorial diameter. Kiandra.

Fig.10. *Biretisporites* sp., proximal focus; specimen on 147/6 (1237-112), 36 µm, equatorial diameter. Nerriga.

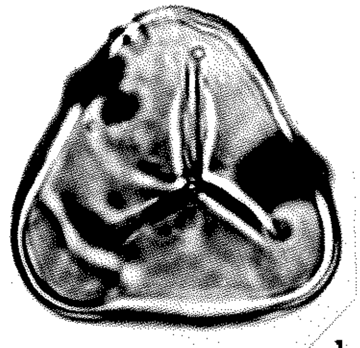
Fig.11. *Stereisporites* (*Tripunctisporis*) sp., interference contrast; specimen on 147/1 (1265-176), 36 µm, equatorial diameter. Nerriga.

Fig.12. *Biretisporites* sp., equatorial focus; specimen on 028/4 (1008-047), 30 µm, equatorial diameter. Kiandra.

Fig.13. *Deltoidospora* sp., proximal focus; specimen on 028/1 (892-206), 30 µm, equatorial diameter. Kiandra.

Fig.14. *Stereisporites antiquasporites* (Wilson & Webster) Dettmann; a, proximal focus, b, equatorial focus; specimen on 025/1 (1230-062), 24 µm, equatorial diameter. Kiandra.

Plate 1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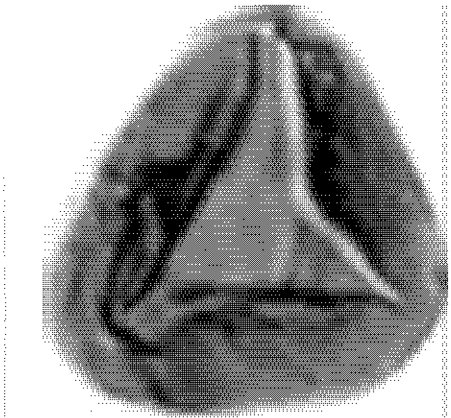
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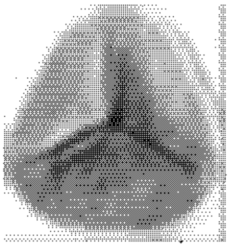
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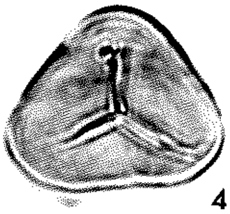
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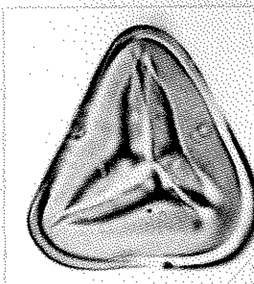
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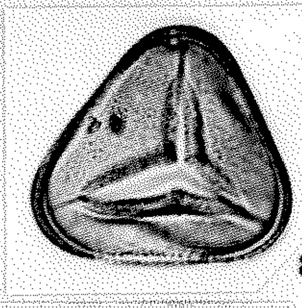
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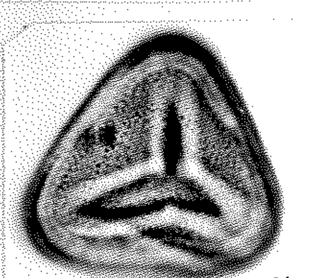
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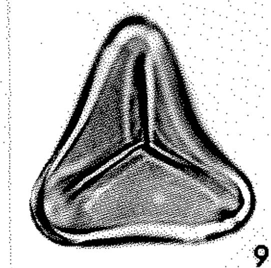
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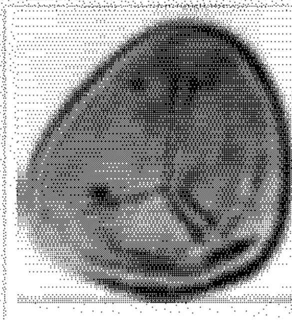
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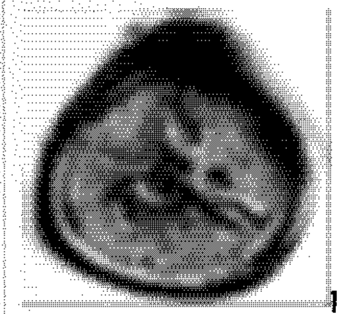
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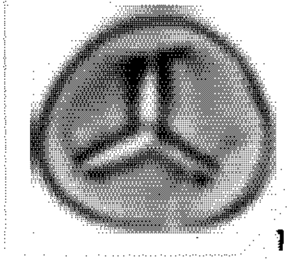
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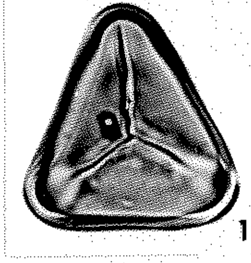
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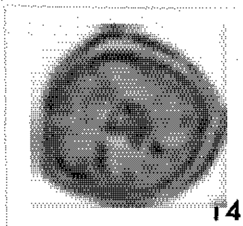
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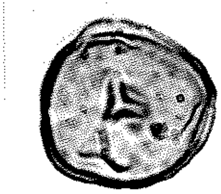
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Plate 2

All photographs X1000, unless otherwise noted.

Fig.1. *Verrucosisporites kopukuensis* (Couper) Stover, interference contrast; specimen on 028/5 (1236-201), 77 µm, equatorial diameter. Kiandra. X750.

Fig.2. *Verrucosisporites kopukuensis* (Couper) Stover, proximal focus, specimen on 015/1 (1204-173), 74 µm, equatorial diameter. Kiandra. X750.

Fig.3. *Verrucosisporites aristatus* Partridge, interference contrast; specimen on 028/3 (1165-014), 85 µm, equatorial diameter. Kiandra. X750.

Fig.4. *Leptolepidites tuberosus* sp. nov., a, distal focus, b, proximal focus; specimen on 028/2 (1109-233), 41 µm, equatorial diameter. Kiandra. Specimen slightly distorted, emphasizing apical projections.

Fig.5. *Verrucosisporites* cf. *V. cristatus* Partridge, a, proximal focus, b, equatorial focus; specimen on 028/6 (1253-032), 77 µm, equatorial diameter. Kiandra. X750.

Plate 2


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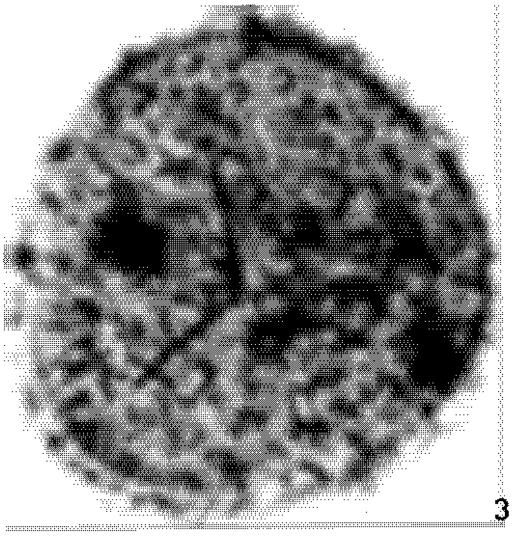
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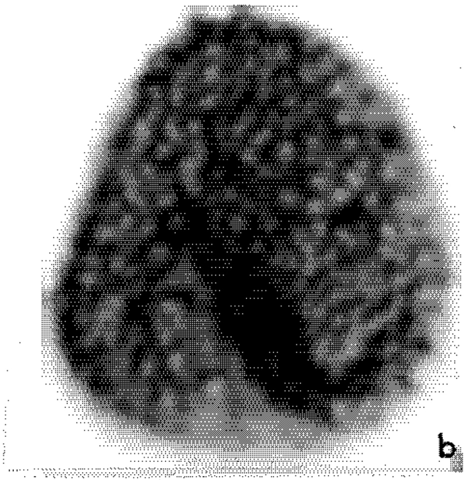
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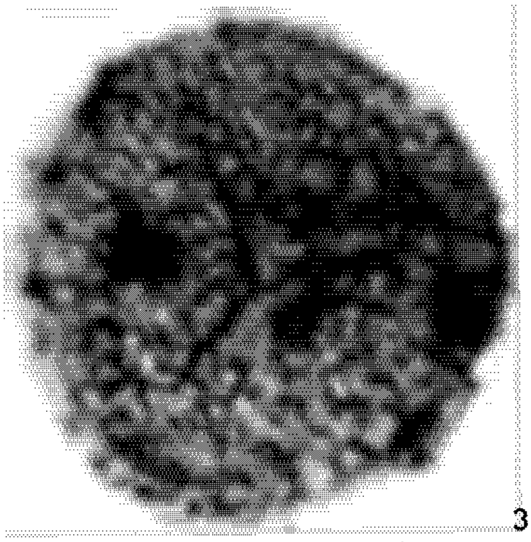
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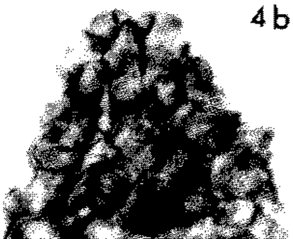
4b

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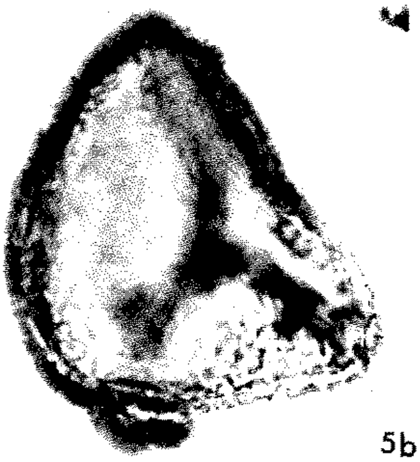
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Plate 3

All photographs X1000, unless otherwise noted.

Fig.1. *Verrucosisporites* cf. *V. cristatus* Partridge, interference contrast. Same specimen as Plate 2, fig.5. X750.

Fig.2. *Leptolepidites tuberosus* sp. nov., a, proximal focus, b, equatorial focus; specimen on 028/5 997-012), 50 µm, equatorial diameter. Kiandra.

Fig.3. *Leptolepidites tuberosus* sp. nov., holotype, a, equatorial focus, b, distal focus; specimen on 028/1 (1084-036), 52 µm, equatorial diameter. Kiandra.

Fig.4. *Osmundacidites* sp. 1, distal focus; specimen on 025/1 (1230-062), 36 µm, equatorial diameter. Kiandra.

Fig.5. *Baculatisporites comaumensis* (Cookson) Potonié, proximal focus; specimen on 065/3 (885-071), 40 µm, equatorial diameter. Kiandra.

Fig.6. *Osmundacidites* sp. 2, proximal focus; specimen on 028/1 (940-183), 56 µm, equatorial diameter. Kiandra.

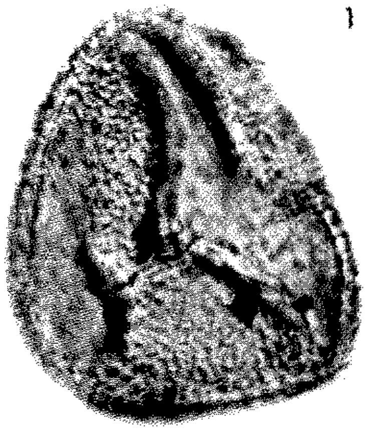
Fig.7. *Foveosporites lacunosus* (Partridge), a,b, proximal focus, c, equatorial focus, d, distal focus; specimen on 101/4 (1067-025), 30 µm, equatorial diameter. Cadia.

Fig.8. *Lycopodiumsporites* sp. 1, a, proximal focus, b, distal focus; specimen on 065/1 (968-062), 40 µm, equatorial diameter. Kiandra.

Fig.9. *Baculatisporites comaumensis* (Cookson) Potonié, proximal focus; specimen on 028/6 (1188-146), 47 µm, equatorial diameter. Kiandra.

Fig.10. *Foveotriletes crater* Partridge, a, equatorial focus, b and c, distal foci; specimen on 150/6 (1139-119), 26 µm, equatorial diameter. Nerriga.

Plate 3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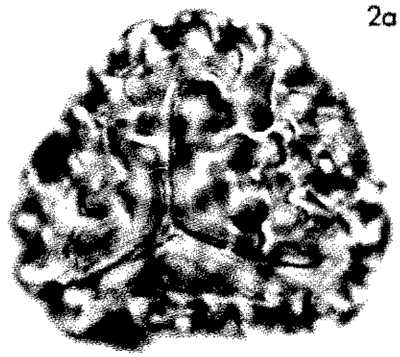
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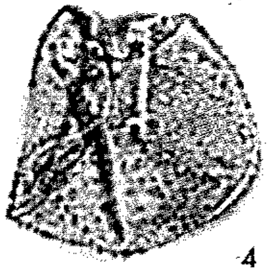
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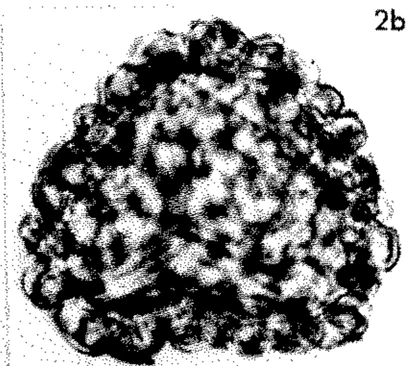
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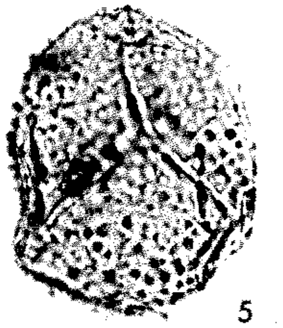
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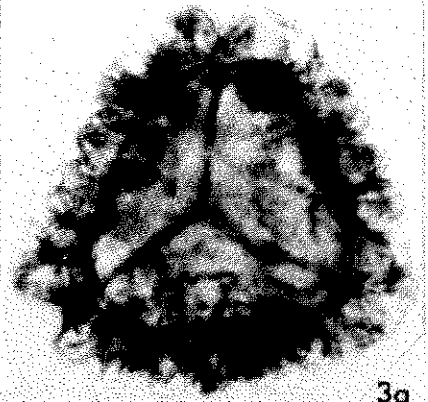
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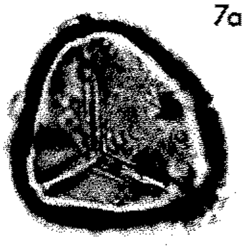
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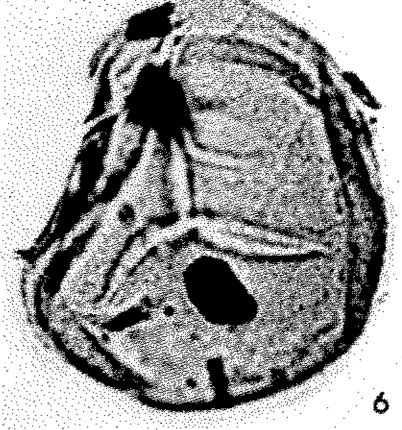
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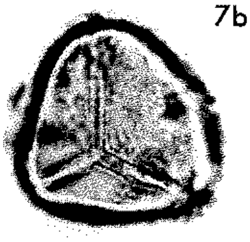
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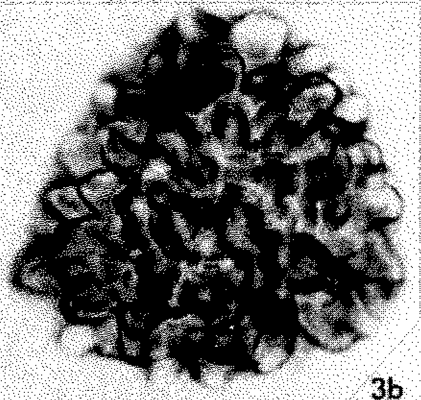
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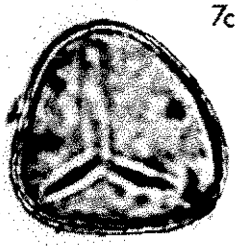
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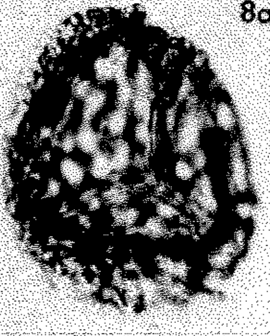
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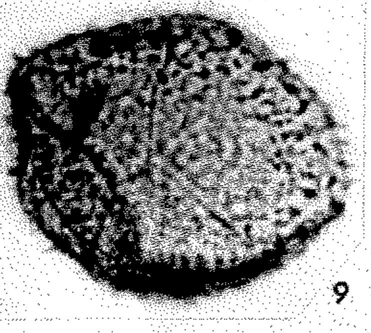
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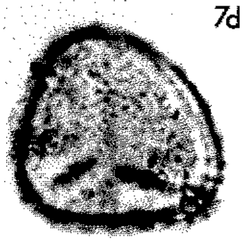
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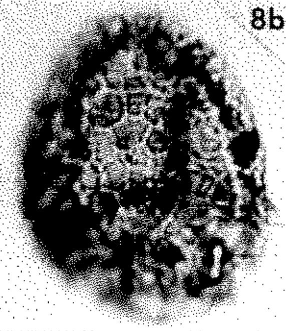
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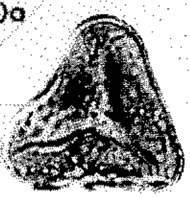
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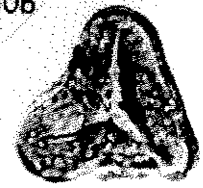
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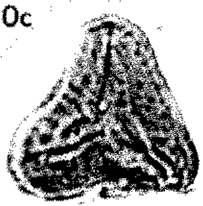
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Plate 4

All photographs X1000, unless otherwise noted.

Fig.1. Foveotriletes palaequetrus Partridge, a distal focus, b, proximal focus; specimen on 147/5 (980-114), 40 µm, equatorial diameter. Nerriga.

Fig.2. Lycopodium sporites sp. 2, a, proximal focus, b, distal focus; specimen on 065/1 (952-143), 29 µm, equatorial diameter. Kiandra.

Fig.3. Lycopodiumsporites sp. 3, a, distal focus, b, proximal focus; specimen on 112/1 (1124-118), 31 µm, equatorial diameter. Cadia.

Fig.4. Lycopodiumsporites sp. 3, equatorial view; specimen on 112/1 (1274-177), 24 µm, polar diameter. Cadia.

Fig.5. Rugulatisporites micraulaxus Partridge, a, proximal focus, b, equatorial focus, c, distal focus; specimen on 101/3 (1322-137), 36 µm, equatorial diameter. Cadia.

Fig.6. Rugulatisporites trophus Partridge, proximal focus; specimen on 028/2 (1095-196), 49 µm, equatorial diameter. Kiandra.

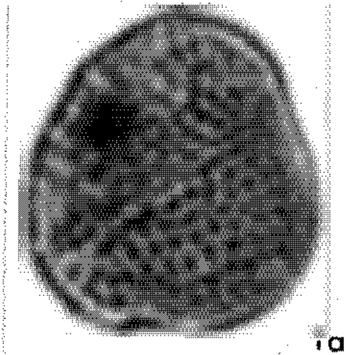
Fig.7. Rugulatisporites mallatus Stover, proximal focus; specimen on 028/2 (1141-100), 45 µm, equatorial diameter. Kiandra.

Fig.8. Rugulatisporites mallatus Stover, equatorial focus; specimen on 028/1 (1153-085), 43 µm, equatorial diameter. Kiandra.

Fig.9. Klukisporites reticulatus sp. nov., a, proximal focus, b, equatorial focus; specimen on 026 (883-094), 36 µm, equatorial diameter. Kiandra.

Fig.10. Klukisporites reticulatus sp. nov., holotype, a, proximal focus, b, distal focus; specimen on 028/5 (1044-117), 47 µm, equatorial diameter. Kiandra.

Plate 4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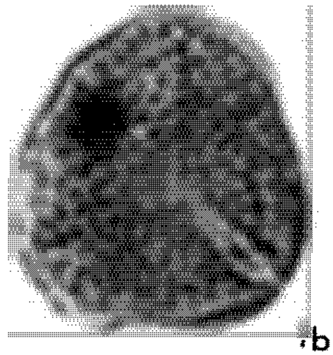
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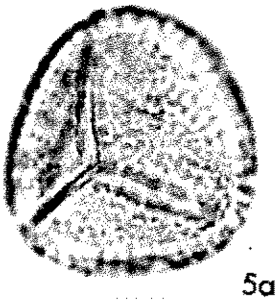
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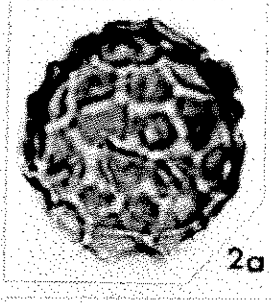
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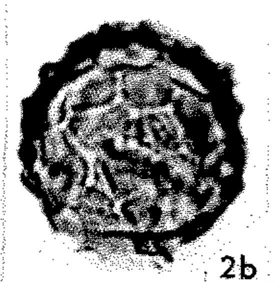
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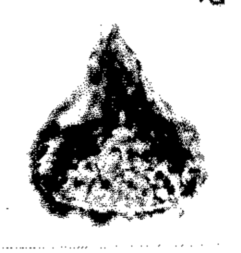
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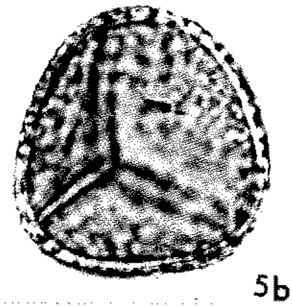
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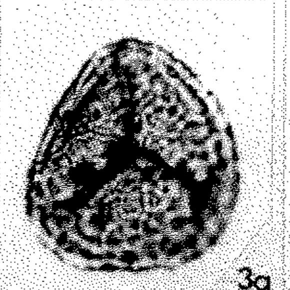
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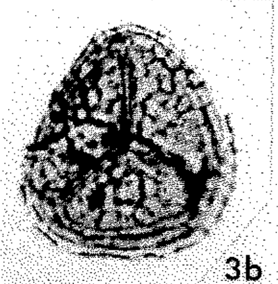
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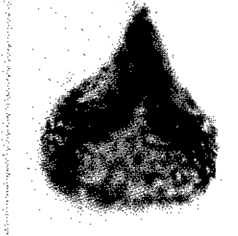
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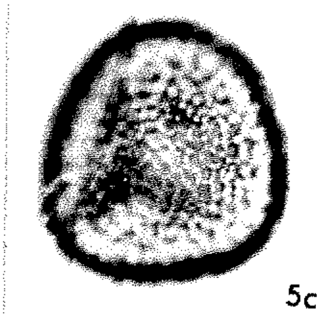
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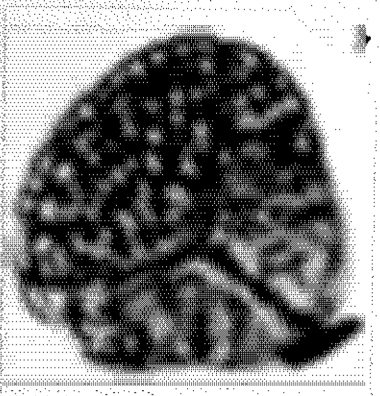
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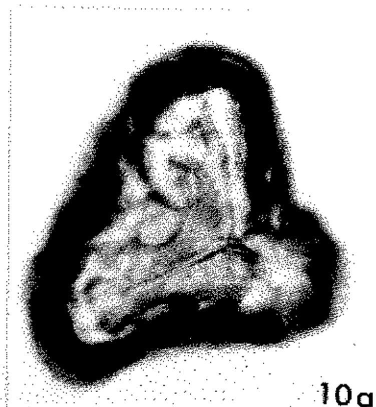
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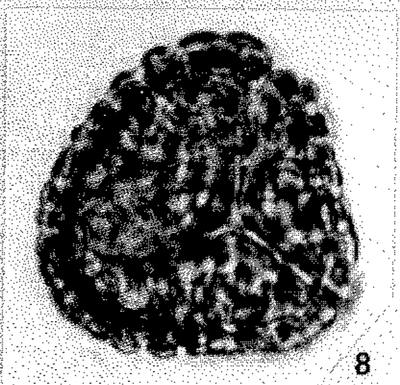
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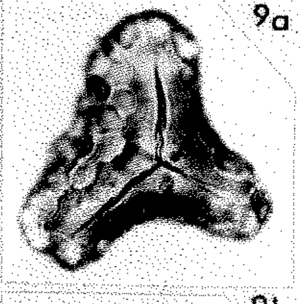
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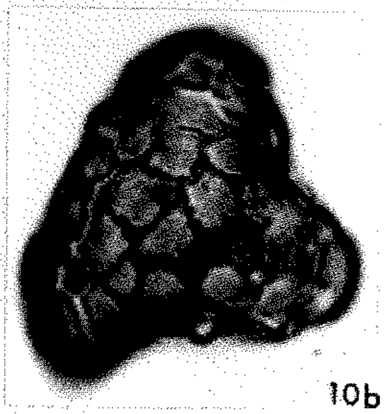
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Plate 5

All photographs X1000, unless otherwise noted.

Fig.1. Matonisporites ornamentalis (Cookson) Partridge, interference contrast, a, proximal focus, b, distal focus; specimen on 065/1 (851-069), 40 µm, equatorial diameter. Kiandra.

Fig.2. Ischyosporites sp. 1, interference contrast, a, proximal focus, b, distal focus; specimen on 101/2 (1047-038), 54 µm, equatorial diameter. Cadia.

Fig.3. Trilites tuberculiformis Cookson, a,b, proximal foci, c, distal focus; specimen on 147/5 (952-094), 48 µm, equatorial diameter. Nerriga.

Fig.4. Matonisporites ornamentalis (Cookson) Partridge, a, proximal focus, b, distal focus; specimen on 028/1 (988-032), 32 µm, equatorial diameter. Kiandra.

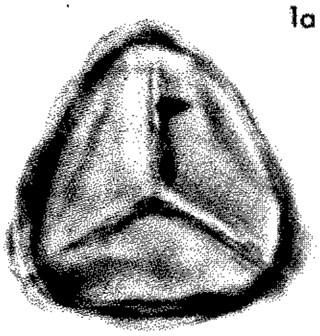
Fig.5. Gleicheniidites circinidites (Cookson) Dettmann, proximal focus; specimen on 032/f2 (1284-184), 30 µm, equatorial diameter. Kiandra.

Fig.6. Gleicheniidites circinidites (Cookson) Dettmann, proximal focus, with weak interradial crassitudes; specimen on 147/5 (1031-206), 29 µm, equatorial diameter. Nerriga.

Fig.7. Ischyosporites sp. 1, aberrant "quadrilete" type; a, proximal focus, b, distal focus; specimen on 028/5 (1223-080), 50 µm, equatorial diameter. Kiandra.

Fig.8. Ischyosporites sp. 1, a, distal focus, b, proximal focus; specimen on 028/2 (1050-087), 50 µm, equatorial diameter. Kiandra.

Plate 5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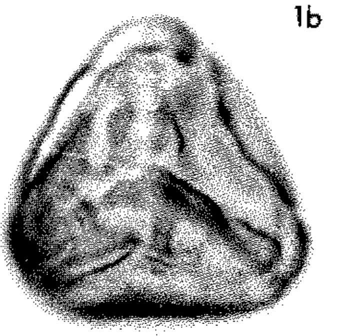
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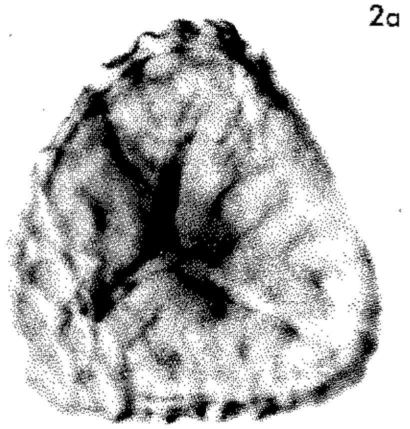
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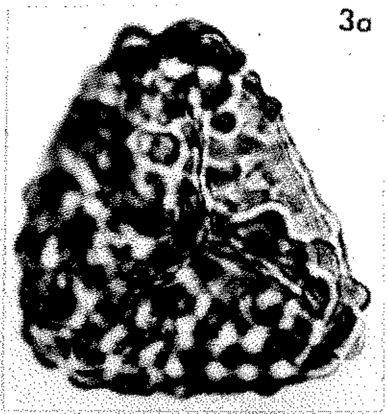
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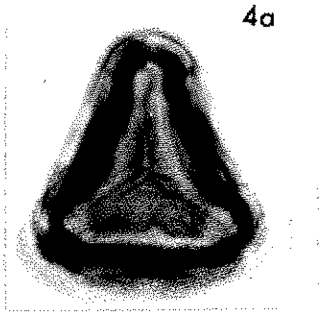
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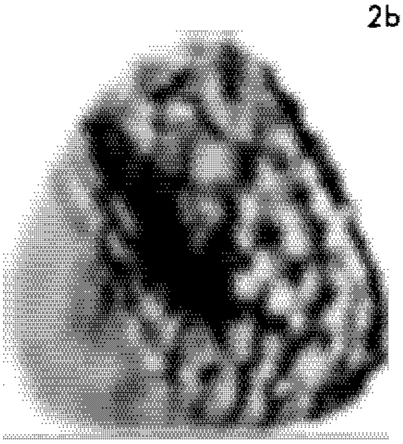
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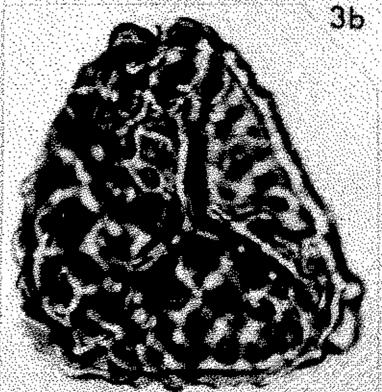
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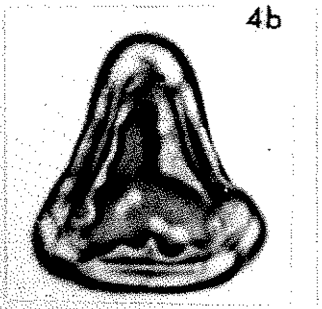
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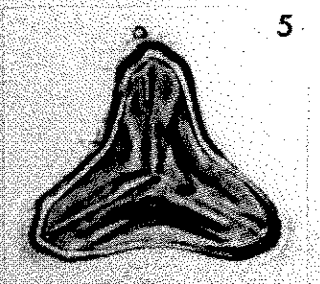
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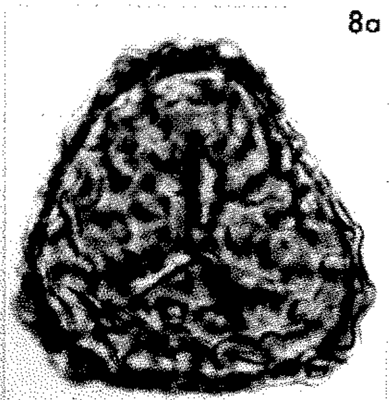
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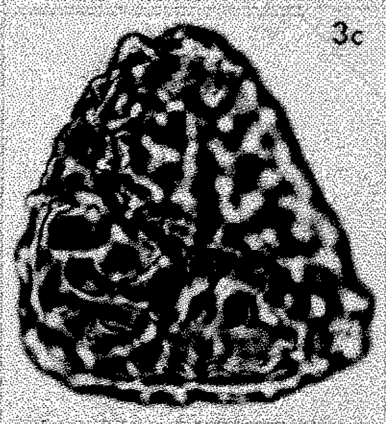
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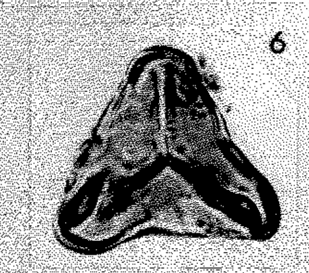
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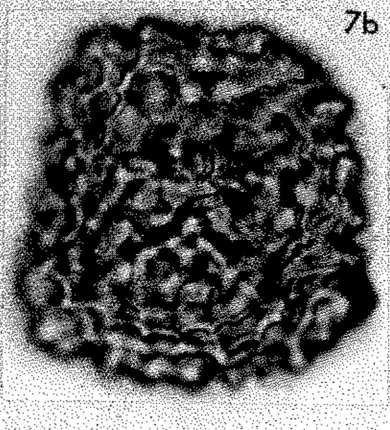
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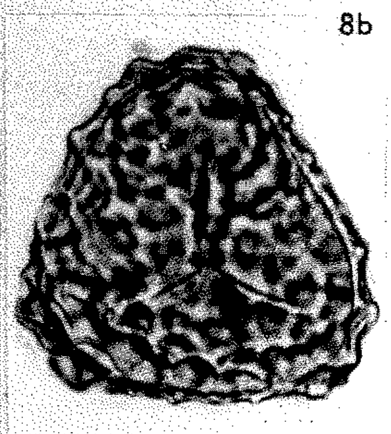

8b

Plate 6

All photographs X1000, unless otherwise noted.

Fig.1. *Ischyosporites* sp. 2, interference contrast; specimen on 147/3 (895-085), 54 µm, equatorial diameter. Nerriga.

Fig.2. *Cingutriletes clavus* (Balme) Dettmann, proximal focus; specimen on 065/2 (1228-019), 25 µm, equatorial diameter. Kiandra.

Fig.3. *Cingutriletes clavus* (Balme) Dettmann, a, proximal focus, b, equatorial focus; specimen on 065/1 (1126-039), 26 µm, equatorial diameter. Kiandra.

Fig.4. *Clavifera triplex* (Bolkovitina) Bolkovitina, two proximal foci; specimen on 147/1 (988-045), 44 µm, equatorial diameter. Nerriga.

Fig.5. *Cyatheacidites annulatus* Cookson, proximal focus; specimen on 028/5 (1195-074), 53 µm, equatorial diameter. Kiandra.

Fig.6. *Cyatheacidites annulatus* Cookson, a, proximal focus, b, distal focus; specimen on 028/5 (1252-137), 65 µm, equatorial diameter. Kiandra.

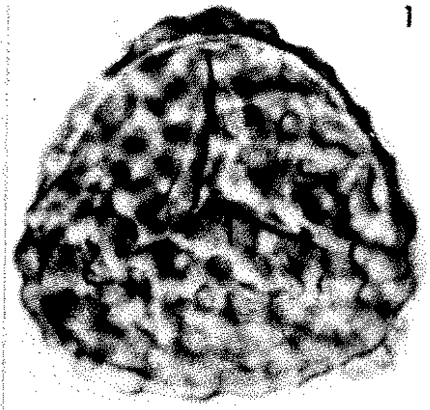
Fig.7. *Laevigatosporites ovatus* Wilson & Webster, interference contrast; specimen on 028/3 (1137-053), 30 µm. Kiandra.

Fig.8. *Laevigatosporites major* (Cookson) Krutzsch; specimen on 028/3 (894-051), 48 µm. Kiandra.

Fig.9. *Polypodiisporites speciosus* (Harris), a, focus on sculpture, b, focus on margin; specimen on 147/6 (1227-217), 40 µm. Nerriga.

Fig.10. *Reticuloidosporites escharus* Partridge (ms name), a, focus on sculpture, b, focus on margin; specimen on 028/1 (1168-090), 36 µm. Kiandra.

Plate 6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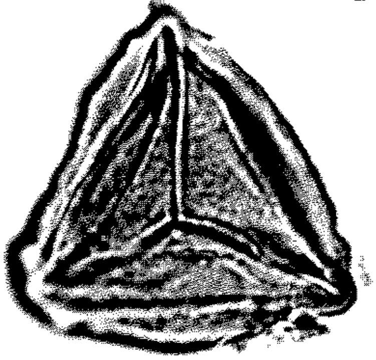
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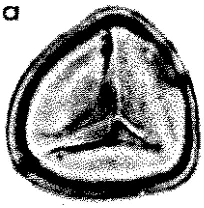
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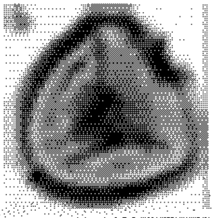
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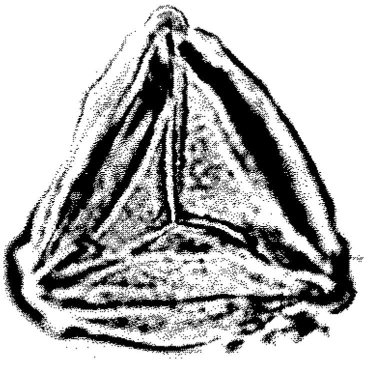
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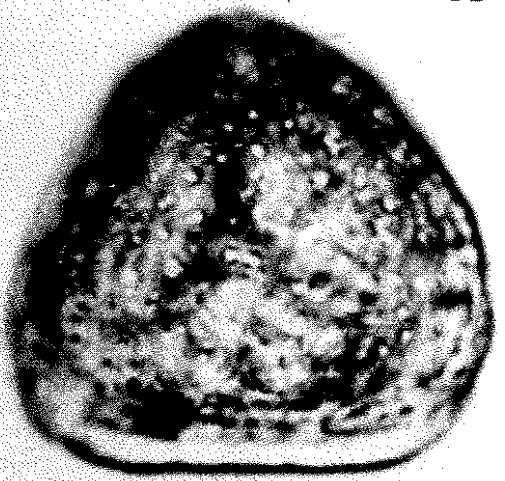
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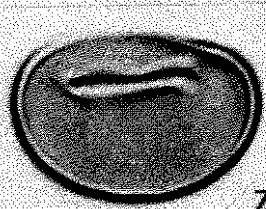
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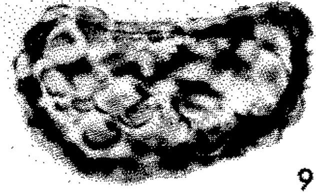
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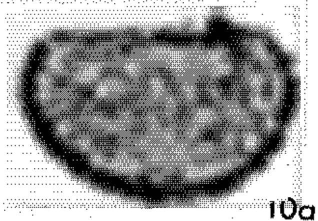
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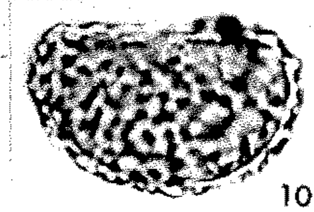
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Plate 7

All photographs X1000, unless otherwise noted.

Fig.1. Polypodiisporites sp. 2, a, focus on sculpture, b, focus on margin; specimen on 153/2 (1273-117), 56 µm. Nerriga.

Fig.2. Polypodiisporites sp. 1, interference contrast; specimen on 095/2 (1107-081), 42 µm. Cadia.

Fig.3. Microfoveolatosporis sp. 2, interference contrast; specimen on 147/1 (1070-026), 30 µm. Nerriga.

Fig.4. Microfoveolatosporis sp. 1, interference contrast, specimen on 028/3 (923-063), 66 µm. Kiandra.

Fig.5. Peromonolites densus Harris, two planes of foci; specimen on 028/2 (973/185), 55 µm. Kiandra.

Fig.6. Echinosporis sp., specimen on 028/3 (1045-216), 28 µm. Kiandra.

Fig.7. Peromonolites vellosus Partridge, interference contrast; specimen on 028/2 (991-182), 44 µm. Kiandra.

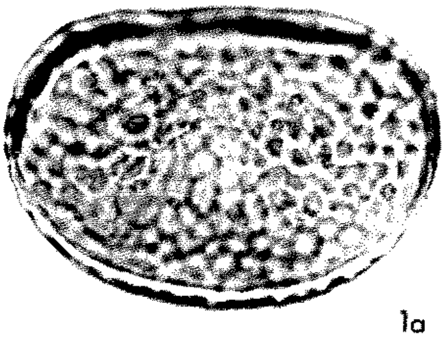
Fig.8. Peromonolites vellosus Partridge, a, focus on suture, b, focus on laesura; specimen on 028/4 (1176-119), 45 µm. Kiandra.

Fig.9. Peromonolites densus Harris, specimen on 028/2 (885-227), 49 µm. Kiandra.

Fig.10. Hypolepis spinysporis Martin, two planes of foci; specimen on 065/6 (1018-192), 35 µm. Kiandra.

Fig.11. Hypolepis spinysporis Martin, three planes of foci; specimen on 065/5 (1181-166), 38 µm. Kiandra.

Plate 7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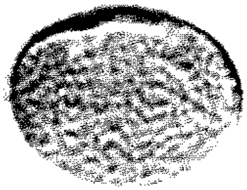
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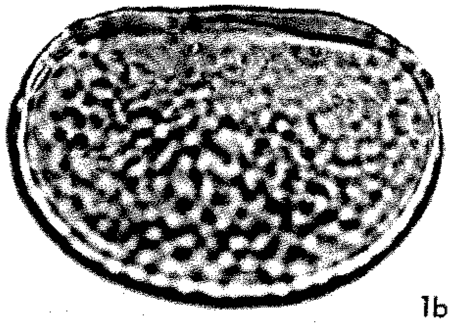
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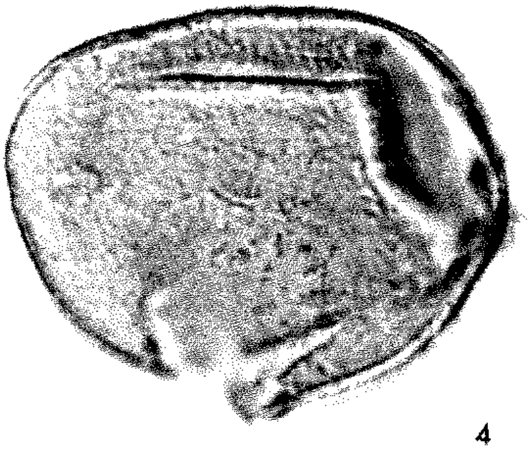
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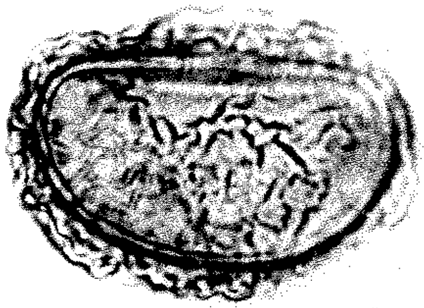
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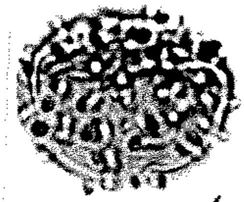
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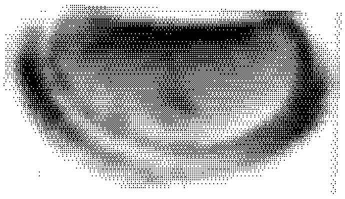
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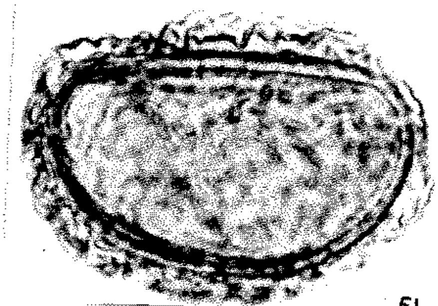
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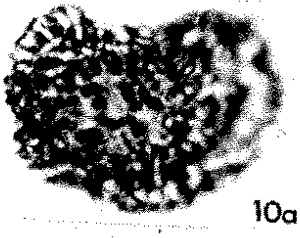
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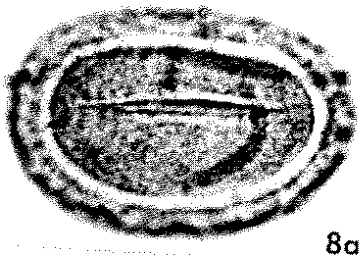
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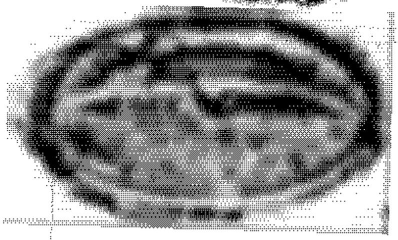
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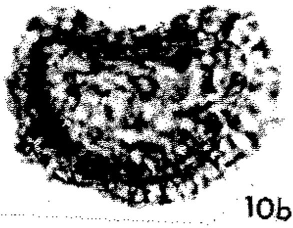
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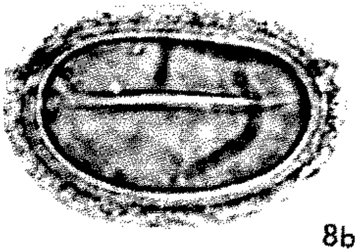
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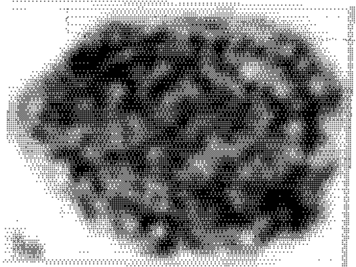
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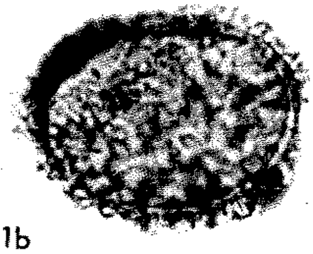
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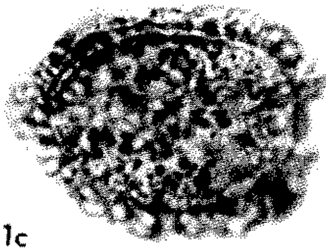
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Plate 8

All photographs X1000, unless otherwise noted.

Fig.1. *Podocarpidites ellipticus* Cookson; specimen on 065/1 (951-167) 55 µm, total width. Kiandra.

Fig.2. *Podocarpidites marwickii* Couper, interference contrast, two planes of focus; specimen on 028/2 (1205-106), 70 µm, total width. Kiandra.

Fig.3. *Podocarpidites marwickii* Couper; specimen on 150/1 (973-091), 69 µm, total width. Nerriga.

Fig.4. *Podocarpidites* cf. *P. multesimus* (Bolkovitina) Pocock; specimen on 028/6 (926-043), 65 µm, total width. Kiandra.

Fig.5. *Podocarpidites* sp., two planes of focus; specimen on 028/5 (1235-134), 80 µm, total width. Kiandra. X750.

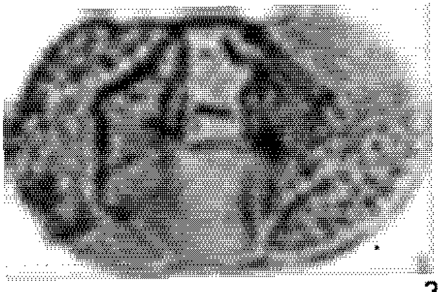
Fig.6. *Lygistepollenites florinii* (Cookson & Pike) Stover & Evans, disaccate type; three planes of focus; specimen on 028/1 (876-067), 55 µm, total width. Kiandra.

Fig.7. *Lygistepollenites florinii* (Cookson & Pike) Stover & Evans, monosaccate type; specimen on 028/5 (1063-175), 52 µm in diameter. Kiandra.

Fig.8. *Parvisaccites catastus* Partridge, oblique view; specimen on 147/6 (1061-123), 30 µm high. Nerriga.

Fig.9. *Parvisaccites catastus* Partridge, oblique view, two planes of focus; specimen on 028/5 (1190-091), 35 µ, height. Kiandra.

Plate 8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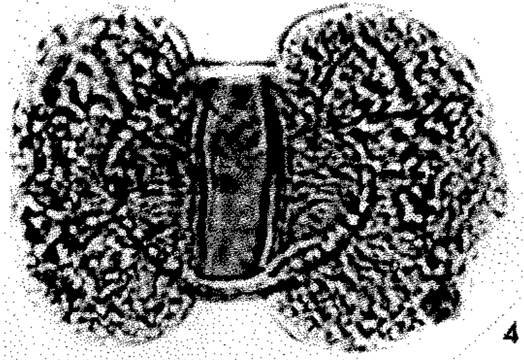
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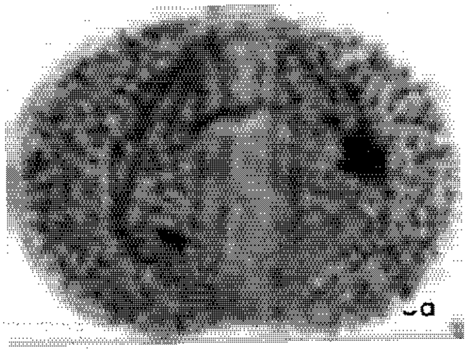
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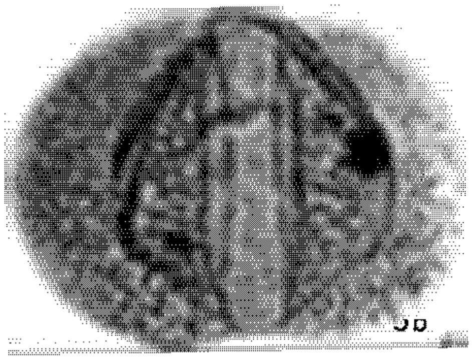
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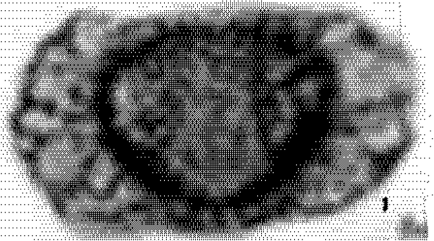

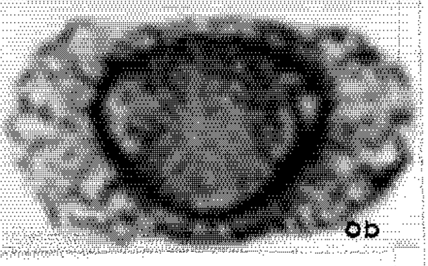
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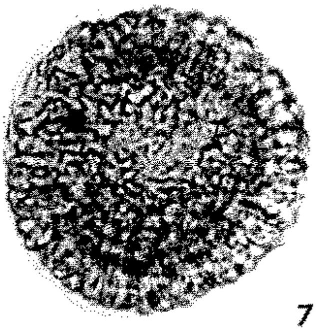
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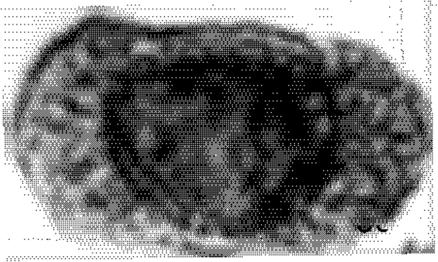
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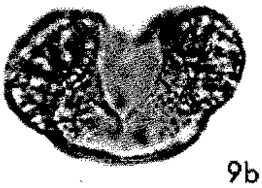
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Plate 9

All photographs X1000, unless otherwise noted.

Fig.1. Alisporites grandis (Cookson) Dettmann, two planes of focus; specimen on 028/1 (1108-017), 80 μm, total width. Kiandra. X750.

Fig.2. Podocarpidites sp., two planes of focus; specimen on 028/1 (1070-100), 85 μm, total width. Kiandra. X750.

Fig.3. Podocarpidites ellipticus Cookson, two planes of focus; specimen on 028/1 (952-035), 50 μm x 46 μm, total width x total height. Kiandra.

Fig.4. Lygistepollenites florinii (Cookson & Pike) Stover & Evans, trisaccate form, interference contrast; specimen on 101/4 (1101-105), 55 μm, maximum width. Cadia.

Fig.5. Phyllocladidites mawsonii Cookson ex Couper, two planes of focus; specimen on 121/2 (1025-038), 30 μm, total width. Cadia. Note proximal exine thickenings.

Fig.6. Phyllocladidites mawsonii Cookson ex Couper, interference contrast, two planes of focus; specimen on 028/4 (1095-116), 30 μm, total width. Kiandra. Note proximal exine thickenings.

Fig.7. Dacrycarpites australiensis Cookson & Pike, polar view, two planes of focus; specimens on 028/1 (1068-155), 62 μm, maximum diameter. Kiandra.

Plate 9


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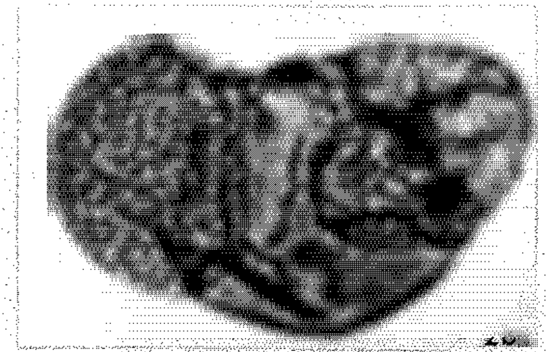

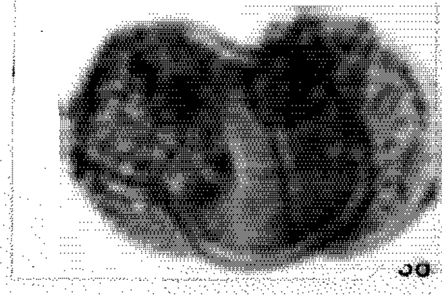

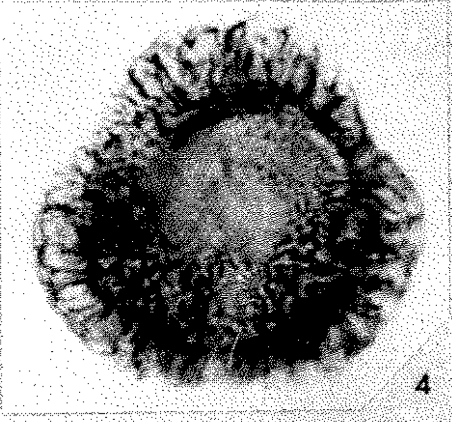
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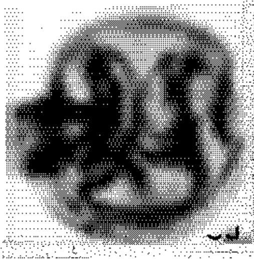

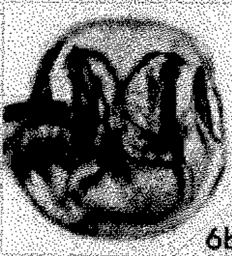
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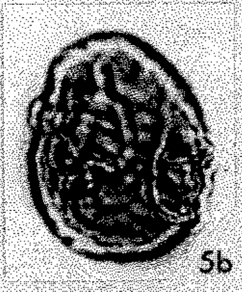
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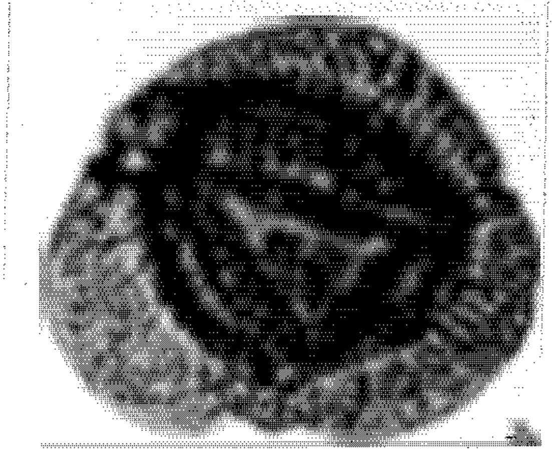

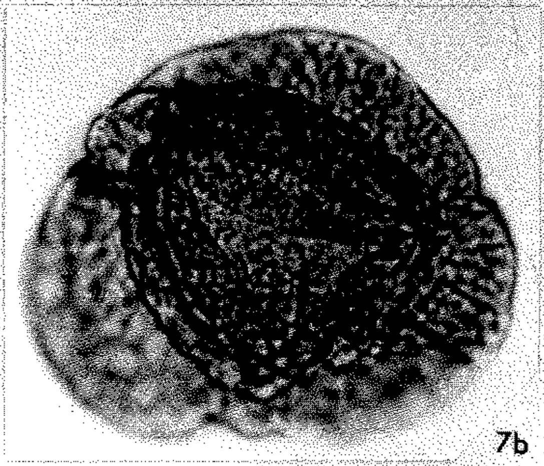
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Plate 10

All photographs X1000, unless otherwise noted.

Fig.1. *Dacrycarpites australiensis* Cookson & Pike, equatorial view, two planes of focus; specimen on 028/2 (891-225), 55 µm, maximum diameter. Kiandra.

Fig.2. *Microcachryidites parvus* Couper, interference contrast; specimen on 028/4 (870-122), 26 µm, maximum diameter. Kiandra.

Fig.3. *Podosporites microsaccatus* (Couper) Dettmann; specimen on 065/3 (987-016), 22 µm, maximum diameter. Kiandra. Unexpanded grain.

Fig.4. *Microcachryidites antarcticus* Cookson, two planes of focus; specimen on 158/1 (1063-088), 40 µm, maximum diameter. Nerriga.

Fig.5. *Phyllocladus palaeogenicus* Cookson & Pike, interference contrast; specimen on 028/6 (1153-181), 28 µm, total width. Kiandra.

Fig.6. *Microcachryidites antarcticus* Cookson; specimen on 028/2 (875-051), 47 µm, maximum diameter. Kiandra.

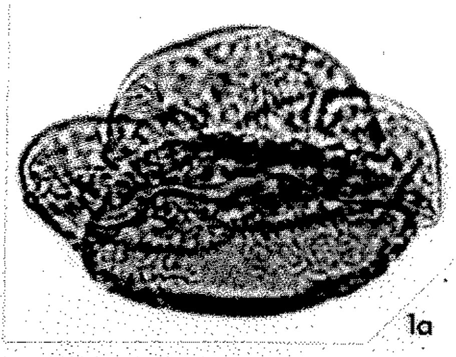
Fig.7. *Araucariacites australis* Cookson, three planes of focus; specimen on 028/5 (1216-057), 46 µm, maximum diameter. Kiandra.

Fig.8. *Podosporites microsaccatus* (Couper) Dettmann, two planes of focus; specimen on 028/6 (1090-159), 30 µm, maximum diameter. Kiandra. Expanded grain.

Fig.9. *Araucariacites* sp., specimen on 028/2 (980-206), 35 µm, maximum diameter. Kiandra.

Fig.10. *Araucariacites australis* Cookson, two planes of focus; specimen on 028/2 (1232-097), 55 µm, maximum diameter. Kiandra.

Plate 10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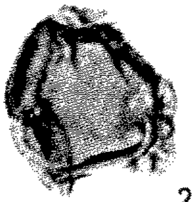
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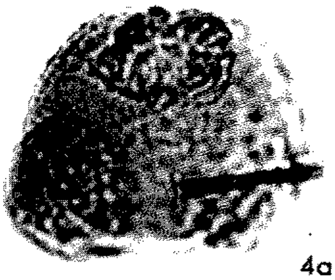
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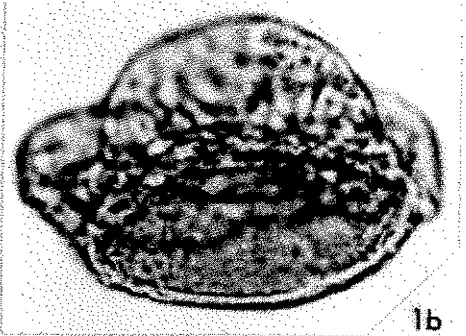
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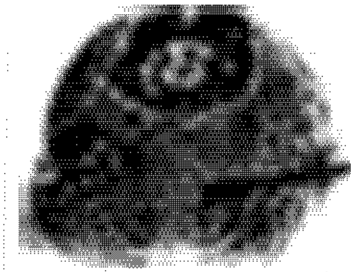
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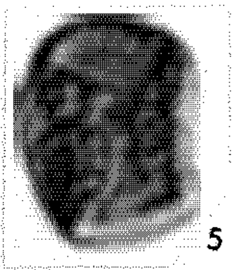
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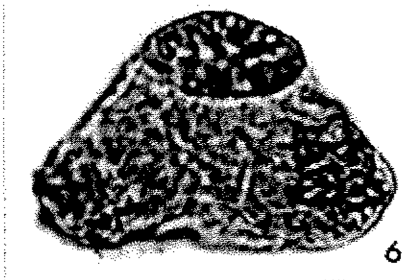
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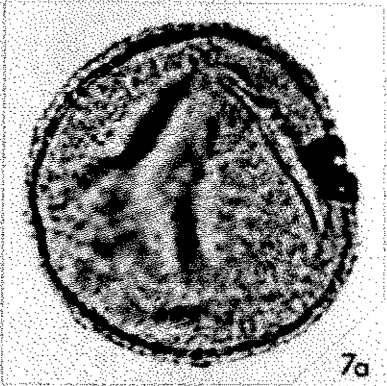
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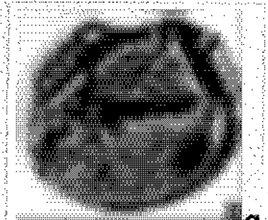
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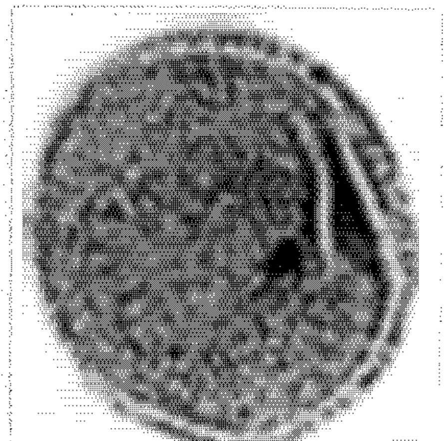
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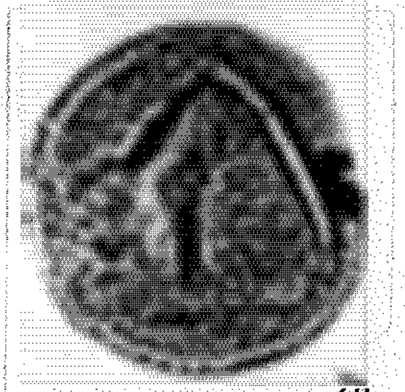
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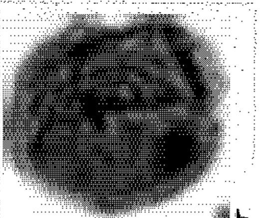
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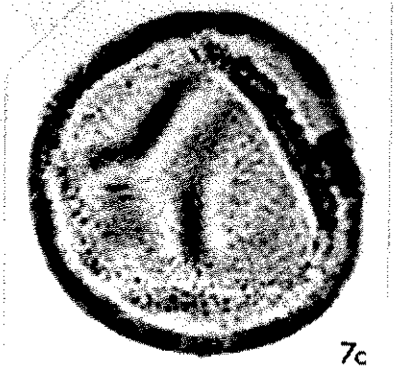
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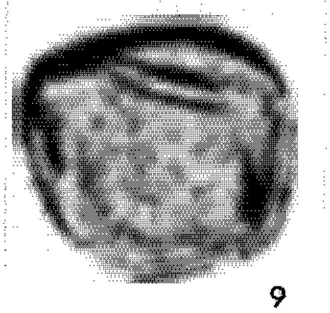
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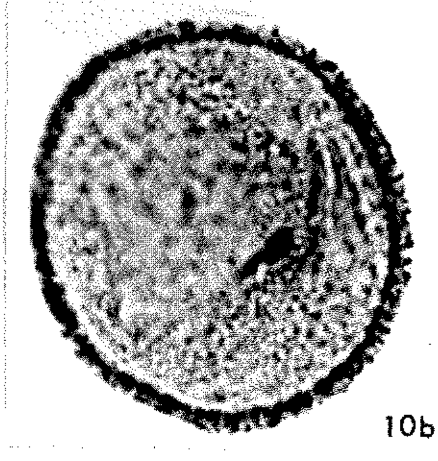
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Plate 11

All photographs X1000, unless otherwise noted.

Fig. 1. *Araucariacites* sp., interference contrast; specimen on 028/4 (1205-106), 62 µm, maximum diameter. Kiandra.

Fig. 2. *Araucariacites* sp., interference contrast, two planes of focus; specimen on 028/2 (750-206), 62 µm, maximum diameter. Kiandra.

Fig. 3. *Ephedripites notensis* (Cookson); specimen on 147/6 (999-146), 40 µm, length. Nerriga.

Fig. 4. *Ephedripites notensis* (Cookson), two planes of focus; specimen on 147/3 (1027-044), 44 µm, length. Nerriga. Note slight separation of exine layers or thickening at extremities of grain.

Fig. 5. *Dilwynites granulatus* Harris, two planes of focus; specimen on 147/1 (966-128), 48 µm, maximum diameter. Nerriga.

Fig. 6. *Dilwynites* cf. *D. tuberculatus* Harris, two planes of focus; specimen on 155/6 (1111-208), 52 µm, maximum diameter. Nerriga. X750.

Fig. 7. *Arecipites* sp.; specimen on 028/6 (1054-214), 47 µm, length. Kiandra.

Fig. 8. *Liliacidites* sp.; specimen on 028/2 (1261-200), 34 µm, length. Kiandra.

Fig. 9. *Monosulcites verrucosus* sp. nov.; specimen on 028/1 (1040-129), 26 µm, length. Kiandra.

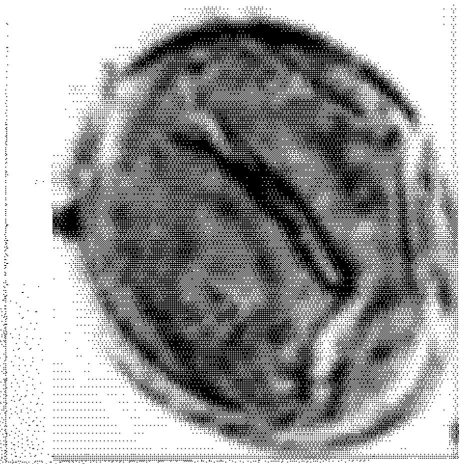
Fig.10. *Monosulcites verrucosus* sp. nov., holotype, two planes of focus; specimen on 028/1 (987-152), 26 µm, length. Kiandra.

Fig.11. *Monosulcites verrucosus* sp. nov.; specimen on 065/1 (1013-073), 20 µm, length. Kiandra.

Fig.12. *Liliacidites lanceolatus* Stover; specimen on 147/4 (1142-079), 30 µm, length. Nerriga.

Fig.13. *Liliacidites lanceolatus* Stover; same specimen as previous figure, interference contrast. Nerriga.

Plate 11

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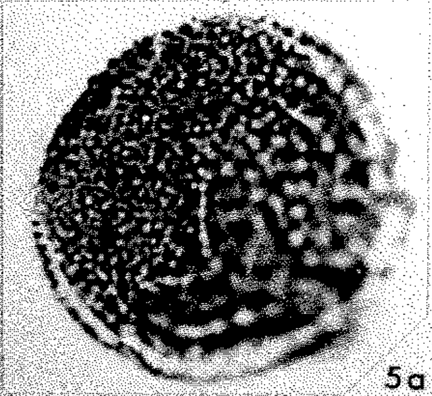
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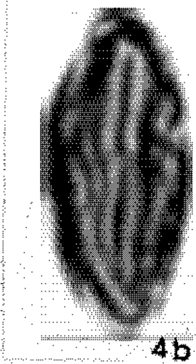
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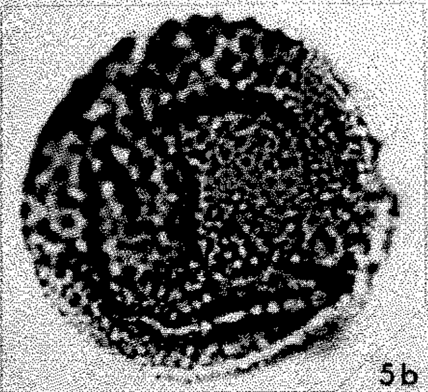
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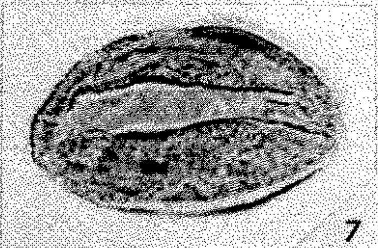
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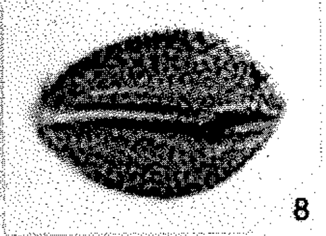
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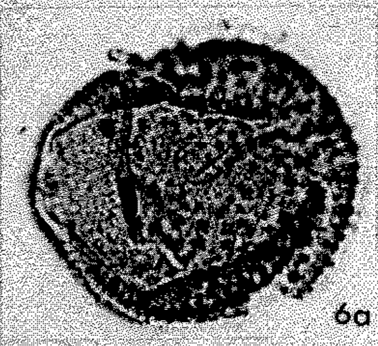
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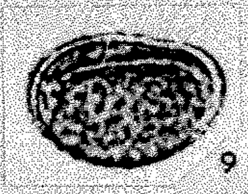
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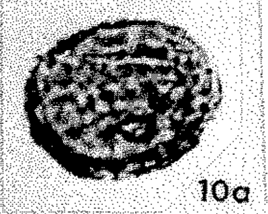
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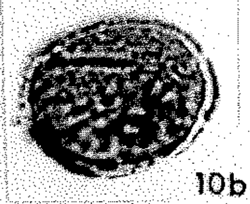
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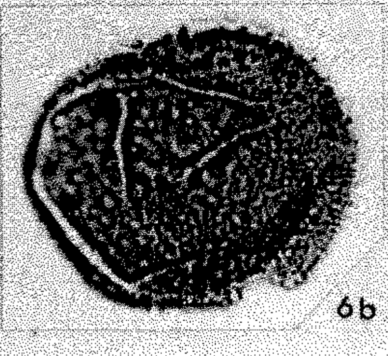
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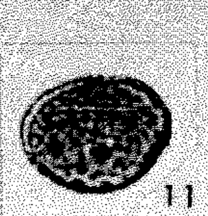
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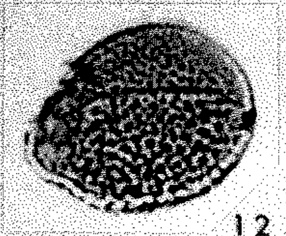
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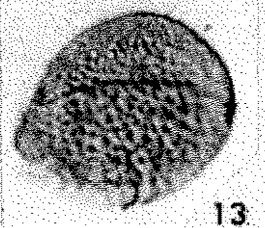
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Plate 12

All photographs X1000, unless otherwise noted.

Fig. 1. *Beaupreaidites verrucosus* Cookson, two planes of focus; specimen on 028/5 (1200-166), 32 µm, equatorial diameter. Kiandra.

Fig. 2. *Beaupreaidites elegansiformis* Cookson ex Couper, two planes of focus; specimen on 032/f2 (1132-149), 44 µm, equatorial diameter. Kiandra.

Fig. 3. *Tricolpites psilatus* Martin, three planes of focus; specimen on 028/2 (923-178), 24 µm, polar diameter. Kiandra.

Fig. 4. *Tricolpites delicatulus* Couper; specimen on 028/5 (956-058), 40 µm, polar diameter. Kiandra.

Fig. 5. *Tricolpites punctaticulus* McIntyre, two planes of focus; specimen on 065/2 (1073-070), 20 µm, polar diameter. Kiandra.

Fig. 6. *Gothanipollis* cf. *G. gothani* Krutzsch, three planes of focus; specimen on 065/1 (1033-201), 16 µm, equatorial diameter. Kiandra.

Fig. 7. *Gothanipollis* cf. *G. gothani* Krutzsch; specimen on 065/2 (1054-227), 14 µm, equatorial diameter. Kiandra.

Fig. 8. *Tricolpites patulus* sp. nov., holotype, three planes of focus; specimen on 147/2 (1082-222), 31 µm, equatorial diameter. Nerriga.

Fig. 9. *Gothanipollis* cf. *G. bassensis* Stover, two planes of focus; specimen on 028/4 (1035-194), 26 µm, equatorial diameter. Kiandra.

Fig.10. *Tricolpites patulus* sp. nov., oblique view, two planes of focus; specimen on 147/1 (1023-180), 23 µ, maximum diameter. Nerriga.

Fig.11. *Tricolporites sphaerica* Cookson, interference contrast, two planes of focus; specimen on 101/2 (1170-072), 26 µ, polar diameter. Cadia.

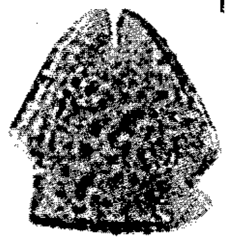
Fig.12. *Tricolpites patulus* sp. nov., two planes of focus; specimen on 161/2 (1210-185), 24 µ, equatorial diameter. Nerriga.

Fig.13. *Tricolporites* cf. *T. angurium* Partridge, three planes of focus; specimen on 099/1 (1129-178), 30 µm, polar diameter. Cadia.

Fig.14. *Tricolporites microreticulatus* Harris, two planes of focus; specimen on 147/6 (1203-167), 40 µm, polar diameter. Nerriga.

Fig.15. *Tricolporites paenstriatus* Stover, interference contrast, two planes of focus; specimen on 147/6 (1112-209), 36 µm, polar diameter. Nerriga.

Plate 12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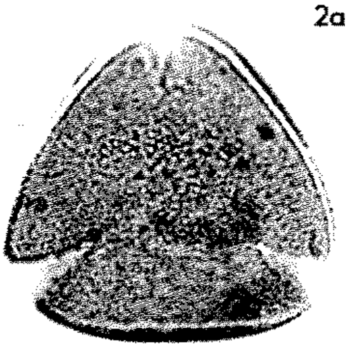
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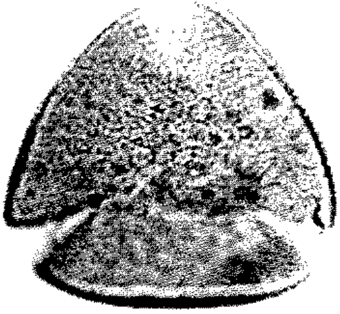
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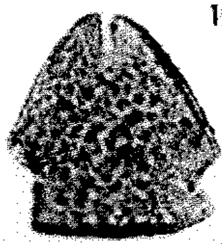
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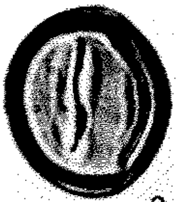
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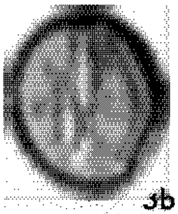
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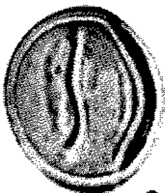
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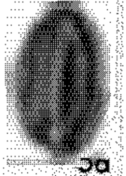
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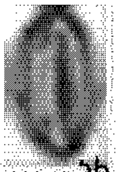
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6a


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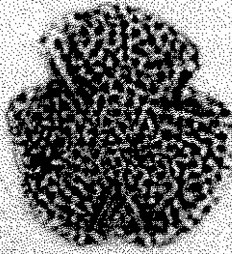
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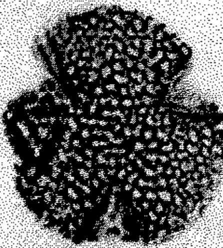
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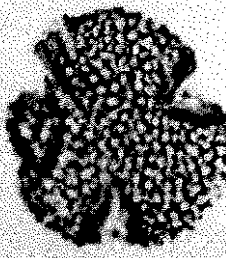
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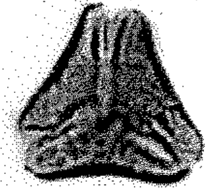
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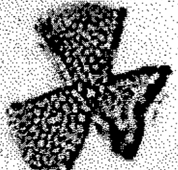
11a


12a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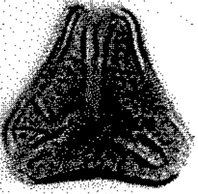
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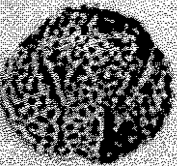
10b


11b


13a


13b


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14a


14b


15a


15b

Plate 13

All photographs X1000, unless otherwise noted.

Fig.1. *Tricolporites scabratus* Harris, two planes of focus; specimen on 147/1 (1160-047), 52 µm, polar diameter. Nerriga.

Fig.2. *Tricolporites retequetrus* Partridge, two planes of focus; specimen on 028/3 (1215-079), 32 µm, equatorial diameter. Kiandra.

Fig.3. *Tricolporites* cf. *T. endobalteus* (McIntyre), four planes of focus; specimen on 096/1 (1123-030), 26 µm, equatorial diameter. Cadia.

Fig.4. *Tricolporites* sp. 1, two planes of focus; specimen on 101/1 (1129-157), 60 µm, equatorial diameter. Cadia.

Fig.5. *Tricolporites retequetrus* Partridge, interference contrast, two planes of focus; specimen on 028/2 (943-238), 44 µm, equatorial diameter. Kiandra.

Fig.6. *Tricolporites valvatus* Harris, two planes of focus; specimen on 150/4 (1211-051), 46 µm, polar diameter. Nerriga.

Fig.7. *Tricolporites prolata* Cookson, three planes of focus; specimen on 095/1 (1203-155), 17 µm, polar diameter. Cadia.

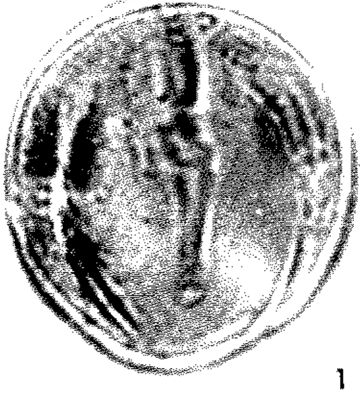
Fig.8. *Tricolporites* sp. 3, interference contrast, specimen on 150/3 (1178-059), 50 µm, equatorial diameter. Nerriga.

Fig.9. *Tricolporites* sp. 2, interference contrast, two planes of focus; specimen on 155/4 (1044-200), 25 µm, maximum diameter. Nerriga.

Fig.10. *Tricolporites* sp. 4, two planes of focus; specimen on 028/1 (965-173), 27 µm, polar diameter. Kiandra.

Plate 13


1a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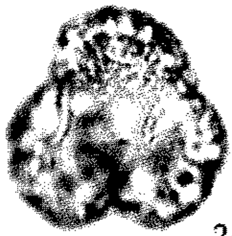
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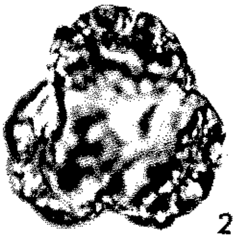
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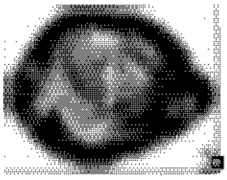

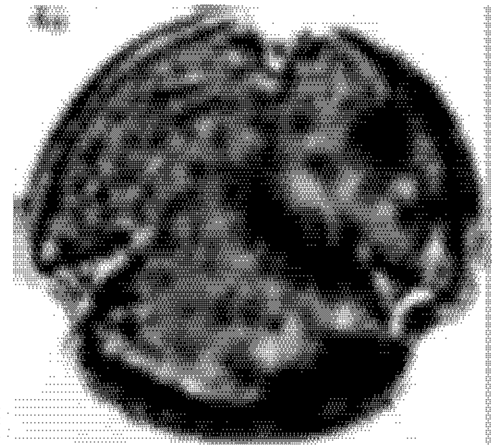

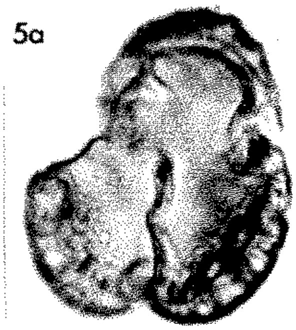
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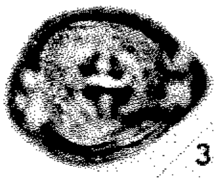
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3c


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3d


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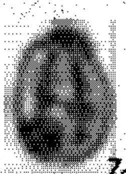
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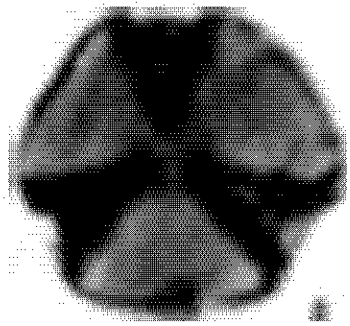

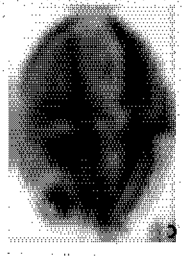

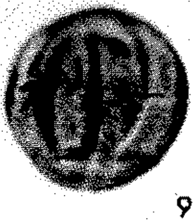
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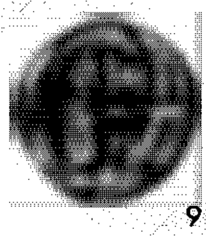
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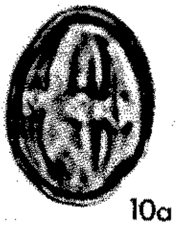

10a


10b

Plate 14

All photographs X1000, unless otherwise noted.

Fig.1. *Tricolporites* sp. 3, three planes of focus; specimen on 147/1 (1025-022), 52 µm, equatorial diameter. Nerriga.

Fig.2. *Tricolporites* sp. 5, two planes of focus; specimen on 155/6 (1193-146), 44 µm, equatorial diameter. Nerriga.

Fig.3. *Myrtaceidites verrucosus* Partridge, interference contrast; specimen on 065/5 (1180-028), 15 µm, equatorial diameter. Kiandra.

Fig.4. *Myrtaceidites parvus* Cookson & Pike, interference contrast; specimen on 065/2 (1064-123), 14 µm, equatorial diameter. Kiandra.

Fig.5. *Myrtaceidites eugeniioides* Cookson & Pike; specimen on 028/1 (1058-129), 12 µm, equatorial diameter. Kiandra.

Fig.6. *Myrtaceidites eucalyptoides* Cookson & Pike, three planes of focus; specimen on 065/2 (1103-227), 12 µm, equatorial diameter. Kiandra.

Fig.7. *Myrtaceidites mesonesus* Cookson & Pike, interference contrast; specimen on 028/1 (1221-123), 20 µm, maximum diameter. Kiandra.

Fig.8. *Cupanieidites major/orthoteichus* Cookson & Pike; specimen on 147/6 (1232-080), 26 µm, equatorial diameter. Nerriga.

Fig.9. *Myrtaceidites eucalyptoides* Cookson & Pike, interference contrast; specimen on 099/1 (1121-041), 16 µm, equatorial diameter. Cadia.

Fig.10. *Myrtaceidites mesonesus* Cookson & Pike; specimen on 100/1 (1262-050), 20 µm, maximum diameter. Cadia.

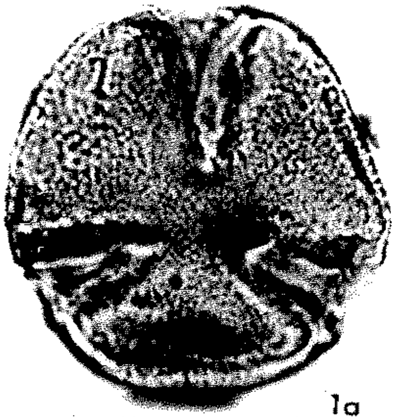
Fig.11. *Gemmatricolporites* cf. *G. gestus* Partridge, two planes of focus; specimen on 147/2 (1001-161), 30 µm, equatorial diameter. Nerriga.

Fig.12. *Sapotaceoidaepollenites* cf. *S. rotundus* Harris, two planes of focus; specimen on 028/2 (1254-212), 32 µm, polar diameter. Kiandra.

Fig.13. *Intratriporopollenites notabilis* (Harris) Stover, two planes of focus; specimen on 147/5 (1010-177), 56 µm, equatorial diameter. Nerriga.

Fig.14. *Cupanieidites major/orthoteichus* Cookson & Pike, interference contrast; specimen on 147/6 (1278-145), 26 µm, equatorial diameter. Nerriga.

Plate 14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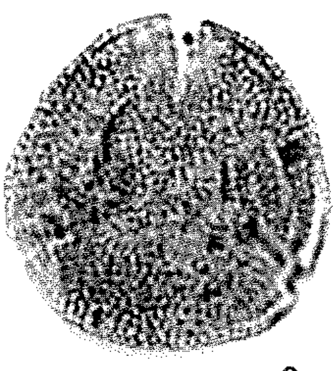
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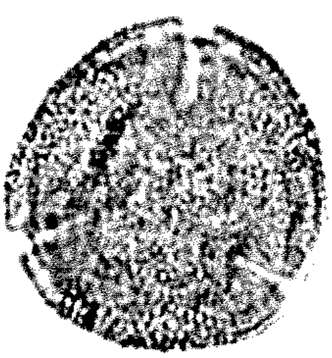
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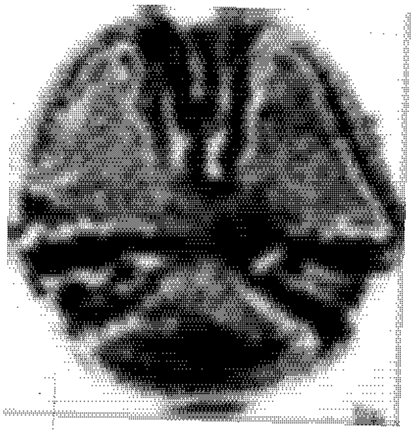

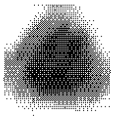
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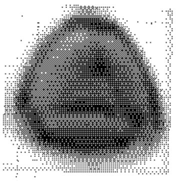
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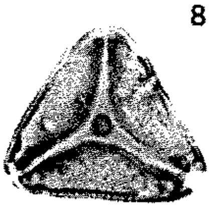
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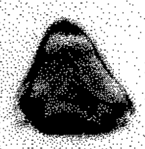
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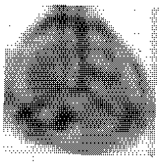
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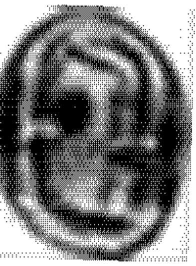
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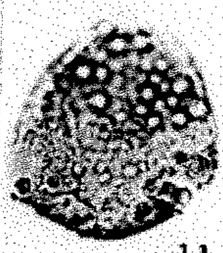
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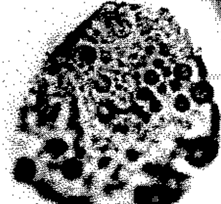
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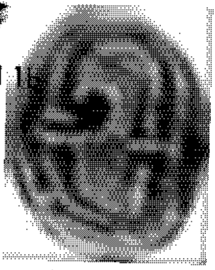
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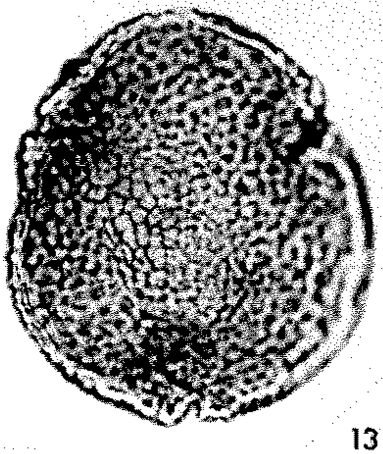
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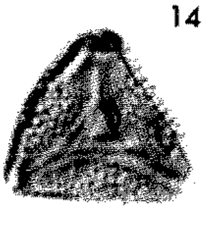
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Plate 15

All photographs X1000, unless otherwise noted.

Fig.1. *Tricolpites cancellatus* sp. nov., polar view, three planes of focus; specimen on 028/4 (972-209), 24 µm, equatorial diameter. Kiandra.

Fig.2. *Tricolpites* cf. *T. pachyexinus* Couper; specimen on 158/2 (1026-029), 29 µm, maximum diameter. Nerriga.

Fig.3. *Tricolpites cancellatus* sp. nov., equatorial view, four planes of focus; specimen on 028/2 (912-140), 24 µm, polar diameter. Kiandra.

Fig.4. *Gemmatricolporites* cf. *G. gestus* Partridge, three planes of focus; specimen on 147/2 (942-030), 36 µm, equatorial diameter. Nerriga.

Fig.5. *Tricolporites sphaerica* Cookson, interference contrast, two planes of focus; specimen on 147/6 (997-131), 45 µm, maximum diameter. Nerriga. X750.

Fig.6. *Dodonaea sphaerica* Martin, three planes of focus; specimen on 101/1, (953-154), 27 µm, maximum diameter. Cadia.

Fig.7. *Ilexpollenites clifdenensis* McIntyre, interference contrast, two planes of focus; specimen on 028/3 (1180-132), 40 µm, polar diameter. Kiandra.

Fig.8. *Graminidites media* Cookson, three planes of focus; specimen on 101/1 (1100-041), 37 µm, maximum diameter. Cadia.

Fig.9. *Symplocoipollenites austellus* Partridge, three planes of focus; specimen on 100/1 (1057-089), 30 µm, equatorial diameter. Cadia.

Fig.10. *Graminidites media* Cookson, interference contrast; specimen on 101/1 (1106-173), 40 µm, maximum diameter. Cadia.

Fig.11. *Symplocoipollenites austellus* Partridge, three planes of focus; specimen on 101/1 (1053-195), 22 µm, equatorial diameter. Cadia.

Fig.12. *Banksieaeidites elongatus* Cookson, interference contrast; specimen on 150/3 (1102-125), 26 µm, length. Nerriga.

Plate 15

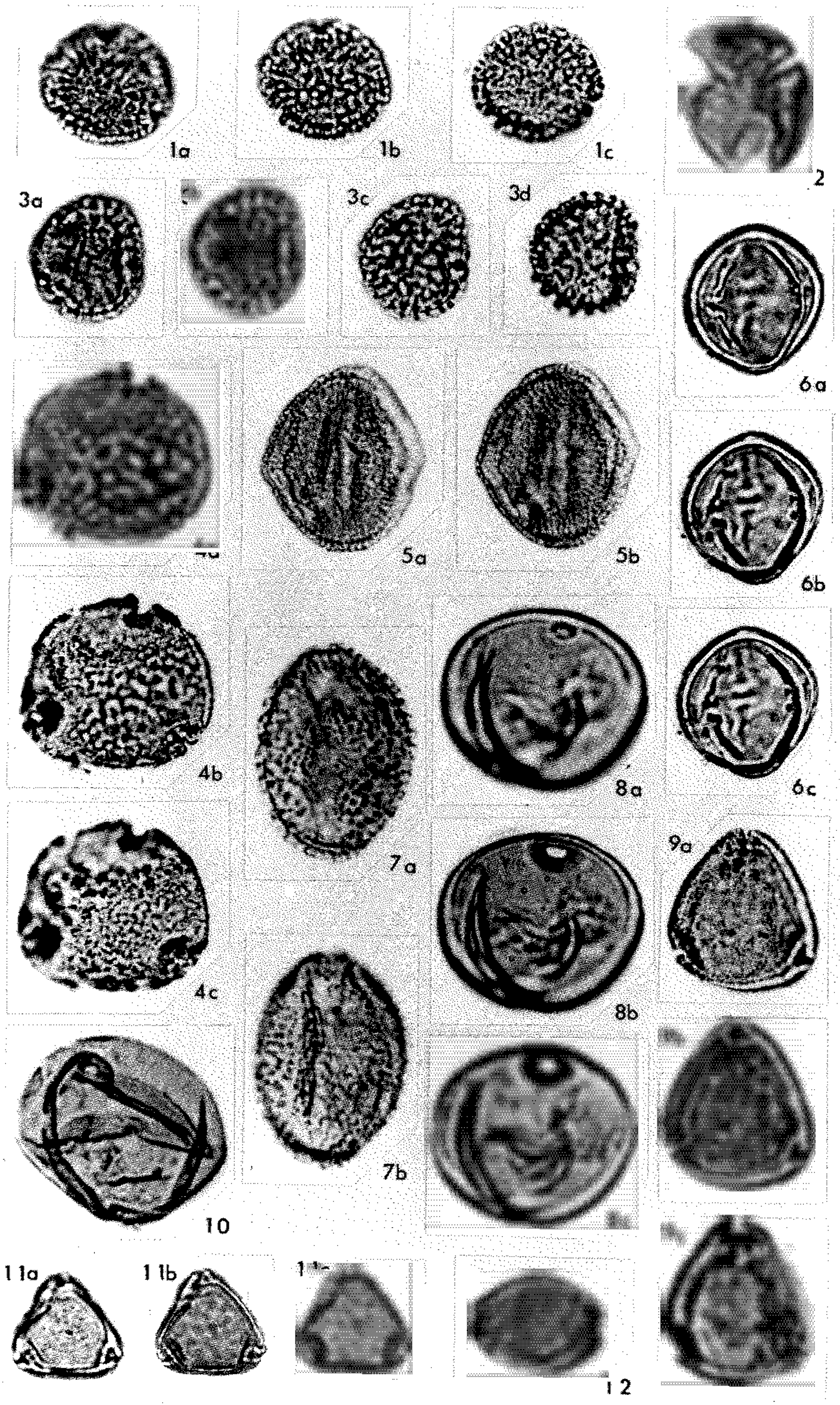


Plate 16 (cont.)

Fig.16. *Nothofagidites falcatus* (Cookson) Stover & Evans, interference contrast; specimen on 028/3 (896-061), 30 µm, maximum diameter. Kiandra.

Fig.17. *Triporopollenites chnosus* Partridge, interference contrast, two planes of focus; specimen on 065/5 (1246-177), 42 µm, equatorial diameter. Kiandra.

Fig.18. *Polycolpites esobalteus* McIntyre; specimen on 065/3 (1014-182), 28 µm, polar diameter. Kiandra.

Fig.19. *Polycolpites esobalteus* McIntyre, two planes of focus; specimen on 147/6 (1239-211), 26 µm, maximum diameter. Nerriga.

Plate 16

All photographs X1000, unless otherwise noted.

Fig.1. *Sparganiaceaepollenites* cf. *S. barungensis* Harris, three planes of focus; specimen on 028/4 (881-033), 35 µm, maximum diameter. Kiandra.

Fig.2. *Banksieaeidites elongatus* Cookson, two planes of focus; specimen on 147/1 (1131-104), 40 µm, length. Nerriga.

Fig.3. *Banksieaeidites arcuatus* Stover, two planes of focus; specimen on 147/6 (1273-059), 29 µm, length. Nerriga.

Fig.4. *Nothofagidites brachyspinulosus* (Cookson) Harris, interference contrast; specimen on 024/1 (931-145), 25 µm, maximum diameter. Kiandra.

Fig.5. *Nothofagidites asperus* (Cookson) Stover & Evans, interference contrast; specimen on 028/6 (1151-217), 38 µm, maximum diameter. Kiandra.

Fig.6. *Nothofagidites brachyspinulosus* (Cookson) Harris, interference contrast; specimen on 153/6 (1286-104), 25 µm, maximum diameter. Nerriga.

Fig.7. *Nothofagidites flemingii* (Couper) Potonié, interference contrast, two planes of focus; specimen on 161/1 (1035-121), 38 µm, maximum diameter. Nerriga. X750.

Fig.8. *Nothofagidites flemingii* (Couper) Potonié, two planes of focus; specimen on 028/1 (1080-209), 24 µm, maximum diameter. Kiandra.

Fig.9. *Nothofagidites goniatus* (Cookson) Stover & Evans; specimen on 101/1 (1091-117), 38 µm, maximum diameter. Cadia.

Fig.10. *Nothofagidites deminutus* (Cookson) Stover & Evans; specimen on 028/6 (1151-196), 24 µm, maximum diameter. Kiandra.

Fig.11. *Nothofagidites emarcidus* (Cookson) Harris; specimen on 028/1 (874-073), 28 µm, maximum diameter. Kiandra.

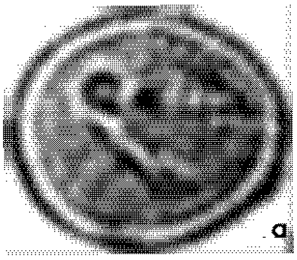
Fig.12. *Nothofagidites heterus* (Cookson) Stover & Evans; specimen on 065/3 (1014-182), 28 µm, maximum diameter. Kiandra.

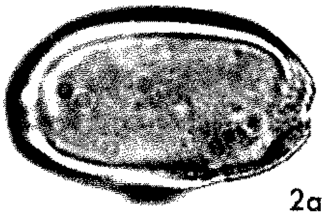
Fig.13. *Polycolpites* sp., four planes of focus; specimen on 028/1 (923-093), 26 µm, maximum diameter. Kiandra.

Fig.14. *Nothofagidites vansteenisii* (Cookson) Stover & Evans, interference contrast; specimen on 147/5 (1061-068), 26 µm, maximum diameter. Nerriga.

Fig.15. *Nothofagidites incrassatus* (Cookson); specimen on 065/3 (938-048), 23 µm, maximum diameter. Kiandra.

Plate 16

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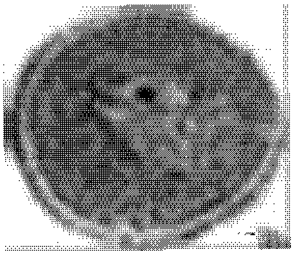

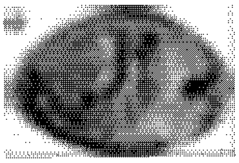
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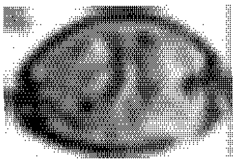

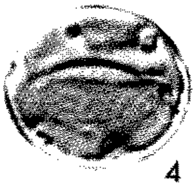
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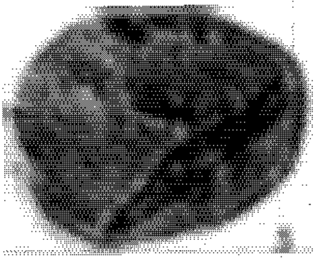

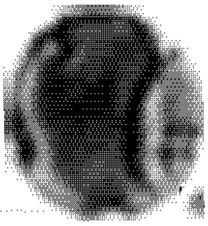

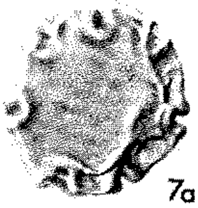
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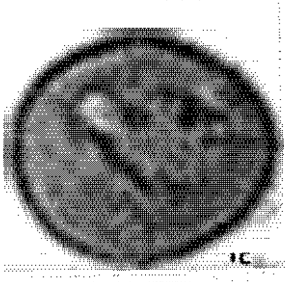

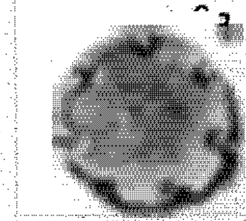

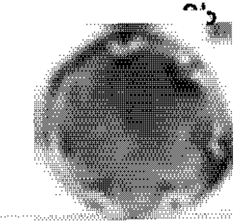

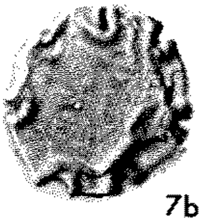
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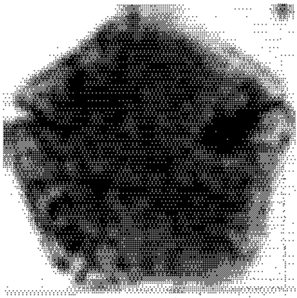

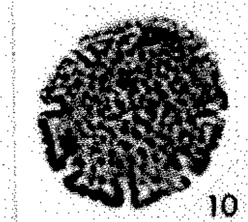
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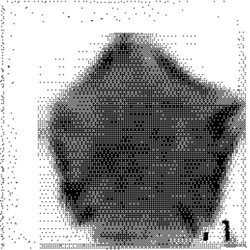

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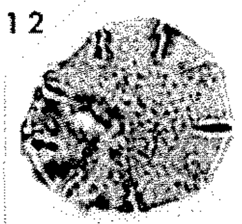

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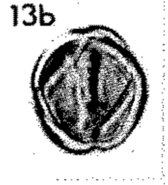

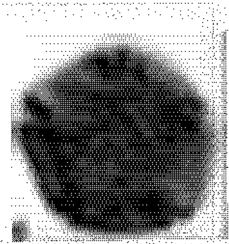

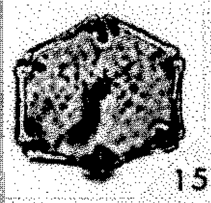
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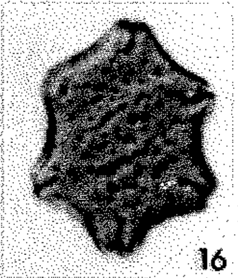
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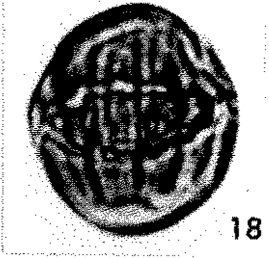
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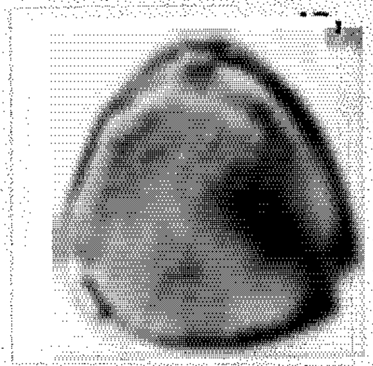

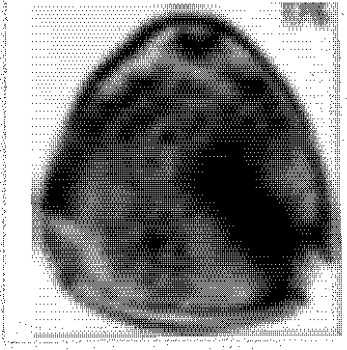

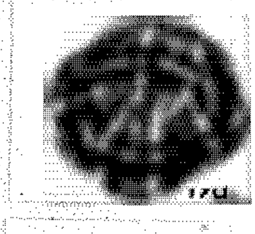

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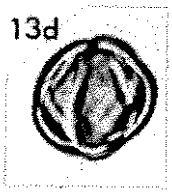

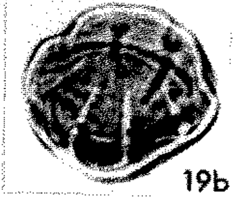
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Plate 17

All photographs X1000, unless otherwise noted.

Fig.1. *Triporopollenites ambiguus* Stover, interference contrast; specimen on 147/6 (1004-125), 40 µm, equatorial diameter. Nerriga.

Fig.2. *Triporopollenites bellus* Partridge, three planes of focus; specimen on 100/2 (983-200), 29 µm, maximum diameter. Cadia. Sculpture is finer than on Figure 3.

Fig.3. *Triporopollenites bellus* Partridge, four planes of focus; specimen on 101/1 (1118-212), 25 µm, maximum diameter. Cadia. Arrows indicate pores.

Fig.4. *Proteacidites crassus* Cookson, four planes of focus; specimen on 147/4 (1055-206), 42 µm, equatorial diameter. Nerriga.

Fig.5. *Santalumidites cainozoicus* Cookson & Pike; specimen with coarser sculpture, on 147/1 (1121-197), 42 µm, polar diameter. Nerriga.

Fig.6. *Santalumidites cainozoicus* Cookson & Pike, three planes of focus; specimen on 150/1 (1017-064), 44 µm, polar diameter. Nerriga.

Fig.7. *Proteacidites annularis* Cookson, two planes of focus; specimen on 028/1 (975-087), 23 µm, equatorial diameter. Kiandra.

Fig.8. *Proteacidites concretus* Harris; specimen on 155/4 (1091-031), 26 µm, equatorial diameter. Nerriga.

Fig.9. *Proteacidites asperopolus* Stover & Evans, equatorial view, three planes of focus, showing polar thickening; specimen on 147/4 (937-129), 44 µm, equatorial diameter. Nerriga.

Fig.10. *Proteacidites asperopolus* Stover & Evans, polar view, interference contrast, two planes of focus; specimen on 147/5 (1173-206), 37 µm, equatorial diameter. Nerriga.

Plate 17

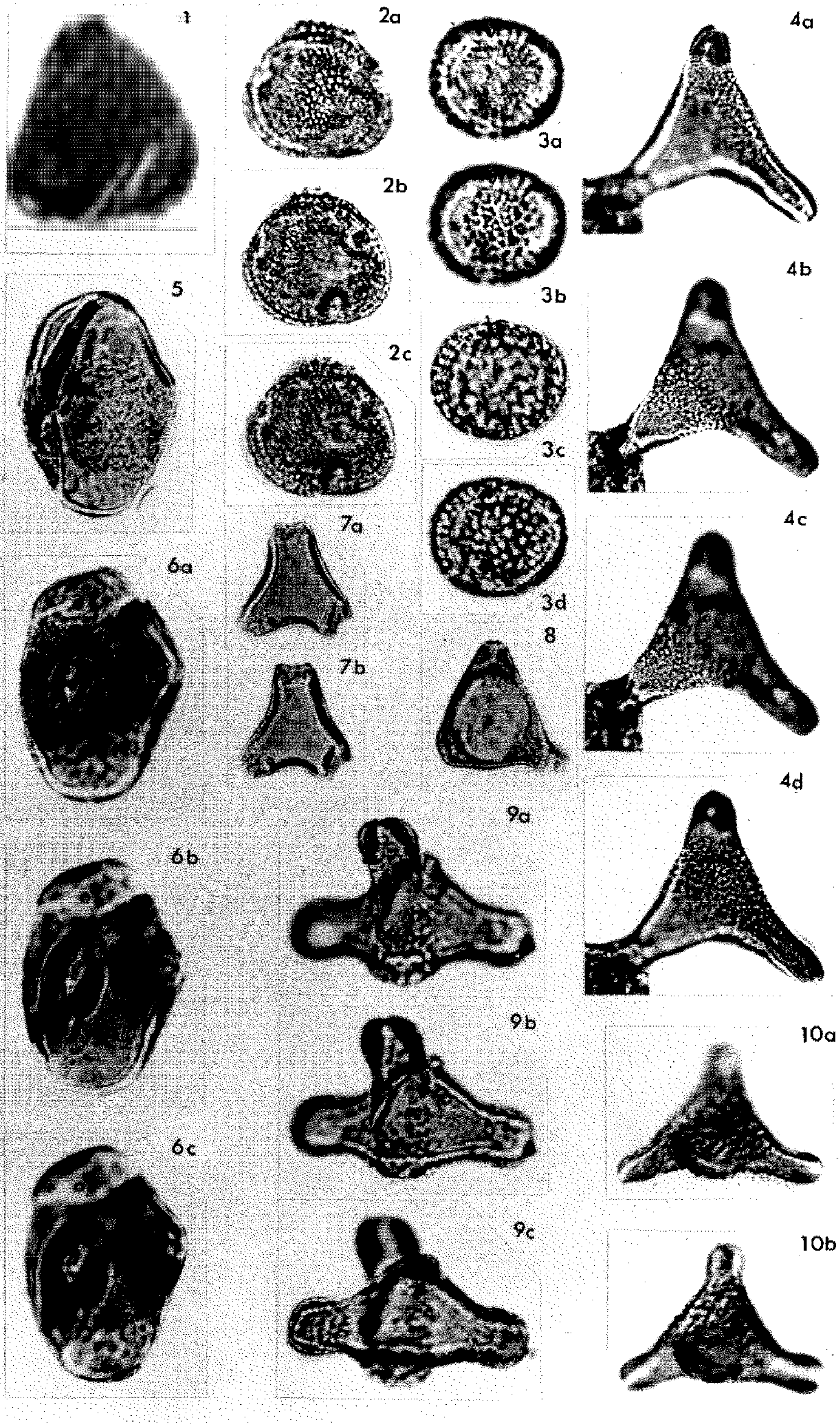


Plate 18

All photographs X1000, unless otherwise noted.

Fig.1. *Proteacidites pachypolus* Cookson & Pike, interference contrast; specimen on 147/5 (1012-052), 38 μm, maximum diameter. Nerriga.

Fig.2. *Proteacidites pachypolus* Cookson & Pike, three planes of focus; same specimen as in previous figure. Nerriga.

Fig.3. *Proteacidites cadiensis* sp. nov., four planes of focus; specimen on 095/1 (1238-210), 35 μm, maximum diameter. Cadia.

Fig.4. *Proteacidites ?callosus* Cookson, three planes of focus; specimen on 147/1 (1250-170), 40 μm, maximum diameter. Nerriga.

Fig.5. *Proteacidites latrobensis* Harris, two planes of focus; specimen on 158/3 (1070-033), 40 μm, maximum diameter. Nerriga.

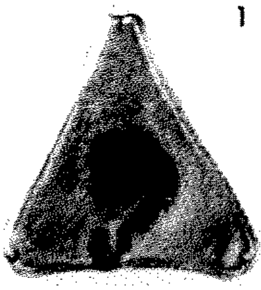
Fig.6. *Proteacidites kopiensis* Harris, two planes of focus; specimen on 147/2 (1044-211) 48 μm, maximum diameter. Nerriga.

Fig.7. *Proteacidites reticuloscabratus* Harris, two planes of focus; specimen on 026/1 (1030-130), 27 μm, maximum diameter. Kiandra.

Fig.8. *Proteacidites* cf. *P. rectomarginis* Cookson, two planes of focus; specimen on 147/5 (1280-085), 46 μm, maximum diameter. Nerriga.

Fig.9. *Proteacidites parvus* Cookson, two planes of focus; specimen on 028/1 (1086-173), 35 μm, maximum diameter. Kiandra.

Plate 18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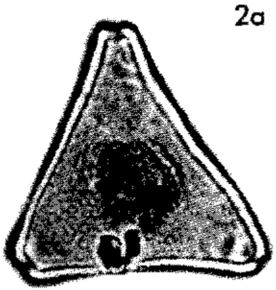
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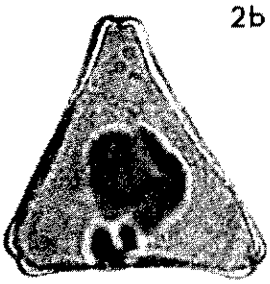
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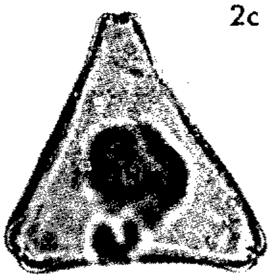
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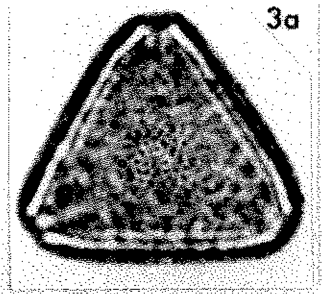
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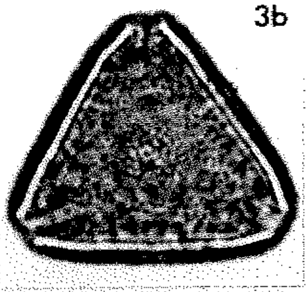
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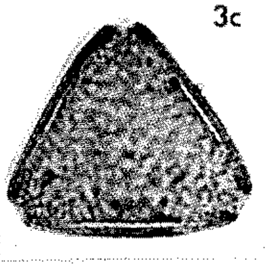
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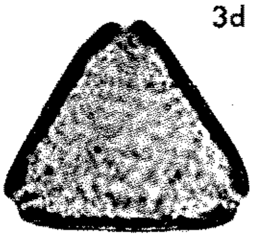
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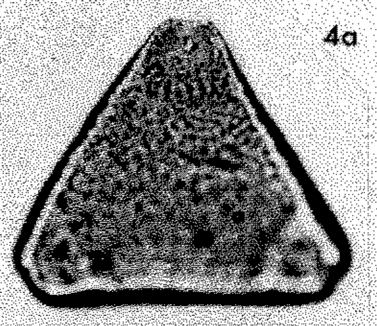
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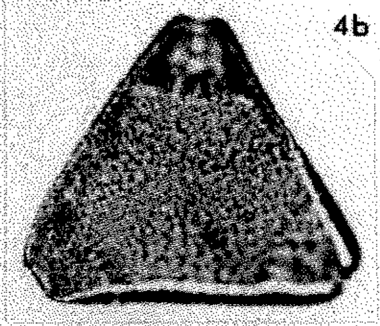
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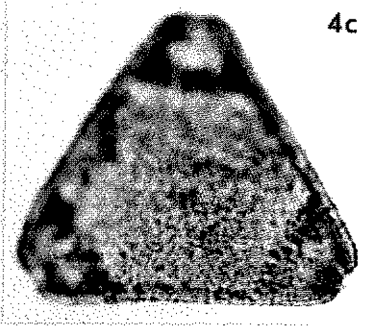
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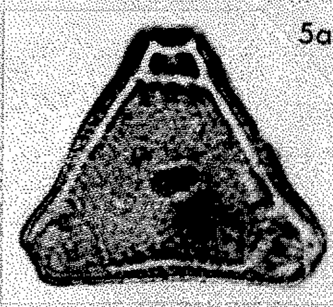
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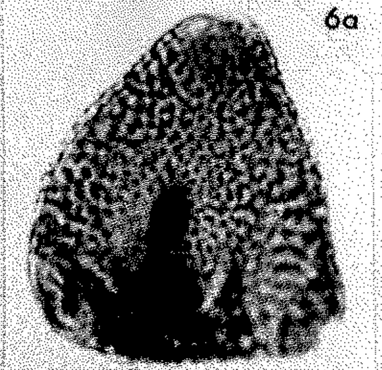
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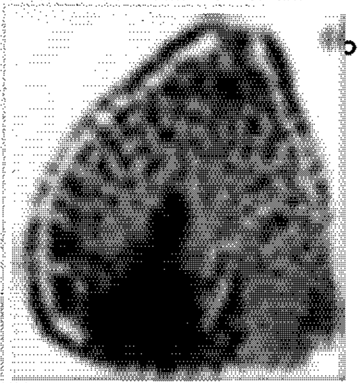
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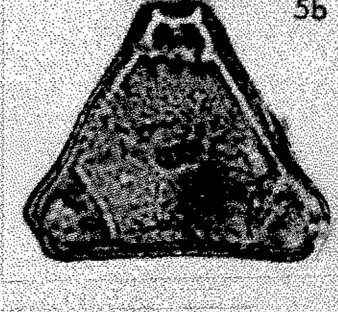
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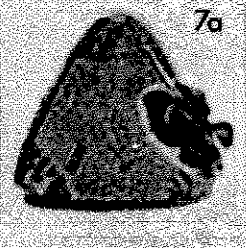
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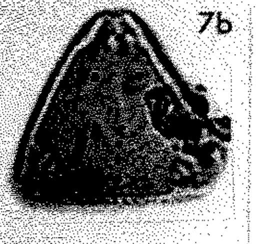
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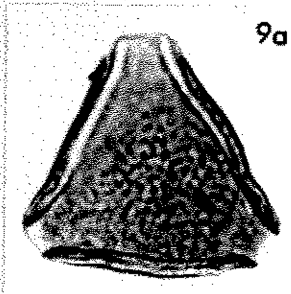
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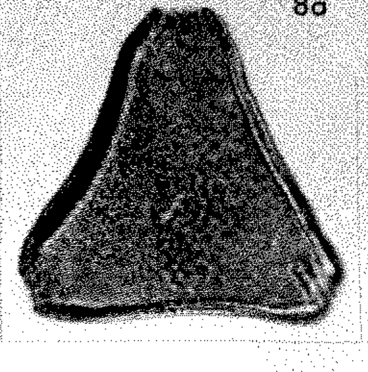
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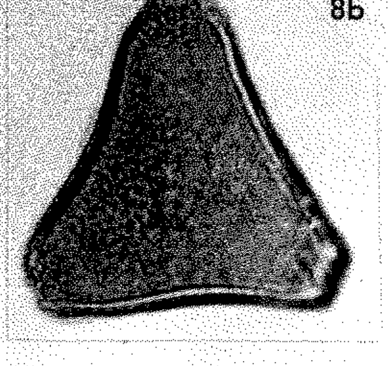
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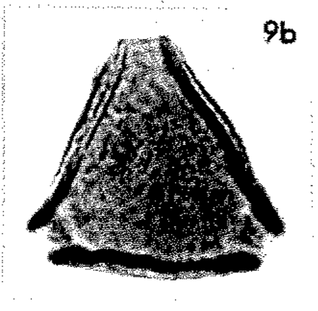

9b

Plate 19

All photographs X1000, unless otherwise noted.

Fig.1. *Proteacidites grandis* Cookson, diporate grain, two planes of focus; specimen on 147/1 (1265-230), 66 µm in length. Nerriga.

Fig.2. *Proteacidites ornatus* Harris, interference contrast; specimen on 155/5 (1180-045), 60 µm, maximum diameter. Nerriga.

Fig.3. *Proteacidites tuberculiformis* Harris, interference contrast, two planes of focus; specimen on 155/1 (1114-118), 112 µm, maximum diameter. Nerriga. X750.

Fig.4. *Proteacidites grandis* Cookson, two planes of focus; specimen on 155/4 (1051-213), 50 µm, maximum diameter. Nerriga.

Fig.5. *Proteacidites pseudomoides* Stover, three planes of focus; specimen on 147/4 (964-069), 26 µm, maximum diameter. Nerriga.

Fig.6. *Proteacidites minimus* Couper; specimen on 147/5 (982-067), 22 µm in diameter. Nerriga.

Fig.7. *Proteacidites subpalisadus* Couper, two planes of focus; specimen on 028/1 (1234-174), 25 µm in diameter. Kiandra.

Fig.8. *Proteacidites* cf. *P. obscurus* Cookson, two planes of focus; specimen on 028/1 (882-157), 18 µm, maximum diameter. Kiandra.

Fig.9. *Proteacidites symphyonemoides* Cookson, two planes of focus; specimen on 118/2 (1234-008), 25 µm, maximum diameter. Cadia.

Fig.10. *Proteacidites subpalisadus* Couper, two planes of focus; specimen on 028/1 (892-185), 17 µm, maximum diameter. Kiandra.

Plate 19

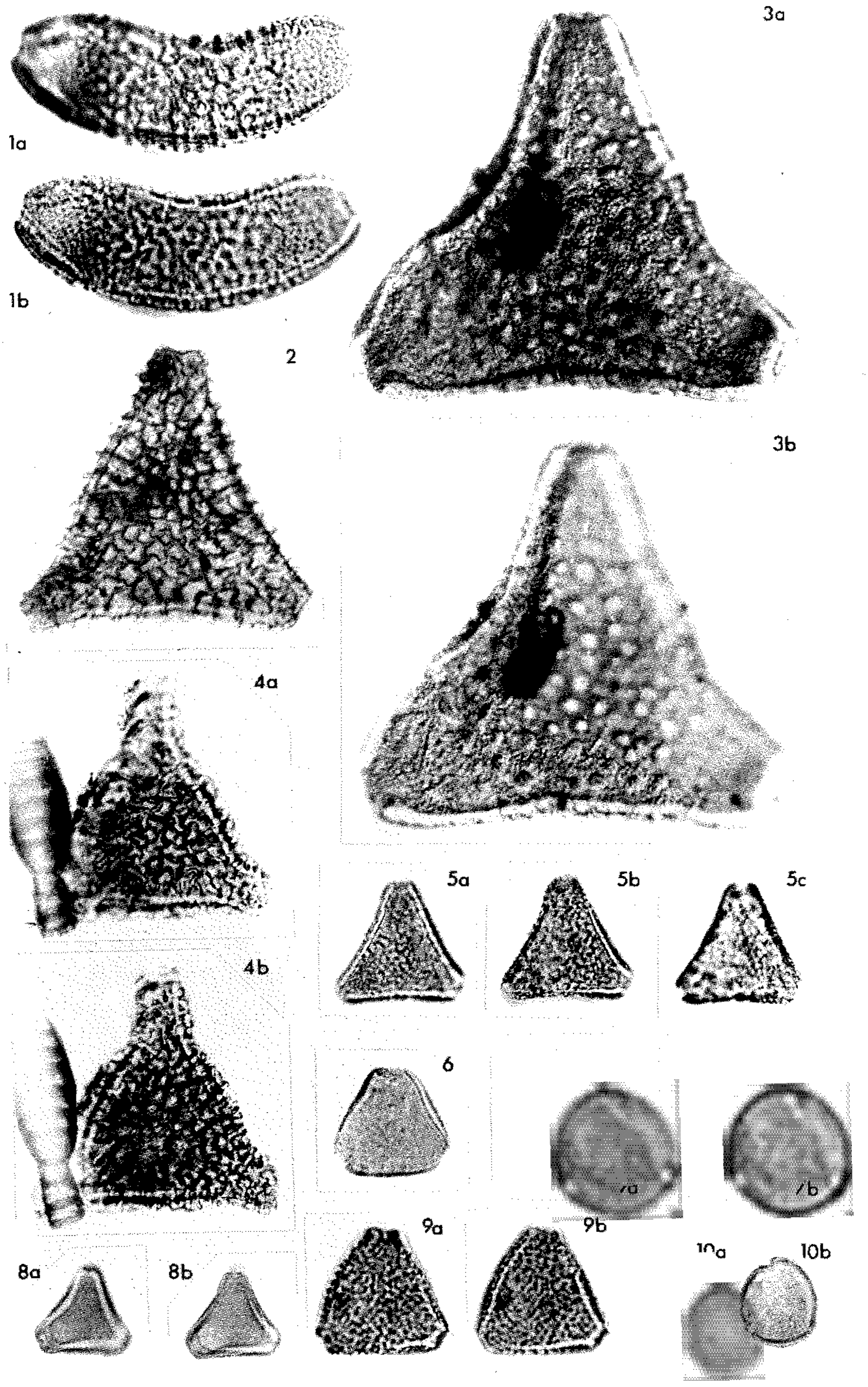


Plate 20

All photographs X1000, unless otherwise noted.

Fig.1. *Proteacidites similis* Harris, three planes of focus; specimen on 095/1 (435-085), 30 µm, maximum diameter. Cadia.

Fig.2. *Proteacidites subscabratus* Couper, three planes of focus; specimen on 101/1 (1124-137), 22 µm, maximum diameter. Cadia.

Fig.3. *Proteacidites tenuiexinus* Stover; specimen on 147/6 (1266-046), 28 µm, maximum diameter. Nerriga.

Fig.4. *Proteacidites tenuiexinus* Stover, interference contrast; same specimen as previous figure. Nerriga.

Fig.5. *Proteacidites tripartitus* Harris, interference contrast; specimen on 161/1 (1146-110), 30 µm, maximum diameter. Nerriga.

Fig.6. *Proteacidites tripartitus* Harris, two planes of focus; same specimen as previous figure. Nerriga.

Fig.7. *Haloragacidites harrisii* (Couper) Harris; specimen on 028/2 (890-239), 34 µm, maximum diameter. Kiandra.

Fig.8. "*Triorites*" sp., four planes of focus; specimen on 028/4 (941-177), 38 µm, maximum diameter. Kiandra.

Fig.9. "*Triorites*" *introlimbatus* McIntyre, two planes of focus; specimen on 065/2 (1054-274), 23 µm, maximum diameter. Kiandra.

Fig.10. *Haloragacidites haloragoides* Cookson & Pike, two planes of focus; specimen on 095/1 (1040-107), 24 µm, maximum diameter. Cadia.

Fig.11. "*Triorites*" *minisculus* McIntyre; specimen on 101/1 (1230-147), 17 µm, maximum diameter. Cadia.

Fig.12. *Anacolosidites acutullus* Cookson & Pike, two planes of focus; specimen on 155/1 (978-048), 42 µm, maximum diameter. Nerriga.

Fig.13. *Anacolosidites luteoides* Cookson & Pike; specimen on 147/1 (1111-150), 22 µm, maximum diameter. Nerriga.

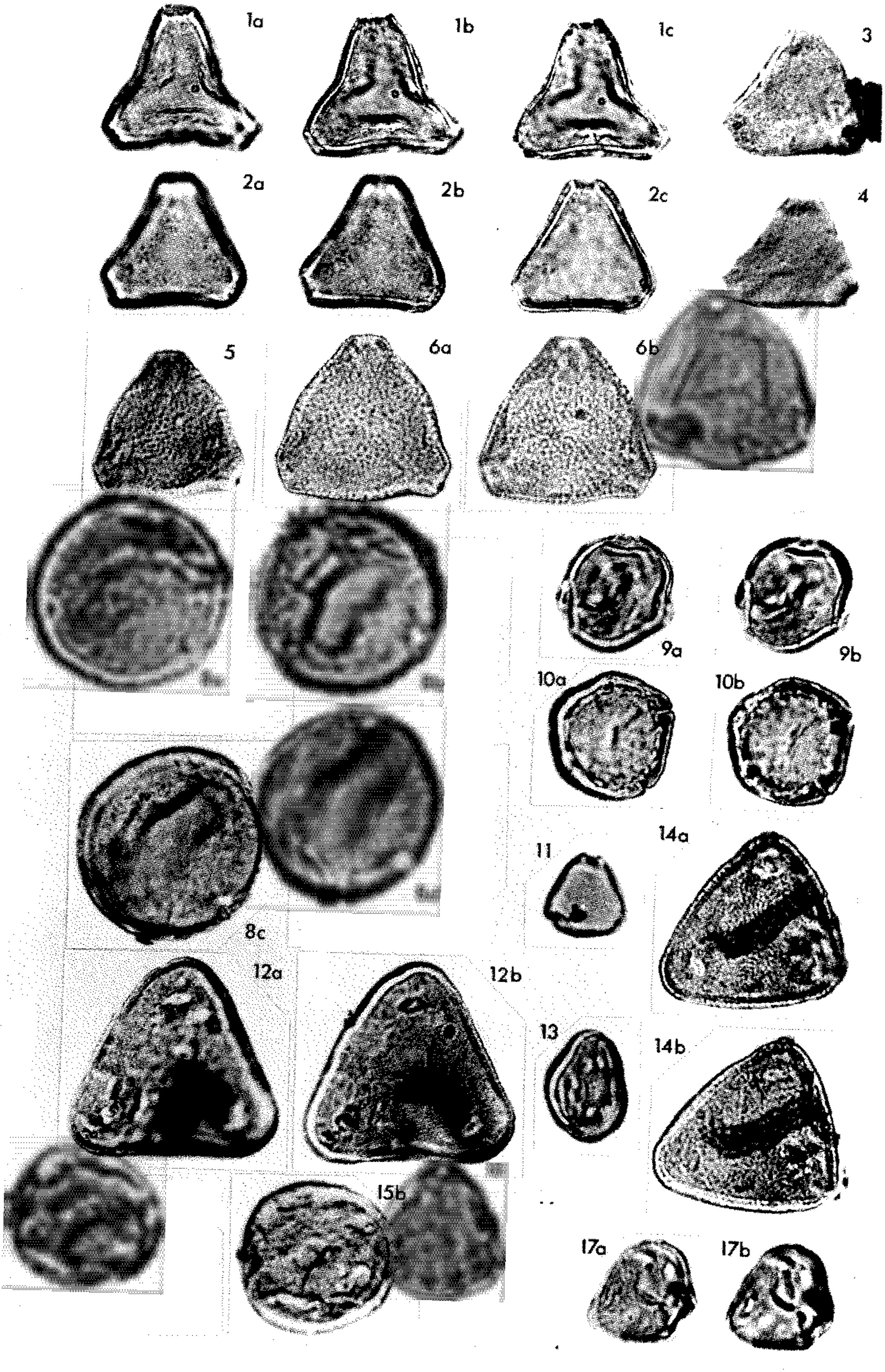
Fig.14. *Anacolosidites acutullus* Cookson & Pike, two planes of focus; specimen on 158/1 (1110-077), 37 µm, maximum diameter. Nerriga.

Fig.15. *Periporopollenites vesicus* Partridge, interference contrast, two planes of focus; specimen on 028/1 (986-067), 32 µm, maximum diameter. Kiandra.

Fig.16. *Haloragacidites trioratus* Couper; specimen on 028/2 (885-204), 26 µm, maximum diameter. Kiandra.

Fig.17. *Anacolosidites luteoides* Cookson & Pike, two planes of focus; specimen on 158/1 (1204-075), 22 µm, maximum diameter. Nerriga.

Plate 20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15b
17a
17b

Plate 21

All photographs X1000, unless otherwise noted.

Fig.1. *Periporopollenites vesicus* Partridge, four planes of focus; specimen on 028/1 (956-067), 32 µm, maximum diameter. Kiandra.

Fig.2. *Periporopollenites demarcatus* Stover; specimen on 147/6 (1090-023), 30 µm, maximum diameter. Nerriga.

Fig.3. *Periporopollenites demarcatus* Stover, two planes of focus; specimen on 147/6 (1177-210), 26 µm, maximum diameter. Nerriga. Note symmetrical arrangement of pores.

Fig.4. *Periporopollenites* sp. 1, three planes of focus; specimen on 028/1 (1031-195), 28 µm, maximum diameter. Kiandra.

Fig.5. *Malvacipollis diversus* Harris, three planes of focus; specimen on 101/4 (1260-159), 26 µm, maximum diameter. Cadia.

Fig.6. *Periporopollenites* sp. 2, three planes of focus; specimen on 028/1 (922-089), 40 µm, maximum diameter. Kiandra.

Fig.7. *Polyporina* cf. *P. chenopodiaceoides* Martin, three planes of focus; specimen on 101/2 (1095-140), 24 µm, maximum diameter. Cadia.

Fig.8. *Polyorificites* sp.; specimen on 101/4 (1263-101), 24 µm, maximum diameter. Cadia.

Fig.9. *Echiperiporites* sp., interference contrast, two planes of focus; specimen on 028/1 (1167-121), 26 µm, maximum diameter. Kiandra.

Fig.10. *Malvacipollis subtilis* Stover, interference contrast; specimen on 028/5 (1221-196), 48 µm, maximum diameter. Kiandra.

Fig.11. *Echiperiporites* sp., three planes of focus; specimen on 028/4 (1022-031), 36 µm, maximum diameter. Kiandra.

Plate 21

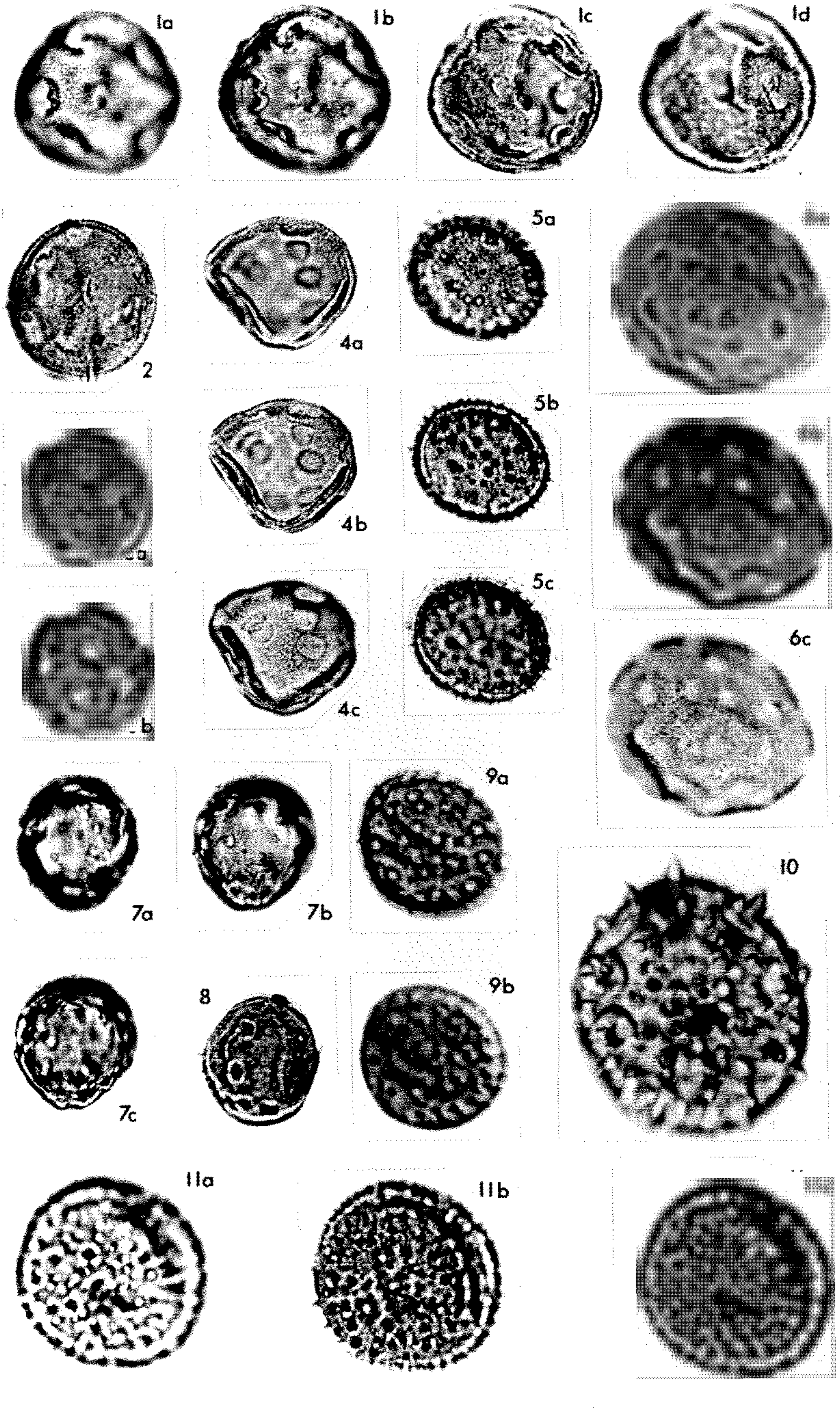


Plate 22

All photographs X1000, unless otherwise noted.

Fig.1. *Polyporina* cf. *P. chenopodiaceoides* Martin, interference contrast, two planes of focus; specimen on 101/1 (1218-165), 16 µm, maximum diameter. Cadia.

Fig.2. *Polyadopollenites myriosporites* (Cookson) Partridge; specimen on 121/1 (1210-078), 39 µm, maximum diameter of tetrad.

Fig.3. *Ericipites scabratus* Harris, interference contrast, two planes of focus; specimen on 028/5 (1060-049), 38 x 35 µm, diameter of tetrad. Kiandra.

Fig.4. ?*Schizosporis rugulatus* Cookson & Dettmann; specimen on 147/1 (1020-019), 88 µm, maximum diameter. Nerriga. X750.

Fig.5. *Gephyrapollenites calathus* Partridge, three planes of focus; specimen on 065/3 (890-121), 30 µm, maximum diameter of tetrad. Kiandra.

Fig.6. *Circulisporites* sp.; specimen on 147/2 (1244-137), 52 µm, maximum diameter. Nerriga.

Fig.7. *Circulisporites* sp., interference contrast of same specimen as Fig.6.

Fig.8. *Schizosporis parvus* Cookson & Dettmann, interference contrast; specimen on 028/1 (1182-040), 60 µm, maximum diameter. Kiandra.

Fig.9. *Polyorificites* sp., two planes of focus; specimen on 101/3 (952-177), 30 µm, maximum diameter. Cadia.

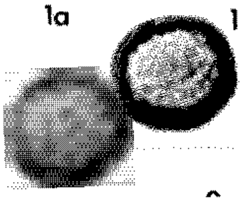
Fig.10. *Circulisporites* sp.; specimen on 095/1 (1048-174), 48 µm, maximum diameter. Cadia.

Fig.11. *Ericipites crassiexinus* Harris, two planes of focus; specimen on 101/2 (1023-078), 24 µm, maximum diameter of tetrad. Cadia.

Fig.12. *Simplicepollis meridianus* Harris, two planes of focus; specimen on 147/6 (1054-096), 36 µm, maximum diameter of tetrad. Nerriga.

Fig.13. *Simplicepollis meridianus* Harris; specimen on 147/6 (1204-090), 30 µm, maximum diameter of tetrad. Nerriga.

Plate 22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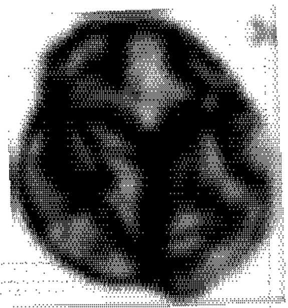

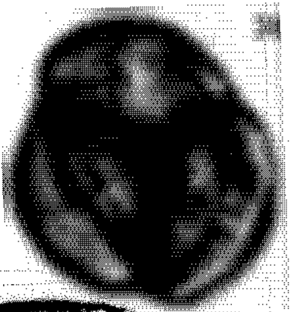


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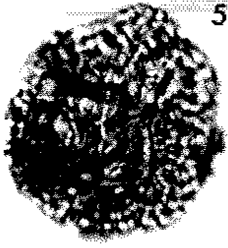


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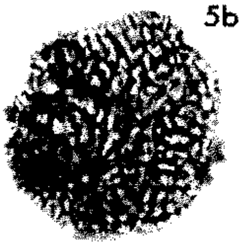

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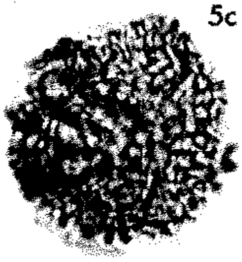

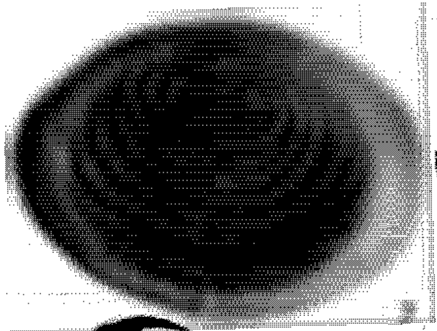

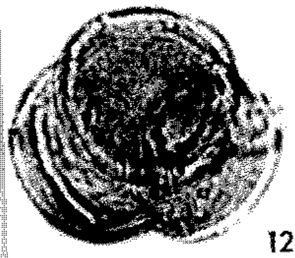
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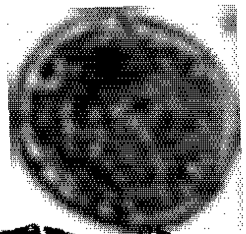


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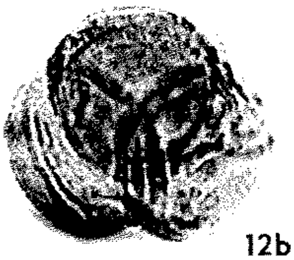
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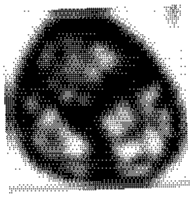

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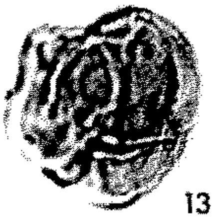
13

Plate 23

Photographs of fungal spores and fructifications are not to a standard magnification; dimensions of specimens are given in each caption.

Fig.1. *Inapertisporites* sp.; large sphere with numerous perforations, possibly a result of biological degradation; specimen on 028/4 (1230-195), 42 µm in diameter. Kiandra.

Fig.2. *Inapertisporites* sp.; irregularly shaped spore; specimen on 147/3 (1131-168), 22 µm, maximum diameter. Nerriga.

Fig.3. *Monoporisporites* sp.; specimen on 147/3 (1191-162), 9 µm, maximum diameter. Nerriga.

Fig.4. *Inapertisporites* sp.; spherical spore, showing radial tears perhaps due to congression; specimen on 147/3 (991-171), 40 µm in diameter. Nerriga.

Fig.5. *Inapertisporites* sp.; fusiform-shaped spore, with scabrate-punctate sculpture; specimen on 147/3 (1194-204), 30 µm, length. Nerriga.

Fig.6. Diporisporites sp.; specimen on 028/5 (1252-164), 20 µm, length. Kiandra.

Fig.7. *Lacrimasporonites* sp.; specimen on 028/5 (1041-128), 50 µm, maximum diameter. Kiandra.

Fig.8. *Inapertisporites* sp.; large, spherical spore, 60 µm in diameter; specimen on 147/3 (961-049). Nerriga.

Fig.9. *Ornatisporonites spectabilis* gen. et sp. nov.; holotype; specimen on 028/4 (1011-032), 48 µm in diameter. Kiandra.

Fig.10. *Inapertisporites* sp., elongate fusiform spore; specimen on 147/3 (1210-182), 44 µm, length. Nerriga.

Fig.11. cf. *Hypoxylon* sp.; specimen on 147/3 (1045-035), 30 µm, length. Nerriga.

Fig.12. *Fusiformisporites* sp.; specimen on 147/1 (1230-205), 52 µm, length. Nerriga.

Fig.13. *Ornatisporonites spiculus* gen. et sp. nov.; holotype; specimen on 028/5 (936-207), 22 µm in diameter. Kiandra.

Fig.14. *Striatisporonites clinatus* gen. et sp. nov.; holotype; specimen on 147/5 (1103-169), 29 µm in diameter. Nerriga.

Fig.15. *Striatisporonites minutus* gen. et sp. nov.; holotype; specimen on 147/3 (1212-187), 12 µm in diameter. Nerriga.

Fig.16. *Dicellaesporites* sp.; specimen on 065/5 (1094-029), 38 µm, length. Kiandra.

Fig.17. *Fusiformisporites* sp.; specimen on 147/3 (970-107), 44 µm, length. Nerriga.

Fig.18. *Dyadosporonites* sp.; specimen on 101/2 (875-135), 35 µm, length. Cadia.

Plate 23

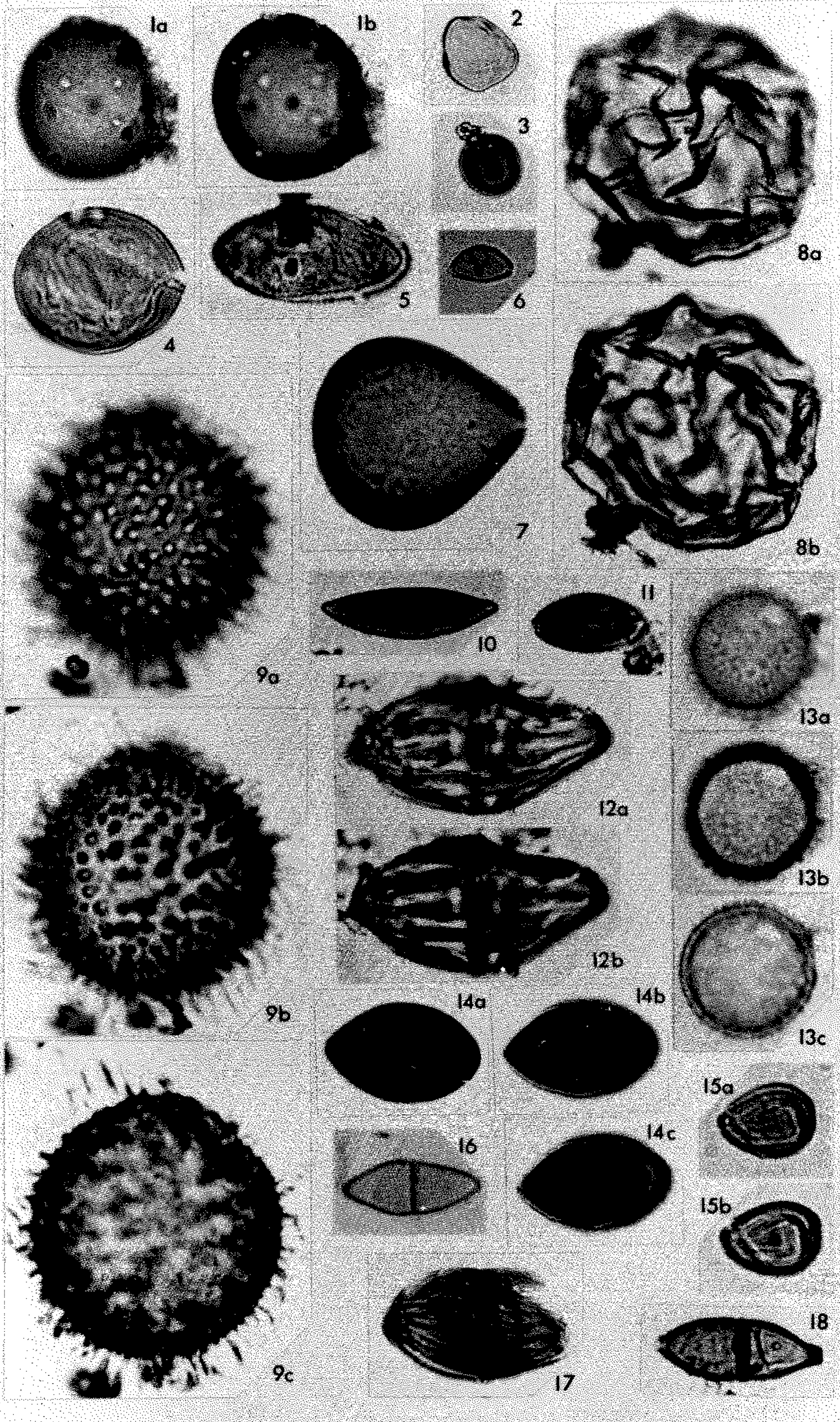
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Plate 24

Photographs of fungal spores and fructifications are not to a standard magnification; dimensions of specimens are given in each caption.

Fig.1. *Diporicellaesporites endogranulosus* Kemp; specimen on 147/3 (1175-032), 70 µm, length. Nerriga.

Fig.2. *Involutisporonites* sp.; specimen on 028 D (1188-658), 40 µm, maximum diameter. Kiandra.

Fig.3. *Diporicellaesporites endogranulosus* Kemp; specimen on 101/1 (1030-078), 65 µm, length. Cadia.

Fig.4. *Dicellaesporites* sp.; specimen on 065/6 (1251-040), 44 µm, length. Kiandra.

Fig.5. *Multicellaesporites* sp.; tetracellate spore; specimen on 065/6 (1257-137), 36 µm long. Kiandra.

Fig.6. *Diporicellaesporites* sp. nov.; specimen on 147/3 (1217-040), 44 µm in length. Nerriga.

Fig.7. *Diporicellaesporites* sp. nov.; specimen on 147/3 (1136-057), 52 µm, length. Nerriga.

Fig.8. *Diporicellaesporites* sp.; specimen on 147/6 (1233-210), 44 µm long. Nerriga.

Fig.9. *Pluricellaesporites* sp.; specimen on 065/5 (1188-143), 90 µm long. Kiandra.

Fig.10. *Multicellaesporites* sp., linear curved spore; specimen on 147/3 (931-033), 70 µm, length. Nerriga.

Fig.11. *Pluricellaesporites* sp.; specimen on 147/3 (1021-084), 50 µm in length. Nerriga.

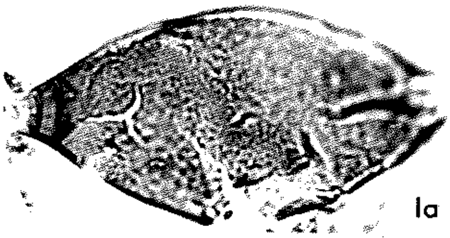
Fig.12. *Brachysporisporites* sp.; specimen on 065/1 (1206-103), 70 µm, maximum diameter. Kiandra.

Fig.13. *Fractisporonites* sp.; specimen on 028 D (1005-646), 60 µm long. Kiandra.

Fig.14. *Pluricellaesporites* sp.; specimen on 028 C (1175-198), 45 µm long. Kiandra.

Fig.15. *Fractisporonites* sp.; specimen on 028 C (1175-698), 110 µm long. Kiandra.

Plate 24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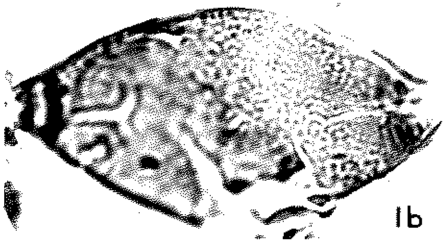
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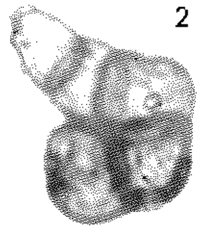
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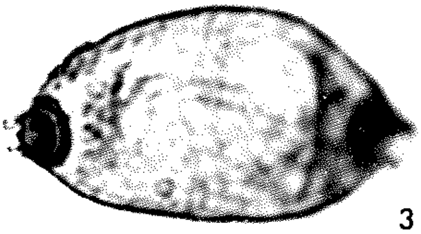
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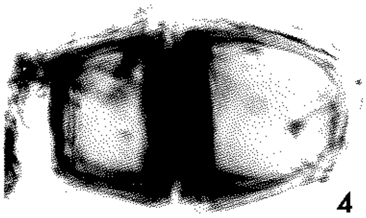
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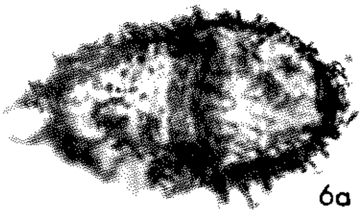
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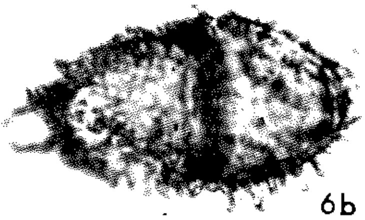
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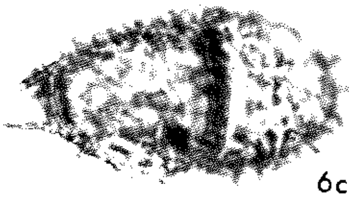
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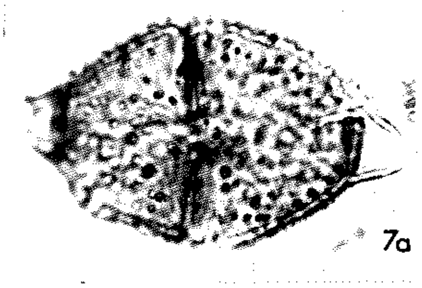
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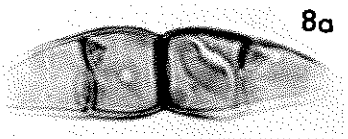
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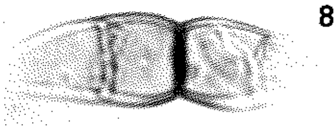
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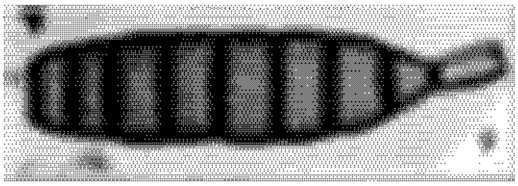


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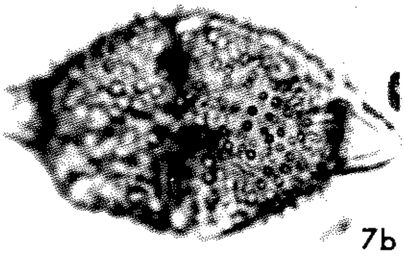
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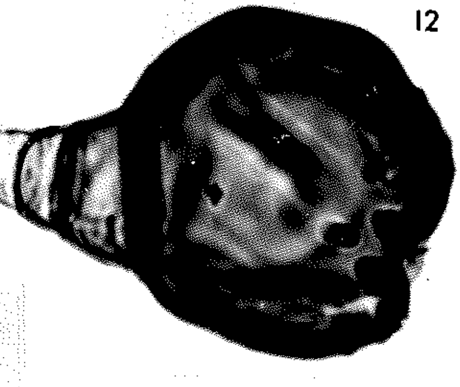
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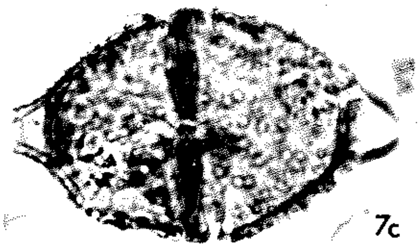
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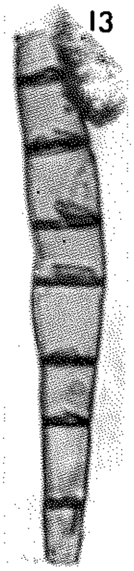
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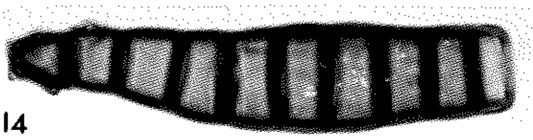
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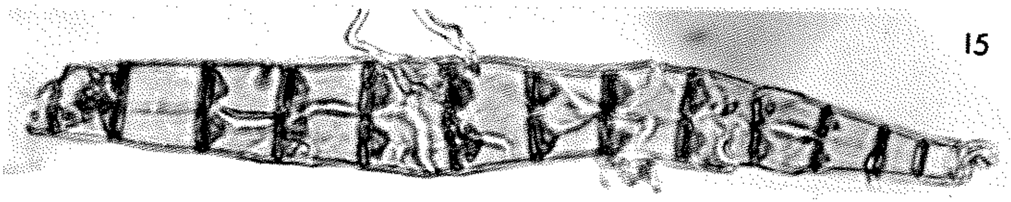
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Plate 25

Photographs of fungal spores and fructifications are not to a standard magnification; dimensions of specimens are given in each caption.

Fig.1. *Brachysporisporites* sp.; specimen on 065/5 (1257-137), 54 µm, length. Kiandra.

Fig.2. *Involutisporonites* sp.; spore ornamented with punctae and coiled in a single plane; specimen on 095/1 (972-035), 44 µm in diameter. Cadia.

Fig.3. *Staphlosporonites* sp.; specimen on 101/1 (1235-187), 55 µm, maximum diameter. Cadia.

Fig.4. *Involutisporonites* sp.; specimen on 028 C (1163-805) 36 µm, maximum diameter. Kiandra.

Fig.5. *Staphlosporonites* sp.; specimen on 147/3 (1236-152), 55 µm, maximum diameter. Nerriga.

Fig.6. ?Fungal; specimen on 028/4 (1143-126), 80 x 90 µm. Kiandra.

Fig.7. ?Fungal; specimen on 028/4 (1230-195), 42 µm. Kiandra.

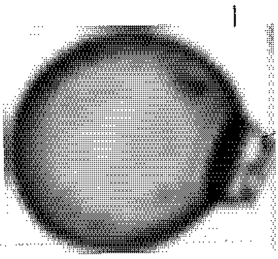
Fig.8. *Callimothallus pertusus* Dilcher; specimen on 028/G (1214-128), 100 µm in diameter. Kiandra.

Fig.9. Fungal "cluster"; specimen on 095/1 (1090-207), 24 µm in diameter. Cadia.

Fig.10. *Staphlosporonites* sp.; specimen on 147/3 (1236-152), 44 µm, maximum diameter. Nerriga.

Fig.11. Germling of microthyriaceous fungi; specimen on 147/6 (1233-208), 17 µm, maximum diameter. Nerriga.

Plate 25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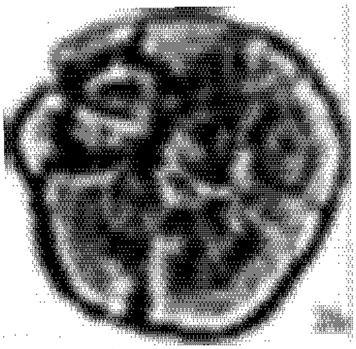

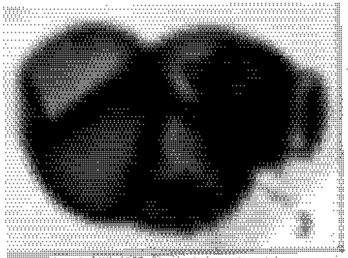

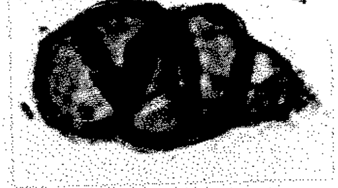
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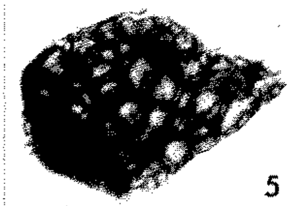
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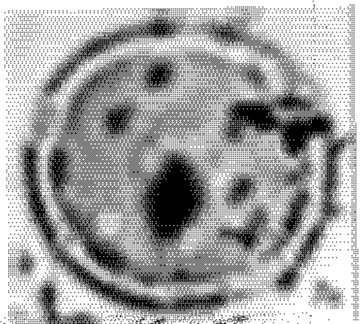

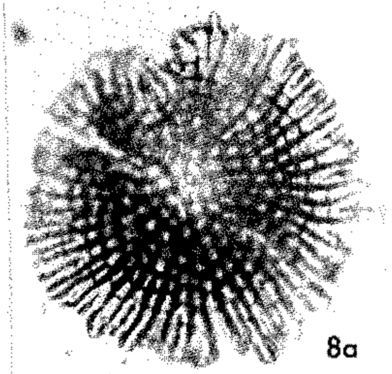
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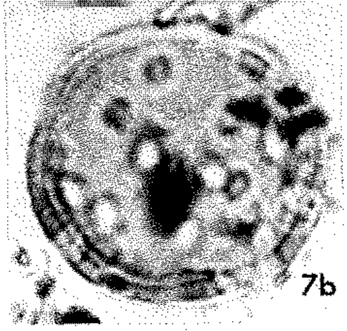
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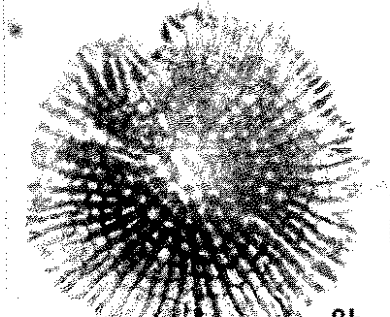
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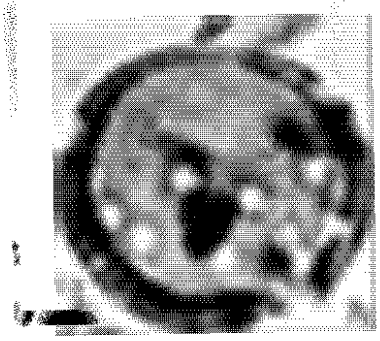


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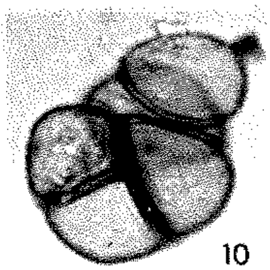
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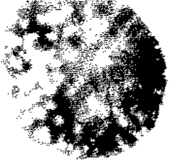
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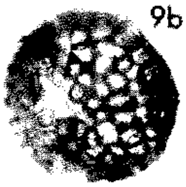
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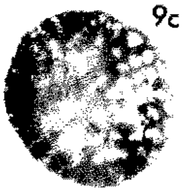

9c


11

Plate 26

Photographs of fungal fructifications are not to a standard magnification; dimensions of specimens are given in each caption.

Fig.1. *Callimothallus pertusus* Dilcher; specimen on 147/1 (1115-064), 90 µm in diameter. Nerriga.

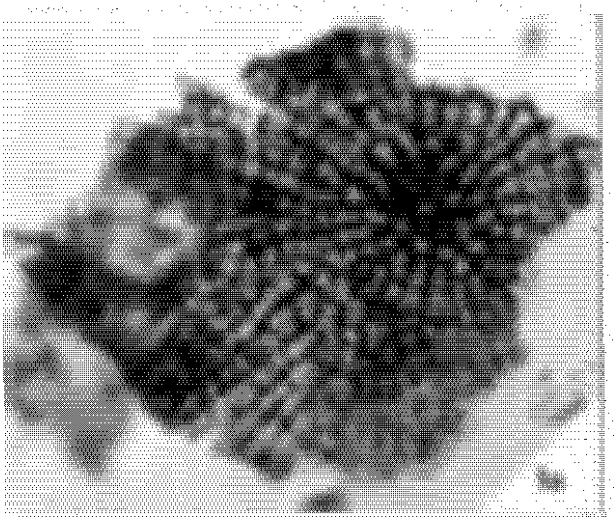
Fig.2. *Callimothallus pertusus* Dilcher; specimen on 065/6 (1116-033), 130 µm in diameter. Kiandra.

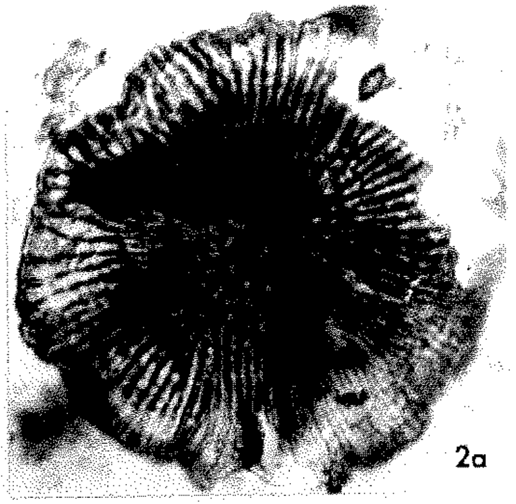
Fig.3. *Callimothallus assamicus* Kar, Singh, & Sah; specimen on 147/3 (1213-189), 66 µm in diameter. Nerriga.

Fig.4. *Callimothallus assamicus* Kar, Singh, & Sah; specimen on 147/1 (1237-138), 60 µm in diameter. Nerriga.

Fig.5. *Callimothallus assamicus* Kar, Singh, & Sah; specimen on 147/3 (1220-030), 40 µm in diameter. Nerriga.

Plate 26





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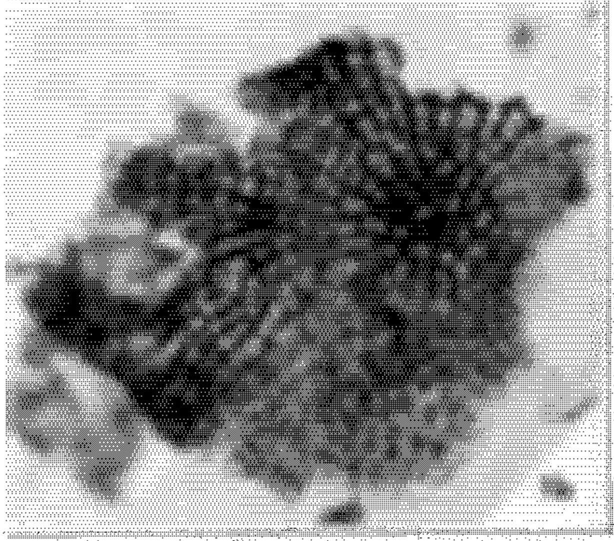

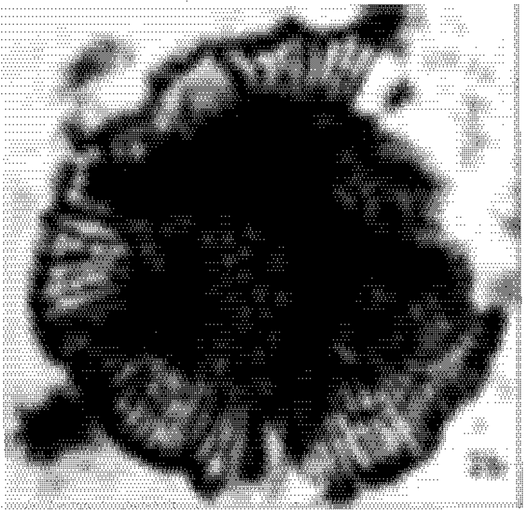

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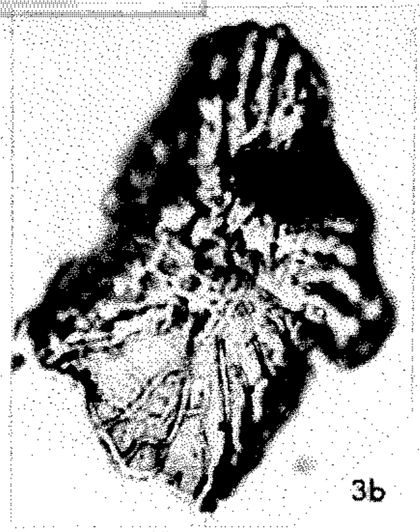

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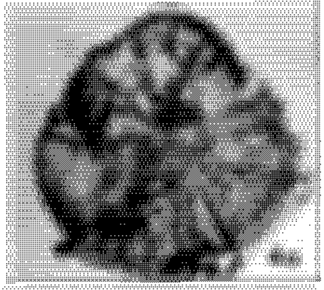
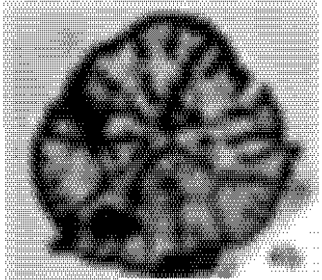




5a

5b

Plate 27

Photographs of fungal fructifications are not to a standard magnification; dimensions of specimens are given in each caption.

Fig.1. *Callimothallus pertusus* Dilcher; specimen on 101/1 (970-045), 52 µm in diameter. Cadia.

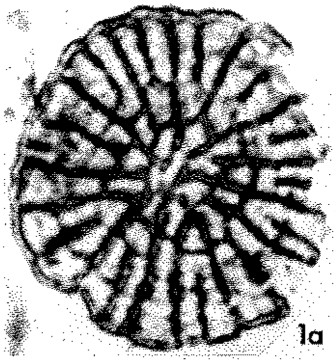
Fig.2. *Callimothallus* cf. *C. assamicus* Kar, Singh, & Sah; specimen on 147/1 (1193-194), 80 µm in diameter. Nerriga.

Fig.3. ?*Phragmothyrites ostiolatus* (Cookson); specimen on 065/6 (1116-033), 130 µm in diameter. Kiandra.

Fig.4. *Plochmopeltinites masonii* Cookson emend. Selkirk; specimen on 065/1 (1072-198), 92 µm in diameter. Kiandra.

Fig.5. ?*Phragmothyrites ostiolatus* (Cookson); specimen on 065/1 (1243-115), 80 µm in diameter. Kiandra.

Plate 27



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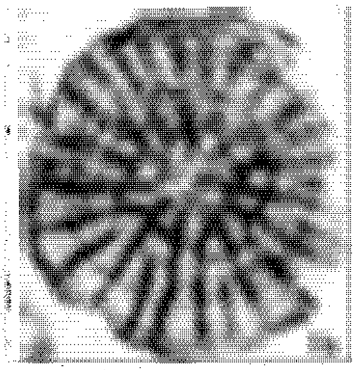

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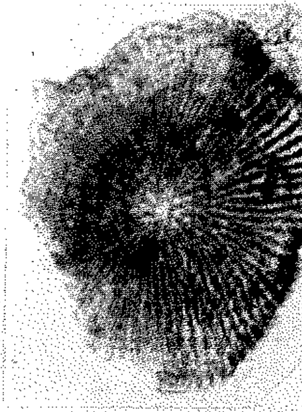

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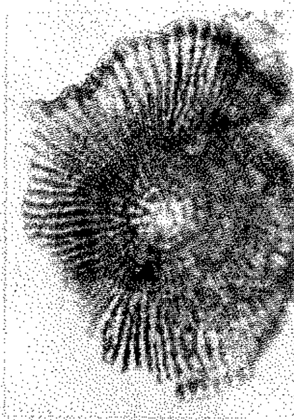

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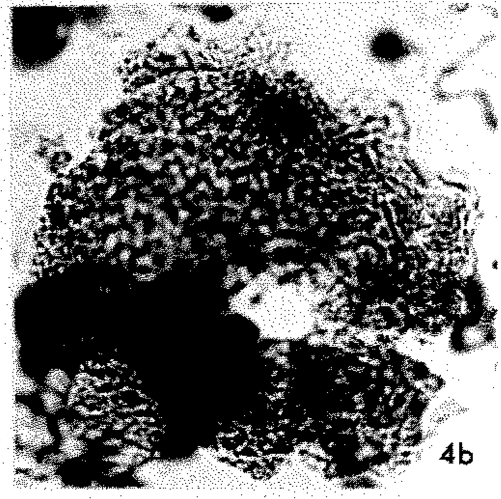

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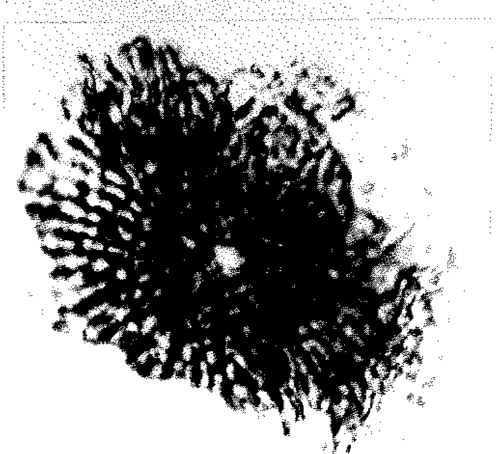

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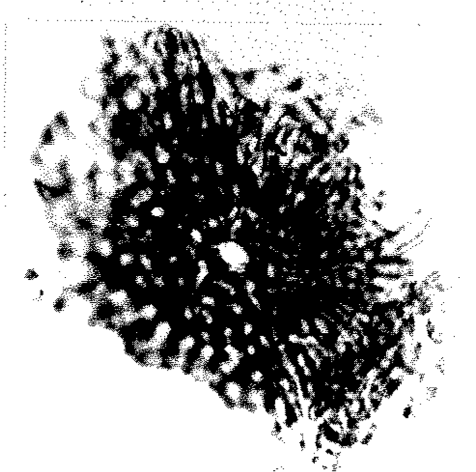


5b

Plate 28

Photographs of fungal fructifications are not to a standard magnification; dimensions of specimens are given in each caption. Photographs of algae are X1000, unless otherwise noted.

Fig.1. *Plochmopeltinites masonii* Cookson emend. Selkirk; specimen on 028/5 (1247-123), 130 μm in diameter. Kiandra.

Fig.2. Cf. *Pediastrum*; specimen on 028/5 (961-110), 60 μm in diameter. Kiandra.

Fig.3. Cf. *Pediastrum*; specimen on 147/3 (1160-042), 88 μm in diameter. Nerriga. X750.

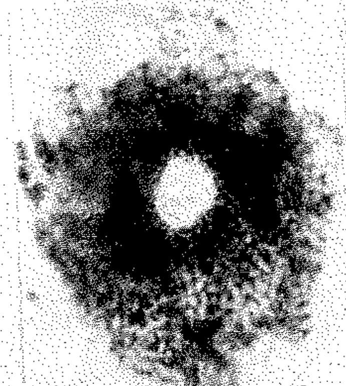
Fig.4. Cf. *Botryococcus braunii* Kützing; specimen on 101/1 (950-127), 100 μm in diameter. Cadia. X750.

Fig.5. Acritarch; specimen on 028/5 (916-109), 50 μm in diameter. Kiandra.

Fig.6. Acritarch; specimen on 028/5 (908-128), 36 μm in diameter. Kiandra.

Fig.7. Cf. *Botryococcus braunii* Kützing; specimen on 028/5 (1261-130), 44 μm in diameter. Kiandra.

Plate 28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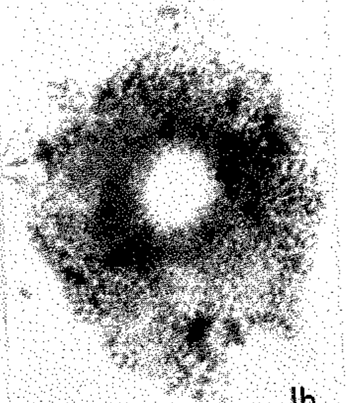
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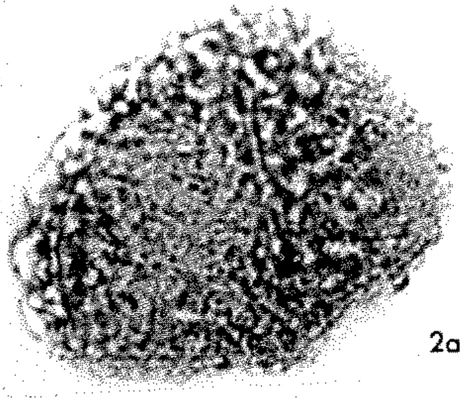
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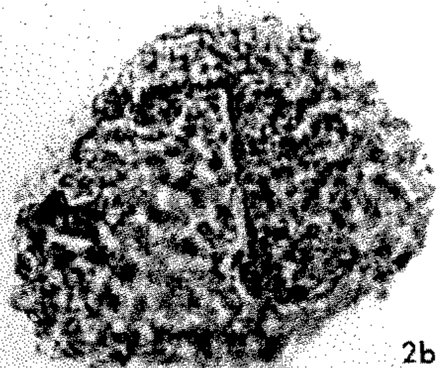
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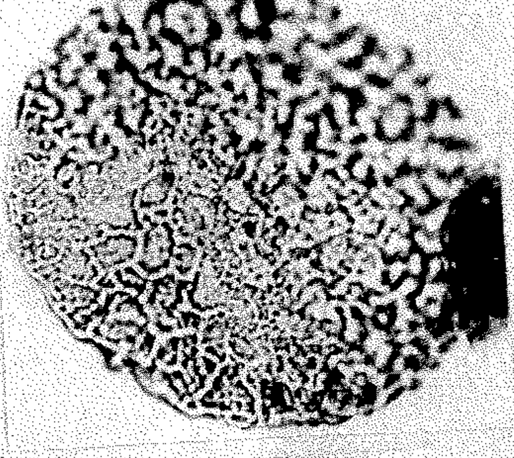

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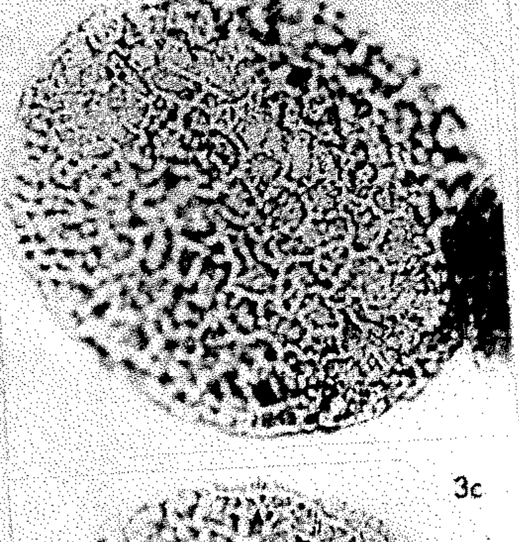

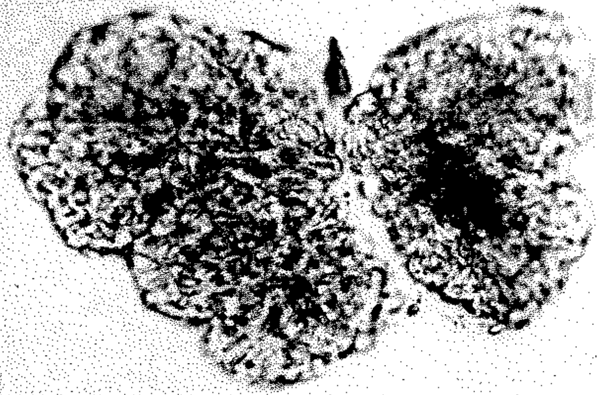
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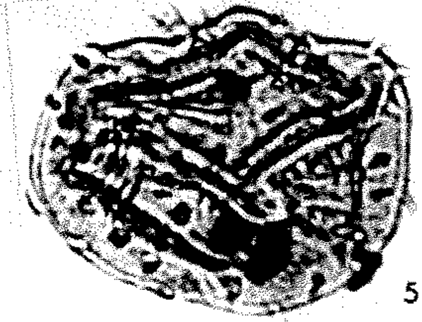
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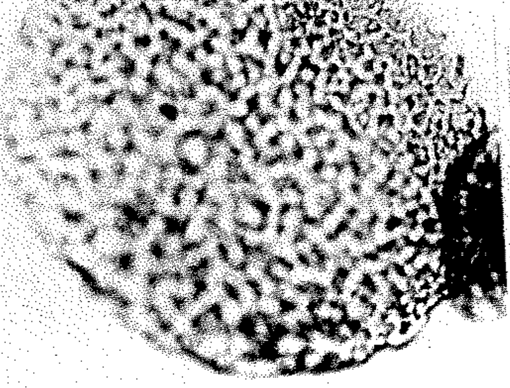

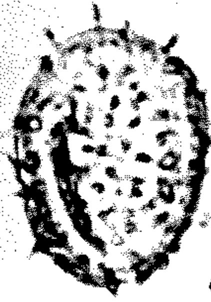
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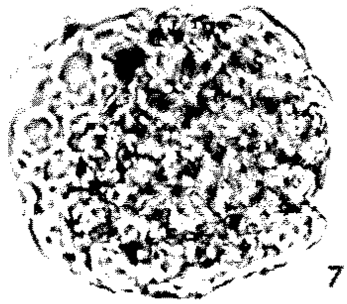
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