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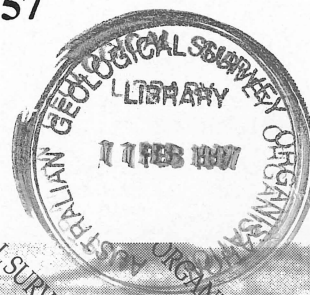
PALYNOSTRATIGRAPHY OF THE MURRAY BASIN, INLAND SOUTHEASTERN AUSTRALIA

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M. K. MACPHAIL

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PALYNOSTRATIGRAPHY OF THE MURRAY BASIN, INLAND SOUTHEASTERN AUSTRALIA

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ABSTRACT

To date, the only published comprehensive zonation for dating and correlating late Tertiary non-marine sequences in Australia is that developed in the 1970s for the offshore Gippsland Basin on the extreme southeastern margin of the continent. In this paper an analogous zonation scheme is presented for the Murray Basin, a large intracratonic basin which covers some 300 000 km² of inland New South Wales, Victoria and South Australia. Major spore and pollen sequences identified within this basin correspond with major periods of marine transgression-regression, in the Middle Eocene to Early Oligocene, Early Oligocene to Middle Miocene and Late Miocene to Pliocene. Presence/absence data allow the first two sequences to be subdivided into palynological zones that can be confidently correlated with zones established for the Gippsland Basin, viz. Equivalents of the Middle to Late Eocene, Lower, Middle and Upper *Nothofagidites asperus* Zones, and the Oligocene to Middle Miocene, *Proteacidites tuberculatus* and *Canthiumidites bellus* Zones respectively. Late Miocene-Early Pliocene and Late Pliocene-Pleistocene intervals are assigned to the *Monotocidites galeatus* Zone and *Tubulifloridites pleistocenicus* Zone respectively. Changes in the relative abundance of commonly occurring species support the above subdivisions in a general way only but are

not reliable as a basis for basin-wide correlations. Until some independent geological or geophysical *datum* is found allowing a direct comparison of species time distributions across the basin, further formal subdivision of the zones is not recommended.

Introduction

Seafloor spreading which led to the isolation of Australia from other continental fragments of Gondwana by Late Eocene time (VEEVERS *ET AL.* 1991) also resulted in the formation of a number of peripheral basins which collectively span Late Jurassic to Plio-Pleistocene time. During this 200 million year period, the focus of deposition of coarse clastic sediments shifted from the north-west to the south-east margin. Many of the basins host important hydrocarbon accumulations and (onshore) important aquifer systems, and the assessment and exploitation of these has required palynostratigraphies to link the geometry and depositional histories of the reservoir sediments.

Of particular importance in Australia is the spore and pollen based zonation developed by STOVER & PARTRIDGE (1973 & subsequent proprietary revisions) to date and correlate Late Cretaceous and Tertiary successions in Australia's major petroleum producing province, the offshore Gippsland Basin in eastern Bass Strait (see GLENIE 1986). Major zone boundaries are defined by the presence or absence of indicator spores and pollen and, less often, by changes in the relative abundance of long-ranging, common species.

Independent age control is provided by marine dinoflagellates whose time distributions have been linked to the international time scale through correlations with marine fauna (PARTRIDGE 1976, HARRIS 1985, HELBY *ET AL.* 1987, WILSON, 1988).

This zonation scheme is now widely used to date and correlate Santonian to Miocene sediments elsewhere in Australia - to the extent that the individual zone names have

become *defacto* stage names for the Australian Paleogene (see DETTMANN 1994, MACPHAIL *ET AL.* 1994). Potassium-Argon dating of basalts has demonstrated that the zones *per se* do provide a working chronostratigraphic framework for correlative sequences onshore in Tasmania and Victoria and New South Wales (OWEN 1988, TAYLOR *ET AL.* 1990, PICKETT *ET AL.* 1990, MACPHAIL *ET AL.* 1991, POLE *ET AL.* 1993, MACPHAIL & HILL 1994; summarized in CHAPRONIERE *ET AL.* 1995). Marine dinoflagellates confirm the same is true for the three major basins immediately to the west of the Gippsland Basin, the Bass, Murray Basin and Otway Basin (Fig. 1) as well as other Late Mesozoic to Cenozoic basins further to the west along the southern margin, e.g. Basins, the St. Vincents Basin in South Australia and the Eucla Basin in south-west Western Australia (STOVER & PARTRIDGE 1982, MACPHAIL & TRUSWELL 1989, 1993, HARRIS 1985, MARTIN 1991, 1993a, ALLEY & CLARKE 1992, ALLEY & BROADBRIDGE 1992, ALLEY & BEECROFT 1993, MACPHAIL & KELLETT 1993, MACPHAIL *ET AL.* 1993a PARTRIDGE & MACPHAIL unpublished results). However the criteria defining the zone boundaries have had to be adapted to take account of (1) demonstrated or suspected diachronism in the times of first appearance and extinction of zone 'index' species and in the maximum relative abundance of common, long-ranging taxa, and (2) the occurrence of species that have not been recorded, or are too rare to be biostratigraphically useful in the Gippsland Basin.

This paper presents a palynostratigraphy developed to date and correlate Middle Eocene to Late Pliocene sediments infilling the Murray Basin, the only large Tertiary intracratonic basin to extend onto the southern margin of Australia. Although not known to be prospective for hydrocarbons, the Murray Basin is one of the country's most economically important agricultural areas. Land salinization and the related problem of rising water tables within the basin now constitute one of Australia's most serious environmental problems (Cook 1989).

Geological setting

The Murray Basin forms the southern half of the single largest co-ordinated drainage basin in Australia, the Murray Darling system which covers some 1 036 000 km² of semi-arid and arid country (Fig. 1). The basin itself is some 300 000 km² in area and is encircled by subdued mountain ranges of Proterozoic and Palaeozoic rocks except in the south-west where the concealed Padthaway Ridge forms a rim effectively isolating the basin from the Southern Ocean. Within the basin, the extremely flat surface dips gently from about 200m at the margins to about 20m elevation in the lowest-lying areas in the central western area. The structural framework and hydrogeology of aquifer systems in the Murray Basin have been reviewed by BROWN (1989) and EVANS & KELLETT (1989). The lithology and stratigraphic relationships of all formally recognised Cenozoic units have been discussed in detail by BROWN & STEPHENSON (1991).

Pre-Cenozoic geology

Aeromagnetic, gravity and borehole data indicate that the pre-Cenozoic basement consists of a collage of north-trending Proterozoic to Palaeozoic tectonostratigraphic terranes and the remnants of Late Palaeozoic-Mesozoic infrabasins infilled with thick Devonian to Lower Carboniferous rocks and discontinuous erosional remains of Upper Carboniferous, Permian, Triassic and Early Cretaceous platform sediments (BROWN & STEPHENSON 1991). Because the Cenozoic cover beds are mostly less than 300m thick, subtle movements of the basement have had a disproportionate influence on the location of the Tertiary depocentres as well as the patterns of flow and surface discharge of groundwater.

Cenozoic geology and hydrogeology

Cenozoic sediments have a maximum thickness of about 600m only, preserved in the deeper central-western sector of the basin. A subsidiary depocentre infilled with about 400m of sediments occurs in the central eastern sector, underlying the Riverine Plain (Fig. 2). but elsewhere thicknesses are mostly less than 200-300 m. The Tertiary succession consists of three major sequences, bounded by disconformity surfaces of which the Mologa Surface, representing a period of prolonged subaerial weathering during the Late Miocene, is the most prominent. Vertical and lateral facies variation within the succession reflects partial flooding by shallow epicontinental seas on at least three separate occasions - during the Paleocene to latest Eocene/earliest Oligocene, Oligocene to Middle Miocene, and late Miocene to Early Pliocene (Fig. 3) - although the relationship with changes in relative sea level is complicated by the still poorly understood tectonic relationship between uplift of the flanking Southeastern Highlands and subsidence in the basin (see JONES & VEEVERS 1982, BISHOP & BROWN 1992).

Of particular importance to the flow of groundwater through the basin is the architecture of clay-rich, shallow to marginal marine facies deposited in an arc about 100 km wide through the south-west and centre of the basin (BROWN & RADKE 1989). The most important of these low permeability barriers (aquitards) are the Late Eocene-Early Oligocene Buccleuch beds, the Late Oligocene-Middle Miocene Geera Clay (Fig. 4) and Winnambool Formation (representing the maximum extent of the marine transgression into the Murray Basin), and the Late Miocene-Pliocene Bookpurnong beds.

Correlative formations to the south-west are the carbonate-dominated successions of the Murray Group and Ettrick Formation. These were deposited in a shallow-marine

embayment and are underlain by fluvio-lacustrine and deltaic sands and silts of the Renmark Group whose constituent formations, the ?Paleocene-Eocene Warina Sand and lower Olney Formation, form the basal depositional sequence of the Cenozoic succession across the basin. The Olney Formation underlies much of the north-east of the Murray Basin although marine dinoflagellates indicate a weak saline influence along palaeo-drainage lines infilled with lithologically identical sands, silts and clays of the informally named Buccleuch beds equivalent (MACPHAIL & TRUSWELL 1989), and Geera Clay equivalent (MACPHAIL *ET AL.* 1993a). KELLETT (1989) has subdivided the Renmark Group into three (Upper, Middle and Lower) units, based on salinity stratification and geophysical data.

The same south-west to north-east gradient in depositional environments is seen in the Upper Tertiary succession where marine and marginal marine sediments of the basal Loxton-Parilla Sands and Bookpurnong beds underlie the western (Mallee) region and fluvio-lacustrine sediments of the Wunghnu Group (upper Loxton-Parilla Sands, Calivil Formation, Shepparton Formation) underlie Quaternary cover beds in the northern (Darling River-Willandra Lakes) and eastern (Riverine Plain) regions of the basin. Correlative alluvial sediments (Lachlan Fan) infilling the middle and upper Lachlan Valley incised into the western flanks of the Southeastern Highlands are the Middle (Late?) Miocene to Pliocene? Lachlan Formation and Plio-Pleistocene Cowra Formation (BISHOP & BROWN 1992).

Economic activity in the Murray Basin depends on groundwater extracted from high permeability facies within the Renmark Group, the Murray Group, and the Pliocene sands. Aquitards such as the Geera Clay-Winnambool Formation and Bookpurnong beds together with subsurface basement highs such as the Neekarboo Ridge form natural hydrogeologic divides which separate the aquifer systems in the basin into three major

provinces -the Mallee Limestone Province in the south-west, the Scotia Province in the north-west and the Riverine Province in the south and east (see Fig. 2). Within each province the individual aquifers differ markedly in terms of age, water quality and hydrostatic pressure but have proved difficult to distinguish using lithologic criteria.

Previous studies

Up to 1985, palynological studies of Cenozoic sediments in the Murray basin focused on the predominantly non-marine eastern sector and adjoining Lachlan and Murrumbidgee Valleys (references in MARTIN 1989). Here, good recoveries and preservation of fossil pollen and spores tends to be restricted to thin/infrequent horizons of finer textured sediments or lignites. Biostratigraphic indicator species are rare, and the ranges of some of these occur outside the established time range for the species in the Gippsland Basin. For these reasons, MARTIN (*ibid*) developed a semi-quantitative (ratio) method in which palynological zones are defined in terms of high or low frequencies of selected long-ranging species, chiefly Myrtaceae, Casuarinaceae, a clade of the southern beech (*Nothofagus*) that is now wholly extinct in Australia, the *Brassospora* group of HILL & READ (1991), and gymnosperms that are now extinct on mainland Australia, e.g. *Phyllocladidites mawsonii*. In the Neogene, maxima in the relative abundance of these taxa were used to define four major vegetation phases MARTIN (1973, 1987).

MARTIN (1984) has proposed that these taxa represent an ecological *continuum* in which *P. mawsonii* represents the wettest, and Myrtaceae and Casuarinaceae, the driest habitats. Since relative abundance also reflects strong ecological controls, such zones almost certainly will be difficult to apply across the basin as a whole (see MACPHAIL & TRUSWELL 1989). Nevertheless the method appears to work well in limited geographic areas such as the Lachlan and Murrumbidgee Valleys.

During the 1980s attention became focused on the centre and west of the Basin, leading to the drilling of five fully cored stratigraphic boreholes Oakvale-1 (TRUSWELL *ET AL* 1985) and Hatfield-1, Manilla-1, Piangil West-2 and Woodlands-1 (Fig. 4). In these boreholes, thick (up to 320m) sections of Geera Clay and underlying marine and marginal marine clays have allowed closely spaced samples to be analysed for fossil spores, pollen and marine dinoflagellates (MACPHAIL & TRUSWELL 1989).

High diversities and excellent preservation allowed these palynosequences to be subdivided using the same suite of zone index species as in the Gippsland Basin, viz. *Triorites magnificus*, *Cyatheacidites annulatus* and *Canthiumidites bellus* to identify intervals that are correlatives of the Late Eocene, Middle *Nothofagidites asperus* Zone, Early Oligocene-late Early Miocene *Proteacidites tuberculatus* Zone and late Early-?Late Miocene *Triporopollenites bellus* Zone respectively. Samples lacking the index species could be reliably dated using simultaneous first appearances or extinctions of a range of accessory species such as *Proteacidites leightonii*, *P. rectomarginis*, *P. reticulatus* and/or dinoflagellates such as *Corrudinium incompositum* and *Alisocysta ornata*. One problem was the identification of zones which in the Gippsland Basin are defined by the absence of indicator species of the adjoining zones, in particular the earliest Oligocene Upper *Nothofagidites asperus* Zone. In this instance, the base of the equivalent zone in the Murray Basin was defined using pollen of pan-tropical species such as *Polyadopollenites* sp. cf *P. granulosus* which do not occur in the Gippsland Basin. In both basins, independent age control is provided by marine faunas (see TAYLOR 1971, BROWN & STEPHENSON 1991), supported by marine dinoflagellate distributions (PARTRIDGE, 1976, TRUSWELL *ET AL*. 1985, MCMINN 1992, MACPHAIL & KELLETT 1993).

Only an informal zonation exists for Late Miocene-Pleistocene sequences in the Gippsland basin (A.D. PARTRIDGE & M.K MACPHAIL unpublished results) and MACPHAIL & TRUSWELL (1993) formally proposed the *Monotocidites galeatus* Zone to cover Late Miocene to Early Pliocene successions overlying the *Triporopollenites bellus* Zone sequence in the Murray Basin. The zone boundary is defined by the first appearance of *Monotocidites galeatus*, *Myrtaceidites lipsis*, *Rhoipites ampereaformis*, and a range of accessory species including *Densoisporites implexus*, *Proteacidites punctiporus* and *Amylothea pliocenica*. The upper boundary is defined by the first appearance of *Tubulifloridites pleistocenicus*. The overlying Late Pliocene-Pleistocene palynosequences were left unzoned.

Material and methods

The zonation described here is based on a total of 435 samples from 54 selected boreholes (Table 1). These comprise 143 conventional core and 277 cuttings samples, analysed for fossil spores, pollen and dinoflagellates by M.K. Macphail between 1987-1993 for the Bureau of Mineral Resources (subsequently Australian Geological Survey Organisation) Groundwater Projects 241.01-241.05. Included for comparison purposes are 4 samples from the Lachlan Valley on the eastern margin, and 32 samples from correlative units in the Darling Basin to the north, of the basin. Lithological and formation boundary data were provided by C.M. Brown, J. R. Kellett, W.R. Evans, B. Radke and G. Jacobson, Australian Geological Survey Organization (AGSO). To minimise the risk of down-hole contamination from caved sediment, the boreholes were fully flushed between sampling.

All core and cutting samples were processed using standard palynological techniques centred around the use of hydrofluoric acid to remove siliceous material and Schultze solution to remove the more labile organic fraction. The acid insoluble extracts were made up into permanent strew mounts using glycerol jelly or *Eukit* and scanned for plant

microfossils using a *Zeiss* Photomicroscope II fitted with top-of-the-range *Planapo* objectives. Stratigraphic distributions were recorded and compared using *Checklist*.

Palynostratigraphic data base

Formations sampled for palynological analysis are listed in Table 2. Full lithostratigraphic and palynostratigraphic data for each borehole are given in MACPHAIL (1993). Zone boundaries are qualified using the AGSO/*Eso Australia* 'Strat-data' system in which the highest and lowest depths at which a particular palynological zone has been identified are shown as the preferred *datum* points. The reliability of the zonal determinations are indicated by a qualitative confidence rating (high, moderate, low) and alternative depth picks given where the preferred *datum* points had a low rating. The data base is complemented by published studies of palynosequences from the western (Oakvale-1), southwestern (SADME MC63 borehole) and central (Mallee Cliff borehole) by TRUSWELL *ET AL* (1985) and MARTIN (1989, 1993a) respectively.

Spore-pollen zones

More than 250 identifiable fossil species are present in Middle Eocene to Early Pliocene palynofloras in the Murray Basin. The overwhelming majority are long-ranging and are of significance only as records of past floras in the region. Time distributions of many of these species are given in Fig. 5. Questionable and anomalous records are indicated by 'Q'. Authorities and nearest living equivalent(s) (analogues) for these fossil taxa are listed in Appendix 1. Correlations with the international time scale follow those proposed by A.D. Partridge for the Gippsland Basin (Fig. 6).

The following vertical succession of palynostratigraphic zones is recognised in the late Paleogene to Neogene sections of the Murray Basin. The name of the *Triporopollenites bellus* Zone is formally changed to the *Canthiumidites bellus* Zone in accordance with the current accommodation of the nominate species. A new zone is proposed for sequences in the Murray Basin that overlie the Late Miocene-Early Pliocene *Monotocidites galeatus* Zone succession of MACPHAIL & TRUSWELL (1993) - the Late Pliocene to Pleistocene *Tubulifloridites pleistocenicus* Zone.

***Malvacipollis diversus* Zone Equivalent**

Early Eocene

None of the samples analysed in this study yielded a palynoflora that can be unequivocally dated as Paleocene or Early Eocene although several assemblages included taxa that do not range as high as the Lower *N. asperus* Zone in the Gippsland Basin, e.g. *Myrtacidites tenuis* and *Proteacidites tuberculiformis*.

Lower *Nothofagidites asperus* Zone Equivalent

Middle Eocene

To date, relatively few Lower *Nothofagidites asperus* Zone Equivalent palynofloras have been identified in the Murray Basin, leading to a situation where many long-ranging species which first appear in the Gippsland Basin in the Paleocene or Early Eocene have not been recorded earlier than the Late Eocene, Middle *N. asperus* Zone Equivalent in the Murray Basin (indicated by downward arrows in Fig. 5).

Accordingly the zone is provisionally defined on the occurrence of *Nothofagidites falcatus*, a widely distributed species which first appears in the Middle Eocene in Gippsland Basin, in assemblages lacking index or accessory species of the Late Eocene, Middle *Nothofagidites asperus* Zone Equivalent (see below). The top of the zone is

defined by the highest occurrence of (*in situ*) *Proteacidites asperopolus*. These assemblages may or may not include accessory species of the Lower *N. asperus* Zone in the Gippsland Basin, e.g. *Anacolosidites luteoides*, *Gothanipollis bassensis*, *Tricolpites simatus* and *Tricolporites leuros*.

The palynofloras are dominated by *Nothofagus (Brassospora)* spp., chiefly *Nothofagidites emarcidus-heterus*. Some species have not been recorded to date in the Gippsland Basin, e.g. *Nothofagidites longispinosa*; others, e.g. rare specimens of *Aglaoreidia qualumis* and *Proteacidites reticulatus*, are considered to be caved from the overlying Middle *N. asperus* Zone Equivalent.

Middle *Nothofagidites asperus* Zone Equivalent

Late Eocene

The base of the zone is defined by the first appearances of *Triorites magnificus*, *Anacolosidites sectus*, *Tricolpites thomasi*, *Verrucatosporites* sp. A and/or the marine dinoflagellates *Alisocysta ornata*, *Deflandrea leptodermata* or *Gippslandica extensa* in palynofloras dominated by *Nothofagus (Brassospora)* spp. *Nothofagidites flemingii* is usually frequent and the diversity of *Proteacidites* spp. is higher than in the Lower *N. asperus* Zone.

The index species are rare, in particular *Triorites magnificus*, and a number of age determinations have had to be made using accessory species which to date have not been recorded in the Lower *N. asperus* Zone palynofloras in the Gippsland Basins, e.g. *Proteacidites confragosus*, *P. rectomarginis*, *P. stipplatus* and *P. tuberculatus*. Pan-tropical taxa recorded in the Murray Basin but not so far in correlative palynofloras in the Gippsland Basin include *Dicolpopollis* sp. cf *D. metroxylonoides*, *Margocolporites*

vanwijhei, *Perforicolpites* sp. cf *P. digitatus*, *Perisyncolporites pokorny*, *Psilodiporites* (*Alyxia*) sp. and *Rubipollis oblatus*.

Otherwise the zone is characterised by the consistent presence of *Santalumidites cainozoicus*, and the highest appearance of *Malvacipollis diversus* and a number of *Proteacidites* species (which terminate in the Middle *N. asperus* Zone in the Gippsland Basin), e.g. *P. leightonii*, *P. nasus*, *P. ornatus* and *P. rugulatus*. It is unknown whether rare specimens of *Anacolosidites acutullus*, *A. luteoides*, *Proteacidites beddoesii*, *P. tuberculiformis* and *Tricolpites incisus* have been reworked from underlying zones.

The top of the zone is defined by the highest occurrence of *Triorites magnificus*. The associated dinocyst flora includes *Corrudinium incompositum* and *Gippslandica extensa*.

Upper *Nothofagidites asperus* Zone Equivalent

earliest Oligocene

The lower boundary of the zone is defined by the first appearance of *Polyadopollenites* sp. cf *P. granulatus*, *Acaciapollenites miocenicus* and/or *Corsinipollenites* sp. cf *C. epilobioides*. Accessory species include *Diporites aspis*, *Foveotriletes crater*, *Granodiporites nebulosus*, *Malvacearumpollis* sp. cf *M. mannanensis* and *Proteacidites isopogiformis*. Limited data (see MACPHAIL & TRUSWELL 1989) indicate that pollen dominance is shared between *Nothofagus emarcidus-heterus* and Casuarinaceae (*Haloragacidites harrisii*). *Nothofagidites brachyspinulosus*, *N. flemingii* and/or *Phyllocladidites mawsonii* may be frequent. The diversity of *Proteacidites* spp. is usually lower than in the Middle *N. asperus* Zone Equivalent.

Species which to date have not been recorded below this zone in the Murray Basin include *Crotonipollis* (*Croton*) sp., *Nuxpollenites* sp. (*Dodonaea triquetra*-type),

Stephanocolpites oblatius and *Tetrapollis campbellbrownii*. Others in the same category however include species with well-authenticated first appearances in the Middle *N. asperus* or earlier zones in the Gippsland Basin and elsewhere, e.g. *Dryadopollenites retequetrus*, *Proteacidites kopiensis* and *P. sinulatus*. Species last recorded in the Upper *N. asperus* Zone Equivalent include: *Cyathidites splendens*, *Periporopollenites polyoratus*, *P. crassus*, *P. recavus*, *P. rynthius* and *Tricolpites thomasii*, and, less certain *Beaupreaidites verrucosus*, *Proteacidites adenanthoides* and *Santalumidites cainozoicus*.

The top of the zone is defined by the last appearance of *Anacolosidites sectus*, *Tricolpites thomasii* and the marine dinoflagellates *Corrudinium corrugatum* and *C. incompositum*.

***Proteacidites tuberculatus* Zone Equivalent** Early Oligocene to late Early Miocene

The lower boundary of the zone is defined by the first appearance of *Cyatheacidites annulatus* and/or *Cyathidites subtilis*. *Granodiporites nebulosus* becomes extinct within, and *Bluffopollis scabratus* is distinctly rare above, this zone.

Other species to date not convincingly recorded below this zone in the Murray Basin include *Acaciapollenites myriosporites*, *Camarozonosporites* sp. B, *Chenopodipollis chenopodiaceoides*, *Foveosporites lacunosus*, *Hakeidites* (*Hakea*?) sp., *Palaeocoprosmadites zelandiae*, *Proteacidites ivanhoensis*, *P. symphyonemoides*, *Rugulatisporites trophus*, *Striasyncolpites laxus*, *Tricolpites pelargonioides*, *T. stylidioides* and *Tubulifloridites simplis*.

Pollen dominance is shared between *Nothofagus* (*Brassospora*) spp. and Casuarinaceae, with Araucariaceae increasing in relative abundance up section. Myrtaceae are sporadically common in some facies. *Proteacidites rectomarginis* is often common

relative to other *Proteacidites* spp. near the base of the zone. The top of the zone is defined by the highest consistent records of *Bluffopollis scabratus*.

The overwhelming majority of species found in *P. tuberculatus* Zone Equivalent palynofloras are equally typical of the *Canthiumidites bellus* Zone Equivalent palynofloras in the Murray Basin. Nevertheless, specimens of some species are so rare in the latter zone that occurrences of three or more in the one assemblage become a moderately reliable indication of an Early Oligocene to late Early Miocene age: Examples are *Bysmapollis emaciatus*, *Bluffopollis scabratus*, *Concolpites leptos*, *Ephedra notensis*, *Foveotrilletes palaequetrus*, *Liliacidites bainii*, *Liliacidites lanceolatus*, *Microcachrydites antarcticus*, *Periporopollenites demarcatus*, *Podosporites erugatus*, *Tricolporites leuros* and *Tripoporopollenites ambiguus*.

***Canthiumidites bellus* Zone Equivalent**

late Early to Middle Miocene

The lower boundary is defined by the first appearance of *Canthiumidites bellus* and *Symplocoipollenites austellus* in Araucariaceae-dominated palynofloras. These species are relatively uncommon at the time of first appearance and accessory species that usually are reliable indicators of this zone include *Glencopollis ornatus*, *Haloragacidites haloragoides*, *Polypodiaceoisporites tumulatus*, *Proteacidites symphyonemoides* and *Rugulatisporites cowrensis*. Additional rare species whose first appearance may prove to be useful in defining the base of the zone are *Cingulatisporites ornatus*, *Polypodiisporites usmensis*, *Triporotetradites* (*Gardenia*), and, less certain, *Proteacidites truncatus* and *Tubulifloridites antipodica*. The dinoflagellates *Lingulodinium machaerophorum* and *Operculodinium* species are frequent in palynofloras recovered from marginal marine facies of late Early to Middle Miocene age.

A significant number of species last appear in this zone in the Murray Basin, including at least 12 proteaceous species that are typical of much older (Paleocene-Early Eocene) successions across southern Australia. Examples are *Dilwynites tuberculatus*, *Propylipollis latrobensis*, *P. reticuloscabratus*, *Proteacidites biporus*, *P. differentipolis*, *P. pseudomoides*, *P. rectomarginis*, *P. stipplatus*, *P. tuberculatus*, *Triporopollenites chnosus* and *T. delicatus*.

Other taxa which almost certainly had become extinct in the basin by the upper boundary include: *Dilwynites tuberculatus*, *Herkosporites elliotii*, *N. goniatus*, *Parvisaccites catastus*, *Peromonolites densus*, *Psilastephanocolporites micus*, *Schizocolpus marlinensis*, *S. (Alchornea) sp.*, *Tetracolporites palynius*, *Tetrapollis campbellbrownii*, *Tricolpites reticulatus*, *T. simatus*, *T. stylidioides*, *Tricolporites scabratus* and *Verrucosisporites kopukuensis*. Records of *Microcachrydites antarcticus*, and *Rugulatisporites trophus* in the zone are considered to be reworked.

The top of the zone is defined by the highest consistent occurrence of *Ilexpollenites anguloclavatus*, *Nothofagidites flemingii* and *Perisyncolporites pokorny*. Dinoflagellates last recorded in the zone include *Apteodinium australiense* and *Pentadinium laticinctum*.

***Monotocidites galeatus* Zone**

Late Miocene to Early Pliocene

The base of the zone is defined by the first appearances of *Monotocidites galeatus*, *Myrtaceidites lipsis*, *Proteacidites punctiporus*, *Rhoipites ampereaformis* and/or *Densoisporites implexus* and *D. simplis*. With few exceptions, pollen dominance is shared between Araucariaceae, Casuarinaceae and Myrtaceae (*Myrtaceidites* spp.). The relative abundance of *Nothofagus* (*Brassospora*) species declines to low to trace levels within the zone.

As noted by MACPHAIL & TRUSWELL 1993), the overwhelming majority of species first appearing in the *M. galeatus* Zone are produced by plants that are widespread in the modern Australian sclerophyll vegetation, including semi-arid plant communities which are widely distributed within the Murray-Darling Basin. Species include (modern analogue in parentheses): *Amylothea pliocenica* (Loranthaceae), *Cingulatisporites bifurcatus* (Hepaticae: *Phaeoceros*-type), *Fenestrites* sp. (Asteraceae: Liguliflorae), *Gothanipollis perplexus* (Loranthaceae: *Lysiana*-type), *Hakeidites* sp. (Proteaceae: *Grevillea*), *Haloragacidites myriophylloides* (Haloragaceae: *Myriophyllum*), *Hypolepis spinysporis* (Dennstaedtiaceae: *Hypolepis australis*-type), *Malvacipollis regattaensis* (Malvaceae), *Myrtaceidites* (Myrtaceae: *Leptospermum*), sp., *Myrtaceidites lipsis* (Myrtaceae: *Eucalyptus spathulata*-type), *Poluspissusites ramus* (Goodeniaceae), *Polyporina* sp. (Chenopodiaceae: *Hemichroa*-type), *P. granulata* (Caryophyllaceae: *Stellaria*), *P. reticulata* (Caryophyllaceae: *Silene*-type), and *Rhoipites* sp. cf *R. isoreticulatus* (Verbenaceae: *Avicennia*). It is uncertain whether *Thymelaepollis* (Thymeleaceae: *Pimelea*) sp. appears within this or the overlying zone.

Conversely the zone includes the youngest reliable records of at least 50 spore and pollen types. Some of these had been part of the palaeoflora in southern Australia since Late Cretaceous-Paleocene time, e.g. *Lygistepollenites florinii* (Podocarpaceae: *Dacrydium*), *Banksiaeaidites arcuatus* (Proteaceae: Musgraveinae), *Nothofagidites brachyspinulosus* (*Nothofagus* subgenus *Fuscospora*) and *N. flemingii* (*Nothofagus* subgenus *Nothofagus*). Others had appeared as recently as the Oligocene to late Early Miocene, e.g. *Acaciapollenites miocenicus* (Mimosaceae: *Archidendron*-type) and *Canthiumidites bellus*. Because the bulk of the data come from the Bookpurnong beds and other marginal marine correlatives, it is possible some records are due to reworking from the underlying Oligo-Middle Miocene marine succession. The majority have clear affinities with modern

taxa that are restricted to mesotherm rainforest and other, wet, vegetation types now restricted to warm temperate to tropical environments.

To date it is not possible to define the top of the zone in terms of extinctions and this boundary is placed below the first occurrence of *Tubulifloridites pleistocenicus*.

Dinoflagellates found in marginal marine assemblages include *Labyrinthodinium truncatum*, *Melitasphaeridium aequabile*, *M. choanophorum*, *Selenopemphix* spp. and *Tuberculodinium vancampoe*. Evidence is mounting that least one species (*Systematophora placacantha*) which became extinct in the Middle Miocene in open marine situations (WILLIAMS & BUJAK 1985) survived into Late Miocene-Pliocene time in the restricted marine Murray Basin.

***Tubulifloridites pleistocenicus* Zone** (new zone) - Late Pliocene to Pleistocene

The lower boundary is defined by the first appearance of *Tubulifloridites pleistocenicus*, *Acaciapollenites octosporites* and/or a *Crotonipollis* sp. that closely resembles pollen of the living Euphorbiaceae *Beyeria*. Asteraceae (*Tubulifloridites* spp) and Poaceae (*Graminidites* spp.) are usually common to abundant. The 'index' species - and the majority of taxa which first appear in the *M. galeatus* Zone - are rare to common elements of Late Pleistocene and Holocene palynofloras across southeastern Australia. The top of the zone remains undefined.

Discussion

Major spore and pollen sequences correspond with the three major periods of marine transgression-regression in the Murray Basin, in the Middle Eocene to Early Oligocene, Early Oligocene to Middle Miocene and Late Miocene to Pliocene. This is not unexpected given theoretical and observational evidence for clustering of first and last occurrences at major lithostratigraphic boundaries in basins where deposition is strongly influenced by changes in relative sea level (see GREGORY & HART 1992, HOLLAND 1995).

Presence/absence data allow the the Middle Eocene to Early Oligocene and Early Oligocene to Middle Miocene sequences to be subdivided into palynological zones that can be confidently correlated with zones established for the Gippsland Basin, viz. Lower to Upper *Nothofagidites asperus* Zones, and the *Proteacidites tuberculatus* to *Canthiumidites bellus* Zones respectively. Late Miocene-Early Pliocene and Late Pliocene-Pleistocene intervals are assigned to the *Monotocidites galeatus* Zone and *Tubulifloridites pleistocenicus* Zone respectively. Whether the zone boundaries in marine-influenced successions represent major flooding surfaces (HOLLAND *ibid*) remains untested.

Because of the potentially very large size of the pollen source area, it is difficult to distinguish between *in situ* and caved/reworked specimens of species at the ends of their ranges. Bioturbation almost certainly has led to blurring of zone boundaries in marine units such as the Bookpurnong beds (MACPHAIL & KELLETT 1993). Accordingly the zonation proposed here should be considered as a 'working' hypothesis only until such time as information on the geographic distribution and stratigraphic occurrences of the

species improves. 'Anomalous' occurrences of species are to be expected for several reasons:

(a) Unlike eastern Bass Strait, the Murray Basin is located within a region characterised by the development of strong east to west and south to north (decreasing) gradients in precipitation during the Cenozoic (MACPHAIL *ET AL* 1994) and its sheer size makes it unlikely that first appearances or extinctions or changes in relative abundance will have been synchronous on a basin wide basis.

(b) The zonation is limited by low sample densities for most boreholes, by possible imprecision in the identification of formation boundaries, and by the location of many samples close to presumed formation boundaries. An example is the occurrence of two lithologically similar facies, the Bookpurnong beds and Geera Clay, in disconformable contact over large areas in the southwest of the basin. To date no basin-wide lithological or geophysical event has been found which provides an independent *datum* for correlating the usually widely spaced, individual biostratigraphies (see MACPHAIL & TRUSWELL 1989 p 305). Accordingly the primary control on the reliability of the zonation proposed in this paper depends on its internal consistency (Fig. 3) with the lithostratigraphic framework developed by BROWN (1989), EVANS & KELLETT (1989), KELLETT (1989) and BROWN & STEPHENSON (1991)

It is uncertain whether more detailed palynological subdivisions are possible for the individual aquifer provinces or even smaller areas within the basin. On present indications, the method formulated by MARTIN (1984) for the Lachlan and Murrumbidgee Valleys would seem to be inapplicable since (a) the ratios to reflect shifts in plant communities growing on the lower (and upper?) slopes of the Southeastern Highlands, and (b) forcing factors may include some that are unique to the eastern margins of the basins, e.g. a

effectively higher precipitation/cooler temperatures due to orographic clouding on the western slopes of the Southeastern Highlands. That conditions were effectively cooler and wetter is provided by the increased relative abundance of the tropical microterm treefern *Lophosoria* (*Cyatheidites annulatus*) in Oligo-Miocene palynofloras from boreholes in this region (MACPHAIL unpubl. data). Otherwise the lack of systematic trends in e.g. the relative abundance of rainforest trees such as Araucariaceae (MACPHAIL & TRUSWELL 1989) implies environmental controls in the central and western sectors of the basin were neither simple nor unidirectional.

In spite of these limitations, a number of firm general conclusions can be made regarding the sedimentary and vegetational history of the Murray Basin, which in turn will assist the development of a more comprehensive palynostratigraphic framework for the basin:

A. Lithostratigraphy

1. Fluvio-lacustrine formations. - The Upper Renmark Group appears to have accumulated wholly during *Canthiumidites bellus* Zone Equivalent time. There is no compelling evidence for the presence of facies of this age in northern areas of the Scotia Aquifer province (Blantyre Trough) or in the north of the Riverine Aquifer Provinces.

The Middle Renmark Group was deposited predominantly during *Proteacidites tuberculatus* Zone Equivalent time and facies of this age appear to be present in all provinces of the basin. The Lower Renmark Group accumulated predominantly during Lower to Upper *Nothofagidites asperus* Zone Equivalent time.

2. Marginal to restricted marine formations - The basal Loxton-Parilla Sands and Bookpurnong beds were deposited during *Monotocidites galeatus* Zone time. The Geera

Clay, Winnambool Formation and Murray Group Limestones accumulated during both the *Canthiumidites bellus* Zone Equivalent and *Proteacidites tuberculatus* Zone Equivalent time whilst the Ettrick Formation appears to have been deposited wholly during the latter zone only. The Buccleuch beds accumulated during Middle and Upper *Nothofagidites asperus* Zone Equivalent time.

3. The geographic limits of marine transgression are difficult to establish with precision. However there can be little doubt that a weak marine influence extended up paleodrainage lines well beyond the limits of marine formations such as the Buccleuch beds and Geera Clay. On present indications, such units within the Upper and Middle Renmark Group or directly overlying Geera Clay (Geera Clay equivalent) were deposited during *Canthiumidites bellus* Zone Equivalent time, except in the Scotia Aquifer Province where correlative sediments are *Proteacidites tuberculatus* Zone Equivalent in age. Units within the Lower Renmark Group (Buccleuch beds equivalent) accumulated during Middle and Upper *Nothofagidites asperus* Zone Equivalent time.

Vegetation history

All fossil pollen and spore-based reconstructions of Tertiary vegetation assume that modern plant community/pollen deposition relationships are applicable. In the case of the Murray Basin, this is complicated not only by the usual problems of scale and representivity arising from differences in pollen production and transport but also by biases associated with deposition in a highly diverse range of depositional environments (see Fig. 7, 8).

A major difference between the Cenozoic floras of Australia and temperate regions of the Northern Hemisphere are that pollen transport is relatively reduced due to the prevalence

of insect and bird pollination. By analogy with the modern Australian, New Guinea, New Zealand and Indo-Malaysian floras, the overwhelming majority of Tertiary plants will be severely under-represented by pollen unless the source plants grew at, or upstream, of the site (see MACPHAIL *ET AL.* 1994, 1996a). Not surprisingly, macrofossils often are the only evidence for many important angiosperm families in the Tertiary vegetation, e.g. Ebenaceae, Eucryphiaceae, Lauraceae and Monimiaceae (CRISTOPHEL 1994, HILL 1994). In other cases, more than one species, if not genera, are concealed by broad fossil pollen species definitions and a significant number of these species now are wholly extinct or survive only outside of Australia, chiefly in Malesia, New Zealand or South America. Since many of the modern equivalents also include a range of life forms with overall wide ecological tolerances, equating pollen dominance with physical or numerical prominence of the source plant(s) in the paleovegetation remains as questionable an assumption for the Murray as for other Australian Tertiary basins.

For these reasons, reconstructions of community composition and structure of past vegetation in the Murray Basin are based primarily on the relatively few taxa that do produce distinctive pollen and which now are diagnostic of particular vegetation types or environments in the Australian region (see Nix 1991). Of particular importance are (a) *Nothofagus* (Fagaceae), the canopy dominant in cool temperate evergreen rainforest; Araucariaceae, the canopy dominant in 'dry' rainforest; Podocarpaceae such as *Dacrycarpus*, *Dacrydium*, *Lagarostrobos* and *Podocarpus*, present in a range of rainforest and semi-swamp forest types; and (b) *Acacia* (Mimosaceae), Casuarinaceae, and *Eucalyptus* species of the 'bloodwood' group (Myrtaceae), all of which are prominent in drier sclerophyll forest and coastal communities.

Macrofossil data, chiefly from Tasmania (see HILL 1994), confirm that at least some of the pollen types represent tall, as well as understorey rainforest trees and shrubs. Examples

are *Nothofagidites emarcidus-heterus* (Fagaceae: *Nothofagus* subgenus *Brassospora*), *N. asperus* (subgenus *Lophozonia*), *N. brachyspinulosus* (subgenus *Fuscospora*), *N. flemingii* (subgenus *Nothofagus*), *Araucariacites australis* (Araucariaceae) and podocarps including *Lygistipollenites florinii* (*Dacrydium*), *Podocarpidites* species (*Podocarpus*), and *Phyllocladidites mawsonii* (*Lagarostrobos franklinii*-type). Casuarinaceae (*Casuarinidites cainozoicus*, *Haloragacidites harrisii*) and non-eucalypt Myrtaceae such as *Myrtaceidites parvus-mesonesus* represent shrub-tall tree species with both modern rainforest and xerophytic affinities.

Pollen diagrams illustrating changes in the relative abundance of commonly occurring taxa during the Late Eocene to Middle Miocene have been published for western (TRUSWELL *ET AL.* 1985), central (MACPHAIL & TRUSWELL 1989) and eastern (MARTIN 1987) sectors of the Murray Basin. MARTIN (1993b) has summarised changes in the relative proportions of these taxa within five sectors across of the basin via pollen groups averaged for each palynological zone

These verify that the replacement of *Nothofagus* evergreen rainforest by drier and more open types in which Araucariaceae, Myrtaceae and/or Casuarinaceae were prominent , was a basin-wide phenomenon, although the trend is diachronous and exhibits considerable local variation at both the regional and local geographic level (cf. MACPHAIL & TRUSWELL 1989). Martin (1993) argues that at any point in time, community dominance and distributions reflect edaphic gradients within the basin. For example *Nothofagus* (*Brassospora*) species and podocarps occupied low-lying, swampier areas of the basin whilst *Nothofagus* (*Fuscospora*) species flourished on well-drained sites, particularly in the north-east of the basin. Araucariaceae and Casuarinaceae occupied the coastal zone at the edges of the marine-transgressed sector (Fig. 7, 8).

The increased representation of Araucariaceae during the Late Oligocene to Middle Miocene and *Nothofagus* (*Lophozonia*) during the Middle Miocene is linked with the onset of increasingly dry/seasonal climates during the Neogene. The distribution of *Lagarostrobos*, a conifer now confined to riparian habitats in superhumid south-west Tasmania, shows a marked contraction towards the extreme southeast of the basin, and Myrtaceae (including *Eucalyptus* at some sites) show a marked increase in relative abundance in the east and northeast of the basin, over the same period.

Quantitative data for the late Neogene are available only for the central (marginal marine) sector of the basin (MACPHAIL & TRUSWELL 1993) and the Lachlan Valley (MARTIN 1987). Again the impression given is of marked heterogeneity in the vegetation at both the local and regional scale. For example, palynosequences from boreholes closest to the Late Miocene-Pliocene shoreline show a collapse of *Nothofagus* (*Brassospora*) populations, and an overall increase in herbaceous/swamp taxa such as Cyperaceae and Restionaceae, within the *Monotocidites galeatus* Zone. Araucariaceae, Casuarinaceae and Myrtaceae are frequent to abundant but show no consistent trends. At sites where the marine influence is less marked, *Nothofagus* (*Brassospora*) species remained relatively common. Correlative sequences from the Lachlan Valley are dominated by Myrtaceae and Casuarinaceae, except for a transient phase (Early-Mid Pliocene?) in which *Nothofagus* (*Fuscospora*, *Lophozonia*) species, Podocarpaceae and/or Cupressaceae are prominent. *Nothofagus* (*Brassospora*) species are rare or absent.

Such reconstructions ignore one of the more distinctive features of the Murray Basin palynofloras, notably the very high diversity of described and undescribed fossil pollen and spores relative to correlative assemblages in the Bass Strait basins and Tasmania.

Many of these taxa represent (rare?) subcanopy/riparian taxa and some are of considerable palaeoecological or phytogeographical significance. For example, *Reevesiapollis reticulatus* is identical to pollen of *Ungeria floribunda* (Sterculiaceae), now endemic to Lord Howe Island in the western Pacific. The nearest modern equivalent of *Bluffopollis scabratus* is *Strasburgeria* (Strasburgeriaceae: see Jarzen & Pocknall 1993), a genus which like *Beaupreaidites* spp. (*Beauprea*: Proteaceae) is now endemic to New Caledonia. An undescribed *Clavastephanocolporites* sp. closely resembles pollen of the African *Alangium chinense*. (*A. chinense* Type C of Reitsma.1970); *Granodiporites nebulosus*, pollen of the endemic South American Proteaceae *Embothrium* (Weston & Crisp 1994) and *Diporites aspis*, pollen of *Fuchsia* (Onagraceae), now confined to montane regions of South and Central America, and in New Zealand and Tahiti (BERRY ET AL. 1990).

Many of rare angiosperm trees and shrubs which first appear in the late Eocene have strong megatherm-mesotherm (Nix 1982) affinities e.g. *Margocolporites vanwijhei* (Caesalpinaceae) *Perisyncolporites pokorny* (Malpighiaceae), *Rubipollis oblatus* (Rubiaceae: *Canthium*) and *Asseretospora* and *Polypodiaceoisporites retirugatus* (Adiantaceae: *Pteris*). It is tempting to associate the extinction of other probable megatherm-mesotherm species such as *Anacolosidites sectus* (Olacaceae: *Anacolosa*) and many of *Proteacidites* (Proteaceae) with isotopic and glaciological evidence for marked cooling of surface waters along the southern margin during the terminal Eocene-earliest Oligocene (see KAMP ET AL. 1990; MACPHAIL ET AL 1993b).

The same cooling event(s) may explain both the re-appearance of the *Lophosoria* (see MACPHAIL ET AL 1994) and the increased relative abundance of *Nothofagus* (*Brassospora*) species during the Early Oligocene. Whether the latter represents an actual expansion of *Nothofagus*-dominated rainforest within the basin, or is an artefact resulting from the

extinction of other palynologically less well represented species, is unknown.

Nevertheless, the data suggest a trend from floristically complex (mixed) to floristically more simple rainforest communities at this time.

Temperatures show a rapid recovery during the Early Oligocene, consistent with the appearance (migration into the basin?) of other species with mesotherm affinities, e.g. *Polyadopollenites* sp. cf *P. granulatus*, *Acaciapollenites miocenicus* (Mimosaceae: cf. *Adenanthera* and *Archidendron*), *Canthiumidites bellus* (Rubiaceae: *Randia*) and *Symplocoipollenites austellus* (Symplocaceae: *Symplocos*).

Most of these survived into Middle Miocene time. Nonetheless, forest communities appear to have become more open, allowing low shrubs and herbs such *Corsiniipollenites* (Onagraceae: *Epilobium*-type), *Chenopodipollis chenopodiaceoides* (Chenopodiaceae-Amaranthaceae) and *Tubulifloridites* species (Asteraceae: Tubuliflorae) to become prominent for the first time in the flora. There can be little doubt that this phenomenon, associated with the extinction of rainforest taxa and appearance/expansion of taxa with sclerophyll affinities, reflect increasingly seasonal and overall drier climates resulting from global cooling and the northward drift of the Australian continent (see Bowler 1982).

The Murray Basin will continue to yield valuable evidence for past Tertiary floras, vegetation and palaeoenvironments in Southern Australia. On the broader stage, the association of diverse fossil palynofloras and its strategic location make the basin an ideal place to link the Gippsland zonation to other regional palynostratigraphies being developed for the hydrocarbon-prospective Otway and Eucla Basins on the southwestern margin and Cenozoic groundwater basins in the arid interior of the continent (see SLUITER 1991, SENIOR *ET AL.* 1994; Macphail, 1995, 1996b).

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TABLE 1

Borehole	DWR No.	Co-ordinates	Depth (m)	Number Samples	Aquifer Province
Amphitheatre	36891	E667459 N6411230	47-191	14	Scotia (NW)
Baden Park	36917	E236849 N6436735	54-242	5	Riverine (N)
Bambilla	36918	E233935 N6416380	82-167	2	Riverine (N)
Berangerine	36798	E890551 N6220828	116-219	4	Riverine
Bonton	36915	E778656 N6390774	77- 78	1	Scotia (NW)
Burtundy	36914	E749684 N6394300	58- 75	2	Scotia (NW)
Cal Lal	36783	E512130 N6421450	67-112	13	Scotia
Conoble	36952	E285687 N6349975	67-125	5	Riverine
Coombah	36843	E556578 N635646	60-331	3	Scotia
Cowary	36881	E739165 N6448142	82-222	6	Scotia (NW)
(Cowra Fm.)	12438	not available	14- 16	1	(Lachlan Fan)
Cumbung	36721	E772431 N6201694	112-421	3	Riverine
(unnamed)	36839	not available	8-127	17	(Darling)
(unnamed)	36841	not available	29-102	6	(Darling)
Euston	36723	E671028 N6178891	80-370	3	Mallee
Hatfield-1	36675	E764400 N6244291	145-427	35	Riverine
Ivandale	36919	E245903 N6358323	41- 93	3	Riverine
Kajuligah	36920	E271891 N6378262	74- 75	1	Riverine (N)
Kookabong	36953	E311564 N6365380	48- 88	4	Riverine
(Lachlan Fm.)	14747	not available	67- 88	3	(Lachlan Fan)
Leaghur	36855	E688683 N6276047	66-261	16	Mallee
Manilla-1	36669	E612020 N6302233	90-329	23	Scotia
Magrath Flat1	-	not available	91- 92	2	Mallee
Marma	36854	E667873 N6241093	63-280	14	Mallee
Menindee-1	36838	E600289 N6379821	111-219	5	Scotia
Menindee-2	36840	E560842 N6390681	22-160	5	Scotia
Maude	36797	E802927 N6179531	95-352	11	Riverine
Nelia	36912	E684821 N3800100	37-116	4	Scotia (NW)
Noora-1	-	E486250 N6191700	33- 66	16	Mallee
Perekerton	36719	E759625 N6131297	53-356	4	Riverine
Piangil West2	-	E701175 N6118200	82-383	48	Riverine
Pomona	36784	E585120 N6234500	92-446	3	Scotia
Scotia-1	-	E533582 N6334693	5- 60	11	Scotia
Scotia-2	-	E534602 N6337399	22- 59	3	Scotia
Shl Land	-	not available	8.3	1	Scotia
Sil-2	-	not available	6 9	1	Scotia
Strathavon	36802	E815241 N6319768	74-198	4	Riverine
Taldra-1	-	E485000 N6201800	84- 90	7	Mallee
Talgarry	36851	E537285 N6246536	60-495	30	Scotia

Talyawalka	36887	E720630 N6410476	34-216	16	Scotia (NW)
Tandou	36816	E601500 N6379750	21-328	5	Scotia
Tarwong	36803	E796890 N6243513	58-363	10	Riverine
Tchelery	36720	E796172 N6132800	131-405	3	Riverine
Teryawina	36804	E718507 N6439292	75-141	4	Scotia (NW)
Tintinallogy	36836	E680467 N6442200	70- 78	2	Scotia (NW)
Toogimbie	36799	E800133 N6156875	97-310	10	Riverine
Wampo	36790	E698125 N6235880	104-210	2	Mallee
Weimby	36720	E704798 N6155215	70-300	4	(Darling)
Wilcannia	36839	not available	118-121	2	(Darling)
Winbar	36848	not available	25- 59	3	(Darling)
Woodlands-1	-	E579040 N6315703	105-363	31	Scotia
Yallock	36951	E291005 N6406763	46-138	5	Riverine (N)

TABLE 2

Formation (Field data)	Blantyre Trough	Ivanhoe- Manara	Mallee	Riverine Nth. Sth.	Scotia
Quaternary Formations					+
Shepparton Formation					+
Calivil Formation	+				
Loxton-Parilla Sands			+		+
Bookpurnong beds			+		+
Upper Renmark Group	+	+	+	+	+
Middle Renmark Group	+	+	+	+	+
Geera Clay			+	+	+
Winnambool Formation			+		+
Murray Group			+		
Ettrick Formation			+		+
Lower Renmark Group	+		+	+	+
Buccleuch beds			+		
Warina sands					+
pre-Tertiary basement	+	+	+	+	+

TABLE 3

Formation	M. galeatus Zone	C. bellus Zone	P. tubercul. Zone	N. asperus Zone		
				Upp.	Mid.	Low.
Quaternary Fm.						
Shepparton Fm.						
Calivil Fm.	Q					
Lachlan Fm.	+					
Pliocene Sands	+					
Loxton-Parilla Sands	+					
Bookpurnong beds	+					
Upper Renmark Gp.		+				
Middle Renmark Gp.		+	+			
Geera Clay Equiv.		+	+			
Geera Clay		+	+			
Winnambool Fm.		+				
Murray Group		+	+			
Ettrick Fm.			+			
Lower Renmark Gp.				+	+	Q
Buccleuch Equiv.				+	+	
Buccleuch beds					Q	
Warina Sands					+	+

Q = questionable age determination

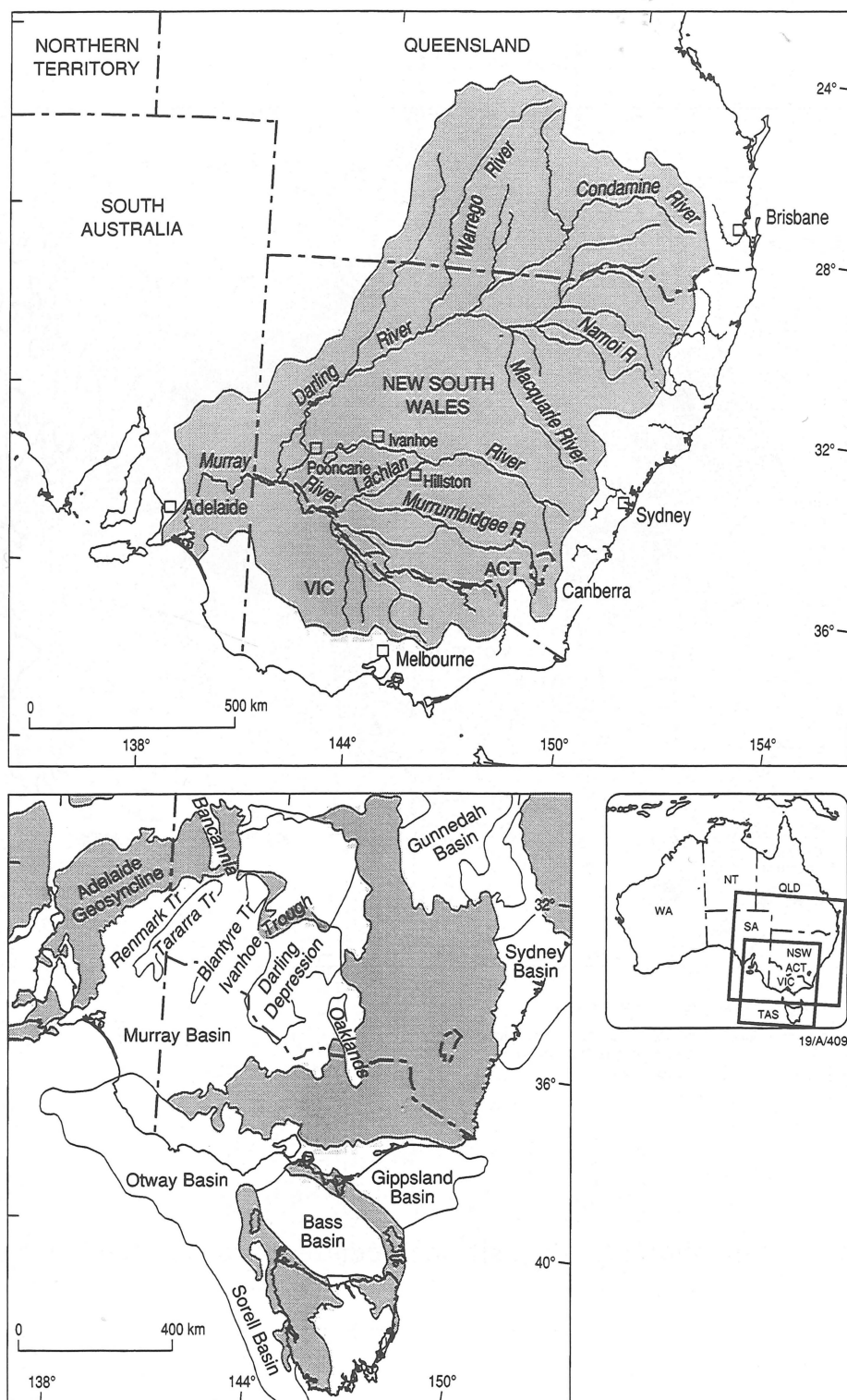


Fig. 1 Map showing basins and other localities mentioned in the text.

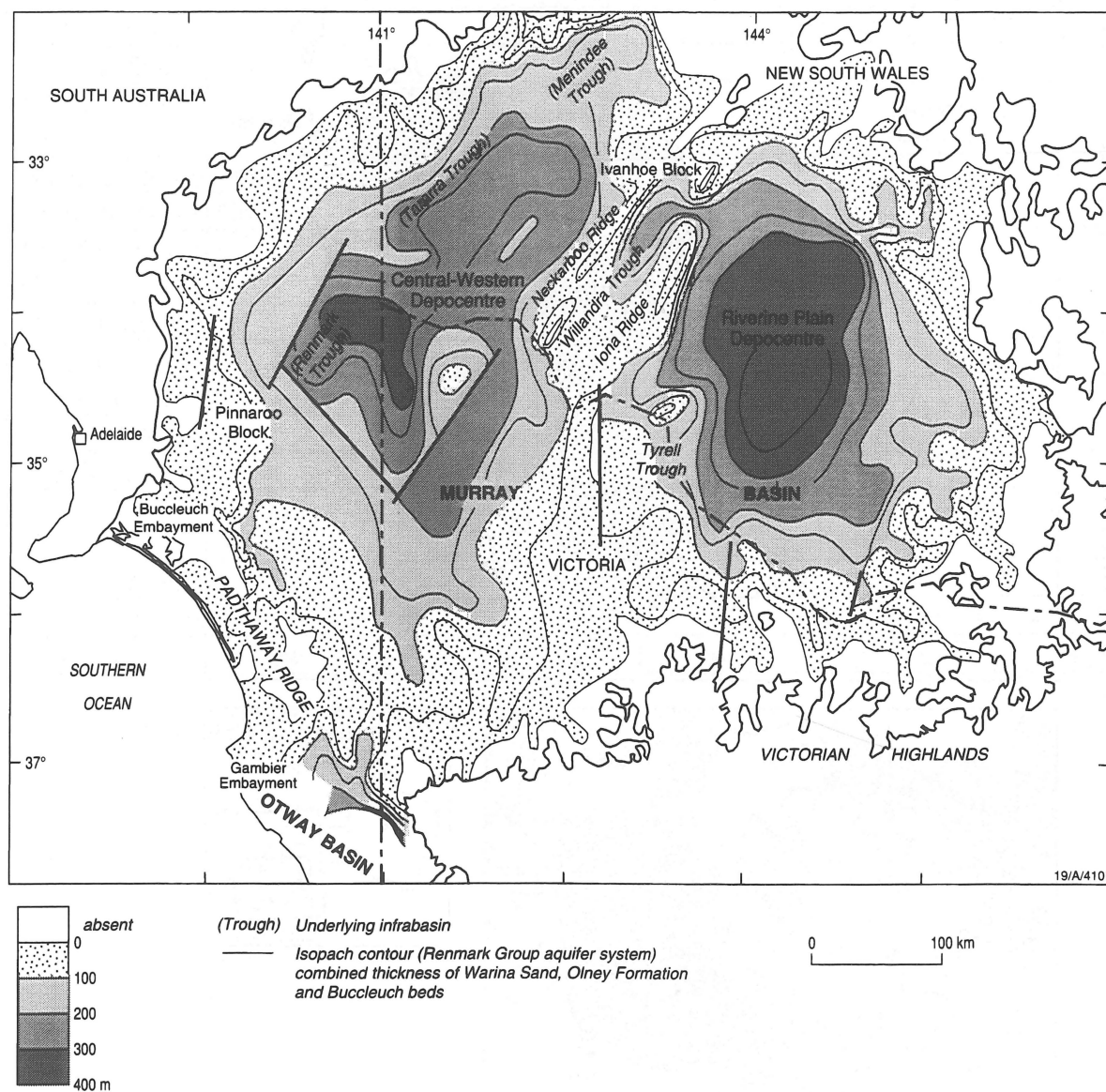


Fig.2 Isopach map showing depositional centres and groundwater provinces.

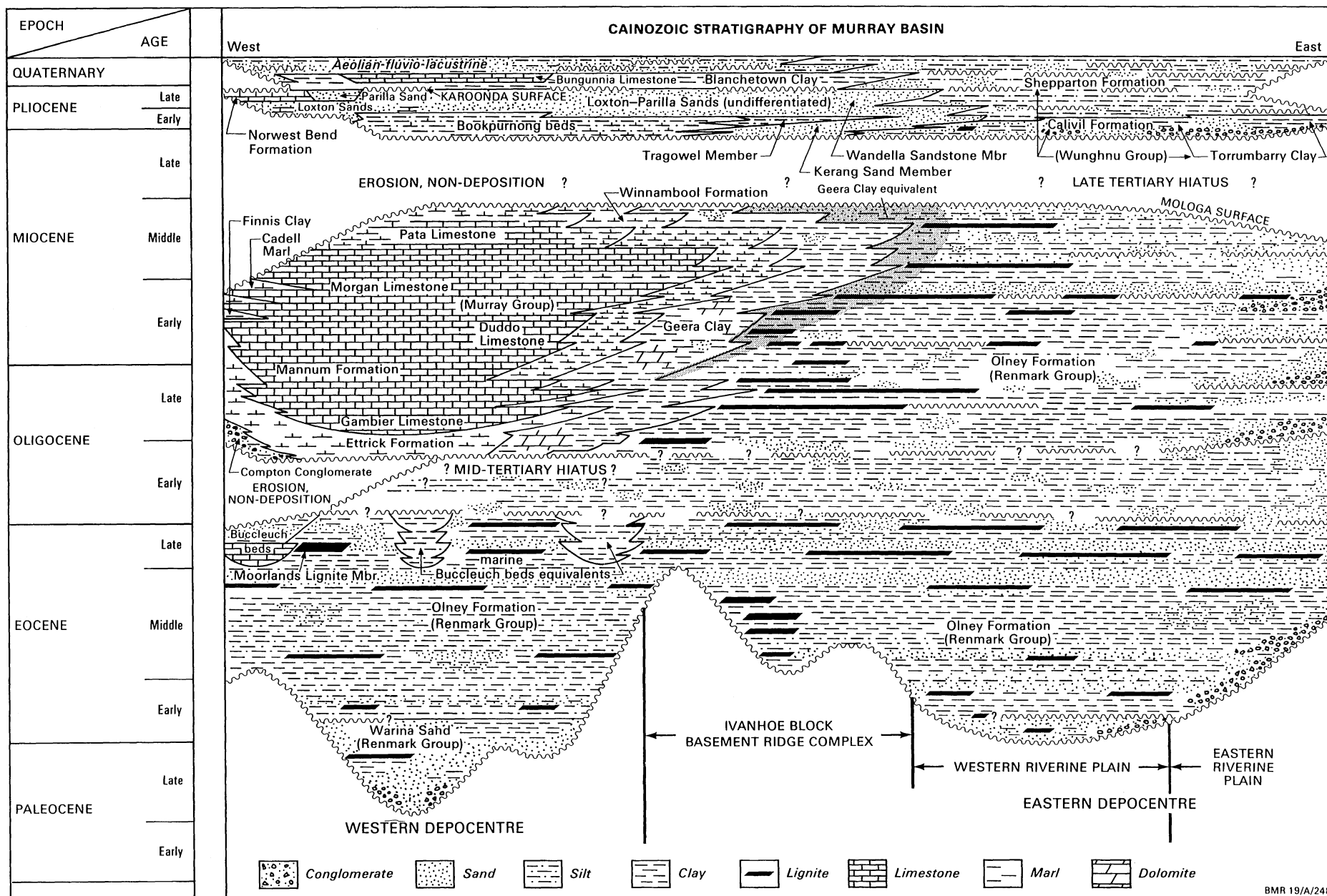


Fig.3 Cenozoic lithostratigraphy (after Brown, 1989).

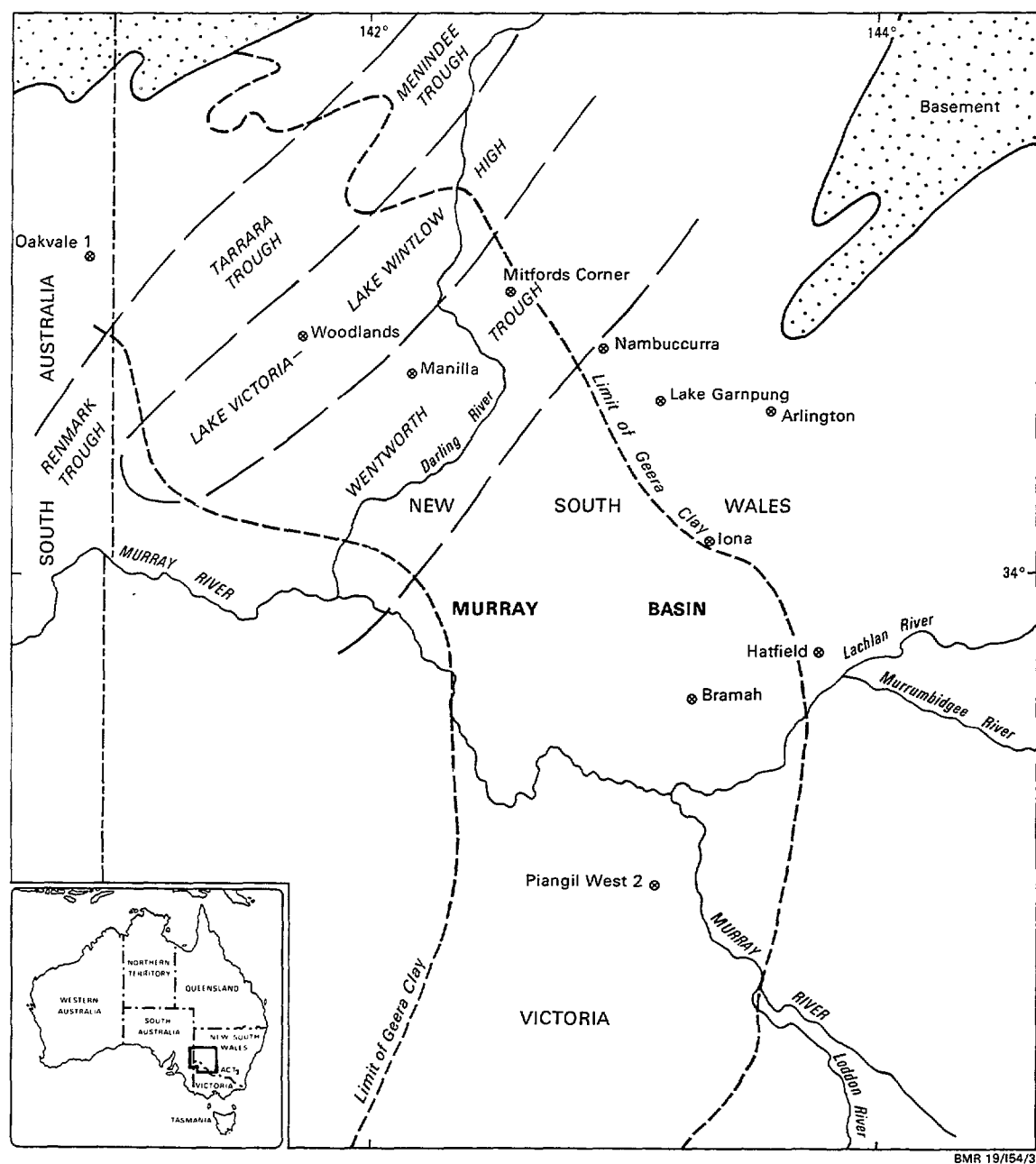


Fig.4 Location of key stratigraphic boreholes with respect to the Geera Clay.

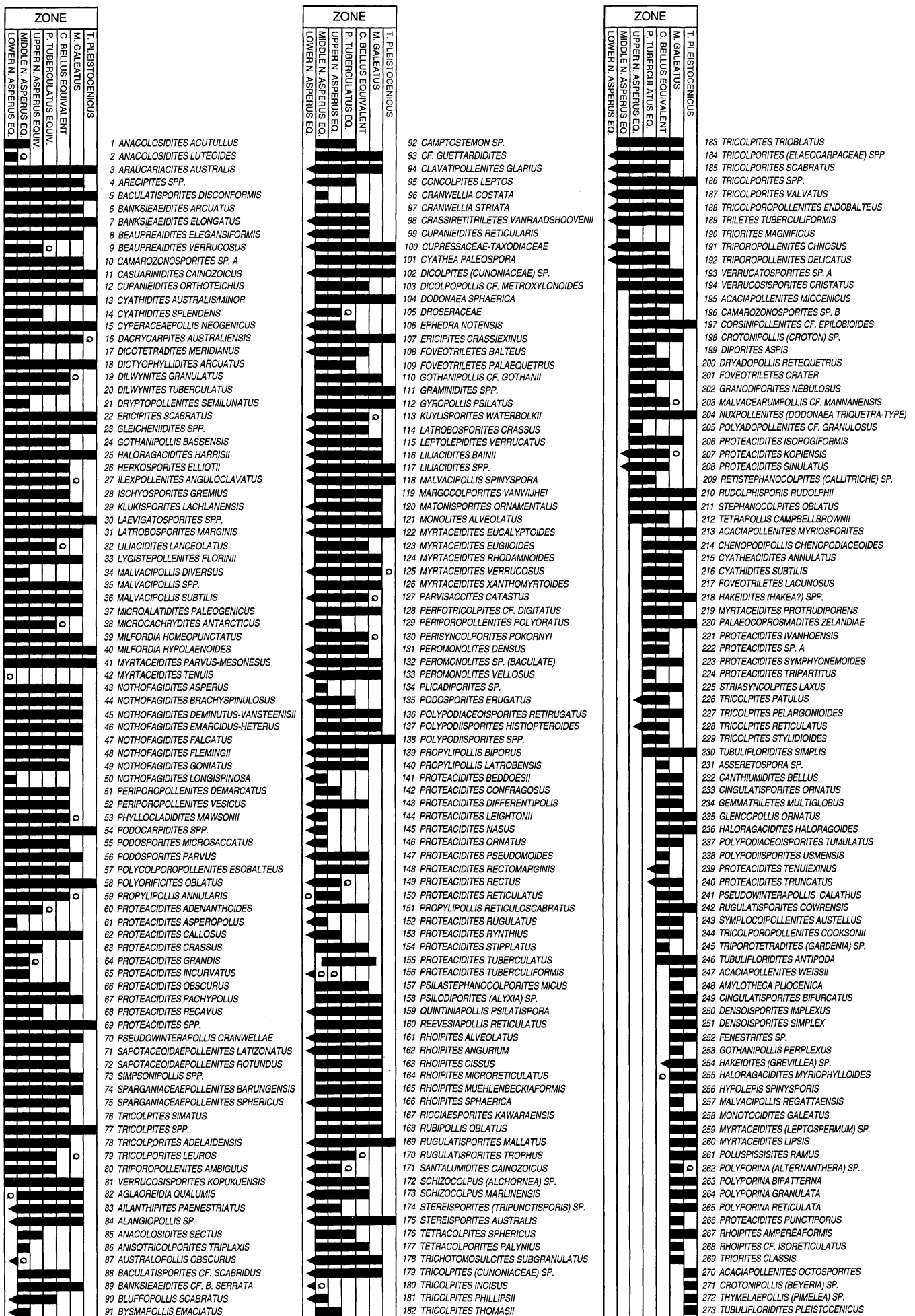


Fig.5 Time distributions of fossil spore and pollen species.

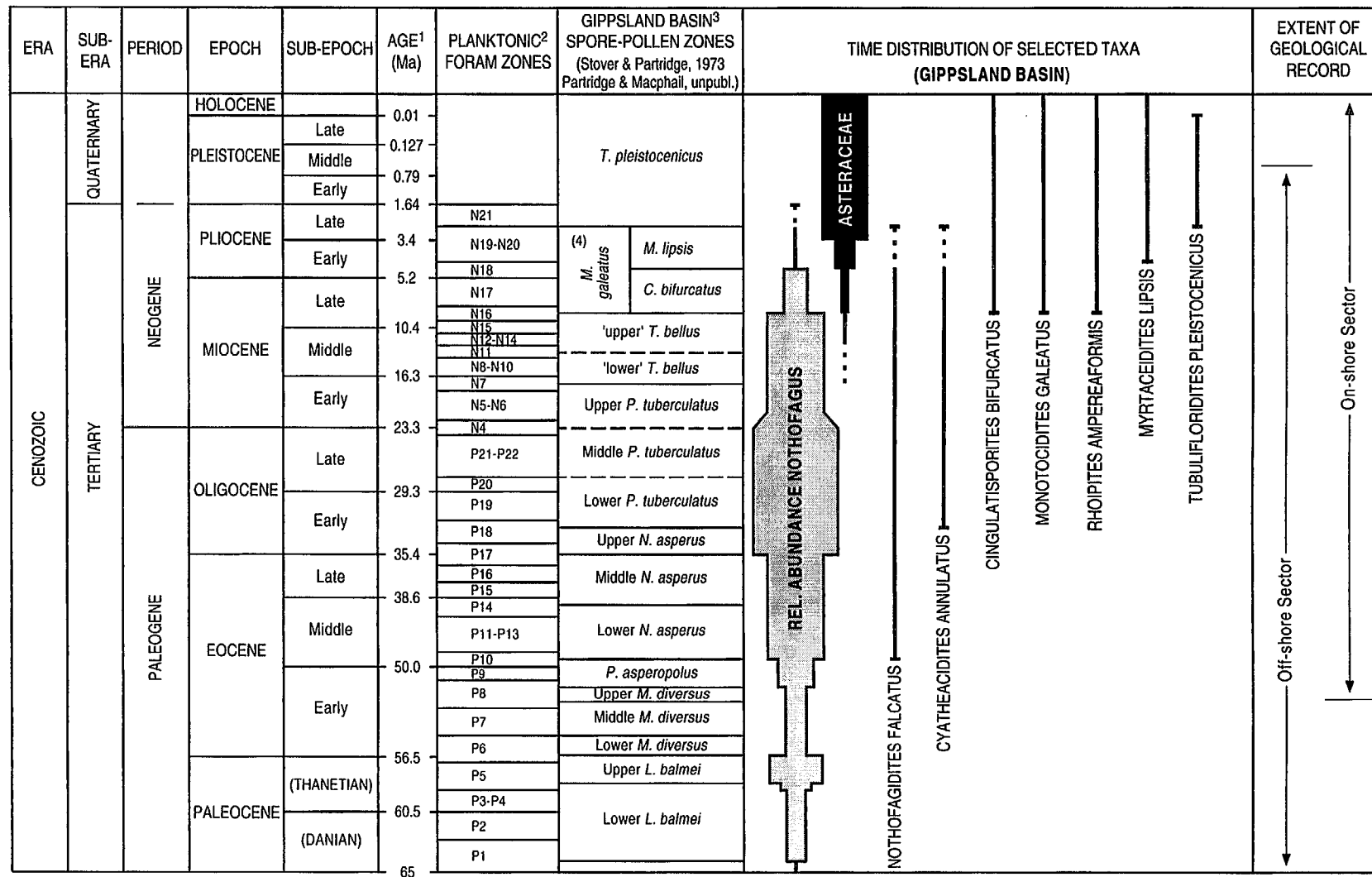
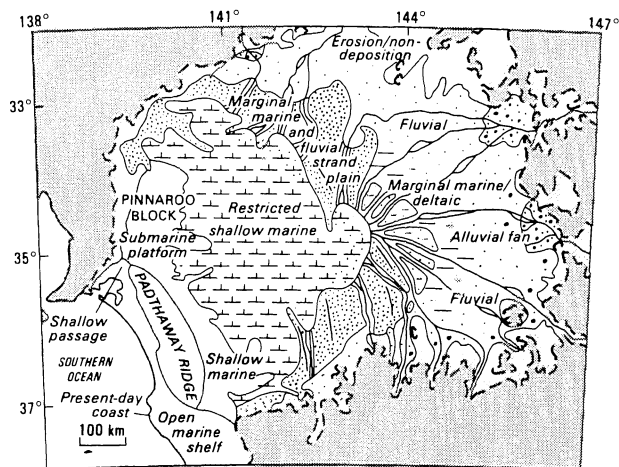
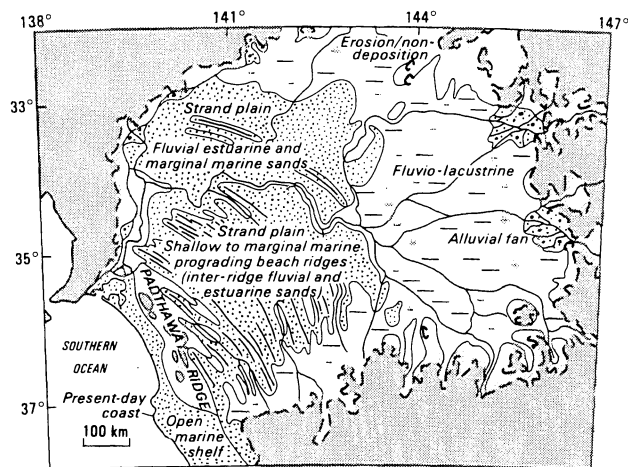


Fig.6 Correlation of palynostratigraphic zones in the Gippsland and Murray Basins.



LATE MIOCENE TO EARLY PLIOCENE

- Restricted-platform marls, silts and minor sands (Bookpurnong beds)
- Shallow to marginal-marine, and strand plain sands (Loxton-Parilla Sands)
- Fluvial fine to coarse clastics (Calivil Formation)
- Estuarine sands and oyster beds (Norwest Bend Formation)

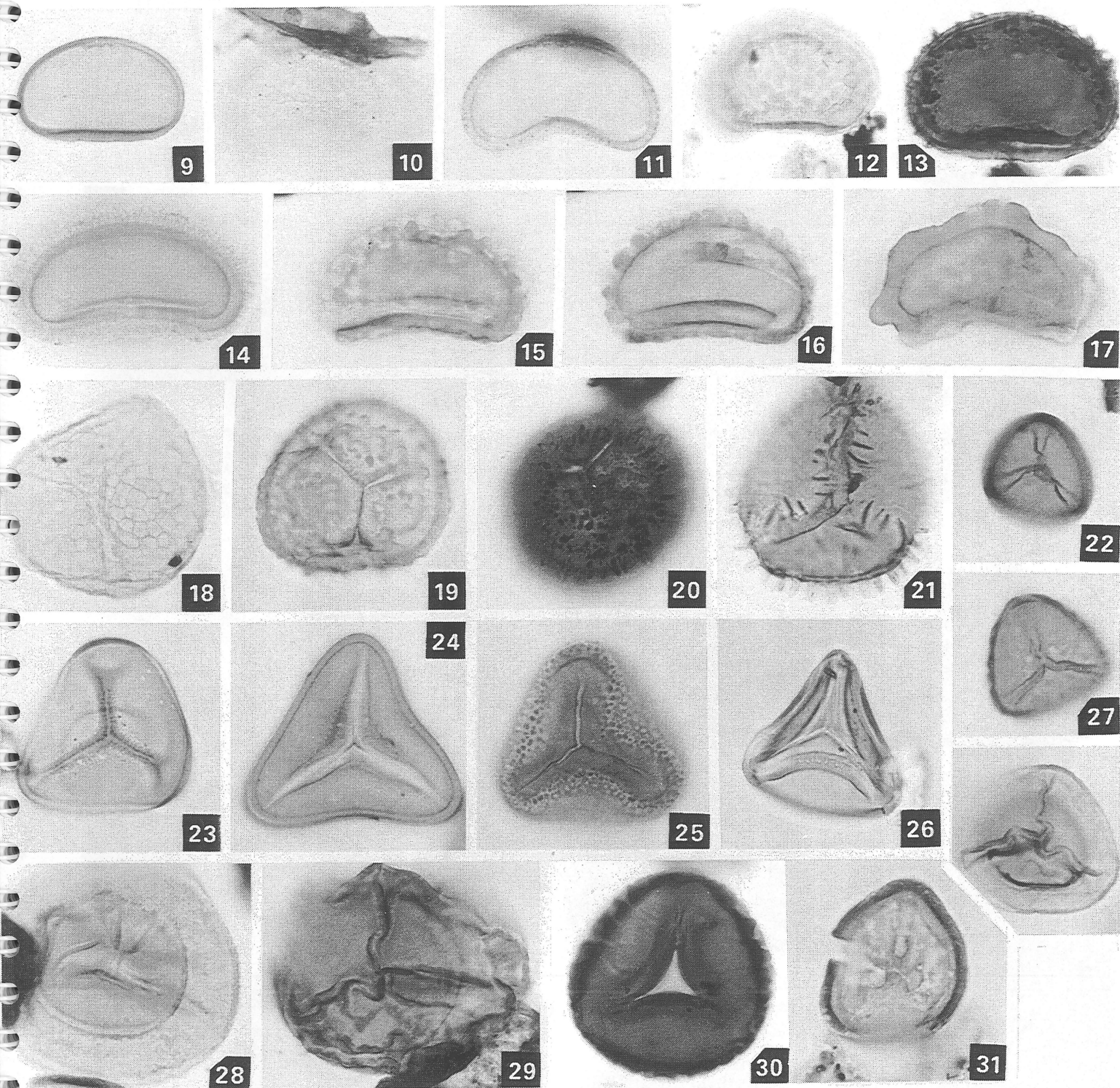


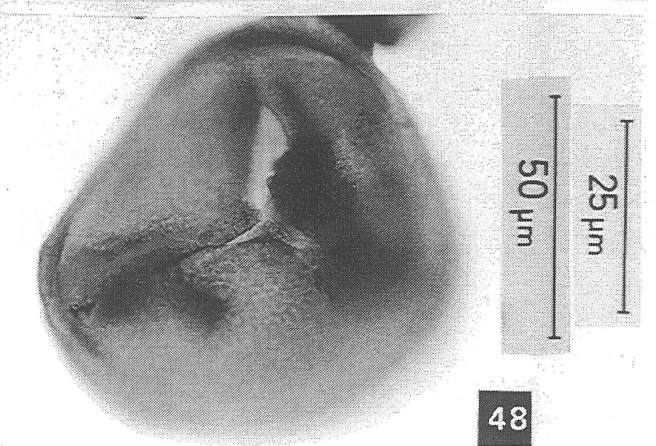
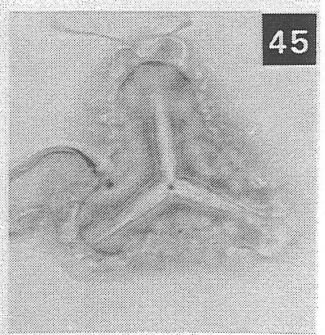
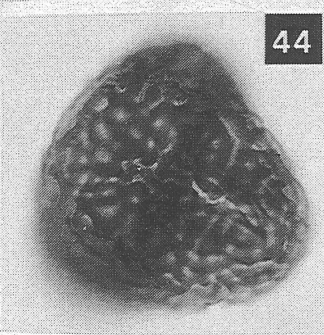
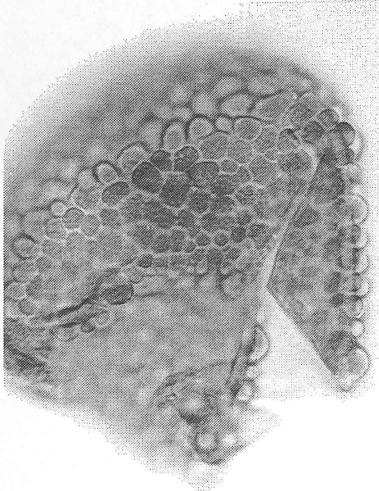
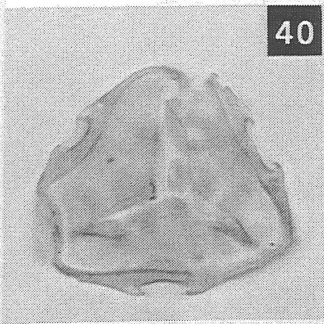
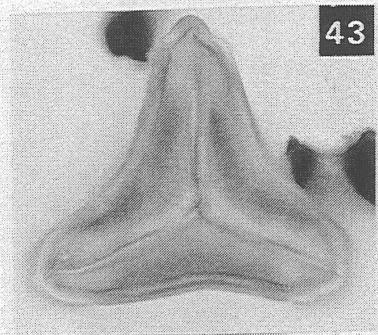
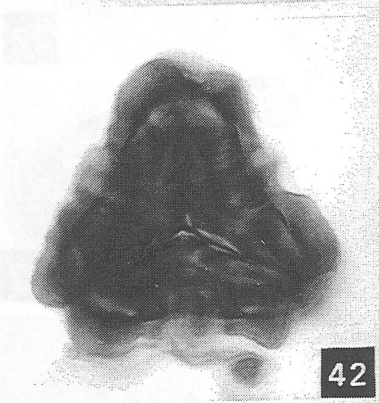
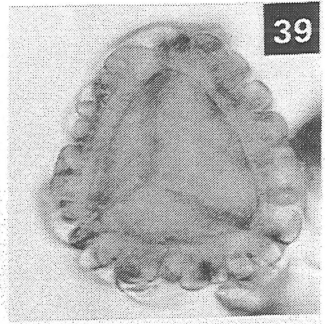
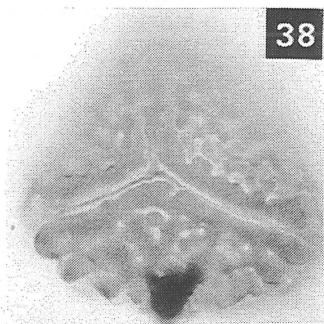
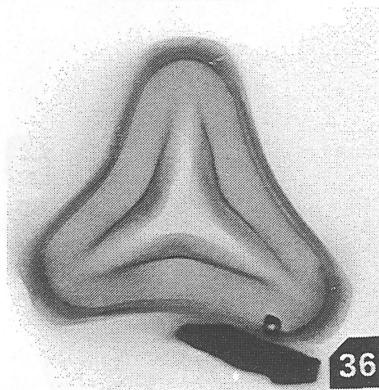
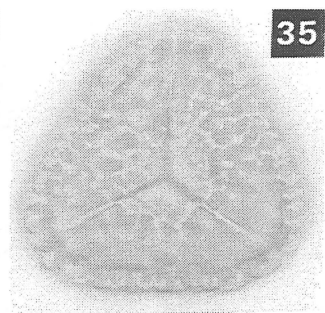
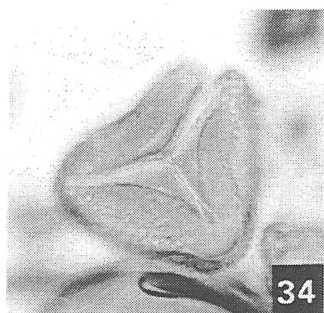
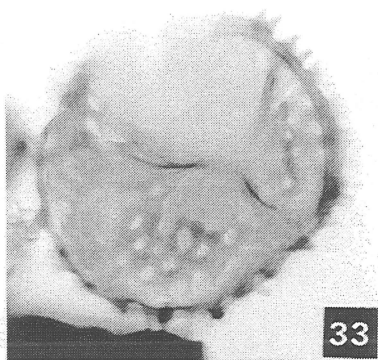
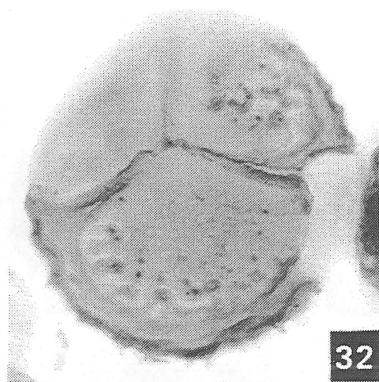
PLIOCENE

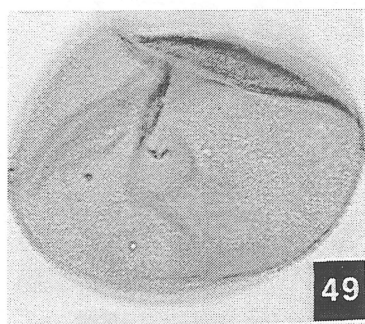
- Fluvio-lacustrine clastics (Shepparton Formation)
- Alluvial fan coarse clastics
- Areas of predominant non-deposition/erosion
- Pre-Cainozoic basement of present-day basin margins
- Former strandlines

BMR 19/A/218

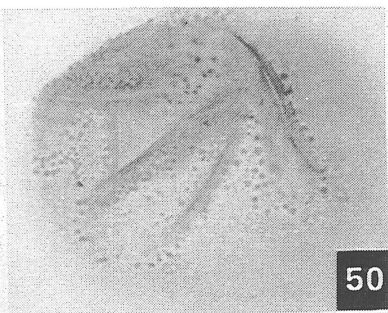
Fig. 8 Depositional environments in the Murray Basin: Late Miocene - Pliocene.



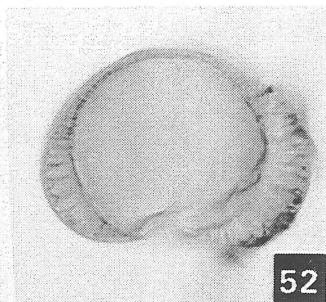




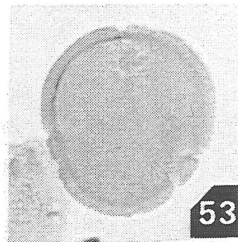
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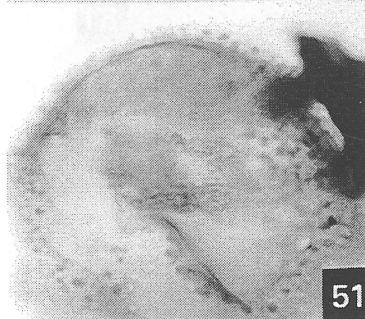
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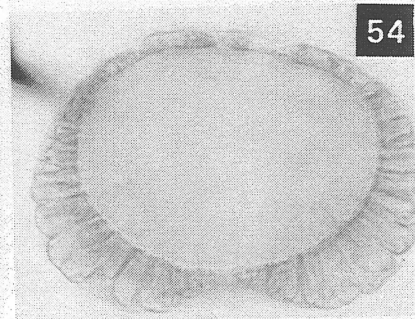
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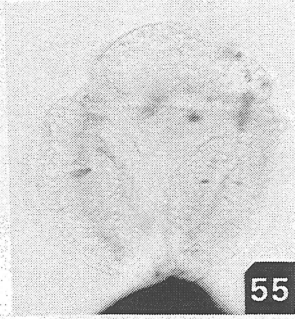
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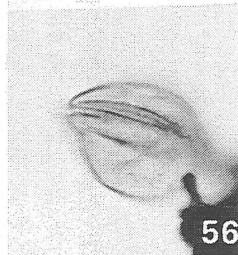
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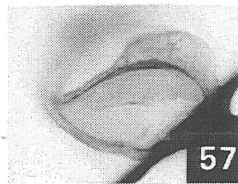
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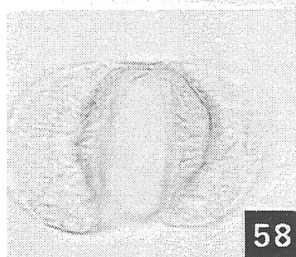
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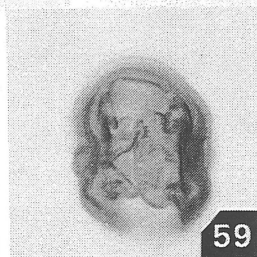
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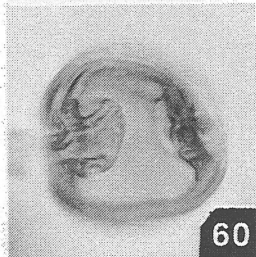
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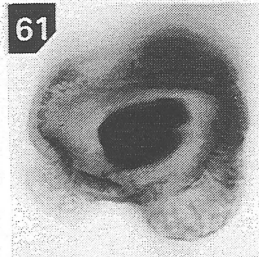
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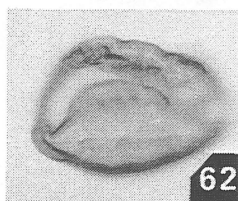
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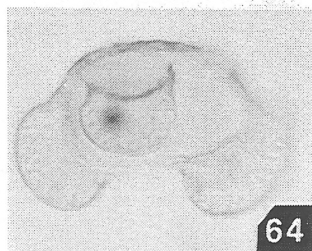
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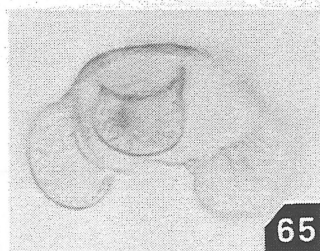
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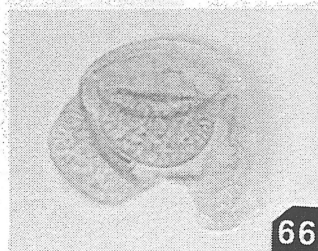
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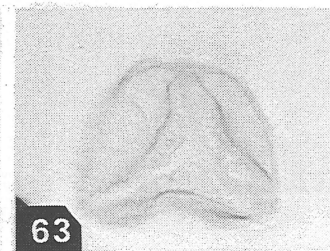
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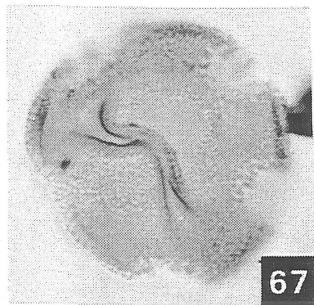
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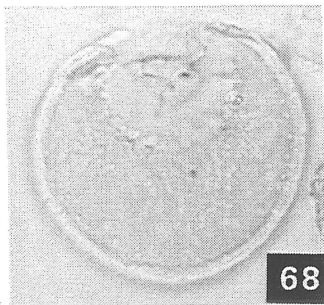
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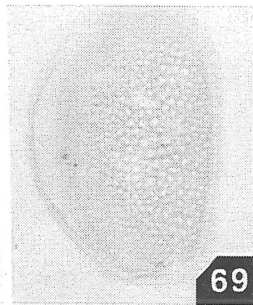
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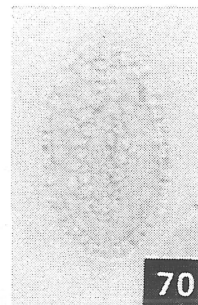
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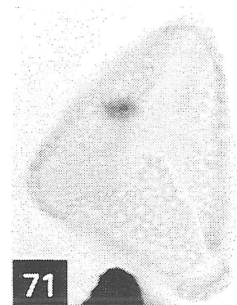
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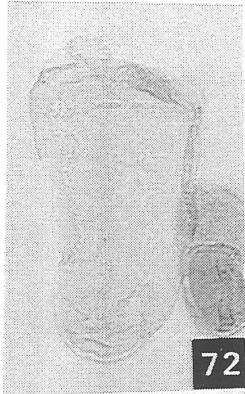
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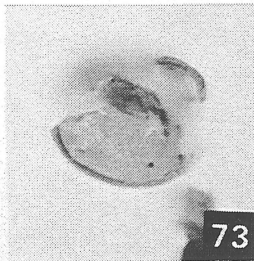
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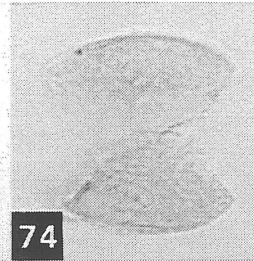
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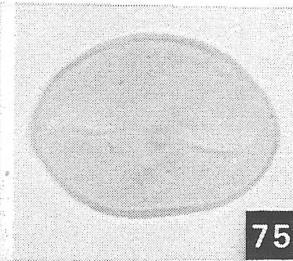
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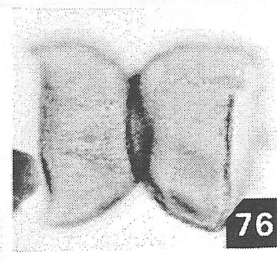
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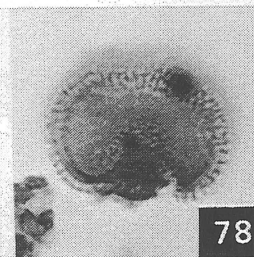
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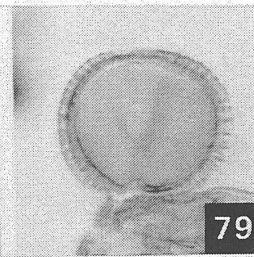
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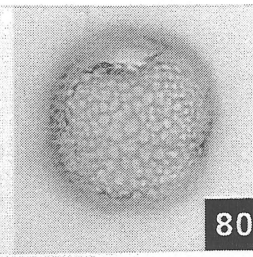
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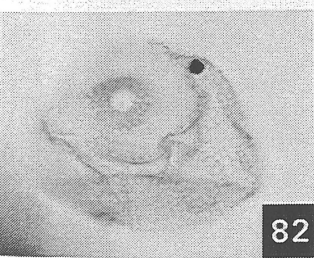
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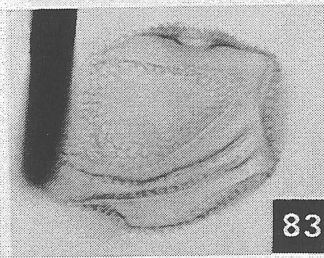
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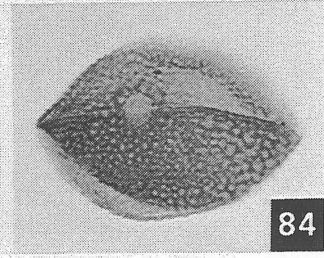
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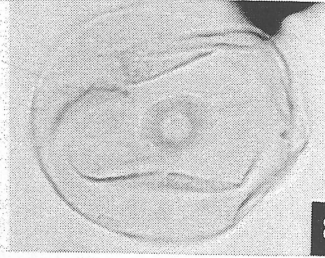
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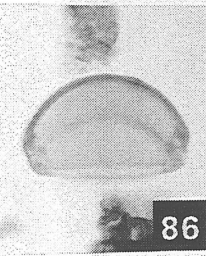
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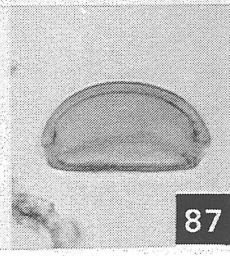
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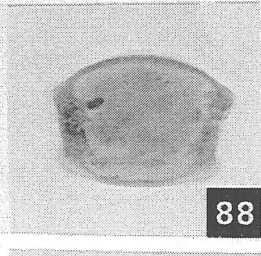
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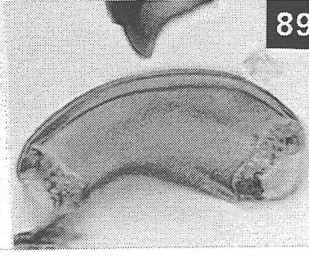
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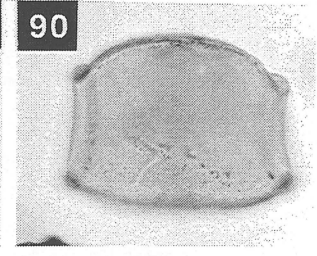
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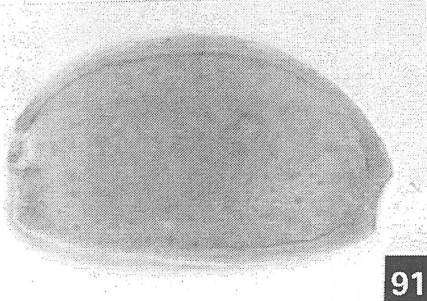
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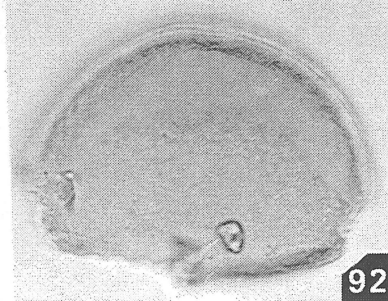
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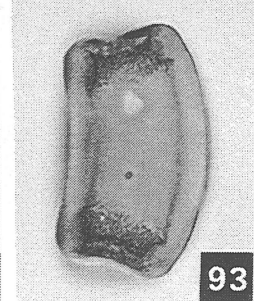
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91



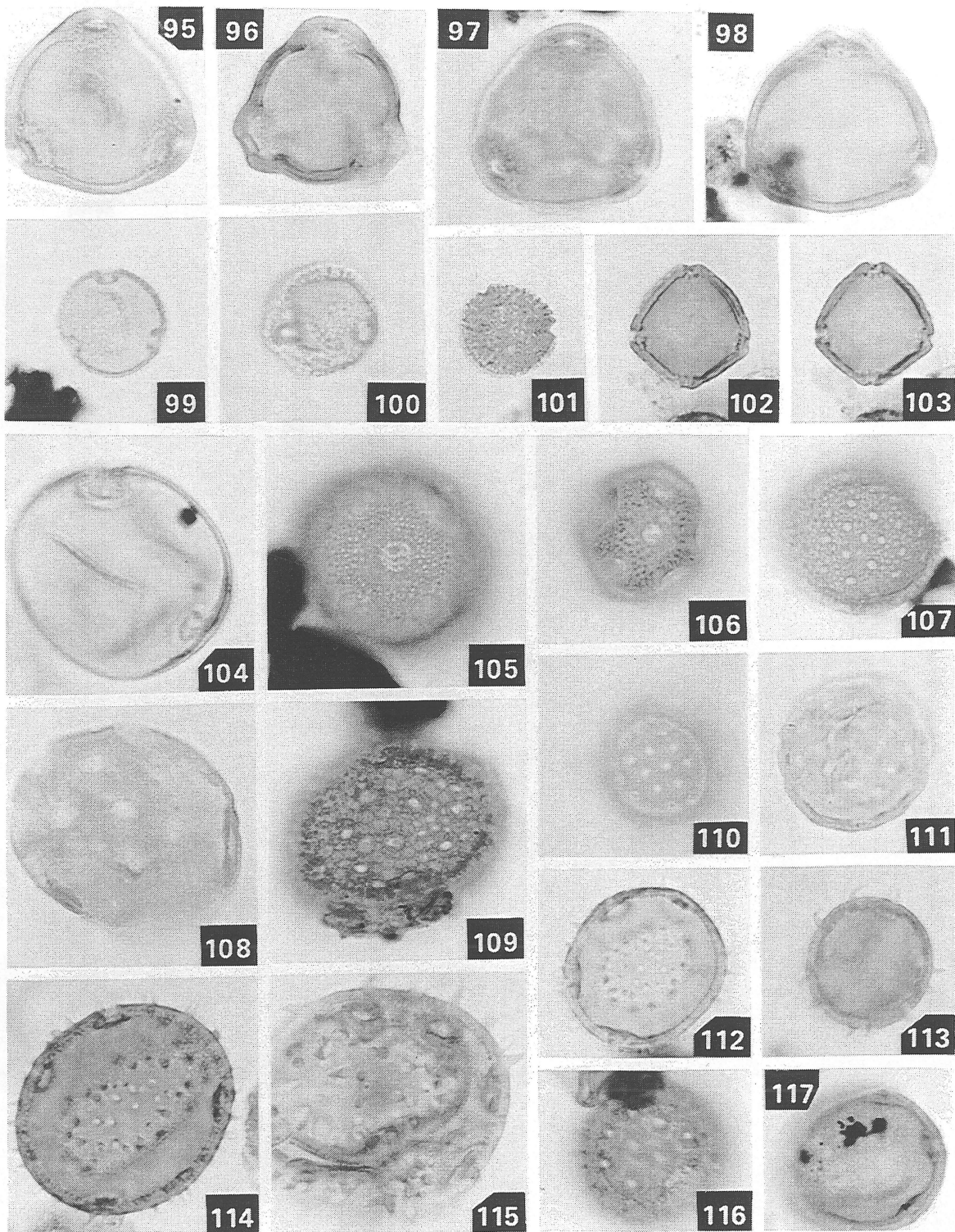
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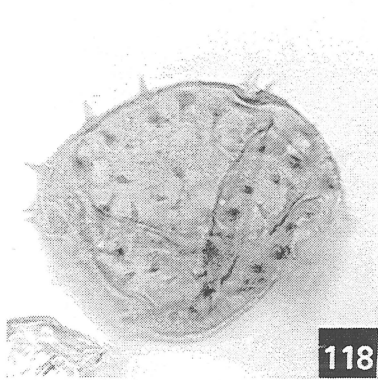


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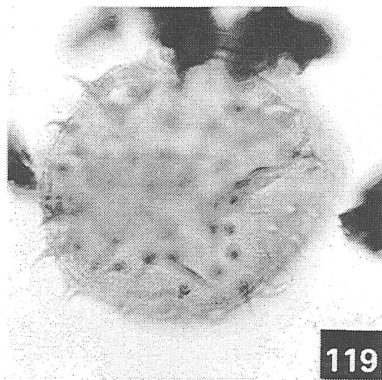


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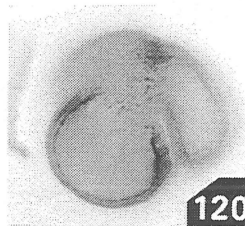




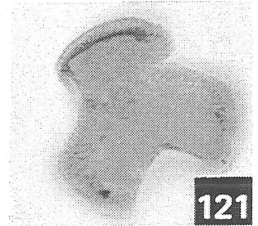
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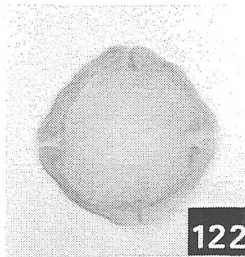
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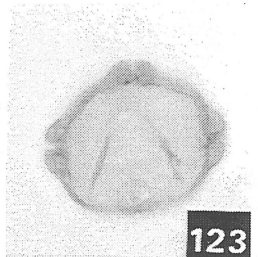
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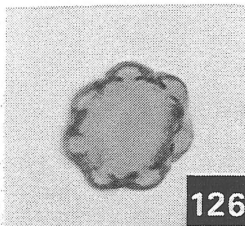
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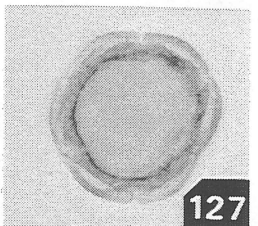
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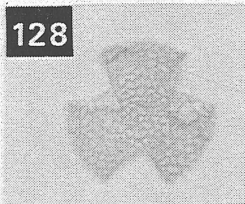
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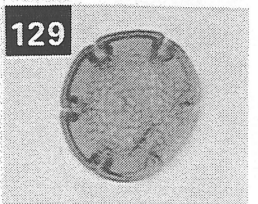
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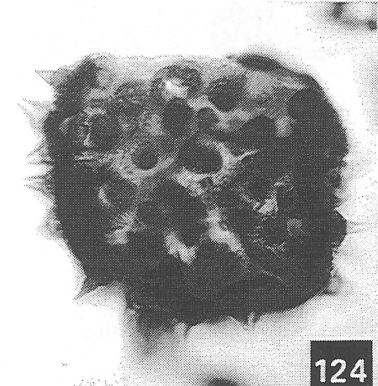
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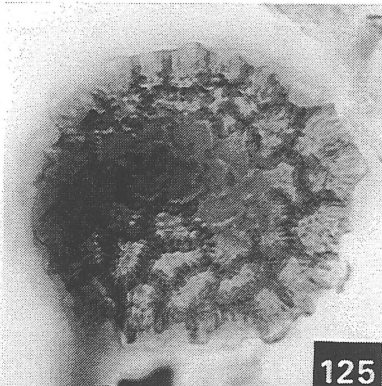
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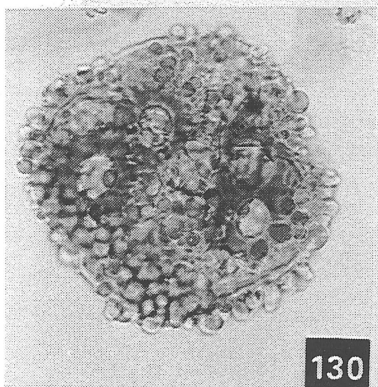
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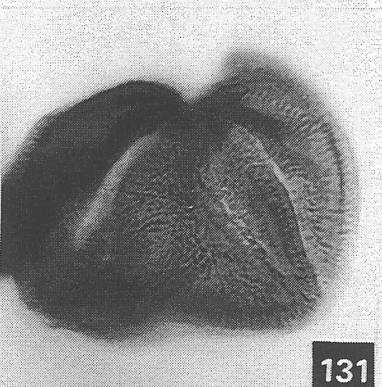
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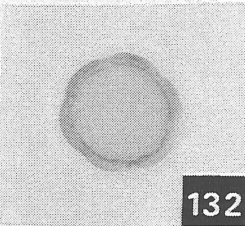
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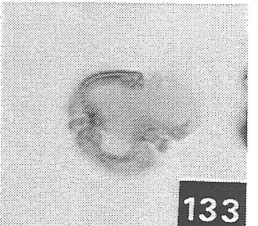
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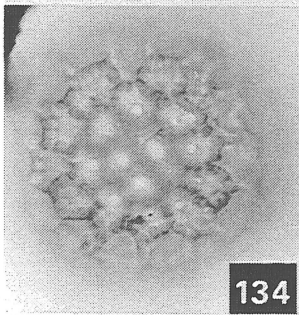
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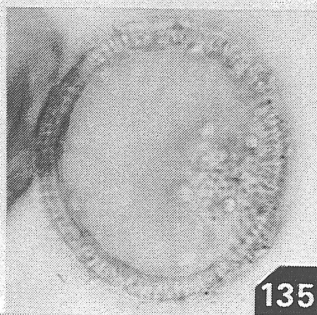
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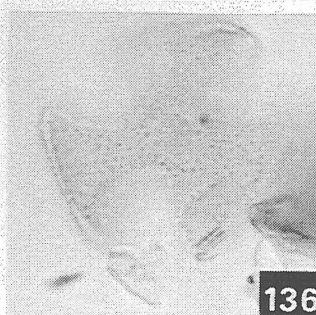
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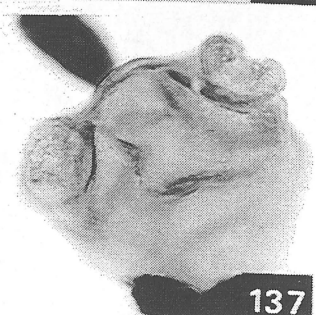
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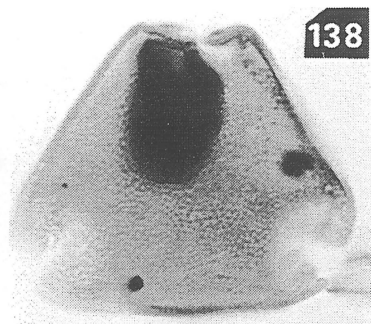
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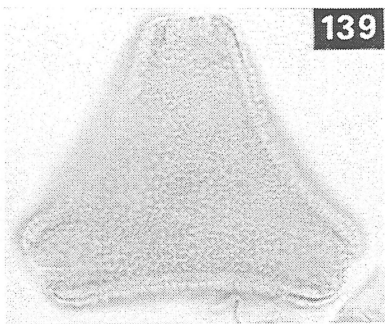
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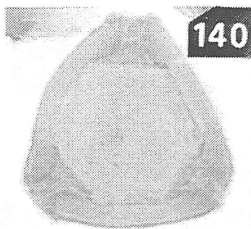
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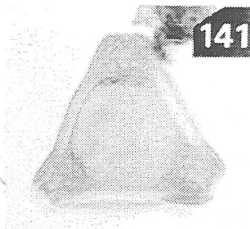
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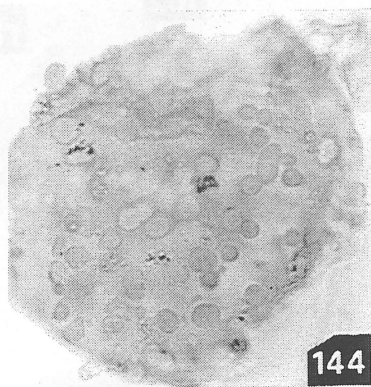
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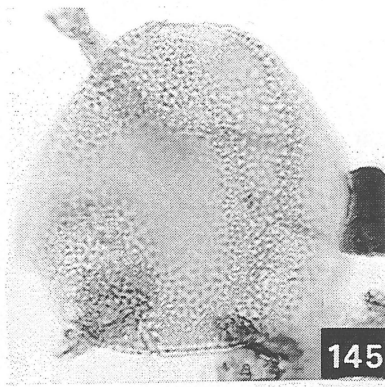
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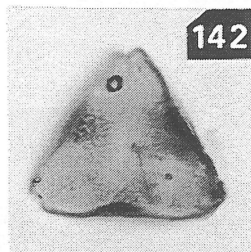
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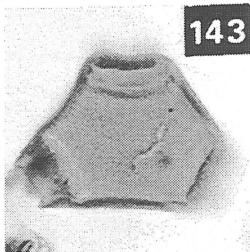
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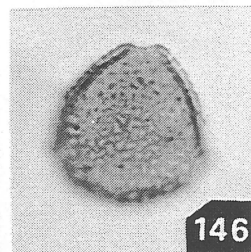
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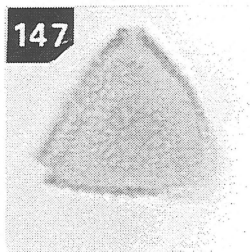
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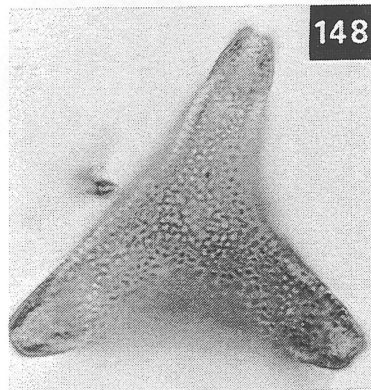
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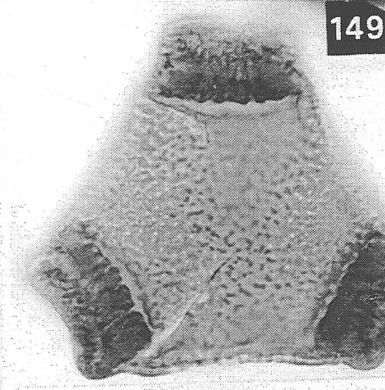
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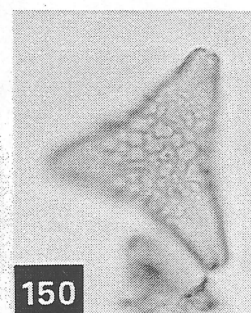
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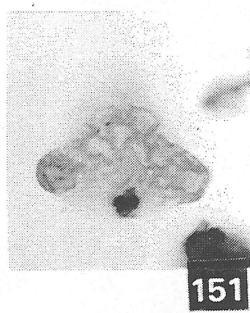
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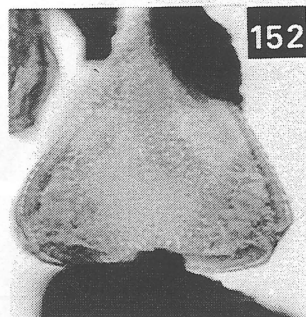
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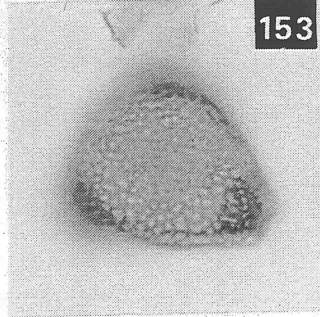
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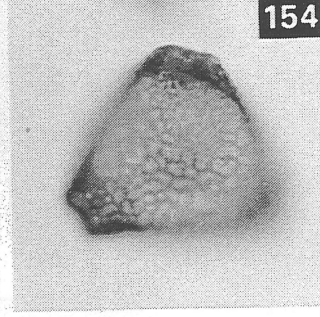
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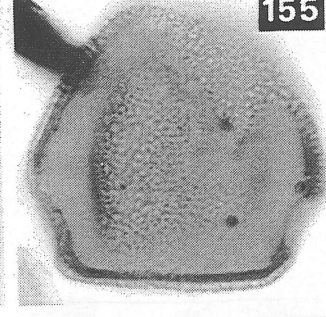
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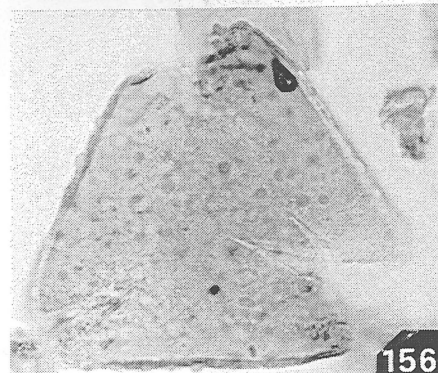
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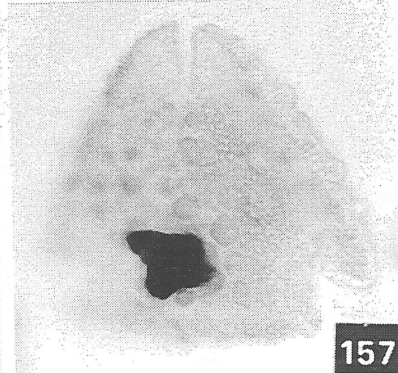
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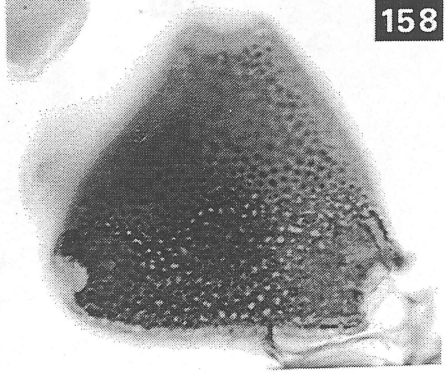
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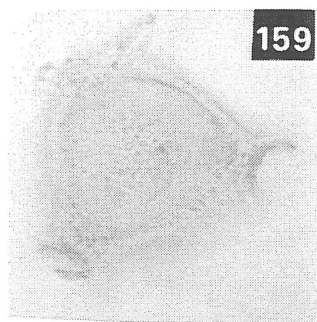
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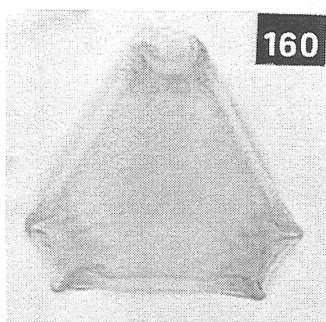
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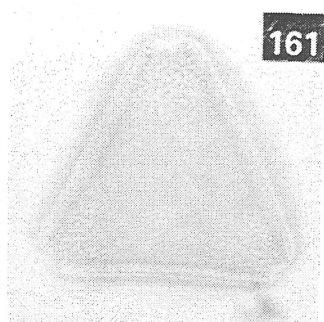
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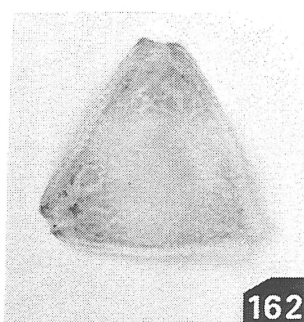
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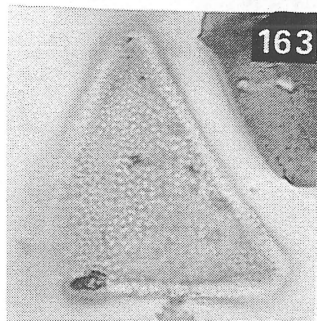
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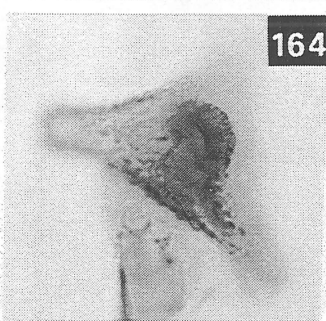
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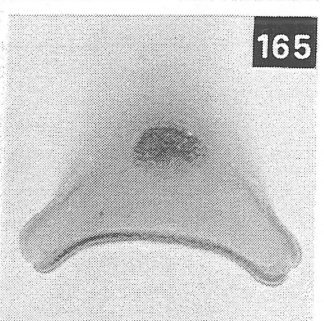
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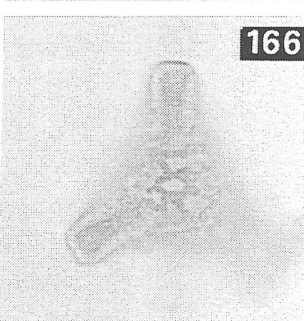
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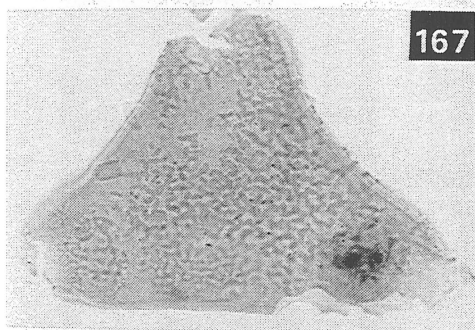
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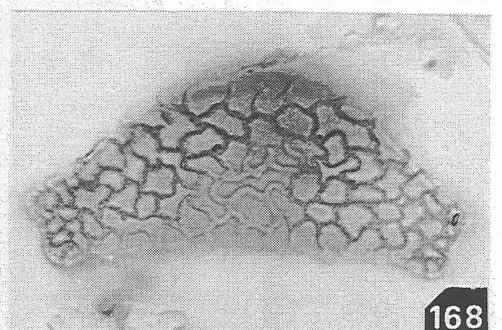
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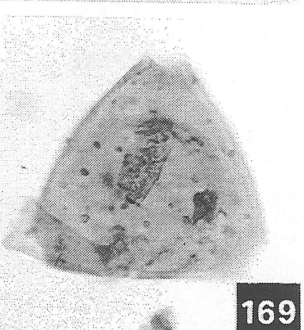
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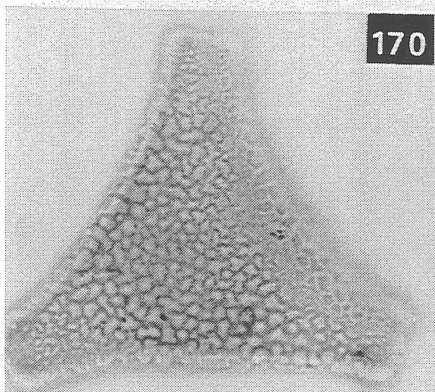
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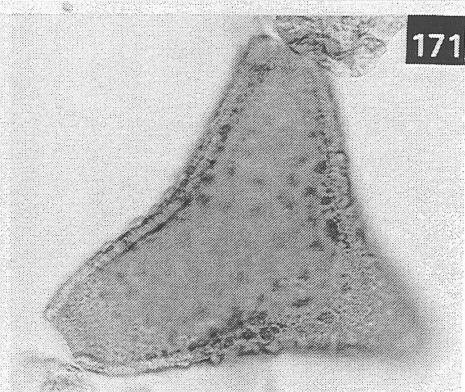
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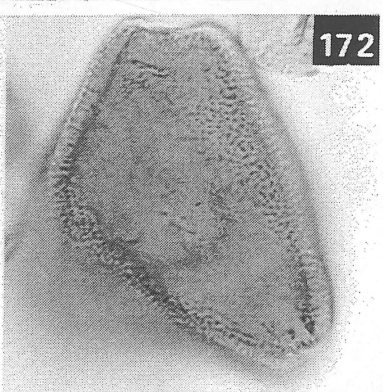
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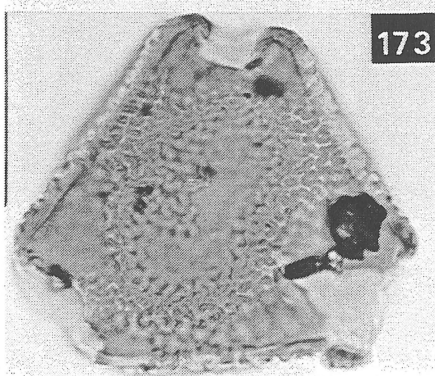
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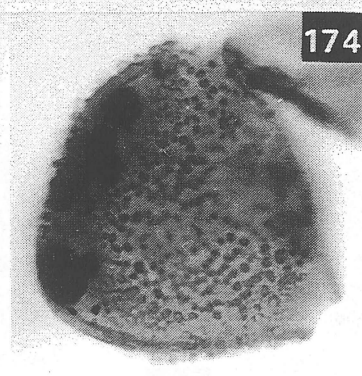
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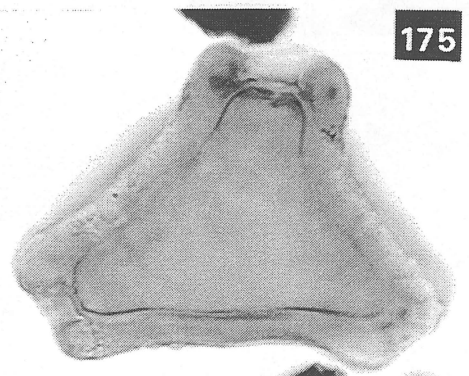
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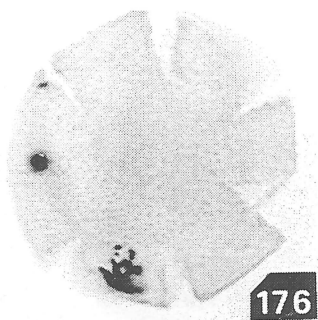
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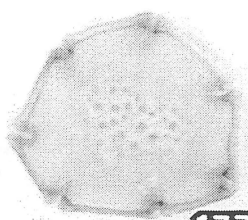
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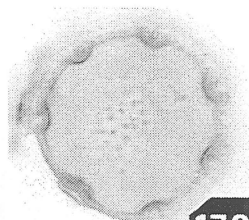
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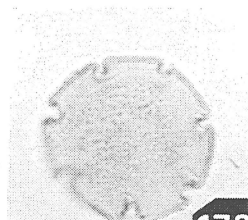
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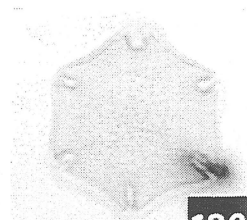
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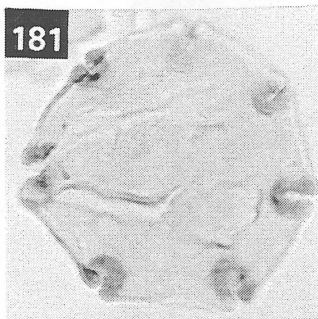
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179



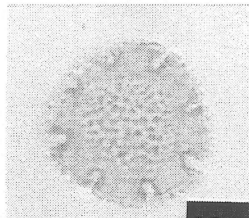
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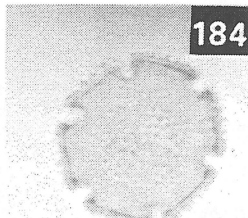
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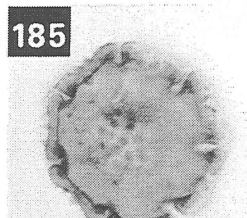
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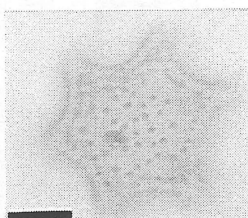
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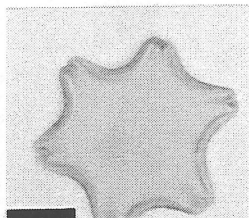
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185



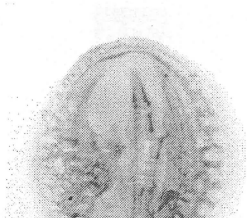
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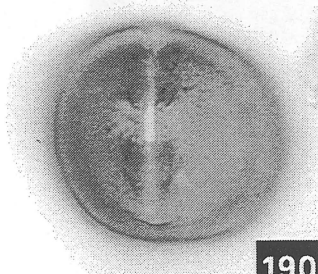
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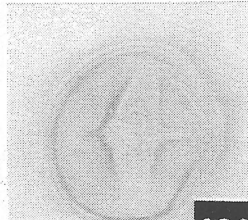
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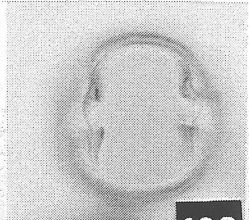
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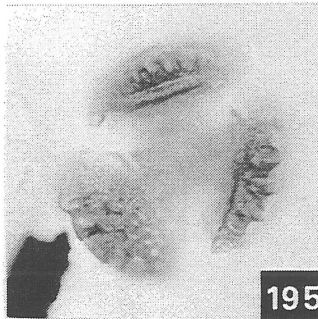
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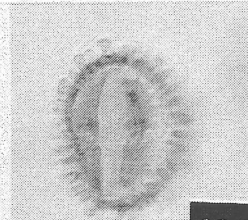
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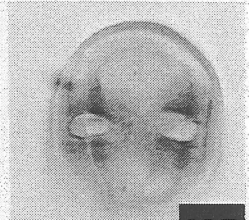
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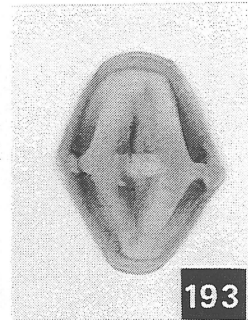
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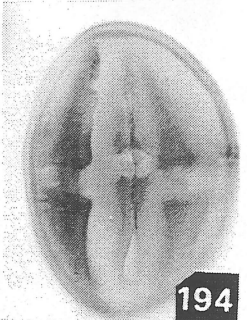
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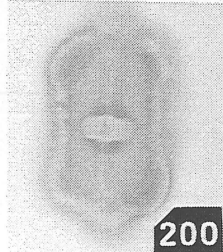
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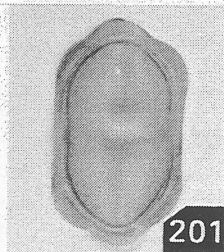
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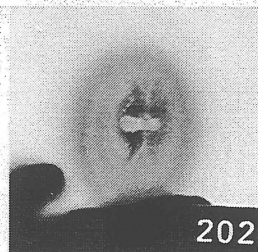
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200



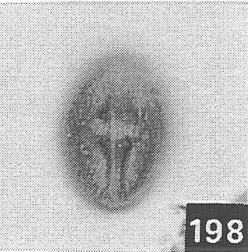
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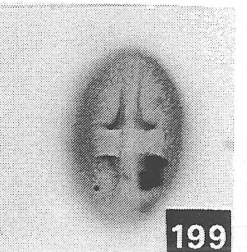
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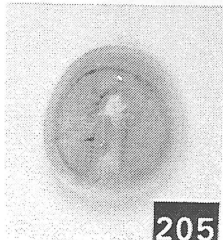
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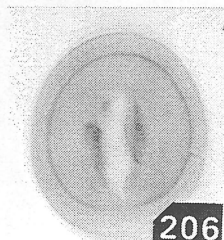
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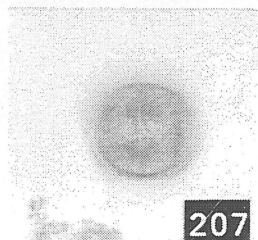
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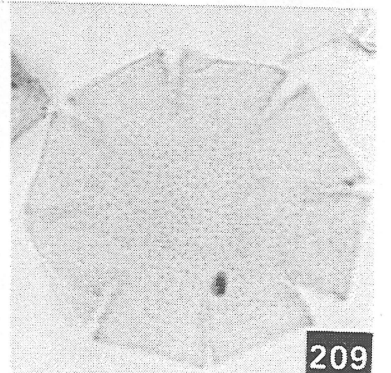
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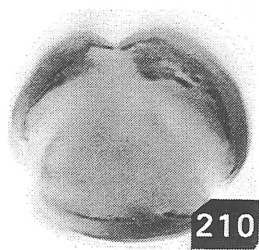
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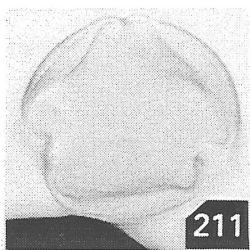
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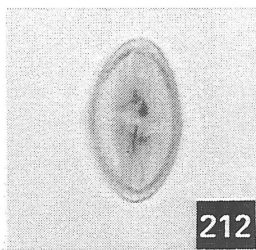
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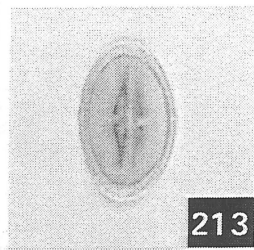
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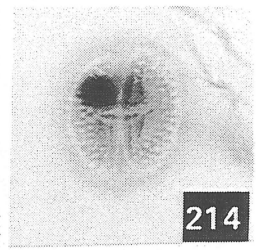
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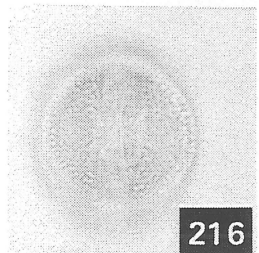
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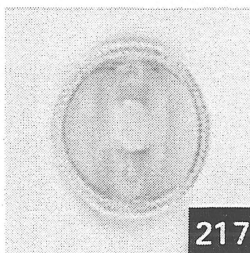
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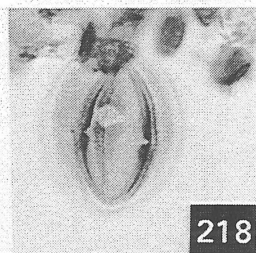
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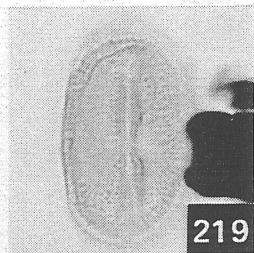
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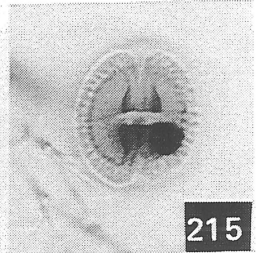
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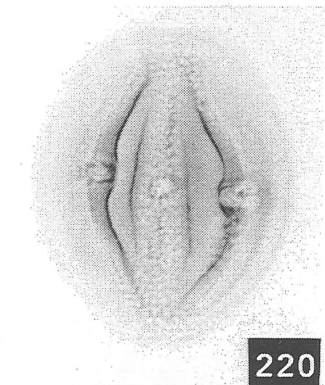
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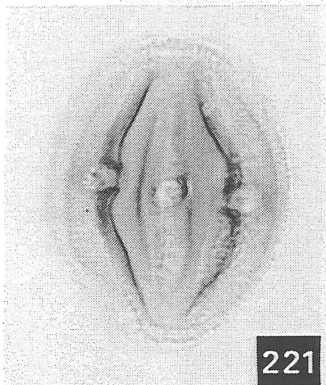
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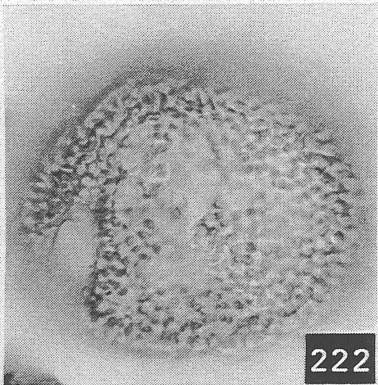
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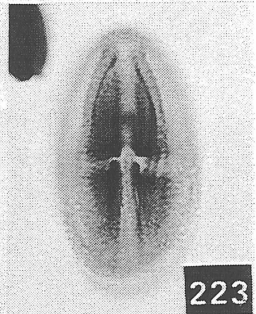
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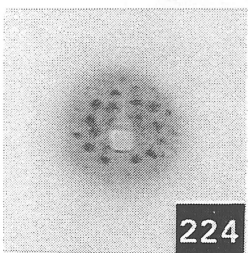
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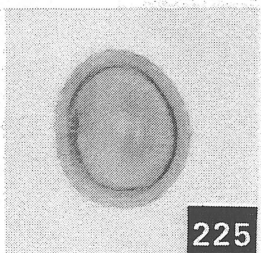
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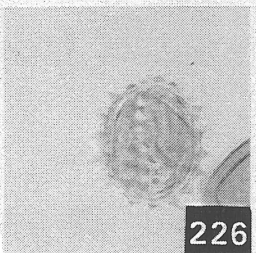
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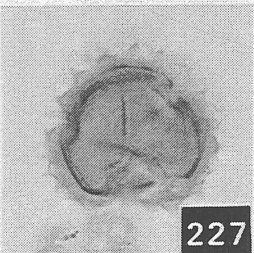
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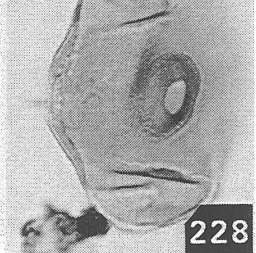
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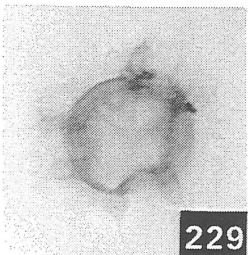
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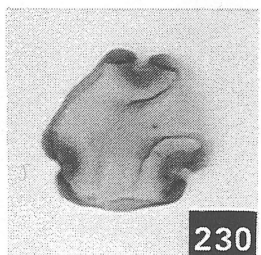
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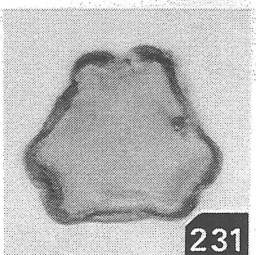
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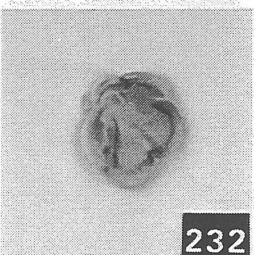
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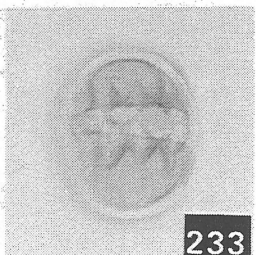
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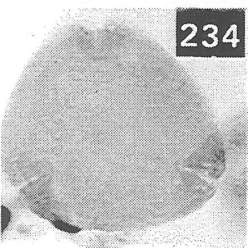
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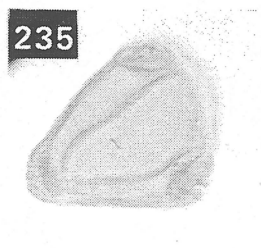
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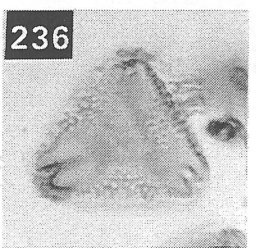
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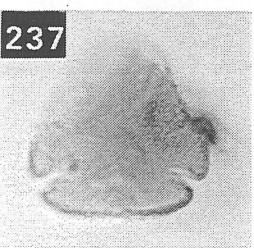
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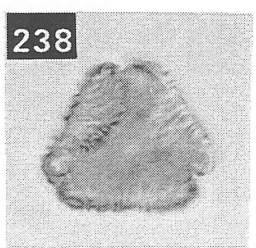
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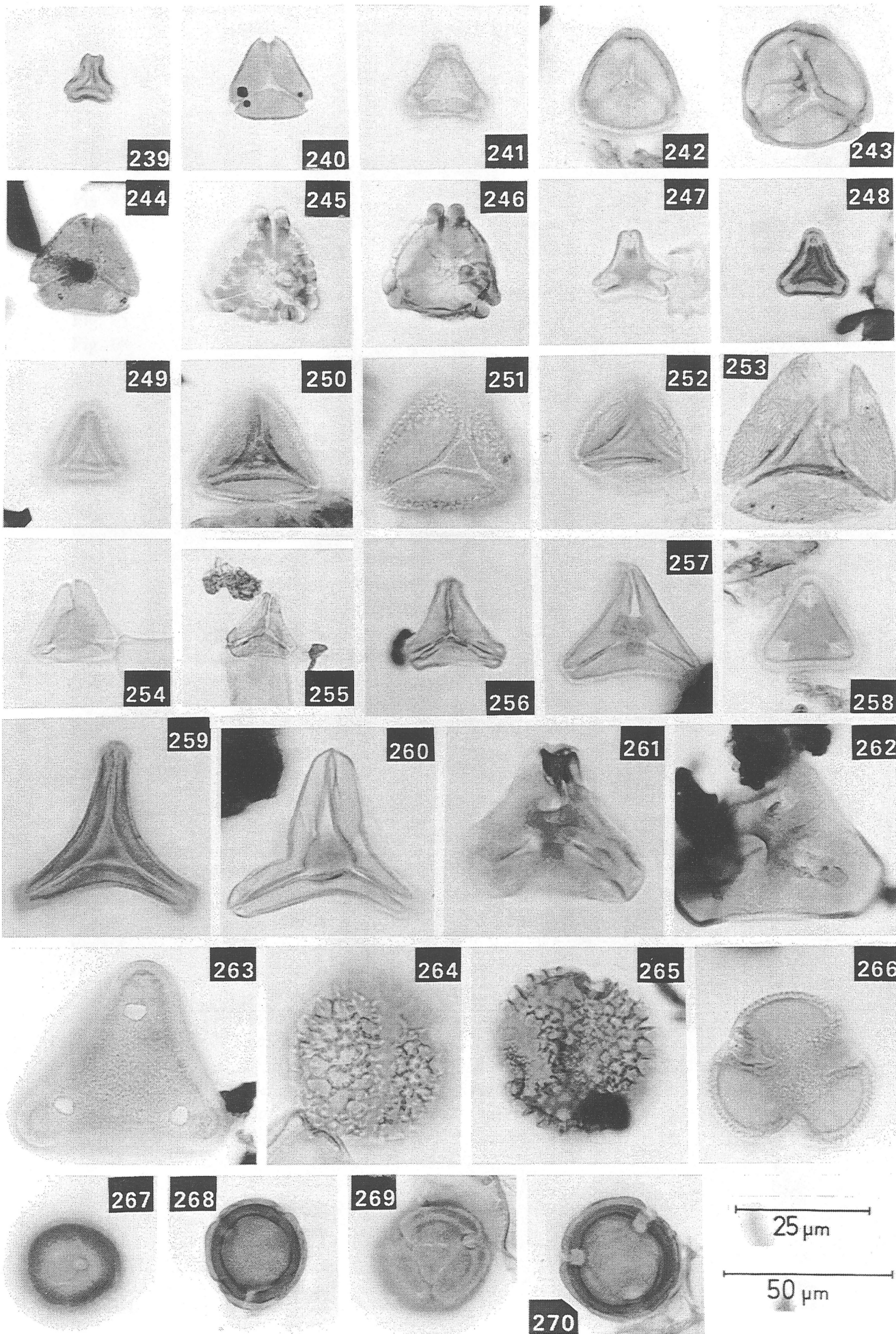
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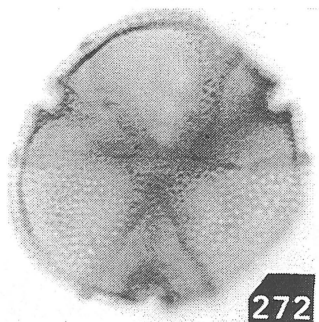


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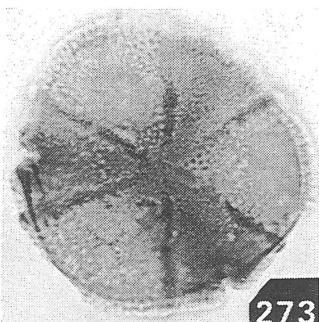




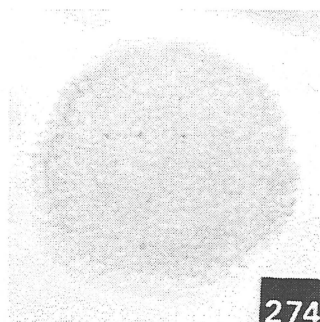
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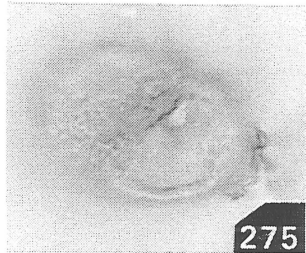
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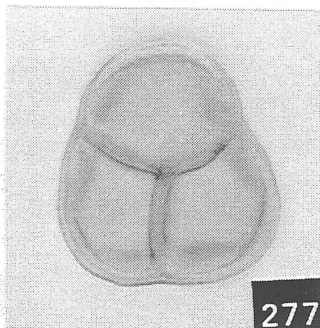
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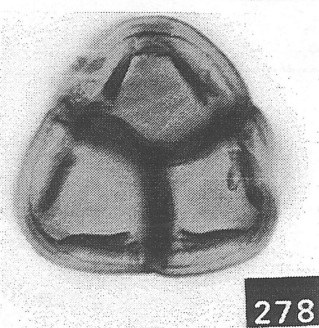
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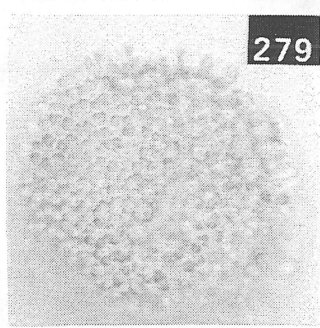
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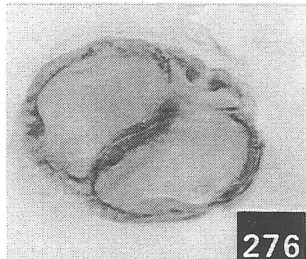
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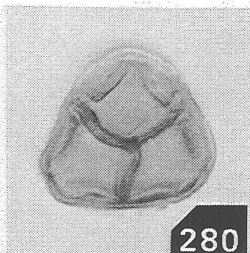
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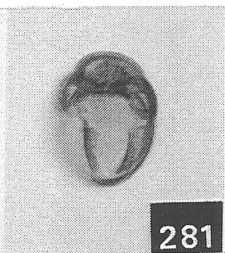
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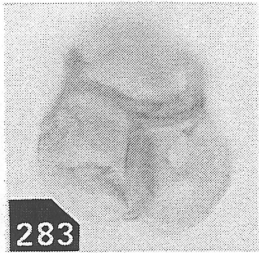
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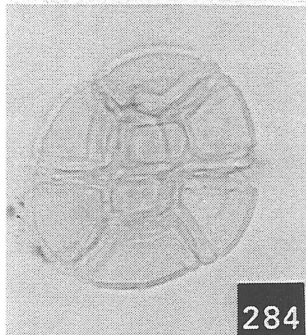
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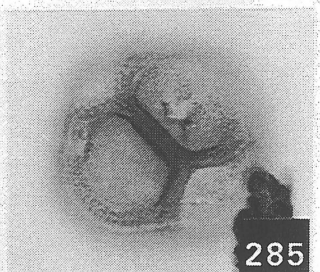
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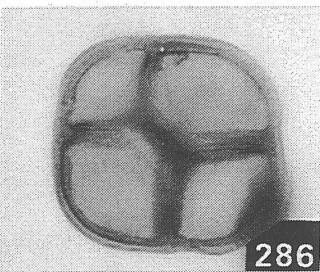
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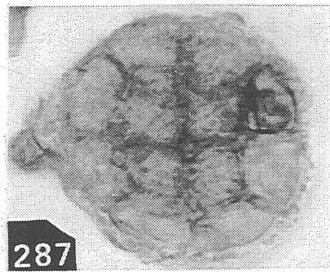
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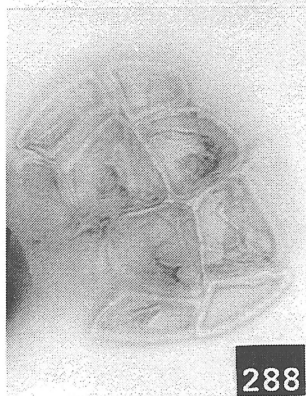
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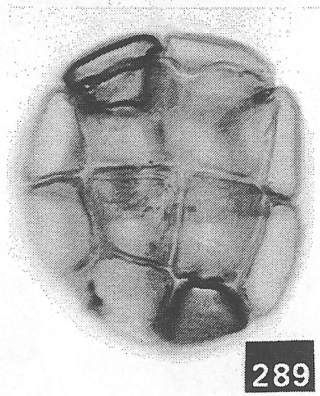
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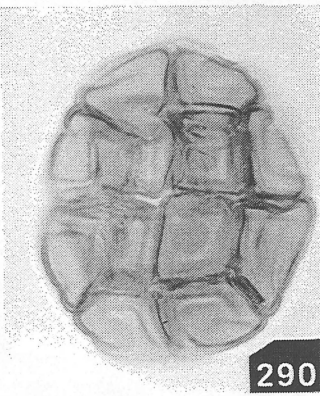
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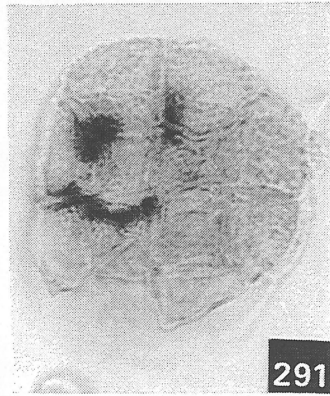
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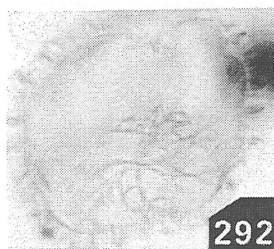
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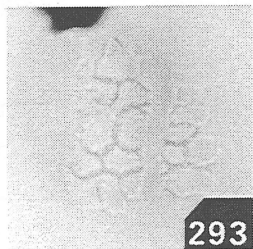
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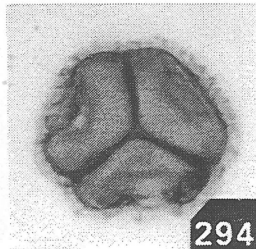
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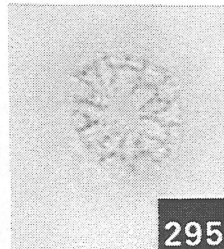
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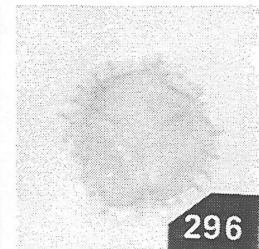
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Photomicrographs

All photomicrographs taken at x1250 magnification (= 25 micron scale) except when indicated otherwise (x 788 magnification = 50 micron scale bar)

Monolete spores

- Fig. 9 *Levigatosporites ovatus* Wilson & Webster
- Figs 10-11 *Monolites alveolatus* Couper
- Fig. 12 *Polypodiisporites* sp. x788
- Fig. 13 *Peromonolites* sp. (baculate perine)
- Fig. 14 *Peromonolites vellosus* Stover & Partridge
- Fig. 15 *Polypodiisporites histiopteroides* Mildenhall & Pocknall
- Fig. 16 *Verrucatosporites* sp. A

Trilete spores

- Fig. 18 *Ricciaesporites kawaraensis* Mildenhall & Pocknall x788
- Fig. 19 *Cingulatisporites bifurcatus* Martin
- Fig. 20 *Baculatisporites disconformis* Stover & Partridge x788
- Fig. 21 *Herkosporites elliotii* Stover & Partridge
- Fig. 22 *Stereisporites australis* Cookson x788
- Fig. 23 *Cyathidites minor* Couper
- Fig. 24 *Cathea paleospora* Martin
- Fig. 25 *Cyathidites subtilis* Stover & Partridge
- Fig. 26 *Gleicheniidites* sp. x788
- Fig. 27 *Leptolepidites verrucatus* Couper
- Fig. 28a, b *Denoisporites simplis* Macphail *et al.*
- Fig. 29 *Denoisporites implexus* Macphail *et al.*
- Fig. 30 *Camaronosporites* sp. A
- Fig. 31 *Stereisporites* (*Tripunctisporis*) sp.
- Fig. 32 *Baculatisporites* sp. cf. *B. scabridus* Playford
- Fig. 33 *Rudolphisporis rudolphi* (Krutzsch) Krutzsch
- Fig. 34 *Foveotriletes balteus* Stover & Partridge x788
- Fig. 35 *Rugulatisporites cowrensis* (Martin) Mildenhall & Pocknall
- Fig. 36 *Matonisporites ornamentalis* (Cookson) Stover & Partridge
- Fig. 37 *Cyatheacidites annulatus* Cookson x788
- Fig. 38 *Rugulatisporites mallatus* Stover & Partridge
- Fig. 39 *Rugulatisporites trophus* Stover & Partridge
- Fig. 40 *Kuylipsorites waterbolkii* Potonie
- Fig. 41 *Foveotriletes palaequetrus* Stover & Partridge
- Fig. 42 *Triletes tuberculiformis* Cookson x788
- Fig. 43 *Dictyophyllidites arcuatus* Pocknall & Mildenhall
- Fig. 44 *Crassiretitriletes vanraadshoovenii* Germeraad *et al.* (distal face) x788
- Fig. 45 *Matonisporites* sp. cf. *M. ornamentalis* (Cookson) Stover & Partridge x788
- Fig. 46 *Verrucosisorites kopukuensis* (Couper) Stover & Evans x788
- Fig. 47 a, b *Ischyosporites gremius* Stover & Partridge
- Fig. 48 *Cyathidites splendens* Harris x788



* R 9 6 0 5 7 0 3 *

Gymnosperms

- Fig. 49 *Araucariacites australis* Cookson x788
Fig. 50 *Dilwynites granulatus* Harris x788
Fig. 51 *Parvisaccites catastus* Stover & Partridge
Fig. 52 '*Tetracolpites*' *sphericus* Couper
Fig. 53 *Dilwynites tuberculatus* Harris
Fig. 54 *Lygistepollenites florinii* ((Cookson & Pike) Stover & Evans
Fig. 55 *Dacrycarpites australiensis* Cookson & Pike x788
Fig. 56 Cupressaceae-Taxodiaceae
Fig. 57, 62 *Microalatidites palaeogenicus* (Cookson) Mildenhall & Pocknall
Fig. 58 *Podocarpidites* sp. x788
Figs. 59, 60 *Phyllocladidites mawsonii* Cookson ex Couper
Fig. 61 *Microcachrydites antarcticus* Cookson
Fig. 63 *Trichotomosulcites subgranulosus* Couper
Figs 64, 65 *Podosporites erugatus* Mildenhall
Fig. 66 *Podosporitessp.* cf *P. parvus* (Couper) Mildenhall

Angiosperms

- Fig. 67 *Australopollis obscurus* Harris
Fig. 68 *Milfordia hypolaenoides* Erdtman
Fig. 69 *Liliacidites bainii* Stover & Partridge
Fig. 70 *Liliacidites lanceolatus* Stover & Partridge
Fig. 71 *Liliacidites* sp. cf *L. phormioides* Stover & Partridge
Fig. 72 *Cyperaceapollis neogenicus* Mildenhall & Pocknall x788
Fig. 73 *Dicolpopollis* sp. x788
Fig. 74 *Dicolpopollis* sp. cf *D. metroxylonoides* Khan
Fig. 75 *Arecipites* sp.
Fig. 76 *Dryptopollenites semilunatus* Stover & Partridge
Fig. 77 *Dicolpites* (Cunoniaceae) sp.
Fig. 78, 79 *Clavatipollenites glarius* Stover & Partridge
Fig. 80 *Sparganiaceapollenites barungensis* Harris
Fig. 81 *Graminidites* sp.
Figs. 82, 83 *Aglaoreidia qualumis* Stover & Partridge
Fig. 84 *Sparganiaceapollenites sphericus* (Couper) Mildenhall & Crosbie
Fig. 85 *Milfordia homeopunctata* (McIntyre) Stover & Partridge
Fig. 86, 87 *Banksieaeidites arcuatus* Stover & Partridge
Fig. 88 *Banksieaeidites elongatus* Cookson
Fig. 89 *Banksieaeidites* sp. of Macphail & Truswell (cf *Banksia serrata*) x788
Fig. 90 *Psiladiporites (Alyxia)* sp. x788
Fig. 91 *Granodiporites nebulosus* Stover & Partridge
Fig. 92 *Plicadiporites* sp.
Figs. 93, 94 *Banksieaeidites* sp. cf *B. elongatus* Cookson x788
Figs. 95, 96 *Casuarinidites cainozoicus* Cookson & Pike
Figs. 97, 98 *Haloragacidites harrisii* (Couper) Harris
Figs. 99, 100 *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall
Fig. 101 cf *Guettardidites* sp. x788

- Fig. 102, 103 *Tetrapollis campbellbrownii* Macphail & Truswell
 Fig. 104 *Parsonsidites psilatus* Couper
 Fig. 105 *Periporopollenites demarcatus* Stover & Partridge
 Fig. 106 *Polyporina granulata* Martin
 Fig. 107 *Polyporina reticulata* Martin
 Fig. 108 *Periporopollenites polyoratus* (Couper) Stover & Evans
 Fig. 109 *Thymelaepollis (Pimelea)* sp.
 Figs. 110, 111 *Chenopodipollis chenopodiaceoides* (Martin) Truswell *et al.*
 Fig. 112 *Malvacipollis subtilis* Stover & Partridge
 Figs. 113-115 *Malvacipollis* spp.
 Fig. 116 *Malvacipollis spinyspora* (Martin) Mildenhall & Pocknall x788
 Fig. 117 *Polyorificites oblatulus* Martin
 Figs. 118, 119 *Malvacearumpollis* spp. x788
 Fig. 120 *Tricolpites reticulatus* Cookson
 Fig. 121 *Tricolpites trioblatus* Mildenhall & Pocknall
 Fig. 122 *Haloragacidites haloragoides* Cookson & Pike
 Fig. 123 *Haloragacidites myriophylloides* Cookson & Pike
 Fig. 124 *Malvacearumpollis* sp. cf *M. mannensis* Wood x788
 Figs. 125, 134 *Glencopollis ornatus* Pocknall & Mildenhall
 Figs. 126, 127 *Psilastephanocolporites micus* Stover & Partridge
 Fig. 128 *Tricolpites patulus* Truswell & Owen
 Fig. 129 *Reevesiapollis reticulatus* (Couper) Krutzsch
 Fig. 130 *Clavastephanocolporites* sp. x788
 Fig. 131 *Perforitricolpites* sp. cf *P. digitatus* Gonzalez Guzman
 Fig. 132 *Stephanocolpites oblatulus* Martin
 Fig. 133 *Schizocolpus Alchornea* sp.
 Fig. 135 *Malvacipollis regattaensis* Macphail *et al.*
 Fig. 136 *Tricolpites stylidioides* Macphail *et al.*
 Fig. 137 *Corsinipollenites* sp cf *C. epilobioides* Krutzsch x788
 Fig. 138 *Beaupreaidites elegansiformis* Cookson
 Fig. 139 *Proteacidites rectomarginis* Cookson x788
 Fig. 140 *Proteacidites* sp. cf *P. callosus* Cookson
 Fig. 141 *Propylipollis latrobensis* (Harris) Martin & Harris
 Fig. 142 *Proteacidites sinulatus* Dudgeon
 Fig. 143 *Propylipollis annularis* (Cookson) Martin & Harris
 Fig. 144 *Proteacidites* sp. aff *P. tuberculatus* Cookson
 Fig. 145 *Proteacidites isopogiformis* Stover & Partridge x788
 Fig. 146 *Proteacidites symphyonemoides* Cookson
 Fig. 147 *Proteacidites pseudomoides* Stover & Partridge
 Fig. 148 *Proteacidites crassus* Cookson x788
 Fig. 149 *Proteacidites* sp.
 Figs. 150, 151 *Proteacidites reticulatus* Cookson
 Fig. 152 *Proteacidites concretus* Dudgeon
 Figs. 153, 154 *Proteacidites differentipolis* Dudgeon
 Fig. 155 *Proteacidites* sp. cf *P. truncatus* Cookson
 Fig. 156, 157 *Beaupreaidites verrucosus* Cookson
 Fig. 158 *Proteacidites* sp. cf *Proteacidites alveolatus* Stover & Partridge
 Fig. 159 *Hakeidites (Grevillea)* sp. x788
 Fig. 160 *Hakeidites (Hakea)* sp. x788

- Fig. 161 *Proteacidites punctiporus* Macphail *et al.*
 Fig. 162 *Proteacidites* sp. cf *Propylipollis reticuloscabratus* (Harris) Martin & harris
 Fig. 163 *Proteacidites adenanthoides* Cookson
 Fig. 164 *Proteacidites asperopolus* Stover & Evans
 Fig. 165 *Proteacidites pachypolus* Cookson & Pike
 Fig. 166 *Proteacidites reticulatus* Cookson
 Fig. 167 *Proteacidites recavus* Stover & Partridge x788
 Fig. 168 *Proteacidites leightonii* Stover & Partridge x788
 Fig. 169 *Triporopollenites ambiguus* Stover & Partridge x788
 Fig. 170 *Proteacidites grandis* Cookson x788
 Fig. 171 *Proteacidites tuberculiformis* Harris x788
 Fig. 172 *Proteacidites stipplatus* Stover & Partridge
 Fig. 173 *Proteacidites rugulatus* Stover & Partridge
 Fig. 174 *Proteacidites tuberculatus* Cookson
 Fig. 175 *Triorites magnificus* Cookson
 Figs. 176, 209 *Nothofagidites asperus* (Cookson) Stover & Evans
 Figs. 177, 178 *Nothofagidites brachyspinulosus* (Cookson) Stover & Evans
 Figs. 179, 180 *Nothofagidites emarcidus-heterus* (Cookson) Stover & Evans
 Figs. 181, 182 *Nothofagidites flemingii* (Cookson) Potonie
 Figs. 183, 184 *Nothofagidites vansteenisii* (Cookson) Stover & Evans
 Fig. 185 *Nothofagidites* sp. cf *N. vansteenisii* (Cookson) Stover & Evans
 Figs. 186, 187 *Nothofagidites falcatus* (Cookson) Hekel
 Fig. 188 *Nothofagidites goniatus* (Cookson) Stover & Evans
 Figs. 189, 195 *Dryadopollis retequetrus* (Stover & Partridge) Pocknall & Mildenhall
 Fig. 190 *Tricolporites adelaidensis* Stover & Partridge x788
 Fig. 191, 192 *Palaeocoprosmadites zelandiae* Pocknall x788
 Fig. 193 *Sapotaceoidaepollenites latizonatus* (McIntyre) Pocknall & Mildenhall
 Fig. 194 *Tricolporites valvatus* Harris
 Fig. 196 *Ilexpollenites anguloclavatus* McIntyre
 Fig. 197 *Sapotaceoidaepollenites rotundus* Harris
 Fig. 198, 199 *Ailanthipites paenestriatus* (Stover & Partridge) Milne
 Fig. 200, 201 *Nuxpollenites* (*Dodonaea triquetra*) sp.
 Fig. 202 *Dodonaea sphaerica* Martin
 Fig. 203 *Quintiniapollis psilatus* (Martin) Mildenhall & Pocknall
 Fig. 204 *Tricolporites* (*Elaeocarpaceae*) sp.
 Figs. 205, 206 *Gyropollis psilatus* Mildenhall & Pocknall
 Figs. 207, 208 *Tricolporopollenites endobalteus* McIntyre
 Figs. 210, 211 *Tricolporites leuros* Stover & Partridge
 Figs. 212, 213 *Tricolporopollenites cooksonii* Martin
 Figs. 214, 215 *Rhoipites ampereaformis* Macphail *et al.*
 Figs. 216, 217 *Rhoipites* sp. cf *R. isoreticulatus* Kemp & Harris
 Fig. 218 *Rhoipites muehlenbeckiaformis* Macphail *et al.*
 Fig. 219 *Poluspissusites ramus* Pocknall
 Fig. 223 *Rhoipites microreticulatus* (Harris) Macphail *et al.*
 Figs. 220, 221 *Rhoipites cissus* Macphail *et al.*
 Fig. 222 '*Tricolpites*' *pelargonioides* Martin x788
 Figs. 224, 225 *Tubulifloridites pleistocenicus* Martin
 Fig. 226 *Tubulifloridites simplis* Martin
 Fig. 227 *Tubulifloridites antipodica* Cookson

- Fig. 228 *Santalumidites cainozoicus* Cookson & Pike
 Fig. 229 *Fenestrites* sp.
 Figs. 230, 231 *Bluffopollis scabratus* (Couper) Pocknall & Mildenhall
 Fig. 232 *Quintiniapollis* sp. cf *Q. psilatus* (Martin) Mildenhall & Pocknall
 Fig. 233 *Polycolporopollenites esobalteus* (McIntyre) Pocknall & Mildenhall
 Figs. 234, 235 *Symplocoipollenites austellus* Stover & Partridge
 Fig. 236 *Tricolpites thomasi* Stover & Partridge
 Fig. 237 *Cranwellia striata* (Couper) Srivastava
 Fig. 238 *Cranwellia costata* (Couper) Srivastava
 Fig. 239 *Myrtacidites* sp. cf *M. eugenioides* Cookson & Pike
 Fig. 240 *Myrtacidites parvus-mesonesus* (Cookson) Stover & Evans
 Figs. 241 *Myrtacidites eucalyptoides* Cookson & Pike
 Fig. 242 *Myrtacidites* sp. cf *M. tenuis* Harris
 Fig. 243 *Myrtacidites* sp. cf *M. eucalyptoides* Cookson & Pike
 Fig. 244 *Myrtacidites verrucosus* Stover & Partridge
 Figs. 245, 246 *Myrtacidites lipsis* Macphail *et al.*
 Figs. 247, 248 *Concolpites leptos* Stover & Partridge
 Figs. 249, 250 *Cupanieidites orthoteichus* Cookson & Pike
 Fig. 251 *Cupanieidites reticularis* Cookson & Pike
 Figs. 252, 253 *Striasyncolpites latus* Mildenhall & Pocknall
 Fig. 254 *Tricolpites simatus* Stover & Partridge
 Fig. 255 *Gothanipollis* sp. cf *G. bassensis* Stover & Partridge
 Fig. 256 *Gothanipollis bassensis* Stover & Partridge
 Fig. 257 *Gothanipollis* sp. cf *G. gothanii* Krutzsch
 Fig. 258 *Anacolosidites sectus* Stover & Partridge
 Figs. 259, 260 *Gothanipollis perplexus* Pocknall & Mildenhall
 Figs. 261, 262 *Amylothea pliocenica* Cookson
 Fig. 263 *Anacolosidites acutulus* Cookson & Pike
 Fig. 264, 265 *Rubipollis oblatum* (Pocknall & Mildenhall) Mildenhall & Pocknall
 Figs. 266, 271 *Rhoipites alveolatus* (Couper) Pocknall & Crosbie
 Figs. 267-270 *Perisyncolpites pokorny* Germeraad *et al.*
 Figs. 272, 273 *Margocolporites vanwijhei* Germeraad *et al.*
 Fig. 274 *Crotonipollis* (*Beyeria*) sp.
 Figs. 275, 276 *Bysmapollis emaciatum* Stover & Partridge
 Figs. 277, 280 *Eriopites scabratus* Harris
 Fig. 278 *Eriopites crassiexinus* Harris
 Fig. 279 *Crotonipollis* (*Croton*) sp.
 Figs. 281, 282 *Monotocidites galeatus* Macphail *et al.*
 Fig. 283 *Dicotetradites meridianus* (Harris) Crosbie & Clowes
 Fig. 284 *Acaciapollenites octosporites* (Cookson) Mildenhall
 Fig. 285, 286 *Dicotetradites meridianus* (Harris) Crosbie & Clowes
 Figs. 287, 291 *Acaciapollenites weissii* Macphail *et al.* x788
 Figs. 288, 289 *Acaciapollenites miocenicus* Mildenhall & Pocknall x788
 Fig. 290 *Acaciapollenites myriosporites* (Cookson) Mildenhall x788
 Figs. 292, 293 *Pseudowinterapollis cranwellae* (Stover & Partridge) Mildenhall & Crosbie
 Fig. 294 *Pseudowinterapollis* sp. cf *Drimys tetradites* Martin
 Figs. 295, 296 *Pseudowinterapollis calathus* (Stover & Partridge) Mildenhall & Crosbie

APPENDIX 1

INDEX OF FOSSIL SPORES AND POLLEN SPECIES

[numbers refer to species order on Range Chart (Fig. 5):
modern analogues in parentheses]

- 195 *Acaciapollenites miocenicus* Mildenhall & Pocknall 1989
(Mimosaceae: cf *Archidendron*)
- 213 *Acaciapollenites myriosporites* (Cookson) Mildenhall 1972 (Mimosaceae: *Acacia*)
- 270 *Acaciapollenites octosporites* (Cookson) Mildenhall 1972 (Mimosaceae: *Acacia*)
- 247 *Acaciapollenites weissii* Macphail *et al.* 1993 (Mimosaceae: *Acacia*)
- 82 *Aglaoreidia qualumis* Stover & Partridge 1973 (Sparganiaceae)
- 83 *Ailanthipites paenestriatus* (Stover & Partridge) Milne 1988 (Anarcardiaceae??)
- 84 *Alangiopollis* sp. (Alangiaceae: *Alangium villosum*-type)
- 248 *Amylotheca pliocenica* Cookson 1957 (Loranthaceae: *Amylotheca*-type)
- 1 *Anacolosidites acutullus* Cookson & Pike 1954 (Olacaceae: *Anacolosia*)
- 2 *Anacolosidites luteoides* Cookson & Pike 1954 (Olacaceae: *Anacolosia*)
- 85 *Anacolosidites sectus* Stover & Partridge 1973 (Olacaceae: *Anacolosia*)
- 86 *Anisotricolporites triplaxis* Pocknall & Mildenhall 1984 (unidentified angiosperm)
- 3 *Araucariacites australis* Cookson 1947 (Araucariaceae: *Araucaria*-type)
- 4 *Arecipites*. spp. (Arecaceae?, Liliaceae?)
- 231 *Asseretospora*. sp. of Foster 1982 (Adiantaceae: cf *Pteris*)
- 87 *Australopollis obscurus* Harris 1965 (Callitrichaceae)
- 5 *Baculatisporites disconformis* Stover & Partridge 1973 (unidentified Hepaticae)
- 88 *Baculatisporites* sp. cf *B. scabridus* Playford 1982 (unidentified Hepaticae)
- 6 *Banksiaeidites arcuatus* Stover & Partridge 1973 (Proteaceae: Musgraveinae)
- 7 *Banksiaeidites elongatus* Cookson 1950 (Proteaceae: *Banksia/Dryandra*)
- 89 *Banksiaeidites* sp. cf *Banksia serrata* (Proteaceae: *Banksia serrata*-type)
- 8 *Beaupreaidites elegansiformis* Cookson 1950 (Proteaceae: *Beauprea*)
- 9 *Beaupreaidites verrucosus* Cookson 1950 (Proteaceae: *Beauprea*)
- 90 *Bluffopollis scabratus* (Couper) Pocknall & Mildenhall 1984 (Strasburgeriaceae: cf *Strasburgeria*)
- 91 *Bysmapollis emaciatus* Stover & Partridge 1973 (Epacridaceae? *Epacris*?)
- 10 *Camarozonosporites* sp. A. (Lycopodiaceae)
- 196 *Camarozonosporites* sp. B (Lycopodiaceae)
- 92 *Camptostemon* sp. (Bombacaceae: *Camptostemon*)
- 232 *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall 1989
(Rubiaceae: *Randia*)
- 11 *Casuarinidites cainozoicus* Cookson & Pike 1954 (Casuarinaceae)
- 214 *Chenopodipollis chenopodiaceoides* (Martin) Truswell *et al.* 1985
(Amaranthaceae-Chenopodiaceae)
- 249 *Cingulatisporites bifurcatus* (Couper) Martin 1973 (Hepaticae: cf *Phaeoceros*)
- 233 *Cingulatisporites ornatus* Martin 1973 (unidentified Hepaticae)
- 94 *Clavatipollenites glarius* Stover & Partridge 1982 (Chloranthaceae: *Ascarina*)
- 95 *Concolpites leptos* Stover & Partridge 1973 (Cunoniaceae: *Gillbeea*-type)
- 197 *Corsinipollenites* sp. cf *C. epilobioides* Krutzsch 1968 (Onagraceae: *Epilobium*-type)
- 96 *Cranwellia costata* (Couper) Srivastava 1966 (Loranthaceae)
- 97 *Cranwellia striata* (Couper) Srivastava 1966 (Loranthaceae)

- 98 *Crassiretitriletes vanraadshoovenii* Germeraad *et al.* 1968 (Schizaceae: *Lygodium microphyllum*-type)
- 271 *Crotonipollis* (*Beyeria*) sp. (Euphorbiaceae: *Beyeria*-type)
- 198 *Crotonipollis* (*Croton*) sp. (Euphorbiaceae: *Croton*-type)
- 12 *Cupanieidites orthoteichus* Cookson & Pike 1954 (Sapindaceae: *Cupanieae*)
- 99 *Cupanieidites reticularis* Cookson & Pike 1954 (Sapindaceae: *Cupanieae*)
- 100 Cupressaceae-Taxodiaceae
- 101 *Cyathea paleospora* Martin 1973 (Cyatheaceae: *Cyathea*)
- 215 *Cyatheacidites annulatus* Cookson ex Potonie 1956 (Lophosoriaceae: *Lophosoria*)
- 13 *Cyathidites australis/minor* Couper 1953 (numerous trilete pteridophytes)
- 14 *Cyathidites splendens* Harris 1965 (Adiantaceae: *Acrostichum*-type)
- 216 *Cyathidites subtilis* Stover & Partridge 1973 (Cyatheaceae: *Cyathea*)
- 15 *Cyperaceapollis neogenicus* Mildenhall & Pocknall 1989 (Cyperaceae)
- 16 *Dacrycarpites australiensis* Cookson & Pike 1953 (Podocarpaceae: *Dacrycarpus*)
- 250 *Densoisporites implexus* Macphail *et al.* 1993 (Selaginellaceae: *Selaginella uliginosa*-type)
- 251 *Densoisporites simplex* Macphail *et al.* 1993 (Selaginellaceae: immature *Selaginella uliginosa* spores)
- 102 *Dicolpites* (Cunoniaceae) sp. (Cunoniaceae: *Ceratopetalum*-type)
- 103 *Dicolpopollis* sp. cf *D. metroxylonoides* Khan 1976 (Arecaceae)
- 17 *Dicotetradites meridianus* (Harris) Crosbie & Clowes 1980 (Asclepiadaceae?)
- 18 *Dictyophyllidites arcuatus* Pocknall & Mildenhall 1984 (Gleicheniaceae)
- 19 *Dilwynites granulatus* Harris 1965 (Araucariaceae)
- 20 *Dilwynites tuberculatus* Harris 1965 (Araucariaceae)
- 199 *Diporites aspis* Pocknall & Mildenhall 1984 (Onagraceae: *Fuchsia*)
- 104 *Dodonaea sphaerica* Martin 1973 (Sapindaceae: *Dodonaea ericifolia*-type)
- 105 Droseraceae
- 200 *Dryadopollis retequetrus* (Stover & Partridge) Pocknall & Mildenhall 1984 (unidentified angiosperm)
- 21 *Dryptopollenites semilunatus* Stover & Partridge 1973 (Pandanaceae)
- 106 *Ephedra notensis* Cookson 1956 (Ephedraceae: *Ephedra*)
- 107 *Ericipites crassiexinus* Harris 1972 (Ericales: Epacridaceae?)
- 22 *Ericipites scabratus* Harris 1965 (Ericales: Epacridaceae?)
- 252 *Fenestrites* sp. (Asteraceae: Liguliflorae)
- 108 *Foveotritriletes balteus* Stover & Partridge 1973 (Lycopodiaceae?)
- 201 *Foveotritriletes crater* Stover & Partridge 1973 (Lycopodiaceae: *Lycopodium*)
- 217 *Foveotritriletes lacunosus* Stover & Partridge 1973 (Lycopodiaceae: *Lycopodium varium*-type)
- 109 *Foveotritriletes palaequetrus* Stover & Partridge 1973 (Lycopodiaceae: *Lycopodium australianum*-type)
- 234 *Gemmatriletes multiglobus* Mildenhall & Pocknall 1989 (Grammitidaceae)
- 23 *Gleicheniidites* spp. (Gleicheniaceae)
- 235 *Glencopollis ornatus* Pocknall & Mildenhall 1984 (Polygonaceae: *Polygonum persicaria*-type)
- 24 *Gothanipollis bassensis* Stover & Partridge 1973 (Loranthaceae)
- 253 *Gothanipollis perplexus* Pocknall & Mildenhall 1984 (Loranthaceae: cf *Lysiana*)
- 110 *Gothanipollis* sp. cf *G. gothanii* Krutzsch 1959 (Loranthaceae: cf *Amyema*)
- 111 *Graminidites* spp. (Poaceae)
- 202 *Granodiporites nebulosus* Stover & Partridge 1973 (Proteaceae: *Embothrium*)

- 93 cf *Guettardidites* Khan 1976 (Rubiaceae: *Guettarda*)
- 112 *Gyropollis psilatus* Mildenhall & Pocknall 1989 (Gyrostemonaceae)
- 254 *Hakeidites* (*Grevillea*) sp. (Proteaceae: cf *Grevillea*)
- 218 *Hakeidites* (*Hakea*?) sp. (Proteaceae: cf *Hakea*)
- 236 *Haloragacidites haloragoides* Cookson & Pike 1954 (Haloragaceae: *Gonocarpus*)
- 25 *Haloragacidites harrisii* (Couper) Harris 1971 (Casuarinaceae)
- 255 *Haloragacidites myriophylloides* Cookson & Pike 1954 (Haloragaceae: *Myriophyllum*)
- 26 *Herkosporites elliotii* Stover & Partridge 1973 (Lycopodiaceae: *Lycopodium* *deuterodensum*-type)
- 256 *Hypolepis spinysporis* Martin 1973 (Dennstaedtiaceae: *Hypolepis*)
- 27 *Ilexpollenites anguloclavatus* McIntyre 1968 (Aquifoliaceae: *Ilex*)
- 28 *Ischyosporites gremius* Stover & Partridge 1973 (Dicksoniaceae?)
- 29 *Klukisporites lachlanensis* Martin 1973 (Dicksoniaceae?)
- 113 *Kuylisporites waterbolkii* Potonie 1956 (Cyatheaceae: *Hemitelia*)
- 30 *Laevigatosporites* spp. (numerous monolete ferns; includes Blechnaceae)
- 114 *Latrobosporites crassus* Harris 1965 (Lycopodiaceae)
- 31 *Latrobosporites marginis* Mildenhall & Pocknall 1989 (Lycopodiaceae: *Lycopodium* *laterale*-type)
- 115 *Leptolepidites verrucatus* Couper 1953 (lycopsid?)
- 116 *Liliacidites bainii* Stover & Partridge 1973 (Liliaceae)
- 32 *Liliacidites lanceolatus* Stover & Partridge 1973 (Liliaceae)
- 117 *Liliacidites* spp. (Liliaceae)
- 33 *Lygistepollenites florinii* (Cookson & Pike) Stover & Evans 1973 Podocarpaceae: *Dacrydium*)
- 203 *Malvacearumpollis* sp. cf *M. mannanensis* Wood 1986 (Malvaceae)
- 34 *Malvacipollis diversus* Harris 1965 (Euphorbiaceae: *Austrobuxus*)
- 257 *Malvacipollis regattaensis* Macphail *et al.* 1993 (Malvaceae)
- 118 *Malvacipollis spinyspora* (Martin) Mildenhall & Pocknall 1989 (Euphorbiaceae: *Micrantheum*)
- 36 *Malvacipollis subtilis* Stover & Partridge 1973 (Euphorbiaceae: *Austrobuxus*)
- 35 *Malvacipollis* spp. (Euphorbiaceae: *Austrobuxus*)
- 119 *Margocolporites vanwijhei* Germeraad *et al.* 1968 (Caesalpiniaceae)
- 120 *Matonisporites ornamentalis* (Cookson) Stover & Partridge 1973 (Dicksoniaceae: *Dicksonia antarctica*-type)
- 37 *Microalatidites palaeogenicus* (Cookson) Mildenhall & Pocknall 1989 (Podocarpaceae: *Phyllocladus*)
- 38 *Microcachrydites antarcticus* Cookson 1947 (Podocarpaceae: *Microcachrys*)
- 39 *Milfordia homeopunctata* (McIntyre) Stover & Partridge 1973 (graminoid Restionaceae)
- 40 *Milfordia hypolaenoides* Erdtman 1960 (non-graminoid Restionaceae)
- 121 *Monolites alveolatus* Couper 1960 (cf Polypodiaceae: *Belvisia*)
- 258 *Monotocidites galeatus* Macphail *et al.* 1993 (Epacridaceae: *Monotoca*)
- 122 *Myrtaceidites eucalyptoides* Cookson & Pike 1954 (Myrtaceae: *Eucalyptus* *gummifera*-type)
- 123 *Myrtaceidites eugenioides* Cookson & Pike 1954 (Myrtaceae: *Eugenia*-type)
- 259 *Myrtaceidites* (*Leptospermum*) sp. (Myrtaceae: *Leptospermum*-type)
- 260 *Myrtaceidites lipsis* Macphail *et al.* 1993 (Myrtaceae: *Eucalyptus* *spathulata*-type)

- 41 *Myrtaceidites parvus-mesonesus* (Cookson & Pike) Stover & Evans 1973 (unattributed Myrtaceae)
- 219 *Myrtaceidites protrudiporens* Martin 1973 (Myrtaceae)
- 124 *Myrtaceidites rhodmnoides* Martin 1973 (Myrtaceae: *Rhodamnia*-type)
- 42 *Myrtaceidites tenuis* Harris 1965 (Myrtaceae: cf *Eucalyptus*)
- 125 *Myrtaceidites verrucosus* Stover & Partridge 1973 (Myrtaceae: *Austromyrtus*-type)
- 126 *Myrtaceidites xanthomyrtoides* Martin 1973 (Myrtaceae: *Xanthomyrtus*-type)
- 259 *Myrtaceidites* (*Leptospermum*). sp. (Myrtaceae: *Leptospermum*-type)
- 43 *Nothofagidites asperus* (Cookson) Stover & Evans 1973 (Fagaceae: *Nothofagus* subgenus *Lophozonia*)
- 44 *Nothofagidites brachyspinulosus* (Cookson) Stover & Evans 1973 (Fagaceae: *Nothofagus* subgenus *Fuscospora*)
- 45 *Nothofagidites deminutus-vansteenisii* (Cookson) Stover & Evans 1973 (Fagaceae: *Nothofagus* subgenus *Brassospora*)
- 46 *Nothofagidites emarcidus-heterus* (Cookson) Stover & Evans 1973 (Fagaceae: *Nothofagus* subgenus *Brassospora*)
- 47 *Nothofagidites falcatus* (Cookson) Hekel 1972 (Fagaceae: *Nothofagus* subgenus *Brassospora*)
- 48 *Nothofagidites flemingii* (Cookson) Potonie 1960 (Fagaceae: *Nothofagus* subgenus *Nothofagus*)
- 49 *Nothofagidites goniatus* (Cookson) Stover & Evans 1973 (Fagaceae: *Nothofagus* subgenus *Lophozonia*?)
- 50 *Nothofagidites longispinosus* (Couper) Dettmann *et al.* 1990 (Fagaceae: *Nothofagus* subgenus *Brassospora*)
- 204 *Nuxpollenites* sp. (Sapindaceae: *Dodonaea triquetra*-type)
- 220 *Palaeocoprosmadites zealandiae* Pocknall 1982 (Rubiaceae: *Coprosma-Opercularia*)
- 127 *Parvisaccites catastus* Stover & Partridge 1973 (Podocarpaceae: *Dacrydium bidwillii*-type)
- 128 *Perforicolpites* sp. cf *P. digitatus* Gonzalez Guzman 1967 (Convolvulaceae)
- 51 *Periporopollenites demarcatus* Stover & Partridge 1973 (Trimeniaceae)
- 129 *Periporopollenites polyoratus* (Couper) Stover & Evans 1973 (Caryophyllaceae?)
- 52 *Periporopollenites vesicus* Stover & Partridge 1973 (Trimeniaceae?)
- 130 *Perisyncolporites pokornyi* Germeraad *et al.* 1968 (Malpighiaceae)
- 131 *Peromonolites densus* Harris 1965 (unidentified pteridophyte)
- 133 *Peromonolites vellosus* Stover & Partridge 1973 (unidentified pteridophyte)
- 132 *Peromonolites* sp. (baculate) (Dryopteridaceae?)
- 53 *Phyllocladidites mawsonii* Cookson ex Couper 1953 (Podocarpaceae: *Lagarostrobos franklinii*-type)
- 134 *Plicodiporites* sp. (Proteaceae)
- 54 *Podocarpidites* spp. (Podocarpaceae: *Podocarpus*)
- 135 *Podosporites erugatus* Mildenhall 1978 (Podocarpaceae: *Microstrobos*)
- 55 *Podosporites microsaccatus* (Couper) Dettmann 1963 (Podocarpaceae: cf *Microcachrys*)
- 56 *Podosporites parvus* (Couper) Mildenhall 1978 (Podocarpaceae: cf *Microcachrys*)
- 261 *Poluspissusites ramus* Pocknall 1982 (Goodeniaceae)
- 205 *Polyadopollenites* sp. cf *P. granulosus* Sah 1967 (Mimosaceae: cf *Anadenanthera*)
- 57 *Polycolporopollenites esobalteus* (McIntyre) Pocknall & Mildenhall 1984 (Polygalaceae)
- 58 *Polyorificites oblatius* Martin 1973 (unidentified angiosperm)

- 136 *Polypodiaceoisporites retirugatus* Muller 1968 (Adiantaceae: *Pteris*)
- 237 *Polypodiaceoisporites tumulatus* Stover & Partridge 1973
- 137 *Polypodiisporites histiopteroides* Mildenhall & Pocknall 1989
- 238 *Polypodiisporites usmensis* (van der Hammen) Khan & Martin 1971 (Blechnaceae: cf *Stenochlaena palustris*)
- 138 *Polypodiisporites* spp. (Polypodiaceae: cf *Microsorium*)
- 263 *Polyporina bipatterna* Martin 1973 (Caryophyllaceae?)
- 264 *Polyporina granulata* Martin 1973 (Caryophyllaceae: *Stellaria*)
- 265 *Polyporina reticulata* Martin 1973 (Caryophyllaceae: *Silene*-type)
- 262 *Polyporina (Hemichroa)* sp. (Chenopodiaceae (*Hemichroa*-type))
- 59 *Propylipollis annularis* (Cookson) Martin & Harris 1974 (Proteaceae: *Xylomelum occidentale*-type)
- 139 *Propylipollis biporus* Dudgeon 1983 (Proteaceae)
- 140 *Propylipollis latrobensis* (Harris) Martin & Harris 1974 (Proteaceae)
- 141 *Propylipollis reticuloscabratus* (Harris) Martin & Harris 1974 (Proteaceae: *Gevuina/Hicksbeachia*)
- 60 *Proteacidites adenanthoides* Cookson 1950 (Proteaceae: cf *Adenathos*)
- 61 *Proteacidites asperopolus* Stover & Partridge 1973 (Proteaceae)
- 142 *Proteacidites beddoesii* Stover & Partridge 1973 (Proteaceae)
- 143 *Proteacidites confragosus* Harris 1972 (Proteaceae)
- 62 *Proteacidites callosus* Cookson (Proteaceae)
- 63 *Proteacidites crassus* Cookson 1950 (Proteaceae)
- 142 *Proteacidites differentipolis* Dudgeon 1983 (Proteaceae)
- 64 *Proteacidites grandis* Cookson 1950 (Proteaceae)
- 65 *Proteacidites incurvatus* Stover & Partridge 1973 (Proteaceae)
- 206 *Proteacidites isopogiformis* Couper 1960 (Proteaceae: *Isopogon*)
- 221 *Proteacidites ivanhoensis* Martin 1973 (Proteaceae: cf *Orites*)
- 207 *Proteacidites kopiensis* Harris 1972 (Proteaceae)
- 145 *Proteacidites leightonii* Stover & Partridge 1973 (Proteaceae)
- 146 *Proteacidites nasus* Truswell & Owen 1988 (Proteaceae)
- 66 *Proteacidites obscurus* Cookson 1950 (Proteaceae: *Agastachys*-type)
- 147 *Proteacidites ornatus* Harris 1965 (Proteaceae)
- 67 *Proteacidites pachypolus* Cookson & Pike 1954 (Proteaceae)
- 148 *Proteacidites pseudomoides* Stover & Partridge 1973 (Proteaceae: cf *Lomatia*)
- 266 *Proteacidites punctiporus* Macphail *et al.* 1993 (Proteaceae: cf *Conospermum*)
- 68 *Proteacidites recavus* Stover & Partridge 1973 (Proteaceae)
- 149 *Proteacidites rectomarginis* Cookson 1950 (Proteaceae)
- 150 *Proteacidites rectus* Pocknall & Mildenhall 1984 (Proteaceae)
- 151 *Proteacidites reticulatus* Cookson 1950 (Proteaceae)
- 152 *Proteacidites rugulatus* Stover & Partridge 1982 (Proteaceae)
- 153 *Proteacidites rhyntius* Stover & Partridge 1982 (Proteaceae)
- 208 *Proteacidites sinulatus* Dudgeon 1983 (Proteaceae)
- 154 *Proteacidites stipplatus* Stover & Partridge 1973 (Proteaceae)
- 223 *Proteacidites symphyonemoides* Cookson 1950 (Proteaceae: cf *Symphionema*)
- 239 *Proteacidites tenuiexinus* Stover & Partridge 1973 (Proteaceae)
- 240 *Proteacidites truncatus* Cookson 1950 (Proteaceae: *Isopogon*)
- 224 *Proteacidites tripartitus* Harris 1972 (Proteaceae)
- 155 *Proteacidites tuberculatus* Cookson 1950 (Proteaceae)
- 156 *Proteacidites tuberculiformis* Harris 1965 (Proteaceae)

- 222 *Proteacidites* sp. A of Macphail & Truswell 1989 (Proteaceae)
69 *Proteacidites* spp. (Proteaceae)
241 *Pseudowinterapollis calathus* (Stover & Partridge) Mildenhall & Crosbie 1979
(Winteraceae)
70 *Pseudowinterapollis cranwellae* (Stover & Partridge) Mildenhall & Crosbie 1979
(Winteraceae)
157 *Psilastephanocolporites micus* Stover & Partridge 1973 (extinct angiosperm)
158 *Psilodiporites* (*Alyxia*) sp. (Apocynaceae: *Alyxia*)
159 *Quintiniapollis psilatipora* (Martin) Mildenhall & Pocknall 1989
Grossulariaceae: *Quintinia*)
160 *Reevesiapollis reticulatus* (Couper) Krutzsch 1970 (Sterculiaceae: *Ungeria*)
209 *Retistephanocolpites* (*Callitriche*) sp. (Callitrichaceae: *Callitriche*)
161 *Rhoipites alveolatus* (Couper) Pocknall & Crosbie 1982 (Caesalpinaceae?)
267 *Rhoipites ampereaformis* Macphail *et al.* 1993. (Euphorbia: *Amperea*)
162 *Rhoipites angurium* (Stover & Partridge)
163 *Rhoipites cissus* Macphail *et al.* 1993 (Vitaceae: *Cissus*)
268 *Rhoipites* sp. cf *R. isoreticulatus* Kemp & Harris 1977 (Verbenaceae: *Avicennia*)
164 *Rhoipites microreticulatus* (Harris) Macphail *et al.* 1993 (unidentified angiosperm)
165 *Rhoipites muehlenbeckiaformis* Macphail *et al.* 1993 (Polygonaceae: *Muehlenbeckia*)
166 *Rhoipites sphaerica* (Stover & Partridge) (unidentified angiosperm)
167 *Ricciaesporites kawaraensis* Mildenhall & Pocknall 1989 (Ricciaceae)
168 *Rubipollis oblatum* (Pocknall & Mildenhall) Mildenhall & Pocknall 1989
(Rubiaceae: *Canthium*)
210 *Rudolphisporis rudolphi* (Krutzsch) Krutzsch 1963 (Hepaticae: *Anthoceros*-type)
242 *Rugulatisporites cowrensis* (Martin) Mildenhall & Pocknall 1989
(Thyrsopteridaceae: cf *Culcita*).
169 *Rugulatisporites mallatus* Stover & Partridge 1973 (Thyrsopteridaceae: *Culcita*).
170 *Rugulatisporites trophus* Stover & Partridge 1973 (Thyrsopteridaceae: cf
Culcita).
171 *Santalumidites cainozoicus* Cookson & Pike 1954 (Santalaceae: *Santalum*)
71 *Sapotaceoidapollenites latizonatus* (McIntyre) Pocknall & Mildenhall 1984..
(Sapotaceae)
72 *Sapotaceoidapollenites rotundus* Harris 1972 (Sapotaceae)
173 *Schizocolpus marlinensis* Stover & Partridge 1973. (Didymelaceae)
172 *Schizocolpus* (*Alchornea*) sp. (Euphorbiaceae: *Alchornea*)
73 *Simsonipollis* sp. (Anacardiaceae)
74 *Sparganiaceapollenites barungensis* Harris 1972 (Sparganiaceae)
75 *Sparganiaceapollenites sphericus* (Couper) Mildenhall & Crosbie 1974
(Sparganiaceae)
211 *Stephanocolpites oblatum* Martin 1973 (Haloragaceae: *Haloragodendron*-
Glischrocaryon)
174 *Stereisporites* (*Tripunctisporis*) sp. (Sphagnaceae)
175 *Stereisporites australis* Cookson 1953 (Sphagnaceae: *Sphagnum*)
225 *Striasyncolpites laxus* Mildenhall & Pocknall 1989 (Menyanthaceae: cf
Liparophyllum-*Villarsia*)
243 *Symplocoipollenites austellus* Stover & Partridge 1973 (Symplocaceae: *Symplocos*)
176 *Tetracolpites sphericus* Couper 1960 (unidentified ?angiosperm)
177 *Tetracolporites palynius* Stover & Partridge 1982 (Meliaceae: *Dysoxylum*)
212 *Tetrapollis campbellbrownii* Macphail & Truswell 1993 (?Casuarinaceae)

- 272 *Thymelaepollis (Pimelea)* sp. (Thymeleaceae: *Pimelea*-type)
- 178 *Trichotomosulcites subgranulatus* Couper 1953 (Podocarpaceae)
- 179 *Tricolpites* (Cunoniaceae) spp. (Cunoniaceae)
- 184 *Tricolpites* (Elaeocarpaceae) spp. (Elaeocarpaceae)
- 180 *Tricolpites incisus* Stover & Partridge 1973 (unidentified angiosperm)
- 226 *Tricolpites patulus* Truswell & Owen 1988 (unidentified angiosperm)
- 227 *Tricolpites pelargonoides* Martin 1973 (Geraniaceae: *Pelargonium*)
- 181 *Tricolpites phillipsii* Stover & Partridge 1973 (unidentified angiosperm)
- 228 *Tricolpites reticulatus* Cookson 1947 (Gunneraceae)
- 76 *Tricolpites simatus* Stover & Partridge 1973 (Loranthaceae)
- 229 *Tricolpites stylidioides* Macphail *et al.* 1993 (Stylidiaceae)
- 182 *Tricolpites thomasi* Cookson & Pike 1954 (Loranthaceae?)
- 183 *Tricolpites trioblatus* Mildenhall & Pocknall 1989 (Scrophulariaceae)
- 77 *Tricolpites* spp. (unidentified angiosperms)
- 78 *Tricolporites adelaidensis* Stover & Partridge 1982
- 79 *Tricolporites leuros* Stover & Partridge 1973 (unidentified angiosperm)
- 185 *Tricolporites scabratus* Harris 1965 (unidentified angiosperm)
- 187 *Tricolporites valvatus* Harris 1972 (unidentified angiosperm)
- 186 *Tricolporites* spp. (unidentified angiosperms)
- 244 *Tricolporopollenites cooksonii* Martin 1973 (unidentified angiosperm)
- 188 *Tricolporopollenites endobalteus* McIntyre 1965 (Euphorbiaceae: *Macaranga*-type)
- 189 *Triletes tuberculiformis* Cookson 1947 (Dicksoniaceae?)
- 269 *Triorites classis* Martin 1973. (unidentified angiosperm)
- 190 *Triorites magnificus* Cookson 1950 (Proteaceae?)
- 80 *Tripoporopollenites ambiguus* Stover & Partridge 1973 (Proteaceae: cf *Telopea*)
- 191 *Tripoporopollenites chnosus* Stover & Partridge 1973 (Proteaceae?)
- 192 *Tripoporopollenites delicatus* Stover & Partridge 1982 (Proteaceae: cf *Lomatia*)
- 245 *Triporotetradites (Gardenia)* sp. (Rubiaceae: *Gardenia*)
- 246 *Tubulifloridites antipodica* Cookson 1947 (Asteraceae: Tubuliflorae)
- 273 *Tubulifloridites pleistocenicus* Martin 1973 (Asteraceae: *Cassinia arcuata*-type)
- 230 *Tubulifloridites simplis* Martin 1973 (Asteraceae: Tubuliflorae)
- 193 *Verrucatosporites* sp. A. (Polypodiaceae?)
- 194 *Verrucosisporites cristatus* Stover & Partridge 1973 (unidentified lycosid)
- 81 *Verrucosisporites kopukuensis* (Couper) Stover & Partridge 1973 (unidentified lycosid)