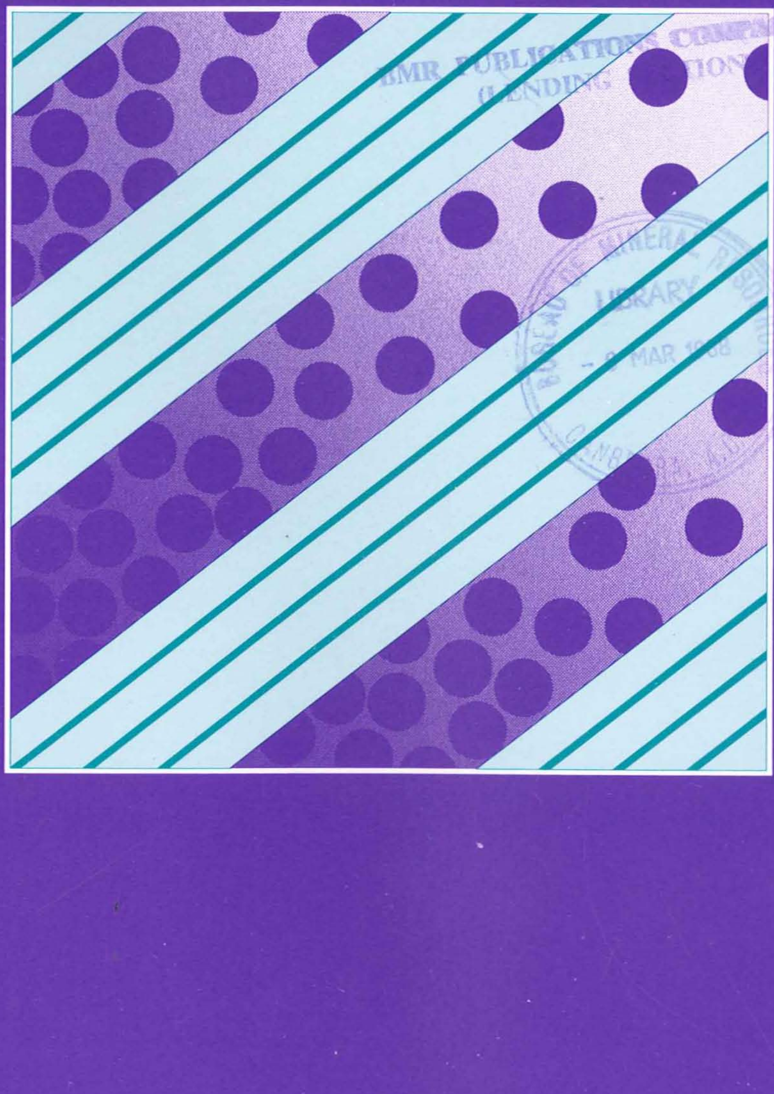
GROUNDWATER 9

Studies in Hydrogeology

PALYNOLOGICAL ANALYSIS BMR MANILLA - 1 BOREHOLE, MURRAY BASIN

M. K. MACPHAIL



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PALYNOLOGICAL ANALYSIS

B.M.R. MANILLA-1 BOREHOLE

MURRAY BASIN

by

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FOREWORD

Most if not all salinisation problems in the Murray Basin are related directly or indirectly to groundwater flow. In order to fully understand the controls on groundwater flow, as a precursor to developing salinity management options, we need to acquire basic geological and hydrogeological information. Such information is being obtained through joint Commonwealth-State hydrogeological studies in the Murray Basin co-ordinated and supported through the Bureau of Mineral Resources. The Federal Water Resources Assistance programme and the New South Wales Department of Water Resources also provided some support for this work. The work is therefore an excellent example of Commonwealth-State cooperation.

Understanding the sequence of geological events that have shaped the Murray Basin is important if we are to understand the movement of groundwater within the basin, and geological events can be interpreted only in the context of a reliable time framework against which to measure change.

Fossils still provide the major means of establishing a time framework for sequences of sedimentary rocks.

In this report, Dr M.K. Macphail, a consultant retained by the BMR Division of Continental Geology, uses fossil pollen and spores to provide dates on the rock sequence penetrated in the Manilla-1 borehole, in the central part of the subsurface Wentworth Trough. The use of these microfossils shows the presence within the section of a rock unit of Early Cretaceous age (i.e. some 110 to 120 million years old) directly underlying the Murray Basin sequence.

It also provides vital age information on the Geera Clay, the major permeability barrier to groundwater flow through the aquifers of the Renmark Group of the Murray Basin.

The study of pollen and spores also provides some fascinating insights into the enormous environmental changes that have occurred within the Murray Basin area during the past 100 million years. The sequence revealed here reflects changing climates and environments which supported conifer forests in the Cretaceous, and mixed rainforests of southern beech and conifers during the time of Geera Clay deposition, all of which are in stark contrast to the present open, eucalypt-dominated vegetation of the area, and helps to put the present vegetational changes presently taking place within the basin into a longer time frame.

Peter J. Cook

Chief

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ABSTRACT

Palynological analysis of twenty three core samples from Manilla -1 has enabled a biostratigraphic subdivision of the sequence to be effected. Below 317.8 m the sampled interval is of Early Cretaceous age, and has been assigned to the *Dictyotosporites speciosus* Zone, of Aptian to Early Albian age; a non-marine environment is indicated. Cores from the Geera Clay between 149.7 and 223.2 m are assigned to the *Proteacidites tuberculatus* Zone, which was first defined in the Gippsland Basin, and which is of Oligocene to Early Miocene age. Assemblages in this interval, and in the overlying *Triporopollenites bellus* Zone, reflect marked fluctuations in salinity, with a range of environments from shallow marine to coastal freshwater lagoons.

The Geera Clay from 100.5 to 145.8 m has been assigned to the *Triporopollenites bellus* Zone of late Early to Late Miocene age; the zone possibly extends as high as the sample at 94.9 m, but determinations of the upper limit are tentative. A Plio/Pleistocene age is cautiously suggested for the sample at 90.11 m, an interval which reflects a freshwater, lacustrine habitat.

INTRODUCTION

The Manilla hole (Fig. 1) was drilled to investigate the stratigraphy and hydrogeology of the central part of the Wentworth Trough. Large scale linear gravity anomalies had previously been interpreted as a possible post-Devonian trough; thick Tertiary sequences have been found in similar features elsewhere in the basin. The hole was sited to test the thickness of Tertiary sediment, to sample the Oligo-Miocene transgression, to establish the Pliocene stratigraphy of the area, and to provide water pressure and quality information for the main aquifer systems.

Twentythree conventional core samples processed by B.M.R. were examined for spore-pollen and dinoflagellates. Recovery, preservation and diversity were mostly fair with many palynomorphs being crumpled, broken or corroded. As is typical of Tertiary sediments in Southeastern Australia, zone index species were rare. Consequently zone boundaries should be treated as provisional until assessed against foraminiferal and electric log data (not available at the time of writing).

Lithological units and palynological zones in the cored interval are summarized below in Table 1. The distributions of described spore-pollen species are shown in the accompanying range chart (Table 2) with the ranges of selected taxa in the Oligocene-Miocene section plotted as a bar chart (Fig. 2). Interpretative data, including zonal determinations, are given in Table 3. The relative abundance of the more commonly occurring taxa (greater than 1% of the total identifiable spore-pollen count in any sample) is given in Table 4. Anomalous occurrences and rare spore-pollen taxa are listed in Table 5. Basic data on yield and diversity are provided in Table 6.

AGE	UNIT	ZONE #	ENVIRONS	DEPTH
?PLIO- PLEISTOCENE		"T. pleistocenicus"	Freshwater	90.11m
Late EARLY - LATE MIOCENE	GEERA CLAY	T. bellus	Lagoonal/ Tidal Flat	94.9- 145.8m
OLIGOCENE - EARLY MIOCENE		P. tuberculatus	Lagoonal/ Tidal Flat	149.7- 223.2m
EARLY CRETACEOUS	Unnamed	D. speciosus	Terrestrial	317.8
EARLY CRETACEOUS	Unnamed	"M. antarcticus"	Terrestrial	328.6- 328.9m

TD 339m

Table 1: Summary of palynological zonal units identified in Manilla-1, with age and environmental attributions. Zone names in parentheses are informal, based on unpublished data of Esso Australia Ltd. and Helby, Morgan & Partridge, 1987.

GEOLOGICAL COMMENTS

1. Manilla-1 contains essentially the same sequence of Oligocene-Miocene clastic facies and spore-pollen zones as Oakvale-1 (cf Truswell & others, 1985). All core samples taken above 224m are interpreted as Geera Clay. Lithological data indicate that the unsampled interval between ca. 226-315m comprises units of Renmark Group. Palynological analysis of a potentially fossiliferous, carbonaceous clay at 249.5- 249.8m (handwritten core descriptions) could help confirm this.

2. Unlike Oakvale-1 which is located close to the western margin of the basin where Cainozoic sediments onlap and overlie Proterozoic basement rocks, the Manilla-1 bore penetrated a unit of Early Cretaceous sediments accumulated in the Wentworth Trough. These are non-marine and, unlike bores such as Woodlands-1 (33^{o}24'S 141^{o}12'E), recycled Early Cretaceous palynomorphs in the Geera Clay are wholly terrestrial in origin. In Manilla-1, the recycled Early Cretaceous spore-pollen is most abundant in the basal (223.2m) and highest (90.11m) samples from the Geera Clay.

Recycled Permian spores are much less common, with *Didecitriletes* spp. and *Dulhuntyispora parvithola* being the most distinctive taxa recorded as in Oakvale-1. Both indicate the existence of late Permian (Upper Stage 5) (see Kemp & others, 1977) within infrabasins underlying the Tertiary sediments.

3. The occurrence of an exceptionally well-preserved suite of Early Cretaceous spores at 317.8 m may be related to the ecological and erosional effects of one or more wildfires which are geologically recorded by a charcoal 'conglomerate' (E.M. Truswell, pers. comm.) at 328.1-330.5m). The succession from a gymnosperm-dominated (328.6-328.9 m) to a cryptogam-dominated vegetation is and probably has long been, common following burning of wet forest. Assuming the succession in Manilla-1 is a fire-sere, then the unit of lignitic, laminated silts between 315-330m was deposited very rapidly - within several centuries based on modern recovery rates in fired wet forests.

4. The majority of the Geera Clay samples contained both freshwater (*Pediastrum, Saeptodinium, Botryococcus*) and marine alga and (fresh-brackish water) swamp angiosperms (*Sparganiaceaepollenites, Aglaoreidia*). This 'mixed' association implies marked fluctuations in salinity, conditions that are typical of coastal lagoons or tidal flats within or adjoining a river system. This general environment appears to have persisted during the period of accumulation of the Geera Clay at Manilla-1. Less commonly, an abundance of one of the above indicator microfossils allows the local hydrologic conditions to be interpreted with a fair degree of precision:

(a) At 223.3m, the borehole was situated within an *Aglaoreidia* (probably freshwater) swamp. This is likely to have been close to the shoreline at that time.

(b) The marine influence at the bore site was greatest between 136.9-217.2m. Sediments in this interval are glauconitic, indicating low sedimentation rates. The sample at 136.9m is wholly dominated by dinoflagellates (130% of pollen sum) and may represent the maximum eustatic highstand. The marine-influence appears to have waned above 136.9m.

(c) Freshwater lacustrine conditions developed across the bore site at some time between 94.9 and 90.11m. The abundance of *Pediastrum* indicates this lake was open and persistent although not necessarily particularly deep. Interestingly, Zhisheng & others, (1986) postulate that such a large lake, L. Bungunnia, extended over much of the Murray Basin during the Late Pliocene-Early Pleistocene.

5. The sequence - from swamp to open marine to freshwater lake - is ecologically consistent with the Geera Clay having been deposited during a single marine transgression. This may be an artifact of the sampling interval. If not, then the eustatic highstand at Manilla-1 was latest Early Miocene based on the current correlation of the *P. tuberculatus*/*T. bellus* Zone boundary with Planktonic Foraminiferal Zone (N6/7 of Berggren (1972) at approximately 18 million years ago.

If this interpretation is correct then:

(a) during the upper *P. tuberculatus* Zone interval (217.2-136.9m) the inferred low sedimentation rates at Manilla-1 were due to migration of the zone of sediment accumulation 'upshelf' i.e. north, of the site.

(b) Increased representation of spore-pollen and the general absence of marine dinoflagellates between 131.75-94.9m may reflect progradation of the shoreline southwards towards Manilla-1 during the Middle Miocene.

BIOSTRATIGRAPHY

In the absence of a formal palynological zonation scheme for the Murray Basin, age-determinations and zone boundaries have been made using criteria established for the Gippsland Basin by Stover & Partridge (1973). As discussed below, age-ranges of stratigraphically important species appear to vary between basins, particularly in times of extinction. This is partly related to differences in depositional environment but mostly reflects the time-transgressive nature of change in the source vegetation (see Hill & Macphail, 1983; Truswell & others., 1985). For this reason correlation of 'zoned' intervals in Manilla-1 against the geologic time- scale may need to be revised although spore-pollen and dinoflagellates will remain a fairly precise tool for correlating individual boreholes.

PREVIOUS STUDIES

Tertiary sediments in the north-east of the Murray Basin have been pollen-analysed in detail by Martin (1973-84; reviewed 1986). Because of the extreme rarity of "Gippsland" index fossils, particularly those used to subdivide the Oligocene-Early Miocene *P. tuberculatus* Zone sediments, Martin *(ibid)* has proposed a number of quantitative criteria to correlate Late Tertiary sections, viz. the ratio of *Nothofagidites flemingii* to Total *Nothofagidites,* the ratio of Total *Myrtaceidites* to Total *Nothofagidites* and ratio of Araucariaceae to other gymnosperms (see Fig. 5 in Martin, 1986)..

Biostratigraphic data for other areas of the basin are sparse or lacking. One notable exception is the Oakvale-1 bore in the north-west sector (Truswell & others, 1985). Here, diverse palynofloras complemented by foraminiferal data have allowed the development of parallel qualitative and quantitative zonation schemes:

1. Gippsland Basin spore-pollen zones.

Both nominate and accessory species of the *P. tuberculatus* and *T. bellus* Zones are present. Occurrences of *Triporopollenites bellus, Proteacidites symphyonemoides* and *Symplocoipollenites austellatus* above an Early Miocene foraminiferal assemblage agree well with the (revised) first appearances of these species in the Gippsland Basin. The probable late Oligocene first appearance of *Haloragacidites haloragoides* does not. A number of species which have not been recorded in Gippsland have restricted ranges in the Murray Basin and may prove to be useful albeit local accessory taxa, e.g. *Glencopollis_ornatus, Malvacearumpollis sp.,* "*Nuxpollenites*" sp. (= modern *Dodonaea triquetra* pollen) and *Perfotricolpites* sp. cf. *P. digitatus*. Others will be proposed on the basis of the Manilla-1 range data.

2. Quantitatively-defined zones.

The Oakvale-1 sequence has been subdivided into two zones, one of which contains four subzones, by (computer) statistical comparison of relative abundance values between adjacent samples (PERCINF: see Kershaw & Sluiter, 1982). As with Martin's *(ibid)* ratios, zone boundaries represent times of major change in the regional source vegetation. Whether a similar sequence of objectively recognizable zones occurs in other Murray Basin bores has yet to be tested except via recalculation of the Oakvale-1 quantitative data as ratios (see Martin, 1986). PERCINF analysis and comparison of Palaeocene and Late Cretaceous sections in selected Gippsland Basin wells (Sluiter & Macphail, unpubl. data; Tulip & Macphail, unpubl. data) indicate that the technique *may* be useful as a correlation technique but that PERCINF zone boundaries only correspond with those defined by presence/absence at times of major environmental change.

CONTAMINATION

The majority of samples in Manilla-1 contained trace numbers of modern pollen, mostly exotic pines and pastoral weed species but also including some species which first appear in the late Tertiary, e.g. (modern taxon in parentheses) *Haloragacidites haloragoides (Gonocarpus)* and *Tubulifloridites* spp. (Compositae). Contaminants introduced after processing retained their intine and were immediately recognizable as such. This was not the case with contaminants which had been 'artificially fossilized' during chemical processing and the main difference between these contaminants and *in situ* fossils was colour saffranin-stained assemblages.

The status of two *Tubulifloridites* specimens in Manilla-1 is critical to dating of the Geera Clay. These are (a) *T. pleistocenius* at 90.11m and *T. antipodica* at 223.2m. The interpretation proposed here is that the former may have been reworked downwards into the highly bioturbated clays at the top of the Geera Clay. The latter, which occurs in a sample otherwise wholly dominated by the (Gippsland) Late Eocene-Oligocene species *Aglaoreidia qualumis*, is considered to be a contaminant. *If in fact the pollen is in situ, then the interval between 149.7 and 223.2m is T. bellus Zone, not P. tuberculatus Zone as proposed.*

MANILLA-1 ZONATION

1. *Dictyotosporites speciosus* Zone (Early Cretaceous) 317.8m

The sample at 317.8m contains an exceptionally well preserved palynoflora including *Cyclosporites hughesii, Dictyotosporites complex* and *D. speciosus*. Based on the range data of Morgan (1980) the assemblage, which is dominated by lycopod spores and, less common gymnosperm pollen, is Aptian - Early Albian. *Crybelosporites striatus* and angiosperm pollen, which first appear in the Early Albian, are absent.

The basal two samples at 328.6 and 328.9m contain poorly preserved assemblages dominated by long-ranging gymnosperm species such as *Alisporites grandis*. Rare occurrences of *Microcachrydites antarcticus, Classopollis* cf *classoides* and *Gleicheniidites* show both samples are no older than the Late Jurassic, *M. antarcticus* Superzone. An Early Cretaceous age is likely on geological grounds.

2. "Upper"*ProteaciditesTuberculatus* Zone (Late Oligocene-Miocene) 149.7- 223.2m

Palynofloras in this interval are mostly dominated by *Nothofagidites emarcidusheterus (N. brassi* type in Table 2) with significant amounts of *Myrtaceidites* and gymnosperm species. The base of the zone is provisionally picked at 223.2m (see above). *Cyatheacidites annulatus*, whose first appearance defines the base of the *P. tuberculatus* Zone occurs at 217.8 m and consistently thereafter throughout the interval. The accessory species *Chenopodipollis chenopodiaceoides* first appears at 179.5m.

On the basis of *Acaciapollenites myriosporites* at 217.8m, the interval is provisionally assigned to the upper zonule of the *P. tuberculatus* Zone. However it is noted that in Gippsland *Aglaoreidia qualumis*, present to abundant in all samples from 223.2 to 245.8m, does not range higher than the lower zonule. A related characteristic of the interval is the persistent presence of Gippsland Eocene taxa, viz. *Tricolpites simatus, Tricolporites leuros* and a variety of *Periporopollenites demarcatus*. All are present in *P. tuberculatus* Zone assemblages from onshore Tasmania (Hill & Macphail, 1983) and, given the presence of Eocene sediments in the Murray Basin, reworking is an alternative explanation. *Proteacidites symphyonemoides,* which is confined to the *T. bellus* Zone in Oakvale-1, occurs at 217.8m.

Taxa restricted to the *P. tuberculatus* Zone in Manilla-1 include *Corsinipollis* sp., *Diporites aspis, Malvacearumpollis, Proeacidites rectomarginis* (cf Oakvale-1) and *Rugulatisporites trophus.*

3. ***Triporopollenites bellus*** **Zone (late Early-Late Miocene) 90.11-145.8m**

Palynofloras in this interval mostly are dominated by gymnosperms, in particular Araucariaceae, *Lygistepollenites florinii* and *Podocarpidites* spp. *Nothofagidites* values are consistently lower than in the underlying interval. Although maximum values of *Myrtaceidites* and *Haloragacidites harrisii* (= Casuarinaceae) occur at or above 145.8m, percentages are too irregular to indicate sustained trends.

The base of the zone is picked at 145.8m, a sample containing the first reliable occurrence of the accessory *T. bellus* Zone species *Tubulifloridites antipodica. Proteacidites symphyonemoides* occurs in the same sample. The nominate species occurs at 126.75 and 119.5m. Other distinctive taxa restricted to the interval include *Alangiopollis* (cf Figs 6-7 in Foster, 1982). *Crotonipollis* sp(p?), *Lymingtonia* sp. and *Perfotricolpites* cf *P. digitatus.* Fragments of what appear to be the distinctive spore *Crassiretitriletes vanraadshoovenii* are mostly confined to the unit, as is *Polycolpites reticulatus.*

The highest sample confidently dated as *T. bellus* Zone is at 100.5m, based on the occurrence of *Tubulifloridites antipodica.* The sample at 94.9m contains long-ranging taxa only but in terms of quantitative composition is not unlike other Oligocene and Miocene palynofloras in Manilla-1.

4. "*Tubulifloridites pleistocenicus*" Zone (? Plio-Pleistocene) 90.11m

The highest core sample taken contains a palynoflora that is wholly dominated by the freshwater alga *Pediastrum;*, it is the only sample with this composition in Manilla-1 (628% relative to total identifiable pollen).

The zonal determination is based on a single (*in situ* ?) occurrence of *Tubulifloridites pleistocenicus*, a species which first appears in the Plio- Pleistocene in the Gippsland Basin (A.D. Partridge, unpubl.data). The pollen type, which is characteristic of Last Glacial deposits in Southeastern Australia, also occurs in Plio-Pleistocene sediments in the northeast of the Murray basin (Martin, 1973). Its presence in sands overlying the Geera Clay is probable although whether sands infilling burrows at the top of the Geera Clay are younger than that unit is unknown.

DINOFLAGELLATES

The majority of samples contain low to negligible numbers of marine/marginal marine dinoflagellate species, most of which cannot be assigned to any described species. On the basis of their abundance relative to freshwater algae *(Pediastrum, Saeptodinium* and *Botryococcus)*, the most marine-influenced samples occur at 136.9m (130% of the spore- pollen count), 141.7m, 162.72m, 169.08m, 179.5m and 217.8m.

QUANTITATIVE COMPARISONS

The same small group of taxa dominate both the Manilla-1 and Oakvale-1 sequences: *Nothofagus brassii* group species, Casuarinaceae, Myrtaceae, Araucariaceae, *Dacrydium* Group B species, *Podocarpus*, with lesser amounts of *Nothofagus menziesii, N. fusca* group, Proteaceae, herbaceous taxa and fern and fern allies.

Consistent with the depositional environment, pollen values tend to fluctuate markedly from level to level, more so in Manilla-1 than in Oakvale-1, with isolated samples being dominated by single taxon, e.g. Casuarinaceae at 131.75m in Manilla-1, Myrtaceae at 110.50m in Oakvale-1. Because of this it is difficult to attach much significance to differences between the two bores in maximum values recorded for phytosociologically important taxa. For example, pollen values of the potentially tall tree Araucariaceae are generally higher at Manilla-1 than at Oakvale-1, but the highest individual pollen value recorded is in the latter bore (46% at 89.00m). Conversely, trends in relative abundance are significant.

Both sequences record the same shift in pollen dominance - from an overall prominence of *Nothofagus brassii* group species to assemblages in which gymnosperms and (Oakvale-1) Casuarinaceae were common. Myrtaceae appear to have behaved independently at each site but this may not be unexpected given the diverse life forms and range of habitats occupied by Myrtaceae species - from epiphytes on *Nothofagus* to tall canopy species in 'mixed' forest to xerophytic shrubs. There is little reason to doubt that both sequences record essentially the same change in a regional vegetation, from evergreen rainforest in which *Nothofagus brassii* group species and Myrtaceae were prominent or dominant, to a drier type of rainforest in which gymnosperms were dominant (see Truswell & others, 1985).

This shift occurred within the *P. tuberculatus* Zone at Oakvale-1 some 25m below the local base of the *T. bellus* Zone and immediately (8m) below the *T. bellus* Zone in Manilla-1 as defined by the first appearance of *Triporopollenites bellus* and *Tubulifloridites antipoda* respectively. Whether the difference in depth represents a significant difference in time is unclear. The point is of some geologic importance since if major shifts in the regional vegetation were significantly time transgressive, then the use of relative abundance data as a dating or correlation tool is unlikely to be reliable except between closely spaced bores.

Modern *Nothofagus*, Myrtaceae, Casuarinaceae and gymnosperm pollen may or may not be widely dispersed depending on the particular source species and the topographic location of the source plants. Although the Oakvale -1 and Manilla -1 data indicate all these taxa were abundant in the Murray Basin at particular times during the Late Tertiary, each may have been *locally* dominant at almost any time during this period. Accordingly quantitative criteria, including ratios between taxa, should be used with extreme caution when dating 'spot' samples or correlating sediments in wells with poor sample control.

SPORE-POLLEN TAXONOMY

As is usually the case with Australian Tertiary palynofloras, significant numbers of the spore and pollen types present have yet to be formally described. The majority are referable to the form genera *Tricolpites* and *Tricolporites* of Cookson. In the case of Manilla-1, undescribed *Liliacidites,* ? *Arecipites* and *Monosulcites* are also prominent. In addition a number of palynomorphs that can be referred to species described from other basins are atypical of topotype populations or intermediate between two named species. An example of the latter is the *Ischyosporites* complex present in Murray Basin bores. These appear to have a more robust 'reticulate' surface ornamentation than *Klukisporites lachlanensis* Martin 1973 but the muri and lumina are more discontinuous and convolute than occur in *Ischyosporites gremius* Stover & Partridge 1973. *Trilites tuberculiformis* Cookson 1947 is evidently an end member of the same morphological spectrum (cf Hill & Macphail, 1983).

Fossil names used in this report primarily follow Stover & Partridge (1973), Stover & Evans (1973) and Martin (1973), amended in part by Pocknall & Mildenhall (1984). All distinctive unknowns have been photomicrographed in order to improve the taxonomic base for correlating Murray Basin sediments. Where possible, these types have been referred to published illustrations, e.g. in Foster (1982) and Truswell & others, (1985). Comments and/or brief descriptions of several previously unrecorded types are given below:

(a) *Canthiumidites oblatus* Pocknall & Mildenhall 1984

Figure 3, S-V

Isopolar; oblate to subprolate, amb subcircular; tricolporate, apertures interradial, colpi long gaping in crushed specimens; ora often obscure but in some specimens annulate; semi-tectate, nexine less than 0.5 microns thick, sexine 3-4 microns thick, thinning towards colpi, coarsely reticulate with large polygonal lumina and muri 3-4 microns wide underlain by irregularly spaced, single columellae, lumina decrease in size across poles. Polar diameter approx. 35 microns.

Comment: The type differs from *Canthiumidites oblatus* in being smaller and possessing long. indistinct colpi. *Rhoipites sp.* C of Foster (1982) appears to have a more delicate reticulum and specimens in Manilla-1 resembling this 'species' have been listed separately on the range chart. It is entirely possible that both types are part of the same species complex. Except that the ora are "indistinct" (Germeraad *& others*., 1968), *Retitricolporites irregularis* Van der Hammen & Wymstra is broadly similar to both the Manilla-1 and Fosters (*ibid*) types.

(b) cf *Guettardidites* Khan 1976

Figure 3 , O-Q

Pollen similar to the above but smaller (22-26 microns across in polar view). Triaperturate with narrow, usually indistinct colpi. The sexine is coarsely reticulate with the muri becoming vermiculate across the poles. The type is provisionally referred to *Guettardidites* Khan 1976 but is smaller than any described species. *Retitricolporites irregularis* Van der Hammen & Wymstra is also similar to but larger than the Manilla-1 type (See Germeraad *& others,* 1968). Pollen with the same basic morphology is produced by living species of Euphorbiaceae (*Amanoa*) and Rubiaceae, and in all probability other angiosperm families.

(c) *Perisyncolporites polkornyi* Germeraad *& others,* 1968 (provisional identification; species cited as *Periporopollenites* sp. A in Fig. 2)

Figure 3, A-H

Subspherical, amb circular to polygonal; exine stratified, nexine 2.5-3.5 microns thick becoming thinner and insert towards apertures, sexine less than 0.5 microns thick, often stripped, psilate-scabrate with well-defined 'colpoid' sexinous 'rifts' joining but not developed across the pores, giving a parasyncolporate appearance to favourable orientated grains; columellae obscure except in ruptured specimens; pores (? ora) circular, 2-3 microns across, broadly aspidate but appearing sunken in equatorial view owing to thickening of nexine, 7-9 located equidistantly around the grain or with 5 located equatorially and 2-4 on each hemisphere, rarely operculate; 24-35 microns in diameter.

Comment: A very similar pollen type also referred to *Perisyncolporites polkornyi* Germeraad & others, 1968, occurs in Miocene sediments in the Bonaparte Basin (A.D. Partridge, pers. comm.). This species, described as having perisyncolporate apertures (extexinous apertures syncolpate, often very wide, sometimes very shallow, margins costate; pores endexinous, 2.5-4 microns wide, circular-oval, if colpi present then located eccentrically) ranges from the Middle/Late Eocene (Verrucatosporites usmensis Zone) upwards in Venezuela and Nigeria but has not been recorded in Borneo (Germeraad *& others. ibid*).

Recognition of this species via the literature is made difficult by the uncertain nature of the 'colpi'. This uncertainty is reflected in descriptions of modern Malpighiaceae pollen (Erdtman, 1966) to which *Perisyncolporites polkornyi* is referred. The modern genus which most closely resembles *P. polkornyi* is *Bunchosia*, a taxon in which the colpi are "degraded" (Erdtman, *ibid)* to sexinous rifts. The taxonomic identity of the Manilla-1 pollen type will be considered in more detail when additional fossil specimens and recent Malpighiaceae pollen are available.

(d) *Proteacidites* sp. A

Figure 3, R

Comment: Similar to *P. asperopolus* and *P. pachypolus* in being concavely triangular with a prominent dome-like protrusion on one pole but distinguished from both by the possessing a sexine that is medium reticulate away from the apertures. A superficially similar undescribed species occurs in the Gippsland Basin. In this species the 'polar boss' is formed by doming of the exine across one pole rather than by actual thickening.

(e) Striate tricolporate types

Figure 3, I-N

'Striate' tricolporate pollen is a persistent, occasionally frequent component in the Manilla-1 palynofloras. Types present frequent component in the Manilla-1 palynofloras. Types present range from ca. 15-35 microns max. diameter and include all extremes in prolate and oblate shape categories As noted by Kemp & Harris (1977), 'striate' pollen includes semi-tectate taxa in which the muri and lumina run broadly parallel to each other (eureticulate) to intectate/tectate taxa characterized by parallel ridges of sexine ('epistriate'). *Tricolporopollenites substriatus* is an example of the former; *Simpsonipollis* and (?) *Tricolporites paenestriatus* are examples of the latter. Both sculptural types are represented in Manilla-1.

(f) 'New Zealand' species/genera

Four taxa recently described from Late Oligocene-Early Miocene sediments in New Zealand (Pocknall, 1982; Pocknall & Mildenhall, 1984) also occur in sediments of equivalent age in Manilla-1. These are: *Corsinipollis* sp., *Diporites aspis, Lymingtonia cenozoica* and *Palaeocoprosmidites* sp. The *Lymingtonia* species may not be conspecific with Martin's (1973a) Portulaceae type from Plio- Pleistocene sediments in the north-east of the Murray Basin since the Manilla-1 fossils have essentially the same exine structure (but not apertural arrangement) as *Perfotricolporites* cf *P. digitatus.* This similarity makes it difficult to distinguish obliquely crushed specimens of *Lymingtonia* sp. and *Perfotricolporites. Lymingtonia cenozoica* Pocknall & Mildenhall 1984, and modern Portulaceae pollen (*Neopaxia, Montia*) have a different exine structure and arrangement (Truswell, 1987.)

(g) Cyperaceae

Two distinct morphotypes are present:

(a) *Cyperaceaepollis* sp. A (= C. sp. of Truswell *& others.* 1985, Fig. 7:W, X-Y). This type is characterized by a long tapering tetrahedral amb and robust, stratified exine less than 1 micron thick, tectate and distinctly scabrate. Although some rare specimens are periporate, the majority are inapertuate or with a single, well developed ulceroid pore on the apex.

Comment: the type belongs to the modern elaecharacoid group, represented by modern sedge genera such as *Cyperus, Elaeocharis, Heleocharis* and *Schoenus*. Most of these have well developed lateral pores.

(b) *Cyperaceaepollis sp.* B. This type is subsphaerical, with a thin exine and (mostly) several well developed ulceroid pores. Modern genera closely resembling the fossil type are *Lepidosperma* and *Elynanthe.*

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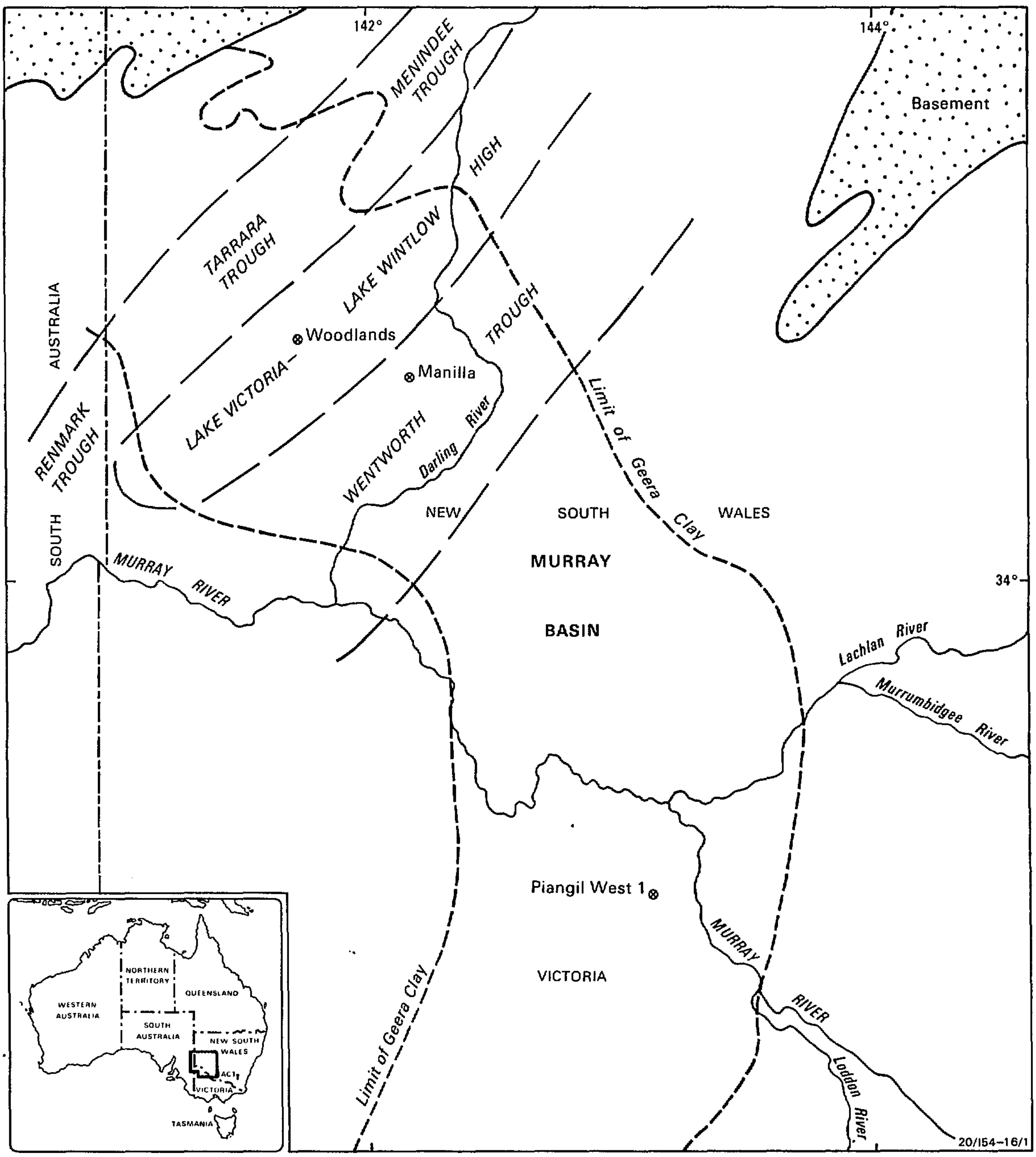

1. Location of Manilla 1 borehole, Murray Basin

FIG. 2 DISTRIBUTION OF SELECTED OLIGOCENE-MIOCENE SPORE-POLLEN TAXA

MANILLA-1

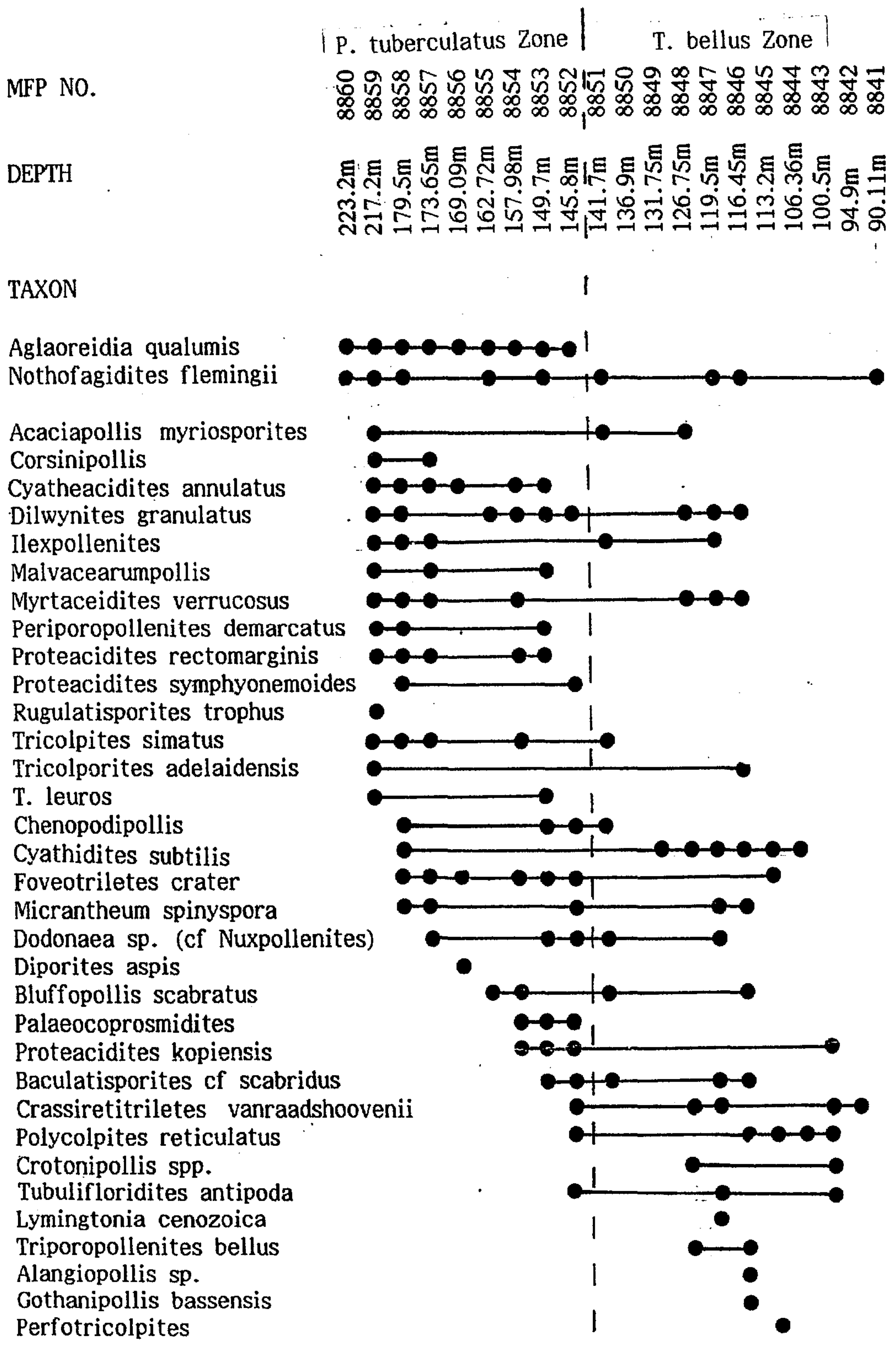

FIGURE EXPLANATIONS (MANILLA -1)

Figure 3. Selected pollen species from Manilla-1. (Magnification x1000 approx.)

A-H *Perisyncolporites polkornyi* Germeraad & others

A,B. Median, high foci on specimen from 174.5 m (MFP 8858)

C Specimen showing nexine partly stripped. 174.5 m (MFP 885)

D, E High and median foci on specimen with 7 pores, weakly developed furrows. 126.75m (MFP) 8848).

F-H Prolate specimen with 3 only well developed pores and colpi. 217.2 m (MFP 8859).

I-L cf. *Simpsonipollis* sp.

I,J Oblique polar view. J under phase contrast. 217.2m (MFP 8859).

K,L Equatorial view. 217.2m (MFP 8859).

M,N *Tricolporites paenestriatus* complex. Median and high foci on one colpus.173.65m (MFP 8857).

O-Q cf. *Guettardidites.*

O, Polar view. 126.7m (MFP 8848)

P,Q Polar view, median focus and high focus on collumellae of reticulum. (MFP 8842).

R *Proteacidites* sp. A 173.65 m (MFP 8857).

S-V cf. *Canthiumdites oblatus* Pocknall & Mildenhall 1984.

S Equatorial view. Thickening around endopore not apparent. 126.7 m (MFP8848)

T Polar view. 173.65 m (MFP 8857)

U,V Polar view. Heavily thickened endopores, colpi extending close to pole. 9.5 m (MFP 8847).

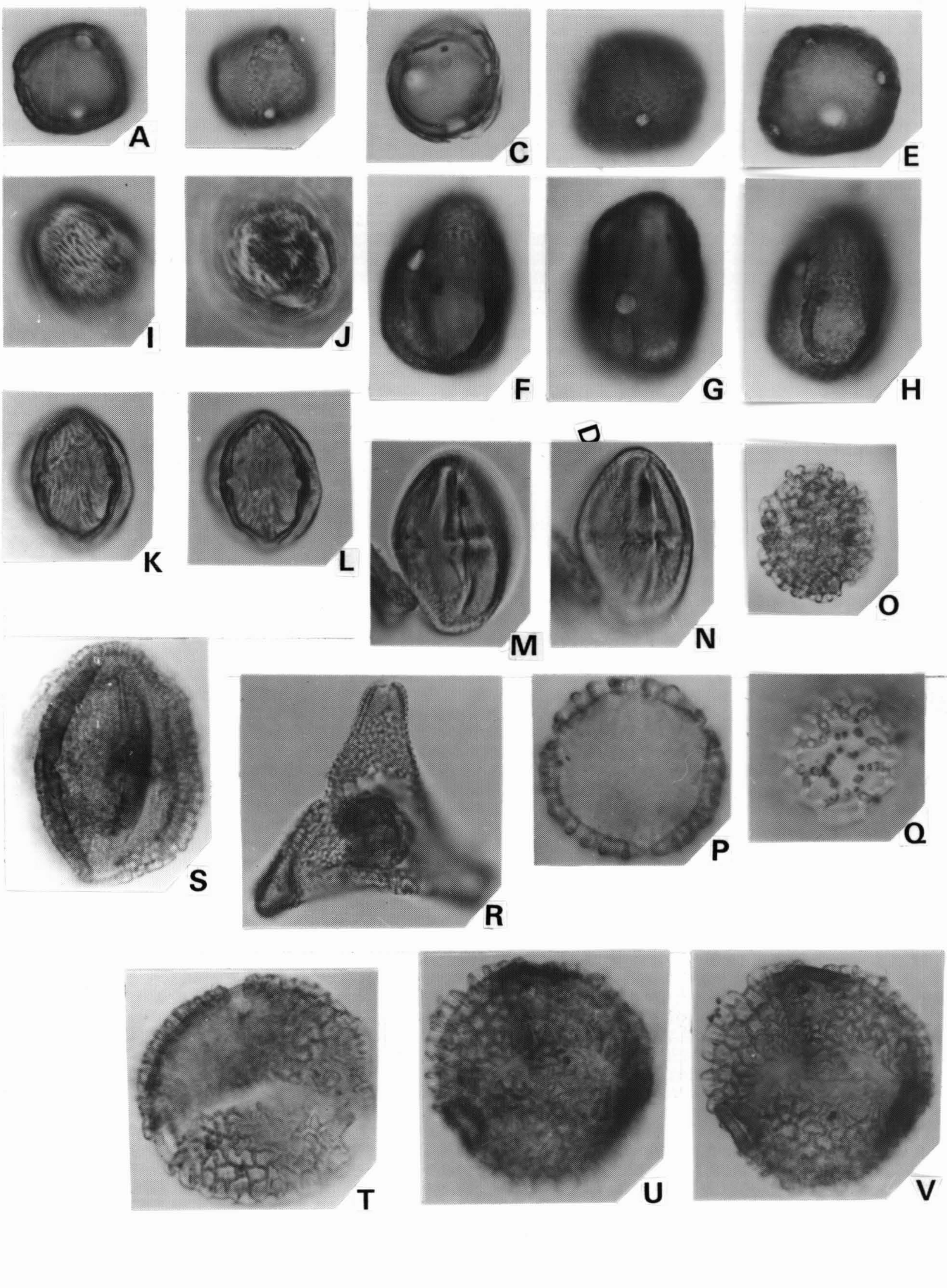

FIGURE 3. Selected pollen species from Manilla 1. Explanations are given on p.17.

TABLE 2 Spore-pollen range chart (Sheet 1)

Well Name MANILLA Basin MURRAY Sheet No. 1 of 4

SAMPLE TYPE OR NO. *	MFP	8841	8842	8843	8844	8845	8846	8847	8848	8849	8850	8851	8852	8853	8854	8855	8856	8857	8858	8859	8860	8861	8862	8863
FOSSIL NAMES / DEPTHS		90.11 m	94.9m	100.5m	106.36m	113.2m	116.45m	119.5m	126.75m	131.75m	136.9m	141.7m	145.8m	149.7m	157.98	162.72	169.08m	173.65m	179.5m	217.2m	223.2m	317.8m	328.6m	328.9m
SPORES																								
Baculatisporites comaumensis		●	●																			●		●
B. disconformis								●						●	●		●	●	●	●				
Ceratosporites equalis															R							●		
Cicatricosisporites			R	R																				
cf. Clavifera triplex					●									●										
Crassiretitriletes vanraadshoovenii			●	●				●	●				●							●				
Cyathea palaeospora			●	●	●	●		●	●					●				●	●	●				
Cyatheacidites annulatus									●					●	●		●	●	●	●				
Cyathidites australis														R								●		
C. concavus													R									●		
C. sp. cf C. splendens Harris															●									
C. minor		●	●						●					●	●	●		●		●	●	●		
Cyathidites subtilis					●	●	●	●	●	●									●					
Cyclosporites hughesii			R															R				●		
Dictyophyllidites cf arcuatus				●	●	●	●		●			●	●		●	●		●		●				
Dictyotosporites complex						R																●		
D. speciosus								R	R													●		
Foveotriletes crater						●							●	●	●		●	●	●					
F. parviretus			R																			●		
Gleicheniidites spp.		●	●				●	●	●		●	●	●	●	●			●	●	●		●		●
Ginkocycadophytus				R		R																●		●
Herkosporites elliottii							●									●		●		●				
Ischyosporites sp. cf. I. gremius				●	●		●	●	●			●		●	●	●		●	●	●				
I. sp. cf. Klukisporites lachlanensis				●	●		●		●		●				●			●	●					
I. punctatus			R												R									
Laevigatosporites spp.		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Latrobosporites amplus			R																					
L. crassus									●						●				●	●				
Leptolepidites major								R															●	
L. verrucatus									R			R										●		
Lycopodiacitidites asperatus																						●		
Lycopodiumsporites austroclavatidites															R							●	●	
L. eminulus			R																					
L. nodosus																					R	●		
L. reticulumsporites																						●		
indeterminate L. spp.					R	●	R	R	●							●								
Matonisporites ornamentalis				●	●		●	●	●			●	●	●	●			●	●	●				
Neoraistrickia truncata			R	R		R			R											R		●		
Ornamentifera sp.								●																
Polypodiaceoisporites cf. P. retirugatus				●				●	●				●		●				●					
Polypodiidites/Polypodiisporites		●		●		●	●	●	●			●	●		●			●						
Reticulatisporites cowrensis														●	●									
Rouseisporites sp. of Truswell et. al. 1985			●	●		●	●	●	●			●	●	●			●	●	●	●				
Rugulatisporites mallatus.			●				●	●				●	●					●		●				
R. sp. cf. R. mallatus				●	●	●	●												●	●				
Stereisporites spp.		●	●		●		●		●			●		●	●			●	●	●				
Triletes tuberculiformis						●													●	●				
Verrucosisporites cristatus									●					●						●				
V. kopukuensis							●																	

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

PALAEO.CHART-2
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R8705803

TABLE 2 Spore-pollen range chart (Sheet 2)

Well Name MANILLA Basin MURRAY Sheet No. 2 of 4

SAMPLE TYPE OR NO. *	MFP	8841	8842	8843	8844	8845	8846	8847	8848	8849	8850	8851	8852	8853	8854	8855	8856	8857	8858	8859	8860	8861	8862	8863
FOSSIL NAMES / DEPTHS		90.11m	94.9m	100.5m	106.36m	113.2m	116.45m	119.5m	126.75m	131.75m	136.9m	141.7m	145.8m	149.7m	157.98	162.72m	169.09m	173.65m	179.5m	217.2m	223.2m	317.8m	328.6m	328.9m
~~POLLEN: GYMNOSPERMS~~																								
Podocarpidites spp.		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Alisporites grandis			R				R															●	●	●
A. similis											R		R									●		
Araucariacites australis			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
Cupressaceae-Taxodiaceae												●												
Dacrycarpites australiensis		●	●	●	●			●		●	●	●	●			●	●	●	●					
Dilwynites granulatus							●	●	●				●	●	●	●			●	●				
D. tuberculatus				●									●	●				●		●				
Ephedra notensis																		●						
Lygistepollenites florinii		●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●				
Microcachrydites antarcticus			●	●	●								●	●	●			●	●	●		●	●	●
Phyllocladidites mawsonii			●								●	●	●	●	●			●	●	●				
Phyllocladus palaeogenicus				●								●	●	●	●	●		●	●	●				
Podosporites microsaccatus			●						●						●	●				●	●			
taeniate bisaccates (Protohaploxpinus?)		R	R																					
Tsugaepollenites sp.			R																					
POLLEN: ANGIOSPERMS																								
Acaciapollenites myriosporites									●			●								●				
Aglaoreidia qualumis													●	●	●	●	●	●	●	●	●			
Arecipites (sensu lato)						●	●	●	●	●			●			●		●		●	●			
Banksieaeidites cf. arcuatus																	●							
B. elongatus-minimus			●	●								●				●	●			●				
Basopollis sp.								●							●			●	●					
Bluffopollis scabratus							●					●			●	●								
cf Canthiumidites oblatus				●			●	●	●				●		●			●		●				
Chenopodipollis chenopodiaceoidites												●	●	●	●				●					
Corsinipollis sp																		●		●				
Crotonipollis sp.				●					●															
Cunoniaceae								●				●	●		●									
Cupanieidites orthoteichus					●		●	●	●					●	●			●	●	●				
C. reticularis							●		●			●		●	●			●	●	●				
Cyperaceaepollis sp. A		●	●	●	●	●		●	●		●		●	●		●	●	●	●	●	●			
C. sp. B			●	●	●	●	●						●		●	●	●	●						
Diporites aspis																	●							
Dodonaea cf. sphaerica														●				●	●	●				
D. sp. (= cf. Nuxpollenites sp. of Truswell et. al. 1985)								●				●	●	●				●						
cf Elaeocarpaceae							●		●					●										
Ericipites crassiexinous								●	●				●	●		●		●						
E. scabratus									●				●	●	●	●	●	●	●					
Gothanipollis bassensis							●																	
Graminidites spp.				●	●		●	●			●		●			●			●	●				
cf Guettardidites			●	●			●	●	●			●				●				●				
Gyrostemonaceae.														●	●					●				
Halagoracidites harrisii (sensu lato)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Ilexpollenites spp.								●						●				●	●	●				
Liliacidites spp.		●	●	●	●	●	●	●	●	●			●	●		●	●	●	●	●				
Lymingtonia cenozoica								●																
Malvacearumpollis sp.														●				●		●				
Malvacipollis subtilis		●					●	●	●				●	●	●	●		●	●	●				
indeterminate M. spp.				●		●	●		●	●		●	●		●					●				
Margocolporites cf scabratus							●		●				●											
Micrantheum spinyspora							●	●					●					●	●					
Milfordia homeopunctata		●		●	●	●		●	●			●	●	●	●	●	●	●	●	●				
M. hypolaenoides		●	●	●	●	●								●		●	●		●		●			
Myrtaceidites eucalyptoides (sensu lato)		●					●	●	●		●	●		●	●			●	●		●			
M. parvus-mesonesus				●		●	●	●	●	●	●	●	●	●	●		●	●	●		●			

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

PALAEO.CHART-2
DWG.1107/OP/287

TABLE 2 Spore-pollen range chart (Sheet 3)

Well Name MANILLA Basin MURRAY Sheet No. 3 of 4

SAMPLE TYPE OR NO. *	MFP	8841	8842	8843	8844	8845	8846	8847	8848	8849	8850	8851	8852	8853	8854	8855	8856	8857	8858	8859	8860	8861	8862	8863
FOSSIL NAMES / DEPTHS		90.11m	94.9m	100.5m	106.36m	113.2m	116.45m	119.5m	126.75m	131.75m	136.9m	141.7m	145.8m	149.7m	157.98	162.72m	169.08m	173.65m	179.5m	217.2m	223.2m	317.8m	328.6m	328.9m
POLLEN: ANGIOSPERMS cont.																								
Myrtaceidites rhodamnoides							●		●						●				●					
M. verrucosus							●	●	●						●			●	●	●				
Nothofagidites asperus				●	●	●	●		●			●	●	●	●	●		●	●	●				
N. brachyspinulosus							●	●				●		●	●	●		●	●	●	●			
N. deminutus-vansteenii				●			●							●	●	●		●	●	●				
N. emarcidus-heterus		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
N. falcatus				●	●		●	●	●	●		●	●	●	●	●		●	●	●				
N. flemingii		●					●	●				●		●		●			●	●	●			
N. goniatus				●										●										
Palaeocoprosmadites cf zelandiae													●	●	●									
Perfotricolpites sp. cf P. digitatus																								
Periporopollenites demarcatus														●					●	●				
P. cf. polyoratus														●	●			●		●				
P. sp. A							●	●	●										●					
Polycolpites endobalteus								●						●										
P. reticulatus				●	●	●	●						●							cf				
Polyorificites oblatus			●	●	●	●	●	●	●	●		●		●	●			●	●	●				
Propylipollis annularis									●							●		●		●				
P. cf annularis															●			●		●				
P. latrobensis							●											●						
Proteacidites cf confragosus					●																			
P. kopiensis				●									●	●	●									
P. ivanhoensis															●									
P. pseudomoides						●																		
P. rectomarginis														●	●			●	●	●				
P. rectus				●																				
P. cf reflexus				●									●					●						
P. reticuloscabratus								●												●				
P. cf rynthius														●										
P. scitus								●																
P. stipplatus				●																				
P. tuberculatus														●										
P. sp. A																		●						
undescribed P. spp.				●	●	●	●	●	●	●		●	●	●	●	●	●	●	●		●			
Quintinia psilatispora				●			●	●	●						●			●	●					
Q. sp.														●										
Rhoipites alveolatus							●		●				●											
R. sphaerica																								
R. sp. C of Foster 1982						●			●						●									
Sapotaceoidaepollenites rotundus							●							●	●					●				
Schizocolpus marlinensis																					●			
Sparganiaceaepollenites barungensis			●	●	●				●				●	●		●		●	●	●				
S. robustisporis			●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●					
Stephanocolpites oblatus							●						●	●				●	●		●			
Tetracolpites sp.							●											●			●			
Tetracolporites cf palynius								●										●						
Tricolpites reticulatus									●															
T. simatus												●			●			●	●	●				
indeterminate T. spp.		●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●				
Tricolporites adelaidensis							●													●				
T/ angurium					●				●															
Tricolpites sp. A (cf Goodeniaceae)								●						●	●									
indeterminate T. spp.			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Triporopollenites bellus							●		●															

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

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TABLE 2 Spore-pollen range chart (Sheet 4)

Well Name MANILLA Basin MURRAY Sheet No. 4 of 4

SAMPLE TYPE OR NO. *	MFP	8841	8842	8843	8844	8845	8846	8847	8848	8849	8850	8851	8852	8853	8854	8855	8856	8857	8858	8859	8860	8861	8862	8863		
FOSSIL NAMES / DEPTHS		90.11m	94.9m	100.5m	106.36m	113.3m	116.45m	119.5m	126.75m	131.75m	136.9m	141.?m	145.8m	149.7m	157.98m	162.72m	169.08m	173.65m	179.5m	217.2m	223.2m	317.8m	328.6m	328.9m		
Angiosperm Pollen: cont.																										
Triporopollenites sp. A																		●								
Tubulifloriditès antipoda				●				●					●								?C					
T. pleistocenicus		?C																								
cf Weinmannia				●										●	●			●								
ADDITIONAL TAXA																										
SPORES																										
Baculatisporites cf B. scabridus							●	●				●	●	●												
Camarozonosporites spp.							●											●								
Contignisporites cooksoniae																						●				
Cyathidites subtilis									●																	
C. sp. cf Cyathea australis			●		●	●			●					●			●	●		●						
Didecitriletes spp.			R						R																	
Deltoidospora granulomargo							●		●						●											
Dictyophyllidites crenatus																						●				
Dulhuntyispora parvithola									R																	
Lycopodiumsporites circolumenus																						●				
Reticulatisporites pudens																						●				
POLLEN: GYMNOSPERMS																										
Classopollis cf classoides																				R	R	●	●	●		
POLLEN: ANGIOSPERMS																										
Alangiopollis cf A. sp. of Foster 1982							●																			
Beaupreadites elegansiformis																		●								
Perfotricolpites cf digitatus						●																				
Proteacidites symphyonemoides													●							●						
Pseudowinterapollis calathus				●																						
P. cranwellae							●																			
Rhoipites sphaerica							●								●			●	●		●					
Tricolporites leuros														●						●						
Tricolporites paenestriatus/Tricolporopollenites substriatus complex				●		●	●		●			●	●	●	●	●		●	●	●						
ALGAE: FRESHWATER																										
Botryococcus		●	●	●					●				●		●		●									
Pediastrum		●	●	●	●	●	●	●	●					●			●		●							
Saeptodinium									●			●					●									
ALGAE: MARINE/MARGINAL MARINE			●		●	●	●	●	●		●	●	●	●	●	●	●	●	●							

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

PALAEO.CHART-2
DWG.1107/OP/287

TABLE 3

SUMMARY OF INTERPRETATIVE PALYNOLOGICAL DATA

SAMPLE MFP	DEPTH (m)	SPORE-POLLEN ZONE	AGE	CONF. RTG.	COMMENTS
8841	90.11	T. pleistocenicus	? Plio-Pleistocene	-	bioturbated sample
8842	94.9	Indeterminate	? Miocene	-	
8843	100.5	T. bellus	Middle Miocene	1	T. antipoda
8844	106.36	Indeterminate	Oligo-Miocene	-	P. cf confragosus
8845	113.2	T. bellus	Miocene	2	Perfotricolpites
8846	116.45	T. bellus	Middle Miocene	0	T. bellus, S. rotundus
8847	119.5	T. bellus	Miocene	1	T. antipoda
8848	126.75	T. bellus	Middle Miocene	0	T. bellus , C. annulatus
8849	131.75	Indeterminate	-	-	
8850	136.9	Indeterminate	-	-	
8851	141.7	T. bellus	Oligo-Miocene	2	Acaciapollis, Chenopod
8852	145.8	T. bellus	Miocene	1	T. antipoda
8853	149.7	No older than P. tuberculatus		-	C. annulatus,
					P. rectomarginis
8854	157.98	No older than P. tuberculatus		-	as above
8855	162.72	Indeterminate	Oligo-Miocene	-	P. demarcatus
8856	169.08	No older than P. tuberculatus		-	F. crater
8857	173.65	No older than P. tuberculatus		-	C. annulatus
8858	179.5	No younger than T. bellus		-	P. rectomarginis
8859	217.2	No older than P. tuberculatus		-	C. annulatus, Acaciapollis
					P. rectomarginis
8860	223.2	No older than Middle	N. asperus	-	A. qualumis , contam.
					by T. antipoda?
8861	317.8	D. speciosus	Apt.-Early Alb.	1	D. speciosus, C. hughesii,
					D. complex
8862	328.6	M. antarcticus	Early Cretaceous	2	M. antarcticus
~~8863~~	328.9	M. antarcticus	Early Cretaceous	2	M. antarcticus

Please note that each age-determination is based on the internal evidence of that sample

0 SWC or Core High Confidence. Assemblage contains index fossil(s)

1 SWC or Core Medium Confidence. Diverse, well-preserved assemblage, lacking index species but otherwise characteristic of zonule

2 SWC or Core Low Confidence. Low diversity/poorly preserved assemblage of long-ranging species

3 Cuttings or badly contaminated SWC Low to Very Low Confidence

4 Barren Samples

TABLE 4

RELATIVE ABUNDANCE OF SPORE-POLLEN SPECIES IN MANILLA-

(all percentages expressed as percentages of total identifiable Tertiary spore-pollen count. Percentages less than 1% given as +.

Well Name MANILLA

SAMPLE TYPE OR NO. *	MFP	8841	8842	8843	8844	8845	8846	8847	8848	8849	8850	8851	8852	8853	8854	8855	8856	8857	8858	8859	8860	8861	8862	8863
FOSSIL NAMES / DEPTHS		90.11m	94.9m	100.5m	106.36m	113.2m	116.45m	119.5m	126.75m	131.75m	136.9m	141.7m	145.8m	149.7m	157.98m	162.72m	169.08m	173.65m	179.5m	217.2m	223.2m	317.8m	328.6m	328.9m
TREES & SHRUBS																								
Nothofagus menziesii-type				+		+	1	2	2			+		1	2	+		2	+	1				
Nothofagus brassii-type			4	28	2	2	25	16	15	6		7	5	32	36	13	9	41	48	31	3			
Nothofagus fusca-type								+				+		1	4	+		+	1	1	2			
Casuarinaceae			9	21	5	8	11	15	9	66		8	19	11	9	19	9	8	3	3	6			
Myrtaceae				1	+	+	35	6	12	1		23	1	5	6		+	5	5	8	+			
Araucariaceae			4	3	25	27	8	15	22	3		29	19	7	7	1	1	7	23	39	+			
Dacrydium (Group B spp.)			20	9	6	12	+	5	1	5		4	8	3	3	4	4	1	1	2	+			
Dacrycarpus			3	1	13	2	+	2	2	+		+	3	2	1	2		+						
Podocarpus			11	9	7	10	3	13	13	4		13	34	8	12	3	4	12	5	8	3			
Phyllocladus												+	+		1	+			+					
Banksia																2	3							
cf Elaeocarpaceae							1							+	1									
Epacridaceae-Ericaceae														+		+		1						
Quintinia		NEGIGIBLE SPORE-POLLEN		2							NEGIGIBLE SPORE-POLLEN		+						+					
Proteaceae				2	+	2	+	+	+	+		+	+	3	+	4	5	2	+		1			
HERBS																								
Liliaceae (sensu lato)			9	+	3	17	+	+	+	+			+	2	+	8	6	+						
Gramineae				+	+							+	2			1			+					
Cyperaceae			5	4	4	2	+	2	+			+	7	+	+	6	13	4		+	+			
Restionaceae			9	3	+	2	+	+				+	2	1		12	28	2		+	+			
Sparganiaceae			2	+	3	1	+	3	2			+	5	1	+	9	15	1	+	+				
ANGIOSPERMS OF UNKNOWN HABIT																								
Aglaoreidia qualumis																2	+			+	74			
Polyorificites oblatus			+	1			+	+	+	1		+		1	+				+					
Tricolpites			1	3	3	3	2	2	2	2		+	3	1	1		2	1	2	1	+			
Tricolporites			1	2	2	1	1	2	2	2		6	1	6	5	2	2	4	2	2	+			
CRYPTOGAMS																								
Lycopsida			4	1	+	6	1	2	3			3	+	+	+	2	+		+		1			
Cyathaceae			6	4	11	6	2	6	7	3		11	7	3	3	2	3	2	+	+	1			
Gleicheniaceae			+		+				+	+		7		2	2	+		+	+	+				
Monolete fern spores			5	3	11	5	+	4	2	+		7	4	4	+	4	2	4	+	+	1			
FRESHWATER ALGAE																								
Botryococcus		+	1	3	+				1			1	1	3	1	11	1	2						
Pediastrum		(628)	1	2	1	2		+		2			3		4	10	+	3	+					
Saeptodinium										2							2							
Zygnemales				+				+					+			+								
~~MARINE/MARGINAL MARINE ALGAE~~ (dinoflagellates)		+	+			+			+		(130)	13	1		+	5	7		4	7				
% UNIDENTIFIABLE SPORE-POLLEN			23	6	4	11	12	5	4	2		7	11	7	7	5	5	8	10	6	13			
% RECYCLED SPORE-POLLEN		+	11	4	+	3	+	+	+	4		7				1	3				38			
% IN SITU EARLY CRETACEOUS SPORE-POLLEN																						100	100	101
POLLEN SUM			188	310	300	265	313	341	338	164		245	287	419	308	285	163	283	250	282	187	—	—	—

TABLE 5

ANOMALOUS AND UNUSUAL OCCURRENCES OF SPORE POLLEN SPP. IN MANILLA -1

90.11 m	*Tubulifloridites pleistocenicus*	Plio-Pleistocene sp. in Gippsland
94.9 m	*Crassiretitriletes vanraadshoovenii*	Early Miocene sp. in pantropic areas, Early-Middle Eocene in Gippsland Basin.
100.5 m	*Polycolpites reticulatus*	Rare sp. Also in 106.36-119.5m, 145.8m, 217.2m
100.5m	*Proteacidites rectus*	Not recorded above Middle *N. asperus* zone in Gippsland. In Oligocene-Miocene strata in N.Z.
113.2 m	*Perfortricolpites cf. P. digitatus*	Rare, distinctive sp.
116.45 m	*Micrantheum spinyspora*	Uncommon sp. Also at 145.8m, 217.2m
116.45 m	*Propylipollis latrobensis*	Eocene sp. in Gippsland, extends to Oligocene in Tas
116.45 m	*Alangiopollis* sp.	Very rare sp.
119.5 m	*Tetracolporites palynius*	? rare sp
119.5 m	*Lymingtonia* cf. *cenozoica*	Very rare sp.
126.75 m	*Verrucosisporites cristatus*	Rare sp.
141.7 m	*Bluffopollis scabratus*	Very rare above Eocene in Gippsland. Occurs in Oligocene in Tas. and Oligo-Miocene in N.Z.
141.7 m	*Tricolpites simatus*	Not recorded above Late Eocene in Gippsland
145.8 m	*Aglaoreidia qualumis*	Not occurring above Lower P. *tuberculatus* Zone in Gippsland. Abundant at 223.2m in Manilla-1
149.7 m	*Malvacearumpollis sp.*	Rare pantropic sp.
149.7 m	*Reticulatisporites cowrensis*	? rare below Pliocene
1149.7 m	*Palaeocoprosmidites* sp.	= modern Coprosma/Opercularia/Pomax pollen
149.7 m	*Tricolporites leuros*	Rare in Miocene
162.72 m	*Periporopollenites demarcatus*	Rare above Eocene
169.08 m	*Diporites aspis*	Very rare sp.
173.65 m	*Corsinipollis* sp.	Very rare sp.
217.2 m	*Rugulatisporites trophus*	Middle Eocene- Early Oligocene sp. in Gippsland Basin

TABLE 6

BASIC DATA

SAMPLE MFP NO.	DEPTH (m)	LITHOLOGY	YIELD		PRESERV'N	DIVERSITY	
			S-P	DINOS		S-P	DINOS
8841	90.11	Cly, blk, bioturb.	v. low	v.low	fair	low	low
8842	94.9	Cly, dk. grey	v. low	v. low	fair	high	low
8843	100.5	cly, dk. grey	high	v. low	fair	high	low
8844	106.36	Cly, blk., bioturb.	low	v. low	fair	high	low
8845	113.2	Cly, lam., glau.	v. low	v. low	fair	medium	low
8846	116.45	Cly, blk, bioturb.	high	v. low	good	high	medium
8847	119.5	Cly, blk., bioturb.	medium	low	fair	high	low
8848	126.75	Cly, blk.	high	low	fair	high	medium
8849	131.75	Cly, green., shelly	v. low	-	fair	low	-
8850	136.9	as above, pyritised	v. low	low	poor	low	high
8851	141.7	as above, rare gypsum	low	low	fair	medium	medium
8852	145.8	Cly, glau.	high	medium	fair	high	medium
8853	149.7	Cly, blk., glau.	high	low	fair	high	low
8854	157.98	Cly., blk., glau	high	v. low	fair	high	low
8855	162.72	Cly, blk.	medium	low	fair	medium	low
8856	169.08	Slt., glau., shelly	low	medium	fair	medium	medium
8857	173.65	Cly, blk., lam.	High	v. low	good	high	low
8858	179.5	Cly, blk., pyrit.	high	low	good	high	low
8859	217.2	lignite/lam. slty cly	v.high	medium	good	high	medium
8860	223.2	Slty cly, blk.	medium	-	good	medium	-
8861	317.8	Carb. cly	high	-	good	high	-
8862	328.6	Slts, lam., lignitic	medium	-	poor	medium	-
8863	328.9	charcoal conglom.	medium	-	poor	medium	-

DIVERSITY: SPORE-POLLEN low = less than 10 spp., medium = 10-30, high = greater tha 30 spp.

DINOS low = 1-3 spp., medium = 3-10 spp., high = greater than 10