

STRATIGRAPHY AND PALYNOLOGY OF
THE PERMIAN AT WATERLOG BAY,
YORKE PENINSULA, SOUTH AUSTRALIA

C. B. FOSTER, B.Sc.

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ABSTRACT

The Permian microflora from Waterloo Bay is systematically described and quantified. One microfloral assemblage-zone is present and is dominated by monosaccate and monocolpate pollen. The low frequency of taeniatae disaccate pollen indicates that the microflora is of pre-late 'Sakmarian' age.

The assemblage is equated with Evans' (1969) Stage 2 microflora. Resulting from this the sediments from Waterloo Bay are correlated with the Upper Nangetty Formation of the Perth Basin, also of 'Sakmarian' age.

A reworked Devonian microflora is recorded and its excellent preservation suggests a local origin. It is postulated that the microflora was recycled in a sub aqueous environment during or at the end of deglaciation. This and the presence of arenaceous foraminifera, spinose acritarchs, and Botryococcus suggest a low salinity 'marine' environment of deposition.

Palynological correlation of this suite of sediments with other South Australian Permian deposits shows a general marine influence during 'Sakmarian' time. Subsidence and lifting (McGowan, 1972) is postulated to explain this ingressión which is recorded in all continents of Gondwanaland, with the exception of Antarctica.

I INTRODUCTION

1. HISTORICAL

Evidence of a glaciation including striated pavements, roches moutonnées, faceted pebbles and tillites, has long been known from areas within the Troubridge Basin (Fig. 2b). The age of the event had been considered as Permo-Carboniferous since 1895 (cf. Segnit (1940) - Lower Cretaceous glaciation) when Howchin correlated the 'Inman Valley Beds' with glacial sequences at Bacchus Marsh, Victoria (Howchin, 1926).

These sediments were thought to have been outwash deposits or fluvio-glacials (e.g. Mawson, 1926). This attitude was partially due to the apparent absence of marine fauna (see below) particularly the rich marine invertebrate mega faunas seen in eastern and western Australian Permian basins. Not only did the lack of fossils affect the sedimentary facies interpretation, but it restricted workers to lithostratigraphic correlations.

In 1956 Ludbrook reported the occurrence of arenaceous foraminifera from the Minlaton No. 1 and Stansbury No. 1 Stratigraphic Boreas (locations shown Fig. 2b). The assemblages gave a Lower Permian age to the sequences which had up until that time been referred to as "Permo-Carboniferous". This and later work by Ludbrook (1965, 1967, 1969) indicated the ubiquity of a marine influence within the South Australian Permian with the exception of the Cooper Basin (although see Wass, 1969, 1970; and later text p. 11A). Although Ludbrook (1965) suggested a correlation with the Quamby Mudstone of Tasmania (Lower Sakmarian) the "restricted nature of the microfaunas precludes correlation by this means alone" (Ludbrook, 1969, p.43).

The importance of palynomorphs* as biostratigraphic indicators, as opposed to the longer ranging arenaceous foraminifera, was shown by Balme (1957). He found spores of "diagnostic value which characterise Lower Permian assemblages in New South Wales, Tasmania and Western Australia"

* Acid resistant microfossils including spores, pollen, dinoflagellates and acritarchs. Tschudy & Scott (1969).

(Balme, 1957, p.62) in sediments from the Lake Phillipson Bore (Arckaringa Basin, South Australia). The age assigned to them ranged from (?) Lower Carboniferous to Middle Artinskian.

It was then a major discovery when Harris recorded a rich Permian microfloral assemblage from samples, collected by R. F. Harris, Dept. of Geology, of blue-black clay exposed in the coastal profile at Waterloo Bay (Fig. 2a; Harris & McGouran, 1971). This was the first reliable age for at least some of the Permian sequence within the Troubridge Basin.

The microflora from Waterloo Bay has great potential in its contribution to Australian and Gondwanaland correlations, particularly with the use of palynology, as a biostratigraphic tool, within the last decade (e.g. Balme, 1962, 1970).

2. AIMS OF THE STUDY

As the results from this important find given by Harris & McGouran (1971) are preliminary, it was suggested to the writer that a full investigation of this microfloral assemblage would be a useful project. The main aims of this study were to extend this initial work by providing the first fully documented microfloral assemblage, and in so doing evaluate its biostratigraphic usefulness by comparisons with stratigraphically controlled assemblages within Australia (see p. 11).

Associations of palynomorphs with other microfossil groups (see Biofacies, p. 6) has led to their increasing use as palaeo-environmental indicators. Such data are useful in palaeogeographical reconstructions. Consequently the contribution of this Assemblage to these problems was investigated (p. 12).

To complete the micropalaeontological survey of the project area (Fig. 1) samples were collected and examined for foraminifera (Appendix 2). The significance of these finds is discussed later (p. 3). The study, although requiring much laboratory work, has been retained within its geological framework.

3. METHODS

(a) FIELDWORK

This was confined to the coastal cliff sections (Fig. 2a) at Waterloo Bay, although some samples (barren) were collected from Point Turton (Fig. 2b). Many of the cliff sections are near vertical (max. height 31 m) and were only accessible from the beach. Consequently in most places fieldwork was restricted to low tide periods and the absence of on-shore winds.

The best low tide times were obtained by subtracting 0030 hours from the official times given for Outer Harbour (S.A. Dept. of Marine and Harbours, Tide Tables: for the current year). Using a Jacob's staff with sighting attachment and working from the water's edge, the tables also provided a means of calculating the height of the base of the cliff section above mean sea level (the datum, Fig. 2a).

A 7 cm diameter 'post hole digger' was used for field sampling to obtain at depth (max. 1.2 m) less weathered samples for palynological examination (further details Appendix 1a).

(b) LABORATORY WORK

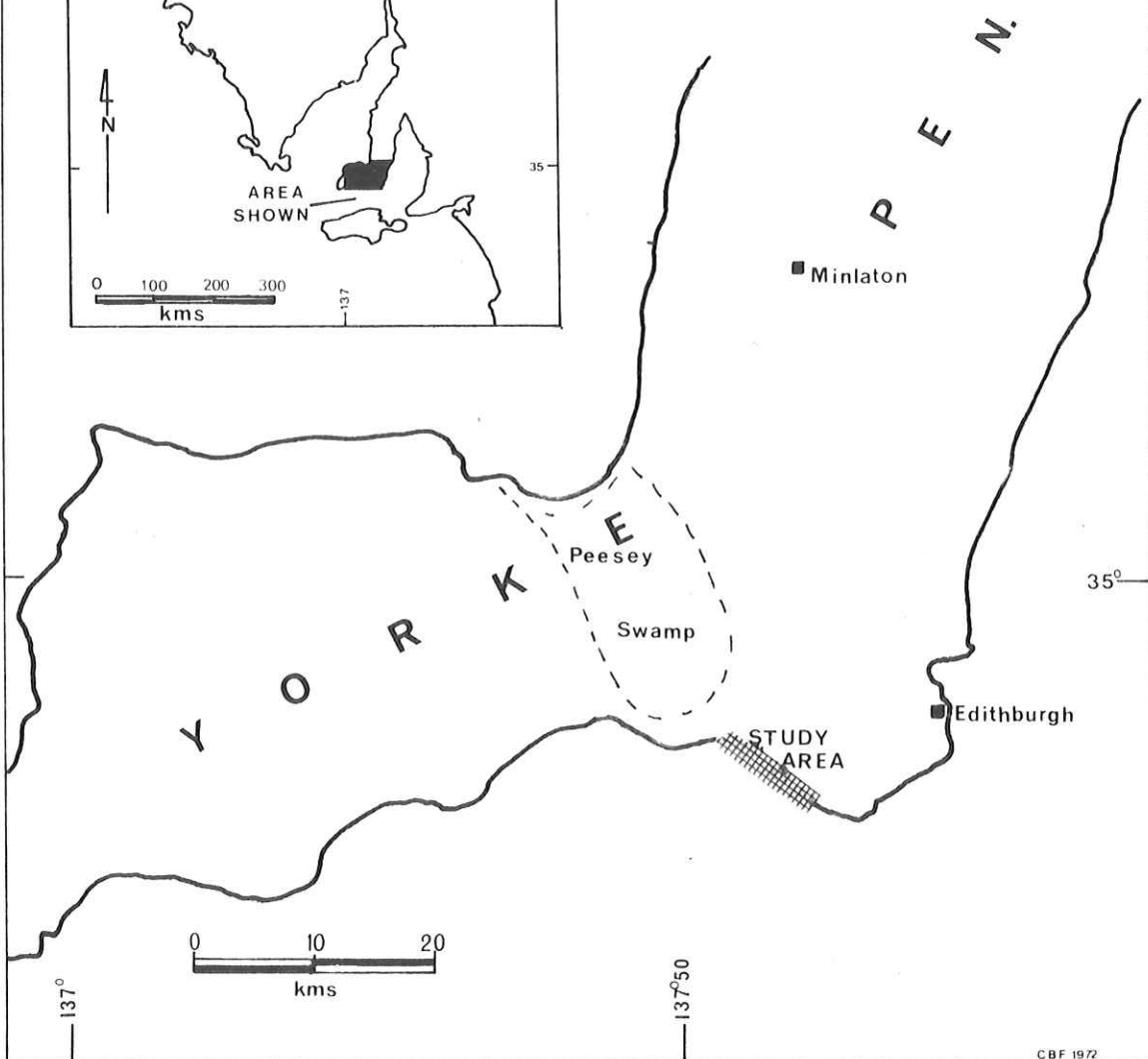
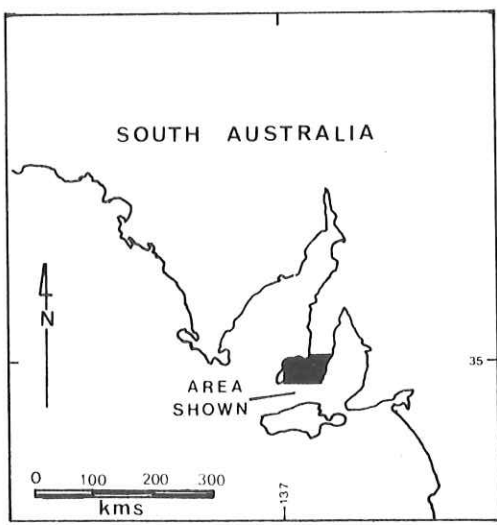
(i) Palynomorphs: the maceration procedure was essentially similar to that used by the Palynology Laboratory, Geological Survey of South Australia. In short, samples were treated with hydrofluoric acid to remove the silicates. Excess organic material was then removed using a Schultze solution followed by alkali. Full details of the preparation are given in Appendix 1b.

Sample numbers of residues and straw slides deposited in the Geological Survey Palaeontological Collection are prefixed S (Appendix 2). A Leitz Laborlux Microscope No. 579756 from the Palynology Laboratory was used during the study and slide coordinates are from this instrument.

(ii) Foraminifera: standard techniques as given in Glaessner (1945) were used in preparing samples for examination.

LOCALITY MAP WATERLOO BAY

Fig. 1



II GEOLOGY

1. THE TROUBRIDGE BASIN (Fig. 2b)

This is one of the smallest South Australian Permian intracratonic infra basins (2592 km²). The basin margin (as shown in Fig. 2b) has been defined by Wopfner (1969) from the "geometry of (proven) sediment fill" (my brackets; Wopfner, *op. cit.*, p.3). Such data are limited to obvious glacial features (p. 1) and to that from micropalaeontological evidence. Both are scarce within the area shown, especially the submarine portions of the basin, and so the boundary must be regarded as flexible.

Stackler and Sprigg who first defined the basin did so on the results of a submarine gravity survey within the St. Vincent Gulf region. The two boundaries however are not coincident (see Sprigg & Stackler, 1965). The problem need not concern us further if the Troubridge Basin is regarded as a concept which has been developed for the convenience of discussion.

2. REGIONAL SETTING

A thin soil horizon overlying nodular, sheet calcretes, thickening toward the coast, covers underlying sediments. Topographic lows within the gently undulating landscape are usually occupied by salt lakes, and their presence infers the ubiquity of Permian clays on Southern Yorke Peninsula (Crawford, 1965). Reports of large granite erratics along the margins of some of the larger impermeable clay-based lakes (e.g. Howchin, 1900) support this.

Exposures of the underlying sediments are limited to coastal sections. They were first mapped by Howchin (1900) who recorded "Pre Tertiary glacial clays" (i.e. Permian) from the coastal exposures 0.8 km west of Troubridge Hill to Port Macrowie (Fig. 2a). The most recent geological survey by Crawford (1965) is a major reference. Subsurface studies by Johnson and Laws (1969) summarise data from thirty-one auger holes drilled at Peasey Swamp (Location, Fig. 1). They record "at least 156 m" of Permian overlain

either by Tertiary (Oligocene) limestones or recent sediments overlying "Archean" gneissic rocks.

Seismic reflection studies by Stuart and Yakunin (1971) have shown that these exposures occur as upthrown blocks along rejuvenated late Precambrian - early Palaeozoic faults.

3. STRATIGRAPHY AT WATERLOO BAY (Summarised, Fig. 2a)

BASEMENT

No basement outcrop occurs within the area.

PERMIAN

Biostratigraphic Correlation - (a)

The maximum thickness of palynologically proven Permian sediments is 12 m. They are correlated with the Upper Nangetty Formation (Fig. 4) of the Perth Basin and are included within the Cape Jervis Beds (Ludbrook, 1967). A comparison of the outcrop with the lithologies logged from the Stansbury No. 1 and Minlaton No. 1 Stratigraphic Bores (Ludbrook, 1965) places them high in the local Permian section.

Lithologies - (b)

The sediments which occur at the base of the cliff sections (lateral extent 6 km) are generally black to blue-grey sandy, micaceous clays, which weather grey-white. These carbonaceous (in parts) claystones* have no obvious bedding features. Small erratics (3 cm²) of varied lithological type including granite, gneissic fragments and quartzite, occur throughout the sediment. Much larger erratics occur loose on the beach (subject material of thesis; Harris, 1971) and have been reworked to form recent lag deposits.

Much of the outcrop is severely iron stained (which renders it unsuitable

* Claystones - moderately indurated clays - do not have the fissility of a shale, nor exhibit the conchoidal fractures of a mud stone (Pettijohn, 1957, p.341).

for palynology, Appendix 1a) and this apparent laterization could be a post Permian surface feature. Ludbrook (1965), however, has recorded some iron staining in sub-surface material. Reynolds and Johnson (1972) have reported chemical weathering (laterization) in a recent sub-glacial environment and so the possibility of this being a Permian feature cannot be discounted.

The lowermost Permian outcrop occurs at beach level and is poorly exposed. It is a brown gritty siltstone, containing larger erratics, with evidence of slumping. Samples from this level were barren.

Interbedded within the claystones are discontinuous sand lenses. These range from light blue to white fine grained sands to red coarser sands. The origin of these sands is not known although Harris (1971) has suggested that they are wind-blown. Samples collected for foraminiferal analysis were barren.

Many of the lenses have prominent concretions which are probably weathering features (Plate 7, Fig. 71). Generally the contact between the claystones and the sand is sharp; at one locality, however (Section 8, Fig. 2a) the lens overlies a cobble bed (40 cm thick; Plate 7, Fig. 73), but it is not traceable for more than 2 m. This bed could represent Permian reworked sediments in an old channel deposit. Similar lag deposits were seen at Point Turton (Fig. 2b).

? Permian Clays and Sandrock

(a) The combined thickness of these two units is 5 m. No microfossils were found in samples from either unit; they do, however, contain erratics. In the absence of palaeontological evidence and with the possibility that they have undergone post Permian reworking, the stratigraphic position cannot be accurately determined, but the units do overlie the Lower Permian claystones and are themselves overlain unconformably by the Pleistocene Ardrossan Clays and Sandrock.

(b) (i) ? Permian Clays: these are mottled reddish green clays which occur mainly as slope cover. The heavily weathered nature of the unit obscures its boundary contacts.

(ii) Permian Sandrock: this unit is a grey white, ill sorted, poorly indurated clayey sand with erratics. Where it is not in direct contact with the sea (e.g. Section 8, Fig. 2a) it weathers to form peculiar column-like structures. These appear to be the result of two sets of 'jointing'; the earlier horizontal set could be following bedding planes with the later set perpendicular to the first.

An essentially similar outcrop was found at beach level at Port Moorowiee (Sections 2 and 3, Fig. 2a) and has been mapped as Permian by Crawford (1965).

TERTIARY

(a) Benthonic foraminifera recovered from samples of these buff to pink bryozoa limestones indicate, for the first time, an Upper Eocene age for the unit. It is referred to as the Rogue Formation and correlated with the basal Port Willunga Beds (Lindsay, 1972).

(b) The horizontally bedded limestones (first seen in Section 10, Fig. 2a) are sporadically calccreted forming resistant headlands for 2 km along the coast to Troubridge Hill. Crawford (1965) indicates Hallett Cove Limestone at Point Gilbert (Fig. 2a); however, the unit is not present and sediments of Quaternary age outcrop almost at beach level (Fig. 2a).

ARDROSSAN CLAYS AND SANDROCK

(a) Maximum thickness is 1.72 m, and includes the unconformably overlying red clays with alunite bands, described by Crawford (1965, pp.40-41).

(b) The underlying unit consists of mottled brown green sandy clays which contain grit bands and deeply weathered erratics, suggesting that they are derived from the underlying Permian clays. The overlying red brown clays contain distinct white bands of alunite and/or kaolinite (Crawford, 1965). Samples were collected by the writer and X-ray diffractometer (X.R.D.) analysis

indicated mainly illite (R. J. Love, pers. comm.). Samples of a similar lithology were collected from the Tertiary/Permian contact (Section 10) and X.R.D. analysis indicated a similar clay mineralogy to that in the Quaternary sequence (R. J. Love, pers. comm.). Therefore, these bands are considered as a post-depositional feature (cf. Crawford, op. cit., p.41).

QUATERNARY AEOLIANITE AND CALCRETE

(a) The maximum thickness of the two units is 10 m. The lithology of the aeolianite, a poorly indurated calcarenite and the presence of the benthonic foraminiferal assemblage, suggests a correlation with the Bridgewater Formation (Lindsay, 1972).

(b) (i) Aeolianite: the grey-white calcarenite is first seen at Section 5 (Fig. 2a) as a prominent headland associated with an aeolianitic wave cut platform. This is the only section which exhibits large-scale cross bedding. A well bedded buff calcarenite (1 m thick) occurs within the aeolianite and partly overlies, unconformably, the Permian claystones. The bed represents a probable marine ingression (Lindsay, 1972).

(ii) The calcrete of varying thickness, forms a blanketing surface and is seen in all sections. Mostly it is sandy and friable at the base becoming more nodular to flaggy at the top.

III THE WATERLOO BAY MICROFLORAL ASSEMBLAGE

1. INTRODUCTION

(a) Previous work within the Troubridge Basin

Cookson (1955) recorded a reworked Permian microfossil assemblage from "a marine carbonaceous deposit of probable Eocene age from a shaft near Noarlunga" (Cookson, op. cit., p.57). Although it is the first record, its usefulness is limited as no further details accompany the report. Harris and McGouran (1971) reported Permian palynomorphs from Minlaton No. 1, Troubridge Sheal No. 1 and Donna No. 1 bores (localities shown in Fig. 2b). All assemblages (sensu lato) however are poorly preserved and do not contain any diagnostic species (see p. 12). One feature common to all samples is the presence of spinose acritarchs (organic walled microplankton; see p. 16).

(b) Sample Reliability

Most samples were from Waterloo Bay (Methods, p. 3), but two samples examined were cuttings from a rotary percussion drill hole, Peesey Swamp No. 1 (Fig. 2b). Generally cuttings are subject to contamination (e.g. drilling fluid used, cavings) and the recovery depth of the sample is unreliable due to loss of circulation and/or settling effects with depth. The drilling fluid for this hole was water and no loss of circulation, or caving was reported. The depth effect is negligible as the hole was relatively shallow (80.5 m). Consequently the depths given for the two samples used (Appendix 2) are considered to be accurate (± 1.5 m).

2. THE ASSEMBLAGE

No significant quantitative change in microfossil composition was recorded from any of the samples (Appendix 3a). Unfortunately assemblages from the top of the Permian in Peesey Swamp No. 1 (Fig. 2b) were too poorly preserved to allow any firmer conclusions other than the assemblage is of Permian age. Consequently only one assemblage (i.e. Biostratigraphic assemblage-zone) is considered to be present.

The moderately diverse assemblage (30 genera and 46 species, Appendix 3b) is well preserved, apart from some compressed specimens in a few samples. The assemblage is dominated by monosaccate pollen including Potonisporites balmei and Parasaccites spp. (av. 20%, max. 36%). The monocolpate pollen Cycadonites cymbatus is also abundant (5-10%) as is the trilete spore Microbaculispora tentula (12%). Non striate disaccates form a minor element of the assemblage (3%) and striate disaccates are rare (<1%). The significance of this is discussed later (p. 14). Four genera of spinose acritarchs* are present (up to 13%) and include Veryhachium, Microhystridium, Diplofusa and Leiofusa. (Fig. 3c, Graphic representation of the assemblage).

Apart from these major elements a well preserved reworked Middle to Upper Devonian microflora (up to 2%) is present (Plate 6, Figs. 59-70). Fungal spores and wood fragments form a minor background element. No Permian spores were found.

The biofacies significance of this assemblage is discussed later. (p. —). However, such an assemblage is only useful for biostratigraphic correlations if it can be compared with and placed into a previously erected scheme (see below).

IV BIOSTRATIGRAPHY AND AGE

1. Palynological Subdivisions of the Australian Permian

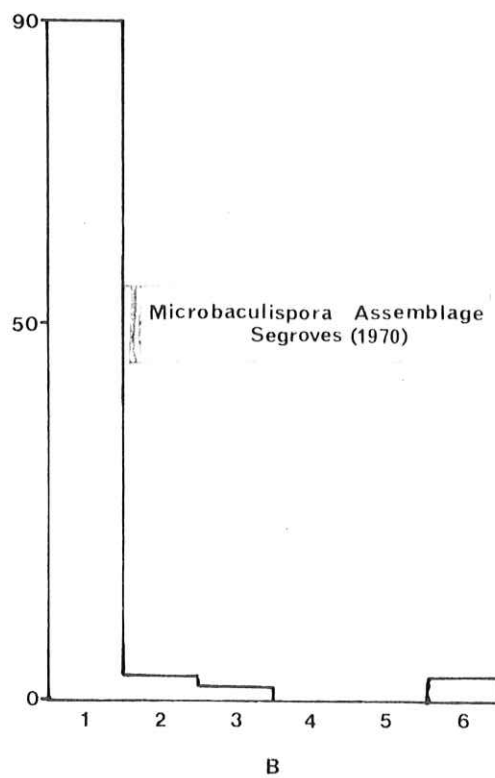
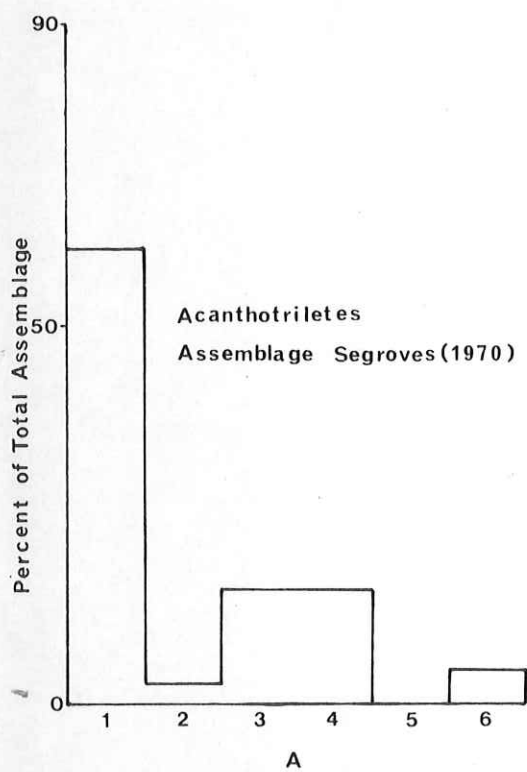
(a) Boundaries

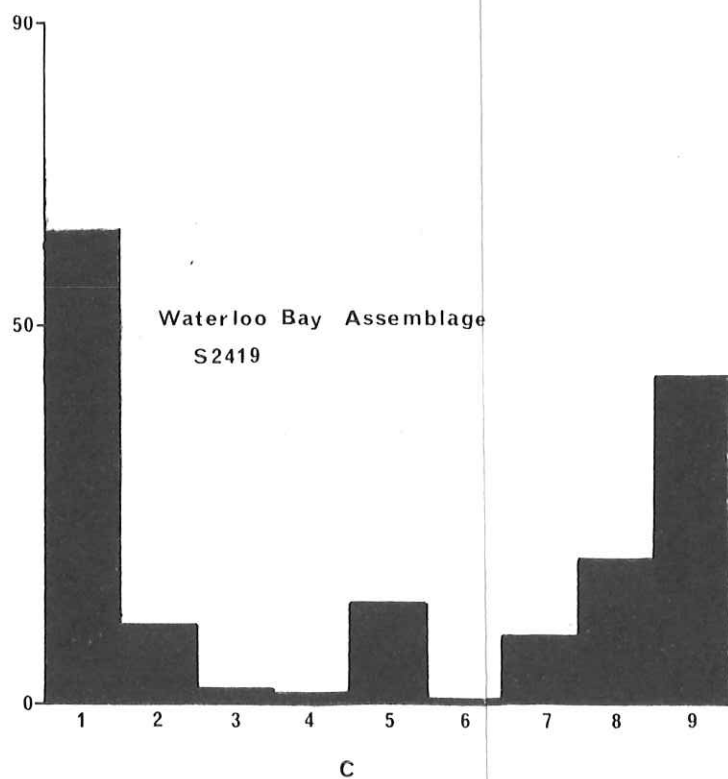
The boundaries of the Permian interval within Australia have been redefined on the basis of microfloral evidence. The lower, Permian-Carboniferous boundary (which need only concern us) has been defined by the appearance of the large monosaccate pollen Potonisporites spp. (Helby, 1969). This includes the Seaham Beds of the Sydney Basin within the Permian. Thus the Stage I microflora of Evans (1969, see below) is here considered as Lower Permian (Fig. 4) and not Upper Carboniferous (Evans, op. cit., p.43).

* A heterogeneous group of acid resistant microfossils of unknown biological affinity. Tachy & Scott, 1969.

QUANTITATIVE COMPARISON OF MICROFLORAL ASSEMBLAGES

Fig. 3





A & B , PERTH BASIN

C , WATERLOO BAY

- 1 Total Spores
- 2 Monosaccate Pollen
- 3 (Non Striate) Disaccate Pollen
- 4 (Striatiti)
- 5 Spinose Acritarchs
- 6 Non Spinose Acritarchs
- 7 Monocolpate Pollen
- 8 Monolete Spores
- 9 Trilete Spores

Note 1 Segroves did not include groups
7, 8 & 9

2 Total Spores from the summation
of 8 & 9

(b) Subdivisions

The Permian microflora has been subdivided into various distinct microfloral assemblages. The initial three-fold subdivision by Balme (1964) has been extended by Evans (1969) and more recently by Segroves (1970b). The relationship between the three schemes is shown in Figure 4. The table (Fig. 4) was drawn up by placing the rock stratigraphic units given for each assemblage in a faunal biostratigraphic framework.

Paten (1969) working in the Cooper Basin re-subdivided Evans' 'Stages' 4 and 5 into six sub stages. They are shown in Figure 5, along with the southern and central Australian biostratigraphic subdivisions of the Permian. The upper Lower Permian and Upper Permian subdivisions do not apply to this study but are included (Figs. 4 & 5) for completeness.

Apart from key species as indicators of these subdivisions the importance of the quantitative composition of the assemblage has been emphasized. Accordingly the correlation between the Waterloo Bay Assemblage and those of Evans and Segroves has been made using these criteria (problems such as facies effects are discussed below).

2. Correlation of the Waterloo Bay Assemblage

From the preliminary study Harris and McGowran (1971) concluded "In terms of Evans' units the Waterloo Bay Assemblage equates with Stage 2" (Harris & McGowran, op. cit., p.6). Further evidence (below) is in agreement with this statement.

As Segroves' work (1969, 1970a,b) was used extensively in the systematic section of this study an attempt was made to correlate this assemblage with those of the Perth Basin. The correlation with both works is shown separately and the differences are discussed below.

(a) Correlation with Evans' Stage 2 (Fig. 4)

This 'stage' is defined by the first appearance of

EXPLANATION TO FIGURE 4

1. Microfloral Subdivisions

- BALME (1964) Based on microfloral diversification in Western Australian basins.
- EVANS (1967) Eastern Australia, including South Australia and the Northern Territory. The five 'STAGES' (i.e. biostratigraphic assemblage-zones) are compared with the earlier subdivisions of Balme (op. cit.¹⁹⁶⁴).
- SEGROVES (1970b) Limited to the Perth Basin (W.A.). Although showing assemblages along with key species on his range chart (op. cit., Fig. 4) from the Nangetty Formation and the overlying Holmwood Shale, there is no record of samples from either unit (also see Segroves, 1969, 1970a). This detracts seriously from the work.

Stratigraphic localities of the Assemblages are given by each worker (exception above); consequently rock units from both eastern and western Australia can be correlated using mega faunal biostratigraphic zones. The basic correlation chart is after Wasse (1970a).

2. Faunal

- ** DICKENS (1963) Faunal Units A-F; erected using gastropods and bivalves (W.A.).
- *** DICKENS (1968a,b) Faunal Units I-IV; erected using brachiopods, bivalves, fenestellids and the crinoid Calceolispongia (eastern Australia).

NOTES

1. Wasse (1969, 1970b) has postulated a sea way across Australia during Permian times to explain the similarities of the two faunas. The connection via the Cooper Basin is based on a fenestellid fragment recovered from a rotary cutting from a well in the basin. Problems with the correlation, outside the scope of this study, are discussed by Runnegar (1969).
2. There are problems in correlating these faunas with those of the Ural Region (e.g. Waterhouse, 1970); however, the Standard Stage names are used in this study.
3. Biostratigraphic correlations of the Permian of southern and central Australia are given in Fig. 5.

Biostratigraphic Subdivisions of the Australian Permian Fig.4*

STAGES OF URAL AREA	STAGES IN WESTERN PART OF AUSTRALIA	PERTH BASIN (Irwin River Area)	CARNARVON BASIN (North end of Kennedy Range)	CANNING BASIN (Fitzroy River Area)	BOWEN BASIN		SYDNEY BASIN (Hunter Valley)	BALME (1964)	EVANS (1967)	SEGROVES (1970b)
					(Blentheim Area)	(Springsure Area)				
TATARIAN	F	Upper marine beds incl. Hardman Member	Upper marine beds incl. Hardman Member	Liveringa Fm.	Upper Bowen Coal Measures	Bandanna Fm. (upper part)	Munmorrah Congl. Newcastle Coal Measures	5	Dulhuntyispora - Assemblage	Dulhuntyispora Assemblage
							Tomaga Coal Measures			
KAZANIAN	E	Upper marine beds incl. Hardman Member	Upper marine beds incl. Hardman Member	Liveringa Fm. (middle part)	Fauna IV Unit C (upper part of Middle Bowen Beds)	Bandanna Fm. (lower part)	Mulbring Fm.	4	Vitalina - Assemblage	Haplocystia
						Mantuan Productus Peawaddy Fm.	Muree Fm.			
KUNGURIAN	D	Upper marine beds incl. Hardman Member	Upper marine beds incl. Hardman Member	Liveringa Fm. (lower part) Light and Baloo Members	Fauna III Unit B (=middle part of Middle Bowen Beds - Collinsville Coal Measures)	Catherine Sst.	Upper part of Braxton Fm.	3	Nuskoisporites - Assemblage (N-A)	Acanthotriletes Ass.
						Ingelara Fm.	"Penestella Zone" Lower part of Braxton Fm.			
ARTINSKIAN	C	Carynginia Fm. Irwin River Coal Meas. High Cliff Sst.	Wooramel Gp.	Noonkanbah Fm.	Unit A (lower part of Middle Bowen Beds)	Aldebaran Sst.	Greta Coal Meas.	2	Vitalina Ass.	Haplocystia
						Staircase Sst.	Fairley Fm.			
SAKMARIAN	B	Fossil Cliff Fm.	Callytharra Fm.	Poole Sst. (upper part)	Fauna II	Stanleigh Fm.	Rutherford Fm.	1	Nuskoisporites - Assemblage (N-A)	Microbaculispora Ass.
						Nura Nura Member of Poole Sst.	Fauna I			
	A	Holmwood Shale*	Lyons Gp. (with Carrandibby Fm. at top)	Grant Fm.	Lower Bowen Volcanics	Allandale Fm.	Lochinvar Fm.			

*Either position doubtful or only partly referable to the subdivision.

*For full details see facing page

Boundary of Permian as defined by Helby (1969)

UPPER PERMIAN

LOWER PERMIAN

- (i) Striatiti pollen, in particular Protohaploxylinus goraiensis, P. amplus and P. seawardi.
- (ii) Monocolpate pollen, in particular Maraupipollenites spp.
- (iii) The trilete spore Deltoidispora directa.

Evans (1969, Fig. 4, p.50) has also indicated that Punctatisporites gretensis is not found above stage 2.

Therefore the presence of the striate pollen P. rugatus excludes the assemblage from stage 1 (see above). The absence of Verrucosisporites pseudoreticulatus indicating Stage 3 (op. cit., p.47) precludes it from this and consequently any higher Stage. Both D. directa and M. triradiatus forma triradiatus were in the Waterloo Bay Assemblage. P. gretensis was also recorded, although rare.

On the basis of this evidence the assemblage correlates well with Stage 2, notwithstanding the presence of Granulatisporites trisinus, which Evans regards as a Stage 3 indicator. This is not considered a good index species as it shows, unlike V. pseudoreticulatus, a broad species variation.

(b) Correlation with the Perth Basin

Using the range chart given by Segroves (1970b, text-fig. 4) the Waterloo Bay Assemblage (W.B.-A) equates with the Acanthotriletes Assemblage (Fig. 4; Stage 3, lower Stage 4 of Evans' units). The species whose ranges define this Assemblage and are in common with the W.B.-A are G. trisinus, Tuberculosporites medicus and Laevigatosporites flexus. However, only three of the ten species considered as diagnostic of the assemblage are present (op. cit., pp.513-514).

The quantitative microfloral data from the two assemblages are shown in Figure 3. The major differences between the two are

- (i) The abundance of monosaccate pollen (W.B.-A).
- (ii) The greater abundance of spinose acritarchs (W.B.-A).
- (iii) The low frequency of disaccate pollen (W.B.-A).

The first two can be explained by facies variations, the acritarchs indicating saline conditions (see later) whilst the monosaccate pollen indicate the proximity of the floral source, as their dispersal is affected by wind and water currents (Muller, 1959). The low frequency of winged bisaccates, however, cannot be explained by the same reasoning, and their absence is considered significant as they represent a 'stage' in floral evolution (Balme, 1962). Consequently the apparent correlation with this Perth Basin Assemblage is rejected.

Discussion

V. pseudoreticulatus is first recorded from the base of the Holmwood Shale (Perth Basin, Fig. 4) and is regarded as Stage 3 in terms of Evans' units. Consequently the underlying Nangetty Formation and the Microbaculispora Assemblage (Fig. 4) equates with Stage 2.

Quantitatively this assemblage and the Waterloo Bay Assemblage equate well (Fig. 3, B & C) although key species of the former are absent. The presence of slightly more disaccate striate pollen (p.) suggests that the W.B.-A is stratigraphically higher than the Perth Basin Assemblage. Therefore it is equated with the Upper Nangetty Formation.

There is no record as to what depth the bores penetrated the Nangetty Formation (max. thickness 457 m, McWhae et al., 1958) nor is the Formation mentioned in the 'Source of Samples' (Segroves, 1969, 1970a). (The omission is serious and detracts from his study).

One other problem needs to be explained; why the species using the range chart indicated that the Assemblage could have been of Lower Artinskian age. The total ranges of some of these palynomorphs are not fully known and a study showing ranges from western and eastern Australia, where other bio-stratigraphic controls can be applied, is required.

For example, Balme (1964, p.59) records Calamospora sp. cf. C. microrugosa from the Canning Basin (W.A.) as ranging from the Famennian-Upper Carboniferous.

Segroves records the same species as ranging from Upper Sakmarian to Lower Artinskian. Similarly Harris and McGouran (1967) have recorded T. medicus in a well defined Stage 2 sequence from the Arckaringa Basin. These differences show how little is known of facies controls for spores and pollen (Balme, 1969) and emphasize the need for biofacies studies.

3. Age

The high proportions of monosaccate and monocolpate pollen and the low proportions of taeniatae disaccate pollen (< 1%) indicate that the assemblage is of pre late 'Sakmarian' age. Hart (1971), Segroves (1969) and Balme (1962) have emphasized the importance of the taeniatae disaccate pollen as an age indicator with the lowest percentages occurring in sediments of middle 'Sakmarian' age.

One of the type localities of Evans' (1969) Stage 2 microflora is the upper Lochinvar Formation (Sydney Basin). Dickens (1963, 1963a,b) has correlated it with the Nangetty Formation of Western Australia the age of which has been determined as 'Sakmarian'. This is consistent with the age determination based on quantitative microfloral content.

Therefore the Waterloo Bay Assemblage, equating with Stage 2, is considered as pre late 'Sakmarian' in age.

4. Local Implications

1. Correlations with other palynologically proven Permian sediments within South Australia are shown in Figure 5. These are useful in palaeo-environmental interpretation as they indicate the extent of marine influence within the state (see later, p. 18).

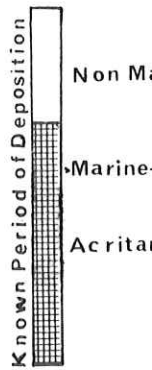
2. The high frequency of reworked, excellently preserved Devonian spores suggests a local origin. Long distance transport from areas of proven Devonian sedimentation (e.g. Antarctica, Helby & McElroy, 1969) would destroy the palynomorphs, particularly those with delicate appendages such as Anchryospora reported by Harris and McGouran (1971).

AGE	MICROFLORAL "STAGES" PATEN 1969	TROUBRIDGE Bsn	COOPER BASIN		ARCKARINGA BASIN		PEDIRKA	DENMAN BASIN	RENMARK
		This Study	Gatehouse (1972)		S.A.G. Cootanoorina No 1 (see text)	Muddy Tank No1 Harris 1972b	BASIN Harris 1972a	Harris et al. 1969	TROUGH Harris (1963)
UPPER PERMIAN	TARTIAN			Upper m.					
	Upper	5	Toolachee Fm.	FORMATION					
	Upper-Lower	5	Daralingie Beds						
	Lower	5	Roseneath Shale						
	Upper-Upper	4	Epsilon Fm.						
	Upper	4	Murteerie Shale		Middle m.				
	Lower	4	Patchewarra Fm.	GIDGEE ALPA					
	3	Tirrawarra Fm.	Lower m.		Mt Toondina Beds	Mt Toondina Beds	Purni Fm.		
	2	Meerimelia Fm.			Unit 1		?	?	?
	LOWER PERMIAN	SAKMARIAN				Unit 2			

PALYN

S. A.

* Basin Loc



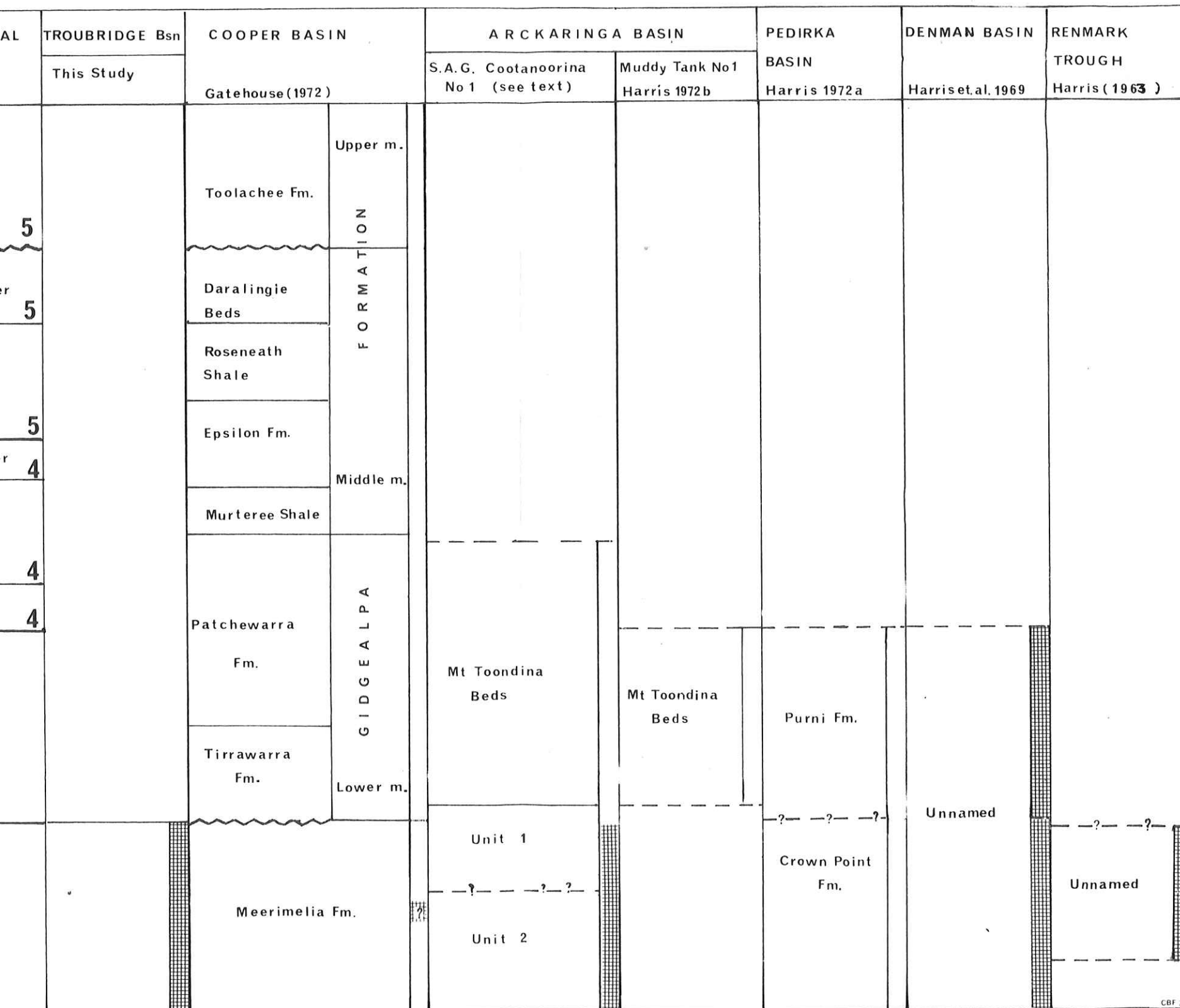
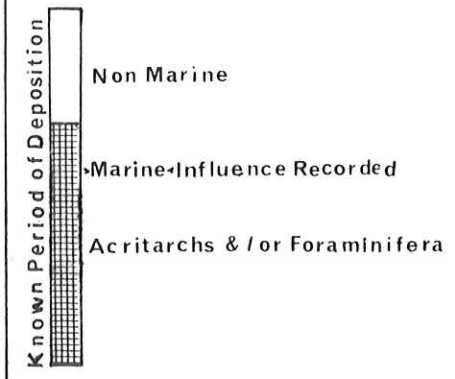


Fig. 5
PALYNOLOGICAL CORRELATION
of the
S. A. PERMIAN BASIN* DEPOSITS

* Basin Locations see Wopfner 1970



Such preservation demands rapid recycling which would require increased rates of sedimentation in a preferably reducing environment (see p. 17). Deformation with uplift would provide such rates. Stuart and Von Sanden (1972) using preliminary information have postulated a period of deformation immediately prior to Permian sedimentation.

It is considered by the writer that the subsequent recycling in a sub-aerial glacial environment would not allow this excellent preservation. Instead, an alternative mechanism is proposed which explains the preservation and supports Wopfner (1970) who has emphasized the importance of syn-depositional movement during the Permian.

The degree of microfloral diversity indicates an amelioration of climate and with the evidence of a marine ingression (see Biofacies, ~~p. 16~~) it is suggested that the period of glaciation had ended. During such a period increased run-off from meltwaters would give rise to erosional rejuvenation and so increase the rate of sedimentation.

Should this coincide with uplift the rapid recycling of the Devonian microflora, in a suitable sub-aqueous reducing environment, would be achieved. Other evidence such as a low salinity palaeoenvironmental (see Biofacies, p.) supports such a mechanism.

V BIOFACIES

1. Types of Inferences

Classification of Palaeozoic palynomorphs is made by assignment to form or organ genera (as defined by Schopf, 1969). Consequently palaeo-phytic conclusions made on the basis of comparisons with extant forms are highly suspect (Tchudy, 1969). The following palaeoecological and palaeo-geographical inferences are made from a consideration of associations of fossil groups. The larger the number of groups occurring together, the stronger the inference.

The contributions of the spinose acritarchs, spores and pollen and the arenaceous foraminifera are considered under separate headings. A synthesis is presented at the end.

Spinose Acritarchs (Organic Walled Microplankton)

Downie et al. (1963) have stated that in general the group (Acritarcha) is marine. Smith and Saunders (1970) have recently shown that Silurian spinose acritarchs of the same genera as those from Permian sequences are confined to "depositional areas continuously or intermittently open to marine waters and do not occur in fluvial deposits."

The occurrence of spinose acritarchs with arenaceous foraminifera in the Permian of Waterloo Bay is further evidence of their association with 'marine' conditions.

What is exactly meant by 'marine' is not clear - an example of their salinity tolerance is illustrated by data from S.A.G. Cootanocorina No. 1 (Arckaringa Basin, Harris & McGowan, 1967). Conditions described as 'fully marine' are indicated at 701 m (Unit 1, Stage 2 microflora) where foraminifera and microplankton occur together. With the onset of evaporitic conditions (a regressive phase) the foraminifera disappear (571 m) - whilst the acritarchs remain, tolerating increasingly higher salinities. Their

disappearance is marked by the onset of freshwater deposition (528 m prior to the deposition of the Mt. Toondina Beds, Fig. 5). It is apparent that a threshold salinity is required for their appearance. Botryococcus which also occurs within the assemblage is, however, generally regarded as a freshwater genus. To explain the occurrence of both groups a low salinity environment of deposition is suggested (see later). \neq \neq

Other occurrences of the acritarchs within 'marine' sediments have been recorded by Evans (1969) in Stage 2 microfloras in western New South Wales. Segroves (1970b) records them in the Microbaculispora Assemblage (above) but refers to the sediments of the Nangetty Formation as "glacial to fluvio-glacial in origin" (Segroves, op. cit., p.514). Crespin (1958, p.16), however, has recorded arenaceous and calcareous foraminifera from the same formation.

Spores and Pollen

Harris (1969) has reported megaspores from freshwater sediments of Lower Permian age (e.g. Mt. Toondina Beds). No megaspores were found in samples from Waterloo Bay. Although negative evidence their absence in this 'marine' environment is in keeping with Harris' findings.

Tschudy (1969a) has stated that palynomorphs are best preserved when deposited under acidic, reducing conditions. Such conditions are commonly developed in lake bottoms or closed basins, and in such an environment microbial degradation of the exine would also be reduced. The preservation of the Permian and reworked Devonian spores suggest such conditions.

Arenaceous Foraminifera

Six Hemidiscus balmei were found during this study. This brings the number found at Waterloo Bay to eighteen. Harris and McGowan (1971) considered that the low numbers and low species diversity represent cold and/or low salinity conditions. This is consistent with the other evidence (above). Ludbrook (1969) postulated that such assemblages were deposited in coastal fiords (see next section).

2. Palaeogeographic Conclusions

Wopfner (1970, p.277) concludes that fiords (and an immature landscape) were unlikely to have been part of the South Australian Permian landscape (cf. Campana & Wilson, 1955) and that structures attributed to them can be explained by grabens and half grabens produced by faulting. This does not affect the palaeoenvironment proposed by Ludbrook (1969).

Tectonic movements such as these are considered by the writer partly responsible for the marine ingression which has been recorded from sediments of 'Sakmarian' age, throughout Gondwanaland. Evidence from southern Australia (above), Peninsular India, Argentina (Ahmad, 1970) and South West Africa (Martin & Wilczewski, 1970; Dickens, 1961) indicates that these regions were interconnected by seaways during the 'Sakmarian'. McGowan (1972, M.S.) has suggested that initial rifting between Antarctica and Australia took place at this time. Evidence of the transgression has not yet been found in Antarctica.

Consequently subsidence and possibly the rifting between Antarctica and Australia initiated a marine ingression affecting most of Gondwanaland. This period coincided with the deglaciation of southern and eastern Australia, with melt waters appreciably lowering the salinity of the ingressing sea. The abnormal salinity restricted faunas to arenaceous foraminifera. Microbial activity in this environment would also be lessened and so explain the preservation of the palynomorphs.

This equates the sediments with the second (marine shale) unit of Wopfner's (1969) three part lithological sequence for the Permian of South Australia. The youngest unit (generally freshwater deposits) has not been recorded within the Troubridge Basin.

VI SUMMARY AND CONCLUSIONS

Thirty genera and forty-six species of Permian palynomorphs have been described and figured from sediments at Waterloo Bay. The assemblage (sensu lato) from each stratigraphically located sample has been quantified (Appendix 3a) and from this it was concluded that only one microfossil assemblage-zone was present.

This has allowed comparison and correlation with eastern and western Australian microfossil assemblages, which have been dated by their association with marine faunas (Fig. 4). The assemblage was correlated with Evens' (1969) Stage 2 microflora from the lower Dalwood Group of the Sydney Basin. The need for biofacies studies of Permian palynomorphs is apparent, as such a study would eliminate false correlations (p. 13).

The correlation was achieved by using key species and by quantitative microfossil comparisons. The type of lithology associated with the assemblage has been given as well as its stratigraphic position in relation to the other outcrop (Fig. 2a). The lithological information is important as it indicates the type of preservation and in part the environment of deposition. Both can affect the quantitative microfossil expression and allowance for such a bias must be made when correlations are made using this technique. Quantitative data was also used in the age determination. A pre-late 'Sakmarian' age for the Assemblage was concluded from two lines of evidence:

- (i) the quantitative composition of the microflora
- and (ii) the correlation with the Upper Nangetty Formation of Sakmarian age (p. 13, Fig. 4).

The age determination has allowed a brief palaeogeographical comparison with other Gondwanaland continents of a similar age.

A low salinity Permian depositional palaeoenvironment has been concluded from the preservation and types of palynomorphs of the assemblage. The occurrence of arenaceous foraminifera and the spinose acritarchs is further

evidence of the association of these genera with marine conditions.

Field work has also contributed to two important Cainozoic discoveries at Waterloo Bay; the dating of the Tertiary Limestones as Upper Eocene and the second record of planktonic foraminifera within the Quaternary aeolianite sequence.

VII SYSTEMATIC PALYNOLOGY

The following descriptions are the result of the examination of fifty-two strew slides prepared from ten samples. Method of preparation and sample locations are given in Appendices 1 and 2.

The two main systematic studies of the Australian Permian microflora (Balme & Kennelly, 1955, 1956a,b; Segroves, 1969, 1970a) were used extensively. The latter provides the more recent synonymy and the reader is referred to this. Only a selected synonymy is given here.

Descriptive terminology used is in keeping with Kremp (1965). Disaccate measurements given are in accord with Segroves (1969; see Fig. 6).

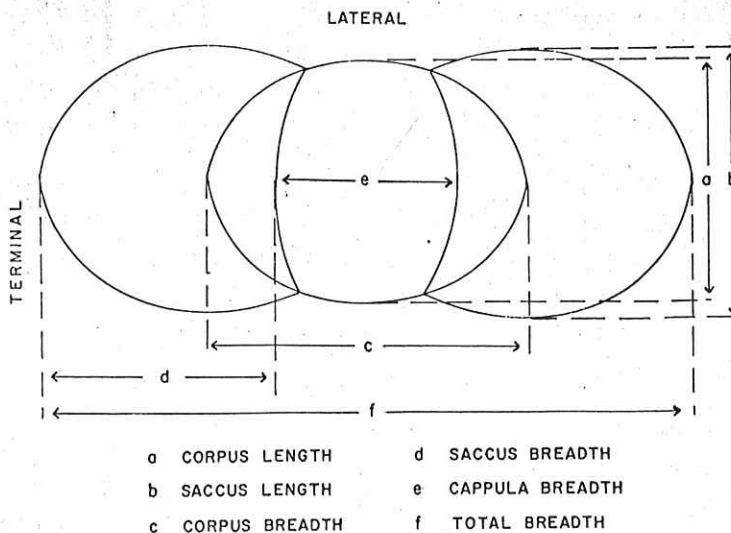


Fig. 6. Diagrammatic explanation of terms used in expression of dimensions and construction of disaccate pollen grains.

from Segroves(1969) p176

ANTETURMA SPORITES H. Potonie 1893

TURMA MONOLETES Ibrahim 1933

Suprasubturma ACAVATOMONOLETES Dettmann 1963

Subturma AZONOMONOLETES Luber 1935

Genus LAEVIGATOSPORITES Ibrahim emend. Schopf, Wilson
and Bentall 1944

Laevigatosporites flexus Segroves Pl. 1, fig. 1

1970a Laevigatosporites flexus Segroves pl. 11, figs. C-D

Dimensions: (6 specimens) Longitudinal axis 30-50 μ , transverse axis 21-34 μ .

Remarks: The figured specimen differs from the holotype with conspicuous thickened raised lips (2.2 μ in width).

Laevigatosporites sp.
Pl. 1, fig. 5

Description: Monolete with sub-rounded amb. shows prominent distal folds.
Exine 1.5 μ thick and finely punctate.

Dimensions: (2 specimens) 31 μ diameter.

Remarks: Shape and thicker exine distinguish it from Laevigatosporites vulgaris forma colliensis Balme & Hennelly (1956a, p.55, figs. 1-5).

Genus TUBERCULATOSPORITES Imgrund ex Potonie & Kremp, 1954

Tuberculatosporites modicus Balme & Hennelly
Pl. 1, fig. 6

1956a Tuberculatosporites modicus Balme & Hennelly
p.56, pl. 1, figs. 10-13

Dimensions: (10 specimens) Longitudinal axis 19 μ (av); transverse axis 14 μ .

Remarks: This species is common. Specimens are smaller than those recorded from the Perth Basin.

TURMA TRILETES Reinsch, emend. Dettmann 1963

Suprasubturma ACAVATITRILETES Dettmann 1963

Subturma AZONOTRILETES Luber emend. Dettmann 1963

Genus CALAMOSPORA Schopf, Wilson & Bentall 1944

Calamospora sp. cf. C. microruosa (Ibrahim) Schopf, Wilson &
Bentall.
Pl. 1, fig. 7

Synonymy Segroves (1970a) p.48.

Description: Trilete, amb circular to subcircular, often folded and compressed, exine thin (1 μ). Laesura distinct and straight in most specimens. May or may not be thickened at proximal pole.

Dimensions: (3 specimens) av; 42 μ diameter, laesura length 12 μ .

Calamospora ? diversiformis Balme & Hennelly
Pl. 1, figs. 8 & 9

Description: Amb circular, and smooth, trilete with straight laesura. May have darkened proximal thickening (Fig. 9) or incipient curvaturae (tetrad Fig. 8).

Dimensions: (10 specimens) av; 20 μ diameter.

Remarks: Fig. 9 has a diameter of 10 μ and is much smaller than other published size ranges.

Genus PUNCTATISPORITES Ibrahim emend. Potonie & Kremp 1954

Punctatisporites gretensis Balme & Hennelly
Pl. 1, fig. 11

1956b Punctatisporites gretensis Balme & Hennelly p.245
Figs. 11-13

Dimensions: Diameter 71 μ (2 specimens).

Remarks: Specimens are rare in the assemblage.

Punctatisporites sp. cf. P. gretensis Balme & Hennelly
Pl. 1, fig. 12

Description: In all details these specimens are like P. gretensis except size. Thickness of exine 2 μ .

Dimensions: (4 specimens) av. diameter 20 μ . (cf. published size ranges P. gretensis mean 118 μ , Balme, and Hennelly (1956b)).

Genus GRANULATISPORITES Ibrahim emend. Potonie & Kremp 1954

Granulatisporites sp. cf. G. trisinus Balme & Hennelly
Pl. 1, fig. 13

Description: Triangular amb with straight to slightly convex sides. Trilete with laesura extending three-quarters of spore radius and in most bifurcating at the ends. Laesura have thin raised (2 μ) unsculptured lips (1 μ in thickness). Exine is thin. Distal surface ornament widespread low grana. Absent on proximal face.

Dimensions: (5 specimens) av. diameter 50 μ .

Remarks: Specimens differ from G. trisinus in that the grana are non-uniform and sparse; although this could be a function of preservation.

Granulatisporites trisinus Balme & Hennelly
Pl. 1, figs. 17 & 18

1956b Granulatisporites trisinus Balme & Hennelly
p.244, pl.1, figs. 5-8

Dimensions: Av. diameter 42 μ , which is smaller than those described by Segroves (1970a).

Genus MICROBACULISPORA Bharadwaj 1962

Microbaculispora tentula Tiwari
Pl. 1, fig. 16

1965 Microbaculispora tentula Tiwari, p.175
Pl. 2, figs. 35-37

Dimensions: (20 specimens) av. diameter 40 μ .

Remarks: Although very common some specimens were difficult to identify from Granulatisporites spp. The genus is currently under review (Glikson, 1972), but results are not yet available.

Genus and Species indeterminate
Pl. 1, fig. 15

Description: Trilete, amb triangular with apices broadly rounded, sides concave to straight. Laesura straight to slightly sinuous extending to 'equator' and bifurcating. Inter radial crassitudes at proximal pole. Exine 2 μ thick. Distal ornament sparse irregularly spaced grana, reduced on proximal face.

Dimensions: (1 specimen) diameter 38 μ .

Remarks: The presence of the inter radial crassitudes suggest that this Spore belongs to the infra turma BARBITI Madler 1954 (Hart, 1965).

Genus DELTOIDISPORA Miner emend. Potonie 1956

Deltoidispora directa (Balme & Hennelly) Norris
Pl. 1, fig. 14

1956b Leiotrilates directus Balme & Hennelly, p.244
Pl. 1, figs. 1-4

1965 Deltoidispora directa (Balme & Hennelly) Norris p.240
Figs. 1b, 7-8

Dimensions: Av. diameter (10 specimens) 40 μ .

Remarks: Differs from M. tentula by its conspicuous exinal folds bordering the laesura (up to 10 μ in width).

Genus VERRUCCOSISPORITES Ibrahim, emend.
Smith & Butterworth 1964

Verrucosisporites sp.
Pl. 2, fig. 19

Description: Trilete amb sub-rounded. Laesurae are well defined but without lips. Exine thick, bearing long verrucae 1-2 μ high regularly spaced (5-1 μ). Ornament reduced on proximal face.

Dimensions: (1 specimen) diameter 50 μ (rare).

Genus LOPHOTRILETES Naumova emend. Potonie & Kremp 1954

Lophotriletes sp.
Pl. 2, fig. 20

Description: Trilete, triangular amb with strongly developed concave sides, paralleling the laesurae. Raised lips (1 μ), slightly thickened. Exine approximately 1 μ thick supporting on the distal surface and at the 'equator' small blunt cones (2 μ high, 1 μ apart) and spines 2-4 μ high, 1.5 μ apart. Ornament lacking on proximal face.

Dimensions: (1 specimen) 35 μ .

Remarks: Differs from cf. L. rarus Bharadwaj & Saluja (1964, p.193) by the strong concavity of the amb and the increased ornament. But lacks the thickened interradial exine of the L. novicus Singh.

Genus ACANTHOTRILETES (Naumova) Potonie & Kremp 1954

Acanthotriletes teretianquilatus Balme & Hennelly
Pl. 2, fig. 21

1956b Acanthotriletes teretianquilatus Balme & Hennelly
p.247, Pl. 2, figs. 27-29

Dimensions: Diameter 28-42 μ (3 specimens).

Genus BACULATISPORITES Thomas & Pflug 1953

Baculatisporites sp. indet.
Pl. 2, figs. 22 & 26

Description: Amb circular, trilete, laesura distinct extending three-quarters radius of spore. Thickened raised lips, exine thickness 2 μ . Strong

polar compressions may be present (Fig. 22). Ornament close spaced
grana and baculae 0.5-1 μ high reduced on proximal face.

Dimensions: (Fig. 22) 27 μ diameter, 30 μ (Fig. 26).

Genus HORRIDITRILETES Bharadwaj & Saluja 1964

Horriditriletes ramosus (Balme & Hennelly) Bharadwaj &
Saluja 1964
Pl. 2, fig. 23

Synonymy Segroves (1970a) p.55.

Dimensions: (5 specimens) 45 μ av. diameter.

Genus APICULATISPORIS Potonie & Kremp 1956

Apiculatisporis sp.
Pl. 2, fig. 24

Description: Amb round to oval, boundary uneven. Trilete laesura extending
to 'equator' and sometimes bifurcating at termini. Lips developed
0.5 μ wide and unsculptured. Sparsely spaced broad conl (1-2 μ wide)
arranged concentrically on the distal surface.

Dimensions: (6 specimens) range 18-37 μ diameter.

Apiculatisporis levis (Balme & Hennelly) Segroves
Pl. 2, fig. 27

1956b Apiculatisporites levis Balme & Hennelly, p.246
Pl. 2, figs. 19-21

1970a Apiculatisporis levis (Balme & Hennelly) Segroves
p.59, pl. 5, fig. 1

Dimensions: (3 specimens) 25 μ av. diameter.

Genus LESCHIKISPORIS Potonie 1958

Leschikisporis cretus Segroves
Pl. 2, fig. 25

1970a Leschikisporis cretus Segroves
p.52, pl. 3, figs. A-C

Dimensions: (figured specimen) 50 μ diameter.

Suprasubturma PERINOTRILETES Erdtman, emend. Dettmann 1963

Genus and Species indeterminate
Pl. 1, fig. 10

Description: Trilete, cingulate mesosporoid, with rounded triangular amb. Raised lips extending to periphery of spore, finely punctate. Cingulum is slightly spongy.

Dimensions: Total diameter 24 μ , corpus diameter 20 μ . Thickness of cingulum 3.5 μ .

ANTETURMA POLLENITES R. Potonie 1931

TURMA PLICATES Neumova 1939

Subturma MONOCOLPATES Iverson & Troels-Smith 1950

Genus CYCADOPITES Wodehouse ex Wilson & Webster 1946

Cycadopites cymbatus (Balme & Hennelly) Segroves
Pl. 1, figs. 2-3

1961 Ginkgocycadophytus cymbatus (Balme & Hennelly) Potonie & Lele
p.33, Pl. 3, figs. 85-96

1970a Cycadopites cymbatus (Balme & Hennelly) Segroves
p.72, pl. 11, fig. E

Dimensions: (6 specimens) Longitudinal axis av. 51 μ ; transverse axis 22 μ (av)

Remarks: Specimens are relatively abundant.

Genus MARSUPIPOLLENITES Balme & Hennelly 1956

Marsupipollenites triradiatus forma triradiatus Balme & Hennelly
Pl. 1, fig. 4

1956a Marsupipollenites triradiatus Balme & Hennelly
p.60, pl. 2, figs. 29-35

Dimensions: (3 specimens) Longitudinal axis 50 μ ; transverse axis 30 μ .

Remarks: Specimens of this species are rare in the assemblage.

TURMA SACCITES Erdtman 1947

Subturma MONDSACCITES Chitaley emend. Potonie & Kremp 1954

Genus PARASACCITES Bharadwaj & Tiwari 1964

1964 PLICATIPOLLENITES Lele
p.159, pl.1, figs. 6-10; pl. 2, figs. 11-14

Parasaccites gondwanensis (Balme & Hennelly) Segroves
Pl. 2, fig. 28

1956b partim. Nuskoisporites gondwanensis Balme & Hennelly
p.253, pl.7, figs. 66-67

1969 Parasaccites gondwanensis (Balme & Hennelly) Segroves
Pl. 2, fig. B, p.183

non 1961 Nuskoisporites triangularis (Mehta) Potonie & Lele
p.27, pl. 2, fig. 40

Dimensions: (10 specimens) Total diameter 70-90 μ ; corpus diameter
54-60 μ . Figured specimen T.D. 90 μ ; C.D. 60 μ .

Parasaccites sp. A
Pl. 2, fig. 29

1966 Nuskoisporites sp. Helby
p.674, Taf. 5, fig. 9

Description: Monosaccate, trilete, scar ruptured on several specimens.
Distal saccus attachment overlaps 1/3 of corpus diameter. Bronchi
are elongate 0.5-1 μ in diameter. Amb triangular, undulant margin.
Corpus rounded triangular in shape.

Dimensions: (3 specimens) Total diameter 60 μ ; corpus diameter 30 μ .

Remarks: This species differs from Virrkippollenites triangularis (Mehta) Lele
(p.162, pl.2, fig. 15, 1964) in that the corpus is roundly triangular
and not circular.

Parasaccites sp.
Pl. 2, figs. 30 & 34

1956 partim. Nuskoisporites gondwanensis Balme & Hennelly
p. 253, pl. 6, fig. 62

Description: Monosaccate with circular amb, grain margin is not undulant.
Trilete scar is clearly defined. Laesura extending less than $\frac{1}{2}$ corpus
diameter. Marginal folds present at periphery of corpus.

Dimensions: Fig. 30, T.D. 78 μ ; C.D. 51 μ . Fig. 34 T.D. 80 μ ; C.D. 46 μ .

Remarks: The genus is currently under review (Glikson, 1972). Microtome
sections of the grains showing the saccus attachment areas would remove
any ambiguity in assigning specimens to a specific taxa.

Parasaccites sp. cf. Virrkippollenites methae Lele
Pl. 2, figs. 31; pl. 3, figs. 32, 33, 35

1956b partim. Nuskoisporites gondwanensis Balme & Hennelly
p.253, pl.6, fig. 65

Description: Monosaccate, trilete mark may be poor to well defined, with
lip development (fig. 32, raised lips 2 μ). Grain margin, even to
markedly undulant (fig. 33). Bronchi are generally radially elongate

av. 0.5 μ in diameter. Corpus circular to sub-circular. Line of detachment of exoexine, equatorial on distal face, sub-equatorial on proximal face (Fig. 32). Absence of peripheral folds of corpus important. Both the latter features appear to be characteristics of V. methae Lele (1964, p.159, pl. 2, fig. 16; text-fig. 9, 13,b).

Dimensions: (10 specimens) Total diameter 100 μ (77) 62 μ ; corpus diameter 60 μ (47) 30 μ ,

Parasaccites diffusis Tiwari
Pl. 3, fig. 36

1965 Parasaccites diffusis Tiwari
p.183, pl. 4, fig. 72

Dimensions: Total diameter 90 μ ; corpus diameter (poorly outlined) 54 μ .

Genus POTONIEISPORITES Sharadwaj emend. Sharadwaj 1964

Potonieisporites balmei (Hart) Segroves
Pl. 3, figs. 37, 38

1969 Potonieisporites balmei (Hart) Segroves
p.179, pl. 1, figs. A-C

Dimensions: Total longitudinal axis 80-100 μ ; corpus longitudinal axis 50-70 μ .

Genus and Species indeterminate
"Monosaccites" sp. 1
Pl. 4, fig. 39

Description: Monosaccite. Amb, oval, corpus sub-circular with marginal folds. Trilete mark is not apparent. Attachment of saccus is equatorial and sub equatorial. Saccus bronchi are fine and radiating.

Dimensions: Total longitudinal axis 160 μ ; transverse axis 100 μ ; corpus 75 μ in diameter.

Remarks: Has ^{some of} the generic characters of Parasaccites, but is much larger than any published specimen.

Subturma DISACCITES Cookson 1947

Genus ALISPORITES Daugherty, emend. Nilsson 1958

Alisporites gracilis Segroves
Pl. 4, fig. 40

1969 Alisporites gracilis Segroves
p.190, pl. 6, figs. H-J

Dimensions: Refer to fig. 6 p. 2 for an explanation of terms used for disaccate measurements. Figured specimen. Total breadth 140 μ ; saccus length 100 μ . One other specimen was found. Total breadth 60 μ ; corpus breadth 40 μ ; length of body 46 μ .

Remarks: Both these specimens are outside the size range of those from the Perth Basin.

Genus LIMITISPORITES Leschik, emend. Potonie 1958

Limitisporites moeraensis (Grebe) Klaus

Pl. 4, fig. 41

1962 Illinites delassaucei (Potonie & Klaus) Grebe
p. 12, Taf. 7, figs. 1, 2, 4, 6, 11

Dimensions: Total breadth 70 μ ; corpus breadth 28 μ ; length of saccus 40 μ ; corpus length 38 μ ; cupula 12 μ .

"Monosaccate"

Pl. 4, fig. 42

1962 Taf. 7, fig. 8. Grebe & Schweitzer

Dimensions: Total diameter 40 μ ; corpus diameter 26 μ .

Remarks: Grebe et al. (1962) concluded that this form was a developmental stage in the formation of disaccate pollen; after finding this and disaccate forms associated with a macrofloral organ in situ. Note the similarity of the size of the corpus of this form and fig. 41.

Limitisporites sp. cf. L. rectus Leschik

Pl. 4, fig. 43

1956 Limitisporites rectus Leschik
p. 133, pl. 21, fig. 15

Dimensions: Total breadth 76 μ ; breadth of corpus 42 μ ; saccus length 38 μ ; corpus length 46 μ ; cupula width 26 μ . Differs from published specimen being much larger.

Remarks: Specimens are rare in the assemblage.

Genus VITTATINA Luber ex Wilson 1962

Vittatina sp.

Pl. 4, fig. 44

Description: Subaccate with tetrad scar on proximal face. Rays of scar 6-7 μ , corpus slightly longitudinally elongate to oval. Taeniae (10?) 3 μ wide are sinuous and uneven. Clefts approx. 0.5 μ wide.

Dimensions: Total breadth 70 μ ; corpus breadth 54 μ .

Genus STRIATOABIETITES Zoricheva & Sedova ex Sedova, emend.
Hart 1964

Striatoabietites multistriatus (Balme & Hennelly) Hart
Pl. 4, fig. 45; Pl. 5, figs. 46, 47

1955 partim. Luackisporites multistriatus Balme & Hennelly
p.93, pl. 2, figs. 16-17, 20

1965 Striatoabietites multistriatus (Balme & Hennelly) Hart
p. 41, text-fig. 90

Dimensions: (5 specimens) Total breadth 70 μ ; corpus breadth 55 μ ;
length of corpus 49 μ . These specimens are larger than those described
by Hart (1965, p.41).

Genus SULCATISPORITES Leschik, emend. Bharadwaj 1962

Sulcatisporites sp.
Pl. 5, fig. 48

Description: Disaccate, haploxyloid. Amb of body elongate longitudinally.
Sacci in contact on proximal face, a generic characteristic. They are
semi-circular in outline, and intra microreticulate. Bronchi become
coarser toward the margins of these distally inclined sacci.

Dimensions: Total breadth 55 μ ; corpus breadth 21 μ ; saccus length 49 μ ;
body length 38 μ .

Sulcatisporites sp. cf. splendens Leschik
Pl. 5, fig. 50

1956 Sulcatisporites splendens Leschik
p.137, pl. 22, fig. 10

Dimensions: Total breadth 62 μ ; corpus breadth 46 μ ; length of saccus 50 μ ;
length of body 48 μ .

Remarks: This differs from S. splendens in that the corpus is clearly
outlined but differs from Vesicasporea milvinus (Balme & Hennelly) Hart
in that a well defined sulcus with labra is absent.

Genus PROTOHAPLOXYPINUS Samoilovich, emend. Hart 1964

Protohaploxypinus rugatus Segroves
Pl. 5, fig. 49

1969 Protohaploxypinus rugatus Segroves
p.200, pl. 7, figs. G-H; pl. 9, figs. D-I

INCERTAE SEDIS

Note the Acritarche figured are classified according to Downie et al. (1963).

GROUP ACRITARCHA Evitt 1963

Subgroup ACANTHOMORPHITAE Downie et al. 1963

Genus BALTISPHAERIDIUM Eisenach 1958, emend. Downie & Sarjeant
1963

? Baltisphaeridium sp.

Pl. 5, fig. 51

Genus MICRHYSRIDIDIUM Deflandre 1937, emend. Downie & Sarjeant
1963

Micrhysrididium spp.

Pl. 5, figs. 52, 53

Subgroup POLYGONOMORPHITAE Downie et al. 1963

Genus VERYHACHIUM Deunff, emend. Downie & Sarjeant 1962

Veryhachium spp.

Pl. 5, figs. 54, 55

Subgroup NETROMORPHITAE

Genus LEIOFUSA Eisenach 1938

Leiofusa spp.

Pl. 5, figs. 56, 57

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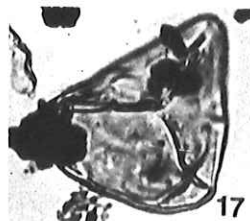
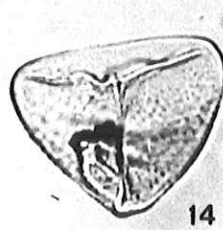
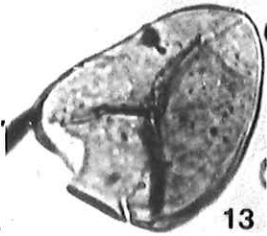
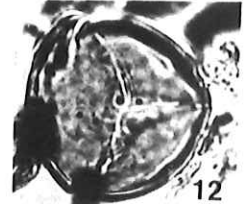
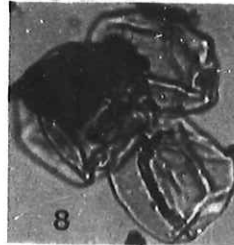
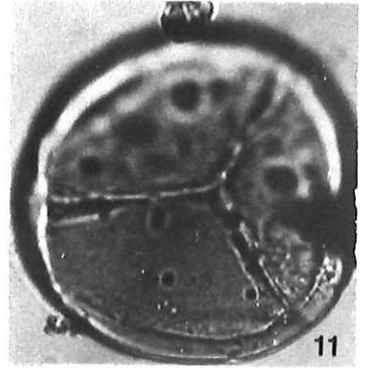
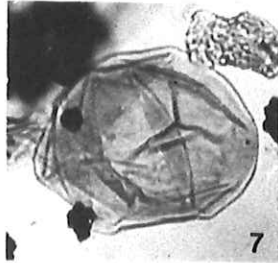
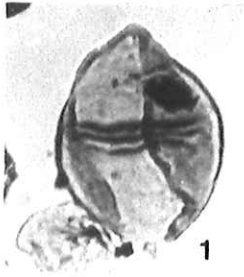
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EXPLANATION OF PLATE 1

All figures are from untouched negatives and unless otherwise stated are x 500.

- Fig. 1 Laevigatosporites flexus Segroves
S 2267/4, 25.8 : 110.3
- Figs. 2-3 Cycadopites cymbatus (Balme & Hennelly) Segroves
Fig. 2. S2441/4, 28.8 : 104.4. Note conspicuous distal furrow extending length of grain.
Fig. 3. S2388/6, 30.5 : 110.5. Furrow margins overlapping
- Fig. 4 Marsupipollenites triradiatus forma triradiatus
Balme & Hennelly
S2267/4, 26.7 : 110.3
- Fig. 5 Laevigatosporites sp.
S2388/6, 42.5 : 106.3
- Fig. 6 Tuberculatosporites medicus Balme & Hennelly
S2267/2, 36.6 : 102.5
- Fig. 7 Calamospora sp. cf. C. microrugosa (Ibrahim) Schopf,
Wilson & Bentall
S2267/3, 22.6 : 110.1. Proximal focus
- Figs. 8-9 Calamospora ? diversiformis Balme & Hennelly
Fig. 8. S2267/2, 39.0 : 107.0. Tetrad.
Fig. 9. S2267/4, 26.7 : 109.0
- Fig. 10 Gen. et sp. in. det.
S2419/1, 44.8 : 103.1
- Fig. 11 Punctatisporites gretensis Balme & Hennelly
S2388/2, 29.5 : 97.2
- Fig. 12 Punctatisporites sp. cf. P. gretensis Balme & Hennelly
S2267/4, 40.8 : 111.9
- Fig. 13 Granulatisporites sp. cf. G. trisinus Balme & Hennelly
S2267/3, 21.9 : 110.1
- Fig. 14 Deltoidispora directa (Balme & Hennelly) Norris
S2441/4, 41.2 : 96.2. Proximal focus.
- Fig. 15 Gen. et sp. in. det.
S2390/5, 38.0 : 105.5
- Fig. 16 Microbaculispora tentula Tiwari
S2267/4, 42.8 : 100.6. Lateral view
- Figs. 17-18 Granulatisporites trisinus Balme & Hennelly
Fig. 17, S2267/4, 40.0 : 99.4
Fig. 18. S2267/3, 20.5 : 107.7. Note well developed lips

PLATE 1

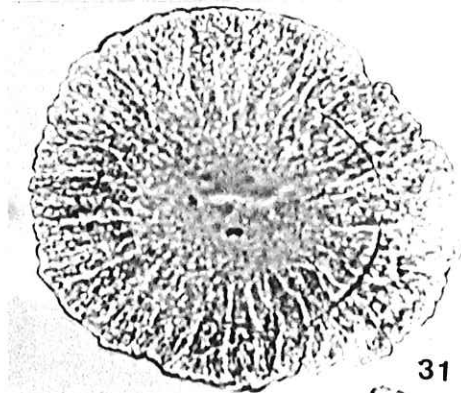
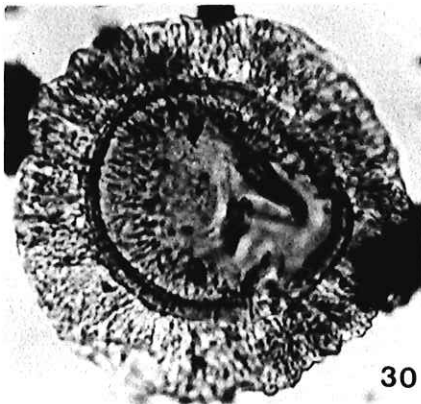
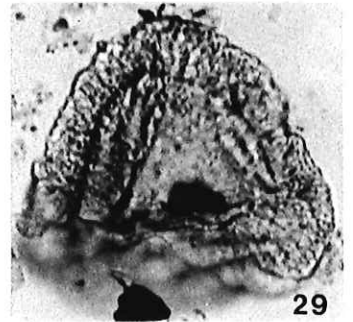
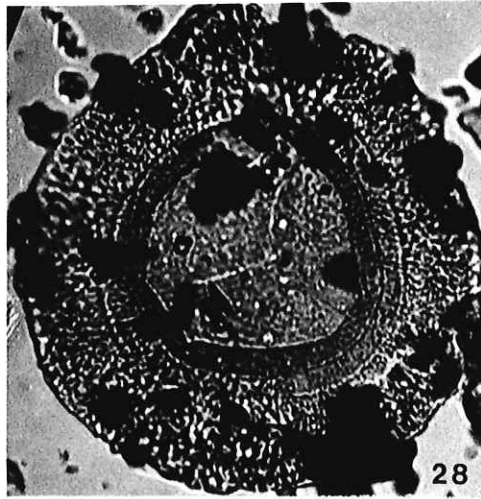
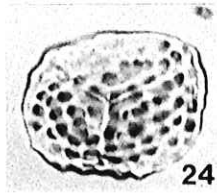
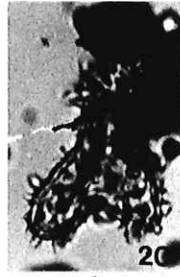
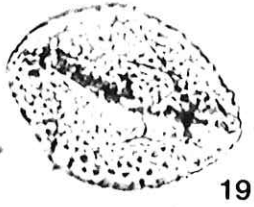


EXPLANATION OF PLATE 2

All figures are from untouched negatives and unless otherwise stated are x 500.

- Fig. 19 Verrucisporites sp.
S2441/3, 39.0 : 98.9
- Fig. 20 Lophotriletes sp.
S2388/1, 48.0 : 104.7
- Fig. 21 Acenthotriletes teretiangulatus Balme & Hennelly
S2390/6, 27.0 : 100.8. Proximo-distal focus
- Figs. 22 & 26 Baculatisporites sp.
Fig. 22. S2386/3, 29.9 : 113.0
Fig. 26. S2267/2, 26.5 : 102.5
- Fig. 23 Horriditriletes ramosus (Balme & Hennelly)
Bharadwaj & Salajha
S2267/2, 36.0 : 111.4. Distal focus
- Fig. 24 Apiculatisporis sp.
S2441/2, 27.8 : 110.1
Note concentrically arranged sculptural elements
- Fig. 25 Leachikisporis catus Segroves
S2441/2, 40.0 : 108.6
Note off polar compression; lateral view
- Fig. 27 Apiculatisporis lavis (Balme & Hennelly) Segroves
S2267/1 26.4 : 102.9
- Fig. 28 Parasaccites gondwanensis (Balme & Hennelly) Segroves
S2267/2, 36.8 : 109.2
- Fig. 29 Parasaccites sp. A
S2419/1, 41.1 : 112.4
- Fig. 30 Parasaccites sp.
S2388/1, 33.0 : 100.4
- Fig. 31 Parasaccites sp. cf. Virrkipollenites methae Lele
S2441/1, 31.6 : 101.5
Note absence of folds at margin of corpus

PLATE 2

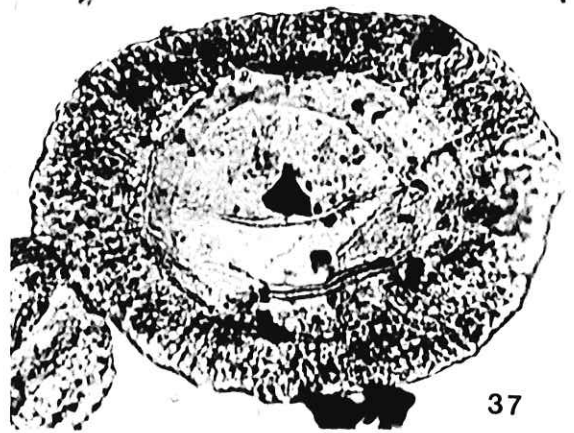
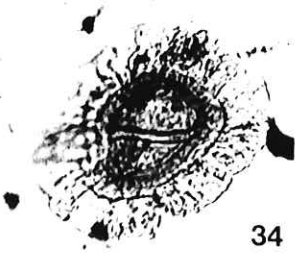
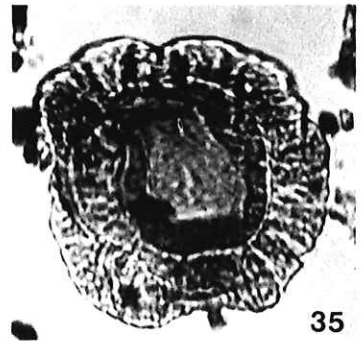
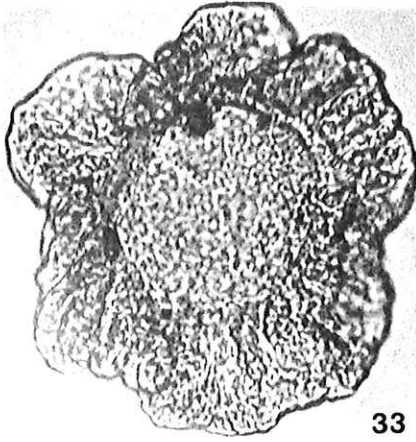
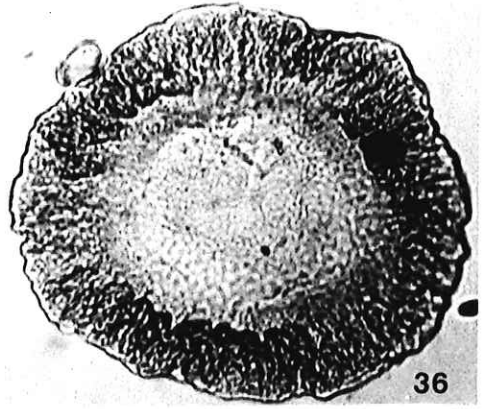
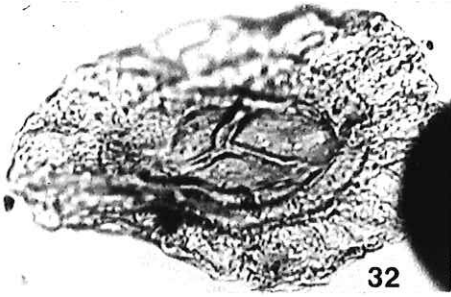


EXPLANATION OF PLATE 3

All figures are from untouched negatives and unless otherwise stated are x 500.

- Figs. 32, 33 & 35 Parasaccites sp. cf. V. msthae Lele
Fig. 32. S2667/4, 26.6 : 101.4. Compressed grain, note the raised lips.
Fig. 33. S2441/1, 29.4 : 100.2
Fig. 35. S2267/4, 26.6 : 114.0
- Fig. 34 Parasaccites sp.
S2390/5, 35.0 : 91.4 (x 250)
- Fig. 36 Parasaccites diffusus Tiwari
S2267/4, 26.4 : 95.0
- Figs. 37, 38 Potonisaccites balnei (Hart) Segroves
Fig. 37. S2390/1, 32.3 : 99.8. Laesura torn
Fig. 38. S2267/2, 36.5 : 98.8

PLATE 3

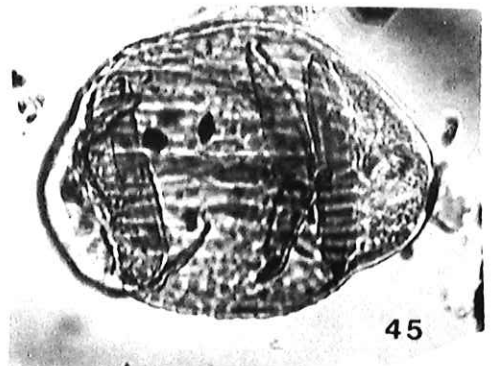
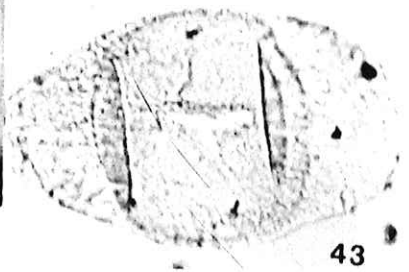
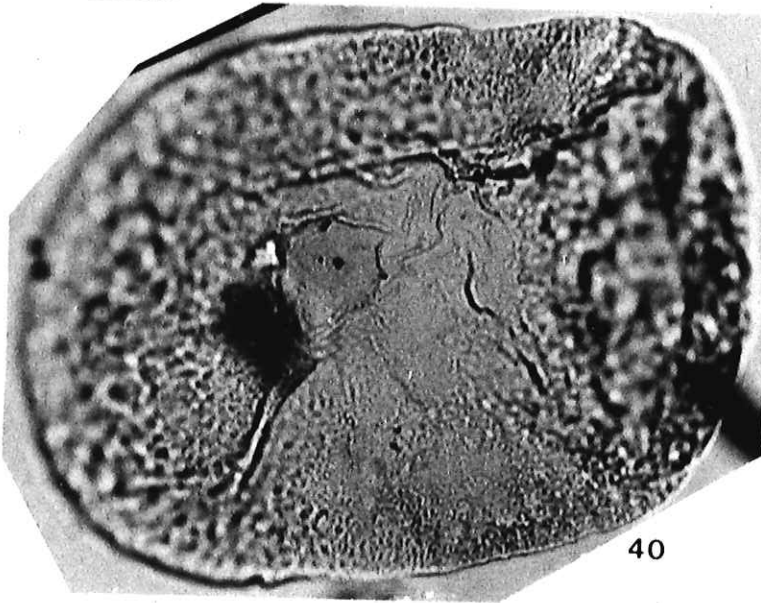
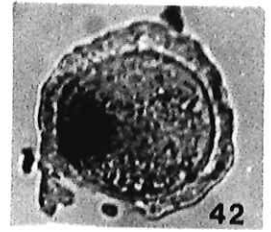
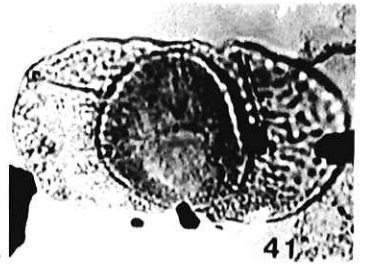
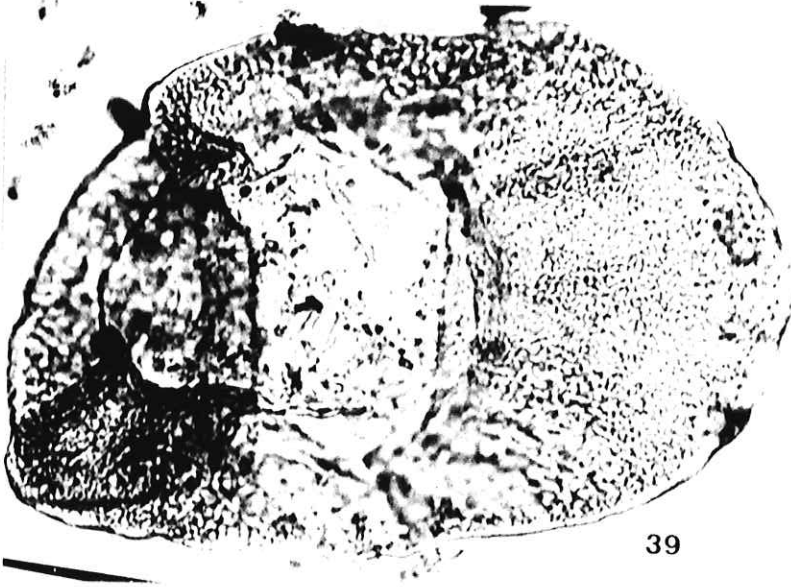


EXPLANATION OF PLATE 4

All figures are from untouched negatives and unless otherwise stated are x 500.

- Fig. 39 "Monosaccites" sp.
S2390/5, 39.6 : 109.6. Note the large size of
this monosaccate pollen
- Fig. 40 Alisporites gracilis Segroves
S2441/1, 22.8 : 99.9. Particularly large specimen
- Fig. 41 Limitisporites moersensis (Grebe) Klaus
S2267/4, 25.5 : 110.8
- Fig. 42 "Monosaccate"
S2383/3, 32.6 : 92.8. Developmental stage of
disaccates, compare size of corpus with Fig. 41
- Fig. 43 Limitisporites sp. cf. L. rectus Leschik
S2388/3, 32.6 : 92.8
- Fig. 44 Vittatina sp.
S2390/1, 45.0 : 96.5. Torn specimen
- Fig. 45 Striatoabietites multistriatus (Balme & Hennelly) Hart
S2267/3, 23.8 : 114.1

PLATE 4

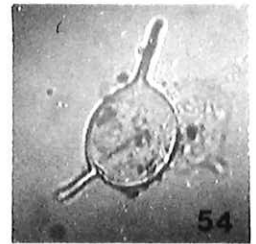
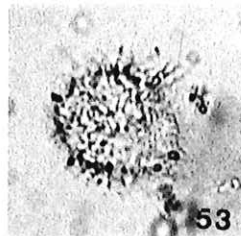
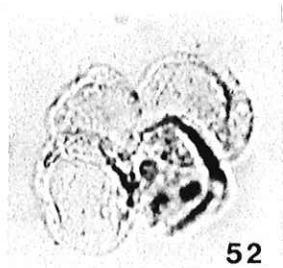
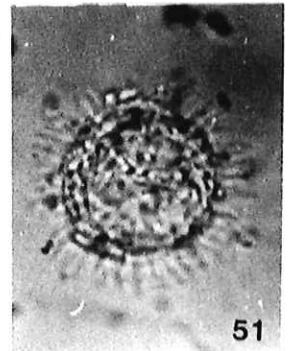
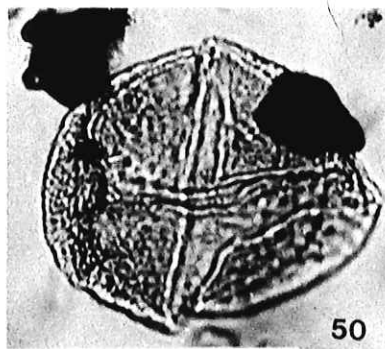
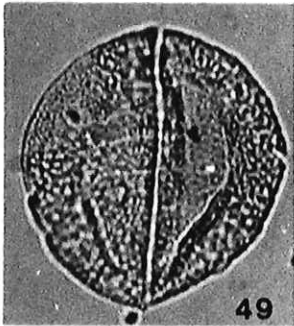
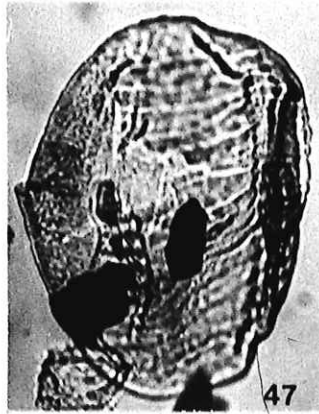
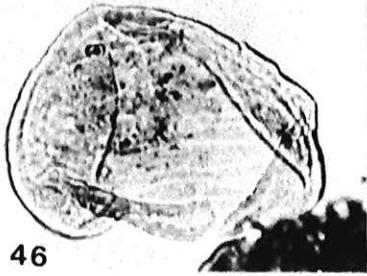


EXPLANATION OF PLATE 5

All figures are from untouched negatives and unless otherwise stated are x 500.

- Figs. 46, 47 Striatoabietites multistriatus (Balme & Hennelly) Hart
Fig. 46. S2441/1, 30.0 : 95.0
Fig. 47. S2267/4, 26.2 : 98.5. Note increased length of corpus.
- Fig. 48 Sulcatisporites sp.
S2441/2, 34.0 : 106.0. Note line of contact of sacci
- Fig. 49 Protoploxypinus rugatus Segroves
S2441/1, 25.4 : 95.5
- Fig. 50 Sulcatisporites sp. cf. S. splendens Leechik
S2390/5, 30.0 : 109.1
- Figs. 51-57 Group Acriterche Evitt 1963
- Fig. 51. ? Baltisphaeridium sp.
S2389/1, 39.0 : 95.0 (x 1000)
- Figs. 52 Microhystridium spp.
& 53 Fig. 52. S2387/1, 33.5 : 109.0 (tetrad)
Fig. 53. S2267/5, 41.2 : 92.3
- Figs. 54. Veryhachium spp.
& 55 Fig. 54. S2386/2, 43.5 : 106.5. Note globose test
Fig. 55. S2386/3, 28.1 : 112.5
- Figs. 56 Leiofusa spp.
& 57 Fig. 56. S2389/1, 33.0 : 93.3
Fig. 57. S2389/4, 27.0 : 105.8. Folded with torn horn
- Fig. 58 Botryococcus sp.
S2267/1, 25.5 : 113.0

PLATE 5



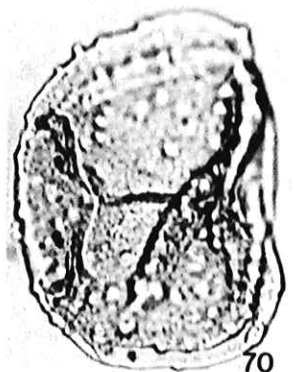
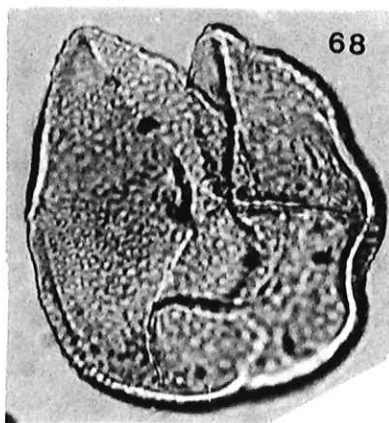
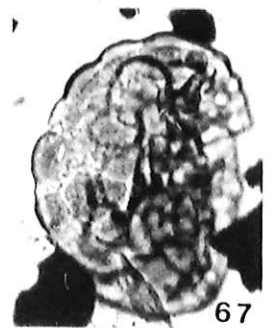
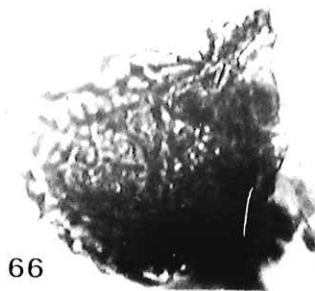
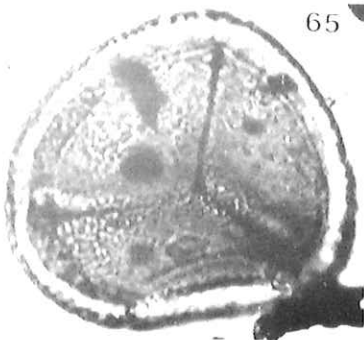
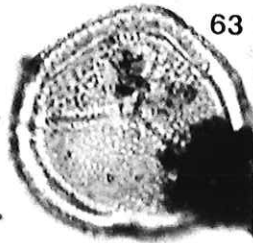
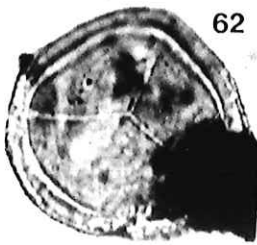
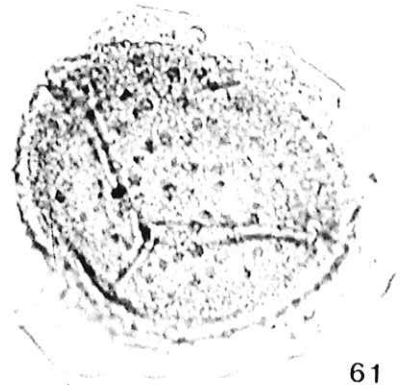
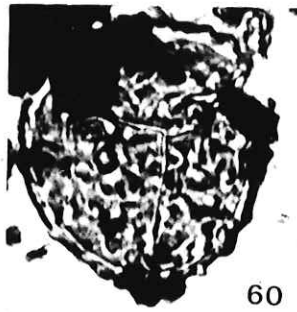
EXPLANATION OF PLATE 6

REWORKED DEVONIAN PALYNOMORPHS

All figures are from untouched negatives and unless otherwise stated are x 500.

- Fig. 59 ? Archaeozonotriletes micromanifestus var. micromanifestus
Naumova
S2267/6, 35.3 : 96.0
- Fig. 60 Convolutispora fromensis Balme & Hassell
S2267/3, 33.7 : 113.6
- Fig. 61 Grandispora sp.
S2441/4, 28.0 : 105.2. Convex distal surface
- Figs. 62-66 Geminospora lamurata Balme
Fig. 62. S2388/6, 40.6 : 104.8. Proximal focus, showing absence of ornament on proximal face
Fig. 63. Distal focus
Fig. 64. S2267/4, 99.6 : 39.5. Proximal
Fig. 65. Distal, showing size range within the species
Fig. 66? S2387/4, 39.7 : 96.5 (Archaeozonotriletes?)
Equatorial view, showing well developed lips extending to proximo-distal margin
- Fig. 67 ? Verrucosiporites sp.
S2267/1, 32.6 : 105.4
- Fig. 68 ? Planisporites sp.
S2441/1, 30.5 : 99.9. Trilete amb broadly triangular. Laesura bifurcate at termini, and here thin (1 μ) lips which extend to the 'equator'. Covered with closely spaced small spines and baculae. Exine 1.5 μ thick, diameter 85 μ . Could be dome shaped distally. Has similarities with Planisporites forfuris Balme & Hassell.
- Fig. 69 Gen. et sp. in det.
S2389/1, 37.1 : 103.4. Amb sub circular, trilete with straight laesura extending 3/4 of spore radius. Well defined contact area, thin raised lips 1 μ wide. Distal polar compression, and conspicuous exinal folds. Appears not to have a central body. Diameter 81 μ , finely granulate, with small baculae.
- Fig. 70 Hymenozonotriletes sp.
S2441/2, 34.8 : 98.0

PLATE 6



EXPLANATION OF PLATE 7

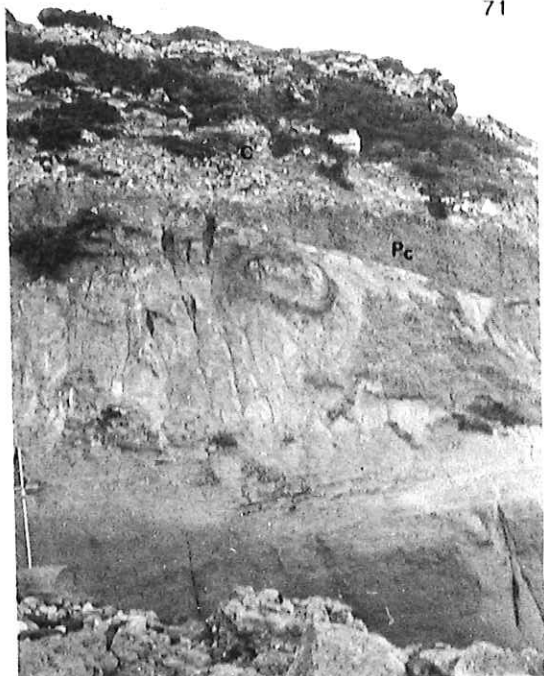
Field Photographs

Fig. 71 S.E. of Section 8 (Fig. 2a). Permian sand lens overlain by Permian clays (Pc) and calcrete (C). Note the large concentric weathering features of the sand lens (Scale; staff 2m).

Fig. 72 Severely iron-stained ? Permian sandy clays, with small erratics. Near Section 2 (Fig. 2a). Overlain by red brown/olive clays with white clay bands, and 'friable' to flaggy calcretes (C).

Fig. 73 'Boulder' bed, S.E. of Section 8 (Fig. 2a) underlying a Permian sand lens (5 m from Fig. 71 location).

71



72



73



APPENDIX I

(a) Field Sampling Techniques

(i) Although palynomorphs are acid resistant they are subject to exinal degradation and destruction by normal oxidising processes. Consequently unweathered black to blue-grey carbonaceous clays yielded the best assemblages. Fresh surface exposures were sampled after storm activity, but samples collected at depth using a post hole digger generally yielded the better assemblages.

(ii) There are no obvious bedding features in the claystones at Waterloo Bay. The outcrop was sampled at one metre vertical intervals so that if any microfloral changes occurred with increasing thickness, they would be detected.

As little as 20 gms. is enough for a palynological preparation; however at least 200 gms. were collected so that preparations could be repeated if necessary. The samples were put in polythene bags and labelled. The bag tops were then folded double and stapled to prevent contamination. Only the centre of the 'cores' from the digger were collected to avoid 'down hole contamination'.

Samples from the top and bottom of the Permian sequence in Peasey Swamp No. 1 were prepared to see if any microfloral change had occurred over a greater depth (≈ 80 m). However, samples from the top of the sequence were too weathered to yield well preserved assemblages.

(b) Preparation of Samples

To ensure consistent results from all samples a standard procedure was followed. The method (below) is basically similar to those described by earlier workers in particular that of Salme and Hassell (1962).

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

1. Boil about 5g. of the crushed (> 2 mm) carbonate free sediment with 50 ml. 60% hydrofluoric acid until only a sludge remains. Wash by centrifuging twice with water. This step is carried out in 250 ml. nickel or copper beakers. Alternatively, crushed sample is left for 24 hours (in a plastic beaker) in hydrofluoric acid; this removes more silicates than the faster boiling method.
2. Transfer residue to beaker and add 40 ml. of 10% hydrochloric acid. Boil for one or two minutes. Centrifuge and wash twice.
3. Add 50 ml. of Schultze solution (1 part concentrated potassium chlorate solution: 2 parts concentrated nitric acid) to the moist residue, transfer to a beaker and heat gently for about one minute. Centrifuge and wash three times. This is a critical step in the procedure as too much oxidation will destroy all spores and pollen. In some samples better results were obtained by allowing the residue to stand in the Schultze solution for 10-20 minutes before boiling.
4. Transfer residue to a beaker, add 40 ml. of 10% potassium carbonate solution and heat to boiling point. Centrifuge and wash until supernatant liquid is clear.
5. Add 30 ml. of concentrated nitric acid, stir for 10 to 20 seconds then wash immediately three or four times.
6. Add 30 ml. of 10% potassium carbonate solution for 20 seconds. Centrifuge and wash residue until solution is clear.

Steps 5 and 6 are not always necessary for all samples. The best results are obtained by examining a drop of the sample (using a microscope) after each step.

The residue is stored in glass phials to which has been added an aliquot of glycerine and a few drops of 1% phenol solution. At least four strew slides are made up using glycerine jelly, two of which are stained with

safranin. A drop of melted glycerine jelly with or without safranin is mixed thoroughly with a small quantity of residue on a microscope slide and the coverslip lowered. The slides are immediately inverted to permit the microfossils to settle closer to the coverslip. These are allowed to stand for at least three days before being cleaned of excess glycerine jelly and ringed with goldsize varnish or nail lacquer.

APPENDIX II

Sample Locations

1. Unless otherwise stated all sampled were collected by the writer during this study.
2. Samples prefixed S are stored at the Palynological Laboratory, Geological Survey of South Australia.
3. Other samples: Sp = palynological, F = foraminiferal

No.	Reference Fig. 2a	Comments
S 2267	Beach level approx. Section 5	Coll. R. F. Harris, 1971
FEE ₁	" " " " (BARREN)	Excellent barren preservation
S 2386	Section 5, 1 m above beach level	Auger sample, poor preservation;
F6	" " " "	Barren
S 2387	Section 5, 1 m above last sample	Poor preservation
S 2388	Section 5, 1 m above last sample	Reasonable assemblage
S 2389	15 m N.E. section 5, beach level	Moderate preservation
FEE ₁	" " " "	6 foraminifera
S2390	Bottom of Peesey Swamp No. 1 80.5 m P.D.H. No. 1 (Fig. 2b)	Coll. Geosurveys Excellent preservation
S 2440	20 m W of Section 6 at beach level	Poor
S 2441	5 m W of Permian sand lens, Section 8, beach level	Excellent preservation
FE3	"	FE3 barren
S 2419	East of sand lens, Section 8 auger sample	Good preservation
S 2451	10.6 m, top of Permian Sequence Peesey Swamp No. 1	Very poor
Sp. Pt. Turton (Fig. 2b)	50 m W of jetty at base of low cliffs. 6 auger samples (1.2 m)	All barren
Sp1 & F1	Port Moorowie, Section 1	Barren
Sp2 & F2	Section 3, 1 m above beach level	Barren
Sp19	Section 10, Tertiary/Permian contact	Barren

No.	Reference Fig. 2a	Comments
F3,4	Section 5, 1 m and 2 m from beach level	Barren
F5 = L1 slide 28672	Section 5	See LINDSAY (1972)
F9	Section 6	Barren
F13	Section 8, P. sand lens, 4, 1 m samples collected	Barren
F33 = L32	Section 8, Permian sand rock	Barren
Ft.1 = F122/72	Section 10, 2 m above Permian clays	See LINDSAY (1972)

CLASS								TOTAL	SAMPLE No.	No. SLIDES COUNTED	DOMINANT Sp.	NOTES
1	2	3	4	5	6	7	8					
4	0	0	10	2	7	14	23	60	S 2451	4	Statistically unsatisfactory	1). Classes 1 Monosaccate pollen 2 Disaccate Non Striate Pollen 3 Disaccate Striate pollen 4 Monocolpates eg. <u>Cycadopites cymbatus</u> 5 Spinose acritarchs 6 Non Spinose acritarchs 7 Monolete spores. 8 Trilete spores. 2). Fig. 3 has a plot of 'Total Spores' this number is the result of the summation of classes 7 and 8. <u>and does NOT</u> include the pollen content. 3). Two hundred palynomorphs per sample have been counted (if the sample was rich enough to contain 200 palynomorphs) as this number is considered representative of a sample (Tschudy & Scott 1969). Samples with less than 200 palynomorphs are considered as poor and are unrepresentative of the assemblage. 4) All slides prepared. were scanned.
52	8	3	22	5	0	23	87	200	S 2390	1	<u>Microbaculispora tentula</u>	
48	6	2	21	11	6	11	96	200	S 2390	2	<u>M. tentula</u> 34 of 96 trilete (8)	
48	9	2	18	8	3	12	99	200	S 2267	1	<u>M. tentula</u> . (31 of class 8)	
2	1	0	0	4	2	1	20	30	S 2386	2	Statistically unsatisfactory.	
28	7	1	21	1	7	46	90	200	S 2388	6	Decrease in <u>M. tentula</u>	
21	5	2	10	6	5	13	59	121	S 2387	7	Poor assemblage fragmentary and folded material.	
5	2	0	8	18	4	8	31	76	S 2389	5	↓ poor assemblage; ↑ increase in spinose acritarchs, <u>Microhystridium</u> .	
109	16	4	32	3	10	25	101	300	S 2441	2	Excellent preservation, Monosaccates dominate.	
21	4	3	18	27	1	39	87	200	S 2419	1	Increase in no. of spinose acritarchs particularly <u>Veryhachium</u> spp.	

Appendix 3 (a)

Quantitative Microfloral Data

Appendix 3b.

SPECIES LIST; WATERLOO BAY- ASSEMBLAGE.

- Acanthotriletes teretiangulatus
Alisporites gracilis
Alisporites indarraensis +
Apiculatisporis lewis
Apiculatisporis sp.
Raculatisporites sp.
Calamospora ? diversiformis
Calamospora sp. cf. C. microrugosa
Cycadonites cymbatus
Deltoidispora directa
Densosporites solidus
Gen. et sp. in det.
Granulatisporites sp. cf. G. trisimus
Granulatisporites trisimus
Horriditriletes ramosus
Krauselisporites sp.
Laevigatosporites flexus
Laevigatosporites sp.
Leschikisporis cestus
Limitisporites moersensis
Limitisporites sp. cf. L. rectus
Lophotriletes sp.
Marsupipollenites triradiatus forma triradiatus

"Monosaccate"

"Monosaccites" sp.

Parasaccites diffusus

Parasaccites gondwanensis

Parasaccites sp.

Parasaccites sp. A

Parasaccites sp. cf. Virrikinollenites methae

Potonieisporites helmeri

Protohaploxypinus rugatus

Punctatisporites gretensis

Punctatisporites sp. cf. P. gretensis

Striatobietites multistriatus

Sulcatissporites sp.

Sulcatissporites sp. cf. S. sriendens

Tuberculatosporites medicus

Vittatina sp.

Microplankton:

? Baltisphaeridium sp.

Botryococcus sp.

Diplofusa sp.

Leiofusa spp.

Leiosphaera sp.

Micrhvstridium spp.

Verhachium spp.

Reworked Devonian :

? Archaeozonotriletes micromanifestus var. micromanifestus

Convolutispora fromensis

Geminispora lemurata

Grandispora sp.

Hymenozonotriletes sp.

? Planisporites sp.

? Verrucorisporites sp.