GEOLOGICAL SURVEY
OF
WESTERN AUSTRALIA

REPORT 7

PALYNOLOGICAL ZONATION OF THE LATE JURASSIC AND EARLY CRETACEOUS SEDIMENTS OF THE YARRAGADEE FORMATION CENTRAL PERTH BASIN WESTERN AUSTRALIA

by John Backhouse

1978

FOREWORD

This is the first publication by this Survey wholly devoted to palynology a discipline which was introduced into our practice some 16 years ago. More and more recognition has been given to its usefulness in identifying the stratigraphy, particularly in hydrogeological investigations. Our hydrogeologists now consider that this type of work is essential.

In an attempt by this Survey to evaluate the groundwater potential of the Perth Basin, many bores have been drilled in Jurassic and Cretaceous sediments. In the monotonous, mainly continental, sandstone and shale encountered in some parts of the sequence, palynology has proved an invluable tool for unravelling the stratigraphy.

This Report presents a zonation of the Cretaceous part of the Yarragadee Formation, and describes and illustrates the stratigraphically most important spores and pollen grains.

The information presented should be of great assistance to persons involved in the scientific search for groundwater and oil and gas.

J H Lord
DIRECTOR

14 April, 1978.

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PALYNOLOGICAL ZONATION OF THE LATE JURASSIC AND EARLY CRETACEOUS SEDIMENTS OF THE YARRAGADEE FORMATION, CENTRAL PERTH BASIN WESTERN AUSTRALIA

by
John Backhouse

ABSTRACT

Thirty three biostratigraphically useful spores and pollen grains are described from the Late Jurassic and Early Neocomian part of the Yarragadee Formation in the central Perth Basin, Western Australia. Four species, *Biretisporites eneabbaensis, Retitriletes watherooensis, Matonisporites agatonensis* and *Polypodiidites horridus* are new. The samples are from three east-west lines of bores in the central Perth Basin. Spore and pollen assemblages are used to divide the sequences encountered in these bores into six zones and the palynological criteria used to define the zones are discussed. The occurrence of the zones in all boreholes is outlined and illustrated. Correlation with previous palynological zonations proposed in the Perth Basin and in eastern Australia is discussed, and an attempt is made to relate the zones to standard European Stages. On the evidence of spore and pollen distributions, five zones appear to be entirely Jurassic in age and the base of the uppermost zone probably lies near the Jurassic-Cretaceous boundary and extends into the Neocomian.

INTRODUCTION

Between 1965 and 1974, a drilling programme was carried out in the onshore part of the central Perth Basin in an effort to locate underground water resources. As part of this programme, samples were taken for palynological age determination. The aim of this report is to provide a palynological zonation of the upper part of the Yarragadee Formation based on these samples and applicable to future subsurface exploration in the area.

The drilling programme, carried out by the Department of Mines, Western Australia, consisted of three east-west lines of boreholes (Fig.1). From north to south the lines are known as the Eneabba, Watheroo and Gingin Brook Lines. Earlier accounts of the geology of these lines of bores are to be found in Sanders (1967), on the Gingin Brook Line, Harley (1975), on the Watheroo Line, and Commander (in press), on the Eneabba Line.

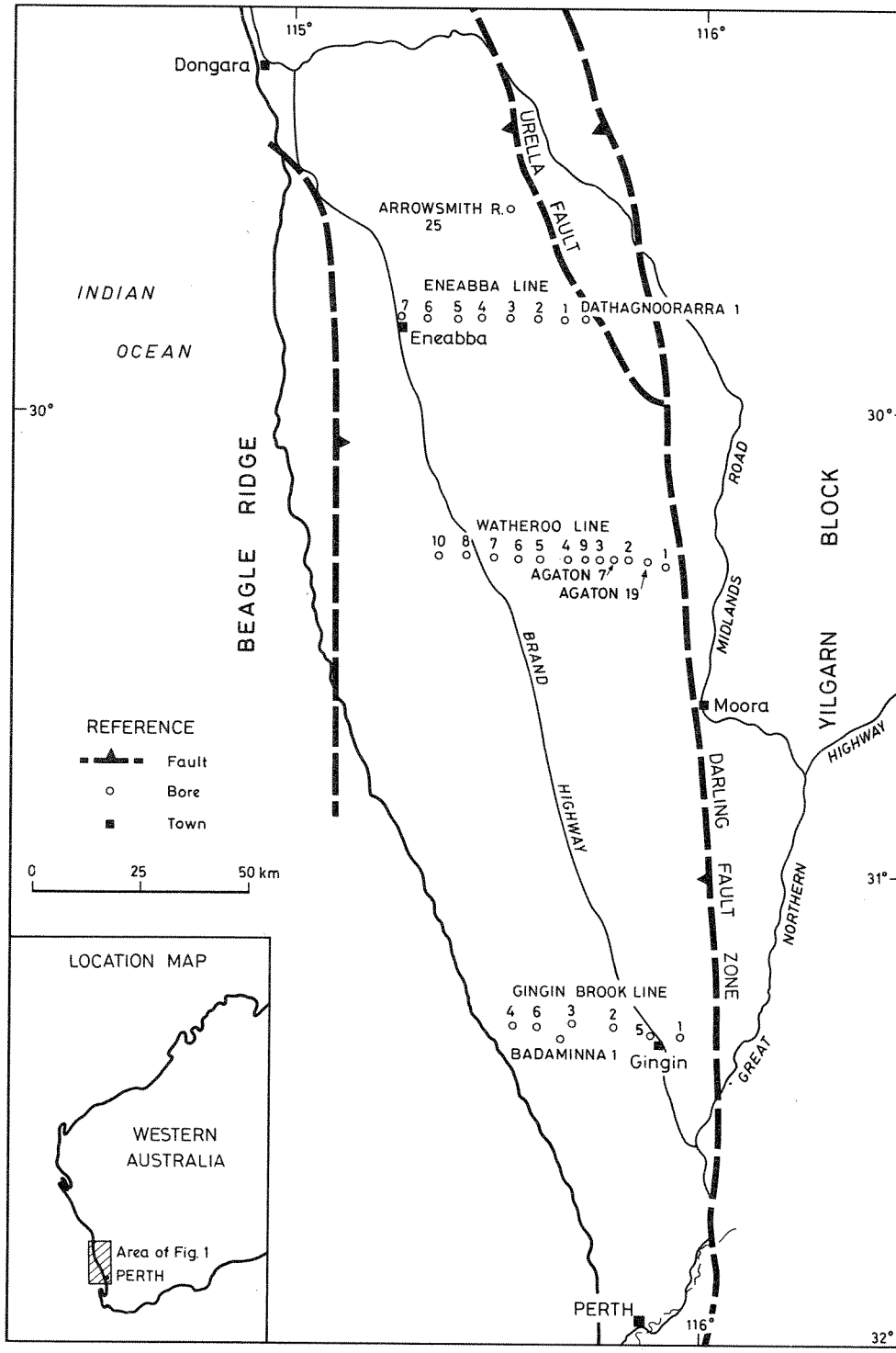

Figure 1. Location of boreholes mentioned in text.

G.S.W.A. 14666

Although several formations are intersected along each line, most of the drilling took place in the Yarragadee Formation (Fairbridge, 1953; emend. Playford and Wilmott *in* McWhae and others, 1958), of Middle Jurassic to Early Neocomian age. Most samples are from siltstone and shales in the upper part of the formation, but some productive samples were also obtained from lower parts of the formation. Sections of the Yarragadee Formation in some bores are almost completely devoid of argillaceous sediments, and palynological information from these sections is sparse.

The biostratigraphic zonation applied in this report is based partly on the work of Filatoff (1975) and partly on revision of work previously carried out on this material (Backhouse, 1974, 1975; Ingram, 1966a).

GEOLOGY OF THE AREA

Comprehensive accounts of the structure and stratigraphy of the Perth Basin are given in Playford and others (1975) and in Playford, Cockbain and Low (in press). Briefly, the Perth Basin is a narrow, 1 000-km-long, sedimentary basin extending north-south, bounded on the east by the Darling Fault zone, and on the west by the continental slope.

The Perth Basin is subdivided into several sub-basins, the largest of these is the Dandaragan Trough, which extends from the Harvey Ridge south of Perth, to the Northampton Block near Geraldton. The Dandaragan Trough is bounded on the east by the Darling and Urella Faults, and on the west by the Beagle Ridge. All the drilling lines are in this subdivision of the basin.

The Yarragadee Formation subcrops a large part of the central Dandaragan Trough and is extensively cut by north-south faults. It consists predominantly of sandstone but contains some shale and siltstone units, particularly in the upper part. The formation conformably overlies the Middle Jurassic Cadda Formation, and is overlain unconformably by the Early Cretaceous Warnbro Group, or in some areas by the mid to Late Cretaceous Coolyeena Group. Sand and limestone of Quaternary age cover much of the area so that the Mesozoic formations seldom crop out.

Cockbain and Playford (1973) recognized two members within the Yarragadee Formation: the Quinns Shale Member, which occurs in several oil

exploration wells in the offshore area near Perth, and the Otorowiri Siltstone Member, which was described by Ingram (1967) from boreholes in the Arrowsmith River area about 27 km north of the Eneabba Line. Several other siltstone/shale beds are known above the Quinns Shale Member, in the upper part of the Yarragadee Formation in the offshore area. The Quinns Shale and Otorowiri Siltstone Members, and many of the other shale beds are characteristically slightly marine. Based on lithological and palynological similarity Backhouse (1975) suggested that the Quinns Shale Member and the Otorowiri Siltstone Member are the same unit, in which case the name Otorowiri Siltstone has priority.

DRILLING AND SAMPLING

The Gingin Brook Line was drilled in 1965 and 1966. The eastern part of the Watheroo Line was drilled in 1967; drilling recommenced in 1971 when the Watheroo Line was completed and drilling of the Eneabba Line followed in 1972 to 1974.

Before 1971, conventional cores were cut in each borehole at about 60 m intervals. Because of the predominantly sandy lithology of the Yarragadee Formation cores were often cut entirely in sandstone, which yielded very few palynomorphs. From 1971 onwards sampling was by sidewall cores shot at horizons selected from gamma-ray logs. Shales and siltstones were the targets because these lithologies yielded the richest samples. Generally, sidewall coring has proved a most satisfactory method of obtaining material from the predominantly sandstone Yarragadee Formation.

The location of the boreholes is shown in Figure 1, and sample horizons are listed in the Appendix.

PREVIOUS PALYNOLOGY

Balme (1957) made the first palynological investigation of Mesozoic sediments in Western Australia. He described material from a number of bores south of Bunbury, from the Geraldton and Hill River areas, and from

the central Perth Basin in the vicinity of Moora and Gingin. Of the samples from the central Perth Basin, those from seismic shot hole C12, seismic shot hole 1 SW, and the Moora Bore at 1 840 ft are probably from the Yarragadee Formation. Balme's other samples from the Cretaceous in the Perth Basin are more probably from sediments now assigned to the Warnbro Group.

Balme divided his material into three microfloral assemblages of Early Jurassic, Oxfordian to Kimeridgian, and Neocomian to Aptian age. Later, he (Balme, 1963) named these the *Exesipollenites*, *Dampieri* and *Microcachryidites* Assemblages after the dominant species in each. The *Microcachryidites* Assemblage was defined as commencing with the appearance of *Microcachryidites antarcticus* Cookson and several other species, most notably *Cicatricosisporites australiensis* (Cookson). Balme regarded the *Microcachryidites* Assemblage as becoming established in the Tithonian, an opinion shared by Evans (1966a, b, c).

Ingram (1967a,b) gave an account of the palynology of the Gingin Brook bores and of the Otorowiri Siltstone in the Arrowsmith River bores. At the time, the subsurface geology of the Gingin area was not well established and the stratigraphy of the Gingin Brook Line has since been revised.

Preliminary accounts of the palynology in the Watheroo and Eneabba Line bores are given by Backhouse (1974, 1975). The present report is largely a revision of this work, but also incorporates a re-examination of material from the Gingin Brook Line.

Filatoff (1975) carried out a major study of Jurassic palynology in the Perth Basin, including the Jurassic section of the Yarragadee Formation. He subdivided the Late Jurassic into the*Dictyotosporites complex* Oppel-zone, *Klukisporites scaberis* Oppel-zone, *Contignisporites cooksonii* Oppel-zone, and a broader unit the *Murospora florida* Microflora. The top of the *M. Florida* Microflora is also the top of Balme's *Dampieri* Assemblage and is regarded by Filatoff as being approximately the top of the Kimeridgian.

PALYNOLOGICAL ZONATION

The zonation used in this report is summarized below:

Defined in this paper	*Biretisporites eneabbaensis* Zone
	Aequitriradites acusus Zone
	Retitriletes watherooensis Zone
Defined in Filatoff (1975)	*Murospora florida* Microflora
	Contignisporites cooksonii Zone
	Klukisporites scaberis Zone

As relatively few samples are from the bottom three zones, they will not be discussed in detail. The distribution of spores and pollen in these zones generally agrees with Filatoff's recorded distribution. The distribution of individual species within the zonation is shown in Figure 2.

The *Klukisporites scaberis* Zone occurs only in Gingin Brook 3, in which the yield of palynomorphs per sample is extremely low. The assignment to the *K. scaberis* Zone is therefore tentative, and for this reason the zone is not included in Figure 2.

The *Contignisporites cooksonii* Zone, as defined by Filatoff, commences with the appearance of *Contignisporites cooksonii* (Balme), and several other species appear within the zone. Similarly, the *Murospora florida* Microflora starts with the first appearance of *Murospora florida* (Balme).

The three uppermost zones are based on palynological observations in the Watheroo and Eneabba Line bores, which intersected a substantial thickness of strata above the *M. florida* Microflora. They are defined as follows:

RETITRILETES WATHEROOENSIS ZONE

The *Retitriletes watherooensis* Zone is not entirely represented in any single section. The greatest thickness of the zone in a single bore is in Watheroo 6, from 0 to 560 m.

The zone is defined as the interval between the first appearance of *Retitriletes watherooensis* n. sp. and the first appearance of *Aequitriradites acusus* (Balme). Other species appearing at the base of this zone are *Microcachryidites antarcticus* Cookson, *Polypodiidites horridus* n. sp., *Ceratosporites equalis* Cookson and Dettmann, and *Velosporites triquetrus*

(Lantz). *Nevesisporites* sp. cf. *N. vallatus* de Jersey and Paten and *Contignisporites multimuratus* Dettmann also appear in this zone. However, de Jersey and Paten (1964) and Filatoff (1975) record *N. vallatus* from the Early Jurassic and Filatoff (1975) regards *C. multimuratus* as appearing in the *M. florida* Microflora. The absence of these species below the *R. watherooensis* Oppel-zone in this area may be a local feature.

Trilobosporites antiquus Reiser and Williams and *Microcachryidites castellanosii* Menendez disappear before the base of the *R. watherooensis* Zone. *Polycingulatisporites crenulatus* Playford and Dettmann, which Filatoff (1975) records as dying out in the *M. florida* Microflora is recorded as a very rare form in this zone and may be reworked.

No productive samples have been obtained from about the boundary of the *M. florida* Microflora and the *R. watherooensis* Zone. As the *R. Watherooensis* Zone commences with the appearance of the zone species and other species noted above, a section remains at the top of the *M. florida* Microflora from which there is no palynological information.

AEQUITRIRADITES ACUSUS ZONE

The *Aequitriradites acusus* Zone is present in Eneabba 1 where it extends from 684 m to the base of the *Biretisporites eneabbaensis* Zone at about 347 m, an interval of 337 m.

This zone extends between the first appearance of *Aequitriradites acusus* (Balme), and the first appearance of species marking the start of the *B. eneabbaensis* Zone. Other species appearing at the same level as the zone species are: *Trilobosporites apiverrucatus* Couper, *Foraminisporis dailyi* (Cookson and Dettmann), *Laevigatosporites belfordii* Burger and *Biretisporites* sp. cf. *B. spectabilis* Dettmann. No species are recorded as dying out in this zone.

The *R. watherooensis* and *A. acusus* Zones represent a subdivision of a single zone, the *Baculatisporites* Zone, used previously by Backhouse (1974 and 1975) in the Watheroo and Eneabba lines.

Spore and pollen assemblages in the *R. watherooensis* and *A. acusus* Zones are often sparse, reflecting the predominantly sandstone lithology.

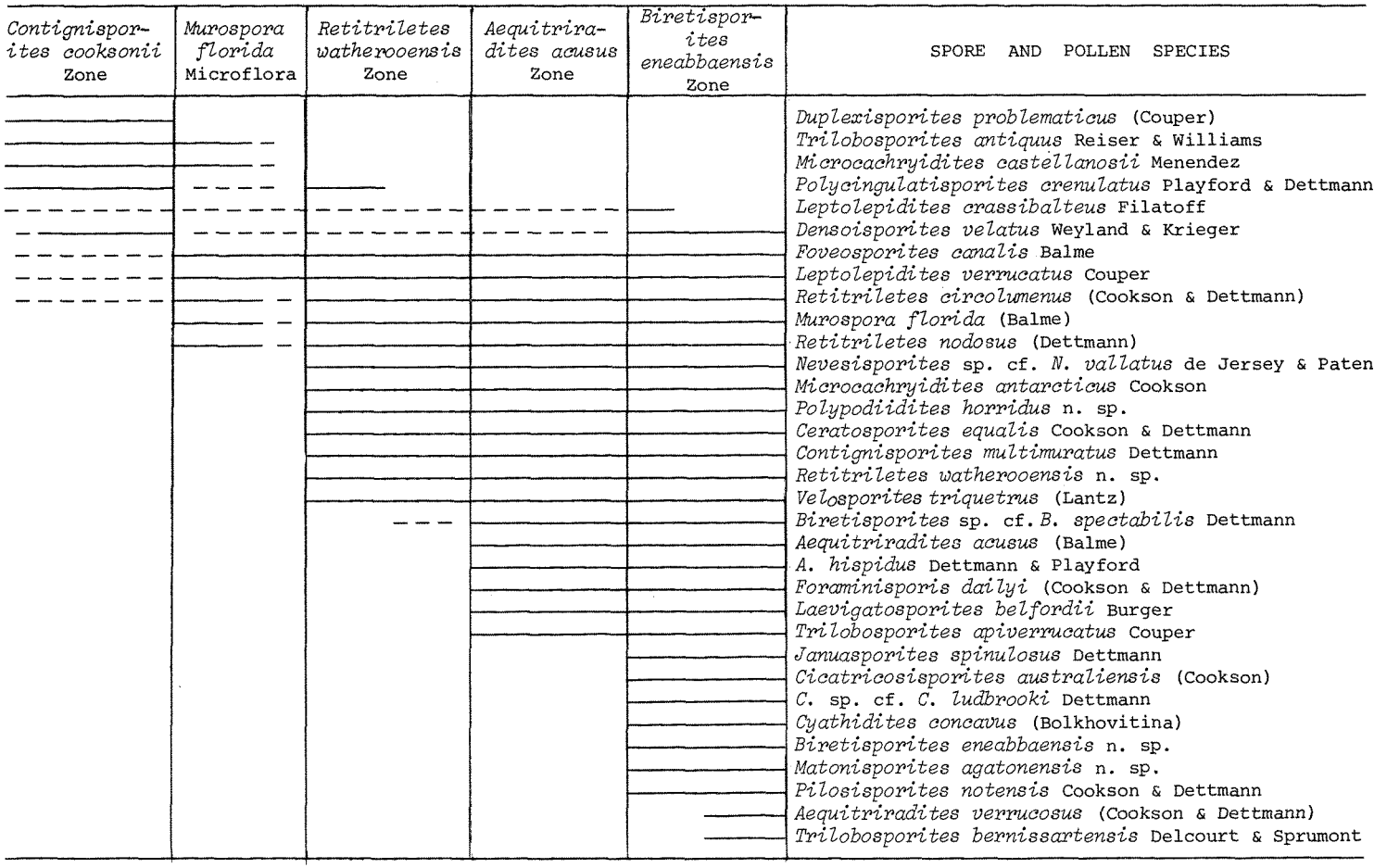

FIGURE 2. Distribution spore and pollen species

BIRETISPORITES ENEABBAENSIS ZONE

This zone was originally named the *Cicatricosisporites australiensis* Zone in Backhouse (1974, 1975), but this name has already been used by Burger (1973) for the *C. australiensis* Subzone in the Great Artesian Basin. Because Burger's sub-zone may not correspond exactly to the Perth Basin zone, this has been renamed the *Biretisporites eneabbaensis* Zone.

The base of the *Biretisporites eneabbaensis* Zone is present in Watheroo 5 and Eneabba 1 to 4. The top of this zone is not defined, for, in the sections examined, it is truncated by the unconformity at the base of the Warnbro Group. Assemblages in the Warnbro Group lack many of the species present in the *B. eneabbaensis* Zone. The section within the Yarragadee Formation, above the base of this zone in the Watheroo Line, is probably at least 900 m thick and considerably thicker (at least 1 300 m) in the offshore area near Perth.

The base of the *B. eneabbaensis* Zone is marked by the appearance of *Biretisporites eneabbaensis* n. sp., *Cictricosisporites australiensis* (Cookson), *Cicatricosisporites* cf. *C. ludbrooki* Dettmann, *Cyathidites concavus* (Bolkhovitina), *Pilosisporites notensis* Cookson and Dettmann, *Matonisporites agatonensis* n. sp. and *Januasporites spinulosus* Dettmann.

In every bore in which the bottom of the *B. eneabbaensis* Zone has been observed it coincides with the base of the lithological unit known as the Otorowiri Siltstone Member. The unusual palynology of this member was described by Ingram (1966b). It contains reworked palynomorphs of Devonian, Early and Late Permian, Early and Late Triassic and Early and Late Jurassic age; and appears to represent a restricted marine environment, with a very small number of dinoflagellate species present.

ZONATION IN INDIVIDUAL LINES OF BORES

The distribution of zones in the Gingin Brook, Watheroo and Eneabba Line bores is shown in Figure 3.

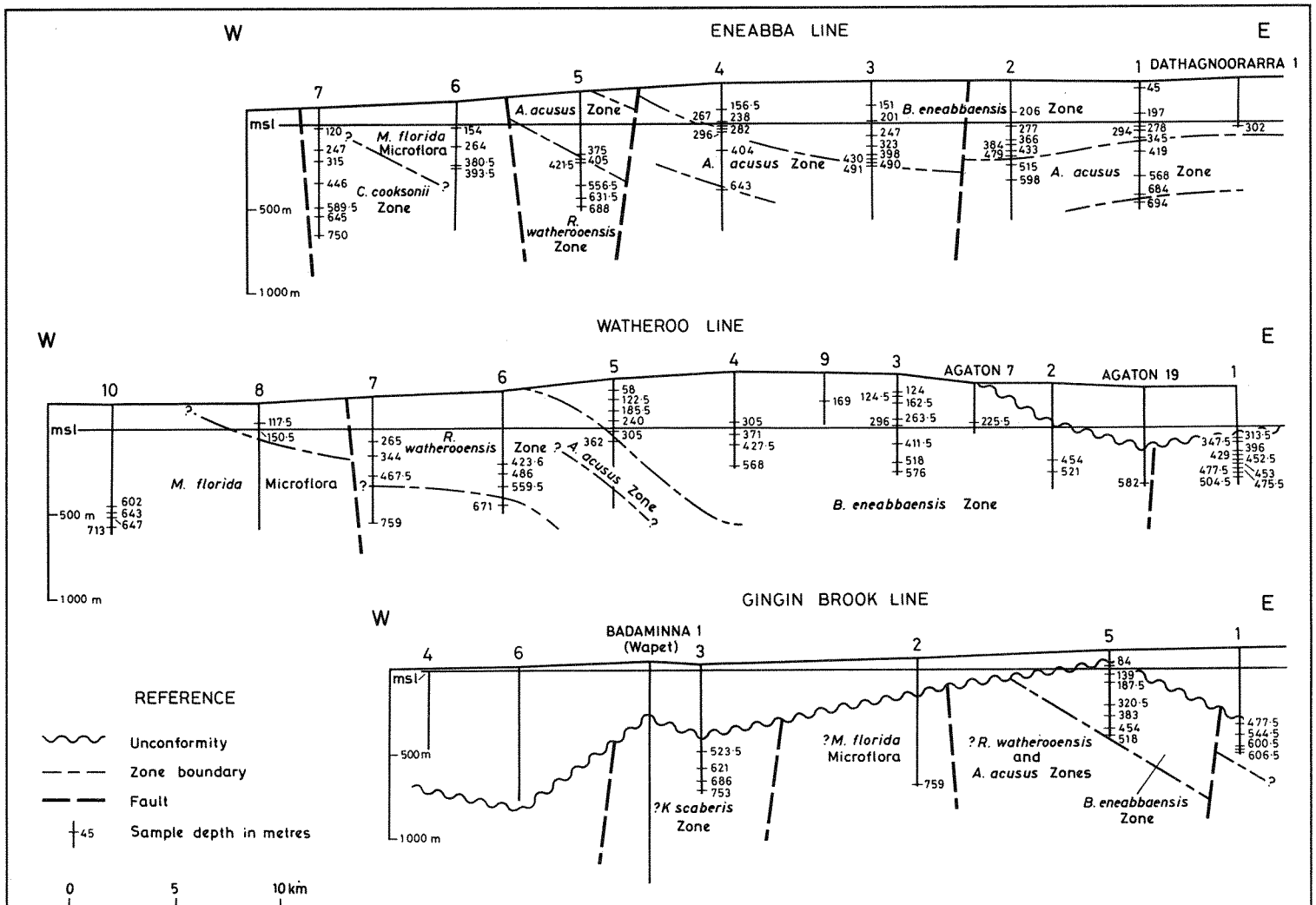

Figure 3. Palynological correlation of Eneabba, Watheroo and Gingin Brook Line boreholes

Gingin Brook Line modified from Lowry, Barragoon Subsidy Application 1974

GINGIN BROOK LINE

A preliminary zonation of the Gingin Brook Line was published by Ingram (1966a). The revised section shown in Figure 3, is based partly on a section by Lowry in an unpublished subsidy application report for West Australian Petroleum Pty Ltd. From east to west the Yarragadee Formation occurs in Gingin Brook 1 below the interval 430 to 447.5 m, in Gingin Brook 5 below 82 m, in Gingin Brook 2 below 173 m and in Gingin Brook 3 below 376.5 m.

The palynomorph assemblages from Gingin Brook 3 are sparse and largely devoid of diagnostic species. They are tentatively assigned to the *K. scaberis* Zone, but may belong to the *C. cooksonii* Zone. Assemblages in Gingin Brook 2 are also very sparse and again their assignment to a biostratigraphic unit, in this case the *M. florida* Microflora, is tentative. All assemblages from the Yarragadee Formation in Gingin Brook 1 and 5 are from the *B. eneabbaensis* Zone.

WATHEROO LINE

An earlier account of the palynology of the Watheroo Line is given by Backhouse (1974). The Yarragadee Formation is encountered in Watheroo 1 to 10 and also in Agaton 7 and 19, which form part of the line. According to Harley (1975), the Leederville Formation of the Warnbro Group unconformably overlies the Yarragadee Formation in Watheroo 1 and 2 and in Agaton 19.

The *B. eneabbaensis* Zone commences in the Otorowiri Siltstone in Watheroo 5. *Aequitriradites acusus* (Balme) and *A. hispidus* Dettmann are recorded at a slightly lower level, but there is no palynological information from the lower part of this borehole, and the *A. acusus* Zone in Watheroo 5 may be thicker than shown in Figure 3.

ENEABBA LINE

The Yarragadee Formation is intersected in Eneabba 1 to 7 and in Dathagnoorarra 1 which is east of Eneabba 1. The strata dip steadily east except at the western end of the line where a shallow syncline is present. All bores start and finish in the Yarragadee Formation. The zonation of the

Eneabba Line shown in Figure 3 is essentially the same as in Backhouse (1975), except that the *Baculatisporites* Zone is now represented by the zones of *R. watherooensis* and *A. acusus*, and the *C. australiensis* Zone is renamed the *B. eneabbaensis* Zone.

In Eneabba 7, the assemblages belong to the *C. cooksonii* Zone and in Eneabba 6 to the *M. florida* Microflora. The *R. watherooensis* Zone is present in the lower part of Eneabba 5 and in the lowest sampled sections in Eneabba 1 and 4. The *A. acusus* Zone is only recorded in Eneabba 1, 4 and 5, as samples are not available from the lower parts of bores 2 and 3. Species diagnostic of the *B. eneabbaensis* Zone appear in the Otorowiri Siltstone Member in Eneabba 1 to 4, and are present throughout the section in Dathagnoorarra 1.

COMPARISON WITH OTHER AUSTRALIAN ZONATIONS

Figure 4 is a comparison of the present zonation with other zonations in the Perth Basin and in eastern Australia. Filatoff's (1975) zonation is restricted to the Jurassic and does not extend beyond the first appearance of *Microcachryidites antarcticus* Cookson.

Evans (1966a,c) subdivided the Australian Mesozoic into a series of zones with J5-J6 as the youngest units in the Jurassic where *Murospora florida* (Balme), *Retitriletes circolumenus* (Cookson and Dettmann) and *Contignisporites* spp. first appear. He defined the basal Cretaceous unit, Kla, as where the ranges of *M. florida* and *Cictricosisporites australiensis* (Cookson) overlap, but expressed reservations about the base of the unit being actually at the base of the Cretaceous owing to reported occurrences of *Cicatricosisporites* in the Tithonian of the Canning Basin (Evans, 1966a, Balme, 1957, 1964).

Burger (1973) subdivided the Kla Zone (which he named the *Murospora florida* Zone) into three subzones with the lowest, the *Cicatricosisporites australiensis* Subzone, commencing with the appearance, among others of *C. australiensis*, *Cyathidites concavus* (Bolkhovitina) and *Velosporites triquetrus* (Lantz). Burger regards Dettmann and Playford's (1969) *Crybelosporites stylosus* Subzone as commencing slightly above the base of the *C. australiensis* Subzone.

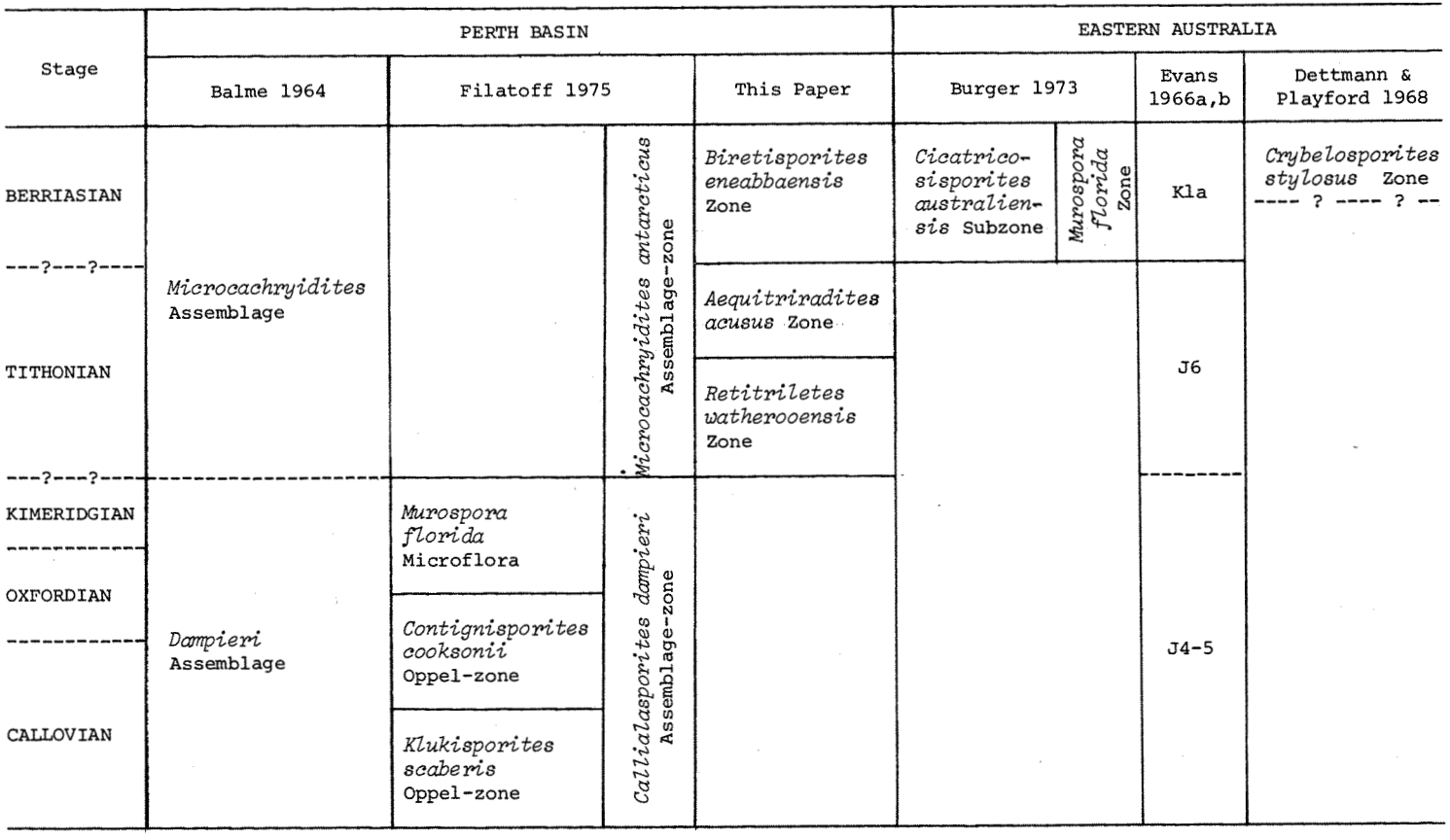

FIGURE 4. Comparison with other zonations in Australia

The base of Burger's *C. australiensis* Subzone and Evans' Kla Zone appear to correspond well with the base of the *B. eneabbaensis* Zone in the central Perth Basin.

There is considerable evidence that *C. australiensis* appears in the Late Jurassic in Britain and Canada (Norris 1969, and 1970; Williams 1975; Brideaux and Fisher, 1976). In Australia however, *C. australiensis* first appears at, or near the same level as a number of other species which are not known from the Late Jurassic. Consequently, the age of the base of the *B. eneabbaensis* Zone, where *C. australiensis* first appears, is problematical but the evidence suggests it is likely to be near the Jurassic-Cretaceous boundary.

If the top of the *M. florida* Microflora corresponds with the top of the Kimeridgian, as Filatoff (1975) suggests, then the *R. watherooensis* and *A. acusus* Zones both occur in the Tithonian.

STORAGE OF MATERIAL

Cores, sidewall cores and ditch cuttings samples are stored in the Geological Survey of Western Australia core store.

Slides and residues are numbered and stored in the palaeontological collection of the Geological Survey of Western Australia (prefix F). Holotypes and figured specimens are located by means of mechanical stage coordinates for the Leitz Orthoplan microscope, no.834965, in the Palaeontology Section of the Geological Survey of Western Australia.

ACKNOWLEDGEMENTS

The writer wishes to thank Dr. A.E. Cockbain of the Geological Survey of Western Australia and Dr. B.E. Balme of the University of Western Australia for reading and commenting on the manuscript.

SYSTEMATIC PALYNOLOGY

All the species treated in this section are of stratigraphic significance in the Late Jurassic and Early Cretaceous of the central Perth Basin. Species are described in full: (a) if they are new species, (b) if they occur in significant numbers and have not been described previously from the Perth Basin, or (c) if their descriptions have been expanded. Synonomies are not intended to be complete, but include all previous records from Western Australia where the species have been treated systematically.

The suprageneric classification is based on Dettmann (1963) and Potonié (1966, 1970).

Anteturma SPORITES Potonié 1893

Turma TRILETES Reinsch emend. Dettmann 1963

Subturma AZONOTRILETES Luber emend. Dettmann 1963

Infraturma LAEVIGATI Bennie and Kidston emend. Potonié 1956

Genus *CYATHIDITES* Couper 1953
Type species *Cyathidites australis* Couper 1953

CYATHIDITES CONCAVUS (Bolkhovitina) Dettmann 1963
Pl. 1, figs 1, 2

1953 *Stenozonotriletes concavus* Bolkhovitina, p.46, Pl.6, fig.7
1963 *Cyathidites concavus* (Bolkhovitina) Dettmann, p.24, Pl.1, figs, 17-19

REMARKS: *C. concavus* is an infrequently occurring species which first appears in the *B. eneabbaensis* Zone.

Genus *BIRETISPORITES* Delcourt and Sprumont, emend.
Delcourt, Dettmann and Hughes 1963
Type species *Biretisporites potoniaei* Delcourt and Sprumont

BIRETISPORITES ENEABBAENSIS n. sp.
Pl. 1, figs 3-6

HOLOTYPE: F8528/2, 38.8 x 103.8, Eneabba 3, 151 m, Plate 1, fig.3, Dimensions - Equatorial diameter 104 µm, exine 3 µm thick.

DESCRIPTION: Trilete spores, biconvex, amb subcircular to subtriangular, sides convex. Laesurae straight, half to full radius in length, variable. Lips high, narrow and membraneous, 8 to 15 µm high at the proximal pole, becoming lower towards the equator. Exine smooth, very faintly patterned, 2.5 to 3.5 µm thick, often bearing large folds.

DIMENSIONS: Overall equatorial diameter (35 specimens) 81 (94.5) 111.5 µm.

REMARKS: *B. eneabbaensis* is distinguished from *Biretisporites spectabilis* Dettmann by its thinner exine and more circular amb. The type species *Biretisporites potoniaei* Delcourt and Sprumont is smaller with a thinner exine and lower lips.

OCCURRENCE: *B. eneabbaensis* appears at the base of the *B. eneabbaensis* Zone in the Perth Basin but the upper limit of its range is not known. It is a frequently occurring form, sometimes present in large numbers.

BIRETISPORITES sp. cf. *B. SPECTABILIS* Dettmann 1963
Pl. 1, fig. 7

cf. 1963 *Biretisporites spectabilis* Dettmann, p.26, Pl.2, figs.3-8.

REMARKS AND OCCURRENCE: Insufficient specimens are available for a detailed examination of this species. It has been recorded from the top of the *R. watherooensis* Zone, the *A. acusus* Zone and the *B. eneabbaensis* Zone.

Infraturma APICULATI Bennie and Kidston emend. Potonié 1956

Subinfraturma VERRUCATI Dybová and Jachowicz 1957

Genus *LEPTOLEPIDITES* Couper 1953
Type species *Leptolepidites verrucatus* Couper 1953

LEPTOLEPIDITES CRASSIBALTEUS Filatoff 1975
Pl. 1, figs 8, 9

1975 *Leptolepidites crassibalteus* Filatoff, p.49, Pl.5, figs 4-6.

REMARKS: These specimens generally conform with the description by Filatoff. However, the opportunity to study the distal verrucae in side view is provided by four specimens occurring in a tetrad. The verrucae are seen to be smoothly rounded, sometimes asymmetric and occasionally truncate. They have a maximum height of 2 µm but are more usually 1 µm high.

It is doubtful if this is the correct generic assignment for this species which appears to possess a narrow cingulum, 2.5 to 4 µm wide, in the interradial areas, which Filatoff refers to as a thickening of the proximal exine.

OCCURRENCE: Filatoff (1975) records *L. crassibalteus* from the Callovian and Oxfordian of the Perth Basin. In this report it is encountered in only three samples from the *B. eneabbaensis* Zone.

LEPTOLEPIDITES VERRUCATUS Couper 1953
Pl. 1, fig. 10

1953 *Leptolepidites verrucatus* Couper p.28, Pl.2, figs 14, 15
1963 *Leptolepidites verrucatus* Couper: Dettmann, p.29, Pl.3, figs 6-9.

DESCRIPTION: Triletes spores, biconvex, amb subtriangular. Laesurae straight extending to, or almost to, the equator. Exine including sculpture 2 to 3.5 µm thick sometimes, but not always, slightly thicker (up to 5 µm) in

the interradial areas. Distal sculpture of closely spaced dome-shaped verrucae with polygonal bases 3 to 6.5 µm in diameter. The verrucae often coalesce but the individual verrucae can still be distinguished. When the verrucae coalesce extensively the sculpture becomes similar to that of *Camarozonosporites ramosus* (de Jersey) McKellar 1974. Proximal sculpture consists of low, slightly elongated and radially oriented verrucae extending a variable distance from the equator. Occasionally low elongated verrucae, or rugulae, cover the entire proximal face.

DIMENSIONS: Overall equatorial diameter (20 specimens) 27 (34) 40 µm.

OCCURRENCE: *L. verrucatus* appears in the *C. cooksonii* Zone, becomes a frequently occurring species in the *R. watherooensis* Zone and continues through the *B. eneabbaensis* Zone.

Subinfraturma BACULATI Dybova and Jachowicz 1957

Genus *PILOSISPORITES* Delcourt and Sprumont 1955
Type species *Pilosisporites trichopapillosus* Delcourt and Sprumont 1955

PILOSISPORITES NOTENSIS Cookson and Dettmann 1958
Pl. 2, fig. 1

1958 *Pilosisporites notensis* Cookson and Dettmann (in part), p.102, Pl.15, figs 1, 3

1963 *Pilosisporites notensis* Cookson and Dettmann: Dettmann, p.37, Pl.4, figs 1-5.

DESCRIPTION: Trilete spores, amb triangular with concave sides and broadly rounded angles. Laesurae straight with membraneous lips. Exine 2.5 to 5 µm thick bearingstraight or curved spines distally and proximally. Spines concentrated in the radial areas, where the spines tend to be longest, maximum length 6 to 8.5 µm.

DIMENSIONS: Equatorial diameter excluding sculpture (10 specimens) 72.5 (86) 99 µm.

OCCURRENCE: *P. notensis* was recorded by Ingram (1967b) from the Otorowiri Siltstone at Arrowsmith River, at the same stratigraphic level as it is first recorded in this work. These occurrences in the Perth Basin extend the stratigraphic range of *P. notensis* to at least the base of the Cretaceous, whereas in eastern Australia it is not recorded earlier than the Late Neocomian (Burger 1973).

In this work *P. notensis* appears at the base of the *B. eneabbaensis* Zone and occurs rarely higher in the zone.

Genus *CERATOSPORITES* Cookson and Dettmann 1958
Type species *Ceratosporites equalis* Cookson and Dettmann 1958

CERATOSPORITES EQUALIS Cookson and Dettmann 1958
Pl. 1, fig. 5

1958 *Ceratosporites equalis* Cookson and Dettmann, p.101, Pl.14, figs 17-20

1963 *Ceratosporites equalis* Cookson and Dettmann: Dettmann p.36, Pl.5, figs 6-8.

REMARKS: The specimens of *Ceratosporites equalis* Cookson and Dettmann closely conform with the description by Dettmann (1963).

OCCURRENCE: Burger (1973) records *C. equalis* as extending below his *Cicatricosisporites australiensis* subzone in the Great Artesian Basin and therefore presumably into the Tithonian. This range agrees with the record from the Perth Basin where it appears at the base of the *R. watherooensis* Zone and continues through the rest of the section.

Infraturma MURORNATI Potonié and Kremp 1954

Genus *FOVEOSPORITES* Balme 1957
Type species *Foveosporites canalis* Balme 1957

FOVEOSPORITES CANALIS Balme 1957
Pl. 2, fig. 6

1957 *Foveosporites canalis* Balme, p.17, Pl.1, figs 15-17
1963 *Foveosporites canalis* Balme: Dettmann, p.43, Pl.6, figs 14-17.

DESCRIPTION: Trilete spores, amb subtriangular with convex sides and an invaginated equatorialoutline. Laesurae distinct, length 3/4 radius, with low (2 µm) lips. Exine thickness 1.5 to 2 µm, sometimes slightly thicker (2 to 3.5 µm) in the interradial areas. Proximal and distal foveolae 0.5 µm in diameter (more in corroded specimens), 1 to 2.5 µm apart and with short canals developed between some foveolae. The canals usually taper out between foveolae which are, therefore, seldom fully connected.

DIMENSIONS: Equatorial diameter (16 specimens) 35 (41.5) 47.5 µm.

OCCURRENCE: *F. canalis* is recorded in this report from the *C. cooksonii* Zone and all higher zones, but it is very rare below the *R. watherooensis* Zone. Balme (1957) recorded it from the Jarlemai Siltstone (Oxfordian to Tithonian) of the Carnarvon Basin and from Cretaceous sediments in the Perth Basin.

Genus *CICATRICOSISPORITES* Potonié and Gelletich 1933
Type species *Cicatricosisporites dorogensis* Potonié and Gelletich 1933

CICATRICOSISPORITES AUSTRALIENSIS (Cookson) Potonié 1956
Pl. 2, fig. 3

1953 *Mohrioisporites australiensis* Cookson p.470, Pl.2, figs 31-34
1956 *Cicatricosisporites australiensis* (Cookson) Potonié, p.48
1957 *Cicatricosisporites australiensis* (Cookson) Balme, p.20, Pl.2, figs 27-29

1963 *Cicatricosisporites australiensis* (Cookson) Potonié, Dettmann, p.53, Pl.9, figs 10-16.

REMARKS: The specimens encountered here conform with the description by Dettmann (1963, p.53).

DIMENSIONS: Equatorial diameter (22 specimens) 43 (56.5) 70 µm.

OCCURRENCE: In the central Perth Basin *C. australiensis* appears at the base of the *B. eneabbaensis* Zone. It is a rare species at the start of its range, becoming more common higher in the *B. eneabbaensis* Zone. *C. australiensis* has been recorded by Norris (1969, 1970) from the Kimeridgian of southern England, and by Williams (1975) and Brideaux and Fisher (1976) from the Kimeridgian in Canada, but in Australia it seems to occur first near the base of the Cretaceous (Burger, 1973, this paper).

CICATRICOSISPORITES sp. cf. *C. LUDBROOKI* Dettmann 1963
Pl. 2, fig. 2

cf. 1963 *Cicatricosisporites ludbrooki* Dettmann, p.54, Pl.9, figs 17-22.

REMARKS: The muri of this form resemble those of *Cicatricosisporites ludbrooki* Dettmann in shape and size but are more closely spaced.

OCCURRENCE: *Cicatricosisporites* sp. cf. *C. ludbrooki* is a very rare form present only in the *B. eneabbaensis* Zone.

Genus *JANUASPORITES* Pocock 1962
Type species *Januasporites reticularis* Pocock 1962

JANUASPORITES SPINULOSUS Dettmann 1963
Pl. 2, fig. 4

1963 *Januasporites spinulosus* Dettmann, p.50, Pl.10, figs 17-20.

REMARKS: Insufficient specimens are available from this material to provide an adequate description.

OCCURRENCE: In eastern Australia *Januasporites spinulosus* Dettmann is not known below the *Foraminisporis wonthaggiensis* Subzone of Burger (1973). In the Perth Basin it occurs at the base of the *B. eneabbaensis* Zone in samples from the Otorowiri Siltstone (this paper), but has not been recorded at higher levels.

Genus *RETITRILETES* van der Hammen ex Pierce emend. Döring, Krutzsch, Mai and Schulz 1963

Type species *Retitriletes globosus* Pierce 1961

REMARKS: The validity of *Lycopodiumsporites* Thiergart ex Delcourt and Sprumont 1955 and its merits relative to *Retitriletes* are discussed by Döring, Krutzsch, Mai and Schulz in Krutzsch (1963), Srivastava (1972) and McKellar (1974). Döring and others (1963) consider the genus *Lycopodiumsporites* to be invalid but Srivastava and McKellar consider it to be a valid genus and restrict it to forms with foveo-reticulate sculpture. Foveo-reticulate sculpture is formed by pits closely spaced to form a reticulum, rather than a positive reticulate sculpture formed by raised muri (Harris, 1955, Couper, 1959). The following species have a reticulate sculpture formed by raised muri, and are therefore assigned to *Retitriletes*.

RETITRILETES CIRCOLUMENUS (Cookson and Dettmann 1958) n. comb.

Pl. 2, figs 7, 8

1958 *Lycopodiumsporites circolumenus* Cookson and Dettmann, p.105, Pl.15, figs 10, 11

1975 *Lycopodiumsporites circolumenus* Cookson and Dettmann: Filatoff, p.54, Pl.8, fig.4

DESCRIPTION: Triletes spores, amb subcircular. Laesurae straight, reaching equator, with low lips. Exine 2 to 3 µm thick. Distal and equatorial sculpture reticulate with concave sided flat topped muri 1 to 2.5 µm wide at the top and 2.5 µm high. Lumina circular, oval or

rounded polygonal in plan view, maximum diameter 3.5 to 7.5 µm but normally 5 to 6 µm. Each contact face bears a low sculpture which varies from two to four separate or interconnected grana. Where the grana are connected by substantial ridges the sculpture becomes rugulate. In rare instances the proximal grana or rugulae are connected by low ridges to form a slightly thickened equatorial zone.

DIMENSIONS: Overall equatorial diameter (21 specimens) 36.5 (45.5) 55 µm.

OCCURRENCE: Filatoff (1975) recorded *R. circolumenus* as appearing in the *K. scaberis* Zone. Here it is recorded throughout the sequence but it is only common in the *A. acusus* and *B. eneabbaensis* Zones.

RETITRILETES CLAVATOIDES (Couper) Döring, Krutzsch, Mai and Schulz 1963
Pl. 2, figs 9, 10

1958 *Lycopodiumsporites clavatoides* Couper (in part), p.132, p.15, figs 10, 11

1963 *Retitriletes clavatoides* (Couper) Döring, Krutzsch, Mai and Schulz, in Krutzsch, p.16

1967 *Retitriletes clavatoides* (Couper) Döring, Krutzsch, Mai and Schulz: Schulz, p.575, Pl.8, figs 7-9, Pl.5, fig. 3

1974 *Retitriletes austroclavatidites* (Cookson) Döring, Krutzsch, Mai and Schulz: McKellar, p.13, Pl.5, figs 1-3.

DESCRIPTION: Trilete spores, amb subtriangular to subcircular. Laesurae straight, 2/3 to full radius in length, with low narrow lips. Exine 1 to 2.5 µm thick. Distally the equatorially a complete reticulum is formed by concave-sided flat-topped muri 3 to 5 µm high and 1 to 1.5 µm wide at the top. Lumina rounded polygonal in plan view, 5 to 15 µm in maximum diameter. Contact faces bear a low sculpture of individual grana, or a series of connected grana or rugulae.

DIMENSIONS: Overall equatorial diameter (20 specimens) 32.5 (37) 41.5 µm.

REMARKS: The forms referred to *Lycopodiumsporites clavatoides* Couper by Tralau (1968) and Kemp (1970) appear to lack proximal sculpture and do not have a very high reticulum, but are otherwise very similar to the forms assigned here to *Retitriletes clavatoides*.

The proximal sculpture is visible on the holotype (Couper 1958, Pl.15, figs 10,11), which also shows muri about 3 µm high.

OCCURRENCE: *R. clavatoides* occurs in the Early Jurassic of Britain (Couper, 1958), Early and Middle Jurassic of Germany (Schulz, 1967) and Queensland (McKellar, 1974), and the Late Jurassic and early Neocomian of the Perth Basin, Western Australia (this paper) where it is recorded from the *C. cooksonii* to the *B. eneabbaensis* Zone.

RETITRILETES NODOSUS (Dettmann) Srivastava 1977
Pl. 2, fig. 11

1963 *Lycopodiumsporites nodosus* Dettmann, p.46, Pl.7, figs 13-16.
1977 *Retitriletes nodosus* (Dettmann) Srivastava p.58

REMARKS: The specimens assigned here to *Retitriletes nodosus* (Dettmann) broadly conform with the description by Dettmann (1963, p.46). In a few specimens the proximal sculpture of muri and grana is better developed than indicated by Dettmann.

DIMENSIONS: Overall equatorial diameter (22 specimens) 46 (52) 63 µm.

OCCURRENCE: In the Perth Basin *R. nodosus* appears in the *M. florida* Microflora and extends into the *B. eneabbaensis* Zone.

RETITRILETES WATHEROOENSIS n. sp.
Pl. 3, figs 1-3

HOLOTYPE: F6595/3, 43.7 x 94.1; Watheroo 2, 521 m; Plate 3, fig.1. Dimensions - Equatorial diameter 37.5 m, exine 1.5 µm thick, distal reticulum 1.2 µm high, lumina 1 to 2.5 µm in max. diameter.

DESCRIPTION: Trilete spores, amb subcircular, distal face convex, proximal face pyramidal. Laesurae straight, 1/2 to 3/4 radius in length and typically gaping, with lips up to 3.5 µm high. Exine, excluding sculpture 1 to 2 µm thick. Distal and equatorial sculpture a perfect reticulum with concave-sided, flat topped muri 0.5 to 1.5 µm wide at the top and 1 to 2 µm high. Lumina circular to oval, 1 to 3.5 µm maximum

diameter. Contact faces with a sculpture of low lobate rugulae, connected to a slightly thickened equatorial zone and directed towards the proximal pole.

DIMENSIONS: Overall equatorial diameter (24 specimens) 32.5 (37) 41 µm.

REMARKS: In the general form of its distal and proximal sculpture, *R. watherooensis* is similar to *R. circolumenus*. However, the most common proximal sculpture for *R. circolumenus* is two or three connected verrucae, a form of sculpture which has not been observed in *R. watherooensis*. *R. watherooensis* also has a finer reticulum, a thinner exine and is smaller than *R. circolumenus*. No morphologically intermediate forms have been observed.

OCCURRENCE: *R. watherooensis* ranges from the base of the *R. watherooensis* Zone (Tithonian) through to the *B. eneabbaensis* Zone and has also been recorded in some samples from the Warnbro Group of late Neocomian to Aptian age.

Subturma AURITOTRILETES Potonié and Kremp 1954

Infraturma AURICULATI Schopf emend. Dettmann 1963

Genus *MATONISPORITES* Couper emend. Dettmann 1963
Type species *Matonisporites phlebopteroides* Couper 1958

MATONISPORITES AGATONENSIS n. sp.
Pl. 3, figs 4, 5

1967 *Matonisporites* sp. Ingram, Pl.37, fig.1
1974 *Matonisporites* sp. Backhouse, fig.65c.

HOLOTYPE: F6669/1, 45.9 x 97.1; Watheroo 1, 477.5 m; Plate 3, fig.4. Dimensions - Equatorial diameter 103 µm.

DESCRIPTION: Trilete spores, amb triangular with straight or slightly concave or convex sides, angles broadly rounded. Exine unsculptured, 5 to 7.5 µm thick, thicker (6 to 12 µm) in the equatorial radial areas. Laesurae straight, extending to the inner margin of the thickened exine. Lips narrow, 6 to 10 µm high becoming lower away from the proximal pole.

DIMENSIONS: Overall equatorial diameter (26 specimens) 87 (101.5) 127 µm.

REMARKS: *M. agatonensis* differs from *Biretisporites spectabilis* Dettmann in possessing a thicker exine which is also differentially thickened in the radial areas (valvate). *Matonisporites praeclarus* (Sukh Dev) is slightly smaller, has more pronounced valvae and seems to develop a strongly punctate exine in corroded specimens, a feature not observed so far in *M. agatonensis*.

OCCURRENCE: *M. agatonensis* is a rare species which appears at the base of the *B. eneabbaensis* Zone but is only rarely observed higher in the zone.

Genus *TRILOBOSPORITES* Pant ex Potonié 1956
Type species *Trilobosporites hannonicus* (Delcourt and Sprumont)

TRILOBOSPORITES ANTIQUUS Reiser and Williams 1969
Pl. 3, fig. 6

1969 *Trilosporites antiquus* Reiser and Williams, p.8, Pl.3, fig.15, Pl.4, fig.1

1975 *Trilobosporites antiquus* Reiser and Williams: Filatoff, p.66, Pl.13, figs 9-11

OCCURRENCE: Filatoff (1975) records *T. antiquus* from all his Jurassic zones up to the *M. florida* Microflora. In this report it is also recorded up to the *M. florida* Microflora but does not occur above this level.

TRILOBOSPORITES APIVERRUCATUS Couper 1958

Pl. 3, fig. 7

1958 *Trilobosporites apiverrucatus* Couper, p.142, Pl.21, figs 11-13

1974 *Trilobosporites perverulentus* (Verbitskaya): Backhouse, fig. 65 n-o.

OCCURRENCE: *T. apiverrucatus* is a frequently occurring species which first appears at about the base of the *A. acusus* Zone and is present through the rest of the section.

TRILOBOSPORITES BERNISSARTENSIS (Delcourt and Sprumont) Potonié 1956

Pl. 3, fig. 8

1955 *Lygodioisporites bernissartensis* Delcourt and Sprumont, p.34, text fig. 5.

OCCURRENCE: *T. bernissartensis* is a rare species which appears near the base of the *B. eneabbaensis* Zone and is a rare form throughout the zone.

Subturma ZONOTRILETES Waltz 1935

Infraturma CINGULATI Potonié and Klaus emend. Dettmann 1963

Genus *CONTIGNISPORITES* Dettmann 1963

Type species *Contignisporites glebulentus* Dettmann 1963

CONTIGNISPORITES MULTIMURATUS Dettmann 1963

Pl. 4, fig. 1

1963 *Contignisporites multimuratus* Dettmann, p.76, Pl.16, figs 6-13.

OCCURRENCE: *C. multimuratus* is first recorded at about the base of the *R. watherooensis* Zone. It is a rare species in the *R. watherooensis* and *A. acusus* Zones, becoming more common in the *B. eneabbaensis* Zone.

Genus *DUPLEXISPORITES* Deak emend. Playford and Dettmann 1965
Type species *Duplexisporites generalis* Deak 1962

DUPLEXISPORITES PROBLEMATICUS (Couper) Playford and Dettmann 1965
Pl. 4, fig. 7

1958 *Cingulatisporites problematicus* Couper, p146, Pl.24, figs 11-13

1965 *Duplexisporites problematicus* (Couper) Playford and Dettmann, p.140

1975 *Duplexisporites problematicus* (Couper) Playford and Dettmann; Filatoff, p.64, Pl.13, figs 1-8.

OCCURRENCE: Filatoff (1975) lists the known occurrences of *D. problematicus*, which range in age from Middle Triassic to Early Cretaceous. In this work it has not been observed above the *C. cooksonii* Zone.

Genus *FORAMINISPORITES* Krutzsch 1959
Type species *Foraminisporis foraminis* Krutzsch 1959

FORAMINISPORIS DAILYI (Cookson and Dettmann) Dettmann 1963
Pl. 4, fig. 2

1958 *Granulatisporites dailyi* Cookson and Dettmann, p.99, Pl.14, figs 2-4

1963 *Foraminisporites dailyi* (Cookson and Dettmann) Dettmann, p.72, Pl.14, figs 15-18

DESCRIPTION: Trilete spores, amb subtriangular to subquadrangular. Laesurae straight, reaching equator and bordered by low lips. Distal surface

finely granulate or almost smooth, proximal face with low grana about the centre of each contact face. Cingulum with a ragged outer margin, 2 to 6 µm wide, but normally 3 µm wide.

DIMENSIONS: Overall equatorial diameter (22 specimens) 36.5 (46) 55.5 µm.

OCCURRENCE: *F. dailyi* appears in the *A. acusus* Zone and continues through the *B. eneabbaensis* Zone.

Genus *MUROSPORA* Somers 1952
Type species *Murospora kosankei* Somers 1952

MUROSPORA FLORIDA (Balme) Pocock 1961
Pl. 4, fig. 6

1957 *Cingulatisporites floridus* Balme, p.26, Pl.5, figs 60, 61
1961 *Murospora florida* (Balme) Pocock, p.1233, text fig.1, figs 6, 7
1975 *Murospora florida* (Balme) Pocock: Filatoff, p.73, Pl.18, fig. 7.

OCCURRENCE: According to Filatoff (1975) the first appearance of *M. florida* marks the base of the *M. florida* Microflora. *M. florida* is rare in the lower part of its range but becomes a more frequently occurring species in the *B. eneabbaensis* Zone.

Genus *NEVESISPORITES* de Jersey and Paten 1964
Type species *Nevesisporites vallatus* de Jersey and Paten 1964

NEVESISPORITES sp. cf. *N. VALLATUS* de Jersey and Paten 1964
Pl. 4, fig. 3

cf.1964 *Nevesisporites vallatus* de Jersey and Paten, p.8, Pl.5, figs 11-15, Pl.6, figs 1, 2

1974 *Nevesisporites vallatus* de Jersey and Paten: Backhouse, fig. 65i

cf.1975 *Nevesisporites vallatus* de Jersey and Paten: Filatoff, p.72, Pl.18, figs 3, 4.

REMARKS: The present specimens differ from *Nevesisporites vallatus* de Jersey and Paten (1964) in having a slightly greater overall diameter and slightly wider cingulum (average maximum width 3.7 µm). The proximal sculpture of grana and rugulae is always arranged in a radial pattern or along the laesurae as in *N. vallatus*. Bifurcations of the laesurae occur in some specimens but are not so frequent as indicated in the type description of *N. vallatus*.

DIMENSIONS: Overall equatorial diameter (17 specimens) 42.5 (48) 54 µm.

OCCURRENCE: In the Perth Basin *N.* sp. cf. *N. vallatus* appears in the *R. watherooensis* Zone and is present through the rest of the section.

N. vallatus has been recorded from the Australian Early Jurassic by de Jersey and Paten (1964), Reiser and Williams (1969), de Jersey (1971), McKellar (1974) and Filatoff (1975). The only record of *N. vallatus* from younger strata is by Burger (1973) who recorded it from the basal Cretaceous and uppermost Jurassic in the Great Artesian Basin, Queensland.

Genus *POLYCINGULATISPORITES* Simoncsics and Kedves emend. Playford and Dettmann 1965

Type species *Polycingulatisporites crenulatus* Simoncsics and Kedves 1961

POLYCINGULATISPORITES CRENULATUS Playford and Dettmann 1965

Pl. 4, fig. 5

1965 *Polycingulatisporites crenulatus* Playford and Dettmann, p.145, Pl.14, figs 30-32

1975 *Polycingulatisporites crenulatus* Playford and Dettmann; Filatoff, p.40, Pl.1, figs 11-13

OCCURRENCE: Filatoff (1975) recorded *P. crenulatus* from the *Dictyophyllidites harrisii* Assemblage subzone to the lower part of the *M. florida* Microflora in the Perth Basin. In this work, it is recorded as an extremely rare form up to the *R. watherooensis* Zone.

Suprasubturma PERINOTRILETES Erdtman emend. Dettmann 1963

Genus *VELOSPORITES* Hughes and Playford 1961
Type species *Velosporites echinatus* Hughes and Playford 1961

VELOSPORITES TRIQUETRUS (Lantz) Dettmann 1963
Pl. 4, fig. 4

1958 *Laricoidites triquetrus* Lantz, p.926, Pl.5, figs 51-54
1963 *Velosporites triquetrus* (Lantz) Dettmann, p.82, Pl.19, figs 1-3

DESCRIPTION: Triletes spores, amb circular to subtriangular, Exine two-layered, exoexine thin (less than 1 µm) and finely punctate, intexine 1 µm thick and smooth. Laesurae are present as slightly raised ridges which extend to the equator.

DIMENSIONS: Overall equatorial diameter (14 specimens) 40.5 (49) 57 µm, intexine diameter 29 (35) 42.5 µm.

OCCURRENCES: *V. triquetrus* is one of the species appearing at the base of the *R. watherooensis* Zone in the central Perth Basin. It is also present in the *A. acusus* and *B. eneabbaensis* Zones.

Turma MONOLETES Ibrahim 1933

Subturma AZONOMONOLETES Luber 1935

Intraturma LAEVIGATOMONOLETI Dybova and Jachowicz 1957

Genus *LAEVIGATOSPORITES* Ibrahim 1933
Type species *Laevigatosporites vulgaris* (Ibrahim) Ibrahim 1933

LAEVIGATOSPORITES BELFORDII Burger 1976

Pl. 5, fig. 4

1967 *Laevigatosporites* sp., Ingram, Pl.37, fig.7

1974 *Laevigatosporites* sp., Backhouse, fig. 64o

1976 *Laevigatosporites belfordii* Burger, p.13, Pl.9, figs 3, 4, Pl.10, fig.1

DESCRIPTION: Monolete spores, bean-shaped in side view, oval in polar view. Laesurae straight, length about 3/4 total length, bounded by high, transparent, membraneous lips 6 to 15 µm high. Exine smooth, 1.5 to 3.5 µm thick.

DIMENSIONS: Overall length (10 specimens) 61.5 (89) 115 µm.

OCCURRENCE: Burger (1976) recorded *L. belfordii* from his *M. florida* Zone in the Eromanga and Surat Basins and also reports it from Dettmann and Playford's *Crybelosporites stylosus* and lower *Dictyotosporites speciosus* Zones in southeastern Australia.

In the Perth Basin *L. belfordii* appears in the *A. acusus* Zone and extends through the *R. eneabbaensis* Zone. It is also known from the Warnbro Group of late Neocomian and Aptian age, in the Perth Basin.

Intraturma SCULPTATOMONOLETI Dybova and Jachowicz 1957

Genus *POLYPODIIDITES* Ross emend. Potonié 1966

Type species *Polypodiidites senonicus* Ross 1949

POLYPODIIDITES HORRIDUS N. SP.

Pl. 5, figs 1-3

1974 *Reticuloidosporites* sp., Backhouse, fig.65 l, m

HOLOTYPE: F8606/2, 33.9 x 110.4; Eneabba 1, 197 m; Plate 5, fig.1. Dimensions - Overall length 37 µm, overall polar diameter 24 µm.

DESCRIPTION: Monolete spores, bean-shaped in side view and oval in polar view. Laesura straight, length 2/3 total length of amb. Exine 1 to 2 µm thick sculptured distally and proximally with spines, coni, rugulae and verrucae 0.5 to 3.5 µm high, up to 4 µm maximum basal diameter and spaced 0.5 to 4 µm apart. Sculptural elements often asymmetric. Sculpture reduced about the laesura.

DIMENSIONS: Overall equatorial length (20 specimens) 27 (35.5) 45 µm, polar diameter (10 specimens) 21 (22.5) 24 µm.

REMARKS: *P. horridus* is similar to the type species *Polypodiidites senonicus* Ross from the Senonian of Sweden. However, the sculpture of *P. horridus* always includes some spines or coni which are not present on *P. senonicus*.

Polypodiidites spinulosus Chlonova bears a more spinose sculpture than *P. horridus* and *Polypodiisporites flexus* Chlonova is slightly larger with a more consistently verrucate sculpture.

OCCURRENCE: *P. horridus* appears at the base of the *R. watherooensis* Zone and continues through the *A. acusus* and *B. eneabbaensis* Zones.

Turma HILATES Dettmann 1963

Genus *AEQUITRIRADITES* Delcourt and Sprumont emend. Cookson and Dettmann 1961

Type species *Aequitriradites dubius* Delcourt and Sprumont emend. Delcourt, Dettmann and Hughes 1963

AEQUITRIRADITES ACUSUS (Balme) Dettmann 1963

Pl. 4, figs 8, 9

1957 *Zonalasporites acusus* Balme, p.27, Pl.5, figs 64,65, Pl.6, fig.66

1963 *Aequitriradites acusus* (Balme) Dettmann, p.91

DESCRIPTION: Spores hilate, amb subtriangular or rarely subcircular. The trilete mark consists of radial granular ridges on the zona and outer part of the proximal spore body. Where a hilum has not opened, the distal pole is covered by closely spaced verrucae 1 to 2.5 µm in basal diameter bearing spines of indeterminate length. The remainder of the distal spore body is sparsely or densely covered with spines of variable shape and size, 1.5 to 3.5-µm long and 0.5 to 2.5 µm in basal diameter. The proximal face bears narrow spines 1 to 3.5 µm long and 1 to 3 µm apart. The zona is membraneous, 6 to 12 µm in maximum width and thickened near the inner margin. The outer margin is irregular, and small spines sometimes present on the zona may protrude. Rarely, thickened ridges may be present in the zona, other than the radial ridges of the trilete mark.

DIMENSIONS: Overall equatorial diameter (21 specimens) 44 (57) 75 µm. Spore cavity (22 specimens) 32.5 (37.5) 44 µm.

REMARKS: *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann 1961 is probably a junior synonym of *A. acusus*. The overall diameter range for *A. spinulosus* given by Cookson and Dettmann (1958, p.113) and Dettmann (1963; p.94) is greater than that given here for *A. acusus*. However, some large heavily spinose specimens which occur in the present material have not been included in *A. acusus* because they differ significantly from the holotype in the size and density of sculpture. If these specimens are included in *A. acusus*, the maximum size of the overall diameter would extend to over 80 µm.

OCCURRENCE: In this work *A. acusus* is recorded from the *A. acusus* and *B. eneabbaensis* Zones.

AEQUITRIRADITES VERRUCOSUS (Cookson and Dettmann) Cookson and Dettmann 1961
Pl. 5, figs 9, 10

1958 *Cirratriradites verrucosus* Cookson and Dettmann, p.112, Pl.18, figs 2-6

1961 *Aequitriradites verrucosus* (Cookson and Dettmann), Cookson and Dettmann 1961, p.427, Pl.52, figs 1-6

DESCRIPTION: Spores hilate and zonate, amb subtriangular to subcircular. Zona 10 to 17 µm in maximum width, granulate or scabrate and thickest at the

inner margin. The hilum is developed at the distal pole where the exine is composed of closely spaced, polygonal plates, each bearing a rounded verruca. The remainder of the distal face has a sculpture of verrucae or grana. The proximal face has a rough surface bearing irregular low rugulae and grana and a trilete mark of raised ridges often sinuous near the pole. The trilete ridges usually extend from the proximal pole to the equator but are sometimes absent from the polar area. Several additional, radially oriented, ridges are usually present on the zona in the interradial areas.

DIMENSIONS: Overall equatorial diameter (22 specimens) 62 (79.5) 93 µm. Spore cavity (21 specimens) 38.5 (49.5) 55.5 µm.

OCCURRENCE: *A. verrucosus* appears near the base of the *B. eneabbaensis* Zone and ranges through the zone.

AEQUITRIRADITES HISPIDUS Dettmann and Playford 1968
Pl. 5, fig. 8

1968 *Aequitriradites hispidus* Dettmann and Playford, p.82, Pl.7, fig.13

REMARKS: These specimens are smaller than those described by Dettmann and Playford (1968) but they correspond with the type description in every other respect.

DIMENSIONS: Overall equatorial diameter (20 specimens) 45 (58.5) 71.5 µm.

OCCURRENCE: *A. hispidus* appears at about the same level as *A. acusus* and extends through the *A. acusus* and *B. eneabbaensis* Zones.

Anteturma POLLENITES Potonié 1931

Turma SACCITES Erdtman 1947

Subturma POLYSACCITES Cookson 1947

Genus *MICROCACHRYIDITES* Cookson ex Couper 1953
Type species *Microcachryidites antarcticus* Cookson 1947

MICROCACHRYIDITES ANTARCTICUS Cookson 1947

1947 *Polysaccites (Microcachryidites) antarcticus* Cookson p.132, Pl.13, figs 12-15, Pl.14, figs 16-19

1957 *Microcachryidites antarcticus* Cookson: Balme, p.34, Pl.9, figs 95-100

OCCURRENCE: *M. antarcticus* appears at about the base of the *R. watherooensis* Zone. As *Calliasporites dampieri* (Balme) is no longer abundant above this level this is also taken as the junction of the *M. dampieri* and *M. antarcticus* Microfloral Assemblage Zones. *M. antarcticus* becomes common in the *A. acusus* and *B. eneabbaensis* Zones.

MICROCACHRYIDITES CASTELLANOSII Menendez 1968
Pl. 5, figs 5, 6

1968 *Microcachryidites castellanosii* Menendez, p.393, Pl.4, figs A-F

1975 *Podosporites castellanosii* (Menendez) Filatoff, p.79, Pl.23, figs 5-9

REMARKS: *M. castellanosii* is a fairly frequently occurring species in the *C. cooksonii* Zone and the *M. florida* Microflora. Above this level, only one or two specimens of trisaccate pollen have been observed which could not easily be accommodated in *Microcachryidites antarcticus* (Cookson).

APPENDIX

DETAILS OF SAMPLES

G.S.W.A. F NO.	BOREHOLE	DEPTH IN METRES	SAMPLE TYPE	PALYNOLOGICAL ZONE
F 6417	Gingin Brook No.1	477.5	C	*B. eneabbaensis*
F 6418	"	544.5	C	"
F 9456	"	600.5	DC	"
F 9457	"	606.5	DC	"
F 6086	Gingin Brook No.5	84	C	*B. eneabbaensis*
F 6087	"	139	C	"
F 6088	"	187.5	C	"
F 6089	"	320.5	C	"
F 6090	"	383	C	"
F 6091	"	454	C	"
F 6092	"	518	C	"
F 5982	Gingin Brook No.2	759	C	?*M. florida* Microflora
F 9176	Gingin Brook No.3	523.5	C	?*K. scaberis*
F 9177	"	621	C	"
F 9178	"	686	C	"
F 9179	"	753	C	"
F 6662	Watheroo Line No.1	313.5	C	*B. eneabbaensis*
F 6663	"	347.5	C	"
F 6664	"	396	C	"
F 6665	"	429	C	"
F 6666	"	452.5	C	"
F 6667	"	453	C	"
F 6668	"	475.5	C	"
F 6669	"	477.5	C	"
F 6670	"	504.5	C	"
F 7930	Agaton No.19	582	C	*B. eneabbaensis*
F 6594	Watheroo Line No.2	454	C	*B. eneabbaensis*
F 6595	"	521	C	"
F 78171	Agaton No.7	225.2	DC	*B. eneabbaensis*

c = core DC = ditch cuttings SWC = sidewall core

F 6684	Watheroo Line No.3	124	C	*B. eneabbaensis*
F 6685	"	124.5	C	"
F 6686	"	162.5	C	"
F 6687	"	263.5	C	"
F 6688	"	296	C	"
F 6690	"	411.5	C	"
F 6691	"	518	C	"
F 6692	"	576	C	"
F 8191	Watheroo Line No.9	169	C	*B. eneabbaensis*
F 7856	Watheroo Line No.4	305	C	*B. eneabbaensis*
F 7857	"	371	C	"
F 7858	"	427.5	C	"
F 7860	"	568	C	"
F 8186	Watheroo Line No.5	58	C	*B. eneabbaensis*
F 8187	"	122.5	C	"
F 8188	"	185.5	C	"
F 8189	"	240	C	"
F 8190	"	305	C	"
F 8195	"	362	C	*A. acusus*
F 8224	Watheroo Line No.6	423.6	C	*R. watherooensis*
-	"	486	C	"
F 8225	"	559.5	C	"
-	"	671	C	*M. florida* Microflora
F 8230	Watheroo Line No.7	265	SWC	*R. watherooensis*
F 8231	"	344	SWC	"
F 8232	"	467.5	SWC	"
F 8233	"	759	DC	?*M. florida* Microflora
F 8234	Watheroo Line No.8	117.5	SWC	*R. watherooensis*
F 8235	"	150.5	SWC	"
F 8246	Watheroo Line No.10	602	SWC	*M. florida* Microflora
F 8247	"	643	SWC	"
F 8248	"	647	SWC	"
F 8249	"	713	SWC	"
F 8653	Dathagnoorarra No.1	302	DC	*B. eneabbaensis*

F 8605	Eneabba Line No.1	45	DC	*B. eneabbaensis*
F 8606	"	197	SWC	"
F 8607	"	278	SWC	"
F 8608	"	294	SWC	"
F 8609	"	345	SWC	"
F 8610	"	419	DC	*A. acusus*
F 8612	"	568	SWC	"
F 8613	"	684	SWC	"
F 8614	"	694	SWC	*R. watherooensis*
F 8578	Eneabba Line No.2	206	SWC	*B. eneabbaensis*
F 8579	"	277	SWC	"
F 8580	"	366	SWC	"
F 8581	"	384	SWC	"
F 8582	"	433	SWC	"
F 8583	"	479	SWC	"
F 8584	"	515	SWC	*A. Acusus*
F 8585	"	598	SWC	"
F 8528	Eneabba Line No.3	151	SWC	*B. eneabbaensis*
F 8529	"	201	SWC	"
F 8530	"	247	SWC	"
F 8531	"	323	SWC	"
F 8532	"	398	SWC	"
F 8533	"	450	SWC	"
F 8534	"	490	C	"
F 8535	"	491	C	"
F 8460	Eneabba Line No.4	156,5	SWC	*B. eneabbaensis*
F 8461	"	238	SWC	"
F 8463	"	267	SWC	"
F 8465	"	282	SWC	"
F 8466	"	296	SWC	"
F 8467	"	404	SWC	*A. acusus*
F 8468	"	643	SWC	*R. watherooensis*
F 8433	Eneabba Line No.5	375	SWC	*A. acusus*
F 8434	"	405	DC	*R. watherooensis*
F 8435	"	421.5	SWC	"
F 8437	"	556.5	SWC	"
F 8438	"	631.5	SWC	"
F 8439	"	688	SWC	"

F 8335	Eneabba Line No.6	154	SWC	*M. florida* Microflora
F 8336	"	264	SWC	"
F 8337	"	380.5	SWC	"
F 8338	"	393.5	SWC	"
F 8311	Eneabba Line No.7	120	SWC	*C. cooksonii*
F 8312	"	247	SWC	"
F 8313	"	315	SWC	"
F 8314	"	446	SWC	"
F 8317	"	589.5	C	"
F 8315	"	645	DC	"
F 8316	"	750	DC	"

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PLATE 1

All figures x 500 unless otherwise indicated.

figs 1,2 *Cyathidites concavus* (Bolkhovitina), p.15.

1. Median focus; F6595/3, 47.2 x 112.7.
2. Median focus; F8606/1, 30.4 x 112.0.

figs 3-6 *Biretisporites eneabbaensis* n. sp., p.16.

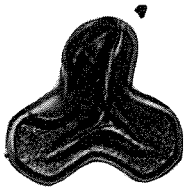
3. Holotype, proximal focus; F8528, 38.8 x 103.8.
4. Proximal focus; F8528/2, 54.4 x 96.0.
5. Median focus; F8528/2, 52.7 x 108.5.
6. Side view; F8528/2, 38.2 x 96.3.

fig. 7 *Biretisporites* sp. cf. *B. spectabilis* Dettmann, p.16.
Proximal focus; F8187/3, 43.2 x 99.7.

figs 8,9 *Leptolepidites crassibalteus* Filatoff, p.17.

8. (X1000) Proximal focus (a), distal focus (b), F8528/3, 34.1 x 95.5.
9. (X1000) Spore tetrad; F8528/3, 48.0 x 94.6.

fig.10 *Leptolepidites verrucatus* Couper, p.17.
Distal focus; F6595/3, 42.9 x 97.4.



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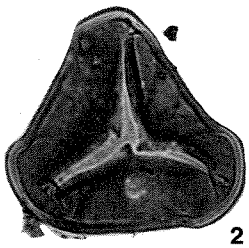

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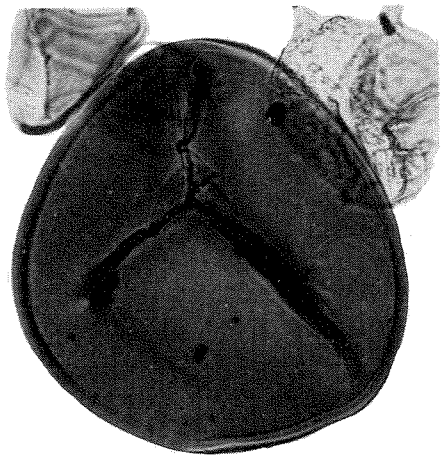

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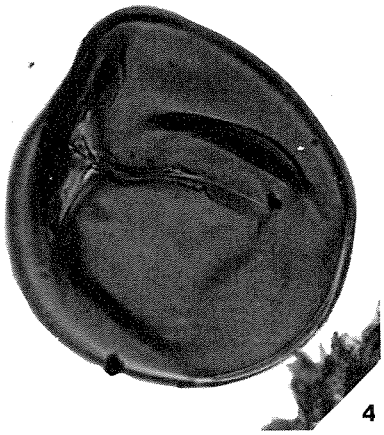
8a



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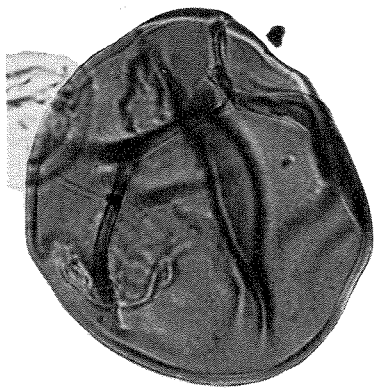

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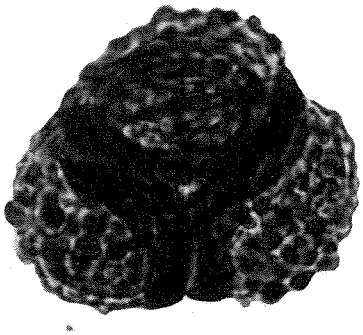
8b



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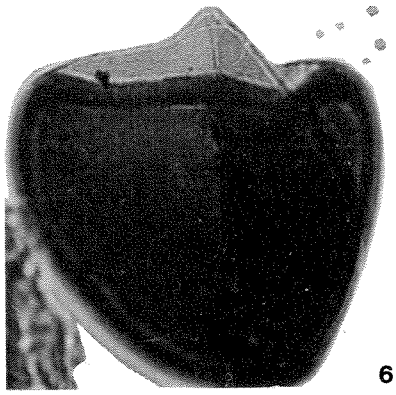

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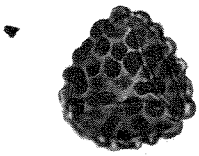


10

PLATE 2

All figures X 500

fig. 1 *Pilosisporites notensis* Cookson and Dettmann, p.18.
Median focus; F6686/1, 31.2 x 105.9.

fig. 2 *Cicatricosisporites* sp. cf. *C. ludbrooki* Dettmann, p.21.
Proximal focus (a), distal focus (b); F6688/3, 49.7 x 106.0.

fig. 3 *Cicatricosisporites australiensis* (Cookson), p.20.
Proximal focus; F6685/4, 59.6 x 103.9.

fig. 4 *Januasporites spinulosus* Dettmann, p.21.
Proximal focus (a), distal focus (b); F8608/1, 59.2 x 101.9.

fig. 5 *Ceratosporites equalis* Cookson and Dettmann, p.19.
Distal focus; F6595/8, 45.1 x 106.5.

fig. 6 *Foveosporites canalis* Balme, p.20.
Distal focus; F6087/3, 32.7 x 113.0.

fig. 7,8 *Retitriletes circolumenus* (Cookson and Dettmann), p.22.
7. Proximal focus; F6595/3, 36.1 x 102.2.
8. Proximal focus (a), distal focus (b); F6595/3, 31.7 x 97.7.

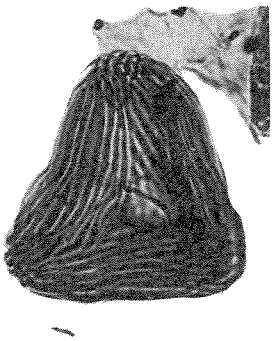
figs 9,10 *Retitriletes clavatoides* (Couper), p.23.
9. Proximal focus (a), distal focus (b); F6595/8, 40.7 x 102.7.
10. Median focus; F8607/2, 50.0 x 111.9.

fig. 11 *Retitriletes nodosus* (Dettmann), p.24.
Proximal focus (a), distal focus (b); F6087/5, 45.2 x 95.0.

1

2a

2b



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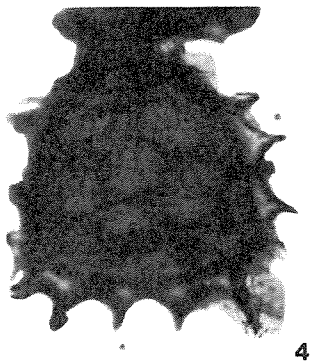
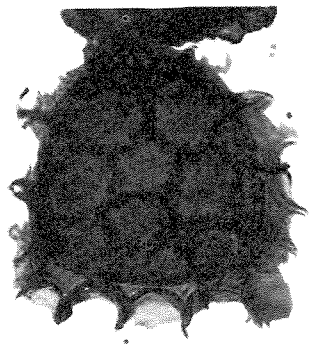
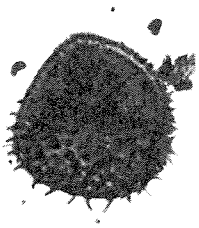


4a



4b



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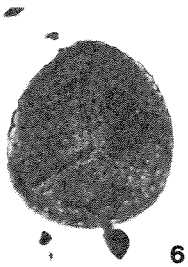

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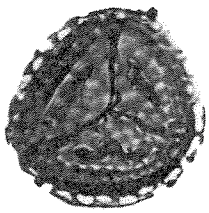

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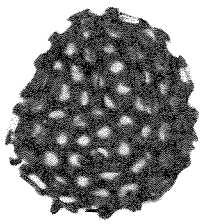

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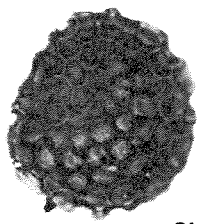

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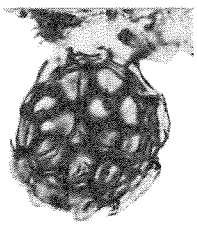

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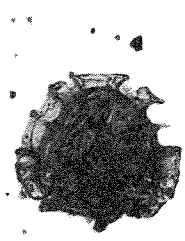

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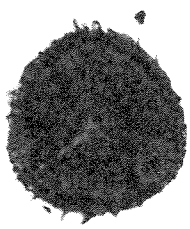

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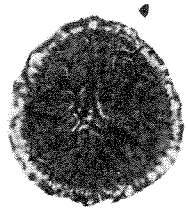


11b

PLATE 3

All figures X 500 unless otherwise indicated.

figs 1-3 *Retriletes watherooensis* n. sp., p.25.

1. (X1000) Holotype, proximal focus (a), median focus (b), distal focus (c); F6595/3, 43.7 x 94.1.
2. Median focus; F8528/3, 31.3 x 104.0.
3. Lateral view; F8523/3, 34.2 x 97.9.

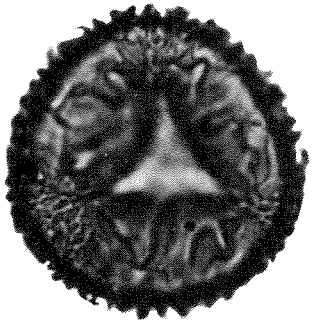
figs 4,5 *Matonisporites agatonensis* n. sp., p.25.

4. Holotype, proximal focus (a), distal focus (b); F6669/1, 45.9 x 97.1
5. Median focus; F6666/2, 33.7 x 104.9.

fig. 6 *Trilobosporites antiquus* Reiser and Williams, p.26.
Median focus; F8311/4, 24.3 x 108.2.

fig. 7 *Trilobosporites apiverrucatus* Couper, p.27.
Median focus; F6684/5, 33.2 x 104.6.

fig. 8 *Trilobosporites bernissartensis* Delcourt and Sprumont, p.27.
Median focus; F6669/1, 40.9 x 93.5.



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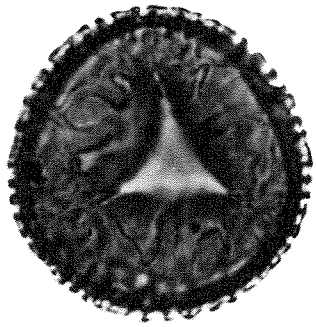

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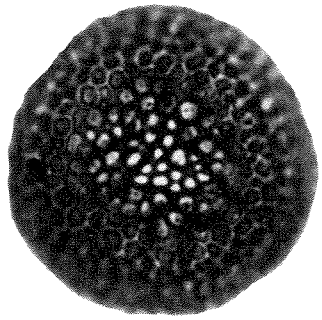

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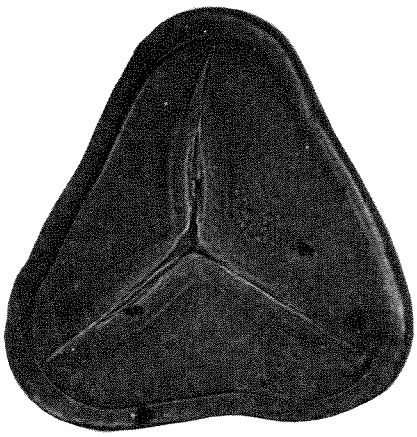

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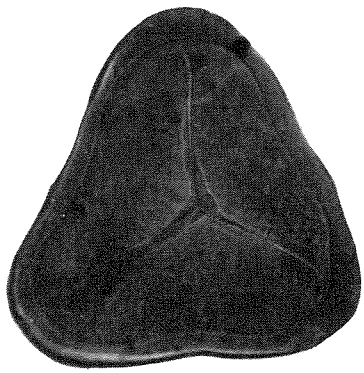

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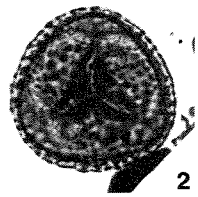

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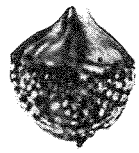

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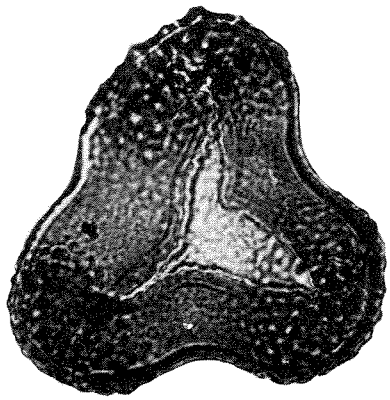

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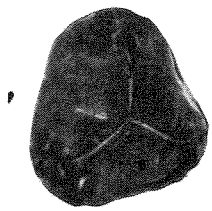

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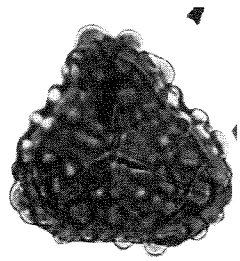


8

PLATE 4

All figures X 500

fig. 1 *Contignisporites multimuratus* Dettmann, p.27.
Distal focus; F6669/1, 36.1 x 112.0.

fig. 2 *Foraminisporis dailyi* (Cookson and Dettmann), p.28.
Proximal focus, F6595/41, 42.4 X 103.2.

fig. 3 *Nevesisporites* sp. cf. *N. vallatus* de Jersey and Paten, p.29.
Proximal focus; F6668/2, 40.0 x 112.3.

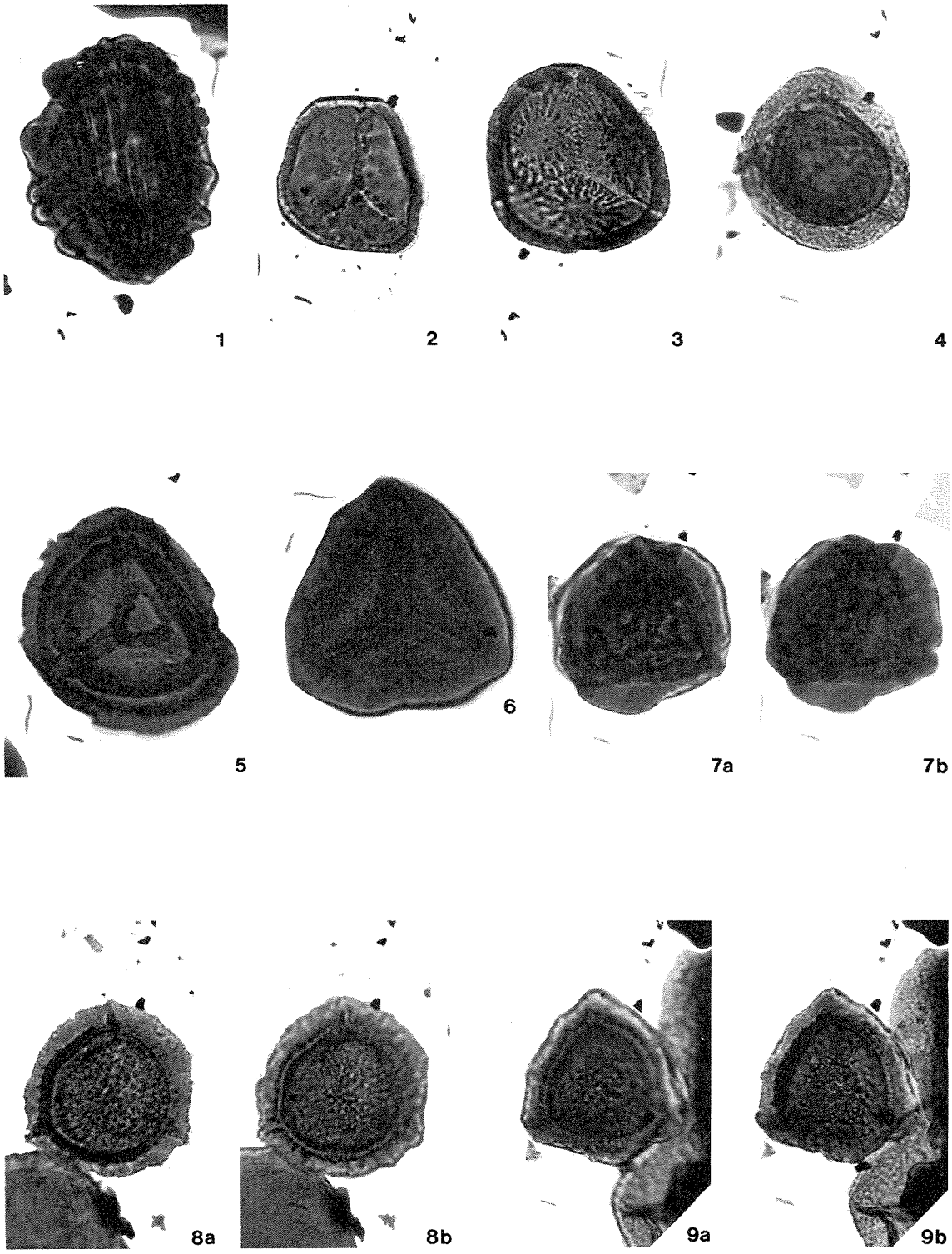
fig. 4 *Velosporites triquetrus* (Lantz), p.31.
Median focus; F8187/3, 45.2 x 96.2.

fig. 5 *Polycingulatisporites crenulatus* Playford and Dettmann, p.30.
Median focus; F8314/2, 39.3 x 101.4.

fig. 6 *Murospora florida* (Balme), p.29.
Proximal focus; F6669/1, 34.7 x 105.8.

fig. 7 *Duplexisporites problematicus* (Couper), p.28.
Proximal focus (a), distal focus (b); F8315/1,
40.3 x 105.4.

figs 8,9 *Aequitriradites acusus* (Balme), p.33.
8. Proximal focus (a), distal focus (b);
F8606/1, 37.4 x 109.8.
9. Proximal focus (a), distal focus (b);
F8606/1, 48.2 x 98.5.


1
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7a
7b
8a
8b
9a
9b

PLATE 5

All figures X 500 unless otherwise indicated

figs 1-3 *Polypodiidites horridus* n. sp, p.32.

1. (X1000) Holotype, lateral view, high focus (a), median focus (b), low focus (c); F8606/2, 33.9 x 110.4.
2. Oblique lateral view, median focus; F6665/1, 40.5 x 106.5.
3. Lateral view, top focus (a), median focus (b); F8187/2, 43.0 x 101.6.

fig. 4 *Laevigatosporites belfordii* Burger, p.32.
Lateral view; F6595/37, 36.0 x 104.2.

figs 5,6 *Microcachryidites castellanosii* Menendez, p.36.

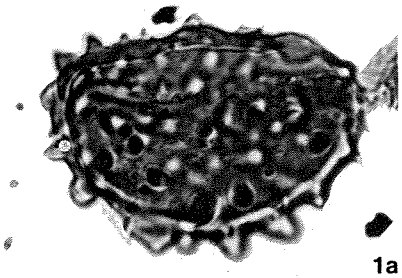
5. Oblique lateral view; F8315/1, 40.0 x 111.9.
6. Oblique lateral view; F8314/1, 39.9 x 111.0.

fig 7 *Microcachryidites antarcticus* Cookson, p.36.
Distal view; F8581/1, 40.9 x 97.4.

fig. 8 *Aequitriradites hispidus* Dettmann and Playford, p.35.
Median focus; F8606/2, 49.6 x 94.2.

figs 9,10 *Aequitriradites verrucosus* (Cookson and Dettmann), p.34.

9. Proximal focus (a), distal focus (b); F8528/1, 41.9 x 101.5.
10. Distal focus; F8528/1, 41.3 x 100.5.



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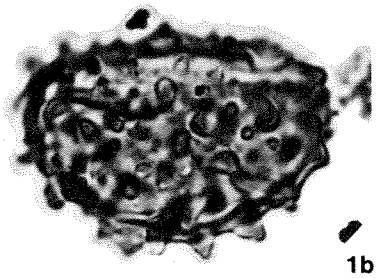

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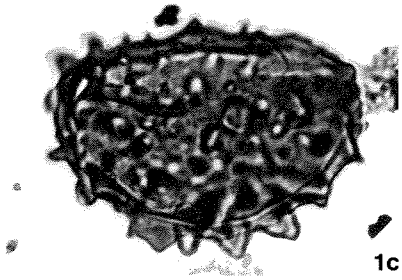

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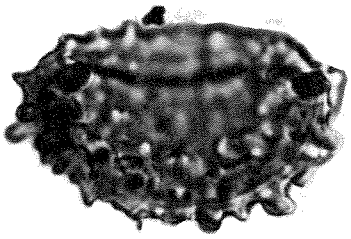

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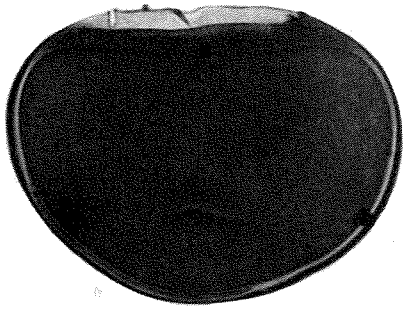

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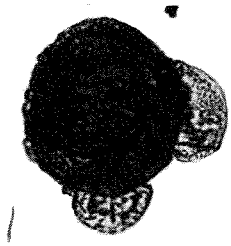

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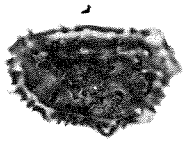

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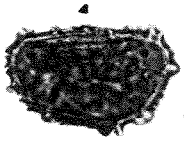

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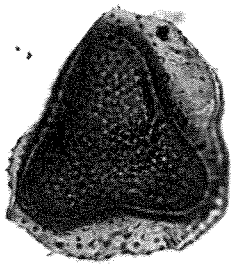

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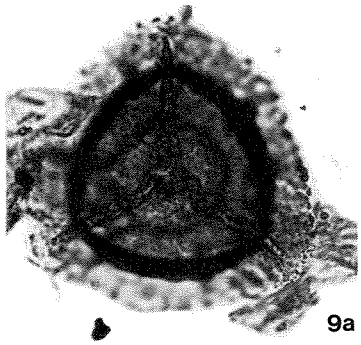

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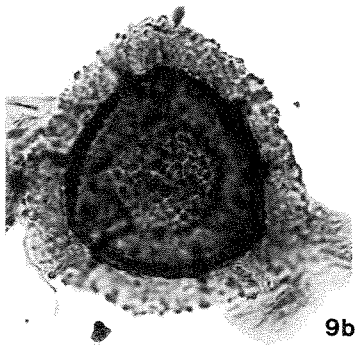

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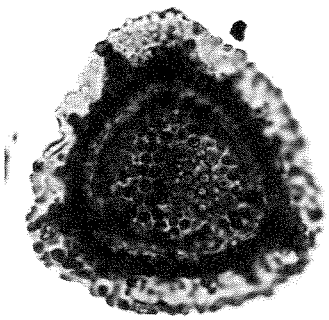

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