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SOME EARLY CRETACEOUS PLANT MICROFOSSILS FROM QUEENSLAND

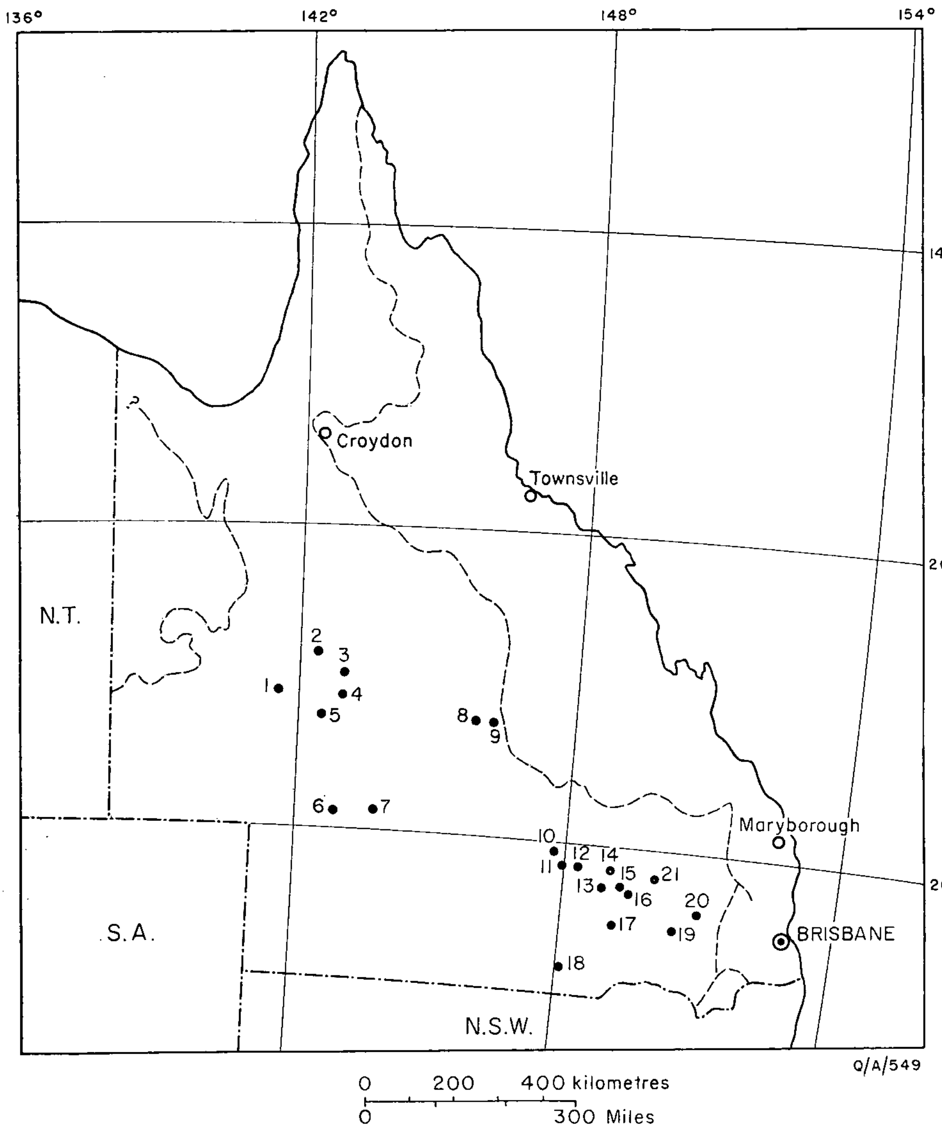
by

D. Burger

SUMMARY

Ten trilete species, three monolete species, and one ?monosulcate species of dispersed miospores and pollen grains are described from Lower Cretaceous (Neocomian to basal Aptian) sediments of the Great Artesian Basin in Queensland. Of these, two new trilete species, *Endoculeospora delicata, Crybelosporites berberioides,* and one monolete species, *Laevigatosporites belfordii,* are proposed.

The problematic organism 'Gen. et sp. indet. Form A' Eisenack & Cookson, 1960, is described and discussed; its origin and affects are unknown, but it may represent detached parts of a larger filiform organism.



1. Conorada Ooroonoo 1
2. Hematite Lovelle Downs 1
3. Hematite Clyde 1
4. AAO Penrith 1
5. Amerada Newlands 1
6. Alliance Chandos 1
7. Ph.-S. Cothalow 1
8. F.D. Alice River 1
9. BMR Jericho 1
10. BMR Mitchell 7
11. BMR Mitchell 1
12. BMR Mitchell 11
13. GSQ DRD 27
14. BMR Roma 1
15. AAO 1 (Roma)
16. AAO Pickanjinnie 1
17. GSQ Surat 1
18. NAI Whyenbirra 1
19. UKA Cabawin 1
20. BMR Dalby 3
21. GSQ Roma 3; BMR Roma 8

Fig. 1. Locations of petroleum exploration wells and shallow stratigraphic boreholes.

INTRODUCTION

Early Cretaceous spore-pollen assemblages from the Great Artesian Basin in Queensland contain several new species, and other types which have presented systematic and taxonomic difficulties. Many of them are considered to be stratigraphically significant, as they have short time ranges. Initially, these species were assigned identification numbers only, pending further examination (Burger, 1973, 1975). They are here described and illustrated, previous misidentifications are corrected, and the vertical and geographical distribution of each species is given. Vertical ranges of species are also shown in Table 1.

The fossils were extracted from rock samples collected during exploration drilling by companies in the search for petroleum, and shallow stratigraphic drilling by the Geological Survey of Queensland and the Bureau of Mineral Resources. Locations of wells and stratigraphic bores mentioned below are shown in Figure 1.

The preparations containing the illustrated specimens are deposited in the Commonwealth Palaeontological Collection of the Bureau of Mineral Resources in Canberra, under CPC numbers 12188 and 13880 to 13936. The identification numbers of the preparations (see the Plate legends) carry the affix MFP. The locations of the specimens in the slides are expressed in mechanical stage co-ordinates of Leitz Ortholux binocular microscope no. 741826, of the Palynological Laboratory.

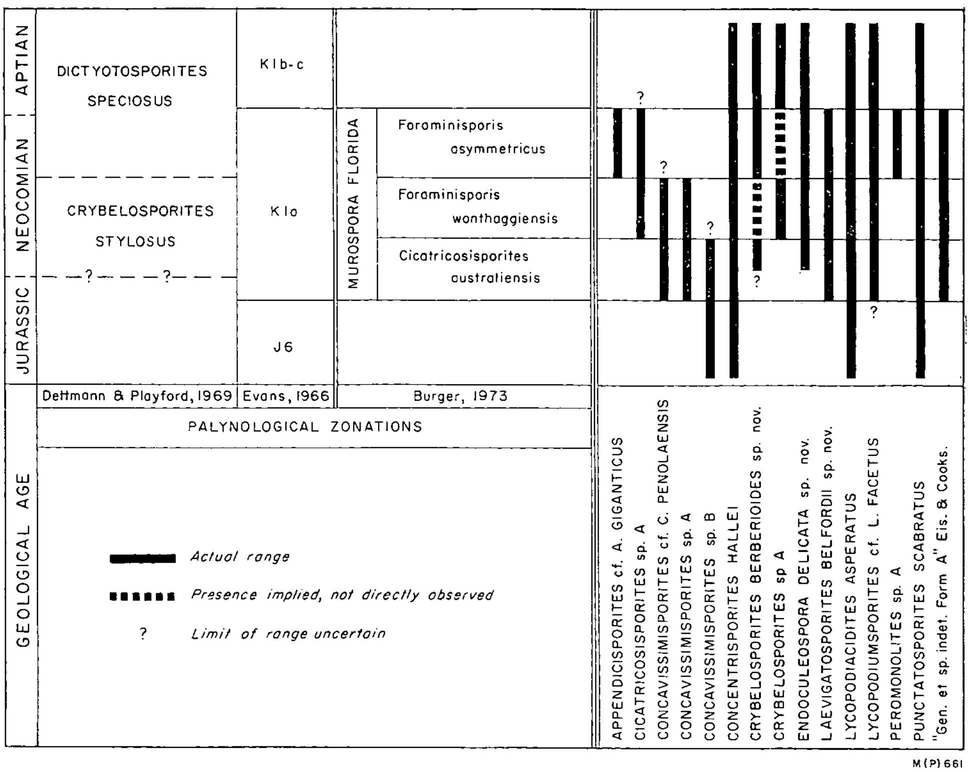


Table 1. Geological distribution of species in the Great Artesian Basin, Queensland.

SYSTEMATIC PALYNOLOGY

DIVISION SPORES AND POLLEN GRAINS

Anteturma SPORITES H. Potonié
Turma TRILETES Reinsch emend. Dettmann
Suprasubturma ACAVATITRILETES Dettmann
Subturma AZONATI Luber emend. Dettmann

Genus LYCOPODIACIDITES Couper, 1953, emend. Potonié, 1956

Type species (by original designation): *Lycopodiacidites bullerensis* Couper, 1953, from the Jurassic of New Zealand.

LYCOPODIACIDITES ASPERATUS Dettmann, 1963
(Pl. 1, figs 1-5)

1963 *Lycopodiacidites asperatus* Dettmann, p. 40, pl. 6, figs 1, 2.

BMR Species Catalogue number 813

Description: Trilete, azonate miospores, spherical or proximo-distally flattened; many are torn along the laesurate commissures; amb circular to oval. Trilete mark weakly visible, laesurae simple, straight, and reaching to amb. Exine not visibly lamellated, 4-6 μm thick inclusive of sculpture, densely covered with coarse bacula or rugulae about 1.5-3 μm high, with characteristically flattened and sometimes slightly expanded tops. Outline of sculptural elements variable, irregular, basal diameter of single elements 2-6 μm. Elements may be merged into large, smooth exine areas interrupted by isolated sinuous grooves and irregular pits.

Dimensions: Equatorial (16 specimens) 40-64 μm.

Occurrence: Dettmann (1963) recovered the species from Lower Cretaceous strata of southeastern Australia. Burger (1973, 1975) reported it as *L. ambifoveolatus* Brenner, 1963, from Jurassic and Lower Cretaceous strata of Queensland.

Comments: The illustrated specimens show the different types of sculptural elements found in the species. Specimens can be baculate (Pl. 1, fig. 3), i.e. the elements are approximately equidimensional; they can be rugulate (Pl. 1, figs 1, 5), with the individual elements forming short, broad, sinuous, and sometimes forked ledges; they can also be more heavily sculptured with the ledges expanded into large thickened exine areas separated by increasingly narrower slits or grooves (Pl. 1, figs 2, 4). The specimens from Queensland are similar to *L. asperatus* except that the sculptural elements have smooth instead of granulate crests. *L. ambifoveolatus* Brenner, 1963, has a thinner exine and strongly reduced proximal sculpture.

Genus CONCAVISSIMISPORITES Delcourt & Sprumont, 1955, emend. Delcourt, Dettmann, & Hughes, 1963.

Type species (by original designation): *Concavissimisporites verrucosus* Delcourt & Sprumont, 1955, from the Early Cretaceous of Belgium.

Comments: Spores assignable to the genus, with weakly to strongly verrucate ornament, have been found sporadically in Late Jurassic and Early Cretaceous microfloras from the Great Artesian Basin and earliest Cretaceous microfloras from the

Otway Basin (Dettmann, pers. comm.). Not enough specimens were available for a detailed comparative examination; so no attempt was made to specifically assign every specimen. Instead, three broad groups are separated on the basis of the sculpture, and representative specimens are illustrated in Plate 2.

CONCAVISSIMISPORITES cf. C. PENOLAENSIS Dettmann, 1963
(Pl. 2, fig. 3)

1963 *Concavissimisporites penolaensis* Dettmann, p. 31, pl. 3, figs 13, 14, 15.

BMR Species Catalogue number 1076.

Description: For a detailed description of the species see Dettmann (1963). The specimens from the Great Artesian Basin measure in equatorial diameter (6 specimens) 64-75 μm; the exine is 2.5-3.5 μm thick; verrucae are approximately circular in basal outline, with a diameter of 1-4 μm, average 2-3 μm, and a height of 0.5-1 μm.

Occurrence: Dettmann reported the species from the Albian of the Otway Basin, South Australia. Burger (1973, 1975) recovered the species from sediments associated with the *Murospora florida* Zone in the Surat and Eromanga Basins.

Comments: The specimens from the Great Artesian Basin match Dettmann's description of the species in their essential features, but the verrucae are more closely-spaced and the amb tends to be more concavely triangular than in the specimens from the Otway Basin.

CONCAVISSIMISPORITES sp. A
(Pl. 2, fig. 2)

BMR Species Catalogue number 1167

Description: Trilete azonate miospores, in polar view with more or less concave sides and rounded apices. Trilete mark distinct, laesurae as long as radius of spore and bordered by inconspicuous exine thickenings about 1-3 μm wide. Exine 2 μm thick, weakly verrucate; verrucae crowded, more or less circular, low, 1-3 μm in basal diameter.

Dimensions: Equatorial (4 sepcimens) 53-78 μm.

Occurrence: The species has been found as a very rare component of the *Cicatricosisporites australiensis* and *Foraminisporis wonthaggiensis* Subzones in the Surat Basin and Eromanga Basin. It was recovered from the Kingull Member, Bungil Formation, at 348 ft (106.1 m) in BMR Roma 1, the Hooray Sandstone at 2038 ft (621.2 m) in NAI Whyenbirra 1, the Ronlow Beds at 86 ft (26.2 m) in BMR Jericho 1, and the Longsight Sandstone at 3535 ft (1077.5 m) in Hematite Lovelle Downs 1 and 3100 ft (944.9 m) in Hematite Clyde 1.

Comments: These specimens differ from *Cyathidites asper* (Bolchovitina) Dettmann, 1963, in having a thinner exine and more defined sculpture. They are more weakly sculptured than *C. penolaensis,* but the two forms cannot be sharply divided on the basis of sculpture alone. *C. granulatus* Pocock, 1964, is smaller and has a thicker exine.

CONCAVISSIMISPORITES sp. B
(Pl. 2, fig. 1)

BMR Species Catalogue number 1168

Description: Trilete, azonate miospores with a concavely triangular amb, apices rounded. Trilete laesurae distinct, almost as long as radius of spore and bordered by exine thickenings 2-3 μm. Exine inclusive of sculpture 3-4 μm thick, entirely and densely covered with verrucae of 2-6 μm basal diameter and 0.5-2 μm high.

Dimensions: Equatorial (3 specimens 66-77 μm.

Occurrence: A very rare species associated with the lower part of the *Murospora florida* Zone; identical specimens have also been found in Upper Jurassic strata of the Great Artesian Basin. The species occurs in the Mooga Sandstone at 645 ft (196.6 m) in GSQ DRD 27, and the Longsight Sandstone at 3100 ft (944.9 m) in Hematite Clyde 1.

Comments: This species has slightly more pronounced verrucae than *C. penolaensis*. Some specimens showed slightly reduced sculpture in the distal and proximal polar regions. The species resembles, and could be identical with, *C. informis* Döring, 1965, from the 'Wealden' (Early Cretaceous) of Germany.

Genus CICATRICOSISPORITES Potonié & Gelletich, 1933

Type species (by monotypy): *Cicatricosisporites dorogensis* Potonié & Gelletich, 1933, from the Early Tertiary of Hungary.

CICATRICOSISPORITES sp. A
(Pl. 2, fig. 4; Pl. 3, fig. 2; text-fig. 2)

BMR Species Catalogue number 1169

Description: Large, trilete, azonate miospores, with a probably two-layered, acavate, striate exine 1.5-2 μm thick. Amb rounded triangular. Trilete laesurae straight and bordered by indistinct membranous lips. Striae in each proximal interradial region straight to slightly curved and oriented approximately parallel to one of the adjacent laesurae, so that two sets of striae enclose acute angles. A small psilate contact area remains. Striae at distal side arranged parallel to one of the sides, commonly slightly diverging from one of the equatorial radial regions. Ribs straight, smooth, slightly narrower than grooves. A set of 4 neighbouring ribs and intervening grooves at the distal face is 6-8 μm wide.

Dimensions: Equatorial (4 specimens) 50-62 μm; polar (3 specimens) 48-52 μm.

Occurrence: The species is a less common component of the *Foraminisporis wonthaggiensis* and *Foraminisporis asymmetricus* Subzones in the Eromanga and Surat Basins. It was recovered from the Minmi and Nullawurt Sandstone Members, Bungil Formation, at 1582 ft (482.2 m) in UKA Cabawin 1, and 158 ft. (48.0 m) in BMR Mitchell 11, respectively. It also occurs in the Hooray Sandstone at 4685 ft (1428.0 m) in Alliance Chandos 1 and 3376 ft (1029.0 m) in Phillips Sunray Cothalow 1, and the Longsight Sandstone of Conorada Ooroonoo 1 at 2376 ft (724.2 m).

Comments: The arrangement of ribs in this species is illustrated in Text-figure 2. The spores are delicate in structure and are therefore often intensely folded or ruptured. The species differs from *C. cuneiformis* Pocock, 1964, and *C. ludbrookae* Dettmann, 1963, in its narrower ribs and different arrangement of the striae. It also differs from *C. australiensis* (Cookson) Potonié, 1956, and *C. sternum* Amerom, 1965, which are distinguished by the different arrangement of ribs and the presence of a narrow, radial, unsculptured exine area in the equatorial radial regions. An identical feature is also characteristic of the otherwise similar species *C. apiteretus* Phillips & Felix, 1971. *C. sprumontii* Döring, 1965, has thicker striae and slight exine extensions in the equatorial radial regions, and a large, smooth contact area. Busnardo & Taugourdeau (1964) illustrated and described spores from the Albian of Spain as '*Cicatricosisporites* cf. *C. remissa* (Bolchovitina, 1956) nov. comb.'; these are similar to the spores from Queensland but have coarser striae. *C. augustus* Singh, 1971, has a different pattern of distal striae. The specimens from Queensland are not unlike spores which Hughes & Moody-Stuart (1966) extracted from macrofossil material of *Schizaeopsis americana* Berry, from the Early Cretaceous of Virginia, USA, but have a thinner exine.

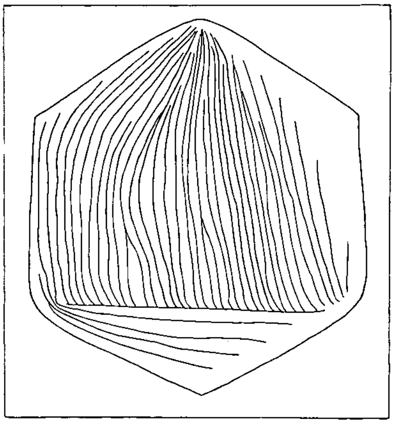


Fig. 2. Arrangement of striae in *Cicatricosisporites* sp. A.

Genus LYCOPODIUMSPORITES Thiergart, 1938, ex Delcourt & Sprumont, 1955

Type species (designated by Delcourt & Sprumont, 1955): *Lycopodiumsporites* (al. *Sporites*) *agathoecus* (Potonié, 1934) Thiergart, 1938, from the Early Tertiary of Germany.

LYCOPODIUMSPORITES cf. L. FACETUS Dettmann, 1963

(Pl. 5, figs 2, 3; Pl. 6, fig. 1; text-fig. 3)

1963 *Lycopodiumsporites facetus* Dettmann, p. 47, pl. 7, figs 17-20.

BMR Species Catalogue number 1166.

Description: Trilete miospores with a spherical to ellipsoidal shape. Exine dark-coloured, 8-9 μm thick, consisting of a smooth, strongly refractive basal layer 0.5-1 μm thick, a spongeous, rigid, intermediate layer 3-8 μm thick, and an outer, uniformly reticulate layer, with very thin and smooth muri 2-6 μm high, enclosing polygonal, equidimensional to elongated lumina 3-(6-8)-14 μm in diameter. Trilete mark rarely visible, developed only in innermost layer; laesurae straight, simple, and approximately as long as radius of spore cavity. Basal layer in many specimens folded or deflated and in places detached from middle layer of exine.

Dimensions (without orientation): Longest axis of spore cavity (3 specimens) 34-38 μm; entire spore (13 specimens) 50-66 μm.

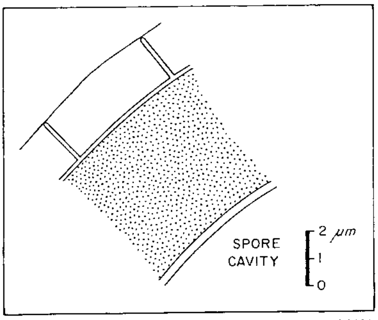


Fig. 3. Wall stratification of *Lycopodiumsporites* **cf.** *L. facetus* **Dettmann.**

Occurrence: The species has been found only in the Surat Basin, where it occurs rarely in the *Murospora florida* Zone and the succeeding spore sequence (palynological unit K1b-c). Specimens of the species were recovered from the Mooga Sandstone in GSQ DRD 27 at 584 ft (178.0 m), and GSQ Roma 3 at 674 ft (205.4 m) and 603 ft (183.8 m) and the Bungil Formation in BMR Dalby 3 at 200-210 ft (61-63 m), BMR Roma 8 at 54 ft (16.5 m), and GSQ Roma 3 at 315 ft (96.0 m) and 199 ft (60.7 m). The species also occurs in the Kingull Member, Bungil Formation at GSQ DRD 27 at 436 ft (132.9 m), and the Minmi Member of the same borehole at 273 ft (83.2 m) and 178 ft (54.3 m), BMR Mitchell 11 at 48 ft (14.6 m), and GSQ Surat 1 at 1139 ft (347.3 m).

Isolated specimens of the species have been found in Upper Jurassic sediments of the basin; it is expected that current palynological work in the Jurassic by the Geological Survey of Queensland will establish its restricted occurrence more accurately.

Comments: The orientation of many specimens is doubtful, as the trilete mark is rarely visible. The exine stratification (Text-fig. 3) resembles that described in *Crybelosporites* (Dettmann, 1963), but no specimens have yet been found in which the wall was genuinely cavate. The species is somewhat comparable to *L. facetus* (Dettmann, pers. comm.), but its exine is more opaque and the surface reticulum gives no indication of the position of the trilete mark. The specimens from Queensland are tentatively assigned to the species, until examination of more specimens from the Aptian and Albian now in progress allows a more definite assignment.

Subturma AURICULATI Schopf emend. Dettmann

Genus APPENDICISPORITES Weyland & Krieger, 1953

Type species (by original designation): *Appendicisporites tricuspidatus* Weyland & Greifeld, 1953, from the Late Cretaceous of Germany.

Comments: In Europe and North America, *Appendicisporites* is known from the earliest Cretaceous (Pocock, 1962; Burger, 1966; Norris, 1969; Hughes & Moody-Stuart, 1969; and others); but in Australia, the genus has not been previously reported from strata older than Albian. Dettmann & Playford (1968, 1969) described and reported *A. distocarinatus* from the Albian of southeastern Australia, and Burger (1968) recovered specimens of the genus from the (Albian) Allaru Mudstone and Mackunda Formation in the Eromanga Basin. The late Neocomian specimens recovered from the Surat Basin and described below probably represent the earliest known occurrence of the genus in the Australian-Papuan region.

APPENDICISPORITES cf. A. GIGANTICUS Groot & Groot, 1962
(Pl. 3, fig. 3; Pl. 4, fig. 1; Pl. 5, fig. 1; text-fig. 4)

1962 *Appendicisporites giganticus* Groot & Groot, p. 144, pl. 1, fig. 3.

BMR Species Catalogue number 1170.

Description: Large trilete miospores with rounded triangular amb and short appendages in the equatorial radial regions, protruding 12-17 μm from the spore cavity. Trilete mark simple, laesurae straight and almost as long as radius of spore. Exine striate, about 5-6 μm thick, not visibly lamellated. Striae straight, smooth, 2-4μm wide, intervening grooves 1-3 μm wide. Striae on proximal face in each interradial region approximately parallel to adjoining margin of spore, leaving no contact area free of sculpture. Distal striae either curved and parallel to one of the sides of the spore, or arranged in a set of 5-7 triangles, with the sides parallel to the spore margins and the distal pole as centrum (see Text-fig. 4).

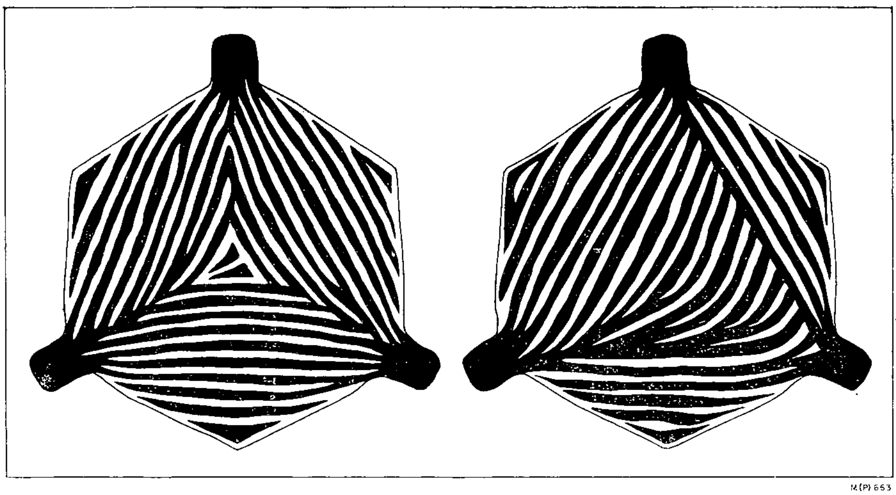


Fig. 4. Arrangement of striae in *Appendicisporites* cf. *A. giganticus* Groot & Groot.

Dimensions: Equatorial (4 specimens) 86-113 μm.

Occurrence: Groot & Groot (1962) recovered the species from Aptian and Cenomanian rock samples from Portugal. In Queensland the spore seems to have a restricted range; it was found only in the Surat Basin in association with the *Foraminisporis asymmetricus* Subzone in the Minmi Member, Bungil Formation, at 241 ft (73.6 m) in BMR Roma 1 and the Nullawurt Sandstone Member at 351 ft (106.9 m) in GSQ DRD 27. No representatives of the genus have so far been recovered from the Aptian and early Albian of the Great Artesian Basin.

Comments: This form differs from most described species of *Appendicisporites* in its equatorial dimensions. Among those of comparable size range, *A. giganticus* Groot & Groot most resembles the specimens from Queensland, and differs only in that the striae 'appear to be pitted by numerous minute depressions'; this, however, could have been caused by corrosion. *'Anemia' globulifera* Bolchovitina, 1961, has coarser ribs and apparently spherical appendices. *'Cicatricosisporites' baqueroensis* Archangelsky & Gamerro, 1966, develops foveolae on the surface of the ribs, which are much coarser. Deák (1963) described similar spores from the

Aptian of Hungary as *A. stylosus* (Thiergart), but the appendices in those specimens partly continue onto the distal surface of the grains and are strongly lobed, a feature which is also apparent in the otherwise similar species *A. cristatus* (Markova) Pocock, 1964, and *Appendicisporites* sp. A Phillips & Felix, 1971. *A.* cf. *A. giganticus* resembles spores illustrated by Thiergart (1953, pl. 14, fig. 7) as *A.* cf. *A. tricuspidatus* Weyland & Greifeld; however, these appear to lack the extended appendages of *tricuspidatus*. *Plicatella trichacantha* Maliavkina, 1949, develops much stronger ribs.

Suprasubturma PERINOTRILITES Erdtman emend. Dettmann

Genus ENDOCULEOSPORA Staplin, 1960

Type species (by original designation): *Endoculeospora rarigranulata* var. *rarigranulata* Staplin, 1960, from the Early Carboniferous (Mississippian) of Alberta, Canada (see Kremp & Ames, 1964, p. 75).

Comments: The assemblages from the Great Artesian Basin contain trilete spores with a bilamellate, psilate to near-psilate wall which initially is cavate distally and equatorially. Similar spores have been described from Palaeozoic and Mesozoic sediments world-wide, and have been assigned to a plethora of form-genera of which the diagnoses, unfortunately, overlap in various degrees. The genus *Endoculeospora* is here selected to incorporate the Queensland specimens on the grounds that its diagnosis is relatively broad, and that it is senior to the genera *Velamisporites* Bhardwaj & Venkatachala, 1962, and *Ricaspora* Bhardwaj & Salujha, 1964, which include morphologically similar types. According to its diagnosis, the genus *Auroraspora* Hoffmeister, Staplin, & Malloy, 1955 emend. Richardson, 1960, is also closely associated, but the holotype of its type species *A. solisortus,* which I have examined through courtesy of the Smithsonian Institution, is so poorly preserved that exine details were invisible; this makes comparison very difficult. The genus *Aculeispores* Artüz, 1957, may well incorporate spores identical with *Endoculeospora* (Potonié, 1966, p. 133); this will depend on close examination of the type specimens.

The genus *Velosporites* Hughes & Playford, 1961, incorporates types with a relatively thick-walled, sculptured central body, and strongly developed trilete laesurae which continue onto the margin of the spore. The genus *Thomsonisporites* Leschik, 1955, incorporates trilete, equatorially cavate (saccate) forms (B. Scheuring, pers. comm.). The genus *Perotrilites* Erdtman ex Couper, 1953 emend. Evans, 1970, incorporates acavate, zonate spores (Evans, 1970).

ENDOCULEOSPORA DELICATA sp. nov.

(Pl. 6, figs 2-6)

Holotype: BMR Mitchell 11 Stratigraphic Hole, depth 48 ft (14.6 m), Minmi Member, Bungil Formation, Cretaceous, lower Aptian. (MFP 4276-1, 423/1158; CPC 13893, Plate 6, fig. 4).

Derivation of name: Refers to the thin and fragile sclerine layers.

BMR Species Catalogue number 1171.

Description: Trilete miospores with a two-layered, cavate sclerine. Central body proximo-distally flattened, amb rounded triangular to circular. Inner sclerine layer less than 0.5 μm thick and psilate. Trilete mark weakly developed, laesurae often opened, straight, measuring between half and three-quarters of the radius of the spore body, and sometimes bordered by weak, narrow exine thickenings. Outer sclerine layer detached except in the proximal contact area, very thin and transparent, and minutely but distinctly and evenly granulate.

Dimensions: Spore body, equatorial (8 specimens) 26-34 μm; entire spore, equatorial (8 specimens) 34-44 μm.

Occurrence: The species occurs in some of the microfloras associated with the *Murospora florida* Zone and the immediately following sequence of the Surat Basin. It has been recovered from the Minmi Member in BMR Mitchell 11 at 48 ft (14.6 m) and the Hooray Sandstone of NAI Whyenbirra 1 at 1800 ft (548.6 m) and BMR Mitchell 7 at 180 ft (55.0 m).

Comments: Endoculeospora delicata sp. nov. is smaller than *Auroraspora kerimii* Artüz, 1957, and *Velosporites triquetrus* (Lantz, 1958) Dettmann, 1963. It resembles *Endosporites minutus* Hoffmeister, Staplin, & Malloy, 1955, but has a thinner sclerine.

Released bodies of *E. delicata* sp. nov. would differ from *Cyathidites minor* Couper by the thinner wall and shorter laesurae. Some specimens which are split open along the trilete laesurae resemble *Concentrisporites hallei* (Nilsson), but have a minutely but distinctly granulate outer sclerine layer.

Genus CRYBELOSPORITES Dettmann, 1963

Type species (by original designation): *Crybelosporites* (al. *Perotrilites*) *striatus* (Cookson & Dettmann, 1958) Dettmann, 1963, from the Albian of southeastern Australia.

CRYBELOSPORITES BERBERIOIDES sp. nov.
(Pl. 8, figs 1, 2, 3; Pl. 9, figs 1, 2)

Holotype: BMR Mitchell 11 Stratigraphic Hole, depth 213 ft (94.6 m), Nullawurt Sandstone Member, Bungil Formation, Cretaceous, upper Neocomian (MFP 4289-1, 403/1192; CPC 13908, Plate 8, fig. 3; specimen indicated by arrow).

Derivation of name: From Greek *berberion;* shabby, ragged garment.

BMR Species Catalogue number 825.

Description: Trilete miospores, frequently united in tetrahedral tetrads, with a bilamellate, cavate sclerine. Spore body spherical, ellipsoidal, or proximo-distally flattened, amb circular to oval. Trilete mark indistinct, laesurae may be of unequal length in one specimen, simple, straight, and measuring half to two-thirds of radius of central body. Inner wall smooth, about 0.5 μm thick; outer wall about equally thick, loosely enveloping, psilate to weakly punctate. In free specimens outer wall readily separating proximally and arranged into loose folds presenting a typical 'rugulate' zig-zag pattern distally.

Dimensions: Main body maximum (10 specimens) 28-34 μm; entire single spore (9 specimens) 33-50 μm.

Occurrence: Burger (1973, 1975) referred to the species as 'perinate trilete spore no. 825' and reported it from the *Murospora florida* Zone and the succeeding spore sequence in the Surat and Eromanga Basins. Re-examination of the spores showed that in several preparations specimens of *Endoculeospora delicata* sp. nov. had been misidentified and erroneously included under the same designation. This is here corrected.

C. berberioides sp. nov. was recovered in the Surat Basin from the Mooga Sandstone in BMR Mitchell 1 at 284 ft (86.6 m), and the Minmi Member, Bungil Formation, in GSQ DRD 27 at 178 ft (54.3 m), BMR Mitchell 11 at 99 ft (30.3 m), BMR Roma 1 at 55 ft (16.9 m), and A.A.O. Pickanjinnie 1 at 200-210 ft (61-63 m). The species has not been observed in the Eromanga Basin within the interval of the *Murospora florida* Zone, probably because of its comparative rarity. Dettmann (pers. comm.) observed similar specimens from the lower *Dictyotosporites speciosus* Zone in southeastern Australia (see Table 1).

Comments: The species differs from *Crybelosporites striatus* Dettmann, 1963, by its slightly larger spore cavity, less pronounced gula-like proximal sculptine projection, and distal sculpture which is not murornate, and presents a 'rugulate' rather than 'reticulate' appearance. It differs from *Endoculeospora delicata* sp. nov. by its thicker wall and characteristically wrinkled outer sclerine layer without distinct sculpture. *Perotilites pannuceus* Brenner, 1963, is larger and has a thicker body wall.

Released inner bodies of *C. berberioides* sp. nov. would resemble *Cyathidites minor* Couper, but would probably appear more spherical, and the trilete laesurae would be shorter. Most specimens of the species were found still united in tetrads, and some appeared to be well below normal size, which may be a sign of immaturity. As no suitable single specimen was available, an apparently fully developed grain within a tetrad was designated as holotype for the species.

CRYBELOSPORITES sp. A

(Pl. 7, figs 1-3)

BMR Species Catalogue number 1172.

Description: Small to medium-sized, trilete miospores with an apparently two-layered, cavate sclerine. Inner body spherical or compressed in direction of polar axis, amb circular to oval, wall about 0.5 μm thick, psilate. Trilete laesurae indistinct, simple, straight, measuring more than half of radius of spore body, in some specimens of unequal length. Outer sculptine about 0.5 μm thick, very transparent, minutely but distinctly granulate, loosely enveloping, readily folding and detaching from central body in the tetrad.

Dimensions: Central body, equatorial diameter (6 specimens) 28-40 μm; entire spore (6 specimens) 40-52 μm; maximum dimensions of 2 tetrads 70, 72 μm.

Occurrence: The species has been found in a few assemblages of the *Murospora florida* Zone. It occurs in the Kingull Member of BMR Roma 1 at 348 ft (106.1 m) and GSQ DRD 27 at 436 ft (132.9 m), and the Minmi Member of BMR Roma 1 at 136 ft (41.6 m). It occurs also in assemblages extracted from upper Aptian strata in the Surat Basin.

Comments: The specimens found within the interval of the *Murospora florida* Zone were united in tetrads, which implies that the parent plant grew in the immediate vicinity of the sample localities. All specimens found have a distinctly cavate sclerine, but only very recently specimens of the species were recovered from higher parts of the sequence, with a proximally cavate wall, and fully developed gula-like projections of the sculptine (study in progress).

The species differs from *Crybelosporites punctatus* Dettmann, 1963, as it has a thinner wall consisting of two instead of three layers. Specimens in which no gula-like projection has developed resemble *Endoculeospora delicata* sp. nov. but have slightly thicker sclerine layers.

Turma MONOLETES Ibrahim
Suprasubturma ACAVATOMONOLETES Dettmann

Genus LAEVIGATOSPORITES Ibrahim, 1933

Type species (by monotypy): *Laevigatosporites* (al. *Sporonites*) *vulgaris* (Ibrahim, *in* Potonié, Ibrahim, & Loose, 1932) Ibrahim, 1933, from the Late Carboniferous of Germany.

LAEVIGATOSPORITES BELFORDII sp. nov.
(Pl. 9, figs 3, 4; Pl. 10, fig. 1)

Holotype: BMR Mitchell 11 Stratigraphic Hole depth 347 ft (105.8 m), Mooga Sandstone, Cretaceous, lower Neocomian. (MFP 4279-1, 285/1091; CPC 13911, Plate 9, fig. 3).

Derivation of name: In honour of Dr D. J. Belford, of the Bureau of Mineral Resources.

BMR Species Catalogue number 824.

Description: Large, smooth, monolete miospores, elongated oval in polar view and kidney-or boat-shaped in side view. Monolete mark unobtrusive, reaching over two-thirds of the length of the spore, and flanked by membraneous lips up to 8-16 μm high near the proximal pole and tapering laterally. Exine not visibly lamellated, psilate, distally and equatorially 2-3.5 μm thick.

Dimensions: Polar (12 specimens) 40-74μm, equatorial length (16 specimens) 66-(97)-120 μm.

Occurrence: Burger (1973, 1975) reported the species as *Laevigatosporites* sp. no. 824 in the interval of the *Murospora florida* Zone in the Eromanga and Surat Basins. Dettmann (pers. comm.) recovered the species from the *Crybelosporites stylosus* Zone and the lower *Dictyotosporites speciosus* Zone in southeastern Australia. Similar specimens have been found in basal Cretaceous sediments of the Perth and Carnarvon Basins, Western Australia.

Comments: The species is larger than most other representatives of *Laevigatosporites* so far described. It is larger than *L. major* (Cookson, 1947) Krutzsch, 1959. It resembles *L. robustus* Kosanke, 1950, but has a thicker exine and more pronounced laesurate lips. It also resembles *L. discordatus* Pflug *in* Thomson & Pflug, 1953, but has a longer laesura and more pronounced lips. *'Azonomonoletes' magnus* Bolchovitina, 1953, seems to be more delicate in appearance. *L. major* Venkatachala & Bhardwaj, 1964 (non (Cookson) Krutzsch) is larger than *L. belfordii* sp. nov.

Genus PUNCTATOSPORITES Ibrahim, 1933

Type species (by monotypy): *Punctatosporites minutus* Ibrahim, 1933, from the Late Carboniferous of Germany.

PUNCTATOSPORITES SCABRATUS (Couper) Norris, 1965
(Pl. 10, figs 4, 5, 6)

1958 *Marattisporites scabratus* Couper, p. 133, pl. 15, fig. 20.
1965 *Punctatosporites scabratus* (Couper) Norris, p. 248, figs 34, 35.
1971 *Punctatosporites scabratus* (Couper) Singh, p. 106, pl. 14, fig. 15.

BMR Species Catalogue number 1096.

Description: Small, monolete, bean-shaped miospores, with a two-layered acavate exine 0.5-1 μm thick. Inner layer smooth, very difficult to observe, outer layer thicker and in close contact. Granules between 0.5-1 μm, and occasionally larger, in basal diameter are regularly scattered across the surface of the spore. Monolete mark simple and spanning about three-quarters of the length of the spore.

Dimensions: Polar (7 specimens) 22-28 μm; equatorial length (19 specimens) 24-34 μm.

Occurrence: The species has been reported from the Jurassic and Early Cretaceous of the United Kingdom (Couper, 1958), the Early Jurassic of Sweden (Nilsson, 1958) and Antarctica (Norris, 1965), the Albian of northwestern Alberta, Canada (Singh, 1971), and the mid-Jurassic of Argentina (Menendez, 1968).

In Australia the species occurs in Upper Jurassic sediments of the Surat Basin and Lower Cretaceous sediments of the Eromanga and Surat Basins, from where Burger (1973, 1975) reported it as 'granulate monolete species no. 1096'.

Comments: The fact that the exine is stratified could be observed only in a few specimens in which the layers were partly separated. One such specimen is illustrated in Plate 10, figure 5. The spores were initially regarded as belonging to other species and reworked from older sediments, but a closer comparison proved that they were different from species so far described from the Australian Triassic and Permian. *P. scabratus* is larger than *Tuberculatosporites modicus* Balme & Hennelly, 1956, from the Permian of Western Australia, and has smaller sculptural elements. *Verrucososporites leopardus* Balme & Hennelly, 1956, is larger, has coarser sculpture and a longer monolete mark. *Punctatosporites walkomi* De Jersey, 1962, from the Triassic of Queensland has a thicker exine and slightly coarser sculpture.

From the contemporaneous microfloral sequence, *Reticuloidosporites arcus* (Balme) Dettmann, 1963, which is illustrated here for comparison (Pl. 10, fig. 3) is larger and has a considerably thicker exine, with different sculpture. *Schizaeoisporites delcourtii* Pocock, 1964, is larger and has coarser grana.

Suprasubturma PERINOMONOLETES Erdtman

Genus PEROMONOLITES Erdtman ex Couper, 1953

Type species (by original designation): *Peromonolites bowenii* Couper, 1953, from the Cretaceous of New Zealand.

Peromonolites sp. A
(Pl. 10, fig. 8; Pl. 11, fig. 1)

BMR Species Catalogue number 1165.

Description: Ellipsoidal, monolete miospores, loosely wrapped in an uninterrupted outer membrane. Monolete laesura distinct, straight, simple, and equal to length of spore. Inner wall layer smooth, about 0.5 μm thick, enveloping layer thinner, without sculpture, wrinkled in a typically 'rugulate' fashion, and not visibly attached to main body.

Dimensions: Length of central body (4 specimens) 30-44 μm; length of entire spore (2 specimens) 45-50 μm.

Occurrence: This form is very rare and has been recovered only in the Surat Basin from the interval of the *Foraminisporis asymmetricus* Subzone, in the Bungil Formation of GSQ Roma 3 at 275 ft (83.8 m) and the Minmi Member of that formation in BMR Roma 1 at 210 ft (64.2 m).

Comments: The species differs from the type species *P. bowenii* Couper in having a smooth central body and a loosely enveloping outer membrane. It is smaller than *P. asplenioides* Couper, 1958. It is longer than *P. fragilis* Burger, 1966, and has a typically wrinkled outer membrane, without sculpture. The specimens observed were still entirely or partly united in (bilateral) tetrads.

Anteturma POLLENITES R. Potonié
Turma MONOSULCATES, MONOCOLPATES Iversen & Troels-Smith
Suprasubturma PERINOMONOSULCATES

Genus Concentrisporites Wall, 1965 emend. Pocock, 1970

Type species (by original designation): *Concentrisporites* (al. *Equisetosporites*) *hallei* (Nilsson, 1958) Wall, 1965, from the Rhaetic of Sweden.

Concentrisporites hallei (Nilsson) Wall, 1965
(Pl. 11, figs 2, 3, 4, 5, 6; Pl. 12, figs 1, 2, 3, 4, 5)

1958 *Equisetosporites hallei* Nilsson, p. 66, pl. 5, fig. 20.

1958 *Perinopollenites elatoides* Couper (pars), pl. 27, fig. 11.

1962 *Monosulcites minimus* Cookson; Pocock, pl. 13, figs 207, 208.

1963 *Perinopollenites pseudosulcatus* Danzé-Corsin & Laveine, p. 90, pl. 8, figs 8, 9, 10.

1965 *Concentrisporites hallei* (Nilsson) Wall, p. 166, pl. 9, fig. 13.

1969 *Perinopollenites elatoides* Couper; Reiser & Williams (pars), pl. 6, fig. 12.

1970 *Concentrisporites pseudosulcatus* (Danzé-Corsin & Laveine) Pocock, p. 106, pl. 26, figs 5, 6, 7, 8, 9.

BMR Species Catalogue number 329, into which number 1073 is now incorporated.

Description: Spherical or ellipsoidal, prolate to oblate pollen grains with a bilamellate, cavate exine. Exine of main body smooth, 0.5-1 μm thick, with a (distal?) line of weakness which spans approximately half the circumference of the body; the body of many specimens is split in a typical way along this line, in which case the exine at the margin may be slightly folded inwards. The body is entirely and more or less tightly wrapped into an outer membrane which is not visibly attached. The membrane is smooth, up to 0.5 μm thick, hyaline, folded, and occasionally missing.

Dimensions: Maximum diameter of central body (16 specimens) 24-40 μm; entire specimen only slightly larger.

Occurrence: The species occurs in the Early Jurassic of Sweden (Nilsson, 1958) and France (Danzé-Corsin & Laveine, 1963), and the Jurassic and Early Cretaceous of the United Kingdom (Wall, 1965) and western Canada (Pocock, 1962, 1970).

In Australia, Reiser & Williams (1969) recovered identical specimens from the Early Jurassic of the Surat Basin. The species also occurs in low abundance in many assemblages of the *Murospora florida* Zone and the succeeding spore sequence in the Eromanga and Surat Basins.

Comments: To typify the species, Nilsson selected a specimen which is distinctly cavate and whose central body is split along (the distal?) half of its circumference. Although he did not observe any specimens with a trilete mark in the microfloras from Schonen, both Wall (1965) and Pocock (1962), in describing similar spores from elsewhere, mentioned the occasional presence of such a feature. I have had the opportunity of examining this species from the Frodringham Ironstone (Sinemurian) of Lincolnshire in England. The specimens were well preserved; they had a smooth body and smooth to finely granulate outer membrane which was not always preserved. No pore or trilete mark was observed; instead, the main body was frequently split open over half or considerably more of its circumference. Its diameter thus appeared to be increased; unopened specimens measured from Queensland were smaller. Apart from this, the specimens from England and Queensland are similar and there is no reason to separate them specifically.

Pocock (1970) realized the singular nature of the aperture and emended the generic diagnosis so as to restrict it to include cavate (saccate) pollen grains, monosulcate or with a line of weakness in the body exine along which the body is commonly split into two more or less equal parts. This is a clear distinction which separates *hallei* from *Endoculeospora delicata* sp. nov. and *Perinopollenites elatoides* Couper, 1958.

Burger (1973, 1974) separated unopened specimens of *C. hallei* as a different species and provisionally designated these as 'perinate inaperturate pollen type no. 1073'. This proved to be unfounded, as under interference contrast illumination many specimens showed a faint line of exine weakness. *C. hallei* and *C. pseudo*-sulcatus Danzé-Corsin & Laveine can be regarded as identical species (Pocock, 1970, p. 106). *C. hallei* differs from *C. sulcatus* (Rogalska) Pocock, 1970, in lacking nexinal infoldings alongside and parallel with the sulcus. Unopened specimens of *hallei* resemble *Thomsonisporites rasilis* Phillips & Felix, 1971, but the species seems to be genuinely inaperturate; so is *Peroaletes convolutus* Bhardwaj & Singh, 1964. (It should be noted that *Thomsonisporites* incorporates trilete and not alete spores; see comments at page 10). Species of the genus *Perisaccus* Naumova ex Potonié, 1958, emend. Klaus, 1963, incorporate more or less similar forms, which are slightly different in having more pronounced granulation on the saccus and a minute trilete mark. Species of the genus *Taxodiaceaepollenites* Kremp, 1949, are commonly split open in a similar fashion but lack an outer, detached wall layer.

DIVISION INCERTAE SEDIS

'Gen. et sp. indet. Form A' Eisenack & Cookson

(Pl. 12, figs 6, 7, 8, 9, 10, 11, 12; Text-fig. 5)

1960 'Gen. et sp. indet. Form A' Eisenack & Cookson, p. 10, pl. 3, figs 12, 13, 14.

BMR Species Catalogue number 405.

Description: Organisms in the form of short, hollow, open cylinders, which are usually compressed into oblong or oval rings. Cylinder wall consists of 16 to 18 vertical, slender, pillow- or tube-shaped structures which are laterally connected by a thin, filmy membrane. Tubes are hollow, often deflated, with slightly wider ends which are closed and merge with the ends of adjacent tubes. In many specimens a thread-like ligament is visible, which connects the ends of the tubes and forms the two rims of the cylinder. Tubes are smooth, often minutely wrinkled, or with fine granulation.

Dimensions: Maximum diameter of cylinders (24 specimens) 20-44 μm; height of tubes (7 specimens) 9-17 μm.

Occurrence: Eisenack & Cookson recovered the organism from the South Australian portion of the Great Artesian Basin in sediments from which Dettmann & Playford (1969) described microfloral assemblages of part of their *Dictyotosporites speciosus* Zone, equivalent to the *Murospora florida* Zone (Burger, 1973, p. 102; see also Table 1). The organism also occurs in the Birdrong Formation, Carnarvon Basin, Western Australia; this formation contains spore-pollen assemblages (Balme, 1957) equivalent to the *Murospora florida* Zone. Evans (1966a) reported the organism from restricted intervals in the Gippsland and Otway Basins, but at the

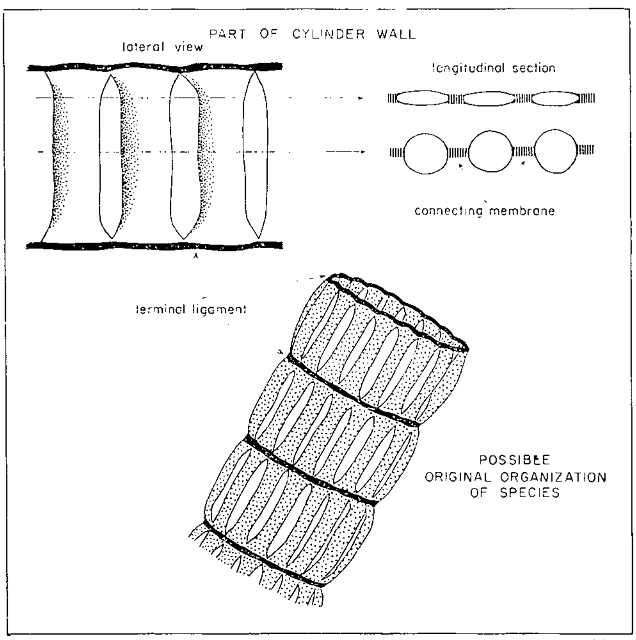


Fig. 5. Structure of 'Gen. et sp. indet Form A' Eisenack & Cookson.

time did not specify its range accurately. He subsequently (1966b) reported it in association with the *Murospora florida* Zone (palynological unit K1a, see Table 1) of the Archer River area, Cape York Peninsula. Farther to the south, the organism occurs in low to moderate frequency in the Surat and Eromanga Basins, associated with the Zone; it has not been found in assemblages outside the interval of the Zone.

Comments: The origin and affinity of this form are unknown. It occurs in both nonmarine and marginally marine sediments in eastern Australia but has not been found in sediments from the Great Artesian Basin which contain the open marine (Aptian) Roma faunas. The periodical abundance of the species in the Otway and Gippsland Basins led Evans (1966a) to think that it is associated with an aquatic and not terrestrial flora.

The organization of the species is schematically illustrated in Text-figure 5. The relative positions of some specimens in one of the preparations give the impression that they may initially have been joined by the ligaments, and fitted together in such a way that the ends of the tubes were in opposite positions. The specimens might thus represent detached segments of large filiform structures (of algal affinity?).

CONCLUSIONS

Three of the fourteen sporomorph species described here are known from the Mesozoic outside the Australian region. *Punctatosporites scabratus* (Couper) and *Concentrisporites hallei* (Nilsson) occur in the same geological interval in Australia as elsewhere, but their geological ranges are too extended to be of much value in stratigraphic palynology. The third species, *Appendicisporites* cf. *A. giganticus* Groot & Groot, must be evaluated on the basis of more observations. Its presence considerably increases the area of distribution of the genus in the Southern Hemisphere during the Early Cretaceous.

Of the remaining species, those of *Concavissimisporites* seem to be restricted to Late Jurassic and Early Cretaceous microfloras in eastern Australia and are moderately useful as a group; individually they occur too infrequently for detailed stratigraphic application. This is also the case with *Cicatricosisporites* sp. A, *Crybelosporites* sp. A, and *Peromonolites* sp. A, of which no specimens have yet been found outside the Early Cretaceous. *Endoculeospora delicata* sp. nov. and *Crybelosporites berberioides* sp. nov. are potentially valuable in that their first occurrence in the spore record approximately coincides with the Jurassic-Cretaceous boundary.

Of special interest are the restricted ranges of *Laevigatosporites belfordii* sp. nov. and 'Gen. et sp. indet. Form A' of Eisenack & Cookson; both forms are associated with the *Murospora florida* Zone in Queensland, and the available information indicates that they are restricted to early Lower Cretaceous strata throughout Australia.

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PLATE 1
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Figs 1-5 *Lycopodiacidites asperatus* Dettmann. Showing variations in sculpture patterns. 1, 4, proximal and distal aspects of specimens. 2, 3, specimens in lateral view, proximal side upwards; sculpture elements typically flattened, uniform in shape across entire spore surface. 5, specimen ruptured along the laesurae 4

1. Ph.-S. Cothalow 1; Hooray Sandstone, 1029.0 m; *Foraminisporis asymmetricus* Subzone; MFP 5555-1, 491/1013; CPC 13880.
2. BMR Mitchell 11; Minmi Member, 30.3 m; *Foraminisporis asymmetricus* Subzone; MFP 4286-2, 288/1029; CPC 13881.
3. GSQ Roma 3; Bungil Formation, 160.3 m; *Cicatricosisporites australiensis* Subzone; MFP 5787-2, 305/1151; CPC 13882.
4. F.D. Alice River 1; Hooray Sandstone, 265.2 m; *Foraminisporis wonthaggiensis* Subzone; MFP 2369-2, 330/1121; CPC 13883.
5. BMR Roma 8; Bungil Formation, 16.5 m; palynological unit K1b-c; MFP 4675-1, 323/1138; CPC 13884.

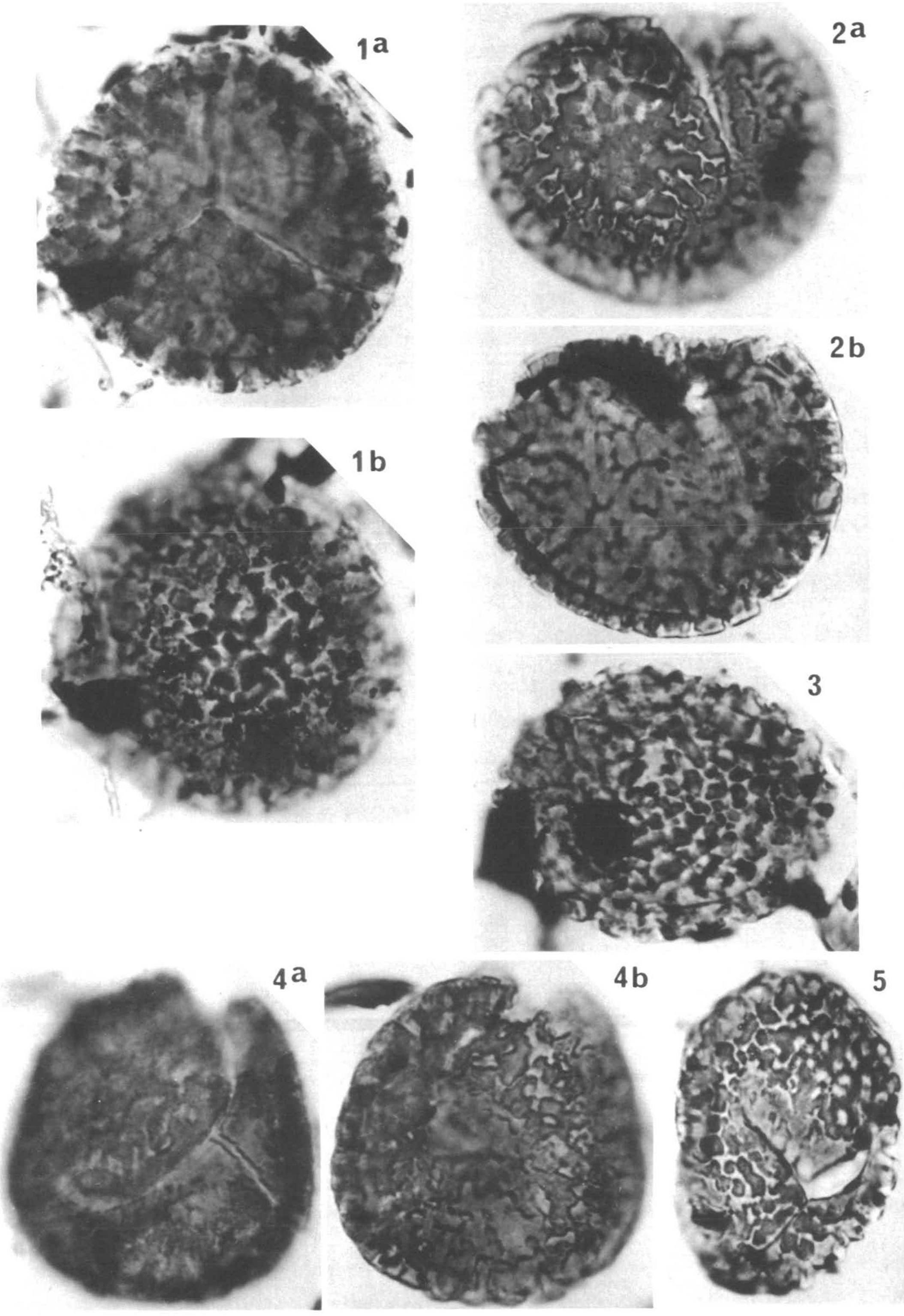
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PLATE 2

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Fig. 1	*Concavissimisporites* sp. B. Specimen with relatively pronounced verrucae	6
Fig. 2	*Concavissimisporites* sp. A. Specimen weakly but distinctly verrucate	5
Fig. 3	*Concavissimisporites* cf. *C. penolaensis* Dettmann	5
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1. Hematite Clyde 1; Longsight Sandstone, 944.9 m; *Murospora florida* Zone; MFP 5943-1, 382/1064; CPC 13885.
2. BMR Roma 1; Kingull Member, 106.1 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4460-1, 409/1142; CPC 13886.
3. BMR Mitchell 11; Mooga Sandstone, 105.8 m; *Cicatricosisporites australiensis* Subzone; MFP 4279-2, 405/1146; CPC 13887.
4. Conorada Ooroonoo 1; Longsight Sandstone, 724.2 m; *Foraminisporis wonthaggiensis* Subzone; MFP 942-1; 400/1016; CPC 13888.

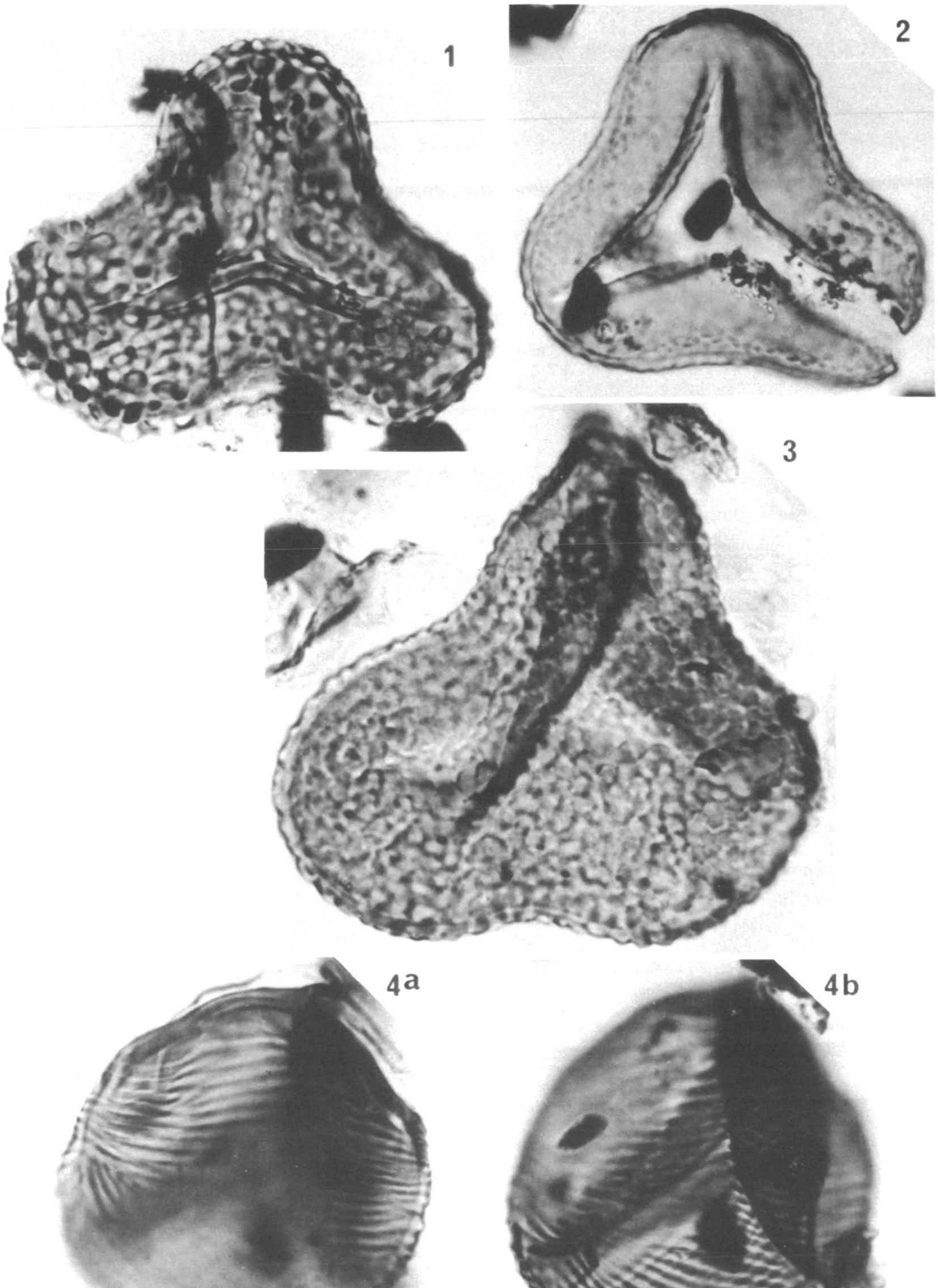
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PLATE 3
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Fig. 1	*Appendicisporites* sp. Not described.. Specimen poorly preserved. Surface of striae dotted with tiny foveolae	
Fig. 2	*Cicatricosisporites* sp. A. Proximal and distal aspect of specimen, showing orientation of striae	6
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1. BMR Roma 1; Nullawurt Sandstone Member, 85.1 m; *Foraminisporis asymmetricus* Subzone; MFP 4330-1, 342/1095, CPC 13897.
2. BMR Roma 1; Nullawurt Sandstone Member, 85.1 m; *Foraminisporis asymmetricus* Subzone; MFP 4330-1; 309/1194; CPC 13898.
3. BMR Roma 1; Nullawurt Sandstone Member, 85.1 m; *Foraminisporis asymmetricus* Subzone; MFP 4330-1; 442/1071; CPC 13899.

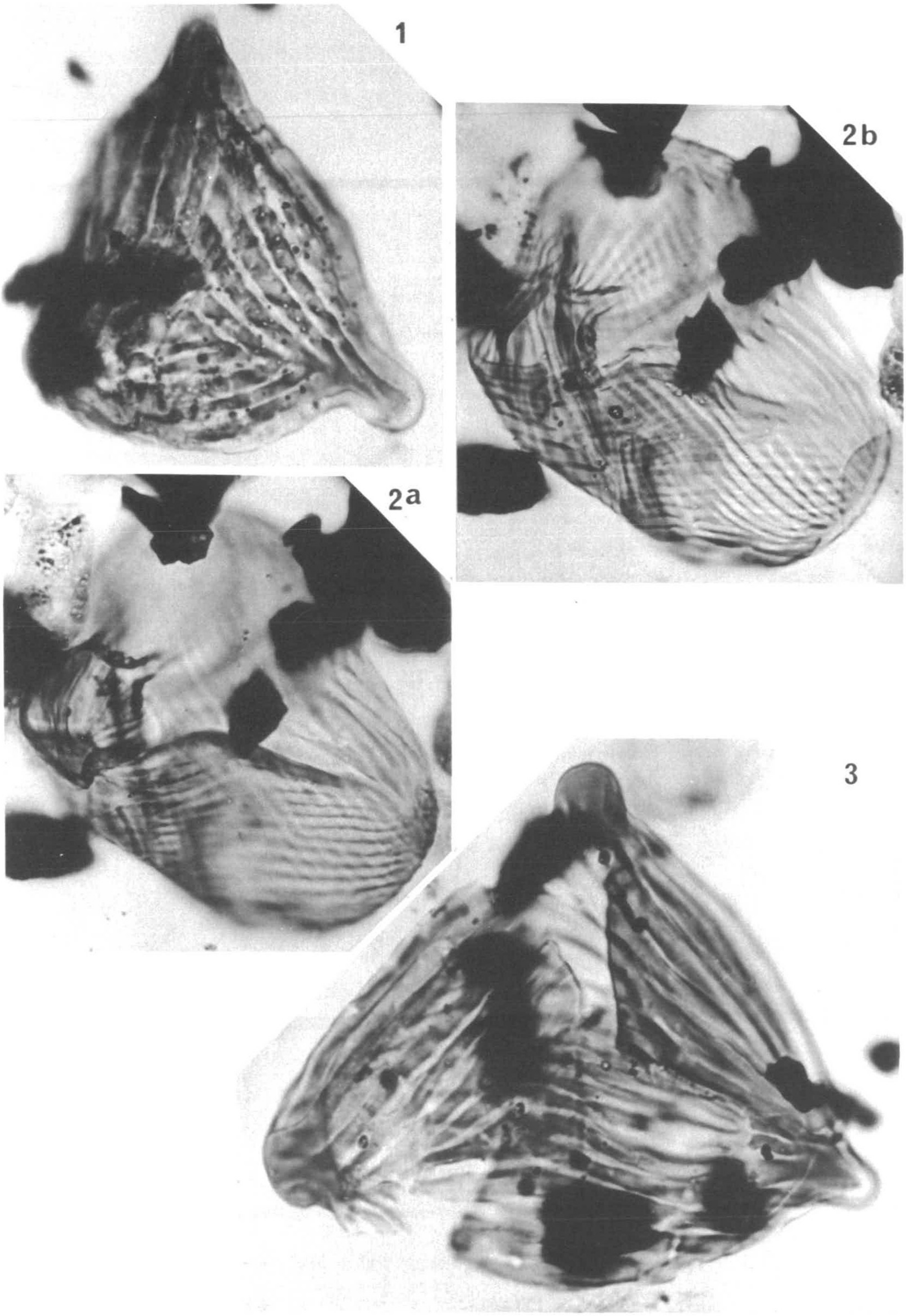
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PLATE 4
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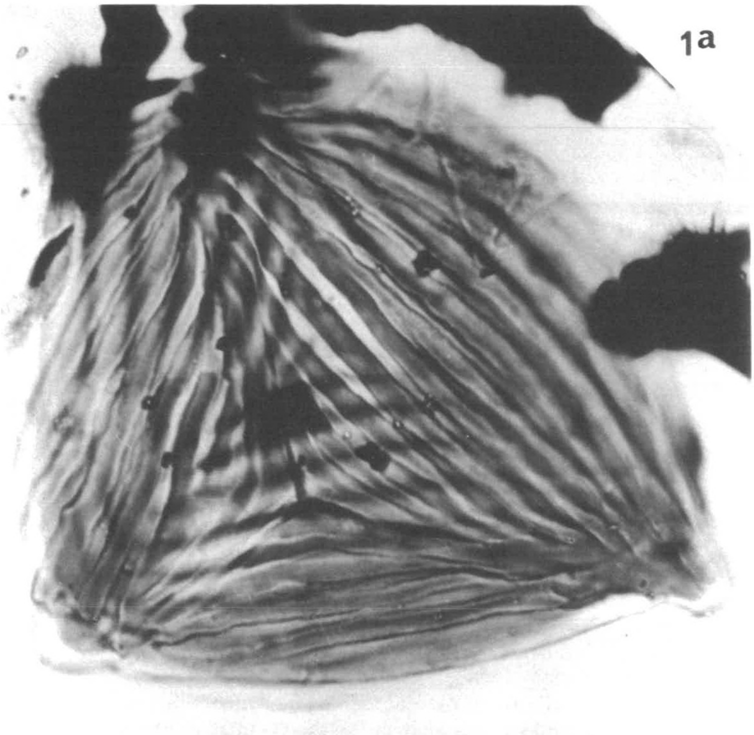
Fig. 1	*Appendicisporites* cf. *A. giganticus* Groot & Groot. Proximal and distal aspect, showing triangular pattern of striae and appendices restricted to the equatorial areas	9
	BMR Roma 1; Nullawurt Sandstone Member, 85.1 m; *Foraminisporis asymmetricus* Subzone; MFP 4330-1; 470/1144; CPC 13889.	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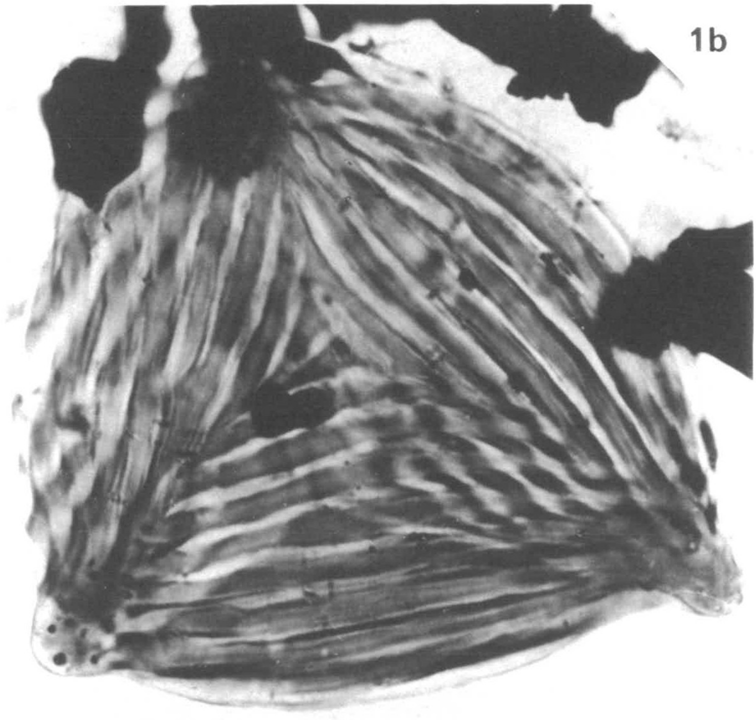
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PLATE 5
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1. BMR Roma 1; Nullawurt Sandstone Member, 85.1 m; *Foraminisporis asymmetricus* Subzone; MFP 4330-1, 375/1193; CPC 13890.
2. GSQ Surat 1; Minmi Member, 347.3 m; *Foraminisporis asymmetricus* Subzone?; MFP 5154-1, 383/1179; CPC 13901.
3. GSQ DRD 27; Minmi Member, 83.2 m; *Foraminisporis asymmetricus* Subzone?; MFP 5804-3, 320/1197; CPC 13902.

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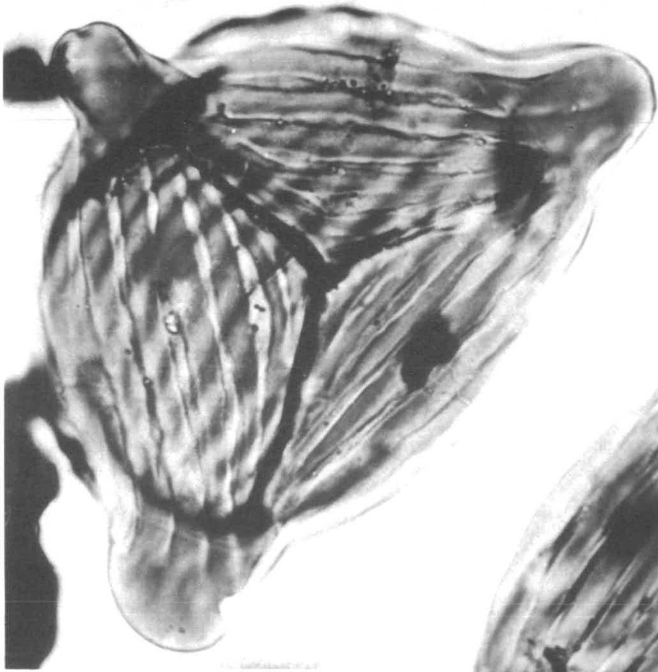

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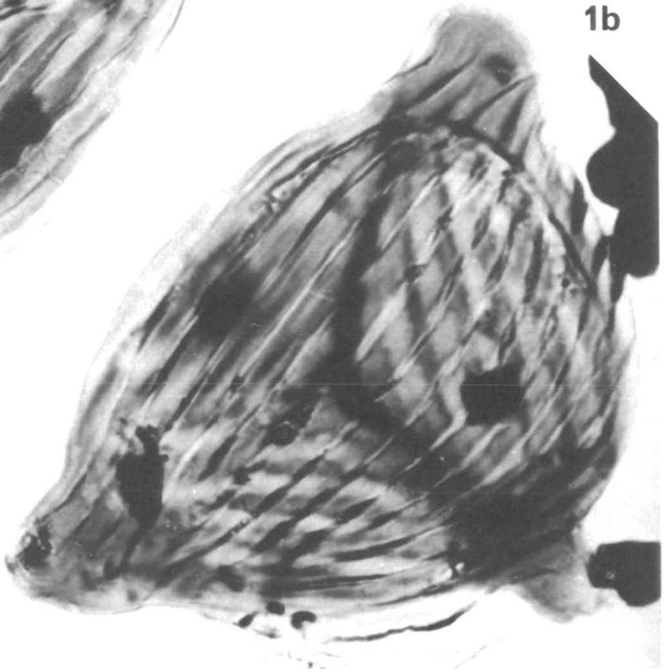

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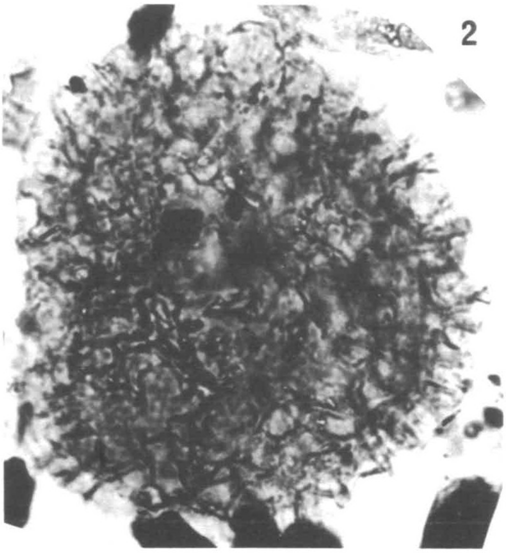

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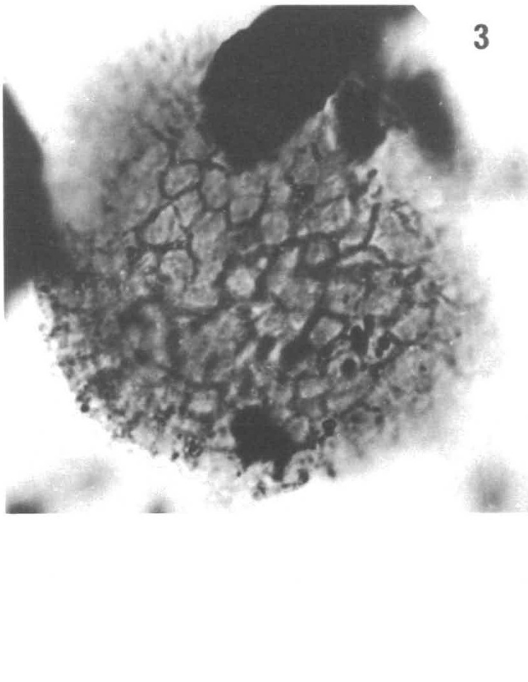

PLATE 6
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Fig. 1 *Lycopodiumsporites* cf. *L. facetus* Dettmann. Specimen damaged; stratification of sclerine distinct. a, focus on inner wall layer. b, focus on outer reticulum with high, thin muri. c, interference contrast illumination, showing spongeous nature of inner sculptine layer and outermost layer partly detached 7

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1. BMR Mitchell 11; Minmi Member, 14.6 m; palynological unit K1b-c; MFP 4276-2, 358/1064; CPC 13900.
2. A.A.O. Pickanjinnie 1; Minmi Member, 61-63 m; palynological unit K1b-c; MFP 773-1, 370/1160; CPC 13891.
3. N.A.I. Whyenbirra 1; Hooray Sandstone, 548.6 m; *Cicatricosisporites australiensis* Subzone; MFP 4270-2, 394/1085; CPC 13892.
4. **Holotype,** BMR Mitchell 11; Minmi Member, Bungil Formation, 14.6 m; MFP 4276-1, 423/1158; CPC 13893.
5. BMR Mitchell 7; Hooray Sandstone, 55.0 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4311-1, 303/1065; CPC 13894.
6. N.A.I. Whyenbirra 1; Hooray Sandstone, 548.6 m; *Cicatricosisporites australiensis* Subzone; MFP 4270-1, 345/1108; CPC 13895.

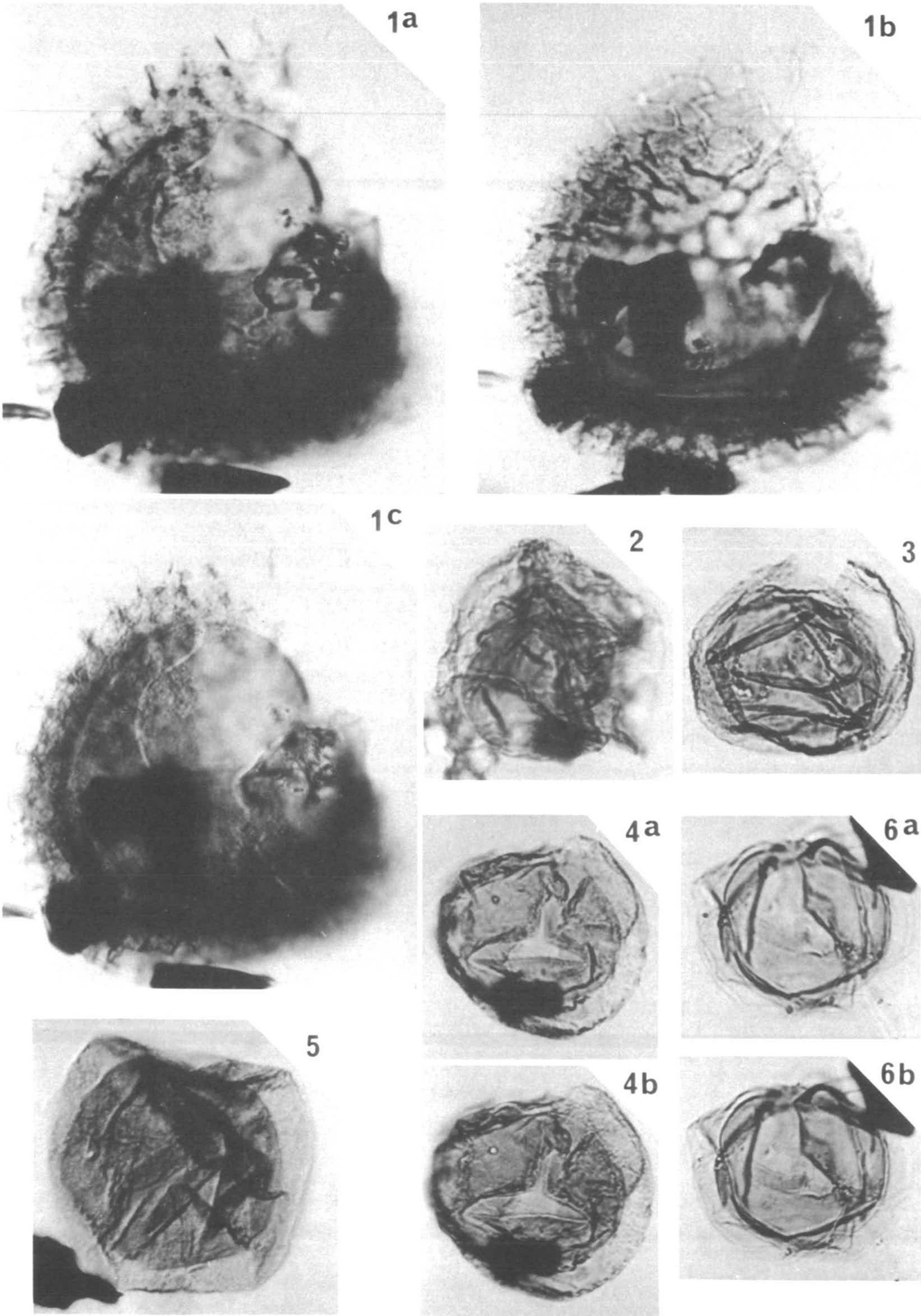
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PLATE 7
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Figs 1-3 *Crybelosporites* sp. A. 1, specimens in (incomplete) tetrahedral tetrad, specimen at right shows distinct trilete mark. b, interference contrast illumination, which enhances the trilete mark and the granulation of the outer sclerine layer. 2, single specimen, lateral view. 3, specimens united in complete tetrad. b, specimen at lower right shows opened trilete mark. c, interference contrast illumination shows specimen with opened laesurae and wall of main body folded 12

1. GSQ DRD 27; Kingull Member, 132.9 m; *Foraminisporis wonthaggiensis* Subzone; MFP 5806-2, 398/1068; CPC 13903.
2. BMR Roma 1; Minmi Member, 42.4 m; palynological unit K1b-c; MFP 4324-1, 398/1173; CPC 13904.
3. BMR Roma 1; Kingull Member, 106.1 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4460-1, 299/1058; CPC 13905.

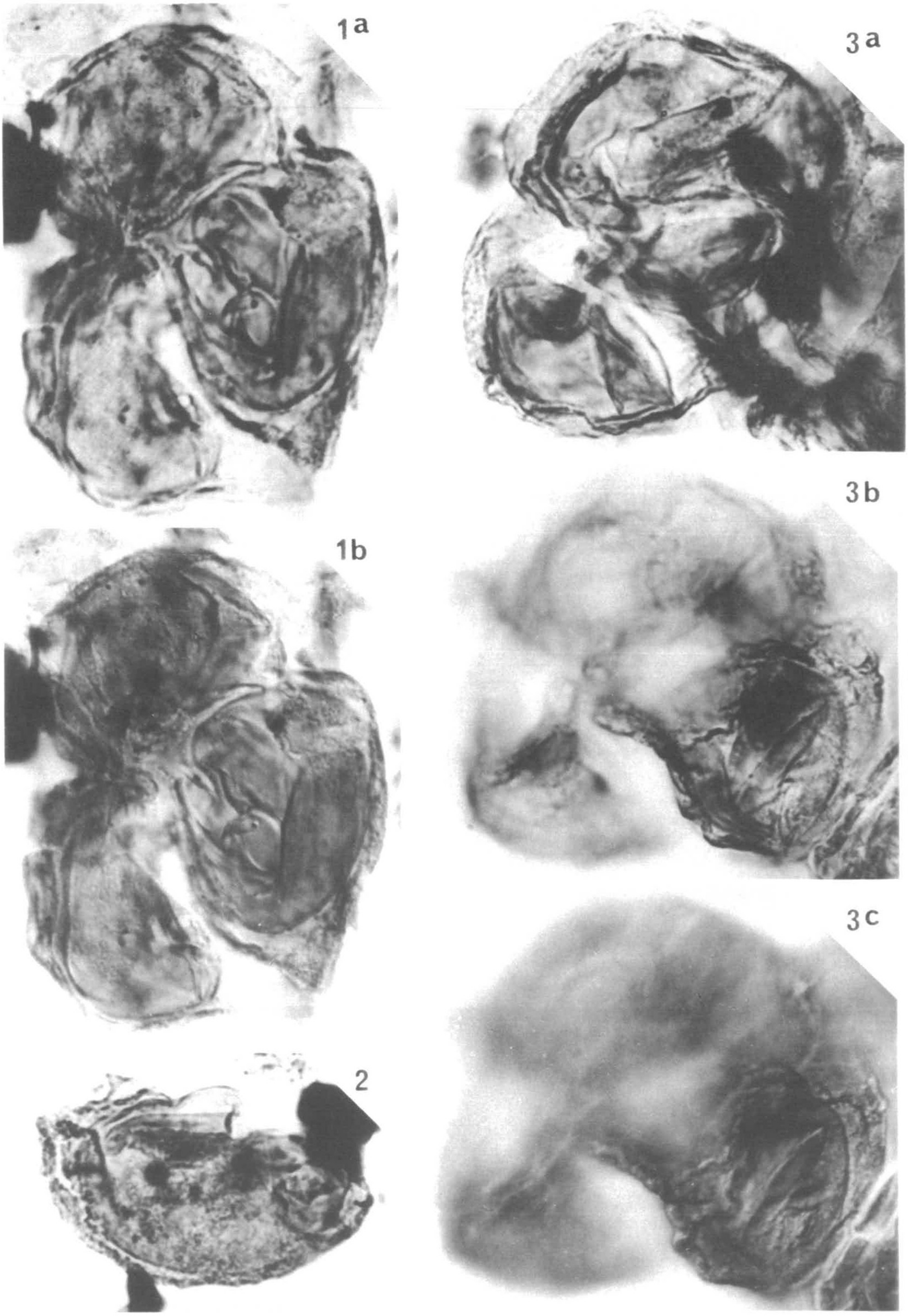
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PLATE 8
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Figs 1-3 *Crybelosporites berberioides* sp. nov. Specimens united in tetrads. 1, tetrad incomplete, specimens distinctly cavate, outer sclerine layer with minute punctation. b, focus on spore bodies, specimen at lower left shows faint trilete mark with opened laesurae. 2, specimens with outer sclerine layers wrinkled in a zigzag pattern at distal side, folds at proximal side of spores more radially oriented. 3, specimens in tetrad, showing distinct trilete laesurae and typically folded outer sclerine layer. Specimen at right indicated by arrow selected as holotype of the species. c, interference contrast illumination 11

1. BMR Mitchell 11; Minmi Member, 30.3 m; *Foraminisporis asymmetricus* Subzone; MFP 4286-1, 435/1093; CPC 13906.
2. BMR Mitchell 11; Minmi Member, 30.3 m; *Foraminisporis asymmetricus* Subzone, MFP 4286-1, 349/1046; CPC 13907.
3. **Holotype,** BMR Mitchell 11; Nullawurt Sandstone Member, Bungil Formation; 94.6 m; MFP 4289-1, 403/1192; CPC 13908.

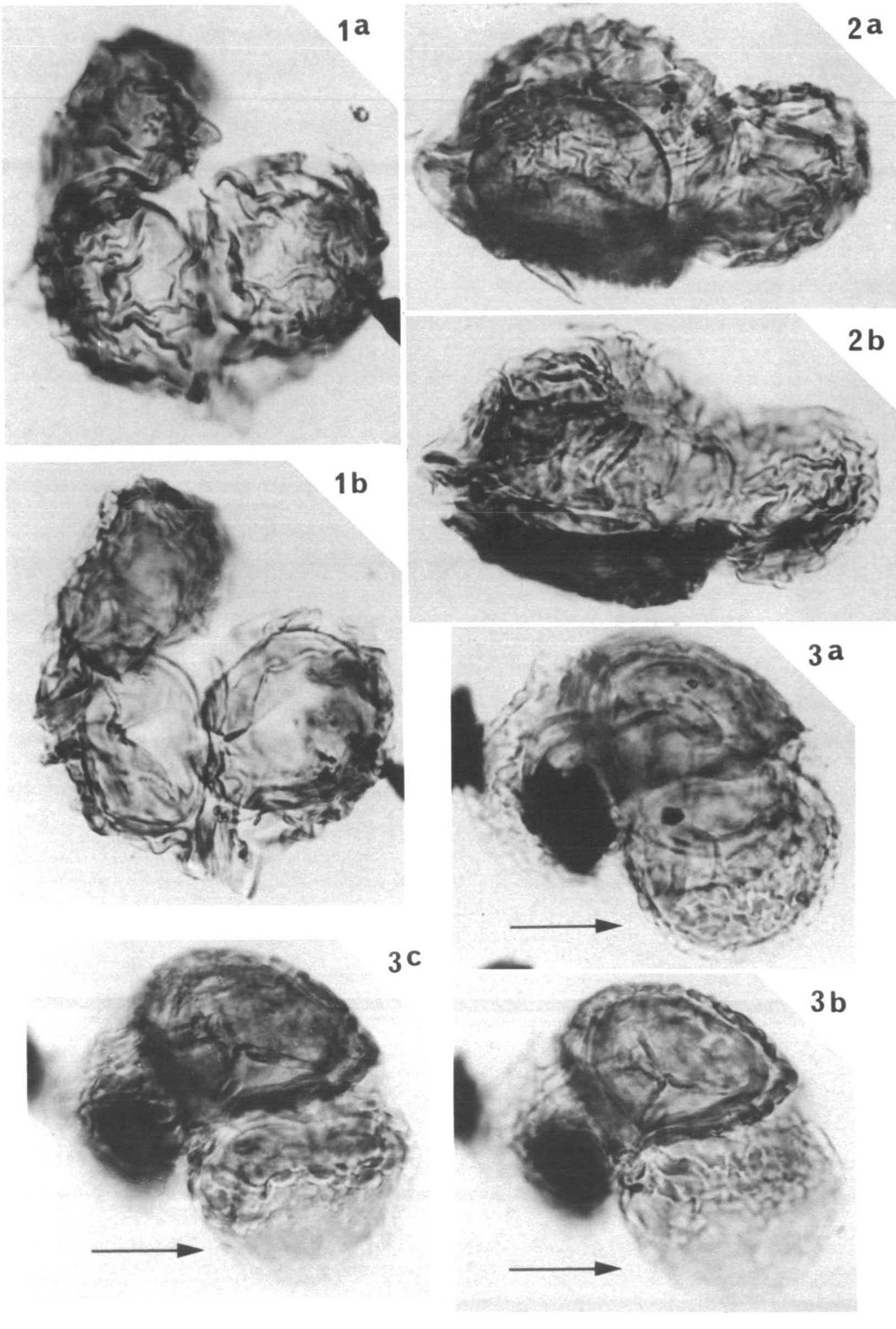
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PLATE 9

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Figs 1, 2	*Crybelosporites berberioides* sp. nov. 1a, possibly prematurely released tetrad, specimen at left showing tetrad mark. b, same specimen enlarged to show trilete laesurae. 2, single specimen, polar view, main body at proximal side ruptured along trilete mark	11
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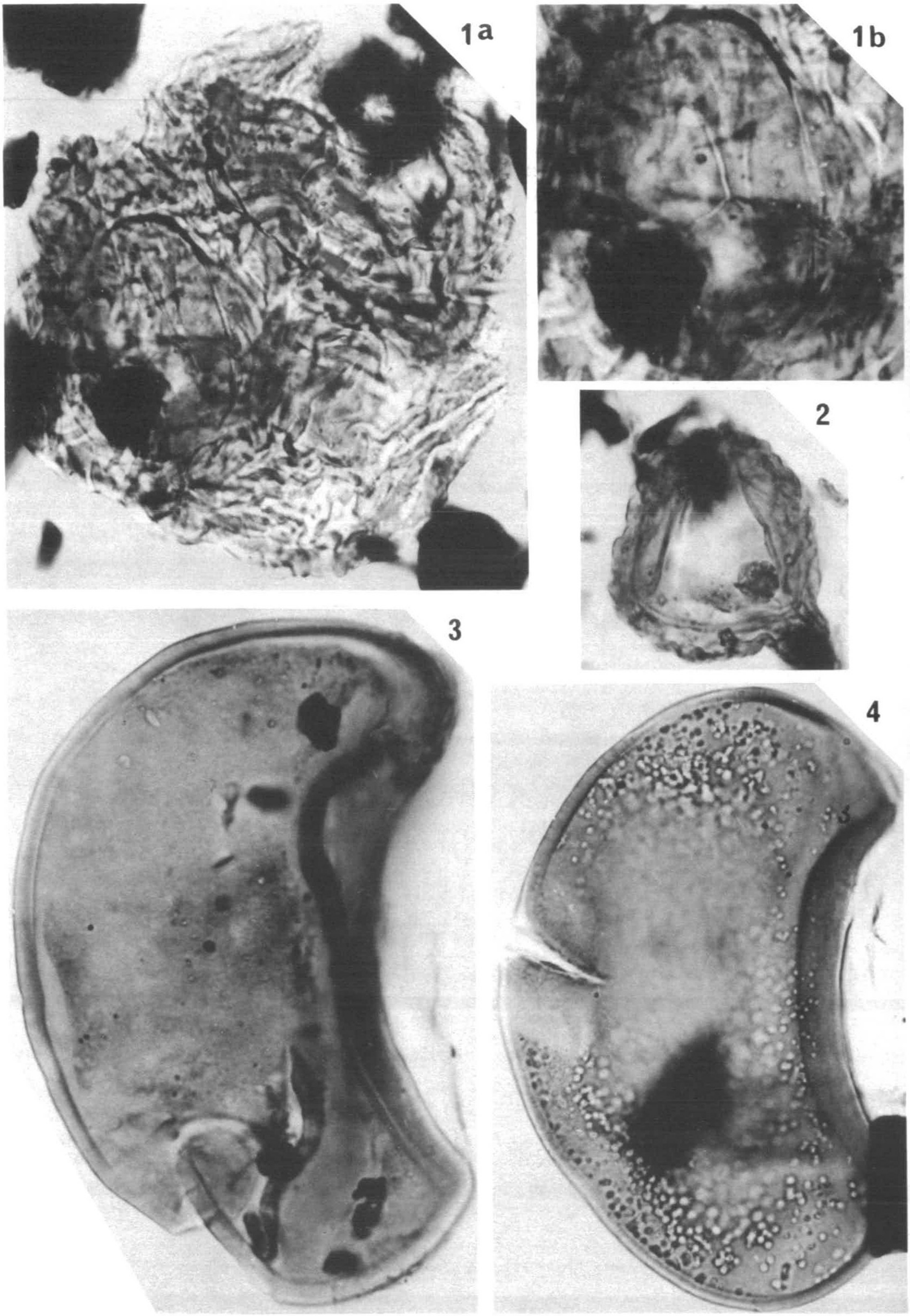
1. BMR Roma 1; Minmi Member, 16.9 m; palynological unit K1b-c; MFP 4321-1, 462/1107; CPC 13909.
2. BMR Mitchell 1; Mooga Sandstone correlate, 86.6 m; *Cicatricosisporites australiensis* Subzone; MFP 3969-2, 401/1085; CPC 13910.
3. **Holotype,** BMR Mitchell 11; Mooga Sandstone, 105.8 m; MFP 4279-1, 285/1091; CPC 13911.
4. N.A.I. Whyenbirra 1; Hooray Sandstone, 548.6 m; *Cicatricosisporites australiensis* Subzone; MFP 4270-2, 408/1144; CPC 13912.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1. BMR Jericho 1; Ronlow Beds, 26.2 m; *Foraminisporis wonthaggiensis* Subzone; MFP 5545-2, 327/1140; CPC 13913.
2. GSQ Roma 3; Bungil Formation, 160.3 m; *Cicatricosisporites australiensis* Subzone; MFP 5787-2, 437/1072; CPC 13914.
3. A.A.O. Penrith 1; Hooray Sandstone, 839.4 m; *Cicatricosisporites australiensis* Subzone; MFP 2223-2, 422/1083; CPC 13915.
4. BMR Dalby 3; Bungil Formation, 61-63 m; *Foraminisporis asymmetricus* Subzone?; MFP 5975-2, 320/1042; CPC 13916.
5. GSQ Roma 3; Bungil Formation, 160.3 m; *Cicatricosisporites australiensis* Subzone; MFP 5787-1, 368/1033; CPC 13917.
6. Conorada Ooroonoo 1; Longsight Sandstone, 785.8 m; *Murospora florida* Zone; MFP 1171-2, 394/1100; CPC 13918.
7. A.A.O. Penrith 1; Hooray Sandstone, 839.4 m; *Cicatricosisporites australiensis* Subzone; MFP 2223-2, 365/1160; CPC 13919.
8. GSQ Roma 3; Bungil Formation, 83.8 m; *Foraminisporis asymmetricus* Subzone?; MFP 5792-1, 327/1042; CPC 13920.

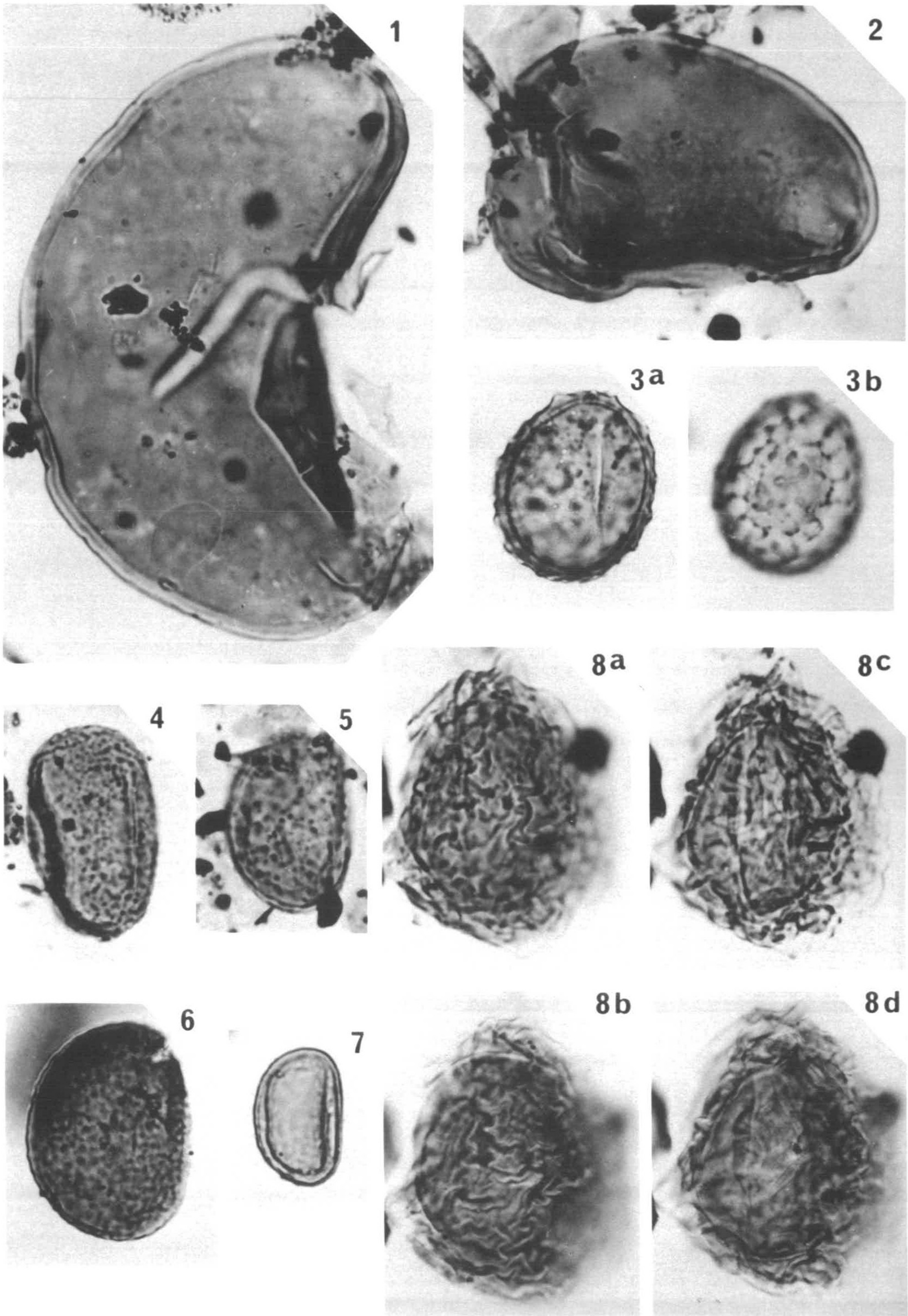
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PLATE 11
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Fig. 1	*Peromonolites* sp. A. Bilateral tetrad. b, interference contrast illumination, focus on specimen showing monolete mark	15
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1. BMR Roma 1; Minmi Member, 64.2 m; *Foraminisporis asymmetricus* Subzone; MFP 4328-1, 436/1071; CPC 13922.
2. BMR Roma 1; Mooga Sandstone, 123.9 m; *Cicatricosisporites australiensis* Subzone; MFP 4463-1, 325/1177; CPC 12923.
3. GSQ Roma 3; Bungil Formation, 160.3 m; *Cicatricosisporites australiensis* Subzone; MFP 5787-1, 236/1113; CPC 13924.
4. BMR Roma 1; Kingull Member, 93.6 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4457-2, 349/1176; CPC 13925.
5. BMR Mitchell 1; Mooga Sandstone correlate, 86.6 m; *Cicatricosisporites australiensis* Subzone; MFP 3969-2, 447/1102; CPC 13926.
6. BMR Mitchell 1; Mooga Sandstone correlate, 86.6 m; *Cicatricosisporites australiensis* Subzone; MFP 3969-1, 440/1053; CPC 13927.

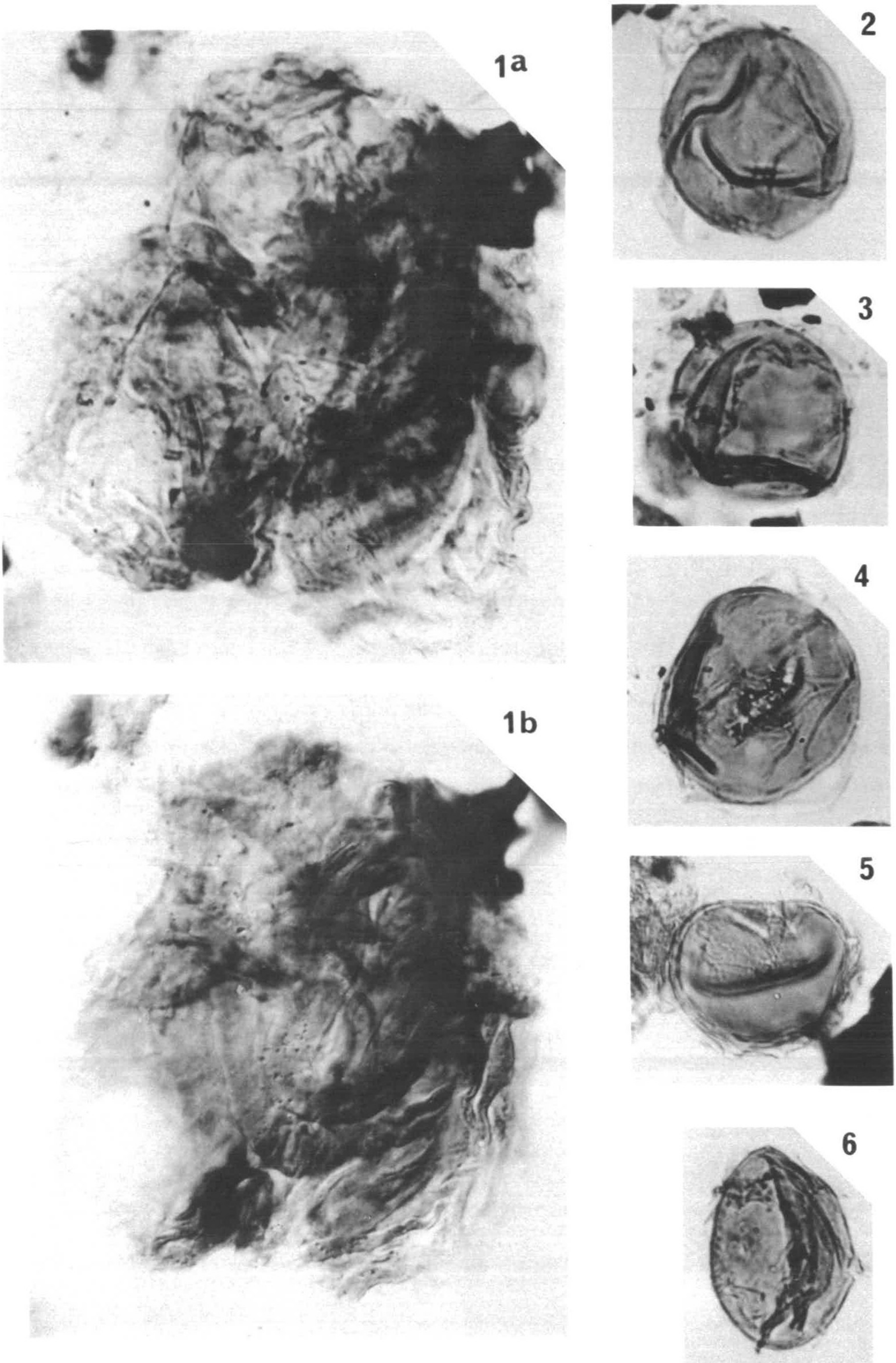
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PLATE 12
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Figs 1-5	*Concentrisporites hallei* (Nilsson) Wall. 1, body of specimen split, only fragments of outer membrane preserved. 2, unopened specimen, line of exine weakness seen crossing body diagonally from lower right. 3, specimen larger than average, body damaged. 4, 5, body split open, membrane entirely preserved	15
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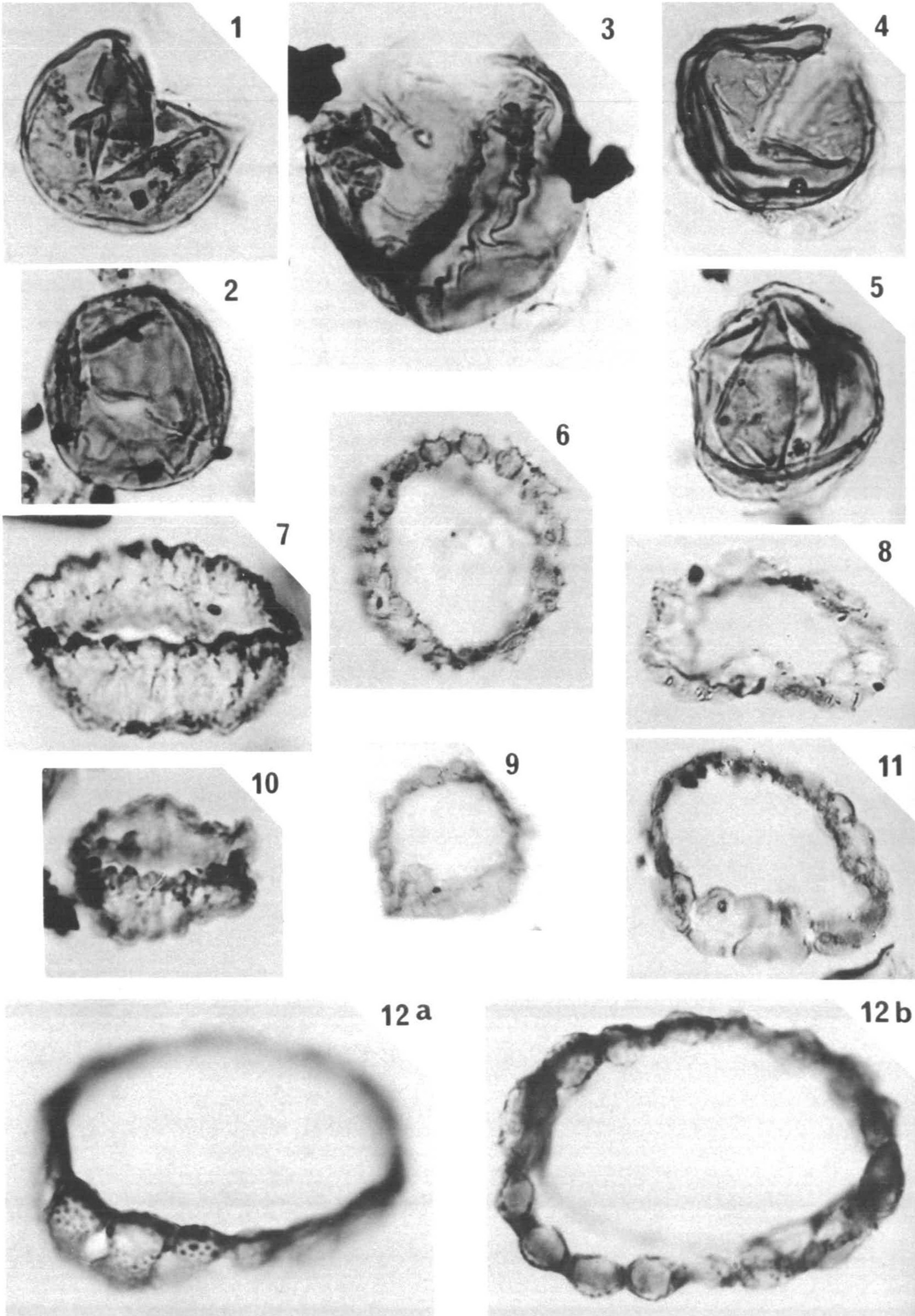
1. BMR Mitchell 11; Kingull Member, 85.8 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4278-2, 396/1064; CPC 13928.
2. GSQ Roma 3; Bungil Formation, 160.3 m; *Cicatricosisporites australiensis* Subzone; MFP 5787-1, 313/1182; CPC 13929.
3. BMR Roma 1; Minmi Member, 41.6 m; palynological unit K1b-c; MFP 4325-1, 280/1082; CPC 13930.
4. N.A.I. Whyenbirra 1; Hooray Sandstone, 487.7 m; *Foraminisporis wonthaggiensis* Subzone; MFP 4269-1, 349/1060; CPC 13931.
5. Conorada Ooroonoo 1; Longsight Sandstone, 724.2 m; *Foraminisporis wonthaggiensis* Subzone; MFP 942-1, 381/1012; CPC 13933.
6. N.A.I. Whyenbirra 1; Hooray Sandstone, 548.6 m; *Cicatricosisporites australiensis* Subzone; MFP 4270-2, 304/1152; CPC 13934.
7. A.A.O. Penrith 1; Hooray Sandstone, 839.4 m; *Cicatricosisporites australiensis* Subzone; MFP 2223-1, 307/1140; CPC 12188.
8. BMR Mitchell 1; Mooga Sandstone correlate, 105.9 m; *Cicatricosisporites australiensis* Subzone; MFP 3970-2, 264/1112; CPC 13935.
9. BMR Mitchell 1, Mooga Sandstone correlate, 105.9 m; *Cicatricosisporites australiensis* Subzone; MFP 3970-1, 263/1044; CPC 13936.
10. Amerada Newlands 1; Hooray Sandstone, 1163.7 m; *Cicatricosisporites australiensis* Subzone; MFP 4114-1, 390/1078; CPC 13921.
11. BMR Mitchell 1; Mooga Sandstone correlate, 105.9 m; *Cicatricosisporites australiensis* Subzone; MFP 3970-2, 380/1191; CPC 13932.
12. A.A.O. Penrith 1; Hooray Sandstone, 839.4 m; *Cicatricosisporites australiensis* Subzone; MFP 2223-1, 410/1162; CPC 13896.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PALYNOLOGICAL OBSERVATIONS IN THE OFFICER BASIN, WESTERN AUSTRALIA

by

ELIZABETH M. KEMP

SUMMARY

Palynological data from BMR stratigraphic drillholes and from petroleum exploration wells in the Western Australian sector of the Officer Basin have been compiled. Acid-insoluble microfossils have been recovered, in this and earlier studies, from sedimentary rocks of late Proterozoic, Early Permian, and Early Cretaceous age.

Acritarchs and abundant but unidentifiable organic detritus occur in the Babbagoola Beds and the Browne Beds, which are evaporitic sequences of probable late Proterozoic age. The Paterson Formation, of glacial, fluvioglacial, and lacustrine origin, has yielded well-preserved spore and pollen assemblages at several localities. These are referable to upper Stage 2 of the eastern Australian palynological sequence, a unit which is tentatively assigned a late Asselian to Sakmarian age. Diverse and well-preserved assemblages of spores, pollen, and microplankton have been recovered from the Cretaceous Samuel Formation, and suggest that this marine unit was deposited during the Aptian.

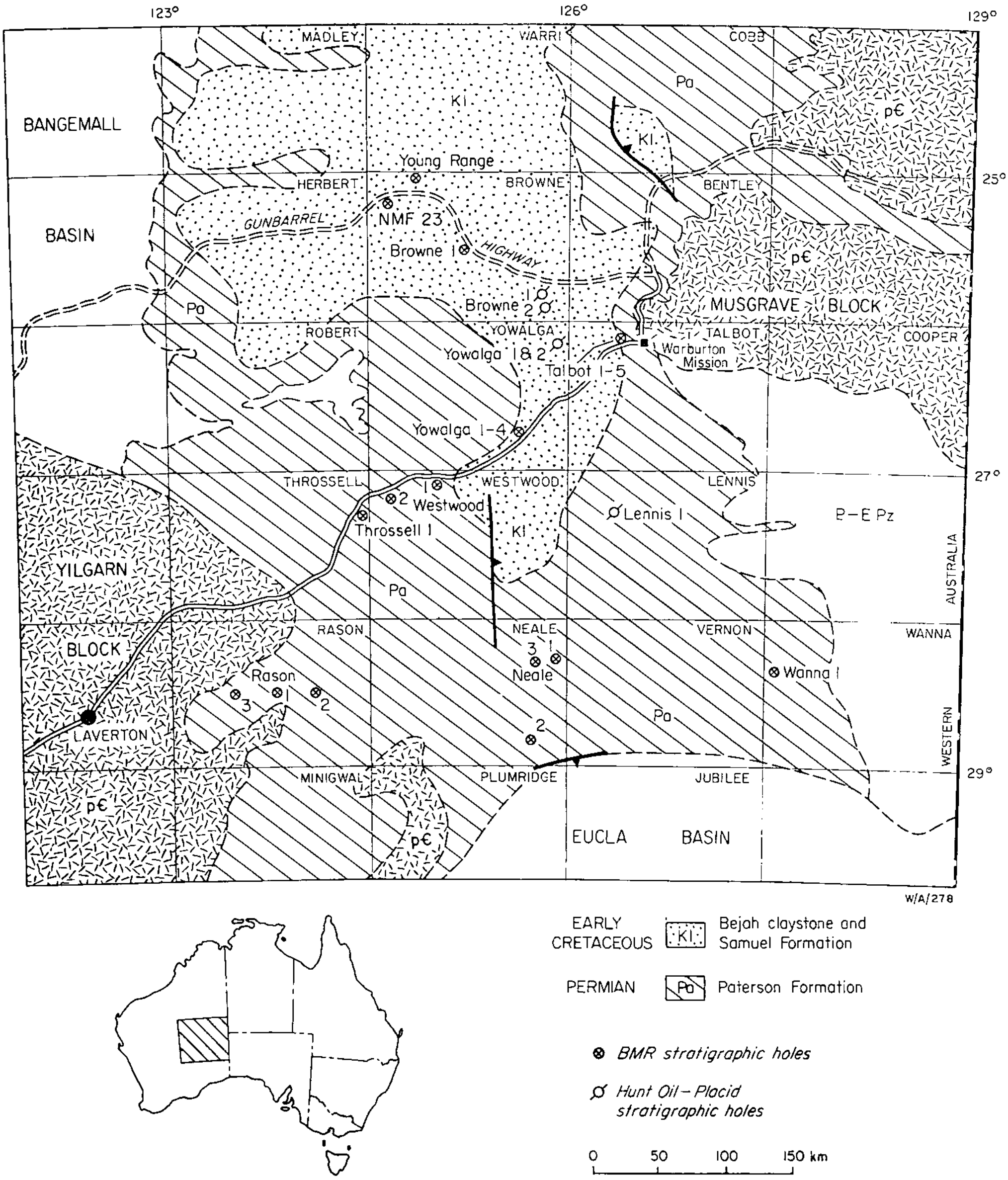

Fig. 1. Sampling localities and regional geology.

INTRODUCTION

The Officer Basin is a deep intracratonic depression that underlies the Great Victoria Desert and the southern part of the Gibson Desert, in a region extending from the northwest of South Australia through the part of Western Australia that lies east of the Yilgarn Block. In Western Australia, the basin is 'a poorly delineated, northwesterly trending structural depression, containing a little known sequence of essentially undisturbed Proterozoic and Phanerozoic rocks that lies between the Yilgarn Block to the southwest and the Musgrave Block to the northeast' (Jackson, *in* Krieg & Jackson, 1973, p. 13). The northern limit of the basin has been taken as the Warri Gravity Ridge; the Bangemall Basin forms part of its western margin, and its southern edge is hidden below the Tertiary deposits of the Eucla Basin.

The sedimentary sequence may reach a thickness of 12 000 m near the centre of the basin, according to preliminary seismic data (Harrison & Zadoroznyj, in prep.). Most of the sequence is probably of Proterozoic age, and is as yet known in broad outline only. Summaries of the distribution of rock units in this part of the sequence have been given by Jackson (*in* Krieg & Jackson, loc. cit.), and the units within it were defined formally by Lowry et al. (1972). A Lower Palaeozoic sequence overlies the Proterozoic, and crops out in the southeast of the basin. It includes shallow marine sandstone and siltstone overlying a basal volcanic unit, the Table Hill Volcanics, that has been isotopically dated, though not unequivocally, as Early Cambrian (Compston, 1974).

Upper Palaeozoic and younger rocks form a flat-lying cover over much of the Western Australian part of the Officer Basin. The sequence is essentially continuous with successions in the southern part of the Canning Basin. It consists of fluvio-glacial and lacustrine deposits of Early Permian age, referred to the Paterson Formation, disconformably overlain by a marine Cretaceous sequence comprising the Samuel Formation and Bejah Claystone. Cainozoic alluvial and colluvial deposits cover some 80 percent of the basin area.

The history of geological reconnaissance in the Officer Basin dates back to 1916 (see Krieg & Jackson and Lowry et al. for details of the geological exploration history). The whole basin, however, was not systematically mapped until the early 1970s, when a program of mapping, stratigraphic drilling, and gravity and seismic surveys was carried out by the Bureau of Mineral Resources and the Geological Survey of Western Australia. Correspondingly, palaeontological studies in the basin have been few. In the Phanerozoic part of the sedimentary sequence, the Lower Palaeozoic formations are apparently unfossiliferous. The Upper Palaeozoic Paterson Formation does not appear to contain diagnostic macrofossils, although problematic structures that may indicate polychaete worm activity were identified as *Tasselia* sp. by Cockbain (1973, unpubl.). There is, however, some doubt as to whether these fossils are in fact from the Paterson Formation. The Cretaceous sequences contain relatively rich macrofossil suites, chiefly molluscs, that have been described in some detail by Skwarko (1967 and earlier).

Microfossils also have been little studied. Rare, poorly preserved radiolaria were described by Lloyd (1963) from outcrop samples of the Bejah Beds. The first palynological examination of Officer Basin material was by Evans (quoted in Wells, 1963), who examined samples of the Paterson and Samuel Formations from seismic shotholes on the Browne Sheet area (Fig. 1), but did not list the species present. Further palynological work was undertaken when the Hunt Oil-Placid Oil consortium instituted a petroleum exploration program in the Western Australian part of the basin in 1965-66. Studies made by Balme during this period (reported in Jackson, 1966a, 1966b) included examination of cores from the Proterozoic and Permian sections in Yowalga No. 2 well.

Material examined in the present study comes from the Hunt Oil wells Yowalga 1 and Browne 1 and 2, and from the BMR shallow stratigraphic holes Wanna 1, Neale 2, Rason 2, and Browne 1. In addition, unsuccessful attempts were made to recover palynomorphs from the BMR holes Throssell 1, Westwood 2, Talbot 4, Neale 1, and Yowalga 4. The locations of these sites are shown in Figure 1. Lithological and palaeontological details of all samples examined are shown in Appendix I.

ACKNOWLEDGMENTS

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PROTEROZOIC

Rocks of probable Proterozoic age constitute the major part of the sedimentary pile in the Officer Basin in Western Australia. The upper part of the Proterozoic section contains evaporitic sequences that may be up to 5000 m thick; however, the ages of the lithological units and their relationships with each other remain obscure.

Acid-insoluble microfossils were reported by Balme (*in* Jackson, 1966a) from core samples cut between 887 and 989 m in the Hunt Oil-Placid Oil Yowalga 2 well, in a sequence which has been interpreted as being largely of evaporitic origin. The microfossils were recovered from grey laminated shales in an interval that is now referred to as the Babbagoola Beds (Lowry et al., 1972). Balme reported that all cores in this interval yielded simple but well-preserved leiospheres; one group of microfossils from the assemblage was, however, tentatively compared to the acanthomorph acritarch genus *Michrystridium.* The assemblages were considered by Balme to show some similarity to those known from Riphean (late Proterozoic) sequences in the USSR. A younger age was considered less likely on the somewhat negative evidence of the absence of characteristic Early Palaeozoic microfossils.

From dolomitic stromatolites cropping out on the western edge of the Madley Sheet area, M. Norvick (unpublished BMR files) recovered a variety of acid-insoluble microfossils. These included irregular branching filaments, and small spheres (some perforate) which are either discrete, in clusters, or in strings.

In the present study, core material from an evaporitic sequence referred to as the Browne Beds (Lowry et al., 1972) was examined from the Hunt Oil-Placid Oil Browne 1 and 2 wells, the only localities from which this particular sequence is known. The age of the unit is unknown, although it appears to be Proterozoic, and on regional considerations, probably underlies the Babbagoola Beds. Core 3 from Hunt Oil Browne 1 (256-259 m) was cut from a limestone, shale, and gypsum interval, and, although it yielded no recognizable palynomorphs, did contain an abundance of organic material. This shows some degree of organization; rare roughly circular bodies may be plant cells, and there are diffuse, rather spongeose aggregates that may be tissue fragments. In Hunt Oil Browne 2 well, similar though less abundant organic material was recovered from the deepest sample in Core 2 (260 m). None of this material was as organized as that from Yowalga 2 or from outcrop. No age determination is possible from it, but its presence is noteworthy in view of the supposed Proterozoic age of the beds.

PERMIAN

Distribution and previous studies

Upper Palaeozoic rocks in the Western Australian section of the Officer Basin are referred to the Paterson Formation, as they are regarded as being continuous with, and lithologically similar to, the formation of that name in the southern Canning Basin (Wells, 1963; Lowry et al., 1972). The Paterson Formation is essentially flat-lying, and contains diamictite, coarse sandstone, and laminated siltstones and claystones, some with dropstones.

The formation was penetrated in the Yowalga 1 & 2 and Browne 1 & 2 wells, drilled in the central part of the basin by Hunt Oil-Placid Oil in 1965 and 1966. At these sites the formation is 300 to 370 m thick. Subsequently, shallow stratigraphic drilling by BMR in 1972 penetrated the formation in the southern areas of its distribution—on the Rason, Neale, and Wanna Sheet areas (see Fig. 1). The shallow borehole BMR Browne 1 also probably penetrated the top of the formation, although this could not be confirmed palaeontologically.

The first report of palynomorphs from the Paterson Formation in the Officer Basin was made by Evans (quoted in Wells, 1963), who examined a core sample from a BMR seismic shothole near the National Mapping trig. station NMF 23, some 45 km west of Mount Everard in the Browne Sheet area. Evans did not list the species present in this sample, but reported that the spore assemblage indicated equivalence with part of the Grant Formation in the Fitzroy Trough, equating it with the *'Nuskoisporites'* assemblage of Balme.

Spore and pollen assemblages from what is now referred to as the Paterson Formation were examined further by Balme (*in* Jackson, 1966a, summarized in Jackson, 1966b). Balme described a microflora from cuttings recovered from the Yowalga 2 well, at depths of 306 and 384 m, from lithic sandstones which were then referred to the 'Yowalga Formation'. Balme listed some ten palynomorph form-species from the cuttings, and assigned an Early Permian (Sakmarian) age to the unit. He noted the presence of rare spinose acritarchs, and very tentatively suggested that these might indicate some marine influence.

In the present study, spore assemblages were recovered from the Paterson Formation from the Hunt Oil-Placid Oil wells Browne 1 and 2 and Yowalga 1. Core samples from BMR stratigraphic holes Wanna 1, Neale 2, and Rason 2 were also productive. The core sample examined by Evans from the seismic shothole at NMF 23 was re-examined, and is described in detail here. Species lists for all samples are shown in the accompanying Table 1; the species listed by Balme from Yowalga 2 are also included in this table. Samples of supposed Paterson Formation from the base of BMR Browne 1 were examined, but proved barren.

Composition of microfloral assemblages

Microfloral assemblages recovered from all localities in the Paterson Formation are basically similar, and all are referable to Stage 2 of the Permo-Carboniferous zonal scheme established by Evans (1969). Assemblages characteristic of this unit are distinguished by a high frequency of monosaccate pollen, referred here to three genera—*Potonieisporites, Parasaccites,* and *Caheniasaccites;* by a low frequency (around 1-2 percent) of disaccate striatitid pollen; and by a distinctive suite of trilete spores, many of which belong to undescribed species. This relatively broad assemblage zone was subdivided by Norvick (1971, and in prep., 1974), into Lower and Upper Stage 2 units on the basis of spore and pollen distribution

LOCALITY DEPTH	YOWALGA 1-C1 181-184m	YOWALGA 1-C3 362-365m	YOWALGA 2- Cuttings 306m	YOWALGA 2- Cuttings 384m	BROWNE 1- C1 112-115 m	BROWNE 2-C2(a) 257m	BMR WANNA 1-C1 30·32m	-C1 30·58m	-C1 30·78m	BMR NEALE 2-C1 56·69m	-C1 56·99m	-C1 58·21 m	BMR RASON 2-C1 99·21m	-C2 110·95m	-C3 143·36m	NMF 23 -127-130m
MFP No	3892	3893			3889	3902	5971	6147	5972	5970	5939	6137	6132	6133	6136	2414
NON-SACCATES																
Punctatisporites gretensis Balme and Hennelly	X	X			X	X	X	X	X	X	X	X	X	X	X	X
Punctatisportes sp.	X	X	X	X						X	X					
Phyllothecotriletes sp. 10	X	X			X							X	X	X		
Phyllothecotriletes sp. 7																X
Phyllothecotriletes sp.																
Calamospora microrugosa (Ibrahim)		X			X	X	X	X			X	X			X	X
Calamospora sp. 58	X												X	X		X
Retusotriletes diversiformis (Balme and Hennelly)	X	X			X	X	X							X		X
Cyclogranisporites sp. 107					X									X		X
Baculatisporites aff. sp. 109							X							X		
Leiotriletes directus Balme and Hennelly	X		X	X	X	X			X					X		
Microbaculispora tentula Tiwari	X	X	?	?	X		X	X	X	X	X	X	X	X	X	X
Apiculatisporis levis (Balme and Hennelly)	X				X			X		X		X	X	X	X	X
Apiculatisporis sp. 62					X		X					X	X	X	X	X
Apiculatisporis sp. 908		X											X		X	
Lophotriletes sp. 64	X	X			X		X	X	X	X		X		X	X	X
Neoraistrickia ramosa (Balme and Hennelly)	X			X	X		X	X		X		X	X	X		X
Granulatisporites micronodosus (Balme and Hennelly)													X	X		cf
Verrucate trilete spore sp. 1107		X														
Rugulatisporites sp. 22	X	X							X				X			
Densoisporites solidus Segroves													X	X	X	
Dentatispora sp.	X				X		X					X	X	X		
Patellasporites sp.													X	X	X	
Vallatisporites aff. sp. 57	X															
aff. *Gondisporites* sp.	X													X		
aff. *Cristatisporites* sp.	X	X														
Densosporites cf. *rotundidentatus* Segroves																X
Monocolpate pollen sp. 186	X	X			X		X	X	X	X	X	X	X	X	X	X
Laevigatosporites sp. A Segroves										X						X
Marsupipollenites triradiatus Balme and Hennelly												X	X	X		
SACCATES																
Parasaccites gondwanensis (Balme and Hennelly)					X				X			X	X	X	X	X
Parasaccites cf. *V. mehtae* Lele	X							X				X		X		
Parasaccites spp.	X		X	X		X	X	X		X	X					
Potonieisporites neglectus Potonié	X	X		cf	cf		X	cf.				X	X			X
Caheniasaccites ovatus Bose and Kar	X							X	X	X						X
Vestigisporites sp.														X		X
Sulcatisporites ovatus (Balme and Hennelly)														X	X	X
Protohaploxypinus goraiensis (Pot and Lele)	X			cf				X				X	X	X		X
Protohaploxypinus limpidus (Balme and Hennelly)								X		X		X	X	X		
Protohaploxypinus sp.														X		
Striatoabietites aff. *multistriatus* Balme and Hennelly													X			
Vittatina subsaccata Samoilovitch													X	X		
Vittatina sp.												X			X	X
ACRITARCHS																
Peltacystia venosa Segroves	X															
Tasmanites punctatus Newton	X							X								
Leiosphaeridia sp.			X	X	X				X	X	X	X	X	X		X
fusiform acritarch	X	X							X	X		X			X	
Veryhachium sp.													X	X		
Cymatiosphaera sp.													X			
Botryococcus sp.	X		X		X		X	X					X		X	X

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TABLE 1. DISTRIBUTION OF PALYNOMORPHS IN PATERSON FORMATION SAMPLES. (MFP Nos. refer to BMR Palynological Collection).

in the Galilee Basin of Queensland. The younger of these two units is characterized by the incoming of the distinctive trilete species *Microbaculispora tentula* Tiwari (= BMR species 59) and *Granulatisporites micronodosus* Balme & Hennelly; by undescribed species of *Lophotriletes* and *Apiculatisporis* (referred to here as *L.* sp. 64, and *A.* spp. 81 and 908 in the terminology of the BMR species index); and by monocolpate pollen (species 186; probably conspecific with *Cycadopites cymbatus* Balme & Hennelly). Upper Stage 2 is distinguished from the overlying Stage 3 palynological zone by its lower frequency of disaccate striatitid pollens, and by the absence of Zone 3 index fossils.

All Paterson Formation assemblages from the Officer Basin fall within Norvick's Upper Stage 2. As well as the characteristic abundance of monosaccate pollens and the low disaccate striatitid frequency, all contained *M. tentula,* usually in significant quantities. Monocolpate pollen sp. 186 was present in most samples, in abundances ranging up to 20 percent of the total assemblage in samples from Wanna 1. (Monocolpate forms were not, however, noted by Balme in the Yowalga 2 samples.)

The three core samples examined from BMR Rason 2 differ slightly from the others examined. The assemblages recovered contain marginally higher frequencies and a greater diversity of disaccate striatitid pollen. Also, specimens referable to the genus *Vittatina* were identified. Some of these forms display rudimentary sacci, and are referable to *V. subsaccata* Samoilovitch; others which lack sacci but are identical in all other respects are probably members of the same morphological series. The Rason 2 samples also yielded *Marsupipollenites triradiatus* Balme & Hennelly. The overall composition of the assemblage suggests that the youngest part of Upper Stage 2 is here represented, possibly equivalent to an interval which Norvick (1971) designated Association B.

Evidence for marine depositional conditions in the Paterson Formation is weak. Balme recorded the rare occurrence of the acritarch *Michrystridium* in Yowalga 2; no representatives of the genus were observed in the present survey. Rare specimens of a species of *Veryhachium,* which is again usually associated with marine beds, were, however, noted in the Rason 2 cores. No other localities yielded any palynomorphs which could confidently be interpreted as indicative of marine or near-marine depositional conditions.

Non-spinose acritarchs, which are probably of algal affinity but are not necessarily marine indicators, are present in all samples. A large intensely folded leiosphere (>100 μm diameter) occurs in nearly all samples; a fusiform, hyaline form identical with that figured by Kemp (1975, pl. 1, fig. 13) from the Talchir Formation of the Salt Range of Pakistan, occurs in a number of samples. Very rare specimens of *Tasmanites punctatus,* which were observed in Yowalga 1 and Wanna 1 samples, possibly point to at least a brackish depositional regime during part of the sequence, although there is no unanimity of opinion concerning the habitat of this probable green alga (Brooks, 1971).

Correlation and age

Palynomorph assemblages similar to those of the Paterson Formation are known in Western Australia from the lower part of the Grant Formation in the Fitzroy Trough (where Balme, *in* Johnson, 1968, referred them to his '*Nuskoisporites* II' microfloral unit), and from the upper part of the glacial Nangetty Formation in the Perth Basin (where they were described by Segroves (1972) as the '*Microbaculispora*' assemblage). In South Australia they occur below the Eucla

Basin (in the Denman Basin of Wopfner, 1973) in sediments that bear some glacial imprint; in the Troubridge Basin (Harris & McGowran, 1971); and in the Merrimelia Formation of the Cooper Basin (Paten, 1969). In the Northern Territory, microfloras from the possibly fluvioglacial Crown Point Formation appear closely similar to those from the Paterson Formation (Evans, 1964), although the former may be marginally younger. For eastern Australia, the distribution of Stage 2 microfloras was reviewed by Evans (1969), although at that time Upper Stage 2 had not been recognized as a separate sub-unit.

The age of Stage 2 in terms of the standard Russian sequence is probably earliest Permian. In the Perth Basin, the Upper Stage 2 microfloras are overlain by the Holmwood Shale, which on ammonoid evidence is considered to be late Asselian. The same age relationships hold in the Sydney Basin, where Stage 2 microfloras occur with Allandale faunas. These are again considered to be of late Asselian or early Sakmarian age. On this somewhat meagre evidence, it seems likely that the Stage 2 palynological unit can be correlated with the Asselian or early Sakmarian stages of the Russian terminology.

CRETACEOUS

In the Officer Basin, Cretaceous sediments occur as flat-lying, commonly deeply-weathered deposits that crop out in the northern part of the basin. Two lithological units have been recognized and formally defined within the Cretaceous sequence (Lowry et al., 1972). The older, the Samuel Formation, consists of laminated to thin-bedded medium-grained sandstone, siltstone, and claystone. It is conformably overlain by the Bejah Claystone, a dominantly white claystone with some intercalated sandstone. Both have been interpreted as having been deposited under shallow marine conditions. The molluscan fauna suggests an Aptian age (Skwarko, 1967). Radiolaria have also been recognized within the Cretaceous sequence (Lloyd, 1963). None of these fossils, however, could be used to give a more precise age.

The shallow stratigraphic hole BMR Browne 1 was drilled to provide a reference section for the Bejah Claystone and the Samuel Formation, and to penetrate the upper part of the Paterson Formation. In the present study, all these units in this borehole were examined for palynomorphs, but sampling was concentrated in the lower part of the Samuel Formation. Both the Bejah Claystone and the upper part of the Samuel Formation proved, after maceration, to be barren of palynomorphs; the cream and yellow coloration of the claystones and siltstones above 70 m suggests that they may have been weathered or leached down to this depth. These processes would destroy any organic remains which might have been present originally.

The dark grey carbonaceous siltstone and claystone penetrated between 70 and 109 m proved to be richly fossiliferous: most samples yielded abundant and well-preserved spores, pollen, and microplankton of Early Cretaceous age. The assemblage is uniform throughout the sequence, apart from quantitative differences in the proportions of spores and microplankton. Palynological analysis is in accord with the Aptian age suggested by the marine invertebrates; the spore and pollen assemblages add little to this determination, but the microplankton suggest that the sequence may be of late Aptian age. Samples below 109 m are predominantly sandy, and have been interpreted as Paterson Formation; but they proved barren of acid-insoluble microfossils.

In addition to the samples from BMR Browne 1, a sample from a seismic party waterbore near Charlies Knob in the Young Range, in the extreme north of the Browne Sheet area, was examined. This yielded further well-preserved palynological material, similar in composition to that of the Browne samples. The occurrence of palynomorphs of Aptian age (including marine forms) from this sample was reported by Evans (*in* Wells, 1963), although no compositional details were given. Lists of spore, pollen, and dinoflagellate species recorded from the two localities in the course of the present study are given in Tables 2 and 3.

Spores and pollen

Sequences of Early Cretaceous age in Australian sedimentary basins have been subdivided, on the basis of their spore and pollen content, into a number of assemblage zones (Dettmann, 1963; Balme, 1964; Evans, 1966a; Dettmann & Playford, 1969; Burger, 1973). Some measure of age control on the palynological zonal units is provided by marine invertebrates in the Great Artesian Basin sequences, so that the palynological units can be expressed very broadly in terms of European stage terminology.

For eastern Australia, Dettmann & Playford have recognized three palynological subdivisions within the Early Cretaceous; these they termed the *Crybelosporites stylosus, Dictyotosporites speciosus,* and *Coptospora paradoxa* Zones, which span an interval extending from the early Neocomian to approximately the top of the Albian. An independent scheme was proposed by Burger (1973), because of the rarity of the nominate species of the Dettmann & Playford Zones at many localities. Burger gave the name *Murospora florida* Zone to the interval extending, in Great Artesian Basin sequences, through the Neocomian into the Aptian. He further subdivided this unit into three subzones, which he called the *Cicatricosisporites australiensis, Foraminisporis wonthaggiensis,* and *F. asymmetricus* Subzones. It appears from Burger (op. cit., p. 103), that the uppermost, the *F. asymmetricus* Subzone, corresponds in time to the older part of the *Dictyotosporites speciosus* Zone of Dettmann & Playford.

The spore and pollen assemblage recovered from the Samuel Formation in the course of the present study is a diverse one. Saccate pollen grains of probable podocarpaceous origin dominate the samples; these are referable to the form species *Microcachryidites antarcticus* Cookson, *Podosporites microsaccatus* (Couper), and *Podocarpites ellipticus* Cookson. Fern spores are common and diverse; the presence of the schizaeaceous types *Cicatricosisporites australiensis* Cookson, *C. ludbrooki* Dettmann, *C. hughesi* Dettmann, and *Appendicisporites* sp. is noteworthy in this group, although species of *Gleicheniidites* and *Cyathidites* are more abundant. *Classopollis torosus* Reissinger, of coniferous affinity, is present in all samples, although never in quantity. Cycadophyte pollen is rare. Such a composition suggests a parent vegetation growing under conditions which were certainly more humid, and possibly warmer, than at present, although conclusions concerning temperatures are speculative.

The most stratigraphically useful elements are among the rarer trilete spores. Included in this group are *Foraminisporis dailyi* (Cookson & Dettmann), *F. wonthaggiensis* (Cookson & Dettmann), *Kuylisporites lunaris* Cookson & Dettmann, *Murospora florida* Balme, *Pilosisporites notensis* Cookson & Dettmann, *Trilobosporites purverulentus* (Verbitskaya), and *Cyclosporites hughesi* Dettmann. With the exception of *Cyclosporites hughesi,* none of the nominate forms of Dettmann & Playford's zonal scheme were identified, although some of the subsidiary elements that are used to define these units were present.

Analysis of the spore assemblage from the Samuel Formation suggests that an

SPORES	BMR BROWNE 1 DEPTH 70.41m MFP Nº 6248	BMR BROWNE 1 73.46m 6250	BMR BROWNE 1 78.64m 6249	BMR BROWNE 1 84.43m 6292	BMR BROWNE 1 89.00m 6254	BMR BROWNE 1 90.83m 6255	BMR BROWNE 1 95.71m 6259	BMR BROWNE 1 99.14m 6251	BMR BROWNE 1 100.89m 6260	BMR BROWNE 1 106.68m 6293	BMR BROWNE 1 108.20m 6252	BMR BROWNE 1 108.97m 6261		YOUNG RANGE 81.83m 2413
Appendicisporites sp.			×											
Ceratosporites distalgranulatus (Couper)	×													
C. equalis Cookson and Dettmann	×		×	×	×	×	×	×						×
Cicatricosisporites australiensis Cookson		×		×										
C. hughesi Dettmann	×			×										×
C. ludbrooki Dettmann	×		×	×	×	×								
Cingulatisporites saevus Balme				×										
Contignisporites spp.	×	×	×	×	×	×		×	×	×				×
cf. Coptospora sp	×	×	×	×				×		×	×			×
Cyathidites aff asper (Bolkhovitina)	×													
C. australis Couper		×	×					×						
C. concavus (Bolkhovitina)						×	×				×			
Densoisporites velatus Weyland and Kreiger			×	×		×		×	×	×				
Dictyophyllidites cf. pectinataeformis (Bolkhovitina)					×									
Dictyotosporites complex Cookson and Dettmann		×			×	×	×	×	×	×	×			×
Foraminisporis dailyi (Cookson and Dettmann)						×					×			
F. wonthaggiensis (Cookson and Dettmann)	×	×	×	×										
Foveotriletes parviretus Balme								×						
Foveotriletes sp.			×			×			×		×			×
Gleicheniidites senonicus (Ross)	×	×	×	×	×	×	×	×	×	×	×			×
Ischyosporites punctatus Cookson and Dettmann						×								×
Kuylisporites lunaris Cookson and Dettmann										×				
Laevigatosporites sp.	×													
Leptolepidites verrucatus Couper										×				
Lycopodiumsporites austroclavatidites (Cookson)	×	×		×	×	×	×	×	×	×	×			×
L. circolumenus Cookson and Dettmann	×	×	×	×					×					×
Matonisporites cooksoni Dettmann											×			
Murospora florida Balme			×							×				
Neoraistrickia truncatus (Cookson)		×		×			×	×	×					
Osmundacidites wellmanni Couper	×	×		×		×			×					×
Pilosisporites notensis Cookson and Dettmann	×	×	×	×										×
Polycingulatisporites aff. mooniensis de Jersey								×	×					
Reticulatisporites aff. pudens Balme											×			
Sestrosporites pseudoalveolatus (Couper)											×			
Staplinisporites caminus (Balme)				×		×			×	×				
Stereisporites antiquasporites (Wilson and Webster)						×	×							
Trilobosporites purverulentus (Verbitskaya)	×		×	×		×					×			
Cyclosporites hughesi Dettmann										×				
POLLEN														
Classopollis torosus Reissinger	×	×	×	×	×	×	×	×	×	×	×	×		×
Cycadopites sp						×			×		×			
Ephedripites sp.							×							
Exesipollenites sp.							×							
Inaperturopollenites sp.					×									×
Microcachryidites antarcticus Cookson	×	×	×	×	×	×	×	×	×	×	×	×		×
Podocarpidites ellipticus Cookson	×	×	×		×	×		×		×	×	×		×
Podosporites microsaccatus (Couper)	×								×		×			
Tsugaepollenites dampieri (Balme)		×	×			×			×		×			×
T. trilobatus (Balme)			×	×		×				×	×			
Vitreisporites pallidus (Reissinger)														
								×						
RECYCLED PERMIAN PALYNOMORPHS	×			×						×				

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TABLE 2. DISTRIBUTION OF SPORE AND POLLEN SPECIES IN SAMUEL FORMATION SAMPLES.

MICROPLANKTON	BMR BROWNE 1 DEPTH 70·41 m	" 73·46m	" 78·64m	" 84·43m	" 89·00m	" 90·83m	" 95·71 m	" 99·14m	" 100·89m	" 106·68m	" 108·20m	" 108·97m		YOUNG RANGE 81-83m
MFP Nº	6248	6250	6249	6292	6254	6255	6259	6251	6260	6293	6252	6261		2413
Broomea jaegeri Alberti	X													
B. aff. longicornuta Alberti	X									X				
B. micropoda Eisenack and Cookson	X													
Canningia colliveri Cookson and Eisenack	X			X										
Chlamydophorella nyei Cookson and Eisenack	X		X	X		X	X		X	X	X			
Coronifera oceanica Cookson and Eisenack	X													
Cribroperidinium edwardsi (Cookson and Eisenack)		X	X	X	X	X								
C. cf. ventriosum (O. Wetzel) sensu Cookson and Eisenack 1958	X													X
Cyclonephelium attadalicum Cookson and Eisenack	X				X	X	X	X	X	X				X
C. sp.				X										
Cymatiosphaera stigmata Cookson and Eisenack	X			X	X			X						
Dictyopyxidia aff. circulata Clarke and Verdier	X								X					
D. sp.									X					
Dingodinium cerviculum Cookson and Eisenack	X	X	X	X	X	X			X	X	X			X
Fromea amphora Cookson and Eisenack	X													
Gonyaulacysta aff. perforans (Cookson and Eisenack)	X			X										
Horologinella sp.		X			X	X	X	X	X	X	X			X
Muderongia mcwhaei Cookson and Eisenack	X	X	X		X	X		X		X				X
M. staurota Sarjeant		X			?	X								X
Odontochitina operculata (O. Wetzel)	X	X				X								
Oligosphaeridium pulcherrimum (Deflandre)	X				X		X							
Pareodinia aphelia Cookson and Eisenack									X		X			
Ovoidinium cincta (Cookson and Eisenack)												X		
Pterodinium cf. magnoserratum Cookson and Eisenack														X
Pterospermopsis aureolata Cookson and Eisenack						X					X			
Rhombodella natans Cookson and Eisenack								X			X			
Spiniferites spp.	X		X											
Tanyosphaeridium sp.					X	X	X							X
Tytthodiscus sp.				X										
Veryhachium sp.		X		X		X	X				X			X
Wallodinium luna (Cookson and Eisenack)				X										
Leiosphaeridia spp.	X	X	X	X	X	X	X	X	X	X	X			X
SPORE/MICROPLANKTON RATIO	1:1	2:1	1:1	3:1	2:1	3:2	-	1:2	2:5	1:1	1:2	-		

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TABLE 3. DISTRIBUTION OF MICROPLANKTON IN SAMUEL FORMATION SAMPLES.

equivalent of the *Dictyotosporites speciosus* Zone of Dettmann & Playford is represented, although *D. speciosus* itself was not observed. The presence of *Murospora florida* and *Cyclosporites hughesi* may indicate that the basal part of this zone (which Dettmann & Playford designated the *Cyclosporites hughesi* Subzone) is present, but the extreme rarity of these species makes a definite determination difficult. The consistent presence in the Samuel Formation samples of *Pilosisporites notensis* and *Trilobosporites purverulentus* accords with its being an equivalent of the *D. speciosus* Zone. The absence of any of the forms, either nominative or subsidiary, which characterize the overlying *Coptospora paradoxa* Zone is a negative kind of supporting evidence for such a determination. In the zonal terminology of Burger, the presence of *P. notensis* and *T. purverulentus* indicates that the sediments are at least as young as the *Foraminisporis asymmetricus* Subzone of the *Murospora florida* Zone.

Correlation of the *Dictyotosporites speciosus* Zone and the *Foraminisporis asymmetricus* Subzone with European stages suggests that these units occupy a time interval that may extend from the late Neocomian through the Aptian (see Dettmann & Playford, 1969; Burger, op. cit.). On spore evidence alone, the Samuel Formation appears to fall within this interval, but cannot be dated more precisely.

Recycled spores

Several samples from BMR Browne 1 (see Table 2) yielded rare Permian spores and pollen, apparently recycled. The species identified included *Didecitriletes ericianus* (Balme & Hennelly), *Dulhuntyispora inornata* Segroves, *Protohaploxypinus* sp., and *Parasaccites* sp. The presence of *D. ericianus* and *P. inornata* indicates that the sediments that were eroded to give the reworked forms were of Late Permian (Stage 5) age. This is of some interest, as no sediments of that age are presently known from the Officer Basin; the nearest Late Permian sediments occur in the southern part of the Canning Basin, in the A.P.P. Wilson Cliffs well, and, possibly, in outcrop at Ryan Buttes.

The presence of the recycled spores within the Cretaceous sequence means either that some sediments were deposited during the Late Permian within the Officer Basin, and have since been eroded; or that the recycled material has been transported south during the Cretaceous marine transgression. The latter does not seem very likely, in view of the apparently quiet depositional regime that the Cretaceous sediments reflect.

Microplankton

All Samuel Formation samples yielded marine microplankton on maceration, including dinoflagellate cysts, and acritarchs of problematic origin. The species identified in BMR Browne 1 borehole and from the Young Range seismic party waterbore are shown in Table 3, together with the proportions of marine forms to terrestrially derived spores and pollen in each sample.

These marine phytoplankton are in general well-preserved, and contain a number of undescribed forms, some of which are illustrated in Plates 1 & 2. Deposition from a quiet sea is suggested. They are generally numerically subordinate to spores and pollen, suggesting that deposition was at no time far from the Cretaceous shoreline, nor from the parent vegetation which provided the source of the spores and pollen. Only in two samples, in BMR Browne 1 at 99.14 and 100.89 m, did marine forms outnumber terrestrial remains.

The assemblage from the Samuel Formation is a typical Aptian one, with the species *Dingodinium cerviculum* Cookson & Eisenack and *Muderongia mcwhaei*

Cookson & Eisenack prominent in most samples. Other characteristically Aptian elements include *Cyclonephelium attadalicum* Cookson & Eisenack, *Cribroperidinium* cf. *ventriosum* (O. Wetzel), and an undescribed species of *Horologinella*. This last species (Pl. 1, figs 1-3) occurs commonly in Aptian sediments in the offshore Carnarvon Basin of Western Australia. Another group of species includes forms commonly occurring in Aptian sediments, but known to range into younger strata; in this group are *Canningia colliveri* Cookson & Eisenack, *Chlamydophorella nyei* Cookson & Eisenack, *Odontochitina operculata* (O. Wetzel), and a form showing some similarity to *Pterodinium magnoserratum* Cookson & Eisenack (Pl. 2, figs 3, 4).

In a general sense the assemblage has much in common with those from the Muderong Shale of the Carnarvon Basin and the Leederville Formation of the Perth Basin (Cookson & Eisenack, 1958, 1962). They also resemble the microflora described from Eucla Basin boreholes by Ingram (1968). The similarities between microplankton assemblages from all these localities are greatest at the level of the dominant species; ancillary species are different in all cases. A broad similarity with assemblages from the Doncaster Member of the Wallumbilla Formation of the Great Artesian Basin is also indicated (D. Burger, pers. comm.).

The age of the assemblage cannot easily be fixed more precisely within the Aptian because of the lack of published information on the stratigraphic ranges of dinoflagellate species in Australian Cretaceous sequences. Although taxonomic studies of species are readily available, largely through the efforts of Cookson and her co-workers, they come mostly from geographically scattered samples rather than continuous sequences. These samples were referred to European stages on the basis of their faunal content, but correlation between the ranges of dinoflagellate species in Australia and those in the classic European sequences remains poor. The microplankton zonation erected by Evans (1966a, b) for northern Queensland and Papuan sections, and for part of the Great Artesian Basin sequence, remains the only one available for the Australian Early Cretaceous. However, attempts have been made to document microplankton assemblages occurring in association with the more formally defined spore and pollen zones in eastern Australia (Dettmann & Playford, 1969; Burger, 1973).

The Samuel Formation assemblage shows the closest correlation with the *Dingodinium cerviculum* Zone of Evans' scheme. In the Great Artesian Basin this encompasses the Doncaster Member, which is faunally dated as late Aptian on the basis of its ammonite content. The presence of *Canningia colliveri* and the absence of *Scriniodinium attadalense* from the Samuel Formation confirm that it is this interval, rather than the older *D. cerviculum/S. attadalense* unit of Evans' scheme, which is represented. A late Aptian age for the unit is thus possible, though this remains a tentative determination in the light of current information.

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APPENDIX 1. SAMPLES EXAMINED PALYNOLOGICALLY IN OFFICER BASIN

Locality	*Sample Depth*	*Lithology*	*Palynology*	*Age*
Hunt Oil Yowalga 1	181-184 m	Dark brown to grey mudstone, some rock fragments	Palynomorphs rare, well preserved	Sakmarian? Upper Stage 2
Hunt Oil Yowalga 1	362-365 m	Light grey fine sandstone, some granite pebbles	Palynomorphs rare, well preserved	Sakmarian? U. Stage 2
Hunt Oil Browne 1	112-115 m	Dark grey non-calcareous shale	Recovery sparse, preservation poor	Sakmarian? U. Stage 2
Hunt Oil Browne 1	254-257 m	Dark grey limestone, shale, some gypsum	Abundant organic debris	? Late Proterozoic
Hunt Oil Browne 2	257 m	Light grey lithic sandstone	Recovery very sparse, preservation poor	Sakmarian?
Hunt Oil Browne 2	260 m	Limestone with some dark grey shale lenses	Abundant organic debris	?Late Proterozoic
BMR Wanna 1	30.32 m; 30.58 m; 30.78 m	Brown silty sandstone with fusinized woody fragments	Recovery sparse, preservation excellent	Sakmarian? U. Stage 2
BMR Neale 1	66.82 m	Light to medium grey fine to medium sandstone	Barren	—
BMR Neale 1	112.08 m	Medium grey fine to medium sandstone	Barren	—
BMR Neale 1	203 m	Fine reddish sandstone	Barren	—
BMR Neale 2	56.69 m; 56.99 m; 58.21 m	Dark grey laminated claystone	Sparse, fragmented spores and pollen	Sakmarian? U. Stage 2
BMR Rason 2	99.21 m	Laminated grey siltstone	Spores and pollen abundant, well preserved	Sakmarian? Late U. Stage 2
BMR Rason 2	110.95 m	Laminated grey siltstone	Spores and pollen abundant, well preserved	Sakmarian? Late U. Stage 2
BMR Rason 2	143.36 m	Light grey sandy diamictite	Spores and pollen sparse, preservation poor	Sakmarian? Stage 2
Seismic shothole near NMF 23	127-130 m	Unknown	Spores and pollen abundant, preservation excellent	Sakmarian? U. Stage 2
BMR Browne 1	13.69 m	Pale pink claystone, patchy ferruginization	Barren	—
BMR Browne 1	70.41 m	Dark grey carbonaceous siltstone	Spores, pollen and microplankton abundant, well preserved	?Late Aptian
BMR Browne 1	73.46 m	Dark grey carbonaceous siltstone	Spores, pollen and microplankton abundant, well preserved	?Late Aptian
BMR Browne 1	78.64 m	Dark grey siltstone	Spores, pollen and microplankton abundant, well preserved	?Late Aptian
BMR Browne 1	84.43 m	Medium grey micaceous siltstone	Spores, pollen and microplankton abundant, well preserved	?Late Aptian

APPENDIX 1—*continued*

Locality	*Sample Depth*	*Lithology*	*Palynology*	*Age*
BMR Browne 1	89.00 m	Dark grey laminated siltstone and claystone	Palynomorphs abundant but fragmented	?Late Aptian
BMR Browne 1	90.83 m	Medium grey micaceous siltstone	Palynomorphs abundant, well-preserved	?Late Aptian
BMR Browne 1	95.71 m	Yellowish-grey micaceous siltstone	Palynomorphs much fragmented	?Late Aptian
BMR Browne 1	99.14 m	Dark grey sandy carbonaceous siltstone	Palynomorphs common, fragmented	?Late Aptian
BMR Browne 1	100.89 m	Yellowish grey micaceous siltstone	Palynomorphs common, fragmented	?Late Aptian
BMR Browne 1	106.68 m	Medium grey sandy siltstone	Palynomorphs common, well preserved	?Late Aptian
BMR Browne 1	108.20 m	Medium grey micaceous siltstone	Palynomorphs common, well preserved	?Late Aptian
BMR Browne 1	108.59 m	Yellow sandy siltstone	Barren	
BMR Browne 1	108.97 m	Pale grey micaceous clay, some yellow sand	Very rare dinoflagellates, some woody debris	Aptian
BMR Browne 1	109.07 m	Pale yellow clay and coarse sand	Barren	—
Young Range	81-83 m	Unknown	Spores, pollen, dinoflagellates abundant, preservation excellent	?Late Aptian
BMR Throssell 1	27.12 m	Soft pale grey-brown clay with limestone fragments	Barren	—
BMR Throssell 1	32.91 m	Mottled grey/white clay	Barren	—
BMR Throssell 1	60.50 m	Grey clay with gypsum crystals	Barren	—
BMR Throssell 1	62.48 m	Grey clay with gypsum crystals	Barren	—
BMR Yowalga 4	41.75 m	Pale pink claystone and siltstone	Barren	—
BMR Talbot 4	42.67-45.72 m	Reddish silty sandstone	Barren	—
BMR Westwood 2	98.45 m	Light grey sandy siltstone	Barren	—
Hunt Oil Lennis 1	151-154 m	Grey-green shale	Barren	—

PLATE 1

Selected dinoflagellate cysts and acritarchs from the Samuel Formation, Officer Basin. All specimens photographed using interference contrast. Magnification x 800 unless otherwise specified. Specimen numbers shown are those of the Commonwealth Palaeontological Collection (CPC).

Figs 1-3 *Horologinella* sp. Sample MFP 2413; Young Range seismic waterbore, 81-83 m. Differs from previously described species of the genus in presence of granulose to spinose processes distributed over entire test surface. CPC 14401, 14402, 14403.

Fig. 4 *Dictyopyxidia* sp. Sample MFP 6260; BMR Browne 1, 100.89 m. CPC 14404.

Figs 5, 6 *Cymatiosphaera stigmata* Cookson & Eisenack 1958. Samples MFP 6248, MFP 6254; BMR Browne 1, 70.41 m, 89.00 m. Interference contrast shows thickening in centre of each polygonal area distinctly. CPC 14405, 14406.

Figs 7, 8 *Dictyopyxidia* aff. *circulata* Clarke & Verdier. Sample MFP 6248; BMR Browne 1, 70.41 m. Species is invariably poorly preserved, so that cingulum and wall stratification are not obvious. CPC 14407.

Fig. 9 *Wallodinium luna* (Cookson & Eisenack 1960) Sample MFP 6292; BMR Browne 1, 84.43 m. CPC 14408.

Fig. 10 Gen. and sp. indeterminate. Sample MFP 6248; BMR Browne 1, 70.41 m. CPC 14409.

Fig. 11 *Broomea micropoda* Eisenack & Cookson 1960. Sample MFP 6248; BMR Browne 1, 70.41 m. CPC 14410.

Fig. 12 *Broomea jaegeri* Alberti. Sample MFP 6248; BMR Browne 1, 70.41 m. CPC 14411.

Figs 13, 14 *Broomea* sp. aff. *longicornuta* Alberti. Sample MFP 6293; BMR Browne 1, 106.68 m. Differs from *B. longicornuta* in shape; is smaller and lacks sieve-like wall sculpture on processes. Apical archeopyle is distinctive. (x 500). CPC 14412.

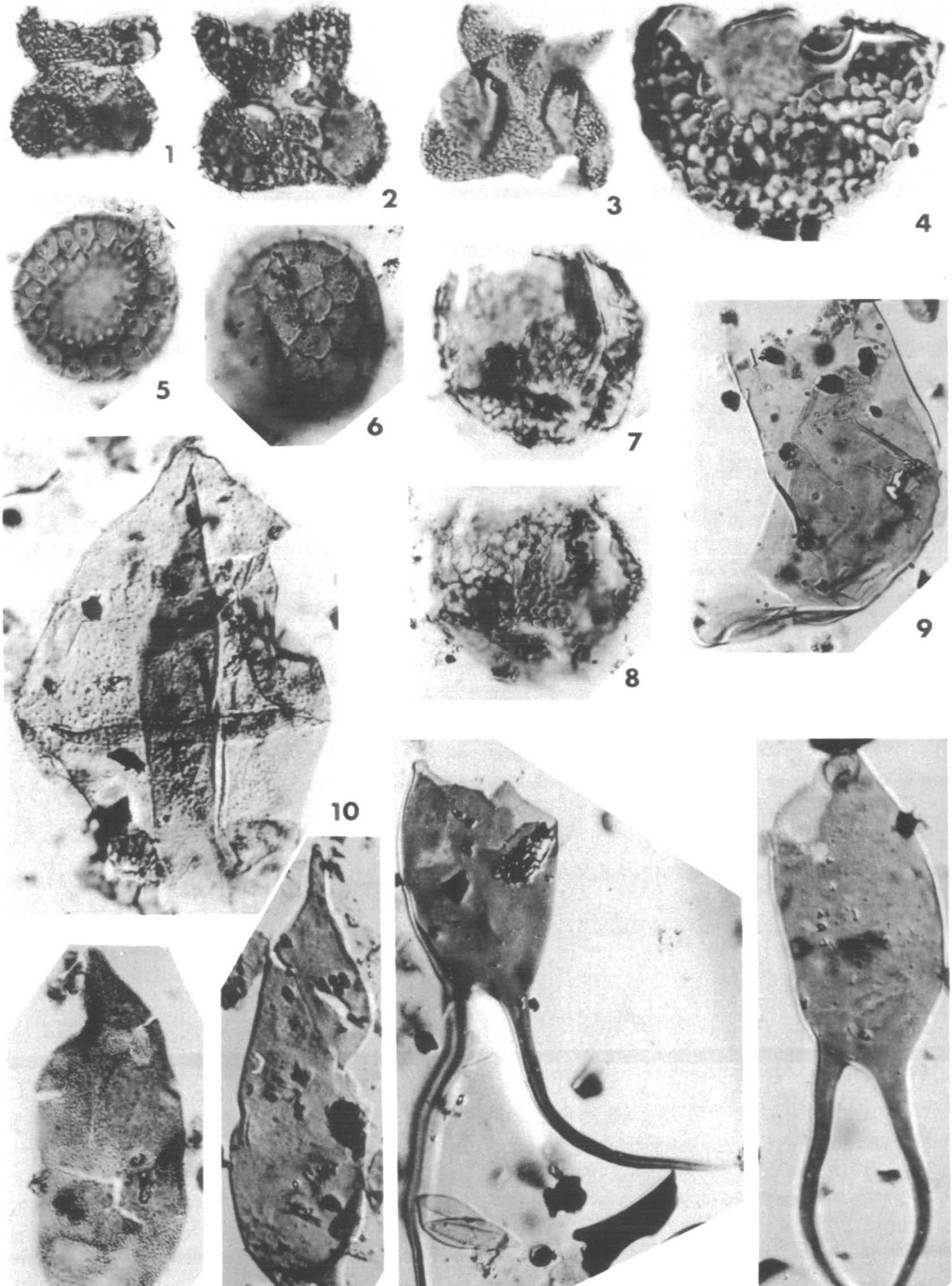


PLATE 2

Selected dinoflagellate cysts and acritarchs from the Samuel Formation, Officer Basin. All specimens photographed using interference contrast. Magnifications x 800.

Figs 1, 2 — *Tanyosphaeridium* sp. Sample MFP 2413. Young Range seismic waterbore, 81-83 m. Species is distinguished by flaring distal process ends and by granulate test. CPC 14413.

Figs 3, 4 — *Pterodinium* cf. *magnoserratum* Cookson & Eisenack 1962. Sample MFP 2413; Young Range seismic waterbore, 81-83 m. Differs from *P. magnoserratum* in being smaller, and in having lists which are spongeose and less deeply serrate. CPC 14414.

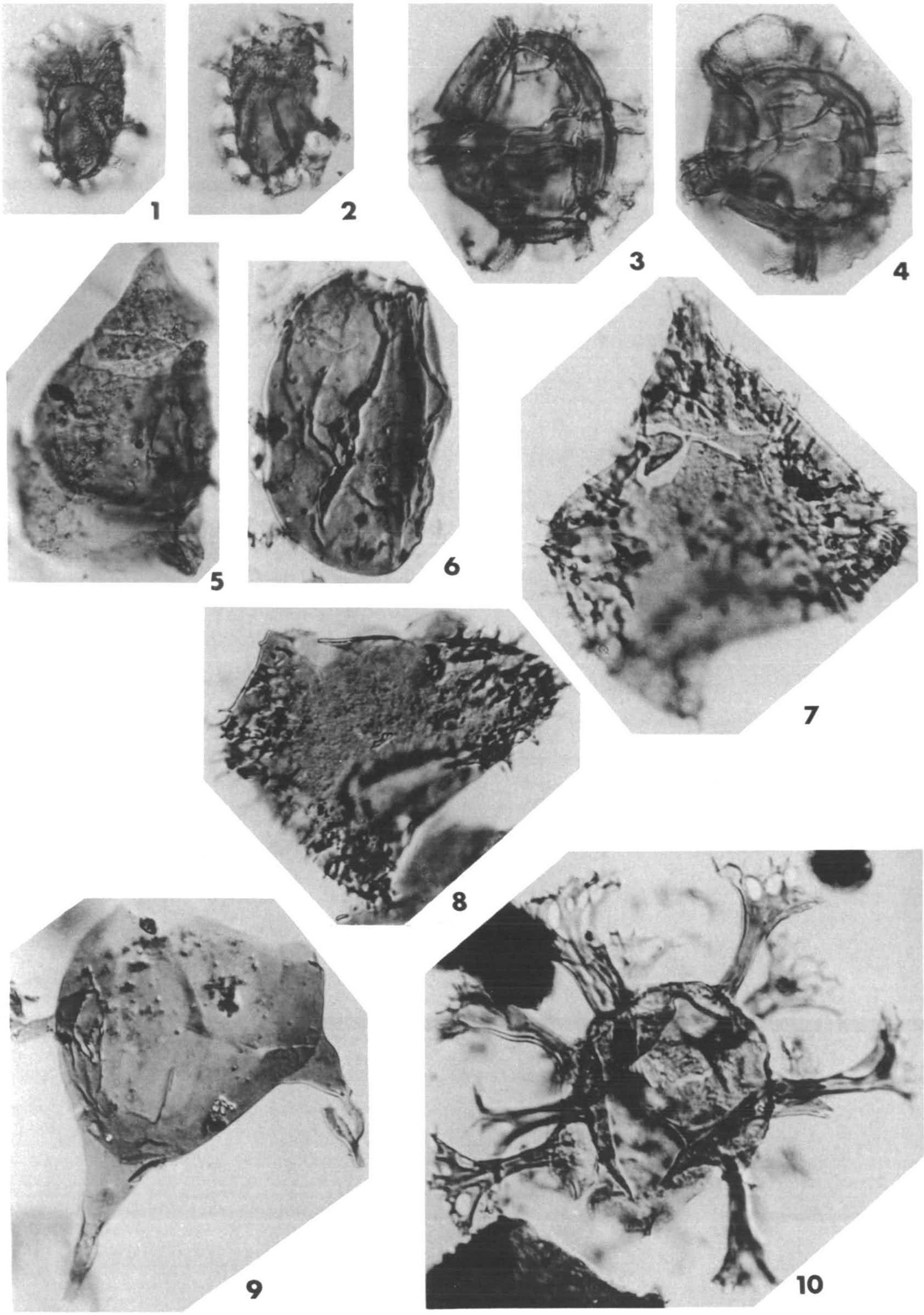
Fig. 5 — *Ovoidinium cincta* (Cookson & Eisenack 1958) Sample MFP 6261. BMR Browne 1, 108.98 m. CPC 14415.

Fig. 6 — *Fromea amphora* Cookson & Eisenack 1958. Sample MFP 6248. BMR Browne 1, 70.41 m. CPC 14416.

Figs 7, 8 — *Cyclonophelium attadalicum* Cookson & Eisenack 1962. Sample MFP 2413; Young Range seismic waterbore, 81-83 m. 7, whole specimen with apical archeopyle partly detached. 8, specimen with archeopyle missing. CPC 14417, 14418.

Fig. 9 — *Muderongia staurota* Sarjeant. Sample MFP 2413; Young Range seismic waterbore, 81-83 m. This species shows some morphological intergradation with *M. mcwhaei*. CPC 14419.

Fig. 10 — *Oligosphaeridium pulcherrimum* (Deflandre & Cookson). Sample MFP 6248; BMR Browne 1, 70.41 m. CPC 14420.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