

PALYNOLOGY OF LOWER CRETACEOUS  
(SWAN RIVER) STRATA OF SASKATCHEWAN  
AND MANITOBA

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ABSTRACT. A varied and generally well-preserved suite of spores and pollen grains is disclosed by palynological study of two sequences (one subsurface, the other type-outcrop) of the Swan River Group in the western Canadian provinces of Saskatchewan and Manitoba. The Swan River Group represents the initial Cretaceous continental-transgressive phase of the far eastern portion of the western Canada sedimentary basin, and rests unconformably upon Jurassic and older rocks; its uppermost horizons contain microplanktonic indications of a marine environment and pass transitionally upwards into the shaly marine Ashville Group. The palynological data indicate a wholly Albian age for the subject Swan River samples by comparison with other palynologically studied North American Lower Cretaceous strata (particularly of Alberta). More precisely the age appears to be Middle Albian, possibly to early Late Albian.

The microflora includes 108 species of miospores, some of which are accorded detailed systematic description. *Kraeuselisporites hastilobatus*, *Crybelosporites breunnerii*, and *Coptospora williamsii* are instituted as new species; *Rouseisporites* Pocock 1962 is shown to be a junior synonym of *Triporoletes* Mtchedlishvili 1960. Natural affinities of the bulk of the Swan River palynomorphs are with the Coniferophyta, Pteridophyta (notably Filicales), and Bryophyta. Simple tricolpate angiospermous grains appear in younger horizons of the group; their introduction serves as a useful biostratigraphic marker, recognized elsewhere in North America. Closest extra-North American comparisons can be made with Albian palynological floras of Siberia and eastern Australia.

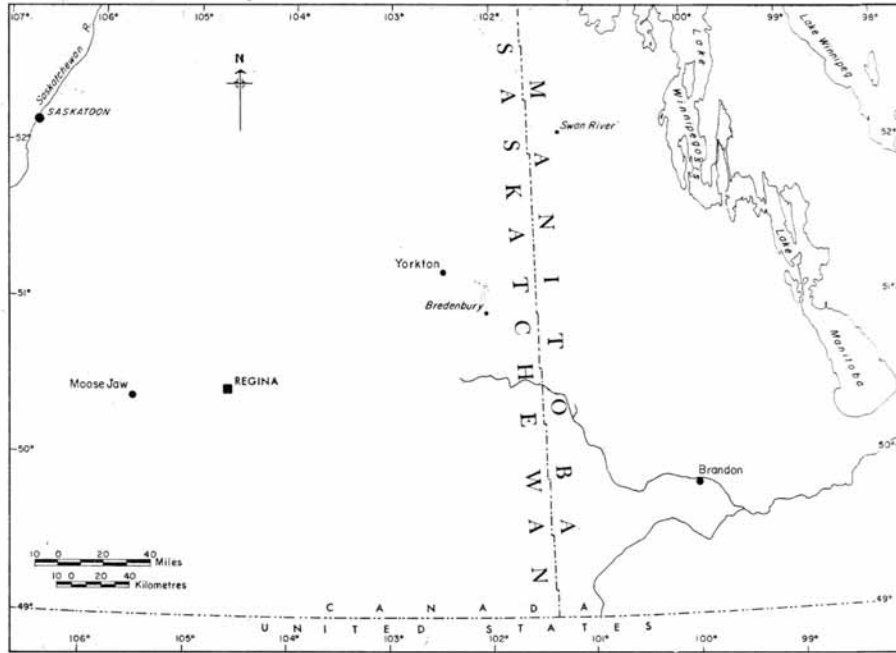
THIS paper contains results of palynological studies of Early Cretaceous sediments penetrated by a borehole near Yorkton, south-eastern Saskatchewan and exposed to the north-east in the Swan River area of south-western Manitoba (text-fig. 1). This region is situated close to the eastern limit of the western Canada sedimentary basin, where Lower Cretaceous sandy sediments, of largely non-marine character, form a relatively thin veneer along the western margin of the Canadian Precambrian Shield. Despite extensive drilling activity the Lower Cretaceous stratigraphy of the area awaits detailed integrated study, following the pioneer, broadly based work of Wickenden (1945). Price (1963) investigated the Lower Cretaceous succession of southern Saskatchewan (principally the south-eastern portion of the province); he recognized an informally designated 'Basal Cretaceous Sandy Group' succeeded conformably by the Ashville Group (marine shale, glauconitic beds). According to Price, the basal sandy unit is divisible into two formations: Cantuar Formation (type section, 130 feet thick) and overlying Pense Formation (type, 116 feet) which was said to be finer grained, more indurated, and less heterogeneous than the Cantuar. The Pense Formation was regarded by its designator as environmentally transitional between the Cantuar, considered to be non-marine (perhaps deltaic), and the grey marine shale of the overlying Joli Fou Formation, which constitutes the basal portion of the Ashville, and Colorado, Groups. Price's two-fold division of the 'Basal Cretaceous Sandy Group' is typified by well sections in the Swift Current (Cantuar Formation), and Regina (Pense) areas and, according to him (1963, p. 5), 'the combinations of facies typical of each division are broadly consistent over most of southern Saskatchewan and probably a considerably greater area'. The divisions were not, however, recognized in the correlative section of

[Palaeontology, Vol. 14, Part 4, 1971, pp. 533-565, pls. 103-107.]

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the Bredenburg well, sampled during this study; nor in the Swan River, western Manitoba exposures, to which the name Swan River Group was originally applied (Wickenden 1945) for similar sandy/shaly sediments (reaching thicknesses of as much as 400 feet) developed beneath the marine Ashville Group. Price (1963, pp. 2, 35, 40) commented on likely diachroneity of the contact between the marine shale and underlying sandy strata. He considered that the demarcation between the two groups becomes younger north-eastward from southern Saskatchewan to the Swan River area in its marginal shield situation.



TEXT-FIG. 1. Locality map.

Assignment of the Swan River Group and laterally contiguous strata to stages of the Lower Cretaceous has been hindered by their lack of marine fossils, or at least obvious ones. Their general Early Cretaceous age is, however, clearly established. The sediments rest with prominent unconformity on Jurassic or older strata, which constitute the eroded undulating surface on which the Cretaceous sedimentation regime was initiated throughout the western Canada sedimentary basin; and are succeeded, seemingly conformably, by marine shaly strata dateable as (late) Middle Albian (Joli Fou Formation and correlatives). East-west lateral relationships of the Lower Cretaceous strata are well displayed on Rudkin's (1964, fig. 11-7) cross-section of the southern Plains, stretching from east of Brandon, Manitoba, to the southern Alberta Foothills west of Lethbridge.

From this it may be seen that the Early Cretaceous arenaceous sequence, resting on a Jurassic erosion surface, thickens westward, passing laterally, in nomenclatural terms, from the Swan River Group into the Mannville Group (see Glaister 1959, Williams 1963) of Alberta and Saskatchewan, and thence into the thick Blairmore Group of the Foothills. The Blairmore covers a much greater stratigraphic interval than either the Mannville or the Swan River, since its upper strata intergrade with the shaly Colorado/Ashville strata that succeed the Mannville and Swan River on the Plains (Mellon 1967). In contrast to the essentially non-marine Blairmore and Swan River sequences, the intervening Mannville includes, principally in Alberta, prominent marine intercalations, recording periodic advances of the boreal sea (depositing notably shales and glauconitic sandstones of the Clearwater Formation: see Williams 1963). The present geographic relations of the three groups are depicted by Price (1963, fig. 1). The marine strata carry faunal elements which permit the Clearwater to be dated as Middle Albian (see summary by Singh 1964, p. 13), which is also applicable to the other, overlying component of the Upper Mannville, the Grand Rapids Formation. The precise age of the Lower Mannville (McMurray Formation and correlatives) is less clear, but as its relationship with the Clearwater is conformable, it is presumably not greatly older. It is also apparent that being the initial continental-transgressive Cretaceous unit, its base would hardly be expected to be time-concordant over the western interior.

Pocock (1962) ascribed a Neocomian (Berriasian–Late Barremian) age to the Lower Mannville strata (from 18 localities in Alberta/southern Saskatchewan) on the basis of his biostratigraphic appreciation of the microflora. In contradistinction, the age of the Calcareous Member at the top of the McMurray Formation has been adduced as Aptian from its ostracode assemblage (Loranger 1951) and Albian from foraminiferal evidence (Mellon and Wall 1963). The detailed work of Singh (1964) on the palynological flora of three cored borings in the Mannville Group of east-central Alberta evidenced that the base of the McMurray Formation of that area (i.e. Deville Member) is of Late Neocomian (Late Barremian) age. Singh further adduced palynologically that the middle portion of the McMurray (Eggsdale Member) is Aptian; and he supported Mellon and Wall's contention that the upper McMurray (Calcareous Member) is referable to the Albian (Early to early Middle Albian). Vagvolgyi and Hills (1969) analysed the palynological content of subsurface samples from the McMurray Formation and succeeding basal Clearwater Formation as penetrated by Socony Vacuum Hole No. 27, north-eastern Alberta (supplementary type section of the McMurray: Carrigy 1959). Vagvolgyi and Hills reported the occurrence of mainly long-ranging palynomorphs but, by reference to Singh's (1964) data, were able to infer an Early to early Middle Albian age for the McMurray Formation in the type well from the presence of a few spore species of known restricted vertical distribution.

Collectively, therefore, the biostratigraphic evidence signifies an Early Cretaceous age for the Mannville strata, with the base perhaps no older than Late Neocomian and the top indubitably of Middle Albian age.

Up to the present, virtually no palaeontological or palynological data were available on the Swan River or 'Basal Cretaceous Sandy' Groups. Consequently the dating of their bases, and, hence, of the inception of Cretaceous sedimentation in the south-eastern Saskatchewan–south-western Manitoba area has been depicted on correlation charts in a fairly vague manner. It has, however, been generally regarded as somewhat

later than in the better understood, westerly regions (e.g. Price 1963, table I). Rudkin's (1964, fig. 11-1) chart suggests that the base in southern Saskatchewan is as old as Late Neocomian (as elsewhere to the west) and that it becomes progressively younger towards Manitoba, where the lowest Swan River Group is shown as young as Early Albian. Hence in places (extreme eastern part of the basin) the Swan River has been regarded as coeval *in toto* with Upper Mannville strata (cf. also Rudkin 1964, figs. 11-2, 11-3).

The purpose of the present work is to seek evidence pertinent to the precise correlation and dating of the Swan River Group, the easterly correlatives of the Mannville. Because, firstly, the palynological sequence of the latter and the succeeding Lower Colorado Group have come to be known in a certain amount of detail, and secondly, the Swan River appears to be virtually bereft of marine megafossils, the best available facility for Swan River-Mannville comparisons is certainly palynological. It is emphasized that the current work, being restricted to one subsurface section and to samples from only the uppermost exposed Swan River section, constitutes essentially a reconnaissance study.

#### PREVIOUS WORK ON LOWER CRETACEOUS PALYNOLOGY OF THE WESTERN CANADA PLAINS

Pocock (1962), Singh (1964), and Vagvolgyi and Hills (1969), all investigated Mannville Group palynology of Alberta and also, in the case of Pocock, of southern Saskatchewan. In a later paper, Pocock (1965) discussed and illustrated the morphology of

#### EXPLANATION OF PLATE 103

All figures  $\times 500$  and from unretouched negatives.

- Fig. 1. *Biretisporites potoniaei* Delcourt and Sprumont 1955; median focus; GO24c/20, 106-7 13-4; Y.1337.
- Fig. 2. *Stereisporites antiquasporites* (Wilson and Webster) Dettmann 1963; proximal focus; GO24c/15, 106-2 7-3; Y.1338.
- Fig. 3. *Kuylisporites lunaris* Cookson and Dettmann 1958; median focus; GO46/3, 95-6 14-7; Y.1339.
- Figs. 4, 5. *Undulatisporites pannuceus* (Brenner) Singh 1971; proximal and distal foci; GO45/3, 101-7 3-2; Y.1340.
- Figs. 6, 7. *Pilosisporites* spp. 6, *P. verus* Delcourt and Sprumont 1955; proximal focus; GO46/8, 102-0 9-7; Y.1341. 7, *P. trichopapillosus* (Thiergart) Delcourt and Sprumont 1955; median focus; GO45/1, 109-0 19-2; Y.1342.
- Figs. 8, 9. *Concavissimisporites* spp. 8, *C. minor* (Pocock) Delcourt, Dettmann, and Hughes 1963; proximal focus; GO45/3, 119-0 3-4; Y.1343. 9, *C. variverrucatus* (Couper) Brenner 1963; median focus; GO64/2, 113-9 15-3; Y.1344.
- Fig. 10. *Lophotriletes babsae* (Brenner) Singh 1971; proximal focus; GO65/97, 108-8 8-9; Y.1345.
- Fig. 11. *Lycopodiacidites intraverrucatus* Brenner 1963; median focus; GO65/48, 114-8 16-2; Y.1346.
- Figs. 12, 13. *Lycopodiumsporites* spp. 12, *L. austroclavatidites* (Cookson) Potonié 1956; proximal focus; GO24c/66, 113-3 8-3; Y.1347. 13, *L. marginatus* Singh 1964; distal focus; GO65/2, 111-0 19-1; Y.1348.
- Fig. 14. *Reticulisporites elongatus* Singh 1971; median focus; GO59b/1, 113-5 12-8; Y.1349.
- Figs. 15, 16. *Microreticulatisporites uniformis* Singh 1964; proximal and distal foci; GO45/20, 105-4 2-8; Y.1350.
- Fig. 17. *Klukisporites pseudoreticulatus* Couper 1958; proximal focus; GO43b/2, 81-7 16-9; Y.1351.
- Fig. 18. *Tigrisporites scurrandus* Norris 1967; median focus; GO65/36, 103-5 17-3; Y.1352.
- Figs. 19-25. *Cicatricosisporites* spp. 19, *C. hallei* Delcourt and Sprumont 1955; median focus; GO24c/11, 86-6 17-0; Y.1353. 20, *C. australiensis* (Cookson) Potonié 1956; distal focus; GO69/18, 110-2 8-2; Y.1354. 21, 22, *C. spiralis* Singh 1971; proximal and distal foci; GO24c/74, 120-5 10-7; Y. 1355. 23, *C. potomacensis* Brenner 1963; proximal focus; 89-4 13-8; Y.1356. 24, 25, *C. hughesi* Dettmann 1963; proximal and distal foci; GO45/2, 124-7 20-9; Y.1357.

certain elements of the Upper Mannville (late Middle Albian) palynological flora. The forms treated by Pocock were attributed to the gymnospermous category Chlamydo-spermidae (principally the Ephedraceae) and to the pterophyte family Schizaeaceae; the core samples concerned were from two wells in the Saskatoon area, Saskatchewan. Steeves and Wilkins (1967) also isolated and described dispersed spores from Lower Cretaceous sediments of the Saskatoon area. Although their paper contains no explicit information on the locality and horizon from which their core sample was collected, Dr. W. G. E. Caldwell (Department of Geological Sciences, University of Saskatchewan, Saskatoon) has informed the writer (pers. comm.) that it came from within the interval 1620–1880 feet (below K.B.) of Potash Corporation of American Saskatoon No. 2 well (location: Lsd. 6, Sec. 16, Tp. 36, R. 3, W. 3rd Mer.). Dr. G. D. Williams's reading of the electric log of the latter indicated that the particular interval is probably all Upper Mannville equivalent. Steeves and Wilkins (p. 2330) intimated that a subsequent work of theirs will include description of the pollen elements of the microflora and a discussion of the age of the enclosing sediment.

Norris (1967) studied in detail the spore-pollen sequence of the Lower Colorado Group (Joli Fou Formation, Viking Formation, Upper Shale Unit) as intersected in Fort Augustus No. 1 well, east-central Alberta. This represented an upward continuation of Singh's (1964) study, which was concerned (in part) with Mannville Group palynology of the same well. In Fort Augustus No. 1, and elsewhere, a disconformable relationship has been postulated (Mellon and Wall 1963) between the Upper Mannville (Grand Rapids Formation) and the Lower Colorado (Joli Fou Formation). Norris's studied interval comprised cores from the base of the Joli Fou to 50 feet below the Fish-scale marker bed separating the Upper Shale Unit of the Lower Colorado from the Upper Colorado; in age its range was cited as late Middle Albian to Late Albian, the latter in acceptance of the conventional Lower-Upper Cretaceous boundary at the Fish-scale marker bed.

Singh (1971) has described the morphology and the stratigraphic distribution of spores, pollen, and non-calcareous microplankton from Middle–Upper Albian stratal sections in the lower Peace River area, north-western Alberta. Rock units studied by Singh are the Loon River Formation (upper part), Peace River Formation, and Shaftesbury Formation (lower part) (see Table 2).

#### MATERIAL AND METHODS

Samples used in the current investigation consist of fine clastic sediments (light to dark-grey siltstones, shales, fine-grained silty sandstones) from two western Canadian localities, as cited below and representative of the Lower Cretaceous Swan River Group. The latter appears in both instances to have a conformable relationship with the overlying Ashville Group.

Localities are designated according to the Canadian Provincial Survey System (explained by Pocock 1962, fig. 1).

##### 1. *Swan River area, south-western Manitoba* (type area, Swan River Group).

- (a) Samples 69-W-26 and 69-W-27: transitional beds of uppermost Swan River Group–lowermost Ashville Group from north bank of Swan River (location: NE.  $\frac{1}{4}$ , Sec. 6, Tp. 37, R. 26, W. P. Mer.).
- (b) Samples 69-W-28 and 69-W-29: upper Swan River Group, about 20 feet below transitional beds, north bank of Swan River (SE.  $\frac{1}{4}$ , Sec. 8–SW.  $\frac{1}{4}$ , Sec. 9, Tp. 37, R. 26, W. P. Mer.).

(c) Sample 69-W-32: upper Swan River Group, about 45 feet below transitional beds, north bank of Swan River (SW.  $\frac{1}{4}$ , Sec. 10, Tp. 37, R. 27, W. P. Mer.).

The above were collected by G. D. Williams and the writer, 12 June 1969, and all proved to be productive palynologically. For geology see Wickenden (1945, Mafeking map 637A).

2. *South-West Potash Bredenburg No. 11-36 well, south-eastern Saskatchewan.*

The Lower Cretaceous sequence intersected in this well (located at Lsd. 11, Sec. 36, Tp. 22, R. 1, W. 2nd Mer.—about 30 miles south-east of Yorkton, Sask.) is divisible according to G. D. Williams (pers. comm.) as follows: base of Fish-scale marker bed at 645 feet (below K.B.); top of Swan River Group at 1275 feet; ? top of Jurassic sequence at 1495 feet.

Cored material representative of the following intervals (in feet below K.B.) were processed and examined palynologically: 1273-1278\*, 1278-1283\*, 1283-1288\*, 1288-1293\*, 1293-1300\*, 1300-1305, 1305-1310\*, 1310-1315\*, 1315-1320\*, 1320-1325\*, 1325-1327, 1329-1335, 1340-1345\*, 1345-1349, 1349-1353, 1353-1358\*, 1367-1372, 1372-1377\*, 1377-1381\*, 1386-1391\*, 1391-1395\*, 1395-1399, 1403-1408, 1408-1413\*, 1413-1417, 1441-1445, 1462-1466, 1491-1495. Sample intervals asterisked in the foregoing list were palynologically productive; the others were not. Of the productive samples, all but the last one cited are clearly Lower Cretaceous. The lowest spore-containing sample (1408-1413 feet) yielded a well-preserved Middle Jurassic palynological flora (determined as such from Pocock, 1970) and is not discussed further in this paper. From these data it is evident that the base of the Cretaceous, presumably disconformable, lies in the depth-interval 1395-1408 feet; and the thickness of Swan River Group in the well is approximately 125 feet.

The samples were subjected to conventional laboratory procedures for extraction and concentration of the contained acid-resistant microfossils. About 3-7 grams of sediment were treated in each case, depending on quantity available. Following dissolution of carbonates with dilute hydrochloric acid, several days' immersion in cold 40 per cent. hydrofluoric acid sufficed for the removal of silicates; resultant insoluble fluoride precipitates were then removed through several treatments with warm dilute hydrochloric acid. On average, only about 5 minutes' treatment with Schulze solution was appropriate for maceration of organic material; this was followed by rapid washing (by centrifugation) with very weak (*ca.* one per cent.) ammonium hydroxide and then, repeatedly, with distilled water. Where present, obtrusive amounts of structureless organic debris were removed by a single washing with Darvan No. 4. The residues were mounted in glycerine jelly (unstained, or lightly stained with Safranin '0') under No. 0 coverslips as both strew-slides and single-spore mounts. All slides were thoroughly sealed with gold-size varnish. Mounted residues of the productive samples contain spores and pollen in varying concentrations and in fair to excellent states of preservation. A cross-reference between samples and preparation numbers (prefixed 'G') is to be found on Table 1.

#### TAXONOMIC LIST OF FORMS IDENTIFIED

All spore and pollen specimens illustrated in the current work are housed in the micropalaeontological type collection of the Department of Geology and Mineralogy, University of Queensland, Brisbane. Each specimen is designated, as in the plate explanations and in ensuing text, according to the following sequence: preparation/slide number, east-west and north-south mechanical-stage readings (of Zeiss Photomicroscope II, no. Mx3237, of the above-cited Department) and registered specimen number (prefixed 'Y').

The following list consolidates the spore and pollen species identified in the subject samples of the Swan River Group. For convenience of reference, the species are categorized according to the morphographic scheme of R. Potonié (1956, etc.); in the case of the *Anteturma* Sporites certain of the modifications and innovations proposed by Dettmann (1963) and Smith and Butterworth (1967) are adopted. Most of the specific taxa listed are illustrated herein, as specified by the square-bracketed plate/figure numbers. Comprehensive systematic-descriptive coverage of all species has not

been undertaken because the majority have been adequately described, figured, and satisfactorily treated taxonomically in existing publications. Those which are accorded systematic appraisal later in this paper are asterisked below; they are mainly new species, new combinations, or species for which emended or restated circumscriptions or brief comments are deemed appropriate.

Anteturma SPORITES H. Potonié 1893  
 Turma TRILETES Reinsch emend. Dettmann 1963  
 Suprasubturma ACAVATITRILETES Dettmann 1963  
 Subturma AZONOTRILETES Lubert emend. Dettmann 1963  
 Infraturma LAEVIGATI Bennie and Kidston emend. R. Potonié 1956

*Cyathidites australis* Couper 1953  
*Cyathidites minor* Couper 1953  
*Stereisporites antiquasporites* (Wilson and Webster) Dettmann 1963 [Pl. 103, fig. 2]  
*Biretisporites potoniaei* Delcourt and Sprumont 1955 [Pl. 103, fig. 1]  
*Undulatisporites pannuceus* (Brenner) Singh 1971 [Pl. 103, figs. 4, 5]\*

Infraturma APICULATI Bennie and Kidston emend. R. Potonié 1956

*Concavissimisporites minor* (Pocock) Delcourt, Dettmann, and Hughes 1963 [Pl. 103, fig. 8]  
*Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner 1963  
*Concavissimisporites variverrucatus* (Couper) Brenner 1963 [Pl. 103, fig. 9]  
*Osmundacidites wellmanii* Couper 1953  
*Baculatisporites comaumensis* (Cookson) R. Potonié 1956  
*Lophotriletes babsae* (Brenner) Singh 1971 [Pl. 103, fig. 10]  
*Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont 1955 [Pl. 103, fig. 7]  
*Pilosisporites verus* Delcourt and Sprumont 1955 [Pl. 103, fig. 6]  
*Kuylisporites lunaris* Cookson and Dettmann 1958 [Pl. 103, fig. 3]

Infraturma MURORNATI R. Potonié and Kremp 1954

*Lycopodiumsporites austroclavitudites* (Cookson) R. Potonié 1956 [Pl. 103, fig. 12]  
*Lycopodiumsporites marginatus* Singh 1964 [Pl. 103, fig. 13]  
*Lycopodiacidites intraverrucatus* Brenner 1963 [Pl. 103, fig. 11]  
*Reticulisporites elongatus* Singh 1971 [Pl. 103, fig. 14]  
*Microreticulatisporites uniformis* Singh 1964 [Pl. 103, figs. 15, 16]  
*Khukisporites pseudoreticulatus* Couper 1958 [Pl. 103, fig. 17]  
*Tigrisporites scurrandus* Norris 1967 [Pl. 103, fig. 18]  
*Cicatricosisporites australiensis* (Cookson) R. Potonié 1956 [Pl. 103, fig. 20]  
*Cicatricosisporites hallei* Delcourt and Sprumont 1955 [Pl. 103, fig. 19]  
*Cicatricosisporites hughesi* Dettmann 1963 [Pl. 103, figs. 24, 25]  
*Cicatricosisporites patapscoensis* Brenner 1963  
*Cicatricosisporites potomacensis* Brenner 1963 [Pl. 103, fig. 23]  
*Cicatricosisporites spiralis* Singh 1971 [Pl. 103, figs. 21, 22]

*Cicatricosporites* sp. B of Singh 1964  
*Costatoperforosporites foveolatus* Deák 1962 [Pl. 104, fig. 1]  
*Balmeisporites* sp. cf. *B. holodictyus* Cookson and Dettmann 1958  
*Arcellites disciformis* Miner emend. Ellis and Tschudy 1964

Subturma ZONOTRILETES Waltz 1935  
 Infraturma AURICULATI Schopf emend. Dettmann 1963

*Appendicisporites bifurcatus* Singh 1964 [Pl. 104, fig. 10]  
*Appendicisporites bilateralis* Singh 1971 [Pl. 104, fig. 4]  
*Appendicisporites crimensis* (Bolkovitina) Pocock 1965 [Pl. 104, figs. 2, 3]  
*Appendicisporites jansonii* Pocock 1962 [Pl. 104, fig. 9]  
*Appendicisporites matesovae* (Bolkovitina) Norris 1967 [Pl. 104, fig. 11]  
*Appendicisporites potomacensis* Brenner 1963 [Pl. 104, figs. 5, 6]  
*Appendicisporites problematicus* (Burger) Singh 1971 [Pl. 104, figs. 7, 8]  
*Trilobosporites apiverrucatus* Couper 1958 [Pl. 104, fig. 14]  
*Trilobosporites hannonicus* (Delcourt and Sprumont) R. Potonié 1956 [Pl. 104, fig. 26]  
*Trilobosporites humilis* Delcourt and Sprumont 1959 [Pl. 104, figs. 15, 16]  
*Trilobosporites marylandensis* Brenner 1963 [Pl. 104, fig. 13]  
*Trilobosporites purverulentus* (Verbitskaya) Dettmann 1963 [Pl. 104, figs. 24, 25]  
*Ischyosporites* sp. cf. *I. crateris* Balme 1957

Infraturma TRICRASSATI Dettmann 1963

*Gleicheniidites senonicus* Ross 1949 [Pl. 104, fig. 12]  
*Clavifera rudis* Bolkovitina 1968 [Pl. 104, figs. 18, 19]\*  
*Asbeckiasporites wirthi* von der Brellie 1964 [Pl. 105, figs. 11, 12]\*  
*Sestrosporites pseudoalveolatus* (Couper) Dettmann 1963 [Pl. 104, fig. 27]  
*Coronatispora valdensis* (Couper) Dettmann 1963 [Pl. 104, figs. 20, 21]  
*Camaronosporites ambigenus* (Fradkina) comb. nov. [Pl. 104, figs. 22, 23]\*

Infraturma CINGULATI R. Potonié and Klaus emend. Dettmann 1963

*Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann 1963 [Pl. 104, fig. 17]  
*Foraminisporis dailyi* (Cookson and Dettmann) Dettmann 1963 [Pl. 105, fig. 1]  
*Foraminisporis wonthaggiensis* (Cookson and Dettmann) Dettmann 1963 [Pl. 105, fig. 2]  
*Polycingulatisporites reduncus* (Bolkovitina) Playford and Dettmann 1965 [Pl. 105, figs. 3, 4]  
*Tauocusporites segmentatus* Stover 1962 [Pl. 105, fig. 5]  
*Cingutritiles clavus* (Balme) Dettmann 1963

Suprasubturma LAMINATITRILETES Smith and Butterworth 1967  
 Subturma AZONOLAMINATITRILETES Smith and Butterworth 1967

Spore Type A [Pl. 105, figs. 9, 10]\*



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Subturma ZONOLAMINATRILETES Smith and Butterworth 1967  
Infraturma CINGULICAVATI Smith and Butterworth 1967

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*Kraeuselisporites hastilobatus* sp. nov. [Pl. 105, figs. 23–25]\*  
*Lundbladispora reticingula* (Brenner) comb. nov. [Pl. 105, fig. 8]\*  
*Densoisporites circumundulatus* (Brenner) comb. nov. [Pl. 105, figs. 6, 7]\*  
*Densoisporites microrugulatus* Brenner 1963 [Pl. 105, fig. 17]

Suprasubturma PERINOTRILITES Erdtman 1947

*Crybelosporites brennerii* sp. nov. [Pl. 105, figs. 18–20]\*  
*Perotrilites pannuceus* Brenner 1963

Turma MONOLETES Ibrahim 1933  
Suprasubturma ACAVATOMONOLETES Dettmann 1963  
Subturma AZONOMONOLETES Lubert 1935  
Infraturma LAEVIGATOMONOLETI Dybová and Jachowicz 1957

*Laevigatosporites ovatus* Wilson and Webster 1946 [Pl. 105, fig. 22]  
*Cicatricosporites auritus* Singh 1971 [Pl. 105, fig. 21]

Turma HILATES Dettmann 1963

*Coptospora williamsii* sp. nov. [Pl. 106, figs. 8–13]\*  
*Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann 1961  
[Pl. 106, fig. 7]  
*Couperisporites complexus* (Couper) Pocock 1962 [Pl. 107, figs. 22, 23]  
*Cooksonites variabilis* Pocock 1962  
*Triporoletes involucratu*s (Chlonova) comb. nov. [Pl. 105, figs. 13–15]\*  
*Triporoletes laevigatus* (Pocock) comb. nov. [Pl. 105, fig. 16]\*  
*Triporoletes radiatus* (Dettmann) comb. nov. [Pl. 106, figs. 3, 4]\*  
*Triporoletes reticulatus* (Pocock) comb. nov. [Pl. 106, fig. 5]\*  
*Triporoletes simplex* (Cookson and Dettmann) comb. nov. [Pl. 106, fig. 2]\*  
*Triporoletes singularis* Mtchedlishvili in Mtchedlishvili and Samoilovich 1960 [Pl. 106,  
fig. 1]\*

Anteturma POLLENITES R. Potonié 1931  
Turma SACCITES Erdtman 1947  
Subturma MONOSACCITES Chitaley emend. R. Potonié and Kremp 1954  
Infraturma SACCIZONATI Bhardwaj 1957

*Tsugaepollenites dampieri* (Balme) Dettmann 1963

Subturma DISACCITES Cookson 1947

*Vitreisporites pallidus* (Reissinger) Nilsson 1958 [Pl. 107, fig. 2]  
*Alisporites bilateralis* Rouse 1959 [Pl. 107, fig. 1]

*Alisporites grandis* (Cookson) Dettmann 1963  
*Podocarpidites canadensis* Pocock 1962  
*Podocarpidites* sp. cf. *P. ellipticus* Cookson 1947  
*Podocarpidites multesimus* (Bolkhovitina) Pocock 1962 [Pl. 107, fig. 21]  
*Podocarpidites radiatus* Brenner 1963  
*Parvisaccites radiatus* Couper 1958 [Pl. 107, fig. 19]  
*Phyllocladidites inchoatus* (Pierce) Norris 1967  
*Rugubivesiculites reductus* Pierce 1961 [Pl. 107, fig. 20]

Turma ALETES Ibrahim 1933

Subturma AZONALETES Lubber emend. R. Potonié and Kremp 1954

*Inaperturopollenites limbatus* Balme 1957 [Pl. 107, fig. 8]  
*Araucariacites australis* Cookson 1947  
*Reticulatasporites dupliexinoux* Brenner 1963

Subturma ZONALETES Lubber 1935

*Perinopollenites elatoides* Couper 1958

Turma Plicates Naumova emend. R. Potonié 1958

Subturma PRAECOLPATES R. Potonié and Kremp 1954

*Eucommiidites minor* Groot and Penny 1960 [Pl. 107, fig. 3]  
*Eucommiidites troedssonii* Erdtman 1948 [Pl. 107, fig. 4]

Subturma POLYPLICATES Erdtman 1952

*Equisetosporites* sp. cf. *E. concinnus* Singh 1964  
*Equisetosporites jansonii* Pocock 1965 [Pl. 107, fig. 6]  
*Equisetosporites multicostatus* (Brenner) Norris 1967 [Pl. 107, fig. 7]

Subturma MONOCOLPATES Iversen and Troels-Smith 1950

*Clavatipollenites hughesii* Couper emend. Kemp 1968 [Pl. 107, fig. 13]  
*Clavatipollenites rotundus* Kemp 1968 [? = *Liliacidites dividius* (Pierce) Brenner 1963]  
 [Pl. 107, fig. 14]  
*Liliacidites peroreticulatus* (Brenner) Singh 1971

Subturma TRIPTYCHES Naumova 1939

*Retitricolpites georgensis* Brenner 1963 [Pl. 107, figs. 11, 12]  
*Retitricolpites prosimilis* Norris 1967 [Pl. 107, fig. 18]  
*Retitricolpites vulgaris* Pierce 1961 [Pl. 107, fig. 17]  
*Tricolpites sagax* Norris 1967 [Pl. 107, fig. 16]  
*Fraxinoipollenites venustus* Singh 1971 [Pl. 107, figs. 9, 10]  
*Striatopollis paraneus* (Norris) Singh 1971

Turma POROSSES Naumova emend. R. Potonié 1960  
Subturma MONOPORINES Naumova 1939

*Exesipollenites tumulus* Balme 1957 [Pl. 107, fig. 15]

*Circulina parva* Brenner 1963 [Pl. 107, fig. 5]

*Classopollis classoides* Pflug emend. Pocock and Jansonius 1961

SPORAE INCERTAE SEDIS

*Schizosporis reticulatus* Cookson and Dettmann 1959 [Pl. 106, fig. 6]

The distribution of these specific taxa in samples utilized in this study is set out in Table 1. The stratigraphic significance of the palynological assemblages is discussed in a later section of this paper.

SYSTEMATIC SECTION

Genus UNDULATISPORITES Pflug in Thomson and Pflug 1953

*Type species* (by original designation). *Undulatisporites microcutis* Pflug in Thomson and Pflug 1953

*Undulatisporites pannuceus* (Brenner) Singh 1971

Plate 103, figs. 4, 5

1963 *Alsophilidites pannuceus* Brenner, p. 56; pl. 12, figs. 5, 6.

1971 *Undulatisporites pannuceus* (Brenner) Singh, pl. 20, figs. 9, 10.

*Description.* Spores radial, trilete. Amb subtriangular with somewhat acute apices and slightly concave to slightly convex sides. Laesurae distinct, sinuous, lipped, extending to equatorial margin; sometimes with terminal bifurcation; lips elevated, maximum width (usually at pole) up to 6  $\mu\text{m}$ , tapering equatorially. Proximal exine laevigate; distal exine undulant with relatively broad smooth sinuous elevations, in places with subradial arrangement, separated by very fine, sinuous, irregularly branching channels (vermiculi). Exine thickness 1.5–2  $\mu\text{m}$ .

*Dimensions* (12 specimens). Equatorial diameter 24 (36) 43  $\mu\text{m}$ .

*Remarks.* The Swan River specimens are on average somewhat larger than those reported previously, but in other respects accord well with the original diagnosis. Although *Undulatisporites* Pflug is not as yet clearly differentiated from other simple, acavate, trilete genera, it provides a more suitable repository for the species than does *Alsophilidites* Cookson ex Potonié 1956. *U. sp. cf. U. undulapolus* Brenner 1963 (Norris 1967, p. 87; pl. 10, figs. 6, 7), from the Late Albian of central Alberta, differs from *U. pannuceus* (Brenner) Singh in having rounded amb apices, narrower lips, and irregular distal channels which are probably corrosion effects.

*Previous records.* *U. pannuceus* has been reported previously from all formational units of the Potomac Group (Barremian–Albian) of Maryland as studied by Brenner (1963); and from the uppermost Peace River and Lower Shaftesbury Formations (late Middle–Late Albian) of north-western Alberta (Singh 1971).

For synonymy see Dettmann and Playford (1968, p. 76).

*Type species* (by original designation). *Clavifera triplex* (Bolkhovitina) Bolkhovitina 1966.

*Discussion.* *Clavifera* is one of four form-generic entities that have been circumscribed and discussed by Bolkhovitina (1966, 1968) in her comprehensive discourse on gleicheniaceus-like trilete spores. It differs from the other three (*Gleicheniidites* Ross emend. Bolkhovitina 1968, *Ornamentifera* Bolkhovitina 1966, and *Plicifera* Bolkhovitina 1966) in possessing bulbous or clavate projections at equatorial radii (as well as inter-radial equatorial thickenings typical of the *Tricrassati*) and exine that is essentially devoid of fine sculpture.

*Clavifera rudis* Bolkhovitina 1968

Plate 104, figs. 18, 19

1968 *Clavifera rudis* Bolkhovitina, p. 48; pl. 13, figs. 9–18; pl. 14, figs. 1–15; pl. 15, figs. 1–12.

*Description.* Microspores radial, trilete; distal surface arched. Amb subtriangular with almost straight sides and relatively short appendices. Laesurae long, extending near to equatorial margin, with narrow, slightly thickened lips. Exine 1–2  $\mu\text{m}$  thick; thicker at equator. Equatorial thickenings consisting of three, smooth, interradial crassitudes,

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EXPLANATION OF PLATE 104

All figures  $\times 500$  and from unretouched negatives.

- Fig. 1. *Costatoperforosporites foveolatus* Deák 1962; distal focus; GO65/2, 91·6 16·5; Y.1358.  
 Figs. 2–11. *Appendicisporites* spp. 2, 3, *A. crimensis* (Bolkhovitina) Pocock 1965; proximal and distal foci; GO61/1, 118·8 2·9; Y.1359. 4, *A. bilateralis* Singh 1971; median focus; GO45/16, 109·9 3·6; Y.1360. 5, 6, *A. potomacensis* Brenner 1963. 5, Proximal focus; GO65/10, 104·8 13·2, Y.1361. 6, Distal focus; GO24b/50, 101·0 19·3; Y.1362. 7, 8, *A. problematicus* (Burger) Singh 1971; proximal and distal foci; GO65/112, 119·1 9·7; Y.1363. 9, *A. jansonii* Pocock 1962; proximal focus; GO61/11, 108·8 13·1; Y.1364. 10, *A. bifurcatus* Singh 1964; proximal focus; GO64/6, 93·5 11·6; Y.1365. 11, *A. matesovae* (Bolkhovitina) Norris 1967; median focus; GO21b/23, 124·9 20·0; Y.1366.  
 Fig. 12. *Gleicheniidites senonicus* Ross 1949; median focus; GO31b/3, 107·1 7·9; Y.1367.  
 Figs. 13–16, 24–26. *Trilobosporites* spp. 13, *T. marylandensis* Brenner 1963; proximal focus; GO65/2, 100·0 17·8; Y.1368. 14, *T. apiverrucatus* Couper 1958; proximal focus; GO24c/4, 112·8 11·7; Y.1369. 15, 16, *T. humilis* Delcourt and Sprumont 1959; proximal and distal foci; GO64/18, 109·5 15·7; Y.1370. 24, 25, *T. purverulentus* (Verbitskaya) Dettmann 1963. 24, Median focus; GO65/39, 109·5 20·5; Y.1371. 25, Proximal focus; GO65/3, 100·5 7·7; Y.1372. 26, *T. hannonicus* (Delcourt and Sprumont) Potonié 1956; median focus; GO63/6, 104·8 8·6; Y.1373.  
 Fig. 17. *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann 1963; distal focus; GO24b/43, 129·1 14·6; Y.1374.  
 Figs. 18, 19. *Clavifera rudis* Bolkhovitina 1968; proximal and distal foci; GO64/13, 98·6 4·2; Y.1375.  
 Figs. 20, 21. *Coronatipora valdensis* (Couper) Dettmann 1963; proximal and distal foci; GO64/20, 104·8 13·0; Y.1376.  
 Figs. 22, 23. *Camarozonosporites ambigens* (Fradkina) comb. nov.; proximal and distal foci; GO21b/31, 111·3 8·0; Y.1377.  
 Fig. 27. *Sestrosporites pseudoalveolatus* (Couper) Dettmann 1963; proximal focus; GO21b/37, 108·3 17·1; Y.1378.

with maximum width (6–12  $\mu\text{m}$ ) at centres of interradii, and gently undulating margins. Proximal surface laevigate. Distal surface with conspicuous rugulate and/or verrucate elevations typically confined to triangular region, the sides of which parallel amb and are 6  $\mu\text{m}$  or more from latter. Rugulae/verrucae smooth, width 3–9  $\mu\text{m}$ , usually disposed  $\pm$  parallel to radii; projecting as rounded appendices (4–10  $\mu\text{m}$  long), one at each apex of amb.

*Dimensions* (8 specimens). Overall equatorial diameter 55–78  $\mu\text{m}$ .

*Previous records.* Bolkhovitina's (1968) records are from Russian Aptian to Cenomanian strata.

#### Genus ASBECKIASPORITES von der Brelie 1964

*Type species* (by original designation). *Asbeckiasporites wirthi* von der Brelie 1964.

*Discussion.* In a German Lower Cretaceous palynological study, von der Brelie (1964, p. 141) founded the genus *Asbeckiasporites* for the reception of certain trilete, 'cingulate' miospores in which the equatorial thickening is prominent interradially and reduced by invagination or truncation at the three apices of the subtriangular amb. Such differential development of the thickening served to separate von der Brelie's genus from *Murospora* Somers 1952, which has been applied to otherwise similar Upper Jurassic–Lower Cretaceous miospores, viz. *M. florida* (Balme) Pocock 1961.

#### *Asbeckiasporites wirthi* von der Brelie 1964

Plate 105, figs. 11, 12

1964 *Asbeckiasporites wirthi* von der Brelie, pp. 141–142; pl. 8, figs. 7, 8; pl. 9, figs. 1–6.

1971 *Murospora truncata* Singh, pl. 18, figs. 1, 2.

*Description.* Spores radial, trilete. Amb subtriangular with concave to almost straight sides; equatorial contour distinctly to slightly undulating. Laesurae usually distinct, simple, straight; extending to spore-cavity margin. Equatorial thickening smooth and homogeneous, or showing fine radial striations; strongly developed interradially (maximum width 8–12  $\mu\text{m}$ ), restricted at each of the 3 radial positions where it is distinctly embayed or truncated. Outline of spore cavity (polar view) subtriangular with concave to almost straight sides and pointed to rounded apices. Unthickened exine (i.e. delimiting spore cavity proximally and distally) laevigate, scabrate, chagrenate, or punctate.

*Dimensions* (20 specimens). Overall equatorial diameter 40 (48) 60  $\mu\text{m}$ .

*Remarks.* Von der Brelie (1964, p. 142) noted that the distal exines of some of his specimens possess sparse verrucate projections, circular to elongate-oval in surface view and irregular in distribution. He regarded these as 'secondary features without taxonomic significance'. A few of the Canadian specimens encountered during the current work display similar verrucate modification.

*Previous records.* The species was originally described from Lower Cretaceous (? Aptian or Albian) sediments of north-western Germany (von der Brelie 1964). The subsequent

Canadian record by Singh (1971) is from north-western Alberta strata of Late Albian age (Paddy Member, Peace River Formation–Lower Shaftesbury Formation).

Genus CAMARAZONOSPORITES Pant ex R. Potonié emend. Klaus 1960

*Type species* (by subsequent designation of Potonié 1956, p. 65). *Camarazonosporites cretaceus* (Weyland and Krieger) R. Potonié 1956.

*Camarazonosporites ambigens* (Fradkina) comb. nov.

Plate 104, figs. 22, 23

- 1963 *Lycopodiacidites cerniidites* (non Ross) Brenner, pp. 43–44; pl. 5, fig. 2.  
 1964 *Lycopodiacidites cerniidites* (non Ross) Brenner 1963; von der Brellie, p. 138; pl. 6, figs. 12–14.  
 1964 *Camptotriletes ambigens* Fradkina in Fradkina and Kiseleva, p. 70; pl. 1, figs. 3–5.  
 1967 *Camarazonosporites insignis* Norris, pp. 96–97; pl. 13, figs. 12–16.

*Description.* Spores radial, trilete, with convexly subtriangular to subcircular amb. Laesurae distinct, simple, straight, extending two-thirds to three-quarters of the distance to equator. Exine tricassate—at amb apices, exine is 1–2  $\mu\text{m}$  thick; at equatorial inter-radii, 3–6  $\mu\text{m}$ . Sculpture rugulate (usually much more conspicuously so on distal surface). Proximal rugulae usually sparse and with subradial orientation. Distal rugulae well defined, sinuous, smooth, typically with irregularly pleated appearance; width 1.5–4  $\mu\text{m}$ , height 1.5–2.5  $\mu\text{m}$ ; separated by sharply defined channels about

EXPLANATION OF PLATE 105

All figures  $\times 500$  unless otherwise specified; from unretouched negatives.

- Figs. 1, 2. *Foraminisporis* spp. 1, *F. dailyi* (Cookson and Dettmann) Dettmann 1963; median focus; GO31b/2, 110.5 16.6; Y.1379. 2, *F. wonthaggiensis* (Cookson and Dettmann) Dettmann 1963; proximal focus; GO31a/1, 105.4 14.6; Y.1380.  
 Figs. 3, 4. *Polycingulatisporites reduncus* (Bolkhovitina) Playford and Dettmann 1965; proximal and distal foci; GO65/2, 96.6 16.7; Y.1381.  
 Fig. 5. *Taurocusporites segmentatus* Stover 1962; median focus; GO65/88, 107.8 17.7; Y.1382.  
 Figs. 6, 7, 17. *Densoisporites* spp. 6, 7, *D. circumundulatus* (Brenner) comb. nov. 6 ( $\times 750$ ), Proximal focus; GO65/70, 109.8 11.2, Y.1383. 7, Median focus; GO24c/14, 110.4 4.3; Y.1384. 17, *D. micro-rugulatus* Brenner 1963; proximal focus; GO65/8, 104.2 18.0; Y.1385.  
 Fig. 8. *Lundbladispora reticingula* (Brenner) comb. nov.; proximal focus; GO65/1, 89.6 5.4; Y.1386.  
 Figs. 9, 10. Spore type A; proximal and distal foci; GO65/7, 110.1 10.0; Y.1387.  
 Figs. 11, 12. *Asbeckiasporites wurthi* von der Brellie 1964; proximal foci. 11, GO21b/35, 109.4 17.4; Y.1388. 12, GO62/13, 110.1 7.0; Y.1389.  
 Figs. 13–16. *Triporeletes* spp. 13–15, *T. involucreatus* (Chlonova) comb. nov. ( $\times 750$ ). 13, 14, Low and high foci; GO31b/3, 111.0 2.9; Y.1390. 15, Median focus; GO65/79, 105.8 10.9; Y.1391. 16, *T. laevigatus* (Pocock) comb. nov.; median focus; GO24c/16, 107.0 6.6; Y.1392.  
 Figs. 18–20. *Crybelosporites brennerii* sp. nov.; lateral views. 18, Holotype; GO24b/15, 106.2 4.1; Y.1393. 19, GO46/10, 106.4 16.0; Y.1394. 20, GO29c/1, 101.3 14.0; Y.1395.  
 Fig. 21. *Cicatricosporites auritus* Singh 1971; lateral aspect; GO65/25, 107.5 11.7; Y.1396.  
 Fig. 22. *Laevigatosporites ovatus* Wilson and Webster 1946; median focus; GO24c/65, 117.0 10.7; Y.1397.  
 Figs. 23–25. *Kraeuselisporites hastilobatus* sp. nov. 23, 24, Holotype; median and distal foci; GO26/15, 108.2 6.7; Y.1398. 25 ( $\times 1000$ ), showing distal sculptural projections; GO65/100, 95.2 8.9; Y.1399.

0.5–1.5  $\mu\text{m}$  wide. Inner exine layer (nexine) uniformly thin. Equatorial contour normally crenate.

*Dimensions* (30 specimens). Equatorial diameter 28 (43) 54  $\mu\text{m}$ . This accords closely with the size ranges quoted by previous authors [Fradkina 1967, p. 99–27 (43) 60  $\mu\text{m}$ ; Norris 1967, p. 97–30 to 55  $\mu\text{m}$ ].

*Previous records.* According to Fradkina (1964, 1967), *Camarozonosporites ambigens* (Fradkina) comb. nov. occurs in Albian–Senonian strata of Vilyui and Lena River Basins, Yakutsk, U.S.S.R. It occurs also in imprecisely dated Lower Cretaceous sediment of north-west Germany (von der Brellie 1964). From North America, Brenner (1963) noted its rare occurrence in the Albian Patapsco Formation, Maryland; Norris (1967) described it from the Late Albian, central Alberta; and Singh (1971) plots the initial entry of the species (as *C. insignis*) in the lower part of the Cadotte Member (late Middle Albian) of the Peace River Formation and shows its consistent presence higher in the sequence (Shaftesbury Formation). Another (probably late Middle) Albian record is from Oklahoma (Hedlund and Norris 1968).

#### Spore Type A

Plate 105, figs. 9, 10

*Description.* Spores radial, trilete, cavate, with subcircular to convexly subtriangular amb having notched periphery. Laesurae simple or narrowly lipped, perceptible to distinct, extending about one-half to two-thirds of distance to equator. Exoexine relatively thin proximally on (usually) well-defined, laevigate-scabrate, subtriangular contact area (ca. 30–40  $\mu\text{m}$  in diameter). Remainder of exoexine sculptured with pits (foveolae) and/or fine sinuous channels (vermiculi), especially in distal and equatorial regions, less commonly on equatorial region of proximal surface; unsculptured exoexine (outside contact areas) 2.5–3.5  $\mu\text{m}$  thick. Foveolae subcircular to polygonal or irregularly elongate in surface view, diameter ranges from less than 1–10  $\mu\text{m}$ , spacing up to 8  $\mu\text{m}$  apart. Vermiculi, where present, have similarly variable spacing, are usually less than 0.5  $\mu\text{m}$  broad, and average about 1–2  $\mu\text{m}$  in length. Sculptural elements incised 2  $\mu\text{m}$  or less in exoexine. Inner layer (intexine) featureless, about 0.5  $\mu\text{m}$  thick, more or less distinctly separated from exoexine, forming central body with subcircular-roundly subtriangular outline in polar view.

*Dimensions* (5 specimens). Overall equatorial diameter 48 (54) 65  $\mu\text{m}$ ; intexinal body diameter 32 (40) 52  $\mu\text{m}$ .

*Remarks.* So far as the author is aware no closely comparable form has appeared in the literature. Thus although a new taxon appears to be represented, formal systematic treatment must be withheld, pending the discovery of many more specimens than the five currently available.

#### Genus KRAEUSELISPORITES Leschik emend. Jansonius 1962

For synonymy and discussion see Playford and Helby (1968, p. 112).

*Type species* (by original designation). *Krauselisporites dentatus* Leschik 1955.

*Kraeuselisporites hastilobatus* sp. nov.

Plate 105, figs. 23–25

*Diagnosis.* Spores radial, trilete, zonate. Amb convexly subtriangular; margin undulate to somewhat crenulate. Laesurae frequently indistinct but accompanied by well-defined, narrow (individually 1  $\mu\text{m}$  or less in width), elevated, sinuous lips extending to equatorial margin; in most examples a distinct subtriangular gape in the exoexine (and often also in the intexine), defined by dehiscent lips/laesurae, occurs over the spore cavity to which it approximates in extent. Exoexine zonate, with well-developed distal sculpture usually confined to area over spore cavity (i.e. absent or rare on zona). Sculptural projections consist of large, discrete spinae, tapering from circular bases (1.5–4  $\mu\text{m}$  broad) to sharp, rounded, or truncate tips; length of spinae 4–12  $\mu\text{m}$ , spacing about 1–11  $\mu\text{m}$ . Proximal surface of exoexine featureless apart from fine minor compression-folding. Zona of approximately uniform width on a given specimen. Intexine thin, occasionally recognizable as a fairly distinct inner body partly separated from outer layer.

*Dimensions* (14 specimens). Overall equatorial diameter 66 (82) 103  $\mu\text{m}$ ; width of zona 5 (8) 12  $\mu\text{m}$ .

*Holotype.* Preparation GO26/15, 108.2 6.7, Y.1398. Pl. 105, figs. 23, 24. Distal aspect. Amb roundly subtriangular. Well-defined, narrow laesurate lips defining proximal, convexly subtriangular gape, 34  $\mu\text{m}$  in diameter, and thereafter extending radially to equatorial margin. Distal exoexine, excluding zona, bearing discrete, simple spinae, mostly with pointed apices. Dimensions of spinae—length 8–10  $\mu\text{m}$ , basal diameter 3–5  $\mu\text{m}$ ; spinae spaced up to 8  $\mu\text{m}$  apart. Exoexine otherwise laevigate apart from radial compression folds on proximal face. Intexine very thin, situated close to inner margin of exoexine. Overall diameter 85  $\mu\text{m}$ . Zona averages 11  $\mu\text{m}$ ; margin crenulate.

*Type locality.* Saskatchewan, S.W.P. Bredebury 11–36, core, 1353–1358 feet; Swan River Group.

*Comparison.* The Austrian Carnian form, *Kraeuselisporites cooksonae* (Klaus 1960, p. 141; pl. 31, figs. 29, 31) Dettmann 1963, differs from *K. hastilobatus* sp. nov. in having a conate (rather than spinose) sculpture, shorter laesurae, and an almost entire periphery.

## Genus LUNDBLADISPORIA Balme emend. Playford 1965

*Type species* (by original designation). *Lundbladispora willmotti* Balme 1963.

*Lundbladispora reticingula* (Brenner) comb. nov.

Plate 105, fig. 8

1963 *Cingulatisporites reticingulus* Brenner, p. 42; pl. 4, figs. 2, 3.

*Description.* Spores radial, trilete, cavate, cingulate. Amb convexly subtriangular. Laesurae accompanied by membranous lips, 1–3  $\mu\text{m}$  in overall width, extending to inner margin of cingulum. Exoexine, with finely spongy appearance (superficially scabrate), bearing discrete simple spinae on distal surface and at equator; spinae 1.5–5.5  $\mu\text{m}$  in basal diameter (bases circular in surface view), 3–8.5  $\mu\text{m}$  long, spaced 2–10  $\mu\text{m}$  apart, sides regularly tapering, apices sharp. Cingulum 3–6.5  $\mu\text{m}$  wide (somewhat variable on given specimen). Intexinal body usually well defined, wall about 1  $\mu\text{m}$  thick, homogeneous; in polar view body shape is subtriangular, diameter 20–28  $\mu\text{m}$ ; often only partly detached from exoexine.



*Dimensions* (8 specimens). Overall equatorial diameter 35 (40) 43  $\mu\text{m}$ .

*Remarks.* The few Swan River specimens described above are in close morphological accord with those described originally (Brenner 1963, p. 42). Brenner's generic allocation of the species cannot be upheld because *Cingulatisporites* Thomson (*in* Thomson and Pflug 1953), though narrowly cingulate, is acavate and where sculptured is only finely so (see Pocock's (1961) clarified circumscription of the latter genus). The species does, however, find appropriate inclusion in *Lundbladispota* Balme as emended by Playford (1965). The spores figured by Singh (1971, pl. 17, figs. 10, 11) almost certainly belong to the species under consideration.

*Previous records.* Initially recorded from the Lower Cretaceous (Barremian–Albian) Potomac Group of Maryland (Brenner 1963), this species has also been reported from the Albian of Oklahoma (Hedlund and Norris 1968). Singh's possible record (1971) is from the Cadotte Member (late Middle Albian), Peace River Formation, north-western Alberta.

Genus *DENSOISPORITES* Weyland and Krieger emend. Dettmann 1963

*Type species* (by original designation). *Densoisporites velatus* Weyland and Krieger 1953 emend. Krasnova 1961 (= *D. perinatus* Couper 1958).

*Densoisporites circumundulatus* (Brenner) comb. nov.

Plate 105, figs. 6, 7

1963 *Psilatriteles circumundulatus* Brenner, pp. 67–68; pl. 20, figs. 4, 5.

*Description.* Spores radial, trilete. Amb subtriangular with convex to almost straight sides and rounded apices. Laesurae distinct, usually sinuous, length at least three quarters of spore radius; bordered by elevated thickened lips, 1–3.5  $\mu\text{m}$  in overall width, often displaying terminal bifurcation. Exine two-layered, cavate, consisting of a thin, well-defined, featureless intexine (0.5–1  $\mu\text{m}$  thick) showing slight and partial contraction from enclosing exoexine (separation of two layers rarely more than 4  $\mu\text{m}$ ). Exoexine laevigate or with fine irregular pitting (? result of corrosion); thickness similar to that of intexine except at equator where a continuous thickening (i.e. cingulum, 2.5–5  $\mu\text{m}$  wide) is developed. Exoexine frequently but not invariably contorted with radial folds; where present these give an undulating appearance to equatorial margin. Arcuate compression folds developed marginally on intexinal body of some specimens.

*Dimensions* (10 specimens). Overall equatorial diameter 34 (40) 46  $\mu\text{m}$ .

*Remarks.* The original generic attribution of this species to *Psilatriteles* van der Hammen ex van der Hammen 1956 (or to *Poroplanites* Pflug 1953, regarded by Potonié (1956, p. 18) as a senior synonym of *Psilatriteles*) cannot be maintained on account of the two-layered, cavate nature of its exine, which in being virtually unsculptured conforms with *Densoisporites*.

*Previous records.* *Densoisporites circumundulatus* (Brenner) comb. nov. is known sparsely from Lower Cretaceous (Barremian–Albian) strata of Maryland (Brenner 1963) and from north German sediments of Barremian–Aptian age (Döring 1966).

Genus *CRYBELOSPORITES* Dettmann 1963

*Type species* (by original designation). *Crybelosporites striatus* (Cookson and Dettmann) Dettmann 1963.

*Crybelosporites brennerii* sp. nov.

Plate 105, figs. 18–20

1963 *Perotriletes* [sic] *striatus* non Cookson and Dettmann; Brenner, pp. 66–67, pl. 19, fig. 3, pl. 20, fig. 1.

*Diagnosis.* Spores radial, trilete, spheroidal. Sclerine stratified, proximally cavate, consisting of: a relatively thick, homogeneous inner layer, 1–1.5  $\mu\text{m}$  thick; and an outer layer (sculptine), about 0.5  $\mu\text{m}$  thick, that is in close proximity to inner layer around distal surface and equator but projected proximally (and thus distinctly separated from inner layer by a cavum) to form a gula-type projection over proximal pole. Sculptine very finely sculptured (scabrate to microrugulate); sculpture usually even less conspicuous on proximal projection which may be superficially almost laevigate. Laesurae usually very difficult to detect; where visible, are simple, straight slits extending about two-thirds of the distance to equator. Compressional folds of sculptine common.

*Dimensions* (12 specimens). Equatorial diameter 33 (39) 46  $\mu\text{m}$ ; polar diameter 42 (51) 60  $\mu\text{m}$ ; diameter of inner layer (measured along polar axis) 30 (37) 44  $\mu\text{m}$ .

*Holotype.* Preparation GO24b/15, 106-2 4-1, Y.1393. Pl. 105, fig. 18. Equatorial aspect. Spore spheroidal; equatorial diameter 42  $\mu\text{m}$ , polar diameter 57  $\mu\text{m}$ . Sclerine 2  $\mu\text{m}$  thick. Sculptine very thin, scabrate to microrugulate (lumina not delimited); microrugulae less than 0.5  $\mu\text{m}$  in width, up to 7  $\mu\text{m}$  long. Inner layer of sclerine about 1–1.5  $\mu\text{m}$  thick, featureless apart from several large-scale folds resulting from compression; diameter 40  $\mu\text{m}$  (measured along equatorial axis)  $\times$  39  $\mu\text{m}$  (along polar axis).

*Type locality.* Saskatchewan, S.W.P. Bredenbury 11–36, core, 1391–1395 feet; Swan River Group.

*Remarks and comparison.* From specimens currently available it is not entirely certain whether the sculptine is one- or two-layered. The former seems to be the case, though in all other respects the species is clearly conformable with *Crybelosporites* Dettmann 1963. '*Perotriletes*' *bursatus* Hall 1963 (pp. 434, 436; figs. 16, 17) from Iowa (U.S.A.) Cenomanian strata is close to, possibly identical with *C. brennerii* sp. nov. Although Hall's pictures are none too clear, his species seems to be less distinctly sculptured than *C. brennerii* and the sculptine is thicker and forms a relatively minor proximal projection. *C. striatus* (Cookson and Dettmann) Dettmann 1963 (p. 81; pl. 18, figs. 1–6), which occurs in Late Aptian–Turonian sediments of eastern Australia (Dettmann and Playford 1969), differs from the present species in the sculptural characteristics of the outer exine layer, which is distinctly reticulate.

*Previous records.* Brenner (1963) initially illustrated the form described above and noted its distribution throughout the Lower Cretaceous Potomac Group of Maryland.

Genus *COPTOSPORA* Dettmann 1963

*Type species* (by original designation). *Coptospora striata* Dettmann 1963.

*Coptospora williamsii* sp. nov.

Plate 106, figs. 8–13

*Diagnosis.* Spores hilate, biconvex; amb circular, subcircular, or convexly subtriangular. Exine stratified, comprising two layers that are closely adpressed or show only slight, partial detachment from one another (maximum separation up to  $7\ \mu\text{m}$ ). Exoexine  $5\text{--}9\cdot5\ \mu\text{m}$  thick (often variable, same specimen), very finely sculptured (scabrate, punctate, microvermiculate, granulate, to microrugulate). Distinct, circular to subcircular, potentially hilate area, centrally located on distal surface, and  $52\text{--}65\ \mu\text{m}$  in diameter; area with sharply defined, incised, undulating margin and somewhat coarser, sparser sculpture (vermiculate–punctate) than remainder of exoexine to which it approximates in thickness. Hilum results from detachment of this caplike structure (see Pl. 106, fig. 8). Intexine  $0\cdot5\text{--}1\ \mu\text{m}$  thick, homogeneous, featureless. Tetrad mark absent or (occasionally) represented by poorly defined, low, subradial folds, up to  $3\cdot5\ \mu\text{m}$  wide and half the spore radius in longitudinal extent.

*Dimensions* (12 specimens). Equatorial diameter 82 (104)  $140\ \mu\text{m}$ .

*Holotype.* Preparation GO65/2, 98-7 23-2, Y.1408. Pl. 106, figs. 9, 10. Distal aspect. Diameter  $91\ \mu\text{m}$ , amb broadly roundly subtriangular. Exoexine averaging  $8\ \mu\text{m}$  thick, with very fine sculptural pattern of microvermiculi and punctae, which are sparser and better defined on potentially hilate area. Latter area is subcircular in outline,  $56\ \mu\text{m}$  in diameter, with clearly incised, undulating margin. Intexine about  $0\cdot5\ \mu\text{m}$  thick, in part contracted (by up to  $2\ \mu\text{m}$ ) from exoexine. No tetrad mark.

*Type locality.* Manitoba, Swan River area, SW.  $\frac{1}{4}$ , sec. 10, Tp. 37, Range 27 W. P. Mer.; Swan River Group (sample 69-W-32), about 40 feet below base of Ashville Group.

*Comparison.* *Coptospora williamsii* sp. nov. is readily distinguishable from other species ascribed to the genus. The most closely comparable form appears to be *C. dettmannae*, which was described by Döring (1966, p. 110; pl. 6, figs. 1–4) from the German Neocomian. The latter is distinct, however, from the Manitoba species in being differently and more coarsely sculptured (verrucate) and in having an apparently one-layered exine.

## Genus TRIPOROLETES Mtchedlishvili 1960 emend.

1960 *Triporoletes* Mtchedlishvili in Mtchedlishvili and Samoilovich, pp. 127–128.

1962 *Rouseisporites* Pocock, pp. 52–53.

*Emended diagnosis.* Spores invariably devoid of proximal aperture; tetrad mark, where evident, comprises three radial ridges that are faintly or distinctly developed. Amb convexly subtriangular to subcircular. Sclerine consists of two layers; the outer being thin, membraneous, often loosely enveloping, zonate. Zona with a flask-shaped to conical invagination at each radial position of equator. Distal surface bearing mureoid ridges, which may anastomose to form a reticulum; proximal surface smooth to reticulate.

*Type species* (by monotypy). *Triporoletes singularis* Mtchedlishvili in Mtchedlishvili and Samoilovich 1960 (pp. 128–129; figs. 13, 14). Synonym: *Rouseisporites triangularis* Pocock 1962 (p. 54; pl. 7, figs. 110, 111). Illustrated herein as Pl. 106, fig. 1. Occurrence: U.S.S.R., Siberia; Albian–Turonian (Mtchedlishvili and Samoilovich 1960; Samoilovich *et al.* 1961; Chlonova 1969). Western Canada, Lower Cretaceous (Pocock, 1962; Singh 1964, 1971; Vagvolgyi and Hills 1969; this paper).

*Other species.*

1. *Triporoletes granospeciosus* (Delcourt and Sprumont) comb. nov. Synonymy: *Cingulatisporites granospeciosus* Delcourt and Sprumont 1955, p. 39; pl. 4, fig. 2. Occurrence: Belgium, Wealden.
2. *Triporoletes involucratus* (Chlonova) comb. nov. [described, illustrated, and formally combined below].
3. *Triporoletes laevigatus* (Pocock) comb. nov. (Pl. 105, fig. 16). Synonymy: *Rouseisporites laevigatus* Pocock 1962, pp. 53–54; pl. 7, figs. 106–109. Occurrence: Western Canada, Lower Cretaceous (Pocock 1962; Singh 1964; this paper). U.S.A. (Oklahoma), Albian (Hedlund and Norris 1968).
4. *Triporoletes radiatus* (Dettmann) comb. nov. (Pl. 106, figs. 3, 4). Synonymy: *Rouseisporites radiatus* Dettmann 1963, p. 98; pl. 23, figs. 13–17. Occurrence: South-eastern Australia, Lower Cretaceous (Dettmann 1963). Western Canada, Lower Cretaceous (Singh 1971; this paper).
5. *Triporoletes reticulatus* (Pocock) comb. nov. (Pl. 106, fig. 5). Synonymy: *Rouseisporites reticulatus* Pocock 1962, p. 53; pl. 7, figs. 101–105. Occurrence: Western Canada, Lower Cretaceous (Pocock 1962; Singh 1964, 1971; Vagvolgyi and Hills 1969; this paper). U.S.A. (Oklahoma), Albian (Hedlund and Norris 1968). South-eastern Australia, Lower Cretaceous (Dettmann 1963). Siberia, Lower Cretaceous (Chlonova 1969). Rumania, Albian (Baltes 1967). Argentina, Lower Cretaceous (Barremian–Aptian) (Archangelsky and Gamberro 1967).
6. *Triporoletes simplex* (Cookson and Dettmann) comb. nov. (Pl. 106, fig. 2). Synonymy: *Cingulatisporites simplex* Cookson and Dettmann 1958, p. 110; pl. 17, figs. 7, 8. Occurrence: South-eastern Australia, Lower Cretaceous (Aptian–Albian) (Dettmann 1963). Western Canada, Lower Cretaceous (this paper).

In addition, several other relatively poorly known species regarded as possibly comparable with *Rouseisporites* (see Dettmann 1963, p. 96) must be considered similarly as akin to *Triporoletes*.

*Discussion.* The type species of Mtchedlishvili's genus *Triporoletes* (*in* Mtchedlishvili and Samoilovich 1960), *T. singularis* Mtchedlishvili, has been fully described in two Russian works—Mtchedlishvili and Samoilovich (1960) and Samoilovich *et al.* (1961). There remains no doubt as to its synonymy with *Rouseisporites triangularis*, a similarly well-documented species initially described (along with the genus) by Pocock (1962). *Triporoletes*, being instituted two years earlier, takes priority over Pocock's genus. The diagnosis of *Triporoletes* given here is essentially based upon Dettmann's (1963, p. 96) 'restated' version of the original *Rouseisporites* diagnosis.

Delcourt, Dettmann, and Hughes (1963, p. 219) pointed to *Zlivisporis* Pacltova 1961 and *Seductisporites* Chlonova 1961 as being comparable with *Rouseisporites*. Further

## EXPLANATION OF PLATE 106

All figures  $\times 500$  unless otherwise specified; from unretouched negatives.

- Figs. 1–5. *Triporoletes* spp. 1, *T. singularis* Mtchedlishvili 1960; median focus; GO26/8, 113.1 10.5; Y.1400. 2, *T. simplex* (Cookson and Dettmann) comb. nov.; distal focus; GO46/6, 104.2 20.4; Y.1401. 3, 4, *T. radiatus* (Dettmann) comb. nov. 3, Median focus; GO46/1, 135.2 9.6; Y.1402. 4, Distal focus; GO65/117, 104.7 11.9; Y.1403. 5, *T. reticulatus* (Pocock) comb. nov.; distal focus; GO26/23 109.4 14.8; Y.1404.
- Fig. 6. *Schizosporis reticulatus* Cookson and Dettmann 1959; GO21b/26, 104.9 1.6; Y.1405.
- Fig. 7. *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann 1961; median focus; GO69/6, 94.6 9.1; Y.1406.
- Figs. 8–13. *Coptospora williamsii* sp. nov. 8, Lateral aspect; GO65/106, 109.0 13.5; Y.1407. 9, 10, Holotype; distal and proximal foci; GO65/2, 98.7 23.2; Y.1408. 11, 12, Proximal and distal foci. 13, distal focus ( $\times 1000$ ); GO65/2, 96.7 15.4; Y.1409.

information on the two first named genera could result in their being attributed to *Triporoletes*.

*Ricciaesporites* Nagy 1968, from Hungarian Miocene strata, is closely similar to *Triporoletes* (al. *Rouseisporites*) as Nagy (1969, p. 317 footnote) has commented. Aside from their considerable age-disparity, it does not seem appropriate at this stage to merge the two generic taxa, for both species allocated by Nagy to *Ricciaesporites* show a much closer resemblance to extant ricciaceous spores (in particular to those of *Riccia*—see Nagy 1968, pl. 7) than they do to the type (and other) species of *Triporoletes*.

*Affinity.* Mtchedlishvili and Samoilovich (1960) implied that *Triporoletes* is angiospermous; but this is considered much less likely than the hepatic relationship that has subsequently been suggested (see Dettmann 1963, p. 96). The latter author considered it probable that the (distal) muroid elevations represent germinal exits as in extant Ricciaceae and Cleveaceae.

*Triporoletes involucratus* (Chlonova) comb. nov.

Plate 105, figs. 13–15

1969 *Rouseisporites involucratus* Chlonova, p. 55; pl. 9, figs. 8–12.

*Description.* Spores circular to subcircular in equatorial outline; no tetrad mark evident. Sclerine two-layered: very thin, hyaline, outer layer enveloping thicker (0.75–1  $\mu\text{m}$  thick) inner layer and extending beyond the latter equatorially as a discontinuous zonate structure. Except for zonate extensions, the two layers are in close contact. Outline of inner layer (polar view) undulating; zona attains maximum width (up to 10  $\mu\text{m}$ ) within smoothly concave embayments, and is narrowest or non-existent (1.5  $\mu\text{m}$  or less) about convex projecting areas ('blades' of Chlonova 1969). Embayments unequal, number per specimen varies from 4 to 7. One surface (? distal) partly sculptured with fine, close-spaced, somewhat sinuous ridges, which are about 0.5–1  $\mu\text{m}$  high and wide; sculpture typically displays radial or subradial orientation and extends about half the distance to equator. Remainder of spore surface smooth to faintly scabrate.

*Dimensions* (15 specimens). Overall equatorial diameter 35 (44) 50  $\mu\text{m}$ .

*Remarks and comparison.* The species shows obvious morphological similarities with *Triporoletes* (al. *Rouseisporites*), but because only vague indications of pore-like or cone-like marginal invaginations were seen on an occasional specimen, the generic allocation must be regarded as provisional. Cookson and Eisenack (1962, p. 271; pl. 37, figs. 6–8) have illustrated and described *Halophordia xena*, an incertae sedis palynomorph from probable Albian–Cenomanian of Western Australia which shows some resemblance to *Triporoletes involucratus* (Chlonova) comb. nov. The Australian species, however, is unwrinkled and displays a much more regular inner body or capsule with 4 strongly concave sides (hence 'hour-glass-shape'), together with a more extensively encompassing outer layer.

*Previous records.* The first and only previous report of *T. involucratus* is from Albian–Cenomanian deposits of western Siberia (Chlonova 1969).

NOTE ON *RETITRICOLPITES* AND *TRICOLPITES*

The dispersed pollen genus *Retitricolpites* van der Hammen 1956 appears to be of confused status and uncertain validity (see discussion by Srivastava 1966, p. 547, and Potonié 1966, pp. 163–164). Two 'lectogenerotypes' have been nominated independently at different times—viz. *R. ovalis* van der Hammen and Wymstra 1964 and *R. vulgaris* Pierce 1961 by van der Hammen and Wymstra (1964, p. 235) and Potonié (1966, p. 163), respectively—since the type originally chosen, *R. ornatus* v. d. H., came from an extant species, *Neea macrophylla* Poepp. and Endl. (van der Hammen 1956, p. 60). Even accepting the ultimately correct typification of *Retitricolpites*, the problem remains as to whether it can meaningfully be separated from *Tricolpites* Cookson ex Couper 1953 which also accommodates reticulate, tricolpate, fossil pollen. Such a problem can only be solved by a thorough reappraisal of the type and other contents of the two taxa. For the present purpose, no alteration is made or suggested in the generic allocation of species hitherto placed in *Retitricolpites*.

## DISCUSSION OF THE PALYNOLOGICAL FLORA

Swan River stratal occurrences of the spore-pollen forms identified are shown on Table 1, which also notes the presence of non-calcareous microplankton (dinoflagellate cysts and acritarchs) in certain of the samples. These latter palynological components are not discussed further in this work; their presence may be taken as a reasonable indication of marine conditions or at least of nearby marine influences.

*Biostratigraphic significance*

Although a detailed palynological scheme has yet to be established for the western Canada Lower Cretaceous, a reasonably accurate assessment of the age and correlation of the Swan River sediments is possible by reference to existing published information and particularly to Singh (1971). The latter, in the most intensive study carried out to date in the region, emphasizes the biostratigraphic utility of the introduction of angiospermous microfossils which in his studied section is charted at a horizon in the Harmon Member (Middle Albian) of the Peace River Formation. Useful also in a biostratigraphic sense are Norris's (1967) data which demonstrate a distinct 'microfloral break', marked especially by abrupt angiosperm introduction, at the Grand Rapids–Joli Fou contact. Norris (pp. 81–82) commented on this at some length, suggesting the possibility of a disconformable relationship between the two formations.

The Early Cretaceous age which has generally been held for the Swan River strata is exemplified by their palynological flora, which possess numerous spore-pollen elements known previously from Lower Cretaceous sediments of Canada and U.S.A., and of many distant localities, viz. in western Europe, U.S.S.R., and Australia. Such affiliations with coeval extra-North American assemblages will be discussed in an ensuing section of this paper.

The subsurface Saskatchewan sequence studied herein (Bredenbury no. 11–36 well) shows some microfloral variation within its 122 feet of Lower Cretaceous Swan River strata (see Table 1). Certain forms, known from previous work to have biostratigraphic utility, show restricted vertical distribution, viz. certain angiospermous elements; trilete spores attributed to *Camarozonosporites ambigens* and *Asbeckiasporites wurthi*; and

bisaccate grains of the taxa *Phyllocladidites inchoatus* and *Rugubivesiculites reductus*. These all appear in the Bredenbury well at 1340–1345 feet and higher levels and are present also in the sampled type outcrops of the upper Swan River Group of the Swan River area, Manitoba. Accordingly, the latter are correlative with the Bredenbury well interval 1273–1345 feet.

As noted previously a Middle Jurassic spore-pollen suite is recognizable in the Bredenbury well at a depth of 1408–1413 feet. The overlying sampled interval between 1395 and 1273 feet is clearly of Early Cretaceous age, as testified by association of such spores as *Cicatricosisporites australiensis*, *C. hallei*, *Pilosporites trichopapillosus*, *Appendicisporites* spp., *Trilobosporites apiverrucatus*, *T. marylandensis*, *T. purverulentus*, *Foraminisporis asymmetricus*, *Aequitriradites spinulosus*, *Triporeletes* (al. *Rouseisporites*) spp., *Classopollis classoides*, *Circulina parva*, *Exesipollenites tumulus*, *Clavatipollenites* spp., *Alisporites bilateralis*, *A. grandis*, and *Podocarpidites multesimus*. In addition, many other less consistently occurring species conform with an Early Cretaceous dating for both subsurface and outcrop material; e.g. *Undulatisporites pannuceus*, *Concavissimisporites* spp., *Kuylisporites lunaris*, *Microreticulatisporites uniformis*, *L. marginatus*, *Cicatricosisporites hughesi*, *Crybelosporites brennerii*, *Couperisporites complexus*, *Cooksonites variabilis*, *Equisetosporites multicostatus*, *Liliacidites peroreticulatus*, and *Podocarpidites canadensis*.

The subsurface Bredenbury section below 1345 feet (i.e. sampled section 1353–1395 feet) is devoid of such angiospermous elements as *Retitricolpites*, *Tricolpites sagax*, *Fraxinoipollenites*, and *Striatopollis*. From this it is considered that the lower Bredenbury Swan River sequence is a Mannville Group equivalent, being just older than the Harmon Member of the Peace River Formation and certainly antedating the Joli Fou Formation (cf. Singh 1964, Norris 1967). In a more positive sense, the lower Bredenbury section includes *Clavatipollenites rotundus* (probable synonym: *Liliacidites dividuus*) which is unknown from pre-Albian strata (Kemp 1968, Brenner 1963, Hedlund 1966, Hedlund and Norris 1968); *Triporeletes involucratus* for which the same age-restriction seems likely, at least in western Siberia (Chlonova 1969); *Cicatricosisporites spiralis*, which in Singh's (1971) Peace River section occurs only in the Loon River Formation (early Middle Albian); *Trilobosporites purverulentus* (not known indubitably from below the Aptian: Dettmann 1963); and *Triporeletes simplex* (Aptian–Albian: Dettmann 1963). Moreover, the distinctive '*Cicatricosisporites* sp. B' of Singh (1964), a component of the oldest Cretaceous sample of the Bredenbury well, is known elsewhere only from Upper Mannville (Grand Rapids Formation) and younger Alberta strata (cf. Singh 1964, Norris 1967). Collectively the palynological evidence suggests that the immediately supra-Middle Jurassic Bredenbury section of lower Swan River strata is Albian in age, probably early Middle Albian, and correlative with the Upper Mannville/Loon River segments of the Alberta Lower Cretaceous to the west (see Table 2).

The upper Swan River sequence of the Bredenbury well (i.e. 1273–1345 feet) and of sampled type exposures near Swan River contain undisputed angiospermous elements together with other palynomorph species not encountered in the lower well section. Stratigraphic significance of the entrance levels of certain of these forms has already been connoted by Singh (1971) and Norris (1967), although as mentioned earlier the sequence studied by the latter was probably interrupted by non-deposition in the later Middle Albian. The following appear, from previous knowledge of their North American

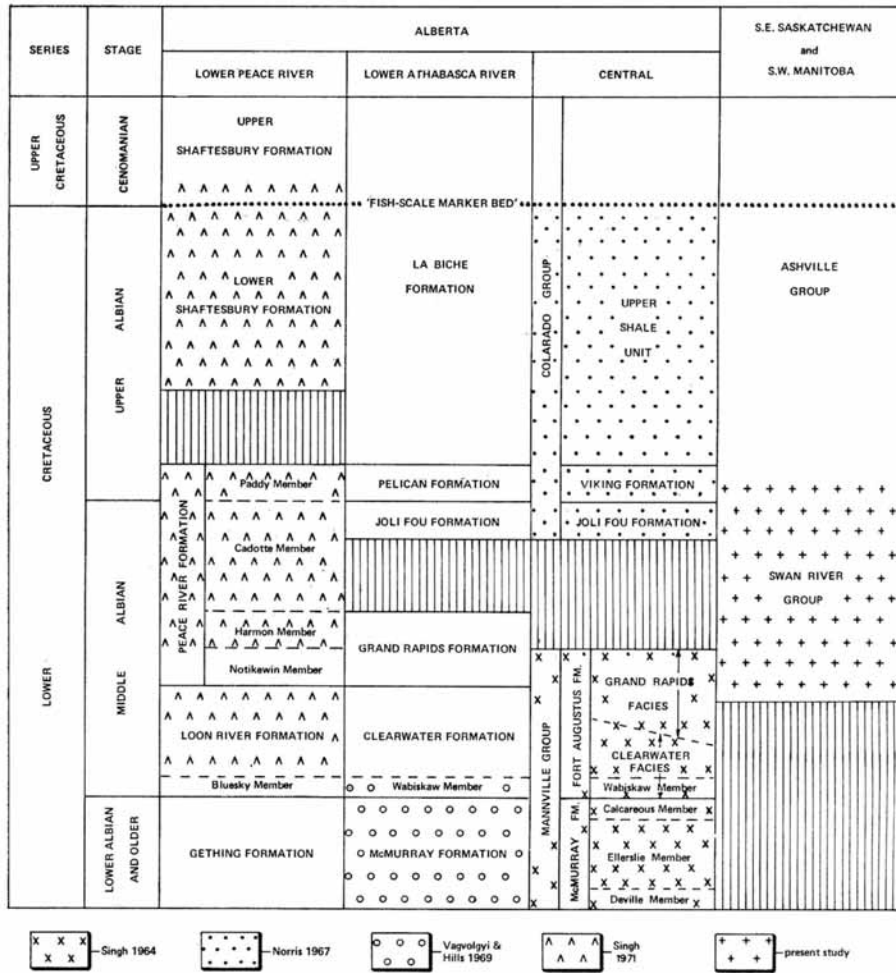


TABLE 2. Correlation chart of western Canadian Lower Cretaceous strata which have been studied palynologically. In addition to authors documented, Pocock (1962) studied Upper Jurassic-Lower Cretaceous material from various localities in Alberta and Saskatchewan; and Pocock (1965) and Steeves and Wilkins (1967) investigated Upper Mannville correlatives in the Saskatoon area, Saskatchewan. Stratigraphic nomenclature, intraprovincial correlation, and age of the Alberta columns are extracted from Singh (1971).



distribution (cited below), to be stratigraphically important components of these upper horizons:

- Retitricolpites vulgaris*: ? Cenomanian, Minnesota (Pierce 1961); Albian, Maryland (Brenner 1963); (? late Middle) Albian, Oklahoma (Hedlund and Norris 1968); Joli Fou–Upper Shale Unit, Alberta (Norris 1967); Harmon–upper Shaftesbury, Alberta (Singh 1971).
- Fraxinoipollenites venustus*: Cadotte–upper Shaftesbury, Alberta (Singh 1971).
- Retitricolpites prosimilis*: Joli Fou–Upper Shale Unit, Alberta (Norris 1967); Harmon–upper Shaftesbury, Alberta (Singh 1971).
- Tricolpites sagax*: Joli Fou–upper Shale Unit, Alberta (Norris 1967); (? late Middle) Albian, Oklahoma (Hedlund and Norris 1968); Cadotte–upper Shaftesbury, Alberta (Singh 1971).
- Camarozonosporites ambigens*: Albian, Maryland (Brenner 1963); (? late Middle) Albian, Oklahoma (Hedlund and Norris 1968); Viking–Upper Shale Unit, Alberta (Norris 1967); Cadotte–upper Shaftesbury, Alberta (Singh 1971).
- Asbeckiasporites wurthi*: Paddy–lower Shaftesbury, Alberta (Singh 1971).
- Phyllocladidites inchoatus*: ? Cenomanian, Minnesota (Pierce 1961); Joli Fou–Upper Shale Unit, Alberta (Norris 1967); Cadotte–upper Shaftesbury, Alberta (Singh 1971).
- Retitricolpites georgensis*: Albian, Maryland (Brenner 1963); (? late Middle) Albian, Oklahoma (Hedlund and Norris 1968); upper Joli Fou–Upper Shale Unit, Alberta (Norris 1967); Harmon–upper Shaftesbury, Alberta (Singh 1971).
- Striatopollis paraneus*: (? late Middle) Albian, Oklahoma (Hedlund and Norris 1968); Joli Fou–Upper Shale Unit, Alberta (Norris 1967); Harmon–lower Shaftesbury, Alberta (Singh 1971).
- Rugubivesiculites reductus*: ? Cenomanian, Minnesota (Pierce 1961); Albian (younger Patapsco), Maryland (Brenner 1963); Viking–Upper Shale Unit, Alberta (Norris 1967); Cadotte only, Alberta (Singh 1971).
- Undulatisporites pannuceus*: Upper Barremian–Albian, Maryland (Brenner 1963); Cadotte–lower Shaftesbury, Alberta (Singh 1971).
- Lophotriteles babsae*: Albian, Maryland (Brenner 1963); Cadotte, Alberta (Singh 1971).
- Pilosisporites trichopapillosus*: youngest documented occurrence is upper Middle Albian (Cadotte), Alberta (Singh 1971).
- Microreticulatisporites uniformis*, *Appendicisporites bifurcatus*: youngest known occurrences are lowest Upper Albian (Paddy), Alberta (Singh 1971).

From the occurrence of these forms (see Table 1) it is evident that the upper Swan River strata (1273–1345 feet, Bredenbury well; type exposures, Swan River) are late Middle Albian, possibly to earliest Late Albian in age; and that they are correlatives of the Peace River Formation (probably mainly of its Harmon and Cadotte Members) of north-western Alberta (see Table 2). No microflora is available from the lowest Peace River member, the Notikewin Member.

The sequence of entrance levels of certain species cannot be matched precisely with those documented by Singh (1971) in the Peace River Formation, but this is not altogether surprising in view of the rarity of many of the taxa and the possibility of hiatuses, however minor, in neritic strata like the Swan River. There appears, in fact, to be no palynological or other evidence of a pronounced break in the subject sequence,

which from the above is adduced as being wholly Albian (largely, if not entirely, Middle Albian) in age.

Indication of the presence or proximity of marine conditions is found only in the uppermost part of the Bredenbury sequence (1273–1288 feet) and in the upper Swan River of its type area. The overlying strata of the Ashville Group are, of course, marine, and although lithostratigraphically correlative with the Joli Fou of Alberta are on the palynological data presented here somewhat later Albian in age. These considerations accord with the comments of Price (1963, pp. 34–35) that north-eastwards from southern Saskatchewan, towards Swan River, 'the sand-shale boundary (i.e. Swan River–Ashville boundary) rises stratigraphically above the first occurrence of distinctly marine beds' (cf. also Price, table 1, p. 3).

An alternative possibility concerning the correlation and age of the Swan River Bredenbury section should not be overlooked. Keeping in mind the somewhat erratic distribution and general rarity of the tricolpate angiosperm palynomorphs, their seeming absence below the 1345-foot level might be one of fortuity and not necessarily truly indicative of non-existence. Were this the case, deposition of the studied Swan River might wholly post-date introduction of tricolpate angiosperm pollen and could be regarded as coeval with Joli Fou accumulation. This alternative idea would conform with Stelck's (1958, p. 6) suggestion that the Swan River Group, together with the St. Edouard Member and other 'basal Colorado sands' to the west, represents an early onlap phase of the Joli Fou sea, regarded as having transgressed northwards from the Gulf of Mexico late in the Early Cretaceous (post-Mannville). As documented above, monosulcate grains of possible angiospermous alliance (*Clavatipollenites hughesii*, *C. rotundus*, *Liliacidites peroreticulatus*) do occur in the lower Swan River portion of the Bredenbury drill-hole. Although none of these has yet been recorded from Alberta strata older than the Harmon Member, they are known elsewhere (e.g. U.S.A., England) to range considerably lower in the Lower Cretaceous than the here-recorded initial tricolpate forms (cf. Brenner 1963, Doyle 1969). Taking all the available data into account, the proposition that the Swan River strata are entirely of post-Mannville age, belonging wholly to the basal Colorado gulfian depositional realm, seems rather less tenable than the view expressed earlier herein that the sediments are partly correlative with the Upper Mannville.

Farther south, correlation of the Swan River strata with the Albian sector (Patapsco Formation) of the Maryland Lower Cretaceous (Brenner 1963) is also evident from the above discussion. Fredericksburgian sediments (Antlers Sand and 'Walnut' clay) of Oklahoma (Hedlund and Norris 1968) include many palynological features in common with the Saskatchewan and Manitoba sediments. However, the Oklahoma material contains a considerably greater diversity of angiospermous pollen (viz. tetra- and pentacolpate and tetra- and pentachotomosulcate grains) suggesting that it may be somewhat younger than the Swan River Group; or alternatively such disparity could reflect differing phytogeographic situations.

#### *Natural relationships*

Attribution of dispersed spores and pollen grains to natural botanical groups still remains a difficult objective so far as pre-Tertiary palynological floras are concerned. Some authors who have studied the Canadian Lower Cretaceous (e.g. Singh 1964, 1971;

Pocock 1962, 1965) endeavour to utilize a natural scheme, to family level, for supra-generic placements of the morphographically founded taxa; whereas others (e.g. Norris 1967; Steeves and Wilkins 1967; present study) apply the artificial (Turma) scheme in the systematic-descriptive portions of their papers. As Norris (1967, p. 83) has mentioned, natural affiliations of many *spora dispersae* can be elucidated, albeit with varying precision, on the basis of morphological comparisons with *in situ* spores and pollen from fructifications of fossil and extant plants. Synopses compiled by Potonié (1962, 1967) show how far palaeopalynology has progressed towards the desirable objective of natural classification of plant microfossils.

On the basis of current knowledge of affinities of Mesozoic sporomorphs, the following tabulation depicts the most likely natural allocation of the Swan River taxa:

**BRYOPHYTA:** *Stereisporites antiquasporites*, *Foraminisporis asymmetricus*, *F. dailyi*, *F. wonthaggiensis*, *Cingutritetes clavus*, *Coptospora williamsii*, *Aequitriradites spinulosus*, *Couperisporites complexus*, *Cooksonites variabilis*, *Triporeletes involucratum*, *T. laevigatus*, *T. radiatus*, *T. reticulatus*, *T. simplex*, *T. singularis*.

**PTERIDOPHYTA.** Lycopodiales: *Lycopodiumsporites austroclavitudites*, *L. marginatus*, *Sestrosporites pseudoalveolatus*, *Camarozonosporites ambigens*, *Kraeuselisporites hastilobatus*, *Lundbladispota reticungula*, *Densoisporites circumundulatus*, *D. microrugulatus*. Filicales: *Cyathidites australis*, *C. minor*, *Biretisporites potoniaei*, *Concavissimisporites minor*, *C. punctatus*, *C. variverrucatus*, *Osmundacidites wellmanii*, *Baculatisporites comaumensis*, *Pilosisporites trichopapillosus*, *P. verus*, *Microreticulatisporites uniformis*, *Klukisporites pseudoreticulatus*, *Cicatricosisporites australiensis*, *C. hallei*, *C. hughesii*, *C. patascoensis*, *C. potomacensis*, *C. spiralis*, *C. sp. B*, *Costatoperforosporites foveolatus*, *Balmeisporites* sp. cf. *B. holodictyus*, *Arcellites disciformis*, *Appendicisporites bifurcatus*, *A. bilateralis*, *A. crimensis*, *A. jansonii*, *A. matesovae*, *A. potomacensis*, *A. problematicus*, *Trilobosporites apiverrucatus*, *T. hannonicus*, *T. humilis*, *T. marylandensis*, *T. purverulentus*, *Ischyosporites* sp. cf. *I. crateris*, *Gleicheniidites senonicus*, *Clavifera rudis*, *Crybelosporites brennerii*, *Cicatricosisporites auritus*. Pteridophyta incertae sedis: *Undulatisporites pannuceus*, *Lophotritetes babsae*, *Kuylisporites lunaris*, *Lycopodiacidites intraverrucatus*, *Reticulatisporites elongatus*, *Tigrisporites scurrandus*, *Coronatispora valdensis*, *Polycingulatisporites reduncus*, *Taurocusporites segmentatus*, *Asbeckiasporites wurthi*, *Laevigatosporites ovatus*.

**CAYTONIALES:** *Vitreisporites pallidus*.

**CONIFEROPHYTA.** Coniferales: *Tsugaepollenites dampieri*, *Alisporites bilateralis*, *A. grandis*, *Podocarpidites canadensis*, *P.* sp. cf. *P. ellipticus*, *P. multesimus*, *P. radiatus*, *Parvisaccites radiatus*, *Phyllocladites inchoatus*, *Rugubivesiculites reductus*, *Araucariacites australis*, *Perinopollenites elatoides*. Coniferophyta incertae sedis: *Eucommiidites minor*, *E. troedssonii*, *Exesipollenites tumulus*, *Circulina parva*, *Classopollis classoides*.

**GNETALES.** Ephedraceae: *Equisetosporites* sp. cf. *E. concinnus*, *E. jansonii*, *E. multicostatus*.

**ANGIOSPERMOPHYTA:** *Clavatipollenites hughesii*, *C. rotundus*, *Liliacidites peroreticulatus*, *Retitricolpites georgensis*, *R. prosimilis*, *R. vulgaris*, *Tricolpites sagax*, *Fraxinoipollenites venustus*, *Striatopollis paraneus*.

**SPORES AND POLLEN GRAINS INCERTAE SEDIS:** *Perotrilites pannuceus*, *Inaperturopollenites limbatus*, *Reticulatisporites dupliexinous*, *Schizosporis reticulatus*.

From the above data, it is evident that the Swan River palynological flora is composed, qualitatively and quantitatively, of predominantly pteridophytic-coniferophytic vegetational elements; this is comparable to the situation adduced elsewhere in coeval North American strata (e.g. Brenner 1963, Norris 1967). Ferns were prominent and diverse contributors, especially those of the family Schizaeaceae which is represented by a variety of cicatricose-sculptured trilete spores belonging to the genera *Cicatricosisporites* and *Appendicisporites*. The family Gleicheniaceae is also represented, albeit much less diversely, by abundant and persistent occurrence of *Gleicheniidites*. Water ferns contributed spasmodically, as suggested by the rare presence of *Balmeisporites*, *Arcellites*,

and *Crybelosporites*. Lower plants of the division Bryophyta produced a variety of trilete and hilate spores, which are, however, numerically inconspicuous in the subject flora. Abundance of coniferalean plants is attested by high frequency of bisaccate pollen attributed to the genera *Alisporites*, *Podocarpidites*, and *Parvisaccites*. From the rare occurrence of *Ephedra*-type pollen, it appears that the Gnetales made strictly minor contributions. The class Caytoniales is persistently represented by small bisaccate grains of the species *Vitreisporites pallidus*. A poorly differentiated angiosperm flora is suggested by the palynological analysis. Grains of possible angiospermous affiliation (belonging to the genus *Clavatipollenites*), occur in strictly minor amounts and are associated in the younger Swan River sediments with simple dicotyledonous (tricolpate) pollen.

Angiosperm or possible angiosperm components are greatly subordinate to the pteridophytic, bryophytic, and gymnosperm elements. It is uncertain whether this reflects a truly minor and unspecialized representation of angiosperms in the contemporary terrestrial flora or is a function of the sedimentology of the strata concerned. However, the suggested neritic depositional environment could well explain the presence of diverse pteridophytic and bryophytic palynomorphs.

#### *Comparison with assemblages beyond North America*

Several authors concerned with Late Mesozoic palynology (e.g. Mchedlishvili and Samoilovich 1962, Verbitskaya 1966) have taken cognizance of the ubiquity of many spore and pollen elements of this age through northern and southern hemisphere

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#### EXPLANATION OF PLATE 107

All figures  $\times 500$  unless otherwise specified; from unretouched negatives.

- Fig. 1. *Alisporites bilateralis* Rouse 1959; median focus; GO24c/57, 115.7 18.8; Y.1410.  
 Fig. 2. *Vitreisporites pallidus* (Reissinger) Nilsson 1958; median focus; GO24b/29, 103.9 8.8; Y.1411.  
 Figs. 3, 4. *Eucommiidites* spp. 3, *E. minor* Groot and Penny 1960; GO46/1, 122.1 19.7; Y.1412. 4, *E. troedssonii* Erdtman 1948; GO62/15, 104.3 14.8; Y.1413.  
 Fig. 5. *Circulina parva* Brenner 1963; median focus; GO24c/24, 107.3 17.8; Y.1414.  
 Figs. 6, 7. *Equisetosporites* spp. 6, *E. jansonii* Pocock 1965; GO65/64, 110.9 15.0; Y.1415. 7, *Equisetosporites multicostatus* (Brenner) Norris 1967; GO29b/1, 119.0 20.6; Y.1416.  
 Fig. 8. *Inaperturopollenites limbatus* Balme 1957; GO21b/16, 104.1 16.8; Y.1417.  
 Figs. 9, 10. *Fraxinoipollenites venustus* Singh 1971; lateral views ( $\times 1000$ ). 9, GO61/3, 118.8 3.3; Y.1418. 10, GO61/1, 93.1 22.1; Y.1419.  
 Figs. 11, 12, 17, 18. *Retitricolpites* spp. ( $\times 750$ ). 11, 12, *Retitricolpites georgensis* Brenner 1963; lateral aspect, high and low foci; GO59b/1, 106.9 4.7; Y.1420. 17, *R. vulgaris* Pierce 1961; lateral aspect; GO59b/1, 127.2 20.7; Y.1425. 18, *R. prosimilis* Norris 1967; lateral aspect; GO64/1, 105.6 13.6; Y.1426.  
 Figs. 13, 14. *Clavatipollenites* spp. ( $\times 750$ ). 13, *C. hughesii* Couper emend. Kemp 1968; median focus; GO65/1, 113.1 12.6; Y.1421. 14, *C. rotundus* Kemp 1968; distal focus; GO61/2, 100.5 16.9; Y.1422.  
 Fig. 15. *Exesipollenites tumulus* Balme 1957 ( $\times 750$ ); GO65/1, 89.6 8.7; Y.1423.  
 Fig. 16. *Tricolpites sagax* Norris 1967 ( $\times 750$ ); polar aspect; GO23b/1, 114.5 13.2; Y.1424.  
 Fig. 19. *Parvisaccites radiatus* Couper 1958; oblique aspect; GO62/11, 112.2 12.0; Y.1427.  
 Fig. 20. *Rugubivesiculites reductus* Pierce 1961; proximal focus; GO61/5, 101.0 12.0; Y.1428.  
 Fig. 21. *Podocarpidites multesimus* (Bolkhovitina) Pocock 1962; median focus; GO24c/60, 96.3 19.2; Y.1429.  
 Figs. 22, 23. *Couperisporites complexus* (Couper) Pocock 1962; proximal and distal foci; GO46/7, 104.9 18.2; Y.1336.

deposits that have been subjected to such study. This is particularly true of the basal part of the system (Neocomian–Aptian) which may thus be correlated widely on palynological grounds. Dettmann and Playford (1969, pp. 198–199), for instance, have noted strong microfloral uniformity among Neocomian–Aptian assemblages of Australia, South America, and India, and further that certain (bryophytic and pteridophytic) elements from these areas occur also in the Soviet Union (especially Siberia) and western Canada. Likewise the Wealden facies of north-west Europe displays conspicuous palynological uniformity over its area of development (cf. Couper 1958; Hughes 1958; Döring 1965, 1966; Burger 1966; Levet-Carette 1966; Hughes and Moody-Stuart 1967). In turn, the Wealden microfloras show certain similarities to those from the Early Cretaceous of eastern U.S.A. (see Stover 1964) and to a lesser extent of western Canada and U.S.S.R.

There is less published palynological information available on the Albian than on the earlier Cretaceous. The most notable widespread palaeobotanical feature of the Albian is the occurrence, in many areas and in significant proportions, of undisputed angiosperms following their presumed inception in mid-late Early Cretaceous times (Hughes 1961). This feature is displayed by the Swan River sequence, in the younger horizons of which tricolpate grains of presumed dicotyledonous type are introduced. These early angiosperm grains are very small and morphologically simple. Their taxonomy tends to have somewhat limited (localized) application: this is probably a result of the difficulty of illustrating their critical morphological features with conventional optical equipment. With more sophisticated techniques, the taxa may well prove to have wider geographic application than is currently documented.

Table 3 shows currently known extra-North American Albian occurrences of specific miospore taxa that have been identified in the Swan River samples of this study. Apart from *Clavatipollenites* and *Schizosporis*, the taxa are of bryophytic, pteridophytic, or coniferophytic derivation. Omitted from this tabulation are the following cosmopolitan and relatively long ranging forms which are common to all or most of the regions: *Stereisporites antiquasporites*, *Cyathidites australis*, *C. minor*, *Osmundacidites wellmanii*, *Baculatisporites comaumensis*, *Lycopodiumsporites austroclavatidites*, *Gleicheniidites senonicus*, *Laevigatosporites ovatus*, *Araucariacites australis*, *Vitreisporites pallidis*, and *Classopollis classoides*. The table emphasizes the paucity of Albian palynological data available on a world-wide scale. It indicates a close palynological similarity between the Saskatchewan–Manitoba assemblages and those from the Siberian and eastern Australian Albian (embracing all or part of the *Coptospora paradoxa* and *Tricolpites pannosus* Zones of Dettmann and Playford 1969). The apparently only slight resemblance between the Saskatchewan–Manitoba assemblages and those of England, Portugal, Germany, and Rumania may reflect, at least in part, the strictly minor amount of pertinent palynological data relating to those European areas. For instance the English Albian column is founded upon a single paper (Kemp 1968) that is concerned exclusively with Barremian–Albian pollen of probable angiosperm origin.

A possibly Albian assemblage from south-west Nelson, New Zealand (Norris 1968), bears little similarity to those of the western Canadian Albian. The same is true of Albian microfloras illustrated by Jardiné and Magloire (1965) from Senegal and Ivory Coast, west Africa.

*Acknowledgements.* This work was largely undertaken at the Department of Geology, University of Alberta, Edmonton, during the writer's 1969 sojourn there as Visiting Professor; it was completed

subsequently at the University of Queensland. The assistance and helpful advice given by Drs. G. D. Williams, C. R. Stelck (both of University of Alberta) and Dr. C. Singh (Research Council of Alberta) are gratefully acknowledged.

Selected species in Swan River strata	Albian occurrences outside North America					
	England	Germany	Portugal	Rumania	U.S.S.R.	Australia
<i>Biretisporites potoniaei</i> . . . . .						cf. X
<i>Concavissimisporites punctatus</i> . . . . .		X		X		X
<i>Pilosisorites trichopapillosus</i> . . . . .				X	X	
<i>Pilosisorites verus</i> . . . . .					X	
<i>Kuylisporites lunaris</i> . . . . .					X	X
<i>Klukisporites pseudoreticulatus</i> . . . . .			X		X	
<i>Cicatricosporites australiensis</i> . . . . .					X	X
<i>Cicatricosporites hughesi</i> . . . . .						X
<i>Balmesporites cf. holodictyus</i> . . . . .						X
<i>Appendicisporites crimensis</i> . . . . .					X	
<i>Appendicisporites matesovae</i> . . . . .					X	
<i>Trilobosporites apiverrucatus</i> . . . . .			X		X	
<i>Trilobosporites hannonicus</i> . . . . .		X				
<i>Trilobosporites purverulentus</i> . . . . .					X	X
<i>Clavifera rudis</i> . . . . .					X	
<i>Sestrosporites pseudoalveolatus</i> . . . . .				X		X
<i>Camarozonosporites ambigenus</i> . . . . .		X			X	
<i>Foraminisporis asymmetricus</i> . . . . .					X	X
<i>Foraminisporis dalyi</i> . . . . .		X				X
<i>Foraminisporis wonthaggiensis</i> . . . . .					X	X
<i>Asbeckiasporites wurthi</i> . . . . .		X				
<i>Cingulitoides clavus</i> . . . . .					X	X
<i>Aequitriradites spinulosus</i> . . . . .				X	X	X
<i>Cooksonites variabilis</i> . . . . .					X	
<i>Triporoletes involucreatus</i> . . . . .					X	
<i>Triporoletes radiatus</i> . . . . .						X
<i>Triporoletes reticulatus</i> . . . . .				X	X	X
<i>Triporoletes simplex</i> . . . . .						X
<i>Triporoletes singularis</i> . . . . .					X	
<i>Tsugaepollenites dampieri</i> . . . . .						X
<i>Alisporites grandis</i> . . . . .				X		X
<i>Podocarpidites cf. ellipticus</i> . . . . .						X
<i>Podocarpidites multesimus</i> . . . . .		X		cf.		cf.
<i>Parvisaccites radiatus</i> . . . . .		X				
<i>Eucommiidites minor</i> . . . . .			X			
<i>Eucommiidites troedssonii</i> . . . . .		X				
<i>Clavatipollenites hughesii</i> . . . . .	X	X				
<i>Clavatipollenites rotundus</i> . . . . .	X					
<i>Schizosporis reticulatus</i> . . . . .		X				X

TABLE 3. Albian occurrences of Swan River palynomorphs outside North America. Sources of data: England, Kemp 1968; Germany, von der Brelie 1964; Portugal, Groot and Groot 1962; Rumania, Baltés 1967; U.S.S.R. (principally Siberia), Bolkhovitina 1956, 1959, 1961, 1966, 1968, Chlonova 1969, Fradkina 1967, Kotova 1968, Samoilovich *et al.* 1961, Verbitskaya 1962; (eastern) Australia, Dettmann 1963, Dettmann and Playford 1969.

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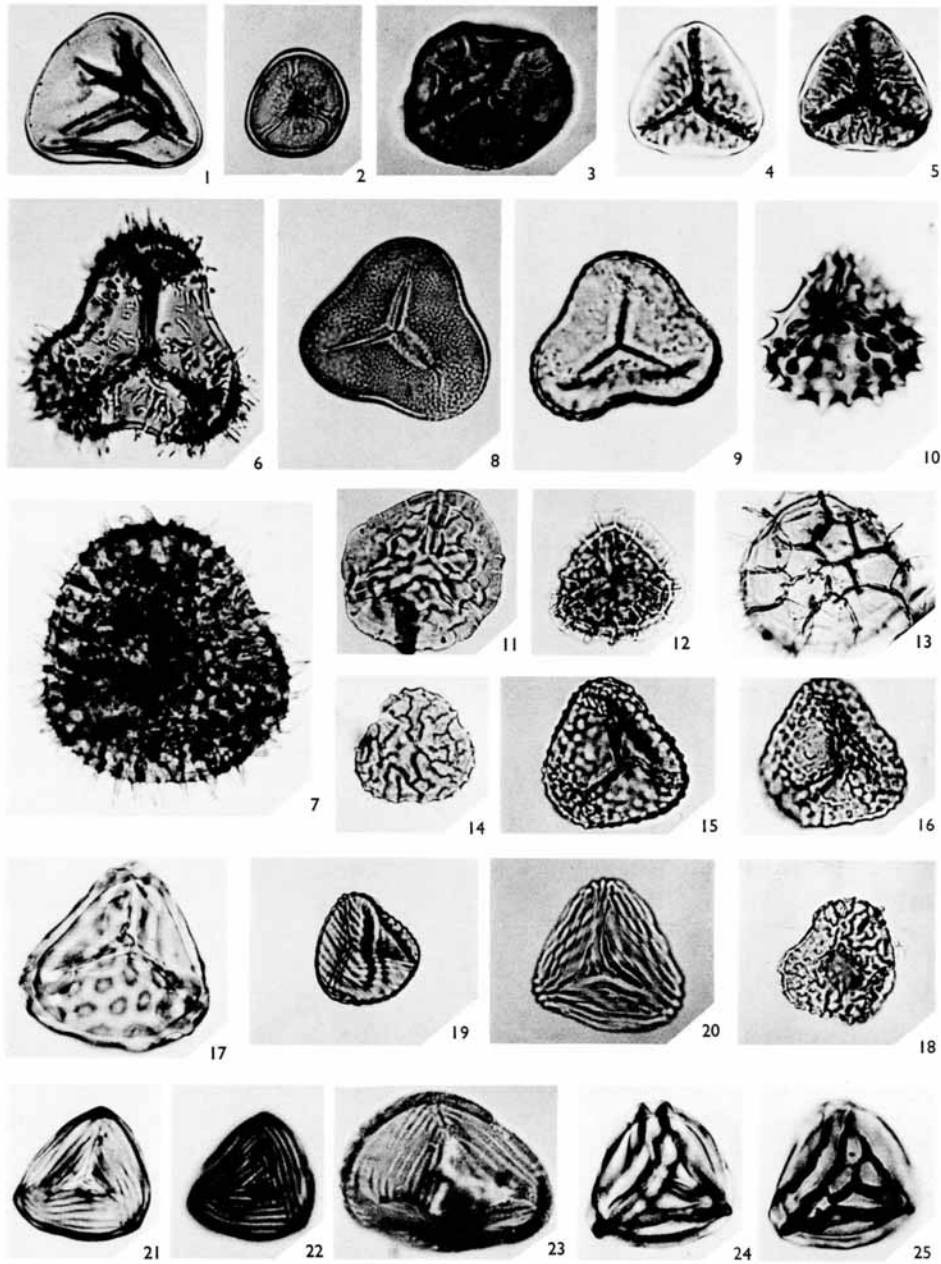
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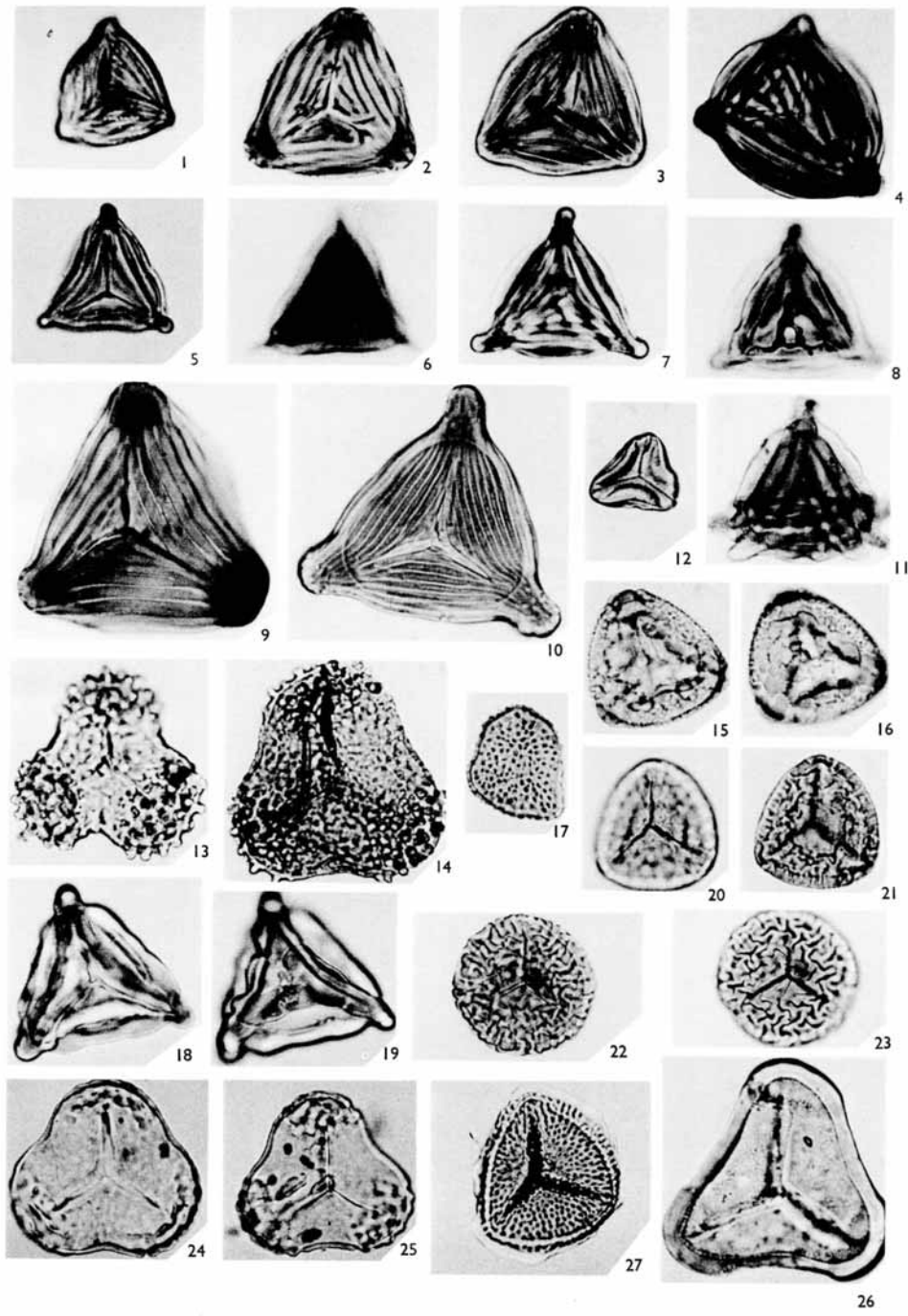
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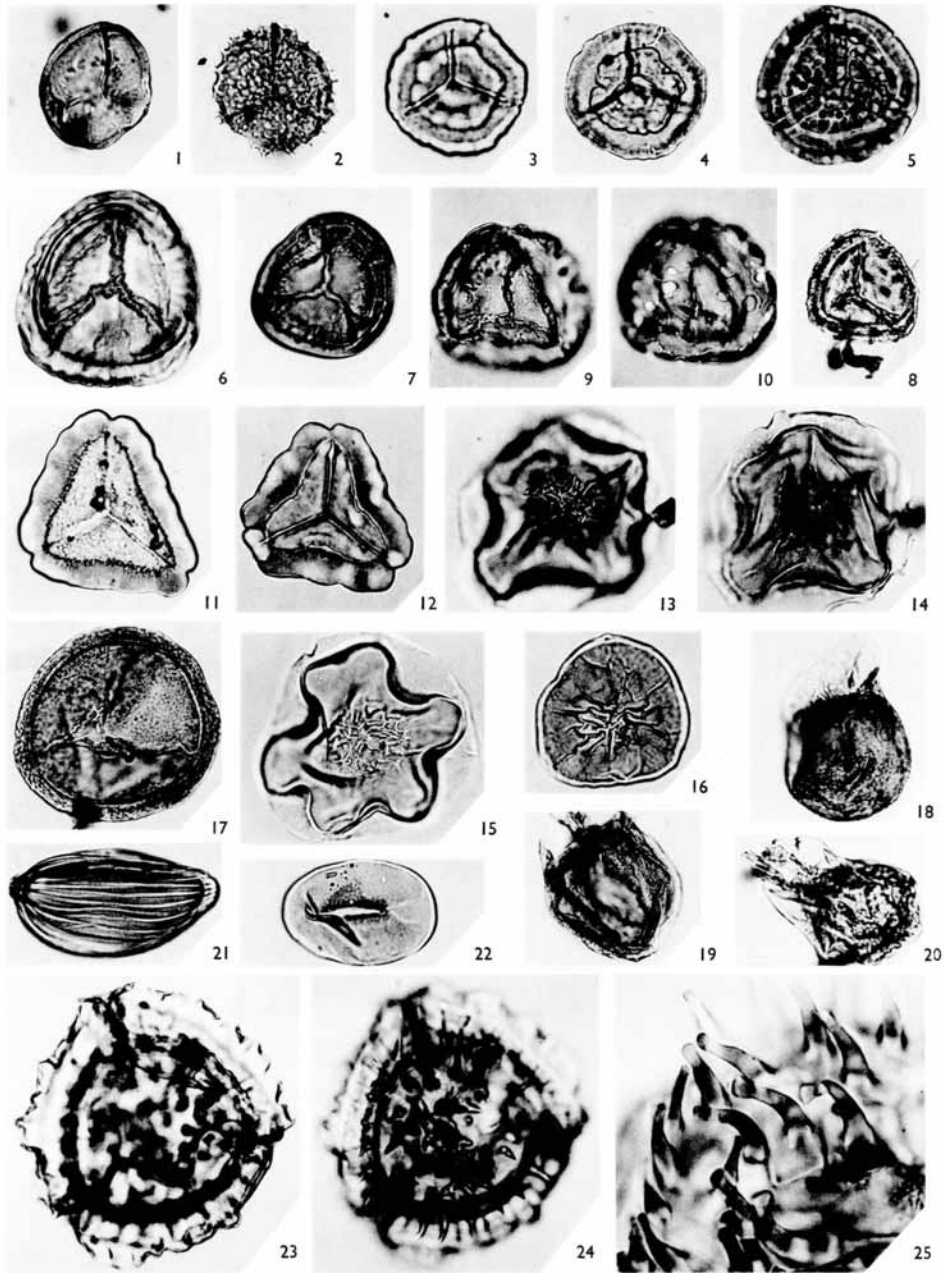
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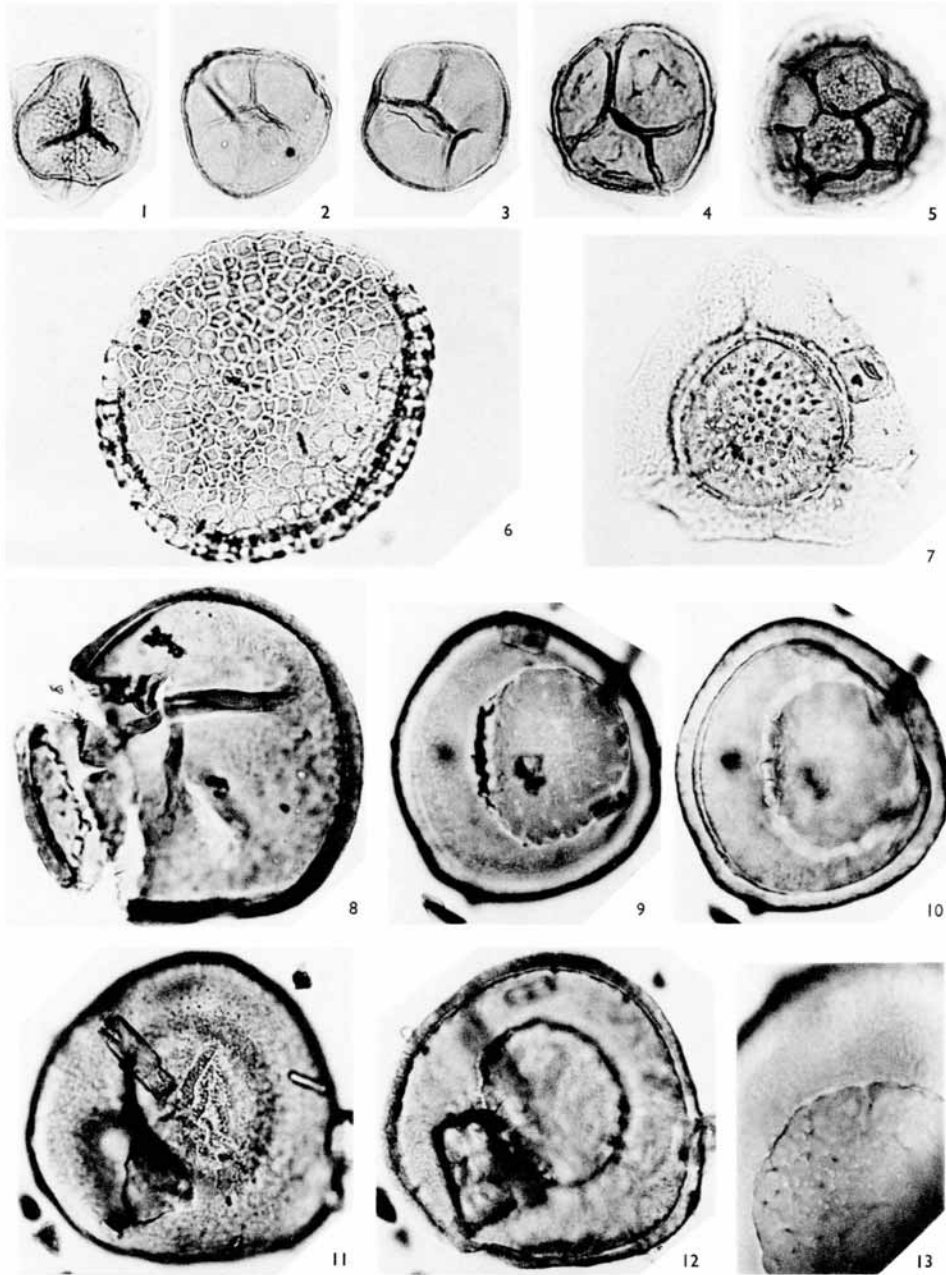
PLAYFORD, Lower Cretaceous miospores



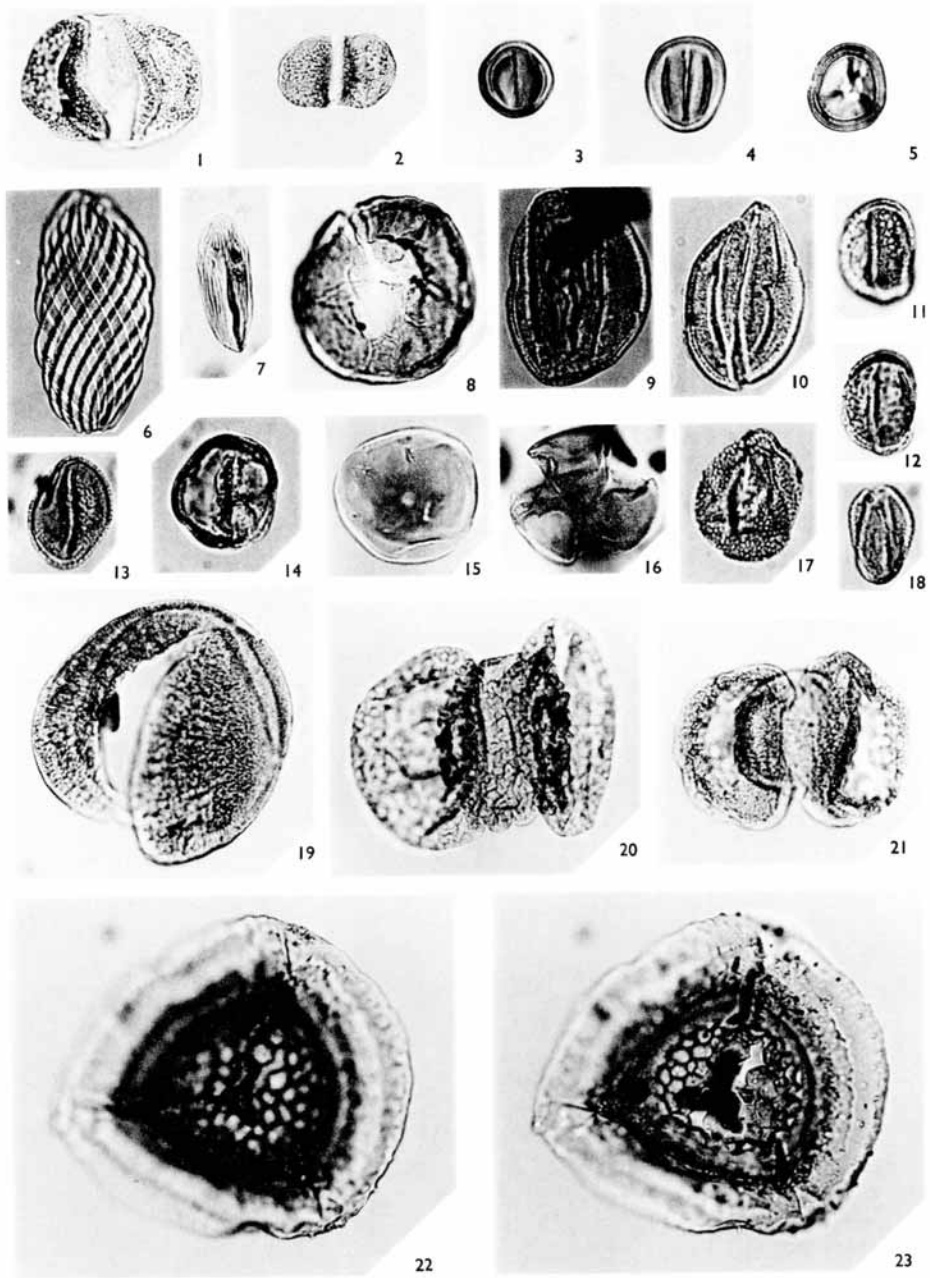
PLAYFORD, Lower Cretaceous miospores



PLAYFORD, Lower Cretaceous miospores



PLAYFORD, Lower Cretaceous miospores



PLAYFORD, Lower Cretaceous miospores

Prep <sup>n</sup> Number	Depth (feet)	Species																																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30				
SW.P. BREDENBURY No. 11-36	G 021	1273-78																																	
	G 059	1278-83																																	
	G 025	1283-88																																	
	G 041	1288-93																																	
	G 022	1293-1300																																	
SWAN R. DISTRICT	G 042	1305-10																																	
	G 049	1310-15																																	
	G 043	1315-20																																	
	G 023	1320-25																																	
	G 045	1340-45																																	
	G 026	1353-58																																	
	G 029	1372-77																																	
	G 030	1377-81																																	
	G 046	1386-91																																	
	G 024, G 031	1391-95																																	
SWAN R. DISTRICT	G 061	69-W-26																																	
	G 062	69-W-27																																	
	G 063	69-W-28																																	
	G 064	69-W-29																																	
	G 065	69-W-32																																	

- Cyathidites australis*
- Cyathidites minor*
- Stereosporites antiquasporites*
- Biretisporites potaniaei*
- Undulatisporites pannuceus*
- Concavissimisporites minor*
- Concavissimisporites punctatus*
- Concavissimisporites variverrucatus*
- Osmundacidites wellmanii*
- Baculatisporites comaumensis*
- Lophotriletes babsae*
- Pilosporites trichopapillosus*
- Pilosporites verus*
- Kyllisporites lunaris*
- Lycopodiumsporites austroclavoidites*
- Lycopodiumsporites marginatus*
- Lycopodioidites intraverrucatus*
- Reticulisporites elongatus*
- Microreticulatisporites uniformis*
- Klukisporites pseudoreticulatus*
- Tigrisporites scurrandus*
- Cicatricosisporites australiensis*
- Cicatricosisporites hallei*
- Cicatricosisporites hughesi*
- Cicatricosisporites patapcoensis*
- Cicatricosisporites spiralis*
- Cicatricosisporites potomacensis*
- Cicatricosisporites* sp. B
- Costatoperforosporites foveolatus*
- Balmesporites* sp. cf. *B. holdiclyus*





