MIOSPORES FROM THE LOWER CARBONIFEROUS BASEMENT BEDS IN THE MENAI STRAITS REGION OF CAERNARVONSHIRE, NORTH WALES

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ABSTRACT. A well-preserved miospore flora from the Basement Beds of the Lower Carboniferous in the Menai Straits region of Caernarvonshire, North Wales is described. A total of 47 species is recorded from the deposits. One new genus *Umbonatisporites*, and 7 new species are proposed. The assemblage contains spores characteristic of both Tournaisian and Viséan deposits, but is considered to be Viséan in age.

THE Lower Carboniferous succession throughout North Wales consists largely of a series of limestones underlain by Basement Beds and resting unconformably on Lower Palaeozoic rocks. Lower Carboniferous deposits outcrop on both sides of the Menai Straits and in Caernarvonshire lie on Ordovician rocks. Greenly (1928) described conglomeratic sandstones, shales and thin limestones which he placed at the base of the Lower Dibunophyllum zone (D_1). There is a fragmentary fauna, mainly of brachiopods; the lowest horizon containing abundant faunal remains lies close to the base of the overlying Brown Limestone. There is no clear indication of the precise age of the Basement Beds and they have been variously assigned to the base of the D_1 or the top of the S_2 (Greenly 1928, Neaverson 1946, George 1958).

Three samples were taken from a lenticle of shale, approximately 40 yards long and 3 ft. in thickness, where the Basement Beds outcrop by the Britannia Tubular Bridge on the Caernarvonshire side of the Menai Straits (Grid Ref. SH541708).

Plant remains from these beds were first described by Walton in Greenly (1928), the list of species later being extended by Lacey (1952 *a*, *b*). The later work indicated the presence of a rich assemblage of plant micro-fossils and seeds.

The three samples were collected from the shale in the following ascending order: sample LC2 from the base of the shale outcropping on the foreshore; sample LC3 one foot above LC2 and associated with the plant bed described by Walton and Lacey; LC4 at the top of the shale band two feet above LC3. The three samples showed no marked differences in miospore content and are accordingly treated as one assemblage, characteristic of the Basement Beds.

Preparation of samples. The samples were immersed in 40% hydrofluoric acid at 40 °C for up to four days, to remove the silicates. The residue was oxidized in fuming nitric acid for up to two hours, then washed with progressively more dilute nitric acid and transferred to a sinter-glass Buchner funnel. Here the residue was further washed with a 5% solution of potassium hydroxide and then, repeatedly, with distilled water using the technique described by Neves and Dale (1963).

Permanent slides were made using 'Cellosize with a thermosetting plastic as a mountant (Jeffords and Jones 1959).

[Palaeontology, Vol. 12, Part 3, 1969, pp. 420–440, pl. 78–83.]

The terminology used is that outlined by Couper and Grebe (1961) and expanded by Smith and Butterworth (1967). The classification of the dispersed miospores follows the scheme first proposed by Dettmann (1963) as revised and extended by Smith and Butterworth (1967).

Only those species which are described for the first time, or are considered to be more critical to the present study, are given systematic treatment. In addition to the illustrations using the transmitted light microscope, a number of photographs are reproduced using the scanning reflection electron microscope developed by Cambridge Scientific Instruments following the technique described by Hibbert (1967).

The slides containing holotypes and other figured specimens have been deposited in the School of Plant Biology, University College of North Wales. They are marked with the preparation number and the co-ordinates are those of the Leitz Laborlux microscope no. 582096 of the above Department. Single grain mounts bear the prefix MS.

SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié 1893
Turma TRILETES (Reinsch) Dettmann 1963
Suprasubturma ACAVATITRILETES Dettmann 1963
Subturma AZONOTRILETES (Luber) Dettmann 1963
Infraturma LAEVIGATI (Bennie and Kidston) Potonié 1956
Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. P. punctatus Ibrahim 1933.

Punctatisporites irrasus Hacquebard 1957

Plate 78, fig. 1

Description. Diameter 58–89 μ, mean 74 μ (45 specimens); amb circular to sub-circular. Laesura distinct, straight, length one-half to three-quarters spore radius, occasionally low lips are developed. Frequently the laesura are gaping with dark intertectal areas.

Remarks. Spores with dark intertectal areas were included in this species by Sullivan (1964*a*). It is thought to be a miospore characteristic of Tournaisian assemblages (Sullivan 1967).

Previous records. Horton Bluff (Tournaisian) Canada (Hacquebard 1957). Lower Limestone Shales (Tournaisian) Forest of Dean Gloucestershire (Sullivan 1964a). Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968). Springer formation (Mississippian/Pennsylvanian boundary) of Oklahoma (Felix and Burbridge 1967).

Infraturma APICULATI (Bennie and Kidston) R. Potonié 1956
Subinfraturma GRANULATI Dybova and Jachowicz 1957
Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. G. granulatus Ibrahim 1933.

Granulatisporites visensis sp. nov.

Plate 78, fig. 4

Holotype. Slide LS9b, 57.2 104.9. Size 41 μ.

Diagnosis. Diameter 26–51 μ, mean 37 μ (56 specimens); amb subtriangular with concave interradial margins and rounded apices. Laesura simple, straight, length from three quarters to equal the spore radius. Ornamentation consists of grana 1·5–4·0 μ wide at the base and up to 2·0 μ high; the grana may coalesce to form short, verrucate ridges. Ornament well developed at the apices where it forms an indented margin; the interradial margins mostly smooth. The grana are most strongly developed on the distal surface and are frequently concentrated at the distal pole and along the triangular radii. Exine punctate between the grana.

Remarks. The development of irregular ridges characterises this species; its development is not strong enough to warrant different generic assignment.

Subinfraturma VERRUCATI Dybova and Jachowicz 1957
Genus VERRUCOSISPORITES (Ibrahim) Smith and Butterworth 1967

Type species. V. verrucosus Ibrahim 1932.

Verrucosisporites eximius Playford 1962

Plate 78, figs. 9, 10

Remarks. The present specimens show a larger size from 62 to 92 μ, mean 82 μ than those described by Playford (mean 72 μ); otherwise they are similar.

Previous records. Lower Carboniferous of Spitsbergen (Playford 1962, 1963*a*).

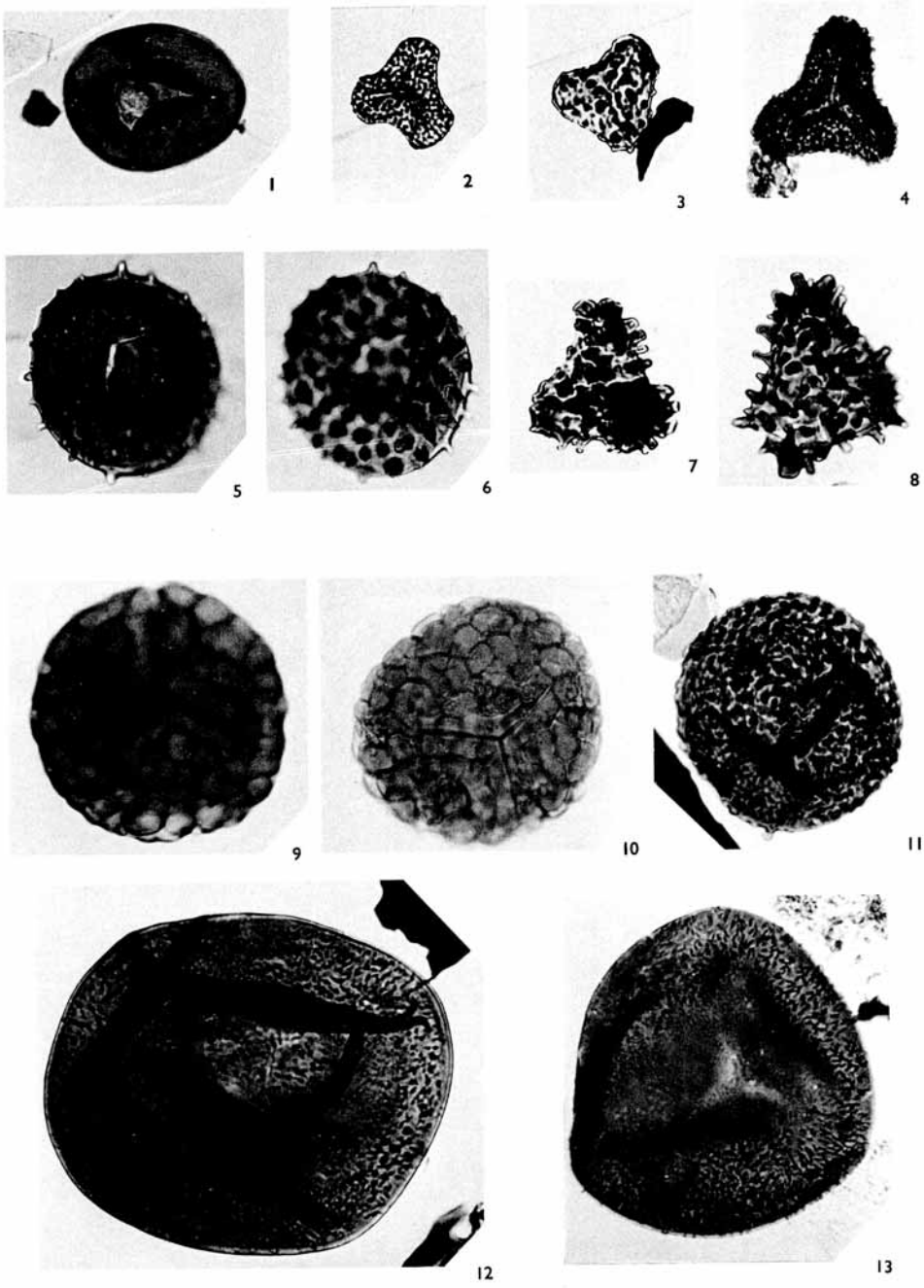
Subinfraturma NODATI Dybova and Jachowicz 1957
Genus WALTZISPORA Staplin 1960

Type species. W. lobophora (Waltz) Staplin 1960.

EXPLANATION OF PLATE 78

All figures × 500

Fig. 1. *Punctatisporites irrasus* Hacquebard 1957; Slide LC5b, 21·3 110·0.
Fig. 2. *Waltzispora planiangulata* Sullivan 1964; Slide LC2e, 41·4 101·7.
Fig. 3. *Lophotriletes tribulosus* Sullivan 1964; Slide LC9b, 33·3 95·4.
Fig. 4. *Granulatisporites visensis* sp. nov., Holotype; Slide LC9b, 57·2 104·9.
Figs. 5–6. *Raistrickia nigra* Love 1960; slide MS80. 5, proximal surface. 6, distal surface.
Figs. 7–8. *Neoraistrickia drybrookensis* Sullivan 1964. 7, slide LC2b, 23·0 100·2. 8, slide MS14.
Figs. 9–10. *Verrucosisporites eximius* Playford 1962. 9, proximal surface; slide MS144. 10, proximal surface; slide MS182.
Fig. 11. *Grumosisporites verrucosus* (B. and W.) Smith and Butterworth 1967; LC2c, 32·9 98·5.
Figs. 12–13. *Umbonatisporites variabilis* gen. et sp. nov. 12, distal surface; slide LC2c, 14·6 106·8 13, Holotype, proximal surface; slide LC2e, 44·0 99·0.



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Waltzispora planiangulata Sullivan 1964

Plate 78, fig. 2

Description. Diameter 30–41 μ, mean 35 μ (50 specimens); amb triangular with bluntly rounded apices, having angular junctions with the concave, interradial margins. Laesura distinct, simple, straight, length from three-quarters to equal to spore radius. Exine 1·0–1·5 μ thick, ornamented with grana and coni, 0·5 μ high and 1·0–1·5 μ in basal diameter; ornament absent from the proximal contact area.

Remarks. The variation in ornament between the specimens was not as evident as Sullivan describes. The angular junction between the apex and the concave side was variable but never approaches the distinct angularity described by Staplin (1960) for *W. lobophora*.

Previous records. Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

Genus LOPHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. L. gibbosus (Ibrahim) Potonié and Kremp 1954.

Lophotriletes tribulosus Sullivan 1964

Plate 78, fig. 3

Remarks. The size range, diameter 28–39 μ, mean 32 μ (40 specimens), varies from that originally given by Sullivan (30–45 μ, mean 36·5 μ). Otherwise the range of ornament in the present specimens agrees with the original description.

Previous records. Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

Genus UMBONATISPORITES gen. nov.

Type species. U. variabilis sp. nov.

Diagnosis. Radial, trilete miospores, amb circular to sub-circular. Laesura simple, straight, one sixth of the spore radius; frequently indistinct. Ornament of variable shape, predominantly narrow at the base, widening towards the apex and terminating in a rounded head, which is topped by a short, sharply tapering spine. There may be from one to three rounded 'heads' on the apex of the element (text-fig. 1). There are tapering spines interspersed over the surface of the spore. Exine is frequently folded.

Umbonatisporites variabilis sp. nov.

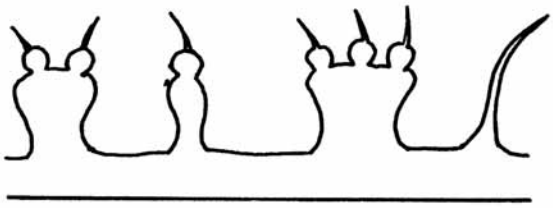
Plate 78, figs. 12, 13; Plate 79, figs. 1–3

Holotype. Slide LC2e, 44·4 90·0. Size 120 μ.

Diagnosis. Diameter 95–134 μ, mean 106 μ (34 specimens); amb sub-circular to circular. Laesura one-sixth spore radius, simple, frequently indistinct. Exine 1–2 μ thick, covered

with a distinctive ornament arranged in indiscriminate patterns. Ornament variable in both size and shape; one element up to 4·5 μ high and 1·0–1·5 μ in basal diameter, widening towards the apex where it terminates in a rounded head which is topped with a thin tapering spine. There may be from one to three rounded projections at the apex of the element. These elements are interspersed with spines 0·5–1·0 μ at the base and from 2·0 to 4·0 μ long. The exine is commonly folded.

Remarks. The only other spore showing variable branching at the apex of the elements making up the ornament is the megaspore *Singhisporites* (Potonié 1956), 'die terminal ± kleine Verzweigungen aufweisen'. There is no indication of the short terminal spine seen in *Umbonatisporites* nor of tapering spines interspersed with the 'bacula'. The ornament in *Singhisporites* is frequently adpressed on to the spore body as is typical of *Umbonatisporites* (Pl. 79, figs. 2, 3).



TEXT-FIG. 1. Profile view of sculpture of *Umbonatisporites variabilis* gen. et. sp. nov.

Subinfraturma BACULATI Dybova and Jachowicz 1957

Genus RAISTRICKIA (Schopf, Wilson, and Bentall) Potonié and Kremp 1954

Type species. R. grovensis Schopf 1944.

Raistrickia nigra Love 1960

Plate 78, figs. 5, 6

Remarks. The size range of the present specimens, from 48 to 67 μ, mean 56 μ (33 specimens) is smaller than that given by Love, the bacula are also of a smaller dimension. Love comments that his description is based on only a small number of specimens and it is considered that the present material represents an extension of his original description. The sizes do not differ markedly from those given by Sullivan and Marshall (1966).

Previous records. Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary Group (Viséan) of Scotland (Sullivan and Marshall 1966).

Raistrickia cf. *clavata* (Hacquebard) Playford 1963

Plate 79, figs. 4, 5

Description. Diameter 34–128 μ, mean 109 μ (30 specimens); amb circular. Laesura straight, length two-thirds to three-quarters the spore radius, with slight lip development. Exine 3·0–6·0 μ thick (excluding ornament) covered with a variable ornament

of verrucae, mushroom-shaped processes and bacula; their basal diameter varies from 5·5 to 8·0 μ and height from 2·0 to 9·0 μ. The ornament is irregular and occurs on both faces of the spore.

Remarks. The character and positioning of the ornament in *R. clavata* (Hacquebard) Playford 1963) is very similar to the present specimens. The size, however, is that of *R. ponderosa* Playford 1963, which has less verrucae and a more uniform ornament.

Genus NEORAISTRICKIA Potonié 1956

Type species. N. truncatus (Cookson) Potonié 1956.

Neoraistrickia drybrookensis Sullivan 1964

Plate 78, figs. 7, 8

Description. Diameter 31–53 μ, mean 45 μ (35 specimens); amb triangular with rounded apices and straight to slightly concave, or convex sides. Laesura often indistinct, straight, length three-quarters of spore radius; slight lip development. The distal face of the spore is ornamented with cones, bacula, and verrucae. The coni are often blunt, up to 3·0 μ in height and 4·0 μ in basal diameter; the bacula are up to 9·0 μ high and 5·0 μ in basal diameter and the verrucae from 3·0 to 7·0 μ high and up to 9·0 μ in basal diameter. Exine 2·0–2·5 μ thick.

Remarks. The specimens agree closely with the description given by Sullivan; the size range is extended. The large verrucae when occurring on the equator, in particular towards the triangular apices, give the impression that the spore has a flange.

Previous records. Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

Infraturma MURORNATI Potonié and Kremp 1954
Genus CONVOLUTISPORA Hoffmeister, Staplin, and Malloy 1955

Type species. C. florida Hoffmeister, Staplin, and Malloy 1955.

Convolutispora labiata Playford 1962

Plate 79, figs. 8, 9

Remarks. Diameter 47–89 μ, mean 64 μ (50 specimens). The size of the miospores from the Basement Beds is considerably smaller than those described by Playford, diameter 82–114 μ, mean 99 μ. Apart from size difference the present specimens have the same characteristics as Playford originally described and they are therefore placed in *C. labiata*.

Previous records. Lower Carboniferous of Spitsbergen (Playford 1962).

Convolutispora vermiformis Hughes and Playford 1961

Plate 79, figs. 6, 7

1957 *Convolutispora flexuosa* forma *minor* Hacquebard, p. 312; pl. 2, fig. 10.

Remarks. A number of the present specimens have lower, more insignificant muri than was originally described by Hughes and Playford. They form a continuous morphological series to the more typical form and were all included under *C. vermiformis.*

Previous records. Lower Carboniferous of Spitsbergen (Hughes and Playford 1961, Playford 1962). Horton Group (Tournaisian) of Canada (Hacquebard 1957, Playford 1963). Upper Devonian of Melville Island (McGregor 1960). Springer formation (Mississippian/Pennsylvanian boundary) of Oklahoma (Felix and Burbridge 1967).

Genus DICTYOTRILETES (Naumova) Smith and Butterworth 1967

Type species. D. bireticulatus (Ibrahim) Potonié and Kremp 1954.

Dictyotriletes tesselatus sp. nov.

Plate 80, figs. 1, 2, 4, 5, 7, 8

Holotype. Slide LC3a, 55·7 93·2. Size 95 μ.

Diagnosis. Diameter 78–105 μ, mean 91 μ (50 specimens); amb circular to sub-circular. Laesura distinct, straight, length from three-quarters to equal to the spore radius; accompanied by prominent lips up to 6·0 μ broad on each side of the mark, having a number of blunt crests up to 5·0 μ high. Ornamentation on both faces of the spore of smooth muri, 2·5–4·0 μ wide and up to 11·0 μ high, frequently with a clavate profile when seen equatorially. The muri are frequently expanded where they anastamose, and may terminate abruptly on the proximal face. Lumina very irregular in shape, from 5·0 to 27·0 μ in longest diameter, there may be clavate projections within them. Exine 2·5 to 4·0 μ thick (excluding ornament).

Comparison. Reticulatisporites variolatus Playford 1962 is characterized by a higher frequency of more clavate muri when seen in profile. The lumina are more regularly arranged and are rounded to polygonal in shape; the exine is also thicker and the laesura is not accompanied by lips. *R. cancellatus* Playford 1962 has lower muri which are not clavate in section.

EXPLANATION OF PLATE 79

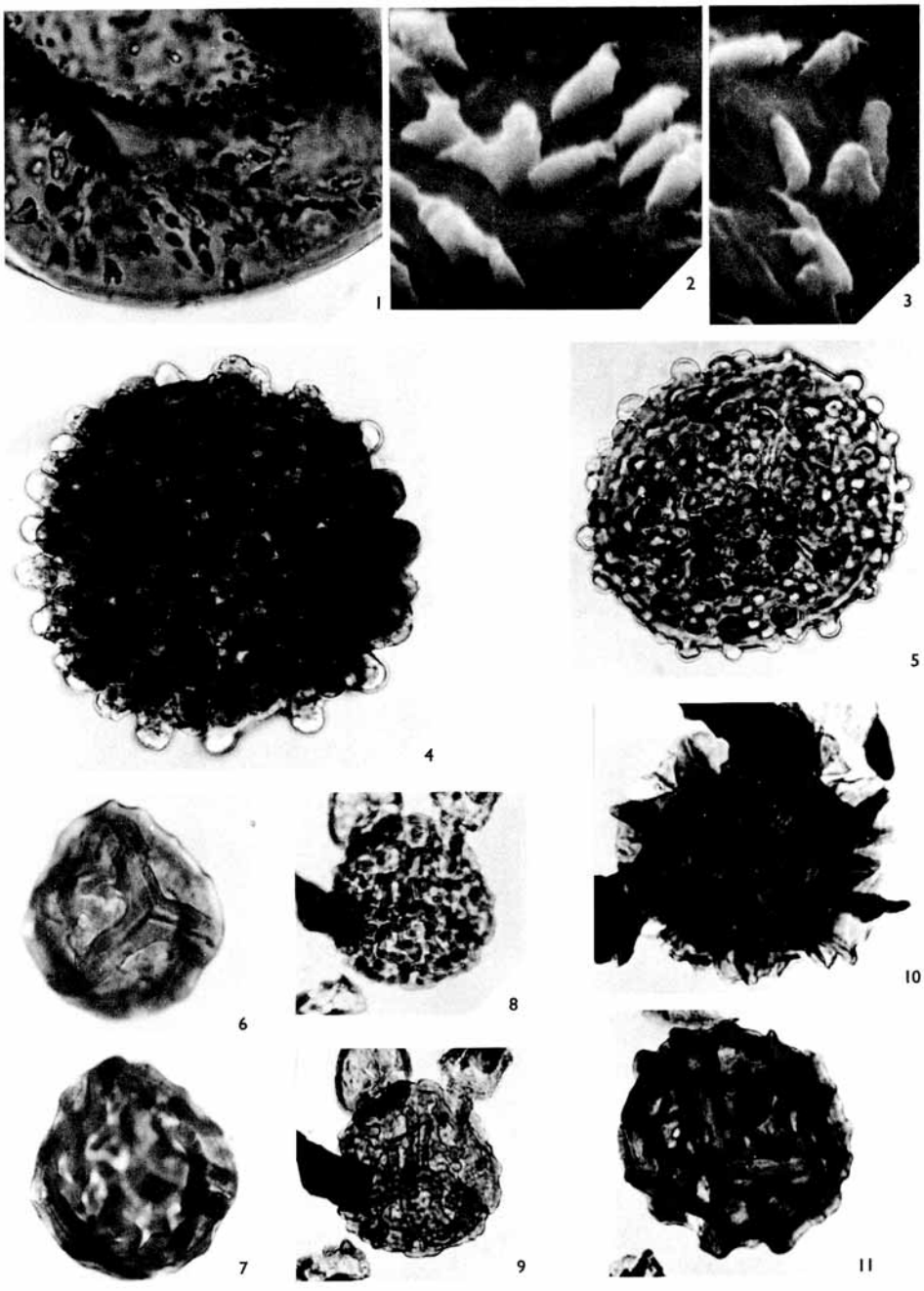
All figures × 500 unless otherwise stated

Figs. 1–3. *Umbonatisporites variabilis* gen. et sp. nov. 1, Details of ornament; slide LC2c, 14·6 106·8; × 1000. 2, 3, Stereoscan pictures showing detail of ornament. 2, negative S/28/32, × 5650. 3, negative S/28/37, × 5650.

Figs. 4–5. *Raistrickia* cf. *clavata* (Hacquebard) Playford 1963. 4, Distal surface; slide MS174. 5, Proximal surface; slide MS177.

Figs. 6–9. *Convolutispora* spp. 6–7, *C. vermiformis* Hughes and Playford 1961; Slide MS153. 6, Proximal surface. 7, Distal surface. 8–9, *C. labiata* Playford 1962; Slide LC3a, 32·8 96·2. 8, Distal surface. 9, Proximal surface.

Figs. 10–11. *Dictyotriletes* spp. 10, *D. pactilis* Sullivan and Marshall 1966; Slide LC5c, 16·5 106·7. 11, *D. cancellatus* Playford 1962. Proximal surface, slide LC3d, 37·8 110·9.



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Dictyotriletes cancellatus (Waltz) Potonié and Kremp 1955

Plate 79, fig. 11

1938 *Azonotriletes cancellatus* Waltz, in Luber and Waltz, p. 11; pl. 1, fig. 8 and pl. 5, fig. 73.
1955 *Sphenophyllotriletes cancellatus* (Waltz) Luber, pp. 41–2, pl. 4, figs. 78*a*, *b*, 79.
1955 *Dictyotriletes cancellatus* (Waltz) Potonié and Kremp, p. 108.
1956 *Dictyotriletes cancellatus* (Waltz) Ishchenko, p. 43; pl. 7, figs. 88, 89.
1957 *Dictyotriletes cancellatus* (Waltz) Naumova; Kedo, p. 1166.
1957 *Reticulatisporites varioreticulatus* Hacquebard and Barss, p. 17, pl. 2, figs. 15, 16.
1962 *Reticulatisporites cancellatus* (Waltz) Playford, pp. 597–8; pl. 82, figs. 11–13 and pl. 83, figs. 1, 2.

Remarks. The inclusion of this species within the genus *Dictyotriletes* follows the emendation of *Reticulatisporites* by Neves (1964) and the subsequent emendation of *Dictyotriletes* by Smith and Butterworth (1967). In the comparison of their new genus *Corbulispora* with *Dictyotriletes* Bharadwaj and Venkatachala (1962) separate the two on the basis of the latter having 'flat muri . . . a simple trilete mark' (p. 24). There is no valid reason for emphasizing the simple trilete mark as an important difference between the two and it would seem that the interpretation of flat muri is not objective. It would seem that these characteristics are not of sufficient significance to separate the two genera. A more detailed study of the type material is needed to resolve the problem.

Previous records. Lower Carboniferous of the U.S.S.R. (Waltz in Luber and Waltz 1938, Luber 1955, Ishchenko 1956, 1958 and Kedo 1957, 1958). Lower Carboniferous of Canada (Hacquebard and Barss 1957) and of Spitsbergen (Playford 1962).

Dictyotriletes pactilis Sullivan and Marshall 1966

Plate 80, fig. 10

Description. Diameter 62–105 μ, mean 85 μ (50 specimens); amb circular to subcircular. Laesura not seen. Ornament of thin, tall muri 0·5 to 2·0 μ wide and up to 18·0 μ high, clearly visible as radial projections at the equator. Lumina irregular in shape, from 5·0 to 33·0 μ in longest diameter. Muri frequently folded. Exine 2·0 to 4·0 μ thick.

Remarks. In measuring eleven specimens Sullivan and Marshall gave a size range of 52–63 μ, mean 58 μ. On the basis of a greater number of specimens this size range is extended. *Reticulatisporites* sp. B recorded by Love (1960) would seem to be *D. pactilis*. Love records a size of 74 μ for his specimen.

Previous records. Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary Group (Viséan) of Scotland (Sullivan and Marshall 1966). Goddard formation (upper Mississippian) of Oklahoma (Felix and Burbridge 1967).

Dictyotriletes submarginatus Playford 1963

Plate 80, figs. 3, 6, 11, 12.

Description. Diameter 52–69 μ, mean 60 μ (25 specimens); amb sub-triangular. Laesura distinct, sinuous or straight, extending to the equator, accompanied by elevated lips up to

3 μ wide. Proximal surface laevigate, occasionally the muri run on to the proximal surface in the equatorial region. Distal surface ornamented with low, narrow, sinuous muri, which may both anastamose and terminate freely; the lumina formed are irregular in shape. Equatorial outline irregular to deeply indented.

Remarks. The spores described here agree closely with the original description given by Playford, with the exception that the ornament of the distal surface appears to be less dense and the incisions at the equator are deeper than his figured specimens. It is not clear if the equatorial structure is a true cingulum, or is a feature produced by the fusion of muri.

Previous records. Horton Group (Tournaisian) of Canada (Playford 1963).

Subturma ZONOTRILETES Waltz 1935
Infraturma CINGULATI (Potonié and Klaus) Dettmann 1963
Genus KNOXISPORITES (Potonié and Kremp) Neves and Playford 1961

Type species. K. hageni Potonié and Kremp 1954.

Knoxisporites stephanophorus Love 1961

Plate 80, figs. 9, 10

Remarks. Diameter 46–84 μ, mean 68 μ (20 specimens). The distal thickenings and distinctive structure of the lips, thinning proximally, are characteristic of this species.

Previous records. Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary group (Viséan) of Scotland (Sullivan and Marshall 1966). Springer formation (Mississippian/Pennsylvanian boundary) and Goddard formation (Upper Mississippian) of Oklahoma (Felix and Burbridge 1967).

Knoxisporites pristinus Sullivan 1968

Plate 81, figs. 5, 6, 9

Description. Diameter 53–89 μ, mean 68 μ (27 specimens); amb circular to sub-circular, frequently irregular. Laesura distinct, length from three-quarters to almost equal to

EXPLANATION OF PLATE 80

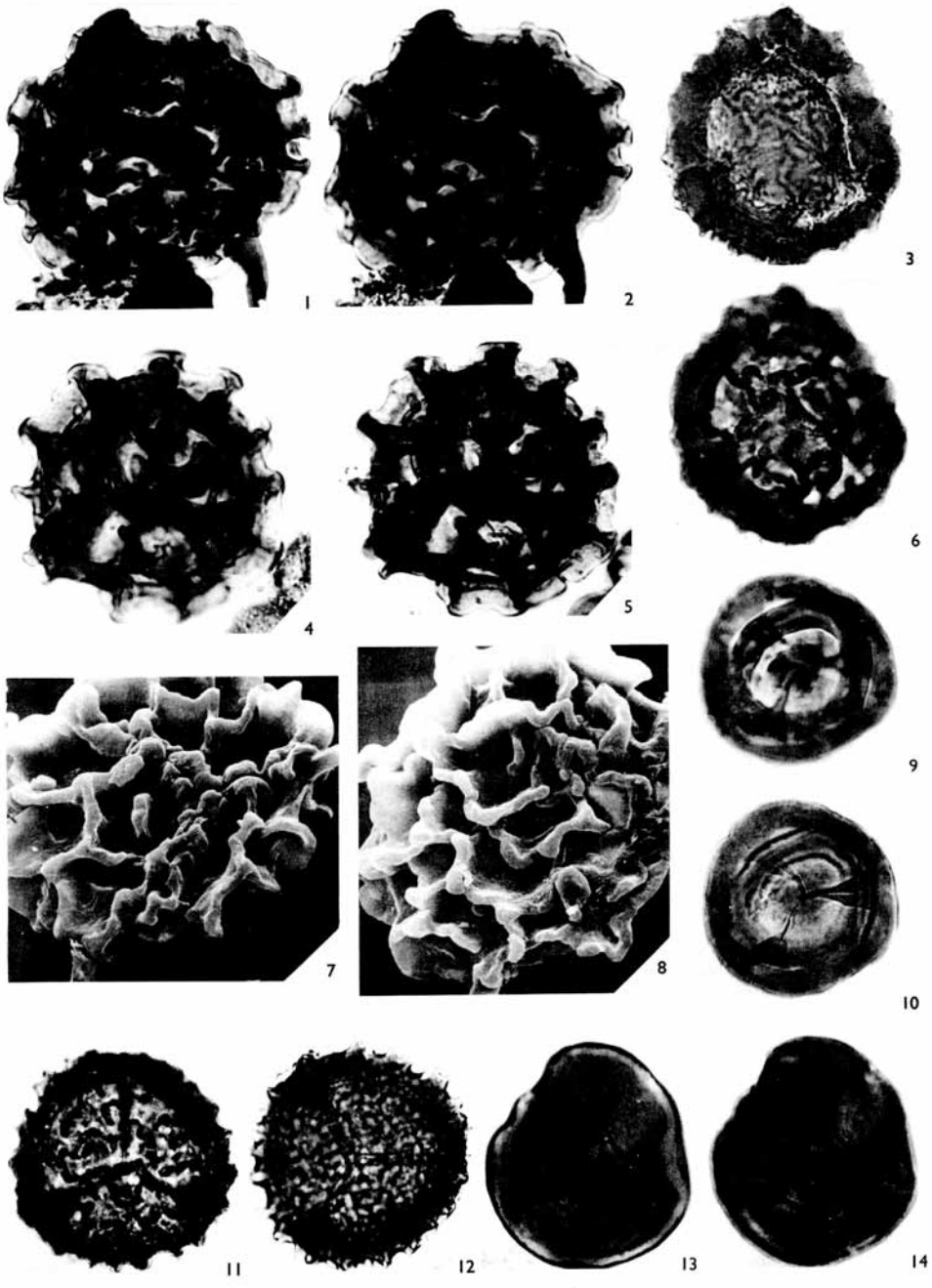
All figures $\times$ 500 unless otherwise stated

Figs. 1, 2, 4, 5, 7, 8. *Dictyotriletes tesselatus* sp. nov. 1, Holotype, distal surface; slide LC3a, 55·7 93·2. 2, Holotype, proximal surface, 4, Proximal surface; slide LC3c, 31·0 99·8 5, Distal surface; slide LC3c, 31·0 99·8 7, Stereoscan, proximal surface; negative S/26/40, $\times$ 600. 8, Stereoscan, distal surface; negative S/26/29, $\times$ 630.

Figs. 3, 6, 11, 12. *Dictyotriletes submarginatus* Playford 1963. 3, Proximal surface; slide MS122. 6, Distal surface; slide MS122. 11, Distal surface; slide MS81. 12, Proximal surface; slide MS81.

Figs. 9, 10. *Knoxisporites stephanophorus* Love 1961; Slide MS108. 9, Distal surface. 10, Proximal surface.

Figs. 13, 14. *Knoxisporites seniradiatus* Neves 1961; Slide MS91. 13, Proximal surface. 14, Distal surface.



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the radius of the central body, occasionally lips are developed. Exine thickened on the distal surface, the thickenings are irregular in shape and frequently only slightly developed.

Remarks. The present specimens clearly fit into the description given by Sullivan. The variability and often ill-defined nature of the thickenings make it likely that many spores which are rather badly preserved will be placed in this species. Certainly some of the present material approximates to *K. hederatus* (Ishchenko) Playford 1963 and *K. rotatus* Hoffmeister, Staplin, and Malloy 1956.

Previous records. Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968).

Knoxisporites seniradiatus Neves 1961

Plate 80, figs. 13, 14

Remarks. Although very few specimens of this spore were seen, they were clearly referable to this species; the laesura having wide, prominent lips, so distinguishing the specimens from *K. triradiatus* Hoffmeister, Staplin, and Malloy 1955. Sullivan (1964a) records *K.* cf. *triradiatus* from Tournaisian deposits; in these specimens the trilete has narrow lips, narrower than those of *K. seniradiatus*. This may rather be a representation of the morphological range of *K. seniradiatus*.

Previous records. Namurian of the southern Pennines (Neves 1961).

Genus CINCTURASPORITES Hacquebard and Barss 1957

Type species. C. altilis Hacquebard and Barss 1957.

Remarks. This genus includes specimens which have a cingulum and a distinct convolute ridge, or boss distal ornament. It is likely that the genus *Orbisporis* Bharadwaj and Venkatachala 1962 does possess an equatorial cingulum, although the authors do not describe such a feature; this, together with its variable distal ornament, makes it difficult to separate from *Cincturasporites*. Critical reassessment of the type material of the genus *Orbisporis* is necessary to resolve the problem.

Cincturasporites intestinalis sp. nov.

Plate 81, figs. 11–13; Plate 82, figs. 1–3

Holotype. MS132. Size 130 μ.

Diagnosis. Over-all diameter 92–143 μ, mean 104 μ (70 specimens); amb circular to sub-circular. Laesura distinct, straight, length two-thirds to equal to the central body radius, often gaping and frequently accompanied by a development of the proximal ornament. Cingulum from 10·0 to 19·0 μ in width, showing a poleward overlap onto the central body; the equatorial amb is irregular and has several thickened lobes. Cingulum is concentrically thickened, having a peripheral band of thickening and a further band adjacent to the body with a thinner area between. The distal and, to a lesser extent, the proximal faces of the central body are ornamented with convolute,

vermiform ridges, only rarely anastamosing, from 5·0 to 30·0 μ in length and 4·0 to 9·0 μ in width. The central body is most often displaced laterally.

Remarks. *Orbisporis convolutus* Butterworth and Spinner 1967 is similar but has a thickened band on the proximal side of the equator and lacks proximal ornament. *Cincturasporites* sp. Balme and Hassell 1962 seems to approach the structure of *C. intestinalis*.

Suprasubturma LAMINATITRILETES Smith and Butterworth 1967
Subturma ZONOLAMINATITRILETES Smith and Butterworth 1967
Infraturma CINGULICAVATI Smith and Butterworth 1967
Genus MUROSPORA Somers 1952

Type species. *M. kosankei* Somers 1952.

Murospora intorta (Waltz) Playford 1962

Plate 81, fig. 8

1938 *Zonotriletes intortus* Waltz, in Luber and Waltz, p. 22; pl. 2, fig. 24.
1954 *Simozonotriletes intortus* (Waltz) Potonié and Kremp, p. 159.
1956 *Simozonotriletes intortus* (Waltz) Ishchenko, pp. 88–9; pl. 17, fig. 204.

Description. Diameter 50–69 μ, mean 58 μ (30 specimens); amb subtriangular with straight to concave sides and rounded apices. Laesura simple, distinct, straight, length from two-thirds to equal to the spore body radius. Cingulum laevigate, 6–12 μ wide, may be thicker and wider at the apices, overlaps the central body on the proximal side.

Remarks. The validity of the generic assignment of this species remains in doubt. Staplin (1960) showed that *Murospora* Somers, *Simozonotriletes* (Naumova) Potonié and Kremp, and *Westphalensisporites* Alpern could be included in a single genus having patellate and capsellate forms, the equatorial feature being a tightly attached but separate part of the spore and not a centrifugal extension of the spore body. He did not amend the diagnosis of Somers. It is not known what is the true nature of the equatorial structure in the type material of *Simozonotriletes* and until this is understood the present specimens are placed in the genus *Murospora* following the work of Staplin.

EXPLANATION OF PLATE 81

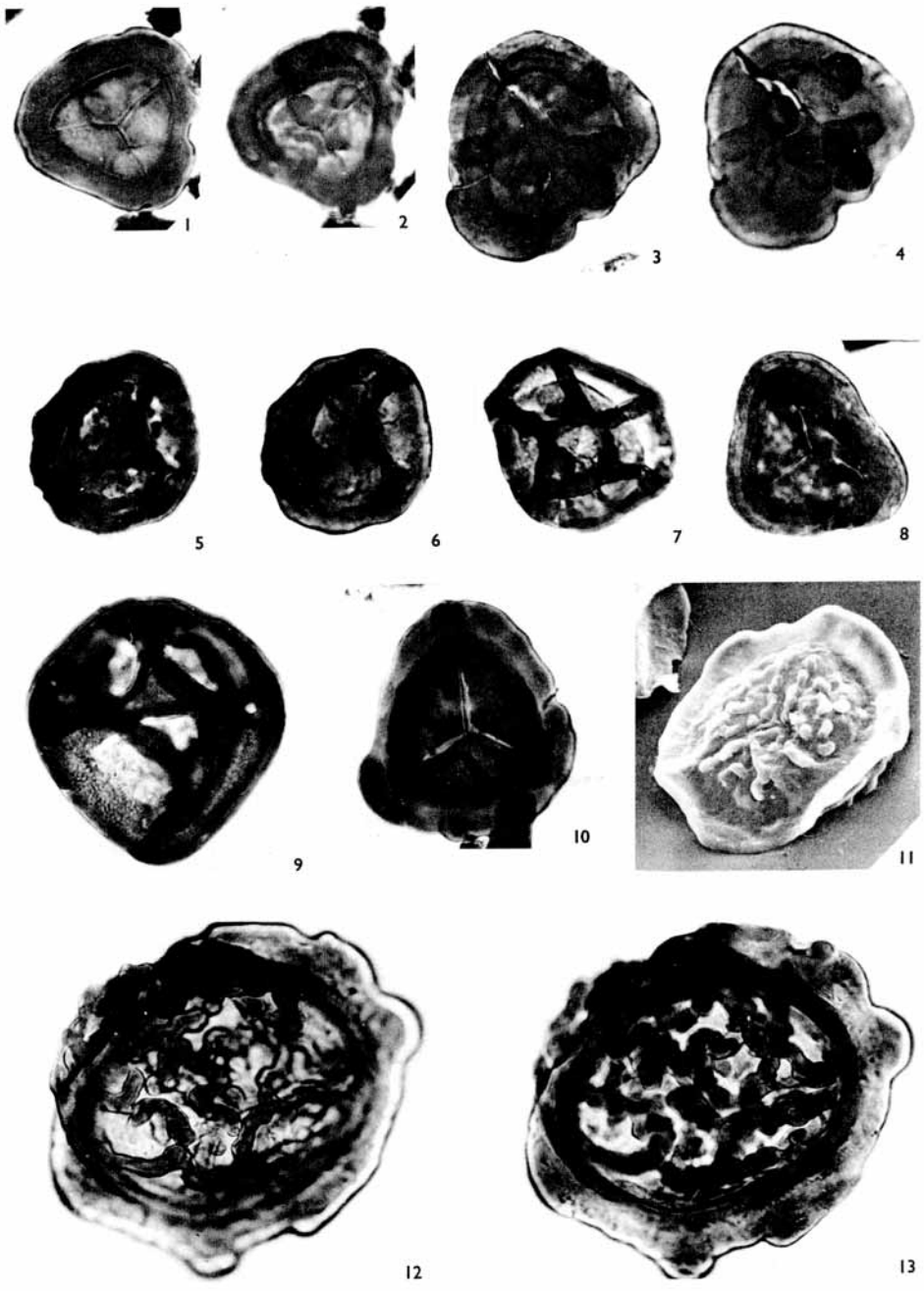
All figures ×500 unless otherwise stated

Figs. 1–4. *Lophozonotriletes muricatus* sp. nov. 1, Holotype, proximal surface; slide LC5b 46·7 101·4. 2, Holotype, distal surface. 3, Proximal surface; slide MS29. 4, Distal surface; slide MS29.

Figs. 5, 6, 7, 9. *Knoxisporites* spp. 5, 6, 9. *K. pristinus* Sullivan 1968. 5, Distal surface; slide MS26. 6, Proximal surface; slide MS26. 9, Distal surface; slide MS219. 7, *K. literatus* (Waltz) Playford 1962; Slide MS145.

Figs. 8, 10. *Murospora* spp. 8, *M. intorta* (Waltz) Playford 1962, Proximal surface; slide LC5a, 43·6 97·1. 10, *M. aurita* (Waltz) Playford 1962, Proximal surface; slide LC7b, 33·4 101·6.

Figs. 11–13. *Cincturasporites intestinalis* sp. nov. 11, Stereoscan, proximal surface; negative S/26/41, ×360. 12, Holotype, distal surface; slide MS132. 13, Holotype, proximal surface.



HIBBERT and LACEY, Early Carboniferous miospores

Previous records. Widely recorded from the Lower Carboniferous of the U.S.S.R. (Luber and Waltz 1938, Ishchenko 1956) and Spitsbergen (Playford 1962). The Upper Carboniferous of Britain (Sullivan 1958) and Upper Mississippian of Canada (Playford and Barss 1963).

Murospora aurita (Waltz) Playford 1962

Plate 81, fig. 10

1938 *Zonotriletes auritus* (Waltz) in Luber and Waltz, p. 17, pl. 2, fig. 23.
1956 *Simozonotriletes auritus* (Waltz) Potonié and Kremp, p. 109.
1957 *Cincturasporites auritus* (Waltz) Hacquebard and Barss, p. 23, pl. 3, fig. 1.
1957 *Cincturasporites irregularis* Hacquebard and Barss, pp. 25–6; pl. 3, fig. 19.
1960 *Murospora varia* Staplin, p. 30, pl. 6, figs. 16, 18.
1960 *Murospora* sp. cf. *varia* Staplin, p. 30, pl. 6, fig. 19.
1962 *Murospora aurita* (Waltz) Playford, pp. 609–10, pl. 87, figs. 1–6; text figs. 6*a–q*, *s*, 7.

Description. Diameter 49–73 μ, mean 59 μ (30 specimens); amb sub-triangular, margin smooth to undulating. Laesura distinct, straight, reaching to the equator of the central body, accompanied by lips 2·5–6·0 μ broad and slightly elevated. Cingulum from 5·0 to 13·0 μ wide, laevigate, showing variation in thickening and in equatorial outline, thickenings commonly situated at the radial apices.

Remarks. The overlap of the cingulum onto the central body is not considered to be a constant feature of *M. aurita* by Playford; he rejects the assignment to *Cincturasporites*. Certainly the continuous morphological series of cingulum width and thickness which he describes is present in the Basement Bed material, cingulum overlap occurring indiscriminately throughout this series.

Previous records. Lower Carboniferous of the U.S.S.R. (Luber and Waltz 1938, 1941). Upper Mississippian of Canada (Hacquebard and Barss 1957, Playford and Barss 1963). Lower Carboniferous of Spitzbergen (Hughes and Playford 1961, Playford 1962.)

Genus LOPHOZONOTRILETES (Naumova) Potonié 1958

Type species. L. lebedianensis Naumova 1953.

Remarks. Potonié (1958) includes spores in the genus *Lophozonotriletes* which were cingulate and had a prominent verrucate ornament. Playford (1963*a*) found an overlap of the cingulum onto the central body in rather less than a half of the specimens of *Cincturasporites appendices* Hacquebard and Barss which he examined. He discounted this overlap and placed the specimens in *Lophozonotriletes*.

Lophozonotriletes muricatus sp. nov.

Plate 81, figs. 1–4

Holotype. Slide LC5b, 46·7 101·4. Size 59 μ.

Diagnosis. Over-all diameter 48–69 μ, mean 58 μ (55 specimens); amb sub-triangular with convex sides and rounded apices. Laesura distinct, simple, straight, length from three-quarters to equal to the central body radius. Cingulum from 11·0 to 20·0 μ in

width. Distal surface of both the cingulum and the central body bears an ornament of verrucae which may coalesce to form ridges, from 3·4 to 7·5 μ in basal diameter.

Remarks. L. appendices (Hacquebard and Barss) Playford 1963, has an irregular distal ornament which is not elongate and is only rarely coalescent; it is also larger (110–70 μ).

Genus VALLATISPORITES Hacquebard 1957

Type species. V. vallatus Hacquebard 1957.

Vallatisporites vallatus Hacquebard 1957

Plate 82, figs. 6, 13.

Remarks. The present specimens agree with the descriptions given both by Hacquebard 1957 and by Staplin and Jansonius (1964). There is a variability in the size of the vacuoles which are not considered by Staplin and Jansonius to be of secondary origin but rather as a specific character.

Previous records. Horton group (Tournaisian) of eastern Canada (Hacquebard 1957, Playford 1963). Banff formation (Tournaisian) of Alberta (Staplin and Jansonius 1964). Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968).

Vallatisporites ciliaris (Luber) Sullivan 1964

Plate 82, fig. 8

1938 *Zonotriletes ciliaris* Luber, in Luber and Waltz, p. 25, pl. 6, fig. 82.
1964 *Vallatisporites ciliaris* (Luber) Sullivan, p. 370, pl. 59, figs. 14, 15.

Remarks. Over-all diameter 52–77 μ, mean 62 μ (50 specimens). The ornament described by Sullivan as galeae and spines is variable in size and density. In the present material there seems to be a continuous morphological series between this species and *V.* cf. *ciliaris* Sullivan 1964, in which the ornament is more or less completely absent. In this series there is considerable variation in the size and shape of the vacuoles.

Previous records. Drybrook Sandstone (Viséan) Forest of Dean Gloucestershire (Sullivan 1964). Bewcastle Beds (Upper Tournaisian/Lower Viséan) of north-west England (Butterworth and Spinner 1967).

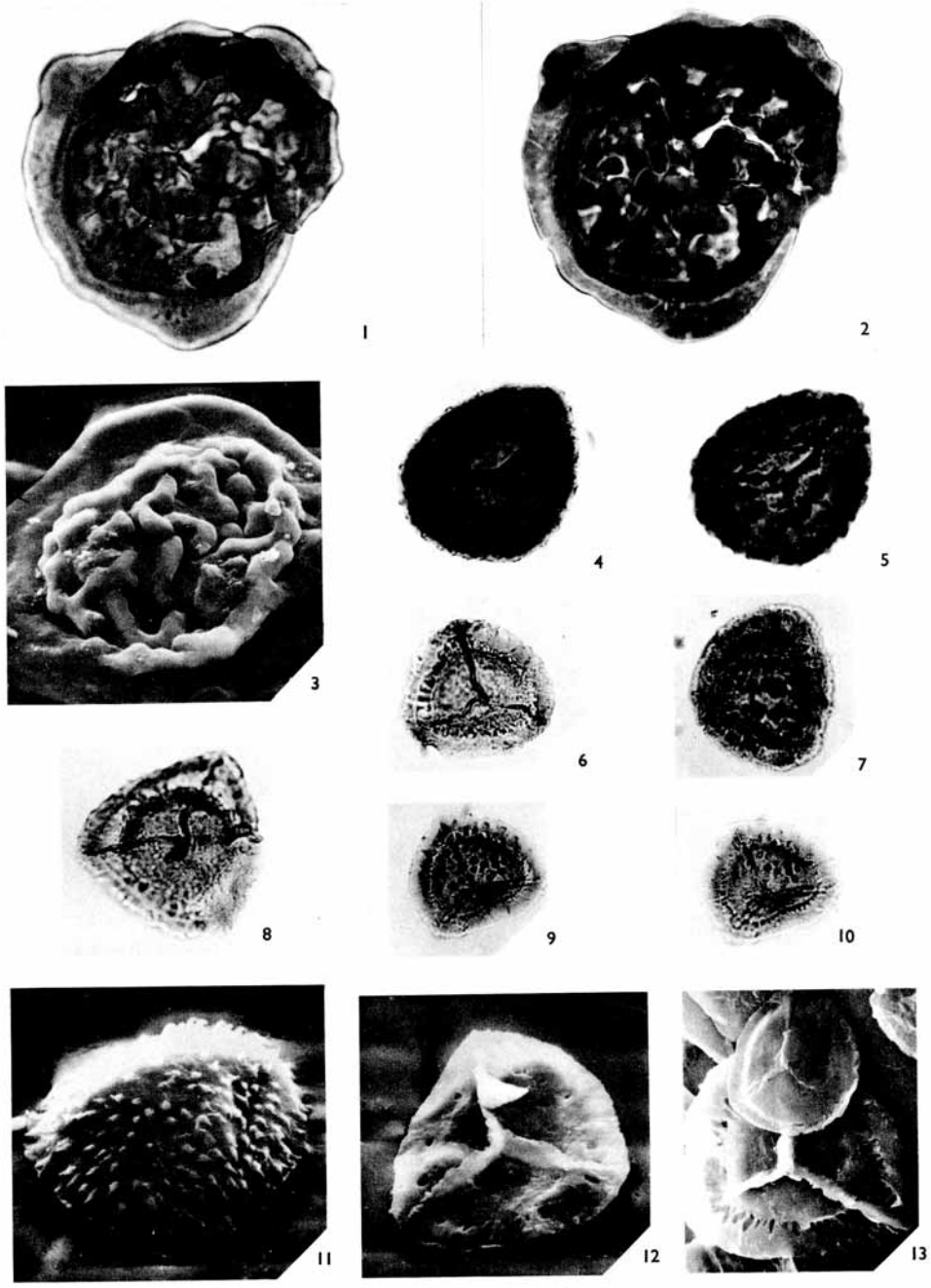
EXPLANATION OF PLATE 82

All figures × 500 unless otherwise stated

Figs. 1–3. *Cincturasporites intestinalis* sp. nov. 1, Distal surface, slide MS69. 2, Proximal surface, slide MS69. 3, Stereoscan picture, distal surface, negative S/28/25, × 625.

Figs. 4, 5, 7, 9–12. *Vallatisporites microgalearis* sp. nov. 4, Holotype, proximal surface, slide LC2a 23·5 102·2. 5, Holotype, distal surface, slide LC2a 23·5 102·2. 7, Distal surface, slide MS231. 9, Distal surface, slide LC2c 28·9 95·5. 10, Proximal surface, slide LC2c 28·9 95·5. 11, Stereoscan picture, distal surface, negative S/28/27, × 600. 12, Stereoscan picture, proximal surface, negative S/28/26, × 600.

Figs. 6, 8, 13. *Vallatisporites* spp. 6, *V. vallatus* Hacquebard 1957, Proximal surface; slide MS248. 8, *V. cilliaris* (Luber) Sullivan 1964, Proximal surface; slide MS233. 13, *V. vallatus* with *Lycospora uber*, stereoscan, proximal surface; negative S/26/2, × 650.



HIBBERT and LACEY, Early Carboniferous miospores

Vallatisporites microgalearis sp. nov.

Plate 82, figs. 4, 5, 7, 9–12

Holotype. Slide LC2a, 23.5 102.2. Size 56 μ.

Diagnosis. Over-all diameter 39–59 μ, mean 49 μ (56 specimens); amb sub-triangular with convex sides. Laesura indistinct obscured by sinuous, elevated lips which are equal to the over-all radius of the spore. The distal surface of the central body and the cingulum is ornamented with verrucae and galeae, the bases of which are often fused, from 1·5 to 4·0 μ in basal diameter and up to 3·0 μ in height. The cingulum is internally vacuolate; in addition there are a number of vacuoles opening into the proximal face of the spore.

Remarks. This spore is smaller than *V. galearis* Sullivan 1964, and the distal ornament is found both on the central body and the cingulum.

Suprasubturma PERINOTRILITES (Erdtman) Dettmann 1963
Genus PEROTRILITES (Erdtman) ex Couper 1953

Type species. P. granulatus Couper 1953.

Perotrilites magnus Hughes and Playford 1961

Plate 83, fig. 7

Remarks. Diameter 101–54 μ, mean 123 μ (20 specimens); the perine is torn away from several of the present specimens, otherwise the spore is as described by Hughes and Playford.

Previous records. Lower Carboniferous of Spitsbergen (Hughes and Playford 1961, Playford 1962). Horton Group (Tournaisian) of eastern Canada (Playford 1963.)

Perotrilites perinatus Hughes and Playford 1961

Plate 83, fig. 6

Remarks. Diameter 61–86 μ, mean 65 μ (22 specimens). The folding of the perine gives a wrinkled appearance to the spore which can assume a reticulate pattern. Punctations occasionally seen on the perine are likely to be due to corrosion.

Previous records. Lower Carboniferous of Spitsbergen (Hughes and Playford 1961, Playford 1962). Upper Sedimentary Group (Viséan) of Scotland (Sullivan and Marshall 1966). Springer formation (Mississippian/Pennsylvanian boundary) of Oklahoma (Felix and Burbridge 1967).

Suprasubturma PSEUDOSACCITITRILETES Richardson 1965
Infraturma MONOPSEUDOSACCITI Smith and Butterworth 1967
Genus GRANDISPORA Hoffmeister, Staplin and Malloy 1955

Type species. G. spinosa Hoffmeister, Staplin and Malloy 1955.

Grandispora reticulatus sp. nov.

Plate 83, figs. 1, 2, 4, 5, 8

Holotype. Slide MS192. Size 82 μ.

Diagnosis. Over-all diameter 75–130 μ, mean 101 μ, diameter of central body 52–96 μ, mean 72 μ (36 specimens); amb circular to sub-circular. Laesura distinct, may be obscured by lips, straight, length one-half to three-quarters over-all diameter. Distal and proximal faces ornamented with simple spines from 2·0 to 5·0 μ in basal diameter and 5·0–15·0 μ high; they may have expanded bases which anastamose to form a reticulate pattern over the surface of the spore. The exo-exine is strongly punctate and the central body is distinct and laevigate.

Remarks. It is not clear whether the reticulate nature of the exo-exine is caused by the development of the bases of the spines or by its thickening. The reticulate pattern is most clearly seen in those specimens where the ornament is well developed and rather crowded. *Grandispora* sp. A of Sullivan and Marshall 1966 is likely to be *G. reticulatus*. The size and disposition of the ornament distinguish *G. reticulatus* from other species in the genus.

Genus HYMENOZONOTRILETES (Naumova 1937?, 1939) Potonié 1958

Type species. H. polyacanthus Naumova 1953.

Hymenozonotriletes? hastulus Sullivan 1968

Plate 83, fig. 3

Description. Diameter 51–72 μ, mean 60 μ (35 specimens); amb circular to rounded triangular. Laesura indistinct, obscured by raised lips which are sinuous, length equal to the radius of the central body or reaching onto the cingulum. The distal face of the central body is ornamented with small cones grading into well-developed spines on the cingulum which are 1·5–4·0 μ in basal diameter and from 2·5 to 7·0 μ high, spines frequently have a swollen base. Proximal face of the central body laevigate to finely punctate. Spines occur on the proximal face of the cingulum.

Remarks. The genus cannot be placed with any certainty in the present system of classification because details of the structure and exine stratification of the type species is not fully known. The designation of these specimens as *Hymenozonotriletes* follows Sullivan (1968).

Previous records. Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968).

EXPLANATION OF PLATE 83

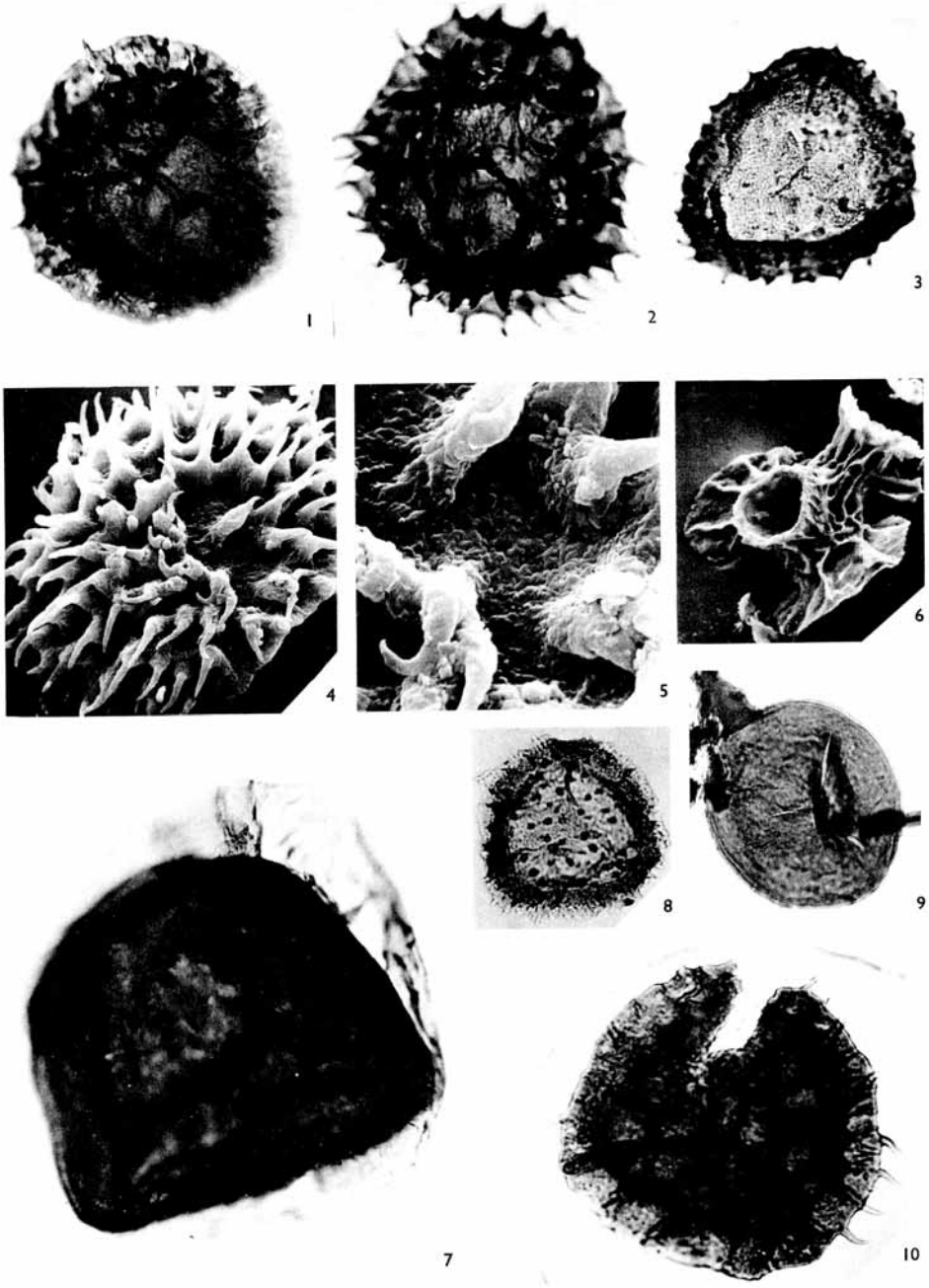
All figures × 500 unless otherwise stated

Figs. 1, 2, 4, 5, 10. *Grandispora reticulatus* sp. nov. 1, Holotype, distal surface; slide MS192. 2, Distal surface; slide MS187. 4, Stereoscan, negative S/26/32, × 1900. 5, Stereoscan, detail of ornament; negative S/26/31, × 630. 8, Proximal surface; slide MS76.

Figs. 3, 8. *Hymenozonotriletes? hastulus* Sullivan 1968. 3, Slide MS9. 8, Slide MS6.

Fig. 6. *Tetrapterites visensis* Sullivan and Hibbert 1964, Stereoscan, negative S/26/35, × 190.

Fig. 7, 9. *Perotrilites* spp. 7, *P. magnus* Hughes and Playford 1961; Slide MS147. 9, *P. perinatus* Hughes and Playford 1961; Slide LC2*e*, 43·4 99·1.



HIBBERT and LACEY, Early Carboniferous miospores

THE MIOSPORE ASSEMBLAGE FROM THE BASEMENT BEDS

The assemblage from the Basement Beds contained a total of 47 species, as shown in Table 1. It was dominated by *Lycospora uber*; species of *Punctatisporites* and *Vallatisporites* were present in quantities greater than 10% of the total (500 spores were counted). *Cyclogranisporites lasius* and species of *Leiotriletes* and *Dictyotriletes* had representation between 1 and 8%, the remainder individually contributing less than 1% of the total.

The assemblage contains miospores which are restricted elsewhere to assemblages of Tournaisian age: *Dictyotriletes submarginatus*, *Knoxisporites pristinus*, *Vallatisporites vallatus*, whilst others have been recorded mainly from deposits of Viséan age: *Leiotriletes tumidus*, *Waltzispora planiangulata*, *Lophotriletes tribulosus*, *Raistrickia nigra*, *Neoraistrickia drybrookensis*, *Convolutispora mellita*, *Dictyotriletes pactilis*, *Knoxisporites stephanophorus*, *Grumosisporites verrucosus*, *Remysporites magnificus*, and *Tetrapterites visensis*.

COMPARISON WITH OTHER LOWER CARBONIFEROUS MIOSPORE ASSEMBLAGES

Comparisons between the miospore assemblage from the Basement Beds and others of Lower Carboniferous age are set out in Table 1. This table is compiled from data of the following authors: Butterworth and Williams 1958, Felix and Burbridge 1967, Hacquebard 1957, Hacquebard and Barss 1957, Hoffmeister, Staplin and Malloy 1955, Ishchenko 1958, Kedo 1958, Love 1960, Luber 1955, Luber and Waltz 1938, Playford 1962, 1963*a*, 1963*b*, Playford and Barss 1963, Smith and Butterworth 1967, Staplin 1960, Sullivan 1964*a*, 1964*b*, and Sullivan and Marshall 1966.

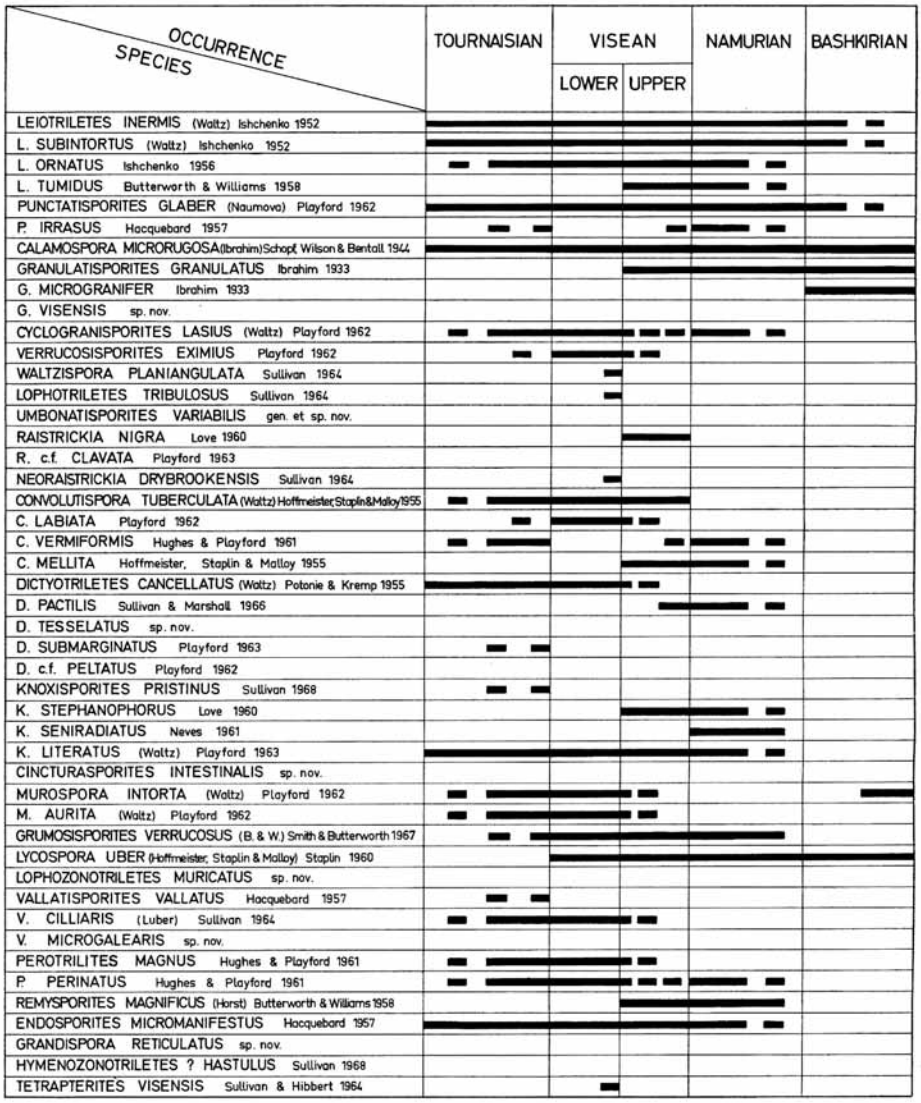
The correlation and zonation for the Carboniferous follows that set out by Francis and Woodland (1964) in Table 1, p. 222. Correlations between faunal assemblages is that of Prentice and Thomas (1965), and the S_2/D_1 boundary is used to define upper from lower Viséan (Murray Mitchell pers. comm.).

The assemblage from the Caernarvonshire Basement Beds closely resembles that described by Sullivan (1964) from the Drybrook Sandstone of the Forest of Dean, which is Viséan in age (S_2). There are species which are only recorded from these two deposits, namely *Lophotriletes tribulosus* Sullivan 1964, *Waltzispora planiangulata* Sullivan 1964, *Neoraistrickia drybrookensis* Sullivan 1964, and *Tetrapterites visensis* Sullivan and Hibbert 1964. Both of these deposits lack characteristic species which are recorded from the Viséan–Namurian deposits of the north of England and Scotland (Sullivan and Marshall 1966).

The assemblages described by Knox 1948, Butterworth and Williams 1958, Love 1960, Sullivan and Marshall 1966, Owens and Burgess 1965, and Butterworth and Spinner 1967 complete a range from middle Viséan to Namurian A and have been grouped together, on the basis of spore content, as the *Grandispora* suite by Sullivan (1965, 1967). This suite has also been recognized from the mid continent of U.S.A., Spain, Poland, Czechoslovakia, Romania, and Turkey (Sullivan 1967). None of the characteristic species of this suite are recorded from the Basement Beds but other species commonly found in the *Grandispora* suite do occur. *Raistrickia nigra* Love 1960 and *Dictyotriletes pactilis* Sullivan and Marshall 1966 both indicative of upper Viséan deposits in Scotland,

TABLE 1

Stratigraphic distribution of miospores found in the Menai Straits assemblage. Broken line indicates uncertainty regarding stratigraphic dating or precise age limits; B & W = Butterworth and Williams. Stratigraphic time scale as defined in Harland, W.B., *et al*, (eds.) 1967, *The Fossil Record*, Geological Society of London.



occur in the Basement Beds, as does *Remysporites magnificus* (Horst) Butterworth and Williams 1958, restricted to Namurian A and younger deposits in Scotland.

Similarities also exist between the assemblage from the Basement Beds and the 'Aurita' assemblage described by Playford (1963*a*), from Spitsbergen. This latter assemblage is characterized by zonate spores and is thought to be of Viséan, possibly Namurian age. Many of the species of this assemblage are found in North Wales, notably *Verrucosisporites eximius* Playford 1962, *Convolutispora labiata* Playford 1962, *C. vermiformis* Hughes and Playford 1961, *Murospora aurita* (Waltz) Playford 1962, and *M. intorta* (Waltz) Playford 1962, all of which have not been previously recorded in the United Kingdom, also *Dictyotriletes cancellatus* (Waltz) Potonié and Kremp 1966, *Convolutispora tuberculata* (Waltz) Hoffmeister, Staplin, and Malloy 1955, and *Perotrilites magnus* Hughes and Playford 1961 which have previously been recorded from Tournaisian and Viséan deposits of the British Isles. According to Sullivan (1967) elements of the Spitsbergen miospore flora place it in his *Monilospora* suite.

The assemblages described from the Horton Group of Eastern Canada have similarities with the flora of the Basement Beds, *Dictyotriletes submarginatus* Playford, *Raistrickia* cf. *clavata*, *Perotrilites perinatus*, and *P. magnus* being conspicuous in both assemblages.

AGE OF THE BASEMENT BEDS

The miospore assemblage from the Basement Bed has affinities with other assemblages of Viséan age, in particular that of the Drybrook Sandstone (Sullivan 1964). It also contains important species characteristic of the Tournaisian *Vallatisporites* suite (Sullivan 1968) and is similar to the Viséan miospore floras from Scotland (Love 1960, Sullivan and Marshall 1966), both of which are assigned to the *Grandispora* suite, and the 'Aurita' assemblage from Spitsbergen (Playford 1962, 1963*a*).

There is very little published information on lower to mid-Viséan miospore floras with which comparisons can be made. Also there is no opportunity to extend the stratigraphic range of Lower Carboniferous fossils in the Menai Straits area because of the limited nature of the deposits.

The appearance of miospores typical of Tournaisian assemblages is likely to be due to reworking (Wilson 1962). The Basement Group of the Carboniferous Limestone is a transgressive sequence and a shale lenticle in a sandstone-conglomerate is a situation where such reworking would take place. Yet these spores are not less well preserved than those more typical of the later deposits. The presence of the widely recorded miospore *Lycospora uber* may be taken as evidence that the deposits are of Viséan, rather than Tournaisian, age. The presence of other upper Viséan to Namurian miospores would place a minimum age on the deposit without entirely excluding the possibility that further work on early Viséan deposits may extend the range of some of these spores. Since, however, many of the typical late Viséan types are absent it is believed that the Basement Beds are of early upper Viséan age.

This agrees well with the tentative S_2–D_1 age assigned to the deposits on the basis of fragmentary faunal evidence and the middle to upper Viséan age suggested for the overlying Brown Limestone elsewhere in North Wales on the basis of floral and faunal macrofossil evidence (Lacey 1962).

Acknowledgements. The authors thank Professor P. W. Richards for the use of facilities in the University College of North Wales. Their thanks are also due to Dr. R. Neves, Dr. H. J. Sullivan, and Dr. M. A. Butterworth for their advice and assistance at various times during the course of the work. Cambridge Scientific Instruments provided valuable help with the scanning electron microscope. This paper is part of a thesis prepared by F. A. H. while in receipt of a D.S.I.R. Studentship.

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Typescript received 4 October 1968