LOWER AND MIDDLE DEVONIAN SPORES OF NORTH AND CENTRAL VESTSPITSBERGEN

by K. C. ALLEN

ABSTRACT. From the Devonian succession in North and Central Vestspitsbergen, seven hundred rock-specimens collected by the author and over three hundred collected by previous Expeditions have been examined macroscopically; two hundred and fifty of these were prepared for microscopic investigation. These included specimens from every Spitsbergen formation, and consisted typically of medium to fine-grained clastic sediments. Eighty-two dispersed spore species are recorded, of which forty-eight new species are systematically described. Five new genera (*Bullatisporites*, *Craspedispora*, *Cymbosporites*, *Aulicosporites*, and *Chelinospora*) are proposed, and another genus (*Archaeozonotriletes*) is emended. Twenty-five morphologically complex species were sectioned, in order to elucidate and interpret their structure. Consideration is given to corrosion and preservation of the spore exine.

THIS paper describes only the preparation and systematics of the dispersed spores from the Devonian succession of North and Central Vestspitsbergen. In a later paper the microfloral assemblages and their stratigraphical applications will be discussed.

The study of the dispersed spores from the Devonian succession of Spitsbergen was undertaken at the joint suggestion of Mr. N. F. Hughes and Mr. W. B. Harland. An initial study by Dr. P. F. Friend and Mrs. M. Mortimer had shown the presence of spores from horizons in the Mimer Valley Series.

All the samples studied were collected by members of various Spitsbergen Expeditions organized from the Sedgwick Museum, although prior to 1959 few samples were collected for this purpose; samples for palynological preparation and examination were collected by Dr. P. F. Friend and Dr. D. J. Gobbett in 1959, and by the author in 1961.

The spore genera and species are based solely on morphological criteria, their botanical affinities are for the most part unknown.

The Devonian succession in Spitsbergen is confined to the island of Vestspitsbergen, where the Devonian outcrops over a large area (Friend 1961, p. 79, fig. 1). It consists of about six thousand metres of predominantly Old Red Sandstone facies. Numerous sections were collected for palynological study throughout the area by the author, in the hope of producing a stratigraphical succession based on dispersed spores. Well-localized samples collected by previous Cambridge Spitsbergen Expeditions were also used. For general stratigraphy and stratigraphical nomenclature, I have followed Friend (1961) throughout.

Acknowledgements. The writer expresses his sincere gratitude to Mr. N. F. Hughes for constant advice and encouragement throughout the course of this study. The investigation was made possible through the fieldwork of members of various Cambridge Spitsbergen Expeditions. The writer is particularly indebted to Mr. W. B. Harland who organized most of these Expeditions, and who jointly with Mr. Hughes suggested the research topic; to Dr. P. F. Friend who led the 1961 Cambridge Spitsbergen Expedition and who in 1959 with Dr. D. J. Gobbett, collected many of the samples investigated. Grateful acknowledgement is extended to Professor O. M. B. Bulman, F.R.S., for the use of research facilities of the Sedgwick Museum, Cambridge, where the study was carried out. The writer also

[Palaeontology, Vol. 8, Part 4, 1965, pp. 687–748, pls. 94–108.]

thanks Dr. M. E. Dettmann for helpful discussions, and Mr. A. Barlow for kindly assisting with much of the photography.

Through the courtesy of Professor O. A. Høeg, of the University of Oslo, the writer was able to examine collections of Devonian plants from Spitsbergen housed in the Palaeontological Museum, Oslo.

The writer is indebted to the Shell International Petroleum Company Limited for financial assistance during the tenure of one of their Postgraduate Studentships.

PREPARATION AND EXAMINATION OF SAMPLES

Specimens were examined macroscopically, and information on colour, grain-size, calcareous and micaceous content, plant fragments, and any weathering was recorded. A representative selection of two hundred and fifty specimens, comprising a variety of lithological types ranging from coals to coarse-grained sandstones, and all of probable continental origin, were prepared for microscopic examination. Red oxidized shales and sandstones failed to produce any spores, but all other lithological types, though not all other samples, produced spores; the grey and green siltstones yielded the best preserved and most diverse assemblages.

Although the same basic technique was used throughout, with such a variety of lithologies every sample required individual attention and timing at each stage of its preparation. The macroscopic record of each sample prepared was studied, so that any constant reaction might perhaps be related to some visible feature, thus helping to improve the selection of suitable samples. Each specimen for microscopic investigation was scrubbed in distilled water to remove any Recent contamination. About 3 gm. of sediment were broken up with a hammer into approximately 3–5 mm. fragments. To avoid any contamination, the specimen was crushed within sheets of newspaper on an anvil, both the hammer and anvil surfaces being washed after each crushing. If the specimen was superficially weathered, care was taken to use only the central part.

Calcareous samples were treated with 20–30 per cent. hydrochloric acid, and left for at least 2 hours (and frequently overnight). All clastic samples were then treated with cold 50–60 per cent. hydrofluoric acid for 2–14 days; the remaining sediment was then transferred to a nickel crucible to which fresh hydrofluoric acid was added and boiled for 30–40 minutes.

Insoluble fluorides resulting from the previous treatment were removed in warm 10–30 per cent. hydrochloric acid in a water-bath. Frequently as many as ten of these 5-minute treatments were needed to remove all the fluorides.

To the washed residue in 10 cc. of distilled water were added 2–3 drops of 50 per cent. Stergene (or other non-ionic detergent). This was then subjected to a 5–20 second treatment with an ultrasonic disintegrator (1:1 end ratio steel probe vibrating at 20 kilocycles per second). This disaggregated clumps of organic and mineral matter. The residue was then washed in distilled water until the top fluid remained clear.

Oxidation of the humic material was then carried out in Schulze solution. Maceration time varied from 10 minutes to 5 hours, with different samples.

Frequently, further clearing and concentration with an alkali was necessary, and a few drops of 5 per cent. potassium hydroxide, sodium hydroxide, or ammonium hydroxide were used, the latter seemingly gave the best results. The residue was left in alkali for about 15 seconds.

Often minerals which survived the HF treatments were in such concentration that they required removal by a heavy liquid separation. Acidified zinc bromide (S.G. 2·2) was used, the preparation being centrifuged for 20 minutes at 1,800 revolutions per minute.

Only two coals are present in the Spitsbergen Devonian succession; these were crushed and then macerated in Schulze solution for 24–48 hours, thereafter following the preparation technique for clastic sediments.

From these residues at least two strew-slides were prepared for each productive sample, the residue being mounted in unstained glycerine jelly on standard glass slides, and covered with No. 0 coverslips. The slide was tapped lightly, to encourage the residue to settle in one plane, and after allowing the glycerine jelly at least three days to set, the coverslips were sealed with gold size. Single megaspore and microspore mounts were made of several species. Single spores were also separated from residues for serial sectioning, following the embedding and sectioning techniques of Wigglesworth (1959) and Hughes, Dettmann, and Playford (1962). From one to four specimens of twenty-three species were sectioned at 2–3 μ intervals, perpendicular to the equatorial plane, mounted in glycerine jelly and sealed as before. From unproductive samples, one slide was usually prepared as a negative record of the sample. Surplus residue was stored in polythene-stoppered glass tubes, in 50 per cent. glycerine containing a few drops of phenol to prevent fungal growth.

All the strew-slides were first surveyed at $\times 125$ magnification. However, after all productive samples had been studied, the interpretation of morphological features and specific identification was completed at magnifications of $\times 500$ and $\times 1250$, using as many well-preserved specimens as possible and the sections where available. After the specific descriptions were complete, a quantitative estimation was made of the species present, by counting under high power 200 specimens from each sample yielding a sufficient number of well-preserved spores.

DISPERSED SPORE SYSTEMATICS

Nomenclature and Classification. The nomenclature of the described Spitsbergen Devonian spores follows the rules of priority and typification of the International Code of Botanical Nomenclature (1961, Montreal). No botanical affinities are implied with generic designations, which relate to form genera based solely on their morphological features. The nomenclature of suprageneric categories is the artificial classification proposed by Potonié and Kremp (1954), later amplified by them (1955, 1956*a*) and by Potonié (1956, 1958, 1960), and subsequently revised in part by Dettmann (1963).

Terminology. In the systematic section, the descriptive terms used are for the most part those which have been well defined, clearly understood, and widely accepted by previous authors. An effort has been made to keep the number of terms to a minimum.

The author uses the terms intexine and exoexine (Potonié and Kremp 1955) to denote respectively the inner and outer layers of a two-layered spore wall (exine). Where the exoexine is stratified (occasionally separate, but never truly cavate), for example in *Cirratriradites avius* sp. nov. (Pl. 99, fig. 11), the terms outer exoexine and inner exoexine are used. In Spitsbergen Devonian species referred to the genus *Perotrilites* (Erdtman)

ex Couper 1953, the exact nature of the outermost layer is unknown; it may be a true perine, or it may be an outer exoexine, and the non-committal term outer sculptine is used.

The term cavate (Dettmann 1961) is used for asaccate spores in which the spore wall layers are separated from each other by a cavity, the width of which is at least 20 per cent. of the total spore radius, or if less, then the outer layer is thinner and loosely enveloping, as for example in *Perotrilites pannosus* sp. nov. (Pl. 102, fig. 14). This excludes *Densosporites* and *Anulatisporites* which, as demonstrated by Smith (1960, pl. 20, figs. 1–8), occasionally have a small cavity between the intexine and exoexine, and *Geminospora* in which the intexine sometimes separates wholly or partially from the exoexine.

Equatorial flange is used for what appears in proximo-distal aspect to be a membranous zona, but proves from sections to be a sharply tapering cingulum.

Granulate pseudosculpture is used where corrosion of the infra-granulate structure of a spore wall has resulted in an upstanding 'ornament' of granules.

A crumina is defined as a separation and extension of the outer part of the exine (or exoexine). This may occur primarily in the distal region, as for example in *Hystricosporites monosaccus* (Archangelskaya) comb. nov. (Pl. 96, figs. 1, 2), where it is a separation of the outer exoexine; or in the equatorial region as in *Labiadensites fimbriatus* (Waltz) Hacquebard and Barss 1957, see Dettmann and Playford 1963 (pl. 96, figs. 1, 2), where the outer part of the exine is separated and extended.

Miospore is used for dispersed spore species, in which the mean diameter is less than 200 μ, and megaspores for dispersed spore species in which the mean diameter is more than 200 μ.

New species have been erected only where fifteen or more adequately preserved specimens were available for study. Assignment to previously described species is made only when there is reasonable evidence for identity from published illustrations and descriptions. Frequently, however, descriptions are short and illustrations poor, and although the Spitsbergen specimens may appear similar, I cannot be certain that their construction is identical. In most of these cases I have erected new species, recording in my comparisons where conspecifity may occur; in the event of a re-examination of poorly described species, any conspecifity may be easily located. All type and other figured specimens here described, are housed in the Sedgwick Museum, Cambridge, and referred to by a preparation slide number, followed by the 'east–west' and 'north–south' mechanical stage readings, and then by the Sedgwick Museum Spitsbergen Specimen number and a Sedgwick Museum number. In single mount preparations, the slide number is prefixed 'M', with sections the slide number is prefixed 'S'. The stage readings are from the Leitz Dialux microscope No. 3 (serial no. 526724) in the Sedgwick Museum, Cambridge.

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

Type species. Leiotriletes sphaerotriangulus (Loose) Potonié and Kremp 1954.

Leiotriletes parvus Naumova 1953

Dimensions. (Twenty specimens) Equatorial diameter 16–24 μ (mean 19 μ).

Occurrence. Fraenkelryggen Division, and Lower Reuterskiøldfjellet Sandstone; Gedinnian and Siegenian.

Leiotriletes pyramidalis (Luber) comb. nov.

1941 *Azonotriletes pyramidalis* Luber, in Luber and Waltz, p. 54, pl. 12, fig. 182.
1955 *Filicitriletes pyramidalis* Luber, p. 60, pl. 3, fig. 70.

Dimensions. (Eighteen specimens) Equatorial diameter 54–95 μ (mean 70 μ). Elevated lips, individually 2–3 μ wide, 4–9 μ high.

Remarks. Filicitriletes lacks type species designation, and embraces within it spores of several previously well-established genera (Potonié 1958, p. 35).

Occurrence. Reuterskiøldfjellet Sandstone and Mimer Valley Series; Siegenian to Eifellian.

Comparison. Leiotriletes pulvereus Balme and Hassell 1962 (p. 5, pl. 1, fig. 182) has a larger size range, weaker lip development, and is punctate. *L. tumidus* Butterworth and Williams 1958 (p. 359, pl. 1, figs. 5, 6) has a smaller size range and is tumid. *L. ornatus* Ishchenko 1956 (p. 22, pl. 2, figs. 18–21) is smaller and has thicker lips.

Leiotriletes pagius sp. nov.

Plate 94, figs. 1, 2

Diagnosis. Miospores trilete; amb convexly triangular with broadly rounded apices. Laesurae distinct, simple, straight, almost reaching the equatorial margin. Exine 2·5–4 μ thick, homogeneous, laevigate.

Dimensions. (Twenty-two specimens) Equatorial diameter 46–63 μ (mean 54 μ).

Holotype. Preparation KA 251/9, 21·5 94·8, K905, N231.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Siegenian.

Description. Holotype diameter 58 μ. Exine 4 μ thick.

Comparison. Leiotriletes dissimilis McGregor 1960 (p. 27, pl. 11, fig. 1) has punctate contact areas, low distinct lips and a thinner exine. *Leiotriletes confertus* McGregor 1960 (p. 27, pl. 11, fig. 2) also has distinct lips and a thinner exine, and the only difference between these two McGregor species is the punctate contact area and open commissure in *L. dissimilis*, which might be the result of preservation. *Leiotriletes devonicus* Naumova 1953 (p. 22, pl. 1, fig. 5) and *L. trivialis* Naumova 1953 (p. 45, pl. 5, fig. 14) are both considerably smaller. Naumova (1953) in describing *L. devonicus* states 'exine dense, thick, spore margin thickened'. This thick wall might be misinterpreted as a cingulum, unless seen in broken specimens or in oblique aspect, and many form species included within *Stenozonotriletes*, may in fact be thick-walled representatives of *Leiotriletes* or *Punctatisporites*. If *Stenozonotriletes simplex* Naumova 1953 (p. 36, pl. 3, fig. 17; p. 69, pl. 10, fig. 3; and p. 130, pl. 19, figs. 16, 17) should prove to have a thick wall and not a cingulum, then *Leiotriletes pagius* sp. nov. would be synonymous with it.

Occurrence. Lower Reuterskiøldfjellet Sandstone; Siegenian.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. *Punctatisporites punctatus* Ibrahim 1933.

Punctatisporites glaber (Naumova) Playford 1962

Dimensions. (Twenty specimens) Equatorial diameter 29–44 μ (mean 38 μ).

Occurrence. Throughout the Lower and Middle Devonian succession.

Punctatisporites laevigatus (Naumova) comb. nov.

1953 *Stenozonotriletes laevigatus* Naumova, p. 70, pl. 10, figs. 9, 10.

Dimensions. (Twenty specimens) Equatorial diameter 51–71 μ (mean 61 μ). Exine 3·5–6 μ thick.

Remarks. Variation in length of laesurae frequently occurs within a single specimen. Naumova (1953, p. 70) in her description, records 'a thick exine', and the narrow border to which she refers (which is approximately 4 μ thick in her illustration) is probably an optical section through this thick exine, rather than a cingulum as suggested by her generic placing; the species is therefore more appropriately placed within *Punctatisporites*.

Comparison. *Punctatisporites aerarius* Butterworth and Williams 1958 (p. 360, pl. 1, figs. 10, 11) is larger and has a thinner exine. *Stenozonotriletes facilis* Ishchenko 1956 var. *facilis* (p. 73, pl. 14, figs. 162–4) may be conspecific, but it is not clear from the description whether the otorochka (5 μ wide) is a cingulum or the optical section of a thick wall.

Occurrence. Fraenkelryggen Division, Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Mimer Valley Series; Gedinnian to Givetian.

Punctatisporites flavus (Kosanke) Potonié and Kremp 1955

1950 *Calamospora flava* Kosanke, p. 41, pl. 9, fig. 2.
1955 *Punctatisporites flavus* (Kosanke) Potonié and Kremp, p. 42.

Dimensions. (Twenty-two specimens) Equatorial diameter 95–152 μ (mean 120 μ).

Occurrence. Lower Mimer Valley Series and probable Upper Reuterskiøldfjellet Sandstone, Emsian and Eifelian.

Genus CALAMOSPORA Schopf, Wilson, and Bentall 1944

Type species. *Calamospora hartungiana* Schopf, in Schopf, Wilson and Bentall 1944.

Calamospora microrugosa (Ibrahim) Schopf, Wilson, and Bentall 1944

Synonymy. See Playford 1962, p. 579.

Dimensions. (Twenty specimens) Equatorial diameter 50–110 μ (mean 86 μ). Exine 2 μ or less thick.

Occurrence. Kapp Kjeldsen Division, Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Mimer Valley Series; Siegenian to Givetian, more common in the Givetian.

Calamospora nigrata (Naumova) comb. nov.

1953 *Leiotriletes nigratus* Naumova, p. 23, pl. 1, fig. 9.
1958 *Leiotriletes nigratus* Ishchenko, p. 35, pl. 1, fig. 5; non Naumova 1953.

Dimensions. (Twenty-six specimens) Equatorial diameter 60–80 μ (mean 76 μ). Exine 1 μ or less thick.

Remarks. The short laesurae, and thin folded exine suggest correct inclusion within *Calamospora*. Naumova (1953) quotes dimensions of 60–70 μ, and Ishchenko (1958) 90–110 μ. Neither author states the number of spores measured. Naumova's readings are probably two equatorial axes of the same spore. The Spitsbergen spores are of intermediate size. In some specimens there is a tetrad impression of narrow arcuate folds (the curvaturae and curvaturae imperfectae of Potonié and Kremp 1955).

Comparison. Leiotriletes atavus Naumova 1953 (p. 23, pl. 1, fig. 8) is smaller and lacks folding. *Calamospora saariana* Bhardwaj 1957 (p. 81, pl. 22, figs. 13–15) is also smaller and possesses lips.

Occurrence. Present in the majority of well-preserved samples; Gedinnian to Givetian, most common in the Emsian.

Calamospora witneyana Chaloner 1963

Dimensions. (Fifteen specimens) Equatorial diameter 116–212 μ (mean 151 μ).

Occurrence. Reuterskiøldfjellet Sandstone and Lower Mimer Valley Series; Siegenian and Emsian.

Genus TRILEITES (Erdtman 1945, 1947) ex Potonié 1956

Type species. Trileites (al. *Triletes*) *spurius* (Dijkstra) Potonié 1956.

Trileites oxfordiensis Chaloner 1963

Dimensions. (Twenty specimens) Equatorial diameter 186–530 μ (mean 290 μ).

Occurrence. Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone and Mimer Valley Series; Siegenian to Givetian.

Infraturma APICULATI (Bennie and Kidston) R. Potonié 1956
Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. Granulatisporites granulatus Ibrahim 1933.

Granulatisporites muninensis sp. nov.

Plate 94, figs. 3–5

Diagnosis. Miospores trilete; amb triangular with straight to slightly convex sides and rounded apices. Laesurae straight, length two-thirds to full spore radius, accompanied by smooth, raised lips, individually up to 2 μ wide. Exine 1 μ thick, homogeneous to infragranulate, contact areas laevigate, proximo-equatorial and distal surfaces sculptured with evenly spaced granules.

Dimensions. (Twenty specimens) Equatorial diameter 24–30 μ (mean 27 μ).

Holotype. Preparation KA 293/1, 56·7 105·1, K556, N233.

Locus typicus. East Munindalen, Central Dicksonland, Vestspitsbergen; Plantekløfta Conglomerate, probable Givetian.

Description. Holotype triangular with straight sides, diameter 25 μ. Laesurae four-fifths spore radius, accompanied by lips individually 1 μ wide, slightly separating equatorially. Slight curvatural ridges in radial regions.

Remarks. The lips are frequently inaperturate, and are sometimes separated equatorially. Slight curvaturae are occasionally present in the radial regions.

Comparison. Granulatisporites triconvexus Staplin 1960 (p. 15, pl. 3, figs. 11, 12) is larger, more finely granulose, the lips are less prominent and there is no suggestion of laevigate contact areas. *Granulatisporites planiusculus* (Luber) Playford 1962 (p. 533, pl. 79, fig. 18) is larger, has a thinner exine and lacks the laevigate contact areas. *Archaeozonotriletes parvibasilaris* Naumova var. *triangulatus* Chibrikova 1959 (p. 71, pl. 11, fig. 5) has a thicker exine and sculptured contact areas. *Anapiculatisporites devonicus* var. *azonatus* (Chibrikova) Vigran 1964 (p. 13; pl. 1, figs. 21–23) differs only in having a sculpture of coni.

Occurrence. Present in most productive samples; Gedinnian to Givetian, most common in the Givetian.

Genus CYCLOGRANISPORITES Potonié and Kremp 1954

Type species. Cyclogranisporites leopoldi (Kremp) Potonié and Kremp 1954.

Cyclogranisporites rotundus (Naumova) comb. nov.

1953 *Lophotriletes rotundus* Naumova, p. 58, pl. 7, fig. 19; p. 108, pl. 16, fig. 34.
1953 *Lophotriletes rotundus* Naumova var. *minor*, p. 96, pl. 15, fig. 10; p. 108, pl. 16, figs. 29, 30. No type designated.

Dimensions. (Twenty-five specimens) Equatorial diameter 29–45 μ (mean 35 μ).

Remarks. Lophotriletes rotundus Naumova var. *minor*, lacks both holotypic designation and description. Its separation from *L. rotundus* Naumova is made on its slightly smaller

---

EXPLANATION OF PLATE 94

All figures × 500 unless otherwise stated; from unretouched negatives.

Figs. 1, 2. *Leiotriletes pagius* sp. nov. 1, Holotype, sectional focus; KA 251/9, 21·5 94·8, K905, N231. 2, Proximal surface; KA 251/7, 40·2 97·5, K905, N232.

Figs. 3–5. *Granulatisporites muninensis* sp. nov. 3, 4, Holotype, proximal and distal surfaces respectively; KA 293/1, 56·7 105·1, K556, N233. 5, Holotype, × 1000; distal surface, showing granules.

Figs. 6–9. *Cyclogranisporites plicatus* sp. nov. 6, Holotype, KA 258/3, 50·4 100·1, K922, N234. 7, Showing curvaturae; KA 258/2, 49·4 91·4, K922, N235. 8–9, Specimens showing variation in size of granules. 8, KA 258/4, 35·1 91·2, K922, N236. 9, KA 258/2, 49·1 91·6, K922, N237.

Figs. 10–18. *Geminospora spp.* 10–11. *G. tuberculata* (Kedo) comb. nov. 10, Proximal surface; KA 229/3, 22·1 89·4, K550, N238. 11, Distal surface; KA 255/2, 41·3 87·5, K760, N239. 12–16. *G. svalbardiae* (Vigran) comb. nov. 12, Distal surface, showing intexine; KA 255/2, 48·2 93·5, K760, N240. 13, 14, Proximal and distal surfaces respectively; KA 243/2, 35·8 91·5, K767, N241. 15, Distal surface; KA 243/2, 47·0 97·2, K767, N242. 16, Section, showing lips and uniformly thick exine; KA 286/S2, 52·5 94·9, K773, N243. 17–18. *G. spinosa* sp. nov. Holotype, proximal and distal surfaces respectively; KA 243/1, 30·4 107·3, K767, N244.

Figs. 19–20. *Acanthotriletes raptus* sp. nov. Holotype, proximal and distal surfaces respectively; KA 258/3, 47·0 108·7, K922, N245.

size. However, as only two specimens of *L. rotundus* var. *minor* were measured and as the Spitsbergen specimens span the size range of both, the variety is included within the synonymy. Its circular amb and granulose sculpture indicate more appropriate inclusion within *Cyclogranisporites*.

Occurrence. Upper Mimer Valley and Wijde Bay Series; Givetian.

Cyclogranisporites plicatus sp. nov.

Plate 94, figs. 6–9

Diagnosis. Miospores trilete, originally spherical; amb circular to subcircular. Laesurae distinct to discernible, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius, simple, or accompanied by smooth often sinuous lips, individually 0·5–2 μ wide. Exine thin, 1 μ or less, homogeneous, supporting a granulose ornament of variable density. Low, narrow curvaturae or curvaturae imperfectae are present in approximately one-third specimens. Major compressional folds always present.

Dimensions. (Forty-five specimens) Equatorial diameter 51–82 μ (mean 66 μ).

Holotype. Preparation KA 258/3, 50·4 100·1, K922, N234.

Locus typicus. Mimerdalen, Central Dicksonland, Spitsbergen; ? Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype subcircular, diameter 53 μ. Laesurae simple, length two-thirds spore radius. Exine less than 1 μ thick, densely sculptured. Three compressional folds.

Remarks. Variation in size and density of ornament is demonstrated in Plate 94, figs. 8, 9. Curvaturae imperfectae seen in Plate 94, fig. 7.

Comparison. *Lophotriletes rugosus* Naumova 1950 (pl. 2, fig. 6) var. *rugosus* Naumova 1953 (p. 27, pl. 2, fig. 1 and p. 54, pl. 7, fig. 1), is smaller, and may have a sculpture of cones. *Cyclogranisporites lasius* (Waltz) Playford 1962 (p. 585, pl. 79, figs. 19, 20) has more distinct laesurae and a thicker exine. *Retusotriletes verruculatus* Naumova 1953 (p. 29, pl. 2, fig. 10) is smaller, and is roundly triangular. *R. punctatus* Chibrikova 1959 (p. 52, pl. 5, fig. 7) is also smaller and roundly triangular. Miospores recorded from ?*Enigmophyton superbum* fructification Høeg 1942 (p. 118, pl. 49, figs. 9–11) appear to be very similar, but are probably laevigate.

Occurrence. Present in most well-preserved samples, but extremely common in the Reuterskiøldfjellet Sandstone and Lower Mimer Valley Series; Gedinnian to Givetian.

Genus GEMINOSPORA Balme 1962

Type species. *Geminospora lemurata* Balme 1962.

Discussion. Although the type species has a slightly thicker distal surface (a feature common to many Devonian spores), the difference is not appreciable and the genus cannot be regarded as truly patinate. Although the species described below do not show this feature, they are regarded as being of similar construction, and are included within this genus.

Geminospora tuberculata (Kedo) comb. nov.

Plate 94, figs. 10, 11

1955 *Archaeozonotriletes tuberculatus* Kedo, p. 35, pl. 5, figs. 6, 7.

Description of specimens. Miospores trilete; amb roundly triangular to subcircular. Laesurae straight, length two-thirds to full spore radius, simple, or rarely accompanied by narrow, sharp lips, individually 0·5–1 μ wide. Exine two-layered; intexine very thin, 1 μ or less, homogeneous, separated at least in part from the exoexine; exoexine 2–3 μ thick, finely infragranulate. Proximal surface laevigate, distal surface sculptured with granules and small cones 1 μ or less high. Major folding common, frequently the intexine is more strongly folded.

Dimensions. (Twenty specimens) Equatorial diameter 40–65 μ (mean 56 μ).

Remarks. Chibrikova (1959, p. 58), includes *Geminospora tuberculata* (Kedo) in synonymy with *Archaeozonotriletes meonacanthus* Naumova *nom. nud.* The latter, however, lacks both holotypic designation and description.

Comparison. Archaeozonotriletes plicatus Naumova *nom. nud.* in Chibrikova 1959 (p. 64, pl. 8, fig. 10) is very similar, and may prove to be conspecific.

Occurrence. Upper Mimer Valley Series; Givetian.

Geminospora svalbardiae (Vigran) comb. nov.

Plate 94, figs. 12–16

1964 *Lycospora svalbardiae* Vigran, p. 23, pl. 3, figs. 4, 5; pl. 4, figs. 1, 2.

Description of specimens. Miospores trilete; amb roundly triangular to subcircular. Laesurae usually straight, occasionally slightly sinuous, length three-quarters to full spore radius, frequently accompanied by low lips, individually 1–3 μ wide. Exine, at least in some specimens visibly two-layered; intexine thin, less than 1 μ thick, homogeneous, rarely folded, closely appressed to or slightly separate from the exoexine; exoexine 3–7 μ thick, finely infragranulate. Contact areas laevigate, occupying most of the proximal surface, proximo-equatorial (where the contact areas are short of the equatorial margin) and distal surfaces densely granulate. Exoexine frequently with tangential and acuate folds.

Dimensions. (Thirty-four specimens) Equatorial diameter 50–88 μ (mean 72 μ).

Remarks. The arcuate folding (Pl. 94, fig. 13), often gives the impression of a cingulum under lower power, however, the section (Pl. 94, fig. 16) although very compressed, clearly demonstrates the constant exine thickness; also the exclusively distal ornament, and lips formed by an upturning of the exoexine; no intexine is visible in the sections. This constant exine thickness and exclusively distal sculpture indicate more appropriate inclusion in *Geminospora*.

Comparison. Apiculatisporis sp. Hoffmeister, Staplin, and Malloy 1955*a* (pl. 1, fig. 13) appears to be very similar. However, it is not possible to see from the photograph whether it is sculptured proximally. *Retusotriletes parvimammatus* Naumova 1953 var. *famenensis* Naumova 1953 (p. 124, pl. 18, fig. fig. 22) is clearly similar to some specimens, but there is no mention of a laevigate proximal surface, lips, or the presence of major

folds. *Geminospora lemurata* Balme 1962 (p. 5, pl. 1, figs. 5–10) is smaller, lacks lips, and has a slightly thicker distal surface. *Archaeozonotriletes atratus* Naumova 1953 (p. 99, pl. 15, fig. 25) has much wider and higher lips, and has an ornament of verrucae. *Archaeozonotriletes notatus* Naumova 1953 (p. 84, pl. 13, fig. 12) lacks lips, and there is no mention of a laevigate proximal surface.

Occurrence. Very common throughout the Upper Mimer Valley Series, but also occurs in the Wijde Bay Series, Lower Mimer Valley Series and Reuterskiøldfjellet Sandstone; Emsian to Givetian.

Geminospora spinosa sp. nov.

Plate 94, figs. 17–18

Diagnosis. Miospores trilete; amb roundly triangular to subcircular. Laesurae straight, length three-quarters to full spore radius, simple or more usually accompanied by narrow sharp lips, individually 0·5–2 μ wide, up to 5 μ high. Exine two-layered; intexine thin, 0·5–2 μ wide, homogeneous, usually slightly separate at least in part from the exoexine; exoexine 2–5 μ thick, coarsely infragranulate. Contact areas laevigate, frequently depressed, occupying from two-thirds to the whole of the proximal surface, proximo-equatorial (where the contact areas are short of the equatorial margin) and distal surfaces sparsely sculptured with spines, 0·5–1·5 μ wide, 3–6 μ long.

Dimensions. (Fifteen specimens) Equatorial diameter 59–91 μ (mean 70 μ).

Holotype. Preparation KA 243/1, 30·4 107·3, K767, N244.

Locus typicus. North ridge of Kinanderfjellet, Central Dicksonland, Spitsbergen; Upper Mimer Valley Series, probable Upper Givetian.

Description. Holotype subcircular, diameter 80 μ. Laesurae indistinct, masked by elevated lips totalling 4 μ wide. Intexine very thin, partly separate from exoexine; exoexine 5 μ thick, radial diameter of depressed contact area 30 μ. Proximo-equatorial and distal spines 1–2 μ wide, 3–5 μ long.

Remarks. The spines are usually appressed against the exoexine. Darkening at the equatorial end of the laesurae in some specimens is usually due to slight folding, and gives the spores an appearance similar to *Pulvinispora* Balme and Hassell. However, in this genus the darkened appearance is due to a thickening rather than a folding (Balme and Hassell 1962, p. 10).

Comparison. Archaeozonotriletes comans Chibrikova 1959 (p. 70, pl. 19, fig. 3) has shorter simple laesurae, and a denser ornament.

Occurrence. Mimer Valley Series; Eifelian and Givetian.

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

Type species. Acanthotriletes ciliatus (Knox) Potonié and Kremp 1954.

Acanthotriletes raptus sp. nov.

Plate 94, figs. 19–20

Diagnosis. Miospores trilete; amb circular, subcircular to roundly triangular. Laesurae distinct to discernible, simple, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius. Exine 1–2 μ thick, homo-

geneous to finely infragranulate; proximal surface laevigate, distal surface evenly crowded with spines and subordinate cones, 0·5–2·5 μ wide, 1·5–4 μ high, with polygonal bases, and often only tapering at their apices.

Dimensions. (Fifteen specimens) Equatorial diameter 34–42 μ (mean 38 μ).

Holotype. Preparation KA 258/3, 47·0 108·7, K922, N245.

Locus typicus. South Mimerdalen, Central Dicksonland, Vestspitsbergen; Reuterskiøldfjellet Sandstone, Eifelian.

Description. Holotype subtriangular with convex sides and broadly rounded apices, diameter 38 μ. Laesurae approximately half spore radius. Exine 1 μ thick, spines 0·5–1·5 μ wide, up to 4 μ high.

Remarks. This species is included within *Acanthotriletes* rather than *Apiculatisporis* on the basis of its dominant, albeit short, spinose ornament.

Comparison. All species which may be closely compared with *Acanthotriletes raptus* sp. nov. have no record of a laevigate proximal surface. This feature alone I regard as sufficient for specific separation. However, I am aware that unless studied under oil immersion, it is not always easy to identify this feature in small, proximo-distally compressed specimens, and an absence of proximal sculpture may have been overlooked by some authors. I have assumed that this might be the case, and therefore list below other differing features. *A. usitatus* Naumova 1953 (p. 24, pl. 1, fig. 15) is triangular and has longer laesurae. *Apiculatisporis pineatus* Hoffmeister, Staplin, and Malloy 1955*b* (p. 38, pl. 38, fig. 3) has a larger, more varied ornament. *Acanthotriletes parvispinosus* Naumova 1953 (p. 24, pl. 1, fig. 16) is smaller and has longer laesurae. *A. tenuispinosus* Naumova var. *tenuispinosus* has longer laesurae and narrower spines.

Occurrence. Reuterskiøldfjellet Sandstone; Eifelian.

Genus HYSTRICOSPORITES McGregor 1960

Type species. Hystricosporites delectabilis McGregor 1960.

Hystricosporites porrectus (Balme and Hassell) comb. nov.

Plate 95, figs. 1–3

1962 *Archaeotriletes porrectus* Balme and Hassell, p. 10, pl. 5, figs. 1–4.

Description of specimens. Miospores trilete; amb circular to subcircular. Laesurae obscured by membranous, often sinuous, elevated lips, 32–60 μ high, length equal to full spore radius. Exine three-layered; intexine approximately 1 μ thick, homogeneous, closely appressed to the exoexine and often indistinct; exoexine 4–9 μ thick, inner exoexine infragranulate, outer exoexine and sculptural elements homogeneous. Contact areas laevigate, proximo-equatorial and distal surfaces support a dense ornament of grapnel-tipped spines, typically 25–35 μ long (range 15–40 μ) rarely with a bulbous base, the shaft tapering gradually towards the apex. The majority are preserved in lateral compression.

Dimensions. (Twenty specimens) Equatorial diameter 90–184 μ (mean 118 μ), polar diameter (including apical processes) 102–170 μ (mean 141 μ).

Remarks. Since the submission for publication of the paper by Balme and Hassell (1962) there has been further generic subdivision of spores with grapnel-tipped appendages, and the Australian species may now more suitably be included within *Hystricosporites* McGregor. Sections (Pl. 95, figs. 2, 3) demonstrate clearly the homogeneous intexine, the infragranulate inner exoexine and the homogeneous outer exoexine and sculptural elements. The elevated lips are formed only from the outer layer of the exoexine.

Comparison. Hystricosporites delectabilis McGregor 1960 (p. 32, pl. 11, figs. 13, 14, text-fig. 2) is larger, and lacks the greatly elevated lips. *Hystricosporites corystus* Richardson 1962 (p. 173, pl. 25, figs. 1, 2) has a sparse ornament of spines, and a thinner exine.

Occurrence. Upper Mimer Valley Series; Givetian.

Hystricosporites porcatus (Winslow) comb. nov.

Plate 95, figs. 4–6

1962 *Dicrospora porcata* Winslow, p. 52; pl. 11, figs. 4, 5, 5*a*; pl. 12, fig. 5; pl. 22, fig. 15.
1964 *Hystrosporites costatus* Vigran, p. 14, pl. 5, figs. 3–5.

Description of specimens. Miospores trilete; amb circular to subcircular. Laesurae indistinct, obscured by sinuous, elevated lips, 10–34 μ high, 2–5 μ wide, length $\frac{2}{3}$–$\frac{4}{5}$ spore radius. Exine three-layered; intexine 2 μ or less thick, homogeneous, usually closely appressed to the exoexine and often indistinct; exoexine 6–12 μ thick, inner exoexine infragranulate, outer exoexine and sculptural elements homogeneous. Contact areas, radial diameter $\frac{2}{3}$–$\frac{3}{4}$ spore radius, each supporting 8–15 low, slightly sinuous muri, 2–8 μ wide, 3–6 μ high, 1–8 μ apart, bordered by low curvaturae 6–10 μ wide. Proximo–equatorial and distal surfaces support bulbous based grapnel-tipped spines, typically 15–30 μ long (range 10–45 μ), 17–23 round the equatorial margin.

Dimensions. (Twenty-six specimens) Equatorial diameter 84–164 μ (mean 111 μ); radial diameter of contact area 26–44 μ.

Remarks. In ill-preserved specimens, the intexine separates from the exoexine, and is often folded. Section (Pl. 95, fig. 6) demonstrates clearly the low, wide, proximal radial muri; but in this strongly compressed specimen the stratification of the exine is not seen. Dimensions recorded for the Spitsbergen specimens are somewhat smaller than those recorded by Winslow (1962, p. 52).

Comparisons. This is the only species recorded to date, which reports the presence of proximal, radial muri, though it would appear from the illustrated holotype that *Hystricosporites delectabilis* McGregor 1960 (pl. 11, fig. 13) may possess this feature.

Occurrence. Upper Mimer Valley Series; Givetian.

Hystricosporites mitratus sp. nov.

Plate 95, figs. 7, 8

Diagnosis. Miospores trilete; amb circular to subcircular. Laesurae indistinct, length approximately half of the spore radius, accompanied by smooth, narrow often sinuous, elevated lips, 2–4 μ wide, 16–27 μ high. Exine 5–12 μ thick, finely infragranulate; contact areas laevigate, small, radial diameter approximately half of the spore radius,

bounded by smooth, narrow elevated curvaturae, basally 3–7 μ wide, 12–20 μ high; proximo-equatorial and distal surfaces support an ornament of grapnel-tipped spines, typically 20–35 μ long (range 12–40 μ), with enlarged, often bulbous bases, 12–25 round the equatorial margin.

Dimensions. (Twenty-three specimens) Equatorial diameter 88–136 μ (mean 113 μ); radial diameter of contact area 23–40 μ (mean 32 μ).

Holotype. Preparation KA 148/5, 28·8 92·7, F1598, N252.

Locus typicus. Huginaspiskardet, Central Dicksonland, Vestspitsbergen; Lower Mimer Valley Series, Eifelian.

Description. Holotype subcircular, diameter 120 μ. Lips 18 μ high, each 2–3 μ thick. Curvaturae 18 μ high, radial diameter of contact area 30 μ. Grapnel-tipped spines 24–44 μ long.

Remarks. This species was not sectioned, and although no intexine was visible it seems very probable that the exinal stratification is similar to sectioned species of the genus *Hystricosporites* McGregor. The curvaturae are of the same dimensions as the lips, and probably formed during the same developmental stages within the tetrad, and formed only from the outer homogeneous layer of the exoexine.

Comparison. Archaeotriletes honestus Naumova 1953 (p. 124, pl. 18, figs. 24, 25) has a thicker exine, thicker, lower curvaturae, and lacks lips, a feature associated with the curvaturae in *H. mitratus* sp. nov.

Occurrence. Upper Reuterskiøldfjellet Sandstone; and Lower Mimer Valley Series; Emsian and Lower Eifelian.

Hystricosporites monosaccus (Archangelskaya) comb. nov.

Plate 96, figs. 1, 2

1963 *Archaeotriletes monosaccus* Archangelskaya, p. 19, pl. 2, figs. 1–5.
1964 *Hystricosporites coronatus* Vigran, p. 15, pl. 3, figs. 1–3.

Description of specimens. Miospores trilete; amb circular to subcircular. Laesurae obscured by high, membranous, sinuous lips, 20–72 μ high, individually 2–4 μ wide at their base, narrowing upwards, length three-quarters to full spore radius. Exine three-layered; intexine 1–3 μ thick, homogeneous, frequently partly separated from the exoexine; exoexine 8–18 μ thick, inner exoexine coarsely infragranulate, outer exoexine

---

EXPLANATION OF PLATE 95

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

Figs. 1–8. *Hystricosporites spp.* 1–3. *H. porrectus* (Balme and Hassell) comb. nov. 1, Lateral view; KA 123/4, 35·6 94·0, G1358, N246. 2, Section showing the three-layered exine; KA 123/S9, 47·5 102·7, G1358, N247. 3, Section ($\times$1000) showing the homogeneous outer exoexine forming the spines, and the infra-granulate inner exoexine; KA 123/S10, 52·2 105·5, G1358, N248. 4–6. *H. porcatus* (Winslow) comb. nov. 4, Proximal surface; KA 261/4, 49·4 89·3, K891, N249. 5, Proximal oblique aspect (most of the grapnel-tipped spines have been eroded); KA 133/1, 42·3 93·1, G1385, N250. 6, Section showing proximal radial muri; KA 123/S4, 42·3 93·8, G1358, N251. 7–8. *H. mitratus* sp. nov. 7, Holotype, central oblique focus; KA 148/5, 28·8 92·7, F1598, N252. 8, Proximal oblique aspect; KA 148/5, 25·0 98·4, F1598, N253.

homogeneous to infragranulate. Distally, the outer exoexine separates from the inner exoexine, and distends distally as a crumina, typically 70–90 μ long (range 23–109 μ). Proximal surface supports an ornament of radial muri, 6–10 μ wide, up to 8 μ high; distal surface with grapnel-tipped spines, 10–32 μ high, with enlarged and frequently bulbous bases, more sparsely disposed on the crumina.

Dimensions. (Twenty-two specimens) Overall equatorial diameter 63–143 μ (mean 99 μ), polar diameter (including apical processes and crumina), 77–248 μ (mean 172 μ).

Remarks. This species is included within *Hystricosporites* McGregor 1960, rather than *Archaeotriletes* Naumova 1953, because of the absence of an equatorial extension. The great difference between the equatorial and polar axial measurements, results in the spores lying parallel to the longer polar axis, and because the proximal surface is flat, details of the contact areas are rarely seen. Sections (Pl. 96, fig. 2) clearly demonstrate the construction of the distal crumina; this feature is not seen in other Spitsbergen Devonian species. Sections of *Labiadensites fimbriatus* (Waltz) Hacquebard and Barss 1957, in Dettmann and Playford 1962 (p. 679, pl. 96, figs. 1, 2) demonstrates the slight development of a cruminate cingulum.

Comparison. H. monosaccus (Archangelskaya) comb. nov. differs from all other grapnel-tipped species, in possessing a crumina.

Occurrence. Upper Mimer Valley Series; Givetian.

Hystricosporites corystus Richardson 1962

Description of specimens. Miospores trilete, amb subcircular to subtriangular. Laesurae straight, length approximately three-quarters to full spore radius, frequently obscured by membranous, often sinuous, elevated lips, 34–68 μ high, extending to the equatorial margin. Exine three-layered; intexine rarely seen, approximally 1 μ thick, homogeneous; exoexine 14–30 μ thick, inner exoexine infragranulate, outer exoexine and sculptural elements homogeneous. Contact areas laevigate, proximo-equatorial and distal surfaces support a sparse ornament of grapnel-tipped spines 30–60 μ long, 8–13 μ wide, 10–13 spines round the equatorial margin.

Dimensions. (Fifteen specimens) Equatorial diameter 64–210 μ (mean 141 μ), polar diameter (including apical processes) 96–214 μ (mean 151 μ).

Occurrence. Upper Mimer Valley Series; Givetian.

Genus RAISTRICKIA (Schopf, Wilson, and Bentall 1944) Potonié and Kremp 1954

Type species. Raistrickia grovensis Schopf in Schopf, Wilson, and Bentall 1944.

Raistrickia aratra sp. nov.

Plate 96, figs. 3, 4

Diagnosis. Miospores trilete; amb circular to subcircular. Laesurae indistinct, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius, simple or rarely accompanied by low narrow lips. Exine 2–6 μ thick, homogeneous; supporting a very variable sculpture of predominantly high baculo-verrucae, 3–12 μ wide, 6–14 μ high, with occasional rugulae, 5–7 μ wide, 7–10 μ

high, up to 25 μ long, cones and spines 2–10 μ wide, 4–12 μ high, the cones often with papillate tips. Concentration of sculptural elements variable, but they are always sparser and more reduced proximally, where spines and cones are more frequent.

Dimensions. (Twenty specimens) Equatorial diameter 38–92 μ (mean 61 μ).

Holotype. Preparation KA 243/1, 27·0 92·3, K767, N256.

Locus typicus. East Munindalen, Central Dicksonland, Vestspitsbergen; Plantekløfta Conglomerate; probable Upper Givetian.

Description. Holotype circular, diameter 78 μ. Laesurae simple, straight, length two-thirds of spore radius. Exine 4 μ thick, variable ornament of baculo-verrucae 9–13 μ high, rugulae, up to 8 μ wide and 25 μ long, cones up to 9 μ high, often with papillate tips, and a few small spines. Sculpture reduced proximally.

Remarks. Although the specimens appear well preserved, evidence from occasional specimens suggests that many of the verrucae, spines and cones, are the result of corrosion of bacula and rugulae by a splitting and 'rounding off' of originally high, flat-topped sculptural elements. This species is included with the genus *Raistrickia* on the basis of predominant baculo-verrucae and variable sculptural elements.

Comparison. Lophozonotriletes macrogrumosus Kedo 1957 (pl. 4, figs. 21, 22) has a thicker wall, and lower more rounded processes. *Raistrickia irregularis* Kosanke 1950 (p. 47, pl. 11, fig. 5) has longer laesurae accompanied by lips, and smaller sculptural elements. *Raistrickia*? *gibberosa* Hacquebard 1957 (p. 310, pl. 2, fig. 1) has longer laesurae and a more regular ornament. *R.* cf. *clavata* Vigran 1964, p. 16, pl. 2, fig. 10, is smaller, and never has sculptural elements over 9 μ high, but is otherwise similar.

Occurrence. Upper Mimer Valley Series; Givetian.

Genus BULLATISPORITES gen. nov.

Type species. Bullatisporites bullatus sp. nov.

Diagnosis. Miospores trilete; amb circular to subcircular. Exine sculptured with pila, the caput frequently supporting a small spine; sculpture somewhat reduced proximally. Contact areas occasionally depressed, and sometimes bounded by curvatural folds.

EXPLANATION OF PLATE 96

All figures ×500 unless otherwise stated; from unretouched negatives.

Figs. 1–2. *Hystricosporites monosaccus* (Archangelskaya) comb. nov. 1, Lateral view; KA 255/M2, 28·6 108·0, K760, N254. 2, Section showing three-layered exine and crumina; KA 255/S3, 54·4 101·0, K760, N255.

Figs. 3–4. *Raistrickia aratra* sp. nov. 3, Holotype, proximal oblique aspect; KA 243/1, 27·0 92·3, K767, N256. 4, Lateral view; KA 243/1, 52·3 96·8, K767, N257.

Figs. 5–7. *Bullatisporites bullatus* gen. et sp. nov. 5, Holotype, proximal surface; KA 258/1, 55·7 101·8, K922, N258. 6, Proximal surface; KA 258/1, 27·8 88·3, K922, N259. 7, (×1000) Details of the pila on the holotype.

Figs. 8–13. *Convolutispora spp.* 8, *C. vermiformis* Hughes and Playford, Distal surface; KA 261/4, 49·0 98·2, K891, N260. 9–13. *C. disparalis* sp. nov. 9, Holotype, optical section; KA 243/2, 54·9 103·8, K767, N261. 10, Distal surface; KA 293/1, 48·9 93·4, K556, N262. 11, Proximal surface; KA 243/1, 41·8 105·9, K767, N263. 12, (×1000) Details of sculpture; KA 243/3, 54·4 88·9, K767, N264. 13, Holotype (×1000).

Comparison. Differs from other genera within the Infraturma Apiculati, in being both circular and pilate. *Dibolisporites* Richardson (1965) includes species with variable ornament which may possess pila, but the sculptural elements are predominantly biform.

Derivation of name. L. *bulla*—knob, boss.

Bullatisporites bullatus sp. nov.

Plate 96, figs. 5–7

Diagnosis. Miospores trilete; originally spherical, amb circular. Laesurae straight, length $\frac{1}{3}$–$\frac{2}{3}$ spore radius, accompanied and frequently obscured by lips, 1–3 μ wide, up to 5 μ high. Exine 1–2 μ thick, infragranulate; proximo-equatorial and distal surfaces densely covered with pila, caput 1–2 μ wide, collum 0·5–1·5 μ wide, 1–3 μ high, the caput frequently supports at its apex a minute spine. The contact areas support a somewhat reduced sculpture of variable concentration and extent; curvaturae sometimes present in the radial regions. Major and minor folding common.

Dimensions. (Twenty-two specimens) Equatorial diameter 84–112 μ (mean 100 μ).

Holotype. Preparation KA 258/1, 55·7 101·8, K922, N258.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype 98 μ. Laesurae just perceptible (under oil), length approximately half of the spore radius. Lips each 1·5 μ wide, slightly raised. Exine 1 μ thick, two major distal folds; proximo-equatorial and distal pila 1–2·5 μ high, caput 1–2 μ wide, collum 0·5–1·5 μ wide. In the contact areas, pila reduced only in the region adjacent to the lips.

Remarks. Lack of preferred orientation suggests a spherical shape. Curvaturae imperfectae are present in approximately one-quarter of the specimens. Only under oil immersion can the finer details of the pila be seen.

Comparison. Retusotriletes gibberosus Naumova nom. nud. 1953 (pl. 22, fig. 110) see Kedo 1955 (p. 21, pl. 1, fig. 16) lacks typification and description; however, the specimen illustrated by Kedo is clearly similar to *B. bullatus* sp. nov. and may be conspecific. Kedo states that the 'protuberances are round' but his illustration indicates that they may be pila.

Occurrence. Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Siegenian to Eifelian.

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

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

Convolutispora vermiformis Hughes and Playford 1961

Plate 96, fig. 8

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

Dimensions. (Seventeen specimens) Equatorial diameter 37–52 μ (mean 46 μ).

Remarks. The Spitsbergen Devonian specimens are somewhat smaller than those described from other areas.

Occurrence. Upper Mimer Valley Series; Givetian.

Convolutispora disparalis sp. nov.

Plate 96, figs. 9–13

Diagnosis. Miospores trilete; amb circular to subcircular, equatorial margin undulating. Laesurae indistinct, simple, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius. Exine excluding ornament 1–2 μ thick, homogeneous; distal and proximo-equatorial surfaces sculptured with a variable ornament of sinuous, narrow, frequently anastomosing rugulo-cristae, 1–3 μ wide, decreasing in width from their base, 2–5 μ high, usually with an undulating crest, often forming an imperfect reticulum, the intersections of which occasionally support a small papillum or spine. Lumina irregular, up to 6 μ in longest diameter. Contact areas support a reduced, sparse ornament, of low, smooth rugulae, small cones and granules.

Dimensions. (Sixty-one specimens) Equatorial diameter (excluding muri) 31–52 μ (mean 40 μ).

Holotype. Preparation KA 243/2, 54·9 103·8, K767, N261.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype subcircular, diameter 44 μ. Laesurae length $\frac{2}{3}$ spore radius. Exine approximately 1 μ thick; rugulo-cristae 1–2 μ wide, 1–3 μ high, the intersections often with papillate tips.

Comparison. The presence of a reduced proximal sculpture, and of papillae on many of the intersections, separates this species from *Convolutispora fromensis* Balme and Hassell 1962 (p. 8, pl. 1, figs. 14–16) which in addition has lower muri; and *Convolutispora venusta* Hoffmeister, Staplin, and Malloy 1955*b* (p. 385, pl. 38, fig. 11) which also has wider, lower ridges.

Occurrence. Common throughout the Upper Mimer Valley Series; Givetian.

Convolutispora mimerensis (Vigran) comb. nov.

Plate 97, figs. 1–3

1964 *Reticulatisporites mimerensis* Vigran, p. 17, pl. 2, figs. 16, 17.

Description of specimens. Miospores trilete; amb convexly subtriangular to circular. Laesurae simple, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius, frequently obscured by sculptural elements. Exine 5–8 μ thick (including muri), supporting low, smooth, slightly sinuous muri, 2–5 μ broad, 1–3 μ high, most of which anastomose, forming an imperfect reticulum. Lumina irregular, 7 μ wide in longest diameter.

Dimensions. (Twenty specimens) Equatorial diameter 36–68 μ (mean 53 μ).

Remarks. Variation occurs in the orientation and spacing of the muri which are often radially directed and more widely spaced equatorially (Pl. 97, fig. 2). I have included this species in *Convolutispora* on the basis of its imperfect rather than perfect reticulum.

Comparison. Convolutispora crassa Playford 1962 (p. 594, pl. 81, figs. 10–12) is larger, has a thicker exine and flat-topped muri. *Camptotriletes simplex* Naumova nom. nud. in Kedo 1955 (p. 26, pl. 2, fig. 14) may be conspecific, but the illustration is too poor to see details of the sculpture, and the species lacks holotypic designation.

Occurrence. Upper Mimer Valley Series; Givetian.

Convolutispora tegula sp. nov.

Plate 97, figs. 4–8

Diagnosis. Miospores trilete; amb circular to subcircular, occasionally oval. Laesurae frequently indistinct, simple, straight, length $\frac{2}{3}$–$\frac{3}{4}$ spore radius. Exine including ornament 5–9 μ thick, homogeneous, often punctate, with a crowded sculpture of short, broadly rounded, partly anastomosing muri, 2–7 μ wide, 2–4 μ high, the shorter muri often polygonal in outline, lumina subordinate, less than 1 μ wide.

Dimensions. (Thirty-five specimens) Equatorial diameter 41–70 μ (mean 53 μ).

Holotype. Preparation KA 286/2, 27·4 107·8, K773, N267.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype circular, diameter 68 μ. Laesurae indistinct, length approximately two-thirds spore radius. Exine punctate, 8 μ thick, muri 3–7 μ wide, 2–4 μ high.

Remarks. Plate 97, fig. 7, shows corrosion of the muri.

Comparison. Convolutispora fromensis Balme and Hassell 1962 (p. 8, pl. 1, figs. 14–16) closely resembles *C. tegula* sp. nov. in sculptural pattern, but has a much thinner exine and narrower muri. *Convolutispora florida* Hoffmeister, Staplin, and Malloy 1955*b* (p. 384, pl. 38, figs. 5, 6) has a more extensively anastomosing muroid pattern, and wider lumina. *Convolutispora usitata* Playford 1962 (p. 595, pl. 82, figs. 4, 7, and 8) has similar sculpture, but is much larger.

Occurrence. Upper Mimer Valley Series; Givetian.

Genus RETICULATISPORITES (Ibrahim) Potonié and Kremp 1954

Type species. Reticulatisporites reticulatus Ibrahim 1933.

Reticulatisporites emsiensis sp. nov.

Plate 97, figs. 9–11

Diagnosis. Miospores trilete; amb circular to sub-circular. Laesurae distinct to discernible, length $\frac{1}{2}$–$\frac{3}{4}$ spore radius, simple or more usually accompanied by low narrow folds. Exine 2–4 μ thick (excluding muri), infra-granulate; proximal surface laevigate or more frequently sparsely sculptured with small verrucae or granules, 2 μ or less in height and width, distally sculptured with strongly developed muri 1–4 μ wide, 3–8 μ high, enclosing more or less uniform lumina 8–20 μ in longest diameter, polygonal in outline centrally, more rounded equatorially.

Dimensions. (Twenty-three specimens) Equatorial diameter 49–82 μ (mean 65 μ). Number of equatorial muri 11–20, number of distal lumina 14–36.

Holotype. Preparation KA 240/2, 37·4 101·5, K582, N269.

Locus typicus. Manchesterbreen spur, Central Dicksonland, Spitsbergen; Lower Mimer Valley Series, Emsian.

Description. Holotype circular, diameter 72 μ. Laesurae simple, length two-thirds spore radius. Exine 4 μ thick, very sparse proximal ornament of granules, distal muri 2–3 μ wide basally, narrowing upwards, 5–8 μ high, lumina 12–20 μ wide.

Remarks. Both Naumova (1953) and Chibrikova (1959) include species assignable to *Reticulatisporites*, within *Archaeozonotriletes*.

Comparison. Small size and exclusively distal reticulate sculpture, separates *Reticulatisporites emsiensis* sp. nov. from the majority of other well-described species of Devonian and Carboniferous age. *Reticulatisporites speciosus* Hacquebard and Barss 1957 (p. 18, pl. 2, fig. 7) has an exclusively distal reticulum, but is larger, has longer laesurae, wider lips and a thicker exine. *Archaeozonotriletes retiformis* Naumova 1953 (p. 87, pl. 14, fig. 4) is very similar and may be conspecific, but no mention is made of a granulate proximal surface or a reticulum confined to the distal surface.

Occurrence. Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian.

Reticulatisporites sp. cf. *Dictyotriletes minor* Naumova 1953

Plate 97, figs. 12, 13

Description of specimens. Miospores trilete; amb circular to subcircular. Laesurae simple, straight, length approximately two-thirds spore radius. Exine 1–2 μ thick, finely infra-

EXPLANATION OF PLATE 97

All figures ×500 unless otherwise stated; from unretouched negatives.

Figs. 1–8. *Convolutispora spp.* 1–3. *C. mimerensis* (Vigran) comb nov. 1, Proximal surface; KA 286/3, 20·8 97·0, K773, N265. 2, Distal surface; KA 227/1, 38·0 98·9, K623, N266. 3, (×1000) Sculptural details (proximal). 4–8. *C. tegula* sp. nov. 4–6, Holotype, proximal, sectional and distal foci; KA 286/2, 27·4 107·8, K773, N267. 7, Poorly preserved specimen; KA 241/3, 28·5 95·0, K767, N268. 8, (×1000) Sculptural details of the holotype.

Figs. 9–13. *Reticulatisporites spp.* 9–11. *R. emsiensis* sp. nov. 9, 10, Holotype, proximal and distal surfaces respectively; KA 240/2, 37·4 101·5, K582, N269. 11, Distal surface; KA 281/6, 57·0 107·5, K850, N270. 12–13. *R. sp.* cf. *Dictyotriletes minor* Naumova, Proximal and distal surfaces respectively; KA 274/7, 36·0 107·3, K872, N271.

Fig. 14. *Perforosporites sp.* Proximal surface; KA 209/M2, 32·0 97·7, K519, N272.

Figs. 15–21. *Emphanisporites spp.* 15–18. *E. decoratus* sp. nov. 15, 16, Holotype, proximal and distal surfaces respectively; KA 251/3, 33·5 88·9, K905, N274. 17, 18, Proximal and distal surfaces respectively; KA 251/9, 20·6 96·5, K905, N275. 19. *E. neglectus* Vigran, Proximal surface; KA 162/1, 37·5 89·1, G1356, N273. 20. *E. minutus* sp. nov. Holotype, proximal surface; KA 262/4, 56·8 91·5, K908, N276. 21. *E. patagiatus* sp. nov. Holotype, proximal surface; KA 271/3, 38·1, 99·3, K897, N277.

Figs. 22–23. *Craspedispora craspeda* gen. et sp. nov. 22, Holotype, proximal surface; KA 258/3, 42·8 89·4, K922, N278. 23, Holotype (×1000).

Figs. 24–25. *Diatomozonotriletes sp.* 24, Distal surface (×1000); KA 243/2, 54·1 103·6, K767, N279. 25, Proximal surface; KA 229/1, 38·0 94·8, K550, N280.

granulate, contact areas laevigate, proximo-equatorial and distal surfaces sculptured with narrow, low muri, basally 1 μ or less wide, narrowing upwards, approximately 1 μ high; lumina 3–7 μ in longest diameter.

Dimensions. (Five specimens) Equatorial diameter 18–32 μ (mean 27 μ).

Comparison. Too few specimens are present for exact comparison: *Dictyotriletes minor* Naumova 1953 (p. 28, pl. 2, fig. 7) is clearly similar, but is triangular, and the muri are somewhat higher. However, the illustration of *D. minor* in Kedo 1955 (p. 2, pl. 2, fig. 13) has lower muri, is subcircular, and compares very closely with the Spitsbergen specimens.

Occurrence. Reuterskiøldfjellet Sandstone and Mimer Valley Series; Emsian to Givetian.

Genus PERFOROSPORITES Scott and Rouse 1961

Type species. Perforosporites robustus Scott and Rouse 1961.

Discussion. Separable from *Foveosporites* Balme 1957 on its regular distribution of fovea.

Perforosporites sp.

Plate 97, fig. 14

Descriptions of specimens. Miospores trilete; amb circular. Laesurae simple, straight, length $\frac{1}{2}$–$\frac{3}{4}$ spore radius. Exine 6–10 μ thick, infragranulate; contact areas laevigate, proximo-equatorial and distal surfaces with a sparse, regular ornament, of circular to oval fovea, 1–4 μ wide, 3–6 μ long, 3–24 μ apart. Distally the exine slightly 'overhangs' the fovea.

Dimensions. (Two specimens) Equatorial diameter 116–17 μ.

Comparison. Perforosporites robustius Scott and Rouse 1961 (p. 978, pl. 113, figs. 1–6, pl. 114, figs. 1–5) the only species previously attributed to this genus, is roundly triangular, smaller, has less distinct and longer laesurae, and frequently has blunt, short papillae. *Reticulatisporites textilis* Balme and Hassell 1962 (p. 9, pl. 2, figs. 11, 12) has sculptured contact areas, indistinct laesurae, and more numerous fovea.

Occurrence. Top of the Reuterskiøldfjellet Sandstone, and bottom of the Lower Mimer Valley Series; Upper Emsian.

Genus EMPHANISPORITES McGregor 1961

Type species. Emphanisporites rotatus McGregor 1961.

Emphanisporites rotatus McGregor 1961

1962 *Radforthia radiata* Winslow, p. 72, pl. 16, figs. 15, 15*a*, pl. 22, fig. 17.

Dimensions. (Ten specimens) Equatorial diameter 34–47 μ (mean 39 μ).

Comparison. Stenozonotriletes ornatissimus Naumova nom. nud. (pl. 22, fig. 11) lacks holotypic designation and description, but may have proximal muri, in which case it would be synonymous. *Radiaspora* sp. A Balme 1962 (p. 6, pl. 1, figs. 11, 12), may prove to have proximal rather than distal muri, and would then be conspecific with *E. rotatus*

McGregor. *Radforthia radiata* Winslow 1962 (p. 72, pl. 16, figs. 15, 15*a*, pl. 22, figs. 17) appears to differ only in its greater size range, and although neither McGregor (1961) nor Winslow (1962) give the mode of their measurements, *R. radiata* must be synonymous at least in part, with *E. rotatus*.

Occurrence. Reuterskiøldfjellet Sandstone and Lower Mimer Valley Series; Siegenian to Lower Eifelian.

Emphanisporites neglectus Vigran 1964

Plate 97, fig. 19

Description of specimens. Miospores trilete; amb circular to roundly triangular. Laesurae distinct, straight, length $\frac{2}{3}$–$\frac{4}{5}$ spore radius, narrow, occasionally accompanied by slightly sinuous lips, each up to 1 μ wide. Exine 0·5–2·5 μ thick, infragranulate; depressed contact areas support a distinct to discernible ornament of low, narrow muroid folds, surrounded by low, sharp, curvaturae; proximo-equatorial and distal surfaces laevigate or very finely granulose.

Dimensions. (Twenty-six specimens) Equatorial diameter 30–47 μ (mean 40 μ). Radial diameter of contact area approximately four-fifths of total spore radius.

Comparison. Emphanisporites obscurus McGregor 1961 (p. 5, pl. 1, fig. 14), is larger and lacks curvaturae.

Occurrence. Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Siegenian, Emsian.

Emphanisporites decoratus sp. nov.

Plate 97, figs. 15–18

Diagnosis. Miospores trilete; amb roundly triangular to subcircular and occasionally oval. Laesurae distinct, straight, length two-thirds to full spore radius, occasionally accompanied by low, smooth lips, individually less than 1 μ wide. Exine 1–4 μ thick, homogeneous to infragranulate; proximal surface with distinct to discernible radially disposed muroid folds of variable number, 2 μ or less wide, distal surface supporting an ornament of cones and spines, 1·5–5 μ high, 0·5–2 μ wide.

Dimensions. (Twenty-nine specimens) Equatorial diameter 34–61 μ (mean 49 μ).

Holotype. Preparation KA 251/3, 33·5 88·9, K905, N274.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Siegenian.

Description. Holotype roundly triangular, diameter 51 μ. Laesurae simple, almost reaching equatorial margin. Exine 3 μ thick; proximal muri indistinct, distal surface supporting a predominance of cones, 1 μ wide, up to 1·5 μ high.

Remarks. Although cones usually predominate, specimens with a dominance of spines exist.

Comparison. Differs from other species of *Emphanisporites* yet described in having a strongly sculptured distal surface. *Emphanisporites neglectus* Vigran (Pl. 97, fig. 19) is occasionally sculptured, but then, only with very fine granules.

Occurrence. Lower Reuterskiøldfjellet Sandstone, Siegenian.

Emphanisporites minutus sp. nov.

Plate 97, fig. 20

Diagnosis. Miospores trilete; amb roundly triangular to subcircular. Laesurae straight, length three-quarters to full spore radius, accompanied by smooth, narrow lips, individually less than 1 μ wide. Exine 2–3 μ thick, homogeneous to infragranulate; proximal surface with 15–30 radially disposed muri, approximately 1 μ wide, distal surface laevigate.

Dimensions. (Twenty specimens) Equatorial diameter 16–27 μ (mean 24 μ).

Holotype. Preparation KA 262/4 56·8 91·5, K908, N276.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Siegenian.

Description. Holotype subtriangular, diameter 26 μ. Lips extend almost to the equatorial margin. Exine 2 μ thick; proximal surface with twenty-five radially disposed ribs, 0·5–1 μ wide.

Comparison. Emphanisporites rotatus McGregor 1961 (p. 3, pl. 1, figs. 1–4) is considerably larger and the laesurae are frequently unaccompanied by lips.

Occurrence. Fraenkelryggen Division and Reuterskiøldfjellet Sandstone, Gedinnian to Lower Emsian.

Emphanisporites patagiatus sp. nov.

Plate 97, fig. 21

Diagnosis. Miospores trilete; amb subcircular to subtriangular, periphery often undulating. Laesurae simple, straight, length $\frac{1}{2}$–$\frac{3}{4}$ spore radius. Exine 2–6 μ thick, homogeneous to infragranulate; proximal surface with 8–15 radially disposed muri, 3–14 μ wide, up to 4 μ high, extending $\frac{1}{3}$–$\frac{1}{2}$ spore radius from the equatorial margin, proximal polar region and distal surface laevigate.

Dimensions. (Fifteen specimens) Equatorial diameter 33–50 μ (mean 45 μ).

Holotype. Preparation KA 271/3, 38·1 99·3, K897, N277.

Locus typicus. South Munindalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype roundly triangular, diameter 49 μ. Laesurae length two-thirds of spore radius. Exine 6 μ thick, finely infragranulate, nine proximal radial ribs, 4–13 μ wide, extend $\frac{1}{3}$–$\frac{1}{2}$ spore radius from the equatorial margin.

Comparison. Emphanisporites robustius McGregor 1961 (p. 4, pl. 1, fig. 13) is larger and lacks the laevigate proximal polar region.

Occurrence. Reuterskiøldfjellet Sandstone; Siegenian and Emsian.

Subturma ZONOTRILETES Waltz 1935
Infraturma TRICRASSATI Dettmann 1963
Genus CRASPEDISPORA gen. nov.

Type species. Craspedispora craspeda sp. nov.

Diagnosis. Miospores trilete; amb subcircular to roundly triangular. Laesurae usually

well defined, simple or accompanied by lips. Central area encompassed inter-radially by a narrow zona. Central area sculptured proximo-equatorially and distally.

Discussion. Differs from both *Reinschospora* Schopf, Wilson, and Bentall 1944 and *Diatomozonotriletes* (Naumova) Playford 1962 in having a more roundly triangular shape, and a nonfimbriate zona rather than a corona. *Camarozonotriletes* (Naumova) Potonié 1958 has a thick interradial crassitude.

Derivation of name. Gr. *krespedon*—edge, border.

Craspedispora craspeda sp. nov.

Plate 97, figs. 22, 23

Diagnosis. Miospores trilete; amb subcircular to roundly triangular. Laesurae straight, distinct, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius, simple or accompanied by narrow, smooth lips individually 0·5–1 μ wide. Exine of central area 1–2·5 μ thick, sometimes slightly thicker inter-radially, homogeneous to finely infragranulate, extending interradially as a thin, membranous zona 2–5 μ wide, the zona never develops in the radial regions. Contact areas often slightly darkened, laevigate, proximo-equatorial and distal surfaces of the central area with a distinct ornament of cones, 1·5 μ or less in height and basal diameter. Zona laevigate, or occasionally with a few small cones. Curvatural folds sometimes present.

Dimensions. (Thirty-four specimens) Equatorial diameter (including zona) 35–42 μ (mean 39 μ).

Holotype. Preparation KA 258/3, 42·8 89·4, K922, N278.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype roundly triangular, diameter 41 μ. Laesurae length two-thirds of spore radius. Exine 2 μ thick, slightly less at the apices, zona 2·5 μ wide.

Remarks. Corrosion of the thin zona frequently occurs, giving the outer margin an irregular appearance. In oblique aspect, the zona is very difficult to see.

Occurrence. Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Genus DIATOMOZONOTRILETES (Naumova) Playford 1962

Type species. Diatomozonotriletes saetosus (Hacquebard and Barss 1957) Hughes and Playford 1961.

Diatomozonotriletes sp.

Plate 97, figs. 24, 25

Description of specimens. Miospores trilete; amb triangular, with straight to slightly concave sides, and rounded apices. Laesurae indistinct, simple, straight, length approximately three-quarters spore radius. Corona composed of discrete, closely spaced, pointed saetae, 2·5 to 3 μ long interradially, diminishing in size towards the triangular apices, from which they are absent. Exine of central area approximately 1 μ thick, finely infragranulate, proximally laevigate, distally supporting an ornament of small discrete cones, 1·5 μ or less in height and basal diameter. Exine folded.

Dimensions. (Three specimens) Overall equatorial diameter 25–27 μ.

Remarks. Although too few specimens are present to warrant specific assignment, these specimens are interesting in that they provide the lowest stratigraphical record for this genus.

Occurrence. Plantekløfta Conglomerate and Fiskekløfta Formation; probable Upper Givetian.

Infraturma CINGULATI (Potonié and Klaus) Dettmann 1963
Genus STENOZONOTRILETES (Naumova) Potonié 1958

Type species. Stenozonotriletes conformis Naumova 1953.

Stenozonotriletes furtivus sp. nov.

Plate 98, figs. 2, 3

Diagnosis. Miospores trilete; amb roundly triangular to subcircular. Laesurae distinct, straight, length $\frac{1}{2}$–$\frac{2}{3}$ spore radius, simple or more frequently accompanied by low, flat-topped lips, individually 2–3 μ wide at the polar end, decreasing gradually equatorially. Exine laevigate to finely punctate; cingulum smooth, uniform or slightly narrower interradially.

Dimensions. (Seventeen specimens) Overall equatorial diameter 65–108 μ (mean 81 μ); width of cingulum 10–19 μ (mean 12 μ).

Holotype. Preparation KA 274/4, 44·8 94·4, K872, N281.

Description. Holotype roundly triangular, overall diameter 70 μ. Laesurae half spore radius, accompanied by low thickened lips, individually 3 μ wide. Cingulum uniform, 10 μ wide.

Remarks. Frequently the cingulum is eroded, giving it an irregular appearance.

Comparison. Archaeozonotriletes subcompactus Naumova 1955 (p. 84, pl. 13, fig. 14 and p. 35, pl. 13, fig. 9) is circular and has a sculpture of small protuberances. *Triletes dubius* Eisenack 1944 (p. 115, pl. 2, fig. 7, text-fig. 14) has a narrower cingulum and the exine thickens towards the polar axis, forming a darkened triangular area, unlike the lip formation in *S. furtivus* sp. nov.

Occurrence. Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Upper Siegenian to Eifelian.

Stenozonotriletes insessus sp. nov.

Plate 98, fig. 1

Diagnosis. Miospores trilete; amb convexly subtriangular. Laesurae straight, extending almost to the equatorial margin, accompanied by narrow lips, each approximately 0·5 μ wide, up to 2·5 μ high. Exine homogeneous to finely infragranulate, laevigate. Cingulum uniform.

Dimensions. (Twenty specimens) Overall equatorial diameter 24–36 μ (mean 30 μ); width of cingulum 3–6 μ (mean 4 μ).

Holotype. Preparation KA 223/2, 35·5 89·7, K829, N283.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype overall diameter 36 μ, lips individually 0·5 μ wide, 2 μ high. Cingulum 4 μ wide.

Comparison. Archaeozonotriletes pusillus Naumova 1953 (p. 86, pl. 13, fig. 19) has simple laesurae which often have 'clavate endings'; but is otherwise similar. *Stenozonotriletes extensus* Naumova var. *minor* Naumova 1953 (p. 37, pl. 3, fig. 18; p. 72, pl. 10, fig. 21; p. 130, pl. 19, figs. 19, 20) is more coarsely infragranulate and has simple laesurae.

Occurrence. Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Siegenian to Eifelian.

Stenozonotriletes sp.

Plate 98, fig. 4

Description of specimens. Miospores trilete; amb convexly subtriangular. Laesurae straight or slightly sinuous, length three-quarters to full central area radius. Exine finely punctate; cingulum smooth, usually slightly thicker interradially.

Dimensions. (Six specimens) Overall equatorial diameter 54–66 μ (mean 58 μ), width of cingulum 6–8 μ interradially, 4–6 μ radially.

Comparison. Too few specimens are present to warrant the erection of a new species. *Stenozonotriletes perforatus* Playford 1962 (p. 607, pl. 86, figs. 8–9, text-fig. 5*c*), has a narrower, laevigate cingulum, but is otherwise similar. *Stenozonotriletes sp.* cf. *S. recognitus* var. *recognitus* Naumova in Balme and Hassell 1962 (p. 14, pl. 3, figs. 3, 4) differs only in having a darker contact area.

Occurrence. Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Upper Emsian, Lower Eifelian.

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

Type species. Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall 1944.

EXPLANATION OF PLATE 98

All figures × 500; from unretouched negatives.

Figs. 1–4. *Stenozonotriletes spp.* 1, *S. incessus* sp. nov. Holotype, sectional focus; KA 223/2, 35·5 89·7, K829, N283. 2–3. *S. furtivus* sp. nov. 2, Holotype, proximal surface; KA 274/4, 44·8 94·4, K872, N281. 3, Proximal surface; KA 209/2. 42·7 92·1, K519, N282. 4. *S. sp.* Sectional focus; KA 230/4, 36·0 101·7, K638, N284.

Figs. 5–6. *Densosporites devonicus* Richardson. 5, Proximal surface; KA 209/M1, 63·8 90·8, K519, N285. 6, Section; KA 286/S12, 32·6 95·8, K773, N286.

Figs. 7–8. *Lycospora culpa* sp. nov. Holotype, proximal and distal surfaces respectively; KA 262/4, 57·7 106·4, K908, N287.

Figs. 9–16. *Samarisporites spp.* 9–10. *S. praetervisus* (Naumova) comb. nov., Proximal and distal surfaces respectively; KA 243/1, 52·2 98·4, K767, N288. 11, *S. senotus* sp. nov. Holotype, sectional focus; KA 243/2, 32·8 105·3, K767, N289. 12–16. *S. hesperus* sp. nov. 12, 13, Holotype, proximal and distal surfaces respectively; KA 243/3, 51·7 102·7, K767, N290. 14, Distal surface; KA 243/3, 24·7 93·4, K767, N291. 15, Distal surface showing cristo-reticulate sculpture; KA 243/3, 37·6 103·4, K767, N292. 16, Section, showing the cingulate exine and distal sculpture; KA 243/S11, 43·4 90·8, K767, N293.

Lycospora culpa sp. nov.

Plate 98, figs. 7, 8

Diagnosis. Miospores trilete; amb roundly triangular with acute to broadly rounded apices, occasionally subcircular, conformable with the central area outline. Laesurae indistinct, straight, length two-thirds to full central area radius, accompanied by narrow, smooth, low lips, individually 0·5–1·5 μ wide, length three-quarters to full spore radius. Exine two-layered; intexine approximately 1 μ thick, closely appressed to the exoexine and usually indistinct, exoexine of both central area and equatorial flange finely infragranulate. Proximal surface laevigate, distal surface of central area sparsely covered with small cones and granules 1·5 μ or less in height and basal diameter, equatorial flange laevigate. Proximal surface usually with numerous folds.

Dimensions. (Twenty specimens) Overall equatorial diameter 33–60 μ (mean 47 μ), width of cingulum 2–14 μ (mean 6 μ).

Holotype. Preparation KA 262/4, 57·7 106·4, K908, N287.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Lower Reuterskiøldfjellet Sandstone, Siegenian.

Description. Holotype roundly triangular with convex sides and acute apices, diameter 51 μ, width of cingulum 6 μ. Laesurae indistinct, lips 1 μ wide, extending full radius of the central area. Intexine 1 μ thick, exoexine proximally folded, distally with grana and small cones on the central area.

Remarks. Some specimens are slightly thicker at the very inner margin of the cingulum, but in no specimen is it truly bizonate. This species provides a very low stratigraphical record for the genus *Lycospora*.

Comparison. Lycospora uber (Hoffmeister, Staplin, and Malloy) Staplin 1960 (p. 20, pl. 4, figs. 13, 17, 18, 20) is smaller, and only faintly granulose. *Hymenozonotriletes millegranus* Naumova 1953 (p. 126, pl. 18, figs. 31, 32) is bizonate, and more densely sculptured. *Hymenozonotriletes mancus* Naumova 1953 (p. 63, pl. 8, fig. 17) has a laevigate distal central area. *Hymenozonotriletes limpidus* Naumova 1953 (p. 98, pl. 15, fig. 21) is circular, lacks lips, and is more densely sculptured.

Occurrence. Lower Reuterskiøldfjellet Sandstone, Siegenian.

Genus DENSOSPORITES (Berry) Potonié and Kremp 1954

Type species. Densosporites covensis Berry 1937.

Densosporites devonicus Richardson 1960

Plate 98, figs. 5, 6

Dimensions. (Forty specimens) Overall equatorial diameter 66–156 μ (mean 99 μ); total width of cingulum 18–40 μ (mean 26 μ), inner zone 12–27 μ (mean 18 μ).

Remarks. The section of *D. devonicus* Richardson (Pl. 98, fig. 6) demonstrates the raised lips, distal sculpture, and thick exoexine. The intexine cannot be seen in this section.

Occurrence. Upper Mimer Valley Series; Givetian.

Genus SAMARISPORITES Richardson 1965

Type species. Samarisporites (*Cristatisporites*) *orcadensis* (Richardson) Richardson 1965.

Discussion. Samarisporites triangulatus sp. nov. and *Samarisporites inusitatus* sp. nov. (see below) both have equatorial structures which vary from a zona to a cingulum (here referred to as an equatorial flange), giving evidence in support of Dettmann's (1963) emendation of the infraturma Cingulati (Potonié and Klaus 1954), to include zonate forms.

Samarisporites praetervisus (Naumova) comb. nov.

Plate 98, figs. 9, 10

1953 *Hymenozonotriletes praetervisus* Naumova, p. 40, pl. 4, fig. 8.

Description of specimens. Miospores trilete; amb roundly triangular to subtriangular. Laesurae indistinct, obscured by smooth elevated lips, individually 1–2 μ wide, 5–10 μ high, almost extending to the equatorial margin. Exine two-layered; intexine homogeneous 2 μ or less wide, closely appressed to the exoexine and often indistinct; exoexine of both central area and cingulum finely to coarsely infragranulate, proximally laevigate, distal surface densely ornamented with cones, 2–7 μ wide, 3–8 μ high. Cones on the central area variable both in shape and distribution, commonly with rounded apices, often supporting an apical capitate spine, the cones are usually closely spaced, with rounded polygonal or occasionally fused bases. Cones on the cingulum less dense, with pointed to slightly rounded apices, 33–52 cones round the equatorial margin. Cingulum uniform, tapering, differentiation from the central area distinct to obscure.

Dimensions. (Sixteen specimens) Overall equatorial diameter 70–124 μ (mean 86 μ); width of cingulum 16–30 μ (mean 21 μ).

Comparison. Samarisporites orcadensis (Richardson 1960, p. 58, pl. 14, fig. 12, text-fig. 8) Richardson 1965, is considerably larger.

Occurrence. Upper Mimer Valley Series; Givetian.

Samarisporites senotus sp. nov.

Plate 98, fig. 11

Diagnosis. Miospores trilete; amb convexly triangular, irregular, central area outline circular. Laesurae straight, length two-thirds to full radius of the central area, accompanied by smooth, narrow, often sinuous lips, individually 1–1·5 μ wide, extending on to the cingulum, usually to the equatorial margin. Exine two-layered; intexine thin, approximately 1 μ wide, closely appressed to the exoexine, and often indistinct; exoexine of both central area and cingulum finely infra-granulate. Proximal surface laevigate, distal surface very sparsely covered with small spines and cones, 1–4 μ wide, 2–4 μ high, the cones frequently support a small apical spine. Cingulum of uniform width, proximally occasionally raised above the central area, the inner distal margin may be slightly thickened, but the cingulum is never distinctly bizonate.

Dimensions. (Sixteen specimens) Overall equatorial diameter 50–64 μ (mean 57 μ); width of cingulum 12–16 μ (mean 15 μ).

Holotype. Preparation KA 243/2, 32·8 105·3, K767, N289.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype diameter 57 μ, cingulum 12 μ wide. Laesurae straight, length two-thirds central area radius, lips each 1 μ wide, extending almost to the equatorial margin. Distal spines and cones 1–3 μ wide, 2–3 μ high, somewhat corroded.

Remarks. In corroded specimens, the sculptural elements may be partially or completely eroded.

Comparison. Hymenozonotriletes spinosus Naumova 1953 (p. 41, pl. 14, fig. 9) is much larger, and has a more regular ornament. *Zonotriletes deliquescens* Luber, in Luber and Waltz 1941 (p. 50, pl. 1, fig. 6), is larger, and the inner part of the cingulum is not thickened. *Hymenozonotriletes pusillus* (Ibrahim) Ishchenko 1952 (p. 50, pl. 13, fig. 122) is smaller, the lips are shorter, and there is a sparser ornament on the cingulum. *Densosporites landesii* Staplin 1960 (p. 25, pl. 5, fig. 11) has an ornament only of cones, shorter lips, and a distinctly bizonate cingulum.

Occurrence. Upper Mimer Valley Series; Givetian.

Samarisporites hesperus sp. nov.

Plate 98, figs. 12–16

Diagnosis. Miospores trilete; amb circular to subcircular conformable with the central area outline. Laesurae indistinct, length three-quarters to full central area radius, accompanied and usually obscured by narrow, often slightly sinuous, elevated lips, individually 1–2·5 μ wide, extending to the inner margin of the cingulum. Exine one-layered, finely infra-granulate, proximally laevigate, distally with an even distribution of cones on both central area and cingulum. The cones 2–6 μ wide, 2–6 μ high, have rounded apices, and a capitate apical spine in well-preserved specimens; the bases of the cones on the central area are usually fused, often to such an extent as to form an imperfect reticulum. Cingulum uniform, tapering abruptly at the outer margin, differentiation from the central area is sometimes indistinct.

Dimensions. (Fifty-three specimens) Overall equatorial diameter 52–89 μ (mean 73 μ); width of cingulum 7–12 μ (mean 10 μ).

Holotype. Preparation KA 243/3, 51·7 102·7, K767, N290.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probably Upper Givetian.

Description. Holotype subcircular, diameter 68 μ, cingulum 9 μ wide. Laesurae indistinct, lips approximately 1 μ wide, cones 4–6 μ wide, 3–6 μ high, occasionally fused near the distal pole. Capitate spines eroded from many cones.

Remarks. The section (Pl. 98, fig. 16) clearly demonstrates the laevigate proximal surface, raised lips, one-layered exine, and abruptly tapering cingulum. In specimens where the cones are eroded, the fused bases are clearly seen (Pl. 98, fig. 15).

Comparison. Archaeozonotriletes crassispinosus Chibrikova 1959 (p. 62, pl. 8, fig. 5) is roundly triangular, lacks lips, and there is no evidence of small spines on the cones.

Lycospora magnifica McGregor 1960 (p. 35, pl. 12, fig. 5, pl. 13, figs. 2–4) is much larger, and has a smaller sculptural pattern. *Lycospora rugulatus* Vigran 1964 (p. 23, pl. 1, figs. 17, 18; pl. 2, fig. 15) is clearly similar, but lacking cones, has a rugulate rather than a cristate sculpture. The lack of cones in Vigran's specimens may be due to poor preservation; if this is proved to be so, then *Samarisporites hesperus* sp. nov. would be synonymous with *L. rugulatus*.

Occurrence. Upper Mimer Valley Series, particularly common in the Plantekløfta Conglomerate; probable Givetian.

Samarisporites triangulatus sp. nov.

Plate 99, figs. 1–6

Diagnosis. Miospores trilete, amb triangular, with straight to moderately convex sides, central area outline circular to roundly triangular. Laesurae indistinct, length where seen two-thirds to full central area radius, accompanied by smooth, elevated lips, individually 0·5–3 μ wide, extending on to the equatorial flange, and frequently to the equatorial margin. Exine two-layered; intexine 1–2 μ wide, closely appressed to the exoexine, and often indistinct; exoexine of both central area and equatorial flange finely infragranulate. Proximal surface laevigate, distally the central area supports a closely spaced ornament of cones, 2–5 μ in height and basal diameter, the cones occasionally support a small apical spine. Variation occurs in the basal sculpture of the elements, which may be separate, occasionally fused, or more comprehensively associated, forming an imperfect reticulum; distally the equatorial flange is laevigate, or rarely with a sparse ornament of small cones. Equatorial flange acutely tapering, irregular, reaching its maximum width radially, frequently being only just perceptible in the inter-radial regions.

Dimensions. (Forty-five specimens) Overall equatorial diameter 46–78 μ (mean 62 μ); diameter of central area 32–54 μ (mean 43 μ); width of cingulum radially 10–20 μ (mean 13 μ), interradially 1–9 μ (mean 5 μ).

Holotype. Preparation KA 243/1, 39·6 97·6, K767, N294.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

EXPLANATION OF PLATE 99

All figures × 500; from unretouched negatives.

Figs. 1–9. *Samarisporites spp.* 1–6. *S. triangulatus* sp. nov. 1, 2, Holotype, proximal and distal surfaces respectively; KA 243/1, 39·6 97·6, K767, N294. 3, Proximal surface; KA 243/3, 57·8 108·3, K767, N295. 4, Lateral view; KA 243/3, 35·1 87·6, K767, N296. 5, 6, Sections showing the equatorial flange; KA 242/S3, 36·5 100·0, K772, N297 and KA 242/S3, 51·4 97·7, K772, N298 respectively. 7–9. *S. inusitatus* sp. nov. 7, 8, Holotype; proximal and distal surfaces respectively; KA 243/3, 52·2 101·3, K767, N299. 9, Lateral view; KA 243/1, 30·6 98·0, K767, N300.

Figs. 10–13. *Cirratriradites avius* sp. nov. 10, Holotype, proximal surface; KA 242/1, 21·2 89·7, K772, N301. 11, 12, Sections showing the three-layered exine; KA 290/S11, 53·3, 105·0, K681, N302, and KA 290/S12, 32·9 90·5, K681, N303. 13, Proximal oblique aspect; KA 290/2, 45·9 108·4, K681, N304.

Figs. 14–15. *Camptozonotriletes asaminthus* sp. nov. 14, Holotype, proximal oblique aspect; KA 290/4, 53·0 91·2, K681, N307. 15, Proximal surface; KA 290/1, 38·8 103·2, K681, N308.

Figs. 16–17. *Cirratriradites dissutus* sp. nov. 16, Holotype, the equatorial flange is somewhat eroded, as in all specimens; KA 251/3, 33·0 89·2, K905, N305. 17, Specimen showing the flange characteristically eroded in the inter-radial areas; KA 262/M5, 36·6 99·6, K908, N306.

Description. Holotype amb triangular, central area circular, overall diameter 54 μ, central area 40 μ, width of equatorial flange radially 12 μ, inter-radially 1–4 μ. Lips individually 2·5 μ wide, extend almost to equatorial margin. Distal central area cones 3–4 μ wide, 2–5 μ high, with separate bases, distal equatorial flange laevigate. Sculptural elements obscure the equatorial flange completely in one inter-radial region.

Remarks. There is some variation in the proximo-distal thickness of the cingulum, which may be very thin (Pl. 99, fig. 4) and represent a zona, or more definitely a cingulum, as demonstrated in the sections (Pl. 99, figs. 5, 6). Sections also show the intexine and exclusively distal ornament.

Comparison. The distinctive equatorial flange separates this species from others assignable to *Samarisporites*.

Occurrence. Upper Mimer Valley Series; Givetian.

Samarisporites inusitatus sp. nov.

Plate 99, figs. 7–9

Diagnosis. Miospores trilete; amb circular to roundly triangular, conformable with the central area outline. Laesurae obscured by smooth, elevated lips, individually 1–2 μ wide, 3–8 μ high, extending to the equatorial margin. Exine homogeneous to finely infragranulate, proximally laevigate, distally the central area supports an ornament of cones, 1–4 μ wide, 1–6 μ high, the cones often supporting a small apical spine. Considerable variation occurs in the basal sculpture of the cones which may be separate, fused, or more comprehensively associated as an imperfect reticulum; distally the equatorial flange is laevigate or rarely with a sparse ornament of small cones. Equatorial flange acutely tapering, uniform.

Dimensions. (Eighteen specimens) Overall equatorial diameter 60–66 μ (mean 62 μ); width of equatorial flange 5–9 μ (mean 6·5 μ).

Holotype. Preparation K243/3, 52·2 101·3, K767, N299.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype circular, overall diameter 62 μ, equatorial flange 7 μ. Lips each approximately 1 μ wide, 3 μ high. Distal cones 1–3 μ in height and diameter, occasionally fused basally.

Remarks. Specimens in oblique aspect (Pl. 99, fig. 9) demonstrate the thin equatorial flange.

Comparison. Samarisporites hesperus sp. nov. (Pl. 98, figs. 12–16) has a larger, denser sculpture, and a strong cingulum. *Hymenozonotriletes celeber* Chibrikova 1959 (p. 77, pl. 13, fig. 3) is considerably larger, and has a much wider equatorial flange.

Occurrence. Fiskekløfta Formation, Planteryggen Sandstone, and Plantekløfta Conglomerate; probable Upper Givetian.

Genus CIRRATRIRADITES Wilson and Coe 1940

Type species. Cirratriradites saturni (Ibrahim) Schopf, Wilson, and Bentall 1944.

Discussion. Cirratriradites avius sp. nov. (Pl. 99, figs. 10–13) and *Cirratriradites dissutus* sp. nov. (Pl. 99, figs. 16–17) are included within this genus on the basis of their apparently thin equatorial flange, and reduced sculpture.

Cirratriradites avius sp. nov.

Plate 99, figs. 10–13

Diagnosis. Miospores trilete; amb roundly triangular, with convex sides and sharply to broadly rounded apices. Laesurae indistinct, accompanied by smooth elevated lips, individually 1–3 μ wide, length three-quarters to full spore radius. Exine three-layered; intexine finely infra-granulate, approximately 2 μ thick, closely appressed to the exoexine, and seen only in over-macerated specimens or sections; exoexine two-layered, inner exoexine coarsely infra-granulate, outer exoexine homogeneous. Proximal surface laevigate, distal surface laevigate, or very sparsely ornamented with cones 1–2 μ wide, 1–4 μ high; equatorial flange moderately to acutely tapering, uniform, differentiation from the central area often indistinct.

Dimensions. (Twenty specimens) Overall equatorial diameter 84–172 μ (mean 123 μ), width of equatorial flange 16–36 μ (mean 27 μ).

Holotype. Preparation KA 242/1, 21·2 89·7, K772, N301.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype diameter 121 μ, equatorial flange approximately 22 μ wide. Lips narrow, total width 5 μ, inaperturate, extend on to the inner margin of the cingulum. Exine laevigate, equatorial flange corroded.

Remarks. Sections (Pl. 99, figs. 11, 12) show the three-layered exine, and the elevated lips formed as an extension of the homogeneous outer exoexine only, which in this specimen are inaperturate. The inner exoexine is very thick distally, which probably accounts for the indistinct intexine and central area outline. As demonstrated in *Cirratriradites elegans* by Hughes, Dettmann, and Playford (1962), sections of what appears in proximo-distal aspect to be a thin equatorial flange, is in fact surprisingly thick.

Comparison. Cirratriradites elegans (Waltz) Potonié and Kremp 1956 (p. 126) is clearly similar, but has a more distinct and scabrate central area, and as seen in section (Hughes, Dettmann, and Playford 1962, p. 251, pl. 38, figs. 6, 7), has a thinner intexine, and an undivided exoexine.

Occurrence. Upper Mimer Valley Series; Givetian.

Cirratriradites dissutus sp. nov.

Plate 99, figs. 16, 17

Diagnosis. Miospores trilete; amb circular, subcircular to oval, conformable with the central area outline. Laesurae straight often open, length equal to full central area

radius, accompanied by membranous, elevated lips, individually 1·5–6 μ wide, up to 8 μ high, extending on to the equatorial flange, and frequently to the equatorial margin. Exine apparently one-layered, coarsely infra-granulate, central area 4–10 μ thick, slightly thicker distally, punctate, occasionally microreticulate proximally, laevigate distally; equatorial flange much lighter in colour, thin, uniform, laevigate, often broken radially. Proximal and distal minor folds occasionally present.

Dimensions. (Twenty-one specimens) Overall equatorial diameter 71–123 μ (mean 90 μ), diameter of equatorial flange 4–20 μ (mean 11 μ).

Holotype. Preparation KA 251/3, 33·0 89·2, K905, N305.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Lower Reuterskiøldfjellet Sandstone, Siegenian.

Description. Holotype subcircular, diameter 96 μ, flange 10 μ wide. Laesurae open, lips up to 6 μ wide extend to the equatorial margin. Exine of central area 8 μ thick, proximally microreticulate.

Remarks. The majority of specimens are dark and ill preserved, and are very difficult to macerate satisfactorily. The breakdown of the equatorial flange radially (Pl. 99, fig. 17) in the majority of specimens, gives the spore a very distinctive appearance. Corrosion of the coarsely infra-granulate exine gives the spore a pseudosculpture of granules.

Comparison. Hymenozonotriletes varius Naumova 1953 var. *varius* (p. 38, pl. 4, fig. 10) is smaller, and has a very different lip construction.

Occurrence. Common in the Lower Reuterskiøldfjellet Sandstone, but extends up into the Lower Mimer Valley Series; Siegenian and Emsian.

Genus CAMPTOZONOTRILETES Staplin 1960

Type species. Camptozonotriletes vermiculatus Staplin 1960.

Camptozonotriletes asaminthus sp. nov.

Plate 99, figs. 14, 15

Diagnosis. Miospores trilete; proximally flattened, distally convex, amb circular, conformable in outline with the central area. Laesurae indistinct, straight, length two-thirds to full central area radius, accompanied and frequently masked by smooth, often sinuous, elevated lips, individually 3–5 μ wide, 7–12 μ high, extending on to the equatorial flange, and occasionally reaching the equatorial margin. Exine one-layered, coarsely infra-granulate, central area exine 2–10 μ thick, slightly thicker distally, equatorial flange lighter in colour, tapering equatorially; proximal surface laevigate, distal surface densely sculptured with low verrucae and occasional cones, 2–5 μ wide, 2–4 μ high, somewhat reduced and occasionally absent from the equatorial flange. Proximal surface frequently with conspicuous radially directed folds.

Dimensions. (Twenty-eight specimens) Overall equatorial diameter 80–108 μ (mean 89 μ) equatorial flange 6–24 μ wide (mean 13 μ).

Holotype. Preparation KA 290/4, 53·0 91·2, K681, N307.

Locus typicus. West Lagercrantzberget, Central Dicksonland, Spitsbergen; Upper Mimer Valley Series, Upper Givetian.

Description. Holotype diameter 96 μ, equatorial flange 11 μ wide. Laesurae indistinct, lips each 3 μ wide, 7 μ high, extending to equatorial margin. Distal verrucae 3–4 μ in height and basal diameter, only slightly reduced on the equatorial flange.

Remarks. The majority of specimens are only slightly compressed, and as the proximal surface is flat, and the distal surface deeply convex, they are preserved in oblique aspect. The coarsely infra-granulate structure of the distal verrucae often results in their gradual corrosion and specimens with only a slightly undulose distal surface are frequent.

Comparison. Hymenozonotriletes trichomirovii Naumova 1953 (p. 62, pl. 8, fig. 12) is smaller, and has an ornament of spines on the equatorial flange. *Cirratriradites ornatus* Neves 1960 (p. 269, pl. 33, fig. 3) has a punctate central exine, and an ornament of cones.

Occurrence. Upper Mimer Valley Series; Givetian.

Camptozonotriletes aliquantus sp. nov.

Plate 100, figs. 1, 2

Diagnosis. Miospores trilete; amb roundly triangular, with moderately to strongly convex sides and well rounded or occasionally acute apices, conformable in outline with the central area. Laesurae distinct to discernible, simple, straight, length two-thirds to full central area radius. Exine two-layered; intexine 1–3 μ thick, infra-punctate, often slightly separate from the exoexine and usually distinct; exoexine homogeneous to infra-punctate extending beyond the intexine as a membranous flange. Proximal surface laevigate, distal central area comprehensively sculptured with high, narrow muri 1–3 μ wide, which frequently anastomose to form an imperfect reticulum; on the equatorial flange, the muri are somewhat lower, and are radially directed, occasionally extending to the equatorial margin. Major compressional folding frequent, the intexine is sometimes folded independently of the exoexine. All specimens are slightly corroded.

Dimensions. (Fifteen specimens) Diameter of exoexine 57–97 μ (mean 76 μ); diameter of intexine 40–74 μ (mean 55 μ); equatorial flange 9–16 μ (mean 12 μ).

Holotype. Preparation KA 281/2, 37·0 96·4, K850, N309.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen; Emsian.

Description. Holotype roundly triangular, diameter of exoexine 80 μ, of intexine 50 μ, equatorial flange 10–12 μ wide. Laesurae indistinct, only one laesura clearly seen. Intexine 3 μ thick, unfolded; distal exoexine with an imperfect reticulum centrally, muri slightly corroded; radially directed muri do not reach the equatorial margin of the flange. One major distal fold.

Remarks. The radially directed muri on the equatorial flange are an easily recognizable feature of this species. *Camptozonotriletes aliquantus* sp. nov. is included in this genus and not in *Cirratriradites* Wilson and Coe 1940, on the basis of the very prominent distal sculpture.

Occurrence. Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Siegenian to Lower Eifelian.

Infraturna PATINATI Butterworth and Williams 1958
Genus ARCHAEOZONOTRILETES (Naumova) emend.

1953 *Archaeozonotriletes* Naumova, p. 30.
1958 *Archaeozonotriletes* (Naumova) Potonié, p. 28.

Emended diagnosis. Miospores trilete; amb circular, subcircular to subtriangular. Laesurae usually long, simple, or accompanied by lips. Exine one- or two-layered, acavate, laevigate, or punctate; distally patinate. The patina may be of uniform thickness, or thickest in the distal polar region.

Type species. *Archaeozonotriletes variabilis* Naumova 1953, p. 30, pl. 2, fig. 12 (designated by Potonié 1958, p. 28).

Other species. The following species can probably be included within *Archaeozonotriletes* (Naumova) emend.

1. *Archaeozonotriletes accitus* Chibrikova 1959, p. 66, pl. 9, fig. 5. Occurrence: Western Bashkiria, U.S.S.R.: Givetian.
2. *Archaeozonotriletes tschernovii* Naumova 1953, p. 81, pl. 12, fig. 12. Occurrence: Chkalov province, U.S.S.R.; Lower Frasnian.

Discussion. The type species selected by Potonié 1958, is somewhat atypical amongst the large number of species recorded within *Archaeozonotriletes* by Naumova (1953). More typical, are thick-walled apiculate forms, which have an intexine partly separated from the exoexine; many of these latter species, however, can be included within *Geminospora* Balme 1962. Potonié 1958 (p. 28) interpreted the construction of *A. variabilis* as an irregular cingulum. Evidence from the Spitsbergen specimens, however, shows that *A. variabilis* has a very thick distal patina, and therefore is frequently preserved in oblique aspect, thus giving the impression of an irregular cingulum.

Comparison. The validation of *Archaeozonotriletes* by Potonié 1958, precedes by one month the erection of *Tholisporites* Butterworth and Williams 1958. In *Tholisporites*, however, the patina is thickest in the equatorial region, and is, according to Butterworth and Williams 1958 (p. 382) closely related to *Densosporites* and *Anulatisporites*; whereas the uniform or distal polar thickened patina of *Archaeozonotriletes* shows little constructive similarity to *Densosporites*. Also in *Tholisporites*, the patina appears to end abruptly on the proximal area, whereas in *Archaeozonotriletes*, the exine gradually thins over the proximal surface.

Archaeozonotriletes variabilis (Naumova) emend.

Plate 100, figs. 3–6

1953 *Archaeozonotriletes variabilis* Naumova 1953, p. 30, pl. 2, figs. 12, 13, pl. 12, figs. 8–11; p. 83, pl. 13, figs. 7–9.

Emended diagnosis. Miospores trilete, amb circular to subcircular, conformable with the central area outline. Laesurae straight, length three-quarters to full central area radius. Exine homogeneous, laevigate to finely punctate, proximally 1·5–4 μ thick; distally strongly patinate, 5–23 μ thick.

Dimensions. (Nineteen specimens) Equatorial diameter 42–60 μ (mean 53 μ); polar diameter 49–74 μ (mean 61 μ).

Locus typicus. Kaluga province, Starooskol beds, U.S.S.R.: Givetian.

Description. (From the illustration in Naumova 1953, pl. 2, fig. 12.) Holotype diameter in oblique aspect 50 μ. Laesurae simple, straight, length equal to full central area radius exine patinate, proximal oblique aspect 6 μ, distal oblique aspect 20 μ.

Remarks. The thickness of the patina is often as much as 30 per cent. of the total polar diameter (Pl. 100, fig. 4). In well-preserved specimens, the punctate nature of the exine is not always obvious, whilst in poorly preserved specimens the punctae are clearly seen (Pl. 100, fig. 5). Spores with a thicker distal hemisphere, are common both in Devonian samples from Melville Island, Arctic Canada, McGregor 1960 (p. 38) and from Spitsbergen. It is quite possible that some of the species included within the genus *Stenozonotriletes* by many Russian authors, may in fact possess a patina. Specimens in oblique aspect are the most informative for distinguishing species of *Archaeozonotriletes* from thick-walled *Punctatisporites*, and *Stenozonotriletes*. Russian authors who use the term 'otorochka', appear to use it both for equatorial structures and normal exine thickness.

Comparison. Tholisporites tenuis McGregor 1960 (p. 38, pl. 13, fig. 9) has a proximal membranous veil and a thinner patina. *T. scoticus* Butterworth and Williams 1958 (p. 382, pl. 3, figs. 48–50) is smaller, and the patina has its greatest thickness equatorially. *Trematozonotriletes irregularis* (Andrejeva, in Luber and Waltz 1941) Ishchenko 1959 (p. 79, pl. 9, fig. 116) appears very similar, but the punctae are confined to the inner margin of the patina. *Stenozonotriletes fixus* Ishchenko 1952 (p. 56, pl. 16, fig. 141) with its punctate exine, appears to be similar to poorly preserved specimens of *A. variabilis* (Naumova), but is cingulate rather than patinate.

Occurrence. Upper Mimer Valley Series; Givetian.

Previous records. Recorded by Naumova (1953) from the Frasnian and Givetian of Kaluga, Chkalov, and Voronezh provinces, U.S.S.R., and by Kedo (1957) from the Famennian of Belorussia, U.S.S.R.

EXPLANATION OF PLATE 100

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

Figs. 1–2. *Camptozonotriletes aliquantus* sp. nov. 1, Holotype, distal surface, KA 281/2, 37·0 96·4, K850, N309. 2, Proximal surface, showing more distinct laesurae; KA 209/1, 34·1 97·2, K519, N310.

Figs. 3–10. *Archaeozonotriletes spp.* 3–6. *A. variabilis* (Naumova) emend. 3, Proximal oblique aspect; KA 286/2, 27·5 107·3, K773, N311. 4, Lateral view, showing thick distal patina; KA 286/1, 20·6 99·6, K773, N312. 5, Showing corroded punctate exine; KA 286/3, 20·7 96·0, K773, N313. 6, Proximal oblique aspect; KA 286/1, 52·4 108·3, K773, N314. 7, *A. sarus* sp. nov. Holotype; KA 261/1, 32·4 103·2, K891, N315. 8–10. *A. columnus* sp. nov. 8, Holotype, proximal oblique aspect; KA 278/1, 27·6 101·8, K855, N316. 9, Section; KA 286/S4, 40·1 101·7, K773, N317. 10, ($\times 1000$) Showing punctate exine; KA 286/2, 28·8 87·6, K773, N318.

Figs. 11–12. *Cymbosporites catillus* gen. et sp. nov. 11, Holotype; KA 287/2, 34·1 94·2, K846, N329. 12, Distal surface; KA 243/1, 28·5 95·1, K767, N330.

Figs. 13–14. *Archaeozonotriletes meandricus* sp. nov. 13, Holotype, proximal surface; KA 209/2, 35·7 88·6, K519, N319. 14, Proximal surface; KA 209/M4, 24·7 100·5, K519, N320.

Archaeozonotriletes sarus sp. nov.

Plate 100, fig. 7

Diagnosis. Miospores trilete; amb circular. Laesurae short, distinct, length $\frac{1}{3}$–$\frac{1}{2}$ spore radius, accompanied at least in part by narrow lips, individually 1 μ or less wide, the laesurae often extend equatorially beyond the lips. Exine infra-punctate, laevigate; proximally 2–3 μ thick, distal surface slightly patinate, 3–5 μ thick.

Dimensions. (Twenty-five specimens) Equatorial diameter 42–57 μ (mean 50 μ).

Holotype. Preparation KA 261/1, 32·4 103·2, K891, N315.

Locus typicus. North Mimerdalen, Central Dicksonland, Spitsbergen; Fiskeløfta Formation, Givetian.

Description. Holotype diameter 56 μ. Laesurae approximately half spore radius, lips individually 0·5 μ wide, length one-third spore radius. Proximal oblique aspect 2·5 μ_2 distal oblique aspect 4·5 μ.

Comparison. Trematozonotriletes irregularis (Andrejeva, in Luber and Waltz 1941) Ishchenko 1958 (p. 79, pl. 9, fig. 116) is smaller, has longer laesurae and a thicker patina. *Tholisporites tenuis* McGregor 1960 (p. 38, pl. 13, fig. 9) has simple laesurae and a thin membranous proximal surface. *T. densus* McGregor 1960 (p. 37, pl. 13, figs. 6, 7) has longer, simple laesurae, a thicker patina and a proximal membranous veil. *A. variabilis* (Naumova) emend. has longer, simple laesurae, and a thicker patina.

Occurrence. Upper Mimer Valley Series; Givetian.

Archaeozonotriletes columnus sp. nov.

Plate 100, figs. 8–10

Diagnosis. Miospores trilete; amb circular, subcircular to oval. Laesurae simple, straight, length three-quarters to full central area radius. Exine thick, homogeneous to infra-granulate, finely to coarsely punctate; proximally 4–10 μ thick, distally patinate 8–28 μ thick.

Dimensions. (Forty specimens) Equatorial diameter 76–145 μ (mean 107 μ).

Holotype. Preparation KA 278/1, 27·6 101·8, K855, N316.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen; Plantskløfta Sandstone, probably Upper Givetian.

Description. Holotype 116 μ, laesurae extend full central area radius. Proximal oblique aspect 9 μ, distal oblique aspect 21 μ.

Remarks. The section (Plate 100, fig. 9) clearly demonstrates the overall thickness of the exine, together with the thickened distal hemisphere. Corrosion of the exine results in an increase in the diameter of the punctae and more drastically in their fusion.

Comparison. Tholisporites punctatus McGregor 1960 (p. 38, pl. 13, fig. 10) is somewhat smaller, and has the suggestion of a thin proximal membrane. *Archaeozonotriletes variabilis* (Naumova, p. 30, pl. 2, fig. 12) emend. is smaller, and in relation of its proximal hemisphere, is more strongly patinate. *A. vivax* Chibrikova 1959 (p. 69, pl. 10, fig. 4) has according to Chibrikova, a tuberculate ornament, though it would appear from the

illustration to be foveo-reticulate, rather than punctate. *Foveosporites pertusus* Vigran 1964 (p. 18, pl. 4, figs. 3, 4; pl. 5, figs. 1, 2*a–d*) is clearly similar, but although the thickness of the exine varies from 4–17 μ, Vigran gives no indication that this species is patinate.

Occurrence. Upper Mimer Valley Series; Givetian.

Archaeozonotriletes meandricus sp. nov.

Plate 100, figs. 13, 14

Diagnosis. Miospores trilete, amb circular. Laesurae straight, length $\frac{1}{2}$–$\frac{3}{4}$ spore radius, accompanied by distinctive, smooth, sinuous, elevated lips, which increase markedly in width equatorially (total width at polar end 4–8 μ, at equatorial end 21–26 μ), length $\frac{2}{3}$–$\frac{3}{4}$ spore radius. Exine probably one-layered, 4–9 μ thick equatorially and distally, thinning proximally, coarsely infra-granulate, laevigate (punctate in corroded specimens). Contact areas depressed, radial diameter 26–50 μ, bounded by distinct, low, curvatural ridges.

Dimensions. (Eighteen specimens) Equatorial diameter 82–173 μ (mean 117 μ).

Holotype. Preparation KA 209/2, 35·7 88·6, K519, N316.

Locus typicus. West Odellfjellet, North Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype 137 μ. Laesurae straight, lips totalling 5 μ wide proximally, 24 μ wide equatorially, length two-thirds spore radius, extending beyond the contact areas. Radial diameter of contact areas 40–42 μ.

Comparison. The very distinctive sinuous lips which increase in thickness equatorially, separate *A. meandricus* sp. nov. from other laevigate, patinate species.

Occurrence. Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Genus THOLISPORITES Butterworth and Williams 1958

Type species. Tholisporites scoticus Butterworth and Williams 1958.

Tholisporites ancylus sp. nov.

Plate 101, figs. 1–7

Diagnosis. Miospores trilete; amb subcircular to roundly triangular, with convex sides and broadly rounded apices, occasionally oval. Laesurae straight, length $\frac{1}{3}$–$\frac{2}{3}$ spore radius, rarely accompanied by lips. Exine two-layered; the inner layer (? intexine) 2–5 μ thick, homogeneous, proximally minutely granulose, distally laevigate (seen only when the outer layer is absent); outer layer (? exoexine) laevigate, patinate, equatorially 4–18 μ wide, decreasing in thickness towards the distal pole, extends proximally only a short distance, its maximum extension being in the radial regions. The outer patinate layer is corroded in all specimens, and probably because of its structure, corrodes in a constant pattern, giving the spores a 'sculptured' appearance. Equatorially the corroded patina appears as large broadly rounded segments, and distally as irregular, partly anastomosing ridges, often radially directed.

Dimensions. (Twenty-one specimens) Overall equatorial diameter 80–116 μ (mean 94 μ), diameter of the inner layer 64–100 μ (mean 78 μ). Maximum proximal enclosure of the inner layer by the outer layer, radially 18 μ, inter-radially 6 μ.

Holotype. Preparation KA 240/2, 50·2 100·6, K582, N321.

Locus typicus. Manchesterbreen Spur, Central Dicksonland, Spitsbergen; Lower Mimer Valley Series; Upper Emsian.

Description. Holotype roundly triangular, with broadly rounded apices and convex sides, overall diameter 96 μ, diameter of inner layer 80 μ. Laesurae indistinct, length approximately one-third of spore radius. Inner layer 2 μ thick, outer layer equatorially approximately 16 μ thick, absent from the distal pole, where the laevigate inner layer can be seen. Proximal overlap of the outer layer 12 μ radially, 3 μ inter-radially.

Remarks. The author regards the 'sculpturing' as the effect of corrosion of a finely punctate exine rather than a true sculptural pattern primarily for two reasons. The considerable variation in the size of the 'sculptural' elements, being much larger and less numerous in the best preserved specimens (Pl. 101, fig. 5) suggesting further breakdown of the exinal layer with increased corrosion. True sculptural elements in miospores are frequently more homogeneous than the exine which supports them, and with corrosion they tend to become shorter and rounder, rather than breaking up into more numerous elements as in *Tholisporites ancylus* sp. nov. If these were true sculptural elements, it is unlikely that they would extend completely to the base of the outer exinal layer, as demonstrated in the sections (Pl. 101, figs. 3, 4).

The corrosion pattern occurs in all specimens, and is a morphological feature easily recognizable, and is here included in the diagnosis. Sections (Pl. 101, figs. 3, 4) show the distal and proximo-equatorial extension of the outer layer. The outer layer occasionally breaks away from the inner layer.

Occurrence. Dicksonfjorden Sandstone, Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Genus CYMBOSPORITES gen. nov.

Type species. Cymbosporites cyathus sp. nov.

Diagnosis. Miospores trilete; amb circular, subcircular, to roundly triangular. Laesurae long, usually accompanied by lips. Exine thin proximally, equatorially and distally patinate, the patina of even thickness, or with its greatest thickness in the distal polar region. Patina variably sculptured with cones, spines, and granules.

Comparison. Archaeozonotriletes (Naumova) emend, has a laevigate or punctate patina. *Tholisporites* Butterworth and Williams 1958 has its greatest thickness equatorially, and is laevigate or with very small sculptural elements.

Derivation of name: L. *cymba* (Gr. *kymbe*)—cup, bowl.

Cymbosporites cyathus sp. nov.

Plate 101, figs. 8–11

Diagnosis. Miospores trilete; amb subcircular to roundly triangular with convex sides and broadly rounded apices, conformable with the central area outline. Laesurae

straight often indistinct, extending full central area radius, accompanied by smooth, elevated lips, individually 0·5–3 μ wide, 2–5 μ high. Exine proximally 1–3 μ thick, equatorially and distally patinate, 8–12 μ thick, homogeneous to finely infra-granulate. Proximal surface laevigate; patina supporting a variable concentration of cones, 2–5 μ wide, 1–5 μ high, often supporting a small apical spine; where densely packed, the cones have polygonal bases. Arcuate folding of the proximal exine at the central area margin is very common.

Dimensions. (Twenty-four specimens) Equatorial diameter 53–80 μ (mean 63 μ).

Holotype. Preparation KA 287/2, 55·2 94·0, K846, N326.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen; Estheriahaugen Formation, Givetian.

Description. Holotype subcircular, diameter 61 μ. Laesurae indistinct, accompanied by narrow lips, individually 0·5 μ wide. Exine very thin proximally, patina equatorially 12 μ thick; patina densely covered with cones, 3–5 μ wide, 2–5 μ high, often with polygonal bases.

Remarks. The very thin proximal exine often sags into the 'cup-shaped' patina, resulting in arcuate folding along the central area margin.

Comparison. It is difficult to make exact comparisons with Russian species of similar appearance in proximo-distal aspect; unless mentioned in the description, or illustrated in oblique aspect, these species may appear cingulate. Many of the Russian species may in fact be patinate rather than cingulate. *Archaeozonotriletes famennensis* Naumova 1953 (p. 117, pl. 17, figs. 31–34) is probably of similar construction, but is smaller, and has lips which extend on to the thicker equatorial exine. *A. pustulatus* Naumova 1953 (p. 35, pl. 3, fig. 10) is smaller, lacks lips, and has a sparser ornament. *A. decorus* Naumova 1953 (p. 35, pl. 3, figs. 11, 12) lacks lips, and the equatorial exine is thicker. *Lepidozonotriletes subtriquetrus* (Luber, in Luber and Waltz 1941) Luber 1955 (pl. 5,

---

EXPLANATION OF PLATE 101

All figures ×500, unless otherwise stated; from unretouched negatives.

Figs. 1–7. *Tholisporites ancylus* sp. nov. 1, 2, Holotype, proximal and distal surfaces respectively, the proximal view shows the extent of the outer layer; KA 240/2, 50·2 100·6, K582, N321. 3, Section showing extent of the outer layer; KA 274/S3, 24·2 94·8, K872, N322. 4, (×1000) the same. 5, Corrosion pattern; KA 202/5, 30·6 92·2, K555, N323. 6, Pseudo-ornament of verrucae formed by corrosion of the patina; KA 271/3, 23·8 87·8, K897, N324. 7, Corrosion pattern, much of the outer layer has corroded away; KA 274/6, 52·7 104·2, K872, N325.

Figs. 8–11. *Cymbosporites cyathus* gen. et sp. nov. 8, 9, Holotype, proximal and distal surfaces respectively; KA 287/2, 55·2 94·0, K846, N326. 10, Proximal oblique aspect, showing patina and distal sculpture; KA 293/1, 42·5 94·5, K556, N327. 11, Proximal surface; KA 243/3, 23·4 95·7, K767, N328.

Figs. 12–20. *Chelinospora concinna* gen. et sp. nov. 12, 13, Holotype, proximal and distal surfaces respectively, KA 293/1, 31·7 91·2, K556, N331. 14, Paratype, proximal oblique aspect, showing patina; KA 286/1, 50·3 105·0, K773, N332. 15, 16, Specimens showing proximally reduced sculpture; KA 243/2, 35·6 106·3, K767, N333, and KA 243/2, 55·0 90·0, K767, N334 respectively. 17, Distal surface; KA 243/1, 54·8 96·5, K767, N335. 18, Lateral view showing very thick corroded patina; KA 293/1, 26·9 90·7, K556, N336. 19, 20, Specimens showing corrosion of the patina; KA 243/2, 24·8 103·5, K767, N337, and KA 293/1, 35·4 89·7, K556, N338 respectively.

figs. 94 and 95) is smaller, and is probably cingulate. *Lycospora magnifica* McGregor 1960 (p. 35, pl. 12, fig. 5, pl. 13, figs. 2–4) is considerably larger, and has some fusion of the basal ornament.

Occurrence. Upper Mimer Valley Series; Givetian.

Cymbosporites catillus sp. nov.

Plate 100, figs. 11–12

Diagnosis. Miospores trilete; amb circular, subcircular to roundly triangular, with moderately convex sides and broadly rounded apices, conformable with the central area outline. Laesurae straight, often indistinct, extend almost to the central area margin, accompanied by smooth, slightly elevated lips, individually 0·5–2 μ wide. Exine proximally 1–2 μ thick, distally and equatorially patinate, 6–9 μ thick, homogeneous. Proximal surface laevigate, patina sculptured with densely packed granules or small verrucae, 1·5 μ or less in height. Frequent arcuate folding of the thin proximal exine occurs at the central area margin.

Dimensions. (Thirty-five specimens) Equatorial diameter 34–50 μ (mean 40 μ).

Holotype. Preparation KA 287/2, 34·1 94·2, K846, N329.

Locus typicus. Estheriahaugen; Central Dicksonland, Spitsbergen; Estheriahaugen Formation, Givetian.

Description. Holotype roundly triangular, with convex sides and broadly rounded apices, diameter 44 μ. Laesurae indistinct, accompanied by lips, individually 0·5 μ wide. Exine very thin proximally, equatorial patina 7 μ thick, patina densely covered with granules.

Remarks. Specimens in oblique aspect clearly demonstrate the nature of the uniform distal patina. As in *Cymbosporites cyathus* sp. nov. the thin proximal surface sags into the 'cup-shaped' patina, resulting in arcuate folding of the proximal surface at the central area margin, which tends to support the thin proximal wall at this point.

Comparison. Cymbosporites cyathus sp. nov. (Pl. 101, figs. 8–11) is larger, and has an ornament of cones. Several Russian species included within *Archaeozonotriletes* and *Retusotriletes* have a similar proximo-distal appearance, descriptions make it difficult to interpret their construction, which may be patinate, cingulate, or thick-walled apiculate. Below are listed species with somewhat similar proximo-distal appearance, size range, and sculptural elements, which may prove to have a patinate construction similar to *C. catillus* sp. nov.:

Retusotriletes verrucosus Kedo 1955, p. 22, pl. 1, fig. 17.
Archaeozonotriletes basilaris Naumova 1953, p. 81, pl. 13, fig. 16; p. 33, pl. 3, fig. 30; p. 128, pl. 19, fig. 8.
Retusotriletes accuratus Chibrikova 1959, p. 51, pl. 5, fig. 6.
Archaeozonotriletes subpusillus Chibrikova 1959, p. 61, pl. 8, fig. 2.
Archaeozonotriletes truncatus Naumova 1953, p. 34, pl. 3, fig. 7.

Occurrence. Upper Mimer Valley Series, particularly common in shale samples; Givetian.

Genus CHELINOSPORA gen. nov.

Type species. *Chelinospora concinna* sp. nov.

Diagnosis. Miospores trilete; amb circular to roundly triangular. Laesurae distinct, usually long, simple or accompanied by narrow folds. Exine one or two-layered, acavate, thin proximally, equatorially and distally patinate, the patina may be of even thickness, or with its maximum thickness either equatorially or distally. Patina reticulate or foveo-reticulate, contact areas laevigate or with a reduced sculpture of muri, granules, and cones.

Comparison. Differs from other patinate genera in having a reticulate or foveo-reticulate patina.

Derivation of name. Gr. *Chelinos*—netted.

Chelinospora concinna sp. nov.

Plate 101, figs. 12–20

Diagnosis. Miospores trilete; amb circular to subcircular, conformable with the central area outline. Laesurae distinct to discernible, straight, length three-quarters to full central area radius, simple or accompanied by low, smooth, narrow lips, less than 1 μ wide. Exine homogeneous to infra-punctate, equatorially 3–12 μ thick (including muri), proximal oblique aspect 2–5 μ thick, distal surface variably patinate 5–32 μ thick, the patina is usually thickest in the distal polar region, and occasionally extends on to the proximal surface. Contact areas support a sparse ornament of small verrucae or granules, 2 μ or less in width and height, and less frequently rugulae or muri, 4–6 μ long, 0·5–2 μ wide. Patina coarsely reticulate, muri 0·5–2 μ wide, 1–4 μ high, enclosing large polygonal to irregularly rounded lumina 5–22 μ in longest diameter.

Dimensions. (Thirty specimens) Equatorial diameter 32–54 μ (mean 41 μ), polar diameter 36–74 μ.

Holotype. Preparation KA 293/1, 31·7 91·2, K556, N331.

Paratype. Preparation KA 286/1, 50·3 105·0, K773, N332.

Locus typicus. North ridge of Kinanderfjellet, Central Dicksonland, Spitsbergen; Upper Mimer Valley Series, Givetian.

Description. Holotype subcircular, equatorial diameter 48 μ. Laesurae straight, length three-quarters central area radius, accompanied by narrow lips. Exine 6–11 μ thick equatorially (including muri), patina thins abruptly on the proximal surface. Contact areas with a sparse ornament of verrucae and granules 2 μ or less wide, distal muri 1 μ or less wide, 2 μ high, lumina 10 to 22 μ in longest diameter.

Paratype in oblique aspect, proximally 2–3 μ thick, distally 12–13 μ thick. Laesurae straight, length two-thirds spore radius. Muri 1 μ wide, approximately 1 μ high, lumina 10–24 μ wide. Reduced muroid ridges proximally.

Remarks. There is considerable variation in width of the patina, thickness of muri and size of lumina. Corrosion of the reticulum and patina is common, giving spores an unusual appearance (Pl. 101, figs. 19, 20).

Comparison. Knoxisporiites reticulatus Vigran 1964 (p. 22, pl. 1, figs. 10–12; pl. 2, figs. 8, 9) is similar but has a laevigate proximal surface. *Verrucosisporites variabilis* McGregor 1960 (p. 30, pl. 11, fig. 15) resembles ill-preserved specimens, in which the patina has broken down, and the variable ornament recorded, including large flat-topped elements, may be the result of a corroded patina. However, there is no mention by McGregor of any reticulate sculpture. *Archaeozonotriletes strangulatus* Naumova 1953 (p. 73, pl. 11, figs. 22, 23) is subtriangular, has shorter laesurae, is proximally laevigate, and there is no mention of variable exine thickness.

Occurrence. Mimer Valley Series; Givetian and probable Upper Eifelian.

Chelinospora ligurata sp. nov.

Plate 102, figs. 1–7

Diagnosis. Miospores trilete; amb circular to roundly triangular, with convex sides and broadly rounded apices. Laesurae simple, straight, length three-quarters to full central area radius. Exine at least in some specimens two-layered; intexine 1–2 μ thick, homogeneous; exoexine homogeneous to infra-punctate, proximally thin, distally patinate 10–21 μ thick (including muri), maximum thickness either equatorially or in the distal polar region; the patina occasionally extends on to the proximal surface, where it may thin gradually or abruptly. Proximal surface laevigate or with a sparse ornament of small verrucae or cones, 2 μ or less in height and basal diameter; patina with a high indistinct reticulum, muri 1–3 μ wide, 2–7 μ high, lumina 4–9 μ wide.

Dimensions. (Thirty specimens) Equatorial diameter 42–70 μ (mean 55 μ).

Holotype. Preparation KA 243/2, 53·5 91·0, K767, N339.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype roundly triangular, diameter 58 μ. Laesurae equal full central area radius. Intexine indistinct; exoexine proximal surface sparsely sculptured with small cones and verrucae 1–2 μ in height and basal diameter, equatorially patina 10 μ wide (excluding muri), muri 2–3 μ wide, 5–6 μ high; distal reticulate pattern indistinct.

Remarks. Corrosion in the majority of specimens results in both the reticulum and the patina breaking down, giving the spore a very distinctive 'sculptured' appearance of high, close bacula (Pl. 102, figs. 6, 7).

Comparison. Chelinospora concinna sp. nov. (Pl. 101, figs. 12–20) has a coarser, lower reticulum.

Occurrence. Fiskekløfta Formation, Planteryggen Sandstone, and Plantekløfta Conglomerate; probable Upper Givetian.

Chelinospora perforata sp. nov.

Plate 102, figs. 8–10

Diagnosis. Miospores trilete; amb roundly triangular, to subcircular, conformable with the central area outline. Laesurae straight, length three-quarters to full central area radius, accompanied and frequently obscured by smooth, narrow lips, individually 0·5–

2 μ wide. Exine infra-granulate, thin proximally, distally patinate, equatorially 11–17 μ thick, gradually thinning towards the distal pole. Contact areas laevigate, patina foveo-reticulate, fovea 2–6 μ in longest diameter, circular, oval, or occasionally irregular, 1–5 μ apart.

Dimensions. (Sixteen specimens) Equatorial diameter 58–86 μ (mean 71 μ).

Holotype. Preparation KA 272/2, 30·0 97·6, C626, N344.

Locus typicus. Huginaspiskardet, Central Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype roundly triangular, diameter 58 μ. Laesurae length two-thirds of spore radius, lips each 1–5 μ wide. Equatorial patina 11 μ thick. Fovea 2–5 μ in longest diameter.

Comparison. Perforosporites robustus Scott and Rouse 1961 (p. 978, pl. 113, figs. 1–6, pl. 114, figs. 1–5) is smaller, lacks lips, is frequently sculptured with papillae, and lacks a patina.

Occurrence. Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Subsuperturma PERINOTRILITI (Erdtman) Dettman 1963
Genus AURORASPORA Hoffmeister, Staplin, and Malloy

Type species. Auroraspora solisortis Hoffmeister, Staplin, and Malloy 1955.

Auroraspora macromanifestus (Hacquebard) Richardson 1960

Dimensions. (Six specimens) Diameter of exoexine 192–216 μ; diameter of intexine 107–26 μ.

Occurrence. Fiskekløfta Formation and Planteryggen Sandstone; Upper Givetian.

Genus PEROTRILITES (Erdtman) ex Couper 1953

Type species. Perotrilites granulatus Couper 1953.

EXPLANATION OF PLATE 102

All figures × 500 unless otherwise stated; from unretouched negatives.

Figs. 1–10. *Chelinospora spp.* 1–7. *C. ligurata* sp. nov. 1–3, Holotype, proximal, sectional and distal foci; KA 243/2, 53·5 91·0, K767, N339. 4, Proximal oblique aspect, showing thick corroded patina; KA 243/1, 41·8 105·3, K767, N340. 5, Showing distal reticulum; KA 243/2, 46·8 91·8, K767, N341. 6, 7, Corroded specimens; KA 243/1, 26·0 96·4, K767, N342, and KA 243/3, 35·8 107·5, K767, N343 respectively. 8–10. *C. perforata* sp. nov. 8, 9, Holotype; proximal and distal surfaces respectively, KA 272/2, 30·0 97·6, C626, N344. 10, (× 1000) detail of distal foveo-reticulate exine; KA 271/3, 37·9 109·3, K897, N345.

Figs. 11–20. *Perotrilites spp.* 11–13. *P. eximius* sp. nov. 11, Holotype, proximal surface; KA 295/M4, 49·2 96·1, K922, N346. 12, Section showing the three-layered sclerine; KA 258/S2, 22·8 92·1, K922, N347. 13, Section showing outer sculptine only partly separate from inner sculptine; KA 258/S3, 28·5 90·2, K922, N348. 14–15. *P. pannosus* sp. nov. Holotype, proximal and distal surfaces respectively; KA 243/1, 29·2 96·6, K767, N353. 16–20. *P. ergatus* sp. nov. 16, 17, Holotype, proximal and distal surfaces respectively; KA 261/4, 53·0 98·5, K891, N349. 18, Showing distal muroid fold pattern; KA 290/5, 54·9 103·6, K681, N350. 19, 20, Sections showing the very thick inner sculptine; 19, (× 1000) KA 290/S8, 30·8 106·4, K681, N351. 20, KA 290/S9, 35 0 99·5, K681, N352.

Discussion. The species listed below are included within *Perotrilites* (Erdtman) ex Couper 1953, on the basis that they possess a thin homogeneous or finely infra-granulate outer layer, in comparison with the much thicker infra-granulate inner layer. As the exact nature of this outer layer is not known (it may in fact be an outer exoexine layer), the term perine is not used, and the terms inner and outer sculptine (Erdtman 1952, p. 468) are employed for these two layers. Where an intexine is also demonstrated, the term sclerine (Erdtman 1952, p. 468) is used for all three layers. The cavity occurs between the outer and inner sculptine, and not between the inner sculptine and intexine. Sectioned species included in *Grandispora* (Pl. 103, fig. 9) and *Calyptosporites* (Pl. 103, fig. 11), show an exoexine and intexine of approximately equal thickness.

Perotrilites eximius sp. nov.

Plate 102, figs. 11–13

Diagnosis. Miospores trilete; cavate; amb and inner sculptine outline convexly triangular to circular. Laesurae straight, short, length $\frac{1}{3}$–$\frac{2}{3}$ central area radius, often accompanied and exceeded equatorially by triradiate folds of the outer sculptine, total width 4–12 μ. Exine three-layered; intexine thin, 0·5–1·5 μ, homogeneous, closely appressed to the inner sculptine, and seen only in sections; inner sculptine 4–9 μ thick, homogeneous to finely infra-granulate, laevigate; outer sculptine 1–2·5 μ thick, homogeneous. Proximal surface laevigate, distal surface supporting a variable ornament of cones and occasional spines, 3–7 μ wide, 4–8 μ high, the majority of cones supporting a smaller apical cone or bifurcate-tipped spine. Proximal surface often with numerous minor folds.

Dimensions. (Forty-four specimens) Diameter of outer sculptine 80–160 μ; diameter of inner sculptine 52–105 μ (mean 90 μ).

Holotype. Preparation KA 295/M4, 49·2 96·1, K922, N346.

Locus typicus. South Mimerdalen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype roundly triangular, outer sculptine diameter 136 μ; inner sculptine diameter 102 μ. Laesurae approximately half inner sculptine radius, elevated lips 11 μ high, length four-fifths spore radius. Inner sculptine 9 μ thick, outer sculptine 2 μ thick. Distal cones 3–6 μ wide, 3–8 μ high, somewhat smaller on the outer sculptine extension.

Remarks. The section (Pl. 102, fig. 12) clearly shows the three-layered sclerine, composed of an intexine and an inner and outer sculptine. Although the outer sculptine is not diaphanous, the thick inner sculptine is undoubtedly an exoexinal layer, and the species is included within *Perotrilites* (Erdtman) ex Couper 1953, on the basis of having a much thinner layer outside this exoexinal layer.

Occurrence. Dicksonfjorden Sandstone, Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Perotrilites ergatus sp. nov.

Plate 102, figs. 16–20

Diagnosis. Miospores trilete; cavate; amb and inner sculptine outline convexly triangular to circular. Laesurae straight, length $\frac{2}{3}$–$\frac{4}{5}$ central area radius, usually obscured by

triradiate folds of the outer sculptine, totalling 1–2 μ wide, 2–7 μ high, extending to the equatorial margin. Inner sculptine inter-radially 6–10 μ thick, radially 4–7 μ thick, coarsely infra-granulate, laevigate; outer sculptine 1–2 μ thick, homogeneous to finely infra-granulate, extends 4–14 μ beyond the inner sculptine, proximally laevigate, distally supporting a sparse ornament of cones, 1–3 μ in height and basal diameter. Distal surface frequently with small muroid folds, 1–3 μ wide, occasionally anastomosing as an imperfect reticulum.

Dimensions. (Thirty-two specimens) Diameter of outer sculptine 71–124 μ (mean 91 μ); diameter of inner sculptine 60–108 μ (mean 79 μ).

Holotype. Preparation KA 261/4, 53·0 98·5, K891, N349.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen: Fiskekløfta Formation, Givetian.

Description. Holotype amb and inner sculptine roundly triangular, outer sculptine diameter 84 μ, inner sculptine diameter 69 μ. Laesurae length three-quarters inner sculptine radius. Inner sculptine 4 μ thick radially, 8 μ thick inter-radially, outer sculptine 1–2 μ thick. Distal surface with occasionally anastomosing muroid folds.

Remarks. Sections (Pl. 102, figs. 19, 20) show clearly the cavate nature of the sculptine, the thick infra-granulate inner sculptine, and the triradiate folds. It is not certain from the strongly compressed sections whether an intexine is present as seen in *Perotrilites eximius* sp. nov. (Pl. 102, fig. 12).

Comparison. Perotrilites eximius sp. nov. (Pl. 102, figs. 11–13) has much larger sculptural elements, and a uniformly thick inner sculptine. *Diaphanospora* sp. Balme and Hassell 1962 (p. 22, pl. 4, figs. 8, 9) is smaller, and has a laevigate outer sculptine. *Archaeozonotriletes arduus* Archangelskaya 1963 (p. 23, pl. 8, figs. 1–5) has a thicker distal surface, and the muroid folds are in the contact areas and not proximo-equatorial and distal.

Occurrence. Dicksonfjordon Sandstone, Upper Reuterskioldfjellet Sandstone, and Mimer Valley Series; Emsian to Givetian.

Perotrilites pannosus sp. nov.

Plate 102, figs. 14, 15

1964 *Perotrilites* cf. *perinatus* Vigran, p. 19, pl. 3, figs. 7, 8.

Diagnosis. Miospores trilete; cavate; amb and inner sculptine outline convexly triangular to circular. Laesurae straight, $\frac{2}{3}$–$\frac{4}{5}$ central area radius, usually masked by triradiate folds of the outer sculptine, totalling 2–3 μ wide, 2–5 μ high. Inner sculptine 3–5 μ thick, infra-granulate, laevigate; outer sculptine 1–2 μ thick, homogeneous, loose-fitting. Contact areas laevigate, proximo-equatorial and distal surfaces with a distinct pattern of muroid folds, 0·5–2 μ wide, which may be arcuate, or anastomosing to form an imperfect reticulum. Distal surface with a sparse ornament of small cones, 1–2·5 μ in height and basal diameter, the cones frequently support a small apical spine.

Dimensions. (Forty-one specimens) Diameter of outer sculptine 40–74 μ (mean 62 μ); diameter of inner sculptine 37–64 μ (mean 54 μ).

Holotype. Preparation KA 243/1, 29·2 96·6, K767, N353.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype amb and inner sculptine outline subcircular, outer sculptine diameter 63 μ, inner sculptine diameter 56 μ. Laesurae straight, length half inner sculptine radius, triradiate folds $\frac{1}{2}$–$\frac{2}{3}$ outer sculptine radius. Muroid folds on proximo-equatorial and distal surfaces, forming an imperfect reticulum. Distal cones 1–2 μ wide, 1–2·5 μ high.

Comparison. Perotrilites bifurcatus Richardson 1962 (p. 174, pl. 25, figs. 4, 5, text-fig. 3) is considerably larger, has a larger ornament of spines and the outer sculptine is not folded in a definite pattern. *Perotrilites* sp. McGregor 1960 (p. 35, pl. 12, fig. 8) has a granulate outer sculptine. *Diaphanospora riciniata* Balme and Hassell 1962 (p. 22, pl. 4, figs. 1–4; text-fig. 5) has a laevigate outer sculptine, and a cingulate inner sculptine. *Perotrilites ergatus* sp. nov. (Pl. 102, figs. 16–20) is larger and lacks a uniformly thick inner sculptine.

Occurrence. Dicksonfjorden Sandstone, Upper Reuterskiøldfjellet Sandstone, and Mimer Valley Series; Emsian to Givetian.

Genus GRANDISPORA Hoffmeister, Staplin, and Malloy 1955

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

Grandispora diamphida sp. nov.

Plate 103, figs. 1–6

Diagnosis. Miospores trilete; cavate; amb and intexine outline circular to subcircular. Laesurae straight, often indistinct, length three-quarters to full radius of the intexine, accompanied and usually masked by narrow elevated lips, 0·5–2 μ wide, 10–26 μ high, extending on to the exoexinal extension, frequently reaching the equatorial margin and occasionally separating equatorially. Intexine 1–4 μ thick, finely infra-granulate. Exoexine 2–4 μ thick, infra-granulate, proximal surface laevigate, distal surface sculptured with cones and spines of variable shape, 3–6 μ wide basally, 3–10 μ high, the cones are often flask-shaped, and may possess a small bifurcate tip. The cones and spines are often more concentrated on the exoexinal extension.

Dimensions. (Twenty-three specimens) Diameter of exoexine 67–90 μ (mean 75 μ); diameter of intexine 54–66 μ (mean 59 μ).

Holotype. Preparation KA 281/5, 55·3 98·8, K850, N354.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype circular, exoexine diameter 71 μ, intexine diameter 55 μ. Laesurae indistinct, raised lips 1·5 μ wide, 8 μ high, separating equatorially and extending to the equatorial margin. Distal spines and cones 3–5 μ wide, 3–6 μ high; few cones have a small bifurcate tip.

Remarks. Grandispora diamphida sp. nov. resembles species of *Calyptosporites* Richardson 1962 in having cones and spines with bifurcate tips; but is here assigned to *Grandispora* Hoffmeister, Staplin, and Malloy on the basis of its smaller size and circular outline.

Comparison. Hymenozonotriletes polyacanthus Naumova 1953 (p. 41, pl. 4, figs. 11, 12) has similar ornament, but appears to possess a bizonate cingulum.

Occurrence. Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Grandispora inculta sp. nov.

Plate 103, figs. 7–9

Diagnosis. Miospores trilete; cavate; amb and intexine outline subcircular to roundly triangular. Laesurae indistinct, length $\frac{1}{3}$–$\frac{2}{3}$ intexine radius, accompanied and frequently masked by smooth, narrow lips, total width 1–4 μ, 2–6 μ high, extending one-third to full radius of the exoexine. Intexine 1·5–3 μ thick, infra-granulate, laevigate, rarely folded; exoexine 1–3 μ thick, homogeneous to infra-granulate, often folded. Proximal surface laevigate, distal surface densely covered with cones 1–2 μ in height and basal diameter. Minor folds frequent on the exoexine.

Dimensions. (212 specimens) Diameter of exoexine 51–86 μ (mean 70 μ); diameter of intexine 34–63 μ (mean 49 μ).

Holotype. Preparation KA 261/4, 39·6 88·8, K891, N359.

Locus typicus. Estheriahaugen, Central Dicksonland, Spitsbergen; Fiskekløfta Formation, Givetian.

Description. Holotype amb roundly triangular, exoexine diameter 72 μ, intexine outline subcircular, diameter 42 μ. Laesurae indistinct, lips individually 1–1·5 μ wide, length of two lips one-third of exoexine radius, the third extending almost to the exoexinal margin. Distal cones 1–2 μ in height and basal diameter.

Remarks. The section (Pl. 103, fig. 9) demonstrates the cavate nature of the exine, the approximately equal thickness of the exoexine and intexine, and the exclusively distal ornament. The short laesurae and infra-granulate nature of the intexine is well seen in broken specimens or where the exoexine is removed.

Comparison. Zonotriletes explanatus Luber, in Luber and Waltz 1941 (p. 10, pl. 1, fig. 4) has 'the entire surface of the exine covered with small tubercles', but is otherwise similar, although it may not be cavate. *Hymenozonotriletes brevimammus* Naumova 1953 (p. 39, pl. 4, fig. 3) has a verrucose ornament. *Spore number 4* Apiculatozonales Group Thompson 1940, figured in Thompson 1952 (p. 10, fig. 14) is larger, and although the exine is clearly two-layered, it appears to have an equatorial flange.

Occurrence. Upper Mimer Valley Series; Givetian.

EXPLANATION OF PLATE 103

All figures × 500 unless otherwise stated; from unretouched negatives.

Figs. 1–9. *Grandispora spp.* 1–6. *G. diamphida* sp. nov. 1, 2, Holotype, proximal and distal surfaces respectively; KA 281/5, 55·3 98·8, K850, N354. 3, Proximal surface; KA 281/5, 43·0 100·1, K850, N355. 4, Showing distal arcuate folds; KA 240/M1, 39·6 98·7, K582, N356. 5, 6, Sections showing raised lips and cavate exine; 5, KA 274/S7, 25·6 103·7, K872, N357. 6, (× 1000) KA 274/S7, 43·4 88·9, K872, N358. 7–9. *G. inculta* sp. nov. 7, Holotype, sectional focus; KA 261/4, 39·6 88·8, K891, N359. 8, Distal surface; KA 261/1, 37·5 98·4, K891, N360. 9, Section showing cavate exine and exclusively distal sculpture; KA 290/S2, 59·3 93·6, K681, N361.

Figs. 10–11. *Calyptosporites proteus* (Naumova) comb. nov. 10, distal surface; KA 290/M1, 48·4 96·6, K681, N362. 11, Section showing cavate exine and exclusively distal sculpture; KA 290/S21, 34·5 91·6, K681, N363.

Genus CALYPTOSPORITES Richardson 1962

Type species. *Calyptosporites velatus* (Eisenack) Richardson 1962.

Calyptosporites microspinosus (Richardson) emend. Richardson 1962

1960 *Cosmosporites microspinosus* Richardson, p. 53, pl. 14, figs. 5, 6.
1962 *Calyptosporites microspinosus* Richardson, p. 192.

Dimensions. (Fifteen specimens) Diameter of exoexine 216–301 μ (mean 264 μ); diameter of intexine 70–120 μ (mean 100 μ).

Remarks. Occasionally one or more of the lips are absent, presumably the result of compression or corrosion. Cone coverage is never dense, but in some corroded specimens as few as two cones are present. None of the Spitsbergen specimens exhibit the bifurcate tips noted by Richardson (p. 53).

Occurrence. Fiskekløfta Formation; Givetian.

Calyptosporites proteus (Naumova) comb. nov.

Plate 103, figs. 10, 11

1953 *Hymenozonotriletes proteus* Naumova, p. 40, pl. 14, fig. 5.
1955 *Hymenozonotriletes proteus* Naumova var. *eximius* Kedo, p. 31, pl. 4, fig. 3.

Description of specimens. Miospores trilete; cavate, amb subtriangular with moderately to strongly convex sides and acute to well-rounded apices, intexine outline roundly triangular to subcircular. Laesurae often indistinct, straight, length half to full intexine radius, usually masked by smooth, elevated lips, individually 2·5–6 μ wide, 4–9 μ high, length half to full exoexine radius. Intexine distinct, 1–4 μ thick, infra-granulate, laevigate; exoexine 2–4 μ thick, infra-granulate. Proximal surface laevigate, distal surface sculptured with cones 3–5 μ wide, 3–7 μ high, the rounded apices frequently supporting a small spine. The ornament is usually sparse, but is occasionally more dense. Distal folding of the exoexine frequent.

Dimensions. (Twenty-three specimens) Diameter of exoexine 110–170 μ (mean 144 μ); diameter of intexine 58–100 μ (mean 79 μ).

Remarks. Sections demonstrate the cavate nature of the spore, the absence of a limbus, the approximately equal thickness of the two exine layers, and the infra-granulate intexine.

Comparison. *Calyptosporites velatus* (Eisenack) Richardson 1962, p. 192, in Richardson 1960 (p. 52, pl. 14, fig. 4, text-fig. 3) has very similar dimensions, but has an ornament of much smaller cones, which have acute rather than rounded apices. *Hymenozonotriletes ventosus* Kedo 1957 (pl. 3, fig. 1) is much smaller. *Calyptosporites microspinosus* Richardson 1962 (p. 192) in Richardson 1960 (p. 53, pl. 14, figs. 5, 6) is considerably larger (the mean of the Spitsbergen specimens of *C. microspinosus* being over 100 μ greater than the mean of *C. proteus*).

Occurrence. Mimer Valley Series; Givetian and probably Upper Eifelian.

Calyptosporites optivus (Chibrikova) comb. nov.

Plate 104, figs. 1–4

1959 *Archaeozonotriletes optivus* Chibrikova, p. 60, pl. 7, fig. 9.
1960 *Retusotriletes* sp. Taugourdeau-Lantz, p. 145, pl. 1, fig. 5.
1964 *Biharisporites spitsbergensis* Vigran, p. 12, pl. 2, figs. 1–4.

Description of specimens. Megaspores trilete; cavate; amb and intexine outline subcircular to roundly triangular, with convex sides and rounded apices. Laesurae straight, often indistinct, length three-quarters to full intexine radius, accompanied by smooth, elevated lips, individually 6–17 μ wide, 7–30 μ high, extending on to the exoexinal extension, and occasionally to the equatorial margin. Intexine 2–5 μ thick, homogeneous, laevigate; exoexine 3–5 μ thick, infra-granulate. Contact areas laevigate, proximo-equatorial and distal surfaces support an ornament of cones of very variable size and distribution 1–10 μ wide, 2–8 μ high; the ornament may be sparse, or closely packed and with polygonal bases, often supporting a small apical spine or cone. Arcuate folds 7–20 μ wide are usually present, which separate the raised contact area from the proximo-equatorial region; the intexine is positioned within this raised central region.

Dimensions. (Forty-five specimens) Diameter of exoexine 160–384 μ (mean 273 μ); diameter of intexine 112–230 μ (mean 160 μ).

Remarks. The section (Pl. 104, fig. 4) demonstrates the cavate nature of the spore, but not the proximal arcuate folds. This species is included within *Calyptosporites* on the basis of its large size, ornament of cones, and approximately equal thickness of the two exine layers. *Biharisporites* Potonié 1956 includes specimens with a very thin, membranous intexine (mesosporium).

Comparison. Triletes sp. A. Winslow 1962 (p. 38, pl. 19, fig. 10) is clearly very similar, but there is no mention of an intexine, and the exine is considerably thicker. *Biharisporites submamillarius* McGregor 1960 (p. 33, pl. 11, fig. 16, pl. 12, figs. 1–3) is larger, lacks the prominent arcuate folds and raised contact area, and has a much thinner intexine.

Occurrence. Upper Mimer Valley Series; Givetian.

EXPLANATION OF PLATE 104

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

Figs. 1–4. *Calyptosporites optivus* (Chibrikova) comb. nov. 1, ($\times 200$) Proximal surface; KA 269/M1, 48·8 104·1, K558, N364. 2, ($\times 500$) the same. 3, ($\times 1000$) Showing cones with papillate apices; KA 242/M1, 32·7 98·2, K772, N365. 4, Section showing the cavate nature of the exine; KA 203/S2, 50·8 105·1, K555, N366.

Figs. 5–12. *Rhabdosporites spp.* 5–8. *R. cymatilus* sp. nov. 5, 6, Holotype, proximal and distal surfaces respectively; KA 274/4, 21·9 104·2, K872, N372. 7, Distal surface; KA 274/2, 51·6 93·3, K872, N373. 8, Section, showing cavate exine and folded exoexine; KA 251/S2, 57·2 88·4, K905, N374. 9–12. *R. scamnus* sp. nov. 9, 10, Holotype, proximal and distal surface respectively; KA 290/2, 38·7 100·0, K681, N369. 11, Section, very compressed; the cavate nature of the exine is not clearly seen; KA 290/S5, 29·8 91·6, K681, N370. 12, Distal surface showing numerous folds; KA 290/4 37·8 100·3, K681, N371.

Calyptosporites indolatus sp. nov.

Plate 106, figs. 1, 2

Diagnosis. Megaspores trilete; cavate; amb irregular, subcircular to roundly triangular, occasionally oval or roundly rectangular. Laesurae straight, length $\frac{1}{2}$–$\frac{3}{4}$ intexine radius, frequently obscured by smooth lips, individually 2–5 μ wide, extending half to full spore radius. Intexine approximately 6–12 μ thick, laevigate, outline usually indistinct; exoexine 2–4 μ thick, infra-granulate, with a sparse distal ornament of cones and spines, 2–10 μ wide, 5–24 μ high. Exoexine strongly folded.

Dimensions. (Twenty-seven specimens) Diameter of exoexine 156–540 μ (mean 290 μ); diameter of intexine 90–278 μ (mean 155 μ).

Holotype. Preparation KA 235/M1, 45·7 104·1, K590, N367.

Locus typicus. Gonvillebreen–Horbyebreen Col, Central Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype diameter 408 μ, exoexinal extension 98 μ. Laesurae indistinct, elevated lips totalling 7 μ wide. Distal cones and spines 2–10 μ wide, 5–24 μ high. Exoexine with irregular prominent folds.

Remarks. Sections of this species appear to be zonate and prove to be somewhat confusing: evidence from broken and dissected specimens, from excentric intexines, and from independent cross-folding on the exoexinal extension, demonstrate that the spore is clearly cavate. It would appear that specimens are sometimes so compressed, that there has been fusion of the equatorial exoexine; even the spore cavity (Pl. 106, fig. 2) is represented only by a faint line.

Occurrence. Upper Mimer Valley Series; Givetian.

Genus RHABDOSPORITES Richardson 1960

Type species. Rhabdosporites langii (Eisenack) Richardson 1960.

Rhabdosporites scamnus sp. nov.

Plate 104, figs. 9–12

Diagnosis. Miospores trilete; cavate; amb and intexine outline roundly triangular to circular. Laesurae straight, length two-thirds to full intexine radius, accompanied by low thickened lips, 1–2 μ wide, frequently extending beyond the laesurae on to the exoexinal extension. Intexine distinct, 1·5–4 μ thick, homogeneous, laevigate; exoexine 1·5–3 μ thick, infra-granulate, sculptured with a dense ornament of minute granules. Distal surface with a distinctive, variable distribution of muroid folds, frequently three in number, radially directed and usually situated inter-radially, but occasionally with a more comprehensive pattern. Short minor folds particularly on the equatorial exoexine are common.

Dimensions. (Fifty-eight specimens) Diameter of exoexine 54–119 μ (mean 82 μ); diameter of intexine 42–84 μ (mean 60 μ).

Holotype. Preparation KA 290/2, 38·7 100·0, K681, N369.

Locus typicus. West Lagercrantzberget, Central Dicksonland, Spitsbergen; Upper Mimer Valley Series, Givetian.

Description. Holotype roundly triangular, exoexine diameter 80 μ, intexine diameter 58 μ. Exoexine and intexine of approximately equal thickness. Three large distal interradial muroid folds present.

Remarks. The section (Pl. 104, fig. 11) demonstrates the two-layered exine, both layers of approximately equal thickness. Because of strong compression, the cavate nature of the equatorial exine is not clearly seen.

Comparison. Camptozonotriletes velatus (Waltz) Playford 1963 (p. 645, pl. 93, figs.1–3) closely resembles *Rhabdosporites scamnus* sp. nov. Sections of *C. velatus* (Waltz) Playford, in Dettmann and Playford 1962 (p. 680, pl. 96, figs. 10–12) are clearly similar, and are probably cavate, as they have tentatively suggested. However, *R. scamnus* sp. nov. lacks the 'spanner like' lips, and except in a few specimens, also lacks the more comprehensive distal folding. *Rhabdosporites langi* (Eisenack) Richardson 1960 (p. 54, pl. 14, figs. 8–9) is larger, and lacks lips. *Rhabdosporites parvulus* Richardson 1965, is of similar size, but lacks the major folding so prominent in *R. scamnus* sp. nov. Naumova (1953) assigned to *Archaeozonotriletes* and *Hymenozonotriletes* probable cavate forms, several of which exhibit major distal folding. *Archaeozonotriletes notatus* Naumova 1953 (p. 84, pl. 13, fig. 12) and *Hymenozonotriletes angulatus* Naumova 1953 (p. 65, pl. 8, fig. 21) both have three major radially directed distal folds, but are considerably smaller. Naumova has clearly misinterpreted the radially directed folds as 'the bordered aperture of the perisporium', and the real trilete mark as the 'aperture of the spore body' only. Size alone is not usually a criterion for specific separation, but insufficient details of the exact construction of *A. notatus* Naumova and *H. angulatus* Naumova makes closer comparison impossible. *Hymenozonotriletes facetus* Archangelskaya 1963 (p. 28, pl. 15, figs. 5, 6) has muroid folds proximally and lacks the major distal folds.

Occurrence. Upper Mimer Valley Series; Givetian.

Rhabdosporites cymatilus sp. nov.

Plate 104, figs. 5–8

Diagnosis. Miospores trilete; cavate; amb and intexine outline roundly triangular, subcircular to oval, undulating. Laesurae often indistinct, straight, $\frac{1}{2}$–$\frac{2}{3}$ spore radius, frequently accompanied and often obscured by sinuous lips, individually 1–3 μ wide, 5–10 μ high. Intexine indistinct, 1–3 μ thick, infra-granulate, unfolded; exoexine

---

EXPLANATION OF PLATE 105

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

Figs. 1–6. *Aulicosporites spp.* 1–3. *A. aulicus* gen. et sp. nov. 1, Holotype, proximal surface; KA 209/M1, 63·3 98·8, K519, N375. 2, Section, showing cavate exine and exclusively distal sculpture; KA 240/S1, 37·6 101·6, K582, N376. 3, ($\times$1000) Details of distal sculpture; KA 209/M3, 36·7 91·2, K519, N377. 4–6. *A. vitabilis* sp. nov. 4, Holotype, proximal surface ($\times$250); KA 243/M1, 30·3 94·5, K767, N378. 5, ($\times$1000) Details of the cristo-reticulate ornament; KA 243/M1, 41·0 100·2, K767, N379. 6, Section, showing sharp raised lips, and intexine; KA 243/S4, 40·7 100·4, K767, N380.

2–4 μ thick, coarsely infra-granulate, laevigate, with a regular pattern of slightly sinuous muroid folds, 2–8 μ wide, 2–4 μ high, more or less radially directed (at least equatorially), and frequently absent from the contact areas.

Dimensions. (Twenty-four specimens) Diameter of exoexine 64–172 μ (mean 112 μ); diameter of intexine 68–92 μ (mean 79 μ).

Holotype. Preparation KA 274/4, 21·9 104·2, K872, N372.

Locus typicus. Reuterskiøldfjellet, Central Dicksonland, Spitsbergen; Reuterskiøldfjellet Sandstone, Emsian.

Description. Holotype subcircular, exoexine diameter 64 μ, intexine diameter 58 μ. Laesurae simple, straight, length approximately half intexine radius. Exoexine and intexine of approximately equal thickness. Muroid folds confined to the proximo-equatorial and distal surfaces, being very sinuous in the distal polar region, and being straighter and radially directed equatorially.

Remarks. The majority of the specimens are dark; and it is often difficult to see details of the intexine. Further maceration fails to clear the spores; however, even in dark specimens the regularly undulating exoexinal margin, the result of the radially directed folds, is an easily recognizable feature. Sections are difficult to cut from spores in this low horizon, but Plate 104, fig. 8 shows clearly the intexine and the folded exoexine.

Comparison. Rhabdosporites langii (Eisenack) Richardson 1960 (p. 54, pl. 14, figs. 8, 9, text-figs. 4, 6B) lacks the intricate and regular fold pattern, a feature present in all specimens of *Rhabdosporites cymatilus* sp. nov.; a distinctive diagnostic feature justifying its specific separation.

Occurrence. Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Siegenian, Emsian and probably Lower Eifelian.

Genus AULICOSPORITES gen. nov.

Type species. Aulicosporites aulicus sp. nov.

Diagnosis. Megaspores trilete; cavate; amb circular to roundly triangular. Intexine and exoexine of approximately equal thickness, intexine laevigate, exoexine sculptured at least distally with a cristate or cristo-reticulate ornament, with cones or occasional spines.

Discussion. Differs from both *Calyptosporites* Richardson 1962 and *Biharisporites* Potonié 1956, in having a cristate or cristo-reticulate ornament.

Derivation of name. Gr. *aulakos*—with small furrows.

Aulicosporites aulicus sp. nov.

Plate 105, figs. 1–3

Diagnosis. Megaspores trilete; cavate; amb and intexine outline circular, subcircular to roundly triangular. Laesurae distinct, straight, length one-third to full radius of the intexine, accompanied by conspicuous, smooth, elevated lips, 5–12 μ wide, 6–10 μ high, length three-quarters to full spore radius. Intexine 6–9 μ thick, infra-granulate; exoexine

7–12 μ thick, coarsely infra-granulate, proximally laevigate, distally sculptured with cones, variable both in size and distribution. The cones (6–40 μ wide, 6–24 μ high) have rounded apices, occasionally supporting a very small cone or spine; usually more densely packed in the distal polar region, where they are fused basally or have a polygonal outline. Distally the exoexinal extension is often laevigate.

Dimensions. (Thirty-eight specimens) Diameter of exoexine 180–306 μ (mean 217 μ); diameter of intexine 90–190 μ (mean 146 μ).

Holotype. Preparation KA 209/M1, 63·3 98·8, K519, N375.

Locus typicus. Odellfjellet, North Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype diameter of exoexine 208 μ, diameter of intexine 120 μ. Laesurae approximately half intexine radius. Lips each 8–10 μ wide, extend almost to the equatorial margin. Distal cones 6–12 μ wide, 6–10 μ high, with both separate polygonal and fused bases, and occasionally with small apical spines. Small folds present on exoexinal extension.

Remarks. The section (Pl. 105, fig. 2) demonstrates the cavate nature of the spore, the thick intexine, and the exclusively distal sculpture of cones.

Occurrence. Dicksonfjorden Sandstone, Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Aulicosporites vitabilis sp. nov.

Plate 105, figs. 4–6

Diagnosis. Megaspores trilete, amb circular to roundly triangular with convex sides and broadly rounded apices. Laesurae straight, length $\frac{3}{4}$–$\frac{4}{5}$ spore radius, accompanied and often obscured by acute, thickened lips, individually 5–25 μ wide, 25–44 μ high at the proximal pole, 16–26 μ high equatorially. Intexine seen only in sections, approximately 5 μ thick, homogeneous, laevigate; exoexine 8–10 μ thick (excluding ornament), infrapunctate. Contact areas occupying most of the proximal surface, laevigate or punctate, except adjacent to the lips, where they may support an ornament of cones; contact areas bounded by curvaturae, up to 20 μ wide, formed by a fusion of cones. Distal surface cristo-reticulate, with cones and occasional spines 6–12 μ wide, 7–20 μ high.

Dimensions. (Seventeen specimens) Diameter of exoexine 265–364 μ (mean 322 μ); diameter of intexine approximately 70 μ.

Holotype. Preparation KA 243/M1, 30·3 94·5, K767, N378.

EXPLANATION OF PLATE 106

All figures ×500 unless otherwise stated; from unretouched negatives.

Figs. 1–2. *Calyptosporites indolatus* sp. nov. 1, Holotype (×250), proximal surface; KA 235/M1, 45·7 104·1, K590, N367. 2, Compressed section; KA 235/S1, 49·7 105·0, K590, N368.

Figs. 3–4. *Retialetes sp.* 3, KA 251/1, 18·9 94·1, K905, N381. 4, (×1000) the same.

Figs. 5–7. *Ancyrospora langii* (Taugourdeau-Lantz) comb. nov. 5, Distal surface; KA 243/3, 47·7 92·1, K767, N386. 6, 7, Sections, showing the raised lips, equatorial flange, and intexine; KA 243/S8, 52·3 104·6, K787, N387 and KA 243/S8, 33·9 103·4, K767, N388, respectively.

Locus typicus. East Munindalen, Central Dicksonland, Spitsbergen; Plantekløfta Conglomerate, probable Upper Givetian.

Description. Holotype subcircular, exoexinal diameter 296 μ, intexine not seen. Laesurae straight, length four-fifths spore radius, accompanied by lips each up to 24 μ wide. Contact areas laevigate, except for an ornament of cones adjacent to the lips. Distal cristoreticulum well developed.

Remarks. The section (Pl. 105, fig. 6) clearly shows the intexine, the raised sharp lips formed by an upward extension and thickening of the exoexine, the infra-punctate (here corroded) nature of the exoexine, and the homogeneous sculptural elements.

Comparison. Biharisporites ellesmerensis Chaloner 1959 (p. 322, pl. 55, fig. 2, text-fig. 1) is smaller, and has smaller sculptural elements, which are not fused basally. No intexine appears to be present, but this feature is very indistinct in *Aulicosporites vitabilis* sp. nov.

Occurrence. Planteryggen Sandstone, and Plantekløfta Conglomerate; probable Upper Givetian.

Turma ALETES Ibraham 1933
Subturma AZONALETES (Luber) Potonié and Kremp 1954
Infraturma RETICULONAPITA (Erdtman) Vimal 1952
Genus RETIALETES Staplin 1960

Type species. R. radforthii Staplin 1960.

Retialetes sp.

Plate 106, figs. 3, 4

Description of specimens. Spores alete, ellipsoidal. Exine (excluding ornament) thin, 1·5 μ or less, finely sculptured with low, narrow muri, 1 μ or less wide, 0·5–2 μ high. Lumina uniform, usually polygonal, small, typically 2–4 μ wide (range 1–8 μ). Exine strongly plicated with major folds.

Dimensions. (Seven specimens) 40–64 μ (mean 51 μ) by 31–44 μ (mean 38 μ).

Comparison. Retialetes radforthii Staplin 1960 the only other species recorded for this genus, is considerably larger.

Occurrence. Lower Reuterskiøldfjellet Sandstone; Siegenian.

Previous records. The genus has previously been recorded only from the Lower Carboniferous.

INCERTAE SEDIS

Genus NIKITINSPORITES Chaloner 1959

Type species. Nikitinsporites canadensis Chaloner 1959.

Nikitinsporites spitsbergensis sp. nov.

Plate 108, figs. 1–5

Diagnosis. Megaspores trilete, amb subtriangular to subcircular. Laesurae obscured by greatly elevated lips (sometimes broken), individually 7–15 μ wide, 74–160 μ high. Exine

two layered; intexine 2–4 μ thick, homogeneous, closely appressed to the exoexine, and seen only in sections; exoexine 18–45 μ thick, coarsely infra-granulate. Contact areas laevigate, proximo-equatorial and distal surfaces supporting thick, more or less parallel-sided spines, structurally composed of rod-shaped elements parallel to the long axis; apically the spines narrow abruptly, ending with an homogeneous grapnel-tip, this tip is never wider than the main shaft of the spine; typically the spines are 100–50 μ long (range 48–250 μ), typically 40–60 μ wide (range 14–80 μ wide) the equatorial margin supports 8–20 spines. A pseudoflange up to 80 μ wide, formed by the fused bases of the spines, is occasionally present.

Dimensions. (Twenty-four specimens) Equatorial diameter (excluding spines) 240–440 μ (mean 342 μ); polar diameter (including apical prominance) 240–416 μ (mean 303 μ).

Holotype. Preparation KA 203/M4, 30·4 107·1, K555, N382.

Locus typicus. North ridge of Kinanderfjellet, Central Dicksonland, Spitsbergen; Upper Mimer Valley Series, Givetian.

Description. Holotype equatorial and polar diameter (excluding elevated lips) both 256 μ, elevated lips 160 μ. Spines 28–40 μ wide, 80–240 μ long, only a few with the grapnel-tips preserved, basal fusion of spines (pseudoflange) up to 20 μ wide.

Remarks. Sections (Pl. 108, figs. 4, 5) show the very thick exoexine, and very thin closely appressed intexine; the spore cavity appears somewhat irregular in shape. This species is included within *Nikitinsporites Chaloner* 1959, primarily on the shape and structure of the grapnel-tipped spines. Large size and greatly elevated lips, are features of *Nikitinsporites* which are also seen in some species included within *Hystricosporites* McGregor 1960 and *Ancyrospora* Richardson 1960 emend Richardson 1962. For example *Hystricosporites porrectus* (Balme and Hassell) comb. nov. (Pl. 95, figs. 1–3) has elevated lips, but the spines are homogeneous throughout, and with their large grapnel-tips, are clearly different from the spines of *Nikitinsporites* which are homogeneous only at the very apex, with a small grapnel tip never exceeding the diameter of the main shaft of the spine. A pseudoflange (also present in some species of *Ancyrospora*) may be absent, partially developed or strongly developed (Pl. 108, fig. 2) in otherwise identical specimens, and *Nikitinsporites* Chaloner 1959 is therefore included within Incertae sedis.

Comparison. Nikitinsporites sp. Vigran 1964 (p. 20, pl. 2, figs 11–13) has a variable sculpture of conical-based spines, coni and verrucae. *Nikitinsporites canadensis* Chaloner 1959 (p. 328, pl. 55, fig. 5, text-fig. 4) is circular, and is considerably larger. *Dicrospora sp.* Winslow 1962 (p. 55, pl. 10, figs. 1 and 1*a*) illustrated but not described, is probably assignable to *N. spitsbergensis* sp. nov.

Occurrence. Fiskekløfta Formation and Planteryggen Sandstone; Givetian.

EXPLANATION OF PLATE 107

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

Figs. 1–6. *Ancyrospora spp.* 1, *A. trocha* sp. nov., Holotype, proximal surface; KA 209/M6, 39·2 103·3, K519, N389. 2–5. *A. reuta* sp. nov. 2, Holotype, lateral view; KA 209/4, 34·0 88·1, K519, N390. 3, 4, Sections, showing equatorial flange and thick exine; KA 204/S1, 21·0 90·4, K838, N391 and KA 204/S1, 62·0 105·5, K838, N392. 5, ($\times$1000) Details of grapnel-tipped spines; KA 204/M2, 32·3 106·6, K838, N393. 6. *A. sp.* ($\times$250) Proximal surface; KA 242/M1, 33·2 95·1, K772, N394.

Genus ANCYROSPORA Richardson 1960 emend Richardson 1962

Type species. *Ancyrospora grandispinosa* Richardson 1960 emend Richardson 1962.

Ancyrospora langii (Taugourdeau-Lantz) comb. nov.

Plate 106, figs. 5–7

1960 *Archaeotriletes langii* Taugourdeau-Lantz, p. 145, pl. 3, figs. 33, 34, 39.
1964 *Ancyrospora* cf. *simplex* Vigran, p. 26, pl. 6, figs. 1–3.

Dimensions. (Twenty specimens) Overall equatorial diameter 66–140 μ (mean 86 μ); central area diameter 40–81 μ (mean 55 μ); equatorial flange (excluding ornament) 12–48 μ wide. Grapnel-tipped spines typically 12–25 μ long (range 8–38 μ), typically 7–12 μ wide basally (range 5–20 μ).

Remarks. The spines narrow gradually from the base to the apex, ultimately widening into a grapnel-tip. The spines except for the homogeneous grapnel-tip, are infra-granulate. Sections (Pl. 106, figs. 6, 7) demonstrate the elevated membranous lips, thin intexine, and equatorial flange composed only of exoexine. In *Archaeotriletes* (Naumova) Potonié 1958 the spines are confined to the central area, and are absent from the flange.

Comparison. Hymenozonotriletes incisus Naumova 1953 (p. 68, pl. 9, fig. 11) is similar, and should this species prove to have grapnel-tipped spines, then it would be conspecific.

Occurrence. Upper Mimer Valley Series; Givetian.

Ancyrospora trocha sp. nov.

Plate 107, fig. 1

Diagnosis. Miospores trilete; amb and central area outline circular to subcircular. Laesurae straight, length three-quarters to full central area radius, accompanied and often obscured by sinuous, membranous, elevated lips, individually 2–4 μ thick, usually closely appressed to the exoexine, but occasionally separated and folded; exoexine coarsely infra-granulate 7–20 μ thick centrally, extending as an equatorial flange, typically 20–32 μ wide (range 15–50 μ). Contact areas occupy most of the proximal surface inside the flange, and support an ornament of low, broad, flat-topped radial muri, 6–13 μ wide, 4–12 on each contact area; proximo-equatorial and distal surfaces sparsely sculptured with short spines, typically 15–30 μ long (range 10–58 μ), the majority with large bulbous bases, 10–24 μ wide.

Dimensions. (Twenty-five specimens) Overall equatorial diameter (excluding spines) 154–272 μ (mean 189 μ).

Holotype. Preparation KA 209/M6, 39·2 103·3, K519, N389.

Locus typicus. Odellfjellet, North Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype circular, diameter 178 μ. Laesurae straight, length equals full intexine radius, elevated lips 16 μ high. Intexine 3 μ thick, folded; exoexine 16 μ thick, equatorial flange 22 μ wide. Radial muri 8–13 μ wide, 6–8 on each contact area; proximo-

equatorial and distal spines sparse, short, 14–18 μ high, frequently with the grapnel tip broken.

Comparison. Ancyrospora grandispinosa Richardson 1960 emend Richardson 1962 (p. 175, pl. 27, figs. 3–5, text-fig. 4) is clearly similar, but lacks the proximal radial muri. *Hystricosporites porcatus* comb. nov. has longer spines, a curvatural ridge formed in part from the bases of the spines (zonarial ridge of Winslow 1962, p. 52), and lacks the membranous equatorial flange.

Occurrence. Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian and Eifelian.

Ancyrospora reuta sp. nov.

Plate 107, figs. 2–5

Diagnosis. Miospores trilete; amb and central area outline circular to subcircular. Laesurae indistinct, length half to full radius of the central area, occasionally accompanied by smooth lips, individually 1–3 μ wide. Exine two-layered; intexine infra-granulate 1–4 μ thick; exoexine infra-granulate 7–15 μ thick, extending as an equatorial flange, typically 25–40 μ wide (range 14–54 μ); proximal surface laevigate, distal surface densely covered with short grapnel-tipped spines, 6–20 μ long, frequently with large bulbous bases, 6–10 μ wide.

Dimensions. (Sixteen specimens) Overall equatorial diameter 111–180 μ (mean 151 μ); central area diameter 83–128 μ (mean 96 μ).

Holotype. Preparation KA 209/4, 34·0 88·1, K519, N390.

Locus typicus. Odellfjellet, North Dicksonland, Spitsbergen; Lower Mimer Valley Series, Lower Eifelian.

Description. Holotype in oblique aspect, subcircular, overall equatorial diameter 128 μ, central area diameter 100 μ. Laesurae indistinct. Exine 10 μ thick centrally, equatorial flange 14–22 μ wide. Distal spines 6–10 μ long, only a few grapnel-tips being preserved.

Remarks. Specimens are very dark, and difficult to macerate, tending to break down with increased maceration, rather than becoming lighter in colour. Frequently, the grapnel-tip is not preserved. The sections (Pl. 107, figs. 3, 4) demonstrate the equatorial flange and thick exine. No intexine is seen in this specimen.

Comparison. Ancyrospora grandispinosa Richardson 1960 emend Richardson 1962 (p. 175, pl. 27, figs. 3–5, text-fig. 4) is considerably larger, and has much longer spines. *Ancyrospora trocha* sp. nov. (Pl. 107, fig. 1) has proximal radial muri.

Occurrence. Dicksonfjorden Sandstone, Upper Reuterskiøldfjellet Sandstone, and Lower Mimer Valley Series; Emsian to Eifelian.

EXPLANATION OF PLATE 108

All figures ×200 unless otherwise stated; from unretouched negatives.

Figs. 1–5. *Nikitinsporites spitsbergensis* sp. nov. 1, Holotype, lateral view; KA 203/M4, 30·4 107·1, K555, N382. 2, Proximal surface showing pseudoflange; KA 282/M2, 33·9 96·4, K854, N383. 3, (×1000) bifurcate tipped spine from the holotype. 4, 5, Sections showing the thick exoexine and thin intexine. 4, (×500) KA 235/S17, 43·2 99·4, K590, N384. 5, (×1000), KA 235/S11, 20·7 106·0, K590, N385.

Ancyrospora sp.

Plate 107, fig. 6

Description of specimens. Megaspores trilete; amb triangular to roundly triangular, deeply incised, central area outline triangular. Laesurae indistinct, straight, length two-thirds to full spore radius, accompanied by smooth elevated lips, individually 4–12 μ wide, 10–40 μ high. Exine two-layered; intexine approximately 3 μ thick, closely appressed to the exoexine and usually indistinct; exoexine infra-granulate, centrally 15–20 μ thick, thinning and extending equatorially as a pseudoflange up to 60 μ wide. Proximal surface laevigate; equatorially and distally sculptured with flexuous spines, 40–100 μ long, basally 10–40 μ wide, each narrowing gradually towards the apex, where it widens slightly into a grapnel-tip. The spines, except for the homogeneous grapnel-tip, are infra-granulate.

Dimensions. (Six specimens) Overall equatorial diameter (excluding spines) 222–80 μ; central area diameter 120–44 μ.

Remarks. Structurally the spines are similar to those in *Nikinisporites* Chaloner 1959, but differ in sculpture.

Comparison. Archaeotriletes villosus Chibrikova 1959 (p. 44, pl. 2, fig. 1) is clearly similar, and may prove to be identical, but the sculpture is reduced in size towards the distal pole, and there is no evidence of grapnel-tips to the spines, although this may be due to preservation.

Occurrence. Fiskekløfta Formation, Planteryggen Sandstone, and Plantekløfta Conglomerate; probable Middle and Upper Givetian.

SOME GENERAL COMMENTS

The Spitsbergen succession is one of the few Devonian continental successions which extends from the Lower Devonian into the Middle Devonian without a stratigraphical break.

Botanical affinities can tentatively be suggested on the basis of spores of similar construction found *in situ* in Devonian and Carboniferous plants, but many species, including those with proximal radial muri, grapnel-tipped spines, and patinate thickenings, which are restricted to, or abundant in, the Devonian, are as yet unassigned to any plant group.

Dispersed spores of diverse construction, included within the Infraturmae Laevigati, Apiculati, Murornati, Tricrassati, Cingulati, Patinati, and many cavate forms are described from the Lower Devonian. The majority of Lower Devonian plants described by Høeg (1942) from Spitsbergen are assignable to the Psilophytales, and from the evidence of spores *in situ* described from the Devonian, the majority of Psilophytales produced simple laevigate or apiculate forms. This diversity of dispersed spores recovered from the Lower Devonian, suggests that there must have been a greater diversity of parent plants than have as yet been described from, or preserved in, the Lower Devonian of Spitsbergen or elsewhere.

REFERENCES

AMES, H. T. (ed.). 1961. *Catalog of Fossil spores and pollen: vol. 1, Translations.* The Pennsylvania State University.

ARCHANGELSKAYA, A. D. 1963. New spore finds from Devonian deposits of the Russian platform. *Ministerstvo geol. i ochroni Nedr SSSR. Moscow*, **37**, 18–30, 16 pls. (in Russian).

BALME, B. E. 1962. Upper Devonian (Frasnian) spores from the Carnarvon Basin, Western Australia. *Palaeobotanist*, **9**, 1–10.

—— and HASSELL, C. W. 1962. Upper Devonian spores from the Canning Basin. Western Australia. *Micropaleontology*, **8**, 1–28.

BHARDWAJ, D. C. 1957*a*. The palynological investigations of the Saar coals (Part I—Morphography of Sporae Dispersae). *Palaeontographica*, **B101**, 73–125.

—— 1957*b*. The spore flora of Velener Schichten (Lower Westpahlain D) in the Ruhr Coal Measures. Ibid. **B102**, 110–38.

BUTTERWORTH, M. A. and WILLIAMS, R. W. 1958. The small spore floras of coals in the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland. *Trans. roy. Soc. Edinb.* **63**, 353–92.

CHALONER, W. G. 1959. Devonian megaspores from Arctic Canada, *Palaeontology*, **1**, 321–32.

—— 1963. Early Devonian spores from a borehole in Southern England. *Grana palynologica*, **4**, 1. 100–10.

CHIBRIKOVA, E. V. 1959. Spores of the Devonian and older deposits of Bashkir. *Akad. Nauk. S.S.S.R., Materials on Palaeont. and Strat. of Devonian and older deposits of Bashkir*, **3**, 116 (in Russian).

COUPER, R. A. 1958. British Mesozoic microspores and pollen grains, a systematic and stratigraphic study. *Palaeontographica*, **B103**, 75–179.

DETTMAN, M. E. 1961. Lower Mesozoic megaspores from Tasmania and South Australia. *Micropaleontology*, **7**, 71–86.

—— 1963. Upper Mesozoic microfloras from South-Eastern Australia. *Roy. Soc. Vict.* **77**, 1–148.

—— and PLAYFORD, G. 1963. Sections of some spores from the Lower Carboniferous of Spitsbergen. *Palaeontology*, **5**, 679–81.

DYBOVA, S. and JACHOWICZ, A. 1957. Microspores of the Upper Silesian Coal Measures. *Inst. Geol. Prace*, **23**, 1–328.

EISENACK, A. 1944. Über einige pflanzliche funde in Geschieben, nebst Bemerkungen zum Hystrichosphaerideen-Problem. *Z. Geschiebeforsch*, **19**, 103–24.

ERDTMAN, G. 1952. *Pollen morphology and plant taxonomy—Angiosperms.* Waltham, Mass.

—— 1957. *Pollen and spore morphology/plant taxonomy; Gymnospermae, Pteridophyta, Bryophyta*, Almqvist and Wiksells, Stockholm.

FAEGRI, K. and IVERSEN, J. 1950. *Text-book of modern pollen Analysis.* Munksgaard, Copenhagen.

FRIEND, P. F. 1961. The Devonian stratigraphy of North and Central Vestspitsbergen. *Proc. Yorks. Geol. Soc.* **33**, 77–118.

HACQUEBARD, P. A. 1957. Plant spores in coal from the Horton group (Mississippian) of Nova Scotia. *Micropaleontology*, **3**, 301–24.

—— and BARSS, M. S. 1957. A Carboniferous spore assemblage, in coal from the South Nahanni River area, Northwest Territories. *Bull. geol. Surv. Canada*, **40**, 1–63.

HARRIS, W. F. 1955. A manual of the spores of New Zealand Pteridophyta. *Bull. New Zealand Dept. Sci. Indust. Res.* **116**, 186 pp.

HØEG, O. A. 1942. The Downtonian and Devonian flora of Spitsbergen. *Skr. Norges Svalb. og Ishavs—Unders.* **83**, 77–146.

HOFFMEISTER, W. S. 1959. Lower Silurian plant spores from Libya. *Micropaleontology*, **5**, 331–334.

—— STAPLIN, F. L., and MALLOY, R. E. 1955*a*. Geologic range of Paleozoic plant spores in North America. Ibid. **1**, 9–27.

—— —— —— 1955*b*. Mississippian plant spores from the Hardinsburg Formation of Illinois and Kentucky. *J. Paleont.* **29**, 372–99.

HUGHES, N. F., DETTMANN, M. E., and PLAYFORD, G. 1962. Sections of some Carboniferous spores. *Palaeontology*, **5**, 247–52.

HUGHES, N. F. and PLAYFORD, G. 1961. Palynological reconnaissance of the Lower Carboniferous of Spitsbergen. *Micropaleontology*, **7**, 27–44.

ISHCHENKO, A. M. 1952. Atlas of the microspores and pollen of the Middle Carboniferous of the western part of the Donetz Basin. *Izd. Akad. Nauk. Ukrainian S.S.R., Inst. Geol. Nauk.* 1–83 (in Russian).

—— 1956. Spores and pollen of the Lower Carboniferous deposits of the western extension of the Donetz Basin and their stratigraphical importance. *Akad. Nauk Ukrainian S.S.R., Tr. Inst. Geol. Nauk. Strat. Palaeont.* **11**, 1–185 (in Russian).

—— 1958. Spore-pollen analysis of the Lower Carboniferous sediments of the Dnieper-Donetz Basin. Ibid. **17**, 1–188 (in Russian).

KEDO, G. I. 1955. Spores of the Middle Devonian of the north-east of Belorussia S.S.R. *Palaeont. i stratig. B.S.S.R. Minsk, Akad. Nauk B.S.S.R.* **1**, 5–47 (in Russian).

—— 1957. Spores from salt deposits of the Pripiat depression and their stratigraphic significance. Ibid. **2**, 3–43 (in Russian).

KOSANKE, R. M. 1950. Pennsylvanian spores of Illinois and their use in correlation. *Bull. Ill. State Geol. Surv.* **74**, 1–128.

KREMP, G. O. W. (ed.) 1960. *Catalog of Fossil spores and pollen: vols. 11, 12, Devonian spores.* The Pennsylvania State University.

LANJOUW, J. 1961. *International Code of Botanical Nomenclature.* Utrecht.

LUBER, A. A. 1955. Atlas of the spores and pollen grains of the Palaeozoic deposits of Kazachstan. *Tr. Akad. Nauk Kazach. S.S.R.*, Alma-Ata, 1–126 (in Russian).

—— and WALTZ, I. E. 1938. Classification and stratigraphical value of the spores of some Carboniferous coal deposits in the U.S.S.R. *Trans. Central Geol. Prosp. Inst.* **105**, 1–45 (in Russian).

—— —— 1941. Atlas of microspores and pollen grains of the Palaeozoic of the U.S.S.R. *Tr. All-Union Geol. Sci. Res. Inst. (V.S.E.G.E.I.)*, **139**, 1–107 (in Russian).

MCGREGOR, D. C. 1960. Devonian spores from Melville Island, Canadian Arctic Archipelago. *Palaeontology*, **3**, 26–44.

—— 1961. Spores with proximal radial pattern from the Devonian of Canada. *Bull. geol. Surv. Canada*, **76**, 1–12.

NAUMOVA, S. N. 1939. Spores and pollen of coals of the U.S.S.R. *Rep. Int. Geol. Congr., 17th Session U.S.S.R.* **1**, 353–64.

—— 1953. Spore-pollen complexes of the Upper Devonian of the Russian Platform and their stratigraphical value. *Tr. Inst. Geol. Nauk Akad. S.S.S.R.* **143** (Geol. Ser. no. 60), 1–204 (in Russian).

NEVES, R. 1961. Namurian plant spores from the Southern Pennines, England, *Palaeontology*, **4**, 247–79.

PLAYFORD, G. 1962. Lower Carboniferous microfloras of Spitsbergen, Part I. Ibid. **5**, 550–618. 1963. Part II. Ibid. **5**, 619–78.

POTONIÉ, R. 1934. Zur Morphologie der fossilen Pollen und Sporen. *Arb. Inst. Palaob. Petrogr. Brennsteine*, **4**, 5–24.

—— 1956. Synopsis der Gattungen der Sporae dispersae. I. Teil: Sporites. *Beih. Geol. Jahrb.* **23**, 1–103.

—— 1958. Synopsis der Gattungen der Sporae dispersae II. Teil: Sporites (Nächtrage), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. Ibid. **31**, 1–114.

—— 1960. Synopsis der Gattungen der Sporae dispersae. III. Teil: Nächtrage Sporites, Fortsetzung Pollenites. Mit Generalregister zu Teil 1–111. Ibid. **39**, 1–189.

—— 1962. Synopsis der Sporae in situ. Die Sporen der Fossilen Fruktifikationen (Thallophyta bis Gymnospermaphyta) im naturlichen System und im Vergleich mit den Sporae dispersae. Ibid. **52**, 1–204.

—— and KREMP, G. 1954. Die Gattungen der palaozoischen Sporae dispersae and ihre Stratigraphie. *Geol. Jahrb.* **69**, 111–94.

—— —— 1955. Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebeite und Zeitabschnitte; Teil I. *Palaeontographica*, **B98**, 1–136. 1956. Idem; Teil II. Ibid. **B99**, 85–191.

RICHARDSON, J. B. 1960. Spores from the Middle Old Red Sandstone of Cromarty, Scotland. *Palaeontology*, **3**, 45–63.

RICHARDSON, J. B. 1962. Spores with bifurcate processes from the Middle Old Red Sandstone of Scotland. *Palaeontology*, **5**, 171–94.

—— 1965. Middle Old Red Sandstone Spore Assemblages from the Orcadian Basin, North-East Scotland. Ibid. **7**, 559–605.

SCHOPF, J. M., WILSON, L. R., and BENTALL, R. 1944. An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. *Rep. Inv. Ill. State Geol. Surv.* **91**, 1–72.

SCOTT, D. L. and ROUSE, G. E. 1961. *Perforosporites*, a new genus of plant spores from the Lower Devonian of Eastern Canada. *J. Palaeont.* **35**, 977–80.

SMITH, A. H. V. 1960. Structure of the wall in certain miospores belonging to the series Cingulati Pot. and Klaus 1954. *Palaeontology*, **3**, 82–85.

STAPLIN, F. L. 1960. Upper Mississippian plant spores from the Golata Formation, Alberta, Canada. *Palaeontographica*, **B107**, 1–40.

TAUGOURDEAU-LANTZ, J. 1960. Sur la microflore du Frasnian Inferieur de Beaulieu (Boulonnais). *Rev. de Micropaleontologie*, **3**, 144–54.

—— 1962. Remarque sur la structure du genre *Hymenozonotriletes* (Naoumova 1937? 1939) ex Naoumova 1953. Ibid. **5**, 51–53.

THOMPSON, P. W. 1940. Beitrag zur Kenntnis der fossilen flora der Mitteldevons in Estland. *Tartu Uelik Lood. Selt.* **45** (1–4), 195–216.

—— 1952. Beitrag zu Kenntnis der Sporomorphenflora im Unter-und Mitteldevon. *Palaeont. Z.* **25**, 155–9.

VIGRAN, J. 1964. Spores from Devonian deposits, Mimerdalen, Spitsbergen. *Skr. Norsk Polarinst.* **132**, 1–30.

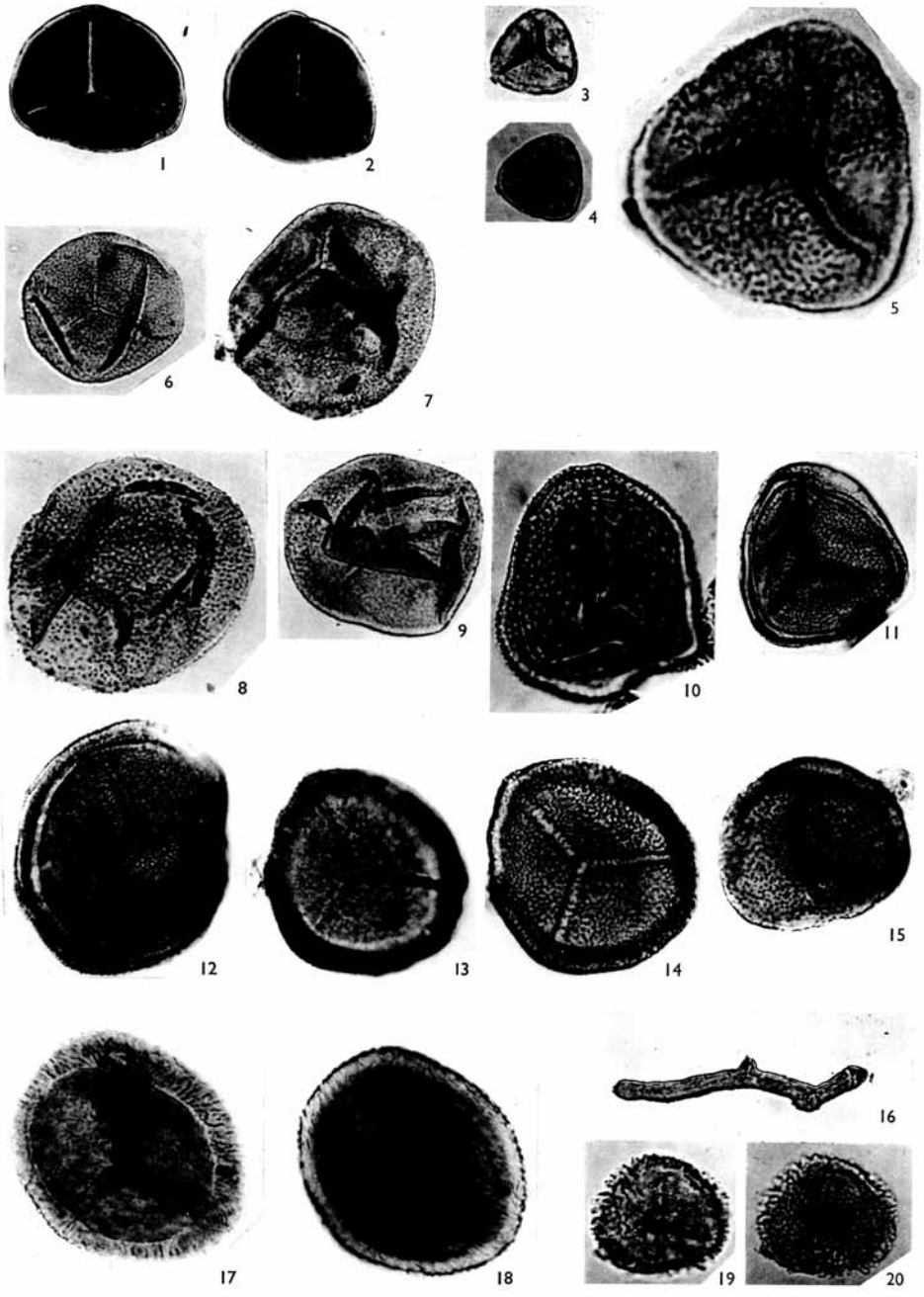
WIGGLESWORTH, V. B. 1959. A simple method for cutting sections in the 0·5 to 1 μ range, and for sections of chitin. *Quart. J. micr. Sci.* **100**, 315–20.

WILSON, L. R. and COE, E. Z. 1940. Descriptions of some unassigned plant microfossils from the Des Moines Series of Iowa. *Amer. Midl. Nat.* **23**, 182–6.

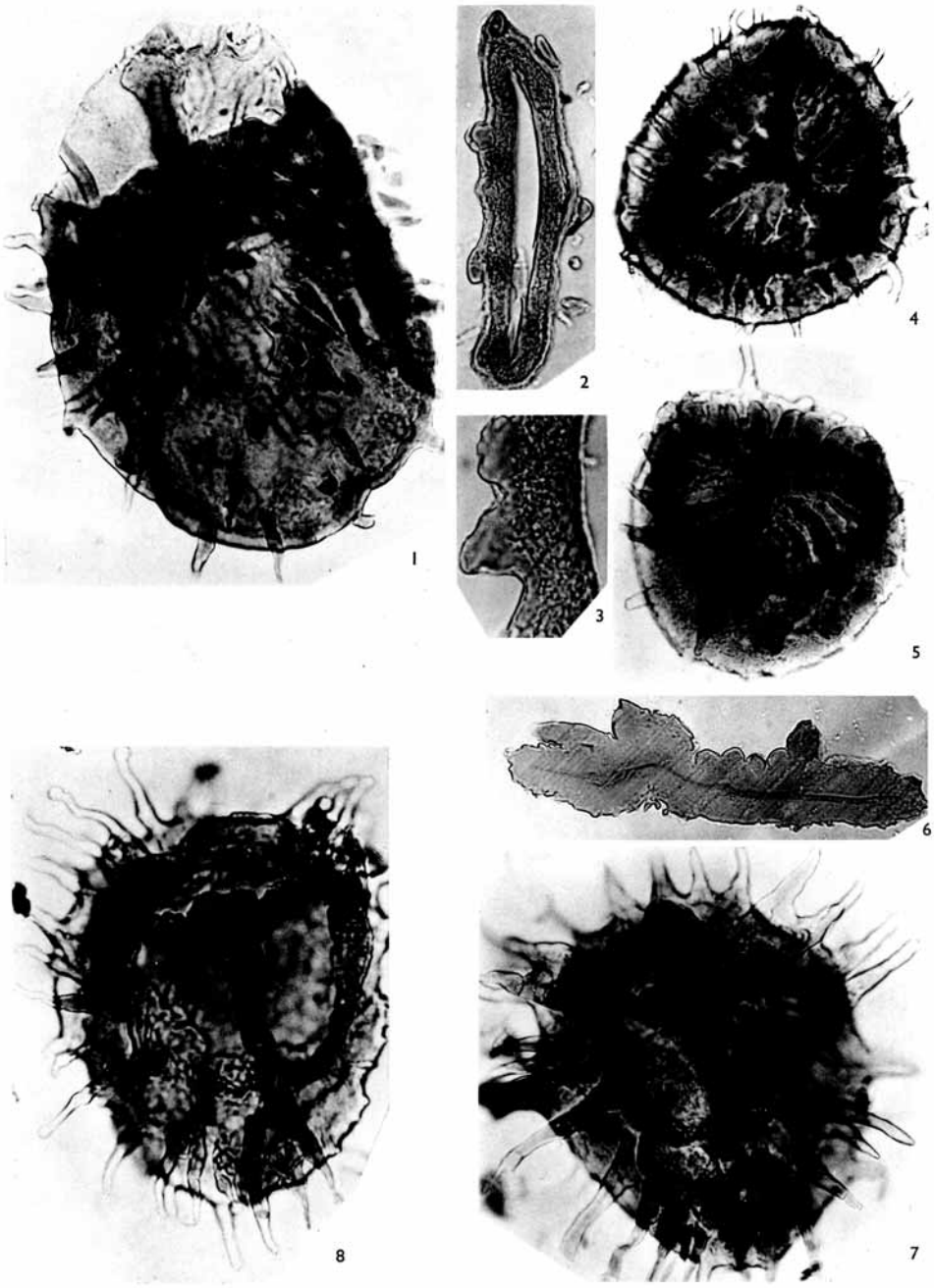
WINSLOW, M. R. 1962. Plant spores and other microfossils from Upper Devonian and Lower Mississippian rocks of Ohio. *Prof. Pap. U.S. geol. Surv.* **364**, 1–93.

K. C. ALLEN
Department of Geology,
Sedgwick Museum,
Cambridge

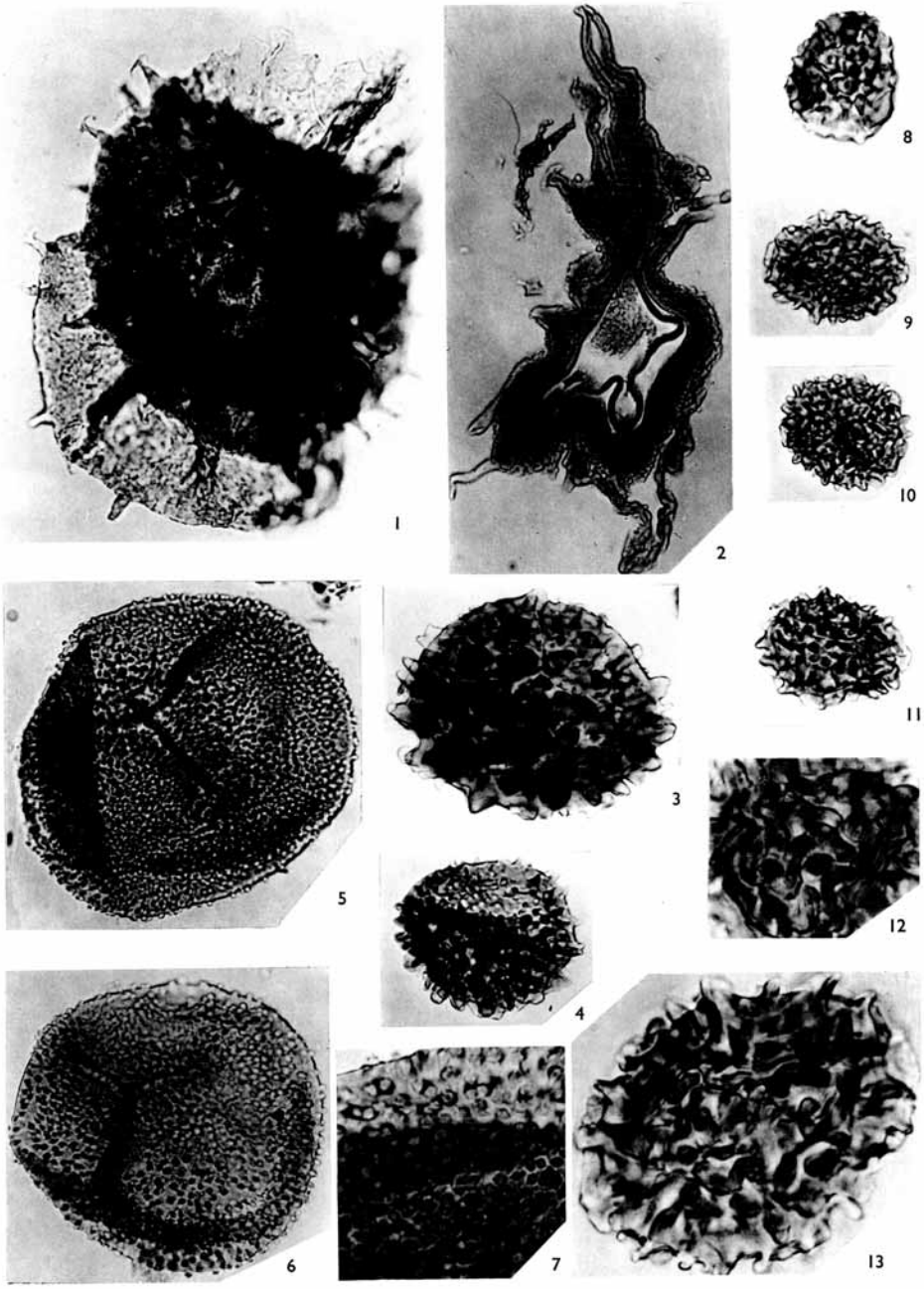
Manuscript received 30 October 1964



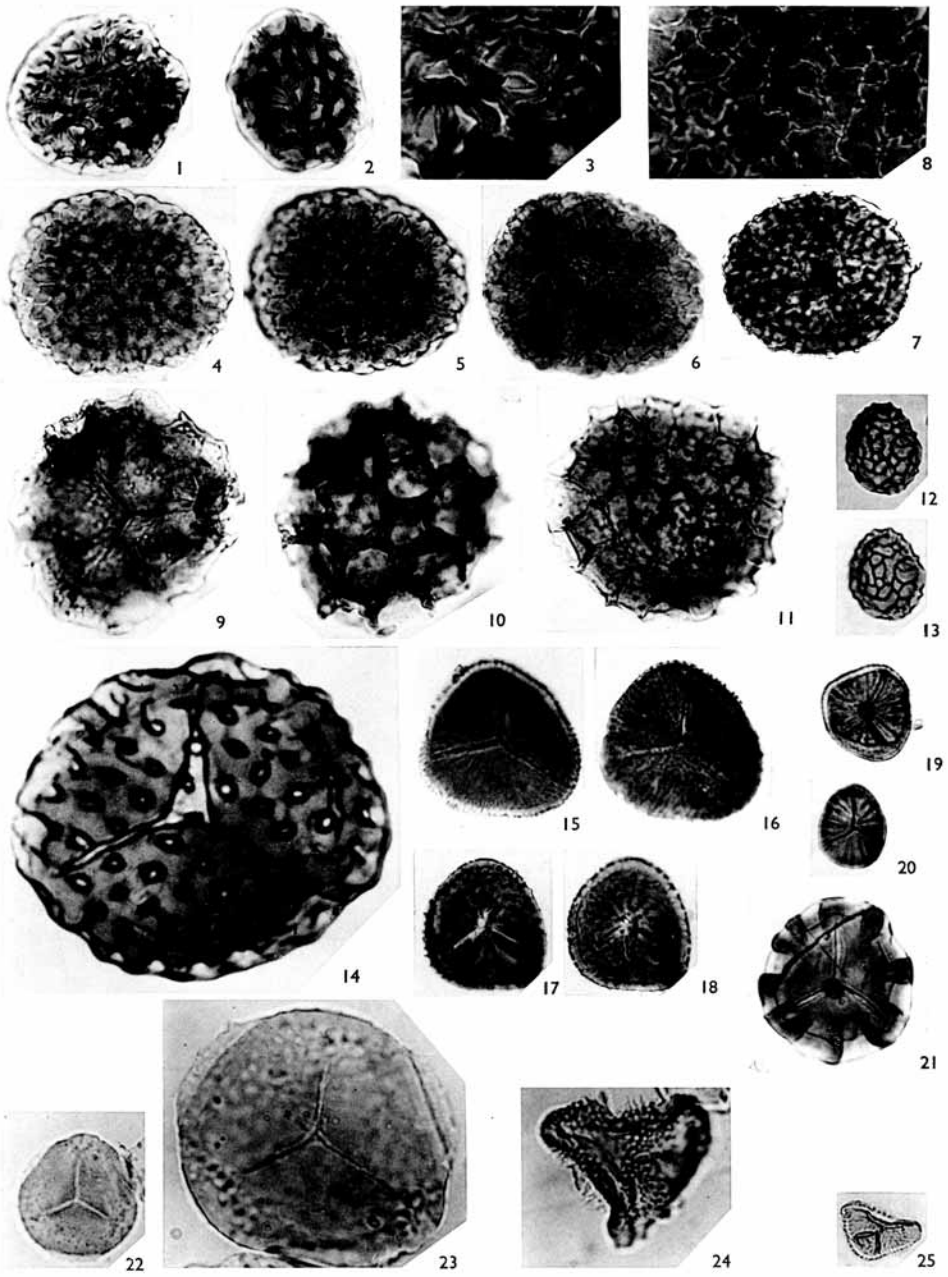
ALLEN, Lower and Middle Devonian miospores



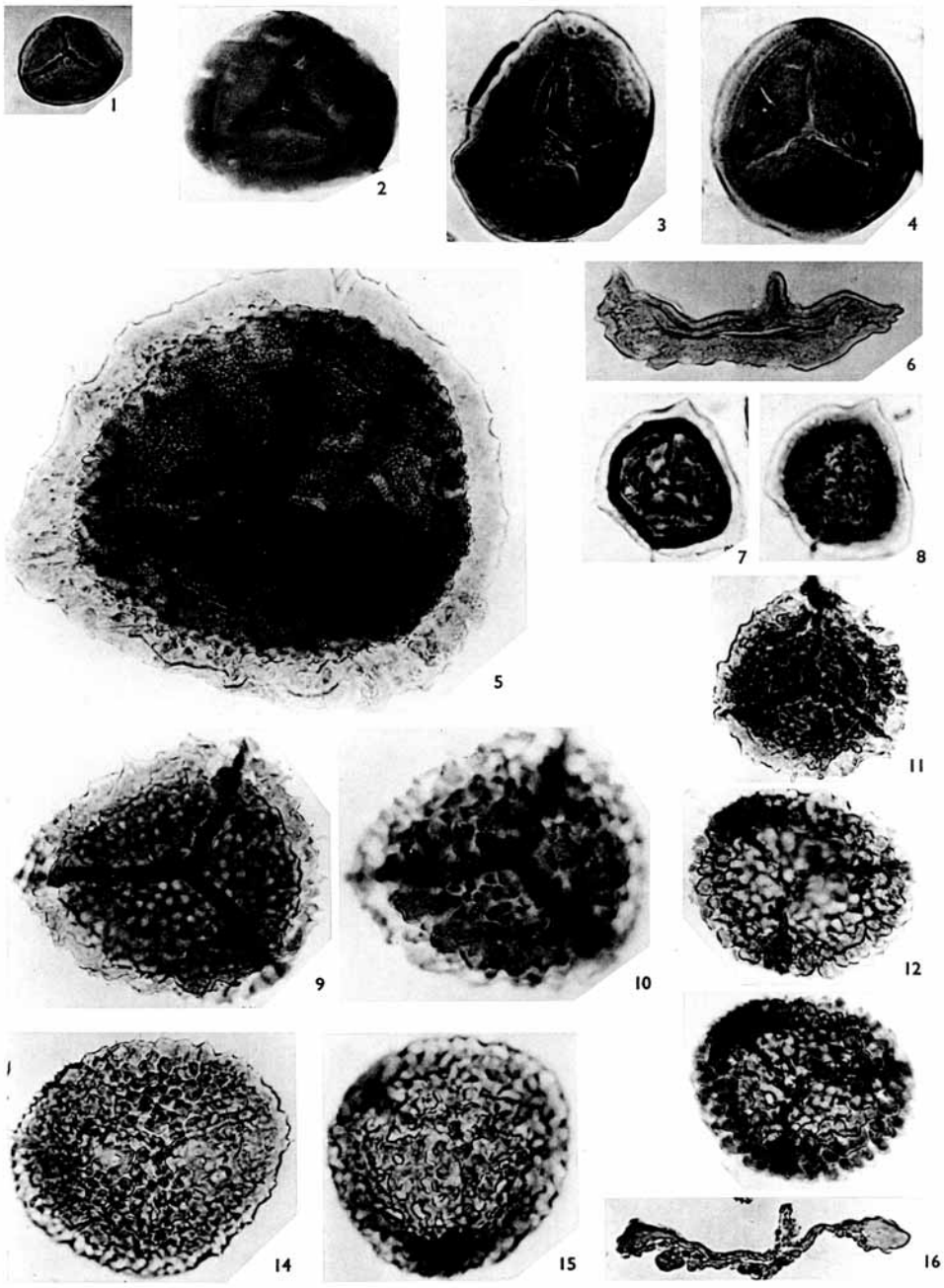
ALLEN, Lower and Middle Devonian miospores



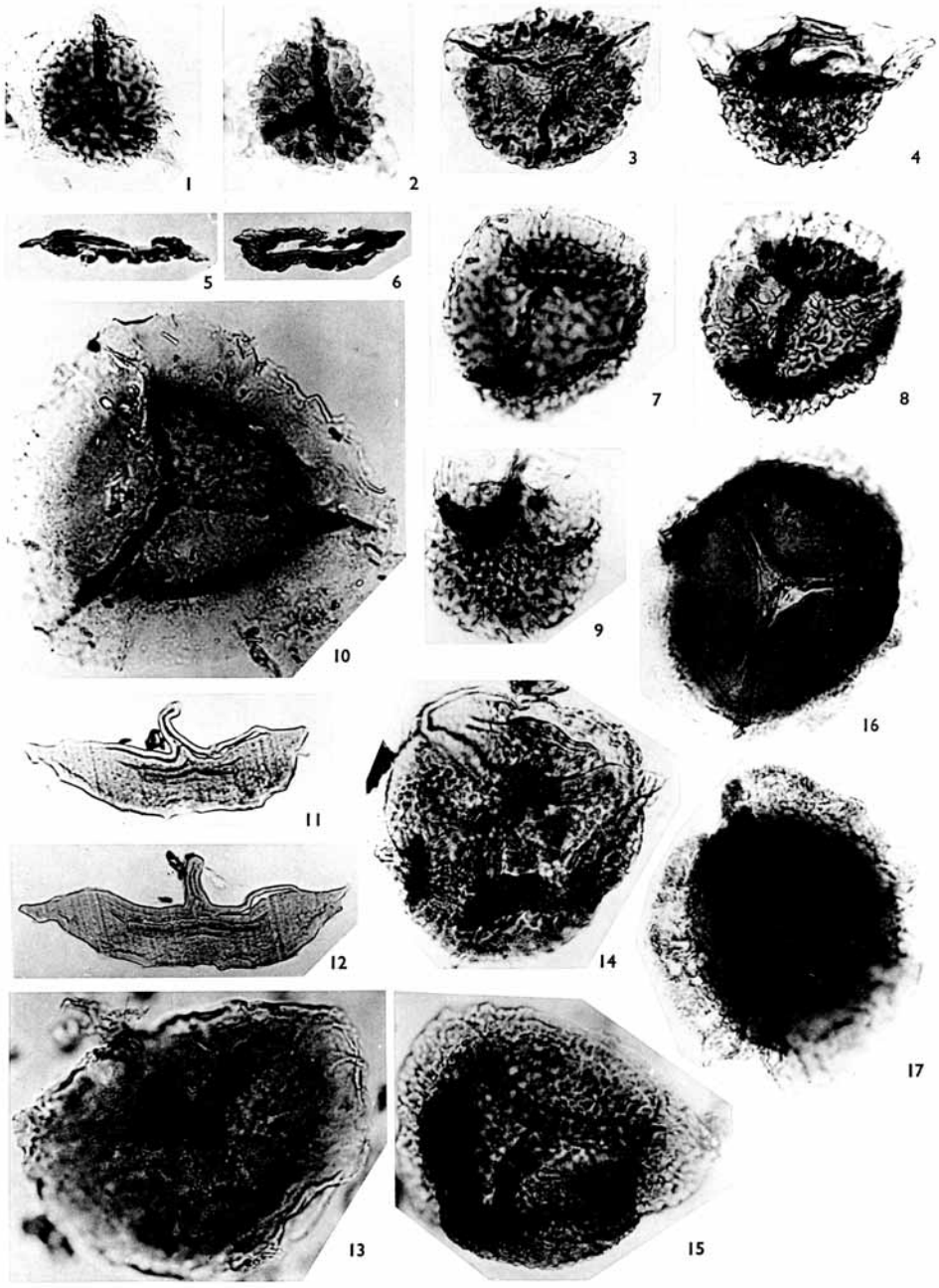
ALLEN, Lower and Middle Devonian miospores



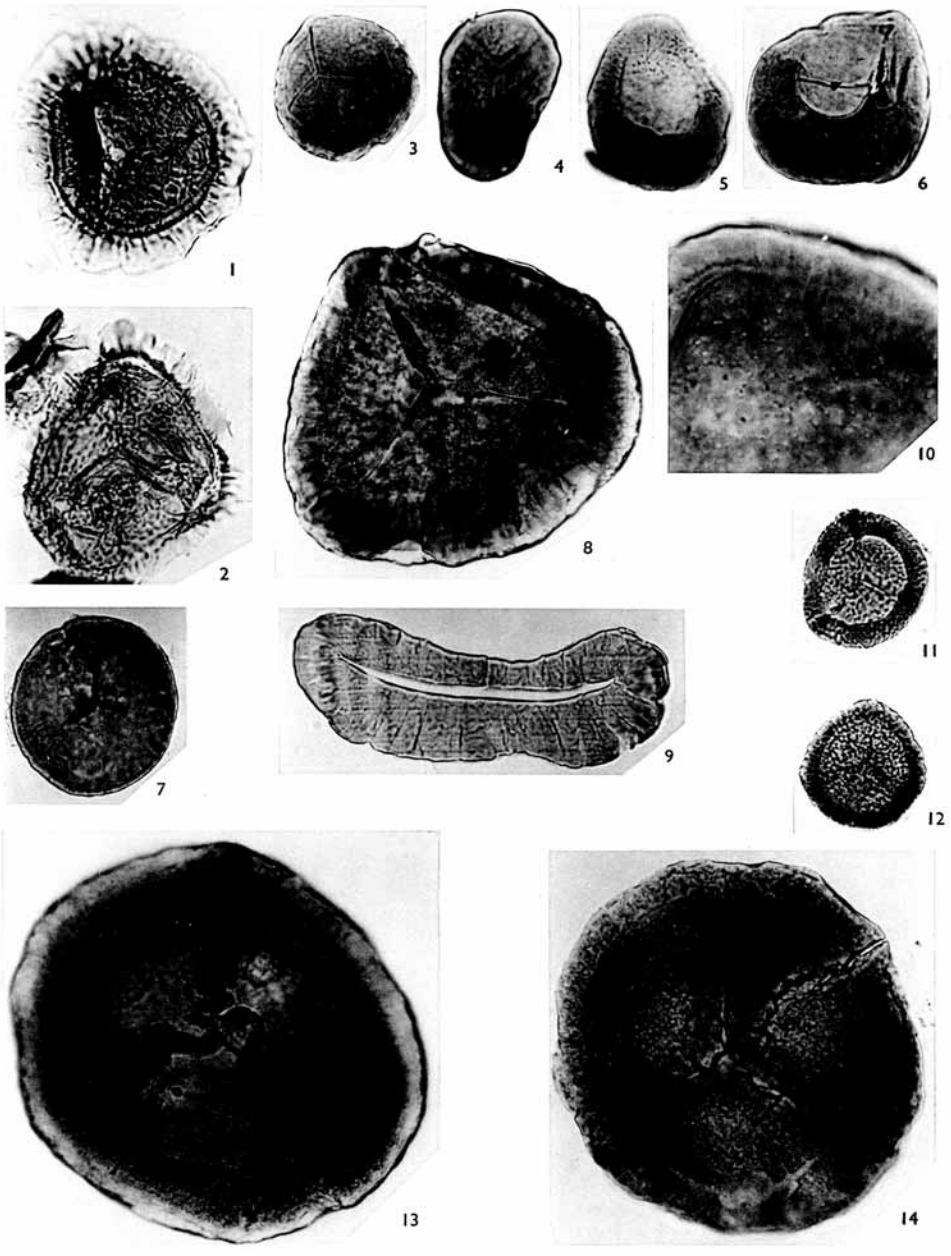
ALLEN, Lower and Middle Devonian miospores



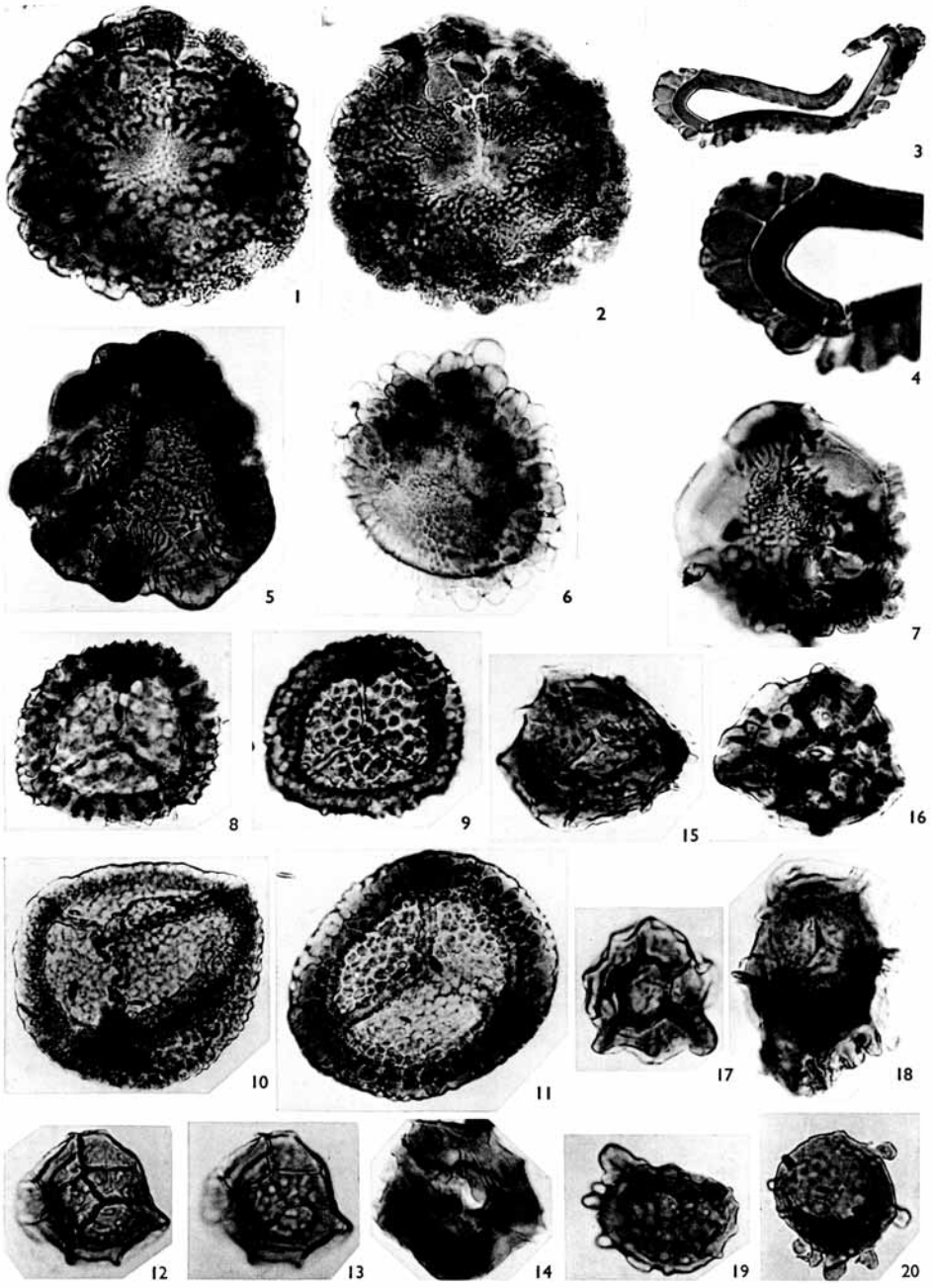
ALLEN, Lower and Middle Devonian miospores



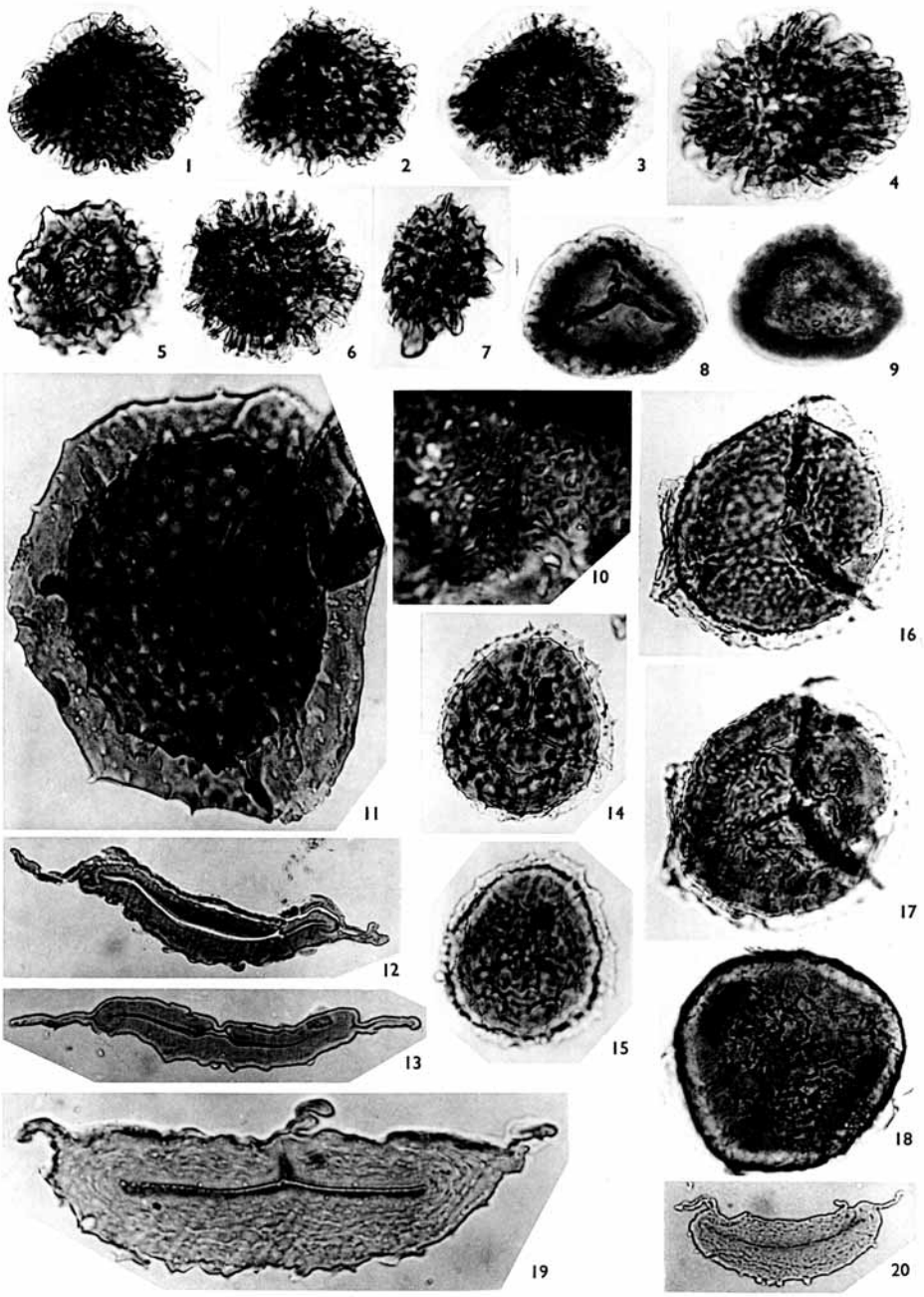
ALLEN, Lower and Middle Devonian miospores



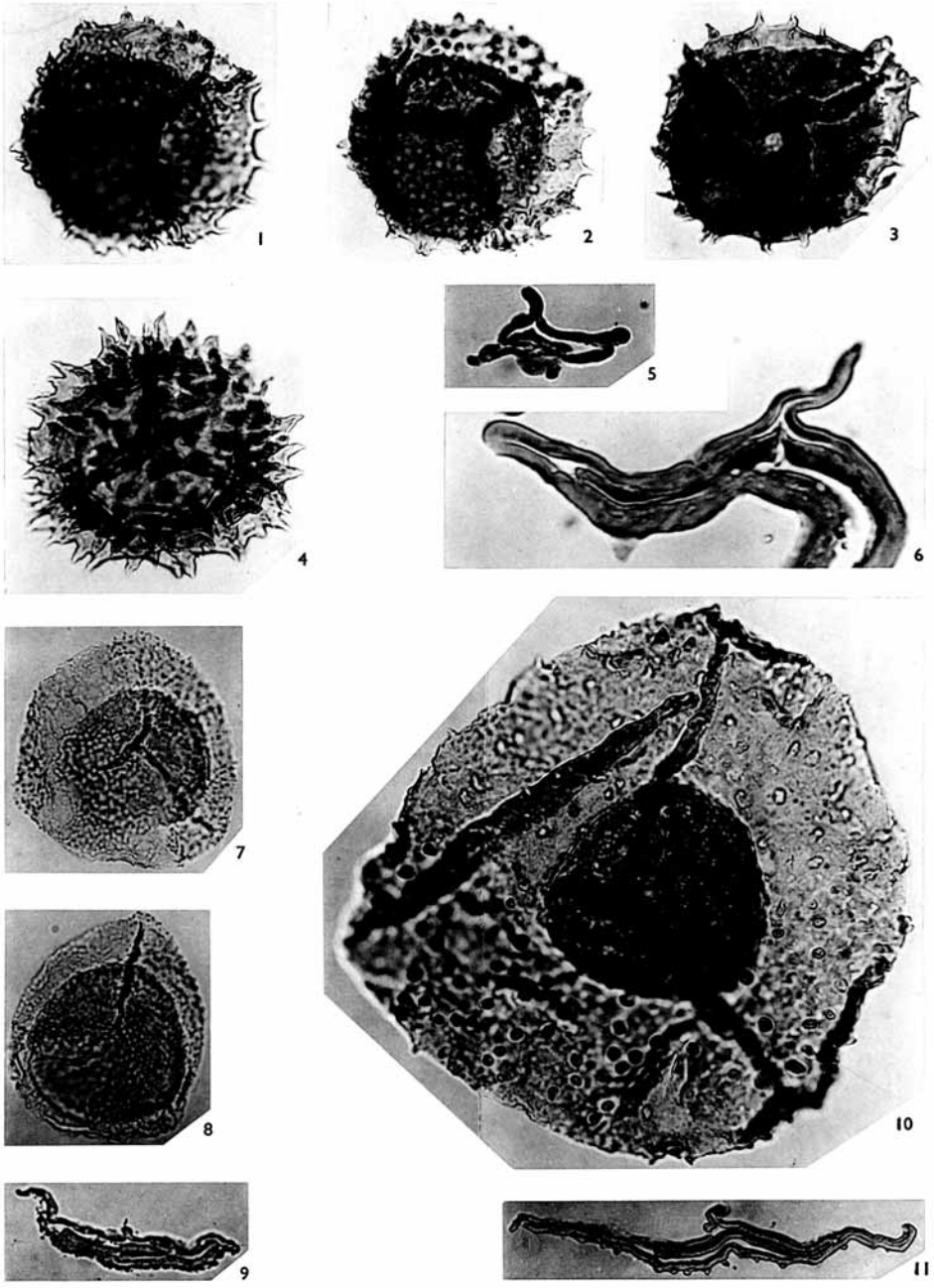
ALLEN, Lower and Middle Devonian miospores



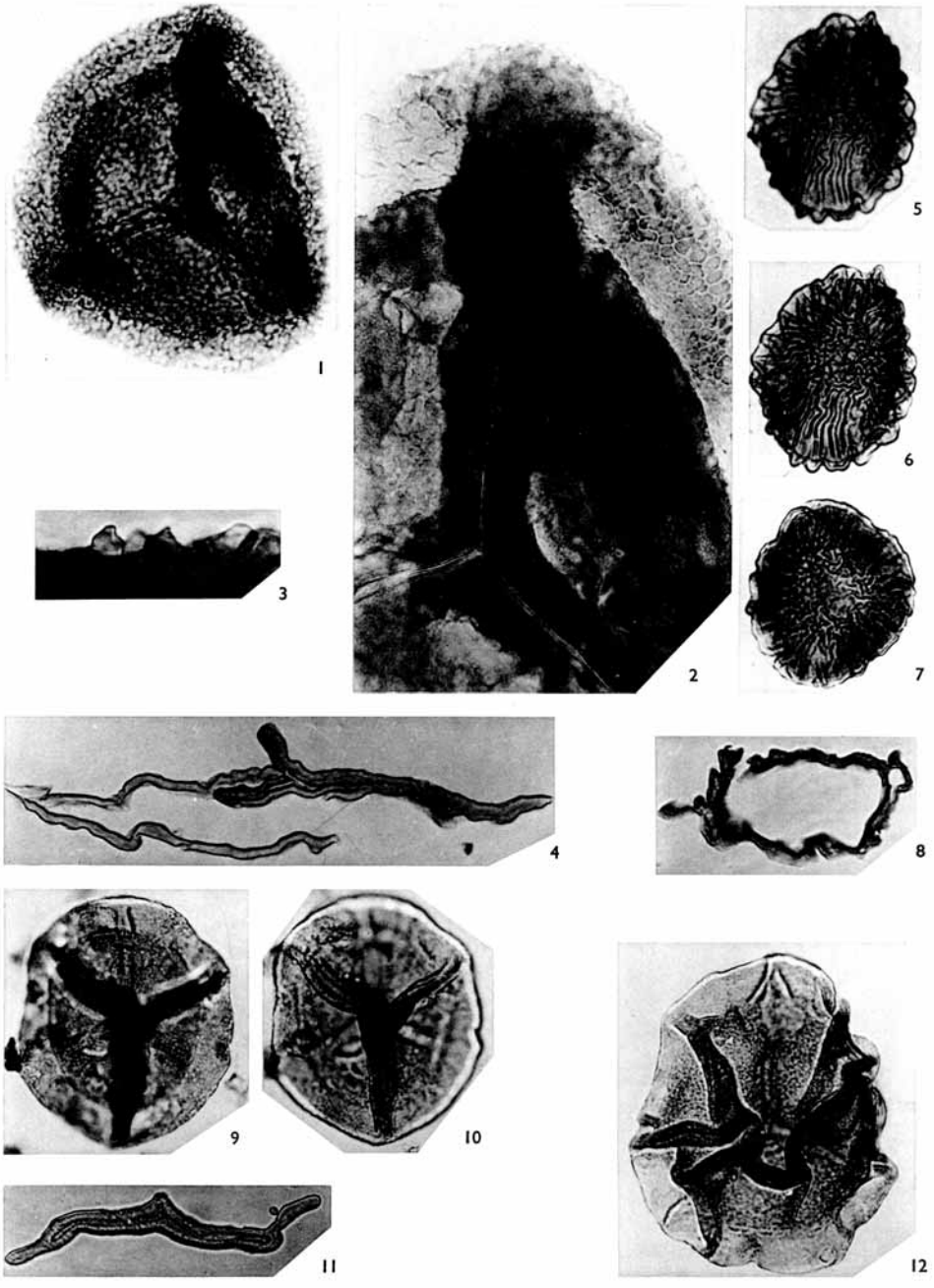
ALLEN, Lower and Middle Devonian miospores



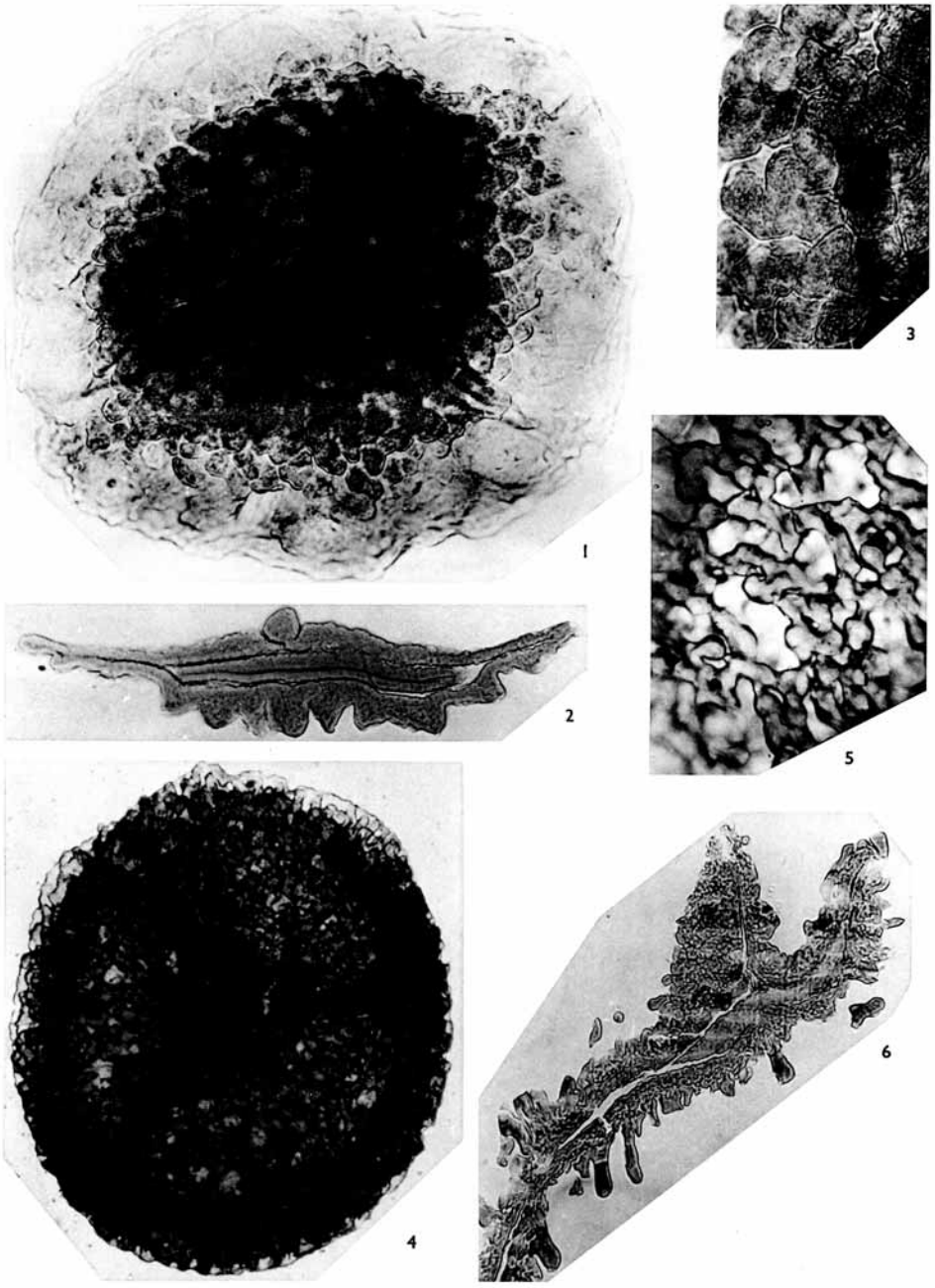
ALLEN, Lower and Middle Devonian miospores



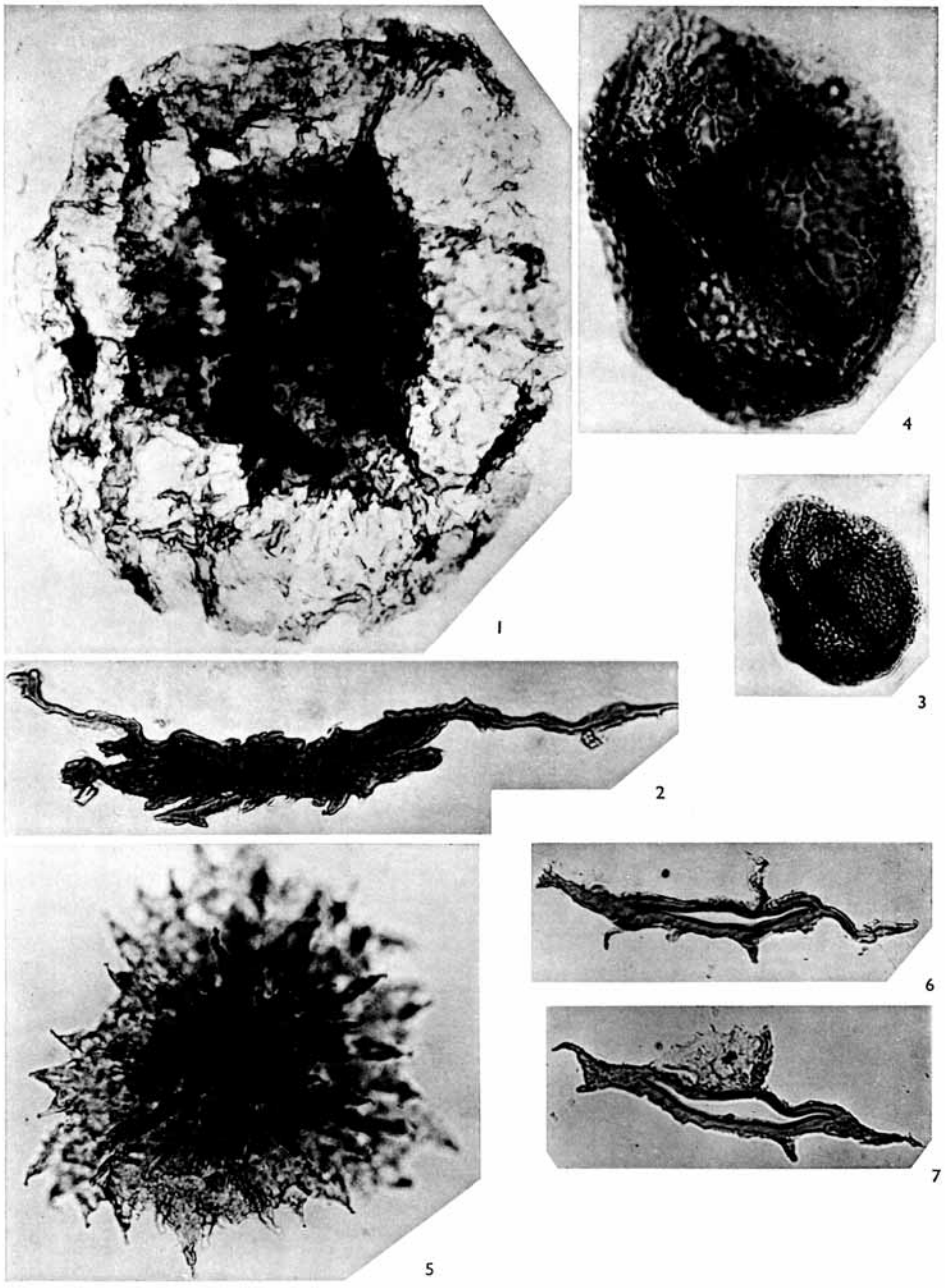
ALLEN, Lower and Middle Devonian miospores



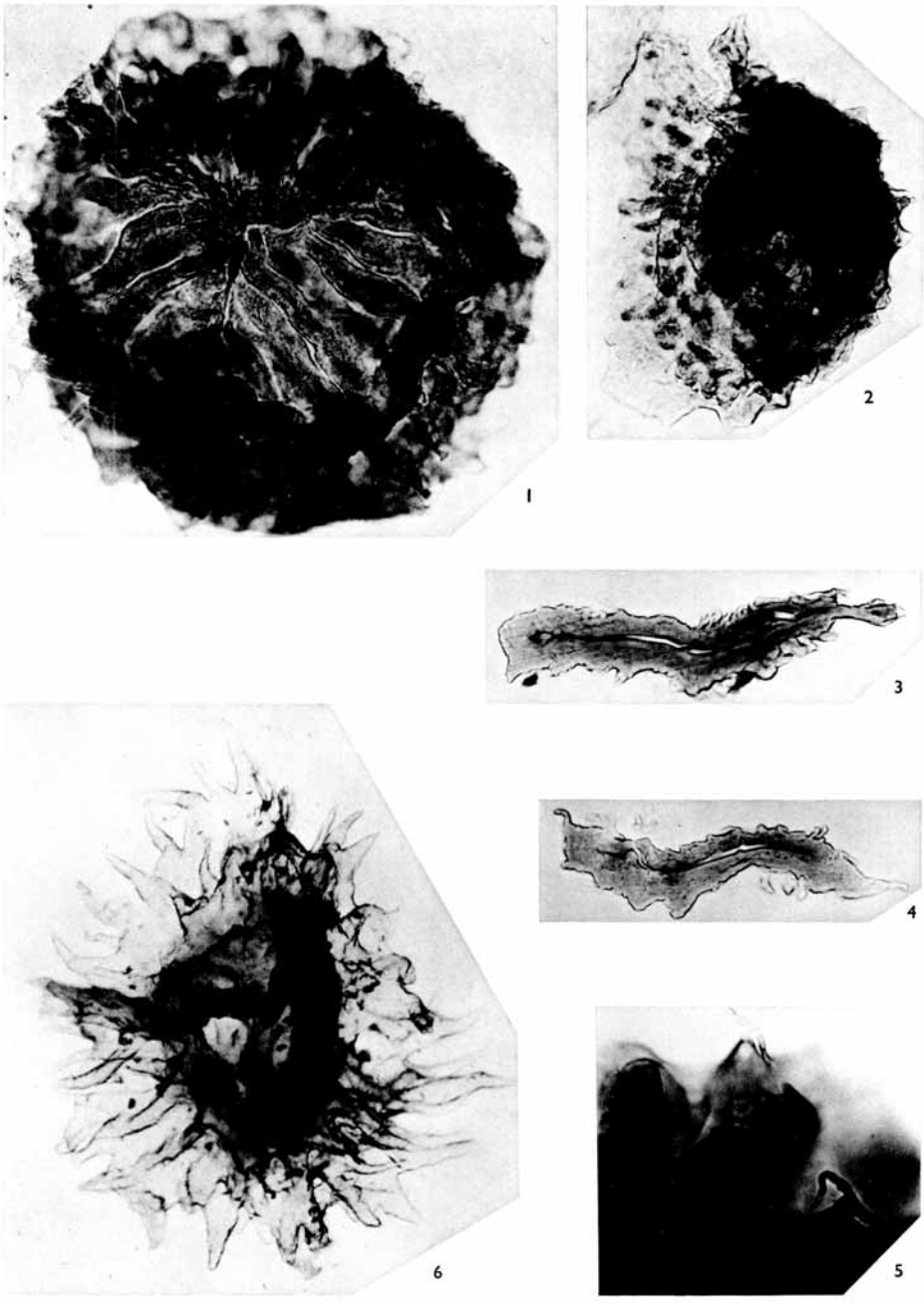
ALLEN, Lower and Middle Devonian miospores



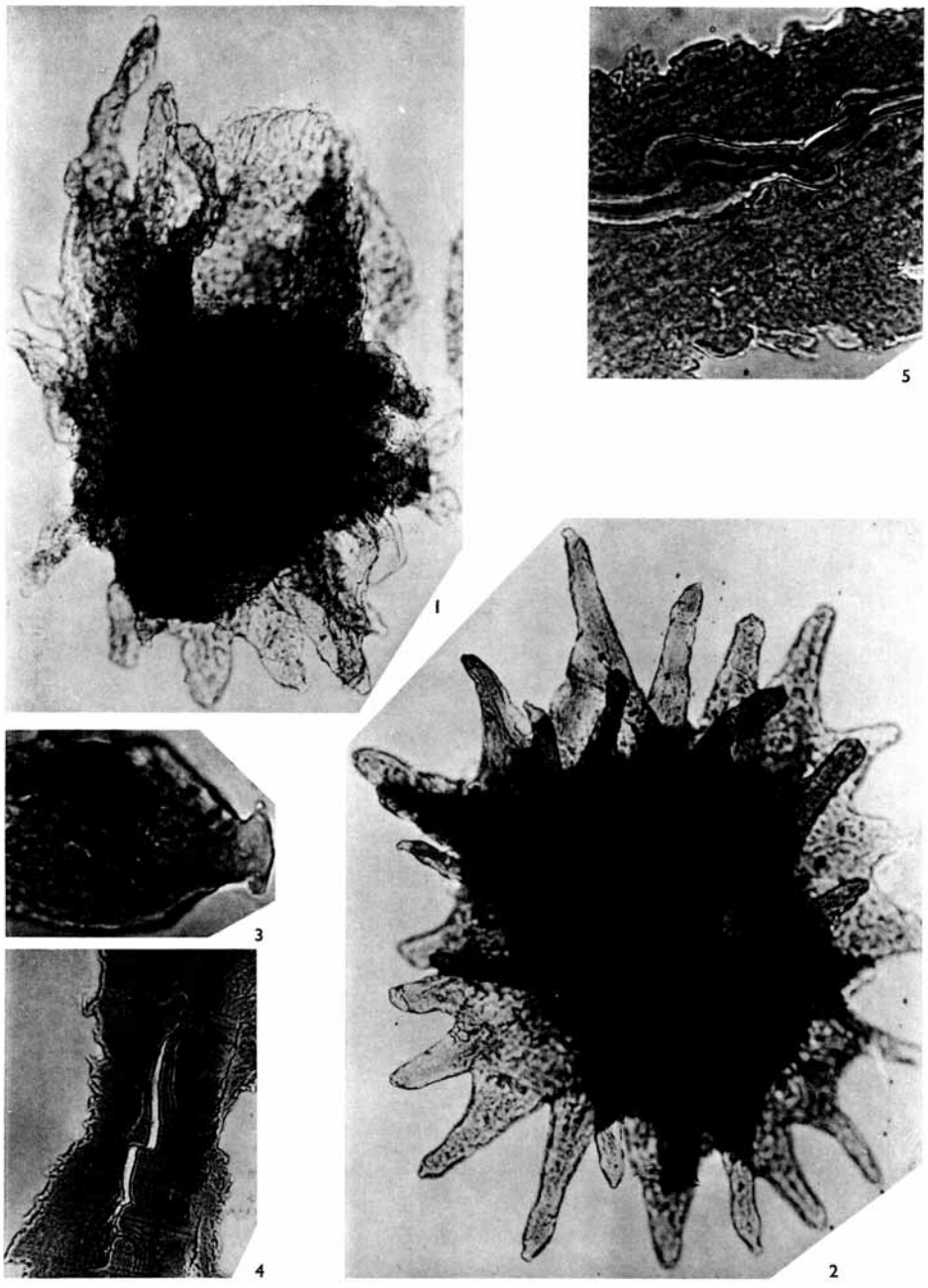
ALLEN, Lower and Middle Devonian miospores



ALLEN, Lower and Middle Devonian miospores



ALLEN, Lower and Middle Devonian miospores



ALLEN, Middle Devonian megaspores