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JORUNN OS VIGRAN

SPORES FROM DEVONIAN DEPOSITS, MIMERDALEN, SPITSBERGEN

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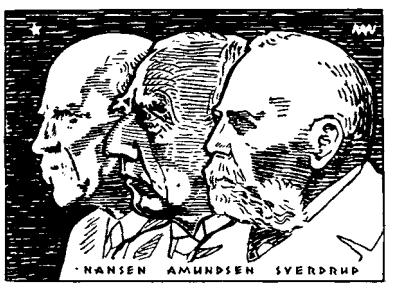

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Contents

Abstract

Spore assemblages from the Middle to Upper Devonian (Givetian and probably Frasnian) of Vestspitsbergen have been studied. Altogether 27 spore types have been recognized, 12 of which are described as new species. One new genus, *Enigmophytospora,* has been established.

Introduction

Material. This paper deals with spores recovered from samples of the Devonian beds in the Mimerdalen area of Vestspitsbergen (HØEG 1942, Figs. 1 and 4, approximate geographical coordinates 78° 40′ N, 16° E). One sample is a cannel coal collected on VOGT's expedition in 1928 (Middle Devonian, bed 5CC, VOGT 1941, pp. 5–7). The other samples come from the Upper Svalbardia Sandstone (bed 8 c, VOGT l.c., p. 5). One specimen (PA 393) was collected on VOGT's expedition in 1925, the others were collected by HØEG on VOGT's expedition in 1928.

The macroflora of the Upper Svalbardia Sandstone was described by HØEG (1942), who also described 9 types of spores. As the result of comparisons with other Devonian floras, HØEG concluded that the age of the sandstone was Middle to Upper Devonian, probably lowermost Upper Devonian.

The specimens used for the present study bear the following catalogue numbers of Universitetets Palontologiske Museum, Oslo, PA 391, 393, and 470 from Planteklöfta, PA 306, 330, 335, 347, 354, 1259, all from Planteryggen, and PA 2080 from Estheriahugen.

Preparation of the material. The cannel coal was ground and treated with Schulze's mixture for approximately 20 hours, then rinsed with water and cleared with cold two per cent potassium hydroxide.

The sandstone samples were left for about 18 hours in hydrofluoric acid, the residues treated with hydrochloric acid followed by maceration with Schulze's mixture; the time required for the maceration was from 10 minutes to a couple of hours. Only a very mild alkali treatment was necessary.

The spore suspensions were mounted unstained in glycerol jelly, and the preparations sealed with wax.

The slides are kept in the collections of Universitetets Paleontologiske Museum, Oslo, under the common catalogue number PAP 5. The coordinates given in each

description refer to the mechanical stage of Leitz Ortholux nr. 518 886. The microscope belongs to Institutt for Geologi, Avd. D, Universitetet i Oslo.

Measurements. Diameter ranges given in the descriptions refer to the total size range of the specimens measured for each species.

The median measurement has been chosen as the representative size for a spore type. From a statistical point of view the median is considered to be better than an arithmetric mean because it is less affected by extreme sizes of the spores. This point is particularly important when the number of spores available for measurement is small and the spores at the same time have a wide diameter range. When the size distribution is symmetrical, the median and the arithmetric mean are identical.

In order to convey more information regarding the most common spore sizes, I have used the interquartile range which for each spore type gives the range of the middle 50 per cent of the measurements.

Classification. When possible, the spores have been compared with and referred to previously described species of corresponding age. In many cases the identification has been complicated by the lack of adequate descriptions or by the use of different systems of classification in the literature. In the present paper the system of POTONIÉ & KREMP (1954) has been followed.

No attempt has been made to describe all the infrequent spore types present in the samples. New species have not been established unless approximately 20 specimens or more were available.

Descriptions

SPORITES
TRILETES
AZONOTRILETES
Laevigati

Genus *Leiotriletes* NAUM. emend. POT. & KR.

1939. *Leiotriletes* NAUMOVA, p. 355.
1954. *Leiotriletes* NAUM. emend. POTONIÉ & KREMP, p. 120.

Leiotriletes sp.
Pl. I, Figs. 1, 2.

Description

Trilete microspores, subtriangular in equatorial outline. The laesurae are of equal length, one half to two thirds of the radius. Terminal parts of laesurae occasionally surrounded by folds. The wall, which is smooth, in most specimens appears punctate to maculate in surface view, while in optical section it seems homogeneous, or as if consisting of radiating elements, like alternating light and dark bands. The outer surface of other specimens shows the presence of scattered pits of varying depth, less than 0,7 μ across.

Dimensions. Range of 40 spores 40–78 μ, median 60 μ, interquartile range 52–67 μ. Thickness of the exine 1,3–2,6 μ.

Figured specimens. 90: 116,7–38,2 (Pl. I, Fig. 1), 91: 124,8–32,1 (Pl. I, Fig. 2). PA 2082.

Comments

The bodies here described as *Leiotriletes* sp. cannot be distinguished from the inner part of the two-layered spores described below (p. 19) under the name of *Calyptosporites plicatus* n. sp.

Leiotriletes sp. is frequent in the cannel coal.

Genus *Punctatisporites* IBR. emend. POT. & KR.

1933. *Punctati-sporites* IBRAHIM, p. 21.
1954. *Punctatisporites* IBR. emend. POTONIÉ & KREMP, p. 120.

Punctatisporites cf. *stabilis* PLAYF.

Pl. I, Figs. 5, 6.

1962. *Punctatisporites stabilis* PLAYFORD, p. 578–9.

Description

Trilete microspores, subcircular in equatorial outline. Laesurae straight or slightly curved, often of unequal length, one third to two thirds of the radius. Exine smooth, maculate, outer surface occasionally with pits, less than 1 μ across. In some specimens an inner very thin layer indicates a two-layered construction of the wall.

Dimensions. Range of 31 spores 26–60 μ, median 46 μ, interquartile range, 41–50 μ. Thickness of exine 1,3–2,6 μ.

Figured specimens. 11: 122,4–38,4 (Pl. I, Fig. 6), 12: 112,0–34,9 (Pl. I Fig. 5). PA 1259.

Comments

P. cf. *stabilis* is considerably smaller than *P. stabilis* PLAYF., the laesurae are shorter and the pits are irregularly distributed.

P. cf. *stabilis* is frequent in samples of the Upper Svalbardia Sandstone.

Genus *Phyllothecotriletes* LUB.

1955. *Phyllothecotriletes* LUBER, p. 37.

Phyllothecotriletes microgranulatus n. sp.

Pl. I, Figs. 7, 8.

1942. Microspores from an *Enigmophyton* (*?*) fructification HØEG, pp. 117–9, Pl. XLIX, Figs. 6–8, 12.

Diagnosis

Trilete microspores, subtriangular to subcircular in equatorial outline, diameter 50–85 μ. Laesurae simple, about one third of the radius. Contact areas indicated by variation in the transparency of the exine. Surface smooth or slightly roughened.

Dimensions: Median of 25 spores 72 μ, interquartile range 65–75 μ. Exine 0,5–1,5 μ thick.

Holotype. 21: 117,2–42,2 (Pl. I, Fig. 7); Paratype. 23: 123,4–37,5 (Pl. I, Fig. 8).

Type locality. Plantekløfta, PA 470.

Description

Holotype: Diameter 73 μ, wall about 1 μ thick. The laesurae are of unequal length, one fourth to one third of the radius. The contact areas are delimited by indistinct, light lines.

Other specimens: In several specimens the contact areas are darker than the rest of the wall. Sometimes scattered elements, like grana, up to 0,6 μ in diameter, occur on the distal surface.

Comments

Identical spores were described by HØEG (1942) from macerated sporangia picked out of a spike (in HØEG's specimen PA 470) of the type which HØEG re-

garded as belonging to *Enigmophyton superbum* although not found in organic connection with the vegetative parts.

I have found these spores in rock samples as well as in macerated sporangia (from HØEG's specimens PA 391 and 470). The spores from sporangia seem to have slightly thinner walls than those found dispersed.

P. microgranulatus resembles *P. rigidus* PLAYFORD (1962, p. 580–581) which, however, has a more restricted size-range and a thicker wall in relation to its size. *Leiotriletes microdeltoidus* MCGREGOR (1960, p. 28) is smaller than *P. microgranulatus* and has shorter laesurae, their terminal parts being connected by dark lines (which, to judge from the illustration, seem to represent thickenings of the exine).

P. microgranulatus is frequent in all samples of the Upper Svalbardia Sandstone.

Phyllothecotriletes sp.
Pl. I, Fig. 13.

Description

Trilete microspores, subtriangular to subcircular in equatorial outline. Laesurae about one third of the radius. The contact areas differ from the rest of the wall by being of a lighter colour, or they are delimited by light lines connecting the terminal parts of the laesurae. Spores smooth or distally ornamented with scattered projections resembling grana, less than 0,7 μ. In optical section the wall appears homogenous while it is punctate in surface view.

Dimensions. Range of 24 spores 26–50 μ, median 33 μ, interquartile range 30–36 μ. Exine about 1,3 μ thick.

Figured specimen. 91: 116,0–29,6 (Pl. I, Fig. 13) PA 2082.

Comments

Phyllothecotriletes sp. resembles *P. microgranulatus* n. sp. but is considerably smaller. It is also smaller and has a thinner wall than *P. rigidus* PLAYFORD (1962, pp. 580–1). *Leiotriletes microdeltoidus* MCGREGOR (1960, p. 28) is of similar size, but differs from *Phyllothecotriletes* sp. by the presence of dark lines (thickenings) connecting the terminal parts of the laesurae. *Phyllothecotriletes* sp. differs from the specimen of *Camarozonotriletes minutus* NAUM. figured by CHIBRIKOVA (1959, p. 81) in which the wall seems thickened in the equatorial region. *Phyllothecotriletes* sp. has been seen only in the cannel coal where it is frequent.

Genus *Enigmophytospora* n. gen.
Type species: *Enigmophytospora simplex* n. sp.

Diagnosis

Trilete megaspores with a smooth, or nearly smooth, wall. Laesurae distinct, about one third of the radius or shorter. Equatorial outline originally circular, subcircular in flattened specimens. Equatorial diameter of laterally flattened specimens shorter than the polar axis.

Comments

Phyllothecotriletes LUB. includes microspores of similar organization. In addition to the difference in size, *Enigmophytospora* is also characterized by the longer polar axis of the spores.

Affinity. The type species includes spores which have been obtained from macerated sporangia (from PA 391) of two spikes probably belonging to *Enigmophyton* HØEG (1942).

Enigmophytospora simplex n. sp.
Pl. I, Fig. 9.

1942. Megaspores from an *Enigmophyton ?* fructification HØEG, pp. 118–9, Pl. XLIX, Figs. 9–11, 13.

Diagnosis

Trilete megaspores, subcircular in equatorial outline, diameter 240–290 μ. Laesurae straight, simple, one third of the radius or shorter. Contact areas indistinct, but the exine may be darker in this region. Surface smooth or minutely granulate.

Dimensions. Median of 39 spores 270 μ, interquartile range 260–295 μ.

Holotype. 137: 118,3–34,9 (Pl. I, Fig. 9).

Type locality. Plantekløfta, PA 470.

Description

Holotype: The spore has several long distal folds giving it a subcircular outline, longest diameter 290 μ. The surface is nearly smooth. In optical section the wall is punctate, 4,0—5,2 μ thick. The laesurae are distinct.

Other specimens: Less well preserved spores often have a more or less roughened, sometimes pitted surface. Laterally flattened specimens are scarce, but when found their polar axis is the longer one. The folds mentioned in the holotype probably indicate that the polar axis, also in this specimen, originally has been longer than the equatorial diameter.

Spores of this type have been recovered from rock samples (of PA 470) and also by maceration of sporangia from two spikes (in PA 391). HØEG (1942, pp. 118–9) obtained the same type of spores from this material (sporangia in spikes assumed to belong to *Enigmophyton* from PA 470). However, trilete scars could not be observed with certainty in these spores. As was also pointed out by HØEG, the megaspores, apart from the difference in size, resemble the microspores from the same fructification, here described as *Phyllothecotriletes microgranulatus* n. sp. (p. 8).

Genus *Emphanisporites* MCGR.

1961. *Emphanisporites* MCGREGOR, p. 3.

Emphanisporites neglectus n. sp.
Pl. I, Figs. 14–16.

Diagnosis

Trilete microspores with finely undulated, sub-triangular equatorial outline, diameter 9,5–17 μ. Laesurae with narrow, slightly elevated lips, extending to, or almost to, the equator. Each contact area with 8–15 thickenings appearing as meridional striations. The exine appears to be thickened equatorially.

Dimensions. Median of 25 spores 15 μ, interquartile range 14–16 μ. Thickness of the wall in the equatorial region 1,3–2,6 μ. Lips about 1 μ broad.

Holotype: 91: 119,2–40,3 (Pl. I, Fig. 16); Paratype. 87: 116,9–37,1 (Pl. 1, Figs. 14, 15).

Type lokality. Estheriahaugen, PA 2082.

Description

Holotype: Diameter 15,5 μ. Lips less than 1 μ broad, extending almost to the equator. Each contact area with about 14 meridional ribs, which seem restricted to the proximal part of the spores; in the equatorial region they make the outline undulate.

Other specimens: The exine is always strongly light deflective. This feature, and the small size of the spores obscure observation of wall-structures. Laterally compressed specimens have not been observed.

Comments

E. neglectus is considerably smaller than any of the spores previously included in the genus *Emphanisporites*. It is with some hesitation that I have referred the spores to this genus because it is often difficult to ascertain whether the meridional thickenings are restricted to the proximal surface. Apart from its smaller size, *E. neglectus* shows similarity to *E. rotatus* McGregor (1961, p. 3) which, however, has a smooth outline and fewer meridional ribs.

These spores have been observed only in macerations of the cannel coal where they occur frequently.

Apiculati

Genus *Verrucosisporites* Ibr. emend. Pot. & Kr.

1933. *Verrucosi-sporites* Ibrahim, p. 24.

1954. *Verrucosisporites* Ibr. emend. Potonié & Kremp, p. 137.

Verrucosisporites sp.

Pl. I, Figs. 19, 20.

Description

Trilete microspores, equatorial outline sub-triangular. Laesurae approximately as long as the spore radius. The exine seems thickened equatorially as if the ornamentation of verrucae or rugae is more prominent in this region. The ornamenting elements of well preserved spores bear scattered conical projections up to 1,3 μ high. The ornamentation of some specimens tends to be in the form of a negative reticulum with meshes of irregular form and size. The exine is punctate, and in a few cases it seems to consist of two layers, the outer layer being punctate, the inner, thinner one radially striated as if consisting of alternating dark and light bands.

Dimensions. Diameter range (18 spores measured) 40–72 μ, median 50 μ, interquartile range 47–56 μ. Exine 1,3–5,2 μ at the equator, ornamentation included. Rugae or verrucae up to 6,5 μ long, 4 μ high.

Figured specimen. 61: 123,9–42,1 (Pl. I, Figs. 19, 20) PA 335.

Comments

The spores described above have been referred to *Verrucosisporites* with some hesitation because of the usually poorly defined sculpture, and because of the thickening of the wall in the equatorial region; however, a distinct cingulum has never been observed.

Spores of this type have been found in small numbers in the cannel coal and in the Upper Svalbardia Sandstone.

Genus *Biharisporites* POT.

1956. *Biharisporites* POTONIÉ, p. 31.

Biharisporites spitsbergensis n. sp.

Pl. II, Figs. 1–4.

1942. *Granulati* type *a*, HOEG, p. 147, Pl. XXXI, Fig. 12.

Diagnosis

Trilete megaspores, subtriangular in equatorial outline, diameter 155–415 μ. Laesurae two thirds of the radius or longer, with slightly elevated lips. Contact areas smooth, surface otherwise densely covered with small coni. Exine two-layered, with an inner, filmy layer which is usually detached and then appear as a separate, folded sac.

Dimensions. Median of 52 spores 240 μ, interquartile range 215–315 μ. Coni 1,0–5,5 μ wide, 1,0–6,5 μ high. Exine 2,5–6,5 μ thick.

Holotype. 157: 121,1–40,3 (Pl. II, Figs. 1, 2). Paratypes. 333: 119,0–37,3 (Pl. II, Fig. 4), 367: 119,2–37,5 (Pl. II, Fig. 3).

Type locality. Planteryggen, PA 335.

Description

Holotype: Equatorial outline triangular with rounded angles, greatest diameter 215 μ. Laesurae straight, unequal in length, not extending to the equator. Lips about 2,5 μ broad, slightly elevated. Contact areas smooth, limited by low folds of the wall. Otherwise the surface has evenly distributed, pointed coni, up to 1,3 μ in diameter, and about 1,3 μ high. Exine 3 μ or thinner.

Other specimens: Outer layer of the exine often maculate. Sculptural elements more or less rounded, always closely arranged, in some specimens touching each other at the base.

Comments

B. spitsbergensis differs from *B. ellesmerensis* CHALONER (1959, pp. 322–4) in its larger size, the two-layered wall, and the smaller, more crowded sculpturing elements. *B. submamillarius* MCGREGOR (1960, p. 33), on the other hand, is larger with coarser and more widely spaced sculpturing elements, and like *B. ellesmerensis* it has broader, more prominent lips than those of *B. spitsbergensis*. Spores identical with *B. spitsbergensis* were first found and described from the Upper Svalbardia Sandstone by HØEG (1942, p. 147) as *Granulati* type *a*.

Genus *Lophotriletes* NAUM. emend. POT. & KR.

1939. *Lophotriletes* NAUMOVA, p. 355.

1954. *Lophotriletes* NAUM. emend. POTONIÉ & KREMP, p. 129–30.

Lophotriletes uncatus NAUM. nov. comb.
Pl. I, Figs. 3, 4.

1953. *Acanthotriletes uncatus* NAUMOVA pp. 26 and 50.

Acording to the emendation of *Acanthotriletes* NAUM. by POTONIÉ & KREMP (1954, p. 133), this species, with an ornamentation of coni rather than of spinae, has to be transferred to *Lophotriletes*.

Description

Spores subcircular to subtriangular in equatorial outline. Laesurae straight, one half to two thirds of the radius, or even longer. Surface ornamented with coni, the largest ones usually found in the equatorial area, and often so closely arranged that they touch each other at the base. The coni of the proximal surface are smaller and rounded, while those of the distal surface are mostly pointed.

Dimensions. Range of 21 spores 26–67 μ, median 46 μ, interquartile range 40–56 μ. The wall is about 2,6 μ thick. Coni 2,6–8 μ high.

Figured specimen. 38: 116,6–33,0 (Pl. I, Figs. 3, 4) PA 393.

Comments

NAUMOVA (1953) included in her species specimens from two horizons, and the specimens in each of them were somewhat different regarding shape of equatorial outline, ranges of diameters, and relative lengths of laesurae. In the Spitsbergen specimens referred to *L. uncatus* a similar variation has been noticed in samples from one horizon. The spores cannot be referred to either of NAUMOVA's two types, but to the combination of the two.

L. uncatus is regularly found in the Upper Svalbardia Sandstone, but it is not of the most frequent species.

Genus *Anapiculatisporites* POT. & KR.

1954. *Anapiculatisporites* POTONIÉ & KREMP, pp. 130–1.

Anapiculatisporites devonicus var. *azonatus* CHIBR. nov. comb.
Pl. I, Figs. 21–23.

1962. *Diatomozonotriletes devonicus* var. *azonatus* CHIBRIKOVA, pp. 447–8.

As a consequence of the emendation of *Diatomozonotriletes* NAUM. by PLAYFORD (1963, pp. 646–7), this species has to be transferred to *Anapiculatisporites*.

Description

Trilete microspores, equatorial outline triangular with rounded angles. Laesurae with narrow lips, equal to or slightly shorter than the spore radius. Proximal surface smooth, distal surface with an ornamentation of evenly distributed coni. The projections of the interradial regions of the equator appear higher than those at the corners.

Dimensions. Diameter 16–34 μ, median 25 μ, interquartile range 22–28 μ, 60 specimens measured. Projections 0,6–1,7 μ wide, usually less than 1,3 μ high. Exine 0,5–1,5 μ thick.

Figured specimens. 87: 114,5–34,7 (Pl. I, Figs. 22, 23), 87: 120,8–29,5 (Pl. I, Fig. 21). PA 2082.

Comments

The specimens described by CHIBRIKOVA (from the uppermost Eifelian and the Givetian of the USSR), has shorter laesurae than those from Spitsbergen. *Anapiculatisporites apiculatus* GUENNEL (1963 pp. 250–1) from Upper Middle or Lower Upper Devonian of Illinois also differs from the Spitsbergen spores by shorter laesurae. It has a more restricted size range, and smaller conical projections, but otherwise closely resembles *A. devonicus* var. *azonatus*.

A. devonicus var. *azonatus* has been found in the cannel coal where it is the most frequent species.

Genus *Hystricosporites* McGr.

1960. *Hystricosporites* McGREGOR, p. 31.

Hystricosporites costatus n. sp.

Pl. V, Figs. 3–5.

1942. *Apiculati* type *f* HØEG, p. 148, Pl. XXXI, Figs. 17–19, Pl. XLIX, Fig. 15.

Diagnosis

Trilete microspores with a thick two-layered exine. Equatorial outline subcircular, diameter 75–165 μ. Laesurae one half to two thirds of the radius, with raised, flange-like, sometimes contorted lips. Contact areas distinct, each with 7–11 meridional ridges (striations). Exine otherwise with an ornamentation of scattered spinae with anchor-shaped tips.

Dimensions. Median of 70 spores 115 μ, interquartile range 100–130 μ. Exine 4–12 μ thick. Spinae 2,6–18 μ wide at the base, maximum height measured 47 μ. Lips 2–6 μ broad at the base, height 20–45 μ.

Holotype. 174: 121,0–38,7 (Pl. V, Figs. 3, 4); Paratype. 356: 120,0–40,8 (Pl. V, Fig. 5).

Type locality. Planteryggen, PA 335.

Description

Holotype: Rounded triangular in equatorial outline, diameter 133 μ. Laesurae about half the radius; lips about 4 μ broad at the base and elevated into a thin flange. The meridional ridges (striations), approximately 9 per contact area, are 4–8 μ broad, and less than 0,5 μ apart. Outside the contact areas the surface is ornamented by scattered spinae ending in an anchorshaped tip. The spinae are 4–8 μ broad at the base and 16–40 μ long. The exine is 5,0–6,5 μ thick in the equatorial region, and in optical section it appears maculate.

Other specimens: The exine of the contact areas has an undulating surface due to the meridional ridges. Along the laesurae the ridges form a "fish-bone" pattern. The contact areas are often delimited from the rest of the spore by low ridges. Outside them the surface is almost smooth or slightly wrinkled. In optical section the outer, thicker layer of the exine seems more or less coarsely maculate, and the thin inner layer is visible as a homogeneous film. The projections which usually appear homogenous, consist of a conical base that bears a more or less

slender stalk with a widened anchor-shaped tip. Occasionally larger elements are maculate.

Comments

Hystricosporites costatus resembles *H. corystus* RICHARDSON (1962, pp. 173–4) in having highly elevated lips and a thick two-layered exine. In Text-figure 2 (RICHARDSON, l.c.) there is a slight indication of meridional striations of the contact areas, but such striations are not mentioned in the text. *H. costatus* is considerably smaller than the *H. corystus*.

The filmy, smooth, apparently homogenous inner exine layer, the characteristic structure of the thick outer layer, and the wrinkled surface, are characters which are also found in species assigned to *Ancyrospora* RICHARDSON (1962).

Spores like those described above were first described by HØEG (1942). As pointed out by RICHARDSON (1962, p. 181), the spores in HØEG's Pl. XXXI, Figs. 17–19 and in Pl. XLIX, Fig. 15 seem to resemble *Ancyrospora ancyrea*, but the characteristic sculpture of the contact areas and the wide separation of the projections are not clearly visible in HØEG's figures.

H. costatus occurs in the Upper Svalbardia Sandstone, but is infrequent.

Hystricosporites coronatus n. sp.
Pl. III, Figs. 1–3.

Diagnosis

Trilete microspores with a thick two-layered wall. Equatorial outline subcircular, diameter 80–140 μ. Laesurae at least two thirds of the radius with flange-like, elevated lips, whose height at the apex approximates the length of the spore radius. Contact areas outlined by low closely sinuous muri. Outside the contact areas the exine is ornamented by scattered spinae with anchor-shaped tips. The distal polar region has a collar-like extension which prolongs the polar axis.

Dimensions. Median of 25 spores 102 μ, interquartile range 93–115 μ. The projections are 4–13 μ wide at the base, and 8–17 μ long; maximum length measured 45 μ.

Holotype. 62: 113,9–38,1 (Pl. III, Figs. 1, 2); Paratype. 138: 121, 2–31,8 (Pl. III, Fig. 3).

Type locality. Planteryggen, PA 335.

Description

Holotype: The spore is laterally compressed and has an equatorial diameter of 117 μ, length of polar axis about 105 μ. The lips are about 39 μ high at apex. Height of the distal collar 39–43 μ, diameter approximately 48 μ. Thickness of exine 9–23 μ. The surface is delicately wrinkled, in optical section the wall is coarsely punctate to maculate. The sculptural elements each consists of a conical base, 7,5–11 μ wide, bearing a slender bifurcating projection, about 7,5 μ high and apparently homogeneous in contrast to the rest of the wall. The sinuous muri outlining the contact areas are about 6,5 μ broad.

Other specimens: The double nature of the wall is not readily seen in the holotype. In most specimens, however, there is a thick outer part, which is punc-

tate to maculate, and a thin inner part in the form of a homogeneous film. The collar of the distal pole usually is incomplete.

Comments

Except for the characteristic extension of the distal polar region, *H. coronatus* resembles the other spores included in the same genus. *H. coronatus* differs from *H. costatus* in its contact areas which lack the meridional ridges and are delimited by curvaturae.

Spores of this type have been found in the Upper Svalbardia Sandstone, but infrequently.

Hystricosporites sp.
Pl. III, Fig. 9.

Description

Trilete microspores, subcircular to subtriangular in outline. Laesurae which are usually indistinct, are straight, about two thirds of the radius with raised, contorted lips. Contact areas smooth, or with indication of meridional ridges, otherwise the spores are ornamented by projections consisting of a lower conical to sphaerical part, bearing a tapering stem with a widened, anchor-shaped tip. The wall seems maculate in optical section. Surface often irregularly pitted.

Dimensions. Range of 12 spores 85–120 μ, median 100 μ. Exine 2,6–15,0 μ. Spinae 12 μ broad at the base, 23–36 μ long.

Figured specimen. 100: 122,2–35,8 (Pl. III, Fig. 9) PA 2082.

Comments

Hystricosporites sp. comes close to *H. delectabilis* McGregor (1960, p. 32) but differs from it in being only half its size and possessing elevated lips. The few spores observed are too poorly preserved to permit the establishment of a new species.

Genus *Raistrickia* S., W. & B. emend. Pot. & Kr.

1944. *Raistrickia* Schopf, Wilson & Bentall, p. 55.
1954. *Raistrickia* S., W. & B. emend. Potonié & Kremp, pp. 133–4.

Raistrickia cf. *clavata* Hacqu.
Pl. II, Fig. 10.

1957. *Raistrickia clavata* Hacquebard, p. 310.

Description

Trilete microspores subcircular to subtriangular in outline. Laesurae usually indistinct, of unequal length, half the radius or longer. Entire surface ornamented with projections of varying size, in the shape of coni, baculae or verrucae.

Dimensions. Range of 20 spores 26–63 μ, median 50 μ, interquartile range 43–53 μ. Exine 1,3–5,0 μ thick. Projections 0,7–9,0 μ heigh, up to 7 μ broad at the base.

Figured specimen. 87: 116,0–36,4 (Pl. II, Fig. 10) PA 2082.

Comments

The specimens described by HACQUEBARD (1957) had an ornamentation mainly of club-shaped, closely set, elements, and a more distinct trilete mark than the spores here referred to as *C.* cf. *clavata*. Spores of this type have been found in small numbers both in the cannel coal and in the Upper Svalbardia Sandstone, and it has not been possible to find any difference between those from the two horizons.

Murornati

Genus *Convolutispora* H., S. & M.

1955. *Convolutispora* HOFFMEISTER, STAPLIN & MALLOY, p. 384.

Convolutispora cf. *tuberculata* (WALTZ) H., S. & M.
Pl. II, Figs. 5–7, 14.

1938. *Azonotriletes tuberculatus* WALTZ in LUBER & WALTZ, p. 12.
1955. *Convolutispora tuberculata* WALTZ nov. comb., HOFFMEISTER, STAPLIN, & MALLOY, p. 384.

Description

Spores with subtriangular to subcircular, undulating to incised outline. Laesurae straight, often indistinct, length one third to two thirds of the radius. Exine ornamented with irregular rugae or short partly anastomosing curved muri; The elements are closely arranged, forming an irregular negative reticulum, which is less prominent on the proximal surface than on the distal.

Dimensions. Range of 33 specimens 40–85 μ, median 60 μ, interquartile range 52–65 μ. Exine 2,5–6,5 μ thick; sculpture, about 2 μ high, included. Sculptural elements about 4 μ broad at the base.

Figured specimens. 87: 120,9–29,7 (Pl. II, Figs. 5, 6), 89: 116,9–37,2 (Pl. II, Fig. 7) both from PA 2082, 54: 120,8–41,0 (Pl. II, Fig. 14) PA 306.

Comments

These spores resemble *C. tuberculata* recorded from the Spitsbergen Lower Carboniferous by PLAYFORD (1962, p. 592), however, the latter has a more prominent ornamentation.

C. cf. *tuberculata* occurs regularly but not abundantly in the cannel coal and in the Upper Svalbardia Sandstone.

Genus *Reticulatisporites* IBR. emend. POT. & KR.

1933. *Reticulati-sporites* IBRAHIM, p. 33.
1954. *Reticulatisporites* IBR. emend. POTONIÉ & KREMP, p. 144.

Reticulatisporites mimerensis n. sp.
Pl. II, Figs. 16, 17.

Diagnosis

Trilete microspores, subtriangular in outline, diameter 26–70 μ. Laesurae, two thirds of the radius or longer. Exine reticulate, with 40–90 irregular lumina of varying size on either spore half. The widest lumina are found in the equatorial region.

Dimensions. Median of 50 spores 51μ, interquartile range 45–55μ. Diameter of lumina 1,0–8,0μ.

Holotype. 34: 114,6–46,7 (Pl. II, Fig. 16); Paratype. 34: 124,5–40,1 (Pl. I,I Fig. 17).

Type locality. Plantekløfta, PA 393.

Description

Holotype: Subtriangular in equatorial outline, diameter 44 μ. Laesurae distinct, of unequal length, about three fourths of the radius. The muri forming the reticulum are about 1,3 μ broad and 1,3–2,6 μ high. The lumina are of irregular shape, in the polar regions about 1,3 μ in diameter, while along the outline there are approximately 25 lumina, 2,6–5,2 μ in diameter.

Other specimens: Along the laesurae the muri anastomose to form lips. Lumina are usually found in greatest number on the proximal surface.

Comments

R. mimerensis is distinguished by the laesurae accompanied by lips which are a part of the reticulum. The laesurae are never obscured by the reticulate pattern. *R. mimerensis* has been found regularly in all sandstone samples, but not abundantly.

Genus *Foveosporites* Balme

1957. *Foveosporites* Balme, p. 17.

Foveosporites pertusus n. sp.

Pl. IV, Figs. 3, 4, Pl. V, Figs. 1, 2 a–d.

Diagnosis

Trilete microspores, subcircular in outline, diameter 50–168 μ. Laesurae straight, about two thirds of the radius. Exine penetrated by narrow tubes, the ends of which form a net-like pattern on the internal exine surface, while on the external surface there is no pronounced regularity in their arrangement.

Dimensions. Median of 34 specimens 92 μ, interquartile range 62–115 μ. Thickness of exine 4–17 μ. Diameter of tubes about 1.3 μ.

Holotype. 161 : 124,1–33,2 (Pl. IV, Figs. 3, 4), Paratype. 146: 120,3–36,3 (Pl. V, Figs. 1, 2 a–d).

Type locality. Planteryggen, PA 335.

Description

Holotype: Equatorial outline subcircular, diameter 106 μ. Laesurae unequal in length, about two thirds of the radius. Exine 9–12 μ thick in the equatorial region. The tubes which penetrate the exine have a diameter of 1,3 μ or less (measured at the outer surface), and they are more than 1,3 μ apart.

Other specimens: Laterally flattened specimens show that the exine is thicker distally than it is in the proximal part of the spores. In some specimens it is difficult to determine whether the tubes really penetrate the exine.

Comments

Specimens of *F. pertusus* ought to be sectioned to ascertain the wall structure. Examination of such sections may make it necessary to transfer the species to another genus.

Foveosporites pertusus is found in most of the sandstone samples, but infrequently.

Perinotrilites

Genus *Perotrilites* COUP.

1953. *Perotrilites* ERDTMAN ex COUPER, p. 31.

Perotrilites cf. *perinatus* HUGH. & PLAYF.

Pl. III, Figs. 7, 8.

1961. *Perotrilites perinatus* HUGHES & PLAYFORD, p. 33.

Description

Spores with two-layered wall. The outer part developed as a wrinkled perispore, ornamented with scattered coni. The inner layer is smooth, subtriangular in equatorial outline; and the laesurae, occasionally split, are about two thirds of the radius. The perispore has triradiate folds which imitate and often obscure the laesurae. There may also be folds in the perispore indicating the supposed limits of the contact areas.

Dimensions. Range of 35 spores 43–96 μ, median 73 μ, interquartile range 59–80 μ. Exine of center part 2–4 μ thick. Sculptural elements of perispore about 1,3 μ wide.

Figured specimens. 5: 121,5–36,4 (Pl. III, Fig. 8) PA 335, 14: 120,8–36,9 (Pl. III, Fig. 7) PA 1259.

Comments

The spores described above have shorter laesurae and lack the distinct lips of *P. perinatus* HUGHES & PLAYFORD (1961) from the Spitsbergen Lower Carboniferous. Specimens from the Upper Svalbardia Sandstone cannot be distinguished from *Perotrilites* sp. described by MCGREGOR (1960, p. 35), from Melville Island.

Perotrilites cf. *perinatus* occur regularly, but not very abundantly in all sandstone samples examined.

Genus *Calyptosporites* RICH.

1960. *Cosmosporites* RICHARDSON, p. 52–3.
1962. *Calyptosporites* RICHARDSON, p. 192.

Calyptosporites plicatus n. sp.

Pl. VI, Fig. 4.

Diagnosis

Microspores with a two-layered wall, the outer layer in the form of a thick perispore, subtriangular to subcircular in outline, diameter 61–96 μ. Perispore ornamented with scattered minute projections. Triradiate folds extending almost to the margin of the perispore and imitating lips, thus obscuring the proper laesurae. The inner layer of the spore wall forms a "body", subtriangular in equa-

torial outline, diameter 45–80 μ. Laesurae half the radius or less. Outline and size of contact areas are suggested by folds of the perispore.

Dimensions. Median of diameters in 22 specimens: perispore 78 μ, "body" 64 μ; interquartile range: perispore 63–86 μ, "body" 52–74 μ. Projections of perispore up to 1,3 μ. Thickness of perispore about 1,3 μ. "Body" wall about 2 μ thick.

Holotype. 89: 117,0–41,3 (Pl. VI, Fig. 4).

Type locality. Estheriahaugen, PA 2082.

Description

Holotype: Equatorial outline subtriangular. Diameter 92 μ ("body" 80 μ). Laesurae about two fifths of the "body" radius, exine punctate to maculate, about 2,0 μ thick. Perispore, about 1,3 μ thick, detached with prominent folds extending almost to the equatorial margin. Perispore with distal ornamentation of scattered minute projections resembling spinae or coni, clearly distinguishable only when examined under oil immersion. Surface of "body" smooth, sometimes with scattered, narrow pits.

Other specimens. The perispore usually has a very minute ornamentation, but there are also specimens with a nearly smooth surface. Laterally compressed specimens, which are quite common, often show the attachement of the two layers in the region of the proximal pole. Several specimens have a broken more or less detached perispore.

Comments

The inner "body" of *Calyptosporites plicatus* corresponds closely to *Leiotriletes* sp., described above (p. 7), and they may be identical.

C. plicatus is considerably smaller and ornamented with smaller projections than spore types hitherto included in *Calyptosporites*.

C. plicatus is frequent in the cannel coal.

CAPULITRILETES

Genus *Nikitinsporites* CHAL.

1959. *Nikitinsporites* CHALONER, p. 328.

Nikitinsporites sp.

Pl. II, Figs. 11–13.

1942. *Apiculati*, type *c*, HOEG, p. 147, Pl. XXXI, Figs. 10, 11, Pl. XLIX, Fig. 16.

Description

Megaspores, subtriangular in equatorial outline, covered with projections of greatly varying shape and size and of a length up to 5 times the width at the base. The longer projections seem to consist of three parts, a conical base bearing a slender, more flexible stem and ending in an apparently structureless tooth. Other elements are in the form of more or less rounded coni and verrucae. The smaller elements appear homogenous, while the larger ones are punctate to spongy or hollow. Because of the dense ornamentation the accurate thickness of the exine is

difficult to measure. Laesurae have not been seen, but two specimens possess flanges, about 70 μ high, which may represent lips.

Dimensions. Range of 17 specimens 250–500 μ, median 300 μ. Spinae 12 μ wide at the base, about 60 μ long, maximum length measured 150 μ. Exine 13–30 μ.

Figured specimens. 104: 115,9–31,9 (Pl. II, Fig. 11), 347: 115,9–35,9 (Pl. II, Fig. 13), 107: 116,8–39,4 (Pl. II, Fig. 12). PA 335.

Comments

Nikitinsporites sp. is identical with *Apiculati* type *c* HØEG (1942), described from the same material. The flanges of *Nikitinsporites* sp. resemble the elevated lips of *N. canadensis* CHALONER (1959), but the latter is larger with spinae that taper gradually and end in a small anchor-shaped tip. The spores from Spitsbergen come close to one that is figured by ARNOLD (1936, Pl. IV, Fig. 5).

ZONALES

ZONOTRILETES

Cingulati

Genus *Densosporites* (BERRY) POT. & KR.

1937. *Denso-sporites* BERRY, p. 157.

1954. *Densosporites* (BERRY) emend. POTONIÉ & KREMP, pp. 160–1.

Densosporites cf. *devonicus* RICH.

Pl. VI, Figs. 5–7.

1960. *Densosporites devonicus* RICHARDSON. pp. 57–8.

Description

Microspores with wall thickened equatorially and extending as a flange, triangular in outline. The laesurae extend to the margin of the spore cavity, while prominent folds formed by an outermost thin layer of the exine (the exoexine, RICHARDSON 1963) extend to, or almost to, the equatorial margin. The thick wall apparently consists of three layers. The thin outer layer forming the proximal folds seems to be of uniform thickness. Proximal surface unornamented, distal surface densely covered with spinae or coni which may bear a slender projection with a slightly swollen tip. The innermost layer is thin and seems homogeneous, but it is distinct only when detached from the rest of the wall. The intermediate layer is the thickest of the three and has a punctate to maculate structure.

Dimensions. Diameter range in 22 spores 52–135 μ, (cavity 45–85 μ), median 80 μ, interquartile range 70–90 μ. Projections about 2,6 μ broad and about 4 μ high, the slender stem at the top 0,6 μ wide or less, and about 2,6 μ long.

Figured specimen. 11: 115,5–32,0 (Pl. VI, Figs 5–7) PA 1259.

Comments

The spores described above come close to *Densosporites devonicus* RICHARDSON (1960) in possessing triradiate flanges formed by an external layer of the exine, in the ornamentation of the distal part of the spores, and in the equatorially thickened

wall which extends into a thinner flange. But they differ in being smaller, their proximal flanges are of equal width from apex to equator, and the external layer is of uniform thickness proximally. The wall of the distal polar region seems thicker than it is in the spores described by RICHARDSON.

In the general construction of the wall there is also superficial resemblance to *Hymenozonotriletes inaequus* MCGREGOR (1960, p. 37), species of *Cristatisporites* (RICHARDSON 1960), and species of *Ancyrospora* (RICHARDSON l.c.). Such similarities were also mentioned by GUENNEL (1963, p. 252).

D. cf. *devonicus* occurs both in the cannel coal and in the Upper Svalbardia Sandstone, but infrequently.

Genus *Knoxisporites* POT. & KR. emend. NEVES

1954. *Knoxisporites* POTONIÉ & KREMP, p. 147.
1961. *Knoxisporites* POT. & KR. emend. NEVES, p. 265.

Knoxisporites reticulatus n. sp.
Pl. I, Figs. 10–12, Pl. II, Figs. 8, 9.

Diagnosis

Trilete microspores with cingulum, subcircular to subtriangular in outline, overall diameter 36–72 μ. Proximal surface smooth or nearly smooth. Laesurae of unequal length, rarely extending to the cingulum. The cingulum extends into a flange which merges with the irregular reticulum of narrow, sinuous ridges found on the distal part of the spores.

Dimensions. Median of 50 spores 52 μ, interquartile range 40–57 μ. Width of cingulum, the flange included, up to 18 μ, usually 8–12 μ.

Holotype. 2: 122,2–25,3 (Pl. I, Figs. 10–12); Paratype. 135: 119,6–39,3 (Pl. II, Figs. 8, 9).

Type locality. Planteryggen, PA 335.

Description

Holotype: Outline subtriangular, diameter 50 μ. The cingulum is about 3–6,5 μ wide, the undulate flange connected to it up to 6 μ wide. The flanges of the distal reticulum have a thicker base about 1,3 μ wide. The lacunae are irregularly polygonal, 5–25 μ in diameter. The proximal surface is almost smooth.

Other specimens: In less well preserved specimens the distal flanges split into shorter ones, and the reticulum is indistinct.

Comments

The spores are referred to *Knoxisporites* because of their cingulum, which forms a part of the distal ornamentation and distinguishes them from *Reticulatisporites*. However, *K. reticulatus* differs from the other species of the same genus in the centrifugal extention of the distal reticulum. The reticulum is less regular than the pattern typical of *Knoxisporites*.

K. reticulatus occurs in all sandstone samples but is not very abundant.

Genus *Lycospora* S., W., & B. emend. POT. & KR.

1944. *Lycospora* SCHOPF, WILSON, & BENTALL, p. 54.
1954. *Lycospora* S., W., & B. emend. POTONIÉ & KREMP, pp. 156–7.

Lycospora rugulatus n. sp.
Pl. I, Figs. 17, 18, Pl. II, Fig. 15.

Diagnosis

Trilete microspores with a cingulum, subtriangular in outline, overall diameter 50–100 μ. Laesurae straight, about two thirds of the radius with slightly elevated lips. Surface ornamented with closely arranged rugae or verrucae which vary in outline and may form a negative reticulum.

Dimensions. Median of 21 spores 71 μ, interquartile range 62–78 μ. Maximum width of cingulum 15 μ.

Holotype. 34: 112,2–44,5 (Pl. II, Fig. 15); Paratypes. 73: 111,0–40,6 (Pl. I, Fig. 17), 27: 113,4–35,7 (Pl. I, Fig. 18).

Type locality. Plantekløfta, PA 393.

Description

Holotype: Equatorial outline triangular with convex sides, diameter 58 μ. The cingulum is about 6,4 μ wide, its slightly undulate margin bears minute rods up to 1,3 μ long. Laesurae two thirds to four fifths of the total radius, lips about 1,3 μ broad. The ornament of the distal surface consists of verrucae which partly fuse to more or less curved ridges of varying length and about 2 μ broad. The contact areas are almost smooth. In optical section the wall seems homogeneous in the outer part, gradually becoming punctate to maculate inwards.

Other specimens: The rods along the outline, observed in the holotype, are also found in other well preserved specimens. In laterally compressed specimens such rods have been found distally as well. Along the contact areas the ornamentation is seen in the shape of a low ridge, generally obscured by the cingulum. The lips are always distinct, sometimes extending into the cingulum. An inner, filmy exine layer has been observed, but it has been detached and clearly visible only in a few specimens.

Comments

L. rugulatus differs from previously described species of *Lycospora* in the coarse sculpture resembling that of *Convolutispora*, but the presence of a cingulum makes it impossible to include the species in the latter genus.

L. rugulatus has been observed, but not abundantly, in all the macerated sand stone samples.

Lycospora svalbardiae n. sp.
Pl. III, Figs. 4, 5, Pl. IV, Figs. 1, 2.

1942. Spores evidently belonging to *Svalbardia polymorpha* HØEG, pp. 76–7, Pl. XXXI, Figs. 5–9.

Diagnosis

Trilete microspores with cingulum, subcircular in equatorial outline, diameter 47–120 μ. Laesurae straight, extending to or almost to the cingulum. Contact areas smoth, otherwise the exine is ornamented with coni of uniform size. Spores

often with one or more distal folds. The wall seems to consist of two layers.

Dimensions. Median of 120 spores 73 μ, interquartile range 65–83 μ. Exine 1,0–3,5 μ thick. Projections about 0,5 μ broad, 0,5–2,5 μ high. Cingulum 4–8 μ wide. Lips 4–8 μ.

Holotype. 7: 114,3–25,8 (Pl. III, Figs. 4, 5); Paratype. 1251/49 c: 123,4–21,3 (Pl. IV, Figs. 1, 2) (HØEG 1942, Pl. XXXI, Fig. 6, the spore to the left).

Type locality. Planteryggen, PA 335.

Description

Holotype: Outline subcircular, diameter 69 μ. Laesurae are about four fifths of the radius with low lips, about 5 μ broad. Width of cingulum 4,0–5,5 μ. The conical projections are densely spaced at intervals about 0,5 μ, equal their diameter at the base. Height of projections 1,0–2,5 μ. The exine is distally about 1,3 μ thick.

Other specimens: The laesurae do not always extend to the base of the cingulum, and the lips may not be observable in thin-walled specimens. The ornamentation consist of rounded coni, or pointed ones ending in a very small tooth. The wall is often two-layered with a thin filmy inner part which is clearly visible only when detached.

Comments

The spores described above have been found in preparations of rock samples, and they have also been obtained in clusters from macerated sporangia of *Svalbardia polymorpha* HØEG (PA 335).

Identical spores were reported by HØEG (1942) from material (PA 1251) containing lots of sporangia of *S. polymorpha.*

BALME & HASSEL (1962, p. 7) mentioned that "a suggestion of depressed contact areas and curvaturae appears in the illustrations" (HØEG, l.c., Pl. XXXI, Fig. 6). However, the folds which may appear as curvaturae, at a higher magnification can be seen to be of secondary origin.

MCGREGOR (1960, pp. 35–6) described two species of *Lycospora* which dominate the Frasnian assemblage from Melville Island. *L. svalbardiae* differs from them by the distinct coni, which are never seen to fuse to larger units.

L. svalbardiae has been found in the Upper Svalbardia Sandstone where it is the dominant type. It has not been seen in the cannel coal from the same area.

Zonati

Genus *Cirratriradites* WILS. & COE

1940. *Cirratriradites* WILSON & COE, p. 183.

Cirratriradites sp.

Pl. III, Fig. 6.

Description

Trilete microspores with a zona, triangular or subtriangular in equatorial outline, overall diameter 50–93 μ, diameter of spore cavity 32–75 μ. The laesurae

extend to the margin of the cavity, while the lips continue into the zona. Distal surface, zona included, ornamented with curved rugae or verrucae forming a negative reticulum, but the ornamentation of the zona is sometimes minute or lacking. Proximal surface smooth.

Dimensions. Range of diameter in 25 spores 50–93 μ (32–75 μ), median 68 μ (cavity 49 μ), interquartile range 62–74 μ (43–53 μ). Lips about 2 μ broad.

Figured specimen. 3: 121,9–28,8 (Pl. III, Fig. 6) PA 470.

Comments

Cirratriradites sp. differs from the species of this genus from the Spitsbergen Lower Carboniferous (HUGHES & PLAYFORD 1961, PLAYFORD 1963) by its smaller size and the different type of ornamentation. It shows superficial resemblance to *Hymenozonotriletes commutatus* NAUMOVA (1953, p. 113) in which the laesurae appear shorter.

Cirratriradites sp. is infrequent in the Upper Svalbardia Sandstone and has not been seen in the cannel coal.

Incertae sedis

Genus *Ancyrospora* RICH.

1960. *Ancyrospora* RICHARDSON, p. 55.
1962. *Ancyrospora* RICH. emend. RICHARDSON, pp. 175–6.

Ancyrospora ancyrea (EIS.) RICH.

Pl. IV, Figs. 5–7.

1942. *Apiculati*, type *d*, HOEG, p. 148, Pl. XXXI, Figs. 14, 15, Pl. XLIX, Fig. 14.
1944. *Triletes ancyreus* EISENACK, pp. 110–2.
1962. *Ancyrospora ancyrea* EIS. RICHARDSON nov. comb., pp. 176–7.

Description

Trilete microspores subcircular to subtriangular in equatorial outline. Laesurae indistinct, accompanied by contorted thin flanges and extending about three fourths of the distance to the equator. The spores are ornamented with projections which are closely set in the distal and equatorial regions, and some times connected at the base. In the equatorial region this connection causes a "pseudoflange" (RICHARDSON 1962 pp. 175–7) which, however, is poorly developed and indistinct in most specimens. The wall seems to consist of three layers, an inner thin homogeneous one, distinct only when it is detached, and a middle thick maculate to spongy part which outwards is covered with a thinner apparently homogeneous layer. The projections seem to consist of a cone bearing a slender flexible extension, which in some specimens has a swollen tip, in others it is almost anchorshaped. The surface is wrinkled.

Dimensions. Range of 38 spores 65–140 μ (cavity 55–132 μ), median of 38 spores 100 μ (cavity 79 μ), interquartile range 85–115 μ (cavity 75–110 μ). Total thickness of exine, sculpture excluded, 4–12 μ, thickness of the inner layer when detached about 1,3 μ. Projections 5–14 μ broad at the base, 8–36 μ high.

Figured specimens. 155: 122,0–35,0 (Pl. IV, Figs. 6, 7), 154: 122,6–37,1 (Pl. IV, Fig. 5). PA 335.

Comments

The spores are identical with those described by HØEG (1942, p. 148) as *Apiculati* type *d. Acanthotriletes horridus* HAQUEBARD (1957, pp. 309–10) from the Upper Devonian of Australia is larger, has distinct laesurae, and the distal projections seem to be more widely spaced. The spores described above are referred to *Ancyrospora ancyrea* because of the "pseudoflange" (RICHARDSON l.c.). The specimens from Spitsbergen differ, however, from the various types of *A. ancyrea* described by RICHARDSON in the smaller size, the usually poorly developed pseudoflange and the indistinct laesurae. Furthermore in contrast to what is found in specimens from the Middle Old Red Sandstone (RICHARDSON 1962), the projections of the Spitsbergen specimens seldom bifurcate.

A. ancyrea is infrequent in the Upper Svalbardia Sandstone.

Ancyrospora cf. *simplex* GUEN.

Pl. VI, Figs. 1–3.

1963. *Ancyrospora simplex* GUENNEL, p. 257.

Description

Microspores with a two-layered wall, the thicker outer layer extending as an equatorial flange of subtriangular outline. Laesurae extend to the margin of the spore cavity, with flange-like undulating lips, formed by the outer layer of the exine and extending to, or almost to, the equatorial margin. The distal surface is ornamented with large projections in the shape of spinae or coni, 15–25 of them along the margin. Sometimes the projections have a swollen tip. Between the ornamenting elements the surface is wrinkled or almost smooth, and so is the unornamented proximal surface. The outer layer has a maculate to spongy structure. The thin inner layer seems to be homogeneous.

Dimensions. Range of 35 specimens, ornamentation along the margin excluded, 79–155 μ (spore cavity 32–93 μ), median 117 μ (cavity 65 μ), interquartile range 100–124 μ (cavity 62–71 μ). Projections, along the margin 12–15 μ broad at the base and 15–25 μ high, distally 5–18 μ broad and 13–29 μ high. Inner layer of the exine about 1,3 μ thick. Lips about 2–6 μ broad.

Figured specimens. 366: 117,6–36,3 (Pl. VI, Fig. 3) PA 315, 55 : 124,1–36,9 (Pl. VI, Figs. 1, 2) PA 306.

Comments

These spores resemble *Ancyrospora simplex* GUENNEL (1963) from deposits of late Middle or early Upper Devonian age in Illinois in possessing prominent lips, a wide equatorial extension and the same type of distal ornamentation. The spores from Spitsbergen are slightly larger with a wider size range, and the inner layer of the exine is thinner.

Reservations are made concerning the identification with *A. simplex* because GUENNEL described this species as possessing a bladder (sensu RICHARDSON 1960). From Fig. 13 (GUENNEL l.c.), however, the spore seems to be in agreement with the genus *Ancyrospora* as emended by RICHARDSON (1962, p. 175).

A. cf. *simplex* is infrequent in the Upper Svalbardia Sandstone.

TABLE 1

The results of countings in slides from 5 specimens. + spores of this type are found in percentages lower than 2. (+) spores of this type are present in the sample but not in the slides which have been used for the counting.

Spore species	Stage	Givetian	Frasnian			
	Local stratigraphic units	Cannel coal bed 5CC (VOGT)	The Upper Svalbardia Sandstone bed 8 c (VOGT)			
	Locality	Estheriahaugen	Plantekløfta		Planteryggen	
	Museum catalogue number	PA 2082 %	PA 393 %	PA 470 %	PA 335 %	PA 347 %
Leiotriletes sp.		15	·	·	·	·
Punctatisporites cf. stabilis		·	23	12	8	8
Phyllothecotriletes microgranulatus		·	12	43	14	10
Phyllothecotriletes sp.		12	·	·	·	·
Enigmophytospora simplex		·	·	(+)	(+)	·
Emphanisporites neglectus		14	·	·	·	·
Verrucosisporites sp.		+	+	+	+	+
Biharisporites spitsbergensis		·	·	(+)	+	(+)
Lophotriletes uncatus		·	5	2	6	2
Anapiculatisporites devonicus var. azonatus		44	·	·	·	·
Hystricosporites costatus		·	+	+	+	(+)
Hystricosporites coronatus		·	·	2	+	·
Hystricosporites sp.		(+)	·	·	·	·
Raistrickia cf. clavata		+	+	+	+	+
Convolutispora cf. tuberculata		4	6	5	3	+
Reticulatisporites mimerensis		·	6	3	+	+
Foveosporites pertusus		·	+	+	3	+
Perotrilites cf. perinatus		·	4	6	6	+
Calyptosporites plicatus		9	·	·	·	·
Nikitinsporites sp.		·	·	·	·	·
Densosporites cf. devonicus		(+)	+	+	2	+
Knoxisporites reticulatus		·	4	+	3	+
Lycospora rugulatus		·	8	3	+	3
Lycospora svalbardiae		·	29	14	41	68
Cirratriradites sp.		·	+	+	2	+
Ancyrospora ancyrea		·	(+)	+	2	+
Ancyrospora cf. simplex		·	(+)	+	+	+
Total number of specimens counted:		513	290	380	290	430

Remarks on the assemblages

In order to obtain an idea of the frequencies of the spore types, countings have been made of slides from five samples. The results of these countings are shown in Table 1. Reservations must be made, however, regarding the reliability of the counting results, because of the great number of unidentified spores in each preparation. The thin-walled simple spores, in particular, are often in a poor state of preservation and have to be counted as unidentified ones.

The cannel coal from Estheriahaugen has few species in common with the Upper Svalbardia Sandstone, but it is not possible to tell whether this is due to differences in ecology or age.

When the results concerning the two localities of the Upper Svalbardia Sandstone, Plantekløfta and Planteryggen, are compared, the samples from Plantekløfta seem to be richer in *Punctatisporites* cf. *stabilis* PLAYF., *Reticulatisporites mimerensis* n. sp. and *Lycospora rugulatus* n. sp.

One sample from Planteryggen is from PA 335 (the slab which is figured by HØEG, 1942, Pls. XXII–XXIV, and contains a fertile *Svalbardia polymorpha* HØEG), the other is from PA 347 (which contains *Svalbardia* and clusters of detached sporangia of the same type as in PA 335). As will be seen from the table, *Lycospora svalbardiae*, which are the spores of *Svalbardia*, are much more frequent in PA 335 and 347 than they are in PA 470 and 393, while in PA 470 (containing spikes probably of *Enigmophyton superbum* HØEG, l.c., Pl. XLVIII, Figs. 1, 2, 7), the frequency of *Phyllothecotriletes microgranulatus*, the supposed microspores of *Enigmophyton*, is evidently higher.

Spores of *Svalbardia* and *Enigmophyton* are on the whole numerous in all the macerated sandstone samples, but the samples from PA 335, 347, and 470 indicate that a great variation in the frequencies of the various sporetypes has been caused by the local vegetation of the respective mother plants or, in the case of allochtonous deposits, by the irregular sedimentation of specimens of the different plant species.

The cannel coal

The cannel coal with its assemblage of spores here assigned to genera as *Emphanisporites*, *Hystricosporites*, *Calyptosporites*, *Anapiculatisporites*, and *Densosporites*, resembles Givetian deposits from Canada, Scotland, and the USSR.

The spores referred to *Emphanisporites neglectus*, however, are exceedingly small, compared with related species from Canada and Estonia (MCGREGOR 1961,

EISENACK 1943). Similar spores (classified as *Stenozonotriletes*) have been reported from the Middle Devonian of the USSR (CHIBRIKOVA 1959). Such spores have hitherto not been reported from beds above the Middle Devonian.

Hystricosporites sp. has been recorded only with few specimens, and is thus less frequent than in the assemblage from the Middle Old Red Sandstone of Scotland (RICHARDSON 1962). Similar types have been reported in small numbers from the Givetian of the USSR (CHIBRIKOVA 1959).

Spores here described as *Calyptosporites plicatus* are frequent, but they are smaller than the spores of the same genus from the Middle Old Red of Scotland (RICHARDSON 1960, 1962). Specimens of *Calyptosporites* have also been recovered in late Middle or early Upper Devonian of Illinois (GUENNEL 1963). Spores comparable to those of *Calyptosporites* have further been reported from various horizons in the USSR, in the Russian literature referred to *Hymenozonotriletes* (NAUMOVA 1953, CHIBRIKOVA 1959, 1962).

The most frequent spore type of the cannel coal, here assigned to *Anapiculatisporites* is possibly identical with *Diatomozonotriletes devonicus* var. *azonatus* CHIBRIKOVA (1962) ranging from the uppermost Eifelian to Upper Givetian of the USSR.

Ancyrospora (RICHARDSON 1962) has not been observed in the cannel coal, while it is frequently found in deposits of Middle Devonian age in other parts of the world as mentioned below.

Three of the infrequent spore types from the cannel coal occur also in the Upper Svalbardia Sandstone: *Convolutispora* cf. *tuberculata* (WALTZ) H., S., & M., *Raistrickia* cf. *clavata* HACQUEBARD, and *Densosporites devonicus* RICHARDSON. Similar spores are known from the Middle and Upper Devonian of the USSR, where they have been classified in other genera.

Judged from the presence of spore types usually considered as typical of deposits younger than Middle Devonian, and the absence of *Ancyrospora* in the cannel coal, the age appears to be Late Givetian, a dating which is in conformity with the conclusions of FRIEND (1961).

The Upper Svalbardia Sandstone

The genera *Reticulatisporites*, *Knoxisporites*, and *Foveosporites*, each represented by one species, have not been reported from beds definitely older than Upper Devonian, and their presence in the Upper Svalbardia Sandstone supports an early Upper Devonian age of this deposit as suggested by HØEG (1942) on the basis of the macrofossils. These genera are abundantly represented in the Spitsbergen Lower Carboniferous (HUGHES & PLAYFORD 1961, PLAYFORD 1962, 1963).

Spores similar to *Lycospora svalbardiae* n. sp., the most frequent type in the assemblage, are very abundant in the Upper Devonian assemblage from the Arctic Canada (MCGREGOR 1960); they are also found in assemblages of this age in the USSR (included in *Archaeotriletes* and *Retusotriletes* NAUMOVA 1953, CHIBRIKOVA 1959, 1962).

Spores referred to as *Perotriletes* cf. *perinatus* HUGHES & PLAYFORD first reported from the Lower Carboniferous of Spitsbergen are frequently found also in the

Svalbardia Sandstone. They cannot be distinguished from the Lower Frasnian spore from Arctic Canada described as *Perotriletes* sp. (McGREGOR 1960).

Ancyrospora, cf. *simplex*, *A. ancyrea*, *Hystricosporites costatus*, and *H. coronatus* form a group of characteristic but infrequent spores in the assemblage. The same types of spores have also been recorded in the Middle Old Red Sandstone of Scotland (RICHARDSON 1960, 1962), in the Givetian and the Frasnian (abundant) of the USSR, there assigned to *Archaeotriletes* and *Hymenozonotriletes* (NAUMOVA 1953, CHIBRIKOVA 1959, 1962), and in the Frasnian of France (TAUGOURDEAU-LANTZ 1962) and Canada (McGREGOR 1960). Deposits of late Middle or early Upper Devonian age from Illinois are distinct by lacking spores with anchor-shaped projections referable to these genera (GUENNEL 1963).

The general composition of the assemblage from the Upper Svalbardia Sandstone resembles that of the Frasnian assemblage from Arctic Canada described by McGREGOR (l.c.). Both assemblages are dominated by *Lycospora* types, and their most frequent megaspores are representatives of *Biharisporites*.

The Canadian assemblage differs from that of the Svalbardia Sandstone by the greater dominance of *Lycospora*. Representatives of *Tholisporites* which are dominant there, have been noticed only very rarely in the preparations of the Upper Svalbardia Sandstone, and therefore they have not been included in the descriptions in the present paper. *Phyllothecotriletes microgranulatus* which is very common in the Upper Svalbardia Sandstone, somewhat resembles *Leiotriletes microdeltoidus* McGR. The latter, however, is scantily represented in the assemblage from Arctic Canada.

The presence of similarities with Frasnian assemblages and of spore genera usually considered as characteristic of deposits younger than Middle Devonian, indicates an Upper Devonian age of the flora.

Acknowledgements

I wish to acknowledge my indebtedness to Prof. O. A. HÖEG for his help and advice during the course of this investigation – and to Norges almenvitenskapelige forskningsråd (N.A.V.F.) for financial support. I also wish to thank Dr. S. MANUM and Dr. I. C. COOKSON for helpful suggestions.

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PLATES

The photographs were made on 35 mm panchromatic film. The slides are kept in the collections of Universitetets Paleontologiske Museum, Oslo, under the common designation PAP 5.

For each figure is given the slide number and then the mechanical stage coordinates referring to Leitz Ortholux microscope nr. 518886, which belongs to Universitetet i Oslo, Institutt for Geologi.

The sample localities are indicated for each specimen: Eh. – Estheriahaugen. Pk. – Plantekløfta. Pr. – Planteryggen.

Photographs and prints were made by the authoress.

PLATE 1

All × 500, except Fig. 9, × 200, and Figs. 14–16, 21–23, × 1000.

Figs. 1, 2. *Leiotriletes sp.* (p. 7) – Fig. 1. 90: 116,7–38,2 Eh. – Fig. 2. 91: 124, 8–32,1 Eh.

Figs. 3, 4. *Lophotriletes uncatus* NAUM. nov. comb. (p. 13) – 38: 116,1–33,0 Pk. Different foci of same specimen.

Figs. 5, 6. *Punctatisporites* cf. *stabilis* PLAYF. (p. 8) – Fig. 5. 12: 112,0–34,9 Pr. – Fig. 6. 11: 122,4–38,4 Pr.

Figs. 7, 8. *Phyllothecotriletes microgranulatus* n. sp. (p. 8) – Fig. 7. Holotype. 21: 117,2–42,2 Pk. – Fig. 8. Paratype. 23: 123,4–37,5 Pk.

Fig. 9. *Enigmophytospora simplex* n. sp. (p. 10) – Holotype. 137: 118,3–34,9 Pk.

Figs. 10–12. *Knoxisporites reticulatus* n. sp. (p. 22) – Holotype. 2: 122,2–25,3 Pk. Different foci of same specimen.

Fig. 13. *Phyllothecotriletes sp.* (p. 9) – 91: 116,0–29,6 Eh.

Figs. 14–16. *Emphanisporites neglectus* n. sp. (p. 10) – Fig. 16. Holotype. 91: 119,2–40,3 Eh. – Figs. 14, 15. Paratype. 87: 116,9–37,1 Eh. Different foci of same specimen.

Figs. 17, 18. *Lycospora rugulatus* n. sp. (p. 23) – Paratypes. Fig. 17. 73: 111,0–40,6 Pk. – Fig. 18. 27: 113,4–35,7 Pk.

Figs. 19, 20. *Verrucosisporites sp.* (p. 11) – 61: 123,9–42,1 Pr. Different foci of same specimen.

Figs. 21–23. *Anapiculatisporites devonicus* var. *azonatus* CHIBR. (p. 13) – Fig. 21. 87: 120,8–29,5 Eh. — Figs. 22,23. 87: 114,5–34,7 Eh. Different foci of same specimen.

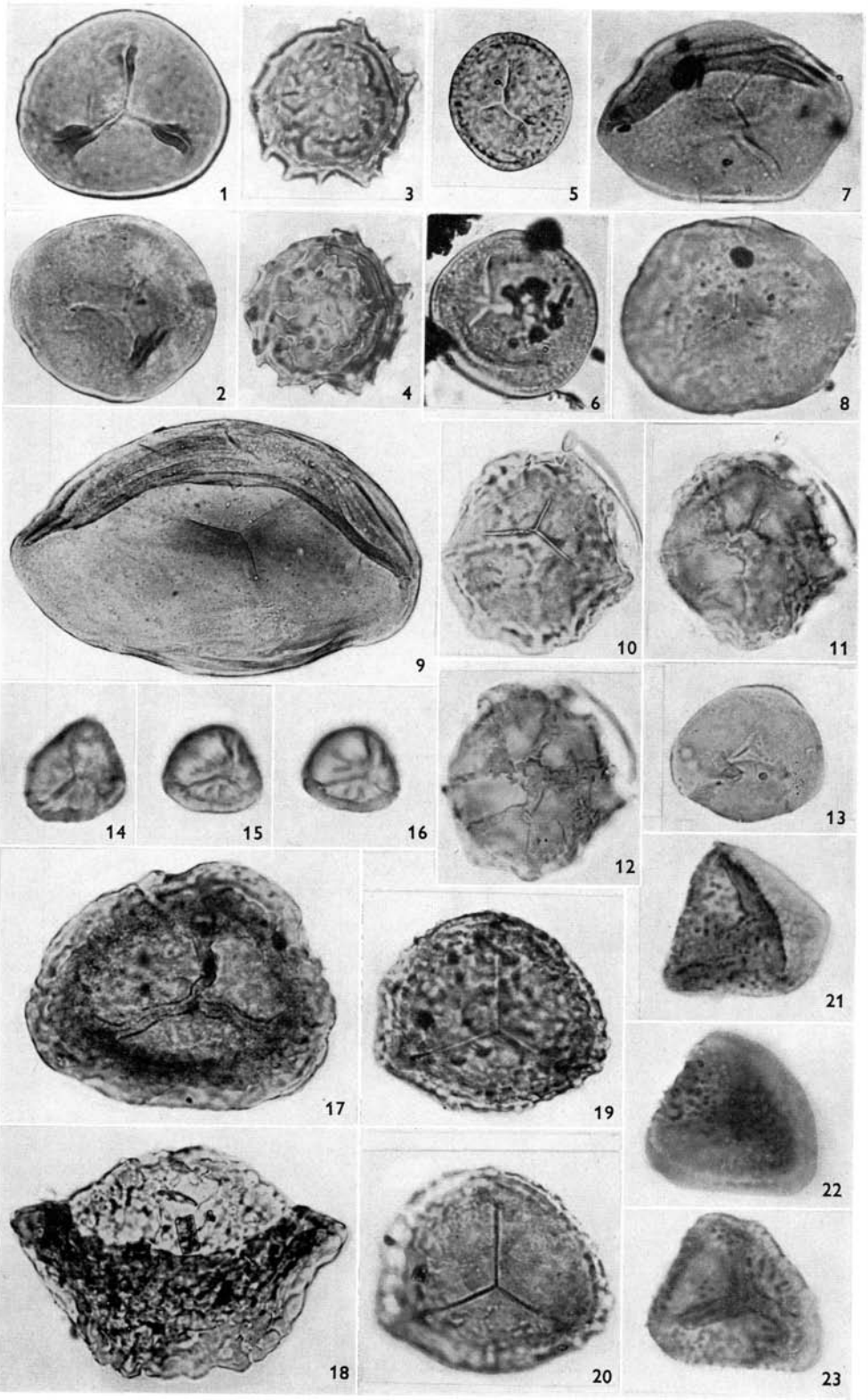
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PLATE II

All × 500, except Figs. 1–3, × 200, and Figs. 11, 13, × 100.

Figs. 1–4. *Biharisporites spitsbergensis* n. sp. (p. 12) – Figs. 1, 2. Holotype. 157: 121,1–40,3 Pr. Different foci of same specimen. – Paratypes. Fig. 3. 367: 119,2–37,5 Pr. – Fig. 4. 235: 119,0–35,2 Pr. Broken specimen in which is seen the inner exine layer.

Figs. 5–7. *Convolutispora* cf. *tuberculata* (WALTZ) H., S., & M. (p. 17) – Figs. 5, 6. 87: 120,9–29,7 Eh. Different foci of same specimen. – Fig. 7. 89: 116,9–37,2 Eh.

Figs. 8, 9. *Knoxisporites reticulatus* n. sp. (p. 22) – Paratype. 135: 119,6–39,3 Pr.

Fig. 10. *Raistrickia* cf. *clavata* HACQU. (p. 16) – 87: 116,0–36,4 Eh.

Figs. 11–13. *Nikitinsporites sp.* (p. 20) – Fig. 11. 104: 115,9–31,9 Pr. – Fig. 12. 107: 116,8–39,4 Pr. Detail of sculpture. – Fig. 13. 347: 115,9–35,9 Pr.

Fig. 14. *Convolutispora* cf. *tuberculata* (WALTZ) H., S., & M. (p. 17) – 54: 120,8–41,0 Pr.

Fig. 15. *Lycospora rugulatus* n. sp. (p. 23) – Holotype. 34: 112,2–44,5 Pk.

Figs. 16, 17. *Reticulatisporites mimerensis* n. sp. (p. 17) – Fig. 16. Holotype. 34: 114,6–46,7 Pk. – Fig. 17. Paratype. 34: 124,5–40,1 Pk.

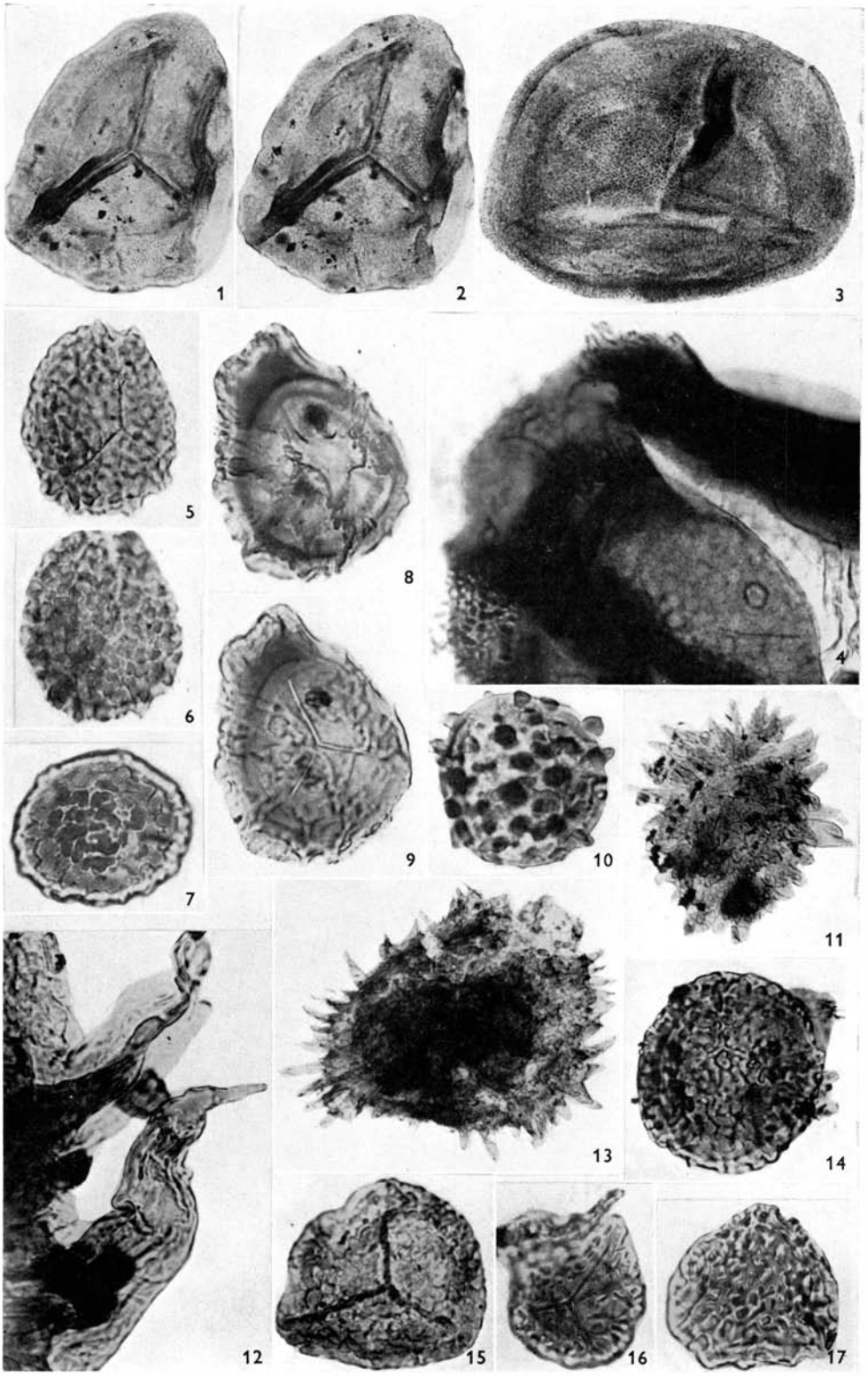
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PLATE III

All × 500.

Figs. 1–3. *Hystricosporites coronatus* n. sp. (p. 15) – Figs. 1, 2. Holotype. 62: 113,9–38,1 Pr. Different foci of same specimen. To the right is seen the thickening of the distal polar area, and the "collar" attached to it. – Fig. 3. Paratype. 138: 121,2–31,8 Pk.

Figs. 4, 5. *Lycospora svalbardiae* n. sp. (p. 23) – Holotype. 7: 114,3–35,8 Pr. Different foci of same specimen.

Fig. 6. *Cirratriradites sp.* (p. 24) – 3: 116,9–38,1 Pk.

Figs. 7, 8. *Perotrilites* cf. *perinatus* HUGH. & PLAYF. (p. 19) – Fig. 7. 14: 120,8–36,9 Pr. – Fig. 8. 5: 121,5–36,4 Pr.

Fig. 9. *Hystricosporites sp.* (p. 16) – 100: 122,2–35,8 Eh.

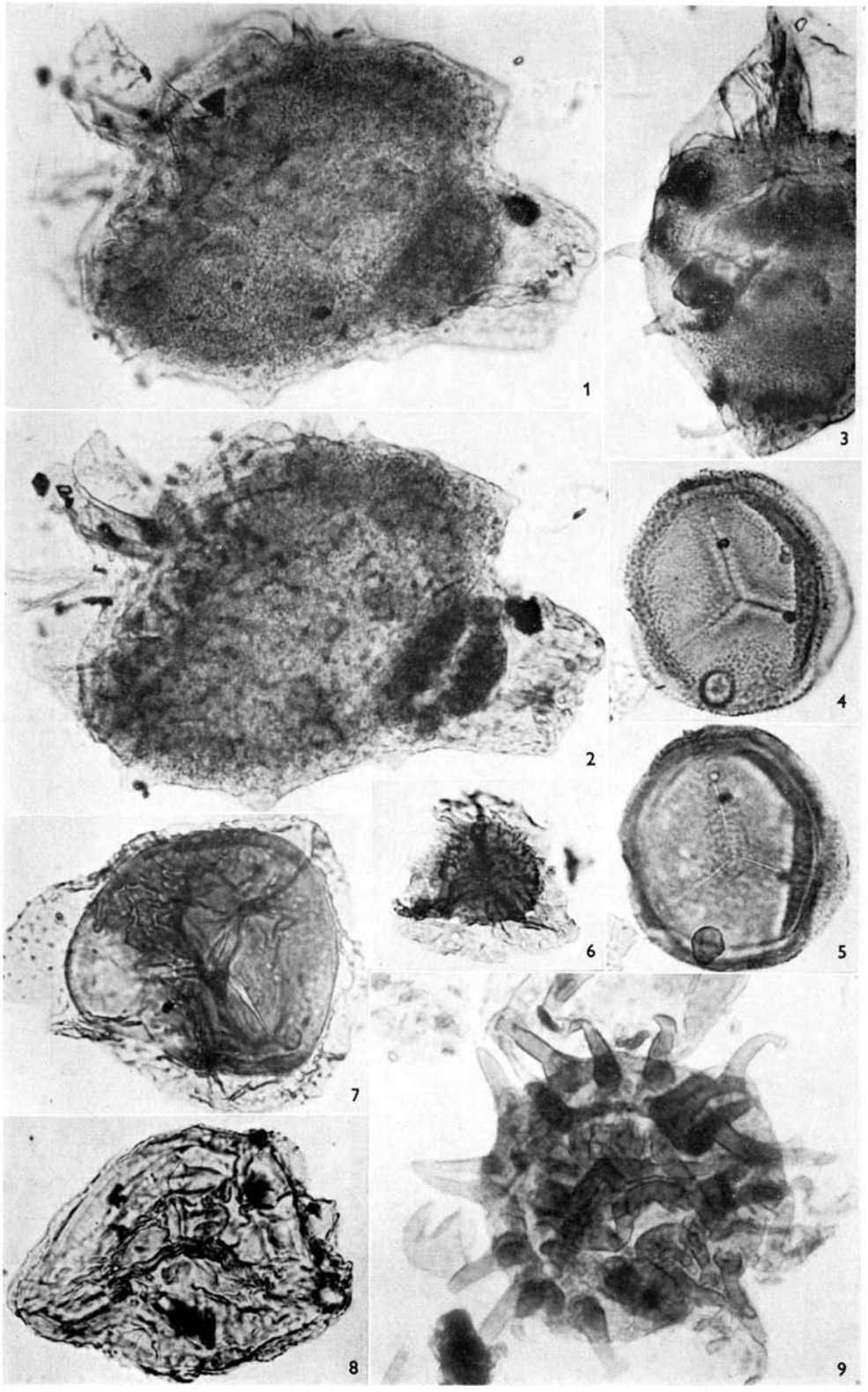
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PLATE IV

All × 500, except Fig. 5, × 400.

Figs. 1, 2. *Lycospora svalbardiae* n. sp. (p. 23) – Paratype. 1251/49 c: 123,4–21,3 Pr. Different foci of same specimen (HØEG 1942, Pl. XXXI, Fig. 6).

Figs. 3, 4. *Foveosporites pertusus* n. sp. (p. 18) – Holotype. 161: 124,1–33,2 Pr. Different foci of same specimen.

Figs. 5–7. *Ancyrospora ancyrea* (EIS.) RICH. (p. 25) – Fig. 5. 154: 122,6–37,1 Pr. – Figs. 6, 7. 155: 122,0–35,0 Pr. Different foci of same specimen.

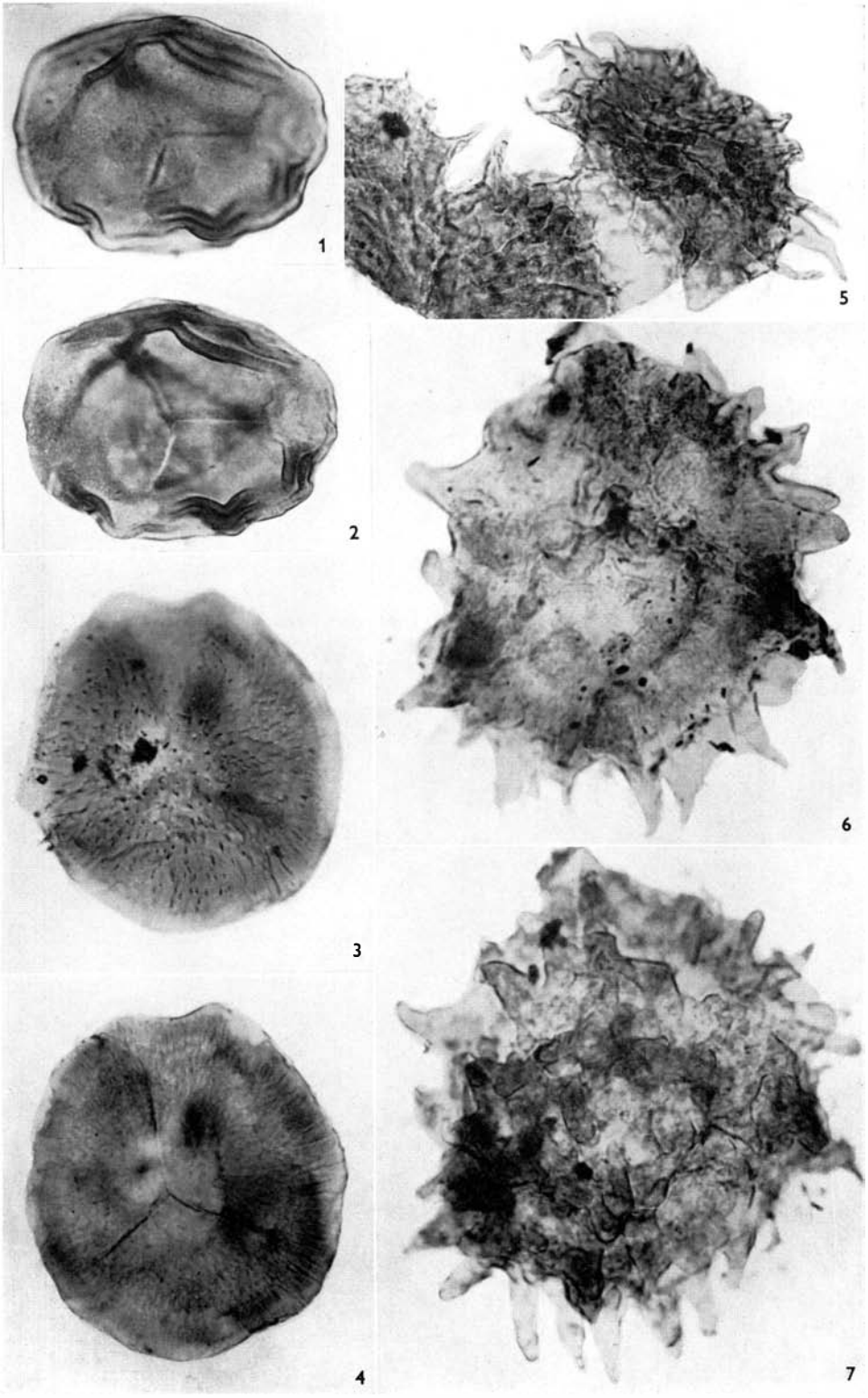
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PLATE V

All × 500, except Figs. 2 a–d, × 1000.

Figs. 1, 2. *Foveosporites pertusus* n. sp. (p. 18) – Paratype. 146: 120,3–36,3 Pr. Fig. 1. Surface view. – Figs. 2 a–d. Successive foci through the exine from the outer towards the inner surface.

Figs. 3–5. *Hystricosporites costatus* n. sp. (p. 14) – Figs. 3, 4. Holotype. 174: 121,0–38,7 Pr. – Fig. 5. Paratype. 356: 120,0–40,8 Pr. Proximal part of the spore with the apical prominence and the ribbed contact areas.

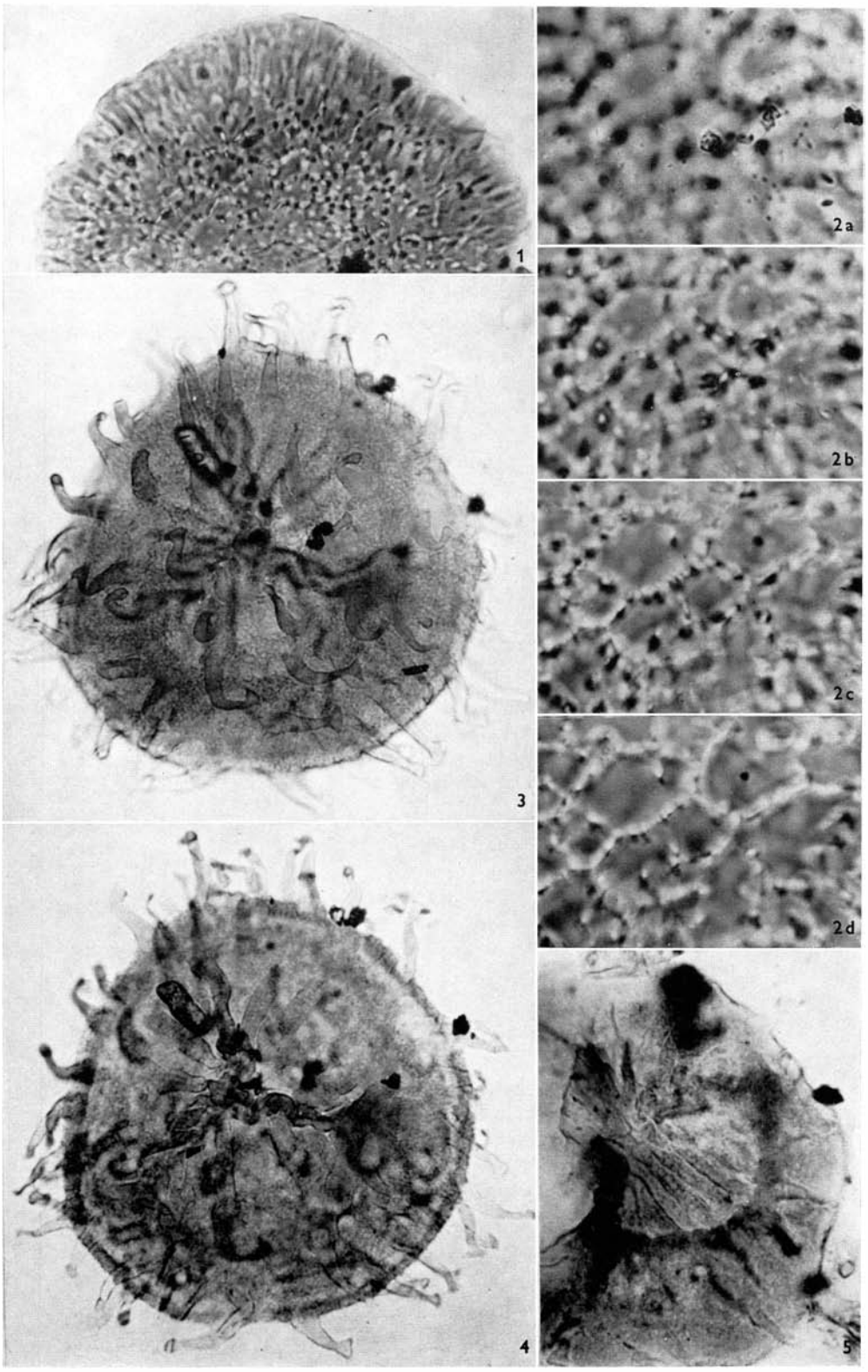
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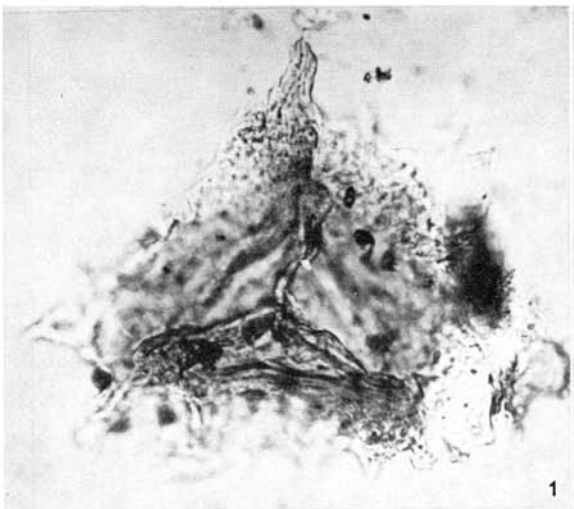
PLATE VI

All × 500.

Figs. 1–3. *Ancyrospora* cf. *simplex* GUFN. (p. 26) – Figs. 1, 2. 55: 124,1–36,9 Pr. Different foci of same specimen. – Fig. 3. 366: 117,6–36,3 Pr.

Fig. 4. *Calyptosporites plicatus* n. sp. (p. 19) – Holotype. 89: 117,0–41,3 Eh.

Figs. 5–7. *Densosporites devonicus* RICH. (p. 21) – 11: 115,5–32,0 Pr. Three different foci of same specimen.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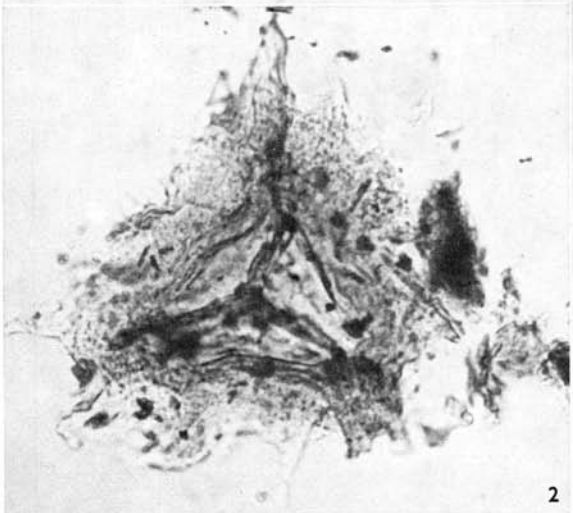
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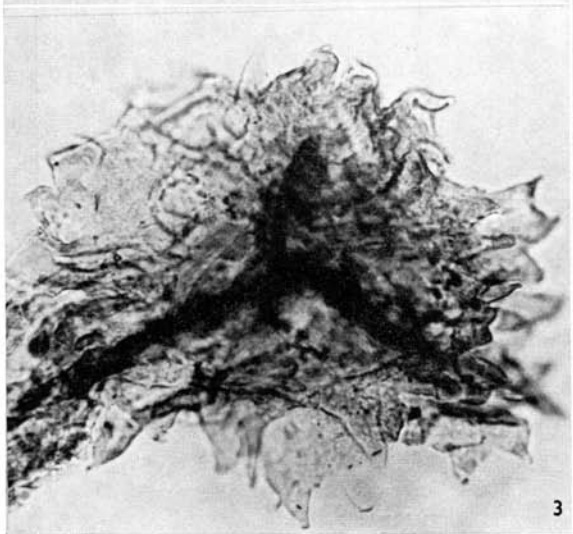
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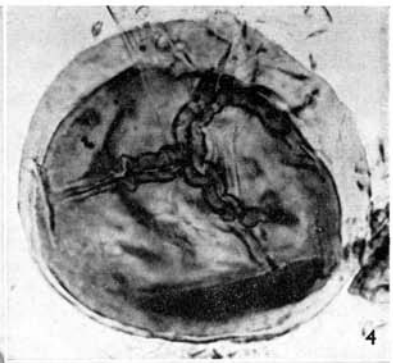
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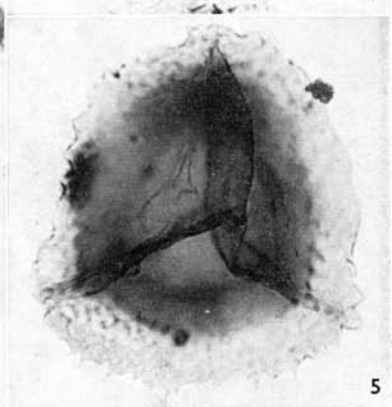
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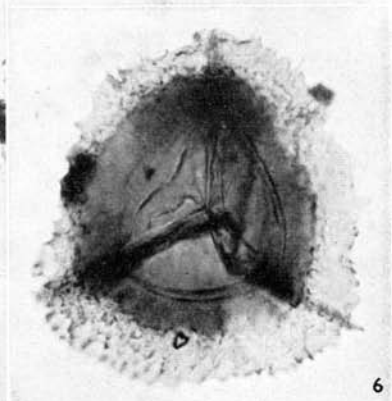
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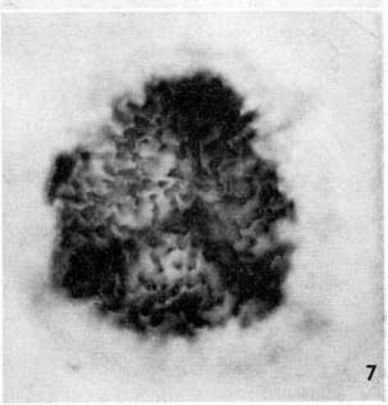
7

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