SPORE ASSEMBLAGE OUT OF A LOWER CARBONIFEROUS SHALE FROM SPITZBERGEN

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ABSTRACT

The *sporae dispersae* recovered from a carbonaceous shale of Lower Carboniferous age from Spitzbergen have been described. In all, 28 genera and 67 species are reported, out of which 6 genera, viz. *Iugisporis, Corbulispora, Velamisporites, Rostratispora, Orbisporis* and *Clavisporis*, and 30 species are new. This spore flora is compared with the spore assemblages of Lower Carboniferous (incl. Namurian) age from Canada, U.S.A., Scotland, Central Europe, European and Asian U.S.S.R. and Turkey.

It has been concluded that the Index-Spore-Association signifying Lower Carboniferous age is comprised by one or more of such genera as *Convolutispora, Cincturasporites, Labiadensites, Tripartites* and *Rotaspora*. A number of other genera, less broadly distributed but found often associated with the index genera of Lower Carboniferous strata, are *Corbulispora, Velamisporites, Orbisporis, Monilospora, Clavisporis, Tendosporites, Perianthospora* and *Grandispora*.

INTRODUCTION

THE spores and pollen grains dispersed in sedimentary strata have proved to be useful tools in coal and oil prospecting as well as in the dating and correlation of seemingly unfossiliferous rocks. At the same time as our knowledge of the spore assemblages from different horizons in various parts of the world is increasing, a better comprehension of the potentialities of *sporae dispersae* in the resolution of floristics through the ages is also becoming apparent.

In the present paper a spore assemblage from a shale of Lower Carboniferous age has been described and the same has been compared with all the other spore assemblages of Lower Carboniferous age recorded earlier. The *sporae dispersae* of Lower Carboniferous strata have been studied from a number of localities in North America (BERRY, 1937; SCHEMEL, 1950; HOFFMEISTER, STAPLIN & MALLOY, 1955; HACQUEBARD, 1957; HACQUEBARD & BARSS, 1957; STAPLIN, 1960), Great Britain (RAISTRICK, 1937; KNOX, 1948; BUTTERWORTH & WILLIAMS, 1958; and LOVE, 1960), Europe (HORST, 1955; ARTÜZ, 1957), Spitzbergen (HUGHES & PLAYFORD, 1961) and U.S.S.R. (LUBER & WALTZ, 1938; ISHCHENKO, 1956).

Lower Carboniferous represents the lower subdivision of the Carboniferous system overlying the Devonian and overlain by the Upper Carboniferous. Whereas the lower boundary between Devonian and Carboniferous is universally, uniformly accepted, the upper limit of Lower Carboniferous is variously set by geologists in different countries. In Europe (incl. U.S.S.R.), Lower Carboniferous or Dinantian is divided into Tournaisian and Visean succeeded by Namurian A of Upper Carboniferous. In Great Britain, the Limestone Coal Group and Upper Limestone Group, underlying the Millstone Grit, are supposed to be Lower Carboniferous (BUTTERWORTH & WILLIAMS, 1958) which, thereof, include Namurian in it. In U.S.A., the lower part of Carboniferous is grouped as Mississipian which, as compared to European scale, comprises Dinantian as well as a part or whole of Namurian A. However, for the purposes of this sporological paper, without entering into any controversy, we include the Dinantian as well as the Namurian in the Lower Carboniferous.

Spitzbergen is known to be rich in plant fossils of various ages. Most of these fossils have already been described by Nathorst (1894, 1897, 1914) and Hoeg (1942). These islands being among the northernmost territories, their fossil flora has always evoked considerable palaeo-geographical interests. However, the dispersed spore flora from the strata of various ages available in these islands has hardly been investigated. Luber & Waltz (1938) consider the spore content of Lower Carboniferous shales of (PYRAMIDENBERG) Spitzbergen as more or less similar to those from the Lower Carboniferous of the European U.S.S.R.

Bharadwaj (1958), while studying *Porostrobus zeilleri* Nathorst from the Lower Carboniferous (Kulm) of Spitzbergen, macerated a piece of the shale matrix to study the nature of such dispersed spores as were similar to the *in situ* spores from the sporangia of *P. zeilleri*. The *sporae dispersae*

recovered thereof being fairly diversified and thus interesting enough for detailed study, further work was carried on by the present authors. Most of the theoretical work (incl. systematics) was done by Bharadwaj and most of the laboratory work (incl. maceration, scanning and photography) was done by Venkatachala.

GEOLOGICAL DETAILS OF THE MATERIAL AND METHODS

The shale, bearing *P. zeilleri*, is dark gray and fine-grained, collected from the carbonaceous Kulm layers associated with coal in Pyramidenberg, Spitzbergen (TEXT-FIG. 1). Underlying this shale, separated by an unconformity, is the Devonian stratum. Overlying the carbonaceous shales is a thick bed of variously coloured Kulm sandstone.

The shale was macerated with commercial nitric acid for 2 days, followed by a treatment with 5 per cent potassium hydroxide for 10 minutes. The residue was finally mounted with glycerine jelly for the study of miospores. A part of the material was dried in a hot chamber and observed under a low-power binocular microscope for their megaspore contents; the megaspores were picked up and stored dry in cavity slides and studied under reflected light.

SYSTEMATIC DESCRIPTION

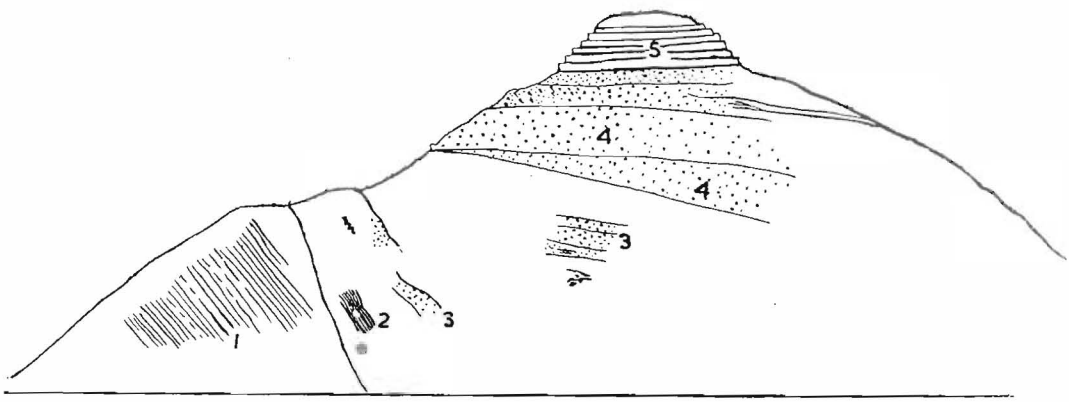
The genera and species described here have been classified according to the system of Potonié & Kremp (1954, 1955, 1956) subsequently amplified by Potonié (1956, 1958). The terminology used for description is that of the above authors. Wheresoever a new genus or species has been created, a diagnosis followed by a detailed description and comparison (differential diagnosis) has been given.

Anteturma ***Sporites*** **H. Pot. 1893**
Turma ***Triletes*** **(Reinsch) Pot. & Kr. 1954**
Subturma ***Azonotriletes*** **Luber 1935**
Infraturma ***Laevigati*** **(B. & K.) Pot. 1956**

Leiotriletes **(Naum.) Pot. & Kr. 1954**

Generotype — *Leiotriletes sphaerotriangulus* (Loose) Pot. & Kr. 1954.

Remarks — Staplin (1960) has replaced *Leiotriletes* by *Deltoidispora* Miner (1935) on grounds of priority considering the two synonymous as apparent from a comparison of their generic diagnosis. *Leiotriletes* as originally circumscribed by Naumova (1937) was a wider taxon including triangular as well as circular, laevigate, trilete miospores. Potonié & Kremp (1954) restricted *Leiotriletes* for only triangular forms assigning an Upper Carboniferous spore as its Generotype. Since then palynological literature is full of references to *Leiotriletes* (Naum.) Pot.



TEXT-FIG. 1 — Sketch of Pyramidenberg, Spitzbergen (after Nathorst, 1914): 1, Devonian. 2, Carbonaceous (Kulm) shale with plant-fossils and coal. 3, Yellowish and whitish. 4, Reddish Kulm-sandstone. 5, Cyathophyllum limestone.

& Kr., especially that pertaining to the *sporae dispersae* of the Palaeozoic. Miner's genus *Deltoidispora* is originally from Cretaceous and hence considerably younger than *Leiotriletes*. In our opinion unless the generotypes of the two genera have been re-examined and compared, a replacement of one by the other is premature and till then the Palaeozoic forms can be referred to *Leiotriletes* and the Mesozoic or still younger forms to *Deltoidispora*.

***Leiotriletes* sp.**

Pl. 1, Fig. 1

Description — Triangular with rounded angles and straight to slightly concave sides, ± 28 μ. Y-mark distinct, arms almost going up to the equatorial contour. Exine ± 2 μ thick in optical section, infrapunctate, inter-radial thickening slightly apparent, *extrema lineamenta* ± laevigate.

Comparison — *L. notatus* Hacquebard (1957) is closely comparable in shape as well as in thickness of the exine but is bigger in size. As far as known to us all the other species of *Leiotriletes* described from contemporary or younger strata, have thinner exine. *L. tumidus* Butt. & Will. (1958) is bigger in size and possesses straight to convex sides in addition to having thinner exine. *L. adnatus* (Kos.) Pot. & Kr. (1955), *L. adnatoides* Pot. & Kr. (1955), and *L. subadnatoides* Bhard. (1957), are all thinner-walled species. *L. sphaerotriangulus* (Loose) Pot. & Kr. is much bigger in size and also has a thinner exine. The other species described are not comparable.

***Punctatisporites* (Ibr.) Pot. & Kr. 1954**

Generotype — *Punctatisporites punctatus* Ibr. 1933

***Punctatisporites* sp.**

Pl. 1, Fig. 2

Description — Spores circular, generally folded to give rise to many derived shapes, diameter 180-200 μ. Y-mark distinct, rays up to two-thirds of the radius long, tecta raised, labra well developed. Exine infrapunctate.

Comparison — *P. punctatus* and *P. obesus* (Loose) Pot. & Kr. are considerably smaller in size and have simple trilete mark though having infrapunctate exine. The other species do not compare.

Infraturma *Apiculati* (B. & K.) Pot. 1956

***Convolutispora* H.S. & M. 1955**

Generotype — *Convolutispora florida* H.S. & M. 1955

Remarks — From a study of the photomicrograph of the diplotype and the other illustrations by Hoffmeister *et al.* (*l.c.*) and Butterworth and Williams (1958), it appears that the exine in *Convolutispora* is ornamented with broad-headed pila which look like vermiculate and obvermiculate ridges when seen in surface view.

The ornamentation in *Verrucosisporites*, *Cyclobaculisporites*, *Convolutispora* and *Raistrickia* as seen along the equator have been figured by Bhardwaj (1955, p. 125). Among the species of *Convolutispora*, *C. stigmoidea* sp. nov. (Pl. 1, Figs. 5-7) shows separate pila which in most of the cases do not cohere, but remain as separate entities, this is also true in *C. geniculata* sp. nov. (Pl. 1, Fig. 12) where though the pila are low set, they do not cohere in most of the cases. However, in *C. tessellata* H.S. & M., and *C. punctatimura* Staplin (Pl. 1, Figs. 9-11) as illustrated by us, the sculptural elements are very much crowded and fused together to appear as obvermiculate ridges on the exine. But even in these cases when they are viewed on the *extrema lineamenta* the individual elements are clearly seen. Among the species of *Convolutispora* illustrated by Hoffmeister, Staplin & Malloy (*l.c.*), the holotype of *C. florida* shows broad-headed pila for its ornamentation, which partly cohere to form vermiculate ridges, the individual elements in this case being clearly seen on the *extrema lineamenta*. The paratype of *C. florida* illustrated by the above authors (Hoffm. *et al.* Pl., 38, Fig. 5) apparently shows a different type of ornamentation, consisting of thick, massive ridges. As compared to *C. florida*, the other species by them, e.g. *C. tessellata*, *C. mellita*, *C. venusta* and *C. ampla*, though ornamented with pila, show their confluence resulting into a convoluted, ridged, vermiculate or obvermiculate appearance. In their *C. tessellata* the individual elements can still be recognized to a great extent even on the surface, while in *C. mellita*, *C. ampla* and *C. venusta* the elements cohere to a greater extent to give the characteristic convoluted appearance. Butterworth & Williams (1958) record a good number of species of *Convolutispora* from the Limestone Group of the Lower

Carboniferous of Scotland. Among the species recorded by them, the spores referred to *C. florida* show distinct individual pila on the surface as well as on the *extrema lineamenta*, while the spores referred to *C.* cf. *florida* show partly confluent pila in their ornamentation. *C. verricosa* Butt. & Will. shows sinuous vermiculate ornamentation and is comparable to *C.* cf. *florida* in its sculpture. Spores ascribed to *C. mellita* and *C.* cf. *mellita* by Butterworth & Williams (*l. c.*) show the confluence of pila to a great extent. Although the specimens in Pl. 2, Figs. 20, 26 of Butterworth & Williams (*l.c.*) show only partly fused pila forming irregular vermiculate ridges, their Pl. 2, Fig. 21 shows a spore with considerably less indication of pila in the ridges, representing the extreme type of confluence of pila. The other species illustrated by them, *C. ampla, C. tessellata, C. venusta, C. cerebra* Butt. & Will. show various grades of confluence of sculptural elements. Potonié (1956) places *Convolutispora* in Infraturma *Murornati*, considering the ornamentation to be composed of irregular muri. In view of the ornamentation among the species of the genus being basically composed of pila, the genus has been placed under *Apiculati* by us.

***Convolutispora tessellata* H.S. & M. 1955**

Pl. 1, Fig. 11

Holotype — Hoffmeister, Staplin & Malloy 1955, Pl. 38, Fig. 9.

Loc. Typ. — Hardinsburg formation, Mississippian, U.S.A.

Description — *See* Hoffmeister, Staplin & Malloy 1955, p. 385.

Remarks — In the spores observed by us as well as those illustrated by Hoffmeister, Staplin & Malloy (*l.c.*) and Butterworth & Williams (*l.c.*) the ornamentation consists of partly confluent pila, running into ridges which irregularly anastomose. Generally the triradiate mark is hidden by the ornamentation.

***Convolutispora punctatimura* Staplin 1960**

Pl. 1, Figs. 9, 10

Holotype — Staplin 1960, Pl. 2, Fig. 20.

For description *see* Staplin 1960, p. 12

***Convolutispora cerebra* Butt. & Will. 1958**

Pl. 1, Fig. 13

Holotype — Butterworth & Williams 1958, Pl. 2, Fig. 18.

For diagnosis and description, *see* Butterworth & Williams 1958, p. 371.

***Convolutispora stigmoidea* sp. nov.**

Pl. 1, Figs. 3-7

Holotype — Pl. 1, Fig. 5.

Loc. Typ. — Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular to oval miospores, 40-60 μ, Y-mark hardly perceptible. Exine covered with blunt pila, which are ± uniform in size and more or less separated from the adjacent ones. *Extrema lineamenta* uneven.

Description — Yellowish brown miospores, holotype 52 μ. Y-mark not clearly seen. Exine uniformly covered over by dark mound-like pila. The pila having a short neck and a broad head, up to 12 μ in width. Exine in between the pila, infrapunctate. *Extrema lineamenta* uneven due to the presence of pila, 8-12 pila can be usually counted along the equatorial margin.

Comparison — The other species of *Convolutispora* differ in possessing smaller sculptural elements which sometimes cohere to form a pseudoreticulate ornamentation. The spore figured as a fragment of *Verrucosisporites* by Hoffmeister, Staplin and Malloy (1955, PL. 3, FIG. 3) from Stanley formation, Oklahoma-Texas, belongs here.

Convolutispora* cf. *C. stigmoidea

Pl. 1, Fig. 8

Description — Circular, 80 μ, Y-mark hardly decipherable. Exine uniformly covered over by pila which are up to 12 μ broad and 10 μ high, the exine in between the pila infrapunctate. Along the *extrema lineamenta* ± 30 pila can be counted.

Comparison — *C. stigmoidea* though possessing a similar ornamentation differs considerably in its overall size as well as the height of the pila. The other species of *Convolutispora* described here and by earlier workers do not compare.

***Convolutispora geniculata* sp. nov.**

Pl. 1, Fig. 12

Holotype — Pl. 1, Fig. 12.

Loc. Typ. — Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 120-130 μ. Y-mark conspicuous, rays of the mark going up to

two-thirds of the radius or slightly more. Exine covered over uniformly by ± 6 μ broad, almost neckless rarely fused pila.

Description — Circular-oval, yellowish brown miospores, holotype ± 125 μ. Y-mark present, sometimes covered over by closely packed pila, apex and vertex low, labra clearly developed, arm-ends blunt. Exine and *extrema lineamenta* uniformly covered all over by densely packed pila.

Comparison — *C. tessellata, C. florida, C. mellita, C. ampla* and other species differ in possessing sculptural elements which anastomose to give a pseudoreticulate appearance. *C. stigmoidea* and *C.* cf. *stigmoidea* differ in possessing bigger sculptural elements which are fewer in number and also lack a distinguishable Y-mark. *C.* cf. *tessellata* Butt. & Will. perhaps belongs here.

Apiculatisporis (Ibr.) Pot. & Kr. 1956

Generotype — *Apiculatisporis aculeatus* Ibr. 1933.

Apiculatisporis cf. *A. maculosus* (Knox) Pot. & Kr. 1956

Pl. 1, Fig. 15

Description — Circular, with semilunar folds, 120-130 μ. Y-mark distinct going up to two-thirds of the radius or slightly more, apex and vertex low, labra thin. Exine ornamented with 2-3 μ broad apiculae, with grana interspersed between them.

Remarks — *Apiculatisporis maculosus* was first described by Knox (1950) as *Verrucosisporites maculosus*. She illustrates the holotype only by a line drawing and gives a brief specific description. The only other record of *A. maculosus* is that figured by Butterworth and Williams (1958, Pl. 1, Figs. 28, 29). Neither Potonié & Kremp (l.c.) who suggested the present combination nor Butterworth & Williams (l.c.) who refer some specimens to this species, have given a revised diagnosis. In fact, it is difficult to comprehend exactly how this species is to be defined. From the illustrations of Butterworth & Williams (l.c.) it appears that this species consists of circular miospores, 80-130 μ in size with distinct Y-mark, the rays going up to two-thirds of the radius or slightly more in length; exine ornamented with ± 2-3 μ broad and as much long coni. However, our specimens show apiculae with granulose elements interspersed.

Apiculatisporis connatus sp. nov.

Pl. 1, Fig. 16

Holotype — Pl. 1, Fig. 16.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 80-100 μ. Y-mark distinct, reaching up to two-thirds of the radius. Exine ± 4 μ thick in optical section, covered with coni which are irregularly placed.

Description — Yellowish brown, circular miospores rarely folded, holotype 90 μ. Y-mark conspicuous, tecta raised, ends blunt and not tapering. Exine ± 4 μ thick, covered with less than 1 μ wide coni which are irregularly distributed and spaced unevenly; coni clearly observed on the *extrema lineamenta*.

Comparison — *A. seperatus* sp. nov. is much smaller in size and has thinner exine. The other species of *Apiculatisporis* hitherto described and listed by Potonié & Kremp (*l.c.*) and later workers do not compare, because all the other species differ in possessing distinctly longer coni for their sculpture.

Apiculatisporis densus sp. nov.

Pl. 1, Figs. 17, 18

Holotype — Pl. 1, Fig. 17.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis—Circular, 35-40 μ, Y-mark present but hardly perceptible. Exine covered uniformly and densely with ± 1·5 μ long, longer than broad, sharply tipped coni. *Extrema lineamenta* uneven.

Description — Circular, holotype 38 μ. Y-mark obscured by the overcrowding coni. Exine and *extrema lineamenta* uniformly covered by sharply tipped, closely packed coni, giving pseudoreticulate appearance when viewed in lower foci, coni bases occasionally cohering.

Comparison — *A. aculeatus* Ibr. is bigger in size and distinguishes by possessing longer and loosely spaced apiculae. *A. abditus* (Loose) Pot. & Kr. and *A. grumosus* (Ibr.) Pot. & Kr. have short and stumpy coni for their ornamentation. *A. latigranifer* (Loose) Pot. & Kr. and *A. maculosus* (Knox) Pot. & Kr. possess circular coni, while *A.* cf. *setulosus* (Kos.) Pot. & Kr. possesses sharply tipped, but sparser coni for the ornamentation. *A. spinosaetosus* Loose, has bigger and sparsely distributed coni, and *A. triangularis* (Kos.) Pot. & Kr. possesses small grana-like

coni. Thus all the species described have different type of ornamentation. *A. densus* distinguishes from the species described earlier in possessing small, sharply tipped and closely packed coni for its ornamentation.

Planisporites (Knox) Pot. & Kr. 1954

Generotype — *Planisporites granifer* (Ibr.) Knox 1950.

Planisporites asperatus sp. nov.

Pl. 1, Figs. 19, 20

Holotype — Pl. 1, Fig. 19

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subtriangular, 30-40 μ. Y-mark distinct, rays almost reaching the equator. Surface covered irregularly with coni.

Description — Yellowish brown, subtriangular miospores, holotype ± 40 μ. Y-mark distinct, apex and vertex low, ray-arms almost reaching the equatorial contour. Exine ornamented with about 1 μ broad coni which are irregularly distributed..

Comparison — All the known species of *Planisporites* are bigger in size. No comparable spores have been described by other workers from Lower Carboniferous strata.

Iugisporis gen. nov.

Generotype — *Iugisporis limpidus* sp. nov.

Generic Diagnosis — Roundly triangular, trilete miospores, labra raised forming distinct ridges, rays not reaching the equator, exine sparsely, irregularly and minutely apiculate.

Description — Trilete miospores of known size ranging from 40 to 70 μ, subtriangular with rounded angles and convex sides. Trilete mark distinct, rays being elevated as ridges. Labra denser due to thickness. Exine mediumly thick, usually not secondarily folded, surface bearing minute coni rather sparsely and irregularly distributed all over.

Derivation of the Name — Latin *iugum* meaning a ridge.

Comparison — Among the known apiculate trilete miospore genera listed by Potonié (1956, 1958) none possesses such distinctly ridge-like Y-rays. Among laevigate, trilete genera, some species of *Calamospora* are known to have ridge-like rays but they are circular in shape as well as lack the apiculate ornamentation as compared to *Iugisporis*.

Iugisporis limpidus sp. nov.

Pl. 2, Figs. 21-25

Holotype — Pl. 2, Fig. 21.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subcircular, 38-52 μ. Y-mark distinct, ray-ends blunt, apex and vertex raised, rays going up to three-fourths of the radius or less. Surface covered over by coni which are irregularly distributed.

Description — More circular than triangular miospores, holotype 40 μ, Y-mark prominent, arms abruptly ending before reaching equatorial margins, tecta raised, vertex high. Exine ±1·5 μ thick in optical section, covered sparsely by less than 1 μ wide coni, the arrangement and distribution of coni not very regular.

Iugisporis sp.

Pl. 1, Fig. 14

Description — Subcircular, Y-mark with thickened and raised labra, exine 4 μ thick, lowly ornamented.

Comparison — Distinctly bigger in size to *I. limpidus* and with thicker exine.

Ibrahimisporis Artüz 1957

Generotype — *Ibrahimisporis microhorridus* Artüz 1957.

Ibrahimisporis spitzbergensis sp. nov.

Pl. 2, Figs. 26, 27

Holotype — Pl. 2, Fig. 27.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular, 60-75 μ. Y-mark indistinct in obliquely flattened specimen otherwise seen clearly. Exine sparsely beset with 3-4 μ long, sharp-tipped, usually curved spines with the in-between space densely and finely ornamented.

Description — Roundly triangular, holotype 72 μ. Trilete mark may or may not be prominent depending upon the plane of flattening, arms reaching the equatorial margin. Exine sparsely covered over by ± 3-4 μ long, sharp, curved, irregularly distributed spinae, ± 30 spinae can be counted on the *extrema lineamenta*.

Comparison — The specimens figured here are closely comparable in organization to *Ibrahimisporis microhorridus* Artüz but differ from it in size.

Infraturma *Murornati* Pot. & Kr. 1954

***Microreticulatisporites* (Knox) Bhardwaj 1955**

Generotype — *Microreticulatisporites lacunosus* (Ibr.) Knox 1950.

***Microreticulatisporites microreticulatus* Knox 1950**

Pl. 2, Fig. 28

Holotype — Knox 1948, Fig. 42.

Loc. Typ.— Scotland, Limestone Coal group, Lower Carboniferous.

For diagnosis and description, *see* Butterworth & Williams 1958, p. 367.

***Reticulatisporites* (Ibr.) Pot. & Kr. 1954**

Generotype — *Reticulatisporites reticulatus* Ibr. 1933.

***Reticulatisporites maximus* sp. nov.**

Pl. 2, Fig. 29

Holotype — Pl. 2, Fig. 29.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 125-150 μ. Y-rays ½ radius long, sometimes longer. Exine covered with ± 25 μ high muri forming broad, polygonal meshes.

Description — Dark, yellowish brown, circular miospores, holotype 145 μ, meshes regular and polygonal.

Comparison — The other species of *Reticulatisporites* hitherto described are smaller in size.

***Reticulatisporites* sp.**

Pl. 2, Figs. 30, 31

Description — Circular in polar view but sphaero-pyramidal in meridional view, Y-rays indistinct, meshes few and large formed by 6-8 μ high and 5-6 μ wide, brownish muri.

***Corbulispora* gen. nov.**

Pl. 2, Figs. 32-34

Generotype — *Corbulispora retiformis* sp. nov.

Generic Diagnosis — Circular to oval miospores possessing prominent trilete mark with thick conspicuous labra. Exine covered by muri forming wide, complete or incomplete meshes, the muri sometimes ending abruptly. Muri low and solid.

Description — Spores with heavy muri which enclose broad lumina. Generally the trilete mark inconspicuous in the maze of muri but when seen it is distinct with broad labra. *Extrema lineamenta* without any membraneous flange, muri seen only in profile. On the exine, meshes regular or irregular due to some muri ending abruptly.

Derivation of Name — Latin *corbul/a* — meaning little basket.

Comparison — *Microreticulatisporites* distinguishes in possessing fine and complete meshes with peaked muri. *Reticulatisporites* differs in possessing broad, but high muri forming complete meshwork and in lacking thick labra so characteristically present in *Corbulispora*. *Dictyotriletes* (Naum.) Pot. & Kr. has flat muri and also possesses a simple trilete mark. *Foveolatisporites* Bhard. (1955) differs in possessing fine muri, enclosing foveolae. *Vestispora* (Wils. & Hoffm.) Bhard. (1957) distinguishes by possessing irregular muri and other characters.

The following species belongs to *Corbulispora*: *Corbulispora* (*Azonotriletes*) *cancellatus* (Waltz) comb. nov. (for holotype, diagnosis and description, *see* Luber & Waltz 1938).

***Corbulispora retiformis* sp. nov.**

Pl. 2, Figs. 32-34

Holotype — Pl. 2, Fig. 32.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Oval-circular miospores, 90-125 μ. Y-mark prominent, rays two-thirds of the radius long or less, labra thick, apex high. Exine ornamented with 5-10 μ high solid muri, which form tetragonal to polygonal meshes in which sometimes muri incomplete. *Extrema lineamenta* uneven.

Description — Dense, dark brownish black miospores, holotype 100 × 120 μ. Y-mark conspicuous, two-thirds of the radius or less, apex raised, labra ± 8 μ thick on either side of the suture, in some cases appearing dissected as if formed by confluence of wart-like fragments. Exine covered by ± 8 μ thick muri which form complete or incomplete meshes, enclosing broad lumina. Certain muri ending abruptly as stubs.

Infraturma *Perinotriliti* Erdt. 1947

***Velamisporites* gen. nov.**

Pl. 4, Figs. 51-55

Generotype — *Velamisporites rugosus* sp. nov.

Generic Diagnosis — Trilete spores with a thick, laevigate exine, enveloped uniformly all over by a perisporial covering.

Description — Circular, oval — roundly triangular miospores with a prominent trilete mark. Body exine ± laevigate, thick-walled and covered over by a granulose perine, wrinkled on the surface giving a corrugated and pseudoreticulate appearance.

Derivation of Name — Latin *Velam/en* meaning covering.

Comparison — *Perotrilites* Couper (1953, 1958) is from the Mesozoic sediments of New Zealand. Though the generic diagnosis given by Couper (1954) is broad enough to accommodate our specimens also, the creation of a new genus is necessitated by the disparity in age between *Perotrilites* and *Velamisporites*. *Proprisporites* Neves (1958) has sparse lobate and linear folding of the perisporial membrane. The other known genus with a perispore is *Thylakosporites* Pot., which is a megaspore genus from the Mesozoic sediments, hence a comparison is not possible. The spore body, without the perisporial covering, is comparable to *Punctatisporites* and *Calamospora*.

***Velamisporites rugosus* sp. nov.**

Pl. 4, Figs. 52-55

Holotype — Pl. 4, Fig. 52.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 120-160 μ. Y-mark present, sometimes obscured due to the perisporial covering. Spore exine ± 2 μ thick in optical section, laevigate, covered over by a granulose perisporial coat, crumpled to give a densely rugose appearance.

Description — Dark yellowish-brown miospores with a perisporial covering. Y-mark present, when distinct the arms seen to reach up to $\frac{1}{2}$-$\frac{2}{3}$ radius, apex and vertex of the trilete mark low. The perisporial covering generally intact, but sometimes torn off exposing the spore (Pl. 4, Fig. 53). In many cases only perisporial coverings, without the inner spore, at first mistaken for a different type of spore, but on finding some specimens like the one figured in Pl. 4, Fig. 55, their real nature clearly understood.

***Velamisporites descretus* sp. nov.**

Pl. 4, Fig. 51

Holotype — Pl. 4., Fig. 51.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 90-110 μ. Y-mark present, rays two-thirds of the radius long. Exine smooth, enveloped by a ± laevigate perisporial coat.

Description — Yellowish-brown miospores, holotype ± 100 μ (excluding the perispore). Circular, Y-mark prominent, almost going up to two-thirds of the radius, apex and vertex low, labra thin, tecta-ends blunt. Perisporial covering 110 μ wide on the equator, ± laevigate, usually showing some irregular, small folds.

Comparison — *V. rugosus* differs in possessing granulose perispore and is much bigger in size.

Infraturma *Lagenotriletes* Pot. & Kr. 1954
Subturma *Gulati* Bhard. 1957

***Rostratispora* gen. nov.**

Pl. 2, Figs. 35-40

Generotype — *Rostratispora iucundus* sp. nov.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Generic Diagnosis — Megaspores, meridionally pitcher-shaped with a round bottom, and sharply converging apical part leading to a gula; equatorially circular to subcircular with thick arcuate ridges enclosing the Y-mark, whose rays are progressively elevated towards the pole. Exine ornamented with verrucae.

Description — Usually flattened in meridional plane, equatorially flattened specimens rare. Gula protruding out like a beak or the neck of a pitcher. The body of the spore all over ornamented with verrucae.

Derivation of Name — Latin *Rostrat/us* meaning beaked.

Comparison — *Lagenicula* (B. & K.) Pot. & Kr. distinguishes in possessing a very much drawn out trilete apparatus and prominent hair-like outgrowths. *Lagenoisporites* Pot. & Kr. possesses a ± laevigate exine and hence differs from *Rostratispora*. *Setosisporites* (Ibr.) Pot. & Kr. differs in possessing hair-like outgrowths on the exine.

***Rostratispora iucundus* sp. nov.**

Pl. 2, Figs. 35-40

Holotype — Pl. 2, Figs. 35, 36.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Gulate megaspores with a pitcher-shaped meridional outline and circular-subcircular equatorial outline in polar view, 400-500 μ. Y-mark prominent, apex

and vertex raised. Exine densely ornamented with verrucae, which irregularly anastomose to form short ridges.

Description — Holotype 400 × 420 μ in equatorial plane. The size range in meridional plane varies from 300 × 350 to 400 × 500 μ, and in equatorial plane from 320 × 360 to 420 × 480 μ. The gula protrudes 50-80 μ high above the rays. Y-mark distinct, apex and vertex raised into a gula with prominent arcuate ridges. Exine densely ornamented with verrucae which coalesce with adjacent ones forming short ridges. The verrucae are 5-10 μ broad at the base with conical apex, spread all over the exine, but those in the area contagionis are smaller in size.

Remarks — These megaspores are similar to those described out of *Porostrobus zeilleri* by Bharadwaj (1958). Among the specimens illustrated here some (PL. 2, FIGS. 37-40) appear not only slightly bigger in sizes but their ornamentation also seems to be coarser. May be that these two groups are specifically different but the differences being very difficult to assess quantitatively they are all grouped under one species.

Turma ***Zonales*** **Pot. & Kr. 1954**
Subturma ***Auritotriletes*** **Pot. & Kr. 1954**
Infraturma ***Auriculati*** **(Schopf) Pot. & Kr. 1954**

Triquitrites **Wils. & Coe 1940**

Generotype — *Triquitrites arculatus* Wils. & Coe 1940.

Triquitrites tribullatus **(Ibr.) Pot. & Kr. 1956**

Pl. 4, Fig. 56

Holotype — Potonié & Kremp, 1956, Pl. 17, Fig. 39; after original Ibrahim, 1932, Pl. 15, Fig. 13.

Loc. Typ.— Ägir seam, Ruhr Coal Measures, Lower Westphalian C.

Diagnosis — (Translated from Potonić & Kremp, 1956, p. 90). 40-70 μ, holotype 62 μ, Y-mark ± reaching the auriculae, these are slightly inflated and ± bilobed, equatorial contour triangular.

Remarks — Potonié and Kremp (*l.c.*) have noted that *T. tribullatus* occurs in Westphalian B of the Saar and Westphalian D of U.S.S.R. but it has also been recorded from the Lower Carboniferous of Scotland (BUTTERWORTH & WILLIAMS *l.c.*) and as reported here it also occurs in the Lower Carboniferous of Spitzbergen.

Triquitrites leiolitus **Bhard. 1957**

Pl. 4, Fig. 57

Holotype — Bhardwaj 1957, Pl. 25, Fig. 61.

Loc. Typ.— *Velener Schichten* (Lower Westphalian D), Ruhr Coal Measures.

For diagnosis and description, *see* Bhardwaj 1957, pp. 122, 123.

Remarks — The specimen illustrated here and the other specimens studied by us show faint angular thickenings as in *T. leiolitus*, but they also show infrapunctate structure in the spore coat which is ± 2 μ thick. Because of the presence of scanty angular thickenings the spores encountered here have been placed in *T. leiolitus*. It is of interest to note that *T. leiolitus*, as assigned by Bhardwaj (*l.c.*) approaches more the specimens of *Leiotriletes* in its organization but because of the presence of angular thickenings, they have to be included in *Triquitrites*. *T. dividuus* (WILSON & HOFFMEISTER, 1956) differs in possessing verrucose thickenings in the commissural area.

Triquitrites **cf.** ***T. bransonii*** **Wilson & Hoffmeister 1956**

Pl. 4, Fig. 59

Holotype (*T. bransonii*) — Wilson & Hoffmeister 1956, Pl. 3, Fig. 1.

Description — Triangular miospores with prominent concave sides and well-developed valvae, 40-60 μ. Y-mark prominent going up to the angular lobes, valvae broad, thick like a cushion, generally massive, sometimes slightly partate. Exine infragranulose and ± 2 μ thick.

Comparison — The specimens observed by us do not very well compare with the holotype and the other specimens described as *T. bransonii* by previous authors, but its closer resemblance with that species necessitates the specimens from Spitzbergen to be placed as *T.* cf. *bransonii* rather than as any other known species. Though a good number of specimens have been encountered in the present assemblage and studied by us, for the present, we defer putting them as a new species. *T. additus* and *T. discoideus* (WILSON & HOFFMEISTER, 1956) differ in possessing finger-like processes emerging out of the valvate thickenings. The other species are distinctly different from *T.* cf. *bransonii*.

Triquitrites golatensis **(Staplin) comb. nov.**

Pl. 5, Figs. 64-75

Syn.— *Tripartites golatensis* Staplin 1960.

Loc. Typ.— Golata formation, Alberta, Canada.

Diagnosis (emend.) — Triangular miospores with straight to concave sides, 40-70 μ. Y-mark almost reaching the base of auriculae. Auriculae up to 36 μ broad, massive club-shaped cushion-like, or partly dissected fan-like, broadly covering the apices of the spore body. Exine infragranulose, 2-4 μ thick.

Description — Dark, blackish brown miospores, prominently auriculate with a broadly triangular contour, generally ± 60 μ but sometimes bigger or smaller specimens are also met with. Auriculae massive, cushion-like or partate or mixed, 20-36 μ broad. Central area of the body very small, ± 30 μ wide, while the auriculae comparatively much larger. Y-mark prominent, arms reaching the base of auriculae, labra slightly raised. Exine of the body infragranulose, 2-4 μ thick, *extrema lineamenta* uneven. Auriculae broadly covering the angular apices of the spore body, but leaving a wide area between them. In over-macerated specimens (as illustrated in Pl. 5, Fig. 66) partate auriculae apparently constituted of laminated layers of thickenings.

Comparison — The specimens illustrated here form an intergraded series from those unquestionably like *Triquitrites* to those referred by other authors to *Tripartites*, e.g. Hoffmeister *et al.* (1955) refer their Pl. 39, Fig. 15 to *Tripartites vetustus*, Butterworth & Williams (1958) refer their Pl. 3, Fig. 6 to *Tripartites* cf. *vetustus* and Hacquebard & Barss (1957) refer their Pl. 2, Fig. 22 as *Tripartites ? trivalvis*. These species differ quantitatively from *T. golatensis* in possessing very much developed auriculate thickenings. This naturally raises an important question about the validity of the distinguishing features between these two genera. Among the other species of *Triquitrites*, *T. triturgidus* (Loose) Pot. & Kr., though admissible in the size range, differs in possessing less pronounced auriculate thickenings and *T. arculatus* Wils. & Coe (*l.c.*) is smaller in size and differs in possessing a very thin membranous flange on the equator as well as the three angles.

Triquitrites coesfeldens **Bhard. 1957**

Pl. 5, Figs. 76, 77

Holotype — Bhardwaj 1957, Pl. 25, Fig. 66.

Loc. Typ.— Velener Schichten (Lower Westphalian D), Ruhr Coal Measures.

For diagnosis and description, *see* Bhardwaj 1957, p. 123.

Remarks — The spores described here are slightly bigger in size than the holotype and paratype illustrated by Bhardwaj (*l.c.*) and possess more developed equatorial flange and valvae. The *extrema lineamenta* in the holotype is toothed whereas in the other specimens illustrated by Bhardwaj (*l.c.*) and the ones illustrated in this account the *extrema lineamenta* is almost even.

Triquitrites inconcinnus **sp. nov.**

Pl. 4, Figs. 60, 61

Holotype — Pl. 4, Fig. 61.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Spores roundly triangular with broad angles, 55-70 μ. Y-mark present but not clearly seen. Body roundly triangular. Valvae covering the apices and broad, irregularly developed on all the three angles of the spore and connected by a flange. Exine in the body region infrapunctate, *extrema lineamenta* uneven.

Description — Broadly triangular, dark brown miospores, with rounded angles, holotype 60 μ. Y-mark not clearly seen, valvae not uniform at all the three angles, sometimes entire but otherwise partate, angular thickenings connected by a ± 6 μ wide flange; in certain cases the valvae of neighbouring angles coming up together and forming a massive thickening.

Comparison — *T. coesfeldens*, though comparable, is much smaller in size. *T. diuturnus* has distinct trilete mark and smooth cushion-like valvae.

Triquitrites subgrandis **Artüz 1957**

Pl. 4, Fig. 58

Holotype — Artüz 1957, Pl. 4, Fig. 28.

Loc. Typ.— Flöz sulu (Westphalian A), Turkey.

For diagnosis and description, *see* Artüz 1957, pp. 248, 249.

Remarks — The size range given by Artüz (*l.c.*) is 55-70 μ, while our specimens are smaller.

***Triquitrites* sp. A.**

Pl. 4, Fig. 62

Description — Roundly triangular with broadly conical auriculae, between the auriculae the body equator showing 2 μ thick, laevigate border, Y-mark only faintly discernible, surface exine irregularly, densely ornamented.

Comparison — None of the many species of *Triquitrites* known are comparable with this solitary specimen discovered so far.

***Triquitrites* sp. B.**

Pl. 4, Fig. 63

Description — Broadly triangular bearing valvae slightly projecting beyond the general outline. Y-mark distinct, rays extending a little into the valvae. Exine laevigate, unequally thick giving a mottled appearance.

Comparison — Not comparable to any of the known species of *Triquitrites*.

General Remarks on Triquitrites — In the description of the foregoing species of *Triquitrites* it can be clearly seen that there is a wide range of variation exhibited in the genus. Certain species like *T. leiolitus* approach more the simpler genera such as *Leiotriletes* (Naum.) Pot. & Kr., by exhibiting minor thickening on the three angular apices, certain other species like *T.* cf. *bransonii*, show typical organization of *Triquitrites* in possessing valvate thickenings which are ± uniform and prominent, but in other species described here such as *T. golatensis*, partate or cushion-like auriculae are present or as in *T. coesfeldens* Bhard., and *T. inconcinnus* there are well-developed angular thickenings and connecting flanges which are ± thick. The last group of species approach *Simozonotriletes* in their organization. In the species of *Simozonotriletes* illustrated by Sullivan (1958), the varieties *S. intortus* var. *lineatus*, *S. intortus* var. *sublobatus*, *S. intortus* var. *polymorphosus*, *S. intortus* var. *concavus*, *S. intortus* var. *trivalvis*, *S. intortus* var. *reinschi* and *S. intortus* var. *mediolobatus* show well-developed angular thickenings very much comparable to those in *Triquitrites*. On the other hand *T. golatensis* approaches *Tripartites* as already pointed out.

Thus there is continuous variation in *Triquitrites* ranging from types coming close to *Leiotriletes* to those approaching *Simozonotriletes* or *Tripartites*, so much so, that it is difficult to maintain the taxonomic individuality of these genera. However, for the present the authors feel it advisable to maintain the normally understood circumscription of these genera, until their morphographical limits are still better known.

Subturma *Zonotriletes* Waltz 1935
Infraturma *Crassiti* infraturma nov.

Diagnosis — Miospores with a crassitudinous margin not distinctly demarcated from the rest of the spore.

***Crassispora* Bhard. 1957**

Generotype — *Crassispora ovalis* Bhard. 1959.

***Crassispora vestita* sp. nov.**

Pl. 5, Figs. 85, 86

Holotype — Pl. 5, Fig. 85.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subcircular miospores 40-59 μ. Y-mark opened like a triangular window, rays up to three-fourths of the radius long, tecta thin and low. Exine minutely apiculate, *extrema lineamenta* sparsely uneven. Crassitudo distinct, 3-4 μ wide.

Description — Dark brown miospores with subcircular or roundly triangular equatorial contour, holotype 43 μ. Y-mark less distinct when closed but usually widely open with the labra rolling backwards, rays not extending up to the margin. Crassitudo 3-4 μ wide appearing as a dense rim. Exine sparsely covered with less than 1 μ wide coni also seen on the *extema lineamenta* and along the open trilete rays.

Comparison — *C. ovalis* Bhard. is distinctly different in possessing longer coni for its ornamentation. *C. pfalzensis* Bhard. & Venk. is much bigger in size and differs in having very sparsely distributed coni. Stratigraphically also, the above species being of uppermost Carboniferous, are widely separated.

***Crassispora spitzbergense* sp. nov.**

Pl. 5, Figs. 87, 88

Holotype — Pl. 5, Fig. 87.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Oval or roundly triangular, 46-62 μ, holotype 60 μ, Y-mark usually

faintly discernible, Crassitudo 8-10 μ wide, exine densely, finely apiculate, coni less than 1 μ high.

Comparison — *C. vestita* has narrower crassitudo and sparser coni. *C.* sp. A. has coarser coni and *C.* sp. B. is distinctly bigger. *C. ovalis* and *C. pfalzensis* are stratigraphically widely separated.

Crassispora sp. A.

Pl. 5, Fig. 89

Description — Dark brownish, subcircular, ± 60 μ. Y-mark not distinct. Crassitudo 14-16 μ wide, diffused. Exine thickly set with ± 2 μ long, sharp tipped coni, coni densely set in the crassitudinous region and sparse in the body region.

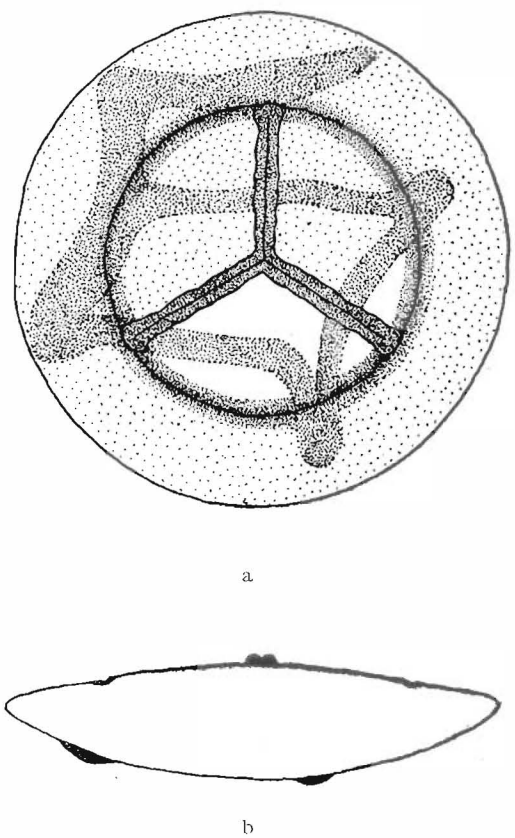
Comparison — *C. ovalis* and *C. pfalzensis* differ in possessing longer and sparsely set coni. *C. vestita* differs in possessing finer and sparser ornamentation.

Crassispora sp. B.

Pl. 5, Fig. 90

Description — Subcircular, 75 μ. Y-mark faint, rays two-thirds of the radius, arm ends indistinct, apex and vertex low, labra thin. Crassitudo 8-10 μ thick. Exine granulose, grana irregularly distributed.

Comparison — *C. ovalis* Bhard. is distinctly smaller and so are *C. vestita*, *C. spitzbergense* and *C.* sp. A., as compared to *C.* sp. B. Only one specimen is known so far.



TEXT-FIG. 2. — *Orbisporis* gen. nov. a, polar view. b, meridional section.

Orbisporis gen. nov.

Generotype — *Orbisporis muricatus* sp. nov.

Generic Diagnosis — Circular to subcircular, radial, trilete miospores with a trilete mark, rays up to three-fourths of the spore radius, having thickened labra ending on the proximal face into a ring of thickening from which short thickenings ensuing forth at wide intervals towards the equator. Distally exine unornamented or ornamented with ring-like or irregularly running thick muri building wide meshes. Equator appears crassitudinous. Exine ± laevigate.

Description — Overall shape ± circular with a few, slightly angular projections in the outline opposite the radial thickenings ensuing from the trilete ring or the distal muri. Known size range 72-100 μ. Ray lips thickened and elevated in opened as well as closed condition, ray ends bulbous. Distal ornamentations, where present, consist of either interlaced muri with wide meshes or in a subequatorial ring, as on proximal side, with interlaced muri within the ring.

Organization — In Pl. 3, Fig. 48 the spore is broken on one side showing the broken edges of the upper and lower wall in the equatorial region separately which would not have been the case had the equatorial region been a cingulum. The organization of the genus as deduced from the specimens observed is given in Text-fig. 2.

Derivation of Name — Latin *Orbis* meaning a ring.

Comparison — *Knoxisporites* Pot. & Kr. differs by not having such characteristically raised and thickened labra as in *Orbisporis*. Further, *Knoxisporites* appears to possess a distinct, equatorial cingulum the like of which is not found in *Orbisporis*. Stratigraphically, typical *Knoxisporites* is younger, starting

from Namurian A and continuing up to Westphalian C. *Labiadensites* lacks distal muricate ornamentation as well as proximal ringed trilete apparatus and possesses a cingulum.

***Orbisporis muricatus* sp. nov.**

Pl. 3, Figs. 41-44

Holotype — Pl. 3, Figs. 41, 42.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subcircular miospores, known size 90-100 μ. Holotype 100 μ, proximally arcuate thickenings low, subtending 5-6 projections towards the margin, distally 3-5 muri running across usually with ends joined and forming a big central mesh.

Description — Labra in trilete apparatus raised as well as 3 μ thick in the middle but up to 5 μ thick at the apex as well as the ends. Thickening continuous round the suture-ends and more prominent and elevated. Arcuate thickening lesser and lower than those of labra. Distally concave muri with ends joined running from near the margin to the other directions enclosing one triangular to polygonal big mesh in the polar region.

***Orbisporis orbiculus* sp. nov.**

Pl. 3, Figs. 45-48

Holotype — Pl. 3, Fig. 45.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 70-90 μ, proximally arcuate ring of the trilete apparatus prominently thickened with 6-8 radial projections towards the margin. Distally muri absent.

Comparison — *O. muricatus* is bigger in size but most characteristically possesses distal muri which are absent in *O. orbiculus*.

***Orbisporis suborbiculus* sp. nov.**

Pl. 3, Figs. 49, 50

Holotype — Pl. 3, Fig. 49.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular, 80-100 μ, proximally an arcuate ring of the trilete apparatus and distally a circular murus with radial, outward projections present.

Comparison — *O. muricatus* has concave muri forming a triangular to polygonal mesh. *O. orbiculus* has no muri distally.

Infraturma *Cingulati* Pot. & Kr. 1954

***Lycospora* (S.W. & B.) Pot. & Kr. 1954**

Generotype — *Lycospora micropapillata* (WILS. & COE) S. W. & B. 1944.

***Lycospora pusilla* (Ibr.) S.W. & B. 1944**

Pl. 5, Figs. 91, 92

For holotype, diagnosis and description *see* Potonié & Kremp 1955, pp. 103, 104

Lycospora pressoides (P. & Kh.) Bh. Pl. 5, Fig. 93.

For holotype, diagnosis and description, *see* Bhardwaj, 1957b, p. 127.

***Simozonotriletes* (Naum. 1937) Pot. & Kr. 1954**

Generotype — *Simozonotriletes intortus* (WALTZ) Pot. & Kr. 1954.

Remarks — In a recent discussion of this genus, Sullivan (1958) has discussed the trends of specialization and the important variations met within the genus. All the specimens studied by Sullivan have a prominent, roundly concavo-triangular ± sculptureless spore body, a prominent triradiate mark and an equatorial girdle which shows many variations from a simple, undivided, broad rim to tripartate expanses and cushioned valvae as in *Tripartites* and *Triquitrites* respectively, with numerous intermediate forms. From the Spitzbergen shales we have also recovered a number of specimens whose generic position appears difficult to resolve if Sullivan's views are taken into consideration. Since the descriptive terminology and classification followed in the present paper is that of Potonié & Kremp (1954) and Potonié (1956 & 1958), it has been thought better to limit the genera and species on the basis of morphography alone.

We are in accord with Potonié (1958, p. 25, 1st para) to retain *Simozonotriletes* as well as *Murospora* Somers. Morphographically the generotypes of these genera show a uniformly wide, regular edged, equatorial extension in the former and comparatively an unequally wide and irregularly edged equatorial extension in the latter. A better idea of *Murospora* is achieved from the illustrations of *Westphalensisporites* Alpern (1958, PL. 1, FIGS. 15-17) which, in our opinion, is congeneric with *Murospora* being morphographi-

cally similar and stratigraphically contemporaneous.

***Simozonotriletes crassimarginatus* sp. nov.**

Pl. 5, Figs. 79, 80

Holotype — Pl. 5, Fig. 79.

Diagnosis — Roundly triangular miospores, 60-95 μ, with a prominent triradiate mark, extending up to the thickened equatorial cingulum; uniformly ± 20 μ wide all round. Body concavo-triangular, exine infragranulose.

Description — Dark, brownish black miospores, roundly triangular sometimes approaching a circular shape but mostly triangular in equatorial plane with convex to slightly concave sides and rounded apices. Body also rounded to roundly triangular with rounded apices and ± concave sides. Y-mark distinct, but in some cases hardly perceptible, due to the thick equatorial rim as well as the ornamentation of the exine. Y-rays going up to the inner margin of the equatorial cingulum, apex and vertex of the ray low, labra thin. Spore body ± 40 μ medianly and equatorial cingulum ± 20 μ wide and girdling the body uniformly. Body laevigate, infragranulose. Cingulum appears to be composed of bacula in some of the overmacerated specimens, *extrema lineamenta* in such cases appearing coarse.

Comparison — *S. intortus* is smaller in size and possesses a thinner cingulum. The different varieties of *Simozonotriletes* described by Sullivan (1958) afford a comparison, but it is difficult to assign our specimens to any one of them. *S. cingulatus* Artüz (1957) is smaller in size and also possesses a thinner cingulum as compared to *S. crassimarginatus*.

***Simozonotriletes reinschi* (Sull.) comb. nov.**

Pl. 5, Figs. 81-84

Holotype — Sullivan 1958, Pl. 28, Fig. 4.

Loc. Typ.— Fenton Seam, Westphalian A, Yorkshire.

For diagnosis and description, *see* Sullivan 1958, p. 133.

Remarks — Sullivan (1958) has exhaustively studied *Simozonotriletes* from Westphalian A sediments. He has recognized nine varieties in the species *S. intortus* (Waltz) Pot. & Kr. He considers these varieties as different trends in a single species. However, in our opinion, in dispersed condition it becomes difficult to recognize them as variations of a fundamental type. It may be that these spore types have a common origin or belong to the same group, but as we find them separated, it is more practical to put them as different taxonomic units. It is also felt more convenient to use a binomial system in describing dispersed spore taxa than to use a trinomial one as used by Sullivan (*l.c.*).

Our specimens agree in morphography and organization with the holotype of *S. intortus* var. *reinschi* (Sullivan, 1958) but are distinctly smaller. The size range of *S. intortus* var. *reinschi* as given by Sullivan is 75-90 μ, whereas our specimens illustrated here as well as those observed, range from 45 to 60 μ. The disparity in age between our material and that of Sullivan as well as the difference in the extent of maceration (Sullivan's specimens appear overmacerated) accounts for the difference in the two size ranges.

***Simozonotriletes intortus* (Waltz) Pot. & Kr.**

Pl. 5, Fig. 78

Holotype — Waltz in Luber and Waltz 1938, Pl. 2, Fig. 24.

Diagnosis — *see* Sullivan, 1958, p. 127.

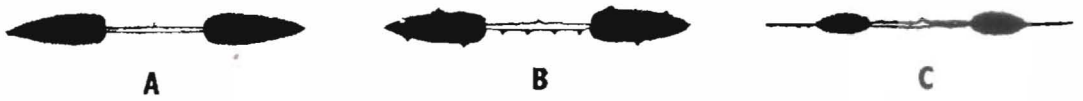
Remarks — Potonié and Kremp (1956), who suggest the combination, have not given a specific diagnosis, however, Sullivan (*l.c.*) gives a diagnosis for this species. The specimen described here under *S. intortus* agrees well with the ones described by Sullivan as *S. intortus* var. *intortus*.

***Densosporites* (Berry 1937) emend.**

Syn.— *Anulatisporites* (Loose) Pot. & Kr. 1954.

Generotype — *Densosporites covensis Berry*, 1937.

Remarks — The name *Densosporites* was given by Berry (*l.c.*) to certain spores characterized by a thick, opaque wall with the central portion clear and without any tetrad mark. He assigned the spores answerable to this definition into 3 species, basing the species on the width and thickness of the equatorial rim which he names as the spore wall. However, he did not define or make any attempt to interpret the nature of the dark equatorial rim and the organization of the spore. It was Schopf, Wilson and Bentall (1944) who elaborately described Berry's genus and emended it. They mention that *Densosporites* has smooth to apiculate



TEXT-FIG. 3 — Sectional view of miospores in Groups A, B, C of *Densosporites*.

and rugose ornamentation and a delicate trilete mark in very well preserved specimens, they also indicate that whenever there is a fissure extending into the margin, it is the extension of the trilete mark. Potonié and Kremp (1954, 1955) later redefined the genus and included there the spores having only verrucose, apiculate or spinose exine as distinguished from *Anulatisporites* having smooth exine. The genus as it stands today includes a number of different types of spores. These can be grouped separately on the basis of the nature of exine ornamentation and the shape of the cingulum as under (TEXT-FIG. 3).

(A) Smooth to faintly granulose and thick, one-zoned, wedge-shaped cingulum.
D. covensis Berry (Generotype)
D. anulatus (Loose) S.W. & B.
D. reynoldsburgensis Kos.

(B) Apiculate and thick, one-zoned, wedge-shaped cingulum.
D. aseki Pot. & Kr.
D. duriti Pot. & Kr.
D. solaris Balme
D. lobatus Kos.
D. spinifer H.S. & M.

(C) Apiculate and two-zoned cingulum.
D. tenuis (Loose) Pot. & Kr.
D. capistratus H.S. & M.

The first group (A) as described above, includes the generotype, as substantiated by the photograph of the holotype (WILSON, 1959, PL. 1, FIG. 2), and hence provides the basic circumscription of *Densosporites*. Group (B) answers to the circumscription of the genus *Cristatisporites* Pot. & Kr., as interpreted by Bhardwaj (1957a), having specimens ornamented with regular or irregular cristae of coni or spinae and possessing a cingulum. Group (C) with the cingulum having a thick (crassitudinous) inner zone and a thin outer zone compares closely with the organization in a section of the genus *Lycospora* (*see* BHARDWAJ, 1957a). The microspores of *Selaginellites canonbiensis* Chaloner (1958) belong here.

We consider that to achieve better standard in the systematics of *sporae dispersae*, *Densosporites* be restricted to Group (A), *Cristatisporites* be emended to conform to species of Group B and the species of Group C be assigned to the comparable section in *Lycospora*.

The emended generic diagnosis of *Densosporites* Berry is as follows:

Triangular to subcircular miospores, Y-mark faint or distinct, may or may not be visible, cingulum thick, single-zoned, wedge-shaped, smooth or faintly granulose.

Densosporites anulatus (Loose) S.W. & B. 1944

Pl. 6, Figs. 94-98

Syn.— *Sporonites anulatus* Loose in Pot., Ibr. & Loose 1932. *Zonales — sporites annulatus* Loose 1934. *Anulatisporites anulatus* (Loose) Pot. & Kr. 1956.

Holotype — Loose 1932, Pl. 18, Fig. 44.

Loc. Typ.— Flöz Bismarck, Ruhr Coal Measures.

For diagnosis, description and remarks, *see* Potonié & Kremp 1956, p. 112 under *Anulatisporites anulatus* (Loose) Pot. & Kr.

Densosporites spitzbergensis sp. nov.

Pl. 6, Figs. 99, 100

Holotype — Pl. 6, Fig. 99.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Triangular with convex sides, 28-36 μ, central body triangular with acute angles, 14-16 μ, Y-mark distinct, rays reaching the outer angles. Cingulum 8-10 μ wide. Exine smooth all over.

Comparison — *D. anulatus* is bigger, more roundly triangular and its central body lacks the sharply acute angles.

Cristatisporites (Pot. & Kr. 1954) emend.

Generotype — *Cristatisporites indignabundus* (Loose) Pot. & Kr. 1955.

Generic Diagnosis (emend.) — Triangular to subcircular miospores, trilete mark present, rays reaching the equator. Exine ornamented with regular or irregular cristae of spinae, verrucae or coni. Cingulum thick, wedge-shaped,

Remarks — After a study of the diplotype and paratypes (*Cristatisporites indignabundus*, illustrated by Potonié & Kremp, 1955, Pl. 16, Figs. 294 & 295) Bhardwaj (1957) came to the conclusion that the spores of *Cristatisporites* are cingulate, having a narrow, subequatorial cingulum. He placed *Cristatisporites* in *Cingulati* along with *Densosporites* and *Lycospora* commenting that "*Densosporites* and *Cristatisporites* appear to be closely related as their structure and organization is closely similar." From a comparative study of the different species of *Cristatisporites* illustrated by Potonié and Kremp (*l.c.*), and Bhardwaj (*l.c.*) there remains no doubt that they distinctly possess a cingulum.

Since *Densosporites* is restricted hereafter to spores with smooth or faintly granulose exine and wedge-shaped, single-zoned, thick cingulum, *Cristatisporites* remains the only genus which can accommodate the spores possessing distinctly verrucose or spinulose ornamentation together with a wedge-shaped cingulum and hitherto included in *Densosporites* (Group B, p. 32). Hence the diagnosis of *Cristatisporites* has been emended.

The spores described from *Porostrobus zeilleri* Nathorst by Bharadwaj (1958) are thick-rimmed with a trilete mark of which the rays enter the equatorial cingulum which is ornamented with grana and spinae. These spores were compared with *Densosporites* Berry by Bharadwaj (*l.c.*). However, such spores in dispersed condition are now referable to *Cristatisporites* as emended here. A study of the *in situ* spores of *Porostrobus zeilleri* as well as similar ones found in dispersed condition, indicates that the trilete mark though present in them is not clearly seen in some cases, and in some other cases it is just seen as thickenings on the cingulum. In overmacerated specimens the rays are sometimes clearly visible but in some other cases are not discernible. It seems that the development of rays cannot be taken as an important character to delimit species in *Cristatisporites*.

***Cristatisporites regalis* sp. nov.**

Pl. 6, Figs. 101-104

Holotype — Pl. 6, Fig. 101.

Loc. Typ. — Pyramidenberg, Lower Carboniferous, Spitzbergen.

Diagnosis — Radial, subtriangular, 62-100 μ, angles blunt and conical, central body hyaline girdled by a dark brown cingulum, 18-26 μ wide between the angles, proximal exine granulose and distal spinose. *Extrema lineamenta* granulose. Y-mark prominent and extending into the cingulum.

Description — Dark brownish black spores, holotype 95 μ, triangular in polar view and dumbbell-shaped in lateral view or vertical section, angles bluntly conical or sometimes rounded with convex sides. Central body ± hyaline, lighter than the dark, thick equatorial cingulum. Body up to 50 μ wide and subtriangular, cingulum up to 35 μ wide at the angles. Y-mark distinct in most of the cases studied as well as in the holotype, rays going up to the equatorial margin, sometimes when the mark not distinct on the body, dark thickened ridges seen on the cingulum in the region of angles indicating that the mark extends up to the cingulum. However, in the spores lying with distal side up, the Y-mark usually obscure. Proximal exine granulose, while the distal side bearing spinules. Ornamentation uniformly present on the body and the cingulum, less dark but dense on the body than on the cingul um. The cingulum very dense around the body and lighter towards the equator. In overmacerated spores outline tending to become more circular, with a prominent Y-mark. Central body containing an inner body bearing three cushions or papillae on the three inter ray areas (Pl. 5, Fig. 84).

Comparison — Spores described as *Densosporites solaris* Balme, *D. duriti* Pot. & Kr., and *D. aseki* Pot. & Kr., differ in possessing bigger spines, which are sparsely distributed over the spore exine; *D. lobatus* Kos., and *D. loricatus* (Loose) S.W. & B., differ from *C. regalis* in exine ornamentation or spore size. *D. cuneicinctus* (H.S. & M.) Staplin (Syn.— *D. tenuis* H.S. & M.) as illustrated by Hoffmeister, Staplin and Malloy (1955, Pl. 36, Figs. 18, 19, 23) resembles our specimens of *C. regalis* to a great extent but differs by lacking spinules on the distal face of central body. The specimen referred to *D. cuneicinctus* by Staplin (1960, Pl. 5, Fig. 14) also belongs to *C. regalis* sp. nov.

Remarks — The spores of *Cristatisporites regalis* sp. nov., are comparable to the microspores recovered from *Porostrobus zeilleri* Nathorst (Bharadwaj, 1958). The overmacerated specimens bearing an inner body having three inter-radial cushions have also been illustrated by Bharadwaj (*l.c.*).

***Cristatisporites spinifer* (Hoffmeister, Staplin & Malloy, 1955) comb. nov**

Pl. 6, Figs. 106-108

Syn.— *Densosporites spinifer* H.S. & M. 1955.

Holotype — Hoffmeister, Staplin & Malloy 1955, Pl. 36, Fig. 17.

Loc. Typ.— Hardinsburg formation Illinois, U.S.A.

Diagnosis — Subtriangular, 32-70 μ. Y-mark prominent. Central body roundly triangular, opaque, with a broad ± uniformly thick cingulum, the central body possessing very closely set grana or coni. The cingulum sparsely covered by ± 8 μ broad and equally long spinae.

Description — Dark brownish miospores, with prominent angles and straight to convex sides, holotype 45 μ. Y-mark distinct and whenever prominent entering the subequatorial cingulum, in certain cases where the mark not very prominent on the body, a dark fissure observed at the three angles of the cingulum, suggesting the extention of the rays right into the cingulum. Spore body roundly triangular covered by grana or coni or both. The cingulum and *extrema lineamenta* ornamented by large spines. The number of spines variable and thus not an important distinguishing character.

Remarks — The holotype and the paratypes illustrated by Hoffmeister, Staplin & Malloy (*l.c.*) are ornamented with spines and coni smaller in size as well as number, as compared to the specimens described here. We prefer to put all these together into *C. spinifer* in view of the similar sculptural pattern met with in all these spores.

***Cristatisporites bellus* sp. nov.**

Pl. 6, Figs. 109, 110

Holotype — Pl. 6, Fig. 109.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular to subcircular miospores, central body small, girdled equatorially by a ± 30 μ wide cingulum, body granulose, cingulum ornamented in basal part by a ring of ± 16 μ broad, sharp-tipped coni. Similar coni also along *extrema lineamenta* and on distal side.

Description — Dark brown miospores, holotype 90 μ. Y-mark seen though indistinct. Exine of central body granulose proximally and cingulum as well as distal face spinose.

Comparison — *C. spinifer* is smaller in size and differs in possessing spines which are much smaller in size and also not arranged in a ring along the base of the cingulum. *C. regalis* has granulose exine and does not possess spinose cingulum.

***Cristatisporites* sp.**

Pl. 6, Fig. 105

Description — Dark brown, roundly triangular, ± 132 μ. Y-mark not seen. Spore body occupied with a number of coni on distal face. Cingulum ± 45 μ wide, dense.

Comparison — The spore described here is comparable to *C. regalis* but for its bigger size and coarser ornamentation on the body.

***Monilospora* Hacq. & Barss 1957**

Generotype — *Monilospora moniliformis* Hacq. & Barss.

Remarks — Staplin (1960) has suggested emendment of *Monilospora* on the assumption that these spores are enclosed by a capsula whereas the original authors contended the spores to be having an equatorial flange with a marginal thickening. We have very carefully examined the illustrations and descriptions given by Hacquebard & Barss (*l.c.*) and Staplin (*l.c.*) as well as some slides of Nahani Coal microflora sent to Bharadwaj by Dr. Barss and contend that the interpretation of the original authors as based on the generotype is correct. The flange is equatorial as the Y-rays do not extend beyond the central body and it consists of a thinner anterior zone followed by a thickened marginal zone. Whether the flange is continued over the central body proximally as well as distally is not clear at least in the generotype. And even if it is there it has to be so thin as to be insignificant morphographically.

***Monilospora crassilimbata* sp. nov.**

Pl. 6, Figs. 111, 112

Holotype — Pl. 6, Fig. 112.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular, 58 to 90 μ. Holotype 90 μ, Y-mark faint, rays reaching the equator, equatorial extension about two-thirds radius in width with a basal densest zone followed by thinner zone in the middle and a crassitudinous marginal zone. Exine densely verrucose,

verrucae on the distal face of the central body coarser.

Comparison — In *M. moniliformis* the flange lacks the innermost dense zone. In species of *Cristatisporites* the subequatorial cingulum has a dense basal zone gradually thinning towards the margin. However, in *M. crassilimbata* the middle zone is the thinnest. A species described by Luber (LUBER & WALTZ, 1938) as *Zonotriletes ciliaris* is comparable but not the same. *Cristatisporites* (as *Densosporites*) *landesii* (STAPLIN, 1960) comb. nov. is also closely comparable but it lacks the marginal crassitudo in the cingulum.

Clavisporis gen. nov.

Generotype — *Clavisporis spitzbergensis* sp. nov.

Generic Diagnosis — Cingulate, trilete miospores, cingulum variable in thickness as well as width, and its marginal portion always dissected partly or wholly into broad, club-shaped, short processes. Central body thin-walled, ± circular in shape and bearing a trilete mark whose rays limited to the central body, labra thin. Exine smooth or punctate on the central body but smooth or granulose on the cingulum, occasionally the basal part of the cingulum warty.

Description — Subcircular to circular miospores; known size range 58 to 157 μ, diplotype ±100 μ; central body ± circular, thin walled bearing a trilete mark with thin and low labra. Cingulum nearly as much wide as the radius of the central body; basal half or lesser part of the cingulum thick and dense but either smooth or subtending some club-shaped processes and the outer half always consisting of variously sized, single or paired, club-shaped processes with short or long necks. Exine normally densely granulose, the grana being most characteristic on the club-shaped processes of some types.

Derivation of Name — Latin *Clav/us*, meaning peg or nail.

Comparison — *Monilospora* has a flange with marginal thickening unlike the cingulum with club-shaped processes in *Clavisporis*. *Tendosporites* Hacq. & Barss has wedge-shaped cingulum without marginal club-shaped processes and laevigate exine. *Labiadensites* Hacq. & Barss has thickened labra. *Cincturasporites* Hacq. & Barss has uniform, wedged-shaped cingulum lacking the club-shaped marginal processes of *Clavisporis*. In *Cristatisporites* the cingulum is subequatorial as well as lacks the marginal club-shaped processes.

Organization — *See* Text-Fig. 4.

Remarks — To enable one get a complete picture of the genus, five specimens of *Clavisporis* from Nahanni River Coals, where this genus is richly represented, have also been illustrated here (PL. 7, FIGS. 115-119).

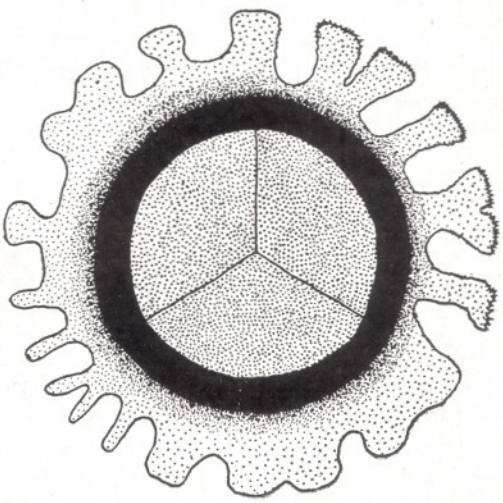
Clavisporis spitzbergensis sp. nov.

Pl. 7, Fig. 113

Holotype — Pl. 7, Fig. 113.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subcircular, size 90-112 μ, holotype 100 μ, central body ± circular, thin-walled, Y-mark present, rays extending ± to the margin of central body, labra thin and low. Cingulum (incl. bacula) ± equally broad as the radius of central body. Cingulum broadly cleft into wide, 10-12, broad, stumpy bacula along the margin. Exine on



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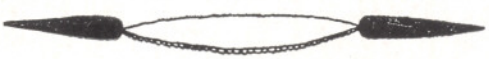


b

TEXT-FIG. 4 — *Clavisporis* gen. nov. a, polar view showing four different types of marginal segmentation of the cingulum observed so far, one in each quarter at the periphery. b, meridional section.

central body punctate and on cingulum laevigate.

Comparison — *C. boletus* (STAPLIN) comb. nov. has thinner cingulum but longish pila.

***Clavisporis boletus* (Staplin) comb. nov.**

Pl. 7, Fig. 114

Syn. — *Raistrickia boleta* Staplin 1960, Pl. 2, Figs. 25, 27, p. 14.

Holotype — Staplin 1960, Pl. 2, Fig. 27.

Emended Diagnosis — Roundly triangular, 60-90 μ, holotype 90 μ, central body roundly triangular, thin-walled, Y-mark present, rays not reaching body margin, thin, labra low. Cingulum (incl. pila) broader than the radius of central body, cingulum margin beset with ± 20, contiguous, short-necked pila. Exine laevigate.

Comparison — *C. spitzbergensis* lacks distinct pila on the margin. The thickness of the basal region of the cingulum as apparent from illustrations appears variable in the species.

Remarks — The apparent resemblance of club-shaped processes in *Clavisporis* with those of *Raistrickia* probably led to this taxonomic assignment by Staplin (1960).

***Cincturasporites* (Hacq. & Barss 1957) emend.**

Generotype — *Cincturasporites altilis* Hacq. & Barss 1957.

Remarks — The diplotype (HACQ. & BARSS, 1957, PL. 3, FIG. 8) is an overmacerated specimen. A critical examination of several better specimens from the type slides reveals that *C. altilis* possesses a few knob or worm-like thickenings on the distal side. In the light of this obseration a scrutiny of the illustration of diplotype also suggests faint indication of unequal thickenings of the distal exine, remnants of the thickenings after overmaceration. In *C. appendices* the presence of a number of thickenings on the distal side are already known so that *C. altilis* and *C. appendices* form a homogeneous group. A new species described here with considerably more elaborated thickenings on distal side extending also into the cingulum and proximal face confirms the importance of these thickenings for specific delimitation.

Staplin (1960) has merged *Cincturasporites* into *Murospora* Somers (same as *Simozonotriletes* according to Staplin *l.c.*), apparently in view of the similar morphography of the equatorial expansion. However, in view of the association of the equatorial cingulum with distal ornamentation, *Cincturasporites* is maintained by us as a valid taxon. The specific differences appear to relate to the size and number of exine thickenings besides other quantitative characters. The generotype and *C. appendices* besides being characterized by thick equatorial expanse and distal thickening also show thin, low labra in the Y-mark. The last named character distinguishes these species from *Cincturasporites auritus* (WALTZ) Hacq. & Barss, *C. literatus* (WALTZ) Hacq. & Barss, and *C. sulcatus* (WALTZ) Hacq. & Barss which possess broad and thick labra — a character of *Labiadensites* Hacq. & Barss. In our opinion, species of *Cincturasporites* showing broad labra should be transferred to *Labiadensites*.

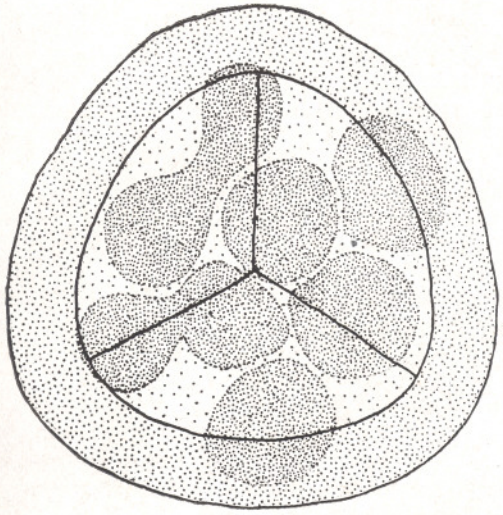
Emended Generic Diagnosis — Miospores radial, trilete, roundly triangular having an equatorial cingulum of ± uniform width round a triangular central body. Cingulum usually thick, dense and laevigate. Central body bearing a distinct trilete mark with rays limited to the body area, labra thin, low and straight; exine all over faintly punctate or granulose and bearing knob-like projections or ridge-like elevations.

Reconstruction — Hacquebard & Barss (*l.c.* FIG. 2) have given a diagrammatic drawing of the organization of *Cincturasporites*. There it is shown that the inner zone of the cingulum indicates the area of overlap towards the pole. However the combined thickness of the area of overlap is distinctly less than the thickness of the outer part of the cingulum suggesting thereby, that had the organization of the cingulum been as suggested by Hacquebard & Barss (*l.c.*) the outer zone of cingulum should have been denser in surface view than the inner zone — which in reality is not the case and instead it is just the opposite. The organization as apparent to us is represented in Text-fig. 5.

***Cincturasporites altilis* Hacq. & Barss emend.**

Pl. 8, Figs. 120, 121

Emended Diagnosis — Roundly triangular, 90-130 μ. Holotype 91·4 × 102·5 μ. Cingulum 14-22 μ wide, mostly uniform in width. Central body subtriangular, Y-mark distinct, rays confined to body, labra thin and low. Exine very faintly and densely granulose all over, distally exine irregular, thick, showing 2-5 knob-like or worm-like thickenings.



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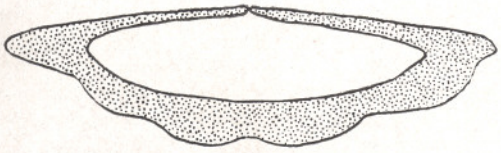

b

TEXT-FIG. 5 — *Cincturasporites* (Hacq. & Barss) emend. a, polar view. b, meridional section.

Comparison—*C. appendices* Hacq. & Barss, diagnosed to have 3-15 thickenings on the distal exine should now be restricted to have 6-15 thickenings.

Cincturasporites radialis sp. nov.

Pl. 8, Figs. 124-126

Holotype — Pl. 8, Figs. 124, 125.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular, known size 114-128 μ. Holotype 128 μ; central body ± 100 μ, bearing a distinct, thin and low-lipped trilete mark, rays limited to central body; cingulum 10-15 μ wide, with characteristic radiating thickenings extending from the body into it. Polar exine showing more than 15 big as well as small tubercles.

Description — Miospores ± rounded with slight indications of a triangular shape. Cingulum comparatively less wide in proportion to the overall size, about 15 radial thickenings in the cingulum.

Comparison — The radial thickenings in the cingulum distinguish this species from *C. altilis, C. appendices, C. spitzbergensis* and *C.* sp.

Cincturasporites spitzbergensis sp. nov.

Pl. 8, Figs. 122, 123

Holotype — Pl. 8, Fig. 122.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular, 90-120 μ. Holotype 100 μ. Central body roundly triangular, ± 60 μ; cingulum 14-22 μ broad, widest at angles, slightly undulating margin, distal exine beset with more than 15 large and small knobs in the polar area.

Comparison — *C. altilis* and *C. appendices* have fewer and mostly bigger distal thickenings.

Cincturasporites sp.

Pl. 8, Fig. 127

Description — Subtriangular, 60 μ, cingulum with entire margin, 8-10 μ wide, distal exine with only one longish thickening.

Comparison — This specimen is considerably smaller than *C. altilis* and has only one thickening distally.

Labiadensites Hacq. & Barss 1957

Generotype — *Labiadensites attenuatus* Hacq. & Barss 1957.

Remarks — An important characteristic of *Labiadensites* is the greatly developed or thickened lips in its species. This characteristic has been given due importance by us also and some species assigned to *Cincturasporites* by Hacquebard & Barss (*l.c.*), viz. *C. auritus* and by Staplin (*l.c.*), viz. *C. literatus* to *Murospora* as *M. varia* have been transferred to *Labiadensites*. We consider the variations in the shape of the cingulum or the presence of distal thickenings as less important characters than that of the haptotypic features. It is possible that by so doing the genus has been considerably widened, yet we believe that it is still more homogeneous than could be possible in any other way, short of splitting it up into more than one genus.

***Labiadensites literatus* (Waltz 1938; Hacquebard & Barss 1957) comb. nov.**

Pl. 8, Figs. 128-130

Syn.— *Cincturasporites literatus* (Waltz) Hacquebard & Barss 1957.

Holotype — Hacquebard & Barss 1957, Pl. 3, Fig. 2.

For diagnosis and description, *see* Hacquebard & Barss 1957, pp. 23, 24.

***Labiadensites novicus* sp. nov.**

Pl. 9, Figs. 131-133

Holotype — Pl. 9, Fig. 132.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Circular to subcircular miospores, 70-105 μ. Y-mark prominent, rays two-thirds of radius, labra ± 6 μ thick on either side of the suture. Cingulum 10-20 μ broad.

Description — Dark, brownish black, generally dense miospores, holotype 104 μ. Y-mark prominent, arms going up to the equatorial cingulum, apex and vertex low, labra thick. Cingulum 10-20 μ wide and equatorial.

Comparison — *L. literatus* possesses thicker labra and is ornamented on the distal side with broad verrucae. *L. attennuatus* is much bigger in size and the other species do not compare.

***Cirratriradites* Wils. & Coe 1940**

Generotype — *Cirratriradites saturnii* (Ibr.) S.W. & B. 1944 syn. *C. maculatus*.

Remarks — Though *Cirratriradites* Wils. & Coe is well represented in the Spitzbergen material, it is important to note that it has only been recorded from the Lower Carboniferous of Canada by Hacquebard (*l.c.*), the other investigators like Butterworth & Williams (*l.c.*) and Knox (*l.c.*) from Scotland, Schemel (1957) and Hoffmeister *et al.* (*l.c.*) from U.S.A. and other workers have not noticed this genus from the Lower Carboniferous deposits.

***Cirratriradites exilis* sp. nov.**

Pl. 9, Figs. 134-136

Holotype — Pl. 9, Fig. 134.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Roundly triangular, 100-150 μ. Y-mark prominent, arms entering into the equatorial zona and ending at the equator, apex and vertex high, labra raised and slightly thick. Body thick, microfoveolate. Zona infragranulose, up to 30 μ wide around the body.

Description — Dark brownish miospores, roundly triangular with rounded angles and convex sides. Spore body subtriangular 50-70 μ, with microfoveolate ornamentation, the foveola being up to 5 μ broad, and widely spaced. Y-mark prominent, tecta extending into the zona up to the equator, elevated in the body region and decreasing in height from the apex towards the equator. Zona generally broader than 30 μ and papery with slightly notched margin. The part of the zona attached to the spore body denser and hence looking dark in contrast to the other part of the zona, apparently infragranulose. In Pl. 9, Fig. 134 a shrivelled inner body seen.

Comparison — *C. saturnii* (Ibr.) S.W. & B. is smaller in size and possesses finer foveolate pits on its exine, and has serrate margin. *C. annulatus* Wils. & Coe also is smaller, and is distinctly different. *C. solaris* Hacquebard & Barss is very much bigger in size and possesses a broader flange and has finer microreticulate body ornamentation.

***Cirratriradites* sp. A**

Pl. 9, Fig. 137

Description — Yellowish brown, roundly triangular miospores, with a prominent equatorial cingulum, 60 μ. Y-mark distinct, rays going up to the equatorial margin, apex and vertex raised, labra thick. The spore body ± 40 μ and roundly triangular, laevigate to infrapunctate; cingulum ± 10 μ wide, closely following the contour of the spore body and infragranulose.

Comparison — The specimen illustrated by Hoffmeister, Staplin and Malloy (*l.c.*; Pl. 37, Fig. 9, p. 397) as ' Spore type A ' and the spore figured by Schemel (1950, Pl. 40, Fig. 4, p. 240) as *Endosporites* sp. A. are both comparable to our specimen. All the three records are from the Lower Carboniferous and the specimens agree to a great extent in their size, ornamentation, nature of the trilete mark and the equatorial zona. Since we have found only one specimen, for the present it is described as *Cirratriradites* sp. *C. annulatus*, *C. saturnii*, *C. solaris*, and *C. exilis*, are bigger in size and distinguish by possessing a broader equatorial zona.

Vallatisporites Hacq. 1957

Generotype — Vallatisporites vallatus Hacq.

Remarks — The main character of the generotype and other specimens illustrated by Hacquebard (1957, PL. 2, FIGS. 12-15) is the presence of a thinner zone between the central body margin and the denser ridge along the equatorial zone of spores. It is apparent from Hacquebard's figures that the width of the thinner zone is variable, it being widest with longest radial extensions in the diplotype. In our material also, a number of specimens (illustrated here) have been found which can be referred only to *Vallatisporites* on account of the presence of a less dense anterior zone followed by a denser ridge tapering off towards the margin. Besides this characteristic our specimens also reveal a tendency of the labra being progressively elevated and thickened from pole towards the equator. In our specimens what appear as pits on the denser ridge in high power are revealed to be small coni in surface view. To us it appears that the real difference between *Vallatisporites* and *Cristatisporites* is that in the former the anterior zone of the flange is thinner whereas in the latter the anterior zone is the thickest. In this respect *Vallatisporites* comes nearer to *Monilospora* organizationally.

Vallatisporites spitzbergensis sp. nov.

Pl. 9, Figs. 138-140

Holotype — Pl. 9, Fig. 138.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subtriangular, 80-96 μ. Holotype 96 μ, central body roundly triangular, 40-52 μ, trilete mark fainter on central body but very prominent and thickened on the flange, rays ending into a swelling at the equator. Flange 10-18 μ wide, more along the rays, anterior zone about two-thirds of the total width of the flange. Exine densely verrucose, verrucae with pointed tips.

Comparison — V. vallatus is distinctly smaller in size, its anterior, thinner zone of the flange is only up to one-half of the total width of the flange and the verrucae are smaller in size. *V. verrucosus* Hacq. is smaller in size and its anterior thinner zone is very narrow. *Vallatisporites* sp. B. Hacq. equals the size but has narrower anterior zone.

Infraturma *Patinati* Butt. & Will., 1958

Tholisporites Butt. & Will. 1958

Generotype — Tholisporites scoticus Butt. & Will.

Tholisporites decorus sp. nov.

Pl. 10, Figs. 142-146

Holotype — Pl. 10, Fig. 142.

Loc. Typ.— Pyramidenberg, Spitzbergen, Lower Carboniferous.

Diagnosis — Subcircular, 40-52 μ, holotype 52 μ; body subcircular, Y-mark distinct, labra thin and low, sutures wavy. Exine 4-6 μ thick along the equator as apparent in polar view, surface densely, minutely granulose.

Description — Miospores apparently looking cingulate but in reality patinate as evident from two of the specimens in meridional and slightly oblique-polar view illustrated here, colour usually darkish brown and appearing dense. Trilete rays less than three-fourth of the radius in length usually ending near the equator of the central body. Patina extending a short distance over to proximal face. Exine ornamentation consisting of uniformly and densely distributed fine grana.

Comparison — T. scoticus though diagnosed by Butterworth and Williams (*l.c.*) as being "smooth, granular or with widely spaced small, conical projections", are only smooth as far as our observations on the slides of the type material tell us. *T. decorus* is mostly flattened in polar view and is very characteristic by virtue of its dense ornamentation.

Tholisporites scoticus Butt. & Will.

Pl. 10, Fig. 141

Holotype — Butterworth & Williams 1958, Pl. 3, Fig. 48.

For diagnosis — *see* Butterworth & Williams 1958, p. 382 — exine smooth.

Tholisporites sp.

Pl. 10, Fig. 147

Description — Roundly triangular, 39 μ; Y-mark distinct, labra thin and low. Patina thickness at equator 2-3 μ, exine lowly verrucose ornamented.

Comparison — T. scoticus is smooth and *T. decorus* is densely granulose besides having greater thickness of patina at the equator.

***Archaeozonotriletes* (Naum.) Pot. 1958**

Generotype — *Archaeozonotriletes variabilis* Naum. 1953.

Cf. *Archaeozonotriletes* sp.

Pl. 10, Fig. 148

Description — Roundly triangular, 66 × 70 μ, central body roundly triangular 40 × 52 μ, bearing a trilete mark with broad and thickened labra. Exine unequally thickened at the equator, patinate, surface uniformly granulose ornamented.

Remarks — *Archaeozonotriletes* has smooth exine and thin labra. However, the eccentric thickness of patina along the equator is common to the specimen described here as well as *Archaeozonotriletes*.

Turma ***Pollenites* Pot. 1931**
Subturma ***Saccites Erdt.*, 1947**
Infraturma ***Monosaccites* (Chitaley) Pot. & Kr. 1954**

***Remysporites* Butt. & Will. 1958**

Generotype — *Remysporites magnificus* (Horst) Butt. & Will.

Remarks — Hughes and Playford (1961) have instituted a genus *Velosporites* contending that in *Remysporites* the bladder encloses lesser extent of central body as compared to *Velosporites*. As such, the difference is quantitative and thus inadequate to warrant institution of a new genus. *Prima facie* the specimens of *Velosporites* and *Remysporites* figured by their respective authors' look extremely alike organizationally.

***Remysporites magnificus* (Horst) Butt. & Will.**

Pl. 10, Fig. 149

Holotype — Horst 1955, Pl. 21, Fig. 37.

Loc. Typ.— West Upper Silesia, Namurian A.

For diagnosis and description, *see* Butterworth & Williams 1958, pp. 386, 387.

***Grandispora* Hoffm. Stapl. & Mall. 1955**
***Grandispora spinosa* H. S. & M.**

Pl. 10, Figs. 151, 152

Holotype — Hoffmeister, Staplin & Malloy 1955; Pl. 39, Fig. 10.

Loc. Typ.— Hardinsburg formation, U.S.A.

For diagnosis and description, *see* Hoffmeister, Staplin & Malloy 1955, pp. 388, 389.

Remarks — It appears that the spores referable to *Grandispora* possess an inner body as in the case of *Calamospora, Foveolatisporites, Vestispora* and others. The genus has been interpreted by Hoffmeister *et al.* as a monowinged spore.

THE COMPOSITION OF SPORE ASSEMBLAGE

The spore genera as described by us comprising the assemblage together with their percentage representation out of 1000 miospores in the shale from Spitzbergen are as follows:

Miospores	*per cent*
Leiotriletes (Naum.) Pot. & Kr.	0·3
Punctatisporites (Ibr.) Pot. & Kr.	0·2
Convolutispora Hoffm. Stap. & Malloy	3·9
Apiculatisporis (Ibr.) Pot. & Kr.	1·8
Iugisporis gen. nov.	0·9
Velamisporites gen. nov.	1·0
Microreticulatisporites (Knox) Bhard.	0·1
Reticulatisporites (Ibr.) Pot. & Kr.	0·1
Corbulispora gen. nov.	5·3
Crassispora Bhard.	0·8
Triquitrites Wils. & Coe	10·7
Simozonotriletes (Naum.) Pot. & Kr.	1·3
Lycospora S.W. & B.	0·4
Densosporites Berry	2·4
Cristatisporites (Pot. & Kr.) emend.	60·8
Orbisporis gen. nov.	0·9
Cincturasporites Hacq. & Barss	2·0
Labiadensites Hacq. & Barss	3·6
Cirratriradites Wils. & Coe	0·8
Clavisporis gen. nov.	0·2
Tholisporites Butt. & Will.	0·4
Remysporites Butt. & Will.	1·1
Grandispora Hoffm. S. & M.	0·2
Rest	0·8
Megaspores	
Rostratispora gen. nov. Fairly common.	

From the list given above it is apparent that *Convolutispora, Apiculatisporis, Velamisporites, Corbulispora, Triquitrites, Simozonotriletes, Densosporites, Cristatisporites, Cincturasporites, Labiadensites* and *Remysporites* are the important constituents of the spore assemblage from Spitzbergen. *Iugisporis* and *Orbisporis* are fairly characteristic and the rest are rare or very rare. *Cristatisporites* is the most abundant genus followed by *Triquitrites*.

COMPARISON WITH OTHER LOWER CARBONIFEROUS SPORE FLORAS

In the published reports on Lower Carboniferous spore assemblages from various regions

the generic names used as well as their definitions are not the same in all cases. Therefore, for successfully comparing these assemblages it became necessary to reduce the spore genera in all the works, uniformly to the standard names and circumscription of genera by Potonié and Kremp and other authors, as used by us in the descriptive part. The illustrations on the basis of which such reassignments have been suggested in the lists below have been cited wheresoever necessary.

The spore assemblage described by Hughes & Playford (1961) from central Spitzbergen differs from our assemblage to some extent. They illustratrate such genera as —

Leiotriletes	H. & P.	Pl. 1, Fig. 1
Cincturasporites	,,	,, Pl. 1, Figs 2, 3; Pl. 3, Figs. 3-7
Corbulispora	,,	,, Pl. 1, Figs. 5, 6
Convolutispora	,,	,, Pl. 1, Figs. 7, 8
Gen. nov.	,,	,, Pl. 1, Figs. 9-14
Labiadensites	,,	,, Pl. 2, Figs. 1-4; Pl. 3, Figs. 14-19
Cf. *Velamisporites*	,,	,, Pl. 2, Figs. 5-8
Triquitrites	,,	,, Pl. 2, Figs. 11-15
Cf. *Clavisporis*	,,	,, Pl. 2, Figs. 16-18; Pl. 3, Figs. 8-10
Cristatisporites	,,	,, Pl.3, 11-12; Pl. 4, Figs. 1-7
Stenozonotriletes	,,	,, Pl. 3, Figs. 1, 2
Endosporites	,,	,, Pl. 4, Fig. 8
Remysporites	,,	,, Pl. 4, Figs. 9-12
Diatomozonotriletes	,,	,, Pl. 4, Figs. 14, 15
Indeterminate		rest

The presence of *Stenozonotriletes, Diatomozonotriletes* and a new genus besides many charactristic species distinguish this assemblage from ours, although in view of the common genera *Cincturasporites, Labiadensites, Corbulispora, Convolutispora* and others, an overall similarity is evident.

The spore flora from Spitzbergen described by us is closely comparable to the assemblage from South Nahanni River Area in N. W. Canada (HACQUEBARD & BARSS, 1957) as far as the qualitative composition of the important genera in the two is concerned. These two spore floras exhibit a common representation of *Convolutispora, Apiculatisporis* [= *Punctatisp.* (pars) — H. & B.] *Triquitrites, Simozonotriletes, Densosporites, Cristatisporites, Cincturasporites, Labiadensites, Clavisporis* and *Remysporites* (= *Microsporites* — H. & B.). Each assemblage also has some individualistic genera such as *Velamisporites, Corbulispora* and *Orbisporis* in Spitzbergen shale and *Tendosporites, Monilospora* (different species) *Perianthospora* and *Reinschospora* in South Nahanni River Coal. The quantitative divergence of the common genera between the two assemblages especially with regard to *Densosporites*-complex (i.e. incl. *Cristatisporites*) and *Triquitrites* is possibly due to different environmental conditions in which the two strata were laid — one being shale and the other coal.

Our spore assemblage from Spitzbergen is also comparable to the spore flora from Lower Moscow Basin and other districts (Tournaisian — Low. Visean) described by Luber & Waltz (1938) as per list given below:

Moscow Basin, Kizel, Borovichi, Selizharovo Districts and Voronazh Region — Luber & Waltz 1938

Leiotriletes	Pl. 1, Figs. 3, 11
Punctatisporites	Pl. 1, Figs. 1, 2, 4
Granulatisporites (Ibr.) Pot. & Kr.	Pl. 1, Fig. 5
Convolutispora	Pl. 1, Fig. 12
Apiculatisporis	Pl. 1, Figs. 13, 14
Reticulatisporites	Pl. 1, Figs. 8, 9
Corbulispora	Pl. 1, Fig. 10
Triquitrites	Pl. 2, Fig. 22; Pl. 4, Fig. 41
Simozonotriletes	Pl. 2, Fig. 24; Pl. 3, Fig. 37
Tripartites Schemel	Pl. 4, Fig. 42
Monilospora H. & B.	Pl. 4, Fig. 53
Crassispora	Pl. 1, Fig. 6
Orbisporis	Pl. 3, Fig. 35
Lycospora	Pl. 2, Figs. 17, 18, 33
Cristatisporites	Pl. 4, Figs. 46, 47, 50, 52, 55
Densosporites	Pl. 2, Fig. 15; Pl. 4, Figs. 44, 45, 51.
Cincturasporites	Pl. 2, Figs. 16, 19
Labiadensites	Pl. 2, Figs. 20, 21, 23, 25, 27-29; Pl. 3, Fig. 36
Clavisporis	Pl. 4, Fig. 43
Cirratriradites	Pl. 3, Figs. 30, 32, 31
Mirisporites Pot. & Kr.	Pl. 3, Fig. 38
Reinschospora S.W. & B.	Pl. 4, Figs. 48, 49
Schulzospora S.W. & B.	Pl. 3, Fig. 39
Bellisporis Artüz	Pl. 3, Figs. 36, 37

A comparison of the list of spore genera from Spitzbergen shale and that for Lower

Moscow Basin and other districts reveal agreement in the association of important spora genera such as *Convolutispora, Apiculatisporis, Corbulispora, Triquitrites, Simozonotriletes, Densosporites, Cristatisporites, Cincturasporites, Orbisporis, Clavisporis* and *Labiadensites*. Among the rare genera also there is considerable agreement in the two lists. The uncommon genera in the two spore floras are *Velamisporites, Microreticulatisporites, Remysporites* and *Grandispora* present in Spitzbergen and *Mirisporites, Schulzospora, Tripartites, Reinschospora* and *Bellisporis* present in Lower Carboniferous coals of European U.S.S.R.

Ishchenko (1956) has published a big work on Lower Carboniferous (Tournaisian — Upper Namurian) deposits of the western extension of the Don Basin. In this work the distribution of various spore genera for the various subdivisions of Lower Carboniferous appears to be as follows:

Western Don Basin — Ishchenko 1956

Tournaisian

Apiculatisporis	Fig. 45
Ibrahimisporis	Fig. 46
Lophotriletes	Fig. 60
Labiadensites	Figs. 110, 118
Cincturasporites	Figs. 98, 99, 104, 117, 146, 150
Orbisporis	Figs. 118, 119, 121
Reticulatisporites	Fig. 123
Densosporites	Fig. 150
Stenozonotriletes (Naum.) Hacq.	Figs. 161-164, 167, 169
Cristatisporites	Figs. 180, 200, 202
Cf. *Raistrickia* S.W. & B. (? *Clavisporis*)	Fig. 191
Camarozonotriletes Naum.	Fig. 246

Lower Visean

Leiotriletes	Figs. 15, 17
Punctatisporites	Figs. 9, 10
Granulatisporites	Figs. 25, 27, 58, 59
Procoronaspora	Figs. 63-65
Convolutispora	Fig. 95
Cincturasporites	Figs. 111, 112
Lycospora	Figs. 114, 115
Labiadensites	Fig. 119
Orbisporis	Fig. 122
Simozonotriletes	Figs. 128, 134, 154, 155, 208, 210, 213.
Cristatisporites	Figs. 141, 203
Cirratriradites	Fig. 142
Murospora Somers	Figs. 156-159, 215
Stenozonotriletes	Figs. 170, 171, 174
Callisporites Butt. & Will.	Fig. 187
Lophozonotriletes (Naum.) Pot.	Fig. 196
Tripartites	Figs. 223, 224, 227
Triquitrites	Fig. 235
Reinschospora	Fig. 242
Rotaspora	Fig. 247

Upper Visean

Leiotriletes	Figs. 12, 13, 18-21, 23
Granulatisporites	Figs. 24, 28
Anapiculatisporites	Figs. 61, 62
Apiculatisporites	Fig. 96
Lophotriletes	Figs. 47, 54, 66-69, 81
Convolutispora	Figs. 79, 82, 192, 193
Pustulatisporites Pot. & Kr.	Fig. 194
Microreticulatisporites	Fig. 31
Cf. *Crassispora*	Fig. 34
Mooreisporites Neves	Fig. 48
Type E. H.S. & M.	Fig. 72
Lophozonotriletes	Fig. 197
Triquitrites	Figs. 219, 222
Tripartites	Figs. 225, 226, 227, 229, 230, 234, 236, 237, 238.
Rotaspora	Fig. 245
Simozonotriletes	Figs. 128, 151-155, 205, 208, 209, 211.
Murospora	Figs. 156-159
Lycospora	Figs. 114, 115
Cincturasporites	Figs. 103, 117, 120, 216-218
Labiadensites	Fig. 119
Cirratriradites	Fig. 126
Stenozonotriletes	Figs. 170, 171
Callisporites	Fig. 187

Lower Namurian

Ibrahimisporis	Fig. 44
Convolutispora	Fig. 91
Simozonotriletes	Fig. 212
Triquitrites	Fig. 221
Mooreisporites	Fig. 228
Cristatisporites	Fig. 201
Cf. *Crassispora*	Figs. 22, 34, 36

Upper Namurian

Granulatisporites	Fig. 29

Unfortunately the hand illustrations of the spores by Ishchenko (*l.c.*) offer considerable

difficulty in reducing them to the system of classification followed here. However, it is apparent that the Tournaisian florule of Don Basin is poor in the number of genera, yet is characterized by such of them as *Labiadensites, Cincturasporites, Orbisporis* and *Rotaspora*. The spore assemblage of Visean is richer and more diversified than Tournaisian with the addition of *Convolutispora, Simozonotriletes, Tripartites, Reinschospora* and a number of other genera.

The Namurian miospore flora of Don Basin is poor in number of spore genera listed and is probably an incomplete representation.

Luber and Waltz (1938) have described also a spore flora of Visean age from Karaganda Basin in the Asiatic part of U.S.S.R. The spore genera are as listed below:

Karaganda Basin, U.S.S.R. — Luber & Waltz 1938

Leiotriletes (Naum.) Pot. & Kr.	Pl. 5, Fig. 58
Punctatisporites (Ibr.) Pot. & Kr.	Pl. 5, Fig. 56
? *Converrucosisporites* Pot. & Kr.	Pl. 5, Figs. 66, 69
Lophotriletes (Naum.) Pot. & Kr.	Pl. 5, Figs. 63-65
Apiculatisporis (Ibr.) Pot. & Kr.	Pl. 5, Fig. 61
Convolutispora H.S. & M.	Pl. 5, Figs. 67, 68, 70
Corbulispora gen. nov.	Pl. 5, Figs. 71-73
? *Crassispora* Bhard.	Pl. 5, Fig. 57
Lycospora S.W. & B.	Pl. 6, Figs. 74, 83, 85, 86
Cristatisporites (Pot. & Kr.) emend.	Pl. 6, Figs. 80, 82, 84
Cirratriradites Wils. & Coe	Pl. 6, Fig. 75
Endosporites Wils. & Coe	Pl. 6, Figs. 78, 79
Indeterminate	Pl. 6, Figs. 76, 77

As compared to the above list our spore assemblage from Spitzbergen is more diversified having the spore genera *Velamisporites, Triquitrites, Simozonotriletes, Orbisporis, Cincturasporites, Labiadensites* and *Remysporites* besides a few others. The genera present in Karaganda Basin but absent in Spitzbergen shale are (?) *Converrucosisporites, Lophotriletes* and *Endosporites*.

The Lower Carboniferous (Chesterian) spore assemblage as described by Berry (1937) and as far as understandable to us, appears to have consisted of *Leiotriletes, Lophotriletes, Lycospora, Densosporites, Cristatisporites* and *Laevigatosporites*. This assemblage, if not incompletely reported by Berry (*l.c.*) probably represents the poorest yet known and is hardly worthy of comparison.

Schemel (1950) has described an assemblage of Meramecian, Chesterian or Springeran age from Utah, U.S.A. consisting of *Leiotriletes, Punctatisporites, Granulatisporites, Verrucosisporites, Lophotriletes, Dictyotriletes, Microreticulatisporites, Rostratispora, Tripartites, Lycospora, Rotaspora, Densosporites, Cristatisporites, Knoxisporites* and *Endosporites*. As compared to our Spitzbergen assemblage, the important genera *Convolutispora, Velamisporites, Corbulispora, Cincturasporites* and *Labiadensites* are absent from Utah assemblage which instead is characterized by the presence of *Tripartites, Rotaspora* and *Knoxisporites* besides the common genera.

Hoffmeister, Staplin and Malloy (1955) have described the spore flora of Hardinsburg Formation (Mid. Chesterian) of Illinois and Kentucky, U.S.A., which, besides almost all the spore genera of Utah assemblage, contains *Calamospora, Convolutispora, Reticulatisporites, Triquitrites, Grandispora* and *Schulzospora*. This one probably represents the most complete assemblage of Chester series (= *ca.* Namurian A). The characteristic spore genera of Spitzbergen shale, viz. *Velamisporites, Corbulispora, Cincturasporites* and *Labiadensites* are absent also in this assemblage which instead is characterized by *Tripartites, Rotaspora, Knoxisporites,* and *Schulzospora*.

The richly described miospore flora of the Limestone Coal Group and Upper Limestone Group from Scotland by Butterworth & Williams (1958) is of Namurian age. The characteristic spore genera of the Limestone Coal Group appear to be *Convolutispora, Tripartites, Rotaspora, Cincturasporites* (B. & W., Pl. 2, Figs. 8, 9), *Labiadensites* (B. & W., Pl. 2, Figs. 11-13), *Lycospora, Tholisporites, Densosporites, Cristatisporites, Callisporites, Procoronaspora, Vestispora, Remysporites* and *Schulzospora*. In the Upper Limestone Group, most of the older assemblage continues but for the genera such as *Labiadensites, Tholisporites* and *Procoronaspora* besides *Pustulatisporites, Acanthotriletes*

and *Raistrickia*. *Clavisporis* is also represented (B. & W., PL. 2, FIG. 10).

Staplin (1960) has published a detailed account of *sporae dispersae* from a coal seam and its associated clays of Lower Chesterian age in Golata formation of west-central Alberta, Canada. Among the spore genera reported by Staplin a number of new genera, and many of the older ones are described. As compared to the genera reported by us from Spitzbergen, Golata assemblage lacks only *Velamisporites, Corbulispora, Crassispora* and *Grandispora*. Such of our genera as *Simozonotriletes* (= STAPLIN — *Murospora* sp. cf. *Zonotriletes intortus* WALTZ), *Cristatisporites* (= STAPLIN — *Densosporites spinifer, D.* sp. cf. *capistratus, D. landesii* and some others), *Cincturasporites* (= STAPLIN — *Murospora circumscutata*), *Labiadensites* (= STAPLIN — *Murospora varia* and *M. paenulata*) and *Clavisporis* (= STAPLIN — *Raistrickia boleta*) are also present. The assemblage from Golata formation is considerably richer in the variety of spore forms than the assemblage from Spitzbergen described by us.

Love (1960) has described a spore assemblage from Lower Oil Shale Group (Visean) of Scotland. In this assemblage but for *Iugisporis, Crassispora, Triquitrites, Simozonotriletes, Clavisporis, Cincturasporites, Cirratriradites, Remysporites* and *Grandispora*, the other genera of the Spitzbergen assemblage including *Velamisporites* (= LOVE — Spore type 4; PL. 2, FIG. 13), *Corbulispora* (= LOVE — *Dictyotriletes falsus* and *D. subalveolaris*), *Orbisporis* (= LOVE — *Auroraspora* sp.; PL. 2, FIG. 5), *Labiadensites* (= LOVE — Spore Type 1; PL. 2, FIG. 9), *Densosporites* (= LOVE — *Anulatisporites*), *Cristatisporites* (= LOVE — *Densosporites*) are all present. This assemblage is also characterized by *Procoronaspora, Raistrickia, Knoxisporites, Endosporites* and *Schulzospora*.

Horst (1955) published an account of the *sporae dispersae* from the coals of Namurian A, B and Westphalian A from West Upper Silesia and Mährisch — Ostrauer basins. His study of Namurian A from both the basins had been more complete than of the other horizons and hence we shall consider here his results for Namurian A only in which *Calamospora, Granulatisporites, Triquitrites, Ahrensisporites, Densosporites, Cristatisporites, Lycospora, Schulzospora* and *Laevigatosporites* are the most regularly distributed genera although others, viz. *Convolutispora* (= *Verrucosisporites*), *Microreticulatisporites, Tripartites* and *Endosporites* are also present though in lesser numbers. Rare genera are *Knoxisporites* and *Rotaspora* besides others. *Reinschospora* and *Simozonotriletes* are singularly absent from Namurian A in these basins.

Another interesting report of the spores out of the one coal seam of Namurian age from Turkish coal basin is by Artüz (1957). This assemblage comprises the genera *Leiotriletes, Verrucosisporites, Punctatisporites, Lophotriletes, Raistrickia, Ibrahimisporites, Convolutispora, Dictyotriletes, Microreticulatisporites, Reticulatisporites, Simozonotriletes, Cristatisporites, Laevigatosporites, Endosporites* and *Grandispora*. As Compared to our Spitzbergen assemblage this spore flora lacks a large number of genera including *Cincturasporites*, and *Labiadensites*.

The spore flora described by Hacquebard (1957) from Horton Group of Nova Scotia (Canada) hardly compares with Spitzbergen assemblage. As Hacquebard (*l.c.*) opines, that sporeflora shows great similarity with the Upper Devonian assemblage though not quite the same due to the absence of such genera as *Archaeotriletes* Naum., which possess spines with grapnel-like ending and are characteristic of most of the Devonian strata (HACQUEBARD, 1957). However, the presence of *Corbulispora* in that assemblage (HACQ., 1957, Pl. 2, FIGS. 8-13) does make it a part of Lower Carboniferous.

INDEX SPORE-ASSOCIATION OF THE LOWER CARBONIFEROUS AGE

A comparison of the miofloras from various Lower Carboniferous formations briefly reviewed here reveals that the spore assemblages from Spitzbergen, South Nahanni River Coals, Lower Moscow Basin Coals, strata from the Western Don Basin, Lower Namurian of Central Europe, Namurian of Scotland and Lower Namurian of U.S.A. are characterized by the presence of some of the following spore genera, viz. *Convolutispora, Cincturasporites, Labiadensites, Tripartites* and *Rotaspora*. These genera also have so far been reported only from unquestionable Lower Carboniferous strata where they are well distributed, and thus, constitute the index spore association for Lower Carboniferous age. Besides these genera a number of others, viz. *Corbulispora, Velamisporites, Orbisporis, Monilospora, Clavisporis, Tendosporites, Perianthospora*

and *Grandispora* though not universally distributed yet, as known so far, are confined to the unquestionable Lower Carboniferous strata. A number of spore genera which begin in Lower Carboniferous but extend to the Lower Westphalian strata, viz. *Knoxisporites*, *Simozonotriletes*, *Reinschospora* and *Schulzospora* are usually characteristically associated with some of the index genera in younger subdivisions of Lower Carboniferous.

The spore flora represented from Horton group (HACQUEBARD, 1957) of strata, lacks most of the characteristic spore genera of Lower Carboniferous and at the same time has some forms comparable to those of Upper Devonian, although lacking the Upper Devonian index genus *Archaeotriletes*. This florule seems to represent the transition between Devonian and Carboniferous.

Sporologically, the Pyramidenberg shale and Billefjorden sandstone from Spitzbergen, Lower Carboniferous (Moscow and other coal basins) of U.S.S.R. (LUBER & WALTZ, 1938), Nahanni coals (HACQ. & BARSS, 1957) and Golata formations (STAPLIN, 1960) appear to belong to one broad stratigraphical zone. The spore floras of Scotland (BUTTERWORTH & WILLIAMS, 1958; LOVE, 1960), Hardinsburg Formation, U.S.A (HOFFM., STAPL. & MALLOY, 1955), Utah, U.S.A. (SCHEMEL, 1950) and Silesia, Europe (HORST, 1955) belong to another, younger, broad stratigraphical zone.

The assemblage from Namurian of Turkey has only *Convolutispora* out of the index genera of Lower Carboniferous age. The rest of the genera but for *Ibrahimisporis* and *Grandispora* are those which are equally well represented in Westphalian strata. This assemblage evidently represents quite late Namurian or a particular facies developed due to its paralo-limnic environment.

The spore flora from Karaganda Basin contains *Convolutispora* and *Corbulispora* both being exclusively characteristic of Lower Carboniferous age. Most of the other genera associated with these are also such as are found in Lower Carboniferous strata elsewhere in Europe and North America. *Corbulispora* has so far been reported only from Karaganda Basin besides Spitzbergen. In our opinion the spore assemblage from Karaganda Basin is after all not too much different from the normal Lower Carboniferous assemblages of Europe and North America.

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EXPLANATION OF PLATES

(Magnification, wheresoever not given is × 500. *The negatives and slides referable to each photo number are preserved at the Birbal Sahni Institute of Palaeobotany, Lucknow, India*

PLATE 1

1. *Leiotriletes* sp.; photo 169/13.

2. *Punctatisporites* sp.; photo 184.

3-7. *Convolutispora stigmoidea* sp. nov.; photo 241/6, 171/33, 171/24, 160/23, 240/23.

8. *Convolutispora* cf. *C. stigmoidea* sp. nov.; photo 172/29.

9, 10. *Convolutispora punctatimura* Staplin; photo 169/16, 241/26.

11. *Convolutispora tessellata* H.S. & M.; photo 159/10.

12. *Convolutispora geniculata* sp. nov.; photo 226/19.

13. *Convolutispora cerebra* Butt. & Will., photo 242/5.

14. *Iugisporis* sp.; photo 171/9.

15. *Apiculatisporis* cf. *A. maculosus* (Knox) Pot. & Kr.; photo 172/24.

16. *Apiculatisporis connatus* sp. nov.; photo 156/18.

17, 18. *Apiculatisporis densus* sp. nov.; photo 169/20, 241/22.

19, 20. *Planisporites asperatus* sp. nov.; photo 243/33, 243/32.

PLATE 2

21-25. *Iugisporis limpidus* gen. et sp. nov.; photo 241/5, 241/4, 169/24, 170/30, 157/35.

26, 27. *Ibrahimisporis spitzbergensis* sp. nov.; photo 243/37, 243/36.

28. *Microreticulatisporites microreticulatus* Knox; photo 159/5.

29. *Reticulatisporites maximus* sp. nov.; photo 171/28.

30, 31. *Reticulatisporites* sp.; photo 243/1, 240/2.

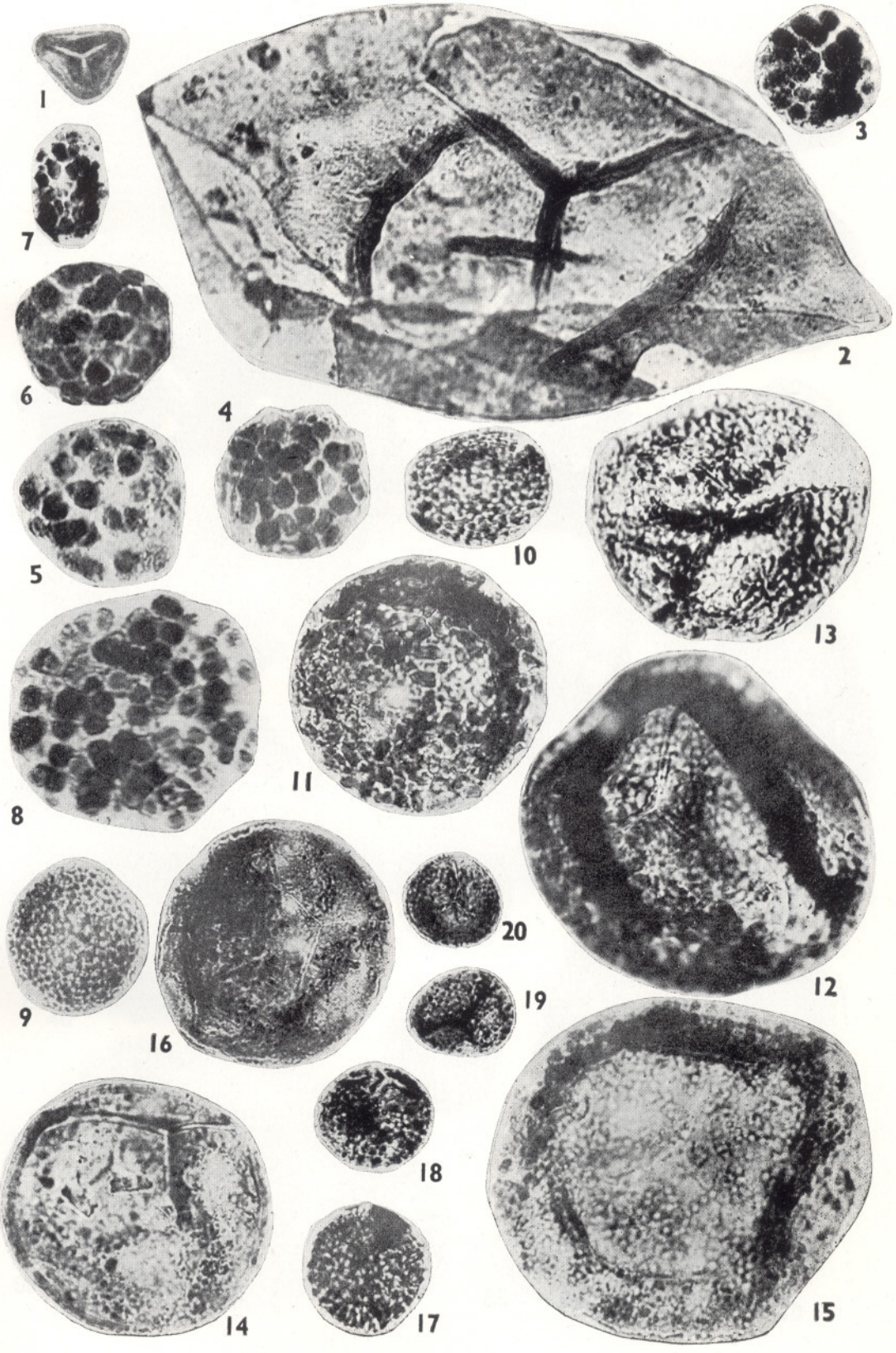
32-34. *Corbulispora retiformis* gen. et sp. nov.; photo 160/25, 226/2, 226/6.

35, 36. *Rostratispora iucundus* gen. et sp. nov.; photo 155/6 (proximal), 155/11 (distal), × 50.

37-40. *Rostratispora iucundus* gen. et sp. nov.; photo 155/13, 155/7, 155/9, × 50; photo 155/12, × 100.

PLATE 3

41-44. *Orbisporis muricatus* gen. et sp. nov.; photo 243/23 (proximal), 243/24 (distal); 243/12 (proximal), 243/11 (distal).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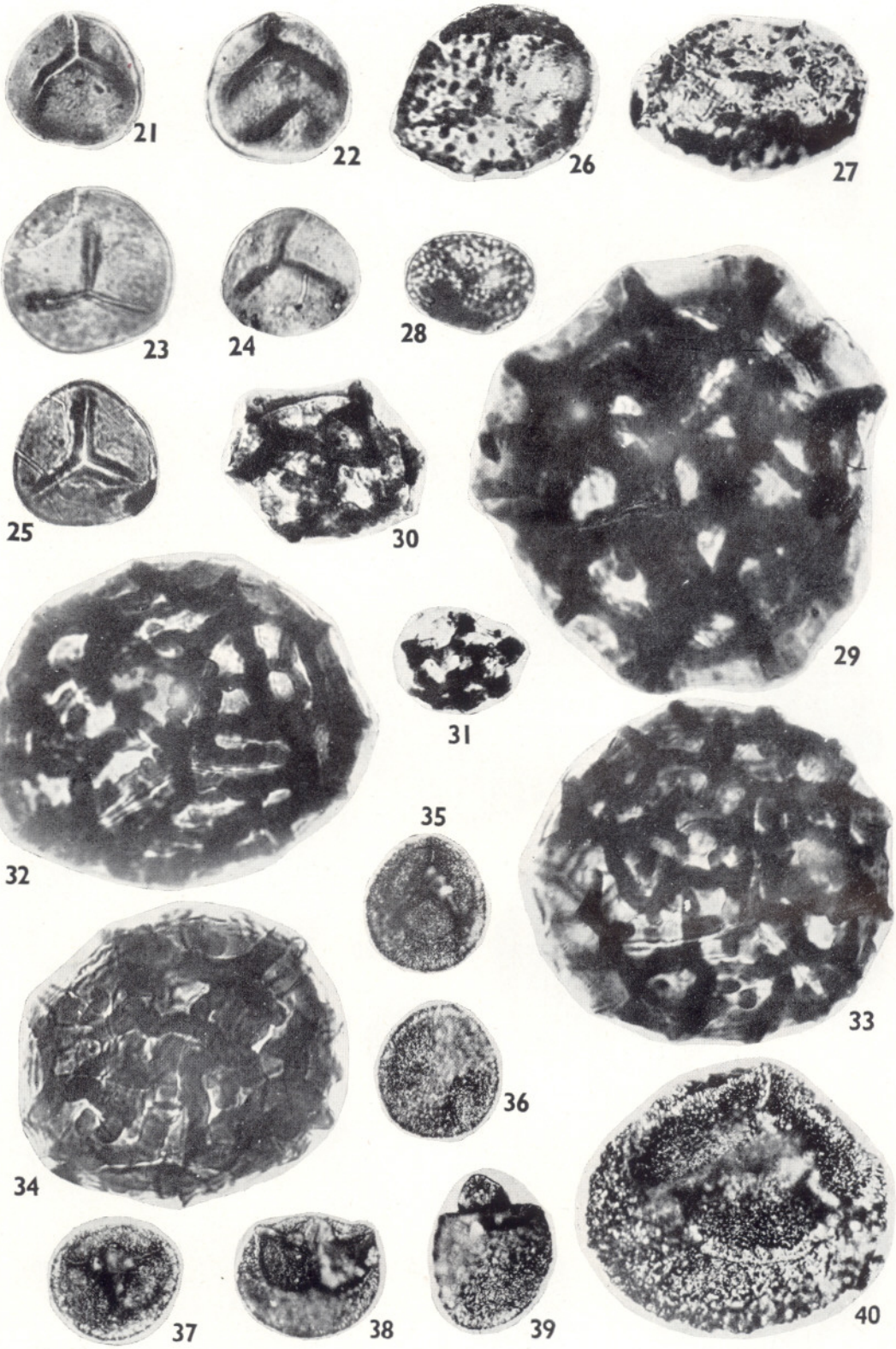
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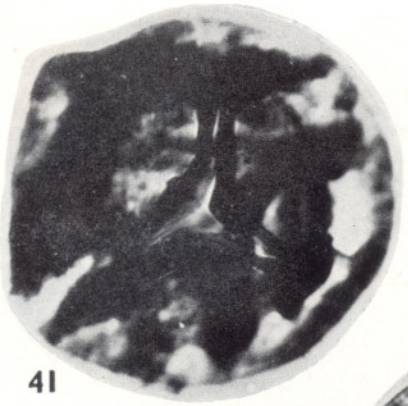
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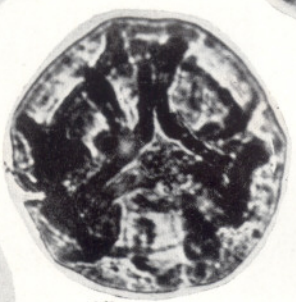
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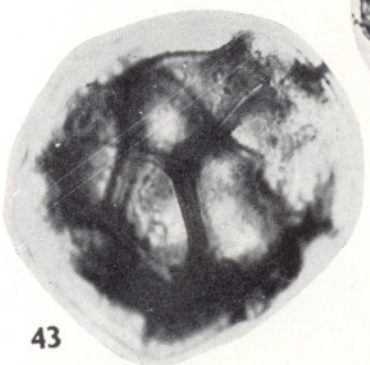
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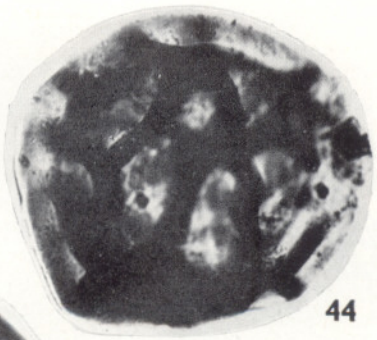
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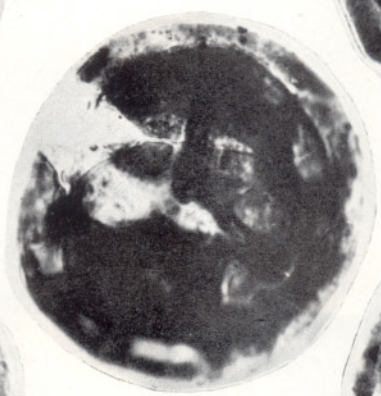
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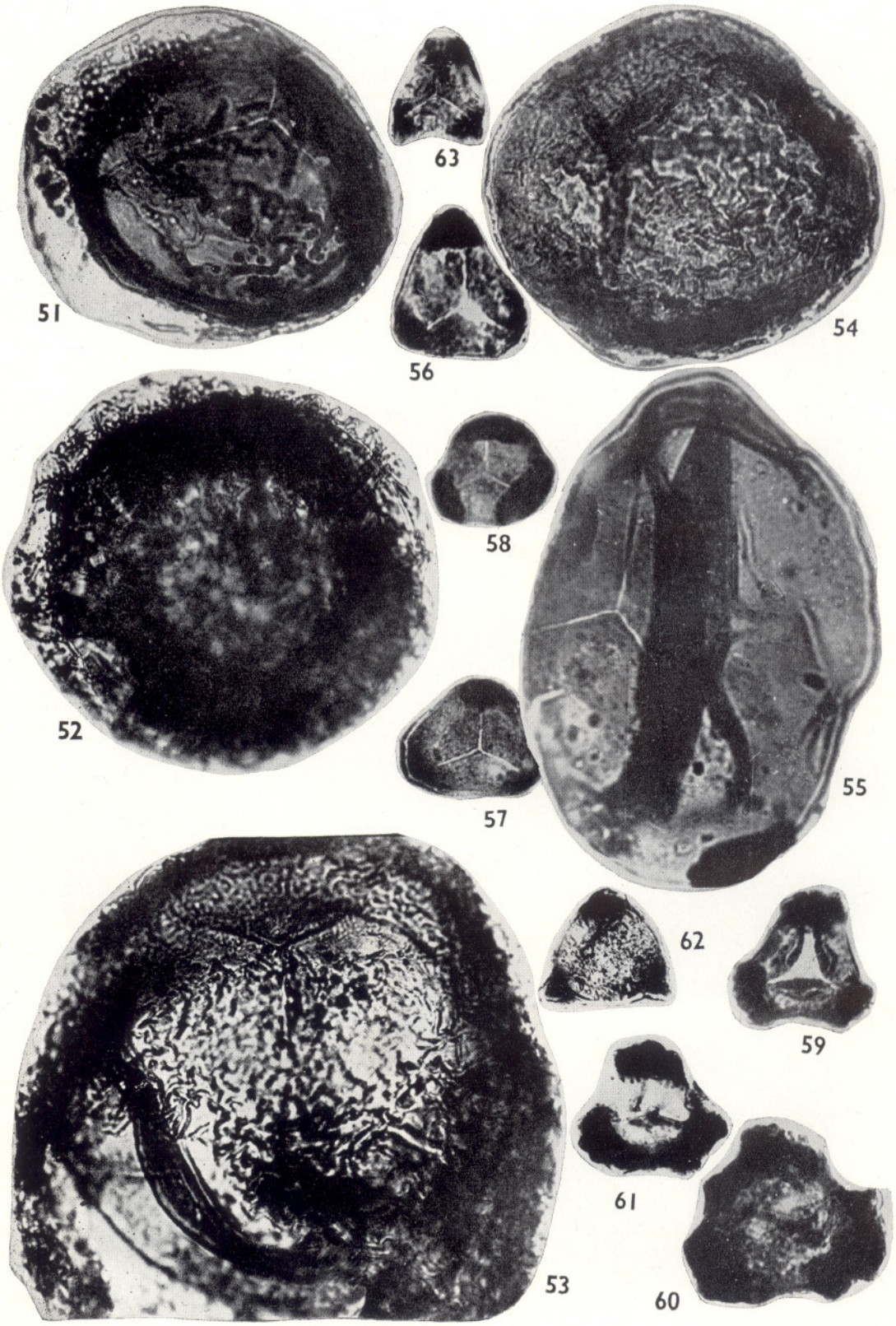
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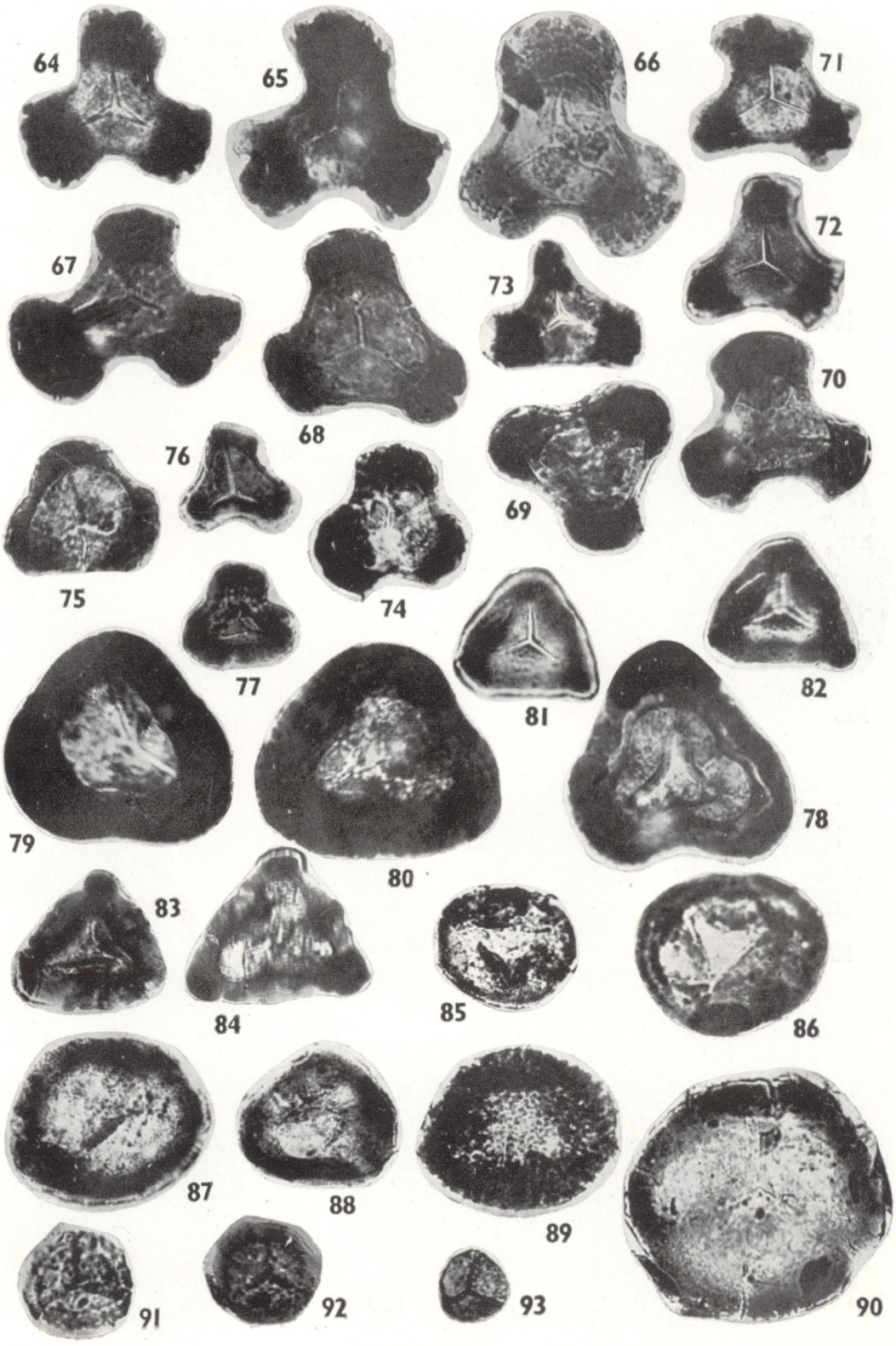
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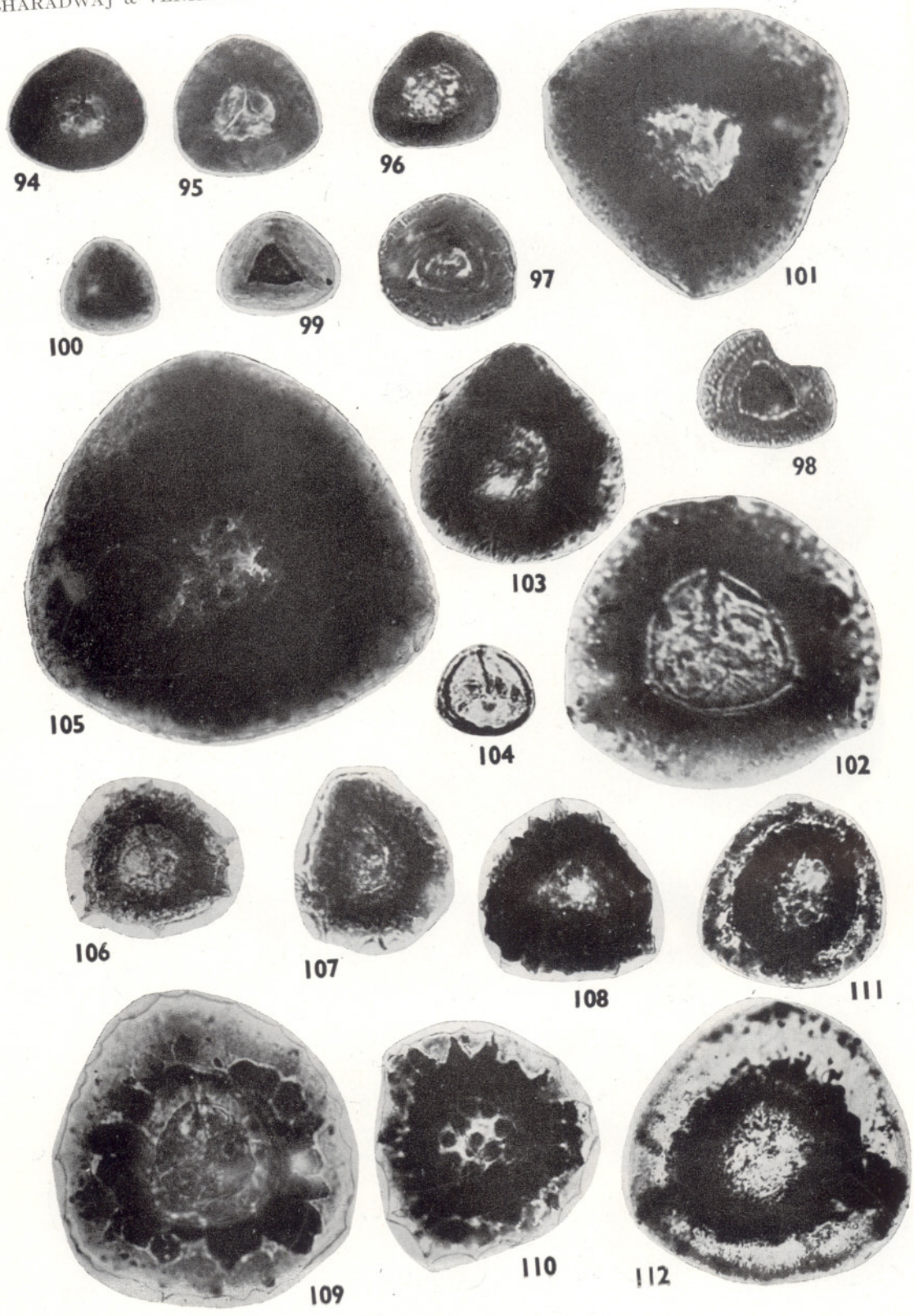
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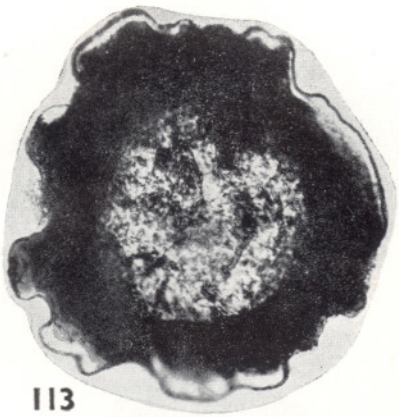

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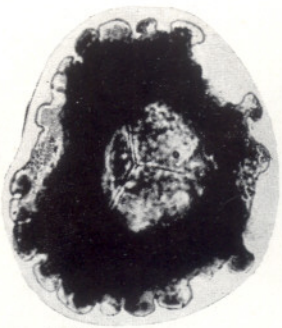

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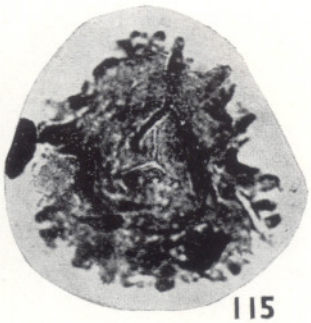

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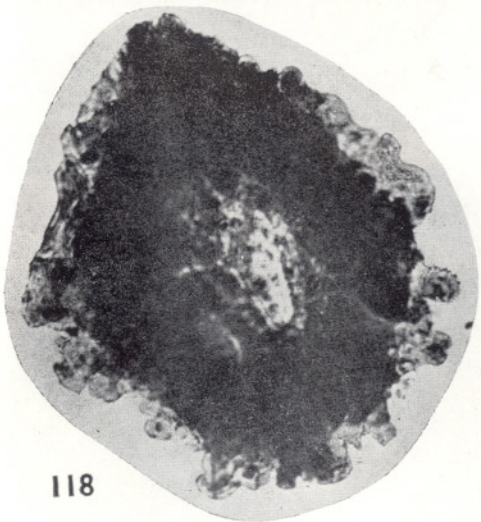

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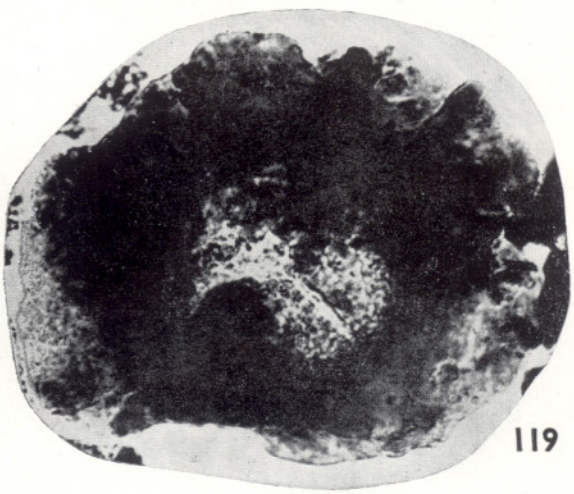

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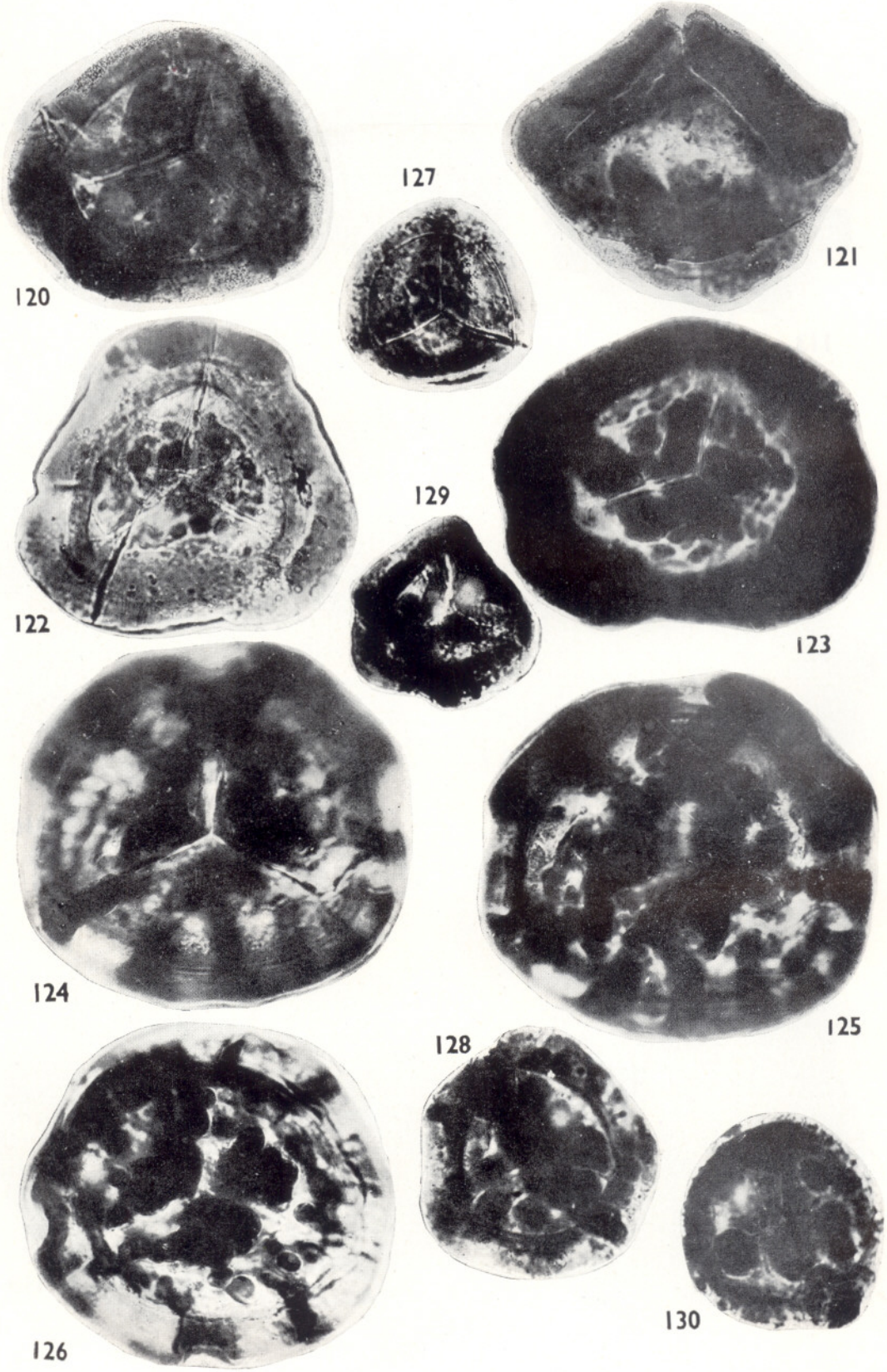
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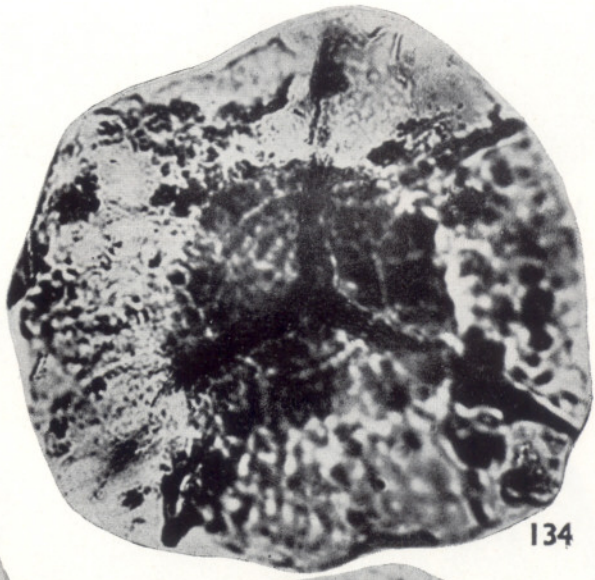
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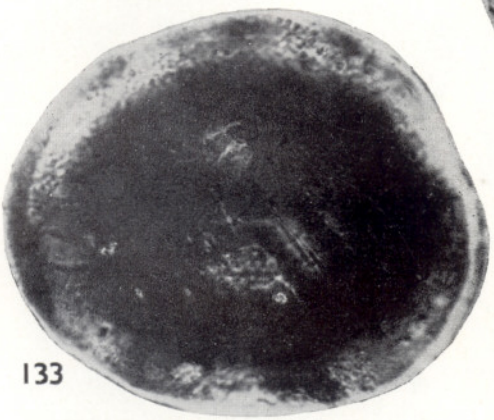
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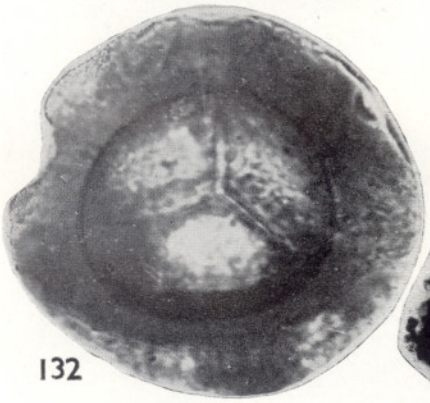
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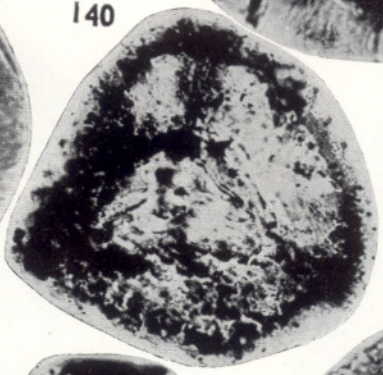

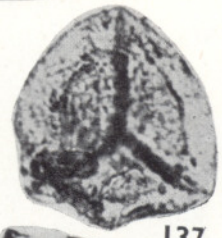
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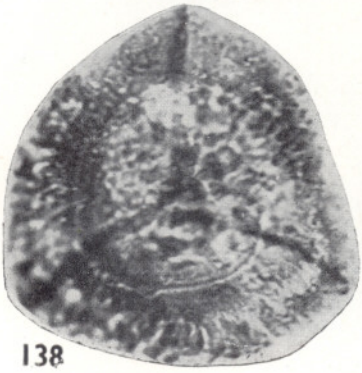
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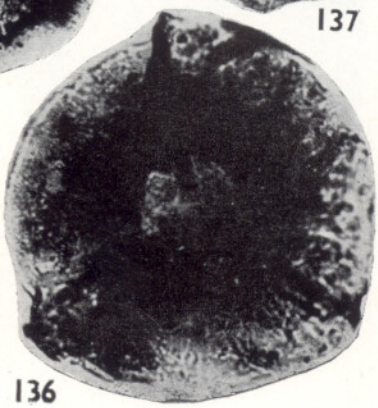
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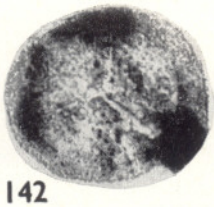
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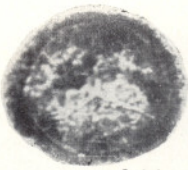
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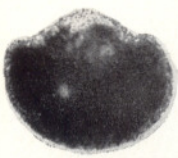
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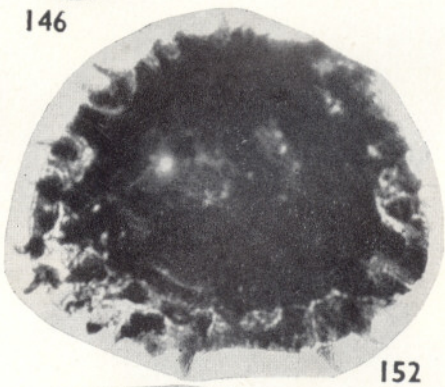
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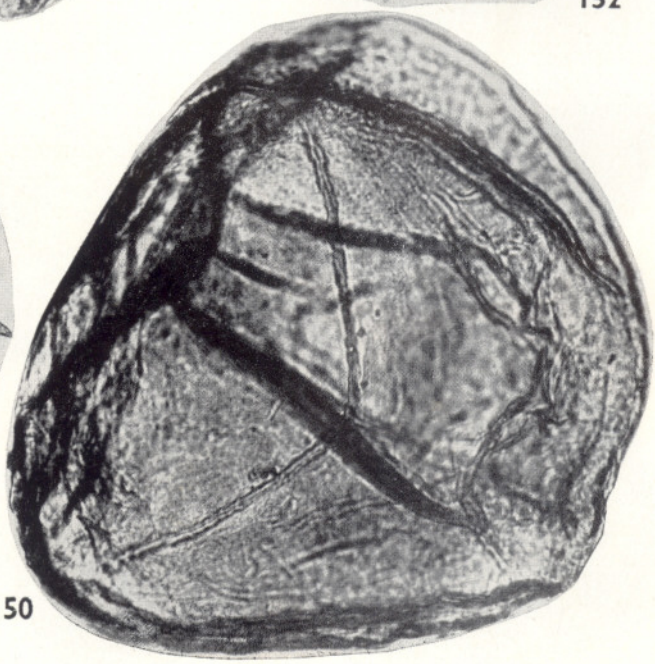
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45-48. *Orbisporis orbiculus* sp. nov.; photo 157/31, 242/4, 242/5, 242/26.
49, 50. *Orbisporis suborbiculus* sp. nov.; photo 159/28, 157/31.

PLATE 4

51. *Velamisporites descretus* sp. nov.; photo 171/19.
52-54. *Velamisporites rugosus* gen. et sp. nov.; photo 185, 179, 178.
55. Spore body of *Velamisporites rugosus* without perisporial covering; photo 171/15.
56. *Triquitrites tribullatus* (Ibr.) Pot. & Kr.; photo 159/1.
57. *Triquitrites leiolitus* Bhard.; photo 157/19.
58. *Triquitrites subgrandis* Artüz; photo 170/37.
59. *Triquitrites* cf. *T. bransonii*; photo 160/9.
60, 61. *Triquitrites inconcinnus* sp. nov.; photo 159/18, 240/34.
62. *Triquitrites* sp. A; photo 243/2.
63. *Triquitrites* sp. B; photo 240/28.

PLATE 5

64-75. *Triquitrites golatensis* (Staplin) comb. nov.; photo 241/9, 159/18, 169/32, 159/19, 170/31, 243/4, 153/13, 241/14, 241/1, 240/29, 157/5, 156/2.
76, 77. *Triquitrites coesfeldens* Bhard.; photo 241/12, 160/3.
78. *Simozonotriletes intortus* (Waltz) Pot. & Kr., photo 170/22.
79, 80. *Simozonotriletes crassimarginatus* sp. nov.; photo 158/1, 155/37.
81-84. *Simozonotriletes reinschi* (Sull.) comb. nov.; photo 241/28, 241/27, 159/34, 159/31.
85, 86. *Crassispora vestita* sp. nov.; photo 243/14, 157/35.
87, 88. *Crassispora spitzbergense* sp. nov.; photo 241/13, 241/25.
89. *Crassispora* sp. A.; photo 156/28.
90. *Crassispora* sp. B.; photo 241/11.
91, 92. *Lycospora pusilla* (Ibr.) S.W. & B.; photo 159/11, 169/5.
93. *Lycospora pressoides* (Pot. & Kr.) Bhard.; photo 160/4.

PLATE 6

94-98. *Densosporites anulatus* (Loose) S.W. & B.; photo 158/36, 170/5, 156/9, 157/4, 157/2.
99, 100. *Densosporites spitzbergensis* sp. nov.; photo 241/23, 241/8.
101-103. *Cristatisporites regalis* sp. nov.; photo 157/4, 171/11, 157/10.
104. Inner body of *Cristatisporites regalis* sp. nov.; photo 156/33.
105. *Cristatisporites* sp.; photo 226/15.
106-108. *Cristatisporites spinifer* (H.S. & M.) comb. nov.; photo 170/13, 170/21, 170/8.
109, 110. *Cristatisporites bellus* sp. nov.; photo 160/20, 243/27 (outline retouched).
111, 112. *Monilospora crassilimbata* sp. nov.; photo 156/5, 243/5.

PLATE 7

113. *Clavisporis spitzbergensis* gen. et sp. nov.; photo 243/3.
114. *Clavisporis boletus* (Staplin) comb. nov.; photo 243/38.
115-119. *Clavisporis* spp. from Nahanni River Coals; photo 244/4, 5 (retouched), 7, 8, 9 (retouched).

PLATE 8

120, 121. *Cincturasporites altilis* Hacq. & Barss (Nahanni Coal); photo 244/11, 244/15 (retouched).
122, 123. *Cincturasporites spitzbergensis* sp. nov.; photo 155/30, 242/22.
124-126. *Cincturasporites radialis* sp. nov.; photo 242/16 (proximal), 242/17 (distal), 242/18.
127. *Cincturasporites* sp.; photo 242/30.
128-130. *Labiadensites literatus* (Waltz) comb. nov.; photo 155/26, 159/17, 160/21.

PLATE 9

131-133. *Labiadensites novicus* sp. nov.; photo 171/34, 155/29, 242/28.
134-136. *Cirratriradites exilis* sp. nov.; photo 160/15, 160/22, 159/16.
137. *Cirratriradites* sp. A.; photo 169/8.
138-140. *Vallatisporites spitzbergensis* sp. nov.; photo 172/2, 243/35, 243/26.

PLATE 10

141. *Tholisporites scoticus* Butt. & Will.; photo 240/4.
142-146. *Tholisporites decorus* sp. nov.; photo 242/2 (retouched), 226/10, 170/4, 240/1 (retouched), 240/31. (retouched).
147. *Tholisporites* sp.; photo 241/21.
148. Cf. *Archaeozonotriletes* sp.; photo 242/10 (retouched.)
149. *Remysporites magnificus* (Horst) Butt. & Will.; photo 183.
150. Indeterminate; Photo 181.
151, 152. *Grandispora spinosa* H.S. & M.; photo 226/21 (retouched), 160/29.