AN UPPER DEVONIAN MIOFLORA FROM NEW ALBANY SHALE, KENTUCKY, U.S.A.

D. C. BHARADWAJ, R. S. TIWARI & B. S. VENKATACHALA*
Birbal Sahni Institute of Palaeobotany, Lucknow, India

ABSTRACT

The palynological contents of New Albany Shale, Kentucky, U.S.A. have been analysed to reveal 17 species of trilete spores and 17 species of alete sphaeromorphs, hystrichospherids and Chitinozoa. Two new genera and 22 new species have been described.

Among the trilete spores, *Cymbosporites* (11%) is associated with *Fossulatisporites* (10%), *Auroraspora* (3%) together with *Ancyrospora* and *Hystricosporites* (1% each). Among the acritarchs, *Leiosphaeridia* (40%), *Tasmanites* (10%) and *Baltisphaeridium* (6%) are the most prominent.

The trilete spores and the associated acritarchs suggest a Famennian age for the New Albany Shale.

INTRODUCTION

PALYNOLOGICALLY, the Devonian rocks of U.S.A. have been studied by a number of workers. A significant work is that by Winslow (1962) who has extensively studied the mioflora and described various types of spore species from the various members of Ohio black shales of Upper Devonian age. This mioflora contains a diversified spore assemblage as well as other algal microfossils. In 1963, Guennel reported a Middle to Upper Devonian mioflora from the fissure-filling in a Middle Silurian reef of Illinois. This assemblage is dominated by cingulate miospore genera. Later on, from Cedar Valley of Johnson County, Iowa, Kosanke (1964) and Urban (1968) recorded few spores from limestones and Sanders (1968) from the coals of the Cedar Valley Formation (Middle Devonian) described in detail a diversified mioflora wherein the genus *Geminospora* is abundant and the assemblage resembles most with the Mid. Givetian to Frasnian miofloras in general. Recently, Peppers and Damberger (1969) have described the microfossil assemblage from a Middle Devonian Coal in Illinois. This mioflora comprises 28 species of miospores and microfossils of marine origin.

The present paper deals with the microfossils in the New Albany Shale from Kentucky, U.S.A. From the same material, Bharadwaj and Venkatachala (1960) have already described *Protosalvinia arnoldii*. The shale (B.S.I.P. Loc. No. 1288), was collected from an outcrop along the road about 10 miles south-east of Winchester which is the *locus typicus* for all the new species described here. It is fine-grained, grey compact and laminated in appearance.

The small pieces of shale were washed and treated with Hydroflouric acid for one day. Thereafter, the sample was washed free of acid and put in 10 per cent Nitric acid (comm.) for 2 days followed by washing and warming in KOH (5%). The alkali free material was mounted in glycerine jelly.

SYSTEMATIC DESCRIPTION

Anteturma — ***Sporites H.* Potonié 1893**
Turma — ***Triletes* (Reinsch) Pot. & Kr. 1954**
Subturma — ***Azonotriletes* (Luber) Dettmann 1963**
Infraturma — ***Laevigati* (Bennie & Kidst.) Pot. 1954**

Genus — Punctatisporites Pot. & Kr. 1954

Genotype — Punctatisporites punctatus Ibrahim 1933.

Punctatisporites distinctus sp. nov.

Pl. 1, Figs. 1-3

Holotype — Pl. 1, Fig. 2; 41 μ.

Diagnosis — Circular to subcircular miospores. Size range 25-41 μ. Trilete mark well defined, rays short, simple, unequal, 1/2-2/3 radius long with thin-lips and low vertex. Exine less than 1 μ thick, indistinctly intrapunctate, psilate.

Comparison — *Punctatisporites punctatus* is bigger in size and possesses distinct intrapunctation on the exine. Among other

*Present Address — Dr. B. S. Venkatachala, Senior Palynologist, Institute of Petroleum Exploration, O.N.G.C., Dehra Dun.

comparable species, *P. planus* Hacq. (1957) differs in being bigger in size and having distinct intrapunctation in the exine.

Punctatisporites sp.

Pl. 1, Figs. 4, 5

Description — The miospores are 48-65 μ in diameter and usually circular or subcircular with a well defined trilete mark. The rays are 1/2-3/4 radius long with the exine along the lips variously thickened; lips are often opened. No contact area or arcuate rims are ever seen joining the ray ends. The exine is medium in thickness and ±1 μ thick in optical section. The intrapunctation is usually of fine nature and may be sometimes indeterminate. The ornaments are completely lacking.

Infraturma — *Apiculati* (Benn. & Kidst.) Pot. 1954

Genus — *Apiculatisporis* Pot. & Kr. 1958

Genotype — Apiculatisporis aculeatus (Ibr.) Pot. & Kr. 1958.

Apiculatisporis sp.

Pl. 1, Fig. 6

Description — Miospores are subcircular, 32-40 μ in size, showing weakly developed trilete mark. The spines are 2-3 μ long, ±1 μ wide at the base and closely set all over the exine.

Remarks — Only a few specimens showing subcircular shape and dense, spinose ornament have been found in this assemblage.

Genus — *Hystricosporites* McGregor 1960

Genotype — H. dilectabilis McGregor 1960.

Hystricosporites corystus Richards. 1962

Pl. 1, Figs. 15, 16

Holotype — Richardson, 1962; Pl. 25, Fig. 1.

Description of — Miospores are subcircular, 90-115 μ in size (excluding processes), thick-walled. Processes are present on equatorial margin and distal surface. Margin of spore is 8-12 μ thick. The appendages are solid, 30-40 μ long, 4-6 μ wide slightly tappering but widening at tips to bifurcate into two, pendant spines. Trilete mark is very prominent and raised in the centre.

Remarks — The miospores described here are slightly smaller than those described by Richardson (1962, p. 173) but in the characters of trilete mark and appendages they closely resemble the latter.

Dicrospora sp. A of Winslow (1962) is organizationally similar but it is distinctly bigger.

Subinfraturma — *Granulati* Dyb. & Jacho. 1957

Genus — *Cyclogranisporites* Pot. & Kr. 1954

Genotype — Cyclogranisporites leopoldi (Kr.) Pot. & Kr. 1954.

Cyclogranisporites sp.

Pl. 1, Fig. 7

Description — Miospores are subcircular, 27-33 μ in size and bearing a feeble trilete mark. The rays are 1/2-3/4 radius long without marked suture or lips. The grana are ±0·5 μ in size and closely packed all over the body.

Remarks — Specimens referable to *Cyclogranisporites* are rare in the present assemblage.

Cyclogranisporites leviradiatus sp. nov.

Pl. 1, Figs. 8, 9

Holotype — Pl. 1, Fig. 9; 76 μ.

Diagnosis — Circular. Size range 63-76 μ. Trilete mark distinct, rays simple, straight, 2/3 radius long, thin-lipped and low. Grana 0·5-1·5 μ, closely packed all over.

Comparison — *Cyclogranisporites plicatus* Allen (1965) has thinner exine with sparser granulation.

Subinfraturma — *Nodati* Dyb. & Jacho. 1957

Genus — *Lophotriletes* (Naum.) Pot. & Kr. 1954

Genotype — Lophotriletes gibbosus (Ibr.) Pot. & Kr. 1954.

Lophotriletes sp.

Pl. 1, Fig. 10

Description — The miospores are triangular with slightly convex sides and

rounded angles. The size ranges from 36 to 45 μ. The trilete mark is prominently developed with rays reaching up to the margin; the ornament is relatively sparser on the inter-radial areas but projects prominently on the outline. The distal exine is ruptured in some cases.

Subinfraturma — *Verrucati* Dyb. & Jacho. 1957

Genus — *Verrucosisporites* (Ibr.) Pot. & Kr. 1954

Genotype — Verrucosisporites verrucosus Ibr. 1933.

Verrucosisporites irregularis sp. nov.

Pl. 1, Figs. 11-14

Holotype — Pl. 1, Fig. 12; 56 μ.

Diagnosis — Subcircular; size range 54-65 μ. Trilete mark prominent, ray lips thick and elevated, thinning out towards the tips. Verrucae less than 1 μ; exine unevenly thickened and irregular in appearance.

Comparison — V. polygonalis Lanninger (1968) from Eifel differs in having bigger, regular verrucae which form a polygonal pattern.

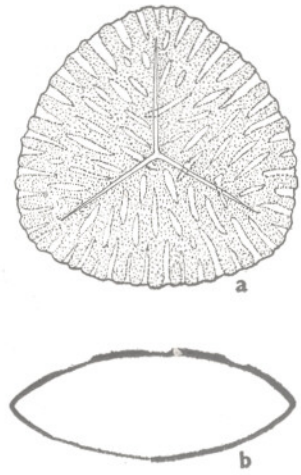
Infraturma — *Murornati* Pot. & Kr. 1954

Genus — *Fossulatisporites* gen. nov.

Genotype — Fossulatisporites triangularis sp. nov.

Generic Diagnosis — Triangular, trilete miospores, exine foveo-fossulate distally and smooth proximally.

Generic Description — The miospores are subtriangular to subcircular in over all shape. The trilete mark is distinct or sometimes faintly discernible; the rays are simple, usually 3/4 radius long, rarely more. The labra are thin in the species studied here and the vertex is low. Trilete rays are never associated with secondary folds. The exine is characteristically foveo-fossulate. The fovea are about 2 μ in diameter, close or 2-3 μ apart from each other intermixed with vermiculi-like, elongated, regular to irregular depressions. The muri are usually low and appear as wavy outline at the equator. On the whole, the exine pattern is coraloid with regular to irregular pittings



TEXT-FIG. 1 — Diagrammatic view of *Fossulatisporites* (a) proximal polar view, (b) vertical section through the poles.

of various shapes and sizes (Fossula = low radiating ridges).

Reconstruction — Text-figure 1.

Comparison — Leiotriletes (Naum.) Pot. & Kr. resembles in the nature of trilete mark and overall shape but differs in having smooth exine. *Microreticulatisporites* (Knox) Pot. & Kr., although shows reticulate ornamentation, differs from *Fossulatisporites* gen. nov., in having regular, reticulate rather than foveo-fossulate sculpture. *Camptotriletes* Naumova (1937), possesses irregular, rudimentary cristae or partly branching strips which are prominently visible and thus, differs from the present genus. The unidentified spores illustrated by McGregor and Owens (1966, PL. 28, FIGS. 17, 18, 21, 22) from Late Famennian seem to belong to *Fossulatisporites*.

Fossulatisporites triangularis sp. nov.

Pl. 1, Figs. 17-21

Holotype — Pl. 1, Fig. 20; 59 μ.

Diagnosis — Subtriangular. Size range 48-62 μ. Y-mark weak in development rays 3/4 radius long or more but not reaching the margin, straight and ±1 μ wide uniformly. Exine thin, and foveo-fossulate, fovea about 2 μ in diameter. Extrema lineamenta wavy, with less than 1 μ high muri.

Turma — *Zonales* Pot. & Kr. 1954
Subturma — *Zonotriletes* Waltz 1933
Infraturma — *Curvaturati* Infraturma nov.

Infraturma Diagnosis — Spores in which ray-ends are joined by arcuate ridges or rims.

Remarks — Lately, a number of spore genera bearing a trilete apparatus bound by curvaturae have been described from the Devonian, viz. *Retusotriletes*, *Apiculiretusispora* and *Acinosporites*. These genera inspite of differences in the ornamentation borne by them appear to be morphologically closer to each other in view of the similarity in their contact areas.

Genus — *Apiculiretusispora* Streel 1964

Genotype — *Apiculiretusispora brandtii* Streel 1964.

Apiculiretusispora imperfecta sp. nov.

Pl. 2, Figs. 22-24

Holotype — Pl. 2, Fig. 23; 80 μ.

Diagnosis — Circular. Size range 58-85 μ. Trilete mark distinct, rays up to 3/4 radius long, curvaturae subequatorial. *Area contagionis* sparsely granular. Exine baculate.

Comparison — *A. brandtii* the genotype, has denser ornamentation. *A. microconus* Richards. & List. (1969), is only 13-24 μ in size though agreeing in the nature of ornamentation. *A. spicula* Richards. & List., and *A. synorea* Richards. & List., have denser and larger spines for ornamentation.

Apiculiretusispora arnoldii sp. nov.

Pl. 2, Figs. 25-27

Holotype — Pl. 2, Fig. 27; 80 μ.

Diagnosis — Circular. Size range 57-82 μ. Y-mark distinct, rays 3/4 radius, lips slightly thick. Contact area discernible. Exine bearing 1·5-3 μ × 1·5 μ blunt to round tipped, close-set bacula.

Comparison — This species is unique in bearing short straightsided, round-tipped, bacula and hence differs from *A. spicula*, *A. synorea* and *A. cherata* Richards. & List., which are spinose while *A. microconus* and *A. brandtii* have finer ornamentation.

Infraturma — *Crassiti* Bharad. & Venkatachala 1961

Genus — *Cymbosporites* Allen 1965

Holotype — *Cymbosporites cyathus* Allen 1965.

Cymbosporites brevis sp. nov.

Pl. 2, Figs. 28-31

Holotype — Pl. 2, Fig. 29; 50 μ.

Diagnosis — Circular to subcircular. Size range 45-54 μ. Y-mark ill-defined, rays more than 3/4 radius long, straight, 2-3 μ thick and slightly raised, contact marking represented by arcuate impressions at the ray ends. Exine thick, equatorially crassate, distally verrucose, verrucae bigger in the marginal region.

Comparison— *C. cyathus* Allen (1965) differs from the present species in having longer rays, more pronounced crassitudo and bearing bigger cones supporting an apical spine. *C. catillus* Allen (1965) is also a different species in its smaller size and by having a broader crassitudo and a more prominent trilete mark.

Cymbosporites verrucosus sp. nov.

Pl. 2, Figs. 32-34

Holotype — Pl. 2, Fig. 33; 64 μ.

Diagnosis — Circular. Size range 60-72 μ. Y-mark prominent, rays 4/5 radius long, ± straight, labra 2-3 μ thick, raised. Crassitudo 6-9 μ wide equatorially. Verrucae 1 × 1 μ, uniformly distributed.

Comparison — *C. cyathus* and *C. catillus* Allen (1965) differ from the present species in the nature of ornamentation. *C. brevis* sp. nov. has bigger verrucae at the equatorial region and thus, differs from the present species. A very similar spore has been illustrated by McGregor (1966, Pl. 28, Fig. 7) from Late Famennian under ? *Punctatisporites*.

Infraturma — *Zonati* Pot. & Kr. 1954

Remarks — Richardson (1962) could not decide the place of *Ancyrospora* in Potonié and Kremp's classification of dispersed spores. However, in view of the evidence of a solid flange being present, *Ancyrospora* should find a place in *Zonati*.

Genus — *Ancyrospora* (Richardson) Richardson 1962

Genotype — Ancyrospora grandispinosa Richardson 1962.

Ancyrospora densispinosa sp. nov.

Pl. 2, Figs. 35-37; Pl. 3, Figs. 38-39

Holotype — Pl. 6, Fig. 36; 60 μ (without appendages).

Diagnosis — Subtriangular. Size range 48-68 μ (without appendages). Y-mark prominent, rays elevated, reaching the outer margin of the flange, abruptly widening at their ends. Central body subtriangular, 45 μ in holotype; exine 2-3 μ thick, ±smooth. Flange equatorial 4-8 μ wide, mediumly thick and finely punctate. Processes present only on margin of flange and on distal side, 4-10 μ apart, 15-35 μ long, 5-10 μ broad at the base, with dense, knotty, tuberous surface and broadened, funnel-like, truncate tips; bases of appendages usually fused. Appendages longer on the margin than on the distal side, sometimes broken (PL. 2, FIG. 35).

Comparison — A. grandispinosa, the genotype differs from the present species in having bigger over all size, wider zona and smaller appendages. From *A. ancyrea* (Eisenack) Richards. (1962), the present species differs in the nature of narrower, thicker flange, bigger, knotty appendages with truncate tips. *A. longispinosa* Richards., is also differentiated by wider, thinner appendages with long bifurcations.

Ancyrospora sp.

Pl. 3, Figs. 40, 41

Description — Miospores are subcircular, 60-64 μ in size bearing 12-26 μ long, 2-3 μ wide truncate bacula. The processes are ± uniformly broad along their length and blunt to slightly truncate at the ends; they are usually fused at bases and found in clusters. Trilete mark is not distinct. The exine is thin and with a narrow zona.

Remarks — Only three specimens in a cluster have been found and hence the variation study was not possible. In the nature of appendages, these specimens compare with *A. densispinosa*. However, they are smaller and narrower in *A.* sp.

Infraturma — *Saccizonati* Bharadwaj 1957

Remarks — Bharadwaj (1957) instituted an Infraturma, Saccizonati for trilete spores having saccus bearing a subequatorial ridge or a membraneous flange all round, to segregate *Endosporites* from other monosaccates. Subsequently, while explaining the organization of *Spencerisporites* and *Endosporites*, Bharadwaj (1965) placed *Gondisporites* also in Saccizonati implying to include therein lycopsid miospores with sculptured pseudosaccus bearing varyingly prominent remains of the arcuate ridges subequatorially.

Auroraspora as emended by Richardson (1960) lacks ornamentation as well as remanants of arcuate ridges yet in the extension of the trilete rays on the saccus up to the spore equator, it resembles Saccizonate genera. In our opinion *Auroraspora* and *Calyptosporites* Richards. (1962) are also lycopsid spores where the arcuate ridges have become obliterated, otherwise the rays would not have extended over the pseudosaccus. Moreover the pseudosaccus in the species of *Auroraspora* (viz. *A. macromanifestus* (Hacqueb.) Richards. 1960, *A. aurora* Richards. 1960, or *A.* spp. described here) does not appear to us to be absolutely ornament free. Hence, *Auroraspora* has been described here under the Infraturma Saccizonati.

Genus — *Auroraspora* (Hoffmeister, Stapl. & Melloy) Richards. 1960

Genotype — Auroraspora solisoitus H. S. & M. 1955.

Auroraspora triangulata sp. nov.

Pl. 3, Figs. 42-44

Holotype — Pl. 3, Fig. 43; 96 μ.

Diagnosis — Triangular in overall shape. Size range 87-120 μ. Y-mark clear, sometimes indistinct, rays 1/2 the body radius long, 12 μ in holotype, straight, lips individually 2 μ wide and slightly raised, pointed at tips. Central body usually well-defined, circular, 48 μ in Holotype. Saccus proximally encroaching the body about 1/2 the body radius but distally continuous and free from the body, very thin, vacuolate with 1·5-12 μ wide irregular fossulae and finely ornamented.

Comparison — A. aurora Richards. (1960), resembles the present species in the nature

of saccus but differs in being subtriangular with convex sides and ± equal width of saccus all round. From another comparable species, *A. macromanifestus*, the present species differs in being triangular with straight sides and narrow angles, and in the absence of folds along the trilete rays.

Auroraspora foveolata sp. nov.

Pl. 3, Fig. 45

Holotype — Pl. 3, Fig. 45; 128 μ.

Diagnosis — Miospore triangular with broadly lobed saccus. Size range 110-140 u. Central body 70 μ, roundly triangular. Trilete mark distinct rays 2 μ thick, extending up to the margin of central body, attenuating. Exine coarsely foveolate on both faces; fovea 1·5 to 4 μ in diameter. Saccus finely granulose with coarsely dentate margin, lobed.

Comparison — No species has been so far described under this genus, with foveolate body exine and the saccus having rounded, conical lobes.

Anteturma — *Sporonites* (R. Pot.) Ibr. 1933
Turma — *Aletes* (Luber) Pot. & Kr. 1964
Infraturma — *Psilonapiti* Erdtm. 1947

Genus — *Pilasporites* (Balme & Henn.) Tiw. & Navale 1967

Holotype — *Pilasporites calculus* B. & H. 1956.

Pilasporites sp. cf. *P. plurigenus* Balme & Henn.

Pl. 3, Fig. 46

Holotype — Balme & Henn. 1956, Pl. 3, Fig. 58.

Remarks — Tiwari and Navale (1967) have emended the generic diagnosis of *Pilasporites* on the basis of the presence of a weak, semicircular zone of splitting in most of the specimens. Similar " circular or crescentic invagination " has also been observed by McGregor (1964) in the present species.

ACRITARCHA

Group — *Acritarcha* Evitt 1963
Subgroup — *Sphaeromorphitae* Downie, Evitt & Sarj. 1963

Genus — *Leiosphaeridia* (Eisenack) Downie & Sarjeant 1963

Genotype — *Leiosphaeridia baltica* Eisenack, 1958.

Remarks — Downie and Sarjeant (1963) have opined that the exine in *Leiosphaeridia* is granulose, punctate or unornamented. The species found in the present assemblage have psilate or fine to coarsely punctate exine.

Leiosphaeridia plicata sp. nov.

Pl. 3, Figs. 47, 48

Holotype — Pl. 4, Fig. 48; 84 μ.

Diagnosis — Circular to subcircular, sphaeromorphs. Size range 60-100 μ. Exine thin, with many semilunar, big folds, irregular in arrangement. Extrema lineamenta psilate.

Comparison — *L. laevigata* Stockm. & Williere (1962) from the Silurian of Belgium is distinctly smaller in size and its exine surface is granulose.

Leiophaeridia magna sp. nov.

Pl. 4, Figs. 49, 50

Holotype — Pl. 4, Fig. 49; 160 μ.

Diagnosis — Circular to subcircular sphaeromorphs. Size range 83-174 μ. Exine leathery, brown in colour with many, criss-cross, big folds; exine foveopunctate; the fovea-like structure measuring 2-4 μ in diameter. Outline psilate.

Comparison — *L. plicata* sp. nov., resembles the present species in the nature of folds but differs in having thinner exine, and indistinct foveopunctation in the exine.

Leiosphaeridia coralata sp. nov.

Pl. 4, Fig. 51

Holotype — Pl. 5, Fig. 51; 150 μ.

Diagnosis — Circular to subcircular sphaeromorphs. Size range 80-180 μ. Exine usually mediumly thick, appearing irregularly coral-like with fovea irregular in shape and 3-9 μ in diameter. Outline roughly serrate and irregular.

Comparison — No species with coral-like appearance of exine has been described in the genus *Leiosphaeridia*. However, in all other characters, the present species is a member of the genus.

Genus — *Tasmanites* (Newton) Schopf., Wils. & Bent. 1944

Genotype — *Tasmanites punctatus* Newton, 1875.

Tasmanites simplex sp. nov.

Pl. 4, Figs. 56-57; Pl. 5, Fig. 58

Holotype — Pl. 5, Fig. 58; 80 μ.

Diagnosis — Circular sphaeromorphs. Size range 45-80 μ. Exine thick, leathery but without a line of thickness in optical section. Exine coarsely and uniformly punctate.

Comparison — *T. mourai* and *T. derbyi* (SOMMER, 1956) closely resemble the present species, however, they are much bigger in size and possess denser arranged pores and canals and hence, differ from the present species.

Tasmanites marginatus sp. nov.

Pl. 4, Figs. 52, 53

Holotype — Pl. 4, Fig. 53; 115 μ.

Diagnosis — Circular sphaeromorphs. Size range 62-130 μ. Exine uniformly 2 μ thick, occasionally with few folds, finely and sparsely punctate.

Comparison — The species is characterized by the punctate, thick exine with a distinct inner line indicating the thickness in optical section.

Tasmanites annulatus sp. nov.

Pl. 4, Figs. 54, 55

Holotype — Pl. 4, Fig. 55; 106 μ.

Diagnosis — Circular sphaeromorphs. Size range 80-110 μ. Exine thick, having a single ± circular fold around the polar region. Exine uneven, mottled in appearance. *Extrema lineamenta* is uneven.

Comparison — The presence of an annulate fold in the exine is a constant characters. *T. marginata* sp. nov. does not show such a fold and hence differs from the present species.

Tasmanites crassus sp. nov.

Pl. 5, Fig. 59

Holotype — Pl. 5, Fig. 59; 110 μ.

Diagnosis — Circular. Size range 105-120 μ. Exine thickness 4-5 μ. Canal and puncta denser in marginal region. Canals 4-5 μ long, less than 0·5 μ wide.

Comparison — *T. roxoi* Sommer (1965) closely resembles the present species but is bigger in size, bears coarser canals and thicker exine. *T. tapajonensis* Sommer (1965) another comparable species differs in its bigger size, uniform distribution of canals and much thicker exine.

Subgroup – *Schizomorphitae* Segr. 1967

Genus — *Hemisphaerium* Hemer & Nygreen 1967

Genotype — *Hemisphaerium inominatum* H. & N. 1967.

Hemisphaerium sp.

Pl. 5, Fig. 60

Description — A sphaerically oval sphaeromorph splitting into two bilateral halves. The specimen measures 112 × 140 μ. The exine is thick, and coarsely punctate.

Remarks — The splitting tendency along the weak zone is characteristic of *Hemisphaerium*. The solitary specimen found here differs from the species described by Hemer and Nygreen (1967) by being bigger in size and in having coarser punctation.

Subgroup — *Reticulosphaeromorphitae* Sinha 1969

Genus — *Cymatiosphaera* (O. Wetzel) Defl. 1954

Genotype — *Cymatiosphaera radiata* O. Wetzel 1933.

Cymatiosphaera sp.

Pl. 5, Figs. 61, 62

Description — The size ranges from 33 to 93 μ. The reticulum is coarse and uniformly disposed all over with low muri. The meshes are wide and mostly hexagonal. The exine is very thin and the structure is finely intramicropunctate. In optical section exine does not show a line of thickness.

Comparison — *C. canadensis* Deunff (1954) and *C. cornifera* Deunff (1955), both from Devonian, have broader and fewer meshes. *C. multisepta* Deunff (1955) has a phlange.

Genus — *Maculatasporites* Tiwari, 1964

Genotype — *Maculatasporites indicus* Tiwari 1964.

Maculatasporites crassus sp. nov.

Pl. 5, Figs. 63-64

Holotype — Pl. 5, Fig. 63; 52 μ.

Diagnosis —Circular sphaeromorph. Size range 51-70 μ. Reticulation coarse, muri 1-5 μ thick, meshes 3-10 μ wide, polygonal to irregular. Muri marginally extending 6-8 μ.

Comparison — *M. indicus* and *M. irregularis* possess irregularly thick muri. The present species shows coarser and thicker muri as well as meshes and thus, differs from them. *M. minimus* and *M. amplus* (SEGROVES, 1967) have regularly wide muri and regular meshes.

Genus — *Rugulasphaeridium* gen. nov.

Genotype — *Rugulasphaeridium venustum* sp. nov.

Generic Diagnosis — Circular sphaeromorph with irregular meshes formed by grooves.

Generic Description — Sphaeromorphs are circular to subcircular. Exine is thin and corsely reticulate. The grooves are shallow as seen on the margin. The meshes are of varied shapes and sizes with restricted distribution of smaller ones towards the margin. Sometimes the exine of one surface ruptures to form a ± circular opening in the central region.

Comparison — *Cymatiosphaera* is positively reticulate with raised muri whereas *Rugulasphaeridium* is negatively reticulate.

Rugulasphaeridium venustum sp. nov.

Pl. 5, Figs. 65, 66

Holotype — Pl. 5, Fig 66; 96 μ.

Diagnosis — Circular to subcircular. Size range 80-110 μ. Rugulae meshing all over the body, complete or incomplete. Meshes 1·5 μ to 21 μ in size, subcircular, oval or polygonal in shape. Grooves up to 1 μ wide. Exine thin, sometimes hayline, finely punctate.

Subgroup — *Acanthomorphitae* Downie, Evitt & Sarj. 1963

Genus — *Baltisphaeridium* (Eisenack) Downie & Sarjeant 1963

Genotype — *Baltisphaeridium longispinosum* Eisenack 1931

Baltisphaeridium radialis sp nov.

Pl. 5, Figs. 67-69

Holotype — Pl. 7, Fig. 67; 38 μ.

Diagnosis — Circular to subcircular sphaeromorphs. Size range 35-53 μ. Exine finely and indistinctly granulose bearing 6-12 μ long × 1-2 μ wide at the base and 3-8 μ apart, ± radially arranged, pointed spines. Exine 1 μ thick, usually rupturing along the equator or getting folded. 10-20 spines present along the margin.

Comparison — The present species differs from *B. longispinosum* in having sparsely and radially arranged spines and in having thinner exine. *B. microcladum* Downie (1963) is similar in size and arrangement of spines but bears furcate processes and hence, differs from the present species.

Baltisphaeridium sp.

Pl. 5, Fig. 70

Description — Sphaeromorph is 48 μ in radius, with thin exine and short, 6-8 μ long, ± 2 μ wide at base, pointed spines which are sparse but uniformly arranged all over the exine.

Remarks — This solitary specimen is characteristic in having short, pointed spines.

CHITINOZOA

Order — *Chitinozoa* Eisenack, 1931
Family — *Conochitinidae* Eisenack, 1931

Genus — *Acanthochitina* Eisenack, 1931

Genotype — *Acanthochitina barbata* Eis. 1931.

Acanthochitina barbata Eis. 1931

Pl. 5, Fig. 71

Description — Vesicle is elongated with ovoidal chamber and long cylindrical neck. Shoulders are quite distinct without an acute angle. Specimen measures 260 × 80 μ and is black and opaque. Internal characters are not visible. Surface of the vesicle is ornamented with fine, anastomosing, low branchioles.

Genus — *Conochitina* Eisenack 1931

Genotype — *Conochitina claviformis* Eisenack 1931.

Conochintina sp.

Pl. 5, Fig. 72

Description — Vesicle is elongated, club-shaped, 300 × 120 μ in size, without distinct angle. Base is flat without any ornamentation or callus. Sides are straight with weak shoulders. Neck is subcylindrical and narrowing at the end. Operculum or prosome structure is not well defined. The wall is thick, psilate and without structure. Some sort of distortion is seen on the surface.

Genus — *Rhabdochitina* Eis. 1931

Genotype — Rhabdochitina magna Eis. 1931.

Rhabdochitina cf. *magna* Eisenack 1931

Pl. 5, Fig. 73

Description — Vesicle elongated, cylindrical without any body chamber, flexure or neck. Size 440 × 70 μ. The cuticle is mostly dark and no internal character is visible. The oral aperture is flat and some indication of prosome is seen. At the aboral pole the specimen is somewhat distorted and shows reticulae. Ornamentation is lacking elsewhere.

Remarks — Similar but slightly bigger specimens have been described by Benoit and Taugourdeau (1961) from Ordovician of Sahara under this species.

PALYNOLOGICAL ASSEMBLAGE

The present assemblage contains diversified plant spores as well as microfossils of algal and animal origin. The miospores are represented by 17 species, and alete, sphaeromorphs, acritarchs and Chitinozoa are represented by 17 species. In all two genera and 22 species are proposed and described here as new.

Quantitative analysis of individual species suggests that *Leiosphaeridia plicata* sp. nov. among microplanktons and *Fossulatisporites triangularis* sp. nov. among trilete spores are the most dominating species in the assemblage. Other important species are :

Leiosphaeridia magna sp. nov.
Leiosphaeridia coralata sp. nov.
Cymbosporites verrucosus sp. nov.
C. brevis sp. nov.
Baltisphaeridium radialis sp. nov.
Tasmanites crassus sp. nov.

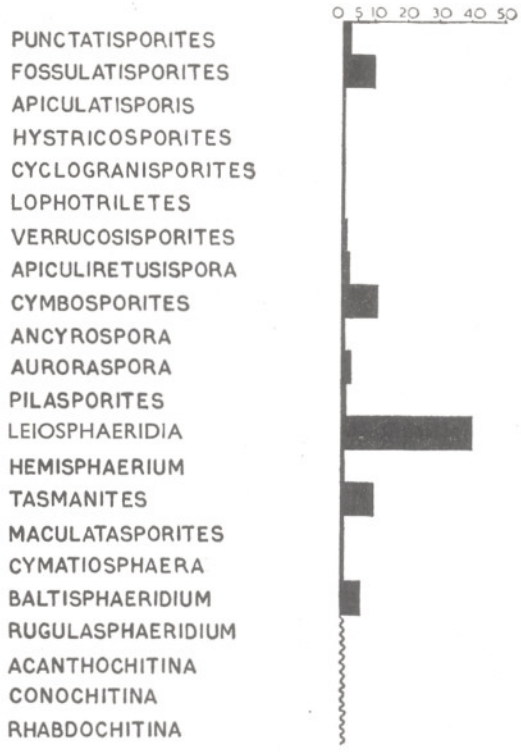
Table 1 gives the percentage frequency of the various species in the mioflora. The trilete spores are about 37 per cent, alete spores 1 per cent, Acritarcha 61 per cent and Chitinozoa less than 1 per cent.

Among the spore genera, *Cymbosporites* ranks high with 11 per cent and in the acritarch genera, *Leiosphaeridia* is about 40 per cent of the total microfossil population (Histogram 1).

Cymbosporites is associated with *Fossulatisporites* (10%), *Auroraspora* (3%) and about 1 per cent each of *Ancyrospora* and *Hystricosporites*. Remarkable by their absence are the spore genera, *Emphanisporites, Chelinospora, Stenozonotriletes, Bullatisporites,*

TABLE 1

1.	*Punctatisporites distinctus* sp. nov.	2·8%
2.	*P.* sp.	+
3.	*Fossulatisporites triangularis* sp. nov.	10·0%
4.	*Apiculatisporis* sp.	1·2%
5.	*Cyclogranisporites leviradiatus* sp. nov.	1·0%
6.	*Cyclogranisporites* sp.	+
7.	*Lophotriletes glabrus* sp. nov.	0·8%
8.	*Verrucosisporites irregularis* sp. nov.	1·6%
9.	*Apiculiretusispora imperfecta* sp. nov.	0·4%
10.	*Apiculiretusispora arnoldii* sp. nov.	2·0%
11.	*Cymbosporites brevis* sp. nov.	4·0%
12.	*C. verrucosus* sp. nov.	7·0%
13.	*Ancyrospora densispinosa* sp. nov.	0·8%
14.	*Ancyrospora* sp.	+
15.	*Hystricosporites corystus* Rich.	0·8%
16.	*Auroraspora triangulata* sp. nov.	2·8%
17.	*A. foveolata* sp. nov.	0·4%
18.	*Pilasporites plurigenus* B. & H.	1·6%
19.	*Tasmanites marginatus* sp. nov.	3·0%
20.	*T. annulatus* sp. nov.	1·6%
21.	*T. simplex* sp. nov.	1·2%
22.	*T. crassus* sp. nov.	4·0%
23.	*Leiosphaeridia magna* sp. nov.	9·0%
24.	*L. plicata* sp. nov.	23·0%
25.	*L. coralata* sp. nov.	8·2%
26.	*Hemisphaerium* sp.	1·2%
27.	*Cymatiosphaera* sp.	1·2%
28.	*Maculatasporites crassus* sp. nov.	1·2%
29.	*Rugulasphaeridium venustus* sp. nov.	0·4%
30.	*Baltisphaeridium radialis* sp. nov.	6·0%
31.	*Baltisphaeridium* sp.	0·4%
32.	*Acanthochtina barbata* Eis.	+
33.	*Conochitina* sp.	+
34.	*Rhabdochitina* cf. *magna* Eis.	0·4%
		98·6%



HISTOGRAM 1 — Percentage frequency of the genera in the assemblage from New Albany shale.

Rhabdosporites, *Diboiisporites*, *Perforosporites*, *Calyptosporites*, *Geminospora*, *Corystisporites*, *Acinosporites*, *Aneurospora*, *Enigmophytospora* and *Heliospora* among the short range genera as given by Chaloner (1967). Subsequent studies have increased the ranges of these genera to some extent. *Cymbosporites* and *Apiculiretusispora* are now known to occur as low down as Gedinnian and *Ancyrospora* up in the Famennian too.

A comparison of the assemblage described above with those from the Middle and Upper Devonian strata of Ohio, Illinois and Iowa in U.S.A., indicates its striking individuality. The Kentucky assemblage has been recovered from a *Protosalvinia* (*Foerstia*) — rich shale. Similar *Foerstia* — rich shale occurs in the Huron member of Ohio shale in a zone 60-150 feet thick and persistent in lateral extent and "possibly representing a correlation time zone (WINSLOW, 1962)". From this zone as well as the shale members overlying and underlying, Winslow (loc. cit.) has studied the mioflora. Surprisingly enough, the spores and acritarchs described from Olentangy shale, base, middle (*Foerstia* zone) and top parts of Huron member, Chagrin shale and Cleveland member are all qualitatively as well as quantitatively different. However there is rather a distant similarity in the common occurrence of *Ancyrospora* (*Dicrospora* of Winslow), *Auroraspora* (*Endosporites* sp. A of Winslow) and *Tasmanites* in the New Albany and Ohio black shales.

From the nature of the palynological association recovered from the New Albany Shale, its age seems to lie in the Famennian.

New Albany shale was deposited in brackish water as apparent from the rich acritarch representation together with a few Chitinozoa.

The trilete spore flora apparently represents the near shore vegetation.

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EXPLANATION OF PLATES

All figures unless otherwise stated are × 500

PLATE 1

1-3. *Punctatisporites distinctus* sp. nov. Sl. Nos. 4072, 4079 (Holotype), 4079.

4-5. *Punctatisporites* sp. Sl. Nos. 4081, 4082.

6. *Apiculatisporis* sp. Sl. No. 4070.

7. *Cyclogranisporites* sp. Sl. No. 4069.

8,9. *Cyclogranisporites leviradiatus* sp. nov. Sl. Nos. 4069, 4070 (Holotype).

10. *Lophotriletes* sp. Sl. No. 4076.

11-14. *Verrucosisporites irregularis* sp. nov. Sl. Nos. 4075, 4079 (Holotype), 4081, 4081.

15,16. *Hystricosporites corystus* Rich. Sl. Nos. 4080, 4080 (× 1000).

17-21. *Fossulatisporites triangularis* gen. et sp. nov. Sl. Nos. 4079, 4075, 4074, 4076 (Holotype), 4074.

PLATE 2

22-24. *Apiculiretusispora imperfecta* sp. nov. Sl. Nos. 4081, 4070 (Holotype), 4080.

25-27. *Apiculiretusispora arnoldii* sp. nov. Sl. Nos. 4070, 4071, 4072 (Holotype).

28-31. *Cymbosporites brevis* sp. nov. Sl. Nos. 4079, 4081 (Holotype), 4080, 4074.

32-34. *Cymbosporites verrucosus* sp. nov. Sl. Nos. 4079, 4082 (Holotype), 4076.

35-37. *Ancyrospora densispinosa* sp. nov. Sl. Nos. 4071 (Holotype), 4071 (× 1000), 4079.

PLATE 3

38,39. *Ancyrospora densispinosa* sp. nov. Sl. Nos. 4079, 4072.

40,41. *Ancyrospora* sp. Sl. Nos. 4081, 4081 (× 1000).

42-44. *Auroraspora triangulata* sp. nov. Sl. Nos. 4070, 4070 (Holotype), 4070.

45. *Auroraspora foveolata* sp. nov. Sl. No. 4070 (Holotype).

46. *Pilasporites* sp. cf. *P. plurigenus* Balme & Henn. Sl. No. 4069.

47,48. *Leiosphaeridia plicata* sp. nov. Sl. Nos. 4080, 4073 (Holotype).

PLATE 4

49,50. *Leiosphaeridia magna* sp. nov. Sl. Nos. 4076 (Holotype), 4069.

51. *Leiosphaeridia coralata* sp. nov. Sl. No. 4074 (Holotype).

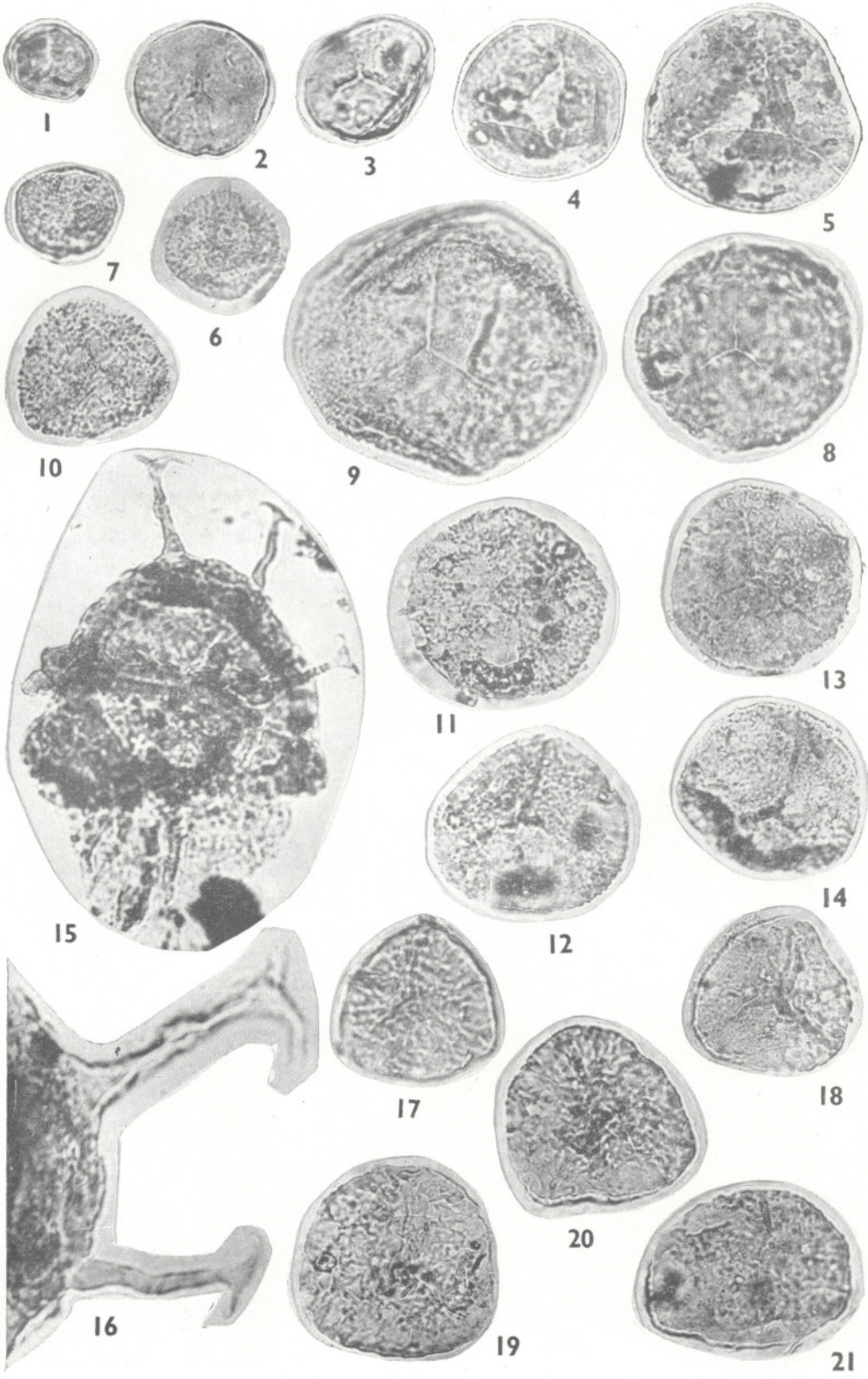
52,53. *Tasmanites marginatus* sp. nov. Sl. Nos. 4074, 4070 (Holotype).

54,55. *Tasmanites annulatus* sp. nov. Sl. Nos. 4069, 4071 (Holotype).

56,57. *Tasmanites simplex* sp. nov. Sl. Nos. 4071, 4081.

PLATE 5

58. *Tasmanites simplex* sp. nov. Sl. No. 4073 (Holotype).
59. *Tasmanites crassus* sp. nov. Sl. No. 4070 (Holotype).
60. *Hemisphaerium* sp. Sl. No. 4080.
61,62. *Cymatiosphaera* sp. Sl. Nos. 4070, 4079.
63,64. *Maculatasporites crassus* sp. nov. Sl. Nos. 4073 (Holotype), 4068.
65,66. *Rugulasphaeridium venustum* gen. et sp. nov. Sl. Nos. 4070, 4071 (Holotype).
67-69. *Baltisphaeridium radialis* sp. nov. Sl. Nos. 4071 (Holotype), 4075, 4070.
70. *Baltisphaeridium* sp. Sl. No. 4076.
71. *Acanthochitina barbata* Eis. Sl. No. 4071.
72. *Conochitina* sp. Sl. No. 4071.
73. *Rhabdochitina* cf. *magna* Eis. Sl. No. 4071.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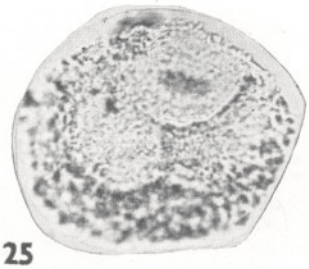
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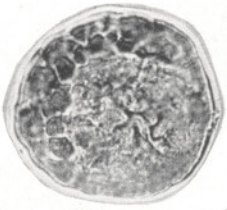
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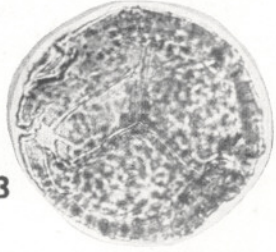
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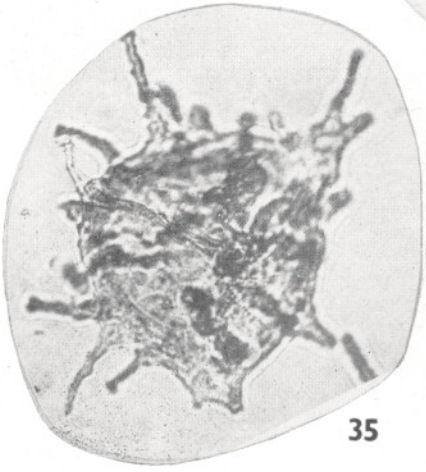
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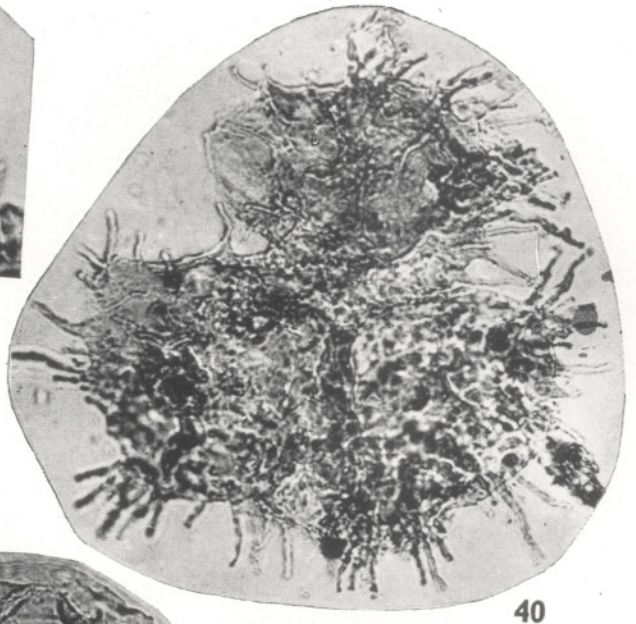

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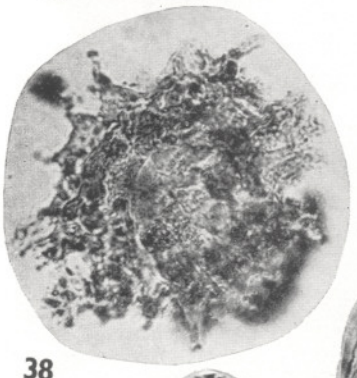

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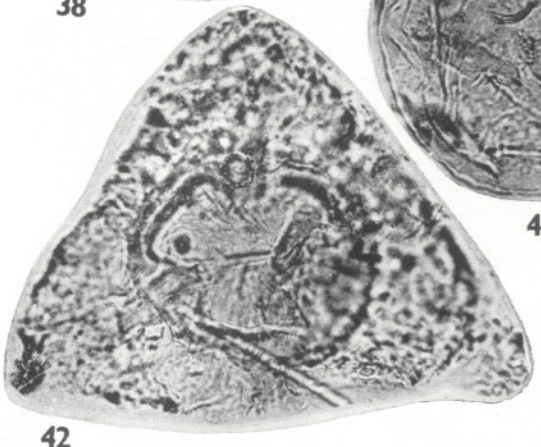

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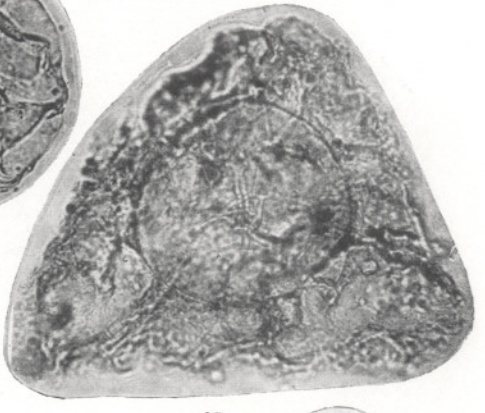

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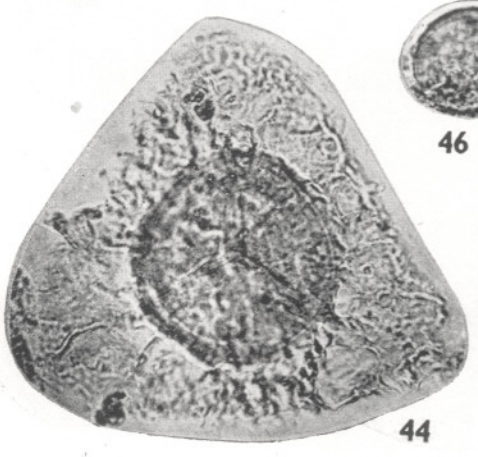

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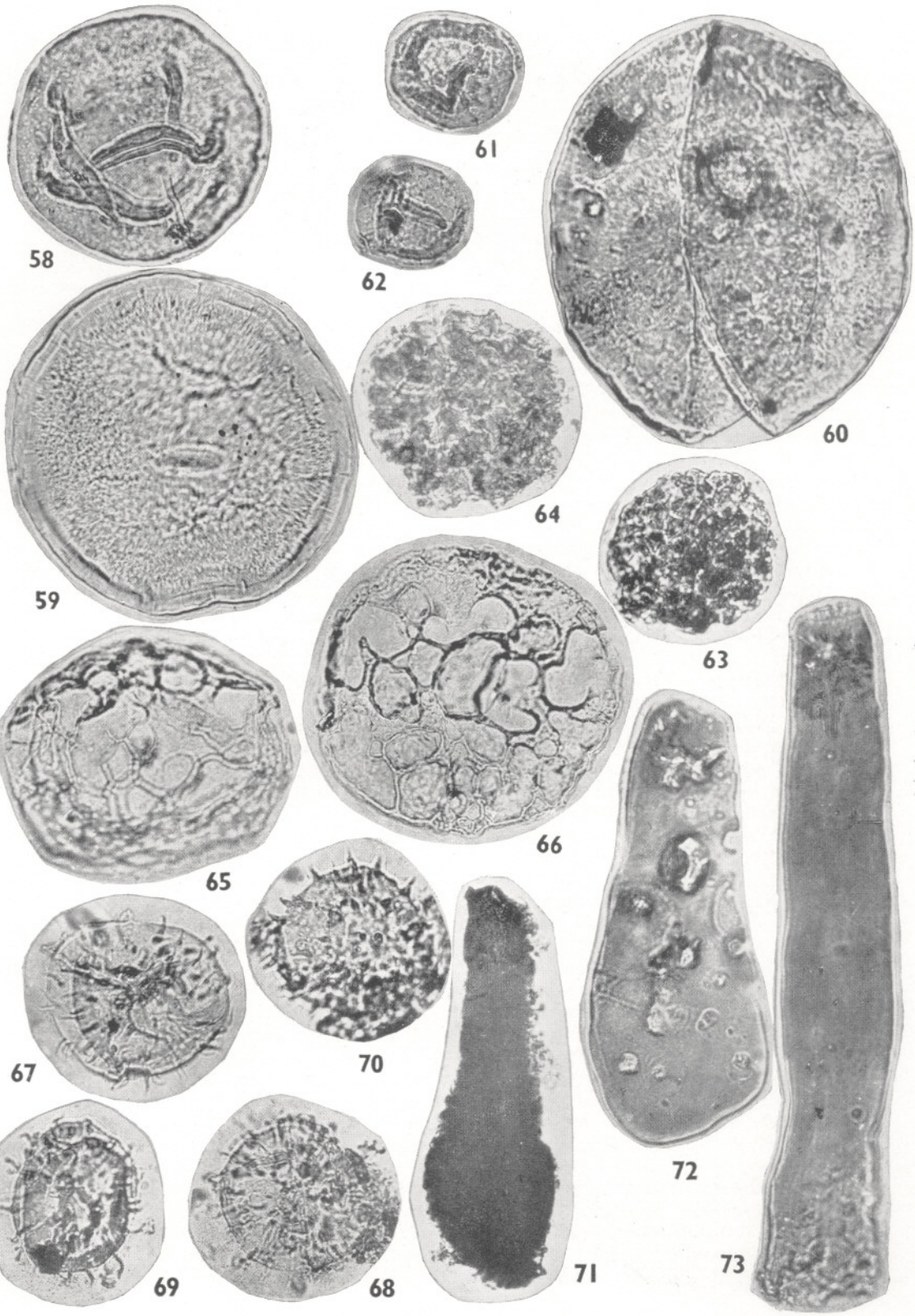
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