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Microflora of the Famennian and Tournaisian deposits from boreholes of Northern Poland

ABSTRACT: Five successive spore assemblages are described from marine carbonate deposits discovered in two boreholes in northern Poland. Upper Famennian to early Tournaisian age of the section is suggested. Fourty-nine spore species and a few acritarchs are recorded, of which five new spore species are described. Correlation is made between the spore zones described and those from the Ardenno-Rhine Basin.

GEOLOGIC SETTING

During the last few years the north-western part of Poland has been the subject of intensive geologic investigations. Numerous deep boreholes were drilled in this area and many of them had penetrated into or throughout the Carboniferous and/or Devonian deposits. One of them is the Babilon *1* borehole (Fig. 1), in which, under the Zechstein deposits a 695 m thick series of rocks representing the Devonian/Carboniferous transition has been discovered at a depth between 2618.7 to 3313.7 m. The boring was stopped at 3313.7 m.

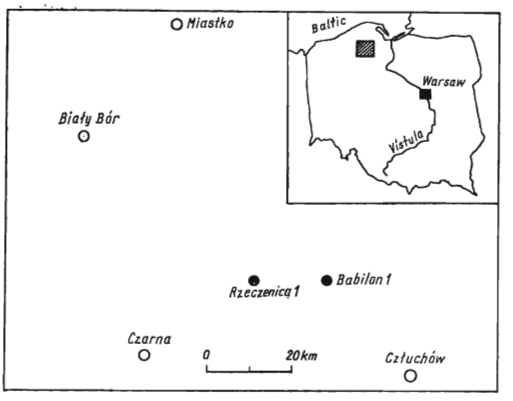


Fig. 1. Mapa lokalizacyjna otworów wiertniczych (Localization map of boreholes)

The detailed description of the core, as well as the descriptions of the molluscs and trilobites found at Babilon *1* are presented by Korejwo (1975). The preliminary brachiopod stratigraphy of these deposits is presented by Matyja (1975).

The recovery of the core in the Babilon *1* borehole was most incomplete (only 22%).

The sequence comprises, in descending order, the following deposits and fossils other than sporomorphs:

2618.7—2867.3 m — Marly limestones, mostly gray, with rare intercalations of encrinites and crystalline limestones. Dips gentle (0—15°). Brachiopods, trilobites, molluscs, scolecodonts, rare ostracods, plant detritus.

2880.5—3193.2 m — Gray and dark gray crystalline and marly limestones with rare siltstone intercalations below the depth 3061.5 m; rare encrinites. Dips gentle (0—15°). Fauna as above.

3207.8—3313.7 m — Gray, dark gray, and gray-beige crystalline and marly limestones, somewhat sandy, in places dolomitized, with siltstone intercalations; encrinites. Brachiopods, scolecodonts, plant detritus. Dips 30—45°.

The Rzeczenica *1* borehole (Fig. 1) penetrated, under the Zechstein deposits, into a series of similarly developed sediments containing marine faunas. This sequence is much thinner than that of the Babilon *1* and corresponds more or less to its top part. It occurs at a depth between 2896.0 to 3003.0 m where the boring was stopped.

MATERIAL AND METHODS

Preparations were attempted from fifty-two samples from the Babilon *1* borehole taken at 23 intervals and from six samples from the Rzeczenica *1* borehole taken at six intervals. These were mostly marly limestones and crystalline limestones (from the lowermost hundred meters of the Babilon *1* borehole). Fifty samples contained moderately preserved spores and also acritarchs and scolecodonts. There was a progressive decrease in state of preservation with an increase in depth. The spores were scarce in most samples from the Babilon *1* column below the depth 2675.3 m and abundant at this depth and above; in the Rzeczenica *1* column spores were quite abundant but poorly preserved.

All type specimens illustrated in this paper are housed in the Institute of Geological Sciences, Polish Academy of Sciences in Kraków. The microscope readings based on a Zeiss microscope *NfPk*, No. 410559 are listed in the manuscript catalogue of slides.

SYSTEMATIC DESCRIPTIONS

Fourty-nine spore species have been determined from the samples from the Babilon *1* and Rzeczenica *1* boreholes but not all these forms have been described in this paper. The twenty species which are omitted are

these including simple, azonate spores or some forms with distinct features but poorly preserved or found in very small quantities. All the species present in the assemblages are listed in Table 1 and figured in Plates 1 to 8.

The system of classification used here is that introduced by Potonié & Kremp (1954, 1955, 1956) and Potonié (1956, 1958, 1960, 1966, 1970).

Anteturma **Proximegerminantes** Potonié, 1970
Turma **Triletes-Azonales** Potonié, 1970
Subturma **Azonotriletes** (Luber, 1935) Dettman, 1963
Infraturma **Retusotriliti** Streel, 1974
Genus *APICULIRETUSISPORA* (Streel, 1964) Streel, 1967
Apiculiretusispora granulatipunctata sp. n.
(Pl. 1, Figs 9—11)

Holotype: Plate 1, Fig. 11.
Type locality: Babillon 1, depth 2647.9—2651.5 m, probably early Tournaisian.

Diagnosis. — Spores trilete; amb subtriangular with broadly rounded apices and convex sides or subcircular. Trilete mark not always distinct, laesurae sinuous, 3/4 spore radius, lips weak. Curvaturae perfect, weak to indistinct. Exine finely, densely infrapunctate, ornamented with granules up to 1 µm wide and 1 µm high, 1—2 µm apart; contact faces smooth.

Dimensions (twenty-one specimens). — Overall diameter 27—52 µm (mean 46 µm).

Description. — Spores often flattened obliquely. Secondary folds of exine common. Thin outermost sculptural layer of exine occasionally separated from the inner one (Pl. 1, Fig. 11).

Comparisons. — *Retusotriletes punctatus* Chibrikova in: Bouckaert & al. (1969, Pl. 93, Figs 1—4) has finer and denser ornamentation and more pronounced lips and curvaturae.

Apiculiretusispora sp. cf. *Retusotriletes greggsi* McGregor
(Pl. 1, Figs 7—9)

(?)1970. ?*Retusotriletes punctatus* Chibrikova; McGregor, Pl. 22, Fig. 9.

Description. — Spores trilete, amb subtriangular with convex sides and rounded apices to oval. Trilete mark distinct, laesurae sinuous, accompanied by narrow lips, reaching almost to equator. Contact faces delimited equatorially by curvaturae; these are variably developed — strong to imperceptible. Exine 3—5 µm thick, ornamented with densely packed cones less than 1 µm high; contact faces smooth. Secondary folds of distal exine common.

Dimensions (fifteen specimens). — Overall diameter 39—52 µm (mean 45 µm).

Remarks. — *Retusotriletes greggsi* McGregor (1964, pp. 8—10, Pl. 1, Figs 1—12) is larger. Cf. *Crassispora balteata* (Playford) Sullivan in: Streel (1966, pp. B84-B85, Pl. 2, Fig. 24), *Retusotriletes punctatus* Chibrikova in: Bouckaert & al. (1969, Pl. 93, Figs 1—4) and ?*Retusotriletes punctatus* Chibrikova in: McGregor (1970) represent

Tab

Spore distribution in

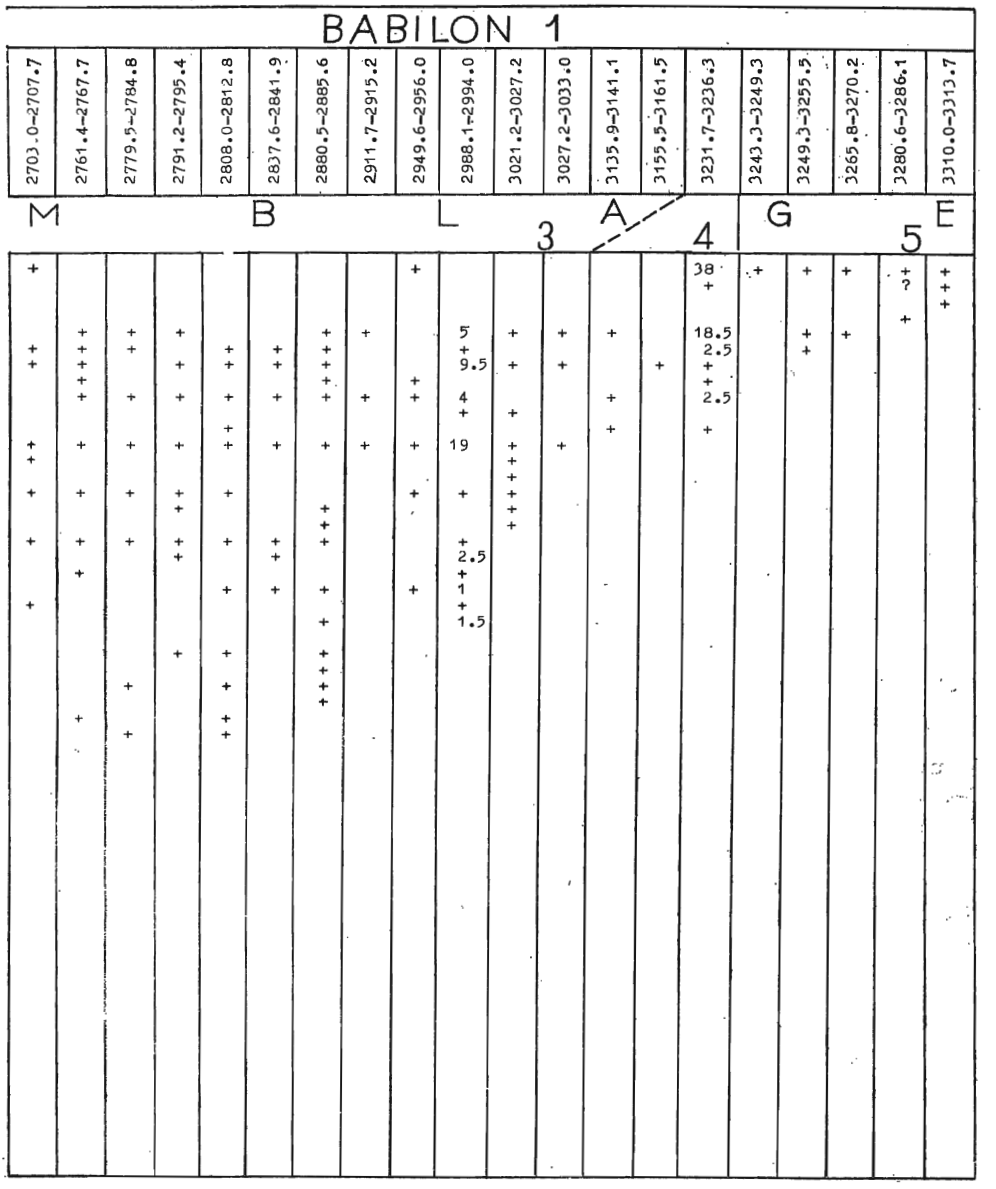
Taxon \ Depth m	RZECZENICA 1											
	2896.0–2899.0	2899.0–2901.3	2907.9–2912.7	2916.7–2920.7	2977.0–2983.2	2999.0–3003.0	2618.7–2624.6	2624.6–2628.0	2629.5–2635.4	2641.4–2646.1	2647.9–2651.5	2675.3–2681.5
	1 A			S			S			E 2		
Grandispora cf. uncata sensu Streel												
Grandispora gracilis												
Trachytriletes minor		+						5.5	3	1	5	6
Leiotriletes trivialis										+		
Auroraspora cf. macra	+	6.5	+		+	+	+		3	1	1	2
Auroraspora multiplex				+	+	+	+	6.5	7	4.5	4	6
Spelaeotriletes lepidophytus			+	11	+	+	+	3.5	7	1	14	1.5
Punctatisporites solidus								1.5	0.5	+	0.5	
Auroraspora versabilis			+			+		4	3	2	5	5
Grandispora conspicua	+	+		2	+			+		1	+	0.5
Retusotriletes incohatus	+	1		1					+			16
Grandispora lupata			+	+	+	+		5	2.5	1.5	6	3.5
Tumulispora lebedianensis				+	+	+		1.5	1	1.5	1	2.5
Sohopfites sp.						+		0.5				+
Ancyrospora sp.				1	+					+	+	+
Hystricosporites sp.							+			+	+	+
Hystricosporites multifurcatus									+			
Tumulispora rarituberculata				+	+	+	+	8	3	1.5	3	8.5
Corbulispora subalveolaris										+		0.5
Spelaeotriletes sp.				+	+	+		+	+	+	+	+
Convolutispora lepida							+	1		0.5	0.5	0.5
Knoxisporites literatus				+		+		0.5	+	+	0.5	+
Apiculiretusispora granulatipunctata				2	+	+		7	18	15.5	18.5	8.5
Grandispora uncata				+								
Raistrickia variabilis				+						1.5	0.5	+
Foveosporites oppositus				+				1	0.5			
Converrucosisporites curvatus						+		1.5	+	0.5	1.5	2.5
Microreticulatisporites hortonensis												+
Verrucosisporites nitidus			+	3					+			
Convolutispora harlandii								+	+	+		+
Knoxisporites pristinus								+	+	+		
Convolutispora venusta					+			1.5		2	+	0.5
Perotrilites obnubilus		2.5		1	+	+		2.5	+	4	4	7
Endoculeospora gradzinskii	+	10		+	+	+		0.5		1.5	1.5	2
Apiculiretusispora sp. cf. R. greggsi				+				6	4	1.5	0.5	2
Knoxisporites sp.									+	+		+
Umbonatisporites spp.		+		+		+					0.5	+
Tumulispora obscura				+			+		+	+		+
?Laevigatosporites sp.				+							0.5	+
Auroraspora granulatipunctata			+	+		+		2	5	+		+
Densosporites sp.								+	+		+	
Microreticulatisporites punctatus					+			1			1	
Verrucosisporites macrogrumosus								+	0.5	1		
Punctatisporites stabilis				2	+			3	+			
Emphanisporites sp.									+			
Lophozonotriletes malevkensis				+		+			+			
Vallatisporites pusillites				+	+							
Auroraspora macromanifesta		+			+							
Perotrilites perinatus		+	+	+								
Tumulispora dentata	+	+		+								
Hymenozonotriletes explanatus		+										
Auroraspora micromanifesta		+										
Cincturasporites spp.		2										
Punctatisporites glaber	+	4.5										
Perotrilites magnus		+										
Dictyotriletes trivialis	+	+										

Constituent species are recorded as percentages based on an account of 200 specimens

probably the same species as the one described above. *Geminospora lemurata* Balme (1960, p. 5, Pl. 1, Figs 5—10) lacks lips and usually possesses intexine detached from exoexine. Streel in: Becker & al. (1974, p. 24) included spores similar to *Apiculi-*

le 1

the examined samples



retusispora sp. to *Aneurospora*; however, the diagnosis of Apiculiretusispora seems to fit better these spores with variable, often very weak curvaturae.

Occurrence. — Possibly Belgium, Frasnian to Tournaisian (Streel 1966; Bouckaer & al. 1969); possibly Canada, Upper Famennian (McGregor 1970); northern Poland, probably early Tournaisian, assemblage 2.

Infraturma **Apiculati** (Bennie & Kidston) Potonié, 1956
Subinfraturma **Verrucati** Dybová & Jachowicz, 1957
Genus *CONVERRUCOSISPORITES* Potonié & Kremp, 1954
Converrucosisporites curvatus (Naumova) n. comb.
(Pl. 1, Figs 14; Pl. 2, Figs 1—3)

1953. *Lophozonotriletes curvatus* sp. n.; Naumova, p. 131, Pl. 19, Figs 25—30.
(?)1965. *Pustulatisporites gibberosus* (Haquebard) Playford; Kerr & al., Pl. 3, Fig. 24.
1970. *Lophozonotriletes bellus* Kedo; Clayton, p. 586, Pl. 2, Fig. 6.
1970. *Pustulatisporites gibberosus* (Haquebard) Playford; Paproth & Streel, Pl. 26, Fig. 3.
(?)1970. *Pustulatisporites gibberosus* (Haquebard) Playford; Almen, Pl. 29, Fig. 3.
1970. *Pustulatisporites cf. gibberosus* (Haquebard) Playford; Combaz & Streel, Pl. 3, Fig. 2.

Description. — Spores trilete; amb rounded-triangular. Trilete mark distinct, laesurae straight or slightly sinuous, simple or with narrow lips, 2/3 of spore radius. Exine thick, thicker over distal surface and equatorial region (up to 5 μm), slightly thinner over contact faces. Distal surface and equatorial region of proximal surface ornamented with stout verruci of irregular basis outline, 3—12 μm wide, up to 4 μm high. Verruci densely packed or spaced up to 8,5 μm apart. Ornament on contact faces reduced or absent.

Dimensions (ten specimens). — Diameter 41—58,5 μm (mean 45 μm).

Remarks. — The exine of these spores corrodes very easily; the corrosion affects the sculptural elements which in corroded specimens are small, loosely distributed and appear as warts or cones. The sculptural features of the corroded forms conform with those of *Pustulatisporites* but the appearance of complete specimens is that of *Converrucosisporites*.

As was noted earlier by Clayton (1970) the thick exine gives the spores a cingulate appearance; the oblique compression (Pl. 2, Fig. 3) shows that the spore is azonate.

Comparisons. — *Pustulatisporites gibberosus* (Haquebard) Playford in: Haquebard (1957, p. 310, Pl. 2, Fig. 1) and in: Playford (1964, pp. 18—19, Pl. 3, Figs 18—20) differs from *C. curvatus* in having more coarse sculpture consisting of flat-topped tubercules of circular outline.

Occurrence. — USSR, Frasnian to Tournaisian (Naumova 1953; Chibrikova 1972; Raskatova 1973); British Isles, Tournaisian (Clayton 1970; Utting & Neves 1970); Belgium and France, Tournaisian (Combaz & Streel 1970; Paproth & Streel 1970); USA (?) possibly Upper Devonian (Almen 1970); Bear Island, Upper Famennian (Kaiser 1971); northern Poland, probably early Tournaisian, assemblage 2.

Genus *VERRUCOSISPORITES* (Ibrahim) Smith & Butterworth, 1967
Verrucosisporites macrogrumosus (Kedo) n. comb.
(Pl. 1, Fig. 16)

1957. *Lophozonotriletes macrogrumosus* sp. n.; Kedo, p. 83, Pl. 4, Figs 21—22.

Description. — Spores trilete; amb subcircular. Trilete mark indistinct, laesurae simple, straight, 3/4 of spore radius. Exine up to 6 μm thick. Distal surface and equatorial region of proximal surface ornamented with irregularly distributed verruci of uneven width. Bases of verruci irregularly subcircular to elongated, 3—11 μm wide (usually 4—6 μm) closely packed to 5 μm apart. Verruci up to 8 μm high, flattened, rounded or bluntly pointed in profile. Ornamentation of contact faces is of the same type but verruci are smaller and more widely spaced.

Dimensions (twelve specimens). — Overall diameter 65—97.5 μm (mean 74 μm).

Remarks. — Thick exine gives the spores a cingulate appearance; this is only superficial and therefore the species is transferred to *Verrucosisporites*.

Occurrence. — USSR, Famennian-Tournaisian (Kedo 1957, 1963; Raskatova 1973); northern Poland, probably early Tournaisian, assemblage 2.

Genus *SCHOPFITES* Kosanke, 1956

Schopfites sp.

(Pl. 2, Fig. 11)

Description. — Spores trilete; amb circular or oval. Trilete mark indistinct to absent; laesurae 2/3 of spore radius. Exine thin, infrapunctate, ornamented with clava or bacula c. 2 μm long, c. 2 μm apart. Contact faces smooth.

Dimensions (six specimens). — Overall diameter 59—82.5 μm (mean 74 μm).

Comparisons. — *Schopfites claviger* Sullivan (1968, p. 121, Pl. 25, Figs 9—10) is smaller but ornamented with larger projections. *Raistrickia inprofusa* Playford (1971, p. 22, Pl. 5, Figs 15—17) has distinct laesurae accompanied by lips.

Occurrence. — Northern Poland, probably early Tournaisian, assemblages 2 and 3.

Subinfraturma **Baculati** Dybová & Jachowicz, 1957

Genus *RAISTRICKIA* (Schopf, Willson & Bentall) Potonié & Kremp, 1954

Raistrickia variabilis Dolby & Neves, 1970

(Pl. 2, Fig. 10)

Dimensions (fourteen specimens). — Overall diameter 43.5—74 μm (mean 64.5 μm).

Remarks. — Specimens observed in this study are similar to the ones originally described and illustrated by Dolby & Neves (1970, p. 636, Pl. 1, Fig. 6).

Occurrence. — Belgium and France, late Famennian to early Tournaisian (Streel 1970; Combaz & Streel 1970; Becker & al. 1974); British Islands, probably late Famennian to early Tournaisian (Dolby 1970; Dolby & Neves 1970; Gayer & al. 1973; Clyton & al. 1974); northern Poland, probably early Tournaisian, assemblage 2.

Infraturma **Murornati** Potonié & Kremp, 1954

Genus *CONVOLUTISPORA* Hoffmeister, Staplin & Malloy, 1955

Convolutispora venusta Hoffmeister, Staplin & Malloy, 1955

(Pl. 2, Fig. 4)

Dimensions (nine specimens). — Overall diameter 43.5—69.5 μm (mean 50 μm).

Occurrence. — USA, Hardingsbourg, Fm, Springer Fm — Mississippian, ?Pennsylvannian (Hoffmeister & al. 1955; Felix & Burbridge 1967); Great Britain, Namurian A (Butterworth & Williams 1958); Australia, Upper Devonian (Balme & Hassel 1962); northern Poland, probably early Tournaisian, assemblage 2.

Convolutispora lepida Felix & Burbridge, 1967

(Pl. 2, Figs 6, 9)

Dimensions (thirteen specimens). — Overall diameter 32.5—74 μm (mean 63 μm).

Occurrence. — USA, Springer Fm, Mississippian — ?Pennsylvanian (Felix & Burbridge 1967); northern Poland, probably early Tournaisian, assemblage 2.

Convolutispora harlandii Playford, 1962
(Pl. 3, Fig. 1)

Dimensions (six specimens). — Overall diameter 87—104 μm (mean 97.5 μm).

Remarks. — Specimens observed are similar to those described and illustrated by Playford (1963, pp. 593—594, Pl. 82, Figs 5—6).

Occurrence. — Spitsbergen, Lower Carboniferous (Playford 1962, 1963); Australia, Lower Carboniferous (Playford 1971); northern Poland probably early Tournaisian, assemblage 2.

Genus *MICRORETICULATISPORITES* (Knox) Potonié & Kremp, 1954
Microreticulatisporites punctatus Knox, 1950
(Pl. 2, Fig. 8)

Dimensions (ten specimens). — Overall diameter 26—40 μm (mean 32.5 μm).

Remarks. — Specimens observed are similar to those illustrated by Smith & Butterworth (1967, Pl. 11, Figs 11—13).

Occurrence. — Great Britain, Visean to Namurian A (Butterworth & Williams 1958; Love 1960; Smith & Butterworth 1967); northern Poland, probably early Tournaisian, assemblage 2.

Turma **Vestitriletes** Potonié, 1970
Subturma **Perinotriletes** Potonié, 1966
Genus *PEROTRILITES* (Erdtman) ex Couper, 1953
Perotrilites obnubilus sp. n.
(Pl. 3, Figs 4, 8)

Holotype: Plate 3, Fig. 4.

Type locality: Babilon *1*, depth 2675.3—2681.5 m, probably early Tournaisian.

Diagnosis. — Spores trilete; amb irregular, amb of central body subtriangular with rounded apices and convex sides to subcircular. Trilete mark distinct, laesurae straight or sinuous, accompanied by very narrow lips, extending to body margin. Perine thin, hyaline, finely, densely granulate, wrinkled irregularly over body, extending at equator in a form of irregular flange up to 4 μm wide.

Comparisons. — The species is readily distinguishable by its minute size and finely granulate perine forming a narrow flange.

Turma **Triletes-Zonales** R. Potonié, 1970
Subturma **Zonotriletes** Valtz, 1935
Infraturma **Cingulati** (Potonié & Klaus) Dettman, 1963
Genus *KNOXISPORITES* (Potonié & Kremp) Neves, 1964
Knoxisporites literatus (Valtz) Playford, 1963
(Pl. 4, Fig. 5)

Dimensions (ten specimens). — Overall diameter 82.5—130 μm (mean 99 μm).

Remarks. — Specimens observed in this study are similar to those described and illustrated by Playford (1963, p. 634, Pl. 90, Figs 7—8).

Occurrence. — Spitsbergen, Lower Carboniferous (Bharadwaj & Venkatachala 1961; Hughes & Playford 1961; Playford 1963); USSR, Tournaisian to Visean (Luber & Valtz 1938; Ishchenko 1956, 1958; Kedo 1963, 1966; Raskatova 1973), rare in the Upper Devonian(?) (Kedo 1966); Belgium, Lower Tournaisian (Streel 1970; Becker &

al. 1974), British Islands, Lower Tournaisian to Visean (Love 1960; Utting & Neves 1970; Gayer & al. 1973); Canada, Upper Devonian to Mississippian (Haquebard & Barss 1958; Playford & Barss 1963; McGregor 1970); Australia, Upper Famennian to Visean (Balme & Hassel 1962; Playford 1971); Poland, Tournaisian to Visean (Jachowicz 1966).

Knoxisporites pristinus Sullivan, 1968
(Pl. 4, Fig. 7)

1970. *Knoxisporites literatus* (Valtz) Playford; Dolby, Pl. 14, Fig. 3.

Dimensions (six specimens). — Overall diameter 65—91 µm (mean 77 µm), cingulum 4—7 µm.

Remarks. — This species closely resembles *Knoxisporites literatus* (Valtz) Playford, but differs in having narrower cingulum and less prominent muri. The species figured in Dolby (1970) belongs probably to *K. pristinus*.

Occurrence. — British Islands, Tournaisian to Visean (Sullivan 1968; Hibbert & Lacey 1969; Johnson & Marshall 1971); Belgium, Upper Famennian — Tournaisian (Becker & al. 1974); northern Poland, probably early Tournaisian, assemblage 2.

Knoxisporites sp.
(Pl. 4, Fig. 3)

Description. — Spores trilete; amb subcircular, irregular or polygonal. Trilete mark distinct, laesurae straight, accompanied by low lips c. 6 µm wide, extending to the margin of the central area. Central area encompassed by cingulum 1/4 spore radius wide. Exoexine densely granulate, grana c. 1 µm wide, rounded in profile, only slightly projecting from exine surface. Distal hemisphaere bears prominent sculpture of widely spaced, broad, rounded muri which are connected in several places to each other and to the cingulum. Secondary folds of exine common.

Dimensions (five specimens). — Overall diameter 76—91 µm (mean 80 µm).

Remarks. — Too few specimens are present to warrant the erection of a new species.

Comparisons. — These spores differ from other species of *Knoxisporites* in having granulate exine.

Occurrence. — Northern Poland, probably early Tournaisian, assemblage 2.

Genus *TUMULISPORA* Staplin & Jansonius, 1964

Remarks. — Some spore species that can be assigned to *Tumulispora* are placed in *Lophozonotriletes* (Naumova) Potonié. However, the original diagnosis of *Lophozonotriletes* (Naumova, 1953) and that emended by Potonié (1958) are not quite satisfactory.

The translation of the diagnosis of Naumova (p. 74) is: "Spores with well developed thick perispore covered with relatively large projections which appear at equator as narrow cingulum". This implies that the spores grouped in *Lophozonotriletes* are not cingulate. Indeed, most of the species assigned by Naumova to *Lophozonotriletes* seem to belong to *Verrucosisporites, Pustulatisporites, Verrucieretusispora* and *Converrucosisporites*. These are the following species: *L. scurrus* (Pl. 3, Figs 22—23), *L. grandis* (Pl. 3, Figs 24—26; Pl. 11, Figs 5—6; Pl. 15, Fig. 42), *L. concessus* (Pl. 11, Figs 7—8), *L. rarituberculatus* (Pl. 11, Fig. 11), *L. curvatus* (Pl. 11, Fig. 17; Pl. 15, Figs 43—45; Pl. 17, Fig. 41; Pl. 19, Figs 25—30), *L. excisus* (Pl. 11, Fig. 18), *L. crassus* (Pl. 17, Fig. 39).

On the other hand Potonié (1958, pp. 27—28) in emended diagnosis of *Lophozonotriletes* included to this genus cingulate spores with rays of the triradiate mark reaching cingulum and with spinose, conate and verrucose ornament.

Tumulispora lebedianensis (Naumova) n. comb.
(Pl. 3, Fig. 12)

1953. *Lophozonotriletes lebedianensis* n. sp.; Naumova, pp. 119, 132, Pl. 17, Fig. 42; Pl. 19, Figs 32—34.
1972. *Lophozonotriletes* cf. *malevkensis* Kedo; Sandberg & al., Pl. 4, Fig. 7.

Description. — Spores trilete; amb subtriangular with rounded apices and convex or subcircular sides. Trilete mark distinct, laesurae simple, straight or sinuous, 3/4 or more of central area radius. Cingulum narrow, 1/8 to 1/4 of spore radius. Exine homogenous to indistinctly infrapunctate, ornamented distally with prominent verruci c. 6 μm wide, 4 μm high, 2—8 μm apart. Verruci more or less circular in outline, rounded in profile. Number of verruci c. ten to fifteen.

Dimensions (nineteen specimens). — Overall diameter 45—68.5 μm (mean 51 μm).

Occurrence. — USSR, Famennian to early Tournaisian (Naumova 1953; Raskatova 1973); USA, Upper Devonian (Sandberg & al. 1972); Belgium and France, Famennian to early Tournaisian (Combaz & Streel 1970; Streel 1970; Becker & al. 1974); northern Poland, probably early Tournaisian, assemblages 2 and 3.

Tumulispora rarituberculata (Luber) n. comb.
(Pl. 4, Figs 1—2, 4, 6)

1963. *Lophozonotriletes rarituberculatus* (Luber) Kedo n. comb.; Playford, pp. 638—639, Pl. 91, Figs 8—9, cum synonimis.

Dimensions (thirteen specimens). — Overall diameter 54—100 μm (mean 74 μm).

Remarks. — The specimens of *T. rarituberculata* from the present material are most variable in size and number and arrangement of the distal tubercules. The lowest number of them is 7, but there may be as many as 22. They project from the distal side of the central area but occasionally also from the innermost distal part of the cingulum; they are discrete or fused at basis, they may form a continuous ring encircling the central area. Some of these spores resemble the coarse-sculptured specimens of *T. variverrucata* (Playford) Staplin & Jansonius (Pl. 26, Figs 17—19) but no specimens of typical *V. variverrucata* appearance have been found.

Tumulispora dentata (Hughes & Playford, 1961) n. comb.
(Pl. 5, Fig. 1)

1963. *Lophozonotriletes bellus* Kedo, pp. 87—88, Pl. 10, Figs 243—244.

Dimensions (eleven specimens). — Overall diameter 43.5—63 μm (mean 53 μm).

Remarks. — Specimens observed are poorly preserved but they seem to be closely similar to those described and illustrated by Hughes & Playford (1961, pp. 36, 38, Pl. 3, Figs 8—9).

Occurrence. — Spitsbergen, Tournaisian (Hughes & Playford 1961; Playford 1963); USSR, Tournaisian (Kedo 1963; Raskatova 1973); Great Britain, Tournaisian (Mortimer & Chaloner 1970; Johnson & Marshall 1971); USA, probably Mississippian (Almen 1970); Canada, Upper Devonian (Kerr & al. 1965); northern Poland, probably early Tournaisian, assemblages 1 and 2.

Infraturma **Zonati** (Potonié & Kremp) Potonié, 1970
Subinfraturma **Promonosacciti, Cameratitrileti** Potonié, 1970
Genus *AURORASPORA* (Hoffmeister, Staplin & Malloy) Richardson, 1960
Auroraspora cf. *macra* Sullivan
(Pl. 5, Figs 3, 6)

Description. — Spores trilete; amb subcircular to rounded triangular, more or less conformable with the central body. Trilete mark distinct, laesurae simple, straight, 2/3 to 3/4 of body radius, often obscured by folds of exoexine. Exoexine attached to the central body in the region of the triradiate mark, transparent, laevigate to scabrate, extending at equator in a form of flange 1/5 to almost half of central body radius wide. Intexine apparently laevigate, margin clearly defined.

Dimensions (eight specimens). — Overall diameter 36—67 µm (mean 49 µm).

Remarks. — Spores of very similar or identical features, described as different species of *Endosporites* and *Hymenozonotriletes*, are widespread in the Famennian and Tournaisian rocks of Europe, America and Australia. These represent probably several different species but are difficult to distinguish one from another, and therefore are of little value for interregional corellations.

Occurrence. — Northern Poland, probably late Famennian to early Tournaisian, assemblages 1—5.

Auroraspora multiplex sp. n.
(Pl. 5, Figs 10—11)

1967. *Archaeozonotriletes* cf. *arduus* Archangelskaja; Jachowicz, p. 57, Pl. 37, Fig. 3.
1969. *Perotrilites* cf. *perinatus* Hughes & Playford; Bouckaert & al., Pl. 94, Fig. 2.
1973. *Perotrilites* sp. cf. *P. perinatus* sensu Bouckaert & al.; Gayer & al., Pl. 15, Fig. K.
1974. *Auroraspora* sp. cf. *Perotrilites perinatus* Hughes & Playford; Streel in: Becker & al., Pl. 21, Figs 6—7.

Holotype: Plate 5, Fig. 10.

Type locality: Babilon 1, depth 2641.4—2646.1 m, northern Poland, probably Uppermost Famennian to early Tournaisian.

Diagnosis. — Spores trilete; amb subtriangular with rounded apices and convex sides, subcircular or oval. Trilete mark often indistinct (obscured), rays simple, straight, extending almost to central body margin. Exoexine relatively thick, smooth, homogenous, wrinkled over central body. Intexine apparently laevigate, margin indistinctly defined, often obscured by folds of exoexine.

Dimensions (nineteen specimens). — Overall diameter 69.5—124 µm (mean 83 µm).

Description. — Laesurae often accompanied by exoexinal folds. Wrinkles of exoexine without any preferred orientation. Spore/body ratio is variable depending on degree of folding of exoexine; in less wrinkled specimens this ratio is 6/5.

Comparisons. — *Perotrilites perinatus* Hunghes & Playford (1961, p. 32, Pl. 2, Figs 7—10) and *Velamisporites rugosus* Bhardwaj & Venkatachala (1962, p. 111, Pl. 2, Figs 14—16) have thinner outer membrane in relation to the central body, which is, therefore, clearly defined. *Auroraspora versabilis* (Kedo) n. comb. (in: Kedo 1957, p. 25, Pl. 3, Fig. 4) has more distinct triradiate mark and exoexinal folds arranged radially.

Occurrence. — Belgium, Famennian to Lower Tournaisian (Bouckaert & al. 1969; Streel 1970; Becker & al. 1974); Great Britain, probably Lower Tournaisian (Gayer & al. 1973); central Poland, Lower Tournasian (Jachowicz 1967), northern Poland, probably late Famennian to early Tournaisian, assemblages 1 to 4.

Auroraspora versabilis (Kedo) n. comb.
(Pl. 5, Fig. 7)

1957. *Hymenozonotriletes versabilis* n. sp.; Kedo, p. 25, Pl. 3, Fig. 4.
1974. *Rugospora versabilis* (Kedo) comb. nov.; Streel in: Becker & al., p. 27, Pl. 21, Figs 3—5.

Description. — Spores trilete; amb subtriangular with rounded apices and convex sides, margin crenulate. Trilete mark distinct to indistinct, laesurae straight, accompanied by low, narrow, often hardly discernible lips, extending almost to body margin. Exoexine laevigate, finely infrapunctate, attached to intexine in the region of tetrad mark, with wrinkled surface. Wrinkles arranged more or less radially. Intexine not always clearly defined, conformable in outline with the exoexine.

Dimensions (eleven specimens). — Overall diameter 61—106 μm (mean 76 μm), central body 37—63 μm (mean 61 μm).

Remarks. — Streel (in: Becker & al. 1974) included *A. versabilis* into *Rugospora* Neves & Owens, which is not correct because this genus contains spores with microverrucose ornament.

Occurrence. — Byelorussian SSR, Upper Famennian (Kedo 1957); Belgium, Famennian to Lower Tournaisian (Bouckaert & al. 1969; Streel 1970; Becker & al. 1974); Great Britain, probably Lower Tournaisian (Gayer & al. 1973); Canada, Upper Devonian (Kerr & al. 1965); northern Poland, probably late Famennian to early Tournaisian, assemblages 2, 3, 4.

Auroraspora granulatipunctata (Hoffmeister, Staplin & Malloy) n. comb.
(Pl. 5, Figs 8—9)

1955. *Cirratriradites granulatipunctatus* Hoffmeister, Staplin & Malloy, pp. 382—383, Pl. 37, Fig. 2.
1957. *Hymenozonotriletes famenensis* Kedo, p. 59, Pl. 5, Fig. 109.
1967. *Hymenozonotriletes granulatipunctatus* (Hoffmeister, Staplin & Malloy) Byvsheva, p. 24, Pl. 3, Figs 8—10.

Description. — Spores trilete; amb circular, subcircular to rounded triangular, margin undulating. Trilete mark indistinct to quite distinct, laesurae straight, accompanied by weakly developed lips, extending to intexine margin or almost so. Exoexine attached to intexine in the region of tetrad mark, homogenous to finally infragranulate, wrinkled. Wrinkles short, curved, arranged more or less radially. In compressed spores exine forms a narrow equatorial zone up to 5 μm wide. Intexine infragranulate, conformable in outline with exoexine, margin clearly defined.

Dimensions (thirteen specimens). — Overall diameter 28—54 μm (mean 36 μm).

Occurrence. — USSR, Tournaisian to Visean (Kedo 1963; Byvsheva 1967); USA, Visean (Hoffmeister & al. 1955); Great Britain, Namurian A to Westphalian A (Butterworth & Williams 1958; Neves 1968); northern Poland, probably early Tournaisian, assemblage 2.

Genus *GRANDISPORA* (Hoffmeister, Staplin & Molloy) Neves & Owens, 1966 (sensu Playford, 1971)

Grandispora sp. cf. *Spinozonotriletes uncatus* Haquebard, 1957 sensu Streel, 1966
(Pl. 6, Fig. 7)

1966. *Spinozonotriletes* cf. *uncatus* Haquebard; Streel, pp. B83—B84, Pl. 2, Fig. 27.
1969. *Spinozonotriletes* cf. *uncatus* Haquebard; Bouckaert & al., Pl. 93, Figs 7—8.
1973. *Spinozonotriletes* cf. *uncatus* Haquebard sensu Bouckaert, Streel, Thorez & Mound; Gayer & al., Pl. 14, Figs A, B.

Description. — Spores trilete; amb subtriangular with broadly rounded apices and convex sides. Trilete mark distinct, laesurae sinuous, accompanied by raised lips c. 4 μm high at apex, extending almost to equator. Exoexine detached from intexine in the equatorial region, infrapunctate, thick over distal surface and equatorial region of proximal surface, thinner over contact faces. Distal surface ornamented with spines with bulbous, 2—4 μm wide bases and tapering tips; spines 4—10 μm apart. Intexine thin, conformable with amb, margin not clearly defined. Spores usually flattened obliquely.

Dimensions (forty-one specimens). — Overall diameter 43.5—69.5 μm (mean 56.5 μm).

Occurrence. — Belgium, Upper Famennian to Lower Tournaisian (Streel 1966, 1970; Bouckaert & al. 1969; Becker & al. 1974); Great Britain, probably Lower Tournaisian (Gayer & al. 1973); northern Poland, probably late Famennian to early Tournaisian, assemblages 2, 4, 5.

Grandispora conspicua (Playford) Playford, 1971
(Pl. 6, Fig. 5)

(?) (p) 1962. *Endosporites? crassispinosus?* Winslow, Pl. 19, Fig. 4.
1963. *Archaeozonotriletes senticosus* (Jushko) Kedo; ex Kedo, p. 45, Pl. 3, Fig. 60.
1963. *Archaeozonotriletes spinosellus* Jushko; ex Kedo, p. 74, Pl. 8, Fig. 132.

Dimensions (thirteen specimens). — Overall diameter 64—95.5 μm (mean 79 μm).

Remarks. — Specimens observed in this study are similar to those described and illustrated by Playford (1964, pp. 22—23, Pl. 5, Figs 3—4).

Occurrence. — Byelorussian SSR, Tournaisian (Kedo 1963); Canada, Horton Group, Mississippian (Playford 1964); Great Britain, probably Tournaisian (Mortimer & Chaloner 1970); Belgium, Upper Famennian to Lower Tournaisian (Streel 1970, Combaz & Streel 1970, Becker & al. 1974); northern Poland, probably late Famennian to early Tournaisian, assemblages 1—4.

Grandispora lupata sp. n.
(Pl. 6, Figs 1—3)

Holotype: Plate 6, Figs 1—2.
Type locality: Babilon 1, depth 2629.5—2635.4 m, northern Poland, probably early Tournaisian.

Diagnosis. — Spores trilete; amb subtriangular with rounded apices and convex sides. Trilete mark distinct, laesurae accompanied by narrow, elevated lips 7 μm high at apex, diminishing in height towards equator, extending almost to spore margin. Exoexine detached from intexine in equatorial region, finely infrapunctate, thick over distal surface and equatorial region of proximal surface, distinctly thinner over contact faces; thicker equatorial portion of exoexine 1/4 to 1/3 of spore radius. Ornamentation of exine confined to distal hemisphaere consists of spines with bulbous basis and tapering tips, up to 2.5 μm high, 1.5 μm wide at basis, 1.5—9 μm apart (usually 5 μm). Intexine thin, radius 3/4 of the total, margin often indistinct.

Dimensions (twenty-six specimens). — Overall diameter 64—95.5 μm (mean 76.5 μm).

Description. — Secondary folds of exoexine were not observed. The difference in exine thickness between the proximal central area and the remaining part of spore wall is a variable feature; equatorial portion appears as dark crassitudo but in specimens with thinner exoexine it may be hardly discernible.

Comparisons. — *Grandispora echinata* Haquebard (1957, p. 317, Pl. 3, Fig. 17) has thin exoexine of uniform thickness and distinctly delimited intexine. *Grandispora* cf. *uncata* (Haquebard) Playford, sensu Streel (present paper, Pl. 8, Fig. 4) has relatively coarser and less dense ornamentation, is smaller. *Grandispora gracilis* (Kedo) Streel in: Becker & al. (1974, Pl. 19, Fig 1—3) has thinner exoexine and finer ornamentation, also is smaller.

Genus *ENDOCULEOSPORA* (Staplin) emend.

Emended diagnosis. — Trilete, camerate miospores; amb subcircular. Exoexine densely infrapunctate, sculptured, mostly distally, with scattered to dense prominent granules, minute pila and/or bacula. Intexine laevigate, relatively large, roughly 2/3—3/4 total spore diameter.

Remarks. — The diagnosis of *Endoculeospora* is emended to include spores of similar appearance but with pilate and baculate ornament.

Endoculeospora gradzińskii sp. n.
(Pl. 7, Figs 1—3)

Holotype: Plate 7, Fig. 1.

Type locality: Bąbilon *1*, depth 2675.3—2681.5 m, northern Poland, probably early Tournaisian.

Diagnosis. — Spores trilete; amb subcircular. Trilete mark distinct, laesurae straight, accompanied by weak lips, extending to intexine margin. Exoexine thin, densely, finely infragranulate, extending at equator in a form of flange 1/10 to 1/3 spore radius wide. Distal surface ornamented with irregularly arranged, scattered to dense prominent granula, minute pila and bacula. Granula c. 1 μm in diameter, pila and bacula c. 1 μm long, 1 to 5.5 μm apart. Intexine conformable with exoexine outline, margin usually clearly defined.

Dimensions (twenty-two specimens). — Overall diameter 45.5—60 μm (mean 55.5 μm), intexine 32.5—48 μm (mean 43.5 μm).

Description. — Laesurae often obscured by exinal folds reaching onto the flange. Distal folds of exoexine were not observed which suggests proximo-distal attachment of exine layers.

Comparisons. — *E. rarigranulata* Staplin (1960, p. 34, Pl. 8, Figs 3, 6) is much larger and has granulate ornamentation.

Genus *SPELAEOTRILETES* Neves & Owens, 1966
Spelaeotriletes lepidophytus (Kedo) Streel
(Pl. 7, Figs 5—7)

1974. *Spelaeotriletes lepidophytus* (Kedo) n. comb.; Streel in: Becker & al., p. 26, Pl. 20, Figs 11—13.

Remarks. — The populations of *S. lepidophytus* present in samples from the Bąbilon *1* and Rzeczenica *1* boreholes were in most cases poor in specimens, and these were often of bad preservation. Therefore it was not possible to make a thorough biometric study of the successive populations. Nevertheless, some measurements have been taken and these are presented in Table 2 in a descending order.

It seems that within the assemblage 2 present in a sequence c. 360 m thick the sizes of populations fall within the same range c. 36—76 μm, which corresponds to the zone C/D of Streel (1966). The specimens of *S. lepidophytus* present in the older assemblages are very scarce, nevertheless, the largest specimen is also the oldest one.

Table 2

Babilon *1* depth (m)	Size range (m)	Number of specimens measured
2618.7–2624.6	37–76	16
2624.6–2628.0	65	1
2629.5–2635.4	45–69.5	7
2641.4–2646.1	48–76	4
2647.9–2651.5	48–70.5	10
2675.3–2681.5	49–65	4
2761.4–2757.7	48–52	3
2791.2–2795.4	65–70	2
2837.6–2841.9	58–62	2
2988.1–2995.6	36–76	12
3027.2–3034.0	56–65	3
3155.5–3161.5	70	1
3231.7–3236.3	91	1

Atypical forms of *S. lepidophytus* described by Streel (1966) are common in the populations of the assemblage 2, and especially those representing the trend A.

Spelaeotriletes sp.
(Pl. 7, Fig. 4)

Description. — Spores trilete; amb rounded triangular to subcircular. Trilete mark distinct, laesurae sinuous accompanied by narrow, elevated lips, extending almost to equator. Exoexine attached to intexine in the region of tetrad mark, extending at equator in a form of flange, ornamented all over except contact faces with coarse, distinct reticulum; lumina up to 20 μm wide, more or less polygonal or pentagonal; muri c. 2 μm wide. Lumina and muri bear very fine and dense conate ornament, cones less than half of 1 μm high. Intexine apparently smooth, 1/2 to 3/4 spore radius in diameter, margin often indistinct.

Dimensions (eleven specimens). — Overall diameter 102—160 μm (mean 133 μm), intexine 61 μm, 108.5 μm (mean 79 μm).

Remarks. — Too few specimens are present to warrant the erection of a new species.

Comparisons. — The described form differs from other reticulate species of *Spelaeotriletes* in having relatively coarse reticulum and narrow muri and in being larger. *H. lepidophytus* Kedo in: Gayer & al. (1973) represents probably the same species.

Occurrence. — Great Britain (?), probably Lower Tournaisian (Gayer & al. 1973); northern Poland, probably early Tournaisian, assemblage 2.

SUCCESSION OF SPORE ASSEMBLAGES

The spore assemblages from the Babilon *1* and Rzeczenica *1* boreholes are diverse and provide information on the age of these deposits.

The comparable spore assemblages which will be mainly referred to in this chapter are those described from the Ardenno-Rhine basin (Streel

1966, 1970, 1972; Bouckaert & al. 1969; Paproth & Streel 1970; Becker & al. 1974). The palyno-stratigraphy of the Devonian/Carboniferous passage beds of that area is most thoroughly worked out, as compared to other regions, and the spore assemblage-zones are fitted into sequences with good stratigraphic control.

The denominations of the faunistic subzones are used here in the sense of Bouckaert & al. (1970).

The distribution of all species in the columns is presented in Table 1. We can see on it that there is a great dissymmetry between the rate of the appearances and the disappearances of the spore species within the Babilon *1* section. This is probably due to a succession of increasingly favourable facies and, on the other hand, to the increasing quality of spore preservation with decreasing depth. Therefore, all stratigraphic conclusions drawn on the basis of the present material must be considered tentative.

The limits between the assemblage-zones distinguished have been established basing on the first appearances of some characteristic spore species. However, it is quite possible that the vertical distribution of the spores is controlled to some extent by facies and therefore the limits between the zones can be lowered. This concerns all the limits established except that between the assemblages 1 and 2. The ratio of the number of species which appear at this limit to that of the disappearing species is c. 1, which suggests the lack of facies control.

Five different, successive spore assemblages are distinguishable within the Babilon-Rzeczenica sections; these are described below in the descending order.

The assemblage 1 was present in samples from the Rzeczenica *1* borehole at the interval 2896.0—2901.3 m. The preservation of spores was poor, as the depth of their derivation was considerable. Therefore the number of the taxa recorded from these samples is low. Nevertheless, this assemblage differs distinctly from the directly older one. It does not contain *Spelaeotriletes lepidophytus* (Kedo) Streel; the characteristic species are: *Hymenozonotriletes explanatus* Kedo (rare), *Dictyotriletes trivialis* Kedo, *Tumulispora dentata* (Hughes & Playford) n. comb., *Perotrilites perinetus* Hughes & Playford (non sensu Streel), *Perotrilites magnus* Hughes & Playford, *Auroraspora micromanifestus* (Haquebard) Richardson, *Aneurospora incohata* (Sullivan) Streel, and *Cincturasporites* sp. The assemblage 1 conforms with the TE assemblage-zone of Streel (Paproth & Streel 1970) and indicates the Lower Tournaisian, upper Tn1b age of these strata.

The assemblage 2 was present in the Rzeczenica *1* samples between 2907.9—3003.0 m and in the Babilon *1* samples between 2618.7—2994.0 m. It contains up to 14% of *S. lepidophytus* (Kedo) Streel, *Knoxisporites literatus* (Valtz) Playford, *Corbulispora subalveolaris* (Luber) Sullivan, *Verru-*

cosisporites nitidus (Naumova) Playford, *Raistrickia variabilis* Dolby & Neves, *Turnulispora rarituberculata* (Luber) n. comb. and *Vallatisporites pusillites* (Kedo) Dolby & Neves (very rare). This assemblage corresponds to the PLs 2 and possibly PLs 3 zones of Streel and indicates the lower Tn1b age. The populations of *S. lepidophytus* (Kedo) Streel from this assemblage containing numerous specimens of the trend A and some of the trend B (Streel 1966) indicate more or less the same age.

The assemblage 3 was present in the samples from the Babilon *1* borehole between 3021.2—3033.0 m. It contains only a few taxa. The characteristic species of this assemblage are *S. lepidophytus* (Kedo) Streel, which is rare, and *Grandispora lupata* sp. n., a species related to *G. echinata* Haquebard. This assemblage may correspond to the PLs 1 and PLm zones of Streel indicating the Tn1 age.

The assemblage 4 from the samples between 3135.9—3236.3 m of the Babilon *1* borehole is characterized by the presence of *S. lepidophytus* (Kedo) Streel, *Auroraspora multiplex* sp. n., *Grandispora conspicua* (Haquebard) Playford and *Grandispora* cf. *uncata* (Haquebard) Playford sensu Streel. It probably corresponds to the PLi zone of Streel and indicates the Upper Famennian Fa2d age.

The limit between the assemblage zones 3 and 4 was placed at the level of the first appearance of *Grandispora lupata.* However, the samples from the interval between 3061.5—3193.2 m were sterile or yielded only very scarce specimens and a few taxa. Therefore it is very likely that this part of the strata may be also of the Tn1a age and the limit between the Famennian and Tournaisian strata should be placed close to the occurrence of the unconformity above the level at 3207.0 m.

The assemblage 5 from the samples between 3249.3—3313.7 m of the Babilon *1* borehole is characterized by the presence of *Grandispora* cf. *uncata* (Haquebard) Playford sensu Streel, *Grandispora gracilis* (Kedo) Streel and *Aurora* cf. *macra* Sullivan. This assemblage corresponds to the VU zone of Streel and indicates the Upper Famennian Fa2c age.

The correlation of the present assemblages with those described from the Devonian/Carboniferous passage beds of the European part of the USSR is difficult because the system of spore classification used by the Russian authors is different from that employed in other countries. Nevertheless, some forms with distinct features may be recognized.

Out of the present assemblages the assemblage 1 is comparable to those from the middle and/or upper part of the Malevka horizon of the Pripyat depression. This is indicated by the presence of *Hymenozonotriletes explanatus* Kedo and *Dictyotriletes trivialis* Kedo (cf. Kedo 1963).

The assemblage 2 conforms with the lower part of the Malevka horizon, which is indicated by the presence of atypical forms of *S. lepidophytus* (Kedo) Streel and the occurrence of *Knoxisporites literatus* (Valtz) Playford.

The assemblages 3 and 4 are probably conformable with those from the middle and upper part of the Dankov-Lebedian horizon of the Pripyat depression (Kedo 1963) and with the middle and upper part of the Dankov horizon of the central part of the Russian platform (Raskatova 1973), which is indicated by the presence of *S. lepidophytus* (Kedo) Streel.

VERTICAL DISTRIBUTION OF ACRITARCHS

The acritarchs were present in all samples which yielded spores and some attention was given to the distribution of them in the profile.

The most common forms were: *Veryhachium trispinosum* (Eisenack) Deunff, *Baltisphaeridium flandrum* Stockmans & Willière, *Micrhystridium pascheri* Stockmans & Willière and *Micrhystridium* sp. (Pl. 7, Fig. 8; Pl. 8, Fig. 10). These species were present in all assemblages. *Protoleiosphaeridium microsaetosum* Staplin was very common in the assemblages 4, 3 and 2. *Gorgonisphaeridium winslowii* Staplin, Jansonius & Pocock was less frequent, present in assemblages 2—5. *Stellinium octoaster* (Staplin) Jardine, Combaz, Magloire, Peniguel & Vachey and *Cymatiosphaera* sp. were rare but occurred in all assemblages. *Cymbosphaeridium* sp. (Pl. 8, Fig. 7) was found only occasionally. Leiosphaerids and protoleiosphaerids were most common in the assemblage 5.

This acritarch flora is very similar to that of the Lower Tournaisian from northern France described by Combaz & Streel (1970). According to these authors the species *Gorgonisphaeridium winslowii* indicates the Tn1a age being the dominant species in the acritarch assemblages of this zone. In the Babilon *1* borehole *G. winslowii* occurs also in the Fa2c and Fa2d strata and is rather a subordinate species in the Tournaisian assemblages.

STRATIGRAPHIC CONCLUSIONS

1. The profile of the Babilon *1* borehole betwen the depth 2618.7—3313.7 m represents deposits of Upper Famennian Fa2c to early Tournaisian, base of Tn1b age.

2. The limit between the Famennian and the Tournaisian deposits can not be precisely established on the basis of spore evidence. It may occur at a depth between 3177.6 and 3207.8 m where the occurrence of an unconformity was observed.

3. The limit between the Tn1a/Tn1b zones is placed at the level of the first occurrence of *Knoxisporites literatus* (Valtz) Playford and *Corbulispora subalveolaris* (Luber) Sullivan. This limit may result from some facies control and it may in reality occur below in the profile.

4. The sediments from the Rzeczenica *1* borehole between 2910.9—3003.0 m are the equivalent of the top part of the Babilon *1* section.

5. The rocks from the Rzeczenica *1* borehole between 2896.0—2901.3 m are younger than the youngest ones from the Babilon *1* section, namely they are of the Lower Tournaisian, upper Tn1b age.

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E. TURNAU

MIKROFLORA FAMENU I TURNEJU Z WIERCEŃ Z POMORZA ZACHODNIEGO

(Streszczenie)

Liczne głębokie wiercenia, wykonane w ostatnich latach na terenie Pomorza Zachodniego, przebiły pod cechsztynem utwory karbonu oraz/lub dewonu. Dwa spośród nich, Babilon *1* i Rzeczenica *1* (fig. 1), natrafiły na osady pogranicza dewonu i karbonu.

Dość bogata mikroflora (por. tabela 1) zawiera, między innymi, spory z gatunku *Spelaeotriletes lepidophytus* (Kedo) Streel, którego występowanie w utworach dewonu i karbonu stwierdzone zostało w różnych rejonach Ameryki Północnej, Europy, Afryki i Australii.

W otworze Babilon *1*, pod utworami cechsztynu, natrafiono na głębokości 2618,7 m na blisko 700-metrową serię morskich osadów węglanowych, zawierających bogatą faunę mięczaków (Korejwo 1975), brachiopodów (Matyja 1975) oraz dość liczne mikroszczątki, a mianowicie skolekodonty, spory i akritarchy.

Zespoły sporowe pozwoliły na wydzielenie czterech poziomów, które skorelowano z podobnymi poziomami ze stratotypowych odsłonięć najwyższego famenu i wczesnego turneju Belgii opisanymi przez Streela (1966, 1970, 1972, in: Becker & al. 1974, in: Bouckaert & al. 1969; Paproth & Streel 1970).

Poziom pierwszy (zespół sporowy 2), z głębokości 2618,7—2994.0 m, charakteryzuje się obecnością następujących gatunków spor: *Spelaeotriletes lepidophytus* (Kedo) Streel, *Tumulispora rarituberculata* (Luber) n. comb., *Corbulispora subalveolaris* (Luber) Sullivan, *Knoxisporites literatus* (Waltz) Playford i *Verrucosisporites nitidus* (Naumova) Playford. Utwory tego poziomu odpowiadają wiekowo wczesnemu turnejowi, dolnej części poziomu Tn1b.

Poziom 2 (zespół sporowy 3), z interwału 3021,2—3033,0 m, charakteryzuje się obecnością *Spelaeotriletes lepidophytus* oraz *Grandispora lupata* sp. nov., formy zbliżonej do *Grandispora echinata* (Haquebard) Playford. Utwory tego poziomu są prawdopodobnie wieku dolnoturnejskiego, Tn1a.

Poziom 3 (zespół sporowy 4), z interwału 3135,9—3236,3 m, zawiera *Spelaeotriletes lepidophytus, Auroraspora versabilis* (Kedo) n. comb., *Grandispora conspicua* (Playford) Playford i *Grandispora* cf. *uncata* (Haquebard) Playford, sensu Streel. Wiek tego poziomu to najwyższy famen Fa2d; wyższa partia wymienionego odcinka wiercenia może należeć już do dolnego turneju, bardzo skąpa na tych głębokościach mikroflora nie pozwala na zbyt precyzyjne datowanie. Wyniki badań nad brachiopodami (Matyja 1975) sugerują, że granica famen/turnej przypada bezpośrednio powyżej głębokości 3207,8 m.

Poziom 4 (zespół sporowy 5), z głębokości 3249,3—3313,7 m, charakteryzuje się brakiem *Spelaeotriletes lepidophytus* oraz występowaniem *Grandispora* cf. *uncata* (Haquebard) Playford sensu Streel, *Grandispora gracilis* (Kedo) Streel oraz *Auroraspora* cf. *macra* Sullivan. Poziom ten odpowiada górnemu famenowi Fa2c.

Osady nawiercone pod cechsztynem w otworze Rzeczenica *1* odpowiadają w swej niższej partii (interwał 2907,9—3003,0 m) najwyższym warstwom profilu Babilon *1*, czyli należą do dolnej części poziomu Tn1b.

Osady z interwału 2896,0—2901,3 m z profilu Rzeczenica *1* należą już do najwyższej części Tn1b, o czym świadczy występowanie gatunków *Hymenozonotriletes*

explanatus Kedo i *Dictyotriletes trivialis* Kedo przy braku *Spelaeotriletes lepidophytus* (zespół sporowy 1).

Korelacja palynologiczna omawianych profilów z utworami najwyższego dewonu i wczesnego karbonu europejskiej części ZSRR przedstawia się następująco.

Najwyższe warstwy z profilu Rzeczenica *1* odpowiadają środkowej i ewentualnie górnej części poziomu malevka z Białorusi. Pozostała, niższa część profilu, oraz poziom 1 z profilu Babilon *1* (do głębokości 2994,0 m) odpowiadają dolnej części poziomu malevka. Niżej leżące warstwy z profilu Babilon *1*, do głębokości 3236,3 m, odpowiadają środkowej i górnej części poziomu dankovsko-lebedianskiego z Białorusi oraz środkowej i górnej części poziomu dankovskiego z centralnej części platformy rosyjskiej.

DESCRIPTION OF PLATES 1—8

PLATE 1

1 — *Retusotriletes incohatus* Sullivan, proximal view, Babilon *1* at 3135.9 m.
2 — *Punctatisporites stabilis* Playford, proximal view, ibidem at 2629.5 m.
3 — *Punctatisporites solidus* Haquebard, proximal view, ibidem.
4 — *Punctatisporites glaber* (Naumova) Playford, proximal view, Rzeczenica *1* at 2899.0 m.
5 — *Leiotriletes trivialis* Naumova, proximal view, Babilon *1* at 2629.5 m.
6 — *Trachytriletes minor* Naumova, proximal view, ibidem at 2675.3 m.
7, 8, 9 — *Apiculiretusispora* cf. *R. greggsi* McGregor; 7, 8 — distal and proximal focus, ibidem at 2629.5 m; 9 — ibidem.
10, 11, 12 — *Apiculiretusispora granulatipunctata* n. sp.; 10 — oblique compression, ibidem at 2675.3 m; 11 — holotype, oblique compression, ibidem at 2647.9 m; 12 — specimen with detached outer layer of sclerine, × 1500, ibidem at 2675.3 m.
13, 15 — *Umbonatisporites* sp., ibidem at 2629.5 m; 13 — fragment of exine × 1500.
14 — *Converrucosisporites curvatus* (Naumova) n. comb., uncorroded specimen, distal focus, ibidem at 2675.3 m.
16 — *Verrucosisporites macrogrumosus* (Kedo) n. comb., distal view, ibidem.

All figures × 750 except when indicated, from unretouched negatives

PLATE 2

1, 2, 3 — *Converrucosisporites curvatus* (Naumova) n. comb.; 1 — corroded specimen, proximal view, Babilon *1* at 2624.6 m; 2 — uncorroded specimen, distal view, ibidem at 2647.9 m; 3 — uncorroded specimen, oblique compression showing lack of cingulum, ibidem.
4 — *Convolutispora venusta* Hoffmeister, Staplin & Malloy, ibidem at 2675.3 m.
5 — *Verrucosisporites nitidus* (Naumova) Playford, ibidem at 2629.5 m.
6, 9 — *Convolutispora lepida* Felix & Burbridge, proximal and distal focus, ibidem at 2624.6 m.
7 — *Foveosporites appositus* Playford, oblique compression, Rzeczenica *1* at 2916.7 m.
8 — *Microreticulatisporites punctatus* Knox, distal view, × 1500, Babilon *1* at 2629.5 m.
10 — *Raistrickia variabilis* Dolby & Neves, ibidem at 2647.9 m.
11 — *Schopfites* sp., ibidem at 2675.3 m.

All figures × 750 except when indicated, from unretouched negatives

PLATE 3

1 — *Convolutispora harlandii* Playford, proximal focus, Babilon *1* at 2629.5 m.
2 — *Corbulispora subalveolaris* (Luber) Sullivan, ibidem.
3 — *Dictyotriletes trivialis* Kedo, distal view, Rzeczenica *1* at 2896.0 m.
4, 8 — *Perotrilites obnubilus* n. sp.; 4 — holotype, proximal view, × 1500, Babilon *1* at 2675.3 m; 8 — oblique compression, × 1500, ibidem at 2629.5 m.
5 — *Emphanisporites* sp., ibidem.
6 — *Perotrilites perinatus* Hughes & Playford, proximal view, Rzeczenica *1* at 2907.9 m.
7 — *Perotrilites magnus* Hughes & Playford, × 500, ibidem at 2899.0 m.
9 — *Microreticulatisporites hortonensis* Playford, oblique compression, Babilon *1* at 2675.3 m.
10 — *Tumulispora obscura* Staplin & Jansonius, distal view, ibidem at 2641.4 m.
11 — *Lophozonotriletes malevkensis* Naumova, Rzeczenica *1* at 2999.0 m.
12 — *Tumulispora lebedianensis* (Naumova) n. comb., distal view, ibidem.

All figures × 750 except when indicated, from unretouched negatives

PLATE 4

1, 2, 4, 6 — *Tumulispora rarituberculata* (Luber) n. comb.; 1 — distal view, Babilon *1* at 2629.5 m; 2 — distal view, ibidem; 4 — proximal view, ibidem; 6 — proximal view, ibidem at 2675.3 m.
3 — *Knoxisporites* sp., distal view, ibidem at 2629.5 m.
5 — *Knoxisporites literatus* (Waltz) Playford, distal view, ibidem at 2624.6 m.
7 — *Knoxisporites pristinus* Sullivan, oblique compression, ibidem at 2629.5 m.

All figures × 750, from unretouched negatives

PLATE 5

1 — *Tumulispora dentata* (Hughes & Playford) n. comb., proximal view, Rzeczenica *1* at 2899.0 m.
2 — *Vallatisporites pusillites* (Kedo) Dolby & Neves, distal view, ibidem at 2916.7 m.
3, 6 — *Auroraspora* cf. *macra* Sullivan; 3 — ibidem at 2907.9 m; 6 — Babilon *1* at 2977.0 m.
4 — *Auroraspora macromanifestus* (Haquebard) Richardson, × 500, Rzeczenica *1* at 2977.0 m.
5 — *Auroraspora micromanifestus* (Haquebard) Richardson, ibidem at 2899.0 m.
7 — *Auroraspora versabilis* (Kedo) n. comb., distal view, Babilon *1* at 2629.5 m.
8, 9 — *Auroraspora granulatipunctata* (Hoffmeister, Staplin & Malloy) n. comb.; 8 — distal view, × 1500, ibidem at 2647.9 m; 9 — proximal view, ibidem at 2629.5 m.
10, 11 — *Auroraspora multiplex* n. sp.; 10 — holotype, oblique compression, ibidem at 2641.4 m; 11 — Rzeczenica *1* at 2999.0 m.

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PLATE 6

1, 2, 3 — *Grandispora lupata* n. sp.; 1, 2 — holotype, proximal and distal focus, Babilon *1* at 2629.5 m; 3 — ibidem at 2808.0 m.
4 — *Grandispora gracilis* (Kedo) Streel, ibidem at 3231.7 m.
5 — *Grandispora conspicua* (Playford) Playford, proximal view, ibidem at 2629.5 m.
6 — *Grandispora uncata* (Haquebard) Playford, distal view, Rzeczenica *1* at 2916.7 m.
7 — *Grandispora* cf. *uncata* (Haquebard) Playford sensu Streel, proximal view, Babilon *1* at 3249.2 m.

All figures × 750, from unretouched negatives

PLATE 7

1, 2, 3 — *Endoculeospora gradzinskii* n. sp.; 1 — holotype, distal view, Babilon *1* at 2675.0 m; 2 — distal view, ibidem at 2647.9 m; 3 — distal view, Rzeczenica *1* at 2899.0 m.
4 — *Spelaeotriletes* sp., distal view, × 500, Babilon *1* at 2629.5 m.
5, 6, 7 — *Spelaeotriletes lepidophytus* (Kedo) Streel; 5 — distal view, ibidem at 2647.9 m; 6 — distal view, ibidem at 2629.5 m; 7 — distal view, ibidem at 2988.1 m.
8 — *Micrhystridium pasheri* Stockmans & Williere, ibidem at 3310.0 m.
9 — *Laevigatosporites* sp., lateral compression, ibidem at 2641.4 m.
10 — *Hymenozonotriletes explanatus* Kedo, Rzeczenica *1* at 2899.0 m.
11 — *Ancyrospora* sp., × 500, ibidem at 2977.0 m.

All figures × 750 except when indicated, from unretouched negatives

PLATE 8

1 — *Gorgonisphaeridium winslowii* Staplin, Jansonius & Pocock, Babilon *1* at 3249.2 m.
2 — *Baltisphaeridium flandrum* Stockmans & Williere, Rzeczenica *1* at 2899.0 m.
3 — *Cymathiosphaera* sp., ibidem at 2916.7 m.
4 — *Stellinium octoaster* (Staplin) Jardiné, Combaz, Magloire, Peniguel & Vachey, Babilon *1* at 2641.4 m.
5 — Indeterminate, ibidem at 2629.5 m.
6 — *Veryhachium trispinosum* (Eisenack) Deunff, Rzeczenica *1* at 2999.0 m.
7 — *Cymbosphaeridium* sp., Babilon *1* at 2675.3 m.
8 — Indeterminate, ibidem at 2641.4 m.
9 — *Protoleiosphaeridium microsaetosum* Staplin, ibidem at 3310.0 m.
10 — *Micrhystridium* sp., ibidem at 2675.3 m.
11 — *Hystricosporites multifurcatus* (Winslow) Mortimer & Chaloner, × 300, ibidem, at 2629.5 m.
12 — *Leiosphaeridia* sp., × 200, ibidem at 3310.0 m.

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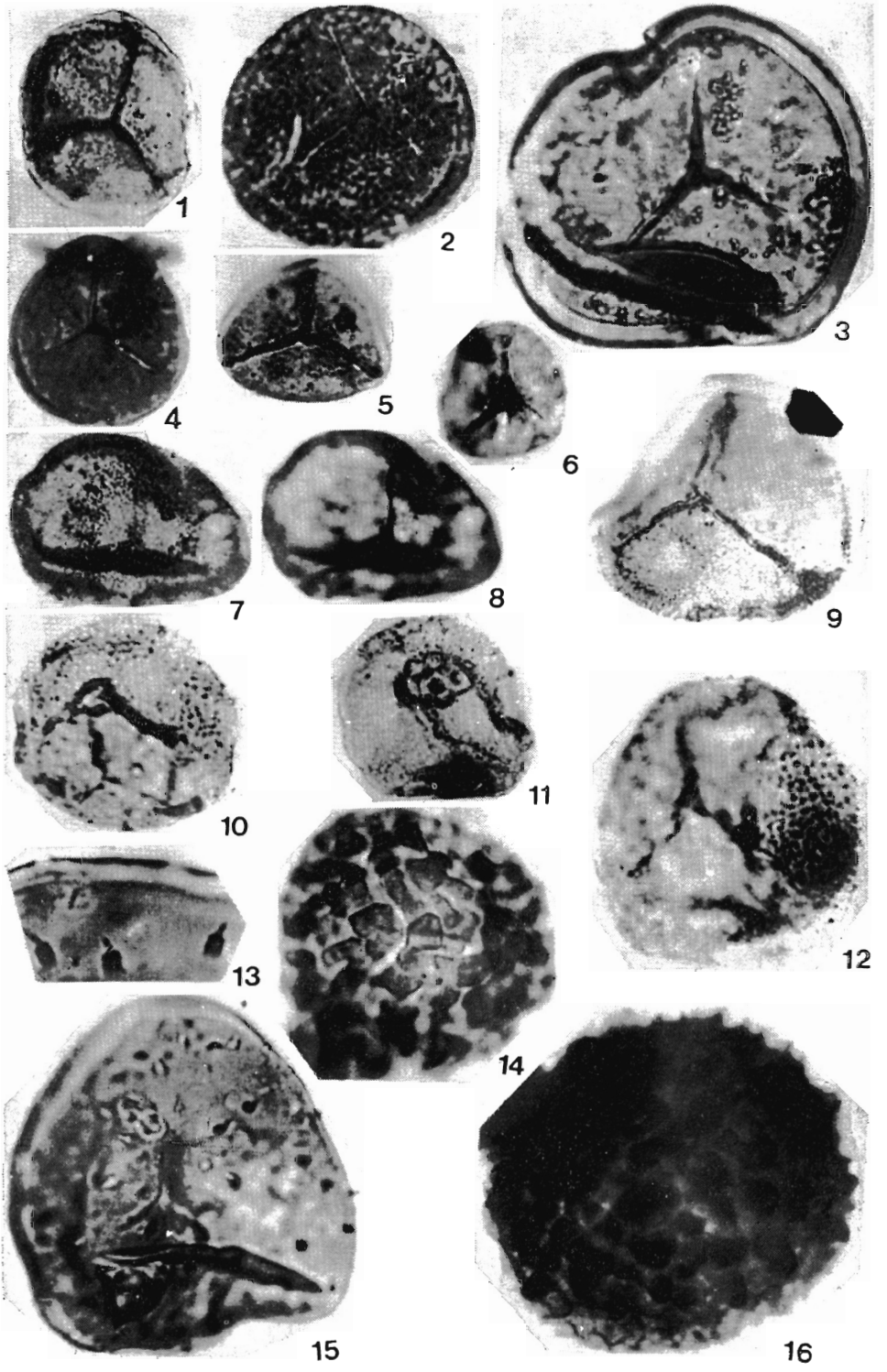
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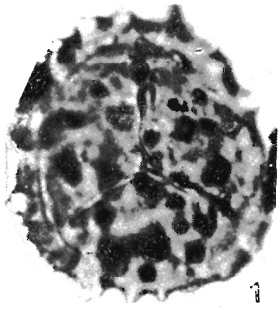
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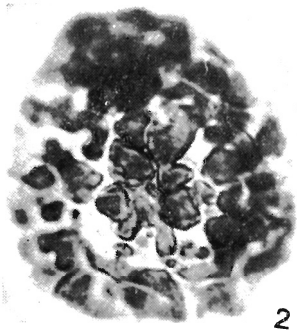
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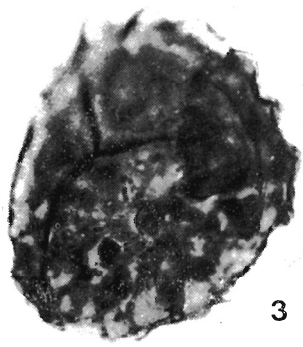
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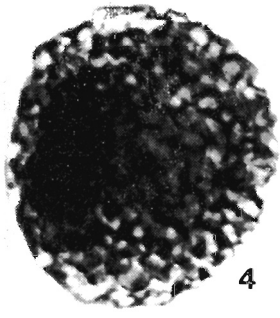
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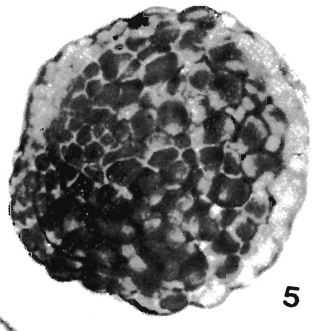
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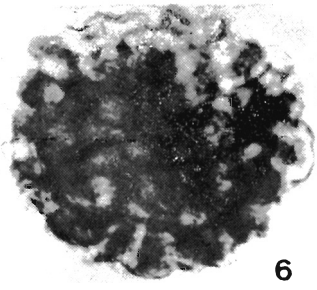
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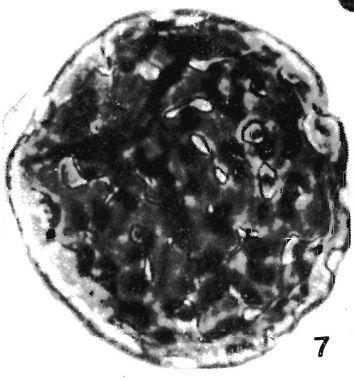
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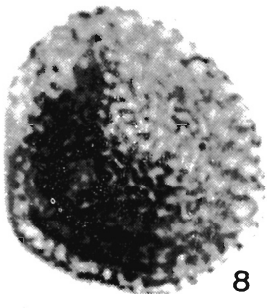
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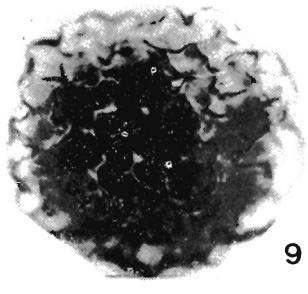
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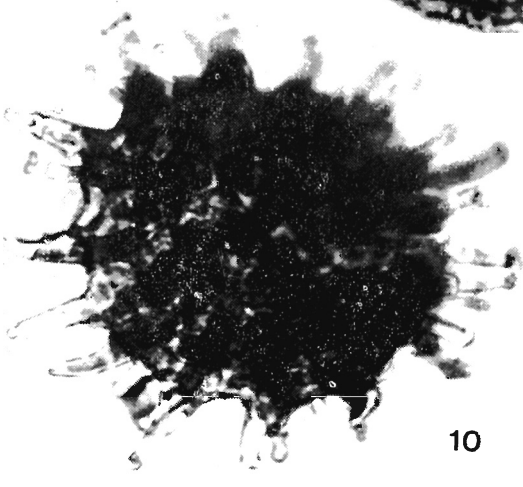
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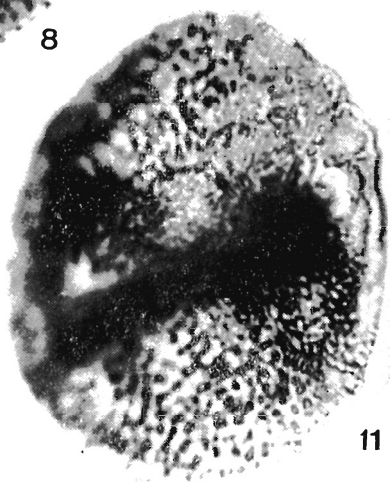
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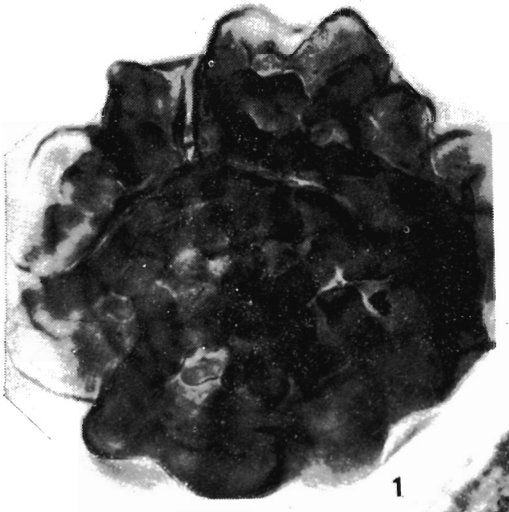
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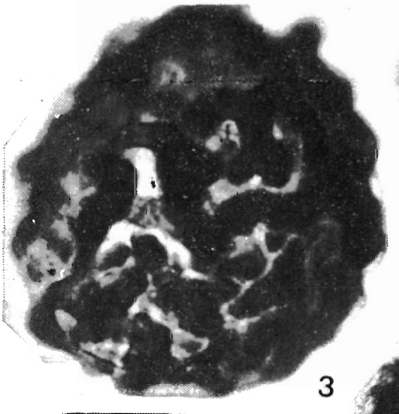
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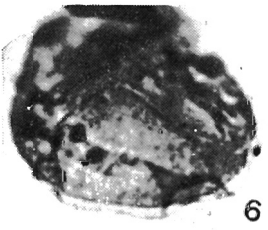
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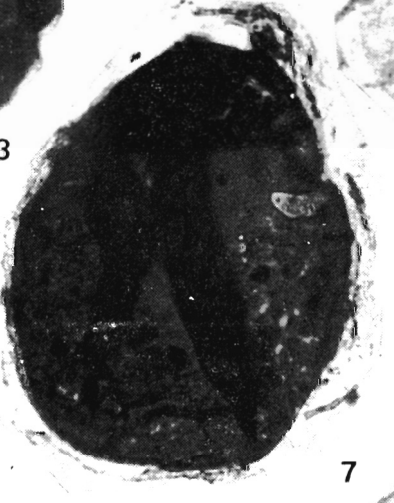
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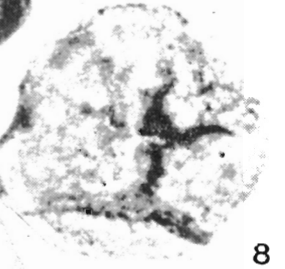
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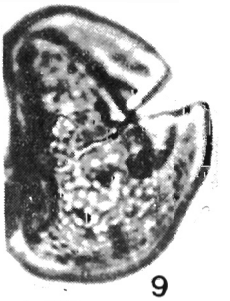
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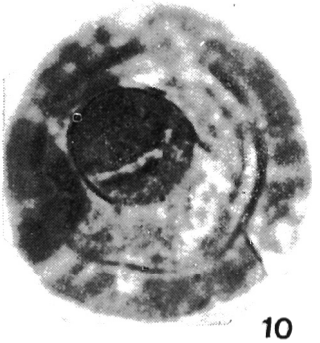
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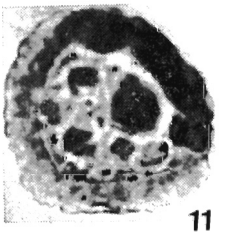
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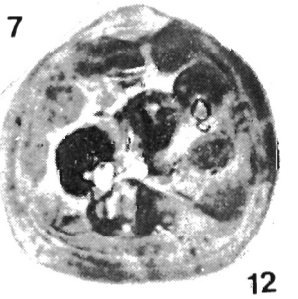
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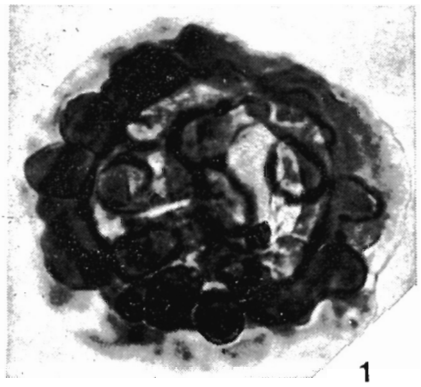
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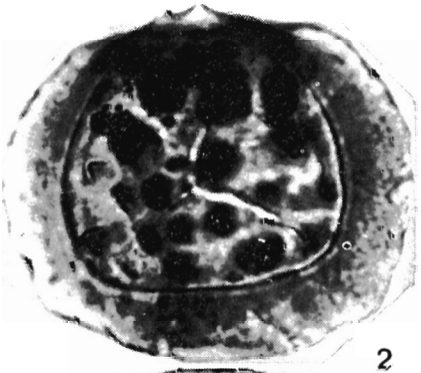
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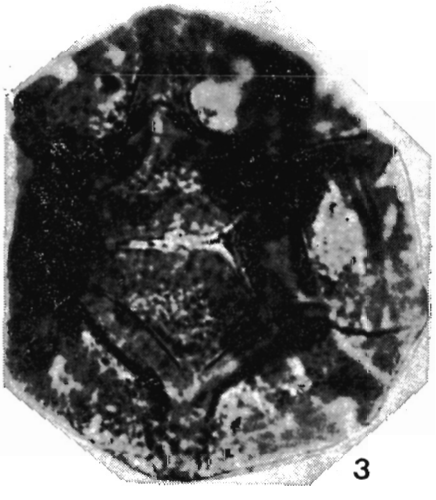
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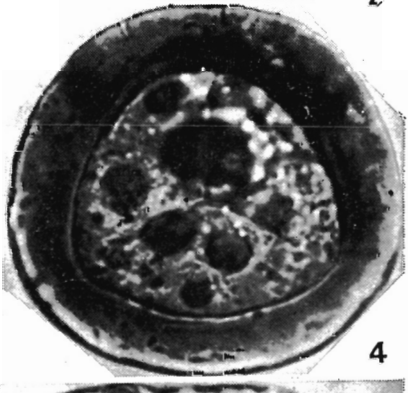
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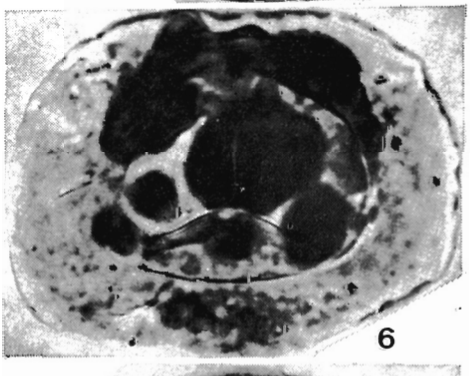
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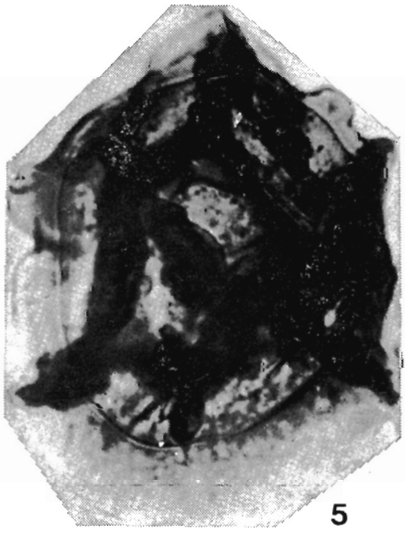
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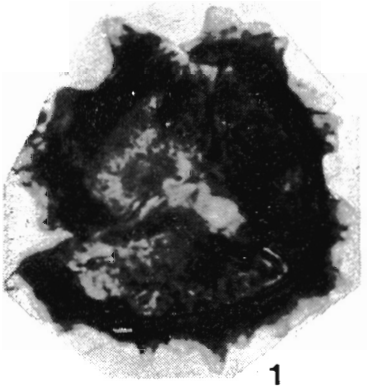
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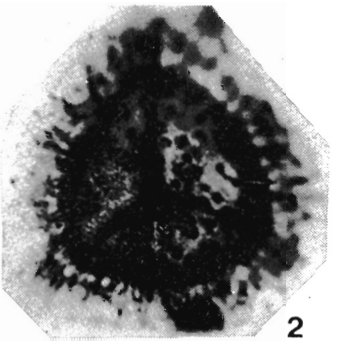
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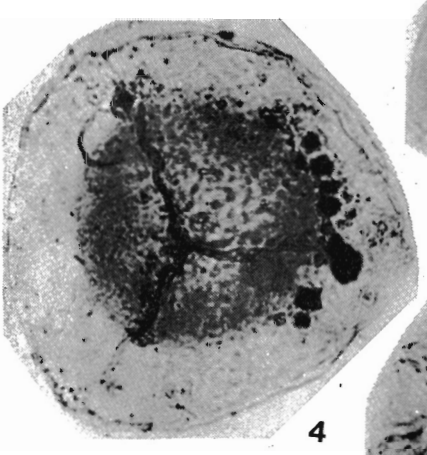
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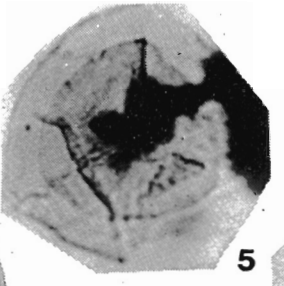
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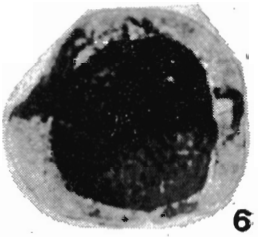
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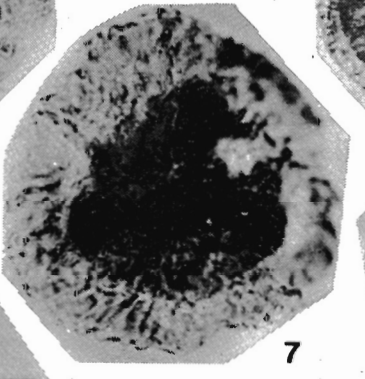
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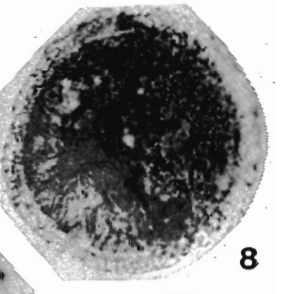
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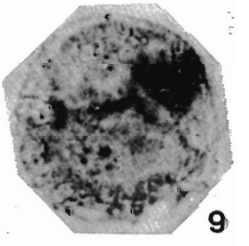
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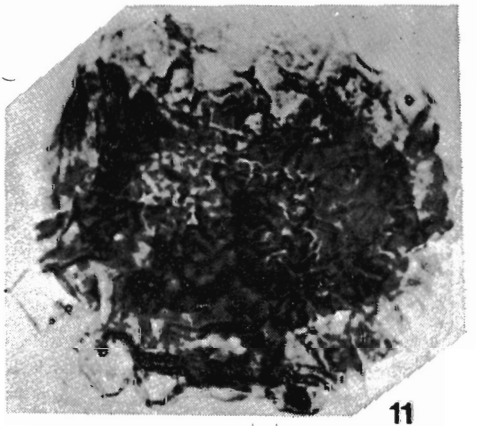
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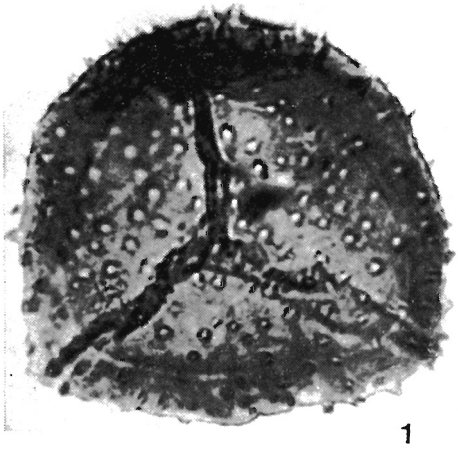

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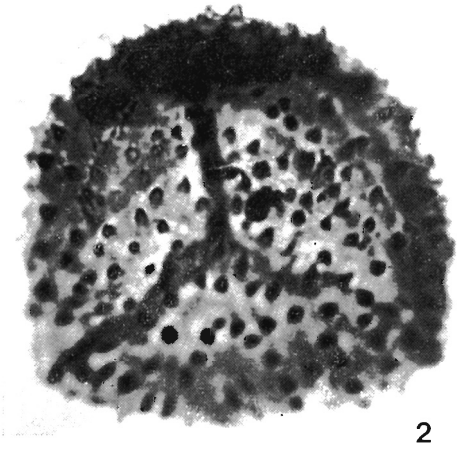

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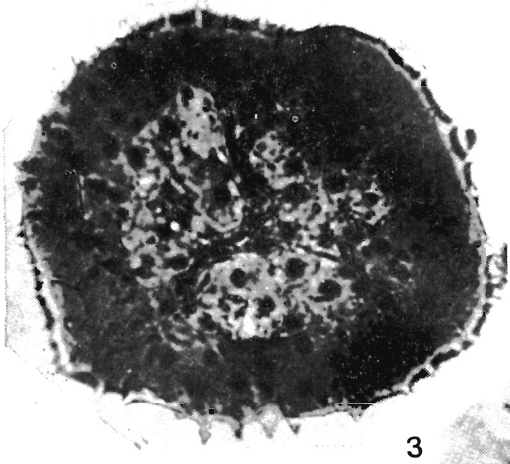

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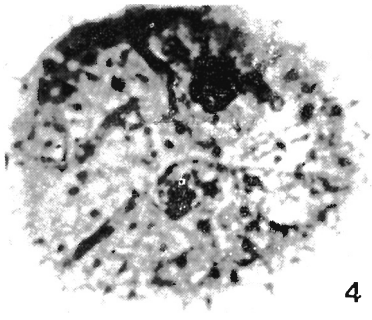

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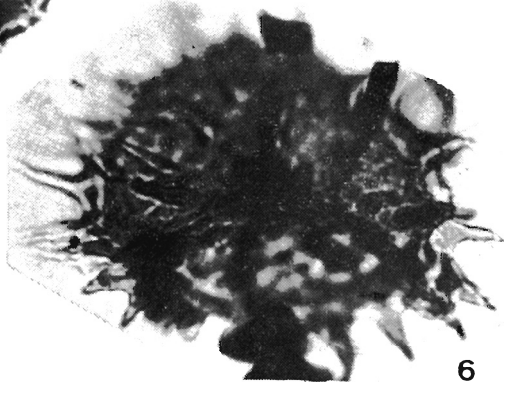

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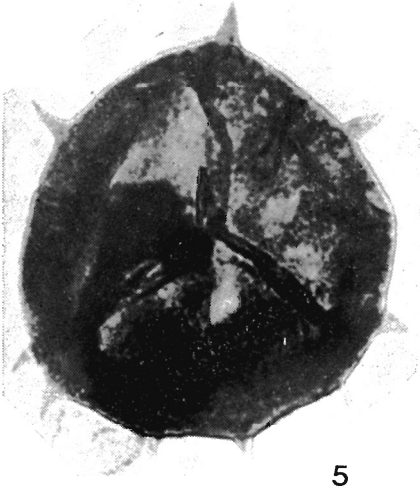

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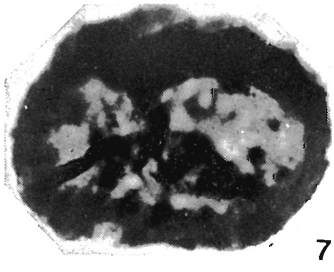

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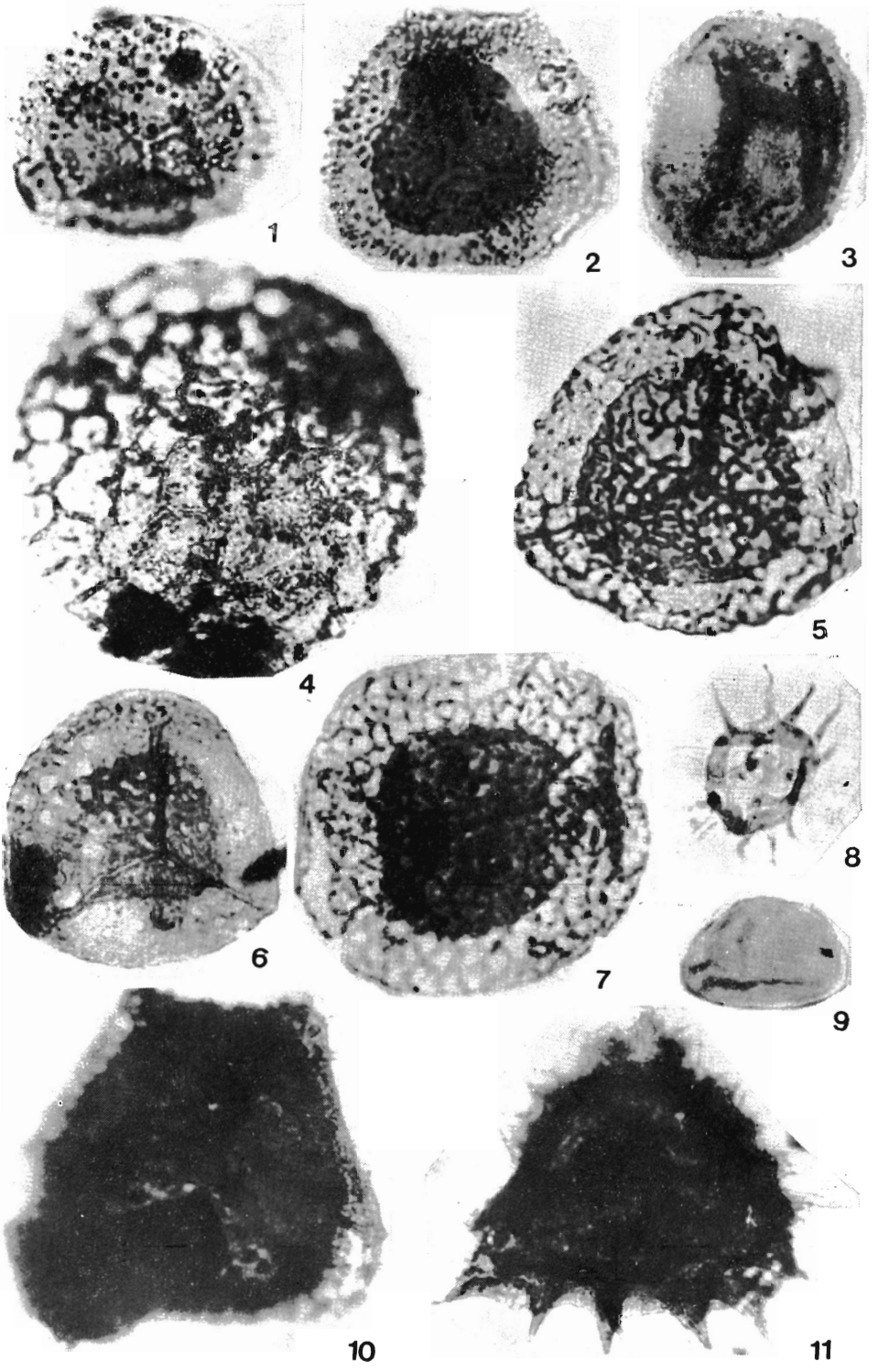
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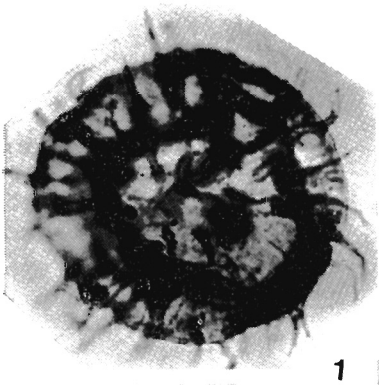
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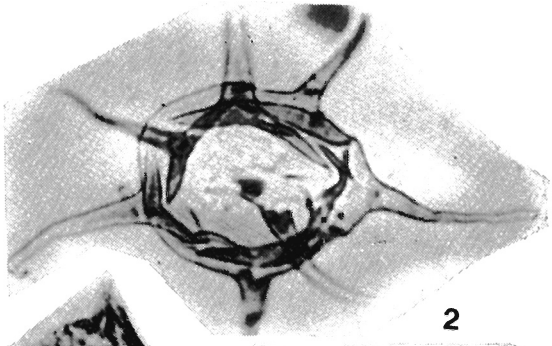
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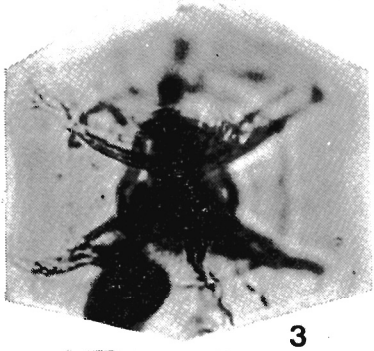
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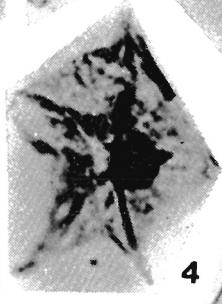
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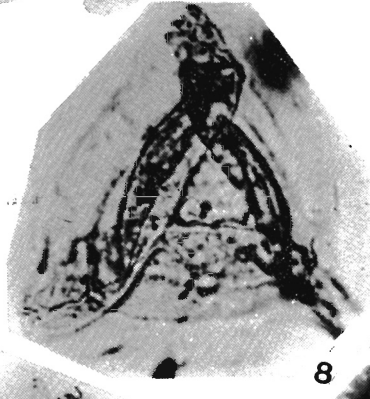
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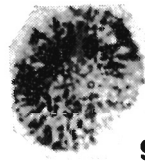
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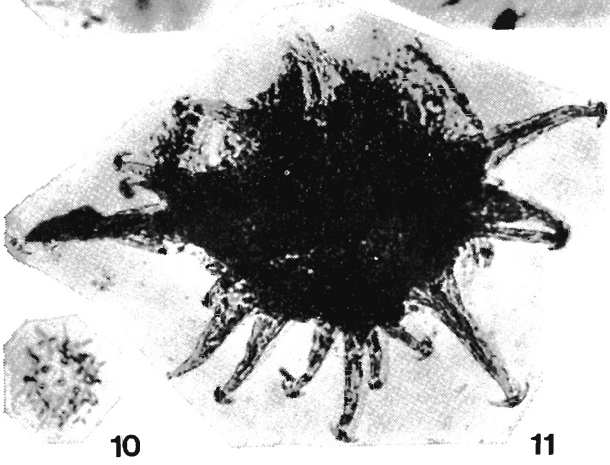
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