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SOME SPORES AND POLLEN GRAINS FROM THE JURASSIC OF THE KRAKÓW REGION

Niektóre spory i ziarna pyłku z jury okolic Krakowa

ABSTRACT. The present paper contains preliminary results of a palynological investigation of three samples from the Grojec Clays. Sixteen species belonging to twelve genera of sporomorphs are described, of which six species represent *Pteridophyta* and ten *Gymnospermae*. The presence of representatives of such families as the *Schizaeaceae*, *Cyatheaceae* and *Marattiaceae* seems to indicate a tropical or subtropical climate. The stratigraphical analysis of the sporomorphs appears to indicate a Middle Jurassic age.

INTRODUCTION

Investigations of pollen and spores from Jurassic strata in Poland were started by Rogalska more thank thirty years ago. Her publications were the first ones on Mesozoic palynology in Poland. The papers by Rogalska concern pollen and spores from the Lower Jurassic of the Polish Lowlands (1954, 1956, 1962, 1976), and from the Middle Jurassic of the Kraków — Wieluń Cuesta (1962) and of the Polish Lowlands (1976). However, pollen and spores from the Middle Jurassic Grojec Clays („glinki grojeckie") in the Kraków region which contain a rich flora described already in 1894 by Raciborski were up to now not examined. Only Oszast (1957) described from the Grojec Clays pollen grains of *Eucommiidites troedssonii*, regarded then as angiospermous. Later Reymanówna (1963, 1968, 1973) described a few sporomorphs found in connection with their parent plants.

The present paper contains the results of palynological studies carried out during the years 1983 to 1985.

MATERIAL AND METHODS

The investigated sporomorphs were found in 3 samples of grey Grojec Clays containing plant remains. They were collected by M. Reymanówna in the outcrop at Orlej, and from waste-tips Grojec 4 and Mirów 1.

The material from Grojec was macerated in nitric acid followed by ammonia and cleaned with hydrofluoric acid. The material from Orlej and Mirów was treated with potassium hydroxide, hydrofluoric acid and hydrochloric acid and then according to the acetolysis method of Erdtman (1960). Sporomorphs were observed and photographed mounted in glycerine jelly, occassionally in glycerine.

INDEX OF SPECIES

1. Cf. *Alisporites robustus* Nilsson 1958
2. Cf. *Alisporites thomasii* (Couper 1958) Nilsson
3. *Cerebropollenites macroverrucosus* (Thiergart 1949) Schulz 1967
4. *Classopollis* sp. 1
5. *Classopollis* sp. 2
6. *Conbaculatisporites mesozoicus* Klaus 1960
7. *Cyathidites minor* Couper 1953
8. *Densoisporites perinatus* Couper 1958
9. *Eucommiidites granulosus* Schulz 1967
10. *Eucommiidites* sp. 1
11. *Eucommiidites troedssonii* Erdtman 1948
12. *Klukisporites variegatus* Couper 1958
13. *Marattisporites scabratus* Couper 1958
14. *Monosulcites minimus* Cookson 1947
15. *Osmundacidites* sp. 1
16. *Vitreisporites pallidus* (Reissinger 1939) Nilsson 1958

SYSTEMATIC DESCRIPTIONS

Anteturma *Proximegerminantes*
Turma *Triletes — Azonales*
Subturma *Azonotriletes*
Infraturma *Laevigati, Quasilaevigati*
Genus *Cyathidites* Couper 1953
Cyathidites minor Couper 1953
Pl. I, figs. 1—3

1953 *Cyathidites minor* n. sp.; Couper, p. 28, pl. 2, fig. 13.
1958 *Cyathidites minor* Couper; Couper, p. 139, pl. 20, figs. 9—10.
1968 *Cyathidites minor* Couper; Tralau, p. 31, pl. X, fig. 8.
1970 *Deltoidospora* minor (Couper) n. comb.; Pocock, p. 28, pl. 5, fig. 3.
1971 *Cyathidites minor* Couper; Guy, p. 16, pl. I, fig. 2.
1976 *Cyathidites minor* Couper; Rogalska, pp. 30, 32, 35, 36, 41, pl. IV, fig. 71.
1978 *Cyathidites minor* Couper; Guy-Ohlson, pl. III, fig. 28.
1981 *Cyathidites minor* Couper; Guy-Ohlson, fig. 6H.
1983 *Cyathidites minor* Couper; Orłowska-Zwolińska, p. 9, pl. I, figs. 3—4.

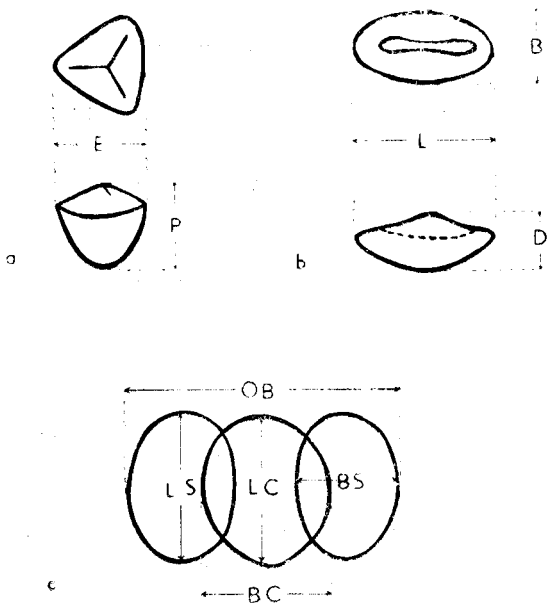

Fig. 1. Explanation of measurements of spores and pollen grains (Schematy pomiarów spor i ziarn pyłku). a — Fern spores with triradiate tetrad mark (Spory paproci z trójramiennym znakiem tetradowym). E — Equatorial diameter (średnica równikowa); P — Polar diameter (średnica biegunowa). b — Fern spores with monolete tetrad mark and monosulcate pollen grains (Spory paproci z pojedynczym znakiem tetradowym i jednobruzdowe ziarna pyłku). B — Breadth (szerokość); L — Length (długość); D — Depth (wysokość). c — Saccate pollen grains (Ziarna pyłku z workami). LC — Length of corpus (długość korpusu); LS — Length of saccus (długość worka); BC — Breadth of corpus (szerokość korpusu); BS — Breadth of saccus (szerokość worka); OB — overall breadth (łączna szerokość)

Description. Spores trilete, laesura arms straight reaching almost the equator, amb triangular with rounded apices and slightly concave sides. Equatorial diameter 31.5—43.2 μm (8 specimens measured). Polar diameter 31.5—45 μm (6 specimens measured). In equatorial view dark fold reaching from pole to pole usually visible. Exine smooth, 1—1.8 μm thick.

Material. 10 specimens from Mirów and Orlej.

Affinity. Similar spores are produced by genera of the *Cyatheaceae* and *Dicksoniaceae*.

Discussion. *Cyathidites minor* spores are usually figured in polar view though e.g. Orłowska-Zwolińska (1983, Pl. I, fig. 4) gives also a photograph of this spore in equatorial view. Couper (1958, Pl. 20, figs. 5—6) figured spores in equatorial view of *Coniopteris hymenophylloides* which resemble *C. minor*. In the examined material such spores were usually seen in equatorial view (Pl. I, fig. 1) and only occasionally in more or less polar view (Pl. I, fig. 2).

Stratigraphical distribution. Jurassic to Upper Cretaceus.

Geographical distribution. Northern and southern hemisphere.

Infraturma *Apiculati*
Subinfraturma *Nodati*
Genus *Osmundacidites* Couper 1953
Osmundacidites sp. 1
Pl. I, fig. 4

Shows certain similarties to:
1953 *Osmundacidites wellmanii* n. sp.; Couper, p. 20, pl. 1, fig. 5.
1954 Cf. *Osmunda* L.; Rogalska, p. 12, pl. III, figs. 6—8.
1956 Cf. *Osmunda* L.; Rogalska, p. 16, pl. V, figs. 2—4.
1960 *Osmundacidites wellmanii* Couper; Couper, p. 38, pl. 1, fig. 1.
1971 *Osmundacidites wellmanii* Couper; Guy, p. 22, 1, fig. 17.
1977 *Baculatisporites wellmanii* (Couper) Krutzsch; Lund, p. 56, pl. 2, figs. 13a—b.
1979 *Baculatisporites wellmanii* (Couper) Krutzsch; Pedersen, Lund, pl. V, fig. 4.

Description. Spores trilete, laesura arms reaching almost to equator, amb circular. Equatorial diameter 30.6—32.4 μm (3 specimens measured). Exine covered with acute or obtuse bacula 0.5 — about 2 μm high occasionally with curved tips. Distance between elements of sculpture about 0.5—1.8 μm. Exine (without bacula) about 1 μm thick.
Material. 3 specimens from Orlej.
Affinity. *Osmundaceae.*
Discussion. These spores are generally similar to *Osmundacidites wellmanii*, but they differ in being slightly smaller and in possesssing the ornament of spines and curved bacula instead of grana and papillae (Couper 1953, 1958), verrucae Pocock 1970) or grana (Guy 1971).
Stratigraphical distribution. (Of *O. wellmanii*) Lower Jurassic to Lower Cretaceous.
Geographical distribution. Europe, New Zealand, Australia.

Subinfraturma *Baculati*
Genus *Conbaculatisporites* Klaus 1960
Conbaculatisporites mesozoicus Klaus 1960
Pl. I, figs. 5—6

1977 *Conbaculatisporites mesozoicus* Klaus; Lund, p. 55, pl. 2, figs. 10a—b.
1979 *Conbaculatisporites mesozoicus* Klaus; Pedersen, Lund, p. 18, pl. V, figs. 1—2.
1981 *Conbaculatisporites mesozoicus*, Klaus; Guy-Ohlson, fig. 8H.
1983 *Conbaculatisporites mesozoicus*, Klaus; Orlowska-Zwolińska, p. 13, pl. VIII, figs. 5— 6.

Description. Spores trilete, laesura arms straight reaching to equator, amb triangular with broadly rounded apices. Equatorial diameter 32.4—37.8 μm (3 specimens measured). Polar diameter 32.4 μm (2 specimens measured). Exine covered

with spines about 0.5—1 μm high and bacula 2 — about 3.6 μm high. Exine about 1 μm thick (wihtout sculpture elements).
Material. 3 specimens from Mirów.
Affinity. *Dipteridaceae*.
Stratigraphical distribution. Rhaetic, Lower Jurassic.
Geographical distribution. Poland, Denmark, Greenland.

Infraturma *Murornati*
Genus *Klukisporites* Couper 1958
Klukisporites variegatus Couper 1958
Pl. I, figs. 7, 16, Pl. II, fig. 1

1958 *Klukisporites variegatus* n. sp.; Couper, p. 137, pl. 19, figs. 6—7.
1967 *Ischyosporites variegatus* (Couper) n. comb.; Schulz, p. 569, pl. V, figs. 9—10.
1971 *Ischyosporites variegatus* (Couper) Schulz; Guy pp. 35—49, pl. III, figs. 3—16.
1976 *Klukisporites variegatus* Couper; Rogalska, pp. 26, 32, 41, pl. VII, fig. 116.
1977 *Klukia exilis* (spore): Harris, Pl. I, figs. 4—6.
1978 *Ischyosporites variegatus* (Couper) Schulz; Guy-Ohlson, pl. IV, figs. 39—40.
Different from species regarded as synonym:
1970 *Dicyotriletes crateris* (Balme) n. comb.; Pocock, p. 51, pl. 9, figs. 3—7.

Description. Trilete spores, laesura arms extending almost to equator, accompanied by a margo not visible in all specimens; amb rounded triangular to almost circular. Equatorial diameter 43.2—55 μm (5 specimens measured). Surface with foveo-reticulate sculpture, pits of circular, elliptical, elongated and irregular shape, occasionally linked by narrow connecting channels, pits 1—5.4 μm wide; intervening walls 1.8—7.2 μm wide. In certain spores the sculpture is reduced, in particular on the proximal face where it may form small papillae or the surface is almost smooth. Exine thickness (because of different height of sculpture) from about 1—6.3 μm.
Material. 5 specimens from Grojec, Orlej and Mirów.
Affinity. Dispersed spores of *Klukisporites* (*Ischyosporites*) are usually atributed to ferns of the family *Schizaeaceae*. *Klukisporites* is similar to spores of the recent genus *Lygodium* and also to spores extracted from sporangia of the Jurassic ferns of the *Schizaeaceae*, *Klukia exilis* (Phillips) Raciborski (Couper 1958, Pl. 19, figs. 2—3) and *Stachypteris hallei* Thomas (Couper 1958, Pl. 19, figs. 4—5).

A detailed discussion of the affinity and distribution of *Klukisporites* is given by Guy (1971, pp. 35—49).

Klukisporites is also similar to spores extracted by Harris from sporangia of *Klukia*, some still attached to lamina fragments. These sporangia were found in a core from Zabierzów near Grojec (Harris 1977, Pl. I, figs. 4—6). It is worth mentioning that it was the material of leaves with sporangia from the Grojec region that permitted the inclusion of *Klukia exilis* to the *Schizaeceae*. It was namely transfered to the new genus *Klukia* by the Kraków palaeobotanist Marian Raciborski (1891).

The species had been described originally by Philips (1829) from Yorkshire and placed in the artificial genus *Pecopteris*. Harris (1946, 1961) at first supposed that *Klukia* from Poland was distinct from *K. exilis*. However, having in 1976 studied the specimens of Raciborski, Harris (1977) decided that Raciborski's species was identical with the Yorkshire original specimens of *K. exilis*.

Nomenclature. Spores of this type were attributed to genera *Dictyotriletes* (Naumova 1937) Potonié et Kremp 1955, *Ischyosporites* Balme 1957 and *Klukisporites* Couper 1958. A detailed discussion of nomenclature is given by Guy (1971, pp. 33—35). According to her the name *Ischyosporites* should be used.

It appears that the spores in the present material are most similar to dispersed spores from Yorkshire described as *Klukisporites variegatus* by Couper (1958) and therefore the generic name *Klukisporites* is used. The discussed spores are also similar to spores isolated by Harris from separate sporangia of *Klukia* from the Kraków region (Harris 1977). Possibly *Ischyosporites* may show a wider range of variability.

Discussion. It seems that the described material of *Klukisporites variegatus* contains two forms, one from Grojec (Pl. II, fig. 1) with much thicker exine and smaller, less regular pits, in comparison with specimens from Mirów and Orlej (Pl. I, fig. 7). However it is not possible to decide whether these differences are essential because of the small number of specimens.

Stratigraphical distribution. If *Klukisporites* is regarded as synonym of *Ischyosporites* then it occurs from Lower Jurassic to Middle Jurassic (for Eurasia) and Lower Jurassic to Lower Cretaceous (Australia). If *Klukisporites variegatus* is treated separately, it occurs in Middle Jurassic.

Geographical distribution. *Ischyosporites* occurs in Eurasia, Australia, Canada. *Klukisporites* in Eurasia.

Turma *Triletes — Zonales*
Subturma *Zonotriletes*
Infraturma *Cingulati*
Genus *Densoisporites* (Weyland et Krieger 1953) Dettman 1963
Densoisporites perinatus Couper 1958
Pl. II, fig. 5

1958 *Densoisporites perinatus* n. sp.; Couper, p. 145, figs. 6—9.
1976 *Densoisporites perinatus* Couper; Rogalska, pp. 26, 31, 34, 41; pl. XVI, figs. 232—233.
Shows certain similarity to:
1978 *Densoisporites velatus* Weyland et Krieger; Guy-Ohlson, pl. IV, figs. 29—30.
1982 *Densoisporites velatus* Weyland et Krieger; Guy-Ohlson, p. 13, pl. 2, fig. 17.

Description. Spores trilete with subtriangular to almost circular amb; spore consisting of subcircular inner body and surrounding layer about 3.6—9 μm wide at equator; inner body covered by smooth membrane about 1 μm thick, surrounding

layer consisting of thin folded laminae. Laesura arms of variable length reaching to or beyond the inner body margin. Equatorial diameter of spores 48.6—61.2 μm, equatorial diameter of inner body 41.4—55.8 μm (3 specimens measured).
Material. 3 specimens from Mirów.
Affinity. Probably *Lycopodiales*. *Densoisporites valatus* was compared with microspores of *Selaginella hallei* Lundblad and of the recent *Selaginella scandens*.
Remarks. Some authors regard *D. velatus* Weyland et Krieger 1953 as a synonym of *D. perinatus* (Tralau 1968, Guy 1971).
Stratigraphical distribution. Jurassic to Lower Cretaceous (*D. perinatus*). Lower Jurassic to Upper Cretaceous (*D. velatus*).
Geographical distribution. Europe (*D. perinatus*). Eurasia, North America, Australia (*D. velatus*).

Turma *Monoletes*
Subturma *Azonomonoletes*
Infraturma *Sculptatomonoleti*
Genus *Marattisporites* Couper 1958
Marattisporites scabratus Couper 1958
Pl. II, fig. 2

1956 *Marattiopsis hoerensis* (Schimper) Thomas; Rogalska, p. 11, pl. I, figs. 5, 7.
1958 *Marattisporites scabratus* n. sp.; Couper, p. 133, pl. 15, figs. 20—23.
1968 *Marattisporites scabratus* Couper; Tralau, p. 53.
1971 *Marattisporites scabratus* Couper; Guy, p. 56, pl. 4, fig. 12.
1976 *Marattisporites scabratus* Couper; Rogalska, pp. 24, 31, 32, 42; pl. III, figs. 44—53.
1977 *Marattisporites scabratus* Couper; Lund, pl. 6, fig. 2.
1982 *Marattisporites scabratus* Couper; Guy-Ohlson, p. 13.

Description. Spores monolete, laesura almost equal to the whole length of spore. Outline in equatorial view convex with flat or slightly concave base. Length of spore 23.4 μm, depth of spore 16.2 μm. Exine finaly granulate to scabrate, about 1 μm thick.
Material. One specimen from Mirów.
Affinity. *Marattiaceae*.
Remarks. The only specimen found was in equatorial view.
Stratigraphical distribution. Lower Jurassic to Lower Cretaceous.
Geographical distribution. Europe.

Anteturma *Variegerminantes*
Turma *Saccites*
Subturma *Disaccites abstriates*
Genus *Alisporites* (Daugherty 1941) Nilsson 1958

cf. *Alisporites robustus* Nilsson 1958

Pl. II, figs. 4, 7

Shows certain similarity to:

1954 typ *Pinus haploxylon* Rudolph; Rogalska, pl. 12, fig. 2.
1968 *Alisporites robustus* Nilsson 1958; Tralau, p. 71, pl. XXI, fig. 1.
1977 *Alisporites robustus* Nilsson; Lund, pl. 9, figs. 1—2.
1978 *Alisporites robustus* Nilsson; Guy-Ohlson, pl. 1, figs. 1—2.
1979 *Alisporites robustus* Nilsson; Pedersen, Lund, pl. 12, fig. 4.
1981 *Alisporites robustus* Nilsson; Guy-Ohlson, fig. 6A.

Description. Bisaccate pollen grain, length of sacci almost equal to length of corpus, corpus longer than broad, elliptical. Overall breadth 68.4 μm, breadth of corpus 34.2 μm, breadth of saccus 27.0 μm, length of corpus 41.4 μm, length of saccus 39.6 μm (one specimen measured). Exine of corpus finely granulate, in light microscope seen as light and dark dots. Sacci showing internal reticulum with lumina 1—2 μm in diameter, muri about 0.5 μm wide. Exine of corpus about 1 μm thick

Material. One specimen from Mirów.

Affinity. *Pteridospermae.*

Remarks. In general the grain is similar to *Alisporites robustus.* It differs however in its smaller size, e.g. the overall breadth of *A. robustus* is given as above 74 μm (Guy 1971), while in the grain from Mirów the overall breadth is 68.8 μm. Lumina of reticulum are given as 1—4 μm in diameter while in the grain from Mirów the diameter of lumina is 1—2 μm.

Stratigraphical distribution. Lower Jurassic to Middle Jurassic.

Geographical distribution. Europe.

Cf. *Alisporites thomasii* (Couper 1958) Nilsson

Pl. II, fig. 6

1971 *Alisporites thomasii* (Couper) Nilsson: van Konijnenburg — van Cittert, pp. 15—18, pl. II, fig. 5.
1975 *Alisporites thomasii* (Couper) Nilsson; Vigran, Thusu, pl. 14, fig. 9.

No identical with:

1958 *Pteruchipollenites thomassi* n. sp.; Couper, p. 150, pl. 26, figs. 10—12.
1975 *Alisporites thomasii* (Couper) Nilsson; Vigran, Thusu, pl. 15, figs. 4, 6.

Description. Bisaccate pollen grain, length of sacci almost equal to length of corpus, corpus longer than broad. Overall breadth 50.4 μm, breadth of corpus 36.0 μm, breadth of saccus 23.4 μm, length of corpus 46.8 μm, length of saccus 45.0 μm (one specimen measured). Exine of corpus granulate, (in light microscope seen as light and dark dots). Sacci showing internal reticulum with penta — or hexagonal lumina 1—3 μm in diameter, muri about 0.5 μm wide. Exine of corpus about 1 μm thick.

Material. One specimen from Orlej.

Affinity. *Pteridospermae.*
Stratigraphical distribution. Lower Jurassic to Upper Cretaceous.
Geographical distribution. Europe.

Genus *Vitreisporites* Leschik 1955
Vitreisporites pallidus (Reissinger 1939) Nilsson 1958

Pl. II, fig. 3

1958 *Caytonipollenites pallidus* (Reissinger) n. comb.; Couper, p. 150, pl. 26, figs. 7—8.
1968 *Caytonipollenites pallidus* (Reissinger) Couper; Tralau, p. 75, pl. XX, figs. 1, 3.
1970 *Vitreisporites pallidus* (Reissinger) Nilsson; Pocock, pp. 85—87, pl. 18, figs. 16—20, 22, 25.
1971 *Caytonipollenites pallidus* (Reissinger) Couper; Guy, p. 64, pl. 5, fig. 16.
1971 *Vitreisporites pallidus* (Reissinger) Nilsson; van Konijnenburg — van Cittert pp. 15 69, pl. I, fig. 6
1976 *Caytonipollenites pallidus* (Reissinger) Couper; Rogalska, pp. 30, 32, 33, 40.
1977 *Vitreisporites pallidus* (Reissinger) Nilsson; Lund, pp. 74—75, pl. 8, fig. 9.
1981 *Caytonipollenites pallidus* (Reissinger) Couper (= *Vitreisporites pallidus* (Reissinger) Nilsson); Guy-Ohlson, fig. 6E.
1982 *Vitreisporites pallidus* (Reissinger) Nilsson; Guy-Ohlson, pp. 15—16.

Description. Bisaccate pollen grain: length of sacci almost equal to length of corpus. Overall breadth 28—34.2 μm, breadth of corpus 9 –10.8 μm, breadth of saccus 10.5—11.6 μm, length of corpus 14.4—19.8 μm, length of saccus 13.5—19.8 μm (5 specimens measured). Exine structure extremely delicate (in light microscope) visible as light and dark dots representing possibly lumina of reticulum, on corpus lumina less distinct than on sacci. No special structure visible on the sacci near the boundary with the corpus. Exine very thin.
Material. 5 specimens from Orlej.
Affinity. *Caytoniales.*
Remarks. According to J. van Konijnenburg-van Cittert (1971) the sacci of in situ pollen grains of *Caytonanthus oncodes* do not show any special structure at the boundary of sacci with the corpus and in this they resemble the pollen grains from Orlej. *C. oncodes* microsporangia are attributed to the fruits *Caytonia sewardi* Thomas which had also been found in the Kraków Jurassic flora in the localities Zabierzów and Grojec which is close to Orlej (Reymanówna 1973).
Stratigraphical distribution. Lower Jurassic to Lower Cretaceous.
Geographical distribution. Eurasia, Western Canada, Australia.

Turma *Aletes, Kryptaperturates*
Subturma *Azonaletes*
Genus *Cerebropollenites* Nilsson 1958
Cerebropollenites macroverrucosus (Thiergart 1949) Schulz 1967

Pl. I, fig. 12, Pl. II, fig. 8

1949 *Pollenites macroverrucosus* n. sp.; Thiergart, p. 3, pl. II, fig. 19.
1954 Cf. *Pollenites macroverrucosus* Thiergart; Rogalska, p. 20, pl. IX, figs. 5—6.
1956 Cf. *Pollenites macroverrucosus* Thiergart; Rogalska, p. 32, pl. XIX, fig. 4.
1958 *Tsugaepollenites mesozoicus* n. sp.; Couper, p. 155, pl. 30, figs. 8—10.
1967 *Tsugaepollenites mesozoicus* Couper; Pocock, pl. I, fig. M.
1967 *Cerebropollenites macroverrucosus* (Thiergart) n. comb.; Schulz, p. 603, pl. XXI, figs. 4—6.
1968 *Tsugaepollenites mesozoicus* Couper; Tralau, pp. 91—92, pl. XX, figs. 2, 4, 5, pl. XVII, figs. 3—4.
1970 *Cerebropollenites mesozoicus* (Couper) Nilsson; Pocock, p. 98, pl. 21, figs. 9, 12.
1971 *Cerebropollenites mesozoicus* (Couper) Nilsson; Guy, pp. 57—58, pl. IV, fig. 14.
1976 *Cerebropollenites macroverrucosus* (Thiergart) Schulz; Rogalska, pp. 30, 31, 32, 35, 40, pl. XLVII, figs. 572—580.
1977 *Cerebropollenites macroverrucosus* (Thiergart) Schulz; Lund, p. 72, pl. 7, fig. 14.
1978 *Cerebropollenites mesozoicus* (Couper) Nilsson; Guy-Ohlson, pl. II, figs. 12—13.
1982 *Cerebropollenites mesozoicus* (Couper) Nilsson; Guy-Ohlson, p. 14, pl. II, fig. 24.

Description. Outline of grains circular to broadly elliptical. Length of grain 37.8—46.8 μm (3 specimens measured), breadth 36.0—45.0 μm (2 specimens measured), depth 32.4 μm (1 specimen measured). Exine composed of two layers, the outer very thin with saccate protrusions from about 3—5 μm wide, and about 2—3.5 μm high; the inner layer of exine smooth, about 1 μm thick. A circular or oval area without protrusions where the exine is smooth, occasionally torn is visible in some specimens.
Material. 3 specimens from Mirów.
Affinity. Usually attributed to *Coniferales*.
Stratigraphical distribution. Jurassic to Lower Cretaceous.
Geographical distribution. Eurasia, Canada.

Infraturma *Circumpollini*
Genus *Classopollis* (Pflug 1953) Pocock et Jansonius 1961
Classopollis sp. 1
Pl. I, fig. 9

1967 *Classopollis classoides* (Pflug) Pocock et Jansonius; Pocock, pl. I, fig. K.
1970 *Classopollis lassoides* (Pflug) Pocock et Jansonius; Pocock, pp. 103—106, pl. 23, figs. 14, 17.
1970 *Classopollis bussoni* sp. nov.; Reyre, p. 314, pl. 56, fig. 1.

Description. Grain circular in polar view, on proximal pole trilete tetrad mark which is triangular with concave sides each about 5.4—12.6 μm long. In equatorial view outline elliptical or oval. Equatorial diameter 27.0—34.2 μm (3 specimens measured). Around the equator a band about 9 μm wide composed of 5—6 striae approximately parallel, occasionally anastomosing. Striae consisting of closely set, inwards pointing elements; exine outside band showing delicate dark and light dots. Exine thickness in equatorial band about 3 μm, outside band 1—1.5 μm.
Material. 3 specimens from Mirów.

Classopollis sp. 2

Pl. I, fig. 10

1954 *Cheirolepidiaceae*; Rogalska, p. 23, pl. XI, fig. 4.
1970 *Classopollis chateaunovi* sp. nov.; Reyre, p. 313, pl. 55, fig. 12.
1971 *Classopollis classoides* (Pflug) Pocock et Jansonius; van Konijnenburg-van Cittert, pp. 61—64, 72, pl. XV, fig. 5.
1978 *Classopollis chateaunovi* Reyre; Guy-Ohlson, pl. II, figs. 16—17.

Description. Grain circular in polar view. Equatorial diameter 27.0—29.4 μm (2 specimens measured). On proximal pole indistinct trilete tetrad mark which is triangular with slightly concave sides 5.4—7.2 μm long. On distal pole indistinct pore. Around equator present band with parallel striae composed of closely arranged inward pointing elements. About 5 μm from the equator (from pollen margin) visible thin ring of exine (rimula) about 1—1.5 μm wide. Exine outside band and rimula with delicate ornamentation composed of light and dark dots. Exine thickness in equatorial band about 6 μm.

Material. 3 specimens from Mirów.

Affinity. Pollen grains of the *Classopollis* type were found in pollen cones of conifers belonging to the extinct Mesozoic family *Cheirolepidiaceae*.

Remarks. In the material from Mirów, 6 specimens of *Classopollis* (Pflug) Pocock et Jansonius were found. They appear to represent two species but it is impossible to ascertain the importance of the differences between them because of the small number of specimens.

The differences appear to be:

1. The more delicate and less expressed pattern of exine ornamentation in *Classopollis* sp. 2 as in comparison with *Classopollis* sp. 1.
2. The more delicate striae in the equatorial band in *Classopolis* sp. 2.
3. The thicker exine in the equatorial band of *Classopollis* sp. 2. The attribution of *Classopollis* pollen grains to the particular species is extremely difficult and some authors think that it is not possible without the use of the scanning electron microscope. So it can only be said that *Classopollis* sp. 1 can approximately be regarded as *C. classoides* (Pflug) Pocock et Jansonius 1961 or *C. bussonii* Reyre 1970. *C.* sp. 2 can be regarded as *C. chateaunovi* Reyre.

Stratigraphical distribution of the genus *Classopollis*. Rhaetic to Cretaceous.

Geographical distribution. Both hemispheres.

Turma *Plicates*

Subturma *Monocolpates — Zonocolpates*

Genus *Monosulcites* Cookson 1947 ex Couper 1953

Monosulcites minimus Cookson 1947

Pl. I, fig. 8

1953 *Monosulcites minimus* Cookson; Couper, p. 65.
1956 Cf. *Ginkgo biloba* L.; Rogalska, p. 26, pl. XI, figs. 1—2.
1958 *Monosulcites minimus* Cookson; Couper, p. 157, pl. 26, figs. 23—25.
1970 *Cycadopites minimus* (Cookson) n. comb.; Pocock, p. 108, pl. 26, figs. 21—24, 26—28.
1971 *Monosulcites* (= *Cycadopites*) *minimus* Cookson; van Konijnenburg — van Cittert, pp. 44, 48, 71, pl. VII, fig. 1.
1976 *Monosulcites minimus* Cookson; Rogalska, pp. 35, 42, pl. LII, figs. 649, 651—654, 657—658, 660—661.
1977 *Monosulcites minimus* Cookson; Lund, p. 67, pl. 6, fig. 10.
1981 *Monosulcites minimus* Cookson; Guy-Ohlson, fig. 5D.
1982 *Monosulcites minimus* Cookson; Guy-Ohlson, p. 17.

Descritpion. Pollen grains monosulcate, elliptical in outline with tapering, rounded or slightly acute ends. Length of grain 23.4—30 μm (6 specimens measured), breadth 12.6—18 μm (4 specimens measured), depth 12—15 μm (2 specimens measured). Sulcus extending along the whole length of grain. Ends of sulcus rounded and widening, as a rule one end wider. Exine smooth about 1 μm thick.
Material. 6 specimens from Orlej.
Affinity. Dispersed pollen grains *M. minimus* are similar to pollen grains found in fructifications of *Cycadales*, *Bennettitales* and *Ginkgoales*.
Remarks. Pollen grains described as *M. minimus* may differ to a considerable extent, in particular in the shape of the grain and of the sulcus. In certain papers e.g. in Couper 1958, Pocock 1970 the exine of *M. minimus* is regarded as smooth. Certain photographs however (e.g. in Guy-Ohlson 1981 fig. 5D, J. van Konijnenburg-van Cittert 1971, pl. 7, fig. 1) may suggest the presence of a delicate sculpture.
Stratigraphical distribution. Rhaetic — Cretaceous.
Geographical distribution. Europe, New Zealand, Canada.

Subturma *Tricolpates, Triptyches*
Infraturma *Heterocolpati, Praecolpati*
Genus *Eucommiidites* Erdtman 1948
Eucommiidites troedssonii Erdtman 1948

Pl. I, figs. 14—15

1957 *Eucommiidites troedssonii* Erdtman; Oszast, pp. 103—105, figs. 1—2, 4—7.
1958 *Eucommiidites troedssonii* Erdtman; Couper, pp. 160—165, pl. 31, figs. 23—27.
1970 *Eucommiidites troedssonii* Erdtman; Pocock, p. 110, pl. 26, figs. 33—34.
1971 *Eucommiidites troedssonii* Erdtman; Guy, p. 69, pl. V, fig. 18.
1971 *Eucommiidites troedssonii* Erdtman; van Konijnenburg-van Cittert, pp. 31—33, pl. IX, fig. 1.
1977 *Eucommiidites troedssonii* Erdtman; Lund, p. 69, pl. 6, fig. 15.
1978 *Eucommiidites troedssonii* Erdtman; Guy-Ohlson, pl. IV, fig. 34.
1979 *Eucommiidites troedssonii* Erdtman; Pedersen, Lund, pl. XX, figs. 3—4.
1982 *Eucommiidites troedssonii* Erdtman; Guy-Ohlson, p. 17, pl. IV, fig. 34.
Not identical with:
1957 *Eucommiidites troedssonii* Erdtman; Oszast, fig. 3.

Description. Pollen grains elliptical with one principal and two accessory furrows. Principal furrow better developed, narrow in the middle and widened at ends, extendending along almost whole length of the grain. Accessory furrows usually shorter and narrower. Exine smooth, two-layered, 1—2.5 μm thick. Length of grain 28.8—41.4 μm, breadth 21.6—30.6 μm (10 specimens measured).
Material. 10 specimens from Orlej, Mirów and Grojec.
Affinity. Originally regarded as angiospermous, now usually attributed to gymnosperms of unknown affinity.
Remarks. In the description the term "furrow" is used instead of the "colpus". In this I follow Doyle (1975), because I would like to avoid the word colpus which means a furrow running from one pole of the grain to the other and passing the equator at an angle of 90° like in the angiosperms. Couper (1958) however regards the principal furrow of *Eucommiidites* as similar in nature to the single sulcus of monosulcate, gymnospermous grains. The sulcus is a thinner area on the distal pole. As far as I know, the tetrad of *Eucommiidites* is not known and the position and nature of the furrow cannot yet be established.
Stratigraphical distribution. Triassic to Cretaceous.
Geographical distribution. Eurasia, Western Canada.

Eucommiidites granulosus Schulz 1967

Pl. I, fig. 13

1967 *Eucommiidites granulosus* sp. n.; Schulz, pp. 600—601, pl. XIX, figs. 8—9.
1968 *Eucommiidites granulosus* Schulz; Tralau, p. 84, pl. XXIII, fig. 4.

Description. Grain elliptical, with three furrows of almost equal length extending approximately along the whole length of the grain. At margins of furrows exine forms folds obscuring furrow outline. Exine sculpture granulate to verrucate, diameter of these elements about 1—1.5 μm. Total exine thickness sculpture included about 2 μm. Length of grain 35.0 μm, breadth 28.0 μm.
Material. 1 specimen from Mirów.
Affinity as *E. troedssonii*.
Remarks. In comparison with the holotype described by Schulz (1967), the specimen shows a slightly thicker exine and slightly larger granules on the exine surface.
Stratigraphical distribution. Lower Jurassic to Middle Jurassic.
Geographical distribution. Northern Europe.

Eucommiidites sp. 1

Pl. I, fig. 11

1957 *Eucommiidites troedssonii*; Oszast, fig. 3.
1976 *Eucommiidites minor*; Hughes, p. 122, figs. 9, 12, H. J.

No identical with:
1960 *Eucommiidites minor* n. sp.; Groot, Penny, p. 234, pl. 2, fig. 14.
1967 *Eucommiidites minor* Groot et Penny; Brenner, p. 123—127, pl. I, fig. 7.
1980 *Eucommiidites* cf. *minor* Groot et Penny; Quattrocchio, p. 19, fig. 45.

Description. Pollen grains circular or subcircular with three narrow furrows, principal furrow extending almost along whole grain, in some specimens wider than accessory furrows. Accessory furrows as a rule parallel to grain margin, occasionally shorter from principal furrow, or of equal length, on certain grains forming ring furrow. Exine 2—2.5 μm thick, two layered, smooth. Length of grain 25.2—30.6 μm, breadth 25.2—30.6 μm (5 specimens measured).
Material. 5 specimens from Mirów, Orlej and Grojec.
Affinity. *Gymnospermae* incertae sedis.
Remarks. In the Grojec Clays there occur *Eucommiidites* grains which are clearly different from *E. troedssonii*, although they are also smooth. They differ from *E. troedssonii* in their circular outline, smaller size ad in having narrow furrows of which the accessory ones show a tendency to form a ring furrow.

Similar grains have been described as *E. minor* although the grains from the Grojec Clays differ from the holotype of *E. minor* Groot et Penny 1960 from the Lower Cretaceous of Maryland in having narrower and longer furrows. Our material is very similar to *E. minor* from the Lower Cretaceous of England figured by Hughes 1976 p. 122, fig. 9, 12, though the English specimens seem in general smaller.
Stratigraphical distribution. From outside Poland usually described from Lower Cretaceous.
Geographical distribution. (Of grains similar to our material) England.

VEGETATION AND CLIMATE

In the Grojec Clays occur spores of pteridophytes and pollen grains of gymnosperms. No angiosperms are yet present, only such plants as the *Caytoniales* and *Eucommiidites* which show certain characters reminding of the angiosperms.

Among the pteridophytes, were found spores of probably *Lycopodiales* (*Densoisporites perinatus*) and of *Filicales* among which were determined 6 species belonging apparently to five families. Among pollen grains of gymnosperms was established the presence of disaccate pollen grains of pteridosperms among which of particular interest are the *Caytoniales*, monosulcate grains *Monosulcites minimus* which might represent the *Cycadales*, *Bennettitales* or *Ginkgoales*; *Eucommiidites* grains with three furrows attributed presently to gymnosperms of unknown affinity; pollen grains attributed to *Coniferales*, among them *Classopollis* of the extinct Mesozoic family *Cheirolepidiaceae*. In this way the spectrum reflects a typical Mesozoic vegetation.

It is interesting to note that in the macroflora from Orlej were not found any fragments of fern leaves (M. Reymanówna, personal communication), while such leaves dominated in the flora described from the neighbouring localities, in parti-

cular from Grojec, by Raciborski (1894). The presence of numerous fern spores in Orlej is evidence that ferns were also present in the vegetation, but probably on a different, more humid habitat than the xeromorphic gymnosperms.

In the Grojec Clays occur spores representing the fern families *Schizaeaceae*, *Cyatheaceae* and *Marattiaceae* which at present live in a tropical and subtropical climate. This seems evidence that during the Jurassic the climate was of a similar kind. Similar is the opinion of Rogalska (1976) who thinks that on Polish territory the microflora of the Middle Jurassic, similarly as the microflora of the Lower Jurassic represents a vegetation of a hot and humid climate.

AGE OF THE GROJEC CLAYS

The age of the Grojec Clays was ontroversial. Usually they were regarded as Lower Jurassic, but more recently (e.g. Jurkiewiczowa 1974) were expressed opinions of their Middle Jurassic age. Then Marcinkiewicz (1980) in her paper on the megaspores of the Grojec Clays reached the conclusion that they are Middle Jurassic and represent one of the stratigraphical members of the Bathonian.

Table 1

Stratigraphical distribution of sporomorph species occurring in the Grojec Clays (according to Bolkhovitina 1956, Couper 1958, Guy 1971, Guy-Ohlson 1982, Konijnenburg van Cittert 1971, Lund 1977, Orłowska-Zwolińska 1983, Pocock 1970, Rogalska 1976, Schulz 1967, Tralau 1968)

Name of species	Triassic	Jurassic			Cretaceous	
		Lower	Middle	Upper	Lower	Upper
1. Cf. *Alisporites robustus*		+	+			
2. Cf. *Alisporites thomasii*		+	+	+	+	+(?)
3. *Cerebropollenites macroverrucosus*		+	+	+	+	
4. *Classopollis*	+(R)	+	+	+	+	+
5. *Conbaculatisporites mesozoicus*	+(R)	+				
6. *Cyathidites minor*		+	+	+	+	+(?)
7. *Densoisporites perinatus*		+	+	+	+	+(?)
8. *Eucommiidites granulosus*		+	+			
9. *Eucommiidites troedssonii*	+	+	+	+	+	+
10. *Klukisporites variegatus*			+			
11. *Marattisporites scabratus*		+	+	+	+	
12. *Monosulcites minimus*	+(R)	+	+	+	+	+
13. *Osmundacidites (wellmanii)*		+	+	+	+	
14. *Vitreisporites pallidus*	+(?)	+	+	+	+	+(?)

+(?) — means that not all authors report the presence of the sporomorph in this time range.
+(R) — Rhaetic.

The present paper on pollen and spores of the Grojec Clays cannot give a decisive answer as to their age, because only certain sporomorphs were described. It can, however, be stated that most of the species described by the present author are known from the Lower Jurassic onwards. Only *Conbaculatisporites mesozoicus*, the species of *Classopollis* and *Monosulcites minimus* are reported starting with the Rhaetic, and *Eucommiidites troedssonii* with the Triassic. This might indicate that the Grojec Clays are not older than Lower Jurassic. One of the species, *Klukisporites variegatus*, is usually recorded only from Middle Jurassic which seems to indicate a Middle Jurassic age.

Rogalska (1976) besing on her investigations regarded certain of the above described species as index species or characteristic species for the Lower and Middle Jurassic of Poland. As index species are regarded those for which the moment of appearance in the profile in the given stratigraphical member had been observed. Characteristic species are those which mark in a special way the given stratigraphical member e.g. in high frequency of occurrence.

According to Rogalska index species for the Lower Jurassic are, among others, *Densoisporites perinatus*, certain species of *Klukisporites* and for the Middle Jurassic the species *Cyathidites minor*. In addition, species of *Cerebropollenites macroverrucosus*, *Marattisporites scabratus* and different species of *Tricolpites* (*Eucommiidites*) occur in the Middle Jurassic more frequently than in the Lower Jurassic.

Although no quantitative analysis of sporomorphs from the Grojec Clays had been carried out, it can be stated that the most frequent sporomorphs are species of *Eucommiidites* pollen grains and spores *Cyathidites minor*. The high frequency of those two sporomorphs seems to indicate the Middle Jurassic age of the Grojec Clays.

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STRESZCZENIE

W niniejszej pracy opisano 16 gatunków spor i ziarn pyłku z 12 rodzajów znalezionych w glinkach grojeckich pochodzących z miejscowości Grojec, Mirów i Orlej. Dziesięć taksonów oznaczono do gatunku, cztery do rodzaju, a dwa uznano za podobne do innych taksonów. Stosowano sztuczny system klasyfikacji Potoniégo.

Podjęto także próbę określenia przynależności botanicznej znalezionych sporomorf. Okazało się, że 6 gatunków należy do *Pteridophyta*, z czego 5 do *Filicales*, a jeden prawdopodobnie do *Lycopodiales*. Pozostałe 10 gatunków należy do *Gymnospermae*, z czego do *Pteridospermae* dwa, do *Caytoniales* jeden, do *Cycadales*, *Bennettitales* lub *Ginkgoales* jeden, do *Coniferales* trzy. Spośród *Coniferales* dwa gatunki należą do *Cheirolepidiaceae*, a dla jednego przynależność w obrębie *Coniferales* nie jest dokładnie znana. Trzy gatunki rodzaju *Eucommiidites* zaliczono do *Gymnospermae* incertae sedis.

Na podstawie składu roślinności wypowiedziano pogląd o możliwości panowania na badanym terenie w okresie jurajskim klimatu ciepłego i wilgotnego, zbliżonego do klimatu subtropikalnego lub tropikalnego. Poruszono także zagadnienie wieku glinek grojeckich i stwierdzono, że obecność sporomorf uznanych za wskaźnikowe i charakterystyczne (Rogalska 1976) może świadczyć o środkowojurajskim wieku glinek grojeckich.

Explanation of plates

All microphotographs ×1000 unless otherwise specified, they were taken with a Carl Zeiss type Lu microscope (nr 383827) with apochromatic objectives: 90× n. a. — 1.30, 40×—0.95, 20×—0.65 and eye-piece projective 6.3 : 1 and photomicrographic equipment mf-matic. SEM microphotographs were taken with a Jeol SMS_1 scanning microscope.

In the explanations after the name of the taxon is given the name of the locality, the slide number and the co-ordinates of the microscope cross-table indicating the position of the sporomorphs on the slide.

Objaśnienia do tablic

Wszystkie mikrofotografie ×1000, o ile nie zaznaczono inaczej; zostały one wykonane przy użyciu mikroskopu świetlenego Carl Zeiss typ Lu (nr 383827) i obiektywów apochromatycznych: 90× n. a. — 1.30, 40×—0.95, 20×—0.65 oraz okularu projekcyjnego 6.3 : 1 i urządzenia do automatycznego naświetlania mf-matic. Zdjęcia skaningowe zostały wykonane przy użyciu mikroskopu Jeol SMS_1.

W objaśnieniach po nazwie taksonu podano kolejno nazwę stanowiska, numer preparatu oraz po średniku współrzędne stolika krzyżowego mikroskopu, wyznaczające położenie sporomorfy na preparacie.

Plate I

1. *Cyathidites minor*, Mirów 1/16; 113/11
2. *Cyathidites minor*, Mirów 1/8; 102, 5/9, 5
3. *Cyathidites minor*, Mirów 1/10; 116/20
4. *Osmundacidites* sp. 1, Orlej 7; 107/13
5. *Conbaculatisporites mesozoicus*, Mirów 1/20; 106/12, 5
6. *Conbaculatisporites mesozoicus*, Mirów 1/12; 106/12
7. *Klukisporites variegatus*, Mirów 1/28; 118/16
8. *Monosulcites minimus*, Orlej 6; 105/13
9. *Classopollis* sp. 1, ×1050, Mirów 1/9; 112/3
10. *Classopollis* sp. 2, ×900, Mirów 1/18; 109/15
11. *Eucommiidites* sp. 1, Orlej 9; 112/14
12. *Cerebropollenites macroverrucosus*, Mirów 1/23; 109/10
13. *Eucommiidites granulosus*, Mirów 1/23; 108/6
14. *Eucommiidites troedssonii*, Orlej 12; 110/6, 5
15. *Eucommiidites troedssonii*, Orlej 1; 112/4
16. *Klukisporites variegatus*, fragment, ×1500, SEM

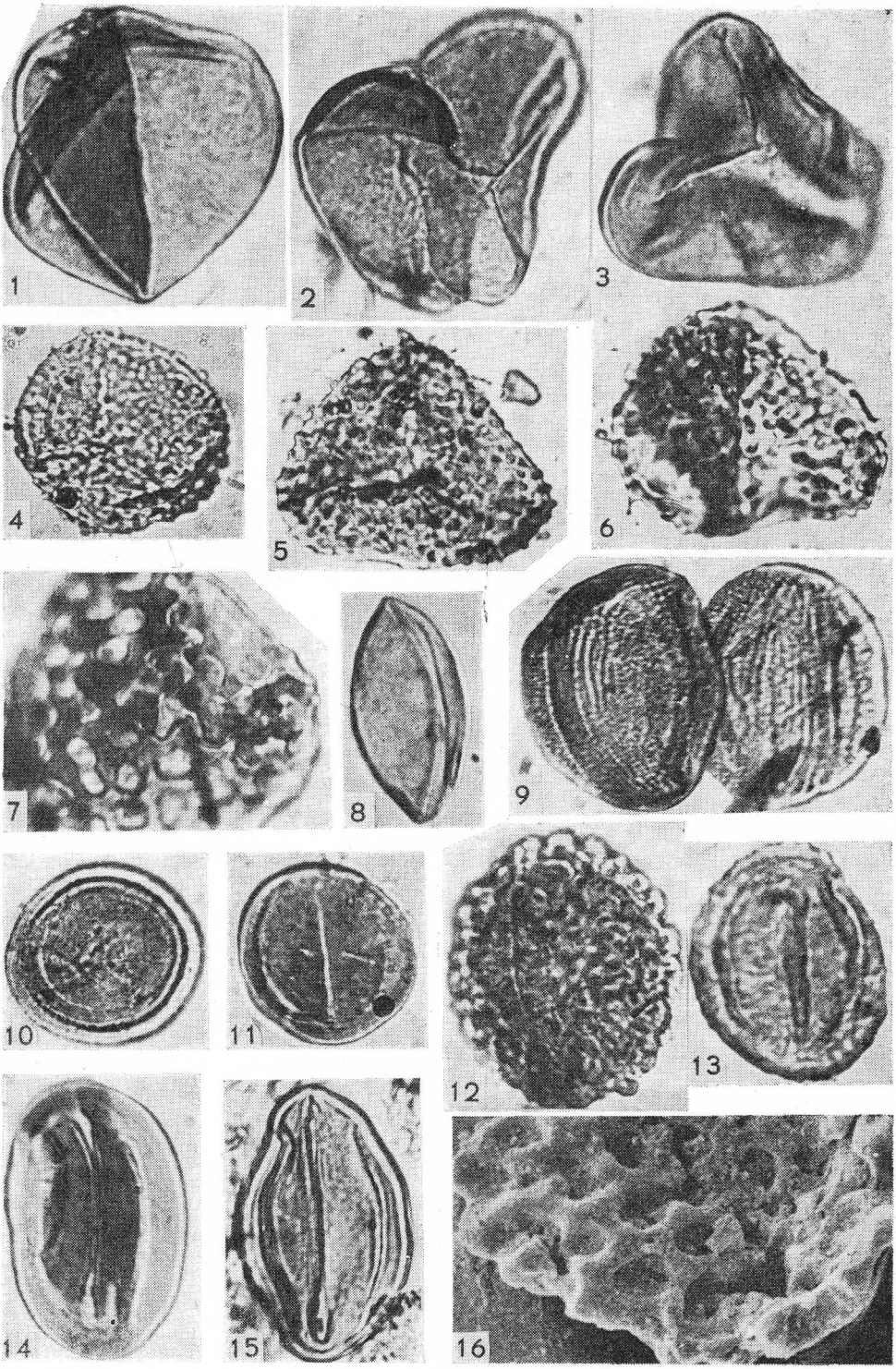

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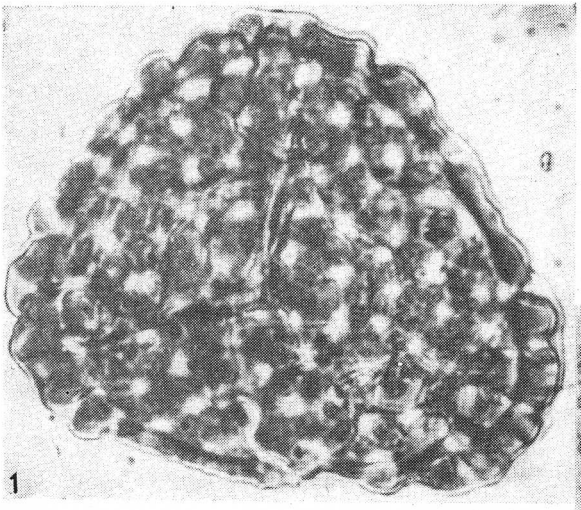
Plate II

1. *Klukisporites variegatus*, ×1160, Grojec 4/11; 108/12
2. *Marattisporites scabratus*, Mirów 1/26; 109/4
3. *Vitreisporites pallidus*, ×1140, Orlej 6; 124/15
4. Cf. *Alisporites robustus*, Mirów 1/19; 108/13
5. *Densoisporites perinatus*, Mirów 1/11; 102/8
6. Cf. *Alisporites thomasii*, Orlej 1; 107/3
8. Cf. *Alisporites robustus*, Mirów 1/19; 108/13
7. *Cerebropollenites macroverrucosus*, ×1000, SEM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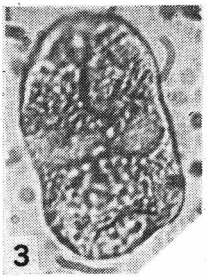
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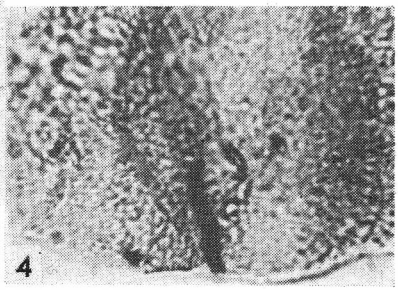
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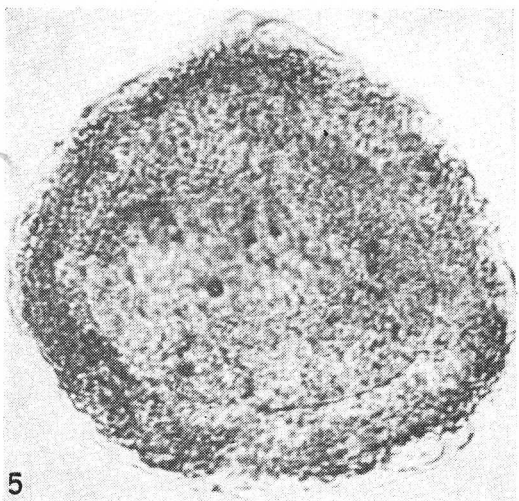
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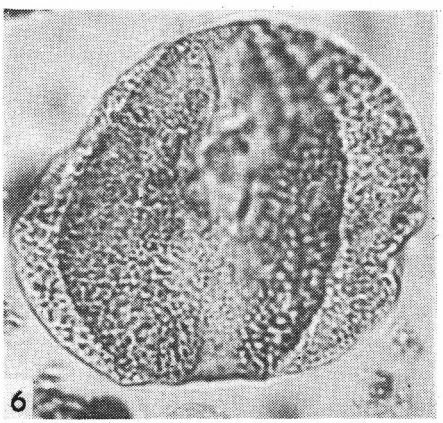
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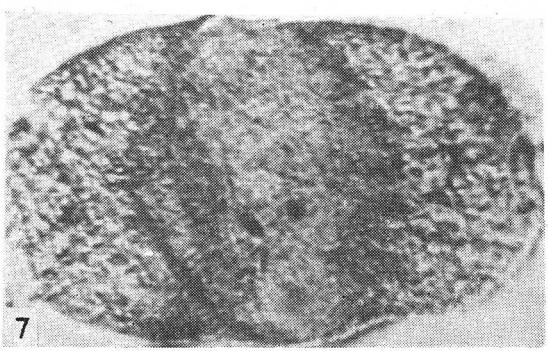
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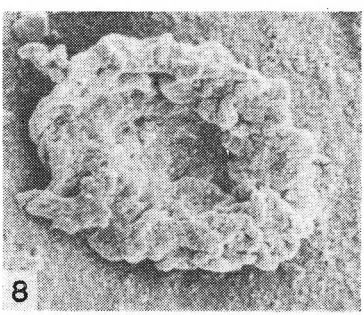
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