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Middle Miocene palynoflora of the Legnica lignite deposit complex, Lower Silesia, Poland

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ABSTRACT. Palynological analysis of three profiles of the Miocene deposits from Legnica site (east field, 33/56 and 41/52 profiles) and Ruja site (fragment of the Komorniki 97/72 profile) has been presented. The samples consisted of material from the 2nd Lusatian lignite seam, the Mużaków series, the 1st Henryk lignite seam and grey clays of the Poznań series. The age of the flora was defined as Badenian (?Late Karpatian – Late Badenian). During the studies a total of 201 taxa from 96 genera (including 195 taxa from 92 genera of pollen and spores) were identified. The systematic part of this work gives descriptions of selected sporomorphs and phytoplankton microfossils. Some informations about botanical affinity, occurrence in fossil floras and in the studied material, as well as about allied recent plants are given in remarks. The results are presented in three pollen diagrams. The taxa have been classified to an appropriate palaeofloristical element mainly on the basis of the checklist of selected pollen and spores taxa from the Neogene deposits. The dominance of warm-temperate (A1) element and frequency of palaeotropical taxa in various parts of the profiles point to a warm-temperate climate. The results were used for reconstruction of changes in local vegetation during the sedimentation of deposits under study. The following types of fossil plant communities were distinguished: swamp forest, bush swamp, riparian forest, mixed mesophytic forest, and reed marshes. The clear and constant predominance of swamp forest pollen taxa in the total sum implies a dominant role of this type of communities in formation of the lignite deposits. The presented pollen diagrams show their strong similarity to elaborated earlier diagrams from the Polish Lowland, but in the Mużaków series marine ingression's influence and presence of reed marshes (considered to be an early stage of succession on the Miocene peat-bogs) were confirmed.

KEY WORDS: pollen analysis, plant communities, palaeoecology, lignite deposits, Badenian, Miocene, Lower Silesia, Poland

CONTENTS

INTRODUCTION

Presence of lignite deposits in the Lower Silesia was the main reason for starting the scientific interest in this region. The first geological and palaeobotanical studies were carried out in the 19th century and at the beginning of the

20th century. Many elaborations of plant macro- and micro-remains were published in the second half of 20th century (Raniecka-Bobrowska 1952, 1962, 1970, Doktorowicz-Hrebnicka 1954, 1956b, c, Romanowicz 1961, Stachurska et al. 1967, 1971, 1973, Sadowska 1970, 1977, 1992, 1995, Ziembińska-Tworzydło 1974, Dyjor & Sadowska 1977, Sadowska & Zastawniak 1978, Jahn et al. 1984, Łańcucka-Środoniowa et al. 1992, and others).

Geological studies in the Legnica region were started by Berg (1936), however, a peculiar interest in the Tertiary sedimentary series of this terrain was aroused by numerous drillings connected with a lignite prospecting. In 1950–1966 in the Legnica–Lubin–Ścinawa region geological and prospecting works were carried out, and the Legnica and Ścinawa lignite deposits were discovered (Ciuk 1961a, b, 1966). The Legnica deposit was documented in 1968, whereas the complex geological investigations connected with project of a lignite mine were carried out in the seventies of 20th century (Szulc & Burzyński 1975). Then a series of drillings was done and some profiles from the Legnica–Ścinawa–Lubin Legnicki region were more or less detailed palynologically elaborated (see catalogue by Grabowska and Słodkowska 1993).

The Legnica lignite deposit is a platform type deposit that extends over a large area in the Legnica Depression. Together with neighbouring Ścinawa deposit they form the largest lignite-bearing area (about 15 × 30 km) in Poland (Jaroń et al. 1978, Ciuk & Piwocki 1990). The Legnica deposit consists of three (west, east and north) fields (Fig. 1). Total thickness of coal seams is 20.6–23.6 m (Ciuk 1987). Seams of the 1st, 2nd and 3rd groups form the major part of the coal resources, and the coal is considered to be one of the best quality brown coal in Poland (Majewski 1976, Jaroń et al. 1978).

The Ruja lignite deposit was discovered at the beginning of the nineties of 20th century. It is considered to be a satellite deposit in the Legnica–Ścinawa complex (Piwocki 1989, Dyląg & Kasiński 1995, Jęczmyk et al. 1997). The deposit is situated about 20 km south-east from Legnica (Fig. 1). The 2nd Lusatian seam is the main one there, at some places the 2ndA Lubin seam occurs. The 1st Henryk seam consists there of a few thin horizons (Dyląg 1995).

The aim of the present study was a detailed palynological analysis of the two profiles from the Legnica east field (Legnica 41/52 and

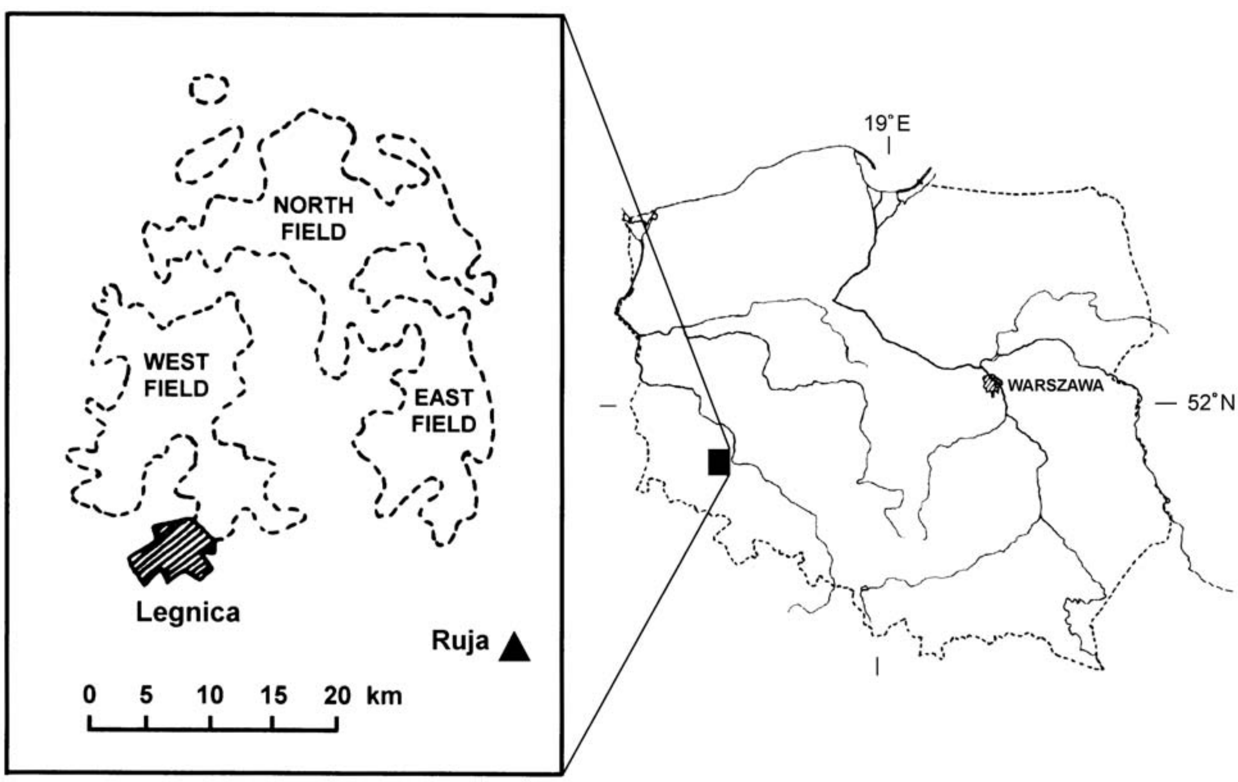

Fig. 1. Location of the Legnica lignite deposit complex (according to Jaroń et al. 1978, Wacnik & Worobiec 2001, slightly changed)

Legnica 33/56) and a fragment of the profile Komorniki 97/72 from the Ruja deposit, as well as the reconstruction of fossil plant communities and main features of palaeogeography and palaeoclimate during the sedimentation of the studied deposits. This paper is based on a PhD Thesis (Worobiec 2000).

GEOLOGY

The Legnica–Ścinawa lignite resource complex is situated on the Fore-Sudetic Block, in the Kaczawa zone. The Tertiary deposits of the studied area are mainly of continental origin, with temporary marine influences. For example the following Tertiary lithostratigraphic units have been distinguished by Dyjor (1970, 1978, 1986) in this region: Sieroszowice series, Lubusha series with 4th Głogów lignite seam, Żary series with 3rd Ścinawa seam, Silesian-Lusatian series with 2nd Lusatian seam, Mużaków series ended by 1st Henryk seam, Poznań series (divided into grey, green and flamy clays horizons), and Gozdnica series. These lithostratigraphic units have been used for the Legnica region, even though, according to the lithostratigraphic scheme of the Polish Lowland, new units (formations and members) have been distinguished (see Piwocki & Ziembińska-Tworzydło 1995, 1997, and Piwocki et al. 2004).

NEOGENE

The oldest Neogene series in the studied area is the Lower Miocene Żary series (correlated with Rawicz and Gorzów formations with Żary Member and 3rd Ścinawa lignite seam group). The above-lying Silesian-Lusatian series (correlated with Ścinawa and Krajenka formations with 2nd group of seams) shows a large variability, consisting mainly of sandy-gravel sediments, intercalated by thick layers of kaolinic clays, as well as silts and coal-bearing kaolinic clays. In the top fine-grained sediments, sandy clays, silts, and lignites occur (Dyjor 1978, 1982, 1986). The sedimentation period of this series ends with the 2nd Lusatian seam which has the largest extent and thickness. The series is Badenian (?Karpatian/Badenian) in age (Piwocki & Ziembińska-Tworzydło 1995, 1997). Deposits of the Silesian-Lusatian series (mainly light-grey clays) occur in the cores Legnica 33/56 (depth 114.2–111.6 m) and Legnica 41/52 (depth ?129.0–125.0 m).

The Lusatian seam is the main part of the fuel resources of the Legnica lignite deposit complex due to its thickness about 20–25 m. It often lies directly on the Palaeozoic basement or on weathering. Because the under-coal series compensate morphological differentiation of the pre-Cainozoic basement thickness (reaching about 120 m), equal sedimentation on large areas took place. At Legnica the Lusatian seam is divided into two horizons (by sands, sandy silts and coaly clays). At Ruja it has a form of one compact seam in central part, and 2–3 (or more) horizons at western and northern margins (Jaroń et al. 1978, Dyląg 1995). Deposits of the Lusatian seam (detritical brown coal with xylites) occur in all studied cores: Legnica 33/56 (depth 111.6–100.2 m), Legnica 41/52 (depth 125.0–114.2), and Komorniki 97/72.

The Mużaków series lies above the Lusatian seam mainly in northern part of the Fore-Sudetic Block and on the Fore-Sudetic Monocline (Dyjor 1978), and is correlated with Pawłowice and Adamów formations with the 2ndA Lubin group of seams (Piwocki & Ziembińska-Tworzydło 1995, 1997). This series consists predominantly of sandy-silt sediments of marine, brackish and partially swampy origin. In sandy clays and coaly silts fossil traces (burrows) were found, whereas in swampy deposits lenses of brown coal and sapropelites are present. Brackish sediments contain glauconite and poor fauna (sponges and foraminifers) remains (Dyjor & Wróbel 1978). Age of the Mużaków series was defined as the Middle Badenian (Piwocki & Ziembińska-Tworzydło 1995). At Legnica and Ścinawa this series is a few to 50 m thick. At some places the 2ndA Lubin seam occurs (Jaroń et al. 1978, Dyląg 1995). Deposits of the Mużaków series, coaly clays, at places with impressions or microremains of leaves, as well as sandy silts and sands, occur in the cores Legnica 33/56 (depth 100.2–76.6 m), Legnica 41/52 (depth 114.2–91.8), and Komorniki 97/72.

The Mużaków series is terminated by the Henryk seam (1st Mid-Polish group of seams), which ends continuous coaly sedimentation in the Tertiary Polish Lowland Basin. Within the Poznań clays only thin horizons or lenses of lignites are present. At places, for example in the Legnica and Ruja region, the seam is divided into two or more horizons. In the studied area its thickness reaches about 2–5 m at Legnica, 1–12 m at Ścinawa and about 0.6 m at Ruja, so it has a small influence on the scale of coal resources in the Legnica and Ruja deposits, whereas distinctly greater in the Ścinawa deposit. The seam consists of detrital, and sometimes hard, coal with inserts of xylites (Jaroń et al. 1978). Its age was determinated as the Late Badenian (Dyjor 1986, Dyjor & Sadowska 1986a, b, Piwocki & Ziembińska-Tworzydło 1995). Deposits of the Henryk seam (detritical brown coal with xylites) occur in the cores Legnica 33/56 (depth 76.6–74.0 m), Legnica 41/52 (depth 91.8–89.0 m), and Komorniki 97/72 (depth 77.5–77.6 m).

The Poznań series (Poznań Formation) is the next one in the lithostratigraphic scheme of the Fore-Sudetic Block. The series is the latest Middle Miocene – Early Pliocene (Late Badenian – Early Dacian) in age (Dyjor 1986, Dyjor & Sadowska 1986a, Piwocki & Ziembińska-Tworzydło 1995, 1997). In the Legnica–Ścinawa region the Poznań series is up to 40 m thick. The grey and green clay horizons are present, whereas the flamy clays occur only in part of the Legnica deposit and in the Ścinawa deposit (Jaroń et al. 1978). Deposits of the Poznań series occur in all studied cores, e.g. Legnica 33/56 (green clays with glauconite and flamy clays, depth 74.0–2.5 m) and Legnica 41/52 (grey clays, green clays with glauconite and flamy clays, depth 89.0–?25.0 m).

The youngest Neogene series in the Lower Silesia is the Gozdnica series (Gozdnica Formation). In the Legnica region only small fragments of these deposits still exist, and their thickness does not exceed 0.5 m (Jaroń et al. 1978, Sawicki 1995). Deposits of the Gozdnica series (light-grey fine-grained sands, clays and silts) occur only in one studied core Legnica 41/52 (depth ?25.0–7.0 m).

MATERIAL AND METHODS

Material from three boreholes – Legnica 33/56 (depth of 74.0–77.0 m and 90.0–112.0 m) and Legnica 41/52 (depth of 77.0–86.8 m, 89.3–91.8 m and 114.4–125.5 m), as well as Komorniki 97/72 from the Ruja deposit (depth of 77.2–81.4 m) have been used for palynological studies (Fig. 2). A total of 103 samples (46 from Legnica 33/56, 45 from Legnica 41/52 and 12 from Komorniki 97/72) have been collected. Material for pollen analysis was prepared by modified Erdtman's acetolysis method using HF acid (Faegri & Iversen 1975, Moore et al. 1991). Depending on frequency 1–6 slides from each sample were examined. Five samples (2 from Legnica 41/52, and 3 from Komorniki 97/72) were barren, and therefore data from 98 samples have been used to construct pollen diagrams (histograms).

The sporomorphs were identified on the basis of available publications and the palynological reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków.

Descriptions of selected sporomorphs and phytoplankton microfossils (that were not described in detail in previous elaborations, or having old descriptions), as well as some synonyms of the taxa are presented. Some informations about botanical affinity, occurrence in fossil floras and in the studied material as well as about allied recent plants are given in remarks. All taxa have been ordered taxonomically according to their botanical affinity, and classified to an appropriate palaeofloristical element mainly on the basis of the checklist of selected pollen and spore taxa from the Neogene deposits (Ziembińska-Tworzydło et al. 1994a), and the Atlas of Pollen and Spores of the Polish Neogene (Stuchlik et al. 2001, 2002, 2009). The following elements have been distinguished: palaeotropical (P): tropical (P1) and subtropical (P2), as well as arctotertiary (A): warm-temperate (A1) and cool-temperate (A2). Some species, of which the nearest living relatives occur in a variety of climatic conditions, were included into cosmopolitan (P/A) climatic element. All illustrations reproduced on the photo plates are presented at 1000 × magnification, except where otherwise stated.

GENERAL RESULTS OF POLLEN ANALYSIS

A total of 201 taxa from 96 genera (including 195 taxa from 92 genera of pollen and spores, and 6 taxa from 4 genera of fresh-water phytoplankton) have been identified. There are some multispecies genera (*Abiespollenites*, *Araliaceoipollenites*, *Cathayapollis*, *Cornaceaepollis*, *Ericipites*, *Graminidites*, *Ilexpollenites*, *Laevigatosporites*, *Nyssapollenites*, *Piceapollis*, *Quercoidites*, *Sciadopityspollenites*, *Sequoiapollenites*, *Stereisporites*, *Zonalapollenites*, and others).

In all studied samples pollen and spores of the arctotertiary palaeofloristical element (mainly A1 – warm-temperate) distinctly prevail. In the upper parts of both Legnica profiles and in the Komorniki profile this domination is the strongest. Taxa of the palaeotropical element (mainly P2 – subtropical) are more frequent in the lowest parts of both Legnica profiles (Tab. 1).

Pollen grains of conifers are numerous, but they show a comparatively small diversity in all studied profiles. Among them Taxodiaceae/

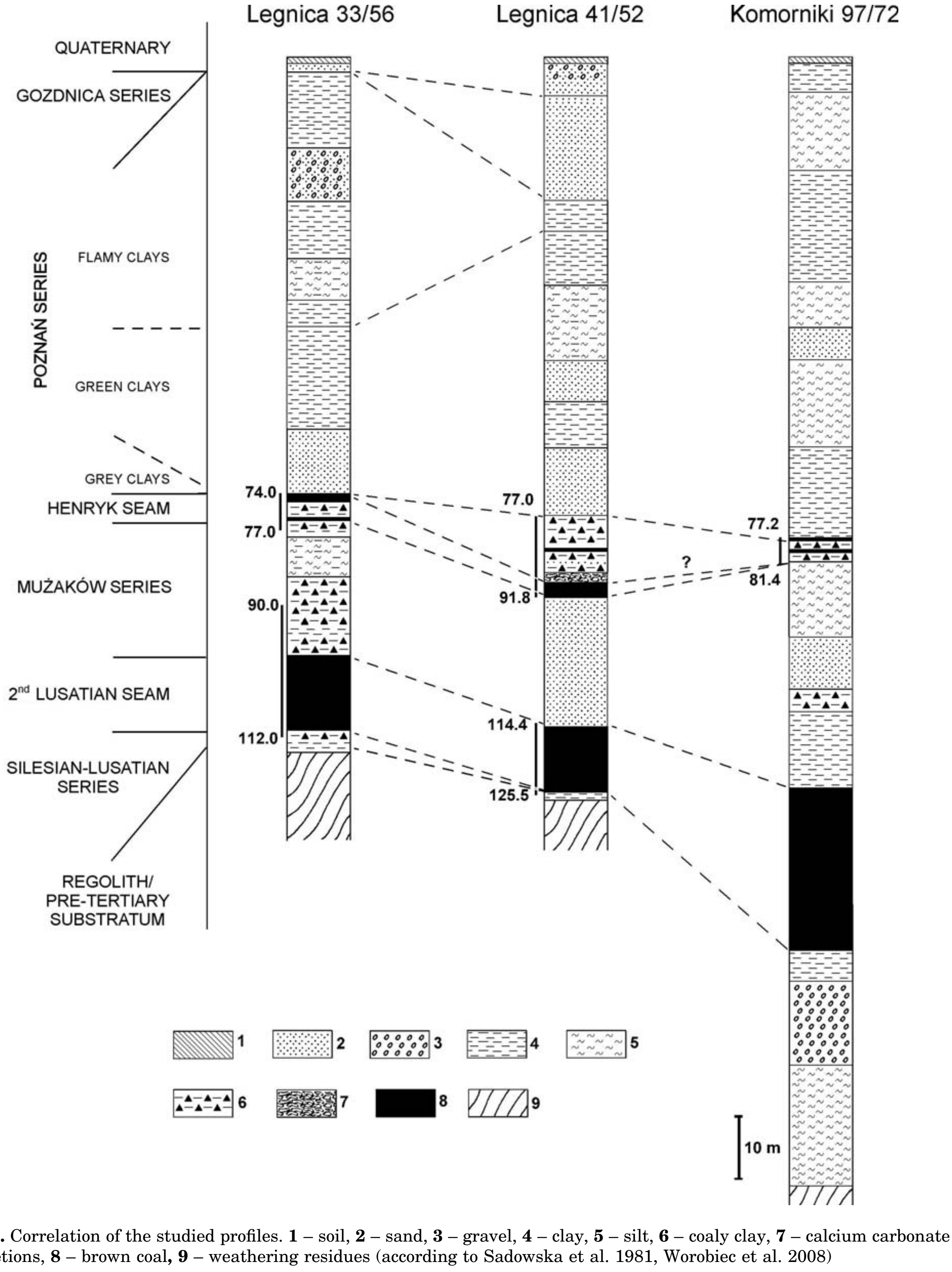

Fig. 2. Correlation of the studied profiles. **1** – soil, **2** – sand, **3** – gravel, **4** – clay, **5** – silt, **6** – coaly clay, **7** – calcium carbonate concretions, **8** – brown coal**, 9** – weathering residues (according to Sadowska et al. 1981, Worobiec et al. 2008)

Cupressaceae (*Inaperturopollenites*, max. 65% of total sum of pollen grains), *Sequoia* (*Sequoiapollenites*, up to 35%), *Pinus* – with predomination of *Pinus sylvestris* type (up to 30%), and *P.* type *Haploxylon* sensu Rudolph + *Cathaya* (up to 15%), are the most frequent. Pollen grains of *Abies* type were encountered in quantities up to 12%. *Picea*, *Tsuga* (*Zonalapollenites*) and *Sciadopitys* reach a few percent, whereas *Cedrus*, *Keteleeria*, and *Larix* were found sporadically.

Deciduous trees are represented by *Alnus* (max. 70%, with distinct predomination of tetraporate pollen grains), *Nyssa* (up to 30%),

Table 1. Distribution of palaeotropical (P1, P2 and P) geoflora elements in various levels distinguished in the Legnica and Komorniki pollen diagrams; L1–L4 – sections of the studied profiles; +: < 2%; ++: 2–5%; +++: > 5%

Element P1 (tropical)	L1	L2	L3	L4
Toroisporis (Toroisporis) teupitzensis medioris Krutzsch	–	+	–	–
Cornaceaepollis satzveyensis (Pflug) Ziembińska-Tworzydło	+	–	+	–
Magnolipollis neogenicus Krutzsch	+	+	+	+
Meliapollis sp.	+	–	–	–
Tetracolporopollenites andreanus Bruch	+	–	–	+
Tetracolporopollenites rotundus (Nagy) Bruch	+	–	–	–
Tricolporopollenites marcodurensis Pflug & Thomson	+	+	+	+
Element P2 (subtropical)				
Araliaceoipollenites edmundi (Potonié) Potonié ex Potonié	+++	+	++	+
Araliaceoipollenites euphorii (Potonié) Potonié ex Potonié	+	–	+	+
Araliaceoipollenites reticuloides Thiele-Pfeiffer	+	–	+	–
Arecipites papillosus (Mürriger & Pflug) Krutzsch	+	–	–	–
Arecipites pseudoconvexus Krutzsch	+	+	+	+
Castaneoideaepollis oviformis (Potonié) Grabowska	++	+	+	+
Castaneoideaepollis pusillus (Potonié) Grabowska	++	+	+	+
Cornaceaepollis major (Stuchlik) Stuchlik	+	–	–	–
Cornaceaepollis minor (Stuchlik) Stuchlik	+	–	+	–
Graminidites bambusoides Stuchlik	+	++	–	–
Ilexpollenites iliacus (Potonié) Thiergart	+++	+	+++	++
Ilexpollenites margaritatus (Potonié) Raatz ex Potonié	++	+	++	+
Ilexpollenites propinquus (Potonié) Potonié	+	–	–	–
Iteapollis angustiporatus (Schneider) Ziembińska-Tworzydło	+	+	–	+
Momipites punctatus (Potonié) Nagy	+++	+	++	+
Nelumbopollenites europaeus (Tarasevich) Skawińska	+	+	–	–
Platycaryapollenites miocaenicus Nagy	+	–	–	+
Quercoidites henrici (Potonié) Potonié, Thomson & Thiergart	+++	+	+	+
Quercoidites microhenrici (Potonié) Potonié, Thomson & Thiergart	+	–	+	–
Reevesiapollis triangulus (Mamczar) Krutzsch	+	+	+	+
Symplocoipollenites latiporis (Pflug & Thomson) Słodkowska	+	–	+	–
Symplocoipollenites vestibulum (Potonié) Potonié ex Potonié	+	+	++	+
Triatriopollenites rurensis Pflug & Thomson	++	+	+	+
Tricolporopollenites bruhlensis (Thomson) Grabowska	+	–	–	–
Tricolporopollenites exactus (Potonié) Grabowska	+++	+	++	+
Tricolporopollenites fallax (Potonié) Krutzsch	+++	+	++	+
Tricolporopollenites indeterminatus (Romanowicz) Ziembińska-Tworzydło	–	–	–	+
Tricolporopollenites liblarensis (Thomson) Grabowska	++	+	+	–
Tricolporopollenites megaexactus (Potonié) Thomson & Pflug	+	+	+	+
Tricolporopollenites pseudocingulum (Potonié) Thomson & Pflug	+++	+	++	+
Tricolporopollenites quisqualis (Potonié) Krutzsch	+	–	+	+
Tricolporopollenites staresedloensis Krutzsch & Pacltová	–	+	–	–
Element P				
Toroisporis (*Toroisporis*)? *pliocaenicus* (Thiergart) Krutzsch	+	+	–	+
Podocarpidites eocaenicus Krutzsch	+	–	–	+
Number of taxa	38	24	25	25
including : +++	7	–	1	–
++	5	1	7	1
+	26	23	17	24

Quercus (*Quercoidites henrici* + *Q. microhenrici* up to 6%; another species up to 12%), *Salix* (up to 16%), *Betula* (*Trivestibulopollenites betuloides*, up to 12%), *Ulmus/Zelkova* (up to 10%), as well as *Carya*, *Castanea/Castanopsis* (*Castaneoideaepollis ovifirmis* + *C. pusillus*), *Celtis*, *Engelhardia* (*Momipites punctatus*), *Fagus*, *Liquidambar* (*Periporopollenites*), and *Pterocarya* (*Polyatriopollenites stellatus*) – reaching a few per cent. Pollen grains of *Acer*, *Carpinus*, *Cercidiphyllum*, *Corylopsis*, *Eucommia*, *Fraxinus*, *Juglans*, *Liriodendron*, *Magnolia*, *Ostrya*, *Parrotia / Distylium* (*Tricolporopollenites indeterminatus* and *T. staresedloensis*), *Platycarya*, and Tilioideae (*Intratriporopollenites instructus*, *I. insculptus*, and *I. cordataeformis*) occur sporadically.

Among shrubs, climbers and small trees the most frequent are *Ilex* (max. 20%), Cyrillaceae/Clethraceae (*Tricolporopollenites exactus* – up to 20% and *T. megaexactus* – up to 1%), Ericaceae (up to 10%), Fabaceae (*Tricolporopollenites fallax* – up to 12%, *T. liblarensis* – up to 3%, *T. quisqualis*, and *Cassia* type – single specimens), *Tricolporopollenites pseudocingulum* (up to 42%), *Myrica* (up to 6%), Vitaceae (*Tricolporopollenites marcodurensis* and *Vitispollenites tener*), Araliaceae, Cornacae, Rosaceae (including *Tricolporopollenites photinioides*), Caprifoliaceae (including *Diervilla / Weigela*, *Lonicera*, *Sambucus*, and *Viburnum* types), *Symplocos*, and Oleaceae. In addition, some pollen grains of palms (*Arecipites pseudoconvexus* and *A. papillosus*), *Reevesia*, *Rhus*, Sapotaceae (*Tetracolporopollenites*), as well as *Itea*, Rubiaceae, Rutaceae, and *Staphylea* were found. It is necessary to stress that some of mentioned here taxa could be trees as well.

Among herbs only grasses (max. 70%; *Graminidites bambusoides* up to 5%) and Cyperaceae (up to 8%; mainly *Cladium* type) are relatively common. Several pollen grains of Lythraceae (including *Decodon* type), Chenopodiaceae, Asteraceae (*Artemisiaepollenites sellularis* and *Tubulifloridites*), Apiaceae (*Umbelliferoipollenites speciosus* and *U. tenuis*), Polygonaceae (*Persicarioipollis pliocenicus*, *P. welzowenze*, and *Rumex* type), Plantaginaceae (*Plantaginacearumpollis miocaenicus*), and Urticaceae (*Triporopollenites urticoides*) were encountered.

Aquatic and coastal plants are very rare, only some pollen grains of *Butomus* (*Butomuspollenites butomoides* and *B. longicolpatus*), *Potamogeton*, *Trapa*, *Nelumbo*, and Sparganiaceae (*Sparganiaceaepollenites magnoides*) were found.

Cryptogams are represented by Polypodiaceae s.l. (*Laevigatosporites gracilis*, *L. haardti*, *L. nitidus*, *Verrucatosporites favus*, *Perinomonoletes*) – max. 75%; *Sphagnum* (*Distancoraesporis*, *Distverrusporis*, and *Stereisporites*) – up to 35%, as well as *Osmunda* (*Baculatisporites* and *Rugulatisporites*) – up to 16%. A few spores of Lycopodiaceae (*Selagosporis selagoides*), Schizeaceae/Cyathaceae (*Monoleiotriletes gracilis*), *Toroisporis* (*Toroisporis*) *teupitzensis medioris*, *T.* (*Toroisporis*)? *pliocaenicus*, Anthocerotaceae (*Rudolphisporis major*), and Bryales (*Corrusporis* cf. *tuberculatus*) were also found.

Besides pollen and spores some plankton forms – mainly dinoflagellate cysts (dinocysts), Zygnemataceae zygospores (*Ovoidites elongatus*, *O. ligneolus*, and *Tetraporina* sp.), *Sigmopollis pseudosetarius* and *S. punctatus*, linings of foraminifers as well as fungi spores, fragments of epidermis, stomata, wood fragments and sporocarps of epiphylous fungi of the family Microthyriaceae (*Microthyriacites*, *Phragmothyrites*, *Plochmopeltinites*, and *Trichothyrites* = *Notothyrites*) occur in the analysed material.

LIST OF SPORE, POLLEN AND FRESH-WATER PHYTOPLANKTON TAXA FOUND IN THE STUDIED MATERIAL

(1) *Distancoraesporis wehningensis* (Krutzsch) Grabowska

(2) *Distverrusporis antiquus* (Krutzsch & Sontag) Grabowska

(3) *Distverrusporis electus* (Mamczar ex Krutzsch) Grabowska

(4) *Stereisporites involutus* (Doktorowicz-Hrebnicka ex Krutzsch) Krutzsch

(5) *Stereisporites minor* (Raatz) Krutzsch

(6) *Stereisporites stereoides* (Potonié & Venitz) Thomson & Pflug

(7) *Stereisporites welzowensis* Krutzsch & Sontag

(8) *Corrusporis* cf. *tuberculatus* Krutzsch

(9) *Rudolphisporis major* (Stuchlik) Stuchlik

(10) *Selagosporis selagoides* Krutzsch

(11) *Baculatisporites major* (Raatz) Krutzsch

(12) *Baculatisporites primarius* (Wolff) Pflug & Thomson

(–) *Baculatisporites nanus* (Wolff) Krutzsch (not illustrated)

(13) *Rugulatisporites quintus* Pflug & Thomson

(14) *Monoleiotriletes gracilis* Krutzsch

(15) *Laevigatosporites gracilis* Wilson & Webster

(16) *Laevigatosporites crassicus* (Krutzsch) stat. nov.

(17) *Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug

(18) *Laevigatosporites nitidus* (Mamczar) Krutzsch

(19) *Verrucatosporites favus* (Potonié) Thomson & Pflug

(20) *Perinomonoletes pliocaenicus* Krutzsch

(21) *Perinomonoletes* cf. *goersbachensis* Krutzsch

(22) *Perinomonoletes spicatus* Nagy

(23) *Perinomonoletes* sp. 1

(24) *Toroisporis* (*Toroisporis*) *teupitzensis medioris* Krutzsch

(25) *Toroisporis* (*Toroisporis*)? *pliocaenicus* (Thiergart) Krutzsch

(26) *Cupressacites bockwitzensis* Krutzsch

(27) *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug

(28) *Inaperturopollenites concedipites* (Wodehouse) Krutzsch

(29) *Inaperturopollenites verrupapilatus* Trevisan

(30) *Sciadopityspollenites antiquus* Krutzsch ex Planderová

(31) *Sciadopityspollenites quintus* Krutzsch ex Ziembińska-Tworzydło

(32) *Sciadopityspollenites serratus* (Potonié & Venitz) Raatz ex Potonié

(33) *Sciadopityspollenites tuberculatus* (Zaklinskaya) Krutzsch

(34) *Sciadopityspollenites varius* Krutzsch ex Ziembińska-Tworzydło

(35) *Sciadopityspollenites verticillatiformis* (Zauer) Krutzsch

(36) *Sequoiapollenites major* Krutzsch

(37) *Sequoiapollenites polyformosus* Thiergart

(38) *Sequoiapollenites rotundus* Krutzsch

(39) *Sequoiapollenites rugulus* Krutzsch

(40) *Sequoiapollenites undulatus* Kohlman-Adamska

(41) *Sequoiapollenites sculpturius* Krutzsch

(42) *Sequoiapollenites largus* (Kremp) Manum

(43) *Abiespollenites absolutus* Thiergart ex Potonié

(44) *Abiespollenites latisaccatus* (Trevisan) Krutzsch ex Ziembińska-Tworzydło

(45) *Abiespollenites maximus* Krutzsch ex Nagy

(46) *Cathayapollis erdtmanii* (Sivak) Ziembińska-Tworzydło

(47) *Cathayapollis potoniei* (Sivak) Ziembińska-Tworzydło

(48) *Cathayapollis wilsonii* (Sivak) Ziembińska-Tworzydło

(49) *Cathayapollis pulaensis* (Nagy) Ziembińska-Tworzydło

(50) *Cedripites lusaticus* Krutzsch

(51) *Cedripites miocaenicus* Krutzsch

(52) *Keteleeriapollenites dubius* (Khlonova) Słodkowska

(53) *Laricispollenites* sp.

(54) *Piceapollis planoides* Krutzsch ex Hochuli

(55) *Piceapollis sacculiferoides* Krutzsch ex Hochuli

(56) *Piceapollis tobolicus* (Panova) Krutzsch

(57) *Pinuspollenites labdacus* (Potonié) Raatz ex Potonié

(58) *Pinuspollenites macroinsignis* (Krutzsch ex Olliver-Pierre) Planderová

(59) *Zonalapollenites gracilis* Krutzsch ex Konzalová et al.

(60) *Zonalapollenites verrucatus* Krutzsch ex Ziembińska-Tworzydło

(61) *Zonalapollenites spectabilis* (Doktorowicz-Hrebnicka) Ziembińska-Tworzydło

(62) *Zonalapollenites maximus* (Raatz) Krutzsch ex Ziembińska-Tworzydło

(63) *Zonalapollenites robustus* Krutzsch ex Kohlman-Adamska

(64) *Podocarpidites eocenicus* Krutzsch

(65) *Liriodendroipollis verrucatus* Krutzsch

(66) *Liriodendroipollis semiverrucatus semiverrucatus* Krutzsch

(67) *Liriodendroipollis semiverrucatus minor* Krutzsch

(68) *Magnolipollis neogenicus major* Krutzsch

(69) *Magnolipollis neogenicus minor* Krutzsch

(70) *Magnolipollis neogenicus neogenicus* Krutzsch

(71) *Nelumbopollenites europaeus* (Tarasevich) Skawińska

(72) *Chenopodipollis stellatus* (Mamczar) Krutzsch

(73) *Persicarioipollis pliocenicus* Krutzsch

(74) *Persicarioipollis welzowenze* Krutzsch

(75) *Rumex* L. type

(76) *Eucommioipollis parmularius* (Potonié) Ziembińska-Tworzydło

(77) *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło

(78) *Periporopollenites orientaliformis* (Nagy) Kohlman-Adamska & Ziembińska-Tworzydło

(79) *Periporopollenites stigmosus* (Potonié) Thomson & Pflug

(80) *Tricolporopollenites* sp. 1 – *Corylopsis* type sensu Oszast

(81) *Tricolporopollenites indeterminatus* (Romanowicz) Ziembińska-Tworzydło

(82) *Tricolporopollenites staresedloensis* Krutzsch & Pacltová

(83) *Castaneoideaepollis oviformis* (Potonié) Grabowska

(84) *Castaneoideaepollis pusillus* (Potonié) Grabowska

(85) *Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug

(86) *Tricolporopollenites theacoides* (Roche

& Schuler) Kohlman-Adamska & Ziembińska-Tworzydło
(87) *Faguspollenites verus* Raatz
(88) *Quercoidites asper* (Pflug & Thomson) Słodkowska
(89) *Quercoidites granulatus* (Nagy) Słodkowska
(90) *Quercoidites henrici* (Potonié) Potonié, Thomson & Thiergart
(91) *Quercoidites microhenrici* (Potonié) Potonié, Thomson & Thiergart
(92) *Alnipollenites verus* (Potonié) Potonié
(93) *Carpinipites carpinoides* (Pfug) Nagy
(94) *Ostryoipollenites rhenanus* Thomson ex Potonié
(95) *Triporopollenites coryloides* Pflug
(96) *Trivestibulopollenites betuloides* Pflug
(97) *Myricipites pseudoruresis* (Pflug) Grabowska & Ważyńska
(98) *Triatriopollenites rurensis* Pflug & Thomson
(99) *Caryapollenites simplex* (Potonié) Raatz ex Potonié
(100) *Momipites punctatus* (Potonié) Nagy
(101) *Juglanspollenites sadowskae* Kohlman-Adamska & Ziembińska-Tworzydło
(102) *Juglanspollenites verus* Raatz
(103) *Platycaryapollenites miocaenicus* Nagy
(104) *Polyatriopollenites stellatus* (Potonié) Pflug
(105) *Symplocoipollenites latiporis* (Pflug & Thomson) Słodkowska
(106) *Symplocoipollenites vestibulum* (Potonié) Potonié ex Potonié
(107) *Ericipites callidus* (Potonié) Krutzsch
(108) *Ericipites ericius* (Potonié) Potonié
(109) *Ericipites hidasensis* Nagy
(110) *Ericipites roboreus* (Potonié) Krutzsch
(111) *Tricolporopollenites exactus* (Potonié) Grabowska
(112) *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug
(113) *Tricolporopollenites bruhlensis* (Thomson) Grabowska
(114) *Tetracolporopollenites andreanus* Bruch
(115) *Tetracolporopollenites rotundus* (Nagy) Bruch
(116) *Salixipollenites capreaformis* Planderová
(117) *Salixipollenites cinereaformis* Planderová
(118) *Salixipollenites helveticus* Nagy
(119) *Intratriporopollenites instructus* (Potonié) Thomson & Pflug
(120) *Intratriporopollenites insculptus* Mai
(121) *Intratriporopollenites cordataeformis* (Wolff) Mai
(122) *Reevesiapollis triangulus* (Mamczar) Krutzsch
(123) *Tricolporopollenites* sp. 2 – Sterculioideae, Rutaceae type
(124) *Celtipollenites bobrowskae* Kohlman-Adamska & Ziembińska-Tworzydło
(125) *Celtipollenites komloensis* Nagy
(126) *Ulmipollenites maculosus* Nagy
(127) *Zelkovaepollenites potoniei* Nagy
(128) *Triporopollenites urticoides* Nagy
(129) *Tricolporopollenites photinioides* Skawińska
(130) *Tricolporopollenites* sp. 3 – Rosaceae type
(131) *Iteapollis angustiporatus* (Schneider) Ziembińska-Tworzydło
(132) *Lythraceaepollenites bavaricus* Thiele-Pfeiffer
(133) *Lythraceaepollenites decodonensis* Stuchlik
(134) *Sporotrapoidites erdtmani* (Nagy) Nagy
(135) *Corsinipollenites oculusnoctis* (Thiergart) Nakoman
(136) *Tricolporopollenites fallax* (Potonié) Krutzsch
(137) *Tricolporopollenites liblarensis* (Thomson) Grabowska
(138) *Tricolporopollenites quisqualis* (Potonié) Krutzsch
(139) *Tricolporopollenites* sp. 4 – *Cassia* L. type
(140) *Tricolporopollenites* sp. 5 – *Staphylea* L. type
(141) *Aceripollenites microrugulatus* Thiele-Pfeiffer
(142) *Aceripollenites* sp. 1
(143) ?Rutaceae type
(144) *Meliapollis* sp.
(145) *Rhuspollenites ornatus* Thiele-Pfeiffer
(146) *Ilexpollenites iliacus* (Potonié) Thiergart ex Potonié
(147) *Ilexpollenites margaritatus* (Potonié) Raatz ex Potonié
(148) *Ilexpollenites propinquus* (Potonié) Potonié
(149) *Spinulaepollis arceuthobioides* Krutzsch
(150) *Tricolporopollenites marcodurensis* Pflug & Thomson
(151) *Vitispollenites tener* Thiele-Pfeiffer
(152) *Nyssapollenites analepticus* (Potonié) Planderová
(153) *Nyssapollenites rodderensis* (Thiergart) Kedves
(154) *Nyssapollenites pseudocruciatus* (Potonié) Thiergart
(155) *Cornaceaepollis major* (Stuchlik) Stuchlik
(156) *Cornaceaepollis minor* (Stuchlik) Stuchlik
(157) *Cornaceaepollis satzveyensis* (Pflug) Ziembińska-Tworzydło
(158) *Araliaceoipollenites edmundi* (Potonié) Potonié ex Potonié
(159) *Araliaceoipollenites euphorii* (Potonié) Potonié ex Potonié
(160) *Araliaceoipollenites reticuloides* Thiele-Pfeiffer
(161) *Tricolporopollenites* sp. 6 – Araliaceae, Cornaceae type

(162) *Tricolporopollenites* sp. 7 – Araliaceae, Rhamnaceae type
(163) *Umbelliferoipollenites speciosus* Nagy
(164) *Umbelliferoipollenites tenuis* Nagy
(165) *Diervillapollenites* sp.
(166) *Lonicerapollis* sp.
(167) *Caprifoliipites viburnoides* (Gruas-Cavagnetto) Kohlman-Adamska
(168) *Caprifoliipites* sp. 1
(169) *Theligonumpollenites baculatus* (Stachurska, Sadowska & Dyjor) Thiele-Pfeiffer
(170) Rubiaceae type
(171) *Tricolporopollenites retimuratus* Trevisan
(172) *Tricolporopollenites sinuosimuratus* Trevisan
(173) *Tricolporopollenites* cf. *retiformis* (Pflug & Thomson) Krutzsch
(174) *Plantaginaceaerumpollis miocaenicus* Nagy
(175) Lamiaceae type
(176) *Tubulifloridites anthemidearum* Nagy
(177) *Tubulifloridites granulosus* Nagy
(178) *Artemisiaepollenites sellularis* Nagy
(179) *Butomuspollenites butomoides* (Krutzsch) Ziembińska-Tworzydło
(180) *Butomuspollenites longicolpatus* (Krutzsch) Ziembińska-Tworzydło
(181) *Potamogetonacidites paluster* (Manten) Mohr
(182) ?Araceae type
(183) *Cyperaceaepollis neogenicus* Krutzsch
(184) *Cyperaceaepollis piriformis* Thiele-Pfeiffer
(185) *Graminidites bambusoides* Stuchlik
(186) *Graminidites crassiglobosus* (Trevisan) Krutzsch
(187) *Graminidites laevigatus* Krutzsch
(188) *Graminidites neogenicus* Krutzsch
(189) *Graminidites pseudogramineus* Krutzsch
(190) *Graminidites subtiliglobosus* (Trevisan) Krutzsch
(191) *Sparganiaceaepollenites magnoides* Krutzsch
(–) *Sparganiaceaepollenites polygonalis* Thiergart ex Potonié (not illustrated)
(192) *Arecipites pseudoconvexus* Krutzsch
(193) *Arecipites papillosus* (Mürriger & Pflug) Krutzsch
(194) *Sigmopollis pseudosetarius* (Weyland & Pflug) Krutzsch & Pacltová
(195) *Sigmopollis punctatus* Krutzsch & Pacltová
(196) *Ovoidites elongatus* (Hunger) Krutzsch
(197) *Ovoidites ligneolus* Potonié ex Krutzsch
(198) *Tetraporina* sp.
(199) *Circulisporites circulus* (Wolff) Krutzsch & Pacltová

SYSTEMATIC DESCRIPTION OF SELECTED SPORES, POLLEN GRAINS AND OTHER MICROREMAINS

SPOROMORPHS

Divisio **TELOMOPHYTA**
Classis **BRYOPSIDA**
Ordo **SPHAGNALES**
Familia **SPHAGNACEAE**

Sphagnum L.

Distancoraesporis (Krutzsch 1963) S.K. Srivastava 1972

(1) ***Distancoraesporis wehningensis*** (Krutzsch 1963) Grabowska in Stuchlik et al. 2001

Pl. 1, fig. 1a, b

1963b *Stereisporites* (*Distancoraesporis*) *wehningensis* n. fsp., Krutzsch, p. 58, pl. 11, figs 1–14.

2001 *Distancoraesporis wehningensis* (Krutzsch) Grabowska comb. nov.; Stuchlik et al., p. 9, pl. 1, fig. 8a, b.

R e m a r k s. This taxon occurs in Europe in the Middle Miocene to Pliocene deposits. It is also known from the Middle Miocene of north-western Poland (Stuchlik et al. 2001). In the analysed material these spores were encountered sporadically.

Distverrusporis (Krutzsch 1963) Jameossanaie 1987

(2) ***Distverrusporis antiquus*** (Krutzsch & Sontag in Krutzsch 1963) Grabowska in Stuchlik et al. 2001

Pl. 1, fig. 3

1963b *Stereisporites* (*Distverrusporis*) *antiquus* Krutzsch & Sontag n. fsp.; Krutzsch, p. 74, pl. 18, figs 1–8.

2001 *Distverrusporis antiquus* (Krutzsch & Sontag in Krutzsch) Grabowska comb. nov; Stuchlik et al., p. 10, pl. 1, fig. 11a, b.

R e m a r k s. This taxon occurs in the European Miocene. It is reported from the Middle Miocene deposits of north-western Poland (Stuchlik et al. 2001). In the analysed material these spores were encountered sporadically.

(3) ***Distverrusporis electus*** (Mamczar 1960 ex Krutzsch 1963) Grabowska in Stuchlik et al. 2001

Pl. 1, fig. 2a, b

1960 cf. *Sphagnum* – *Sporites stereoides* Potonié & Venitz f. *electa*, Mamczar, p. 22, 196, pl. 1, fig. 5.

1963b *Stereisporites* (*Distverrusporis*) *electus* (Mamczar) n. comb., Krutzsch, p. 72, pl. 17, fig. 15.

2001 *Distverrusporis electus* (Mamczar ex Krutzsch) Grabowska comb. nov.; Stuchlik et al., p. 10, pl. 1, fig. 12a, b.

Remarks. This taxon occurs in Europe in the Middle Miocene deposits, e.g. in central Poland (Stuchlik et al. 2001). In the studied material these spores were found sporadically.

Stereisporites Pflug in Thomson & Pflug 1953

(4) ***Stereisporites involutus*** (Doktorowicz-Hrebnicka 1960 ex Krutzsch 1963) Krutzsch 1963

Pl. 1, fig. 6

1960 cf. *Sphagnum* – *Sporites stereoides* R. Pot. & Ven. forma *involuta*, Doktorowicz-Hrebnicka, p. 224, pl. 15, fig. 2.

1963b *Stereisporites* (*Stereisporites*) *involutus* (Doktorowicz-Hrebnicka) subfsp. *involutus*, Krutzsch, p. 44, pl. 4, figs 12–23.

2001 *Stereisporites involutus* (Doktorowicz-Hrebnicka ex Krutzsch) Krutzsch; Stuchlik et al., p. 12, pl. 2, figs 8, 9.

Remarks. This taxon is known in Europe from the Eocene to Pliocene deposits; in Poland occurs sporadically in the Middle Miocene (Doktorowicz-Hrebnicka 1960, Stuchlik et al. 2001). These spores were rare in the analysed material.

(5) ***Stereisporites minor*** (Raatz 1937) Krutzsch 1959

Pl. 1, fig. 5

1937 *Sphagnum-sporites stereoides* Potonié & Venitz f. *minor*, Raatz, p. 9, pl. 1, fig. 5.

1959 *Stereisporites minor* (Raatz) n. comb. subfsp. *minor*, Krutzsch, p. 71.

1963b *Stereisporites* (*Stereisporites*) *minor* (Raatz) Krutzsch subfsp. *minor*, Krutzsch, p. 36, pl. 1, figs 1–40.

2001 *Stereisporites minor* (Raatz) Krutzsch; Stuchlik et al., p. 13, pl. 2, figs 10–12.

Remarks. This species occurs in Europe in the Palaeocene to Pliocene deposits, and it is common all over Poland in the Lower and Middle Miocene (Stuchlik et al. 2001). In the studied material these spores were often found, but they were not numerous.

(6) ***Stereisporites stereoides*** (Potonié & Venitz 1934) Thomson & Pflug 1953

Pl. 1, fig. 7

1934 *Sporites stereoides* n. sp., Potonié & Venitz, p. 11, pl. 1, figs 4, 5.

1953 *Stereisporites stereoides* (Potonié & Venitz) n. comb., Thomson & Pflug, p. 53, pl. 1, figs 63–74.

1963b *Stereisporites* (*Stereisporites*) *stereoides stereoides* (Potonié & Venitz) Thomson & Pflug subfsp. *stereoides*, Krutzsch, p. 42, pl. 3, figs 1–30.

2001 *Stereisporites stereoides* (Potonié & Venitz) Thomson & Pflug; Stuchlik et al., p. 14, pl. 3, figs 7–16.

Remarks. This species occurs in Europe in the Eocene to Pliocene deposits. In Poland it is common in the Miocene and rare in the Pliocene (Stuchlik et al. 2001). In the studied material these spores were encountered regularly in small quantities, mainly in the Lusatian seam.

(7) ***Stereisporites welzowensis*** Krutzsch & Sontag in Krutzsch 1963

Pl. 1, fig. 8

1963b *Stereisporites* (*Stereisporites*) *welzowensis* Krutzsch & Sontag n. fsp., Krutzsch, p. 48, pl. 6, figs 17–22.

2001 *Stereisporites welzowensis* Krutzsch & Sontag in Krutzsch; Stuchlik et al., p. 15, pl. 3, fig. 18a, b.

Remarks. This species occurs in Europe in the Middle Miocene to Pliocene fossil palynofloras. It is also known from the Middle and Upper Miocene deposits from central Poland (Stuchlik et al. 2001). In the studied material these spores were found sporadically. In addition, some other not closely determined Sphagnaceae spores were found.

All fossil spores related to the recent genus *Sphagnum* (*Distancoraesporis*, *Distverrusporis* and *Stereisporites*) represent cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). In Neogene deposits spores of *Sphagnum* usually do not exceed 2–5%. In the studied material, in samples from the Lusatian seam of both

Legnica profiles, they exceeded 10% (reaching max. 20% and 35%, respectively).

The recent genus *Sphagnum* (320 species) is a cosmopolitan element distributed in tropical and temperate zones, mostly on peat bogs, playing an important role in peat genesis. In the Atlantic part of North America *Sphagnum* is a component of Taxodiaceae/Cupressaceae swamp forest.

Ordo **BRYALES**

Corrusporis Krutzsch 1967

(8) ***Corrusporis*** cf. ***tuberculatus*** Krutzsch 1967

Pl. 1, fig. 10a, b

1967 *Corrusporis tuberculatus tuberculatus* n. fsp., Krutzsch, p. 226, pl. 89, figs 1–8.

2001 *Corrusporis tuberculatus* Krutzsch; Stuchlik et al.; p. 16, pl. 3, fig. 19.

An alete spore, circular in outline, 34 µm in diameter. The whole surface covered by densely spaced elements, mostly 1–4 µm high, various in shape.

Remarks. The fossil genus *Corrusporis* is most similar in structure to spores of recent mosses (Bryales), especially Bryaceae (*Pohlia* and *Melichhoferia*), Dicranaceae (*Blindia*), Leptostomaceae, Meeseaceae, Pottiaceae, and Orthotrichaceae (Krutzsch 1967). The fossil genus *Corrusporis* represents cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). One spore was found in bottom sample of the Legnica profile. The spore was smaller than described by Stuchlik et al. (2001).

The recent Bryales (about 10 000 species) grow under widely different ecological and climatic conditions being an important element in peat formation.

Classis **ANTHOCEROPSIDA**
Ordo **ANTHOCEROTALES**
Familia **ANTHOCEROTACEAE**

Rudolphisporis Krutzsch 1963

(9) ***Rudolphisporis major*** (Stuchlik 1964) Stuchlik in Stuchlik et al. 2001

Pl. 1, fig. 12a, b

1964 *Rudolphisporis rudolphi* Krutzsch ssp. *major* n. spm., Stuchlik, p. 10, pl. 1, figs 8–10.

2001 *Rudolphisporis major* (Stuchlik) Stuchlik comb. nov.; Stuchlik et al., p. 16, pl. 3, figs 22, 23.

Remarks. Only one spore of this taxon was found in the Mużaków series. Morphologically, it is most similar to spores of the recent Anthocerothaceae. This taxon is known from the Middle Miocene deposits from north-eastern Poland. It represents cosmopolitan (P/A) climatic element (Stuchlik et al. 2001).

Classis **LYCOPSIDA**
Ordo **LYCOPODIALES**
Familia **LYCOPODIACEAE**

Huperzia selago (L.) Bernh. ex Schrank & Mart. type

Selagosporis Krutzsch 1963

(10) ***Selagosporis selagoides*** Krutzsch 1963

Pl. 1, fig. 11

1963a *Selagosporis selagoides* n. fsp., Krutzsch, p. 136, pl. 49, figs 6–19.

Remarks. The fossil spore found in the Lusatian seam is most similar in structure to those of the recent *Huperzia selago* (L.) Bernh. ex Schrank & Mart. (=*Lycopodium selago*). *Selagosporis selagoides* represents cosmopolitan (P/A) climatic element, and occurs in Europe in the Miocene and Pliocene deposits. It is also found in Polish Middle Miocene (Stuchlik et al. 2001).

Huperzia selago is distributed in the northern hemisphere in the mountains of tropical and subtropical zones, as well in lowlands and mountains in temperate zone.

Classis **PTEROPSIDA**
Familia **OSMUNDACEAE**

Osmunda L.

Baculatisporites Pflug & Thomson in Thomson & Pflug 1953

(11) ***Baculatisporites major*** (Raatz 1937) Krutzsch 1959

Pl. 2, fig. 1a, b

1937 *Sporites primarius* Wolff f. *major* n. f., Raatz, p. 13, pl. 1, fig. 14.

1959 *Baculatisporites major* (Raatz) n. comb., Krutzsch, p. 140.
1967 *Baculatisporites primarius major* Raatz; Krutzsch, p. 56, pl. 10, figs 1–6.
1994b *Osmundacidites primarius major* (Raatz) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 12, pl. 4, fig. 10a, b.
2001 *Baculatisporites major* (Raatz) Krutzsch; Stuchlik et al., p. 30, pl. 24, figs 1–3.

Remarks. According to Krutzsch (1967) spores of this taxon are similar to the recent *Osmunda vachelli* Hook., and *O. presliana* J. Sm. They occur in Europe in the Upper Oligocene to Pliocene deposits, and are common in the Polish Middle Miocene. They are classified to cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). In the studied material these spores were often found.

(12) ***Baculatisporites primarius*** (Wolff 1934) Pflug & Thomson in Thomson & Pflug 1953

Pl. 1, fig. 14a, b

1934 *Sporites primarius* n. sp., Wolff, p. 66, pl. 5, fig. 8.
1953 *Baculatisporites primarius* (Wolff) Pflug & Thomson n. comb.; Thomson & Pflug, p. 56, pl. 2, fig. 51.
2001 *Baculatisporites primarius* (Wolff) Pflug & Thomson in Thomson & Pflug; Stuchlik et al., p. 31, pl. 25, fig. 11, pl. 26, figs 1–8, pl. 27, figs 1–7.

Remarks. Krutzsch (1967) distinguished four subspecies of *Baculatisporites primarius* (*crassiprimarius*, *oligocenicus*, *primarius*, and *semiprimarius*) and compared them e.g. with the recent species *Osmunda banksiaefolia* (Pr.) Kuhn. (from East Asia), *O. interrupta* Michx. (from North America), *O. javanica* Bl., *O. bromeliifolia* (Pr.) Copel. (from Ceylon), and *Osmunda vachelli* Hook. Stuchlik and coauthors (2001) included these subspecies into a synonym list. *Baculatisporites primarius* spores occur in Europe in the Upper Oligocene to Pliocene deposits, and are common in the Polish Neogene. They represent cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). In the studied material these spores were found regularly.

In addition, some spores of fossil species ***Baculatisporites nanus*** (Wolff 1934) Krutzsch 1959 were found in the Komorniki profile. This taxon represents cosmopolitan (P/A) climatic element, and occurs in the Upper Oligocene to Pliocene fossil floras. It is common all over Poland in the Middle Miocene deposits (Stuchlik et al. 2001).

Rugulatisporites Pflug & Thomson 1953

(13) ***Rugulatisporites quintus*** Pflug & Thomson in Thomson & Pflug 1953

Pl. 1, fig. 13

1953 *Rugulatisporites quintus* Pflug & Thomson n. sp.; Thomson & Pflug, p. 56, pl. 2, fig. 46.
1967 *Baculatisporites quintus* (Thomson & Pflug) n. comb., Krutzsch, p. 48, pl. 6–8.
1985 *Osmundacidites quintus* (Pflug & Thomson) n. comb. ssp. *Quintus*, Nagy, p. 75, pl. 13, figs 1, 2.
2001 *Rugulatisporites quintus* Pflug & Thomson in Thomson & Pflug; Stuchlik et al., p. 49, pl. 28, figs 1–5, pl. 29, figs 1–4.

Remarks. *Rugulatisporites quintus* represents subtropical/warm-temperate element (P2/A1). In Europe it occurs in the Upper Oligocene to Pliocene deposits. It is common in the Polish Miocene and Pliocene. Morphologically, these fossil spores are most similar to those of the recent *Osmunda regalis* L. (Krutzsch 1967, Stuchlik et al. 2001). The fossil spores of *Rugulatisporites quintus* were often encountered in the analysed material, mainly in samlpes above the Lusatian seam.

Nowadays the genus *Osmunda* comprises 14 species occurring in humid forests in temperate zone through swampy tropical regions of the northern hemisphere. *O. regalis* is distributed in subtropical and temperate regions of both hemispheres.

Familiae ?SCHIZEACEAE, ?CYATHEACEAE

Monoleiotriletes Krutzsch 1959

(14) ***Monoleiotriletes gracilis*** Krutzsch 1959

Pl. 2, fig. 2a, b

1959 *Monoleiotriletes gracilis* n. sp., Krutzsch, p. 65, pl. 4, fig. 24.
2001 *Monoleiotriletes gracilis* Krutzsch; Stuchlik et al., p. 43, pl. 22, fig. 6a, b.

Remarks. Only one spore of this taxon was found in the Komorniki profile. This taxon occurs in Europe in the Middle Eocene to Middle Miocene deposits. It is reported from the Lower Miocene of south-western Poland.

Its botanical affinity and palaeofloristic element are unknown (Stuchlik et al. 2001).

Familiae **POLYPODIACEAE, DAVALIACEAE**

Laevigatosporites Ibrahim 1933

(15) ***Laevigatosporites gracilis*** Wilson & Webster 1946

Pl. 2, fig. 3

1946 *Laevigato-sporites gracilis* sp. nov., Wilson & Webster, p. 273, fig. 4.
1967 *Laevigatosporites gracilis* Wilson & Webster; Krutzsch, p. 144, pl. 52, figs 1–8.

R e m a r k s. This fossil taxon occurs in Europe in the Lower Oligocene to Pliocene deposits, in Poland it is sporadic in the Palaeogene and common in the Neogene. *Laevigatosporites gracilis* represents cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). In the studied material these spores were encountered sporadically.

(16) ***Laevigatosporites crassicus*** (Krutzsch 1967) stat. nov.

Pl. 2, fig. 4

1967 *Laevigatosporites haardti crassicus* n. subfsp., Krutzsch, p. 149, pl. 53, figs 1–3.

Spores monolete, bean-shaped, 35–40 × 20–25 µm in size. Laesura poorly visible. Exine 2.5–3.0 µm thick, smooth.

R e m a r k s. In morphological taxon *Laevigatosporites haardti* three subspecies (*haardti*, *haardtioides* and *crassicus*) have been distinguished (Krutzsch 1967), but later they were included into a synonym list (Stuchlik et al. 2001). Because the above mentioned spores distinctly differ (in shape and very thick exine) from other subspecies of *L. haardti* they could be distinguished as the morphospecies *Laevigatosporites crassicus*. In the studied material these spores were encountered sporadically.

(17) ***Laevigatosporites haardti*** (Potonié & Venitz 1934) Thomson & Pflug 1953

Pl. 2, fig. 5

1934 *Sporites haardti* n. sp., Potonié & Venitz, p. 13, pl. 1, fig. 13.
1953 *Laevigatosporites haardti* Potonié & Venitz (pro parte), Thomson & Pflug, p. 59, pl. 3, figs 27, 29, 32–37.
1967 *Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug subfsp. *haardti*, Krutzsch, p. 146, pl. 52, figs 12–21.
1967 *Laevigatosporites haardti haardtioides* n. subfsp, Krutzsch, p. 148, pl. 52, figs 22–25.
2001 *Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug; Stuchlik et al., p. 56, pl. 35, figs 13–36, pl. 36, figs 1–6.

R e m a r k s. Spores of *Laevigatosporites haardti* occur in the Lower Cretaceous to Neogene deposits. They are found all over Poland, not abundant in the Palaeogene, whereas very common and abundant in the Neogene. They represent cosmopolitan (P/A) climatic element (Stuchlik et al. 2001). In the studied material these spores were encountered regularly.

(18) ***Laevigatosporites nitidus*** Mamczar 1960 emend. Krutzsch 1967

Pl. 2, fig. 6

1960 *Polypodiaceae – Sporites haardti* Potonié & Venitz forma *nitida*, Mamczar, p. 23, pl. 1, fig. 9.
1967 *Laevigatosporites nutidus* (Mamczar) n. comb., Krutzsch, p. 149, pl. 53, figs 6, 7.
2001 *Laevigatosporites nitidus* Mamczar emend. Krutzsch; Stuchlik et al., p. 57, pl. 36, figs 7–16.

R e m a r k s. This fossil taxon occurs in Europe in the Oligocene to Neogene deposits, and represents cosmopolitan (P/A) climatic element. It is common in the Polish Neogene (Stuchlik et al. 2001). In the analysed material these spores were encountered regularly, reaching max. 60%.

Smooth monolete spores appear recently in the families of Pteridophytes: Aspleniaceae, Blechnaceae, Davalliaceae, Dryopteridaceae, Elaphoglossaceae, Hypolepidaceae, Lindsaeaceae, Lomariopsidaceae, Oleandraceae, Polypodiaceae, Pteridaceae, Thelypteridaceae, and Vittariaceae, widely distributed in tropical to temperate regions of both hemispheres (Stuchlik et al. 2001).

Verrucatosporites Thomson & Pflug 1953

(19) ***Verrucatosporites favus*** (Potonié 1931) Thomson & Pflug 1953

Pl. 2, fig. 7

1931d *Polypodii(?)-sporites favus* n. sp., Potonié, p. 556, fig. 3.

1953 *Verrucatosporites favus* (Potonié) n. comb., Thomson & Pflug, p. 60, pl. 3, figs 52–55, pl. 4, figs 1–3.

1959 *Reticuloidosporis* (*Polypodiisporites*) *favus* (Potonié) n. comb., Krutzsch, p. 215, pl. 42, figs 467–470.

Remarks. Only one spore of this taxon was found in the studied material in the Lusatian seam. Morphologically, it is similar to spores of the recent Dennstaedtiaceae, especially to genus *Paesia*. This taxon represents cosmopolitan (P/A) climatic element, and occurs in Europe in the Middle Eocene to Miocene fossil palynofloras. It was also reported from the Lower and Middle Miocene of central and western Poland.

Dennstaedtiaceae (16 genera) occur worldwide in tropical to temperate areas. *Paesia* is distributed in tropical South and Middle America, Malaysia and Pacific Islands (Stuchlik et al. 2001).

Perinomonoletes Krutzsch 1967

(20) ***Perinomonoletes pliocaenicus*** Krutzsch 1967

Pl. 2, fig. 8

1967 *Perinomonoletes pliocaenicus* n. sp., Krutzsch, p. 222, pl. 87, figs 2–9.

Spores monolete, bilateral, 45–50 × 25–30 µm in size. Laesura poorly visible. Exine 1.0–1.5 µm thick. Perine smooth, waved, protruding up to 3.5 µm from exine surface.

(21) ***Perinomonoletes*** cf. ***goersbachensis*** Krutzsch 1967

Pl. 2, fig. 11

1967 *Perinomonoletes goersbachensis* n. sp., Krutzsch, p. 222, pl. 87, figs 10–12.

Remarks. Several spores resembling in structure *Perinomonoletes pliocaenicus*, but more than 55 µm long, nearest the fossil taxon *P. goersbachensis* were found.

(22) ***Perinomonoletes spicatus*** Nagy 1973

Pl. 2, fig. 9a, b

1973 *Perinomonoletes spicatus* n. sp., Nagy, p. 454, pl. 2, figs 6, 7.

Spores similar in structure to *Perinomonoletes pliocaenicus*, 32–55 µm long. Perine with delicate "spines".

(23) ***Perinomonoletes* sp. 1**

Pl. 2, fig. 10

Spores similar to the above-mentioned ones, but perine thin, very delicate, protruding up to a dozen or so µm from exine surface.

Remarks. Spores of the morphological genus *Perinomonoletes* approach those of recent members of Polypodiaceae s.l.; particularly Aspleniaceae, Blechnaceae and Aspidiaceae (Nayar & Devi 1964a–c, Kremp & Kawasaki 1972), and the genera *Asplenium* L., *Athyrium* Roth, *Bolbitis* Schott, *Byrsopteris* Morton, *Cornopteris* Nakai, *Ctenitis* C. Chr., *Cyclosorum* Link, *Diplazium* Sw., *Dryopteris* Adans., *Egenolfia* Schott, *Lastrea* Bory, *Lithostegia* Ching, *Peranema* Don., and *Polystichum* Roth (Krutzsch 1967, Thiele-Pfeiffer 1980). They were reported from the Eocene and Pliocene (Krutzsch 1967), as well the Miocene deposits of Germany (Thiele-Pfeiffer 1980) and Hungary (Nagy 1985). In the analysed material they occurred only in two samples from the Komorniki profile.

Classis **Pteropsida**

incerte sedis

Toroisporis Krutzsch 1959

(24) ***Toroisporis*** (***Toroisporis***) ***teupitzensis medioris*** Krutzsch 1962

Pl. 3, fig. 1a, b

1962a *Toroisporis* (*Toroisporis*) *teupitzensis medioris* n. subfsp., Krutzsch, p. 80, pl. 33, figs 1–14.

Remarks. Spores of this taxon are slightly similar to those of the recent families Cyatheaceae, Dipteridaceae, Pteridaceae and Lygodiaceae. They represent palaeotropical/warm-temperate element (P/A1), and occur in Europe in the Lower – Middle Miocene. They were also found in the Upper Oligocene to Lower Pliocene deposits in south-western Poland (Stuchlik et al. 2001). In the studied material only one spore was found in the Mużaków series.

(25) ***Toroisporis*** (***Toroisporis***)**?** ***pliocaenicus*** (Thiergart 1940) Krutzsch 1962

Pl. 3, fig. 2

1940 *Sporites neddeni* f. *pliocaenicus* Thiergart, p. 25, pl. 1, fig. 2.

1962a *Toroisporis* (*Toroisporis*)? *pliocaenicus* (Thiergart) n. comb., Krutzsch, p. 86, pl. 36, figs 1–9.

R e m a r k s. Spores of this taxon are intermediate between *Leiotriletes* and *Toroisporis* (Krutzsch 1962a), and are slightly similar in structure to those of the recent Cyathaceae and Lygodiaceae. They represent palaeotropical (P) element and occur in Europe in the Lower Miocene to Pliocene. They were reported from the Lower – Middle Miocene deposits of north-western Poland (Stuchlik et al. 2001). Only one spore of this taxon was found in the Mużaków series.

Classis **PINOPSIDA**
Ordo **PINALES**
Familiae **CUPRESSACEAE** (incl. **TAXODIACEAE**), **SCIADOPITYACEAE**

Cupressacites Bolkhovitina 1956 ex Krutzsch 1971 emend. Kohlman-Adamska in Stuchlik et al. 2002

(26) ***Cupressacites bockwitzensis*** Krutzsch 1971

Pl. 3, fig. 3

1960 *Glyptostrobus* sp.; Oszast, p. 12, pl. 3, figs 13, 16.

1971 *Cupressacites bockwitzensis* n. sp., Krutzsch, p. 196, pl. 62, figs 19–25.

2002 *Cupressacites bockwitzensis* Krutzsch; Stuchlik et al., p. 48, pl. 67, figs 9–18, pl. 69, fig. 1.

R e m a r k s. These pollen grains are similar to pollen of the recent Cupressaceae, especially to species *Cupressus arizonica* Greene., distributed in the mountains in western part of North America. They represent warm-temperate (A1) element, and are common in the Lower and Middle Miocene palynofloras (Stuchlik et al. 2002).

Inaperturopollenites Pflug & Thomson in Thomson & Pflug 1953

(27) ***Inaperturopollenites dubius*** (Potonié & Venitz 1934) Thomson & Pflug 1953

Pl. 3, fig. 4

1934 *Pollenites magnus dubius* n. sp., Potonié & Venitz, p. 17, pl. 2, figs 20, 21.

1953 *Inaperturopollenites dubius* (Potonié & Venitz) n. comb., Thomson & Pflug, p. 64, pl. 5, fig. 11.

R e m a r k s. Pollen grains resembling pollen of the recent families Taxodiaceae, Cupressaceae and Taxaceae (e.g. genera *Cupressus* L., *Thuja* L., and *Taxus* L.). In Europe they occur in the Palaeocene to Pliocene deposits, and represent warm-temperate (A1) element (Ziembińska-Tworzydło 1996). In Poland this taxon is common in the Miocene deposits (Stuchlik et al. 2002). These pollen grains were often encountered in the analysed material.

The former family Cupressaceae contains 19 genera of trees and shrubs. The recent species of *Cupressus* (about 15–20) grow in tropical and subtropical zones of the eastern Mediterranean Region to the Himalayas, in southern China and southern North America. Taxaceae contains 5 genera and about 20 species of trees and shrubs extended mainly in East Asia. Species of *Taxus* occur in the northern hemisphere (Krüssmann 1972).

Taxodium Rich., *Glyptostrobus* Endl.

(28) ***Inaperturopollenites concedipites*** (Wodehouse 1933) Krutzsch 1971

Pl. 3, fig. 5

1933 *Cunninghamia concedipites* n. sp., Wodehouse, p. 495, fig. 19.

1971 *Inaperturopollenites concedipites* (Wodehouse) n. comb., Krutzsch, p. 204, pl. 65.

R e m a r k s. Pollen grains similar to pollen of the recent *Taxodium* and *Glyptostrobus*, representing warm-temperate (A1) element, occurring in the Middle Eocene to Upper Miocene deposits, in Poland are common in the Miocene (Ziembińska-Tworzydło 1996, Stuchlik et al. 2002). These pollen grains were very often encountered in all analysed profiles.

(29) ***Inaperturopollenites verrupapilatus*** Trevisan 1967

Pl. 3, fig. 6

1967 *Inaperturopollenites verrupapilatus* n. fsp., Trevisan, p. 15. pl. 6, figs 9–12.

2002 *Inaperturopollenites verrupapilatus* Trevisan; Stuchlik et al., p. 52, pl. 72, figs 6–11, pl. 73, figs 1–8.

R e m a r k s. These pollen grains are similar to pollen of the recent *Taxodium* and *Glyptostrobus*. They represent subtropical/warm-temperate (P2/A1) element, and occur in the Lower Oligocene to Pliocene palynofloras. In Poland they are known from the Lower Miocene to Pliocene, and are common in the Middle Miocene (Stuchlik et al. 2002).

Nowadays the former family Taxodiaceae (10 genera) is distributed in southern part of North America (from California to Mexico) as well in East Asia and Tasmania. *Taxodium* genus (3 species – *T. distichum* (L.) Rich., *T. ascendens* Brongn., and *T. mucronatum* Ten.) occurs in southern part of North America and in Mexico. The monotypic genus *Glyptostrobus* (*G. pensilis* (Stauton) Koch = *G. lineatus* = *G. heterophyllus*) grows in southern China (Krüssmann 1972) and Vietnam (Hiep & Vidal 1996). The fossil species *Glyptostrobus europaeus* (Brongniart) Unger was wide-spread in the Neogene in Europe. There are known two types of its macro-remains; among them ecotype characteristic of swamp forests prevails (Ţicleanu & Dinulescu 1998).

In addition, in the analysed material numerous stomata, similar in structure to those of the family Cupresaceae were found, particularly in samples with high frequency of pollen of this family.

Sciadopitys Sieb. & Zucc.

Sciadopityspollenites Raatz 1937 ex Potonié 1958

(30) ***Sciadopityspollenites antiquus*** Krutzsch 1971 ex Planderová 1990

Pl. 3, fig. 7

1971 *Sciadopityspollenites antiquus* n. sp. (*Sciadopitys antiqua* n. sp.), Krutzsch, p. 186, pl. 58, figs 1–12.

1990 *Sciadopityspollenites antiquus* Krutzsch ssp. *corrugatus* n. ssp., Planderová, p. 48, pl. 42, fig. 7.

Remarks. Pollen grains of this taxon compared with the recent *Sciadopitys*, are encountered in central Europe in the Upper Cretaceous to Miocene deposits (Krutzsch 1971). In Poland they are rare; known from the Lower and Middle Miocene (Stuchlik et al. 2002). Some pollen grains of this taxon occurred in the Lusatian seam.

(31) ***Sciadopityspollenites quintus*** Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 3, fig. 8a, b

1971 *Sciadopityspollenites quintus* n. sp., Krutzsch, p. 180, pl. 55, figs 1–16.

1974 *Sciadopityspollenites quintus* Krutzsch; Ziembińska-Tworzydło, p. 356, pl. 13, fig. 6.

Remarks. Pollen grains resembling those of the recent *Sciadopitys*. They represent warm-temperate element (A1), and occur all over Poland in the Lower Miocene to Pliocene deposits (Stuchlik et al. 2002). In the studied material they were encountered regularly, but in very small quantities.

(32) ***Sciadopityspollenites serratus*** (Potonié & Venitz 1934) Raatz 1937 ex Potonié 1958

Pl. 3, fig. 9a, b

1934 *Sporites serratus* n. sp., Potonié & Venitz, p. 15, pl. 1, figs 6, 7.

1937 *Sciadopitys-pollenites serratus* (Potonié & Venitz); Raatz, p. 13, pl. 1, fig. 16.

1958 *Sciadopitys-pollenites serratus* (Potonié & Venitz), Raatz; Potonié, p. 81, pl. 10, fig. 109.

Remarks. Pollen grains of this taxon represent warm-temperate element (A1). In Europe they occur in the Upper Eocene to Pliocene. They are common all over Poland in the Miocene and Pliocene deposits (Stuchlik et al. 2002). These pollen grains occurred sporadically in the studied material.

(33) ***Sciadopityspollenites tuberculatus*** (Zaklinskaya 1957) Krutzsch 1971

Pl. 3, fig. 10

1957 *Sciadopitys tuberculata* n. sp., Zaklinskaya, p. 201, pl. 16, fig. 3.

1971 *Sciadopityspollenites tuberculatus* (Zaklinskaya) n. comb., Krutzsch, p. 182, pl. 56, figs 1–9.

Remarks. Taxon encountered in central Europe in the Oligocene and Miocene deposits (Krutzsch 1971). These pollen grains occurred sporadically in the analysed material.

(34) ***Sciadopityspollenites varius*** Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 3, fig. 11

1971 *Sciadopityspollenites varius* n. sp., Krutzsch, p. 188, pl. 59, figs 1–12.

1974 *Sciadopityspollenites varius* Krutzsch; Ziembińska-Tworzydło, p. 356, pl. 13, fig. 3.

Remarks. This taxon occurs in central Europe in the Oligocene to Middle Miocene deposits (Stuchlik et al. 2002). These pollen grains were sporadically encountered in the analysed material.

(35) ***Sciadopityspollenites verticillatiformis*** (Zauer in Pokrovskaya & Stelmak 1960) Krutzsch 1971

Pl. 3, fig. 12

1960 *Sciadopitys verticillatiformis* sp. nov., Zauer in Pokrovskaya & Stelmak, p. 410, pl. 5, fig. 6.

1971 *Sciadopityspollenites verticillatiformis* (Zauer) n. comb., Krutzsch, p. 178, pl. 54, figs 7–24.

Remarks. This taxon occurs in central Europe in the Eocene to Upper Miocene deposits (Krutzsch 1971), in Poland is known from the Lower and Middle Miocene (Stuchlik et al. 2002). These pollen grains were encountered sporadically in the studied material.

Nowadays the genus *Sciadopitys* contains only one species (*S. verticillata* Sieb. & Zucc.) – tall evergreen tree growing in Japan (Hondo, Sikoku) in the mountains up to 1700 m a.s.l. in mixed forests with *Chamaecyparis obtusa*, *Ch. pisifera*, *Tsuga sieboldii*, *Pinus densiflora*, *Abies firma*, *Torrea nucifera*, *Magnolia obovata*, and *Cercidiphyllum japonicum* (Krüssmann 1972, Bugała 1991). Detailed studies of recent pollen grains of *Sciadopitys verticillata* revealed their huge variety (Kvavadze 1988), what suggests that variability of *Sciadopityspollenites* morphological genus could be result of intraspecific variability.

Sequoia Endl., *Sequoiadendron* Buchh., *Metasequoia* Miki

Sequoiapollenites Thiergart 1937 ex Potonié 1958

(36) ***Sequoiapollenites major*** Krutzsch 1971

Pl. 4, fig. 1

1971 *Sequoiapollenites major* n. sp., Krutzsch, p. 220, pl. 72, figs 1–24.

Remarks. Pollen grains of this species occur in the Lower Oligocene to Pliocene, and are rarely found in the Middle Miocene deposits all over Poland (Stuchlik et al. 2002). They were sporadically encountered in the analysed material.

(37) ***Sequoiapollenites polyformosus*** Thiergart 1937

Pl. 4, fig. 2

1937 *Sequoia - pollenites polyformosus* n. sp., Thiergart, p. 301, pl. 23, figs 6–11.

Remarks. Pollen grains of this species are common in the Lower Miocene to Pliocene deposits all over Poland (Stuchlik et al. 2002). At Legnica and Ruja they were often found, usually in quantities of a few per cent.

(38) ***Sequoiapollenites rotundus*** Krutzsch 1971

Pl. 4, fig. 3

1971 *Sequoiapollenites rotundus* n. sp., Krutzsch, p. 222, pl. 73, figs 1–24.

Remarks. A regularly circular shape is the main feature of this morphological species, occuring in the Middle Miocene to Pliocene deposits. In the Polish Miocene pollen grains of this species are found regularly (Stuchlik et al. 2002). At Legnica they were encountered sporadically, mainly in the Lusatian seam.

(39) ***Sequoiapollenites rugulus*** Krutzsch 1971

Pl. 4, fig. 5a, b

1971 *Sequoiapollenites rugulus* n. sp., Krutzsch, p. 218, pl. 71, figs 1–36.

Remarks. Pollen grains of this species occur in the Middle Oligocene to Pliocene deposits. In the Polish Middle and Upper Miocene they are found sporadically (Stuchlik et al. 2002). At Legnica these pollen grains were encountered mainly in the Lusatian seam.

(40) ***Sequoiapollenites undulatus*** Kohlman-Adamska in Stuchlik et al. 2002

Pl. 4, fig. 4

1993 *Sequoia* Endl. – *Cryptomeria* D. Don – type; Kohlman-Adamska, p. 119, pl. 16, fig. 2.

2002 *Sequoiapollenites undulatus* Kohlman-Adamska sp. nov.; Stuchlik et al., p. 57, pl. 81, figs 1–8.

Remarks. Pollen grains of this fossil species differ from all other species of *Sequoiapollenites* by strongly undulate ectexine nearly on the whole surface of pollen grain. They occur in the Middle Miocene deposits (Stuchlik et al. 2002). In the studied material these pollen grains were found rarely.

Pollen grains of the morphological species *Sequoiapollenites major*, *S. polyformosus*, *S. rotundus*, *S. rugulus*, and *S. undulatus* are similar to pollen of the recent genera *Sequoia*, *Sequoiadendron*, and *Metasequoia*. They represent warm-temperate (A1) element (Stuchlik et al. 2002).

(41) ***Sequoiapollenites sculpturius*** Krutzsch 1971

Pl. 4, fig. 6

1971 *Sequoiapollenites sculpturius* n. sp., Krutzsch, p. 216, pl. 70, figs 1–25.

Remarks. Pollen grains of this taxon are similar to pollen of the recent *Metasequoia glyptostroboides* Hu & Cheng. They represent warm-temperate (A1) element, and occur in the Middle Oligocene to Pliocene deposits. They occur commonly but not abundantly in the Lower to Middle Miocene all over Poland (Stuchlik et al. 2002). In the analysed material they were found sporadically.

Sequoia Endl., *Cryptomeria* D. Don.

(42) ***Sequoiapollenites largus*** (Kremp 1949) Manum 1962

Pl. 4, fig. 7

1949 cf. *Cryptomeria – Poll. largus* n. sp., Kremp, p. 58, pl. 5, fig. 30.

1962 *Sequoiapollenites largus* Kremp; Manum, p. 43.

1971 *Sequoiapollenites largus* (Kremp) Manum; Krutzsch, p. 208, pl. 67, figs 1–27.

Remarks. Pollen grains of this taxon are similar to pollen of the recent *Cryptomeria*. They represent warm-temperate (A1) element, and occur in the Oligocene to Pliocene deposits (Stuchlik et al. 2002). They were regularly encountered in the analysed material, in quantities not exceeding 1%.

Most species of the fossil genus *Sequoiapollenites* occur in central Europe in the Middle Oligocene to Pliocene deposits. The most numerous are Miocene localities (Stuchlik 1964, Krutzsch 1971, Ziembińska-Tworzydło 1974, Thiele-Pfeiffer 1980, Nagy 1985, Planderová 1990, Kohlman-Adamska 1993). Pollen grains of this morphological taxon are often referred to the genera *Sequoia* (thin-walled pollen grains with curved papilla) or *Cryptomeria* (thick-walled grains with straight papilla). Relatively frequent occurrence of numerous macro-remains of *Sequoia* (leaves and diaspores) in fossil floras indicates that these trees were growing near the accumulation basins, at the margins of peat-bogs or in riparian forests (Schneider 1992).

Today *Sequoia*, *Sequoiadendron*, *Metasequoia*, and *Cryptomeria* are monotypic genera. *Sequoia sempervirens* (D. Don) Endl. and *Sequoiadendron giganteum* (Lindl.) Buchh. are distributed on the Pacific seashore of North America, *Metasequoia glyptostroboides* Hu & Cheng grows in southern China at altitudes of 800–1500 m above sea level. *Cryptomeria japonica* D. Don. occurs in Japan and southern China (Krüssmann 1972, Stuchlik et al. 2002).

Familia **PINACEAE**

Abies Mill.

Abiespollenites Thiergart 1937 ex Potonié 1958

(43) ***Abiespollenites absolutus*** Thiergart 1937 ex Potonié 1958

Pl. 4, fig. 8

1937 *Abies-pollenites absolutus* n. sp. – *Abies*-Pollen, Thiergart, p. 306, pl. 24, fig. 9.

1958 *Abiespollenites absolutus* Thiergart in Raatz; Potonié, p. 63, pl. 8, figs 77–79.

Remarks. These pollen grains are similar to the recent *Abies alba* Mill. They occur in the Oligocene to Pliocene, most frequently in Miocene deposits, and represent arctotertiary (A) element (Stuchlik et al. 2002). Several pollen grains of this taxon were found in the analysed material.

(44) ***Abiespollenites latisaccatus*** (Trevisan 1967) Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 4, figs 9, 10

1967 *Pityosporites latisaccatus*, *latisaccatus* n. fsp. subf. sp., Trevisan, p. 21, pl. 12, fig. 4, pl. 13, fig. 1.

1971 *Abiespollenites latisaccatus* (Trevisan) n. comb., Krutzsch, p. 88, pl. 16, figs 1–6.

1974 *Abiespollenites latisaccatus* (Trevisan) Krutzsch; Ziembińska-Tworzydło, p. 348, p. 10, fig. 1.

Remarks. Pollen grains similar to pollen of *Abies firma* Sieb. & Zucc., *A. veitchii* Lindl., *A. nordmanniana* (Stev.) Spach, as well *Pinus taeda* L. They represent arctotertiary (A) element, and occur in fossil microfloras since the Eocene/Oligocene boundary, mainly in cooler climatic phases, being more frequent since the Pliocene. They are also known from the Polish Middle Miocene to Pliocene localities (Ziembińska-Tworzydło 1974, Kohlman-Adamska 1993, Ziembińska-Tworzydło et al. 1994a, Stuchlik et al. 2002). In the analysed material they were encountered regularly, in quantities of a few per cent.

(45) ***Abiespollenites maximus*** Krutzsch 1971 ex Nagy 1985

Pl. 4, fig. 11

1971 *Abiespollenites maximus* n. sp., Krutzsch p. 92, pl. 18.

1985 *Abiespollenites maximus* Krutzsch; Nagy, p. 139, pl. 72, fig. 1.

Remarks. According to Krutzsch (1971) large dimensions of the pollen grains (150–170 µm) suggest their affinity with recent genus *Keteleeria*. However, the presence of a thick crest on their corpus supports their affinity to *Abies*. Pollen grains of this fossil taxon are known from the Lower Miocene to Pliocene. In Poland they occur in Lower and Middle Miocene palynofloras. This taxon is included into arctotertiary (A) element (Stuchlik et al. 2002). Several pollen grains of *Abiespollenites maximus* were found in the analysed material.

Nowadays the genus *Abies* (about 50 species) is common in the northern hemisphere, mostly in East Asia (China and Japan) and western North America. These trees grow mainly in the mountains, often on high altitudes; several lowland species have extensive ranges, but most of them occur locally. Their climatic and soil requirements depend on the species (Bugała 1991). *Abies alba* is distributed in the mountains of southern, western and central Europe, Caucasus, Ukraine, and Belarus. *Abies firma* and *A. veitchii* occur in Japan, *A. nordmanniana* grows in western Caucasus and northern Turkey (Stuchlik et al. 2002).

Cathaya Chun & Kuang

Cathayapollis Ziembińska-Tworzydło in Stuchlik et al. 2002

Sivak (1976) among fossil pollen grains of *Cathaya* type from France distinguished 12 species differing in shape, and grouped them into six morphological types of the sacci attachment as well as surface of corpus and sacci (see Stuchlik et al. 2002).

(46) ***Cathayapollis erdtmanii*** (Sivak 1976) Ziembińska-Tworzydło in Stuchlik et al. 2002

Pl. 5, fig. 1a, b

1949 *Pinus haploxylon* – Form Rudolph; Kremp, p. 60, pl. 4, fig. 24.

1976 *Cathaya erdtmanii* sp. nov., Sivak, p. 264, pl. 5, figs 1, 5, pl. 6. figs 1–7.

2002 *Cathayapollis erdtmanii* (Sivak) Ziembińska-Tworzydło comb. nov.; Stuchlik et al., p. 15, pl. 10, figs 1–6.

Remarks. These pollen grains represent I type of sacci attachment to the corpus (after Sivak 1976).

(47) ***Cathayapollis potoniei*** (Sivak 1976) Ziembińska-Tworzydło in Stuchlik et al. 2002

Pl. 5, fig. 2a, b.

1953 *Pityosporites microalatus* (Potonié) n. comb., Thomson & Pflug, p. 67, pl. 5, figs 51, 53, 59.

1954 *Pinus haploxylon* classical type Rudolph; Doktorowicz-Hrebnicka, p. 64.

1976 *Cathaya potoniei* sp. nov., Sivak, p. 272, pl. 13, figs 1–10.

2002 *Cathayapollis potoniei* (Sivak) Ziembińska-Tworzydło comb. nov.; Stuchlik et al., p. 17, pl. 15, figs 1–10.

Remarks. These pollen grains represent III type of sacci attachment to the corpus (after Sivak 1976).

(48) ***Cathayapollis wilsonii*** (Sivak 1976) Ziembińska-Tworzydło in Stuchlik et al. 2002

Pl. 5, fig. 3a, b

1960 *Pinus* type *Haploxylon* Rudolph = *Pollenites microalatus*, Oszast, p. 15, pl. 5, figs 3, 4.

1971 *Pityosporites alatus* (Potonié) Thomson & Pflug [=*Pinus alata* (Potonié) n. comb.]; Krutzsch, p. 51, pl. 2, figs 2, 3, 8, 9.

1976 *Cathaya wilsonii* sp. nov., Sivak, p. 270, pl. 12, figs 1–10.

2002 *Cathayapollis wilsonii* (Sivak) Ziembińska-Tworzydło comb. nov.; Stuchlik et al., p. 16, pl. 14, figs 1–4.

R e m a r k s. These pollen grains represent III type of sacci attachment to the corpus (after Sivak 1976).

(49) ***Cathayapollis pulaensis*** (Nagy 1985) Ziembińska-Tworzydło in Stuchlik et al. 2002

Pl. 5, figs 4, 5

1985 *Cathaya pulaënsis* n. sp., Nagy, p. 134, pl. 65, figs 1–3.

1996 *Podocarpidites libellus* (Potonié) Krutzsch; Ziembińska-Tworzydło, p. 823, pl. 273, fig. 4.

2002 *Cathayapollis pulaënsis* (Nagy) Ziembińska-Tworzydło comb. nov.; Stuchlik et al., p. 18, pl. 18, figs 1–10.

R e m a r k s. These pollen grains represent V type of sacci attachment to the corpus (after Sivak 1976).

All above mentioned species of the fossil genus *Cathayapollis* are morphologically similar to pollen of the recent *Cathaya*. They represent warm-temperate (A1) element (Stuchlik et al. 2002). Most sporomorphs found in the Legnica profiles represent the III type after Sivak (1976).

Fossil pollen grains and leaves of *Cathaya* are known from deposits since the Upper Cretaceous (from USA and Asia); especially numerous are localities from the Miocene and Pliocene of Europe, south-eastern Asia and North America (Schneider 1981, von Bönisch 1990, Liu et al. 1997, Meller et al. 1999). In Poland, pollen grains of *Cathayapollis* occur in the Miocene and Pliocene deposits (Stuchlik et al. 2002). Previously pollen grains of this type were described as *Pinus haploxylon* type, *Pityosporites microalatus, P. alatu*s, *Podocarpidites* or *Podocarpus*. Recently detailed investigations on their structure and sculpture revealed connections of some *Pinus* type *Haploxylon* pollen grains with recent *Cathaya* (Caratini et al. 1972). Nagy (1985) reported from the Hungarian Neogene three species of the *Cathaya* genus. Planderová (1990) mentioned 6 morphological taxa from the Slovak Miocene, and named them *Cathayapollenites*, but she did not give either correct diagnosis or photographs of the type species. Schneider (1990, 1992) classified *Cathaya*, together with *Sequoia* and *Sciadopitys*, in M facies being, according to this author, the last stage of the Miocene peat-bog succession.

Nowadays the monotypic genus *Cathaya* (*C. argyrophylla* Chun & Kuang) is endemic to mountainous region of south-eastern and central China. It grows in evergreen broad-leaved forests and mixed evergreen-deciduous broad-leaved forests on acid soils (Liu et al. 1997).

Cedrus Trev.

Cedripites Wodehouse 1933

(50) ***Cedripites lusaticus*** Krutzsch 1971

Pl. 6, fig. 1

1960 *Tsuga* sp.; cf. *Tsuga pattoniana*; Oszast, p. 14, pl. 4, fig. 10.

1964 *Tsuga pattoniana* Engelm. type; Stuchlik, p. 23, pl. 8, fig. 5.

1971 *Cedripites lusaticus* n. sp., Krutzsch, p. 118, pl. 28, figs 1–4.

1974 *Pityosporites* cf. *Dacrydium*; Grabowska, pl. 7, fig. 6.

R e m a r k s. These pollen grains resemble those of the recent *Cedrus* Trev., and are slightly similar to pollen of *Pinus* L. and *Dacrydium* Solander (see Erdtman 1965, 1972). They differ from *Tsuga* type in presence of two sacci. This taxon is known from the Upper Eocene to Middle Miocene localities, and represents warm-temperate (A1) element (Stuchlik et al. 2002). In the studied material a few pollen grains of this type were found, mainly in the Lusatian seam.

(51) ***Cedripites miocaenicus*** Krutzsch 1971

Pl. 6, fig. 2a, b

1971 *Cedripites miocaenicus* n. sp., Krutzsch, p. 120, pl. 29, figs 1–7.

R e m a r k s. Pollen grains resembling pollen of the recent *Cedrus*, occur in the Lower Miocene to Pliocene deposits, and represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a, Stuchlik et al. 2002). In the studied material they were encountered sporadically.

Nowadays the genus *Cedrus* contains 4 species of evergreen trees distributed in the Mediterranean area, mountains of northern Africa, Lebanon, Caucasus and Himalayas (Krüssmann 1972).

Keteleeria Carr.

Keteleeriapollenites Nagy 1969

(52) ***Keteleeriapollenites dubius*** (Khlonova 1960) Słodkowska in Ziembińska-Tworzydło et al. 1994

Pl. 6, fig. 3

1960 *Keteleeria dubia* n. sp., Khlonova, p. 59, pl. 9, fig. 5.
1971 *Abiespollenites dubius* (Khlonova) n. comb., Krutzsch, p. 98, pl. 21.
1994b *Keteleeriapollenites dubius* (Khlonova) Słodkowska comb. nov.; Ziembińska-Tworzydło et al., p. 14, pl. 7, fig. 4.

Remarks. Pollen grains distinctly differing from those of *Abies* in the lack of crest on their corpus; connected with the genus *Keteleeria*, and warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a, b). Macro-remains and fossil pollen grains of *Keteleeria* are known from almost whole Europe, from the Upper Oligocene to Pliocene localities (Khlonova 1960, Krutzsch 1971, Ziembińska-Tworzydło 1974, Nagy 1985, Kohlman-Adamska 1993, Uzunova & Ivanov 1996). In Russia they are reported from the Upper Cretaceous to Pliocene, whereas in Poland from the Lower Miocene to Pliocene deposits (Ziembińska-Tworzydło 1996, Stuchlik et al. 2002). Uzunova and Ivanov (1996) consider *Keteleeria* to be a component of the Tertiary mesophytic forests in the mountains and, according to these authors, migrations of these trees reflect palaeoclimate fluctuations. In the studied material pollen grains of *Keteleeriapollenites dubius* were found sporadically.

Presently the genus *Keteleeria* (4–8 species of trees) is distributed in China, Taiwan, Vietnam and Laos (Krüssmann 1972, Stuchlik et al. 2002).

Larix Mill.

Laricispollenites Nagy 1985

(53) ***Laricispollenites* sp.**

Pl. 6, fig. 4

Pollen grains inaperturate, circular in outline, 70–80 µm in diameter. Exine about 1 µm thick, surface psilate.

Remarks. Similar forms were described as *Larix* sp., *Phohosphaera pseudotsugoides*, *Pseudotsuga* sp., *Laricoidites magnus*, cf. *Laevigatosporites* sp., *Inaperturopollenites magnus*, and others (Krutzsch 1971, Ziembińska-Tworzydło 1974). Pollen grains of *Laricispollenites* genus occur in the Miocene deposits, and represent arctotertiary (A) element (Stuchlik et al. 2002). Only two pollen grains of *Laricispollenites* sp. were found in the Mużaków series and Lusatian seam.

Today the genus *Larix* (about 10 species) is distributed in cooler areas of the northern hemisphere. The genus *Pseudotsuga* contains about 20 species of evergreen trees extended in East Asia and North America (Krüssmann 1972).

Picea A. Dietr.

Piceapollis Krutzsch 1971

(54) ***Piceapollis planoides*** Krutzsch 1971 ex Hochuli 1978

Pl. 6, fig. 5

1971 *Piceapollis planoides* n. sp. (=?*Picea planoides* n. sp.), Krutzsch, p. 110, pl. 25, figs 1–4.
1978 *Piceapollis planoides* Krutzsch; Hochuli, p. 67, pl. 8, fig. 2.
1985 *Piceapollenites planoides* (Krutzsch) n. comb., Nagy, p. 138, pl. 69, fig. 1.

Remarks. Pollen grains of this taxon resemble pollen of the recent *Picea*. They occur in the Lower Miocene to Lower Pliocene deposits, and represent warm-temperate (A1) element (Stuchlik et al. 2002). Several pollen grains of this taxon were found in the studied material.

(55) ***Piceapollis sacculiferoides*** Krutzsch 1971 ex Hochuli 1978

Pl. 7, fig. 1

1971 *Piceapollis sacculiferoides* n. sp. (=?*Picea sacculiferoides* n. sp.), Krutzsch, p. 108, pl. 24, figs 1–8.
1978 *Piceapollis sacculiferoides* Krutzsch; Hochuli, p. 67, pl. 7, fig. 10.
1985 *Piceapollenites sacculiferoides* (Krutzsch) n. comb., Nagy, p.138, pl. 69, figs 2–5.

Remarks. Pollen grains of *Picea* type, having no living relative species equivalent. They occur in the Miocene and Pliocene deposits (Krutzsch 1971, Nagy 1985), and represent arctotertiary (A) element (Stuchlik et al. 2002). Pollen grains of this taxon were rarely found in the studied material.

(56) ***Piceapollis tobolicus*** (Panova 1966) Krutzsch 1971

Pl. 6, figs 6, 7

1966 *Picea tobolica* n. sp., Panova, p. 220, pl. 105, fig. 5.

1971 *Piceapollis tobolicus* n. comb. (=*Picea tobolica* Panova), Krutzsch, p. 104, pl. 22, figs 1–6.

1985 *Piceapollenites tobolicus* (Panova) n. comb., Nagy, p. 138, pl. 70, fig. 1.

Remarks. Pollen grains approach those of the recent *Picea abies* (L.) Karst. (=*P. excelsa* Link) and *P. jezoensis* Carr. This taxon occurs in the Lower Miocene to Pliocene deposits, and represents cool-temperate (A2) element (Ziembińska-Tworzydło et al. 1994a, Stuchlik et al. 2002). These pollen grains were sporadically encountered in the analysed material.

Fossil pollen grains of *Picea* type are often found in the Polish Neogene, but they are mainly determined only to the genus rank. Today the *Picea* genus (about 50 species) is common in northern temperate and cool regions; many of these species occur in western and central China. *Picea omorica* Purk. is a Tertiary relict growing on steep calcareous rocks in Yugoslavia, in the mountains of Bosnia and Serbia, *P. mariana* (Mill.) B.S.P. is distributed in North America (mainly Canada), often on swamps and marshes, *P. asperata* grows in western China, *P. schrenkiana* occurs in central Asia, *P. abies* grows in northern and central Europe, mostly in the mountains. *Picea jezoensis* forms with *Tsuga diversifolia* mountain coniferous forests in Japan (Krüssmann 1972, Seneta 1987).

Pinus L.

Pinuspollenites Raatz 1937 ex Potonié 1958

(57) ***Pinuspollenites labdacus*** (Potonié 1931) Raatz 1937 ex Potonié 1958

Pl. 7, fig. 2a, b

1931c *Pollenites labdacus* n. sp., Potonié, p. 3, pl. 32.

1937 *Pinus-pollenites labdacus* Potonié; Raatz, p. 16.

1953 *Pityosporites labdacus* (Potonié) n. comb., Thomson & Pflug, p. 68, pl. 5, figs 60–62.

1958 *Pinuspollenites* (al. *Pollenites*) *labdacus* (Potonié) Raatz; Potonié, p. 62.

1971 *Pityosporites labdacus* (Potonié) Thomson & Pflug subsp. *labdacus* (=*Pinus labdaca* subsp. *labdaca*), Krutzsch, p. 64, pl. 7, figs 11–18.

1994a *Pinuspollenites labdacus* (Potonié) Raatz ex Potonié; Ziembińska-Tworzydło et al., pl. 7, fig. 7.

Remarks. Morphologically, these pollen grains are similar to pollen of the recent *Pinus sylvestris* L. They represent arctotertiary (A) element, and occur in Poland in the Lower Oligocene to Pliocene deposits (Stuchlik et al. 2002). They were encountered in all studied samples in quantities up to 10–20%.

(58) ***Pinuspollenites macroinsignis*** (Krutzsch 1971 ex Olliver-Pierre 1980) Planderová 1990

Pl. 7, fig. 3a, b

1971 *Pityosporites macroinsignis* n. sp. (=*Pinus macroinsignis* n. sp.), Krutzsch, p. 62, pl. 6, figs 5–13.

1980 *Pityosporites macroinsignis* Krutzsch; Olliver-Pierre, pl. 10, fig. 6.

1990 *Pinuspollenites macroinsignis* (Krutzsch) n. comb., Planderová, p. 44, pl. 35, figs 1–5.

Remarks. These pollen grains resemble those of the recent *Pinus*, and are the nearest recent species *P. montana* Mill. They occur in central Europe in the Lower Oligocene to Miocene (Krutzsch 1971, Planderová 1990), and are known from the Lower Oligocene of central Poland, as well as the Miocene deposits of the whole Poland. This fossil taxon represents arctotertiary (A) element (Stuchlik et al. 2002). In the analysed material a few pollen grains of this taxon were found in the Mużaków series.

Nowadays the genus *Pinus* contains about 50–100 species of trees and shrubs extended in the northern hemisphere from the Arctic Circle to Guatemala, northern Africa and Indonesia, in temperate climatic conditions as well as in highland and mountain areas in subtropical climatic conditions. *Pinus sylvestris* occurs in central and northern Europe, Crimea, Asia Minor, and Asia from Siberia to the Amur river, growing in lowland and mountains up to altitude 2100 m above sea level. *Pinus montana* is distributed in the mountains of central and southern Europe (Krüssmann 1972, Stuchlik et al. 2002).

Tsuga Carr.

Zonalapollenites Pflug in Thomson & Pflug 1953

(59) ***Zonalapollenites gracilis*** Krutzsch 1971 ex Konzalová et al. 1993

Pl. 7, fig. 5a, b

1971 *Zonalapollenites gracilis* n. sp. (=*Tsuga gracilis* n. sp.), Krutzsch, p. 142, pl. 38, figs 1–15.

1990 *Tsugaepollenites gracilis* (Krutzsch) n. comb., Planderová, p. 49, pl. 44, figs 1–8.

1993 *Zonalapollenites gracilis* Krutzsch; Konzalová et al., pl. 15, fig. 3.

Remarks. Pollen grains of this type are similar to pollen of the recent *Tsuga canadensis* (L.) Carr. They occur in Europe in the Oligocene to Pliocene (Krutzsch 1971, Nagy 1985, Planderová 1990), in Poland in Miocene deposits. They represent arctotertiary (A) element (Stuchlik et al. 2002). In the analysed material they were found very rare, mainly in the Lusatian seam.

(60) ***Zonalapollenites verrucatus*** Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 8, fig. 3a, b

1971 *Zonalapollenites verrucatus* n. sp. (=*Tsuga verrucata* n. sp.), Krutzsch, p. 144, pl. 39, figs 1–10.

1974 *Zonalapollenites verrucatus* Krutzsch; Ziembińska-Tworzydło, p. 353, pl. 12, fig. 4.

1985 *Tsugaepollenites verrucatus* (Krutzsch) n. comb., Nagy, p. 137, pl. 67, figs 3, 4.

Remarks. Pollen grains similar to pollen of *Tsuga*, the nearest to *Tsuga canadensis*, occurring in Europe in the Oligocene to Pliocene (Krutzsch 1971, Nagy 1985, Planderová 1990, Kohlman-Adamska 1993), in Poland in Miocene and Pliocene deposits. They represent arctotertiary (A) element (Stuchlik et al. 2002). They were sporadically encountered in the studied material.

(61) ***Zonalapollenites spectabilis*** (Doktorowicz-Hrebnicka 1964) Ziembińska-Tworzydło 1974

Pl. 9, fig. 1a, b

1964 *Tsuga* typ *diversifolia* Rudolph forma *spectabilis*, Doktorowicz-Hrebnicka, p. 38, pl. 6, figs 17, 17a.

1971 *Zonalapollenites reuterbergensis* n. sp. (=*Tsuga reuterbergensis* n. sp.), Krutzsch, p. 156, pl. 45, figs 1–4.

1974 *Zonalapollenites spectabilis* (Doktorowicz-Hrebnicka) n. comb., Ziembińska-Tworzydło, p. 354, pl. 12, fig. 3.

1994b *Tsugaepollenites spectabilis* (Doktorowicz-Hrebnicka) Słodkowska comb. nov.; Ziembińska-Tworzydło et al., p. 13, pl. 6, fig. 17.

Remarks. These pollen grains are similar to pollen of the recent *Tsuga diversifolia* (Maxim.) Mast., and represent warm-temperate element (A1). They occur in the Polish Miocene and Pliocene deposits (Ziembińska-Tworzydło et al. 1994a, b, Stuchlik et al. 2002). In the studied material they were encountered sporadically.

(62) ***Zonalapollenites maximus*** (Raatz 1937) Krutzsch 1971 ex Ziembińska-Tworzydło 1974

Pl. 8, fig. 2a, b

1937 *Tsugapollenites igniculus* Potonié f. *maximus* n. f., Raatz, p. 15, pl. 1, fig. 13.

1971 *Zonalapollenites maximus* (Raatz) n. comb. (=*Tsuga maxima* (Raatz) n. comb.), Krutzsch, p. 138, pl. 36, figs 1–8.

1974 *Zonalapollenites maximus* (Raatz) Krutzsch; Ziembińska-Tworzydło, p. 352, pl. 12, fig. 2.

1985 *Tsugaepollenites maximus* (Raatz) n. comb., Nagy, p. 135, pl. 66, figs 1, 2.

Remarks. Pollen grains similar to polen of the recent *Tsuga*. They represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a), and occur in deposits since the Eocene, more often in the Oligocene and Miocene (Krutzsch 1971, Ziembińska-Tworzydło 1974, Nagy 1985, Kohlman-Adamska 1993). They are known from the Polish Miocene and Pliocene (Stuchlik et al. 2002). In the studied material they were found regularly, but in quantities not exceeding 1%.

(63) ***Zonalapollenites robustus*** Krutzsch 1971 ex Kohlman-Adamska 1993

Pl. 9, fig. 2a, b

1971 *Zonalapollenites robustus* n. sp. (=*Tsuga robusta* n. sp.), Krutzsch, p. 158, pl. 46, figs 1–9.

1985 *Tsugaepollenites robustus* (Krutzsch) n. comb., Nagy, p. 136, pl. 67, fig. 1.

1993 *Tsuga* Carr.– type, *Zonalapollenites robustus* Krutzsch; Kohlman-Adamska, p. 114, pl. 11, fig. 1.

Remarks. Pollen grains resembling pollen of the recent *Tsuga patens* Downie. They are known from the Upper Oligocene, Middle and Upper Miocene as well as Upper Pliocene of Europe (Krutzsch 1971, Nagy 1985, Kohlman-Adamska 1993). In Poland they occur in the Miocene and Pliocene palynofloras (Stuchlik et al. 2002). They represent arctotertiary (A) element (Stuchlik et al. 2002). Several pollen grains of this taxon were found in the Mużaków series of Legnica 33/56 profile.

Fossil pollen grains of *Tsuga* are often divided into two morphological types – *Tsuga diversifolia* type with distinct collar, and *T. canadensis* type without collar (Stuchlik 1964, Oszast 1967, 1973, Stachurska et al. 1973, Oszast & Stuchlik 1977, Jahn et al. 1984).

The present-day genus *Tsuga* contains about 10–12 species of tall evergreen trees extended in the temperate zone of North America and eastern Asia – from Himalayas to Japan. These trees prefer humid conditions and clayey soils; they are sensitive to drought. *Tsuga diversifolia* grows in mountain forests in Japan, whereas *T. canadensis* is native in North America – from the Hudson Bay to Carolina and Alabama. *T. patens* is distributed in China (Krüssmann 1972, Bugała 1991).

Familia **PODOCARPACEAE**

Podocarpus L'Herit. ex Pers.

Podocarpidites Cookson 1947 ex Couper 1953 emend. Ziembińska-Tworzydło in Stuchlik et al. 2002

(64) ***Podocarpidites eocenicus*** Krutzsch 1971

Pl. 9, fig. 3

1964 *Podocarpus* sp.1; Stuchlik, p. 23, pl. 7, fig. 3.
1971 *Podocarpidites eocenicus* n. sp., Krutzsch, p. 130, pl. 33, figs 12–14.
1994a *Podocarpidites libellus* (Potonié) Krutzsch; Ziembińska-Tworzydło et al., pl. 7, fig. 6.

R e m a r k s. Morphologically, the pollen grains are similar to pollen of the recent *Podocarpus madagascariensis* Baker (endemic on Madagascar) and *P. sellowii* Klotzsch (from Brazilia). They represent palaeotropical (P) element, and occur in the Palaeogene to Miocene deposits. In Poland they are known from the Lower Oligocene to Middle Miocene palynofloras (Stuchlik et al. 2002). In the studied material these pollen grains were encountered sporadically.

The recent genus *Podocarpus* contains about 100 species of trees and shrubs, growing mainly on the southern hemisphere as well as in Japan, China, Malaysia and Philippines (Krüssmann 1972).

Classis **MAGNOLIOPSIDA**
Ordo **MAGNOLIALES**
Familia **MAGNOLIACEAE**

Liriodendron L.

Liriodendroipollis Krutzsch 1970

(65) ***Liriodendroipollis verrucatus*** Krutzsch 1970

Pl. 9, fig. 4

1970a *Liriodendroipollis verrucatus* n. sp., Krutzsch, p. 142, pl. 37, figs 1–16.
1993 *Liriodendroipollis verrucatus* Krutzsch f. *major*, Kohlman-Adamska, p. 138, pl. 21, fig. 1.

Pollen grains monocolpate, in equatorial view oval in outline, elongate, 50–70 × 35–50 µm in size. Exine 1.0–1.5 µm thick. Surface with circular verrucae, 2–5 µm in diameter and 2–3 µm high, between verrucae surface granulate.

R e m a r k s. Pollen grains of this type are connected with recent pollen of *Liriodendron tulipifera* L. (Krutzsch 1970a) from south-eastern part of North America (Praglowski 1974). They represent warm-temperate element (A1). In Poland they occur in the Lower and Middle Miocene deposits (Ziembińska-Tworzydło 1996). They were sporadically encountered in the studied material, particularly in the grey clay horizon and Henryk seam. A few similar pollen grains measuring 80–100 × 60–65 µm (with verrucae 5–7 µm in diameter and about 5 µm high) – *Liriodendroipollis verrucatus* Krutzsch f. *major* Kohlman-Adamska, were also found.

(66) ***Liriodendroipollis semiverrucatus semiverrucatus*** Krutzsch 1970

Pl. 10, fig. 1

1970a *Liriodendroipollis semiverrucatus semiverrucatus* n. sp. et subsp., Krutzsch, p. 138, pl. 35, figs 1–9.

Pollen grains resembling *Liriodendroipollis verrucatus*, 70–105 × 40–45 µm in size. Verrucae flat, 2.0–3.5 µm in diameter, densely distributed on surface, between verrucae surface granulate.

R e m a r k s. This fossil species is similar to the recent *Liriodendron chinense* (Hemsl.) Sarg. (Krutzsch 1970a) from south-eastern China and northern Vietnam (Praglowski 1974), and represents warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a). Only a few pollen grains of this taxon were found in the Henryk seam of Legnica 33/56 profile.

(67) ***Liriodendroipollis semiverrucatus minor*** Krutzsch 1970

Pl. 10, fig. 2

1970a *Liriodendroipollis semiverrucatus minor* n. subsp., Krutzsch, p. 140, pl. 36, figs 1–16.

Pollen grains of the same structure as *L. semiverrucatus semiverrucatus*, but smaller, 50–60 µm in size.

R e m a r k s. This taxon occurs mainly in the Lower and Middle Miocene (Krutzsch 1970a). In the studied material these pollen grains were encountered sporadically, mainly in the Henryk seam.

Magnolia L.

Magnolipollis Krutzsch 1970

(68) ***Magnolipollis neogenicus major*** Krutzsch 1970

Pl. 10, fig. 3

1970a *Magnolipollis neogenicus major* n. subsp., Krutzsch, p. 136, pl. 34, figs 1–10.

R e m a r k s. Only a few pollen grains of this taxon were found in the studied material, in samples from the grey clay horizon.

(69) ***Magnolipollis neogenicus minor*** Krutzsch 1970

Pl. 10, fig. 4

1970a *Magnolipollis neogenicus minor* n. subsp., Krutzsch, p. 134, pl. 33, figs 1–18.

R e m a r k s. Several pollen grains of this taxon were found in the studied material.

(70) ***Magnolipollis neogenicus neogenicus*** Krutzsch 1970

Pl. 10, fig. 5

1970a *Magnolipollis neogenicus neogenicus* n. sp. et subsp., Krutzsch, p. 132, pl. 32, figs 1–16.

R e m a r k s. These pollen grains were regularly encountered in the studied material in quantities not exceeding 1%.

The fossil genus *Magnolipollis* is near pollen of the recent *Magnolia* L., and partially *Michelia* L. (Krutzsch 1970a). Pollen grains of *Magnolia* type are known from sediments since the Middle Eocene (Muller 1981). In Poland *Magnolipollis neogenicus* occurs in the Miocene and Pliocene of northern and south-western parts of the Polish Lowland, as well as Middle Miocene of the Sudety Mountains. This fossil species represents tropical (P1) element (Ziembińska-Tworzydło et al. 1994a, Ziembińska-Tworzydło 1996).

Today *Magnolia* genus with about 80 species of evergreen and deciduous trees and shrubs occurs in East Asia, Himalayas as well as North and central America (Krüssmann 1977), whereas *Michelia* genus with about 40 species of evergreen trees is distributed in south-eastern Asia (Praglowski 1974).

Ordo **PROTEALES**

Familia **NELUMBONACEAE**

Nelumbo Adanson

Nelumbopollenites Skawińska in Ziembińska-Tworzydło et al. 1994

(71) ***Nelumbopollenites europaeus*** (Tarasevich 1983) Skawińska in Ziembińska-Tworzydło et al. 1994

Pl. 10, fig. 6a, b

1983 *Nelumbo europaea* n. sp. Tarasevich; Kuprianova & Tarasevich, p. 142, pl. 2, fig. 27, pl. 5, figs 1–4.

1985 *Nelumbo* sp.; Skawińska, p. 112, pl. 5, figs 3–5.

1994b *Nelumbopollenites europaeus* (Tarasevich) Skawińska comb. nov.; Ziembińska-Tworzydło et al., p. 25, pl. 14, fig. 12a–d.

Pollen grains tricolpate, in equatorial view oval in outline, 65–70 × 55 µm in size, in polar view outline circular. Colpi rather shallow, reaching the poles. Exine 3.0–3.5 µm thick. Grains covered with smooth tectum with irregular perforations less than 0.5 µm in diameter.

R e m a r k s. These pollen grains are the nearest to pollen of the recent *Nelumbo*, especially *N. lutea* Pers., but differ from them in structure of exine (Skawińska 1985, 1989). The oldest fossil grains of this type are known from the Oligocene of Siberia (Muller 1981). From Poland they have been reported from the Miocene of Upper Silesia (Macko 1957) and Ostrzeszów in central part of the Polish Lowland (Skawińska 1989). They represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a, b). Only a few specimens of this species were found in the studied material.

Today species of *Nelumbo* genus occur in south-eastern Asia, Australia, India and the Middle East (*N. nucifera* Gaertn. = *N. speciosa*), as well in North America and northern part of South America (*N. lutea* Pers. = *N. pentapetala*). They grow in stagnant waters, at river mouths, in places of a slow flow of water, in warm and very humid climate (Kearney 1901, Cook et al. 1974, Heywood 1978).

Ordo **CARYOPHYLLALES**
Familia **AMARANTHACEAE**
(incl. **CHENOPODIACEAE**)

Chenopodipollis Krutzsch 1966

(72) ***Chenopodipollis stellatus*** (Mamczar 1960) Krutzsch 1966

Pl. 11, fig. 1a, b

1960 *Pollenites stellatus* n. spm., Mamczar, p. 56, pl. 14, fig. 199a, b.
1966 *Chenopodipollis* (al. *Pollenites*) *stellatus* (Mamczar) n. comb., Krutzsch, p. 35.

R e m a r k s. Pollen grains resembling pollen of the recent Chenopodiaceae, and representing cosmopolitan element. In European Tertiary they are known mainly from the Miocene deposits (Stuchlik et al. 2009). A few specimens of this species were found in the Mużaków series of Legnica 33/56 profile.

Nowadays the family Chenopodiaceae (about 100 genera and 1400 species of annual and perennial plants, rarely shrubs or small trees) is distributed in temperate and subtropical areas. Some of these species grow on salty marshes or on deserts and semideserts (Kubitzki 1993).

Familia **POLYGONACEAE**

Polygonum persicaria L. type

Persicarioipollis Krutzsch 1962

(73) ***Persicarioipollis pliocenicus*** Krutzsch 1962

Pl. 10, fig. 8

1962b *Persicarioipollis pliocenicus* n. fsp., Krutzsch, p. 284, pl. 9, figs 18–25.

Pollen grain pantoporate, circular in outline, about 55 µm in diameter. Surface reticulate, with lumina about 5–10 µm in diameter. Muri built of bacula 3–4 µm high. In “knots” of reticulum elements of sculpture distinctly higher.

R e m a r k s. This pollen grain resembles pollen of the recent *Polygonum persicaria* L. Only one specimen was found in the Mużaków series.

(74) ***Persicarioipollis welzowenze*** Krutzsch 1962

Pl. 10, fig. 7a, b

1962b *Persicarioipollis welzowenze* n. fsp., Krutzsch, p. 284, pl. 9, figs 6–12.

Pollen grain resembling in structure the above-mentioned one, about 37 µm in diameter. Surface reticulate, with polygonal lumina 5–7 µm in diameter. Muri consist of densely spaced bacula linked together in twos, about 2 µm high. Elements of sculpture of more or less equal high on the whole grain surface.

R e m a r k s. Only one specimen was found in the grey clay horizon of Legnica 41/52 profile. This sporomorph resembles pollen of the recent *Polygonum*, particularly species *Polygonum persicaria* (Punt et al. 1988, Sadowska et al. 1996), as well *P. densiflorum* Meisn.

The oldest fossil pollen grains of Polygonaceae are known from the Palaeogene of central Europe and France. Krutzsch (1962b) distinguished 8 species belonging to the organ genus *Persicarioipollis* from the Miocene and Pliocene of Europe. *Polygonum* type pollen grains are sporadically found in the Polish Tertiary (Stuchlik 1964, Oszast 1967, 1973, Stachurska et al. 1973, Ziembińska-Tworzydło

1974, Kohlman-Adamska 1993, Stuchlik et al. 2009). They represent arctotertiary (A) element (Ziembińska-Tworzydło 1996).

Today the family Polygonaceae contains about 30 genera and 750 species of herbaceous plants, rarely shrubs or trees, occurring all over the world, mainly in temperate zone of the northern hemisphere. The genus *Polygonum* (about 150 species) contains mainly perennials, rarely climbers (Heywood 1978). *P. densiflorum* Meisn. and *P. hydropiperoides* Michaux occur e.g. in sawgrass marshes in Florida (Willard et al. 2004).

(75) ***Rumex* L.** type

Pl. 11, fig. 5a–c

1964 *Rumex* sp.; Stuchlik, p. 43, pl. 13, figs 9, 10.

Pollen grains tri- and tetracolporate, round in shape, 20–28 µm in diameter. Colpi rather long, very narrow. Pores small, 1.5–2.0 µm in diameter, circular to slightly equatorially elongate. Exine 1.5 µm thick, surface microreticulate.

Remarks. Pollen grains of *Rumex* type are rarely found in the Tertiary deposits. They are known from the Polish Miocene and Pliocene deposits (Stuchlik 1964, Oszast 1967, 1973, Oszast & Stuchlik 1977, Jahn et al. 1984). Only 3 specimens of this type were encountered in the analysed material.

Today the genus *Rumex* (about 150 species) is distributed in northern temperate zone (Heywood 1978).

Ordo **GARRYALES**
Familia **EUCOMMIACEAE**

Eucommia Oliv.

Eucommioipollis Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

(76) ***Eucommioipollis parmularius*** (Potonié 1934) Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

Pl. 11, fig. 4

1934 *Pollenites parmularius* n. sp., Potonié, p. 52, pl. 2, fig. 7.

1994b *Eucommioipollis parmularius* (Potonié) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 24, pl. 13, fig. 7a, b.

Remarks. These pollen grains represent warm-temperate element (A1). In Europe they occur in the Lower Oligocene to Pliocene deposits (Ziembińska-Tworzydło et al. 1994a, b, Ziembińska-Tworzydło 1996). They were sporadically encountered in the studied material.

In the recent days the monotypic genus *Eucommia* occurs in central China. *E. ulmoides* Oliv. is a tall tree which grows in mesophytic mountain forests (Wang 1961). The variability of fossil pollen grains, leaves, and fruits (Guo 2000) indicates that they could represent not the only one species.

Ordo **SAXIFRAGALES**
Familia **CERCIDIPHYLLACEAE**

Cercidiphyllum Sieb. & Zucc.

Cercidiphyllites Mtshedlishvili in Samoilovich & Mtshedlishvili 1961

(77) ***Cercidiphyllites minimireticulatus*** (Trevisan 1967) Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

Pl. 11, figs 2, 3

1967 *Tricolpopollenites minimireticulatus* n. fsp., Trevisan, p. 38, pl. 24, figs 10–12.

1994b *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 21, pl. 13, figs 1a, b, 2.

Remarks. This species represents warm-temperate element (A1), and is known from the Middle and Upper Miocene (Ziembińska-Tworzydło et al. 1994a, b, Ziembińska-Tworzydło 1996) as well Pliocene localities (Jahn et al. 1984). Macro-remains of *Cercidiphyllum* occur in Poland in the Oligocene to Pliocene deposits (Hummel 1970). These pollen grains were rarely encountered in the studied material, in quantities not exceeding 1%.

Today relics of *Cercidiphyllum* (2 species) are wide-spread in the mountains of Japan and China. *C. japonicum* Sieb. & Zucc. is besides numbered among the oldest elements of the Japanese flora. This species grows in dense and wet forests, mainly on the altitudes above 1500 m a.s.l.; *C. magnificum* (Nakai) Nakai occurs in China (Wang 1961, Bugała 1991).

Familia **Altingiaceae**

Liquidambar L.

Periporopollenites Pflug & Thomson in Thomson & Pflug 1953

(78) ***Periporopollenites orientaliformis*** (Nagy 1969) Kohlman-Adamska & Ziembińska-Tworzydło in Stuchlik et al. 2009

Pl. 11, figs 7a–c, 9 a, b

1969 *Liquidambarpollenites orientaliformis* n. sp., Nagy, p. 171, pl. 42, figs 1, 2.

2009 *Periporopollenites orientaliformis* (Nagy) Kohlman-Adamska & Ziembińska-Tworzydło comb. nov.; Stuchlik et al., p. 71, pl. 58, figs 1–3, 6–11, pl. 59, figs 1–3.

Remarks. These pollen grains are similar to pollen of the recent *Liquidambar orientalis* L. from Asia Minor (Nagy 1969). They differ from *Periporopollenites stigmosus* in ellipsoidal pores. *Periporopollenites orientaliformis* represents warm-temperate (A1) element, and occurs in the Miocene – Pliocene deposits. In Poland, pollen grains of this species are scattered in the Middle and Upper Miocene (Stuchlik et al. 2009). They were rarely found in the studied material, mainly in the Lusatian seam.

(79) ***Periporopollenites stigmosus*** (Potonié 1931) Thomson & Pflug 1953

Pl. 11, figs 6a, b, 8

1931a *Pollenites stigmosus* n. sp., Potonié, p. 332, pl. 2, fig. 1.

1937 *Liquidambarpollenites stigmosus* (Potonié) n. comb., Raatz, p. 17, fig. 26.

1953 *Periporopollenites stigmosus* (Potonié) n. comb., Thomson & Pflug, p. 111, pl. 15, fig. 58.

Remarks. This species is morphologically identical with pollen of the recent *Liquidambar*. This is confirmed by finding this type of pollen *in situ* in fossil inflorescence of *Liquidambar europea* A. Braun (Kohlman-Adamska et al. 2004, Stuchlik et al. 2007). *Periporopollenites stigmosus* is most similar to pollen of the recent *Liquidambar styraciflua* L. from North America (Nagy 1969), which grows in mixed forests with *Liriodendron tulipifera*, *Tsuga canadensis*, and *T. caroliniana*, on humid soils. *Periporopollenites stigmosus* represents warm-temperate (A1) element, and occurs in the Miocene to Pliocene deposits. In Poland it is encountered in the Middle and Upper Miocene (Stuchlik et al. 2009). Pollen grains of this species were regularly encountered in the studied profiles, particularly in the Lusatian seam, but in quantities not exceeding 2%.

Pollen grains of *Liquidambar* type occur in fossil palynofloras since the Palaeocene, but they are more frequent since the Eocene (Kuprianova 1960, Muller 1981).

Today the genus *Liquidambar* (about 6 species of trees) grows in East Asia (southern China, Taiwan, Vietnam), eastern part of the Mediterranean Region (Turkey, Rhodes, Cyprus), south-eastern part of North America, and Mexico and Nicaragua in central America (Krüssmann 1977, Kubitzki 1993).

Familia **Hamamelidaceae**

Tricolporopollenites Pflug & Thomson in Thomson & Pflug 1953

Corylopsis Sieb. & Zucc.

(80) ***Tricolporopollenites* sp. 1 – *Corylopsis*** type sensu Oszast 1960

Pl. 11, fig. 12a, b

1960 *Corylopsis* sp.; Oszast, p. 24, pl. 8, figs 6, 8–10.

Remarks. Pollen grains of this type occur in the Neogene sediments and are usually named *Corylopsis* (Oszast 1960, 1967, 1973, Stuchlik 1964, Oszast & Stuchlik 1977, Skawińska 1989). They were sporadically found in the studied material.

The present-day genus *Corylopsis* includes about 20 (7–22) species of deciduous shrubs and trees, which grow from Assam to Japan, with the greatest variability in China (Krüssmann 1976, Kubitzki 1993).

Parrotia C.A. Mey., *Distylium* Sieb. & Zucc.

(81) ***Tricolporopollenites indeterminatus*** (Romanowicz 1961) Ziembińska-Tworzydło 1974

Pl. 11, fig. 13

1961 *Pollenites indeterminatus* n. sp., Romanowicz, p. 355, pl. 21, fig. 275.

1974 *Tricolporopollenites indeterminatus* (Romanowicz) n. comb., Ziembińska-Tworzydło, p. 397, pl. 24, fig. 9a, b.

Remarks. Pollen grains of this species

represent subtropical element (P2), and occur in the Polish Lowland in the Lower Oligocene to Pliocene deposits (Stachurska et al. 1973, Ziembińska-Tworzydło 1974, 1996, Ziembińska-Tworzydło et al. 1994a). In the studied material they were encountered sporadically.

(82) ***Tricolporopollenites staresedloensis*** Krutzsch & Pacltová in Krutzsch 1969

Pl. 11, fig. 14

1969 *Tricolporopollenites staresedloensis* Krutzsch & Pacltová; Krutzsch, p. 474, pl. 2, figs 26–30.
1974 *Tricolporopollenites starosedloensis* Krutzsch & Pacltová; Ziembińska-Tworzydło, p. 397, pl. 24, fig. 7a, b.
1994a *Tricolporopollenites staresedloensis* Krutzsch & Pacltová; Ziembińska-Tworzydło et al., pl. 16, figs 21–23.

Remarks. Pollen grains of this species occur in the Eocene to Middle Miocene of the Polish Lowland (Grabowska 1996a). They represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a). Only two pollen grains of this species were found in one sample from the Mużaków series.

Fossil pollen grains of *Parrotia* type are known from the Miocene and Pliocene deposits (Oszast 1967, 1973, Stachurska et al. 1973, Jahn et al. 1984). Tarasevich (1980) has reported pollen grains of *Parrotia maxima* Taras. from the Upper Miocene of the Oka–Don plain.

Today *Parrotia persica* C.A. Mey. is an endemic tree of the Caspian Sea region and the Caucasus. The genus *Distylium* (about 10–18 species) is distributed mainly in south-eastern Asia, Japan and Malaysia (Kubitzki 1993).

Ordo **FAGALES**
Familia **FAGACEAE**
Subfamilia **CASTANEOIDEAE**

Castanea Mill., *Castanopsis* (D. Don) Spach.

Castaneoideaepollis Grabowska in Ziembińska-Tworzydło et al. 1994

(83) ***Castaneoideaepollis oviformis*** (Potonié 1931) Grabowska in Ziembińska-Tworzydło et al. 1994

Pl. 11, fig. 10

1931a *Pollenites oviformis* n. sp., Potonié, p. 328, pl. 1, fig. 20.
1934 *Pollenites oviformis* Potonié, p. 95, pl. 5, figs 23, 27.
1953 *Tricolporopollenites cingulum* (Potonié) n. comb. subsp. *oviformis* (Potonié) n. comb., Thomson & Pflug, p. 100, pl. 12, figs 42–49.
1994b *Castaneoideaepollis oviformis* (Potonié) Grabowska comb. nov.; Ziembińska-Tworzydło et al., p. 21, pl. 12, fig. 10.

Remarks. In the analysed material pollen grains of this taxon were encountered mainly in the Lusatian seam.

(84) ***Castaneoideaepollis pusillus*** (Potonié 1934) Grabowska in Ziembińska-Tworzydło et al. 1994

Pl. 11, fig. 11

1934 *Pollenites quisqualis pusillus* n. f., Potonié, p. 71, pl. 3, fig. 21.
1953 *Tricolporopollenites cingulum* (Potonié) n. comb. subsp. *pusillus* (Potonié) n. comb., Thomson & Pflug, p. 100, pl. 12, figs 28–41.
1994b *Castaneoideaepollis pusillus* (Potonié) Grabowska comb. nov.; Ziembińska-Tworzydło et al., p. 21, pl. 12, figs 8, 9.

Remarks. Pollen grains of *Castaneoideaepollis oviformis* and *C. pusillus* occur in the Palaeocene to Miocene deposits, and are similar to pollen of *Castanea* Hill., *Castanopsis* Spach., as well *Lithocarpus* Bl. They represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a, b, Grabowska 1996a). They were encountered regularly in the studied material, but in quantities not exceeding 2%.

The present-day genus *Castanea* (about 12 species of deciduous trees) is distributed in temperate zone of the northern hemisphere, while *Castanopsis* (120 species of deciduous and evergreen trees) grows in tropical and subtropical zones of southern and south-eastern Asia. *Lithocarpus* (about 100 species of mainly evergreen trees) occurs in the noth-eastern India, through China and Malaysia to New Guinea (Krüssmann 1976, Kubitzki 1993).

Subfamilia **FAGOIDEAE**

(85) ***Tricolporopollenites pseudocingulum*** (Potonié 1931) Thomson & Pflug 1953

Pl. 12, figs 1a, b, 2a, b

1931a *Pollenites pseudocingulum* n. sp., Potonié, p. 328, pl. 1, figs 3, 4.
1953 *Tricolporopollenites pseudocingulum* (Potonié) n. comb., Thomson & Pflug, p. 99, pl. 12, figs 99–111.

1960 *Rhoipites* (*Pollenites*) *pseudocingulum* (Potonié) n. comb., Potonié, p. 101, pl. 6, fig. 114.

2000 *Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug (s.s.); Kohlman-Adamska & Ziembińska-Tworzydło, p. 51, pl. 2, figs 2–4, pl. 3, figs 1–5.

Remarks. This taxon used to be connected with the recent family Anacardiaceae and the genera: *Rhus* (Tourn.) L., *Mangifera* L., and *Spondias* L. (Mamczar 1962). However, detailed studies of pollen grains under SEM revealed their similarity to recent pollen of the family Fagaceae, subfamily Fagoidae, and within the collective taxon *Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug (s.l.) a few species varying in morphology of tectum sculpture have been distinguished (Kohlman-Adamska & Ziembińska-Tworzydło 1999, 2000). This taxon represents subtropical element (P2), in Europe it occurs in the Palaeogene to Upper Miocene deposits (Ziembińska-Tworzydło 1996). Pollen grains of *T. pseudocingulum* were very often found in the studied material, in quantities of a few per cent in the Henryk seam and max. 42% in the Lusatian seam.

(86) ***Tricolporopollenites theacoides*** (Roche & Schuler 1976) Kohlman-Adamska & Ziembińska-Tworzydło 2000

Pl. 12, fig. 3

1974 *Rhoipites pseudocingulum* (Potonié) Potonié; Ziembińska-Tworzydło, pl. 23, fig. 5.

1976 *Verrutricolporites theacoides* n. f sp., Roche & Schuler, p. 27, pl. 10, figs 31, 32.

2000 *Tricolporopollenites theacoides* (Roche & Schuler) comb. nov., Kohlman-Adamska & Ziembińska-Tworzydło, p. 54, pl. 5, figs 3–5.

Pollen grains with coarsely verrucate tectum. Verrucae 1.5–2.0 µm in diameter and 3–5 µm high.

Remarks. Pollen grains of *Tricolporopollenites theacoides* were sporadically encountered in the studied material.

Fagus L.

Faguspollenites Raatz 1937 ex Potonié 1960

(87) ***Faguspollenites verus*** Raatz 1937

Pl. 11, fig. 15

1937 *Fagus-pollenites verus* n. sp., Raatz, p. 23, pl. 1, fig. 17.

Remarks. This fossil species represents cool-temperate (A2) element (Ziembińska-Tworzydło et al. 1994a). Within fossil pollen of *Fagus* some authors distinguish two morphological types: grains 30–35 µm in size with coarser sculpture are reported as *Fagus ferruginea* type, whereas bigger ones with delicate sculpture – as *F. orientalis* type (Oszast 1960, Stuchlik 1964, Nagy 1969). Kohlman-Adamska (1993) has also distinguished two morphological types differing in sculpture and thickness of exine: type 1 (*F. sylvatica* and *F. longipetiolata*) and type 2 (*F. orientalis* and *F. ferruginea*). Konzalová (1976) has recorded *Faguspollenites verus* from the Lower Miocene of Bohemia, but in Europe this taxon is more frequent since the Middle Miocene, becoming numerous in the Pliocene. In the studied material pollen grains of *F. verus* were encountered regularly, in both morphological types, in quantities 2–4%.

The present-day genus *Fagus*, with about 10 species of trees, occurs in temperate zone of the northern hemisphere. *Fagus ferruginea* Ait occurs in North America, *F. sylvatica* L. in central Europe to the Caucasus, *F. orientalis* Lipsky grows on lower altitudes of the Caucasus, *F. longiopetiolata* Seemen. – in mixed mesophytic forests and evergreen broad-leaved forests in central and south-eastern China (Wang 1961, Krüssmann 1977, Kubitzki 1993).

Subfamilia **QUERCOIDEAE**

Quercus L.

Quercoidites (Potonié, Thomson & Thiergart 1950 ex Potonié 1960) Słodkowska in Ziembińska-Tworzydło et al. 1994

(88) ***Quercoidites asper*** (Pflug & Thomson 1953) Słodkowska in Ziembińska-Tworzydło et al. 1994

Pl. 12, fig. 4a, b

1953 *Tricolpopollenites asper* n. sp. (Pflug & Thomson); Thomson & Pflug, p. 96, pl. 11, figs 43–47.

1961 *Tricolporopollenites asper* (Potonié) n. comb., Krutzsch, p. 322.

1994b *Quercoidites asper* (Pflug & Thomson) Słodkowska comb. nov.; Ziembińska-Tworzydło et al., p. 26, pl. 15, fig. 1.

Remarks. This species approaches the

recent *Quercus robur* L. from Europe, North America and Asia Minor. *Quercoidites asper* represents warm-temperate element (A1), in Europe it occurs in the Oligocene to Pliocene deposits (Ziembińska-Tworzydło et al. 1994a, b, Ziembińska-Tworzydło 1996). These pollen grains were regularly found in all studied profiles.

(89) ***Quercoidites granulatus*** (Nagy 1969) Słodkowska in Ziembińska-Tworzydło et al. 1994

Pl. 12, fig. 5

1969 *Quercopollenites granulatus* n. sp., Nagy, p. 223, pl. 52, fig. 21.
1994b *Quercoidites granulatus* (Nagy) Słodkowska comb. nov.; Ziembińska-Tworzydło et al., p. 26, pl. 15, figs 10, 11.

Remarks. Pollen grains with coarser granulate sculpture. The taxon *Q. granulatus* represents warm-temperate element (A1), and occurs in the Miocene deposits (Ziembińska-Tworzydło et al 1994a, b). In the studied material pollen grains of this taxon were found sporadically.

(90) ***Quercoidites henrici*** (Potonié 1931) Potonié, Thomson & Thiergart 1950

Pl. 12, fig. 6

1931a *Pollenites henrici* n. sp., Potonié, p. 332, pl. 2, fig. 19.
1950 *Quercoidites henrici* (Potonié); Potonié, Thomson & Thiergart, p. 54, pl. B, figs 22, 23.
1953 *Tricolpopollenites henrici* (Potonié) n. comb., Thomson & Pflug, p. 95, p. 11, figs 39, 40.
1961 *Tricolporopollenites henrici* (Potonié) n. comb., Krutzsch, p. 322.

Remarks. Pollen grains of this taxon were often found in the Lusatian seam (up to 6%) and Henryk seam (a few percent), in other horizons they were encountered sporadically.

(91) ***Quercoidites microhenrici*** (Potonié 1931) Potonié, Thomson & Thiergart 1950

Pl. 12, fig. 7

1931b *Pollenites microhenrici* n. sp., Potonié, p. 26.
1950 *Quercoidites microhenrici* (Potonié) n. comb., Potonié, Thomson & Thiergart, p. 55, pl. B, figs 24, 25, pl. C, fig. 22.
1953 *Tricolpopollenites microhenrici* (Potonié) n. comb., Thomson & Pflug, p. 95, p. 11, figs 62–110.
1961 *Tricolporopollenites microhenrici* (Potonié) n. comb., Krutzsch, p. 322.
1994a *Quercoidites microhenrici* (Potonié) Potonié, Thomson & Thiergart; Ziembińska-Tworzydło et al., pl. 15, figs 5, 6.

Remarks. Several pollen grains of this taxon were found in the Lusatian seam.

The taxa *Quercoidites henrici* and *Q. microhenrici* represent subtropical element (P2) and occur in the Polish Lowland in the Upper Palaeocene to Middle Miocene deposits, whereas in Slovakia, Turkey and former Soviet Union to the Pliocene (Grabowska 1996a).

The recent members of genus *Quercus* (about 350–450 species of deciduous and evergreen trees and shrubs) are distributed in temperate and subtropical zones of the northern hemisphere, as well as in the mountains of tropical Malaysia and north-western part of North America (Krüssmann 1977, Kubitzki 1993).

Familia BETULACEAE

Alnus Mill.

Alnipollenites Potonié 1934

(92) ***Alnipollenites verus*** (Potonié 1931) Potonié 1934

Pl. 12, figs 9, 10

1931a *Pollenites verus* n. sp., Potonié, p. 320, pl. 2, fig. 40.
1934 *Alnipollenites verus* (Potonié); Potonié, p. 58, pl. 2, figs 13, 17, 18, 25, 26.
1953 *Polyvestibulopollenites* (*Alnipollenites*) *verus* (Potonié) n. comb., Thomson & Pflug, p. 90, pl. 10, figs 62–76.

Remarks. These pollen grains correspond to the recent pollen of *Alnus* Mill., especially *A. glutinosa* (L.) Gaertn., *A. hirsuta* Turcz., *A. incana* (L.) Moench., *A. rugosa* (Du Roi) Spreng., and *A. tenuifolia* Nutt. In previous elaborations tetraporate grains 15–25 μm in size were described as *Alnus kefersteinii* Goepp. type, whereas bigger forms (above 30 μm in diameter), mainly 5- 6-porate as *Alnus glutinosa* (L.) Gaertn. type (Doktorowicz-Hrebnicka 1956a, Oszast 1960, 1973, Stuchlik 1964). Recently pollen grains of *Alnipollenites verus* type were isolated from male catkins of *Alnus kefersteinii* (Goeppert) Unger, found in the Oligocene deposits at Bechlejovice, Czech Republic (Dašková 2008). *Alnipollenites verus* represents subtropical/arctotertiary (P2/A) element, and occurs in deposits since the Eocene (Stuchlik et al. 2009). In older sediments tetraporate forms are distinctly more frequent. Pollen grains of *Alnipollenites verus* were regularly encountered in all studied profiles. In the Lusatian seam they occurred in quantities of a few per cent, whereas in the younger strata they reached 25–70%. In all samples tetraporate grains distinctly prevailed.

The present-day species of the genus *Alnus* (about 50 species of trees and shrubs) are distributed in temperate, boreal and subarctic zones of the northern hemisphere, in lowlands and highlands, reaching southern Argentina (Krüssmann 1976, Kubitzki 1993). They need humid soils, and often grow near stagnant and flowing waters, on swampy and peaty soils (Bugała 1991), so their abundance in fossil material is recognized as an index of humid and swampy environment (Oszast & Stuchlik 1977).

Carpinus L.

Carpinipites Srivastava 1966 emend. Grabowska & Ważyńska in Stuchlik et al. 2009

(93) ***Carpinipites carpinoides*** (Pfug in Thomson & Pflug 1953) Nagy 1985

Pl. 12, figs 11, 12a, b

1953 *Polyporopollenites carpinoides* n. sp. (Pflug); Thomson & Pflug, p. 92, pl. 10, figs 79–84.

1985 *Carpinipites carpinoides* (Pfug) n. comb., Nagy, p. 198, pl. 112, figs 9–14.

R e m a r k s. Pollen grains the nearest to pollen of the recent *Carpinus betulus* L. and *Carpinus orientalis* Mill. The morphological genus *Carpinipites* occurs since the Palaeocene, more frequently in younger Tertiary (Krutzsch 1970d). *C. carpinoides* represents subtropical/warm-temperate element (P2/A1), and occurs in sediments since the Lower Oligocene (Stuchlik et al. 2009). In the studied material their quantities did not exceed 1–2%.

The present-day genus *Carpinus* (about 35 species of trees and shrubs) is distributed in northern temperate zone of Europe, south-eastern Asia and central America. *C. betulus* grows in Europe, *C. caroliniana* in swamp forests in North America, *C. orientalis* in south-eastern Europe and Asia Minor (Kearney 1901, Krüssmann 1976).

Ostrya Scop., *Ostryopsis* Decn.

Ostryoipollenites Potonié 1951 ex Potonié 1960

(94) ***Ostryoipollenites rhenanus*** Thomson in Potonié, Thomson & Thiergart 1950 ex Potonié 1960

Pl. 12, fig. 16

1950 *Ostrya? – Poll. megagranifer rhenanus* n. spm. (Thomson); Potonié, Thomson & Thiergart, p. 52, pl. B, figs 9, 10.

1951 *Ostryoipollenites rhenanus* Thomson; Potonié, pl. 20, fig. 46.

1953 *Triporopollenites rhenanus* (Thomson) n. comb., Thomson & Pflug, p. 84, pl. 8, figs 150–152.

1960 *Ostryoipollenites rhenanus* (al. *Ostrya? – pollenites*) *rhenanus* (al. *granifer rhenanus*) Thomson in Potonié, Thomson & Thiergart; Potonié, p. 116, pl. 7, fig. 145.

1960 *Ostryoipollenites* (al. *Triporopollenites*) *rhenanus* Thomson in Thomson & Pflug; Potonié, p. 116.

1969 *Ostryapollenites rhenanus* (Thomson) n. comb., Nagy, p. 226, pl. 3, fig. 10.

R e m a r k s. This species is the nearest to the recent *Ostrya* (e.g. *O. carpinifolia* Scop.) and *Ostryopsis*, and represents warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a, Stuchlik et al. 2009). In Poland, pollen grains of *Ostryoipollenites rhenanus* have been reported from the Miocene to Upper Pliocene deposits (Stuchlik et al. 2009). In the studied material they were encountered sporadically.

The recent 7 species of the *Ostrya* genus occur in northern temperate zone. *Ostrya carpinifolia* grows in southern Europe and Asia Minor (Krüssmann 1977), it needs similar ecological conditions as the genus *Carpinus* (Bugała 1991). The recent 2 species of the *Ostryopsis* genus occur in China, e.g. in Yunnan (Krüssmann 1977).

Corylus L.

Triporopollenites Pflug & Thomson in Thomson & Pflug 1953

(95) ***Triporopollenites coryloides*** Pflug in Thomson & Pflug 1953

Pl. 12, fig. 13

1953 *Triporopollenites coryloides* n. sp. (Pflug); Thomson & Pflug, p. 84, pl. 9, figs 20–24.

1960 *Triporopollenites coryloides* Pflug emend. Potonié, p. 116.

1994b *Corylopollis coryloides* (Pflug) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 16, pl. 8, figs 18, 19.

R e m a r k s. These pollen grains represent arctotertiary element (A). They occur in fossil palynofloras since the Oligocene, more frequently in the Neogene, and commonly in the Pliocene (Stuchlik et al. 2009). Pollen grains of this taxon were encountered in all studied profiles, mainly in the grey clay horizon and Henryk seam, in quantities not exceeding 1%.

Today *Corylus* genus (about 15–19 species of tall shrubs and trees) occurs in northern temperate zone of Europe, America and Asia (Krüssmann 1976, Kubitzki 1993).

Betula L.

Trivestibulopollenites Pflug in Thomson & Pflug 1953

(96) ***Trivestibulopollenites betuloides*** Pflug in Thomson & Pflug 1953

Pl. 12, fig. 8

1953 *Trivestibulopollenites betuloides* n. sp. (Pflug); Thomson & Pflug, p. 85, pl. 9, figs 25–34.

1969 *Betulaepollenites betuloides* (Pflug) n. comb., Nagy, p. 228, pl. 3, fig. 12.

R e m a r k s. Pollen grains of *Betula* type occur in Europe since the Palaeocene (Krutzsch 1970d, Muller 1981). *Trivestibulopollenites betuloides* occurs in the Eocene to Pliocene deposits, and represents arctotertiary (A) element (Ziembińska-Tworzydło et al. 1994a, Stuchlik et al. 2009). Pollen grains of *T. betuloides* were regularly noted in all analysed profiles in quantities of a few per cent (max. 10–12% in the Mużaków series and Lusatian seam).

The recent species of *Betula* genus (about 60) are distributed in temperate and boreal zones of the northern hemisphere (Krüssmann 1976). They are photophilous plants, but they have little requirements about soil (Bugała 1991).

Familia **MYRICACEAE**

Myrica L.

Myricipites Wodehouse 1933 emend. Grabowska & Ważyńska in Stuchlik et al. 2009

(97) ***Myricipites pseudorurensis*** (Pflug in Thomson & Pflug 1953) Grabowska & Ważyńska in Stuchlik et al. 2009

Pl. 12, fig. 17

1953 *Triatriopollenites pseudorurensis* n. sp. (Pflug); Thomson & Pflug, p. 79, pl. 7, figs 76–80.

2009 *Myricipites pseudorurensis* (Pflug in Thomson & Pflug) Grabowska & Ważyńska comb. nov.; Stuchlik et al., p. 27, pl. 16, figs 1–7.

R e m a r k s. These pollen grains resemble recent pollen of *Myrica gale* L. They occur in the Eocene to Pliocene, and represent arctotertiary (A) element. In Poland they are reported from the Upper Oligocene to Miocene deposits (Stuchlik et al. 2009). They were regularly encountered in the studied material.

Triatriopollenites Pflug & Thomson in Thomson & Pflug 1953

(98) ***Triatriopollenites rurensis*** Pflug & Thomson in Thomson & Pflug 1953

Pl. 15, figs 18, 19

1953 *Triatriopollenites rurensis* n. sp. (Pflug & Thomson); Thomson & Pflug, p. 79, pl. 7, figs 81–109.

1969 *Myricipites rurensis* (Pflug & Thomson) n. comb., Nagy, p. 245, pl. 53, fig. 27.

R e m a r k s. These pollen grains represent subtropical/arctotertiary (P2/A) element, and occur in Poland in the Eocene to Miocene deposits (Stuchlik et al. 2009). Kohlman-Adamska (1993) compares this species with *Myrica nagy* Thunb. and *M. salicifolia* Hochst. ex Rich. Pollen grains of *Triatriopollenites rurensis* were regularly encountered in the studied material. They were more frequent in the Lusatian seam.

The oldest pollen grains of *Myrica* type are known from the Cretaceous (Santonian) of USA. In Europe they are more frequent since the Eocene and Oligocene (Muller 1981). Nowadays this genus (with about 35 species of evergreen or deciduous trees and shrubs) is distributed in temperate and subtropical zones of both hemispheres. *Myrica adenophora* grows in China, *M. carolinensis* in North America, *M. nagy* in north-western Himalayas, *M. rubra* in Asia, *M. salicifolia* in Ethiopia (Krüssmann 1977). *M. gale* occurs on sea-shores of northern and western Europe in maritime climate zone and in northern part of North America. *Morella cerifera* (L.) Small. (=*Myrica cerifera* L.)

grows on "Everglades" reed marshes in Florida (Gleason & Cronquist 1968, Hofstetter 1983, Willad et al. 2004). In Poland *Myrica gale* is a postglacial relict growing on peat-bogs, peat meadows, moorlands, margins of peaty lakes and ditches, as well in *Salix–Frangula* and *Salix* brushwoods or margins of humid pine and alder forests (Ciaciura & Stępień 1998).

Familia **JUGLANDACEAE**

Carya Nutt

Caryapollenites Raatz 1937 ex Potonié 1960 emend. Krutzsch 1961

(99) ***Caryapollenites simplex*** (Potonié 1931) Raatz 1937 ex Potonié 1960

Pl. 13, fig. 1

1931c *Pollenites simplex* n. sp., Potonié, p. 3, fig. 4.
1937 *Carya-pollenites simplex* Potonié f. *communis* n. f., Raatz, p. 19, pl. 1, fig. 6.
1960 *Caryapollenites simplex* (Potonié) Raatz; Potonié, p. 123, pl. 7, figs 162, 163.

Remarks. These pollen grains represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a), and are known from the Palaeocene to Neogene of America, Europe, and Asia (Muller 1981, Manchester 1987). In Poland they occur in the Upper Oligocene to Upper Miocene deposits (Stuchlik et al. 2009). Pollen grains of *Caryapollenites simplex* were encountered in almost all studied samples, in quantities up to 4%.

The present-day members of *Carya* genus (28 species of deciduous trees) grow in temperate zone of North America (25 species) and in eastern China (Krüssmann 1976). They need humid climate, as well as humid and fertile soils (Bugała 1991).

Engelhardia Leschen. ex Bl.

Momipites Wodehouse 1933 emend. Nichols 1973

(100) ***Momipites punctatus*** (Potonié 1931) Nagy 1969

Pl. 12, figs 14, 15

1931a *Pollenites corypheus punctatus* n. f., Potonié, p. 332, pl. 2, fig. 7.
1951 *Engelhardtioipollenites punctatus* Potonié, pl. 20, fig. 24.
1969 *Momipites punctatus* (Potonié) n. comb., Nagy, p. 246, pl. 54, figs 9, 10.

Remarks. Pollen grains of this taxon are the nearest to pollen of Juglandaceae, especially of *Engelhardia* Leschen. ex Bl., as well *Alfaroa* Standley, and *Oreomunnea* Oerst. They represent subtropical element (P2). In Europe they occur in the Eocene to Pliocene, whereas in Poland in the Oligocene to Pliocene deposits (Stuchlik et al. 2009). In the studied material they were encountered regularly, mainly in the Lusatian seam, reaching max. 6%.

Nowadays the genus *Engelhardia* with 5 species of deciduous and evergreen trees, is distributed in subtropical and tropical zones of south-eastern Asia (northern and eastern India to eastern China, Vietnam and Philippines), whereas the monotypic genera *Alfaroa* and *Oreomunnea* occur in central America and Costa Rica (Stachurska 1961, Kubitzki 1993).

Juglans L.

Juglanspollenites Raatz 1937

(101) ***Juglanspollenites sadowskae*** Kohlman-Adamska & Ziembińska-Tworzydło in Stuchlik et al. 2009

Pl. 13, fig. 5

2009 *Juglanspollenites sadowskae* Kohlman-Adamska & Ziembińska-Tworzydło sp. nov.; Stuchlik et al., p. 50, pl. 38, figs 1–4.

Remarks. These pollen grains are similar to pollen of the recent *Juglans*, and are the nearest to *J. allardiana* Dode from Japan. *Juglanspollenites sadowskae* represents warm-temperate element (A1), and occurs in the Oligocene to Miocene deposits (Stuchlik et al. 2009). Only a few specimens were found in the Komorniki profile.

(102) ***Juglanspollenites verus*** Raatz 1937

Pl. 13, fig. 4a, b

1937 *Juglans-pollenites verus* n. sp., Raatz, p. 18, pl. 1, fig. 9.

Remarks. These pollen grains are most similar to recent pollen of *Juglans cinerea* L. from warm-temperate zone of North America. They represent warm-temperate element (A1), and occur in the Oligocene and Miocene deposits (Ziembińska-Tworzydło et al. 1994a, b). A few pollen grains of this species were found in the analysed material, mainly in the grey clay horizon.

Platycarya Sieb. & Zucc.

Platycaryapollenites Nagy 1969 emend. Frederiksen & Christopher 1978

(103) ***Platycaryapollenites miocaenicus*** Nagy 1969

Pl. 13, figs 6, 7

1969 *Platycaryapollenites miocaenicus* n. sp., Nagy, p. 207, pl. 116, figs 5–9.

R e m a r k s. This morphological species represents warm-temperate (A1) element (Stuchlik et al. 2009). Pollen grains of *Platycarya* type occur in the Upper Palaeocene/Lower Eocene to Miocene deposits (Muller 1981), and are found sporadically in the Pliocene (Thomson & Pflug 1953). They are known from numerous localities of Europe and North America (Mueller 1981, Manchester 1987). In Poland they occur in the Middle Miocene, rather not exceeding 1% (Stuchlik et al. 2009). In the studied material several pollen grains of this type were found.

The present-day monotypic genus *Platycarya* (*P. strobilacea* Sieb. & Zucc.) is distributed in Japan, Korea, China, and Vietnam (Krüssmann 1977, Kubitzki 1993).

Pterocarya Kunth

Polyatriopollenites Pflug 1953

(104) ***Polyatriopollenites stellatus*** (Potonié 1931) Pflug in Thomson & Pflug 1953

Pl. 13, fig. 2

1931b *Pollenites stellatus* n. sp., Potonié, pl. 2, fig. V47b.

1937 *Pterocarya-pollenites stellatus* (Potonié); Raatz, p. 18, fig. 8.

1953 *Polyatriopollenites stellatus* (Potonié) n. comb. (Pflug); Thomson & Pflug, p. 91, pl. 10, figs 85–94.

R e m a r k s. These pollen grains represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a), and occur in the Eocene to Miocene of Europe, North America and Asia (Manchester 1987). In Poland they are common in the Middle and Upper Miocene (Stuchlik et al. 2009). Pollen grains of *Polyatriopollenites stellatus* were found *in situ* in fossil inflorescences of *Platycarya sosnicensis* Kohlman-Adamska, Ziembińska-Tworzydło & Zastawniak from the Late Miocene flora of Sośnica (Kohlman-Adamska et al. 2004). Pollen grains of *Polyatriopollenites stellatus* were encountered regularly in all studied profiles, reaching max. 8%.

The recent members of *Pterocarya* genus (10 or 6 species of deciduous trees) grow in the Caucasus, Iran, Japan, China, Laos, and Vietnam in river valleys on fertile, humid alluvial soils, in polydominant broad-leaved forests (Krüssmann 1978, Bugała 1991, Kubitzki 1993).

Ordo **ERICALES**
Familia **SYMPLOCACEAE**

Symplocos Jacq.

Symplocoipollenites Potonié 1951 ex Potonié 1960 emend. Słodkowska in Ziembińska-Tworzydło et al. 1994

(105) ***Symplocoipollenites latiporis*** (Pflug & Thomson 1953) Słodkowska in Ziembińska-Tworzydło et al. 1994

Pl. 13, fig. 8a, b

1953 *Porocolpopollenites latiporis* n. sp. (Pflug & Thomson); Thomson & Pflug, p. 93, pl. 10, figs 123, 124.

1994b *Symplocoipollenites latiporis* (Pflug & Thomson) Słodkowska comb. nov.; Ziembińska-Tworzydło et al., p. 30, pl. 18, figs 1a, b, 2.

R e m a r k s. Pollen grains of *Symplocoipollenites latiporis* differ from *S. vestibulum* in triangular outline with concave sides and delicate gemmate surface. Only a few pollen grains of this species were found, mainly in the Lusatian seam.

(106) ***Symplocoipollenites vestibulum*** (Potonié 1931) Potonié 1951 ex Potonié 1960

Pl. 13, fig. 9a, b

1931a *Pollenites vestibulum* n. sp., Potonié, p. 329, pl. 2, fig. 23.

1951 *Symplocoipollenites vestibulum* Potonié, p. 147.

1953 *Porocolpopollenites vestibulum* n. sp. (Pflug); Thomson & Pflug, p. 94, pl. 11, figs 3–23.
1960 *Symplocoipollenites* (al. *Pollenites*) *vestibulum* (Potonié) Potonié, p. 107.
1994a *Symplocoipollenites vestibulum* (Potonié) Potonié; Ziembińska-Tworzydło et al., pl. 18, figs 9–12.

Remarks. These pollen grains were encountered regularly in all analysed profiles in quantities up to 2–3%.

The species *Symplocoipollenites latiporis* and *S. vestibulum* are similar to recent *Symplocos*, and represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a, b). They occur in Europe in deposits since the Eocene, more frequently in Miocene (Thomson & Pflug 1953, Krutzsch 1970d, Muller 1981).

Today the monotypic family Symplocaceae (about 350 species of evergreen and deciduous trees and shrubs) is distributed mainly in tropical and subtropical zones (van der Meijden 1970, Krüssmann 1978).

Familia **ERICACEAE**

Ericipites Wodehouse 1933

(107) ***Ericipites callidus*** (Potonié 1931) Krutzsch 1970

Pl. 13, fig. 10a, b

1931a *Pollenites callidus* n. sp., Potonié, p. 329, pl. 2, figs 24, 27.
1953 *Tetradopollenites callidus* (Potonié) n. comb., Thomson & Pflug, p. 112, pl. 15, figs 67–70.
1970b *Ericipites callidus* (Potonié) n. comb., Krutzsch, p. 422, pl. 54, figs 7–10.

Remarks. This taxon occurs in the European Oligocene to Pliocene, and represents arctotertiary (A) element (Ziembińska-Tworzydło 1996). In the studied material these pollen grains were encountered regularly, but in low quantities.

(108) ***Ericipites ericius*** (Potonié 1931) Potonié 1960

Pl. 13, fig. 11

1931a *Pollenites ericius* n. sp., Potonié, p. 329, pl. 2, fig. 25.
1953 *Tetradopollenites ericius* (Potonié) n. comb., Thomson & Pflug, p. 112, pl. 15, figs 71–73, 75–77, 79.
1960 *Ericipites ericius* (Potonié) n. comb., Potonié, p. 138.

Remarks. Pollen grains of this species occur in the Eocene to Pliocene deposits, and represent arctotertiary (A) element (Ziembińska-Tworzydło 1996). In the studied material they were encountered regularly, but in low quantities.

(109) ***Ericipites hidasensis*** Nagy 1969

Pl. 13, fig. 12

1969 *Ericipites hidasensis* n. sp., Nagy, p. 212, pl. 50, figs 1, 2.

Pollen grains tricolporate, arranged in tetrads, 34–38 µm in diameter. It is difficult to recognize a single pollen grain. Exine about 1 µm thick, surface finely granulate.

Remarks. Nagy (1985, 1992) compared this taxon with the family Ericaceae and reported it from the Upper Egerian to Pontian of Hungary. In the studied material similar tetrads were found sporadically.

Rhododendron L.

(110) ***Ericipites roboreus*** (Potonié 1931) Krutzsch 1970

Pl. 13, fig. 13a, b

1931a *Pollenites roboreus* n. f sp., Potonié, p. 325, pl. 2, fig. 20.
1970b *Ericipites roboreus* (Potonié) n. comb., Krutzsch, p. 422.

Remarks. This taxon is known from deposits since the Upper Eocene, and represents arctotertiary (A) element (Ziembińska-Tworzydło 1996). In the analysed material these pollen grains were found mainly in samples from brown coal, in the Lusatian seam reaching max. about 2%.

The morphological genus *Ericipites* is similar to pollen of the recent genera: *Arbutus* L., *Arctous* Niedenzu, *Calluna* Salisb., *Erica* L., *Gaultheria* L., *Ledum* L., *Lyonia* Nutt., *Rhododendron* L., *Vaccinium* L., and others of the family Ericaceae (Thiele-Pfeiffer 1980). Similar tetrads were also observed in families Empetraceae, Pyrolaceae, and Epacridaceae (Erdtman 1971).

Today Ericaceae is a family of mainly evergreen shrubs and shrublets. The monotypic genus *Calluna* (*C. vulgaris* (L.) Hull.) grows on marshes in Europe and Asia Minor. The genus *Erica* (about 630 species) occurs mainly in southern Africa and Europe, on the Atlantic islands, in Asia Minor and Syria. The genus *Rhododendron* (about 500–600 species) grows in East Asia, North America, Caucasus and Malaysia. *Arbutus unedo* is an evergreen tree characteristic for the Mediterranean makhia (Krüssmann 1976, 1977, 1978).

Familiae CLETHRACEAE, CYRILLACEAE

(111) ***Tricolporopollenites exactus*** (Potonié 1931) Grabowska in Ziembińska-Tworzydło et al. 1994

Pl. 13, fig. 14

1931b *Pollenites exactus* n. sp., Potonié, p. 26, pl. 1, fig. V49b.
1953 *Tricolporopollenites megaexactus* (Potonié) n. comb. subsp. *exactus* (Potonié) n. comb., Thomson & Pflug, p. 101, pl. 12, figs 87–92.
1960 *Cyrillaceaepollenites exactus* (Potonié) n. comb., Potonié, p. 102.
1994b *Tricolporopollenites exactus* (Potonié) Grabowska comb. nov.; Ziembińska-Tworzydło et al., p. 28, pl. 16, figs 8–10.

R e m a r k s. This species occurs in the Eocene to Miocene deposits. At Legnica these pollen grains were encountered regularly, reaching max. 20%.

(112) ***Tricolporopollenites megaexactus*** (Potonié 1931) Thomson & Pflug 1953

Pl. 14, fig. 1

1931b *Pollenites megaexactus* n. sp., Potonié, p. 26, pl. 1, fig. V42b.
1953 *Tricolporopollenites megaexactus* (Potonié) n. comb., Thomson & Pflug, p. 100, pl. 12, figs 50–57, 74, 75.
1960 *Cyrillaceaepollenites megaexactus* (Potonié) n. comb., Potonié, p. 102.

R e m a r k s. This species is known from the Oligocene and Miocene deposits. In the studied material these pollen grains were encountered sporadically in samples with *Tricolporopollenites exactus*, in quantities not exceeding 1%.

The two above-mentioned taxa (*Tricolporopollenites exactus* and *T. megaexactus*) represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994b), and are similar to pollen of the recent Cyrillaceae (genus *Cyrilla* Gard.) and Clethraceae (genus *Clethra* L.).

The present-day genus *Clethra* (about 30 species of evergreen and deciduous trees and shrubs) is distributed in subtropical zone of South and North America, south-eastern Asia, as well as in the mountains in tropical zone. *Clethra alnifolia* L. is a shrub growing on peat-bogs and in humid forests in the Atlantic zone of North America. The monotypic genus *Cyrilla* (*C. racemiflora* L.) occurs on peat-bogs in North America (Kearney 1901, Krüssmann 1976).

Familiae CYRILLACEAE, CLETHRACEAE, ?ROSACEAE

(113) ***Tricolporopollenites bruhlensis*** (Thomson 1950) Grabowska in Ziembińska-Tworzydło et al. 1994

Pl. 13, fig. 15

1950 *Pollenites cingulum brühlensis* n. spm. (Thomson); Potonié, Thomson & Thiergart, p. 56, 63, pl. B, figs 31–33.
1994b *Tricolporopollenites brühlensis* (Thomson) Grabowska stat. nov.; Ziembińska-Tworzydło et al., p. 27, pl. 16, figs 1–5.

R e m a r k s. Pollen grains of this species represent subtropical element (P2), and occur in the Eocene to Pliocene deposits (Ziembińska-Tworzydło et al. 1994a, b). Several pollen grains of this taxon were found in the studied material.

Familia SAPOTACEAE

Tetracolporopollenites Thomson & Pflug 1953

(114) ***Tetracolporopollenites andreanus*** Bruch 1998

Pl. 14, fig. 2a, b

1998 *Tetracolporopollenites andreanus* n. sp., Bruch, p. 99, pl. 14, figs 20–22.

Pollen grains tetracolporate, in equatorial view rectangular in outline, 25–30 × 20–22 µm in size. Colpi diagonally crossed. Exine about 2 µm thick, surface very finely granulate.

R e m a r k s. This species was described from the Upper Oligocene (?) deposits of Slovenia (Bruch 1998). Its characteristic features are diagonally crossed colpi. In the studied material these pollen grains were encountered sporadically.

(115) ***Tetracolporopollenites rotundus*** (Nagy 1969) Bruch 1998

Pl. 14, fig. 3

1969 *Sapotaceoidaepollenites rotundus* n. sp., Nagy, p. 219, pl. 50, fig. 16, 17, 24.
1998 *Tetracolporopollenites rotundus* (Nagy) n. comb., Bruch, p. 99, pl. 14, figs 18, 19.

Pollen grains tetracolporate, in equatorial view circular to square in outline, 20–24 µm in size. Colpi parallel, pores oval, equatorially elongated. Exine 1.5–2.0 µm thick, surface psilate.

Remarks. Nagy (1969, 1985, 1992) reported *Sapotaceoidaepollenites rotundus* from the Miocene of Hungary. In the studied material a few specimens were found.

The two above-mentioned taxa (*Tetracolporopollenites andreanus* and *T. rotundus*) represent tropical (P1) element.

Today the family Sapotaceae (with about 35–75 genera and 800 species of evergreen trees and shrubs) occurs mainly in tropical and subtropical areas, rarely in temperate zone (Heywood 1978).

Ordo **MALPIGHIALES**
Familia **SALICACEAE**

Salix L.

Salixipollenites Srivastava 1966

(116) ***Salixipollenites capreaformis*** Planderová 1990

Pl. 14, fig. 4a, b

1990 *Salixipollenites capreaformis* n. sp., Planderová, p. 80, pl. 78, figs 5–8.

Pollen grains tricolpate (poroidal), in equatorial view oval in outline, 26–28 × 16–18 µm in size. Exine about 1.5 µm thick, surface per-reticulate. Lumina polygonal-circular, up to 1.5 µm in diameter, muri narrow.

Remarks. These pollen grains are similar to pollen of the recent *Salix caprea* L. (Erdtman et al. 1963, Kuprianova 1965, Planderová 1990). They were regularly encountered in the analysed material.

(117) ***Salixipollenites cinereaformis*** Planderová 1990

Pl. 14, fig. 5a, b

1990 *Salixipollenites cinereaformis* n. sp., Planderová, p. 80, pl. 77, figs 17–19.

Pollen grains tricolpate (poroidal), in equatorial view oval in outline, 25–28 × 15–16 µm in size. Colpi parallel, narrow, with poorly visible poroids. Exine about 1.5 µm thick, surface per-reticulate. Lumina polygonal-circular, 1.0–1.2 µm in diameter, muri narrow, built of one row of columellae.

Remarks. These pollen grains are similar to pollen of the recent *Salix cinerea* L. (Erdtman et al. 1963, Kuprianova 1965, Planderová 1990). They were regularly encountered in the analysed material.

(118) ***Salixipollenites helveticus*** Nagy 1969

Pl. 14, fig. 6a, b

1969 *Salixipollenites helveticus* n. sp, Nagy, p. 246, pl. 55, figs 24, 25.

Pollen grains tricolpate, oval in outline, 18–22 × 8–10 µm in size. Exine up to 1 µm thick, surface micro-reticulate.

Remarks. Pollen grains resembling those of the recent genus *Salix*, the nearest species *S. babylonica* L., *S. matsudana* Koidz., and *S. variegata* Franch. (Nagy 1969), in the studied material found sporadically.

Pollen grains of *Salix* type occur in Europe since the Miocene (Muller 1981), and represent cool-temperate (A2) element (Ziembińska-Tworzydło et al. 1994a).

The present-day genus *Salix* (with about 500 species of trees, shrubs and rarely shrublets) is distributed mainly in the northern hemisphere, as well as in some regions of South America and Africa. They have various soil requirements. Most of them grow on peaty, swampy and fertile alluvial soils. All of them are photophilous plants (Krüssmann 1978, Bugała 1991).

Ordo **MALVALES**
Familia **MALVACEAE**
Subfamiliae **BROWNLOWIOIDEAE**, **TILIOIDEAE**

Intratriporopollenites Pflug & Thomson 1953 emend. Mai 1961

(119) ***Intratriporopollenites instructus*** (Potonié 1931) Thomson & Pflug 1953

Pl. 14, fig. 9a, b

1931d *Tiliae-pollenites instructus* n. sp., Potonié, p. 556, fig. 9.

1953 *Intratriporopollenites instructus* (Potonié) n. comb., Thomson & Pflug, p. 89, pl. 10, figs 10–23.

Remarks. According to many authors (Thomson & Pflug 1953, Thiele-Pfeiffer 1980, Planderová 1990, Ziembińska-Tworzydło 1996) pollen grains of the morphological taxon *Intratriporopollenites instructus* resemble pollen of the recent genus *Tilia* L. However, in the Miocene deposits of Wiesa (Germany) similar ones have been found together with flowers of the fossil species *Burretia instructa* (Potonié) Mai (Mai 1961). According to this author the fossil flowers resemble those of the recent genera *Brownlowia* Roxb. and *Pentace* Hassk. Pollen grains of *Intratriporopollenites instructus* occur in Europe in the Oligocene to Pliocene deposits, with maximum in the Middle Miocene, and represent warm-temperate (A1) element (Mai 1961, Ziembińska-Tworzydło 1996). Several pollen grains of this taxon were found in the studied material.

(120) ***Intratriporopollenites insculptus*** Mai 1961

Pl. 14, figs 10, 11

1961 *Intratriporopollenites insculptus* n. sp., Mai, p. 65, pl. 11, figs 10–27.

Remarks. This taxon is similar to pollen grains of the recent subfamily Brownlowioideae (Mai 1961). *Brownlowia argentata* is a component of mangrove formation on Borneo, where pollen grains of this type occur in deposits since the Eocene (Muller 1964). In Poland *Intratriporopollenites insculptus* is known from the Miocene of central and south-western part of the Polish Lowland. They also occur in the Miocene of Hungary, Oligocene – Miocene of Germany and former Soviet Union, as well Pliocene of Slovakia (Ziembińska-Tworzydło 1996). They represent warm-temperate (A1) element (Ziembińska-Tworzydło 1996). Only 3 pollen grains of this taxon were found in bottom sample of Legnica 33/56 profile.

Pollen grains of the two above-mentioned morphological species (*Intratriporopollenites insculptus* and *I. instructus*) were isolated from flower buds of one fossil species *Craigia bronnii* (Unger) Z. Kvaček, Bůžek et Manchester, from the Late Miocene flora of Hambach, Germany (Kvaček et al. 2002).

Subfamilia **TILIOIDEAE**

(121) ***Intratriporopollenites cordataeformis*** (Wolff 1934) Mai 1961

Pl. 14, fig. 8a, b

1934 *Tiliae-pollenites instructus cordataeformis* n. f., Wolff, p. 73, pl. 5, fig. 22.

1961 *Intratriporopollenites cordataeformis* (Wolff) n. comb., Mai, p. 67, pl. 13, figs 4–7.

Remarks. These pollen grains are the nearest pollen of recent *Tilia cordata* Mill., and represent cool-temperate (A2) element (Ziembińska-Tworzydło et al. 1994a). According to Mai (1961) *Intratriporopollenites cordataeformis* is a Pliocene taxon. Similar pollen grains have been found in the Upper Miocene and Pliocene of Paratethys (Planderová 1990), and Middle Miocene of Sudetic Foredeep (Ziembińska-Tworzydło et al. 1994a). Only 3 pollen grains of this type were found in the analysed material in one sample from the Mużaków series.

Nowadays the former family Tiliaceae contains about 41 genera and 400 species of trees and shrubs, rarely herbs, extended mainly in temperate zone. The genus *Tilia* (about 30 species of deciduous trees) occurs in northern temperate zone (Heywood 1978, Bugała 1991). According to Mai (1961) the *Tilia* genus can be demonstrated with certainty by pollen only since the Pliocene.

Subfamilia **STERCULIOIDEAE**

Reevesia Lindl.

Reevesiapollis Krutzsch 1970

(122) ***Reevesiapollis triangulus*** (Mamczar 1960) Krutzsch 1970

Pl. 14, fig. 13

1960 *Pollenites triangulus* n. spm., Mamczar, p. 220, pl. 14, fig. 202.

1970c *Reevesiapollis triangulus* (Mamczar) comb. nov., Krutzsch, p. 374, pl. 5, figs 19–35, pl. 6, figs 1–11, pl. 7, figs 1–44, pl. 8, figs 1–21.

Remarks. Pollen grains of similar structure have been previously described under various names (see Sadowska 1973), and connected with the recent families Salicaceae, Oleaceae, Caprifoliaceae, Hamamelidaceae, Tiliaceae, and Balsaminaceae. Sadowska (op.

cit.) confirmed their botanical affinity with the genus *Reevesia*. The morphological species *Reevesiapollis triangulus* represents subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a). It is characteristic for the Middle Miocene to Upper Pliocene deposits (Sadowska 1973, Jahn et al. 1984). Tertiary localities of *Reevesia* are known from southern and central Europe, as well as from Asia (Petrov & Drazheva-Stamatova 1972). In the studied material pollen grains of *Reevesiapollis triangulus* were encountered regularly, but in quantities not exceeding 1% (exceptionally reaching 2–3% in bottom samples of both Legnica profiles).

Nowadays members of the genus *Reevesia* (15 species of trees and shrubs) are distributed in East Asia, from the Himalayas to Taiwan in evergreen broad-leaved forests and rain forests (Krüssmann 1978).

Familiae **STERCULIOIDEAE, RUTACEAE**

(123) ***Tricolporopollenites* sp. 2**

Pl. 14, fig. 12a, b.

1993 Sterculiaceae–Rutaceae, *Tricolporopollenites* sp. 12; Kohlman-Adamska, p. 149, pl. 25, fig. 3a, b.

Pollen grains tricolporate, in equatorial view circularly oval in outline, 22 × 18 µm in size. Colpi long, pores about 2 µm in diameter. Exine about 1 µm thick, surface reticulate with regular lumina (about 1 µm in diameter) and thin muri.

Remarks. A few pollen grains of this type of structure were found in the analysed material.

Ordo **ROSALES**
Familia **ULMACEAE**

Celtis L.

Celtipollenites Nagy 1969 emend. Kohlman-Adamska & Ziembińska-Tworzydło in Stuchlik et al. 2009

(124) ***Celtipollenites bobrowskae*** Kohlman-Adamska & Ziembińska-Tworzydło in Stuchlik et al. 2009

Pl. 14, fig. 18

2009 *Celtipollenites bobrowskae* Kohlman-Adamska & Ziembińska-Tworzydło sp. nov.; Stuchlik et al., p. 64, pl. 50, figs 10–15, pl. 51, figs 1–5.

Remarks. These pollen grains are close to the recent species *Celtis sinensis* Pers. *Celtipollenites bobrowskae* represents warm-temperate (A1) element, and is known from the Miocene – Pliocene deposits (Stuchlik et al. 2009). These pollen grains were regularly encountered in all studied profiles in quantities not exceeding 1–2%, only in the grey clay horizon reaching 2–5%.

(125) ***Celtipollenites komloensis*** Nagy 1969

Pl. 14, fig. 17

1969 *Celtipollenites komlóensis* n. g. n. sp., Nagy, p. 456, pl. 43, figs 3, 7.
1985 *Celtipollenites komloënsis* Nagy, p. 197, pl. 111, figs 17–20.
2009 *Celtipollenites komloensis* Nagy; Stuchlik et al., p. 65, pl. 50, figs 1–3, 5.

Remarks. These pollen grains are close to the recent species *Celtis occidentalis* L., and represent warm-temperate element (A1). They are reported from the Miocene-Pliocene deposits. In Poland they are rarely encountered in the Middle Miocene deposits (Stuchlik et al. 2009). Several pollen grains of this species were found in the studied material.

The present-day genus *Celtis* contains about 80 (100) species of trees, shrubs, rarely climbers, extended in temperate and tropical zones. *Celtis sinensis* Pers. is distributed in eastern China, Japan and Korea. *Celtis occidentalis* grows on humid soils in the Atlantic zone of North America (Kearney 1901, Krüssmann 1976, Kubitzki 1993).

Ulmus L.

Ulmipollenites Wolff 1934

(126) ***Ulmipollenites maculosus*** Nagy 1969

Pl. 14, fig. 19

1969 *Ulmipollenites maculosus* n. sp., Nagy, p. 223, pl. 52, figs 1, 2.

Remarks. These pollen grains represent cool-temperate element (A2), and occur in the Oligocene to Pliocene deposits (Ziembińska-Tworzydło 1996, Stuchlik et al. 2009). In the studied material these pollen grains occurred regularly in quantities 1–2%, in several samples of the grey clay horizon and Mużaków series reaching about 5%.

The present-day genus *Ulmus* contains about 45 species of trees and shrubs distributed in northern temperate and boreal zones, being particularly common in central and northern Asia (Krüssmann 1978, Kubitzki 1993).

Zelkova Spach.

Zelkovaepollenites Nagy 1969

(127) ***Zelkovaepollenites potoniei*** Nagy 1969

Pl. 14, fig. 20

1969 *Zelkovaepollenites potoniei* n. sp., Nagy, p. 225, pl. 51, figs 17, 20.

Remarks. These pollen grains are similar to pollen of the recent *Zelkova carpinifolia* (Pall.) Koch, and represent warm-temperate element (A1). They occur in the Miocene – Pliocene deposits (Stuchlik et al. 2009). Low quantities of *Zelkovaepollenites* in fossil material could be explained by small pollen productivity of *Zelkova* trees and weak resistance of their pollen grains (Stuchlik & Kvavadze 1993). In the analysed material pollen grains of *Zelkovaepollenites potoniei* were encountered sporadically.

Today the genus *Zelkova* contains 6–7 species of deciduous trees, rarely shrubs growing on Crete, in eastern and western Asia, as well as on Taiwan. *Zelkova carpinifolia* is native to the Caucasus (Krüssmann 1978, Kubitzki 1993).

Two morphological genera *Ulmipollenites* and *Zelkovaepollenites* have been distinguished, but in the analysed material often occurred pollen grains with intermediate features. Therefore in histograms they were presented together as the *Ulmus*/*Zelkova* column.

Familia **URTICACEAE**

Triporopollenites Pflug & Thomson in Thomson & Pflug 1953

(128) ***Triporopollenites urticoides*** Nagy 1969

Pl. 14, figs 14, 15

1969 *Triporopollenites urticoides* n. sp., Nagy, p. 453, pl. 51, figs 11, 12.

Remarks. Pollen grains approach pollen of Urticaceae, of unknown species affinity. Similar ones are rare in the Polish Tertiary. They are known from the Miocene (Stachurska et al. 1967, 1971, Ziembińska-Tworzydło 1974) and Pliocene deposits (Jahn et al. 1984), and represent cosmopolitan (P/A) climatic element (Stuchlik et al. 2009). In the studied material only a few pollen grains of *Triporopollenites urticoides* were found.

Today the family Urticaceae with 45 genera and about 1000 species of herbs, shrubs, climbers and small trees, occurs almost all over the world, particularly often in tropics. The majority of species grow in humid conditions, such like forest bottom, along streams, in mountain tropical forests, rarely in lowland tropical forests. *Boehmeria cylindrica* (L.) Sw. is frequent along streams in swamp forests of North America (Kearney 1901, Kubitzki 1993).

Familia **ROSACEAE**

Photinia Lindl., *Sorbus* L.

(129) ***Tricolporopollenites photinioides*** Skawińska in Ziembińska-Tworzydło et al. 1994

Pl. 15, fig. 1a, b

1994b *Tricolporopollenites photinioides* Skawińska sp. nov.; Ziembińska-Tworzydło et al., p. 28, pl. 16, figs 27a, b, 28.

Remarks. Pollen grains resembling in structure pollen of the genera *Photinia* and *Sorbus*. However, the genus *Photinia* could be more probable because of the occurrence of *Photinia* macro-remains in Mirostowice Dolne (Zastawniak 1978) and Domański Wierch (Łańcucka-Środoniowa 1980b) fossil floras. These pollen grains are the nearest those of recent *P. serrulata* Lindl. (Skawińska 1989). They are known from the Miocene deposits, and represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a, b). In the analysed material pollen grains of *Tricolporopollenites photinioides* were encountered regularly, but in small quantities.

Nowadays genus *Photinia* (about 60 species) is distributed in south-eastern Asia and central America, whereas *Sorbus* (more than 100 species) grows in northern temperate zone (Krüssmann 1977).

Familia **Rosaceae**

(130) ***Tricolporopollenites* sp. 3**

Pl. 15, fig. 2a, b

R e m a r k s. Pollen grains resembling pollen of family Rosaceae, but not determined closely. In the studied material they were found regularly, but in small quantities.

Ordo **Saxifragales**
Familia **Iteaceae**

Itea L.

Iteapollis Ziembińska-Tworzydło 1974

(131) ***Iteapollis angustiporatus*** (Schneider 1965) Ziembińska-Tworzydło 1974

Pl. 14, fig. 16a, b

1965 *Psilodoporites angustiporatus* n. sp., Schneider, p. 205, pl. 1, fig. 10.
1974 *Iteapollis angustiporatus* (Schneider) n. comb., Ziembińska-Tworzydło, p. 402, pl. 25, figs 2, 3.

R e m a r k s. Pollen grains resembling those of the recent *Itea* occur in deposits since the Eocene (Muller 1981), and are sporadically found in the Polish Miocene. They represent subtropical (P2) element (Ziembińska-Tworzydło 1996). In the studied material pollen grains of *Iteapollis angustiporatus* were encountered sporadically.

The recent members of *Itea* genus (15 species of evergreen and deciduous shrubs and trees) are distributed in south-eastern Asia, from the Himalayas to Japan and western Malaysia. *Itea chinensis* Hook. et Arn. and *I. macropylla* Wall. grow in evergreen forests in southern China. One species (*I. virginica* L.) grows in swampy bushes and along streams in North America (Kearney 1901, Wang 1961, Krüssmann 1977).

Ordo **Myrtales**
Familia **Lythraceae**

Lythraceaepollenites Thiele-Pfeiffer 1980

(132) ***Lythraceaepollenites bavaricus*** Thiele-Pfeiffer 1980

Pl. 15, fig. 5

1980 *Lythraceaepollenites bavaricus* n. sp., Thiele-Pfeiffer, p. 165, pl. 16, figs 1–10.

R e m a r k s. This fossil taxon has been described from the Miocene of Germany (Thiele-Pfeiffer 1980). In the analysed material pollen grains of this species were found very rarely.

Decodon J.F.Gmel.

(133) ***Lythraceaepollenites decodonensis*** Stuchlik in Ziembińska-Tworzydło et al. 1994

Pl. 15, fig. 6

1964 *Decodon* cf. *globosus* (Reid) Nikit.; Stuchlik, p. 49, pl. 15, figs 6, 7.
1994b *Lythraceaepollenites decodonensis* Stuchlik sp. nov.; Ziembińska-Tworzydło et al., p. 24, pl. 14, figs 9–11.

R e m a r k s. Pollen grains of *Decodon* type occur in the Polish Miocene and Pliocene (Stuchlik 1964, Oszast 1967, 1973, Stachurska et al. 1973, Oszast & Stuchlik 1977, Jahn et al. 1984 – also in macro-remains). They represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a, b). In the studied material their frequency did not exceed 1%.

Nowadays the genus *Decodon* (with one species *D. vetricillatus* (L.) Ell.) grows in swampy areas in the Atlantic zone of North America (Kearney 1901, Krüssmann 1976).

Trapa L.

Sporotrapoidites Klaus 1954

(134) ***Sporotrapoidites erdtmani*** (Nagy 1979) Nagy 1985

Pl. 15, fig. 4

1979 *Goerboepollenites erdtmanii* n. sp., Nagy, p. 185, figs 2, 3E–N, 4A–D.
1985 *Sporotrapoidites erdtmani* (Nagy) n. comb., Nagy, p. 163, pl. 93, figs 18–20, pl. 94, figs 1–8.
1994b *Trapapollis erdtmanii* (Nagy) Kohlman-Adamska comb. nov.; Ziembińska-Tworzydło et al., p. 27, pl. 15, figs 23a, b, 24.

Pollen grain tricolporate, 48 μm in diameter, in equatorial view broadly oval in outline, in polar view triangular in outline with three thin crests formed of ectexine. Crests 6–8 μm broad, arranged meridionally, meeting at the poles. Surface granulate.

R e m a r k s. The taxon *Sporotrapoidites erdtmani* occurs in the Miocene to Pliocene deposits and represents warm-temperate (A1) element

(Ziembińska-Tworzydło et al. 1994a, b). At Legnica only one specimen was found in the Lusatian seam.

The present-day genus *Trapa* contains 1–3 (about 20?) species growing in warm-temperate zone of Europe, Asia, Africa, and North America (e.g. Hutchinson 1973, Cook et al. 1974).

Familia **ONAGRACEAE**

Corsinipollenites Nakoman 1965

(135) ***Corsinipollenites oculusnoctis*** (Thiergart 1940) Nakoman 1965

Pl. 15, fig. 3

1940 *Pollenites oculus noctis* n. sp., Thiergart; p. 47, pl. 7, fig. 1.
1964 Oenotheraceae, *Pollenites oculi noctis* Thiergart; Stuchlik, p. 51, pl. 15, figs 20–22.
1965 *Corsinipollenites oculusnoctis* Thiergart nov. comb., Nakoman, p. 156, pl. 8, figs 1–5.

Remarks. This pollen grain resembles in its structure pollen of the recent Onagraceae (genera *Circaea* L. and *Epilobium* L.), and represents subtropical/arctotertiary element (P2/A). *Corsinipollenites oculusnoctis* occurs in the Eocene to Pliocene. In Poland it is encountered in the Upper Oligocene to Pliocene deposits (Stuchlik et al. 2009). Only one pollen grain of this taxon was found in the Komorniki profile.

Recently the family Onagraceae contains about 20 genera of herbs, rarely shrubs extended in temperate and tropical zones (Heywood 1978).

Ordo **FABALES**
Familiae **FABACEAE, FAGACEAE, COMBRETACEAE, VERBENACEAE**

(136) ***Tricolporopollenites fallax*** (Potonié 1934) Krutzsch in Krutzsch et al. 1960

Pl. 15, fig. 7

1934 *Pollenites fallax* n. sp., Potonié, p. 70, pl. 3, fig. 10.
1960 *Tricolporopollenites fallax* (Potonié) n. comb. (Krutzsch); Krutzsch et al., p. 140.

Remarks. Pollen grains of this species are common in the European Palaeogene to Miocene palynofloras (Ziembińska-Tworzydło 1996). In the studied material they were often encountered, in samples from the Henryk seam in quantites of a few per cent, whereas in Lusatian seam they reached 12%.

(137) ***Tricolporopollenites liblarensis*** (Thomson 1950) Grabowska in Ziembińska-Tworzydło et al. 1994

Pl. 15, fig. 8

1950 *Pollenites liblarensis* n. spm. (Thomson); Potonié, Thomson & Thiergart, p. 55.
1994b *Tricolporopollenites liblarensis* (Thomson) Grabowska comb. nov.; Ziembińska-Tworzydło et al., p. 28, pl. 16, figs 13, 14.

Remarks. This morphological species is common in the Palaeocene to Pliocene deposits (Ziembińska-Tworzydło et al 1994a, b, Ziembińska-Tworzydło 1996). In the studied material pollen grains of *Tricolporopollenites liblarensis* were rather often found, usually in samples with *T. fallax*, making up 2–3%.

(138) ***Tricolporopollenites quisqualis*** (Potonié 1934) Krutzsch 1954

Pl. 15, fig. 9

1934 *Tricolpopollenites quisqualis* n. sp., Potonié, p. 70, pl. 3, figs 13–16.
1954 *Tricolporopollenites quisqualis* (Potonié) n. comb., Krutzsch, p. 284.
1994a *Tricolporopollenites quisqualis* (Potonié) Krutzsch; Ziembińska-Tworzydło et al., pl. 16, figs 15–17.

Remarks. Several pollen grains of this species were found in the analysed material.

The three above-mentioned taxa (*Tricolporopollenites fallax*, *T. liblarensis* and *T. quisqualis*) represent subtropical (P2) element. They can belong to the families Fabaceae, Fagaceae, Combretaceae or Verbenaceae (Ziembińska-Tworzydło et al. 1994a).

The family Fabaceae contains about 600 genera and 13 000 species occurring in tropical, subtropical and temperate zones. The Combretaceae is a family of tropical, rarely subtropical trees and shrubs. The family Verbenaceae contains arboreal and herbaceous plants occurring mainly in tropics and southern temperate zone (Hutchinson 1973).

Cassia L.

(139) ***Tricolporopollenites*** **sp. 4**

Pl. 15, figs 10, 11

1977 Leguminosae t. *Cassia*; Oszast & Stuchlik, pl. 8, figs 1–3.

1993 Leguminosae – *Tricolporopollenites* sp. 7; Kohlman-Adamska, p. 144, pl. 23, fig. 1a, b.

Pollen grains tricolporate, in equatorial view oval in outline, 40–42 × 20–26 µm in size. Colpi with thick edges, extending parallel to the polar axis. Pores rather big, oval, in the middle of the colpi. Exine about 2 µm thick, surface very finely granulate.

Remarks. Morphologically, these pollen grains approach pollen of the genus *Cassia* (Fabaceae). Similar ones have been reported from the Neogene of Poland (Oszast 1967, Oszast & Stuchlik 1977, Kohlman-Adamska 1993). Only two pollen grains of this type were found in one sample from the Henryk seam of Legnica 33/56 profile.

Nowadays the genus *Cassia* (500–600 species of shrubs, trees and herbs) is distributed in subtropical and tropical zones (Krüssmann 1976).

Ordo **Crossosomatales**
Familia **Staphyleaceae**

Staphylea L.

(140) ***Tricolporopollenites* sp. 5**

Pl. 15, fig. 12a, b

1964 *Staphyllea* sp.; *Pollenites perexpressus* Doktorowicz-Hrebnicka; Stuchlik, p. 59, pl. 18, figs 7–10.
1973 *Staphylea* sp.; Stachurska et al., pl. 13, figs 3, 4.
1990 *Tricolporopollenites* sp. type *"Staphylea"*; Planderová, p. 79, pl. 77, figs 5, 6.

Pollen grains tricolporate, in equatorial view oval in outline, 35–50 µm in size. Colpi long, pores oval, elongated meridionally. Exine about 2 µm thick, surface reticulate with irregular lumina. Size of lumina and muri the largest at the poles.

Remarks. These sporomorphs resemble pollen of *Staphylea*. Pollen grains of this type are known from the Polish Miocene and Pliocene (Doktorowicz-Hrebnicka 1956b, c, Stuchlik 1964, Oszast 1973, Stachurska et al. 1973, Sadowska 1977, Oszast & Stuchlik 1977, Jahn et al. 1984). At Legnica a few specimens were found.

Today the genus *Staphylea* contains about 12 species of deciduous shrubs and small trees occurring in northern temperate zone (Krüssmann 1978).

Ordo **Sapindales**
Familia **Sapindaceae**
Subfamilia **Aceroideae**

Acer L.

Aceripollenites Nagy 1969

(141) ***Aceripollenites microrugulatus*** Thiele-Pfeiffer 1980

Pl. 15, fig. 14a, b

1980 *Aceripollenites microrugulatus* n. sp., Thiele-Pfeiffer, p. 146, pl. 11, figs 26–31.

Pollen grains tricolpate, in equatorial view oval elongate in outline, 28–32 × 16–18 µm in size. Colpi narrow, running parallel. Exine 1.5–2.0 µm thick, surface delicate, rugulate. Sculpture elements short, arranged in various directions.

Remarks. Pollen grains approaching those of the recent *Acer negundo* L. (section Negundo – Biesboer 1975) were described from the Miocene and Pliocene of Germany (Thiele-Pfeiffer 1980). They represent arctotertiary (A) element. A few specimens of this fossil species were found in the Komorniki profile.

(142) ***Aceripollenites* sp. 1**

Pl. 15, fig. 15a–c

1993 *Acer tataricum* L., *A. truncatum* Bge. type, *Aceripollenites* sp. 2; Kohlman-Adamska, p. 151, pl. 26, fig. 5a, b.

Pollen grains tricolporate, in equatorial view oval elongate in outline, 25–30 × 15–20 µm in size. Poles somewhat rounded, colpi go deep into polar areas. Exine about 1.5 µm thick, surface striato-rugulate. Striae long, arranged variously, mostly meridionally.

Remarks. Pollen grains resembling pollen of the recent *Acer tataricum* L. and *A. truncatum* Bge. (section Platanoidea – Biesboer 1975, Kohlman-Adamska 1993). They represent arctotertiary (A) element. Several pollen grains of this type were found in the studied material.

Nowadays the genus *Acer* (about 150 species) is common throughout northern temperate zone as well as in the mountains of tropical zone. *Acer platanoides* L. is distributed in Europe to the Caucasus, *A. pseudoplatanus* L. in central Europe, *A. negundo* L. in eastern and central USA, *A. rubrum* L. is an important component of swamp bushwoods and forests in the Atlantic zone of North America (Kearney 1901, Krüssmann 1976, Willard et al. 2004).

Familia ?RUTACEAE

(143) **?Rutaceae** type

Pl. 15, fig. 13

Pollen grain ?8-colporate, in equatorial view oval in outline, 50 × 35 µm in size. Colpi parallel, not meeting each other at the poles. Pores about 5 µm in diameter, situated equatorially in the colpi. Exine 1.0–1.5 µm thick, surface micro-reticulate. Lumina circular, of the same diameter on all grain surface.

R e m a r k s. A few pollen grains of this type (5- 8-colporate) were found in the analysed material. Some of them were smaller than the described one.

Familia MELIACEAE

Meliapollis Sah & Kar 1970

(144) ***Meliapollis* sp.**

Pl. 15, fig. 16

1964 cf. *Melia* sp.; Stuchlik, p. 56, pl. 17, figs 3, 4.
1993 Meliaceae – type; Kohlman-Adamska, p. 149, pl. 25, fig. 7a–c.

Pollen grains tetracolporate, in polar view circular in outline, in equatorial view oval to oval-rectangle in outline, 24–30 × 15–25 µm in size. Colpi long and narrow. Pores situated equatorially, circular, 4–5 µm in diameter. Exine 1.5–2.0 µm thick, surface psilate.

R e m a r k s. Pollen grains similar to pollen of the recent Meliaceae occur in the Polish Miocene (Stuchlik 1964, Oszast & Stuchlik 1977, Sadowska 1977, Skawińska 1989, Kohlman-Adamska 1993), and represent tropical (P1) element (Ziembińska-Tworzydło et al. 1994a). In the studied material pollen grains of *Meliapollis* sp. were encountered sporadically in the Lusatian seam.

Nowadays the family Meliaceae contains about 50 genera and 550 species of trees and shrubs extended in tropical and subtropical zones (Heywood 1978).

Familia ANACARDIACEAE

Rhus L.

Rhuspollenites Thiele-Pfeiffer 1980

(145) ***Rhuspollenites ornatus*** Thiele-Pfeiffer 1980

Pl. 15, fig. 17a–c

1980 *Rhuspollenites ornatus* n. sp., Thiele-Pfeiffer, p. 23, pl. 16, figs 15–22.

Pollen grains tricolporate, in equatorial view oval in outline, 21–23 × 17–20 µm in size. Colpi almost reaching the poles. Pores oval, in the colpi at equator. Exine about 1.5 µm thick, surface striato-reticulate. Striae arranged meridionally.

R e m a r k s. These pollen grains represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a). The species *Rhuspollenites ornatus* has been described from the Upper Oligocene and Miocene of Germany (Thiele-Pfeiffer 1980). Only a few pollen grains of this taxon were found in the studied material.

The present-day genus *Rhus* contains about 250 species of evergreen and deciduous trees and shrubs, distributed mainly in tropical and subtropical zones of North America, China, and Japan (Krüssmann 1978). Some species prefer drier places – e.g. *R. copallina* L. and *R. toxicodendron* L.; whereas some grow on wet soils – e.g. *R. vernix* L. and *R. radicans* L. (Kearney 1901).

Ordo AQUIFOLIALES
Familia AQUIFOLIACEAE

Ilex L.

Ilexpollenites Thiergart 1937

(146) ***Ilexpollenites iliacus*** (Potonié 1931) Thiergart 1937 ex Potonié 1960

1931d *Pollenites iliacus* n. sp., Potonié, p. 556, fig. 5.
1937 *Ilex-pollenites iliacus* (Potonié) n. comb., Thiergart, p. 321, pl. 25, fig. 30.
1960 *Ilexpollenites iliacus* (Potonié) Thiergart; Potonié, p. 99.

R e m a r k s. These pollen grains resemble pollen of the recent *Ilex*, and are nearest the species: *I. aquifolium* L., *I. cymosa* Bl., and *I. sieboldii* Miq. (Kohlman-Adamska 1993). They occur in Europe in the Oligocene to Pliocene deposits, and represent subtropical (P2) element (Ziembińska-Tworzydło 1996). In the analysed material two subspecies differing in grain size and sculpture were distinguished:

(146a) ***Ilexpollenites iliacus*** (Potonié 1931) Thiergart 1937 **f. *major*** Thomson & Pflug 1953

Pl. 16, fig. 1

1953 *Ilexpollenites iliacus* (Potonié) Thiergart f. *major* Thomson & Pflug, p. 106, pl. 14, figs 43–45.

R e m a r k s. Pollen grains above 45 µm in size, with large sculpture elements. They were sporadically encountered in the studied material, in several samples from the Lusatian seam.

(146b) ***Ilexpollenites iliacus*** (Potonié 1931) Thiergart 1937 **f. *medius*** Thomson & Pflug 1953

Pl. 16, fig. 2

1953 *Ilexpollenites iliacus* (Potonié) Thiergart f. *medius*, Thomson & Pflug, p. 106, pl. 14, figs 46–60.

R e m a r k s. Pollen grains up to 45 µm in size, common in the analysed material.

(147) ***Ilexpollenites margaritatus*** (Potonié 1931) Raatz 1937 ex Potonié 1960

Pl. 15, fig. 18a, b

1931a *Pollenites margaritatus* n. sp., Potonié, p. 332, pl. 1, figs 32, 33.

1937 *Ilex-pollenites margaritatus* (Potonié); Raatz, p. 321, pl. 25, figs 27–29.

1960 *Ilexpollenites* (al. *Pollenites*) *margaritatus* (Potonié) Raatz; Potonié, p. 99.

R e m a r k s. These pollen grains resemble e.g. pollen of the recent *Ilex asprella* Champ., *I. cinerea* Champ. ex Benth., and *I. mitis* (L.) Radlk. (Kohlman-Adamska 1993). They were regularly encountered in the analysed material.

(148) ***Ilexpollenites propinquus*** (Potonié 1934) Potonié 1960

Pl. 15, fig. 19

1934 *Pollenites propinquus* n. sp., Potonié, p. 74, pl. 3, fig. 33.

1960 *Ilexpollenites* (al. *Pollenites*) *propinquus* (Potonié); Potonié, p. 100.

Pollen grains similar in structure to above-mentioned ones, but smaller, 20–25 × 15–20 µm in size. Surface baculate. Bacula small (about 1.5–2.0 µm in size), densely distributed on surface.

R e m a r k s. Pollen grains similar to pollen of the recent *Ilex cassine* L., sporadically found in the studied material.

The above-mentioned taxa (*Ilexpollenites iliacus*, *I. margaritatus* and *I. propinquus*) represent subtropical element (P2), and occur in Europe in the Oligocene to Pliocene deposits (Ziembińska-Tworzydło et al. 1994a). According to Thiele-Pfeiffer (1980) pollen grains of *Ilexpollenites* are also similar to pollen of the recent genus *Nemopanthus* Raf. (*N. canadensis*), from the Atlantic zone of North America.

Nowadays the genus *Ilex* contains about 400 species of evergreen and deciduous trees and shrubs extended in temperate and tropical zones of both hemispheres (Krüssmann 1977). *Ilex cassine* L. and *I. coriacea* (Pursh) Chapman grow in wetlands in the Atlantic zone of North America (Haynes 2000).

Ordo SANTALALES

Familia LORANTHACEAE

Arceuthobium Bieb.

Spinulaepollis Krutzsch 1962

(149) ***Spinulaepollis arceuthobioides*** Krutzsch 1962

Pl. 16, fig. 3a, b

1962b *Spinulaepollis arceuthobioides* n. fsp., Krutzsch, p. 278, fig. 7, pl. 6, figs 1–15.

R e m a r k s. Pollen grains of this species occur in the Oligocene and Miocene deposits, and represent warm-temperate (A1) element (Ziembińska-Tworzydło 1996). They are similar to recent pollen of *Arceuthobium* (species *A. oxycedri*), and occurred together with *Arceuthobium* macro-remains in the Upper Miocene flora of Gozdnica (Łańcucka-Środoniowa 1980a, Łańcucka-Środoniowa et al. 1992). In the studied material pollen grains of *Spinulaepollis arceuthobioides* were encountered regularly, usually not exceeding 1% (max. 3% in one sample).

Today the genus *Arceuthobium* contains about 32 species of parasitic plants living on conifers (*Juniperus*, *Picea* and others) in North and central America as well as in south-eastern Asia (3 species) and Europe (1 species – *A. oxycedri*).

Ordo **VITALES**
Familia **VITACEAE**

Parthenocissus Planch.

(150) ***Tricolporopollenites marcodurensis*** Pflug & Thomson in Thomson & Pflug 1953

Pl. 16, fig. 4a, b

1953 *Tricolporopollenites marcodurensis* n. sp. (Pflug & Thomson); Thomson & Pflug, p. 103, pl. 13, figs 5–9.

Remarks. The fossil taxon *Tricolporopollenites marcodurensis* occurs in the Oligocene and more often in the Miocene deposits, and represents tropical (P1) element (Ziembińska-Tworzydło et al. 1994a). In the studied material these pollen grains were encountered sporadically, in quantities not exceeding 1%.

Nowadays the genus *Parthenocissus* contains about 15 species of deciduous and evergreen climbers native in North America, Mexico and East Asia. *P. henryana* grows in central China (Krüssmann 1977).

Vitis L.

Vitispollenites Thiele-Pfeiffer 1980

(151) ***Vitispollenites tener*** Thiele-Pfeiffer 1980

Pl. 16, fig. 5

1964 *Vitis*; Stuchlik, p. 61, pl. 18, figs 14–17.
1980 *Vitispollenites tener* n. sp., Thiele-Pfeiffer, p. 22, pl. 16, figs 11–14.

Remarks. Pollen grains approach those of *Vitis*, nearest the recent species *Vitis vinifera* L., *V. simpsoni* Munson, and *V. cornifolia* Baker (Kohlman-Adamska 1993), occurring in the Miocene and Pliocene deposits (Stuchlik 1964, Oszast 1967, Stachurska et al. 1973, Sadowska 1977, Jahn et al. 1984, Kohlman-Adamska 1993). They represent warm-temperate (A1) element. In the analysed material these pollen grains were encountered sporadically.

Today the genus *Vitis* (about 60–70 species) occurs in warm-temperate zone of the northern hemisphere (Krüssmann 1978).

Ordo **CORNALES**
Familia **NYSSACEAE**

Nyssa L.

Nyssapollenites Thiergart 1937

In morphological taxon *Nyssapollenites kruschi* (=*Tricolporopollenites kruschi*) three, differing in size, subspecies (Thomson & Pflug 1953) or species (Nagy 1985, Planderová 1990) have been distinguished (*analepticus*, *contortus* and *rodderensis*). In the studied material two of them were encountered:

(152) ***Nyssapollenites analepticus*** (Potonié 1934) Planderová 1990

Pl. 16, fig. 6

1934 *Pollenites kruschi* f. *analepticus* n. sp., Potonié, p. 65.
1953 *Tricolporopollenites kruschi* (Potonié) subsp. *analepticus* (Potonié) n. comb., Thomson & Pflug, p. 103, pl. 13, figs 14–24.
1969 *Nyssapollenites kruschi* (Potonié) ssp. *analepticus* (Potonié) n. comb., Nagy, p. 409.
1990 *Nyssapollenites analepticus* (Potonié) n. comb., Planderová, p. 74, pl. 71, figs 10–14.
2004 *Nyssapollenites kruschi* (Potonié) Potonié, Thomson & Thiergart ssp. *analepticus* (Potonié) Nagy; Liang, p. 37, pl. 8, fig. 11a, b, pl. 9, fig. 3a, b.

Remarks. Pollen grains 22–30 µm in size, sporadically found in the analysed material.

(153) ***Nyssapollenites rodderensis*** (Thiergart in Potonié, Thomson & Thiergart 1950) Kedves 1978

Pl. 16, fig. 10a, b

1950 *Nyssoidites rodderensis* Thiergart; Potonié et al., p. 59, pl. B, fig. 49.
1953 *Tricolporopollenites kruschi* (Potonié) subsp. *Rodderensis*, Thomson & Pflug, p. 104, pl. 13, figs 32, 33.
1978 *Nyssapollenites rodderensis* (Thiergart in Potonié, Thomson & Thiergart) n. comb., Kedves, p. 45.
1994a *Nyssapollenites kruschi* (Potonié) Nagy *rodderensis* (Thiergart) Thomson & Pflug; Ziembińska-Tworzydło et al., pl. 14, fig. 13.
1998 *Nyssapollenites rodderensis* (Thiergart) Kedves; Słodkowska, pl. 6, fig. 2, pl. 9, fig. 11, pl. 11, fig. 25.
2004 *Nyssapollenites kruschi* (Potonié) Potonié, Thomson & Thiergart ssp. *rodderensis* (Thiergart) comb. nov., Liang, p. 38, pl. 7, fig. 3.

Remarks. Pollen grains 45–55 × 40–45 µm in size, not numerous in the studied material.

Pollen grains of fossil taxon *Nyssapollenites kruschi* (and its subspecies) occur in Europe in the Oligocene to Pliocene deposits, and represent warm-temperate (A1) element (Ziembińska-Tworzydło 1996).

(154) ***Nyssapollenites pseudocruciatus*** (Potonié 1931) Thiergart 1937

Pl. 16, figs 7a, b, 8

1931a *Pollenites pseudocruciatus* n. sp., Potonié, p. 328, pl. 1, fig. 10.

1937 *Nyssapollenites pseudocruciatus* (Potonié) n. comb., Thiergart, p. 322, pl. 25, figs 32–34, pl. 26, fig. 1.

Pollen grains 27–32 µm in size, resembling those of *Nyssapollenites kruschi*. Pores with very thick edges, surface granulate, somewhat more delicate than *N. analepticus*.

Remarks. This taxon represents warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a). In the studied material these pollen grains were encountered regularly, but in low quantities.

Pollen grains of *Nyssapollenites* morphological genus are similar to pollen of *Nyssa*. They are frequent in the Neogene, though they are reported also from the Palaeogene (Muller 1981). In the younger Neogene larger forms prevail (Doktorowicz-Hrebnicka 1954).

Presently the genus *Nyssa* contains 6 species of deciduous trees; four of them occur in the Atlantic zone of North America, whereas the other two grow in south-eastern Asia (Krüssmann 1977). *Nyssa aquatica* L. and *N. sylvatica* Marsh are components of swamp forests (Kearney 1901, Kac 1975, Haynes 2000).

Familia CORNACEAE
Subfamilia CORNOIDEAE

Cornaceaepollis Stuchlik in Ziembińska-Tworzydło et al. 1994

(155) ***Cornaceaepollis major*** (Stuchlik 1964) Stuchlik in Ziembińska-Tworzydło et al. 1994

Pl. 16, fig. 13a, b

1964 *Cornoidites major* n. sp., Stuchlik, p. 62, pl. 19, figs 1–4.

1994b *Cornaceaepollis major* (Stuchlik) Stuchlik comb. nov.; Ziembińska-Tworzydło et al., p. 22, pl. 13, fig. 11a–c.

Pollen grains tricolporate, in equatorial view broadly oval in outline, 55–60 µm in size, in polar view triangularly oval in outline. Colpi rather long, bent in equatorial plain, nearly meeting each other at the poles. Pores in the middle of the colpi, set transversally to them, up to 15 µm in diameter. Exine 4–5 µm thick. Ectexine thicker than endexine. Surface granulate.

Remarks. In the analysed material a few pollen grains of this taxon were found in the Lusatian seam.

(156) ***Cornaceaepollis minor*** (Stuchlik 1964) Stuchlik in Ziembińska-Tworzydło et al. 1994

Pl. 16, fig. 11a, b

1964 *Cornoidites minor* n. sp.; Stuchlik, p. 62, pl. 19, figs 5–7.

1994b *Cornaceaepollis minor* (Stuchlik) Stuchlik comb. nov.; Ziembińska-Tworzydło et al., p. 22, pl. 13, figs 12a, b, 13.

Pollen grains resembling in structure above-mentioned ones, but 24–28 µm in size. Exine about 2 µm thick, surface finely granulate.

Remarks. Pollen grains of this taxon were sporadically encountered in the Lusatian seam of both Legnica profiles.

Pollen grains of both above-mentioned taxa (*Cornaceaepollis major* and *C. minor*) are similar to pollen of the recent *Cornus* L. They occur in the Oligocene and Miocene deposits of the Polish Lowland, and represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a, b).

Nowadays the family Cornaceae contains 12 genera extended in tropical to temperate zones of North America and in temperate Asia. The genus *Cornus* (about 40 species) is common throughout northern temperate zone (Krüssmann 1976).

Subfamilia MASTIXIOIDEAE

(157) ***Cornaceaepollis satzveyensis*** (Pflug in Thomson & Pflug 1953) Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

Pl. 16, fig. 9a, b

1953 *Tricolporopollenites satzveyensis* n. sp. (Pflug); Thomson & Pflug, p. 103, pl. 13, figs 10–13.

1994b *Cornaceaepollis satzveyensis* (Pflug) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 22, pl. 13, figs 8–10a, b.

Remarks. This morphological species occurs in the Palaeocene to Miocene deposits, and represents tropical (P1) element (Ziembińska-Tworzydło 1998). Pollen grains of this type of structure are presently excluded from the collective morphological genus *Tricolporopollenites* due to their similarity to pollen of Cornaceae, particularly to the subfamily Mastixioideae (Ziembińska-Tworzydło et al. 1994b). In the studied material pollen grains of *Cornaceaepollis satzveyensis* were found mainly in the Lusatian seam, in quantities not exceeding 1%.

Today subfamily Mastixioideae with one genus – *Mastixia* Bl. (25 species of evergreen trees) occurs in the Indo-Malayan region in temperate zone (Heywood 1978).

Ordo **Apiales**
Familia **Araliaceae**

(158) ***Araliaceoipollenites edmundi*** (Potonié 1931) Potonié 1951 ex Potonié 1960

Pl. 17, fig. 1a, b

1931b *Pollenites edmundi* n. sp., Potonié, p. 26, pl. 1, fig. V53e.
1951 *Araliaceoipollenites edmundi* (Potonié); Potonié, pp. 137, 142, pl. 21, figs 135, 137.
1953 *Tricolporopollenites edmundi* (Potonié) n. comb., Thomson & Pflug, p. 101, pl. 12, figs 125–132.
1960 *Araliaceoipollenites edmundi* (Potonié); Potonié, p. 97.

Remarks. This taxon occurs in Europe in the Oligocene to Lower Pliocene deposits, and represents subtropical (P2) element (Ziembińska-Tworzydło 1996). It used to be compared with *Cornus alba*, *C. brachypoda*, *C. sanguinea* and *C. stolonifera* (Mamczar 1962). Nevertheless, pollen grains of *A. edmundi* have reticulate surface related to family Araliaceae. Kohlman-Adamska (1993) compares them with the recent species *Acanthopanax sciadophylloides* Franch & Sav. (from Japan) as well as *Panax* L. – *P. pinnatum* and *P. pentadactylon* (from south-eastern Asia) from the Araliaceae family. In the studied material pollen grains of *Araliaceoipollenites edmundi* were encountered regularly. In the Lusatian seam they occurred in quantities a few per cent (max. 8%).

Aralia L.

Araliaceoipollenites Potonié 1951 ex Potonié 1960

(159) ***Araliaceoipollenites euphorii*** (Potonié 1931) Potonié 1951 ex Potonié 1960

Pl. 16, fig. 12a, b

1931a *Pollenites euphorii* n. sp., Potonié, p. 328, pl. 1, figs 12, 28.
1951 *Araliaceoipollenites euphorii* (Potonié); Potonié, pp. 147, 151, pl. 21, figs 139, 140.
1953 *Tricolporopollenites euphorii* (Potonié) n. comb., Thomson & Pflug, p. 102, pl. 12, figs 133–140.
1960 *Araliaceoipollenites euphorii* (Potonié); Potonié, p. 97.

Remarks. These pollen grains occur in Europe in the Oligocene and Miocene deposits, and represent subtropical (P2) element (Ziembińska-Tworzydło 1996). They are similar to pollen of the recent *Aralia chinensis* L. (Kohlman-Adamska 1993) from mesophytic forests of south-eastern China. Pollen grains of *Araliaceoipollenites euphorii* were encountered in all studied profiles in small quantities, usually in samples with *A. edmundi*. Similarly these species were observed together by Mamczar (1962).

Hedera L.

(160) ***Araliaceoipollenites reticuloides*** Thiele-Pfeiffer 1980

Pl. 16, fig. 14a, b

1960 cf. *Hedera helix*; Oszast, p. 31, pl. 10, fig. 9.
1980 *Araliaceoipollenites reticuloides* n. sp., Thiele-Pfeiffer, p. 164, pl. 15, figs 26–34.

Remarks. These pollen grains represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a). They occur in the Miocene and Pliocene deposits (Oszast 1960, Stachurska et al. 1973, Thiele-Pfeiffer 1980, Muller 1981). In the examined material several pollen grains of this type of structure were found, in samples with *Araliaceoipollenites edmundi* and *A. euphorii*.

Nowadays the family Araliaceae contains herbs, shrubs, trees and climbers occurring mainly in warm-temperate zone of North America and tropical South America and Asia (Hutchinson 1973). The genus *Aralia* (about

35 species) occurs in warm zone of North America, Asia and Australia (Krüssmann 1976). The genus *Hedera* (with about 5 species of evergreen climbers) grows in Europe, North America and Asia (Krüssmann 1977).

Familiae **ARALIACEAE, CORNACEAE**

(161) ***Tricolporopollenites* sp. 6**

Pl. 17, fig. 3a, b

1977 Araliaceae–Cornaceae; Oszast & Stuchlik, pl. 11, fig. 8.

Remarks. Pollen grains similar to pollen of both Araliaceae and Cornaceae families, with not visible pores. Araliaceae/Cornaceae group has been distinguished e.g. by Oszast and Stuchlik (1977). In the studied material these pollen grains were encountered regularly, reaching max. 2–3%.

Familiae **ARALIACEAE, RHAMNACEAE**

(162) ***Tricolporopollenites* sp. 7**

Pl. 17, fig. 2a, b

Pollen grains tricolporate, in equatorial view circular to broadly oval in outline, in polar view triangular to triangular-circular in outline, 18–22 µm in size. Colpi long, bent in equatorial plain. Pores oval to circular, 1.5–2.0 µm in size. Exine about 1 µm thick, surface reticulate, lumina irregular.

Remarks. These pollen grains resemble those of families Rhamnaceae and Araliaceae, not determinated closer. Fossil pollen grains of Rhamnaceae type are found in deposits since the Oligocene (Muller 1981). From the Miocene they were reported by Doktorowicz-Hrebnicka (1956a – *Pollenites insignis* Doktorowicz-Hrebnicka), Stuchlik (1964 – *Tricolporopollenites haanradensis* Manten), Thiele-Pfeiffer (1980 – *Rhamnaceaepollenites triquetrus* Thiele-Pfeiffer), and other authors. In the studied material similar pollen grains were encountered sporadically, in quantities up to a few per cent.

Nowadays the family Rhamnaceae contains about 58 genera and 900 species of trees, shrubs and rarely herbs occurring almost all over the world in temperate to tropical climate (Engler 1964, Hutchinson 1973, Heywood 1978).

Familia **APIACEAE**

Umbelliferoipollenites Venkatachala & Kar 1968 emend. Nagy 1985

(163) ***Umbelliferoipollenites speciosus*** Nagy 1985

Pl. 17, fig. 4a–c

1985 *Umbelliferoipollenites speciosus* n. sp., Nagy, pp. 46, 172, pl. 97, fig. 35, pl. 98, figs 4–7.

Pollen grains tricolporate, in equatorial view oval in outline, elongate, about 22 × 10 µm in size. Ectopores 2.0–2.5 µm in diameter, endopores 5–6 × 2.5–3.0 µm in size. Exine 2.0–2.5 µm thick, surface granulate, grains massive in structure.

(164) ***Umbelliferoipollenites tenuis*** Nagy 1985

Pl. 17, fig. 5a, b

1985 *Umbelliferoipollenites tenuis* n. sp., Nagy, pp. 46, 173, pl. 98, figs 8–12.

Pollen grains tricolporate, similar in structure to the above-mentioned species, 21–26 × 10–12 µm in size, with a narrowing in equatorial plain. The mutual ratio of length and width is 2 : 1. Colpi narrow, ectopores circular about 1 µm in diameter, endopores equatorially elongated about 4 × 2.0–2.5 µm in size. Exine 1.0–1.5 µm thick, in pole areas thicker, surface finely granulate.

Remarks. Pollen grains of Apiaceae type are known from deposits since the Lower Eocene (Muller 1981), but they are more frequent in younger Tertiary. They have been reported from the Polish Neogene (Stuchlik 1964, Oszast 1967, 1973, Stachurska et al. 1967, Sadowska 1977, Jahn et al. 1984). In the studied material a few specimens of both above-mentioned species were found in the Lusatian seam.

Today the family Apiaceae (about 300 genera with 2500–3000 species, mainly perennial plants) is distributed all over the world, especially in temperate zone (Heywood 1978).

Ordo **DIPSACALES**
Familia **CAPRIFOLIACEAE**

Diervilla Mill., *Weigela* Thunb.

Diervillapollenites
Doktorowicz-Hrebnicka 1956

(165) ***Diervillapollenites* sp.**

Pl. 17, figs 6, 7

R e m a r k s. Pollen grains similar to the fossil taxon *Diervillapollenites megaspinosus*, but differing in sculpture. Besides pollen grains with spines, some were covered with circular outgrowths 2.0–3.5 µm in diameter. Some grains were smaller than usually described (Pl. 17, fig. 6). Pollen grains of close species *D. megaspinosus*, which occur in the Polish Miocene and Pliocene, represent cool-temperate (A2) element (Ziembińska-Tworzydło 1996) and are connected with recent genera *Diervilla* (Doktorowicz-Hrebnicka 1956a) or *Weigela* (*W. hortensis* (Sieb. & Zucc.) C.A. Mey., and *W. florida* DC.; Jahn et al. 1984). Macro-remains of *Weigela* have been found in the Polish Neogene (Łańcucka-Środoniowa 1967, Jahn et al. 1984). In the studied material pollen grains of this type were encountered sporadically, mainly in the Lusatian seam, only once exceeding 1% (in bottom sample of Legnica 41/52 profile).

The recent genus *Diervilla* contains 3 species of deciduous shrubs occurring in North America, whereas the genus *Weigela* (with 12 species) grows in East Asia (Krüssmann 1978).

Lonicera L.

Lonicerapollis Krutzsch 1962

(166) ***Lonicerapollis* sp.**

Pl. 17, fig. 8

Pollen grains tricolporate, on the poles flattened, in polar view circular in outline, 40–42 µm in diameter. Exine 1.2–2.0 µm thick, ectexine thicker than endexine. Surface covered with up to 1 µm long spines loosely and regularly distributed on the grain surface.

R e m a r k s. Pollen grains resembling pollen of the recent *Lonicera*, as well *Triosteum* L. and *Linnaea* L. from the family Caprifoliaceae. In Europe the oldest pollen grains of *Lonicera* type are known from the Oligocene (Krutzsch 1962a). They occur also in the Polish Neogene (Stuchlik 1964, Oszast 1973, Stachurska et al. 1973, Ziembińska-Tworzydło 1974, Sadowska 1977, Jahn et al. 1984). In the analysed material pollen grains of this type were found only in one sample from the Lusatian seam.

Nowadays the genus *Lonicera* contains about 200 species of evergreen and deciduous shrubs occurring in the northern hemisphere (Krüssmann 1977).

Caprifoliipites Wodehouse 1933

Viburnum L.

(167) ***Caprifoliipites viburnoides*** (Gruas-Cavagnetto 1978) Kohlman-Adamska in Ziembińska-Tworzydło et al. 1994

Pl. 17, fig. 9a, b

1978 *Tricolporopollenites viburnoides* n. f sp., Gruas-Cavagnetto, p. 36, pl. 14, figs 16–19.

1993 *Viburnum* L. – type; Kohlman-Adamska, p. 154, pl. 33, figs 7a, b, 8a, b.

1994b *Caprifoliipites viburnoides* (Gruas-Cavagnetto) Kohlman-Adamska comb. nov.; Ziembińska-Tworzydło et al., p. 20, pl. 12, figs 12–14.

Pollen grains tricolporate, in equatorial view broadly oval to circular in outline, 25–28 × 22–25 µm in size, in polar view circular in outline. Colpi with thick edges, running along polar axis deep into polar area. Exine thick; ectexine distinctly thicker than endexine. Surface reticulate, lumina polygonal, 1.5–2.0 µm in size. Muri built of one row of columellae about 1 µm thick.

R e m a r k s. These pollen grains resemble polen of the recent *Viburnum*, e.g. *V. odoratissimum* Ker., *V. carlessi* Hemsl., and *V. lentago* L. They represent warm-temperate element (A1). Pollen grains of *Viburnum* type occur in the Eocene to Pliocene deposits (Ziembińska-Tworzydło et al. 1994b). In the examined material pollen grains of *Caprifoliipites viburnoides* were found regularly, but in small quantities.

Presently the genus *Viburnum* contains about 200 species of evergreen and deciduous trees and shrubs extended in temperate and subtropical zones of the northern hemisphere, particularly in Asia (*V. carlessi* – Korea) and North America (*V. lentago*) (Krüssmann 1978). *V. dentatum* L. and *V. nudum* L. grow in swamp forests in the Atlantic zone of North America (Kearney 1901, Neyland et al 2000).

Sambucus L.

(168) ***Caprifoliipites* sp. 1**

Pl. 17, fig. 10a, b

Pollen grains tri- ?colporate, in equatorial view oval in outline, measuring 22–30 × 15–20 µm. Exine about 1.5 µm thick, surface reticulate. Lumina polygonal, various in size, muri narrow, built of one row of columellae.

R e m a r k s. Pollen grains of *Sambucus* type occur in deposits since the Miocene (Oszast 1960, 1967, Sadowska 1977, Jahn et al. 1984, Kohlman-Adamska 1993), and represent warm-temperate (A1) element (Ziembińska-Tworzydło 1998). In the studied material pollen grains of *Sambucus* type were found sporadically.

Today the genus *Sambucus* (40 species) is distributed in temperate and subtropical zones of both hemispheres (Krüssmann 1978). *S. canadensis* L. grows in swamps in the Atlantic zone of North America (Neyland et al. 2000).

Ordo **GENTIANALES**
Familia **RUBIACEAE**

Theligonum L.

Theligonumpollenites Thiele-Pfeiffer 1980

(169) ***Theligonumpollenites baculatus*** (Stachurska, Sadowska & Dyjor 1973) Thiele-Pfeiffer 1980

Pl. 17, fig. 11a, b

1973 *Polyporopollenites baculatus* n. sp., Stachurska et al., pl. 18, figs 1–7.
1980 *Theligonumpollenites baculatus* (Stachurska, Sadowska & Dyjor) n. comb., Thiele-Pfeiffer, p. 138, pl. 10, figs 19–22.

R e m a r k s. Pollen grains connected with the recent genus *Theligonum* are included into warm-temperate element (A1). In Poland they occur in the Miocene to Pliocene of south-western Polish Lowland and Upper Pliocene of the Sudetes (Ziembińska-Tworzydło 1996). Only 3 pollen grains of this taxon were found in the studied profiles.

Today the genus *Theligonum* contains 2 or 3 species of annual and perennial plants extended in the Mediterranean Region as well as in China and Japan (Praglowski 1973, Heywood 1978).

(170) **Rubiaceae** type

Pl. 17, fig. 12

R e m a r k s. Pollen grains poly- (6- 7-) colpate, micro-reticulate, resembling pollen of family Rubiaceae, but not determined closely. In the studied material several pollen grains of this type of structure have been recorded.

The Rubiaceae are trees, shrubs, or infrequently herbs comprising about 450 genera and 6 500 species, including some climbers.

Ordo **LAMIALES**
Familia **OLEACEAE**

(171) ***Tricolporopollenites retimuratus*** Trevisan 1967

Pl. 17, figs 15a, b, 16a, b

1967 *Tricolporopollenites retimuratus* n. f sp., Trevisan, p. 43, pl. 28, figs 1, 2.
1980 *Tricolporopollenites retimuratus* Trevisan; Thiele-Pfeiffer, p. 156, pl. 13, figs 12, 13.

R e m a r k s. Pollen grains resembling pollen of the recent Oleaceae. They occur in Europe in the Miocene to Pliocene deposits (Thiele-Pfeiffer 1980). In the analysed material these pollen grains were encountered regularly, but in small quantities.

(172) ***Tricolporopollenites sinuosimuratus*** Trevisan 1967

Pl. 17, figs 13, 14

1967 *Tricolporopollenites sinuosimuratus* n. f sp., Trevisan, p. 38, pl. 25, fig. 4.
1973 *Fraxinus* sp.; Stachurska et. al., p. 169, pl. 14, figs 8, 9.

R e m a r k s. Pollen grains resembling pollen of the recent *Fraxinus*; previously reported in Upper Miocene of Italy (Trevisan 1967) and Upper Miocene to Lower Pliocene of Germany (Mohr 1984). In the studied material they were encountered sporadically, mainly in the Henryk seam.

Today the family Oleaceae (about 27 genera) is distributed in tropical and temperate zones (Hutchinson 1973). The genus *Fraxinus* (about 65 species) occurs in temperate and warm-temperate zones of the northern hemisphere (Krüssmann 1977). Some species (*F. caroliniana* and others) grow in wetlands (Haynes 2000).

Familia ?**OLEACEAE**, ?**SALICACEAE**

(173) ***Tricolporopollenites*** cf. ***retiformis*** (Pflug & Thomson 1953) Krutzsch 1961

Pl. 18, fig. 14

1953 *Tricolpopollenites retiformis* (Pflug & Thomson)

n. sp., Thomson & Pflug, p. 97, pl. 11, figs 56–61.
1994a *Tricolporopollenites retiformis* (Pflug & Thomson) Krutzsch; Ziembińska-Tworzydło et al., pl. 16, figs 29a, b, 30a–c.

R e m a r k s. Botanical affinity of *T. retiformis* is not sure. Some authors connected these pollen grains with the family Salicaceae and even with the genus *Salix* (e.g. Stuchlik 1964, Stachurska et al. 1973). This taxon represents warm-temperate (A1) element, and occurs in Poland in the Lower Miocene to Pliocene deposits (Ziembińska-Tworzydło 1996). These pollen grains were sporadically encountered in the analysed material.

Familia **PLANTAGINACEAE**

Plantaginaceaerumpollis Nagy 1963

(174) ***Plantaginaceaerumpollis miocaenicus*** Nagy 1963

Pl. 18, figs 1, 2a, b

1963 *Plantaginaceaerumpollis miocaenicus* n. sp., Nagy, p. 396, pl. 5, figs 33–35.
1985 *Plantaginaceaerumpollis miocaenicus* Nagy, p. 181, pl. 105, figs 1–5.

Pollen grains multiporate (about 12 pores), circular in outline, 22–24 µm in diameter. Pores circular, 3–4 µm in diameter with thin annulus, regularly distributed on grain surface. Exine about 1.5–2.0 µm thick, surface micro-echinate.

R e m a r k s. Pollen grains of Plantaginaceae are known from deposits since the Lower Miocene from Spain, France, Germany, Hungary and other countries (Muller 1981, Nagy 1985). In Poland, pollen grains of *Plantaginaceaerumpollis miocaenicus* are encountered sporadically in the Middle Miocene – Pliocene deposits. They repreent cosmopolitan (P/A) climatic element (Stuchlik et al. 2009). Oszast (1967) reported *Plantago* cf. *maritima* from the Miocene of Tarnobrzeg as well as *Plantago* cf. *major* from the Pliocene of Domański Wierch and *Plantago media* type from the Pliocene of Krościenko. In the analysed material two pollen grains of *P. miocaenicus* were found – in the Mużaków series and in the Komorniki profile.

Nowadays the family Plantaginaceae contains 3 genera with about 253 species of annual and perennial plants distributed in temperate zone, as well as in the mountains of tropical zone. The genus *Littorella* P.J. Bergius contains two species of water plants (Heywood 1978). *Plantago cordata* Lam. is an aquatic plant growing in south-eastern part of North America (Haynes 2000).

Ordo **LAMIALES**
Familia **LAMIACEAE**

(175) **Lamiaceae** type

Pl. 18, fig. 4

Pollen grains 4- or 6-colpate, circular-oval in outline, about 27 × 25 µm in size. Colpi straight, almost parallel. Exine about 1 µm thick, surface micro-reticulate.

R e m a r k s. Pollen grains approaching those of the recent *Lycopus* L. were found in the Komorniki profile. These and other pollen grains similar to pollen of Lamiaceae, but not determined closely, were encountered sporadically in the studied material.

The recent family Lamiaceae contains about 7 000 species, mainly herbs, shrubs, and rarely trees.

Ordo **ASTERALES**
Familia **ASTERACEAE**
Subfamilia **ASTEROIDEAE**

Tubulifloridites Cookson 1947 ex Potonié 1960

(176) ***Tubulifloridites anthemidearum*** Nagy 1969

Pl. 18, fig. 3a, b

1969 *Tubulifloridites anthemidearum* n. sp., Nagy, p. 207, pl. 49, figs 9–11.

Pollen grains tricolporate, in equatorial view oval in outline, in polar view circular-triangular in outline, 24–30 µm in diameter. Exine up to 4–6 µm thick, in middle part of mesocolpium thicker, covered with spines 3–4 µm long and about 5 µm wide at the basis.

R e m a r k s. Several pollen grains of this taxon were found in the Mużaków series.

(177) ***Tubulifloridites granulosus*** Nagy 1969

Pl. 18, fig. 6a, b

1969 *Tubulifloridites granulosus* n. sp., Nagy, p. 206, pl. 49, figs 3, 4.

Pollen grains tricolporate, in equatorial view oval in outline, in polar view circular-triangular in outline, 20–25 µm in diameter. Exine up to 1–2 µm thick, covered with 5–8 spines per lobe. Spines 2–3 µm long and about 2–3 µm wide at the basis.

Remarks. Fossil pollen grains of Tubuliflorae different from *Artemisia* occur rarely in the Polish Neogene – mainly in the Upper Miocene and Pliocene (Stuchlik 1964, Stachurska et al. 1973, Jahn et al. 1984). The fossil genus *Tubulifloridites* represents cool-temperate (A2) element (Ziembińska-Tworzydło 1998). Several pollen grains of this taxon were found in the Mużaków series.

Artemisia L.

Artemisiaepollenites Nagy 1969

(178) ***Atremisiaepollenites sellularis*** Nagy 1969

Pl. 18, fig. 7a, b

1964 *Artemisia*; Stuchlik, p. 73, pl. 22, fig. 5.
1969 *Artemisiaepollenites sellularis* n. sp., Nagy, p. 208, pl. 49, figs 16, 17.

Remarks. These pollen grains represent warm-temperate (A1) element (Ziembińska-Tworzydło et al. 1994a), and occur in the Middle Miocene and probably Palaeocene – Eocene deposits (Muller 1981). In Poland fossil pollen grains of *Artemisia* type occur in deposits since the Miocene (Stuchlik 1964, Stachurska et al. 1967, Oszast 1973, Oszast & Stuchlik 1977, Jahn et al. 1984, Kohlman-Adamska 1993). In the analysed material several pollen grains of this taxon were found.

The recent subfamily Asteroideae contains about 16 000 species, mainly of herbs and shrubs. The genus *Artemisia* (about 400 species of herbs and shrubs) occurs in the northern hemisphere and in South America (Krüssmann 1976).

Classis **LILIOPSIDA**
Ordo **ALISMATALES**
Familia **BUTOMACEAE**

Butomus L.

Butomuspollenites Doktorowicz-Hrebnicka 1956 emend. Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

(179) ***Butomuspollenites butomoides*** (Krutzsch 1970) Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

Pl. 18, figs 8, 9a, b

1970a *Arecipites butomoides* subsp. *butomoides*, Krutzsch, p. 112, pl. 24, figs 12–29.
1994b *Butomuspollenites butomoides* (Krutzsch) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 19, pl. 10, fig. 14a, b.

Pollen grains monocolpate, oval in outline, 32–45 µm long. Exine 1.0–1.5 µm thick, surface reticulate. Lumina more or less circular 1.0–1.5 µm in diameter, decreasing towards the colpus. Muri very thin, about 0.5 µm thick.

Remarks. In the analysed material pollen grains of this species were encountered sporadically, only in one sample from the Henryk seam they reached 8%.

(180) ***Butomuspollenites longicolpatus*** (Krutzsch 1970) Ziembińska-Tworzydło in Ziembińska-Tworzydło et al. 1994

Pl. 18, fig. 10a, b

1970a *Arecipites longicolpatus* n. sp., Krutzsch, p. 112, pl. 25, figs 1–13.
1994b *Butomuspollenites longicolpatus* (Krutzsch) Ziembińska-Tworzydło comb. nov.; Ziembińska-Tworzydło et al., p. 19, pl. 10, fig. 14a, b.

Pollen grains monocolpate, oval elongate in outline, 38–40 × 22–23 µm in size. Exine 1.0–1.5 µm thick, surface reticulate. Lumina regular, circular to polygonal, about 1 µm in diameter, muri up to 1 µm thick.

Remarks. Pollen grains sporadically encountered in the studied material, mainly in the Henryk seam and grey clay horizon.

The two above-mentioned morphological taxa (*Butomuspollenites butomoides* and *B. longicolpatus*) are similar to pollen of the recent *Butomus*. They represent cool-temperate element (A2), and occur in the Miocene and Pliocene deposits (Ziembińska-Tworzydło et al. 1994a, b). In the Middle Miocene of the Polish Lowland they are encountered sporadically (Grabowska 1998).

Nowadays the genus *Butomus* contains only one species (*B. umbellatus* L.) occurring in stagnant and slowly flowing waters as well as wetlands in temperate zone of Europe and Asia (Heywood 1978).

Familia POTAMOGETONACEAE

Potamogeton L.

Potamogetonacidites Sah 1967

(181) ***Potamogetonacidites paluster*** (Manten 1958) Mohr 1984

Pl. 18, fig. 5

1958 *Inaperturopollenites paluster* n. sp., Manten, p. 461, fig. 5.
1984 *Potamogetonacidites paluster* (Manten) n. comb., Mohr, p. 60, pl. 7, fig. 12.

Remarks. Fossil pollen grains of *Potamogeton* are rarely found in the Polish Miocene and Pliocene (Oszast 1973, Oszast & Stuchlik 1977, Stuchlik et al. 1990, Kohlman-Adamska 1993). *Potamogetonacidites paluster* occurs in Europe in the Oligocene to Pliocene deposits, and represents cosmopolitan (P/A) climatic element (Stuchlik et al. 2009). Two pollen grains of this species were found in the analysed material (in the Mużaków series and Lusatian seam).

Nowadays the genus *Potamogeton* contains about 100 species of cosmopolitan aquatic plants (Heywood 1978).

Ordo ?ALISMATALES
Familia ?ARACEAE

(182) **?Araceae** type

Pl. 20, figs 5a, b, 6

Pollen grain circular in outline, 42 µm in diameter. Exine about 1 µm thick, covered with verrucae 1.5–5.0 µm in diameter.

Tetrad circular-triangular in outline, 60 µm in diameter. Elements of tetrad (?pollen grains) circular-oval in outline, 36–40 µm in size. Exine 1.5–2.0 µm thick, surface baculate-verrucate. Elements of sculpture 1–4 µm in size, rather densely but irregularly distributed on the surface.

Remarks. These sporomorphs, of rare type of structure, are similar to pollen of the recent *Amorphophallus* Blume ex Decne. (Araceae), nearest the species *A. abyssinicus* (see van der Ham et al. 1998). Only one single pollen grain and one tetrad were found in the Komorniki profile.

Ordo POALES
Familia CYPERACEAE

Cyperaceaepollis Krutzsch 1970

(183) ***Cyperaceaepollis neogenicus*** Krutzsch 1970

Pl. 18, fig. 13

1970a *Cyperaceaepollis neogenicus* n. sp., Krutzsch, p. 66, pl. 7, figs 4–14.

Remarks. Pollen grains related to the recent *Carex* L., *Scirpus* L., and *Cladium* R. Br. (Cyperaceae) represent cosmopolitan (P/A) element, and occur in deposits since the Miocene in Germany (Krutzsch 1970a), Slovakia (Planderová 1990) and Hungary (Nagy 1969, 1992). In the Polish Tertiary they have been found in the Lower and Middle Miocene deposits of northern and central parts of the Polish Lowland (Ziembińska-Tworzydło 1996, Stuchlik et al. 2009). In the studied material they were encountered sporadically, in quantities up to 1–2%.

(184) ***Cyperaceaepollis piriformis*** Thiele-Pfeiffer 1980

Pl. 18, figs 11, 12

1964 *Cladium* sp.; Stuchlik, p. 75, pl. 23, fig. 4.
1980 *Cyperaceaepollis piriformis* n. sp., Thiele-Pfeiffer, p. 121, pl. 7, figs 20–22.

Remarks. Pollen grains of this fossil species are morphologically similar to pollen of the recent *Carex* L. and *Cladium* R. Br. (Thiele-Pfeiffer 1980). They occur in the Upper Eocene to Miocene deposits, and represent cosmopolitan (P/A) element (Stuchlik et al. 2009). They were found in four samples from the Mużaków series; in one of them they reached 8%.

Today the genus *Cladium* (3 species) occurs almost all over the world on swampy and marshy areas (Cook et al. 1974). The Cyperaceae is a cosmopolitan family, particularly common in open and wet places.

Familia POACEAE

Graminidites Cookson 1947 ex Krutzsch 1970

Subfamilia BAMBUSOIDEAE

(185) ***Graminidites bambusoides*** Stuchlik in Ziembińska-Tworzydło et al. 1994

Pl. 19, figs 1–3

1964 Gramineae *"Bambusa"* type; Stuchlik, p. 76, pl. 24, figs 1, 2.

1970a *Graminidites* sp. A (*Bambusa* – typus); Krutzsch, p. 51, pl. 1, fig. 1.

1994b *Graminidites bambusoides* Stuchlik sp. nov.; Ziembińska-Tworzydło et al., p. 14, pl. 8, figs 4, 5.

Pollen grains monoporate, oval to spheroidal, 50–72 µm in diameter. Pore 4–6 µm in diameter, with annulus 4.0–4.5 µm broad. Exine composed of two layers, very thin (about 1.0 µm thick), with secondary falts, surface very finely granulate.

Remarks. Pollen grains of this type are connected with the recent genus *Bambusa* Schreb., but similar pollen grains have also been observed in other grass genera, e.g. *Oryza* L., *Dendrocalamus* C.G. Nees, and others (Stuchlik 1964), as well as *Arundinaria* Michx. (comp. pl. 19, fig. 6). They differ from pollen of the recent *Triticum* L. in thinner exine (*Triticum* – about 2 µm) and more delicate annulus (comp. pl. 19, fig. 5). From the recent *Secale* L. they differ in shape and thinner exine, as well as fine grain surface (comp. pl. 19, fig. 4). *Graminidites bambusoides* represents subtropical/warm-temperate (P2/A1) element, and occurs in the Miocene deposits (Ziembińska-Tworzydło et al. 1994a, b). Stuchlik (1964) was the first who has described fossil bamboo type pollen grains (Gramineae *"Bambusa"* type from the Miocene of Rypin). According to this author these sporomorphs were quite frequently encountered in various parts of the Rypin profile.

The rare occurrence of bamboo pollen in fossil floras can be caused by dozen-year flowering cycle of these plants (McClure 1967). Pollen grains of *Graminidites bambusoides* were encountered in several samples from the Mużaków series in Legnica 33/56 profile, making up to 2–5%.

From Poland there were also reported fossil leaves of bamboos (*"Bambusa" lugdunensis* Saporta), morphologically corresponding to the recent *Arundinaria*, from the Miocene of Bełchatów (Worobiec 2003, Worobiec & Worobiec 2005).

The present-day genus *Bambusa* (75 species) is distributed in tropical and subtropical Asia and America. *Arundinaria gigantea* (Walter) Muhlenberg (=*A. macrosperma* Michx.) is frequent in swamp forests; *A. tecta* occurs in open humid forests in North America (Kearney 1901).

Subfamilia **POOIDEAE**

(186) ***Graminidites crassiglobosus*** (Trevisan 1967) Krutzsch 1970

Pl. 18, fig. 15

1967 *Monoporopollenites crassiglobosus* n. fsp., Trevisan, pp. 49, 63, pl. 33, fig. 5a–e.

1970a *Graminidites crassiglobosus* (Trevisan 1967) n. comb., Krutzsch, p. 56, pl. 3, figs 1–17.

Pollen grains monoporate, circular-oval in outline, 24–28 µm. Pore round 1.0–1.5 µm in diameter, surrounded by distinct annulus 2.0–2.5 µm wide. Exine about 1 µm thick, surface granulate.

(187) ***Graminidites laevigatus*** Krutzsch 1970

Pl. 18, fig. 16

1970a *Graminidites laevigatus* n. comb., Krutzsch, p. 60, pl. 5, figs 1–12.

Pollen grains monoporate, circular in outline, 28–32 µm in diameter. Pore round 2–3 µm in diameter, surrounded by distinct annulus 1.5–2.5 µm wide. Exine less than 1 µm thick, surface finely granulate to psilate.

(188) ***Graminidites neogenicus*** Krutzsch 1970

Pl. 18, fig. 17a, b

1970a *Graminidites neogenicus* n. sp., Krutzsch, p. 54, pl. 2, figs 13–19.

Pollen grains circular-oval in outline, 28–29 µm in size. Pore round about 1.5 µm in diameter, surrounded by distinct annulus 2.5–3.0 µm wide. Exine 1.0–1.5 µm thick, surface regularly granulate.

(189) ***Graminidites pseudogramineus*** Krutzsch 1970

Pl. 19, fig. 7

1970a *Graminidites pseudogramineus* n. sp., Krutzsch, p. 52, pl. 1, figs 6–11.

Pollen grains oval in outline, 40–45 × 35–40 µm in size. Pore 4–5 µm in diameter, with fine annulus about 2 µm broad. Exine up to 1 µm thick, surface finely granulate. Grains often deformed.

(190) ***Graminidites subtiliglobosus*** (Trevisan 1967) Krutzsch 1970

Pl. 19, fig. 8

1967 *Monoporopollenites subtiliglobosus* n. f sp., Trevisan, pp. 49, 63, pl. 33, fig. 6a–f.

1970a *Graminidites subtiliglobosus* (Trevisan) n. comb., Krutzsch, pp. 54, 62, pl. 2, figs 1–12.

Pollen grains circular in outline, 29–37 µm in diameter. Pore round about 3 µm in diameter, surrounded by annulus about 2.5 µm wide. Exine 1–2 µm thick, surface distinctly granulate.

Remarks. In the studied material pollen grains of genus *Graminidites* were encountered mainly in the Mużaków series, in one sample they reached 70%.

The oldest fossil pollen grains of subfamily Pooideae are known from the Palaeocene, but they become more frequent in the Eocene deposits (Muller 1981). In the Miocene deposits they are noted regularly, but usually in quantities not exceeding 5%. The fossil genus *Graminidites* (excluding *G. bambusoides*) represents cosmopolitan (P/A) climatic element (Stuchlik et al. 2009).

Familiae **SPARGANIACEAE**, **TYPHACEAE**

Sparganium L.

Sparganiaceaepollenites Thiergart 1937 emend. Krutzsch 1970

(191) ***Sparganiaceaepollenites magnoides*** Krutzsch 1970

Pl. 20, fig. 2a, b

1964 *Sparganium ramosum* Huds. type; Stuchlik, p. 78, pl. 24, figs 10, 11.

1970a *Sparganiaceaepollenites magnoides* n. sp., Krutzsch, p. 82, pl. 13, figs 14–23.

Remarks. *Sparganiaceaepollenites magnoides* represents cosmopolitan (P/A) climatic element, and occurs in the Lower and Middle Miocene (Stuchlik et al. 2009). These pollen grains were sporadically encountered in the analysed material, in several samples they reach 1–2% (max. 8%).

Nowadays the genus *Sparganium* (about 15 species) occurs mainly in northern temperate zone, in shallow waters and in swampy places (Heywood 1978).

Besides sporomorphs of this type in the studied material were found several pollen grains resembling those of recent *Typha* L. (fossil taxon ***Sparganiaceaepollenites polygonalis*** Thiergart 1937 ex Potonié 1960).

Ordo **ARECALES**
Familia **ARECACEAE**

Arecipites Wodehouse 1933

(192) ***Arecipites pseudoconvexus*** Krutzsch 1970

Pl. 19, figs 10, 11a, b

1970a *Arecipites pseudoconvexus* n. sp., Krutzsch, p. 103, pl. 21, figs 1–5.

Pollen grains monocolpate, oval elongate in outline, 34–45 × 24–28 µm in size. Exine composed of two layers about 1.5 µm thick, surface reticulate. Lumina regular, polygonal 1.5–2.0 µm in diameter, decreasing distinctly towards colpus to a diameter about 1 µm. Muri about 1 µm thick.

Remarks. These pollen grains are close to Arecaceae, and somewhat resemble pollen grains of the recent genus *Trachycarpus* Wendl., but differ from them in the structure of muri (Kohlman-Adamska 1993). Their SEM reticulate pattern revealed similarities to the recent palm *Chamaedorea* (*Ch. elegans* Mart.) from Middle and South America (Konzalová & Ziembińska-Tworzydło 2008). This taxon occurs in the Miocene deposits (Krutzsch 1970a, Ziembińska-Tworzydło 1974, Kohlman-Adamska 1993), and represents subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a). In the studied material these pollen grains were found regularly, mainly in the Lusatian and Henryk seams, in quantities not exceeding 1%.

?*Corypha* L.

(193) ***Arecipites papillosus*** (Mürriger & Pflug in Thomson & Pflug 1953) Krutzsch 1970

Pl. 20, fig. 1a, b

1953 *Monocolpopollenites papillosus* (Mürriger & Pflug) n. comb., Thomson & Pflug, p. 63, pl. 4, figs 38, 48, 49.

1970a *Arecipites papillosus* (Mürriger & Pflug in Thomson & Pflug) n. comb., Krutzsch, p. 100, pl. 20, figs 1–6.

1993 *Corypha* L. type; Kohlman-Adamska, p. 171, pl. 36, fig. 7a, b.

Pollen grains monocolpate, oval in outline, 40–42 × 30–32 µm in size. Exine composed of two layers 1.5–2.0 µm thick, surface reticulate.

Lumina polygonal 1–3 µm in diameter. Muri about 1 µm thick, built of two rows of bacula. Towards the colpus sculpture distinctly decreases.

Remarks. These pollen grains resemble in shape and structure of reticulum those of the recent genus *Corypha*, and represent subtropical (P2) element (Ziembińska-Tworzydło et al. 1994a). Krutzsch (1970a) described similar pollen grains from the Upper Eocene and Middle Oligocene of Germany, whereas Kohlman-Adamska (1993) – from the Middle Miocene of north-western Poland. Several pollen grains of this type were found in the Lusatian seam.

FRESH-WATER PHYTOPLANKTON

incerte sedis

Sigmopollis Hedlund 1965

(194) ***Sigmopollis pseudosetarius*** (Weyland & Pflug 1957) Krutzsch & Pacltová 1990

Pl. 20, fig. 3a, b

1957 *Inaperturopollenites pseudosetarius* n. sp., Weyland & Pflug, p. 103, pl. 22, fig. 30.
1969 ?*Nympheaepollenites pannonicus* n. g., n. sp., Nagy, p. 169, pl. 41, fig. 5.
1970a *Monogemmites pseudosetarius* (Weyland & Pflug) n. comb., Krutzsch, p. 146, pl. 39, fig. 30.
1990 *Sigmopollis pseudosetarius* (Weyland & Pflug) n. comb., Krutzsch & Pacltová, p. 388, pl. 9, figs 152–166B.

Microfossils circular in outline, 12–30 µm in diameter. Wall composed of two layers, about 1.5 µm thick, psilate, densely covered with very thin spines. On surface arcuate crevice a half of the circumference long.

Remarks. Similar microfossils are known from the Polish Miocene and Pliocene (Grabowska 1996c). In the examined material they were found mainly in the grey clay horizon and in bottom samples of both Legnica profiles.

(195) ***Sigmopollis punctatus*** Krutzsch & Pacltová 1990

Pl. 20, fig. 4

1990 *Sigmopollis punctatus* n. sp., Krutzsch & Pacltová, p. 388, pl. 9, figs 149–151.

Microfossils circular in outline, 10–25 µm in diameter, wall about 1 µm thick, covered with very thin and short spines.

Remarks. Microfossils occurring together with *S. pseudosetarius*.

According to some authors the *Sigmopollis* microfossils are morphologically similar to fresh-water Cyanophyta. They are known from the Middle Cretaceous to Pliocene (?Lower Pleistocene) deposits (Krutzsch 1970a, Krutzsch & Pacltová 1990).

Divisio **CHLOROPHYTA**
Ordo **ZYGNEMATALES**
Familia **ZYGNEMATACEAE**

Ovoidites Potonié 1951 ex Krutzsch 1959

(196) ***Ovoidites elongatus*** (Hunger 1952) Krutzsch 1959

Pl. 21, fig. 7

1952 *Sporites elongatus* n. sp., Hunger, p. 193, pl. 1, fig. 12.
1959 *Ovoidites elongatus* (Hunger) n. comb., Krutzsch, p. 252.
1990 *Ovoidites elongatus* (Hunger) Krutzsch; Krutzsch & Pacltová, p. 360, pl. 3, figs 26, 27.

Zygospores oval in outline, 70–100 µm in size. Wall about 2 µm thick, surface psilate.

Remarks. Only a few specimens of this species were encountered in the studied material.

(197) ***Ovoidites ligneolus*** Potonié 1931 ex Krutzsch 1959

Pl. 21, fig. 6a, b

1931b *Pollenites? ligneolus* n. sp., Potonié, pl. 2, fig. V25a.
1959 *Ovoidites ligneolus* (Potonié) subfsp. *ligneolus*, Krutzsch, p. 250.
1966 *Sporites ligneolus* R. Pot.; Ziembińska & Niklewski, pl. 2, figs 11–13.
1990 *Ovoidites ligneolus* (Potonié) Krutzsch – Gruppe; Krutzsch & Pacltová, p. 362, pl. 4, figs 38, 40–43.

Zygospores oval in outline, 90–200 µm in size. Wall about 3 µm thick, with very distinct undulate sculpture.

Remarks. In the studied material these microfossils were encountered regularly, but in very small quantities (max. 1%).

The *Ovoidites* microfossils are related to recent zygospores of algae from the family Zygnemataceae, and they are most similar to the present-day genera *Spirogyra* Link, as well as

Sirogonium Kutzing, *Pleurodiscus* Lagerheim, and *Zygnema* Agardh (Krutzsch & Pacltová 1990, Grenfell 1995). From Poland they have been reported from the Eocene to Pliocene deposits (Grabowska 1996c).

Tetraporina Naumova 1939 ex Bolkhovitina 1953

(198) ***Tetraporina* sp.**

Pl. 21, fig. 4

1953 *Tetraporina quadrata*, Bolkhovitina, p. 102, pl. 16, fig. 43.
1956 *Tetrapidites psilatus* Klaus; Meyer, p. 107, pl. 25, fig. 13.
1959 *Triceratium adriaticum* Agardh; Macko, pl. 25, figs 1–7.
1964 *Triceratium*; Stuchlik, p. 81, pl. 25, figs 3, 4.
1996b *Tetraporina quadrata* Bolkhovitina; Grabowska, p. 390, pl. 127, figs 5, 6.

Zygospores quadrilateral in outline, often with concave sides, 30–50 µm in size. Wall thin, surface psilate or with very fine sculpture. Triangular forms occurred very rare.

Remarks. These microfossils are related to recent zygospores of *Mougeotia* Agardh from the family Zygnemataceae (Grenfell 1995). In Poland they are known from the Eocene to Pliocene sediments; in other countries of Europe from the Miocene to Quaternary (Grabowska 1996b, c). They were sporadically encountered in the studied material, mainly in the grey clay horizon.

Zygnemataceae are among the most common algae in fresh waters. Most representatives of this cosmopolitan group of algae occur in shallow, stagnant, clean, oxygene-rich waters. They may also occur near the margins of lakes, in flowing water and in moist soils or bogs (Kadłubowska 1972, van Geel & Grenfell 1996).

Familia ?ZYGNEMATACEAE

Circulisporites De Jersey 1962

(199) ***Circulisporites circulus*** (Wolff 1934) Krutzsch & Pacltová 1990

Pl. 21, fig. 5

1934 *Sporites circulus* n. sp., Wolff, p. 67, pl. 5, fig. 28.
1962 *Concentricystes rubinus*, Rossignol, p. 134, pl. 2, figs 5, 6.
1976 *Pseudoschizaea rubina* Rossignol ex Christopher n. sp.; Christopher, p. 147, pl. 1, figs 1–10, 21.
1990 *Circulisporites circulus* (Wolff) n. comb., Krutzsch & Pacltová, p. 376, pl. 7, figs 88, 89.

Microfossil circular in outline, 36 µm in diameter, with characteristic concentric rings on its surface.

Remarks. Microfossils of this type are tentatively placed in the Zygnemataceae, even though they have never been collected alive (Grenfell 1995). Similar microfossils are described under various names, such as *Chomotriletes* Naumova, *Circulisporites* De Jersey, *Concentricystes* Rossignol, and *Pseudoschizaea* Thiergart & Frantz ex Potonié emend. Christopher. Its presence in subtropical and Mediterranean environments suggests that this microfossil could be an indicator of warm climate, possibly with unfavourable seasonal fluctuations (Scott 1992). Similar microfossils have been reported from the Tertiary and Quaternary of Germany, Hungary, Egypt, India and North America (Krutzsch & Pacltová 1990). In the studied material only one specimen was found in the Mużaków series.

DINOPHYCEAE

In the studied material Dinoflagellate cysts occurred mainly in samples from the Mużaków series of the Legnica 33/56 profile, on depth 97.6–99.6 m. In one of them (depth 97.6 m) 72 cysts and some foraminiferal linings were found. State of preservation of dinocysts were various, most of them were damaged, but some of them were even better preserved than most of sporomorphs. Samples with dinocysts were examined closely by P. Gedl (Gedl & Worobiec 2005). The most frequent dinocyst assemblage found in sample No. 19 (depth 97.6 m) consists of a majority of specimens believed to be *in situ*. They were dominated by *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich (42%), and species of *Batiacasphaera*: *B. hirsuta* Stover, *B. micropapillata* Stover and *B. sphaerica* Stover; together comprising 22% of the dinocyst assemblage (Gedl & Worobiec op. cit.). *Spiniferites ramosus* is a marine taxon, characteristic for shallow waters, outer shelf and transgressive facies (Słodkowska 2004).

FUNGI

Besides pollen grains, spores and plankton forms some sporocarps of epiphylous fungi of the family Microthyriaceae (*Microthyriacites*

Cookson, *Phragmothyrites* Edwards, *Plochmopeltinites* Cookson, and *Trichothyrites* Rosendahl emend. Smith = *Notothyrites* Cookson) were found.

The Microthyriaceae fungi are usually ectoparasites extended in tropical and subtropical regions. Their presence is an important index of high total annual rainfall – above 1000 mm. They usually live on leaves of seed plants (Betulaceae, conifers and others) and ferns – *Pteridium*, *Aspidum* and others (Neuy-Stolz 1958, Elsik 1978). According to Elsik (op. cit.) they occur in deposits since the Lower Cretaceous, but the most numerous are Eocene and Miocene localities.

ABRIDGED DESCRIPTION OF POLLEN DIAGRAMS

The results of palynological investigations are presented in three pollen diagrams (Figs 3–5) constructed using the POLPAL computer program (Nalepka & Walanus 2003). The percentage values are based on the total sum of pollen grains and spores. Most taxa have their own columns. However, some columns present a sum of a few taxa (two or more genera, one family or two families). The sporomorphs are arranged in the diagrams according to plant communities from mesophytic to wet. Herbs, pteridophytes and mosses are presented separately at the end of the histograms.

The pollen diagrams have been divided into four sections (L1–L4), containing samples with similar frequency of thermophilous taxa.

LUSATIAN SEAM

This part (section L1) contains samples from the profile Legnica 33/56 from the depth 112.0–100.5 m (Nos 46–24) as well as Legnica 41/52 – depth 125.5–114.4 m (Nos. 43–20), taken mainly from brown coal. The bottom samples of both profiles, taken from light-grey sandy clay, could represent the Silesian-Lusatian series. However, rather bad preservation of sporomorphs makes impossible detailed studies and distinguishing a separate section for the Silesian-Lusatian series.

Although the arctotertiary element prevails, the palaeotropical taxa play an important role (Tab. 1), and are represented mainly by *Tricolporopollenites pseudocingulum* (up to 42% of total sum) and *Quercoidites henrici* (up to 6%), as well as *Momipites punctatus*, *Castaneoideaepollis oviformis* and *C. pusillus* (a few per cent). Pollen grains of palms (*Arecipites pseudoconvexus*) are encountered regularly, whereas Sapotaceae (*Tetracolporopollenites andreanus* and *T. rotundus*) and Meliaceae occur sporadically. In bottom samples of both profiles pollen grains of *Reevesiapollis triangulus* reach about 2%. Relatively high quantities of *Tricolporopollenites exactus* (up to 20%), *T. megaexactus* (up to 1%), *T. fallax* (up to 12%), *T. liblarensis* (up to 3%), *Araliaceaeoipollenites edmundi*, *A. euphorii* (a few per cent), *Ilexpollenites* (*I. iliacus*, *I. marcodurensis* and *I. propinquus* – together up to 10%), *Myricipites* + *Triatriopollenites rurensis* (up to 6%), *Symplocoipollenites vestibulum* and *S. latiporis* (together up to 2%), as well as *Corylopsis* type (up to 1%) are also characteristic features of this section. Moreover, pollen grains of *Nelumbopollenites europaeus* are sporadically found.

Among the arctotertiary taxa the most numerous are Taxodiaceae/Cupressaceae (*Inaperturopollenites* – max. 50%), *Nyssapollenites* (up to 12%), *Alnipollenites verus* (a few per cent), *Ericipites* (up to 12%; including *E. roboreus* up to 2%), *Sequoiapollenites* (up to 35%), *Pinuspollenites* + *Cathayapollis* (up to 40%), and *Abiespollenites* (up to 12%). Pollen grains of *Sciadopityspollenites* are encountered regularly. In addition, in bottom samples *Intratriporopollenites insculptus* (present in only one sample) and *Periporopollenites orientaliformis* occur.

Section L1 is characterized also by high frequency of *Sphagnum* spores (max. 35%), while Polypodiaceae s.l. and *Osmunda*, as well as spores of Lycopodiaceae and *Toroisporis* are found sporadically. In addition, the Microthyriaceae fungi, fragments of plant tissues as well as stomata resembling those of the Taxodiaceae family, and fresh-water phytoplankton (*Ovoidites ligneolus*, *Tetraporina* and *Sigmopollis*) were found. In bottom samples of both Legnica profiles *Sigmopollis* is very numerous, and accompanied by single dinoflagellate cysts.

In the upper part of this section of the profile Legnica 33/56 frequency of Cyrillaceae/Clethraceae, Ericaceae, *Ilex*, *Myrica*, and *Sequoia* distinctly increases. Moreover, in these samples the role of mesophilous taxa *Tricolporopollenites pseudocingulum*, Araliaceae, Fabaceae, *Engelhardia*, *Castanea*/*Castanopsis*, *Quercus* (including *Quercoidites henrici*), Caprifoliaceae, Rosaceae, and Cornaceae become significant.

MUŻAKÓW SERIES

This section (L2) covers samples from the profile Legnica 33/56, taken from clays of the depth 100.0–75.5 m (Nos. 23–4).

The highest values of Poaceae (in one sample even 70%) and regular appearance of *Graminidites bambusoides* (up to 2–5%) are characteristic features of this section. Moreover, grasses are accompanied by such herbs as Cyperaceae (up to 2%; mainly of *Cladium* type), Asteraceae, Lythraceae, and *Sparganium*. Ferns are numerous and represented by Polypodiaceae s.l. (max. 50%) and *Osmunda* (up to 6%), as well as single spores of Cyathaceae/ Schizeaceae, Lycopodiaceae, and *Toroisporis.*

Frequency of the palaeotropical element decrease radically. The palaeotropical taxa are represented by single sporomorphs (Tab. 1), reaching 2–4%. The warm-temperate taxa (predominantly swampy and riparian ones) prevail and are represented by Taxodiaceae/ Cupressaceae (max. 65%), *Alnus* (up to 70%), *Salix* (up to 12%), *Ulmus*/*Zelkova*, *Betula* (up to 10–12%), as well as *Pterocarya* (max. 8%), *Quercus* (up to 5%), *Carya* (up to 2%), and *Acer.* Pollen grains of shrubs (Ericaceae, Cyrillaceae/ Clethraceae and *Ilex*) and spores of *Sphagnum* are encountered sporadically.

In samples from the lower part of this section (100.0–97.6 m) sporomorphs are badly preserved. In addition, some dinoflagellate cysts (max. 72 cysts = 20% in sample No. 19) and linings of foraminifers are present.

HENRYK SEAM

This part (section L3) contains samples from the profile Legnica 33/56 – depth 75.0–74.0 m (Nos. 3–1) and Legnica 41/52 – depth 91.8–89.3 m (Nos. 19–13), taken from brown coal and coaly clays.

In this section the representation of the palaeotropical taxa becomes significant again (Tab. 1). Relatively high percentages of *Tricolporopollenites pseudocingulum* (max. 4%), *Quercoidites henrici* (up to 2%), *Araliaceoipollenites edmundi* (up to 3%), *Tricolporopollenites fallax* (up to 3%), *T. liblarensis* (up to 2%), *Ilexpollenites iliacus* and *I. margaritatus* (together up to 17%), *Castaneoideaepollis pusillus* (up to 2%), and *Symplocoipollenites* (up to 3%) are noted. Frequency of the arctotertiary taxa – Taxodiaceae/Cupressaceae (max. 40%), *Sequoiapollenites* (up to 30%), *Pinuspollenites* + *Cathayapollis* (up to 15%), *Nyssapollenites* (up to 18%), and *Alnuspollenites verus* (up to 16%) are still high. Pollen grains of *Myricipites* + *Triatriopollenites rurensis*, Cyrillaceae/ Clethraceae and Ericaceae are noted in quantities of a few per cent. The role of spores of Polypodiaceae s.l. (max. 40%), *Osmunda* (up to 18%) and *Sphagnum* (up to 2%) is significant, whereas such aquatic and swamp plants as *Butomus*, *Sparganium*, and *Cladium*, as well as fresh-water phytoplankton (*Tetraporina* and *Ovoidites*) occur sporadically. In addition, some moss spores, fungi and fragments of plant tissues (mainly wood, epidermis and stomata) are present.

POZNAŃ SERIES, GREY CLAY HORIZON

This section (L4) covers samples from the profile Legnica 41/52 – depth 85.5–77.0 m (Nos. 12–1), taken from grey clays, as well as Komorniki 97/72 – depth 78.8–77.2 m (Nos. 9–1), taken from grey clays with two thin layers of lignites.

This part differs from the above-mentioned one in lower frequency of taxa of high climatic requirements (Tab. 1). In the Legnica profile these palaeotropical taxa reach max. 1–2%; only *Ilex* reaches 5%. In the Komorniki profile these percentages are even lower – only a few pollen grains of *Tricolporopollenites pseudocingulum*, *T. fallax*, *Araliaceoipollenites edmundi*, *Quercoidites henrici*, *Reevesiapollis triangulus*, and Sapotaceae are present. The dominance of the arctotertiary element is well seen. High percentages of Taxodiaceae/Cupressaceae (max. 45% in the Legnica profile and 65% in the Komorniki profile), *Alnipollenites verus* (50% and 18% respectively in two above-mentioned profiles), *Nyssapollenites* (25% and 3% respectively), *Pinuspollenites* + *Cathayapollis* (35% and 25% respectively), as well as *Sequoiapollenites* (18% and 5% respectively) are noted.

In relatively high quantities appear also riparian taxa: *Carya* (up to 10%), *Salix* (up to 6–8%), *Ulmus* (max. 6% and 2% respectively in two above-mentioned profiles), *Celtis* (up to 4%), and *Pterocarya* (up to 2%). In addition, pollen grains of *Fraxinus*, *Juglans*, *Quercus*, and

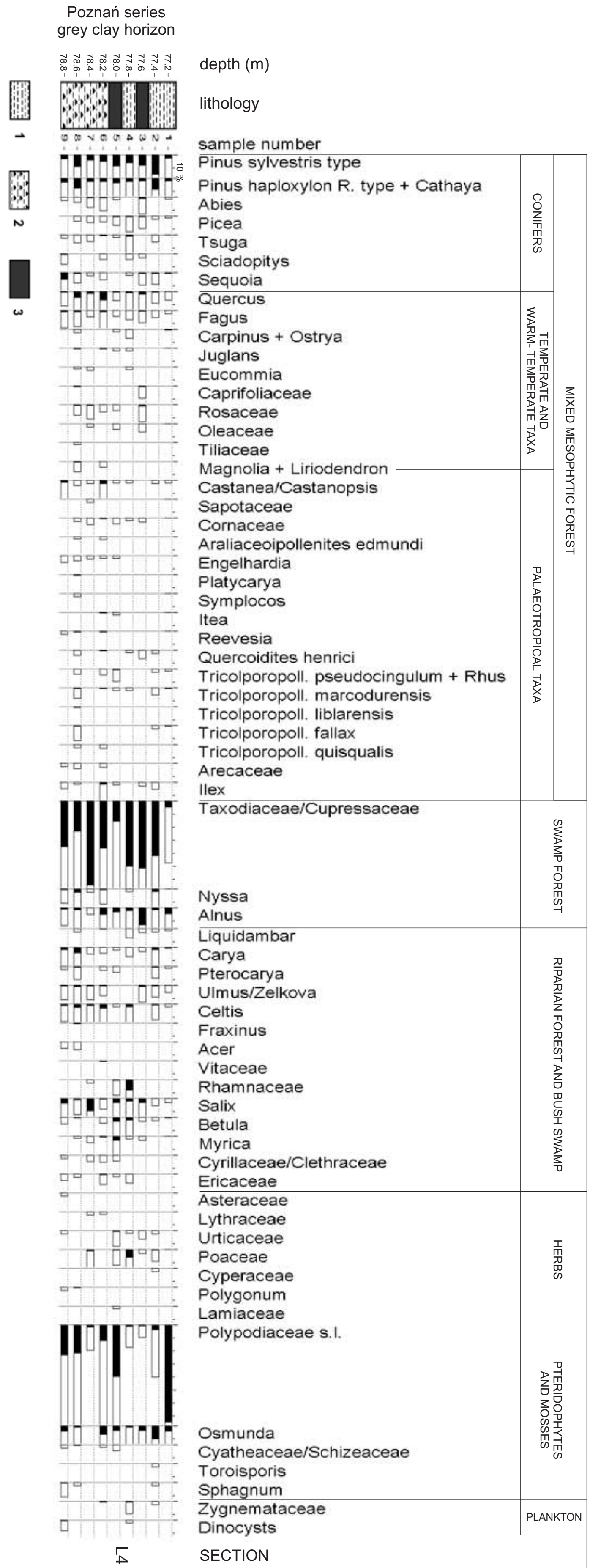

Fig. 5. Komorniki 97/72. Percentage pollen diagram of selected taxa. **1** – clay, **2** – coaly clay, **3** – brown coal

Liquidambar were found. Ferns are numerous (max. 40% and 75% respectively), whereas grasses (up to 6% in the Komorniki profile), sedges, *Sparganium* and *Butomus* occur quite often, but in small quantities. Fresh-water phytoplankton (*Sigmopollis*, *Ovoidites elongatus* and *Tetraporina*), as well as Microthyriaceae fungi are relatively frequent.

In addition, in the examined part of the Komorniki profile, leaf remains of *Osmunda parschlugiana* (Unger) Andreánszky, *Byttneriophyllum tiliifolium* (Al. Braun) Knobloch & Z. Kvaček, *Myrica* sp., as well as Monocotyledons and conifers were identified (G. Worobiec, pers. com.).

RECONSTRUCTION OF THE NEOGENE PLANT COMMUNITIES WITH REFERENCES TO RECENT VEGETATION

The results of pollen analysis were used to reconstruct main types of the Neogene plant communities. The recent vegetation picture has the form of a mosaic, in which element arrangement depends on environmental and climatic conditions. The knowledge about requirements of the nearest living relatives is necessary to draw conclusions about requirements of fossil plants and about structure of the ancient vegetation. Thus in this paper types of plant communities were distinguished according to publications related to fossil plant communities (Teichmüller 1958, Neuy-Stolz 1958, Sadowska 1977, Mai 1981, 1985, Schneider 1990, 1992, Kohlman-Adamska 1993, Słodkowska 1994, and others), as well as publications concerning recent vegetation.

Many taxa identified in the studied material are allied to the recent ones from North America (mainly south-eastern part) and south-eastern Asia (comp. Guo & Ricklefs 2000). Among recent taxa occurring in North America the most important for reconstruction of the Neogene plant communities are *Taxodium* (*T. ascendens*, *T. distichum*, and *T. mucronatum*), *Sequoia sempervirens*, *Clethra alnifolia*, and *Decodon verticillatus*. In eastern and south-eastern Asia occur *Cathaya argyrophylla*, *Cryptomeria japonica*, *Glyptostrobus pensilis*, *Metasequoia glyptostroboides*, *Sciadopitys verticillata*, *Cercidiphyllum japonicum*, *C. magnificum*, *Eucommia ulmoides*, and *Platycarya strobilacea*, as well as the genera *Keteleeria*, *Castanopsis*, *Corylopsis*, *Engelhardia*, *Pterocarya*, and *Reevesia*. Some genera have their members in both above-mentioned areas. For example in North America occur *Tsuga canadensis*, *Itea virginica*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Myrica carolinensis*, *Nelumbo lutea*, *Nyssa aquatica*, *N. ascendens*, and *N. sylvatica*, whereas in south-eastern Asia *Tsuga diversifolia*, *Itea sinensis*, *I. macrophylla*, *Liquidambar formosana*, *Liriodendron chinense*, *Myrica adenophora*, *M. rubra*, *Nelumbo nucifera*, and *Nyssa sinensis* grow.

Recent species allied to the mentioned above occur also in the Mediterranean Region, the Asia Minor and the Caucasus, where *Cedrus*, *Liquidambar orientalis*, *Ostrya carpinifolia*, *Parrotia persica*, and *Zelkova carpinifolia* grow.

Extensive ranges, limited by climate conditions, have the genera *Carya*, *Castanea*, *Celtis*, *Clethra*, *Ilex*, *Ostrya*, *Symplocos*, the families Meliaceae, Sapotaceae, and bamboos as well as, growing today in Poland: *Osmunda*, *Abies*, *Picea*, *Pinus*, *Acer*, *Alnus*, *Betula*, *Carpinus*, *Cornus*, *Corylus*, *Fagus*, *Lonicera*, *Quercus*, *Salix*, *Ulmus*, *Viburnum*, and *Cladium*.

The following main types of the Neogene plant communities in the investigated Legnica lignite deposit complex have been distinguished: swamp forests, riparian forests, bush swamps, mixed mesophytic forests, and reed marshes.

SWAMP FOREST

Swamp forests developed in areas with high ground-water level. They consisted of coniferous and deciduous trees, and were floristically not very diversified. Their most important trees were *Taxodium* and *Glyptostrobus*, as well as *Nyssa* and hydrophilous *Alnus* species, with admixture of *Salix*, *Acer*, *Fraxinus*, *Ilex*, *Myrica*, *Vitis*, ferns (*Osmunda*), and others. In dense and shaded parts of these forests both shrub and herb layers were poor, only in small periodical water bodies within these forests herbaceous aquatic plants grew. The swamp forests produced a lot of organic mater, which accumulating in boggy ground was subject to peat-forming processes. In such conditions humic brown coal, mainly detrital – originated from deciduous trees and herbs, as well as xylitic brown coal – from resin-containing coniferous trees was formed. This coal is dark and contains a lot of wood and bark remains (Teichmüller 1958, Neuy-Stolz 1958).

These swamp forests were wide-spread in Europe during the Oligocene to Pliocene period. In the Polish Lowland they had most favourable conditions in the Early and Middle Miocene. Presently, similar forests occur in the Mississippi River delta, Florida, Georgia, North Carolina, and the Gulf of Mexico coast. In south-eastern China (Canton, Hainan) forests with *Glyptostrobus pensilis* grow (Wang 1961, von Jux 1966, Kac 1975, Mai 1981).

Today swamp forests grow in stagnant water-bodies that are nearly filled with sediments (sloughs) or in areas where water is impounded behind the river levee and remains for much of the year. The principal species are *Taxodium distichum*, *Nyssa aquatica*, and *N. ogeche* (northern Florida and southern Georgia). In the coastal lowland also *Taxodium ascendens* and *Nyssa sylvatica* (including var. *biflora*), as well as *Ilex myrtifolia* grow (Knapp 1965, Kac 1975, Barnes 1991). *Pinus caribaea*, *Fraxinus profunda*, and *F. caroliniana* could also play a considerable role in these forests (Hall & Penfound 1943). Associated with the swamp forests are valleys, in which many species of the swamp forests have their dominant role. For example on the Dismal Swamps in both types of forests *Acer rubrum* plays a significant role. Besides there occur *Fraxinus caroliniana*, rarely *Quercus phellos*, *Magnolia virginiana*, *Ilex opaca*, *Carpinus caroliniana*, *Salix nigra*, *Alnus rugosa*, *Liriodendron tulipifera*, *Liquidambar styraciflua*, and others. There also grow climbers *Vitis rotundifolia*, *V. labrusca*, *Ampelopsis arborea*, *Rhus radicans*, *Smilax rotundifolia*, *S. walteri*, and others. Along ditches and in open places *Arundinaria gigantea* (=*A. macrosperma*), a bamboo grass up to 5–6 m high, is frequent. Herbs are very rare – *Boehmeria cylindrica* (Urticaceae), *Polygonum arifolium*, and *Aster difusus* are some of them. Such ferns as *Osmunda regalis*, *O. cinnamomea*, *Polypodium polypodioides* (*incanum*), and *Woodwardia virginica* are frequent in some places (Kearney 1901).

In Florida there occur cypress swamps predominated by *Nyssa sylvatica*, *Taxodium distichum*, and *Salix caroliniana* as well as swamp hardwoods with *Acer rubrum*, *Nyssa sylvatica*, and *Taxodium distichum* (Crumpacker et al. 2001), accompanied by *Fraxinus pennsylvanica*, *F. caroliniana*, *Carya aquatica*, *Persea borbonia*, *Magnolia virginiana*, *Ilex cassine*, *Juniperus virginiana*, and *Sabal palmetto* (Hofstetter 1983, Abbott & Judd 2000), as well *Morus rubra*, *Quercus laurifolia*, and *Rhus copallinum* (Willard et al. 2004). Similar forests also grow in Louisiana (Neyland et al. 2000).

RIPARIAN FOREST

Along riversides and streams favourable conditions existed for riparian forests dominated by *Liquidambar*, *Carya*, *Ulmus*, *Salix* as well as *Alnus*, *Acer*, *Celtis*, *Fraxinus*, *Pterocarya*, *Juglans*, *Quercus*, *Staphylea*, and *Itea*, accompanied by climbers *Parthenocissus* and *Vitis*. Nowadays similar plant communities occur among others in the Atlantic zone of North America as well as in the Tierra Templada in Central America (Mai 1981). Riparian forests in the eastern part of North America are distinctly richer than European ones. Among them elm–maple riparian forests, with *Acer saccharinum*, *A. negundo* var. *violaceum*, and *Ulmus americana*, accompanied by *Platanus occidentalis* and *Aesculus glabra*, have the great species diversity. In these forests such climbers as *Parthenocissus quinquefolia* and *Smilax herbacea* play an important role. There also occur birch–alder, poplar and, the nearest the water, willow riparian forests. Towards the south they are replaced by *Quercus–Fraxinus–Carya* forests (Podbielkowski 1987a). In the Mississippi Alluvial Plain grow forests dominated by *Liquidambar styraciflua*, *Acer rubrum*, ash species (predominantly *Fraxinus pennsylvanica*), *Acer saccharum*, *Nyssa aquatica*, *Carya* species (such as *C. cordiformis*), *Ulmus americana*, oak species (such as *Q. rubra*), *Aesculus discolor*, *Fagus grandifolia*, *Populus deltoides*, *Celtis laevigata*, *Platanus occidentalis*, *Tilia americana*, *Ilex decidua*, *Cornus foemina*, *C. florida*, *Carpinus caroliniana*, *Diospyros virginiana*, *Liriodendron tulipifera*, *Salix nigra*, and *Smilax* species (Robertson et al. 1978).

Penfound (1952) recognized four types of wet forests, growing on soils which are inundated for only short periods during the growing season: 1. *Salix nigra* and *S. exigua* – floodplains having deepest water and longest periods of inundation of all shallow swamps; 2. *Quercus* *lyrata*, *Carya aquatica*, *Diospyros virginiana*, and *Fraxinus pennsylvanica* – poorly drained depressions, sloughs, and shallow swamps primarily in Louisiana and Mississippi; 3. *Celtis reticulata*, *Ulmus americana*, *Fraxinus pennsylvanica*, *Carya aquatica*, and *Quercus phellos* – low flats and sloughs in the Mississippi Alluvial Plain; 4. *Acer rubrum*, *Liquidambar styraciflua*, and *Quercus palustris* – transitional or river swamp. In the lower Mississippi plain *Quercus nuttalis* and *Q. phellos* replace *Q. palustris*; additional species include *Salix nigra*, *Fraxinus pennsylvanica*, *Acer rubrum*, *Liquidambar styraciflua*, and *Platanus occidentalis*.

In north-central Florida Monk (1966) studied hardwood swamps of two types: 1. mixed swamps which correspond closely to shallow swamps and are dominated by *Fraxinus caroliniana*, *Acer rubrum*, *Nyssa sylvatica* (including var. *biflora*), *Liquidambar styraciflua*, *Taxodium distichum*, and *Sabal palmetto*; 2. bayheads – similar to the red bay – sweet bay (*Persea borbonia – Magnolia virginiana*) community where, although evergreen hardwoods are dominant, *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Acer rubrum* are important locally.

BUSH SWAMP

Periodically flooded areas were covered with bush swamps dominated by shrubs. The most characteristic elements of these communities were Cyrillaceae, Clethraceae, Betulaceae, Ericaceae, Myricaceae, *Salix*, *Ilex*, Magnoliaceae, *Rhus*, and Vitaceae, as well as single *Liquidambar* trees. There could also grow Rosaceae, Fabaceae, Oleaceae, as well as *Sphagnum*, ferns, sedges, and grasses (Sadowska 1977), including bamboos. These communities supplied atritic brown coal rich in wood and bark remains.

Similar plant communities ("pocosins") occur today in southern part of North America (North Carolina, Florida). There grow *Cyrilla racemiflora*, *Ilex lucida*, *I. glabra*, *I. coriacea*, *Cornus stricta*, *Itea virginica*, *Morella cerifera* (=*Myrica cerifera*), *Myrica inodora*, *Pieris mariana*, *P. nitida*, *Vaccinium virgatum*, *Zenobia pulverulenta*, *Magnolia virginiana*, *Clethra alnifolia*, *Rhamnus caroliniana*, *Sabal adansonii*, *Arundinaria tecta*, and *A. gigantea* (Knapp 1965, Hofstetter 1983). The reconstructed composition of the Miocene swamps is near their species composition.

On the margins of the peat-bogs there existed favourable places for mixed temperate-humid forests with *Sequoia*, *Sciadopitys*, *Cathaya*, *Pinus*, and *Myrica* (Sadowska 1977, Schneider 1990, 1992).

MIXED MESOPHYTIC FOREST

Mixed mesophytic forests had the greatest species diversity. They grew in drier, more elevated terrains near swamps and peat-bogs. These forests were dominated by deciduous trees of such genera as *Fagus*, *Quercus*, *Castanea*, *Zelkova*, *Tilia*, *Juglans*, *Carpinus*, *Parrotia*, *Eucommia*, *Acer*, *Corylus*, *Ulmus*, *Carya*, *Liquidambar*, *Liriodendron*, *Betula*, and many others. Among conifers *Pinus*, *Abies*, *Picea*, *Tsuga*, *Sequoia*, and *Sciadopitys* played a considerable role. The undergrowth was also very rich, consisting of Rosaceae, Caprifoliaceae, *Ilex*, *Reevesia*, *Itea*, *Corylopsis*, and others. In warmer places existed favourable conditions for such warm-loving tree genera as *Magnolia*, *Platycarya*, *Engelhardia*, and shrubs of families Araliaceae, Cornaceae, Anacardiaceae (including *Rhus*), and Rutaceae, as well as *Symplocos* and *Parthenocissus.* The herb layer was dominated by grasses and ferns, whereas on conifers lived the parasitic *Arceuthobium* (Sadowska 1977, Mai 1981, Kohlman-Adamska 1993, Słodkowska 1994).

These forests could, depending on conditions, resemble distinguished by Mai (1981) *Fagus–Quercus–Carpinus* forest or *Quercus–Carpinus–Castanea* forest without *Fagus* and *Picea* admixture. Nowadays similar mesophytic forests occur in warm and temperate climatic zones, among others in China, Japan, Korea, Vietnam, and north-western part of North America (Wang 1961, Mai 1981, Barnes 1991, Ching 1991). The deciduous angiosperm forests distributed in eastern part of North America are distinctly floristically richer than the contemporary European ones. Peculiar species richness is characteristic for mixed oak–tuliptree forests dominated by *Liriodendron tulipifera*, *Castanea dentata*, oak species (*Quercus montana*, *Q. alba*, *Q. borealis*, and *Q. coccinea*), *Tilia heterophylla*, *Liquidambar styraciflua*, *Magnolia acuminata*, *M. fraseri*, *Carpinus caroliniana*, *Carya ovata*, *C. tomentosa*, *Fraxinus americana*, *Juglans* *cinerea*, and *Acer saccharum*. In these forests the tree layer is composed of more levels, and shrub and herb layers are also well developed. In south-eastern part of North America grow beech–magnolia forests characterized by the great species diversity and presence of evergreen species. They consist of *Fagus grandifolia* var. *caroliniana*, *Magnolia* (predominantly *M. grandiflora*), and *Tilia* species, as well as *Acer floridanum*, *Carpinus caroliniana* and *Liquidambar styraciflua* (Podbielkowski 1978a, b, Barnes 1991).

Broad-leaved forests in uplands and mountains of eastern Asia are floristically also very rich. The principal species in northern part of this region are *Quercus mongolica* (and *Q. dentata* in southern part), *Fraxinus rhinchophylla*, *Kalopanax ricinifolia*, *Phellodendron amurense*, *Tilia mandschurica*, and *Acer mono*, whereas in lower altitudes grow rich deciduous forests with *Tilia amurensis*, *Fraxinus mandschurica*, *Juglans mandschurica*, *Ulmus macrocarpa*, *Phellodendron amurense*, and *Acer mandschuricum*. The lower tree layer is formed by *Carpinus*, *Padus*, *Cerasus*, and others. The shrub layer is of a great diversity, with *Acanthopanax sessiliflorum*, *Aralia mandschurica*, as well as *Lonicera* and *Diervilla* species. Climbers (such as *Vitis amurensis*) are very numerous. The herb layer is also very rich (*Panax schin-seng* grows there). Towards the south coniferous forests with *Pinus*, *Cryptomeria japonica*, as well as *Quercus monogyna*, *Juglans*, *Acer* species, and *Magnolia kobus* prevail. Main genera of the shrub layer are *Lonicera*, *Syringa*, *Rhododendron*, and *Ligustrum*. Climbers and epiphytes are numerous there. In the northern part of this area and in mountain regions grow coniferous and mixed forests with deciduous trees, whereas towards the south subtropical forests with a conciderable frequency of *Pinus*, *Cunninghamia lanceolata*, and *Cryptomeria japonica*, as well as evergreen oaks (e.g. *Quercus fabri*) occur. The dense shrub layer is dominated by *Rhododendron* species. In subtropical zone, in lower mountain belt and lowlands, humid forests grow with deciduous tree domination. *Liriodendron chinense*, *Liquidambar*, *Acer*, *Quercus* (many evergreen species), *Magnolia* (many evergreen), *Castanopsis*, *Aesculus*, *Ilex*, Meliaceae, Araliaceae, Fabaceae, and Rosaceae are important there. Some species from subtropical and tropical zones (such as *Diospyros* and bamboos) as well as climbers and epiphytes also play a considerable role (Podbielkowski 1987a, Ching 1991).

Mixed broad-leaved forests with a special variety of species, and of particular floristic interest for comparisons with the Neogene plant communities, occur east of the Black Sea (Colchis Province) and west of the Caspian Sea (Lenkoran depression and Talysh Mountains). The Colchian forests cover the mountain slopes from sea level up to 600 m. These are relict forest, in which *Quercus iberica*, *Carpinus caucasica*, *Zelkova carpinifolia*, and *Pterocarya fraxinifolia* prevail (Röhrig 1991). There also occur *Carpinus orientalis*, *Fagus orientalis*, *Fraxinus excelsior*, *Acer laetum*, *A. ibericum*, *Ulmus glabra*, *U. suberosa*, *Prunus spinosa*, and *Tilia caucasica*. The shrub layer is formed by *Lonicera caprifolium*, *L. caucasica*, *Cornus mas*, *Hedera helix*, and others (Stuchlik & Kvavadze 1993). In the Lenkoran and the Talysh Mountains (Talyshskiye Gory) occur forests with *Acer velutinum*, *Alnus subcordata*, *Carpinus caucasica*, *Diospyros lotus*, *Fraxinus excelsior*, *Gleditsia caspica*, *Parrotia persica*, *Populus hyrcana*, *Prunus caspica*, *Ulmus elliptica*, *Zelkova carpinifolia*, and rarely *Fagus orientalis*. The dense undergrowth is formed by *Buxus hyrcana*, *Crataegus*, *Danaë racemosa*, *Ilex hyrcana*, and *Ruscus hyrcanus*. Climbers such as *Hedera pastuchovii*, *Periploca graeca*, *Smilax excelsa*, and *Vitis orientalis* are also present (Röhrig 1991).

It is necessary to stress that various species of *Acer*, *Betula*, *Celtis*, *Fraxinus*, *Quercus*, *Ulmus*, and *Rhus*, as well as Rosaceae, Fabaceae, and Ericaceae, recorded in the studied material, could grow in both swamp and mesophytic plant communities. It is also difficult to say in which communities conifers grew. *Taxodium* pollen grains come from swamp forests, whereas some pollen grains of *Pinus*, *Sequoia*, *Abies*, *Tsuga*, *Picea*, and *Sciadopitys* could originate from long-distance transport, from such plant communities as coniferous forests growing on more elevated terrains (Stachurska et al. 1971, 1973, Oszczypko & Stuchlik 1972, Sadowska 1977, Słodkowska 1994).

Some pollen grains of the above-mentioned genera of conifers could originate from trees growing as an admixture in both mixed mesophytic or wet forests. Forests from the eastern part of North America, dominated by *Pinus serotina*, *P. caribaea*, *P. strobus*, *Picea rubra*, and *Tsuga canadensis* are an example of wet forests with Pinaceae (Kac 1975, Sadowska 1977, Mai 1981).

There could also exist mixed pine-deciduous forests with the domination of *Pinus*, *Cupressus*, and *Sequoia*, and an admixture of Fabaceae, Ericaceae, *Betula*, *Engelhardia*, *Liquidambar*, and *Platycarya*. Today similar forests, dominated by *Pinus massoniana* and *P. tabulaeformis*, grow in China (Wang 1961, Mai 1981). In the western part of North America, in mild climate and good moisture conditions, grow humid coniferous forests – predominantly coastal forests with *Sequoia sempervirens*, and *Acer macrophyllum* and *Pseudotsuga menziesii* var. *viridis* as additional species. Towards the north they are replaced by humid coniferous forests with *Tsuga heterophylla* and *Thuja plicata*. Along the Pacific Ocean coast grow forests with *Picea sitchensis*, where *Rhododendron californicum* and numerous *Vaccinium* species occur (Podbielkowski 1987a).

AQUATIC VEGETATION

Forest communities in the Miocene probably formed dense plant cover, which made impossible the development of extensive communities of photophilous aquatic vegetation (Tran Dinh Nghia 1974, Sadowska 1977). Aquatic plants were limited to water bodies within the swamp forests. In the shallow fresh-water oxygene-rich basins Zygnemataceae algae (such as *Mougeotia* and *Spirogyra*) occurred. Among plants floating at water surface and fixed to the bottom *Nelumbo*, *Potamogeton*, and *Trapa* occurred, whereas in shallow waters and in marginal zones of water bodies *Sparganium*, *Butomus*, and *Typha* appeared, as well as members of the families Cyperaceae (*Carex* and *Cladium*), Poaceae (including bamboos), Apiaceae, Polygonaceae (*Polygonum* and *Rumex*), Lythraceae (such as *Decodon*), Rubiaceae (such as *Galium*), Lamiaceae, Urticaceae, Chenopodiaceae, Asteraceae, Rosaceae, as well as Osmundaceae and Aspidiaceae grew. Water and swamp vegetation have an azonal character and is similarly developed in various climatic zones (see Kearney 1901, Knapp 1965, Cook et al. 1974, Pawłowski & Zarzycki 1977, Mai 1985, Podbielkowski 1987a, b).

REED MARSHES

Temporary also existed reed marshes, consisting mainly of grasses, sedges, aquatic and swamp herbaceous plants as well as, in drier places, such shrubs as *Myrica* and *Salix*. These nonarboreal communities might cover large areas, and they yielded light brown coal (Teichmüller 1958, Neuy-Stolz 1958). Their recent equivalent are "Everglades" – extensive reed marshes in south-western Florida, with surfaces of open water, islands of trees and shrubs, as well as areas of sedges, grasses, and bulrush (Willard et al. 2004). In dense sawgrass marshes on thick (above 1 m) peat the most frequent and characteristic plant is *Cladium* (*C. jamaicense* = *C. mariscus* var. *jamaicense*). Sparse sawgrass marshes (on thin peat or marl) are dominated by *Cladium*, other Cyperaceae, and Poaceae. In addition, some species of Asteraceae, Alismataceae, Apiaceae, Nympheaceae, Polygonaceae, Typhaceae, and Pteridaceae, as well other families occur (Willard et al. op. cit.). At places, thickets of *Morella cerifera* (=*Myrica cerifera*), *Salix caroliniana*, *Persea borbonia*, *Magnolia virginiana*, and *Ilex cassine* are developed (Gleason & Cronquist 1968, Hofstetter 1983).

DEVELOPMENT PHASES OF THE PLANT COVER IN THE LEGNICA REGION AND THEIR COMPARISON WITH OTHER REGIONS OF THE POLISH LOWLAND

The presented here pollen diagrams of Legnica 33/56, Legnica 41/52 and Komorniki 97/72 profiles (Figs 3–5) from eastern part of the Legnica lignite deposit complex show their strong similarity to elaborated earlier diagrams from the Polish Lowland. The three studied profiles present the whole Badenian sequence: from the 2nd Lusatian seam originated in the Early Badenian (?Late Karpatian – Early Badenian) to the grey clay horizon of the Poznań series Late Badenian in age. These sediments are correlated with spore-pollen zones V *Quercoidites henrici* to IX *Tricolporopollenites pseudocingulum*, distinguished in the studied profiles according to Piwocki and Ziembińska-Tworzydło (1995, 1997), and Ziembińska-Tworzydło (1998).

LUSATIAN SEAM

Subsidence movements (Styrian phase) became more intensive in the beginning of the Middle Miocene and caused significant extension of deposits in fluvial, lacustrine and swampy environments in the Polish Lowland area. Humid and warm-temperate climate close to subtropical one in Middle Miocene favoured the peat-producing vegetation, forming the 2nd Lusatian group of seams (the Lusatian lignite seam in the studied area). Origin of this seam is connected with extensive swamps occurring on coastal plains surrounded a bay of the then North Sea, extended far to the East. In western and partially central Poland, where this group of seams has a continuous range, the brown coal is of paralic origin, whereas in isolated basins in south-western, central and eastern Poland it is of limnic or limno-fluvial origin. The Lusatian group of seams is a marker of the great lithostratigraphical correlative importance, composed of 1–4 horizons usually making together more than 3 m thick seam (Piwocki 1992, 1998).

Presence of this seam in the Legnica deposit complex has been confirmed in boreholes from the west field – Legnica 5/53, 7/49, 7/58, and 8/59 (Sadowska et al. 1976), as well as the east field – Legnica 33/56, 41/52, 41/56, 41/64, 47/55, 47/62, 47/68, and 53/56 (Sadowska et al. 1981, Nowak 1998, Wacnik & Worobiec 2001). Two of these cores (33/56 and 41/52) were subjects of current study. In all profiles from the Legnica deposit results of pollen analysis were similar. Pollen grains of conifers were numerous (mainly Taxodiaceae/Cupressaceae – up to 50%, with a significant contribution of *Sequoia*, as well *Pinus* – up to 50%, with domination of *Pinus sylvestris* type). Among the angiosperms, pollen grains of *Tricolporopollenites pseudocingulum* (in previous studies misidentified as *Rhus*), *Quercoidites henrici* (up to 15–25%), *Araliaceoipollenites edmundi* (=*Tricolporopollenites edmundi*), and other Araliaceae (up to 8–10%), as well as *Myrica*, *Ilex*, *Alnus*, *Liquidambar*, *Nyssa*, *Quercus*, *Engelhardia*, Ericaceae, and palms (usually less than 10%) prevailed. There were also found *Abies*, *Sciadopitys*, *Betula*, *Fagus*, *Castanea*, *Ulmus*, *Carya*, Rosaceae, Fabaceae (=Leguminosae), *Symplocos*, *Celtis*, and single pollen grains of other plants. *Tricolporopollenites liblarensis* (+ *T. fallax*) and *T. cingulum* were present in all profiles (Sadowska et al. 1976, 1981, Nowak 1998, Wacnik & Worobiec 2001). In the Legnica deposit (for example in Legnica 47/68 profile) the Lusatian seam is divided into two horizons, what was caused by the situation of the deposit in the marginal zone of the basin and strong lability of this zone during the sedimentation time (Sadowska et al. 1981). At Ruja it has a form of one compact seam in central part, and 2–3 (or more) horizons at the western and northern margins (Dyląg 1995).

Plant communities, both the swamps and the mesophilous forests growing outside the swampy basins, were floristically rich and had a relatively significant contribution of plants of the palaeotropical geoflora, which contained the tropical (P1) and subtropical (P2) elements of large taxonomic differentiation (Tab. 1), with a considerable role of warm-temperate plants (A1). Picture of vegetation shown by the pollen diagrams (Figs 3–5) implies a warm and humid climate, favourable for abundant peat-producing vegetation. This was the warmest phase of the Legnica profiles, when swamp and peat-bog vegetation dominated. Large areas were constantly covered by shallow water or marshes. Only on elevations there existed patches of riparian and mesophilous vegetation. Swamp forests were luxuriant and dominated by *Taxodium*, *Glyptostrobus*, *Nyssa*, and *Alnus*. In the upper part of the bottom section of Legnica 33/56 profile the contribution of bush swamp elements: Cyrillaceae, Clethraceae, Ericaceae, *Ilex*, and *Myrica*, as well as *Sequoia* increases, what indicates more mesophilous conditions during the sedimentation.

Results of palynological investigations of the Legnica profiles are similar to spectra from the 2nd group of seams correlated with the V spore-pollen zone – ***Quercoidites henrici*** phase, distinguished by several authors (Ziembińska-Tworzydło & Ważyńska 1981, Piwocki & Ziembińska-Tworzydło 1995, 1997, Ziembińska-Tworzydło 1998, Słodkowska 1998). Deposits of this phase occur on large areas of the Polish Lowland, mainly in western, south-western (Nowe Czaple, Zielona Góra – Sadowska 1977), north-western and central (Wyrzysk region – Kohlman-Adamska 1993, Bełchatów B seam – Stuchlik et al. 1990, Lubstów near Konin – Ciuk & Grabowska 1991), as well as northern parts (Grabowska 1987, Grabowska & Ważyńska 1997).

Upper part of the bottom section of the Legnica 33/56 profile refers to the VI spore-pollen zone – ***Tricolporopollenites megaexactus*** phase, previously distinguished as the Cyrillaceae phase by Raniecka-Bobrowska (1970) from the upper part of the Lower Badenian. In the lithostratigraphic scheme this zone corresponds with the lower part of the Mużaków series with accompanied seam (according to Dyjor 1970) or the lower part of the Pawłowice Formation (with 2[nd]A Lubin seam) and Adamów Formation (according to Piwocki & Ziembińska-Tworzydło 1995). In our profile phases V and VI are considered together, because of gradual changes in contribution of characteristic taxa. The VI *Tricolporopollenites megaexactus* phase was previously confirmed in north-western Poland, e.g. from the Krostkowo region near Wyrzysk and Trzcianka near Piła (Raniecka-Bobrowska 1970), Nakło, as well as Kosztowo and Liszkowo near Wyrzysk (Kohlman-Adamska 1993). Only in Legnica 33/56 profile the frequency of *Tricolporopollenites megaexactus* pollen in this section was near 1%, when pollen of *T. exactus* reached 20%. In the majority of the Legnica profiles pollen grains of Cyrillaceae-Clethraceae occurred in a few per cent only (Sadowska et al. 1976, 1981, Sadowska 1977, Wacnik & Worobiec 2001). Also in the other previously examined profiles from south-western Poland (Zielona Góra, Nowe Czaple – Sadowska 1977) contribution of Cyrillaceae-Clethraceae pollen reached a few per cent (max. 10–15%).

Besides, in the Legnica deposit spectra from this section are very similar to analogous zones in other diagrams from the western (Mosina, Gołębin Stary, Ślepuchowo – Ziembińska-Tworzydło 1974), south-western (Zielona Góra, Nowe Czaple – Sadowska 1977; Ustronie – Ziembińska & Niklewski 1966, Ziembińska-Tworzydło 1974), and central Poland (Lubstów – Ciuk & Grabowska 1991). These spectra are rich in pollen, with relatively high content and diversity of palaeotropical taxa. In the Lower Badenian sediments contribution of tropical element (P1) is low in the whole of Polish Lowland (e.g. in the Legnica region), and frequency of subtropical element (P2) is a little higher. In these profiles *Tricolporopollenites pseudocingulum*, *Quercoidites henrici*, *Myricipites* (*M. rurensis* and others), *Tricolporopollenites liblarensis* (+ *T. fallax*), *Araliaceoipollenites edmundi*, *Momipites punctatus*, Cornaceae/Araliaceae, Symplocaceae, palms, and others occur, whereas in profiles from the Wyrzysk region (Kosztowo, Liszkowo – Kohlman-Adamska 1993) in the Ścinawa beds (with 0.5 to 0.8 m thick coal horizons), pollen grains of *Quercoidites henrici* and *Tricolporopollenites liblarensis* are not numerous. Only *T. pseudocingulum* and *Momipites punctatus* are more frequent in the Wyrzysk region. It could be caused by the kind of sediment – different composition of sporomorphs connected with various stages of succession caused that spectra from lignites seem to be older (richer in thermophilous taxa) than spectra from clays (Sadowska 1994). In the Kosztowo profile (Kohlman-Adamska 1993) in the dusty coaly sands (between these two coal horizons) pollen grains of aquatic and reed mire plants (*Typha*, Cyperaceae, *Sparganium*, *Potamogeton*, and *Nymphea*) are relatively frequent, and accompanied by some marine plankton, which indicates a considerable role of aquatic communities. Similar situation occurs at Rypin (Stuchlik 1964), where two thin lignite horizons are intercalated by compact clays and coaly clays bearing numerous pollen grains of *Sparganium, Decodon*, Cyperaceae, and *Potamogeton*, as well as *Tetraporina* zygospores (determined as *Triceratium*).

In all profiles of the 2[nd] Lusatian seam contribution of *Abies*, *Picea*, and *Tsuga* pollen is approximate and low, whereas contribution of *Pinus* is approximate and high, what points to long-distance transport of these pollen grains (Ziembińska-Tworzydło 1974, Sadowska 1977, Stuchlik et al. 1990, Kohlman-Adamska 1993). Most profiles are characterized by high proportion of Taxodiaceae/Cupressaceae. At the time of sedimentation of the 2[nd] group of seams swamp forests occurred on large area of Poland. Bush swamps existed temporary, whereas on more elevated terrains rich mixed mesophytic forests were growing (Piwocki & Ziembińska-Tworzydło 1995, 1997).

MUŻAKÓW SERIES

The Mużaków series lies above the Lusatian seam mainly in northern part of the Fore-Sudetic Block and on the Fore-Sudetic Monocline (Dyjor 1970, 1978), and is correlated, on other areas of the Polish Lowland, with the 2[nd]A Lubin group of seams and the Pawłowice and Adamów formations (Piwocki & Ziembińska-Tworzydło 1995, 1997). In the Legnica deposit the occurrence of this series has been evidenced in profiles from the west field – Legnica 0/59 and 2/57 (Sadowska et al. 1976), as well as the east field – Legnica 33/56, 41/56, 47/62, and 47/68 (Sadowska et al. 1981, Wacnik & Worobiec 2001). The Legnica 33/56 profile was a subject of this study. In all these profiles, in comparison with the Lusatian seam, the proportion of palaeotropical taxa decreases; *Quercoidites henrici* and *Myrica* reach about 4–6%, *Tricolporopollenites pseudocingulum* (in previous studies misidentified as *Rhus*) – max. 16%, *Engelhardia* and Araliaceae – about 2%. There are also fewer pollen grains of palms and *Araliaceoipollenites edmundi* (=*Tricolporopollenites edmundi*). We can still observe continuous curves of *T. liblarensis* (+ *T. fallax*) and *T. cingulum.* In addition, the frequency of pollen grains of warm-temperate trees *Abies*, *Picea*, *Tsuga*, *Quercus*, *Ulmus*, *Celtis*, *Carya*, *Pterocarya*, and others, is higher. In most profiles pollen spectra of the Mużaków series are more similar to those from the Lusatian seam than to the Henryk seam (Sadowska et al. 1976, 1981). However, in Legnica 33/56 profile pollen grains of thermophilous plants were noted sporadically (Tab. 1). Only a few pollen grains of *Araliaceoipollenites edmundi*, *Ilexpollenites iliacus*, and *Reevesiapollis triangulus* were recorded. *Castaneoideaepollis pusillus*, *Quercoidites henrici*, and *Tricolporopollenites pseudocingulum* were also found rarely. Similar situation is observed in Legnica 47/62 profile (Wacnik & Worobiec 2001).

During the sedimentation of this series the ingression of the North Sea to the Fore-Sudetic area through the depression of northern Germany took place (Oberc & Dyjor 1968, Dyjor 1970, 1978, Piwocki 1998). In southern part of the basin, within sands and clays, numerous layers of coaly clays, coaly silts and grey clays typical for marginal zone of the basin occur (Sadowska et al. 1981). In samples from the lower part of this section of the profile Legnica 33/56 (100.0–97.6 m) sporomorphs were worse preserved, and accompanied by some dinoflagellate cysts (max. 20%) and some linings of foraminifers, which indicates sea transgression on the studied area. Samples with dinocysts were re-studied in detail by P. Gedl (Gedl & Worobiec 2005). In the above-mentioned profile, beside dinoflagellate cysts, shallow-marine forms, characteristic for shelf environment (mainly *Spiniferites* and *Batiacasphaera*) distinctly prevail. Several reworked dinocysts were recorded and some pollen grains from this section have traces of reworking process (see Stanley 1966). They probably originate from the deposits of the Upper Eocene Sieroszowice series and Oligocene Lubusha series, which must have been eroded during the marine ingression. It should be mentioned that this is the southernmost record of the marine transgression in the Polish Lowland during the Middle Miocene.

Influence of the transgression is well seen in neighbouring areas. In eastern part of Germany Lotsch (in Dyjor & Wróbel 1978) found poor fauna, sparse glauconite, as well as lenses and layers of sapropelites pointing to accumulation in shallow brackish basin with numerous bays and lagoons. In the upper members of the Mużaków series some horizons of clayey and sandy sapropelites with bioturbations (burrows) are present, what indicates shallowing of the basin and covering with plants. There are transitional deposits to the Henryk lignite seam, ending sedimentation of this series. Dyjor (1978) also reported glauconite, fragments of spicules of sponges, fragments of calcareous tubes, as well as calcareous and aglutinic foraminifers in the Mużaków series in the Polkowice, Nowe Miasteczko, and Głogów regions. Moreover, in the Lubuska Ziemia region fragments of mollusc shells occur. Influence of the North Sea transgression was also confirmed in the Mużaków region, in the Poznań–Rawicz graben, where in the Adamów beds glauconite and poor microfauna occur (Dyjor & Wróbel 1978). In the Pawłowice beds also quite often glauconite, foraminiferal remains, spicules of sponges, as well as ichnocenozes typical for brackish and shall-marine facies are found (Piwocki & Ziembińska-Tworzydło 1995). Narrow zone between Wymiarki and Mirostowice Dolne (Lutynka), where "glass sands" (white and grey quartzitic sands) were found, probably marks out a line of seashore with dunes. Similar sands were found in the Sieniawa and Wielowieś region, in northern part of the Mużaków series basin (Dyjor 1969, Dyjor & Grodzicki 1969, Dyjor & Chlebowski 1973, Dyjor & Wróbel 1978).

In the Tuplice profile sediments of the Mużaków series were also confirmed (Sadowska 1970, 1977), and in samples from this section single dinocysts ("Hystrichosphaeridae", up to 6%) were encountered. In the lower part of this sandy sediment pollen grains of Coniferae, mainly *Pinus sylvestris* type, as well as *Abies*, *Tsuga*, and *Sciadopitys* prevailed, whereas the group of pollen grains of plants from swampy habitat had relatively poor representation. Taxodiaceae-Taxaceae-Cupressaceae occurred in quantity of a few to 20%, while *Alnus*, *Liquidambar*, *Nyssa*, Cyrillaceae/Clethraceae, and *Myrica* made up only a few per cent. Among more mesophilous plants *Sequoia*, *Betula*, *Quercus*, *Fagus*, *Tricolporopollenites pseudocingulum* (misidentified by Sadowska as *Rhus*), and Juglandaceae prevailed, and admixture of other trees, shrubs, and not numerous herbs was observed. According to Sadowska (1970) this section probably represents shallow marine coastal zone – beach or bay (in the upper part of the sandy sediments vertical roots were present), neighbouring on forests which produced the above mentioned pollen grains (Sadowska op. cit.).

Results of the present palynological studies imply that in the Legnica vicinity the shallow bay was covered with swamp vegetation. It was mentioned that in samples from Mużaków series of the profile Legnica 33/56 pollen grains of herbs (mainly grasses max. 70%) are relatively abundant. In several samples *Graminidites bambusoides* was noted (2–5%). In the other profile from this deposit (Legnica 47/68) sum of pollen grains of herbs reached 15%. It is connected with location of these cores in marginal zone of the sedimentation basin. The results of investigations of the Legnica profiles (mainly Legnica 33/56, as well 47/62) indicate the existence of plains with shallow water, and the presence of swamp forests and reed marshes, composed mainly of grasses, sedges (*Cladium* and others), and other herbs. Within this area of grasses and sedges, in somewhat drier places, thickets of *Myrica* and *Salix* grew. Swamp forests consisted of *Taxodium*, *Glyptostrobus*, *Alnus*, and *Nyssa*, with an admixture of *Salix*, *Acer*, *Betula*, *Myrica*, *Osmunda*, and bamboos. In comparison with the Lusatian seam the role of *Alnus* increased definitely. As the sea has been moving back the role of these communities and riparian forests became more significant.

Reed marshes are considered to be an early stage of succession on the Miocene peat-bogs. In Legnica 33/56 profile sample with the highest proportion of pollen grains of grasses, accompanied by other herbs (Cyperaceae, Lythraceae and *Theligonumpollenites baculatus*), occurs in the upper part of the Mużaków series, and directly precedes samples from the Henryk seam. So, here is well seen early stage of succession, which yielded this seam. It is necessary to stress that in the Middle Miocene sediment pollen grains of grasses are rarely encountered in such high quantity, and usually they do not exceed 5% (Tuplice – Sadowska 1977; Gierlachowo, Krosinko, Gołębin Stary, Ślepuchowo – Ziembińska-Tworzydło 1974). Similar situation is observed in most of the Legnica profiles (Sadowska et al. 1976, 1981, Sadowska 1977, Nowak 1998, Wacnik & Worobiec 2001). So, Legnica 33/56 profile can advance our understanding the palaeoenvironment of this area. High percentages of pollen grains of grasses are more often encountered above the Henryk seam – Mirostowice and Gozdnica 40–50% (Sadowska 1977). Reed marshes are very rarely recorded in the fossil material, what could be caused by their features determining weak resistance, or by features of sediment in which pollen grains from these communities are found (in Legnica 33/56 borehole there were coaly clays with large admixture of very fine plant remains, difficult to carry out pollen analysis). Nonarboreal swampy communities were previously described by Teichmüller (1958) and Neuy-Stolz (1958) from Germany. From Poland Kohlman-Adamska (1993) reported high contribution of Cyperaceae (50%) and Poaceae (18%) in sample from the Mid-Polish beds of the Karolewo-Dąbki profile. At Mirostowice (upper part of the Mużaków series) relatively high frequency of *Sparganium* (17%) was observed (Sadowska & Zastawniak 1978). Pollen grains of *Graminidites bambusoides* were known from Rypin (Stuchlik 1964), the only one locality until now.

In the Pawłowice and Adamów beds from western Poland, in the localities Gierlachowo, Gołębin Stary, Krosinko, Ślepuchowo, Mosina (Ziembińska-Tworzydło 1974) pollen grains of *Tsuga* (10%) and *Sciadopitys* (5%) occur in relatively high quantities, whereas sporomorphs of thermophilous taxa are not numerous. Similar situation was observed in profiles from the Mużaków arch (Tuplice, Mirostowice – Sadowska 1970, 1977, Sadowska & Zastawniak 1978), as well as the Wyrzysk and Nakło region (Kohlman-Adamska 1993), whereas in Legnica profiles pollen grains of both these genera are somewhat more numerous than in other sections, but still sparse. This fact is probably connected with ecology of these trees and with relief of this region during the sedimentation of these deposits. Conifers grew on elevated terrains surrounding the sedimentary basin. In the Legnica region shallow bay probably existed, with marginal zones covered with swamp forests and reed marshes. It is evidenced by transgression visible in one from 18 studied profiles (Legnica 33/56), and the domination of spectra of the Mużaków series by pollen grains of swamp plants (mainly Taxodiaceae/Cupressaceae, *Alnus* and grasses in the upper part). There were unfavourable conditions for accumulation of sporomorphs from long-distant transport, because the local vegetation was dense, and the presence of pollen grains from long-distant transport is masked by overrepresentation of local vegetation pollen.

Decreasing of pollen grains of thermophilous plants in the Mużaków series (Tab. 1) could be interpreted as a result of colder climate during sedimentation time of this series. However, taking into consideration changes of vegetation connected with changes of ecological conditions (decrease of mesophilous forests and bush swamps, in which occurred many warm-loving plants, and simultaneous increase of swamp forests and reed marshes), the interpretation of climate changes is not so obvious.

HENRYK SEAM AND POZNAŃ SERIES (GREY CLAY HORIZON)

After the period of more dynamic clastic sedimentation, in later Middle Miocene in the Polish Lowland the climatic conditions favoured the development of rich and vast peat-bogs. These sediments yielded brown coal of 1st group (Henryk seam in the Fore-Sudetic region). The swampy terrains were most extensive of the whole Neogene, what is evidenced by the broadest extent of the 1st lignite seam group. This seam is a few metres thick, only locally in depressions and fossil river valleys in the Fore-Sudetic area, as well as on western slopes of the Pomeranian–Kujawy Swell its thickness reaches a dozen or so metres (up to 20 m in the Pątnów deposit). Usually it is a single seam, sometimes divided into 2–4 horizons. It is considered a lithostratigraphic correlative level because of forming almost continuous horizon in the bottom of the Poznań series, the best developed in central and south-eastern Poland (Piwocki 1992). The grey clay horizon originated during the flooding of swamps, which yielded material for the Henryk seam formation. This horizon consists of grey and brown clays with abundant plant remains, and well preserved leaf impressions. The presence of islands in the Poznań series basin, over the area of Polish Lowland, was evidenced by coal beds or coaly clays occurring in the upper horizons of the Poznań series in the Legnica region (Sadowska 1977).

The Henryk seam and grey clays of the Poznań series are correlated with the VIII ***Celtipollenites verus*** and IX ***Tricolporopollenites pseudocingulum*** spore-pollen zones (Piwocki & Ziembińska-Tworzydło 1995, 1997, Ziembińska-Tworzydło 1998).

In the Legnica lignite deposit the occurrence of the Henryk seam and grey clays of the Poznań series has been evidenced in boreholes from the west field – Legnica 0/59, 2/57, 5/53, 7/49, 7/58, and 8/59 (Sadowska et al. 1976), as well as the east field – Legnica 33/56, 41/52 41/56, 41/64, 47/55, 47/62, 47/68, and 53/56 (Sadowska et al. 1981, Nowak 1998, Wacnik & Worobiec 2001). Two of the last-mentioned profiles (33/56 and 41/52) were subjects of this study. At Legnica this seam is divided into two horizons, whereas at Ruja it occurs as a few thin horizons intercalated by grey clays. In the borehole Legnica 47/68 the lack of the Henryk seam is caused by situation of this profile in the marginal zone of the basin. In Legnica 53/56 profile this seam consists of a few horizons intercalated by coaly clays, because this core is situated in maximal lowering and on the margin of a strong lability zone. In most profiles this seam is accompanied in the upper and bottom parts by dark clays being fossil soils at the bottom and top of existing peat-bogs (Sadowska et al. 1981). The results of pollen analysis of these sediments from all profiles from Legnica are similar. In the samples from Henryk seam and grey clays pollen grains of Taxodiaceae/Cupressaceae (max. 60%) with *Sequoia*, as well *Pinus*, *Nyssa*, *Alnus* (up to 30–35%), *Quercus*, *Tricolporopollenites pseudocingulum* (in previous studies misidentified as *Rhus* – up to 15–17%), *Fagus*, and *Celtis* (up to 8–10%) are the most frequent. Some pollen grains of *Myrica*, *Liquidambar*, *Salix*, *Ilex*, Ericaceae, *Abies*, *Castanea*, *Ulmus*, *Acer*, *Carya*, *Pterocarya*, Rosaceae, Fabaceae, *Symplocos*, *Engelhardia*, and *Quercoidites henrici* occur. In addition, spores of Polypodiaceae and *Osmunda* are numerous (Sadowska et al. 1976, 1981).

The plant communities, both swamp and mesophilous forests outside the marsh basins, became once more floristically rich, and dominated by plants of relatively high climatic requirements, representing warm-temperate element, whereas palaeotropical element was distinctly poorer and with smaller taxonomic differentiation (Tab. 1). In comparison with the Lusatian seam the proportion of *Tricolporopollenites pseudocingulum*, *Engelhardia*, *Quercoidites henrici*, Araliaceae (excluding Legnica 7/58 profile), and *Ilex* pollen is low. In addition, here there are more pollen grains of *Nyssa*, *Alnus*, *Quercus*, and *Fagus*. Pollen grains of *Tricolporopollenites liblarensis* (+ *T. fallax*) occur sporadically (Sadowska et al. 1976, 1981). The climate was warm-temperate and humid. There was again the time of slowly flowing waters and large-area marshes with low peat-bogs on the accumulation terraces (Piwocki & Ziembińska-Tworzydło 1995, 1997). In the Legnica region swamp forests and bush swamps grew. In drier terrains there existed favourable conditions for mixed mesophitic forests with the domination of warm-temperate taxa, and with an admixture of evergreen plants, mainly forming the undergrowth. In samples from the grey clays arctotertiary taxa prevail, but relatively high diversity of palaeotropical element (Tab. 1) points out a still warm, mild and humid climate, favourable for swamp and riparian plant communities.

In pollen diagrams of these sediments from various regions of Poland (both distant and near ones, even in the same locality), we can observe differences in contributions of pollen grains of individual taxa (genera and families), which reflect changes of plant communities. These differences agree with the kind of sediment and are connected with changes of edafic conditions. This problem has been studied by Dyjor and Sadowska (1977). On the basis of profiles of the Henryk seam from many localities (Nowe Czaple, Tuplice, Staszów, Mirostowice, Gozdnica, Ruszów, Milików, Wołów, Łojowice, Jaworzyna, Żarów, Rusko, Jerzmanowa, Tarpno, Chróścina, and Wielowieś) the main features differing this seam from other ones have been given (Dyjor & Sadowska op. cit.). In addition, profiles from the Zielona Góra region (Sadowska et al. 1973, 1974), Żary and Mirosławice (=Mirostowice; Doktorowicz-Hrebnicka 1954, 1956b), Rogóźno deposit (Doktorowicz-Hrebnicka 1961, Mamczar 1961), Konin region (Kremp 1949, Mamczar 1960), margin of the Bełchatów graben (Sadowska 1974), upper coal series from Bełchatów (Kościelniak & Wanat 1974), and Ustronie (Ziembińska & Niklewski 1966, Ziembińska-Tworzydło 1974) were recognized as analogical ones. The main stratigraphic criterion was a variable percentage of pollen grains of thermophilous families and genera (*Quercoidites henrici*, *Myrica*, *Tricolporopollenites pseudocingulum*, *Engelhardia*, *Symplocos*, Araliaceae, Araliaceae/Cornaceae, *Araliaceoipollenites edmundi* (=*Tricolporopollenites edmundi*), *Itea*, *Arceuthobium*, Meliaceae, Solanaceae, palms, and *Tricolpopollenites liblarensis*) in individual stages of the Miocene. In samples from the Henryk seam they make up on the average 5.8% (in comparison in the 2nd Lusatian seam 14.9%, in the Kędzierzyn seam 2.5%). In comparisons of these profiles the attention was also paid to percentage contribution of pollen grains of temperate and warm-temperate plants, including *Abies*, *Picea*, *Tsuga*, *Sciadopitys*, *Betula*, *Carpinus*, *Corylus*, *Ostrya*, *Quercus*, *Fagus*, *Castanea*, *Ulmus*, *Celtis*, *Parrotia*, and *Acer*. In samples from the Henryk seam they make up an average of 25.4% (in the 2nd Lusatian seam 17.5%, in the Kędzierzyn seam 39.2%). Sporomorphs of the facial element have the highest frequency (60–80%) in all these profiles. Their differentiation in individual profiles is a result of various ecological and regional conditions (Dyjor & Sadowska 1977).

In many palynological profiles from the Polish Lowland (for example from the Wyrzysk region – Kohlman-Adamska 1993) towards the top of cores an increase of the contribution of *Alnus* pollen grains can be observed, what is interpreted as a result of changes in taxonomical composition of the swamp forest. During the sedimentation of the 2nd Lusatian seam there probably were forests with the domination of *Taxodium*, *Nyssa* and *Glyptostrobus*, while during the sedimentation of the 1st seam there were forests with a considerable role of *Alnus*. In the Legnica profiles pollen grains of *Alnus* reach a few per cent in the Lusatian seam, in the Mużaków series – up to 70%, in the Henryk seam – up to 16%, and in the grey clay horizon – up to 50%. So, we can assume that during accumulation time of the Mid-Polish group of seams (Henryk seam) and grey clays of the Poznań series alder was an important component of forests.

During the sedimentation of these deposits on large areas of the Polish Lowland changes of vegetation consisting in increase of the role of riparian forests were evident. In the lower Mid-Polish beds (and corresponding with them deposits on the Fore-Sudetic Block) the presence of pollen grains of plants characteristic for mixed forests (with domination of arctotertiary taxa, and a considerable admixture of palaeotropical element), as well swamp forests (with domination of *Taxodium* and *Nyssa*) is well seen. During sedimentation of the upper Mid-Polish beds (and corresponding with them deposits) in western and south-western Poland swamp forests with *Alnus*, *Nyssa*, and *Taxodium* grew, and an increasing role of riparian forests with *Quercus*, *Celtis*, *Ulmus*, and *Liquidambar* or *Celtis*, *Pterocarya*, *Quercus*, and *Liquidambar* is visible (Wyrzysk region – Kohlman-Adamska 1993; Gierlachowo, Oczkowice, Gołębin Stary – Ziembińska-Tworzydło 1974; Legnica – Sadowska 1977). In the studied profiles from Legnica, in samples from the Henryk seam and grey clays of the Poznań series, the contribution of *Ulmus*, *Celtis*, *Carya*, *Pterocarya*, *Quercus*, and *Liquidambar* also increases.

In the profile Legnica 41/52 relatively high contribution of *Sequoia* pollen (max. 30%) was confirmed, what could be interpreted as a symptom of temporary presence of *Sequoia* forests on the peat-bogs (Sadowska & Giża 1991). Similar phenomenon has been observed in many other profiles from the Polish Lowland, for example from Ustronie (Ziembińska & Niklewski 1966, Ziembińska-Tworzydło 1974), Jerzmanowa and Łojowice (Dyjor & Sadowska 1977), Rogóźno (Mamczar 1961), and Lubstów (Ciuk & Grabowska 1991). Significant contribution of pollen grains of this genus is sometimes considered to be a characteristic feature of this lignite seam, what find its expression in distinguishing the *Sequoia* phase (Raniecka-Bobrowska 1970) or *Sequoia–Nyssa–Quercus* phase (Ziembińska-Tworzydło & Ważyńska 1981). Similar in this respect to the Legnica profiles are pollen diagrams from the Konin region (*Sequoia* above 30%), but they differ from them in high contribution of *Sciadopitys* – max. 20% (Kremp 1949, Mamczar 1960, Doktorowicz-Hrebnicka 1960). Similarly, a considerable percentages of *Sciadopitys* were observed in the Wyrzysk region – up to 15% (Kohlman-Adamska 1993) and Żary – in some samples above 10% (Doktorowicz-Hrebnicka 1954). Significant contributions of pollen of this tree and *Tsuga* were also considered to be essential in identification of lignite seams (Mamczar 1961). However, at Legnica their frequency did not exceed 2%. In the A seam from Bełchatów pollen grains of both these genera occur sporadically (Stuchlik et al. 1990). In pollen diagrams from western Poland, worked out by Ziembińska-Tworzydło (1974), the frequency of pollen grains of *Sciadopitys* was usually low, only at Mosina somewhat higher. These observations point out the connection of high frequency of pollen grains of *Sciadopitys* and *Tsuga* with palaeogeography, whereas increase of *Sequoia* has a facial nature. Composition of spectra from the Konin region could be explained by the occurrence of the Mid-Polish seam in this region almost only in erosional river valleys developed on the Upper Cretaceous marls' surface. This seam is characterized by equal arrangement within main and side valleys. During the sedimentation of this seam these valleys used to be a swampy, temporary flooded area. In the valleys peat-bogs occurred, while on surrounding more elevated terrains mesophytic forests grew. These peat-bogs were temporary dried and covered with forests (Sadowska & Giża 1991).

In the profiles from Milików near Nowogrodziec and Jaworzyna (Sadowska 1977) generally higher frequency of conifers (*Tsuga* – at Milików max. 20%, *Sciadopitys*, *Abies*, *Picea*, and *Pinus*), as well *Betula* is well seen, what is connected with localization of these profiles in the Fore-Sudetic region. The frequency of *Sciadopitys* pollen grains increases simultaneously with other conifers, in clayey, silty and sandy sediments. Trees of this genus were components of forests, which grew on somewhat drier areas, on slopes, in the distance from swamp communities. Pollen grains of these trees were easily transported to open water reservoirs, whereas in spectra from swamp communities they are masked by high frequency of pollen grains from swamp forests (Sadowska op. cit.).

At Pątnów (Konin region) pollen grains of *Tricolporopollenites pseudocingulum* (misidentified as *Rhus*) are very numerous (max. 55.8%). It is well seen in samples characterized by low frequency of swamp taxa (mainly

Taxodiaceae/Cupressaceae), and high percentage of shrubs *Ilex*, *Myrica*, Cyrillaceae, Ericaceae, Rosaceae, and others. These shrubs were probably components of bush swamps, which grew on temporary flooded areas (Sadowska & Giża 1991). At Ruszów the contribution of pollen grains of trees characteristic for swamp forest is also lower, and frequency of pollen grains of shrubs (Rosaceae, Fabaceae, *Tricolporopollenites pseudocingulum*, Ericaceae, and Araliaceae/Cornaceae) is also high, what could be connected with varied relief – on elevated areas there were favourable conditions for bush swamps (Sadowska 1970, Dyjor & Sadowska 1977). Similar in this respect is pollen diagram from Ustronie (Ziembińska & Niklewski 1966, Ziembińska-Tworzydło 1974). Significant proportion of shrubs was also observed in profiles from Mirostowice, Staszów, Jerzmanowa, Tarpno, and Jaroszów (Sadowska 1977). Contributions of pollen grains of deciduous trees (*Betula*, *Quercus*, *Fagus*, *Ulmus*, *Celtis*, and others) are similar in individual diagrams, what indicates the growth of the forests with these trees in far distance from the sedimentary basin (Dyjor & Sadowska 1977).

The above-mentioned observations lead to a conclusion that on the margins of sedimentary basin of the Henryk seam and grey clays of the Poznań series (and equivalental deposits on other areas) the relief was more varied, what made possible a significant diversity of plant communities. On wide swampy areas of the Polish Lowland mainly swamp forests and bush swamps were growing. In the marginal zone and in local depressions, between elevated areas (Konin and Turek, Jaroszów–Udanin–Budziszów, Węgliniec–Ruszów, Trzcianka deposit near Piła, and Szamotuły), in valleys mainly peat-bogs, and mesophilous forests on elevations were occurring (Dyjor & Sadowska 1977, Sadowska & Giża 1991). Regional differences, analogous to these ones, are seen in spectra from the Lusatian seam and the Mużaków series (as well as in the Adamów and Pawłowice beds). Therefore these differences in pollen spectra within one coal seam are connected with differences in plant communities (which depend on palaeogeography), and with the kind of sediment bearing the sporomorphs (what depends on type of sedimentation – fitogenous or clastic one), and not with different time of sedimentation (changes of climate in time).

The results of investigations received up to now indicate that the deposition of the Henryk seam, and its equivalent the Mid-Polish seam, occurred in one sedimentary cycle. Its occurrence in two horizons and extension of coaly sedimentation in the grey clay horizon were caused by facial changes and greater lability of basin's bottom in tectonic activity zones and on its margins (Sadowska 1977, Dyjor 1986). Fragmentation and current range of this seam is also a result of erosion in the Quaternary time, and because of its lying on small depth, is connected with the route of the Pleistocene fossil valleys in the Polish Lowland (Piwocki 1992).

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PLATES

Plate 1

× 1000

1a,b. (1) *Distancoraesporis wehningensis* (Krutzsch) Grabowska; Legnica 33/56, 111.5 m
2a,b. (3) *Distverrusporis electus* (Mamczar ex Krutzsch) Grabowska; Legnica 33/56, 108.5 m
3. (2) *Distverrusporis antiquus* (Krutzsch & Sontag) Grabowska; Legnica 33/56, 111.5 m
4. (–) ?*Distverrusporis* sp.; Legnica 33/56, 108.5 m
5. (5) *Stereisporites minor* (Raatz) Krutzsch; Legnica 33/56, 108.5 m
6. (4) *Stereisporites involutus* (Doktorowicz-Hrebnicka ex Krutzsch) Krutzsch; Legnica 41/52, 123.0 m
7. (6) *Stereisporites stereoides* (Potonié & Venitz) Thomson & Pflug; Legnica 33/56, 111.5 m
8. (7) *Stereisporites welzowensis* Krutzsch & Sontag; Legnica 33/56, 108.0 m
9. (–) *Stereisporites* sp.; Legnica 33/56, 108.5 m
10a,b. (8) *Corrusporis* cf. *tuberculatus* Krutzsch; Legnica 33/56, 112.0 m
11. (10) *Selagosporis selagoides* Krutzsch; Legnica 33/56, 101.0 m
12a,b. (9) *Rudolphisporis major* (Stuchlik) Stuchlik; Legnica 33/56, 92.5 m
13. (13) *Rugulatisporites quintus* Pflug & Thomson; Komorniki, 78.0 m
14a,b. (12) *Baculatisporites primarius* (Wolff) Pflug & Thomson; Komorniki, 78.2 m

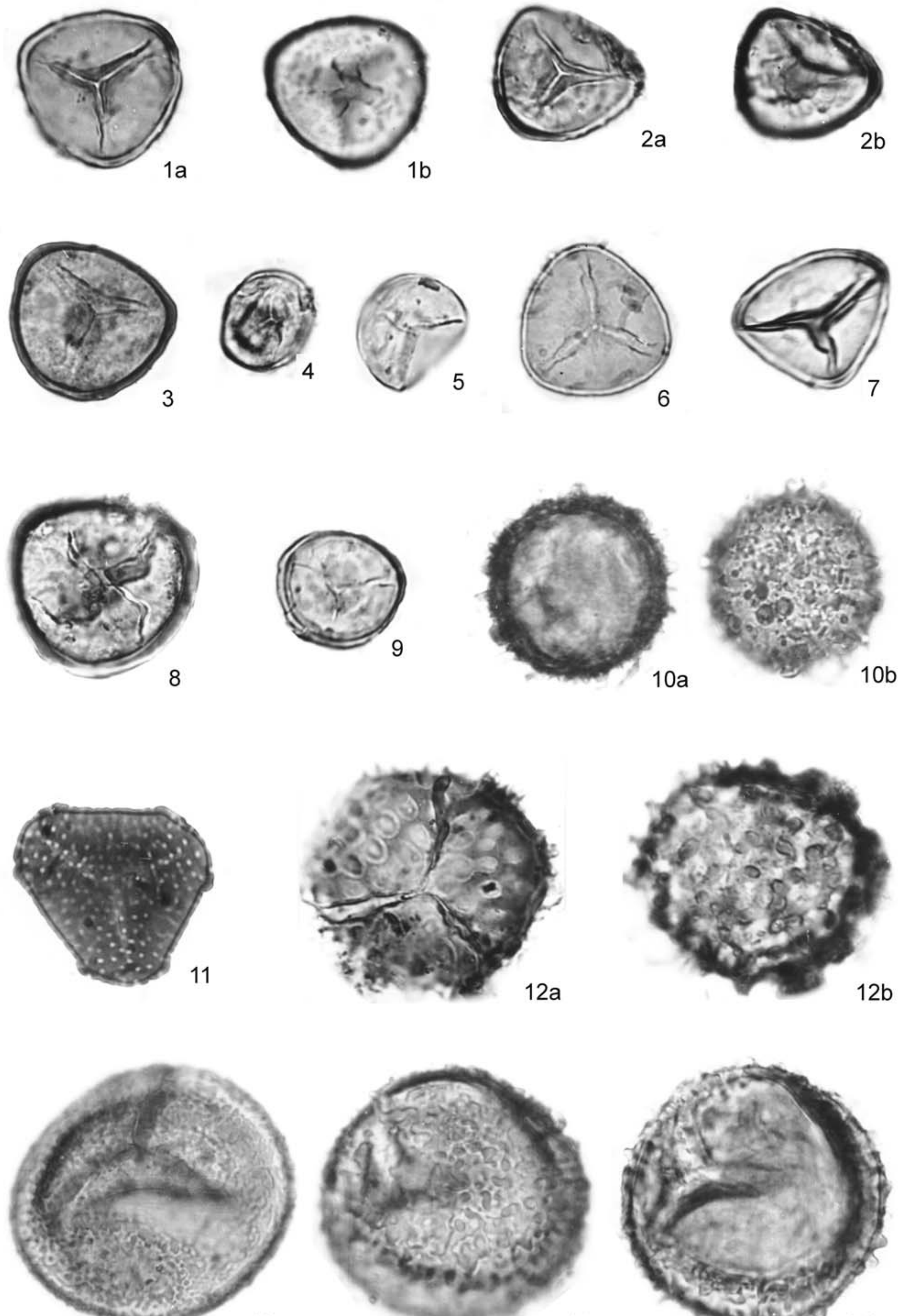
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Plate 2

× 1000

1a,b. (11) *Baculatisporites major* (Raatz) Krutzsch; Komorniki, 78.2 m

2a,b. (14) *Monoleiotriletes gracilis* Krutzsch; Komorniki, 78.6 m

3. (15) *Laevigatosporites gracilis* Wilson & Webster; Komorniki, 77.6 m

4. (16) *Laevigatosporites crassicus* (Krutzsch) stat. nov.; Legnica 33/56, 104.0 m

5. (17) *Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug; Komorniki, 77.2 m

6. (18) *Laevigatosporites nitidus* (Mamczar) Krutzsch; Legnica 33/56, 75.5 m

7. (19) *Verrucatosporites favus* (Potonié) Thomson & Pflug; Legnica 33/56, 101.0 m

8. (20) *Perinomonoletes pliocaenicus* Krutzsch; Komorniki, 78.0 m

9a,b. (22) *Perinomonoletes spicatus* Nagy; Komorniki, 78.0 m

10. (23) *Perinomonoletes* sp. 1; Komorniki, 78.0 m

11. (21) *Perinomonoletes* cf. *goersbachensis* Krutzsch; Komorniki, 78.0 m

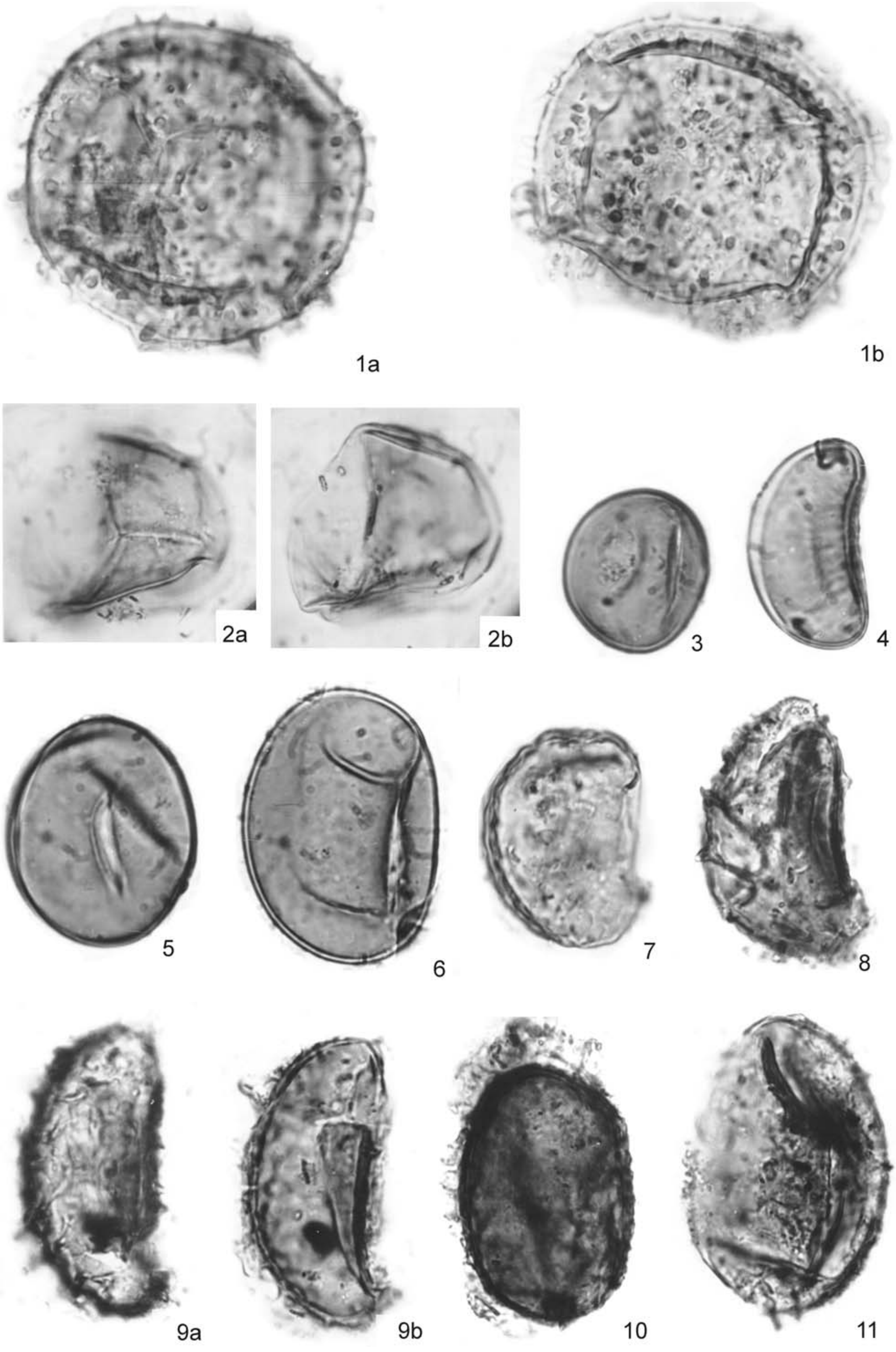
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Plate 3

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1a,b. (24) *Toroisporis (Toroisporis) teupitzensis medioris* Krutzsch; Legnica 33/56, 108.0 m
2. (25) *Toroisporis (Toroisporis)? pliocaenicus* (Thiergart) Krutzsch; Legnica 33/56, 97.6 m
3. (26) *Cupressacites bockwitzensis* Krutzsch; Legnica 33/56, 106.5 m
4. (27) *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug; Legnica 33/56, 76.5 m
5. (28) *Inaperturopollenites concedipites* (Wodehouse) Krutzsch; Legnica 33/56, 101.0 m
6. (29) *Inaperturopollenites verrupapilatus* Trevisan; Legnica 33/56, 75.0 m
7. (30) *Sciadopityspollenites antiquus* Krutzsch; Legnica 33/56, 109.5 m
8a,b. (31) *Sciadopityspollenites quintus* Krutzsch; Legnica 33/56, 104.0 m
9a,b. (32) *Sciadopityspollenites serratus* (Potonié & Venitz) Raatz; Legnica 33/56, 75.0 m
10. (33) *Sciadopityspollenites tuberculatus* (Zaklinskaya) Krutzsch; Komorniki, 77.8 m
11. (34) *Sciadopityspollenites varius* Krutzsch; Legnica 33/56, 103.0 m
12. (35) *Sciadopityspollenites verticillatiformis* (Zauer) Krutzsch; Legnica 33/56, 106.5 m

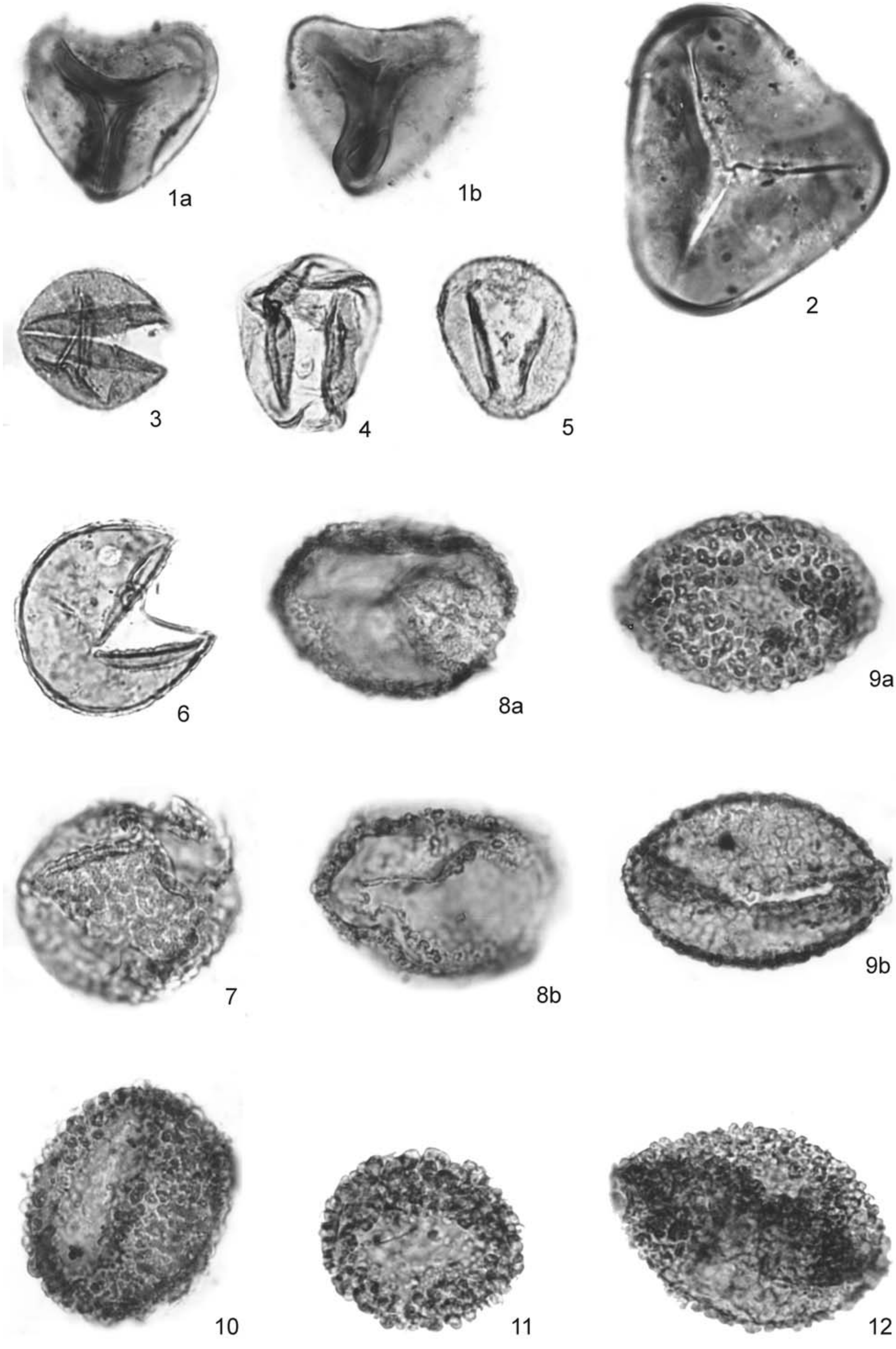
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Plate 4

1. (36) *Sequoiapollenites major* Krutzsch; Legnica 33/56, 101.0 m; × 1000
2. (37) *Sequoiapollenites polyformosus* Thiergart; Legnica 33/56, 101.0 m; × 1000
3. (38) *Sequoiapollenites rotundus* Krutzsch; Legnica 33/56, 101.0 m; × 1000
4. (40) *Sequoiapollenites undulatus* Kohlman-Adamska; Legnica 33/56, 101.0 m; × 1000; arrow shows the papilla

5a,b. (39) *Sequoiapollenites rugulus* Krutzsch; Legnica 33/56, 104.0 m; × 1000

6. (41) *Sequoiapollenites sculpturius* Krutzsch; Legnica 33/56, 101.0 m; × 1000
7. (42) *Sequoiapollenites largus* (Kremp) Manum; Legnica 33/56, 101.0 m; × 1000
8. (43) *Abiespollenites absolutus* Thiergart; Komorniki, 78.2 m; × 1000
9. (44) *Abiespollenites latisaccatus* (Trevisan) Krutzsch ex Ziembińska-Tworzydło; Legnica 33/56, 97.6 m; × 1000
10. (44) *Abiespollenites latisaccatus* (Trevisan) Krutzsch ex Ziembińska-Tworzydło; Legnica 33/56, 97.6 m; × 500
11. (45) *Abiespollenites maximus* Krutzsch; Legnica 33/56, 109.5 m; × 500

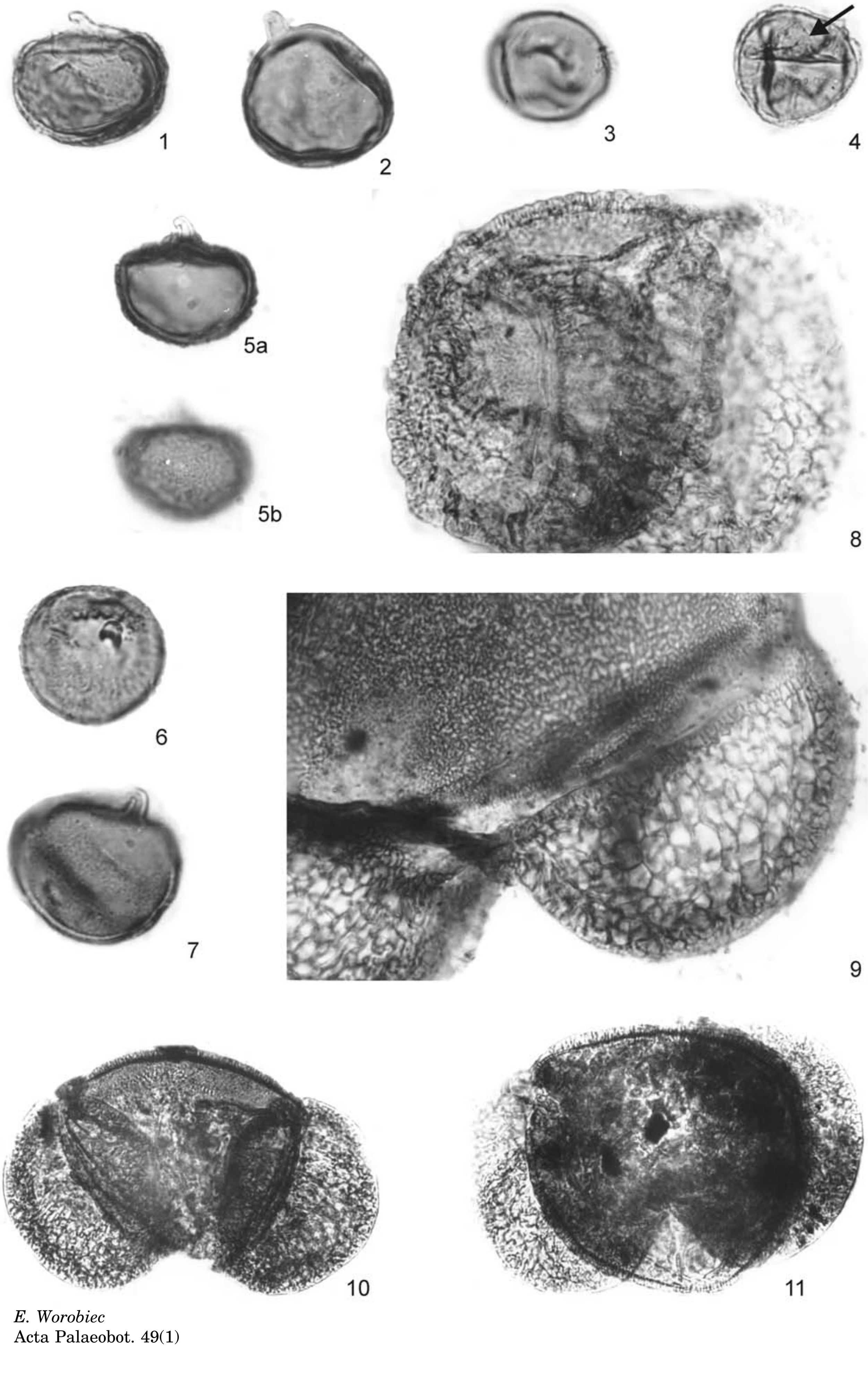
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Plate 5

× 1000

1a,b. (46) *Cathayapollis erdtmanii* (Sivak) Ziembińska-Tworzydło; Legnica 33/56, 101.0 m
2a,b. (47) *Cathayapollis potoniei* (Sivak) Ziembińska-Tworzydło; Legnica 33/56, 75.0 m
3a,b. (48) *Cathayapollis wilsonii* (Sivak) Ziembińska-Tworzydło; Legnica 33/56, 106.0 m
4, 5. (49) *Cathayapollis pulaensis* (Nagy) Ziembińska-Tworzydło; Legnica 33/56, 109.5 m

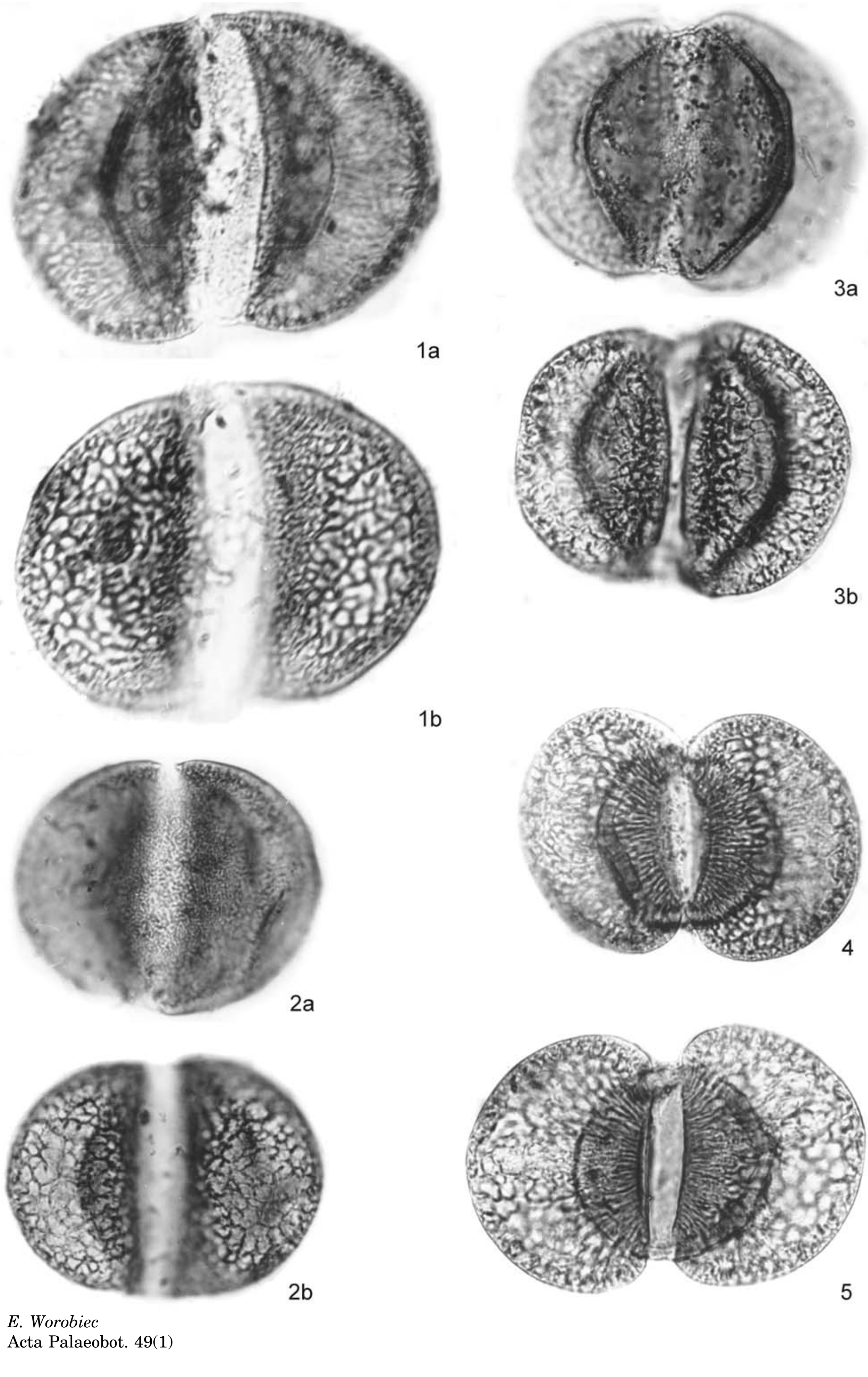
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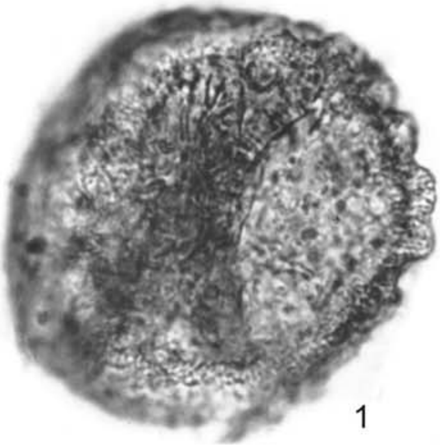
Plate 6

1. (50) *Cedripites lusaticus* Krutzsch; Legnica 33/56, 106.0 m; × 1000
2a,b. (51) *Cedripites miocaenicus* Krutzsch; Legnica 33/56, 75.0 m; ×1000
3. (52) *Keteleeriapollenites dubius* (Khlonova) Słodkowska; Komorniki, 78.2 m; × 500
4. (53) *Laricispollenites* sp.; Legnica 33/56, 108.0 m; ×1000
5. (54) *Piceapollis planoides* Krutzsch ex Hochuli; Legnica 33/56, 75.0 m; × 500
6. (56) *Piceapollis tobolicus* (Panova) Krutzsch; Legnica 33/56, 76.0 m; ×1000
7. (56) *Piceapollis tobolicus* (Panova) Krutzsch; Legnica 33/56, 91.5 m; ×1000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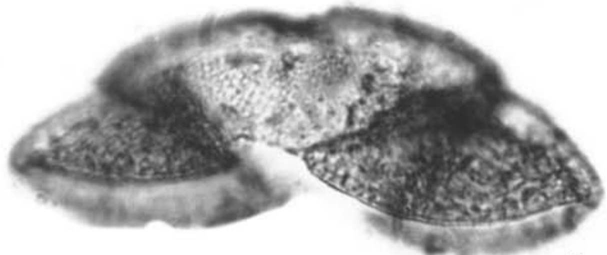
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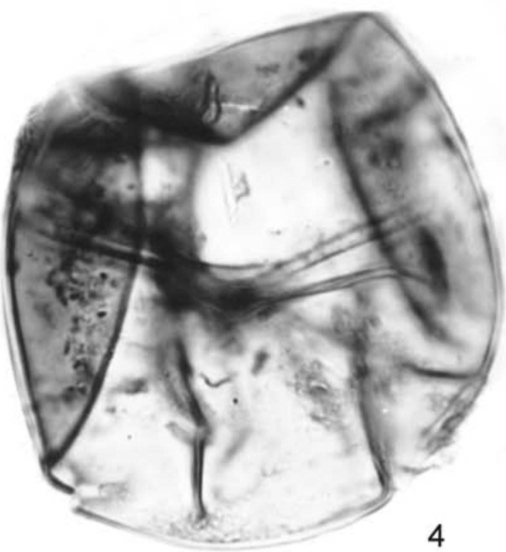
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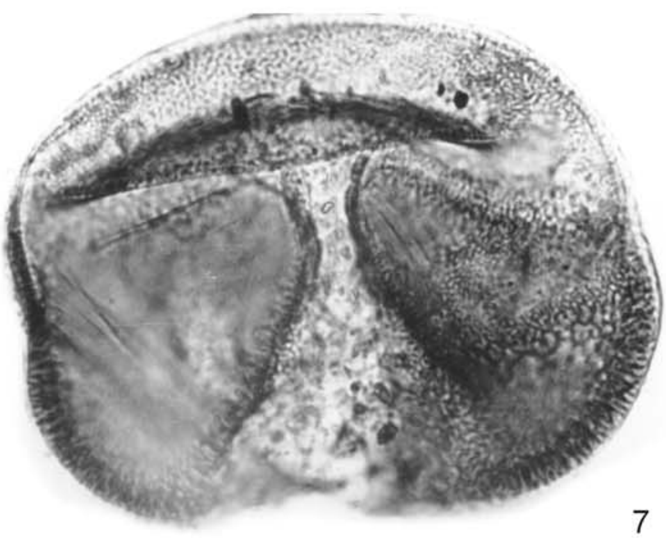
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Plate 7

× 1000

1. (55) *Piceapollis sacculiferoides* Krutzsch ex Hochuli; Legnica 33/56, 91.5 m
2a,b. (57) *Pinuspollenites labdacus* (Potonié) Raatz ex Potonié; Legnica 33/56, 101.0 m
3a,b. (58) *Pinuspollenites macroinsignis* (Krutzsch ex Olliver-Pierre) Planderová; Legnica 33/56, 97.6 m
4. (–) *Pinuspollenites* sp.; Legnica 33/56, 101.0 m
5a,b. (59) *Zonalapollenites gracilis* Krutzsch ex Konzalová et al.; Legnica 33/56, 108.0 m

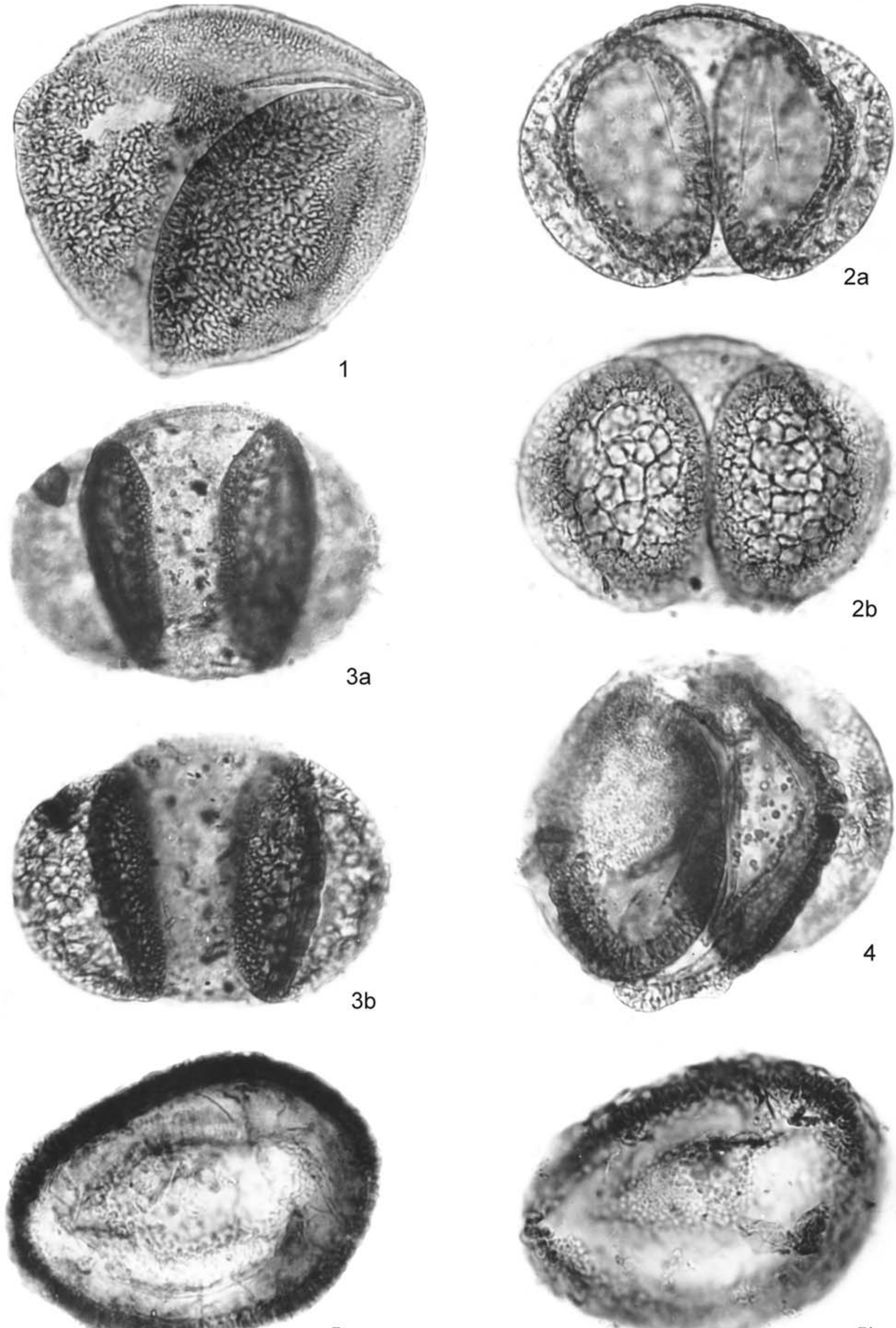
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Plate 8

× 1000

1a,b. (–) ?*Zonalapollenites maximus* (Raatz) Krutzsch ex Ziembińska-Tworzydło; Komorniki, 77.8 m

2a,b. (62) *Zonalapollenites maximus* (Raatz) Krutzsch ex Ziembińska-Tworzydło; Legnica 33/56, 91.5 m

3a,b. (60) *Zonalapollenites verrucatus* Krutzsch ex Ziembińska-Tworzydło; Komorniki, 78.6 m

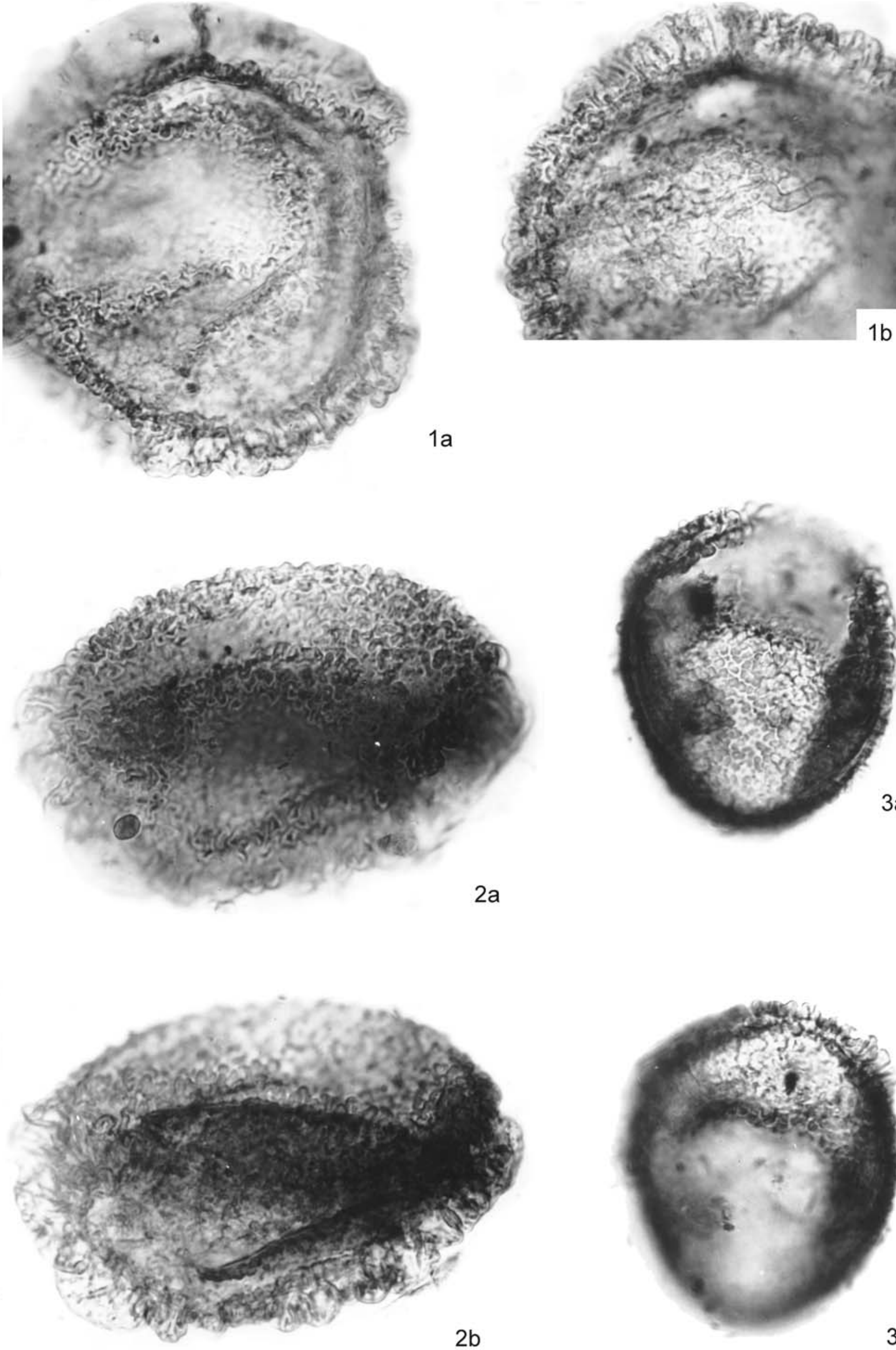
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Plate 9

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1a,b. (61) *Zonalapollenites spectabilis* (Doktorowicz-Hrebnicka) Ziembińska-Tworzydło; Komorniki, 77.2 m
2a,b. (63) *Zonalapollenites robustus* Krutzsch ex Kohlman-Adamska; Legnica 33/56, 91.5 m
3. (64) *Podocarpidites eocenicus* Krutzsch; Komorniki, 78.2 m
4. (65) *Liriodendroipollis verrucatus* Krutzsch; Legnica 33/56, 75.0 m

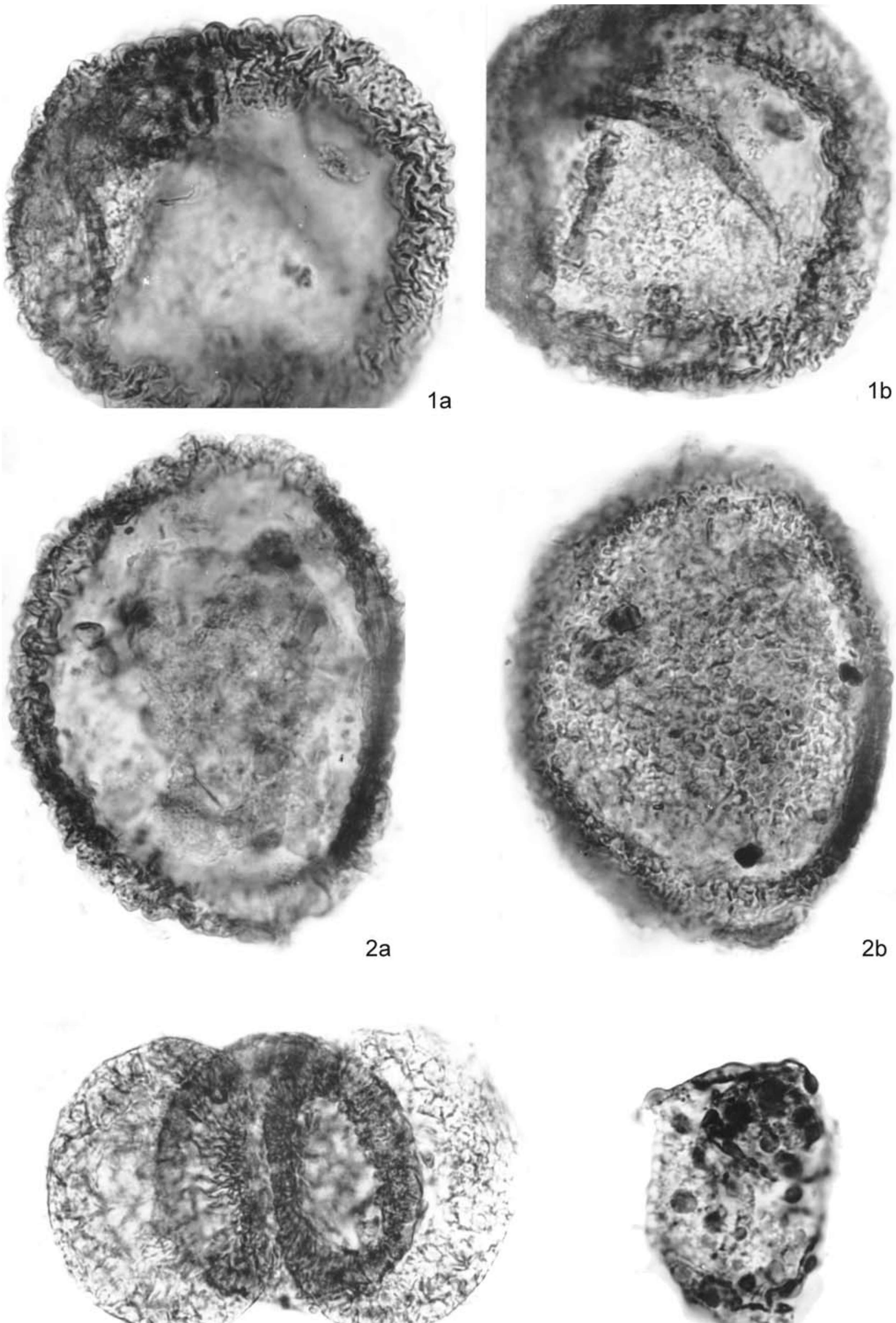
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Plate 10

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1. (66) *Liriodendroipollis semiverrucatus semiverrucatus* Krutzsch; Legnica 33/56, 75.0 m
2. (67) *Liriodendroipollis semiverrucatus minor* Krutzsch; Legnica 33/56, 75.0 m
3. (68) *Magnolipollis neogenicus major* Krutzsch; Legnica 41/52, 79.6 m
4. (69) *Magnolipollis neogenicus minor* Krutzsch; Komorniki, 78.6 m
5. (70) *Magnolipollis neogenicus neogenicus* Krutzsch; Legnica 41/52, 79.6 m

6a,b. (71) *Nelumbopollenites europaeus* (Tarasevich) Skawińska; Legnica 33/56, 95.5 m

7a,b. (74) *Persicarioipollis welzowenze* Krutzsch; Legnica 41/52, 79.6 m

8. (73) *Persicarioipollis pliocenicus* Krutzsch; Legnica 33/56, 94.9 m

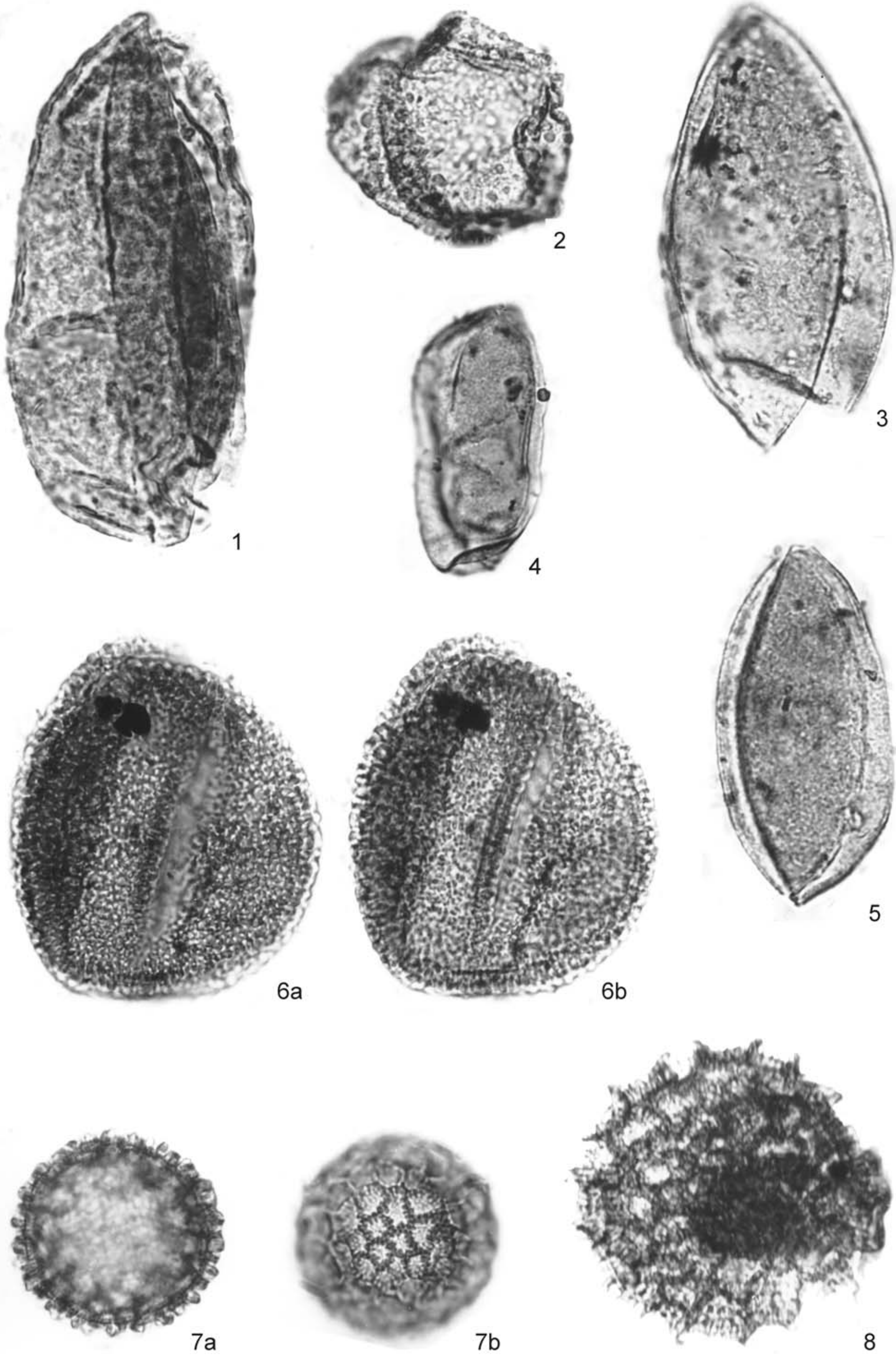
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Plate 11

× 1000

1a,b. (72) *Chenopodipollis stellatus* (Mamczar) Krutzsch; Legnica 33/56, 95.5 m

2. (77) *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło; Legnica 33/56, 108.0 m

3. (77) *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło; Legnica 33/56, 75.0 m

4. (76) *Eucommioipollis parmularius* (Potonié) Ziembińska-Tworzydło; Komorniki, 78.4 m

5a-c. (75) *Rumex* L. type; Komorniki, 78.6 m

6a,b. (79) *Periporopollenites stigmosus* (Potonié) Thomson & Pflug; Legnica 41/52, 120.5 m

7a-c. (78) *Periporopollenites orientaliformis* (Nagy) Kohlman-Adamska & Ziembińska-Tworzydło; Legnica 33/56, 104.0 m

8. (79) *Periporopollenites stigmosus* (Potonié) Thomson & Pflug; Legnica 33/56, 76.5 m

9a,b. (78) *Periporopollenites orientaliformis* (Nagy) Kohlan-Adamska & Ziembińska-Tworzydło; Legnica 33/56, 108.0 m

10. (83) *Castaneoideaepollis oviformis* (Potonié) Grabowska; Legnica 33/56, 106.5 m

11. (84) *Castaneoideaepollis pusillus* (Potonié) Grabowska; Legnica 33/56, 104.0 m

12a,b. (80) *Tricolporopollenites* sp. 1 – *Corylopsis* type sensu Oszast 1960; Legnica 33/56, 109.0 m

13. (81) *Tricolporopollenites indeterminatus* (Romanowicz) Ziembińska-Tworzydło; Legnica 33/56, 76.5 m

14. (82) *Tricolporopollenites staresedloensis* Krutzsch & Pacltová; Legnica 33/56, 94.9 m

15. (87) *Faguspollenites verus* Raatz; Legnica 33/56, 75.0 m

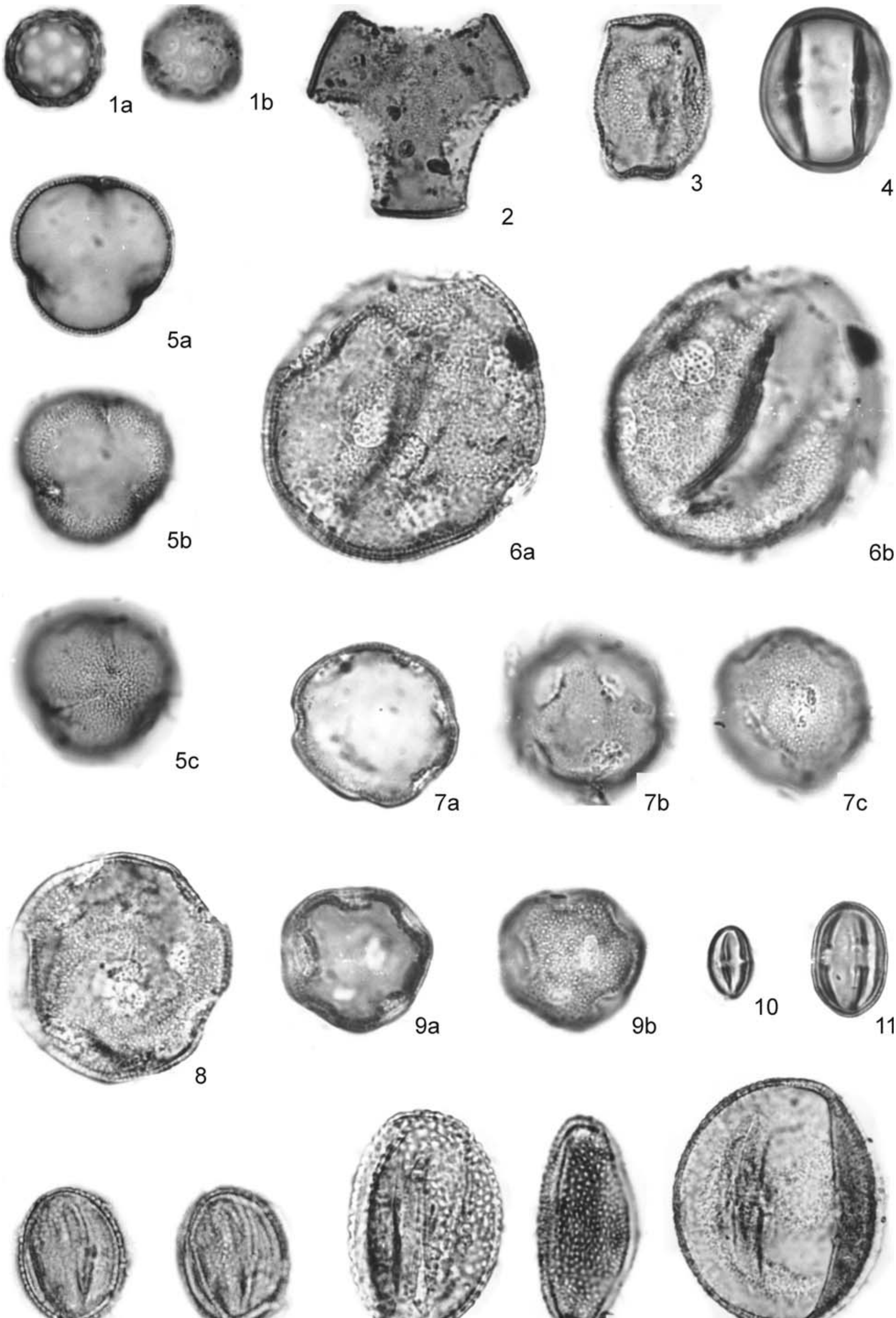
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Plate 12

× 1000

1a,b. (85) *Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug; Legnica 33/56, 106.5 m

2a,b. (85) *Tricolporopollenites pseudocingulum* (Potonié) Thomson & Pflug; Legnica 33/56, 108.5 m

3. (86) *Tricolporopollenites theacoides* (Roche & Schuler) Kohlman-Adamska & Ziembińska-Tworzydło; Legnica 33/56, 75.0 m

4a,b. (88) *Quercoidites asper* (Pflug & Thomson) Słodkowska; Komorniki, 78.2 m

5. (89) *Quercoidites granulatus* (Nagy) Słodkowska; Legnica 33/56, 75.0 m

6. (90) *Quercoidites henrici* (Potonié) Potonié, Thomson & Thiergart; Legnica 33/56, 107.0 m

7. (91) *Quercoidites microhenrici* (Potonié) Potonié, Thomson & Thiergart; Legnica 33/56, 75.0 m

8. (96) *Trivestibulopollenites betuloides* Pflug; Legnica 33/56, 106.5 m

9, 10. (92) *Alnipollenites verus* (Potonié) Potonié; Legnica 33/56, 76.5 m

11. (93) *Carpinipites carpinoides* (Pfug) Nagy; Komorniki, 78.2 m

12a,b. (93) *Carpinipites carpinoides* (Pfug) Nagy; Komorniki, 78.6 m

13. (95) *Triporopollenites coryloides* Pflug; Legnica 33/56, 75.0 m

14. (100) *Momipites punctatus* (Potonié) Nagy; Legnica 33/56, 104.0 m

15. (100) *Momipites punctatus* (Potonié) Nagy; Legnica 33/56, 106.5 m

16. (94) *Ostryoipollenites rhenanus* Thomson ex Potonié; Legnica 33/56, 101.0 m

17. (97) *Myricipites pseudorurensis* (Pfug) Grabowska & Ważyńska; Legnica 33/56, 101.0 m

18. (98) *Triatriopollenites rurensis* Pflug & Thomson; Legnica 33/56, 75.0 m

19. (98) *Triatriopollenites rurensis* Pflug & Thomson; Komorniki, 78.0 m

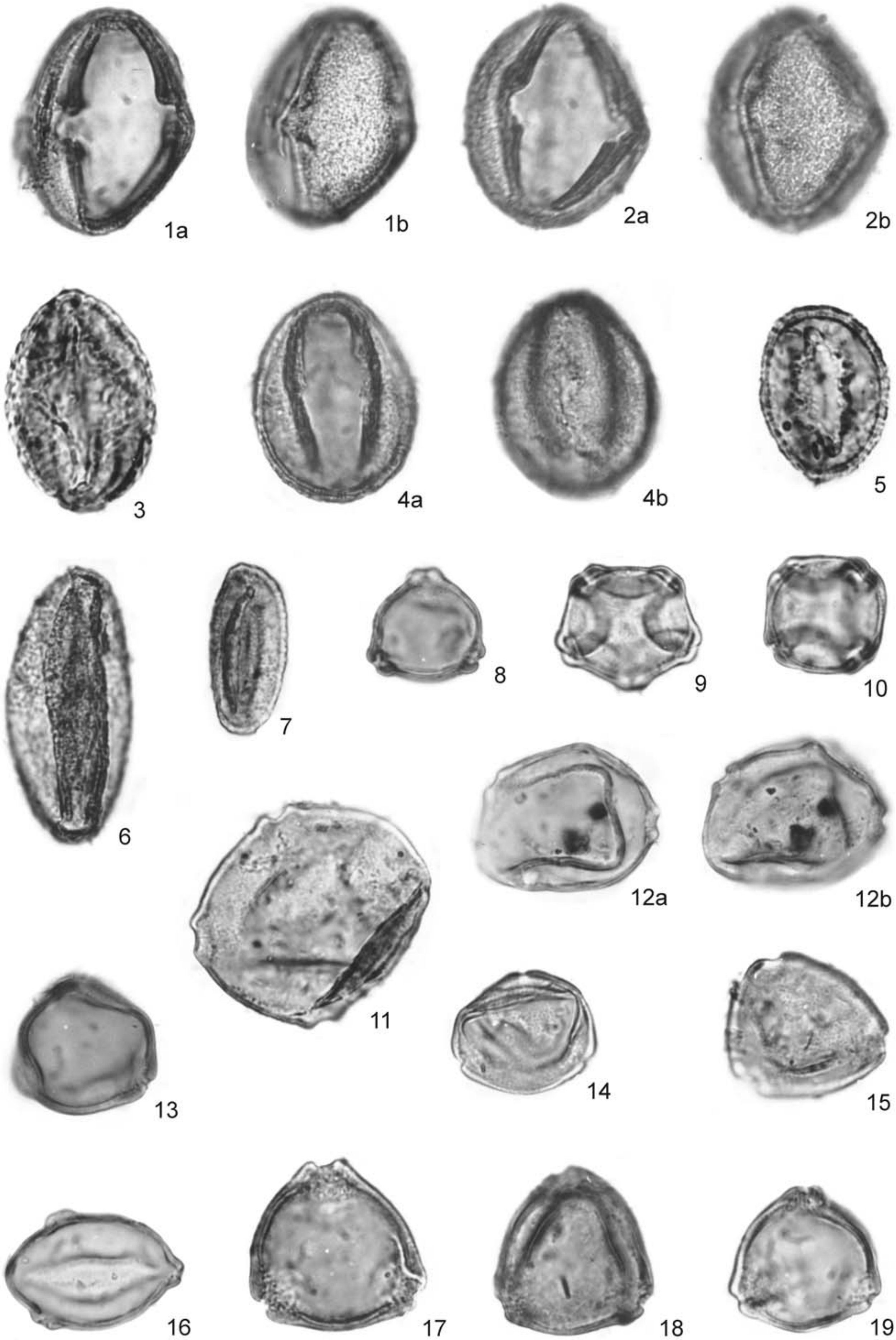
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Plate 13

× 1000

1. (99) *Caryapollenites simplex* (Potonié) Raatz ex Potonié; Legnica 33/56, 75.0 m
2. (104) *Polyatriopollenites stellatus* (Potonié) Pflug; Legnica 33/56, 76.5 m
3. (–) *Juglanspollenites* sp.; Komorniki, 77.8 m

4a,b. (102) *Juglanspollenites verus* Raatz; Komorniki, 77.2 m

5. (101) *Juglanspollenites sadowskae* Kohlman-Adamska & Ziembińska-Tworzydło; Komorniki, 78.6 m
6. (103) *Platycaryapollenites miocaenicus* Nagy; Legnica 33/56, 101.0 m
7. (103) *Platycaryapollenites miocaenicus* Nagy; Legnica 33/56, 110.5 m

8a,b. (105) *Symplocoipollenites latiporis* (Pflug & Thomson) Słodkowska; Legnica 33/56, 104.0 m

9a,b. (106) *Symplocoipollenites vestibulum* (Potonié) Potonié ex Potonié; Legnica 33/56, 75.0 m

10a,b. (107) *Ericipites callidus* (Potonié) Krutzsch; Legnica 33/56, 101.0 m

11. (108) *Ericipites ericius* (Potonié) Potonié; Legnica 33/56, 106.5 m
12. (109) *Ericipites hidasensis* Nagy; Legnica 33/56, 108.0 m

13a,b. (110) *Ericipites roboreus* (Potonié) Krutzsch; Legnica 33/56, 107.5 m

14. (111) *Tricolporopollenites exactus* (Potonié) Grabowska; Legnica 33/56, 106.5 m
15. (113) *Tricolporopollenites bruhlensis* (Thomson) Grabowska; Legnica 33/56, 101.0 m

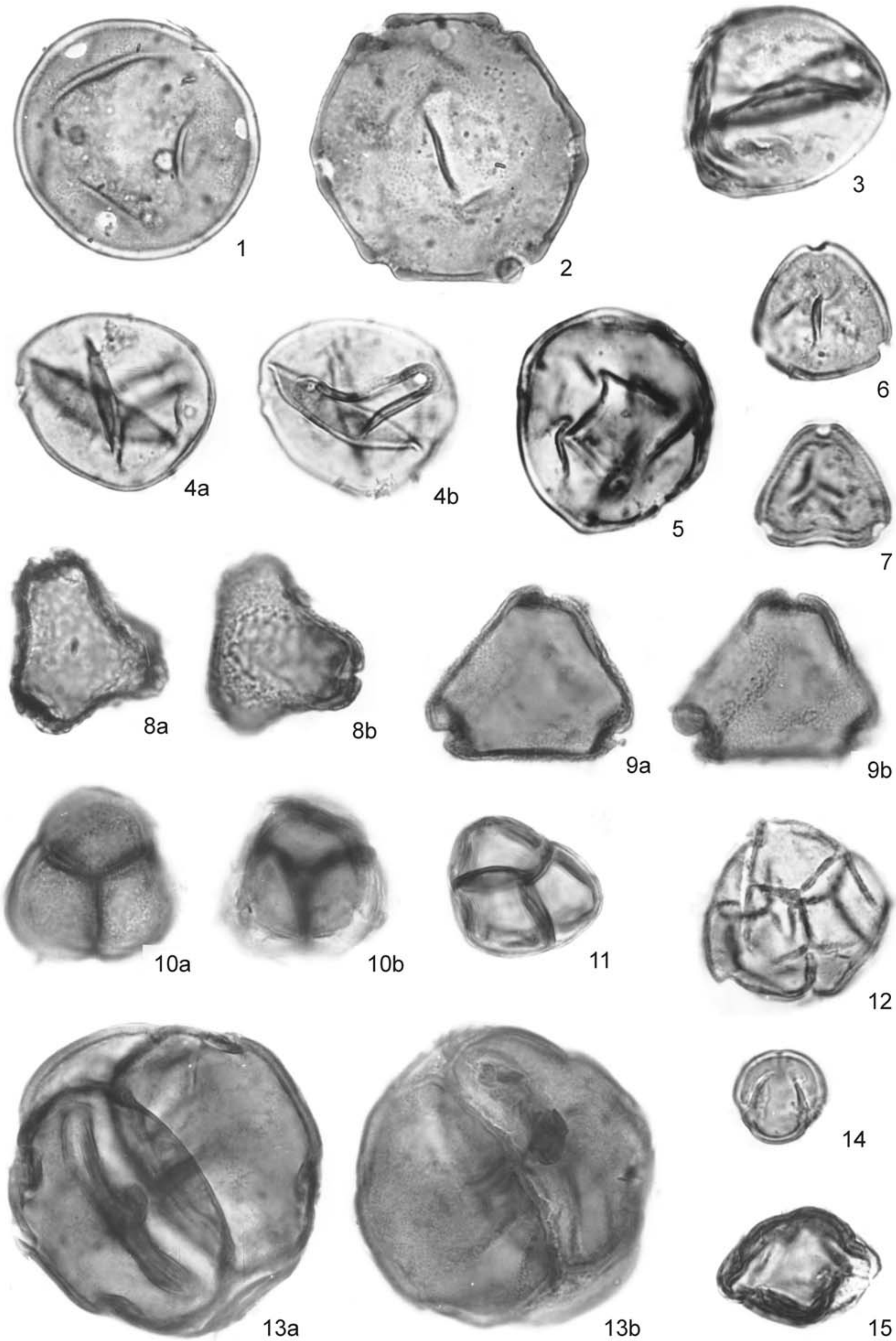
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Plate 14

× 1000

1.	(112) *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug; Legnica 33/56, 106.5 m
2a,b.	(114) *Tetracolporopollenites andreanus* Bruch; Komorniki, 77.2 m
3.	(115) *Tetracolporopollenites rotundus* (Nagy) Bruch; Legnica 33/56, 106.5 m
4a,b.	(116) *Salixipollenites capreaformis* Planderová; Legnica 33/56, 76.5 m
5a,b.	(117) *Salixipollenites cinereaformis* Planderová; Legnica 33/56, 108.0 m
6a,b.	(118) *Salixipollenites helveticus* Nagy; Legnica 33/56, 104.0 m
7.	(–) *Salixipollenites* sp. 1; Legnica 33/56, 75.0 m
8a,b.	(121) *Intratriporopollenites cordataeformis* (Wolff) Mai; Legnica 33/56, 76.5 m
9a,b.	(119) *Intratriporopollenites instructus* (Potonié) Thomson & Pflug; Legnica 33/56, 99.0 m
10, 11.	(120) *Intratriporopollenites insculptus* Mai; Legnica 33/56, 112.0 m
12a,b.	(123) *Tricolporopollenites* sp. 2 – Sterculioideae, Rutaceae type; Legnica 33/56, 104.0 m
13.	(122) *Reevesiapollis triangulus* (Mamczar) Krutzsch; Legnica 33/56, 75.0 m
14, 15.	(128) *Triporopollenites urticiodes* Nagy; Komorniki, 77.6 m
16a,b.	(131) *Iteapollis angustiporatus* (Schneider) Ziembińska-Tworzydło; Komorniki, 78.0 m
17.	(125) *Celtipollenites komloensis* Nagy; Legnica 33/56, 76.5 m
18.	(124) *Celtipollenites bobrowskae* Kohlman-Adamska & Ziembińska-Tworzydło; Legnica 33/56, 75.5 m
19.	(126) *Ulmipollenites maculosus* Nagy; Legnica 33/56, 76.5 m
20.	(127) *Zelkovaepollenites potoniei* Nagy; Legnica 33/56, 75.0 m

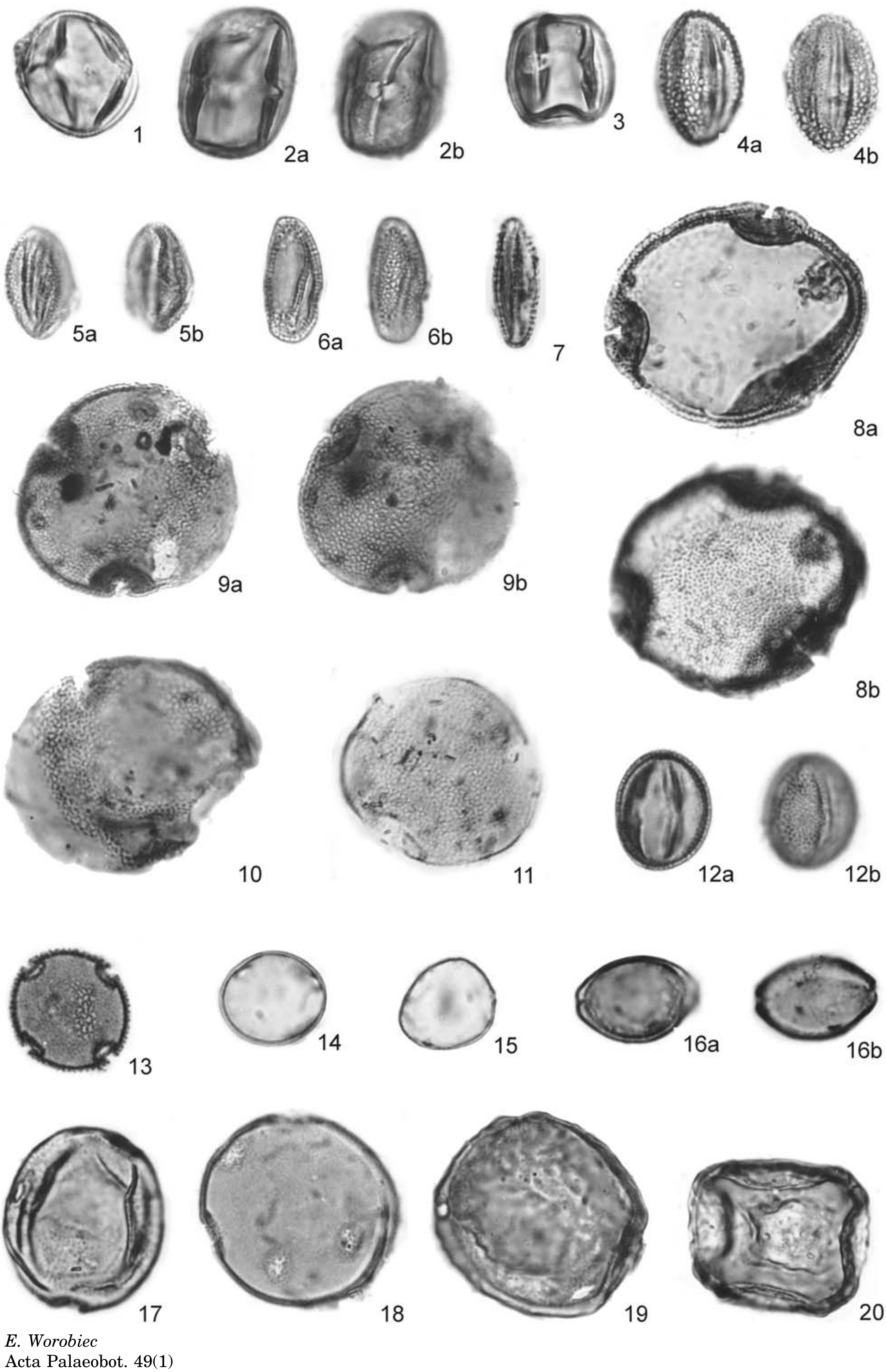
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Plate 15

× 1000

1a,b. (129) *Tricolporopollenites photinioides* Skawińska; Legnica 33/56, 75.0 m
2a,b. (130) *Tricolporopollenites* sp. 3 – Rosaceae type; Komorniki, 78.4 m
3. (135) *Corsinipollenites oculusnoctis* (Thiergart) Nakoman; Komorniki, 78.6 m
4. (134) *Sporotrapoidites erdtmani* (Nagy) Nagy; Legnica 33/56, 101.5 m
5. (132) *Lythraceaepollenites bavaricus* Thiele-Pfeiffer; Legnica 33/56, 77.0 m
6. (133) *Lythraceaepollenites decodonensis* Stuchlik; Komorniki, 78.4 m
7. (136) *Tricolporopollenites fallax* (Potonié) Krutzsch; Legnica 33/56, 104.0 m
8. (137) *Tricolporopollenites liblarensis* (Thomson) Grabowska; Legnica 33/56, 104.5 m
9. (138) *Tricolporopollenites quisqualis* (Potonié) Krutzsch; Legnica 33/56, 104.5 m
10, 11. (139) *Tricolporopollenites* sp. 4 – *Cassia* L. type; Legnica 33/56, 75.0 m
12a,b. (140) *Tricolporopollenites* sp. 5 – *Staphylea* L. type; Legnica 33/56, 75.0 m
13. (143) ?Rutaceae type; Legnica 33/56, 105.5 m
14a,b. (141) *Aceripollenites microrugulatus* Thiele-Pfeiffer; Komorniki, 78.6 m
15a-c. (142) *Aceripollenites* sp. 1; Komorniki, 78.6 m
16. (144) *Meliapollis* sp.; Legnica 33/56, 108.5 m
17a-c. (145) *Rhuspollenites ornatus* Thiele-Pfeiffer; Legnica 33/56, 110.5 m
18a,b. (147) *Ilexpollenites margaritatus* (Potonié) Raatz ex Potonié; Legnica 33/56, 76.5 m
19. (148) *Ilexpollenites propinquus* (Potonié) Potonié; Legnica 33/56, 75.0 m

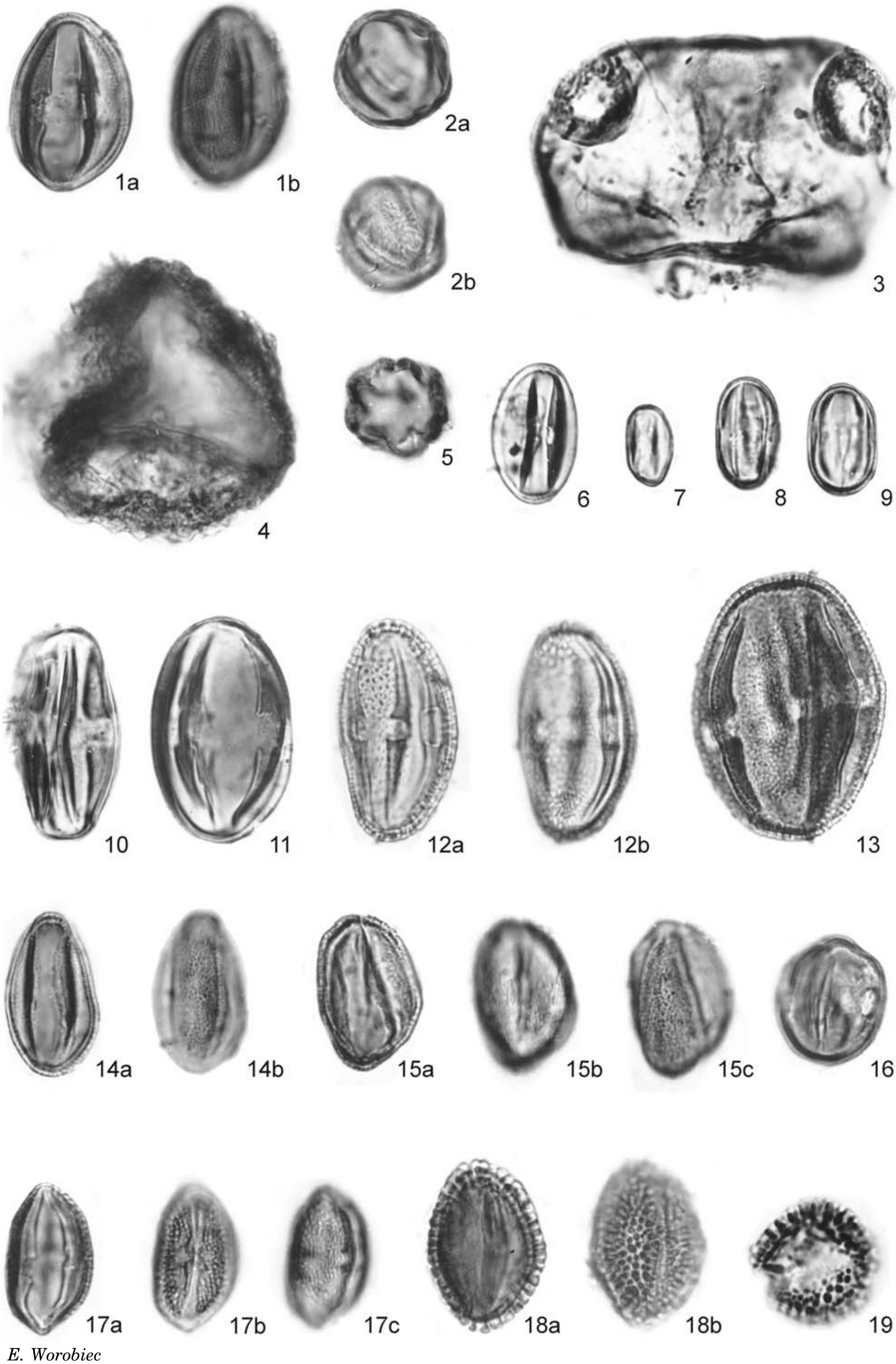
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Plate 16

× 1000

1. (146) *Ilexpollenites iliacus* (Potonié) Thiergart f. *major*; Thomson & Pflug; Legnica 33/56, 101.0 m
2. (146) *Ilexpollenites iliacus* (Potonié) Thiergart f. *medius* Thomson & Pflug; Legnica 33/56, 105.0 m

3a,b. (149) *Spinulaepollis arceuthobioides* Krutzsch; Legnica 33/56, 103.5 m

4a,b. (150) *Tricolporopollenites marcodurensis* Pflug & Thomson; Legnica 33/56, 75.0 m

5. (151) *Vitispollenites tener* Thiele-Pfeiffer; Legnica 33/56, 104.0 m
6. (152) *Nyssapollenites analepticus* (Potonié) Planderová; Komorniki, 78.2 m

7a,b. (154) *Nyssapollenites pseudocruciatus* (Potonié) Thiergart; Legnica 33/56, 76.5 m

8. (154) *Nyssapollenites pseudocruciatus* (Potonié) Thiergart; Legnica 33/56, 75.0 m

9a,b. (157) *Cornaceaepollis satzveyensis* (Pflug) Ziembińska-Tworzydło; Legnica 33/56, 109.5 m

10a,b. (153) *Nyssapollenites rodderensis* (Thiergart) Kedves; Legnica 33/56, 76.5 m

11a,b. (156) *Cornaceaepollis minor* (Stuchlik) Stuchlik; Legnica 33/56, 104.0 m

12a,b. (159) *Araliaceoipollenites euphorii* (Potonié) Potonié ex Potonié; Legnica 33/56, 101.5 m

13a,b. (155) *Cornaceaepollis major* (Stuchlik) Stuchlik; Legnica 33/56, 101.0 m

14a,b. (160) *Araliaceoipollenites reticuloides* Thiele-Pfeiffer; Legnica 33/56, 75.0 m

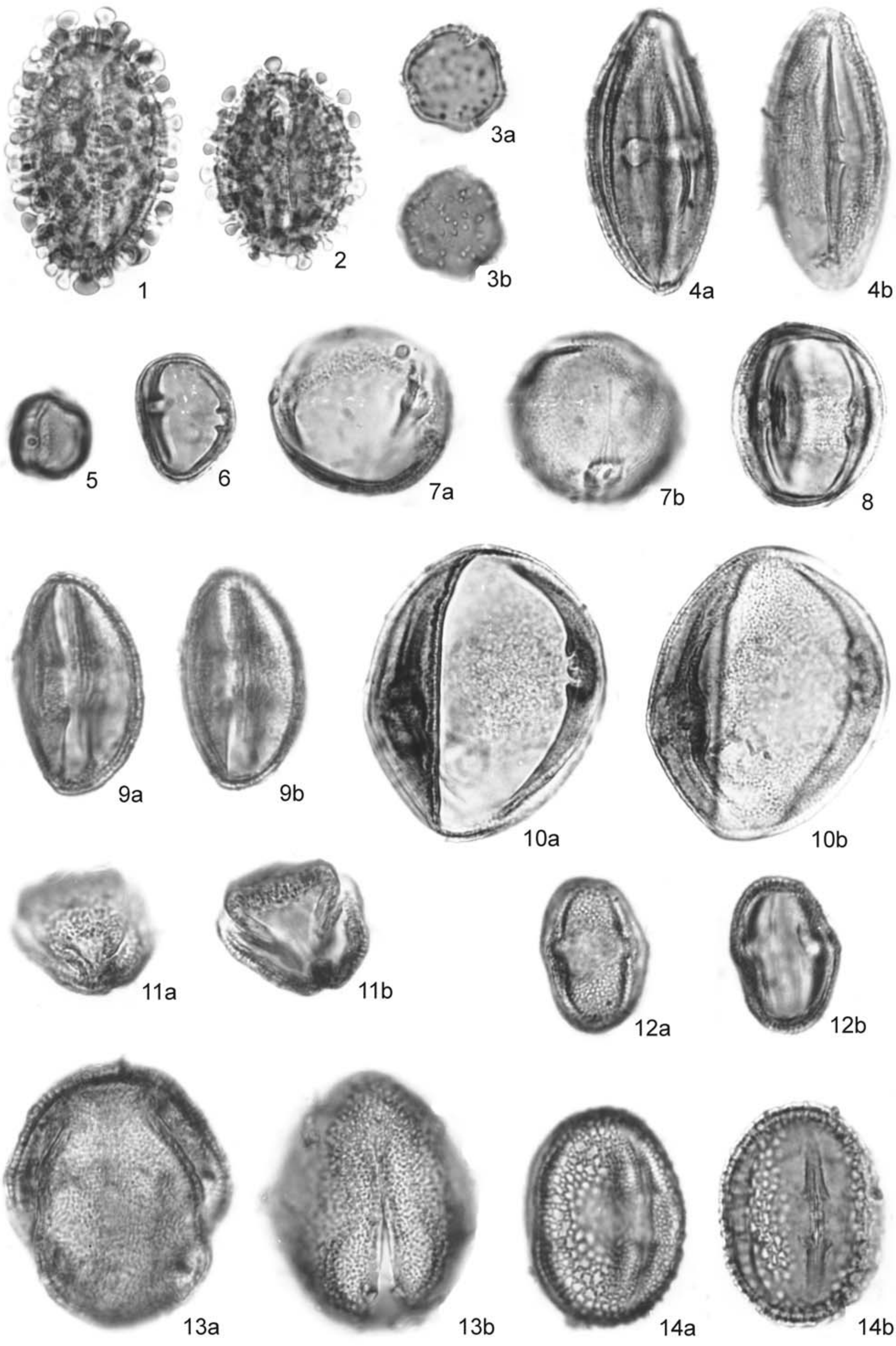
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Plate 17

× 1000

1a,b. (158) *Araliaceoipollenites edmundi* (Potonié) Potonié ex Potonié; Legnica 33/56, 75.0 m
2a,b. (162) *Tricolporopollenites* sp. 7 – Araliaceae, Rhamnaceae type; Legnica 33/56, 109.5 m
3a,b. (161) *Tricolporopollenites* sp. 6 – Araliaceae, Cornaceae type; Legnica 33/56, 75.0 m
4a-c. (163) *Umbelliferoipollenites speciosus* Nagy; Legnica 33/56, 111.5 m
5a,b. (164) *Umbelliferoipollenites tenuis* Nagy; Legnica 33/56, 110.5 m
6. (165) *Diervillapollenites* sp.; Legnica 33/56, 101.0 m
7. (165) *Diervillapollenites* sp.; Legnica 33/56, 75.0 m
8. (166) *Lonicerapollis* sp.; Legnica 33/56, 105.5 m
9a,b. (167) *Caprifoliipites viburnoides* (Gruas-Cavagnetto) Kohlman-Adamska; Legnica 33/56, 108.5 m
10a,b. (168) *Caprifoliipites* sp. 1; Legnica 33/56, 75.0 m
11a,b. (169) *Theligonumpollenites baculatus* (Stachurska, Sadowska & Dyjor) Thiele-Pfeiffer; Komorniki, 78.6 m
12. (170) Rubiaceae type; Komorniki, 78.2 m
13. (172) *Tricolporopollenites sinuosimuratus* Trevisan; Legnica 33/56, 103.0 m
14. (172) *Tricolporopollenites sinuosimuratus* Trevisan; Legnica 33/56, 75.0 m
15a,b. (171) *Tricolporopollenites retimuratus* Trevisan; Legnica 33/56, 101.0 m
16a,b. (171) *Tricolporopollenites retimuratus* Trevisan Legnica 33/56, 108.5 m

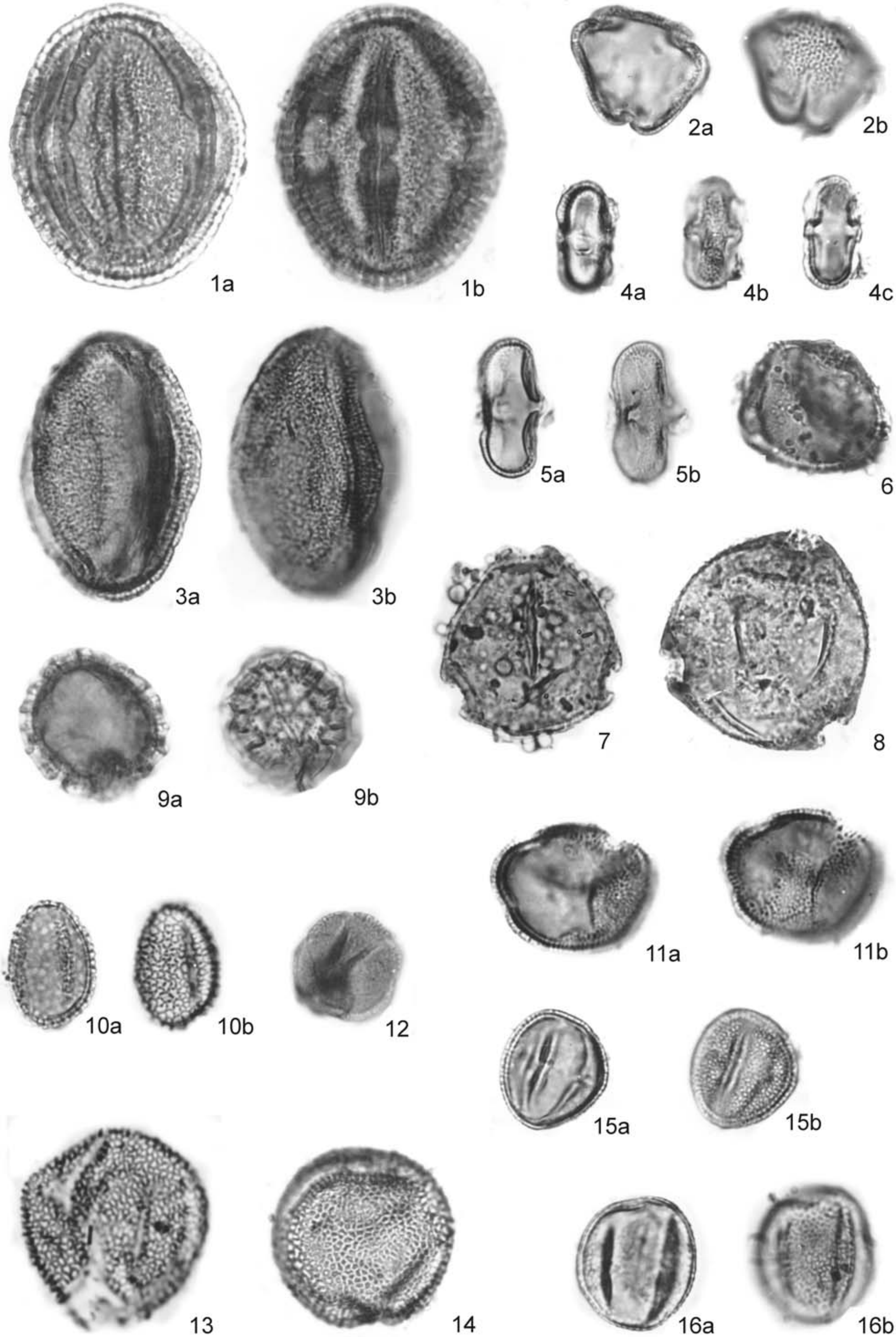
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Plate 18

× 1000

1.	(174) *Plantaginaceaerumpollis miocaenicus* Nagy; Legnica 33/56, 75.5 m
2a,b.	(174) *Plantaginaceaerumpollis miocaenicus* Nagy; Komorniki, 77.8 m
3a,b.	(176) *Tubulifloridites anthemidearum* Nagy; Legnica 33/56, 77.0 m
4.	(175) Lamiaceae type; Komorniki, 78.2 m
5.	(181) *Potamogetonacidites paluster* (Manten) Mohr; Legnica 33/56, 91.5 m
6a,b.	(177) *Tubulifloridites granulosus* Nagy; Legnica 33/56, 91.5 m
7a,b.	(178) *Atremisiaepollenites sellularis* Nagy; Legnica 33/56, 112.0 m
8.	(179) *Butomuspollenites butomoides* (Krutzsch) Ziembińska-Tworzydło; Legnica 33/56, 104.0 m
9a,b.	(179) *Butomuspollenites butomoides* (Krutzsch) Ziembińska-Tworzydło; Legnica 41/52, 90.5 m
10a,b.	(180) *Butomuspollenites longicolpatus* (Krutzsch) Ziembińska-Tworzydło; Legnica 33/56, 75.0 m
11, 12.	(184) *Cyperaceaepollis piriformis* Thiele-Pfeiffer; Legnica 33/56, 95.5 m
13.	(183) *Cyperaceaepollis neogenicus* Krutzsch; Legnica 33/56, 95.5 m
14.	(173) *Tricolporopollenites* cf. *retiformis* (Pflug & Thomson) Krutzsch; Legnica 33/56, 110.5 m
15.	(186) *Graminidites crassiglobosus* (Trevisan) Krutzsch; Legnica 33/56, 94.9 m
16.	(187) *Graminidites laevigatus* Krutzsch; Legnica 33/56, 76.0 m
17a,b.	(188) *Graminidites neogenicus* Krutzsch; Komorniki, 77.4 m

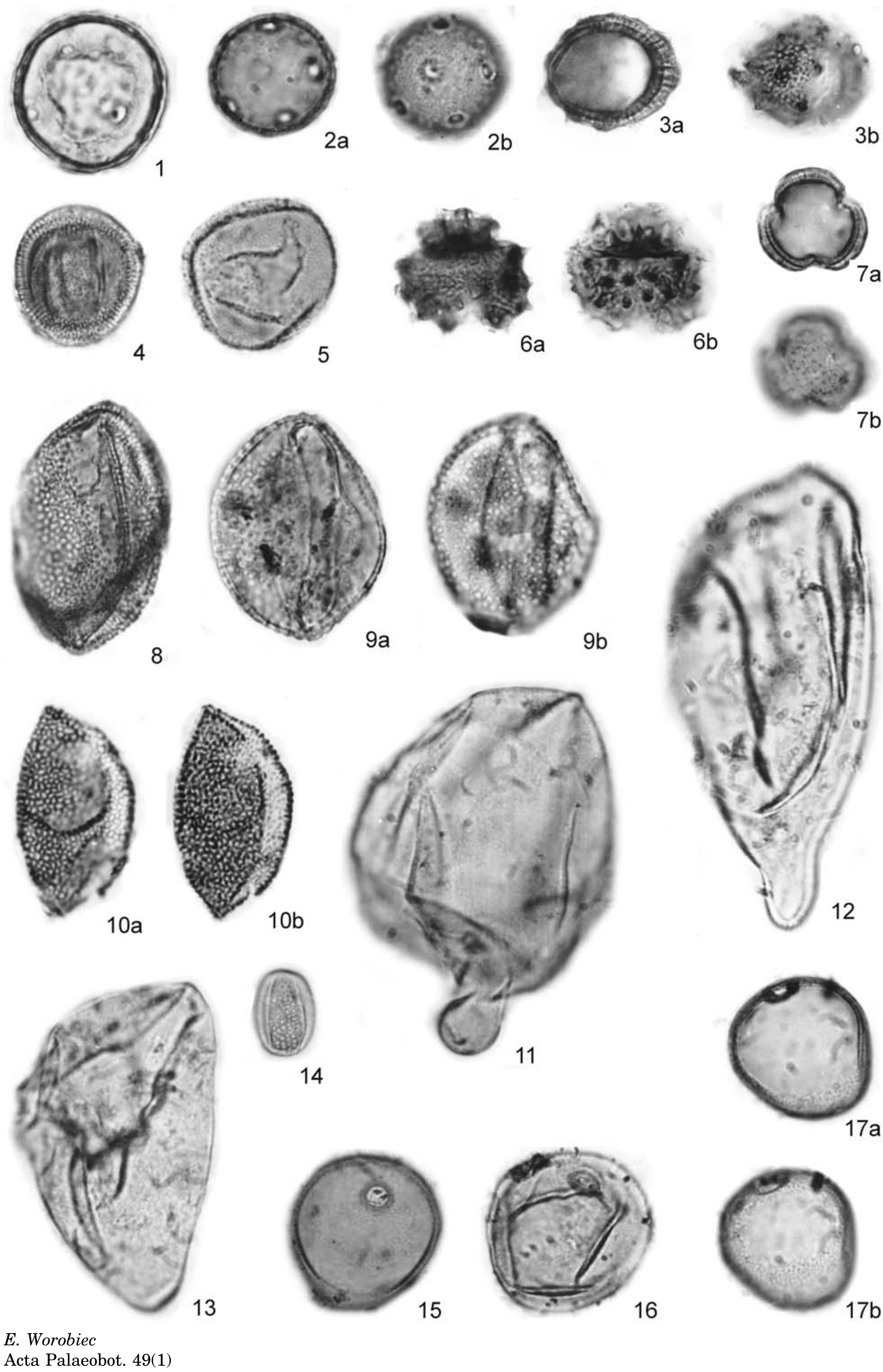
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Plate 19

× 1000

1–3. (185) *Graminidites bambusoides* Stuchlik; Legnica 33/56, 99.0 m

4. *Secale cereale* L. (rec.); [palynological reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, PAS in Kraków]

5. *Triticum vulgare* Host. (rec.); [palynological reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, PAS in Kraków]

6. *Arundinaria* sp. (rec.); [palynological reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, PAS in Kraków]

7. (189) *Graminidites pseudogramineus* Krutzsch; Legnica 33/56, 91.5 m

8. (190) *Graminidites subtiliglobosus* (Trevisan) Krutzsch; Legnica 33/56, 76.0 m

9. (–) *Graminidites* sp. 1; Legnica 33/56, 76.0 m

10, 11a,b. (192) *Arecipites pseudoconvexus* Krutzsch; Legnica 33/56, 75.0 m

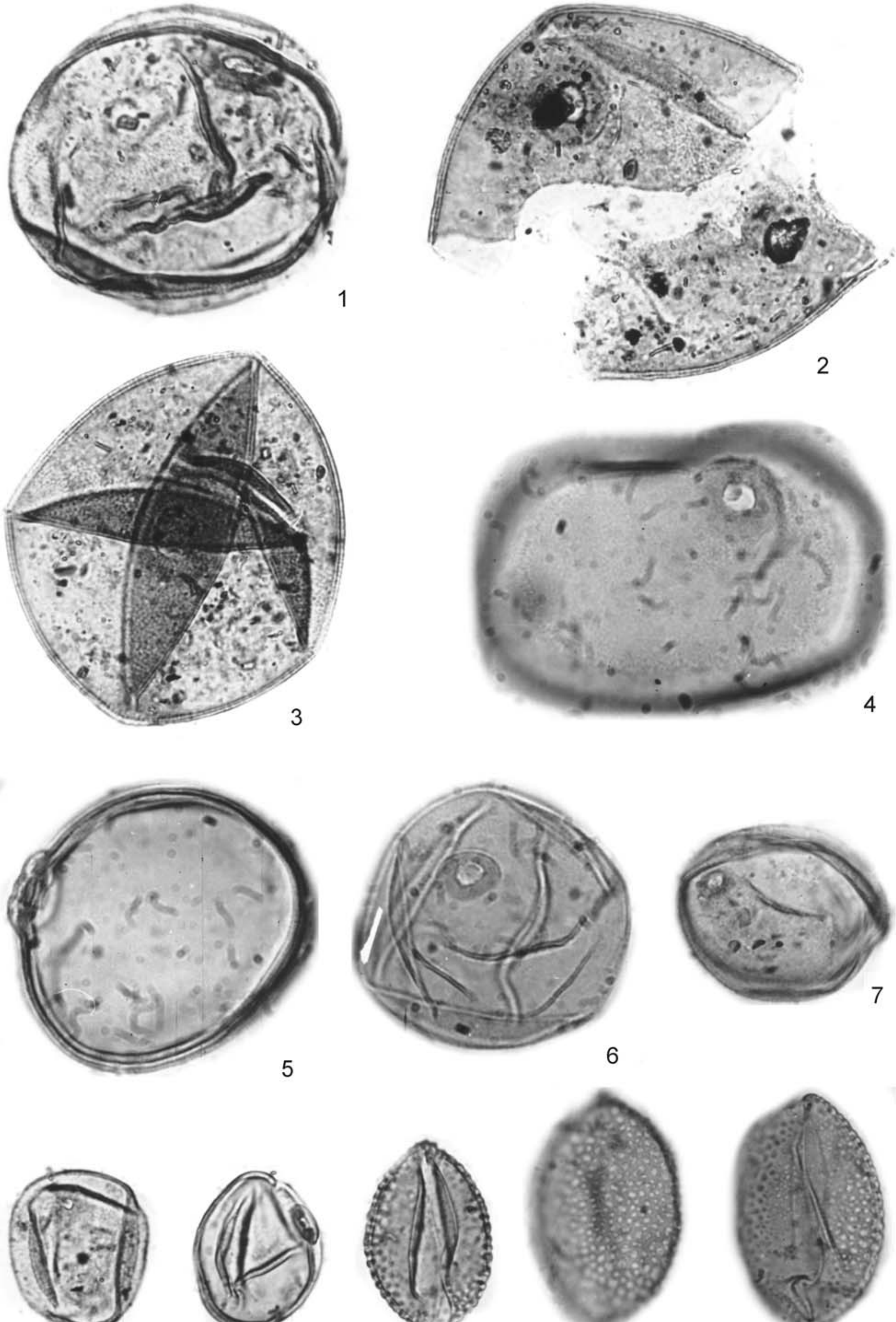
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Plate 20

× 1000

1a,b. (193) *Arecipites papillosus* (Mürriger & Pflug) Krutzsch; Legnica 33/56, 107.0 m
2a,b. (191) *Sparganiaceaepollenites magnoides* Krutzsch; Legnica 41/52, 120.5 m
3a,b. (194) *Sigmopollis pseudosetarius* (Weyland & Pflug) Krutzsch & Pacltová; Komorniki, 77.4 m
4. (195) *Sigmopollis punctatus* Krutzsch & Pacltová; Komorniki, 77.4 m
5a,b. (182) ?Araceae type, tetrad; Komorniki, 78.2 m
6. (182) ?Araceae type; Komorniki, 78.2 m
7a,b. (–) *Homotryblium* sp.; Legnica 33/56, 97.6 m
8a,b. (–) *Homotryblium* sp.; Legnica 33/56, 97.6 m

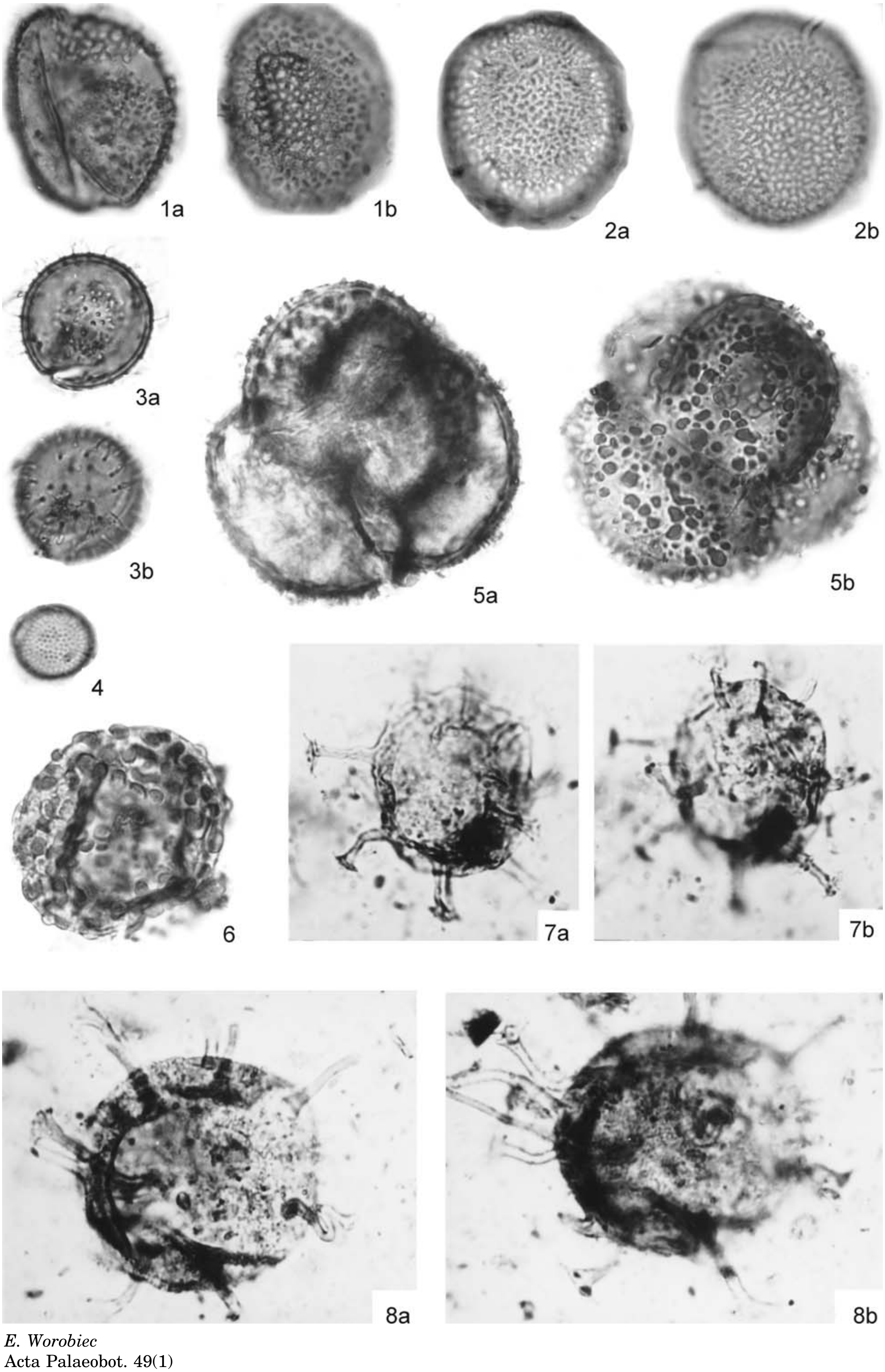
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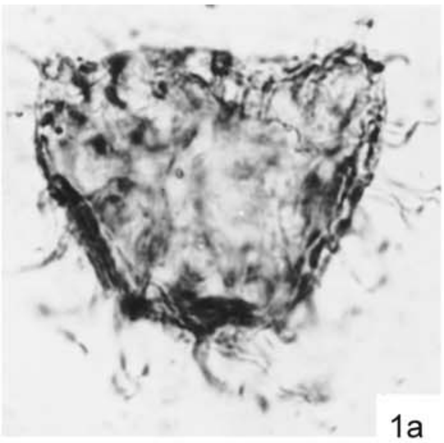
Plate 21

× 1000

1a,b. (–) *Systematophora* sp.; Legnica 33/56, 97.6 m
2. (–) ?*Impagidinium* sp.; Legnica 33/56, 97.6 m
3. (–) *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich; Legnica 33/56, 97.6 m
4. (198) *Tetraporina* sp.; Legnica 33/56, 101.0 m
5. (199) *Circulisporites circulus* (Wolff) Krutzsch & Pacltová; Legnica 33/56, 97.6 m
6a,b. (197) *Ovoidites ligneolus* Potonié ex Krutzsch; Legnica 33/56, 110.5 m; × 1000
7. (196) *Ovoidites elongatus* (Hunger) Krutzsch; Komorniki, 77.8 m; × 1000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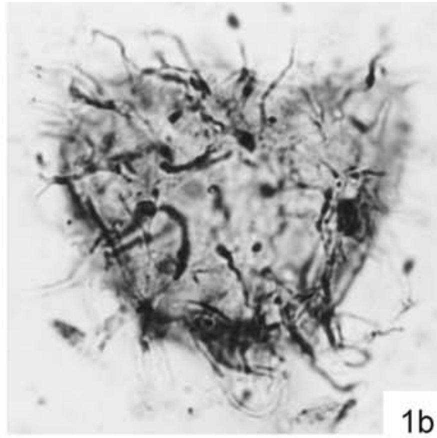
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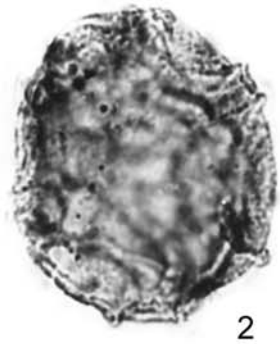
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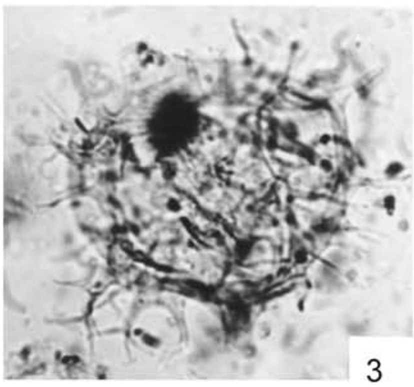
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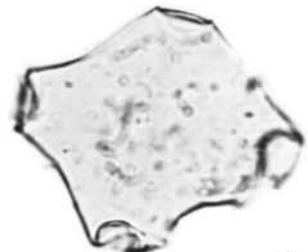
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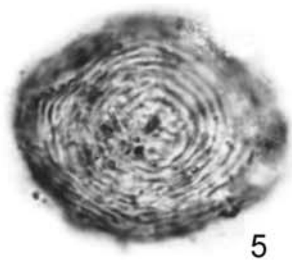
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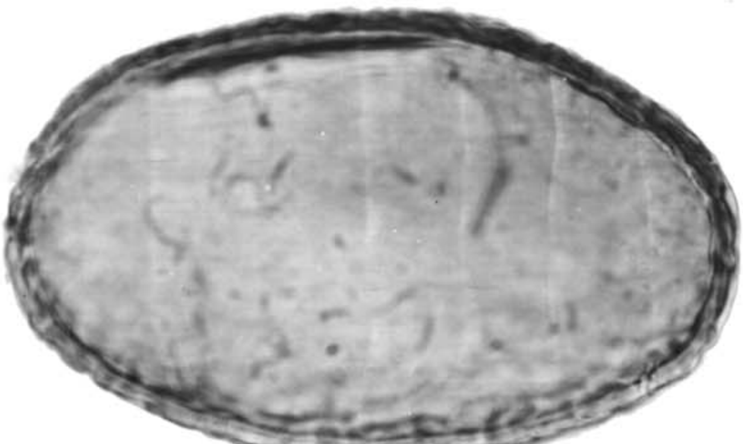
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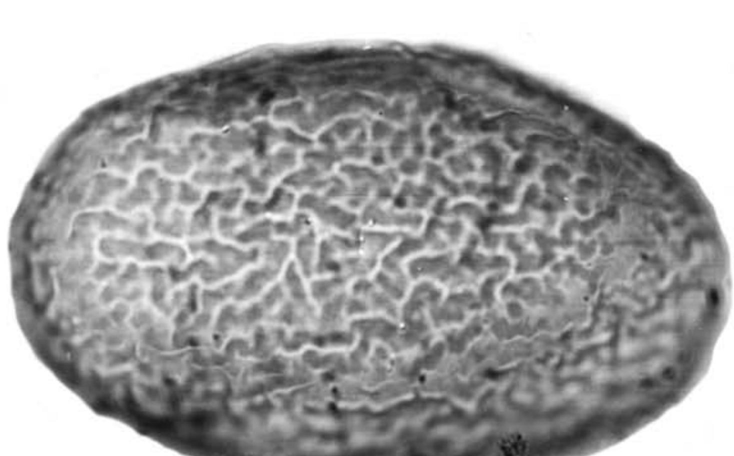
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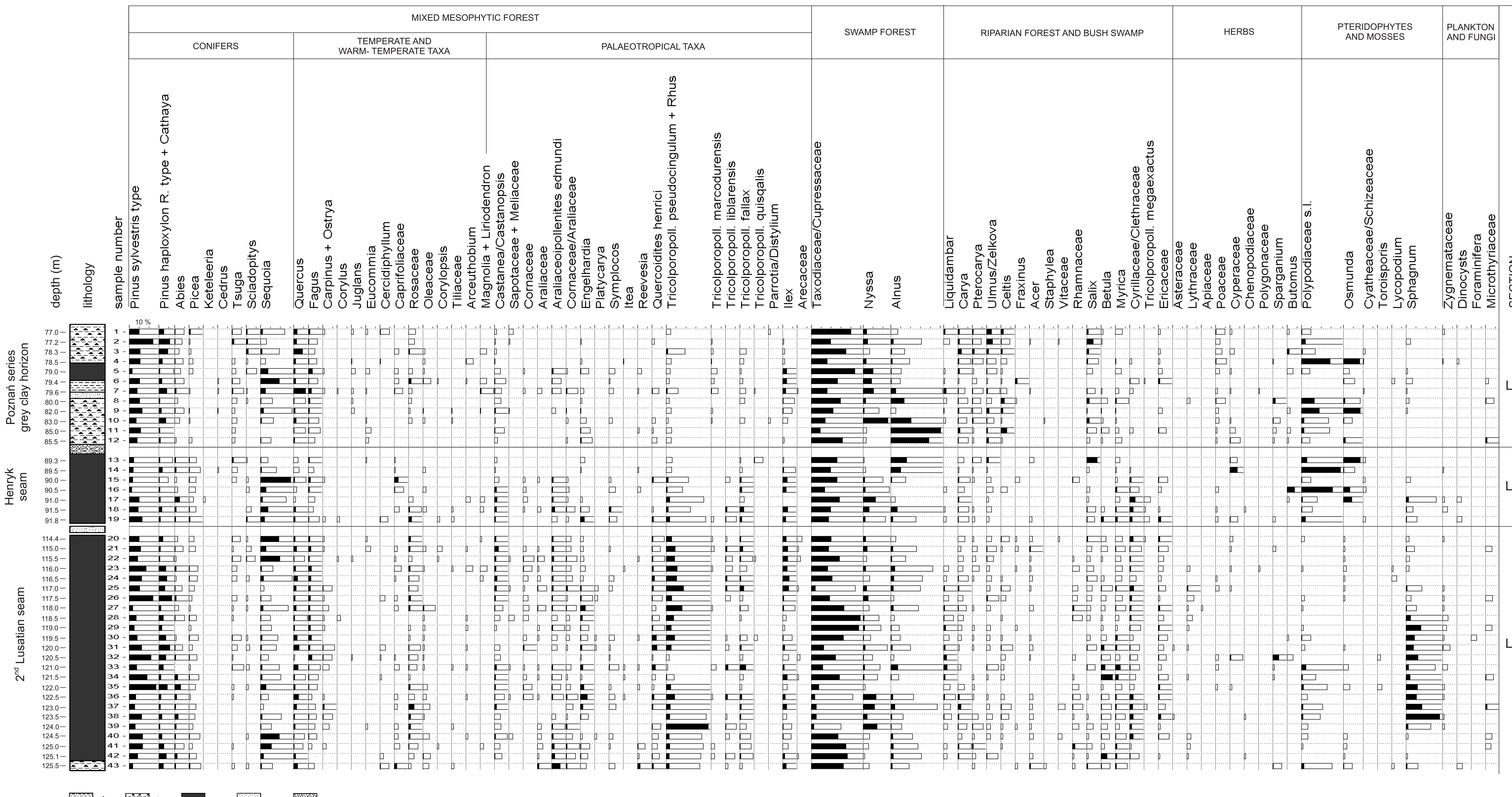

Fig. 3. Legnica 41/52. Percentage pollen diagram of selected taxa. **1** – clay, **2** – coaly clay, **3** – brown coal, **4** – sand, **5** – calcium carbonate concretions

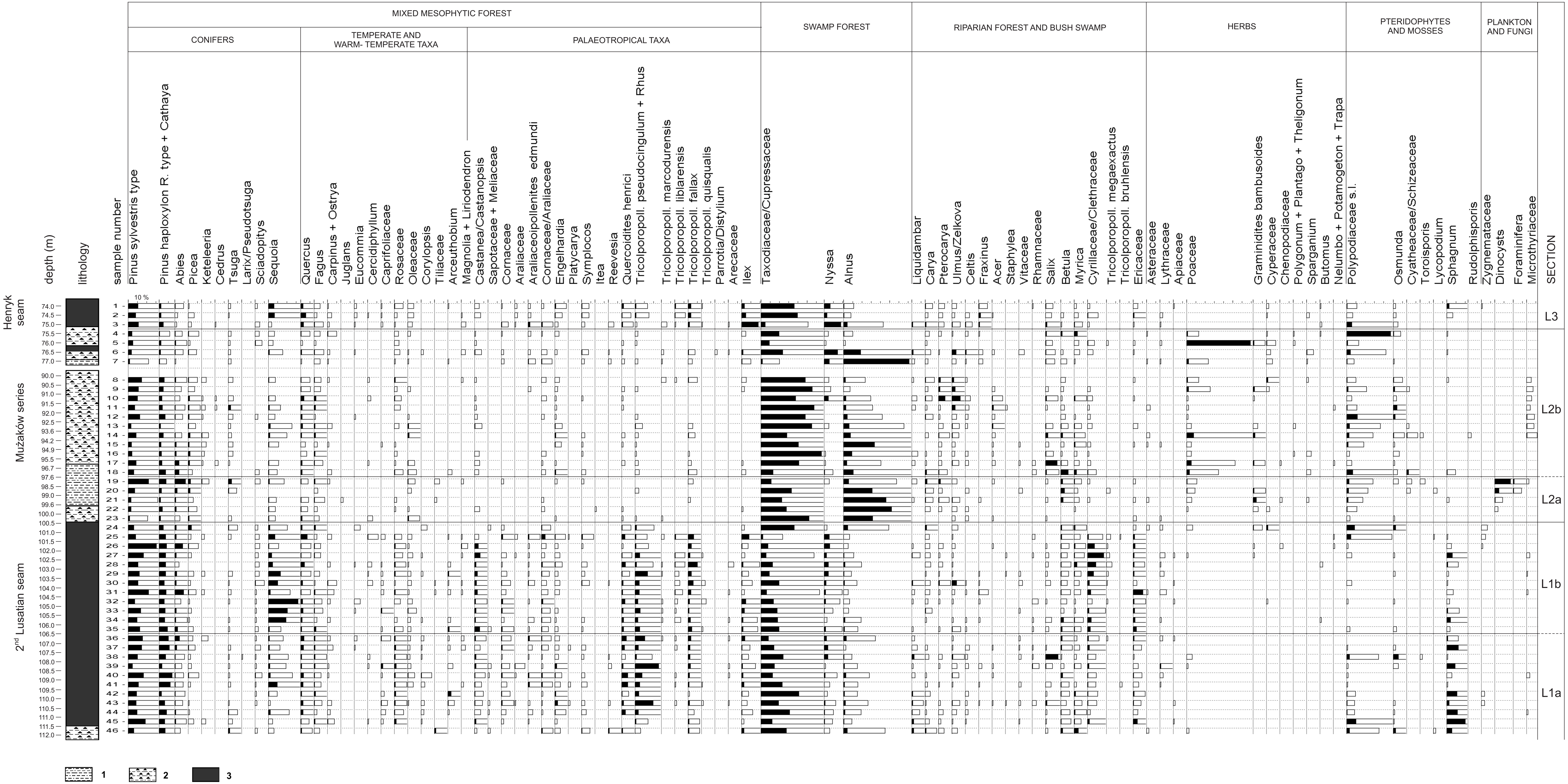

Fig. 4. Legnica 33/56. Percentage pollen diagram of selected taxa. **1** – clay, **2** – coaly clay, **3** – brown coal