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# Pollen analysis of the Middle Miocene profile from Legnica, southwestern Poland

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ABSTRACT. Palynological analysis of 26 samples of the Miocene deposits from Legnica site (east field, 47/62 profile) has been presented. The samples consisted of material from the II Lusatian brown coal seam, the Mużaków series and the I Henryk brown coal seam. During the studies the presence of 97 taxa including 27 palaeotropical taxa was evidenced. The results have been used for the reconstruction of changes in the local vegetation during the sedimentation time of deposits under study. The following types of fossil plant communities have been distinguished: swamp forest, bush swamp, riparian forest and mixed mesophytic forest. The clear and constant predominance of swamp forest pollen taxa in the total sum implies the dominant role of this type of communities in the formation of brown coal deposits. The age of the flora has been defined as the Badenian.

KEY WORDS: pollen analysis, brown coal, plant communities, Badenian, Lower Silesia, Poland

## INTRODUCTION

The Tertiary formations from SW Poland have been the subject of many geological and palaeobotanical investigations which include several important palynological studies. The detailed information about geology and the Neogene floras of this region have been presented in many publications (Stachurska et al. 1967, 1971, 1973, Sadowska 1970, 1977, 1993, 1995, Dyjor 1970, Dyjor & Sadowska 1977, 1984, Sadowska & Zastawniak 1978, Jahn et al. 1984). The first geological studies in the Bolesławiec-Legnica-Ścinawa region were carried out by Berg (1936), whereas palynological research in the Bolesławiec and Zebrzydowa region was started by Romanowicz (1961). Palynological studies in the Ścinawa brown coal bed were carried out by Ziembińska (1964), Ziembińska and Niklewski (1966) and Ziembińska-Tworzydło (1974).

Eighteen palynological profiles from Legnica site have been studied in the sixties and seventies of last century (Raniecka-Bobrowska & Grabowska 1963, Sadowska et al. 1976, 1981, Sadowska 1977, Grabowska & Słodkowska 1993). The profile Legnica 47/62 has been preliminary analysed by Sadowska et al. (1981), and Neogene sedimentary series as well as brown coal seams were distinguished then. The results of our palynological investigations at Legnica are partly comparable with profiles investigated earlier, but the aim of our study was the reconstructions of fossil plant communities and main features of palaeoclimate during the sedimentation time of studied deposits. In addition in our profile the sampling resolution was smaller, a greater amount of samples was taken and the number of counted sporomorphs was higher, so it was possible to make a general comparison of the regional changes of vegetation.

## GEOLOGY

The Neogene deposits of the Legnica brown coal bed complex are mainly of continental origin and they are composed of replicated complexes of clays, sands, gravels and lignites. For example the following Neogene lithostratigraphic units have been distinguished in this region (Dyjor 1978, 1986): the Żary series with the III Ścinawa brown coal seam, the Silesian-Lusatian series with the II Lusatian seam, the Mużaków series ended by the I Henryk seam, the Poznań series (divided into grey, green and flamy clays horizons), and the Gozdnica series. These lithostratigraphic units are still being used for Legnica region, even though according to the lithostratigraphic scheme of the Polish Lowland (Piwocki & Ziembińska-Tworzydło 1995, 1997) new unformal units (formations and members) have been distinguished.

The studied core (borehole 47/62) was taken from Legnica east field (Fig. 1). In these investigations some selected samples from the 158 m core representing entire sequence of deposits from the Middle Miocene until the present time have been collected.

Bottom section of the core consists of a 23 m thick kaolinic clay which is covered with the Silesian-Lusatian series comprising coal horizon (formed in turn by coaly clay and brown coal). The 18 m thick II Lusatian brown coal seam terminates the sedimentation period of Silesian-Lusatian series forming the major part of the Legnica and Ścinawa coal deposits. These are the main parts of the fuel resources of the Legnica and Ścinawa brown coal beds due to their wide-spread occurrence and thickness (Dyjor & Wróbel 1978). In the new lithostratigraphic scheme of the Polish Lowland (Piwocki & Ziembińska-Tworzydło 1995, 1997) these sediments are included into the Ścinawa and Krajenka Formations with the II Lusatian group of seams.

The 45 m thick complex of Mużaków series deposits is the next part of the profile. It is formed by sandy silts, sands, silts and grey sandy clays intercalated by grey clay horizons. No concomitant brown coal horizon has been found. The 1.2 m thick I Henryk brown coal seam ends the sedimentation cycle of this series. The Henryk seam is not divided into two horizons (by coaly clay) like in the other profile from the Legnica area worked out by Sadowska (1977). In the new lithostratigraphic scheme these sediments are included into the Pawłowice and Adamów Formations and in the I Middle Polish group of seams.

The next 49 m thick complex is composed of clay of the Poznań series (the Poznań Formation). In the analysed profile the grey clays horizon at the bottom of the Poznań series is absent. The similar geological situation was observed at Kędzierzyn-Paczków-Wrocław vicinities and it is connected with the extension

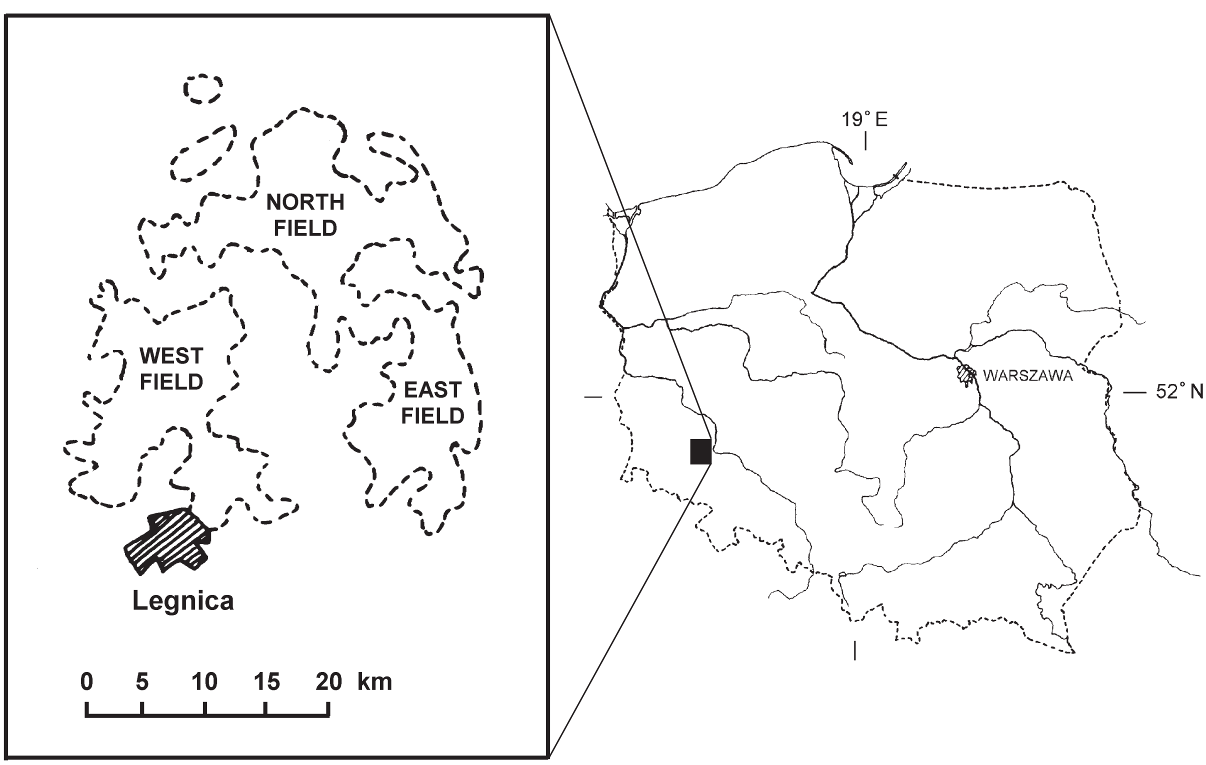


**Fig. 1**. Location of the Legnica brown coal deposit complex (according to Jaroń et al. 1978)

of the Poznań basin towards the S-E (Dyjor & Sadowska 1984). Grey clays developing in flooded swamp environments occur in the other profiles from Legnica (Sadowska 1977, Sadowska et al. 1981, Worobiec 1999, 2000), confirming additionally a topographical differentiation of this area. The Tertiary sedimentation is ended by the 16 m thick Gozdnica series (in the new scheme the Gozdnica Formation). The 2 m thick horizon of Quaternary deposits including clay and soil is deposited at the top of the core.

## MATERIAL AND METHODS

Twenty seven samples have been collected at various intervals (1.5–2 m) from the depth of 71.0 to 134.0 m from the core containing the II Lusatian seam (samples 26–7), the Mużaków series (samples 6–2) and the I Henryk seam (sample 1). The majority of samples (22) were collected from the 18 m thick II Lusatian brown coal seam. Material for pollen analysis was prepared by the modified Erdtman's acetolysis method (Moore et al. 1991). The silt, clay and clay-coal samples were pre-treated with hydrofluoric acid to remove mineral matter. In each sample an average of 550 pollen grains of trees, shrubs and all accompanying herbs and spores have been counted. For several low frequency samples at the depths of 102.5, 104.0, 118.0, and 132.0 m the basic sum was reduced to about 250–300 grains. Two slides from each sample were studied. One sample at the depth 116.5 m contained no pollen. The palynological collection of Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków was used in the determination of pollen grains and spores. Morphological taxa were identified on the basis of works by Thomson and Pflug (1953), Oszast (1960), Krutzsch (1970, 1971), Thiele-Pfeiffer (1980), Nagy (1985), Planderová (1990), Ziembińska-Tworzydło et al. (1994a) and others. The results of our investigations are presented on the histogram (Fig. 2). The palaeotropical and arctotertiary geofloristic elements were distinguished after Ziembińska-Tworzydło et al. (1994b).

The results were used for the reconstruction of changes in the local vegetation during the sedimentation of deposits under study. It goes without saying that the taxa of family, genus or type rank may include a number of species. Though they have similar or even the same pollen morphological type, their ecological requirements could be completely different. In this article the classification of plant communities according to available publications (Teichmüller 1958, Mai 1981, Kohlman-Adamska 1993, Słodkowska 1994, and others) was used. The classification can only be treated as a trail of the main ecological groups which occurred in the vegetation. The results have been compared with spore-pollen zones of the Neogene in the Polish Lowlands (Piwocki & Ziembińska-Tworzydło 1995, 1997).

## DESCRIPTION OF POLLEN DIAGRAM

The results of the investigations were used to construct pollen diagram (histogram) (Fig. 2), in which the percentage values were based on the total sum including trees, shrubs (AP) and herbs (NAP) and excluding pollen of aquatic plants and spores. The occurrence of dinoflagellate cysts were indicated by "+" in our data. The sporomorphs are arranged in the diagram according to plant communities from wet to mesophytic. Herbs, pteridophytes and mosses are presented separately at the end of the histogram.

Some columns present a sum of a few taxa: *Lycopodium* (*L. clavatum* type, *Lycopodium* undiff.), *Tsuga* (*T. canadensis* and *T. diversifolia* types), Araliaceae (*Araliaceoipollenites euphorii*, *A. reticuloides*), Caprifoliaceae (*Viburnum* type, *Diervilla* type, Caprifoliaceae undiff.), *Castanea/Castanopsis* (*Tricolporopollenites cingulum* ssp. *pussillus* and *T. cingulum* ssp. *oviformis*), Cornaceae (*Cornaceaepollis satzveyensis*, *Cornus* type), Ericaceae (*Ericipites callidus*, *E. ericius*, *E. roboreus*), *Ilex* (*Ilexpollenites iliacus*, *I. margaritatus*), *Liriodendron* (*Liriodendroipollis verrucatus*, *L. semiverrucatus*), *Quercoidites henrici* (with *Q. microhenrici*), Rosaceae (*Tricolporopollenites photinioides*, Rosaceae undiff.), *Symplocos* (*Symplocoipollenites vestibulum*, *S. latiporis*), Vitaceae (*Tricolporopollenites marcodurensis*, *Vitis* type).

The pollen diagram has been divided into three parts corresponding to the previous investigations carried out by Sadowska et al. (1981) and based on the frequencies of palaeotropical taxa in various parts of the profile (Fig. 2).

### THE LUSATIAN SEAM

This part of the pollen diagram contains samples from the depth 134.0–118.0 m, taken from brown coal and coaly grey clay. The arctotertiary element prevails, but the representation of palaeotropical taxa is significant. Some of these taxa are presented on the Plate 1. This is a phase of maximum diversity of the palaeotropical element. Relatively high quantities of *Tricolporopollenites pseudocingulum* (max. 20%), *Engelhardtia* (*Engelhardtioipollenites punctatus*), *Myrica* (*Myricipites rurensis*), *Castanea/Castanopsis* (*Tricolporopollenites cin-*

*gulum* ssp. *pussillus* and *T. cingulum* ssp. *oviformis*), *Tricolporopollenites fallax*, *T. liblarensis*, *Ilex* (*Ilexpollenites iliacus*, *I. margaritatus*), *Araliaceoipollenites edmundi* and *Quercoidites henrici* are characteristic features of this section. The abundant values of Taxodiaceae/Cupressaceae accompanied by *Alnus* and *Nyssa* as well as *Carya*, *Pterocarya*, *Ulmus/Zelkova*, and *Acer* (particularly in the bottom part of the profile) were recorded. In the upper part of this section, pollen of shrubs Cyrillaceae/Clethraceae (*Tricolporopollenites exactus* and *T. megaexactus*), Ericaceae, *Myrica* and others distinctly increases.

### THE MUŻAKÓW SERIES

This part of the pollen diagram covers samples from the depth 117.0–102.5 m, taken from coaly-clayey deposits. The palaeotropical element frequencies decrease radically. Plants of wet and moist habitats prevail. The highest percentages of Taxodiaceae/Cupressaceae, *Alnus*, *Nyssa*, *Liquidambar*, *Myrica*, *Ulmus*, *Carya* and *Pterocarya* are noted. The contribution of aquatic plants and Poaceae pollen grains is the highest in the whole profile. In the samples from this series some dinoflagellate cysts were also found. These data suggest that the studied site was flooded and became a part of a brackish lagoon.

### THE HENRYK SEAM

The sample no. 1, taken from brown coal horizon, at the depth 71.0 m, shows a great pollen diversity. The palaeotropical taxa *Araliaceoipollenites edmundi*, *Quercoidites henrici*, *Ilex* (*Ilexpollenites iliacus*, *I. margaritatus*) and *Tricolporopollenites pseudocingulum* appear in relatively large quantities – higher than in the samples from the Mużaków series. However, the results of palynological study of a single sample could not be used as a base for characterizing a local vegetation and making any conclusions. In this study it has been impossible to reconstruct the vegetation which formed the brown coal horizon. We are only able to point out the main and accompanying taxa in the palynoflora.

## RESULTS OF PALYNOLOGICAL STUDIES

The recorded palynoflora contains a total of 97 taxa, predominated by Angiospermae which include 76 taxa. Among them pollen grains of *Alnus*, *Nyssa*, *Quercus*, *Salix*, *Ulmus/Zelkova*, *Liquidambar*, *Ilex*, *Myrica*, *Engelhardtia*, *Tricolporopollenites pseudocingulum*, *Tricolporopollenites fallax* and *T. liblarensis* are the most frequent. Herbs are very rare, only Poaceae exceed 5% in one sample. The conifers show a comparatively small diversity, though, they reach about 55% of the total sum (max. 80%, min. 35%). The mutual ratio of pollen grains with and without air-sacks is about 2:1. Among conifers Taxodiaceae/Cupressaceae group (*Inaperturopollenites* sp. div.) play important role. They are accompanied by pollen of *Pinus sylvestris* type, *Pinus* type *Haploxylon* Rudolph, *Sequoia*, *Abies*, *Picea*, *Sciadopitys*, *Tsuga* as well as single pollen grains of *Podocarpus*, *Cryptomeria*, *Cathaya* and *Cedrus*. Mosses and pteridophytes are represented by 10 taxa which are predominated by *Osmunda* and other ferns (Polypodiaceae s.l.).

The following types of fossil plant communities have been distinguished: swamp forest, bush swamp, riparian forest and mixed mesophytic forest (according to Teichmüller 1958, Mai 1981, Kohlman-Adamska 1993, Słodkowska 1994, and others).

Swamp forests occurred in areas with high ground-water level, and they were floristically not very diversified. Their most important elements were *Taxodium*, *Glyptostrobus*, *Nyssa* and *Alnus*, on the more elevated areas accompanied by *Salix*, *Betula*, *Myrica* and ferns (*Osmunda*). These forests played important role in Legnica region during the whole studied period. Herbaceous aquatic plants were probably limited to small periodical water basins within these swamp forests. Only a few pollen grains of *Potamogeton*, *Utricularia* and Haloragaceae were found.

Along water courses existed favourable conditions for riparian forests with *Carya*, *Ulmus*, *Pterocarya*, *Liquidambar*, *Salix*, *Celtis*, *Alnus*, *Acer*, *Fraxinus*, *Staphylea* and climbers *Parthenocissus* and *Vitis*. Pollen grains of this taxa were encountered in all studied samples, but usually in small quantities, except *Alnus*.

Periodically flooded areas were covered by bush swamps with the following shrubs and

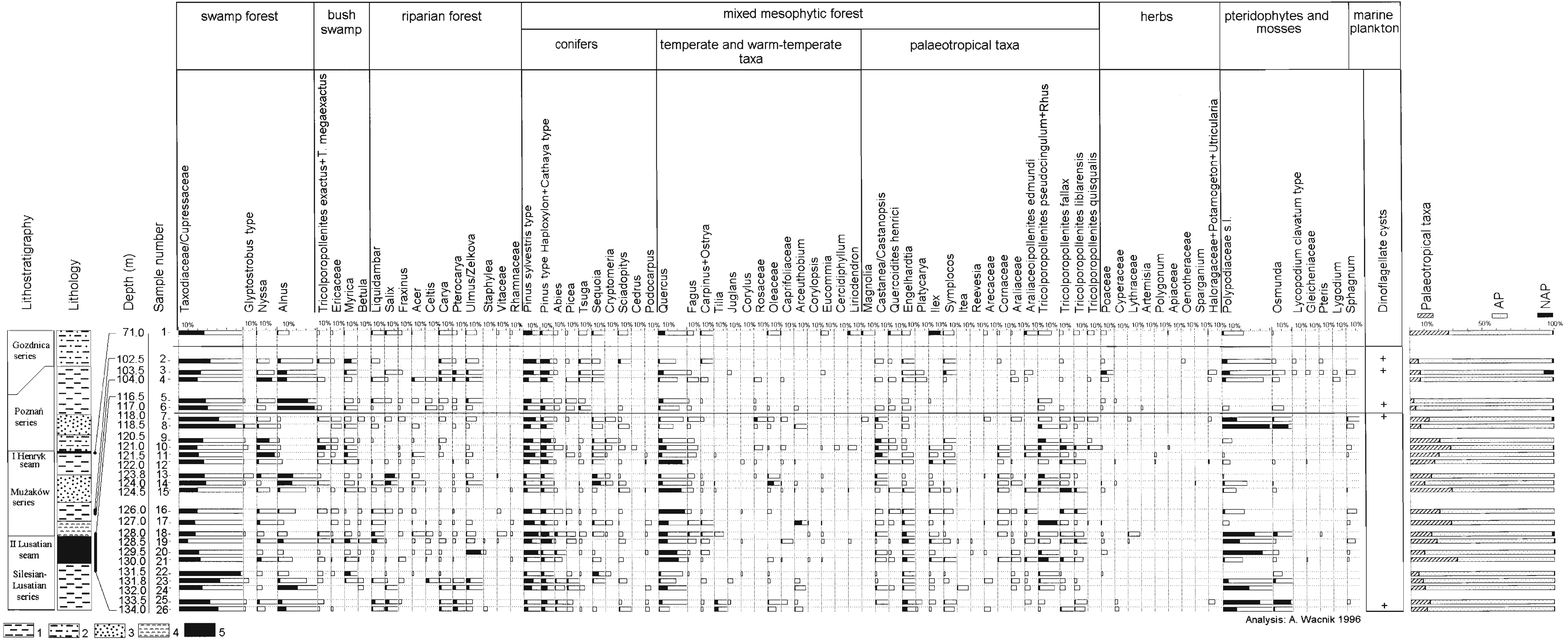


**Fig. 2**. Legnica 47/62. Percentage pollen diagram of selected taxa. **1** – clay, **2** – sand with clay, **3** – sand, **4** – silt, **5** – coal

trees: Cyrillaceae, Clethraceae, Ericaceae, *Ilex*, Betulaceae, Myricaceae, *Salix*, Rosaceae, *Liquidambar* and others accompanied by Poaceae, Cyperaceae, ferns and mosses (*Sphagnum*). Sporomorphs of plants characteristic of these communities were encountered in analysed material regularly, but in small quantities. It could be caused by temporary existence of shrubby peat-swamps. Their role was more distinct in the upper part of the Lusatian seam.

On the margins of the peat-bogs coniferous forest with *Sequoia*, *Pinus*, *Sciadopitys* and *Cathaya* grew (Sadowska 1977, Schneider 1992).

Mixed mesophytic forests occurred in drier terrains. Their composition was very rich in both arctotertiary and palaeotropical taxa. There occurred deciduous trees: *Fagus*, *Quercus*, *Carpinus*, *Castanea*, *Acer* and *Zelkova*, conifers: *Picea*, *Abies*, *Tsuga*, *Sciadopitys*, *Sequoia* and *Pinus*, shrubs: Rosaceae, Caprifoliaceae, *Ilex* and many others. The arctotertiary element prevailed, but the contribution of thermophilous taxa (*Podocarpus*, *Engelhardtia*, *Platycarya*, Magnoliaceae, Araliaceae, Cornaceae and *Symplocos*) was probably significant. Some pollen grains found in the material under study, particularly of such coniferous trees as *Pinus*, *Picea*, *Abies*, *Tsuga*, *Sciadopitys* and *Sequoia* could origin from long-distance transport.

The fossil plant communities are similar to the recent ones occurring in the south-eastern part of North America (Mississippi Valley, Florida, Georgia, North Carolina). The swamp forests correspond closely to growing on floodplains of large rivers cypress swamp with dominant *Taxodium distichum* and *Nyssa aquatica* or *Nyssa sylvatica* accompanied by *Acer rubrum*, *Fraxinus caroliniana*, *Liquidambar styraciflua* and others (Barnes 1991).

Bottom hardwood forests in the Mississippi River Valley contain *Liquidambar styraciflua*, *Acer rubrum*, *Fraxinus pennsylvanica*, *Acer saccharum*, *Nyssa aquatica*, *Carya* sp. div., *Ulmus americana*, *Quercus* sp. div., *Fagus grandifolia*, *Celtis laevigata*, *Ilex decidua*, *Cornus foemina*, *C. florida*, *Carpinus caroliniana*, *Liriodendron tulipifera*, *Salix nigra* and others (Robertson et al. 1978).

In the Atlantic zone of North America there occur also bush swamps with *Cyrilla racemiflora*, *Clethra alnifolia*, *Ilex lucida*, *I. glabra*, *Itea virginica*, *Myrica cerifera*, *M. inodora*, *Pieris mariana*, *P. nitida* and *Vaccinium virgatum* (Knapp 1965).

The fossil mixed mesophytic forests are similar to both North-American and Eastern-Asiatic ones. In North America grow forests with *Liriodendron tulipifera*, *Castanea dentata*, *Quercus montana*, *Q. alba*, *Q. borealis*, *Q. coccinea*, *Liquidambar styraciflua*, *Magnolia acuminata*, *M. fraseri*, *Carpinus caroliniana*, *Carya ovata*, *C. tomentosa*, *Fraxinus americana*, *Juglans cinerea*, *Acer saccharum* and many others (Barnes 1991). In eastern and south-eastern Asia occur *Cathaya argyrophylla*, *Cryptomeria japonica*, *Sciadopitys verticillata*, *Cercidiphyllum japonicum*, *C. magnificum*, *Eucommia ulmoides*, *Platycarya strobilacea* and the genera *Keteleeria*, *Podocarpus*, *Castanopsis*, *Corylopsis*, *Engelhardtia*, *Pterocarya* and *Reevesia* (Ching 1991).

In all samples from the Legnica 47/62 profile pollen and spores of arctotertiary geoflora prevailed, but the relatively high abundance and diversity of palaeotropical element (Tab. 1, Fig. 2) points at the warm-temperate climate. The phase containing the II Lusatian seam was the warmest one in the whole profile from Legnica. The predominance of swamp, peat-bog and riparian taxa implies the high humidity of the climate during sedimentations of studied deposits.

## THE AGE OF THE FLORA

The attempt to define the age of studied sediments was based on comparisons with data from other palynologically elaborated geological sites from this region. A great similarity was noticed to the pollen diagrams from SW Poland, particularly from Legnica as well as Nowe Czaple and Zielona Góra (Sadowska 1970, 1977, Sadowska et al. 1976, 1981, Worobiec 2000). The comparison of diagrams from the vicinity of Legnica was restricted to pollen spectra from the II Lusatian seam only. The similarity was noticed not only in taxonomical composition and frequencies but also in general trends of Taxodiaceae/Cupressaceae, *Nyssa*, *Pinus* and Polypodiaceae s.l. in pollen diagrams. It is most likely that they could be connected with environmental conditions of the accumulation processes, as is suggested by the character and thickness of the lithological series in these profiles.

**Table 1**. List of palaeotropical elements distinguished in Legnica 47/62 profile

| |
|---|
| tropical element (P1) |
| ***Podocarpidites libellus*** (Potonié 1931) Krutzsch 1971 |
| ***Magnolipollis neogenicus*** Krutzsch 1970 |
| ***Tricolporopollenites marcodurensis*** Pflug & Thomson 1953 |
| ***Cornaceaepollis satzveyensis*** (Pflug 1953) Ziembińska-Tworzydło 1994 |
| subtropical element (P2) |
| ***Tricolporopollenites cingulum*** (Potonié 1931) Thomson & Pflug 1953 **ssp. *oviformis*** (Potonié 1931) Thomson & Pflug 1953 |
| ***Tricolporopollenites cingulum*** (Potonié 1931) Thomson & Pflug 1953 **ssp. *pusillus*** (Potonié 1934) Thomson & Pflug 1953 |
| ***Quercoidites henrici*** (Potonié 1931) Potonié, Thomson & Thiergart 1950 |
| ***Quercoidites microhenrici*** (Potonié 1931) Potonié, Thomson & Thiergart 1950 |
| ***Myricipites rurensis*** (Pflug & Thomson 1953) Nagy 1969 |
| ***Engelhardtioipollenites punctatus*** (Potonié 1931) Potonié 1951 ex Potonié 1960 |
| ***Platycaryapollenites miocaenicus*** Nagy 1969 |
| ***Symplocoipollenites vestibulum*** (Potonié 1931) Potonié 1960 |
| ***Symplocoipollenites latiporis*** (Pflug & Thomson 1953) Słodkowska 1994 |
| ***Tricolporopollenites exactus*** (Potonié 1931) Grabowska 1994 |
| ***Tricolporopollenites megaexactus*** (Potonié 1931) Thomson & Pflug 1953 |
| ***Reevesiapollis triangulus*** (Mamczar 1960) Krutzsch 1970 |
| ***Iteapollis angustiporatus*** (Schneider 1965) Ziembińska-Tworzydło 1974 |
| ***Tricolporopollenites fallax*** (Potonié 1934) Krutzsch 1960 |
| ***Tricolporopollenites liblarensis*** (Thomson 1950) Grabowska 1994 |
| ***Tricolporopollenites quisqualis*** (Potonié 1934) Krutzsch 1954 |
| ***Tricolporopollenites pseudocingulum*** (Potonié 1931) Thomson & Pflug 1953 |
| ***Ilexpollenites iliacus*** (Potonié 1931) Thiergart 1937 ex Potonié 1960 |
| ***Ilexpollenites margaritatus*** (Potonié 1931) Raatz 1937 ex Potonié 1960 |
| ***Araliaceoipollenites edmundi*** (Potonié 1931) Potonié 1951 ex Potonié 1960 |
| ***Araliaceoipollenites euphorii*** (Potonié 1931) Potonié 1951 ex Potonié 1960 |
| ***Araliaceoipollenites reticuloides*** Thiele-Pfeiffer 1980 |
| ***Arecipites pseudoconvexus*** Krutzsch 1970 |

On the other hand these results confirm a topographical differentiation which occurred in this region during the younger Tertiary. Palynological investigations show a stable predominance of Tertiary sporomorphs in the total sum which achieved on average about 65% (max. 89% at the depth 131.5 m) what indicates Tertiary character of this flora (according to Stuchlik 1964, Ziembińska-Tworzydło et al. 1994b). The frequency of palaeotropical elements is high and oscillate around 20%. There are high quantities of Taxodiaceae/Cupressaceae (max. 60%), *Quercus* (max. 28%), *Alnus* (max. 15% – with predominance of tetraporate pollen grains), and *Nyssa* (max. 20% – the small type of pollen grains is more frequent). A significant role is played by the following taxa: *Tricolporopollenites pseudocingulum* (max. 20%), *Myrica* (max. 10%), *Engelhardtia* (max. 10%), *Castanea/Castanopsis* (max. 8%), *Sequoia* (max. 10%), *Tricolporopollenites fallax*, *T. liblarensis* and *Araliaceoipollenites edmundi*. Pollen grains of *Quercoidites henrici*, *Symplocos*, *Platycarya*, Araceae, *Magnolia* and Cyrillaceae/Clethraceae were only found sporadically. All of these taxa are treated as indicators of the Miocene age for these deposits (Sadowska 1994).

*Pinus sylvestris* type is more frequent then *Pinus* type *Haploxylon*. This ratio is disturbed only in clay-coal and clay samples. *Abies*, *Picea*, *Sciadopitys* and *Tsuga* percentages are low (about 3%, max. 7%). Herbs (excluding Polypodiaceae s.l. and *Osmunda*) oscillate from about 1–2%, reaching only in the pollen spectra from clay horizon, up to 5%. All indicator taxa are characteristic for the Middle Miocene sediments (Sadowska 1994). On the basis of these results it is possible to correlate the main brown coal seam with the II Lusatian seam sedimented in the Early Badenian (?Late Karpatian/Early Badenian) (Sadowska 1993, Piwocki & Ziembińska-Tworzydło 1995, 1997). This brown coal seam is situated below sand, clay and silt of the Mużaków series and the other brown coal series. The age of the I Henryk seam is fixed as the Late Badenian. This statement is in agreement with geological data and spore-pollen spectra of the Neogene in the Polish Lowlands (Sadowska 1977, Dyjor 1986, Dyjor & Sadowska 1986). The lower part of the Legnica profile corresponds to the V *Quercoidites henrici* and VI *Tricolporopollenites megaexactus* spore-pollen zones, while the spectrum from the upper part could correspond to the spectra from the VIII *Celtipollenites verus* spore-pollen zone (although pollen grains of the taxon *Celtipollenites verus* were not found) of the Neogene in the Polish Lowlands, connected with the Upper Badenian (Piwocki & Ziembińska-Tworzydło 1995, 1997). We can assume that the sedimentation of studied deposits was limited to the Badenian (?Late Karpatian-Late Badenian).

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# PLATE

Plate 1

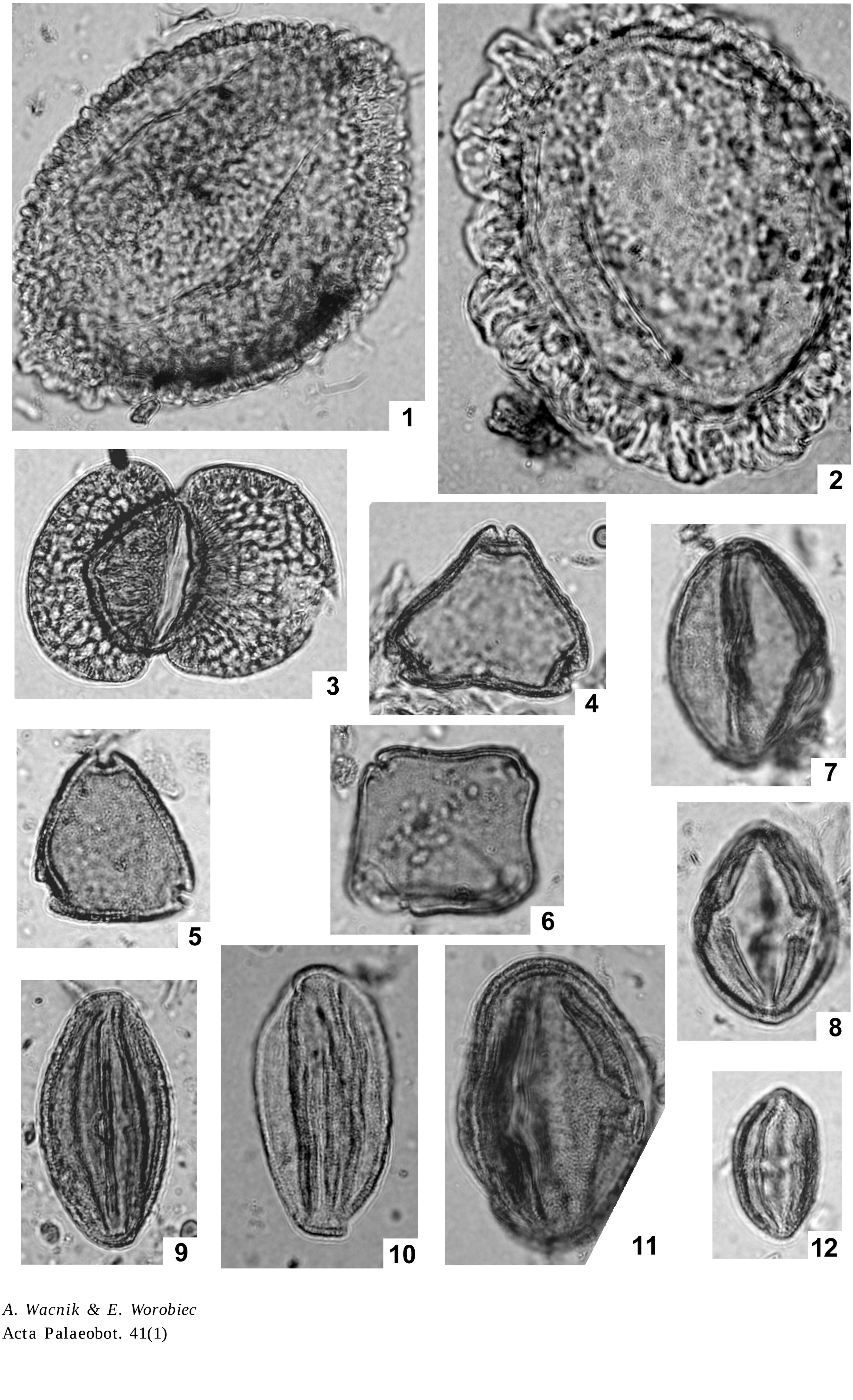
× 1000

1. *Tsugaepollenites spectabilis* (Doktorowicz-Hrebnicka 1954) Słodkowska 1994; 122.0 m
2. *Tsugaepollenites spinosus* (Doktorowicz-Hrebnicka 1954) Słodkowska 1994; 122.0 m
3. *Cathaya pulaënsis* Nagy 1985; 124.0 m
4. *Symplocoipollenites vestibulum* (Potonié 1931) Potonié 1960; 71.0 m
5. *Symplocoipollenites latiporis* (Pflug & Thomson 1953) Słodkowska 1994; 124.0 m
6. *Symplocoipollenites* sp.; 124.0 m

7–8. *Tricolporopollenites pseudocingulum* (Potonié 1931) Thomson & Pflug 1953 (s.l.) 122.0 m

9. *Tricolporopollenites marcodurensis* Pflug & Thomson 1953; 122.0 m
10. *Quercoidites henrici* (Potonié 1931) Potonié, Thomson & Thiergart 1950; 124.0 m
11. *Araliaceoipollenites edmundi* (Potonié 1931) Potonié 1951 ex Potonié 1960; 122.0 m
12. *Rhuspollenites ornatus* Thiele-Pfeiffer 1980; 122.0 m

phot. S. Florjan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