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Late Glacial and Holocene vegetation history of the "Little Desert", dune area south-eastern Silesian Upland, southern Poland

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ABSTRACT. On the basis of pollen and plant macrofossil analyses and ^{14}C datings of organic sediments from basin in the dune area in the "Little Desert" (Jęzor and Jaworzno area), changes of local and regional vegetation were reconstructed from about 11 680 ± 100 years BP and up to the present. Eight local pollen assemblage zones (L PAZ) and seven local macrofossil assemblage zones (L MAZ) were correlated with chronozones of Late Glacial and Holocene. They illustrated phases of vegetation changes in the nearest neighbourhood of the studied site and also in the region, where a considerable part of the territory was covered by thick sediments of fluvio-glacial sands, gravels, aeolian sand sheets and dunes. The age of the organic deposits from the "Little Desert" supports the conclusion that dune formation took place in the Late Glacial and also in the older Holocene (older part of Boreal). The local dune formation at that time were triggered by fire. Its traces were found in the top of two studied profiles.

KEY WORDS: pollen, macrofossils, vegetation changes, Late Glacial and Holocene, aeolian processes, inland dunes, Silesian Upland, Poland

INTRODUCTION

In southern Poland a large part of the Silesian Upland and the Kraków-Wieluń Upland (Fig. 1) are covered by thick sediments of Middle Polish and Vistulian glaciations, especially by fluvio-glacial sandy and gravelly formations superimposed by aeolian sand sheets and dunes.

It is well-known that dune formation plays a significant role in these physical-geographic units. However, detailed studies of the aeolian problems have not been performed for many years (Lencewicz 1922, Różycki 1960, 1972). Only at the end of the 20th century Szczypek (1986) studied different features of aeolian material and covers in detail in the central part of the Kraków-Wieluń Upland (north-western part of the Kraków-Częstochowa Upland) against a background of the areas adjacent to this region.

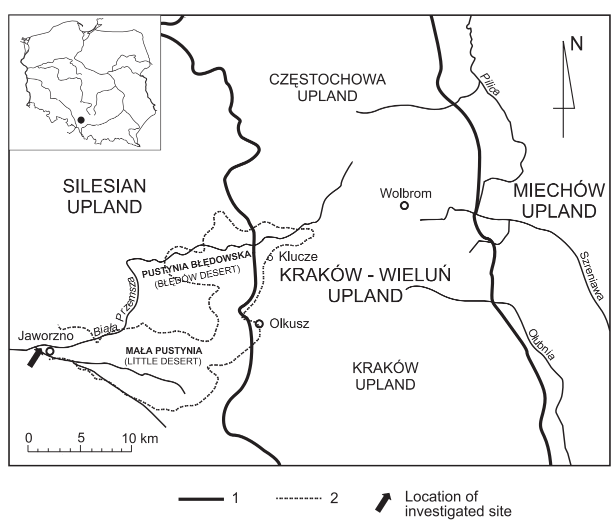

Fig. 1. Location of the investigation site: southern Poland (after Czeppe 1972, simplified). **1** – borders of macroregions, **2** – borders of the sand and dune areas (after Kozioł 1952, changed)

The region with aeolian sand accumulations in the eastern part of the Silesian Upland is characterized by a rich, inland psammophilous flora e.g. *Corynephorus canescens*, *Koeleria glauca* and by a relict glacial flora including *Doronicum austriacum*, the endemic *Cochlearia polonica*, and the arctic moss species *Scorpidium turgescens*.

In this area on the sand sheets and dunes pine forests prevail among forest communities with such rare taxa as *Dianthus gratianopolitanus*, *Pulsatilla vernalis*, *P. pratensis*, *Lembotropis nigricans*, *Chamaecytisus supinus*, *Ch. ratisbonensis*, *Astragalus arenarius*, *Scabiosa canescens*, and *Arctostaphylos uva-ursi*. Spruce, sycamore, maple, oak, and lime play locally important role as forest elements. In shady forests with spruce and beech montane plants occur e.g. *Streptopus amplexifolius*, *Aconitum variegatum*, *Dentaria glandulosa*, *D. bulbifera*, and *D. enneaphyllos*. In forests growing on a ridge of limestone beech (*Fagus sylvatica*) dominates, while on slopes mixed deciduous forest of *Querco-Carpinetum* type and relicts of calciphilous and xerothermic plants are present (Szafer 1972, Tokarska-Guzik 1999).

In this part of the Silesian Upland, small lakes and peat formation were formed in depressions among dune with no outlet, later overgrown by vegetation which produced organic sediments.

HISTORY OF INVESTIGATION

The find of pine cones of *Pinus sylvestris* in gyttja and peat near Jęzor-Jaworzno in 1955 stimulated the study of these deposits using palaeobotanical methods (Staszkiewicz 1961). On the basis of biometric analysis of the cone Staszkiewicz concluded that they represented a morphological type of common pine occurring in Poland in lowlands and montane areas (Staszkiewicz op. cit.). In 1955, pollen analysis was applied to determine the age of the lake sediments and peat, from which the cones were collected. The sediments filled depressions 2.5 m deep and 50 m wide, located in the central part of a sand-pit under exploitation (Fig. 2). Samples were collected from the layer of gyttja and peat about 2 m thick, underlaying the dune sand (150–200 cm deep) in the south-western part (Fig. 2). The pollen diagram from the first site and pollen spectra from the second site showed that the organic sediments were accumulated in the Late Glacial and at the beginning of Holocene. Plant macrofossils, especially of aquatics (*Isoëtes*, *Potamogeton*), were found in great numbers.

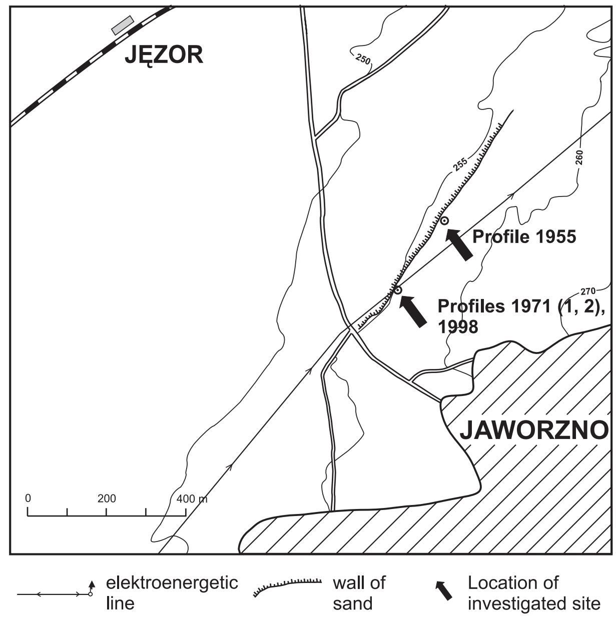

Fig. 2. Positions of the profiles of the organic sediments in Jęzor-Jaworzno, 1955; 1971, profile 1 and profile 2; 1998

The intention of the first author was that the results would be published when pollen analyses had been carried out for the second site, located in the south-western part of the sand-pit, and detailed analysis of plant macrofossils had been completed.

The organic deposits exsposed in the central part of the sand-pit were destroyed during exploitation, soon after sampling was performed in 1955. The second site ca. 200 m south-west of site 1 was available for several years and in 1971 samples for pollen analysis and ^{14}C dating, were collected from two profiles situated near each other (Fig. 2). Samples from the profile 1 were studied using pollen analysis by Soliman in 1973. Analysis of profile 2 was performed by Szczepanek for comparison. Two samples from this profile were radiocarbon dated, by Dr W.R. Mook in Grøningen in 1972.

In 1998 the authors started to complete the biostratigraphical studies started in the 1950s. At the sampling we could not reach the gyttja and peat dated in Grøningen in 1972, covered by dune sands because the slope of the sand-pit was overgrown. However, 20 m south of the sand-pit wall, behind a dune ridge, a 3 m deep section uncovered by dune sand could be sampled.

MATERIAL AND METHODS

The samples were taken from 3 sites situated near Jęzor-Jaworzno (50°14′6″ N, 19°12′12″ E, 255 m a.s.l.) 1 – north-eastern part of the sand-pit (one profile from 1955), 2 – central part of the sand-pit (two profiles from 1971), 3 – 20 m south of the central part of the sand-pit (one profile from 1998).

The samples collected from the profile found in 1998, using an "Instorf" sampler, were studied by pollen and plant macrofossil analysis methods. Six radiocarbon datings were performed by the Radiocarbon Laboratory of the Silesian Technical University at Gliwice in 1999. On the basis of the pollen analyses performed in 1955, 1971 and 1998 and macrofossil analyses the Late Glacial and the Holocene vegetation history was reconstructed for the "Little Desert" in the catchment-area of the Przemsza river.

The samples for pollen analyses were cut out directly from an outcrop wall of organic deposits located between the railway station of Jęzor and the north-western border of the town Jaworzno. In 1955, 55 samples were taken and analysed by Szczepanek. In 1971, 38 samples were analysed by Soliman, and 45 samples by Szczepanek. In 1998 the samples were taken, using an "Instorf" borer, from the organic sediments 3 m deep close to the profiles from 1971; 66 samples were cut out at intervals of 5 cm, each of volume 1 cm^3 for pollen analysis, and 65 samples about 200 cm^3 in volume (half of cylinder of 5 cm long and 10 cm in diameter) for plant macrofossil analysis. For macrofossil analyses were also taken and identified two additional samples described as "top of bottom" and "middle of bottom" in the profile from 1971.

All samples for pollen analysis were prepared using the standard acetolysis method of Erdtman (1943). Sand was removed by decantation before acetolysis (samples from 1955 and 1971). Samples from 1998 were also decanted and boiled in hydrofluoric (HF) acid before acetolysis. The samples were coloured and mounted in glycerine. In samples from 1955 and 1971 about 500, and in samples from 1998 over 1000 pollen grains of trees, shrubs and herbs, and spores of Filicales and *Sphagnum* were identified and counted.

The samples for plant macrofossil analysis were soaked in water with an admixture of 5% KOH and boiled. Then the sediment was rinsed under running water through a sieve of 0.2 mm diameter mesh and the identifiable plant macrofossils were picked out using a low-power stereomicroscope. The macrofossils were stored in glycerine with alcohol and water (1:1:1), and a few drops of thymol. Before identification the macrofossils were rinsed with alcohol and dried in order to store them dried further.

Fossil plant macro remains are stored in the collection of the Department of Palaeobotany, Institute of Botany, Jagiellonian University, Kraków.

Qualitative and quantitative results of pollen and spore identification are presented in the pollen percentage diagrams plotted using the POLPAL program for Windows (Walanus & Nalepka 1996, 1999). The basic sum for calculation of pollen percentage values of all identified taxa excluding aquatics and reedswamps pollen, spores (of Filicales and *Sphagnum*) and unidentified pollen grains (varia) was accepted as 100%. Percentage of the taxa excluded from basic sum was calculated when the pollen grain or spore numbers of a given taxon were added to the basic sum. In the pollen and plant macrofossil diagrams local pollen assemblage zones (L PAZ) and local macrofossil assemblage zones (L MAZ) were distinguished

LITHOLOGY
(Depth in cm from the surface)

The Jęzor-Jaworzno profile from 1955 (samples for pollen analysis 1–55):

0–15 cm	sandy peat of high humification
15–100 cm	peat with large contribution of amorphic humic matter, dark brown, wet, plastic, wood fragments, tree trunks in lower part
100–210 cm	peat, wet, plastic, with wood fragments, *Phragmites*, *Equisetum*, seeds and fruits of *Carex* and *Menyanthes trifoliata*
210–250 cm	coarse-grained detritus gyttja, dark grey to brown, seeds of *Menyanthes trifoliata*, cones of *Pinus sylvestris*, and endocarps of *Potamogeton* in lower part
Below 250 cm	sand, light grey

The Jęzor-Jaworzno profile 1 from 1971 (samples for pollen analysis 1–38):

0–155 cm	sand, yellow, slightly laminated, dark ferrous spots and bright ones indicating podsolization processes, below 100 cm with thin organic interbeddings
155–200 cm	peat, dark brown, interbedded with sand, single trunks or branches of trees (*Pinus sylvestris*) up to 25 cm in diameter with traces of fire (in top a partly burnt pine trunk of 30 cm in diameter), streaks of sand
200–310 cm	peat, dark brown, with wood fragments up to 15 cm in diameter and with substantial sand admixture
310–340 cm	coarse detritus gyttja, dark brown, sandy interbeddings and numerous macrofossils (pine needles, seeds and fruits of *Carex* and *Potamogeton*)
Below 340 cm	sand, yellow, downwards light grey

The Jęzor-Jaworzno profile 2 from 1971 (samples for pollen analysis 1–45):

0–100 cm	sand, yellow, well rounded, not laminated clearly, with dark ferrous spots and light ones indicating podsolization processes
100–130 cm	sand, yellow with dark, organic interbeddings
130–155 cm	sand, yellow with numerous thin organic layers
155–210 cm	peat, dark brown, laminated, forms a layer of various thickness, sandy with partly burnt wood fragments and pine cones
210–310 cm	peat, dark brown, sandy with wood frag-

	ments and clearly dislocated streaks of sand
310–350 cm	coarse detritus gyttja, dark brown, numerous macrofossils (pine needles, seeds and fruits of *Carex* and *Potamogeton*)
Below 350 cm	sand, yellow, downwards light grey

The Jęzor-Jaworzno profile from 1998 (samples for pollen analysis 1–66):

0–10 cm	peat of high humification, sandy, wood fragments
10–25 cm	peat, wet, plastic, slightly sandy, dark brown to black, numerous wood fragments and charcoal pieces
25–50 cm	peat, dry, with very frequent wood fragments and charcoal pieces, dark brown to black
50–70 cm	peat, amorphic, wet, plastic, many wood and charcoal fragments
70–90 cm	peat, slightly sponge-like, wet, frequent fragments of *Eriophorum vaginatum*
90–200 cm	peat, sponge-like, wet, frequent leaflets and twigs of *Sphagnum* and sclerenchymatic spindles of *Eriophorum vaginatum*, dark brown in top (10 cm) becoming light brown with several thin, sandy layers downwards
200–230 cm	peat, sponge-like, wet, wood fragments and frequent needles of *Pinus sylvestris* and shoots of *Eriophorum vaginatum*
230–250 cm	peat, amorphic, with large contribution of amorphic humic matter, plastic, dark brown
250–270 cm	peat, dry, slightly plastic, interbeddings of detritus gyttja, dark brown to black
270–275 cm	detritus gyttja (peat-like), dark brown sandy interbeddings
275–300 cm	coarse detritus gyttja (peat-like), dark brown to brown, sandy in the bottom, frequent endocarps of *Potamogeton*
Below 300 cm	sand, light grey

RADIOCARBON DATINGS

Radiocarbon dates of eight samples from the organic sediments in the studied profiles are given as uncalibrated years before present:

(Depth in cm from the surface)

1. Two samples from the coarse detritus gyttia in the profile 2 from 1971:

Gr. N.6769-A = 11 680 ± 100 BP
Gr. N.6770-B = 9035 ± 80 BP

2. Six samples in the profile from 1998:

45–50 cm	Gd 10 871 = 3750 ± 110 BP
60–65 cm	Gd 11 443 = 4790 ± 70 BP
145–150 cm	Gd 10 875 = 7160 ± 120 BP
200–205 cm	Gd 10 873 = 8310 ± 150 BP
245–250 cm	Gd 13 020 = 9120 ± 220 BP
295–300 cm	Gd 10 881 = 10 750 ± 180 BP

To define the absolute age of eight selected zones (samples) in the pollen percentage diagram and macrofossil diagram from 1998 an interpolation of the radiocarbon dates was applied. The interpolated dates are marked by an asterisk* in the diagrams and text.

The sedimentation was calculated by division of a sediment depth (mm) by the number of years between two neighbouring radiocarbon dates.

POLLEN ANALYSIS

DESCRIPTION OF LOCAL POLLEN ASSEMBLAGE ZONES

In four pollen diagrams from the Jęzor-Jaworzno site from 1955, 1971 and 1998 (Figs 3–6) local pollen assemblage zones (J-J1–8) were distinguished.

J-J1, *Pinus-Betula-Larix* L PAZ

Profile 1, 1971 (Fig. 3): samples 38–35 (340–325 cm) and profile 2 (Fig. 4): samples 45–40 (350–325 cm). Samples 45–44 (350–345 cm) were dated at 11 680 ± 100 BP (Gr. N.6769-A).

Tree pollen dominates in zone, especially *Pinus* (50%) and *Betula* (about 20%). Pollen of *Larix* and *Juniperus* (< 1%) also occurs. Herbaceous pollen (about 20%) is represented mostly by Poaceae (±10%), Cyperaceae (about 5%). Spores of *Isoëtes* are frequent (> 5%).

J-J2, *Pinus-Artemisia-Potamogeton* L PAZ

Profile 1, 1971 (Fig. 3): samples 34–11 (325–205 cm); profile 2, 1971, (Fig. 4): samples 39–32 (325–285 cm); profile 1955 (Fig. 5): samples 55–50 (250–220 cm); profile 1998 (Fig. 6): samples 66–61 (300–275 cm); samples 66–65 (300–295 cm) were ^{14}C dated at 10 750 ± 180 BP (Gd. 10 881).

The percentage value of tree pollen declines, especially *Betula*, *Larix*, *Pinus cembra* type. The values of Poaceae, Cyperaceae, *Artemisia*, Chenopodiaceae, and *Potamogeton* increase. Megaspores of *Isoëtes* occur sporadically. The interpolated date of the upper boundary of this zone is 9935* BP in the profile from 1998, 275–270 cm.

J-J3, *Betula-Pinus-Ulmus* L PAZ

Profile 1, 1971 (Fig. 3): samples 11–1 (205–155 cm), and profile 2, (Fig. 4): samples 31–16 (285–275 cm); profile 1955 (Fig. 5): samples 49–44 (215–210 cm); profile 1998 (Fig. 6): samples 60–55 (270–260 cm).

In the profile from 1998 ^{14}C date of samples 55–54 (250–245 cm) at the upper boundary of zone is 9120 ± 220 BP.

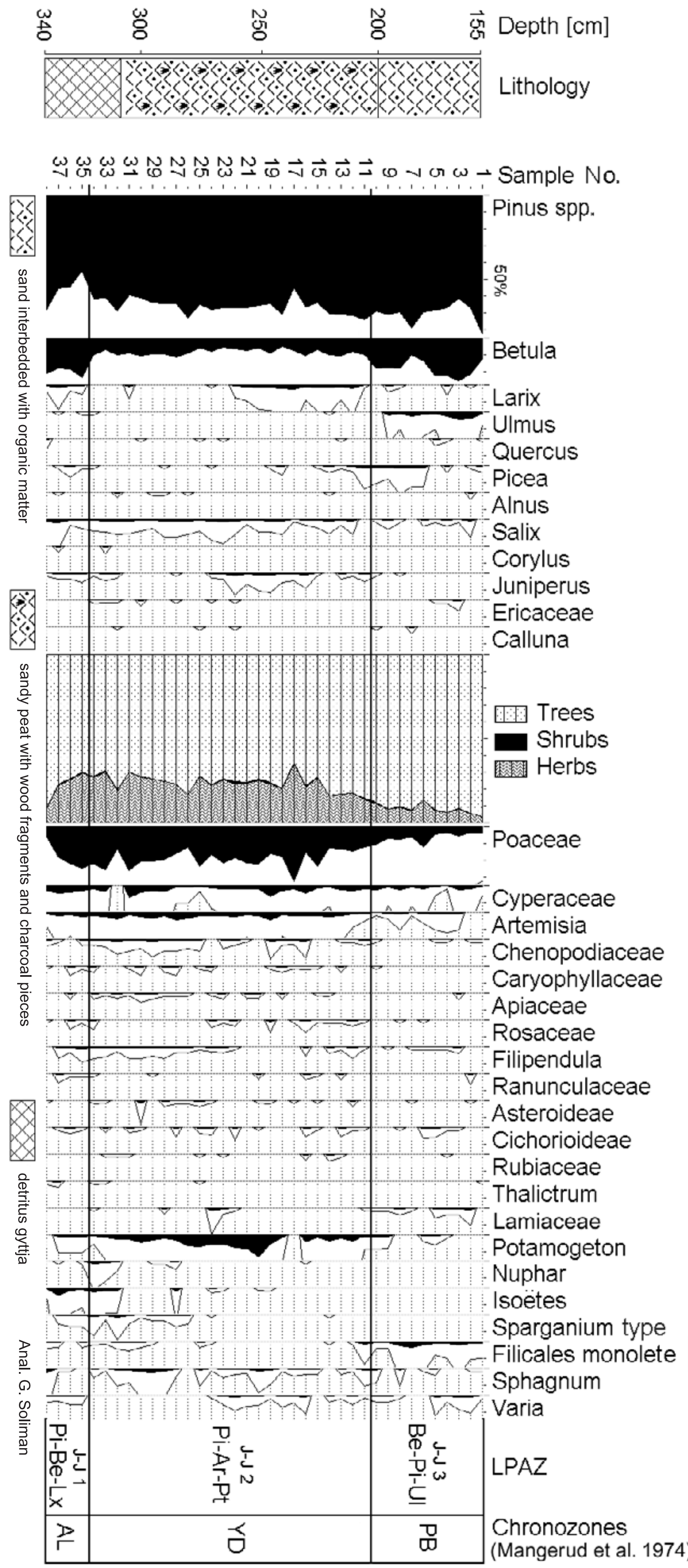

Fig. 3. Percentage pollen diagram from Jęzor-Jaworzno 1971, profile 1

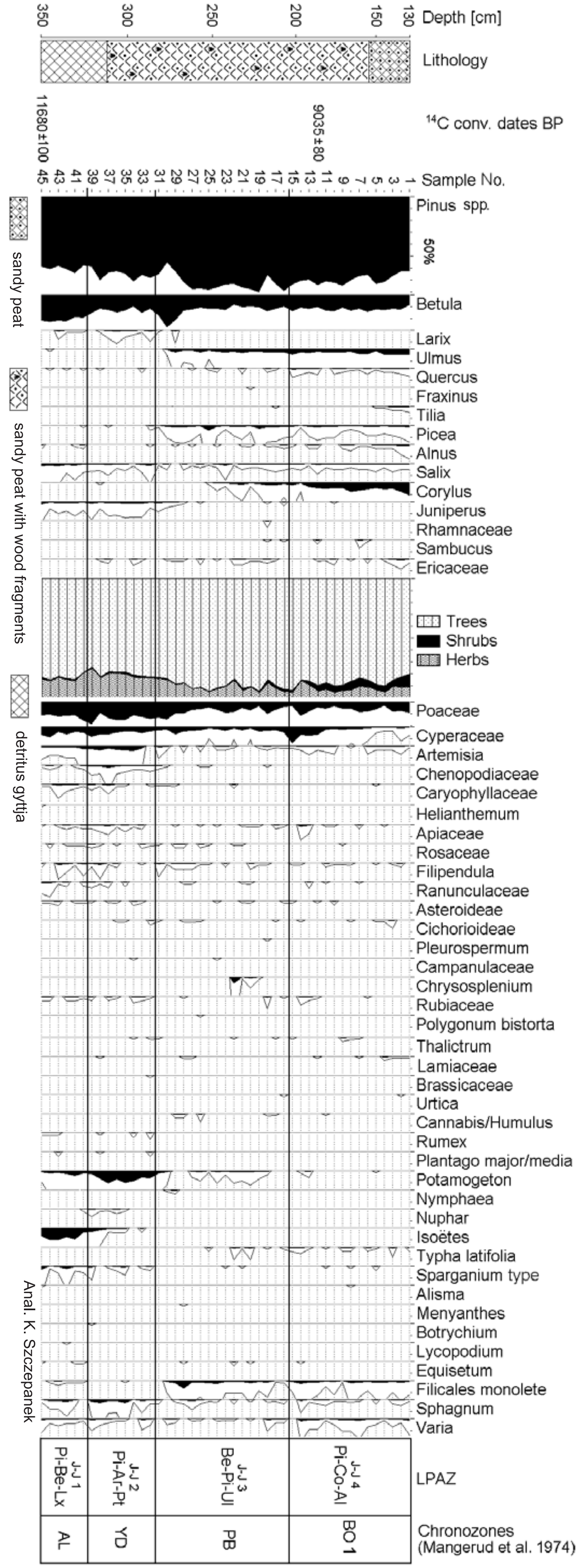

Fig. 4. Percentage pollen diagram from Jezor-Jaworzno 1971, profile 2

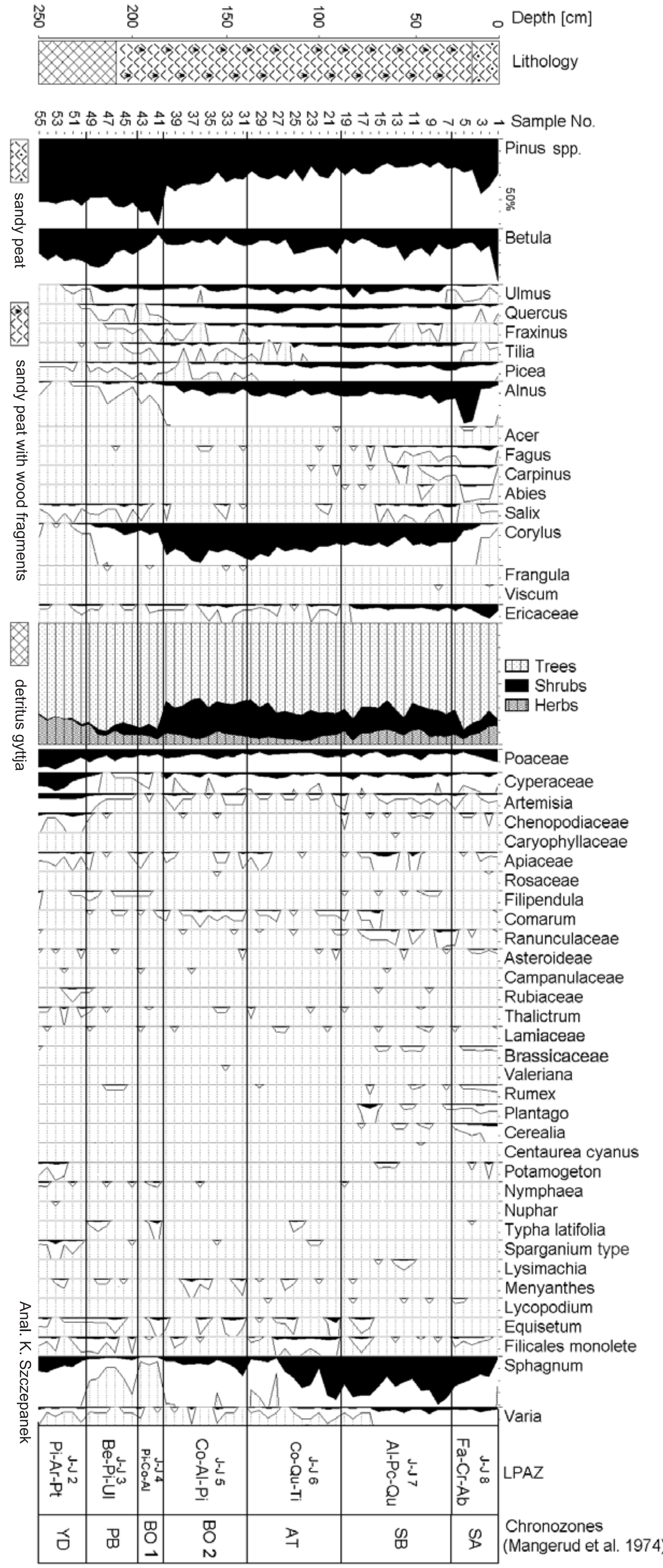

Fig. 5. Percentage pollen diagram from Jęzor-Jaworzno 1955

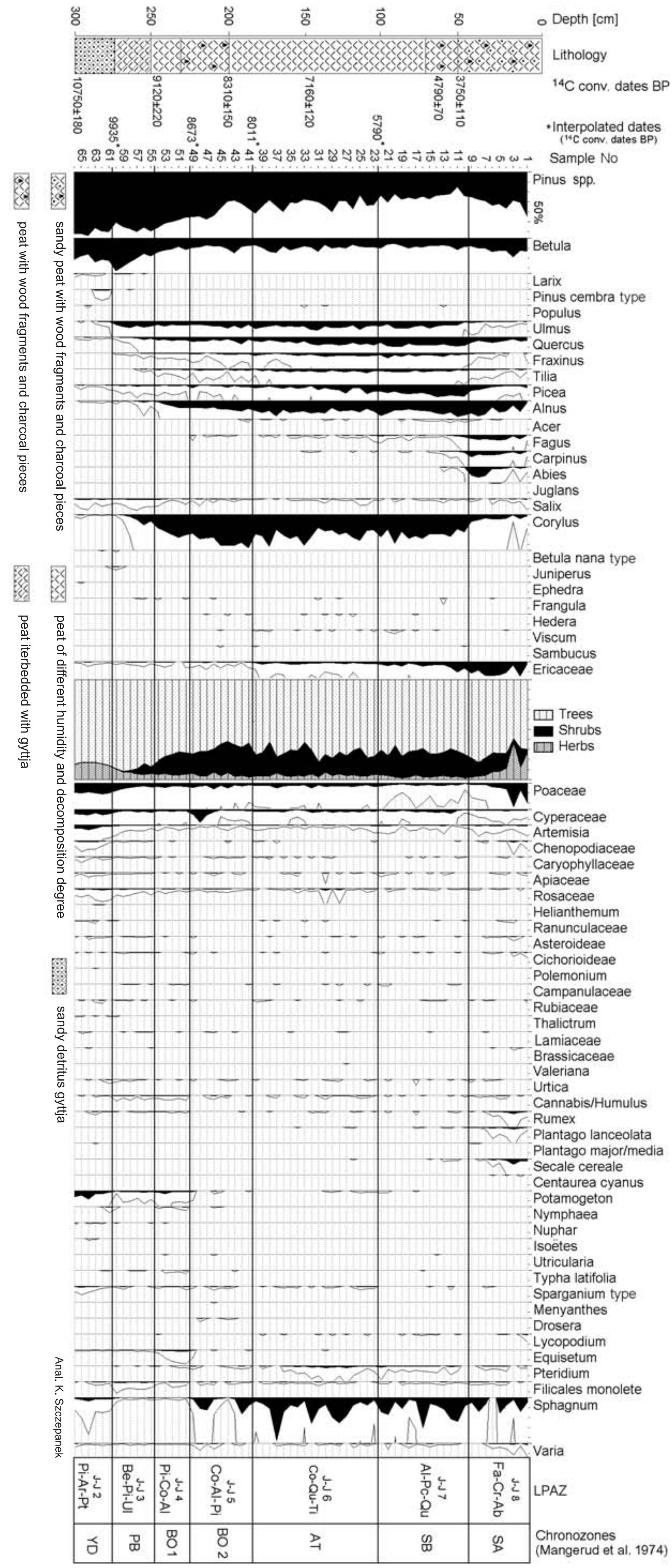

Fig. 6. Percentage pollen diagram from Jęzor-Jaworzno 1998. Interpolated dates are marked by an asterisk*

In all four diagrams the percentage values of *Betula* pollen rise, while *Pinus* pollen shows a slight decrease. Pollen of *Larix* occurring sporadically in preceding zone now disappears. *Ulmus* pollen shows a continuous curve. *Picea*, *Alnus*, *Quercus*, and *Corylus* values increase. NAP pollen especially Poaceae curve decrease.

J-J4, *Pinus-Corylus-Alnus* L PAZ

Profile 2, 1971 (Fig. 4): samples 15–1 (205–135 cm); profile 1955 (Fig. 5): samples 43–41 (225–195 cm); profile 1998 (Fig. 6): samples 54–50 (250–225 cm).

In the profile from 1998 ^{14}C date of samples 50–49 (225–220 cm) at the upper boundary of zone is 8673* BP. In the profile from 1971 ^{14}C date of samples 12–11 (185–180 cm) is 9035 ± 80 BP.

In the profiles from 1955 and 1998 the *Betula* frequence decreases. The *Ulmus*, *Quercus*, *Fraxinus*, *Alnus*, and *Corylus* curves are continuous (especially in the diagram from 1998). The NAP value falls. In the lower part of this zone the contribution of pollen of aquatic taxa and swamp plants (*Potamogeton*, *Nuphar*, *Nymphaea*, *Equisetum*, *Sparganium*, *Typha*) occur.

J-J5, *Corylus-Alnus-Pinus* L PAZ

Profile from 1955 (Fig. 5): samples 40–31 (195–140 cm); profile 1998 (Fig. 6): samples 49–41 (225–180 cm); ^{14}C date of samples 41–40 (180–175 cm) at the upper boundary of the zone is 8011* BP.

Pollen percentage values of *Corylus* increase markedly to a maximum value especially in the profile from 1955 (Fig. 6). Also *Alnus* and *Quercus* values rise. The *Pinus* curve gradually falls. *Fraxinus*, *Tilia*, and *Picea* show continuous curves. In the profile from 1998 *Fagus* exposes an almost continuous curve. NAP values are very low.

J-J6, *Corylus-Quercus-Tilia* L PAZ

Profile from 1955 (Fig. 5): samples 30–20 (140–45 cm); profile from 1998 (Fig. 6): samples 40–23 (180–175 to 105–100 cm); ^{14}C date of samples 41–40 (180–175 cm) at the lower boundary of zone is 8011* BP; samples 23–22 (105–100 cm) at the upper boundary of zone is 5790* BP.

In both pollen diagrams the curves of *Pinus*, *Betula*, and *Corylus* occur with minor oscillations. *Alnus*, *Picea*, and Ericaceae slightly increase. In the diagram from 1998 the contribution of *Quercus* rises. In the upper part of the zone *Fagus* value increases and the *Ulmus* contribution declines. In the upper part of the zone pollen of *Rumex*, *Plantago lanceolata*, and *Secale* occurs sporadically. Varying values of *Sphagnum* spores appear.

J-J7, *Alnus-Picea-Quercus* L PAZ

Profile from 1955 (Fig. 5): samples 19–7 (45–25 cm); profile from 1998 (Fig. 6): samples 22–10 (105–100 to 45–40 cm); ^{14}C date of samples 23–22 (105–100 cm) at the lower boundary of zone is 5790* BP; samples 10–9 (50–45 cm) at the upper boundary of zone is 3750 ± 110 BP.

In the pollen diagram from 1998 the contributions of *Alnus*, *Picea*, *Quercus*, *Ulmus*, and *Corylus* increase. In the upper part of zone continuous curves of *Fagus*, *Carpinus*, and *Abies* are seen. The proportion of Ericaceae rises. Indicators of human activity such as *Rumex*, *Plantago lanceolata*, *Secale cereale*, *Urtica*, and *Artemisia* occur more abundantly than in the preceding zone. In the diagram from 1955 *Ulmus*, *Fraxinus*, and *Tilia* decrease in the upper part of the zone. The NAP, particularly Poaceae, Cyperaceae, and *Artemisia* increase slightly. The indicators of human activity and also *Fagus*, *Carpinus*, and *Abies* occur.

J-J8, *Fagus-Carpinus-Abies* L PAZ

Profile from 1955 (Fig. 5): samples 6–1 (25–20 to 0 cm); profile from 1998 (Fig. 6): samples 9–1 (45–0 cm). ^{14}C date of samples 11–10 (50–45 cm below the lower boundary of zone is 3750 ± 110 BP.

In the lower part of zone *Fagus*, *Carpinus*, and *Abies* reach their maximum values (about 10%). Pollen of *Ulmus*, *Quercus*, *Fraxinus*, and *Tilia* decreases distinctly. *Picea*, *Acer*, and *Corylus* also nearly disappear. In the upper part of the pollen zone the values of *Pinus*, *Betula*, Ericaceae, and particularly NAP such as Poaceae, Cyperaceae, *Artemisia*, Chenopodiaceae, and other indicators of human activities such as cultivation and grazing increase.

MACROFOSSIL ANALYSIS

The diagram of plant macrofossils (profile from 1998, Fig. 7) is divided into 7 local macrofossil assemblage zones (L MAZ, JJ-1–7) numbered from the bottom to the top. The appear-

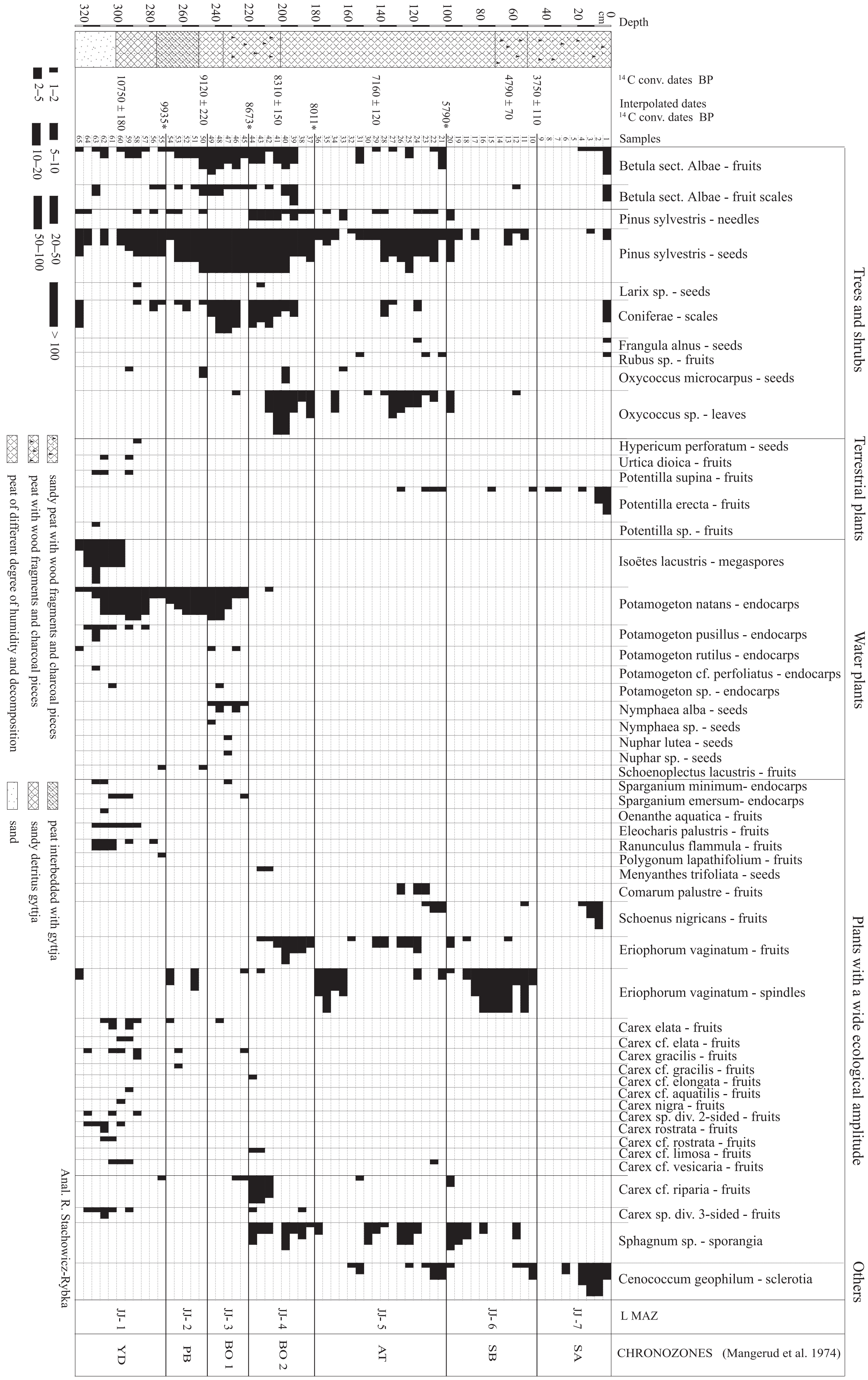

Fig. 7. Plant macrofossil diagram from Jęzor-Jaworzno 1998. Macrofossil numbers are given in seven different intervals. Interpolated dates are marked by an asterisk*

ance or decline of macrofossils of one or several taxa characteristic for a given zone or occurring abundantly, and the presence of plant taxa with similar ecological requirements were criteria to determine the zone boundaries.

In 1971 two samples from the profile 2 were taken, from which macrofossils were obtained. In the sample named as “middle of bottom” 12 seed scales and 50 nuts of *Betula* sect. *Albae*, 15 seeds and over 100 needles of *Pinus sylvestris* were identified. Aquatics were represented by 12 megaspores of *Isoëtes lacustris* (Fig. 8), 125 endocarps of *Potamogeton natans*, 3 endocarps of *P. pusillus*, 2 seeds of *Schoenoplectus lacustris*. Peat-bog plants were represented by 5 seeds of *Potentilla* sp., 41 nuts of *Carex* sp. div., including *C. elata*, *C.* cf. *elata*, *C. gracilis*, *C. canescens*, *C. rostrata*, and *C.* cf. *rostrata*. Single seeds of *Arctostaphylos uva-ursi* (Fig. 9: 9), *Nuphar pumila* and *Linaria vulgaris* were also identified.

In the sample named as “top of bottom” the floristic composition was somewhat poorer in taxa. 21 nuts of *Betula* sect. *Albae*, 1 seed and 54 needles of *Pinus sylvestris* and 1 seed of *Arctostaphylos uva-ursi* were identified. Aquatics were represented by 86 megaspores of *Isoëtes lacustris*, 95 endocarps of *Potamogeton natans* and 4 seeds of *Nuphar pumila*. Plants of peat-bogs and swamps were represented by nuts of *Carex* sp. div., including *C. elata*, *C. gracilis*, *C.* cf. *elongata*, *C. rostrata*, *C.* cf. *rostrata*, and *C. limosa*.

The precise localization of the samples from 1971 (profile 2) is unknown. On the basis of the presence of the *Isoëtes* megaspores it is possible to place the samples within or below zone JJ-1, *Isoëtes lacustris-Potamogeton natans-Carex* sp.div. in the profile of macrofossils from 1998 (Fig. 7).

LOCAL MACROFOSSIL ASSEMBLAGE ZONES L MAZ IN THE PROFILE FROM 1998

JJ-1, *Isoëtes lacustris-Potamogeton natans-Carex* L MAZ

Samples 65–55 (325–280 cm). ^{14}C date of samples 55–54 (275–270 cm) at the upper boundary of zone is 9935* BP (Fig. 7).

This zone is distinguished by the presence of *Isoëtes lacustris* megaspores (in sample No. 63 over 100 specimens). Endocarps of *Potamogeton natans* are very frequent and single ones of *P. pusillus* (Pl. 1, fig. 4), *P. rutilus*, and *P.* cf. *perfoliatus* (Pl. 1, fig. 3) occur here. Nuts and seed scales of *Betula* sect. *Albae*, seeds and needles of *Pinus sylvestris* are frequent. Seeds of *Larix* sp. were noted in one sample.

In the middle part of the zone (dated at 10 750 ± 180 BP) the megaspores of *Isoëtes lacustris* disappear. The decrease in number endocarps of *Potamogeton natans* and *Carex* sp. div. nuts marks the upper boundary of the zone.

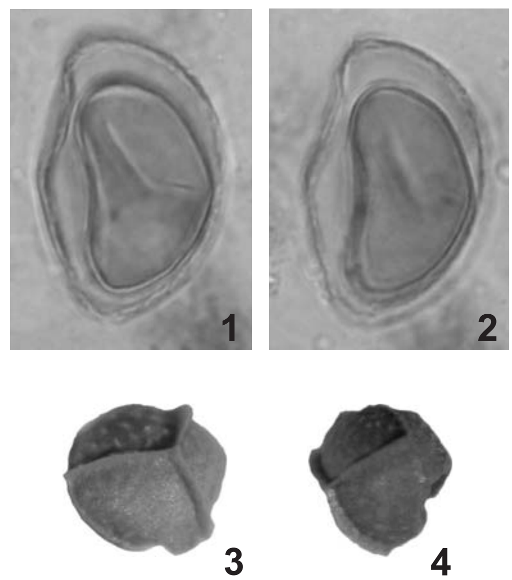

Fig. 8. *Isoëtes lacustris* L., microspores (**1**, **2**, × 1000), megaspores (**3**, **4**, × 100), Jęzor-Jaworzno site 1971

JJ-2, *Pinus sylvestris-Potamogeton natans* L MAZ

Samples 54–50 (275–220 cm). ^{14}C date of samples 50–49 (250–245 cm) at the upper boundary of the zone is 9120 ± 220 BP.

The macrofossils of *Pinus sylvestris* reach its maximum in top of the zone, and the number of macrofossils of *Betula* sect. *Albae* increases. The endocarps of *Potamogeton natans* (Pl. 1, figs 1,2) increase upwards. In the top sample several seeds of *Oxycoccus microcarpus* were found. *Eriophorum vaginatum* was identified in this zone.

JJ-3, *Pinus sylvestris-Potamogeton natans-Nymphaea alba* L MAZ

Samples 49–45 (250–220 cm). ^{14}C date of samples 45–44 (225–220 cm) at the upper boundary of the zone is 8673* BP.

Macrofossils of trees such as *Betula* sect. *Albae* and *Pinus sylvestris* occur most abundantly in the zone. In all samples needles of *Pinus sylvestris*, and nuts and seed scales of *Betula* sect. *Albae* prevail. The occurrence of macrofossils of *Nymphaea alba* (in all samples) and *Nuphar lutea* (Pl. 1, fig. 5) and *Nuphar* sp. (in sample No. 47) is limited to this zone. The upper boundary of the zone is marked by the disappearance of macrofossils of Nymphaeaceae and *Potamogeton.*

JJ-4, *Pinus sylvestris-Oxycoccus-Eriophorum vaginatum* L MAZ

Samples 44–37 (225–180 cm). ^{14}C date of samples 37–36 (185–180 cm) at the upper boundary of the zone is 8011* BP.

The occurrence of macrofossil of trees is the highest in this zone. Nuts and seed scales of *Betula* sect. *Albae*, and seeds and needles of *Pinus sylvestris* (Fig. 9: 6) dominate. Numerous macrofossils of bog plants were identified

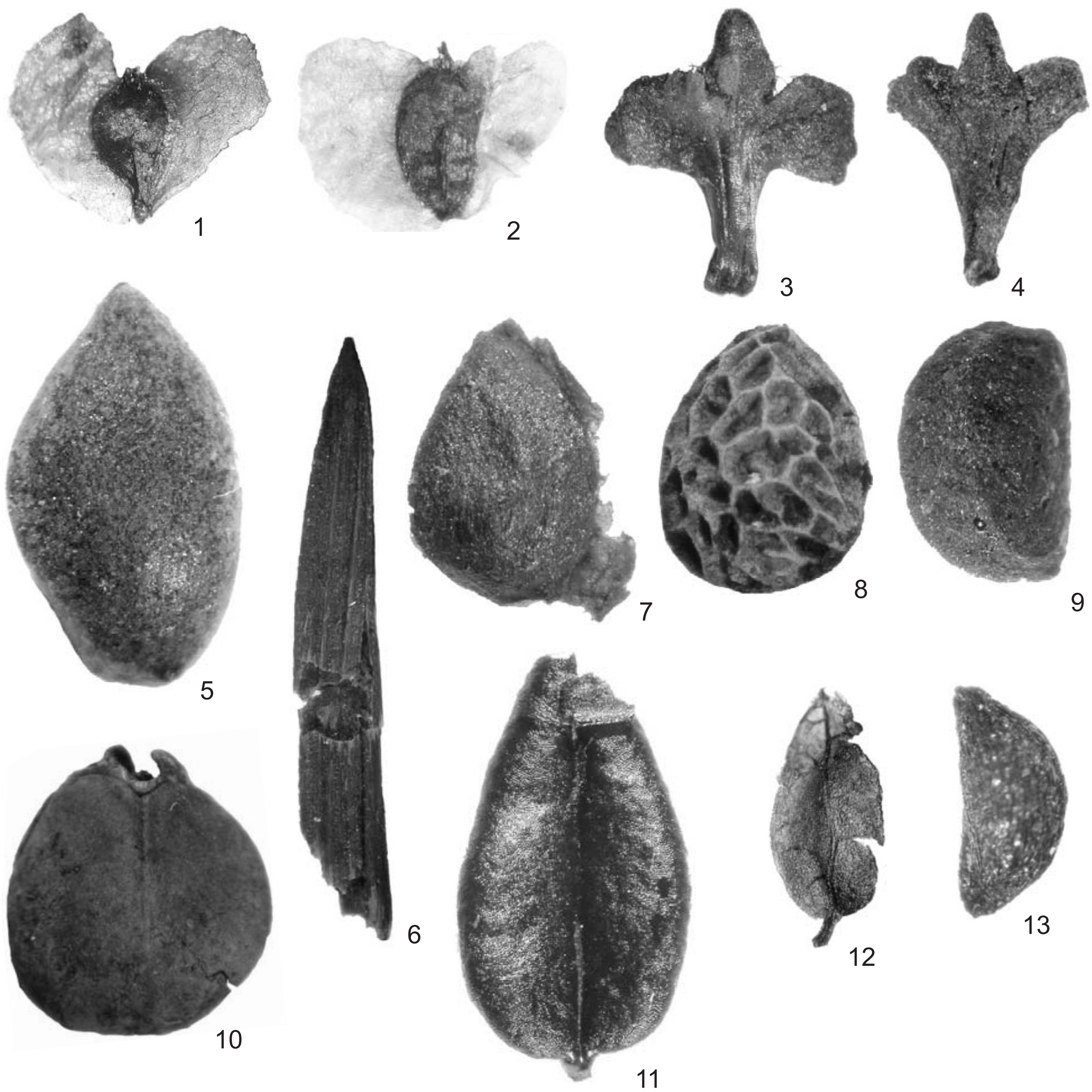

Fig. 9. Fossil plant remains of trees and shrubs from Jęzor-Jaworzno 1998: **1** – *Betula pendula* Roth., fruit, × 15, zone JJ-4; **2** – *Betula pubescens* Ehrh., fruit × 15, zone JJ-3; **3** – *Betula pendula* Roth., bud scale × 10, zone JJ-4; **4** – *Betula pubescens* Ehrh., bud scale × 10, zone JJ-3; **5** – *Pinus sylvestris* L., seed × 15, zone JJ-4; **6** – *Pinus sylvestris* L., needle × 10, zone JJ-4; **7** – *Larix* sp. L., seed × 15, zone JJ-1; **8** – *Rubus* sp. L., fruit × 15, zone JJ-5; **9** – *Arctostaphylos uva-ursi* (L.) Spreng., seed × 15, "middle of bottom"; **10** – *Frangula alnus* Mill., seed × 10, zone JJ-1; **11** – *Oxycoccus palustris* Pers., leaf × 10, zone JJ-6; **12** – *Oxycoccus microcarpus* Turcz. ex Rupr., leaf × 10, zone JJ-4; **13** – *Oxycoccus microcarpus* Turcz. ex. Rupr., seed × 20, zone JJ-2

including *Oxycoccus* sp. leaves, and also seeds of *Oxycoccus microcarpus* and *Eriophorum vaginatum*, *Menyanthes trifoliata*, nuts of *Carex* cf. *riparia* and frequent moss sporangia of the *Sphagnum* genus.

JJ-5, *Oxycoccus-Eriophorum vaginatum-Sphagnum* L MAZ

Samples 36–21 (185–180 to 105–100 cm). ^{14}C date of samples 21–20 (105–100 cm) at the upper boundary of the zone is 5790* BP.

The number of macrofossils of trees, particularly *Betula* declines. Seeds of *Pinus sylvestris* are still frequent. Spindles of *Eriophorum vaginatum*, *Oxycoccus* sp. leaves and *Sphagnum* sp. sporangia occur most abundantly. Sclerotia of *Cenococcum geophilum* (= *Cenococcum graniformae*) appear for the first time in this profile and fruits of *Comarum palustre* (Pl. 1, fig. 9) haracterizes this zone.

JJ-6, *Eriophorum vaginatum-Sphagnum* L MAZ

Samples 20–10 (105–45 cm). ^{14}C date of samples 10–9 (50–45 cm) at the upper boundary of the zone is 3750 ± 110 BP.

This zone is characterized by the occurrence of numerous spindles of *Eriophorum vaginatum*, sporangia of *Sphagnum*, and *Oxycoccus* sp. leaves (Fig. 9: 11,12) in the lower part of zone. Sclerotia of *Cenococcum geophilum* occur only in the top of zone.

JJ-7, *Cenococcum geophilum-Betula* sect. *Albae-Pinus sylvestris* L MAZ

Samples 9–1 (45–0 cm).

Sclerotia of *Cenococcum geophilum* and charcoal pieces are relatively frequent here. In the top sediments rare nuts and seed scales of *Betula* sect. *Albae*, needles of *Pinus sylvestris*, single seeds of *Rubus* sp., *Frangula alnus*, *Potentilla erecta*, and *Schoenus nigricans* (Pl. 1, fig. 16) were found.

CHANGES OF LOCAL AND REGIONAL VEGETATION IN THE LATE GLACIAL AND THE HOLOCENE

Pollen analysis of four profiles of organic sediments, which accumulated in depressions located in the dune area close to the present north-western border of the Jaworzno town, allowed to reconstruct vegetation changes in the "Little Desert" in the last ca. 12 000 years.

Results of macrofossil analysis, from one of the profiles complemented the reconstruction.

Pinus-Betula-Larix L PAZ (J-J1): 1971 is 11 680 ± 100 to 10 750 ± 180 BP. This zone correlates with the upper (declining) part of the Allerød chronozone according to Mangerud et al. (1974).

Pinus-Artemisia-Potamogeton L PAZ (J-J2) and *Isoëtes lacustris-Potamogeton natans-Carex* sp. div. L MAZ (JJ-1): 1971, 1955, 1998 = 10 750 ± 180 – 9935* BP. These zones correlate with the Younger Dryas chronozone.

The forests with pine (*Pinus*), birches (*Betula* sect. *Albae*) and larch (*Larix*) occurred in the neighbourhood of the studied basin. It is likely that stone pine occurred not far from the studied site. The presence of these taxa, excluding *Pinus cembra*, was evidenced by macrofossils (Fig. 7). The curves of heliophilous plants such as *Juniperus*, Poaceae, *Artemisia*, Chenopodiaceae, and Cyperaceae indicated open forests, especially in the Younger Dryas. This conclusion was supported, with respect to the Younger Dryas, by many macrofossils and relatively high amount of pollen of other herbs such as Ranunculaceae, Rubiaceae, Rosaceae, and Lamiaceae. In the littoral zone of the water body and in wet habitats willow thickets (*Salix*) and swamps with *Sparganium minimum* and *S. emersum* were present. In somewhat drier places, particularly in habitats of higher nitrogen content, *Urtica dioica* occurred.

In the oligotrophic waterbody *Isoëtes lacustris* (species characteristic here for the Allerød sediments) and several species of the *Potamogeton* genus (here characteristic for the Younger Dryas) surely occurred abundantly. These aquatics were represented by numerous macrofossils (Pl. 1, fig. 7) which were accompanied by nuts of *Carex rostrata* and *Eleocharis palustris*.

The present day association of *Isoëto-Lobelietum* is of similar floristic composition. It occurs in oligo- and mesotrophic lakes up to a 2 m depth with a bottom covered with sand, mud and stones (Podbielkowski & Tomaszewicz 1982). Mega- and microspores of *Isoëtes lacustris* indicate that water in the waterbody during the Allerød was quite cool with small amount of nutritive substances. In the Younger Dryas rather progressive eutrophication processes than more severe climate caused disappearance of *Isoëtes*. Its dominating role was taken over by other species of *Potamogeton*, particularly *P. natans*, *P. pusillus*, and *P.* cf. *perfoliatus*. Abundance of macrofossils and pollen of this genus was typical for this zone. The above mentioned taxa characterize the present-day vegetation of meso- and eutrophic waterbodies (lakes and old river-beds).

At the end of the Allerød and in the Younger Dryas, *Eleocharis palustris*, *Carex elata*, *C. riparia*, *C. gracilis*, *C. rostrata*, and *C. vesicaria*, occurring in the present day communities of tall sedges in the shallow littoral waters, invaded as pioneer species the waterbody, which changed its trophy.

The presence of mega- and microspores of *Isoëtes lacustris* and endocarps of *Potamogeton pusillus* was an indicator of cool climate at the end of the Allerød and in the Younger Dryas.

Betula-Pinus-Ulmus L PAZ (J-J3) and *Pinus sylvestris-Potamogeton natans* L MAZ (JJ-2): 1971, 1955, 1998 is 9935* – 9120 ± 220 BP. These zones correlate with the Preboreal chronozone.

At the beginning of this period the forest communities underwent changes from the pine forest to pine-birch forest. Heliophilous trees such as *Ulmus*, *Alnus*, *Quercus*, *Fraxinus*, *Picea abies*, and *Corylus avellana* spread in the forest communities of the region in more fertile habitats, particularly in the Wisła and Pilica river valleys. These trees became forest forming elements. Very frequent fruits and fruit scales of birch and needles of pine seem to support the conclusion that the forest on dunes surrounding the water body was denser than that at the end of Allerød and Younger Dryas.

Aquatics were dominated by *Potamogeton natans*, a species with partly submerged and partly floating leaves.

The formation of *Sphagnum* peat communities represented by abundant macrofossils of *Eriophorum vaginatum* and less numerous *Oxycoccus* could have started in the Preboreal period.

Pinus-Corylus-Alnus L PAZ (J-J4) and *Pinus sylvestris-Potamogeton natans-Nymphaea alba* L MAZ (JJ-3): 1971, 1955, 1998 is 9120 ± 220 – 8673* BP. The ^{14}C dates allow to correlate these zones with older part of the Boreal chronozone (Mangerud et al. 1974).

Pine-birch forest still occurred around the basin. *Quercus*, *Fraxinus*, *Tilia*, as well as *Ulmus*, *Picea*, and *Alnus* spread in the area.

Among macrofossils, seeds of *Pinus sylvestris* were the significant elements, beside fruits and fruit scales of *Betula* sect. *Albae* indicating the occurrence of these trees in the nearest vicinity of the lake body.

In the waterbody, aquatics occurred, especially *Potamogeton natans* (at the upper boundary of this zone about 8675* BP the continuous curve of *Potamogeton* pollen and the abundant occurrence of *Potamogeton natans* endocarps are finished). *Nymphaea alba* and *Nuphar lutea* also occurred in this area. It can be concluded that both species reflect overgrowth of the lake. These species are characteristic for the present association of *Nupharo-Nymphaeetum Albae*, which reaches their optimum in shallow lakes and old river-beds with organic sediments and alkaline water.

In the littoral zone reedswamp plants such as *Schoenoplectus lacustris*, *Sparganium minimum*, and *S. emersum*, and also peat-bog plants such as *Eriophorum vaginatum* and *Oxycoccus* occurred in meso- and dystrophic habitats of peaty ground.

Corylus-Alnus-Ulmus L PAZ (J-J5) and *Pinus sylvestris-Oxycoccus-Eriophorum vaginatum* L MAZ (JJ-4): 1955, 1998 is 8673* – 8011* BP. These zones correlate with the younger part of the Boreal chronozone (Mangerud et al. 1974).

On the dunes, close to lake, pine forest dominated with an admixture of birch. *Larix* also was present. Since the area has a varying geomorphology (the difference between the highest and the lowest altitudes was over 120 m) forests of various composition occurred with contributions of *Ulmus*, *Alnus*, *Quercus*, *Fraxinus*, *Tilia*, *Picea*, and possibly also *Fagus*. The forests occurred in the Przemsza and Biała Przemsza river valleys, and also in depressions and on slopes. In all the types of forest communities *Corylus* occurred abundantly. In this zone *Corylus* pollen was represented by the highest values.

The lake basin became filled in with sediments. The type of sediment also changed i.e. the proportion of *Sphagnum* mosses increased together with mire plants, primarily *Eriophorum vaginatum* and *Oxycoccus*. Small ponds, however, could still have existed with aquatic plants e.g. *Potamogeton*, *Menyanthes trifoliata*, and *Comarum palustre*. At the shore of the waterbody, on a peaty ground, species of *Carex* were dominating among tall sedge communities. *Carex* produced a great number of biomass, which were slowly decomposed and thus contributed to the overgrowth of the lake.

Corylus-Quercus-Tilia L PAZ (J-J6) and *Oxycoccus-Eriophorum vaginatum-Sphagnum* L MAZ (JJ-5): 1955, 1998 is 8011* – 5790* BP. These zones correlate with the Atlantic chronozone.

Pinus sylvestris dominated the forests occurrring on sandy dunes around the peat-bog. In the near surroundings *Alnus* prevailed together with *Picea abies* and *Fraxinus* in habitats at least periodically wet. On richer soils *Quercus*, *Tilia*, and *Ulmus* were important forest forming elements. On calcareous slopes and rich soils beech doubtless occurred or its range was very close to this area. In all forest types *Corylus avellana* was very frequent although its importance was already limited by shade-giving deciduous trees.

From about 7160 ± 120 BP *Carpinus* began to spread in the forest but pollen of this taxon was found less abundantly and not so regularly as *Fagus* pollen. Surely also *Acer* occurred but rarely.

In the macrofossil diagram a clear decrease in the number of remains, particularly of *Pinus* and *Betula*, can be seen in the section from about 8011* BP to about 7160 ± 120 BP. The appearance of sclerotia of *Cenococcum geophilum* may indicate a lack of dense vegetation close to the water body. A slight increase in pollen of *Salix* and *Pteridium aquilinum* can be interpreted as an indicator of local reduction of the forest density and an increase in the water level.

In the depressions among dunes with no outlet, peat communities developed, with characteristic plants such as *Sphagnum*, *Eriophorum vaginatum*, and *Oxycoccus microcarpus*. Single pollen grains of *Rumex acetosa/acetosella* type, *Plantago lanceolata*, and even *Secale cereale* seem to indicate that grazing already influenced the vegetation composition.

Alnus-Picea-Quercus L PAZ (J-J7) and *Eriophorum vaginatum-Sphagnum* L MAZ (JJ-6): 1955, 1998 is 5790* – 3750 ± 110 BP. These zones correlate with the Subboreal chronozone.

It is possible that trees, particularly pine and birch, disappeared in the surroundings of the peat-bog which is reflected by only a small number of macrofossils. Mixed deciduous forests, which dominated in the region, were differentiated according to trophy and moisture conditions of the habitats. *Pinus sylvestris*, *Alnus glutinosa*, and probably also *A. incana*, *Picea abies*, and *Fraxinus excelsior*, associated with a relatively high ground water level were dominant. Trees such as *Ulmus*, *Quercus*, *Tilia*, and *Acer* prevailed in fertile and moderately wet habitats. These habitats were also occupied by *Fagus sylvatica*, *Carpinus betulus*, and *Abies alba*. *Corylus avellana* still occurred abundantly in different types of forests. Herbs were limited mainly to undergrowth and the specific habitats such as peat-bogs and their margins, where mire plants occurred.

The pollen diagrams for this zone (L PAZ J-J7) seem to indicate forest regeneration and higher forest density except for pine forest occurring on sandy soils and dunes. Simultaneously human activity increased, which was reflected by the increase in pollen of *Rumex acetosa/acetosella* type, *Plantago lanceolata*, *Centaurea cyanus*, and *Secale cereale*, and also charcoal pieces and sclerotia of *Cenococcum geophilum*. The presence of *Cenococcum* indicate that local vegetation became more open (Ławrynowicz 1983). The intensification of human activity started about 4790 ± 90 BP.

Fagus-Carpinus-Abies L PAZ (J-J8) and *Cenococcum geophilum-Betula* sect. *Albae-Pinus sylvestris* L MAZ (JJ-7): 1955, 1998 is 3750 ± 110 BP–AD ca. 1998. These zones correlate with the Subatlantic chronozone.

In the Holocene vegetation history this period is particularly important because of vegetation changes, which resulted from human activities and climatic variations. Undoubtedly the spread of *Fagus*, *Carpinus*, and *Abies* was caused primarily by climate changes but also more intensive human activities could have accelerated these changes. As a result it involved the significant reduction of the tree occurrence in the younger part of the zone. Grazing caused a reduction of forests, selective use of particular tree species and an increase in the proportion of herbs in the nearest vicinity of the site and in the larger area.

DUNE FORMING PROCESSES AND THEIR AGE IN VIEW OF THE RESULTS OF POLLEN ANALYSIS AT THE JĘZOR-JAWORZNO SITE

Reports on a number of dune forming periods and the age of the inland dunes in Poland were discussed in review articles by Galon already in 1958 and 1959 (Galon 1958, 1959). Later studies (Wasylikowa 1964, Tobolski 1966, 1969, Nowaczyk 1976, 1986, Szczypek 1986, Izmaiłow & Nalepka 1994) of organic deposits from dune areas included pollen and macrofossil analysis and radiocarbon datings.

The results of pollen and macrofossil analyses obtained hitherto evidenced that the dune forming processes took place in the Late Glacial and Holocene. The periods of aeolian accumulation in the Late Glacial coincided with climate changes. In the Holocene these periods were, however, not associated with climate changes. Starting from the Atlantic chronozone the formations of dunes occurred periodically up to the present. The results obtained hitherto give foundations to conclude that dune formation was initiated by anthropogenic factors during the middle and late Holocene (Tobolski 1966, 1969, Kozarski & Tobolski 1968, Rotnicki 1970).

Szczypek (1986) defined the age of aeolian sands in the studied sites located in the central part of the Silesian-Małopolska Uplands. On the basis of ^{14}C dated charcoals, occurring in 14 soil horizons which separated series of dune sand, Szczypek assumed that 10 dates marked the beginning of consecutive aeolian series in the different sites of the studied area 430 ± 75 BP; 900 ± 70 BP; 1360 ± 65 BP; 1590 ± 60 BP; 2160 ± 100 BP; 2840 ± 100 BP; 6630 ± 75 BP; 8670 ± 100 BP; 10 540 ± 220 BP; 11 230 ± 220 BP. The above-mentioned dates singled out, according to Szczypek, 10 phases of dune formation. In last 5–6 phases, in his opinion, the dune formation was initiated by human activities.

According to Szczypek (1986) the oldest dune forming phase on the Małopolska Upland (particularly on the Silesian Upland) took place in the Older Dryas. Most researchers consider that aeolian activity ceased during the Allerød. The climate conditions then favoured the spread of forest dominated by pine (*Pinus sylvestris*) on dunes and in the neighbouring areas. A change of climate at the end of the Allerød limited the growth of forest communities which probably resulted in the increase in the water level of lakes in the dune area and formation of so-called small ephemeral lakes (Kopytowski 1931, Tobolski 1963). In such lakes sedimentation of gyttja and peat could have started. It is possible that such an increase in the water level in the younger part of the Allerød and the Younger Dryas is reflected in the bottom sediment in the Jęzor-Jaworzno profiles 1 and 2 from 1971 and profiles from 1955 and 1998. The sediments deposited at the end of the Allerød (profiles from 1971) were ^{14}C dated to 11 680 ± 100 BP. The lowermost sediment in the Jęzor-Jaworzno profiles from 1955 and 1998 correlated with the end of the Younger Dryas and was ^{14}C dated to 10 750 ± 180 BP.

The increase in ground water level and formation of ephemeral lakes could have also been associated with local fire and after that with a start of dune forming processes. The interruption of organic sedimentation and the start of local dune accumulation in the Jęzor-Jaworzno profiles 1 and 2 from 1971 (Figs 3, 4) took place after a fire. It is evidenced by partly burnt wood fragments and a pine trunk in top of the sediments, and also by a layer of dune sand, 150–200 cm thick, covering the organic sediments. The ^{14}C date is 9035 BP in the top part of the profile 2 from 1971 (Fig. 4) and the overlaying section of the pollen diagram correlated with the older part of the Boreal chronozone (BO 1). The most intensive formation of this dune was at the end of the older part of the Boreal chronozone when fire occurred.

In the sediment profiles from 1955 and 1998, which originated from the same site but at a distance of 200–300 m from each other, dune sand did not cover the organic deposits. There was no clear interruption in the organic sediment growth.

The above-mentioned facts allow to conclude that at the Jęzor-Jaworzno site, in the profiles 1 and 2 from 1971 (Figs 3, 4) the beginning of the local dune formation followed fire in the older part of the Boreal chronozone. In the Jęzor-Jaworzno profiles from 1955 (Fig. 5) and 1998 (Fig. 6) the organic sedimentation started in the late Younger Dryas and continued to the present time i.e. to the drainage of the peat-bog before industrial exploitation of sand began. The profiles studied using pollen and macrofossil analysis methods, comprised more or less numerous charcoal pieces in several zones. However, their presence did not show clear connections with vegetation changes reconstructed on the basis of results obtained with the above-mentioned methods.

Abundant fragments of charcoal, particularly in top, and peat substantially dried up and of high humification made it impossible to reconstruct the influence of human activity on vegetation in the Subatlantic chronozone.

CONCLUSIONS

1. The vegetation changes reconstructed on the basis of pollen and macrofossil analyses, show that open pine forest which was established at the end of the Allerød, survived through the Younger Dryas only slightly changed. At the beginning of the Holocene, expansion of trees (*Ulmus*, *Quercus*, *Tilia*, *Fraxinus*, *Alnus*, and *Corylus avellana*) with higher ecological requirements started. They occurred in different habitats with respect to geomorphology, water conditions and soil type. Differentiated mixed deciduous forests including these taxa, dominated in the region up to 5000 BP.

2. From about 8700 BP *Fagus* spread in the mixed deciduous forests growing on limestone heights and from about 4800 BP *Carpinus*, *Fagus*, and *Abies* immigrated in the forests of mesotrophic habitats, and reached a dominating position after ca. 3750 ± 110 BP.

3. Significant vegetation changes took place around the studied profiles and in the region in the late Holocene (Subboreal and Subatlantic chronozones), as result of increasing human activities and deforestation.

Reconstruction of the vegetation history in the Subatlantic chronozone was limited by the changes in sedimentation, which were caused by drainage before and during sand exploitation for industrial purposes (since the second half of the 20th century).

4. In the lakes and at their shores, aquatic and mire plants occurred at the end of the Allerød and in the Younger Dryas. *Isoëtes lacustris* and *Potamogeton* spp. were most common. From about 8700 BP the lakes became overgrown and turned into bogs, where *Eriophorum vaginatum* and *Oxycoccus* occurred.

5. The dune forming processes, took place before the accumulation of organic sediments started in depressions among the dunes. The oldest studied sediments were deposited at the end of the Allerød. Then it could be assumed, following Szczypek (1986), that the oldest phase of dune formation took place in this region in the Older Dryas. The second phase of dune formation in the Late Glacial could be associated with the end of the Younger Dryas. The third phase of this process, but of a local range, occurred in the older part of the Boreal chronozone triggered by fire, was represented by dune sands about 150–200 cm thick. Sands covered the analysed organic sediments of the profiles 1 and 2 from 1971.

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REFERENCES

CZEPPE Z. 1972. Regiony fizycznogeograficzne Wyżyny Krakowsko-Wielińskiej (Physical-geographical regions of the Kraków-Wieluń Upland). Studia Ośrodka Dokumentacji Fizjograficznej, 1: 68–77. (in Polish).

ERDTMAN G. 1943. An introduction to pollen analysis. Chronica Botanica, Waltham, Massachusetts.

GALON R. 1958. Z problematyki wydm śródlądowych w Polsce. (summary: Sur les dunes continentales en Pologne): 13–31. In: Galon R. (ed.) Wydmy śródlądowe Polski. PWN, Warszawa.

GALON R. 1959. New investigations of inland dunes in Poland. Przegl.Geogr, Suppl., 31: 93–110.

IZMAIŁOW B. & NALEPKA D. 1994. Wiek i efektywność najmłodszej fazy rozwoju wydmy w Przerytym Borze na Wysoczyźnie Tarnowskiej (summary: Age and effectiveness of the youngest development phase of the dune in Przeryty Bór on the Tarnów Plateau): 33–44. In: Nowaczyk B. & Szczypek T. (eds) Vistuliańsko-holoceńskie zjawiska i formy eoliczne – wybrane zagadnienia (Vistulian and holocene aeolian phenomena and landforms – selected problems). Stowarzyszenie Geomorfologów Polskich, Poznań.

KOPYTOWSKI C. 1931. Jeziorka efemeryczne na obszarze wydmowym Warciańsko-Noteckim (summary: Les petits lacs éphémères entre les dunes sur la Warta). Bad. Geogr. nad Polską Płn.-Zach., 6–7: 125–135.

KOZARSKI S. & TOBOLSKI K. 1968. Holoceńskie przeobrażenia wydm śródlądowych w Wielkopolsce w świetle badań geomorfologicznych i palynologicznych (summary: Holocene transformation of inland dunes in Wielkopolska in the light of geomorphological and palynological investigation). Folia Quaternaria, 29: 127–134.

KOZIOŁ S. 1952. Budowa geologiczna Pustyni Błędowskiej (summary: Geological structure of the

Błędów Desert). Państw. Inst. Geol., Biul., 65: 383–410.

LENCEWICZ S. 1922. Wydmy śródlądowe Polski. Przegl. Geogr., 2: 301–316.

ŁAWRYNOWICZ M. 1983. *Cenococcum graniformae* w Polsce (summary: *Cenococcum graniformae* in Poland). Acta Mycologica., 19(1): 31–40.

MANGERUD J., ANDERSEN S.T., BERGLUND B.E. & DONNER J.J. 1974. Quaternary stratigraphy of Norden, a proposal for terminology and classification. Boreas, 3(3): 109–128.

NOWACZYK B. 1976. Geneza i rozwój wydm śródlądowych zachodniej części Pradoliny Warszawsko – Berlińskiej w świetle badań struktury uziarnienia i stratygrafii budujących je osadów (summary: The genesis and development of inland dunes in the western part of the Warsaw - Berlin Pradolina in the light of examinations of the structure, granulation and stratigraphy of the sediments which build them). Prace Kom. Geogr.-Geol. Poznań. Tow. Przyj. Nauk, 16: 1–108.

NOWACZYK B. 1986. Wiek wydm, ich cechy granulometryczne i strukturalne a schemat cyrkulacji atmosferycznej w Polsce w późnym vistulianie i holocenie (summary: The age of the dunes, their textural and structural properties against atmospheric circulation pattern of Poland during the late Vistulian and Holocene). Adam Mickiewicz Univ. Poznań, Ser. Geogr., 28: 1–245.

PODBIELKOWSKI Z. & TOMASZEWICZ H. 1982. Zarys hydrobotaniki. PWN, Warszawa.

ROTNICKI K. 1970. Główne problemy wydm śródlądowych w Polsce w świetle badań wydmy w Węglewicach (summary: Main problems of inland dunes in Poland based on investigations of the dune at Węglewice). Prace Kom. Geogr.-Geol. Poznań. Tow. Przyj. Nauk, 11(2): 1–146.

RÓŻYCKI S. 1960. Czwartorzęd regionu Jury Częstochowskiej i sąsiadujących z nią obszarów (summary: Quaternary of the Częstochowa Jura Chain and the adjacent area). Przegl. Geol., 8: 424–429.

RÓŻYCKI S. 1972. Plejstocen Polski Środkowej na tle przeszłości w górnym trzeciorzędzie. PWN, Warszawa.

SOLIMAN G. 1973. Wyniki analizy pyłkowej profilu z obszaru wydmowego doliny Białej Przemszy w okolicy Jęzora koło Szczakowej. Archives of the Institute of Botany, Jagiellonian University, Kraków.

STASZKIEWICZ J. 1961. Zmienność współczesnych i kopalnych szyszek sosny zwyczajnej, *Pinus silvestris* L. (summary: Variation in recent and fossil cones of *Pinus silvestris* L.). Fragm. Florist. Geobot., 7(1): 97–160.

SZAFER W. 1972. Szata roślinna Polski niżowej. In: SZAFER W. & ZARZYCKI K. (eds) Szata Roślinna Polski, 2. PWN, Warszawa.

SZCZYPEK T. 1986. Procesy wydmotwórcze w środkowej części Wyżyny Krakowsko-Wieluńskiej na tle obszarów przyległych (summary: Dune forming processes in the middle part of the Cracow-Wieluń Upland against a background of the neighbouring area). Prace Nauk. Uniw. Śląskiego, 823: 1–177.

TOBOLSKI K. 1963. Analizy pyłkowe z Osieckiego Bagna – pow. Lębork (summary: Pollen analysis from Osieckie Bagno – Osieckie Bog). Bad. Fizj. Pol. Zach., 12: 301–316.

TOBOLSKI K. 1966. Późnoglacjalna i holoceńska historia roślinności na obszarze wydmowym w dolinie środkowej Prosny (summary: The Late-Glacial and Holocene history of vegetation in the dune area of the middle Prosna valley). Prace Kom. Geogr.-Geol. Poznań. Tow. Przyj. Nauk, 32(1): 1–68.

TOBOLSKI K. 1969. Fazy wydmowe w świetle badań palinologicznych – zagadnienie ich liczby i charakterystyka przebiegu (summary: Dune-forming stages in the light of palynological examinations – problems dealing with the number of stages and the characteristic of their history). In: Galon R.(ed.) Procesy i formy wydmowe w Polsce. Prace Geogr. Inst. Geogr. PAN, 75: 101–116.

TOKARSKA-GUZIK B. 1999. Atlas rozmieszczenia roślin naczyniowych w Jaworznie (Wyżyna Śląska) Atlas of vascular plants distribution in Jaworzno (Silesian Upland). Institute of Botany of the Jagiellonian University, Botanical Papers, 34: 1–292.

WALANUS A. & NALEPKA D. 1996. Program POLPAL – Palinologiczna Baza Danych. Instrukcja obsługi (1994). Instytut Botaniki im. W. Szfera Pol. Akad. Nauk, Kraków.

WALANUS A. & NALEPKA D. 1999. POLPAL. Program for counting pollen grains, diagrams ploting and numerical analysis. Acta Palaeobot., Suppl., 2: 659–661.

WASYLIKOWA K.1964. Roślinność i klimat późnego glacjału w środkowej Polsce na podstawie badań w Witowie koło Łęczycy (summary: Vegetation and climate of the Late-Glacial in Central Poland based on investigations made at Witów near Łęczyca). Biul. Perygl., 13: 261–417.

PLATE

Plate 1

Fossil plant remains of herbcaeous plants from Jęzor-Jaworzno 1998

1,2. *Potamogeton natans* L., endocarps, ×15, zone JJ-2
3. *Potamogeton* cf. *perfoliatus* L., endocarp, ×15, zone JJ-1
4. *Potamogeton pusillus* L., endocarp, ×15, zone JJ-1
5. *Nuphar lutea* (L.) Sibth. & Sm., seed, ×15, zone JJ-3
6. *Nuphar pumila* (Timm) DC., seed, ×15, "middle of bottom"
7. *Nymphaea alba* L., seed, ×15, zone JJ-3
8. *Nymphaea alba* L., sculpture of seed, ×100, zone JJ-3
9. *Comarum palustre* L., fruit, ×20, zone JJ-5
10. *Menyanthes trifoliata* L., seed, ×15, zone JJ-4
11. *Potentilla supina* L., fruit, ×30, zone JJ-1
12. *Potentilla erecta* (L.) Raeusch., fruit, ×20, zone JJ-5
13. *Ranunculus flammula* L., fruit, ×20, zone JJ-1
14. *Schoenoplectus lacustris* (L.) Palla, fruit, ×15, zone JJ-1
15. *Eleocharis palustris* Roem. & Schult., fruit, ×15, zone JJ-1
16. *Schoenus nigricans* L., fruit, ×15, zone JJ-7
17. *Oenanthe aquatica* (L.) Poir., fruit, ×15, zone JJ-1
18. *Carex elata* All., fruit, ×15, zone JJ-2
19. *Carex* cf. *riparia* Curtis, fruit, ×15, zone JJ-4
20. *Carex riparia* Curtis, epicarp, ×15, zone JJ-4
21. *Sparganium minimum* Wallr., endocarp, ×15, zone JJ-1
22. *Linaria vulgaris* Mill., seed, ×15, "middle of bottom"
23. *Eriophorum vaginatum* L., sclerenchymatic spindles, ×15, zone JJ-5
24. *Eriophorum vaginatum* L., fruit, ×15, zone JJ-4
25. *Carex gracilis* Curtis, fruit, ×15, zone JJ-1
26. *Sparganium emersum* Rehmann, endocarp, ×15, zone JJ-1
27. *Urtica dioica* L., fruit, ×15, zone JJ-1
28. *Hypericum perforatum* L., seed, ×30, zone JJ-1

phot. R. Stachowicz-Rybka


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