INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION
POLISH ACADEMY OF SCIENCES
www.igipz.pan.pl

www.geographiapolonica.pl

SUPPLEMENTARY MATERIAL TO THE ARTICLE:

Hrynowiecka, A., Brzozowicz, D., Żarski, M., Stachowicz-Rybka, R., Pidek, I. A. (2024). Sedimentation gaps documented in the Eemian (MIS 5e) record in four profiles from the Żabieniec palaeolake (Central Poland). *Geographia Polonica*, *97*(3), 231-259. https://doi.org/10.7163/GPol.0278

Table I. Vegetation development description acc. to pollen zones in the Żabieniec Ża19 diagram (Fig. 4) with references to the Ża0 pollen and plant macrofossils data (Fig. 7)

RPAZ no and name Corresponding depth in the Ża19 pollen diagram	Terrestrial vegetation description	Aquatic and reed-swamp vegetation description
E1 Pinus-Betula 1070-1105 cm (Ża19-1 *Betula-Pinus*-NAP and Ża19-2 *Betula-Pinus*)	Pioneering birch-pine forests in the early interglacial. The lake was surrounded by pines and woody birches (records of *Pinus sylvestris* bud scales and fruits of *Betula* sect. *albae*). Formation of birch swamp wood type communities with *Betula pubescens* was also possible. Despite the rapid increase in the values for arboreal birch pollen in the *Pinus-Betula* zone and the significant share of *Pinus sylvestris* t., there is still a significant share of NAP, which suggests that the open herbaceous communities continued to play a significant role in the landscape. Drier habitats were occupied by communities of grasses, *Artemisia*, Chenopodiaceae and *Anthemis*. Wet habitats were occupied by sedges, *Thalictrum,* Rubiaceae, and *Filipendula*. *Juniperus* could grow on drier habitats, while willow thickets were frequent in wet habitats.	Relatively well formed littoral zone with *Typha latifolia* is reflected by plant macrofossils in Ża0 (Fig. 7), despite their low frequency in the zone corresponding to the transition from the Late Saalian to E1 RPAZ. At the initial phase of lake formation there were also bryozoans *Cristatella mucedo*. Local vegetation in all three palaeolakes documents the presence of a reedswamp community with *Sparganium*, *Phragmites*, and *Typha*, the presence of aquatic vegetation represented by Nymphaeaceae and *Ceratophyllum* species, as well as *Pediastrum*, *Botryococcus*, *Tetraedron* algae. Pollen diagrams (Figs 3-6) indicate the presence of brown mosses, as well as *Sphagnum* near the deepest fossil lake (possibly in a mosaic with sedges).

RPAZ no and name Corresponding depth in the Ża19 pollen diagram	Terrestrial vegetation description	Aquatic and reed-swamp vegetation description
E2 Pinus-Betula-Ulmus 1035-1070 cm	Pine-birch forests still dominated. However, were quickly replaced in river valleys by encroaching riverine communities, mainly formed by *Ulmus* and *Quercus* with Filicales monolete in undergrowth. Granoszewski (2003) emphasized that one oak species (i.e. *Quercus robur*) has a strong affinity to riverine communities. *Fraxinus* arrived soon after oaks and elms.	No significant changes in comparison to the previous phase were recorded. Aquatic and reedswamp vegetation was composed of the same taxa as before, but there was a slightly more abundant record of *Pediastrum, Botryococcus* and *Tetraedron* algae, more frequent pollen of *Typha latifiolia* t. and *Sparganium*, as well as nympheids and hair-like leaves of *Ceratophyllum*
E3 Quercus-Fraxinus-Ulmus (Ża19 – 995-1030 cm; Ża0 – 720-740 cm; Ża1 – 315-335 cm; Ża2 – 270- 305 cm)	Withdrawal of pioneering forests dominated by pine and birch, and the expansion of oak is visible in the rapid drop in pollen values for *Betula* and *Pinus* together with a rapid increase in the share *of Quercus* indicate. Riverine communities transformed: the role of *Ulmus* and *Quercus* increased, and there is a growing record of *Fraxinus* that gained importance. At the end of the E3 RPAZ values of *Corylus* increase significantly, which is probably associated with the arrival of hazel and withdrawal of birch from drier habitats. At the same time there are the first records of *Tilia* and *Alnus* pollen grains.	An increased share of seeds of *Najas marina*, statoblasts of *Cristatella mucedo*, and the presence of Characeae oospores (Fig. 7). In Ża0-2 LMAZ corresponding to the E3 phase the structure of vegetation in the lake slightly changed compared to that during the E2. The significant difference is a slight increase in the share of reedswamp plants.
E4 Corylus-Quercus-Tilia (Ża19 – 950-990 cm; Ża0 – 700-720 cm, Ża1 – 280-325 cm; Ża2 – 215-280 cm)	Elm-ash riverine communities were still widespread, but they might have been enriched with new trees of *Alnus* and *Tilia cordata*. Vines of *Humulus lupulus* and *Hedera helix* were present in the floodplain forests. The expansion of *Corylus* took place (*Corylus* pollen values reached high maximum) and marked the beginning of the climatic optimum. On drier habitats hazel could form patches of hazel thickets. *Alnus* spread to more waterlogged places. *Taxus baccata* probably grew in mixed riverine forests under the canopy of taller trees. Soon after the peak of *Corylus* there was an expansion of *Carpinus* and *Tilia*. The composition of thermophilic riverine communities included *Quercus*, *Fraxinus* and *Ulmus*, and probably *Acer* and *Taxus*. Alder was also spreading to form communities resembling contemporary alder carrs. *Alnus* together with *Fraxinus* could also form riverine communities in the type of *Fraxino-Alnetum*. Arboreal willows and *Humulus lupulus* were also present in these communities.	Ża0-3 LMAZ which bottom part corresponds to E4 RPAZ bears a record of significant change (Fig. 7). It involves the arrival of taxa demanding a milder climate and indicates significant warming. The presence of *Aldrovanda vesiculosa* and megaspores of *Salvinia natans*, an aquatic fern usually associated with the warm zone of the temperate suboceanic climate, is characteristic of Eemian floras. Pollen diagrams (e.g. Fig. 4) now contain a greater number of hair-like leaves of *Ceratophyllum,* indicating an increased abundance of this pond weed and directly an increase in water level. The record of *Myriophyllum spicatum* pollen is continuous. There are also more abundant trichosclereids of Nymphaeaceae, but almost no record of *Phragmites* pollen. Throughout the zone, there is a scarce record of *Sphagnum* spores evidencing the presence of peat-forming communities.

RPAZ no and name Corresponding depth in the Ża19 pollen diagram	Terrestrial vegetation description	Aquatic and reed-swamp vegetation description
E5 Carpinus-Corylus-Alnus RPAZ (Ża19 – 865-945 cm; Ża0 – 640-690 cm; Ża1 – 220-275 cm; Ża2 – 145-210 cm)	Rapid increase in pollen values for *Carpinus betulus* means that hornbeam was a forest-forming tree, and together with lime it co-dominated most of the area. Other taxa present in these multi-species forests were *Acer*, *Quercus*, *Fraxinus*, *Ulmus*, as well as *Taxus* and *Picea abies* in some locations. An abundance of spruce in forests in the analysed area is dated to a relatively early time, because *Picea* pollen values in this zone are high from the early hornbeam phase. Such a high share of spruce might indicate a high humidity of habitat. This is also supported by other findings, i.e. an increased share of Filicales monolete and Cyperaceae in the pollen diagram. Initially, the share of *Corylus* in forest communities was high and this species formed the understorey and occupied forest margins. However, hazel withdrew relatively fast, giving way to the expansive hornbeam. At that time the underwood was also formed by *Ilex aquifolium*, *Hedera helix*, and *Viscum*. According to Iversen (1944), all the three plant species are indicators of a warm climate with oceanic features. In the younger part of this zone there is a drop in the share of lime, and an increase in the shares of hornbeam and spruce. Spruce could occured also in alder carr type communities. The withdrawal of lime is observed. Alder forests on wet habitats remained stable. Different types of wet forests were the source of pollen from *Humulus lupulus*, *Filipendula*, *Thalictrum* and partly Apiaceae, and very abundant spores of ferns,	There was a clear change in aquatic and reedswamp vegetation since the beginning of the zone. There is no record of Nymphaeaceae, *Myriophyllum spicatum*, *Ceratophyllum*, *Typha latifolia*, or *Sparganium* in the pollen diagram. On the other hand, pollen values for Cyperaceae increased significantly, with a peak in the middle of the hornbeam phase, just before the increase in the value for *Picea abies*. In parallel, there is also a considerable increase in the share of Filicales monolete spores, including *Thelypteris palustris*. An increase in the share of Musci spores is observed, including an occasional record of *Sphagnum*. These changes indicate paludification of the lake and the formation of peatbog communities. In the upper part of the Ża0-3 LMAZ, corresponding to E5, where taxa characteristic for milder climate were recorded, clearly indicating an increase in temperature. The presence of *Brasenia* sp. and *Aldrovanda vesiculosa*, taxa characteristic of the Eemian flora as well as *Carpinus betulus* and *Acer campestre* allows this zone to be related to the E5 RPAZ. The presence of *Salvinia natans* – an aquatic thermophilic fern is also important. Analysis of the diagram of plant macrofossils recorded in the Ża-0 profile indicated the withdrawal of most planktonic taxa during this time, while in pleustonic communities there was a more abundant presence of *Lemna trisulca,* preferring very shallow eutrophic lakes.

RPAZ no and name Corresponding depth in the Ża19 pollen diagram	Terrestrial vegetation description	Aquatic and reed-swamp vegetation description
	including *Thelypteris palustris* (=*Drypteris thelypteris*). However, the overall share of NAP in pollen diagrams is low, except for Cyperaceae, indicating that most habitats were occupied by forests. The persistently waterlogged habitats were occupied by sedge mires communities typical of river valleys. At the end of E5 RPAZ a drop in the share of lime and elm in the pollen diagram is synchronised with an increase in the share of spruce, but also the arrival of fir and pine pollen, as well as the greater abundance of birch pollen. An increase in the share of spruce is very rapid, which might evidence the increased wetness of habitat. The presence of communities composed of conifers could certainly intensify the leaching and acidification of soils. However, the presence of *Hedera*, *Viscum* and *Buxus* shows that increased climate humidity was not associated with cooling. Persistently high shares of *Carpinus* in pollen diagrams still document a significant role of communities dominated by hornbeam. There was a gradual withdrawal of *Tilia*, *Acer*, *Fraxinus* and *Ulmus*.	
E6 Picea-Abies-Alnus RPAZ (Ża19 – 785-786 cm; Ża0 – 510-630 cm; Ża1 – 200-240 cm; Ża2 – 120-140 cm)	Conifers become dominant in this zone, and *Picea abies* has a special role. Such a significant spread of spruce, documented by its very high values in pollen diagrams, was certainly promoted by an increase in climate humidity, but also a decrease in temperature and more distinct differences between seasons. The increase in the share of spruce is accompanied by an increase in the share of *Abies*, but also a marked decrease in the that of *Carpinus*. Other thermophilic trees withdrew earlier. This zone also no longer contains a record of thermophilic shrubs or vines.	The diagram of plant macrofossils for Ża0 profile (Fig. 7) indicates a significant drop in the water level, and this results in the total disappearance of aquatic vegetation and the formation of a transitional peatbog. A change towards oligotrophization of water was already marked earlier, in the upper layer of the Ża0-4 zone, and from the bottom of Ża0-5 LMAZ. *Rhynchospora alba* occurred, and this species, along with *Scheuchzeria palustris*, or *Carex diandra*, is found mainly in transitional bogs and in wet depressions of raised bogs. Sediment mostly contained shoots of brown mosses, and there was an increased share of sedges, e.g. *Carex elata* and *C. vesicaria*. An increase in water level might also be evidenced by the simultaneous increase in the share of *Alnus* pollen and the presence of sedges. Ża0-6 LMAZ, containing very abundant sclerotia of *Cenococcum geophilum*, gemmules of Porifera, and wood debris, might indicate a large supply of sediment washed from the banks of the lake.

RPAZ no and name Corresponding depth in the Ża19 pollen diagram	Terrestrial vegetation description	Aquatic and reed-swamp vegetation description
E7 Pinus RPAZ (Ża19 – 730-780 cm; Ża0 – 430-500 cm; Ża1 – 145-180 cm; Ża2 – 105-115 cm)	The complete dominance of pine forests initially with an admixture of *Picea* indicates a further gradual deterioration of climate conditions. In lower areas of peatlands, mixture of *Picea* may have been more abundant and may created spruce-pine boreal forest (*Sphagno–Piceetum),* as confirmed by *Sphagnum* spores. Herbaceous vegetation was of increasing importance, which indicates a thinning of forest.	Records for the late E6 and E7 in the analysis of plant macroremains are very scarce. Ża0-7 LMAZ, corresponding to these phases, contains very few remains of plants with a broad ecological spectrum, such as woody birches *Betula* sect. *albae*. There is still a record of shoots from brown mosses, as well as the remains of sedges, e.g. *Carex riparia*, *C. elata* and *C. vesicaria*. A single fragments of *Myriophyllum* spines has been found, which together with increasing values for *Pediastrum* indicate a rise in water level.
Early Vistulian Glaciation (Ża0 – 420 cm; Ża1 – 50 cm)	Characteristic for the first post-Eemian cooling of Vistulian is the growth of open communities of herbaceous vegetation. *Pinus* probably withdrew completely from the vicinity of the palaeolake. In drier habitats, steppe communities with a high proportion of Poaceae, *Artemisia*, Chenopodiaceae, *Juniperus* spread. In more humid areas dominated Cyperaceae and *Salix*. The presence of *Sphagnum* spores is evidence of peat bogs presence in the area. It is these that formed habitats suitable for shrub tundra communities.	At the end of the interglacial the increase in climate humidity resulted in an increase in the groundwater level and the return of many taxa representing aquatic vegetation. *Callitriche autumnalis* and *Hippuris vulgaris* occurred in cool waters. The taxonomic composition of the upper part of Ża0-7 and Ża0-8 LMAZ in Ża0 profile, corresponding to the Early Vistulian (EG in Fig. 7) indicates a gradual deterioration of climate, which is confirmed by the presence of *Betula humilis* and *B. nana* fruits.