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Palynology of biogenic sediments of the Eemian Interglacial at Bieganin near Kalisz, Central Poland

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The paper presents palynological data from Bieganin, a village located near Kalisz, Central Poland, where organic sediments were deposited in a subglacial trough dating from the Wartanian Glaciation. The succession of vegetation is characteristic of the Eemian Interglacial. The pollen diagram indicates six local pollen assemblages: B1 — *Pinus-Betula*, B2 — *Betula-Pinus-Ulmus*, B3 — *Quercus-Corylus*, B4 — *Corylus*, B5 — *Carpinus-Tilia*-Polypodiaceae, B6 — *Pinus-Picea* which correlate well with regional pollen assemblages obtained by Mamakowa (1989*b*) and Tobolski (1991). The plant succession in Bieganin started in the beginning of the Eemian (zone E1) and ended with the development of coniferous forest (zone E6). The profile does not include the final zone, E7, of the interglacial.

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Key words: Central Poland, Eemian Interglacial, pollen analysis, history of vegetation.

INTRODUCTION

The biogenic deposits analysed were collected from a borehole core, described by Krzysztof Boniecki and Jan Jeziorski, made for the *Detailed Geologic Map of Poland* (1:50 000 scale, Skalmierzyce Sheet). The site is located about 27 km to the west of Kalisz, on the Kalisz Plateau (Fig. 1).

Before the 1990's only one palaeobotanical study of Eemian vegetation from Kalisz was known (Tołpa, 1952) and only one palynological study from Zębców (Borówko-Dłużakowa, 1978) (Fig. 1). The Kalisz Plateau has since been described as regards the history of vegetation of the Eemian Interglacial (Malkiewicz, 2002).

GEOLOGY

The main deposits of the Kalisz Plateau consist of sediments deposited during the Wartanian Glaciation (Boniecki and Jeziorski, 1995). Intense denudation processes during the Eemian Interglacial and the Vistulian Glaciation caused a significant levelling of this upland and a marked thinning of the thickness of the Wartanian Glaciation deposits. The Pleistocene cover has been affected by this erosion to such a degree, that the Pliocene clays are exposed locally. The heights typical for the lowland areas vary from about 104 m a.s.l. in the northeastern part of the upland, to about 161.5 m a.s.l. in the western part of the area. However, inselbergs of frontal moraines and Wartanian Glaciation kames are locally preserved, and their heights may reach up to 190 m a.s.l. (Kondracki, 1965, 1994).

The boreholes revealed three sedimentary basins in which organic accumulation occurred, in a N–S oriented narrow subglacial trough several kilometers long. This trough was carved at the end of the Wartanian Glaciation (Boniecki and Jeziorski, 1995) (Fig. 2). The age of deposits from the borehole in the northern part of the trough date from the Eemian Interglacial and the beginning of the Vistulian (Malkiewicz, 2002).

A lacustrine succession 2.00 m thick was drilled in the southern part of the trough (borehole W 51). Deposits from the depth interval 1.60–2.60 m were analysed for pollen (Fig. 3). They are underlain by clayey silts and boulder clay of the Wartanian Glaciation. The top of the organic succession comprises fine sands with gravel and clayey sands, dating from the Vistulian Glaciation. The locality is situated in the zone between the maximum limit of the Wartanian Glaciation (W) and the maximum limit of the Vistulian Glaciation (V) (Fig. 1).

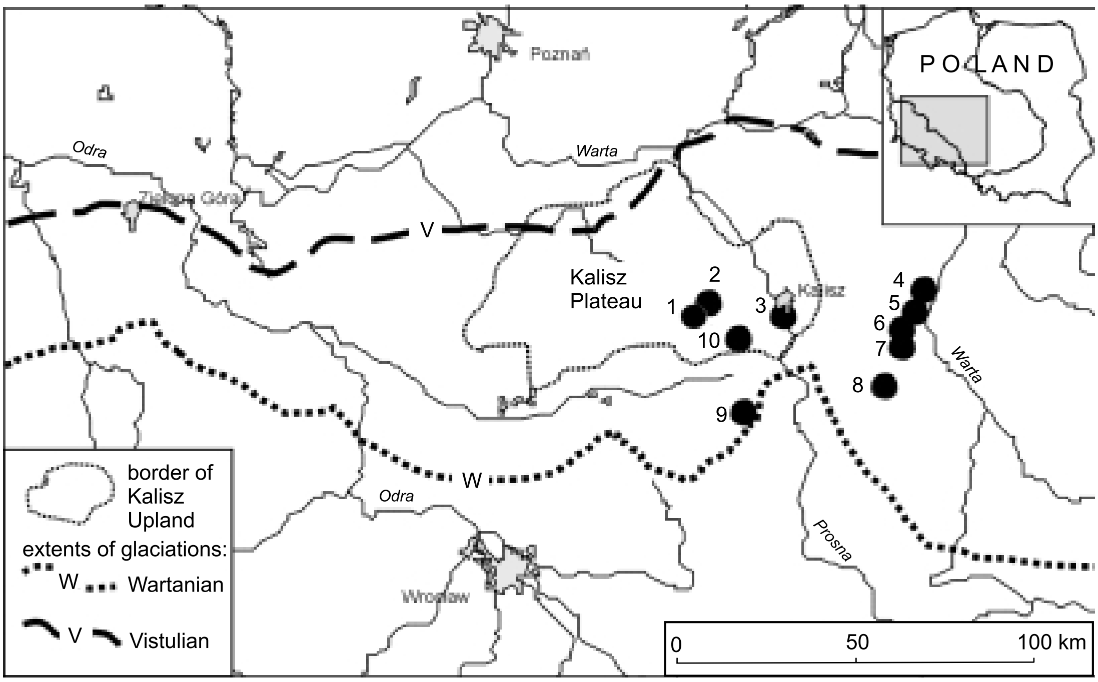

Fig. 1. Location of sites with Eemian biogenic deposits near Kalisz (Wielkopolska Lowland)

1 — Bieganin, 2 — Grudzielec Nowy (Malkiewicz, 2002), 3 — Kalisz (Tołpa, 1952), 4 — Maszew (Klatkowa, 1990), 5 — Ustków (Klatkowa and Załoba, 1991), 6 — Raczków (Załoba and Jastrzębska-Mamełka, 1990*a*), 7 — Zagajew (Załoba and Jastrzębska-Mamełka, 1990*b*), 8 — Emilianów (Klatkowa and Załoba, 1991), 9 — Domasłów (Rotnicki and Tobolski, 1965), 10 — Zębców (Borówko-Dłużakowa, 1978)

METHOD

22 samples collected *ca*. every 5 cm were subjected to palynological analysis. The peat sediments were boiled in 10% KOH, while the samples with significant mineral contents (silts with sand) were treated for 24 hours with hydrofluoric acid. The material prepared this way was macerated by acetolysis (Erdtman, 1952). Pollen spectra were counted on two or three preparations. The basic sums varied from 800 up to 1000. The results of pollen analysis are shown on a pollen diagram (Fig. 4). The percentage calculations were based on the total sum (AP + NAP), in that the trees and shrubs (AP) as well as the herbaceous plants (NAP) were included. Aquatic, swampy plants and Polypodiaceae were excluded from the total sum.

POLLEN ANALYSIS

In the pollen diagram, six local pollen zones (L PAZ) were distinguished, numbered from the bottom to the top of the section and indicated by the symbol B (Fig. 4).

Zone B1 — *Pinus-Betula* L PAZ (sample 22, depth 2.60 m). *Pinus* (56.0%) and *Betula* (20.5%) predominate. Pollen of *Juniperus, Salix, Ulmus, Quercus, Tilia* and *Picea* were rarely found. NAP is to 16.2% and is mainly composed of *Artemisia*, Chenopodiaceae, Cyperaceae and Poaceae. Among aquatic and swampy plants, *Myriophyllum spicatum* (2.9%), *Sparganium* (0.5%) and *Lemna* (0.5%) were recorded.

Zone B2 — *Betula-Pinus-Ulmus* L PAZ (samples19–21, depth 2.40–2.60 m), predominantly with *Betula* (60.0%) and *Pinus* (32.0%). *Ulmus* (maximum 3.2%) and *Quercus* (maximum 2.5%) occur regularly. The NAP percentage is below 10.0%. Among aquatic and swampy plants, *Myriophyllum spicatum* (3.3%) still dominates.

Zone B3 — *Quercus-Corylus* L PAZ (samples 12–18, depth 2.05–2.40 m). Pollen spectra of this zone are dominated by *Quercus* (maximum to 45.0%) and *Pinus* (maximum to 28.0%). The percentage content of *Corylus* increases to 47.0%. The herbaceous plants equal 4.6%. A smooth curve is formed by *Sparganium* and *Typha*. The proportion of *Myriophyllum spicatum* decreases to 1.2%.

Zone B4 — *Corylus* L PAZ (samples 7–11, depth 1.80–2.05 m) is dominanted by pollen of *Corylus* (49.0–69.0%), accompanied by *Quercus* (to 22.0%), *Carpinus* (to 7.1%), *Ulmus* (to 2.8%), *Fraxinus* (to 2.5%), *Tilia* (to 4.8%) and *Alnus* (to 6.3%). The content of herbs reaches *ca*. 5.0%. The Polypodiaceae increase up to 25.5%.

Zone B5 — *Carpinus-Tilia*-Polypodiaceae L PAZ (samples 3–6, depth 1.65–1.80 m). Among the trees, there predominantly pollen of *Corylus* (18.0–47.0%), *Carpinus* (17.5–26.5%) and *Tilia* (4.0–12.5%). A smoth curve is formed by *Quercus* (2.0–8.3%), *Alnus* (4.1–14.5%), *Ulmus* (1.9–3.4%) and *Picea* (2.1–5.5%). The total of NAP is still low (5.0–5.8%). The Polypodiaceae reach a maximum in this profile (70.0%).

Zone B6 — *Pinus-Picea* L PAZ (samples 1–2, depth 1.60–1.65 m) with high contents of coniferous trees: *Pinus* (43.0–44.0%), *Picea* (3.2–6.0%) and *Abies* (0.6–1.7%). Herbs

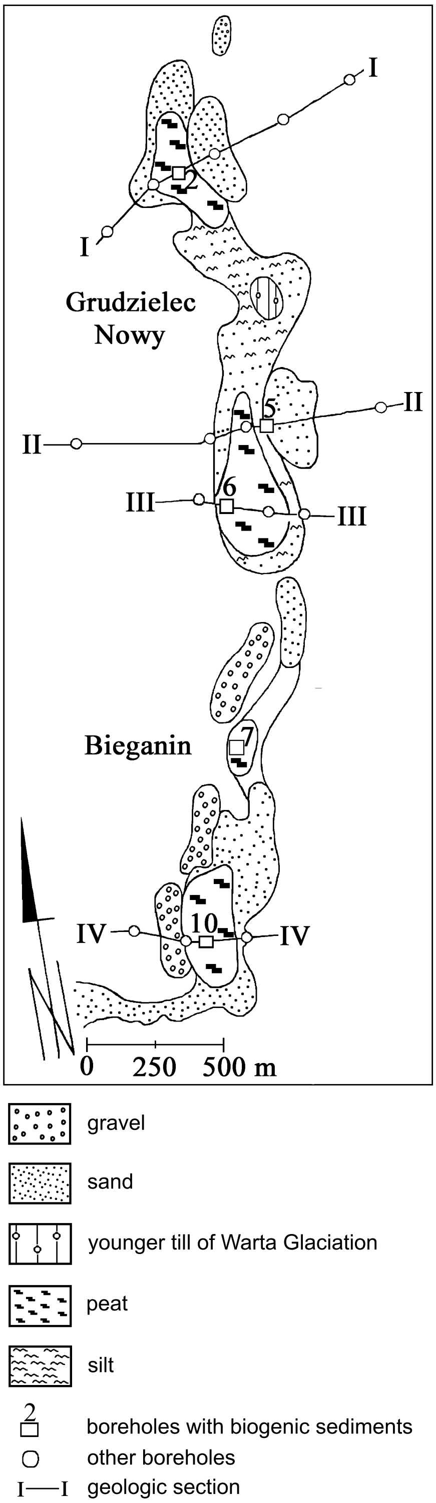

Fig. 2. Subglacial trough Grudzielec Nowy–Bieganin

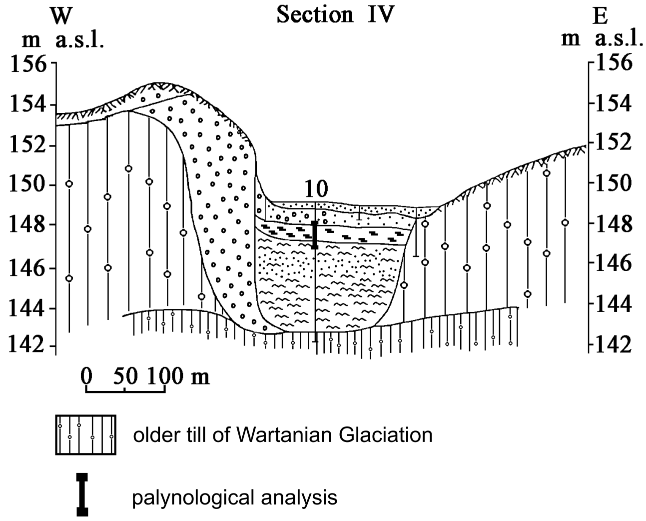

Fig. 3. Geological section IV of the sites with deposits of the Eemian Interglacial (Boniecki and Jeziorski, 1995)

For other explanations see Figure 2

reach their maximum in this zone (25.7%). Among aquatic and swampy plants *Myriophyllum spicatum, Nymphaea alba, Sparganium* and *Typha* are present.

HISTORY OF LOCAL VEGETATION AND BIOSTRATIGRAPHY

The vegetational changes clearly point to the Eemian age of these deposits. The local pollen assemblage zones (L PAZ) distinguished may be correlated with the regional pollen zones (R PAZ) proposed for Poland (Mamakowa, 1989*b*), and the Konin region (Tobolski, 1991) (Table 1). The plant succession in Bieganin started with the development of pine-birch forest (E1) and ended as coniferous forest began to grow (zone E6). The profile does not include the final zone, E7, of the interglacial.

The palynological analysis indicated that in the bottom part of the profile (B1) there are pollen grains characteristic of the initial phase of the Eemian Interglacial, with *Betula* and *Pinus* marking the development of a local pine-birch forest. Willows and elm occurred in moist habitats. The photophilous plants *Juniperus, Artemisia*, Chenopodiaceae, Cyperaceae and *Helianthemum* were important. The climate was not so cold and dry as in the older part of the zone E1 (Mamakowa, 1989*b*; Tobolski, 1991). The presence of *Typha-Sparganium* and *Myriophyllum* suggests an average temperature in the warmost month of 14–15°C (Mamakowa, 1989*b*; Tobolski, 1991; Kuszell, 1997).

Zone B2 represents the communities of birch forest with an admixture of pine. The increasingly warm climate resulted in the development of forest with elm, oak and hazel in the undergrowth. On moist soils forest communities developed, with the participation of elm, alder and spruce, as well as with an admixture of ash and willow. The distinctive feature of zone B2 in Bieganin is the culmination of *Ulmus*.

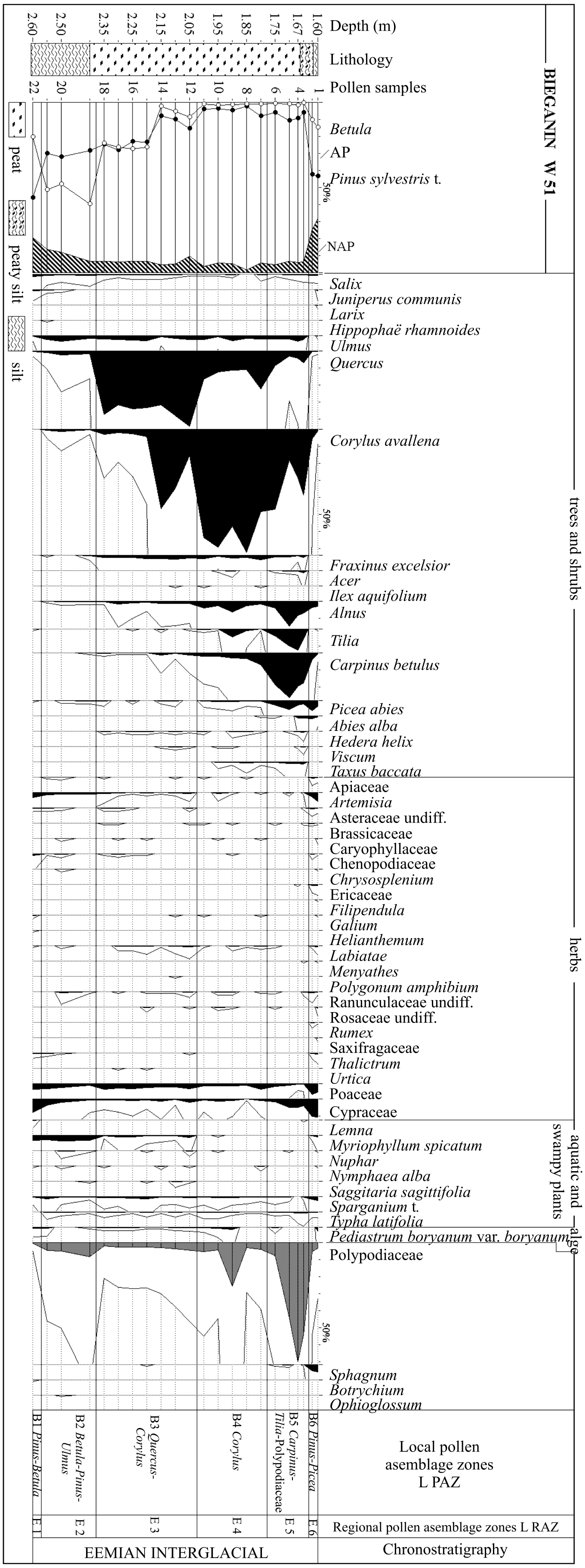

Fig. 4. Pollen diagram of biogenic sediments from Bieganin

In the next zone (B3) of the region studied there spread oak-pine forest, with increasing proportions of hazel in the undergrowth. As like in other localities of the southwestern area of Poland (Mamakowa, 1989*b*) and Wielkopolska (Kuszell, 1997; Malkiewicz, 2002), there were also communities of light oak forest type. Riverside forest with elm, ash, alder, willow and spruce also became more significant. The climate was considerably warmer in this period. The appearance of *Hedera* and *Viscum* in zone B3 points to moderately high temperatures in the summer and with temperatures in January higher than –1.5°C (Iversen, 1944).

Zone B4 representats the climatic optimum, when a marked development of thermophilous deciduous forest occurred in the area studied. These above all comprised hazel forest, beside which still occurred oak forest and oak-pine forest, with local communities of hornbeam-lime forest. Riverside communities still prevailed in moist habitats. The forest around Bieganin, also included *Hedera, Viscum*, *Ilex* and *Taxus*. The climate was warm and oceanic. The average temperature of the climatic optimum of the Eemian Interglacial was higher than during the Holocene: for July it was 20–22°C, and, for January, over 0°C (Zagwijn, 1961; Litt, 1993).

Zone B5 is conspicuous for the greatest diversity of forest communities in the entire Eemian Interglacial. The oak forest, riverside forest and hazel communities were joined by hornbeam-lime forest with a high participation of hazel in the undergrowth. The lake basin at Bieganin was then markedly overgrown, as indicated by the appeareance of *Sphagnum* spores, very high quantities of Polypodiaceae, as well as by a lack of aquatic plants. Furthermore, the maximum of *Alnus* pollen also indicates a marked local spreading of alder forest on to and around the peatbog. A similar lake overgrow the succession zone B5 was observed in a neighbouring profile from Grudzielec Nowy (Malkiewicz, 2002). At that time the climate was still warm and moist and approximated to the Eemian climatic optimum.

In zone B6 there was a gradual disappearance of thermophilous trees and shrubs. These were replaced by coniferous forest with pine, spruce and admixture of fir. Herbaceous plants, including *Artemisia,* Apiaceae, Ericaceae, *Thalictrum,* Cyperaceae and Poaceae, became more prominent. The climate became moderately cool, comparable to that of the upper subalpine-forest zone today (Mamakowa, 1989*b*).

CONCLUSIONS

The results of this palynological study are consistent with current opinions of the Vistulian Glaciation limit in Central Poland.

The vegetational succession in the vicinity of Bieganin closely compares with that shown by the Eemian Interglacial flora at other localities on the Kalisz Plateau and Łódź Upland (Fig. 1). Profiles showing the oak phase was found have similar, high proportions of *Quercus*. They vary from almost 50.0% in Bieganin and Ustków, to over 60.0% in Grudzielec. Moreover, *Corylus* appears suddenly in all the profiles studied; in Bieganin it appears in florae, while the proportion of

Table 1

Pollen zones of the Eemian Interglacial in the Bieganin section (L PAZ), compared with the regional pollen zones (R PAZ) for Poland (Mamakowa, 1989) and for the Konin region (Tobolski, 1991)

Bieganin L PAZ Malkiewicz (2003)	R PAZ	Poland Mamakowa (1988, 1989)	Konin Region Tobolski (1991)
–	E7	*Pinus*	*Pinus*
B6 *Pinus-Picea*	E6	*Pinus-Abies-Alnus*	*Picea-Abies*
B5*Carpinus-Tilia*-Polypodiaceae	E5	*Carpinus-Corylus-Alnus*	*Carpinus*
B4 *Corylus*	E5	*Corylus-Quercus-Tilia*	*Corylus*
B3 *Quercus-Corylus*	E3	*Quercus-Fraxinus-Ulmus*	*Quercus*
B2 *Betula-Pinus-Ulmus*	E2	*Betula-Pinus-Ulmus*	*Betula-Pinus*
B1 *Pinus-Betula*	E1	*Pinus-Betula*	*Betula*

oak is still high. Hazel was probably the dominant species of the shrub-layer in light oak forest, where it had good conditions for flowering. *Carpinus* appears early, while hazel was abundant. In most of the Polish Eemian successions, *Carpinus* appears and reaches its maximum values as *Corylus* decreases, or even later (Noryśkiewicz, 1978; Jastrzębska-Mamełka, 1985; Mamakowa, 1989*a*, *b*; Tobolski, 1991; Kuszell, 1994, 1997). In most of the localities from Kalisz, lime reaches its maximum value after the highest values of hazel, but before the culmination of hornbeam. These profiles represent the localities with "late lime" (Mamakowa, 1989). A different picture was recorded at Kalisz, where lime appears very early, before the highest values of hazel, whereas at Bieganin and Raczków it reached its maximum values very late, after the culmination of hornbeam, not before zone E5. Because of the termination of sedimentation in the basin studied it is difficult to estimate the role of fir at Bieganin. Its proportion in the area investigated is low, and varies from 5–20%. At Kalisz the maximum values of fir were very high (80.0%) only. These differences which occur also in neighbouring profiles (Kuszell, 1980; Mamakowa, 1989; Klatkowa, 1990), have been previously discussed (Mamakowa, 1989; Krupiński, 1992).

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