www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

Studia Quaternaria, vol. 27 (2010): 35–41.

REINVESTIGATION OF THE INTERGLACIAL POLLEN FLORA AT ZBÓJNO, CENTRAL POLAND

Krzysztof Bińka

Institute of Geology, Warsaw University, Al. Żwirki i Wigury 93, 02-098 Warszawa, Poland; e-mail: k.binka@uw.edu.pl

Abstract

The interglacial deposits at Zbójno near Radoszyce (central Poland) was drilled again and reinvestigated by means of pollen analysis. The pollen succession, partly recorded in subaerial sediments with many stratigraphic gaps, treated hitherto as the stratotype of Zbójnian interglacial, does not seem to differ from the Eemian sequence, and may actually be of the Eemian age. This strongly suggests that the term "Zbójno" should be removed from the Polish Pleistocene stratigraphy.

Key words: Eemian, pollen, Zbójno, interglacial, Pleistocene

INTRODUCTION

Looking at the stratigraphic schemes of the Pleistocene in Poland, one can notice that they include some interglacial units which were created first of all on the basis of detailed geological studies, however without reliable palynological record. The Augustovian and Zbójnian interglacials are the best examples (Lindner *et al.* 2006, Ber *et al.* 2007). In the opinion of some palynologists (Janczyk-Kopikowa 1991, Mamakowa 2003) these units should be treated as new interglacials that differ in their succession of vegetation from the Ferdynandovian and the Eemian sequences.

In the late 70-th, at Zbójno near Radoszyce (Fig. 1), western slopes of the Holy Cross Mts, highly decomposed peat, covered by over 2.5 m thick layer of minerogenic sediments, partly interpreted as glacial till, was found. According to Lindner and Brykczyńska (1980) these deposits could be ascribed to the Odranian glaciation. The palynological investigation has revealed unclear pattern of vegetational changes however representing undoubtedly the warm temperate succession. It has then been classified as a new interstadial within the Odranian, placed between the Liwiec stadial in the bottom and the Krzna stadial. Its key feature was the high proportion of *Tilia* pollen – up to 48%, in contrast *e.g.* to the nearby Eemian site at Bedlno (Środoń, Gołąbowa 1956), where it not exceeds 12%. At later time, because of its similarity to the interglacial succession, stratigraphers decided to create new unit – the Zbójno interglacial – placed between the Eemian and the Mazovian (Holsteinian) (Lindner 1984, Ber 2005, Lindner *et al.* 2006, Ber *et al.* 2007). This pollen sequence was similar to those known from the Eemian, except for the mentioned above high proportion of linden and lack of some pollen zones characteristic for the last interglacial.

Succession of this kind, with *Tilia*-rich spectra is known from other regions of Poland *e.g.* at Marantów near Konin, central Poland (Borówko-Dłużakowa 1967). Highly characteristic is the fact that these sites are represented by short sequence of deposits which usually badly influences the state of pollen preservation because of probable sedimentation hiatuses.

Creation of new interglacial unit in Poland between the Eemian and the Mazovian corresponds with discovery, in a few maar lakes of the Massif Central, of four major warm episodes including the two new interglacial units in the similar position (Tab. 1, Reille, de Beaulieu 1995, Reille *et al.* 1998). This pattern of vegetational changes would be a close equivalent of stratigraphic schemes in the area of the Central European Plain where between the Mazovian and the Eemian two warm temperate sequences are proposed – in Poland the Zbójnian and the Lubavian and in Germany the Reinsdorf and the Schöningen (Urban 1995, Lindner, Marciniak 1998, Lindner *et al.* 2006, Ber *et al.* 2007, Lindner, Marciniak 2008).

The pollen sequence recorded at Zbójno in a thin peat layer seems to contain only fragments of a full succession. Unfortunately in the original paper of Lindner and Brykczyńska (1980) there was a lack of such important information like the state of pollen preservation, which did not allow for critical assessment of the presented palynological record. For that reason pollen analysis of additional cores was surely desirable.

MATERIAL AND METHODS

The depositional basin is situated about 1 km south to the village Zbójno in a small depression, now occupied by meadow communities. Two cores were taken to the depth of 4 m in the centre of depression, at a distance of about 100 m from one another. Description of the analysed deposits is given below.

Fig. 1. Location of the Zbójno site in Poland.

Table 1
Scheme of the Quaternary stratigraphy in Western Europe and Poland (cold units printed in italics)

Reille, Beaulieu 1995 FRANCE	Urban 1995 GERMANY	Ber 2005 POLAND	Lindner *et al.* 2006 POLAND
Holocene	Holozan	Holocene	Holocene
	Weichsel	*Vistulian*	*Vistulian*
Eemian	Eem	Eemian	Eemian
	Warthe	*Wartanian*	*Wartanian*
Le Bouchet	Schöningen	Lubavian?	Lubavian
	Drenthe	*Krznanian*	*Krznanian*
Landos	Reinsdorf	Zbójnian	Zbójnian
	Fuhne	*Liviecian*	*Liviecian*
Praclaux	Holstein	Mazovian	Mazovian

Core Zbójno 1 (Fig. 2)

3.10–3.30 m – silt with organic matter, pollen grains numerous, highly destructed, typical deposits of astatic basin partly with the subaerial sedimentation,

3.30–3.65 m – weakly decomposed peat, pollen grains well preserved, to the top more numerous and with signs of corrosion,

3.65–3.75 m – partly decomposed peat, pollen frequency higher, pollen worse preserved,

3.75–3.80 m – silt, pollen destructed.

Core Zbójno 2 (Fig. 3)

3.0–3.7 m – silt, pollen well preserved, sometimes with traces of corrosion, pollen frequency high,

3.7–4.1 m – highly decomposed peat, pollen grains strongly destroyed.

Samples for pollen analysis were treated using 10% HCl (to remove $CaCO_3$), 10% KOH and then with hot HF (to remove siliceous particles). Next, Erdtman's acetolysis was applied and the residuum was stored in glycerin.

RESULTS

Results of pollen analysis are presented in Figs 2 and 3, and basing on it, the analyzed profiles were divided into several pollen assemblage zones (PAZ).

Zbójno 1 (Fig. 2)

Z1-1 L PAZ (3.75–3.70 m). Different deposits with badly preserved pollen grains characterize this zone. First, bottom silt sample was accumulated in wet, periodically drying depression and the upper one – peaty – was deposited in the peat bog with numerous sedges (*Carex*) and members of Polypodiaceae (probably *Dryopteris thelypteris*). Spectrum AP is dominated by *Pinus* and *Quercus* pollen.

Z1-2 L PAZ (3.65–3.60 m) – 2 peaty samples with well preserved pollen. The forests of this zone are occupied by linden (*Tilia*) with admixture of hazel (*Corylus*) and alder (*Alnus*). Towards the end of the zone hornbeam (*Carpinus*) expanded into the communities.

Z1-3 L PAZ (3.55–3.50 m) – 2 peaty samples, pollen well preserved. Hornbeam, alder and, to a lesser extent, spruce and linden were the main components of the forest. Depositional basin throughout the Z1-2 and Z1-3 L PAZ was a small peat bog overgrown by *Dryopteris thelypteris*. Pollen of plants of the littoral zone of the lake and the open water – *Lemna*, *Typha latifolia*, *Nymphaea* – are rarely noted in the spectra.

Z1-4 L PAZ (3.45–3.35 m) – 3 peaty samples with well preserved pollen. Forest communities of this interval were dominated by *Picea* and *Alnus* with a small admixture of fir and pine. The peat bog with abundant sedges (*Carex*) as well as *Sparganium* t. and Polypodiaceae declined at the end of the zone.

Z1-5 L PAZ (3.30–3.10 m). Silty, partly subaerial accumulation with badly preserved pollen is typical for this level. The zone is characterized by the dominance of *Pinus* reaching the highest values in the uppermost sample. This is probably final interglacial pollen zone. However, we should bear in mind that the pollen concentration is rather low in this zone.

Zbójno 2 (Fig. 3)

The second sequence reveals similar pattern of vegetational changes within interglacial. However, only three L PAZ – Z2-1, Z2-2 and Z2-3 – were identified in this warm, temperate interval. Additionally two pollen zones, which differ in both their pollen concentration and their character of vegetation, follow interglacial succession:

Z2-4 L PAZ (3.55–3.45 m). Low pollen concentration and the dominance of tree-less vegetation with grasses (Gramineae), sedges (Cyperaceae) and mugwort (*Artemisia*) as well as a range of other herbs characterize the zone. Percentages of arboreal pollen – *Pinus* and *Betula* – are low and this pollen was surely wind transported from the south. Other AP taxa – *Larix*, *Salix* and *Juniperus* – occurred in the local communities.

Z2-5 L PAZ (3.35–3.05 m). The pollen concentration rises again and this fact marks the appearance of forest communities with pine and birch as well as sparsely occurring

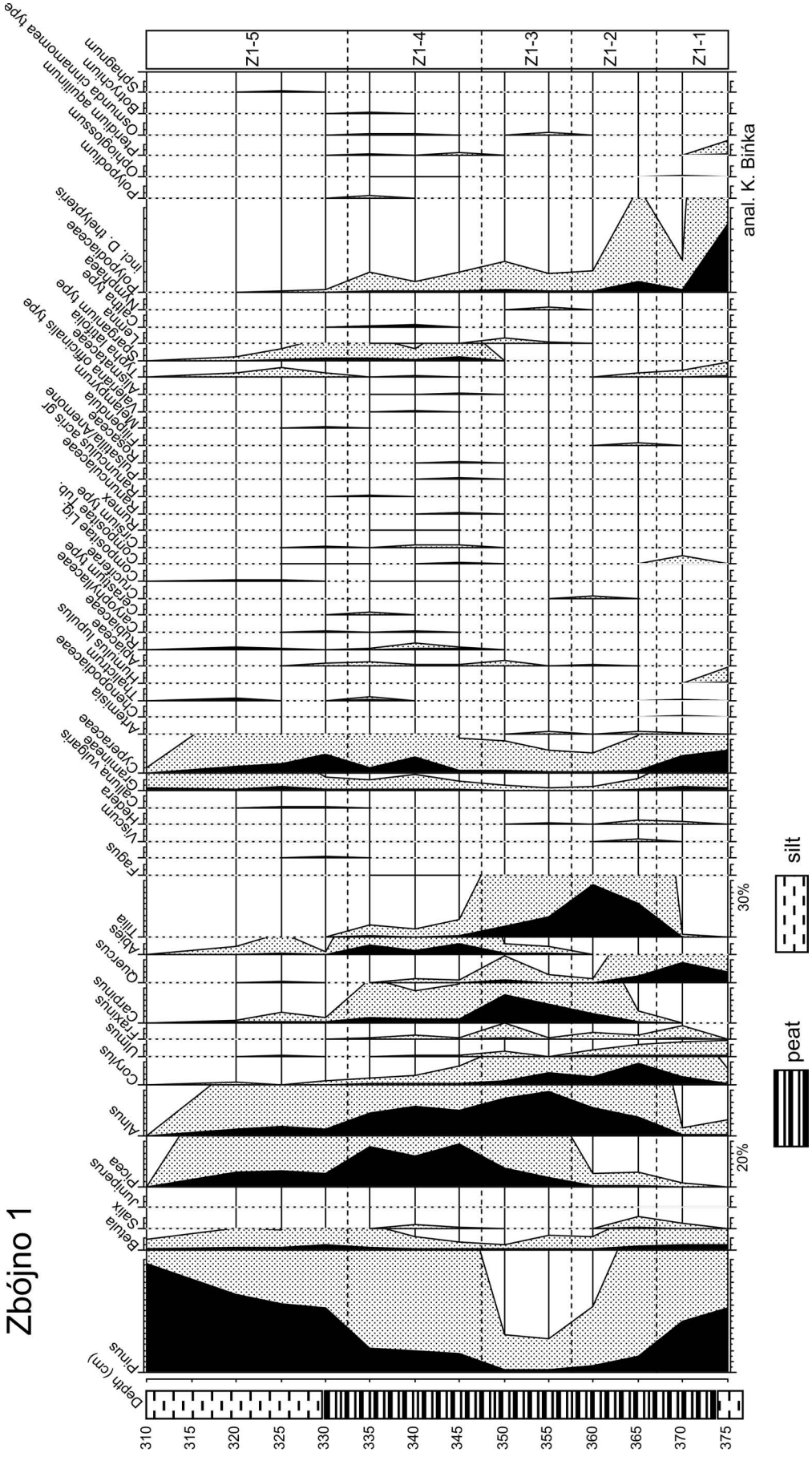

Fig. 2. Pollen diagram – Zbójno 1 core.

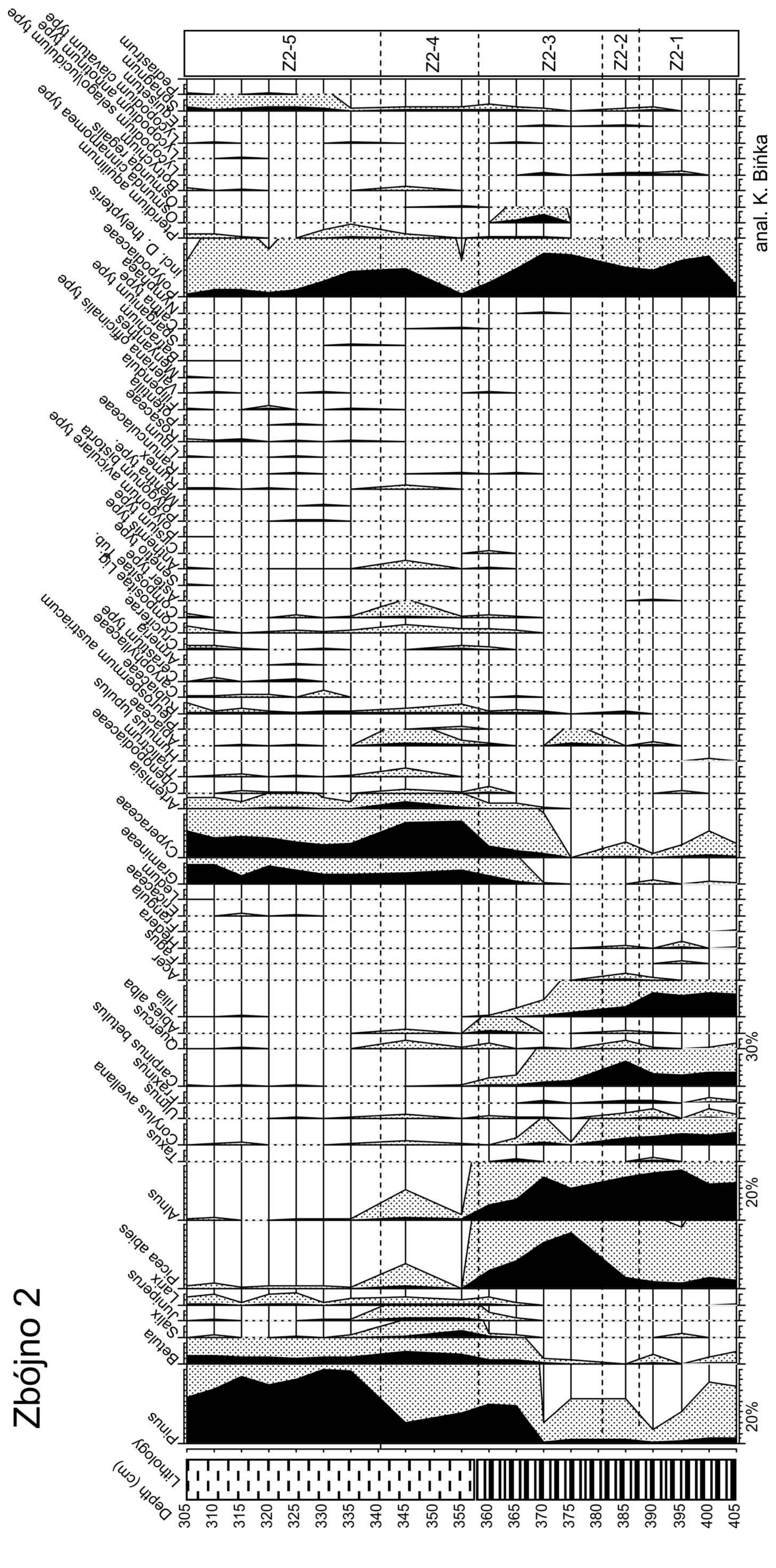

Fig. 3. Pollen diagram – Zbójno 2 core.

larch. Quite large percentages of grasses and sedges are probably of the local nature.

The two analyzed sequences revealed a somewhat different time of deposition. Warm temperate phases have been recorded in the first boring (Fig. 2). The second core in turn noted short intervals of the interglacial succession, overlain with post-interglacial zones (Z2-4, Z2-5; Fig. 3).

The reliability of these sequences as a tool for reconstruction of regional changes of vegetation has proved to be of very limited value. The sediments of the basin were accumulated in shallow, astatic lake or in the peat bog and the subaerial deposition with badly preserved pollen was often the case. Therefore the examined sequences are surely interrupted by numerous hiatuses – mainly in the intervals with destroyed sporomorphs and for this reason the reconstructed pattern is incomplete and discontinuous.

DISCUSSION

The pollen assemblage of the newly analyzed cores matches very well that found by Lindner and Brykczyńska (1980). The longer post-interglacial sequence noted in the second analyzed core, is the only difference. The fragmentary record of the reinvestigated cores does not allow for the precise reconstruction of the regional changes of the past communities.

The interglacial sequence from Zbójno has been originally classified as a new stratigraphic unit (Lindner, Brykczyńska 1980) with characteristic high proportion of linden pollen. In the spectra currently analyzed, the maximum content of *Tilia* pollen reached 47%, similarly as in the core examined by Brykczyńska. However, is it correct that a high content of *Tilia* forms a good basis to create a new interglacial? Linden is an insect pollinated plant and its pollen is most frequently transferred to depositional basins first of all in the insect faeces (Bińka 2003, 2003a, 2005). In fossil spectra we can rarely observe signs of exine degradation of fossil pollen of *Tilia* as an effect of the enzyme action in the animal intestines (Bińka *et al.* 2006) – possibly because of its greater resistance to destruction. Knowledge on activity of insects, birds and bats as well as other animals in the depositional areas suggests that the concentration of *Tilia* pollen in the lake deposits should be different in various parts of the basin. In the center of large lakes the concentration will be lower because *e.g.* birds and bats, the most important transport agents, visit more frequently marginal areas where they defecate pollen-laden insects. For that reason we can expect rather higher concentration of *Tilia* pollen in ponds/peat-bogs and the highest values should be noted in periods of astatic, subaerial sedimentation where the distance between pollen producer and the deposits is surely the shortest one.

In fact, confirmation of the above mechanism emerges from the Eemian records. In large basin found at Nidzica, northern Poland (Bińka *et al.* 2010) the content of *Tilia* pollen is relatively low and it does not exceed 16 percent of the total pollen sum. At Horoszki, the site reinvestigated by Granoszewski (2003), this content is not higher than 11%. This basin, as it results from cartographic works, was large in the interglacial period (A. Albrycht – oral information).

Site at Bedlno, about 11 km to the east of Zbójno, with the maximum content of *Tilia* 11.6%, also represents large lake, judging from the considerable thickness of deposits (Środoń, Gołąbowa 1956). At Solniki, where gytjja was accumulated in the temperate phases, *Tilia* pollen does not exceed 23% (Kupryjanowicz *et al.* 2005). The same goes for large Eemian lake at Warszawa-Żoliborz with maxium *Tilia* content about 9% (Raniecka-Bobrowska 1954).

In the small basins infilled with peat in turn, very characteristic for the Eemian, frequency of *Tilia* is high, *e.g.* about 44% at Szwajcaria (Borówko-Dłużakowa, Halicki 1957) and *ca.* 30% at Niewodowo (Bińka *et al.* 1988), because the distance between the pollen source and the place of accumulation was short.

All of this can indicate that the warm temperate sequence found at Zbójno is likely of the Eemian age and it fits well into classical scheme of the Eemian succession as recognized in pollen records in Poland (Mamakowa 1989, Tobolski 1991). The interglacial succession from Zbójno seems to represent fragmentary preserved pollen zones – from *Quercus-Fraxinus-Ulmus* to *Pinus* in the Mamakowa's scheme and from *Quercus* to *Pinus* zone in the Tobolski's zonation. Consequently the post-interglacial interval would correspond with well-known phases of the Vistulian – the Herning stadial and the Brörup interstadial. The only less obvious point in this view is the presence in the core of minerogenic bed (sands and silts without pollen) 2.8–3.0 m thick, which overlain the pollen-bearing deposits of the Eemian and the Early Vistulian. This is also the case at the nearby Bedlno (Środoń, Gołąbowa 1956), where the Eemian is noted at the depth below 3.5 m. These estimates are similar to those found in northern Podlasie region, outside the range of last glaciations (Kupryjanowicz 2008). However, in the area covered by deposits of older glaciations, the thickness of such sediments does not exceed 1.8 m (*e.g.* at Główczyn – Niklewski 1968; at Dziewule – Bińka, Nitychoruk 2001). These deposits were accumulated subaerally in the depressions during the tree-less phases. The main forces of these erosional processes are wind and the gravitational flow.

The minerogenic strata at Zbójno have a maximum thickness of 3 m and they do not differ sedimentologically from those in the other sites in Poland. Lindner and Brykczyńska (1980) during earlier borings found a thin layer of glacial till overlying interglacial beds, the presence of which might suggest the temperate sequence being older than the Eemian. In two drilled boreholes, analyzed in this paper, we did not find any signs of glacial till. It is worth mentioning that at Eemian site at Bedlno the presence of glacial till above the organogenic deposits was also postulated by Passendorfer (1930). Later investigation of Środoń and Gołąbowa (1956) did not confirm these observations.

It is not excluded that at Zbójno till occurs only locally and it is flow till in origin. The higher thickness of deposits may be explained by proximity of the Holy Cross Mts. Anyway, the examined sequence does not need to be treated as the ,,missing'' interglacial unit between the Eemian and the Holsteinian. Such additional stage, the status of which remains still unclear, may be in Poland the so called Lubavian interglacial which differs from the Eemian in a few features: by the presence of *Azolla*, the early dominance of *Alnus* and

Tilia (Krupiński 2006) as well as by the very early appearance of *Buxus*, that is atypical for the history of migration of this plant in the Eemian (Zagwijn 1996).

In the neighboring countries the records of "missing" interglacials have also the limited value. The best example is the sequence from Schöningen (Urban *et al.* 1991) represented by rather shallow water sediments and for that reasons, the record from Schöningen may not be a valuable source of palynological data. This found the expression in the quite unusual course of pollen curves of trees.

FINAL REMARKS

The examined pollen sequence from Zbójno contains in parts badly preserved pollen deposited in the non-lacustrine conditions and for this reason it cannot serve for the precise paleoenvironmental reconstructions because of the discontinuous accumulation. Despite the fragmentary preserved pollen zones, the character of the vegetational succession shown by the Zbójno pollen diagrams strongly indicates that this sequence may be ascribed to the Eemian interglacial/ Early Vistulian.

The high content of *Tilia* pollen in the spectra is typical for small basins or the peat bogs, often with the subaerial deposition, and cannot serve as the distinguishing feature of the new interglacial succession.

In the case of the Zbójno sequence it is still not excluded that it may represent a new interglacial stage but this pollen record cannot be the basis for calling a new unit. We must keep in memory the fact that three interglacial sequences found in the Massif Central above the Holsteinian show quite similar successions of all the interglacial (Reille, de Beaulieu 1995, Reille *et al.* 1998). Hence the problems of distinguishing the different interglacial sequences may be resolved only if the reliable, deep water deposits, are at disposal.

Acknowledgements

I am particularly grateful to Prof. Tomasz Goslar and Prof. Mirosława Kupryjanowicz, who offered constructive comments to improve the manuscript. The new cores for pollen analysis were taken at Zbójno with the assistance of prof. Nitychoruk and prof. Lindner. I am, indeed, enormously grateful to them.

REFERENCES

Ber A. 2005. Polish Pleistocene stratigraphy – A review of interglacial stratotypes. *Netherlands Journal of Geosciences – Geologie en Mijnbouw* 84, 61–76.

Ber A., Lindner L., Marks L. 2007. Proposal of a stratigraphic subdivision of the Quaternary of Poland (original: Propozycja podziału stratygraficznego czwartorzędu Polski). *Przegląd Geologiczny* 55/2, 115–118 (in Polish).

Bińka K., Nitychoruk J. 2001. Late Saalian climate changes in Europe in the light of pollen analysis and the problem of two-step deglaciation at the oxygen isotope stage 6/5e transition. *Boreas* 30, 307–316.

Bińka K. 2003. Palynological evidence for plant-animal interaction in the late Holocene. *Vegetation History and Archaeobotany* 12, 37–47.

Bińka K. 2003a. Apiaceae – contribution to the flora history in the light of the pollen analysis with a special reference to the Holocene site at Błędowo (Central Poland). *Studia Quaternaria* 20, 25–49.

Bińka K. 2005. Pollen analysis of barn swallow faeces (*Hirundo rustica*). *Acta Palaeobotanica* 45, 187–194.

Bińka K., Musiał A., Straszewska K. 1988. Interglacial lake reservoir Niewodowo II (Kolno Plateau, northeastern Poland). *Geological Quarterly* 32, 681–692 (in Polish with English summary).

Bińka K., Ber A., Bałuk A. 2006. Eemian and Vistulian pollen records in the Łomża vicinity (NE Poland). *Geological Quarterly* 50, 437–446.

Bińka K., Nitychoruk J., Dzierżek J. 2010. The climate stability during the Eemian – new pollen evidence from the Nidzica site, northern Poland. *Boreas* DOI: 10.1111/j.1502-3885.2010.00179x.

Borówko-Dłużakowa Z., Halicki B. 1957. Interglacial sections of the Suwałki region and of the adjacent territory. *Acta Geologica Polonica* 7, 361–399 (in Polish with English summary).

Borówko-Dłużakowa Z. 1967. Palaeobotanical studies of the Late Pleistocene deposits (Brörup) in the Konin-Marantów area. *Prace Instytutu Geologicznego* 48, 81–136 (in Polish with English summary).

Granoszewski W. 2003. Late Pleistocene vegetation history and climatic changes at Horoszki Duże, eastern Poland: a palaeobotanical study. *Acta Palaeobotanica*, suppl. 4, 1–95.

Janczyk-Kopikowa Z. 1991. Problems of the palynostratigraphy of the pleistocene in Poland and the palynological analysis of the interglacial deposits from Besiekierz (Central Poland). *Annales Universitatis Mariae Curie-Skłodowska* 46, 1–26.

Lindner L., Brykczyńska E. 1980. Organogenic deposits at Zbójno by Przedbórz, western slopes of the Holy Cross Mts, and their bearing on stratigraphy of the Pleistocene of Poland. *Acta Geologica Polonica* 30, 153–163 (in Polish with English summary).

Lindner L. 1984. An outline of Pleistocene chronostratigraphy in Poland. *Acta Geologica Polonica* 34, 27–49.

Lindner L., Marciniak B. 1998. The occurrence of four interglacials younger than the Sanian 2 (Elsterian 2) Glaciation in the Pleistocene of Europe. *Acta Geologica Polonica* 48, 247–263.

Lindner L., Marciniak B. 2008. Proposal of interglacial stratotype sites for the Middle Pleistocene of Poland. *Biuletyn Państwowego Instytutu Geologicznego* 428, 35–53 (in Polish with English summary).

Lindner L., Bogutsky A., Gozhik P., Marks L., Łanczont M., Wojtanowicz J. 2006. Correlation of Pleistocene deposits in the area between the Baltic and Black Sea, Central Europe. *Geological Quarterly* 50, 195–210.

Krupiński K. M. 2006. Palaeobotanical study of interglacial sediments from Losy near Lubawa (original: Badania paleobotaniczne biogenicznych osadów interglacjalnych z Losów koło Lubawy). XIII Konferencja Stratygrafia Plejstocenu Polski. Plejstocen południowej Warmii i zachodnich Mazur na tle struktur podłoża. Maróz 4-8 września 2006, 23–26 (in Polish).

Kupryjanowicz M., Ciszek D., Mirosław-Grabowska J., Marciniak B., Niska M. 2005. Two climatic oscillations during the Eemian Interglacial – preliminary results of multi–proxy researches of palaeolake at Smolniki, NE Poland. Proceedings of the Workshop „Reconstruction of Quaternary Palaeoclimate and palaeo-evironments and their abrupt changes", Biało- wieża 2005. *Polish Geological Institute Special Papers* 16, 53–57.

Kupryjanowicz M. 2008. Vegetation and climate of the Eemian and the early Vistulian lakeland in northern Podlasie. *Acta Palaeobotanica* 48, 1–130.

Mamakowa K.1989. Late Middle Polish Glaciation, Eemian and Early Vistulian vegetation at Imbramowice near Wrocław and the pollen stratigraphy of this part of the Pleistocene in Poland.

Acta Palaeobotanica 29, 11–179.

Mamakowa K. 2003. Pleistocene. Quaternary (original: Plejstocen. Czwartorzęd). In Dybova-Jachowicz S., Sadowska A. (eds), *Palinologia*, Wydawnictwa Instytutu Botaniki PAN, Kraków (in Polish).

Niklewski J. 1968. The Eemian Interglacial at Główczyn near Wyszogród (Central Poland). *Monographiae Botanicae* 27, 125–192 (in Polish with English summary).

Passendorfer E. 1931. The interglacial in Bedlno near Końskie (Kielce voiv.). Geological description. Polska Akademia Umiejętności *Sprawozdanie Komisji Fizjograficznej* 65, 97–104 (in Polish with English summary).

Raniecka-Bobrowska J. 1945. Pollen analysis of Quaternary profiles at Wola and Żoliborz. *Biuletyn Instytutu Geologicznego* 69, 107–138 (in Polish with English summary).

Reille M., de Beaulieu J.-L. 1995. Long Pleistocene Pollen Records from the Praclaux Crater, South-Central France. *Quaternary Research* 44, 205–215.

Reille M., Andrieu V., de Beaulieu J-L., Gunet P., Goeury C. 1998. A long pollen record from Lac du Bouchet, Massif Central, France: for the period ca. 325 to 100 ka BP (OIS 9c to OIS 5e). *Quaternary Science Review* 17, 1107–1123.

Tobolski K. 1991. Biostratigraphy and palaeoecology of the Eemian Interglacial and the Vistulian Glaciation of the Konin region. In Stankowski W. (ed.), *Przemiany środowiska geologiczego obszaru Konin - Turek. Wyniki realizacji Programu PR II 14 w okresie 1986-1990*, Instytut Badań Czwartorzędu UAM. Poznań, 45–87 (in Polish with English summary).

Środoń A., Gołąbowa M. 1956. Pleistocene flora of Bedlno, Central Poland. *Biuletyn Instytutu Geologicznego, Z badań czwartorzędu w Polsce* 100, 7–44 (in Polish with English summary).

Urban B., Lenhard R., Mania D., Albrecht B. 1991. Mittelpleistozän im Tagebau Schöningen, Ldkr. Helmstedt. *Zeitschrift der Deutschen Geologischen Gesellschaft* 142, 351–372.

Urban B. 1995. Palynological evidence of younger Middle Pleistocene Interglacials (Holsteinian, Reinsdorf and Schöningen) ine the Schöningen open cast lignite mine (eastern Lower Saxony, Germany). *Mededelingen Rijks Geologische Dienst* 52, 175–186.

Zagwijn W. H. 1966. An analysis of Eemian climate in Western and Central Europe. *Quaternary Science Review* 15, 451–469.