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Evolution of a small Eemian lake in a unique location on a kame hill: Haćki site, NE Poland

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ABSTRACT

An Eemian lake in a unique location at the top of a kame hill was found in NE Poland. Results of pollen and microscopic plant remains analyses show that despite the unusual location, its development and terrestrialization were typical for small meso-/eutrophic lakes of the temperate zone. At the end of the interglacial period an overgrown basin was flooded with water and again transformed into a lake. It existed until the beginning of the Brørup interstadial, and then it was covered with diluvia and/or aeolian sediment and finally disappeared.

1. Introduction

During geological mapping for the Detailed Geological Map of Poland, 1:50 000 scale, a fossil hollow filled with peat-lacustrine sediments located at the top of a kame hill was discovered (the vicinity of Haćki village, Bielsk Plain, NE Poland) (Brud and Kupryjanowicz, 2002). The palaeobasin is only several dozen meters in diameter and is not reflected in the contemporary relief. On the basis of pollen analysis, the deposits have been dated to the post-optimal part of the Eemian interglacial, as well as the beginning of the Early Vistulian.

The occurrence of Eemian peat-lacustrine sediments on kame hills is very rare. In Poland, apart from the Haćki site, only one location has been described: Proniewicze, also located on Bielsk Plain (Krupiński, 1995; Mycielska-Dowgiałło et al., 1995). Contemporary lakes and mires situated at the top of hills are a great rarity. Two were noted in northeastern Poland, Tatarska Góra, near Gołdap, and Góra Zamkowa, near Orzysz. There is no knowledge about analogous objects in other parts of Poland or abroad. The aim of this study, based on palynological and macrofossil analyses, was to reconstruct the developmental stages of the Eemian lake in a unique location at the top of a kame hill.

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2. Study area

The studied site is located on the Bielsk Plain (Fig. 1), which is part of the North Podlasie Lowland (Kondracki, 1998). The Bielsk Plain is a vast morainic plateau with ice-dammed lake deposits. The age of this plain is considered to be Saalian, i.e. Wartanian in Polish stratigraphy (Nowicki, 1971; Ber, 2005).

The most common landforms occurring in the central part of Bielsk Plain are kames (Fig. 2). They rise from a few to about a dozen metres above extensive melt-out depression. Of particular interest are small closed depressions filled with Eemian organic deposits, situated on top of flat kame surfaces (Proniewicze PR.1/93 profile; Krupiński, 1995). West of the depression, a vast kame terrace occurs. Its flat surface is pitted by small and shallow melt-out depressions, which during the Eemian interglacial existed as lakes or peat-bogs. In one of these depressions, organic sediments of this interglacial were recognised (Proniewicze P-3 profile; Kupryjanowicz, 2008).

Within the extensive depression, in the vicinity of Haćki village, a small isolated melt hollow is situated (Fig. 2). Kame hills and kame ridges are present. The main kame ridge is linguoid. On its top, shallow boreholes (Haćki S-3 profile; Figs. 2 and 3) showed the presence of a palaeodepression filled with Eemian biogenic deposits (Brud and Kupryjanowicz, 2002), which are the subject of this study.

3. Material and methods

Pollen analysis was carried out by a standard method according to Berglund and Ralska-Jasiewiczowa (1986). Analysis of plant

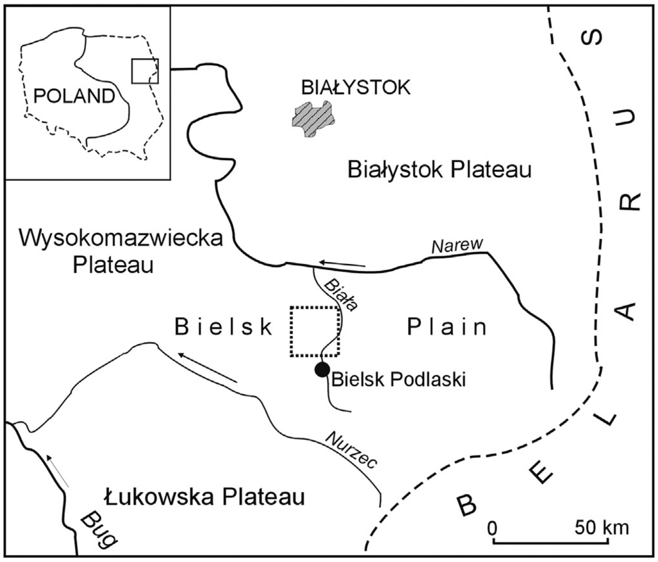

Fig. 1. Location of the study area.

macrofossils was according to Grosse-Brauckmann (1986) and Tobolski (2000).

4. Results and discussion

Changes in the frequency of sporomorphs of aquatic and mire plants, as well as plant macrofossils allowed the recognition of four stages of development of the studied basin (Fig. 4). Stage I covered the hazel phase (E4) of the Eemian interglacial. The basin was a water body at this time, with coarse-detritus gyttja accumulated in the bottom. Nympheids occurred in a lake, which is evidenced both in the pollen record and in carpological findings (seeds of *Nymphaea alba*). According to Matuszkiewicz (2001), the presence of *Nymphaea alba* confirms the meso-to eutrophic state of the lake and its small depth, to 2.5 m. The Eemian hazel phase was a period when most of the lakes of the North Podlasie region were formed (Kupryjanowicz, 2008).

Stage II was connected with the older part of the hornbeam phase (E5). The lake was shallow. Probably, it was an effect both of filling by bottom sediments, and lowering of the water table, which has been noted for the Northern Podlasie region at this time. (Kupryjanowicz, 2008). In shallow parts of the water body, rushes with *Schoenoplectus mucronatus*, *Schoenoplectus lacustris* and *Eleocharis palustris* were spread. The appearance of *S. mucronatus* could be caused by high temperatures in this period of the Eemian interglacial, which is considered as a climatic optimum in this region (Kupryjanowicz, 2008). *Schoenoplectus mucronatus* is a thermophilous species (today it is native to tropical regions of Africa, temperate and tropical regions of Asia, and southeastern and southwestern regions of Europe). The presence of this species in interglacial profiles provides evidence of its predominantly optimal climatic requirements. Eemian localities of this species are quite numerous in eastern Europe (Velichkevich and Zastawniak, 2006). The spread of this species could also be an effect of the degradation of the water body connected with the lowering of the water level. Currently in North America, this species invades habitats that have been degraded in some way (Swearingen et al., 2010).

In the pollen record *Thelypteris palustris* spores appeared at this time. The frequency of Filicales monolete (a morphological taxon including perine-free spores of numerous pteridophyte species) spores increased. They could represent this species. This type of pollen record suggests that the plant community dominated by *Thelypteris palustris* invaded a part of this lake. Currently, this plant community takes part in the final stages of overgrowing meso- and eutrophic lakes (Matuszkiewicz, 2001). It forms thick, highly hydrated floating mats and it could be a succession stage mainly leading to the formation of alder communities. Macrofossil data show that the floating mat of the Haćki water body was also built by brown mosses, *Menyanthes trifoliata*, *Lycopus europeaus*, *Comarum palustre*, *Cladium mariscus*, and tall sedges, like *Carex vesicaria* and *Carex rostrata*, and *Alnus glutinosa*.

Stage III started in the middle of the hornbeam phase (E5) and remained probably to the end of the spruce phase (E6). The surface of the terrestrialized palaeolake was overgrown by some alder communities, indicated in the sediment by the presence of numerous *Alnus glutinosa* nuts, seeds of *Solanum dulcamara*, and *Osmunda regalis* spores. Peat from this layer is strongly decomposed. Spore-pollen materials as well as vegetative macrofossils are preserved in extremely poor conditions. In most samples, except sporadic sedge radicles, leaves of brown mosses, single pollen grains of *Alnus*, and spores of Filicales monolete, no other findings remained. Probably, this is a result of the specific water balance of alder communities, which is characterised by periodic summer lowering of the ground water table, which leads to drying of the surface peat layers. Consequently, the peat is strongly decomposed and micro- and macrofossils are poorly preserved.

The presence of *Sphagnum* spores, as well as the higher frequency of *Pinus sylvestris* periderm and fragments of coniferous wood during the spruce phase (E6), signal impoverishment and acidification of habitats. Local alder communities transformed

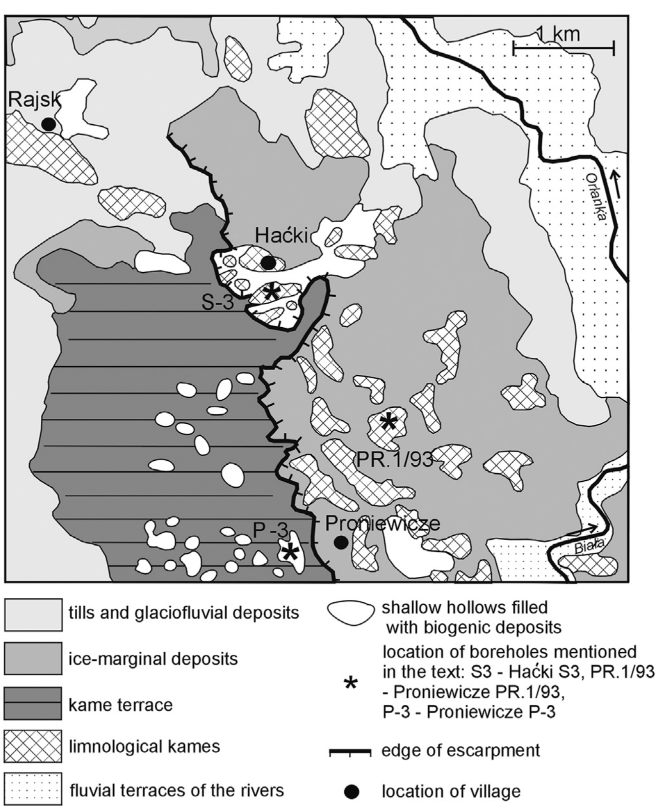

Fig. 2. Simplified geomorphological sketch of the study area (according to Brud and Kupryjanowicz (2002) with changes made by Ber (2005)).