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Eemian Interglacial deposits at Haćki near Bielsk Podlaski: implications for the limit of the last glaciation in northeastern Poland

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Pollen analysis was conducted on organic deposits on a kame ridge at Haćki in northeastern Poland. The deposits are referred to the Eemian Interglacial. Slope sediments only covered these biogenic deposits. The glacigenic landforms therefore relate to the Wartanian Glaciation, and so this area has not been occupied by an ice sheet of the Vistulian Glaciation.

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INTRODUCTION

Numerous sites with biogenic deposits have been found during geological mapping of the Bielsk Podlaski sheet Detailed Geological Map of Poland, 1:50 000 scale. All of these are located on the Bielsk Plain, a vast morainic plateau with ice-dammed lake deposits (Fig. 1). The age of this plain is considered to be the Wartanian (Nowicki, 1971). On the basis of pollen analysis, the deposits at Proniewicze P-3 borehole have been referred to the Eemian Interglacial (Kupryjanowicz, 2000). Deposits from the same interglacial were already found in another borehole (PR. 1/93) near Proniewicze (Krupiński, 1995; Mycielska-Dowgiałło *et al.*, 1995*a*).

Organic deposits at Haćki S-3 borehole have been subjected to pollen analysis (Brud and Kupryjanowicz, 2000), in order to determine their age.

GEOMORPHOLOGICAL SETTING OF THE BIELSK PODLASKI AREA

The area to the north of Bielsk Podlaski shows geomorphological characteristics typical of areal deglaciation (Mojski, 1969) (Fig. 2). This deglaciation consisted of gradual reduction in ice sheet thickness, its dismembering into individual dead ice blocks, and their further melting. The most common landforms occurring north of Bielsk Podlaski are kames (Mojski and Nowicki, 1961). They rise from a few to about a dozen metres above melt-out depressions, marking an accumulation level at 145.0 m a.s.l. Limnoglacial kames are composed mostly of fine-grained sediments, only their topmost parts comprising tills and gravels. Of particular interest are closed depressions filled with the Eemian Interglacial organic deposits, situated on top of flat kame surfaces (Mycielska-Dowgiałło, 1995*a*; Krupiński, 1995). The origin of these depressions is probably associated with melting of small dead ice blocks. The depositional origin of the clastic overlying the organogenic deposits are difficult to reconstruct without detailed sedimentological studies.

West of Proniewicze, a vast kame terrace composed of silty deposits occurs. Its flat surface is pitted by shallow melt-out depressions. In one of them, Eemian Interglacial organic deposits have been found by drilling beneath organic and washout deposits (Kupryjanowicz, 2000). To the south, near Bielsk Podlaski and Augustowo, the study area is surrounded by vast glaciomarginal fans shed during the Wkra Stadial of the Wartanian Glaciation (Mycielska-Dowgiałło *et al.*, 1995*b*; Brud, 2000).

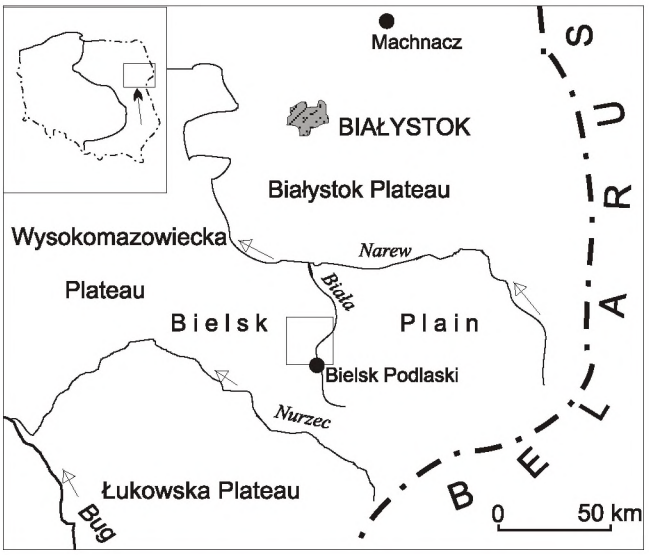

Fig. 1. Location of the study area

GEOMORPHIC AND GEOLOGICAL SETTING OF THE HAĆKI SITE

The most characteristic morphological element of the Haćki area is a vast depression, bearing two kame hills at its base (Fig. 3). One of them, called Góra Zamkowa, is a constructed prehistoric refuge. Steep scarps, over a dozen metres high, surround the depression. The kame ridges occur perpendicular to the scarps, subdividing the depression into individual hollows. The latter are filled with peat and washout fines, overlying typical melt-out silts. In the central part of the northern hollow, a cultural layer dated to the Roman period (before 2000 years BC?) has been found by drilling beneath a peat (Banaszuk *et al.*, 1996). The main kame ridge is linguoid in shape (Klajnert, 1998), its top being situated at the main accumulation level of 145.0 m a.s.l. (Fig. 4). The ridge is composed of silts overlain by flow tills. Shallow boreholes showed the presence of palaeodepressions filled with biogenic deposits, and overlain by washout sediments and a cultural layer of unspecified age. These deposits are not covered by till. The present-day flat kame surface is a product of anthropogenic processes. Water flowing from the plateau west of Haćki strongly eroded the proximal part of the kame tongue, forming a gully and filling up the depression in its distal part. These processes were intensified after construction of a local road and land cultivation.

POLLEN ANALYSIS RESULTS

Deposits of the Haćki S3 borehole (depth 3.47–5.40 m) have been subjected to palynological analysis. The lithology of these deposits is as follows:

3.52–3.47 m — grey, organic sandy clay,
3.58–3.52 m — grey-greenish silty clay,
3.60–3.58 m — steel-grey clayey silt,
3.64–3.60 m — black, organic clayey silt,
5.40–3.64 m — strongly decayed peat.

A detailed description of the palynology and the vegetational reconstruction will be given in another paper. Here, the palynological results from the basis for age determination.

In the pollen diagram of biogenic deposits recovered from the S3 borehole at, six local pollen assemblage zones (L PAZ) were distinguished (Fig. 5). The diagram shows that the lower part of the analysed borehole, from the bottom to a depth of 3.62 m (H-1–H-4 L PAZ), represents an interglacial succession. This succession is not complete, but shows some characteristic features, namely:

— a very high pollen value of *Corylus avellana* (max. 60%),

— a high proportion of *Carpinus betulus*, coinciding with a gradual drop of *Corylus*,

— a very high values of *Picea abies*, characteristic of the penultimate phase of the succession, as well as the accompanying peak of *Abies*.

All these features make it possible to compare the Haćki site with the Eemian Interglacial succession (*cf.* Mamakowa, 1989; Janczyk-Kopikowa, 1991).

The development of vegetation recorded in the segment of the Haćki borehole studied spans the E4–E7 zones of the re-

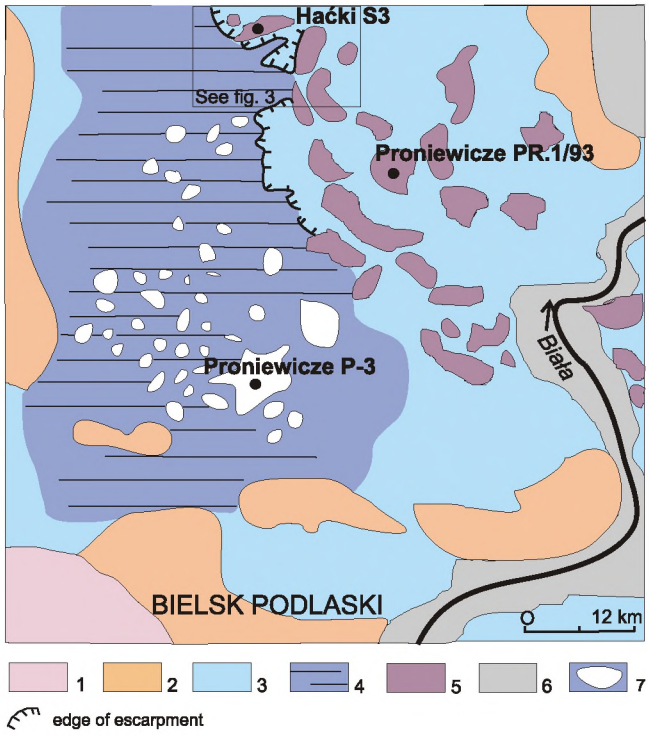

Fig. 2. Simplified geomorphological sketch of the Bielsk Podlaski-Haćki area

Wartanian Glaciation: 1 — end moraine, 2 — tills and glaciofluvial deposits, 3 — ice-marginal deposits, 4 — kame terrace, 5 — limnoglacial kames; **Vistulian Glaciation and Holocene**: 6 — fluvial terraces of the Biała River, 7 — shallow hollows filled with biogenic deposits; Proniewicze P-3 — location of boreholes mentioned in the text

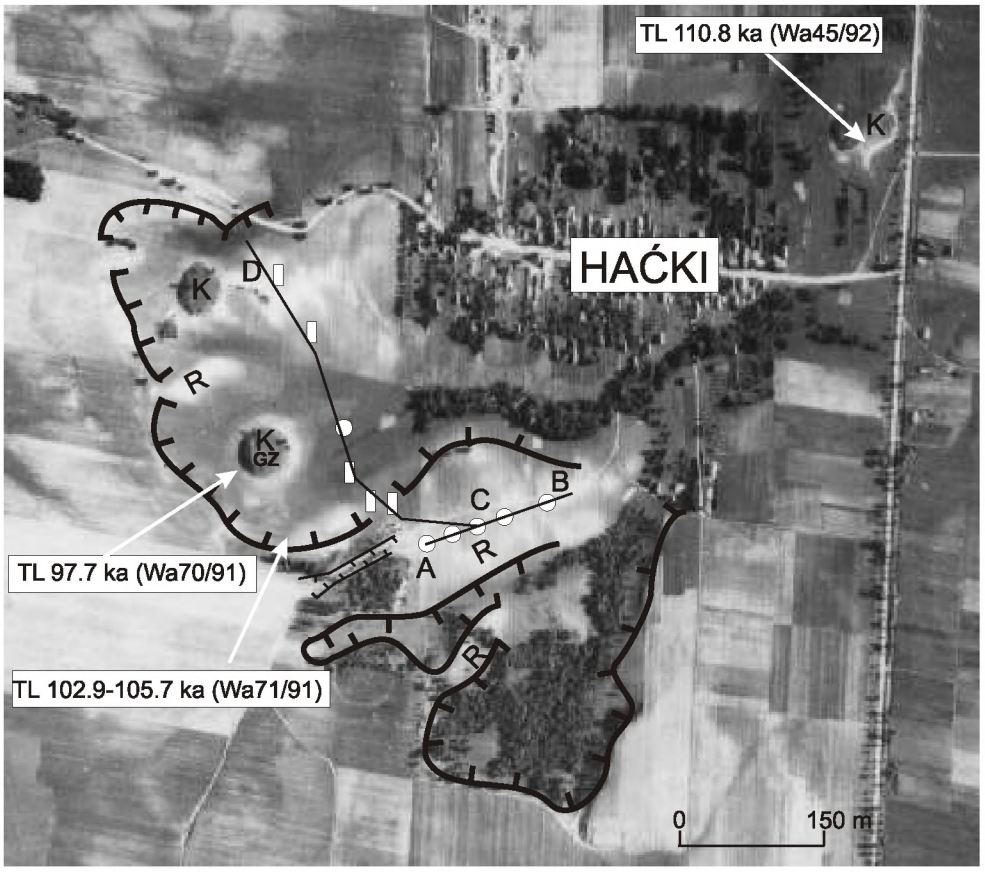

Fig. 3. Aerial photograph of the study area

gional biostratigraphy of the Eemian Interglacial (Mamakowa, 1989). Local pollen assemblage zones distinguished in the Haćki borehole can be easily correlated, based on the *Corylus*, *Carpinus*, *Tilia*, *Alnus* and *Pinus* percentages, with analogous zones found in the PR. 1/93 borehole at Proniewicze (Fig. 2), and the MI borehole at Machnacz (Fig. 1) (Kupryjanowicz, 1991).

The topmost part of the Haćki borehole, including local pollen assemblage zones H-5 and H-6, however, is difficult to correlate with the regional biostratigraphy of the Eemian Interglacial and the Early Vistulian stages.

The H-6 *Betula* zone showing exceptionally high percentages of birch, probably correlates with the lower *Betula* subzone of the regional horizon EV2, corresponding to an older birch phase of the Amersfoort/Brörup Interstadial (Mamakowa, 1989). Similarly high birch values have neither been recorded in any segment of the Early Vistulian, nor during the Eemian Interglacial. At the end of the pine phase terminating the Eemian succession in diagrams from some Polish sites e.g. from Konopki Leśne, Klewinowo (Mamakowa, 1989, p. 129) and Machnacz (Kupryjanowicz, 1991), a marked increase in birch percentages can be seen, but never exceeding values typical of EV2a *Betula* R PASZ (78% at Zgierz-Rudunki, a type locality for this regional zone; *cf.* Mamakowa, 1989).

Correlation of the local H-5 zone is even more difficult. The record of this zone in the Haćki borehole is only contained in a 2 cm thick layer of steel-grey clayey silt. Location of this zone between the pine phase of the Eemian Interglacial and the birch phase of the Amersfoort/Brörup Interstadial suggests that it could represent the first post-Eemian cooling. However, its pollen composition, characterised by relatively high percentages of pine and birch and poorly marked peaks of *Juniperus*, *Salix*, and NAP, makes its correlation with a regional EV1 Gramineae-*Artemisia*-*Betula nana* horizon problematic (Mamakowa, 1989). It seems possible that the H-5

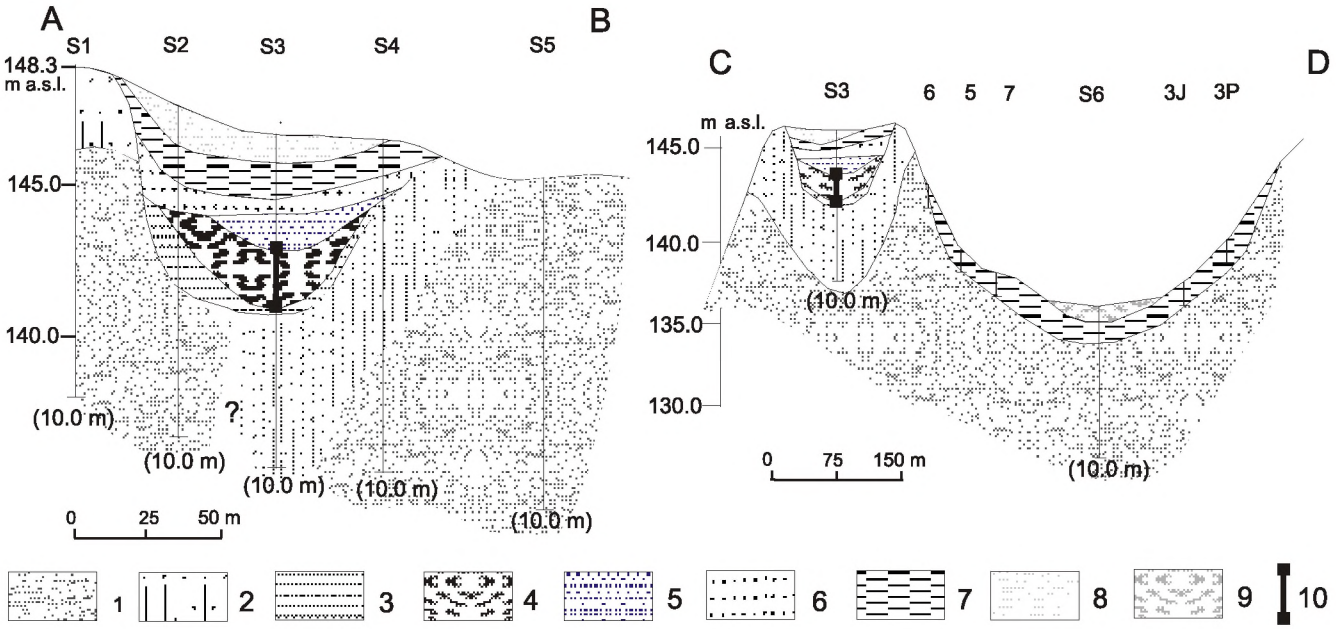

Fig. 4. Geological cross-sections A–B and C–D through the organic deposits of the Haćki area (*cf.* Fig. 2)

Wartanian Glaciation: 1 — silts and fine-grained sands, 2 — flow till; **Eemian Interglacial**: 3 — silts, 4 — peats with clayey silt at the top; **Vistulian Glaciation and Holocene**: 5 — silts and clay with organic matter, 6 — slope-wash sands, 7 — grey silts (archaeological layer), 8 — slope-wash silts and fine-grained sands; 9 — peats; 10 — palynological analysis; S1–S5 and 3, 5, 3J, 3P — location of boreholes and pits

Table 1

Correlation of the local pollen assemblages zones distinguished in the profile from Haćki with the local pollen assemblages zones from Proniewicze and regional pollen assemblage zones

Proniewicze PR.1/93 (L PAZ) Krupiński (1995)	Haćki S-3 (L PAZ)	Regional pollen assemblage zones Mamakowa (1989)
–	H-6 *Betula*	EV2 *Pinus-Betula* subzone EV2a *Betula*
–	H-5 *Pinus-Betula-Juniperus*-NAP	EV1 Gramineae-*Artemisia-Betula nana*
PR-6 *Pinus-(Picea*-NAP)	H-4 *Pinus*	E7 *Pinus*
Hiatus	H-3 *Picea-(Abies)*	E6 *Picea-Abies-Alnus*
PR-4 *Carpinus-(Corylus-Alnus)*	H-2 *Carpinus-Corylus-Alnus*	E5 *Carpinus-Corylus-Alnus*
PR-3 *Corylus-(Tilia-Alnus)*	H-1 *Corylus-Tilia-Quercus*	E4 *Corylus-Quercus-Tilia*

horizon is an equivalent of the declining pine phase of the Eemian Interglacial, being followed higher by a hiatus. On the other hand, the unusually high content of pollen, rarely encountered in clastic deposits, suggests a very low accumulation rate. Therefore, the studied 1 cm thick sample could have represented a sediment deposited over a long time, and its pollen material seems to contain sporomorphs both of the declining pine phase of the Eemian Interglacial, and of the first post-Eemian cooling, as well as the beginning of the first Vistulian interstadial. The very good state of preservation, both of AP and of NAP, does not indicate redeposition.

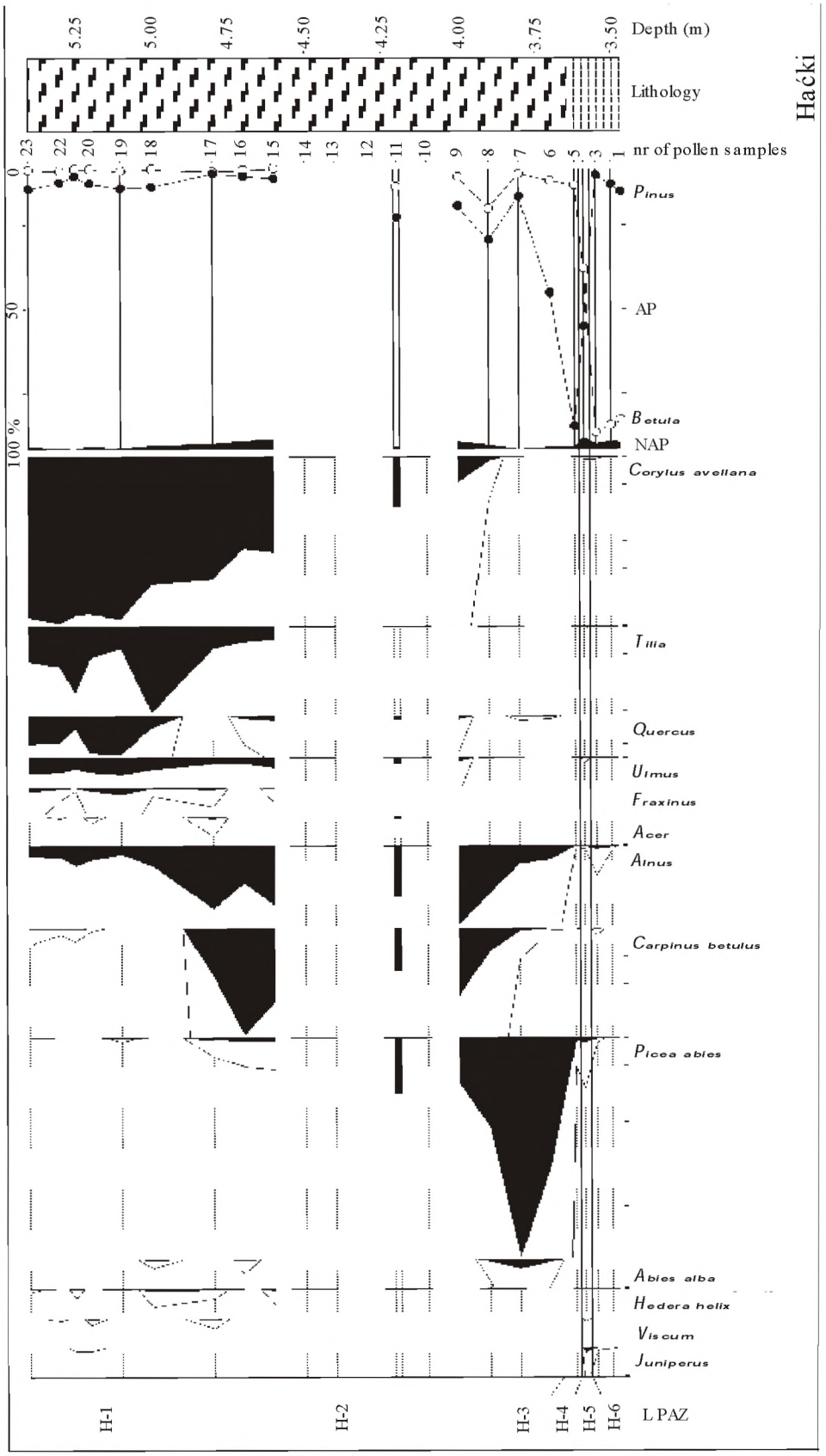

Fig. 5. Hańcki S3: percentage pollen diagram (selected pollen only); analysed by Kupryjanowicz (2000)

For lithological explanations see Fig. 4

DISCUSSION

Results of the pollen analysis of biogenic deposits at Haćki, suggesting an Eemian age, has implications for the geological evolution of the area during the Vistulian. This problem has recently been discussed by Banaszuk (1998) who places the southernmost extent of the Vistulian Glaciation in the Nurzec River valley. Such a conclusion is based on several tens of TL age determinations made in the Białystok and Wysokomazowiecka Plateaus, three of them determined at Haćki. Other TL determinations from this region have also been reported by Mycielska-Dowgiałło (1995*a, b*), averaging around 110 ka. The errors associated with these dates suggest that the kames of the Bielsk Plain originated during the end of the Wartanian or during the Early Vistulian. Detailed geological studies do not provide evidence for the presence of the Vistulian ice sheet in this area. The region studied was located in a periglacial zone, as shown by the presence of ice wedge casts a few metres long preserved in kames, as well as of wind-polished clasts. All the Eemian biogenic sites on the Bielsk Plain (Haćki S-3, Proniewicze P-3 and PR. 1/93) clearly correlate with each other. None of them is covered by till. The presence of numerous glacigenic hollows filled by biogenic deposits on the Bielsk Plain (Brud, 2000) suggests that this area formed a lakeland during the Eemian.

CONCLUSIONS

1. Pollen analysis of peat and organic silt and clay at Haćki (borehole S-3, depth 3.47–5.40 m) documents the presence of a new Eemian Interglacial site on the Bielsk Plain. The deposits show a record of the post-optimal part of this interglacial (from the hazel phase onwards) as well as the Early Vistulian, most probably up to the birch phase of the Amersfoort/Brörup Interstadial.

2. The geomorphological setting of the Eemian deposits at Haćki is similar to the other sites related to kame accumulation, where the Eemian deposits are overlain by washout-lacustrine sediments only, and not by a till. Only periglacial structures are preserved. One can infer, therefore, that the Bielsk Plain has not been covered by a Vistulian ice sheet.

3. The origin of the glacigenic landforms should be related to the Wkra Stadial of the Wartanian Glaciation. These landforms were only moderately remodelled under periglacial conditions during the Vistulian.

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