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TWO CLIMATIC OSCILLATIONS DURING THE EEMIAN INTERGLACIAL — PRELIMINARY RESULTS OF MULTI-PROXY RESEARCHES OF PALAEOLAKE AT SOLNIKI, NE POLAND

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Abstract. Lake series from the Eemian Interglacial and Early Vistulian has been discovered at Solniki in the Białystok Upland region, north-eastern Poland. Preliminary results of interdisciplinary researches (pollen, diatom, Cladocera, isotopic and magnetic susceptibility analyses) were used to illustrate the changes of the Eemian climate. At present stage of investigations, there are found signs of two abrupt climatic oscillations — first with very humid climate took place at middle part of the regional *Carpinus* pollen zone (E5 R PAZ), and second with cold and dry climate at middle part of the regional *Pinus* zone (E7 R PAZ).

Key words: pollen, diatom, Cladocera, stable isotope, magnetic susceptibility, climate changes, Eemian Interglacial, NE Poland.

Abstrakt. W Solnikach na Wysoczyźnie Białostockiej (północno-wschodnia Polska) odkryto serię osadów jeziornych reprezentujących interglacjał eemski i wczesny vistulian. Wstępne wyniki badań interdyscyplinarnych (analiza pyłkowa, okrzemkowa i Cladocera, pomiary podatności magnetycznej osadów oraz zawartości izotopów stabilnych tlenu i węgla) wykorzystano do zilustrowania zmian klimatu podczas interglacjału eemskiego. Udokumentowano dwie gwałtowne oscylacje klimatu — pierwsza z ciepłym i bardzo wilgotnym klimatem (?opady) miała miejsce w środkowej części poziomu pyłkowego E5 *Carpinus*, druga z klimatem suchym i bardzo zimnym — w środkowej części poziomu E7 *Pinus*.

Słowa kluczowe: pyłek, okrzemka, Cladocera, izotopy stabilne, podatność magnetyczna, zmiany klimatu, interglacjał eemski, północno-wschodnia Polska.

INTRODUCTION

Lake series 10 m thick at Solniki (Fig. 1) was discovered during cartographic works at Trześcianka sheet of Detailed Geological Map of Poland in scale of 1:50,000 (Kupryjanowicz, 2000; Kurek, Preidl, 2001). It is covered with 3-m layer of sands and sandy clays. The till is not present at covering layer. Lake deposits fill a relatively large melt depression.

Interdisciplinary researches of the Solniki profile, started from 2003, concentrate around reconstruction of climate changes during the Eemian Interglacial as well as around the verification of the hypothesis about the presence of intra-interglacial cool oscillations. An occurrence of these episodes is suggested by numerous studies from various parts of the world (e.g. de Beaulieu, Reille, 1992; Dansgaard *et al.*,

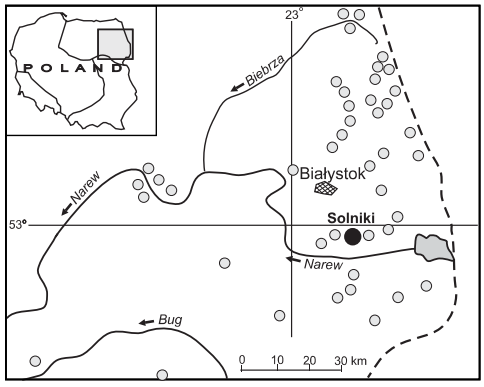

Fig. 1. Location of Solniki site and other Eemian localities

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1993; Guiot *et al.*, 1993; Field *et al.*, 1994; Thouveny *et al.*, 1994; Maslin *et al.*, 1996; Adkins *et al.*, 1997; Cheddadi *et al.*, 1998; Karabanov *et al.*, 2000).

Preliminary data obtained by pollen analysis as well as analyses of magnetic susceptibility, stable isotopes of carbon and oxygen, diatoms and Cladocera remains are presented in the article.

RESULTS

POLLEN ANALYSIS

Pollen data document that discovered sediments were accumulated from the beginning of the Eemian Interglacial to the second stadial of Early Vistulian. Lower part of analysed profile, below depth of 6.25 m, contains the full record of the Eemian vegetation succession (Fig. 2). It is about 7 m thick. The *Carpinus* pollen zone (S-5 L PAZ = E5 R PAZ) includes till 2 m of this section. Five local pollen sub-zones are distinguished within hornbeam zone. They register vegetation changes, which probably resulted from climatic reasons. However small-scale of these changes clearly indicates the absence of abrupt oscillations of the climate.

At Solniki profile, the opening of vegetation is noted in the middle part of the *Pinus* zone (S-7 L PAZ = E7 R PAZ), which closes the Eemian succession. Similar record was obtained in some other profiles from north Podlasie (e.g. Kupryjanowicz, 1991; Kupryjanowicz, Drzymulska, 2002) and various regions of Poland (e.g. Granoszewski, 2003). In our opinion, this phenomenon resulted from temporary cooling of the climate. In pollen diagram from Solniki this oscillation is recorded most clearly. At first boreal forest with high proportion of birch developed. Then open communities in type of steppe (with *Artemisia* and Chenopodiaceae domination) and dwarf-shrub tundra (with willows and birches) spread.

MAGNETIC SUSCEPTIBILITY

Lithological variability of the sediments of the palaeolake Solniki makes palaeoenvironmental interpretations of the magnetic susceptibility changes difficult (Fig. 2). Rapid rise of magnetic susceptibility during the *Quercus* pollen zone (S-3 L PAZ = E3 R PAZ) and its clear decline, existing from the end of *Carpinus* zone (S-5 L PAZ = E5 R PAZ), entire *Picea* zone (S-6 L PAZ = E6 R PAZ) and beginning of the *Pinus* zone (S-7 L PAZ = E7 R PAZ), are certainly caused by lithological changes. However twofold increasing of MS values within relatively homogenous deposits of the *Carpinus* pollen zone may indicate some climatic oscillations — probably cooling or rise of humidity.

STABLE ISOTOPE ANALYSIS

The carbon and oxygen isotope composition was estimated for the calcareous sediments using the classical phosphoric acid method. The concentration of ^{13}C and ^{18}O isotopes in the analysed samples was presented as $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratios versus the V-PDB standard. The analytical error was ±0.05‰ for $\delta^{13}C$ and ±0.1‰ for $\delta^{18}O$. On the ground of the results of stable isotope analyses the isotopic horizons (Is) were defined and characterised (Fig. 2). Isotopic data enabled reconstruction of the evolution of studied palaeolake. In spite of the lithological variability of lacustrine sediments, especially the presence of organic interlayers, the most detailed picture of environmental changes was presented only for the *Carpinus* pollen zone. The beginning of this period was characterised by considerable warming and probably low humidity of climate. Then the precipitation increased leading to lake deepening and enriching water in light isotopes (the low values of $\delta^{18}O$). Shallowing of lake (more dry climatic conditions?) and the gradual climate cooling caused the next fluctuations of the isotopic curves.

CLADOCERA ANALYSIS

The presence of 17 Cladocera species, including 3 species of deep-water zone, was documented in sediments of palaeolake from Solniki (Fig. 2). Diversity of their frequency permits to distinguish seven phases of the basin evolution. Two periods with very favourable conditions for development of zooplankton were noted. The first of these is correlated with the beginning of the *Carpinus* pollen zone (S-5 L PAZ = E5 R PAZ), and the second with the *Picea* pollen zone (S-6 L PAZ = E6 R PAZ). Significant decrease of Cladocera frequency in analysed basin was connected with the cooling and lowering of water level which took place only in the final part of the Eemian Interglacial.

DIATOM ANALYSIS

Preliminary results of the diatom analysis document numerous occurrences and very various species composition of diatoms at sediments representing the Eemian Interglacial. The presence of epiphytic and benthic taxa typical for shallow and peaty water basins with macrophytes is noted at the lowest part of the profile. At its middle part first the proportion of planktonic diatoms from the genus *Cyclotella* increases that suggests a deepening of the lake and its oligo- to mesotrophic character. In this part is present *Stephanocostis chantaicus* Genkal, Kuzmina (Fig. 3). The monotypical genus *Stephanocostis* is rare the entire world. Up to year 2000, the genus was found at 17 locations or research sites circumpolar in the Northern Hemisphere (Scheffler, Padisák, 2000; Scheffler, Morabito 2003). The species seems to prefer deep, dimictic oligo- to mesotrophic lakes. All the research sites are known to be slightly alkaline (Scheffler,

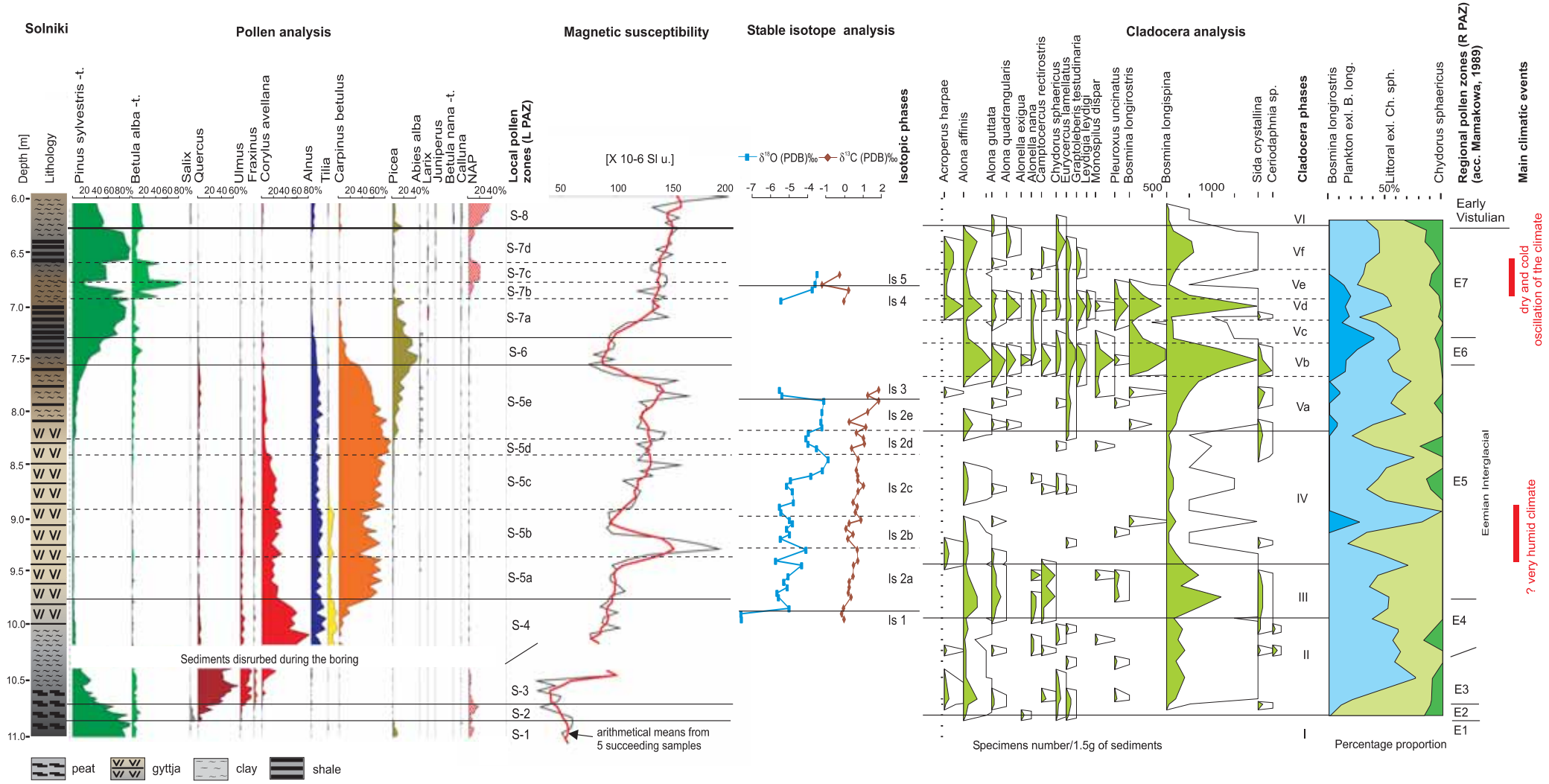

Fig. 2. Palaeoenvironment changes during Eemian Interglacial reconstructed from data used by various methods

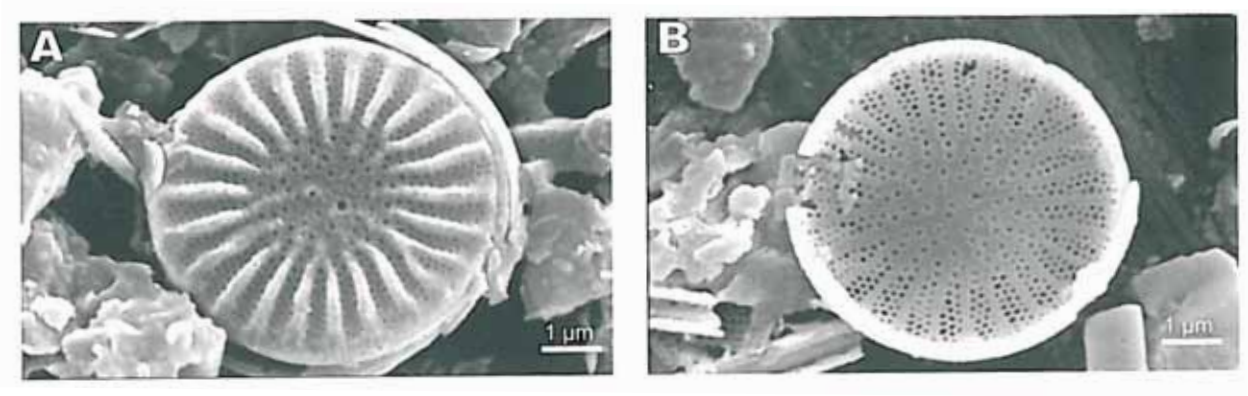

Fig. 3. *Stephanocostis chantaicus* Genkal, Kuzmina, SEM; A — external view of valve; B — internal view of valve

Morabito, 2003). Then a frequency of some other genera of planktonic diatoms rises (e.g. *Aulacoseira, Stephanodiscus, Asterionella*). This record indicates significant improvement of thermal conditions and progressing eutrophication of lake waters, which resulted from climate changes and development of vegetation during the optimum (*sensu lato*) of the Eemian Interglacial. The decreases of frequency of planktonic diatoms and the appearance of littoral diatoms are noted in upper section of the Eemian sediments. A corrosion of some diatoms at this part of the profile suggests oscillations of water level and, perhaps, temporary disappearance of the lake and peat bog during the last period of the Eemian Interglacial.

DISCUSSION

On the basis of obtained results the two events of abrupt changes of climate during the Eemian Interglacial are visible in evolution of palaeolake at Solniki. The first of them is noted within the *Carpinus* pollen zone, at the transition between S-5a and S-5b subzone, and is documented by rapid increase of magnetic susceptibility values. Magnetic susceptibility of the lacustrine sediments infilling palaeolake seems to be an important proxy record to reconstruct the changes of palaeoenvironments. Rate of denudation in this lake neighbourhood has an influence on both magnetic minerals supply as well as increasing of magnetic susceptibility (Opdyke, Channell, 1996). Cool climatic oscillations caused less vegetation capacity, which leads to faster denudation and supplying of magnetic fraction to the lake basin. It is possible that the same effect could be obtained during the periods of more humid climate. Pollen record, with indicators of high temperature such as *Hedera helix*, *Viscum album,* of the *Carpinus* zone excludes that the visible a high peak of magnetic susceptibility could be connected with temporary cooling of the climate. We suppose that this event reflects an increase of humidity, which causes the increase of both amount of incoming water into the lake and supply of magnetic minerals. At the same time the appearance of deep-water Cladocera species *Bosmina longirostris* points to a rising of water level in the lake. In addition the decreasing of $\delta^{18}O$ and $\delta^{13}C$ are observed in this part of *Carpinus* zone (isotopic horizon Is 2b). It might be caused by increase of precipitation leading to lake deepening and enriching water in light isotopes (the low values). Temporary increase of humidity during hornbeam zone documented in the sediments of palaeolake at Solniki might be correlated with one of intra-Eemian cool oscillations, noted in different regions of the world. The divergences might be associated with the interpretation of obtained results of analyses, where the same record can be an effect of cooling as well as humidity of climate.

The second abrupt climatic oscillation is noted in the sediments of palaeolake at Solniki at the end of the Eemian Interglacial, in pine zone. It is mainly registered by pollen record, which points to the very cold and dry climatic conditions, similar to climate of Early Vistulian, existing in the region, The changes are expressed by Cladocera record. The Cladocera data indicate the considerable shallowing of the lake and temporary decrease of frequency of Cladocera remains were caused by deterioration of environment. This change is weakly noted in curve of magnetic susceptibility, which shows, except of two little drops, the consist trend of increasing. This rising trend points to probably the gradual deterioration of climate condition.

CONCLUSIONS

Preliminary results of interdisciplinary researches were used to illustrate the Eemian Interglacial climate changes. At present stage of investigations, we have found signs of two abrupt climatic oscillations — the first with very humid climate took place at middle part of the *Carpinus* pollen zone (E5 R PAZ) and second with cold and dry climate at middle part of the *Pinus* zone (E7 R PAZ). Each of these changes are documented by results of two at least methods — the first is

registered by curve of magnetic susceptibility, isotopic curves and Cladocera data, second by pollen and Cladocera data. Others of them are not reflected simultaneously by all methods. Such confirms, at the next time, that reconstructions of palaeoclimate changes can not base on singular analysis, but the multidisciplinary researches are necessary.

A full study of Eemian Interglacial climate changes recorded in the palaeolake at Solniki will be present after ending of detailed chemical and diatom analyses.

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