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Eemian and Vistulian (Weichselian) paleoenvironmental changes: A multi-proxy study of sediments and mammal remains from the Ławy paleolake (Eastern Poland)

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ABSTRACT

The Eemian-Vistulian developmental history of the Ławy paleolake (Eastern Poland) has been studied by analysing records of micro- (pollen, Cladocera, Ostracoda), macrofossils (molluscs, mammal remains), the lithological record and radiocarbon dating from a 5.30 m sediment core. At Ławy, in the Paterebo stream valley, well-preserved mammal fossil remains accompanied by organic deposits have also been investigated. The results of the multi-proxy analyses suggest explicitly that the climate was the main driving force of the changes in terrestrial and aquatic ecosystems, and in the geomorphological processes in the catchment. However, we propose that the water level fluctuations were also an important factor in the modification of the aquatic assemblages. Pollen, cladocerans, molluscs and ostracods from Ławy indicate the existence of a small, shallow, well-vegetated paleolake during the warm Eemian climate optimum. In the final phase of the Eemian the lake was transformed into a mire. In the Early Vistulian, the variable hydrological conditions were the main driver force for the development of the study area. Finally the existence of the basin at Ławy was closely associated with periodic coexistence of limnic, telmatic and river environments.

1. Introduction

In the area of the South Podlasie Lowland (SE Poland) nearly 100 sites with biogenic sediments of Eemian Interglacial age (MIS 5e) have been discovered. The large number of sites indicates the presence of a fossil Eemian Lakeland. The Eemian lake sediments occur mostly in depressions on the surface of tills deposited during the Warta Stadial of the Odranian Glaciation (MIS 6, Fig. 1).

Vegetational and paleoenvironmental changes in Southern Podlasie during the Eemian have been mainly reconstructed on the basis of palynological research (Albrycht et al., 1997; Granoszewski, 2003; Żarski et al., 2005; Kupryjanowicz, 2008; Krupinski, 2009). The beginning of the interglacial was characterized by the dominance of cool temperate *Betula-Pinus* forests. During the climatic optimum mixed deciduous forests prevailed. Initially they were dominated by *Quercus*, next *Corylus* and later *Carpinus* occurred in greater amounts. The average temperature of the warmest month during the warmest period reached 18.2 °C (Kühl and Litt, 2007). Vegetational evidence suggests that summers were characterized by long and humid periods and winters were moderately moist and mild (Kupryjanowicz, 2008). After the thermal optimum, the average temperature of the warmest month decreased to 15.8 °C (Kühl and Litt, 2007). During the later part of the Eemian, *Pinus-Picea* boreal forests, reflecting a continental climatic influence, were finally replaced by pure pine communities. At that time, the

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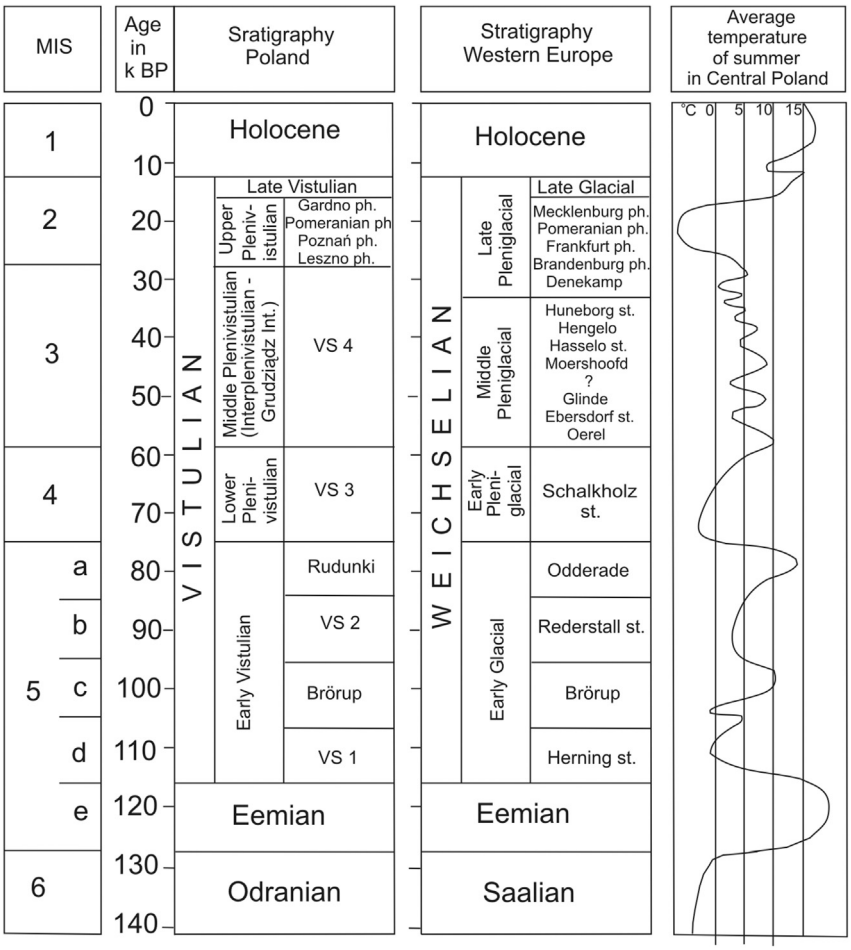

Fig. 1. Chronostratigraphy of Upper Quaternary in Poland (after Menke and Tynni, 1984; Behre, 1989; Mangerud, 1989; Mojski, 2005; Cyrek and Madeyska, 2011; Marks et al., 2015; modified). MIS – Marine Isotope Stages, ka BP – age in thousands years, int. – interstadial, st. – stadial, ph. – phase.

average temperature of the warmest month decreased to approximately 14.7 °C (Kühl and Litt, 2007). This heralded the onset of the dominance of the tundra-forest and tundra communities of the Early Vistulian. In the Podlasie region the best paleoenvironmental record (based on pollen and macrofossils analysis) was obtained from the nearby Horoszki Duze (Fig. 2), where the long core covers the Eemian, Early- and Plenivistulian interval (Granoszewski, 2003). Unfortunately, the Cladocera remains from the Horoszki section (Niska, 2012) were too damaged to be identified at species level and hence, not incorporated in the analysis. Other well-recognized palynological records in the Southern Podlasie region are from Wisniew (Pidek and Terpiłowski, 1993), Dziewule (Bińka and Nitychoruk, 2001) and Czaple (Bińka and Nitychoruk, 2011) (Fig. 2).

Most of sites in the study area with Eemian and Vistulian deposits were only investigated by pollen analysis (Kupryjanowicz, 2008; Żarski et al., 2009), and in some profiles a Cladocera analysis was also conducted (Mirosław-Grabowska et al., 2015; Niska and Kołodziej, 2015). However, detailed multi-proxy studies of Eemian lacustrine deposits from river valleys are still rare (Bińka et al., 2011; Petera-Zganiacz et al., 2013). The present paper presents new information on past climatic changes during the Eemian and Vistulian. It focuses on the evolution of the Ławy paleolake deduced from detailed palynological and Cladocera studies, supported by some malacological and ostracod data.

Additionally, the rich freshwater faunal data from the Ławy paleolake is supplemented by the unexpected discovery of bone and teeth remains of Pleistocene large mammals. Late Pleistocene megafaunal material is quite common in Polish caves (Nadachowski et al., 2009), in loess deposits (Woroncowa-Marcinowska et al., in press), especially at Paleolithic sites (Wojtal, 2007; Nadachowski et al., 2015) and in river sediments (Lorenc and Pawłowska, 2010; Żarski et al., 2014; Pawłowska et al., 2014; Pawłowska, 2015b). Remains without archaeological context found in gravel-pits and in river banks are also relatively frequent (Pawłowska, 2015a,b). However, due to taphonomic processes the preservation of bones in paleolakes and peat-bogs is very rare (Pawłowska, 2010), and it is restricted up to now to a few sites, mostly dated to the Pleistocene/Holocene transition (e.g. Gizejewski et al., 2004; Pawłowska, 2015a) or the Holocene (e.g. Guminski, 1995). The sequence from Ławy is the first Late Pleistocene site in Poland where large mammal remains have been found in peat-bog sediments.

The aim of this study is to reconstruct the paleoecological history of the small Paterebo stream valley from the end of the Eemian to the Plenivistulian. The paleobotanical and faunal proxies are discussed in detail and conclusions about climate and local changes are drawn.

2. Study area and geological setting

The Ławy site is located on the Siedlce Plateau which is part of

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