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Late Pleniglacial and Late Glacial lake-mire transformations in south-eastern Poland reflected in aquatic and wetland vegetation changes

Piotr Kołaczek [a,*], Mariusz Gałka [a], Monika Karpińska-Kołaczek [b], Monika Lutyńska [c]

[a] Department of Biogeography and Palaeoecology, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Dzięgielowa 27, 61–680 Poznań, Poland

[b] Department of Palaeobotany and Palaeoherbarium, Faculty of Biology and Earth Sciences, Jagiellonian University, Lubicz 46, 31–512 Kraków, Poland

[c] Department of Quaternary Geology and Paleogeography, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Dzięgielowa 27, 61–680 Poznań, Poland

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A B S T R A C T

This paper presents reconstruction of lake/mire vegetation changes recorded in a continuous profile, which spans the Late Pleniglacial and Late Glacial in south-eastern Poland. This is done on the basis of pollen, non-pollen palynomorphs (NPPs), plant macrofossils and diatom evidence. Initially, a small eutrophic lake, which originated and developed through permafrost thawing, existed at the site from ca. 14,910 cal. BP. The lake was characterized by mass algae blooms and wide taxonomic diversity of *Potamogeton* representatives. The succession of submersed macrophytes started with the appearance of Characeae and ranged from communities composed of taxa preferring alkaline conditions and the thin organic layer at the bottom, such as *Potamogeton filiformis* and *Potamogeton praelongus*, to those requiring alkaline-neutral waters with a thick organic layer (e.g. *Potamogeton alpinus*, *Potamogeton friesii*, *Potamogeton obtusifolius* and *Potamogeton pectinatus*). Despite the alkaline pH of water in the lake, there were also suitable niches for *Nuphar pumila*, a taxon associated with acidic waters. About 13,730 cal. BP a rich fen developed within the lake basin where *Carex* was prevalent, with more oligotrophic patches being occupied by *Sphagnum* mosses. The water table of this mire fluctuated, which is visible in the irregular occurrences of NPPs suited to an aquatic environment. The local vegetation points to slightly alkaline conditions on the fen. An eutrophic water body reappeared ca. 12,700 cal. BP and was functioning at least until ca. 11,620 cal. BP. This alteration of palaeoecosystem created niches for *Ranunculus sceleratus* in the shoreline section of the water body. The algae content and *Potamogeton* diversity was significantly smaller than in the water body that had existed there during the Late Pleniglacial and early Late Glacial. The succession of submersed macrophytes was the reverse of that of the initial water body. Taxa preferring more neutral-acidic conditions, such as *P. alpinus*, appeared at the onset of the renewed lake. Together with the accumulation of a layer of calcareous-detritus gyttja there was the spread of more 'alkaline' taxa, such as *P. pectinatus* and *Myriophyllum spicatum*. The present study revealed a lack of diatoms in the deposits along the entire length of the profile. In the case of peat section it stems from limited niches for their occurrence in fen habitats and their consequent low concentrations in peat deposits. However, the problem of the diatoms' absence in lacustrine sediments remains unsolved.

1. Introduction

The last deglaciation period triggered several geomorphic processes decisive for the Holocene landscape and surface sediment composition (comp. Lundqvist et al., 2007). Not only was the area covered by an ice-sheet and its vicinity affected by these processes, but more distant areas were affected as well. Among those effects was the appearance of several lakes which originated through permafrost thawing (Burn, 2007). These new ecological niches were occupied by several plant species. However, the climate fluctuations of the Late Glacial (e.g. Lowe et al., 2008) might have been a factor which moderated the composition of vegetation in such lakes.

Among those areas that were not covered by the Weichselian ice-sheet but affected by permafrost thawing during the Late Glacial was the Sandomierz Basin (a part of Subcarpathian basins), an area located in south-eastern Poland (Superson et al., 2010). Nowadays, in this part of Europe there are many oxbow lakes, and

* Corresponding author.
E-mail addresses: pkolacz@amu.edu.pl, piotrkolaczek@op.pl (P. Kołaczek).

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there is a substantial lack of large natural lakes (Kondracki, 2002). However, there are geomorphological traces of more numerous palaeolakes, whose origin was connected with the permafrost retreat (such as those reported by Wojtanowicz, 1997), but there is little information about the patterns of vegetation changes in such paleoecosystems.

To address these issues, this paper is focused on the lacustrine/mire vegetation succession recorded in one of the lakes whose origin and development was directly linked with the dynamics of permafrost thawing during the Pleniglacial–Late Glacial transition in south-eastern Poland. Palaeobotanical data including pollen, spores, non-pollen palynomorphs (NPPs), diatoms, and plant macrofossils (analysed with 1-cm resolution) were tools for the reconstruction of vegetation changes during climate-induced transformations from lake to mire. The chronology of deposits is based on a reliable ^{14}C age–depth model based on six dates. The set of analyses used in this research is unique as far as the Late Pleniglacial and Late Glacial in Poland are concerned. To the best knowledge of the authors the analysis of NPPs is the first from south-eastern Poland. NPPs constitute a group found with pollen in palynological samples, mainly composed of the remains of fungi (e.g. spores, conidia and hyphae), algae (several dormant stages and colonies), testate amoebae and other zoological remains (e.g. van Geel et al., 1981). They are considered valuable indicators of palaeoecological conditions (van Geel, 2001). Nonetheless, there is a significant deficiency of information about NPPs from Late Pleniglacial and Late Glacial profiles from Poland (e.g. Latałowa and Borówka, 2006) and other parts of Europe (e.g. van Geel et al., 1981; Miola et al., 2006; Huber et al., 2010). Among NPPs, microalgae seem to be the group most frequently used for reconstructions of past environmental conditions from Polish sites spanning this time interval (e.g. Bałaga, 2007a, 2007b; Wacnik, 2009; Apolinarska et al., 2012). Diatoms, biota-proxy also used in the studies presented in this paper, are an important tool for reconstructing water pH, nutrient content, salinity, organic carbon content, water and air temperature, ice cover duration, lake level and other environmental parameters (Korhola, 2007). Even though palaeodiatomological research into the final stages of the Weichselian ice-sheet deglaciation has been conducted in Central Europe (e.g. Marciniak, 1986; Amon et al., 2010; Żelazna-Wieczorek, 2010), the area of south-eastern Poland is still terra incognita in this context. The analysis of plant macrofossils, which makes possible the identification of plant remains at a species level, is crucial to reconstructions of local vegetation in the past (Birks, 2007; Gałka, 2014). This proxy is conventionally used for palaeoecological reconstructions and brings valuable information about temperatures and water level (e.g. Bennike, 2000; Tobolski and Ammann, 2000; Milecka et al., 2011; Fajer et al., 2012; Gałka and Sznel, 2013). However, presented in this paper analysis of macrofossil remains, carried out on very thin 1-cm slices of the profile, has rarely been carried out with such resolution in palaeo-reconstructions of the Late Pleniglacial and Late Glacial (Gałka and Sznel, 2013; Gałka et al., 2014). This approach gives an opportunity to gain detailed information about the order of the appearance of several aquatic and telmatic taxa, information which is frequently lost in the analysis of samples with a lower resolution (i.e. from thicker slices of profiles).

2. Study area

The site is situated in the Tarnogród Plateau (south-eastern Poland, 220 and 280 m a.s.l.; Fig. 1), a geographical unit which is built of sands originating in the Miocene covered by Quaternary tills, sands, and loesses (Kondracki, 2002). The area is dominated by luvisols (loessive soils) and endoeutric cambisols (developed on clayey sands, till and dusts of various origin) (Dobrzański et al., 1984). Climate data over the period 1996–2000 reveal a mean annual temperature of 7.5 °C, a mean July temperature of 17.5 °C and a mean January temperature of −3 °C. In the same period annual precipitation ranged between 700 and 800 mm (Lorenc, 2005). The main type of natural water bodies in the area, are oxbow lakes, whose aquatic vegetation belongs mainly to the *Nympheion* and *Potamion* alliances (http://www.ine.eko.org.pl/).

The site is a nameless small rich fen with a surface smaller than 0.1 ha (ca.215.5 m a.s.l.) located in the Kobylnica Wołoska (KW) village. It is situated in the valley of the Szkło River, which is a right-bank tributary of the San River (Fig. 1). Although the origin of the depression, within which the fen developed, has not been precisely investigated (there is no geological cross-section of the fen deposits), the shape and ^{14}C dates of the bottom sediments confirm that it was established during the ablation of the Weichselian permafrost (A. Wójcik, personal communication).

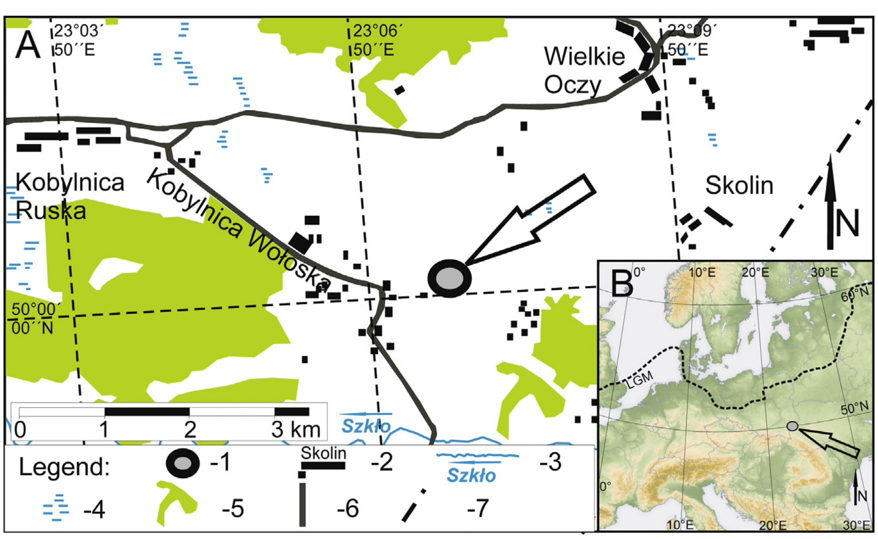

Fig. 1. Location of the Kobylnica Wołoska (KW) site; A. Sketch map of the vicinity of the site: 1 – site location, 2 – towns and villages, 3 – rivers, 4 – mires, 5 – woodlands, 6 – main roads, 7 – country border, B. The site location on the map of Central and Western Europe (source: http://pl.wikipedia.org/wiki/Europa#mediaviewer/Plik:Europe_topography_map.png, Author: San Jose; modified); LGM – maximum extent of ice sheet during the Last Glacial Maximum.

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