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Lateglacial and early Holocene environmental dynamics in northern Lithuania: A multi-proxy record from Ginkūnai Lake

Miglė Stančikaitė [a], Vaida Šeirienė [a, *], Dalia Kisielienė [a], Tonu Martma [b], Gražyna Gryguc [a], Rimantė Zinkutė [a], Jonas Mažeika [a], Petras Šinkūnas [a]

[a] Nature Research Centre, Institute of Geology and Geography, T. Ševčenkos 13, 03223 Vilnius, Lithuania
[b] Institute of Geology, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

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ABSTRACT

To reconstruct the Lateglacial and early Holocene palaeoenvironmental dynamics in the northern part of Lithuania, the sediment record from Ginkūnai Lake was studied applying a multi-proxy approach, involving pollen, diatom, and plant macrofossil surveys as well as $\delta^{18}O$, $\delta^{13}C$, ^{14}C and loss on ignition (LOI) measurements, together with geochemical investigations. The obtained data suggest the deglaciation of the area started at approximately 16,000–16,500 cal BP, followed by the formation of a tree-less tundra. The obtained palaeobotanical records indicate the scarcity of the vegetation cover and the flourishing of the non-arboreal taxa in the local flora, suggesting a severe climatic regime. After 13,700 cal BP, the *Pinus-Betula* predominating forest progressively expanded, although this process was partly reversed during the recurrence of a cold interval recorded from 13,000 to 13,100 cal BP. Since 12,600 cal BP, rapid aridification of the climatic regime reflected in the isotope record was accompanied by the formation of cold-adapted vegetation, including *Picea* stands, which acted as an intensive supply of allochthonous material into the basin, thereby decreasing the water level. The identified period of physical disturbance lasted until approximately 11,800 cal BP. Significant changes of the palaeoenvironmental regime subsequently occurred in the area and were manifested in most of the obtained proxies, i.e., changes in the sediment type, transformations of the vegetation cover, and fluctuations of the sedimentation regime. Isotope records along with the geochemical data indicate a major climatic turn in terms of the temperature and moisture after 11,500 cal BP. The rising productivity of the basin was coincident with the stabilisation of the soil layer and the formation of dense vegetation cover enriched by *Corylus* (ca 9800 cal BP) and *Ulmus* (ca 10,300 cal BP) during the early Holocene. After 10,800 cal BP, the investigated part of the basin changed to a peat bog.

1. Introduction

Marked by rapid and pronounced climatic oscillations (Walker et al., 1994, 1999), the Weichselian Lateglacial period is especially important for describing climate history and the subsequent ecosystem response in the North Atlantic realm. Numerous studies based on multi-proxy data obtained from terrestrial, marine and ice archives have revealed and characterised post-glacial climatic episodes (Walker, 1995; von Grafenstein et al., 1999; Lowe et al., 2008; Brooks and Birks, 2000a,b) and the tree population dynamics (Huntley and Birks, 1983; Birks and Birks, 2004; Willis and van Andel, 2004; Giesecke, 2005; Latałowa and van der Knaap, 2006; Birks and Willis, 2008; Binney et al., 2009; Väliranta et al., 2011), in northern Europe. The existing data sets suggest a high synchronicity of the main climatic events and the associated environmental response in this region (Lowe et al., 2008), while some alterations, such as the delay of the early Holocene warming and the subsequent environmental shifts in the northeastern part of the continent, were fixed (Wohlfarth et al., 2002, 2007; Stančikaitė et al., 2008, 2009). Increasing the number of chronologically well-supported high-resolution multi-proxy archives representing areas where the number of similar investigations is still low may aid in improving the understanding of the Lateglacial climatic evolution and the ecosystem reaction in the Northern Hemisphere.

Situated in the southeastern sector of the Scandinavian Ice Sheet (SIS), the eastern Baltic region can be described as a key area for improved understanding of these relationships in the east-west

* Corresponding author.
E-mail address: seiriene@geo.lt (V. Šeirienė).

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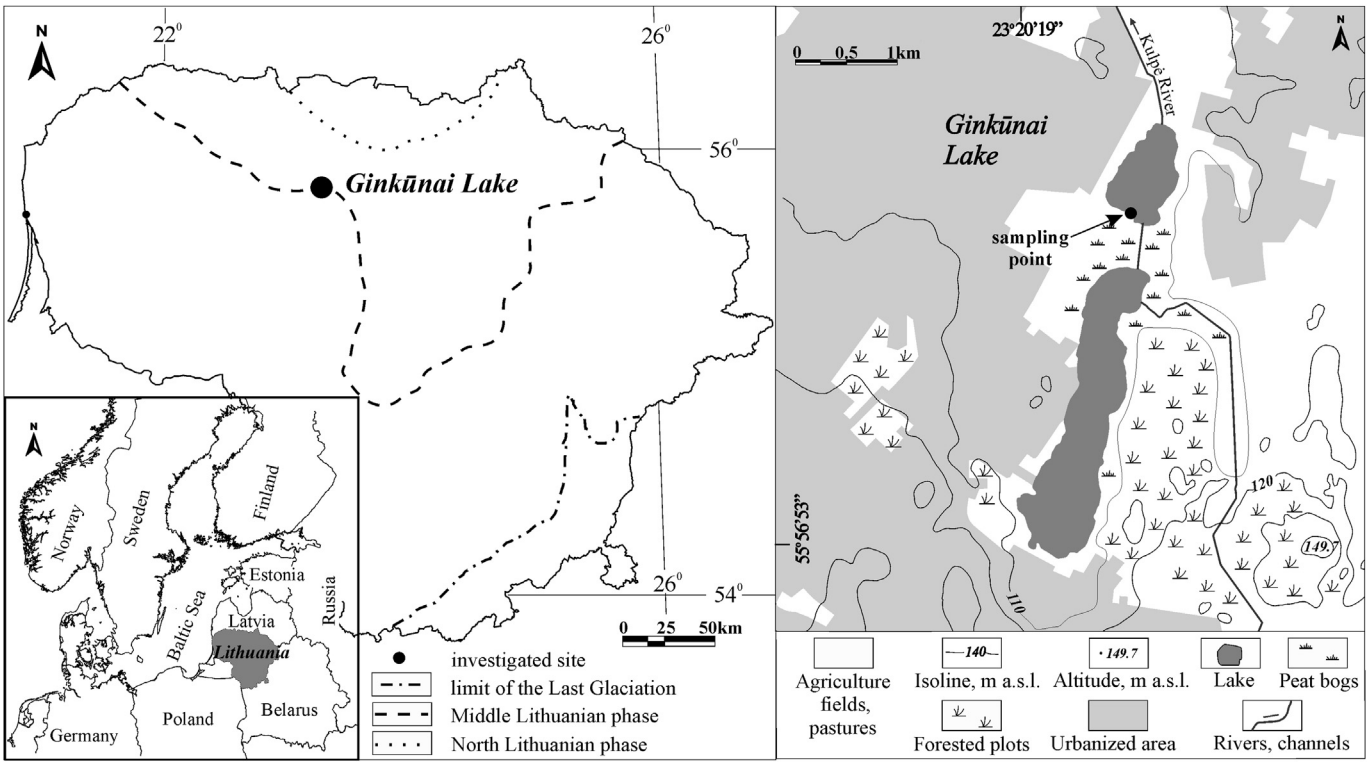

Fig. 1. Location of the Ginkūnai Lake study site.

transect. Although studies of the Lateglacial, i.e., the deglaciation history (Hausen, 1913), vegetation dynamics (Weber, 1902; Thomson, 1931), among others, started in the region over one-hundred years ago many questions related to the particular episodes in palaeoenvironmental history, including the timing and spatial variations of the recorded changes, remains unclear. Only resent research in which the multi-proxy approach has been increasingly used has farther described the ice-recession pattern (Bitinas, 2011; Guobytė and Satkūnas, 2011; Kalm et al., 2011; Zelčs et al., 2011), vegetation history (Stančikaitė et al., 2004, 2009; Šeirienė et al., 2006; Heikkilä et al., 2009; Saarse et al., 2009; Amon and Saarse, 2010; Amon et al., 2010, 2012; Veski et al., 2012), changes of the lacustrine environment (Novik et al., 2010; Ozola et al., 2010) and chronology of particular climatic and environmental events (Rinterknecht et al., 2006, 2008) in the region. By increasing the temporal resolution, it has also been possible to correlate the results regionally.

To further describe the Lateglacial and early Holocene palaeoenvironmental dynamics in the eastern Baltic, a sediment core was obtained from Ginkūnai Lake, northern Lithuania. As very few records covering the above mentioned time interval are known from this relatively unexplored territory, these new data may contribute to the reconstruction of the spatial-temporal pattern of the palaeoenvironmental fluctuations, both in the eastern Baltic and elsewhere. The objectives of this multi-proxy investigation are a) to reconstruct the floral dynamics representing the vegetation responses to climatic oscillations of different scales; b) to describe the sedimentary environment of the investigated aquatic system; and c) to contribute to the understanding of the paleoenvironmental changes in the context of the regional and global ones. To achieve the above-mentioned objectives, the authors combined pollen, diatom, and plant macrofossil evidence as well as the results of stable isotope ($\delta^{18}O$, $\delta^{13}C$, ^{14}C) measurements together with loss on ignition (LOI) and geochemical data.

2. Study site

Ginkūnai Lake, with the coring point (55°56′53″N, 23°20′19″E, Fig. 1), is situated in the territory characterized as the Middle Lithuanian ice-marginal ridge formed during the Last (Weichselian) Glaciation (Guobytė and Satkūnas, 2011). The sedimentary basin stretches in a depression surrounded by morainic hills reaching to 140 m a.s.l. The middle part of the investigated eutrophic lake is waterlogged area, dividing the lake into two parts: a 16 ha northern (107 m a.s.l.) and 56.2 ha southern one (103 m a.s.l.). The core was made in the northern basin (Fig. 1). Low lake shores are boggy, and the headwaters of Kulpė River are situated in the northern part of the investigated lake. Pastures and agriculture fields predominate northwards from the lake, and the outskirts of Šiauliai Town stretch southwards.

The study area belongs to a boreo-nemoral vegetation zone and is characterized by the dominance of *Pinus sylvestris* L., *Picea abies* (L.) Karst., *Betula pubescens* Ehrh. and *Betula pendula* Roth. (Natkevicaite-Ivanauskiene, 1983). In the northern part of Lithuania, the annual average air temperature is 6 °C, with mean January temperature at −5 °C and mean July temperature at approximately 16.5 °C. The average precipitation is approximately 550 mm y^{-1} (Bukantis, 1994).

3. Methods

3.1. Coring and sampling

Four adjacent 715 cm depth cores situated in a distance of 1.5–2 m from each other were taken using a “Russian” peat sampler with 1 m length and a 5 cm inner-diameter chamber. Multiple, parallel, overlapping sediment cores were transported into the laboratory, described, and sub-sampled for further survey. Characteristic lithological limits were easily determined due to the sharp transition between layers. One sediment sequence was sub-