Palaeogeography, Palaeoclimatology, Palaeoecology 396 (2014) 155–172

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Late glacial climatic and environmental changes in eastern-central Europe: Correlation of multiple biotic and abiotic proxies from the Lake Švarcenberk, Czech Republic

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ARTICLE INFO

Article history:
Received 8 July 2013
Received in revised form 9 December 2013
Accepted 16 December 2013
Available online 3 January 2014

Keywords:
Last Glacial Termination
Lacustrine sediments
Climate changes
Biotic/abiotic responses
Eastern-Central Europe

ABSTRACT

Thick lake sediments discovered in the southern part of the Czech Republic provide a high-resolution archive for detailed study of paleoenvironmental changes during the Late Pleistocene to Holocene in eastern-central Europe. Until recently, no similar records were available for this important region in the transition from oceanic to continental macro-climatic settings. Using a multi-proxy approach that combines sedimentological, pollen-analytical, paleozoological (Chironomids), geochemical and mineral-magnetic methods we demonstrate that major climatic events of the Late Glacial can be correlated with Atlantic rather than continental regimes as reported in paleoclimatic literature for the area of the interest. The sensitivity of applied biological and abiological techniques to climatically-driven processes allows trans-regional comparisons and enables us to discuss the pattern of geographic variation in these processes. We are able to establish a clear relationship between vegetation cover, soil development and erosional processes. A short-term intra-Alleröd cool event has been correlated with the Gerzensee oscillation. Proxy evidence suggests that the early half of the Younger Dryas was rather humid, whereas the latter half was dry and had significant impact on vegetation, sedimentary dynamics and lake level status during the YD/Preboreal transition.

1. Introduction

The Last Glacial–Interglacial Transition (including the Late Weichselian period and onset of the Holocene) is marked by rapid and pronounced climatic oscillations associated with successive climatic steps during global deglaciation (Ruddiman and McIntyre, 1981; Lowe et al., 1994; Björck et al., 1996; Clark et al., 2001; Lowe et al., 2008). While these changes are well documented in the high-resolution record of the Greenland ice cores (Johnsen et al., 1992; Stuiver et al., 1995), as well as in marine sediments (Bergsten, 1994), our knowledge on environmental transformations of the continents is still relatively fragmental due to the heterogenic deployment of suitable sedimentary archives. In continent interiors, abrupt Late Glacial and Early Holocene climatic oscillations caused deep changes in local vegetation and soil development, resulting in changes in sedimentary processes. Yet, as indicated by a large scale geographic comparison of the pollen records throughout Europe (Davis et al., 2003), considerable interregional differences both in timing and intensity of the respective climatic and environmental rearrangements might have occurred. Consequently, geographic variation in the regional response to general climatic trends along the Weichselian–Holocene transition becomes a topic of urgent importance. A dense network of high resolution records from different geographic locations once available will present a basic prerequisite for its analysis.

The records of the lacustrine series providing data on the course of vegetation development and its relations to local erosion and lithogenetic dynamics are in these connections of particular significance (Walker, 1995; Brauer et al., 1999; von Grafenstein et al., 1999; Ammann et al., 2000; Birks and Wright, 2000; von Grafenstein et al., 2000). Yet, the geographic distribution of such series is far from being homogeneous. While a large number of lake deposits are available from northern and NW Europe, most of central Europe (except for the

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http://dx.doi.org/10.1016/j.palaeo.2013.12.024

Alpine piedmont and Panonnian basin) is rather poor in this respect. This very much holds for the area of the eastern part of Central Europe where the absence of lacustrine deposits is explained both by the high relief dynamics of the region and by its unfavorable hydrologic context, far from the sources related to either continental or Alpine glaciations. Until recently, only three sites with Late Weichselian lacustrine deposits were reported from the interior of the Czech Republic: Plešné Lake in Šumava Mts., Labský důl mire in Krkonoše Mts. (both with a total thickness of 200–250 cm: Engel et al., 2004; Jankovská, 2006), and the Švarcenberk Lake in Třeboň basin (Pokorný, 2002; Pokorný et al., 2010). In contrast to the former two that are high mountain deposits with rather specific conditions, the latter is situated at a medium altitude and represents a continuous lacustrine and peat series of a total thickness of over 10 m of which about 4 m cover just the Late Weichselian–Early Holocene transition.

The Švarcenberk Lake is, in this sense, a unique archive for environmental reconstructions and the best sedimentary record known for the Late Glacial and Early Holocene periods in the eastern-central Europe. The sensitivity of the site's setting to climatic oscillations of this particular period is due to its altitudinal position (412 m a.s.l.) that is transitional in terms of altitudinal zonation of vegetation. In addition, the character of the lake itself (small catchment, a single outlet) makes its water level sensitive to climatic oscillations. Detailed high-resolution data on the Late Glacial and Holocene vegetation development are already available from this site (Pokorný and Jankovská, 2000; Pokorný, 2002) together with data on the dynamics of the Mesolithic occupation of the lake catchment area (Šída et al., 2007; Pokorný et al., 2010).

The present paper supplements this information with the results from a multi-proxy approach, which combines several techniques of instrumental sedimentological analyses with the pollen record, plant macrofossils and analyses of insect (Chironomid) remains. We provide some new data on the former series (a core in the center of the lake), yet the paper is particularly based on a new core in the littoral area, where a relatively quiet, continuous sedimentation prevailed and allochtonous material from the catchment together with autochtonous biotic sediment accumulated. We correlate a record from both series and discuss a degree of correspondence between the results of particular techniques and, furthermore, the timing and intensity of paleoenvironmental changes in the lake catchment during the Alleröd and Younger Dryas periods.

2. The study area and site

The study site (49°08′45″ N, 14°42′45″ E) is situated in South Bohemia (Czech Republic) at 412 m a.s.l. (Fig. 1). The former lake Švarcenberk lies in the northern section of the flat landscape of the Třeboň Basin. The geological substratum of the lake catchment is represented by sandy Cretaceous sandstones and Tertiary sandy/clayey fluvio-lacustrine sediments. Depressions are filled with Quaternary fluvial silt and sandy gravel, aeolian sands, and particularly organic lake and peat sediments (Fig. 3). Various types of podsols and sandy or peaty gleysols prevail in the area. The present climate is suboceanic and is determined by prevailing westerly air masses, already significantly reduced in moisture by their passage across central Europe.

Lacustrine clastic sediments of the Lake Švarcenberk basin are overlain by peat, which have formed after the natural infilling of the lake occurred at approx. 5500 years BP according to ^{14}C dating (Pokorný and Jankovská, 2000). Nowadays, the site is heavily influenced by intensive management: between 1698 and 1701 a fishpond was constructed directly on the site, and its waters have almost completely flooded over the peat and the underlying lake sediments.

3. Basin morphology and stratigraphy of deposits

The extent of lake deposits and morphology of the basin was mapped using approximately 150 hand borings (Pokorný, 2002) and

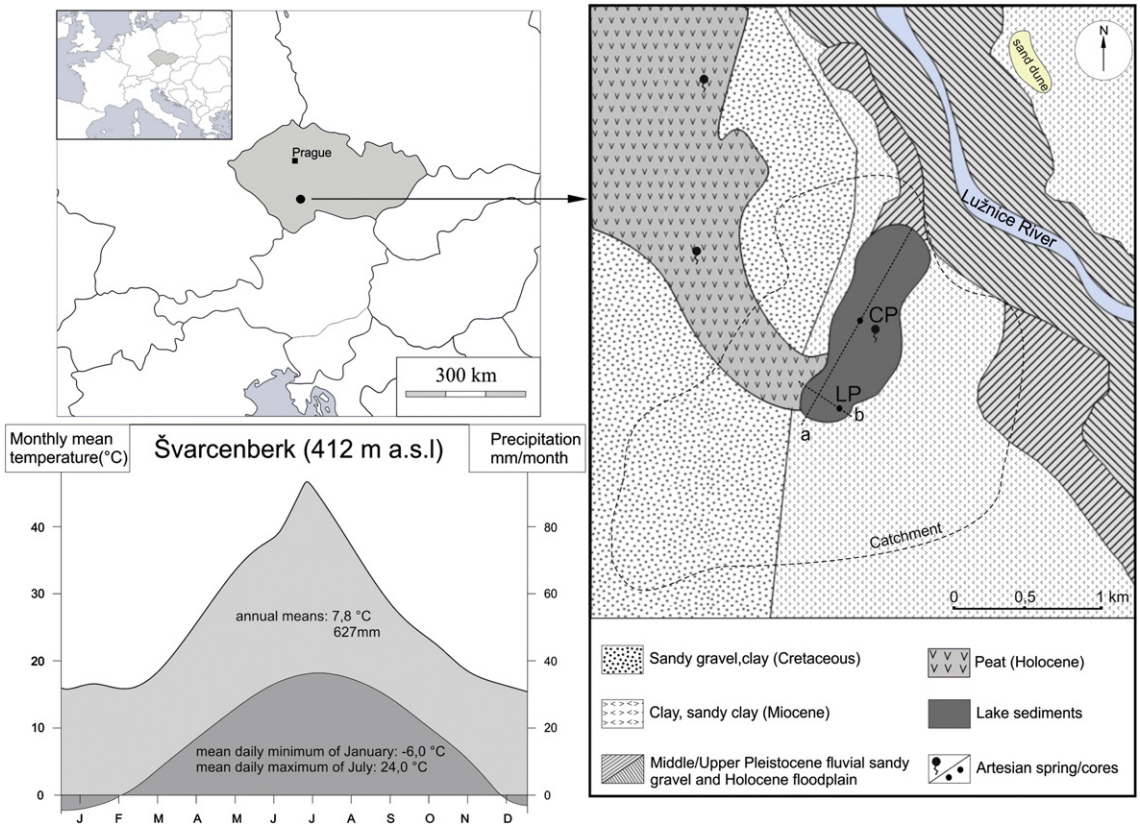

Fig. 1. Location of Švarcenberk lake; simplified geological situation of the site; climatic diagram for Třeboň (16 km south from the site); a,b — two cross sections used for stratigraphic investigation.