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Environmental inferences and chironomid-based temperature reconstructions from fragmentary records of the Weichselian Early Glacial and Pleniglacial periods in the Niederlausitz area (eastern Germany)

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Abstract

We inferred past climate conditions from lacustrine sediments intercalated in Weichselian Early Glacial and Early Pleniglacial fluvial and aeolian sediments, exposed in two opencast lignite mines from the Niederlausitz area (eastern Germany). A chronology was established using radiocarbon and luminescence dating methods. Both lithology and chironomid fauna indicate that the former shallow lakes were situated on a floodplain. Palaeotemperature estimates calculated from the fossil chironomid-assemblages of the Early Glacial lacustrine deposit indicate mean July air temperatures of ca. 15 °C, which is in line with results derived in earlier studies from the Niederlausitz area and from northwestern Europe. The Early Pleniglacial lacustrine deposits consist of an organic-rich gyttja, intercalated with sand and silt lenses. The chironomid-assemblages show that a shallow meso- to eutrophic lake was present at the study site, and chironomid-inferred palaeotemperature estimates indicate an abrupt decline in July air temperatures from 15–16 °C to ca. 13 °C. In combination with other proxies from the same record, this suggests a Dansgaard/Oeschger like climate event.

Keywords: Weichselian; Chironomids; Pollen; Plant macrofossils; Climate reconstruction; Lake sediments; Floodplain; Germany

1. Introduction

The Weichselian period has been a research topic of interest for several decades as it is a period of dynamic climate evolution that was not substantially influenced by human activity. The number of lacustrine records covering (parts of) the Weichselian on the European continent is limited, and high-resolution quantitative reconstructions of past climate change are scarce. With the development of the so-called transfer function approach (e.g. Birks, 1998), new tools have become available to quantitatively infer past changes in climate from fossil assemblages of different groups of organisms such as diatoms, pollen or chironomids.

Chironomids are sensitive indicators of past changes in water depth, nutrient availability and summer temperatures (e.g. Walker and Cwynar, 2006; Brooks, 2006) and well-preserved head capsules of the larvae are usually abundant in lake sediments. In recent years the development of chironomid-based transfer functions has greatly improved the usefulness of chironomids for palaeoenvironmental reconstruction. Using transfer functions, we are able to provide quantitative estimates of past environmental conditions based on fossil chironomid-assemblages (e.g. Walker et al., 1997; Brooks and Birks, 2001; Heiri and Lotter, 2005). Initial applications of these transfer functions have focussed on the Late-Glacial period (e.g. Walker et al., 1991; Brooks and Birks, 2000) and the Holocene (e.g. Heiri et al., 2003; Velle et al., 2005) and were aimed at reconstructing past July air

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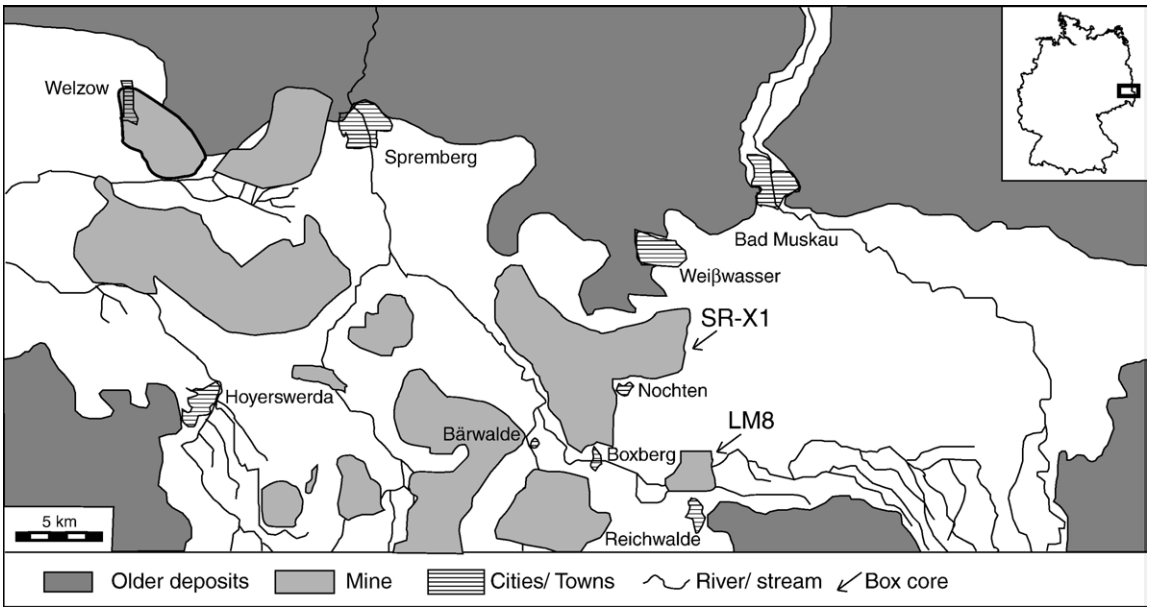

Fig. 1. Location map of the Nochten and Reichwalde mines in the Niederlausitz area (after Mol, 1997a). The locations of the SR-X1 and LM8 sample boxes are indicated by arrows.

temperatures. Chironomid-based studies on lacustrine sediments from Europe predating the Late-Glacial are scarce, and include Becker et al. (2006), Gandouin et al. (2007) and Engels et al. (2007a). The latter study provides (to our knowledge) the first chironomid-inferred palaeotemperature estimates for the Middle Weichselian.

The opencast lignite mines of eastern Germany provide large exposures of Weichselian sediments that are mostly of fluvial origin, and have been the subject of extensive studies in the past (e.g. Wolf and Alexowsky, 1994; Mol, 1997a; Bos et al., 2001; Kasse et al., 2003; Hiller et al., 2004; Bohncke et al., 2008). Lacustrine deposits, intercalated in these fluvial and aeolian sediments, are suitable archives for palaeoenvironmental reconstructions based on the multitude of proxies available to infer past changes in vegetation, environment and climate from lake sediments (e.g. Smol et al., 2001a,b).

Lacustrine sediments encountered in the opencast mines of eastern Germany all originate from former lakes situated on river floodplains. Hence, they potentially may have been affected by flooding by the nearby river. Modern training sets normally do not include lakes that are prone to flooding by rivers, which creates a non-analogue situation between our fossil floodplain lakes and the existing modern training sets. To our knowledge, no quantitative palaeoenvironmental reconstructions on chironomid remains from floodplain lakes has been attempted so far.

In a recent study of 33 lakes in Finland, Engels et al. (2007b) have shown that the variability of chironomid-based reconstructions and prediction residuals from floodplain lakes is similar to lakes unaffected by riverine influence. This suggests that floodplain lakes are suitable alternatives for reconstructing summer temperatures in situations where no lakes isolated from riverine influence are available, as is the case in the Niederlausitz area of eastern Germany.

In this paper we show the results of a detailed analysis of the sedimentary succession of deposits, exposed in two opencast lignite mines in the Niederlaustiz area: Nochten and Reichwalde (Fig. 1). Two lacustrine deposits, dated to the Early Glacial and the Early Pleniglacial, are analysed for a range of proxies and in this paper we aim to reconstruct mean July air temperatures by applying chironomids as a proxy for these two time-windows for which quantitative data on past climate conditions is scarce.

2. Geological setting

The Lausitzer ice-marginal valley, situated in the southern part of eastern Germany, was formed during the Saalian glaciation and has an E–W orientation. The former valley is characterised by a number of large opencast lignite mines, including the Reichwalde and Nochten mines (Fig. 1). Active recovery of Miocene browncoal, situated approximately 100 m below the current surface, exposes the overlying sediments that are mainly of Saalian (130–200 ka) and Weichselian (12–110 ka) age. Previous studies in the Nochten mine include studies of the fluvial succession (Mol, 1997a,b; Kasse et al., 2003) and of the vegetation and climate development (Bos et al., 2001). The Reichwalde mine was previously visited by Bohncke et al. (2008) who qualitatively reconstructed environmental and climatic conditions from a short lacustrine record and provided a first chironomid record for the sequence.

3. Methodology

3.1. Data acquisition

In June 2004 we studied a 1000 m long N–S oriented exposure in the Nochten mine. As scree was present on the slopes, no continuous sections could be analysed but instead,