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Short-term changes in a Saalian glacial lake – The Parchliny C site, central Poland

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ABSTRACT

The paper discusses results of sedimentological, faunal (molluscs, ostracods) and geochemical studies of an 80-cm-thick rhythmite succession within a glaciolacustrine sequence (8–10 m in thickness) of the Ławki Formation exposed at the Parchliny C site, in the tectonically active Kleszczów Graben, central Poland. Sedimentological studies show the predominance of rhythmically deposited pale grey muds (2.0–7 cm thick) and black clays (0.5–5 cm thick).

The pro-glacial sediments have yielded the first examples of Saalian molluscan and ostracod communities to be recorded from Europe and probably globally. The presence of a lake basin is confirmed by the freshwater species fauna: *Candona neglecta*, *Cypridopsis vidua*, *Fabaeformiscandona protzi*, *Limnocythere inopinata*, *Limnocytherina sanctipatricii Cyclocypris laevis*, *Metacypris cordata* (ostracods) and *Anodonta cygnaea*, *Ancylus fluviatilis*, *Theodoxus fluviatilis*, *Bithynia tentaculata*, *Valvata piscinalis* and *Pisidium* sp. (molluscs), suggestive of deposition during a period of colder climatic conditions, although some species might be indicative of a warmer period, resembling an interglacial. The whole section has a high carbonate content, up to several tens percent. The carbonates are enriched in the heavy isotope of oxygen. The isotopic composition of carbon and oxygen indicates two stages of lake development. The transition of the lake from a hydrologically open to a closed system with significant evaporation has been reconstructed from correlation of $\delta^{13}C$ and $\delta^{18}O$. Sedimentological, faunal (molluscs, ostracods) and stable-isotope studies of the Saalian Ławki Formation have revealed an important snapshot – a 14-year record in the hydrological transformation of this specific pro-glacial lake system.

1. Introduction

Investigations of glacial lakes at mid-latitudes have generally relied on contemporary models of glaciolacustrine deposition in the northern hemisphere (e.g., De Geer, 1912; Ashley, 1975; Gustavson, 1975; Shaw, 1977; Merta, 1978; Sturm, 1979; Strömberg, 1983, 1985; Ashley et al., 1985; Ojala, 2001; Zillén et al., 2003; Zolitschka, 2003; Tylmann et al., 2006; Winsemann et al., 2007; Breckenridge et al., 2012; Murton and Murton, 2012; Livingstone et al., 2015). Such studies have demonstrated how lacustrine basins were formed and filled with non-organic deposits in tectonically stable regions.

Among glacigenic deposits, glaciolacustrine sediments provide the best evidence for environmental reconstruction. Records of plant and animal fossils in those sediments are rare, but are very important, as their presence determines environmental conditions in the palaeolake (e.g. Krzymińska et al., 2016). Most examples of such reconstruction apply to the last glacial (LGM) episode (eg. in North America, Tuthill, 1963; Karrow et al., 1975; Gibbard and Dreimanis, 1978; Miller et al., 1979; Karrow and Mackie, 2013; in Europe, Marcussen, 1967; Gibbard and Stuart, 1974; Gibbard, 1977; Schwalb et al., 1998; Uchman et al., 2009; Sohar, 2010; Schwalb et al., 2013). The reported assemblages can suggest the presence of terrestrial or aquatic vegetation and water conditions at individual sites varying from oligotrophic to eutrophic. Palaeozoological investigations can help to characterise the lacustrine palaeoecological conditions because species that inhabit either littoral or deeper environments can be indicative of the bathymetry of the lake. Thus they provide an indirect indication of paleotemperature. Furthermore oxygen and carbon stable-isotope studies of ostracods, and

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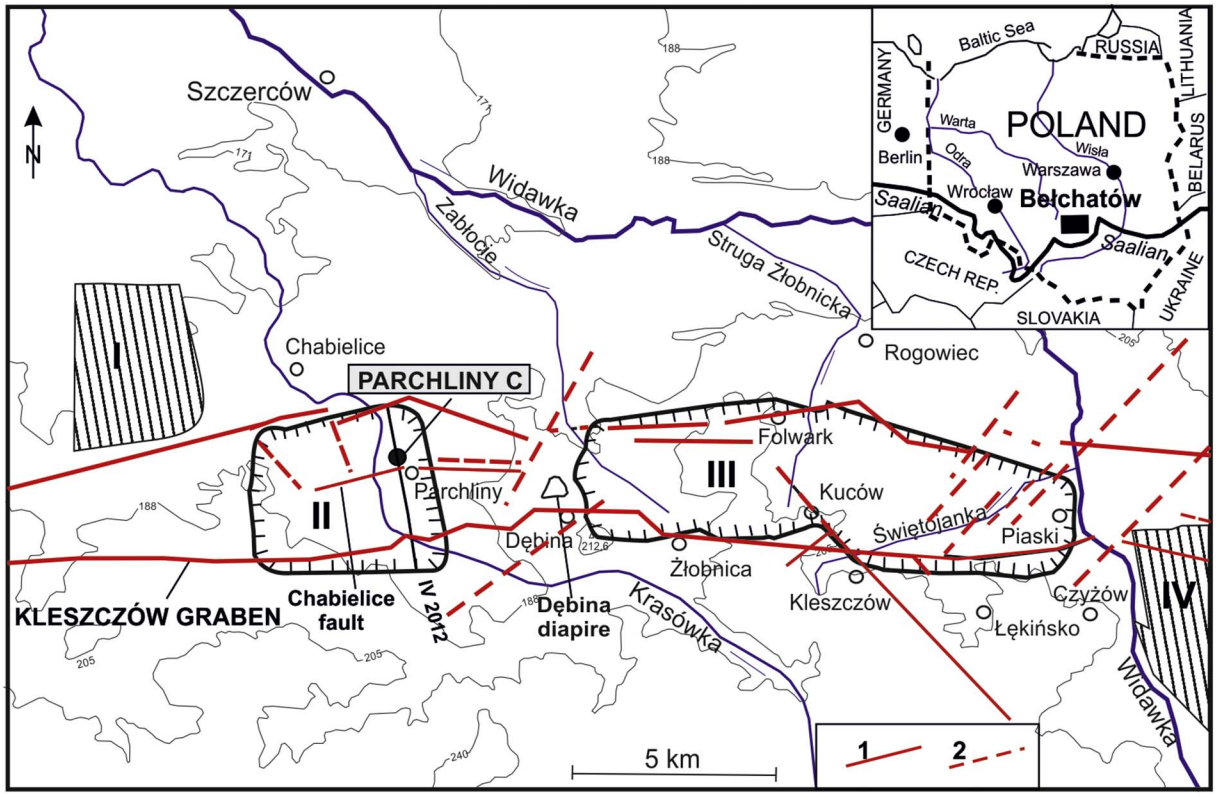

Fig. 1. Location of the Parchliny C section in the Kleszczów fault and river system and the Bełchatów open-mine complex. 1 – confirmed faults; 2 – probable faults. Szczerców: I – external dump; II – exploitation field; Bełchatów: III – exploitation field; IV – Kamieńsk external dump (Kamieńsk Mt. 384 m a.s.l.) The insert shows the position of the study area in Poland.

especially interpretation of $\delta^{18}O$ values, can indicate the annual mean air temperature (Schwalb et al., 2013).

The first observation of trace fossils (tracks) from Saalian deposits dates back to 1938, when Schwarzbach (1938) undertook a sedimentological investigation of Saalian deposits within the Bystrzyca River Valley (central part of the Sudetes Mountains, the Sowie Range). With the exception of the above, there are no reports in the literature of molluscan or ostracod assemblages from Saalian glaciolacustrine sediments in the northern hemisphere (Europe and North America). However, Cladocera assemblages have recently been found in a late Saalian deposits from central Poland (Pawłowski et al., 2013).

In 2012 large fragments of snails were found in muddy-clay lacustrine deposits at the Parchliny C site, within the Szczerców outcrop, central Poland. The presence of a mollusc and ostracod fauna in those deposits has allowed for further study and revision of existing views on the presence of a cold pro-glacial lake during the penultimate Saalian glacial in the investigated area (Fig. 1). For this reason, a malacological and isotopic study was undertaken, to address research questions such as under what conditions glaciolacustrine sedimentation had occurred in which Mollusca and Ostracoda were incorporated, and whether that fauna co-existed with the occupation of the area by Saalian ice whether central Poland was subject to short-term flashes or long-term climate swings.

The paper discusses an examination of glaciolacustrine deposits, some of which contain enigmatic invertebrate remains. These discoveries are of great significance to our understanding of environmental change in ice-marginal lakes following deglaciation. Sedimentological, faunal and stable-isotope analyses have been carried out to produce a palaeoenvironmental reconstruction of the development of a pro-glacial lake in close proximity to the Saalian ice sheet.

2. The regional setting

The Parchliny C site is situated in the eastern part of the Szczerców Field at the Bełchatów lignite mine, within the tectonically active Kleszczów Graben (Fig. 1), in the Łódź Cretaceous Syncline. The graben is filled with Miocene sands, mottled clays and lignites, as well as Quaternary glacial and non-glacial deposits reaching an overall thickness of 340 m. Progressive extraction of the uppermost Quaternary deposits, > 200 m thick and overlying the lignite (Fig. 1), has enabled assessment of glacial complexes containing glaciolacustrine sediments. The contrast in lithology within the Quaternary sediments allows several formations to be distinguished as primary units of lithostratigraphy (see: http://www.stratigraphy.org/upload/bak/litho.htm; Table 1).

The glaciolacustrine origin of the Ławki Formation sediments was established from studies in the nearby Bełchatów field by Krzyszkowski, 1991, 1993, 1994, 1995; Brodzikowski, 1993, 1995; Gruszka and Zieliński, 1996; Gruszka, 2007; Gruszka and van Loon, 2007. In the Bełchatów field (Fig. 1) these sediments were also been examined in order to determine the effect of tectonic activity in lacustrine basins (Krzyszkowski, 1991, 1992, 1993, 1994, 1995; Brodzikowski, 1995; Brodzikowski et al., 1997; Gruszka, 2007; Gruszka and van Loon, 2007). Geochemical analyses of glaciolacustrine deposits at the Kuców C site in the Bełchatów field show cyclic winter-summer sedimentation and variable carbon and oxygen isotopic composition in pro-glacial deposits of a Saalian lake (Krzyszkowski et al., 2011). Comparable rhythmically layered sediments have now been recognized at the Parchliny C site (see above).

2.1. Studies of limnic deposits in the Kleszczów Graben

As well as sedimentological analyses, the limnic and fluviolimnic deposits at Bełchatów have been studied in terms of their potential palaeontological contents. Makowska (1987) reconstructed a littoral environment with aeolian influences using malacofauna, but failed to provide dates for this. Recent diatom investigations undertaken by Balwierz et al. (2006, 2008) have provided evidence of a Holsteinian