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Early Holocene hydrology and environments of the Ner River (Poland)

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ABSTRACT

The Ner River valley (central Poland) underwent substantial transformation during the Weichselian–Holocene transition as a result of fluvial processes and climate changes, resulting in the establishment of its present shape in the Holocene. A multiproxy study based on organic deposits from a palaeochannel fill (Lutomiersk–Koziówki) shows that after the channel was cut off during the late glacial termination, it became a shallow oxbow, fed by local springs. In the Boreal period, the oxbow lake was also fed by precipitation and became a telmatic environment overgrown by rush and swamp vegetation. Finally, it was covered by overbank deposits. The first flooding phase (9900–9600 cal. BP) was followed by the accumulation of overbank sediments (after 9500 cal. BP) and flooding increased after ca. 9300–9000 cal. BP. Pollen data provide information on the regional vegetation context for local and regional changes. In the Atlantic period, an increase in both summer and winter temperatures is inferred from the pollen data, corresponding to an expansion of thermophilous deciduous forests. While in general, flooding phases of the Early Holocene are poorly recognised in Eastern Europe, the Lutomiersk–Koziówki site may be considered as one of the reference points for this phenomenon in the region.

Introduction

High climatic variability for the early Holocene in the European temperate zone is documented by numerous detailed multiproxy studies in recent years (e.g. Bond et al., 2001; Hoek and Bos, 2007; Magny et al., 2007; Ortu et al., 2010). This climatic variability resulted in a sequence of rapid palaeoenvironmental changes, as well as phases of intensified geomorphological processes and a clustering of extreme events (Starkel, 2002a, 2002b).

Based on the Greenland Ice Core Chronology 2005 time scale (GICC05) (Rasmussen et al., 2006), three main periods of distinct oscillations in the stable oxygen isotopic record were recognised in Greenland ice-cores by Rasmussen et al. (2007): the Preboreal Oscillation (PBO, between ca. 11,500–11,300 cal yr BP), the 9.3 ka event, and the 8.2 ka event. There was also an isotopic anomaly at 9950 cal yr BP.

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In terrestrial record, the PBO and cold event at 9500–9200 cal yr BP have been defined by Björck et al. (1997) and the short event at ca. 10,300 cal yr BP (Boreal oscillation) by Björck et al. (2001). The very distinct 8.2 ka event was recognised for the first time by Alley et al. (1997) and von Grafenstein et al. (1998). Clustering of globally-recorded events during the 8500–8000 cal yr BP interval was noted by Starkel (2002a, 2002b). Dry and cool climatic conditions of the 8.2 ka event in the Northern Hemisphere have been reconstructed as having lasted 150–160.5 years, between 8.3 ka and 8 ka with a peak of cooling taking place 60–69 yr into this interval (Thomas et al., 2007; Baker, 2012). The 8.2 ka event was generally cold and dry, especially in winter, but in North-West Europe (e.g. Scandinavia) it might be characterised by cool and wet summers (Alley and Áugústsdóttir, 2005; Baker, 2012). It caused remarkable changes in plant communities including Central Europe over 180 years (Baker, 2012). According to the reconstructions of Magny and Bégeot (2004) and Magny et al. (2003, 2007), Central Europe experienced wet conditions, but northern (including central Poland) and southern Europe experienced drier conditions during the 8.2 ka event (see also Morrill et al., 2013).

The Preboreal (11,750–10,650 cal yr BP) climatic oscillation is widely recorded in the vegetation history of western and central Europe

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(Welten, 1958; Zoller, 1960; Wijmstra and de Vin, 1971; Iversen, 1973; Behre, 1978; van Geel et al., 1981; Lotter et al., 1992; Ammann et al., 1994; Björck et al., 1997; Haas et al., 1998; Wick, 2000; Bos, 2001; Ralska-Jasiewiczowa et al., 2003; Bohncke and Hoek, 2007; Bos et al., 2007; Stančikaitė et al., 2009; Litt et al., 2009; Turner et al., 2013). Based on palaeoecological data, Haas et al. (1998) defined cold phases in the early Holocene at: 9600–9200 (oscillation CE-1), 8600–8150 (CE-2), and 7550–6900 (CE-3) ^{14}C yr. BP.

Beside the palaeobotanical evidence, early Holocene ecological oscillations have also been recorded by palaeozoological proxies (Coope et al., 1998; Brooks, 2000; Pawłowski, 2010; Kulesza et al., 2012; Brooks and Langdon, 2014). Płóciennik et al. (2011), based on subfossil Chironomidae, identified a cooling phase correlated with the 8.2 ka event in lacustrine deposits from an ancient basin in Central Poland. However, this signal may also be related to local habitat oscillations.

An increase of activity of early Holocene geomorphic processes is recorded in fluvial, lake, aeolian, and slope systems. Notebaert and Verstraeten (2010) emphasize fluvial system stability in the Early Holocene in Europe. In contrast, episodes of increased fluvial activity in that period have been recorded by Starkel et al. (2006) for Poland; Hoffman et al. (2008) and Kaiser et al. (2012) for Germany; Macklin and Lewin (2003), Lewin et al. (2005), Macklin et al. (2005, 2006, 2010) and Macklin et al. (2006) for Great Britain, Spain, and Poland. Evidence of Early Holocene fluvial activity has been found sporadically in mid-Europe (Kalicki, 2006). Fluvial records in Central Poland have not often been recognised until now, and evidence of river activity in that period are very rare — e.g., the Ner River in Łódź (Turkowska, 1990), the Moszczenica River (Kamiński, 1993), the Koło Basin at the Koźmin Las site (Dzieduszyńska et al., 2014; Twardy, 2014; Kittel, 2015) and Grabia River (Pawłowski et al., 2015a).

An increase in aeolian activity in the early Holocene has been described from numerous sites in the Polish Lowland (Wasylikowa, 1964, 2001; Kozarski et al., 1969; Nowaczyk, 1986; Manikowska, 1985, 1995; Kozarski and Nowaczyk, 1991; Kamiński, 1993; Kowalkowski et al., 1999; Jankowski, 2007). Dune reactivation between ca. 10,500 and. 7500 cal yr.BP (with small peak ca. 9000 cal yr. BP) is recorded in Germany by Hilgers (2007).

Slope deposits are also recorded from the early Holocene, and distinct phases of slope process activity have been recognised in Germany at ca. 10,300, 9500 and 8200 cal yr BP, and correlated to climatic oscillations as recorded by Dreibrodt et al. (2010a, 2010b).

Our research focuses on multiproxy palaeoenvironmental studies of the deposits of a large scale palaeochannel found in the mid-Ner River valley at the Lutomiersk–Koziówki site. The limit of both organic and allochthonous inorganic sediments is dated to ca. 9400–9000 cal yr BP. After that the palaeochannel fill was covered by inorganic sediments (sands), mainly of flood, but also partly of slope and aeolian origin.

The aims of the research are: (1) detailed reconstruction of the palaeoecological evolution of the basin and its environment and (2) discussion of distinct environmental changes in the mid-European river valley in the Early Holocene transition, and their correspondence to global, regional and/or local signals.

Regional setting

The Lutomiersk–Koziówki site (51°45′16.3″ N, 19°13′28.6″ E, 152.5 m a.s.l.) is situated in Central Poland in the north-western part of the Łódź region (after Turkowska, 2006) about 10 km west of Łódź on the Łask Plateau (Kondracki, 2002). It is located near Lutomiersk city in the Ner River valley (tributary of the Warta River), in the vicinity of the confluence of the Zalewka (Wrząca) River (Fig. 1).

The site is located within area that was glaciated during the Odranian (Saalian) and the ice sheet was present here for the last time during the Wartanian Cold Stage of the Odranian glaciation during MIS 6 (Marks, 2011). Intense periglacial transformation of the relief, especially in river valleys, took place during the Weichselian glacial period. The area is part of the "European sand belt" (Zeeberg, 1998) characterised by dunes, aeolian cover sands and silts, and fluvial terraces. In the Łódź region two or three terraces are recognised in most river valleys (Turkowska, 1988, 2006). In the Ner River valley, in the immediate surrounding of Lutomiersk, two terraces of Wartanian and Weichselian age are documented (Kittel, 2012a,2012b). The site is situated on a north-western foot slope of the high Weichselian (Vistulian) Ner River terrace (Fig. 1). The terrace is composed of medium- and coarse-grained sands accumulated during the Pleniglacial period of the Weichselian Glaciation. The high terrace was formed in the Late Weichselian as a result of cut-off by a large palaeochannel of the Ner River. The palaeochannel bounded the terrace remnant on the northern and north-western side. The channel was abandoned during the late Weichselian–Holocene transition, as documented by radiocarbon (^{14}C) ages — before 9030 ± 160 BP (MKL-284), i.e. 10,580–9662 cal. BP (2δ range). Then it was filled by organic deposits, and covered with overbank sands and silts in the early Holocene, followed by the late Holocene slope cover (Kittel, 2012a,2012b, 2014) (Fig. 2).

Climatic conditions in the area are highly variable because of the influence of oceanic and continental air masses. The average annual temperature from 1931–1989 in the western part of Łódź (Lodz) was 7.7°C. The mean temperature of the warmest month (July) is 18°C and mean temperature of the coldest month (January) is −3.3°C (Kłysik, 2001). Average annual precipitation from 1951–1989 was 590 mm, but varied between 438 and 937 mm (http://www.tutiempo.net).

The potential natural plant community of the Ner River valley near Lutomiersk is willow-poplar swamp forest (*Salici-Populetum*). The natural vegetation of the local uplands is a rich lime-hornbeam deciduous forest (*Tilio-Carpinetum*) (http://www.igipzpan.pl/Roslinnosc-potencjalna-zgik.html). However, the Ner valley plant communities have been strongly transformed by humans during modern times (Kittel, et al., 2014) and even in prehistoric periods (Mueller-Bieniek et al., 2015).

Materials and methods

Field work

The field work was undertaken in 2009 as part of geoarchaeological studies (Kittel, 2014) during archaeological investigations of the Lutomiersk–Koziówki site 3C (Muzolf, 2012). Three main series of deposits have been recorded: (1) organic deposits of the palaeochannel fill, (2) sandy and silty overbank alluvium interfingering with slope wash deposits, and (3) slope wash deposits with buried soils described in detail by Kittel (2014). During field work, stratigraphic and structural analyses were undertaken and samples and profiles were collected (Fig. 2).

Two profiles of samples taken every 10 cm were collected from the slope unit and the overbank deposits. Textural and geochemical analyses were conducted on these samples and the charcoal content was examined. The NKZ 3C core contained organic deposits of a palaeochannel fill; this was collected as a monolith into a metal box with dimensions of 50 × 10 × 5 cm. This method preserves the undisturbed structure of sediments. The monolith covers deposits between 170 and 220 cm below surface level. Samples were taken in 1 cm slices at 5 cm intervals (i.e. 172–173 … 217–218 cm) for pollen, diatom and Cladocera analyses and as contiguous 5 cm slice (i.e. 170–175 … 215–220 cm) for plant macrofossils, fossil wood and charcoal, subfossil Chironomidae, and geochemical analyses. According to the stratigraphic depths associated with the sediments in the NKZ 3C core, four samples were collected for radiocarbon dating and one more of selected charcoal from the slope cover. It seems that the excavation was not situated in the deepest part of the palaeochannel. This is currently inaccessible because of strong human alteration of the area in the most recent period.

Accompanying research was conducted at contiguous areas of Lutomiersk–Koziówki. The spatial extent of the studied