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Disentangling the drivers for the development of a Baltic bog during the Little Ice Age in northern Poland

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ABSTRACT

This paper presents the results of multi-proxy research (pollen, plant macrofossil, testate amoebae and bulk density) on a 100-cm core collected from a Baltic raised bog in N Poland. The impact of the variability of the climate as well as human disturbance in the last 650 years on the development of the peat bog Kusowskie Bagno is described. Based on the results, the development of the raised bogs to the south of the southern coast of the Baltic Sea during the Little Ice Age occurred differently than in NW Europe. In NW Europe (e.g., Great Britain, Ireland, Denmark and N Germany) during the periods of climate cooling associated with lower solar activity, there was a characteristic wet phase, whereas N Poland was characterised by a dry phase. In the years AD 1450–1500, AD 1640–1720 and AD 1810–1840, which correlate with the periods of lower solar activity (the Spörer, Maunder and Dalton minima) and the periods of lower temperatures in Europe, the water table in Kusowskie Bagno decreased, and this was followed by changes in the vegetation. The largest drop in the water table occurred in the years AD 1640–1720. The dry phase resulted in the reduction of the population of *Archerella flavum* and *Amphitrema wrightianum*, which are organisms that are typical of wet habitats, and the appearance of, e.g., *Arcella artocrea* and *Phryganella acropodia*, which are indicators of dry habitats. The humidity decline halted the growth of *Sphagnum* sec. Cuspidata (*Sph. cuspidatum* and *Sph. balticum)* and *Sphagnum magellanicum*. At the same time, *Eriophorum vaginatum*, *Baeothryon caespitosum* and *Pinus sylvestris* appeared, and a dramatic increase in the bulk density is also observed. Since AD 1720, when the solar activity and the water table increased, the bog regenerated, and the population of *Sphagnum fuscum/capillifolium* developed. The development of the studied raised bog depended mainly on climate change. The increasing human impact in the area, which started in approximately AD 1320 and lasted for several centuries, was manifested in deforestation and in the increase in the surface area of farmland. However, this result did not have a significant impact on the development of the peat bog.

1. Introduction

Raised bogs, due to their peat accumulation ability and their dependence on rain supply, are a good object for acquiring data on climate change (Charman 2002, Charman et al., 2009; Chambers et al., 2011a,b). An increase or decrease in the climate humidity has a direct impact on the water table in the bog (Charman et al., 2006). The reconstruction of climate change in the past few thousand years and its influence on the development of raised bogs is a frequent topic of palaeoecological research (Mauquoy et al., 2002, 2008; Barber et al., 2004; Charman et al., 2006; Sillasoo et al., 2007; Andersson and Schoning, 2010). The latest palaeoecological analyses of peat cores focus on the palaeoecological reconstruction of the last millennium. This effort is related to an attempt to develop criteria for separating the climate impact signal from the human impact in the context of the further development and protection of ombrogenic bogs. The climate history of the last thousand years was complex due to the presence of distinct climate fluctuations, such as warming periods (Medieval Warm Period) and cooling periods (Little Ice Age), which are associated with changes in solar activity (Mauquoy et al., 2002, 2004, 2008; Bard and Frank, 2006; Swindles et al., 2007). The impact of climate change on peat bog development in the last millennium has been disturbed by a gradual increase of anthropopressure, which makes climate reconstructions difficult (Van der Linden and van Geel, 2006; Lamentowicz et al., 2008a,b; Van der Knapp et al., 2011; de Vleeschouwer et al., 2012).

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The aims of the study were as follows: a) to reconstruct a possible climatic signal over the last 650 years and determine the wet and dry phases; b) determine the potential impact of changes in solar activity on the development of the Baltic raised bog; c) to distinguish between natural and anthropogenic causes contributing to the development of the peatland; d) to determine the pristine vegetation typical of Southern Baltic raised bogs for protection and restoration needs.

The objectives were realised through the simultaneous use of several paleoecological methods (i.e., pollen, plant macrofossil, testate amoebae, bulk density and radiocarbon dating) performed at high resolution. The reconstruction of the water table presented in the article was based on the occurrence of subfossil testate amoebae, which allow the quantitative reconstruction of past water table depths (Lamentowicz and Mitchell, 2005a,b; Mitchell et al., 2008; Väliranta et al., 2012), and the presence of *Sphagnum* mosses. *Sphagnum* species are generally good indicators of palaeohydrology (Barber et al., 2004; Yeloff and Mauquoy, 2006; Väliranta et al., 2007).

Despite the existence of over 40 Baltic raised bogs in N Poland (Pawlaczyk et al., 2005), which are located at the southern limit of the Baltic raised bogs in Europe (Kulczyński, 1949; Eurola, 1962; Ellenberg, 1988), knowledge about the history of these bogs' development is limited. To date, multi-proxy palaeoecological studies were performed on only two peatlands, Słowińskie Bagno (Lamentowicz et al., 2008a,b; de Vleeschouwer et al., 2009) and Stążki (Lamentowicz et al., 2009, 2011; Gałka et al., 2013). The development of two of these bogs (Janiewickie Bagno and Słowińskie Błoto), based on the low-resolution analysis of the botanical composition and lithology of the entire peat deposits, was investigated by Herbichowa (1998). Other research focused mainly on the analysis of the modern vegetation, the thickness of the peat deposits and palynological analyses (incl. Ołtuszewski, 1948; Ołtuszewski and Borówko, 1954; Jasnowski, 1962; Pacowski, 1967; Pawlaczyk et al., 2005; Herbichowa et al., 2007). Currently, multi-proxy palaeoecological studies are implemented in three raised bogs (Mechacz Wielki, Gązwa, Kusowskie Bagno) located in different parts of N Poland, which cover the entire history of these bogs' development (Gałka, 2011).

2. Site location

Kusowskie Bagno is located in N Poland (Fig. 1) in the young glacial area formed by the activity of the last Scandinavian ice sheet,

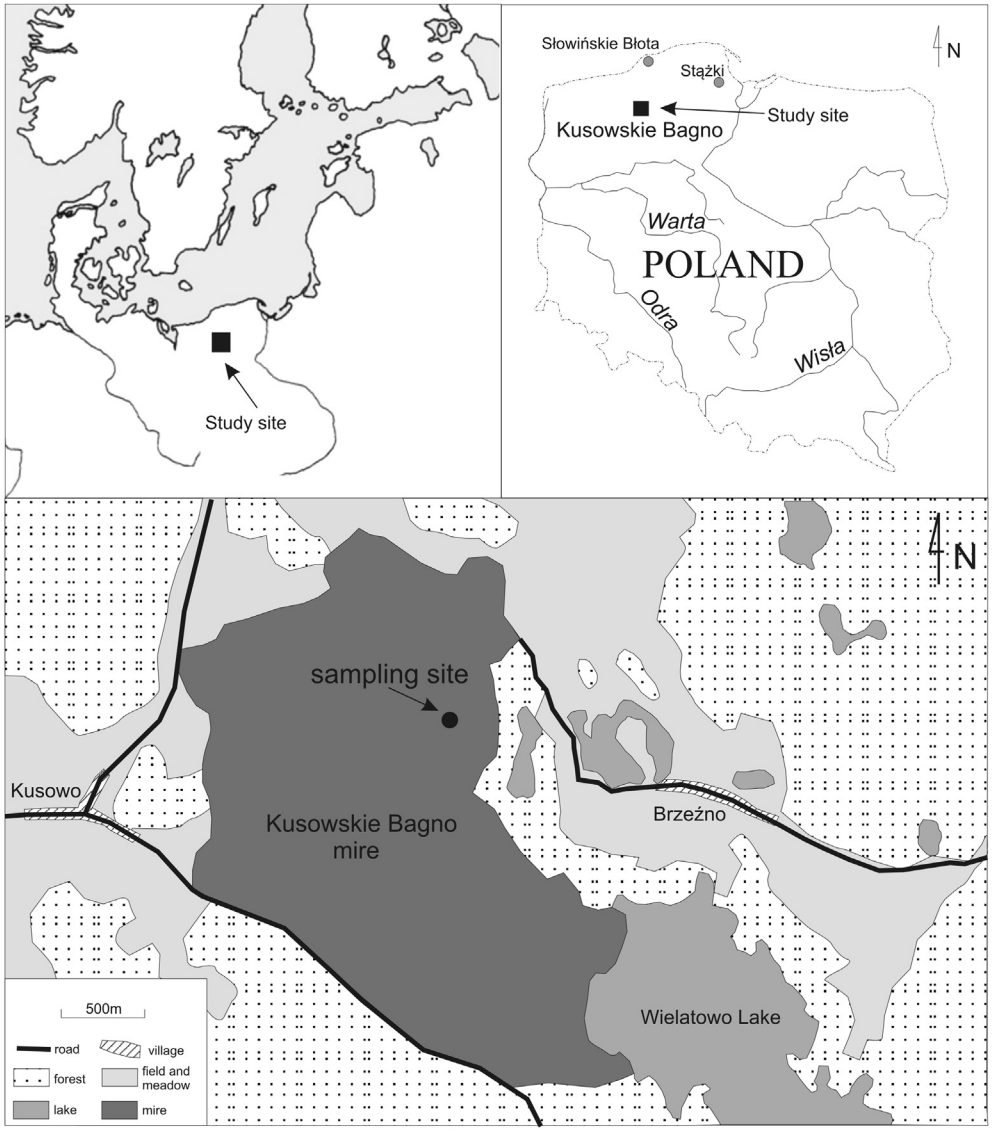

Fig. 1. Setting of the study site.