Quaternary International xxx (2015) 1–13

Contents lists available at ScienceDirect

Quaternary International

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

Climate, environment and stratigraphy of the last Pleistocene glacial stage in Poland

Leszek Marks [a, b, *], Dariusz Gałązka [a], Barbara Woronko [b]

[a] Polish Geological Institute – National Research Institute, Warsaw, Poland
[b] University of Warsaw, Faculty of Geology, Warsaw, Poland

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Pleistocene
Weichselian
Paleoclimate
Index of continentality
Poland

ABSTRACT

The aim of the paper is to present general characteristics of the climate in Poland during the Vistulian (Weichselian), expressed by changes of its continentality during warm and cold intervals. This last glacial stage in Poland is commonly subdivided into Early Vistulian (MIS 5d-a), Lower Plenivistulian (MIS 4), Interplenivistulian (MIS 3), and Upper Plenivistulian and Late Vistulian (MIS 2). Main climatic features of this glacial stage could be reconstructed, based on compilation from published data concerning characteristics of glacial, fluvial and aeolian sedimentary environments, geomorphology, analysis of indicator plant species, Coleoptera, and geographical distribution of periglacial structures. These data were indicative especially for evaluation of mean temperature of the warmest and the coldest months but could be also helpful in determination of drier intervals and some aspects of general atmospheric circulation. Paleoclimatic characteristics of the last glacial stage from the territory of Poland were put into the European context. During the Early Vistulian in eastern Poland, higher continentality was characteristic for interstadials (Amersfoort, Brörup and Odderade), and was considerably lower during the intervening colder stadials (Herning, a cooling between Amersfoort and Brörup, Rederstall). Among the interstadials, the most continental climate occurred during Brörup (similar continentality as at present), considerably less during Amersfoort and the least during Odderade. A decreasing trend of continentality for the cold stadials of the Early Weichselian eastwards in Europe could result from a remarkably less dynamic Gulf Stream in the North Atlantic when the ocean was covered with vast sea ice during winters, whereas the adjoining continent was occupied by permafrost, and the atmospheric circulation was presumably driven also by the Scandinavian ice sheet.

1. Introduction

Paleoenvironmental and paleoclimate reconstruction of the Vistulian (Weichselian) in Poland has been based on multi-proxy examination of sedimentary sequences in several sites with lake, aeolian, and fluvial sediments in different parts of the country (e.g. Kozarski, 1991; Klatkowa, 1997; Starkel et al., 2007; Jary, 2009; Roman et al., 2014). However, the past climate conditions were described generally in qualitative terms, although more and more quantitative paleoclimatic parameters (especially temperature and occasionally precipitation) have been estimated recently. An examination of sites for climatic parameters was gradually associated in northern continental Europe with high-resolution time control (cf. Huijzer and Isarin, 1997; Isarin and Renssen, 1999; Renssen et al., 2001; Huissteden et al., 2003; Kühl and Litt, 2003; Engels et al., 2010; Wohlfarth, 2013; Helmens, 2014; Šeirienė et al., 2014).

The last glacial stage in Poland has been traditionally and informally subdivided into two first-rank cold intervals (Lower and Upper Plenivistulian, roughly corresponding to MIS 4 and 2), preceded by Early Vistulian (MIS 5d-a) and separated by Interplenivistulian or Middle Plenivistulian (MIS 3), characteristic for its milder but unstable climatic conditions (van Huissteden et al., 2003, Fig. 1). Lower Plenivistulian, Interplenivistulian and Upper Plenivistulian were occasionally named Lower, Middle and Upper Pleniglacial (e.g. Kozarski and Nowaczyk, 1999). The final part of the Vistulian was the Late Vistulian or the Late Glacial. A number of individual sites in Poland provided valuable but limited in time

* Corresponding author. Polish Geological Institute – National Research Institute, Warsaw, Poland.
E-mail addresses: leszek.marks@pgi.gov.pl, leszek.marks@uw.edu.pl (L. Marks), dgal@pgi.gov.pl (D. Gałązka), bworonko@uw.edu.pl (B. Woronko).

http://dx.doi.org/10.1016/j.quaint.2015.07.047
1040-6182/

Age in ka BP	Western Europe		Poland		MIS
11.7 cal – present	Holocene		Holocene		1
15 – 11.7 cal	Late Pleniglacial	Late Glacial	Late Vistulian		2
16.8-16.6 cal		Mecklenburg	Upper Plenivistulian	Gardno	
17-16 cal		Pomeranian		Pomeranian	
20-19 cal		Frankfurt		Poznań	
24 cal		Brandenburg		Leszno	
32.0-36.6 cal		Denekamp	Middle Plenivistulian (Interplenivistulian)	VS 4	3
	Middle Pleniglacial	Huneborg			
41.2-43.2 cal		Hengelo			
		Hasselo			
46.3-49.8 cal		Moershoofd			
51-53		Glinde			
		Ebersdorf			
55-58		Oerel			
58-71	Early Pleniglacial	Schalkholz	Lower Plenivistulian	VS 3	4
110-71	Early Glacial	Odderade	Early Vistulian	Rudunki	5a
		Rederstall		VS 2	5b
		Brörup		Brörup	5c
		cooling			
		Amersfoort			
		Herning		VS 1	5d
126-110	Eemian		Eemian		5e

Fig. 1. Stratigraphy of the last glacial stage in Poland and its correlation with Western Europe after Behre and Lade (1986), Behre and Plicht (1992), Hammen (1995), Caspers and Freund (2001) and Marks et al. (2014b). Dating of Oerel and Glinde is approximate, because their radiocarbon ages (53.5–57.7 and 48.7–51.55 ^{14}C ka BP respectively) are beyond the calibration curve.

paleoclimate data that could not be extended across the country in reliable north-south and west-east transects.

Climate records for the most severe episodes of early and middle Vistulian in non-glacial areas were scarce. It has not been until recently when this information hiatus started to be partly filled with substantial data, but there were still numerous gaps that made the paleoclimatic sequence discontinuous (cf. Klatkowa, 1997). There were several reasons for this, including a lack of continuous continental sedimentary records, insufficient resolution of results and poor age control (Guiot et al., 1989; Kasse et al., 2003; Bohncke et al., 2008; Meerbeeck et al., 2011). Although several regional works on environmental and climatic conditions during the last cold stage in Poland have been published recently (Kozarski, 1991; Jary, 2007; Starkel et al., 2007; Kupryjanowicz, 2008; Jary and Ciszek, 2013; Roman et al., 2014; and others), a detailed stratigraphic subdivision of the Interplenivistulian into warmer and intervening cold episodes has not been possible. The lack of time control suggested that different habitats existed at the same time. Irregular short warm spells could not allow a more continuous cover of more thermophilous vegetation, but rapid temperature rises could destroy the existing plant communities adapted to cooler conditions and therefore could result in activation of slope and aeolian processes (cf. Kolstrup, 1995; Kasse, 1997). It seems probable that geosystems in Poland in that time formed a mosaic pattern (Starkel, 1988).

The environmental and paleoclimate reconstructions were based on multiproxy examination of available past sedimentary environments, periglacial structures, and paleontological data in several sites (Figs. 2–3). This approach had several advantages compared with single indicators (cf. Vandenberghe et al., 1998; Huissteden et al., 2003). Among them, there was a range of climatic parameters, a consistency of results based on different individual indicators and a determination of the uncertainty margin in interpretation. A multi-proxy approach enabled testing of different methods against one another (cf. Vandenberghe et al., 1998).

At present in Poland, in spite of a small latitudinal extent (10°07′), there is considerable latitudinal differentiation of mean temperature of the warmest (July) and the coldest (January) months. This difference is equal to 1 C° in July and 3.5 C° in January (Lorenc, 2005). The northeastern part of Poland possesses a more continental climate that is more distinct in winter than in summer months. There is a distinct temperature gradient southwards, connected with gradually rising altitude.

The objective of the study was to reconstruct the paleogeography of Poland during the Vistulian and to find differences between the present and the Vistulian climatic gradients from west to east. Finally, analysis was expected to help in better understanding of the climate system and determination of the factors responsible for climate changes in Poland.

Please cite this article in press as: Marks, L., et al., Climate, environment and stratigraphy of the last Pleistocene glacial stage in Poland, Quaternary International (2015), http://dx.doi.org/10.1016/j.quaint.2015.07.047