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Quaternary aeolian activity of Eastern Europe (a Poland case study)

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ABSTRACT

The emergence of the Pleistocene aeolian processes and their intensity was revealed through morphoscopy—the observation and analysis of quartz grain shape and microtexture. Sediments from 39 cored boreholes and three outcrops located in central and eastern Poland were analysed using methodology developed in 1942 by Cailleux to identify past wind action. This method is based on the recognition of the degree of roundness observed on quartz grains along with their surface typology (matt or shiny). The obtained results allowed us to separate seven distinct periods where the content of quartz grains with matt surfaces and varying degrees of roundness increased indicating the presence of an aeolian environment. These processes were different in their nature and intensity, with the wind-action periods varying from long-lasting and very intense (identified across the entire research area) to periods with low intensity and local wind-action events. These periods can be correlated with the advance of oldest glacials—the Narevian/Nidanian (MIS 36-34/MIS 22), the Sanian 1 (MIS 16) the Sanian 2 (MIS 12), the advance and retreat of the Odranian Ice Sheet (MIS 6, maximum stadial), and the Odranian Glaciation (MIS 6. post-maximum stadial [Wartanian]). These aeolian processes lead to the formation of coversands and fluvial sediments that are rich in aeolianized grains.

1. Introduction

The Quaternary cold climate aeolian processes are considered to be among the most important in shaping the landscape in the periglacial environment (French, 2007). For example, the Vistulian, aeolian activity generated vast dune deposits, their extant being well documented across Europe from the East Anglia (Bateman, 1995, 1998; Murton et al., 2003), Netherlands (Koster, 1988; Kasse, 1997, 2002) and Belgium (De Moor, 1981), through Germany (Küster et al., 2014) and Poland (Dylikowa, 1968; Nowaczyk, 1986; Manikowska, 1991; Woronko et al., 2015; Zieliński et al., 2015), Belarus (Stančikaitė et al., 2011), to Russia (Drenova et al., 1997; Matlakhova, 2015a, b), the Ukraine (Zieliński et al., 2015), and Lithuania, Latvia and Estonia (Raukas and Hüüt, 1988; Molodkov and Bitinas, 2006; Kalińska-Nartiša et al., 2015a, b; 2016a, b). This is the European Sand Belt (Zeeberg, 1993, 1998). In contrast, little is known about aeolian activity as expressed in sandy deposits from the older Pleistocene glacials (Mycielska-Dowgiałło and Woronko, 2004; Rich and Stokes, 2011; Woronko, 2012). This omission may have resulted from a number of reasons: 1) a lack of precise age attribution to multiple series of well-defined stratigraphic units of the Quaternary; 2) technical limits to achieving accurate dates on many mineral deposits (*e.g.,* glacial tills); 3) the presence of stratigraphic gaps, unconformities as a result of erosion to sediments from older glaciations by subsequent ice sheets, including sandy aeolian sediments; 4) the occurrence of numerous glaciotectonic disturbances of the sediments; 5) aeolian deposits became interbedded with, or constituents of glacial and fluvioglacial stream deposits (*e.g.,* fluvial or slope deposits); and 6) a lack of explicit criteria to ascertain the record of cold-climate aeolian processes in ancient sediments (Brookfield, 2011) from study samples obtained by drilling instead of exposures, as the actual nature of the deposit structure is often difficult to discern or may even be impossible to recognize.

The first significant work to note an aeolian origin for sediments rich in quartz grains was Cailleux (1942) who described them as having *round-matt* or *round-frosted* surfaces (RM). He used the microsculpture of individual quartz grains as the basis of a methodology to distinguish between the Early Pleistocene and Pliocene sediments of Poland. He correlated sediments with a large contribution of RM grains with the Early Pleistocene of “northern” origin, related to the decay of the first ice sheet. These sediments

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contained over 80% of RM grains, in contrast with Pliocene sands with only 1% aeolian grains. He also assumed that the degree of grain roundness largely depended on the duration of aeolian processes and the provenance of grains. Moreover, based on the occurrence frequency of wind-modified sand grains (0.4–1.0 mm), Cailleux (1942) constructed a map of wind action intensity in Europe during the Pleistocene cold periods. This assumption has repeatedly been applied by others with success in the reconstruction of past aeolian processes, and other related stratigraphic and palaeogeographic issues (*e.g.*, Seppälä, 1969; Goździk, 1980a, b, 1982, 1992, 1995, 2001a, b, 2007a; Maruszczak and Goździk, 1998, 2001; Murton et al., 2000; Mycielska-Dowgiałło and Woronko, 2001, 2004; Woronko, 2012; Zieliński, 2004; Bujak et al., 2006, 2016; Dulias, 2009; Zieliński et al., 2015; Kalińska-Nartiša and Nartišs, 2016a, b). Goździk (1995, p. 128) claimed that, by the analysis of grain shapes, " … *even at relatively low precision of the determinations, many significant palaeogeographic and stratigraphic conclusions can be drawn*". However, Tricart (1965) cautioned that the morphoscopy of quartz grains can be used to reconstruct a specific aeolian process for a specific time period only if that process had long-term dominance its affects were particularly advanced.

This paper discusses the stratigraphic position of the Quaternary cold climate aeolian sandy deposits in northeastern Poland (Fig. 1). The objectives are to: 1) discuss the significance of sandy aeolian deposits to help understand regional palaeoenvironmental changes; and 2) determine which sediments contain records of the Pleistocene wind-action. Well-documented Vistulian sediments have been excluded from the discussion on the Pleistocene aeolian process records because this issue has already been adequately described in the literature and the data presented in this article would not bring anything new, but they may be analogous to the processes of reconstruction of older periods of the Pleistocene. This paper is based on the manuscript of Woronko (2012), modified and completed by new results.

2. Study area

According to the latest stratigraphic subdivisions for the Pleistocene in Poland, seven main ice sheets, advancing from Scandinavia, have been distinguished (Table 1). The oldest is the Nidanian ice sheet (MIS 22), followed by the Sanian 1 (MIS 16), Sanian 2 (MIS 12), Liwiecian (MIS 10), Krznanian (MIS 8), Odranian (MIS 6) glaciations, and the youngest Vistulian Glaciation (MIS 2–5d) (Table 1; Marks et al., 2016a). A Narevian Glaciation was also distinguished in older reports; its age was determined at c. 1.2 Ma and it was attributed to MIS 34–36 (Table 1; Ber et al., 2007a, b).

The maximum extent of the Pleistocene glaciations is indicated by the southern limit of Scandinavian erratic boulders (Fig. 1; Marks, 2004). Glacial till correlated with the oldest ice sheet is recorded in north-eastern Poland and lies below the Brunhes/Matuyama boundary (Lindner et al., 2013).

The furthest range south is noted for the Sanian 1 and Sanian 2 ice sheets, which reached the Sudetes and the Carpathians

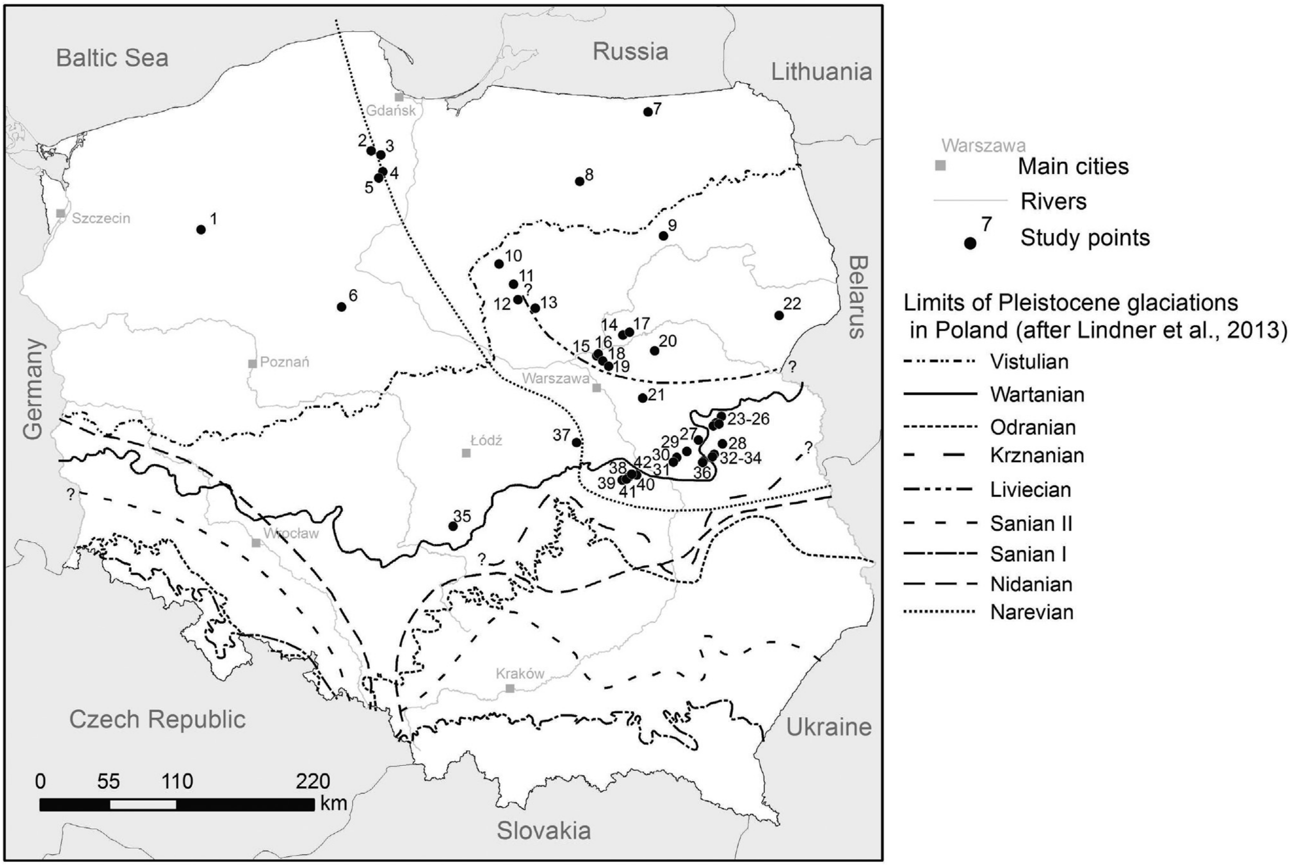

Fig. 1. Location of study sites on the limits of the Pleistocene glaciations in Poland (after Lindner et al., 2013); study points: 1 – Laski Wałeckie, 2 – Pałubinek, 3 – Sucumin, 4 – Wielki Bukowiec, 5 – Smolniki, 6 – Wapienno, 7 – Olszewo Węgorzewskie, 8 – Sąpłaty, 9 – Niksowizna, 10 – Galumin, 11 – Gryty, 12 – Łaszewo-Pieńki, 13 – Glinojeck, 14 – Kozłowo, 15 – Dębe, 16 – Borowa Góra, 17 – Leszczydół, 18 – Dąbkowizna, 19 – Słupno, 20 – Myszadła, 21 – Prusy, 22 – Kozły, 23 – Celiny, 24 – Łuków 3, 25 – Łapiguz, 26 – Łuków 3A, 27 – Kosiorki, 28 – Wola Chomejowa, 29 – Gózd, 30 – Wylezin, 31 – Niwa Babicka, 32 – Kolonia Bronisławów, 33 – Serokomla, 34 – Budziska, 35 – Bełchatów, 36 – Ferdynandów, 37 – Rożce, 38 – Wólka Brzóska, 39 – Brody, 40 – Maciejowice, 41 – Wólka Ursynowska, 42 – Sewerynów.

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