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Some aspects of the last glaciation in the Mazury Lake District (north-eastern Poland)

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ABSTRACT. The morphology of the Mazury Lake District (north-eastern Poland) dates from 24–19 ka (main stadial of the youngest Vistulian glaciation). During this last glacial maximum (MIS 2) a belt with lacustrine basins was formed when the ice sheet retreated at the end of the Pomeranian phase. The ice-sheet retreat is morphologically also expressed by the occurrence of end moraines.

The study area is situated in the Skaliska Basin, in the northern part of the Lake District (near the Polish/Russian border), at the periphery of zone with end moraines. Originally the basin was an ice-dammed depression filled with melt water; the water flowed out into the developing Pregoła valley when the ice retreated and did no longer dam off the depression. The basin, which is surrounded by hill-shaped moraines, is filled now with Late Glacial and Holocene glaciolacustrine sediments. The organic sediments of the basin record the history of the Late Glacial and Holocene climatic changes in this region.

KEYWORDS: glacial lacustrine sediments, Vistulian glaciation, deglaciation, Mazury Lake District, Skaliska Basin

INTRODUCTION

The Mazury Lake District was formed when the ice sheet of the Vistulian main glaciation retreated. The basin's development continued in the Holocene. The Lake District includes the Great Mazurian Lakes, the lake less Węgorapa District to the north, and the Mazurian Plain to the south (Fig. 1). The Szeskie Hills in the east largely determine the geological setting of the region (Ber 2000). The depression forming the Skaliska Basin is located in the Węgorapa District, approximately 120 km to the north of the zone with end moraines that indicate the line of maximum ice advance during the Pomeranian phase.

EARLIER STUDIES

Early studies of the geology of outcropping deposits in the Mazury Lake District date from over a century ago. For instance, Bludau (1894) prepared a map at a scale of 1: 100 000, presenting the numerous types of relief and the hydrography of Eastern Prussia. Soil maps at a scale of 1: 25 000, forming a part of the series "Geologische Karte von Preussen und benachbarten Bundesstätten". The outcropping geological strata on these maps were presented following interpretations that were consistent with the views of the time.

Kondracki (1952, 1972, 2000) distinguished four recessional phases of the Pomeranian stadial in the central part of the Mazury Lake District, documenting the disappearance of the last ice sheet of the Vistulian glaciation. The compilation by Roszko (1968) correlate the ice limits of the Pomeranian phase (south of the Szeskie Hills) with those of the Kashubian-Varmian phase north-eastern of Kętrzyn, near the Russian border. It should be mentioned, however, that these limits were outlined mainly on the basis of geomorphic criteria.

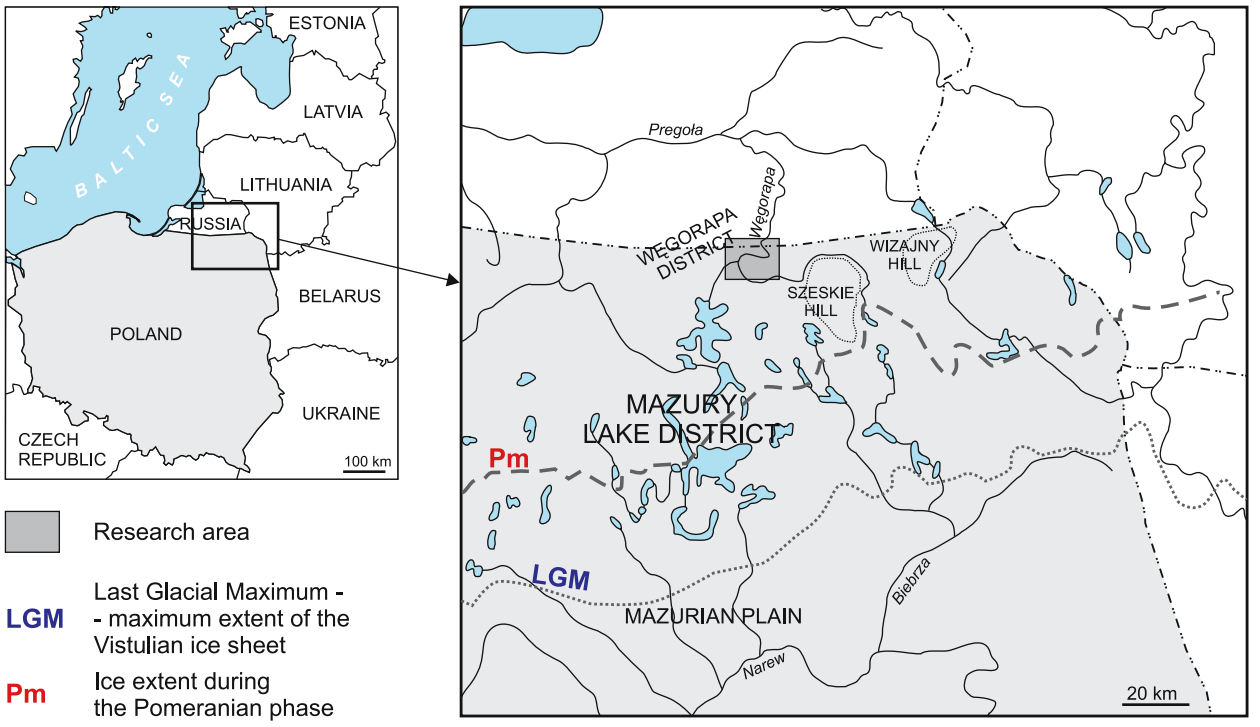

Fig. 1. Location of the study area

GEOLOGY, GEOMORPHOLOGY AND HYDROGRAPHY

The geology of the surface sediments was thoroughly investigated during geological mapping conducted since the mid of the 1990s. The maps are partly at a scale of 1: 50 000 (e.g. Pochocka-Szwarc 2012, Pochocka-Szwarc & Lisicki 2001a, b, 2006, Krzywicki 2009, Rychel 2009, Lisicki & Rychel 2006), partly at a scale of 1: 200 000 (Ber 1971, Lisicki 2009, Słowański 1975) and partly at a scale of 1: 500 000 (Marks et al. 2006). The area of the Skaliska Basin was investigated in detail for its sedimentological, palaeobotanical and physicochemical characteristics (Pochocka-Szwarc 2005, 2010, Pochocka-Szwarc et al. 2008). The general geological profile of glacial sediments from the Cretaceous bottom to the surface of the Skaliska Basin is presented as a cross-section on Figure 2.

The ice sheet of the last glacial maximum of the Vistulian glaciation (LGM – MIS 2) extended approximately to the southern area with lacustrine basins (Fig. 3) and is indicated by remnants of moraines located south-east of the present-day Lake Śniardwy. In the Mazurian Plain, the maximum ice extent cannot be traced directly because of the overlying (younger) fluvioglacial sediments. The extent of the Pomeranian phase is indicated by end moraines, easily recognized in the area because of their morphology (Fig. 3). These forms are found in a zone extending to the north from the vast depression with the Lake Śniardwy and farther to the north-east, towards the Szeskie Hills (Marks et al. 2006). Around this zone depressions exist that are presently filled with peat or shallow lakes, e.g. the Lake Łuknajno and the Nietlickie mires. This zone of end moraines forms the beginning of most sandurs. Eskers and kames, which represent forms accumulated in crevasses, as well as moraines formed by the melting of dead-ice, and fluvioglacial and ice-dammed sediments are common in this area.

The end moraines are separated by lakes (Kondracki 1972, 2000, Pochocka-Szwarc 2010) which either fill the north-east oriented depressions of glacial channels or form vast lakes that were originally filled with melt water (Fig. 3). The end moraines, consisting of sands, gravels and boulders, occasionally developed into distinctice-marginal fans, for instance in the area of Węgorzewo (Pochocka-Szwarc 2010), or they now form the northern shores of Lake Święcajty. They represent the line of maximum ice extent that corresponds with the easily recognizable end moraines of the Piłackie Hills (Fig. 3).

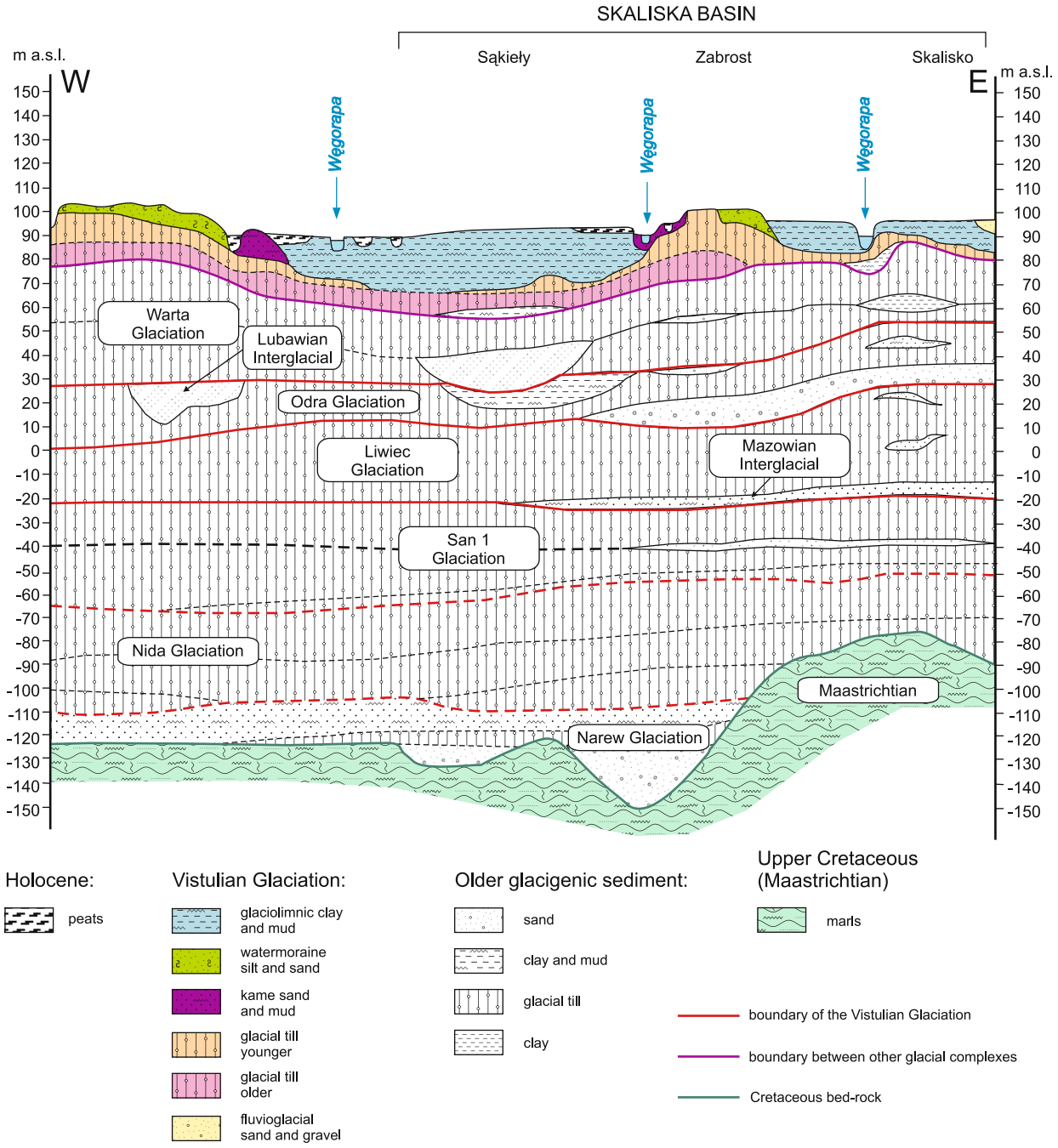

Fig. 2. Fragment of a geological profile overlapping the Skaliska Basin from the map sheet of Budry of the Detailed Geological Map of Poland at a scale of 1: 50 000 (Pochocka-Szwarc & Lisicki 2001b)

The Skaliska Basin covers an area of approx. 90 km^2, being up to over 90 m below the adjacent forms. The study area in this basin is surrounded by moraines that form an upland area or hill-shaped forms (Fig. 3). The Węgorapa river, fed partly by a tributary (the Gołdapa river) flows out into this basin and leaves the basin through a deeply incised valley of approx. 1 km long; it continues beyond the Polish borders.

THE LAST GLACIATION IN THE MAZURY LAKE DISTRICT

Around 23 ka ago, the ice sheet of the LGM ended south-east of the present-day Lake Śniardwy (Fig. 3). The ice sheet retreated during the Pomeranian phase. After a longer standstill of the front of the ice sheet, now visible as the line of moraines, the ice sheet started to retreat in a number of stages (Marks 2010). The retreating ice sheet uncovered large areas of earlier formed sandurs.

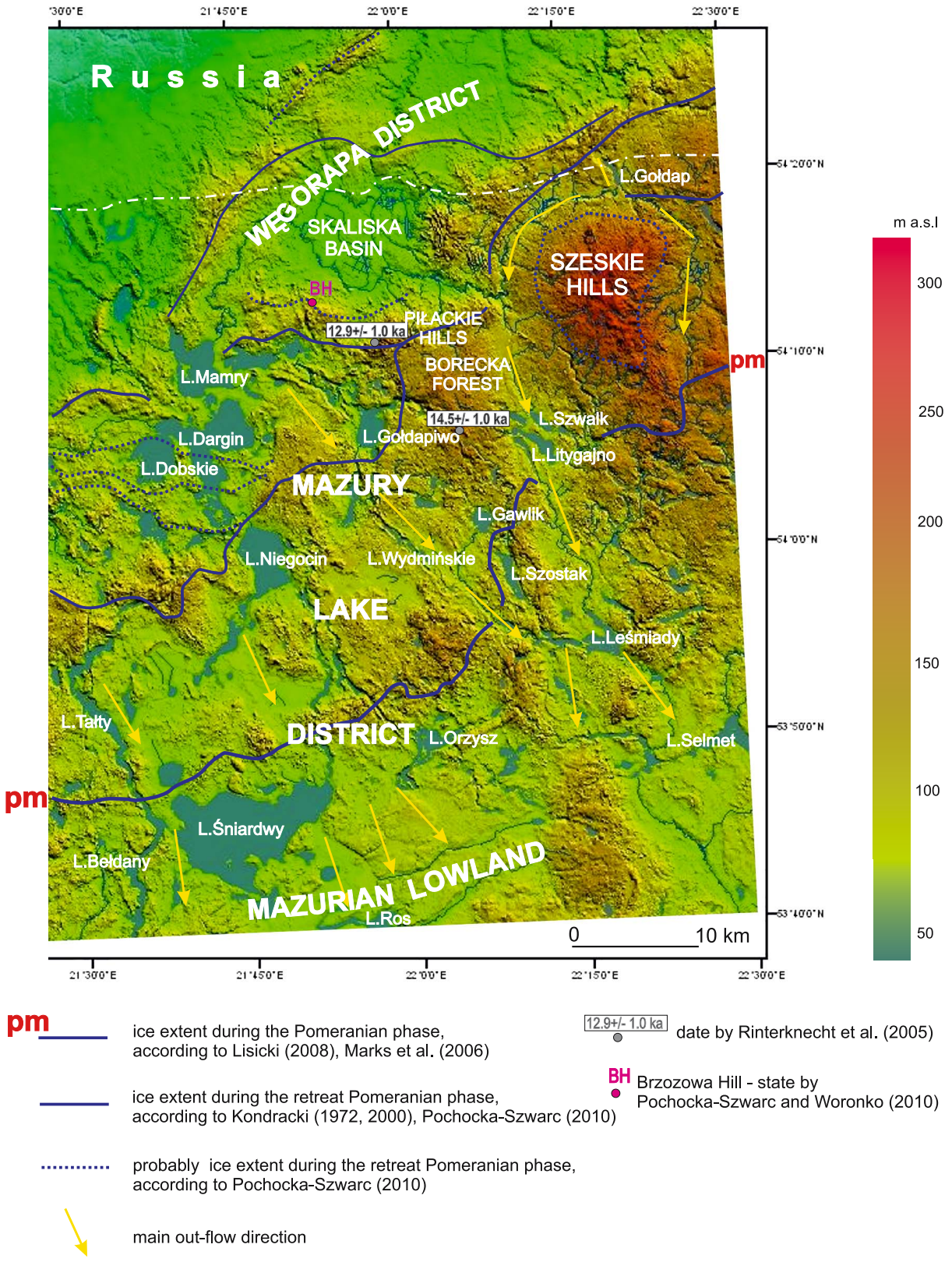

Fig. 3. Locations on a Digital Terrain Model of the lines of ice extent in the Mazury Lake District during the Pomeranian phase and during retreat of ice sheet

The standstill of the ice sheet during the Pomeranian phase, dated as approx. 19–17 ka ago (Marks 2010), is recorded by a linear zone, beginning at the northern side of Lake Śniardwy, turning north-eastern (Lisicki 2009) and continuing in the southern part of the Szeskie Hills (Marks et. al 2006). Numerous ice-marginal basins then came into being (e.g. the

Śniardwy and Łuknajno lakes) and uncovered glacial channels were preserved (e.g. the channels of the Bełdany and Mikołajskie lakes). The ice front was also associated with the development of sandurs. The Pomeranian phase represents regional advances of the Scandinavian ice sheet margin in central Europe during the LGM or shortly after it (Litt et al. 2007, Marks 2010).

After the stillstand, the front of ice sheet retreated along the following lines: Lake Niegocin – Lake Gołdapiwo – Piłackie Hills – Audyniskie Hills, and farther to the north, toward the Russian moraines. This retreat is comparable with the retreat indicated by the extent of the southern Lithuanian moraines approx. 14.5 ka (Marks 2010, Guobyte 1999). The age of erratic boulders, located south of the ice extent and dated with the ^{10}Be method (Rinterknecht et al. 2005) as 14.51 ka and 12.9 ± 1.0 ka, suggests that the area was gradually uncovered from ice.

It is still under discussion whether the Szeskie Hills formed an interlobe area (Ber 2000) or whether they were covered by the ice sheet (Krzywicki 2010). The front of the ice sheet was in contact with a large area affected by deglaciation, e.g. the Borecka Forest (Pochocka-Szwarc & Lisicki 2006), and with depressions that became the Mamry, Święcajty and Dargin lakes (Fig. 3). The depressions, including channels, were filled with dead-ice preserved for several thousands of years. The gradual melting may have been going on locally for as long as from the Oldest Dryas until the end of the Preboreal (Böse 1995, Błaszkiewicz 2005). This resulted from changes in the thickness of the mineral cover on top of the dead-ice and from the presence of permafrost (Błaszkiewicz 2005). Melting of the blocks of dead-ice was also easily affected by the drainage capability and morphology of the depressions.

Snow-derived melt water, running away from the front of ice sheet, formed a distinct, north-eastern oriented, sandur track of some 20 km long, passing along the Szeskie Hills from the west (Fig. 3). The retreat of the ice sheet was interrupted, however, by slight, temporary re-advances of its front, as indicated by the study (Pochocka-Szwarc & Woronko 2010) of an outcrop at the periphery of the zone with end moraines (Fig. 3).

The fluctuations in the extent of the front of ice sheet resulted in the development of the end moraines that surround the Skaliska Basin at the north and north-east. It cannot be excluded that the decline of the basin was associated with the formation of an ice-marginal basin (Pochocka-Szwarc 2005, 2010). After the final retreat of the ice sheet to the north, i.e. to the line of the central Lithuanian moraines (middle Lithuanian phase: Guobyte 1999) and the formation of an erosive base level, the developing Pregoła valley (Dodonov 1975). The basin was characterized by the outflow of water (Pochocka-Szwarc 2005, 2010). It should be noted in this context that studies carried out west of the Skaliska Basin (Pochocka-Szwarc & Krawczyk 2009) indicate that the Pregoła valley may have attracted water from numerous smaller ice-dammed basins, situated even 40 m below the Skaliska Basin. Small, isolated water-filled depressions still present at the surface of the Skaliska Basin are filled with mineral and organic sediments, recording the post-glacial and Holocene history of this site (Pochocka-Szwarc et al. 2008).

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