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Transverse, supraglacially derived crevasse infillings in a Pleistocene ice-sheet margin zone (eastern Poland): Genesis and sedimentary record

Anna Godlewska *, Sławomir Terpiłowski

Department of Geoecology and Palaeogeography, Maria Curie-Skłodowska University in Lublin, Krasnicka 2 c,d, 20-718 Lublin, Poland

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ABSTRACT

The so-called 'crevasse infillings' in the marginal zone of the Saalian ice sheet in eastern Poland are atypical relief forms for lowlands glaciated in the Pleistocene. They are located on a high of the Cretaceous/Palaeogene substratum and form isolated ridges arranged in trains parallel to the former ice-sheet margin, i.e., transverse to the movement of the ice sheet. The sedimentary succession of the crevasse infillings consists mainly of undeformed glaciodeltaic deposits. We propose a model of the crevasse infilling development in three phases against the background of ice mass dynamics: 1) ice-sheet advance over a high of the substratum — compressive ice flow that bumped against the high's slope and enrichment of the ice with debris; 2) an overriding of the substratum high by ice masses — a tensional ice-flow regime resulted in significant crevassing; and 3) ice mass stagnation — low energy, supraglacial deltaic sedimentation in isolated ponds between disintegrated ice blocks under frozen bed conditions. Considering this genesis, we suggest classifying these forms as kames instead of crevasse infillings.

1. Introduction

Crevasse infillings are common elements of the formerly glaciated lowland regions of Europe and North America. Their descriptions point to various morphology, lithology and genesis.

The term 'crevasse infillings' was introduced by Flint (1928) for forms resulting from the infilling of crevasses with supraglacially supplied material in stagnant ice near the marginal zone of the ice sheet (see also Gravenor and Kupsch, 1959; Eyles et al., 1999). Crevasse infillings typically comprise individual, short ridges rarely forming linear trains and most frequently oriented parallel to the direction of ice flow. They are mainly composed of glaciofluvial deposits (cf. Brodzikowski and Van Loon, 1991). Some authors classified them as 'kames' (among others Holmes, 1947; Bartkowski, 1967).

Afterward, investigations of crevasse infillings pointed to not only their supraglacial genesis but also their subglacial infilling as a result of squeezing of basal deformation till into widening crevasses (cf. Benn and Evans, 1998). Such subglacial–supraglacial landforms were termed 'crevasse fillings' for ridges composed of basal clay and ablation stratified till (Dreimanis, 1995) or 'hummocky moraine' for ridges consisting of subglacial, clay-rich deformation till and supraglacial glaciolacustrine sediments (Eyles et al., 1999). Both distinguished landforms were oriented parallel to ice-sheet movement and formed in stagnant ice.

Recently, many studies have focused on the subglacial genesis of crevasse infillings composed of basal deformation till squeezing into crevasses as the glacier ice sinks into a soft bed. 'Crevasse infills' (Hart and Boulton, 1991) and 'linear disintegration ridges'(Eyles et al., 1999) were used to describe Pleistocene ridges formed in stagnant debris-rich ice and oriented parallel to ice-sheet movement. In turn, 'crevasse fillings' (Sharp, 1984), 'crevasse fill ridges' (Sharp, 1985), 'crevasse-intrusion ridges' (Boulton et al., 1996) and 'crevasse squeeze ridges' (Johnson, 1972, 1975; Clarke et al., 1984; Evans and Rea, 1999; Evans et al., 1999) were used to describe landforms formed during glacier surges in crevasses arranged transversely to ice flow.

In this paper, we study again the forms, which were investigated and termed 'crevasse infillings' by Albrycht (2004a,b). They are located in the marginal zone of the Saalian ice sheet in eastern Poland (Fig. 1). In our opinion, their morphology and lithology are atypical of crevasse infillings described until now and characteristics of kames.

2. Geomorphological and geological setting

The crevasse infillings under study are located in the inner zone of the Klukowka Lobe (Mojski, 1972) (Fig. 2) of the younger Saalian ice sheet. They form a narrow (3 km) belt with a length of 9 km, running from Zienie to Kornica, in the highest part of the area (165–170 m asl) (Fig. 2A) once covered by the Klukowka Lobe. It is a part of the till plain built of the diamictic deposits: tills in the lower part, and diamictic sands and gravels in the upper part (Albrycht, 2004b) (Fig. 2B). The individual ridges of the crevasse infillings are 1 km long, 200 m wide, and up to 10 m high. They are symmetrical and mainly arranged parallel to

* Corresponding author. Tel.: +48 81 537 68 41; fax: +48 81 537 68 62.
E-mail addresses: anna.godlewska@poczta.umcs.lublin.pl (A. Godlewska), terpis@poczta.umcs.lublin.pl (S. Terpiłowski).

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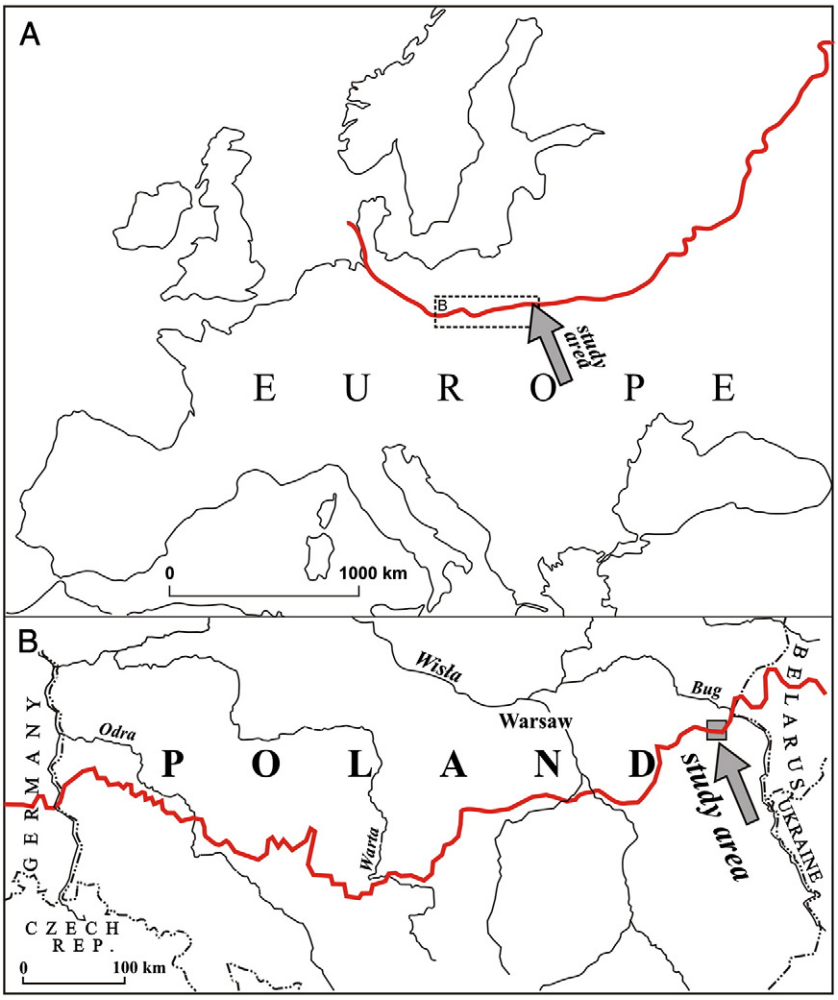

Fig. 1. Location of the study area in the marginal zone of the younger Saalian ice sheet in (A) Europe (after Mojski, 1993) and (B) Poland (after Marks, 2004). Red line indicates maximum ice extent.

the end moraines that indicate the maximum extent of the Klukowka Lobe. Between them the elongated (up to 1.5 km) and generally shallow (up to 20 m) melt-out depressions occur, which separate the crevasse infillings and have the same orientation (Fig. 2). The lithology of all crevasse infillings is similar: sands are most frequent in the lower parts, whereas gravels dominate in the upper parts (Albrycht, 2004b).

The belt of the crevasse infillings is located on a high in the Cretaceous/Palaeogene substratum which was glaciotectonically squeezed upward (to 160 m asl) during the Elsterian glaciation (Ruszczyńska-Szenajch, 1976; Aleksandrowicz and Radwan, 1992). This was thought to be a result of the force exerted by the ice on the unconsolidated surficial sediments when it found its way blocked by the Palaeozoic tectonic structure — Łuków Horst in the foreland of the Podlasie Depression (Żelichowski, 1972) (Figs. 3, 4). A regular relief of alternating Cretaceous chalks and Paleogene sands resulted. They occur in form of the glaciotectonic wedges with imbrications and shear planes, emphasized by tectonic mirrors, dipping into the NW (Figs. 4, 5) (Żelichowski, 1972; Albrycht, 2004a,b).

3. Description and interpretation of the crevasse infillings deposits

Ten crevasse infillings were investigated sedimentologically. We describe their lithofacies characteristics on the basis of an example in the best recognizable succession at the Nowa Kornica site (Fig. 2). Field data were subjected to a three-step sedimentological analysis. The description of the distribution and lithology, as well as the genetic interpretation of the lithofacies, is the first step of the analysis. The lithofacies are coded by a Miall (1977) lithofacies code, slightly modified by Zieliński (1995). The modification of lithofacies includes double textural signature (SF — silty sands, SG — gravelly sands, GS — sandy gravels). In the second step, lithofacies of similar lithology are grouped into lithofacies associations. Facies of dominant frequency are in the first two/three places of the lithofacies association code, e.g., Sm,SFh. Lithofacies that occur sporadically are indicated with brackets, e.g., lithofacies GSh in lithofacies association SGh,Sh,(GSh). In the third step, sets of the related lithofacies associations that originated under similar sedimentary conditions were grouped into three units indicated by the letters: *ci* (crevasse infilling) with division on *l* — lower, *m* — middle, and *u* — upper.

3.1. Description

The sedimentary succession was examined in the central part of the crevasse infilling ridge. Detailed lithological analysis of the crevasse-infilling deposits allow distinguishing three various units in vertical succession: *ci-l*, *ci-m*, *ci-u*. Their mutual boundaries are sharp but have a sedimentary nature (Fig. 6A,B).

3.1.1. Crevasse infilling-lower unit (unit ci-l)

The 1-m-thick unit *ci-l*, which is gently inclined up to 10° toward the NW, comprises two lithofacies associations: Sm,SFh and Sm,SFrc,SFh (Fig. 6B,C). They occur in lateral (in the direction of layer inclination) and vertical sequence: Sm,SFrc,SFh → Sm,SFh. Lithofacies association Sm,SFh (Figs. 6B, 7A) is built of rhythmites up to 15 cm thick. It is composed of massive fine-grained sands (lithofacies Sm) and horizontally