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Genesis of a till/sand breccia (Pleistocene, Noteć Valley near Atanazyn, central Poland)

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ABSTRACT

The study area in Atanazyn in Noteć Valley, NW Poland, is located on the surface of terrace III in Toruń–Eberswalde ice-marginal valley. Terrace III is correlated with the Pomeranian Phase and the Oldest Dryas, during which most of the fluvio-periglacial sedimentation in the Noteć Valley took place.

Four units are distinguished in the terrace: (1) horizontally stratified, ripple-drift cross-laminated and massive sand (unit Sh, Src, Sm) deposited in a shallow, sand-bed channel with a low-energy current; (2) a unique till/sand breccia formed by disintegration of a lodgement till due to drying out and frost activity under periglacial conditions, which was fluvially transported over a short distance; (3) a massive gravelly diamicton (DGm) representing a subaerial, cohesive debris flow; and (4) sand with low-angle cross-stratification (Sl) forming a coversand layer over the terrace.

The presence of the till/sand breccia, which is unique for Quaternary sediments, sheds new light on the depositional conditions in ice-marginal valleys. The till/sand breccia lithofacies can be considered to be a diagnostic criterion for fluvio-periglacial conditions in ice-marginal valleys.

1. Introduction

Ice-marginal valleys (pradolinas, Urstromtäler) are 'endemic' in the Polish–German Plains. During the Pleistocene, these glaciation-related valleys, which are oriented parallel to the then ice front, drained the water from both proglacial streams which flowed from these sheet in the North and extraglacial rivers coming from the South. Nowadays, they are occupied by secondary rivers or peat fields. As a rule, ice-marginal valleys contain numerous terraces that represent various stages of valley development. The main ice-marginal valleys of the Polish–German lowlands are the Wrocław–Magdeburg–Bremen, the Głogów–Baruth–Hamburg, the Warsaw–Berlin, the Toruń–Eberswalde (Noteć–Warta) and the Reda–Łeba valleys. They were formed during successive cold stages, from the Saalian to the Gardno Phase of the Weichselian.

Ice-marginal valleys have raised many controversies about their origin and precise functioning. Most studies of ice-marginal valleys took place from the beginning of the 20th century until the 80's. The first to describe the Toruń–Eberswalde pradolina as a uniform landform in Germany was Keilhack (1897, 1898). His idea was supported by Galon (1934), Ost (1935), Woldstedt (1935), Bartkowski (1957), Pilarczyk (1959) and Berendt (1879). Maas (1904) opposed the concept of single-origin pradolinas (with the Toruń–Eberswalde pradolina as an example) and claimed that ice-marginal valleys were formed due to the merger of previously isolated dammed lakes in basins which had developed in former valleys. Beschoren (1934) claimed that the western part of Toruń–Eberswalde ice-marginal valley developed in tectonic depressions, carved by glacial erosion and filled with huge dead-ice blocks during the last Weichselian glaciation. The Beschoren concept was also postulated by Ost (1932, 1935), Louis (1934), Lembke (1939) and Woldstedt (1935). Liedtke (1957, 1961, and 1962) discussed the functioning of the western part of the Toruń–Eberswalde ice-marginal valley and the role of dead-ice in ice-marginal valley development. Galon (1961, 1964, 1968, and 1972) correlated terrace fragments and discussed the relationship of the ice-marginal valley with the buried relief. The system of terraces in the Toruń–Eberswalde ice-marginal valley consist of four main levels (floodplain, lower, middle and upper terraces), but in some reaches there is also an older, higher terrace, which was formed before the Pomeranian deglaciation (Kozarski, 1962). The middle and lower terraces and the basal part of the floodplain were formed during the late Weichselian (Kozarski, 1988).The correlation of the terraces, the deglaciation process during the formation of the Toruń–Eberswalde ice-marginal valley and the role of fluvial processes in the development of this ice-marginal valley were discussed also by Kozarski (1965, 1966) and Rotnicki (1963, 1966).

The different interpretations of the genesis and functioning of ice-marginal valleys must be considered a logical result of the poorly developed geological record that can be analyzed in outcrops and the lack of robust research methods. During the last 25 years, no

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significant work about the Toruń–Eberswalde ice-marginal valley has been published.

The aim of the present study was to unravel the enigmatic origin of a unique breccia that occurs within the fluvial deposits of the uppermost terrace. Such a remarkable deposit has not been described from the Quaternary earlier. In our opinion, the breccia sheds light on the palaeoenvironmental conditions during the formation of the Toruń–Eberswalde ice-marginal valley.

2. Geological setting and geomorphology

The middle and lower reaches of the Noteć River are located within the Toruń–Eberswalde ice-marginal valley. This 10-km wide valley is oriented W–E and is incised in a till plain which is locally covered by outwash sand and gravel. In the North, the Noteć Valley meets a push-moraine ridge formed during a short glacial advance during the final event of the Poznań Phase (Weichselian, approx. 18.8 ka) (Kozarski, 1986).

Three terraces are distinguished within the study area (Figs. 1, 2). Terrace I (50 m a.s.l.) is the Holocene floodplain of the Noteć River. Its 10–20 m fluvial sands are covered with gyttia, peat and silt. The onset of the organic accumulation has been dated as Younger Dryas or Preboreal (Kozarski, 1962). Terrace II reaches up to 5 m above the floodplain. It is composed of gravelly sands and sands. Its formation is attributed to the Late Glacial. The surface of terrace III is 13 m above the floodplain. Core deposits of terrace III consists of till or glaciofluvial deposits with erosional top. This glaciogenic basement is overlain by a gravelly pavement which is succeeded by several metres of fluvial sands. Kettle holes occur on the surface of this terrace. The largest ones now form shallow lakes (Figs. 1, 2). Another characteristic surficial feature is the occurrence of large erratics. Terrace III developed during the Oldest Dryas, which is recognized as the main phase of fluvio-periglacial sedimentation in the Noteć Valley (Galon, 1961; Kozarski, 1962). The analyzed deposits occur in a pit located at terrace III (Fig. 1). The highest terrace (IV) occurs only locally in the Noteć Valley; no erosional remnants are left in the study area. This oldest terrace is built of sand and gravel, which pass laterally into outwashes. The proximal zones of these outwashes start from the Weichselian end moraines of the Pomeranian Phase 70 km north from the Noteć Valley.

3. The Atanazyn sedimentary succession

Four sedimentary units have been recognized in the studied site — Atanazyn outcrop (Fig. 3A–C). The first (lowermost) unit consists of horizontally stratified, ripple-drift cross-laminated and massive sands (unit Sh, Src, (Sm)); the second unit contains angular till clasts in a sandy matrix; the third is a massive gravelly diamicton (DGm); and the overlying, uppermost deposit is sand with low-angle cross-stratification (Sl).

3.1. The Sh, Src, (Sm) unit

3.1.1. Description

This unit is mainly composed of fine-grained sands with horizontal stratification and ripple-drift cross-lamination, but has a locally massive appearance (Fig. 4A–B). Less common are low-angle cross-laminated sands (lithofacies Sl), whereas trough cross-stratified sands (lithofacies St), horizontally laminated silty–clayey sands (lithofacies SFh) and sandy silt and clay (lithofacies FSh) occur only sporadically. All lithofacies form sheet-like beds from a few to 60 cm thick and have an average lateral extent of some 10 m. A positive correlation between the maximum particle size and the bed thickness is characteristic of all lithofacies in this unit.

The total thickness of the unit is 2.5–3 m. The contact with the overlying breccia is sharp and erosional. A characteristic feature is the rhythmic nature. Four types of rhythmite are recognized: they form couplets of Sm/Sh (log I in Fig. 3A), Sh/Sl (log II in Fig. 3B), St/Sm (log II in Fig. 3B), and SFh/Fh (log II in Fig. 3B). The orientation of the cross-stratification indicates palaeoflow directions towards the South and South-West.

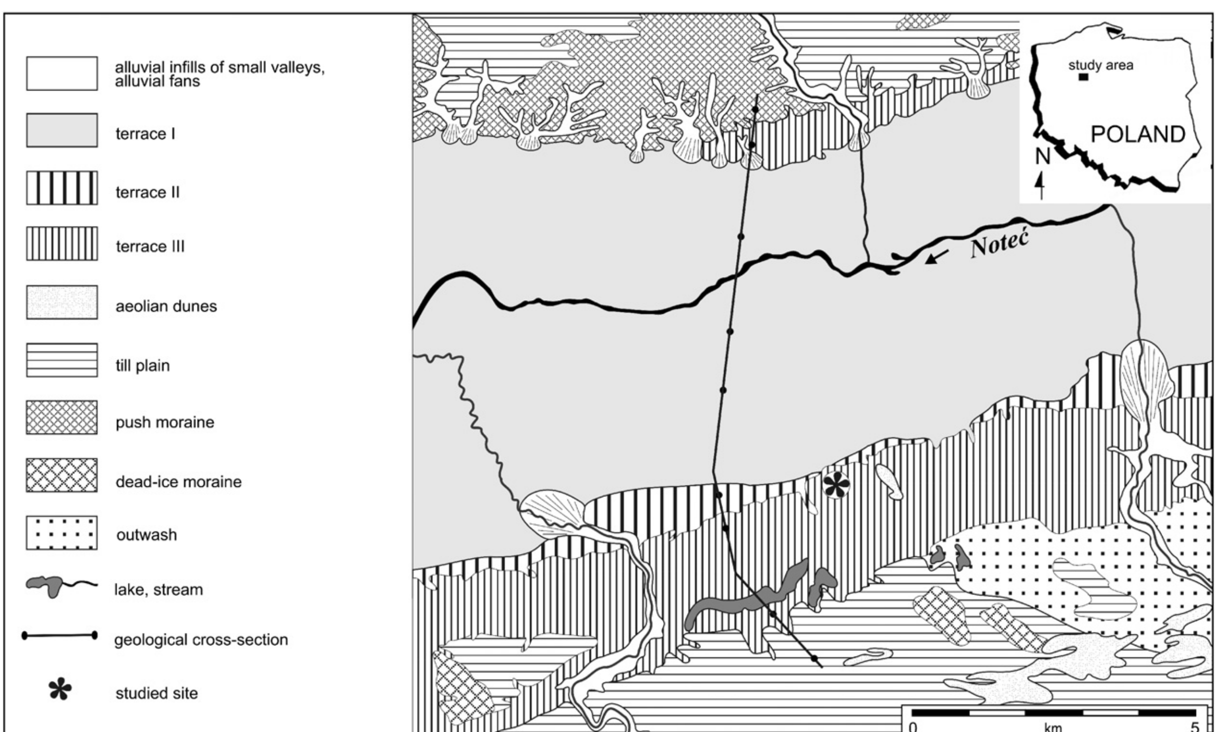

Fig. 1. Study area near Atanazyn (Noteć Valley) in the Toruń–Eberswalde ice-marginal valley, and distribution of Quaternary deposits. Modified from Szupryczyński, 1966; Uniejewska and Włodek, 1976.