Quaternary Glaciations – Extent and Chronology
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The main glacial limits in Belarus

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Introduction

The present interpretation of glacial limits in Belarus is based on data from the Geomorphological Maps of the Belarussian SSR (Gurski, 1980, 1986) drafted in accordance with the stratigraphical scheme of the Pleistocene which was accepted in the past by the majority of geologists (Gurski, 1974; Makhnach, 1971; Matveyev, 1995; Matveyev *et al.*, 1988). The aim of this paper is to present some of the latest modifications to the glacial pattern in Belarus in comparison to the 1980 Geomorphological Map. These modifications are based on the results of geological and geomorphological investigations undertaken during the last decade. The present authors follow the new stratigraphical scheme of the Pleistocene in Belarus as elaborated by Velichkevich and co-authors (1996) and the digital map 1: 1,000,000 presented is an attempt to integrate the revised ice-marginal positions into the previously-mapped glacial limits.

The present-day landscape of Belarus was shaped by repeated Pleistocene glaciations. In order to understand the glacial pattern in Belarus it is necessary first of all to summarize the glacial history. Five major ice sheets affected the country during the Pleistocene: the Narev, Berezina, Dnieper, Sozh and Poozerian glaciations. The sequence of glacial/interglacial deposits reaches a maximum thickness of 325 m, with an average thickness of 75-80 m (here and below: data on the thickness of glacial deposits cited after Matveyev, 1995).

Narev Glaciation

The oldest-known glaciation in Belarus is the Narev Glaciation. Deposits of this glaciation have been mostly eroded and disturbed during the subsequent ice advances. Today, Narev glacial sediments are nowhere exposed; they underlie the Berezina deposits.

Berezina Glaciation

The Berezina ice sheet covered almost all of Belarus (except the southernmost part of the country). Generally, the Berezina glacial sediments are 10-15 m thick in the northern part of the country, 50-70 m in the centre and 15-25 m in the southern part. One of the peculiarities of the Berezina deposits is the abundance of glaciolacustrine sediments which are widespread, especially in western and eastern Belarus. The other is the presence of an intricate network of glacial channels which are deeply-incised into the pre-Quaternary bedrock (to 125 m b.s.l.). After deglaciation, the landscape was dominated by relatively flat surfaces with very few highlands and with large morainic plateaux dissected by deep glacial valleys.

Dniepr Glaciation

The main morainic highlands of Belarus were originally formed during the Dniepr Glaciation. The Dniepr Stage saw the most extensive Pleistocene glaciation which advanced well beyond the limits of the country. The thickness of glacial deposits reaches over 100 m and is generally 40-50 m. The most remarkable result of this glaciation was the formation of the cores of the Grodno, Minsk, Oshmiany, Mozyr and other morainic highlands. In many respects these uplands controlled the dynamics of the last (Poozerian) glaciation, as well as peculiarities of the last ice advance during the Sozh Stage.

Sozh Glaciation

The Sozh glacial complex is 10-20 m thick on average with a maximum thickness of about 100 m (in the Minsk highland area). The distribution of the Sozh Till is irregular. In the northern part of Belarus it has been almost completely eroded. Some patches of the original till cover were preserved within the largest glacial depression in Belarus - the Polotsk glacial depression. Recent investigations have shown that the Sozh deposits are absent from eastern Belarus (Pavlovskaya *et al.*, 1997). This discovery has significantly changed opinions concerning the age of the upper till in that area. These results confirm the view of Velichkevich *et al.* (1996) that there was only the Dniepr and the Sozh deposits represent glacial stage sediments in the strict stratigraphic sense of this term.

Poozerian Glaciation

Deposits of the subsequent Poozerian Glaciation cover the northern and north-western part of Belarus. The thickness of the glacial sequence varies from a few metres to 70 m; on average they reach about 20-30 m. During the Poozerian

Table 1. Glaciations and interglacials (grey) in Belarus.

Gursky *et al.*, 1986		This paper (after Velichkevich *et al.*, 2001)	
Poozierie	Late Pleistocene	Late Pleistocene	Poozierie
Murava			Murava
Sozh	Middle Pleistocene	Middle Pleistocene	Pripyat Sozh Stage Dnieper Stage
Shklov			
Dniepr			
Aleksandriya			Aleksandriya
Berezina	Early Pleistocene		Berezina
Beloviezha			Beloviezha
Narev			Narev

Glaciation the Svir, Braslav, Nevel, Gorodok, Vitebsk and Orsha glacial highlands were formed. Similarly, large glacial lakes such as the Polotsk, Surazh and Luchosa lakescame into existence as a result of blocked southward meltwater drainage. The maximum extent of the last ice-sheet was controlled by the pre-existing topography and depended on the distribution of the morainic highlands and lowlands remaining from the Dniepr and Sozh ice sheets. The Poozerian glacier extended thefurthest south within the Vilia, Berezina and Luchosa drainage basins.

New data obtained in the past few years for NW and N Belarus have resulted in a partial revision of the previously-mapped glacial limits and maximum extent of the last glaciation. The limits of sub-stages and phases of the Poozerian (Weichselian) Glaciation are based on geomorphological analysis of glacial landform complexes, taking into account the results of geological investigations. Interpretation of aerial photographs has been applied to the study of landforms. The dominant role of the morphological approach is conditioned for two main reasons. Firstly, there is a lack of sections with interstadial deposits in northern and north-western Belarus. Secondly, the landform assemblages of corresponding phases of the last glaciation exhibit essential morphological differences. The availability of satellite images and aerial photographs has allowed the application of remote-sensing techniques in a new approach to large-scale geomorphology.

New geomorphological data have been obtained, and these data coupled with a spatial analysis of the distribution and structure of the main ice-marginal complexes in the Belarussian-Lithuanian border region led to the conclusion that the limits of the main phases of the last glaciation in NW Belarus required revision (Guobyte & Pavlovskaya, 1998). The maximum extent of the last glaciation in Belarus is based not only on studies of glacial landforms, but also on till mineralogy and petrography investigated by Baltrunas *et al.* (1985) and Gaigalas (1995) in Lithuania, and Karabanov (1987), Gurski *et al.* (1990) and Sanko (1987) in Belarus. The mineralogical and petrographical data also allow the clarification of the course of deglaciation.

The distribution of ice-marginal formations clearly indicates that the outermost limit of the last ice sheet in NW Belarus lay south of the Vilia valley where several glaciofluvial deltas and outwash cones have been recognised on aerial photographs. This position lies 10 km (in some places 20 km) farther to the south than previously assumed (Geomorphological Map of the Belarussian SSR, 1980; Geomorphological Map of the Belarussian SSR, 1986). This glacial limit corresponds well with the equivalent limit in Lithuania (Guobyte, 1999). Further field investigations by Pavlovskaya in 1998-1999 in NW Belarus (middle part of the Vilia drainage basin), confirmed the supposed position of the maximum extent of the Poozerian Glaciation. Two lithologically-different tills have been identified there. Clast orientation and till fabrics at the Zamok and Belaya Gora outcrops has revealed differences between the lower and the upper till. The lower till is interpreted as the Dniepr (Saalian) Till, on the basis of its clast orientation and the upper is interpreted as a Poozerian (Weichselian) till.

The process of deglaciation in the marginal zone of the Poozerian maximum ice advance created vast fields of dead ice, especially in NW Belarus. This explains partly, why there is no massive end-moraine complex, but instead a great number of kames, eskers and pitted outwash plains are found. The occurrence of Poozerian end moraines is limited to the Svir highland in Belarus as well as to the Mickunai glacial depression in Lithuania. The distribution of ice-marginal complexes and the orientation of glacial dislocations suggest that the Weichselian ice cover was separated into two lobes: the Disna lobe in NW Belarus and the Zeimena lobe in NE Lithuania. This division probably took place during the Gruda-Ozerskaya phase, which probably correlates with the Brandenburg phase. The lobate pattern of ice flow is indicated by the occurrence of almost longitudinal (N-S trending) ice-marginal and glaciofluvial formations. It is very likely that the basal topography affected or even controlled glacier dynamics and played a major role in the formation of the two-lobate pattern.

The two ice lobes were separated by the Shvencionys (Lithuania) and Lyntupy (Belarus) highland areas. Such a

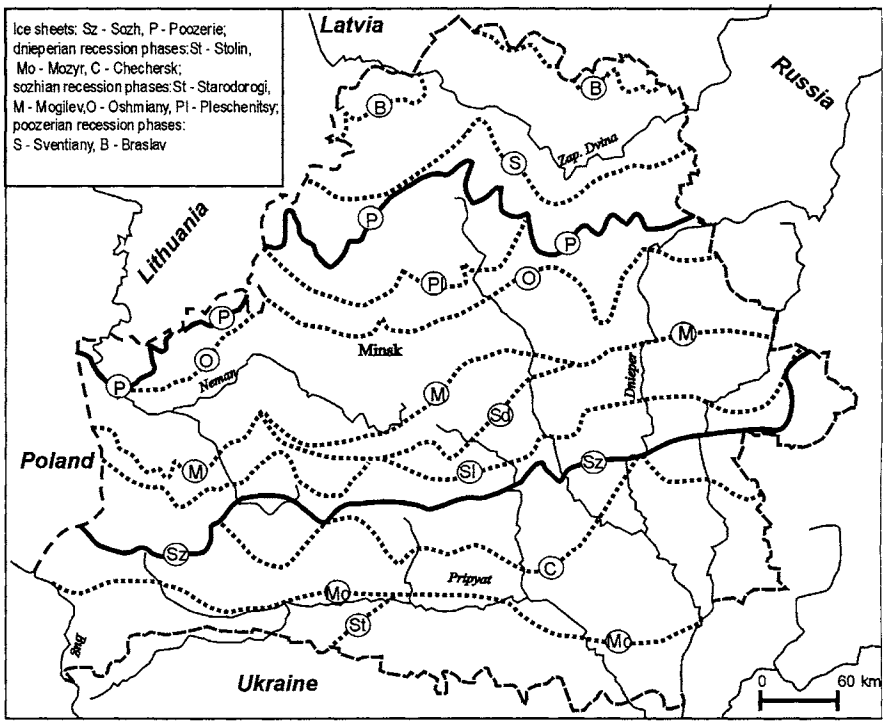

Fig. 1. The glacial limits in Belarus. Solid lines: maximum extent of the glaciations. Dotted lines: recessional phases.

supposition is not new. Baltrunas *et al.* (1985) also concluded that the ice margin was separated into two parts on both sides of these highlands. But they assumed that the Sventiany highland was formed during their Baltija substage. The present authors suppose that this ice-marginal complex is older and that the limit of the Baltija - Braslav substage (which corresponds with the Pomeranian stage) was situated much further north.

Both ice lobes had a relatively passive glacial regime. However, the Disna lobe decayed faster. This might have been caused by climatic factors, but it seems to be more likely that the basal conditions of the ice played a decisive role. For example, an abundant inflow of water at the bottom might be a possible explanation of this mode of deglaciation Moreover, the faster retreat of the Disna lobe might have resulted from the wide distribution of ice-dammed lakes, which began to form in this area in the Shvencionys - Sventiany phase (possibly to be correlated with the Frankfurt ice-marginal line). These lakes might have encouraged more rapid decay of the ice margin. The largest waterbody in the region was the Disna glacial lake, situated between the ice-marginal complexes of the Shvencionys - Sventiany phase and the Baltija - Braslav substage. The existence of such an extensive water basin provoked a relatively high rate of melting, accelerated by calving. Traces of calving, in the form of ice-rafted detritus, are found in numerous sections of glaciolacustrine deposits.

The passive regime of ice dynamics changed during the Baltuja - Braslav substage, when a prolonged stagnation phase of the Weichselian ice sheet occurred, probably interrupted by short ice-marginal advances which pushed up a series of end-moraine ridges (Pavlovskaya, 1994). A great number of glacial dislocations and the morphology of ridges point to the existence of an active ice margin and a change in the direction of glacial pressure from a NNW to NNE - the latter direction being peculiar of the Baltija substage (Gaigalas, 1995). It is very likely that there were three short pulses of local ice advance which formed the northern, central and southern ridges of the Braslav highland.

In the central and eastern parts of Belarus, the limits of the Poozerian Glaciation and the Sozh Substage of the Dniepr Glaciation have been based on morphological data from the Geomorphological and Quaternary geological maps of Belarus. In general, they correspond with the position of ice-marginal glacial highlands. Particular investigations of tills have determined that the Poozerian ice sheet in this area extended further south than that mapped previously.

Detailed investigations of the outcrops along the Berezina river valley between Lake Palik and Borisov have revealed the following stratigraphical sequence:

1. A brown and greenish-grey till which occurs within the end moraines and which is partly exposed within glaciofluvial plains.
2. A thin reddish-brown till. It is distributed mainly in the vast Upper Berezina lowlands and appears to be a flow till.
3. Glaciolacustrine deposits which overlie the upper till. In the vicinity of Borisov, a transition from these glaciolacustrine sediments into the alluvium of the second Berezina river terrace has been seen at an altitude of about 11-13 m above the recent water level.
4. Late Poozerian and Holocene alluvium of the first Berezina river terrace and the floodplain.

Analysis of the pebble fraction (2-5 cm) in both tills indicates their different composition. Clasts of sedimentary rocks (mainly dolomite, limestone, sandstone, marl, flint) prevail in the lower till, whilst crystalline rocks dominate in the upper till (Gurski *et al.,* 1990).

Since the same characteristics have been found in other sites within the Poozerian limits, it has been possible to identify the upper reddish-brown unit as the Poozerian Till. Therefore, these data suggest that the Upper Berezina lowland, above Borisov, was overridden by the Poozerian Glaciation. The maximum limit of the glaciation can be identified 40-50 km to the south along the Berezina river valley up to its bend at Bolshoye Stakhovo (some 5-7 km north of Borisov). This area was previously attributed to the Sozh Glaciation.

Further downstream, in the section of the Berezina river valley between Bobruisk and Parichi and also in the Sozh river valley downstream of Slavgorod, investigations of the till clast petrography (fractions of 1-2, 2-3, 3-5, 5-7, 7-10 cm) have been carried out (Gurski *et al.,* 1990). The results of these investigations suggest that separate glacial tongues might have extended significantly farther to the south (30-40 km in this area) then previously assumed.

Conclusions

On the basis of the results of recent investigations, the glacial pattern in Belarus was more complicated than previously thought. The most significant recent modifications of this pattern concern the limits of the Poozerian Glaciation in the northwestern and northern parts of the country. The maximum limit of this glaciation in NW Belarus was located south of the Vilia valley and the glacier also spread further south within the Upper Berezina lowland.

The modified limits of the older glaciations (the Dniepr Glaciation and the Sozh Substage) are mainly based on the results of till lithological studies and palaeobotanic investigations (Gurski, 1974; Makhnach, 1971; Pavlovskaya *et al.,* 1997; Savchenko & Pavlovskaya, 1999; Velichkevich, 1982; Velichkevich *et al.,* 1993). The main modifications concern the position of the glacial limit of the Sozh Substage in eastern Belarus and the maximum extent of the Dniepr Glaciation in southern Belarus.

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