

THIRTY-NINE

Reconstructing the pattern and style of deglaciation of Kola Peninsula, northeastern Fennoscandian Ice Sheet

Clas Hättestrand* and Chris D. Clark†

*Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm, Sweden

†Department of Geography, The University of Sheffield, Sheffield S10 2TN, UK



The last deglaciation of the Fennoscandian Ice Sheet is fairly well constrained, particularly around the southern and eastern margin. The deglaciation of the northeastern sector of the ice sheet, including the Kola Peninsula, is much less well understood. The area is of particular interest for ice-sheet reconstructions, however, because of its position between three ice masses: the Fennoscandian Ice Sheet, the Barents Sea Ice Sheet and the White Sea ice lobes.

Kola Peninsula displays a rich and complex pattern of glacial landforms, and yet the ice-sheet history remains elusive. Even the main deglaciation pattern is uncertain, and little or no attention has been paid to prior glacial phases. Deglaciation reconstructions range from a coherent ice-marginal retreat towards the central part of the peninsula (Kleman *et al.*, 1997), to almost complete deglaciation of the central part of the Kola Peninsula while ice lobes still flanked it (Niemelä *et al.*, 1993). A third alternative has been the possible existence of a more or less independent Ponoy Ice Cap, centred on eastern Kola Peninsula in Late-glacial time (e.g. Ekman & Iljin, 1991). These discrepancies result partly from an incomplete coverage of detailed geomorphological maps over the area, which would allow a reconstruction of the spatial patterns of deglaciation, and partly from the lack of geochronological data, which would allow the advancement of time constraints on the ice-flow events.

To reconstruct the pattern and style of deglaciation, we have focused specifically on mapping the distribution and direction of meltwater channels and eskers (Fig. 39.1a). Cold-based ice sheets,

which were common in arctic regions during the last glaciation, leave no subglacial landform record (e.g. Dyke, 1993), and only a sparse and patchy sedimentary record. However, all ice sheets leave a meltwater record during deglaciation. In areas where warm-based conditions dominate, eskers will constitute the main record of deglaciation, whereas lateral and marginal meltwater channels will form in areas where the ice sheet was predominantly cold-based.

In this study, we have used Landsat 7 ETM+ satellite images to map the glacial geomorphology over Kola Peninsula and adjacent areas in northwestern Russia. This imagery has a spatial resolution of 15 m, which allows both eskers and meltwater channels to be mapped accurately (Fig. 39.1b), at least in areas without extensive forest canopy. For some regions, primarily in and around the central Kola mountains, the satellite-image-based mapping has been complemented with interpretation of aerial photographs (ca. 1 m resolution) and field-based mapping in 2001 and 2002.

The distribution of eskers and meltwater channels is shown in Fig. 39.1a. Eskers are common along the peripheral and western parts of the peninsula, whereas meltwater channels are frequent in most areas, although particularly in the east-central Kola Peninsula and generally in the highlands. The directional pattern of these meltwater landforms provides a uniform picture of the ice retreat, indicating an ice sheet with a lobate ice margin that retreated westwards across the peninsula, without major deviations (Fig. 39.2). It also appears that the highest part of the ice

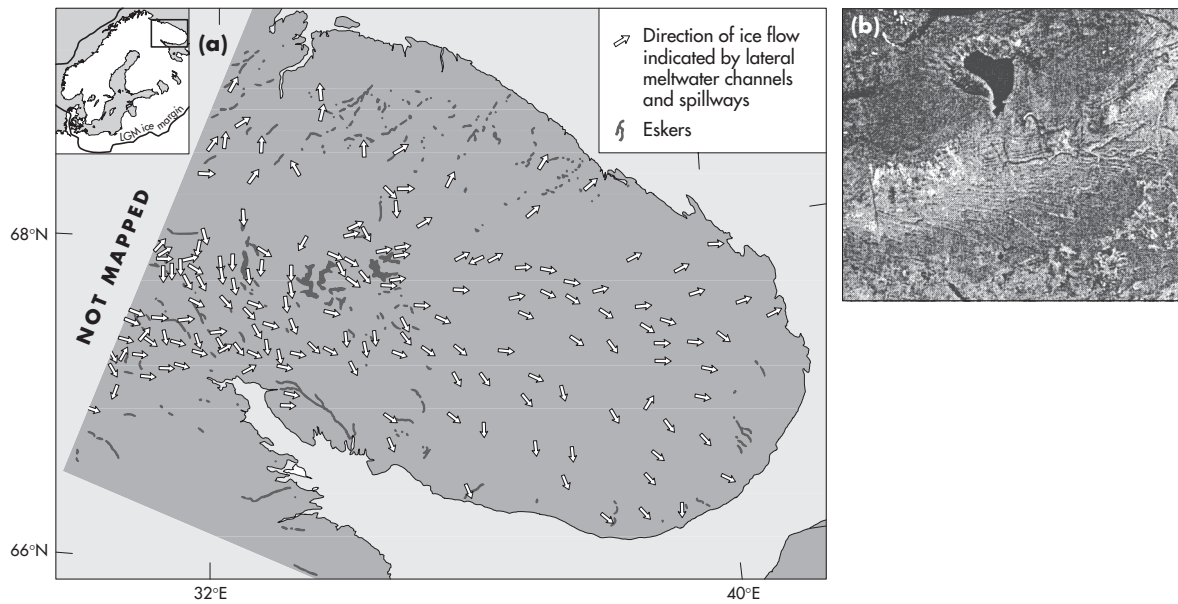


Figure 39.1 (a) Meltwater landforms on Kola Peninsula. The central Kola mountains are shown as dark areas in the terrain model. (b) Satellite image of a suite of lateral meltwater channels on the southern slope of Lovozero Mountains, central Kola Peninsula, indicating that the latest ice flow was towards the east, and that the margin successively backstepped from northeast to southwest. North is towards the top.

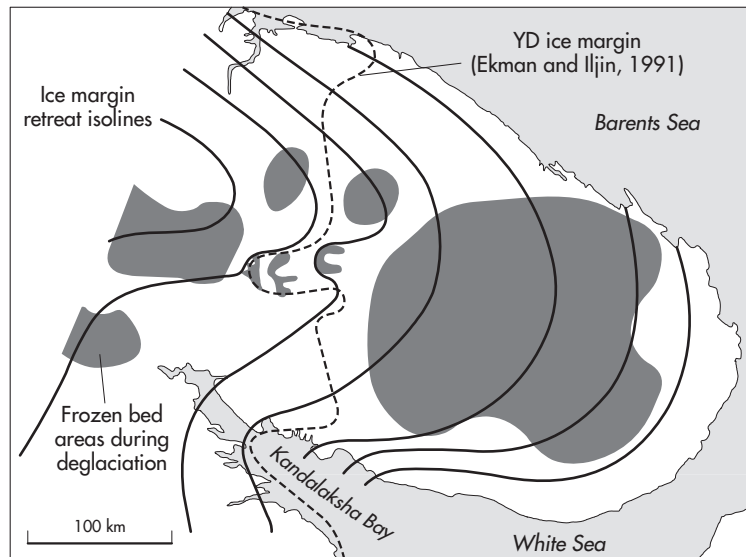


Figure 39.2 Ice-marginal retreat pattern reconstructed from lateral meltwater channels and eskers (see Fig. 39.1a). Frozen-bed areas are reconstructed based on the distribution of (i) lateral meltwater channels, indicating little or no penetration of meltwater through the ice, and (ii) subglacial landforms (e.g. eskers, drumlins), directly marking warm-based conditions.

mass was centred along the elevation axis of the peninsula, and ice flowed out radially to the east. Kandalaksha Bay probably acted as a calving bay, draining ice from the interior of the ice sheet, which caused an embayment in the ice margin.

There are no lateral meltwater channels, eskers, or marginal moraines, indicating ice flow from east to west on the central part of the peninsula. There are some (<10) extramarginal spillway

channels going in a southwesterly direction just east of the central Kola mountains (Fig. 39.1a). Because they are not marginal, they do not by themselves prove ice-flow direction, and when set against the large number and consistent pattern of lateral channels documenting systematic west to east retreat, we relegate the significance of these and tentatively presume that they relate to local-scale intricacies of the ice margin. Hence, it appears very

unlikely that an independent Ponoy Ice Cap existed during Late-glacial time. Such an ice sheet, even if cold-based (which would explain the lack of subglacial ice flow indicators, such as striae and drumlins, pertaining to this hypothetical ice cap), probably would have left at least some meltwater landforms when it melted away. We do not challenge the existence of ice cover over eastern Kola Peninsula in Late-glacial time, but demonstrate that ice in this area was part of the ordered retreat of the Fennoscandian Ice Sheet (Fig. 39.2) rather than an ice mass of its own (i.e. the hypothesized Ponoy Ice Cap).

In the westernmost part of the region, all meltwater channels indicate general ice flow towards the east during deglaciation, but we note an unusual complexity in the pattern. There appear to be two sets of channel direction: one generally towards the northeast and one towards the southeast. These may represent two different deglaciations, where the southeast channels probably relate to the last deglaciation, because of their directional alignment with eskers and the wider pattern of channels. Alternatively, they all belong to the last deglaciation and just reflect local topographically induced ice flow variations when the ice sheet thinned.

The spatial relationship between the distribution of lateral meltwater channels against eskers and other subglacial landforms also provides information on former subglacial temperature conditions. The shaded areas in Fig. 39.2 are areas with extensive sets of lateral meltwater channels and with a complete lack of subglacial landforms (eskers, drumlins, ribbed moraine, etc). We therefore interpret these areas as being dry-, and hence, cold-based during the last deglaciation.

Although the *spatial* deglaciation pattern can be deduced from the landform record, less is known about the *timing* of events. Between the central Kola mountains and the northern coast, a series of end moraines running north–south have been mapped (e.g. Ekman & Iljin, 1991; Niemelä *et al.*, 1993). These moraines have been suggested to be of Younger Dryas (YD) age, and based on these, Ekman & Iljin (1991) reconstructed an ice margin for that stage, running more or less north–south across the peninsula (Fig. 39.2). We note that their YD ice margin fits reasonably well with the ice margin reconstructed from the meltwater landform record in some places (in the coastal areas), whereas it is almost perpendicular in other areas. We argue, however, that any credible ice-marginal reconstruction has to be compatible with the meltwater landform record. Although a YD age of these moraines seems plausible from a theoretical point of view (the spatial continuity with the Karelian Salpausselkä ridges; Niemelä *et al.*, 1993), there is very little direct evidence. As this is the only major sector along the Fennoscandian Ice Sheet margin where the YD ice margin is not well established, resolving this issue is an important task for the understanding of YD ice-sheet dynamics.

In conclusion:

- 1 there was no separate Ponoy Ice Cap in Late-glacial time;
- 2 the Fennoscandian Ice Sheet in the northeastern sector, over Kola Peninsula, accomplished deglaciation as a simple ordered ice-margin retreat westwards with a large ice lobe centred along the elevation axis of the peninsula;
- 3 Kola Peninsula was largely deglaciated under cold-based conditions.

FORTY

The Laurentide Ice Sheet: a review of history and processes

John T. Andrews

*INSTAAR and Department of Geological Sciences, Box 450,
University of Colorado, Boulder, CO 80309, USA*

40.1 Introduction

For most individuals the Laurentide Ice Sheet (LIS) refers to Antarctic-size ice sheets that extended from the general area of the Great Lakes in the USA northward to the Canadian Arctic



coast, and westward from the uplands and fjords of Baffin Island and Labrador to the foot of the Rocky Mountains (Fig. 40.1). However, the late V. Prest insisted that the term was applicable only to the ice sheet during the last glaciation. In this section I will adopt the more general usage for an ice sheet that had an