A new glacial geomorphological landforms map database of Finland

Purpose

Newly available high resolution airborne LiDAR (Light Detection And Ranging) technology is generating unprecedented next-generation imagery of Earth surface features. Such datasets are being employed in Finland as part of new national geological initiative (Glacier Dynamic database) by the Geological Survey of Finland (GTK) to rapidly and cost-effectively map glacial landforms and sediments left by the last (Late Weichselian) Fennoscandian Ice Sheet. Such data is needed for hydrogeological, geoengineering and mineral exploration projects and for reconstructing ancient ice sheets and identification of the role of climate forcing in their growth and decay. At the same time as technological advances in imaging of glacial landforms, there is renewed understanding of the structure of modern ice sheets in Greenland and Antarctica, together with the paleoglaciology of ancient Northern Hemispheric ice sheets, which is based on recognition of the importance of ice streams as fast flowing (< 1 km yr^{-1}) corridors within surrounding stagnant or sluggish flowing ice.

Precise geomorphic criteria are now available for recognition of paleo-ice streams based on the elongation of subglacial streamlined bedforms such as megascale glacial lineations. Flow sets of drumlins and megascale glacial lineations can now be mapped in high resolution using LiDAR and are now seen as genetically related forms in a continuum that records increasing ice flow velocity and the creation of a low friction bed. This paper briefly outlines the nature of the Glacier Dynamic database and the methodology behind its construction and provides examples of principal bedform types that record the dynamic interplay of paleo-ice stream lobes in the Finnish sector of the last Fennoscandian Ice Sheet.

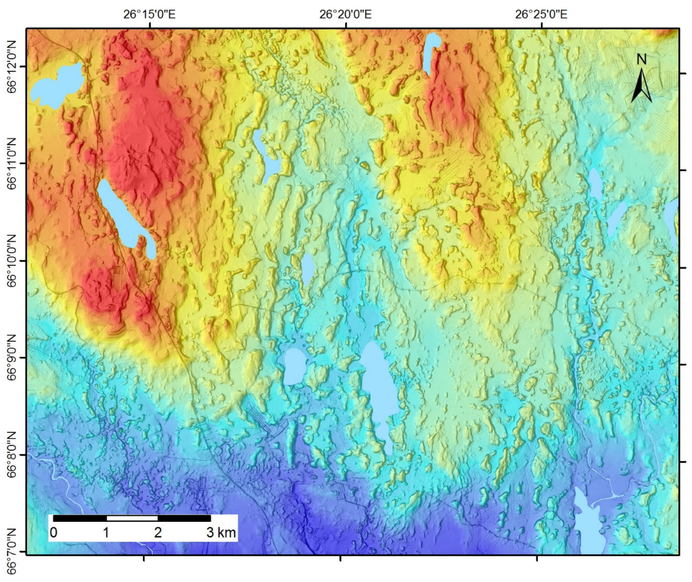

Figure 1. Classic Rogen moraine type morphology in Portimojärvi, Ranua. Dimensions of the separate ridges are generally 100–1000 m in length, 50–200 m in width, and 2–10 m in height. The ridges are typically oriented transversal to ice-flow direction with an interdistances between individual ridges are 100–300 m. Rogen moraines are one type of ribbed moraines, where there are clear indication of ice-flow direction as bended heads to the down-ice direction and/or fluted surface of the ridges; in places, direct transition to drumlins can be observed.

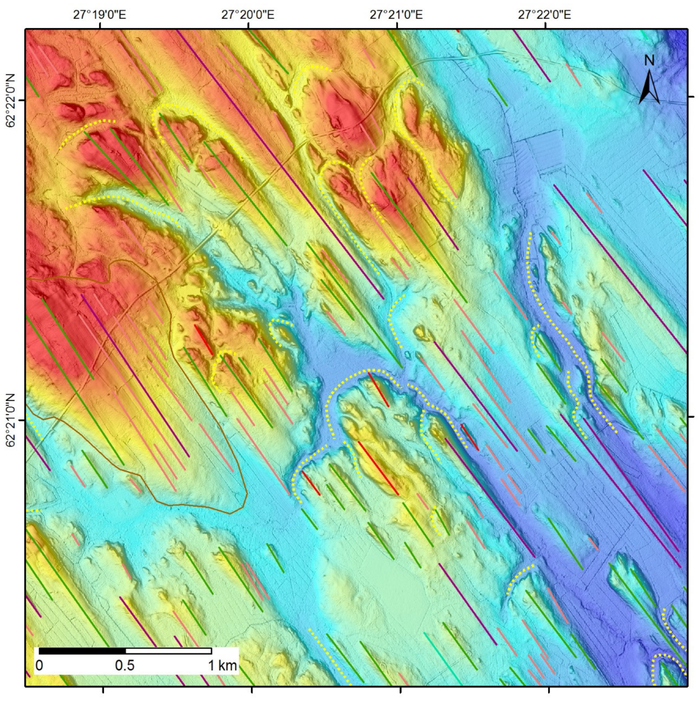

Figure 2. Heinämäki, Pieksamäki. The main flow corridor of the Finnish Lake District ice lobe represented by various types of MSGL beds. An intensive glacier erosion is described by crescent throughs (yellow dash lines) (code 3.3) stoss side of the bedrock hills and drumlins (green) (code 3.1), rock drumlins (red) (code 3.2), flutings (pink) (code 3.4) and megaflutings (purple) (code 3.5).

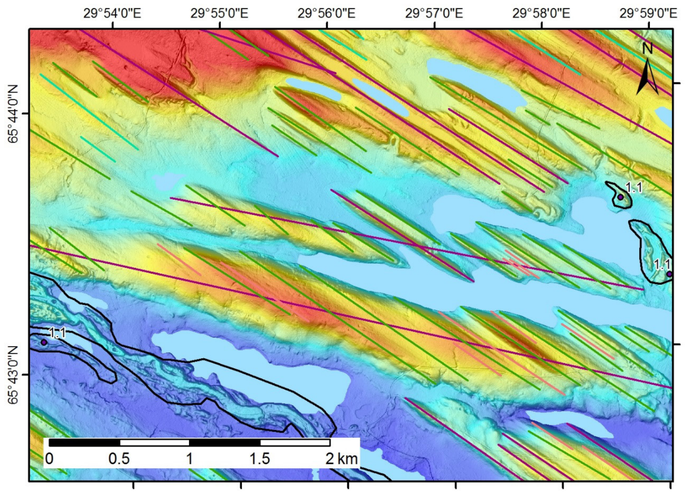

Figure 3. Russian border zone, Ilvaara region. Palimpsest MSGL landscape near the Kuusamo ice Lobe terminus. Older megaflutings (purple) (code 3.5) are eroded by drumlins (green) (code 3.1), flutings (pink) (code 3.4), megaflutings (purple) (code 3.5) and undefined lineations (light green) (code 3) that are running toward the Pääjärvi end moraine.

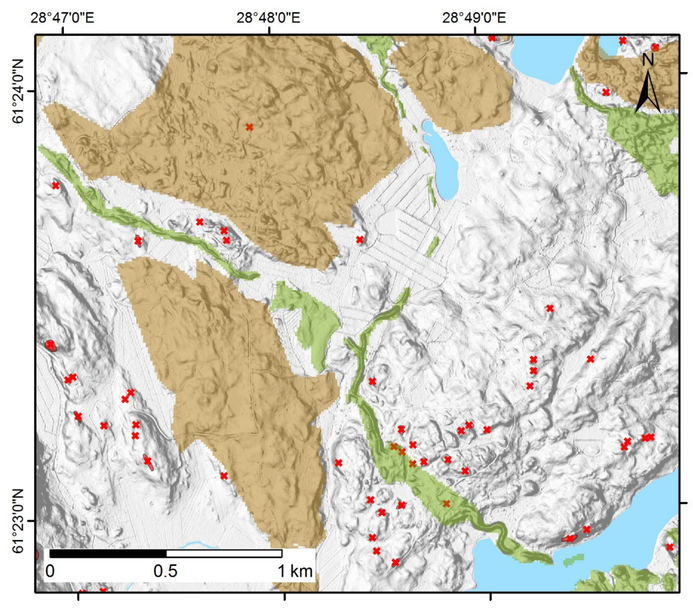

Figure 4. Salpausselkä end moraine zone at the village of Paajasenkylä, Ruokolahti, Southeastern Finland. Sinuous, narrow, esker ridges (green) (code 1.1) and hummocky moraine fields (brown) (code 4.3.2) are indicated. The esker ridge components comprise a network system, which vary widely in their direction. The esker system is associated with a hummocky moraine area, presumably the depositional environment was the stagnant zone near ice margin. The highest shoreline in the area is interpolated to be approximately 105 m a.s.l., so for the esker and the associated hummocky moraine area the deglaciation environment was partly supra-aquatic and partly the theoretical water depth at the ice margin was 0-10 meters, with a maximum of 20 m. Bedrock outcrops are marked as red.

GTK landforms database:

1. Glaciofluvial deposits
- 1.1 Esker
- 1.2 Interlobate esker
- 1.3 Ice marginal glaciofluvial deposit
  - 1.3.1 Delta
  - 1.3.2 Sandur
  - 1.3.3 Proximal ice-contact deposit
- 1.4 Extramarginal deposit
- 1.5 Littoral deposit
- 1.6 Glaciofluvial erosional area
- 1.7 Buried glaciofluvial deposit

2. Glacially lineated terrain (area)
- 2.1 Fluted terrain (area)
- 2.2 Drumlin upland (area)

3. Glacially lineated terrain (lines)
- 3.1 Drumlin
- 3.2 Rock Drumlin
- 3.3 Through valley and crescent through
- 3.4 Fluting
- 3.5 Megafluting
- 3.6 Pre-crag

4. Moraine
- 4.1 Ice marginal moraines (area)
  - 4.1.1 Large diamicton-dominated dump-moraine, often in end moraine complexes (area)
  - 4.1.2 De Geer moraines (area)
  - 4.1.3 Minor recessional moraines (area)
- 4.2 Ice marginal moraine (single form)
  - 4.2.1 Large diamicton-dominated ridges, often in end moraine complexes (single form)
  - 4.2.2 De Geer moraine (single form)
  - 4.2.3 Minor recessional moraine (single form)
- 4.3 Hummocky moraines (area)
  - 4.3.1 Subglacial hummocky moraine (active ice) (area)
  - 4.3.2 Ice contact hummock moraine (passive/partly active, pro-glacial/ice frontal) (area)
- 4.4 Ribbed moraines (area)
  - 4.4.1 Hummocky ribbed moraines (area)
  - 4.4.2 Rogen moraines (area)
  - 4.4.3 Minor ribbed moraines (area)
- 4.5 Hummocky moraine (single form)
  - 4.5.1 Subglacial hummock moraine (active ice) (single form)
  - 4.5.2 Ice contact hummock moraine (passive ice/proglacial) (single form)
- 4.6 Ribbed moraine (single form)
  - 4.6.1 Hummocky ribbed moraine (single form)
  - 4.6.2 Rogen moraine (single form)
  - 4.6.3 Minor ribbed moraine (single form)

5 Covering Deposit
- 5.1 Covering littoral deposit
- 5.2 Covering diamicton

6. Channels (polyline)

7. End moraine complex (area)

Geological Survey of Finland

N. PUTKINEN[1], P. SARALA[2], S. PUTKINEN[1], J.-P. PALMU[3], A. OJALA[3] AND N. AHTONEN[4]
[1] GTK, P.O. Box 97, 67101, Kokkola, FINLAND (correspondence: niko.putkinen@gtk.fi)
[2] GTK, P.O. Box 77, 96101, Rovaniemi, FINLAND
[3] GTK, P.O. Box 96, 02151, Espoo, FINLAND
[4] GTK, P.O. Box 1237, 70211, Kuopio, FINLAND

GTK
gtk.fi

Lay-out: Harri Kutvonen