

Development of glacial landforms in transitional cold – warm bed subglacial conditions in the central part of Fennoscandian Ice Sheet, in northern Finland

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An airborne LiDAR (Light Detection And Ranging) interpretation has revealed new data and revolutionized the mapping of glacial landforms. Previously detected landforms, such as streamlined landforms, hummocky moraines and end moraine complexes show up in LiDAR based digital elevation models (DEM) in greater detail than ever before. Landforms that are smaller than resolved from topographic maps and earlier DEMs (e.g. 10 m grid) can now be detected and examined with high resolution. This opens new possibilities for landform evolution analysis and glaciodynamic examination in the glaciated terrains. At the moment, the project for LiDAR DEM based glaciomorphological mapping is on-going in Finland (Putkinen et al. 2017) carried out by the Geological Survey of Finland together with the universities.

One of the key study areas for glacial landforms and dynamics in Finland is the Kuusamo Ice Lobe area close to the Late Weichselian ice-divide zone in southern Finnish Lapland. The glacial morphology of the ice lobe is composed mainly of moraine morphologies such as the glacial streamlined lineations of the Kuusamo drumlin field in the eastern part (Räsänen et al. 2012) and different hummocky and ribbed moraines in the western part, i.e. at the core of the ice lobe (Sarala & Räsänen 2017). The drumlin field was formed under surging type glacial movement during and just after the Younger Dryas while the core part of the glacier remained cold-based. Glaciofluvial deposits (eskers and delta formations) occur as chains representing last deglaciation phase.

Ribbed moraines, a unique morphology type formed of transversal moraine ridges in the centre of last continental glaciers, represent the depositional formations formed under subglacial conditions at the transitional zone between the warm and cold based glacier (Sarala 2005). It forms relative large, uniform ridge fields in the area having also well-formed transitional series with streamlined morphologies such as flutings and drumlins (Fig. 1).

LiDAR based mapping has revealed new knowledge of the formation phases of subglacial moraine formations in the core part of continental glacier. For example, an erosional, subglacial meltwater channel network has cut the ribbed moraine ridges before the deposition of glaciofluvial deposits, such as eskers (Fig 2). At the same time, the surfaces of ribbed moraine ridges were smoothly lineated under gently glacier reworking during a later phase of deglaciation. This means that the formation of the ribbed moraines must be earlier process than drumlin and meltwater channel formation, happened close to cold-based core part.

References:

- Putkinen, N., Eyles, N., Putkinen, S., Ojala, A., Palmu, J.-P., Sarala, P., Väänänen, T., Räsänen, J., Saarelainen, J., Ahtonen, N., Rönty, H., Kiiskinen, A. & Tervo, T. 2017. *Bulletin of the Geological Society of Finland* 89:2, 64–81.
- Räsänen, J., Johansson, P., Kejonen, A., Räsänen, J., Sarala, P., Valkama, J. & Väisänen, U., 2012. *Ruka - Oulanka: geological outdoor map, guidebook*. Rovaniemi, Geological Survey of Finland, 51 p.
- Sarala, P., 2005. *Bulletin of the Geological Society of Finland* 77, 71-104.
- Sarala, P. & Räsänen, J., 2017. *Bulletin of the Geological Society of Finland* 89:2, 82-99.

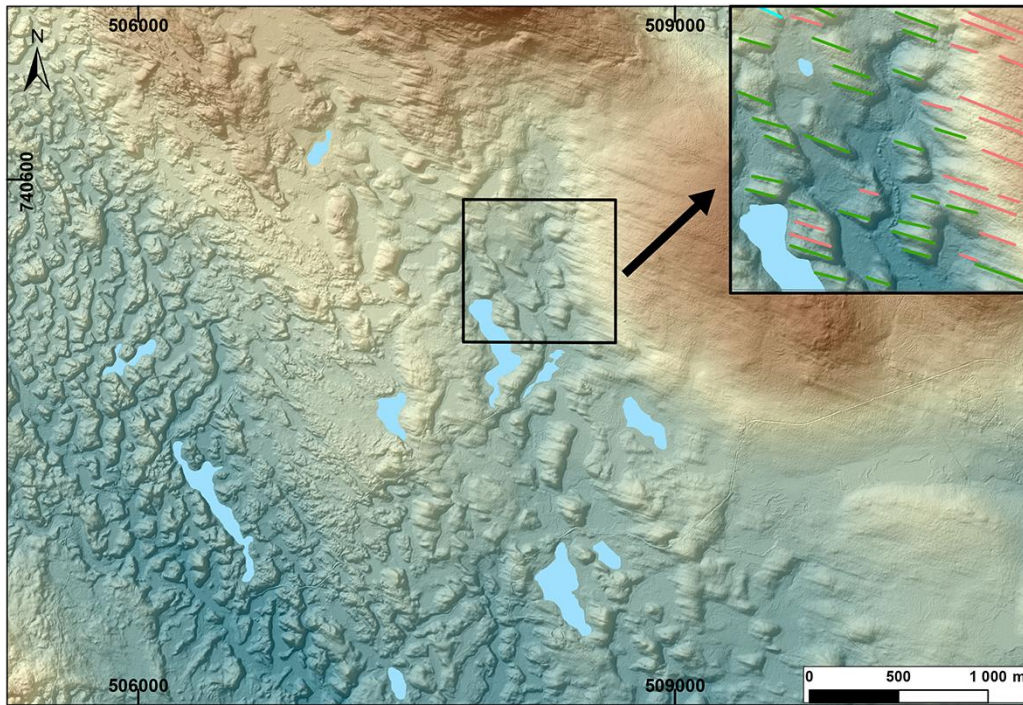


Fig. 1. Ribbed moraine field with transition to flutings and drumlins on the western side of Kemijärvi town. Ice flow direction from west-northwest direction. After Sarala & Räsänen (2017).

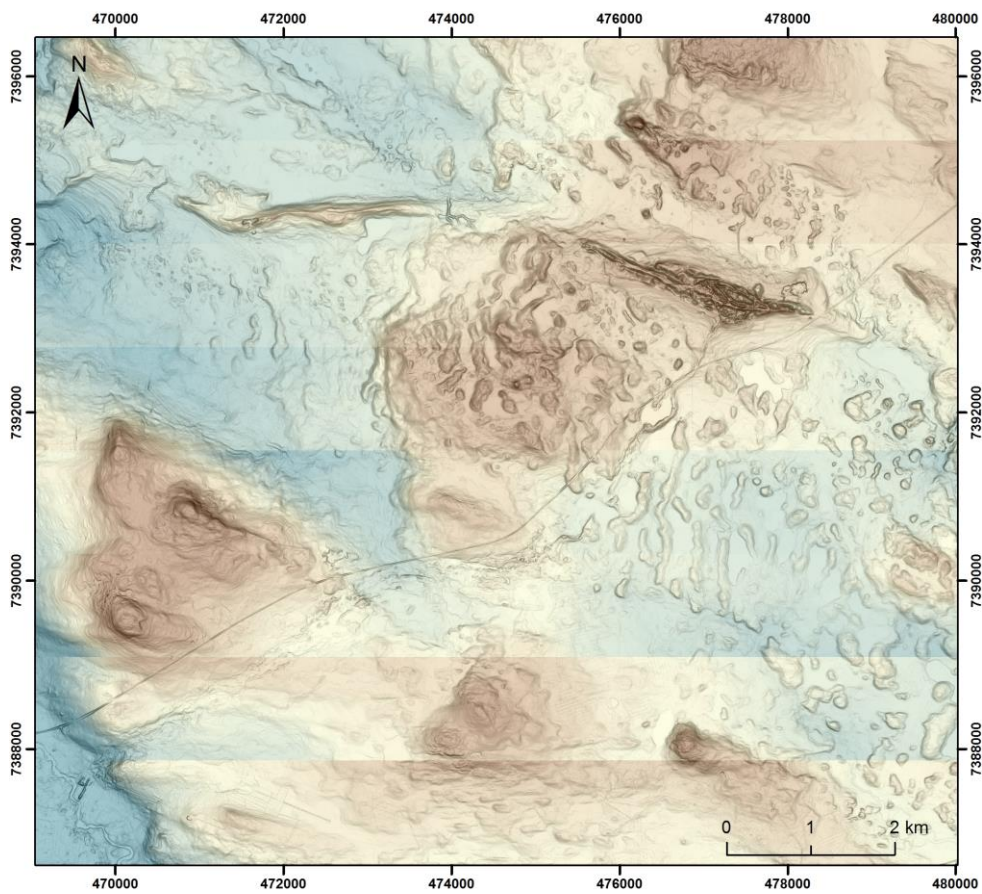


Fig. 2. Well-formed Rogen moraine type ribbed moraine field cut by subglacial meltwater channel filled with glaciofluvial sediments in the core part of Kuusamo Ice Lobe with some streamlined landforms indicating ice flow direction from west to east.