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Glacial erosion and expected permafrost thickness of Fennoscandia and adjacent regions

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Linked geological, geomorphological and tectonic features of Fennoscandia with adjacent regions of East-European plain and Barents-Kara shelf indirectly influenced the history of glacial grows and decays. The first-order bedrock landscape elements (often created or exhumed during pre-glacial Cenozoic stages) were the major factors that could partly control centers of ice nucleation and basal velocities, serve natural barriers shaping ice sheet margin during some time intervals, etc. On the hand, many landforms were powerfully modified by glacial and periglacial processes, in particular by strong glacial erosion with lithological and structural control.

Quantitative estimation of Plio-Pleistocene erosion and deposition was performed combining regional geological-geomorphological analysis (GA) and modeling with rate-based time-scale reconstructions (RR), and mass-balance control. Of special GA importance was to compare and extract changes of preserved elements of pre-glacial Neogene topography from areas that underwent different duration of glacial activity, in comparison with bordering non-glaciated ones.

More distinct radial glacial erosion pattern and larger basal ice velocities seem likely at the beginning of the early ice-age stage, with partial widening of pre-glacial drainage elements. Few wide lowlands with meandering rivers in permafrost condition could provoke early stage onset of topographic ice-streams. Over time, further complication of the pattern from radial to “spider web” is expected due to developing of topographic ice-streams. Worth to mention is progressive exhumation of resistant formations, additional complications of the pattern by fluvioglacial activity and glacial sedimentation, “pendulum” principle, with increasing amount of glacial and interglacial sedimentation in eroded material.

Approximated variable permafrost distribution seems to be additional weighty aspect, changing erosion rates at some time intervals. To estimate mean annual temperatures and solve the Stefan’s problem several known climate reconstructions were involved, but with account of possible ice-sheet related temperature depressions. In time-slices they were reinterpolated in agreement with changing the outlines of the ice sheets. Models of the basal sub-ice temperature based on relevant models for Greenland (Huybrechts P., 1996) and Antarctic ice sheets (Pattyn F., 2010) were accounted to estimate possible zonation and variability of warming effects of ice sheets. Expected lower permafrost thickness (first hundreds meters) and extent in the Barents region could be caused by unfavorable conditions and relatively high heat flow. Lowlands bearing major topographic ice streams were likely represented by taliks not affected by continuous permafrost or – depending on scenarios and parameters – were shortly affected by reduced permafrost with thick active layer. The same is expected for the Novaya Zemlya trench of the Kara Sea, while bordering shallow shelf parts were possibly characterized by thick permafrost, especially growing in time of eustatic ocean lowering. Permafrost in Fennoscandia and adjacent regions could be strongly variable but shortly relatively thick (hundreds meters) over large areas, including higher landscape on sedimentary cover west of Baltic – White Sea lowland. Linear taliks of discontinous permafrost zone on terrigenous sediments could contribute tunnel valley formation.