



## **The Keiva ice marginal zone on Kola Peninsula, NW Russia – a time-transgressive expansion landform belt**

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During the Late Weichselian, Kola Peninsula was covered by the northeastern sector of the Fennoscandian ice sheet. One of the key elements in reconstructing the deglaciation of Kola Peninsula is the Keiva ice marginal zone on the southern and eastern coast of the peninsula. This ice marginal landform system has traditionally been interpreted to have formed during the last deglaciation (~16-12 ka); either along the margin of an ice lobe filling the White Sea depression, or along the margin of a hypothesized Ponoy Ice Cap, centered over eastern Kola Peninsula, or as an interlobate formation in-between the two..

We have conducted detailed geomorphological mapping of the whole Kola Peninsula region using aerial photographs and satellite images and field work, and find that the Keiva ice marginal zone consists of the end moraine formations (the Keiva I and II moraines), eskers, hummocky moraine, meltwater channels, and fluting. From this geomorphological data we conclude the following about the Keiva ice marginal zone: i/ The Keiva moraines display ice contact features (e.g., feeding eskers, collapsed ice contact slopes) along its whole length on both the Kola and the White Sea sides. ii/ There is widespread evidence of warm based ice flow on the White Sea side of the Keiva moraines (eskers, drumlins, flutings), but the Kola side of the moraines is dominated by indicators of cold based ice (lateral meltwater channels). iii/ The whole Keiva ice marginal zone is partly drumlinised and fragmented, indicating that it was overrun from the southwest by erosive White Sea based ice after formation. iv/ The Keiva moraine II is sloping along its 250 km length from ~100 m asl in the west at the Varzuga River to ~250 m asl in the east at the Ponoy River. v/ There is

ubiquitous evidence of massive meltwater discharge eastwards all along the southeast Kola lowland, in the form of large drainage channels between the Keiva moraines and the coast. vi/ It can be traced as far north as Lumbovka, at the northeastern tip of Kola Peninsula, which is substantially further northward than what has been identified before.

From these observations we conclude that the Keiva ice marginal zone is not a synchronous feature formed along the lateral side of a White Sea based ice lobe. If it was, the moraines should slope in the opposite direction, towards the east. We also defy the suggestion that the ice marginal zone was built by an ice lobe extending from the Barents Sea, despite the general slope of the moraines. The direction of associated landforms (eskers, drumlins, channels) conclusively shows that ice flow was towards the Barents Sea instead. We argue that the Keiva ice marginal zone formed time-transgressively from west-to-east, along the suture line between a warm based ice lobe expanding from the southwest into the White Sea depression and a cold based sector of the Fennoscandian ice sheet over Kola Peninsula, as the White Sea ice lobe expanded. At the same time, the expanding ice margin dammed large lakes on southeastern Kola Peninsula, which drained successively to the east via large outlet channels. In contrast to earlier inferences that the Keiva ice marginal zone formed during the deglaciation, we argue that the observed features, including the drumlinisation of the ice marginal features, indicate that it formed before regional ice flow over the peninsula from the southwest occurred. Hence, we propose that the Keiva ice marginal zone formed during the expansion of the Fennoscandian ice sheet towards its LGM configuration, which it attained around 19 ka, and that it is a “time-transgressive expansion landform belt”.