

Interactive comment on “Maskevarri Ráhppát in Finnmark, North Norway – is it an earthquake induced landform complex?” by R. Sutinen et al.

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Received and published: 16 April 2014

Response to Referee Christian Brandes; As suggested by the referee, Results and Discussion are separated in the revised MS. Also scale bars have been added into Figs. 2 and 4B-4D. More literature on postglacial faults (Brandes et al., 2012 *Quat. Sci. Rev.* 38, 49-62; Brandes and Winsemann, 2013 *International Journal of Earth Sciences*; Jakobsson et al., 2014 *Geology*; Lund, 2005 SKBF/KBS Technical Report; Smith et al., 2014 *International Journal of Earth Sciences*) and push moraines (Bennett et al., 2004 *Sedimentary Geology* 192, 269-292; Boulton et al., 1999 *Quat. Sci. Rev.* 18, 339-371; Evans et al. 2014 *Geomorphology* 204, 86-113, Johnson et al., 2013 *Proc. Geol. Assoc.* 124, 738-752) is used in the revised MS. 1. We agree, that cross-sections would be informative. However, airborne LiDAR data are not available in the

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study area in Finnmark (cf. Sutinen et al., 2014. *Global Planet. Change* 115, 24-32). Unfortunately, sedimentary logs are not available. In addition, due to high amount of surface boulders, ground penetrating radar data would be full of hyperbolas effectively masking the inner structures (see e.g. Utting et al. 2009 *Boreas* 38, 471-481).

2. We have previously shown that the initial phase of the esker formation includes full-pipe flow as the dominant phase (Sutinen 1985, *Striae* 22, 21-25). Even though there are no exposures available in the remote Maskevarri Ráhppát study site, the anastomosing esker pattern is rather similar as described in Finnish Lapland (Sutinen et al. 2014 *Global Planet. Change* 115, 24-32). Glacial lake outburst floods are able to (subglacially) create anastomosing esker networks (Sutinen et al. 2009 *Global Planet. Change* 69, 16-28) and large-scale glaciofluvial corridors (Rampton, 2000 *Can. J. Earth Sci.* 37, 81-93; Utting et al. 2009 *Boreas* 38, 471-481), yet the morphological position of the Maskevarri Ráhppát does not fit into the concept of glacial lake outburst. However, the sinusoidality of the esker (esker-like) ridges strongly emphasizes the presence of subglacial water and suggests the origin to be associated with full-pipe flow mechanisms, not time-transgressive evolution at the ice margin (Banerjee and McDonald 1975 *Spec. Publ. Soc. Econ. Paleont. Miner.*, Tulsa 23, 132-154; Clark and Walder 1994 *Geol. Soc. Am. Bull.* 106, 304-314). Possible source of water may be attributed to lithospheric hydromechanics (Neuzil 2012 *Geofluids* 12, 22-37) and the triggering mechanism may have been subglacial earthquake (or glacial earthquake; Ekström et al., 2006 *Science* 311, 1756-1758; Nettles and Ekström, 2010 *Annu. Rev. Earth Planet. Sci.* 38, 467-491; West et al., 2010 *Geology* 38, 319-322). A new paragraph on the esker sedimentation/network has been added into the discussion of the revised MS.

3. In the revised MS, two new paragraphs (w. citations) has been added to discuss on the periglacial features. We have argued that pingos and palsas are typically located on flat terrains (Jones et al., 2012 *Geomorphology* 138, 1-14; Seppälä, 2011 *Quat. Res.* 75, 366-370; Tabuchi and Seppälä, 2012, *Polar Science* 6, 237-251; Wetterich

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et al., 2012 *Quat. Sci. Rev.* 39, 26-44), not on the slope of the fell. Also, pingos tend to be formed of soft-sediments, palsas are ice-cored peat hummocks. We are aware that in some cases thermokarst features can develop on push moraines, such as those in Yukon, Canada (Lenz et al. 2013 *Palaeogeogr. Palaeoclim. Palaeoecol.* 381-382, 15-25). Soft-sediments are absent in the Maskevarri Ráhppát. The lake/pond pattern in Maskevarri is different from talik lakes in the arctic (Grunblatt and Atwood, 2014. *Int. J. Appl. Earth Obs. and Geoinf.* 27, 63-69; Morgestern et al. 2013 *Geomorphology* 201, 262-379). One of the arguments is that no evidence has been found to indicate that permafrost persisted through the Holocene in the Maskevarri area (Lilleøren et al., 2012, *Global Planet. Change* 92-93, 209-223). Although mountain permafrost is commonly found in Norway (Lilleøren et al., 2012, *Global Planet. Change* 92-93, 209-223) and many of the mountain rockslide deformations in northern Norway are permafrost-controlled (Blikra and Christiansen, 2014 *Geomorphology* 208, 34-49), the morphology of the rockslide talus deformations is, however, dissimilar to bouldery esker ridges and mounds in Maskevarri Ráhppát.

4. New references on push moraines are added into the revised MS (Bennett et al. 2004 *Geology* 172, 269-292; Boulton et al. 1999 *Quat. Sci. Rev.* 18, 339-371; Evans et al 2014 *Geomorphology* 204, 86-113; Johnson et al. 2013 *Proc. Geol. Assoc.* 124, 738-752). We consider morphology of the anastomosing eskers and electrical sedimentary in these ridges to argue against the push moraine genesis in Maskevarri.

5. As far as we know, no similar features have been described attributed to recent earthquakes. Most recent features are paleolandslides (as far the best estimate is 5055 cal. yr BP; Sutinen et al. 2014, *Int. J. Appl. Earth Obs. and Geoinf.* 27, 91-99). The earthquakes (or glacial earthquakes; see Nettles & Ekström, *Ann. Rev. Earth Planet. Sci.* 2010) beneath the modern glaciers may generate similar features.

6. We have cited Sutinen et al. 2014 (*Global Planet. Change* 115, 24-32), where we discussed esker formation via pressurized full-pipe flows. Furthermore, some morainic landforms seem to have built up through squeezing processes in the sub-

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glacial crevasses, presumably attributed to seismic event(s). The old cartoon as presented by Hoppe (1952 *Geografiska Annaler* 34, 1-72) for the squeezing mechanism is still valid.

7. In the discussion we have cited Lagerbäck and Sundh (2008 *Sver. Geol. Unders.* C386) as well as Brandes and Winsemann (2013 *Int. J. Earth Sci.*) to indicate that seismites are of great importance in judging neotectonic origin of the landforms. However, seismites are best seen on soft-sediments, not necessarily in the bouldery (esker-like) ridges of the Maskevarri Ráhppát. In addition, the site is logistically extremely difficult for excavator.

Interactive comment on *Solid Earth Discuss.*, 6, 321, 2014.

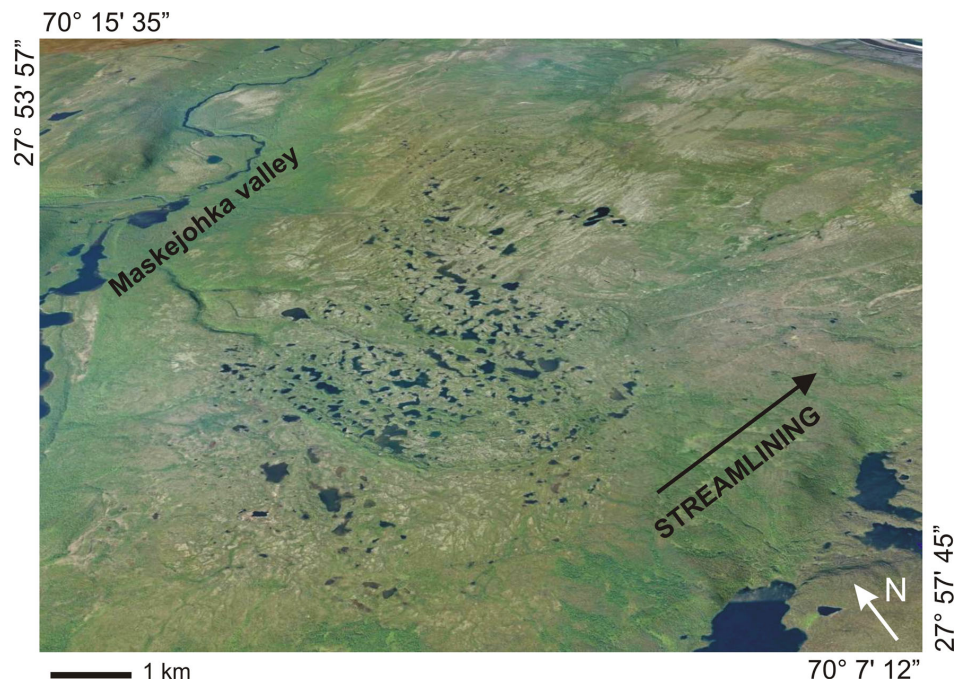


Fig. 1.

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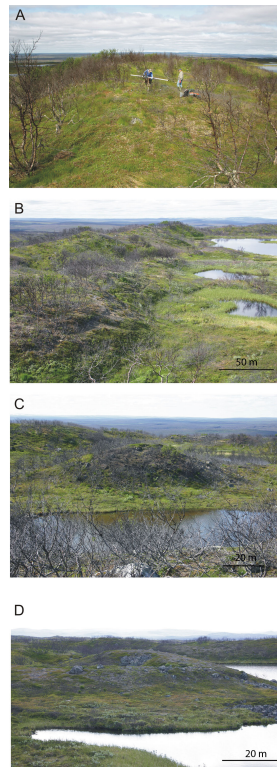


Fig. 2.

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