Forum Comment

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Pliocene-Pleistocene megafloods as a mechanism for Greenlandic megacanyon formation

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Keisling et al. (2020) hypothesize that the Petermann canyon, the largest mapped subglacial feature in Greenland, may have been formed by tens to hundreds of Pleistocene flood events. The Petermann canyon is part of a complex of huge sub-glacial canyon networks that have been mapped by ice-penetrating radar and recently their presence and origin have attracted significant attention (Fig. 1; e.g., Bamber et al., 2013a, 2013b; Morlighem et al., 2017; Dam et al., 2020; Keisling et al., 2020). In this Comment we fully appreciate the numerical simulation model of the ice-sheet evolution in Greenland that Keisling et al. presented and acknowledge that these features, in most cases, were reshaped by glacial processes. However, based on studies we have performed on two other basement-bounded canyon systems in Greenland (Dam et al., 2020), we challenge Pliocene–Pleistocene megafloods as a mechanism for their formation by showing that by pre-glacial times they were already huge, long-lasting features and had been important conduits for sediments into the offshore areas since Mesozoic times. We have no reason to believe that this is not also the case for the Petermann canyon.

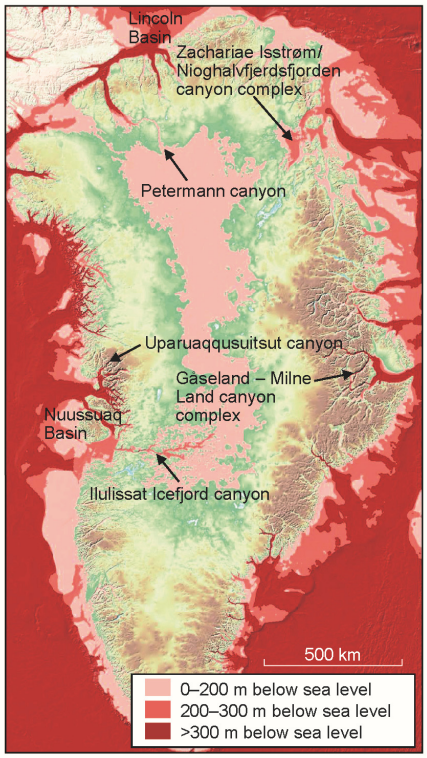

Figure 1. Greenland sub-glacial topography with regions up to 200 m below sea level (light red) that are connected to the ocean and maintain a depth between 200 and 300 m (medium red) and are continuously deeper than 300 m below sea level (dark red; from Morlighem et al., 2017).

The Uparuaqqusuitsut canyon is sitting at the margin of the Cretaceous–Paleocene Nuussuaq Basin that extends north and northeast for more than 100 km (Fig. 1). The Uparuaqqusuitsut canyon is notable for the preservation of a Paleocene fill, indicating that this canyon complex predates the inception of the ice sheet. In outcrop, it is up to 4 km in width and 750 m deep.

Another significant sub-glacial canyon is the Illulissat Icefjord canyon. The present-day canyon extends 400 km east from the head at Ilulissat, is up to 7 km in width and up to 1 km deep, and is obviously reshaped by glacial processes. However, in Albian–Paleocene times it was the main conduit of sediments into Nuussuaq Basin (Dam et al., 2009, and references therein). Facies relationships indicate that a huge Late Cretaceous delta was sourced from an input point close to the present-day Ilulissat area. Zircon provenance data from the deltaic sediments are compatible with a source from the West Greenland crystalline basement, but a small population indicate an additional source from Caledonian- and Grenvillian-aged rocks in East Greenland (Dam et al., 2020), indicating that the Ilulissat canyon drained a vast catchment area in central Greenland extending to East Greenland.

Additional evidence of pre-glacial basement-bounded canyon complexes along the Greenland craton includes the Gåseland–Milne Land area in East Greenland where pre-Paleocene canyons show a relief of more than 1 km (Fig. 1). The canyon complex continues into the Scoresby Sund fjord system and may have drained large parts of central East Greenland. Also the Zachariae Isstrøm/Nioghalvfjerdsfjorden canyon complex recognized in northeast Greenland (Fig. 1) may have acted as a conduit for the thick Cretaceous sedimentary succession deposited in the Danmarkshavn and the Vøring Basins (Dam et al., 2020, and references therein).

The relationships between pre-Paleocene landforms, Cretaceous faults, and weathered basement indicate that the basement experienced strong chemical weathering prior to Mesozoic basin formation in both West and East Greenland (Dam et al., 2020, and references therein). Apatite fission-track analysis (AFTA) data from West and East Greenland indicate discrete cooling events during the Late Triassic and Late Jurassic related to major uplift. These periods could thus be candidates for intense erosion of the weathered basement, and a much more likely mechanism for the formation of the canyons in Greenland, including the Petermann canyon.

Large Carboniferous, Mesozoic, and Cenozoic basins are located off the Lower Paleozoic platform in Arctic Canada and north Greenland, including the Lincoln Basin (Sørensen et al., 2011). It is therefore tentatively suggested that the Petermann canyon, as many of the other basement-bounded canyons in Greenland, is an old inherited canyon that has acted as a conduit for sediments into Lincoln Basin for a long period of time (Fig. 1).

This Comment not only demonstrates two very different views on the genesis of these sub-glacial canyons in Greenland, but the two different models also have huge regional implications for understanding the evolution of the basins in the North Atlantic.

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