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Glacial-derived Waves Impact Morphodynamics of Arctic Coasts, Greenlandic and Svalbard Cases Studies

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A b s t r a c t

Ongoing climate warming is leading to rapid changes in the Arctic environment, including significant alterations to the cryosphere. The recent rapid retreat of marine-terminating glaciers has exposed new coastlines (e.g. Kavan et al. 2025). The calving of these glaciers often causes tsunami-like waves that pose a serious threat to the local environment. These powerful waves can move the glacial debris in front of ice cliffs, redistribute icebergs and flood, and reshape local cliffs and beaches (e.g. Kostrzewa et al. 2024). Another type of wave clearly related to cryospheric processes is the iceberg roll wave observed in the natural conditions during the transport of broken parts of the glacier in Arctic waters (e.g. MacAyeal et al. 2009). Melting causes icebergs to rotate, sway, capsize and collapse to find new equilibrium, creating waves that can hit the coast.

We present a multi-decadal analysis of changes to the coastal zone associated with the impact of waves from glacier calving, using examples from Eqip Sermia in Greenland and Hansbreen in Svalbard. An analysis of the coast at the Eqip Sermia glacier showed that waves from glacial calving play a dominant role in transforming lateral moraines and forming a system of beaches and spits. Additionally, our multi-decadal analysis revealed significant erosion of unconsolidated cliffs on the opposite side of the bay, at a rate of ~0.53 m per year from 1985 to 2023 (Kostrzewa et al. 2024). A single wave from a glacial calving event can reshape the beach surface by entrainment of up to 1.8-m-diameter boulders and the erosion of the beach surface by washing away sand and gravel from rocky outcrops (Kostrzewa et al. 2024).

In the case of the Hansbreen coast (Svalbard), the impact of waves from glacial calving is more subtle. As a result of glacier retreat, the shoreline length of the bay increased on average 220 m/year (years: 2011–2020). The analysis of beach surface sediments from these shores showed an increase in the proportion of coarse-grained sediments with distance from the glacier front. We suggest that wave action, mainly from glacial calving, leads to the washing of fine-grained beach sediments.

Additionally, we present the results of our study on the impact of waves from iceberg roll on weathering patterns in the rocky bay of Zion Church (Ilulissat, Greenland). The main result of the study is a significant reduction in rock resistance in the zone above the high-tide level. We relate this result mainly to waves generated by iceberg roll events.

Our findings suggest that waves resulting from glacial calving and iceberg roll play a significant role in the transformation of local coasts, converting glacial forms into littoral ones or intensifying weathering processes on rocky coasts by weakening their surfaces. Our study represents an important advance towards understanding paraglacial coastal evolution in regions characterised by rapid marine-terminating glaciers' retreat.

Keywords: paraglacial coastal, calving waves, marine-terminating glaciers, Greenland, Svalbard.

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