Iron and nutrients supply to a fjord from glacier-induced pumping in northwestern Greenland

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Glacial fjords in Greenland show high productivity owing to the runoff of meltwater from the glaciers. Nutrient dynamics (of nitrate, phosphate, and silicate) associated with subglacial discharge plumes in front of marine-terminating glaciers are widely cited as important drivers of summer phytoplankton blooms in the fjords (e.g., Kanna et al., 2018). However, the dynamics of iron (Fe), an essential micronutrient for growth of phytoplankton, remain largely unstudied in glacial fjords. To investigate the role of subglacial discharge plumes in Fe-supply processes in glacial fjords, a comprehensive survey of Bowdoin Fjord, adjacent to the marine-terminating Bowdoin Glacier in northwestern Greenland (Figure 1a, b and c), was conducted.

The subglacial discharge of Fe-rich meltwater induces a buoyancy-driven upwelling plume in front of the glacier that entrains nutrient-rich deep fjord waters (Figure 1d). The plume water potentially carried 4.5–8.7 × 10^7 g day^{-1} of total Fe out of Bowdoin Fjord in summer. The concentration of dissolved Fe (dFe) (<0.2 μm size) in the plume water (~15.6 nmol kg^{-1}) was 4 times higher than that in the water in the outer part of the fjord (~3.8 nmol kg^{-1}). The dFe:nitrate+nitrite ratio (mmol mol^{-1}) in the plume water varied between 0.58 and 3.2, several orders of magnitude higher than phytoplankton cellular Fe:nitrogen (N) ratio estimated using the hypothetical Fe:carbon (C) ratio (e.g., Sunda and Huntsman, 1995) and an observed particulate organic C:N ratio of the fjord. Hence, the plume water is replete with Fe with respect to phytoplankton demands. Subglacial discharge drives the upwelling of Fe and macronutrients towards the euphotic zone, which is vital for the generation of summer phytoplankton growth in glacial fjords.

References

N. Kanna et al., Upwelling of Macronutrients and Dissolved Inorganic Carbon by a Subglacial Freshwater Driven Plume in Bowdoin Fjord, Northwestern Greenland. *Journal of Geophysical Research: Biogeosciences*, **123** (2018).

W. G. Sunda and S. A. Huntsman, Iron uptake and growth limitation in oceanic and coastal phytoplankton. *Marine Chemistry*, **50** (1995).

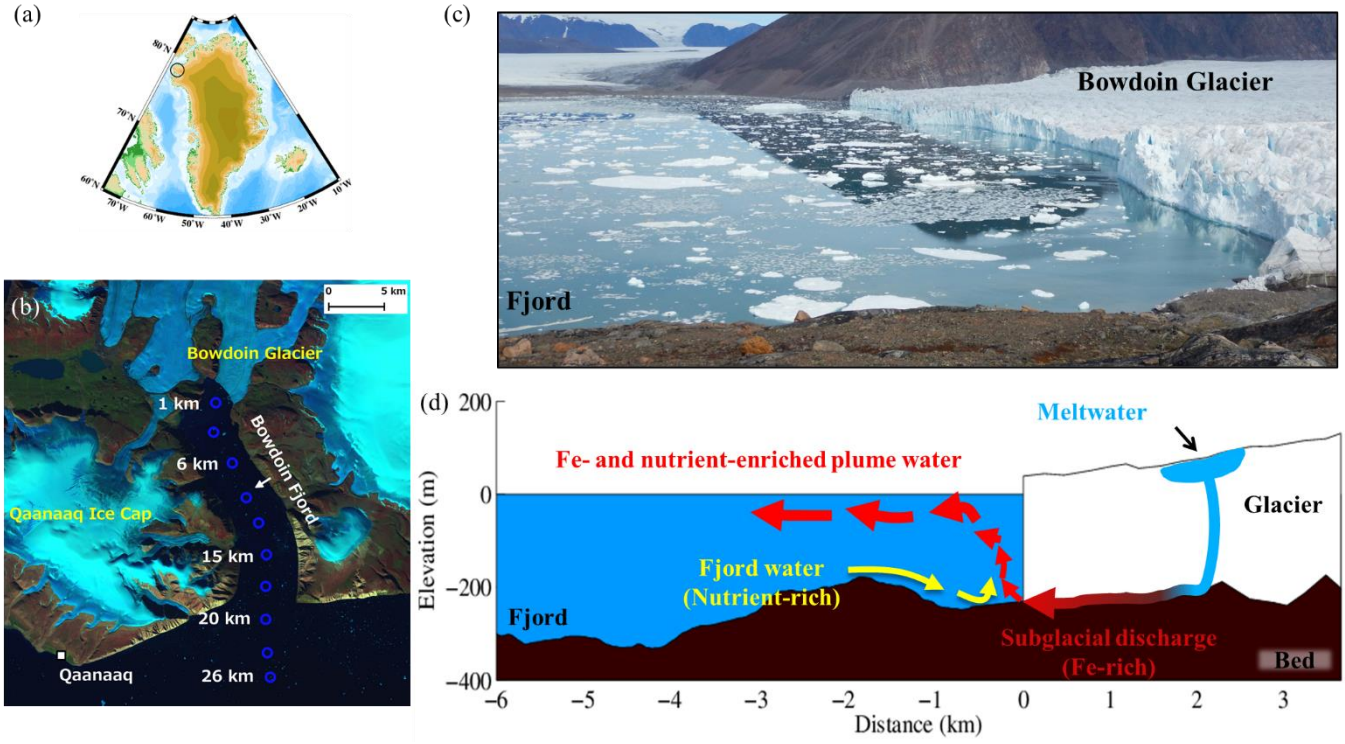

Figure 1. (a-c) Location of study area, sampling stations and a photo of the glacier and fjord. (d) Schematic of formation and distribution of Fe- and nutrient-enriched plume water off the front of Bowdoin Glacier.