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Silicon isotopes reveal how fjords modulate reactive silicate transport from glaciers to coastal regions

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Driven by atmospheric warming, the Greenland Ice Sheet (GrIS) has been experiencing accelerated melting in recent years, the mass loss of which leads to retreating glaciers and enhanced fresh water runoff to surrounding fjords and adjacent coastal regions. This glacial meltwater discharge, together with shallow fjordic sediments, potentially provides additional essential nutrients for downstream primary producers and influences the ecosystems with ongoing climate change. Silicon (Si) is one such nutrient, which is critical for the growth of phototrophic silicifiers, such as diatoms, an important group of algae that are essential for oceanic carbon fixation and biological pumps. However, the role of fjords, a critical zone for glacier-ocean interactions, in modulating the supply of Si from the glacial environment to marine ecosystems remains poorly constrained, especially for quantification of Si fluxes from the fjordic sediments into the overlying water columns.

In this study, we analysed the concentration and stable isotopic composition of dissolved silicon (DSi) in pore waters and core-top waters, and amorphous silica (ASi) in sediments (ASi_{sed}) and suspended particulate matter (SPM; ASi_{SPM}), collected from two fjords in the southwest Greenland margin to address this knowledge gap. We combined downcore observations with core incubations and isotope mass balance models to assess the benthic DSi flux, deconvolve its potential contributors, and estimate the burial efficiency of ASi. Our results suggest that the build-up of pore water DSi is controlled by competing early diagenetic processes including the dissolution of the solid phase, precipitation reactions like reverse weathering, and Si-Fe coupled cycling in these fjordic sediments. Benthic DSi transport is dominated by advection process, with the remaining flux accounted for by molecular diffusion and dissolution of ASi_{SPM}, most likely dominated by glacially-derived ASi. Compared with the proximal continental shelves, our fjord sites show higher burial ASi efficiency but a much smaller benthic DSi flux. Our study also reveals that fjords potentially act as a ‘trap’ for labile Si phases like DSi and ASi_{SPM}, which helps to complete the understanding of reactive Si transport from glaciers to coastal regions.