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Journey down a leaky pipe: silicon transformations and fluxes along glaciated fjords

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High-latitude oceans are biologically rich and play a critical role in regional and global biogeochemical cycling. One of the most important nutrients, dissolved silicon (DSi), is required for the growth of siliceous phytoplankton, diatoms, which form a key component of the biological production in the polar seas. Glacial weathering is thought to be a significant source of DSi to polar coastal waters and is especially important in regions of the Arctic and subantarctic that experience seasonal DSi limitation of diatom growth. However, there are several complex interactions between water, glacial flour and particulates, and biological processes – both in the water column and at the fjord floor after sedimentation – that can modulate the supply of DSi to downstream ecosystems. Here, we review recent field observations that highlight along fjord trends in sediment-water interactions and benthic DSi fluxes from case studies in the Arctic (Svalbard, Greenland and Iceland), Patagonia and the West Antarctic Peninsula. We use a combination of elemental analyses, stable and radioisotopic geochemical methods, and biogeochemical modelling, to provide us with a mechanistic understanding of processes that drive silica mobilisation in fjord sediments. Our findings point towards a strong link between DSi fluxes and both lithology and microbial activity. Fjords draining geological young basaltic regions (e.g., Iceland), exhibit far greater DSi benthic fluxes than those originating from older sedimentary terranes (e.g., Svalbard). Along fjord trends in porewater DSi concentrations and calculated fluxes, generally increasing away from glacial or pro-glacial sources, are likely driven by both biological (diatom biosilicification, microbial cycling) and non-biological (sorption, precipitation) processes. Our case studies reveal commonalities and geographic differences between these vulnerable environments, allowing us to begin to disentangle the drivers of change and quantify how fjordic and coastal silicon cycling will respond to future change.