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Rapid forward and reverse weathering reactions drive cryptic silica and cation cycling in high-latitude fjord sediments

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Early diagenetic processes in marine sediments involving biogenic silica and terrestrially derived reactive silicate minerals play a central role in ocean element cycling due to their controls on oceanic productivity and seawater composition. High-latitude fjords, characterized by high episodic supply of glacially derived, fine-grained allochthonous lithogenic material of varying reactivity and seasonally elevated inputs of autochthonous diatomaceous silica represent unique sedimentary systems where rapid forward and reverse weathering reactions occur and drive the cryptic cycling of silica and alkali and alkaline earth elements [1]. We provide an overview of the early diagenetic silicate reactions and their effects on the boundary exchange of key elements in the sediments of fjords located along Western Svalbard. The rapid dissolution of reactive silica results in the release of dissolved Si into pore-waters and sustains elevated benthic Si fluxes (up to -0.8 mmol m^{-2} d^{-1}), which are on the upper end of values previously determined for Arctic environments. Consistent increases with depth in pore-water Li, K, Mg, and Ba concentrations within the top cm provide evidence for forward weathering of clays quickly upon burial. Decreases in pore-water Rb concentrations with depth, particularly at the near-glacier stations, indicate that reverse weathering also occurs (Figure 1). The superposition of reverse and forward weathering results in cryptic silica and cation cycling that mute net benthic fluxes. In deeper sediments, changes in pore-water solute patterns indicate an interconnected occurrence of reverse and forward weathering, potentially driven by reactive silica-limitation. Pore-water d^7Li values determined for sites in Kongsfjorden show that the benthic net Li^+ flux here is associated with a light isotope signal; small increases of pore-water d^7Li values with depth are consistent with the prevalence of reverse weathering. The complex early diagenetic silicate reaction balances vary spatially and may change seasonally in the investigated fjord systems, demonstrating the uncertainty in global extrapolations of specific elemental cycle budgets based on behavior in particular regions.

[1] Wehrmann, L. M., Aller, R. C., Kasten, S., Dotzler, J., & Steinhoefel, G. (2025). Rapid forward and reverse weathering reactions drive cryptic silica and cation cycling in Arctic fjord sediments. *Global Biogeochemical Cycles*, 39, e2025GB008650.

Figure 1

