

Rapid forward and reverse weathering in Arctic fjord deposits: Kongsfjorden, Svalbard

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Arctic fjords receive complex mixtures of biogenic and lithogenic material with widely varying reactivity, including marine plankton, glacially-derived amorphous silica, and heterogeneous mature and immature rock fragments. Silicate diagenesis in Kongsfjorden, Svalbard sediment demonstrates the substantial variability in reaction balances that can result.

At sites in the inner and mid-fjord sampled in late summer, sharp gradients in non-conservative pore water solutes and solid phase reactant pools (e.g., biogenic silica) occur within the top few centimeters of deposits [1]. Natural radionuclides ²³⁴Th and ⁷Be, as well as sedimentary structures, demonstrate that these gradients are generated on < monthly timescales by locally variable and dynamic inputs. Diffusive fluxes of Si, K⁺, and Li⁺ are out of sediments. Although a portion of these fluxes may be related to reduction of Fe,Mn-oxides (optical sensors show dissolved Fe²⁺ below ~1 cm), they likely reflect rapid net forward weathering. The $\delta^7\text{Li}$ of diffusive fluxes averaged ~ 7.1‰, similar to typical global river inputs with dominant congruent weathering. Dissolved Li compositions show small increases of $\delta^7\text{Li}$ with depth below a minimum (~25–29‰ at 3–5 cm), consistent with a progressive shift to net reverse weathering. Br[–] tracer and incubations in earlier studies indicate that solute fluxes could be ~ 20 – 30% higher than estimated from 1-D models.

Benthic fluxes of Ca²⁺ and Ba²⁺ into the overlying bottom water reflect a combination of carbonate dissolution, redox-sensitive carrier reduction, and forward weathering. An additional flux of Mg²⁺, Ca²⁺, and Ba²⁺ into deposits occurs below 10 cm depth. Stoichiometric analyses are consistent with progressive uptake of Mg²⁺ and Ca²⁺ during reverse weathering (Mg²⁺/Ca²⁺ ~ 5 mol mol^{–1}), although carbonate precipitation may also occur. Ba²⁺ uptake appears largely independent of Mg²⁺ and Ca²⁺.

The superposition of reverse and forward weathering is supported by incubations of diatom frustules over a ~ 2.5 year period, which demonstrated both dissolution of frustules and alteration (Mg²⁺, K⁺, Al – addition).

[1] Wehrmann, L.M., Aller, R.C., Kasten, S., Dotzler, J., and Steinhofel. submitted. Rapid forward and reverse weathering drives cryptic cation and silica cycling in Arctic fjord sediments.