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Controls on benthic alkalinity fluxes from natural and enhanced silicate weathering in coastal and shelf sediments: new diagenetic model insights

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On geological timescales, continental silicate weathering plays a crucial role regulating Earth's climate. Accelerating this slow thermostat might be the key to help mitigate present-day global warming and ocean acidification through increased alkalinity generation produced by enhanced marine silicate weathering. Laboratory studies show that benthic dissolution of olivine minerals can stimulate oceanic CO_2 uptake by increasing seafloor alkalinity release. Although enhanced benthic silicate weathering is an attractive solution to both CO_2 problems, until now its efficiency remains unclear. This is because the intrinsic dissolution rate of silicates in the seafloor remains poorly constrained, while also the impact of secondary reactions such as carbonate precipitation and reverse silicate weathering (authigenic clay formation) remains poorly quantified. Thus, we first need to develop a detailed understanding of natural benthic silicate dissolution and the feedbacks on carbon and silicon cycles.

Here, we couple two well-tested diagenetic model set-ups that resolve benthic carbon, redox and pH dynamics (organic matter degradation, re-oxidation of reduced species, equilibria reactions, carbonate dissolution and precipitation) and benthic silicon dynamics (biogenic silica dissolution, and authigenic silica precipitation) in the uppermost sediments. We use this new framework to resolve natural basalt and/or olivine weathering by explicitly accounting for the dissolution of key basalt constituents (basaltic glass, plagioclase, pyroxene, and olivine). We also account for reverse weathering through illite authigenic formation. The newly coupled model captures the observed shifts in porewater pH and carbonate system, and the dynamics of benthic alkalinity production and consumption associated with marine silicate weathering. We assess the impact of benthic redox state and basalt compositions on benthic alkalinity fluxes by performing an extensive sensitive study over the entire plausible parameter and bottom water forcing space. We find complex links between rates of benthic silicate weathering and net alkalinity production. Ultimately, we will apply the new model framework to explore the geological context of Iceland. As such, we will fully constrain natural rates of benthic silicate weathering associated to the substantial inputs of natural basalts to coastal and shelf sediments.