Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20138

Non-linear sensitivity of mineral weathering to erosion implies an optimum of CO_2 drawdown at moderate erosion rates

AARON BUFE[1], JEREMY CAVES RUGENSTEIN[2] AND NIELS HOVIUS[3]

[1]Ludwig Maximilian University of Munich
[2]Colorado State University
[3]Potsdam University

Presenting Author: a.bufe@lmu.de

Silicate weathering sequesters CO_2 from the atmosphere and stabilizes Earth's climate over geologic timescales. In turn, weathering of accessory carbonate and sulfide minerals is a geologically relevant CO_2 source. Rock-uplift and -erosion is the primary mechanism by which fresh minerals are exposed to weathering at Earth's surface. Therefore, the global inorganic carbon cycle is sensitive to mountain uplift and erosion. However, quantifying this sensitivity is complex, because existing data do not consider weathering of all relevant mineral phases, and because co-variation of multiple environmental factors obscures the role of erosion. Here, we analyze the sensitivity of silicate, carbonate, and sulfide weathering fluxes to erosion in four datasets of solute chemistry from small mountain streams that span well-defined erosion-rate gradients in relatively uniform metasedimentary lithologies and with limited or well-constrained variations in runoff. Across all datasets and 2-3 orders of magnitude of erosion rate, we find that silicate weathering fluxes are almost insensitive to erosion at rates $>10^{-2}$ mm yr^{-1}. In contrast, weathering fluxes from sulfide and carbonate minerals increase sub-linearly with erosion, contradicting expectations from soil data and theory. By fitting a weathering model to these data, we show that the contrasting sensitivities of silicate, carbonate, and sulfide weathering produce a distinct CO_2-drawdown maximum at moderate erosion rates of ~0.1 mm/y. Below this maximum, mineral supply limits silicate weathering. Above the maximum, silicate weathering fluxes plateau and CO_2 emissions from coupled sulfide oxidation and carbonate weathering increasingly dominate the carbon budget. Thus, for metasedimentary lithologies, uplift of landscapes to moderate relief and erosion rates can substantially bolster Earth's CO_2 sink whereas further uplift may decrease, rather than increase CO_2 sequestration rates.