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Rapid rate declines during laboratory dissolution of ERW feedstocks revealed by Si and Ca isotope doping

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Enhanced Rock Weathering (ERW) is a proposed climate change mitigation strategy, aiming to increase atmospheric CO_2 drawdown from about ~0.2 Gt CO_2 per year from natural silicate weathering to the gigaton scale by 2050. Assessing whether this goal is achievable requires accurate constraints on dissolution rates of ERW feedstocks. We applied the isotope-doping method, which we have used for measuring the dissolution of minerals, to quantify Si and Ca release during batch-reactor dissolution of basalt and peridotite at 22 °C over 30 days. Parallel reactors are continuing for up to two years; analyses of samples beyond 30 days are underway, and the full dataset will be presented.

The 30-day data reveal strong temporal variability in dissolution and element release. (1) Experiments using both feedstocks exhibit a sharp pulse of dissolution within 24 hours, consistent with reaction of damaged surfaces and fine particles produced by grinding, followed by a 2–3 order-of-magnitude rate decrease and then an exponential decay toward low rates by day 30. The Si isotope ratios provide a sensitive constraint on the slow Si-release rates (unidirectional dissolution), whereas Si concentration-based net rates become highly uncertain in this regime and can appear negative. (2) By day 30, Si-release rates (10^{-13} – 10^{-14} mol·m^{-2}·s^{-1}) are 2–3 orders of magnitude slower than far-from-equilibrium silicate dissolution rates (e.g., olivine) commonly reported in the literature; (3) Si isotopes revealed that a substantial fraction of released Si is sequestered into secondary phases, causing apparent dissolution rates inferred from Si concentrations to underestimate true Si release by ~0.5–1 order of magnitude; and (4) Ca isotopes show that ~30-40% released Ca is removed from the aqueous phase via precipitation.

The pronounced rate decline observed over the first 30 days suggests that, under comparable conditions, ERW minerals may persist in soils longer than often assumed, with implications for optimized deployment practices (spreading rate and re-application frequency), carbon-credit accounting time horizons, and evaluation of ERW economics and environmental impacts.