Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36600

Quantifying weathering rates and carbon export efficiency of natural and synthetic enhanced weathering feedstocks in a controlled mesocosm trial

GABRIELLA ROELOFS[1], JADE MARCUS[1], JEFFREY DUKES[2], JONAS M SCHNEIDER[1], MATTHEW KANAN[1] AND KATE MAHER[1]

[1]Stanford University
[2]Carnegie Institution for Science

Enhanced weathering (EW) is a promising strategy for nature-based carbon dioxide removal (CDR), yet field-scale CDR rates remain highly uncertain due to the effects of soil heterogeneity, slow weathering rates, and discrepancies among measurement techniques. Here, we quantify weathering rates using a controlled mesocosm trial designed to isolate the impacts of soil heterogeneity and maximize signal-to-noise by applying feedstocks (10 t/ha) to both low-reactivity silica sand and an agricultural soil. We compare common silicate feedstocks (basalt and olivine) to a highly reactive synthetic feedstock (monticellite) that has been shown to weather up to three orders of magnitude faster than olivine under lab conditions. After six months, resolvable cation, alkalinity, and DIC export is observed only in monticellite-amended mesocosms. Leachate headspace pCO2 decreased to 20 ppm in the monticellite mesocosms, compared to minimums of 245-328 ppm in the basalt, olivine, and control systems, indicating that substantial carbonate alkalinity formed in monticellite systems. Despite the enhanced reactivity of monticellite feedstock, in the silica sand experiments only ~10% of the applied Ca and Mg were recovered in the leachate. This limited export suggests that rapid dissolution alone does not guarantee transmissive carbon removal. We propose that secondary precipitation, surface charge evolution, and/or transport limitations constrain export efficiency, while incomplete mineral–water contact and surface passivation may limit realized dissolution rates relative to laboratory expectations. These results demonstrate that even under controlled, high-signal conditions, rapid mineral dissolution does not translate directly to proportional carbon export, underscoring the need to resolve coupled geochemical and transport controls on EW performance.