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B14B-06 Quantifying CO₂ Drawdown into Model Basaltic Catchments: Implications for Enhanced Rock Weathering



Monday, 9 December 2024

17:00 - 17:10

150 A (Convention Center)

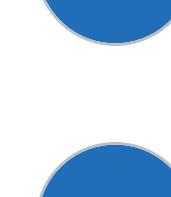
Abstract

Atmospheric CO_{2(g)} concentration is increasing at an unprecedented rate, resulting in a critical imbalance in the global carbon budget. To address this rise, carbon dioxide removal (CDR) technologies are expanding rapidly. A promising option is the incorporation of ground silicate rock into agricultural soils to promote enhanced rock weathering (ERW). However, when geochemical models and data from bench-scale weathering reactors are employed to quantify CO₂ consumption rates, assessments of ERW efficacy may be overestimated. This arises, in part, from idealized laboratory conditions in which dissolution kinetics are optimized, thus failing to fully capture the complexities of field-scale critical zone dynamics. A year-long study was conducted at the Landscape Evolution Observatory (LEO) at Biosphere 2, utilizing three replicated mesoscale hillslopes (each 330 m²) covered in basaltic tephra to quantify CO₂ consumption by weathering under controlled climatic conditions. The experiment consisted of three randomized 30-day irrigation events followed by progressively lengthened dry periods. Aqueous discharge samples were collected every 2 hours for major and trace element chemistry, and subsurface gas phase PCO₂ data were collected at 15-minute intervals across the hillslopes for the experimental duration. CDR was quantified using discharge HCO₃⁻ and non-hydrolyzing (base) cation concentrations and validated by comparison to thermodynamic calculations of HCO₃⁻ from subsurface variation in PCO₂ and total charge balance. The hillslopes exhibited clockwise hysteretic dilution curves for HCO₃⁻, decreasing in CO₂ uptake as subsurface saturation increased. CDR rates averaged 1.64 t CO₂ ha⁻¹ y⁻¹. To compare to previous studies, these rates were normalized to the specific surface area (SSA) of the rock media utilized. LEO basalt (SSA = 0.92 m² g⁻¹) sequesters 5.83 (± 0.49) × 10⁻¹⁴ mol m⁻² s⁻¹ of CO₂, while previous studies reported rates from 10⁻¹⁵ to 10⁻¹¹ mol m⁻² s⁻¹. Through the analysis of concentration-discharge relations for rock derived solutes and hillslope sensor data, we found that basalt CDR rates are impacted by rapid depletions in porewater PCO₂ upon infiltration of rainfall, variable soil saturation, the formation of preferential flow paths, and secondary mineral formation.

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