B14B-06 Quantifying CO_2 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 CO_2 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 m^2) covered in basaltic tephra to quantify CO_2 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 PCO_2 data were collected at 15-minute intervals across the hillslopes for the experimental duration. CDR was quantified using discharge HCO_3^- and non-hydrolyzing (base) cation concentrations and validated by comparison to thermodynamic calculations of HCO_3^- from subsurface variation in PCO_2 and total charge balance. The hillslopes exhibited clockwise hysteretic dilution curves for HCO_3^-, decreasing in CO_2 uptake as subsurface saturation increased. CDR rates averaged 1.64 t CO_2 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 m^2 g^{-1}) sequesters 5.83 (± 0.49) x 10^{-14} mol m^{-2} s^{-1} of CO_2, 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 PCO_2 upon infiltration of rainfall, variable soil saturation, the formation of preferential flow paths, and secondary mineral formation.

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