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Water and plant regulation of enhanced olivine weathering in red clover mesocosms

IRIS O. HOLZER[1], MALLIKA A. NOCCO[1] AND BENJAMIN Z. HOULTON[2]

[1]University of California, Davis

[2]Cornell University

Presenting Author: ioholzer@ucdavis.edu

Enhanced weathering – the purposeful introduction of crushed silicate rocks to agricultural soils – has been proposed for large-scale atmospheric CO_2 removal; however, the efficacy of this negative emission technology has not undergone extensive testing in real-world conditions. A key uncertainty concerns the ability of semi-arid agricultural lands to contribute to enhanced weathering, given their moisture limitations. Previous research has emphasized the core role of hydrology in regulating natural silicate weathering [1], and recent modeling work has suggested >2000 mm mean annual precipitation as the threshold above which major increases in carbon sequestration may be observed [2]. However, during a historically dry winter season (~225 mm local precipitation) in California, we observed a 2.2- to 2.7-fold increase in in-situ soil pore water bicarbonate alkalinity in response to olivine and meta-basalt additions in a multi-acre enhanced weathering trial [3]. To further elucidate this plant-water-weathering relationship, we explore enhanced weathering products across an irrigation gradient with and without red clover in pots amended with 10 wt. % finely crushed olivine (<74 μm). We hypothesize that increased water will lead to a non-linear increase in weathering, yielding more leached bicarbonate and rock-derived ions, including the release of nickel and chromium, and that plant presence will facilitate greater weathering. Here, we present results from the first months of red clover growth following olivine additions, including trends in carbon pools (bicarbonate alkalinity, total carbon, total inorganic carbon), pH, and trace metals across leachate, soil, and red clover biomass. We link these trends to results from our field trials and situate them in the broader context of silicate weathering controls and negative emissions technologies.

[1] Maher & Chamberlain (2014), *Science* 343, 1502-1504.

[2] Cipolla, Calabrese, Noto & Porporato (2021), *Advances in Water Resources* 154, 103949.

[3] Holzer, Nocco, Bingham, Goertzen & Houlton (2021), AGU Fall Meeting.