Immobile Trace Element Based Enhanced Rock Weathering Soil Measurements of Carbon Reductions in the US Midwest

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Abstract

The inorganic carbon cycle moves carbon dioxide from the atmosphere into Earth's subsurface, from soils to rivers and oceans. The interface at which carbon dioxide chemically transforms from gaseous to dissolved, aqueous species involves soils and the presence of surficial silicate minerals. The dissolution of these silicates releases base cations into the soil, inducing alkalinity changes that result in carbon capture. Enhanced rock weathering (ERW), a negative emission technology, has been proposed to accelerate this natural process by increasing the reactivity of these silicate rocks and through application of these feedstocks on terrestrial (and aquatic) systems.

This study addresses the need to directly measure *in-situ* weathering rates and quantify carbon fixation in fields. A four-year trial at the University of Illinois Urbana-Champaign has seen the annual application of a Blue Ridge meta-basalt at 50 t/ha on cropland consisting of maize/soybean and miscanthus. Monitoring, reporting, and verification (MRV) of carbon reductions was performed through direct soil-based measurements; the accumulation of immobile trace elements in the form of naturally present lanthanides in the basalt were monitored alongside the depletion of base cations from the top 30 cm topsoil. The flux of weathering product leaching into the deeper subsurface was further constrained by accounting for secondary mineral formation, plant uptake, and nitric "strong acid" weathering. Cumulative carbon removal associated with ERW application on agricultural land was estimated as 14.9 tCO_2/ha for maize/soy (2016-2020) and 25.7 tCO_2/ha for miscanthus (2018-2020) fields. Base cations (Ca, Mg) released by the rock were minimally affected by plant uptake (< 5%) and nitrate-based weathering (<2%). Thus, these weathering products successfully leached into the deeper subsurface as proxies of alkalinity fluxes at an efficiency of greater than 93%. This work demonstrates the importance of deploying field measurement-based MRV to provide constraints on *in-situ* weathering rates and carbon capture as induced by ERW on terrestrial systems.

Goldschmidt 2023