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The influence of basalt application on calcium and soil organic carbon dynamics at Energy Farm, Illinois: an advanced spectroscopic investigation

SARA MARTINENGO[1], MICHAEL W.I. SCHMIDT[1], DAVID J. BEERLING[2], AMANDA SPIVAK[3], SHARON E. BONE[4], ILSA B. KANTOLA[5], MATTHEW A MARCUS[6], KYOUNGLIM KANG[7] AND **MIKE C. ROWLEY**[1]

[1]University of Zurich
[2]Leverhulme Centre for Climate Change Mitigation, School of Biosciences, The University of Sheffield
[3]University of Georgia
[4]Forschungszentrum Juelich
[5]University of Illinois at Urbana-Champaign
[6]Lawrence Berkeley National Laboratory
[7]University of Minnesota

Enhanced rock weathering (ERW) has emerged as a promising negative emissions strategy in agricultural regions worldwide. The application of ERW can release substantial quantities of calcium (Ca) into soils; however, key uncertainties remain concerning the impacts of this added Ca on soil biogeochemical functioning and the overall effects of ERW on soil organic carbon (SOC).[1] Here, we integrate bulk biogeochemical analyses with synchrotron-based spectromicroscopy to investigate the response of Ca and SOC to ERW at a basalt application experiment, Energy Farm (IL, USA).[1,2]

The effects of 40–50 t ha^{-1} basalt application on the soils were characterised by measuring extractable metals, SOC content with elemental analysis, and SOC quality using diffuse reflectance infrared Fourier transform spectroscopy. Bulk soil measurements were complemented with μ-X-ray fluorescence mapping and μ-X-ray absorption near-edge structure (μ-XRF/μ-XANES) spectroscopy at the Ca K-edge. We used Ca K-edge μ-XRF/μ-XANES to investigate shifts in Ca content and speciation upon ERW treatment, identifying potential carbonate versus silicate-derived Ca pools, and assessing the spatial association of Ca with soil constituents. In parallel, we investigated samples with scanning transmission X-ray microscopy carbon near-edge X-ray absorption fine structure spectroscopy (STXM C NEXAFS) and scanning electron microscopy coupled to energy dispersive spectroscopy. STXM C NEXAFS enabled us to characterise SOC functional group chemistry, its distribution, co-location and preferential association with specific elements (iron-C/Ca-C), at the sub-micron scale.

Together, these datasets provide novel mechanistic insight into how ERW alters soil geochemistry, promotes secondary mineral formation, and influences organic carbon stabilisation through organo-mineral interactions. Our results demonstrate the value of combining bulk and spectromicroscopy to bridge scales and gain new mechanistic insight in ERW studies, improving our understanding of its long-term carbon sequestration potential in agricultural soils.

References

[1]Pihlap, E. *et al.,* Effects of rock amendment on soil physicochemical properties and organic carbon stabilization. iScience 2025, 28 (12), 114232. DOI: https://doi.org/10.1016/j.isci.2025.114232.

[2]Beerling, D. J. *et al.,* Transforming US agriculture for carbon removal with enhanced weathering. Nature 2025, 638 (8050), 425-434. DOI: https://doi.org/10.1038/s41586-024-08429-2.