

Quantifying carbon dioxide removal via enhanced rock weathering: insights from a long-term arable cropland field trial in the UK

XI CHEN¹, CHRISTINA S LARKIN^{1,2}, GRACE ANDREWS^{1,3}, CHRISTOPHER R. PEARCE⁴, FEIFEI DENG⁴, HEATHER GORING-HARFORD¹, DAVID J. BEERLING⁵ AND RACHAEL H. JAMES¹

¹University of Southampton

²InPlanet

³Hourglass Climate

⁴National Oceanography Centre Southampton

⁵School of Biosciences, University of Sheffield

Enhanced rock weathering (ERW) is a greenhouse gas removal technology that accelerates natural weathering processes via application of crushed silicate rocks to soils [1]. Weathering converts atmospheric CO₂ dissolved in rainwater into stable carbon species, such as dissolved inorganic carbon or pedogenic carbonates. Modelling suggests that ERW could deliver net CO₂ removal (CDR) of 6–30 MtCO₂ yr⁻¹ in the UK by 2050 [2]. However, there is an urgent need to validate these estimates through long-term field trials. Significant uncertainties also remain in accurately quantifying CDR via ERW, as no universally accepted method currently exists. Therefore, comparing different quantification methods using extensive geochemical data from field trials is essential to assess the true potential of ERW and to ensure robust monitoring, reporting, and verification of CO₂ removal.

Here, we present results from a large-scale field trial conducted on arable croplands in Norfolk, UK, over a six-year period (2019–2024). Crushed basalt powder was applied to two 0.5-hectare plots at a rate of 40 tonnes per hectare per year, while two adjacent plots remained untreated to serve as controls. By analysing soil water alkalinity, major cation concentrations, and soil inorganic carbon, we quantified CO₂ removal through increased alkalinity

generation and the formation of pedogenic carbonates. Extensive soil sampling and analysis following the final basalt application also enabled us to apply a soil-based mass balance approach (TiCAT, [3]) to quantify the weathering rates of the applied feedstocks. We compare CDR estimates derived from weathering rates, soil water analysis, and changes in cations within the soil exchangeable phase. Finally, we evaluate the uncertainties associated with different methods for quantifying CDR methodologies and assess the overall effectiveness of ERW as a viable strategy for atmospheric CO₂ removal.

[1] Beerling et al. (2020), *Nature* 583, 242–248.

[2] Kantzas E et al. (2022), *Nat. Geosci.* 15, 382–389.

[3] Reershemius T et al. (2023), *Environ. Sci. Technol.* 57, 19497–19507.