Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36848

Validation of Enhanced Rock Weathering Carbon Dioxide Removal Credits via Direct Soil Inorganic Carbon Quantification in Smallholder Farms, India

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Enhanced Rock Weathering (ERW) sequesters atmospheric CO_2 through silicate mineral dissolution, forming stable soil carbonates and dissolved bicarbonate, while improving soil fertility. We report results from Varaha ClimateAg's ERW deployment across 49 smallholder farms (119 ha) in Madhya Pradesh, India (May 2024–May 2025).

A total of 2,549 t of finely ground basalt (<150 µm), sourced as a mine byproduct waste, was manually applied at 22 t ha^{-1}. Mineralogical characterisation confirmed anorthite (56%), augite (29%), and olivine (15%), yielding a CDR_{max} of 7.6 t CO_2e ha^{-1}. Application occurred on mildly acidic clay loam Vertisols (black cotton/Regur soils).

CDR was quantified via direct soil inorganic carbon (SIC) measurement at 0–15 cm, rather than geochemical proxy models. Treatment farms showed a mean SIC increase of 0.015 g C 100 g^{-1} soil (Farms = 49); control farms showed a decrease of 0.014 g C 100 g^{-1} soil (Farms = 6). Control ΔSIC was conservatively set to zero in the gross carbon calculation. Oceanic bicarbonate export (up to 50% of total rock CDR capacity) was not credited in this monitoring period.

Net CDR was calculated from bulk density, sampling depth, and field area, with deductions for project lifecycle emissions, counterfactual feedstock weathering, riverine and marine loss factors under Puro.earth ERW Methodology 2022 V2.

After all deductions, 77.16 tCO_2 were verified and issued as CO_2 Removal Certificates (CORCs) for the first monitoring year. To contextualise these measurements within the long-term sequestration trajectory, SMEW model simulations (Bertagni et al., 2024) showed a progressive increase in soil pH over time and a first-year CDR potential of 20–43% of the ten-year cumulative capacity, depending upon the inherent spatial heterogeneity across smallholder farms. Additional results on soil pH, secondary mineral precipitation, PTE concentrations, crop yield, plant uptake, and FFZ-modelled far-field losses (riverine and ocean) will be presented; a DRN model adapted for Indian smallholder systems is currently under development at Varaha to refine these estimates.

This study shows third-party-validated issuance of ERW credits, representing one of the first deployments for smallholders in subtropical agricultural systems through direct accumulation of inorganic carbon.