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Enhanced weathering and mineralization: Negative emissions or CO_2 avoidance?

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Enhanced weathering and mineralization (EWM) has been proposed as a negative emissions technology (NET) with the potential to sequester gigatonnes of CO_2 at human-relevant timescales by spreading alkaline rock powders over large areas, including agricultural fields. However, carbon accounting during EWM has proven challenging, mainly due to the slow reaction of rock powders (e.g., basalt) and the complexity and heterogeneity of soil systems. This study aims to provide insights into carbon cycling during EWM and determine CO_2 removal rates when applying pulverized wollastonite ($CaSiO_3$; ~21 wt%) skarn to agricultural soils in Southern Ontario, Canada. Columns containing 5 kg of soil and wollastonite-amended soils (10 and 20 wt%) were exposed to wetting and drying cycles for 5 months in the laboratory. CO_2 fluxes were mainly controlled by soil respiration, which depended on water content. Dissolution of pre-existing calcite ($CaCO_3$) and wollastonite skarn minerals limited soil CO_2 emissions. Amended soils only captured atmospheric CO_2 immediately after wetting events, while control soil continuously emitted CO_2. The equivalent of 38–65% of soil CO_2 emissions was sequestered during the first 30 days due to wollastonite dissolution. However, only the 20 wt%-dossed plot continued to avoid CO_2 emissions after the initial reactivity of wollastonite. The slow weathering of wollastonite after the initial reactivity is likely attributed to surface passivation. CO_2 sequestration rates were up to 0.043–0.180 kg $CO_2/m^2/yr$ for amended soils. A field study using the same soil and amendments achieved rates of 1.5–2.9 kg $CO_2/m^2/yr$. Wollastonite applied on the field likely experienced less passivation than in laboratory experiments, thus, achieving greater CO_2 removal rates. The relatively high CO_2 concentrations in soil pore spaces (~0.1% and ~1% for lab and field experiments, respectively) and decreases in the $\delta^{13}C$ isotope values of carbonates indicate that the captured CO_2 originated from microbial respiration rather than removing CO_2 from the atmosphere. While this conclusion does not negate the potential for EWM to offset CO_2 emissions, it provides a further understanding of the carbon cycle, which is essential for long-term carbon accounting and monitoring.