Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5353

Assessing carbon balances through CO_2 mineralization and enhanced rock weathering rates using field-deployable leaching columns

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Pulverized rock, including certain mine wastes, can be used for enhanced rock weathering (ERW) [1], yet their reactivities and rates of CO_2 sequestration require individual assessment. As part of De Beers' Project CarbonVault,kimberlite residues from the Venetia, Voorspoed, and Gahcho Kué mines, as well as pulverized wollastonite skarn and olivine sand were characterized and assessed as feedstocks for ERW and CO_2 mineralization. Reactivity tests (2 days) were conducted using batch leaches (250 mg) inside a CO_2 incubator (30 C, 10% CO_2) to quantify the release of 1) Ca and Mg required for CO_2 mineralization, 2) metals of concern (e.g., Cr, Ni, Al), and 3) nutrients (e.g., K and P). The CO_2sequestration potential of each feedstock was based on the easily extractable Ca and Mg from non-carbonate sources [2]: 3–9 kg CO_2/t kimberlite residues, 12 kg CO_2/t pulverized wollastonite skarn, and 3 kg CO_2/t olivine sand. Concentrations of potentially harmful metals were all below the South African agricultural irrigation guidelines. Furthermore, kimberlite residues contained 0.24–0.35 wt.% P_2O_5 and 1.7–2.6 wt.% K_2O suggesting that these wastes could be beneficial as a soil amendment. Leaching columns (6 kg each) containing the same feedstocks are being used to determine carbon and water balances and assess weathering rates. Carbon is being tracked by measuring CO_2 fluxes at the surface and CO_2concentrations within the feedstocks, alkalinity and dissolved inorganic carbon of drainage waters, and total inorganic carbon of the solids. Negative CO_2 fluxes were observed in kimberlite residues and pulverize wollastonite during the first 50 days, while olivine exhibited values near zero. CO_2 concentrations within wollastonite and olivine columns have remained steady below laboratory concentrations at 250 and 278 ppm, respectively, while an increase from 122 to 240 ppm was measured in kimberlite residues indicating that diffusion of CO_2 into the column is outpacing its consumption. Leaching columns will be deployed outdoors to determine ERW rates and measure drainage chemistry under real-world conditions for future application in pilot studies.

[1] Mervine et al. (2018), Mineral. Petrol. 112 (Suppl 2), S755-765

[2] Paulo et al. (2021), Appl. Geochem. (in review)