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Considering Felsic, Intermediate and (Ultra)mafic Feedstocks for Biotic and Abiotic CO_2 Removal

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Carbon dioxide removal (CDR) is a necessary strategy to achieve net-negative emissions and stabilize Earth's climate. Storing CO_2 as alkalinity through silicate weathering is one of the most efficient forms of inorganic carbon storage. In this study, the CO_2 removal potential of six diverse mine tailings and ores, with felsic to ultramafic lithologies and diverse mineralogical compositions, were investigated (1) using HCl-leaching tests and (2) biotic and abiotic mineral dissolution experiments.

HCl leaching experiments were performed at a nominal pH of 5.60, 4.41, and 3.89 — corresponding to aqueous CO_2 concentrations of 0.04%, 10%, and 100%, respectively — and sampled at 1 week, 1 month and 3 months. Prior to leaching experiments, the feedstocks were characterized by quantitative X-ray diffraction (QXRD) to determine modal abundances of Mg- and Ca-bearing silicates. Modal mineralogy and dissolution rate constants were used to calculate the upper limits of H^+ neutralization associated with mineral dissolution, as well as Mg and Ca release at pH 5.60, 4.41, and 3.89. Mafic and ultramafic feedstocks released more Mg and Ca and approached calculated values, which reflect far-from-equilibrium upper limits of silicate dissolution, more closely than what was observed for felsic feedstocks. Cation release occurred on the same order of magnitude as CO_2-based experiments, indicating that simple HCl-dissolution experiments may be used as a proxy for more labour intensive H_2CO_3-leaching experiments.

In a second set of experiments, cyanobacteria were added to selected feedstocks in a modified BG-11 growth medium. Cyanobacterial mats were incubated for 6 months with either phlogopite (a mica), forsterite (olivine), or tailings from two mines containing up to 32 wt.% phlogopite and 22 wt.% forsterite, respectively. Each substrate was tested under biotic and abiotic conditions. In the biological experiments, cyanobacterial growth increased pH and nutrient cycling, and in some cases reduced silicate dissolution rates.