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Effects of basaltic glass and mineral composition on enhanced rock weathering (ERW) applications

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To achieve the goals of the Paris agreement, including limiting global warming to 1.5°C and CO_2 neutrality, a CO_2 draw down from the atmosphere is necessary. One promising method to remove CO_2 from the atmosphere is enhanced rock weathering ERW, utilizing natural weathering reactions of silicate rocks and minerals to form alkalinity (CO_2 solubility storage) and carbonates (CO_2 mineral storage).

We investigated natural weathering processes in Iceland, where most rocks are relatively young and of basaltic origin. Basaltic dust transported by storm events and tephra fall outs provide fine grained material with variable composition and high reactivity over a large water and land area. In our models we investigated how the chemical composition of basaltic glass, olivine minerals and wollastonite under oxidizing and reducing conditions affect potential ERW applications.

All models suggest volume negative reactions during the formation of secondary minerals at pH <7.5. After the dissolution of 0.25 cm³ of basaltic glass in 1 kg of rainwater under reduced conditions, 43% of initially added dissolved inorganic carbon (DIC) is in the form of H_2CO_3, 50% as HCO_3^- and 7% is mineralized as siderite. Under oxic conditions no siderite formation occurs. Overall, Mg-rich silicates are more efficient in promoting ERW than Fe-rich silicates. High Fe content provides similar results under anoxic conditions, while Fe-oxidation and formation of ferrihydrite leads to no alkalinity formation and no pH increase (pH 4.4) during Fe-olivine weathering. Pure minerals like Mg-olivine and wollastonite are more efficient in promoting ERW than basaltic glass, but are less common than basalt, making basalt, glassy or crystallin, a competitive material for ERW applications.