

# Role of Microbial Activity on the Kinetics of Carbon Mineralization in Basalts

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Anthropogenic combustion of fossil fuels has resulted in an increase of 50% in the atmospheric concentration of Carbon Dioxide (CO<sub>2</sub>) since the beginning of the Industrial Revolution. CO<sub>2</sub> and other greenhouse gases warm the atmosphere leading to a global climate instability in addition to their effects on the environment and human health. Currently, the most permanent solution includes the mineralization of CO<sub>2</sub> into mafic and/or ultramafic rocks (e.g., peridotites, serpentinites) which allows a thermodynamically stable storage. Indeed, CO<sub>2</sub> can react with these minerals producing Mg, Ca and Fe cations forming carbonated minerals, thus reproducing the natural biogeochemical carbon cycle of weathering and carbonate mineral precipitation. Although thermodynamically favored, carbonation reactions at laboratory scale proceed slowly unless reactants are ground to powder and held at elevated pressures and temperatures. Reaction rates are affected by a complex interplay between mineral dissolution, which increases permeability, and the precipitation of solids that decrease the reaction surface area. Microbially induced mineralization has the potential to produce reactive enzymes that can increase the pH creating a more favorable environment for carbonate ion formation. Yet, little is known about the extremophiles that can tolerate the subsurface pressure and temperature conditions required for efficient mineralization.

We conducted a set of experiments to determine the optimal conditions for carbonate mineralization, including the role of microbial activity, and changes in reactive surface area for subsurface carbon sequestration in conjunction with alteration of basaltic rocks. Experiments were run in an externally heated, cold-seal pressure vessel at a temperature and pressure range of 50-150°C and 500-800 bars by reacting Hawaiian basalts, forsterite, diopside, and augite seed crystals with carbonic acid solutions with and without thermophilic bacteria with run times between 24 hrs and 3 weeks. Experiments at 800 bar and 50-80°C did not produce any carbonate minerals regardless of the addition of a thermophilic bacteria or not. This result contradicts previous work on MgCO<sub>3</sub> precipitation at 65°C. While 500 bar and 80°C conditions did not trigger any carbonate mineralization in microbe-free runs, experiments run with thermophilic bacteria stabilized calcite crystals on diopside at 80°C in just 10 days.