Carbon Mineralization in Ultramafic Rocks: Insights from Flow-Through CT-Imaged Experiments

Saleh Almeshari

Abstract

The mineralization of CO_2 in ultramafic rocks provides a promising pathway for long-term carbon sequestration. This study investigates the dynamic evolution of porosity and permeability during CO_2-water-rock interactions using a flow-through experimental setup with time-lapse X-ray computed tomography (CT) imaging. Two serpentinized ultramafic rock samples were exposed to carbonated water at an average pore pressure of 2.6 MPa and 5 to 5.5 MPa confining pressure, simulating geologic conditions relevant for in-situ CO_2 mineralization over a period of one month. In the first experiment, permeability increased, by up to one order of magnitude, followed by a stabilization phase, suggesting competing effects of mineral dissolution and precipitation. The second ongoing experiment shows an initial significant decrease in permeability followed by a significant increase. CT imaging confirmed significant dissolution features, primarily in brucite-rich zones, with porosity changes remaining minor (<0.5% variation) for the first experiment. Post-experimental Raman spectroscopy, for the first experiment, identified hydrated form of magnesium carbonates (nesquehonite and dypingite) forming outside the sample, while secondary chrysotile precipitated within the rock matrix. No measurable hydrogen gas was detected. However, olivine crystals show evidence of reaction and minor secondary chrysotile is present. These findings highlight the complex interplay between dissolution-driven permeability enhancement and precipitation-induced flow restriction, with implications for optimizing in situ CO_2 mineralization strategies.

NICOLA TISATO