CO₂ Mineralization Potential in Ca-Bearing Altered Basalts

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Abstract
Carbon mineralization has been successful in fresh basalts. More common are basalts that have been hydrothermally altered over time by their interaction with warm waters. The most common Ca-bearing silicate alteration phase of basalts altered at temperatures less than 200 oC are zeolite phases. Zeolites are noted for the rapid exchange of their interstitial cations to the aqueous solution. This process suggests zeolite-bearing altered basalts may be a favorable target for subsurface mineral carbonation efforts. This study was designed to assess this possibility.

The dissolution rate and Ca release rate of the Ca-bearing zeolite have been measured in flow-through reactor at 60 oC and a function of pH. The reactor containing the ground stilbite has been placed inside a shaking incubator held at a constant rotational speed. The reacting fluid with varying pH levels is injected into the reactor using a peristaltic pump at a constant flow rate. Fluid samples were frequently collected to monitor the fluid pH and the elemental concentration analysis.

This mineral's BET-surface-area normalized dissolution rate at pH 2 and 60oC was determined at 14.3x10⁻⁹ mol m⁻² s⁻¹. Calcium was preferentially released at all pH at the beginning until it eventually attained a constant, semi-steady-state value, and this release rate is essentially independent of solution pH. Measured reaction rates have been used in reactive transport calculations to assess the efficiency of zeolite carbonation in the subsurface. Results of these calculations indicate that zeolite-bearing basalts strongly favor the fixation of injected CO₂ through the formation of calcite and aragonite.

Our study provides new insights into the feasibility and potential of zeolites as a host rock for CO₂ mineralization, which have been rarely studied in the literature. The results showed that zeolite stilbite could play a significant role in mineral carbonation and suggest the targeting of subsurface carbon mineral storage efforts into zeolite-bearing altered basaltic rocks.