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Modeling the temperature-dependent mineral dissolution and precipitation at a laboratory scale using andesite

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Carbon dioxide (CO_2) mineralization is one of the potential trapping mechanisms in geological CO_2 storage, ensuring a secure and stable phase. To transform CO_2 into carbonates, volcanic rocks containing highly reactive mafic minerals are considered as a target reservoir. The reactivities of these minerals have been investigated across a range of temperatures and pressures in laboratory and field pilot tests. Some observations indicate carbonates generated within a temperature range of 50 to 250°C and various clay minerals formed during the testing period. However, in multicomponent reaction system, types and compositions of secondary minerals were changed upon reaction progress due to interplay among minerals.

For predicting long-term mineral reactions, we apply geochemical models which have the advantage of capability to simulate mineral reactions under any temperature condition leveraging the thermodynamic database, despite uncertainties in temperature-dependent reaction kinetics. Although geochemical models that consider multi mineral reactions can predict temperature effect, verification of these model's capacity to represent the inherent reactivity of minerals and their reactivity interactions at a specific temperature remains insufficient.

Therefore, we verified the temperature functionality through comparison of the batch experimental data at two different temperature conditions, 75 and 150°C. Batch experiments were conducted using andesite to investigate the dissolution and transformation of initial minerals and formation of secondary minerals. Geochemical model was constructed at 150°C by calibrating surface area of each mineral based on experimental results. For validation purpose, calibrated model result where only temperature changed to 75°C was compared with experimental data (75°C). Regrettably, this model couldn't predict experimental results accurately. According to mineral surface observations, reacted initial minerals showed relatively similar dissolution behavior. However, generation of secondary minerals and alteration of clay seemed to differ due to reaction rates gap and temperature-dependent mineral reactivity. This suggested that temperature has a significant impact on mineral dissolution, precipitation and clay alteration in multicomponent mineral systems and it's worth measuring mineral reactivities at target temperature to forecast mineral reactions under in-situ condition using geochemical models. Additionally, by calibrating parameters using experimental data at the modeling temperature, geochemical model could yield reasonable predictions.