

Reaction rates of olivine carbonation obtained from synthetic fluid inclusion studies

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Ultramafic and mafic rocks (e.g. peridotites, serpentinites and basalts) are considered as possible targets for CO₂ sequestration via mineral carbonation. Natural carbonation reactions of these rocks occur in a wide range of geologic environments, from low to high P-T metamorphism, hydrothermal alteration of peridotites on the seafloor, to low T weathering at near-surface conditions, and play an important role in the carbon cycle. The determination of reaction kinetics and the environmental factors (physical, chemical and biological) that control mineralization are key to understand and model the reaction pathways between CO₂-bearing fluids and ultramafic host rocks.

In this study, we used a recently developed experimental approach [1] that uses synthetic fluid inclusions as micro-reactors to follow the reaction of olivine with CO₂ at various temperatures and CO₂ concentrations (50°C-100°C, 10-20 mol% CO₂), *in situ* and in real time. CO₂-bearing synthetic fluid inclusions of seawater composition were produced in gem quality natural olivine. To quantify the amount of CO₂ being consumed by the carbonation reaction, we monitor the decrease of CO₂ density within the inclusion using non-destructive Raman spectroscopy by measuring the Fermi diad splitting (the distance between the ν_+ and ν_- peaks of CO₂), which is CO₂ density (pressure) dependent.

Magnesite formation was observed within several hours of the beginning of the experiments at 100°C and most of the reactions occurred within two days. At 50°C, however, magnesite nucleation and precipitation required weeks to months to start, and the reaction rate was about ~2 orders of magnitude slower than in the experiments at 100°C. High-resolution Raman mapping and FIB-SEM measurements revealed the precipitation of a <100 nm thick Si-rich layer on the inclusion wall, and incorporation of Fe²⁺ into the magnesite.

[1] Lamadrid *et al.* (2017) *Nat. Commun.* **8**: 16107.