

Monitoring and quantifying fluid-mineral reactions using microreactors

HECTOR M LAMADRID¹ AND ESZTER SENDULA²

¹University of Missouri

²UiT – The Arctic University of Norway

Presenting Author: lamadridh@missouri.edu

Serpentinization and carbonation of ultramafic rocks and minerals play an important role in the deep volatile cycle on Earth due to the subduction of hydrothermally altered ultramafic rocks, transporting a significant amount of carbon and other volatiles to the deep mantle. Carbonation of ultramafic rocks is also considered a suitable option for long-term geological storage of CO₂. Understanding the effect of different PTX conditions on these reactions can contribute to making industrial CO₂ more economically feasible and advance our understanding of oceanic hydrothermal systems that are believed to be an essential place for early biological evolution.

Here we present different applications of a recently developed experimental technique that uses the combination of synthetic fluid inclusions as microreactors and various non-destructive analytical techniques that allows us to obtain kinetic data at various environmental conditions. The method has been successfully used to study the rates of both olivine and pyroxene serpentinization and olivine carbonation reactions at different temperatures, pressures, and fluid compositions. Serpentinization reaction rates were determined by measuring the increase in salinity of the aqueous fluid inside the fluid inclusion as H₂O was gradually removed from the solution and incorporated into the hydrous reaction products [1, 2]. Carbonation rates of olivine were determined at temperatures ranging from 50 to 200°C using Raman spectroscopy by monitoring the decrease of CO₂ density (indicated by the decrease in the so-called Fermi diad splitting of CO₂ peaks) in fluid inclusions as a proxy for the reaction progress [3]. The advantage of this method over more traditional experimental approaches is that it allows detailed micron-scale investigations of fluid-rock interactions and the determination of reaction products and reaction rates *in situ*, in real-time, with various fluid compositions at elevated temperatures (and pressures) in tens to hundreds of individual microreactors simultaneously. This technique provides new avenues to obtain detailed kinetic and thermodynamic information at different conditions relevant for natural processes and CCUS.

[1] Lamadrid et al. (2017) *Nature Communications*. 8, 16107.

[2] Lamadrid et al. (2021). *Geochimica et Cosmochimica Acta*, 292, 285-308

[3] Sendula et al. (2021) *Frontiers in Climate*. 3:722447.