Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29565

# Quantifying the rate of olivine dissolution in the $CO_2$-rich fluid phase for engineered mineral carbon storage.

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Engineered carbon dioxide mineralisation in basaltic rocks is emerging as a promising strategy for permanently trapping $CO_2$ as a thermodynamically stable solid. The overall efficiency of this process is critically dependent on the rate of mineral dissolution, which is considered the rate-limiting step in carbonation. While most investigations have focused on fluid-rock reactions in $CO_2$-saturated aqueous solutions, our work explores a novel reaction regime relevant to subsurface storage: water-saturated $CO_2$. In our study, we introduce an innovative flow-through experimental design that quantifies the dissolution kinetics of forsteritic olivine grains (a highly reactive basaltic mineral) under two contrasting conditions—$CO_2$-saturated water versus water-saturated liquid $CO_2$ flow. This approach provides the first direct quantitative comparison of reaction rates between these environments. Complementary micro-CT X-ray imaging is used to map fluid-rock interfacial areas within the olivine bead-pack, allowing for further constraints on the reaction kinetics within the multi-phase fluid system. Together, these techniques offer a robust toolset for assessing the impact of fluid phase composition on subsurface mineral carbonation processes. Our findings provide critical insights that could inform novel $CO_2$ injection methods and improve the overall design of engineered carbon sequestration systems. This work contributes to a deeper understanding of the geochemical processes underpinning subsurface mineral carbonation, paving the way for more effective long-term carbon storage solutions.