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Influence of Microstructure and Impurities on Mineral Reaction Rates Across Multiple Scales

Mineral reactivity is relevant in applied and fundamental geoscience related to energy production (e.g., nuclear waste disposal, oil/gas production, unconventional gas extraction or CO₂ sequestration) as minerals can potentially sequester harmful elements.

Here, I will present what influences mineral reactivity at the mineral-water interface in three studies ranging from the nanoscale to macroscale. At the nanoscale, the effect of strontium on barite growth rates was studied using in-situ hydrothermal atomic force microscopy in combination with high-resolution ex-situ chemical imaging techniques allowing to simultaneously monitor changes in growth rate and cation incorporation. In conjunction with the growth mechanism, also the incorporation mechanism of the impurity shifts. I will discuss the interpretation of my results based on process-based kinetic crystal growth models (Weber et al., 2018).

At the microscale, I will discuss findings on the uptake of radium by barite which allowed the thermodynamic description of the uptake mechanism via solid solution formation. This work provided the comprehensive description of the uptake mechanism on the molecular level utilizing high-resolution electron microscopy techniques (Weber et al., 2016, 2017). These findings are in conjunction with X-ray/neutron scattering studies on the influence of reactivity on the replacement of limestones by fluorite and dolomite. By varying starting porosities and reactivities, I demonstrated the control of microstructure on replacement speed (Weber et al., 2019).