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The relevance and the determination of mineral dissolution kinetics in high pressure experiments and their use in numerical models

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The numerical modeling of geochemical reactions following a CO2 injection into deep aquifers requires the incorporation of certain mineral dissolution and precipitation reaction kinetics. This is the case when the time scale of the dissolution reaction is similar or slower than the time scale of the transport processes the numerical model. As soon as the reaction's time scale is significantly faster than the transport time scale, the kinetic limitation of the reaction can be neglected and a reaction processing in thermodynamic equilibrium can be assumed in the numerical model.
It is well known that the determination of mineral dissolution reactions is highly dependent on the laboratory setup and variations of magnitudes in the kinetic values may occur. To overcome disadvantages evolving from the application of batch experiments, our reactions are performed in a flow-through column system offering a more realistic approach for the determination of reaction kinetic. However, their performance is also more difficult and more susceptible to technical errors, and some desired setups my not be realized sufficiently easy. Within the CO2-MoPa project we have developed and verified a column system to perform mineral dissolution reactions at CO2 pressures up to 100 bars and 60°C. The first application of this system is the determination of the calcite dissolution kinetics at elevated CO2 partial pressures. The results of this test will be compared with results from tests using other laboratory setups (i.e. batch systems) and will be interpreted in the course of sensitivity analyses in numerical transport models.
A possible conclusion will be that for example calcite dissolution occurs quickly enough with respect to the considered time scale, that it can be assumed to proceed in a thermodynamic equilibrium. The numerical model could therefore be simplified for the chemical reactions of the mineral calcite and the question of which rate law, rate constants, or specific surface area should be used can be neglected. For other minerals like feldspars, this simplification will not be acceptable, and their reaction kinetics will have to be incorporated into the numerical models.