



Modelling couplings between reaction, fluid flow and deformation: Kinetics

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Mineral assemblages out of equilibrium are commonly found in metamorphic rocks testifying of the critical role of kinetics for metamorphic reactions. As experimentally determined reaction rates in fluid-saturated systems generally indicate complete reaction in less than several years, i.e. several orders of magnitude faster than field-based estimates, metamorphic reaction kinetics are generally thought to be controlled by transport rather than by processes at the mineral surface. However, some geological processes like earthquakes or slow-slip events have shorter characteristic timescales, and transport processes can be intimately related to mineral surface processes. Therefore, it is important to take into account the kinetics of mineral surface processes for modelling fluid/rock interactions. Here, a model coupling reaction, fluid flow and deformation was improved by introducing a delay in the achievement of equilibrium. The classical formalism for dissolution/precipitation reactions was used to consider the influence of the distance from equilibrium and of temperature on the reaction rate, and a dependence on porosity was introduced to model evolution of reacting surface area during reaction. The fitting of experimental data for three reactions typically occurring in metamorphic systems (serpentine dehydration, muscovite dehydration and calcite decarbonation) indicates a systematic faster kinetics close from equilibrium on the dehydration side than on the hydration side. This effect is amplified through the porosity term in the reaction rate since porosity is formed during dehydration. Numerical modelling indicates that this difference in reaction rate close from equilibrium plays a key role in microtextures formation. The developed model can be used in a wide variety of geological systems where couplings between reaction, deformation and fluid flow have to be considered.