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Experimental study of the mineral evolution and associated mass transport under thermal gradient. Application to the thermal stability of low-temperature phyllosilicates

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Geothermal systems are characterised by intense circulations of fluids and strong thermal gradients. In such systems far from equilibrium, dissolution-transport-crystallisation processes are very effective and control the evolution of the permeability and mineralogy of natural rocks. These processes are also of fundamental importance in a variety of managed processes such as nuclear waste disposal or in the context of geothermy. Modelling fluid-rock interactions and mass transport in systems under a thermal gradient is however a difficult task, as it involves a number of coupled processes and minerals such as clays, with poorly constrained thermodynamic properties.
A series of experiments were conducted under strong temperature gradients, which provide constrains on the magnitude of mass transport and chemical segregation controlled by the temperature gradients. The experiments also provide information on the relative stability of low-temperature phases for which bracketing of equilibrium reactions is hardly possible because of sluggish kinetics. The mineral sequences observed in experiments conducted in the simplified systems or using natural rocks as starting material 1) are in fair agreement with the mineral evolutions with temperature observed in active geothermal systems, 2) provide information about the relative stability and composition-temperature relations among e.g. smectite, illite, kaolinite/pyrophyllite, mica and chlorite, and 3) can be interpreted assuming the achievement of local equilibrium. The experimental results also suggest that the higher temperature occurrence of smectite and mixed-layer in geothermal systems than in the context of burial diagenesis is not necessarily an evidence of their metastable nature, but it possibly reflects different conditions of water availability and/or activity.