Pore Scale Models for Non-Isothermal Mineral Precipitation and Dissolution

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Abstract: Geochemistry has a substantial impact in exploiting geothermal systems. In a geothermal reservoir, the injected water and the in-situ brine have different temperatures and chemical compositions and flow through highly heterogeneous regions. As a consequence of flow and geochemical reactions, composition of reservoir fluids as well as reservoir rock properties will develop dynamically with time. Minerals dissolving and precipitating onto the reservoir matrix can change the porosity and hence the permeability of the system substantially. Mineral solubility can change by the cooling of the rock, or by the different ion content in the in-situ brine and in the injected water. The interaction between altering temperature, solute transport with mineral dissolution and precipitation, and fluid flow is highly coupled and challenging to model appropriately as the relevant physical processes jointly affect each other.

Processes occurring at the pore scale determines the changes in porosity. The pore geometry affects the reaction rates for the dissolution and precipitation processes as the reactive surface area is changed, and the resulting permeability depends on the pore geometry. To achieve expressions for reaction rates and permeability that depend on the pore scale effects, we start with a model at the pore scale and derive the Darcy scale model by homogenization.

In geothermal reservoirs where the reservoir rock is highly fractured while the matrix has otherwise low permeability, the fluid flow is mainly through the fractures. For a porous medium of this kind, a pore scale model of a thin strip is sufficient to describe the relevant pore scale processes. If the matrix permeability is larger, pore scale effects from the matrix should be taken into account. To describe the processes inside the matrix, a pore scale model consisting of circular grains can be considered.

Due to the strong injection of water into a geothermal reservoir, the solute and heat transport will be convection dominated, meaning that the respective Péclet numbers will be large. This phenomena may be honored in the pore scale model by introducing pore size dependent Péclet numbers, leading to possible Taylor dispersion.

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