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A mixed-dimensional model for reactive transport: modeling and computational aspects

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In porous media the presence of fractures has a substantial impact on flow: it tends to focus along highly permeable fractures, which can create "shortcuts" in the domain, or, in the case of cemented fractures, we have low permeability barriers in the domain. In the context of reactive transport fractures can be responsible for fast transport of fluid with different chemical composition with respect to the surrounding matrix: this occurs for instance in geothermal reservoirs where water with different salinity, solutes and temperature is injected in the subsurface. These differences in composition and temperature can trigger transformations such as mineral precipitation, dissolution or replacement, with an impact on porosity and fracture aperture. We propose a model to account explicitly for the presence of fractures and their impact on the flow, transport and reactions. We rely on a geometrically reduced model where fractures can be represented by surfaces or lines coupled with the surrounding porous medium.

The equations describing flow and transport are thus a coupled system of mixed-dimensional PDEs approximated by means of lowest order mixed finite elements. We will consider a simple model for mineral precipitation and dissolution. Being the problem coupled and non-linear, several numerical strategies are investigated for the computation of the solution to obtain a stable and convergent approach. For example, to avoid the occurrence of negative concentrations and oscillations we adopt an event location strategy to detect the discontinuity in the ODE describing the reaction part, which might be split from advection and diffusion by means of a first-order operator splitting.

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