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Numerical Modeling and Simulation of Geochemical Reactions in Fractured Carbonate Formations Induced by Seawater Injection

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Seawater injection is a common method applied in offshore reservoirs although it does trigger a series of complex geochemical water-rock interactions resulting in the formation of scale minerals. Investigating the evolution of porosity due to mineral dissolution/precipitation and the associated change of transport parameters are high on the agenda for a successful waterflooding of offshore oilfields.

In this study, a new numerical model is presented and applied to quantitatively calculate the spatial and temporal development of chemical reactions among rocks and seawater-formation water mixtures in fractured carbonate formations. Our model, which couples the Stokes-Brinkman equation and reactive transport equations, is capable to investigate the coupled process of fluid flow, advective-diffusive transport of solutes and kinetically controlled precipitation/dissolution reactions. In addition, compared to Darcy's equation, the Stokes-Brinkman equation is a unified approach for modeling fluid flow in both porous media and free flow regions, which allows to investigate the influence of fractures on macroscopic (continuum scale) transport. We have developed and implemented a numerical procedure, which solves the Stokes-Brinkman equation and the reactive transport equations in a sequential fashion. In the proposed numerical procedure, the Stokes-Brinkman equation is solved by a staggered grid finite difference method and the reactive transport equations are solved by an implicit control volume finite difference method. Our model is a useful tool to identify the type of scale minerals and to quantify their distribution in space and time. It has the unique capability to predict spatial and temporal variations in porosity and permeability due to mineral precipitation/dissolution induced by seawater injection as the three-dimensional model. Specific geochemical and hydraulic conditions in reservoirs can be investigated during different modeling scenarios. The modeling results can help to optimize the water injection strategy and consequently avoid the worst case of scaling.