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Hydrogeochemical and mineral heterogeneity controls on the clogging of porous media

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In low permeability rocks, fractures constitute the main flow pathway. Reactive fluids have the ability to modify the fracture network, influencing the porous media properties [1,2]. In particular, the subsequent reorganisation of flow and transport during precipitation reactions remains challenging to predict. Several geo-engineering applications (e.g. CO_2 sequestration, geothermy or Uranium ISR), for which the injectivity or recovery of fluids, are of prime importance, can be severely impeded by precipitation reactions. Given the wide range of hydrogeochemical settings, the complexity and heterogeneity of the pore structure in geological media, it is illusory to obtain a representative description of the evolution of the porous media properties. Despite the significant advances in pore scale modelling, their use on engineering scales remain limited. Hence, continuum approaches can constitute a robust predictive tool for several applications, provided they rely on an accurate description of the evolution of the porous media properties. We present the results of a coupled experimental and numerical study of the precipitation of calcite within heterogeneous, anisotropic fractured porous media. Samples were subject to the injection of supersaturated calcite fluids at different flowrates. X-ray micro-tomography images [3] of the samples reveal that the distribution of calcite precipitation is highly dependent on the fracture geometry, the growth substrate and the local hydrogeochemical conditions. These experimental results were reproduced (Ca breakthrough concentrations, calcite precipitation patterns and time before clogging) by calibrated reactive transport simulations using HYTEC [4]. These simulations include the feedback between porosity and permeability, the ability for calcite to precipitate on different substrates with different oversaturation factors. Additionally, the effect of fracture geometry, anisotropy, substrate distribution and hydrogeochemical conditions (through the Péclet and Damköhler numbers) were investigated within numerical fractures (Figure 1). Results of this study show the intricate coupling between the anisotropy (and its evolution), the mineral substrate distribution and the reorganisation of flow and highlight the limits of the representative elementary volume description for continuum approaches.

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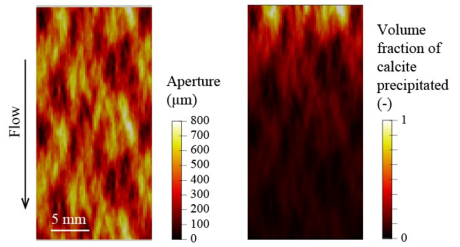

Figure 1: (left) Initial fracture geometry and (right) calcite volume fraction precipitated in a rough fracture, showing preferential precipitation in the areas (1) near the inlet, where the supersaturation is the highest, and (2) in the main flowpaths, where the supply of reactants is higher.