Pore-scale modeling of pore-clogging by aggregation of particles

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Résumé

The injection of cold water into the subsurface to recharge the aquifer during the exploitation of geothermal resources mobilizes fine particles (colloids) that can detach, precipitate, or even deposit irreversibly clogging the porous formation in the vicinity of the well. These processes very often lead to a reduction in the operating time of the wells and additional operating costs are required in order to separate and remobilize the aggregates thus formed. At the reservoir scale, these processes are described using CFT (Colloidal Filtration Theory) and the Kozeny-Carman relationship. Such models, however, rely on heuristic parameters that have to be tuned to fit with experimental data, which limits their predictive capabilities. In this work, we use a novel CFD-DEM (Computational Fluid Dynamics - Discrete Element Method) approach for simulating the transport of particles at the pore-scale. Our model includes both resolved and unresolved coupling, meaning that we are limited by the particle-to-cell aspect ratio. The model relies on a four-way CFD-DEM coupling that includes hydro-mechanical interactions (e.g. collision, drag, buoyancy, gravity) and electro-chemical interactions (e.g. van der Waals attraction, electrostatic double layer repulsion commonly known as DLVO (Derjaguin-Landau-Verwey-Overbeek) forces and JKR (Johnson-Kendall-Roberts) adhesive contact) between the particles, the fluid, and the porous formation. The model, implemented within the open-source platform OpenFOAM, has been validated in cases for which reference solutions exist. It is used to investigate the deposition/remobilization kinetics and the permeability/porosity relationship at the pore-scale under various flow, particle size, concentration, pH, and salinity conditions. These new insights into the transport and deposition of colloids in porous media will guide the development of reservoir-scale models rooted in elementary physical principles.

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