Microfluidic investigation of the impact of colloidal transport on two-phase flow in geological porous media.

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Résumé

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Colloidal particles show potential in facilitating the movement and extraction of trapped contaminants from porous media, which has implications for various energy and water-related applications. To achieve this target, most studies focus on optimizing surface activity of colloidal particles to freely move along the solid matrix with less depositions as possible until they arrive, and bind at the immiscible fluid interface (1). However, few studies focus on how particle depositions (2) and pore-clogging leading to the redirection of local streamlines aid in mobilizing immiscible fluids. In order to assess their impact on the enhanced recovery of trapped contaminants, it is necessary to downscale to the pore scale (order of micrometers). Therefore, an experimental approach using microfluidics combined with CFD simulations has been deployed. These phenomena are directly visualized and tracked using microfluidic devices that mimic the porous structure of rocks. In this study, we will investigate particle depositions, pore-clogging and transport of colloidal particles in both saturated and un-saturated porous medium in microfluidic chips.

We find that during the injection of the supsension in a simplified systems made of a single-grain collector, most particles are deposited mainly in the front part of the grain facing the flow at higher hydrodynamic forces and salt concentrations. However, at lower salt concentrations and Péclet numbers we find more depositions downstream the grain. In complex saturated porous media, we integrate the observed patterns of deposition, the distribution of clogged pores, and the measured variations in flow rate with a digital twin relying on the Darcy-Brinkman-Stokes model. This approach accounts for the actual pore-clogging distribution observed in experiments. It allows us to investigate the variation in the local velocity

*Intervenant

profiles at different stage of the medium clogging, and establish the relationship between K() (permeability) and the experimental conditions. Similar workflow and tools are used in unsaturated condition to to find the optimal physical, electrical and hydrodynamic parameters leading to the maximum recovery of trapped contaminants.

References:
Hendraningrat et al. (2013), Schneider et al. (2021).