Contribution ID: **176** Type: **Oral Presentation**

Colloidal transport and clogging of a rock-like porous medium: effects of concentration, hydrodynamic stresses and geometry on particle deposition.

Wednesday, 24 May 2023 09:45 (15 minutes)

Geothermal fluids are often loaded with mineral and organic particles in suspension, various additives, microorganisms, heavy metals, etc. These compounds result in significant problems on the sustainability of production and the maintenance of injectivity in the short term and, in the long term, on the stability and continuity of the resource. As the migration and deposit of fines concern numerous industrial applications, the physics of colloidal particles in porous media has been widely studied. Historically, most of experimental studies were based on macroscopic measurements, mostly with corefloods. Since the media (rocks) are opaque, there is currently very little experimental data describing the mechanisms involved at the pore scale. Lately, interesting results on colloidal deposition and permeability damage have been obtained using microfluidic devices (Bacchin et al., 2014; Delouche et al., 2020, 2022; Dincau et al., 2022; Duchêne et al., 2020; Kim et al., 2022). However, experiments are often conducted on simplified pore-network micromodel or microchannels with or without constrictions, that are not reproducing real porous media. Thus, in this work we focus on micromodels representative of a rock-like porous medium from the intrinsic properties point of view (permeability, porosity, geometry of the pores…), to describe the characteristics of permeability damage processes under conditions similar to those of geothermal energy (high flow rates, high permeability …).

The use of microfluidics, which allows direct visualization of the phenomena involved at the pore scale and their quantification through advanced optical methods, was coupled to other important measurements such as pressure.
More particularly, two experimental set-ups have been developed and used, based on different visualization techniques: optical imaging and laser-induced fluorescence (LIF) imaging. Both systems have been designed to integrate the following tools: particle concentration monitoring, pressure drop kinetic, direct visualization of the micromodel in which the fluids are injected. The use of these two technics allows us to access complementary information at various scales. With fluorescence, we obtain the concentration field that includes the depth of the micromodel, whereas with classical optical imaging we obtain a better resolution of the images and therefore a better understanding of the mechanisms that result from the interaction between hydrodynamics (velocity, pore geometry, …) and DLVO forces (particle-particle and particle-surface).
Indeed, this experimental study allowed to establish links between the velocity field and the characteristics of the deposit; several "types"of deposits related to the geometry of the porous medium have been highlighted. Clogging of pore-throats is a key mechanism for reducing permeability, but pore bodies can also be critical deposition zones under certain conditions and stages of injection. It has been also shown that, as the concentration of the suspension increases, the kinetics of permeability reduction is delayed, and the clogging mechanisms as well as the type of deposit evolve. Finally, at very high concentrations, significant hydrodynamic effects have been observed.

Participation

In-Person

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Session Classification: MS11

Track Classification: (MS11) Microfluidics and nanofluidics in porous systems