Transport of nanoparticles in confined geometry

Controlling fluid flow in a porous medium may be critical for some industries. For example, in enhanced oil recovery, water is commonly injected into the rock to force the expulsion of captive oil. After this step, as much as 70% of the oil volume is commonly stuck within the rock. In order to improve extraction yields, polymers and solid particles are injected with water. By modifying the boundary conditions at the interfaces for polymers or by obstructing the most permeable part of the network for particles, captive oil can be remobilized and pushed out of the rock by the flow of water as depicted in the figure below.

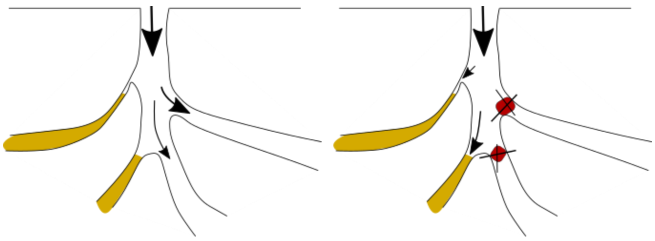

Figure 1 : The small channels of high permeability in which oil is stuck (left) are remobilized by blocking the large channels of low permeability using particles (right).

However, this process is effective only if a large part of the well is actually reached by the particles or the polymers: the distance that these nanoelements can travel before being adsorbed on the walls is thus a critical parameter. A better understanding of these injection phenomena is crucial in this period of energy transition: by optimizing the extraction yields of the wells already in operation, one limits both the ecological footprint associated with the injection of polymer or particles into the soil and the financial pressure on the new fields of virgin hydrocarbons.

In order to meet these objectives, we propose to quantify the range of action of nanoparticles injected into microchannels by attempting to answer the following questions: How far can nanoparticles be transported before interacting with the walls? Is the nature of the flow (flow rate, pressure differential or other) important? How does the nature of the interaction between particles and walls and the nature of the wall affect this distance? How is the transport distance changed if nanoparticles are already adsorbed?

These problems will be addressed experimentally in simple 2D devices made out of different materials with various surface and mechanical properties (uniaxial, axisymmetric or wedge) realized using microfabrication techniques. We will place ourselves within a limit where the ratio between particle size and channel height is typically in the range of 5 to 10. The fluid - seeded with particles - will be flow rate or pressure driven. Pulsatile flows will also be considered to test whether they can peel off and displace already adsorbed particles. The results obtained will be analyzed in the framework of the diphasic fluid mechanics, including long range forces in order to model the particle/ wall interactions and surface tension effects. Numerical simulations (Comsol multiphysics) might also be carried out in order to validate experimental results.

The work will be carried out at LiPhy (Interdisciplinary Laboratory of Physics) from Grenoble Alpes University(UGA) and CNRS in collaboration with PERL laboratory (Lacq Research and Studies Center) and *can be extended to a thesis (CIFRE funding with TOTAL).*

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