
Droplets flow in a micromodel porous network

Elliot Speirs^{*1}, Camille Brigodiot¹, Nicolas Pannacci¹, Maxime Moreaud¹, and Marie-Caroline Jullien²

¹Earth Sciences and Environmental Technologies Division – IFPEN, IFP Energies nouvelles, 1 et 4 avenue de Bois-Préau, 92852 Reuil-Malmaison, France. – France

²Institut de Physique de Rennes – Université de Rennes, Centre National de la Recherche Scientifique – France

Résumé

Multiphase flow in porous media is encountered in many natural phenomena and industrial processes, such as geologic CO₂ sequestration, water infiltration into soil, and particle filtration. Numerous questions are of interest on this topic, such as to the effect of the confinement and the geometry of the porous medium on the transport of dispersions. We address these questions experimentally using controlled transparent 2D porous media: micromodels. We used polydimethylsiloxane (PDMS) micromodels consisting of regular networks of vertical cylindrical posts (50 μm in diameter), at the centres of which we injected water droplets in a continuous oil phase (radial flow). In such a geometry of the porous medium, the alignment of the posts, i.e. the tortuosity of the network, varies angularly in a periodic manner. We show that this tortuosity plays a key role in droplet transport by generating reproducible preferential paths. We characterize the droplet flow varying the geometrical configuration of the posts, injection capillary number, droplet size, and droplet concentration. We observe that at low capillary numbers, the droplet transport is homogeneous (isotropic). By increasing the capillary number, droplets initially follow the least tortuous paths before transitioning to a stable flow regime whereby droplets flow in the most tortuous paths. The axes of symmetry observed at a centimetre scale in the flow are found to be the same as the ones at the microscale of the periodic patterns. Through large-scale droplet tracking, we demonstrate the influence of the geometric tortuosity of the media on the resulting droplet flow patterns and the counter-intuitive responses that can arise. We also report observations on droplet rupture and preliminary results on the effect of patterns of wettability in the porous medium.

*Intervenant