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Effect of Pore-Scale Wettability Distribution Patterns on Fluid Connectivity

Friday, 4 June 2021 15:30 (15 minutes)

Multiphase flow is ubiquitous in natural porous media, synthetic membranes like fuel cells and microfluidics. The wetting state of these materials is one of the key controlling parameters of fluid distribution and it dictates trapping behaviour of each phase. At pore-scale, contact angle measurement by in-situ imaging of phase interfaces can explain phase trapping [1]. However, the spatial distribution of these micro-scale contact angles govern average trapping and flow dynamics at the continuum scale. This is especially critical for porous media with heterogeneous mineral distributions where significant changes in surface energy exist in different flow paths. The main challenge to upscale pore-scale wettability distributions to Darcy scale is the non-uniqueness of the solutions (e.g. capillary and relative permeability curves) because of infinite pore size and wettability distribution combinations. Defining a parameter to classify different spatial distributions can be a step toward reducing the degree of freedom for possible dynamics.

Accordingly, this work aims to understand the effect of different spatial wettability distributions on phase trapping and fluid connectivity patterns. We have used a set of spherical glass bead packs to isolate the effect of pore size distribution from wettability distribution on phase trapping by altering packing methods of silanized glass beads. The produced glass bead packs with different wettability distributions represent common wettabilities of rock types reported in the literature [2–4]. To reduce the uncertainty of measuring contact angles by image analysis two approaches were taken, namely selecting glass beads with negligible surface roughness values (MoSci Class VI, 250µm) and avoiding very low contact angles. The surface roughness of the glass bead samples was measured with Alicona Surface Profilometer. The measured values (arithmetical mean height Sa=100-200nm) are below the effective pixel size of the Nikon MicroCT XT H 225 rig (3µm) used for in-situ imaging. Moreover, the glass beads were treated such that contact angles are above 20º to avoid errors involved with small contact angle measurements. The flow tests through the packed glass beads start by injecting 20 pore volumes (PV) of doped brine to displace air to ensure no further changes in trapped phase distribution during microCT imaging. This was followed by air (20PV) and another water injection period (20 PV each).

The images of fluid distribution in the glass bead packs were analysed with a programmed script for Avizo visualization software and the spatial trapping patterns and quantities are discussed in terms of wetting correlation length ξ. Generally, we observed higher trapping but more uniformly dispersed non-wetting phase for higher wettability heterogeneity at pore-scale (lower ξ). However, ξ values did not fully explain trapping distribution when they approached Darcy scale lengths. The result of this work is a step toward defining a parameter to classify different spatial wettability distributions.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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[3] Singh K, Bijeljic B, Blunt MJ. Imaging of oil layers, curvature and contact angle in a mixed-wet and a water-wet carbonate rock. Water Resour Res 2016;52:1716–28. doi:10.1002/2015WR018072.
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