Contribution ID: **351** Type: **Poster + 3 Minute Pitch**

Determining the Impact of Mineral Composition and Roughness in Multiphase Flow through Fractures

Monday, 14 May 2018 15:40 (2 minutes)

Fractures are ubiquitous in the subsurface, and provide primary pathways for fluids traveling underground. The roughness and wettability of the fractures in the subsurface cause a major impact on multiphase flow behavior. Nevertheless, published analytical solutions for multiphase flow properties of fractures fail to account for the complexity of the surface mineralogy heterogeneity and its effect on production from fractured reservoirs. Since analytical solutions for fracture surfaces with heterogeneous wetting properties are very limited, we propose a direct simulation approach. The purpose of this work is to correlate the reduction of relative permeability in multiphase flow through fractures with different mineralogy and surface roughness.

Utilizing the Shan-Chen multiphase model of the lattice-Boltzmann method (LBM) we are able to simulate oil and water displacement in 3D fractures. Simulation domains were extracted from 3D micro-CT scans and digitally synthesized. A surface interaction parameter is adjusted to mimic the time-dependent microscale wettability of the different minerals present in fractures. We then map the mineralogy of surfaces obtained by SEM imaging and integrate them with contact angle measurements on individual minerals to provide input for the simulations. We also account for the possible change in contact angle over time due to wettability alteration. These simulations were carried out at the Texas Advanced Computing Center.
In this work, we quantify the effect of different mineralogy arrangements and wetting states on the relative permeability. From these measurements, we derive correlations based on fracture aperture, surface roughness, and the spatial distribution of minerals.

References

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Session Classification: Parallel 2-H

Track Classification: MS 2.01: Pore-Scale Modeling and Experiments on Multiphase Flow in Porous Media