Contribution ID: **663** Type: **Oral Presentation**

Drainage pore-invasion patterns in porous media: role of interfacial dynamics

Wednesday, 24 May 2023 10:00 (15 minutes)

Immiscible two-phase flow through porous media is composed of a series of pore invasions; however, the consequences of pore-scale processes on macroscopic fluid front behavior remain to be clarified. In this work, we perform an analytical and experimental investigation of front behavior and pore invasions dynamics during drainage for various viscosity ratios and capillary numbers. We use a microfluidic setup made of a pore-doublet geometry to isolate and explore pore-invasion mechanisms. We apply a model based on volume-averaged Navier–Stokes equations to capture interface dynamics. Different invasion mechanisms are characterized and correlated with front behavior for various flow conditions. For the viscous flow regime a succession of continuous pore invasions is observed, leaving a thick layer of wetting phase behind at pore curvatures. Abrupt interfacial jumps, followed by an apparent stagnant condition of the interface, are observed for the capillary flow regime. We identified a new regime, called crossover flow regime, for which pore invasion shows a mixed behavior between capillary and viscous dominated regimes. The global front behavior is predicted based on the numerical simulation and experimental results for all flow regimes.

Participation

In-Person

References

M. Mansouri-Boroujeni, C. Soulaine, M. Azaroual, S. Roman, How interfacial dynamics controls drainage pore-invasion patterns in porous media, Advances in Water Resources, 171: 104453, 2023

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Primary authors: Dr MANSOURI-BOROUJENI, Mahdi (CNRS, France); Dr SOULAINE, Cyprien (CNRS, France); Dr AZAROUAL, Mohamed (BRGM (French Geological Survey), Orléans, France,); Dr ROMAN, Sophie (Université d'Orléans, France)

Presenter: Dr ROMAN, Sophie (Université d'Orléans, France)

Session Classification: MS06-B

Track Classification: (MS06-B) Interfacial phenomena across scales