Foam Trapping and Foam Mobility in a Model Fracture

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Flux Regression Neural Networks for Backbone Identification in Discrete Fracture Networks

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Characterization of flow and transport through fractured media in the subsurface is a crucial issue in many engineering applications, e.g. oil and gas extraction or water resources preservation. All these applications require models that can accurately simulate flow through networks of subsurface fractures.
Exact position, size, orientation and hydrogeological properties of all fractures (located hundreds of meters below the ground) can't be determined and therefore statistical representations of fracture networks are introduced and used to simulate flow and transport through fractured media. In this framework the Discrete Fracture Network (DFN) model is largely used.
Due to the probabilistic nature of DFNs, flow and transport characterization in a real fractured medium usually requires a statistical analysis of thousands of DFN generations and simulations. Therefore, in order to speed up simulation processes and to build alternative model reduction methods, for flux regression problems in a DFN it is worth considering the application of machine learning (ML) techniques, and more specifically Neural Networks (NNs) 1. On the other hand, for transport problems in DFNs, one possible technique for speeding up simulations consists in the identification of a backbone of fractures where most transport occurs; also in this cases, due to the expensive computational costs of particle tracking simulations, ML based and graph based methods are preferred 2.
In the framework of DFN with fixed geometry and random transmissivities, we introduce here a method for the identification of single backbones able to approximate the behavior of the exiting flux distributions of the given DFN, varying the transmissivities. In particular, the method used is based on the Layer-wise Relevance Propagation (LRP) algorithm [3] applied to NNs trained for flux regression of DFNs 1, using LRP as a feature selection method to compute the "expected relevance of the fractures" and therefore identifying the backbone.

Acceptance of Terms and Conditions:

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Foam Trapping and Foam Mobility in a Model Fracture

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Gas injection often suffers from the poor sweep efficiency because of conformance problems, including gravity override, viscous fingering and channelling, since gas has a lighter density and a

lower viscosity compared to in-situ fluids. Foam, by encapsulating the gas into separate bubbles in surfactant-coated liquid thin films (lamellae), can effectively address the conformance problems and hence improve the sweep.
Strong foam can reduce gas mobility by a factor of hundreds, by trapping gas and reducing its relative permeability in situ1. To efficiently improve the sweep, foam needs to propagate and maintain its strength at locations further away from the injection well. Foam trapping and propagation are highly dependent on porous media geometry, injection rate, foam quality, etc.
Microfluidic system, a medium integrating flow channels of manipulated structures on the order of tens to hundreds of microns, have been increasingly attractive to oil and gas, chemical and pharmaceutical research2. Microfluidics are also becoming one of the most stimulating research fields in foam EOR, because it provides the opportunities to visualize foam behaviour directly, such as foam generation, propagation and foam coarsening[3], etc.
We employ a model similar to microfluidics, directly applicable to flow in geological fractures. The 1-meter-long model represents a fracture channel with one roughened and one smooth wall. It has a width of 15 centimeters and a hydraulic aperture of 128 µm. The model is made of glass plates, therefore enabling direct investigation of foam behaviour through the channel using a high-speed camera. Since roughened glass is available with a range of roughness scales[4], one can relate foam behaviour to the roughness pattern in the channel.
We conduct a series of foam experiments in the model. Local equilibrium of foam (i.e. the rate of bubble generation equals to that of bubble destruction) is reached within our long model. We study the dynamics of gas trapping at different velocities and gas fractional flows.
We observe that velocity affects the fraction of gas which is trapped in the model at low foam qualities. Gas trapping decreases and foam mobility increases as superficial velocity increases. This contributes to shear-thinning mobility of the foam. At high foam qualities, the relation between trapped gas and foam mobility is weaker. Gas trapping is insignificant and has little effect on foam mobility. When gas fractional flow increases at high foam qualities, flow alternates between slugs of gas and foam.

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Fractal analysis of real gas transport in 3D shale matrix

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Shale gas reservoirs are of low porosity, poor permeability, complex pore structures and complex compositional minerals, and multi-scale effect during the transport of gas which results in the transport characteristics that are different from conventional gas transport theory. The transport mechanisms in the shale gas reservoir have not been well understood by now. Shale gas has a significant role in energy supply in the world due to its substantial deposits. Therefore, it is of great importance for efficient exploitation to clarify the transport mechanisms in the shale matrix.
There are mainly three aspects in the stating of shale gas transport mechanisms by now: experimental study, molecular simulation study, and theoretical model study. The theoretical model study has its advantages because it scarcely can be restricted by experimental apparatus and computing