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Equivalent permeability estimation of vugular porous media micromodels

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Reservoir scale modelling of vuggy and fractured porous media requires upscaling and determining their equivalent permeability. The effect of vugs and fractures on single flow behaviour in porous media is still not fundamentally understood. Direct simulation models combining Darcy flow through the porous matrix and Stokes flow through vugs and fractures have been developed in recent years. This approach is computationally expensive, since the geometry configuration of vugs and fractures needs to be well described in the model. Moreover, experimental validation of the predictions is also challenging.
In this work we propose a workflow that combines experimental measurements using vugular microfluidic porous media models with different vugs configurations, solution of Brinkman formulation [1] with an extra term that accounts for the drag force generated by the top and bottom walls of the micromodel, and machine-learning methods to predict permeability of vugular porous media solely based on image of the pore structure. The relevance of the geometric features and vug connectivity taken from the binary image to the machine learning model is assessed to investigate the aspects of vug morphology that contribute to the higher observed permeability.
As a first step, the Brinkman model [2] with the drag-correction term is validated by comparing the predictions to experimental measurement of permeability of different vuggy porous media micromodel [3]. The Brinkman solver is then used to construct a training data-base with different vugs configuration, relating the geometry of the porous media to its equivalent permeability. The accuracy of the data-driven model is tested by comparing its predictions to the ones obtained by solving Brinkman model using different porous media configurations not included in the training data set.
The data-driven model allows predictions of permeability of vuggy porous media at a fraction of the computational cost associated with direct simulation. The validation of the proposed workflow for single phase two-dimensional porous media allows its extension to 3D configurations and multiphase flow.

Participation

In-Person

References

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