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Predicting fracture permeability through pore-scale simulations

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A three-dimensional lattice Boltzmann model (LBM) is used to predict fracture permeability. The LBM is first verified by comparing the predicted permeability of a straight pipe with a rectangular cross section with the analytical solution. Excellent agreement is achieved for various aspect ratios of the cross section. Then the LBM is used to simulate single phase fluid flow in fractures whose geometries are obtained from the segmentation of triaxial direct-shear experiments conducted on shale. The experiments provide shear fracture geometry and permeability as a function of confining stress and fracture displacement. The pixelated representation of the fractures is directly used in the LBM simulation, while body-fit meshes are generated for solving the incompressible Navier-Stokes Equation using OpenFoam. Predicted permeabilities using both numerical methods are compared with each other and in relation to experimental observations. In addition, we compare computational efficiency of the numerical methods.
We simulate multiple fracture geometries under different stress conditions and the dependence of fracture permeability on contact area is investigated. The results are also used to investigate universal scaling relationships between fracture stiffness and fluid flow as proposed by Pyrak-Nolte and Nolte (Nat. Comm. 2016).

References

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