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Numerical simulation of two-phase flow properties in rough fractures considering the normal deformation

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Stress-dependent permeability and capillary force play important roles in determination of flow characteristics in fractures.Traditional empirical equations for relative permeability cannot accurately reflect transport behavior in rough fractures in consideration of normal deformation. In this paper, a systematic approach has been proposed to determine flow properties, such as relative permeability, capillary force, and the relationship between normal stress and flow properties in rough fractures based on the percolation theory. The rough fracture was described as a two-dimensional model, characterized by aperture as a function of position in the fracture plane. On the basis of Gaussian aperture distributions and cubic law in local parallel plate model, capillary force and relative permeability verse wetting phase saturation for both wetting and non-wetting phase were predicted in closed form, and the influence of normal deformation on fluid transport was investigated by decreasing the mean value of Gaussian aperture distributions. Numerical simulation results imply that the two-phase flow properties including the relationships between relative permeability, capillary force and wetting phase saturation depend sensitively on the normal deformation and spatial aperture distributions. Furthermore, a series of experiments data were applied to validate our numerical simulation results.

References

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