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Effect of time constant and rock pore complexity on the shift factor for non-Newtonian fluid flow in porous media

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Non-Newtonian fluid flow within porous media, exemplified by polymer remediation of contaminated groundwater/aquifer systems, presents complex challenges due to the fluids' complex rheological behavior within 3D tortuous pore structures. This paper introduces a pore-scale flow simulator based on the OpenFOAM open-source library, designed to model shear-thinning flow within porous media. Leveraging this developed solver, extensive pore-scale flow simulations were conducted on μ-CT images of various real porous media with varying complexity for Cross-fluid model. We focused on the macroscale-averaged deviation between bulk viscosity and the in-situ viscosity, commonly denoted by a shift factor. We provided an in-depth evaluation of the shift factor's dependency on the time constant and the rock's pore space complexity. The effect of time constant on shift factor is very small. Also demonstrate how the shift factor fluctuates based on tortuosity, characteristic pore length, and the cementation exponent. In particular, less porous/permeable systems with smaller characteristic pore lengths exhibited larger shift factors due to higher variations of shear rate and local viscosity in narrower flow paths. Additionally, the shift factor increased as rock became more tortuous and heterogeneous.

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