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Multicompotent image-based modeling of water flow in mixed wet shale nanopores

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Shale contains abundant multi-component nanopore spaces with different wettability. Water flow in multi-component nanoporous systems is still unclear due to the effects of complex pore throat topology and heterogeneous wettability, which limits knowledge of hydraulic fracturing for enhanced hydrocarbon recovery. This work reconstructs single-component (i.e. clay, organic, inorganic matter) and multi-component coupled nanoporous media utilizing image fusion technique. A numerical model for water flow in complex nanoporous systems is developed considering the heterogeneous wettability, slip effect, and effective viscosity. The water flow mechanisms in single and multi-component heterogeneous wetting systems are systematically analyzed. Results show that the enhancement factor increases exponentially, and the tortuosity increases with increasing contact angle. The flow is weakened under strongly hydrophilic conditions, and the enhancement factor is linearly negatively correlated with specific surface area. Under hydrophobic conditions, a small throat aspect ratio corresponds to a large enhancement factor, and quasi-circular pores limit the enhancement. Due to the differences in pore throat size and wettability, water flow is weakened in clay pores and enhanced in organic pores. For the multi-component heterogeneous wetting system, the global flow is enhanced compared to no slip and uniform wetting systems; the velocity is enhanced non-uniformly due to the altered pathways in organic pores; the flow is slightly weakened in the clay pores. This work provides a numerical perspective for water flow in shale multi-component nanoporous systems.

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