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A new upscaling method for simulating fluid flow in unconventional reservoir with strong heterogeneity

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Unconventional reservoirs like shale or tight reservoirs were usually characterized by its multiscale and unequally distributed pore system, the microporous fabric of unconventional porous media in nanometer size range can cause complex transport mechanisms. For developing a better understanding of flow property in unconventional reservoirs with strong heterogeneity, a new upscaling method combining gray lattice Boltzmann method (GLBM) and pore network model (PNM) is proposed to account for the fluid flow in anisotropic porous media. In this study, we first incorporate gray lattice node to represent the effects of micro structures. Firstly, isotropic samples for which 3D images obtained by X-ray CT and then calibrated with information at finer scales using SEM or FIB-SEM, so that pore space can be classified and grouped by pore structure characteristics to a limited set. Every group has a unique gray-scale value for different flow behaviors, and local flow features of one area in a group can be extrapolated reasonably to other locations in the same group under the constraints of GLBM. Then upscaling of flow simulation can be processed by repeating calculation of GLBM and PNM. Each group which was treated as relatively homogenous would be reconstructed and simulated using PNM. The permeability of few selected locations were estimated through a single-phase simulation to initially determine the material composition parameter(ns) of the GLBM. Porous model with strong heterogeneity then can be simulated for the first time. Misfit which calculated between the measured and simulated quantities would be updated and sent to PNM, which means a new value of ns can be obtained under a new flux distribution at the prescribed outlet. Similar to the history-matching method, iterations would lead to the minimize misfit finally. For verification and comparison, an isotropic carbonate rock was quantified and simulation, and flow data were in good agreement with the know results. With multiple sets of model parameters and samples, new upscaling method proposed in this paper can be done to estimate bulk properties in unconventional reservoir with strong heterogeneity.

References

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