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A Potential Energy based Lattice Boltzmann Model for Two-Phase Flow in Fractured Porous Media

Tuesday, 31 May 2022 15:20 (1h 10m)

The flow law of two-phase flow in complex porous media can be used to explain the variability of development efficiency during the displacement, imbibition, and huff-and-puff process with different construction parameters. Therefore, with the help of nuclear magnetic resonance, micro-CT (micro computed tomography), and tracer method, core samples and microfluidic chip experiment are commonly used as laboratory means to study the displacement and imbibition process in porous media. However, the flow field information obtained by laboratory methods is extremely limited. While, from the perspective of numerical simulation, more detailed flow field information of two-phase flow in complex porous media can be obtained through various computational fluid dynamics methods.
The computational fluid dynamics applied to the simulation of two-phase flow in porous media includes two types of calculation methods: the conventional Navier-Stokes solvers and the particle-based solvers. Specifically, the common numerical simulation methods for two-phase flow include direct numerical simulation, finite element method, volume of fluid-finite volume method, lattice Boltzmann method (LBM), and molecular dynamics method. Whereas, LBM is more suitable to simulate flows in complex porous media because of its simplification and advantageous boundary conditions processing. Thus, the numerous studies have carried out to analyze the flow field in porous media through the pore-scale LBM combined with digital core technology. While, pore-scale LBM depends on the specific interconnected pore network structures which have been the important influence in the flow filed. It indicates that few mechanisms of two-phase flow between fractures and matrix would be deduced because of the lower modeling accuracy of simulated structures. For instance, the submicron structures would be omitted due to smaller size than the microfractures or dispersed dissolution pores contained in tight porous media.
In order to obtain more inherent mechanisms of the two-phase flow in fractured tight porous media. This paper extends the application of the free-energy based LBM and adjusts the equilibrium distribution function and the potential energy model to make the two-phase flow algorithm more suitable for REV-scale porous media. The novel algorithm can be applied in trans-scale, where free-energy model is used in the fracture flow, and the two-phase seepage model is used in porous media simulation. Based on the slices of the real rock samples scanned by micro- and nano-CT, the two-phase flow in tight porous media with discrete fracture network is simulated by the novel algorithm. Compared with the original two-phase flow LBM algorithm, it can reveal not only the two-phase flow mechanism with the presence of discrete fracture network, but also the imbibition process between fracture and matrix. Therefore, it can provide a guidance of trans-scale flow simulations in tight porous media after hydraulic fracturing.

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Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Online

Primary authors: Dr NIU, Zhongkun (Institute of Porous Flow and Fluid Mechanics, Chinese Academy of Sciences); YANG, Zhengming (PetroChina Research Institute of Petroleum Exploration & Development); LUO, Yutian; Mrs ZHANG, Yapu; Dr CHANG, Yilin (University of Chinese Academy of Sciences); Dr CHEN, Xinliang (University of Chinese Academy of Sciences); Dr ZHAO, Xinli (University of Chinese Academy of Sciences)

Presenter: Dr NIU, Zhongkun (Institute of Porous Flow and Fluid Mechanics, Chinese Academy of Sciences)

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