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Digital rock reconstruction considering high stress

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Abstract

As the development of medium and shallow oil and gas reservoirs progresses into the mid-to-late stages, the focus of petroleum exploration is shifting towards deep and ultra-deep reservoirs. Deep oil and gas reservoirs are defined as those with burial depths exceeding 4500 m, while ultra-deep reservoirs refer to those buried beyond 6000 m. These reservoirs exhibit characteristics of high stress, significantly impacting the pore structure of reservoir rocks and, consequently, influencing microscopic flow of oil and gas. Digital rocks serve as a crucial platform for simulating flow at the pore scale. However, existing methods for reconstructing digital rocks fail to account for the effects of high stress. In this study, we propose a novel method for reconstructing digital rock cores considering high stress based on the discrete element method (DEM). The first step involves transforming scanned results obtained under room temperature and pressure conditions into a DEM model. We employ the watershed algorithm to segment CT scan images, utilize spherical harmonic functions to represent particle contours, and transform them into clump particles in PFC3D. Subsequently, a DEM model is established with porosity matching that of the actual rock. The accuracy of the model is evaluated using two-point correlation and linear path correlation functions. The second step involves setting micro-mechanical for the contact constitutive model between particles, applying stress simulation calculations, and converting the results into voxel data. The third step analyzes the geometric and topological structure of pores under different stress combinations, along with the evolution of permeability. The feasibility of the proposed digital rock core reconstruction method is validated through the analysis of Bentheim sandstone as a case study.

Keywords: digital rock reconstruction; the discrete element method; high stress; pore structure

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