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Direct comparing the permeability derivation from Images: Empirical Modeling vs Physics-Based Simulation vs Deep Learning

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As the advantage of directly extracting microstructure information and simulating multiple petrophysical scenarios, estimating permeability from rock images became prevail for studying fluid flow in porous media, which is a fundamental problem in subsurface hydrocarbon recovery, CO_2 underground storage, and geothermal development. This study aims to directly compare three commonly-used approaches: empirical modeling, physics-based simulation, and deep learning on the same Berea sandstone 3D images data, and to lay out the advantages and disadvantages based on their performances. The empirical modeling method used in this study is Kozeny-carman equation which are based on pore-throat size and specific surface area. The physics-based simulation, referred to Lattice-Boltzmann method and Shan-Chen model, where Palabos, the open source LB simulator, is adopted in this study. Deep learning work implemented the MultiScale Network for hierarchical regression (MS-Net), a neural network trainer, on the rock images by using simulation results as the output. The study showed that empirical modeling is simple and easy to follow, but only provides rough estimate of the absolute permeability. LB-based simulation is more accurate and can calculate relative permeability by considering many types of scenarios such that a range of estimates are obtained. However, as the image data increases, simulation requires great time and computation costs. The deep learning results show potential in an efficient way by approaching the accuracy of simulation with increasing training efforts. This direct comparison shows the exact results of all three methods on the same image data and clearly gave the hints to the researchers depending on what they demand.

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Participation

Online

Primary author: Prof. KONG, Lingyun (Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences)

Presenter: Prof. KONG, Lingyun (Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences)

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