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Multi-Scale Simulation of Absolute Permeability Using 3D X-Ray Micro-Tomography Images

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Abstract

Characterizing absolute permeability from cored area in oilfield reservoirs is a crucial step to evaluate hydrocarbon reserves. Numerical simulation approaches based on digital rock physics technology represent a promising tool to better understand behaviour of rock properties in carbonates at pore scale. Indeed, carbonate reservoir rocks can be very complex due to heterogeneities at several length scales ranging from nanometres to centimetres. The aim of our article is to introduce a multi-scale numerical simulation workflow to estimate absolute permeability from core plug samples. In order to achieve this goal, we acquire 3D X-ray Micro-tomography images of 1.5 inches diameter core plug sample with a resolution of 40 micro-m. Then, we extract a smaller cylindrical subset of 0.5 inches diameter and scan it at 13 micro-m. We implement bi-level segmentation method to extract pore network into 3D images. However, connectivity from top to bottom between pore bodies could not be detected into these images because several pore connections are below image resolution. Thus, we divide 3D images into smaller cubes of same sizes as a first approach and run locally permeability simulations using Lattice Boltzmann Method. In a second approach, we segment images based on textural description of main representative classes. Then, we assign local permeability from random values selected in each permeability distribution related to specific texture class. Another, approach is to choose subsets representing different classes of textures and estimate remaining subsets permeability values using kriging. In the last step, we simulate numerically the effective permeability using Darcy's Law simulator and compare results to several averaging techniques. Finally, we discuss and compare our numerical simulation results with experimental measurements from the laboratory.