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A Hybrid Multiscale Pore Network Modeling Method Applied to Complex Carbonate Rocks

Tuesday, 31 May 2022 15:05 (15 minutes)

Accurate modeling of multiphase flow in geological porous media is a critical component of a wide range of energy and environmental science applications, including production of oil and gas, geological sequestration of CO2 and evaluating geothermal systems. This is particularly challenging in carbonate rocks, due to their inherently complex pore systems, associated with multi-scale depositional and diagenetic heterogeneities, varying in a broad range of length scales. A signficicant portion of carbonate pore space is comprised of microporosity (pore size less then 10 microns), and there is an urgent need for pore network modeling methods that can account for the impact of micropores and the connectivity between micro- and macro-pores on the digital rock properties. Traditional pore network modeling and simulation methods that rely on single resolution images fail to adequately capture all these relevant length scales, due to computational limitations. In this work, we present a hybrid/multiscale Pore Network model that enables the integration of micro- and macro-scale imagery derived from micro-CT and SEM for predicting static and dynamic petrophysical properties.
We used multiple heterogeneous carbonate samples, including standard core plugs from a prolific reservoir in the Arab-D Formation of Saudi Arabia, which are representative of the main lithofacies associations. We applied state-of-the-art image processing workflow that allowed integrated image analysis of different modalities (micro-CT and SEM) and multiple resolutions (ranging from 30 μm to <1 μm). Multiple segmentation methods were tested on the micro-CT and SEM images and converged into an automated segmentation routine using Deep Learning models, which enabled us to easily replicate the segmentation work for similar samples. High resolution micro-CT data was used to obtain 3D pore type distribution that accounted for unresolved pore volume, that was subsequently imaged using SEM. Process-Based (PB) modeling approach was used to derive 3D pore space models from the SEM images. The resulting micro-scale pore type models were then used as input in our multiscale Pore Network model to be combined with the macro-scale 3D pore network. The multiscale Pore Network model was used to compute effective rock properties such as porosity, permeability, relative permeability, capillary pressure, and resistivity index. Experimentally measured porosity, permeability and mercury–air primary drainage and oil–water imbibition capillary pressure curves were used used to verify the multiscale Pore Network model. Evidently the micropores and pore throats in the studied samples significantly contribute to flow and electrical properties, and our method captured this multi-scale pore effect on rock properties more effectively compared to traditional PNM workflows.

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References

A Multi-Scale Imaging and Modeling Workflow for Tight Rocks, L. C. Ruspini, G. Lindkvist, S. Bakke, L. Alberts, A. M. Carnerup, and P. E. Øren, FEI Company

Time Block Preference

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

Participation

In person

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