Contribution ID: **390** Type: **Poster Presentation**

Novel multi-scale pore network modeling approach that combines high-resolution pore volume reconstruction and super-resolution segmentation

Wednesday, 24 May 2023 16:10 (1h 30m)

Pore-scale studies of fluid flow in porous media are of critical importance for a wide range of energy and environmental science applications, including geological sequestration of CO2, groundwater remediation, hydrocarbon production, underground energy storage, and evaluating geothermal systems. X-ray micro-CT analysis is the most widely used method to visualize and quantify pore-scale features across multiple length scales, but poses two important challenges: first, the trade-off between sample size and resolution and second, the extremely large data size. In this study, we propose a novel pore-to-core modeling methodology that combines super-resolution and multi-scale pore network modeling that aims to address these limitations of x-ray CT scanning and improve the representation of micro- and macro-pore connectivity.

We applied the proposed method to Upper Jurassic carbonate core plugs from the Middle-East, which are representative of subsurface heterogeneity, and have bi-modal porosity distribution comprised of micro- (pore size < 10 μm) and macro-pores. First, we obtained micro-CT images of the entire core plug (one-inch diameter and three-inch long) at a resolution of 30×30×30 μm3/voxel. Guided by this overview scan, we then drilled miniplugs (0.5-millimeter diameter and one-inch long) representative of the main pore-scale rock types and obtained micro-CT images at a resolution of 6×6×6 μm3/voxel. The miniplug CT images were then segmented into micro-pore, macro-pore and solid phases under the supervision of the prior extracted from the high-resolution SEM images with a resolution of 100×100 nm2/pixel. The pair of segmented miniplug volume and the corresponding sub-volume in the full plug CT image was used to train a deep-learning network model to improve the accuracy of the segmentation of full plug CT volume. Finally, a large multi-scale pore network model of the full plug was obtained by pore network stitching (Kohanpur & Valocchi 2020), which included the macro-pore network from the full plug and micro-pore network elements reconstructed from the SEM image using multiple point statistics.

Because the training image pairs of the deep leaning network are low-resolution CT image and high-resolution segmented images, the applied of super resolution method improves the accuracy of the full plug segmentation, which is evident from the comparison of segmentation based on miniplugs. The multi-scale pore network stitching method allowed the simultaneous representation of micro-pore and macro-pore network elements while maintaining the topological features of the heterogeneous pore structures effectively. The flow property values computed from the large stitched pore network model showed significantly improved match of pore size distributions and absolute permeability values compared to lab measurements.

To the best of our knowledge, this is the first time the combination of SR-segmentation approach and 2D-3D pore volume reconstruction has been applied to generate multi-scale pore network models that are representative of micro- and macro-scale heterogeneities. The pore networks obtained from this methodology cover multiple length scale from pore-to-core and can be applied in a wide variety of pore-scale studies for multiphase flow property predictions and simulations.

Participation

In-Person

References

Kohanpur, A.H., Valocchi, A.J. Pore-Network Stitching Method: A Pore-to-Core Upscaling Approach for Multiphase Flow. Transp Porous Med 135, 659–685 (2020). https://doi.org/10.1007/s11242-020-01491-0

MDPI Energies Student Poster Award

Yes, I would like to submit this presentation into the student poster award.

Country

Saudi Arabia

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary authors: Ms LIU, Xin (Ali I. Al-Naimi Petroleum Engineering Research Center (ANPERC), King Abdullah University of Science and Technology (KAUST)); Dr CHANDRA, Viswasanthi (Ali I. Al-Naimi Petroleum Engineering Research Center (ANPERC), King Abdullah University of Science and Technology (KAUST)); Prof. VAHRENKAMP, Volker (Ali I. Al-Naimi Petroleum Engineering Research Center (ANPERC), King Abdullah University of Science and Technology (KAUST))

Presenter: Ms LIU, Xin (Ali I. Al-Naimi Petroleum Engineering Research Center (ANPERC), King Abdullah University of Science and Technology (KAUST))

Session Classification: Poster

Track Classification: (MS09) Pore-scale modelling