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Pore Network Stitching for Pore-to-Core Upscaling of Capillary-Dominated Two-Phase Flow in Heterogeneous Natural Reservoir Rocks

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Physics of two-phase flows in heterogeneous natural rocks plays an important role in many applications, such as carbon sequestration in deep saline reservoirs and recovery of oil from hydrocarbon reservoirs. Although pore-scale models are used to compute macroscopic average properties required in field-scale simulators, most work is limited to small sample size. There is a need for pore-scale models that can accurately represent the 3D complex pore structure and heterogeneity of real media. Pore network modeling (PNM) simplifies the geometry and flow equations at pore-scale, but can provide characteristic curves in capillary-dominated systems on fairly large samples with huge saving on computational costs compare to direct numerical simulation methods. However, there are limitations for attaining a large representative pore network for heterogeneous cores such as technical limits on scanning size to discern void space and computational limits on pore network extraction methods. To address this issue, we propose a novel pore network stitching method to provide large-enough representative pore network for a core.

In this study, we use industrial (as core-scale) and micro-CT (as pore-scale) scans of actual reservoir rock samples to characterize the pore structure of a core. Few signature parts of the core are selected from industrial scans, and their micro-CT scans are taken. Equivalent 3D pore network of each signature part is extracted by applying maximal ball pore network extraction algorithm. The space between signature networks is filled by using stochastic random network generator that uses statistics (radius, shape factor, connection number, and length of pore elements) of all signature networks and a layered stitching method that glues network pieces. The outcome is a large pore network that can be used in a fast quasi-static PNM solver to obtain absolute permeability, relative permeability and capillary pressure curves. We have tested the developed method on various generated and extracted networks by 1D stitching direction, and it will be improved and extended to 2D and 3D stitching directions.

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References

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