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Dynamic phase connectivity in pore-network models

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Pore-network modelling is an efficient method to simulate pore-scale multi-phase flow. The pore-network consists of a collection of idealized interconnected discrete network elements –pore nodes and pore throats. Capillary-dominated flow is modelled based on invasion-percolation rules. Although pore-network modelling is much less resource-demanding than direct simulation approaches, current implementations of the invasion-percolation algorithm are still time-consuming, in particular its phase clustering component, which identifies and determines phase trapping. Computational efficiency is essential when calculation of representative flow properties requires very large pore-network models of 10-100s millions network elements, for example for carbonates that exhibit multi-scale pore systems, and when performing multiple simulations for uncertainty analysis of, for example, wettability distributions. The present work introduces a new approach, denoted as dynamic phase connectivity, to track the changes in phase clustering after each displacement step. The relative permeability evaluation procedure has been optimised to accommodate for widely accessible multi-core CPU architectures. The combined speed-up factor of the proposed methodology is from two to three orders of magnitude compared to the best conventional pore-network modelling implementations.

References

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