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# Fast digital rock upscaling: from Stokes equation to Darcy equation

**Qinzhuo Liao**[1], Gensheng Li[1], Zhongwei Huang[1], Mao Sheng[1], Jun Li[2], and Dongxiao Zhang[3]
[1]China University of Petroleum-Beijing, Beijing, China (liaoqz@gmail.com)
[2]King Fahd University of Petroleum and Minerals, Saudi Arabia
[3]Southern University of Science and Technology, China

Permeability is a key parameter for characterizing fluid flow in digital rocks. It depends on pore geometry and topology and can be computed numerically via solving the Stokes equation. However, the associated computational effort can be enormous for large-scale models, even using the efficient Lattice-Boltzmann method. In this study, an efficient method is developed for computing the equivalent permeability of digital rocks by simplifying the Stokes equation to Darcy equation. The method is based on the idea that a 3D digital core can be approximated by the combination of multiple 2D slices/layers, and the property of each layer is governed by the Stokes equation. Specifically, to mimic the 2D fine-scale velocity solved from the Stokes equation, a local permeability is assigned according to the velocity for each voxel. In addition, the nearest distance from each voxel to the solid wall is used to approximate the 2D fine-scale velocity, without the need of solving the Stokes equation in 2D for each layer. By this means, the 3D Stokes equation can be simplified to multiple 2D cases that provide the local permeability distribution for the 3D Darcy equation, and thus the computational cost can be significantly reduced. Case studies have been conducted on various samples in different scales. The results demonstrate that the computed 3D permeabilities using finite difference method (based on the Darcy equation) agree well with those using Lattice-Boltzmann method (based on the Stokes equation), and a speedup factor of about O(10) is achieved. The method can be applied to both sandstone and carbonate rocks for fast estimation of block permeability.