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# Filtration and electrical properties of porous media determined via microscale numerical modeling

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Pore structure is one of the main factors defining numerous transport properties of geomaterials. Conventional estimations of such properties using only limited 2D data from thin sections using different Kozeny-Carman, simple pore-network and other approximations are usually inaccurate. In recent decades different numerical methods were developed to quantify single and multi-phase flow in such media on microscale. Among most popular ones are: 1) a wide range of finite difference/element/volume solutions of Navier-Stokes equations and its simplifications; 2) lattice-Boltzmann method; 3) pore-network models. Each method has its own advantages and drawbacks, so utilization of more than one of these approaches is reasonable, depending on the study case. Recent progress in X-ray microtomography and some other techniques allows precise determination of geomatrials three-dimensional structure, however, a trade-off between resolution and sample size is usually unavoidable. There are also situations then only standard two-dimensional information of porous structure is available due to tomography high cost or resolution limitations. However, physical modeling requires 3D information of the pore structure. Some amount of porosity (we call it "under-resolution") is usually not visible on X-ray scans or thin-section low resolution images. Unlike permeability, it may play an important role in resistivity, capillary curve shape and other important properties.

The main aim of this contribution is to verify petrophysical modeling approach on a substantial collection of sandstone samples (30 in total) with wide range of pore space configurations and transport properties (permeabilities from 0.1 to 1000 mD). At first our 3D structure obtaining method using X-ray microtomography (with average resolution of 2.6 microns) is justified via detailed laboratory vs. tomography porosity measurements comparison. Next permeability is determined for all samples using network-model extracted from 3D structure scans. To verify this approach same values are obtained using parallelized finite difference method for Stoke's equation. It is clear that both approaches were successful in permeability determination for representative samples, as compared to laboratory measurements on same scanned cores. However, calculated formation factor and capillary curves in many cases deviated from experimental values, especially for samples with high under-resolution porosity. The influence of resolution and numerical sample size is also studied in detail. The influence of invisible porosity is also supported by coordination number correlations with other physical properties for sample within the same group (same reservoir type). To account for under-resolution pores invisible on X-ray scans two approaches can be utilized based on artificial addition of under-resolution porosity into numerical sample: 1) NMR measurements (under-resolution pore size distributions), and 2) stochastic reconstructions from high resolution 2D cuts (modified Yeong-Torquato technique). Finally, we discuss the applicability of these methods in petrophysics, soil and hydrological sciences and future perspectives.