Slip-flow in tight carbonate for permeability estimation using 3D digital pore space

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Abstract. Permeability is a key parameter in reservoir description. Nowadays, computational fluid dynamics (CFD) provides chance to simulate the fluid flow in porous space. Permeability can be evaluated based on simulation results. Standard simulations are based on continuum flow regime but in the case of tight rocks the slip-flow should be applied.

First stage of the analysis was connected with building the geometrical model of the pore space. Tight carbonate was chosen as an exemplary sample in the analysis (low porosity and permeability, tight gas). Geometrical model of the pore space was generated from computed X-ray tomography data with voxel size 0.8x0.8x.08 μm^3. Digital rock model of the pore space was created and analyzed regarding geometrical parameters for each object and microfracture: volume, x, y and z-coordinate of centroid, surface area and surface mesh area, moment of inertia around shortest principal axis, middle principal axis and longest principal axis, mean thickness, standard deviation of the thickness, maximum thickness, length of best-fit ellipsoid's long radius, intermediate radius and short radius, Feret diameter, shape and also sphericity, flatness, elongation. Tortuosity was calculated based on algorithm for pore space transformation into skeleton. Geometric model was extracted on the pore space and used as an input data to create a mesh and next, finite volume elements. Fluid flow simulation was carried out using nitrogen as a working fluid to compare the results with the pulse-decay permeability measurements on the core sample. Because tight carbonate characterized with narrow pore channels, the slip-flow approach was used to perform the simulation, what reflects the molecules slip on the pore walls. As a result of the simulation several parameters were obtained, e.g. velocity and mass flow rate. Permeability was in a good agreement with the results of permeability measurement on core sample, within the 10% of error.