On determination of the absolute permeability of anisotropic reservoirs using the results of direct and inverse mathematical simulation

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The absolute permeability coefficient characterizes the permeability of the medium during filtration of homogeneous fluid that does not interact with the medium and is determined by the geometry of the pore space. Sedimentary rocks have a pronounced anisotropy of the pore space structure, and their absolute permeability is described by a symmetric tensor of the second rank. Identification of the symmetry group of filtration properties of rock samples is one of the important tasks in geophysical applications related to hydrodynamic effects on the near-wellbore zone.

In this paper, we consider the case of triclinic symmetry. In this case, three directions of the principal axes of the absolute permeability coefficient tensor are not known. Six components are to be determined.

Using the results of non-destructive visualization methods on the basis of X-ray tomography of cores, discrete geometric models of sedimentary rock samples (sandstone) were constructed. A series of direct hydrodynamic calculations of fluid flows in the framework of Newtonian rheology were carried out applying computational schemes of non-conformal finite element methods.

To determine the components of the absolute permeability coefficient tensor, an inverse coefficient problem is posed. For its solution, an algorithm for minimizing the energy norm of deviation of fluid flow velocity in homogenized medium from the calculated fluid flow velocity in heterogeneous medium under the assumption of linear dependence between fluid flow rate and pressure gradient is developed. The analysis of the Fréchet derivative of the target functional is given, the acceptable noise levels of the observation model and variations of the unknown parameters are shown.

When comparing the obtained results of the solution of the inverse coefficient problem with the published data of physical experiments, a discrepancy of no more than 9% is found.

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