COMSOL Multiphysics® Simulation of the Electrokinetic Effect in Gidrogeology

M. A. Narbut[1], K. V. Titov[1], P. K. Konosavsky[1]

[1]Saint Petersburg State University, Saint Petersburg, Russia

Abstract

The groundwater flow is accompanied by the electric field with potential called usually the streaming potential or the Self-Potential (SP) to be measured on the ground surface (e.g., Rizzo et al., 2004; Bolève et al., 2007; Jardani et al., 2009). We studied numerically the SP signals associated with pumping test experiments in layered aquifers using COMSOL Multiphysics® software and GWFGEM program developed by one of the authors (Titov et al., 2005). The numerical simulation helps to understand better the details of the electric source distribution in the aquifer. The study includes three steps: first we solve the diffusion equation for the hydraulic head in the vicinity of the pumping well. At the second step we find the electric source for the Self Potential caused by the electrokinetic coupling. And finally we obtain the streaming potential as the solution of the Poisson equation under the appropriate boundary conditions. The cases of conductive (metallic) tube in the pumping well and the insulating one were considered (Fig.1-4). The work is supported by Saint Petersburg University grants 6.37.171.2014 and 3.37.134.2014.

Reference

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3. E. Rizzo et.al. Self-potential signals associated with pumping tests experiments. Journal of Geophysical Research, 109, B10203, doi:10.1029/2004JB003049 (2004).

4. K. Titov et.al. Numerical modelling of self-potential signals associated with a pumping test experiment. Geophysical Journal International, 162, 641–650.(2005).

Figures used in the abstract

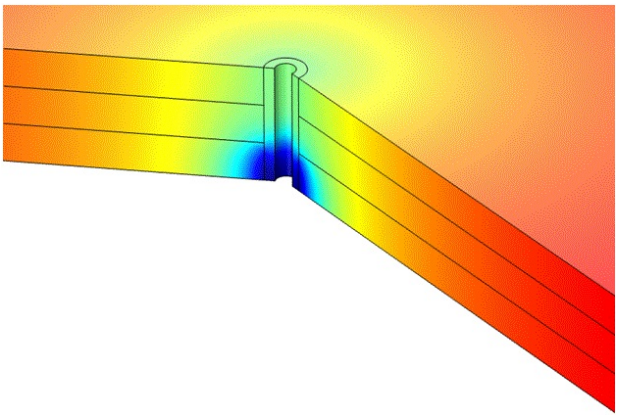

Figure 1: COMSOL simulation of SP distribution produced by pumping test of the layered aquifer in the case of insulating tube

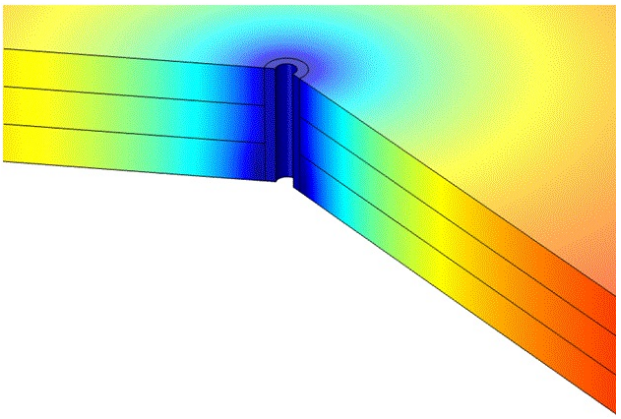

Figure 2: COMSOL simulation of SP distribution produced by pumping test of the layered aquifer in the case of conductive tube

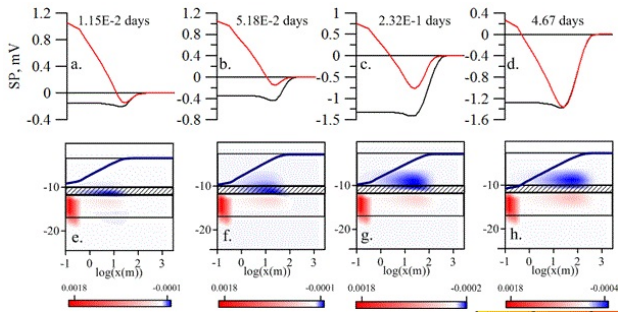

Figure 3: Self-potential signals (a–d) and respective electrical sources (e–h) produced by pumping test of the layered aquifer. Black and red lines show the cases of insulating and conductive tubes in the pumping well respectively. Blue line shows the water head distribution in the main aquifer

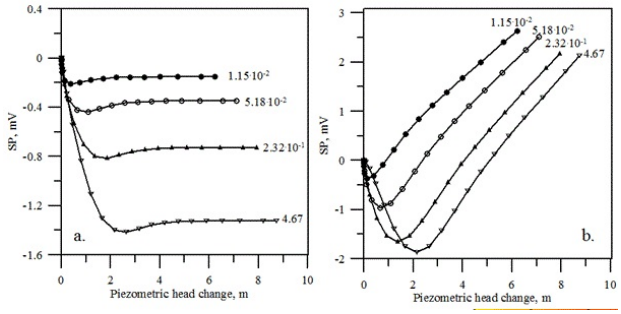

Figure 4: SP signals vs. piezometric head change produced in the course of pumping test of layered aquifer. Different time moments are shown by numbers (in days); non-conductive (a) and conductive (b) casing of the pumping well