LATTICE BOLTZMANN MODELLING OF STREAMING POTENTIALS : INFLUENCE OF THE GAS-WATER INTERFACE DYNAMICS ON THE ELECTROKINETIC COUPLING

E.-A. Fiorentino, R. Toussaint & L. Jouniaux
Institut de Physique du Globe de Strasbourg, CNRS/UMR 7516, Strasbourg, France

Key words   Hydrogeophysics - Streaming Potentials - Multiphase Flows - Lattice Boltzmann Method

The streaming potential phenomenon is an electrokinetic effect that occurs in porous media due to the presence of an electrical double layer at the fluid-rock interface. The electrical double layer generates an excess of positive charges at the immediate vicinity of the rock, which gives rise to an electric streaming current when the fluid flows in the porous medium. This streaming current is counterbalanced by a conduction current which leads to a measurable electrical voltage, characterized by an electrokinetic (EK) coefficient. In monophasic conditions, the EK coefficient is a function of four parameters that are the zeta potential (potential of the plane separating the moving ions from the ions adsorbed to the surface), the viscosity, the permittivity and the conductivity of the electrolyte. This phenomenon is at the origin of seismoelectric signals and self-potential signals, and is not well understood when the medium is partially saturated.

The lattice Boltzmann method allows to model the physical quantities involved in the streaming potential phenomenon (Fig. 1). The model presented in this study is a multiphase extension of the model described in [1]. This model allowed, in monophasic conditions, to assess the impact of the local variations of the electrolyte's viscosity, permittivity and conductivity on the EK coefficient. The local variations of the viscosity and permittivity remain negligible even at high salinity, but the local variations of conductivity can lead to a misinterpretation of the zeta potential in the low salinity domain, or in the presence of a polyvalent counterion. In multiphase conditions, the lattice Boltzmann method is a popular and powerful technique that allows to simulate the pore-scale multiphase dynamics without tracking the moving interface at each step of the calculation.

The aim of the current study is to model the streaming potential phenomenon in a capillary channel in the presence of two immiscible phases. This model does not aim at reproducing the complexity of natural systems, but aims at improving the understanding the electrokinetic mechanism in the presence of a multiphase flow. This study focuses on the behaviour of the electrokinetic coefficient as a function of the water saturation in the capillary, with a comparison to experimental analogs available in the literature.
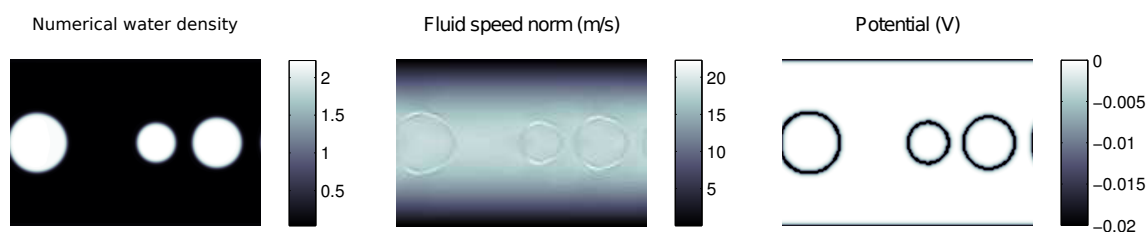

Figure 1. Numerical water density, flow velocity and electrical potential simulated using the lattice Boltzmann method [2, 3]

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