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Lattice Boltzmann simulations of electrokinetic coupling : effects of rugosity and local conductivity

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Streaming-potentials are produced by electrokinetic effects in relation to fluid flow, and are used for geophysical prospecting. The electrokinetic coupling is induced by the coupling between the fluid flow and the electrical flow, which results from the presence of an electrical double layer at the rock/pore water interface. When fluid flows through a porous medium, it gives rise to an electric streaming current, counterbalanced by a conduction current, leading to a resulting measurable electrical voltage. Streaming current generation is well understood in water-saturated porous media, but the streaming potential coefficient at very-low and very-high salinities can show a non-linear behaviour. The aim of this study is to model the streaming potential coefficient using Lattice Boltzmann simulations and to quantify the effect of parameters such as fluid conductivity and rugosity.

The lattice Boltzmann method is computational fluid dynamics technique that allows to solve advection and diffusion phenomena. We implement a coupled lattice Boltzmann algorithm that solves both the flow in a rock channel and the electrical diffusion to calculate the streaming potential coefficient (ratio between the created potential difference and the applied pressure gradient) in various situations. In this study, we aim at quantifying the change that is brought by taking into account the dependence of the local fluid conductivity on the local concentration. We also observe the influence of a rough surface on the behaviour of this coefficient with the fluid salinity. We try to generate non-linearities regarding the theoretical prediction of the streaming potential coefficient with a view to explaining existing experimental measurements.