Geophysical Research Abstracts
Vol. 13, EGU2011-4557, 2011
EGU General Assembly 2011

Laboratory measurements of self-potential signals induced by displacements of saline fronts

Alexis Maineult, Fernand Lopes, Jean-Jacques Sibilla, Lucille Trevez, and Maria Zamora
Institut de Physique du Globe de Paris - Sorbonne Paris Cité, Univ. Paris Diderot and CNRS (UMR7154), Paris, France (maineult@ipgp.fr)

Self-potentials, or natural electrical potentials, are mainly due to the movement of a fluid through a porous medium (the so-called electrokinetic effect) and are, therefore, of geophysical interest for the characterization of groundwater flows from surface measurements. Over the last 15 years, the self-potential method has also been applied for the characterization of underground pollutant plumes, especially in the context of leaking waste landfills. In this case, other potential sources linked to the redox potential distribution and possibly to the ionic concentration distribution (the so-called junction potential) are acting. Here we report on laboratory experiments focusing on signals caused by the diffusion of ionic concentration gradients.

In previous works, Maineult et al. (2004, 2005, 2006) measured the electrical potential inside moving saline fronts (NaCl, KCl, and ZnCl2). They proved that the observed signals were the combination of the junction potential and the variation of the electrokinetic potential resulting from the variation of the fluid conductivity. Moreover, they showed that the fluid velocity could be determined accurately from the self-potential curves, and that the hydrodynamic dispersion coefficient could be roughly estimated. They concluded that this method could be used in the laboratory to study the hydraulic transport properties of porous media. Nevertheless, to apply this method to the characterization of underground saline plumes in the field, we have to know if the signals are measurable from the surface, i.e. outside the plume. In other terms, we have to solve the question of the attenuation with the vertical distance to the source.

We thus performed experiments similar to those previously reported by Maineult et al. but in a bigger experimental device. Briefly, a rectangular Plexiglas tank (100 cm in length, 40 cm in width and height) is divided into three parts: an upstream reservoir (12 cm in length), a central part filled with Fontainebleau sand (29 cm in height), and a downstream reservoir (12 cm in length). The unpolarisable electrodes are placed at the surface of the sand, with reference electrodes in the upstream reservoir. The tank is tilted (4.7°) and the level of the water table is maintained at a given value with respect to the bottom of the sandbox, ensuring a uniform one-dimensional flow through the sand. A certain amount of NaCl is then injected in the upstream reservoir, generating a sudden peak of concentration followed by an exponential decrease in this reservoir. This concentration front is advected through the sand. We reiterated the experiment with different water table levels to increase the vertical distance between the line of electrodes at the surface and the plume. For an identical maximal value of the concentration peak, the shape of the signals was similar for all values of the water level. The amplitude decreased with vertical distance but not so drastically. For that reason, we believe that the self-potential method can be applied to characterize underground saline plumes in the field.

This work is funded by the collaborative project “ModelPROBE” (Model driven Soil Probing, Site Assessment and Evaluation), grant n° 213161, seventh framework programme of the European Union.