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Estimation of electrochemistry/hydraulic coupling parameters in clay medium.

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Argillaceous media characterized by weak water and solute fluxes are presently studied in the context of the research program on the feasibility of a deep geological repository for nuclear waste. In such negatively charged surface media, the hydraulic conductivities are very small, less than $10^{-11}\, m.s^{-1}$ (Marsily, 1986). If the boundary conditions above and below these shale layers are changed, either in terms of hydraulic gradient, or in terms of chemical composition, the classical expression of Darcy's law does not describe accurately the water flow in the medium (Marsily, 1986; Revil and Pessel, 2002). Instead of this classical law, we have to use a generalized Darcy law involving coupled flows.

We consider here the electrochemistry/hydraulic coupling. The pressure gradient is no more the only driving force for fluid flow but it is associated with the chemical potentiel gradient. The water flow due to a chemical potential gradient through a semipermeable membrane is the so-called chemical osmosis. The clay medium can behave as semipermeable membrane (Fritz, 1986; Neuzil, 2000). This characteristic is interpreted as the consequence of the negatively charged surfaces of the clay minerals (Mitchell, 1993). This surface charge modifies the ionic distribution in the pore solution. In the vicinity of the negative surfaces, there is an excess in cations (counter-ions) and a deficit in anions with respect to the concentrations in the solution at equilibrium. This redistribution has an impact on the ionic flow and thus on the water flow.

The identification of the coupling parameters, in the clay medium, is fundamental in order to estimate the water flow. This characterization requires the estimation of two coupling parameters : the intrinsic permeability k and the osmotic coupling parameter

k_c. These coupling parameters can be estimated using two approaches:
(i) theoretical modeling method
• porosity/intrinsic permeability relationships, defined for a clay medium, are used to estimate the intrinsic permeability.
• an electrochemical model is used to estimate the osmotic coupling coefficient. The model used is a triple-layer model. Thus we implement an electrical model to simulate the interactions between the charged surfaces of the clays and the solution present in their vicinity.
(ii) by measurements :
• at the sample scale.
• at the field scale.

Some preliminary results of this approach will be presented.

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