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Effect of minor clay and mica phases on the SP response of KCl front transport

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Self-potential monitoring is presently emerging as one of the most popular geophysical methods in hydrology applications. SPM is easy to implement in the field but interpreting the recorded data in terms of fluid velocity and chemical composition is often very difficult. In order to gain insight into the various processes causing self-potential anomalies in the Earth, small-scale experiments involving reproducible, well-controlled processes and systems, have been conducted in the laboratory. In many studies, the simplest possible porous medium, i.e., nearly pure quartz sand or pure clay powder, is usually used. The choice simplifies the experimental procedures and the analysis of the results but does not realistically duplicate the complexity of natural soils.

In a previous set of sand-box experiments performed using a sand containing small quantities of clays and micas, the self-potential signals corresponding to the advection of a salt front agreed quite well with theory when NaCl was used (Maineult et al., JGR 2005). However, a strong discrepancy between the calculated self-potential and the measurements was observed when using KCl. The amplitude of the signal was higher than the expected one, and the electrical conductivity of the out-flowing fluid was much smaller than the calculated one assuming a simple conservative transport. Therefore, it seemed that some chemical reactions (and in particular entrapment) occurred between the K+ ions and clays. In order to test this hypothesis, we performed a new set of similar sand-box experiments using two different sands, namely, the original one (Haguenau sand) and a very pure quartz sand (Nemours sand).

The new results show that, when KCl salt front is advected in Nemours sand (without any micas nor clays), the electrical conductivity of the out-flowing fluid fits the

prediction of the conservative transport model, and that the SP amplitudes are in the expected value range. Even though the mechanisms involved are not understood to date, this study shows that chemically active minor phases, as micas or clays, can significantly influence the SP signals.