Geophysical Research Abstracts,
Vol. 11, EGU2009-12348, 2009
EGU General Assembly 2009
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Monitoring of water and thermal transfers in the vadose zone of a carbonate reservoir formation.

A. CEREPI, C. LOISY, and R. BURLOT
University of Bordeaux, EA GHYMAC N°4134, 33607, Pessac, France, email: adrian.cerepi@egid.u-bordeaux3.fr

The aim of this study is the monitoring of water and thermal transfers in vadose zone of a carbonate reservoir formation during three hydrological cycles (August 2001– November 2004). The application of the Time Domain Reflectometry (TDR) and Self-Potential (SP) methods to determine the water content of porous rock has been widely investigated. More than 285 studied point measurements of rock water content observed during three hydrological cycles and distributed among an abandoned underground quarry in Gironde, France, show a permanently undersaturated limestone (between 35% and 50 %). We also investigated the unsaturated zone in a borehole between 0 and 20 m depth until the water table. 14 TDR and SP electrodes investigate the vadose zone. For the understanding of the streaming potential and electric behaviour from the SP method of a vadose zone we performed an experimental device which allows us to quantify the measurements of electrokinetic coupling coefficient at various saturation conditions. The results show that the vadose zone is characterized by three different sub-zones which are different water dynamics. The shallow zone down to a depth of seven meters corresponds to a zone with a significant variation of water saturation related to evapotranspiration dynamic water. The second zone (so-called transition zone) between seven to sixteen meters displays a high stability. The third zone (zone of capillary fringe) between sixteen to twenty meter shows a high and constant water saturation.
Experimental results show three periods of maximum water content corresponding to three occurring effective precipitations. The dephasing and the amplitude attenuation of the hydraulic and thermal waves with the depth can be modelled and explained by the physical properties of the porous medium in an unsaturated zone such as the diffusivity, the water relative permeability, the capillarity pressure versus water saturation and the effective porosity.