IN-SITU CHARACTERIZATION OF THE CALLOVO-OXFORDIAN POREWATER COMPOSITION

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INTRODUCTION
The study of the mechanisms governing the composition of the interstitial fluids in clay formations with very low permeability constitutes a part of the scientific programmes associated with the safety analyses of deep repositories for the geological disposal of long-lived radioactive waste. Up to 2005, the knowledge about the Callovo-Oxfordian porewater composition was entirely built on geochemical modeling. A reference geochemical model had been defined from measures performed on bore cores drilled on the site of the Meuse/Haute Marne Underground Research Laboratory (URL) (Gaucher et al. 2006, Jacquot and Altmann 2005). Since 2005, porewater has been sampled in situ in several URL boreholes equipped with various setups. Results obtained from the porewater analyses are presented here and compared to the geochemical model.

EXPERIMENTAL CONCEPT
Experiments called “PAC” were designed to characterize the Callovo-Oxfordian porewater. These experiments were performed in boreholes drilled from the URL drifts (Delay et al., 2006). The experimental concepts were based on feedback from the Mont Terri rock Laboratory (Pearson et al., 2003). They are of two types: one based on water circulation and the other combining gas circulation and water sampling. In addition, sampling of seepage water was possible in an isolated borehole at -490 m (called “SUG”) devoted to hydrogeological measurements. The PAC borehole test intervals were drilled with nitrogen to avoid oxidation of the formation. Furthermore, maximum precautions were taken to avoid bacterial contamination (disinfection of the equipment, of the injected water, etc.). The SUG borehole was drilled with air, without antimicrobial precautions. The water circulation experiment consists in circulating synthetic porewater in a closed loop between the test interval located at 10 to 15 m depth in a borehole and devices for sampling and online measuring installed in the URL drift. The circulating water composition is alike the real porewater and traced with D and Br. It was defined on the basis of the geochemical model. In contact with the rock, the water evolves towards equilibrium with the interstitial water by rock-water reactions, diffusive exchange and inflow. Two water circulation experiments were installed: PAC460 at -460 m and PAC505 at -505 m. The water sampling and gas circulation experiment consists of a vertical ascending borehole with a 5 m long test interval at its far end (Vinsot et al., 2007). After installation of the equipment, the test interval was filled with pure argon at a pressure of 1 bar. The borehole equipment allows the circulation of the gas in contact with the rock in a closed circuit. Due to the large hydraulic gradient between the test interval and the surrounding rock, the water flows into the interval and is pumped out at a rate of 20 to 40 mL/day. The borehole equipment allows the sampling of the water produced in the test interval. Two water sampling experiments were installed: PAC430 at -430 m and PAC475 at -475 m.

GEOCHEMICAL MODEL
The geochemical model is described in Gaucher et al. (2006). It assumes thermodynamic equilibrium between the minerals of the formation and the porewater. The mineral assembly (calcite, dolomite, siderite, celestite, quartz, daphnite, illite, pyrite and either a chlorite-Mg or a fixed pCO₂) constrains the element concentrations. Also cation exchange reactions are considered.
RESULTS AND INTERPRETATION

The experimental results show an overall convergence of the measured water compositions independently of the experimental concepts (collection of seepage water or water circulation), and of the sampling depths (Figure 1).

Comparison of the observed and calculated compositions (Figure 1) shows a discrepancy below a factor of three for all the major species except potassium and strontium. Attempts at explaining the observed differences suggested a review of the Sr solubility constraints as well as the cation exchange parameters. Based on these experimental data and further developments, an improved model is now being proposed (Gaucher et al. 2007).

References:


