Modelling of the hydrochemical influence of the bentonite barrier in a geological repository. The FEBEX experiment

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The FEBEX experiment reproduces a high-level waste repository in granite at a real scale. This experiment is operative since 1996. At moment, it represents the most realistic environment where the processes affecting radionuclide migration from the bentonite to granite can be studied.The main purpose of the FEBEX experiment is the study of solute migration mechanisms in crystalline host-rock in realistic conditions.

Two boreholes parallel to the FEBEX gallery were drilled near the contact granite/bentonite with the objective of providing insights on the mass transfer from the bentonite to the granite. Periodic sampling campaigns and the analysis of the major ions and tracers included in the bentonite reveal two facts: (a) the mass transfer process is affected by the presence of a lamprophyre dyke; (b) geochemical processes such as ionic exchange, albite dissolution and mass transfer from the bentonite are able to explain the ionic content found in the sampled granitic groundwater.

Assuming the mass transfer from the bentonite to the granite, a reactive transport modelling has been performed, in order to simulate the chemical composition of the water from the drilled boreholes. Modelled results corroborate the importance of diffusive transport from bentonite to granite. An effective diffusion coeficient of $De = 6{\cdot}10^{-11}$ m^2/s has been calculated. Also, plagioclase, K-feldspar and fluorite alteration should be considered in the proposed model.

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Bacteria in backfill materials - Effects on radionuclide transport

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This study reports on the physical-chemical behaviour of swelling clays (Fe-smectite and Na-smectite) in presence of the bacteria *Shewanella putrefaciens.* Experimental results are presented for i) interaction in smectite solutions and ii) for smectites hydrated under confined volume conditions relevant to the underground disposal of nuclear waste. Here swelling clays are considered as suitable back-fill material since the hydraulic conductivity and the capacity for radionuclide transport is drastically reduced in the hydrated state. For *in situ* study a new type of reaction-cell was designed for X-ray diffraction (XRD) measurements [1]. Modelling diffraction patterns in combination with water vapour adsorption data enabled determination of the abundance of structured water layers, developed in the interlayer space (responsible for backfill sealing), and the amount of water that remains on surfaces and in open pore spaces (vector for radionuclide transport).

The effect of *S. putrefactions* on batch solution chemistry monitored by ICP-OES and microscopy (TEM coupled to EDX) and showed depletion of the main cations in the Fe-smictite extracted solution attributed to the initial consumption and/or binding. The constantly depleted Ca is most likely stored in the abundant EPS (exopolymeric substance). Enhanced cation release in the case of Fe-smectite in long-term experiments was especially evident for Fe and Al that corresponds to more than 10% partial dissolution. In contrast, the Fe-poor, Na-smectite was not seen to be affected by bacterial activity in this way and the increased release of Al corresponds to only 1.4% partial smectite dissolution. Abundant textural changes were observed by microscopic investigations, associated with the formation of smectite-aggregates and biofilms. In confined volume conditions, the presence of bacteria in Na-smectite was seen to enhance both the uptake of interlayer water (sealing capacity maintained) but as well the amount of externally stored surface and pore water. Here the presence of bacteria leads to enhancement of sample porosity that is attributed to the formation of biofilm-associated aggregates that might enhance the transport capacity for radionuclides.

[1] Warr & Hofmann (2003) *J. Appl. Crystallogr.* **36**, 948-949.