

Hydrogeological and hydrogeochemical investigations at the Andra Meuse/Haute-Marne Underground Research Laboratory.

Vinsot Agnès, Delay Jacques, Dewonck Sarah & Cruchaudet Martin

Andra, Laboratoire de recherche souterrain de Meuse/Haute-Marne, F-55290 Bure, France.
agnes.vinsot@andra.fr, jacques.delay@andra.fr, sarah.dewonck@andra.fr,
martin.cruchaudet@andra.fr

In November 1999 Andra began building an Underground Research Laboratory (URL) on the border of the Meuse and Haute-Marne departments in eastern France. The research activities of the URL are dedicated to reversible, deep geological disposal of high-activity, long-lived radioactive wastes in an argillaceous host rock. The target horizon for the URL is a 130-m-thick layer of argillaceous rocks that lies at about 420 to 550 m below ground level.

One of the major aspects covered by the experimental work in the URL concerns the characterization of the confining properties of the rock. These confining properties come from the physical characteristics of the rock and the physico-chemical characteristics of the interstitial fluids and their interaction with the rock. One of the fundamental physical characteristics is permeability. This property is studied through various specific tests. The chemical characteristics of the interstitial fluids condition the mobility of the various radionuclides likely to be found in the natural environment. This mobility depends on the radionuclide diffusion and retention properties in this argillaceous rock. Dedicated *in situ* experiments focus on knowledge of the geochemistry of the interstitial fluids and on the diffusion and retention capabilities of the radionuclides.

Hydrogeological characterization

Permeability data have been measured with various devices and methods (Distinguin & Lavanchy 2006; Delay et al. 2006):

- through packer tests carried out in deep boreholes,
- deduced from pressure measurements carried out through long-term monitoring devices in deep boreholes,
- deduced from pressure measurements carried out in various types of multi-packer devices in short boreholes in the URL drifts,
- measured on core samples.

Results are very coherent. At the scale of the laboratory site, permeability is below 10^{-12} m/s over the entire thickness of the argillaceous formation with a minimum value estimated at 10^{-14} m/s. No truly perceptible scale effect appears.

Pore water characterization

Two aspects related to pore water composition are being studied. The first one concerns the knowledge of the hydrogeochemical mechanisms governing this composition. The second aspect concerns the distributions of non reactive natural

tracer concentrations. Indeed, the interpretation of the observed distributions helps to evaluate the history of solute transfers.

From the outset, the Callovo-Oxfordian pore water composition has been studied through measurements performed on core samples from deep boreholes. A conceptual model of the pore water composition based on thermodynamic equilibrium has been built and a consistent set of data has been obtained on natural tracers such as water stable isotopes and chloride (Andra 2005; Waber et al. 2005). In 2004, *in situ* direct sampling of the water was carried out for the first time in this formation and has been performed continuously since then.

Analytical results of the water samples show that the model provided satisfactory prediction for the pore water below a factor 2 for most of the major species. The compositions observed on the water samples should help improve the conceptual model. They confirm the vertical variations of the chloride concentrations and should help refine the results obtained on cores for this species over the entire profile.

Diffusion characterization

Diffusion properties were measured i) on a large set of 1 cm-wide samples from drill cores, using through-diffusion cells and ii) *in situ*, in the constrained rock, by seven experiments carried out in the URL. The *in-situ* diffusion experiments gave access to the diffusive parameters for HTO, ²²Na, ¹³⁴Cs, ³⁶Cl and ¹²⁵I. The obtained results are in good agreement with those obtained from through-diffusion tests on drill core samples (Dewonck et al. 2006).

Experiments devoted to hydrogeological and hydrogeochemical characterization are still in progress in the URL and will continue for the next years. They lead to a consistent description of the studied properties of this argillaceous rock.

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