

Context

ONDRAF/NIRAS, the Belgian Agency for Radioactive Waste and Enriched Fissile Materials, together with SCK•CEN is preparing the Safety and Feasibility Case 1 (SFC-1) which is to be submitted to the government by the end of 2013. The aim is to demonstrate that geological disposal of high-level waste and spent fuel in a clay formation is feasible and safe.

In Belgium, Boom Clay is considered as a reference host rock formation to study the geological disposal of high-level waste and long-lived radioactive waste. Determining the containment capacity of the potential host formation is thus essential to guarantee long-term safety.

Objectives

The overall objective of the research performed by the Unit R&D Disposal is helping to build the assessment basis for SFC-1 with respect to radionuclide migration and retention processes. Therefore, research is performed on:

- The characterization of Boom Clay mineralogy and pore water geochemistry.
- Geochemical and reactive transport modelling.
- The migration and retention processes of waste relevant radionuclides.
- The impact of perturbations on Boom Clay properties, such as:
 - thermal induced modifications of Boom Clay;
 - alkaline plume;
 - gas generation and migration;
 - climate change.

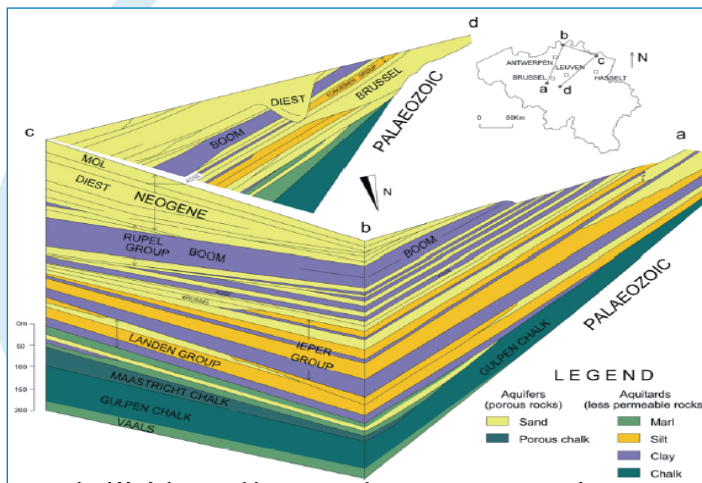


Figure 1. Geological cross-section through the Campine Basin (NE Belgium).

Main activities

• Geosynthesis

The main aim of the geosynthesis project is to compile and integrate all geoscientific knowledge on the Boom Clay and its geological environment in the Campine area, and to evaluate its past and possible future long-term evolution (including seismics, tectonics, magmatism, ...). For millions of years, the Campine area was a large sedimentary basin in which large amounts of sediments were deposited. During the Tertiary period, several transgressions and regressions occurred and resulted in the deposition of mainly clay and sand layers (figure 1). Boom Clay is the thickest clay layer occurring in this sequence of sediments. In the map given in figure 2, the entire Boom Clay thickness and depth within the Campine Basin is illustrated. As the Earth's climate has changed throughout geologic time and will continue to change in the future, another objective of the geosynthesis project is to evaluate the consequences and impact of various climate states on the regional geology and performance of the repository system components.

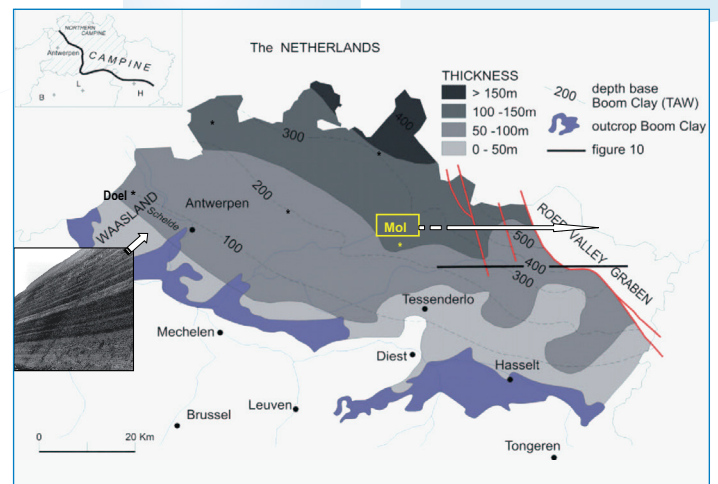


Figure 2. Boom Clay thickness within the Campine Basin (NE Belgium).

• Geochemical and reactive transport modelling

One of the major pillars in data interpretation is the execution of reliable geochemical and reactive transport calculations/simulations. As modelling results are strongly dependent on the used thermodynamic data, their quality has always been a major concern within the Belgian research programme. As a consequence, it was decided to compile a high-quality thermochemical database, i.e. "MOLDATA" (referring to the location of SCK•CEN in Mol). The compilation of MOLDATA has been realized through an in-house developed software tool, the so-called Geochemical Database Processor. The latter represents computer software to convert and recalculate geochemical data from various sources and different formats.

- **Migration and retention processes of waste relevant radionuclides**

For many years, SCK•CEN made a lot of efforts on the direct measurement of radionuclide migration parameters in Boom Clay (figure 3). This pioneering work enabled SCK•CEN to build up an important experience in this field and a huge amount of data is available. However, there remain still open questions and the interpretation of migration experiments is not always straightforward. Therefore, the transport of radionuclides which may escape from the waste packages is studied both, on small scale representative core samples in the surface labs and at large-scale in the Underground Research Laboratory HADES, 225 m under the SCK•CEN site. These experiments try to mimic as close as possible the real situation and can as such be used directly as demonstration. In order to understand the underlying processes of radionuclide migration/retention, detailed studies on the interaction of radionuclides with natural organic matter (e.g. colloid formation), their sorption, solubility and speciation are needed.



Figure 3: Experimental set-ups used for the direct measurement of radionuclide migration parameters.

- **Impact of perturbations on Boom Clay properties**

In order to assess the safety of a repository in Boom Clay, it is necessary to evaluate the impact of perturbations on the original transport properties of the Boom Clay. Therefore, the following perturbations are studied:

- **Thermal induced modifications of Boom Clay**

Even after a cooling period of ~50 years, vitrified high-level waste and spent fuel still generate significant amounts of heat when disposed of in a repository. As a result, the host rock temperature will increase. An important consequence of this temperature increase on the geochemistry, is the decomposition of the kerogen (insoluble organic matter) present in the Boom Clay. This results in CO₂ production which might disturb the rock-water chemical equilibrium.

Within the frame of the European project TIMODAZ, the importance of these various thermo-chemical processes on the mineral stability of Boom Clay are identified and assessed. Special attention is paid to the analysis of safety-relevant clay properties, e.g. swelling, cation-exchange capacity, surface area and hydraulic conductivity. Besides different laboratory studies, SCK•CEN, EIG EURIDICE and ONDRAF/NIRAS carry out a large-scale in situ Heater Test (the PRACLAY Heater experiment, figure below left) in which the thermo-hydro-mechanical-chemical behaviour of the clay environment upon heating will be monitored and studied for a long period on a true scale.



Left: On-line water and gas sampling/analysis systems installed as part of the PRACLAY Heater test to monitor the chemical evolution upon heating. Right: Newly designed set-up for the measurement of gas diffusion coefficients through Boom Clay plugs.

- **Alkaline plume**

The use of concrete materials is omnipresent in the current reference concept (the so-called Supercontainer concept) and therefore host rock-cement interactions and the creation of an alkaline front or plume need to be studied and evaluated.

- **Gas generation/diffusion**

The main mechanisms by which gas could be generated in deep repositories are: anaerobic corrosion of metals in wastes and packaging; radiolysis of water and certain organic materials in the packages, yielding mainly hydrogen; and microbial degradation of various organic wastes, giving methane and carbon dioxide as the main products. The W&D expert group is involved in the EC project FORGE (Fate of repository gases) which has been initiated to tackle research on safety relevant issues associated with the generation and transport of repository gases (figure above right).

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