ON THE WAY TO SITING AND LICENSING A DEEP DISPOSAL: WHAT ABOUT THE RESEARCH PROGRAMME ON THE CALLOVO-OXFORDIAN FORMATION

P. Lebon, P. Landais

Andra. 1-7 rue Jean Monnet, F92298 Châtenay-Malabry (patrick.lebon@andra.fr, patrick.landais@andra.fr)

The French Act published on the 28th of June 2006 has paved the way to siting of a repository in the transposition zone of the Meuse/Haute-Marne laboratory, so that the repository could be built and operational in 2025. Keeping in mind this long term objective, Andra has to prepare a licence application before 2015. The national plan for the management of radioactive materials and wastes (PNGMDR) provides intermediate key milestones to the development plan of the HLW and ILW geological repository project, which fit with our step-by-step approach.

At the 2009 milestone, a limited area in view of detailed survey for the repository location has been proposed and a range of safety and reversibility related options for the design of the repository has been defined. The next 2012 milestone corresponds to the preparation of a public debate to be held in 2013. All the facilities of the repository have to be described in regard of surface location proposal(s) and their main impacts on the site environment identified. A first version of the scientific and technical bases of the future application will be presented. For the last milestone (Dec. 2014), Andra will issue an application for the licensing procedure, containing in particular a preliminary safety report. As a consequence, the research programme has to address the challenging issues and their connection with design, safety and reversibility for these milestones.

While the safety analysis conducted reveals that the repository appears to be robust in all the configurations envisaged with respect to its safety functions, both CNE and safety authority evaluations focus on the necessity to provide more comprehensive and realistic modelling of the repository behaviour for both exploitation and post-closure periods and of the radionuclide migration (e.g. characterising transport properties of EDZ, determining the hydric transient taking into account the gas production within the repository). Such requirements, that frequently request research developments that are at the frontiers of actual science, imply a dedicated organization of the research program that has been set up by Andra in early 2007.

A sustained program has been prepared in view of the 2012 report. It is divided into three thematic: (i) control of the basic phenomenological processes, (ii) process coupling in the repository and with its environment, (iii) data upscaling, and it is supported by a thorough URL experimental programme. This programme is launched progressively with a view of confirming acquired data and reducing further the margins of uncertainty, as far as it can significantly support the robustness of safety and design options.

Full knowledge and control of migration processes taking place in the surrounding environment of a repository tightly depend on the rock sampling representativeness and on the detailed observation of full scale structures in order to assess the real behaviour.

A significant part of the R&D programme is devoted to studying mechanisms responsible for the release of radionuclides and chemical toxics under repository conditions, taking into account the interactions between the materials of the structures and the geological barrier. Long term geochemical experiments were installed in the URL in 2009 to survey interactions between argillite, steel and glass by regular sampling from now to 2030. Determining the chemistry of the radionuclides in solution at temperatures between 50 and 80°C (in relation with argillite porewater chemistry) also represents an important and long last effort intended to supply the thermodynamic databases for the safety assessments.

According to the EC project “FunMig” and the results of our research programme we can reasonably consider that we dispose now of consolidated data on the transport properties of argillite, advective as well as diffusive, under chemical or thermal disturbances. They will be reinforced by characterising the natural

processes resulting from fluid-rock interactions within all the formations from Trias to surface (in progress) and by a new long term diffusion experiment (2012-2027). The assessment of a colloidal transport is pursued based on the accessibility to the rock and undisturbed fluids.

One of the main remaining questions addresses the fate of gases into a geological radwaste disposal. The EC project "Forges" has been built to answer to it. Progress has been obtained on understanding the migration processes and modelling the water and gases coupled transfers into the disposal components. We should now make headway with URL experiments acquiring new data in more realistic conditions.

The construction, operation and closure of underground structures entail strongly coupled mechanical, thermal, chemical and hydric disturbances linked to the loss of rock confinement and the introduction of exogenic materials and air not in equilibrium with the medium's environment. The physical/chemical interactions between alteration processes have to be covered by additional research to ensure an optimisation of the repository architectures and a more detailed phenomenological modelling for future safety assessment.

Excavated Damage Zone geometry and self sealing data have been acquired by five-year *in situ* multi-disciplinary investigations in the URL drifts (observation and characterisation of the processes responsible for the damage, such as fissuring, de-saturation or oxidation). They have been consolidated by the shared conclusions of the EC project "NF-PRO". Even if extensive strain measurements give robust empirical information on the behaviour of the drifts, hydro-mechanical mechanisms responsible for that behaviour remain largely uncertain and let reservations about the long term strain rate. Progress will be met by two complementary ways: development of large scale URL experiments, and enhancement of micro-mechanics studies.

Regarding the THM couplings, questions subsist on the nature of the phenomena to take into account and on their possible competition when the medium is made up of multiple interfaces. In order to specify the impact of temperature on the behaviour of the materials, we will strive to reduce uncertainties on the behaviour of the concretes at higher temperature, for the sake of identifying the nature of the neoformed phases which result from their alteration under saturated and unsaturated conditions. Efforts are made on the argillite THM behaviour during the unsaturated phase with a production of gas. This approach will be tightly associated with technological demonstration actions about HLW cells.

Another recommendation by various reviews was to create demonstrator models not only for building and closing disposal structures. In situ technological demonstrators are being constructed close to scale or at full design scale and operated, to demonstrate adequate design and industrial realism. In situ demonstrators focus on drift construction as well as disposal cell and access drift sealing and backfilling.

A data upscaling challenge is to transcribe all the results into a representation at the disposal scale. 2007-2008 reconnaissance campaign was peculiarly focused on acquiring complementary mechanical and geochemical data on Callovo-Oxfordian within the transposition zone. It has been shown that these properties are tightly linked to the argillite petrofabric and that diagraphy logs and 2-D seismic profiles confirm the petrofabric homogeneity of the transposition zone. The collected information allowed identifying a restricted 30-km^2 area more suitable for a radwaste disposal. A 3-D seismic campaign is about to be carried out onto the selected area. It should then support the decision to designate a specific construction site (2012), to be discussed during public debate.

The last objective is dedicated to monitor the disposal on a long term. The R&D programme aims at proposing a viable monitoring strategy, based on both technical and stakeholder considerations and at developing gauges for acquiring data as distributed temperature and strain measurements by optical fibre sensing, argillite and concrete moisture and hydrogen content, or chemical parameters by means of miniature spectrometer. Another task tackles the disposal conditions (temperature, in situ stress, and irradiation) by hardening gauges and increasing their reliability over several decades. In addition in-situ demonstration of innovative monitoring techniques specifically responding to some cell design will be performed in the URL, notably to test full measurement systems. In this framework the EC project "MoDeRn" aims at providing a reference framework for the development and possible implementation of monitoring activities and associated stakeholder engagement during relevant phases of the radioactive waste disposal process, i.e. during site characterisation, construction, operation and staged closure, as well as a post-closure institutional control phase.