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Uncertainty and sensitivity analysis within the post closure Performance and Safety Assessment of the French deep geological radwaste disposal: methodology, tool and examples of results

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Within the framework of the December 30, 1991 french act, Andra submitted to the French Parliament in December 2005 a report on the feasibility of a high-level and long-lived radwaste disposal in the Callovo-Oxfodien clay layer (Meuse/Haute-Marne site). Further to 2006 french act, Andra is now involved in licensing of the reversible disposal up to 2015, which requires a great scientific and technical knowledge. Studies are based on many years of research carried out in France, in particular in Andra's Meuse/Haute-Marne Underground Research Laboratory (MHM URL), and international programs on radwastes, engineered barriers and deep clay formations. Intensive programs on hydraulic, solute transfer and radionuclides behaviour (solubility, retention) were and are carried out on Callovo-Oxfordian argilites (undisturbed and damaged), concrete materials and swelling clay based material, in order to provide a sound database. All these data allowed to perform firstly a sound description of the expected phenomenological evolution of the repository and its geological environment (including release and migration of radionuclides) from operating period to post closure period up to one million years, secondly a sound post-closure performance and safety assessment covering the different waste types (ILLW, HLW).

Various safety scenarii were defined to quantify radiological impacts and to evaluate performance of the components and safety functions in post closure using specific indicators (concentration, molar rate, water flux…). According to the RFS III2.f (french safety rule related to deep geological radwaste disposad), there is no risk analysis in post closure and assessments are performed using deterministic situations, models and values. To complete analysis, propagation of uncertainties from models and input data in Performance and Safey Assessment (PA/SA) models is done using both deterministic and multiparametric probabilistic approach, with two main objectives: (i) to quantify the dispersion of results (time, maximum...); this part deals with uncertainty analysis, and (ii) to identify relevant models and input data whose uncertainty manages uncertainty of the results; this part deals with sensitivity analysis.

First this paper describes Andra's methodology and numerical tool used. Then it presents results applied to Monte-Carlo probabilistic multi-parametric study on HLW (vitrified waste) disposal, in order to study propagation of uncertainties of input data (Callovo-Oxfordian, EDZ (Excavated Damaged Zone), and Engineering components) on various radionuclide pathways within the disposal.

The methodology consists of (i) setting up probabilistic distribution function (pdf), according to the level of knowledge, (ii) sampling all pdf with Latin Hypercube Sampling methods, (iii) ensuring physical coherence in sets of input data, using correlations and constraints, (iv) using integrated computing tool (Alliances platform) to perform calculations. Results focus on:

- uncertainty analysis: multi-parametric study shows (i) that transfer through undisturbed argillites remains the main pathway, (ii) a large dispersion (several orders of magnitude) of molar rate at the top of clay layer for the two pathways (undisturbed argillites, and repository structures), which includes reference point of altered scenario, such as seal failure one, and which is close to worst case one.

- sensitivity analysis: for undisturbed argillites pathway, calculations highlight that uncertainty on some

input data such as adsorption of Iodine, solubility limit of Selenium, diffusion and vertical permeability of undisturbed argillites, manages dispersion of the results. For repository structures pathway, uncertainty on hydraulic properties, such as permeabilities of EDZ, are relevant. This study is important to identify knowledge of parameters which has to be increased in order to reduce dispersion (uncertainty) of each performance assessment indicator.

Lessons learnt lead Andra to be involved now in a sound work of setting up new methods and tools to treat uncertainties, for non-linear complex problems, using metamodels such as response surface that allow to calculate Sobol indicator, or using Form/Sorm methods.