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Lessons Learned from TSPA 05

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1. Introduction

The study on the long term post closure radiological safety assessment over a potential high-level waste repository in Korea has been pursued since 1990's. Reference and alternative scenarios have been developed from the combination of features, events, and processes (FEP's). Two reference scenarios, well and natural groundwater discharge ones, have been assessed by the MASCOT-K. Case studies have been performed to identify the importance of key parameters and effects of uncertainties in the data. Alternative scenarios, excavation disturbed zone(EDZ), climate change, initial waste container failure, detailed near field ones, have been studied by AMBER and MASCOT-K also. Results indicate that for the scenarios considered in this analysis, the peaks of annual individual doses are below the regulatory guidelines. In 2005-2006 more scenarios will be assessed such as the impact of natural disruptive scenarios. Results indicate that some key parameters are important for further assessment and validation experiments in the future.

2. Lessons

The most feasible pathways fro a radionuclide released from a failed waste container in a repository embedded into fully saturated crystalline rock is fracture networks and subsequent biospheres. Two distinct biospheres are identified in normal release cases,; the one is the small size well dedicated to extract groundwater to cover the needs for daily livings, the other is the natural discharge to the ground surface, a river, or a sea. In the latter case, a radionuclide passing through a buffer flow along a fracture network surrounded by a porous medium. It encounters a major waster conducting feature(MWCF) which can be modeled as an equivalent porous medium. The factors affecting radionuclide transport in reference scenarios are; a waste container life time, a rate of initial defective waste container, nature of dissolution of a radionuclide, solubility limits of uranium matrix and its oxidation to U_3O_8, sorption of a radionuclide onto bentonite buffer and geologic medium, thickness, porosity, and permeability of EDZ, matrix diffusion depth into a porous rock from a water conducting fracture, permeability of a fracture in association with its fracture aperture, length of a fracture, colloidal formation and its transport in a fracture, advective and dispersive characteristics of the MWCF, a length of a the MWCF, and biosphere characteristics.

Among these, following parameters turn out to be important:

(1) a waste container life time if it is longer than 100,000 years,
(2) a permeability and an aperture of a fracture,
(3) matrix diffusion length, and
(4) features of MWCF.

The retardation mechanism turns out to be less important, because the dominant nuclide over the annual individual dose, iodine is not sorbed by the currently proposed bentonite and a geologic medium. From this analysis, following future R&D items are prioritized.

(2.1) Near Field

(1) development of a new additive material to bentonite buffer to enhance the sorption capability of iodine while not disturbing the natural stability of bentonite and its current capacity to sorb other nuclides,
(2) understanding on the time and detailed processes of re-saturation of a bentonite buffer by intruding groundwater from a fracture,
(3) effect of alpha radiolysis and the amount of hydro-peroxide from the reaction,

(4) long term dissolution mechanism such as instantaneous release fraction (IRF), reaction of pore water in a bentonite buffer with a waste matrix, and the time of the first order kinetics before reaching to an equilibrium state, and
(5) more understanding on corrosion mechanisms under reference Korean groundwater compositions and identification of correlation between uniform and pitting corrosions.

(2.2) Far Field

(1) confirmation of the existence of matrix diffusion and if any the length of matrix diffusion in a surrounding porous medium,
(2) long time measure of hydraulic behaviors of a fracture network and new technologies to identify a water conducting fracture,
(3) validity of the current dispersion mechanism and a clear definition of dispersivity in a physical world, and
(4) change of sorption coefficient by salinity.

(2.3) Overall Assessment

(1) new development of a computational tool to assess the coupled behavior of rock stress change, a fracture aperture in association of salt water intrusion,
(2) database in a single package, from geologic data such as strata information, geochemical data, nuclide data, and biosphere one with full graphic user-interface and quality assurance systems,
(3) data for natural events occurring over tens of thousand years, such as erosion, uplift, etc, and
(4) more precise groundwater flow assessment model to accommodate matrix diffusion from the current 1-D approximation.

3. The Way Forward

FEP/Scenario Development

It is important to develop scenarios from the expert elicitation processes. The major elicitation processes will be conducted throughout 2005-2006. Once a new scenario is created the subsequent assessment context and method will be developed by KAERI's cyber R&D platform software under revision now.

Validation by the 1st and 2nd phase KAERI underground research facility(URF)

The characteristics of a crystalline rock will be examined during the operation of the 1st phase K-URF and its potential expansion by 2011. Especially items (2) and (3) in the previous section (2.2) can be tested extensively.

Laboratory research to support the performance assessment and to enhance the function of a proposed disposal system

Items under the section (2.1) can be simulated by laboratory experiments. The item (1) in the section (2.2) will become the interesting topic to be conducted by careful laboratory experiment to really understand whether the current credit of matrix diffusion really happens in Korea fractured porous media.

Overall Assessment

To fulfill the gap between the science world and the general public, more analysis should focus on the what if scenarios. These what if scenarios are combinations of coupled processes such as man made and naturally occurring events. To asses these quantitatively is not an easy task. However, it can be pursued by stretching out the current MDPSA code developed by KAERI step by step.

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