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An Illustrative Nuclide Release Behavior from an HLW Repository due to an Earthquake Event

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1. Introduction

Program for the evaluation of a high-level waste repository which is conceptually modeled as shown in Fig. 1 has been developed by utilizing GoldSim[1] recently. During the last few years, programs developed with the aid of AMBER[2] and GoldSim by which nuclide transports in the near- and far-field of a repository as well as transport through the biosphere under various normal and disruptive release scenarios could be modeled and evaluated, have been continuously demonstrated.[e.g. 3]

To show its usability, as similarly done for the natural groundwater flow scheme[4], influence of a possible disruptive event on a nuclide release behavior from an HLW repository system caused naturally due to an earthquake has been investigated and illustrated with the newly developed GoldSim program.

2. Methodology and Illustrations

Once a leakage from a damaged HLW canister through tiny holes happens, nuclides will spread out to the buffer material surrounding a canister as well as the backfill region in the tunnel before farther transporting into the flowing groundwater in the internal fractures and the major water conducting faults (MWCFs) of the far-field area of the repository. And then the nuclides will finally reach the human environment by passing over the geosphere-biosphere interface for an exposure to human bodies.

In view of a typical Korean geological situation two media could be characterized for the natural fractured rock media: First one is an internal fracture existing between the near-field zone of the repository and frequently modeled as a single fracture and the other one is the MWCF zone through which all the nuclides released from the internal single fracture are assumed to transport upwards into the biosphere. Nuclide transport in the MWCF is also assumed to be dominated by an advection, facilitating in the application of a pipe pathway in the same way as the case of the internal fracture.

Between two nuclides arbitrary chosen for the illustrative purpose, ^{129}I and ^{135}Cs, both of which have long half-lives, ^{129}I is assumed to be almost nonsorbing for the whole media in the near-field and far-filed and thus could give higher and faster breakthroughs than any other nuclides, whereas ^{135}Cs is selected mainly due to its long half-life and one of the principal nuclides in a typical spent PWR canister with some sorption capability. They both have an instant release fraction from the gap and the grain boundaries inside the clad that are assumed to amount to 10% of the total inventory resulting a contribution of early peaks to their breakthrough.

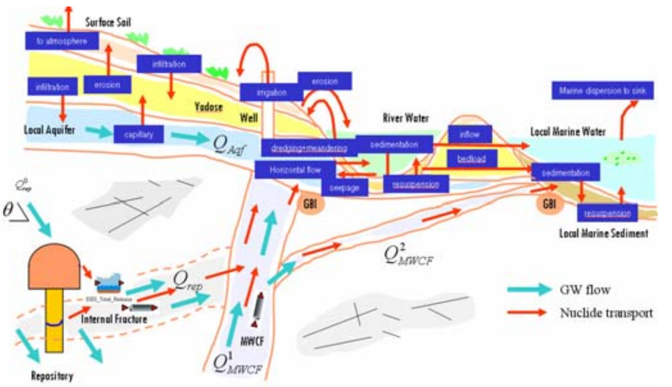


Fig. 1. Conceptual Modeling Scheme for *GoldSim* TSPA Model

A scenario considered here is a simple earthquake event, due to which such disruptive changes as both a decrease of the MWCF length and groundwater flow rate, and a possible loss of some repository system component which could cause a direct connection of the near-field directly to the MWCF, by bypassing the internal fracture could happen.

For two such principal parameters, the magnitude of the earthquake and the distance between the repository and the epicenter are assumed to have statistical behaviors of the loguniform distribution with the range of [5.5, 8.0] and the triangular distribution with the range of [0, 10, 25] km, respectively. Earthquake events are assumed to occur with a frequency of 10^{-4} per year based on a Poisson distribution for a random time interval. A simulated result from a Monte Carlo calculation with each 1000 sampling number for the magnitude of the earthquake and the distance to the epicenter is shown in Fig. 2. For every single earthquake event, whenever the magnitude divided by the distance to the epicenter is greater than 1.0 km^{-1}, the length of the MWCF is assumed to become 0.9 times shorter than the previous length and the flow rate in the MWCF is assumed to increase 2 times from the previous flow rate, and the earthquake has a magnitude greater than 7.0 is also assumed to even allow a bypass of the internal fracture, directly connecting the repository tunnels to the MWCF.

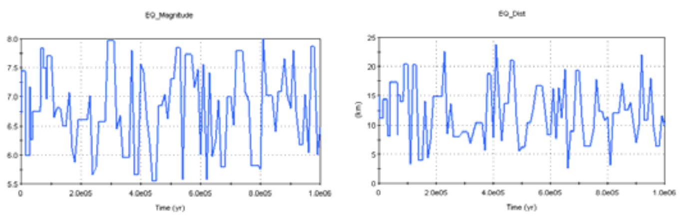
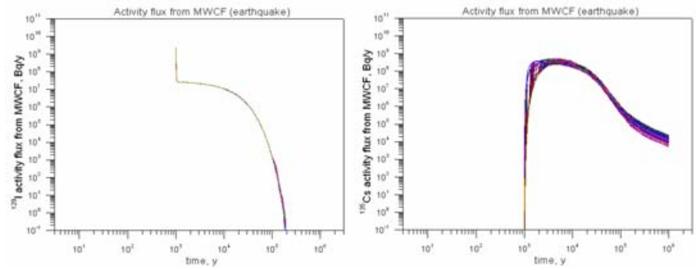
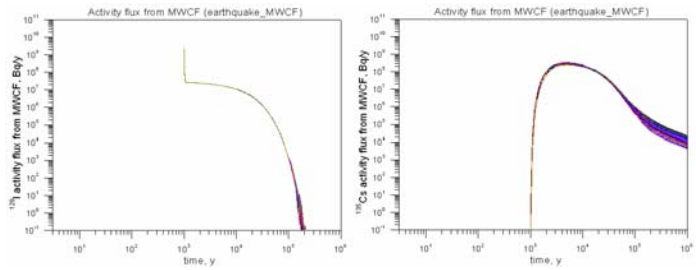


Fig. 2. Simulated earthquake event: a. magnitude distribution and distance to the epicenter from the repository

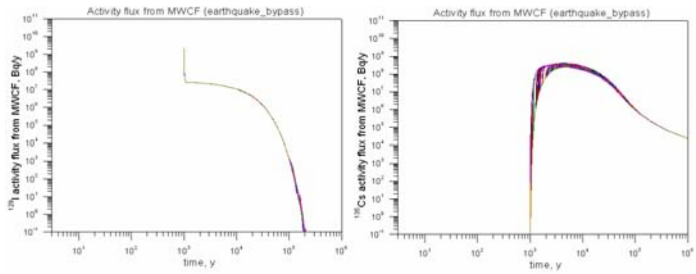
In Fig. 3, where both nuclides show a variation of their breakthroughs both in the early and later times, it is easily known that the variation of the breakthroughs in the early time is influenced from the bypass effect, whereas the variation in the later time is originated from the change of the flow rate and length in the MWCF together.



(1a) (1b)



(2a) (2b)



(3a) (3b)

Fig. 3. Breakthroughsof fluxes of (a) ^{129}I and (b) ^{135}Cs from the MWCF due to earthquake events: (1) both flow and length change and bypass; (2) bypass internal fracture only; (3) flow and length change only

REFERENCES

[1] GoldSim Contaminant Transport Module, User's Guide, Version 4, GoldSim Technology Group, 2006.

[2] AMBER 4.4 Reference Guide, Enviros, U.K., 2002.

[3] Y.M. Lee et al., "Nuclide Release from an HLW Repository: Development of a Compartment Model," *Annals of Nuclear Energy*, 34, 782-791, 2007.

[4] Y.M. Lee and Y. Hwang, "Sensitivity of Nuclide Release Behavior to Groundwater Flow in an HLW Repository," *Transactions of the Korean Nuclear Society Spring Meeting*, Gyeongju, Korea, May 29-30, 2008.