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Influence of a Tunnel Crown on the Nuclide Release from a HLW Repository

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1. Introduction

Spent fuels (SFs) which will be the only type of HLW in Korea and encapsulated in canisters are to be disposed of in deposition holes surrounded by bentonite clay, drilled into the bottom of tunnels at a depth of about 500 m in a crystalline rock. The basic repository design is currently being developed under the name of the Korea Repository System (KRS) [1].

It is very important to quantify the nuclide release through several possible pathways in the near-field of the repository where groundwater bearing fractures are available for carrying the nuclides released from the canisters damaged initially or due to whatever reason after a disposal in view of a safety assessment of the repository as well as its design feed back.

A detailed modeling, quite similar to the one studied in Swedish KBS3 SR97 [2], but with a more in depth approach, for the nuclide transport through the near-field with newly introduced repository system features for a compartment modeling such as the excavation disturbed zone (EDZ) and tunnel crowns, both of which are expected to accelerate a nuclide release from the near-field of the repository has been developed by utilizing AMBER [3] under the name of ACGEO [4-7].

After a leakage from the canister, nuclides will spread out through the buffer material surrounding the canister before migrating farther into the flowing groundwater in the fractures possibly embedded at various locations of the host rock medium through which a preferential nuclide transfer into the far-field seems to take place.

To exclusively investigate the influence of a tunnel crown space in a compartment modeling scheme for the tunnel on a nuclide release, among many other near-field components, nuclide releases for 4 arbitrarily chosen nuclides both from the near-field as well as far-field of the repository are investigated. From among all seven possible sensitive exit points shown in Fig. 1, Q1 which is regarded as the most critical pathway having a fracture intersecting deposition hole is the only are investigated for a far-field nuclide release, whereas all the other leakage points Q1 through Q6 are investigated for near-field nuclide releases. Q6 is directly associated with a tunnel crown and nearby fracture.

2. Modeling

As shown in Fig. 2, an AMBER case template ACGEO is developed based on a compartment modeling method by accounting for the physical geometry and repository materials that could influence a nuclide transport.

Calculation of the nuclide flow rate from the near-field is made by accounting for such important parameters involved in a nuclide transport between compartments as a transport resistance which is determined by the volume and distribution coefficient, interfacing area and diffusion length associated with each compartment.

Once nuclides in the SF matrix as well as in such a gap portion as grain boundaries and cladding, where nuclides are immediately available to a release, are contacted with groundwater, their transfer and transport begins to take place through small holes or canister defects. After this, the nuclides continue to transport to the surrounding buffer, tunnel backfill and rock matrix as well as a tunnel crown space (if any) which could provide a preferred fast groundwater flow pathway as discussed in the literature [8].

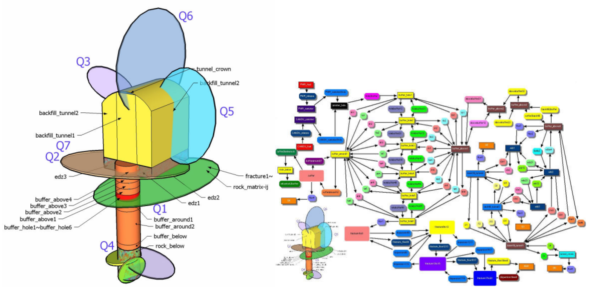
For the groundwater bearing fractures in the surrounding host rock, an advective transport as well as a matrix diffusion into the stagnant groundwater in the rock matrix pores with sorptions onto both the fracture wall and matrix surfaces are also accounted for.

3. Illustration and Discussion

Figs. 2 and 3 show the nuclide releases from various release exits of the near-field and the far-field of the repository. For the far-field release it is assumed that the nuclides are all transferred to the fracture from the Q1 exit where a the canister hole–

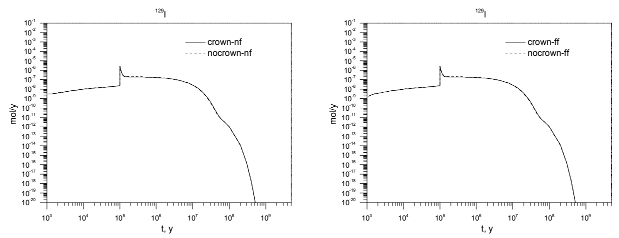
fracture interface exists. The crown space embedded beneath the tunnel roof provides a direct release exit to Q6. The canister hole area is assumed to abruptly grow at 10^5 years for all the calculations.

In each figure, nuclide release rates both from the near- and far-field for two cases, one of which one (solid line) represents the case of a consideration of a tunnel crown and the other which shows the case of no crown space consideration in a compartment modeling scheme for the tunnel are compared, even though no large difference between the two cases are found in Fig. 2. ^{129}I, which is assumed to be nonsorbing for the whole media in the near-field shows its peak at around 10^5 years in Figs. 2(a) and 2(b). The earlier reach to its peak for ^{129}I can be explained by a relatively fast IRF release behavior. Unlike ^{129}I, in Figs. 2(c) and 2(d), ^{235}U, having plenty of an initial inventory, has its peak long and later due to its long half-life (7.04×10^8 years), decay ingrowth from such parent nuclides as ^{239}Pu, and sorption capacity.

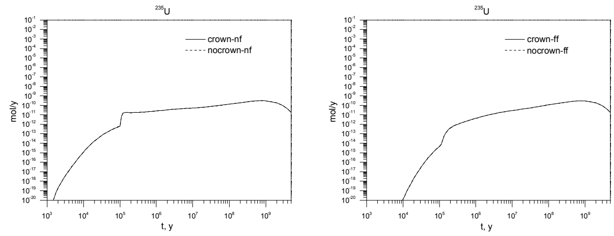


(a) (b)

Fig. 1. (a) Conceptual near-field of the repository system embedded by various fractures and (b) its implication to a compartment scheme for a nuclide release calculation.

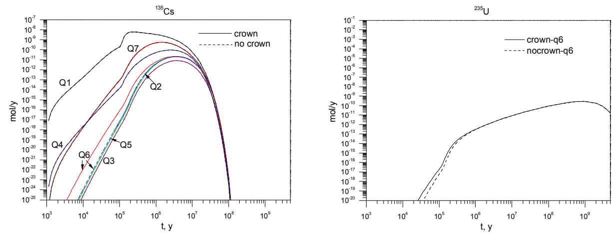


(a) (b)



(c) (d)

Fig. 2. ^{129}I release from (a) the near-field (Q1); and (b) from the far-field; and ^{235}U release from (c) the near-field (Q1); and (d) from the far-field.



(a) (b)

Fig. 3. (a) ^{135}Cs releases from all the release points; (b) ^{235}U release from Q6 point

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Among the 4 chosen nuclides, in Fig. 3, ^{135}Cs, and ^{235}U releases are compared for all the near-field release exits (Fig. 3(a)) and for only the Q6 exit (Fig. 3(b)). Except for the release from the crown space (Q6), for whatever nuclides, no noticeable change of the nuclide release rate between the two modeling schemes has been observed for the other 6 exits for both nuclides.

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