A POOR SEALING SCENARIO FOR DEEP DISPOSAL OF HIGH LEVEL WASTE

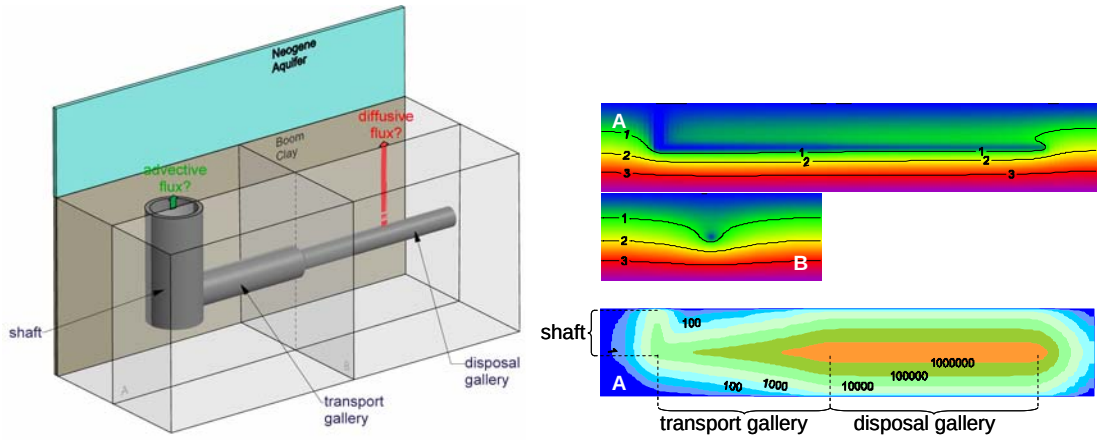
Background

Especially for geological disposal options in clay, the safety of the repository relies chiefly on the performance of the host formation as the main barrier. Understandably, scenarios in which this clay barrier is somehow bypassed earn great concern in PA (Performance Assessment) studies. The PSS (Poor Sealing Scenario) is one of those scenarios that have been recently studied by the PA section of the Waste & Disposal department in the framework of the Belgian programme on deep disposal of high-level radwaste in Boom Clay. This scenario hypothesises that at least one disposal gallery and an access shaft have been poorly sealed off, providing a preferential pathway for RNs (radionuclides). The scenario further assumes a severe climate change, which would invert the presently downward hydraulic gradient, such that the potential impact would be maximal.

Objectives

The main objective is assessing the contribution from two transport processes to the overall radionuclide migration from a spent fuel repository towards the Neogene aquifer. The processes considered are advective transport through the poorly sealed repository and diffusive transport through the host formation. In addition, we would like to identify the most influential parameters with respect to repository design and performance.

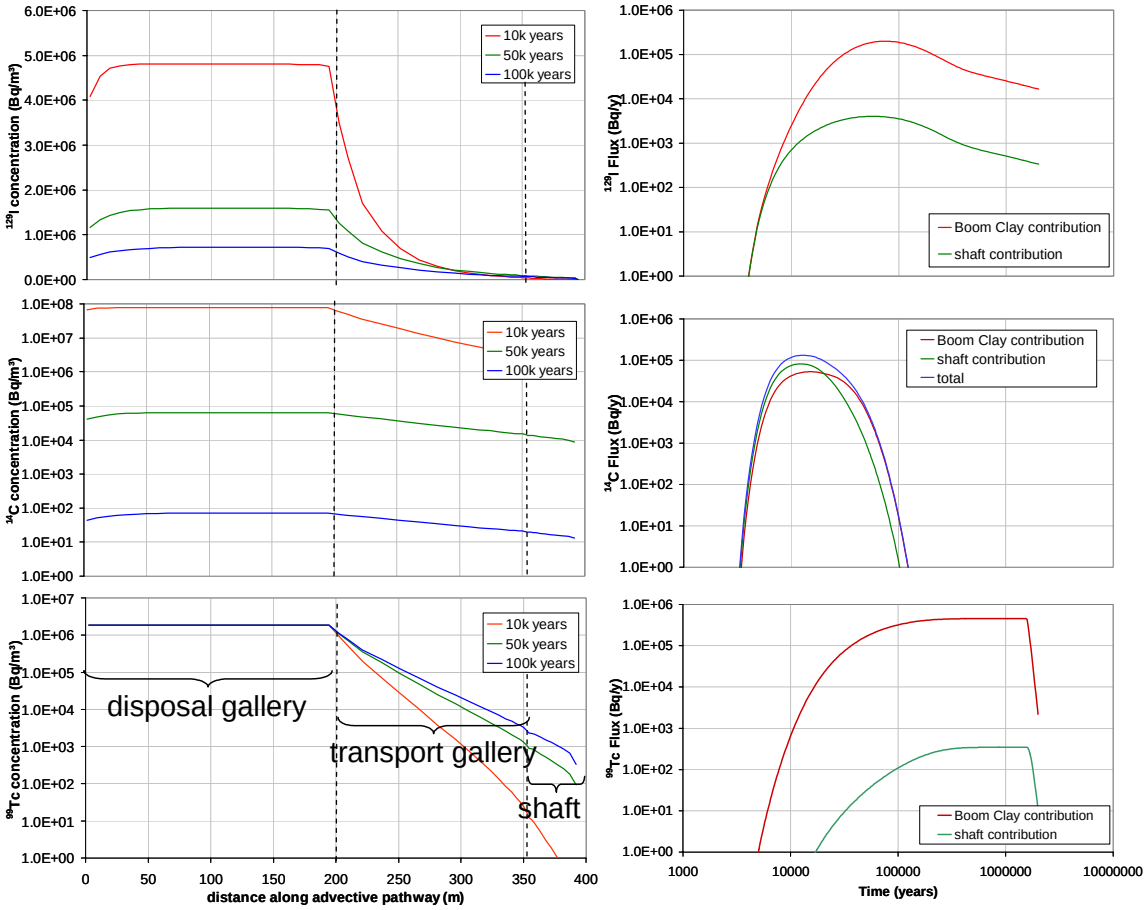
Principal results



Left: reference situation considered in Poor Sealing Scenario calculations: It is assumed that one of the disposal galleries (∅=2.2 m; l=200 m) is poorly sealed. Furthermore, the shaft (∅=6 m; l=40 m) is assumed to be poorly sealed as well. Both are connected through a transport gallery (∅=3.5 m; l=156 m). Other disposal galleries are not shown in the picture. The thickness of the Boom Clay layer is conservatively assumed to be 80 m and the shaft is in direct contact with the Neogene aquifer. Right: fields of hydraulic potential (m) at steady state (top) and ^{129}I concentration (Bq/m^3) 8000 years after canister failure (bottom).

At present, the hydraulic gradient over the Boom Clay layer is very small and oriented downward. As such, even if we conservatively assume that the hydraulic conductivity of the galleries and shaft is several orders of magnitude larger than that of Boom Clay, these conductive features will not provide a preferential pathway. However, when the gradient is inversed, for instance in case of a severe climate change (*e.g.* glaciation), the poorly sealed galleries will act as a large drain in the formation and RN fluxes into the Neogene aquifer could be increased. In this study, we assumed an inversed hydraulic gradient of 0.05, which presumably is an extremely conservative value.

Because of the small gradient across and the low hydraulic conductivity of the host formation, which is supplying the water, the flow rate through a very conductive repository is still very small, *i.e.* around 100 litre/year for a 200 m disposal gallery.



Left: concentrations along the advective pathway for 3 characteristic RNs in the Poor Sealing Scenario. Right: RN fluxes into the Neogene aquifer under Poor Sealing conditions. Advective contributions via the shaft are limited. Only for relatively short-lived RNs characterised by a substantial fraction instantaneously released upon canister failure, such as ^{14}C, the total flux is somewhat larger compared to the NES.

Transport simulations with non-sorbing, non-solubility-controlled RNs characterised by a relatively slow release from the waste matrix, such as ^{129}I, revealed that the impact of a PSS on the performance of the repository is very limited. However, in the case of relatively short-lived (in geological timescales) RNs where a considerable amount of the inventory is quickly released, such as ^{14}C, the releases from the shaft pathway can amount to about the same order of magnitude as the normal diffusive path through the host formation. The evaluation of solubility controlled radionuclides, such as ^{99}Tc, revealed that a PSS is not a problematic scenario as the concentration downstream of a disposal gallery is always inferior to the product of the flow rate by the solubility limit, whatever the inventory of the considered element in the gallery.

As the Boom Clay acts as a considerable diffusive sink for RN all along the advective pathway, it was observed that a small increase of the length of that pathway led to a significant decrease of RN releases.

Future developments

The developed model can now be used to optimise the design of the repository. In addition, the competition between advection and diffusion was found to be especially challenging for the classical numerical tools and could be explored in further benchmark exercises.

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Main reference

X Sillen,.E. Weetjens, J. Marivoet. "*Consequence analysis of a sealing defect in a spent fuel repository in Boom Clay (poor sealing scenario).*" SCK•CEN, Mol, (BLG report to be published - 2005).