TOPIC 08: Fluid flow and radionuclide migration

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Abstract

Bentonite based sealing elements are considered in repository concepts in all host rocks due to low permeability, swelling and sorption capacity of bentonite. Within the framework of the R&D project "Development of a safety and verification concept for a repository for heat-generating radioactive waste in crystalline rock in Germany" (Christa-II), BGE TECHNOLOGY GmbH has developed a conceptual design for drift seals. The conceptual design includes main sealing elements made of bentonite and concrete based abutments (Fig. 1). Regional flow can have strong impact on radionuclide transport and hence, on the long-term safety of repository. In the present study, the influence of three horizontal pressure gradients of 10 Pa /m, 100 Pa /m and 1000 Pa /m on the water velocities in the bentonite based sealing elements was investigated. Furthermore, the robustness of bentonite based drift seal in case of complete chemical degradation of asphalt elements after 10000 years for the case of pressure gradient of 100 Pa/m was analysed.

Three-dimensional simulations using TOUGH2 with module EOS3 have been performed to simulate the fluid migration through the seal.

The average water velocities in the bentonite based drift sealing system were calculated. Under pressure gradient of 10 Pa/m the average velocity is $2.35 \cdot 10^{-12}$ m/s, of 100 Pa/m is $2.35 \cdot 10^{-11}$ m/s, and of 1000 Pa/m is $2.35 \cdot 10^{-10}$ m/s. The migration velocity of the water and thus, the amount of fluid possibly containing radionuclides is increased by several orders of magnitude. Therefore, it was demonstrated that regional flow has a great influence on the water velocities in the bentonite based sealing system and hence, on the radionuclide transport in the repository.

In order to analyse the robustness of the drift seal even in case of degradation of the asphalt elements after 10000 years, the velocities in the sealing elements for the case of pressure gradient of 100 Pa/m in the model without asphalt elements were determined. The velocity in the sealing system with asphalt elements is $2.35 \cdot 10^{-11}$ m/s and increases to $8.25 \cdot 10^{-11}$ m/s after the degradation of asphalt elements. The presence of asphalt elements reduces the water velocity within the bentonite based sealing system by at least half an order of magnitude. Under assumption, that asphalt elements will not last the entire verification period, this is a positive effect that contributes to the robustness of the drift sealing system, at least during the initial

phase of the verification period, especially in the period when the bentonite has not reached its full swelling pressure and thus, its full sealing ability.

Fig. 1 Design of bentonite based drift seal