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Radionuclide migration in granitic rock environment: in-situ tracer test with radionuclide tracers

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Granitic and metamorphic rock environments are being considered as potential host rocks for the construction of deep geological repositories (DGR) for radioactive waste in a number of European countries including the Czech Republic. Therefore the evaluation of radionuclide migration under real conditions is one of the most important imputs for DGR safety assessment.

In-situ experiments with non-active and radioactive tracers were carried out in the Josef underground laboratory (CZ). Due to the significantly damaged rock environment in the Josef underground laboratory, the project focused on a rock environment with the presence of fissures (filled/opened) and a description of its behaviour with regard to the potential migration of radionuclides. Moreover, advection is considered as a main processes within such a type of test.

Firstly, a flow field intersecting a water bearing fracture was identified at the Josef Underground Laboratory. Hereby two boreholes were drilled and instrumented so as to determine and characterise an appropriate location for the potential injection of a radioactive tracer into the rock fractured massif. A number of methods were employed in order to describe the rock system in niche JP-57, fissure system and the hydraulic flow field in detail prior to tracer injection. Detailed system description included thorough core descriptions, fracture determination, Optical Borehole Imaging (OPTV), Acoustic Borehole Imaging (HRTV), tracer dilution tests, hydrochemistry monitoring and hydraulic tests. The pressure levels were monitored in the multipacker system. The pressure responses of the system were tracked during tracer tests and the flow from the selected intervals was measured.

Based upon this, the tracer experiment instrumentation was developed, focusing namely on the maximum accuracy of the tests, the measurement parameters and the setting of the tests. In 2017, 21 tracer tests were performed and 33 penetration curves were evaluated. NaCl solutions (0,1M, 0,05M, 0,01M), KI (0,01M) were tested to be used conservative tracers. The aim of the tests was to thoroughly test the rock environment, tracer behaviour, instrumentation and optimal setup of the test system for active experiments. Moreover, discussion with the SÚJB, the regulator, about the ensuring necessary legislative requirements for radiation safety and the implementation of active tracer tests proceeded. The GoldSim program was used to demonstrate the safety.

Finally, after the regulator SUJB approval, two tests, using 3H (2 MBq.l-1), were performed on 22 September and 6 October 2017 as the very first radioactive tracer test of such a kind in Czech Republic. Subsequently, evaluation of tracer tests and penetration curves was performed using Qtracer2. The transport model was based on MT3DMS on the basis of a verified hydraulic model implemented in MODFLOW2000. The results of both tests were consistent and well monitored. The experiment balance (HTO) was around 95% during tracer tests, with return back rate 99%.

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