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In-situ migration experiment with radionuclides in granitic rock (Josef gallery, Czech Republic)

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Crystalline rocks 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. The aim of the project (PAMIRE) was to determine the degree of reproducibility the laboratory determination of tracer transport processes of the tracers compared to the results of the the larger scale experiments (dm scale); subsequently to implement it into the in-situ granitic real conditions of the and in the models evaluating the radionuclide migration into the rock.
The work consisted of laboratory experiments on cm and dm samples (diffusion 3H, 36Cl, 125I, electromigration experiments 131I, sorption, visualization of pore space etc), in-situ experiments and modeling. Laboratory experiments at various scales have confirmed that the diffusion migration in the rock of a given type (tonalite) uses only part of the pore space, being is available for migrating radionuclides. The presence of cracks, although visually completely healed, leads to the formation of preferential paths, which then lead to an increase in diffusion coefficients of migrating radionuclides. On the basis of the evaluated data, a concept of pore space of samples of granitic material was proposed.
In-situ experiments 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 behavior with regard to the potential migration of radionuclides. Advection is considered as a main processes within such a type of test.
A system consisting of a flow field intersecting a water bearing fracture, was first identified at the Josef Underground Laboratory. Here two boreholes were drilled and fitted with instrumentation so as to determine and characterise an appropriate location for the potential injection of a radioactive tracer into the fractured rock 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 were measured.

Based on the findings and results, 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 tracking tests were performed and 33 penetration curves were evaluated to be used conservative tracers (NaCl, KI). 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 of the experiment under consideration and the Modflow-MT3D program was used to determine the hydraulic conditions in the area concerned.
After the regulator approval, two tests, using 3H (2 MBq.l-1), were performed on 22 September and 6 October 2017 as the very first pilot 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 set up in MT3DMS on the basis of a verified hydraulic model implemented in MODFLOW2000. The results of both tests were consistent and well monitored. The experimental balance (HTO) were around 95% during tracer tests, with return back rate 99%.

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