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Determination of rock transport parameters using short-term radionuclides and nanoparticles

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The aim of the project is to develop and test the short-lived radionuclides in order to describe the contaminant transport processes radionuclides, tracer metals and nanoparticles in the environment. Furthermore, the aim is also to develop on-line detection methods to quantify the processes that influence their movement towards the biosphere. Use of short lived radionuclide in tracer tests brings an advantage of excellent detection and avoids contamination of rock samples/environment during experiments.

The research is focused predominantly on radio-tracers in various forms (solute/nanoparticles) and on development of advanced detection techniques for their monitoring and display. The following pre-selected radionuclides were considered for potential irradiation (²⁴Na, ⁴²K, ⁶⁴Cu, ⁷²Ga, ⁷⁶As, ⁸²Br, ⁹⁹Mo, ¹⁴⁰La, ¹⁴²Pr, ¹⁹⁸Au, ¹⁶⁶Ho, ¹⁸⁸Re, ¹⁵³Sm). After thorough evaluation, holmium and rhenium compounds were selected for irradiation in the LVR- 15 reactor (CVŘ Řež), namely holmium oxide (Ho₂O₃) and ammonium perphenate (NH₄ReO₄). Those compounds were selected based on the computational analyses. Solutions of 50, 200, 300 MBq (¹⁸⁸Re) and 300 MBq (¹⁶⁶Ho) were finally prepared for detection tests. Paralelly, a method for the preparation of chromium oxide nanoparticles was introduced and tested.

A miniaturized spectral camera MiniPIX TPX3 has been developed for radionuclide detection. It is similar to the MiniPIX with a Timepix3 chip, a new generation of chips developed by the collaboration Medipix3. The camera has a resolution of 256 x 256 pixels with a pixel size of 55 x 55 μm (2 mm CdTe sensor).

The developed measurement system enables on-line monitoring and 3D visualization of the radioactivity distribution in the studied rock samples with respect to radionuclide distribution within the rock. Various measurement configurations were tested with respect to source activity, detector/collimator distance, and rock thickness to find optimal measurement parameters.

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