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## Determination of $^3\text{H}$ , $^{36}\text{Cl}$ , $^{22}\text{Na}$ , $^{85}\text{Sr}$ and $^{133}\text{Ba}$ by means of precipitation method

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Spent nuclear fuel from the nuclear power plants owned by TVO (Teollisuuden Voima Oy) and Fortum, is planned to be disposed at a repository at a depth of more than 400 meters in the bedrock of Olkiluoto (Eurajoki, Finland). The repository system includes multiple release barriers: the nuclear fuel, copper canister with a cast iron insert, bentonite buffer around the canister and backfilling of the tunnels. Furthermore, the surrounding rock is the last barrier if the man-made barriers fail during the passage of time. Safe disposal of spent nuclear fuel requires information about the radionuclide transport and retention properties within the porous and water-containing rock matrix along the water conducting flow paths.

The second in-situ experiment within ONKALO, the underground rock characterization facility in Olkiluoto, as part of the project "rock matrix REtention PROPERTIES" (REPRO) was performed during 2013 using  $^3\text{H}$ ,  $^{36}\text{Cl}$ ,  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  as tracer nuclides. The aim is to study the diffusion and sorption properties of nuclear compounds in the rock matrix under real in-situ conditions.

A straightforward way to investigate properties of rock matrix under in-situ conditions is to carry out a water phase matrix diffusion experiment (WPDE2) in a two-meter artificial flow channel along the perimeter of the drillhole. The volume and aperture of the flow channel are minimized by an impermeable cylindrical flow guide inside the packer system. The inlet and outlet positions of water are located at the opposite ends of the packed-off section. WPDE2 tracer test is performed using a slow flow rate that is generated using a piston pump. The experiment is executed using synthetic groundwater to carry the tracer solution.

This work presents the determination of radionuclides activities from the WPDE2 experiment giving the breakthrough curves of the radionuclides as a result. Rapid and precise determination of  $^3\text{H}$ ,  $^{36}\text{Cl}$ ,  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  is of vital importance in the project. The activity of  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  can be measured using gamma detector. Due to their electron emissions  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  disturb the LSC measurement of  $^{36}\text{Cl}$  and  $^3\text{H}$ . So it is essential to seek a simple, convenient way to separate these radionuclides before spectrometric analyses.

From the initial water sample  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  are measured by gamma spectrometry first. Then NaCl carrier is added in solution. AgCl precipitation is produced and  $\text{Ag}(\text{NH}_3)_2\text{Cl}$  solution is measured with liquid scintillation analyzer to obtain the  $^{36}\text{Cl}$  activity.  $\text{Sr}(\text{NO}_3)_2$  and  $\text{Ba}(\text{NO}_3)_2$  carriers are added to the supernate and  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  are precipitated as carbonates;  $\text{SrCO}_3$  and  $\text{BaCO}_3$ . This supernate contains  $^3\text{H}$  and  $^{22}\text{Na}$  and remains of  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$ . Gamma emitting nuclides are measured first and then  $^3\text{H}$  with liquid scintillation analyzer.  $^{22}\text{Na}$ ,  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  disturb the counting of LSC measurement. Thus using the quench curves determined for each of gamma emitting nuclides in  $^3\text{H}$  window of LSC, the amount of counts from the disturbing nuclides in  $^3\text{H}$  window can be calculated and reduced from the actual  $^3\text{H}$  counts. Then the "clean"  $^3\text{H}$  activities are determined by using the  $^3\text{H}$  quench curve.

The separation procedure is optimized. The recovery of  $^{36}\text{Cl}$  is about 100% as well as the recovery of  $^{85}\text{Sr}$  while the recovery of  $^{133}\text{Ba}$  is slightly less, being about 85%. The detection limit for  $^3\text{H}$  in this solution is 1Bq/g. The precipitation procedure is easy and fast to separate  $^{36}\text{Cl}$  from the solution.  $^{85}\text{Sr}$  and  $^{133}\text{Ba}$  can be removed from the solution by carbonate precipitation in a way that  $^3\text{H}$  is measurable.

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