University of Helsinki (UH) contribution to BELBaR

WP 3: Colloid radionuclide & host rock interaction

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Background

Fracture flow and radionuclide transport in granitic rock

- Block fracture, fracture columns and core columns
- Matrix diffusion and retention processes in different scales and flow conditions

Colloid studies

Posiva: Silica sol colloids injection grout

Finnish Research Programme on Nuclear Waste Management KYT2014

The effect of colloids on radionuclide migration

Grimsel CFM project

The effect of colloids on radionuclide migration

Formation and stability of colloids

- Release and stability of inorganic colloids from MX-80 bentonite in different groundwater conditions.
- Testing and applying colloid characterization methods

Colloid-mediated radionuclide transport

- Testing experimental sorption methods (batch/dynamic, solid/liquid separation)
- Radionuclide sorption on silica colloids and bentonite powder (sorption/particle size)
- Determination the effect of ionic strength, pH
- Sorption reversibility/irreversibility (^{85}Sr, ^{152}Eu)

Colloid characterization

Dynamic light scattering (DLS/PCS)

(Malvern Zetasizer Nano ZS)

- Particle size distribution and particle concentration
- Zeta potential

Asymmetrical flow field-flow fractionation (AsFlFFF)

- Particle size distribution

ICP- MS

Scanning electron microscopy (FESEM)

Atomic force microscopy (AFM)

XRD/SAXS

Colloid release and stability

Sample preparation

Mixture of solid material and liquid → storage

- **Bentonite** (MX-80 powder)
- **Reference groundwater**
  - Low salinity Allard, I = 4.2 10^{-3} M
  - Diluted OLSO, I = 0.001 – 0.1 M (OLSO, I = 0.517 M)
  - NaCl- and $CaCl_2$-solutions, I=0.001–0.1 M

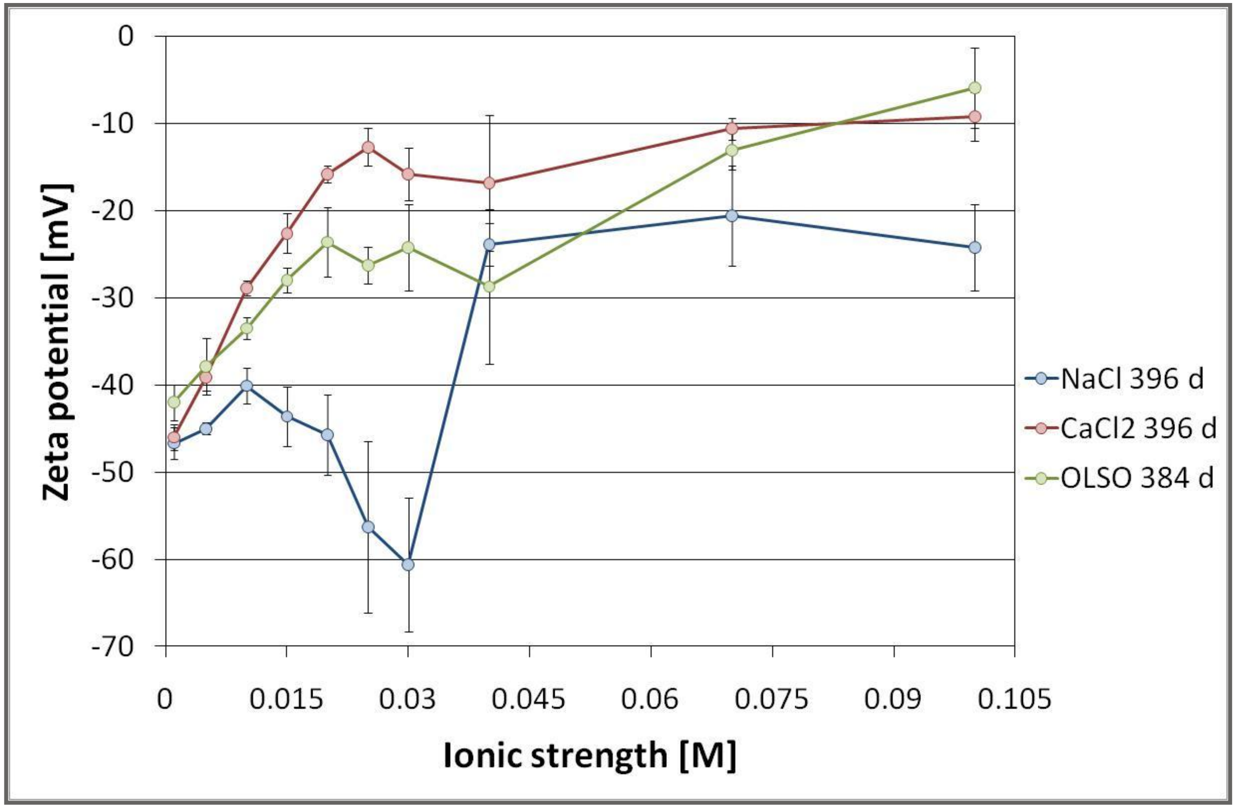
Filtration

- 1.2 µm and 0.45 µm Isopore polycarbonate membrane

Characterization

- Colloidal particle size distributions and concentration
- Stability (zeta potential)

Stability of bentonite colloids



Zeta potential as a function of ionic strength in sodium chloride, calcium chloride and OLSO solutions after one year

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Objectives

To understand processes controlling colloid mobility to be used to identify the colloid attachment probability

To study sorption reversibility/irreversibility

To identify additional retention processes

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Radionuclide sorption/de-sorption onto bentonite colloids

- MX-80 bentonite colloids
- Sr-85, Cs-134, Eu-152, Np-235 and/or other relevant radionuclides
- Na-Ca-Cl electrolyte solutions and Olkiluoto reference groundwater (OLSO) of different ionic strengths

  → the effect of salinity

Radionuclide sorption reversibility in static and dynamic conditions (method development)

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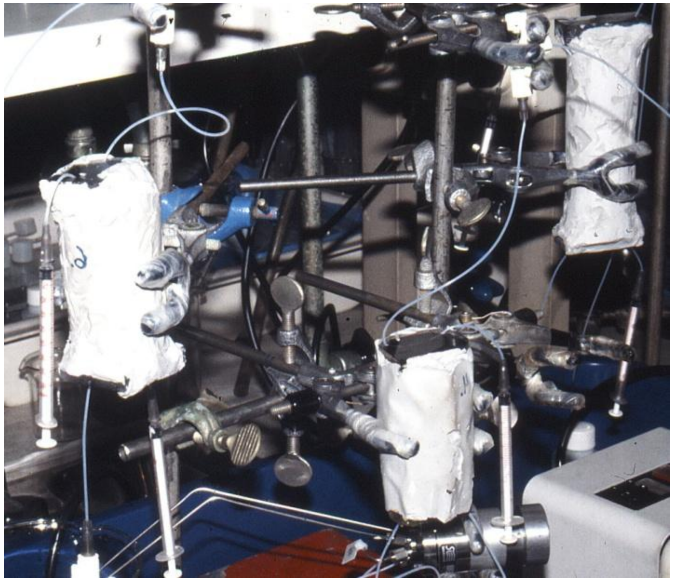
To test and apply colloid characterization methods

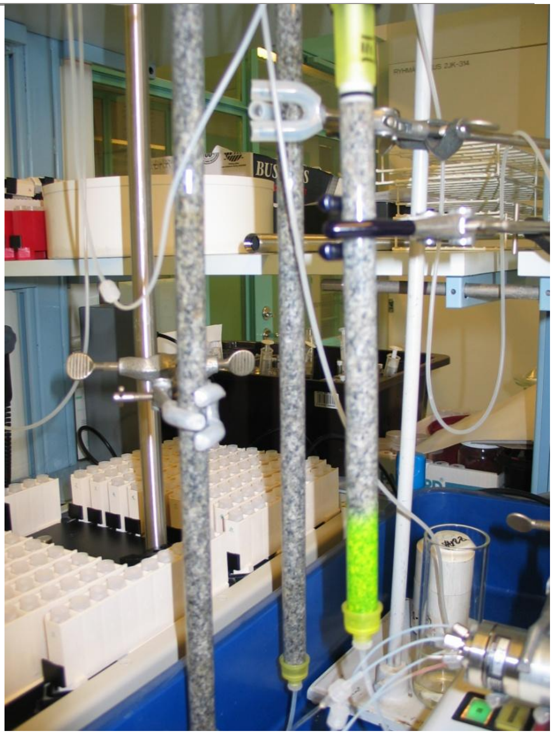
- Colloid concentration determination: a standard series made from MX-80 bentonite and Al determination (ICP-MS)

Colloid mobility and colloid/rock interaction

- Fracture columns (old and new columns)
- Natural fracture (0.9 m x 0.9 m) in Kuru Grey granite block used earlier to study fracture flow and radionuclide transport experiments.

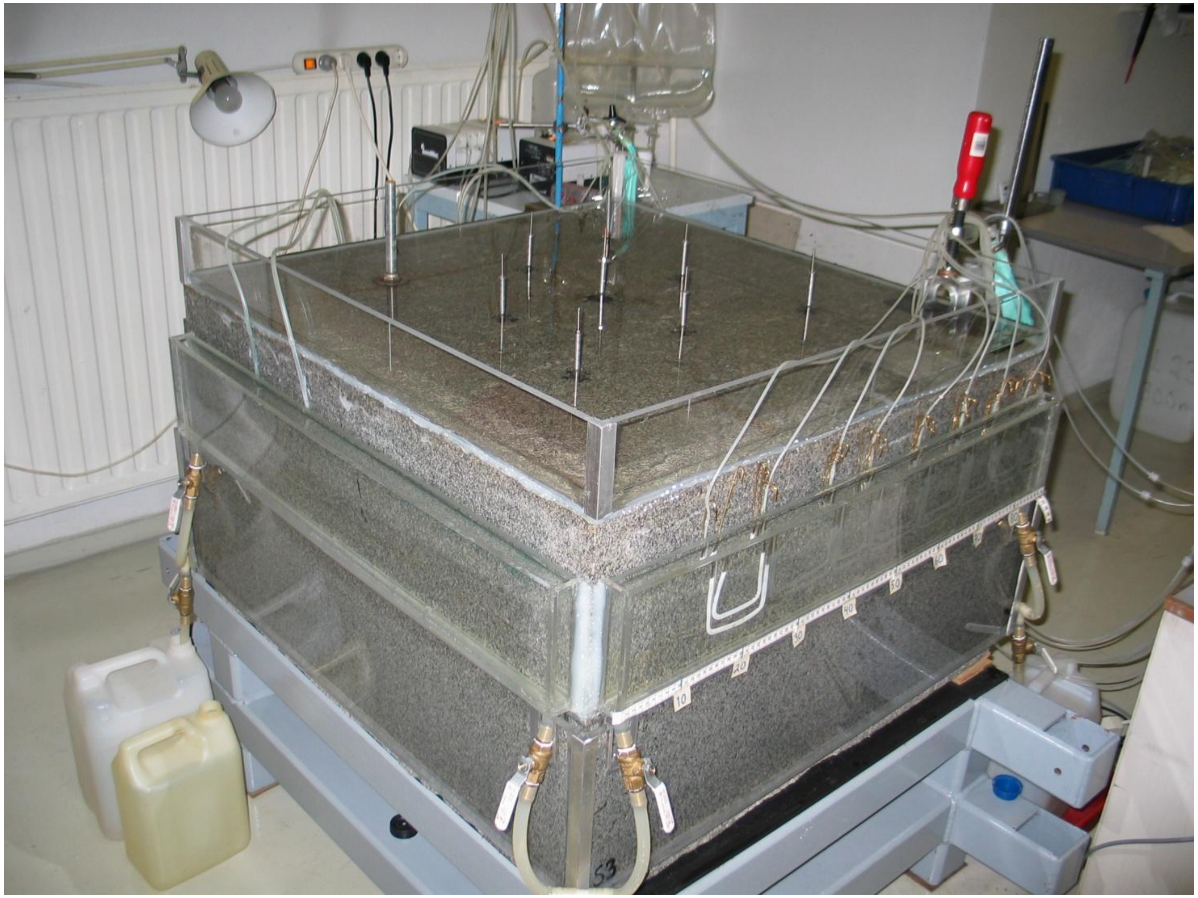
Column experiments



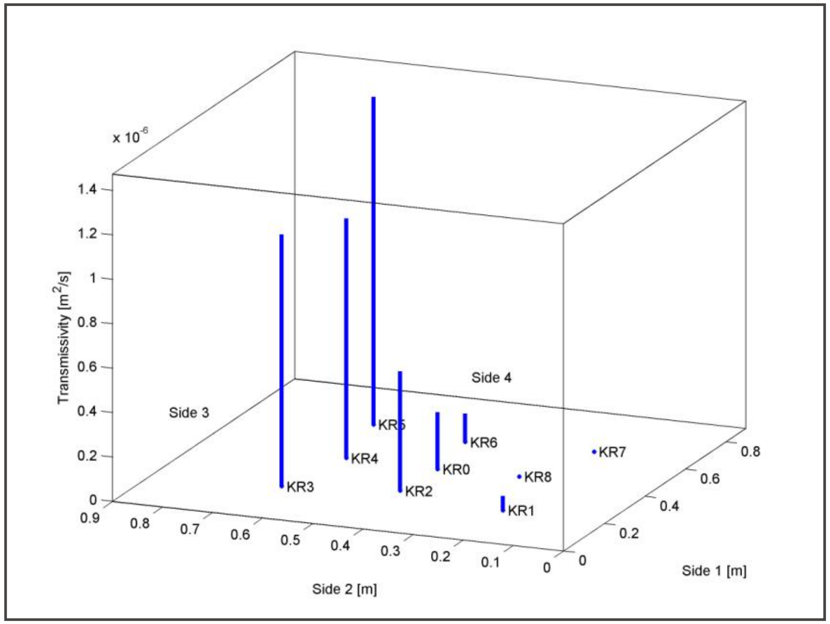


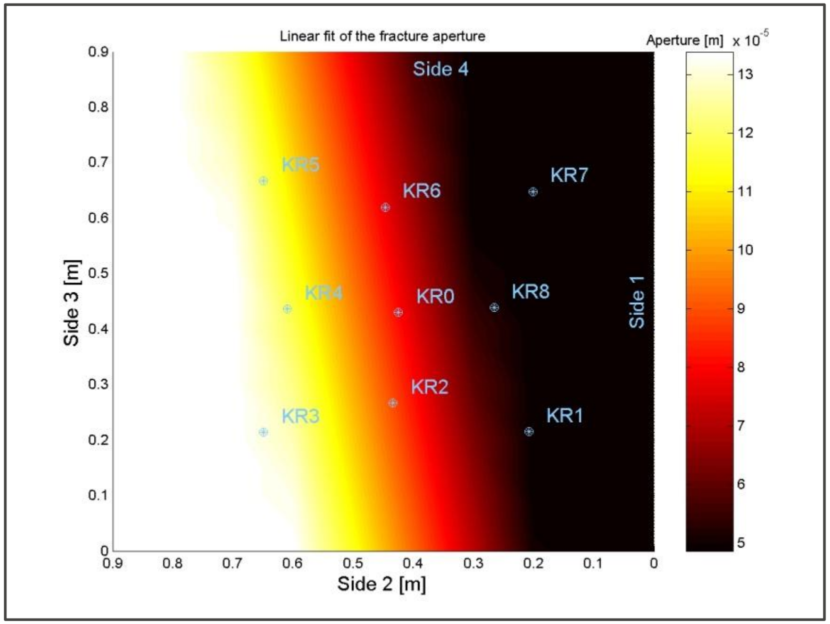
Kuru grey granite block

Natural fracture:
0.9 x 0.9 m
main flow channel 0.75 m,
channel width 0.06 m,
aperture 0.65 mm.



Kuru grey granite block

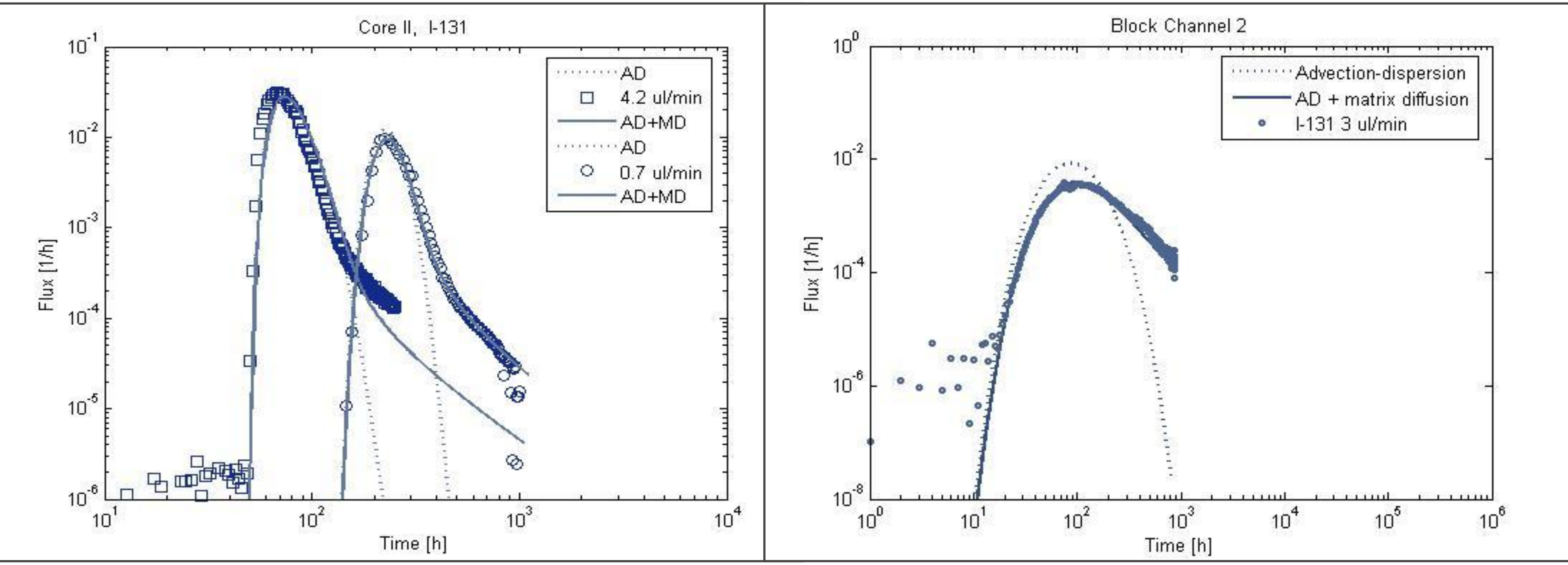




Local transmissivities determined from the water consumption tests in the drill holes.

Linear fit of the fracture aperture calculated from the transmissivities.

Kuru grey granite block



Modelled (solid line) and measured breakthrough curves of ^{131}I through the 0.68 m column (left) and the natural fracture, flow channel 0.75 m (right)