Bentonite colloid studies

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EURATOM

BELBaR

Colloid projects

Finnish Research Programme on Nuclear Waste Management (KYT2014/BOA/KOLORA)

- Formation and stability of colloids
- Radionuclide sorption

EU FP7 BELBaR WP3

- Colloid/radionuclide and host rock interaction

Grimsel Test Site Phase VI,
Colloid formation and migration (CFM)

Objectives

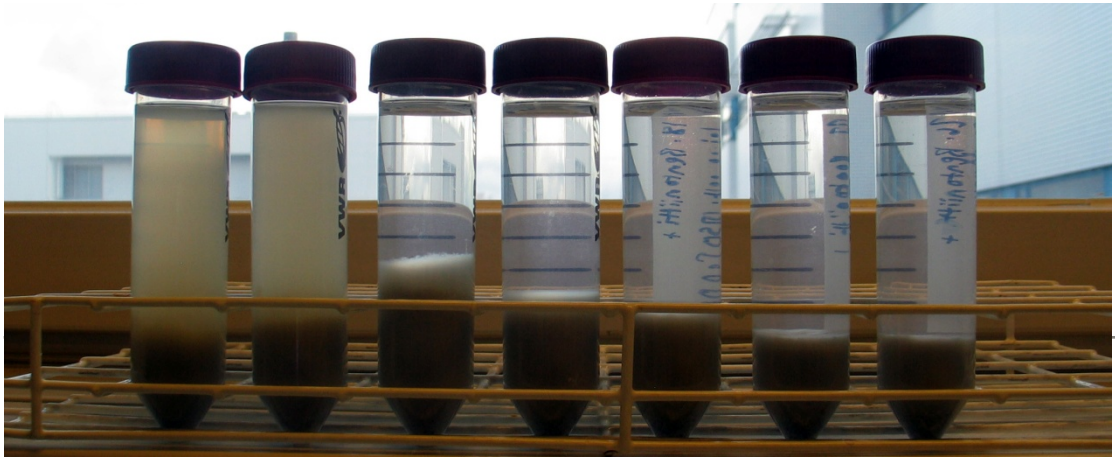
- To determine the release and stability of inorganic colloids in different groundwater conditions
- To study bentonite erosion
- To determine radionuclide sorption (K_d) on MX-80 bentonite powder and bentonite colloids as a function of ionic strength, pH and particle size
- To Study colloid/radionuclide and host rock interaction in dynamic conditions
- To test and apply colloid characterization methods

Characterization methods

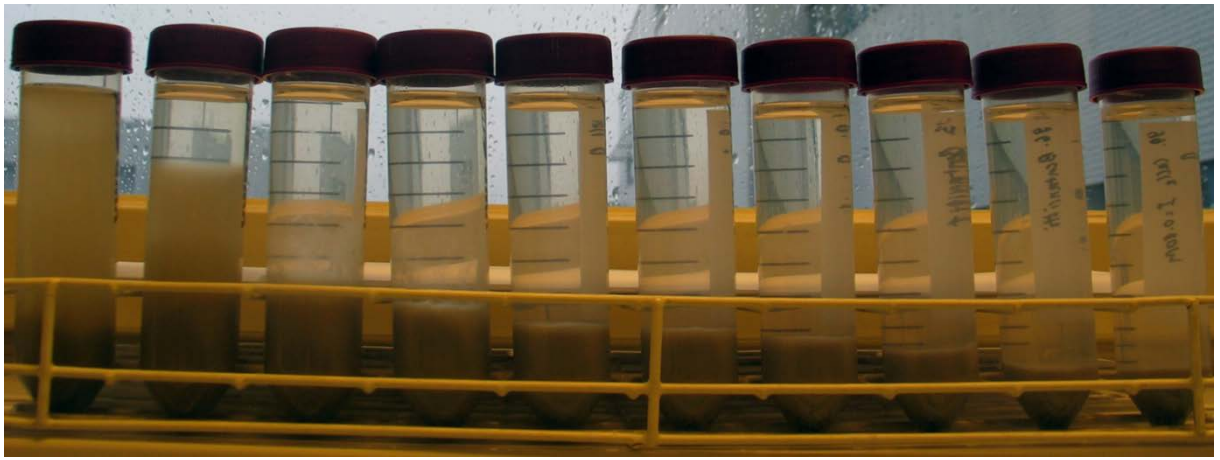
- Dynamic light scattering (DLS: Malvern Zetasizer Nano ZS)
- Asymmetrical flow field-flow fractionation (AsFlFFF)
- ICP- MS, ICP-OES
- Field emission scanning electron microscopy (FESEM/EDX)
- DualBeam focused ion beam/scanning electron microscope with EDS
- Atomic force microscopy (MultiMode V scanning probe microscope)
- X-ray diffraction (XRD), small-angle X-ray scattering (SAXS)

Formation and stability of bentonite colloids

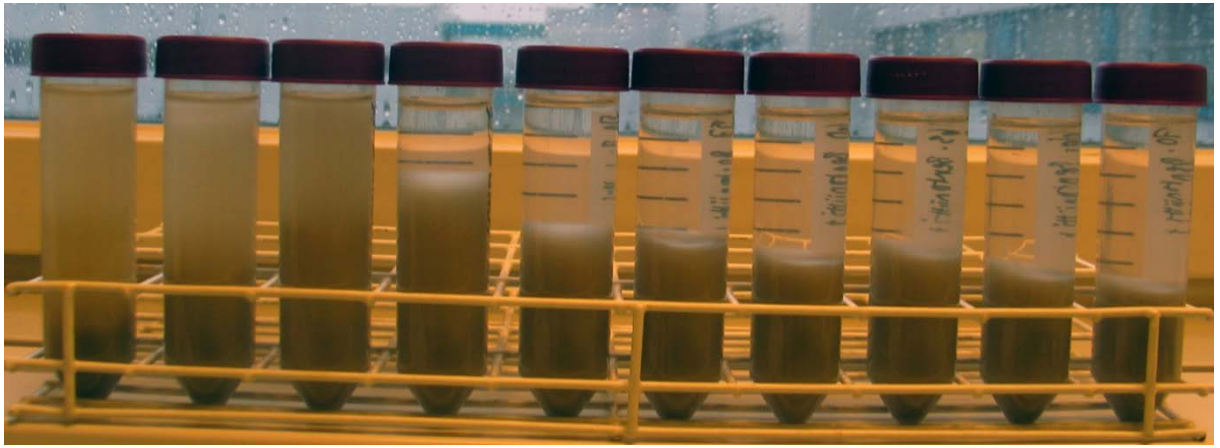
- The release and stability of bentonite colloids have been followed in diluted OLSO reference groundwater, sodium chloride and calcium chloride solutions (I = 0.001 – 0.1 M)
- Colloidal particle size distribution and zeta potential has been determined applying the dynamic light scattering (DLS) method.
- Colloid concentration determination:
  - A standard series made from MX-80 bentonite applying the DLS measurement count rate.
  - Al determination (ICP-MS)



OLSO
0.001- 0.03 M

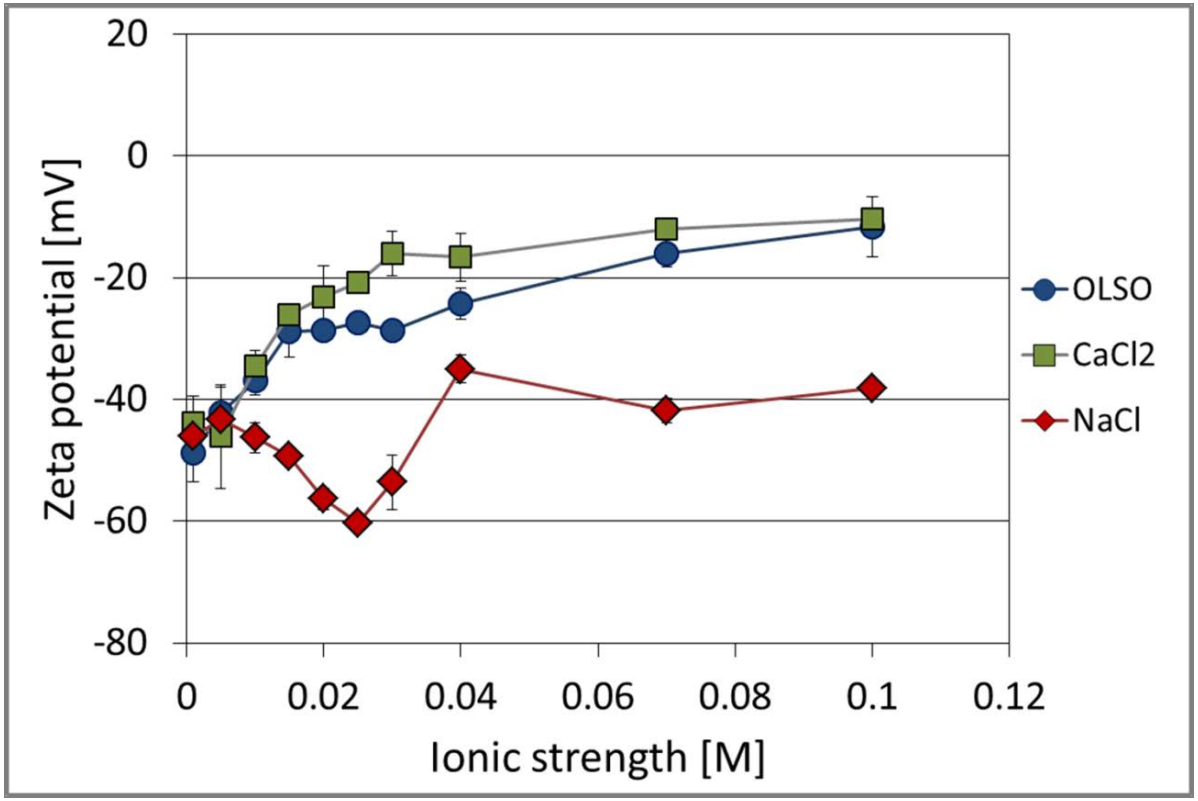


$CaCl_2$
0.001- 0.1 M



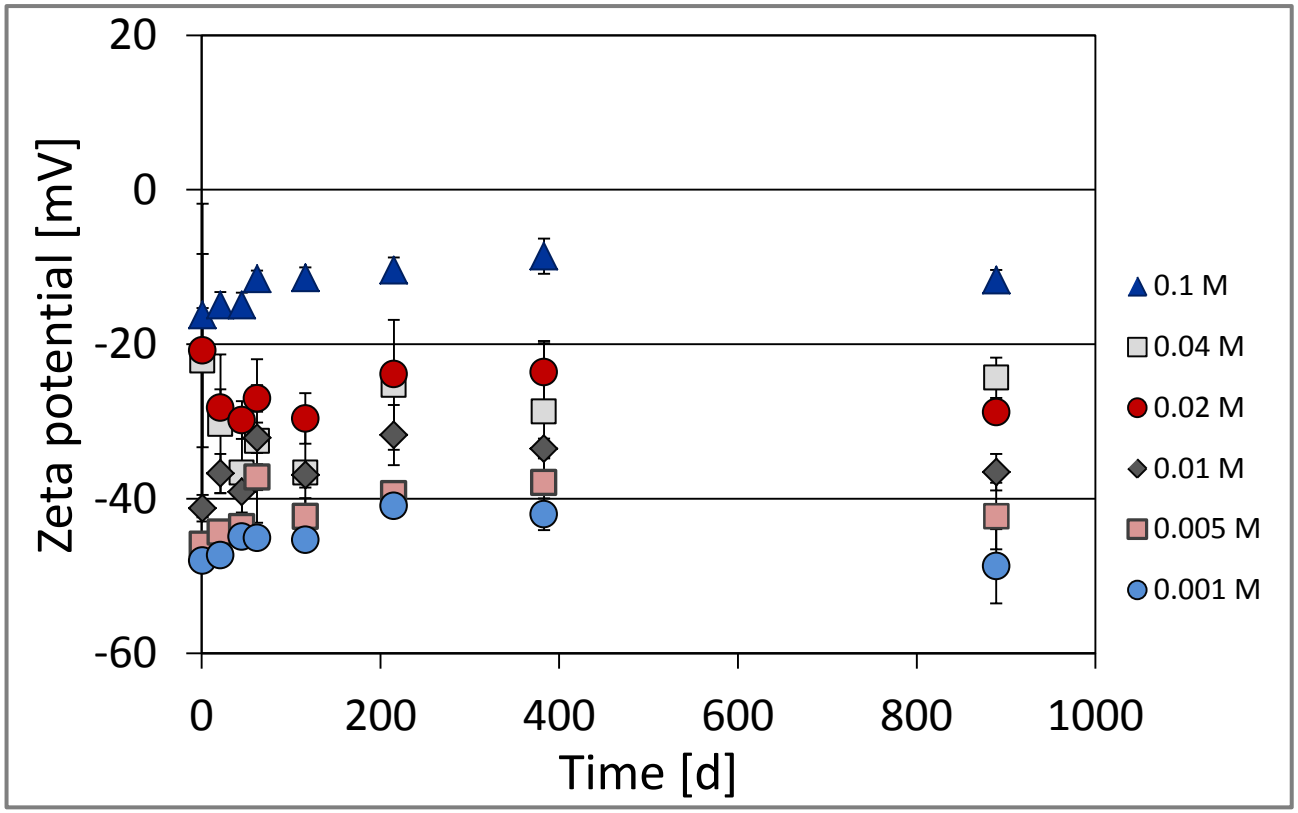
NaCl
0.001- 0.1 M

Stability of bentonite colloids



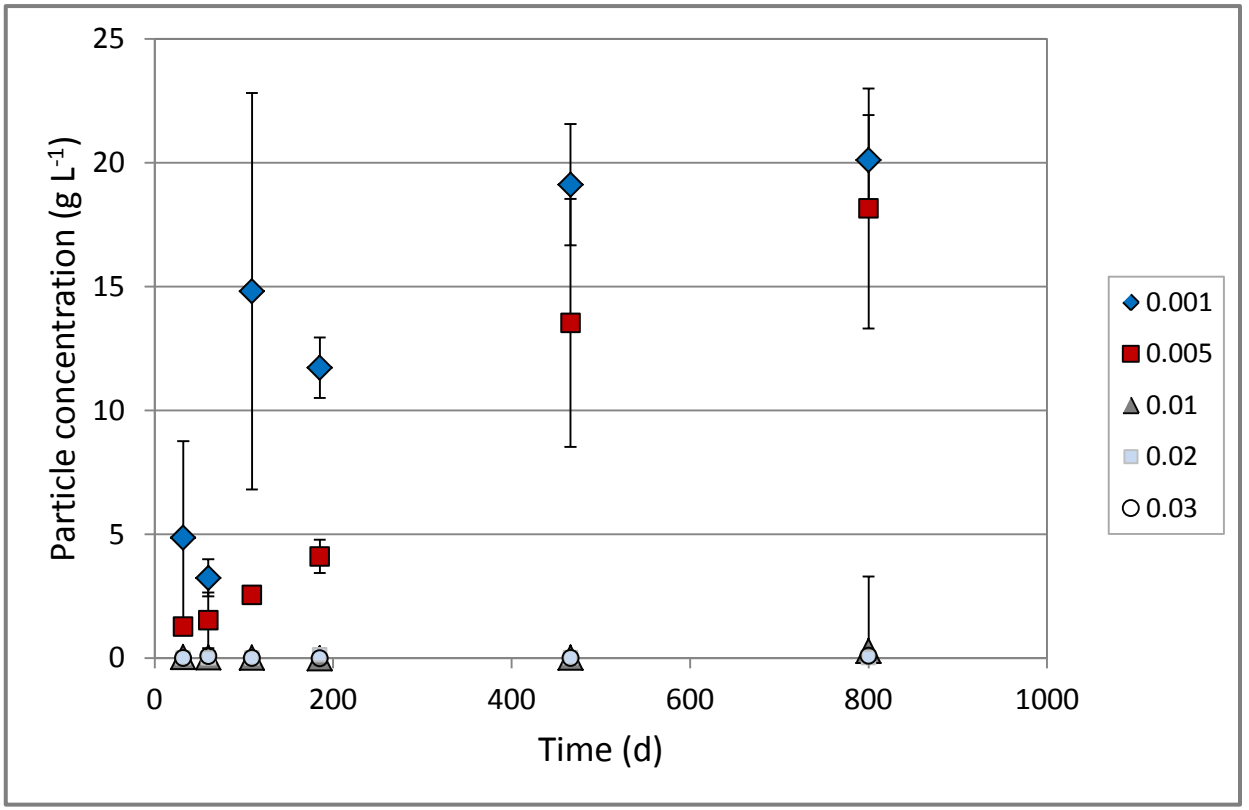
Zeta potential as a function of ionic strength in sodium chloride, calcium chloride and OLSO solutions after 2.5 years.

Stability of bentonite colloids



Mean zeta potential of bentonite colloids in diluted OLSO reference groundwater.

Bentonite colloid concentration



Estimated particle concentration of bentonite colloids in diluted OLSO reference groundwater.

Radionuclide sorption

- Determinations as a function of ionic strength, a batch method, 4 parallel samples.
- ^{85}Sr and ^{152}Eu sorption onto bentonite powder (MX-80)
  - NaCl and $CaCl_2$ solutions (I = 0.001 – 0.1 M)
- ^{152}Eu sorption on bentonite colloids, separated from MX-80.
  - NaCl and $CaCl_2$ solutions and diluted OLSO (I = 0.5 M)
  - Solutions of 10 ionic strengths (I = 0.001 – 0.1 M)
- ^{85}Sr sorption determination on bentonite colloids is under way.
- Radionuclide sorption reversibility in static and dynamic conditions.
  - method development under way

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Sorption onto powdered bentonite

20 mL $NaCl/CaCl_2$-solution
Sr-85 or 120 µl Eu-152 tracer
1 g Bentonite powder
pH ~ 8 (Adjusted)

Shaking (1h/1-2 d/7 d)
Sentrifugation
(7500 rpm/30 min)

10 mL aliquot
Radioactivity measurement (5 min) (Wizard® 3'' gamma counter)
Particle size and zeta potential determination

Filtration 1.2 µm (Isopore polycarbonate filter)
Radioactivity measurement (5 min)
Particle size and zeta potential determination (Zetasizer)

Filtration 0.05 µm (Isopore polycarbonate filter)
Radioactivity measurement (5 min)
Particle size and zeta potential determination (Zetasizer)

Drying and weighing of the filters

Desorption experiments

Sorption onto colloids

90 mL OLSO/NaCl/$CaCl_2$-solution
Sr-85 or Eu-152 tracer
Bentonite colloids solution

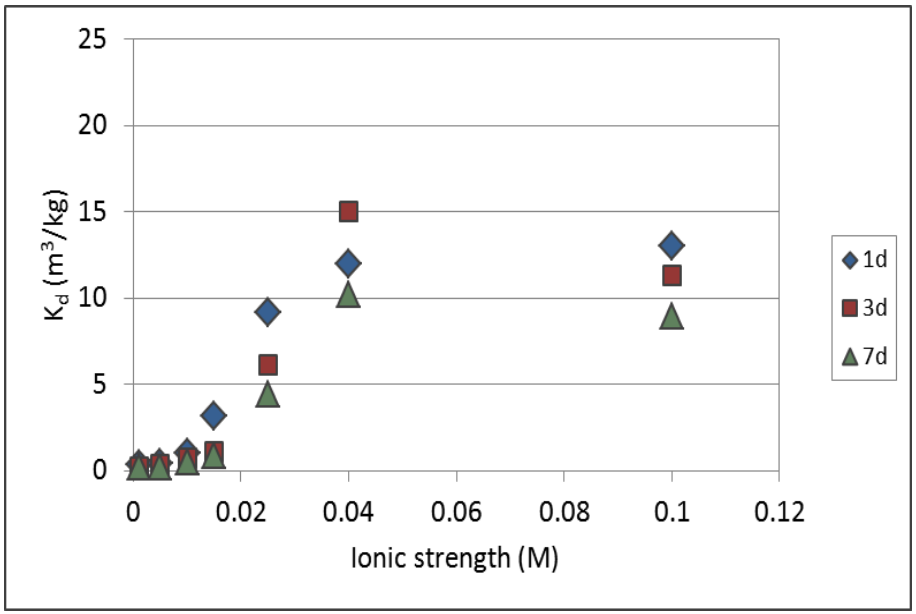
4.5 mL aliquot after 1h/1-2 d/7 d
Ultracentrifugation (90000 rpm/60 min)

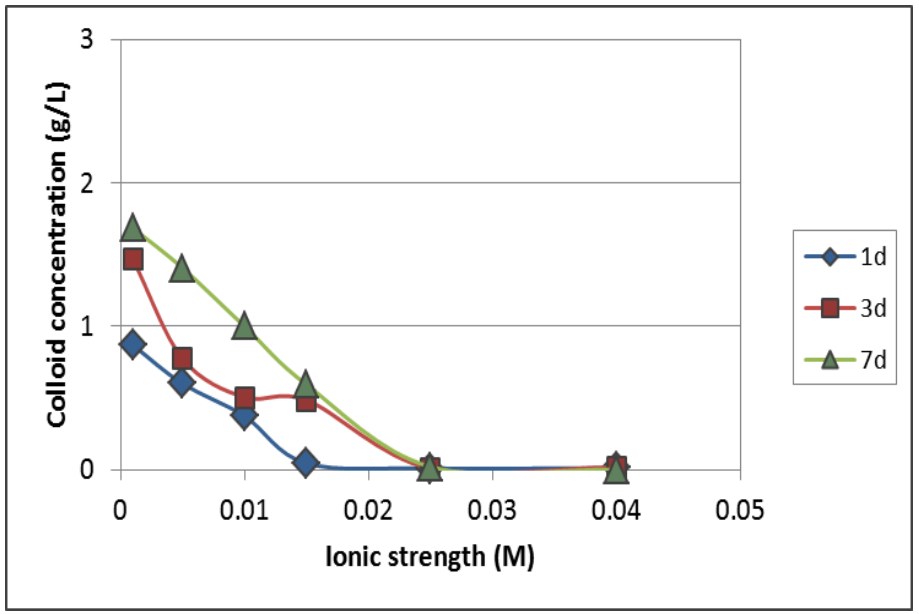
Solution:
Radioactivity measurement (10 min) (Wizard® 3" gamma counter)
Particle size determination (Zetasizer)

Solid phase:
Drying and weighing

Desorption experiments

Eu-152 sorption

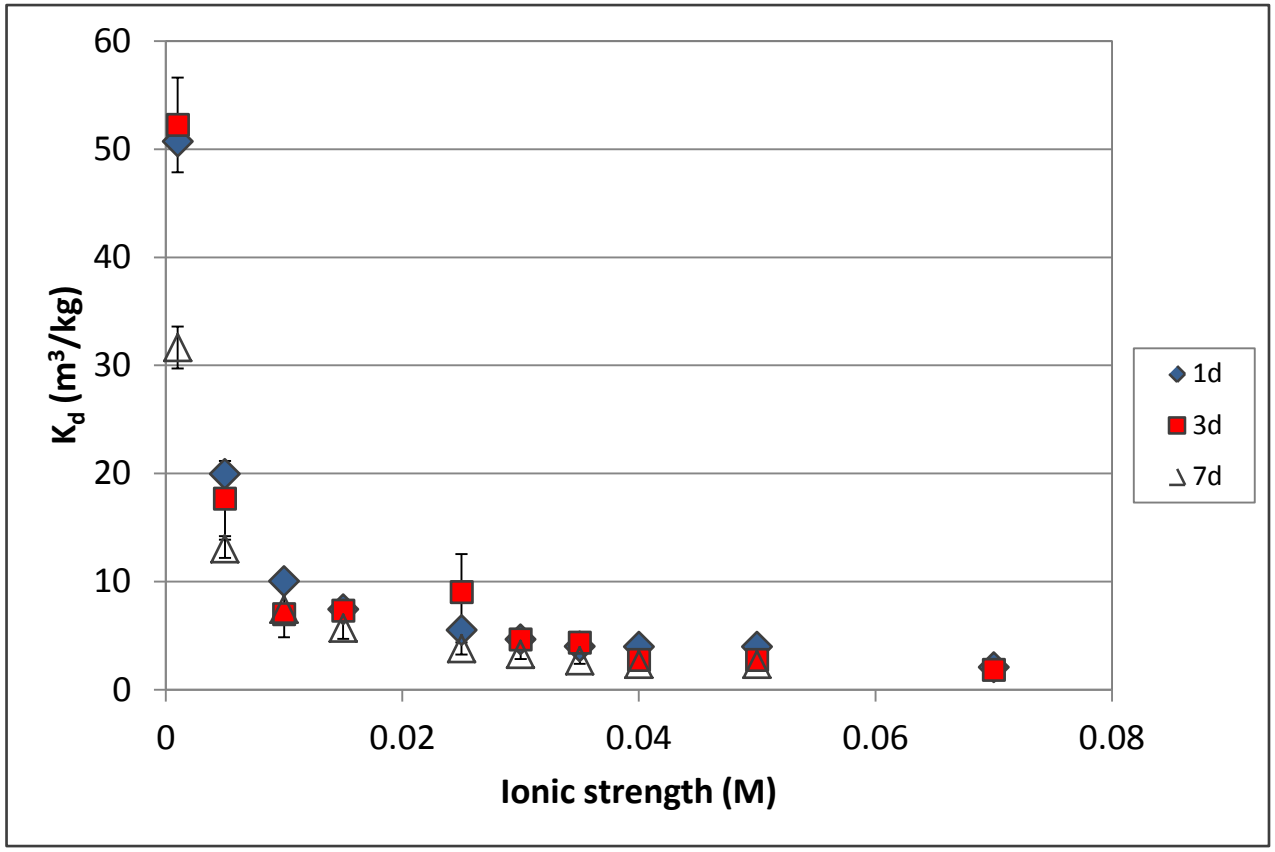




Bentonite powder in NaCl

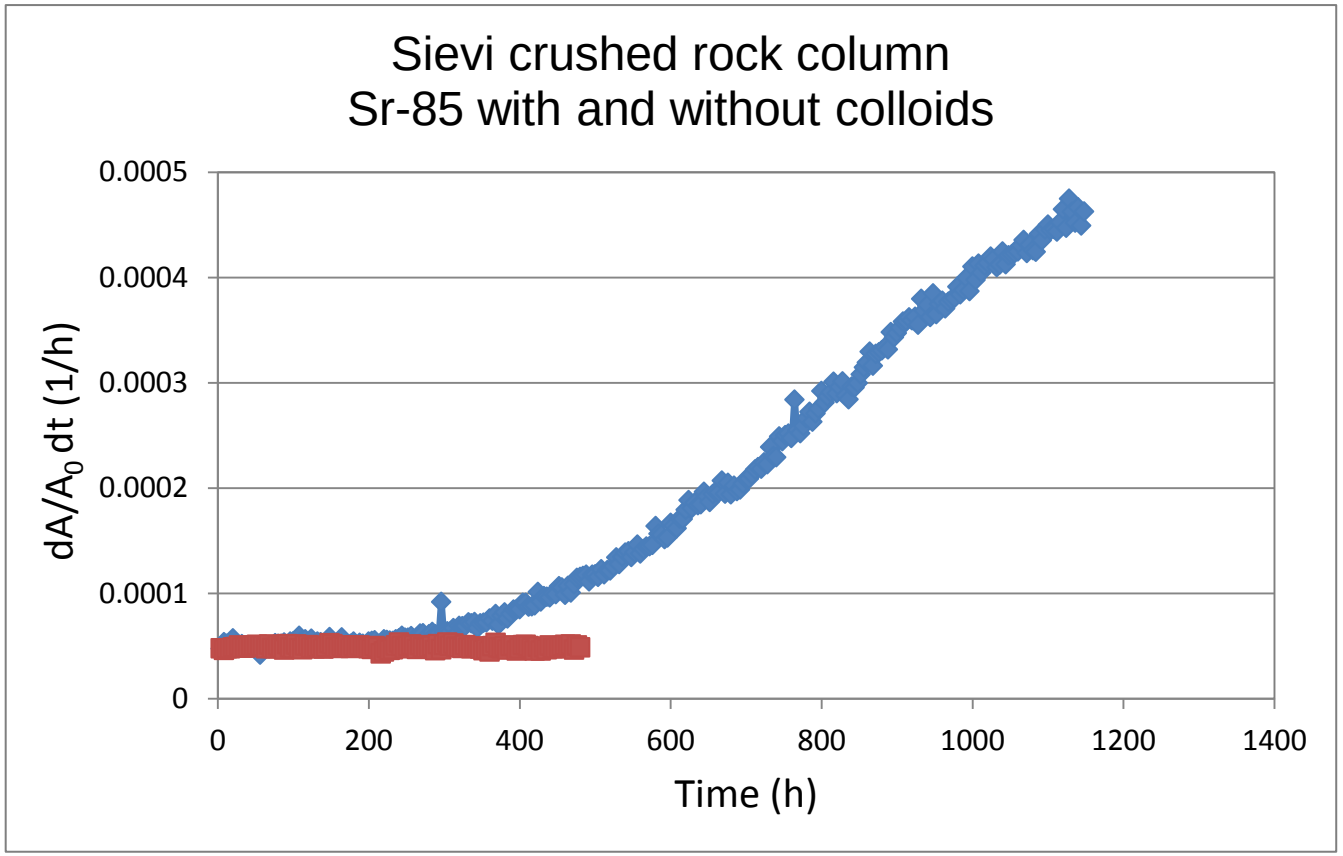
Colloid concentration

Eu-152 sorption on colloids



Colloid/radionuclide and host rock interaction

- Old fracture columns from Olkiluoto tonalite
- New crushed rock columns from Kuru Grey granite and strongly altered tonalite and.
  - The hydraulic properties have been determined using non-sorbing tracers (^{36}Cl, ^{125}I) without colloids
  - Experiments ^{85}Sr and ^{152}Eu with and without colloids are under way
- Natural fracture (0.9 m x 0.9 m) in Kuru Grey granite block
  - Experiments will start in the near future


Sievi crushed rock column
Sr-85 with and without colloids
0.0005
0.0004
0.0003
0.0002
0.0001
0
dA/A0 dt (1/h)
0
200
400
600
800
1000
1200
1400
Time (h)

Conclusions

- The formation and stability of bentonite colloids depends strongly on the ionic strength of the medium and the valence of the cations.
- In NaCl (0.001-0.1 M), $CaCl_2$ and OLSO (0.001-0.01 M) zeta potential was lower than -30 mV indicating stable colloids.
- Colloids were smaller and more stable in monovalent (Na^+) than in divalent (Ca^{2+}) dominated solutions.
- The colloid concentration increased only in 0.001-0.01 M solutions.

Thank you and welcome to laboratory of radiochemistry!