Radionuclide sorption on MX-80 bentonite colloids and colloid associated RN transport

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Outline

Objectives

Materials (colloid suspension)

Batch sorption experiments (Sr-85, Eu-152)

Column experiments

Np-237 sorption on corundum, montmorillonite and bentonite colloids

Conclusions

Objectives

- To determine radionuclide sorption on MX-80 bentonite colloids and montmorillonite
- To study colloid/radionuclide and host rock interaction in dynamic conditions
- To apply new methods to study radionuclide sorption

Bentonite colloid suspension

MX-80 Volclay bentonite powder in Milli-Q

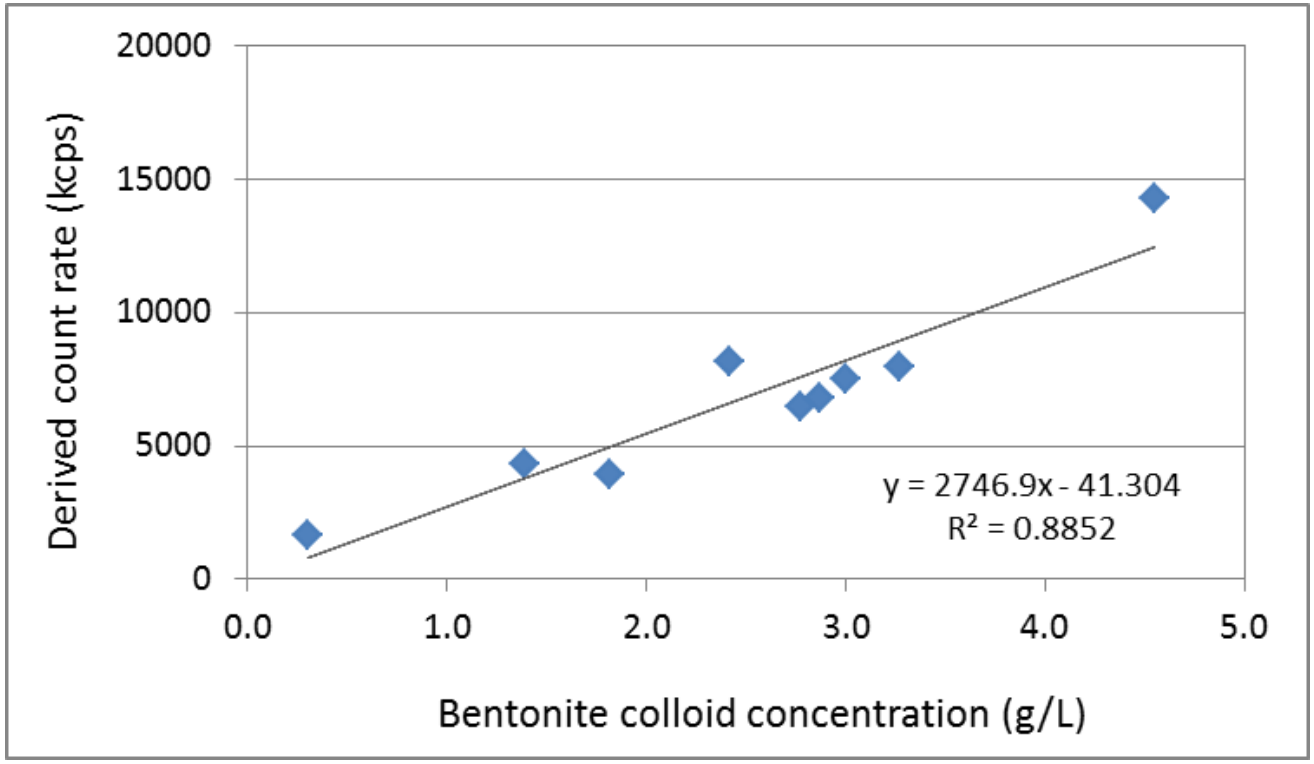
- suspension was shaken for one week → colloidal fraction was separated by centrifugation →colloid concentration was determined by a gravimetric method after drying the suspension
- colloid size 270 – 530 nm
- colloid concentration 1.3 – 5.9 g/L

Allard low saline reference groundwater

- pH 8.1 - 8.3, I = 4.2 mmol/L

MX-80: CEC 0.89 eq/kg

Colloid concentration



Correlation of DLS count rate and colloid concentration calculated based on the aluminium content of bentonite colloid suspension analysed using ICP-MS

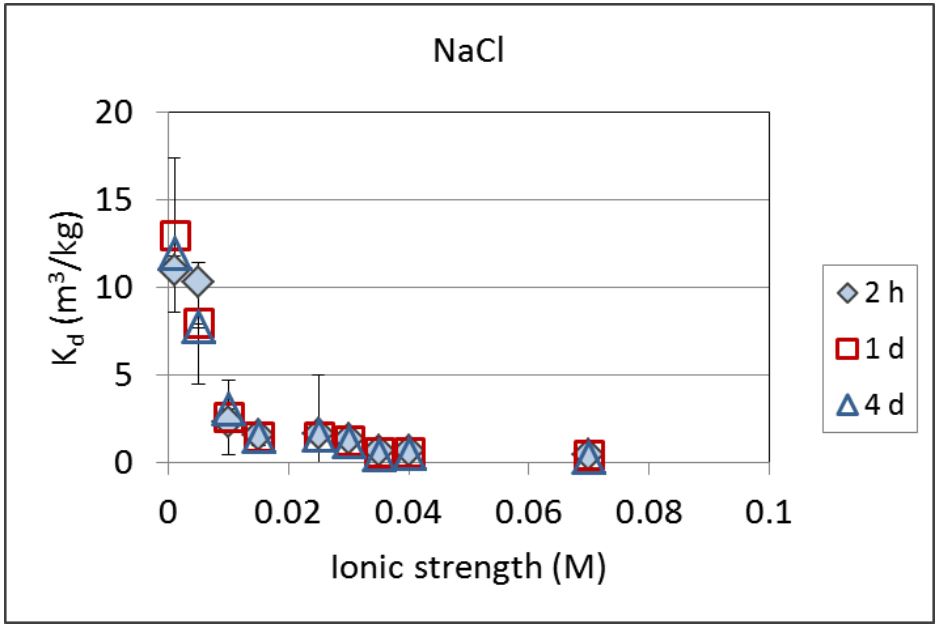
Batch sorption experiments

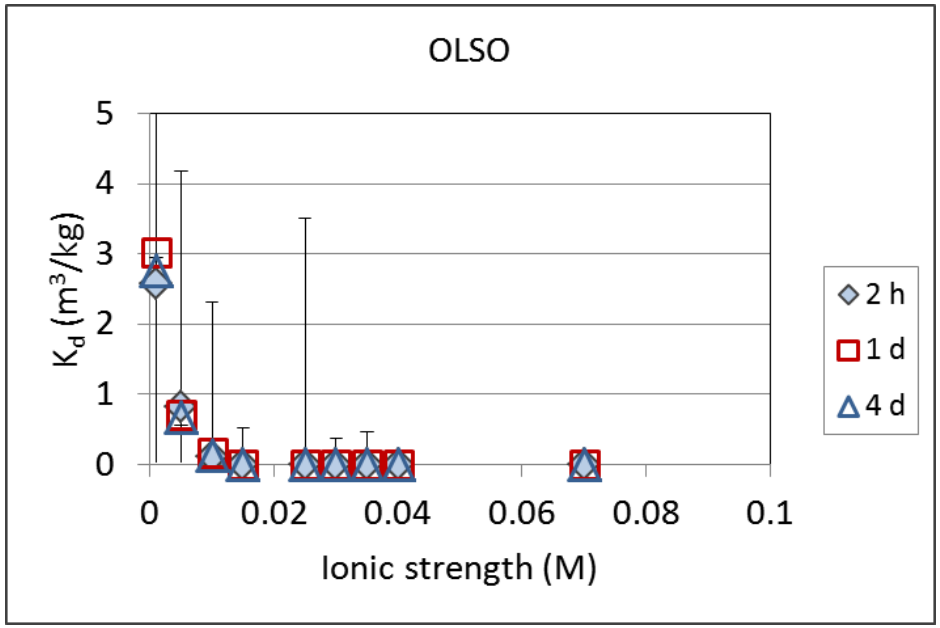
- MX-80 bentonite colloid suspension
- Diluted OLSO reference groundwater and NaCl or $CaCl_2$ solution
  - Ionic strength 0.001–0.1 M
  - pH 2-11 (OLSO)
  - Particle size
- Under ambient air
- 0.1 mL colloid suspension + 90 mL solution + ^{85}Sr or ^{152}Eu → 4.7 mL aliquots after 2 h, 2, 4 and 7 days →Ultracentrifugation (90000 rpm/ 60 min) → Radioactivity and particle size measurements
- Desorption experiments

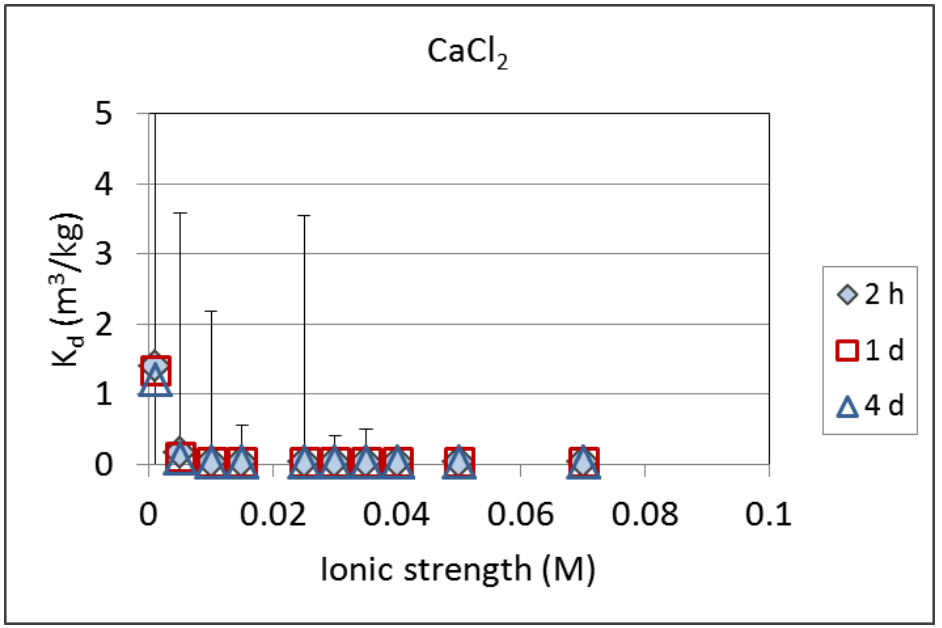
Sr-85 sorption on bentonite colloids

Nearly all of ^{85}Sr was sorbed onto bentonite colloids in 0.001 M solutions.

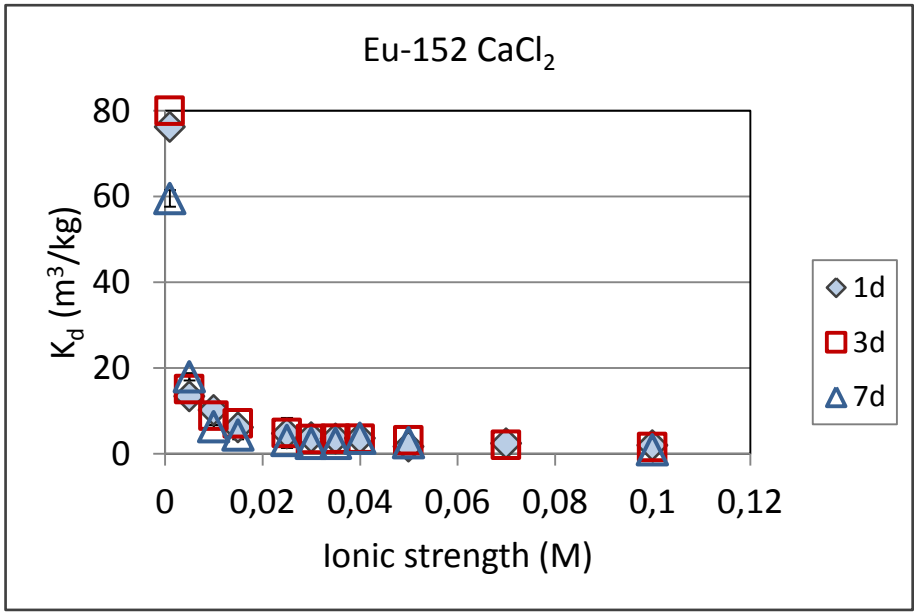
The distribution coefficient (K_d) decreased when the ionic strength increased.

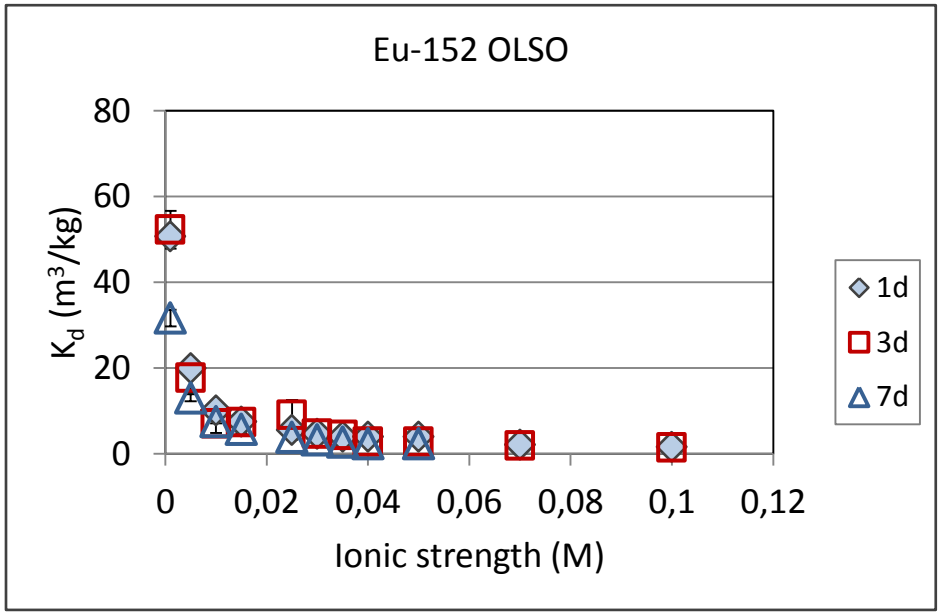




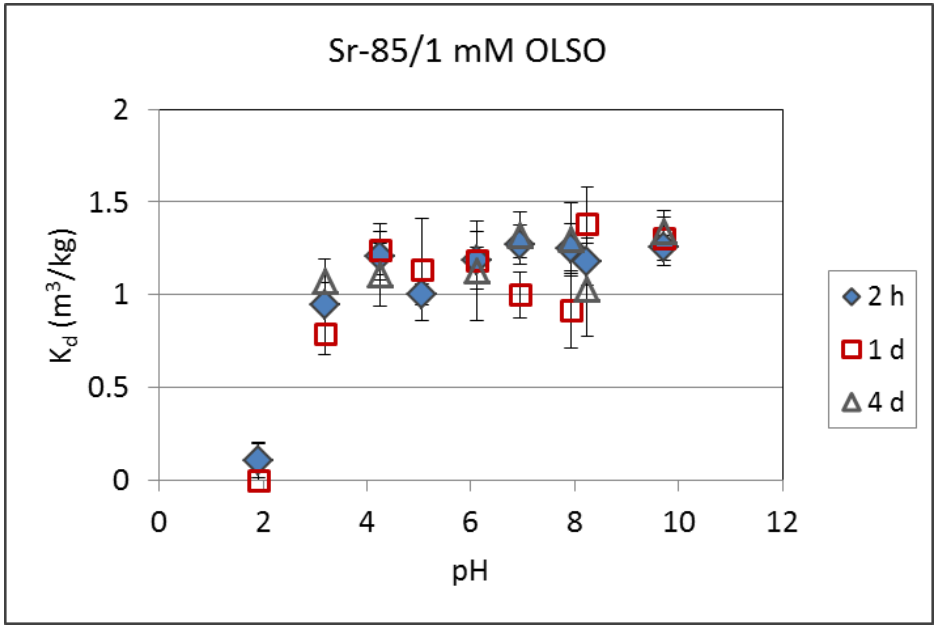


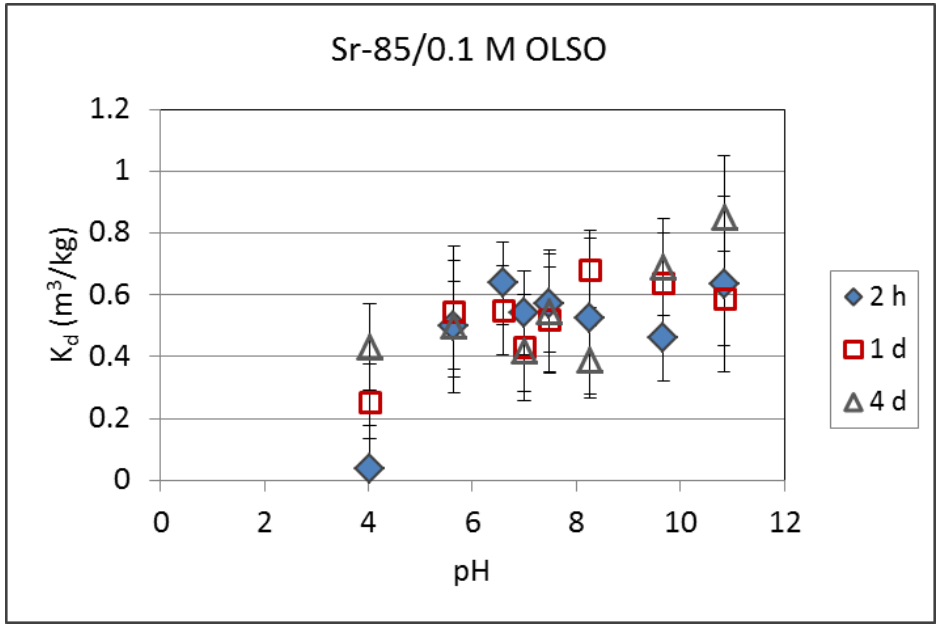
Eu-152 sorption on bentonite colloids





Sr-85 sorption on bentonite colloids





Column experiments

Crushed rock columns:

Kuru grey granite (left) and Sievi strongly altered tonalite (middle)

L = 15 cm or 30 cm, i.d. = 1.5 cm

Drill core columns:

Kuru grey granite core placed inside a tube

Flow channel in a 0.5 mm gap between the core and the tube

L = 68.5 cm, w = 4.4 cm

Fracture column:

Olkiluoto tonalite: natural fracture

L = 8.8 cm, w = 3.5 cm

Column experiments

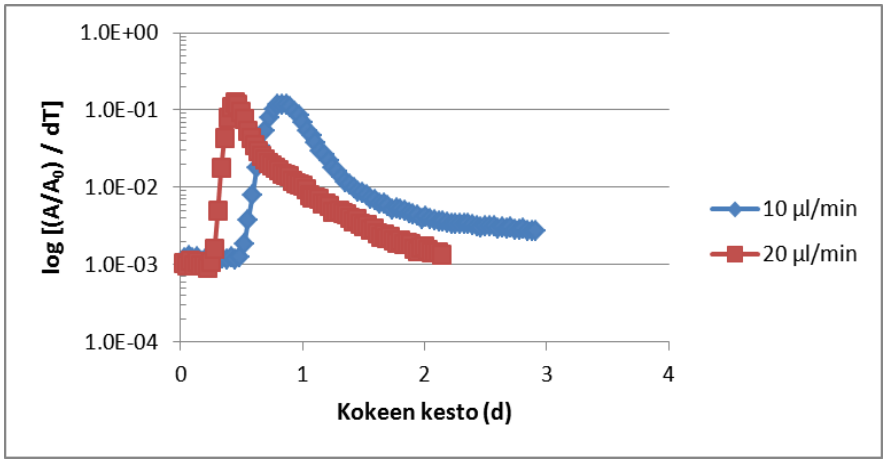
- The hydraulic properties in the columns determined using non-sorbing tracers (^{36}Cl, ^{125}I) without colloids
- Bentonite colloid suspension
- Allard reference ground water
- Flow rates 5 – 20 µL/min
- Colloid migration experiments → recovery of colloids
- Experiments with ^{85}Sr or ^{152}Eu with and without colloids

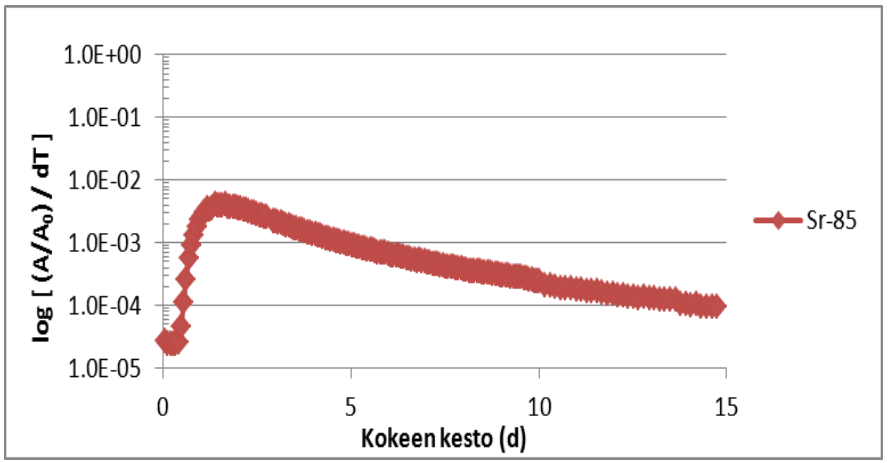
Kuru grey granite crushed rock column (30 cm)

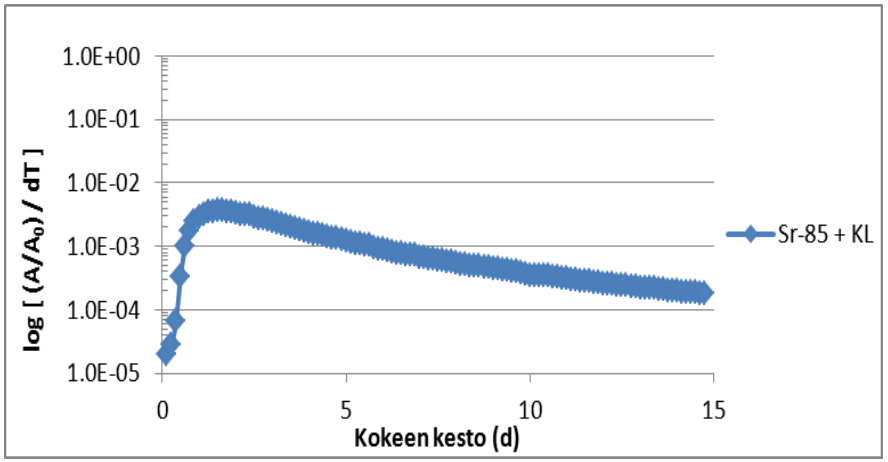
Breakthrough curves of ^{125}I

Breakthrough curve of ^{85}Sr without bentonite colloids

Breakthrough curve of ^{85}Sr with bentonite colloids

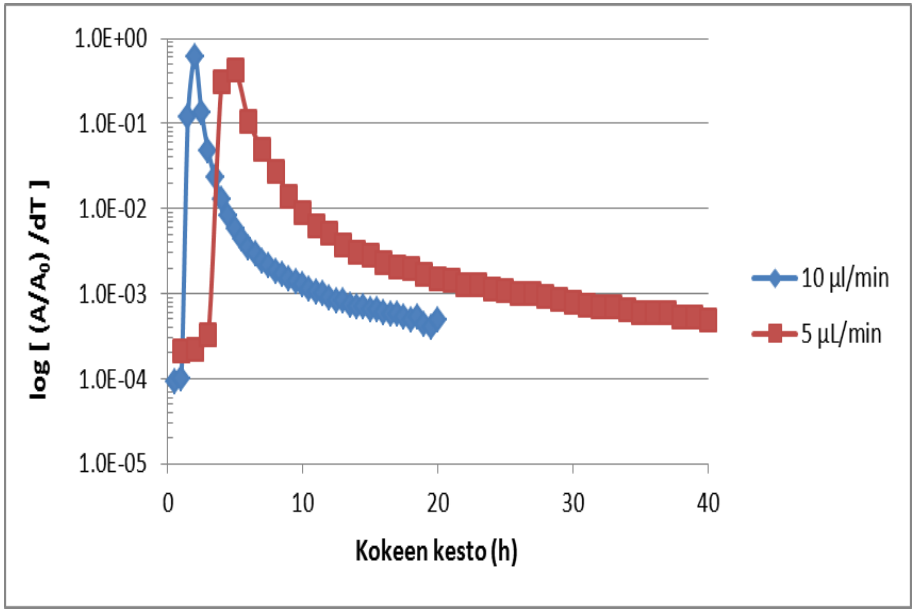




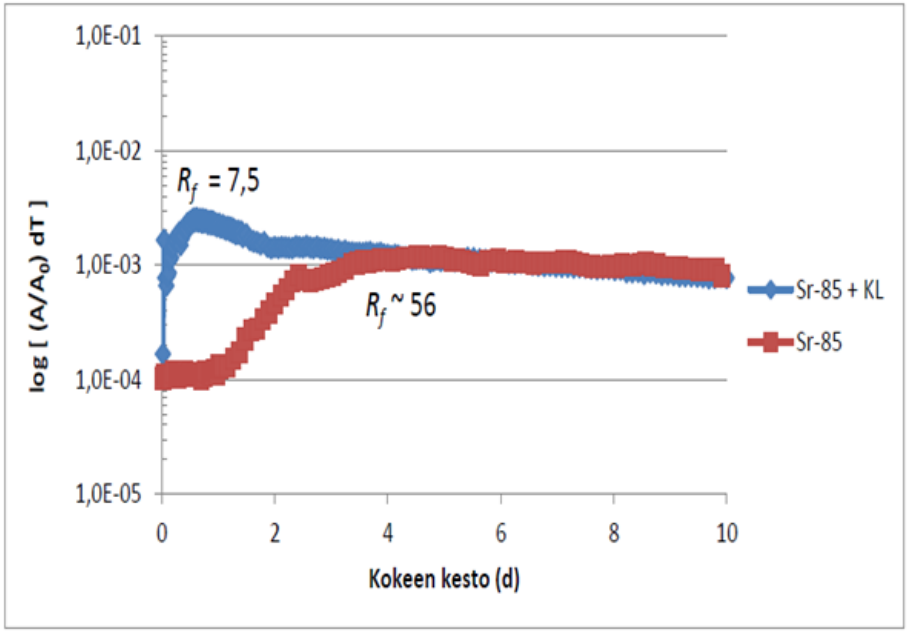


Olkiluoto tonalite fracture column

Breakthrough curves of ^{125}I



Breakthrough curve of ^{85}Sr without (red) and with (blue) bentonite colloids.
Estimated R_f ~56 and ~ 7



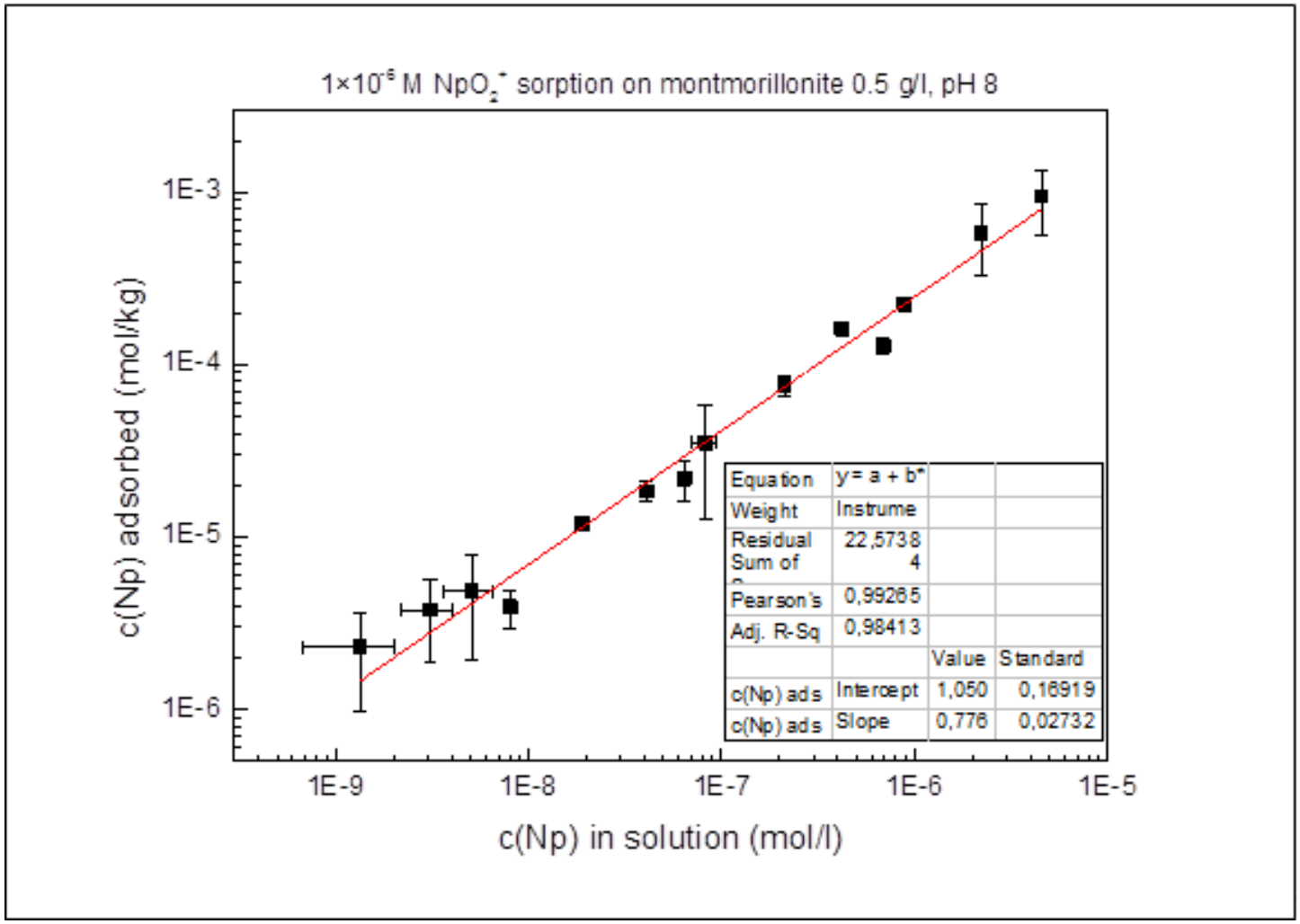
Np-237 sorption on corundum, montmorillonite and colloids

Batch experiments

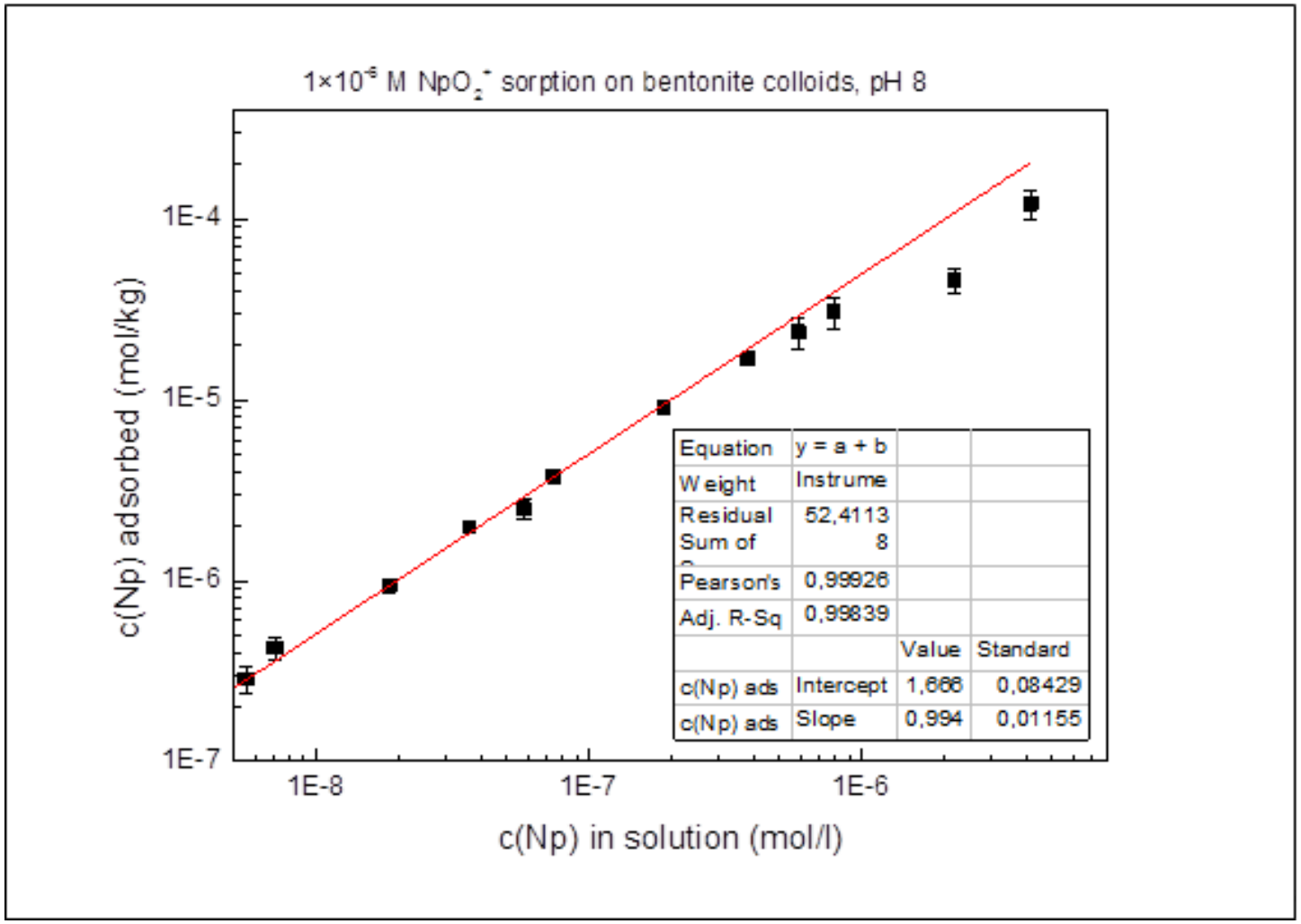
- Under anoxic conditions
- 10 mM $NaClO_4$ (batch)
- 10 mM NaCl (IR, ζ-potential)
- pH edges
- Np-237(V) sorption isotherms
- effect of time and the amount of mineral concentration

In-situ ATR FT-IR measurements in HZDR

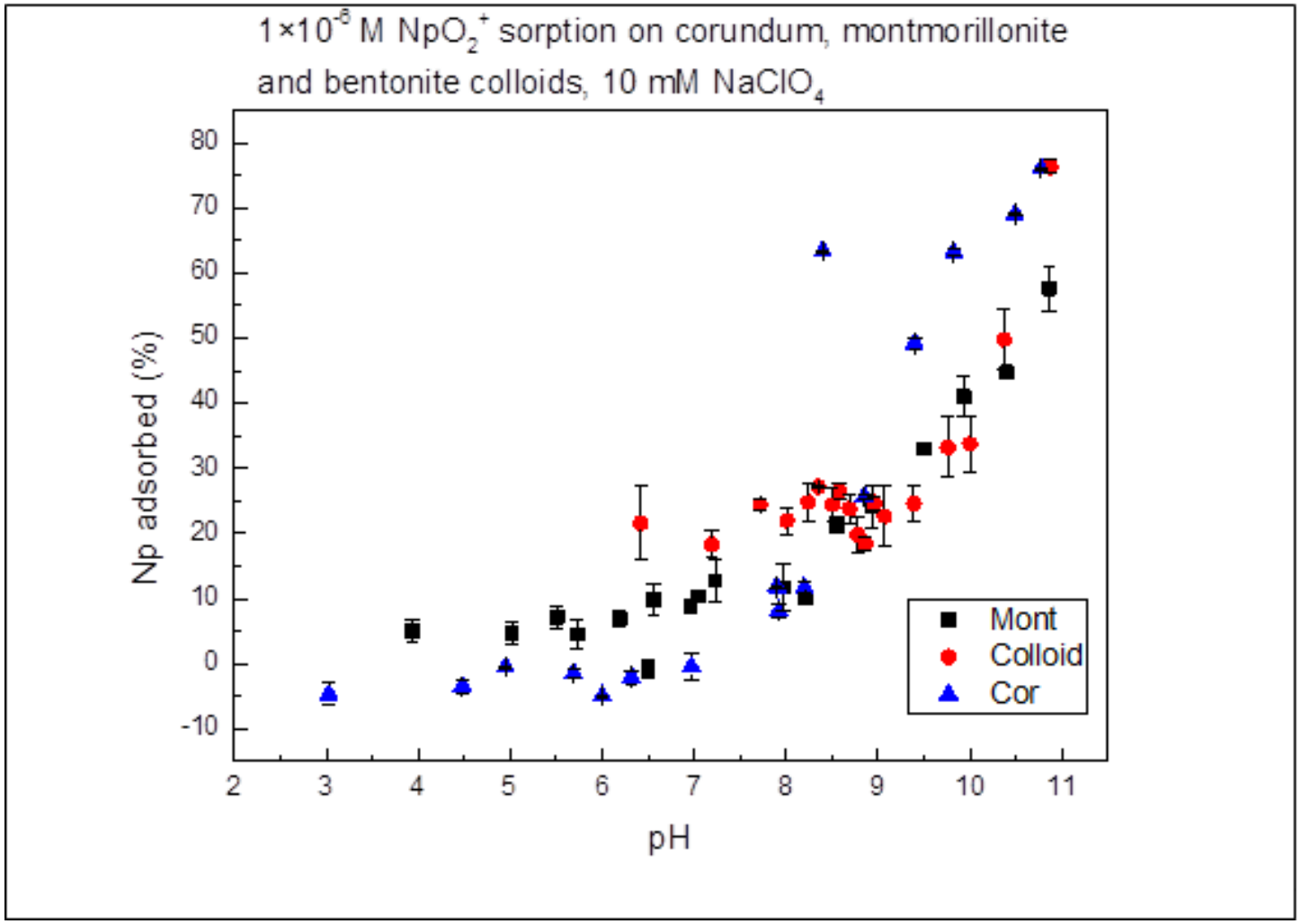
The sorption isotherm of the neptunium onto montmorillonite in pH 8



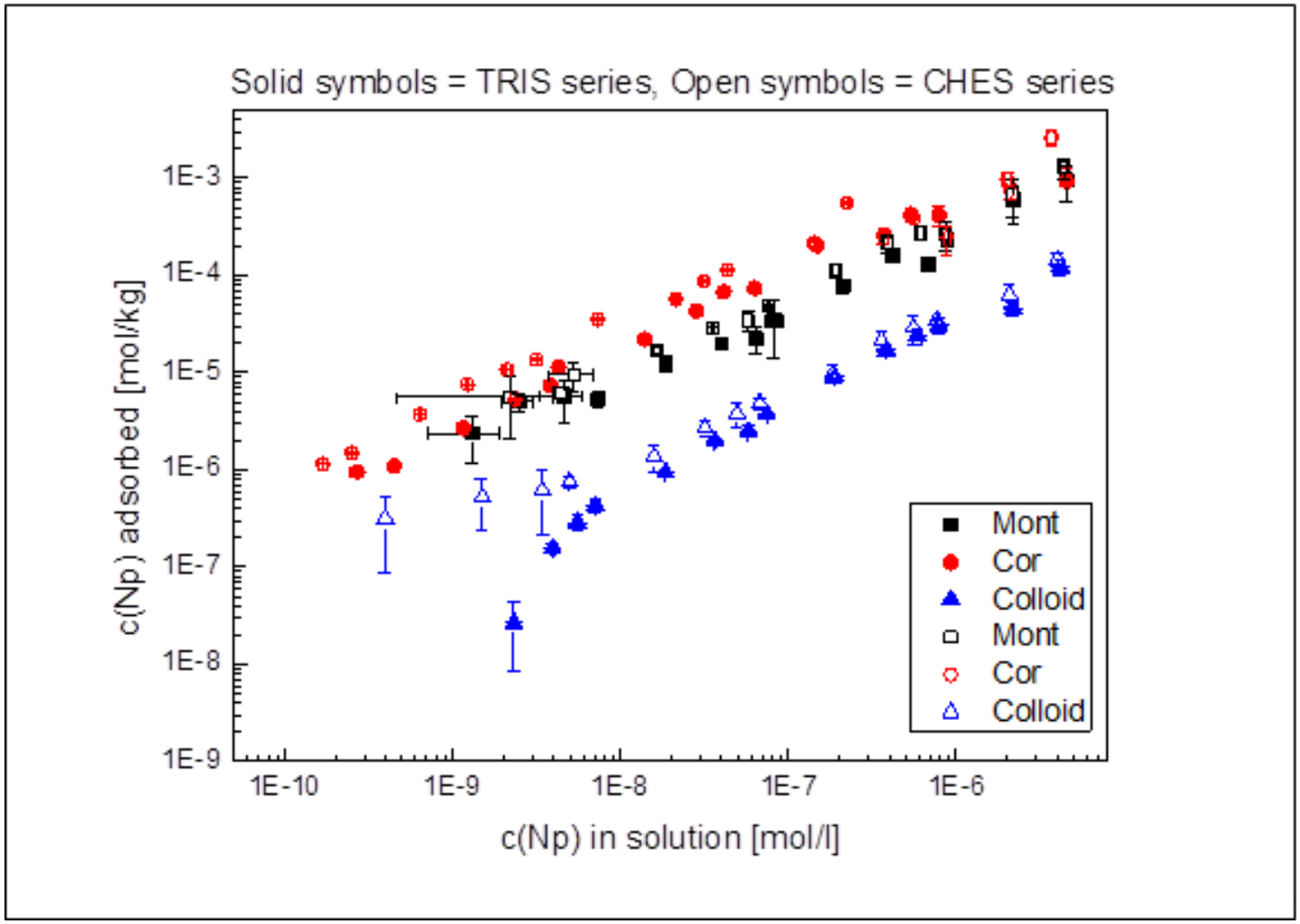
The sorption isotherm of neptunium onto bentonite colloids at pH 8.



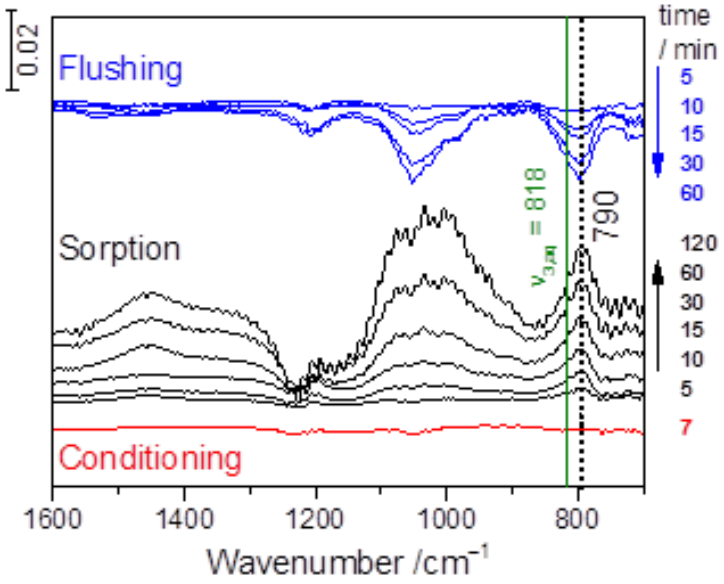
The neptunium adsorption onto corundum, montmorillonite and bentonite colloids as a pH - edge

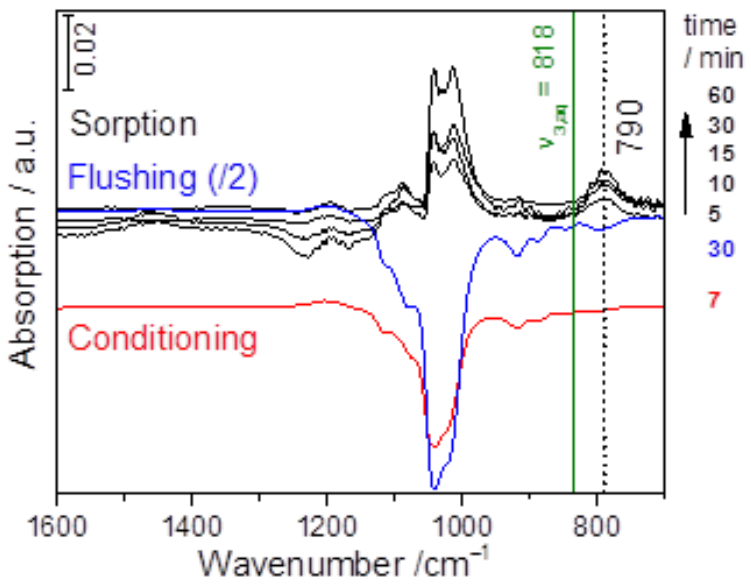


The sorption isotherms of neptunium onto corundum, montmorillonite and bentonite colloids in TRIS and CHES buffer solution



ATR FT-IR measurements of Np(V) sorption





Sorption of 50 µM Np(V) in 0,01 M NaCl in D_2O on corundum at pD 9,6, flow rate 0,1 mL/min.

Sorption of 50 µM Np(V) in 0,01 M NaCl in D_2O on montmorillonite at pD 9,6, flow rate 0,1 mL/min.

Conclusions

The results confirmed the influence of ionic strength and Ca^{2+} concentration on the sorption of Sr-85 and Eu-152 onto bentonite colloids.

Bentonite colloids had an influence on the migration of Sr-85 and Eu-152 in the column experiments.

Migration of bentonite colloids was affected primarily by colloid size but also by water flow rate and column type, stronger effect in fracture column than in crushed rock or drill core columns.

Promising results from Np sorption experiments.

ACKNOWLEDGEMENTS

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Thank you