EFFECTS OF BENTONITE COLLOIDS ON THE RADIONUCLIDE MIGRATION IN GRANITIC ROCK

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INTRODUCTION

The bentonite erosion resulting in the formation of colloids may have a direct impact on the overall performance of the bentonite buffer used in the Engineered Barrier System.

If colloids are sufficiently stable and mobile, irreversible sorption on colloids may increase radionuclide transport.

The objective was to study radionuclide sorption on bentonite colloid solution and clay suspension, colloid mobility and the effect of colloids on radionuclide migration.

EXPERIMENTS

Materials:

- MX-80 Volclay bentonite (76 %) and Nanocor PGN Montmorillonite (98 %). Colloid suspension: ultrasonic separation (2 h) and centrifugation (12000 rpm/20 min)
- Colloid suspension: ultrasonic separation and centrifugation (12000 rpm/20 min), 270 – 530 nm, 2.4 - 5.9 g/L
- Reference groundwater Allard (I = 4.2 mM) or diluted OLSO (I = 0.517 M; 1–100 mM)

Batch sorption experiments:

- Colloid dispersion + 90 mL solution + Sr-85 or Eu-152 tracer
  → 4.7 mL aliquot after 2 h, 1, 2 and 7 days
  → Ultracentrifugation (90000 rpm/60 min)
  → Radioactivity measurement

- In a clove box under CO_2 free conditions
- Zeta potential as a function of pH at the presence and absence of Sr-85 or Eu-152 (PCS/Malvern Zetasizer Nano ZS).

Column experiments:

- Olkiluoto tonalite natural fracture column (8.8 cm, 3.5 cm, 0.1 mm)
- Kuru Grey granite (KGG) Drill core column (28 cm, 4.4 cm, 0.5 mm)
- KGG and Sievi altered tonalite Crushed rock columns (15 and 30 cm, i.d. 1.5 cm)

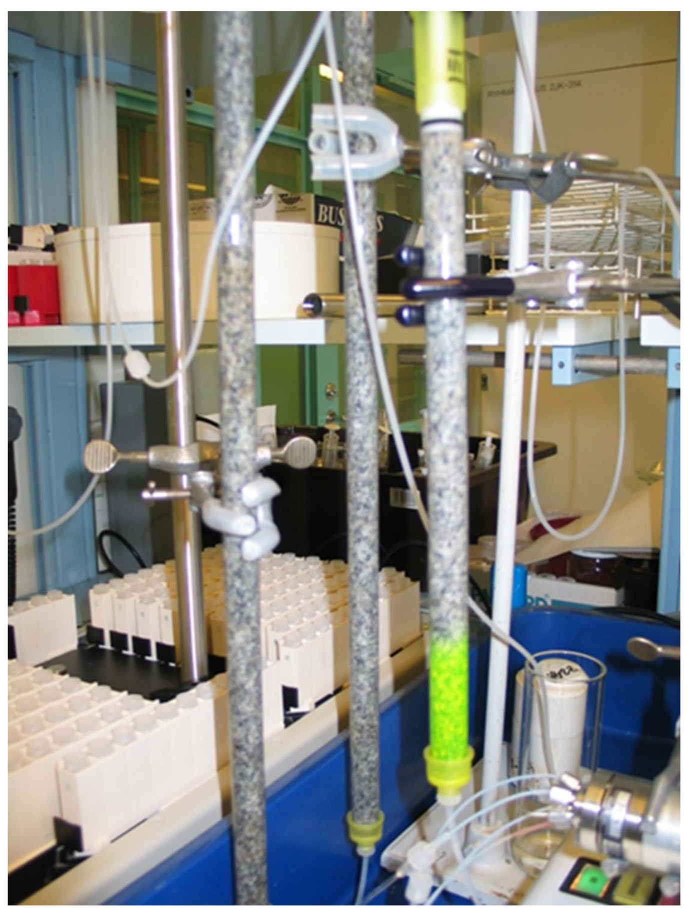

Fig. 1. Experimental set-up for column experiments. Drill core column was made from a core placed inside a tube to form an artificial fracture between the core and the tube wall.

RESULTS

Radionuclide adsorption decreased with increasing ionic strength (Fig. 2) due to particle aggregation and lower specific surface area.

Sr-85 and Eu-152 sorption was highly pH dependent, adsorption increasing with increasing pH (Fig. 3).

60 % of Eu-152 was desorbed from colloids in the Nanocor colloid solution and suspension (pH 8) (Fig. 4).

ZP of colloid solution (Fig. 5) was negative and decreased with increasing pH due to deprotonation and negatively charged mineral surfaces. ZP was slightly less negative with Eu suggesting adsorption also via outer- or inner-sphere complex due to the aluminol sites.

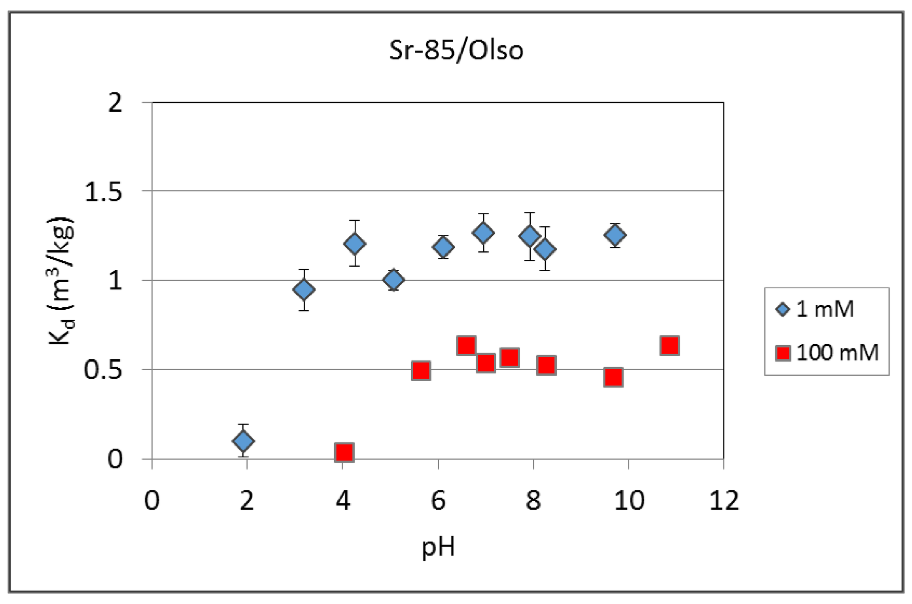

Fig. 2. K_d-values of Sr-85 for MX-80 bentonite colloids in diluted OLSO reference water.

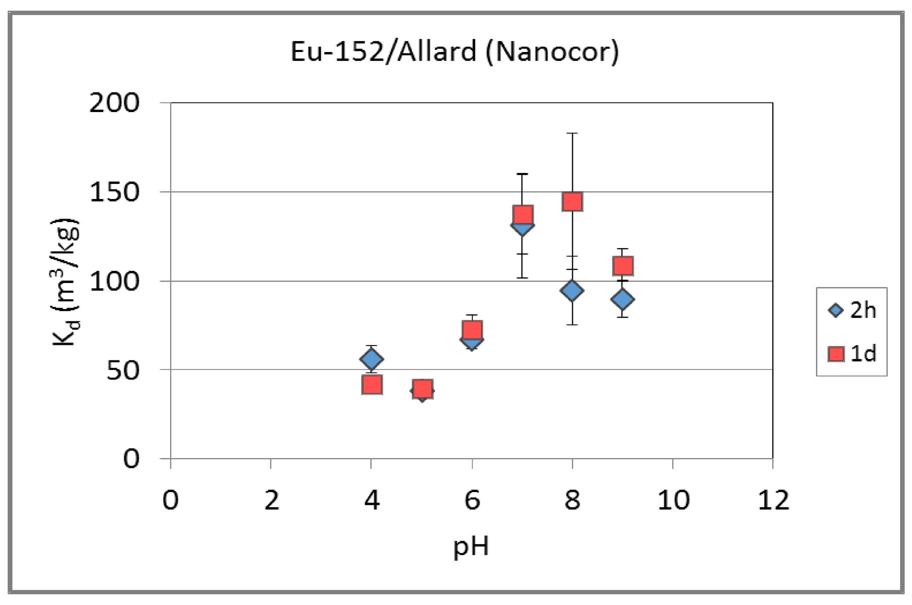

Fig. 3. K_d-values of Eu-152 for Nanocor colloids in Allard water.

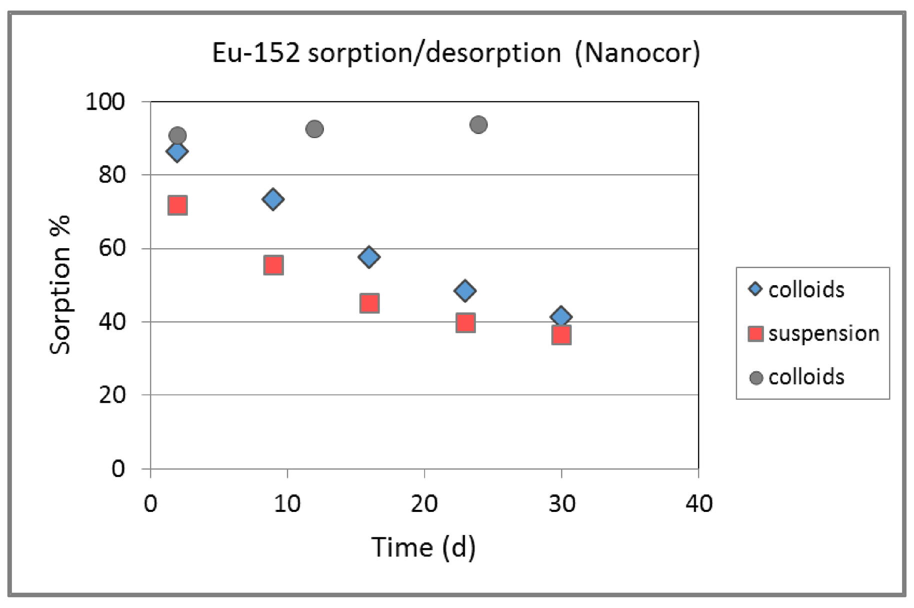

Fig. 4. Eu-152 desorption in Nanocor colloid solution and suspension in Allard water.

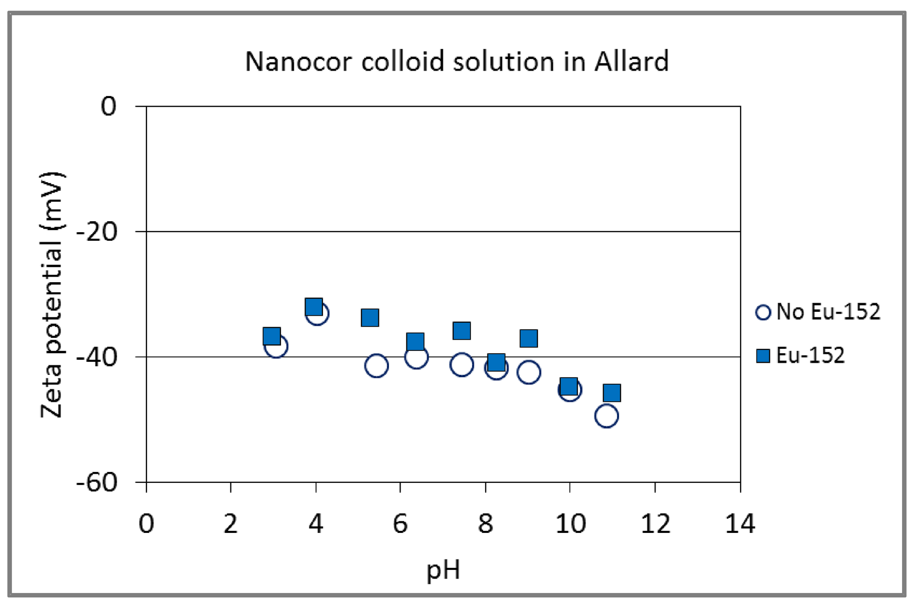

Fig. 5. ZP of Nanocor colloid solution in Allard water at the presence and absence of Eu-152.

The recovery of colloids (Fig. 6) was low and depended on column and rock type. Slowing down the water flow rate, the recovery was decreased.

In the presence of bentonite colloids, the faster elution of Sr-85 was obtained in KGG Drill core column (Fig. 7). No elution of Eu-152 was detected in two weeks without or with bentonite colloids owing to the injected short pulse resulting in very low colloid concentration available.

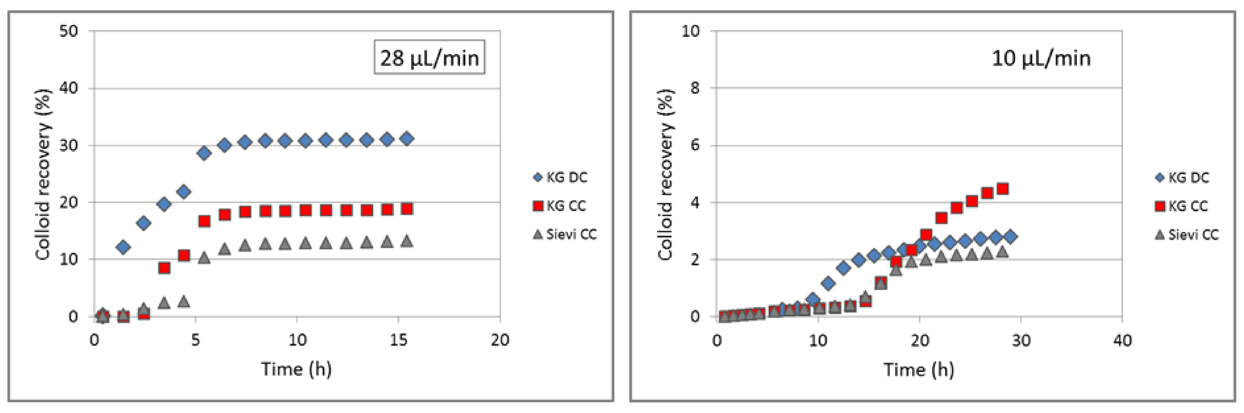

Fig. 6. Colloid recovery in KGG Drill core column (blue), KGG (red) and Sievi (grey) Crushed rock columns (15 cm). Average particle size 230 nm.

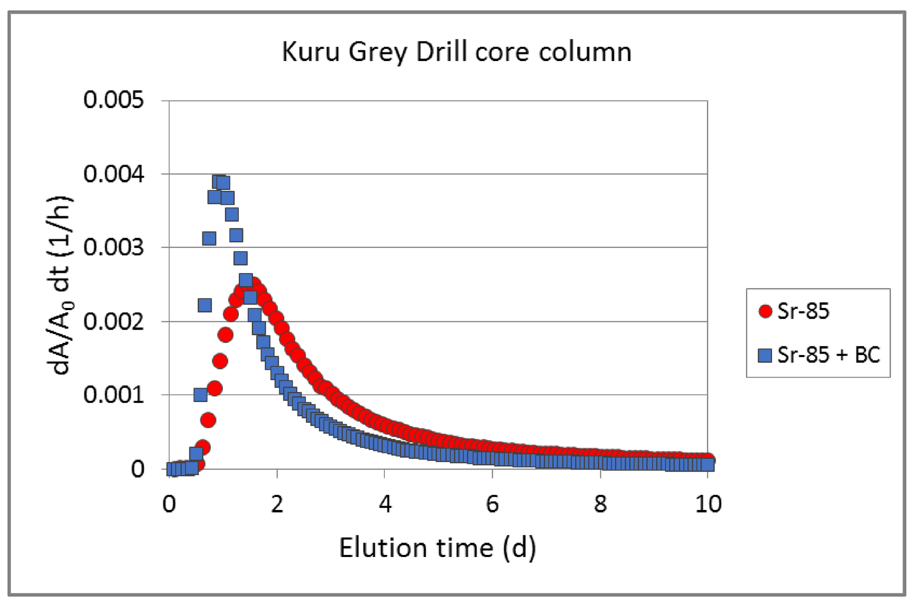

Fig. 7. The elution of Sr-85 through KGG Drill core column in the absence (red) and presence (blue) of MX-80 bentonite colloids. Allard water flow rate was 10 µL/min.

CONCLUSIONS

Geochemical groundwater conditions have a great influence on the radionuclide sorption.

Europium sorption on colloids was reversible, however, fully reversibility was not obtained.

Zeta potential in colloid solution was less negative with europium suggesting that adsorption mechanism was not purely electrostatic but also complex formation.

Mobility of colloids was affected by the flow rate, colloid size, column material and type.

Laboratory scale experiments showed that colloids had an effect on radionuclide transport. However, the water flow rates were orders of magnitudes faster than the groundwater flow.

ACKNOWLEDGEMENT

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