Colloid formation and their relevance in promoting the transport of radionuclides

Pirkko Hölttä, Mari Lahtinen and Jukka Lehto
University of Helsinki, Laboratory of Radiochemistry

Introduction

For colloid-facilitated transport it is essential that stable colloids are generated and radionuclides associated with colloids are transported with the groundwater flow.

In a colloidal system, solid particles dispersed in liquid form suspension where particle size in one dimension is from 1 nm to 1µm in diameter and surface–to–volume ratio is very high.

Colloids can be produced from degraded EBS materials.

The objective was to determine the release and stability of inorganic colloids, study bentonite erosion in colloidal form and test and apply characterization methods.

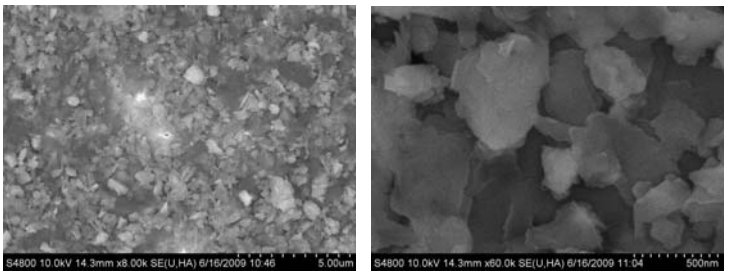

Fig. 4. Field emission scanning electron microscopy (FESEM) images of colloids released from strongly altered tonalite in Allard reference groundwater.

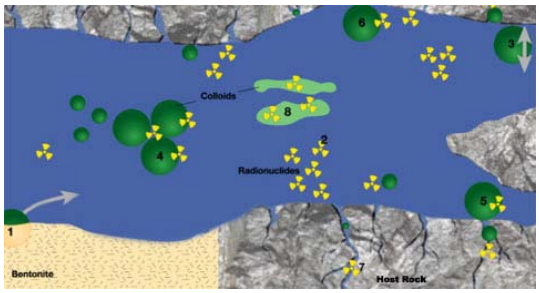

Fig. 1. Colloid processes necessary to inspect at the bentonite/ granite interface in order to assess their importance for radionuclide migration. http://www.grimsel.com/gts-phase-v/crr/crr-introduction

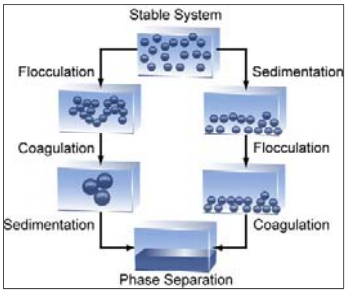

Fig. 2. Processes that deal with the stability of colloidal systems by DLVO theory (Derjaguin, Landau, Verwey and Overbeek)

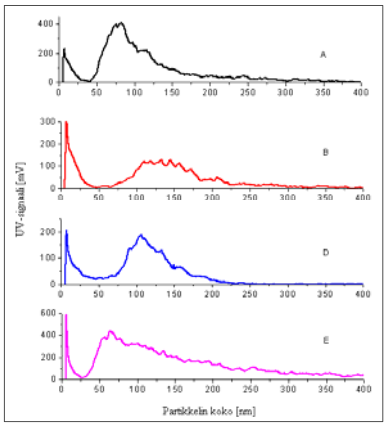

Fig. 5. Particle size distributions from rock and bentonite samples determined by AsFlFFF. A = strongly altered tonalite, B = mica gneiss, D = moderately altered tonalite and E = MX-80 bentonite.

Experimental

EBS materials
Bentonite (MX-80, powder), crushed rock, cement, silica
Reference groundwater
- Allard, I = 4.2 10^{-3} M, OLSO, I = 0.517 M, MilliQ
- Diluted OLSO, NaCl and $CaCl_2$,: I = 0.001 – 0.1 M
Samples: Solid material + solution → Storage → Filtration
Characterization
- Particle size distribution and concentration
- Zeta potential
- Elemental composition
- Morphology
Methods
- Dynamic light scattering (DLS, PCS)
- Asymmetrical flow field-flow fractionation (AsFlFFF)
- ICP- MS
- Scanning electron microscopy (FESEM)

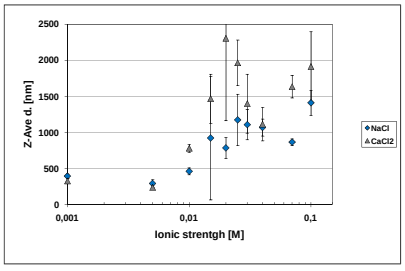

Fig. 6. Mean particle diameter of bentonite colloids in NaCl and $CaCl_2$ solutions as a function of ionic strength.

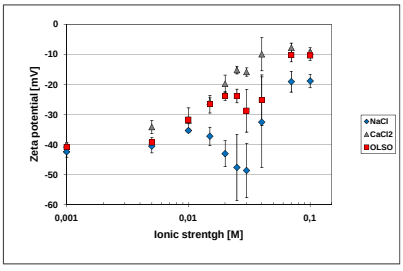

Fig. 7. The zeta potential of bentonite colloids in NaCl, $CaCl_2$ and diluted OLSO reference groundwater as a function of ionic strength.

Results

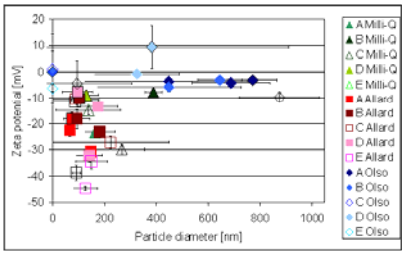

Fig. 3. Zeta potential as a function of number based particle diameter. Samples filtered trough 0.45 µm filters. A = strongly altered tonalite, B = mica gneiss, D = moderately altered tonalite and E = MX-80 bentonite.

Conclusions

The stability of colloids strongly depends on the salinity of the solution and particle size.

At current conditions in Olkiluoto colloids are aggregated and unstable.

Knowledge of bentonite erosion in colloidal form can be utilized in the estimation performance of the bentonite barrier.

The possibility of a post-glacial phase implies that dilute groundwater conditions cannot be excluded and the influence of bentonite and other colloids has to take into consideration.

Reference

Lahtinen, M., Hölttä, P., Riekkola, M-L. and Yohannes, G., 2010. Physics and Chemistry of the Earth 35, 265–270.

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI