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Äspö Hard Rock Laboratory

Project description of the Äspö project Colloid with the aim to investigate the stability and mobility of colloids

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November 2000

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Keywords: Colloids, groundwater, bentonite, transport, bentonite stability, natural colloid concentration

Summary

Colloids are small particles in the size range 10^{-3} to 10^{-6} mm. These colloidal particles are of interest for the safety of spent nuclear fuel because of their potential for transporting radionuclides from a faulty repository canister to the biosphere. The objectives of the proposed COLLOID project are to:

1) Verify the colloid concentration at Äspö-HRL

2) Study the role of bentonite clay as a source for colloid generation

3) Demonstrate the colloid stability and mobility at prevailing conditions

The means are laboratory and field tests. The role of the bentonite clay as a source for colloid generation will be studied in a laboratory experiment. The background colloid concentration associated with the different water types found at Äspö will be sampled at specific locations along the Äspö HRL-tunnel. For the fracture specific measurements two nearby boreholes at HRL will be selected for the COLLOID experiment. One of the boreholes will be used as an injection borehole and the borehole downstream will be used as a monitoring borehole. The boreholes intersect the same fracture and have the same basic geological properties. From the monitoring borehole the colloidal content will be measured with new laser techniques, the water will be filtered and the amount of tracers will be measured. The following results are of interest 1) is the colloid content lower after the transport, 2) is the bentonite clay a potential source for colloid generation.

The outcome of the experiment is used to check the calculations in the safety assessment report TR 91-50 to be used in future colloid transport modelling. The COLLOID project will strengthen the SKB's competence and confidence concerning the role of colloids at repository conditions.

List of content

1. Introduction

Colloids are small particles in the size range 10^{-3} to 10^{-6} mm. These colloidal particles are of interest for the safety of spent nuclear fuel because of their potential for transporting radionuclides from a faulty repository canister to the biosphere.

SKB has, for more than 10 years, conducted field measurements of colloids in ground-water. The outcome of those studies performed nationally and internationally concluded that the colloids in the Swedish granitic bedrock consist mainly of clay, silica and iron hydroxide and that the mean concentration is around 20-45 ppb which is considered to be a low value (Laaksoharju et al., 1995). The low colloid concentration is controlled by the large attachment factor to the rock which reduces stability and transport capacity of the colloids in the aquifer.

It has been argued that e.g plutonium is immobile owing to its low solubility in groundwater and strong sorption onto rocks. Field experiments at the Nevada Test Site, where hundreds of underground nuclear tests were conducted, indicate that plutonium is associated with the colloidal fraction of the groundwater and therefore could be transported with the groundwater flow. The $^{240}Pu/^{239}Pu$ isotope ratio of the samples established that an underground nuclear test 1.3 km north of the sample site is the origin of the plutonium (Kersting et al., 1999). Based on these results SKB decided to initiate a COLLOID project at the Äspö-HRL (Hard Rock Laboratory) to study the stability and mobility of colloids.

2. Aim

The objectives of the COLLOID project is to:

1) Verify the colloid concentration at Äspö-HRL

2) Study the role of bentonite clay as a source for colloid generation

3) Demonstrate the colloid stability and mobility at prevailing conditions.

SKB wants to investigate and test the validity of the earlier measurements and conclusions such as; a) the colloid concentration is generally low and b) the chemical conditions are such (reducing conditions and higher ionic content) that the potential for colloidal uptake and transport of radionuclides is low at Äspö compared with the conditions at e.g, Nevada Test Site. Further SKB wants to investigate/demonstrate a) the role of bentonite clay as a possible source for colloids at varying groundwater salinities, d) test new and improved techniques (which may be of use at future sites) for in-situ determination of colloid concentrations e) demonstrate to the public the awareness of new scientific results (the results from the Nevada Test site have highlighted the issue of colloid transport in the media and in the scientific community, and made a demonstration necessary and the willingness to demonstrate issue at prevailing Äspö conditions. Similar projects are ongoing or planned to be performed at e.g. the Grimsel Test Site in Switzerland. However, the suggested COLLOID project has a different aim and in addition to that, the differences in chemical conditions (higher ionic strength at Äspö) makes the project a natural complement to other international colloid projects. The aim is to work close together with internationally recognized scientist and institutes to exchange information and experiences.

3. Background information for the project

Background information for the project is:

a) the reports and scientific articles needed for the project are listed in appendix#1.

b) project decision

c) the state of knowledge which is the base for the project see section 1 (Introduction/Background) and the literature review in appendix#1.

d) the background data is the colloid sampling performed at Äspö

e) the key persons directly involved in the project work are Susanna Wold, KTH; Ola Karnland, Claytech and Wolfgang Hauser INE.

f) the LIBD laser is necessary to perform the on-line measurements of colloids. M3 (Multivariate Mixing and Mass-balance program) will be used for the separation between natural and bentonite colloids.

4. Execution of the project

The experimental concept for the Colloid project is: laboratory experiments, background measurements and fracture specific measurements. Theses concepts are described below:

Laboratory experiments: The role of the bentonite clay as a source for colloid generation at varying groundwater salinities (NaCl/CaCl) and temperatures (at 20 and 60C°) will be studied in a laboratory experiment performed at KTH (Royal Institute of Technology) and at the company Claytech (Figure 1).

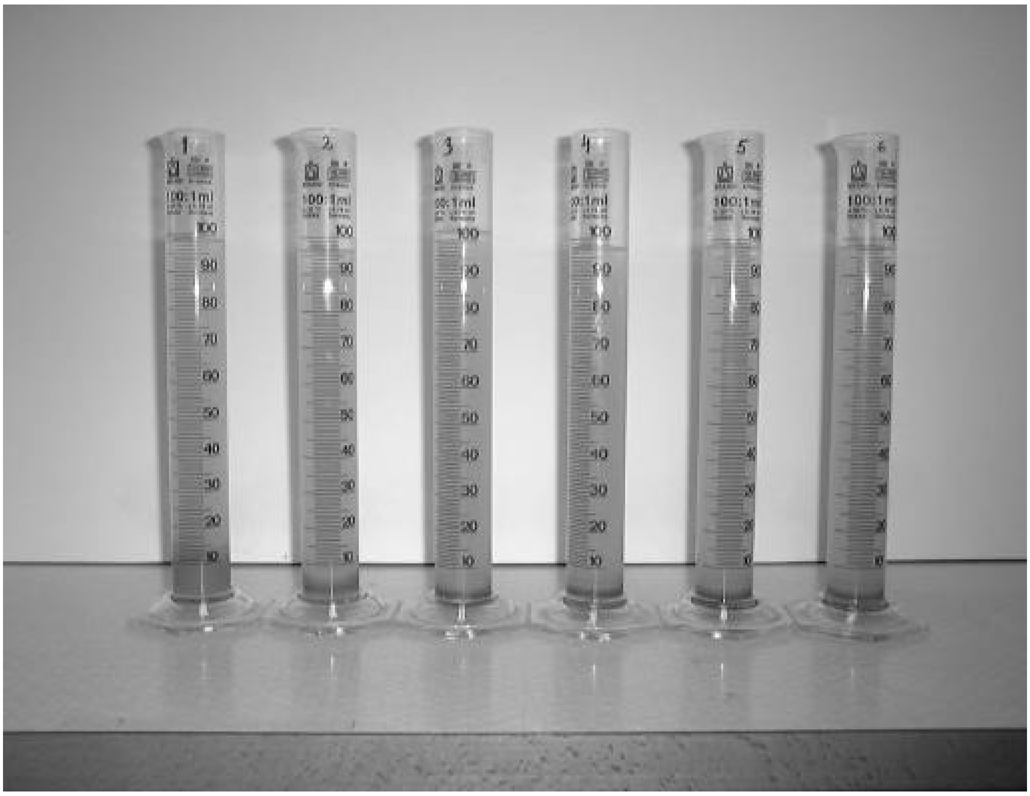


Figure 1: *The salinity of the water may affect the colloid generation. The experiment show different degrees of sedimentations of bentonite clay dependent of the ion content (NaCl) in the water. A very high or low ion content may result in bentonite instability and colloid generation.*

Background measurements: The background colloid concentration associated with the different water types found at Äspö will be sampled at specific locations along the Äspö HRL-tunnel (Figure 2). The colloid content will be measured on-line from the boreholes by using a modified laser based equipment LIBD (Laser-induced Breakdown-Detection) which has been developed by INE in Germany (Figure 3). The advantage is that the resolution of this equipment is higher compared with standard equipment. It is therefore possible to detect the colloid contents at much lower concentrations than previously possible. The outcome of these measurements will be compared with standard type of measurements such as particle counting by using Laser Light Scattering (LLS) at KTH and at INE. Standard type of filtration performed on-line at the boreholes are used in order to be able to compare/transform these results to all the earlier colloid sampling campaigns at Äspö.

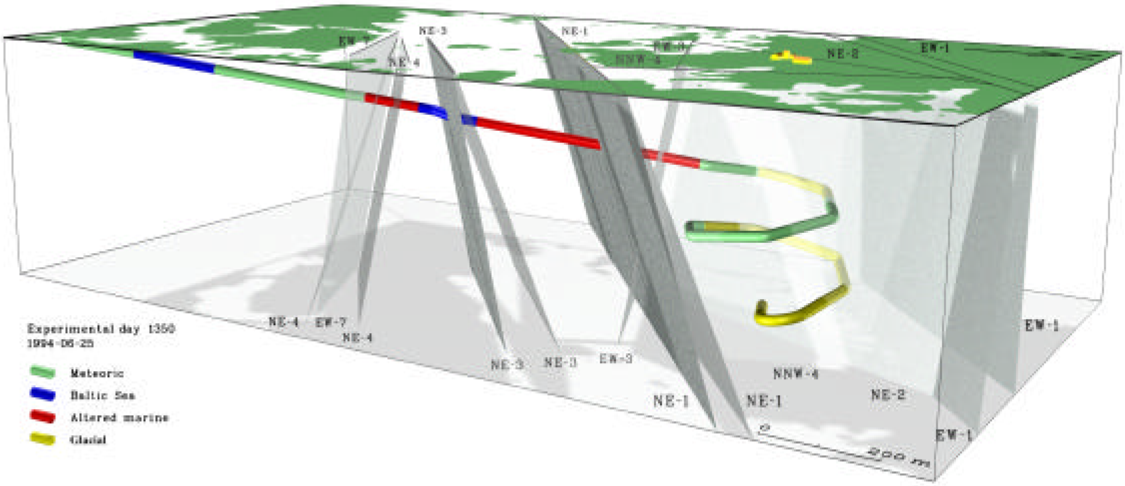


Figure 2: *The background colloid concentration will be measured at the major fracture zones along the Äspö HRL-tunnel and to cover the major water types obtained (Meteoric, Baltic Sea, Altered Marine, Glacial and Brine).*

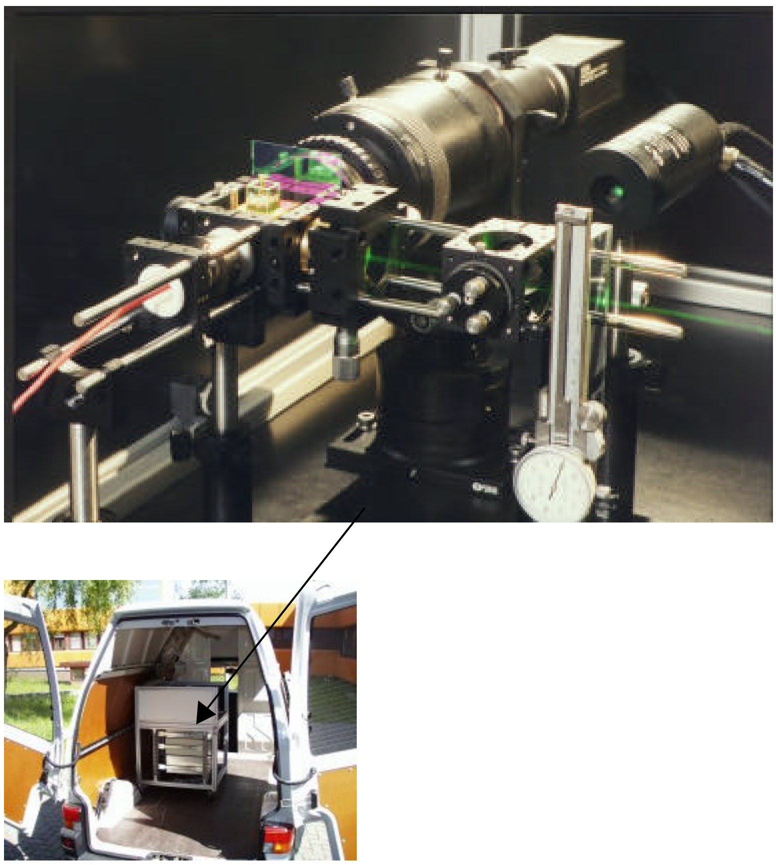


Figure 3: *Equipment for Laser-induced Breakdown-Detection (LIBD) of colloids (upper picture). The equipment is installed in a van in order to allow mobility and on-line measurements (lower picture).*

Fracture specific measurements: For the fracture specific measurements two nearby boreholes at HRL will be selected for the experiment. One of the boreholes will be used as an injection borehole and the borehole downstream will be used as a monitoring borehole. These boreholes intersect the same fracture and have the same basic geological properties. After assessing the natural colloid content in the groundwater bentonite clay will be dissolved in ultra pure water to form colloidal particles. These clay colloids will be labelled with uranine, a water conservative tracer. The mixture will be injected into the injection borehole (Figure 4). From the monitoring borehole the colloidal content will be measured with laser (LIBD/LLS), the water will be filtered and the amount of tracers will be measured. The signature of the bentonite/natural colloids will be traced by using multivariate statistics or a labelling technique.

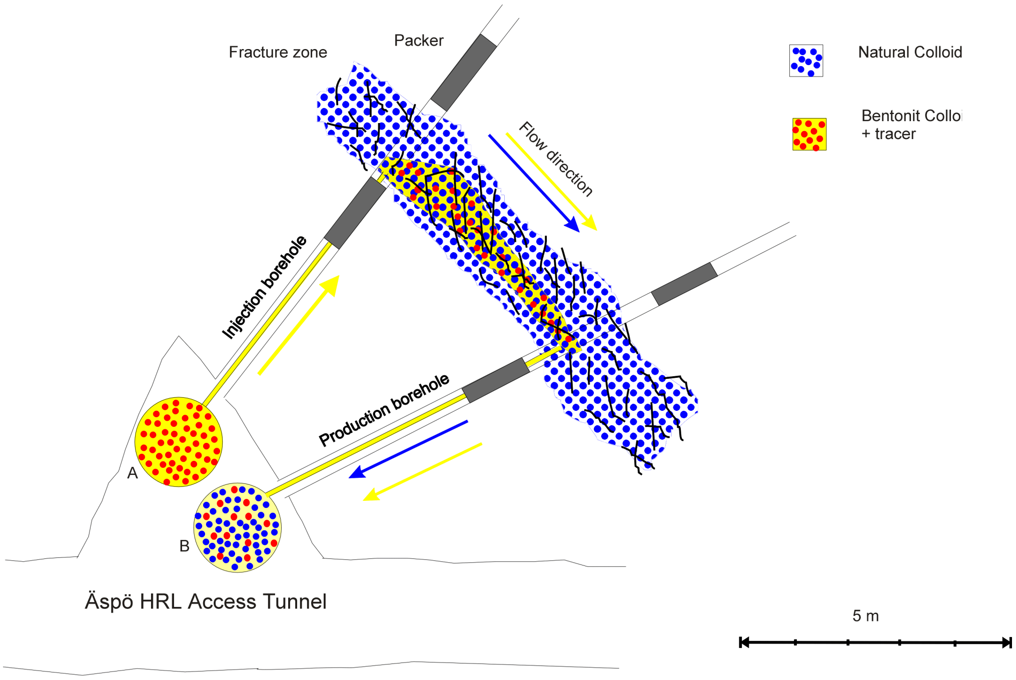


Figure 4: *Injection of bentonite colloids and a tracer at the injection borehole and monitoring of the injected and natural colloids in the production borehole.*

The following issues will be addressed: 1) Is the colloid content lower after the transport ? 2) Is the bentonite clay a potential source for colloid generation? The outcome of the experiment is used to check the calculations in the safety assessment report such as TR 91-50 and to be used in future colloid transport modelling.

5. This project in relation to other projects

The experiment will be performed in association with the TRUE-trace experiment programme (Figure 4). The boreholes and the optimum time for the experiment will be selected in co-operation with the TRUE projects.

6. Technique used in the project

The most of the techniques required for the project is available to SKB or to the expertise group working for SKB. The only exception is the LIBD (Laser-induced Breakdown-Detection) which has been developed by INE in Germany. However, experts at INE will participate in the project with their equipment.

7. Methods

There is no requirements to perform the project with any special method. The aim is to apply new technique in order to obtain high resolution and also to find appropriate techniques for future site investigations.

8. Expected results

The outcome of the experiment is used to check the calculations in the safety assessment report TR 91-50 to be used in future colloid transport modelling. The COLLOID project will strengthen the SKB's understanding and confidence in the role of colloids at repository conditions. The results will be reported as progress reports from all the main activities (laboratory test, background colloid measurements, fracture specific measurements) and as a final report.

9. Problems and alternatives

The problem area is a successful injection of bentonite colloids and identification of natural/versus injected bentonite colloids. The methology will be tested in laboratory experiments.

10. The significance of the project

The significance of the project described as major activities and supporting activities (se below).

10.1. Main activities

The main activities are:

- laboratory tests of bentonite
- background colloid measurements in the field
- fracture specific measurements in the field

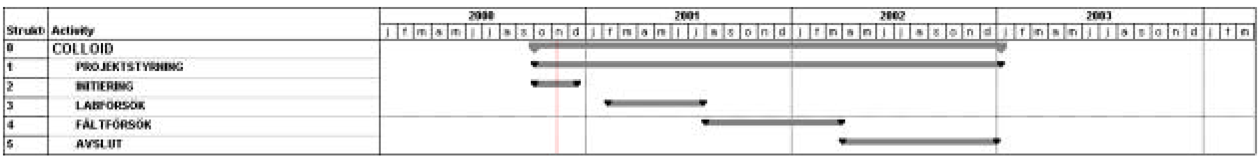
10.2 Supporting activities

Supporting activities are laboratory analysis and field support.

11. Time schedule

The following time plan has been established (graphically see below):

- Updated program November, 2000
- Laboratory tests January-June, 2001
- Field test, background colloid content September 2001 – December 2001
- Fracture specific test January - June 2002
- End of project December 2002



12. Organization

The project organization is:

The work is ordered and suggested by SKB (Peter Wilkberg and Fred Karlsson)

Project leader: Marcus Laaksoharju

Workgroup: Susanna Wold, Ola Karnland and Wolfgang Hauser

Support people at laboratory and field.

Reference group (international review)

13. Acknowledgements

The project was originally suggested by Fred Karlsson at SKB. The support and improvements suggested by Peter Wikberg are acknowledged.

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