

Canister Retrieval Test, a large scale experiment made at Äpö Hard Rock Laboratory with well-defined hydraulic and mechanical boundaries.

Mechanical Properties of Bentonite Barriers

19 - 20 June 2017

Lithuanian Energy Institut

Kaunas, Lithuania

Ola Kristensson, Clay Technology AB

Mattias Åkesson, Clay Technology AB

Lennart Börgesson, Clay Technology AB

Lars-Erik Johannesson, SKB

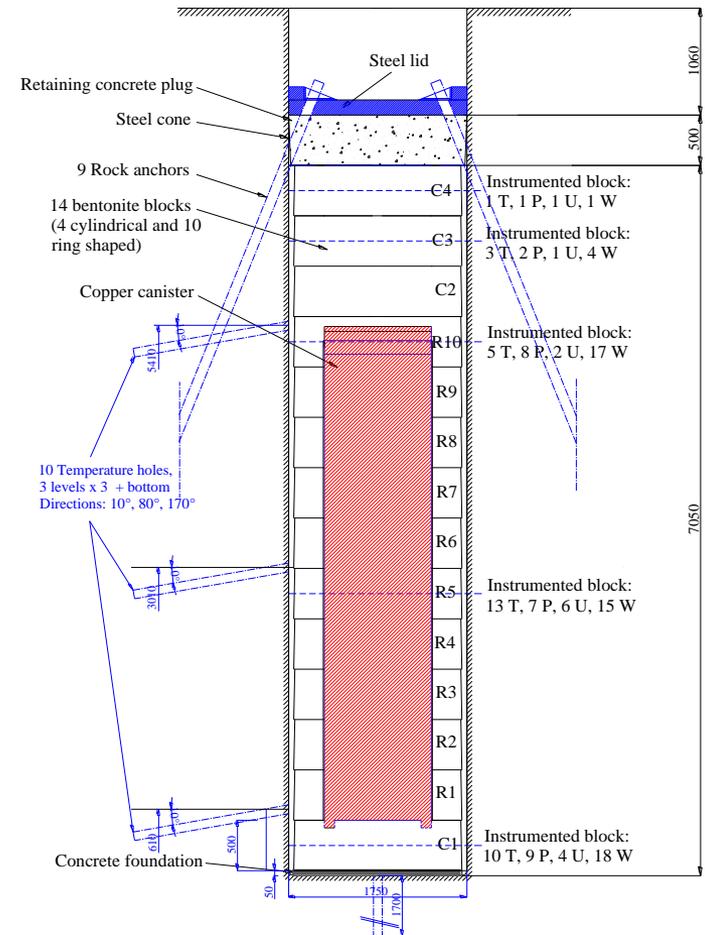


CLAY
TECHNOLOGY AB

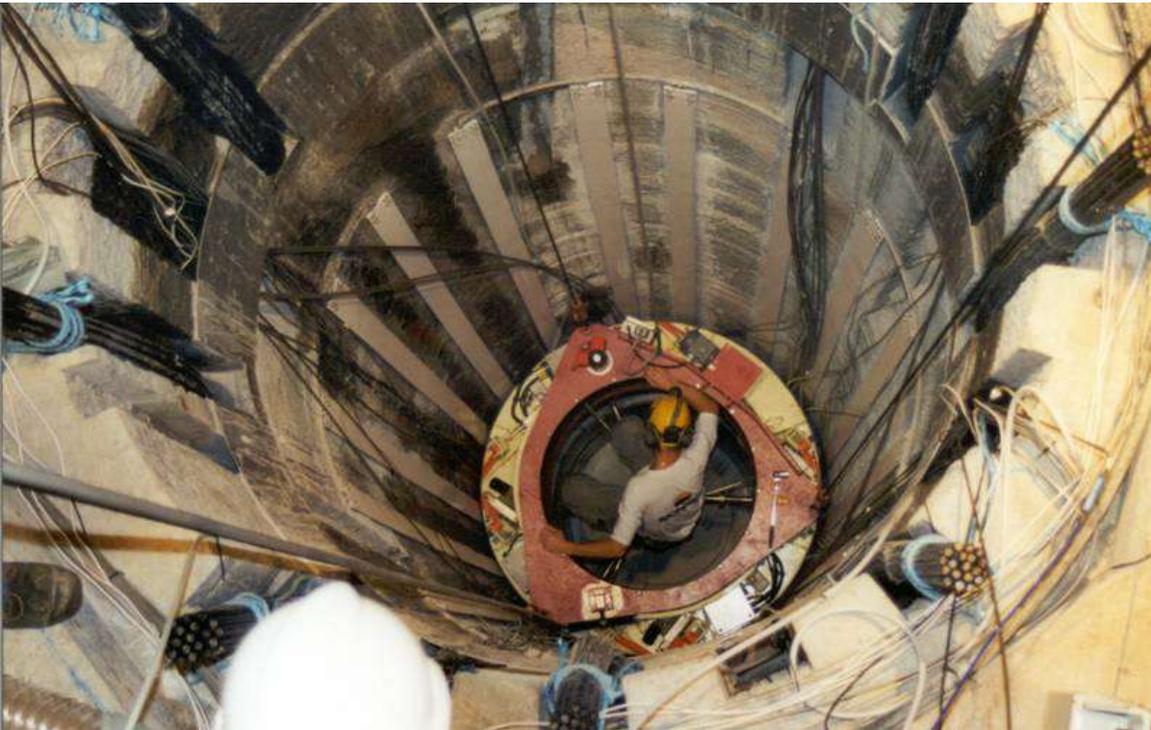
- Background/layout
- Thermal, mechanical and hydraulic boundaries
- Instrumentation and data from the running of the test
- Data from the retrieval of the test
- Modelling of the test
- Summary and conclusions

Background/layout

- In accordance with the Swedish KBS3-concept
- Original designed for testing techniques of retrieving canisters
- A full size canister equipped with heaters
- Artificial wetting of the buffer trough filters placed on the wall of the deposition hole
- Instrumentation in five sections of the buffer
- Measurements of the load and the displacement on the plug
- Instrumentation in the surrounding rock



Background/layout

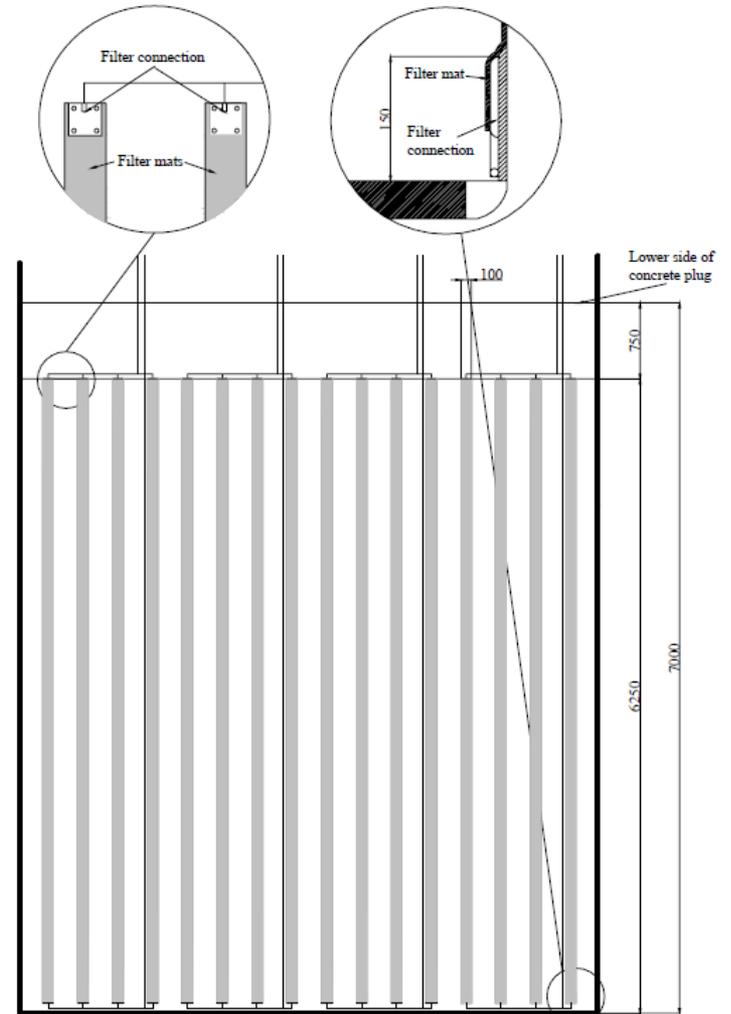


Background/layout



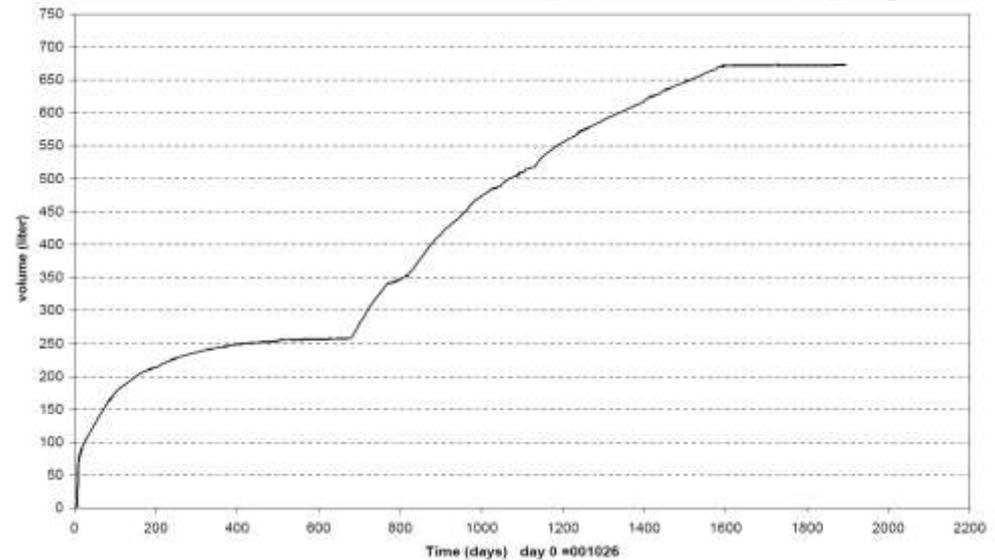
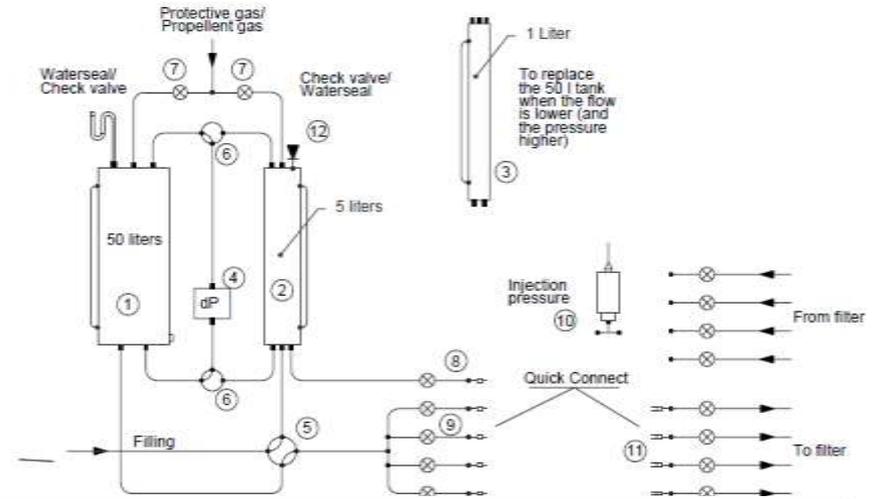
Boundaries

- Hydraulic boundaries
 - ✓ The water pressure in the mats
 - ✓ The total inflow in the mats



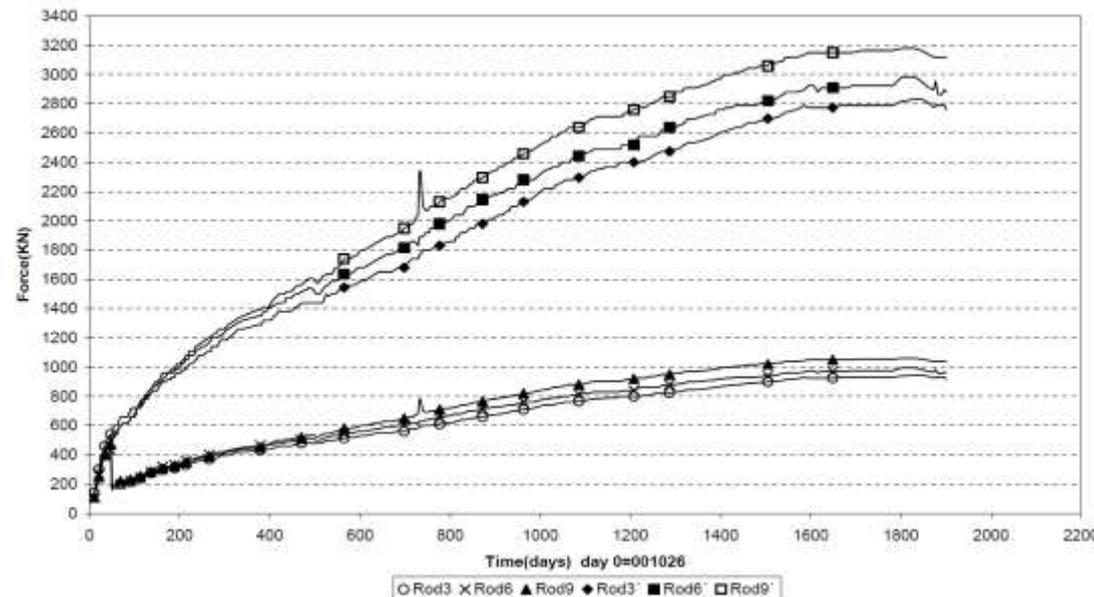
Boundaries

- Hydraulic boundaries
 - ✓ The water pressure in the mats
 - ✓ The total inflow in the mats



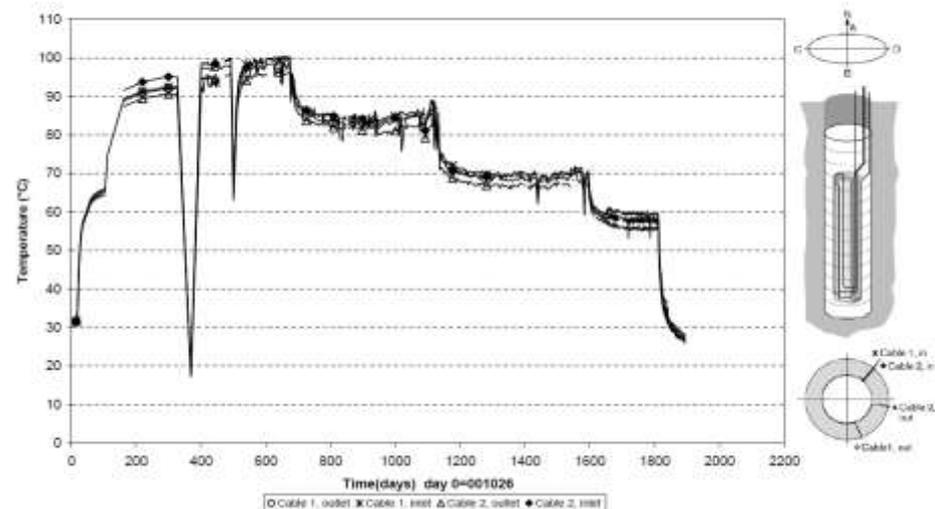
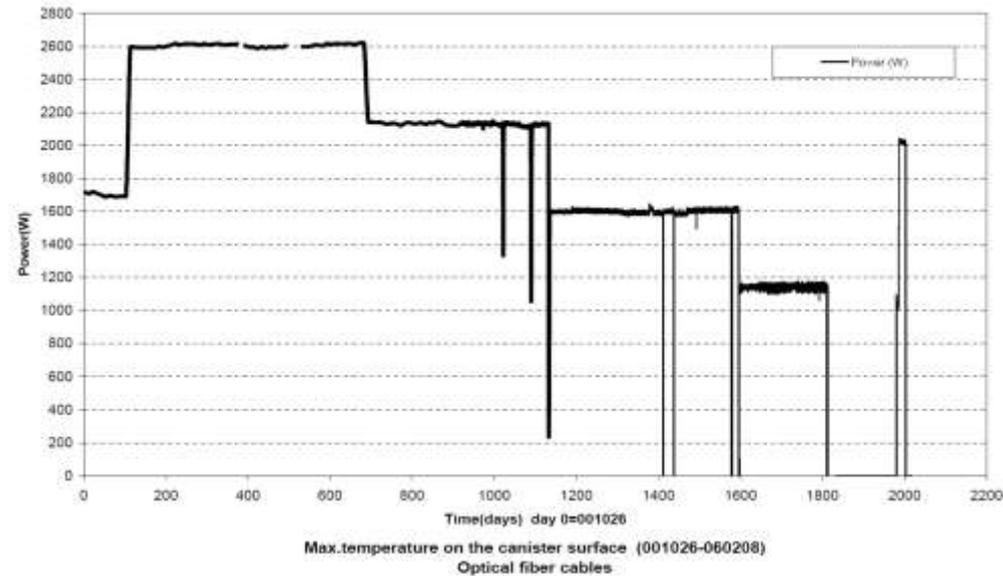
Boundaries

- Hydraulic boundaries
 - ✓ The water pressure in the mats
 - ✓ The total inflow in the mats
- Mechanical boundaries
 - ✓ The forces in the anchors
 - ✓ The displacement of the plug



Boundaries

- Hydraulic boundaries
 - ✓ The water pressure in the mats
 - ✓ The total inflow in the mats
- Mechanical boundaries
 - ✓ The forces in the anchors
 - ✓ The displacement of the plug
- Thermal boundaries
 - ✓ The power applied to the canister
 - ✓ The temperature on the canister surface and in the surrounding rock



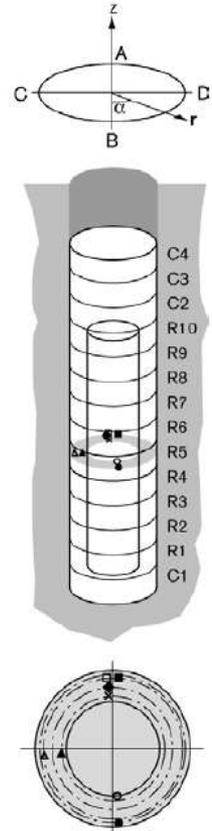
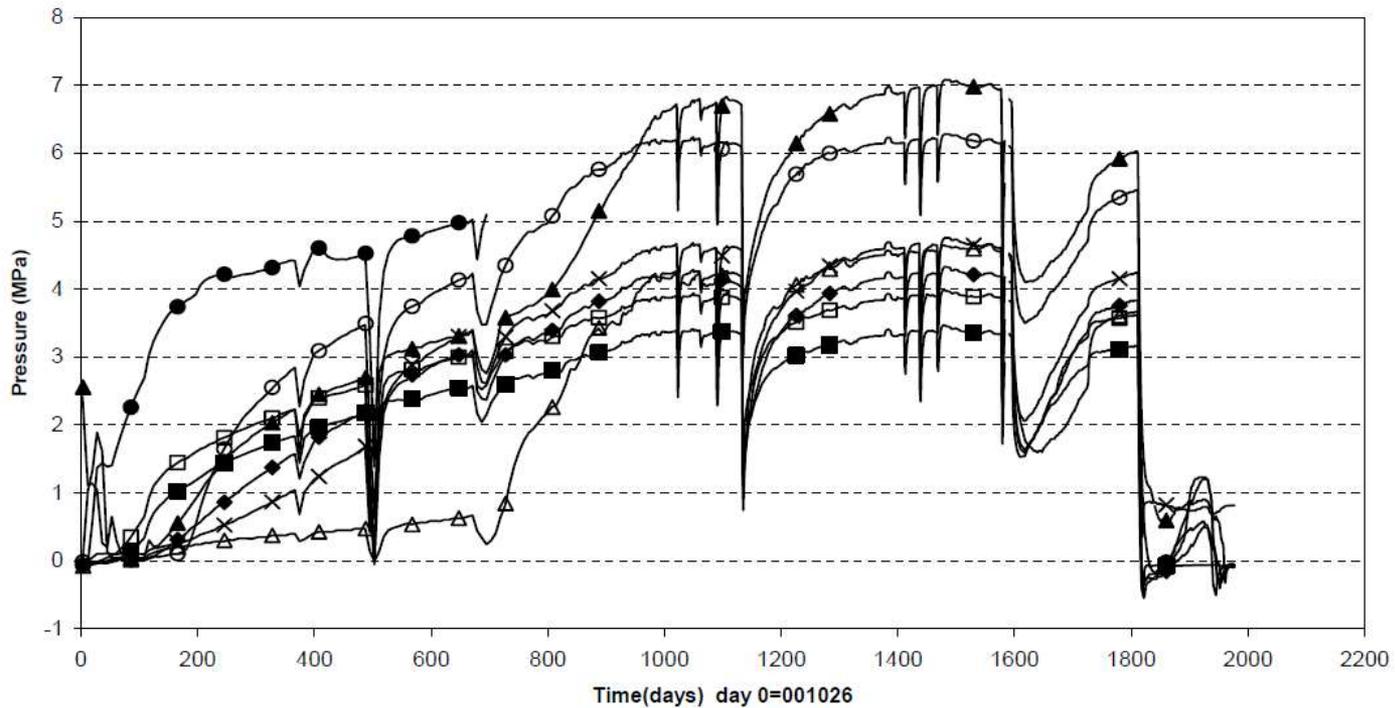
Instrumentation and data



- Measurements in the buffer (temperature, total pressure, pore pressure and relative humidity, in total 128 sensors)
- Temperature in the surrounding rock (in total 40 thermocouples)
- Sensors for measuring strains and stresses in the surrounding rock
- Temperature of the canister (optical fiber cables and thermocouples on the insert)

Instrumentation and data

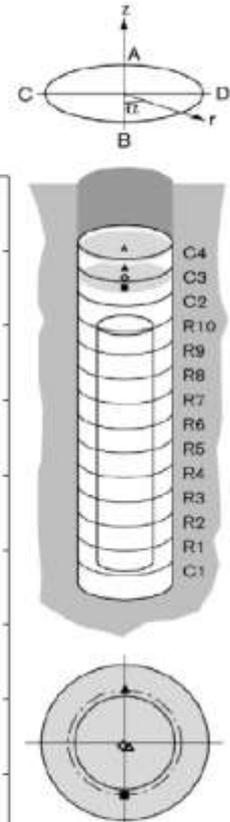
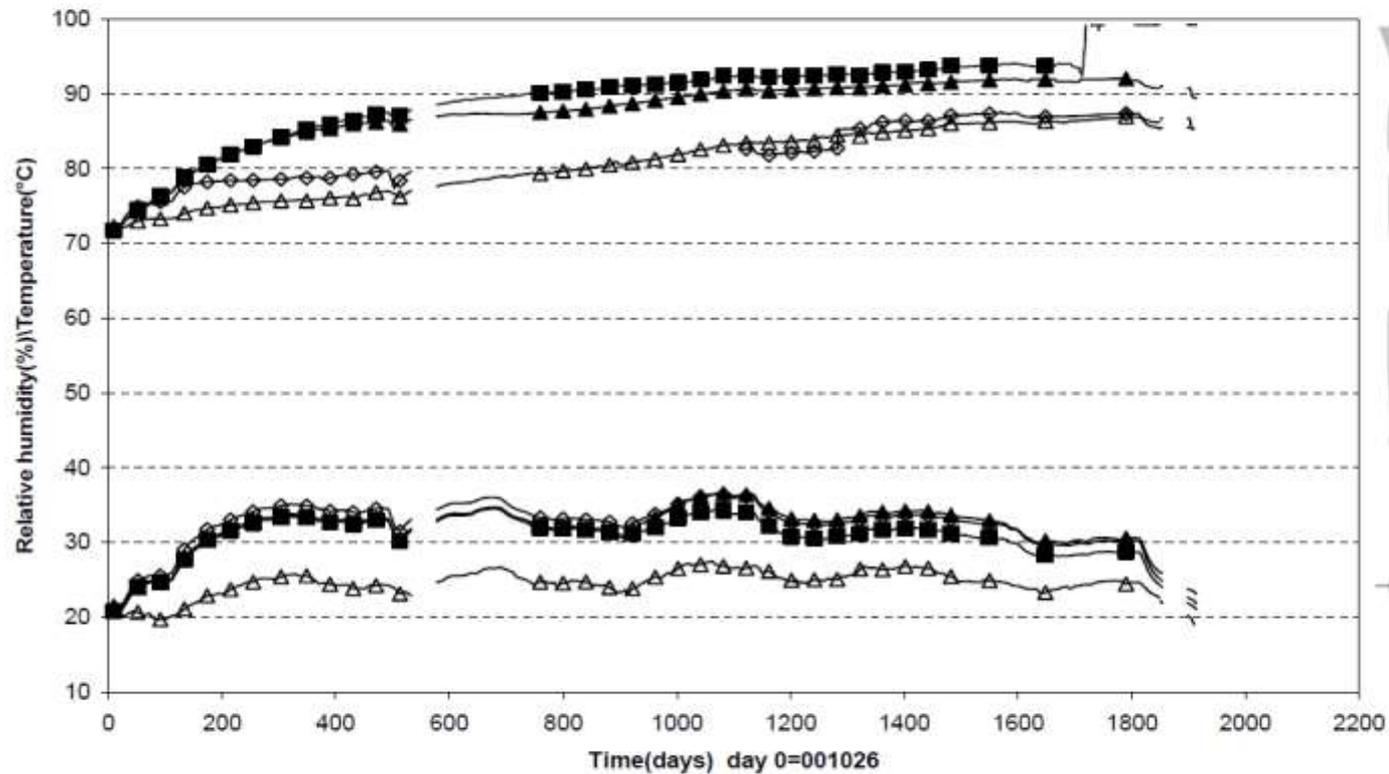
Total pressure - Ring 5 (001026-060501)
Geokon



○ P113(Ring5\B\535)	× P110(Ring5\A\585)	▲ P115(Ring5\C\585)	◆ P111(Ring5\A\685)
■ U106(Ring5\A\785)	□ P112(Ring5\A\785)	△ P116(Ring5\C\785\slot)	● P114(Ring5\B\815\slot)

Instrumentation and data

Relative humidity - Cylinder 3 and Cylinder 4 (001026-060501)
Vaisala



◊ W151(Cyl.3/Center/50)
◊ W151T
▲ W152(Cyl.3/A/585)
▲ W152T
■ W153(Cyl.3/C/585)
■ W153T
▲ W155(Cyl.4/center/50)
▲ W155T

Retrieval of the test

After 5 years of saturation:

- The anchors were cut and the plug was removed
- Samples were taken of the upper part of the buffer , i.e. down to block R6, by core drilling from the tunnel floor
- The water content and the bulk density of the samples were determined, in total about 1500 determinations were made



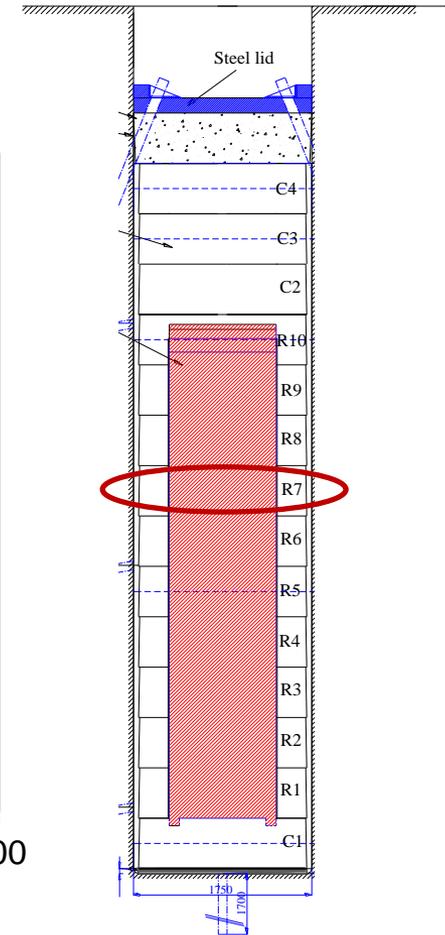
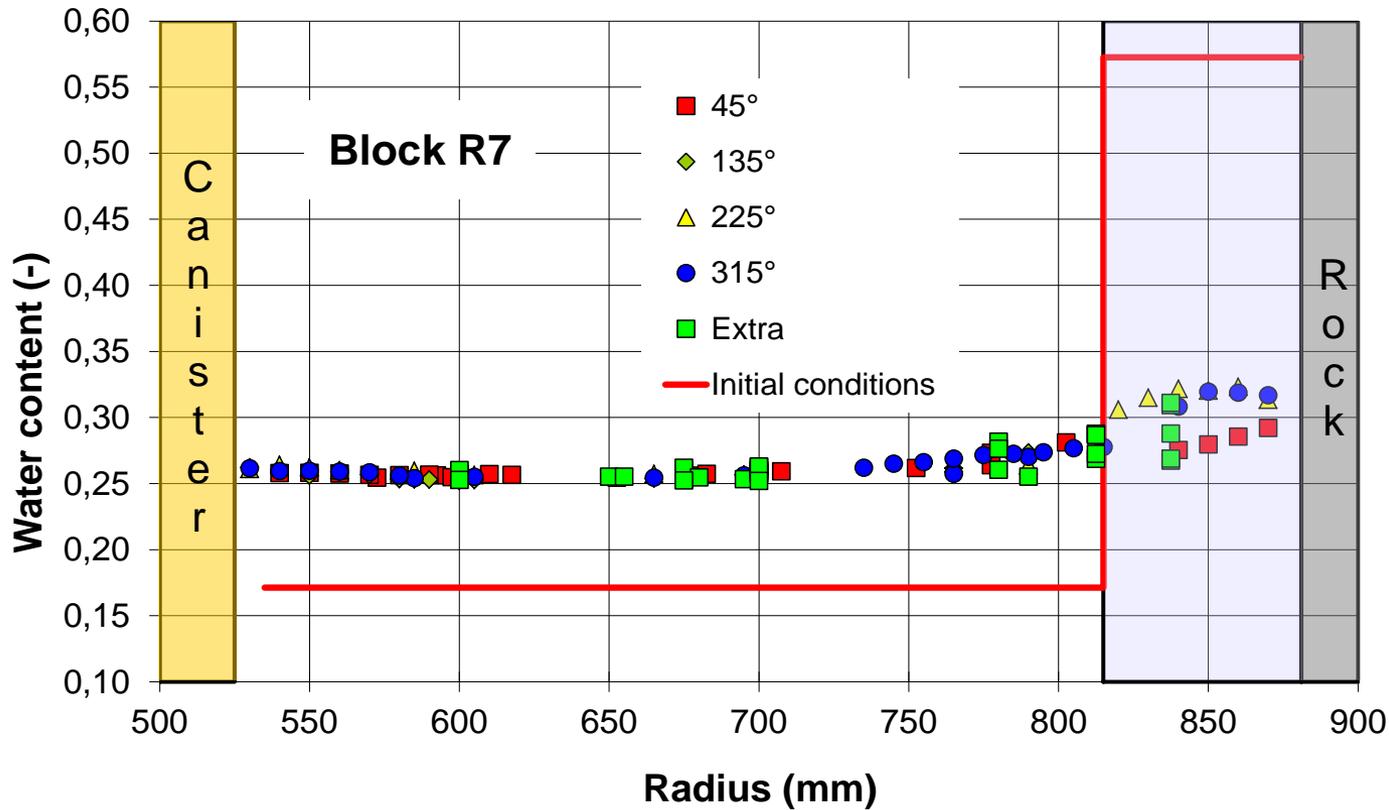
Retrieval of the test

After 5 years of saturation:

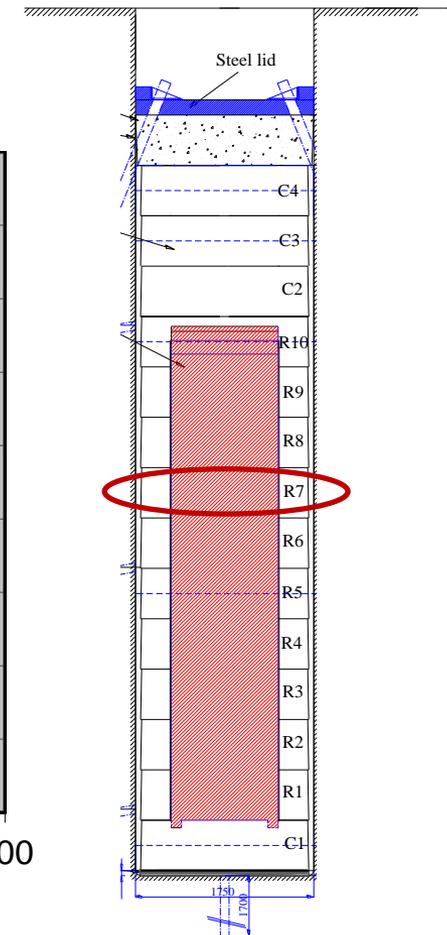
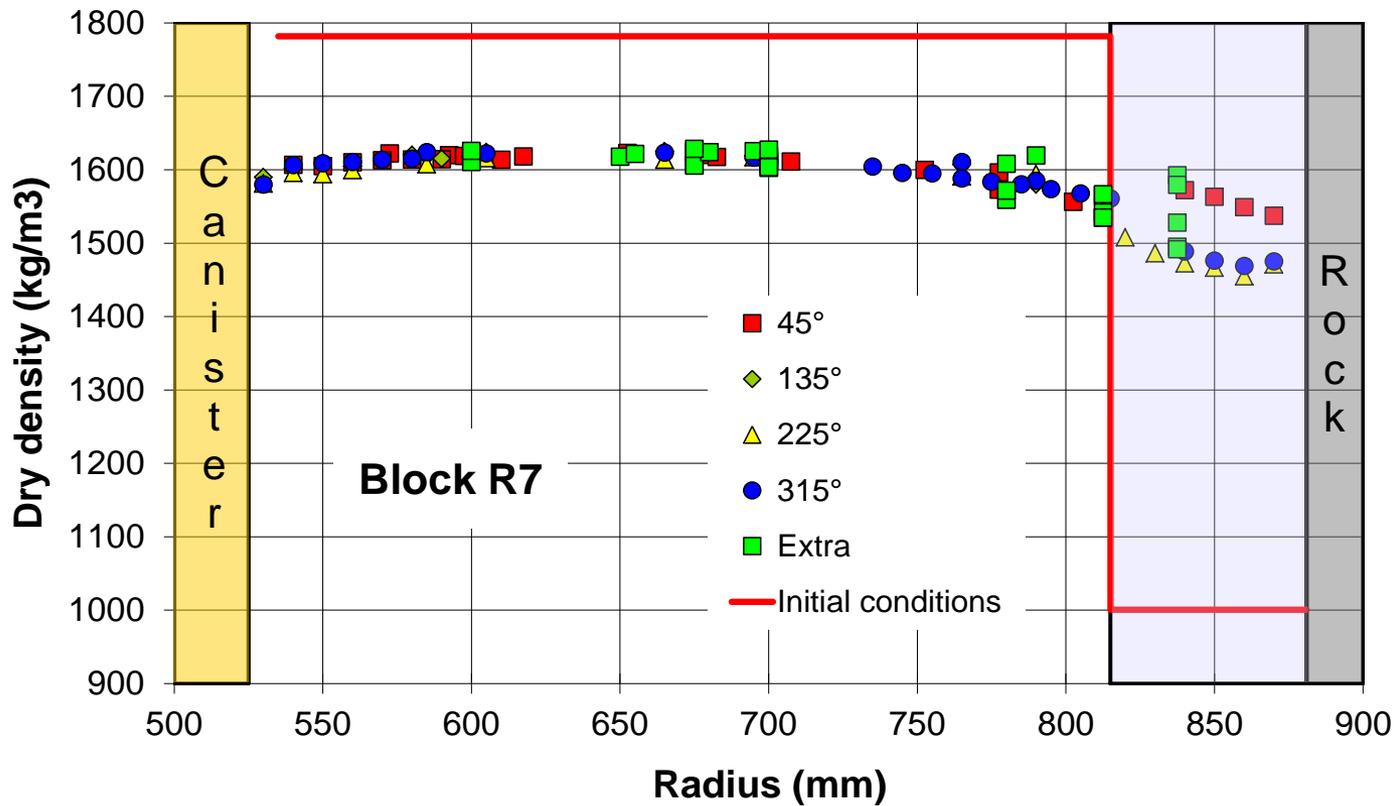
- The anchors were cut and the plug was removed
- Samples were taken of the upper part of the buffer , i.e. down to block R6, by core drilling from the tunnel floor
- The water content and the bulk density of the samples were determined, in total about 1500 determinations were made



Retrieval of the test

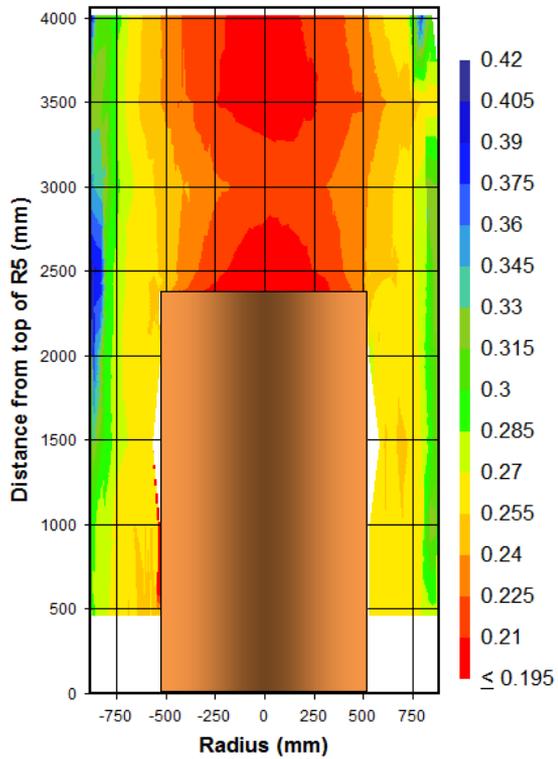


Retrieval of the test

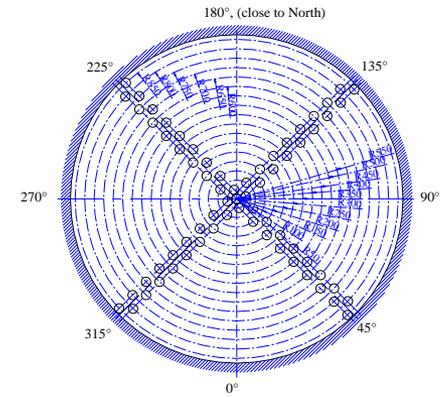
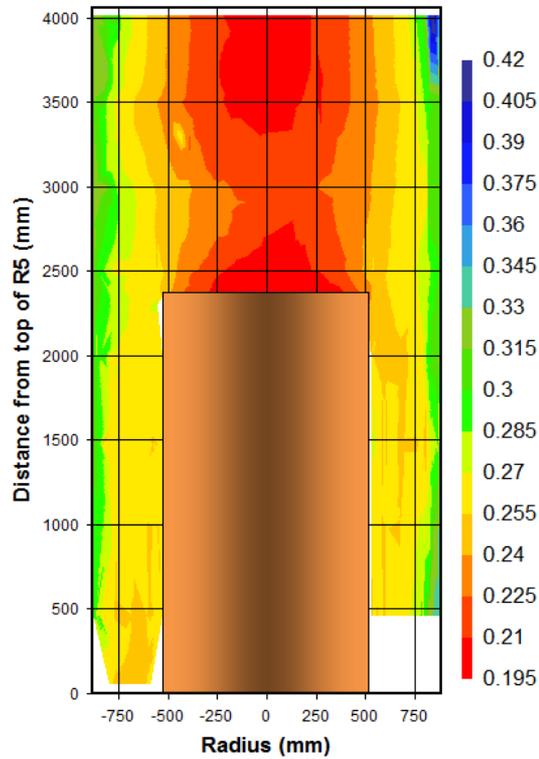


Retrieval of the test

CRT 45-225°
Water content



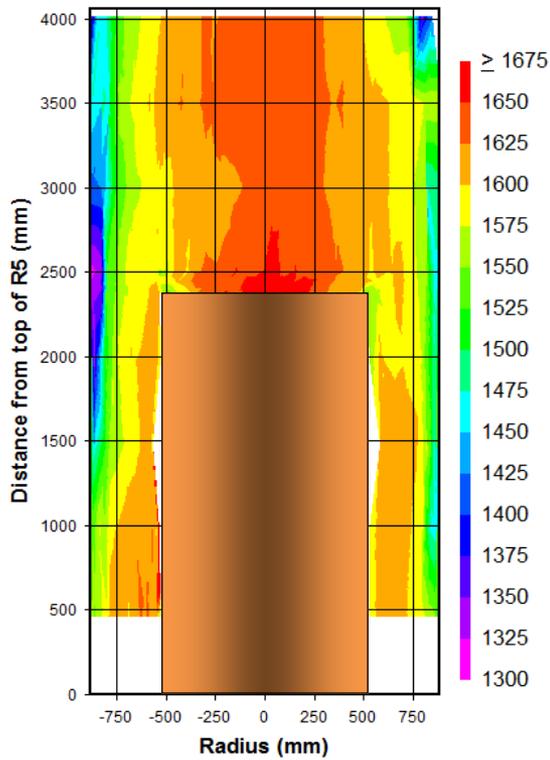
CRT 135-315°
Water content



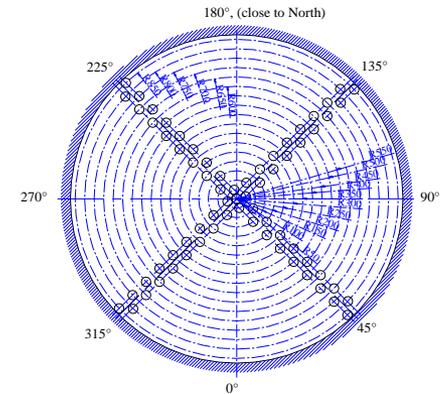
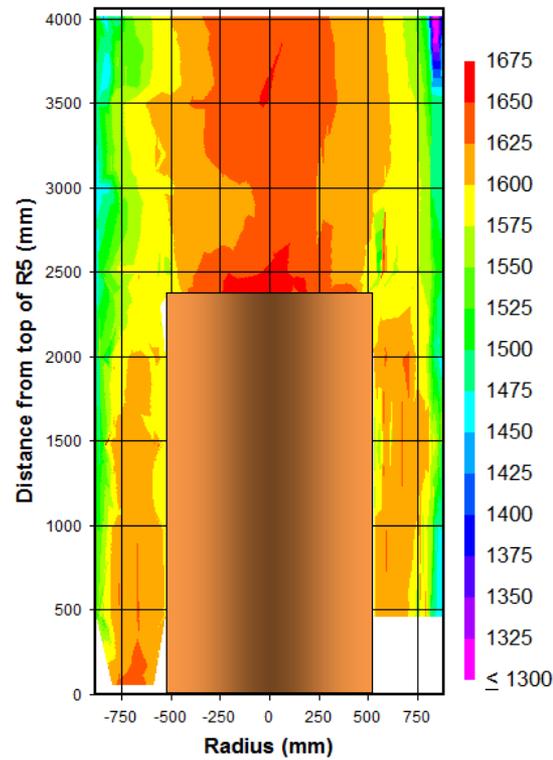
Retrieval of the test



CRT 45-225°
Dry density

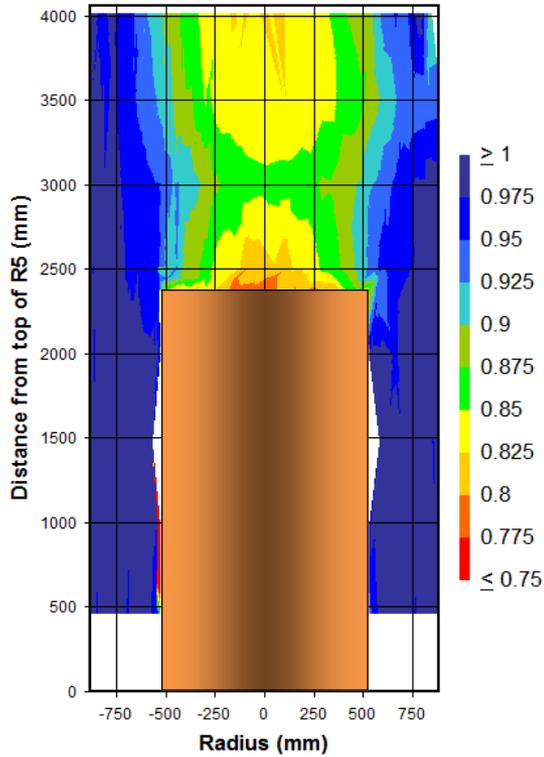


CRT 135-315°
Dry density

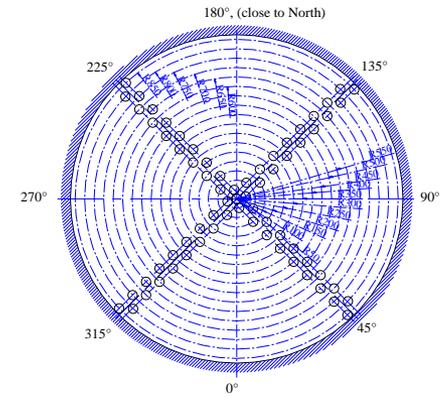
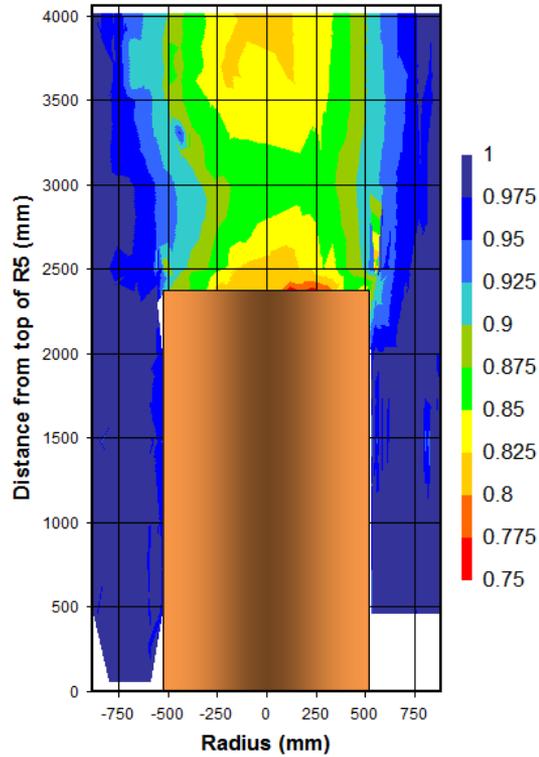


Retrieval of the test

CRT 45-225°
Degree of saturation



CRT 135-315°
Degree of saturation



The modelling of the test has been done within the Task Force on Engineered Barrier Systems (EBS-TF) divided into three sub-tasks:

1. Thermal modelling of CRT and TBT with host rock
2. Detailed THM modelling of a disc of engineered buffer at canister mid-height
3. THM modelling of the entire experiment

Kristensson O, Börgesson L, 2015. Canister Retrieval Test. Final Report SKB TR-14-19, Svensk Kärnbränslehantering AB.

Börgesson L, Åkesson M, Kristensson O, Dueck A, Hernelind J, 2015. EBS TF – THM modelling. BM 2 – Large scale field tests. SKB TR-13-07, Svensk Kärnbränslehantering AB.

Summary and conclusions



The analyses of the samples taken from the buffer indicate the following:

- The water content of the pellets filling in the outer slot was decreased compared to the initial water content after artificial water filling
- The water content of the blocks was increased
- There was a compression of the pellets filling resulting in an increase of its dry density
- The buffer blocks had swollen out towards the canister and compressed the pellets filling resulting in a decrease of the dry density of the blocks
- The buffer around the canister was fully saturated while the central part of the solid blocks above the canister was not saturated.
- Although the buffer around the canister was fully saturated, the buffer was not fully homogenized after 5 years of saturation.

Summary and conclusions



The Canister Retrieval Test is a large scale test with:

- Well defined initial conditions
- Well defined boundaries
- Large amount of installed sensors
- Carefully retrieved and sampled buffer