International
Progress Report

IPR-07-20

Äspö Hard Rock Laboratory

Status Report
July – September 2007

Svensk Kärnbränslehantering AB

December 2007

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Äspö Hard Rock
Laboratory

Report no.	No.
IPR-07-20	F50K
Author	Date
Kemakta	December 2007
Checked by	Date
Approved	Date
Anders Sjöland	2007-12-06

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Keywords: Äspö HRL, Status Report

Overview

The Äspö Hard Rock Laboratory (HRL) constitutes an important part of SKB's work to design and construct a geological repository for spent nuclear fuel and to develop and test methods for characterisation of a suitable site.

The plans for SKB's research and development of technique during the period 2005–2010 are presented in SKB's RD&D-Programme 2004 /SKB 2004/. The RD&D-Programme for the period 2008–2013 /SKB 2007a/ was delivered to the authorities in September 2007. The information given in the RD&D-Programme related to Äspö HRL is annually detailed in the Äspö HRL Planning Report /SKB 2007b/.

This Äspö HRL Status Report is a collection of the main achievements obtained during the third quarter of 2007.

Geoscience

Geoscientific research is a natural part of the activities at Äspö HRL and is conducted in the fields of Geology, Hydrogeology, Geochemistry (with emphasis on groundwater chemistry) and Rock Mechanics. The major aims are to establish and maintain geoscientific models of the Äspö HRL rock mass and to establish and develop the understanding of the Äspö HRL rock mass properties as well as the knowledge of applicable measurement methods.

Natural barriers

Many experiments in Äspö HRL are related to the rock, its properties and in situ environmental conditions. The goals are to increase the scientific knowledge of the safety margins of a final repository and to provide data for performance and safety assessment. The experiments performed at conditions expected to prevail at repository depth are: Tracer Retention Understanding Experiments, Long Term Sorption Diffusion Experiment, Colloid Dipole Project, Microbe Projects, Matrix Fluid Chemistry Continuation, Radionuclide Retention Experiments and Swiw-tests with synthetic groundwater.

Tests of models for groundwater flow, radionuclide migration and chemical/biological processes are one main purpose of the Äspö HRL. The major project is the Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes.

Engineered barriers

One of the goals for Äspö HRL is to demonstrate technology for and function of important parts of the repository system. This implies translation of current scientific knowledge and state-of-the-art technology into engineering practice applicable in a real repository. A number of large-scale field experiments are therefore conducted or planned at Äspö HRL: Prototype Repository, Long Term Test of Buffer Material, Alternative Buffer Materials, Backfill and Plug Test, Canister Retrieval Test, Temperature Buffer Test, KBS-3 Method with Horizontal Emplacement, Large Scale Gas Injection Test, In Situ Corrosion Testing of Miniature Canisters, Cleaning and Sealing of Investigation Boreholes, Rock Shear Experiment and Earth Potentials.

THM processes and gas migration in buffer material are addressed in the Task Force on Engineered Barrier Systems.

Äspö facility

The Äspö facility comprises of the Hard Rock Laboratory that was taken in operation in 1995 and the Bentonite Laboratory which was constructed during 2006 and its inauguration took place in March 2007. An important part of the activities at the Äspö facility is the administration, operation and maintenance of instruments as well as the development of investigation methods. The Public Relations and Visitor Services group is responsible for presenting information about SKB and its facilities e.g. the Äspö HRL. They arrange visits to the facilities all year around as well as special events.

Environmental research

On the initiative of the Äspö Environmental Research Foundation, the University of Kalmar has set up the Äspö Research School. The research school has a special interest in the transport of pollutants and their distribution in rock, groundwater and biosphere. The research school is co-financed by the municipality of Oskarshamn, SKB and the University of Kalmar.

International co-operation

The Äspö HRL has so far attracted considerable international interest. Nine organisations from eight countries participate in the co-operation or in Äspö HRL related activities, apart from SKB, during 2007.

Contents

1 General

The Äspö Hard Rock Laboratory (HRL), in the Simpevarp area in the municipality of Oskarshamn, constitutes an important part of SKB's work with design and construction of a deep geological repository for final disposal of spent nuclear fuel. One of the fundamental reasons behind SKB's decision to construct an underground laboratory was to create an opportunity for research, development and demonstration in a realistic and undisturbed rock environment down to repository depth. The underground part of the laboratory consists of a tunnel from the Simpevarp peninsula to the southern part of Äspö where the tunnel continues in a spiral down to a depth of 460 m. The rock volume and the available underground excavations have to be divided between all the experiments performed at the Äspö HRL. In Figure 1-1, the allocation of a selection of the experimental sites in Äspö HRL is shown.

The Äspö HRL and the associated research, development and demonstration tasks have so far attracted considerable international interest. During 2007, nine organisations from eight countries participate in the co-operation or in related activities at Äspö HRL. SKB's overall plans for research, development and demonstration during the period 2005–2010 are presented in SKB's RD&D-Programme 2004 /SKB 2004/. The RD&D-Programme for the period 2008–2013 /SKB 2007a/ was delivered to the authorities in September 2007. The English version has not yet been published. The planned activities related to Äspö HRL are detailed on a yearly basis in the Äspö HRL Planning Report. The role of the Planning Report is also to present the background and objectives of each experiment and activity. This Status Report concentrates on the work in progress and refers to the Planning Report /SKB 2007b/ for more background information. The Annual Report will in detail present and summarise new findings and results obtained during the present year.

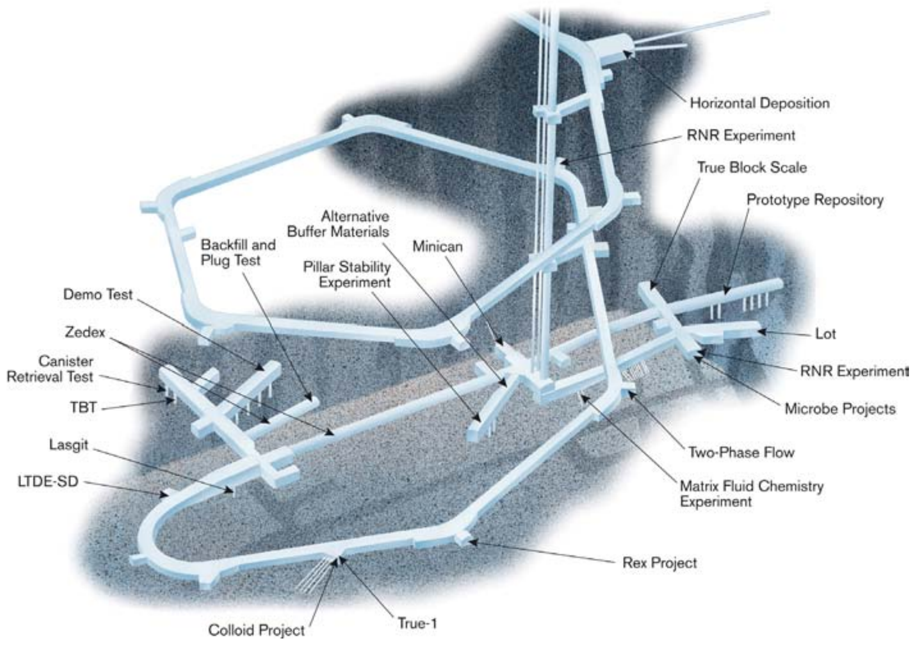


Figure 1-1. *Allocation of some of the experimental sites in Äspö HRL from -220 m to -450 m level.*

2 Geoscience

Geoscientific research is a natural part of the activities at Äspö HRL and is conducted in the fields of geology, hydrogeology, geochemistry (with emphasis on groundwater chemistry) and rock mechanics. Studies are performed in laboratory and field experiments as well as by modelling work. The major aims can be summarised as:

- Establish and maintain geoscientific models of the Äspö HRL rock mass.
- Establish and develop the understanding of the Äspö HRL rock mass properties as well as the knowledge of applicable measurement methods.

The activities further aim to provide geoscientific base data and to ensure high quality of experiments and measurements related to geosciences. The work with a project plan for the development of Äspö Site Description 2008 is in progress. This more long-term geoscientific work is, however, delayed due to limited personnel resources.

2.1 Geology

Geological work at Äspö HRL is focused on several main fields. Major responsibilities are mapping of tunnels, deposition holes and drill cores, as well as continuous updating of the geological three-dimensional model of the Äspö rock volume and contribution with input knowledge in projects and experiments conducted at Äspö HRL. In addition, development of new methods in the field of geology is a major responsibility. As a part of the latter, the Rock Characterisation System (RoCS) feasibility study is being conducted.

2.1.1 Geological Mapping and Modelling

TASQ-tunnel, geological mapping of the floor in TASQ-tunnel (photo Carljohan Hardenby)

All rock surfaces and drill cores at Äspö are mapped. This is done in order to increase the understanding of geometries and properties of rock types and structures, which is subsequently used as input in the 3D-modelling together with other input data.

Modelling tasks are performed both in the general geological 3D-model of the Äspö rock volume (the former GeoMod-project) and in more detailed scale on smaller rock volumes.

Achievements

The main activities during the third quarter of 2007 have been:

- Mapping of two of three core boreholes drilled from the TASI-tunnel (KI0010B01 and KI0014B001) has been documented in Boremap and in the database Sicada. The holes were drilled to investigate the location of the coming TASS-tunnel (to be used for e.g. testing of injection methods and materials).
- The geological mapping of the floor in TASQ-tunnel was finished during July, and the documentation of the geological mapping data into the TMS (Tunnel Mapping System) is on-going. In addition, some old mapping needs to be entered into the TMS.
- The modelling work that commenced in 2005 concerning water bearing fractures at the -450 m level is finished. Still left is to compile the report.

2.1.2 RoCS – Method Development of a New Technique for Underground Surveying

TASQ-tunnel, mounting of the Faro laser scanner used by ATS (photo Björn Magnor)

A feasibility study concerning geological mapping techniques is performed besides the regular mapping and modelling tasks. The project Rock Characterisation System (RoCS) is conducted as an SKB-Posiva joint-project.

The purpose is to investigate if a new system for rock characterisation has to be adopted when constructing a final repository. The major reasons for the RoCS project are aspects on objectivity of the data collected, traceability of the mappings performed, saving of time required for mapping and data treatment and precision in mapping. These aspects all represent areas where the present mapping technique may not be adequate.

In this initial feasibility study-stage, the major objective is to establish a knowledge base concerning existing and possible future methods and techniques to be used for a mapping system suitable for SKB's and also Posiva's requirements.

Achievements

The report by ATS (Advanced Technical Solutions AB) concerning the laser scanning of the TASQ-tunnel in 2006 is not yet completed.

In the autumn the RoCS-project is on hold, waiting for a reorganisation. After the reorganisation the focus will be on geological mapping.

2.2 Hydrogeology

The major aims of the hydrogeological activities are to:

- Establish and develop the understanding of the hydrogeological properties of the Äspö HRL rock mass.
- Maintain and develop the knowledge of applicable measurement methods.
- Ensure that experiments and measurements in the hydrogeological field are performed with high quality.
- Provide hydrogeological support to active and planned experiments at Äspö HRL.

One main task is the development of the integrated Äspö site description. The numerical groundwater flow and transport model is an important part of the site description. The groundwater model is to be continuously developed and calibrated. The intention is to develop the model to a tool that can be used for predictions, to support the experiments and to test hydrogeological hypotheses. The work with a more detailed model of hydraulically conductive structures at the main experimental levels below the -400 m level continues.

2.2.1 Hydro Monitoring Programme

The hydro monitoring programme is an important part of the hydrogeological research and a support to the experiments undertaken in the HRL. The programme had also had legal grounds. It was conditioned by the water rights court, when granting the permission to execute the construction works for the tunnel, that a monitoring programme should be put in place and that the groundwater head conditions should continue to be monitored until the year 2004.

The monitoring of water level in surface boreholes started in 1987 while the computerised Hydro Monitoring System (HMS) was introduced in 1992. The HMS collects data on-line of pressure, levels, flow and electrical conductivity of the groundwater. The data are recorded by numerous transducers installed in boreholes and in the tunnel. The number of boreholes included in the monitoring programme has gradually increased, and comprise boreholes in the tunnel in the Äspö HRL as well as surface boreholes on the islands of Äspö, Ävrö, Mjälen, Bockholmen and some boreholes on the mainland at Laxemar. The tunnel construction started in October 1990 and the first pressure measurements from tunnel drilled boreholes were included in the HMS in March 1992. The tunnel excavation began to affect the groundwater level in many surface boreholes during the spring 1991.

Weekly quality checks of preliminary groundwater head data are performed. Absolute calibration of data is performed three to four times per year. This work involves comparison with groundwater levels checked manually in boreholes.

Achievements

The main activities in the Hydro Monitoring Programme during the third quarter have been:

- Quality check and calibration of data, from the tunnel in August and from the surface boreholes in September.
- Development of a maintenance programme for the tunnel borehole installations.
- A study about renovation of cored surface boreholes has been initiated.

The monitoring system has been performing well and the monitoring points have been maintained. However, maintenance and improvements are continuously made on the system to increase the performance. Instrumentation, measurement methods and the monitoring during 2005 is described in a report /Nyberg et al. 2006/. The report for 2006 is in progress.

2.3 Geochemistry

The major aims within geochemistry are to:

- Establish and develop the understanding of the hydrogeochemical properties of the Äspö HRL rock volume.
- Maintain and develop the knowledge of applicable measuring and analytical methods.
- Ensure that experimental sampling programmes are performed with high quality and meet overall goals within the field area.

One of the overall main tasks within the geoscientific programme is to develop an integrated site description of the Äspö HRL. The use of the achieved knowledge will facilitate the understanding of the geochemical conditions and the development of underground facilities in operation. The intention is to develop the model as to be used for predictions, to support and plan experiments, and to test hydrogeochemical hypotheses. This is important in terms of distinguishing undisturbed and disturbed conditions. In general, hydrogeochemical support is provided to active and planned experiments at Äspö HRL.

New activities within the geochemistry field have been identified regarding the migration of gases. The plan is to analyse isotopes both in the gas and liquid phase and evaluate their possible implication for sulphate reduction or biomineralisation in general.

2.3.1 Monitoring of Groundwater Chemistry

During the construction phase of the Äspö HRL, different types of water samples were collected and analysed with the purpose of monitoring the groundwater chemistry and its evolution as the construction proceeded. At the beginning of the operational phase, sampling was replaced by a groundwater chemistry monitoring programme, aiming at a sufficient cover of the hydrogeochemical conditions with respect to time and space within the Äspö HRL. This programme is designed to provide information to determine where, within the rock mass, the hydrogeochemical changes are taking place and at what time stationary conditions are established. In addition, all on-going experiments have the possibility to request additional sampling of interest for their projects.

Achievements

The yearly chemistry monitoring programme takes place in September and October. According to plans the monitoring was started during this quarter.

2.4 Rock Mechanics

Rock Mechanic studies are performed with the aims to increase the understanding of the mechanical properties of the rock but also to recommend methods for measurements and analyses. This is done by laboratory experiments and modelling at different scales and comprises:

- Natural conditions and dynamic processes in natural rock.
- Influences of mechanical, thermal, and hydraulic processes in the near-field rock including effects of the backfill.

2.4.1 Stress Measurements - Core Disking

The objective of this study was to determine the stress levels at which core disking (solid cores) and ring disking (hollow cores) develop. This was to be achieved by overcoring measurements, supplemented with core drilling, in an area where stress conditions was reasonably well known, i.e. in this case the TASQ tunnel at Äspö HRL. In addition to the field work, geological modelling and numerical stress analysis was conducted to aid in explaining field observations.

The final report is reviewed and in the process of updating. The report titled "Core disking study in the TASQ-tunnel" will be printed during the last quarter 2007.

The conducted field work comprised drilling of four boreholes in the vicinity of deposition hole DQ0063G01. Pilot hole drilling (to obtain hollow cores) was made in all four of these, whereas three-dimensional overcoring measurements were attempted in three boreholes. Practical difficulties and time constraints inhibited additional planned core drilling. Detailed core logging was performed, followed by geological modelling and creating an RVS-model of the test site; see Figure 2-1. The numerical modelling was conducted using the three-dimensional distinct element code 3Dec /Itasca, 2003/.

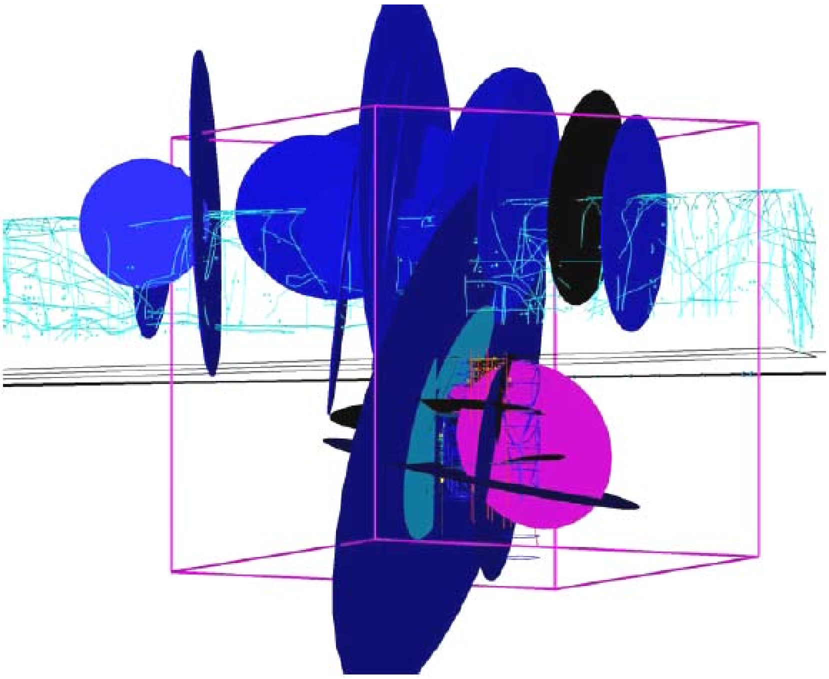


Figure 2-1. *The RVS model of the investigated area shown together with the mapped fractures in the TASQ-tunnel (light blue lines). Data from the characterisation of the Apse experiment volume /Andersson 2007/ and from this study has been used to develop the 3D fracture model. Notice especially the steeply dipping large fractures in a large angle to the tunnel, trending NW –SE. The high frequency of this fracture set in the investigated volume of rock was the major cause for the problems encountered.*

Achievements

The results from this work showed that it was not possible to fulfil the primary objective, i.e., to determine stress levels at which core disking occurs. The reasons for this were: (i) the lack of systematic core disking in the boreholes (only a few, separate, instance of disking observed), and (ii) the practical difficulties in drilling and overcoring, thus achieving only four core holes, and only one successful stress measurement. However, both this single measurement, and the observed isolated instances of core disking and borehole breakouts indicated low stresses in the test volume. An estimated upper bound of the maximum horizontal stress prior to drilling the holes, and for the majority of the rock mass volume at the test site, was 40–55 MPa. Locally, higher stresses probably exist, as evidenced by the observed core disking and the numerical stress modelling. There also appeared to be a strong link between observed core disking and the occurrence of sub vertical fractures intersecting the boreholes. Slightly elevated stresses above and below a fracture coupled with (potentially) weaker rock near the fracture may be a reason for observed core disking.

Any further work along these lines must focus on achieving as low variability as possible in the factors controlling core disking. This means homogeneous geology with as few fractures as possible, well-defined stress conditions and simple stress-path history, better drilling control, and the ability to drill more tests holes and conduct more measurements (to achieve redundancy in the results).

3 Natural barriers

At the Äspö HRL, experiments are performed at conditions that are expected to prevail at repository depth. The experiments are related to the rock, its properties and in situ environmental conditions. The goals are to increase the scientific knowledge of the safety margins of the repository and to provide data for performance and safety assessment and thereby clearly present the role of the geosphere for the barrier functions: isolation, retardation and dilution. As an example, the processes that influence migration of species along a natural rock fracture are shown in Figure 3-1.

Tests of models for groundwater flow, radionuclide migration and chemical/biological processes are one of the main purposes of the Äspö HRL. The programme includes projects with the aim to evaluate the usefulness and reliability of different models and to develop and test methods for determination of parameters required as input to the models.

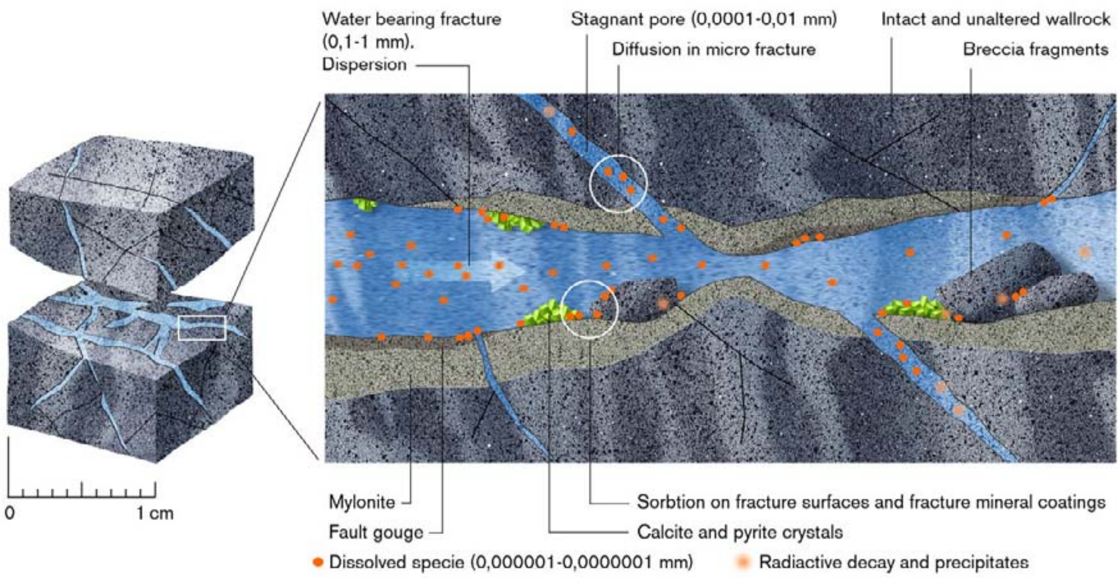
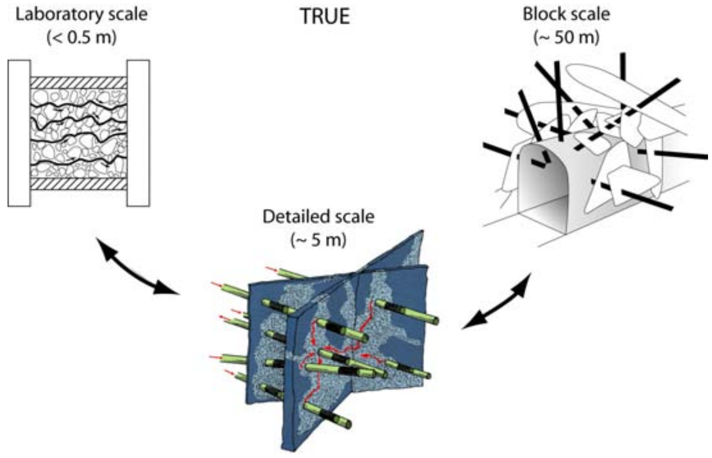


Figure 3-1. *Processes that influence migration of species along a natural rock fracture.*

3.1 Tracer Retention Understanding Experiments



Tracer tests with non-sorbing and sorbing tracers are carried out in the True family of projects. These are conducted at different scales; laboratory scale (< 0.5 m), detailed scale (<10 m) and block scale (up to 100 m) with the aim to improve understanding of transport and retention in fractured rock. The work includes building of hydrostructural models and conceptual microstructure models. Numerical models are used to assess the relative contribution of flow-field related effects and acting processes (diffusion and sorption) on in situ retention.

The first in situ experiment (True-1) performed in the detailed scale and the True Block Scale series of experiments have come to their respective conclusion. Complementary field work and modelling are performed as part of two separate but closely coordinated continuation projects.

The True Block Scale Continuation project aims at obtaining additional understanding of the True Block Scale site. The project is now completed and the final report is published /Andersson *et al*. 2007/.

In the True-1 Continuation and Completion projects the objectives are to obtain insight in the internal structure of the investigated feature and to study fixation of sorbing radioactive tracers. Prior to the resin injection in Feature A complementary hydraulic and tracer tests are performed to better understand Feature A and its relation to the surrounding fracture network. In addition, a dress rehearsal of in situ resin injection is realised through a characterisation project focused on fault rock zones.

3.1.1 True Block Scale Continuation

The True Block Scale Continuation (BS2) project had its main focus on the existing True Block Scale site. Work performed included complementary modelling work in support of planned in situ tests (BS2A) and in situ tracer tests with sorbing tracers and subsequent assessment of the relative retention in flow paths made up of fault rock zones and back ground fractures, respectively (BS2B). Results verified lower retention material properties in the background fractures flow path but also showed a higher overall retention in this flow path owing to the much lower flow rate therein /Andersson et al. 2007/. In the aftermath to the BS2 project, a second step of the continuation of the True Block Scale (BS3) has been set up. This step has no specific experimental components and emphasise consolidation and integrated evaluation of all relevant True data and findings collected thus far. This integration is not necessarily restricted to True Block Scale, but may include incorporation of relevant True-1 and True-1 Continuation results.

Achievements

Work during this quarter has been devoted to review and updating of the draft report submitted in June, the latter which focused on the incorporation of new experimental data (image analysis of fault gouge and sorption experiments on fault gouge and rim zone materials) for constraining retention parameter estimates.

The remainder of the year will be devoted to finalise manuscripts of a two part series of scientific papers devoted to “Sorptive tracer tests from single to multiple fractures in crystalline rock at Äspö”. In the first paper, the methodology and procedures for performed blind predictions of the sorbing tracer tests are presented. The prediction results of the SKB analysis team is compared to the experimental data and the reasons for deviations between predictions and experimental data are analysed and discussed. The second paper covers the evaluation of the sorbing tracer tests and infers effective retention properties. Properties of the structures involved and possible network effects are assessed. Finally, material retention properties are evaluated.

3.1.2 True-1 Continuation

The True-1 Continuation project is a continuation of the True-1 experiments and the experimental focus is primarily on the True-1 site. The continuation includes performance of the planned injection of epoxy resin in Feature A at the True-1 site and subsequent over coring and analysis (True-1 Completion). In addition, this project includes production of a series of scientific articles based on the True-1 project and, furthermore, performance of the Fault Rock Characterisation project, the latter in parts a dress rehearsal for True-1 Completion.

Achievements

During the third quarter, work has continued with the third of the planned papers that are to be submitted to Water Resources Research. The paper deals with effects of micro-scale heterogeneity.

The Fault Rock Zones Characterisation Image Analysis report which treats the analysis of the collected epoxy resin impregnated rock samples are under review and is being edited. Work is on-going with the final report of the Fault Rock Zones Characterisation Project. Finalisation of the latter report is pending update of the Image Analysis report.

3.1.3 True-1 Completion

True-1 Completion is a sub-project of the True-1 Continuation project with the experimental focus placed on the True-1 site. True-1 Completion will be performed at the True-1 site and will be a complement to already performed and on-going projects. The main activity within True-1 Completion is the injection of epoxy with subsequent over-coring of the fracture and following analyses of pore structure and, if possible, identification of sorption sites. Furthermore, several complementary in situ experiments will be performed prior to the epoxy injection. These tests are aimed to secure important information from Feature A and the True-1 site before the destruction of the site, the latter which is the utter consequence of True-1 Completion.

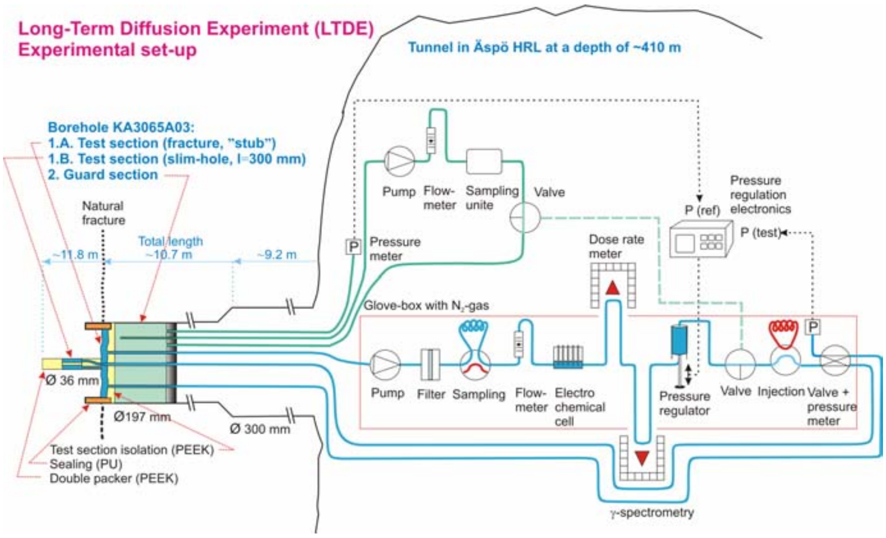
Achievements

The major activity during the period was the continued over-coring of KXTT4 at the True-1 site. The over-coring was performed with the same method as in KXTT3, i.e. over-coring with 300 mm. The core was retrieved gradually during the drilling. In the target section, KXTT4:T3, uranine tagged epoxy from the previous injection was visible in two fractures, Feature A and Feature A’, see Figure 3-2. Unfortunately, the forces acting on the core during drilling and/or retrieving were too large in order to keep the core intact around the fractures in the target section. However, these fractures are still considered to provide a lot of valuable information in coming analysis.

Up-coming activities, such as preparation and analysis of core material, were continuously planned during the period.

Figure 3-2. *Feature A in KXTT3 (to the left) and in KXTT4 (to the right). The green material is uranine tagged epoxy.*

3.2 Long Term Sorption Diffusion Experiment



This experiment is performed to investigate diffusion and sorption of solutes in the vicinity of a natural fracture into the matrix rock and directly from a borehole into the matrix rock.

The aims are to improve the understanding of diffusion and sorption processes and to obtain diffusion and sorption data at in situ conditions.

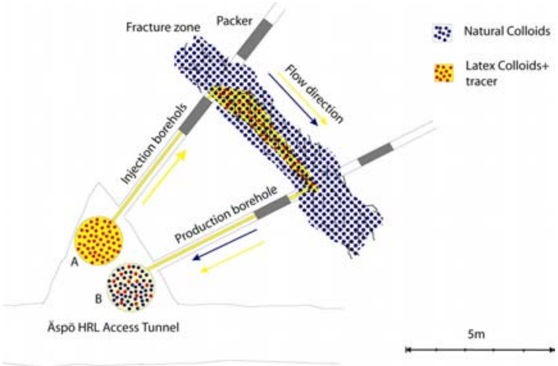
A core stub with a natural fracture surface is isolated in the bottom of a large diameter telescoped borehole and a small-diameter borehole is drilled through the core stub and beyond into the intact unaltered bedrock. Tracers were circulated over a period of 6 ½ months after which the borehole was over cored. This activity will be followed by analyses of tracer content.

Achievements

Small diameter sample cores (24 mm) have been extracted from the 1.1 m long and 278 mm diameter large core retrieved from the over coring that was completed in May (Figure 3-3). Sample cores have been extracted both from the fracture surface on the core stub and from the matrix rock surrounding the test section in the small diameter (36 mm) extension borehole. In total 18 cores were drilled on the fracture surface, covering about 34% of the fracture surface on the core stub, and 16 cores drilled in the matrix rock surrounding the test section. The sample cores have been geologically mapped in detail and will be measured with gamma spectrometry (HPGe) before further analysis.

Figure 3-3. *Sample core A6, about 18 cm long, drilled from the fracture surface on the core stub. Underneath the protective coating of epoxy resin a thin layer of calcite and chlorite is seen on the fracture surface. The rock is altered into about 4 cm from the fracture surface. Close to and in parallel to the fracture surface two fractures sealed with calcite are visible.*

3.3 Colloid Dipole Project



The Colloid Dipole Project is a continuation of the Colloid Project which was ended in 2006. The Colloid dipole experiment comprises studies of the potential of colloids to enhance radionuclide transport and the potential of bentonite clay as a source for colloid generation. The concentration, stability and mobility of colloids in the Äspö environment are studied and in situ experiments where the colloidal effect on actinide transport in a water bearing fracture will be studied.

The ended Colloid Project included laboratory experiments, background colloid measurements and borehole specific measurements.

Achievements

The main activities during the third quarter of 2007 have been:

- Colloid stability experiments in Äspö waters to study the interaction between radionuclides and colloids. The work was presented at the Migration ´07 conference in Munich, $^{26th-31th}$ August 2007.
- Determination of critical coagulation concentrations (CCC) for Na- and Ca-montmorillonite respectively. An article describing the work has been accepted for publication "Kinetic determination of Critical Coagulation Concentration for Sodium-and Calcium-Montmorillonite colloids in NaCl and $CaCl_2$ aqueous solutions".
- Study of pH and temperature effects on montmorillonite colloids. The work was presented at Migration 07 and an article is submitted for publication.
- Colloid transport in the quarried block. Transport experiments have been performed in meter scale. Some of the experiments were presented at Migration 07 and an article is submitted for publication.
- Modelling of data from the quarried block is on-going.
- A licentiate thesis dealing with the impact of groundwater chemistry on the stability of bentonite colloids was presented on the 5th of October /Garcia Garcia, 2007/

3.4 Microbe Projects

3.4.1 The Microbe laboratory and the Bios site

The Microbe laboratory and the Bios site have been installed in the Äspö HRL for studies of microbial processes in groundwater under in situ conditions.
The major objectives are to:

- Offer proper circumstances for research on the effect of microbial activity on the long-term chemical stability of the repository environment.
- Provide in situ conditions for the study of bio-mobilisation of radionuclides.
- Present a range of conditions relevant for the study of bio-immobilisation of radionuclides.
- Enable investigations of bio-corrosion of copper under conditions relevant for a high level radioactive waste repository.
- Constitute a reference site for testing and development of methods used in the site investigations.

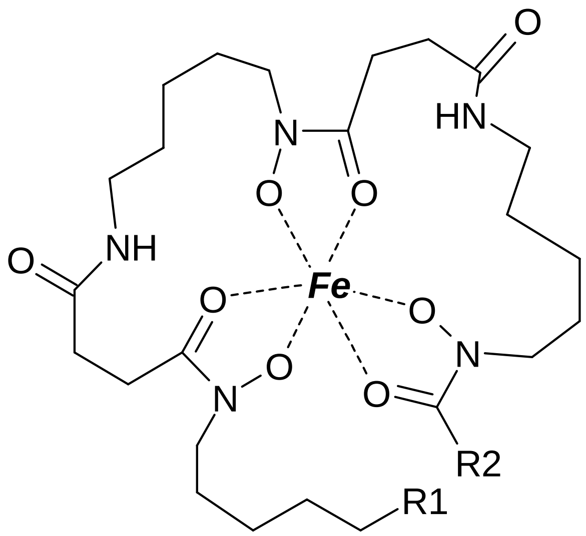
The Microbe site is on the -450 m level where a laboratory container with benches, an anaerobic gas box and an advanced climate control system is located. Three boreholes, KJ0050F01, KJ0052F01 and KJ0052F03, intersecting water conducting fractures are connected to the Microbe laboratory via tubing. Each borehole has been equipped with a circulation system offering 2,112 cm^2 of test surface.

Retention of naturally occurring trace elements in the groundwater by Biological Iron Oxides (Bios) is investigated at tunnel length 2,200 m. There is a vault with a borehole that delivers groundwater rich in ferrous iron and iron oxidising bacteria. The borehole is connected to two 200 × 30 × 20 cm artificial channels that mimic ditches in the tunnel. The channels have rock and artificial plastic support that stimulate Bios formation.

Achievements

Robust, sound, and reproducible methods for estimating the total number of viable micro-organisms in groundwater, their diversity, and the rate at which their microbial processes run have been developed. To this end, a set of cultivation methods was adapted and applied in analysing the diversity of microorganisms using different electron acceptors and energy donors in deep groundwater. Groundwater from boreholes at the Microbe site was analysed using the cultivation methods, and the results were compared to hydrogeochemical analysis data. The reproducibility of the cultivation methods was tested and evaluated. Methods for analysing microbial process rates were developed and tested under open and closed in situ conditions in the Microbe laboratory.

3.4.2 Micomig



Ferrioxamine

It is well known that microbes can mobilise trace elements. Firstly, unattached microbes may act as large colloids, transporting radionuclides on their cell surfaces with the groundwater flow. Secondly, microbes are known to produce ligands that can mobilise soluble trace elements and that can inhibit trace element sorption to solid phases.

A large group of microbes catalyse the formation of iron oxides from dissolved ferrous iron in groundwater that reaches an oxidising environment with oxygen. Such biological iron oxide systems (Bios) will have a retardation effect on many radionuclides.

Biofilms in aquifers will influence the retention processes of radionuclides in groundwater. Recent work indicates that these surfaces adsorb up to 50% of these radionuclides in natural conditions with retention factors (Ka) approaching 10^5 and 10^6 (m) for Co and Pm respectively.

The work within Micomig will:

- Evaluate the influence from microbial complexing agents on radionuclide migration.
- Explore the influence of microbial biofilms on radionuclide sorption and matrix diffusion.

Achievements

The siderophore production of the facultative anaerobe *Pseudomonas stutzeri*, strain CCUG 36651, grown under both aerobic and anaerobic conditions, was investigated by liquid chromatography and mass spectrometry. The bacterial strain has been isolated at 626 metres depth in the Äspö HRL. In bacterial culture extracts, the iron in the siderophore complexes was replaced by gallium to facilitate siderophore identification by mass spectrometry. *P. stutzeri* was shown to produce ferrioxamine E (nocardamine) as the main siderophore together with ferrioxamine G and two cyclic ferrioxamines having molecular masses 14 and 28 atomic mass units lower than ferrioxamine E, suggested to be ferrioxamine D2 and ferrioxamine X1, respectively. In contrast, no siderophores were observed from anaerobically grown *P. stutzeri*. None of the siderophores produced by aerobically grown *P. stutzeri* were found in anaerobic natural water samples from the KJ0052F01 borehole circulation at the Microbe site.

The information gained from the deep groundwater investigation is valuable with respect to the safety analyses of future repositories for spent nuclear fuel. High concentrations of the complexing compounds in question would enhance the transport of several radionuclides because many radionuclides combine with siderophores as discussed in the introduction. Of course, the results here represent only a few of many possible conditions in and around a repository, but the first steps have been taken with respect to method development in the survey of deep groundwater environments for the presence of microbially produced complexing compounds. Future investigations should be expanded to search for complexing compounds produced by fungi in the near and far fields of a repository. Fungi have been found in groundwater, and they are present in the bentonite clay to be used as backfill and buffer. A larger variety of groundwater than investigated here should also be scanned for complexing compounds, and the array of methods for their detection may need to be expanded. This is, to our knowledge, the first study that has analysed anaerobic cultures or has investigated anaerobic deep groundwater samples specifically for the presence of siderophores. One manuscript that involve Äspö HRL investigations has been published.[1]

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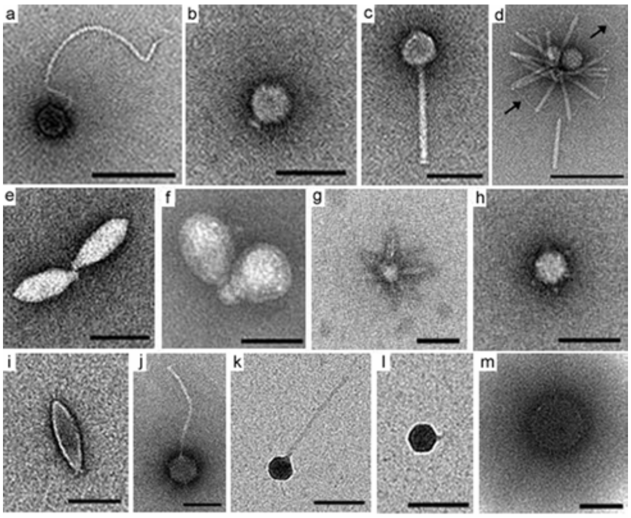
[1] Essén S.A., Johnsson A., Bylund D., Pedersen K. and Lundström U.S. (2007) Siderophore production by P*seudomonas stutzeri* under aerobic and anaerobic conditions. *Appl Environ Microbiol* 73, 5857-5864.

3.4.3 Micored



Virus from Äspö groundwater.

Microorganisms can have an important influence on the chemical situation in groundwater. Especially, they may execute reactions that stabilise the redox potential in groundwater at a low and, therefore, beneficial level for the repository. It is hypothesised that hydrogen from deep geological processes contributes to the redox stability of deep groundwater via microbial turnover of this gas. Hydrogen, and possibly also carbon monoxide and methane energy metabolisms will generate secondary metabolites such as ferrous iron, sulphide, acetate and complex organic carbon compounds. These species buffer towards a low redox potential and will help to reduce possibly introduced oxygen.

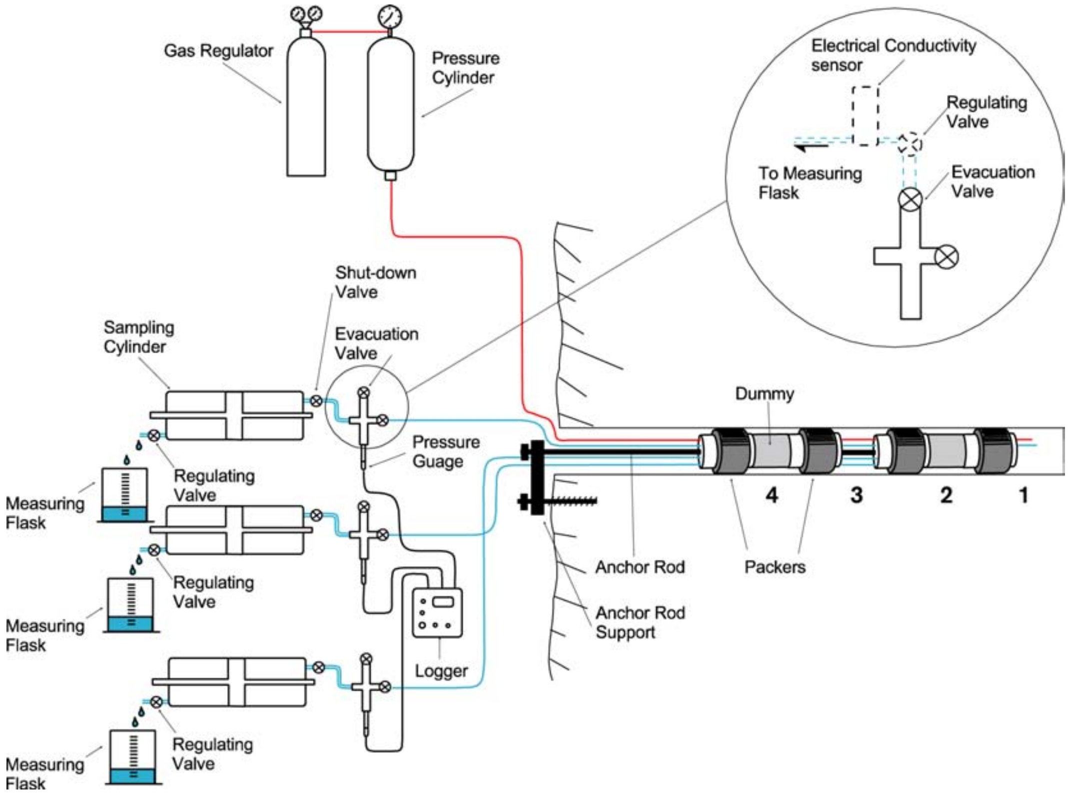
The work within the Micored project will:

- Clarify the contribution from microorganisms to stable and low redox potentials in near-and far-field groundwater.
- Demonstrate and quantify the ability of microorganisms to consume oxygen in the near- and far-field areas.
- Explore the relation between content and distribution of gas and microorganisms in deep groundwater.
- Create clear connections between investigations of microorganisms in the site investigations for a future repository and research on microbial processes at Äspö HRL.

Achievements

Groundwater samples were collected from -69 to -450 m level in Äspö HRL to determine if viruses are present and active members of the deep subterranean biosphere. Fluorescent microscopy counts were in the range of 10^5 to 10^7 virus-like particles (VLP) per mL groundwater. Principle component analysis revealed strong positive correlations of VLP's with bacterial abundance (r = 0.93) and dissolved organic carbon (r = 0.89), and strong negative correlations with salinity (r = -0.92) and ionic strength (r = -0.92). Transmission electron microscopy revealed four distinct bacteriophage groups (polyhedral, tailed, filamentous, and pleomorphic) within the subsurface with at least seven phage families of with some are known to be lytic. The presence of lytic viruses in deep groundwater is a direct indicator of predator–prey (virus–microbe) interactions in intraterrestrial ecosystems that would release nutrients (i.e. cellular debris) into the system. The infection of microorganisms by viruses also contributes to DNA transfer, implying that viral transduction is important for the diversification of intraterrestrial microorganisms. Modelling of microbial effects in a future repository must include the effect from viruses on the microbial populations.

3.5 Matrix Fluid Chemistry Continuation



The main objectives of the Matrix Fluid Chemistry experiment are to understand the origin and age of fluids/groundwater in the rock matrix pore space and in micro-fractures, and their possible influence on the chemistry of the groundwater from the more highly permeable bedrock.

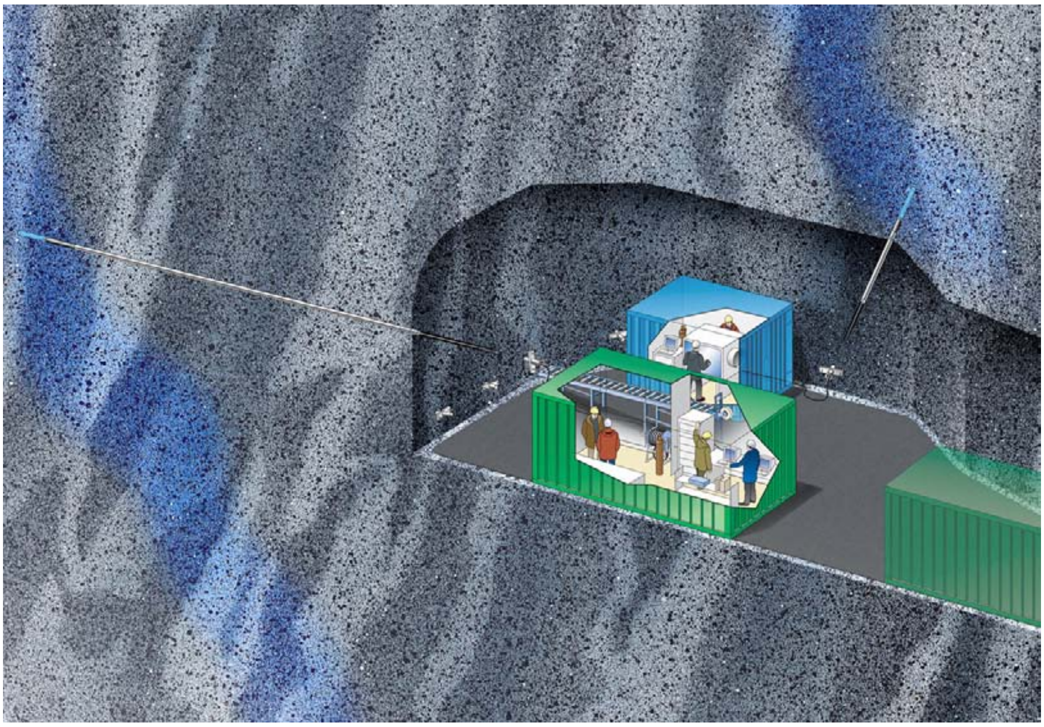
Matrix fluids are sampled from a borehole drilled into the rock matrix. Fluid inclusions in core samples have also been studied to determine their contribution, if any, to the composition of the matrix fluids/groundwater.

A first phase of the project is finalised and reported /Smellie *et al*. 2003/. The major conclusion is that porewater can successfully be sampled from the rock matrix and there is no major difference in chemistry compared to groundwater from more highly conductive fracture zones in the near-vicinity.

Achievements

Final reporting of matrix fluid chemistry and matrix borehole hydraulic testing are underway and scheduled to be finalised at the end of December.

3.6 Radionuclide Retention Experiments



Radionuclide Retention Experiments are carried out with the aim to confirm results of laboratory studies in situ, where natural conditions prevail concerning e.g. redox conditions, contents of colloids, organic matter and bacteria in the groundwater.

The experiments are carried out in special borehole laboratories, Chemlab 1 and Chemlab 2, designed for different kinds of in situ experiments. The laboratories are installed in boreholes and experiments can be carried out on bentonite samples and on tiny rock fractures in drill cores.

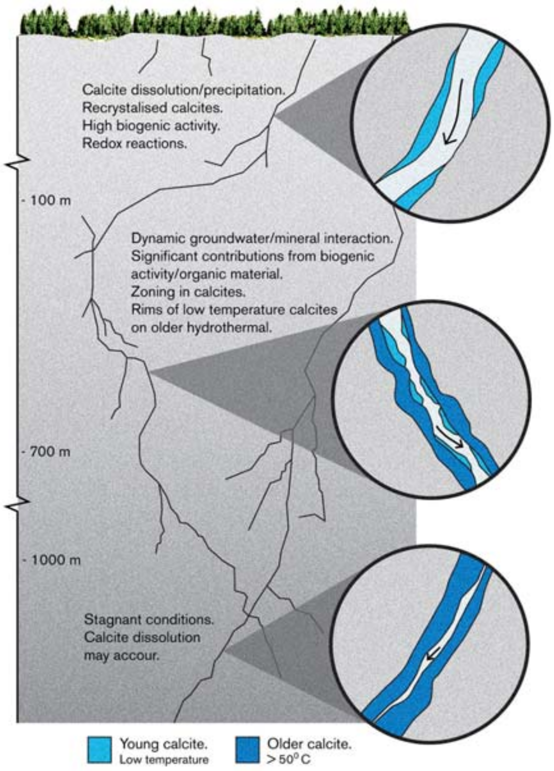
Chemlab 1:
- Investigations of the influence of radiolysis products on the migration of the redox-sensitive element technetium in bentonite (finalised).
- Investigations of the transport resistance at the buffer/rock interface (planned).

Chemlab 2:
- Migration experiments with actinides in a rock fracture (almost finalised).
- Study leaching of spent fuel at repository conditions (planned).

Achievements

All resources from the Radionuclide Retention Experiments have been allocated by other projects with higher priority and therefore there have been no experimental activities since 2005.

3.7 Padamot



Potential calcite-groundwater interaction at various depths at Äspö.

Padamot (Palaeohydrogeological Data Analysis and Model Testing) investigates changes in groundwater conditions as a result of changing climate. Because the long term safety of an underground repository depends on the stability of the repository environment, demonstration that climatic impacts attenuate with depth is important. Currently, scenarios for groundwater evolution relating to climate changes are poorly constrained by data and process understanding.

The objectives of Padamot are to:

- Improve understanding and prioritise palaeo-hydrogeological information for use in safety assessments.
- Collect chemical/isotopic data using advanced analytical methods.
- Construct a database of relevant information and develop numerical models to test hypotheses.
- Integrate and synthesise results to constrain scenarios used in performance assessments.
- Disseminate the results to the scientific community.

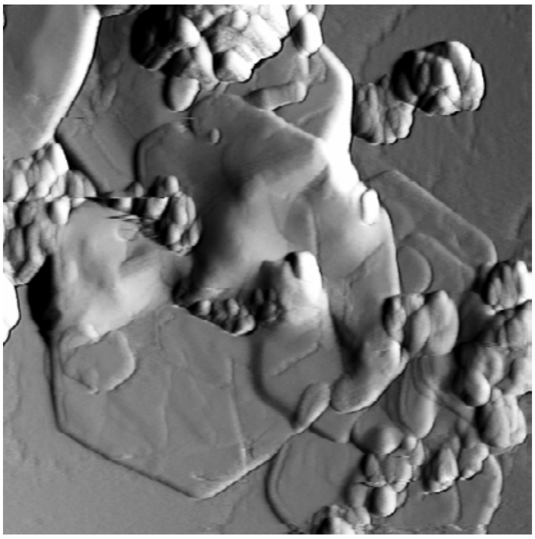
The EC-part of the project was finalised and reported in 2005. The present project comprises analytical and modelling tasks mainly based on uranium series analyses. Material from borehole KAS17 at Äspö is used in this study.

Achievements

The new phase of the project concerns uranium series measurements where different approaches are tested by two different laboratories. The analyses are carried out on split samples of fracture material from a surface borehole drilled at Äspö (KAS17). This borehole penetrates the large E-W fracture zone called the Mederhult zone and several sections with fractured rocks are intersected by the borehole. Six samples from different depths (from 19 to 200 m core length) are analysed.

A presentation of the work dealing with the fundamental principles for uranium series analyses applied on groundwater and mineral samples and with focus on the problems and possibilities with the method was given as a poster presentation at the Migration ´07 conference in Munich in August 2007. Also a manuscript with the title “Uranium series studies for the safety case of deep geological disposal of nuclear wastes” has been prepared for publication.

3.8 Fe-oxides in Fractures



Atomic Force Microscopy image of green rust sulphate. Image is 2.5 x 2.5 microns

Proof of reducing conditions at repository depth is fundamental for the safety assessment of radioactive waste disposals. Fe(II) - minerals are common in the bedrock and along fracture pathways and constitute a considerable reducing capacity together with organic processes. Another area of interest is the radionuclide retention capacity provided by Fe-oxides and -oxyhydroxides in terms of sorption capacity and immobilisation.

The basic idea of the project is to examine Fe-oxide fracture linings, in order to explore for suitable palaeo-indicators for their formation conditions, while at the same time learning about the behaviour of trace component uptake in general, both from the natural material as well as through testing of behaviour in controlled parametric studies in the laboratory.

Achievements

In terms of on-going studies, the aim is to establish the penetration depth of oxidising water below ground. Present status is that the approx. 60 samples collected in September 2006 have been examined with optical microscopy and half have been selected for more detailed study. These samples have been characterised with X-ray diffraction and are awaiting analysis with Mössbauer spectroscopy (MS). Following MS the samples will be studied using scanning electron microscopy (SEM).

Once the solid has been characterised completely, the material will be dissolved for Fe isotope analysis and, possibly, for dating with U-decay series. For a few selected samples, a small amount of solid material will be saved with the aim of performing analysis of their O isotope content.

3.9 Swiw-test with Synthetic Groundwater

The Single Well Injection Withdrawal (Swiw) tests with synthetic groundwater constitute a complement to performed tests and studies on the processes governing retention, e.g. the True-1 and the True Block Scale experiments. This project aims to deepen the understanding of retention. Swiw-tests with synthetic groundwater facilitate the study of diffusion in stagnant water zones and in the rock matrix. It also facilitates the possibility to test the concept of measuring fracture aperture with the radon concept.

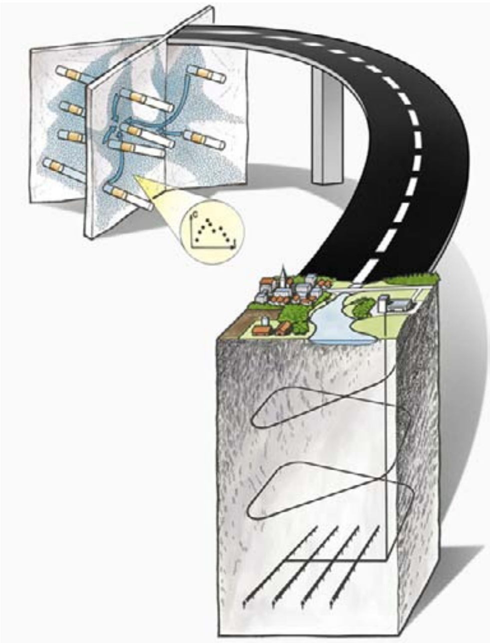
The original location in mind for the tests was the True Block Scale site and the well characterised Structures #19 and #20. The two structures have been object to a large number of tracer tests, possess different characteristics and are located on different distances from the tunnel. The usage of the True Block Scale site gives a unique possibility to ”calibrate” the concept of single hole tracer tests, Swiw, to multiple borehole tracer tests. The results from such a calibration can be applied directly to the Swiw-tests performed within the SKB site investigation programme.

Achievements

The major activity during the period was the on-going feasibility study, which soon will be completed. Results from the study show that a combination of Swiw-tests, with and without waiting period between the forcing of the tracers into the rock and the back-pumping, will be the best way to distinguish between fast and slow diffusion processes. Furthermore, it shows that it is useful to use many tracers with different characteristics to facilitate the interpretation of the tests.

As mentioned in earlier reports, True Block Scale may be used as a test site. However it is not accessible until early 2009 due to the tunnelling in the vicinity and at that point it is a clear risk that the new tunnel has altered the hydraulic conditions in True Block Scale significantly so that it no longer suitable for Swiw tests. Hence, it may be necessary to find an alternative test site for Swiw with synthetic groundwater.

3.10 Task Force on Modelling of Groundwater Flow and Transport of Solutes



The Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes is a forum for the organisations supporting the Äspö HRL to interact in the area of conceptual and numerical modelling of groundwater flow and transport of solutes in fractured rock.

The Task Force shall propose, review, evaluate and contribute to the modelling work in the project. In addition, the Task Force shall interact with the principal investigators responsible for carrying out experimental and modelling works for Äspö HRL.

The work within the Äspö Task Force constitutes an important part of the international co-operation within the Äspö Hard Rock Laboratory.

Achievements

In the Task Force, work has been in progress in Task 6 - Performance Assessment Modelling Using Site Characterisation Data, and in Task 7, which addresses a long-term pumping test in Olkiluoto, Finland. The status of the specific modelling tasks is given within brackets in Table 3-1. Preparations for Task Force meeting 23 in Toronto are on-going.

Task 6 tries to bridge the gap between Performance Assessment (PA) and Site Characterisation (SC) models by applying both approaches for the same tracer experiment. It is hoped that this will help to identify the relevant conceptualisations (in processes/structures) for long term PA predictions and to identify site characterisation data requirements to support PA calculations. All, except one, of the sub-task reports 6D, 6E and 6F from the modelling groups have been printed and the review report for these sub-tasks is in the printing process. A summary of the outcome of Task 6 has been submitted to a scientific journal. In addition, four modelling groups have submitted papers to the same scientific journal and in conjunction with the summary paper.

Task 7 addresses modelling of the OL-KR24 long-term pumping test at Olkiluoto in Finland. The task will focus on methods to quantify uncertainties in PA-type approaches based on SC-type information; along with being an opportunity to increase the understanding of the role of fracture zones as boundary conditions for the fracture network and how compartmentalisation influence the groundwater system. The possibilities to extract more information from interference tests will also be addressed. Earlier it was decided at a meeting to divide Task 7 into several sub-tasks. A task description for the sub-task 7A has been sent out to the modellers and preliminary results from the modelling have been presented. Updated Task 7 information and data deliveries have been made. A workshop on Task 7 was held in June in Gothenburg, and the minutes from that meeting was distributed after the summer.

Table 3-1. Task descriptions and status of the specific modelling sub-tasks.

6	**Performance Assessment (PA) modelling using Site Characterisation (SC) data.**
6A	Model and reproduce selected True-1 tests with a PA model and/or a SC model to provide a common reference. (External review report printed).
6B	Model selected PA cases at the True-1 site with new PA relevant (long term/base case) boundary conditions and temporal scales. This sub-task serves as means to understand the differences between the use of SC-type and PA-type models and the influence of various assumptions made for PA calculations for extrapolation in time. (External review report printed).
6C	Develop semi-synthetic, fractured granite hydrostructural models. Two scales are supported (200 m block scale and 2,000 m site-scale). The models are developed based on data from the Prototype Repository, True Block Scale, True-1 and Fracture Characterisation and Classification project (FCC). (External review report printed).
6D	This sub-task is similar to sub-task 6A and is using the synthetic structural model in addition to a 50 to 100 m scale True Block Scale tracer experiment. (Most modelling reports printed and final review report available).
6E	This sub-task extends the sub-task 6D transport calculations to a reference set of PA time scales and boundary conditions. (Most modelling reports printed and final review report available).
6F	Sub-task 6F is a sensitivity study, which is proposed to address simple test cases, individual tasks to explore processes and to test model functionality. (Most modelling reports printed and final review report available).
7	**Long-term pumping experiment.**
7A1	Hydrostructural model implementation. (Preliminary results were presented at the Task Force Workshop in June).
7A2	Pathway simulation within fracture zones. (Preliminary results were presented at the Task Force Workshop in June).
7A3	Conceptual modelling of PA relevant parameters from open hole pumping.
7A4	Quantification of compartmentalisation from open hole pumping tests and flow logging
7A5	Quantification of transport resistance distributions along pathways
7B	This sub-task is addressing the same as sub-task 7A but in a smaller scale, i.e. rock block scale. Sub-task 7B is using 7A as boundary condition
7C	Here focus is on deposition hole scale issues, resolving geomechanics, buffers, and hydraulic views of fractures
7D	Tentatively this Sub-task concerns integration on all scales

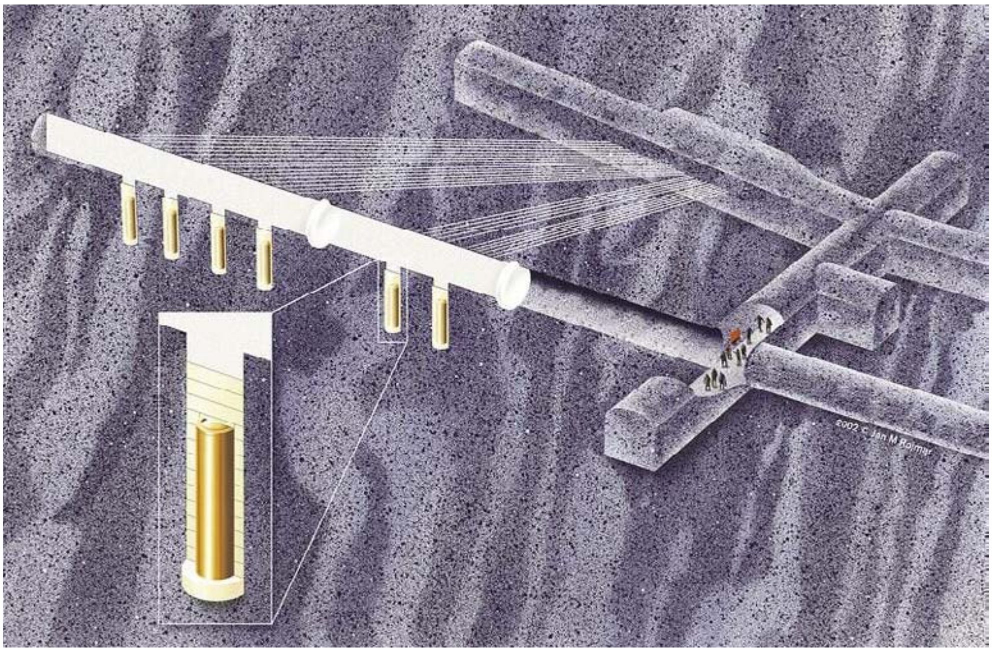
4 Engineered barriers

One of the goals for Äspö HRL is to demonstrate technology for and function of important parts of the repository system. This implies translation of current scientific knowledge and state-of-the-art technology into engineering practice applicable in a real repository.

It is important that development, testing and demonstration of methods and procedures, as well as testing and demonstration of repository system performance, are conducted under realistic conditions and at appropriate scale. A number of large-scale field experiments and supporting activities are therefore conducted at Äspö HRL, see Figure 4-1. The experiments focus on different aspects of engineering technology and performance testing and will together form a major experimental programme.

Figure 4-1. *Grouting tests in Äspö HRL, September 2007.*

4.1 Prototype Repository



The Prototype Repository is located in the TBM-tunnel at the -450 m level and includes six full scale deposition holes. The aims of the Prototype Repository are to demonstrate the integrated function of the repository components and to provide a full-scale reference for comparison with models and assumptions.

The Prototype Repository should, to the extent possible, simulate the real repository system regarding geometry, materials and rock environment.

Instrumentation is used to monitor processes and properties in the canister, buffer material, backfill and the near-field rock. The evolution will be followed for a long time.

The inner tunnel (Section I) was installed and the plug cast in 2001 and the heaters in the canisters were turned on one by one. The outer tunnel (Section II) was backfilled in June 2003 and the tunnel plug with two lead-throughs was casted in September the same year.

Achievements

The data collection system comprises temperature, total pressure, porewater pressure, relative humidity and resistivity measurements in buffer and backfill, as well as temperature and water pressure measurements in boreholes in the rock around the tunnel. The collection of data is in progress and the data report No. 17 covering the period up to May 2007 will soon be finalised. Overhauling of the data acquisition system is in progress and hydraulic tests of the rock mass have been performed.

Measurements of pH and Eh of water samples taken from boreholes in Section I and II of the Prototype Repository and the G-tunnel is on-going. The work will be reported at the end of this year.

A report describing hydraulic tests made in bore holes (single hole tests) close to the prototype tunnel has been published /Forsmark 2007/. Also, a report describing tracer dilution tests made in 16 different borehole sections of the rock has been published /Gokall-Norman and Andersson 2007/.

A programme for sampling and analyses of gases and micro-organisms in the backfill and buffer has started and the first and second campaign has been finalised and reported in a technical document. A third campaign has been finalised and will be reported in an International Progress Report (IPR).

Acoustic Emission and Ultrasonic monitoring results from deposition hole 5 and 6 have been reported for the period between October 2006 and March 2007 and will soon be printed. The Acoustic Emission and Ultrasonic monitoring are continuing.

A thermal FEM model for the Prototype Repository including the rock, backfill, buffer and the six canisters has been developed. The 1D THM modelling of the buffer in deposition hole 1 and 3 has been finished and a report is in progress. Furthermore, a 2D TH modelling of an entire deposition hole is in progress and will soon be reported. The thermal model of the entire experiment has been extended to incorporate mechanical behaviour in order to evaluate whether occurrence of spalling is possible. This work has been finalised and will be reported at the end of this year. Small THM models have been developed in the Mathcad environment in order to calibrate an elasto-plastic material model to be used for the bentonite block and the outer slot filled with bentonite pellets.

4.2 Long Term Test of Buffer Material

The Long Term Test of Buffer Material aims to validate models and hypotheses concerning mineralogy and physical properties in a bentonite buffer.

Seven test parcels containing heater, central tube, clay buffer, instruments and parameter controlling equipment have been placed in boreholes with a diameter of 300 mm and a depth of around 4 m.

Temperature, total pressure, water pressure and water content, are measured during the heating period. At termination of the tests, the parcels are extracted by overlapping core-drilling outside the original borehole. The water distribution in the clay is determined and subsequent well-defined mineralogical analyses and physical testing of the buffer material are made.

The test parcels are also used to study related processes such as bentonite diffusion properties, microbiology, copper corrosion and gas transport in buffer material under conditions similar to those expected in a deep repository.

Achievements

The on-going three tests (see Table 4-1) are functioning well and field data have been inspected and stored in the Sicada database. Laboratory results concerning the A2 test (adverse conditions) have been reported to the Sicada database and the compilation of a final Technical Report including all results from the test is in progress. Additional laboratory tests have been performed in order to give additional information concerning the previously noticed changes in cation exchange capacity and rheological properties in the A2 field material.

Table 4-1. Test series for the Long Term Test of Buffer Material.

Type	No.	max T (°C)	Controlled parameter	Time (years)	Remark
A	2	120-150	T, [K^+], pH, am	5	Reporting in progress
A	3	120-150	T	5	On-going
S	2	90	T	5	On-going
S	3	90	T	>>5	On-going

A = adverse conditions; S = standard conditions; [K^+] = potassium concentration
T = temperature; pH = high pH from cement; am = accessory minerals added

4.3 Alternative Buffer Materials

Installation of one of the three packages illustrating the mixing of the different compacted buffer discs.

In the Alternative Buffer Materials project different types of buffer materials are tested in field scale. The aim is to further investigate the properties of the alternatives to the SKB reference bentonite (MX-80).

The project will be carried out using material that according to laboratory studies are conceivable buffer materials. The experiment will be carried out in the same way and scale as the Long Term Test of Buffer Material.

The objectives are to:

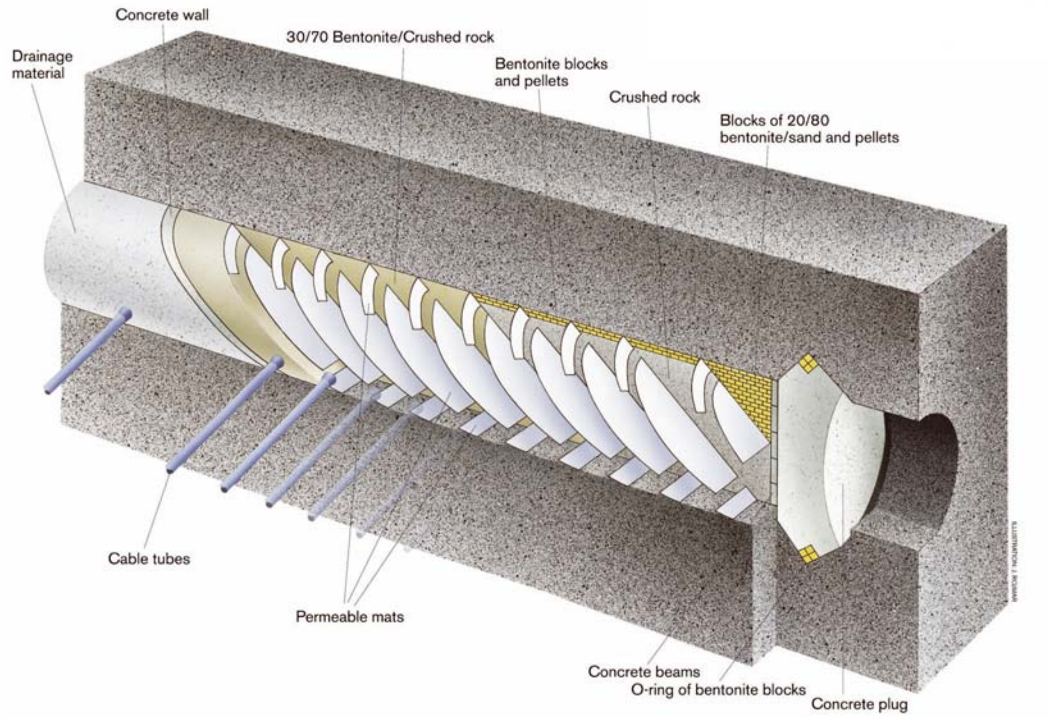
- Verify results from laboratory studies during more realistic conditions with respect to temperature, scale and geochemical circumstances.
- Discover possible problems with manufacturing and storage of bentonite blocks.
- Give further data for verification of thermo-hydro-mechanical (THM) and geochemical models.

The field tests started during 2006 at Äspö HRL. Eleven different clays have been chosen to examine effects of smectite content, interlayer cations and overall iron content. Also bentonite pellets with and without additional quartz are being tested. The different clays are assembled in three packages.

Achievements

During the third quarter 2007 the temperature in the experiment packages has been raised somewhat. The temperature is now above 100°C. The goal temperature is 130°C. The saturation system has also been restarted and is now applying an overpressure of 0.7 bar. The systems are running smoothly and no other issues have been raised during the period.

4.4 Backfill and Plug Test



The Backfill and Plug Test includes tests of backfill materials, emplacement methods and a full-scale plug. The inner part of the tunnel is filled with a mixture of bentonite and crushed rock (30/70) and the outer part is filled with crushed rock and bentonite blocks and pellets at the roof.

The integrated function of the backfill material and the near-field rock in a deposition tunnel excavated by blasting is studied as well as the hydraulic and mechanical functions of the full-scale concrete plug.

The entire test set-up with backfill, instrumentation and casting of the plug was finished in the end of September 1999 and the wetting of the 30/70 mixture through filter mats started in late 1999.

The backfill was completely water saturated in 2003 and flow testing for measurement of the hydraulic conductivity has been running since late 2003.

In autumn 2006 activation of the four pressure cylinders mounted on the floor and in the roof started. These will be used for mechanical testing of the compressibility of the backfill.

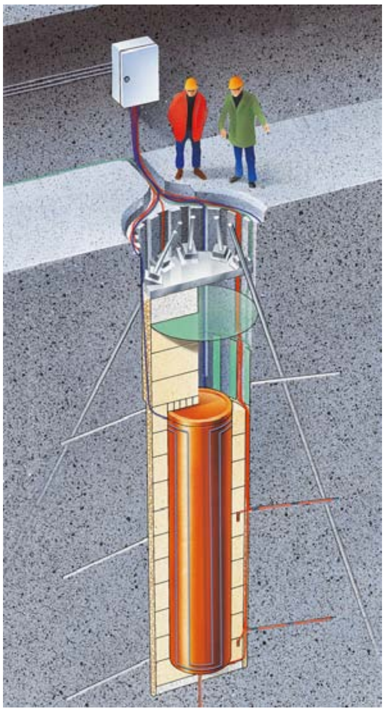
Achievements

The main work during the third quarter has included continuous measurements and registrations of water saturation, water pressure and swelling pressure in the backfill as well as water pressure in the surrounding rock. A new data report covering the period up to 1st July 2007 has been written. The results so far show that the transducers still work properly and that no startling results have been achieved.

The tests with the pressure cylinders in the 30/70 section have been finished during this quarter. High compressibility also in the floor was measured.

A decision has been taken to use the tubes installed in the section with crushed rock for measuring local hydraulic conductivity.

4.5 Canister Retrieval Test



The Canister Retrieval Test is aiming at demonstrating the readiness for recovering of emplaced canisters also after the time when the bentonite is fully saturated.

In the Canister Retrieval Test two full-scale deposition holes have been drilled, at the -420 m level, for the purpose of testing technology for retrieval of canisters after the buffer has become saturated.

These holes have been used for studies of the drilling process and the rock mechanical consequences of drilling the holes.

Canister and bentonite blocks were emplaced in one of the holes in 2000 and the hole was sealed with a plug, heater turned on and artificial water supply to saturate the buffer started.

In January 2006 the retrieval phase was initiated and the canister was successfully retrieved on 12th of May 2006. The saturation phase had, at that time, been running for more than five years with continuous measurements of the wetting process, temperature, stresses and strains.

Achievements

The detailed analyses of the bentonite samples taken during the canister retrieval have now been started at Clay Technology.

Additional material has been sent to be included in the heater analyses. Heater analyses results are expected during the last quarter of 2007.

Modelling of the buffer has started within the Task Force on Engineered Barrier Systems. Results from this work are expected in 2008.

4.6 Temperature Buffer Test

The French organisation Andra carries out the Temperature Buffer Test (TBT) at Äspö HRL in co-operation with SKB.

The aims of the TBT are to evaluate the benefits of extending the current understanding of the THM behaviour of engineered barriers during the water saturation transient to include high temperatures, above 100°C.

The scientific background to the project relies on results from large-scale field tests on EBS, notably Canister Retrieval Test, Prototype Repository and Febex (Grimsel Test Site).

The test is located in the same test area as the Canister Retrieval Test, which is in the main test area at the -420 m level.

The TBT experiment includes two heaters in the axis of the deposition hole, one on top of the other, separated by a compacted bentonite block. The heaters are 3 m long and 610 mm in diameter and are constructed in carbon steel. Each one simulates a different type of confinement system: a bentonite buffer only (bottom section) and a bentonite buffer with inner sand backfill (upper section).

An artificial water pressure is applied in a slot between the buffer and rock, which is filled with sand and functions as a filter.

Achievements

The TBT-test is in the operation and data acquisition phase since March 2003. Data acquisition is continuously on-going and the data link from Äspö to Andra's head office in Paris has been functioning well. Two monthly data reports have been distributed during July-September 2007 and a new data report covering the period up to 1st July 2007 has been published /Goudarzi et al. 2007/.

Evaluations of the artificial watering are in progress. The bentonite around the upper heater appears to be close to saturated, whereas the innermost parts of the blocks around the lower heater still are unsaturated.

The quality of the water used for hydration was changed on 17th of April, and a larger pressure tank was taken in use on 13th of August. It is now possible to maintain a filter pressure of four bars (absolute).

The dry gas venting activity has now been completed and has been replaced by the shield hydration activity. The aim of this is to saturate the sand shield around the upper heater with water. A project meeting was held in Lille in September 2007 to discuss the hydration of the sand shield, the change in power output from the heaters and the future of the project.

4.7 KBS-3 Method with Horizontal Emplacement

The possibility to modify the reference KBS-3 method and make serial deposition of canisters in long horizontal deposition holes (KBS-3H), instead of deposition of single canisters in vertical deposition holes (KBS-3V), is studied in this project.

The KBS-3H project is a joint project between SKB and Posiva. One reason for proposing the change is that the deposition tunnels in KBS-3V are not needed if the canisters are disposed in long horizontal deposition holes and the excavated rock volume and the amount of backfill can be considerably reduced. This in turn reduces the environmental impact during the construction of the repository and also the construction costs.

The site for the demonstration of the method is located at -220 m level. A niche with a height of about 8 m and a bottom area of 25×15 m forms the work area. Two horizontal deposition holes have been excavated, one short with a length of about 15 m and one long with a length of about 95 m. The deposition equipment will be tested in the long hole and the short hole will be used for testing of a low-pH shotcrete plug and of different drift components.

The KBS-3H project is partly financed by the EC-project Esdred – Engineering studies and demonstration of repository designs.

Achievements

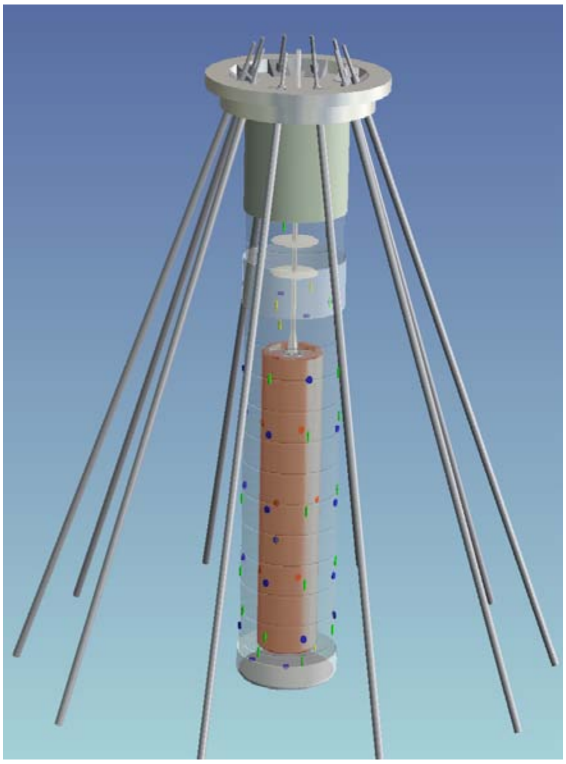
The Mega packer, a special device for grouting of the rock around horizontal deposition holes, has been delivered to Äspö HRL. Assembly, transportation down to the experiment site and initial tests are completed. Additional equipment to perform the grouting has also been assembled and prepared for the tests. Grouting tests will be performed during the last quarter of 2007.

Steel plugs are planned to be used to seal off sections in the deposition hole with too high water inflow. The notch, in which a plug can be installed, has been excavated successfully, see photo above. The method by sawing parallel tracks proved to be effective and gave good results.

Two designs are being considered for the KBS-3H project canisters: the Basic Design, and the DAWE (drainage, artificial watering, and air evacuation) design. A test plan with complete drawing of equipment has been written to test “pipe removal” to verify the ability to remove saturation pipes in the DAWE alternative. The testing will be done in the bentonite laboratory at Äspö during the last quarter of 2007.

The test and demonstration of the KBS-3H deposition machine at the -220 m level have continued successfully. Since February the machine has been transporting one Supercontainer totally approximately 11 km in the 95 m long drift.

4.8 Large Scale Gas Injection Test



Layout of the Lasgit experiment conducted in the assembly hall area at the -420 m level.

Current knowledge pertaining to the movement of gas in a compact buffer bentonite is based on small-scale laboratory studies. These diagnostic tests are designed to address specific issues relating to gas migration and its long-term effect on the hydro-mechanical performance of the buffer clay.

Laboratory studies have been used to develop process models to assess the likely implications of gas flow in a hard-rock repository system. While significant improvements in our understanding of the gas-buffer system have taken place, a number of important uncertainties remain. Central to these is the issue of scale and its effect on the mechanisms and process governing gas flow in compact bentonite.

The question of scale-dependency in both hydration and subsequent gas phases of the test history are central issues in the development and validation of process models aimed at repository performance assessment. To address these issues, a Large Scale Gas Injection Test (Lasgit) has been initiated. Its objectives are:

- Perform and interpret a large scale gas injection test based on the KBS-3 design concept.
- Examine issues relating to up-scaling and its effect on gas movement and buffer performance.
- Provide information on the process of hydration and gas migration.
- Provide high-quality test data to test/validate modelling approaches.

In February 2005 the deposition hole was closed and the hydration of the buffer initiated. When the buffer is fully saturated a series of gas injection tests will be undertaken to examine the mechanisms governing gas flow in KBS-3 bentonite.

Achievements

At the request of project stakeholders a preliminary gas injection history was planned for 2007 with a view to verifying the operation and data reduction methodologies outlined in the original concept report and to provide qualitative data on hydraulic and gas transport parameters for a bentonite buffer during the hydration process.

With this in mind, activities during the third quarter have focused on:

- The continued hydration of the bentonite buffer
- Completion of leak-testing of key experimental systems in anticipation of gas testing
- Carrying out and preliminary interpretation of the hydraulic test for the determination of baseline hydraulic properties
- Carrying out the initial gas test, a second phase of which is continuing into the fourth quarter
- Reprocessing of legacy data
- Conversion of Phase 1 hydration data for archiving by SKB.

Given the current state of saturation within the buffer, it was decided that preliminary mass transport measurements would be undertaken in one of the 100 mm filters positioned in the lower canister array. On 25th of May 2007, the lower filter arrays (FL901 to FL904) were isolated from all neighbouring test circuits and the pressures allowed to decay to provide information on the spatial distribution of local porewater pressures in the vicinity of each filter. Then on 21st June a constant head test was started using FL903, with the pressure on that filter raised to 4.3 MPa. During this hydraulic testing the remaining filters in the lower level remained isolated from the artificial hydration system and their pressure allowed to evolve in order to provide temporal data on local porewater pressures within the buffer clay. At the same time, artificial hydration continued through all remaining canister filters and hydration mats. Pressure on FL903 was maintained at 4.3 MPa until 19th of July, when it was reduced to 560 kPa and then held at that level until 7th of August. During this period the flow rates into and out of FL903 were monitored. Some preliminary modelling of the hydraulic test has been undertaken, considering each of the four filters involved separately, yielding permeability estimates ranging from $7.5 \cdot 10^{-21}$ to $1.6 \cdot 10^{-20}$ m^2 and specific storage estimates ranging from $2.5 \cdot 10^{-5}$ to $5.5 \cdot 10^{-4}$ m^{-1}.

On 7th of August gas injection into FL903 was begun. Starting with an estimated gas volume of 1,280 cm^3, the gas was pressurised by introducing water into the gas reservoir at a steady rate until 20th of August when the test was temporarily stopped and the injection pressure held constant. This continued until 11th of September when the gas volume was reset to around 1,240 cm^3 and pressurisation resumed, continuing through the end of September. Preliminary analysis indicates gas flow out of the filter has been detected at the relatively low pressure of about 775 kPa, suggesting that the gas is migrating along interfaces between bentonite blocks or between bentonite and canister rather than penetrating the bentonite itself.

Current porewater pressures within the clay remain rather low ranging from 230 kPa to 600 kPa. This is in contrast to the water pressure measured at the face of the deposition hole which ranges from 1,120 kPa to 2,530 kPa and is non-uniformly distributed across the rock face (Figure 4-2a). Monitored radial stress around the canister continues to increase steadily ranging in value from 1,650 kPa to 5,470 kPa (Figure 4-2b), with an average value of 4,250 kPa. Axial stress within the clay ranges from 4,910 kPa to 6,150 kPa with an average of 5,360 kPa, and is non-uniformly distributed across the major axis of the emplacement hole.

Analysis of the experimental data indicates that isolation of the FL filters and the running of the hydraulic and gas tests has had no discernable effect on the monitored values of stress and porewater pressure within the Lasgit system.

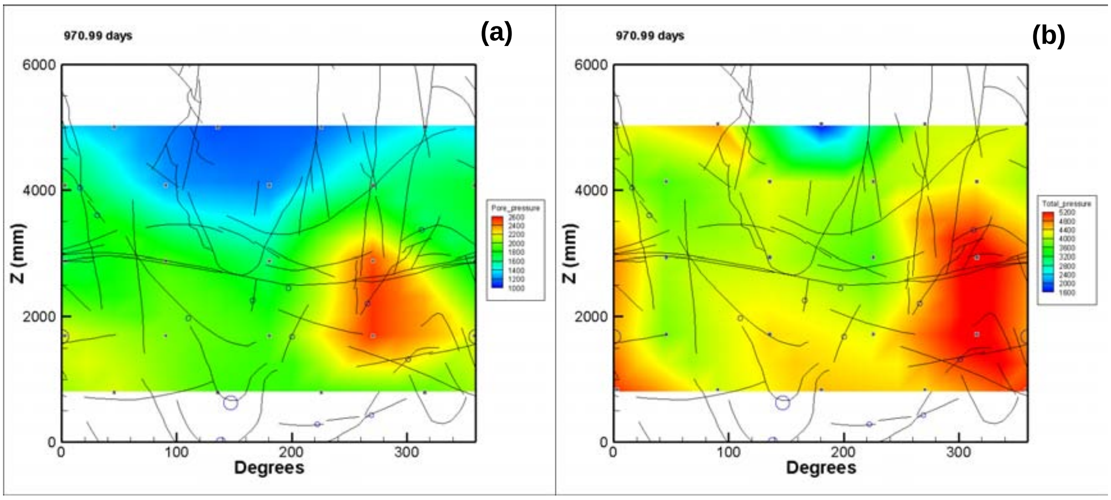
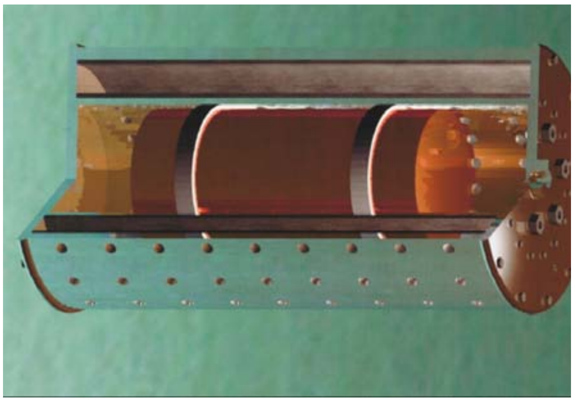


Figure 4-2. *The distribution of porewater pressure (a) and radial stress (b) measured at the rock face of the deposition hole at an elapse time of 970 days. A narrow zone of elevated radial stress can be clearly seen in (b) extending vertically upwards from the base of the deposition hole.*

The test has been in successful operation for in excess of 970 days. Initial results from the preliminary gas tests performed to date within the Lasgit project, vindicate both the philosophy behind the experimental programme as well as the set-up and system design. The Lasgit experiment continues to yield high quality data amenable to the development and validation of process models aimed at repository performance assessment.

4.9 In Situ Corrosion Testing of Miniature Canisters



Miniature canister with support cage

Installation of first model canister assembly

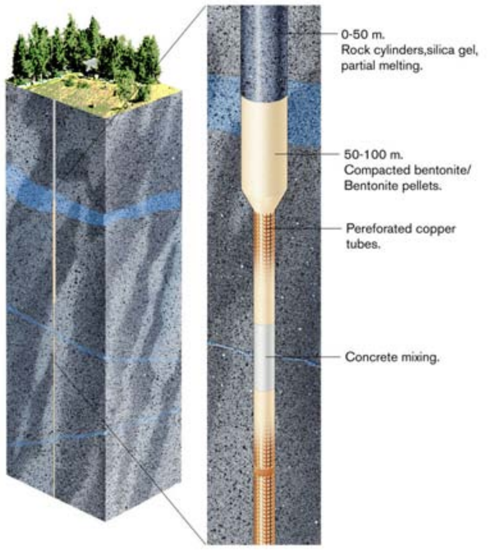
The MiniCan project is designed to provide information about how the environment inside a copper canister containing a cast iron insert would evolve if failure of the outer copper shell were to occur. The development of the subsequent corrosion in the gap between the copper shell and the cast iron insert would affect the rate of radionuclide release from the canister. The information obtained from the experiments will be valuable in providing a better understanding of the corrosion processes inside a failed canister.

Miniature canisters with a diameter of 14.5 cm and containing 1 mm diameter defects in the outer copper shell have been set up in five boreholes with a diameter of 30 cm and a length of 5 m at the Äspö HRL. The canisters are mounted in support cages, four of which contain bentonite, and are exposed to natural reducing groundwater. Together with corrosion test coupons which are also in the boreholes, the canisters will be monitored for several years. The corrosion will take place under realistic oxygen-free repository conditions that are very difficult to reproduce and maintain for long periods of time in the laboratory.

Achievements

All five miniature canisters were installed in the beginning of 2007. Data relating to the environmental conditions, corrosion behaviour of the test specimens and dimensional changes are continuously collected and analysed. An annual technical report summarising the installation of the experiments and collected data will be prepared at the end of 2007.

4.10 Cleaning and Sealing of Investigation Boreholes



A project, with the aim to identify and demonstrate the best available techniques for cleaning and sealing of investigation boreholes, was initiated in 2002. The project is run in co-operation between SKB and Posiva.

The project comprises three phases.
Phase 1 was mainly an inventory of available techniques, and the aim of Phase 2 was to develop a complete cleaning and sealing concept.

The now on-going Phase 3, is divided into four sub-projects, and comprises large-scale testing of the sealing concept in boreholes. Sub-project 1, 2 and 3 are all finished. The aim of sub-project 4 is to test the feasibility of candidate techniques intended for mechanical securing of the tight clay seals emplaced in deep boreholes. The physical conditions for constructing and testing the plugs are represented by three cored boreholes with 200 mm diameter and 1.9 m depth at about 400 m depth in the Äspö HRL.

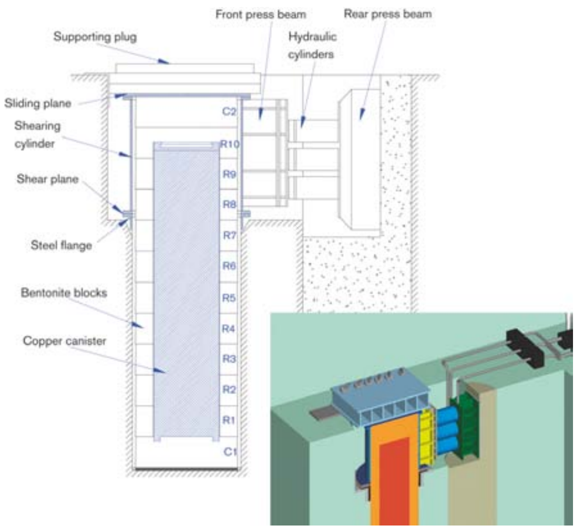
Achievements

Reports of the four sub-projects have been approved and printed as International Progress Reports. The sub-projects comprises of:

Sub-project 1	Design and modelling of the performance of borehole plugs /Pusch and Ramqvist 2006a/
Sub-project 2	Plugging of 5 m boreholes at Äspö /Pusch and Ramqvist 2006b/
Sub-project 3	Plugging of borehole OL-KR24 at Olkiluoto and reference boreholes at Äspö /Pusch and Ramqvist 2007a/
Sub-project 4	Sealing of 200 mm boreholes at Äspö /Pusch and Ramqvist 2007b/

Preparatory planning for Phase 4 on the “Joint Work Programme on Borehole Sealing” has been initiated. An agreement on the co-operation between Posiva and SKB has been signed of both parties comprising the period 2007-2010.

4.11 Rock Shear Experiment



The Rock Shear Experiment (Rose) aims at observing the forces that act on a KBS-3 canister if a displacement of 100 mm would take place in a horizontal fracture that crosses a deposition hole. Such a displacement may be caused by an earthquake and the test set-up need to provide a shearing motion along the fracture that is equal to the worst expected shearing motion in real life.

A possibility is to perform the in situ test at the Äspö Pillar Stability site. Two full scale deposition holes already exist with a rock pillar of one metre in between. One deposition hole can be used for the buffer and canister, while the other deposition hole is used for the shearing equipment.

Achievements

A pre-study of design and feasibility of an in situ test is completed and reported /Börjesson et al. 2006/. The main conclusion is that the test is feasible. A rock shear experiment in full scale in the Äspö HRL is a possibility, however not yet decided on. Presently, the main interest in the area of rock shear effects is laboratory testing.

4.12 Earth Potentials

The main objective of the project is to identify the magnitude of potential fluctuations and stray currents at repository depth and by that estimate the potential problems that could occur. The causes to these effects may be Geomagnetically Induced Currents (GIC) or man-made stray current sources.

Electrical potentials are generated by current flow in conductive media. At shallow depth currents flow parallel to the ground surface because the electrical conductivity of air is very low compared to that of soil and rock. If the conductivity is constant along any plane in the earth the natural current flow is none, while variations in conductivity cause natural currents that can be oriented in different directions.

Achievements

A final report is being compiled. No further work is planned in the project until the report is finished.

4.13 Task Force on Engineered Barrier Systems

The Task Force on Engineered Barrier Systems (EBS) is a natural continuation of the modelling work in the Prototype Repository Project, where also modelling work on other experiments, both field and laboratory tests, are conducted. The Äspö HRL

International Joint Committee (IJC) has decided that in the first phase of this Task Force (period 2004-2008), work should concentrate on:

Task 1 THM modelling of processes during water transfer in buffer, backfill and near-field rock. Only crystalline rock is considered initially, although other rock types could be incorporated later.

Task 2 Gas transport in saturated buffer.

The objectives of the tasks are to: (a) verify the capability to model THM and gas migration processes in unsaturated as well as saturated bentonite buffer, (b) refine codes that provide more accurate predictions in relation to the experimental data and (c) develop the codes to 3D standard (long-term objective).

Participating organisations besides SKB are at present: Andra, BMWi, CRIEPI, Nagra, Posiva, NWMO and RAWRA. All together 12-14 modelling teams are participating in the work.

Since the Task Force does not include geochemistry, a decision has been taken by IJC to also start a parallel Task Force that deals with geochemical processes in engineered barriers. The two Task Forces, THM/Gas and Geochemistry, have common secretariat but separate chairmen.

Achievements

Task Force THM/Gas

For Task 1 the THM modelling during the third quarter has concerned large scale in situ tests (Task 1.2). The modelling of the Buffer/Container Experiment and the Isothermal Test (carried out by AECL; Task 1.2.1) has continued. The other task (Task 1.2.2) that concerns modelling of the Canister Retrieval Test at Äspö HRL has been prepared and a draft task description has been delivered to the participating teams and organisations.

For Task 2 (Gas) additional modelling of the two benchmark tests has been done by Clay Technology during the period.

Task Force Geochemistry

Molecular dynamics modelling have been made by Clay Technology for SKB during the period. The work has focused on ion diffusion in the montmorillonite/water system, and the results were presented at the conference "Clays in Natural and Engineered Barriers for Radioactive Waste Confinement" in Lille in September, and a paper is submitted for publication.

Ion diffusion is central in geochemical modelling, and in bentonite this is a complex matter due to the montmorillonite structure. A literature study of diffusion experiments has been made, which shows that several conceptual models of bentonite micro structure have been used in order to interpret the results. Reinterpretation of some results is now on-going with the aim to present a more coherent view of the structure and of the principles for diffusion in bentonite.

Redistribution of calcium minerals in the Lot-experiment at Äspö HRL will serve as a benchmark modelling task. Three groups representing SKB, Nagra and Posiva will present the first results at the Task Force meeting in Stockholm in November 2007.

5 Äspö facility

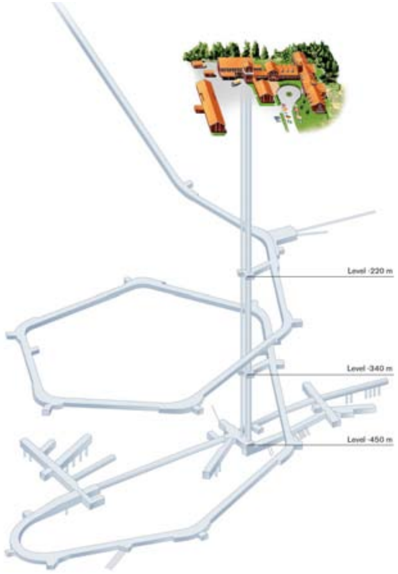
The organisational unit Äspö Hard Rock Laboratory is responsible for the operation of the Äspö facility and the co-ordination, experimental service and administrative support of the research performed in the facility. Activities related to information and visitor services are also of great importance not only to give prominence to Äspö HRL but also to build confidence for SKB's overall commission.

The Äspö HRL unit is organised in four operative groups and a secretariat:

- *Project and Experimental service (TDP)* is responsible for the co-ordination of projects undertaken at the Äspö HRL, for providing services (administration, planning, design, installations, measurements, monitoring systems etc.) to the experiments.
- *Repository Technology and Geoscience (TDS)* is responsible for the development and management of the geo-scientific models of the rock at Äspö and the test and development of repository technology at Äspö HRL to be used in the final repository.
- *Facility Operation (TDD)* is responsible for operation and maintenance of the Äspö HRL offices, workshops and underground facilities and for development, operation and maintenance of supervision systems.
- *Public relations and Visitor Services (TDI)* is responsible for presenting information about SKB and its facilities with main focus on the Äspö HRL. The HRL and SKB's other research facilities are open to visitors throughout the year.

Each major research and development task carried out in Äspö HRL is organised as a project that is led by a Project Manager who reports to the client organisation. Each Project Manager is assisted by an on-site co-ordinator with responsibility for co-ordination and execution of project tasks at the Äspö HRL. The staff at the site office provides technical and administrative service to the projects and maintains the database and expertise on results obtained at the Äspö HRL.

5.1 Hard Rock Laboratory



The main goal for the operation of the facility is to provide a safe and environmentally correct facility for everybody working or visiting the Äspö HRL.

This includes preventative and remedy maintenance in order to withhold high availability in all systems as drainage, electrical power, ventilation, alarm and communications.

Achievements

All systems have been almost 100% operational and there have been no incidents. A new reserve-electricity generator has been purchased to ensure back up electricity for safety related systems. Installation of the system is planned for the fourth quarter.

The work with the system for registration of personnel (RFID) is continuing as planned with quality assurance of the documentation and computer codes. After the project has been completed, an investigation will begin on whether the technology which has been developed can be implemented usefully in other areas.

All buildings have been painted and a new storage is being built for large machines and equipment which will be delivered to the Äspö HRL in 2008.

The first version of the deposition machine for KBS-3V has been scrapped. Delivery of the second version of the deposition machine for KBS-3V to the Äspö HRL is planned for December 2007.

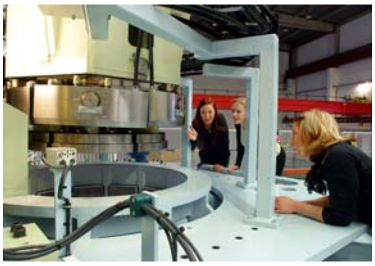
5.2 Bentonite Laboratory

Before building a final repository, where the operating conditions include the deposition of one canister per day, further studies of the behaviour of the buffer and backfill under different installation conditions are required. SKB has built a Bentonite Laboratory at Äspö designed for studies of buffer and backfill materials. The laboratory, a hall with dimensions 15×30 m, includes two stations where the emplacement of buffer material at full scale can be tested under different conditions. The hall will also be used for testing of different types of backfill material and the further development of techniques for the backfilling of deposition tunnels.

Achievements

The construction of the laboratory has been completed. A mixer for bentonite has been ordered and will be operational during the first quarter of 2008. Additional space for material and equipment is needed for the bentonite laboratory.

5.3 Public Relations and Visitors Service



SKB operates three facilities in the Oskarshamn municipality: Äspö HRL, Central interim storage facility for spent nuclear fuel (Clab) and the Canister Laboratory. In 2002 SKB began site investigations at Oskarshamn and Östhammar.

The main goal for the information and public relations group at Äspö HRL, is to in co-operation with other departments at SKB, present information about SKB and its activities and facilities.

Achievements

SKB facilities have been visited by 8,025 persons during the third quarter 2007, and in total 20,364 persons during the first nine months 2007. The numbers of visitors to the main facilities are listed in Table 5-1.

The guided summer-tours "Urberg 500" started in the end of June and ended the 19th of August. The tours sat a new record for the second year in a row. In total 3,204 persons visited the laboratory, which is 300 more visitors than last year.

Table 5-1. Number of visitors to SKB main facilities.

SKB facility	Number of visitors July-September 2007
Central interim storage facility for spent nuclear fuel	174
Canister Laboratory	165
Äspö HRL	3,969
Final repository for radioactive operational waste (SFR)	3,232

Activities organised during the national event "The Day of Geology" attracted about 150 visitors, divided into two separate events. The arrangements took place on 14-15th of September. The theme for the local events was the archipelago.

A contribution to *EU's Researchers' Night*, with the research on microbes in focus, was held at Äspö on the 28th of September. In the afternoon there was first a seminar for especially invited guests, where also the new Nova R&D platform was launched. In the evening there was an open event for the public. Both events attracted about 80 persons.

6 Environmental research

6.1 General

Äspö Environmental Research Foundation was founded 1996 on the initiative of local and regional interested parties. The aim was to make the underground laboratory at Äspö and its resources available for national and international environmental research. SKB's economic engagement in the foundation was concluded in 2003 and the activities thereafter concentrated to the Äspö Research School. The agreement between SKB and Kalmar University, concerning Äspö Research School, is valid until 30th of September 2008. The future plan for the School is just under discussion. One interesting way to continue the co-operation is to adopt the Äspö Research School in the new research and development platform Nova R&D in Oskarshamn. This new platform is the result of a new co-operation between SKB and Oskarshamn's municipality. Nova R&D is open for a much broader range of sciences in comparison to the current activities within Äspö Research School. Kalmar University have got an invitation to be one of several academic partners in Nova R&D.

6.2 Äspö Research School

Kalmar University's Research School in Environmental Science at Äspö HRL, called Äspö Research School, started in October 2002. This School is the result of an agreement between SKB and Kalmar University. It combines two important regional resources, i.e. Äspö HRL and Kalmar University's Environmental Science Section. The activity within the school will lead to: (a) development of new scientific knowledge, (b) increase of geo- and environmental-scientific competence in the region and (c) utilisation of the Äspö HRL for environmental research. The research activities focus on biogeochemical systems, in particular in the identification and quantification of dispersion and transport mechanisms of contaminants (mainly metals) in and between soils, sediments, water, biota and upper crystalline bedrock. In addition to financial support from SKB and the University of Kalmar, the school receives funding from the city of Oskarshamn.

Achievements

One scientific paper titled "Hydrochemical patterns of a small lake and a stream in an uplifting area proposed as a repository site for spent nuclear fuel" has been accepted for publication in the Journal of Hydrology[2] and another paper dealing with uranium in surface and ground waters in boreal Europe is under review at Geochemistry: Exploration, Environment, Analysis. Further, a third paper dealing with evidence of sulphide-oxidation products in a circum neutral stream is submitted to Boreal Environment Research.

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[2] Rönnback P, Åström M, 2007. Hydrochemical patterns of a small lake and a stream in an uplifting area proposed as a repository site for spent nuclear fuel, Forsmark, Sweden. Journal of Hydrology 344: 223-235.

7 International co-operation

Nine organisations from eight countries participate in the Äspö HRL co-operation during 2007, see Table 7-1. Six of them; Andra, BMWi, CRIEPI, JAEA, NWMO and Posiva together with SKB form the Äspö International Joint Committee (IJC), which is responsible for the co-ordination of the experimental work arising from the international participation.

Several of the participating organisations take part in the two Äspö Task Forces on: (a) Modelling of Groundwater Flow and Transport of Solutes, which is a forum for co-operation in the area of conceptual and numerical modelling of groundwater flow and solute transport in fractured rock and (b) THMC modelling of Engineered Barrier Systems, which is a forum for code development on THMC processes taking place in a bentonite buffer and gas migration through a buffer.

Table 7-1. International participation in the Äspö HRL projects during 2007.

Projects in the Äspö HRL during 2007	Andra	BMWi	CRIEPI	JAEA	NWMO	Posiva	Enresa	Nagra	RAWRA
Geo-science									
Äspö Pillar Stability Experiment					X	X			
Natural barriers									
Tracer Retention Understanding Experiments	X			X		X			
Long Term Sorption Diffusion Experiment					X				
Colloid Dipole Project		X				X			
Microbe Project		X							
Radionuclide Retention Project		X							
Task Force on Modelling of Groundwater Flow and Transport of Solutes	X		X	X	X	X			
Engineered barriers									
Prototype Repository	X	X		X		X			
Long Term Test of Buffer Material						X			
Alternative Buffer Materials	X	X		X		X		X	X
Temperature Buffer Test	X	X					X		
KBS-3 Method with Horizontal Emplacement						X			
Large Scale Gas Injection Test	X	X			X	X			
Task Force on Engineered Barrier Systems	X	X	X		X	X		X	X

Participating organisations:
Agence nationale pour la gestion des déchets radioactifs, Andra, France
Bundesministerium für Wirtschaft und Technologie, BMWi, Germany
Central Research Institute of the Electronic Power Industry, CRIEPI, Japan
Japan Atomic Energy Agency, JAEA, Japan
Nuclear Waste Management Organisation, NWMO, Canada
Posiva Oy, Finland
Empresa Nacional de Residuos Radiactivos, Enresa, Spain
Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle, Nagra, Switzerland
Radioactive Waste Repository Authority, Rawra, Czech Republic

8 Documentation

During the period July-September 2007, the following reports have been published and distributed.

8.1 Äspö International Progress Reports

Pusch R, Ramqvist G, 2006. Cleaning and sealing of Borehole. Report of Sub-project 1 on design and modelling of the performance of borehole plugs. SKB IPR-06-28. Svensk Kärnbränslehantering AB.

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Pusch R, Ramqvist G, 2006. Cleaning and sealing of Borehole. Report of Sub-project 3 on plugging of borehole OL-KR24 at Olkiluoto and reference boreholes at Äspö. SKB IPR-06-30. Svensk Kärnbränslehantering AB.

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Kristensson O, Hökmark H, 2007. Prototype Repository. Thermal 3D modelling of Äspö Prototype Repository. SKB IPR-07-01. Svensk Kärnbränslehantering AB.

Gokall-Norman K, Andersson P, 2007. Prototype Repository. Tracer dilution tests during operation phase, test campaign 2. SKB IPR-07-03. Svensk Kärnbränslehantering AB.

Goudarzi R, Åkesson M, Hökmark H, 2007. Temperature Buffer Test. Sensors data report (Period: 030326-070101) Report No:9. SKB IPR-07-07. Svensk Kärnbränslehantering AB.

Äspö Hard Rock Laboratory. Status Report. April - June 2007. SKB IPR-07-11. Svensk Kärnbränslehantering AB.

8.2 Technical Documents and International Technical Documents

No Technical Documents and International Technical Documents were published.

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