International Progress Report

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Äspö Hard Rock Laboratory

Status Report
July – September 2008

Svensk Kärnbränslehantering AB

December 2008

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Äspö Hard Rock Laboratory

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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 2008–2013 are presented in SKB's RD&D-Programme 2007 /SKB 2007/. The information given in the RD&D-Programme related to Äspö HRL is annually detailed in the Äspö HRL Planning Report /SKB 2008/.

This Äspö HRL Status Report is a collection of the main achievements obtained during the third quarter of 2008.

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, Sealing of Tunnel at Great Depth, In Situ Corrosion Testing of Miniature Canisters and Cleaning and Sealing of Investigation Boreholes.

THM processes and gas migration in buffer material are addressed in the Task Force on Engineered Barrier Systems and in a parallel Task Force geochemical processes in engineered barriers are studied.

Äspö facility

The Äspö facility comprises of the Hard Rock Laboratory and the Bentonite Laboratory that was taken in operation in 1995 and 2007 respectively. 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. The municipality of Oskarshamn and SKB have formed a research and education platform, Nova FoU, based at Nova Centre for University Studies Research and Development in Oskarshamn. SKB and Kalmar University is presently working with the integration of the Äspö Research School in the Nova FoU.

International co-operation

The Äspö HRL has so far attracted considerable international interest. Eight organisations from seven countries participate in the co-operation or in Äspö HRL related activities, apart from SKB, during 2008.

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 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 2008, 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 2008–2013 are presented in SKB's RD&D-Programme 2008 /SKB 2007/. 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 2008/ for more background information. The Annual Report presents and summarise new findings and results obtained during the present year.

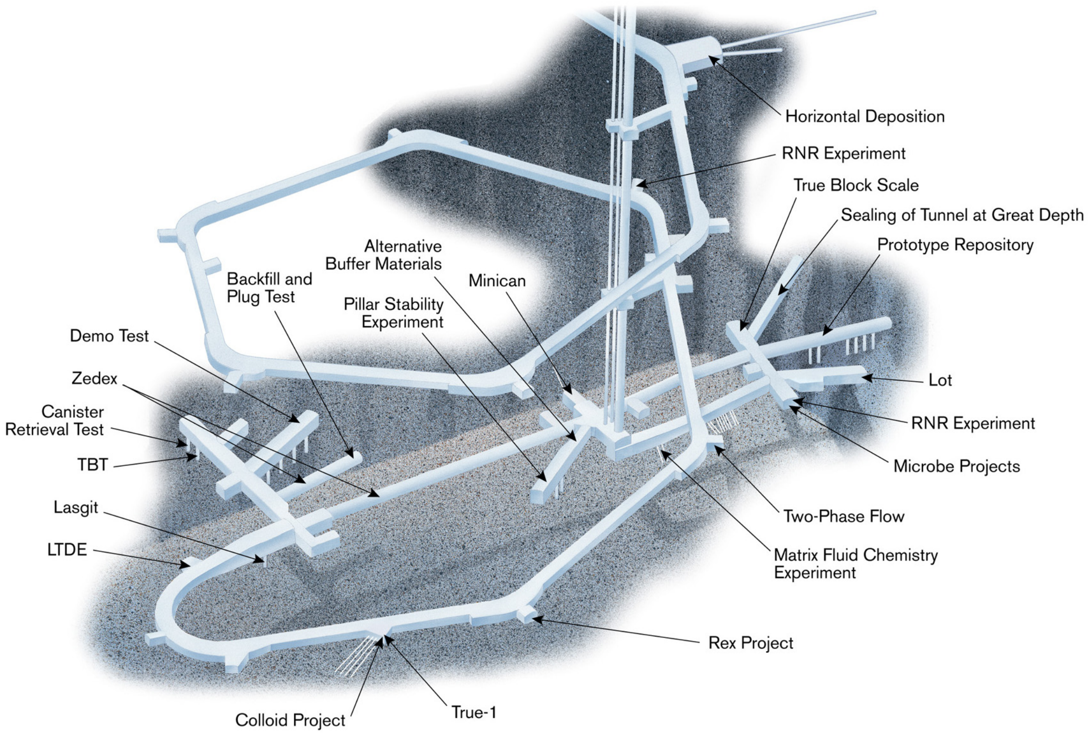


Figure 1-1. *Allocation of some of the experimental sites from the -220 m to -450 m level in Äspö HRL.*

2 Geoscience

2.1 General

Geoscientific research is a natural part of the activities at Äspö HRL and is conducted in the fields of geology, hydrogeology, geochemistry and rock mechanics. Studies are performed in laboratory and field experiments as well as by modelling work. The objectives are to:

- Establish and develop geoscientific models of the Äspö HRL rock mass and its properties.
- Establish and develop the knowledge of applicable measurement methods.

The main task within the geoscientific field is the development of an Äspö Site Descriptive Model (SDM) integrating the information from the fields of geology, hydrogeology, geochemistry and rock mechanics. The activities further aim to provide basic geoscientific data to the experiments and to ensure high quality of experiments and measurements related to geosciences. In Figure 2-1 the installation of test equipment for the experiment Counterforce Applied to Prevent Spalling (Caps) in the Tasq-tunnel is shown.

Figure 2-1. *Installation of test equipment in the first test within the Caps field experiment in the Tasq-tunnel.*

2.2 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 continuation of the Rock Characterisation System (Rocs) project is being conducted.

2.2.1 Geological Mapping and Modelling

Geological mapping of the floor in the Tass-tunnel

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 2008 have been:

- The excavation of the Tass-tunnel (the tunnel for sealing fractures at great depth) has continued. Geological mapping of the tunnel fronts up to section 56.8 m and walls, roof and floor up to section 48.67 m has been completed during the period July-September. Data and drawings have been fed into the TMS (Tunnel Mapping System). Since the last status report laser scanning combined with digital photography has been performed in the section 20.74 - 48.67 m. The laser data have been analysed and used for modelling work (see the Rocs project).

- The logging of the cores from the project “Counterforce Applied to Prevent Spalling” in the Tasq-tunnel is completed. All together 32 cores, about 5 m long each, have been logged with Boremap and the borehole image processing system (BIPS).

- The modelling work that commenced in 2005 concerning water bearing fractures at the -450 m level is finished. Adjustments in the report after being returned from the review are still ongoing.

- Some old mapping of tunnels and deposition holes still needs to be entered into the TMS.

- A study is ongoing on possible differences in the mapping procedure for a drilled and blasted tunnel and a TBM bored tunnel. In addition, differences in the results achieved from the performed geological mapping are investigated. A draft version of the report has been reviewed and adjustments are now ongoing.

2.2.2 Rocs – Method Development of a New Technique for Underground Surveying

Reference markers are put up on the tunnel wall before the laser scanning can begin.

A feasibility study concerning geological mapping techniques has been completed. This study was conducted as a SKB-Posiva joint-project. The purpose was to investigate if a new system for rock characterisation has to be adopted when constructing a final repository. The major reasons for the 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.

Based on the knowledge from the feasibility study SKB has commenced a new phase of the Rocs project. The project will concentrate on finding or constructing a new geological underground mapping system. Laser scanning in combination with digital photography will, at least at the time being, be a part of that system. The resulting mapping system shall operate in a colour 3D environment where the xyz-coordinates are known.

Achievements

The new project plan is in progress and project decisions document for Rocs have been completed and approved. The work with specification of requirements concerning various parts of the project is ongoing, for example requirements for the geological mapping and how to handle laser data.

The second laser scanning event combined with digital photography in the Tass-tunnel has been completed and the data delivered. Scanning and digital photography has now been performed in section 0-48.5 m of the tunnel. The scan data has been used to create 3D-models of the Tass-tunnel. The work concerning tests of software to handle the laser data continues.

2.3 Hydrogeology

The objectives of the hydrogeological work are to:

- Establish and develop applicable methods for measurement, testing and analysis for the understanding of the hydrogeological properties of the Äspö HRL rock mass.
- Ensure that experiments and measurements in the field of hydrogeology are performed with high quality.

The main tasks are firstly to initiate works for further development of quality control and quality assurance procedures in the field of hydrogeology and secondly to initiate an upgrade of the existing Äspö Site Descriptive Model. The main features are the inclusion of additional data collected from various experiments and the adoption of modelling procedures developed during the site investigations. The intention is to develop the model into a dynamic working tool suitable for predictions in support of the experiments in the laboratory as well as to test hydrogeological hypotheses. Another part of the work with the site description is the continued development of a more detailed model of hydraulic structures at the main experimental sites.

2.3.1 Hydro Monitoring Programme

The hydro monitoring programme is an important part of the hydrogeological research and a support to the experiments undertaken in Äspö HRL. 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. 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. To date the monitoring programme comprises a total of about 140 boreholes (about 40 surface boreholes and 100 tunnel boreholes). Many boreholes are equipped with inflatable packers, dividing the borehole into sections. Water seeping into the tunnel is diverted to trenches and further to 25 weirs where the flow is measured.

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

The data collected in HMS is transferred to SKB's site characterisation database, Sicada.

Achievements

During the third quarter, the hydrogeological monitoring system has been performing well and the monitoring points in the tunnels have been maintained. However, in the surface drilled boreholes a gradual deterioration of the equipment has taken place over the years, to the extent that presently most of the Äspö boreholes are only measured manually or discontinuously. An investigation of potential supporting and corrective measures for the surface boreholes is underway. The monitoring is reported quarterly through the quality control documents and annually by describing the measurement system and achieved results.

2.4 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.

The overall main task is development of the integrated Site Descriptive Model of the Äspö HRL. The use of the achieved knowledge will facilitate the understanding of the geochemical conditions at the site and the evolution of the conditions during operation of the facility. The intention is to develop the model as to be used for predictions, to support and plan experiments and to test hydrogeochemical hypotheses. In general hydrogeochemical support is provided to active and planned experiments at Äspö HRL. For example, during the last quarter support and planning for a minor groundwater sampling campaign has been provided. The aim with this campaign is to establish hydrogeochemical conditions due to tunnel excavation and sealing. Analysis has mainly focused on salinity, major components, nitrogen speciation, colloids and isotopes. Available results indicate a slightly increase in nitrogen compounds from one sampling point in the rock wall.

2.4.1 Monitoring of Groundwater Chemistry

Water sampling in a tunnel at Äspö HRL.

During the Äspö HRL construction phase, water samples were collected and analysed with the purpose of monitoring the groundwater chemistry and its evolution as the construction proceeded. The samples were obtained from boreholes drilled from the ground surface and from the tunnel. At the beginning of the Äspö HRL operational phase, sampling was replaced by a groundwater chemistry monitoring programme, with the aim to sufficiently cover the evolution of hydrochemical conditions with respect to time and space within the Äspö HRL.

The monitoring 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.

Achievements

The yearly monitoring campaign for groundwater chemistry was started as planned. Several boreholes, in the upper bedrock (-50 to -100 m), in the tunnel have been dried out and discarded from the sampling programme. Also KAS03 was discarded from being sampled due to problems with no groundwater pressure and failing packed-off sections. In the upper sections in KAS09, no sampling was possible as the groundwater level seems to have been lowered. Sampling for ATP (adenosine triphosphate) has been performed and will be sent for external analysis. The results from the monitoring campaign in May are still not completely reported.

Sampling was performed in conjunction with the Microbe project in June in KA3510A and earlier in April in KA3110A. The results have not been reported and the possible exists that samples were not sent for isotope content analysis of the gas phase. However, analyses of the isotope composition from previous sampling of gases in KA2862 show a $^{13}C/^{12}C$ ratio ($\delta^{13}C$-CO2) of -21.2 ‰ and a $^{18}O/^{16}O$ ratio ($\delta^{18}O$- CO_2) of 23.6 ‰. The results will be used to determine suitable sampling and analytical methods to be used in the future in the Äspö tunnel.

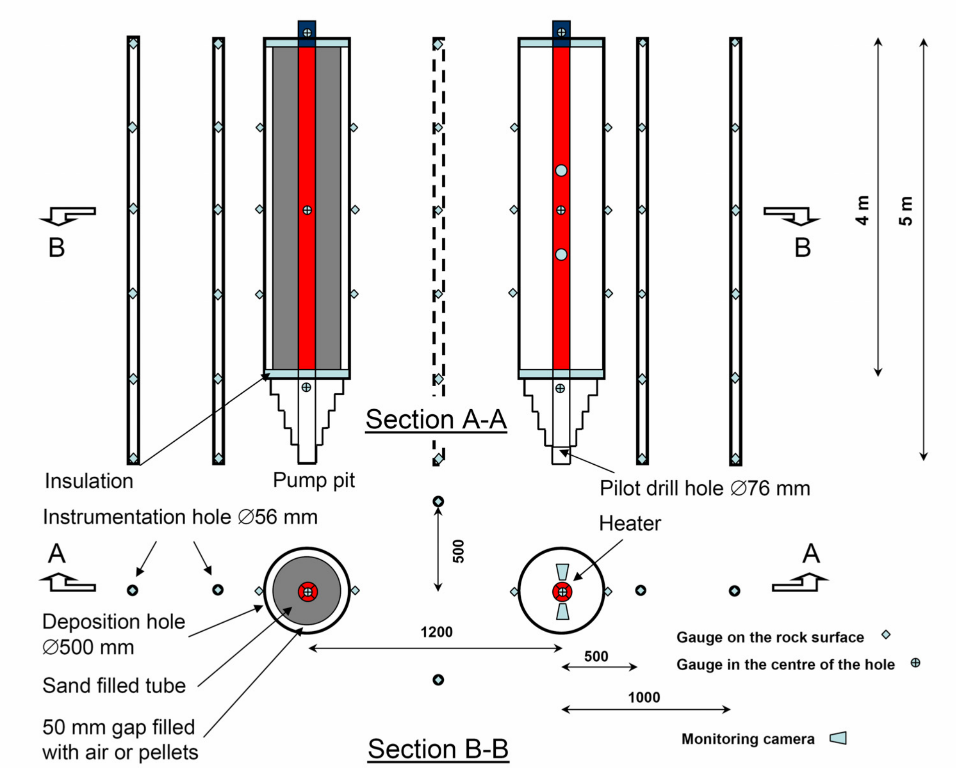
2.5 Rock Mechanics

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 mainly 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.

In addition, a project called Caps (Counterforce Applied to Prevent Spalling) comprising field tests in Äspö HRL and numerical modelling is ongoing.

2.5.1 Counterforce Applied to Prevent Spalling



Configuration of the test holes and the positioning of instruments in the experiments in the Tasq-tunnel.

The field experiment within the Caps has been initiated as a demonstration experiment to determine if the application of dry bentonite pellets is sufficient to suppress thermally-induced spalling in KBS-3 deposition holes. The experience gained from the Äspö Pillar Stability Experiment, conducted between 2002 and 2006, indicated that spalling could be controlled by the application of a small confining stress in the deposition holes.

The field tests, that include four pairs of heated half-scale KBS-3 holes, will be carried out as a series of demonstration experiments in the Tasq-tunnel at Äspö HRL.

Each test consists of two 0.5 m diameter boreholes of 4 m depth separated by a 0.7 m pillar, which are surrounded by a number of boreholes for installation of instruments. The first step in the testing sequence includes heating of one pair of open holes to ensure that spalling will occur and can be observed in the test holes. The next step includes heating and observation of spalling in separate pair of holes. The 50 mm gap created between an inner tube and the borehole wall is filled with a loosely placed pellets substitute. The final step is a complementary test that will be carried out to address questions that arise during the previous tests.

Achievements

The heating period in the first test in the Caps project was initiated on 29th August and terminated on 26th September. Compared to the original plans, the heating period was prolonged from two to four weeks, due to a larger heat loss and a slower temperature increase than expected in the test. The cause for the larger heat loss was mainly the system of circulating water that controlled the temperature of the observation cameras, which worked as a number of heat exchangers.

The first test showed large differences in the proportion of observed spalling between the heating holes. The observations seem to be a result of disturbance of the natural humidity of the holes. The heating and the system of compressed air to keep the camera lenses free from mist resulted in reduced humidity in the heating holes during the test. Most spalling was observed in the heating hole with highest relative humidity, i.e. less disturbance of the natural humidity. The drying-up of the boreholes probably has caused a slight apparent confinement of the borehole wall due to suction within the borehole boundary.

The heterogeneity in the spalling observed in the first pair of heating holes has resulted in a decision to perform the second test as a repetition of the first, however, with controlled humidity in the holes this time. The second test is schedule to start up in the end of October and will be accomplished with improved sealing of the holes, a system that makes it possible to moistening the holes, and without any observation cameras.

3 Natural barriers

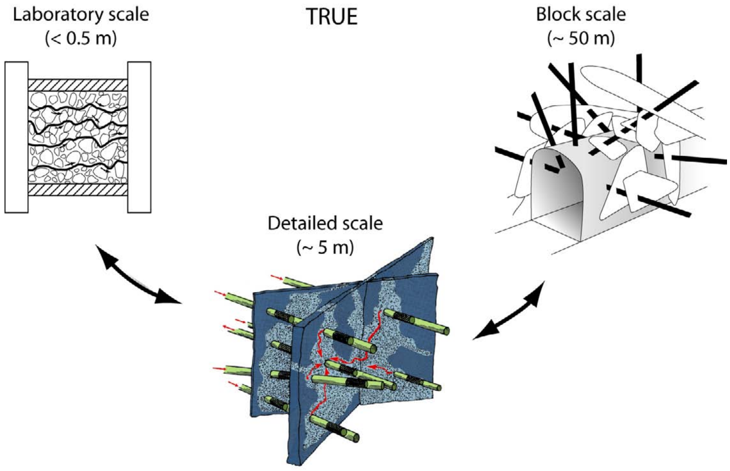
3.1 General

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.

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. The sampling of a fracture surface for microbial presence in a new-drilled rock core within the Microbe Project is shown in Figure 3-1.

Figure 3-1. *Sampling of a fracture surface for microbial presence by using DNA/RNA analysis methods within the Microbe Project.*

3.2 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) /Winberg et al. 2000/ performed in the detailed scale and the True Block Scale series of experiments /Winberg et al. 2003/ have come to their respective conclusion.

Complementary field work and modelling have been performed as part of two separate, but closely coordinated, continuation projects.

The True Block Scale Continuation (BS2) project aimed at obtaining additional understanding of the True Block Scale site /Andersson et al. 2007/. A further extension of the True Block Scale Continuation, (BS3), involves production of peer-reviewed scientific papers accounting for the overall True findings, and in particular those of BS1 and BS2.

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. Additional work includes complementary laboratory sorption investigations on fracture rim and fault gouge materials, plus a series of three scientific articles on the True-1 experiment.

3.2.1 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 in situ tracer tests with sorbing tracers and subsequent assessment of the relative retention in flow paths made up of fault rock zones and background fractures. 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) was 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

Final drafts of the first two of the three-part series of scientific papers accounting for the results from True Block Scale/True Block Scale Continuation have been completed and are currently being reviewed by the participants in the project group. Comments are expected by the end of October 2008 after which paper 1 and 2 will be completed and submitted to the scientific journal Water Resources Research.

The titles of the three-part series of papers are "Transport and retention from single to multiple fractures in crystalline rock at Äspö (Sweden)":

I Evaluation of tracer test results, effective properties and sensitivity.

II Fracture network flow simulations and global retention properties.

III A macro-scale retention model and impact of micro-scale heterogeneity.

3.2.2 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 included performance of the injection of epoxy resin in Feature A at the True-1 site and subsequent overcoring 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

No work has been performed within True-1 Continuation during the third quarter of 2008, with the exception of work performed within True-1 Completion, see below.

3.2.3 True-1 Completion

True-1 Completion is a sub-project of the True-1 Continuation project and is a complement to already performed and ongoing projects. The main activity within True-1 Completion was the injection of epoxy with subsequent overcoring of the fracture and following analyses of pore structure and, if possible, identification of sorption sites. Furthermore, several complementary in situ experiments were performed prior to the epoxy injection. These tests were aimed to secure important information from Feature A and the True-1 site before the destruction of the site.

Achievements

During the last quarter, the focus of the project was detailed planning and writing of the activity plan for the upcoming analysis of the cores from KXTT3 and KXTT4. The analysis itself will begin later during the fall. Project members are still heavily involved within SKB's site investigation programmes which limits the available time for work within True-1 Completion. The situation with limited personnel resources for the project seems to prevail to the beginning of next year.

3.3 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 is followed by analyses of tracer content.

Small diameter (24 mm) sample cores have been extracted from the 1.1 m long and 278 mm diameter large core retrieved from the over coring. 34 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.

Drilling of sample cores from matrix rock surrounding the test section in the small diameter extension borehole.

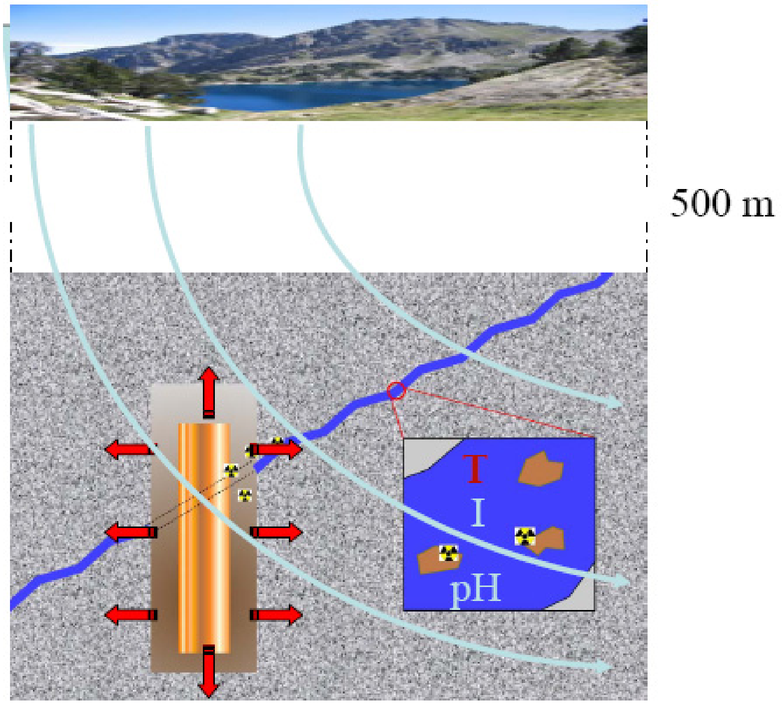
Achievements

Laboratory experiments with specimens from the core of the small diameter extension borehole, the replica core stub and the pilot borehole core are ongoing according to the experimental plan. The same tracer cocktail as for the in situ experiment, with tritiated water added, is used.

At the SKB Baslab laboratory at Äspö the γ-detector and belonging electronics have been changed. The installation of a more efficient detector has been performed to speed up the measurements and increase the reliability in operation.

Analysis of the non γ-emitting tracers (^{99}Tc, ^{102}Pd, ^{236}U, ^{237}Np, ^{35}S, ^{36}Cl and ^{63}Ni) in crushed samples from the sampled cores has started. Four sample cores extracted from fracture surface on the core stub and four from the matrix rock have been selected for the analysis. The tracer content will, after leaching and/or dissolution of the crushed material, be analysed by means of mass-spectrometry and liquid scintillation.

3.4 Colloid Transport Project



The Colloid Project is a continuation of the Colloid Dipole Project which was ended in the beginning of 2008 and final reporting is in progress. The overall goal for the Colloid Project is to answer the questions when colloid transport has to be taken into account in the safety assessment, and how the colloid transport can be modelled.

In the beginning of the lifetime of a deep repository, in bedrock with groundwater of high ionic strength, bentonite and natural colloids are not stable, and colloid transport can be neglected. Of special concern is bentonite erosion, since that could give loss of material leading to a decrease of the barrier function of the bentonite buffer.

In the scenario of intrusion of dilute glacial water the conditions for colloids stability drastically changes. The transport might be the limiting factor in this scenario and has to be taken into account.

In the case of a leaching canister, the bentonite colloids can possibly facilitate the transport of sorbed radionuclide towards the biosphere. In the project, also the transport of organic colloids and other natural colloids are studied and their effect on especially actinide mobility.

The ambition is further to include studies on the transport of colloids which are formed in the spent nuclear fuel.

Achievements

To determine geometry and structure of Ca- and Na-bentonite colloids in solution X-ray microspectroscopy analysis has been performed at PSI in Switzerland. Until now bentonite colloids have been measured with methods as scanning electron microscopy and transmission electron microscopy in which the colloids are either analysed in dry or frozen form. In these images the colloids reveal a heterogeneous and planar structure. These structures are not representative for colloids in solution. For colloid transport modelling it is of crucial importance to describe the geometry as close as possible to the "real" case. One manuscript is soon to be sent for publication and another is in progress.

Well characterised bore cores from Äspö is still under equilibration in glove boxes in nitrogen atmosphere and the actinide cocktails which are going to be injected with bentonite colloids are under preparation.

Studies of sorption characteristics of irradiated bentonite colloids, where the aim is to study if the sorption characteristics of the montmorillonite colloids change upon irradiation, are ongoing.

Modelling of bentonite colloids in a fracture in a granite block is ongoing. The retention can now be quantified and the ambition is to couple the retention to chemical and physical processes such as physical filtration and sedimentation. Mock-up tests of erosion/generation of Na- and Ca-montmorillonite have been performed with artificial Plexiglas fractures of 1 and 5 mm aperture. Milliporwater and Grimselwater have been used in these experiments. Different flows have been used and the different phases of the propagated gel has been analysed with X-ray diffraction for the mineral content. The mock-up tests are now summarised and will be presented in an article. The erosion/ generation test in the block will start after the final evolution of the mock-up tests.

Laboratory studies of colloid transport in filling material are initiated. The aim of these column experiments are to try to quantify physical filtration and sorption of colloids (even if very low) to fracture filling material in varying groundwater chemistry.

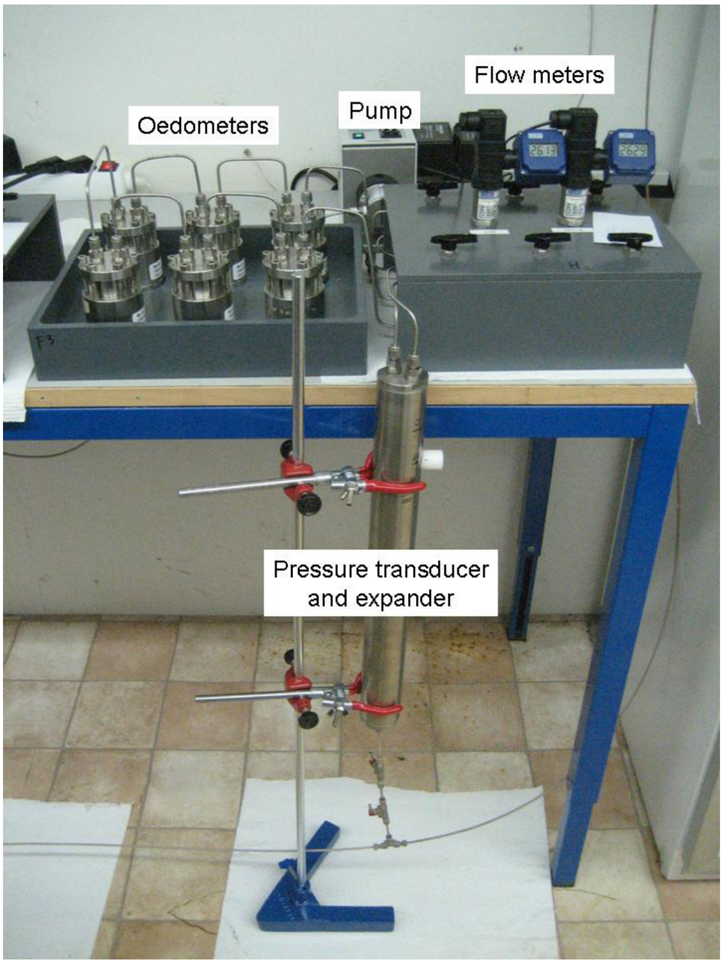
Modelling activities in the Colloid Formation and Migration (CFM) project in Grimsel is ongoing.

3.5 Microbe Projects

Microorganisms interact with their surroundings and in some cases they greatly modify the characteristics of their environment. Several such interactions may have a significant influence on the function of a repository for spent fuel /Pedersen 2002/. There are presently four specific microbial process areas identified that are of importance for proper repository functions and that are best studied at the Microbe Laboratory. They are: bio-mobilisation of radionuclides, bio-immobilisation of radionuclides, microbial effects on the chemical stability of deep groundwater environments and microbial corrosion of copper.

The study of microbial processes in the laboratory gives valuable contributions to our knowledge about microbial processes in repository environments. However, the concepts suggested by laboratory studies must be tested in a repository like environment. The reasons are several. Firstly, at repository depth, the hydrostatic pressure reaches close to 50 bars, a setting that is very difficult to reproduce in the laboratory. The high pressure will influence chemical equilibrium and the content of dissolved gases. Secondly, the geochemical environment of deep groundwater, on which microbial life depends and influence, is complex. Dissolved salts and trace elements, and particularly the redox chemistry and the carbonate system are characteristics that are very difficult to mimic in a university laboratory. Thirdly, natural ecosystems, such as those in deep groundwater, are composed of a large number of different species in various mixes /Pedersen 2001/. The university laboratory is best suited for pure cultures and therefore the effect from consortia of many participating species in natural ecosystems cannot easily be investigated there. The limitations of university laboratory investigations arrayed above have resulted in the construction and set-up of an underground laboratory in the Äspö HRL tunnel. The site is denoted the Microbe Laboratory and is situated at the -450 m level.

3.5.1 The Microbe Laboratory



Configuration of one of the three experimental units used to investigate bio-corrosion in compacted bentonite. The white knob on the pressure transducer indicates the position of the interior piston.

The Microbe Laboratory has been installed in the Äspö HRL for studies of microbial processes in groundwater under in situ conditions.

The Microbe site is on the -450 m level (image above) where a laboratory container with benches 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.

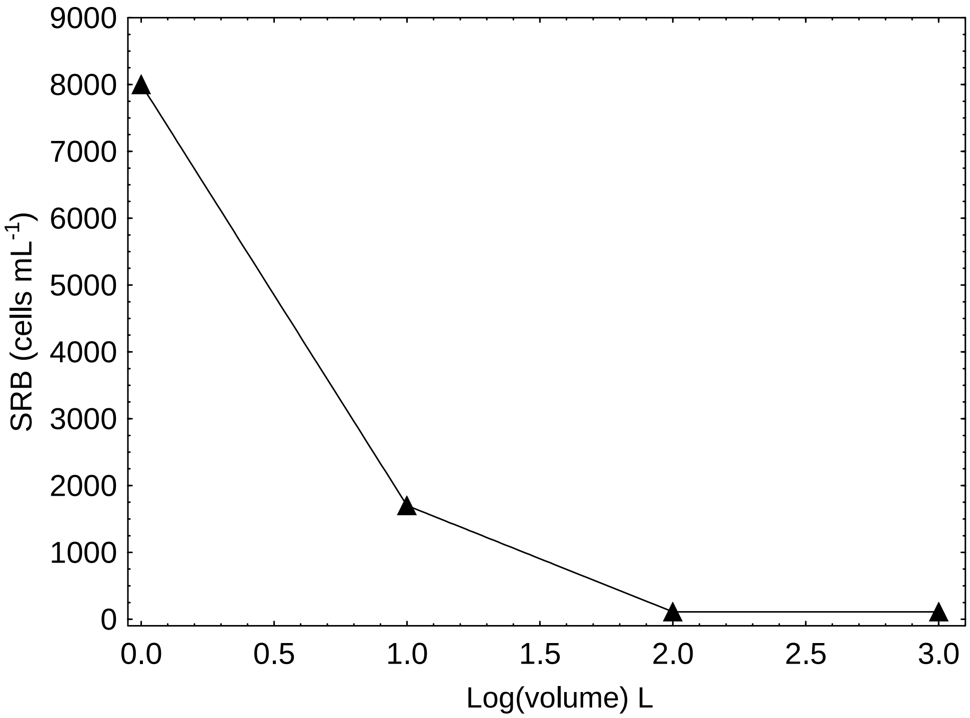
The major objectives are to:

- 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.

Achievements

There have been no activities in the Microbe laboratory during the third quarter of 2008.

3.5.2 Micored



The change in the number of cultivable sulphate reducing bacteria during drainage of a tunnel borehole denoted KA3110A.

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 and possibly also methane from deep geological processes contributes to the redox stability of deep groundwater via microbial turnover of this gas. These metabolisms will generate secondary metabolites such as ferrous iron, sulphide, acetate and complex organic carbon compounds.

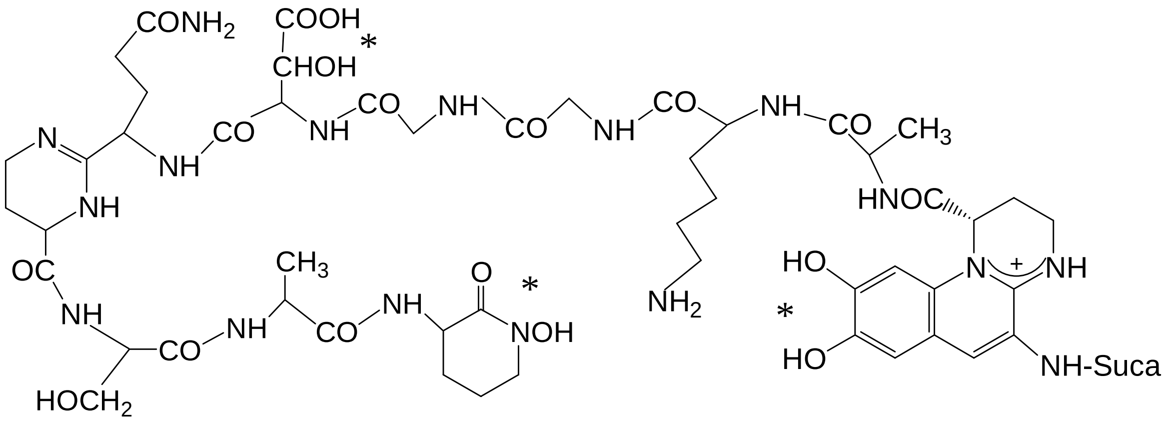
The work within the Micored project will:

- Clarify the contribution from microorganisms to stable and low redox potentials in 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

Observations of surface and tunnel boreholes have shown elevated concentrations of sulphide. Pilot investigations on the effect of drainage on a borehole have been performed. It was found that the number of sulphate reducing bacteria was strongly correlated inversely with the amount of water drained. This pilot experiment will be followed up with repeated drainage experiment. It is expected that the results will be helpful for understanding the reasons behind elevated sulphide concentrations in resting boreholes.

3.5.3 Micomig



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 biofilms may enhance or retard sorption, depending on the radionuclide in question.

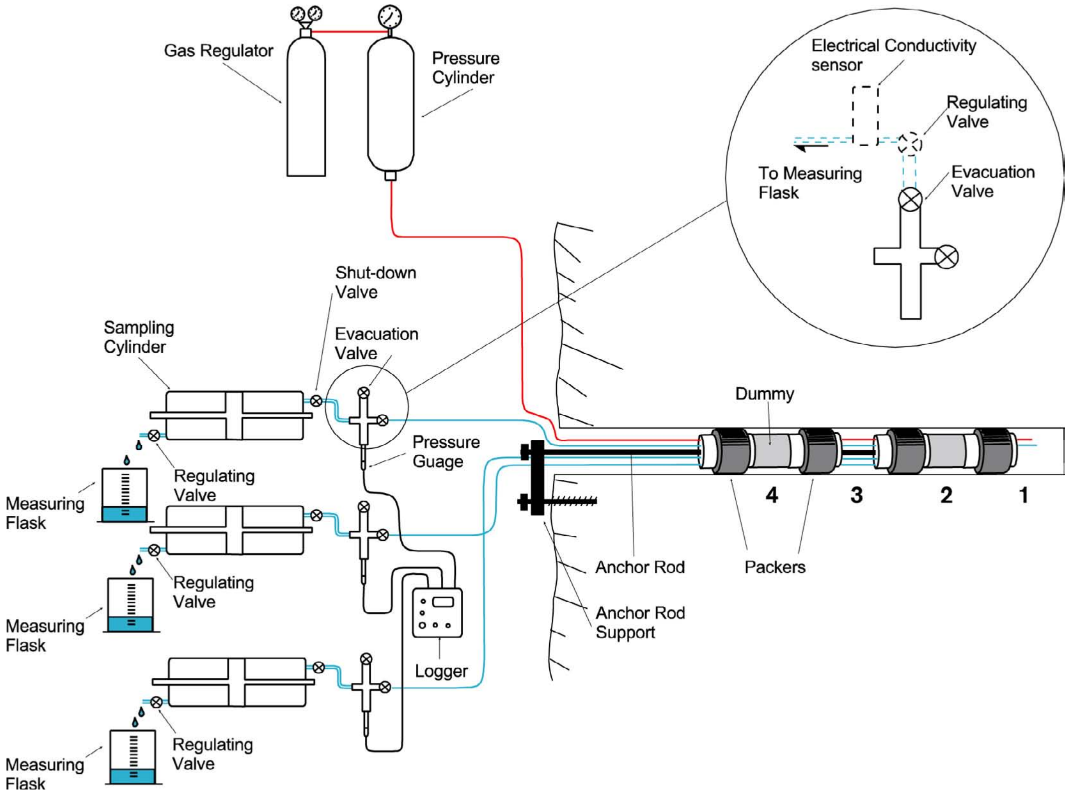
The work within Micomig will:

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

Achievements

Ten boreholes along the Äspö HRL tunnel were sampled for analysis for the most probable number of nitrate reducing bacteria in April 2008. The boreholes were: KR0012B, KR0015B, KA1061A, SA1328A, KA2162B, KA2198A, KA3110A, KA3510A, KJ0052F01 and KJ0052F03. A set of fractures that deliver groundwater to the tunnel were sampled for biofilms in June. Dominating species have been isolated, sub-cultured and identified with DNA technology. The results were used to select a fracture to be over-cored by 300 mm core drilling in October, see Figure 3-1. The dominating species ability to produce siderophores are presently scanned. This will give an overview of the distribution of microorganisms that produce complexing agents in the Äspö groundwater.

3.6 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

There have been no major achievements in the project during the third quarter of 2008. Final reporting of the matrix borehole hydraulic studies is presently ongoing.

3.7 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 for instance bentonite samples and on tiny rock fractures in drill cores.

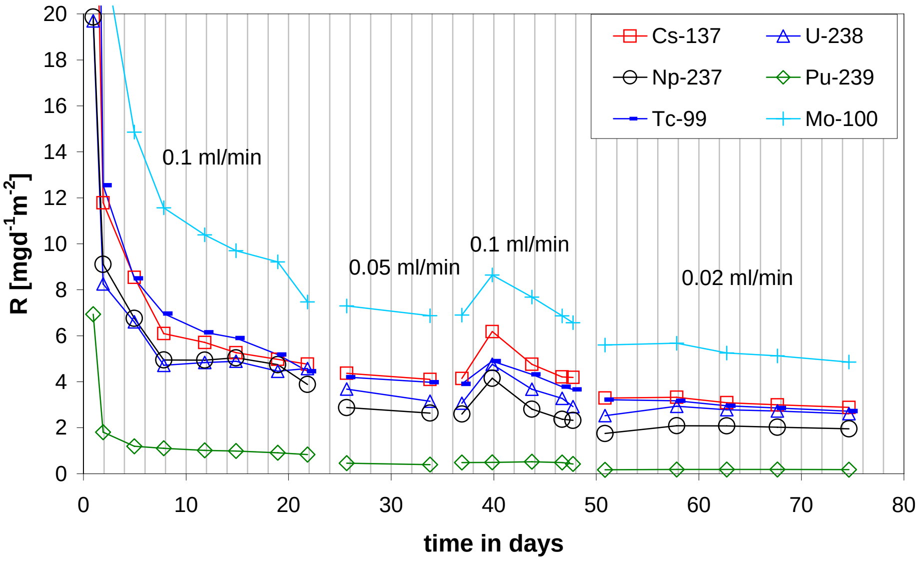
Experiments in Chemlab 1:

- 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).

Experiments in Chemlab 2:

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

3.7.1 Spent Fuel Leaching



Dissolution rates based on different monitors. The spent fuel was leached with 10 mM $NaHCO_3$ under oxidising conditions. Constant dissolution rates could be achieved after some days.

In the Spent Fuel Leaching experiments, to be performed within the framework of the programme for in situ studies of repository processes, the dissolution of spent fuel in groundwater relevant for repository conditions will be studied. The objectives of the experiments are to:

- Investigate the leaching of spent fuel in laboratory batch experiments and under in situ conditions.
- Demonstrate that the laboratory data are reliable and correct for the conditions prevailing in the rock.

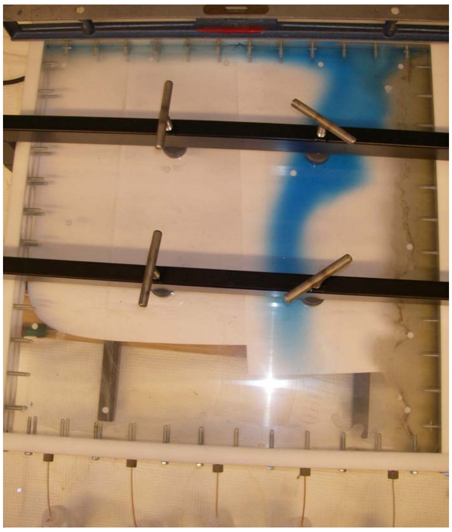
The in situ experiments will be preceded by laboratory experiments where the scope is both to examine parameters that may influence the leaching as well as testing the equipment to be used in the field experiments.

In the field experiments spent fuel leaching will be examined with the presence of H_2 (in a glove box situated in the gallery) as well as without the presence of H_2 (in Chemlab 2).

Achievements

There have been no activities in the project during 2008. However, the experimental set-ups are designed and the laboratory experiments will be performed at Nuclear Chemistry at Chalmers University of Technology with groundwater from Äspö HRL.

3.7.2 Transport Resistance at the Buffer-Rock Interface



The equipment intended for the laboratory experiments. The equipment is currently used in another SKB project, Bentonite Erosion.

If a canister fails and radionuclides are released, they will diffuse through the bentonite buffer. If there is a fracture intersecting the deposition hole, the water flowing in the fracture will pick up radionuclides from the bentonite buffer.

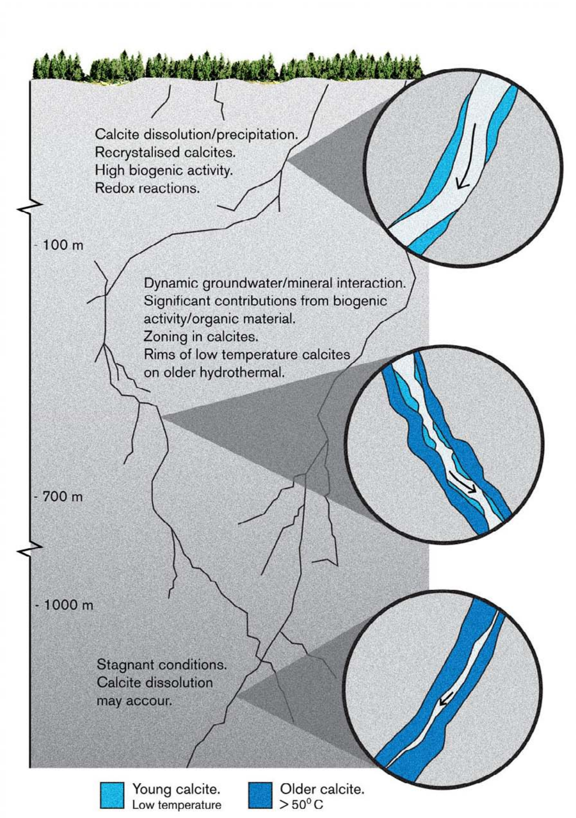
The transport resistance is concentrated to the interface between the bentonite buffer and the rock fracture. The mass transfer resistance due to diffusion resistance in the buffer is estimated to only 6% and the diffusion resistance in the small cross section area of the fracture in the rock to 94% /Neretnieks 1982/. The aim of the Transport Resistance at Buffer-Rock Interface project is to perform studies to verify the magnitude of this resistance.

The experiment will be performed in the laboratory, where a fracture is simulated as a 1 mm space between two Plexiglas plates. The equipment includes a water pump for very low flow rates. The design of field experiments depends on the outcome of the laboratory experiments.

Achievements

There have been no activities in the project during 2008 since the resources needed for this project are currently used in another SKB project. However, a project plan exists and a project decision has been taken.

3.8 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 EC-part of the project was finalised and reported in 2005. The Padamot continuation project comprises:

- Further developments of analytical techniques for uranium series analyses applied on fracture mineral samples.
- The use of these analyses for determination of the redox conditions during glacial and postglacial time.
- A summary of the experiences from the palaeohydrogeological studies carried out at Äspö.

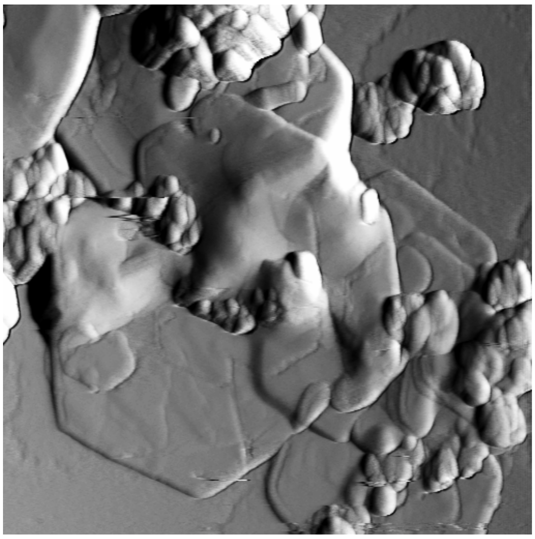
The analyses are carried out on split samples of fracture material from a surface borehole drilled at Äspö (KAS17). This borehole penetrates the large E-W fracture zone called the Mederhult zone.

Achievements

Bulk analyses of uranium decay series isotopes of fracture coating samples from borehole KAS17 have been carried out showing changes from mainly uranium mobilisation in the upper 20 m depth, switching to uranium deposition at larger depth. As a complement to these bulk analyses sequential extraction has been applied to four samples. The analyses have been carried out at the University of Helsinki. The analyses carried out confirms the results of the bulk analyses and add also more details in that the isotope ratios of the most mobile phase can be determined separately.

Ongoing analyses at SUERC in Glasgow will follow the same analytical scheme. However, due to illness during the third quarter no results are available for the interlaboratory comparison.

3.9 Fe-oxides in Fractures



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

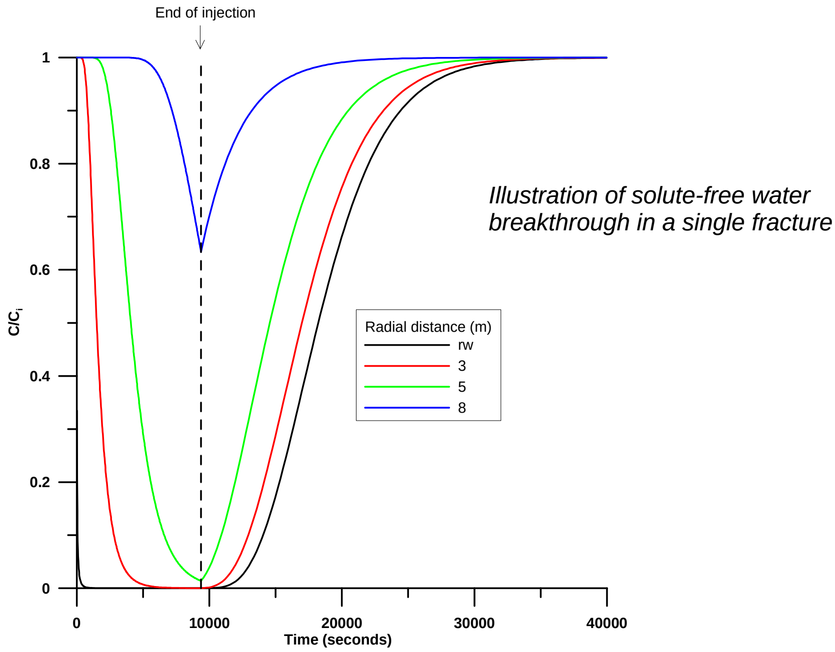
Proof of reducing conditions at repository depth is fundamental for the safety assessment of radioactive waste disposals. Fe(II) – minerals are common in the bedrock and along fracture pathways and constitute a considerable reducing capacity together with organic processes. Another area of interest is 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

Preliminary results suggest that iron oxides have formed at low-temperature down to 50 m below surface and possibly even down to a depth of approximately 90 m. Unfortunately, the lower boundary for the passage of oxidised water is constrained by having only two hydrothermal samples. To resolve this situation, additional three samples from the longer drill core KLX09A have been made available to look for Fe-oxides at greater depth. However, during the third quarter of 2008 there have been no major achievements in the project. Final reporting of the project Fe-oxide in fractures is presently ongoing.

3.10 Swiw-tests 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 experiments as well as Swiw tests performed within the SKB site investigation programme.

The general objective of the Swiw test with synthetic groundwater is to increase the understanding of the dominating retention processes and to obtain new information on fracture aperture and diffusion. The basic idea is to perform Swiw tests with synthetic groundwater with a somewhat altered composition, e.g. replacement of chloride, sodium and calcium with nitrate, lithium and magnesium, compared to the natural groundwater at the site.

Sorbing as well as non-sorbing tracers may be added during the injection phase of the tests. In the withdrawal phase of the tests the contents of the "natural" tracers (chloride sodium and calcium) as well as the added tracers in the pumping water is monitored. The combination of tracers, both added and natural, may then provide desired information on diffusion, for example if the diffusion in the rock matrix or in the stagnant zones dominates.

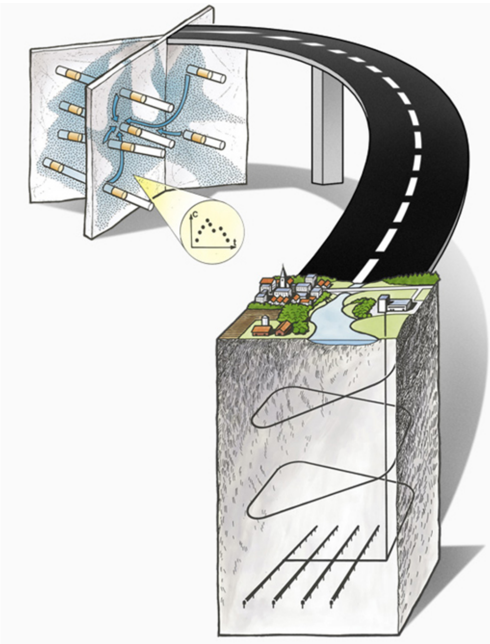
Achievements

The most important activity within the project during the last quarter was a meeting held on the 29th of August. The meeting began with a summary of the feasibility study and after some minor changes the report will now be sent for printing.

A critical issue for the project discussed at the meeting is the site selection for the field tests. Three general candidates are identified; True Block Scale, other test site in the tunnel and test site at the surface. Several of the desirable characteristics of the site for this project are common with the projects Oxygen consumption and redox changes in a fracture zone and Multiple well and Swiw test. Hence, desires and demands from the two oxygen projects as well as coordination benefits should be considered in the site selection process.

It was decided at the meeting that a project decision and project plan should be produced during the fall. The main activities in the project plan will be: site selection, investigations of the selected site, Swiw pre tests, Swiw main tests and finally evaluation and reporting. The majority of the activities will take place during 2009.

3.11 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 Task Force constitutes an important part of the international co-operation within the Äspö HRL.

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, during the third quarter of 2008. The status of the specific modelling tasks is given in Table 3-1.

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 sub-task reports from the modelling groups have been printed. A summary of the outcome of Task 6 has been accepted for publishing in a scientific journal. In addition, papers from four modelling groups have also been accepted by the same scientific journal and in conjunction with the summary paper. An essay describing the framework for all these papers is also accepted. Editorial modifications remain to be done for all papers before they can be published.

Task 7 addresses modelling of the OL-KR24 long-term pumping test at Olkiluoto. At the 23rd Task Force meeting, a modification of the task title was suggested as "Reduction of Performance Assessment uncertainty through modelling of hydraulic tests at Olkiluoto, 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.

Task 7 is divided into several sub-tasks. An updated task description for the sub-task 7B and more data have been sent out to the modellers.

The 24th international Task Force meeting was held at Äspö in September. The presentations were mainly addressing modelling results on sub-task 7B. The discussions on the continuation of Task 7 and also the start up of Task 8 were constructive. Task 8 will be a joint effort with the Task Force on Engineered Barriers, and will be addressing the processes at the interface between the rock and the bentonite in deposition holes. Work is ongoing for the minutes of this venue.

A workshop for Task 7 was held in May in Oxford where modelling approaches and plans for the future modelling were presented and discussed. Work is ongoing for the minutes of this venue.

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 /Hodgkinson and Black 2005/.
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 /Hodgkinson and Black 2005/.
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 /Black and Hodgkinson 2005/.
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. - External review report /Hodgkinson 2007/.
6E	This sub-task extends the sub-task 6D transport calculations to a reference set of PA time scales and boundary conditions. - External review report /Hodgkinson 2007/.
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. - External review report /Hodgkinson 2007/.
7	**Long-term pumping experiment.**
7A	Long-term pumping experiment. (Final results of sub-task 7A1 and A2 are presented. Draft reports in review).
7A1	Hydrostructural model implementation.
7A2	Pathway simulation within fracture zones.
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	Sub-task 7B is addressing the same as sub-task 7A but in a smaller scale, i.e. rock block scale. Sub-task 7B is using sub-task 7A as boundary condition. (Ongoing).
7C	Here focus is on deposition hole scale issues, resolving geomechanics, buffers, and hydraulic views of fractures. (Tentative)
7D	Tentatively sub-task 7D concerns integration on all scales.

4 Engineered barriers

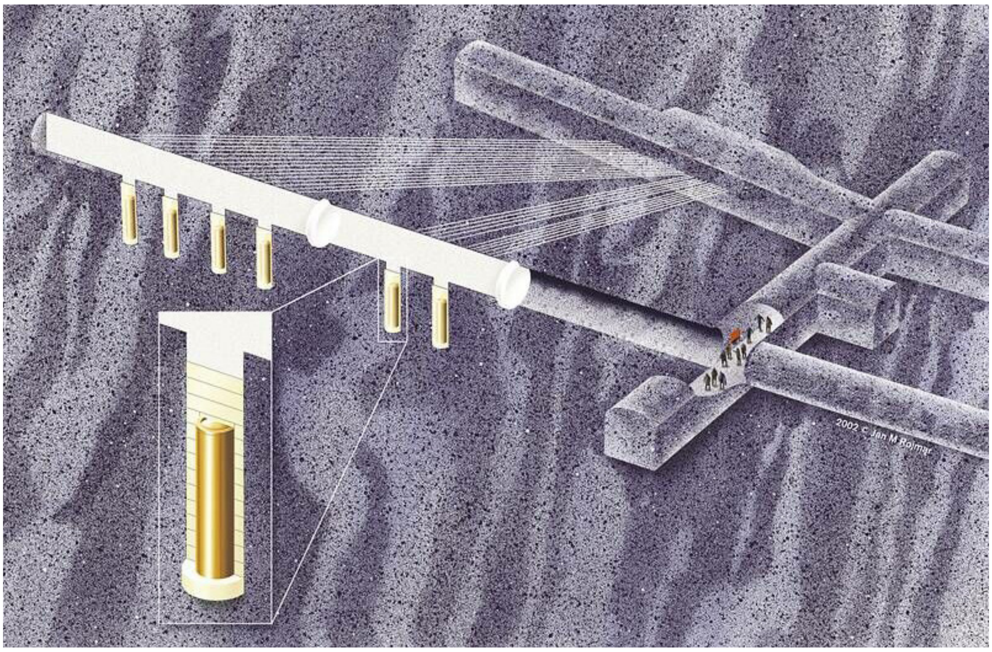
4.1 General

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 (***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. *Inflow measurement in a weir in the Tass-tunnel for the project Sealing of Tunnel at Great Depth.*

4.2 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, canisters #1 - #4) 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, canisters #5 - #6) was backfilled in June 2003 and the tunnel plug with two lead-troughs was cast in September the same year.

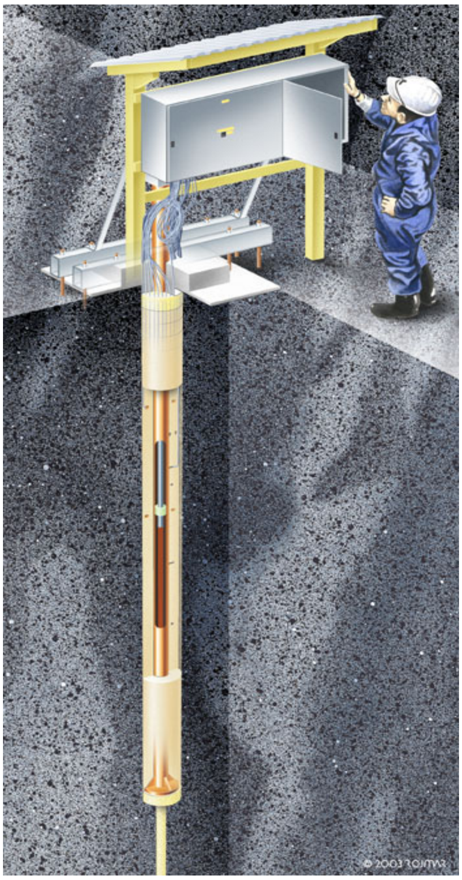
Achievements

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. 18 covering the period up to 1st December 2007 has been published /Goudarzi and Johannesson 2008/. Overhauling of the data acquisition system is in progress and hydraulic tests of the rock mass have been performed.

A programme for sampling and analyses of gases and microorganisms in the backfill and buffer has been finalised and reported /Eriksson 2007/. The measurements will continue during 2009. Acoustic emission and ultrasonic monitoring from the rock around deposition hole 5 and 6 is continuing. A report covering the measuring period 1st April 2007 to 30th September 2007 has been finalised and will soon be published.

Studies using a thermal FEM model for the Prototype Repository including the rock, backfill, buffer and the six canisters has been reported /Kristensson and Hökmark 2007/. The 1 D THM modelling of the buffer in deposition hole 1 and 3 will soon be published and a report concerning a 3D TM model of the entire experiment is in progress. In this report the possibility of spalling and the stress state on a thought fracture plan is studied. Furthermore, 2D TH modelling of an entire deposition hole is in progress and will be reported during 2008.

4.3 Long Term Test of Buffer Material



The project 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 other processes in bentonite such as cation diffusion, microbiology, copper corrosion and gas transport under conditions similar to those expected in a deep repository.

Achievements

During the third quarter of 2008, data from the three ongoing test parcels have been collected and controlled. The report on laboratory experiments and analyses of the A2 parcel is finalised and is now being reviewed. The article "*Ion equilibrium between montmorillonite interlayer space and an external solution - consequences for diffusional transport*" concerning basic principles of diffusive transport in bentonite has been finalised and accepted for publication by the journal "Geochimica et Cosmochimica Acta".

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	140	T, [K^+], pH, am	finalised	Report on review
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, T = temperature, [K^+] = potassium concentration, pH = high pH from cement, am = accessory minerals added

4.4 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. The aim is to further investigate the properties of the alternatives to the SKB reference bentonite (MX-80). The project is carried out using material that according to laboratory studies are conceivable buffer materials. The experiment is carried out in the same way and scale as the Long Term Test of Buffer Material (Lot).

The objectives are to:

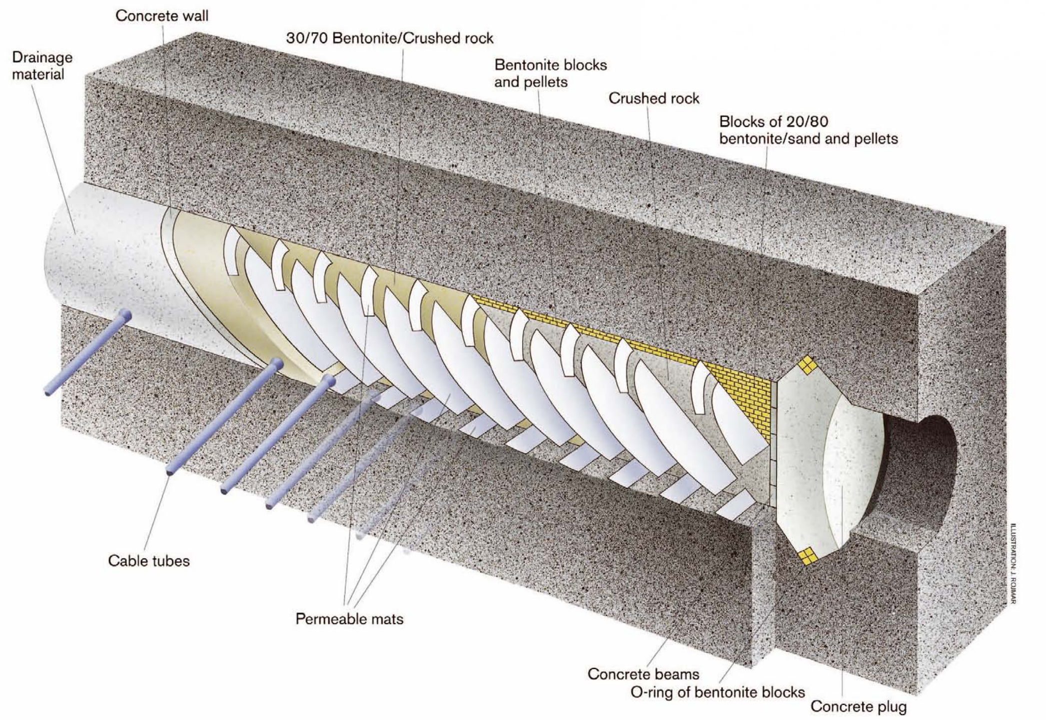
- Verify results from laboratory studies during more realistic conditions with respect to temperature, scale and geochemical circumstances.
- Discover possible problems with manufacturing and storage of bentonite blocks.
- Give further data for verification of thermo-hydro-mechanical (THM) and geochemical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

The field tests started during 2006. 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

A report describing the experimental set-up and the installation of three packages is available /Eng et al. 2007/. In two of the packages the heating was started directly and the goal temperature 130 °C was reached in the end of 2007. During the third quarter, the saturation of package number two was completed and the heating has started.

4.5 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.

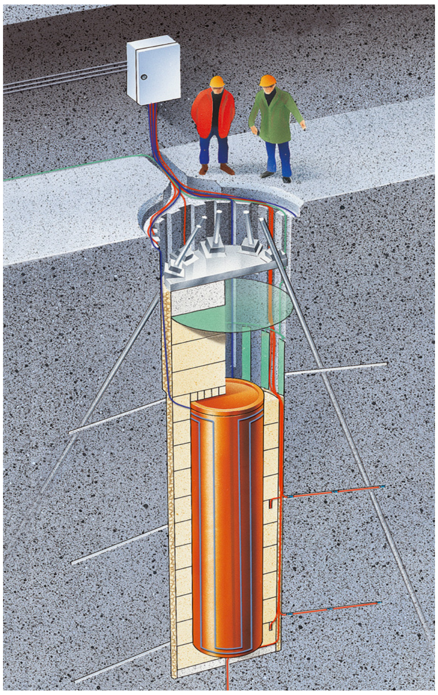
From the end of 2006 until the end of 2007 the compressibility of the backfill was tested by the four pressure cylinders mounted in the roof and the floor.

Achievements

The main work during the third quarter has included continuous measurements and registrations of water pressure and total pressure in the backfill and water pressure in the surrounding rock as well as leakage of water through the plug. The data report covering the period up to 1st January 2007 is available /Goudarzi et al. 2008a/.

Measurement of local hydraulic conductivity in the zone with crushed rock through installed equipments, so called CT-tubes, is ongoing.

4.6 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 in 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 laboratory work concerning the buffer analyses, that were planned up to this point, has progressed at Clay Technology and is close to be finalised. The analyses made concern mechanical strength, swelling pressure/hydraulic conductivity and chemical/mineralogical investigations. The next step is to analyse the obtained data and to continue with reporting of the findings.

In the Task Force on Engineered Barrier Systems, the Canister Retrieval Test was selected to be one of the full scale assignments. At the last meeting (26^{th}-27^{th} May 2008), several teams presented their first results. The modelling by the EBS-Task Force teams has progressed during the present period and will be presented at the next meeting (12^{th}-13^{th} November 2008).

4.7 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 engineered barrier systems, 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 shield (upper section).

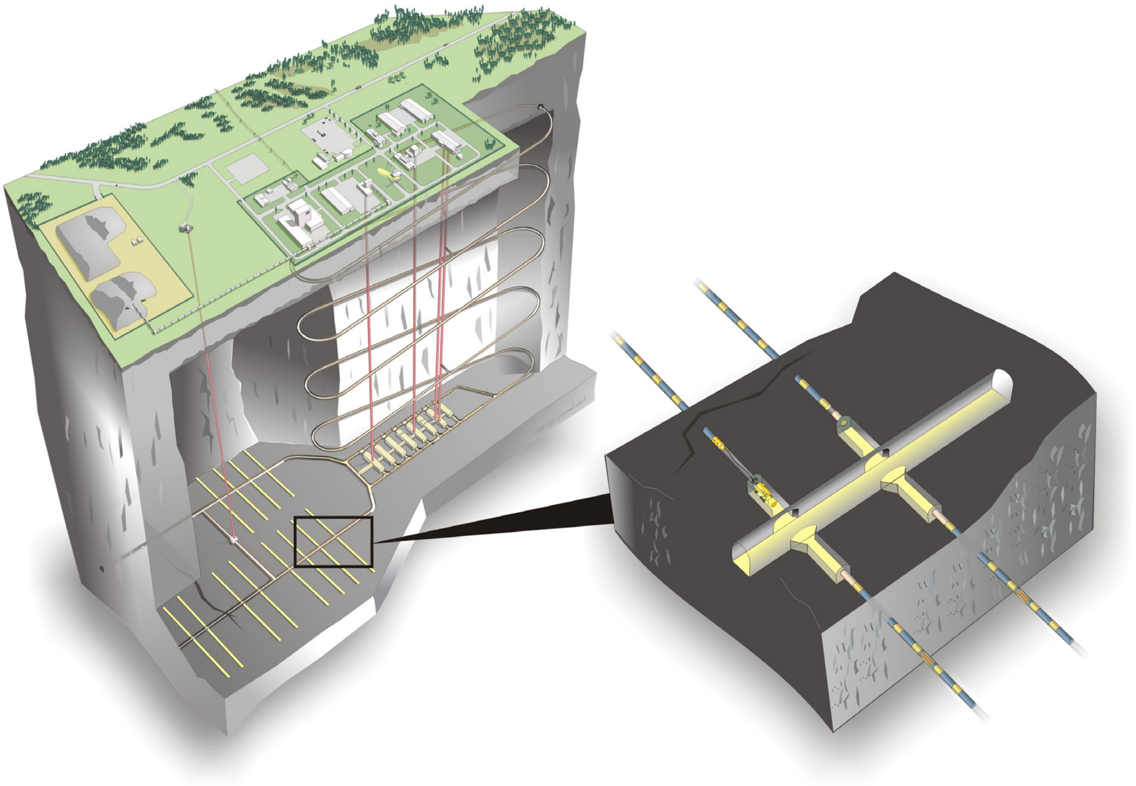
An artificial water pressure is applied in a slot between the buffer and rock, which is filled with sand and functions as a filter.

Achievements

The TBT-test is in the operation and data acquisition phase since March 2003. Data acquisition is continuously ongoing 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 2008 and the sensor data report covering the period up to 1st January 2008 is published /Goudarzi et al. 2008b/. This report also includes a complete description of the hydration of the sand shield around the upper heater, which was completed in the beginning of April 2008.

The test has exhibited some interesting data during August and September 2008. The pressures, as recorded by the two innermost pressure sensors in Ring 3 around the lower heater, have decreased significantly. The total pressure (PB204) decreased from approximately 7 to 4 MPa and the pore pressure (UB201) from approximately 1 to 0.3 bar. The continued evolution of these pressures may reveal if this is a temporary trend or a real change, possibly associated with the high temperatures presently prevailing around the lower heater.

4.8 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.

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 different drift components.

The project is a joint project between SKB and Posiva. Now the next phase of the project “Complementary studies of horizontal emplacement KBS-3H”is ongoing. The main goal of the complementary studies (2008-2010) is to develop KBS-3H solution to such a state that the decision on full-scale testing and demonstration can be made.

Achievements

During the third quarter the Megapacker report has been reviewed. The report will be completed during the fourth quarter of 2008. The results from the grouting tests are very good with a high sealing factor of the water bearing fracture zones.

Work with the compartment plug test has continued. Some delays in the manufacturing process have pushed the delivery until December 2008. A second notch to house the compartment plug has been excavated. The method by sawing the notch was successful also the second time. During the excavation many of the enhancements recommended after the first notch excavation was implemented.

In the Bentonite Laboratory, the last of the three planned pipe removal tests, to verify the ability to remove the saturation pipes for the DAWE design, was finished in the end of the third quarter. The results will be analysed and presented to the project during the fourth quarter.

Tests with the deposition equipment have been performed during the third quarter and the tests will continue. Some problems related to the new stiffer water cushions and also with the communication inside the equipment have occurred.

4.9 Large Scale Gas Injection

Large-scale gas injection test (Lasgit) 420 m below ground at Äspö HRL. A scientist from the British Geological Survey (BGS) works next to the large steel lid anchored over the deposition hole.

Current knowledge pertaining to the movement of gas in a compacted bentonite buffer 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 gas phases of the test history are key 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-3V design concept.
- Examine issues relating to up-scaling and its effect on gas migration 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. During 2007 preliminary hydraulic and gas transport tests were performed. These will be repeated as the buffer matures in order to examine the temporal evolution of these properties. When the buffer is fully-saturated a comprehensive series of gas injection tests will be undertaken to examine the mechanisms governing gas flow in KBS-3 bentonite.

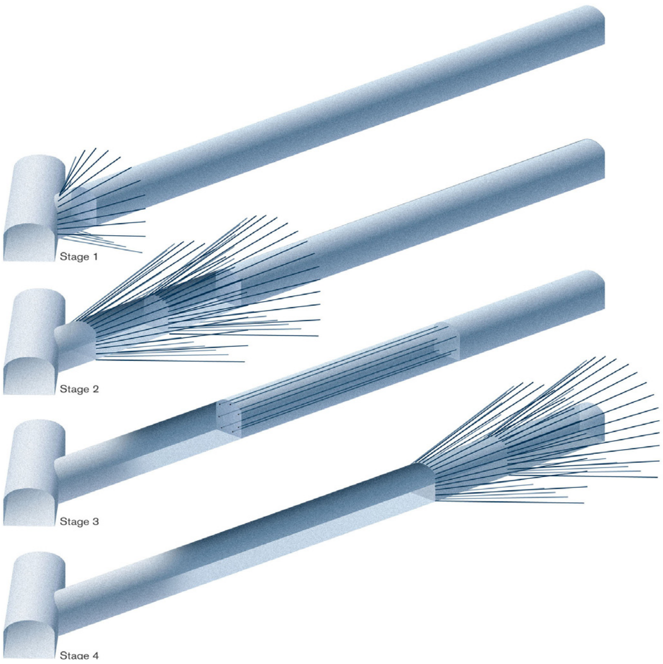
Achievements

During April it was noted that the movement of the metal lid anchored above the deposition hole accelerated. Quality control of all of the data was undertaken to ensure that the movements were not the result of mechanical failure of the rock anchors.

In August Lasgit underwent routine recalibration. Shortly after this time failure of the air compressor led to closure of all servo-assisted valves. This in term resulted in an unexpected opportunity to simultaneously measure the hydraulic properties of the clay in all 12 canister filters as water pressures in the system decayed. Following re-calibration of the test system in August 2008, two additional displacement sensors were added to the canister lid in order to measure lateral movements.

The artificial hydration of the buffer will continue and no new gas injection tests will be performed during the year.

4.10 Sealing of Tunnel at Great Depth



The grouting work will be carried out in stages

Although the repository facility will be located in rock mass of good quality with mostly relatively low fracturing, control of the groundwater will be necessary. The measures to control groundwater will include the sealing of fractures that are conducting groundwater, and may also include local draining or waterproofing as well as infiltration of water. Sealing will be achieved by means of grouting, which means filling the water-conducting fractures with grout so that the permeability of the rock mass close to the tunnel or rock cavern is reduced.

Experience from the grouting of road- and railroad tunnels shows that ordinary grouts based on cement cannot penetrate very fine fractures. Further, from a long-term safety view-point, a sealing agent that produces a leachate with a pH below 11 is preferred. Silica sol, which consists of nano-sized particles of silica in water, has shown to be a promising grout. When a salt is added to the sol, a gel is formed. The concentration of the salt determines the gelling time and thus the grouting can be controlled. However, the use of silica sol under high water pressures has to be tested and equipment and grouting designs evaluated.

The main goals of the project are to confirm that silica sol is a useful grout at the water pressures prevailing at repository level, and to confirm that it is possible to seal to the preliminary tightness requirement for a deposition tunnel at this water pressure.

To achieve this, the construction was started of an approximately 100 m long tunnel at the Äspö HRL. Execution is step-wise and is planned to include grouting with grout holes inside the contour, tests with post-grouting and tests of the sealing of drips. Low-pH cementitious grout is also tested. The project implements and evaluates grouting characterisation methods and grout spread models as developed by KTH and Chalmers.

Another issue for the planned repository is the contour and status of the remaining rock after blasting. The rock is a natural barrier in the KBS-3-system and further the repository includes a backfill with a defined density in the rock openings. Thus the requirement is to minimise the Excavation Damage Zone (EDZ), and the resulting contour after blasting should follow the theoretical with very small deviations, to allow for efficient and controlled backfilling. Special attention is therefore given to drilling and blasting. The results are followed and evaluated closely and subsequent adjustments made. The project also includes the careful sawing and extraction of 0.5 m deep rock blocks from the tunnel wall along a 10 m long stretch, in order to be able examine the EDZ.

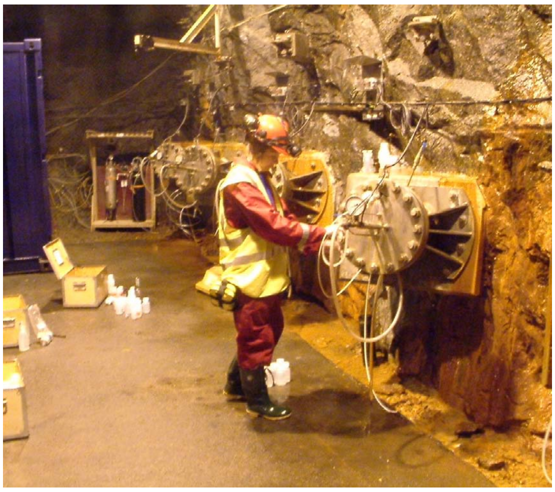
Achievements

The tunnelling front is now at section 64 m. The tunnel includes two grouting fans outside the contour (fan 2 and 3) and two fans (fan 4 and 5) inside the contour. During the summer, the rock blocks for examination of EDZ were sawn out and transported to the surface. The position of the blocks was along fan 4. The examination and evaluation of the blocks is part of another project.

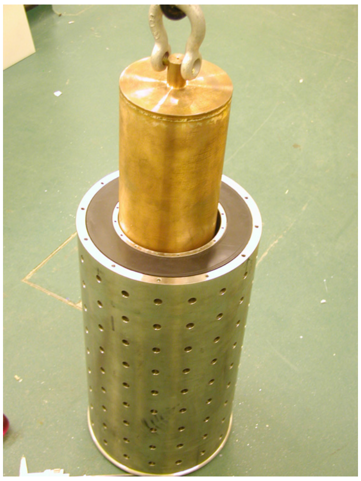
Careful cleaning and mapping of the tunnel floor along fan 2 and 3 was also carried out during the summer. After sealing a leaking grouting hole in the tunnel floor, the inflow to the 24 m long section was reduced to 0.3 litres/minute. The inflow, directly measured in a weir (a dam across the tunnel floor), corresponds to 0.8 litres/minute and 60 m, see ***Figure 4-1***. During grouting the reduction in inflow between the successive grouting rounds was followed by inflow measurements in the control holes. A reduction of the transmissivity of the rock mass with a factor 1,000 was indicated. Thus one of the major project goals is fulfilled: to show that it is possible to reduce the inflow to 1.0 litre/minute and 60 m, using fans within the contour.

Fan 4, where the sawing was carried out will be isolated by weirs. Next, another fan within the contour (fan 6) will be carried out in order to get two undisturbed fans (fans 5 and 6) within the contour, for evaluation of inflow. Reporting that covers the grouting and excavation results up to 30th of September is in progress.

4.11 In Situ Corrosion Testing of Miniature Canisters



Operation of the five miniature canisters



Miniature canister with support cage

This 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. All five canisters were installed in the beginning of 2007.

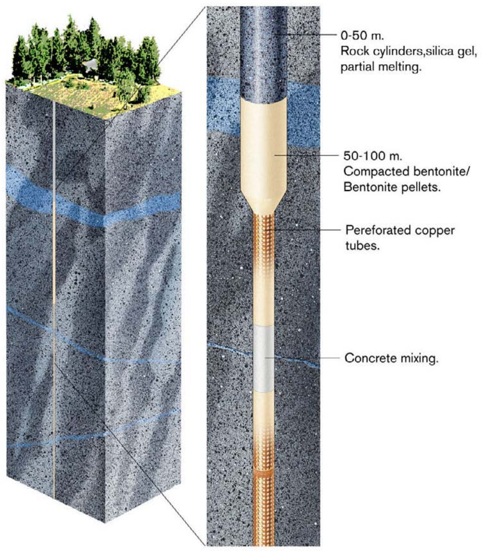
The canisters are mounted in support cages, four of which contain bentonite (three low density bentonite, one compact bentonite), and are exposed to natural reducing groundwater. Together with corrosion test coupons which are also in the boreholes, the canisters will be monitored for several years. The corrosion will take place under realistic oxygen-free conditions that are very difficult to reproduce and maintain for long periods of time in the laboratory.

Achievements

During the third quarter, monitoring of the miniature canister experiments has continued. Data are being collected for corrosion rate of copper and iron electrodes, and electrochemical potentials for a range of electrodes, including Eh, iron and copper. In addition, strain gauge data are being collected for two of the canisters.

Water analysis, including analysis of gases and microbial content, was carried out up to autumn of 2007. The experiment has been left to reach equilibrium for a long period (nearly a year), and a new analysis campaign is planned for mid October 2008. A draft report on the set up of the experiments and the results up to May 2008 has been prepared.

4.12 Cleaning and Sealing of Investigation Boreholes



The project dealing with identifying and demonstrating the best available techniques for cleaning and sealing of investigation boreholes was initiated in 2002 and up to now Phase 1 to 3 have been finalised. The present work that makes up Phase 4 focuses on:

- Characterisation and planning of borehole sealing
- Quality assessment and designation.

The specific goal of this project is to collect available characterisation data of selected reference boreholes for working out generalised rock structure models and for planning sealing of boreholes.

A number of representative boreholes will be considered and those suitable for sealing will be divided into categories for which conceptual designs will be worked out. The project will select boreholes at Äspö, Laxemar, and Forsmark, for detailed design. The holes should represent typical rock conditions with respect to frequency, size and properties of permeable and unstable fracture zones.

Achievements

The project is presently in its fourth phase, which is planned to give principles for selecting strategic positions of plugs in boreholes for preventing axial flow by use of clay material and for stabilising fractured rock by cement-based plugs. The hydraulic performance of the clay plugs at different times after placement will give information on the need for plugging and for selecting the most suitable design.

The hydraulic function of the near-field of the holes is investigated by use of DFN modelling. The modelling of three boreholes at Forsmark (KFM07A, 09A and 09B) using the groundwater modelling code DarcyTools, has recently been completed by Golder. Corresponding work will be made for three boreholes at Laxemar in the remaining part of the last quarter. The studies include the effects on the hydraulic head field around the boreholes, the groundwater flux through the rock volume surrounding the boreholes, and the details of in- and outflows in the boreholes. The effect on the advective transport time for particles released in the rock volume is also studied.

In order to permit studies of the detailed flow conditions around the borehole KFM07A, a detailed DFN has been created around the borehole, see Figure 4-2.

Parallel to this work, quality issues concerning clay plugs are being focused on, primarily those related to variations in borehole diameter and straightness and to loss of clay in the placement phase. These activities make up the first attempt to work out generalised principles for selecting suitable, cost-effective borehole seals. In the subsequent reporting period QC/QA assessment of sub-systems and of the integrated plug system will be one of the major issues.

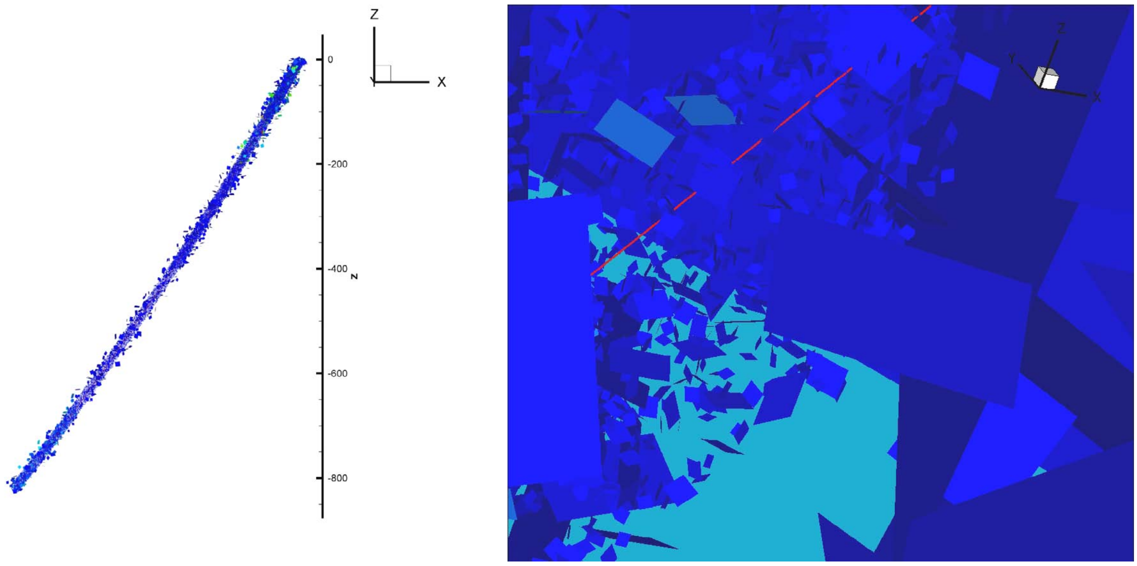
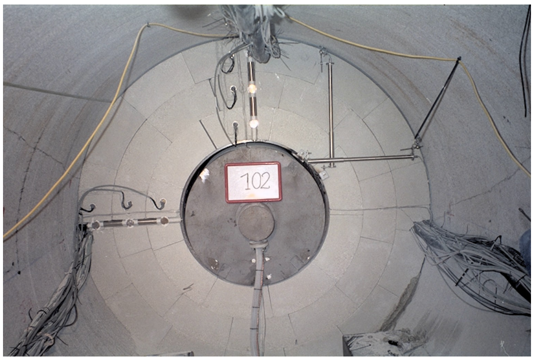


Figure 4-2. *The detailed DFN surrounding the borehole KFM07A (overview to the left and detail to the right).*

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 concerning both field and laboratory tests is conducted. The Äspö HRL International Joint Committee 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 (France), BMWi (Germany), CRIEPI (Japan), Nagra (Switzerland), Posiva (Finland), NWMO (Canada) and RAWRA (Czech Republic). 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 have a common secretariat, but separate chairmen.

Achievements

Task Force THM/Gas

For Task 1 the modelling has concerned large scale in situ tests (Task 1.2). The work to model the two Canadian experiments the Buffer/Container Experiment and the Isothermal Test (Task 1.2.1), carried out by AECL, has been finished and reporting is ongoing. The work with modelling of the Canister Retrieval Test at Äspö HRL (Task 1.2.2) has continued during this quarter. Altogether 8 modelling teams have worked with modelling of this benchmark.

The task to model the Canister Retrieval Test is divided into two parts where the first part is to model the thermo-hydro-mechanical behaviour of a central section of the test hole with given boundary conditions. The second task is to model the whole test. Most teams have finished the first part and are continuing with the modelling of the entire test. The status will be presented at the Task Force meeting in November.

Task Force Geochemistry

A second separate Task Fore Geochemistry meeting was held in Lund in mid September. Presentations, which were followed by extensive discussions, were given concerning:

- Molecular Dynamics (MD) simulations performed by SKB/Clay Technology concerning anion presence in the interlayer space of montmorillonite.
- The impact on diffusion of the always present ion concentration discontinuities between interlayer space and external solutions.
- Pressure consequences of the ion concentrations discontinuities, and the relation between measured pressures and water activities.
- Results from diffusion experiments performed at PSI in Switzerland.

Several kinds of laboratory tests concerning diffusion in bentonite are presently being performed at Clay Technology in Lund. The status will be presented at the Task Force meeting in November.

5 Äspö facility

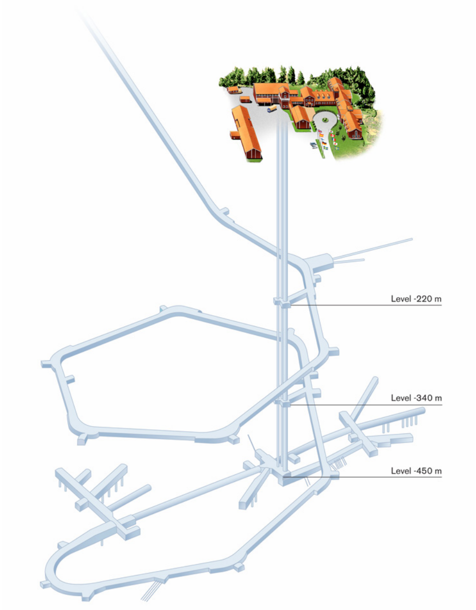
5.1 General

The organisational unit at 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.

5.2 Äspö Hard Rock Laboratory



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

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

Achievements

The facility has been almost 100% operational during the third quarter and no incidents have occurred within the internal systems. However, there has been reduced access during the maintenance of the elevator cage. Thundery weather has again caused problems at the facility. A lightening strike at OKG's switchgear cut out a number of alarm-relays in the facility's alarm collation system. In order to ensure safety, a number of the operational personnel were on-site and took part in comprehensive fault-tracing and repair work. In 2009, a pre-study will be carried out into a new alarm collation system.

Maintenance work was carried out on the elevator cage during the summer holiday period. On inspection of the cable installation in the elevator shaft, the cable-ladders were found to be very rusty. Installation of new cable-ladders will be carried out between the -450 m and -340 m level over a three year period beginning 2009. The cable ladders will be made of rust-free material. Rock-maintenance is being carried out according to plan and nothing unforeseen has occurred during this period.

Maintenance of the roads to Äspö has been carried out according to plan and a new surface has been laid on 3 kilometers of road during this period. The carpark at Äspö HRL is being extended and the work is estimated to be finished at the beginning of November 2008. The construction of the archive is going on. However, rainy weather during construction resulted in damp in the building materials and a large effort is required in order to dry out the materials before building work can continue inside the building. Building work on the new office space on the attic floor has been started during this period. The work is being carried out with internal management and contracted personnel. The office space will be ready to move into in the middle of November. An invitation to tender for the construction of a catering and dining-room has been produced and the offers received are being evaluated. The construction of the planned waste pipe from Äspö laboratory to OKG's water treatment facility is delayed but will begin during 2009.

The system for registration of personnel (RFID) has been moved over to the Alfa-administration. Further development of the system will be carried out under the project ESST (Energy Saving System in Tunnels) where possibilities for the steering of ventilation and lighting will be studied.

5.3 Bentonite Laboratory

Stacking of test blocks in full scale

Before building a final repository, where the operating conditions include 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

During the third quarter the tests concerning the impact of water inflow on buffer and backfill properties have been priority.

A number of tests with varying inflow to the backfilling have been performed to investigate how much water inflow in a deposition tunnel that can be accepted. In the tests have the time for breakthrough, amount of eroded material and inflow of water been measured. After a settled time, the tests are interrupted and excavation and documentation start. The results from the tests indicate that erosion do not control the speed of the backfilling process. It is the water inflow which is the controlling factor. In Figure 5-1 a test set-up before water breakthrough and at excavation is shown.

The next series of tests will be performed with the reference material Milos B, focusing on the course of events before water breakthrough at the front. After that tests in the tunnel in the underground laboratory will be performed and in these tests the influence of the rock contour can also be investigated. However, a lot of work concerning methods and development of techniques for backfilling remain. Especially to make it more industrialised and production adapted.

Figure 5-1. *Test set-up in half-scale (left) and excavation of experiment (right).*

A new series of experiments to study water inflow to the buffer in the deposition hole is ongoing, see Figure 5-2. The aim of the tests is, amongst other, to control the axial expansion of the buffer. The tests are done with an installation above the buffer simulating the counterpressure from the backfilling. Different amount of water inflow is used and eroded material is measured.

The tests concerning choice of method for backfilling the bevel against the deposition hole have continued. The compression of backfilling material at the bevel against the deposition hole has to be done so that high bearing capacity is achieved. If the backfill blocks sink down in the material above the bevel, the block installation risks not reaching the demand for maximum allowed cavity. More tests concerning methods of compressing and choice of material have been performed. Preliminary results from the tests show that it is possible to compress granulated material to sufficient density so the block above the bevel will be stable and do not sink down more than the block placed on the buffer, see Figure 5-2.

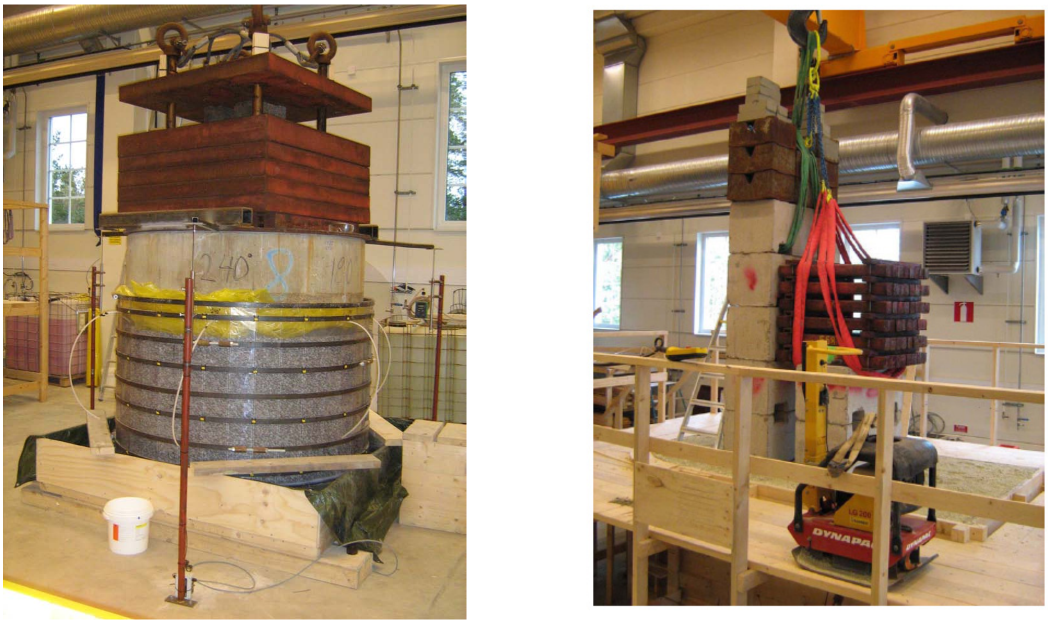


Figure 5-2. *Buffer water inflow test (left) and stacking tests on backfilled bevel and buffer in deposition hole (right).*

5.4 Public Relations and Visitor Services

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

The main goal for the Public Relations and Visitor Services Group is to create public acceptance for SKB, which is done in co-operation with other departments at SKB. The goal will be achieved by presenting information about SKB, the Äspö HRL, and the SKB siting programme on surface and underground.

The team is also responsible for visitor services at Clab and as from 2008 also the Canister Laboratory. In addition to the main goal, the information group takes care of and organises visits for an expanding amount of foreign guests every year. The visits from other countries mostly have the nature of technical visits.

The information group has a special booking team at Äspö HRL which books and administrates all visitors. The booking team also is at OKG's service according to agreement.

Achievements

SKB facilities have been visited by 7,136 persons during the third quarter of 2008, and in total 19,369 persons during the first nine months of 2008. The numbers of visitors to SKB's main facilities are listed in Table 5-1.

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

SKB facility	Number of visitors July-September 2008
Central interim storage facility for spent nuclear fuel	227
Canister Laboratory	266
Äspö HRL	3,329
Final repository for radioactive operational waste (SFR)	2,954

The guided summer-tours "Urberg 500" started in the end of June and ended the 17th of August. During two weeks in July there were no guided tours offered due to maintenance work within the facility even though the summer-tours were visited by totally 2,428 persons. Activities organised during the national event "Geologins Dag" attracted about 150 visitors. The arrangements took place 12-13th of September, and the common public as well as students were invited to two geological trips to the island Öland. The theme for the local events was to show differences between disparate kinds of rock and their influence on the performance of a repository for radioactive waste.

The 26th of September a contribution to EU's Researchers' Night (RIE) was held at Äspö, with the celebration of the 25th anniversary of the KBS-3 method in focus. The RIE initiative allows citizens to get closer to our researchers and gives a face to European research. Three researchers at SKB presented ongoing research with the main purpose to create interest for research from students and the general public. The event 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. Three doctor students have been examined since the start of the Äspö Research School and the forth remaining doctor student will be examined in 2009.

When the Äspö Research School was concluded as planned on the 30th of September 2008, the remaining and new research activities were transferred within the frame of the new co-operation Nova Research and Development. This new research and development initiative was originally taken by the municipality of Oskarshamn and then developed as a co-operation with SKB. The new agreement between the municipality of Oskarshamn and SKB is valid until 31st of August 2012. Most of the new research activities will take place on-site and not by distance as during the previous period of Äspö Research School.

6.2 Äspö Research School

Surface water sampling point at Laxemar catchments area

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 various kinds of research.

Achievements

A new PhD student, Frédéric Mathurin, has been employed. He will work on the chemistry and isotopic composition of bedrock groundwater. Mainly groundwater found in Äspö HRL but also groundwater from the site investigations in Forsmark and Oskarshamn will be studied. Several meetings at different places (Vasa, Stockholm, Äspö and Kalmar) have been held with the aim of finding specific topics and research tasks for Mathurin.

7 International co-operation

7.1 General

Eight organisations from seven countries will in addition to SKB participate in the co-operation at Äspö HRL during 2008, 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.

SKB also takes part in work within the IAEA framework. Äspö HRL is part of the IAEA Network of Centres of Excellence for training in and demonstration of waste disposal technologies in underground research facilities.

Table 7-1. International participation in the Äspö HRL projects during 2008.

Projects in the Äspö HRL during 2008	Andra	BMWi	CRIEPI	JAEA	NWMO	Posiva	Nagra	RAWRA
Natural barriers								
Tracer Retention Understanding Experiments				X		X		
Long Term Sorption Diffusion Experiment					X			
Colloid Dipole Project						X		
Microbe Project		X						
Radionuclide Retention Project		X						
Task Force on Modelling of Groundwater Flow and Transport of Solutes			X	X	X	X		
Engineered barriers								
Prototype Repository	X	X		X		X		
Alternative Buffer Materials	X	X		X		X	X	X
Long Term Test of Buffer Materials					X	X	X	
Temperature Buffer Test	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
Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle, Nagra, Switzerland
Radioactive Waste Repository Authority, Rawra, Czech Republic

8 Documentation

During the period July – September 2008, the following reports have been published and distributed.

8.1 Äspö International Progress Reports

Dershowitz W, Fox A, Lee G, Van Fossen M, Uchida M, 2006. Äspö Task Force on modelling of groundwater flow and transport solutes. Discrete fracture network flow and transport modelling at the rock block scale: Task 6D, 6E, 6F and 6F2. SKB IPR-06-22, Svensk Kärnbränslehantering AB.

Goudarzi R, Åkesson M, Hökmark H, 2008. Temperature Buffer Test. Sensors data report (Period: 030326-080101) Report No:11. SKB IPR-08-16, Svensk Kärnbränslehantering AB.

8.2 Technical Documents and International Technical Documents

Two technical documents have been published during the third quarter 2008.

9 References

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Neretnieks I, 1982. ”Leach Rates of High Level Waste And Spent Fuel. –Limiting Rates as Determined by Backfill And Bedrock Conditions” In: Lutze, W. (Ed.), Scientific Basis for Nuclear Waste Management V, Materials Research Society Symposium Proceedings 11, North-Holland, New York, Amsterdam, Oxford, 1982, pp. 559– 568.

Pedersen K, 2001. Diversity and activity of microorganisms in deep igneous rock aquifers of the Fennoscandian Shield. In Subsurface microbiology and biogeochemistry. Edited by Fredrickson J.K. and Fletcher M. Wiley-Liss Inc., New York, pp 97-139.

Pedersen K, 2002. Microbial processes in the disposal of high level radioactive waste 500 m underground in Fennoscandian shield rocks. In Interactions of microorganisms with radionuclides. Edited by Keith-Roach M.J. and Livens F.R. Elsevier, Amsterdam, pp 279-311.

SKB, 2007. RD&D-Programme 2007. Programme for research, development and demonstration of methods for the management and disposal of nuclear waste. SKB TR-07-12. Svensk Kärnbränslehantering AB.

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