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Äspö Hard Rock Laboratory

Status Report

July - September 2001

December 2001

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Summary

Investigations and experiments

The barrier function of the host rock

The Tracer Retention Understanding (TRUE) aims at further developing the understanding of radionuclide migration and retention processes and evaluation of different approaches to modelling such processes.

One of the TRUE programme projects is the Long-Term Diffusion Experiment, which is intended as a complement to the in situ dynamic experiments and the laboratory experiments performed within TRUE. The objectives are to study diffusion into the rock matrix and to obtain data on sorption processes and properties. The experimental concept is based on a large diameter bore hole at 410 m level, which exposes a fracture surface through which diffusion can be studied. Geo-scientific investigations and modelling of mechanical disturbance have been carried through on the core from the large diameter bore hole with the objective to define the suitable way of setting up the test. The result proposed a small diameter bore hole in the centre of the large diameter bore hole that extends into the undisturbed rock, which would provide studies of migration at two places in the same set-up – through a fracture surface and in rock with virgin rock stress conditions. The boring of the slim hole has been done with a successful result.

The TRUE Block Scale project aims at studying the tracer transport in a fracture network over distances up to 50 m. The monitoring of tracer break-through has been prolonged (Phase C), but some break-throughs have still not taken place for strongly sorbing ^{83}Rb and ^{137}Cs in 35 and 100 m flow paths respectively.

The CHEMLAB probe has been constructed and manufactured for validation experiments in situ at undisturbed natural conditions. The results from experiments with diffusion in bentonite have been reported, the results being in accordance with previous findings. The experiments with migration of actinides, Am, Np and Pu in Chemlab #2, which came to an early stop due to malfunction, are being reported

The Matrix Fluid Chemistry experiment has the aim to determine the origin and age of matrix fluids and to establish to what extent diffusion processes have affected the composition of matrix fluid. Detailed sampling of a rock profile perpendicular to the micro-fissure has been carried out in preparation for detailed study to investigate any evidence of in- or out-diffusion processes. Both bore hole sections, Section 4 (already sampled) and Section 2 have continued to show steady pressure increase although Section 4 has now levelled out. Sampling of this bore hole sections has been planned for October this year. Fluid inclusion characterisation as well as mineralogical and petrophysical studies have continued.

The Stability and Mobility of Colloids (SMC) Project has been initiated to investigate the potential for colloidal transport in natural groundwater. Studies will be made on the colloid concentration in the Äspö HRL and the role of bentonite clay as a source for colloid generation. A project decision to perform the project was taken during December 2000, and work conducted so far has been focused on laboratory studies. Preliminary results indicate a low rate of natural colloid formation at the salinity

concentrations in the Äspö HRL. When this is confirmed the experiment will be planned accordingly.

A set of microbiology research tasks for the performance assessment of high level nuclear waste (HLW) disposal has been identified. A test site at the 450 m level, called the MICROBE site, is in operation consisting of three core drilled holes intersecting water conducting fractures at 12.7, 43.5 and 9.3 m respectively. Each bore hole is equipped with metal-free packer systems that allow controlled sampling from each fracture. The laboratory at 450 m level is still under development and some vital equipment still remains to be installed.

The Task Force is a forum for the organisations supporting the Äspö HRL Project to interact in the area of conceptual and numerical modelling of groundwater flow and solute transport in fractured rock. The final reporting of Task 5 is going on. Within Task 6 the base cases for sub-tasks 6A and 6B have been defined.

Technology and function of important parts of the repository system

The Prototype Repository experiment is located in the last part of the TBM tunnel at the 450 m level and will include 6 deposition holes in full scale. 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. Physical activities in the Prototype Repository tunnel have been the backfilling of the tunnel and successive installation of the instruments in the backfill.

The Backfill and Plug Test comprises full scale testing of backfill materials, filling methods, and plugging. The entire test set-up with backfilling, instrumentation and building of the plug was finished late September 1999 and the wetting of the 30/70 mixture through the filter mats started in November 1999. Water filling of the outer test sections (0/100) has continued and is still not completed. The plug has been post-grouted for final tightning and an increased water pressure is planned for speeding up the saturation process. Water saturation, water pressure and swelling pressure in the backfill and water pressure in the surrounding rock have been continuously measured and recorded. Only the sensors placed in the first layers (about 200 mm from the mat) in the 30/70 section have been clearly water saturated, while the sensors 600 mm away indicate an increased water content.

Canister Retrieval Test aims at demonstrating the readiness for recovering of deposited canisters also after the time when the bentonite has swelled. The heaters as well as the system for artificial saturation were turned on in October 2000 and have been running during the period as planned. On February 13th the thermal power was increased from 1700 W to 2600 W in order to reach 90^{o}C on the surface of the single canister in this particular test. The temperature in the inner part of the steel insert has increase to 102^{o}C at mid-height, while the temperature at the same horizon but on the outside of the canister has reached 91^{o}C, and 84^{o}C in the bentonite 60 mm from the canister's surface. The low temperature difference between the steel insert and the copper mantle thus has sustained.

The Long Term Tests of Buffer Material aims to validate models and hypotheses concerning long-term processes in buffer material. Five bore holes have been filled with highly compacted bentonite and one heater. The bentonite parcels are equipped with instruments, bacteria, copper coupons and with radioactive tracers. The intended test temperatures of 90°C in the standard type parcels and 130°C in the adverse condition parcels have been reached. Saturation and heating has been going on. Parcel A0

(A=adverse conditions) is close to saturation because of the three nozzles installed for addition of water, and is discussed for retrieval later this year.

International Co-operation

Eight organisations from seven countries are currently (October 2001) participating in the Äspö HRL. The NIREX participation ceased during the period.

The EC project CROP, a Thematic Network project, focused the work on the first two work packages, collecting of data for country annexes on repository concepts and experimental procedures in URLs. The draft summary text was compiled for participant´s review.

Facility Operation

The status of the facility is good.

OKG´s (the NPP operator) policy to outsource among other things service activities has now reached full effect for Äspö HRL, and service contracts, which earlier were signed with OKG have now been signed with other contractors.

A project for hands-free registration of underground visits is in progress. The main objective is to improve the safety in case of any incident/accident. After implementation the system will also help in energy conservation as the ventilation system then can operate in accordance to the need of personnel, equipment and vehicles actually being underground.

Data Management and Quality systems

The development of GIS, SICADA and RVS has been focused on the implementation of ESRI/ArcSDE and ArcIMS. ArcSDE requires Oracle RDBMS. These have been ordered and a couple of new Windows NT servers have been purchased and configured.

The old version of SICADA is being upgraded with GTAdmin to the new version “SICADA Admin” by using the programming environment Delphi.

RVS version 3.0 is being implemented. The work is separated into five stages and stage five has been started.

Information activities

During the period July-September, 2001, 2821 persons (3758 during last period) visited the Äspö HRL. These persons represented the public, municipalities where SKB performs feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries. 779 persons represented the six municipalities where SKB has performed feasibility studies.

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1 General

The scientific investigations within SKB's research programme are part of the work conducted to develop and test methods for identification and characterisation of suitable repository sites, design of a deep repository as well as excavation and operation of such a repository. This requires extensive field studies of the active processes and properties of the geological barrier, the interaction between different engineered barriers and host rock, means of construction, and ways of disposal and backfilling. The Äspö Hard Rock Laboratory (Äspö HRL) provides an opportunity for research, development and demonstration of these issues in a realistic setting. Important tasks for the Äspö HRL are:

- to increase scientific understanding of the safety margins of the deep repository,
- to test and verify technology that provide cost reductions and simplifies the repository concept without compromising safety,
- to demonstrate technology that will be used in the deep repository,
- to provide experience and training of staff, and
- to inform about technology and methods to be used in the deep repository.

A set of Stage Goals have been defined for the work at the Äspö HRL. The Stage Goals were redefined in the SKB Research Development and Demonstration (RD&D) Programme 95, which was submitted to the Swedish Authorities in September 1995. An updated program RD&D Programme 1998 was submitted in September 1998. This programme is the basis for the planning and execution of the current work. The just recently submitted RD&D Programme 2001 (submitted to the Swedish Authorities in September 2001) suggests a continuation of the work along the plan that was outlined in 1995 and 1998.

The Stage Goals for the Operating Phase of the Äspö HRL are as follows:

1 Verify pre-investigation methods

demonstrate that investigations on the ground surface and in bore holes provide sufficient data on essential safety-related properties of the rock at repository level.

2 Finalise detailed investigation methodology

refine and verify the methods and the technology needed for characterisation of the rock in the detailed site investigations.

3 Test models for description of the barrier function of the host rock

further develop and at repository depth test methods and models for description of groundwater flow, radionuclide migration, and chemical conditions during operation of a repository and after closure.

4 Demonstrate technology for and function of important parts of the repository system

test, investigate and demonstrate on full scale different components of importance for the long-term safety of a deep repository system and to show that high quality can be achieved in design, construction, and operation of system components

2 Methodology for detailed characterisation of rock underground

Background

A programme for detailed characterisation will be devised before detailed characterisation is initiated on a selected site and construction of the surface and underground portions of the deep repository is commenced. In conjunction with the driving of the Äspö tunnel, several different investigation methods have been tried and the usefulness of these methods for detailed characterisation for a deep repository is being evaluated. Preliminary experience from Äspö shows that there is a need for refinement of these methods to enhance the quality of collected data, boost efficiency and improve reliability in a demanding underground environment. Furthermore, the detailed characterisation programme needs to be designed so that good co-ordination is obtained between rock investigations and construction activities.

The objectives are:

- to try out existing and new methods to clarify their usefulness for detailed characterisation. The methods to be tested are chosen on the basis of their potential use within the detailed characterisation programme,
- to refine important methods in a detailed characterisation programme to enhance data quality, efficiency and reliability.

Detailed characterisation will facilitate refinement of site models originally based on data from the ground surface and surface boreholes. The refined models will provide the basis for updating the layout of the repository and adapting it to local conditions. Due to the heterogeneity of the rock, the layout of the repository needs to be adapted to the gradually refined model of rock conditions. This approach has a long tradition in underground construction and it should be used also for a deep repository.

Results

No new results.

Planned work

A report on underground investigation methods used during the construction phase of the Äspö HRL will be published in the end of 2001. The report will describe the different methods used with regard to instrument or other working tools and measurement methodology. Resolution and accuracy of the measured values as well as general aspects of errors will be discussed. The evaluation part will address the usefulness and feasibility of the methods. Recommendations on possible modifications etc. will also be given.

3 Test of models for description of the barrier function of the host rock

3.1 Natural Barriers

General

The Natural Barriers in the deep geological repository for radioactive wastes are the bedrock, its properties and the on-going physical, chemical and biological processes in the rock. The function of the natural barriers as part of the integrated disposal system can be presented as *isolation, retention* and *dilution*. The common goal of the experiments within Natural Barriers is to increase the scientific knowledge of the safety margins of the deep repository and to provide data for performance and safety assessment calculations. The strategy for the on-going experiments on the natural barriers is to concentrate the efforts on those experiments which results are needed for the planning of the future candidate site investigations, planned to start in 2002. For this focus there is also a need to involve experts of the different geoscientific disciplines into the on-going experiments in order to make them familiar with the work and quality procedures adopted.

Isolation is the prime function of the KBS-3 type repository. It is obtained through the co-function of the engineered and the natural barriers. For deep geological disposal, the flow of water to the canister/waste containment is largely determining the magnitude at which the corrosion and the dissolution of the waste form can take place. For a good isolation it is thus necessary to minimise the groundwater flow to the waste containment. Additional conditions that affect the isolation are the chemistry of the groundwater and the mechanical stability of the rock.

Conceptual and numerical groundwater flow models have been developed through the entire Äspö HRL project. During 2001 focus is on further development of the numerical tools used for groundwater flow and transport calculations. A major step is the start of the TASK#6 modelling work.

Hydrochemical stability and potential variability is assessed within several projects that were completed during 1999 and 2000. The final project report will be printed during 2001.

The *retention* of radionuclides dissolved in groundwater is the second most important barrier function of the repository. Retention will be provided by any system and process that interacts with the nuclides dissolved in the groundwater when eventually the water has come in contact with the waste form and dissolved radionuclides. Retention is provided by the physical and chemical processes, which occur in the near-field and far-field. Some elements are strongly retarded while others are escaping with the flowing groundwater. The major emphasis in the safety assessment calculations has therefore been on the weakly retarded nuclides even if they don’t dominate the hazard of the waste.

The large amount of activity in a repository is caused by the fission products, Cs, Sr, I, Tc, and the transuranic elements Am, Np, and Pu. The transuranics, Cs, and Tc are, if dissolved, effectively sorbed in the near field. However, in case neptunium and technetium are oxidized to neptonyl and pertechnetate by radiolyses from the waste they might be transported into the bentonite buffer before they are reduced to the insoluble tetravalent state.

Strontium and all negatively charged elements will be retarded in the rock by the interaction with the fracture minerals in the flow paths in the rock and through the diffusion into the rock matrix. The effective retention of these nuclides is a combination of radioactive decay, sorption and diffusion.

The more long-lived and the weaker the sorption of the nuclide, the more important is the actual groundwater flow for the migration. The chemical composition of the groundwater is important for the magnitude of sorption for some of the nuclides. Negatively charged nuclides are retarded from the groundwater flow only through the diffusion into the stagnant pores of the rock matrix.

Tracer tests are carried out within experiments in the TRUE-projects. These are conducted at different scales with the aim of identifying detailed scale (5m) and block scale (50m) flow paths, retention of weakly and moderately sorbing tracers and the effect of matrix diffusion. During 2001 the goals are to report the TRUE Block Scale experiment and to plan future tracer experiments. The Long Term Diffusion Experiment (LTDE) will be running for 3 to 4 years to assess the matrix diffusion into an isolated fracture surface. Modelling of the experiments is done by several groups associated to the Äspö Task Force for modelling of groundwater flow and transport of solutes.

CHEMLAB experiments are conducted with the moderately and highly sorbing nuclides. Experiments are carried out in simulated near field conditions (bentonite) and in tiny rock fractures. During 2001 experiments including effects of radiolysis and migration of actinides in a rock fracture.

COLLOID investigations made previously in the Äspö HRL and elswhere faced a concentration that was too low to detect. New findings of colloidal transport and more sensitive instruments for colloid measurements has triggered a new project with the purpose to study the natural concentration, the stability and the mobility of colloids.

Microbes are of particular interest since they can directly influence the chemistry of the groundwater, and indirectly transport nuclides attached to them. Experiments will start within the project MICROBE.

Dilution is the third barrier function. It will take place in the rock volume surrounding the repository. The magnitude of dilution is very much depending on the site specific conditions, and for performance assessment calculations on the conceptualisation of the flow. In the geosphere the dilution is caused by the dispersion in the groundwater flow.

No specific experiment is focussing on dilution. However, this process is included in TASK#6 within the Äspö Task Force for groundwater flow and transport of solutes.

3.2 Tracer Retention Understanding Experiment

Background

The safety of a KBS-3 type repository relies heavily on the engineered barrier system that contains the waste. In the case that the engineered barrier fails, the geosphere provides the remaining waste containment. Realistic estimates and predictions of transport times through the geosphere and release rates to the biosphere are thus critical for any safety assessment. Of particular interest in this regard is the rock adjacent to the canister holes and storage tunnels.

The plans for tracer experiments outlined in the SKB RD&D Programme 92 comprised experiments in the Detailed and Block Scales. The experiments in the Detailed Scale consisted of three; Pore Volume Characterisation (PVC), Multiple-Well Tracer Experiment (MWTE), and the Matrix Diffusion Experiment (MDE). During 1994 detailed Test Plans were prepared for MWTE and MDE. Following review and evaluation the SKB HRL Project management decided to integrate the Detailed and Block Scale experiments within a common framework. This framework is described in a "Program for Tracer Retention Understanding Experiments" (TRUE) (Bäckblom and Olsson, 1994). The basic idea is that tracer experiments will be performed in cycles with an approximate duration of 2 years. At the end of each tracer test cycle, results and experiences gained will be evaluated and the overall program for TRUE revised accordingly.

The general objectives of the TRUE experiments (Bäckblom and Olsson, 1994) are;

- Develop the understanding of radionuclide migration and retention in fractured rock.
- Evaluate to what extent concepts used in models are based on realistic descriptions of rock and if adequate data can be collected in site characterisation.
- Evaluate the usefulness and feasibility of different approaches to model radionuclide migration and retention.

3.2.1 Long Term Diffusion Experiment (LTDE)

Background

The Long-Term Diffusion Experiment is intended as a compliment to the *in-situ* dynamic experiments and the laboratory experiments performed within the TRUE Programme.

The objectives of the planned experiment are to;

- To investigate diffusion into matrix rock from a natural fracture *in-situ* under natural rock stress conditions and hydraulic pressure and groundwater chemical conditions .

- To obtain data on sorption properties and processes of some radionuclides on natural fracture surfaces

- To compare laboratory derived diffusion constants and sorption coefficients for the investigated rock fracture system with the sorption behaviour observed *in-situ* at natural conditions, and to evaluate if laboratory scale sorption results are representative also for larger scales.

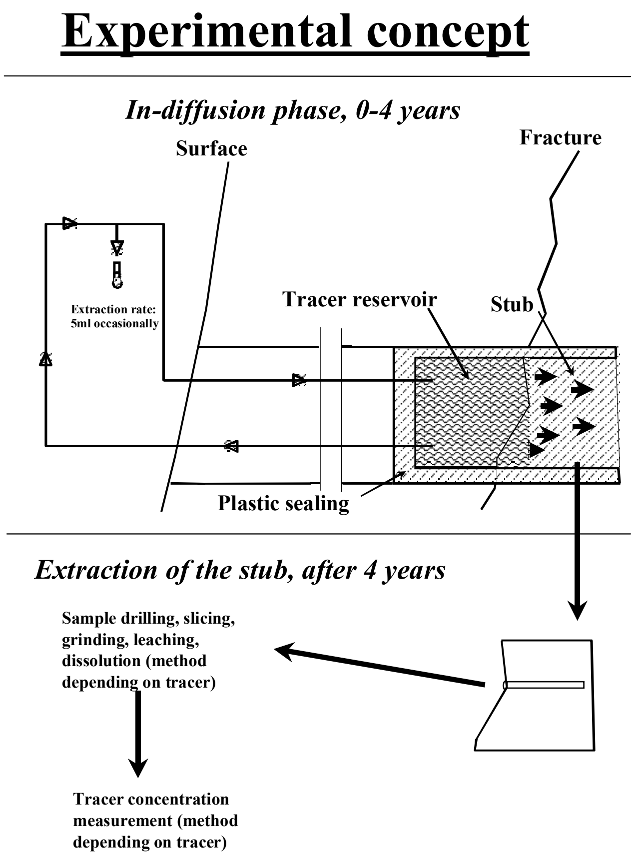


Figure 3-1 *Schematic of LTDE experimental concept including injection bore hole in contact with a fracture surface, combined with excavation and penetration profile studies*

The test plan presents an experimental concept centred on establishment of an experimental (large diameter) bore hole, which exposes a natural fracture surface. This fracture surface is packed off with a cap which seals off the exposed rock cylinder in the bottom of the borehole, similar to the approach used in the REX experiment, cf. Figure 3-1. The intention is to establish an experimental chamber in which a tracer solution is circulated over a period of four years. Performed scoping calculations using available diffusivity data indicates that axial diffusion will range from mm:s for the strongly sorbing tracers to dm:s for the weakly sorbing tracers considered. Apart from tracers used in the TRUE-1 experiment, also PA-relevant tracers (e.g. ^{99}Tc and ^{241}Am) are being proposed. The principal challenge of the experiment is to establish axial diffusion from a natural fracture, through the rim zone of fracture mineralisation and alteration, into the unaltered intact rock matrix, without being affected by any advective component (prevailing hydraulic gradient directed towards the tunnel). This is resolved using a multi-packer system which effectively shields off the gradient. In addition, an intricate pressure regulation system is devised which will effectively allow the pressure in the experiment chamber to adapt to the ambient conditions without causing pressure differences, eliminating advective transport. The reference pressure is obtained either from a packed-off pilot bore hole in the immediate vicinity of the large diameter experimental bore hole, or from a section in the large diameter bore hole itself. The former bore hole has also been used to identify the target fracture to be investigated.

The characterisation of the large diameter bore hole includes i.a. measurements with various logs (bore hole imaging (BIPS) and flow logging). The type of logs restricted by the diameter of the bore hole. In the neighbouring 76 mm pilot bore hole flow logging and resistivity logs will be run. The idea with the latter log being to enable coupling between the electrical resistivity and diffusivity. In addition the cores from the two bore holes will be analysed using mineralogical, petrophysical and geochemical methods.

A suitable target fracture has been identified in bore hole KA3065A02 at a depth of 9.81 m. This structure constitutes a chlorite splay (141/81) to a main fault, the latter on which slicken lines on the surface are evident. It shows mylonitic character in diorite/greenstone with an increasing alteration towards the fault centre. The total inflow at this zone is about 16 l/min. The target structure constitutes the lower fringe of the zone and is followed by a long > 0.5 m long intact section of Äspö diorite.

Construction and manufacturing of prototypes of down hole bore hole and sampling and monitoring equipment has been under way since 1999. Samples of the proposed material used for the down hole equipment (PEEK and polyurethane) have been analysed at CTH-Nuclear Chemistry in Gothenburg to characteristics and possible influence on the experiment. A mock-up bore hole has been manufactured of a steel tube trying to imitate the inner part of the bore hole involving the core stub. The sealing rubber has been manufactured and tested in a mock-up bore hole.

A telescoped bore hole, denoted KA3065A03, has been drilled parallel to the existing pilot bore hole KA3065A02. Drilling with 300 mm (280 mm core) was made to a depth of 9.25 m. after which the bore hole was continued with 196.5 mm (177 mm core) down to a depth of 10.40 m (from the tunnel face). The structural and geological model was successively updated during the drilling and the projected depth to the target structure adjusted accordingly. The correspondence between the predicted structure geometry and outcome is good, with the exception of the innermost parts of KA3065A03. Poor visibility impairing BIPS imaging combined with an apparent convergence of structures seen in KA3065A02 resulted in a stub, which is about 0.16 m long. This should be compared with the desired length of 0.05 m.

Given that the stub turned out about 0.1 m longer that projected, about 50 % of the projected diffusion length of the weakly sorbing tracers will be within the stub. For strongly sorbing tracers, the whole diffusion length will be within the stub. This poses the question whether damage along the mantel surface and stress redistribution within the core stub which provide enhanced porosity/diffusivity will invalidate the possibility to reach the intact rock beyond the root of the core stub. Results of seismic P-wave measurements on 45 mm core from KA3065A02 show an average velocity of about 5550 m/s. The velocity in the 177 mm core is higher, 5780 m/s. The P-wave velocity in undisturbed Äspö bedrock with no, or few macro fractures, is about 5900-6000 m/s based on acoustic emission data from the Prototype and the ZEDEX projects. The results from LTDE indicate a more profound (relative) damage of the 45 mm cores compared to the results from the 177 mm core.

The surface of the stub and the competence of the remaining stub was inspected with remote controlled vehicle with a video camera and a 6 mm camera in the 9.75 mm slot between the stub and the bore hole wall. The stub was found to be fully intact and no fractures were detected. Using the video information, total station measurements from the collar and the remains of the "mate" of the stub, the mineral distribution and relief of stub face was reconstructed.

In order to assess the rock mechanical effects on the stub in terms of drilling and stress unloading/redistribution, the LTDE situation has been reviewed using results presented by Hakala (1999). Using the geometry of LTDE with examples from Hakala no core damage in terms of new induced fractures takes place. This applies to both new fractures at the stub root (bottom of the hole) and new radial fractures. With regards to development of tangential fractures along the core axis, none of the primary loads is found to produce high enough radial tension, which is needed to produce tangential fractures. It should however be noted that stress relaxation would open any existing micro fracture, and such relaxation and associated opening widening would occur everywhere and in all directions.

In the field, components of the planned pre-test program have been completed. These include a detailed flow logging using a single packer in the interior of bore hole KA3065A03, in the interval L=10.083 to 10.883 m. A total of 9 measurements were made which will be differentiated to 0.05 m sections. Pressure responses were collected in the neighbouring bore holes including KA3067A, KA3065A02, KA3068A

Numerical modelling has been performed to simulate the desaturation and resaturation of the core stub as a consequence of the bore hole being opened, and subsequently being shut-in. The simulation results indicate for reasonable assumed values of hydraulic conductivity and specific storage ($K=10^{-14} – 10^{-12}$ m/s and $S_s=10^{-8} – 10^{-6}$ m^{-1}), the initial response is fast (order days or less) but that complete steady state conditions are instated after longer time.

New results

The period QII-QIII has been one of detailed planning. Planning of the detailed installation and pre-test work, but also of the drilling of the slim (36 mm) borehole drilled through the remaining 177 mm stub in KA3065A03. The drilling was carried out successfully in early October. The rock mass beyond the stub root was found to be intact with some minor portions with altered (red/coloured) rock and essentially devoid of natural fractures with a few exceptions. A section, about 35-40 cm in length was indentified as the prime candidate for the test section in the intact rock. Subsequent flow tests have identified one fracture in the interior of the slim hole to be conductive, and connected to the neighbouring pilot borehole KA3065A02.

3.2.2 TRUE Block Scale

Background

Work on the TRUE Block Scale Project started in mid 1996. This subproject of TRUE broadens the perspective from an address of a singular feature in TRUE-1, to flow and transport processes in a network of fractures and a spatial scale between 10 and 50m. The specific objectives of the TRUE Block Scale Project are to;

1. increase understanding and the ability to predict tracer transport in a fracture network,

2. assess the importance of tracer retention mechanisms (diffusion and sorption) in a fracture network,

3. assess the link between flow and transport data as a means for predicting transport phenomena,

A set of desired experimental conditions have been defined and a flexible iterative characterisation strategy has been adopted. The project is divided into five basic stages;

- Scoping Stage
- Preliminary Characterisation Stage
- Detailed Characterisation Stage
- Tracer Test Stage
- Evaluation (and reporting) Stage

The total duration of the project is approximately 4.5 years with a scheduled finish at the end of the year 2000. The project was originally organised as a multi-partite project involving ANDRA, NIREX, POSIVA, and SKB. During 1997, also ENRESA and PNC have joined the project.

During 1997, two bore holes, KI0025F and KI0023B, have been drilled using the triple-tube method from the I-tunnel at L=3/510 m in the access tunnel. These bore holes, 75 mm in diameter, are gently inclined (I=20 degrees) and complement the existing 56 mm bore holes, KA2511A and KA2563A, the latter drilled as a pilot bore hole as part of the TRUE Block Scale Scoping Stage. The latter bore holes have been drilled with a higher inclination from a higher elevation in the laboratory. The bore holes have been characterised using different geological, geophysical and hydrogeological methods. Based on the collected data the structural model of the block has been updated sequentially.

During 1998 the Preliminary Characterisation Stage was concluded with elaborate cross-hole interference tests which involved all available bore holes in the investigated rock block. The primary aim of the tests was to investigate the hydraulic connectivity with the block, and specifically the existence, relative role of north-easterly and sub-horizontal structures. In addition the tests involved performance of tracer dilution tests in selected test sections, whereby not only the drawdown due to an applied disturbance was obtained, but also the change in flow rate through the selected sections. One of the pumpings was driven long enough to study breakthrough of tracer.

The cross-hole interference data together with 3D seismic data were used together with data from KI0023B to produce the September 1998 structural model update.

During the Fall 1998 another bore hole, denoted KI0025F02, was drilled as part of the Detailed Characterisation Stage from the I-tunnel, between KI0023B and KI0025F, was characterised and completed. In this hole the POSIVA flow log was used for the first time in the project. In addition a series of short time cross-hole interference tests and associated tracer dilution tests were performed.

The status of the project per November 1998 was presented at the 2nd TRUE Block Scale Review Seminar held Nov 17, in Stockholm. At this meeting, apart from presenting a conceptual model of groundwater flow, the project group also presented their tentative strategy for upcoming future tracer tests.

During the Spring of 1999 an intensive planning effort has been conducted which has resulted in definition of the important issues of the planned future tracer tests. A set of hypotheses related to the issues of conductive geometry, heterogeneity and retention have been put forward in a Tracer Test Programme. Further design calculations related to the effects of fracture intersections have been performed. In addition, a series of Pre-tests, in essence a series of three interference tests with associated tracer dilution tests have been performed. As a final field activity a multi-injection tracer test was performed which demonstrated breakthrough from four out of four injection sections, two of which showed high recovery in pathways involving multiple structures (>1)). The Tracer Test Programme also defines a tentative strategy for the future tracer tests which will be conducted in three consecutive phases, A through C. The first Phase, A, is a test of alternative sink sections, combined with complementary tracer dilution tests. The focus of Phase B is on the selected sink section, tests over both short and longer distances. The final Phase C is fully devoted to tests with sorbing tracers.

During the Fall of 1999 drilling and characterisation was performed in the last of the bore holes, KI0025F03. Characterisation has included flow and pressure build-up tests with observation of pressure responses in the neighbouring bore holes. The qualitative interpretation showed responses consistent with the reconciled March'99 structural model. The bore hole was subsequently instrumented with a multi-packer system consisting of 9 sections, two of which prepared with metal lines for injection of helium as a tracer.

Phase A of the Tracer Test Stage involved use of two alternative sink sections, and comprised about 70 tracer dilution tests and 8 tracer injections. The results of the tests, co-assessed with existing results from previous tests, indicated that the sink in KI0023B showed the best prospects of producing breakthroughs with a high mass recovery over reasonable time scales. This sink will be used in the subsequent Phase B which is includes demonstration of high mass recovery and test of helium as a tracer.

The Phase A tests have been preceded by model predictions using the existing DFN, Channel network and Stochastic Continuum models which has been updated with the March'99 structural model and all available information including the interference and tracer dilution tests made as part of the Phase A tests.

The subsequent Phase B tests were run in two parts, Phase B1 with a 50% reduction relative to maximum pump rate and Phase B2 where maximum pump rate was employed (approximately 2 l/min). This staged approach was employed to enable identification of stronger retardation of the more diffusive He-gas at reduced flow rate. During the Phase B2 tests, 6 sections were used for tracer injection. The results show > 80 % recovery (stipulated recovery to allow injection of radioactive sorbing tracers) for three injection sections (KI0025F03:P5 (#20), KI0025F03:P7 (#23) and KI0025F03:P3 (#21), involving 1-4 structures along the pathway.

Given the identified constraints (time, recovery, tracers, equipment) it was identified that 5 injections were possible to achieve within the framework of Phase C. In order to test the hypotheses of possible higher retardation for tracers when transported over larger time scales, a cocktail of tracers including both a weakly sorbing (like Na, Ca and Sr) and a more strongly sorbing (e.g. Rb, Ba and Cs) will be used for each injection. One of the planned injections (C4) constitute injection of tracers subject to partial hydrolysis/surface complexation. A permit for performance of the planned tests was obtained from the Swedish Radiation and Protection Board (SSI) early June. So far four of the injections (C1-C3 and C4) have been conducted. Injection C5 have been omitted due to poor performance of the selected injection section. The Phase C experiments will be the subject of blind model predictions and hence no results will be presented until the predictions have been filed.

A reporting structure for TRUE Block Scale has been developed. A series of four final reports will be produced;

#1 Characterisation and model evolution

#2 Tracer tests in the block scale

3 Modelling of flow and transport

#4 Synthesis of flow, transport and retention in the block scale

A first reporting workshop was held late November in Lerum, east of Gothenburg at which the detailed disposition and contents of the first two reports were discussed.

New Results

Work on reporting is proceeding, althougth with some delays.

Tracer Test Stage

Individual reports (IPR) for the modelling concepts employed in the evaluation of the Phase C tracer tests have been obtained for four of the concepts. Production of final drafts of less priority than completion of the Final Report #3, see below. In addition a report (IPR) has been finalised which accounts for the ability to produce a selected fset of tracer tests using the various generation sof hydrostructural models produces. The report demonstrates successive improvement to reporduce the tracer test results with time.

Phase C tracer test report (IPR) is available in a first draft.

Evaluation and Reporting Stage

A final draft of Final report #1 (Characterisation and model development) is available. Final internal review constitutes the reamaining activity.

A Fist draft is available for Final repor #2 (Tracer tests in the block scale). The report will be finalised early QIV.

Work on Final report #3 (Modelling of flow and transport…) has been inhibited by the need to complete the individual evaluation reports first. A second workshop was held in late September at which a detailed agenda was drawn up to complete a first draft of the report by end of October.

Work of Final report #4 (Synthesis…) will be commence in November.

3.2.3 TRUE Continuation

Since mid 2000 plans have been under way to define the continuation of the TRUE Programme following the completion of TRUE-1 (Winberg et al. 2000) and the almost completed TRUE Block Scale project. SKB has decided that any continuation will be conducted within the framework of one single project. Being one project does not, however, rule out the possibility of performing parts of continued filed work at different site.

The proposed general objectives (no yet ratified) of the TRUE continuation are;

- Demonstrate and validate a process for defining the critical geologic element/-s for flow and transport/retention and their transport properties,
- Define, at different scales, the pore space (responsible for/necessary to explain) transport, diffusion, sorption and loss of tracer,
- Integrate experimental results from the laboratory, detailed scale and block scale to obtain a consistent and adequate description of transport to serve as a basis for modelling transport from canister to biosphere,
- Through interaction with Äspö Task Force (Task 6), provide an experimental context in which to test modelling approaches on larger length scales.

In terms of work scope three main components are identified;

1. BS2 2a Continued monitoring of the TRUE Block Scale Phase C experiments. Complementary modelling of the new data with the objective of identifying new hypotheses to test by *in-situ* experiments.
2. BS 2b Complementary in-situ experiments in the TRUE Block Scale rock volume. Address of new hypotheses may entail use of alternative sinks and source sections as well as reversal of sink-source pairs.
3. Complementary work at the TRUE-1 site. This part of the work scope include in the short term complementary tracer dilution /tracer tests and the long-term (3 years from now) resin injection and subsequent excavation and analysis.

New results

TRUE Continuation (BS)

An updated agreement and supporting project description and time plan has been finalised and was distributed for signature mid October. The agreement which originally also included complementary work at the TRUE-1 site, now only includes work at the TRUE Block Scale site and associated work.

Complementary modelling work will commence in April and will be reported by the end of 2002. Complementary experimental work will commence early 2003. Evaluation will be completed by the en of QI, 2004.

TRUE Continuation (TRUE-1)

Planned work on the TRUE-1 include complementary cross-hole tests including tracer dilution and tracer tests using conservative tracers with the intention to improved knowledge of the relationship between feature A and its immediate surroundings. In addition an attempt to evaluate fracture apertures from radon measurements in groundwater will be attempted. The groundwater sampling will be carried out during QIV, 2001. The final activity will be resin injection and subsequent excavation and analysis. This activity is planned to be receded by an in situ cation exchange capacity experiment. The activities are spread in time from QIII, 2001 to 2005, awhile there is a need to take into account developments at the LTDE site.

3.3 Radionuclide retention

Background

The retention of radionuclides in the rock is the most effective protection mechanism, if the engineering barriers have failed and the radionuclides have been released from the waste form. The retention is mainly caused by the chemical properties of the radionuclides, the chemical composition of the groundwater, and to some extent also by the conditions of the water conducting fractures and the groundwater flow.

Laboratory studies on solubility and migration of the long lived nuclides e.g. Tc, Np, and Pu indicate that these elements are so strongly sorbed on the fracture surfaces and into the rock matrix that they will not be transported to the biosphere until they have decayed. In many of these retention processes the sorption could well be irreversible and thus the migration of the nuclides will stop as soon as the source term is ending.

Laboratory studies under natural conditions are extremely difficult to conduct. Even though the experiences from different scientists are uniform it is of great value to demonstrate the results of the laboratory studies in situ, where the natural contents of colloids, organic matter, bacteria, etc. are present in the experiments. Laboratory investigations have difficulties to simulate these conditions and are therefore dubious as validation exercises. The CHEMLAB borehole-laboratory has been constructed and manufactured for validation experiments in situ at undisturbed natural conditions. Figure 3-2 illustrates the principles of the CHEMLAB 1 and CHEMLAB 2 units.

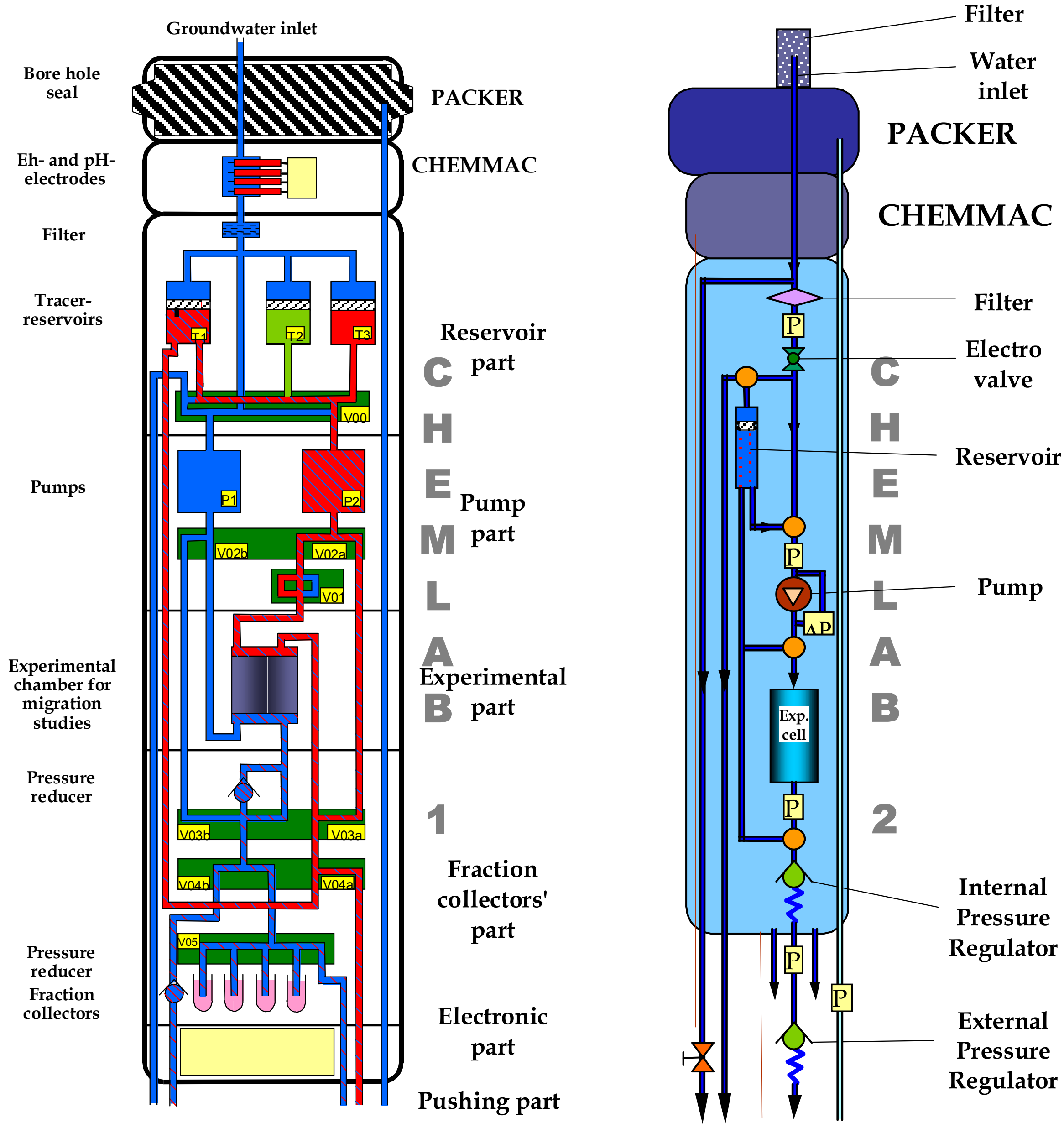


Figure 3-2 *Schematic illustration of CHEMLAB 1 and 2.*

Objectives

The objectives of the Radionuclide Retention (CHEMLAB) experiments are:

- to validate the radionuclide retention data which have been measured in laboratories by data from in situ experiments in the rock,
- to demonstrate that the laboratory data are reliable and correct also at the conditions prevailing in the rock, and
- to decrease the uncertainty in the retention properties of relevant radionuclides.

Experimental concept

CHEMLAB is a borehole laboratory built in a probe, in which migration experiments can be carried out under ambient conditions regarding pressure and temperature and with the use of the formation groundwater from the surrounding rock.

Initially one "all purpose" unit was constructed in order to meet any possible experimental requirement. This unit CHEMLAB 1 has been used for the "diffusion in bentonite" experiments and will now be used for similar experiments including the effects of radiolysis. Others to follow are:

- migration from buffer to rock,
- desorption of radionuclides from the rock, and
- batch sorption experiments.

The CHEMLAB 2 unit is a simplified version of CHEMLAB 1, designed to meet the requirements by experiments where highly sorbing nuclides are involved. These are:

- migration of redox sensitive radionuclides and actinides,
- radionuclide solubility, and
- spent fuel leaching.

New results

The results from experiments with diffusion in bentonite have been evaluated and the reported in SKB Technical Report 01-14. Diffusivity and porosity have been evaluated for Sr, Cs, Co, TcO_4, and I. The results are in accordance with previous findings.

The first experiment carried out in CHEMLAB-2 was the migration of actinides, americium, neptunium and plutonium, in a rock fracture. Due to a failure in the CHEMLAB 2 unit the experiment was stopped in advance. The results obtained will be reported by Institut für Nuklear Endsorchung in Karlsruhe, INE.

Planned work

The next actinide migration experiment will start in October in CHEMLAB 2.

Experiment with radiolysis is planned to also start in October in CHEMLAB 1.

3.4 Matrix Fluid Chemistry

Background

Knowledge of matrix fluids and groundwater from rocks of low hydraulic conductivity will complement the hydrogeochemical studies already conducted at Äspö, for example, matrix fluids might contribute significantly to the salinity of deep formation groundwater. It will also provide a more realistic chemical input to near-field performance and safety assessment calculations, since deposition of spent fuel will be restricted to rock volumes of similar hydraulic character.

Objectives

The main objectives of the task are:

- to determine the origin and age of the matrix fluids,
- to establish whether present or past diffusion processes have influenced the composition of the matrix fluids, either by dilution or increased concentration,
- to derive a range of groundwater compositions as suitable input for near-field model calculations, and
- to establish the influence of fissures and small-scale fractures on fluid chemistry in the bedrock.

Experimental concept

The experiment has been designed to sample matrix fluids from predetermined, isolated borehole sections. The borehole was selected and drilled on the basis of: a) rock type, b) mineral and geochemical homogeneity, c) major rock foliation, d) depth, e) presence and absence of fractures, and f) existing groundwater data from other completed and on-going experiments at Äspö. Special equipment has been designed to sample the matrix fluids ensuring: a) an anaerobic environment, b) minimal contamination from the installation, c) minimal dead space in the sample section, d) the possibility to control the hydraulic head differential between the sampling section and the surrounding bedrock, e) in-line monitoring of electrical conductivity and uranine content, f) the collection of fluids (and gases) under pressure, and g) convenient sample holder to facilitate rapid transport to the laboratory for analysis.

Migration of matrix fluids will be facilitated by small-scale fractures and fissures. Therefore the matrix fluid chemistry will be related to the chemistry of groundwaters present in hydraulically-conducting minor fractures ($K= 10^{-10}$-$10^{-9} ms^{-1}$), since it will be these groundwaters that may initially saturate the bentonite buffer material.

New results

The work during the period has been focussing on reporting, sampling matrix fluids from the sectioned-off borehole KF0051A01 in October, and preparation of the final workshop to be held on October 17th to18th in Stockholm.

Present status of reporting

Fluid inclusions

- **University of Waterloo:** Completed; final check before ITD publication
- **University of Bern:** Completed; final check before ITD publication

- **Kivitieto and Stockholm University:** Completed; draft report available
- **Stockholm University:** Synthesis on-going; draft in time for October Workshop

Petrophysical studies

- **Terralogica:** Completed; ITD-01-03 'Porosity and density measurements on Samples from Drillcore KF0051A01'

Crush/leach experiments

These have been partially reported in the status report IPR-00-35, published in May 2001. A synthesis of the work by the Universities of Bern and Waterloo is being carried out by the University of Bern and should be available for the October Workshop.

Hydraulic character of the rock matrix

- **Geosigma:** Completed; final check before ITD publication

On-going Studies

Äspö Diorite fracture: In- and out-diffusion studies

- **Terralogica:** Pilot study to evaluate the potential of separating matrix mineral and quartz fractions for chemical and isotopic analysis. If successful, there is the possibility of analysing rock slices representing a profile across a fine fracture/fissure in the Äspö diorite close to the borehole section sampled for matrix fluids. The objective is to assess the nature of in- and out-diffusion processes around the fracture/fissure using U-decay series, ^{11}B, ^{37}Cl and strontium isotopes.

Scoping analyses to be presented at the October Workshop.

Pore water leaching

- **University of Bern:** Drillcore leaching studies on Ävrö granite under laboratory conditions; sample was collected from the rock-stress borehole in 'F' Tunnel. The experiment is based on the diffusional exchange of a solution of known composition with the rock pore water. The final equilibrated solution will be analysed for its chemical and isotopic composition. This should provide direct input into helping to characterise the matrix fluid chemistry.

Status to be presented at the October Workshop.

Crush/leach experiments

- **University of Waterloo:** As part of the overall Äspö hydrochemical interpretation of ^{37}Cl isotope signatures, three drillcore sections representing varying lithologies are being crushed and leached and the leachates analysed for ^{37}Cl. It is hoped that these data may have some direct/indirect input to the matrix fluid studies.

Results to be presented at the October Workshop.

Permeability experiment

- **University of Waterloo:** Still on-going after 2 years and still no indication of matrix fluid extraction.

Results to be presented at the October Workshop.

Planned activities

Sampling and analysis of matrix fluid

Directly prior (i.e. October 15th to16th) to the October Workshop (October 17th to18th) both borehole sections (Sections 2 and 4) will be opened, sampled and analysed. Expertise from Mont Terri, Switzerland, will be consulted for planning and execution of the sampling (University of Bern).

Äspö Diorite fracture: In- and out-diffusion studies

- **University of Bern, University of Waterloo, Terralogica:** Depending on the outcome of the Pilot Study mentioned above, plus funding possibilities, the complete suit of samples will be analysed and interpreted.

Timetable

- Project is scheduled to be completed by December 31, 2001.
- Final reporting of the project is scheduled for June, 2002.

3.5 Colloids

Background and objectives

Colloids are small particles with a size in the range of 10^{-3} to 10^{-6} mm, which are of interest for the long-term safety of a deep repository because of their potential for transporting radionuclides in the groundwater system from the repository depth to the biosphere.

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

It has been argued that e.g plutonium is immobile owing to its low solubility in groundwater and strong sorption onto rocks. Field experiments at the Nevada Test Site (NTS), where hundreds of underground nuclear tests were conducted, indicate, however, that plutonium is associated with the colloidal fraction of the groundwater. The $^{240}Pu/^{239}Pu$ isotope ratio of the samples taken downstream the NTS have established that an underground nuclear test 1.3 km north of the sample site is the origin of the plutonium (Kersting et al., 1999). Based on these results SKB decided year 2000 to initiate the project COLLOID at Äspö HRL to study the stability and mobility of colloids. The objectives of the colloid project are to:

- study the role of bentonite clay as a source for colloid generation,
- verify the colloid concentration at Äspö-HRL, and
- investigate the potential for colloid formation/transport in natural groundwater concentrations.

Experimental concept

The experimental concepts for the Colloid project are: laboratory experiments, background measurements, borehole specific experiment and possibly fracture specific experiment. These concepts are described below:

Laboratory experiments: The role of the bentonite clay as a source for colloid generation at varying water salinities has been studied in a laboratory experiment performed at KTH (Royal Institute of Technology). The results from the laboratory test (Wold and Eriksen, 2001) indicate that the bentonite colloid formation is strongly correlated with the ionic strength of the solution. Very low concentration of colloids formed in suspensions with ionic strengths 0.1 and 1 M. This is valid for experiments both with dry (Figure 3-2) and wet prepared bentonite. At 0 and 0.01 M colloids were formed in the experiments with wet prepared bentonite. In the case with dry prepared bentonite where the solutions are shaken initially, the sedimentation is so slow that no measurement was possible. At high ionic strength the colloid formation is minor. At ionic strength 0.01 M, where colloid formation is favourable, the colloid formation seems to increase when using a temperature of 60 ° C for the solution compared with a temperature of 20 ° C. The experiment has been extended to investigate in detail the chemical changes and the size distribution associated with colloid generation. These results will be compared with the parallel experiments conducted at the company Clay Technology AB. In addition a “washed” bentonite is used in order to avoid interference from the clay on the solution. The chemical changes in the solution and formation of small particles are studied in detail during the time period August-December 2001.

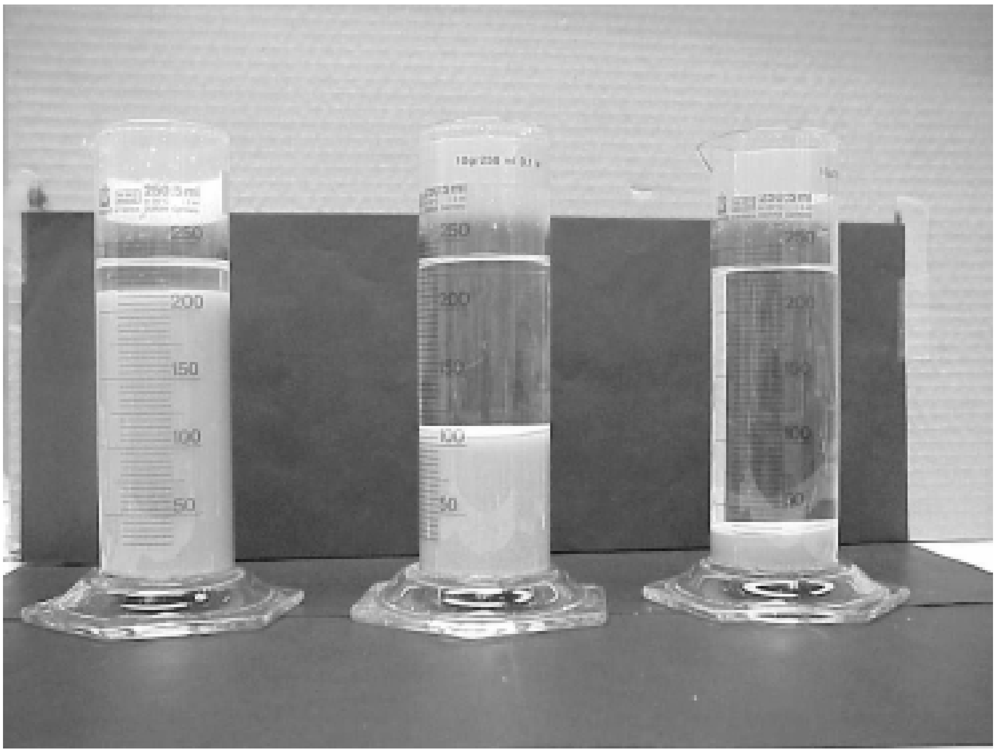


Figure 3-3 *The salinity of the water affects the colloid generation. The experiment shows different degrees of sedimentations of bentonite clay dependent of the ion content of the water. The experimental conditions: Dry bentonite, 10 g/250 ml in contact with 0.01, 0.1 and 1 M solution at 20 °C after 1.5 weeks (Wold and Eriksen, 2001).*

Background measurements: The background colloid concentration associated with the different water types found at Äspö will be sampled at 8 specific borehole locations (Figure 3-4) during the time period October-November 2001. The work will be performed by a SKB-team (Sweden), INE-team (Germany) and a POSIVA-team (Finland). The colloid content will be measured on-line from the boreholes by using a modified laser based equipment LIBD (Laser-induced Breakdown-Detection) which has been developed by INE in Germany (Figure 3-5). The advantage is that the resolution of this equipment is higher compared with standard equipment. It is therefore possible to detect the colloid contents at much lower concentrations than previously possible. The outcome of these measurements will be compared with standard type of measurements such as particle counting by using Laser Light Scattering (LLS) at KTH and at INE. Standard type of filtration performed on-line/at-line at the boreholes are used in order to be able to compare/transform these results to all earlier results. In addition samples of groundwater, microbes and humic material will be collected from the selected boreholes in order to judge the contribution from these on the measured colloid concentration.

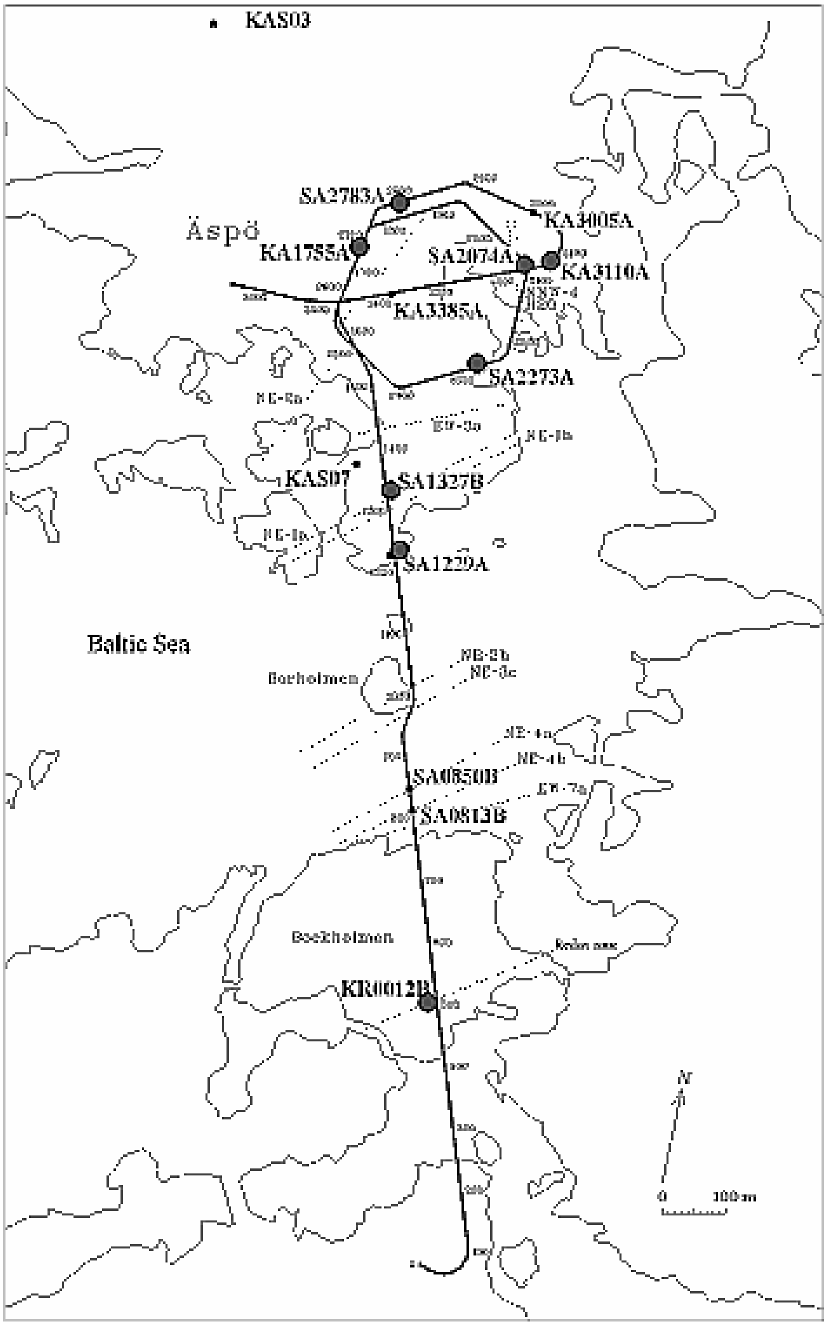


Figure 3-4 Boreholes (large black circles) to be sampled for colloids along the Äspö tunnel.

***Figure 3-5** The equipment for Laser-induced Breakdown-Detection (LIBD) of colloids is installed in a van in order to allow mobility and on-line measurements in boreholes.*

Borehole specific experiment: The aim of the experiment is to determine the colloid generation properties of the bentonite clay in contact with the prevailing groundwater conditions at Äspö. For the borehole specific measurements 3 boreholes along the Äspö tunnel will be investigated. The boreholes are selected so that the natural variation in the groundwater composition at Äspö is covered. The groundwater is led to a pressure vessel with bentonite clay and the colloid content is measured prior and after the pressure vessel (see Figure 3-6) by using LIBD/LLS and conventional filtering.

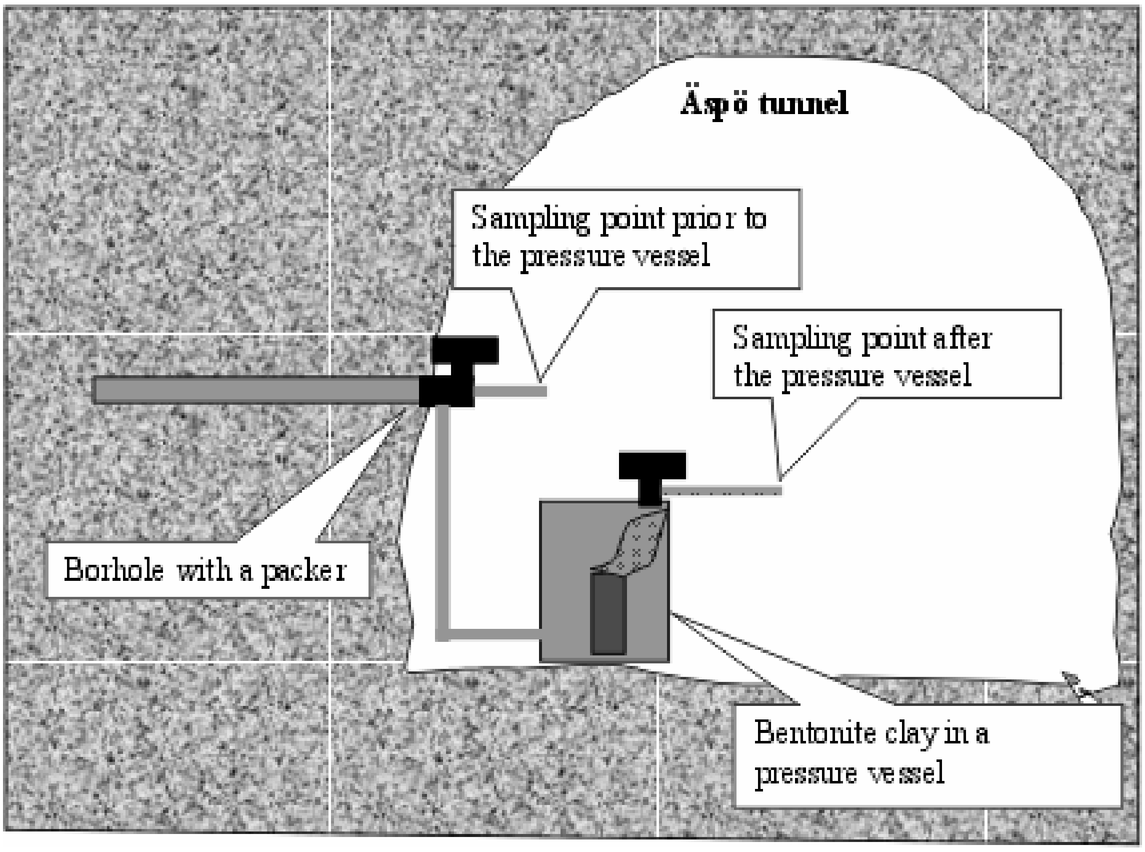


Figure 3-6 *The groundwater is led from the borehole to a pressure vessel containing bentonite clay. The colloid content is measured prior and after the pressure vessel in order to determine the colloid generation potential of the bentonite.*

<u>Fracture specific experiment:</u>

This experiment is dependent of the results from the previous experiments. A final judgement will therefore take place during the spring of 2002. For the fracture specific measurements two nearby boreholes in the Äspö HRL will be selected for the experiment, which tentatively is conducted during the time period January-June 2003. One of the boreholes will be used as an injection borehole and the borehole downstream will be used as a monitoring borehole. The boreholes intersect the same fracture and have the same basic geological properties. After assessing the natural colloid content in the groundwater bentonite clay will be dissolved in ultra pure water to form colloidal particles. The colloids are labelled with a lanthanide (i.e europium) and the fluid is labelled with a water conservative tracer. The mixture will be injected into the injection borehole (Figure 3-7). From the monitoring borehole the colloidal content will be measured with laser (LIBD/LLS), the water will be filtered and the amount of tracers will be measured.

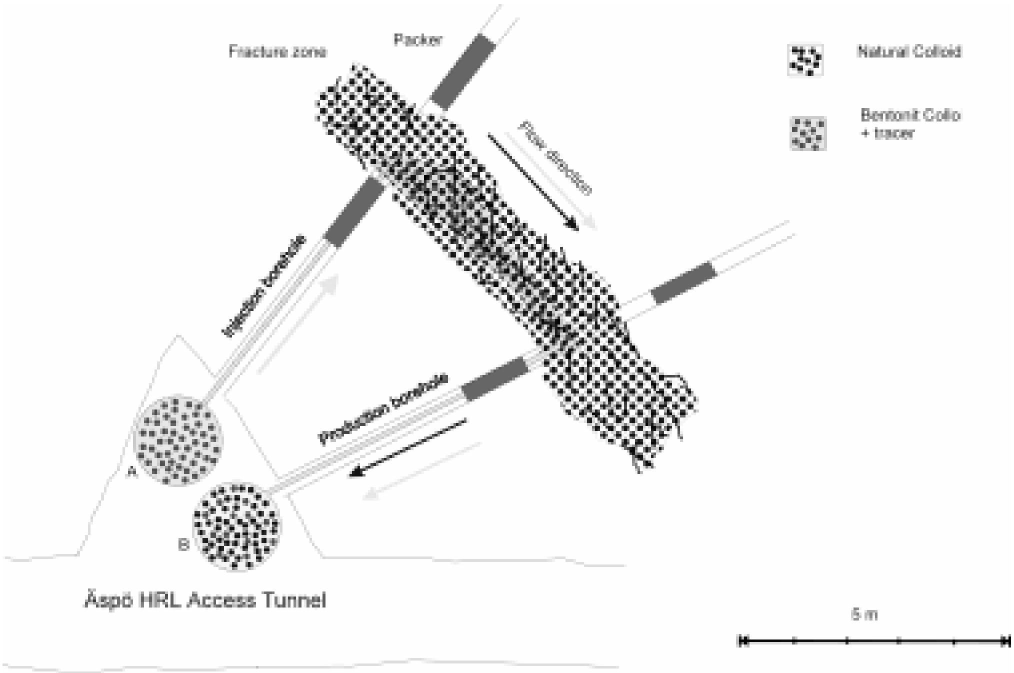


Figure 3-7 *Injection of bentonite colloids and monitoring of the injected and natural colloids in the production borehole.*

The result of interest is to monitor the changes in the colloid content prior and after the transport. The outcome of the experiment is used to check the calculations in the safety assessment reports (such as TR 91-50) and to use the results in future colloid transport modelling.

Time table

The project is conducted during the time period 2000-2003, and has the following time plan:

- laboratory tests during January-December, 2001,
- field measurements, background colloid content during October 2001 – November 2001,
- Borehole specific experiment during January-July 2002,
- fracture specific experiment during January-July 2003, and
- end of project in December 2003.

Ongoing and planned work

The scope of the work for 2001 contains planning, preparation work, laboratory tests and background measurements. The detail laboratory work is ongoing in order to investigate the chemical changes and size distributions of bentonite colloids. The planning for the background measurements have been performed during summer-autumn 2001 and the measurements will be performed during October-November 2001. The end of the year is used for evaluating the background measurements and to plan for the borehole specific experiment to be performed during January-July 2002. POSIVA, Finland decided in August 2001 to participate in the colloid project.

3.6 Microbe

Background

Microorganisms interact with its surroundings and in some cases greatly modify the characteristics of their environment. Several such interactions may have a significant influence on the performance of a deep repository. Planned studies at the MICROBE site concern:

- *bio-mobilisation of radionuclides*. To what extent can bacterial dissolution of immobilised radionuclides and production of complexing agents increase radionuclide migration rates?
- *bio-immobilisation of radionuclides*. What are the retention effects from microbial biofilms forming on groundwater conducting fracture surfaces and in the biosystems forming in ground surface outflow of groundwater.?
- *microbial corrosion of copper*. Bio-corrosion of the copper canisters, if any, will be a result of microbial sulphide production. Two important questions arise: Can sulphide-producing microbes survive and produce sulphide in the bentonite surrounding the canisters? Can microbial sulphide production in the surrounding rock exceed a performance safety limit?
- *microbial effects on the chemical stability*. Microorganisms can have an important influence on the chemical condition in the groundwater. Especially, they may execute reactions that stabilise the redox potential in groundwater at a low and, therefore, beneficial level for the repository. Another very important bio-effect is the microbial reduction of oxygen with hydrogen, methane and organics carbon. In situ data are required for proper modelling.

These tasks have been addressed in a range of projects, of which several are ongoing. Important conclusions have been obtained based on laboratory and field data. While some results seem very solid with general applicability, others are pending inspection at in situ conditions. This is especially true for data generated at the laboratory only. In situ generated data must be obtained for microbial activities in the far- and near-field environment at realistic repository conditions. This can only be achieved at an underground site, developed for microbiological research, using circumstantial protocols for contamination control during drilling and operation. An in situ site allows experiments at high pressure with a proper gas content and biogeochemical situation.

This is of great importance for modelling true subterranean microbial activity and very difficult to obtain in vitro. A site that fulfils those requirements was established in May 1999 in the J-niche at Äspö HRL, 450 m underground, and three test holes were drilled there.

Objectives

The major objectives for the MICROBE site are:

- to provide in situ conditions for the study of bio-mobilisation of radionuclides,
- to present a range of conditions relevant for the study of bio-immobilisation of radionuclides,
- to enable investigations of bio-corrosion of copper under conditions relevant for a high level radioactive waste repository, and
- to offer proper circumstances for research on the effect of microbial activity on the long-term chemical stability of the repository environment.

Experimental concept

The MICROBE site consists of three core drilled holes, KJ0050F01, KJ0052F01 and KJ0052F03, which intersect water conducting fractures at 12.7, 43.5 and 9.3 m respectively. Each borehole is equipped with metal free packer systems that allow controlled sampling of respective fracture. An underground laboratory cabin is installed close to the boreholes and is equipped with a large anaerobic chamber and ready for in-line measurements. Tubings and circulation pumps connect the boreholes with the laboratory so that microbial effects on the mobility of radionuclides, microbial effects on the chemical stability of a repository and in situ copper bio-corrosion experiments can be conducted.

A satellite site have been opened in the Äspö tunnel for experiments related to radionuclide immobilisation processes. A side vault at tunnel length 2200 m, at 296 m depth will be equipped with open flow channels feed from a packed-off borehole used earlier for rock stress measurements. Radionuclide retention by the biological iron oxide systems (BIOS) commonly forming at any groundwater outflow will be investigated. Earlier results indicated a significant metal retention effect from the biological part of naturally occuring iron oxides.

New results and activities during 2001

Laboratory facilities have been installed, including computer, cupboards and laboratory benches. A circulation pump has been installed on KJ0052F01 and trace experiments are ongoing. Such experiments intend to clarify the hydraulic flow conditions in the fractures intersected by the site boreholes. Biofilm reactors are operating from September on KJ0052F03 with the intention to assay the biofilm forming potential in the MICROBE site groundwaters at different pressures. A field reductive gas analytical instrument has been ordered. This instrument will enable analysis of hydrogen on ppb level, and of methane and carbon dioxide on ppm levels. Such measurements are necessary for the study of microbial effects on the chemical stability.

A first series of in situ copper corrosion experiments were initiated in June using groundwater from KJ0052F03 and $^{35}SO_4$. This experimental series was terminated in mid September. Measurements and evaluations are ongoing at the laboratory in Gothenburg.

Radionuclide retention and mobility experiments have been initiated, using biofilms from the site and BIOS from the tunnel, especially site 2200m.

3.7 The Äspö Task Force on modelling of groundwater flow and transport of solutes

Background

The Task Force shall be a forum for the organisations supporting the Äspö Hard Rock Laboratory Project to interact in the area of conceptual and numerical modelling of groundwater flow and solute transport in fractured rock. In particular, the Task Force shall propose, review, evaluate and contribute to such work in the project. The work within the Task Force is being performed on well defined and focused Modelling Tasks. The table show on-going tasks

Task No	Modelling Issues	Cooperating organisations
4E	Modelling of tracer test with sorbing tracers in one fracture.	ANDRA, BMWi, CRIEPI, DOE, JNC, NAGRA, POSIVA, SKB
4F	As Task 4E but with half the flowrate.	ANDRA, BMWi, CRIEPI, DOE, JNC, NAGRA, POSIVA, SKB
5	Compare and integrate hydrology and chemistry through modelling of Äspö tunnel drainage impact on hydraulic and chemical parameters.	ANDRA, BMWi, CRIEPI, ENRESA, JNC, POSIVA, SKB
6	Apply PA[1] and SC[2] approaches for the same tracer experiment and PA boundary conditions. Aims at identifying relevant conceptualisations for longer term PA predictions and identify site characterisation data requirements to support PA calculations.	ANDRA, CRIEPI, JNC, POSIVA, SKB (1) PA: Performance Assessment (2) SC: Site Characterization
6A	Model and reproduce selected TRUE-1 tests with a PA model and/or a SC model. This task provides a common reference platform for all SC-type and PA-type modelling to be carried out as the project progresses. This ensures a common basis for future comparison.	As above

Task No	Modelling Issues	Cooperating organisations
6B	Model selected PA cases at the TRUE-1 site with new PA relevant (long term/base case) boundary conditions and temporal scales. This task serves as a 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.	As above

New results

Work has progressed with the reporting of Task 4 Overall Evaluation (T4OE), Task 5 Summary, Task 5 Review and modelling in Task 6A and 6B. Interim results from all of the forementioned were presented at the 15th International Task Force meeting which was held at Goslar in Germany. In conjunction with this a workshop on Task 6C (construction of structural modell) was held as well.

Planned work

For the next quarter work will continue with modelling for Task 6B and reporting within Task 4OE and Task 5 Summary report and Review report.

4 Demonstration of technology for and function of important parts of the repository system

4.1 General

Stage goal 4 of the 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, is conducted under realistic conditions and at appropriate scale. A number of large-scale field experiments and supporting activities are therefore conducted in the Äspö HRL. The experiments focuses on different aspects of engineering technology and performance testing, and will together form a major experimental program.

With respect to *technology demonstration* important overall objectives of this program are:

- to furnish methods, equipment and procedures required for excavation of tunnels and deposition holes, near-field characterisation, canister handling and deposition, backfilling, sealing, plugging, monitoring and also canister retrieval, and
- to integrate these methods and procedures into a disposal sequence, that can be demonstrated to meet requirements of quality in relation to relevant standards, as well as practicality.

With respect to *repository function*, objectives are:

- to test and demonstrate the function of components of the repository system, and
- to test and demonstrate the function of the integrated repository system.

4.2 The Prototype Repository

Background

Particular aspects of the repository concept have previously been tested in a number of in situ and laboratory tests. There is a need to test and demonstrate the integrated function of the repository in full scale and with state-of-the-art technology. It is envisaged that this technology can be tested, developed and demonstrated in the Prototype Repository. The design, construction and testing of the Prototype Repository is aimed at a simulated deposition sequence starting from detailed characterisation of the host rock to re-saturation of the backfilled deposition holes and tunnel. The

Prototype Repository experiment is located in the inner part of the TBM tunnel at 450 m level and will include 6 deposition holes in full scale.

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, and
- to develop and test appropriate engineering standards, quality criteria and quality systems.

The Prototype Repository will be a long-term test divided into two sections, separated by a concrete plug. One plug will also separate the the test from the rest of the Äspö HRL. One section, the outer one – Section II, is planned to be decommissioned after about 5 years (the bentonite buffer saturated) and the second section, the inner one – Section I, after approximately 20 years.

New results

The Project Group, consisting of basically Task Leaders has met three times during the period. The objective is to plan the activities for Section II that are scheduled to take place directly after the completion of Section I. The project management core group continued to have planning meetings weekly for discussion and decision on activities during the following weeks. Those meetings are documented but considered to be internal meetings.

All instruments in buffer and boreholes, except for temperature gauges in one borehole, have been installed as well as bentonite blocks and canisters in Section I. The one borehole, intended for temperature measurement, encountered a water-bearing fracture and had to be grouted. A new borehole has drilled instead and equipped with the temperature gauges. Instruments placed in the backfill are successively installed as the backfilling proceeds. The instruments are also successively connected to the data acquisition system in the G-tunnel.

Backfilling is ongoing with intermediate stops for removing of plastic protection sheets and filling with bentonite pellets in the slot between the rock and the bentonite blocks. The backfill front passed the third deposition hole on the 10^{th} of October.

Heaters have been turned on in the canisters in the three first deposition holes. The initial power is 1800 W, which will be decreased in accordance to the decay curve of the spent fuel, i.e. with 30 W per canister and year the first 5 years and 24 W per canister and year the 5 years following thereafter.

A decision has been taken to use self-compacting concrete for the tunnel-plugs, which will facilitate the construction.

The following EC Milestones are completed:

- M1 - Project workplan and plan for quality assurance procedure,
- M2 - Sensors and sampling equipment for installation in buffer, backfill, rock and plug in section I are delivered to Äspö HRL, and
- M5 - Selection of THMCB-models to be used

Deliverables coupled to the EC project, which have been completed during the period are:

- D2: Instrumentation of buffer and backfill in Section I,
- D4: Instrumentation for hydraulic measurements in Section I,
- D7: Instrumentation for gas and water sampling in buffer and backfill in Section I,
- D9: Instrumentation for resistivity measurements in buffer, backfill and rock in Section I,
- D12: Preparation of deposition holes prior to emplacement of buffer and canister in Section I, and
- D33: Selection of THMCB models.

Planned work

The last deposition hole will be filled with bentonite pellets and subsequently covered with backfill material. Instrumentation and backfilling of Section I will be finalised before December 2001. Construction of the retaining wall and the plug is planned to be finalised before the 21^{st} of December so that the curing can take place mainly during the Christmas holidays.

In order to make space and shelter for terminal boxes, rock is excavated in the tunnel wall between the lead-through holes.

Detailed planning for execution of Section II will continue. Novelties are:

- design of a lead-through in the outer plug,
- additional measuring of selected joints adjacent to the deposition hole for determination of joint stiffness values,
- drilling of borehole for reference to hydro measurements,
- measuring of inflow to deposition holes # 5 and #6 through diaper measurements,
- measuring of inflow to section II through pumping in the slot for the outer plug, and
- measuring of inflow from the G-tunnel over measuring walls.

No Deliverable and milestone coupled to the EC project is due during the fourth quarter of 2001, but EC is requesting:

- annual report on scientific and technical achievements covering the first year - September 2000-August 2001 - of the project,
- second 6-month presentation of progress in relation to work and time plans and
- first annual report on incurred costs.

These EC reports are due two months after the end of the period they cover.

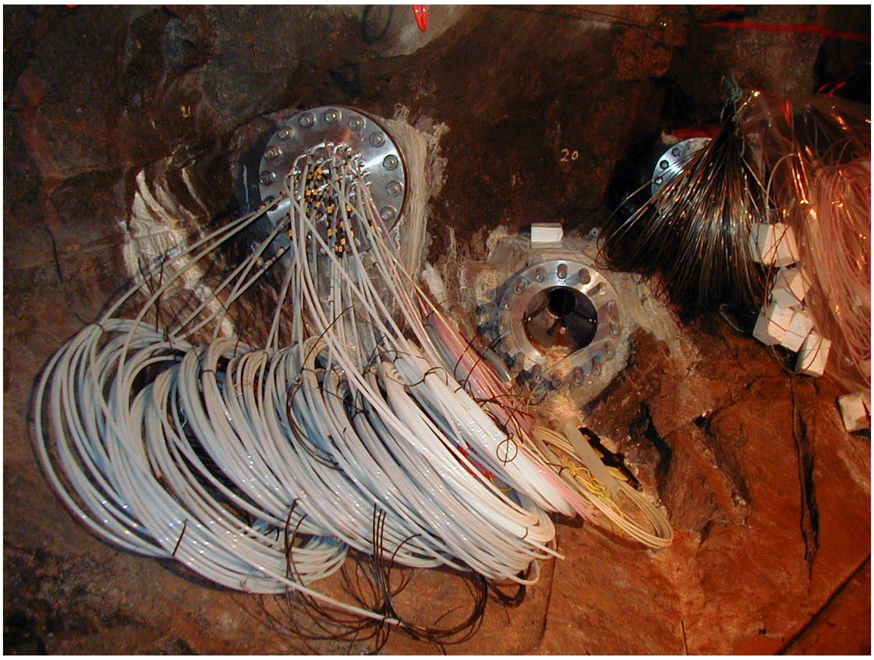


Figure 4-1 *Installed lead-throughs with cables and instruments in the Prototype Repository tunnel ready to be placed in the bentonite blocks in deposition hole # 3. The empty lead-through is for the electrical cables to the heaters and the fibre optical cables attached to the surface of the canister.*

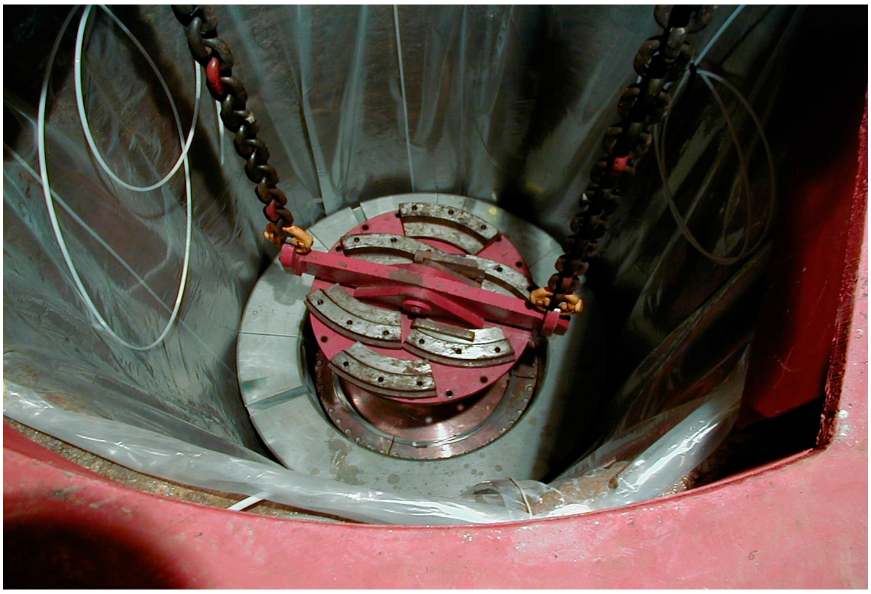


Figure 4-2 *The canister is in place inside the column of bentonite cylinders in hole # 2. The gripping device has been made free from the lid and is being hoisted. The plastic, covering the walls, is installed for protection of the bentonite because of the long time between installation of blocks and backfilling of the tunnel. It will be removed before the slot is filled with bentonite pellets.*

4.3 Backfill and Plug Test

Background

The *Backfill and Plug Test* includes tests of backfill materials and emplacement methods and a test of a full-scale plug. It is a test of the integrated function of the backfill material and the near field rock in a deposition tunnel excavated by drill and blast. It is also a test of the hydraulic and mechanical functions of a plug. The test is partly a preparation for the Prototype Repository.

The entire test setup with backfilling, instrumentation and building of the plug was finished by the end of September 1999 and the wetting of the 30/70 mixture through the filter mats started in late November 1999. Wetting of the backfill from the filter mats and the rock has continued during the years 2000 and 2001.

New results

Figure 4-3 shows an illustration of the experimental set up. The following main events and results from the third quarter of 2001 can be mentioned:

- The interface between the concrete plug and the rock was grouted in the last week of June as reported in the latest status report The grout was allowed to rest during July. The permeable mat was then refilled and the water pressure behind the plug re-established.

- Mesurement of water leaking from the mat through the rock and plug inteface shows a decrease in leakage by a factor 4 compared with the leakage before grouting.

- Water saturation, water pressure and swelling pressure in the backfill and water pressure in the surrounding rock have been continuously measured and recorded. Figure 4-4 and Figure 4-5 show example of measured results. Figure 4-4 shows the water pressure in the rock measured in the short bore holes about 30 cm below the floor of the tunnel. The strong increase at the end of the diagram is the result of the recent water pressure increase after grouting. Figure 4-5 shows the suction (negative pore water pressure) measured in the centre of different layers of the 30/70 mixture. Only the sensors placed in the first layers (about 200 mm from the mat) have been clearly water saturated. A slow decrease in suction in transducers W17 and W20 (about 400 mm from the mat) started in September 2000 and has continued ever since. A small decrease in the central transducers (about 600 mm from the mats) also seems to have started.

Planned work

In the last quarter of 2001 the water saturation will continue with consecutive measurement of water inflow, water pressure, total pressure and wetting.

A stepwise increase in water pressure in the permeable mats will start, in order to reduce the time to reach saturation.

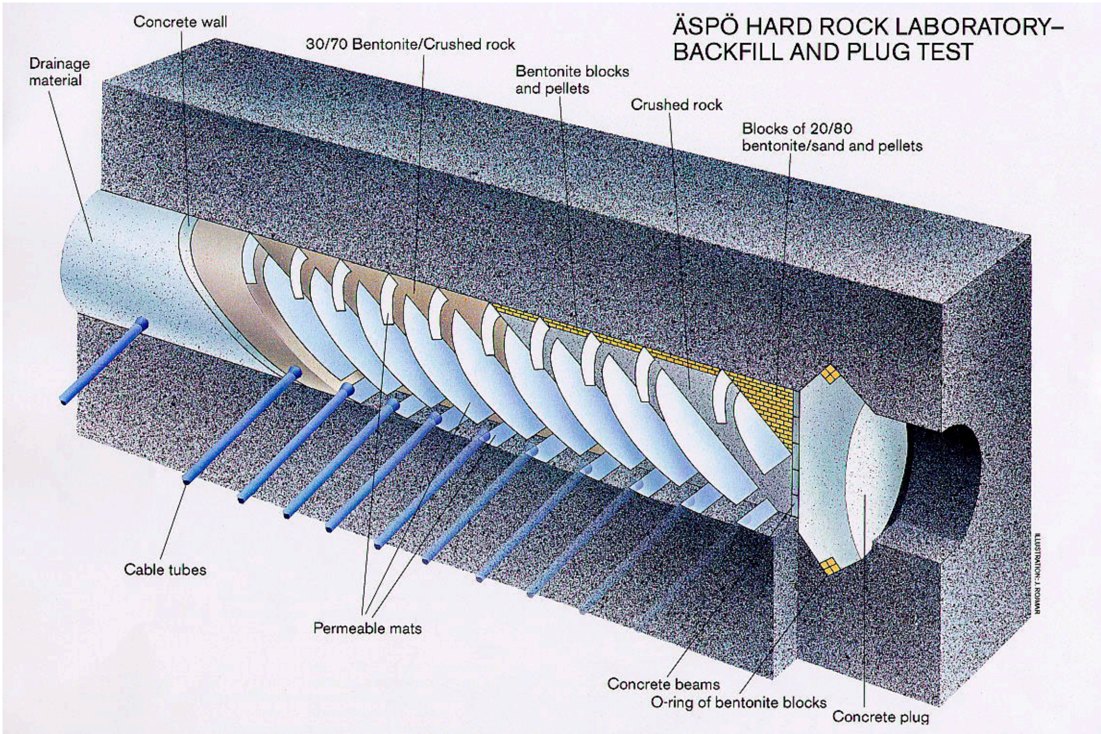


Figure 4-3 *Illustration of the experimental setup of the Backfill and Plug Test*

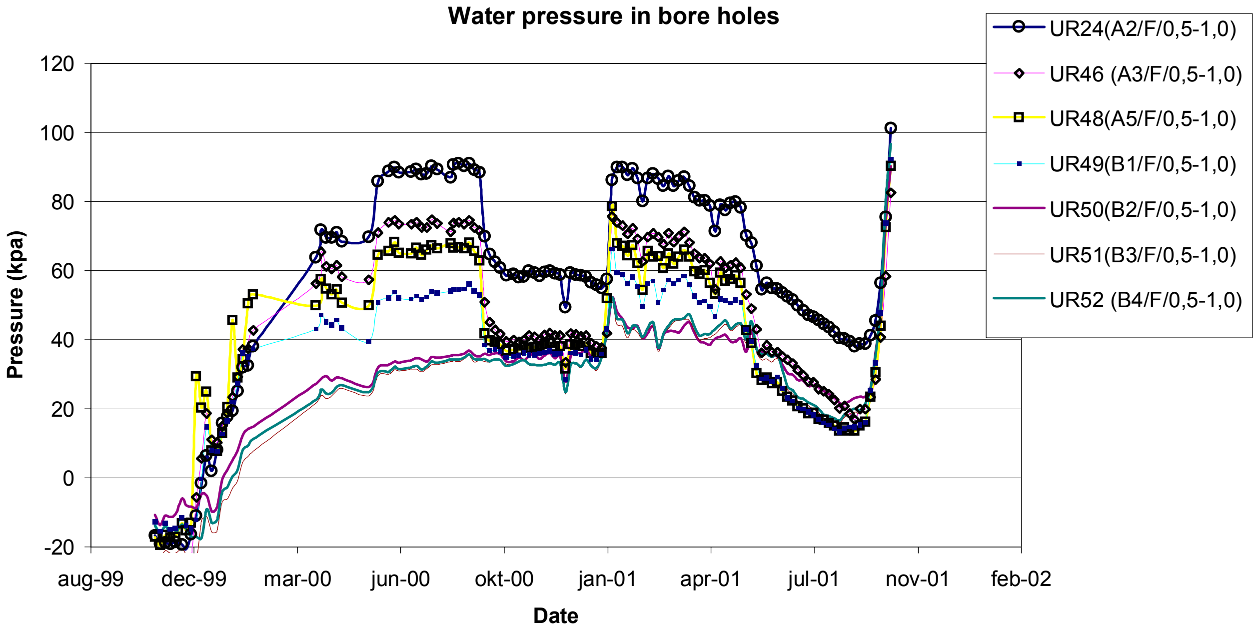


Figure 4-4 *Water pressure measured in the rock 300 mm below the floor. UR24, 46, 48 and 49 are placed in the 30/70 sections and the rest in the 0/100 sections*

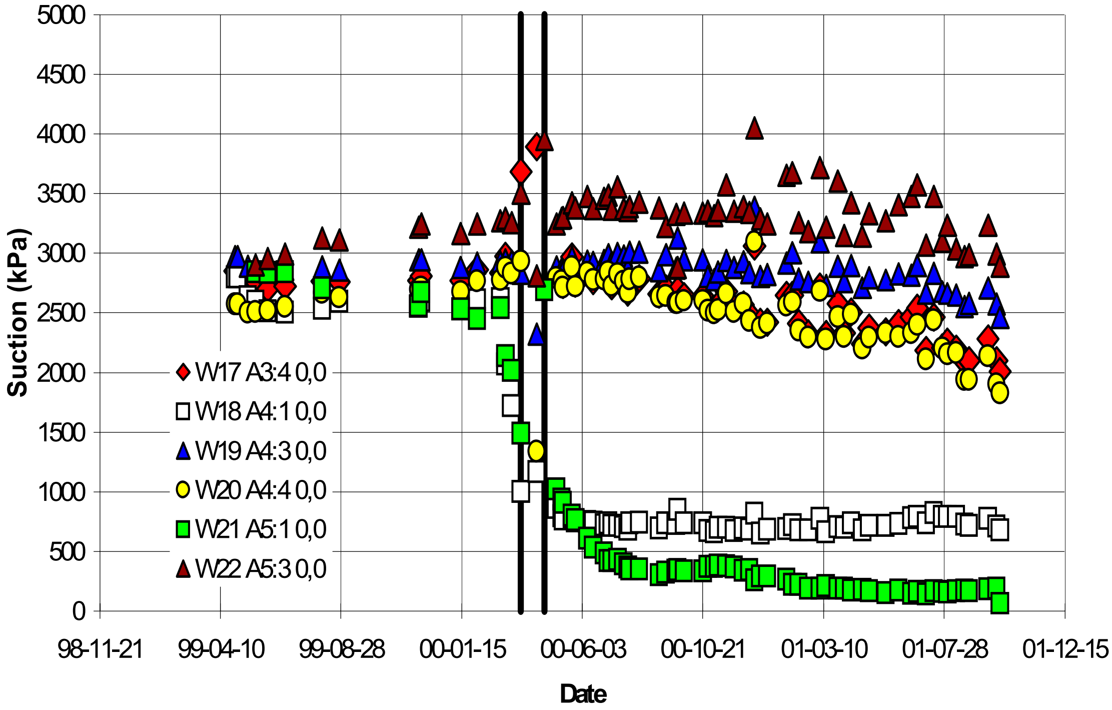


Figure 4-5 *Suction measured in the centre of different layers in the 30/70 backfill. W18 and W21 are placed in the first layer about 200 mm from the mats. W17 and W20 are placed 400 mm and W19 and W22 are placed 600 mm from the mats.*

4.4 Canister Retrieval Test

Background

SKB's strategy for the disposal of canisters with the spent nuclear fuel is based on an initial emplacement of about 10% of the number of canisters followed by an evaluation of the result before any decision is made on how to proceed. One outcome can be that the result is not accepted and that the canisters have to be recovered. In such case some, if not all, canisters can be surrounded by a saturated and swollen buffer, which holds the canister in such a grip that the canister can not just be pulled up. First the bentonite grip has to be released, for which two alternative principles can be applied; remove or shrink the bentonite. Then the canister is free to be lifted up to the tunnel and placed in a radiation shield. A concern is any type of radioactive contamination that the bentonite has been exposed to.

The retrieval test is aiming at demonstrating the readiness for recovering of disposed canisters also after the time when the bentonite has swelled. The process covers the retrieval up to the point when the canister is safely resting in a radiation shield and ready for transport to the ground surface. The test is separated into two phases; Design and Set-up, and the actual Retrieval Test.

The installation of the buffer material and the canister with instrumentation and heaters started mid September 2000 and was completed during October 2000 including the in situ casting of the concrete plug on top of the bentonite buffer. The heaters were turned on and the artificial watering of the buffer material started in October, and the operation of the Canister Retrieval Test is planned to continue for some 4 to 5 years, until the bentonite buffer has been fully saturated. The concrete plug on top of the bentonite buffer is held in position with help of 9 wire ropes that are secured in the rock by grouting. The wire ropes are designed for a maximum swelling pressure of 5 MPa from the buffer material.

The experimental set up is shown in Figure 4-6.

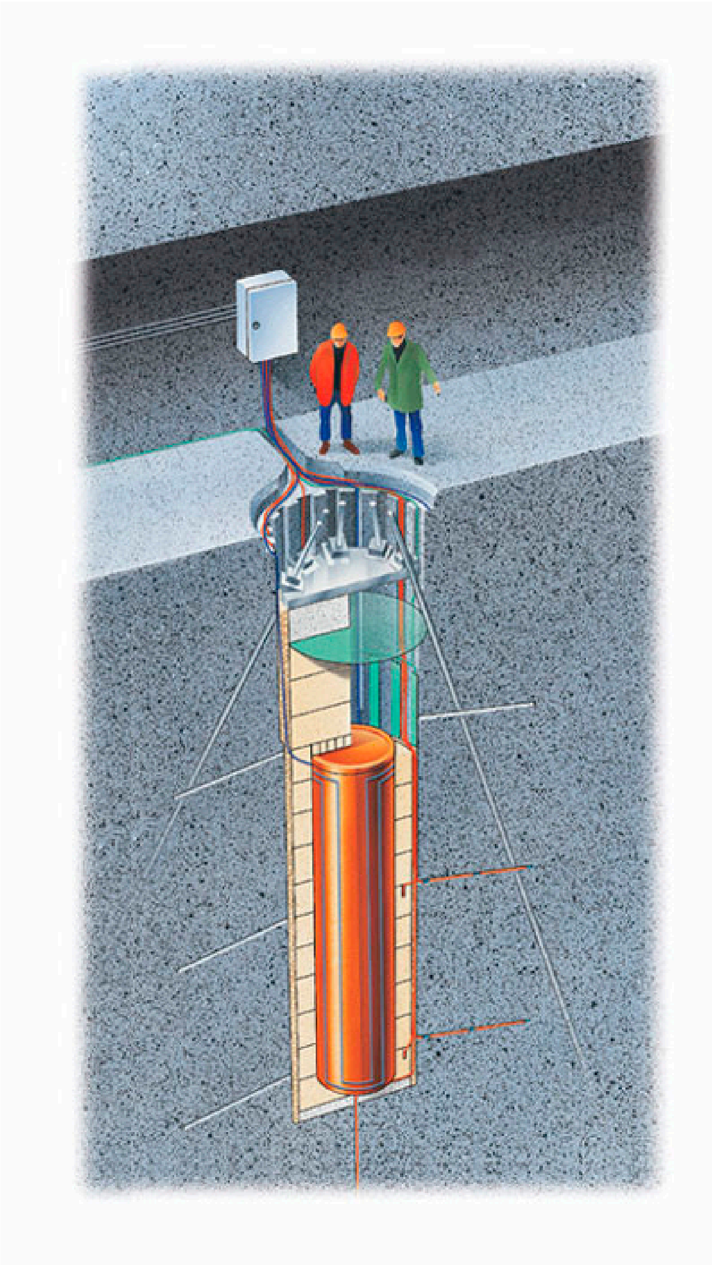


Figure 4-6 *Experimental set up. The horizontal holes are equipped with thermocouples and the sub-vertical holes indicate the anchoring ropes. Instruments in the buffer are placed on the same level as the three levels for thermocouples in the rock. Stripes of permeable mats are attached to the rock wall and fibre optical cables for temperature measurements are attached to the surface of the canister.*

New results

The artificial water supply to the surrounding permeable mats has continued and the flow registered. The final thermal load of 2600 W in the canister has been on since February 13th, and the sensor readings have continued.

No new data report has been published, because of the heavy focus on the installation of the Prototype Repository; the next one will cover six months compared to three during normal conditions.

The general conclusion is that the measuring system and transducers have continued to work well.

Planned work

The plan is to continue the artificial water saturation of the bentonite and to continue the registration of sensor readings. Some modelling may be initiated as the data are of interest to the modellers engaged in the Prototype Repository.

4.5 Long Term Test of Buffer Material (LOT)

Background

Bentonite clay has been proposed as buffer material in several concepts for HLW repositories. In the Swedish KBS3 concept the demands on the bentonite buffer are to serve as a mechanical support for the canister, reduce the effects on the canister of a possible rock displacement, and minimise water flow over the deposition holes.

The decaying power from the spent fuel in the HLW canisters will give rise to a thermal gradient over the bentonite buffer by which original water will be redistributed in parallel to an uptake of water from the surrounding rock. A number of laboratory test series, made by different research groups, have resulted in various buffer alteration models. According to these models no significant alteration of the buffer is expected to take place at the prevailing physico-chemical conditions in a KBS-3 repository neither during nor after water saturation. The models may to a certain degree be validated in long-term field tests. Former large scale field tests in Sweden, Canada, Switzerland and Japan have in some respects deviated from possible KBS-3 repository conditions and the testing periods have generally been dominated by initial processes, i.e. water uptake and temperature increase.

The present test series aims at validating models and hypotheses concerning physical properties in a bentonite buffer material and of related processes regarding microbiology, radionuclide transport, copper corrosion and gas transport under conditions similar to those in a KBS-3 repository. The expression ”long term” refers to a time span long enough to study the buffer performance at full water saturation, but obviously not ”long term” compared to the lifetime of a repository. The objectives may be summarised in the following items:

- data for validation of models concerning buffer performance under quasi-steady state conditions after water saturation, e.g. swelling pressure, cation transport and gas penetration,
- check of existing models concerning buffer-degrading processes, e.g. illitisation and salt enrichment,
- information concerning survival, activity and migration of bacteria in the buffer,
- check of calculation data concerning copper corrosion, and information regarding type of corrosion,
- data concerning gas penetration pressure and gas transport capacity, and
- information that may facilitate the realisation of the full-scale test series with respect to clay preparation, instrumentation, data handling and evaluation.

The testing philosophy for all tests in the series (Table 4-1) is to place prefabricated units of clay blocks surrounding heated copper tubes in vertical boreholes. The test series are performed under realistic repository conditions except for the scale and the controlled adverse conditions in three tests.

Table 4-1. Lay out of the ongoing Long Term Test series.

Type	No.	T °C	Controlled parameter	Time years
A	0	120<150	T, [K^+], pH, am	1
A	2	120<150	T, [K^+], pH, am	5
A	3	120<150	T	5
S	2	90	T	5
S	3	90	T	>>5

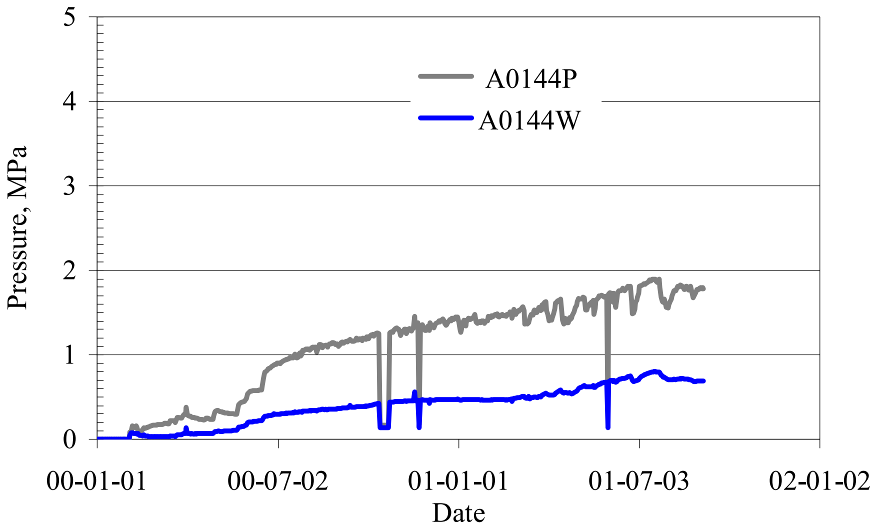
A	= adverse conditions	S	= standard conditions
T	= temperature	[K^+]	= potassium concentration
pH	= high pH from cement	am	= accessory minerals added

Adverse conditions in this context refer to high temperatures, high temperature gradients over the buffer, and additional accessory minerals leading to i.a. high pH and high potassium concentration in clay pore water. The central copper tubes are equipped with heaters in order to simulate the effect of the decay power from spent nuclear fuel. The heater effect are regulated or kept constant at values calculated to give a maximum clay temperature of 90°C in the standard tests and in the range of 120 to 150°C in the adverse condition tests. Test ”parcels” containing heater, central tube, clay buffer, instruments, and parameter controlling equipment are 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 will be extracted by overlapping core-drilling outside the original borehole. The water distribution in the clay will be determined and subsequent well-defined chemical, mineralogical and physical testing will be performed.

New results

The data acquisition concerning temperature, water pressure, total pressure, and moisture has in principle been well functioning. The results show that the water uptake is not completed in any of the 5 parcels. The A0 parcel seems to be closest to full saturation which is in accordance with the artificial water inlets at 3 levels in this parcel. However, the recorded maximum pressure is still significantly lower than expectation, and the pressure is in general increasing in all parcels Figure 4-7. Large differences between the parcels indicate significant differences in water supply from rock. Small temperature tendencies are visible and can be correlated to water uptake, rock heating, and temperature changes in the tunnel due to seasonal changes.



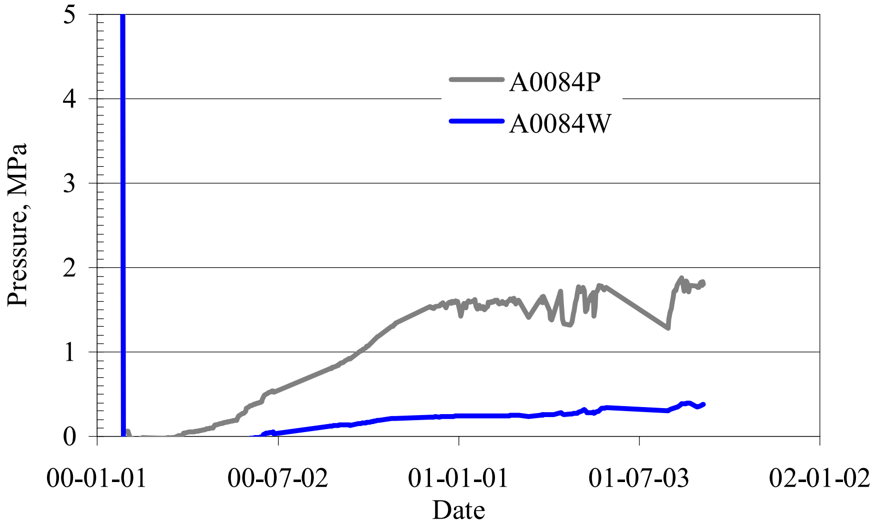


Figure 4-7 *Pressure data from the lower part in Parcel A0 as measured by optical sensor technique (lower diagram), and from the central part as measured by vibrating wire technique (upper diagram). Upper curves show total pressure and the lower ones show water pressure, respectively.*

Planned work

A project meeting was held at Äspö on the 1st of October, at which it was finally decided to terminate the A0 experiment. Drilling is planned to start in week 43 and the subsequent uplift and sampling will include all participants except for the bacteria group. Subsequent tests and analyses of the bentonite material, cupper coupons, tracer test material will start immediately after uptake and will be finalized during the spring 2002.

5 Äspö facility operation

5.1 Plant operation

The status of the facility is good both from an environmental and operational point of view.

The main contractor (OKG) can not any longer support all needs due to its company strategy, and the existing contract has been renegotiated, and maintenance contracts with other companies have been signed instead. This change though indicates increased efficiency for the Äspö HRL.

The Äspö road and the new parking lot, have been refurbished, coated and completed with a layer of fine gravel mixed with bitumen.

The project to improve fire safety is in progress. The project is based on suggestions from a fire risk analysis made in 1999. Traffic lights have been installed in a high-risk part of the tunnel. Additional fire detectors have been installed on the 420-m level, and voice-alarms will be installed in strategic areas of the tunnel later. The project is planned to be completed in November, 2001.

The project for hands-free registration in the underground facility is in progress. A Norwegian company´s system has been chosen, and installation will begin in November, 2001.

5.2 Data management and data systems

Background

Management of investigation data is a highly demanding and critical task in the presented siting process. The safety assessment must be based on correct and relevant data sets. Hence, the data management routines need to be focused on the following aspects in a long term perspective:

- traceability,
- accessibility,
- data security and
- efficiency (system integration and user friendly applications).

A high quality baseline for the safety assessment will be established if the aspects specified above are met. The data needed in a typical safety assessment have been reported in Andersson et al /1998/.

The different parts of SKB's Data Management System will be improved in conjunction with the ongoing and planned activities in SKB' siting work. This to fulfil the requirements expected from the regulatory authorities and the internal organisation as well. The current status and the actual plans of GIS, SICADA and RVS are presented in the following subsections.

New results

GIS

ArcSDE and ArcIMS have been implemented successfully as planned and recently have engaged consultants were engaged in order to transfer existing data into ArcSDE. The consultants will also set up data sets to be accessed with ArcIMS.

SICADA

SICADA *Admin*, the new system administration application described in the previous report, has been delivered for final testing. This is a major event in the history of SICADA. By using this new application the administration of the database structure will be simplified considerably.

RVS

Programming of version 3.0 is ongoing. The efforts are focused on implementation of a new modelling concept developed by a candidate site investigation project named GEOFUNK. The programming activities take place in five stages. Currently the ongoing work is following the time schedule of the project.

Planned work

GIS

The following activities will be executed during the next period (October-December 2001):

- transfer of existing GIS data into ArcSDE,
- compilation of basic GIS data to be accessed by using ESRI/ArcIMS, and
- evaluation of the field application ESRI/ArcPAD.

SICADA

SICADA Admin will be implemented in October 2001. This is a prerequisite before implementing new data structures supporting the investigation methods planned to be used in the coming site investigations.

RVS

Implementation of RVS version 3.0 is planned to take place in December 2001. The new version will be based on MicroStation V8. This new version of MicroStation was released in September 2001. MicroStation is a product of Bentley Systems Incorporated.

5.3 Program for monitoring of groundwater head and flow

Background

The Äspö HRL operates a network for the monitoring of groundwater head, flow in the tunnel and electrical conductivity, as the core parameters. This system goes under the acronym of HMS (Hydro Monitoring System). Water levels and pressure head are collected from surface drilled and tunnel drilled boreholes. Additionally, the electrical conductivity of the water in some borehole sections and in the tunnel water is measured. The network includes boreholes on the islands of Äspö, Ävrö, Mjälen, Bockholmen and some boreholes on the mainland at Laxemar.

Data is transferred by means of radiolink, cable and manually to a dedicated computerised database. The HMS computer system runs on Pentium computers with the Windows NT operating system where a real time engine is accessing the HMS database. This engine provides integrated data acquisition, monitoring, data logging and report generation.

5.3.1 New results

The HMS program has continued running real time data aquisition in support of the various project undertaken in the Äspö Hard Rock Laboratory.

This support consists of providing data from boreholes affected by an experiment and of utilizing the HMS infrastructure for collection and monitoring of experiment specific data.

An overall evaluation of the Hydro Monitoring Program has been completed in support of the Äspö activites. A feedback based on experience is due and also in support of the coming geoscientific site characterization.

Work in the Tidal Fracture Zone project has progressed with the reporting for the first phase for which a draft final report has been produced. This project aims at evaluating the feasibility of utilising tidal flucuation of monitoring data in order to calculate fracture orientation.

5.3.2 Planned work

For the next quarter it is planned to

- Continue to support various projects at Äspö with monitoring data

- Continue with the reporting the Tidal Fracture Zone project with the aim to produce a final report for teh first phase and a draft final for the second phase.

5.4 Program for monitoring groundwater chemistry

Background

During the construction phase of the Äspö HRL, different types of water samples were collected and analysed with the purpose of monitoring the groundwater chemistry and its evolution as the construction proceeded. The samples were obtained from the cored boreholes drilled from the ground surface and from percussion and cored boreholes drilled from the tunnel.

Objectives

At the beginning of the operational phase, sampling was replaced by a groundwater chemistry monitoring program, aiming at a sufficient cover of the hydrochemical conditions with respect to time and space within the Äspö HRL. This program should provide information for determining where, within the rock mass, the hydrochemical changes are taking place and at what time stationary conditions have been established.

New results

The results from year 2000 were presented in report TD-01-06. The sampling programme for 2001, executed during the period, was reduced with some boreholes because of low water flow (<0,001l/min).

Planned work

The analytical results will be presented in December 2001.

5.5 Technical systems

Background

The monitoring of groundwater changes (hydraulic and chemical) during the construction of the laboratory is an essential part of the documentation work aiming at verifying pre-investigation methods. The great amount of data calls for efficient data collection system and data management procedures. Hence, the Hydro Monitoring System (HMS) for on-line recording of these data have been developed and will continuously be expanded along with the tunnelling work and the increased number of monitoring points.

New results

The work with the presentation system for the Canister Retrieval Test is nearly finished. The system will be in full operation during October 2001. A new HMS computer has been installed in the G-tunnel to take care of data from hydro-sections in the Prototype Repository, where about 80 channels have been installed so far.

Planned work

Renovation will be made at the borehole KLX01 in November. Renovation will also be made at the measuring station at 3007 m in the tunnel.

5.6 Information

Background

The information group's main goal is to create public acceptance for SKB in co-operation with other departments at SKB. This is achieved by informing of SKB, the Äspö HRL and the SKB siting programme. The visitors are also taken on a tour of the Äspö HRL.

New results

During the third quarter of 2001 the Äspö HRL had 2821 visitors, which have represented the general public, municipalities where SKB has performed feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries. 779 visitors represented the six municipalities where SKB has performed feasibility studies.

The U500 summer tours for the general public started in June and finished in August.. The tours attracted 2400 visitors, which was 400 visitors more than originally planned.

A 40 minutes video of the Äspö HRL history has been produced. The video presents history from the very beginning in 1986 with site investigations, tunnel construction and research up till today.

The common booking system has finally been ordered and is under construction. The start of running test is planned for January 2002.

Planned work

The information group will select one of the public information officers to be responsible for environmental tasks and questions.

The U500 tours will go on every weekend during the autumn.

6 International Co-operation

6.1 Current international participation in the Äspö Hard Rock Laboratory

Eight organisations from seven countries are currently (October 2001) participating in the Äspö Hard Rock Laboratory. This is a change from the last period as NIREX has decided not to prolong the expired contract due to the actual situation in England, and is thus not any longer counted as a permanent participant.

In each case the cooperation is based on a separate agreement between SKB and the organisation in question. Table 6-1 shows the scope of each organisation's participation under the agreements.

Most of the organisations are interested in groundwater flow, radionuclide transport and rock characterisation. Several organisations are participating in the Äspö Task Force on groundwater flow and radionuclide migration, which is a forum for cooperation in the area of conceptual and numerical modelling of groundwater flow and solute transport in fractured rock.

Most of the organisations are also participating in the Prototype Repository test.

Table 6-1 Scope of international cooperation

Organisation	Scope of participation
Agence Nationale pour la Gestion des Déchets Radioactifs, **ANDRA**, France.	Detailed investigation methods and their application for modelling the repository sites Test of models describing the barrier function of the bedrock Demonstration of technology for and function of important parts of the repository system
Bundesministerium für Wirtschaft und Technologie, **BMWi**, Germany	Two-phase flow investigations including numerical modelling and model calibration Participation in the Task Force on modelling of groundwater flow and transport of solutes by using "German" computer codes Participation in the geochemical modelling efforts in the Äspö HRL Work related to transport and retention of radionuclides and colloids in granitic rock In-situ geoelectrical measurements with respect to water saturation of rock masses in the near field of underground tunnels Work on design and performance of in-situ tests using methods and equipment similar to those used in the Grimsel investigations

Organisation	Scope of participation
Empresa Nacional de Residuos Radiactivos, **ENRESA**, Spain	Participation in the Task Force on modelling of groundwater flow and transport of solutes Backfill and Plug Test Prototype Repository
Japan Nuclear Cycle Development Institute, **JNC**, Japan. The Central Research Institute of the Electronic Power Industry**, CRIEPI,** Japan	The Tracer retention understanding experiments (TRUE) Radionuclide retention experiments Task Force on modelling of groundwater flow and transport of solutes. Prototype Repository Long Term Test of Buffer Materials
Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle, **NAGRA**, Switzerland	Test of models describing the barrier function of the bedrock Demonstration of technology for and function of important parts of the repository system
POSIVA , Finland.	Testing of models describing the barrier function of the bedrock, specifically the task force on modelling of groundwater flow and transport of solutes Testing and demonstration of repository systems in full scale, specifically the Prototype Repository and the Long Term Test of Buffer Material Verification of the function of repository system components
USDOE/**Sandia National Laboratories**, USA	Test of models describing the barrier function of the bedrock

6.2 Prototype Repository – EC project

The Prototype Repository is co-funded by the European Commission during a 42 months period starting September 2000 with SKB as the co-ordinator. The EC part coincide with the project work (see Section 4.2 above) during that specific time with minor exemptions. The participants are shown in Table 6-2.

Tabell 6-2. Participants in the Prototype Repository EC project

Principal contractors	Associated contractors
SKB (co-ordinator)	GeoDevelopment, VBB VIAK and Clay Technology
Posiva (FI)	VTT
ENRESA (E)	AITEMIN and CIMNE
GRS (G)	
BGR (G)	
UWC – Univ Wales Cardiff (UK)	
JNC (J)	
ANDRA (F) (in process of joining)	

6.3 CROP – Cluster repository project

The CROP is a Thematic Network with the intention to form a basis for evaluating and developing concepts of final repositories for high-level radioactive waste. The objects are primarily: to work out a document that can serve as an aid for future repository design and construction with focus on EBS, and to create a forum for exchange of information on repository design, construction and operation. The European Commission funds the participation of the European organisations but not the non-European ones. The project time is 36 months from the start in February 2001 and SKB is the co-ordinator.

The work is separated into four Work Packages:

WP1. Design and construction of engineered barrier systems (EBS)

WP2. Instruments and experimental procedures

WP3. Assessment of the function of EBS and understanding of their performance and the capability to model important processes

WP4. System assessment and development of improved HLW concepts

In each WP one country annex is compiled by each of the participants, see Table 6-3, and one summary text. They make together the deliverable for that WP.

WP #1 and #2 have been further worked at during the period. The deliverables are due12 months after the start of the project, i e February 2002. .

Contractor	Member to Contractor
SKB (co-ordinator)	**GeoDevelopment (S)**
SKC-CEN (B)	
POSIVA (FI)	
GRS (G)	
ENRESA (E)	
ANDRA (F)	
NAGRA (CH)	
OPG (CAN)	
USDOE CBFO (US)	
DBE (G) (in process of joining)	

One Project Progress Meeting was held in Mol during the period.

7 Documentation

During the period July-September 2001, the following reports have been published and distributed:

7.1 Äspö International Cooperation Reports

Byegård J, Widestrand H, Skålberg M
First TRUE Stage. Complementary investigation of diffusivity, porosity and sorptivity of Feature A-site specific geologic material
ICR-01-04

7.2 Äspö International Progress Reports

Johannesson L-E, Börgesson L, Sandén T
Backfill materials based on crushed rock (part 2). Geotechnical properties determined in laboratory.
IPR-99-23

Äspö Hard Rock Laboratory.
Status Report.April - September 2000.
IPR-00-37

Rouhiainen, P., 2000.
Difference flow measurements in borehole KLX02 at Laxemar.
IPR-01-06

Sandén, T., Börgesson, L.
Report on instrument positions in buffer /backfill and preparation of betonite blocks for instrument and cables in section 1.
IPR-01-20

Äspö Hard Rock Laboratory.
Status Report January - March 2001.
IPR-01-22

Goudarzi, R., Börgesson, L., 2001
Sensor data report (Period: 001026-010201). Canister Retrieval Test. Report No: 1.
IPR-01-24

Goudarzi, R., Börgesson, L., 2001
Sensor data report (Period: 001026-010501). Canister Retrieval Test. Report No: 2.
IPR-01-25

15 Technical Documents

2 International Technical Documents

References

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Parameters of importance to determine during geoscientific site investigation
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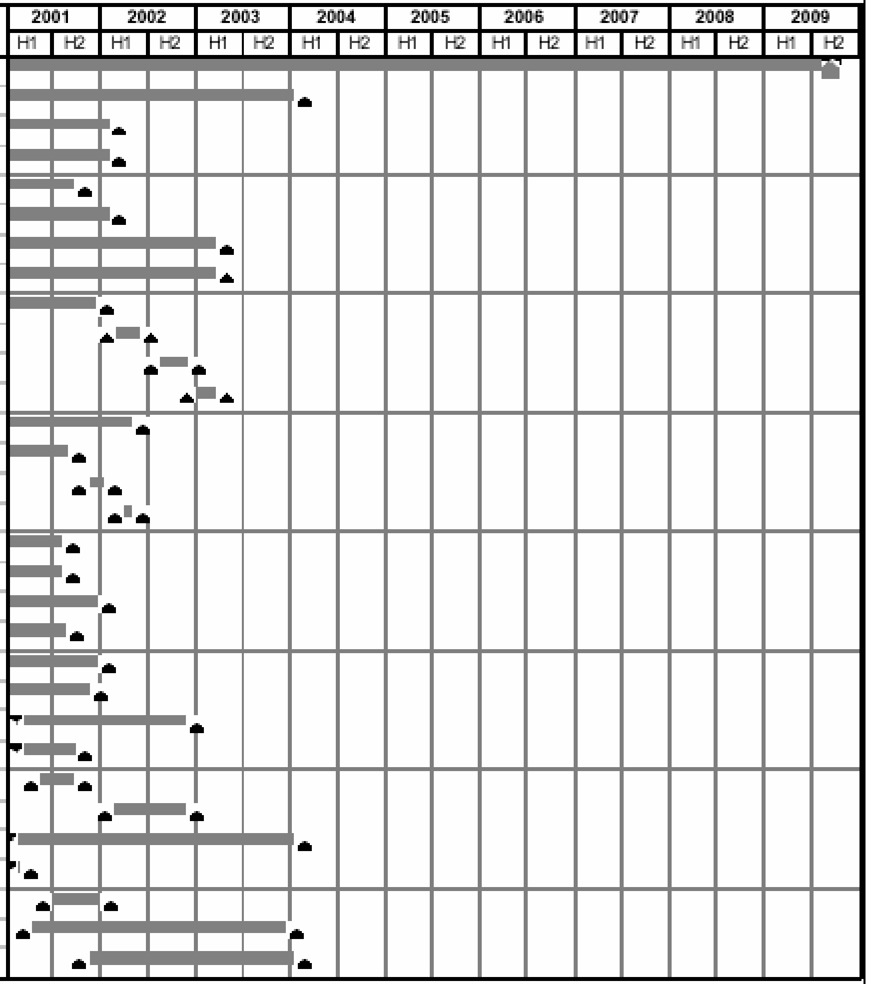
Appendix A

MASTER SCHEDULE ÄSPÖ

Christer Svemar

Äspö Plan Right
Version 2000.1

WBS	Namn
0	MASTER SCHEDULE ÄSPÖ
1	TEST OF MODELS OF THE BARRIER FUNCTION OF THE HOST ROCK
1.1	TRACER RETENTION UNDERSTANDING EXPERIMENTS
1.1.1	TRUE Blocks Scale
1.1.1.1	Tracer test stage
1.1.1.2	Evaluation and reporting stage
1.2	RADIONUCLIDE RETENTION
1.2.1	Actinideexperiment
1.2.1.1	Field experiments I
1.2.1.2	Field experiments II
1.2.1.3	Field experiments III
1.2.1.4	Reporting
1.2.2	Radiolysisexperiment
1.2.2.1	Laboratory work
1.2.2.2	Realization radiolysis
1.2.2.3	Reporting
1.3	LONGTERM STABILITY/HYDROCHEMICAL STABILITY
1.3.1	Realization
1.4	MATRIX FLUID CHEMISTRY
1.4.1	Drillcore study
1.4.2	Fluid sampling
1.4.3	Supplementary studies
1.5	COLLOIDS
1.5.1	Laboratory tests
1.5.2	Field tests
1.5.3	Reporting
1.6	MICROBE
1.6.1	Initiation
1.6.2	Preparation
1.6.3	Realization
1.6.4	Reporting



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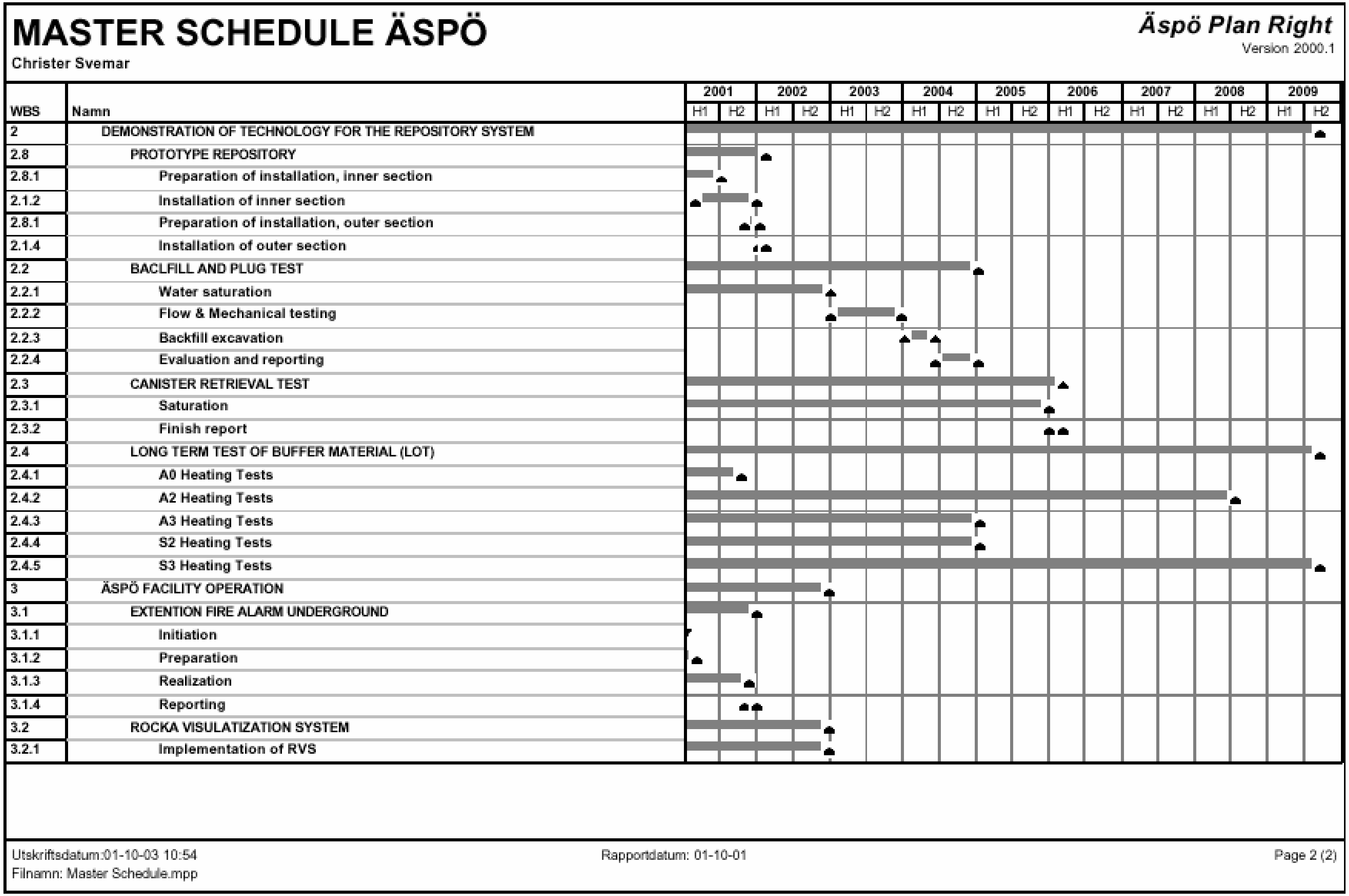
MASTER SCHEDULE ÄSPÖ
Christer Svemar
Äspö Plan Right
Version 2000.1
WBS
Namn
2001
2002
2003
2004
2005
2006
2007
2008
2009
H1
H2
2 DEMONSTRATION OF TECHNOLOGY FOR THE REPOSITORY SYSTEM
2.8 PROTOTYPE REPOSITORY
2.8.1 Preparation of installation, inner section
2.1.2 Installation of inner section
2.8.1 Preparation of installation, outer section
2.1.4 Installation of outer section
2.2 BACLFILL AND PLUG TEST
2.2.1 Water saturation
2.2.2 Flow & Mechanical testing
2.2.3 Backfill excavation
2.2.4 Evaluation and reporting
2.3 CANISTER RETRIEVAL TEST
2.3.1 Saturation
2.3.2 Finish report
2.4 LONG TERM TEST OF BUFFER MATERIAL (LOT)
2.4.1 A0 Heating Tests
2.4.2 A2 Heating Tests
2.4.3 A3 Heating Tests
2.4.4 S2 Heating Tests
2.4.5 S3 Heating Tests
3 ÄSPÖ FACILITY OPERATION
3.1 EXTENTION FIRE ALARM UNDERGROUND
3.1.1 Initiation
3.1.2 Preparation
3.1.3 Realization
3.1.4 Reporting
3.2 ROCKA VISULATIZATION SYSTEM
3.2.1 Implementation of RVS
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