International
Progress Report

IPR-03-09

Äspö Hard Rock Laboratory

Status Report
July – September 2002

February 2003

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Äspö Hard Rock
Laboratory

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Summary

The Äspö Hard Rock Laboratory (HRL) constitutes an important part of SKB's work to design and construct a deep geological repository for spent nuclear fuel and to develop and test methods for characterisation of a suitable site. The Äspö HRL and the associated research, development, and demonstration tasks, managed by the Repository Technology Department within SKB, has so far attracted considerable international interest.

Natural Barriers

At the Äspö HRL experiments are performed at conditions that are expected to prevail at repository depth. The experiments are related to the rock, its properties, and in-situ environmental conditions. The goals are to increase the scientific knowledge of the safety margins of the deep repository and to provide data for performance and safety assessment. The programme includes projects with the aim to evaluate the usefulness and reliability of different models and to develop and test methods for determination of parameters required as input to the models.

Tracer Retention Understanding Experiments are carried out in the TRUE-projects with the aim to identify flow paths, retention of weakly and moderately sorbing tracers and the effect of matrix diffusion. The *TRUE Block Scale* (up to 100 m) completes the sequence of scales addressed within the TRUE-programme. Complementary field works and modelling are currently performed in two projects: TRUE Block Scale Continuation and TRUE-1 Continuation. The *TRUE Block Scale Continuation* project comprises a continuation of the TRUE Block Scale Phase C tracer test, complementary modelling works and additional in-situ tracer tests. The monitoring of the tracer test has been brought to a conclusion during September and a compilation of the results has been reported by Byegård /2000a/. As a next step an activity for water chemistry and radon will be carried out at the site.

In the *TRUE-1 Continuation* project the site will be injected with resin and excavated and analysed. The start of this activity is pending on the development of LTDE although preparatory work with the injection of resins is in progress. The identification of candidate structures has been initiated and the application of resin injection was discussed in a workshop with Nagra personnel in September. Tracer dilution tests have been completed and measurements of radon flux from geological material are continued with measurements on fault gouge material.

The **Long Term Diffusion Experiment** is performed to investigate diffusion of solutes, during 3-4 years, from natural fractures into matrix rock. The aim is to improve the understanding of sorption processes and obtain sorption data for some radionuclides on natural fracture surfaces. The installation of the equipment in the borehole with the core stub was concluded in June. The installations of equipment in the container are in progress and plans are underway for pressure build-up pre-tests.

Radionuclide Retention Experiment with CHEMLAB is carried out with the aim to confirm retention results of laboratory studies in-situ. The experiments are carried out in special borehole probes, CHEMLAB 1 and CHEMLAB 2, designed for different kinds of in-situ experiments. The *radiolysis experiments*, in the borehole probe CHEMLAB 1, are intended to investigate the influence of radiolysis on the migration of oxidised technetium in bentonite clay. Unfortunately the probe has been sent to France to be repaired and it is expected to return in November. Experiments on the *migration of actinides* in a natural rock fracture in a drill core are carried out in CHEMLAB 2. Former problems with the sealing of new drill cores have been solved and the planning of and the preparations for the next field experiment is in progress.

In the **Colloid Project** the concentration, stability, and mobility of colloids in the Äspö environment are studied. The natural *background concentration* of colloids in groundwaters from eight different boreholes has been measured and analysed and a status report will be compiled. The planning of the *borehole specific experiments* in Äspö as well as the preparations of the test equipment is ongoing. This work is done in co-operation with Posiva in Finland since similar experiments will be performed in Olkiluoto. The borehole specific experiments will continue from January 2003 until May 2003.

The **Microbe Project** has been initiated in the Äspö HRL for studies of the microbial activity in groundwater at in-situ conditions. Microbial effects on redox conditions, radionuclide migration, gas composition, and gas consumption will be in focus. Three Microbe sites have been opened in Äspö HRL. The main site is at the 450 m level and consists of three core drilled boreholes intersecting water conducting fractures. At this site a formation groundwater circulation system and a system for sensible measurement of hydrogen and other reducing gases has been set up and the container hosting the laboratory equipment was worked with during August. The growth of microbes in the circulation system is being sampled and the gas measurements can be initiated as soon as the instrumentation is running. At the second Microbe experimental site a unique population of sulphur oxidising bacteria has been established in a constructed shallow pond. The third site, is equipped with open flow channels fed with groundwater from a packed off borehole for studies of the filtering effects of biological iron oxide systems (BIOS).

The main objectives of the **Matrix Fluid Chemistry Experiment** are to understand the origin and age of fluids/groundwaters in the rock matrix pore space and in micro-fractures, and their possible influence on the chemistry of the groundwaters from the more highly permeable bedrock. Matrix fluids have been sampled and fluid inclusions in core samples have been studied to determine their contribution, if any, to the composition of the matrix fluids/groundwaters. The gathering of scientific data has been completed and the main activity during 2002 aims at final reporting of the whole project.

The **Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes** is a forum for the organisations supporting the Äspö HRL to interact in the area of conceptual and numerical modelling of groundwater flow and transport of solutes in fractured rock. The modelling conducted within *Task 4* (Tracer Retention and Understanding Experiment) has been finalised and evaluated and a final draft version of the Task 4 Summary Report will be reviewed during January 2003. The modelling work within *Task 5* (Coupling between hydrochemistry and hydrogeology) has been finalised. The Summary Report and Reviewers Report will be published in the beginning of year 2003. *Task 6* tries to bridge the gap between Performance Assessment (PA) and Site

Characterisation (SC) models. Work on structural models (subtask 6C) will be reported in the beginning of 2003. The specifications of subtasks 6D will be available in the end of 2002.

The general objective of the project **NUMMOD** is to improve the concept and the numerical tool (DarcyTools) for modelling of flow and transport but also to update the regional and local scale groundwater flow models for the Äspö HRL. Part 1 of NUMMOD has been published in two reports and in the next part a second version of DarcyTools will be developed.

PADAMOT (Paleohydrogeological data analysis and model testing) is a three-year EC-project, which started late 2001. In this project the evolution of minerals and groundwater through climate changes will be investigated. The aim is to investigate processes that are significant for repository safety studies on length and time scales that cannot be simulated by experiments. Advanced analytical techniques and numerical modelling tools will be used. Work to find analysis methods for trace elements in small calcite samples has come to a conclusion and dissolved samples will be analysed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

Disposal Technology

The Äspö HRL makes it possible to demonstrate and perform full-scale tests of the function of different components of the repository system that are important for the performance and the long-term safety of a repository. It is also important to show that high quality can be achieved in design, construction, and operation of the repository.

Demonstration of Repository Technology has the aim to test and demonstrate the deposition process which is ongoing, e.g. in the Prototype Repository. The whole system of different machines and equipment needed in a deep repository will be identified and developed to a feasibility stage as part of the ongoing design studies of the deep repository.

In the **Prototype Repository** the integrated function of the repository components is demonstrated and full-scale reference of a KBS-3 repository for comparison with models and assumptions are provided. The inner section (with four canisters) is installed and the supervision of status of the heaters and the measurements in the buffer and backfill is ongoing. The preparation for the installation of buffer and canisters in the outer section is in progress.

The **Backfill and Plug Test** includes tests of backfill materials and emplacement methods and a test of a full-scale plug. The water pressure in the permeable mats and the drained inner part of the drift has been kept constant at 500 kPa during the entire quarter. The amount of water passing through the plug and the surrounding rock has been measured. The results show that the leakage has been rather constant at 0.05 l/min during a long time but seems to start to decrease. Today the entire backfill seems to be close to water saturated. To try to understand the hydraulic effect of the change in water pressure inside the test tunnel on the surrounding rock a plan for building dams for measuring the water flow into the nearby “Demonstration tunnel” and the “TBM tunnel” has been prepared. One dam has been built and the other one will be built at the end of this year.

Canister Retrieval Test has the purpose of testing technology for retrieval of canisters after the buffer has become saturated. One canister with heaters and bentonite blocks were emplaced in a full size deposition hole which was sealed and pluged in 2000. Problems with short-circuit in the electrical system of the heaters occurred in the end of

2001. It has, however, been possible to provide the needed experimental conditions although the heat effect has been decreased.

The **Long Term Tests of Buffer Material** project aim to validate models and hypotheses related to physical properties in a bentonite buffer. Five test parcels with different duration times were installed. In 2001 a 1-year parcel was extracted from the rock by overlapping core drilling. The main task during 2002 is devoted to the examination of the field-exposed material from this parcel. Preliminary results from analyses of the bentonite material were presented at the 18th General Meeting of the International Mineralogical Association, 1st – 6th September 2002 in Edinburgh, Scotland. The results from the analyses of the diffusion of tracers in the exposed bentonite have been published in a Doctoral thesis and the laboratory program concerning copper corrosion is completed. The four long-term parcels are running according to plans and water pressure, total pressure, temperature and moisture are continuously being measured.

The **Pillar Stability Experiment** has been initiated to demonstrate the capability to predict spalling in fractured rock mass and the effect of backfill on the propagation of micro cracks. The second phase of the project is in progress which includes the development of the final experimental design and exploratory core drilling which has been performed at two potential sites. Coupled thermo-mechanical numerical modelling with 2D and 3D tools has been used in the design work.

Low alkali cementitious products are a project, performed in co-operation with Posiva and NUMO, with the aim to investigate the use of low-alkali cementitious products in the deep repository. One of the objectives is to develop recipes for cementitious products to be used as grouting and mortar for anchoring of rock bolts. A recipe for low-alkali cement has been developed. However, a planned small field experiment in Äspö HRL has been postponed since the low-alkali cement developed did not work as grouting material.

KBS-3 method with horizontal deposition. SKB and Posiva are carrying out a R&D program for horizontal deposition of canisters according to the KBS-3H system. The program is divided into four parts: Feasibility study, Basic design, Construction and testing at the Äspö HRL, and Evaluation. The feasibility study has been almost finalised and the project continues with the Basic design. .

Cleaning and sealing of investigation boreholes is a project that was initiated in May this year, with the aim to identify and to demonstrate, in field experiments, the best available techniques for cleaning and sealing of investigation boreholes. The first phase of the project a pre-study to identify available techniques, perform complementary laboratory experiments with potential sealing materials, and to investigate the status of two boreholes at Äspö that can be used for the demonstration is now completed.

Task Force on Engineered Barrier Systems has its focus on the water saturation process in buffer, backfill and near-field rock. Since the water saturation process is also a part of the modelling work in the Prototype Repository, the work of the Task Force was consequently linked together with modelling work within the EC-project concerning the Prototype Repository.

Äspö Facility

An important part of the Äspö facility is the administration, operation, and maintenance of instruments as well as development of investigation methods. This includes providing a safe and environmentally correct facility for everybody working or visiting the Äspö HRL. The plant supervision system has considerably increased the possibility to run the facility in a safe and economic way. The availability in the underground-related systems has been high, 98%, during the period July-October. The automatic registration and object-monitoring system has been taken into operation for testing. New offices have been created in the existing building and the design of an additional extension in the ventilation building has been finalised and the construction work has started.

The operation of the Äspö facility also includes the Hydro Monitoring System (HMS) that collect data on line of groundwater head, salinity, electrical conductivity etc. in different boreholes. The system has been performing will and no main maintenance activity has taken place.

A **monitoring program for groundwater head and flow** to support the experiments undertaken and meet the requirements stipulated by the water rights court is running. The monitoring points from the previous year have been maintained and no additional points are planned during 2002.

At the beginning of the Operational Phase, sampling was replaced by a **groundwater chemistry monitoring programme**, aiming at a sufficient cover of the hydrochemical conditions with respect to time and space within the Äspö HRL. The monitoring points from the previous year have been maintained and a few additional points have been applied for 2002. The sampling took place in September 2002 and apart from a couple of points with too low flow the planned program proceededs without any problems.

In the **GeoMod project** existing geological, geomechanical, hydrogeological and hydrogeochemical models of Äspö will be updated by integration of data collected since 1995. The work is in progress but is delayed compared to the original plan.

International Co-operation

Eight organisations from seven countries are from January 2002 participating in the Äspö HRL.

SKB is through Repository Technology co-ordinating two EC contracts: Prototype Repository and Cluster Repository Project (CROP). SKB takes part in several EC-projects of which the representation is channelled through Repository Technology in five cases: FEBEX II, BENCHPAR, ECOCLAY II, SAFETI and PADAMOT. SKB will also be co-ordinator in the project NET.EXCEL.

Contents

1 General

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

One of the fundamental reasons behind SKB's decision to construct an underground laboratory was to create an opportunity for research, development and demonstration in a realistic and undisturbed rock environment down to repository depth. The underground part of the laboratory consists of a tunnel from the Simpevarp peninsula to the southern part of Äspö where the tunnel continues in a spiral down to a depth of 460 m, see Figure 1-1. The Äspö HRL and the associated research, development, and demonstration tasks, managed by the Repository Technology Department within SKB, have so far attracted considerable international interest.

SKB's overall plans for research, development, and demonstration during the period 2002-2007 are presented in SKB's RD&D-Programme 2001 /SKB, 2001a/. The planned activities related to Äspö HRL are detailed on a yearly basis in the Äspö HRL Planning Report /Äspö HRL, 2002/. The role of the Planning Report is also to present the background and objectives of each experiment and activity. This report, the Status Report concentrates on the work in progress and refers to the Planning Report for more background information. The Annual Report will in detail present new findings and results.

Figure 1-1 *Overview of the Äspö HRL facilities.*

2 Natural barriers

At the Äspö HRL experiments are performed at conditions that are expected to prevail at repository depth. The experiments are related to the rock, its properties, and in-situ environmental conditions. The goals are to increase the scientific knowledge of the safety margins of the deep repository and to provide data for performance and safety assessment and thereby clearly present the role of the geosphere for the barrier functions: isolation, retardation and dilution.

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

The main projects are Tracer Retention Understanding Experiments (TRUE), Long Term Diffusion Experiment, Radionuclide Retention Experiment, Microbial Project, Colloid Project, and Matrix Water Chemistry.

2.1 Tracer Retention Understanding Experiment

Tracer tests are carried out in the TRUE-projects. These are conducted at different scales; laboratory scale (< 0.5 m), detailed scale (~ 5 m) and block scale (up to 100 m) with the aim to identify and characterise flow paths, ia. in terms of retention of weakly and moderately sorbing tracers and the effects of acting processes including matrix diffusion. Experiments in the detailed scale have been completed and reported /Winberg et al., 2000/.

The tracer test stage of the TRUE Block Scale has come to its conclusion during the first half of 2002 and evaluation and reporting have been completed during 2002. Complementary field works and modelling are currently performed or being planned as part of two separate but closely coordinated projects: TRUE-1 Continuation and TRUE Block Scale Continuation.

2.1.1 TRUE Block Scale

The block scale (up to 100 m) completes the sequence of scales addressed within the TRUE programme. Five boreholes have been drilled, characterised and completed with multi-packer systems. The outcomes of the performed characterisation have resulted in a focus on a particular fracture network defined by five structures (#20, #13, #21, #22 and #23) for subsequent tracer tests performed in three phases (A-C). Phase A focused on identification of suitable injection and pumping sections, Phase B demonstrated sufficient mass recovery and demonstrated in-situ matrix diffusion, and Phase C comprised a series of injections with radioactive sorbing tracers.

Achievements during the time period (July - September 2002)

The TRUE Block Scale project will be reported in a series of four final reports (the present status of the reports is given within brackets, two of the reports were printed during the spring):

- Characterisation and model development /Andersson et al., 2002a/.
- Tracer tests in the block scale /Andersson et al., 2002b/.

- Modelling of flow and transport (an updated version was distributed to external reviewers in July) (Poteri et al., in prep.)

- Synthesis of flow, transport and retention in the block scale (A concept for external review was prepared in the end of August) (Winberg et al., in prep.)

In addition to the four Technical Reports mentioned above some ten International Progress Reports (IPR) are being elaborated upon and according to present plans these reports will be printed early next year.

A Second Circular for the 1st International TRUE Block Scale Seminar, November 19-21, 2002 was distributed in September. The theme of the seminar is "Understanding of block scale radionuclide transport and retention in a network of structures/fractures".

2.1.2 TRUE Block Scale Continuation

The TRUE Block Scale Continuation (BS2) project aims at obtaining additional understanding of the TRUE Block Scale site. The project is divided into two separate phases:

- Continuation of the TRUE Block Scale (Phase C) pumping and sampling. Employment of developed enrichment techniques to lower detection limits (BS2a).

- Complementary modelling work that includes evaluation of tails of breakthrough curves and simplified examples related to heterogeneity in flow and retention parameters. In addition, new hypotheses to be tested by in-situ experiments will be formulated (BS2a).

- Additional in-situ tracer tests based on BS2a analysis (BS2b). Tests preceded by reassessment of the need to optimise/remediate the piezometer array. The specific objectives of BS 2b are to be formulated on the basis of the outcome of BS2a.

Achievements during the time period (July - September 2002)

The monitoring of the TRUE Block Scale Phase C test has been brought to a conclusion during September. The database containing the tracer breakthroughs was finalised during September and a compilation of the results of the continued sampling of the TRUE Block Scale Phase C has been reported by Byegård /2002a/. Definitions of the final modelling tasks are being worked on and tentative hypotheses have been listed.

An activity for water chemistry (Class 5/Class 2) and radon (see Section 2.1.3) will be carried out at the site as a next step. The planning of the activities has been initiated and the planned work for BS2a will be compiled in a Project Plan (in October).

2.1.3 TRUE-1 Continuation

The TRUE-1 Continuation project is a continuation of the TRUE-1 experiments /Winberg et al., 2000/. According to present plans the TRUE-1 site will be injected with resin and excavated and analysed. The objectives are to obtain insight in the internal structure of the investigated Feature A and to study fixation of sorbing radioactive tracers. The start of this activity is pending on the development of LTDE, see Section 2.2. Field work at the site prior to resin injection includes complementary cross-hole hydraulic interference tests combined with complementary tracer dilution tests. These tests will explore the singularity of Feature A and will provide insight into the three-dimensionality of the rock block studied including the role and effect of the fracture network connected to Feature A.

As a prequel to the planned resin injection in Feature A resin injections are planned near the tunnel fault rock zones as part of detailed characterisation of fault rock zones. These investigations include an objective to assess the in-situ porosity of fine-grained fault gouge.

Achievements during the time period (July - September 2002)

The complementary tracer dilution tests have been completed and the reports were available for printing in September (Andersson et al., in prep). The measurements of radon flux from geological material are continued with measurements on fault gouge material /Byegård, 2000b/. The radon measurements are part of the testing of a methodology to assess fracture aperture.

The preparatory work with the injection of resins, with the aim to characterise fault rock zones at TRUE-1 site, is in progress. The identification of candidate structures in the Äspö Tunnel has been initiated and the application of resin injection was discussed in a workshop with Nagra personnel in September.

2.2 Long-Term Diffusion Experiment

The Long Term Diffusion Experiment (LTDE) is performed to investigate diffusion and sorption of solutes in the vicinity of a natural fracture into the matrix rock. The aim is to improve the understanding of diffusion and sorption processes and to obtain diffusion and sorption data. A core stub with a natural fracture surface is isolated in the bottom of a large diameter telescoped borehole and a small-diameter borehole is drilled through the core stub and beyond into the intact unaltered bedrock, see Figure 2-1 and Figure 2-2. Tracer will be circulated over a period of 3-4 years after which the borehole is overcored and analysed for tracer content.

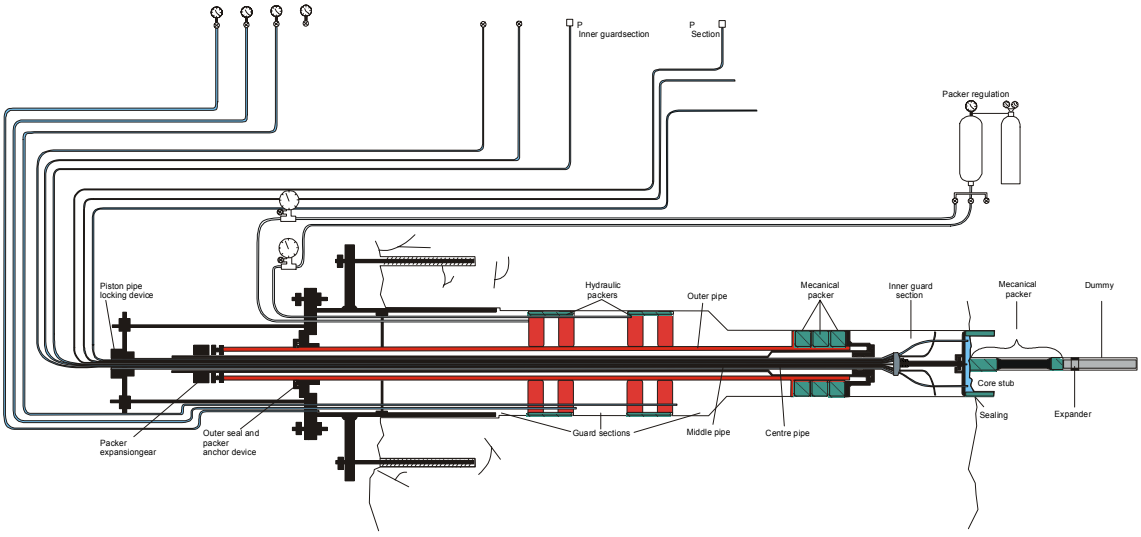

Figure 2-1 *Schematic drawing showing the modified down-hole equipment in the telescoped larger diameter LTDE borehole.*

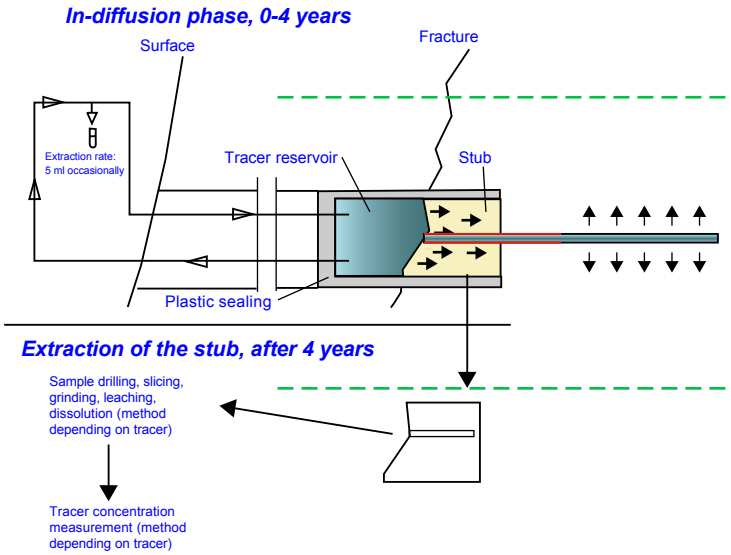

Figure 2-2 *Schematic of LTDE experimental concept including injection borehole in contact with a fracture surface.*

Achievements during the time period (July - September 2002)

The installation of the equipment in the borehole with the core stub was concluded in June. The installations of equipment in the container are in progress and plans are underway for pressure build-up pre-tests.

2.3 Radionuclide Retention Experiment

Radionuclide Retention Experiments are carried out with the aim to confirm results of laboratory studies in-situ, where natural conditions prevail concerning e.g. contents of colloids, organic matter, and bacteria in the groundwater. The experiments are carried out in special borehole probes, CHEMLAB 1 and CHEMLAB 2, designed for different kinds of in-situ experiments, see Figure 2-3. Experiments can be carried out at simulated near field conditions (bentonite) and in tiny rock fractures in drillcores. The present focus is on the influence of radiolysis products on the migration of the redox-sensitive element technetium in bentonite (radiolysis experiments in CHEMLAB 1) and on the experiments with redox-sensitive actinides in a rock fracture (migration of actinides in CHEMLAB 2).

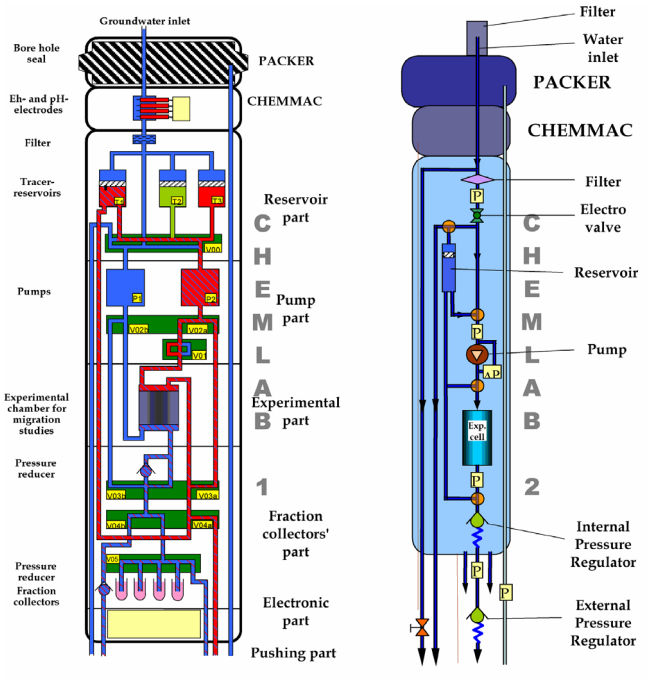

Figure 2-3 *Schematic illustration of CHEMLAB 1 and 2.*

Achievements during the time period (July - September 2002)

Radiolysis experiments

The radiolysis experiments, in the borehole probe CHEMLAB 1, are intended to investigate the influence of radiolysis on the migration of oxidised technetium in bentonite clay. Unfortunately the probe has been sent to France to be repaired and it is expected to return in November.

Migration of actinides

Experiments on the migration of actinides (americium, neptunium and plutonium) in a natural rock fracture in a drill core are carried out in CHEMLAB 2. The rock samples are analysed with respect to the flow-path and to the actinides sorbed onto the solid material. Non-destructive and destructive techniques will be applied, such as x-ray computer tomography and cutting the samples after injection of fluorescent epoxy resin. The distribution of actinides along the flow-path is determined from the abraded material gained by cutting, as well as by coupled laser ablation ICP-MS techniques of the slices.

The former problems with the sealing of new drill cores have been solved and the planning of and the preparations for the next field experiment are in progress. The experiment will start in the end of October and according to present plans it can be finished prior to the planned blasting activities in Äspö HRL in December.

2.4 Colloid Project

In the Colloid Project the concentration, stability, and mobility of colloids in the Äspö environment are studied. The project comprises studies of the potential of colloids to enhance solute transport and the potential of bentonite clay as a source for colloid generation. The Colloid Project includes laboratory experiments, background measurements, borehole specific measurements, and fracture specific measurements.

Achievements during the time period (July - September 2002)

The background measurements of the natural colloid concentrations in the groundwater at Äspö and the laboratory experiments were concluded. Background reports concerning the laboratory experiments and the background measurements are just about to be completed and a status report, based on the background reports, is compiled.

The planning of the borehole specific experiments in Äspö as well as the preparations of the test equipment is ongoing. This work is done in co-operation with Posiva in Finland since similar experiments will be performed in Olkiluoto, where the groundwater salinity is lower than at Äspö. Connected laboratory experiments concerning the design and performance of the so called colloid reactors were performed during this time period by GEOSIGMA. The installations in the boreholes at both Äspö and Olkiluoto will take place in January 2003. The borehole specific experiments will continue from January 2003 until May 2003. The duration of the experiments have been extended compared to original plans since the water flow has to stabilise between the sampling occasions.

2.5 Microbe Project

The Microbe Project has been initiated in the Äspö HRL for studies of the microbial activity in groundwater at in-situ conditions. Microbial effects on redox conditions, radionuclide migration, gas composition, and gas consumption will be in focus. Three Microbe sites have been opened in Äspö HRL.

The main site is at the 450 m level and consists of three core drilled boreholes (KJ0050F01, KJ0052F01 and KJ0052F03) intersecting water conducting fractures at 12.7, 43.5 and 9.3 meters depth respectively. The second Microbe experimental site is located in a side vault (at tunnel length 1127B). A unique population of sulphur oxidising bacteria has been established in a constructed shallow pond (200 x 100 x 10 cm). The third site (2200A), at 296 m depth, is equipped with open flow channels fed with groundwater from a packed off borehole for studies of the filtering effects of biological iron oxide systems (BIOS).

Achievements during the time period (July - September 2002)

At the main site a formation groundwater circulation system and a system for sensible measurement of hydrogen and other reducing gases has been set up. The container hosting the laboratory equipment was worked with during August. Alarm for surveillance of flowrates, temperatures and pressures has been installed and tested and the climate control installation is functioning according to the specifications. The growth of microbes in the circulation system is being sampled and the amount is estimated to be 106 cells per cm^2, which correspond to about five hundred million cells per circulating borehole. The gas measurements can be initiated as soon as the instrumentation is running.

2.6 Matrix Fluid Chemistry Experiment

The main objectives of the Matrix Fluid Chemistry Experiment are to understand the origin and age of fluids/groundwaters in the rock matrix pore space and in micro-fractures, and their possible influence on the chemistry of the groundwaters from the more highly permeable bedrock. Matrix fluids were sampled over many months from a borehole drilled into the rock matrix. Fluid inclusions in core samples have also been studied to determine their contribution, if any, to the composition of the matrix fluids/groundwaters.

The gathering of scientific data has been completed and the main activity during 2002 aims at final reporting of the whole project. A continuation of the project is under consideration.

Achievements during the time period (July - September 2002)

To date, interpretation of the technical data has been reported in Internal Technical Documents (ITD reports) and one IPR report documenting the status achieved during the first half of the project /Smellie J, 2000/. Five ITD reports have been published so far this year (see below); two Synthesis Reports and the Final Report are being worked on and are scheduled to be published in early 2003.

The following ITD reports have been published and distributed:

- Smellie J, 2001. Matrix Fluid Chemistry Experiment. Minutes of the Workshop held at SKB, Stockholm, October, 17-18, 2001. (ITD-02-02)
- Waber N, 2001. Matrix Fluid Chemistry Experiment. Mineralogy and Fluid Inclusion Studies. (ITD-02-03).
- Tullborg E-L, 2001. Matrix Fluid Chemistry Experiment. Borehole KF 0051 A01: 4m-Results from chemical and SEM/EDS analyses and porosity/density measurements. (ITD-02-04).
- Gehör S, Lindblom S, 2002. Matrix Fluid Chemistry Experiment. Textural, microthermometry and Laser Ablation ICP-MS investigations of fluid inclusions in drillcore KF0051A01 (5.03-10.95 m). (TD-02-13).
- Blyth A, Frape S, 2002. Matrix Fluid Chemistry Experiment. Evolution of Äspö groundwaters with time: Additional information from tritium and $\delta^{37}Cl$. (ITD-02-18).

2.7 Modelling of groundwater flow and transport of solutes

An important goal for the activities at Äspö HRL includes projects with the aim to evaluate the usefulness and reliability of different models and to develop and test methods for determination of parameters required as input to the models. Part of this work is performed in the Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes.

Further modelling work includes the development of codes (NUMMOD) for groundwater flow and transport of solutes that will be undertaken and applied to Äspö data and used in the Swedish site investigation programme.

2.7.1 Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes

The Äspö Task Force on Modelling of Groundwater Flow and Transport of Solutes is a forum for the organisations supporting the Äspö HRL to interact in the area of conceptual and numerical modelling of groundwater flow and transport of solutes in fractured rock. The Task Force shall propose, review, evaluate and contribute to the modelling work in the project. In addition, the Task Force shall interact with the principal investigators responsible for carrying out experimental and modelling works for Äspö HRL The work within the Äspö Task Force constitutes an important part of the international co-operation within the Äspö Hard Rock Laboratory.

Achievements during the time period (July - September 2002)

In the Task Force work has been made on the following tasks during 2002:

Task 4 Tracer Retention and Understanding Experiment (TRUE), 1st stage.

Task 5 Coupling between hydrochemistry and hydrogeology.

Task 6 Performance Assessment Modelling Using Site Characterisation Data.

The modelling conducted within *Task 4* has been finalised and evaluated and a final draft version of the Task 4 Summary Report will be reviewed by the Task Force delegates during January 2003.

The modelling work within *Task 5* has been finalised and the ten modelling teams are working with the modelling reports. Work has been done to compile results and summarise approach, execution and conclusions of Task 5 into one Summary Report. The Summary Report will be published in the beginning of year 2003. In addition, a Reviewers Report will also be published in the beginning of year 2003.

Task 6 tries to bridge the gap between Performance Assessment (PA) and Site Characterisation (SC) models by applying both approaches for the same tracer experiment. It is hoped that this will help to identify the relevant conceptualisations (in processes/structures) for long-term PA predictions and identify site characterisation data requirements to support PA calculations. The following specific modelling tasks have been defined:

Subtask 6A Model and reproduce selected TRUE-1 tests with a PA model and/or a SC model to provide a common reference.

Subtask 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 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.

Subtask 6C Develop semi-synthetic, fractured granite hydrostructural models. Two scales are supported (200 m block scale and 2000 m site-scale). The models are developed based on conditions at the TRUE Block Scale site.

Subtask 6D Task 6D is similar to Task 6A, and is using the synthetic structural model in addition to a 50 to 100 m scale TRUE-Block Scale tracer experiment.

Subtask 6E Task 6E extends the Task 6D transport calculations to a reference set of PA time scales and boundary conditions.

The work on the structural models (subtask 6C) will be reported in the beginning of 2003. Subtask 6C provides basis for subtasks 6D and 6E. The specifications of subtask 6D will be available in the end of 2002 and data for the subtask will be distributed in January 2003. Specifications of subtask 6E are planned to be available in the spring of 2003.

Minutes of the 16th Task Force Meeting at Äspö HRL have been distributed according send list. The writing of the Proceedings from the Task Force Meeting and the Task Force Workshop held in June has been ongoing during this quarter.

2.7.2 Numerical Modelling of Groundwater Flow (NUMMOD)

The general objective of NUMMOD is to improve the concept and the numerical tool (DarcyTools) for modelling of flow and transport but also to update the regional and local scale groundwater flow models for the Äspö HRL.

Achievements during the time period (July - September 2002)

Work performed in Part 1 of NUMMOD has been published in two reports:

- DarcyTools – Concepts, Method, Equations and Tests, version 1.0 (SKB TS-02-06).
- DarcyTools – Software description and documentation, version 1.0 (SKB TS-02-05).

The aim of the next part of NUMMOD is to develop a second version of DarcyTools, which will be used in the Swedish site investigation programme. The second version will e.g. be linked to SKB's three-dimensional Rock Visualisation System (RVS) and the user interface will be developed.

2.8 PADAMOT

A new three-year EC-project named PADAMOT (Paleohydrogeological data analysis and model testing) started late 2001. The project is a continuation of the concluded EQUIP-project, which had as specific objective to trace the past hydrochemical conditions by investigating fracture-filling minerals (calcite).

During the Quaternary, global climate has alternated between glacial conditions and climate states warmer than the today. In northerly latitudes the potential for cold region processes to affect groundwater pathways, fluxes, residence times and hydrochemistry is significant, whilst for southern European localities the alternation between pluvial and arid conditions is equally important. PADAMOT will investigate the evolution of minerals and groundwater through these climate changes. The project will use advanced analytical techniques and numerical modelling tools. This Paleohydrogeological approach investigates processes that are significant for repository safety studies on length and time scales that cannot be simulated by experiments. Interpretations will be used to constrain the range of scenarios for conceptual model development and time-variant modelling in performance assessments.

Achievements during the time period (July - September 2002)

Work with the aim to find analysis methods for trace elements in small calcite samples has come to a conclusion and the selectively dissolved samples will be analysed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

A Workshop "The Long-Term Stability of Groundwater Conditions at Repository Sites" will be arranged in Brussels 2-3, October.

3 Disposal technology

The Äspö HRL makes it possible to demonstrate and perform full-scale tests of the function of different components of the repository system that are important for the performance and the long-term safety of a repository. It is also important to show that high quality can be achieved in design, construction, and operation of the repository. To fulfil these tasks several projects are performed, e.g. Demonstration of Repository Technology, Prototype Repository, Backfill and Plug Test, Canister Retrieval Test, Long Term Tests of Buffer Material, and Pillar Stability Experiment.

3.1 Demonstration of repository technology

The project of Demonstration of Repository Technology provides a full-scale example of canister deposition under radiation-shielded conditions and works with testing of canister handling in full size deposition holes. Testing and demonstration of the deposition process is ongoing, e.g. in the Prototype Repository. The whole system of different machines and equipment needed in a deep repository will be identified and developed to a feasibility stage as part of the ongoing design studies of the deep repository.

3.2 Prototype Repository

The Prototype Repository is located in the last part of the TBM tunnel at the 450 m level and will include six deposition holes in full scale, see Figure 3-1. The aims of the Prototype Repository are to demonstrate the integrated function of the repository components and to provide a full-scale reference for comparison with models and assumptions. The Prototype Repository should, to the extent possible, simulate the real deep repository system, regarding geometry, materials, and rock environment. Instrumentation will be used to monitor processes and properties in the canister, buffer material, backfill, and the near-field rock. The installations in the inner section (Section I) with four deposition holes were completed and the plug, which seals off this inner section, was cast during 2001.

The Prototype Repository is co-funded by the European Commission for a 42 months period starting September 2000 with SKB as Co-ordinator and including seven participating organisations. The work reported below has been performed within the frame of the EC-project.

Achievements during the time period (July - September 2002)

The supervision of status of the heaters and the measurements of THM-processes in buffer and backfill in the inner section (Section I) is in ongoing.

The preparation for the installation of buffer and canisters in the outer section (Section II) is in progress. All lead throughs to the adjacent G-tunnel are prepared and the instrumentation in the surrounding rock, except for the equipment for the acoustic emission measurements, has been installed.

According to present plan the two additional canisters and the tunnel backfill will be installed during autumn and the plug grouted at the end of the year. This means that the time schedule has been delayed according to the original plan.

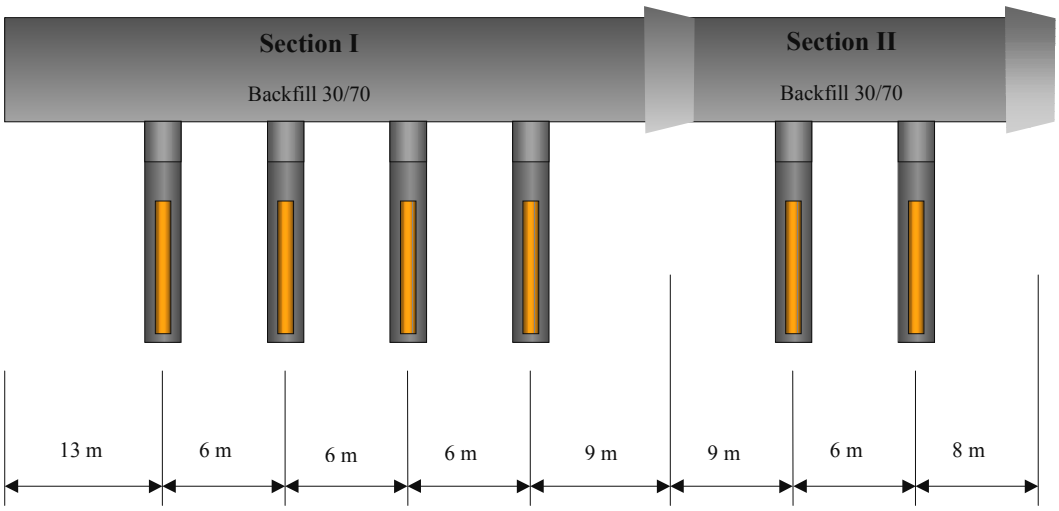

Figure 3-1 *Schematic view of the layout of the Prototype Repository. (not to scale)*

3.3 Backfill and Plug Test

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 blasting. The inner part of the tunnel is filled with a mixture of bentonite and crushed rock (30/70) and the outer part is filled with crushed rock (0/100) and bentonite blocks and pellets at the roof, see Figure 3-2. The test is also a test of the hydraulic and mechanical functions of a plug.

The entire test set-up with backfill, instrumentation and building of the plug was finished in 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. The water pressure in all filters was increased in steps of 100 kPa to 500 kPa from October 2001 to January 2002.

Achievements during the time period (July - September 2002)

The following main events and results from the third quarter of 2002 can be mentioned. The test site is situated between the “Demonstration tunnel” and the TBM tunnel. In order to try to understand the hydraulic effect of the change in water pressure inside the test tunnel on the surrounding rock a plan for building dams for measuring the water flow into the “Demonstration tunnel” and the TBM tunnel has been prepared. One dam has been built (in the “Demonstration tunnel”) and the other one will be built at the end of this year.

The water pressure in the permeable mats and the drained inner part of the drift has been kept constant at 500 kPa during the entire quarter.

The amount of water passing through the plug and the surrounding rock has been measured by collecting the water outside the plug. Figure 3-3 shows the results with a direct response of each pressure increase and then a successive reduction in flow until steady state is reached. The results show that the leakage has been rather constant at 0.05 l/min during a long time but it seems to have decreased during the last month.

Water saturation, water pressure and swelling pressure in the backfill and water pressure in the surrounding rock have been continuously measured and recorded. Figure 3-4 and

Figure 3-5 show examples of measured results. Figure 3-4 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 water pressure increase.

Figure 3-5 shows the suction (negative pore water pressure) measured in the centre of some layers of 30/70 at different distances from the mats. The backfill is water saturated at suction about 1000 kPa. The influence of the increase in water pressure is obvious, with a much faster decrease in suction. Today the entire backfill seems to be close to water saturated.

In the last quarter of 2002 the water saturation will continue with consecutive measurement of water inflow, water pressure, total pressure and wetting. In addition, the dam in the TBM-tunnel will be built.

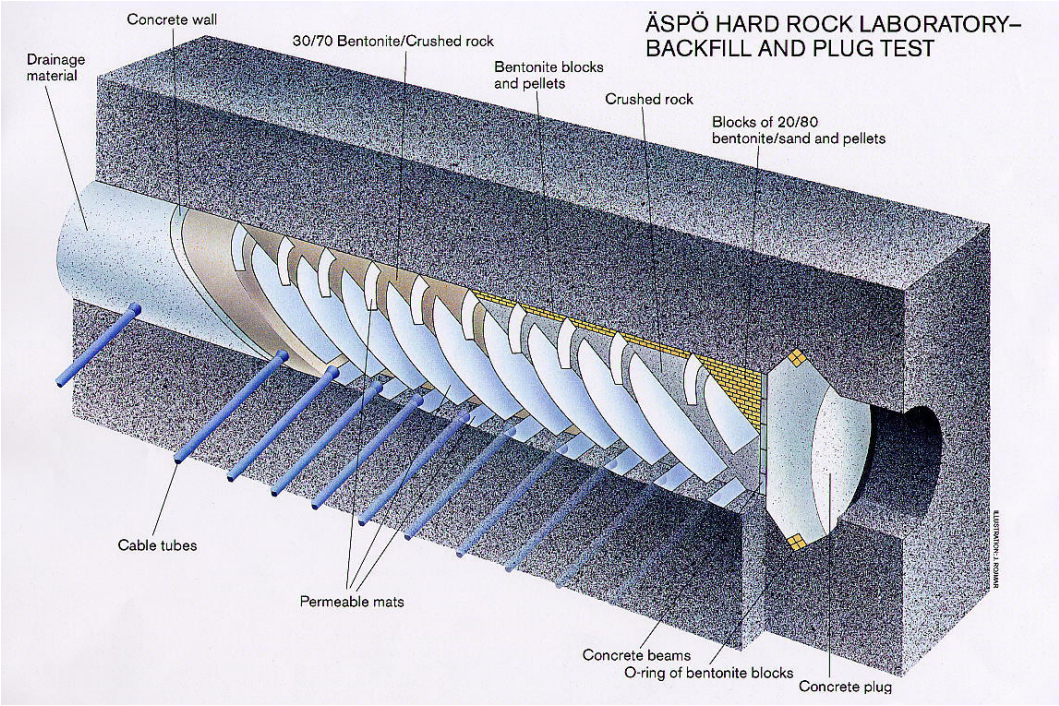

Figure 3-2 *Illustration of the experimental set-up of the Backfill and Plug Test.*

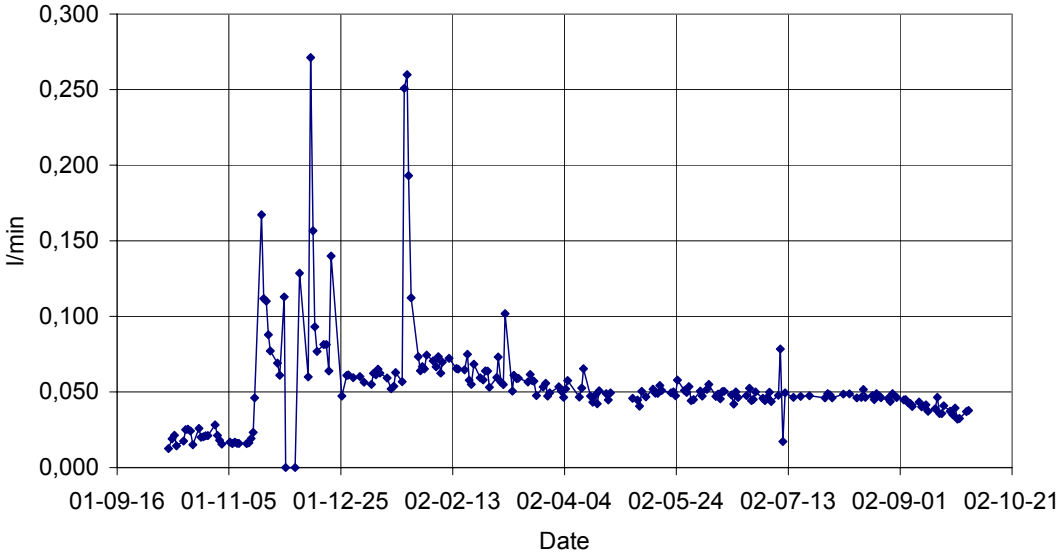

Figure 3-3 *Water flow through the plug and its surroundings. The four highest peaks correspond to 100 kPa pressure increase.*

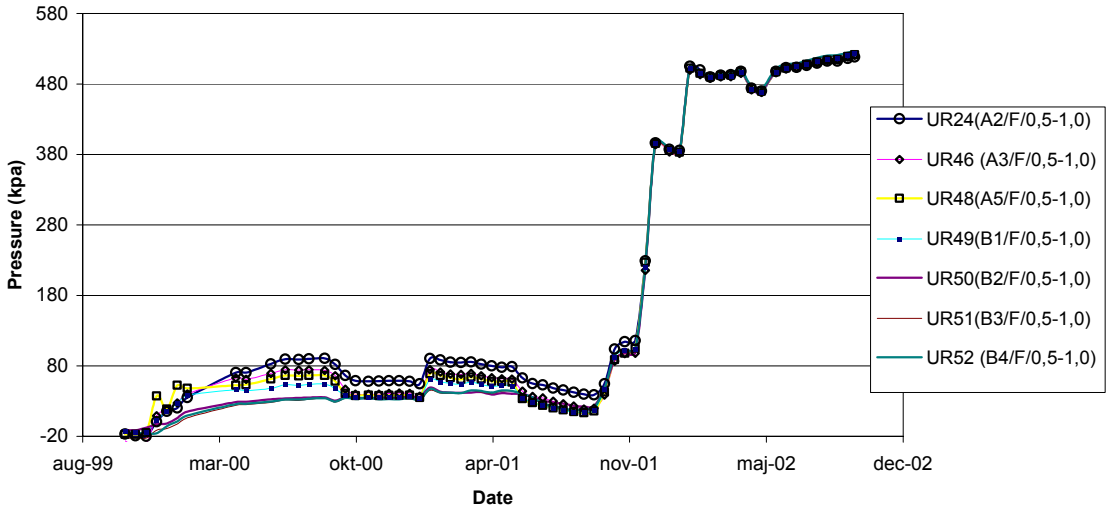

Figure 3-4 *Water pressure measured in the floor 30 cm below the rock surface. UR24, 46, 48 and 49 are placed in the 30/70 sections and the rest in the 0/100 sections.*

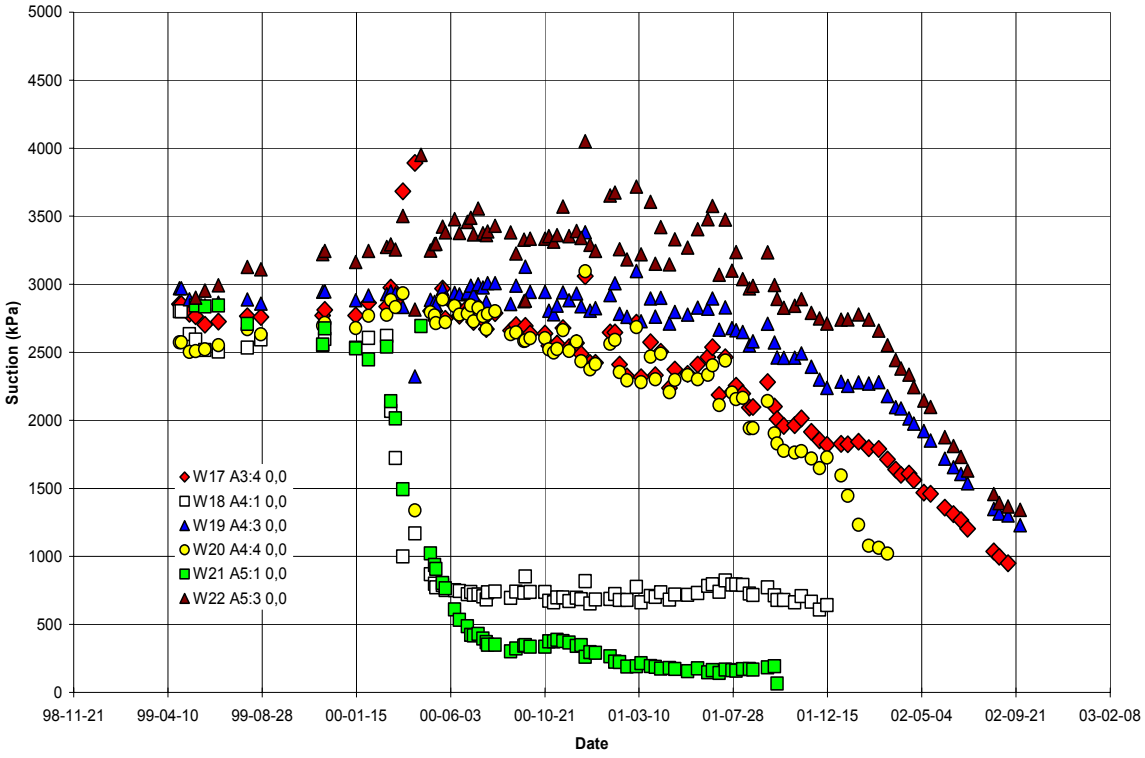

Figure 3-5 *Suction measured in the centre of different layers in the 30/70 backfill. W18 and W21 are placed in the first layer about 20 cm from the mats. W17 and W20 are placed 40 cm and W19 and W22 are placed 60 cm from the mats.*

3.4 Canister Retrieval Test

In the Canister Retrieval Test two full-scale deposition holes have been drilled for the purpose of testing technology for retrieval of canisters after the buffer has become saturated. These holes have also been used for studies of the drilling process and the rock mechanical consequences of drilling the holes. Canister and bentonite blocks were emplaced in one of the holes (see Figure 3-6) during 2000, the hole was sealed with a plug, heater turned on and artificial water supply to saturate the buffer started.

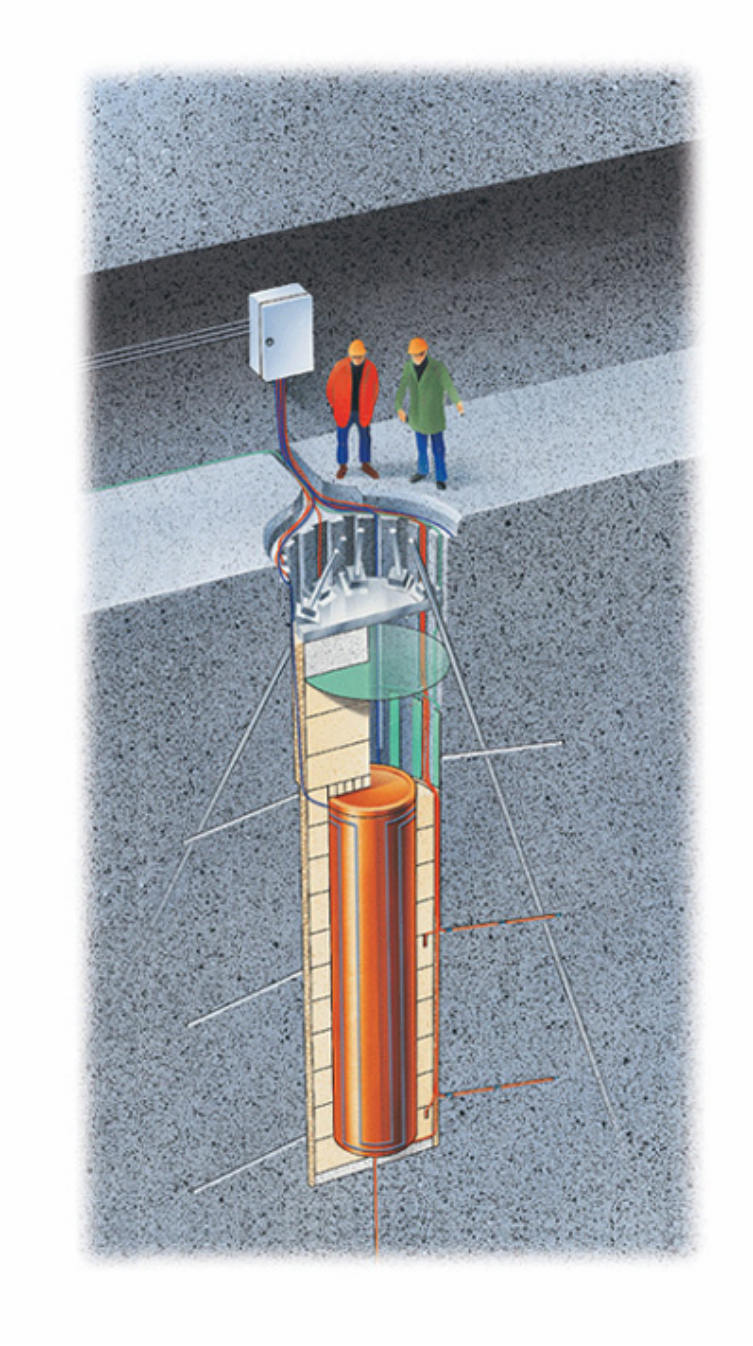

Figure 3-6 *Experimental set-up in Canister Retrieval Test.*

Achievements during the time period (July - September 2002)

A sensor data report /Goudarzi et al, 2002/ has been issued. The report presents data from the measurements in the Canister Retrieval Test from 001026 to 020501.

In November 2001, two of the 36 electrical heaters failed due to short circuit to earth. However, it has been possible to provide the needed experimental conditions and so far the heating has continued without problem although the heat effect has been decreased and therefore the temperature on the copper surface has decreased to 80°C. The plan is to continue the artificial water supply and the heating until the bentonite buffer has been fully saturated.

The general conclusion is that the measuring systems and transducers seem to work well. The data collected so far is used for modelling of the water saturation process.

3.5 Long Term Test of Buffer Material

The Long Term Tests of Buffer Material aim to validate models and hypotheses concerning physical properties in a bentonite buffer and of related processes such as bentonite degradation, microbiology, copper corrosion and gas transport in buffer material under conditions similar to expected repository conditions. Five 300 mm diameter test holes have been drilled and instrumented. Five test parcels (see Figure 3-7) with different duration times were installed in 1999. The intended test temperatures of 90°C and 130°C have been reached. In 2001 the 1-year parcel was extracted from the rock by overlapping core drilling. The remaining four long-term test parcels are planned to run for at least five years.

Achievements during the time period (July - September 2002)

The main task during 2002 is the examination of the field-exposed material from the 1-year parcel (A0).

The analyses of the *bentonite material* comprise:

- Physical properties (hydraulic conductivity, swelling pressure and plasticity)
- Mineralogical stability (montmorillonite, accessory minerals)
- Chemical evolution (Eh, pH, corrosive agents).

The base program for analyses and tests of the bentonite material has been performed by VTT, KTH, Studsvik, and Clay Technology according to plans. The analyses are almost completed and the results will be compiled during 2002. Preliminary results were presented at the 18th General Meeting of the International Mineralogical Association, 1st – 6th September 2002 in Edinburgh, Scotland.

Diffusion of tracers (^{60}Co, ^{134}Cs) in the exposed bentonite has been performed at Royal Institute in Stockholm. The results from the analyses are in accordance with previous laboratory results and are been published in Mats Jansson´s Doctoral thesis: Diffusion of Radionuclides in Bentonite Clay - Laboratory and in-situ Studies (Royal Institute of Technology, Stockholm 2002).

Studsvik has carried out *copper corrosion* analyses of well characterised copper coupons that were placed in the bentonite at installation of the test parcels. The laboratory program is completed.

The work on the 1-year parcel (A0) is planned to be reported during the spring 2003 in a SKB Technical Report.

The four long-term parcels are running according to plans and water pressure, total pressure, temperature and moisture are continuously being measured.

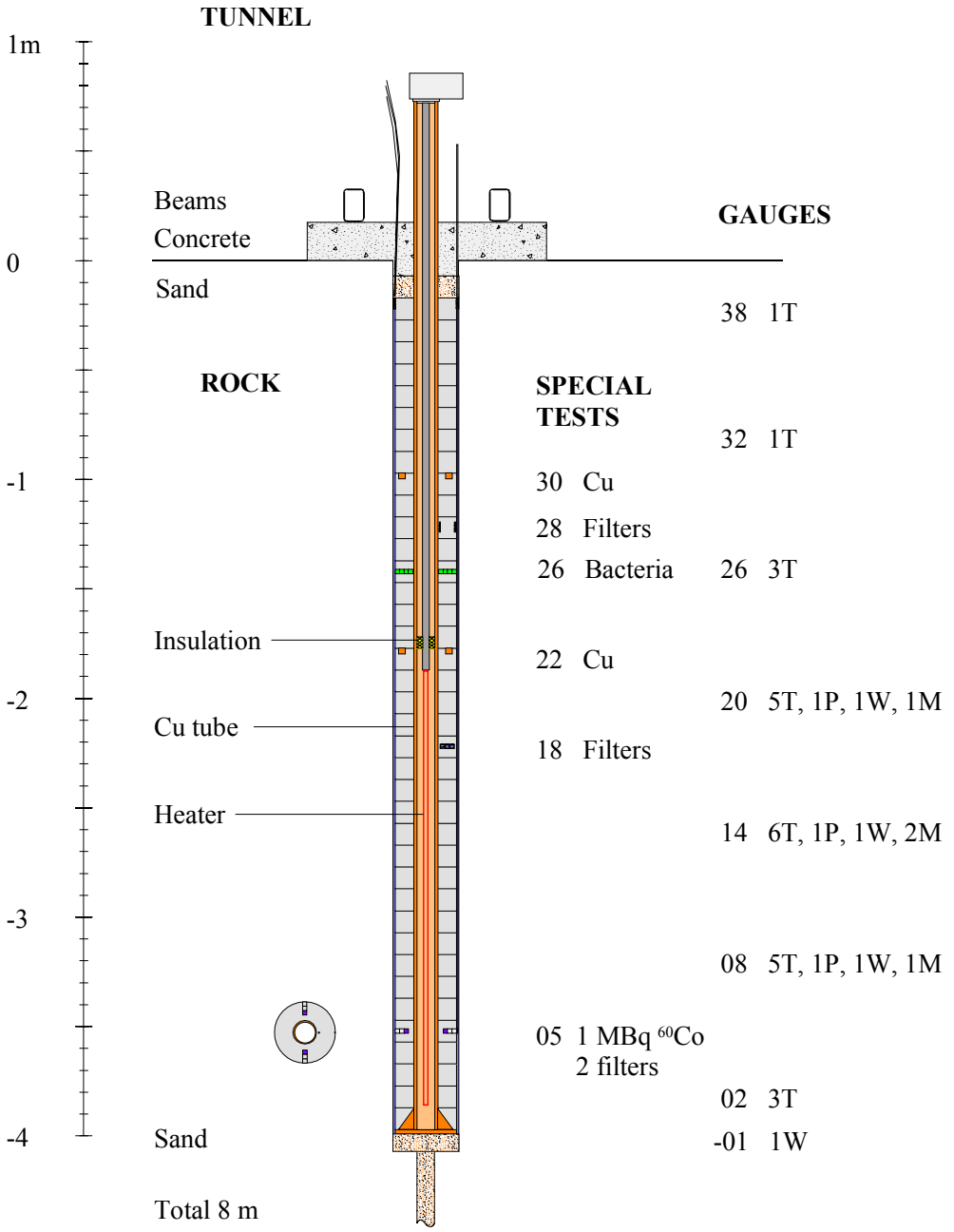

Figure 3-7 *Cross-section view of a standard condition parcel (S-type). The first figures in the columns "special tests" and "gauges" denote block number and second figures in the column "gauges" denote the number of sensors. T denotes thermocouple, P total pressure sensor, W water pressure sensor, and M moisture sensor.*

3.6 Pillar Stability Experiment

A Pillar Stability Experiment has been initiated to complement an earlier study performed at URL in Canada. The major aims are to demonstrate the capability to predict spalling in fractured rock mass and the effect of backfill on the propagation of micro cracks. In addition, the capabilities of two- and three-dimensional mechanical and thermal predictions will be compared.

Achievements during the time period (July - September 2002)

The project is divided into four phases. The first phase, a feasibility study and preliminary design of the experiment, was completed during 2001. A decision to continue with the second phase of the project has been taken. The outcome of this phase is the final experiment design.

Exploratory core drilling of 60-70 m long holes has been performed at two potential sites as part of the second phase of the project. In addition, hydraulic response measurements and test blasting with vibration measurements were performed to evaluate the interaction of tunnelling on adjacent experiments.

Coupled thermo-mechanical numerical modelling has been performed with 2D and 3D tools. The results have been used in the design work.

3.7 Low-alkali cementitious products

A project, in co-operation with Posiva and NUMO, concerning the use of low-alkali cementitious products in the deep repository began in 2001. The objectives of the project are to develop recipes for cementitious products to be used as grouting and mortar for anchoring of rock bolts and to demonstrate the usage of these products in small field experiments in Äspö HRL.

Achievements during the time period (July - September 2002)

The planned small field experiment in Äspö HRL has been postponed since the low-alkali cement recipe developed did not work as grouting material.

3.8 KBS-3 method with horizontal deposition

Late 2001 SKB published an R&D program for KBS-3H /SKB, 2001b/, a variant of KBS-3 with horizontal deposition of the canisters, see Figure 3-8. The R&D program is divided into four parts: Feasibility study, Basic design, Construction and testing at the Äspö HRL, and Evaluation.

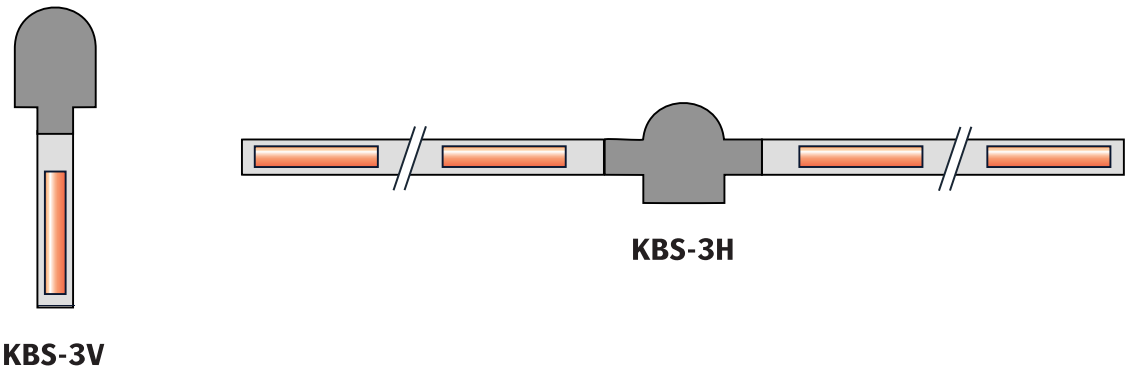

Figure 3-8 *Schematic illustrations of variants of the KBS-3 method.*

Achievements during the time period (July - September 2002)

The feasibility study was initiated during 2001 and has now been almost finalised and it has been recommended to continue the project with the Basic Design in accordance with the R&D program.

As parts of this, a site for construction and testing at Äspö HRL has to be identified and the equipments for boring of drifts and deposition have to be designed. The project is carried through by SKB in co-operation with Posiva.

3.9 Cleaning and sealing of investigation boreholes

A project, with the aim to identify and to demonstrate, in field experiments, the best available techniques for cleaning and sealing of investigation boreholes, was initiated in May 2002.

The first phase of this project comprises identification of available techniques, complementary laboratory experiments with potential sealing materials, and investigation of the status of two boreholes at Äspö. The two boreholes are planned to be used for the demonstration of cleaning techniques, i.e. removing of lost equipment in the holes.

Achievements during the time period (July - September 2002)

The pre-study of the project is now completed and information has been gathered mainly from the oil and petroleum industry.

3.10 Task Force on Engineered Barrier Systems

A Task Force on Engineered Barrier Systems has been initiated. The preparatory workshop suggested that the prior focus should be on the water saturation process in buffer, backfill and near-field rock. Since the water saturation process is also a part of the modelling work in the Prototype Repository, the work of the Task Force was consequently linked together with modelling work within the EC-project concerning the Prototype Repository.

Achievements during the time period (July - September 2002)

No meeting has been held during this time period and the work with the Work Packages proceeds according to plans.

4 Äspö facility

An important part of the Äspö facility is the administration, operation, and maintenance of instruments as well as development of investigation methods. Other tasks are a program for monitoring of groundwater head and flow and a program for monitoring of groundwater chemistry.

The aim of the GeoMod project is to update the existing geological, geomechanical, geohydrological and hydrogeochemical models over Äspö by integrating new data collected since 1995.

4.1 Facility operation

The main goal for the operation of the facility is to provide a safe and environmentally correct facility for everybody working or visiting the Äspö HRL. This includes preventative and remedy maintenance in order to withhold high availability in all systems as drainage, electrical power, ventilation, alarm and communications in the underground laboratory.

Achievements during the time period (July - September 2002)

A plant supervision system was taken into operation during 2000. This has considerably increased the possibility to run the facility in a safe and economic way. The availability in the underground-related systems (ventilation, hoist, lightning, pumps etc) has been highs, 98%, during the period July-October.

The automatic registration and object-monitoring system has been taken into operation for testing. The system will be installed in November if the testing during one month is trouble free.

The existing underground ventilation control will be exchanged and a frequency controlled speed control will be installed. The aim is to decrease the energy consumption and costs for maintenance. A project plan for this work is being prepared.

The decision to host the staff of the site investigation project results in a need for additional office space besides the number of offices that were provided in the temporary barracks. The purchase of new offices in the existing building was done in July and the work started in September. The design of an additional extension in the ventilation building has been finalised and the construction work has started. 22 new offices and two conference rooms will be available in April 2003.

A report summarising the experiences from five years of operation of the Äspö HRL will be published. Three fourth of the information has been gathered and the writing of the report is ongoing.

4.2 Hydro Monitoring System

The Hydro Monitoring System (HMS) collects data on-line of groundwater head, salinity, electrical conductivity of the water in some borehole sections, and Eh and pH in some other boreholes. The data are recorded by more than 400 transducers installed in boreholes on Äspö as well as in boreholes located in the tunnel. Similar system will be set up at candidate sites for the deep repository.

All data are transmitted to the main office at Äspö, by radio or modems. Weekly quality controls of preliminary groundwater head data are performed. Absolute calibration of data is performed three to four times annually. This work involves comparison with groundwater levels checked manually in percussion drilled boreholes and in core drilled boreholes, in connection with the calibration work.

Achievements during the time period (July - September 2002)

The system has been performing well and no main maintenance activity has taken place.

4.3 Program for monitoring of groundwater head and flow

The monitoring of water levels started in 1987 while the computerised HMS was introduced in 1992. The number of boreholes included in the network has gradually increased. The tunnel excavation started in October 1990 and the first pressure measurements from tunnel drilled boreholes were included in the HMS in March 1992.

To date the monitoring network comprises boreholes of which many are equipped with hydraulically inflatable packers, measuring the pressure by means of transducers. The measured data are relayed to a central computer situated at Äspö village through cables and radio-wave transmitters. Once a year the data are transferred to SKB's site characterisation database, SICADA. Manual levelling is also obtained from the surface boreholes on a regular basis. Water seeping through the tunnel walls is diverted to trenches and further to 21 weirs where the flow is measured. The scope of maintaining such a monitoring network has scientific as well as legal grounds.

Achievements during the time period (July - September 2002)

The monitoring points from the previous year have been maintained and no additional points are planned during 2002. The system will continue to support the experiments undertaken and meet the requirements stipulated by the water rights court.

4.4 Program for monitoring of groundwater chemistry

During the Construction Phase of the Äspö HRL, different types of water samples were collected and analysed with the purpose of monitoring the groundwater chemistry and its evolution as the construction proceeded. At the beginning of the Operational Phase, sampling was replaced by a groundwater chemistry monitoring programme, aiming at a sufficient cover of the hydrochemical conditions with respect to time and space within the Äspö HRL. This program is designed to provide information to determine where, within the rock mass, the hydrogeochemical changes are taking place and at what time stationary conditions are established.

Achievements during the time period (July - September 2002)

The monitoring points from the previous year have been maintained and a few additional points have been applied for 2002. The sampling took place in September 2002 and apart from a couple of points with too low fluidity the planned program proceeded without any problems.

4.5 Geo-scientific modelling

Based on pre-investigations geological, geomechanical, hydrogeological and hydrogeochemical models were made over Äspö HRL. During the Construction Phase the models were successively updated based on characterisation data obtained from 1986 until 1995. This work resulted in the Äspö96 models /Rhén et al., 1997/.

In the GeoMod project existing geological, geomechanical, hydrogeological and hydrogeochemical models of Äspö will be updated by integration of data collected since 1995, as well as by integrating the different geoscientific models compiled separately before. A major part of the new data has been collected during the operational phase for the different experiments. The new data have been produced in the lower part of the Äspö HRL. The modelling is restricted to a common virtual cube with 1 km side length extending from +50 m to -1000 m above sea level in elevation.

Achievements during the time period (July - September 2002)

The project has a delay of four month compared to the original time plan. The work with geological, hydrogeological, geomechanical and hydrogeochemical models is in progress. According to present plans a Summary Report will be finalised in March and the subject specific reports will be available in January.

A workshop concerning geo-scientific modelling with invited external expertise will be held in November.

5 International co-operation

Eight organisations from seven countries are from January 2002 participating in the Äspö HRL. The co-operation is based on separate agreements between SKB and the organisations in question, see Table 5-1. The international partners and SKB form the Äspö International Joint Committee (IJC). IJC is responsible for the co-ordination of the work arising from the international participation. The committee meets once every year. The last meeting was on May 27th. In conjunction with each IJC meetings a Technical Evaluation Forum (TEF) is held. TEF consists of scientific experts appointed by each organisation.

Table 5-1 Existing agreements between SKB and the organisations participating in Äspö HRL.

Organisation	Country	Period of agreement
Andra	France	2002-07-01 – 2004-06-30
BMWi	Germany	1999-01-01 – 2002-12-31
Enresa	Spain	2001-01-01 – 2004-12-31
JNC and Criepi [1)]	Japan	1999-03-02 – 2002-12-31
Nagra	Switzerland	1998-01-01 – 2002-12-31
Posiva	Finland	2001-01-01 – 2005-12-31
USDOE/Sandia	USA	1999-12-01 – 2002-09-30

1) The participation by JNC and CRIEPI is regulated by one agreement and one delegate in the International Joint Committee represents the two companies

Most of the organisations are interested in groundwater flow, radionuclide transport and rock characterisation. Several organisations are participating in the experimental work and modelling in the Äspö Task Force on modelling of groundwater flow and transport of solutes and in the Prototype Repository THMC modelling of bentonite and buffer performance during saturation. Table 5-2 shows the scope of each organisation's participation under the agreements.

Table 5-2 International participation in Äspö HRL.

Organisation	Participation
Agence Nationale pour la Gestion des Déchets Radioactifs, ANDRA, France.	Tracer Retention Understanding Experiments (TRUE Block Scale) Task Force on Modelling of Groundwater Flow and Transport of Solutes Prototype Repository Temperature Buffert Test – A test in the second hole in the Canister Retrieval Tunnel consisting of a bentonite column with heaters inside for creation of a line heat source
Bundesministerium für Wirtschaft und Technologie, BMWi, Germany	Radionuclide Retention Project (Actinide experiments) Colloid Project Microbe Project Task Force on Modelling of Groundwater Flow and Transport of Solutes Prototype Repository
Empresa Nacional de Residuos Radiactivos, ENRESA, Spain	Tracer Retention Understanding Experiments (TRUE Block Scale) 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	Tracer Retention Understanding Experiments (TRUE Block Scale Continuation) Task Force on Modelling of Groundwater Flow and Transport of Solutes Prototype Repository Task Force on Modelling of Groundwater Flow and Transport of Solutes Prototype Repository Voluntary project on groundwater dating – Validation of groundwater dating methods and evaluation of stability in groundwater environments after tunnelling.
Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle, NAGRA, Switzerland	Task Force on Modelling of Groundwater Flow and Transport of Solutes
Posiva, Finland.	Tracer Retention Understanding Experiments (TRUE Block Scale) Colloid Project Task Force on Modelling of Groundwater Flow and Transport of Solutes Prototype Repository Long Term Test of Buffer Material Pillar Stability Experiment
USDOE Carlsbad Field Office/Sandia National Laboratories, USA	Task Force on Modelling of Groundwater Flow and Transport of Solutes

EC-projects

SKB is through Repository Technology co-ordinating two EC contracts: Prototype Repository and Cluster Repository Project (CROP). SKB takes part in several EC-projects of which the representation is channelled through Repository Technology in five cases: FEBEX II, BENCHPAR, ECOCLAY II, SAFETI and PADAMOT. SKB will also be co-ordinator in the project NET.EXCEL.

Prototype Repository - Full scale testing of the KBS-3 concept for high-level radioactive waste (2000-09-01 – 2004-02-29)

Co-ordinator: Swedish Nuclear Fuel and Waste Management Co, Sweden

Participating countries: Finland, Germany, Japan, Spain, Sweden and United Kingdom

CROP - Cluster repository project, a basis for evaluating and developing concepts of final repositories for high level radioactive waste (2001-02-01 – 2004-01-31)

Co-ordinator: Swedish Nuclear Fuel and Waste Management Co, Sweden

Participating countries: Belgium, Canada, Finland, France, Germany, Spain, Sweden, Switzerland and USA

FEBEX II - Full-scale engineered barriers experiment in crystalline host rock phase II (1999-07-01 – 2003-12-31)

Co-ordinator: Empresa Nacional de Residuos Radiactivos, Spain

Participating countries**:** Belgium, Czech Republic, Finland, France, Germany, Spain, Sweden, and Switzerland

BENCHPAR - Benchmark tests and guidance on coupled processes for performance assessment of nuclear repositories **(**2000-10-01 – 2003-09-30)

Co-ordinator: Royal Institute of Technology (Dep. of Civil and Environmental Engineering), Sweden

Participating countries: Finland, France, Spain, Sweden and United Kingdom

ECOCLAY II - Effects of cement on clay barrier performance, phase II (2000-10-01 – 2003-09-30)

Co-ordinator: National Radioactive Waste Management Agency of France

Participating countries: Belgium, Finland, France, Germany, Spain, Sweden, Switzerland and United Kingdom

SAFETI - Seismic validation of 3-D thermo-mechanical models for the prediction of the rock damage around radioactive spent fuel waste (2001-09-01 – 2004-09-01)

Co-ordinator: The University of Liverpool (Dep of Earth Sciences), United Kingdom

Participating countries: France, Sweden and United Kingdom

PADAMOT - Paleohydrogeological data analysis and model testing (2001-11-01 – 2004-11-01)

Co-ordinator: Nirex Ltd, United Kingdom

Participating countries: Czech Republic, Spain, Sweden and United Kingdom

6 Documentation

During the period January-June 2002, the following reports have been published and distributed.

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6.2 Technical Documents and International Technical Documents

6 Technical Documents

- International Technical Documents

7 References

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