International Progress Report

IPR-01-22

Äspö Hard Rock Laboratory

Status Report

January - March 2001

April 2001

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel +46 8 459 84 00
Fax +46 8 661 57 19

Äspö Hard Rock
Laboratory

Äspö Hard Rock Laboratory

Status Report

January - March 2001

April 2001

Summary

Investigations and experiments

The barrier function of the host rock

SKB is launching a quality assurance system to be certified in April. Due to high priority of the formalities of that work, no progress from experiments with the Natural Barriers will be reported for the period January to March 2001

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 and planning for Task 6 are going on.

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. The second EC Project Progress Meeting was held in Cordoba, Spain, on March 27-28th. Physical activities in the Prototype Repository tunnel have been:

- Finalising of the 27 lead-throughs to the G-tunnel including lining, cones and grouting around them
- Levelling of the bottom in deposition holes with concrete
- Installation of bentonite packers in long term observation holes
- Detailed mapping of water inflow spots in deposition hole #3

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 since the plug is not tight yet. The filling is made slowly and stepwise since when the water level is raised water leaks out through the plug between the rock surface and the concrete until the bentonite O-ring has enough water to seal the slot at that level. 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 20 cm from the mat) in the 30/70 section have been clearly water saturated. Sensors 40 cm away indicate increased water content but not sensors 60 cm away.

The Demonstration of Repository Technology project aims to show in a perceptible way the different steps in encapsulation, transport, deposition, and retrieval of spent nuclear fuel for specialists and the public.

The Canister Retrieval Test aims at demonstrating the readiness for recovering of emplaced canisters also after the time when the bentonite has swollen. 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 (average calculated thermal load per canister in the Swedish program) to 2600 W in order to reach 90°C on the surface of the single canister in this particular test. The low temperature difference (a few tenth of degrees) between the steel insert and the copper mantle has sustained.

The Long Term Tests of Buffer Material aim to validate models and hypotheses concerning long-term processes in buffer material. Five boreholes 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.

International Cooperation

Nine organisations from eight countries are currently (December 2000) participating in the Äspö HRL.

The EC project CROP, a Thematic Network project, was finally launched in February.

Facility Operation

The supplementary rock reinforcement work has been completed.

A fire risk analyses showed that improved fire safety underground is required and a number of actions were suggested. A fire exercise was carried out in the underground facility in November, 2000, and the report from the experience gained and conclusions drawn is in progress

A two-storey barrack has added 16 new office rooms to the Äspö village.

Data Management and Quality systems

All data produced and used in the feasibility studies have been entrusted to the organisation of the Äspö HRL. The management responsibility for this type of data sets is upon the GIS administrator.

RVS version 2.3 has been implemented and the specification for version 3.0 is currently compiled and discussed.

Groundwater head and chemistry monitoring

A project is ongoing performing an overall evaluation of the Hydro Monitoring Program.

The Tidal Fracture Zone analysis project, which aims at evaluating the feasibility of utilising tidal fluctuation of monitoring data in order to calculate fracture orientation, has reached the final reporting stage.

The sampling occasions have been reduced to one sampling period a year as the groundwater chemistry at Äspö HRL, with a few exceptions, is constant. This sampling is made during the autumn.

Information activities

During the period January-March, 2001, 2331 persons visited the Äspö HRL. The groups have represented the public, communities where SKB performs feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries. 1566 persons represented the six communities where SKB performs feasibility studies.

Table of contents

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 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 boreholes 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 a 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 characterization 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

Models on Rock Mechanics and Heat Transport for a large rock volume have been initiated in order to supplement the existing detailed models on Geology, Geohydrology and Geochemistry. The aim is to compile the respective properties for the Äspö rock volume in a comparable way that has been done for the three existing geo-models. For Rock Mechanics a program on the approach has been developed comprising three phases: model on the Prototype Repository rock volume, model on the 420-450 m level rock volume and model on the Äspö rock volume. The model work on Heat Transport has started but is in an early stage with compilation of the program on the approach.

Planned work

The Rock Mechanics model work continues in all three phases in parallel but by different groups. Rock cores from earlier drilling campaigns will be re-mapped and the rock mechanics response from excavation of the Prototype Repository re-calculated based on the re-evaluated result from the stress measurements done in the tunnel.

A report on underground investigation methods used during the construction phase of the Äspö HRL will be published during mid 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

SKB is launching a quality assurance system to be certified in April. Due to high priority of the formalities of that work, no progress from experiments with the Natural Barriers will be reported for the period January to March 2001

3.2 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 HRL 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

New results

No new results has been produced during this quarter. Work has progressed on the final reporting for Task 4 and 5. With regard to Task 6 work progressed on the definition of basescases for sub-task 6A and 6B

Planned work

For the next quarter work will continue on the final reporting with Task 4 and 5. For Task 6 the first data delivery for sub-tasks 6A and 6B should be completed.

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 planned to be conducted at 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.
- 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.
- 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.
- 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 section is planned to be decommissioned after about 5 years and the second section after more than 10 years.

New results

The Project Group, consisting of basically Task Leaders, met only once during the period (with the objective to plan the activities that are scheduled to take place in the near future), in favour of the project management core group planning meetings taking place each Friday for discussion and decision on activities during the following week. Those meetings are documented but considered to be internal meetings.

The second Project Progress Meeting took place on March 27-28th in Cordoba in conjunction with the FEBEX II, and Backfill and Plug Test meetings. Minutes from this meeting have been distributed to all parties and EC as well as to all participants.

Physical activities in the Prototype Repository tunnel have been:

- Finalising the lining in the 27 lead-throughs to the G-tunnel including cones and grouting around them
- Levelling of the bottom in deposition holes with concrete
- Installation of bentonite packers in long term observation holes
- Adjustment of the road bed
- Final hydraulic testing in borehole sections
- Detailed mapping of water inflow spots in deposition hole #3

One pre-test was made regarding the swelling of bentonite blocks in a deposition hole, and if a plastic cover could be installed and used temporarily in the Prototype Repository. The hole in the assembly hall was used for installing the plastic cover and one bentonite block covered by a few concrete ones. The result confirmed the positive conditions gained when using plastic and the feasibility of installation and later recovery of this plastic.

Another pre-test is full scale was also made regarding compaction of crushed rock mixed with a cheaper bentonite type from Greece. The result confirmed also in this case the feasibility in using the cheaper bentonite type. A more detailed description of this test is presented by Posiva in section 6.2.

Fabrication of bentonite blocks has been completed.

Canisters with heaters are manufactured in accordance to the time plan.

Initiation of adjustment of the gantry crane and the deposition machine. The new trailer for carrying the deposition machine with canister has been ordered.

Detailed planning of the installation of Section I has been made that starts with lowering of the first block into hole # 2 on May 7th.

Planned work

Detail planning of installation in Section I will be finalised.

Installation of 9 cable packages out of 16 in the inner Section will be made prior to start of installation of the first bentonite.

Holes # 2, #3 and # 4 are installed before the summer holiday break, meaning bentonite blocks and canisters. Pellets in the slot outside the blocks, water and backfill on top up to the tunnel floor will be made in conjunction with the backfilling taking place one all four deposition holes have been installed.

No Deliverables or Milestones are due during the next period.

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 blasting. 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 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 during the year 2000.

New results

Figure 4-1 shows an illustration of the experimental setup. The following main events and results from the first quarter of 2001 can be mentioned:

- The forced water inflow into the permeable mat attached to the inside of the plug was increased to 0.5 l/min on January 2nd in order to fill up the mat and wet the entire bentonite O-ring. The leakage in the plug had previously prevented water to fill up the entire mat and to reach the top of the bentonite O-ring. The applied increased water inflow was large enough to also increase the water pressure in the mat so much that the water could reach the entire O-ring. The leakage through the plug at first increased substantially by water passing the O-ring above the previous point of leakage. After two weeks, the O-ring had sealed those passages, and the flow was again only coming through the old leakage point.

- The water pressure applied in the filter mats in the 30/70 mixture was again increased to 100 kPa on January 19th.
- Water saturation, water pressure and swelling pressure in the backfill and water pressure in the surrounding rock have been continuously measured and recorded. Figures 4-2 and 4-3 show examples of measured results. Figure 4-2 shows the water pressure in the rock measured in the short bore holes about 30 cm below the floor of the tunnel. Figure 4-3 shows the suction (negative pore water pressure) measured in the centre of different layers of 30/70. Only the sensors placed in the first layers (about 20 cm from the mat) have been clearly water saturated. A slow decrease in suction in transducers W17 and W20 started in September, which indicates that wetting has reached 40 cm from the mats and that it continues in a slow rate.
- The psychrometer measurements show that most 30/70 sections are water saturated at the perpendicular distance 20 cm from the mats and that an increased wetting has reached 40 cm in most spots but not to the centre of the backfill sections 60 cm from the mats.
- Reporting of the experimental setup is in progress.
- Modelling of the wetting rate of 30/70 with calibrated material models show that the time to full saturation will be more than 5 years with the water pressure 100 kPa in the mats and that a water pressure of 0.5-1.0 MPa is required to reduce the remaining time until full saturation to about 1 year.
- A project meeting was held in March and it was decided to execute the grouting of the concrete/rock interface through the tubes installed beforehand and to increase the water pressure stepwise to 0.5-1.0 MPa after checking the tightness of the plug.

Planned work

In the second quarter of 2001 the water saturation will continue with consecutive measurement of water inflow, water pressure, total pressure and wetting. Attempts will be made to investigate the location of the leakage path and then grouting of the plug will be made. A few weeks after the grouting the tightness of the plug will be tested.

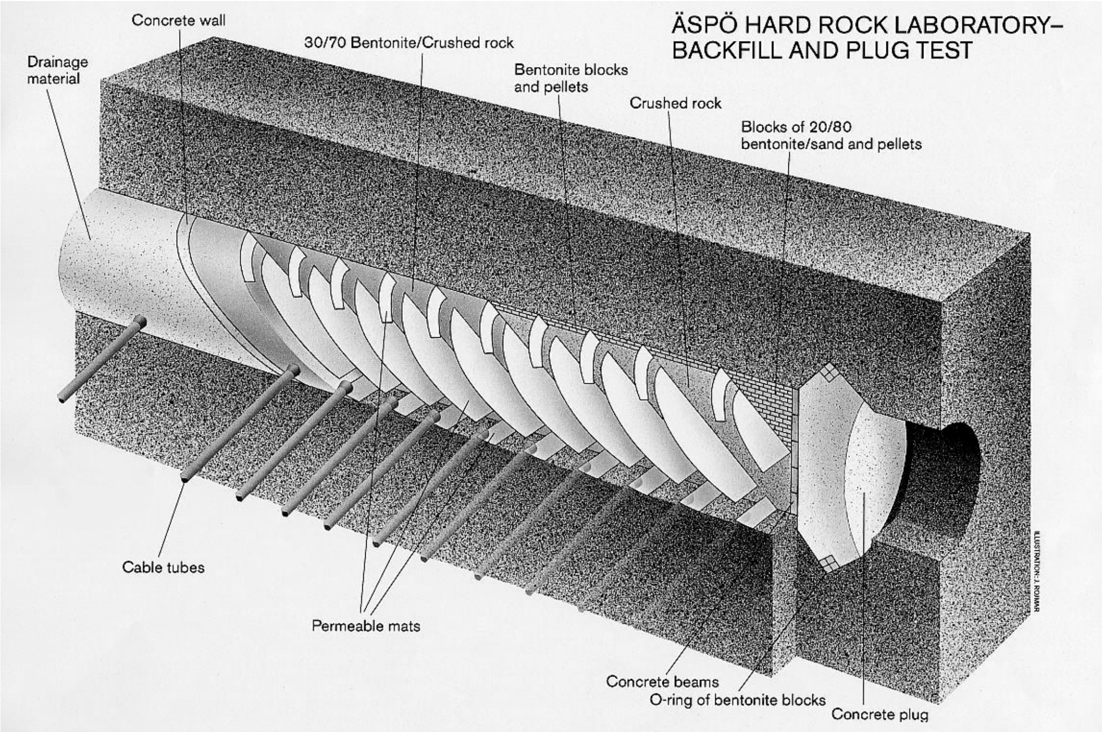


Figure 4-1 Illustration of the experimental setup of the Backfill and Plug Test.

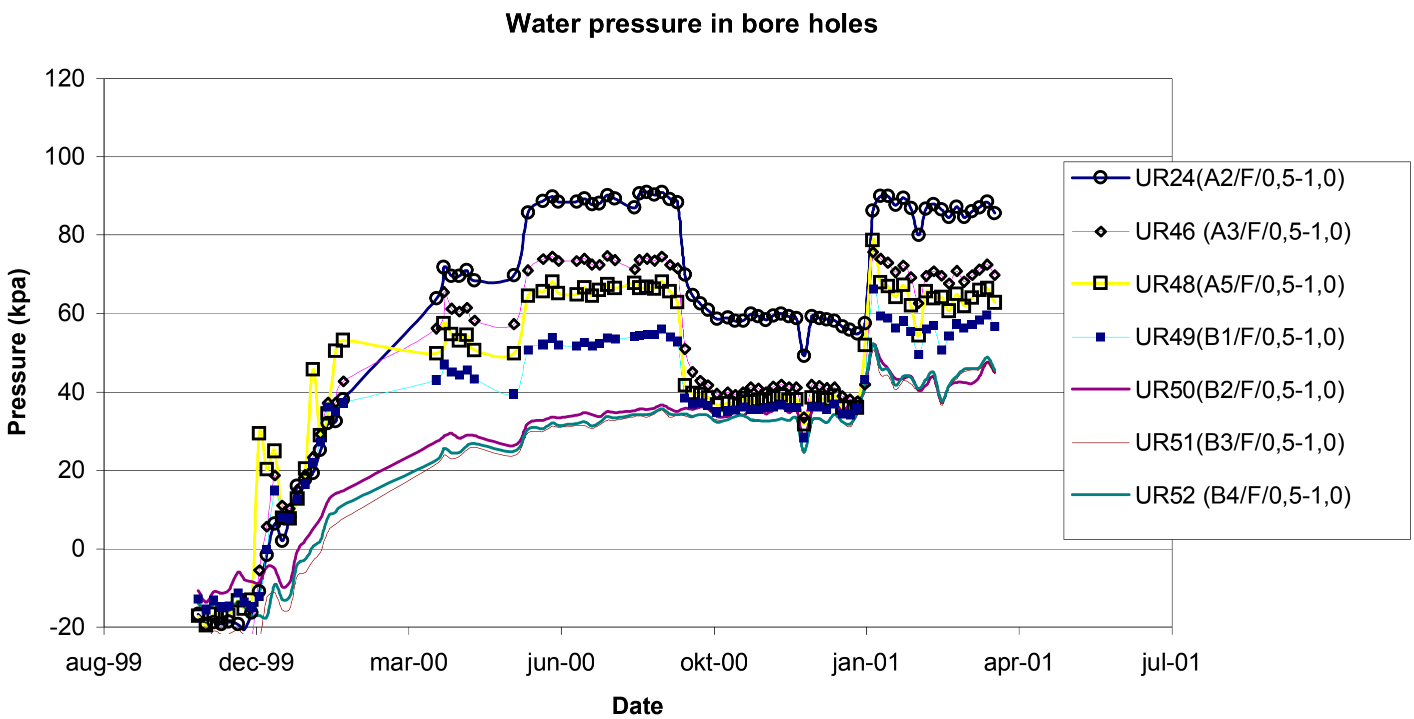


Figure 4-2 *Water pressure measured in the rock 30 cm below the floor. UR24, 46, 48 and 49 are placed in the 30/70 sections and the rest in the 0/100 sections*

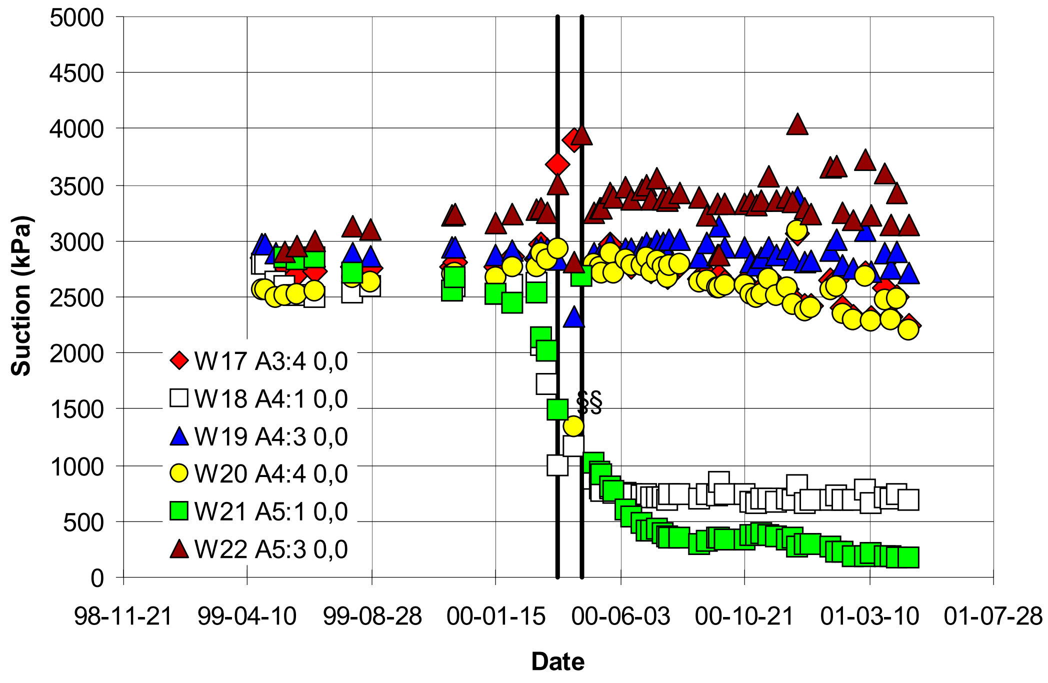


Figure 4-3 Suction measured in the centre of different layers in the 30/70 backfill. W18 and W21 are placed in the first layer about 20 cm from the mats. W17 and W20 are placed 40 cm and W19 and W22 are placed 60 cm from the mats.

4.4 Demonstration of Repository Technology

The development and testing of methodology and equipment for the encapsulation and deposition of spent fuel in the deep repository is an important part of SKB:´s programme. In addition to the technical aspects, it is also important to be able to show in a perceptible way the different steps in encapsulation, transport, deposition, and retrieval of canisters with spent fuel for specialists and the public. As part of the overall programme an Encapsulation Laboratory has been constructed in Oskarshamn and was taken in operation late 1998. Demonstration of deposition and retrieval of canisters will be made at the Äspö HRL. The demonstration project complements the Prototype Repository, the Canister Retrieval Test and the Backfill and Plug Test which focus on the integrated function of the engineered barriers in a realistic environment.

The objective of the demonstration of repository technology are:

- To develop and test methodology and equipment for encapsulation and deposition of spent nuclear fuel,
- to show in a perceptible way for specialist and the public the different steps in encapsulation, transport, deposition, and retrieval of spent fuel and
- to develop and test appropriate criteria and quality systems for the deposition process.

The demonstration of deposition technology is made in a tunnel south of the ZEDEX drift excavated by drill and blast. This location provides good rock conditions, a realistic environment for a future repository, and allow transport of heavy vehicles to this area.

The installation of the full size deposition machine for deposition of copper canisters started in June 1999 and was completed in September 1999. Figure 4-4 shows the deposition machine in the demonstration tunnel at Äspö in May 2000.

Main data for the machine:

Height	4.6 m
Width	3.7 m
Length	11.8 m
Weight, empty	90 tons
Weight, with shielded tube and canister	140 tons
Speed	0-10 m/s
Power supply	Cable
Capacity, main hoist	30 tons
Capacity, auxiliary hoist	5 tons
Capacity, hoist for bentonite top block inside machine	1 ton

Figure 4-4 *Deposition machine in the demonstration tunnel*

The inauguration of the demonstration tunnel with its deposition machine took place on 9th March 2000. After completion of the site test program mid May the deposition machine was handed over to SKB.

The design and construction of a mobile gantry crane with a lifting capacity of 3 tons including some auxcillary equipment for handling and deposition of the buffer material was completed early 2000. The design and construction of a small deposition machine for deposition of the canisters in the Canister Retrieval Test and the Prototype Repository was also completed early 2000. An extensive test program with handling of buffer material and a copper canister was completed in June 2000. Most of the test with buffer material was done with blocks and ring of concrete as compacted bentonite blocks and rings require special control of the environment. However, some tests were made with real bentonite blocks and rings. Restriction in the deposition hole due to instrument and power cables was also considered during these tests. The canister used had almost full weight but the electrical heaters were not installed. The tests of the equipment were performed in the TBM assembly hall at level 420 in the Äspö HRL.

The preparation of one of the deposition holes and the equipment for the Canister Retrieval Test was completed in early September 2000.

New results

Modification are needed both on the gantry crane and the deposition machine before they can be used in the installation of the Prototype Repository.

The Prototype Repository is located in a separate fire zone and the door between the fire zones restricts the size of equipment that can be transported through the door. Because of this the height of the gantry crane has to be reduced and it was decided to install hinges on the legs of the crane in order to reduce the height during transport through the opening of the door. The platform of the gantry crane was also provided with hinges in order to make transport and movements of the crane more easy.

The small deposition machine has been provided with a hydraulic system and four hydraulic jacks for positioning on the roadbed in the Prototype Repository.

A special trailer with 50 tons capacity for transport of the deposition machine with canister down to the Prototype Repository has been purchased and was delivered to Äspö HRL at the end of March.

Planned work

The final testing of the gantry crane and the deposition machine including the trailer will be completed during April 2001.

The installation of buffer material and canisters with heaters in the Prototype Repository is scheduled to start on May 7th, 2001.

The development work of the equipment needed in the future deep repository will also continue based on experiences from the ongoing work at Äspö. The different machines and transport and auxiliary equipment needed are planned to be developed to at least a feasibility stage as part of the ongoing design studies of the deep repository. Some of the major and important equipment may also be designed and constructed and tested at the Äspö HRL at a later stage for verification of the function and suitability of the equipment.

4.5 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 emplaced canisters also after the time when the bentonite has swollen. The process covers the retrieval up to the point when the canister is safely emplaced 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 4-5.

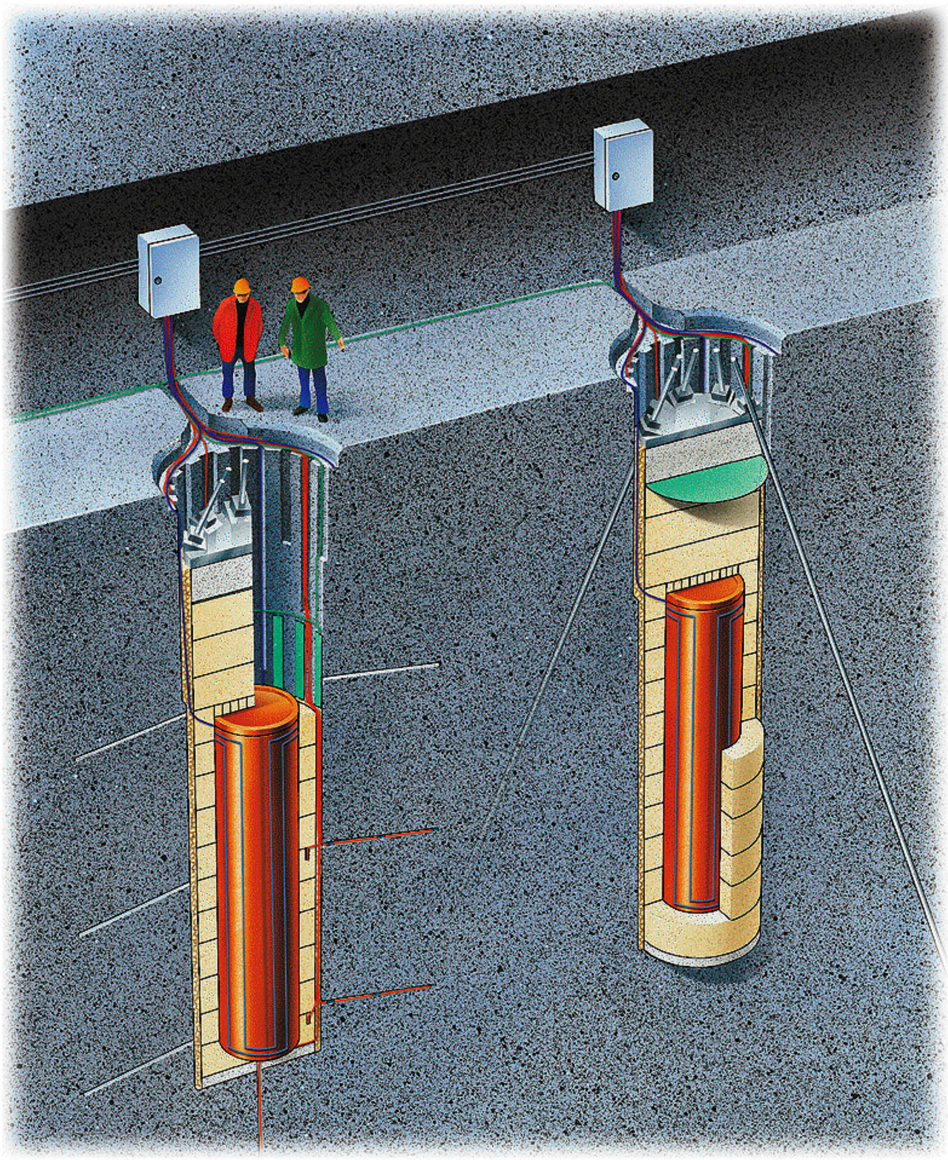


Figure 4-5 *Experimental set up. The picture to the left enhances the holes for the thermocouples in the rock, the permeable mats for artificial watering along the rock wall and the cable routes in the top of the hole, while the right picture enhances the location of the cable anchors in the rock and the sandwich structure of the plug – watertight mat against the bentonite, cast concrete and steel lid.*

New results

The artificial water supply to the surrounding permeable mats has continued and the flow registered.

The initial thermal load of 1700 W in the canister was raised to 2600 W after approximately three months of heating (on February 13th) and the sensor readings continued. The condition on February 2nd is shown in Figure 4-6.

The first data report, after six months of heating, has been compiled and will soon be published.

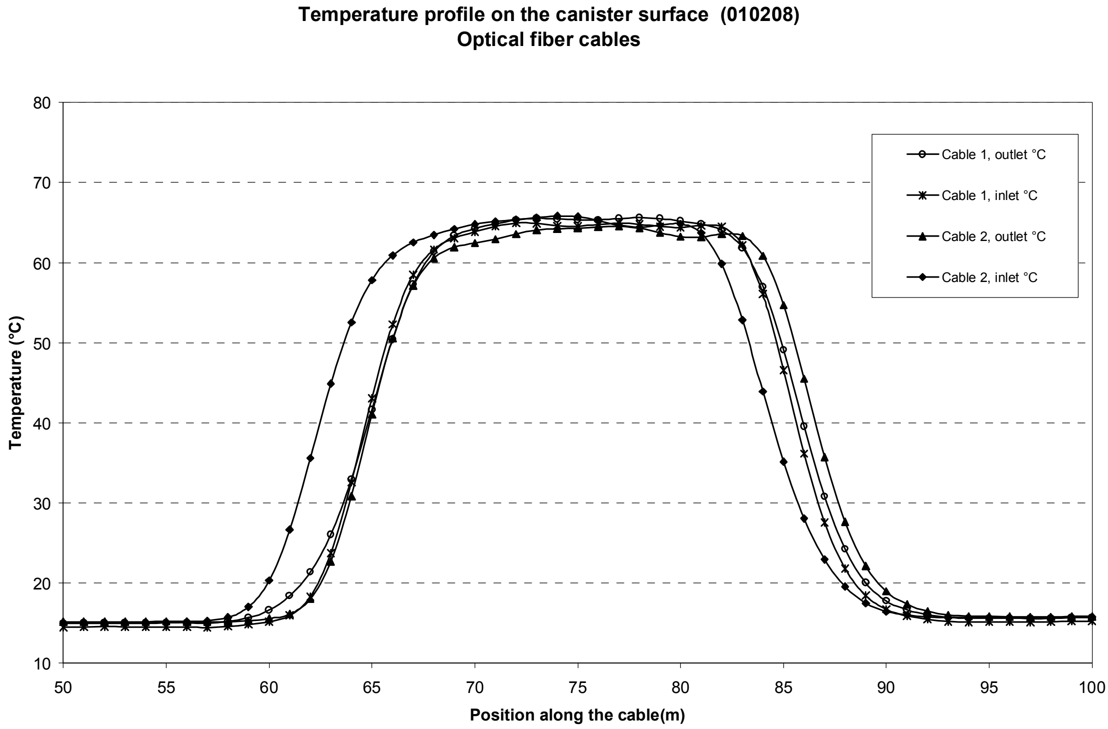


Figure 4-6 *Temperature on the surface of the canister after 104 days of heating with 1700 W, before the thermal load was increased to 2600W (aiming at 90oC on the surface).*

Planned work

The plan is to continue the artificial water saturation of the bentonite and to continue the registration of sensor readings. No modelling work is planned for the next three-month period.

4.6 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 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 KBS3 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 KBS3 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 KBS3 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.

Information which 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 three 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. 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. Development of analyse technique have been made in order to improve the characterisation of field exposed parcel material and will be reported during this quarter. Adoption to SKB quality assurance system (SD 017) has been made of project documentation.

Planned work

Excavation and analyses of the A0 parcel, which seems to be close to full saturation, will be made during the end of the year. Planning and preparation for the uptake will start in May and the drilling for retrieval is planned to begin in October. Subsequent analyses of the bentonite material will start immediate after uptake and will be finalised during the spring 2002.

The planned gas tests are likely not possible to carry through during the year due to the other activities in the tunnel and to the saturation conditions.

5 Äspö facility operation

5.1 Plant operation

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

In order to lower the costs and increase operational efficiency the maintenance agreement with the main contractor is being up-dated. Former services provided is harder to get due to the OKG reorganisation and outsourcing of maintenance groups. Opportunity to make maintenance-agreements with others has therefore emerged and new suppliers are being contracted.

The supplementary work with rock reinforcement was completed in February. Critical parts in the tunnel have been reinforced in order to insure environmental and operational safety. The reinforcement work has expanded as it has proceeded and the need was nearly twice the volume that originally was planned.

The condition of the Äspö road is poor and a major refurbish of the coating is necessary. Contact has been taken with two contractors and offers have been received. The work with the road is planned to be carried out and completed in May 2001.

The project to improve fire safety is in progress. The project is based on suggestions from a fire risk analysis made in 1999. It has included installation of traffic lights in a high-risk part of the tunnel and will continue with additional installation of fire detection system in the 420-m level and voice-alarm in strategic areas of the tunnel. The project is to be completed in late summer of 2001. Connected to the project a fire exercise has been carried out. The scenario included a car crash, injured persons, fire, smoke, electrical failure, blackout and evacuation of the tunnel. The exercise was done in co-operation with the fire brigade and illuminated problems that inevitably will occur in a real fire. Report concerning the exercise is to be completed.

Due to lack of office space a two-level barrack, housing 16 offices and 2 conference rooms has been built adjacent to the laboratory on the ground surface. The work was completed in three months (January-March). The additional office space is to be taken in use in week #15, 2001.

The project for hands-free-registration going underground is in progress. As feasibility study was completed and a request for quotations was sent out. The incoming bids have been evaluated and three companies have been selected and invited to make a detailed study of the facility. This is done to ensure a detailed offer and to determine what type of system and technique to proceed with. The plan is to sign a delivery contract in May 2001.

5.2 Data management and data systems

Background

Management of investigation data is a highly demanding and a 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's siting work, with the aim to establish a system which can meet the requirements from the regulatory authorities and the internal organisation as well. The current status and the actual plans of GIS, SICADA and RVS are presented below.

New results

GIS

All data produced and used in the feasibility studies have been entrusted to the organisation of the Äspö HRL, where the GIS administrator has the management responsibility for the data sets.

SICADA

The Rock Visualisation System requires that modifications are made and efforts have been initiated to improve a part of the data structure used for management of information about all co-ordinate systems handled in the database.

RVS

RVS version 2.3 has been implemented and the specification for version 3.0 is currently being compiled and discussed. Some pre-programming work has also started for some tests. Version 3.0 is focused on implementation of a new modelling concept, named GEOFUNK, developed by the PLU-project.

Planned work

GIS

The following issues will be under addressed during the next period :

- Develop and implement some minor GIS-applications with interfaces to the SICADA database.
- Improve the description of the data sets compiled during the feasibility studies.

SICADA

The data structure of SICADA will partly be modified and the SICADA administration application GTAdmin will be modernised and extended with some important but missing features.

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 is planned to be released before this summer.

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.

New results

The HMS program has continued running real time data a quisition in support of the various project undertaken in the Äspö HRL. 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.

A project is ongoing performing an overall evaluation of the Hydro Monitoring Program. This work is done in support of the Äspö activities where a feedback based on experience is due and also in support of the coming geoscientific site characterization. A draft report has been compiled.

The Tidal Fracture Zone analysis project, which aims at evaluating the feasibility of utilising tidal fluctuation of monitoring data in order to calculate fracture orientation, has reached the final reporting phase.

Planned work

For the next quarter it is planned to

- Continue to support various projects at Äspö with monitoring data
- Complete the overall evaluation and assessment of the Hydro Monitoring System by producing a final report..
- Complete the Tidal Fracture Zone project by producing a final report.

5.4 Program for monitoring of groundwater chemistry

One sampling campaign is made each year and during 2001 the plan is to make the sampling during the third quarter.

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 summer 2001. The weirs in the tunnel have been calibrated. Radio modems have been installed at the boreholes KAS 08 and KAS 12 for data collection.

Planned work

Renovation will be made at the boreholes HAS 15 and KAS07 during summer/autumn 2001.

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 presenting information about SKB, the Äspö HRL and the SKB siting programme. A main attraction is the guided underground tour, which takes the visitor to the U500 centre (U for Urberg = Bedrock) located on the 420 m level.

New results

During January-March of 2001, 2331 persons visited the Äspö HRL. The groups represented the public, communities where SKB has performed feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries.

1566 persons represented the six communities where SKB has performed feasibility studies.

Urberg 500

95 % of the visitors are offered a U500 tour, which starts from the Entrance Building, goes on down in the tunnel by bus, up to the Äspö village by elevator and back to the Entrance Building by bus.

The public tours started in February and will continue over the summer period.

Special projects

- The exhibitions both in the exhibition hall and under ground in the tunnel are updated and renewed.
- Video productions:
  - Welcome to Äspö HRL (safety instructions)
  - Safety precautions for visitors.
  - Deposition machine.
- The Visitors Site, which purpose is to visualise the siting programme, is situated near Äspö Village. The visitors can walk up to the site and be informed on what a site investigation means.
- The new booking system has been delayed, but is scheduled to be purchased during late spring. It can then be taken into operation in August.

6 International cooperation

6.1 Current international participation in the Äspö HRL

Nine organisations from eight countries are currently (April 2001) participating in the Äspö HRL.

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 characterization. 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.

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	Test of models describing the barrier function of the bedrock (TRUE Block Scale) Demonstration of technology for and function of important parts of the repository system, (Backfill and Plug Test)
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 project. 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
United Kingdom Nirex Limited, **NIREX**, Great Britain	TRUE Block Scale
POSIVA , Finland.	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 Prototype repository project
USDOE/**Sandia National Laboratories**, USA	Test of models describing the barrier function of the bedrock

6.2 Highlights of work by participating organisations

Work performed by Posiva

During the February 2001 Posiva participated in “Field compaction test with Friedland Clay” at Äspö HRL as a joint project in accordance with the agreement on Posiva’s participation in Äspö HRL activities. The measured groundwater salinity at the Olkiluoto site on the final repository depth is between 15 -25 g/l. The salinity of groundwater does not cause a problem for using crushed rock and bentonite mixture as a backfill material if the bentonite content is high enough. Instead of crushed rock and bentonite mixture the naturally swelling Friedland clay may be a possible backfill material because it will not loose the swelling capacity in the presence of saline groundwater.

A field test for the use of Friedland Clay was conducted in "Method tunnel" at 70 meters depth along the Äspö entrance ramp. The compaction test of Friedland clay was continuation for the field compaction test with mixture of Greek bentonite and crushed rock, and the compaction technique was similar as in earlier test. Two layers of Friedland clay were compacted with inclination of 35 degrees. Density and water ratio was measured after compaction.

The expected results from the test were

- Friedland clay can be handled in the same way as the mixture of crushed rock and Greek bentonite
- That a dry density of 1,7 g/cm^3 can be achieved in field compaction.

The result was not reached due to too low water ratio of the delivered Friedland Clay. Compaction became difficult because of the dust problem and the material was not well compacted close to the roof of the tunnel. The test continues in the summer 2001 at Äspö HRL. A third layer will be compacted after raising the water ratio in Friedland clay material from 7-8% to 10-12%.

6.3 Cluster of Repository Project – CROP

The contract with the EC was signed in January and the project started consequently in February.

The first project meeting was held in Braunschweig, Germany, on February 13-14th with participation of all nine partners: SKB, SCK-CEN, Posiva, ENRESA, GRS, ANDRA, NAGRA, OPG and USDOE CBFO. The project is a Thematic Network (=only desk studies) and aims at compiling experience from tests on engineered barriers in underground rock laboratories. Five interim reports are scheduled and one final report. The first report on work outline is on the CROP home page for internal project review. The first delivery report on national concepts (country annexes) is due in July this year.

7 Other matters

7.1 Documentation

During the period January-March 2001, the following reports have been published and distributed:

7.1.1 Äspö International Cooperation Reports

None.

7.1.2 Äspö International Progress Reports

Andersson P, Ludvigsson J-E, Wass E, Holmqvist M
TRUE Block Scale Project. Tracer test stage. Interference tests, dilution tests and tracer tests
IPR-00-28

Andersson P, Wass E, Holmqvist M
TRUE Block Scale Project. Tracer test stage. Tracer tests, phase B
IPR-00-29

Goudarzi R, Gunnarsson D, Johannesson L-E, Börgesson L
Backfill and Plug Test. Sensors data report (period: 990408-000601), Report No: 1
IPR-00-32

Hermanson J, Doe T
TRUE Block Scale Project. Tracer test stage. March'00 structural and hydraulic model based on borehole data from KI0025F03
IPR-00-34

17 Technical Documents

2 International Technical Documents

References

Andersson, P., Johansson, H. Nordqvist, R., Skarnemark G., Skalberg, M., and Wass, E. 1998a Parameters of importance to determine during geoscientific site investigation.
SKB TR 98-02

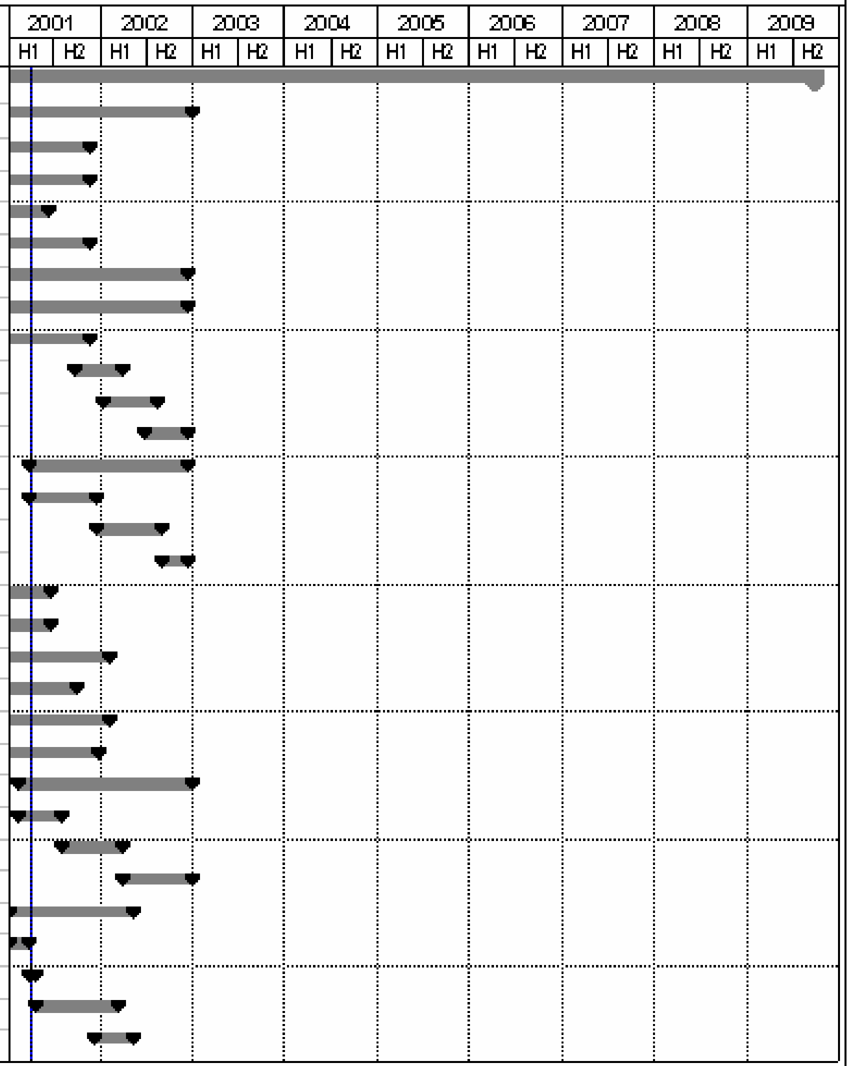
Appendix A

MASTER SCHEDULE ÄSPÖ

Christer Svemar

Äspö Plan Right
Version 2000.1

Struktur	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	Realization indirect radiolysis
1.2.2.2	Realization direct 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



MASTER SCHEDULE ÄSPÖ

Äspö Plan Right
Version 2000.1

Christer Svemar

Struktur	Namn
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 version 3.0