International
Progress Report

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Äspö Hard Rock Laboratory

Status Report

October – December 2000

March 2001

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Äspö Hard Rock
Laboratory

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Summary

Investigations and experiments

The barrier function of the host rock

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

The Long-Term Diffusion Experiment is intended as a complement to the *in-situ* dynamic experiments and the laboratory experiments performed within the TRUE Programme. The objectives are to study diffusion into the rock matrix and to obtain data on sorption processes and properties. The experimental concept is based on a large diameter borehole, which exposes a fracture surface through which difussion is made. A suitable target fracture has been identified at the 410 m level. During the period the project group has started up the process to obtain a "CE-marking" of the experimental set up. Numerical modelling has been performed to simulate the desaturation and resaturation of the core stub as a consequence of the borehole being opened, and subsequently being shut-in.

The TRUE-2 as a stand-alone detailed scale experiment on a single fracture has been omitted as a concept. Rather an extension of the TRUE programme will be focussed on the TRUE Block Scale site.

The TRUE Block Scale project aims at studying the tracer transport in a fracture network over distances up to 50 m. The tracer injections planned have now been performed and final evaluation and reporting is in progress. A reporting structure for TRUE Block Scale has been developed. A series of four final reports will be produced. Modelling of the Phase B tests and predictive modelling of the Phase C tests have continued during the period. Results of the predictive work is expected early 2001.

The CHEMLAB probe has been constructed and manufactured for validation experiments in situ at undisturbed natural conditions. The experiment with migration of actinides, Am, Np and Pu, was started in November and was planned to continue for 12 weeks. One week after strart the experiment was stopped due to an error message of the CHEMLAB-2 probe. At present the failure and the cause of the failure is not know.

The Matrix Fluid Chemistry experiment has the aim to determine the origin and age of matrix fluids and to establish to what extent the composition of matrix fluid has been influenced by diffusion processes. Detailed sampling of a rock profile perpendicular to the microfissure has been carried out in preparation for detailed study to investigate any evidence of in- or out-diffusion processes. Both borehole sections, Section 4 (already sampled) and Section 2, are continuing to show steady pressure increases; Section 4 may even be showing a levelling off indicating it has been refilled. In both cases adequate time will be allocated to ensure suitable water volumes for sampling and analyses.

The Stability and Mobility of Colloids (SMC) Project has been initiated to investigate the potential for colloidal transport in natural groundwater. Studies will be made of colloid concentration at Äspö HRL and the role of bentonite clay as a source for colloid generation. A project description and a project plan have been produced during

November-December 2000. A project decision to perform the project was taken during December 2000.

A set of microbiology research tasks for the performance assessment of high level nuclear waste (HLW) disposal has been identified. A test site, called the MICROBE site, has been prepared at the 450 m level. Groundwater chemistry, cultivable microorganisms, stable isotope and gas data have been obtained from the MICROBE boreholes.

The Task Force is a forum for the organisations supporting the Äspö Hard Rock Laboratory Project to interact in the area of conceptual and numerical modelling of groundwater flow and solute transport in fractured rock. The 14th International Task Force meeting was held at Säröhus, Sweden. Final modelling reports for Task 4E&F and Task 5 were delivered. A new sub-task to Task 4 was initiated with the purpose to perform an overall evaluation of the Task 4 modelling (Task 4OE). It is done from the perspective of the participation organisations in order to assess how the complete Task 4 modelling has meet the purpose and ambitions of the organisations. A new task was initiated, Task 6. The new modelling task tries to bridge the gap between performance assessment (PA) and site characterization (SC) models by applying both approaches for the same tracer experiment, and also for PA boundary conditions.

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 modelling group - WP3 - meet for the first time on December 12 in Lund, Sweden. Physical activities in the Prototype Repository tunnel have been:

- Finalising the drilling of holes for thermocouples and resistivity measurements
- Finalising the drilling of the 27 lead-throughs from the G-tunnel
- Initiation of lining of the 27 lead-throughs

The Backfill and Plug Test comprises full scale testing of backfill materials, filling methods, and plugging. 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 November 1999. Water filling of the outer test sections (0/100), which started in June, 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.

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 retrieval test aims at demonstrating the readiness for recovering of emplaced canisters also after the time when the bentonite has swollen. Installation of bentonite blocks and instrumentation was completed in September. After installation of the canister it was found that all heaters did not work. The canister was retrieved, quickly repaired and sent back to Äspö. Once back the canister was installed, pellets and water filled in the outer slot, the bentonite blocks on top installed and the plug cast and anchored. The artificial water supply to the surrounding permeable mats was opened and the heaters were turned on on October 27th. A thermal load of 700 W was applied for a few days before being raised to 1700 W, which is the calculated average thermal load per canister in the Swedish programme. One major observation is that the temperature inside the canister, in the cast steel insert, is just a few degrees higher than the temperature on the outer surface of the copper canister, thus showing a low temperature gradient across the gap between steel insert and copper.

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 a 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 Hard Rock Laboratory.

Facility Operation

The supplementary work with rock reinforcement is progressing as expected. At present shotcreeting, bolting and mounting of mesh is carried out at the 450-m level. The work is expected to be completed early February 2001. The facility operations monitoring system ALFA, was completed and approved in November and is now in operation.

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 at the 30 November. The scenario included a wrecked car, injured personell, fire with heavy smoke, electrical failure causing a blackout and finally evacuating the tunnel. The exercise was made in co-operation with the local firebrigade and illuminated some of the problems that inevitably will occur in a real fire/accident.

The new car parking space at the Äspö site has been built according to plan. The facility now has 32 additional places for parking cars.

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 set 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 has delivered its first milestone, being a literature review of the theory and example calculation with Äspö data. This project aims at evaluating the feasibility of utilising tidal flucuation of monitoring data in order to calculate fracture orientation.

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. In October, the sampling for year 2000 was performed.

Information activities

During the fourth quarter of 2000, 3055 persons visited the Äspö HRL. The groups have represented the general public, communities where SKB performs feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries. 1681 persons represented the six communities where SKB performs feasibility studies.

Contents

		Page
1	**General**	**7**
2	**Methodology for detailed characterisation of rock underground**	**8**
3	**Test of models for description of the barrier function of the host rock**	**9**
3.1	General	9
3.2	Tracer Retention Understanding Experiments	10
	3.2.1 Long Term Diffusion Experiment (LTDE)	11
	3.2.2 Second TRUE Stage (TRUE-2)	16
	3.2.3 TRUE Block Scale	16
3.3	Radionuclide retention	20
3.4	Hydrochemical modelling/Hydrochemical stability	22
3.5	Matrix Fluid Chemistry	24
3.6	Colloids	26
3.7	Microbe	28
3.8	The Task Force on modelling of groundwater flow and transport of solutes	30
4	**Demonstration of technology for and function of important parts of the repository system**	**32**
4.1	General	32
4.2	Prototype Repository	32
4.3	Backfill and Plug Test	34
4.4	Demonstration of repository technology	37
4.5	Canister Retrieval Test	39
5	**Äspö facility operation**	**42**
5.1	Facility operation	42
5.2	Data management and data systems	43
5.3	Program for monitoring of groundwater head and flow	44
5.4	Program for monitoring groundwater chemistry	45
5.5	Technical systems	46
5.6	Information	47
6	**International cooperation**	**48**
6.1	Current international participation in the Äspö Hard Rock Laboratory	48
7	**Other matters**	**51**
	7.1.1 Äspö International Cooperation Reports	51
	7.1.2 Äspö International Progress Reports	51
	References	**53**
	Appendix A	**54**

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 and for design of a deep repository. This requires extensive field studies of the active processes and properties of the geological barrier and the interaction between different engineered barriers and host rock. The Äspö Hard Rock Laboratory provides an opportunity for research, development and demonstration of these issues in a realistic setting. Important tasks for the Äspö Hard Rock Laboratory 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 characterisation of rock underground

Background

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

The objectives are:

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

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

Results

Reporting of the MWD (Measurement While Drilling) used during drilling of 2 855 metres of percussion probe holes during the excavation of the Äspö HRL tunnel has been performed.

Planned work

Nothing planned during the first tertial of 2001.

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

3.1 General

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

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

Conceptual and numerical groundwater flow models have been developed through the entire Äspö project up to now. During 2000 focus is on further development of the numerical tools used for groundwater flow and transport calculations.

Hydrochemical stability and potential variability is assessed within several ongoing projects. These aim at explaining possible chemical conditions in a repository host rock based on assumption of different climate conditions in the future. The project will be reported during year 2000. Input to this reporting is provided from EQUIP, TASK#5, REX, Matrix Fluid Chemistry and other experiments. Some of these have not been completed yet. For instance the characterisation of the chemistry of water in the pores and micro fractures.

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

Tracer tests are carried out within experiments in the TRUE-projects. These are conducted at different scales with the aim of identifying detailed scale (5m) and block scale (50m) flow paths, retention of weakly and moderately sorbing tracers and the effect of matrix diffusion. During 2000 the goals are to complete the experimental part of

TRUE Block Scale and to start the Long Term Diffusion Experiment (LTDE). Modelling of the experiments is done by several groups associated to the Äspö Task Force for modelling of groundwater flow and transport of solutes.

CHEMLAB experiments are conducted with the moderately and highly sorbing nuclides. Experiments are carried out in simulated near field conditions (bentonite) and in tiny rock fractures. During 2000 experiments including effects of radiolysis will be carried out in the CHEMLAB 1 unit. In the CHEMLAB 2 unit experiments using actinides will be started.

Colloids could affect the transport of radionuclides in the case these exist in a high enough concentration. The investigations made at Äspö and elsewhere give a concentration that it is not possible to detect. That concentration has no impact on the transport of radionuclides. New findings of colloidal transport and the existence of more sensitive instruments are the reasons for a new programme on different aspects of colloid transport.

Microbes are of particular interest since they can directly influence the chemistry of the groundwater, and indirectly transport nuclides attached to them. For continuing the basic studies of the microbes in the Äspö laboratory, a site has been allocated in the J-niche at 430 m dept.

3.2 Tracer Retention Understanding Experiments

Background

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

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

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

- Develop the understanding of radionuclide migration and retention in fractured rock.

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

3.2.1 Long Term Diffusion Experiment (LTDE)

Background

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

The objectives of the planned experiment is to ;

- To investigate diffusion into matrix rock from a natural fracture in situ under natural rock stress conditions and hydraulic pressure and groundwater chemical conditions .
- To obtain data on sorption properties and processes of some radionuclides on natural fracture surfaces
- To compare laboratory derived diffusion constants and sorption coefficients for the investigated rock fracture system with the sorption behaviour observed in situ at natural conditions, and to evaluate if laboratory scale sorption results are representative also for larger scales.

The test plan presents an experimental concept centred on establishment of an experimental (large diameter) borehole which exposes a natural fracture surface. This fracture surface is packed off with a cap which seals off the exposed rock cylinder in the bottom of the borehole, similar to the approach used in the REX experiment, cf. *Figure 3-1*. The intention is to establish an experimental chamber in which a tracer solution is circulated over a period of four years. Performed scoping calculations using available diffusivity data indicates that axial diffusion will range from mm:s for the strongly sorbing tracers to dm:s for the weakly sorbing tracers considered. Apart from tracers used in the TRUE-1 experiment, also PA-relevant tracers (^{99}Tc and ^{241}Am) are being proposed. The principal feat of the experiment is to establish axial diffusion from a natural fracture, through the rim zone of fracture mineralisation and alteration, into the unaltered rock matrix, without any advective component (towards the tunnel). This is resolved using a multi-packer system which effectively shields off the gradient. In addition, an intricate pressure regulation system is devised which will effectively allow the pressure in the experiment chamber to adapt to the ambient conditions without causing pressure differences, and hence no advective transport. The reference pressure is obtained either from a from a packed-off pilot borehole in the immediate vicinity of the large diameter experimental borehole, or from a section in the large diameter borehole itself. The former borehole has also been used to identify the target fracture to be investigated.

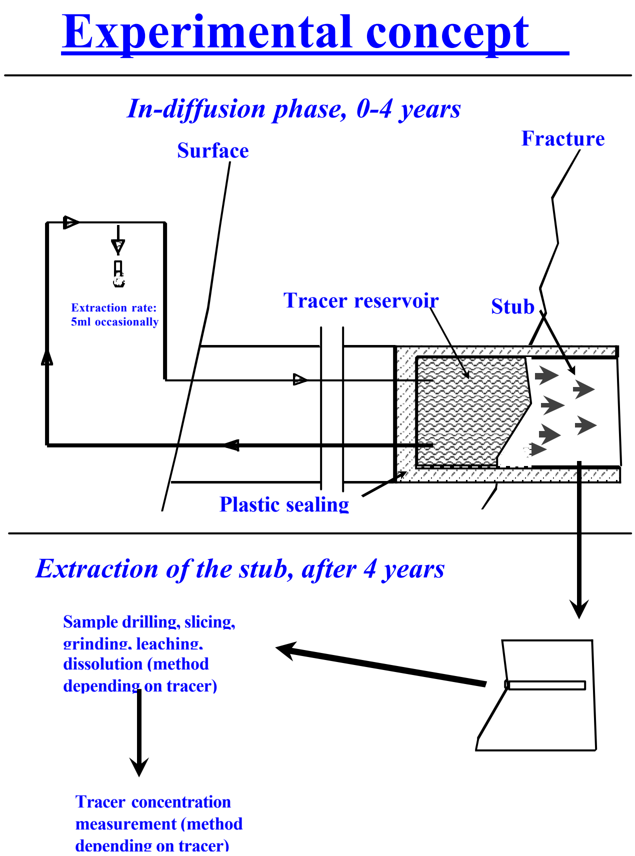

***Figure 3-1** Schematic of LTDE experimental concept including injection borehole in contact with a fracture surface, combined with excavation and penetration profile studies*

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

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

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

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

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

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

In order to assess the rock mechanical effects on the stub in terms of drilling and stress unloading/redistribution, the LTDE situation has been reviewed using results presented by Hakala (1999). Using the geometry of LTDE with examples from Hakala where σ_H=σ_1 = 25 MPa parallel to the fracture surface and with σ_v = σ_h ~ 10 MPa., a tensile strength of 16 MPa and a uniaxial compressive strength = 195 MPa, a Hoek-Brown failure parameter m_i = 7-25, and a slot to diameter ratio of 0.11, the basic assumptions to enable use of Hakala’s results are fulfilled. Under these circumstances no core damage in terms of new induced fractures takes place. This applies to both new fractures at the stub root (bottom of the hole) and new radial fractures. With regards to development of tangential fractures along the core axis, none of the primary loads is found to produce high enough radial tension which is needed to produce tangential fractures. It should however be noted that stress relaxation would open any existing micro fracture, and such relaxation and associated opening widening would occur in all directions.

New results

The updating of the structural model in the vicinity of the LTDE site is not finalised. However, the detailed mineralogical analyses and geochemistry has proved to be an valuable tool for reconciling the mapped structures in the pilot borehole with those observed in the large diameter experimental borehole. It is noted that when doing extrapolations over relatively short distances, 1- 2 m in the case of KA3065A02 to KA3065A03, the projected strikes are affected by variability in the undulation of the fracture plane. The small diameter window (76 mm) provides a much smaller degree of averaging than that obtained in the 3000/197 mm borehole. In addition, the LTDE analysis has not benefited to the same degree as say TRUE-1 or TRUE Block Scale from high resolution pressure response data, by which the geometrical analysis is improved. However, new cross-hole interference data have emerged from the ongoing Pre-test program which will be incorporated in the analysis. It is also noted that the scale of the problem in the case of LTDE may add to this problem.

During the period the project group has started up the process to obtain a "CE-marking" of the experimental set up. This work has included an FMEA Risk analysis which has focused on personal safety and function, and to some extent environmental safety. This work is in line with the ongoing work to set up new quality systems within SKB. It is noted that the CE-marker is not necessary to initiate the experiment.

In the field, components of the planned pre-test program have been completed. These include a detailed flow logging using a single packer in the interior of borehole KA3065A03, in the interval L=10.083 to 10.883 m. A total of 9 measurements were made which will be differentiated to 0.05 m sections. Pressure responses were collected in the neighbouring boreholes including KA3067A, KA3065A02, KA3068A. During the analysis of the data it was discovered that a non-instrumented 56 mm reconnaissance borehole SA3045A (L=20 m) may have affected the measurements. Preliminary results indicate that a conductive structure which runs NNW and intercepts all involved borehole provide connectivity up to the TRUE-1 rock block. Borehole SA3045A will be instrumented with a three-packer system.

Parallel to this work the detailed design of the container components has continued. New components are plexi-glass boxes which will host the pressure regulating unit and the main devices connected to the circulation loop, respectively. Problems with the electric grounding were discovered associated with the electronic control unit for the flow-through cell. An alternate device has been identified and will be used instead.

Numerical modelling has been performed to simulate the desaturation and resaturation of the core stub as a consequence of the borehole being opened, and subsequently being shut-in. The analysis has been performed using an axi-symmetrical model and the numerical code SUTRA. The model included both a homogeneous assumption as well as a simple tw-region model and one where a single fracture of high transmissivity is allowed to connect to the pilot borehole but not to the stub. The simulation results indicate for reasonable assumed values of hydraulic conductivity and specific storage ($K=10^{-14} – 10^{-12}$ m/s and $S_s=10^{-8} – 10^{-6}$ m^{-1}), that the initial response is fast (order days or less) but that complete steady state conditions are instated after longer time, cf. *Figure 3-1*.

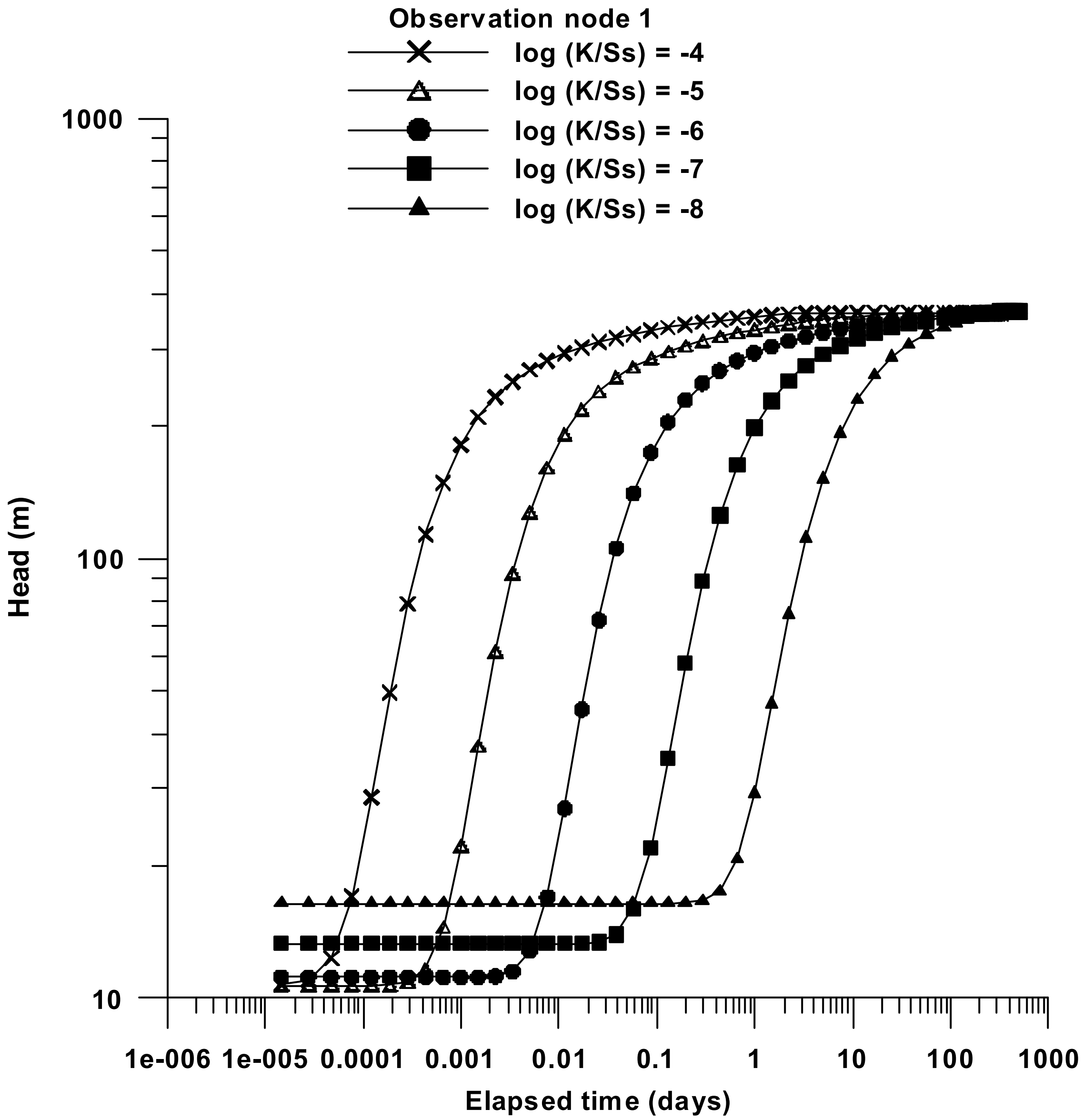

Figure 3-1 *Pressure recovery for different diffusivities (K/Ss) at an observation node position in the middle of the stub about 0.1 m from the surface of the stub.*

Plans for further work

Continued structural modelling of the area in the close proximity of the target

Performance of a pre-test program which includes both hydraulic tests and tracer tests. An attempt will be made to carry out a slug tests on the surface of the stub. The latter result has bearing on ongoing model assessments of the effects of exposing the stub to a significantly reduced head, and the time aspects of reinstating the pressure in the stub. This in order to enable preventive action to building up of a hydraulic gradient between the stub and the test section. The tracer test work is focused on characterisation of the connectivity of the investigated rock volume, simulation of release scenarios in case of accidental leakage from the test section.

Plans are to install the down-hole equipment after necessary preparations in February, 2001. The installation of equipment in the experimental container is scheduled to commence the second half of February, 2001.

A permit for usage of radionuclides is expected from the Swedish Radiation Protection Agency during February, 2001.

The start-up of the initiation of the actual experiment is obviously delayed, and is now scheduled for April, 2001.

3.2.2 Second TRUE Stage (TRUE-2)

The TRUE-2 as a stand-alone detailed scale experiment on a single fracture has been omitted as a concept. Rather an extension of the TRUE programme will be focussed on the TRUE Block Scale site. The scope includes continued monitoring of the tracer injections made as part of TRUE Block Scale Phase C. Additional components are complementary tracer injections in the existing array and an appraisal of the need for remediation of the piezometer in borehole KI0023B. These activities supported by complementary modelling and laboratory work. Since both detailed scale and block scale elements are planned to be covered by the planned continuation, the defined continuation of TRUE will in the future be denoted “Two TRUE”.

3.2.3 TRUE Block Scale

Background

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

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

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

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

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

- Scoping Stage

- Preliminary Characterization Stage

- Detailed Characterization Stage

- Tracer Test Stage

- Evaluation (and reporting) Stage

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

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

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

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

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

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

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

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

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

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

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

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

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

#1 Characterisation and model evolution

#2 Tracer tests in the block scale

3 Modelling of flow and transport

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

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

New results

Modelling of the Phase B tests and predictive modelling of the Phase C tests have continued during the period. Results of the predictive work is expected early 2001.

^{14}C PMMA analyses of wall rock and gouge particles (1-2 mm, 1-2 cm) from intercepts of structures involved in the Phase C experiments have been performed. Final results are expected early January 2001.

From Final report #1 a detailed description of the structures involved in the Phase C tracer tests have been made. This description includes a detailed mineralogical and geochemical description, schematic conceptual models of individual intercepts as well as simplified models of complete structures along their extent. In addition a compilation is given of relevant retention parameters in terms of distribution coefficients and diffusivities. An attempt is also made to quantify the distribution coefficients of gouge materials.

Planned work

1st quarter 2001

LTDE

- Installation of packer equipment in SA3045A and KA3065A03
- Installation of equipment in the experiment container
- Application to Swedish Radiation Protection Board (SSI)
- Pre-tests (function and leakage scenarios)
- Continued work to acquire CE acceptance

TRUE Block Scale

Tracer Test Stage

- Evaluation of Phase C experiments (modelling)
- Finalisation of ^{14}C PMMA analyses of material from structures intercepts

Evaluation and Reporting Stage

- Second in a series of reporting workshops
- Finalisation of Final Reports number 1 and 2

3.3 Radionuclide retention

Background

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

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

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

Objectives

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

- To validate the radionuclide retention data which have been measured in laboratories by data from in situ experiments in the rock
- To demonstrate that the laboratory data are reliable and correct also at the conditions prevailing in the rock

To decrease the uncertainty in the retention properties of relevant radionuclides

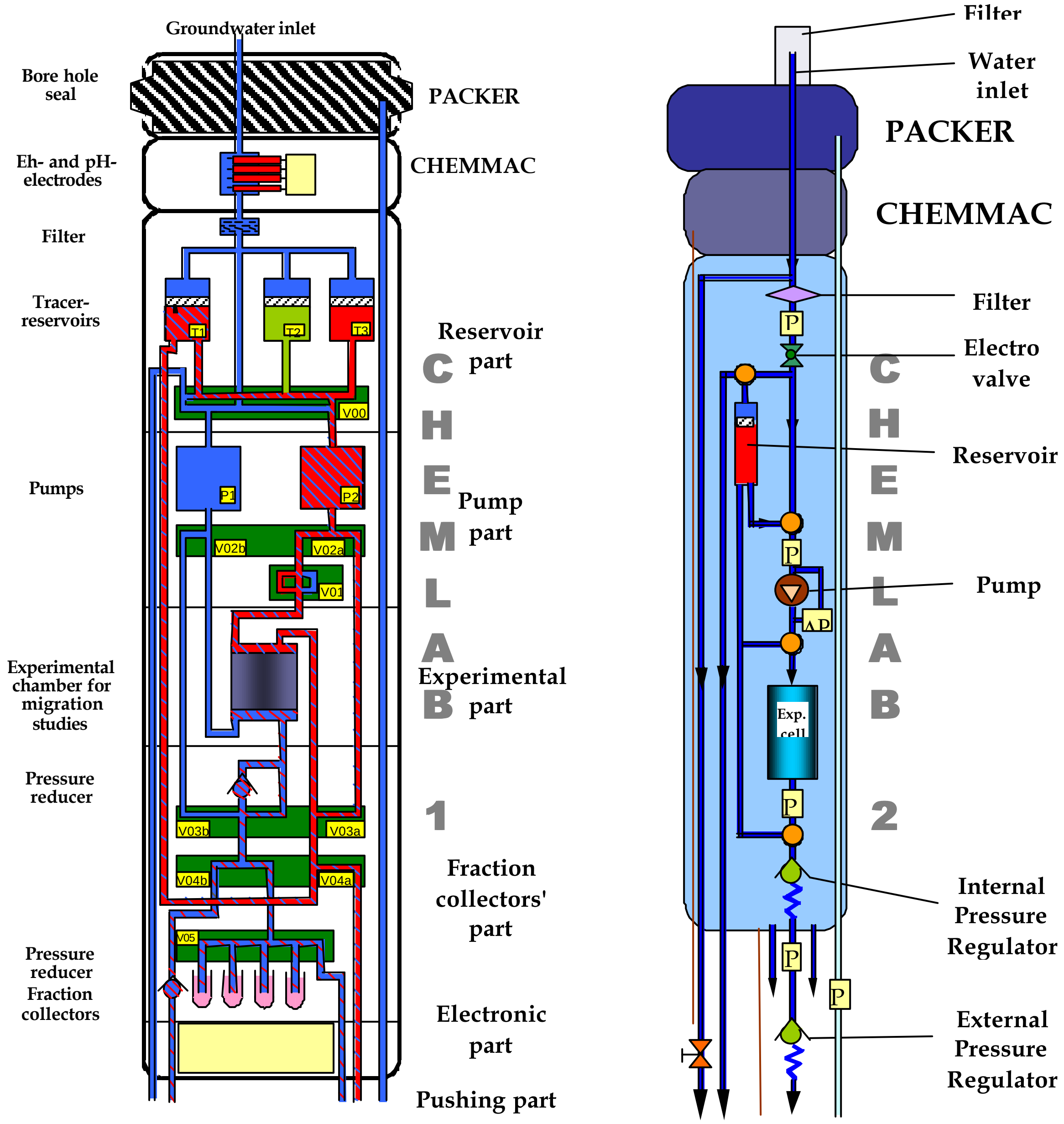

Figure 3-1 Schematic illustration of CHEMLAB 1 and 2.

Experimental concept

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

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

- Migration from buffer to rock
- Desorption of radionuclides from the rock
- Batch sorption experiments

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

- Migration of redox sensitive radionuclides and actinides
- Radionuclide solubility
- Spent fuel leaching

New Results

The experiment with migration of actinides, Am, Np and Pu, was started in November and was planned to continue for 12 weeks. One week after strart the experiment was stopped due to an error message of the CHEMLAB-2 probe. At present the failure and the cause of the failure is not know. However, a blasting in the vicinity of the J-nisch that created large vibrations is possibly the reason.

Awaiting the final diffusion report the radiolysis experiment has not been started.

Planned Work

- Reparation of the CHEMLAB 2 probe and restart of the actinide experiment
- Start of the radiolyses experiment in CHEMLAB 1
- Final report of the diffusion experiments

3.4 Hydrochemical modelling/Hydrochemical stability

Background

The chemical properties of the groundwater affect the canister and buffer stability and the dissolution and transport of radionuclides. It is therefore important to know the possible changes and evolution of the groundwater chemistry during the repository life time. Important questions concern the understanding of the processes which influence and control the salinity, occurrence, character and stability of both saline and non-saline groundwaters.

At present this project is carried out within the framework of the Äspö agreement between SKB and Posiva. It also covers the technical parts of the participation in the EC EQUIP project and the modelling Task #5 within the framework of the Äspö Task Force for modelling of groundwater flow and transport of solutes.

Objectives

The objectives of this project are:

- To clarify the general hydrochemical stability (= groundwater chemistry of importance for canister and bentonite durability and radionuclide solubility and migration)
- To describe the possible scenarios for hydrochemical evolution at Äspö over the next 100.000 years, separated into time slabs of 0-100, 100-1000, 1000-10000 and 10.000-100.000 years.
- To develop a methodology to describe the evolution at candidate repository sites, e.g. Olkiluoto.

Model concepts

Geochemical interpretation of groundwater-rock interaction along flow paths makes use of the results from groundwater chemical investigations, i.e. chemical constituents, isotopes and master variables pH and Eh in combination with the existing mineralogy, petrology and termodynamic data. Useful tools for these calculations are reaction path codes like NETPATH and equilibrium-mass balance codes like EQ 3/6. These codes are frequently used in hydrochemical studies.

A newly developed concept and code, M3, start from the assumption that it is mixing and not chemical reactions that is the dominating process affecting the chemical composition of the groundwater within the investigated system. The principal assumptions behind this concept is that the varying hydraulic conditions of the past have created the complex mixing pattern presently observed. When the effects of mixing has been evaluated, mass balance calculations (resulting from chemical reactions) are then made to explain the difference between the ideal mixing and the observations.

The modelling strategy for the Hydrochemical Stability project involve:

- Identification of the dominant (chemical) processes for Finnish and Swedish sites.
- Geochemical mixing for Äspö and Olkiluoto.
- Site intercomparison and comparison between the M3 and NETPATH techniques based on data from Olkiluoto.
- Transient hydrodynamic modelling for Äspö and Olkiluoto.

The intention with the strategy is to be able to compare the results of the traditional hydrochemical modelling with the results from M3 and to compare the outcome of the hydrodynamic modelling with the results from M3. The latter comparison is done within the Task #5 of the Äspö Task Force for modelling of groundwater flow and transport of solutes.

The Equip project has the specific objective to trace the past hydrochemical conditions through investigation of (calcite)fracture filling minerals. The outcome will beused to check the conclusions from hydrogeological and hydrochemical models.

New Results

The final report of the EQUIP project has been distributed. Evaluation of the Task#5 work is on-going. Comments by external reviewers were given at the Task Force Meeting #14 in November.

Planned work

- Modelling reports for Task#5 will be published in the ICR series.
- The final report of the entire Hydrochemical Stability project will be prepared and reviewed.
- Results of KLX02 groundwater sampling and analyses will be published as a Technical Document.

3.5 Matrix Fluid Chemistry

Background

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

Objectives

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

Experimental concept

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

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

New results

Since the last status report, the main activity carried out has been the preparation of an Äspö International Progress Report (IPR) which marks the midway stage of the experiment. This has been submitted for publication and should be available soon as a 2001 series.

Within the various disciplines work is continuing with: a) mineralogical and petrophysical studies, b) crush/leaching experiments, c) Äspö diorite permeability test, d) fluid inclusion characterisation, e) compilation and reporting of the rock hydraulic properties, and f) compilation and interpretation of isotopic data from groundwaters sampled and analysed from the TRUE Block Scale, Prototype Repository and ‘J’ Niche (Chemlab/Microbe) experiments.

Detailed sampling of a rock profile perpendicular to the microfissure (located intersecting the borehole at some 56.5 cm from Section 4 towards the tunnel) has been carried out in preparation for detailed study which will include mineralogy, petrophysical measurements (porosity) and whole-rock measurements of major and trace elements, U-decay series isotopes, ^{37}Cl, ^{11}B, ^{86}Sr and ^{87}Sr. These data will be used to investigate any evidence of in- or out-diffusion processes.

Both borehole sections, Section 4 (already sampled) and Section 2, are continuing to show steady pressure increases; Section 4 may even be showing a levelling off indicating it has been refilled. In both cases adequate time will be allocated to ensure suitable water volumes for sampling and analyses.

Planned work

Planned work for the immediate future will include:

- continuation of drillcore crush/leach experiments with specific emphasis on lithological variation and porosity profiles,
- continuation of the permeability test,
- continuation of fluid inclusion mineralogical/petrographical characterisation and chemistry,
- expand coverage of drillcore porosity measurements (some integrated with the crush/leach experiments) to achieve a better idea of large-scale heterogeneity or homogeneity in the matrix block, and also to further characterise the Ävrö granite rock type,

- detailed study of a micro-fracture/fissure with respect to in- or out-diffusion processes. This will include whole-rock measurements of the U-decay series, ^{37}Cl, ^{11}B, ^{86}Sr and ^{87}Sr along profiles perpendicular to the fracture intersection with the drillcore,
- leaching of drillcore section using distilled water under inert conditions (Univ. Bern),
- scoping study to locate further examples of low transmissive features already characterised to increase the hydrogeological/hydrochemical database, and
- eventual sampling of borehole Section 2 (and possibly a second sampling of Section 4) when indications show that enough water has accumulated.

3.6 Colloids

Background

Colloids are small particles in the size range 10^{-3} to 10^{-6} mm these colloidal particles are of interest for the safety of spent nuclear fuel because of their potential for transporting radionuclides from a faulty repository canister to the biosphere.

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

It has been argued that e.g plutonium is immobile owing to its low solubility in groundwater and strong sorption onto rocks. Field experiments at the Nevada Test Site, where hundreds of underground nuclear tests were conducted, indicate that plutonium is associated with the colloidal fraction of the groundwater. The $^{240}Pu/^{239}Pu$ isotope ratio of the samples established that an underground nuclear test 1.3 km north of the sample site is the origin of the plutonium. Based on these results SKB decided to initiate a project in the Äspö-HRL to study the <u>S</u>tability and <u>M</u>obility of <u>C</u>olloids (SMC).

Objectives

1. The objectives of the SMC project are to:
2. Verify the colloid concentration at Äspö-HRL
3. Investigate the potential for colloidal transport of nuclides in natural groundwater flow paths
4. Study the role of bentonite clay as a source for colloid generation
5. Demonstrate the colloid stability/instability at prevailing conditions

Experimental concept

The role of the bentonite clay as a source for colloid generation will be studied in a laboratory experiment performed at KTH and Claytech. The background colloid concentration associated with the different water types found at Äspö will be sampled at specific locations along the Äspö HRL-tunnel. For the fracture specific measurements two nearby boreholes at HRL will be selected for the SMC experiment. One of the boreholes will be used as an injection borehole and the borehole downstream will be used as a monitoring borehole. The boreholes intersect the same fracture and have the same basic geological properties. The experiment will be performed in association with the TRUE-trace experiment programme. The boreholes and the optimum time for the experiment will be selected in co-operation with the co-ordinator for the TRUE experiment.

After assessing the natural colloid content in the groundwater bentonite clay will be dissolved in ultra pure water to form colloidal particles. These clay colloids will be labelled with a water conservative tracer. The mixture will be injected into the injection borehole. From the monitoring borehole the colloidal content will be measured with the laser, the water will be filtered and the amount of tracers will be measured. The following results are of interest 1) is the colloid content lower after the transport, 2) is the nuclide association irreversible on the colloids and 3) is the bentonite clay a potential source for colloid generation. The signature of the bentonite/natural colloids will be traced by using multivariate statistics. The outcome of the experiment is used to check the calculations in the safety assessment report TR 91-50 to be used in future colloid transport modelling.

The colloid content will be measured on-line from the boreholes and off-line from the laboratory experiments by using a modified laser based equipment LIBD (Laser-induced Breakdown-Detection) which has been developed by INE in Germany. The advantage is that the resolution of this equipment is higher compared with standard equipment of this type. It is therefore possible to detect the colloid contents at much lower concentrations than previously possible. The outcome of these measurements will be compared with standard type of measurements such as particle counting by using Laser Light Scattering (LLS) at KTH (Royal Institute of Technology) and INE. Standard type of filtration performed on-line at the boreholes or off-line from the laboratory experiments are used in order to be able to compare/transform these results to all the earlier colloid sampling campaigns at Äspö.

New Results

A project description and a project plan have been produced during November-December 2000. A project decision to perform the project was taken during December 2000.

Planned Work

Activity plans for the laboratory tests are being prepared and the laboratory tests will start in January 2001 and will continue until end of June 2001.

3.7 Microbe

Background

A set of microbiology research tasks for the performance assessment of high level nuclear waste (HLW) disposal has been identified. Those with a potential for study at the MICROBE site are:

Microbial influence on radionuclide migration. To what extent can bacterial dissolution of immobilised radionuclides and production of complexing agents increase radionuclide migration rates?

Microbial corrosion of copper. Bacterial corrosion of the copper canisters, if any, will be a result of sulphide production. Two important questions arise: Can sulphide producing bacteria survive and produce sulphide in the bentonite surrounding the canisters? Can bacterial sulphide production in the surrounding rock exceed a performance safety limit?

Microbial production and consumption of gases. Will bacterial production and consumption of gases like carbon dioxide, hydrogen, nitrogen and methane influence the performance of repositories?

These tasks have been addressed in a range of projects, of which several is ongoing. Important conclusions have been obtained based on laboratory and field data. While some results seem very solid with general applicability, others are pending inspection at *in situ* conditions. This is especially true for data generated at the laboratory only. *In situ* generated data must be obtained for microbial activities in the far- and near-field environment at realistic HLW repository conditions. This can only be achieved at an underground site, developed for microbiological research, using circumstantial protocols for contamination control during drilling and operation. An *in situ* site allows experiments at natural pressure with correct gas content in groundwater which is of great importance for microbial activity and very difficult to obtain in vitro. Such a site was drilled in May 1999 in the J-niche at Äspö HRL, 450 m underground. Three boreholes were produced.

Objectives

The major objectives for the microbe site are:

To assay microbial activity in groundwater at *in situ* conditions. Their influence on redox conditions, radionuclide migration and gas composition and consumption will be in focus.

To establish data on hydrogen generation and flow in granitic rock environments. The flow of hydrogen form where it is produced will determine the possible rate of long term microbial subterranean activity.

To enable experiment where the engineered barriers, bentonite, backfill and copper can be investigated for the influence of microorganisms at realistic and controlled conditions with a significant knowledge about the microbiology of the groundwater used.

To generate accurate data about rates of microbial reactions at repository conditions for performance assessment calculations.

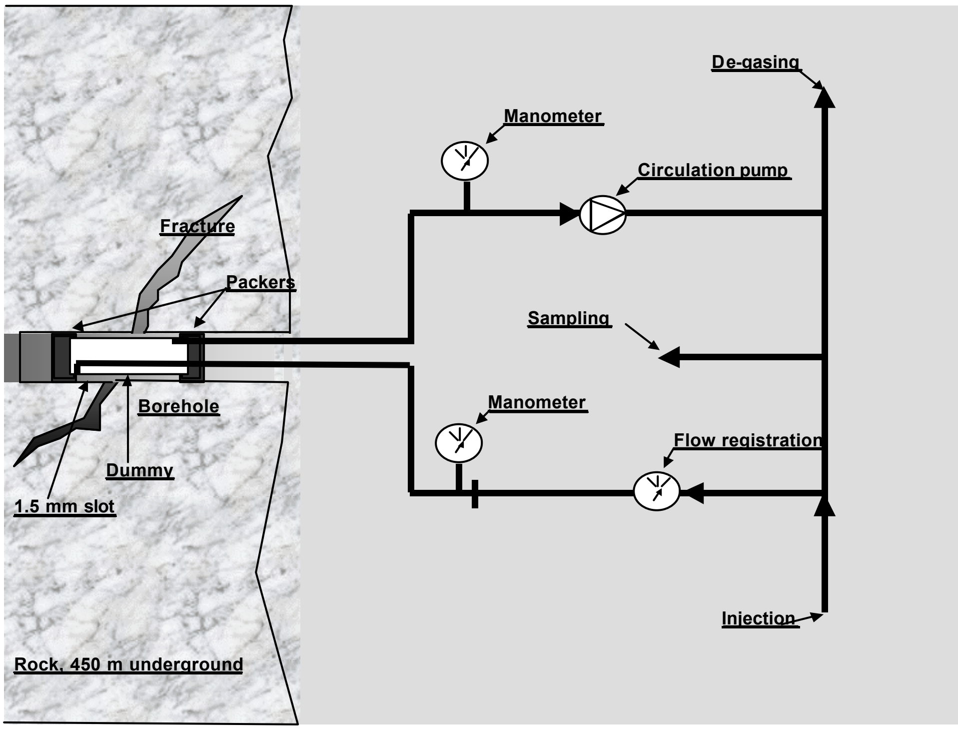

Figure 3-1 The planned circulation system for the MICROBE boreholes.

Experimental concept

The microbe site consists of three core drilled boreholes, KJ0050F01, KJ0052F01 and KJ0052F03, intersecting water conducting fractures at 12.7, 43.5 and 9.3 m respectively. Each borehole is equipped with metal free packer systems that allow controlled sampling of respective fracture. An underground laboratory, approximately 7 x 2.5 m was installed in spring 2000 close to the site and is equipped with a large anaerobic chamber and possibility for set up of on line measurements of dissolved gases. Tubing from the boreholes will be connected to the laboratory via a circulating system, as depicted in *Figure 3-1*.

New results

Groundwater chemistry, cultivable microorganisms, stable isotope and gas data have been obtained from the MICROBE boreholes. A progress report will be submitted during January 2001.

Planned work

A system that allows circulation of groundwater under full formation pressure is presently being designed. This system should enable work with microbes at very close to *in situ* conditions. It will hopefully be operative at the beginning of spring 2001. A system for sensible measurement of hydrogen and other gases will be developed. We will use a reduction gas detector (Trace Analytical, USA), having a detection limit for hydrogen, carbon monoxide and methane close to 1 ppb. This system will be used for characterisation of hydrogen generation and flow in granitic rock environments. The results will be compared with theoretical calculations performed at KTH, Stockholm.

3.8 The Task Force on modelling of groundwater flow and transport of solutes

Background

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

Task No	Modelling Issues	Cooperating organisations
4E	Modelling of tracer test with sorbing tracers in one fracture.	ANDRA, BMWi, CRIEPI, DOE, JNC, NAGRA, POSIVA, SKB
4F	As Task 4E but with half the flowrate.	ANDRA, BMWi, CRIEPI, DOE, JNC, NAGRA, POSIVA, SKB
5	Compare and integrate hydrology and chemistry through modelling of Äspö tunnel drainage impact on hydraulic and chemical parameters.	ANDRA, BMWi, CRIEPI, ENRESA, JNC, POSIVA, SKB
6	Apply PA[1] and SC[2] approaches for the same tracer experiment and PA boundary conditions. Aims at identifying relevant conceptualisations for longer term PA predictions and identify site characterisation data requirements to support PA calculations.	ANDRA, CRIEPI, JNC, POSIVA, SKB (1) PA: Performance Assessment (2) SC: Site Characterization

New results

The 14th International Task Force meeting was held at Säröhus, Sweden.

Final modelling reports for Task 4E&F and Task 5 were delivered. There is however still some reports outstanding.

A report was produced on the deconvolution of breakthrough curves from the STT-2 experiment within the TRUE-1 project: IPR-00-22.

A new sub-task to Task 4 was initiated with the purpose to perform an overall evaluation of the Task 4 modelling (Task 4OE). It is done from the perspective of the participation organisations in order to assess how the complete Task 4 modelling has meet the purpose and ambitions of the organisations.

A new task was initiated, Task 6. The new modelling task tries to bridge the gap between performance assessment (PA) and site characterization (SC) models by applying both approaches for the same tracer experiment, and also for PA boundary conditions. It is hoped 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.

Planned work

For the next quarter we plan to perform the following tasks:

- Publish some of the final reports from Task 4 and Task 5 as IPR.
- The Task 4 overall evaluation will commence.
- Continue the work to summarize the modelling performed within Task 5 into a Summary report.
- The Task 5 reviewers will start their work to produce a Reviewers report.

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

4.1 General

Stage goal 4 of the Äspö HRL is to demonstrate technology for and function of important parts of the repository system. This implies translation of current scientific knowledge and state-of-the-art technology, into engineering practice applicable in a real repository.

It is important that development, testing and demonstration of methods and procedures, as well as testing and demonstration of repository system performance, is conducted under realistic conditions and at appropriate scale. A number of large-scale field experiments and supporting activities are therefore 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 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 resaturation 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 regularly during the period (approx. once each six weeks) with the objective to plan the activities that were scheduled to take place in the near future. The meetings have been open to the participants in the EC project for their information and input, when needed.

The modelling group - WP3 - meet for the first time on December 12 in Lund, Sweden.

Physical activities in the Prototype Repository tunnel have been:

- Finalising the drilling of holes for thermocouples and resistivity measurements
- Finalising the drilling of the 27 lead-throughs from the G-tunnel
- Initiation of lining of the 27 lead-throughs

Pressing of bentonite blocks has started.

Ordering of canisters with heaters has been initiated.

Almost all instruments to Section I have been ordered.

Detailed planning has started for the installation of Section I.

Deliverable D1 “Project work plan” and Deliverable D37 ” Preliminary Technology Implementation Plan” have been submitted according to the time plan, and Milestone M1 “Project work plan and plan for quality assurance procedures completed by month #3” fulfilled.

Planned work

Detail planning of different parts of the Prototype Repository project will continue with installation sequences. The first block is due to be lowered May this year.

Preparatory work in the tunnel during the next period will concern finalisation of lining in the lead-throughs including welding of cones and grouting of the pressure support. Filling with cement of the voids between the rock and the cones and the hole walls and the liners will start. The roadbed will be adjusted for the deposition of canisters and the gantry crane adjusted to fit into the circular tunnel.

Measurements of water inflow with diapers will be made in one of the “dry” holes in Section I.

Installation of permanent packers of bentonit type, and instruments in the rock will be initiated.

One pre-test will start regarding the swelling of bentonite blocks in a deposition hole. The hole in the assembly hall will be used for installing one to two blocks below some of the concrete ones used earlier.

Another pre-test is full scale compaction of crushed rock mixed with a cheaper bentonite type from Greece. The equipment for in situ compaction will be CE-certified.

A Project Progress Meeting will be held in Cordoba on March 27-28 in conjunction with the FEBEX II Progress Meeting.

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.

New results

Figure 4-1 shows an illustration of the experimental setup. The following main events and results from the last quarter of 2000 can be mentioned:

- The water pressure applied in the filter mats in the 30/70 mixture has been about 50 kPa during the last quarter of 2000.
- Water filling of the outer test sections (0/100), which started in June, 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. When the bentonite o-ring has sealed or if there is a leakage through another passage in the concrete or rock, the interface between the concrete and the rock surface will be grouted.
- Water saturation, water pressure and swelling pressure in the backfill and water pressure in the surrounding rock have been continuously measured and recorded.

Figure 4-2 and *Figure 4-3* show example 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

- The psychrometer measurements indicate 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. It is concluded that the saturation needs to continue at least for another year (2001).
- Reporting of the experimental setup is in progress.

Planned work

In the first quarter of 2001 the water saturation will continue with consecutive measurement of water inflow, water pressure, total pressure and wetting. Some tests will be made with increased water supply to the permeable mat attached to the inner wall of the plug with the aim to ensure that the water reaches the crown of the bentonite o-ring in the plug. Grouting of the interface between the plug and the rock surface will be prepared and probably carried out in April.

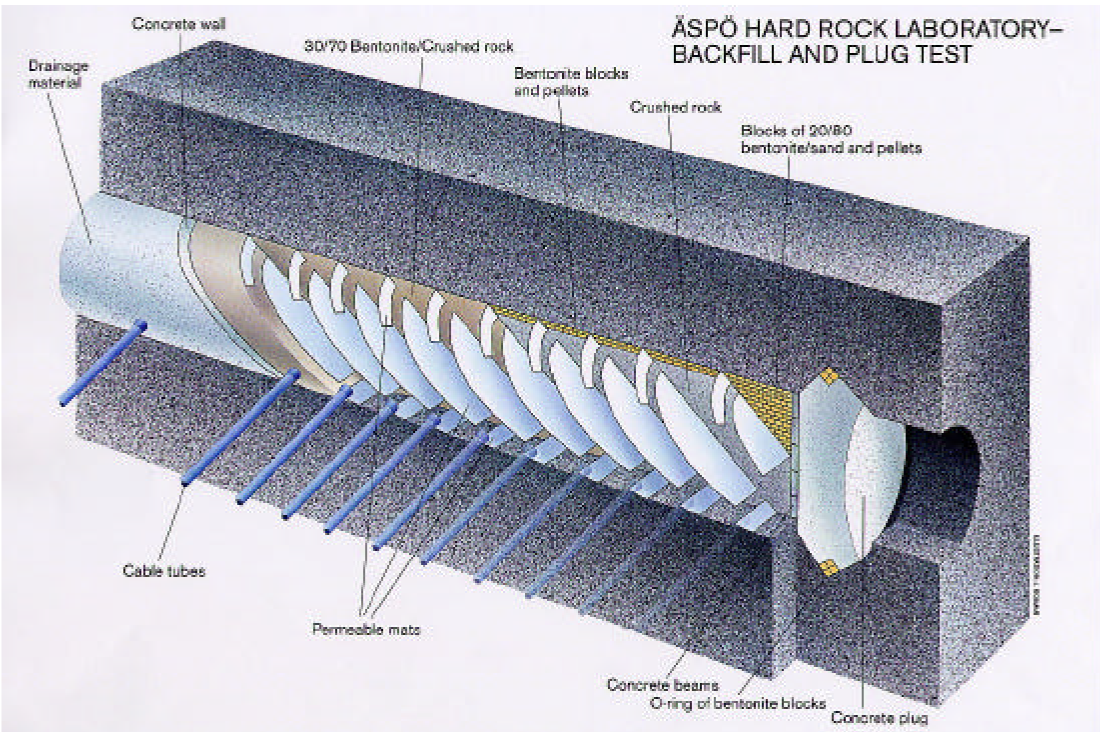

Figure 4-1 *Illustration of the experimental setup of the Backfill and Plug Test.*

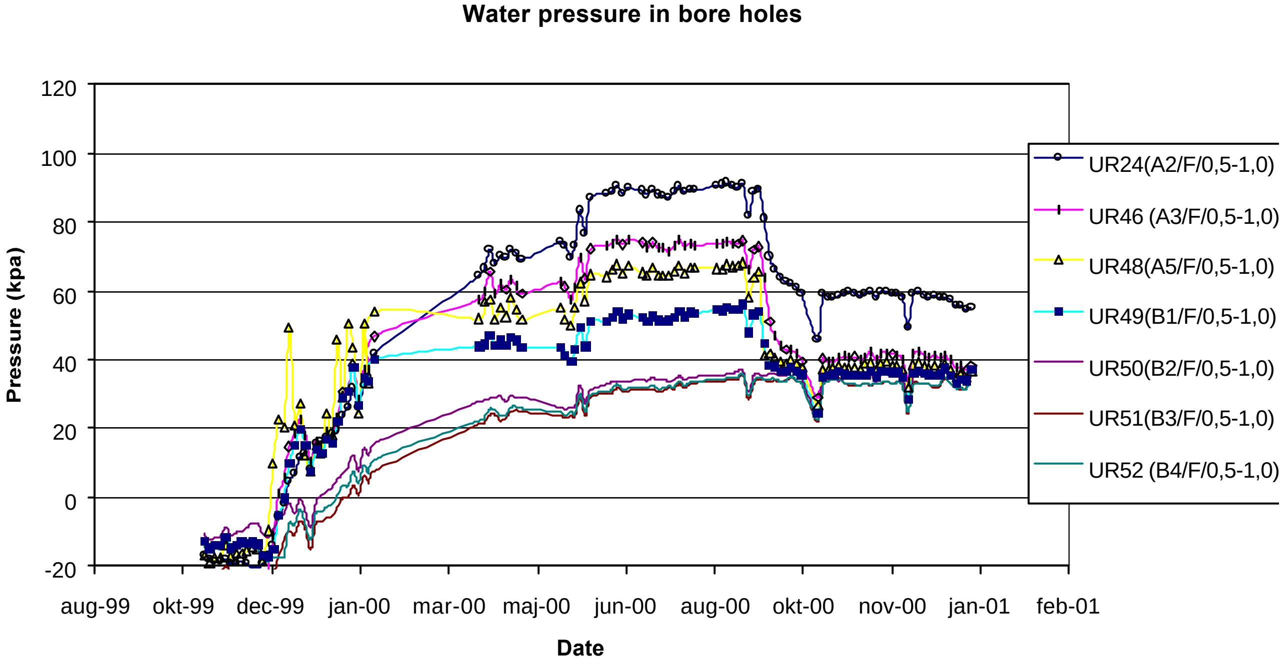

Figure 4-2 *Water pressure measured in the rock 30 cm below the floor. .UR24, 46, 48 and 49 are placed in the 30/70 sections and the rest in the 0/100 sections*

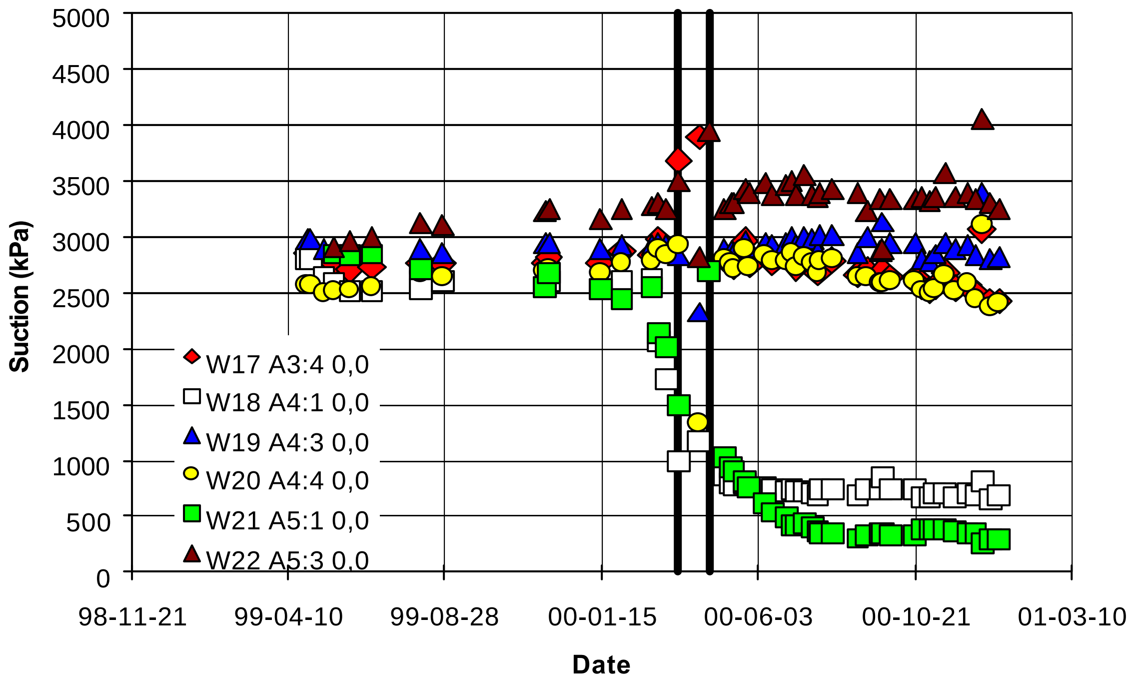

Figure 4-3 *Suction measured in the centre of different layers in the 30/70 backfill. W18 and W21 are placed in the first layer about 20 cm from the mats. W17 and W20 are placed 40 cm and W19 and W22 are placed 60 cm from the mats.*

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 Hard Rock Laboratory. 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 will provide good rock conditions, a realistic environment for a future repository, and allow transport of heavy vehicles to this area.

The testing of the equipment needed for handling of compacted bentonite buffer material and canisters for the Canister Retrieval Test and the Prototype Repository has been made in the assembly hall at level at level 420.

New results

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

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

The design and construction of the temporary equipment for handling and deposition of the buffer material and canisters for the Canister Retrieval Test and the Prototype Repository was completed early 2000. The test program with handling of buffer material and a copper canister was completed in June 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

The preparation of one of the deposition holes and the equipment for the Canister Retrieval Test was completed in early September. The installation of the buffer material and the canister with instrumentation and heaters started mid September and was completed during October 2000 including the in-situ casting of the concrete plug on top of the bentonite buffer. The artificial watering of the buffer material has started and the operation of the Canister Retrieval Test is planned to continue for some 4 to 5 years. The concrete plug on top of the bentonite buffer will be held in position with help of 9 rather thick wire-ropes that are secured in the rock by grouting. The wire-ropes are designed for maximum swelling pressure from the buffer material.

Planned work

The gantry crane and the deposition machine will then be used in the Prototype Repository. Some modification will be needed both on the gentry crane and the deposition machine. The deposition machine must be provided with four hydraulic jacks for positioning on the road-bed in the Prototype Repository. A special wagon for transport of the deposition machine with canister down to the Prototype Repository has been purchased for delivery early March 2001.

The equipment will be tested for operation in the prototype Repository in April and May 2001.

The installation of buffer material and canisters with heaters in the Prototype Repository is scheduled to start mid 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 developed to at leased to a feasibility stage as part of the ongoing design studies of the deep repository. Some of the 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.

New results

The canister was quickly repaired and sent back to Äspö. The cause of the mis-connections was a few too short cables, which were drawn out from their pins in the lid when the lid was put on, and the action taken was to lengthen these cables. Once back the canister was installed, pellets and water filled in the outer slot, the bentonite blocks on top installed and the plug cast and anchored. The experimental set up is shown in *Figure 4-1*.

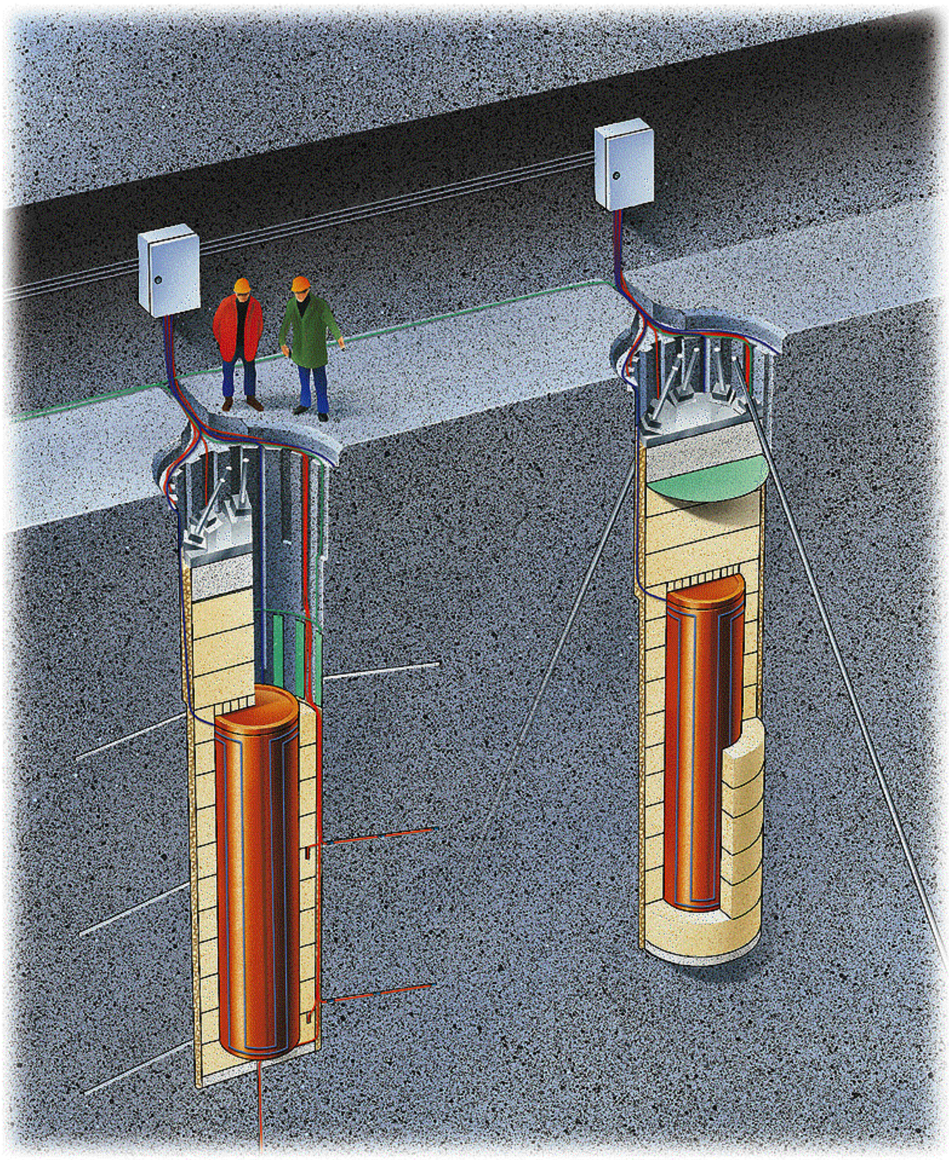

Figure 4-1 *Experimental set up. The picture to the left enhances the holes for the thermocouples in the rock, the permeable mats for artificial watering along the rock wall and the cable routes in the top of the hole, while the right picture enhances the location of the cable anchors in the rock and the sandwich structure of the plug – watertight mat against the bentonite, cast concrete and steel lid.*

The artificial water supply to the surrounding permeable mats was opened and the heaters were turned on on October 27^{th}. A thermal load of 700 W was applied for a few days before being raised to 1700 W, which is the calculated average thermal load per canister in the Swedish programme. The temperature development at mid-height of the canister is shown in *Figure 4-2*. The change from 700 to 1700 W is clearly seen. One major observation is that the temperature inside the canister, in the cast steel insert, is just a few degrees higher than the temperature on the outer surface of the copper canister, thus showing a low temperature gradient across the gap between steel insert and copper.

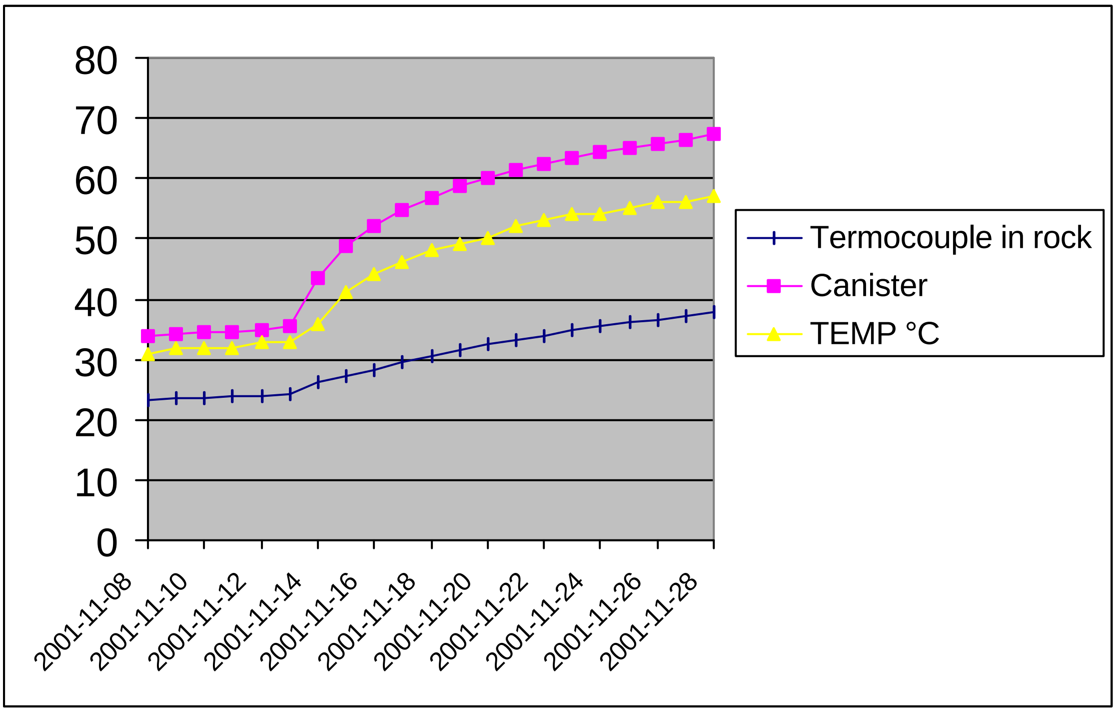

Figure 4-2 Temperature development in a section across the canister and into the rock at mid-height of the canister.

The plug was cast in a form in order to be free from the rock and thus able to float. The judgement was, however, that the plug had to be lifted after curing, so that it would be beyond doubts that it was free. The swelling of bentonite blocks and pellets with water artificially supplied was, however, so fast that it lifted the lid before the crane was scheduled to come.

Planned work

The first priority is to finalise the instrument connections to the computer, so that also the fiber optic system may deliver data to the Äspö computer system.

After 3 month of operation the temperature from an adjacent canister would start to impact the temperature on the canister´s surface, and at that time the thermal load in the experiment is planned to be raised to 2600 W, which is the calculated thermal load needed in order to obtain 90^{o}C on the surface of one single canister in Äspö rock.

5 Äspö facility operation

5.1 Facility operation

In addition to Äspö's two independent power supply cables it has been decided to keep the old "mainland feed" as a spare. An agreement with Sydkraft has been settled to insure that spare feed is maintained and that future and present demand of electrical power is supplied.

The supplementary work with rock reinforcement is progressing as expected. At present shotcreeting, bolting and mounting of mesh is carried out at the 450-m level. The work is expected to be completed early February 2001.

The facility operations monitoring system ALFA, was completed and approved in November and is now in operation.

The fire risk analyses, made by ÖSA (Öresund Safety Advisors), showed that improved fire safety underground is required and a number of actions were suggested. A project, based on the suggestions was formed and started in order to improve this. The work has been initiated with the installation of traffic lights in a narrow, high-risk part of the tunnel. It is to continue with additional installation of fire detection system in the 420-m level and a voice alarm throughout the tunnel. The project is planned to be completed in the summer of 2001.

Connected to the project above a fire exercise was carried out in the underground facility at the 30 November. The scenario included a wrecked car, injured personell, fire with heavy smoke, electrical failure causing a blackout and finally evacuating the tunnel. The exercise was made in co-operation with the local firebrigade and illuminated some of the problems that inevitably will occur in a real fire/accident. Report about the fire exercise is to be completed in January.

The project for hands-free-registration when going underground has been resumed. The project has been initiated with a study in order to determine need, technical possibility and possible deliverer. As the study was completed a request for offers was sent out to nine (9) different and possible system deliverers. The offers are to be completed and sent in at the end of January 2001. After evaluating the offers, decision is taken in how to proceed in this project.

The new car parking space at the Äspö site has been built according to plan. The facilities now have additional 32 places for parking cars. 14 with electrical outlet for motorheating and 18 without. Parking lot is to be completed with lawns surrounding the area in order to blend in into the environment. Estimated time for completion, April 2001.

5.2 Data management and data systems

Background

The regulatory authorities are following SKB's siting work. Before each new stage, they *examine and review the available data.* A repository will never be allowed to be built and taken into service unless the authorities are convinced that the safety requirements are met. Hence, SKB is conducting *general studies* of the entire country and *feasibility studies* in 5-10 municipalities. *Site investigations* will then be conducted on a couple of specific sites. With the result of the studies as supporting material, SKB will then apply for permission to carry out *detailed characterisation* of one of the sites. The licence application for detailed characterisation will include a *safety assessment* and the results will be reviewed under the Act on Nuclear Activities and the Act concerning the Management of Natural Resources by the regulatory authorities, the municipality and the Government.

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

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

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

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

New results

GIS

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 set is upon the GIS administrator.

SICADA

Initial efforts have been undertaken to improve a part of the data structure used for management of information about all co-ordinate systems handled in the database. The Rock Visualisation System required the modifications implemented.

RVS

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

Planned work

GIS

The following subjects will be under consideration during the next period (January-March 2001):

- 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 and missing features.

RVS

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

5.3 Program for monitoring of groundwater head and flow

Background

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

Data is transferred by means of radiolink, cable and manually to a dedicated computerised database. The HMS computer system runs on Pentium computers with the Windows NT operating system where a real time engine is accessing the HMS database.

This engine provides integrated data acquisition, monitoring, data logging and report generation.

New results

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

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

A project is ongoing performing an overall evaluation of the Hydro Monitoring Program.This work is done in support of the Äspö activites 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 has delivered its first milestone, being a literature review of the theory and example calculation with Äspö data. This project aims at evaluating the feasibility of utilising tidal flucuation of monitoring data in order to calculate fracture orientation.

Planned work

For the next quarter it is planned to

- Continue to support various projects at Äspö with monitoring data
- Continue and complete the overall evaluation and assessment of the Hydro Monitoring System by producing a final report..
- Continue project to calculate fracture orientation from tidal groundwater head fluctuations from HMS data analysing new data from Äspö.

5.4 Program for monitoring groundwater chemistry

Background

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

Objectives

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

New results

The results presented in report IPR-99-13 show that the groundwater chemistry at Äspö HRL, with a few exceptions, is constant. The sampling occasions have been reduced to one sampling period a year. In October, the sampling for year 2000 was performed and the results are in January 2001 presented in report kemi-00-04.

Planned work

The monitoring programme has been reduced to one sampling period a year. Next sampling occasion is scheduled to take place w139 and 140.

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 tunneling work and the increased number of monitoring points.

New results

The installation of the presentation system is finished and the test period was succesful. The work with the presentation system has already started with the Canister retrival test as the first objekt.. The system consist of two parts a PLC (Programable logic controller) and the Process system.

The PLC is made by Siemens and the Process system is made by IC (Intouch).

Planned work

The presentation system will be in full operation during Spring 2001.The LTDE projekt will be connected to the HMS during Spring 2001. Two boreholes at the surface are going to get new radio modems for data collections.(KAS 08 and KAS 12).

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 giving information about SKB, the Äspö HRL and the SKB siting programme. The visitors are also given a tour of the Äspö HRL. Today there is one visitor's administrator and three public relations officers stationed at the Äspö HRL.

New results

During the fourth quarter of 2000, 3055 persons visited the Äspö HRL. The groups have represented the general public, communities where SKB performs feasibility studies, teachers, students, politicians, journalists and visitors from foreign countries.

1681 persons represented the six communities where SKB performs feasibility studies.

Urberg 500

Most visits at the HRL are U500-visits. It starts from the Entrance building, goes on down in the tunnel by bus and ends at Äspö village through elevator.

The general public tours have gone every weekend until Christmas.

Special projects

- A new booking system/central together with OKG is planned to be ready for use during the first part of 2001.
- A safety video that is a part of the safety instructions to our visitors.
- A new visitors site at Äspö for information on "The Drilling and Borehole investigations" and the Siting Programme.
- Education on the Siting Programme.
- At least three standard programmes for visitors.

6 International cooperation

6.1 Current international participation in the Äspö Hard Rock Laboratory

Nine organisations from eight countries are currently (January 2001) participating in the Äspö Hard Rock Laboratory.

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

Organization	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-situe tests using methods and equipment similar to those used in the Grimsel investigations
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) The detailed scale redox (REX) experiment Radionuclide retention experiments Task Force on modelling of groundwater flow and transport of solutes. Prototype repository project Long-term test of buffer materials

Organization	Scope of participation
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*
USDOE/**Sandia National Laboratories**, USA	Test of models describing the barrier function of the bedrock

7 Other matters

Documentation

During the period October - December 2000, the following reports have been published and distributed:

7.1.1 Äspö International Cooperation Reports

Winberg A (ed)
TRUE Block Scale Project. Final report of the detailed characterisation stage.
Compilation of premises and outline of programme for tracer tests in the block scale.
ICR-00-02

Svensk Kärnbränslehantering AB
First TRUE Stage (TRUE-1) CD
Conceptual representation of feature. ACompilation and visualisation of tracer test data,
Compilation of relevant reports
ICR-00-03

7.1.2 Äspö International Progress Reports

Forsmark T, Rhén I
Prototype Repository. Hydrogeology interference test campaign 1 after drill campaign 3
IPR-00-07

T Forsmark, Rhén I
Prototype Repository. Hydrogeology drill campaign 3A and 3B
IPR-00-08

Gentzschein B
Demonstration of repository technology.
Flow and pressure measurements in the pilot holes
IPR-00-09

Gentzschein B
Canister retrieval test.
Flow and pressure measurements in the pilot holes
IPR-00-10

Nyberg G, Jönsson S
Hydro Monitoring Program. Report for 1999
IPR-00-17

Ageskog L, Blix P
Canister Retrieval Test. Temperature on the Canister Surface.
IPR-00-18

Kotelnikova S, Pedersen K
Microbial oxygen reduction during the REX field experiment.
IPR-00-19

Forsmark T, Rhén I
Prototype repository. Hydrogeology – Injection test campaign 1
IPR-00-20

Forsmark T, Rhén I
Prototype repository. Hydrogeology – Interference test campaign 2 after drill campaign 3
IPR-00-21

Elert M, Svensson H
Deconvolution of breakthrough curves from TRUE-1 tracer tests (STT-2) with sorbing tracers. Äspö Task Force, Task 4F.
IPR-00-22

Puigdomenech I, Kotelnikova S, Pedersen K, Tullborg E-L
In-Situ determination of O_2 uptake by geologic media: Field data for the redox experiment in detailed scale (REX)
IPR-00-23

Lundholm B
Rock stress and rock stress measurements at Äspö HRL.
IPR-00-24

Lundholm B
Numerical modelling of discontinuities to study the effect on the state of stress.
IPR-00-25

Winberg A (ed)
TRUE Block Scale Project. Final report of the detailed characterisation stage. Compilation of premises and outline of porramme for tracer tests in the block scale.
IPR-00-26

Winberg A, Hermansson J, Tullborg E-L, Andersson P, Carlsten S, Rouhiainen P, Nilsson G, Gustafsson C
Select-2. Evaluation of fracture candidates in boreholes KA2865A01 and KA3065A02. Location of experimental site for the Long-Term Diffusion Experiment.
IPR-00-27

17 Technical Document

5 International Technical Document

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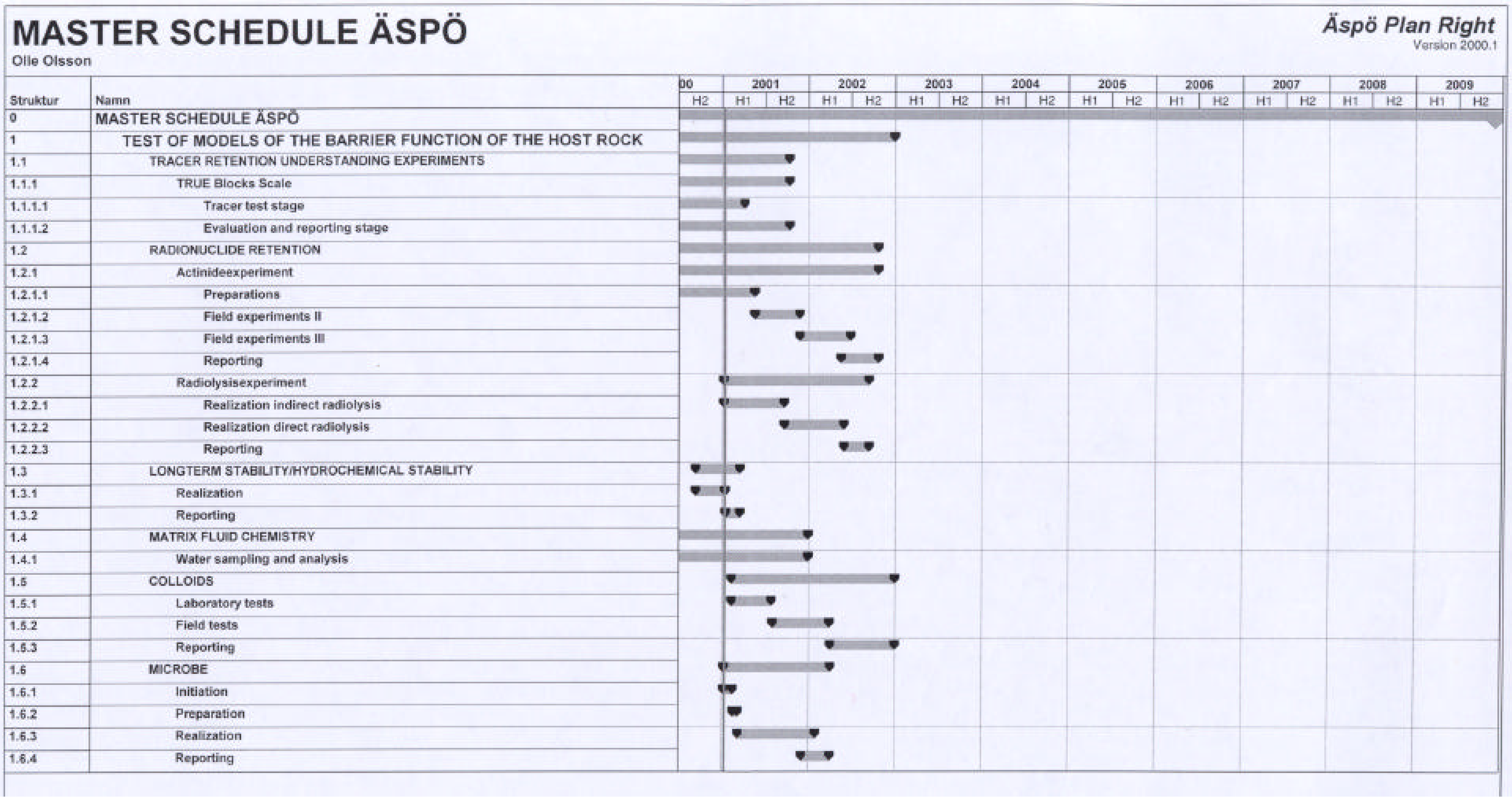
POSIVA Technical Report POSIVA 99-25.

Olsson O, Bäckblom G, Gustafson G, Rhén I, Stanfors R and Wikberg P, 1994. The structure of conceptual models with application to the Äspö HRL Project.
SKB Technical Report 94-08

Rhén I (ed), Gustafson G, Stanfors R and Wikberg P, 1997. ÄSPÖ HRL - Geoscientific evaluation 1997/5. Models based on site characterization 1986-1995.
SKB Technical Report 97-06

Winberg, A., Andersson, P., Hermanson, J., Byegård, J., Cvetkovic, V., Birgersson, L. 2000 : The Final Report of the First Stage of the Tracer Retention Understanding Experiments.
SKB Technical Report TR-00-07.

Appendix A


MASTER SCHEDULE ÄSPÖ
Olle Olsson
Äspö Plan Right
Version 2000.1
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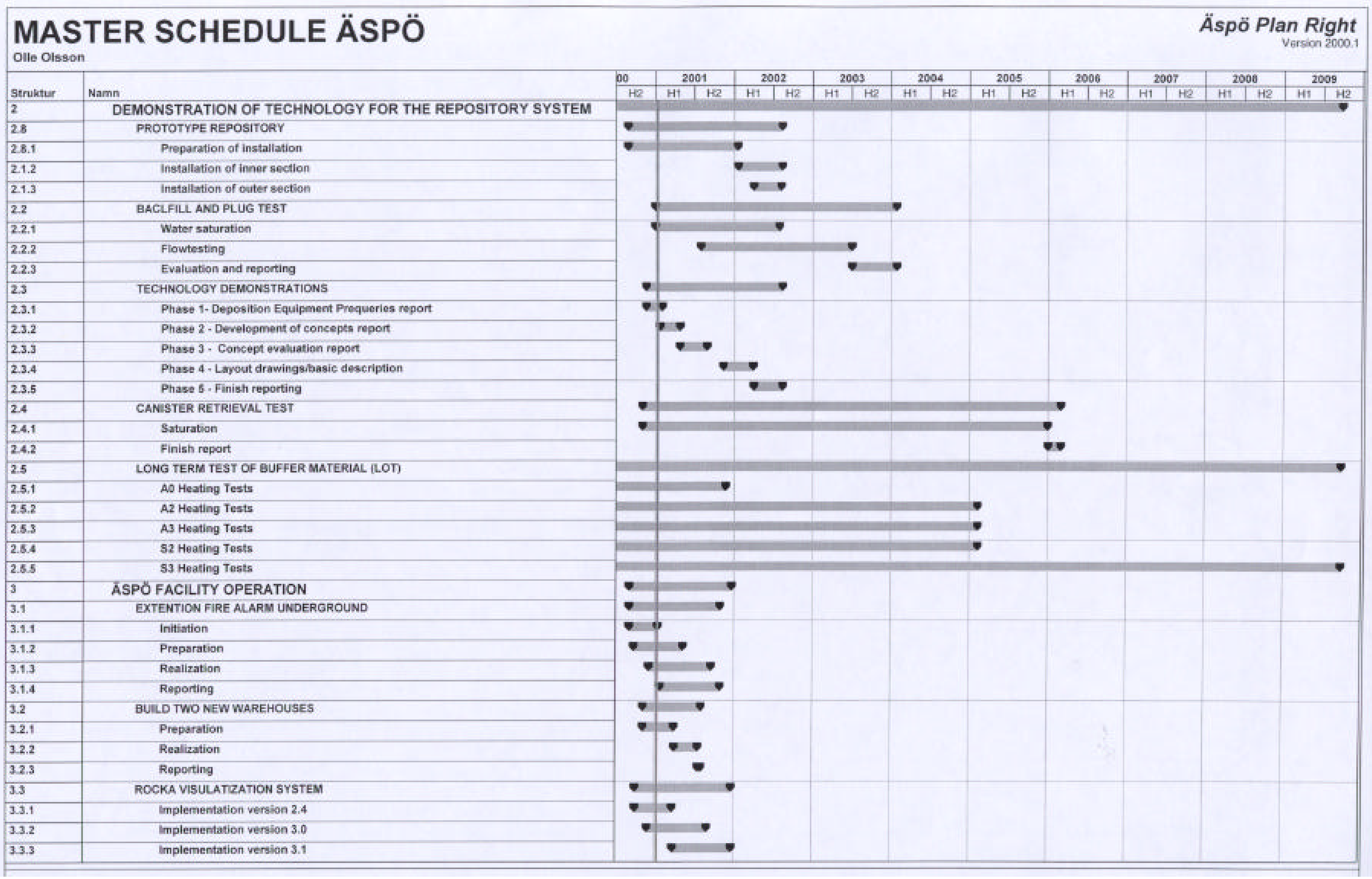
0 MASTER SCHEDULE ÄSPÖ
1 TEST OF MODELS OF THE BARRIER FUNCTION OF THE HOST ROCK
1.1 TRACER RETENTION UNDERSTANDING EXPERIMENTS
1.1.1 TRUE Blocks Scale
1.1.1.1 Tracer test stage
1.1.1.2 Evaluation and reporting stage
1.2 RADIONUCLIDE RETENTION
1.2.1 Actinideexperiment
1.2.1.1 Preparations
1.2.1.2 Field 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
1.3.2 Reporting
1.4 MATRIX FLUID CHEMISTRY
1.4.1 Water sampling and analysis
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
Olle Olsson
Äspö Plan Right
Version 2000.1
Struktur
Namn
00
2001
2002
2003
2004
2005
2006
2007
2008
2009
H1
H2
2 DEMONSTRATION OF TECHNOLOGY FOR THE REPOSITORY SYSTEM
2.8 PROTOTYPE REPOSITORY
2.8.1 Preparation of installation
2.1.2 Installation of inner section
2.1.3 Installation of outer section
2.2 BACLFILL AND PLUG TEST
2.2.1 Water saturation
2.2.2 Flowtesting
2.2.3 Evaluation and reporting
2.3 TECHNOLOGY DEMONSTRATIONS
2.3.1 Phase 1- Deposition Equipment Prequeries report
2.3.2 Phase 2 - Development of concepts report
2.3.3 Phase 3 - Concept evaluation report
2.3.4 Phase 4 - Layout drawings/basic description
2.3.5 Phase 5 - Finish reporting
2.4 CANISTER RETRIEVAL TEST
2.4.1 Saturation
2.4.2 Finish report
2.5 LONG TERM TEST OF BUFFER MATERIAL (LOT)
2.5.1 A0 Heating Tests
2.5.2 A2 Heating Tests
2.5.3 A3 Heating Tests
2.5.4 S2 Heating Tests
2.5.5 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 BUILD TWO NEW WAREHOUSES
3.2.1 Preparation
3.2.2 Realization
3.2.3 Reporting
3.3 ROCKA VISULATIZATION SYSTEM
3.3.1 Implementation version 2.4
3.3.2 Implementation version 3.0
3.3.3 Implementation version 3.1