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Invitation to participate in the retrieval of

The Full-Scale Prototype Repository at Äspö HRL

Removal of the outer plug of the prototype repository

The first canisters in the Prototype Repository were installed in 2001 making it the longest running full-scale, multi-barrier repository experiment in the world. SKB has finally started the planning for the excavation of the prototype repository and is now inviting other organizations to participate in this unique project for evaluation of geological disposal.

The Prototype Repository is a full-scale experiment in crystalline rock at a depth of 450 m in Äspö Hard Rock Laboratory (Äspö HRL). The experiment simulates conditions of relevance to the Swedish/Finnish KBS-3V disposal concept for spent nuclear fuel. The 64 m long experimental tunnel at the very end of the main access ramp of Äspö HRL contains six deposition holes with full-scale copper canisters surrounded by Wyoming (MX-80) bentonite buffer. This part of the access ramp was excavated by a tunnel boring machine (TBM) and was divided into two separate sections. The inner section, with four deposition holes, has been operated since 2001 while the outer section, with two deposition holes, was in operation during 2003-2010.

Each section was backfilled with a mixture of bentonite (30% by weight) and crushed rock (70% by weight) and finally sealed by reinforced concrete dome plugs. An inner plug was installed to separates the two sections allowing for the two sections to be retrieved at different points in time, while an outer plug sealed the Repository. The canisters installed in the prototype repository contain electrical heaters to simulate the decay heat from spent nuclear fuel.

The aim of the Prototype Repository has been to support the application for an operational license for the final repository for spent fuel. The plan was to operate the inner section for approximately 20 years while the outer section was to be excavated after approximately five years of operation in order to support the repository development and the licensing with as accurate information and data as possible during the different stages. Due to the different objectives, the two sections were differently instrumented where the inner section was more sparsely instrumented while the instrumentation of the outer section was extensive.

In accordance with the original intents, the outer plug of the Prototype Repository was opened in 2010 and the outer section (23 meter long with two deposition holes) was retrieved after about seven years of operation. The findings of the excavation of the outer section are documented in TR-13-22 Opening and retrieval of outer section of Prototype Repository at Äspö Hard Rock Laboratory. In addition to the data gathered during the excavation of the outer section SKB has continuously gathered sensor data from the Prototype Repository which has been published in a number of public reports where the last one is P-21-28 Prototype Repository – Sensor data Report No 32.

SKB have now started the planning of the retrieval of the inner section of the prototype repository including the four inner-most canisters and the copper and concrete test specimens installed in the buffer and backfill. The

overall objective of the retrieval is to study the actual conditions of canister, buffer, backfill and the surrounding rock after being subjected to groundwater inflow and heating for a long time.

PROJECT GOALS

SKB's main goal for the project is to support the application for an operational license for the Spent Fuel Repository in Forsmark by demonstrating our ability to model and predict the performance of the components in a KBS-3 repository. This will be done through modelling, combined with analytic predictions of the status of the different components, which in the third and fourth phase of the project will be compared with laboratory and filed data from the excavation and retrieved materials. Primary phases and activities of the project are listed in the table below.

Phase	Activities (subset of planned work)
PLANING & PREMODELLING	• Pre-modelling of the installation • Detailed planning
EXCAVATION	• Excavating the plug • Excavation and sampling of the backfill • Studies of contact areas between the backfill/tunnel wall and backfill/the buffer • Excavation and sampling of the buffer • Measurements of Buffer up-swelling • Studies of contact areas between the buffer and bedrock / canister • Retrieval of pre-installed porewater sampling cups • Retrieval of cellulose-concrete samples • Retrieval of the canisters • Bedrock investigations o *Spalling in deposition hole and tunnel* o *Water inflow*
LABORATORY WORK	• Analysis of buffer and backfill o *Water saturation & density* o *Mineral transformation* • Analysis of the canisters o *Surface-analysis of the canister* o *Drill cores from canister material* o *Laser scanning of the canister* • Groundwater *analysis*
ANALYSIS & REPORTING	• Comparison of predictions and data • Modelling o *Thermal evolution* o *Water saturation* o *Chemical evolution* o *Swelling and homogenization* • Incorporating results from experiment in the safety assessment and the safety report (SAR)

PROJECT STATUS

The project is currently (Q3 2022) in the planning and pre-modelling phase and the next step is to start the site preparations and initiate sampling activities from the adjacent tunnel and through the plug during the fall of 2022. The next main activity is the start of the disassembly of the plug in Q1 2023 after which excavation of backfill will start. The first canister is expected to be retrieved during the summer of 2023 after which sampling and removal of materials will continue until the end of 2024. Laboratory examinations and analysis will be finalized during the spring of 2025 while the modelling, analysis and reporting will continue until the fall of 2026.

INVITATION TO PARTICIPATE

The retrieval of the Prototype Repository is a key component of SKB's licensing process and evolution of the safety assessment and the safety report. In addition, the project can provide unique and valuable insight, data and understanding to other organizations working with the evolution of the engineered barriers in a repository environment.

By involving external participants in the project, we hope to strengthen credibility and acceptability of geological disposal concepts globally and support further scientific development within key areas of relevance to the repository technology. SKB is therefore inviting other organizations to participate in the project both as a partner in the Transfer of information program and through expert level research collaborations.

TRANSFER OF INFORMATION PROGRAM

SKB and SKB International offers a unique opportunity to participate in the transfer of information program within the retrieval of the inner section of the Prototype Repository, where participating organizations are provided access to valuable insight into the repository evolution. The program includes:

- Background information, Project plans and sampling plans
- Updates and information as the project progress through the different phases of planning, excavation, analysis and reporting from October 2022 until November 2026
- Participation in interesting discussions on relevant topics
- Biannual webinars or workshops during the planning and excavation phase (6 events)
- Site visits during the two years of excavation (2023/2024)
- Summary workshops in 2025 (focus: Excavation and findings) and 2026 (modeling and lessons learned)
- Continuous project updates on a web-based portal accessible only to participating organisations
- Web-based forum for questions and answers

The biannual 2-day webinars with pre-recorded presentations will be made available at the web-based portal ahead of the webinars. The webinars will be live streaming events of about 2-3 hours focusing on discussions on specific topics of interest.

Material that can be made available

Samples (available from 2023):

- Bentonite exposed to thermal gradient
- Bentonite exposed to isothermal conditions
- Bentonite/rock mixture exposed to isothermal conditions
- Interface bentonite block/pellet
- Interface bentonite/granite rock
- Interface bentonite/copper
- Interface bentonite/cement
- Drill cores from the copper canister
- Drill cores from the cast iron insert

Data

- Data from the operational phase (20+ years)
- Data from the outer section including: Thermal evolution, Hydration of buffer and backfill, Mechanical interaction between bentonite block/pellet & buffer/backfill, Geochemical evolution
- Model validation/testing (available 2024).

PROPOSAL FOR RESEARCH COLLABORATION

In addition to participating in the transfer of information program SKB also welcomes other organisations to join the project as Scientific partners. Studies by scientific partners can be done in parallel with investigations performed by SKB (verification of findings) or as complementary studies to the SKB program. Scientific partners are expected to submit a preliminarily plan for their activities together with a list of expected deliverables prior to joining the project. Support in formulating the scientific plan can be arranged through the project's scientific coordinator.

SKB is tasked with managing Swedish nuclear fuel and radioactive waste in a safe way. For more information see www.skb.se.

PARTICIPATION FEE

The indicated participation fee for the transfer of information program is in total EUR 200,000 per organisation. The fee covers participation from October 2022 until June 2025 plus summary workshop in 2026. The fee will be invoiced in four instalments of EUR 50,000. The firsts instalment will be invoiced in the beginning of 2023. Organizations that are contributing to the project as scientific partners where the scientific work is deemed beneficial to SKB, are subject to a reduction of the participation fee. Special agreements can also be formulated with organisations participating in scientific work but not taking part in the workshops and webinars.

CONTACT

For additional information (project presentations etc) and further discussions regarding participation in the transfer of information program and/or research collaborations; please contact Mr. Magnus Holmqvist (magnus.holmqvist@skb.se) at SKB International.

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