PACIFIC RIM SPENT FUEL MANAGEMENT PARTNERSHIP WORKSHOP

Organized by the Nuclear Threat Initiative (NTI)

29-30 October 2019

Surfeel Hotel · Wakkanai, Japan

MEETING SUMMARY

Introduction and Objectives

Meeting organizers began with brief introductions, as well as a history/overview of the project, followed by expectations for the meeting. The meeting brought together members of the working group on collaborative research and development at underground research laboratories (URLs). This is one of two Pacific Rim Partnership working groups; a technical and non-technical aspects of siting working group is assembling the components of a common framework for the safe, secure and socially acceptable long-term management of spent fuel.

Working Group Discussions

Presentations were made on the status of the generic URLs in Japan – Mizunami URL in crystalline rock and Horonobe URL in sedimentary rock. The purpose of these URLs is to: confirm applicability of geological disposal technologies; understand the deep geological environment; provide a training area for staff from the Japanese disposal programs; and promote the public's understanding of deep underground repositories.

Horonobe URL

Current R&D at Horonobe URL includes: improving the reliability of disposal technologies both to verify engineered barrier technology and to confirm the applicability of engineered barrier systems (EBS) design methods; and enhancing safety assessment methodologies to confirm the applicability of these methodologies.

Proposed plans for Horonobe URL from FT2020 include:

1. A near-field performance study through a full-scale EBS experiment;
2. Demonstration of repository design options
    a. Demonstration of emplacement, retrievability and sealing techniques
    b. EBS experiment under critical conditions - >100^{o}C
    c. Systemize of techniques for investigation, design, evaluation foe safety at gallery scale to pit scale
3. Verification of buffering capability of sedimentary rock against crustal movement.

Mizunami URL

From 2015-2019, several important experiments were undertaken at Mizunami URL, including the development of countermeasure technologies for reducing groundwater inflow, development of modelling technologies for mass transport and development of drift backfilling technologies. However, it was planned that R&D at Mizunami URL would be completed at the end of FY 2019 and the underground facilities would be dismantled and backfilled by January 2022, the end of the current land lease.

Specific Experiment Readouts

Several experts made presentations on the status of specific R&D projects at Japanese URLs.

Full-Scale EBS Experiment: The major objectives for the full-scale EBS experiment at Horonobe URL were to: (1) evaluate applicability of the repository design technology; (2) demonstrate an excavation technology for the disposal pit, EBS emplacement technology and tunnel sealing technology; and (3) observe near-field coupled thermal-hydraulic-mechanical-chemical (THMC) phenomena in situ and to create confidence in coupled THMC models. Over the course of this experiment, experts confirmed the applicability of the design technology, manufacturing/construction technology and quality control, as well as generated near-field coupled THMC data and developed an applicability evaluation of the THM model for the heating phase.

Emplacement/Retrieval/Sealing Technology: For this experiment, experts worked to determine the role of sealing technology, design requirements and specification of such technology (e.g. constructability, workability and quality assurance). Experts also considered repository design that would allow for retrievability of waste packages and the flexibility of sealing technology selection given this requirement. On sealing, a future R&D program was proposed that would include development of a scenario to define the roles of sealing materials, how the sealing technology and materials will be used in connection with the disposal tunnel and access galleries, and a features, events & processes (FEP) analysis. On emplacement/retrieval experiments, several demonstrations were undertaken including horizontal tunnel emplacement, gap-filling technologies and removal techniques.

Rock Stability Classification: In support of an adaptive repository concept, this experiment considered variations in the geological environment and the effect on repository design. There is interest in establishing a methodology for the development of a rock classification system, as well as validating that methodology. Another focus for the Horonobe URL is selection of countermeasure techniques to address fractures and faults. Understanding near-field damage by exceeding 100°C is a priority as this may present various for disposal concept and repository design advantages, including: shortening the interim storage period required for vitrified waste; a more compact repository (a narrow disposal area with a multilayered disposal panel); a more flexible design; and significant cost savings. The planned study comprises an in-situ experiment, which complements the on-going international HotBENT project (lab and modeling studies to evaluate buffer behavior at 150°C to 200°C), and includes the monitoring of THMC behavior with installed sensors, developing the sampling methods, and working on remaining analysis issues (XRD, SEM, EPMA, ICP-MS, etc.). The experiment aims to generate more data on buffer/host rock performance under temperatures up to 200°C and at realistic scales, as well as upscaling and changing boundary conditions of the buffer and achieve a 1:1 scale modeling. Some secondary objectives include the comparison of different materials, concepts/designs, boundary conditions (considering different bentonites and canister materials, water chemistry, temperatures), evaluation of microbial activities and impact on corrosion and gaseous releases, as well as integrating of THMC modeling with mock-up

experiments. Conducting a literature survey on behavior in the near field at temperatures above 100°C was mentioned as a potential follow-up R&D program. In the future, performing an analysis on features, events and processes based on the survey is envisaged.

Geological Characteristics in Granite and Sedimentary Rock: Knowledge obtained from URLs in Japan was then discussed. Mass transport studies were conducted for both types of host rock, investigating diffusion, retention and sorption processes of some elements of interest in the geological environment. Transport routes were also modeled, revealing the differences between the advective component in granite (Mizunami) and sedimentary rock (Horonobe). Granite has many fractures that are assumed to be connected, and even if the main part of the fracture network is blocked by mineral fillings, the fracture network remains the dominant transport path. Sedimentary rock has few fractures and there is a wide area where the connectivity of fractures is low depending on geo-history. A discrete fracture network (DFN) model, integrating a deterministic and stochastic approach, was developed for the granite host rock using the FracMan Couplys code. A preliminary list of features, events and processes relevant for the transport pathways and processes in both type of rocks, as well as in the excavation disturbed zone and excavation damaged zone, was established but has to be further refined.

South Korea and Australia

Following discussion of the work done at Japanese URLs, presentations were given on the status of research and development in South Korea and Australia.

South Korea currently has 24 operating nuclear reactors. Two units have shut down in recent years and four units are under construction. Spent fuel is stored in on-site spent fuel pools, and in the case of some CANDU spent fuel, in dry storage. The process for deep geological repository site selection must be prepared, along with plans for expansion of on-site storage facilities and long-term storage options. The government of South Korea will prepare a new generic R&D program for developing a national URL based on a new national plan to be released in 2020.

At the KAERI Underground Research Tunnel (KURT), several studies and experiments were done in Phase 1 of operation related to deep borehole investigation, hydrological and geochemical monitoring, EDZ characterization, including a borehole heater test, solute migration experiment and a long-term corrosion experiment, as well as an international collaboration project.

Experiments have now started as part of Phase 2 on in-situ demonstration of engineered barrier system performance and tracer tests for water-conducting fractures. The research at KURT is providing important data to validate the safety and feasibility of a disposal system and is making an important contribution to the implementation of a geological repository program in Korea.

Australia is currently considering a deep borehole option for the disposal of intermediate-level waste (ILW), which includes reprocessed research reactor spent fuel, technological waste, waste products from isotope production, and sealed sources. The Commonwealth Scientific and Industrial Research Organization (CSIRO) is currently in the process of identifying potentially suitable sites and excluding unsuitable sites by analyzing factors such as crystalline basement depth, seismic hazards, heat flow, groundwater resources and resource potential of certain areas of land. The construction of an R&D facility would be very useful for developing novel materials for borehole sealing with extended durability, technological innovation in deep hard-rock drilling, next generation robotics and geochronology.

Proposed Collaborative R&D Projects

The experts in this working group have identified potential collaborative R&D projects that could be beneficial to the Pacific Rim Partnership. These include, but are not limited to:

- Site characterization & repository design
- Near-field perturbation studies
- Engineered barrier integrity experiments
- Radionuclide transport
- Demonstration of integrated system behaviors
- Safety during the operation phase of repositories
- Post-closure considerations

Over the intersessional period, working group members will down-select from this list in order to choose one or two projects to be undertaken over the next several years.

Knowledge Management

The final session focused on knowledge management. Presentations were given on current and future efforts from key stakeholders to promote knowledge management. Key lessons learned from these efforts include:

- Knowledge management needs to be a deliberate effort with adequate resources;
- It requires both technical experts that develop and used the information and understand the interconnectivity between different types of information, as well as IT experts working as an integrated team;
- It is a challenge to keep hardware and software updated during a hiatus in a nuclear waste management project;
- Making changes to knowledge management systems in a highly-regulated environment can be difficult;
- Knowledge management requires a culture in which it is viewed as valuable, not as an obstacle to getting work done.

In addition, it was noted that the important necessary conditions to sustain and advance a cohesive and thorough knowledge management project include:

- Offering a continuous improvement of a user-friendly system for knowledge users and producers;
- Prompt updates and expansion of contents of a knowledge management system by knowledge producers;
- Maintenance of staff and budget.

Over the intersessional period, participants agreed to exchange several papers reflecting knowledge management practices in their organizations, aiming to identify key principles and approaches that can benefit the other members of the group.