MOBILITY MISSION REPORT

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MISSION TITLE

Visit to the UK's National Nuclear Laboratory (NNL), key UK research organisations and knowledge exchange with the UK's Nuclear Waste Services (NWS)

DESCRIPTION

Concerned organisations

Research entities:
Nuclear National Laboratories Ltd
University of Liverpool
University of Manchester

Concerned infrastructures or facilities

NNL Preston laboratories

Concerned phases

Phase 0: Policy, framework and programme establishment

Phase 1: Site evaluation and site selection

Phase 2: Site characterisation

Phase 4: Facility operation and closure

Phase 5: Post-closure

Themes and topics

Remove this entire field as well as every below theme and topic that do not apply

- Theme 1: Managing implementation and oversight of a radioactive waste management programme
  - Programme planning
  - Organisation
  - Resources
- Theme 2: Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal
  - Waste handling, characterisation, treatment and packaging
  - Interim storage
  - Transportation between facilities
  - Radionuclide inventory and source term
  - Waste acceptance criteria
- Theme 3: Engineered barrier system (EBS) properties, function and long-term performance
  - Spent Fuel and high-level waste disposal canisters
  - Containers for long-lived intermediate and low level wastes
  - Clay-based backfills, plugs and seals
  - Cementitious-based backfills, plugs and seals
  - Salt backfills
  - EBS system understanding
- Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution
  - Long-term stability (uplift, erosion and tectonics)
  - Perturbations (gas, temperature and chemistry)
  - Aqueous pathways and radionuclide migration
- Theme 5: Geological disposal facility design and the practicalities of construction, operations and closure
  - Monitoring and retrievability
- Theme 6: Siting and Licensing
  - Site selection process
  - Detailed site investigation
- Theme 7: Performance assessment, safety case development, and safety analyses
  - Integration of safety-related information
  - Performance assessment and system models
  - Treatment of uncertainties

Keywords

Higher education, EBS performance, site characterisation methodologies, radioactive waste management

EXECUTIVE SUMMARY

The aim of the mission was to increase knowledge exchange berween GTK and the UK's National Nuclear Laboratory (NNL) as well as organisations in close collaboration with NNL

(University of Liverpool and University of Manchester). In addition, the aim was to lay out the laboratory cababiltiies in order to assess synergies in experimental and field based research.

In addition, the aim was to exchange experiences how to learn from organisational/national level experiences in Finland within the process of RWM development in different phases of the repository programme.

Engaging PhD student in the discussion was part of the overall aim to increase networking between UK and Finnish organisations.

1. MISSION BACKGROUND

1.1. R&D background

Geological Survey of Finland (GTK) has developed via EURAD-HITEC WP analytical methods to assess bentonite performance in the geological repositories. GTK has also undertaken bentonite and clay rock related research in many parallel projects, including: bentonite performance projects, hydrothermal alteration assessments, and recently also mud rock characterization projects. GTK is collaborating with the department of radiochemistry at University of Helsinki via EURAD-1, and several other nationally funded research projects; we see increasing demand for combining techniques for performance assessment and radionuclide transport analyses as a field for development in the future.

In the UK, Nuclear Waste Services (NWS) are currently working with three different local communities to assess the potential for their communities to host a geological disposal facility. At present, the host rocks of interest in all four communities are all classed as clay-rich Lower Strength Sedimentary Rocks (LSSRs) (Triassic Mercia Mudstone Gorup, and Jurassic Ancholme Group). It is noteworthy that one of the potential host-rocks, named the Mercia Mudstone Group, is highly heterogenous (locally contains interbeds of silts, sands, and evaporites) and will require high resolution characterization to better understand it's potential as a hostrock, and how it may influence the design of the engineered barrier system.

1.2. Mission objectives

The aim of this visit was to visit the UK's National Nuclear Laboratory and organise workshops to exchange experiences in the broad field of analytical methods to characterise host-rock environments and clay-based engineered barriers. The visit would also include visits to Mercia Mudstone Group outcrops in collaboration with local universities (University of Liverpool and/or University of Manchester).

In addition the aim was to exchange experiences on the Finnish and British waste disposal programmes.

1.3. Mission request

As the UK's national laboratory for nuclear fission, NNL leverages the UK's rich heritage to help solve global challenges in four strategic areas: Clean Energy, Health and Nuclear Medicine, Environmental Restoration and Security & Non-proliferation. This requires NNL to establish and develop strong and sustainable research collaborations with academia.

1.4. Mission composition

Host organisation

Nuclear National Laboratories Ltd

Host facility

Nuclear National Laboratories Ltd, Warrington, UK

Mission dates

22 April 2024 – 27 April 2024

2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

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2.1. Practice, technique, method, tool or system operated or studied during the mission

Replace this entire field with the name of the practice, technique, method, tool or system that is the object of this mission.

Description

Quantitative XRD at University of Liverpool

Usage

Discussion how to better utilise quantified clay XRD in various projects related to RWM.

Benefits

Uncertainties can be reduced by utilising dedicated laboratories rather than commercial laboratories especially when samples are clay rich and the aims of the work need specific attention to uncertainties in the final results.

Limitations

Some smectites overlap in this method, e.g. beidellite /montmorillonite detection is difficult.

Applicability

Any bentonite or other clay related mineralogical study.

2.2. Practice, technique, method, tool or system operated or studied during the mission

Rock deformation laboratory, University of Liverpool

Description

Replace this entire field with a description of the implementation of this practice, technique, method, tool or system at the host organisation.

Usage

Laboratory based analysis of rock deformation in various P/T conditions and fluid compositions. Methods also allows using soft, low strength rock materials in the experiments.

Benefits

This would provide a useful tool for integrated bentonite experiments on variable chemical conditions and altering P/T. Results could be compared to bentonite fault studies in natural settings, e.g. IBL-project in Japan.

Limitations

Utilising brines as fluids cause corrosion issues in the system. However, method is very useful in lower salinities and for brine type experiments, some modifications could be made to avoid equipment corrosion.

Applicability

Bentonite or rock experiments regarding their deformation properties. Useful for both host rock and EBS studies.

2.3. Practice, technique, method, tool or system operated or studied during the mission

X-ray Computed Tomography

Description

NXCT: UK's National Research Facility for lab-based X-ray Computed Tomography, facilities at University of Manchester:

« The facility at Manchester has been at the forefront of X-ray imaging since 2008 when Regius Prof. Philip Withers established the Henry Moseley X-Ray imaging Facility (HMXIF). In 2014 the facility was awarded the Queen's Anniversary Prize for "New Techniques in X-ray Imaging of Materials Critical for Power, Transport and Other Key Industries" recognising the special contribution the research and expertise has made to the UK's strategic development in advanced materials and manufacturing. The HMXIF currently hosts ten different X-ray CT scanners which cover scales from metre size objects and resolutions down to 50 nm. The HMXIF also hosts many rigs allowing for in-situ testing and a large computer suite enabling comprehensive 3D analysis. «

See also https://nxct.ac.uk/facilities/manchester/

Usage

HMXIF facility can image samples from meter scale to nano scale and therefore offers a unique potential for multiscale analyses. In addition to traditional XCT devices, such as colour imaging bay offer added value by including chemical aspects to tomography:

« The Colour Imaging Bay is an in-house built system designed as a flexible work bench for spectroscopic X-ray imaging and tomography. In bright field imaging, the energy-sensitive, pixelated detector allows for detection of absorption edges and 3D reconstruction of different atomic elements within a sample. The high-power source (225 kV, 1800 W) allows for X-ray fluorescence (XRF) imaging using a pinhole camera arrangement perpendicular to the beam. X-rays are absorbed

and re-emitted from atoms within the sample. These photons have characteristic energies specific to each atomic element. Spatial resolution depends upon the size of the pinhole optic and geometric magnification but is typically in the range of 20 – 200 microns. Scan times can be very long, normally 5 – 10 mins per projection with a full 3D scan taking up to 24 hrs. »

See also https://nxct.ac.uk/facilities/manchester/colour-bay/

Benefits

Multiscale tomography in a sigle facility from metre to nanoscales.

Limitations

Samples need to have contrasting features and differences in density in order to be visible in most XCT applications.

Applicability

Can be used in host rock characterisation and EBS studies.

2.4. Practice, technique, method, tool or system operated or studied during the mission

Radiochemistry laboratories in general

Description

During the visit two laboratories handling radioactive materials were visited, NNL Preston Laboratory and Manchester University radiochemistry laboratory.

Usage

Versatile techniques are used to analyses radionuclides both in hot labs as at low-level radiation. These facilitie offer potential to develop experimental set ups for developed EBS experiments including the waste forms, assessing natural and anthropogenic radiochemical components in various soil and rock samples.

Benefits

Not assessed fully yet.

Limitations

Not assessed yet.

Applicability

Multiple applications within RWM. Already existing collaboration in EURAD-2 Rampec WP.

3. MISSION FINDINGS AND CONCLUSIONS

3.1. Lessons learned and conclusions

Many synergies exist within the UK and Finnish disposal programmes despite the differences in the likely host rock types in UK. The fracturing, porosity and EDZ formation play the major role in developing conceptual models for the repository development and modelling of the system. In addition, EBS development is ongoing field of research in both countries. NNL as an organisation has the benefit of facilitating experiments that can include radioactive elements, even waste forms, which would allow set ups for new type of EBS system experiments. Geological understanding is needed through the whole process, which supports collaborations with geological surveys and universities with Earth Sciences departments. Climate change related processes are part of the future evolution assessment, and this area of research was also identified as ones of potentially needing more effort in the future. Research via analogues in included in the GDF development, and this has been implemented in both countries, but holds potential for more extensive work.

3.2. Relevant findings and conclusions for home organisation

Research opportunities can be enlarged via collaboration between GTK-NNL, and Universities of Liverpool and Manchester. See sections on methods above.

There is also a lot of lessons that can be learned from the Finnish experience. On major area identified as overlapping was fracturing and structural geology.

3.3. Relevant findings and conclusions for host organisation

Better understanding of British-Finnish synergies and key challenges in radioactive waste disposal. Potential to establish impactful R&D programmes focused on subsurface and engineered barriers. Better understanding of what laboratory and modelling programmes may be needed to support the UK GDF mission, in relation to next generation cement, bentonite, and host-rock environments, in addition to the value of natural analogous. A better understanding of how Finnish institutions (e.g., GTK, VTT), waste management organisations (e.g., POSIVA), and universities (e.g., University of Helsinki) have successfully worked together, which provides a good example to how UK programmes could work. Draft R&D scopes for potential future work, which could be funding through potential collaborative commercial projects or research councils. GTK were able to offer advise and guidance to ongoing and potential research programmes which thus far did not have any international steer.

3.4. Relevant findings and conclusions for other organisations

PhD students would benefit from research collaboration with Finnish institutions. This could be in the form of research visits in the future. In addition synergies were identified for research opportunities in relation to other fields currently under investigations such as geoenergy.

4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

Not applicable

4.1. Generic potentials

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4.2. Potentials for home organisation

Klikněte nebo klepněte sem a zadejte text.

4.3. Potentials for host organisation

Klikněte nebo klepněte sem a zadejte text.

APPENDICES

Mission journal

Day 1

Travel to site.

Field visits: Blue John Cavern; Harpur Hill, Mercia Mudstone group outcrops

Day 2

Workshop at NNL. All day discussions presenting ongoing activities at GTK and NNL and discussion on general synergies.

09:00 – 09:15 Introductions

09:15 – 10:00 Presentation from GTK on Finnish disposal programmes and GTK's experience (subsurface and EBS)

10:00 – 11:00 Presentation from NNL on UK disposal programmes and GTK's experience (subsurface and EBS)

11:00 – 12:00: Initial discussions on synergies

12:00 – 13:00 Lunch

13:00 – 16:00 Workshop on concepts for potential collaborative projects.

Present at the workshop:

J. Griffiths, Liam Abrahamsen, Aislinn Boylan, Vasileios Tsitsopoulos, Nick Smith, Matthew Randall, Anthony Banford, Alan Wareing

Day 3

Visit to the Preston Laboratories: Fuel manufacturing facilities, radioactive waste treatment laboratory and pilot plant, nuclear medical process laboratory.

Time	Agenda Item	Guide
09:45	Arrival (main gate)	Rhianna Jobson/Gen Boshoff
10:20	Pellet Lab	Michael Brogden
10:40	Particle Fuel Rig	Michael Brogden
11:00	M & A (D-004)	Adam Lawton
11:20	Waste Residue	Thomas Mowatt
11:40	Pilot Plant	Thomas Mowatt
Lunch		
13:00	Nuclear Medicine	Rachel Roberts
13:20	Decontamination	Gen/Rhianna
13:40	Rock lab	Gen/Rhianna

14:00 Discussion/Meeting Rhianna Jobson/Gen Boshoff

Drive back to Warrington

Day 4

Visit and workshop and University of Liverpool. Discussions with PhD student and research staff working in the field of geological disposal. Laboratory visits to rock deformation laboratory, petrography and SEM laboratory, XCT laboratory and XRD laboratory.

10:00 – 11:40 Arrival and informal PhD project introductions

11:40 – 12:30 Laboratory Tours

12:30 – 13:30 Lunch

13:30 – 14:30 Discussion on Finnish/British programmes

14:30 – 16:30 General discussion and potential synergies and collaborative programmes (subsurface and engineered barriers)

Day 5

9-16: Laboratory visits, a meeting and public lecture at University of Manchester

Public lecture 11-12 in person + online topic related to GTK's role in RWM in Finland over the years and current activities

Day 6

Reporting and travel home.

(this should be prepared during the course of the mission and should not exceed 1 page).

MISSION BENEFICIARY

Heini REIJONEN
Chief Expert
Energy and Construction Unit
Geological Survey of Finland (GTK), Finland

PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

- Joshua Griffits, Disposal Core Science Theme Lead (Geoscientist), Environmental Science Team, Nuclear National Laboratories Ltd
- Nick Smith, University Lead and Lab Fellow in Geology, Nuclear National Laboratories Ltd
- Aislinn Boylan, Chemistry/Geochemist/Experimentalist/Modeller, Nuclear National Laboratories Ltd
- Vasileios Tsitsopoulos, Mathematician/Modeller, Nuclear National Laboratories Ltd

Home organisation experts

- Lauri Solismaa, Head of Unit, Geological Survey of Finland

Other organisations experts

- University of Liverpool:

James Utley, Research Technical Professional at University of Liverpool

John Wheeler, George Herdman Professor of Geology at the University of Liverpool

David McNamara, Senior Lecturer, Earth, Ocean and Ecological Sciences

- University of Manchester

Prof. Katherine Morris, Earth and Environmental Sciences

REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
23.5.2024	Heini Reijonen	Lauri Solismaa	Joshua Griffiths