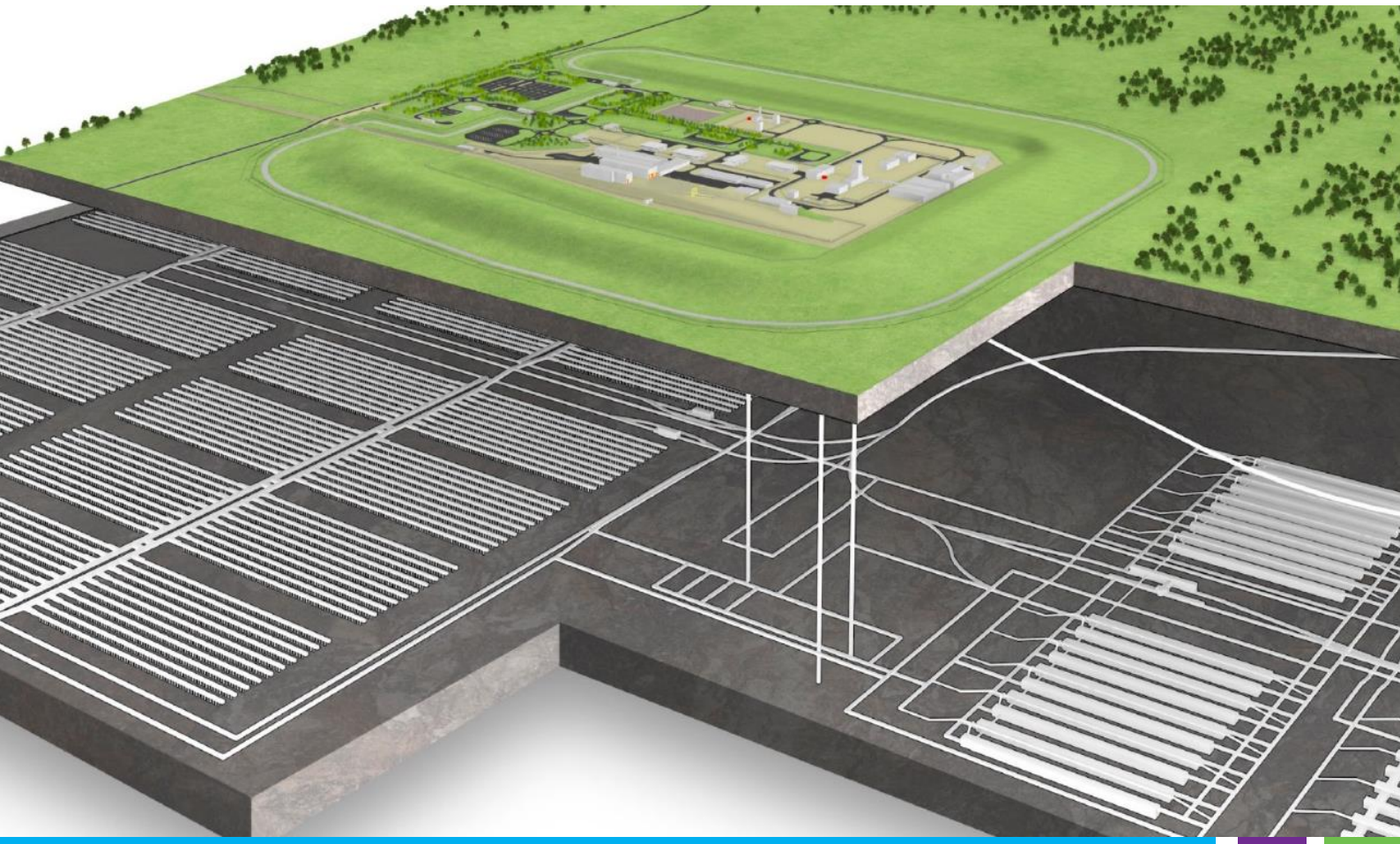
Research Support Office

PhD bursary call 2024

Project briefs



Nuclear Waste Services

Contents

Please email rso-gdf@manchester.ac.uk with any queries by 17th October 2022

1, Application of machine learning and neural network methods to rapid reactive transport modelling

Discipline Area: Computational Science

NWS Subject Matter Expert(s): Niko Kampman

Summary

Numerical reactive transport modelling (RTM) is a powerful tool that can be used to assess a variety of safety critical performance factors such as radionuclide or gas mobility in the geosphere and engineered barrier performance/longevity. Geochemical modelling studies for performance assessments in geologies comprising high salinity groundwaters require simulation codes capable of using complex geochemical activity models for non-ideal solute behaviour such as the Pitzer or the Mixed Solvent Electrolyte thermodynamic models. Such activity models incur a large computational penalty in reactive transport simulations. Similarly, the simulation of a large number of components such as the variety of radionuclide species for which performance must be assessed carries a large computational burden.

For an efficient simulation capability, advanced methods for model speed-up are required. Machine learning and neural network methodologies have the potential to greatly improve computational efficiency. The application of these methods to reactive transport simulation codes and problems applicable to a geological disposal facility will be investigated by projects in this call. It is anticipated that projects under this topic will build on existing work in this area (e.g., Leal et al., 2020; Reaktoro) or develop novel methodologies and/or applied to alternative simulation tools. Collaboration with international researchers working on these topics is encouraged.

Background
Modern reactive transport modelling tools provide the opportunity to better underpin safety assessments, providing the ability to model the variety of geochemical processes that provide chemical retention in the engineered barrier system and geosphere. Currently, the UK capability in this area is immature, and this research topic would act to support development of this capability.

Potential findings may impact upon siting and design. If possible, work should seek to contextualise findings to NWS' ongoing programme, with Community Partnerships formed in both Cumbria and Lincolnshire spanning a range of geologies.

Research output will seek to better underpin the post-closure safety case and assess the potential impacts on GDF performance (isolation and containment of radionuclides).

NWS Themes
3 – Low Heat Generating Waste
4 – High Heat Generating Waste
5 – Pathways (includes Gas and Hydrogeology)
6 – Understanding the natural environment (includes geosphere and biosphere)

References
Leal, A. M., Kyas, S., Kulik, D. A., & Saar, M. O. (2020). Accelerating reactive transport modeling: on-demand machine learning algorithm for chemical equilibrium calculations. Transport in Porous Media, 133(2), 161-204.

2, Surrogate models for sensitivity analysis of computationally expensive multiphase flow models.

Discipline Area: Applied Mathematics

NWS Subject Matter Expert(s): Andy Cooke

Summary

Multiphase flow models are often computationally expensive, making global sensitivity analyses and detailed consideration of parametric uncertainty unfeasible. Surrogate models may provide a solution.

The project will develop a strategy/framework for the application of surrogate models to GDF modelling studies, considering the associated requirements, uncertainties, and limitations of such models. The project will apply this approach to a global sensitivity analysis of a relevant model(s) to demonstrate an efficient approach for calculating parametric uncertainties and sensitivities.

The project will apply surrogate modelling to a novel or pre-existing multiphase flow model addressing risks associated with gas migration through the engineered and/or natural barriers of a GDF.

This will support building confidence in complex models and focus future research needs through understanding key model sensitivities.

Background

Sensitivity and uncertainty analyses are key tools for understanding risk at a given stage in a project. Sensitivity analysis attributes variation in model output factors to variation in model input factors. This is useful for improving system understanding and/or for prioritisation of uncertainty reduction. Uncertainty analysis describes possible outcomes and their associated probabilities of occurrence.

A global analysis or Monte Carlo approach is necessary for holistic and impartial analyses. A global analysis is achieved by varying all of the input factors simultaneously and evaluating the sensitivity over the full input factor space (Iooss & Lemaître, 2015). NWS post-closure safety modelling explicitly includes an aim of sensitivity analysis; NWS has developed an approach for using simplified, abstract and probabilistic Total System Models (TSMs) for system performance calculations of dose and risk for this reason (NDA 2013). However, this is computationally expensive and rarely applied to finite element method (FEM) models because they are computationally expensive and the total demand is multiplicative.

Surrogate models (or response surfaces) are simplified approximations of more complex, higher-order models. Surrogate modelling may be applied to reduce computational expense by bypassing all or part of a complex model (Vurtur Badarinath *et al.*, 2021).

Through application of surrogate models to a specific physics driven model(s), the project will develop a strategy/framework for the application of surrogate models that can be applied to a range of GDF modelling studies. The physics driven model should be a multiphase flow model addressing risks associated with gas migration through the engineered and/or natural barriers of a GDF (e.g., Bond *et al*., 2015). The model may be developed within the project or be pre-existing.

A challenge for a global sensitivity analysis of a multiphase flow model (and of other geological models) is handling dependent input factors (Mara *et al.*, 2015). A challenge for a surrogate model of a multiphase flow model will be producing a reasonably constrained response surface given the inherent non-linearity. The project will apply this approach to a global sensitivity analysis of a relevant model(s) to demonstrate an efficient approach for calculating parametric uncertainties and sensitivities. Therefore, the surrogate model is expected to be trained on a set of input and output data produced by a complex physics driven model.

The research outputs from the PhD will improve NWS's capability in understanding and managing risk through the improved application of sensitivity analyses. The results will

support building confidence in multiphase flow models and focus future research and uncertainty reduction needs through understanding key model sensitivities. The strategy/framework may be incorporated into our modelling strategy to reduce computational demand into our other models.

NWS Themes
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References
Bond, A.E., Thatcher, K.E. and Norris, S., 2015. Multi-scale gas transport modelling for the EC FORGE project. Mineralogical Magazine, 79(6), pp. 1251-1263.

Iooss, B. and Lemaître, P., 2015. A review on global sensitivity analysis methods. Uncertainty management in simulation-optimization of complex systems: algorithms and applications, pp.101-122.

Mara, T.A., Tarantola, S. and Annoni, P., 2015. Non-parametric methods for global sensitivity analysis of model output with dependent inputs. Environmental modelling & software, 72, pp.173-183.

NDA RWMD, Geological Disposal – Framework for Application of Modelling in the Radioactive Waste Management Directorate, September 2013

Vurtur Badarinath, P., Chierichetti, M. and Davoudi Kakhki, F., 2021. A machine learning approach as a surrogate for a finite element analysis: Status of research and application to one dimensional systems. Sensors, 21(5), p.1654.

3, The impact of climate change on marine species and ecosystem function

Discipline Area: Environmental Science

NWS Subject Matter Expert(s): Katherine Raines

Summary
The proposed research will focus on the implications of climate change in relation to the Geological Disposal Facility (GDF) siting process and provide baseline conditions for the biosphere modelling for the post-closure safety case. The overall aim of this project is to provide NWS with supporting information required for environmental assessment work. This is important as our current communities are interested in the inshore area with acknowledgement that potential future communities may also have a marine biosphere component.

This project should focus on understanding how climate change will interact with key marine protected species and those of commercial importance, both now and in the future. The overall aim of this study is to understand how the impacts of climate change will alter distribution of suitable habitats. It should also highlight vulnerable species within UK waters and identify any at risk if their habitats were to become reduced or uninhabitable from predicted climate change processes. A key objective for this research would be to understand which species are the most sensitive and when and how these changes are likely to occur.

Background
Nuclear Waste Services (NWS) needs to understand the implications of climate change sufficiently to support regulatory and permitting requirements in a safe and sustainable way.

This study will focus on the impact of climate factors driving marine habitat changes. A range of issues are presented in the face of climate change, such as seabed temperature rise, marine heat waves, ocean acidification and loss of marine biodiversity. The Met Office has identified sea surface temperature as record breaking, with increased chances of marine heat waves which is already resulting in stressed marine organisms (Met office, 2023). It would, therefore, be beneficial to review the impact of thermal change on particular species and on ecosystem function. Climate modelling studies have identified that many marine species will lose significant amounts of their suitable habitat by 2100, causing large shifts in species distribution (Hodapp, et al., 2022). For example, as sea water temperatures rise, basking sharks may shift territories to follow prey or to find cooler waters (Doherty, 2019). Opportunities may also become available for species outside of UK waters to move in (Evans & Waggitt, 2020). The main groups of marine protected species to be covered in this project are birds, cetaceans, seals, marine turtles, sharks, skates and fish, invertebrates and seahorses.

There are currently two regions under consideration for hosting the GDF; therefore, research should cover and compare the west coast (Irish sea) and east coast of England (North Sea). The GDF construction and operational timescales span over 150 years and provide the baseline for post-closure biosphere modelling. Therefore, these times scales (150 years) should be considered in this project. Furthermore, this research could support and underpin a temporal aspect of future ecosystem modelling for trophic transfer of radionuclides in the marine environment.

Expected outcomes of this project include:

- Explore and develop methodologies to identify protected marine species for the North and Irish Seas relevant for our timescales
- Predict marine species that may not be protected now but would be most vulnerable to change
- Compare using meta-analytical techniques to identify which marine species are likely to be the most sensitive to climate change in UK coastal waters
- Utilise predictive modelling to investigate potential species distribution changes in response to the effects of climate change.

This project relates to S&T tasks:
B1.2.1 Interface of Biosphere Programme with Environmental Impact Assessment (EIA).

NWS Themes

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References

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4, Futures forecasting of resource use and human behavioural change in the context of the GDF programme

Discipline Area: Environmental Science, Social Science

NWS Subject Matter Expert(s): Katherine Raines

Summary
The proposed research will focus on the consumption of water and other important resources during the construction and operational period of the GDF. This project will support NWS approaches to sustainability and site evaluation by understanding and anticipating any demands for the programme. The aim of the project is to use established techniques to expand on current futures forecasting approaches, bringing in a more holistic social context relevant to our programme.

The project will examine water consumption for the GDF, and other significant resources, to understand how much will likely be consumed during construction and operation. For example, water companies forecast supply and demand over a minimum period of 25 years, due to the nature of the timescales associated with the GDF programme, resource forecasting will be required over the next 150 years. The proposed research will identify methodologies for evaluating resilience and availability of water supply (and any other resources) over this period. It will also aim to understand how the United Kingdom will change socio-economically during this period, to horizon scan to mitigate potential changes in resource availability and demand. The significance of this project is that while we want to explore 'behavioural' drivers, social sciences would bring a focus on the wider social, cultural and economic factors ultimately shape human behaviour, resulting in a highly interdisciplinary PhD project.

Background

Futures forecasting refers to systematic approaches to thinking about the future, so that we can employ different tools and methodologies to mitigate potential disruption. Futures forecasting is a useful tool to ensure sustainability, identify techniques to mitigate impacts on our environment and reduce resource consumption. Futures is a developing field, e.g., Government Office for Science, supporting policy and decisions through the best science and long-term thinking. This PhD will use the futures forecasting approach, or similar, to consider resource use during the construction and operational period of a GDF, in the context of changes to human behaviour driving socioeconomic and cultural factors.

This PhD will develop an interdisciplinary approach between the areas of environmental and social sciences to understand the interaction between the changing natural and social environments and the needs of constructing a GDF. This PhD will focus primarily on water resource consumption, but other resources can be additionally considered. The proposed research could identify methodologies for evaluating resilience and availability of water supply and demand over 150-year period in the context of the GDF programme. Additionally considering changes in human behaviour in the UK, taking into account change in terrestrial and marine land use and evaluating potential mitigation options.

Expected outcomes of this PhD project will include:

- Examination of social and economic change during the construction and operation of the GDF and how this interacts with resource use.
- Applying and adapting future forecasting methodologies to estimate water use (and any relevant additional resources) in the context of the construction and operation of a GDF.

This project relates to S & T task:
B1.1.4 Site-Specific Research Needs Identification - Biosphere.

NWS Themes

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References

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5, Development of a geochemical analytical toolkit for constraining regional groundwater hydrodynamics in deep saline coastal systems

Discipline Area: Geoscience

NWS Subject Matter Expert(s): Niko Kampman

Summary

Understanding regional-scale groundwater hydrodynamics and flow rates, now and in the geological past, is critical for the evaluation of the containment function provided by the geology in a geological disposal facility (GDF). A range of techniques exist for the characterisation of groundwaters. Dating of groundwaters from clay-rich geologies, which can be considered as potential GDF host rocks, have typically relied on noble gas-based methods, such as 81-Krypton (e.g., Winter & Einsiedl, 2022), as decay of these atmospherically derived radioisotopes give an indication of recharge age. In UK geologies considered as potential hosts for an inshore GDF, such methods may not be applicable as deep saline groundwaters may be present and these can have a complex origin, comprising mixtures of meteoric waters, (paleo)seawater and/or basinal brines of widely varying ages (e.g., Milodowski et al., 2018). This project would investigate the development of an analytical toolkit comprising multiple isotopic tracers (e.g., Gardner et al., 2014) and dating methods to constrain the origins, residence times and regional hydrodynamics of saline groundwaters in coastal groundwater systems.

It is anticipated that the project would examine the use of novel isotopic chronometers such as uranium series isotopes (e.g., uranium, thorium, radium, radon) (e.g., Weinstein et al., 2021), halogen isotopes (e.g., chlorine, iodine) and/or radiogenic noble gases (krypton, neon, xenon etc), coupled with stable and/or radiogenic isotope tracers to better constrain the hydrodynamics of such systems. It is anticipated that this project would use groundwater (and rock samples) obtained from suitable analogue sites in the UK or elsewhere.

Background
This research is critical to the development of capability and the preparedness of analytical facilities required to support site-specific intrusive investigations and geosphere characterisation. This project would ensure that state-of-the-art tools are available, with suitably development methodologies, to support NWS in future intrusive investigations.

Research output will seek to better underpin the post-closure safety case and assess the potential impacts on GDF performance (isolation and containment of radionuclides). Potential findings may impact upon siting and design. If possible, work should seek to contextualise findings to NWS' ongoing programme, with Community Partnerships formed in both Cumbria and Lincolnshire spanning a range of geologies.

NWS Themes
5 – Pathways (includes Gas and Hydrogeology)
6 – Understanding the natural environment (includes geosphere and biosphere)

S&T plan links
- **B.5.5.7** Use of groundwater chemistry in GDF programmes
- **B.5.5.2.** Tools, Equipment and Techniques for Collecting and Using Groundwater Information to Support GDF Programmes

References
Gardner, P. M., & Heilweil, V. M. (2014). A multiple-tracer approach to understanding regional groundwater flow in the Snake Valley area of the eastern Great Basin, USA. Applied geochemistry, 45, 33-49.

Milodowski, A. E., Bath, A., & Norris, S. (2018). Palaeohydrogeology using geochemical, isotopic and mineralogical analyses: Salinity and redox evolution in a deep groundwater system through Quaternary glacial cycles. Applied geochemistry, 97, 40-60.

Weinstein, Y., Friedheim, O., Odintsov, L., Harlavan, Y., Nuriel, P., Lazar, B. and Burg, A., 2021. Using radium isotopes to constrain the age of saline groundwater, implications to seawater intrusion in aquifers. Journal of Hydrology, 598, p.126412.

Winter, T., & Einsiedl, F. (2022). Combining 14CDOC and 81Kr with hydrochemical data to identify recharge processes in the South German Molasse Basin. Journal of Hydrology, 612, 128020.

6, Steel corrosion and gas generation in high salinity groundwaters

Discipline Area: Materials

NWS Subject Matter Expert(s): Andy Cooke

Summary

The proposed research aims to provide insights and data on the anaerobic corrosion of steels and associated hydrogen gas generation under highly saline GDF conditions. The study will involve conducting laboratory experiments to simulate the long-term exposure of stainless and carbon steel when exposed up to (and potentially beyond) 200 g/L chloride concentrations. The study will target the acquisition of information on rates of acute corrosion, chronic corrosion, and gas generation under variable pH and oxygen availability. Additionally, the work should provide valuable insights to aid understanding of the longevity of stainless, carbon and mild steels exposed to such conditions. A final goal of the project is to demonstrate capability of undertaking studies of this nature at such high salinities. The findings of this research may have significant implications to the GDF safety case and, consequently, for GDF design decisions relating to the selection of waste container and infrastructure materials.

Background

Steel will be present throughout the GDF, comprising part of the waste and potentially being employed as a container material, as part of the mechanical support system or in other areas of infrastructure. The corrosion of steel can impact material longevity and can reduce void spaces or impart stresses on the system due to the precipitation of corrosion products. Additionally, steels are an important source of hydrogen when undergoing corrosion under the anaerobic conditions that are expected to develop in a GDF post-closure.

Because of the extensive use of steels in the GDF system, it is important to the GDF safety case that steel corrosion rates, corrosion products and resulting gas generation rates are understood. This understanding is required to underpin assessments of the disposability of proposed waste packages and wider GDF design choices. Key areas which may be directly impacted by this data will include assessments of radionuclide environmental release, post-closure criticality safety assessments, repository engineered design, operational safety assessments and the long term stability of the post closure safety system. The need to understand steel corrosion in UK specific groundwaters is noted in various areas of the S&T plan under numerous tasks within

- B8 WBS 90 - Waste Container Evolution
- WBS 40.2 - Development of generic knowledge base on gas generation

The aqueous corrosion rates of stainless, mild and carbon steels have been well documented under a range of environmental conditions relevant to the GDF. However, there is little data at chloride concentration exceeding that of seawater, representing a key knowledge gap to be investigated by this project. This is particularly pertinent for the UK's GDF programme given that deep sedimentary basins are currently under consideration for siting the GDF, which may comprise hypersaline groundwaters (potentially exceeding 200 g/L chloride).

NWS Themes

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References

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7, Development of methodologies to undertake spent fuel leaching in challenging groundwaters

Discipline Area: Materials Science

NWS Subject Matter Expert(s): Rosie Hibberd

Summary

To develop leaching and analytical methodologies to allow leaching experiments to be performed on SIMFUELS in a range of challenging groundwaters. These should include high ionic strength and high salinity groundwaters, which often prove challenging to maintain and analyse.

In the first instance the methods should allow leach rates for SIMFUELS to be determined under the conditions. However, the delivery of improved mechanistic understanding and the development of experimental methodologies under these conditions would also be valuable.

Background

A number of the potential sites being investigated by NWS are expected to have high ionic strength groundwaters. These groundwater solutions often pose challenges when utilised in experiments.

The aim of this PhD project is to develop methods to allow leaching studies to be performed on SIMFUELs. However, the methods developed should be applicable to spent fuels and other high heat waste forms as well, reducing the lead times associated with method development for undertaking these experiments.

The work aligns with S&T plan activity B10.4.2 (Further Work on SimFuel to Understand Dissolution Behaviour of Spent Fuel). A successful outcome will provide the methodology needed to support a wide range of future leaching studies. These future studies will aim to determine leach rates in UK relevant GDF conditions for spent fuel and other High Heat Generating Wastes. The availability of this data will be fundamental to determining the major source terms for radiological release from the GDF used in assessments of GDF risks.

This PhD will also train a student in skills which will be of significant use in this area in the future.

NWS Themes

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References

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8, Long lived radionuclide retention in the alteration products formed from HLW glass dissolution

Discipline Area: Materials

NWS Subject Matter Expert(s): Jon Martin & Neil Hyatt

Summary

Aim: to reduce the uncertainty in radionuclide retention and immobilisation within the alteration products formed from HLW glass dissolution.

Objectives:

- To produce and characterise the alteration products of UK HLW glass dissolution.
- To determine the retention and immobilisation of long lived radionuclides in alteration products.
- To establish a conceptual understanding of the retention and immobilisation mechanisms.

Outcome: arguments and evidence to support claims of safety for retention and immobilisation of long lived radionuclides in HLW glass alteration products.

Background

Understanding the mechanisms of HLW glass dissolution, and release of radionuclides to the groundwater pathway, has been the focus of a considerable research. However, much less attention has been directed to understanding the potential for alteration products of HLW glass corrosion to retain or immobilise long lived radionuclides. It is understood that the distinctive chemistry of UK HLW glass affords alteration products that are dissimilar in comparison to international counterparts; this may be an opportunity or risk in terms of selectivity and capacity to retain or immobilise long lived radionuclides. The project will address this opportunity and risk through an integrated experimental and modelling investigation, that will determine, characterise and understand the mechanisms of formation of alteration products arising from the dissolution of simulant UK HLW glass compositions. As a stretch target, the contribution of container corrosion products may also be considered. The key drivers for the research (S&T Plan WBS 110.2) are to underpin waste packaging solutions, disposal concept design, and the disposal system safety case.
The outcome of this work will be to develop the safety case for disposal of HLW glass by reducing the uncertainty in the retention and immobilisation of long lived radionuclides in HLW glass alteration products, through provision of arguments and evidence.

NWS Themes

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References

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9, Brines Behaving Badly? Constraining Radionuclide Behaviour in Analytically Challenging, Highly Saline Solutions

Discipline Area: Radiochemistry

NWS Subject Matter Expert(s): Will Bower

Summary

A Geological Disposal Facility (GDF) will isolate the UK's higher activity radioactive wastes deep underground, inside a suitable rock volume to ensure that no harmful quantities of radioactivity ever reach the surface environment.

A process of volunteerism is currently ongoing in England and Wales to locate a suitable site and willing community to host a GDF, with four community partnerships currently at the early stages of discussions. All four of these communities offer potential host rocks characterised by clay and/or interbedded mudstone/evaporite units, with groundwaters of moderate to extreme salinity.

Overall Aim:
This project will develop novel techniques and approaches to measuring radionuclide and/or chemotoxic behaviour in analytically challenging, highly saline groundwaters, and provide datasets to bolster the environmental safety case for a GDF in a saline setting, comparing the behaviour of key species in saline vs non-saline systems.

Given the highly site-specific nature of chemical species under different groundwater compositions, it is anticipated that, in future, significant radiochemical testing will be required to underpin any site-specific environmental safety case. Ahead of this, several key aspects of radionuclide and chemotoxic behaviour require development of underpinning understanding:

- Radionuclide/chemotoxic solubility in saline groundwaters.
- Radionuclide/chemotoxic speciation in saline groundwaters.
- Rock/mineral sorption and/or competition effects for radionuclides and chemotoxics in brines.

'Traditional' wet-chemical analytical techniques and approaches for measuring speciation and concentration of dissolved species are challenged by the increased ionic strength of hypersaline groundwaters. Mass spectrometry, colourimetry, and standard probe-measurements (e.g. pH, Eh) all suffer from interferences associated with ionic strength, and such techniques often require impractical dilution factors.
As such, a submission under this topic should seek to address one or several of the following questions, via either experimentation or modelling:

- Can robust radiochemical/radiometric techniques be developed that permit the measurement of radionuclide solubility and or uptake to geological media in brines?
- Can radionuclide (or analogue) and chemotoxic element solubility/speciation in brines be effectively investigated using advanced analytical techniques (for example, X-ray spectroscopy, neutron spectroscopy, Nuclear Magnetic Resonance (NMR) spectroscopy, etc)?
- What are the ionic strength limits of conventional colorimetric wet chemical techniques for radionuclide and chemotoxic elements?
- Does the speciation of key safety-relevant radionuclides and chemotoxic elements in variant brine chemistries differ substantially from more dilute groundwater conditions? Are there implications for mobility and fate of these species?
- Does the presence of brines limit the sorption potential of the host rock for radionuclides and chemotoxic elements?
- Can any conservatisms be reduced given the limited solubility of some radionuclides and chemotoxics in brines?
- How applicable are existing thermodynamic datasets (i.e. Pitzer datasets) for representing solubility and speciation of radionuclides and chemotoxic elements in brines?

A mechanistic understanding of radionuclide behaviour under variant groundwater salinities will provide essential underpinning information for the environmental safety case, both in terms of capability building ahead of site-specific investigations, as well as providing analogue data against which to baseline current global understanding of radionuclide behaviour in saline groundwaters.

Objectives:

Development of innovative techniques and approaches for examining post-closure radionuclide behaviour in future site-specific samples from saline environments.

Examination of radionuclide (or analogue) solubility in highly saline UK-relevant LSSR groundwaters to underpin development of predictive modelling.

Examination of radionuclide (or analogue) transport/retardation in the context of variant salinities/salinity evolution along transport pathways in LSSR.

NWS encourages a range of relevant strongly or weakly sorbing long-lived radionuclides and/or non-radiological species/analogues to be considered in this study (see Geological Disposal: Behaviour of Radionuclides and Non-Radiological Species in Groundwater | RWM Tools (nda.gov.uk))

Background

Variable/hyper-salinity is a key characteristic of many UK Lower Strength Sedimentary Rock groundwaters, and a better understanding of radionuclide and chemotoxic behaviour in high ionic strength systems is required to inform a future environmental safety case.
It is acknowledged that the geochemical and radiochemical analysis of brines is challenging. Once site-characterisation studies commence, NWS will need to be in a position to perform laboratory-scale studies to understand radionuclide behaviour along the groundwater pathway, which will contain chemical perturbations and gradients influenced by the local geology, as well as near-field geochemical evolution processes. This project will help to underpin an environmental safety case by developing methodologies to analyse key radionuclide species in brines, improving understanding of the behaviour of radionuclides in brines, understand brine-rock interactions of relevance for radionuclide retention, and anticipate knowledge gaps upon transition to site-specific research. An analytical and technique-development project, the scope is intended to aid NWS in methodology and capability development for site specific radionuclide behaviour parameters, testing novel approaches for environmental radiochemistry in chemically challenging environments.

NWS Themes

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References

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10, Conceptualising the Underground

Discipline Area: Social Science

NWS Subject Matter Expert(s): Tracy Badham

Summary

A geological disposal facility (GDF) for radioactive waste would be built between 200 and 1,000m underground on land or up to 20km off the coast under the seabed. Community engagement is fundamental to the siting process and there is a clear need for NWS to gain understanding of how individuals or groups conceive of the underground in relation to wider environmental relations and engineered structures.

A key benefit of geological disposal is the promise of definitive removal of hazardous materials from the surface environment. However, human beings have long built powerful material and imaginary connections to the underground - through mining endeavours, transport systems, exploratory adventures and works of creative expression. This call is for research proposals that focus on how people connect to the underground, on what they consider to be important about these, often inaccessible sites, and on how they conceptualise the possibilities of transformative engineered intrusion.

Background
UK government policy related to the siting of a geological disposal facility (GDF) requires both a suitable geology and a willing community. A GDF will be located between 200 and 1,000m underground. It could be constructed under land or under the seabed. Multiple engineered barriers will be designed to contain radioactive materials, and thus isolate them from the surface. Human beings have long been fascinated by the underground as a space of scientific exploration, imaginative engagement and artistic expression. The underground for some is both mysterious and powerful - it holds threats and possibilities. It has long associations with extraction (of minerals, coal, oil and gas). Today by contrast, the sub-surface is increasingly in demand as a space for places of work, leisure and transport as well as storage, for example of hydrogen, for carbon-capture, or the disposal of radioactive wastes.

NWS would like to learn more about the diverse ways in which people consider and relate to the underground environment in their area. How do people connect the ground of their daily lives to the deep underground? Who cares about the underground and why? Is the underground considered at all, and if so what influences attitudes towards the possibilities and the limitations of human intervention into the sub-surface? Do areas with long histories of mining have specific understandings of the underground and are these passed on to younger generations who no longer work below ground? Does the deep sub-surface promise protection or provoke anxieties? In what ways does the type, size, location, form or function of subterranean engineering influence people's ideas about living and working in proximity to a GDF.

The research could draw on archival or contemporary empirical research. Projects could, for example, involve museum professionals and/or community-led research initiatives if appropriate.

NWS Themes
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References
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11, Community Connectedness and Decision Making

Discipline Area: Social Science

NWS Subject Matter Expert(s): Tracy Badham

Summary
A positive commitment from a willing community is a necessary condition for the construction and operation of the UKs geological disposal facility (GDF). NWS needs to build strong relationships of trust across heterogeneous communities, where there is not necessarily a shared sense of belonging, or a common sense of what it means for a community to thrive. NWS is interested in learning about what underpins effective community cohesion, how different elements of a community intersect and how constraints to community cohesion, such as social inequality, are overcome.

This call is for proposals to help understand how, for example, physical, digital and socio-economic infrastructures enable community formation, and provide the grounds for collective decision making. What social/community infrastructures underpin the formation of social bonds and what undermines those possibilities? What activities bring people together? Where do people get together? How do people share information and take decisions on specific issues of concern? Does the construction of an economic infrastructure enhance local decision making, community participation and social networks?

Background

UK government policy related to the siting of a geological disposal facility (GDF) requires both a suitable geology and a willing community. As the developer of a GDF, NWS needs to engage with the communities that are participating in the siting process. Policy requires that Community Partnerships are established in an area to facilitate dialogue and decision making. Members of the Partnership should be reflective of the community and will include NWS and local councils.

NWS would like to understand how heterogeneous communities can become effective and inclusive decision-making bodies. It is looking for research that will focus on what might constrain the capacity of communities to form and/ or consider their potential to act as problem-solving entities. The focus could be on the physical, digital and socio-economic infrastructures of communities and the embedded social inequalities & exclusions that deter participation.

The research could consider how different elements of the community are structured and intersect - perhaps as a series of networks of influence embedded in places of education, employment or other sites that foster cultural, social or religious ties? What are the fundamental infrastructural supports on which these networks depend - physical, digital, social and cultural? What undermines community cohesion - for example through indifference to the issues at hand, disconnections between community actors and across generations?

NWS Themes

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References

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