2023_11_DCEE_Butler: Modelling groundwater flow in deep, heterolithic sedimentary sequences under climate change

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The Mercia Mudstone Group (MMG) is an under researched but increasingly important geological formation. It outcrops over areas of the proposed route for HS2. More specifically, it is a potential host rock for an underground Geological Disposal Facility for the permanent disposal of radioactive material. Therefore, understanding of groundwater flow and the potential behaviour of radionuclides in this rock formation is vital for assessing risks associated with its use. The PhD, supported by Nuclear Waste Services, is to develop a hydrogeological model of the MMG and adjacent rocks in the North East Irish Sea Basin (NEISB) based on a conceptual 3D geological model underpinned with field and lab data to explore controls on groundwater flow and the effects of data uncertainty in the context of current and near future climates. As this is a substantial task, the supervision team has planned a detailed work programme. The PhD will comprise three distinct but complementary work packages: 1) Data collection, supported by some laboratory investigations; 2) Development of a conceptual 3D stratigraphic ground model; 3) Exploratory 3D groundwater flow model to assess the controls and groundwater flow in the context of radionuclide movement.

WP1) Data collection: Limited information is available on the stratigraphic, structural, geomechanical and hydrogeological evolution of the NEISB [1]. Therefore, a detailed collation of data at BGS and from previous studies will be conducted. The database will be a compilation of available parameters of rock properties, in particular porosity, compressibility, hydraulic conductivity and water quality. Many of these values will be determined from analogue sites.

WP2) 3D Geological modelling: The database derived from WP1 will be used to develop a conceptual 3D geological ground model of the MMG [2] and surrounding formations within the NEISB using the geological modelling tool, LeapFrog. The output from this work will be a set of stratigraphic and structural surfaces defining the 3D geological geometry of the basin and their uncertainties due to insufficient data.

WP3) Hydrogeological modelling: Groundwater flow pathways in the MMG and associated rock formations in the NEISB will be simulated using a state-of-the-art numerical transport model, the IC-FERST [3]. This has a parallelised 3D adaptive mesh solver, which makes it highly computationally efficient, and geological surfaces can be readily imported into the model. Simulations will be run under current and near future climates.

The project will make a significant contribution to improving our understanding of the hydrogelogy of the MMG and provide comprehensive training in hydrogeology and groundwater modelling for the successful applicant.

References:
[3] www.imperial.ac.uk/earth-science/research/research-groups/norms/software/ic-ferst/

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