Structural modelling of possible contaminant pathways below nuclear installations

[1]**Richard Haslam**, [1]*Stuart Clarke*, [1]*Peter Styles* & [2]*Clive Auton*

[1]Earth Sciences and Geography, School of Physical and Geographical Sciences, Keele University, Keele, Staffordshire, ST5 5BG, United Kingdom
[2]British Geological Survey, Murchison House, West Mains Road, Edinburgh, EH9 3LA, United Kingdom

Dounreay Nuclear Power station is situated in northern Caithness, Scotland on complex normally faulted Devonian sedimentary rocks with a thin, intermittent cover of superficial deposits comprising predominantly glacial tills of varying provenance.

Bedrock structure, fracture patterns and the relationships between bedrock and the overlying superficial deposits can have a considerable impact on the transmissivity of any possible contaminants. An understanding of how the bedrock-superficial boundary and the nature of how fractures and faults influence and control the transport of fluids are of key concern. The principal aims of this work are to gain an understanding of the processes and controls on fluid flow pathways within such complex geological terrains, and develop methods of stochastatically evaluating likely contamination transport within the subsurface.

This work focuses on the near surface bedrock geology and superficial deposits. The near surface geology of the Dounreay site comprises cyclic sequences of lacustrine rocks; their cyclicity has enabled a reference stratigraphy to be created and correlated across the site. This stratigraphy, the coastal exposure and the extensive amount of borehole data available, provide a unique opportunity to construct and constrain a three-dimensional bedrock model; the interpretive element of which has been robustly test using structural restoration techniques.

In the bedrock of Dounreay, three principle fracture sets have been identified previously. The first set trends roughly parallel to the faults and may have formed during early stages of faulting. The second set trends perpendicular to the first and probably formed during the active stage of faulting. The final set of fractures is bedding parallel and, related to unloading. This set appears to have the strongest control on subsurface fluid flow across the site and distinctive iron staining on the fracture surfaces can be observed. Fracture indices and RQD values have been determined from borehole data and interpolated across the extent of the bedrock model. This shows a clear relationship between fracture intensity and depth, and also to different lacustrine facies, as well as the proximity to faults. These relationships can be utilized stochastically to investigate dominant fluid transport pathways and directions within the bedrock.

The weathered bedrock zone, and the nature of its relationship to the fresh bedrock and superficial deposits is critical, as this zone may act as the primary conduit for the flow of shallow groundwater and contaminants. Current geological interpretations of the superficial deposits are based on their genesis. Consequently, subdivisions based on the origin of the sediments do not relate directly to their fluid transmissivity, the bedrock model, or the nature of the weathered zone. Current and future work is aimed at modeling the nature of the superficial deposits and the weathered zone as a function of their fluid transmissivity. This will enable stochastic prediction of likely fluid transport pathways within them, and of the interaction between these near surface pathways and those within the unweathered bedrock.

The research will provide a framework from which likely contamination scenarios can be modelled, both in the well-constrained subsurface of Dounreay, and at other nuclear installations where the nature of the subsurface is less well constrained.