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Digital outcrop characterisation and fracture modelling for a GDF in a crystalline basement.

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Plans to dispose of the UK's legacy nuclear waste in a Geological Disposal Facility (GDF) depend heavily on the geological suitability of the host bedrock. Characterising the geology at the proposed depth of the GDF (500 m to 1 km) is a major challenge facing the industry. Clastic surface outcrop analogues are used in the hydrocarbon industry to characterise potential reservoirs that do not outcrop at the surface. The same approach has, to our knowledge, never been applied to crystalline rocks: one of the proposed settings for a GDF. This project utilises terrestrial lidar scanning to create 3D Digital Outcrop Models (DOM's) of geological exposures which form part of the Borrowdale Volcanic Group (BVG) exposed in several localities around the Lake District of the UK. The BVG is a laterally extensive, highly heterogeneous 6 km thick unit, comprising mainly igneous rocks with associated sedimentary and metamorphic rocks. The rocks, which have a complex tectonic history, were formed by explosive caldera-type eruptions in the Late Ordovician (Caradoc) period, and include lavas, ignimbrites, sills and dykes.

Using the lidar data collected with a Riegl LMS-Z420i terrestrial laser scanner, a DOM has been constructed and the fracture distributions mapped using a combination of manual and automated approaches. The resulting fracture data are analysed to give statistical information on fracture dimension, distribution and spacing. Stochastically generated Discrete Fracture Networks (DFN's) have then been modelled from these fractures statistical data. Uncertainties in the data include biases due to exposure orientation and extent, resolution of lidar data and whether fractures are open or closed at depth (which may be estimated from the current stress regime). Multiple realisations of the DFN are generated to help take into account uncertainty in the fracture-derived statistics. The DFN is then used to calculate porosity and permeability values for the fracture network, which in conjunction with matrix porosity and permeability values form the basis for flow simulation of groundwater fluids through these rocks.

Linking these outcrop derived datasets with regional data from elevation models, satellite images and geological maps form the ideal basis for an updated regional fluid flow model for the BVG, including where it occurs at depth. The highly visual nature of these data is also valuable when presenting data to local communities involved in the site selection process.