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Quantitative Geothermal Interpretation of an Electrical Resistivty Model of the Rathlin Basin, Northern Ireland

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In the evaluation of low– to medium–enthalpy geothermal resources in Ireland, some of the most interesting targets are the deep sedimentary basins in Northern Ireland. The deepest of these is the Rathlin Basin, where Permian and Triassic reservoir sediments are known to exist to at least 2300 m depth. Two deep boreholes within the basin provide evidence of elevated temperatures at depth that are atypical within Ireland, prompting further geophysical exploration of the basin as one component of the IRETHERM project. The magnetotelluric (MT) method was selected as it is capable of locating electrically conductive porous sediments beneath overlying resistive strata, in this case flood basalt sequences. MT data were acquired on a rectangular grid of 39 sites across a third of the onshore portion of the basin to investigate its lithological characteristics and spatial variation.

One-dimensional resistivity models that reproduce the observed MT data were obtained by inversion at each acquisition site, revealing that the sediments of interest lie beneath a mudstone layer of even lower conductivity. As a result of the shielding effect of the overlying mudstone layer, it is both difficult and unreliable to interpret the deeper target sediments based solely upon modelled resistivity. An automatic scheme of interpreting sub-horizontal resistivity layers was developed and applied to facilitate imaging and analysis of the model. Although not a general approach, the boundary identification method functioned well for the 1D MT models within the research area when compared to borehole records, and a conservative reservoir volume of approx. 56 km^3 of combined Permian and Triassic sandstones was estimated to be present beneath the MT survey.

Based upon new, high quality temperature data available in the Ballinlea 1 borehole, an approximate estimation of thermal energy in place as a function of final reservoir temperature has been performed for the interpretable MT resistivity model volume, over a range of final reservoir temperatures from 85 to 25 $^\circ$ C. The resulting best case of a final temperature of 25 $^\circ$ C results in an estimated Indicated Geothermal Reserve (IGR) of 6.1×10^{18} J beneath the MT survey area. The resulting estimates suggest that exploitation of the maximum volume of sediments would occur for a final temperature of $\approx$50 $^\circ$ C.