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IRETHERM: Multidimensional geophysical modeling of the southern margin of the Dublin Basin

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Multi-dimensional magnetotelluric (MT) modelling of data from the Newcastle area west of Dublin, acquired as part of the geothermal potential of Ireland (IRETHERM) project, is presented. The Newcastle area, situated on the southern margin of the Carboniferous Dublin Basin, exhibits elevated geothermal gradient (>30 ˚C/km) in the exploratory boreholes drilled by GT Energy.

The MT soundings were carried out in the highly urbanized Dublin suburb and are heavily noise-contaminated and distorted due to EM noise from nearby industry and the DC tram system (LUAS). We obtained reliable and interpretable MT impedance and geomagnetic transfer functions at most sites by processing the "quietest" 4-hour night time subsets of data using several robust codes and the ELICIT method.

Tensor decomposition was applied at each site to ascertain if the data are suitable for 2-D modelling and to determine the appropriate geoelectric strike direction. The obtained 2-D models underwent examination using a new stability technique, and the final two 2-D profiles with reliability estimations, expressed through conductance and resistivity, were derived.

3-D models, including all usable MT data in the Newcastle area, have also been determined with and without resistivity constrains for shallow structures from resistivity measurements in one of the boreholes (borehole NGE1). The 3-D models exhibit structures with higher conductivity in comparison to the 2-D models, with similarly resistive background rocks. The shallow conductive structures, to a depth of 1 km, have north-south elongations correlated with the surface traces of faults that are perpendicular to the regional Blackrock to Newcastle Fault (BNF). Deeper structures become more oriented to a regional geoelectric strike similar to 2-D regional strike.

To obtain superior characterization of the thermal transport properties of the investigated area, we used porosity and resistivity data from borehole NGE1 to estimate relation between porosity/permeability and electrical conductivity. The formulae are based on a generalized Archie's law for multiple phases. Due to the poor quality of porosity data from the borehole, we used these values as a maximum boundary in the input porosity data for estimation of the relation.

The 2-D and 3-D modeling reveal that the BNF is imaged as a conductive zone to depths of 4 km, and is likely highly fractured. Generally, the area south of the BNF is more resistive and compact, with a horizontal conductive layer at approximately 1 km depth and with a very thin surficial sedimentary layer. In contrast, the structures north of the BNF are more heterogeneous, with deeper conductive layers (2-3 km depth) and thicker (several hundred meters) sedimentary layers above.

The deeper conductive layers are interpreted as water bearing or geothermal fluids and estimated porosity and permeability indicates potential to deliver warm water to the surface.