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IRETHERM: Research and Exploration Challenges in Assessing Ireland's Deep Low-Enthalpy Geothermal Energy Potential

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IRETHERM (www.iretherm.ie) is a new academic-government-industry collaborative research project, funded by Science Foundation Ireland, initiated in 2011, with the overarching objective of developing a holistic understanding of Ireland's low-enthalpy geothermal energy potential through integrated modelling of new and existing geophysical and geological data. All historic geothermal energy research that took place in the 1980s focused on Ireland's three major exposed radiogenic granite intrusions. These granites were found to be characterised by elevated radiogenic heat production (2–7μW/m3) and surface heat-flow (65–85mW/m2), but impetus in assessing their potential stalled at the end of the oil-crisis and remains poorly defined. The accuracy of predictions of temperatures in the depth range of 3000–6000m is limited by the sparse, clustered database provided by relatively shallow industry boreholes – only two boreholes drilled to date exceed 2,500m. While a significant regional trend in surface heat-flow is purported from these borehole data, from $\sim$40mW/m2 in the south of Ireland to >80mW/m2 in the north with thermal gradients in the range 8–32°C/km, the source of the heat variation (whether crustal and/or lithospheric-mantle in origin) is unknown. Except for Permo-Triassic basins in Northern Ireland, which host known geothermal aquifers of promising but currently poorly defined potential, sedimentary rocks with high primary porosity have not been identified elsewhere. Whether any of the shear zones and faults that traverse the country might host geothermal aquifers at depth is also unknown, although the occurrence of warm-spring clusters close to two major fault zones is promising.

Our paper discusses the approaches and strategies that IRETHERM has adopted to meet the challenges of exploring for unknown deep geothermal resources (either aquifers or hot, dry rock) starting from a limited knowledge-base. The objectives of the project over a four-year period are to:
(i) Develop multi-parameter geophysical modelling and interpretation software tools that will enhance our ability to explore for and assess deep aquifers and granitic intrusions.
(ii) Model and understand temperature variations in the upper-crust. Firstly, by building a 3-D model of crustal heat-production based on geochemical analysis of surface, borehole and mid- to lower-crustal xenolith samples. Secondly, by modelling, using a fully self-consistent 3-D approach, observed surface heat-flow variation as a function of variation in the structure and thermal properties of the crust and lithosphere, additionally constrained by surface elevation, geoid and gravity data.
(iii) Test a strategic set of eight "type" geothermal targets with a systematic program of electromagnetic surveys (MT, CSEM) across ten target areas.

As the first product of our research, we present results from two recent magnetotelluric surveys in Northern Ireland, one over the Permo-Triassic Lough Neagh Basin with geothermal aquifer potential (known porosities and permeabilities of 8-24% and 2-1000mD respectively in the Sherwood Sandstone Formation) and the other over the Palaeogene radiogenic (4-7μW/m3) Mournes Granite offering hot, dry rock potential. We assess the geothermal potential of the targets themselves and discuss the limitations of the modelling approaches we have used and the future enhancements necessary to improve our ability to characterise these resources.