Deep geothermal resources of Ireland: Implications from the Tellus and Tellus Border projects

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The Tellus Border project is a European Union INTERREG IVA funded mapping project that will collect scientific data on soils, waters and rocks across the six border counties of Ireland (Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth) and integrate these with existing data collected in Northern Ireland as part of the Tellus project. The project is led by the Geological Survey of Northern Ireland, in conjunction with project partners the Geological Survey of Ireland, the Queen's University Belfast and Dundalk Institute of Technology. Mapping will be completed through two operations which began in 2011 – a ground-based geochemical survey and an airborne geophysical survey. These surveys will provide regional and catchment-scale data which will inform environmental management and support sustainable development of our natural resources, including geothermal energy.

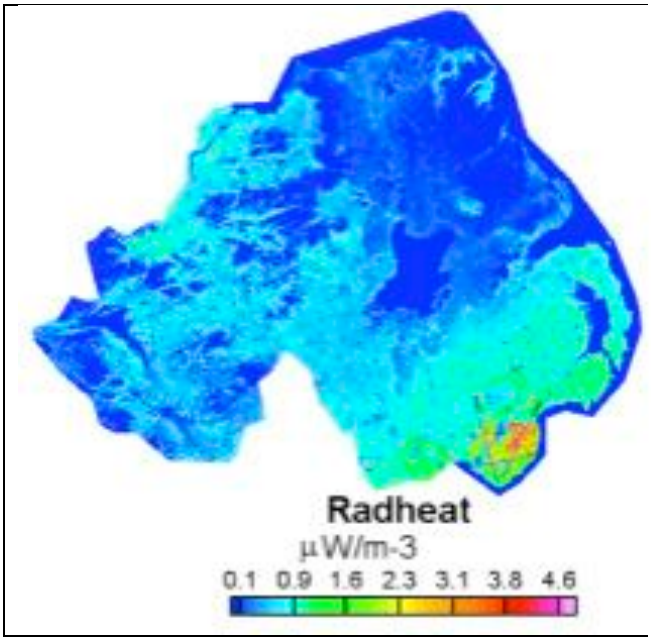

Fig. 1. Tellus radiogenic heat map, with radiogenic heat measured in microwatts per cubic metre.

The Tellus Border project extends the work of the award-winning Tellus surveys in Northern Ireland which occurred in 2004-2007 and 2007-2010. Geophysical data from the Tellus project has been used to help identify suitable areas for Enhanced Geothermal Systems (EGS) in Northern Ireland. EGS use hot dry rock with a high heat-producing capacity to heat up fluids when injected into an artificial reservoir. The Tellus radiometric data shows that three radionuclides (K, Th, and U) have relatively elevated concentrations in the Mourne Mountains, Co. Down (Fig. 1). High concentrations of radiogenic heat due to the decay of these radionuclides, together with relatively high surface heat flow observations, indicate that this region is a good target for EGS geothermal exploration. The thermal heat production of near surface material and deeper rocks can be calculated from radioelement K, U and Th data. Calculated radiogenic heat was found to be localised around the Mourne Granitic Complex (Fig. 1).

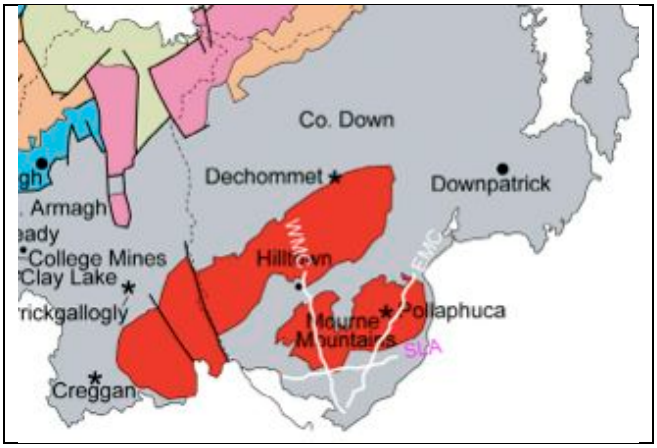

Fig. 2. MT profiles overlain by geological map of the survey area

To ascertain the geothermal energy potential of this high radiogenic heat source area, further investigations were undertaken to characterise the depth, volume and geometry of the deep granitic complex. A magnetotelluric (MT) survey was undertaken from July to August 2010 in collaboration with Dublin Institute for Advanced Studies. Three profiles, across the Eastern Magmatic Centre (EMC), the Western Magmatic Centre (WMC) and from Slieveban to Annalong (SLA), were surveyed (indicated in Figure 2). These lines, totalling 56 line kms, used 20, 19 and 14 MT soundings respectively, spaced at approximately 1 km intervals along the profiles.

The MT data was modelled to produce a cross-section through the Mourne Granite Complex highlighting variations in different resistivity values that correspond to different rock types and structures. A 2D model of profile EMC (Fig. 3) shows a near- vertical resistor (R1) at the northern most extent of the profile interpreted as part of the eastern granite. The depth of this resistive body reaches 10km, and additional soundings are required to help further constrain the extent of this body to the north-east. The vertical

nature of this granite body may indicate a steep wall contact, commonly associated with cauldron subsidence models. This would be consistent with the granite being emplaced as a series of magmatic pulses intruded into the space created by subsidence of the country rock, bounded by outward dipping ring fractures. The close proximity of a similarly vertical conductor (C1), observed between R1 and the main granite body R2, may be due to a fault zone or to a concealed slab of the Silurian greywacke and slate country rock squeezed between granitic pulses.

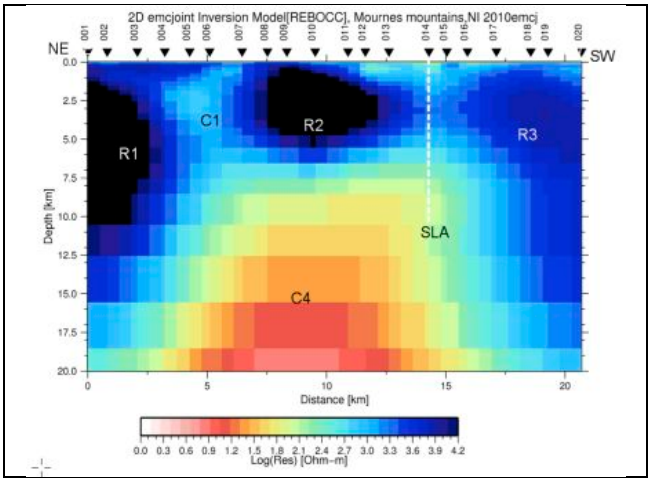

Fig. 3. 2D model along Profile EMC, Mourne Granitic Complex

The model delineates a large central resistor (R2) which has a similar cross-sectional length to the granite at the surface. It is interpreted that R2 is a granitic body corresponding to the eastern magmatic centre and extending to a depth of approximately 7 km. It may be possible through further petrological and petrophysical analysis to distinguish between the different granite facies in this block as part of a layered intrusion. At the southern end of the model, resistor (R3) is less resistive than R1 and R2, and may represent a magmatic feeder zone of either granitic or more mafic affinity (if the former, a very good geothermal energy target) or could be due to consolidated country rock. Additional MT and gravity modelling work is planned and required to better define the geologic origin of R3 and its geothermal potential.

Geologic interpretation of the underlying conductor C4 at depth is less clear and will require further consideration. Possible explanations include the presence of a ductile shear zone, brine-rich rock/saline water, alteration of ultramafic rocks (serpentinization) or sulphide or graphite mineralisation relating to the Mournes magmatism. Further characterisation of the volume of the Mourne granites will help in our understanding of the geothermal energy resource and influence future methods of energy exploitation.

It is anticipated that the extension of the Tellus survey into the 6 northern counties of the Republic of Ireland under the Tellus Border project will identify similar areas of deep geothermal potential. In particular granitic bodies in the Cooley Mountains, Co. Louth; the Ox Mountains, Co. Sligo and the Donegal granites as well as hidden buried bodies can be explored and assessed using data collected during the project. The Tellus Border airborne geophysical survey commenced in October 2011 and will continue into spring /summer 2012. The aircraft, which flies at 60m altitude, carries three geophysical instruments – a magnetometer, gamma ray detector and electromagnetic coils (Fig. 4). Resulting data will be interpreted and integrated with Northern Irish data to produce a suite of regional geophysical maps. Maps and data will be made freely available to all interested stakeholders including researchers, local authorities, planners, policy makers, landowners and the general public in 2013. Project updates, including the latest flight schedules and survey progress, are available at www.tellusborder.eu

The Tellus Border project is funded by the INTERREG IVA programme of the European Regional Development Fund, which is managed in Ireland and Northern Ireland by the Special European Programmes Body (SEUPB). The project is co-funded by the Department of Environment (NI) and the Department of the Environment, Community and Local Government (RoI).

Fig. 4. The Tellus Border survey aircraft equipped with geophysical instrumentation.