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Basin characterisation by means of joint inversion of electromagnetic geophysical data: A case study from the Loop Head Peninsula, western Ireland, and the implications for onshore carbon sequestration

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The Science Foundation Ireland funded IRECCSEM project (www.ireccsem.ie) aims to evaluate Ireland's potential for onshore carbon sequestration in saline aquifers by integrating new electromagnetic geophysical data with existing geophysical and geological data. The main goal of this investigation is to characterise the subsurface beneath the Loop Head Peninsula (part of the Clare Basin, Co. Clare, Ireland) and in particular to identify the main geoelectrical structures that can guide an interpretation of the carbon sequestration potential of this area.

During the summer of 2014, a magnetotelluric (MT) survey was carried out on the Loop Head Peninsula. Data from a total of 140 sites were acquired, including audio-magnetotelluric (AMT), broadband magnetotelluric (BBMT) and long period magnetotelluric (LMT) data. The dataset was used to generate four shallow three-dimensional (3-D) electrical resistivity models to constrain the subsurface to depths of up to 3 km, and an additional deep study to constrain the electrical resistivity values to depths of up to 30 km. Three-dimensional (3-D) joint inversion process was performed using three different types of electromagnetic data to improve the resolution of the electrical resistivity models: MT impedance tensor (Z), geomagnetic transfer functions (T) and inter-station horizontal magnetic transfer-functions (H).

The interpretations of the resulting models were based on the geoelectrical results and compared with independent geological and geophysical data for a high-quality interpretation (i.e. deep borehole data from the peninsula, 2-D seismic reflection profiles, gravity data and geological structural information). Second-derivative models of the resulting MT models were used to define the main interfaces between the geoelectrical structures, facilitating superior comparison with geological and seismic results, and also reducing the influence of the colour scale on the interpretation of the results. Specific analysis was carried out to compare the extant borehole data with the electrical reistivity properties of the MT model; this identified those structures that are better characterised by the MT model, thus producing a more robust interpretation of the obtained results. Finally, the results were used; (1) to evaluate the potential of the area for carbon sequestration, (2) to improve our understanding of the geological and geodynamic processes of the area, and (3) to define the main geological units in the subsurface by their characteristic geoelectrical properties.