Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

Geosolutions Leeds

Subsurface Characterization of Lower Carboniferous Limestones for Geothermal Use in the UK

Mohamed Gouiza[1]*, Dave Healy[1], Nick Shaw[1]
Geosolutions Leeds, School of Earth, Environment and Sustainability, University Of Leeds, United Kingdom

UNIVERSITY OF LEEDS

INTRODUCTION

The Lower Carboniferous Limestones (LCL) represent a promising deep geothermal target in the UK, owing to their regional extent, burial depth, and fracture-controlled permeability (Jones et al., 2023). How-ever, uncertainty in mapping their thickness and continuity at depth—primarily due to sparse well penetration and seismic resolution—remains one of the key challenges for geothermal reservoir characterisation.

This study presents an integrated geophysical workflow (Fig. 1) to better constrain the depth, geometry, and structural framework of the ECL. Legacy 3D seismic reflection and borehole data from the Gainsborough Basin (Fig. 2) were used to map key stratigraphic horizons (Fig. 3) and derive depth-dependent density trends (Tab. 1) for the main lithostratigraphic units. These inputs were incorporated into a 3D voxel-based geological model of the subsurface and used to perform gravity modelling (Figs 4 & 5). We then explored edge detection techniques to further refine the structural architecture (Figs 6 & 7).

Our results show that gravity modelling provides valuable constraints in areas where seismic or well data are limited, improving confidence in the geometry of the LCL aquifer. Magnetic derivatives and Euler methods were helpful for identifying faults and fracture zones. This work highlights the value of integrated geophysical approach in reducing subsurface uncertainty and enhancing geothermal resource evaluation in the UK.

METHODS

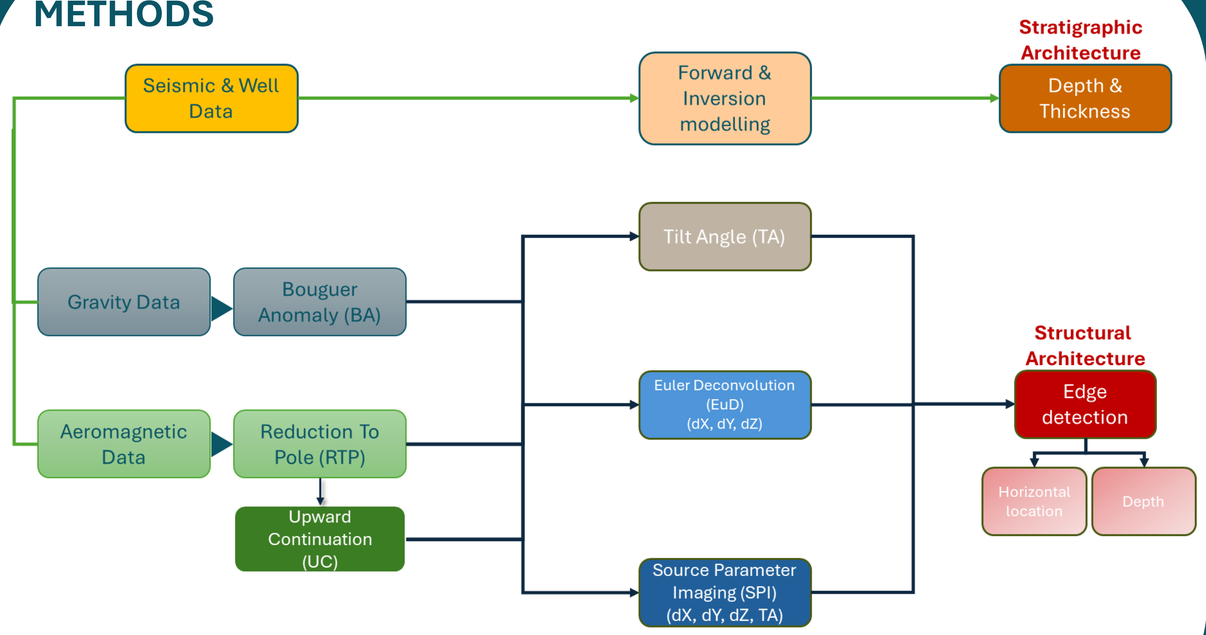

Figure 1: Study workflow based on the integration of various geophysical data to constrain the depth, thickness, and structural architecture of the Lower Carboniferous Limestones (LCL).

RESULTS

A- SEISMIC AND WELL DATA ANALYSIS

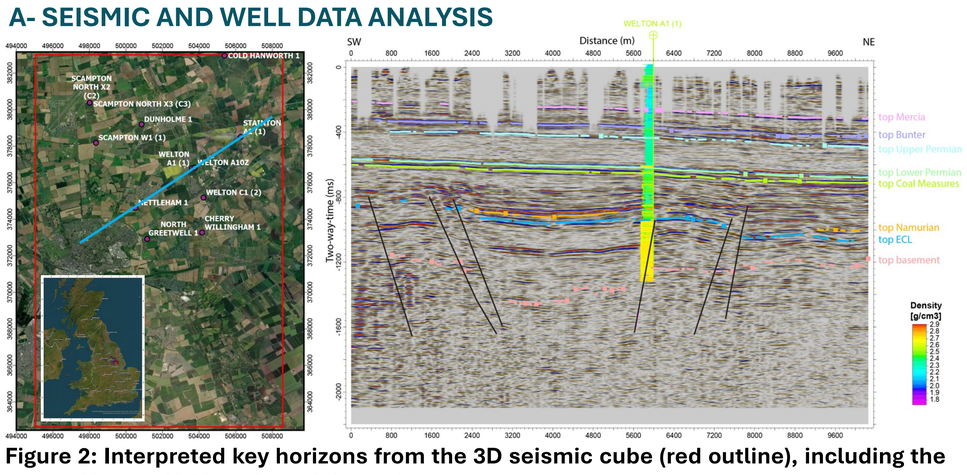

Figure 2: Interpreted key horizons from the 3D seismic cube (red outline), including the top and base of LCL and overlying units.

B– GRAVITY FORWARD MODELLING

Formation	Density (g/cm³)			
	Mean	Std Dev (count)	Min	Max
Overburden	2.26	0.085 (12025)	2.05	2.53
Mercia	2.33	0.077 (10550)	2.19	2.55
Bunter	2.30	0.065 (8575)	2.11	2.50
Upper Permian	2.46	0.151 (7068)	2.31	2.66
Lower Permian	2.48	0.083 (2594)	2.38	2.63
Coal Measures	2.46	0.169 (34797)	2.30	2.65
Namurian	2.53	0.138 (10779)	2.36	2.65
LCL	2.66	0.058 (26640)	2.61	2.69
Basement	2.67	0.074 (6562)	2.59	2.73

Table 1: Density distribution derived from well analysis.

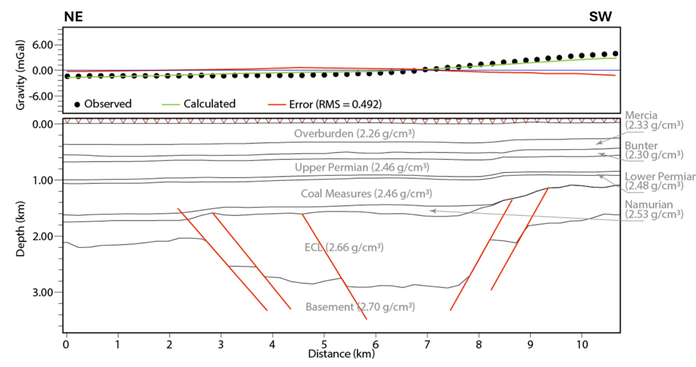

Figure 4: 2D forward model. Location: blue trace in Fig. 5.

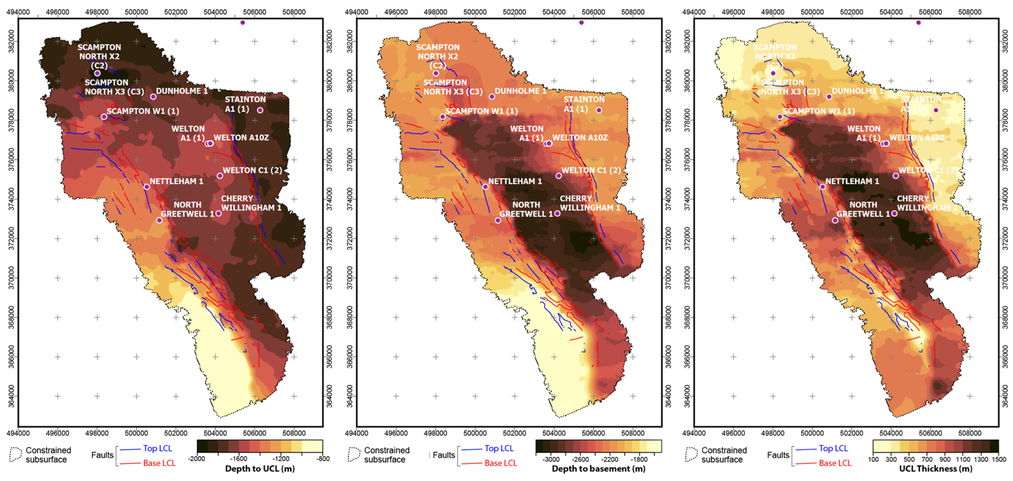

Figure 3: Characterization of the LCL in the subsurface with depth to top (left), depth to base (centre), and thickness (right).

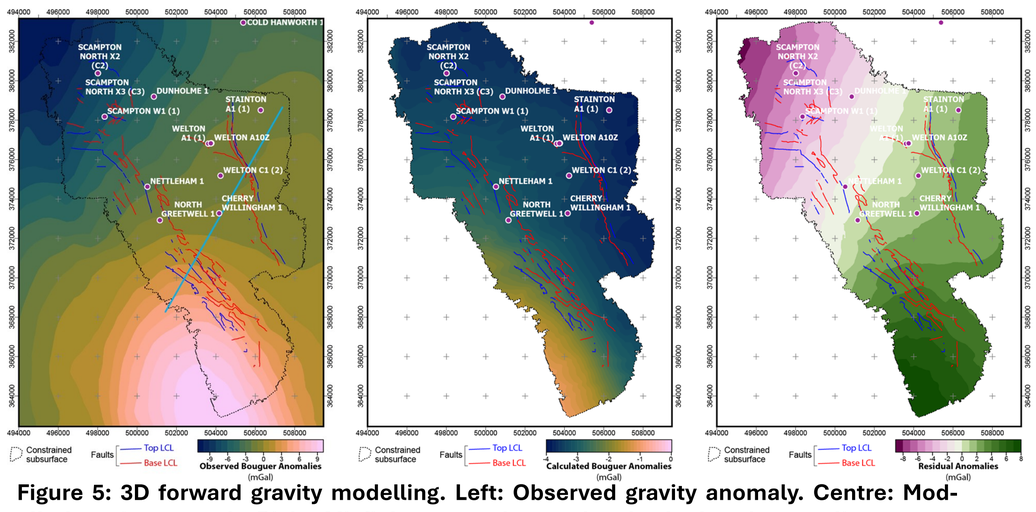

Figure 5: 3D forward gravity modelling. Left: Observed gravity anomaly. Centre: Modelled gravity anomaly. Right: Misfit between observed and calculated anomalies.

C– AEROMAGNETIC DATA ANALYSIS

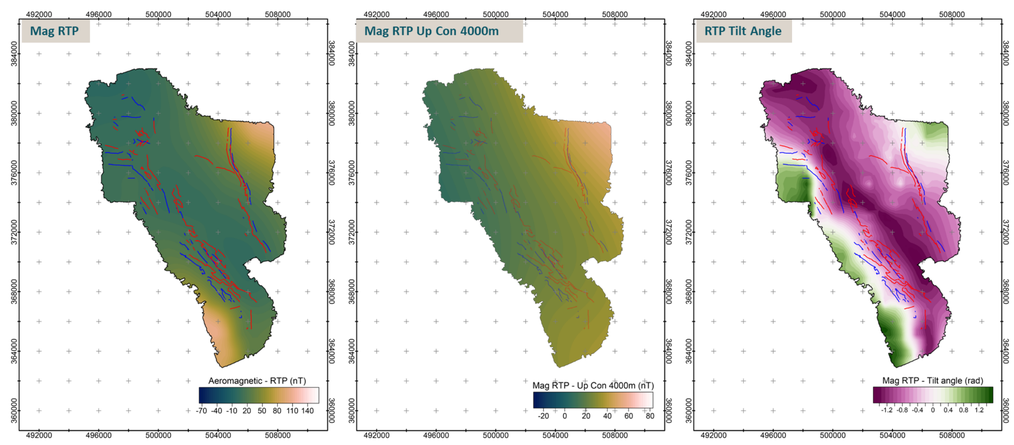

Figure 6: Various aeromagnetic derivatives used for the structural analysis. Left: Reduction To Pole (RTP). Centre: Upward continuation to 4000 m. Right: Tilt angle.

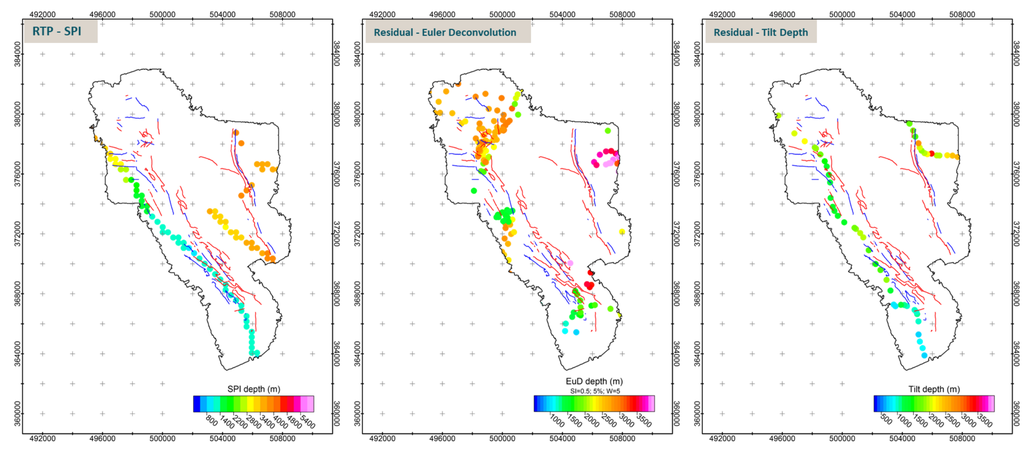

Figure 7: The results of the different edge detection techniques. Left: Source Parameter Imaging (SPI) on RTP magnetics. Centre: Euler deconvolution on aeromagnetic residual. Right: Tilt depth on aeromagnetic residual.

DISCUSSION & CONCLUSIONS

- Seismic and well data alone do not fully constrain LCL thickness.
- Gravity modelling helps validate and refine subsurface mod-els.
- Magnetic derivatives and edge detection methods are helpful for identifying faults and fracture zones.
- Together, these tools provide a more confident foundation for geothermal reservoir modelling.
- These results will support further work to quantify fluid flow and assess the thermal performance of the aquifer.

References

Jones, D. J. R., Randles, T., Kearsey, T., Pharaoh, T. C., & Newell, A. (2023). Deep geothermal resource assessment of early carboniferous limestones for Central and Southern Great Britain. Geothermics, 109, 102649.

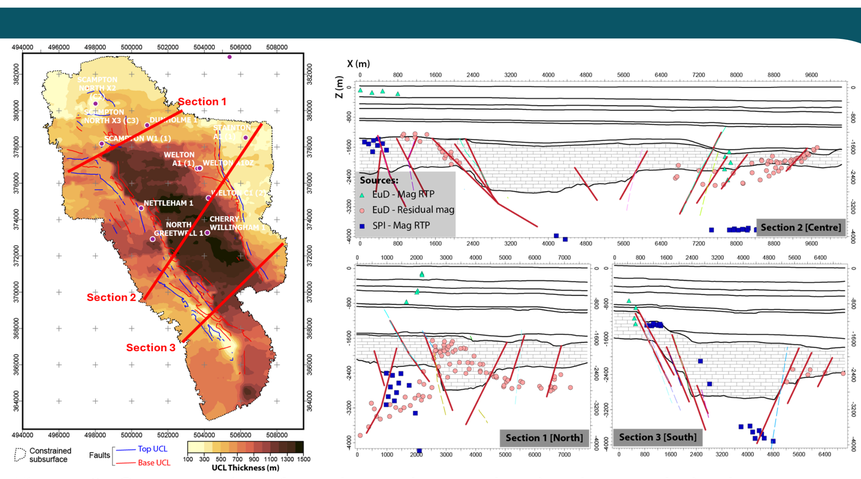

Figure 8: Cross-sections from the study area showing the correlation between mapped faults and identified magnetic sources.

