

Sub-Basalt Integrated Geophysical Study Islandmagee, Northern Ireland

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Summary

Conventional seismic reflection surveys in County Antrim, Northern Ireland are difficult to acquire and process due to surface basalts of variable thickness and composition. A combined gravity/electrical resistivity tomography (ERT) survey was therefore conducted on Islandmagee, Northern Ireland approximately 40 km north of Belfast with the objective of mapping a Permian salt layer at depth for potential gas storage and geological structures with hydrocarbon potential. The ERT/gravity data were integrated with high resolution aeromagnetic data purchased from the British Geological Survey. The ERT data were used to model the short and medium wavelength gravity response of the combined basalt/Ulster limestone package. The long wavelength gravity features remaining were then interpreted in terms of deeper structures such as Permian salt. The integration of these techniques provided constraints on contacts, faults and lineaments as well as combined basalt/Ulster limestone thickness. The gravity modelling, after correcting for short and medium wavelength shallow basalt/limestone thickness variations, provided very good evidence of the location of Permian salt within the survey area.

Introduction

Antrim Energy is exploring for conventional hydrocarbon prospects in County Antrim, Northern Ireland. Conventional exploration methods have been fraught with challenges primarily linked to the presence of

extensive, thick, Tertiary basalts. Antrim has conducted VSP studies to help understand the sub-basalt seismic imaging issue. Recently Antrim recognized the additional economic value of underground gas storage hosted in thick Permian salts known locally in the Larne license area at 1800 m depth. Upon investigating alternate exploration methods Antrim embarked on a small ground-based ERT, gravity, and HC micro-seep survey on Islandmagee in 2008 with the objective of defining deep structures and salt bodies worthy of drilling for petroleum exploration and/or gas storage. The ERT and gravity acquisition and processing was carried out by WorleyParsons Canada Limited and Bemex Consulting International. Antrim also licensed a regional volume of public domain aeromagnetic data from the British Geological Survey. The interpretation of the combined ERT, gravity and aeromagnetic data was carried out by GEDCO and Bemex Consulting International. The ERT survey effectively enabled thickness estimates of the shallow, dense, combined resistive basalt-Ulster limestone layer. Back-stripping of this layer greatly facilitated forward models of the sub-surface gravity field. Some results and examples from the program will be discussed.

Theory and/or Method

An integrated gravity/resistivity survey was therefore employed to determine if such an approach could map the location of Permian salt beneath the basalt cover. A Wenner array using an electrode spacing of 22.5 m provided resistivity data to an approximate depth of 260 m. Standard 2D resistivity inversion (RES2DINV; Loke and Barker, 1996) was carried out to generate resistivity depth profiles from the Wenner apparent resistivity pseudosections. A Scintrex CG-5 gravity meter was used to collect gravity data at 50 m intervals along these survey lines. Elevation and UTM accuracies of ± 5 to 10 cm were achieved using differential GPS. Standard processing methods, including digital terrain corrections, were employed to generate Bouguer gravity profiles along each survey line. The overall accuracy of the Bouguer gravity data was estimated to be ± 5 to 8 microgals. A subset of the Tellus high resolution aeromagnetic (HRAM) survey covering all of Northern Ireland was purchased and integrated with the above data sets. The purchased data covered an area several times larger than Islandmagee (only over land) in order to ensure sufficient coverage to carry out a lineament interpretation.

The high resolution aeromagnetic (HRAM) data were used to locate lineaments and faults within the survey area approximately 40 km north of Belfast (Figure 1). DC resistivity data were used to map the combined thickness of the surface basalt layer and underlying Ulster limestone unit since this combined unit is much more resistive than the underlying mudstones and siltstones. The density of this combined unit was obtained from a well located across Larne Lough to the west of the survey area. Consequently the gravity response of the combined unit could be modeled and compared with the Bouguer

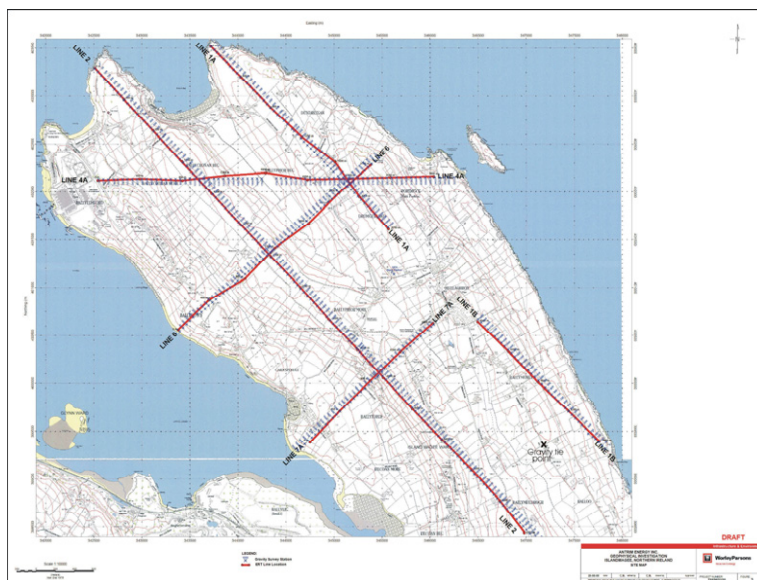


Figure 1: Map showing the north end of Islandmagee and the location of the gravity and DC resistivity survey lines. Belfast is approximately 40 km south.

gravity data. Any gravity features remaining after computing the gravity effect associated with the shallow combined layer would have long wavelengths. These longer wavelength features were then interpreted in terms of deeper geological features such as the Permian salt horizon. A starting geological model based on data from two wells, the Larne-2 and Newmill-1 wells, provided the deep geological control necessary for modeling longer wavelength gravity features. There was over 100 m of Permian salt in the Larne-2 well to the north and no Permian salt in the Newmill-1 well to the south. Faults and lineaments from the HRAM survey provided additional constraints of shallow and deep geological boundaries for the gravity interpretation.

Examples

Figure 2 is an example of the topographically corrected inversion of the resistivity data for the north end of line 2. The shallow red and pink colours (high resistivity values greater than 100 ohm-m) are associated with interpreted basalt and/or Ulster limestone and the dark green and blue colours (low resistivity values less than 10 ohm-m) are associated with the interpreted clastic section beneath the Ulster limestone. There is exposed basalt outcrop at the north end of the line

Figure 3 is a 2.5 D gravity model based on the deeper geological stratigraphy obtained from the Larne and Newmill1 wells. The basalt layer is assumed to have constant thickness along the entire line so there is no gravity effect associated with it. The portion of this model between the Larne -2 and Newmill-1 wells was used as a starting model for each of the combined ERT/gravity lines in the survey area. The combined thickness of basalt/Ulster limestone was specifically included in the model and the remaining long wavelength features were modeled to determine the presence or absence of Permian salt.

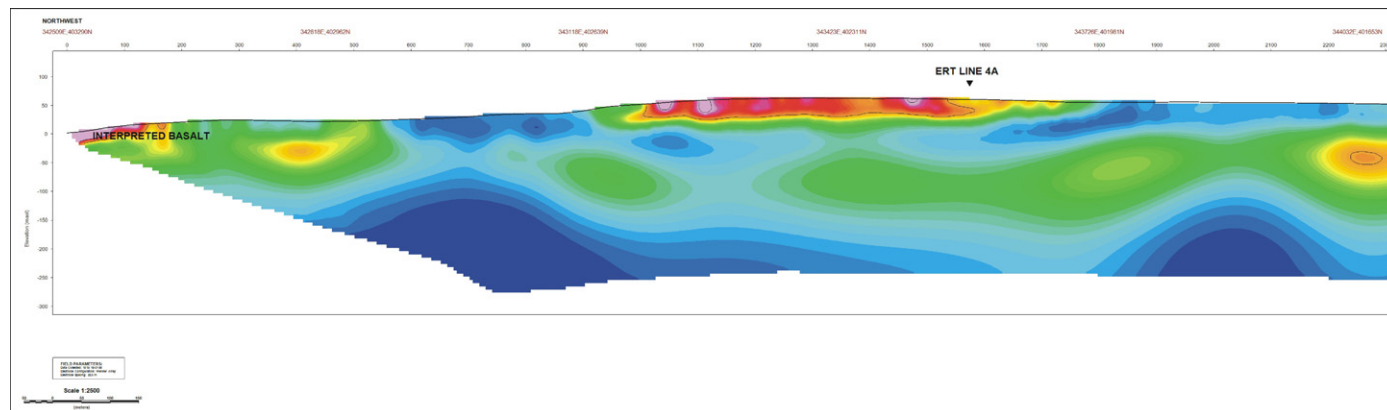


Figure 2: Topographically corrected resistivity inversion of the north end of line 2 using RES2DINV. There is basalt outcrop exposed at the extreme north end of this line (station 0).

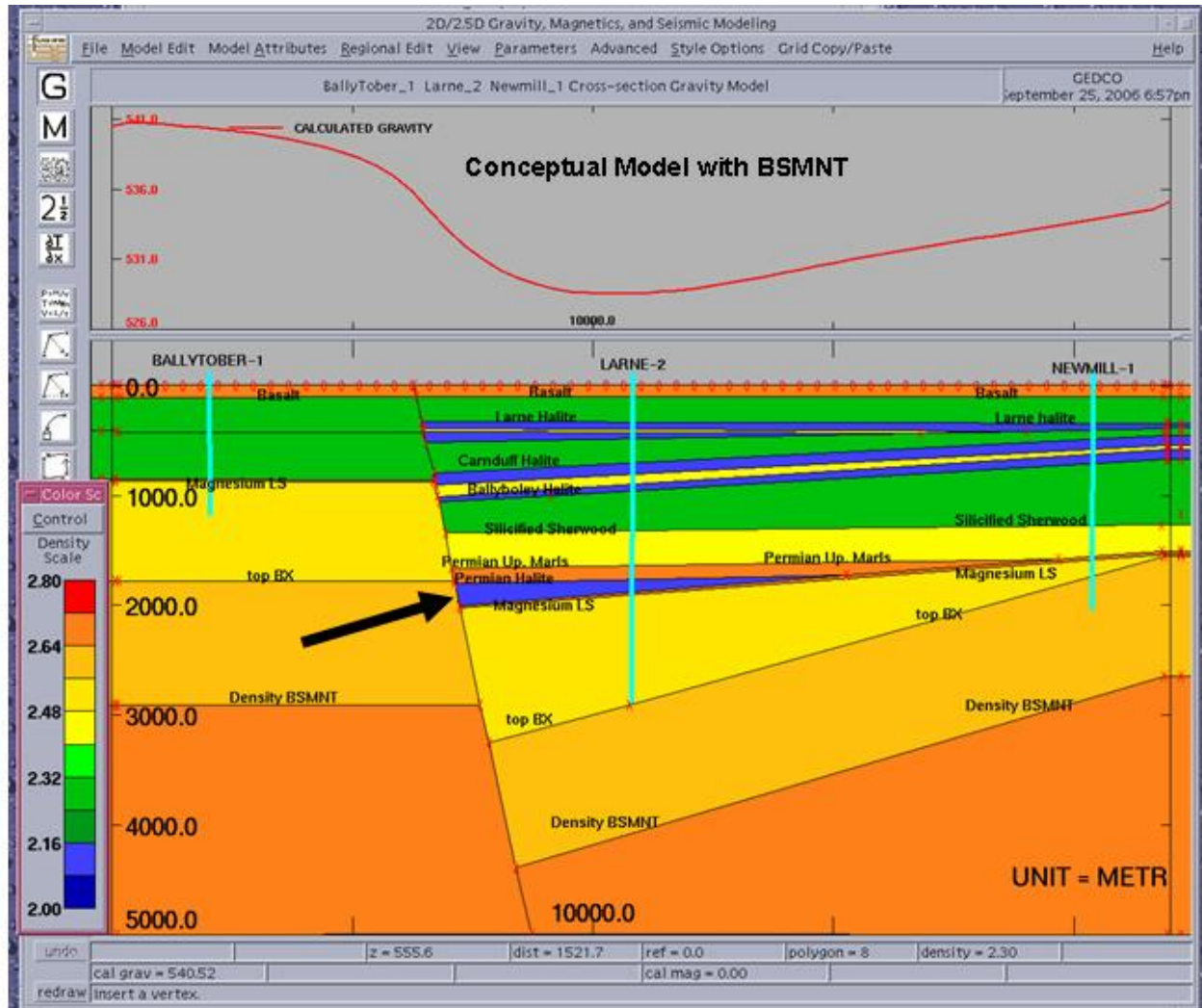


Figure 3: Generic gravity model used for modeling Permian salt (shown in blue in figure)

Conclusions

- 1 The ERT survey was an effective method for estimating the thickness of surface basalt and/or Ulster limestone.
- 2 The high resolution aeromagnetic data provided detailed information on shallow contacts and faults
- 3 The forward gravity sub-surface models strongly indicated discontinuous salt bodies at depth, after correcting for the shallow basalt/limestone variations

Acknowledgements

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References

Loke, M.H., and Barker, R.D., 1996, Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method: *Geophysical Prospecting*, 44, 131-152.