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Interpreting 2D seismic with the assistance of FALCON® Airborne Gravity Gradiometer data in the Canning Basin

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SUMMARY

The interpretation of 'vintage' seismic data acquired in underexplored frontier basins is often challenged by their sparse coverage. This example from the Canning Basin illustrates how FALCON® Airborne Gravity Gradiometer (AGG) data greatly enhances the 2D seismic interpretation, facilitating exploration in such frontier basins.

The initial seismic interpretation was performed by Buru Energy, and given the 'vintage' data, was limited at best. The integration of the AGG, magnetic, well, and other available data allowed the improvement of seismic interpretation. A basement structure map, and two intra-sedimentary structure maps were produced, resulting in an overall geological model.

In particular, the initial seismic interpretation of seismic traverses perpendicular to strike across the AGG survey could be significantly improved by using images of the AGG data and AGG profile data (G_{DD} and g_D). The AGG data and the structure maps were used to constrain fault locations and depths as well as thickness distributions of geological units. The interpreted seismic traverses were validated by 2.5D gravity modelling, ultimately resulting in a conceptual geological model.

This is a key-method to constrain the interpreted geology, providing a more confident interpretation of 'vintage' reflection seismic data with sparse coverage.

Key words: Airborne Gravity Gradiometer data, 2D seismic data, 2.5D gravity modelling, validation, Canning Basin.

INTRODUCTION

The Canning Basin is an underexplored frontier basin where sparse 'vintage' 2D seismic lines accounted for most of the available information about the subsurface structure. Partly due to these limitations hydrocarbon exploration has made little progress for many years. For example, the deep structure of the Fitzroy Trough and its margins was largely unknown. Buru Energy has acquired a large Airborne Gravity Gradiometer (AGG) survey (38800 km^2) over the south-western margin of the Fitzroy Trough and Gregory Sub-basin, also covering parts of the Jurgarra Terrace, the Mowla Terrace, Broome Platform, Barbwire Terrace and Crossland Platform (Figure 1).

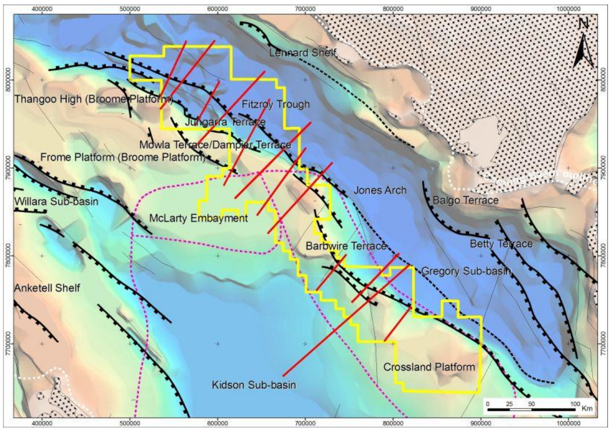

Figure 1. Location of the Airborne Gravity Gradiometer (AGG) survey (boundary shown in yellow) at the south-western margin of the Fitzroy Trough and Gregory Sub-basin. The location of the modelled traverses is shown in red.

Available 'vintage' 2D seismic data was interpreted simultaneously with the AGG data interpretation, also using airborne magnetic, well, Landsat Geocover and SRTM (Shuttle Radar Topography Mission) data, along with published geological maps and literature.

The key to this integrated approach is the interpretation of seismic traverses with the assistance of AGG data, and particularly the validation of the interpreted seismic traverses by 2.5D gravity modelling. Thus the AGG data has proven a powerful complement to 'vintage' seismic data and has enhanced its value. The workflow presented here resulted in a geological model and in an overall better understanding of the 3D structure and stratigraphic relationships in the frontier gravity modelled traverses were used for further planning of seismic acquisition and input for 3D modelling.

METHOD AND RESULTS

The applied interpretation and modelling method involves the following stages:

(1) Through integration of AGG and seismic data with all available datasets, structural interpretation maps of the intra-sedimentary fault structure (Figure 2) and basement fault structure were produced. Maps of the intra-sedimentary fault structure were produced at intermediate and shallow depths. AGG data images basement features as well as dense intra-sedimentary sources, particularly carbonates. The availability of seismic data facilitated the identification of gravity sources that match with anomalies identified in the AGG data, allowing an integrated interpretation. Magnetic data was mostly used for the interpretation of intra-basement features, like igneous intrusions and basement structure. Intra-sedimentary magnetic sources, like lamproite intrusions and mineralised fault zones were also identified. This integrated interpretation allowed a conceptual geological model to be produced.

(2) By applying the Werner (Werner, 1953) and Euler (Reid et al., 1990) methods in line magnetic data a depth to magnetic basement map was produced. Magnetic basement commonly coincides with metamorphic basement, however in this case there are intra-sedimentary magnetic sources in parts of the Fitzroy Trough. The top of the magnetic basement of parts of the Barbwire Terrace and Crossland Platform is well below the base of the Ordovician sediments of the Canning Basin, as interpreted from seismic data, suggesting non-magnetic sequences, possibly of Proterozoic or Cambrian age.

(3) Before the potential field data interpretation project started a seismic interpretation was performed by Buru Energy. Figure 3 illustrates limitations of some of the 'vintage' seismic data along one of the modelled traverses. It shows that the interpretation of some of the seismic lines could not be pushed any further without using the other datasets.

(4) Seismic traverses crosscutting the AGG survey were interpreted using the AGG data and the integrated structural interpretation as constraints (Figure 4). All selected traverses are NE-SW (Figure 1), each of them consisting of up to three seismic lines, occasionally with gaps in between (Figure 3). Images of the AGG data, AGG profile data (GDD and gD) and the structure maps were used together with the seismic data to constrain fault locations and depths as well as thickness distributions of geological units. Gradually an improved understanding of the tectono-sedimentary evolution of the basin was obtained, also facilitated by the number and length of the traverses, allowing for a better understanding of the deep structure.

(5) Time-to-depth conversion of the interpreted traverses was completed using CGG's proprietary software LCT. Using velocity data from scattered wells in the area provided by Buru Energy, the digitised interpreted seismic traverses were converted from the time domain to the depth domain.

(6) The interpretation of the seismic traverses was validated by 2.5D gravity modelling. To account for excess or absent mass, modifications were made to the interpretation. In some cases multiple models were tested to assess the plausibility of alternative geological assumptions. Figure 5 shows an end result of the gravity modelling of the seismic traverse shown in Figures 2 to 4.

(7) Knowledge gained from the 2.5D gravity modelling was fed back into the structural interpretation maps to update the conceptual model. Using this workflow, significantly improved interpretation of 'vintage' seismic data can be achieved. A comparison of the initial seismic interpretation (Figure 3) to the final validated interpretation (Figure 4) clearly shows the value of integrating AGG and other datasets to produce an integrated interpretation that honours all data.

(8) 3D geophysical modelling in GOCAD was performed after the completion of the 2.5D gravity modelling. The completed 2.5D modelled traverses were used as input.

The result of this interpretation and modelling is an improved understanding of the 3D structure, stratigraphy and tectono-sedimentary evolution of the basin. The seismic data that was used to constrain the modelling could be interpreted with increased confidence to deeper levels, as the cross sections are validated by 2.5D gravity modelling. The detail of the interpretation, construction and modelling allowed the identification of potentially prospective stratigraphic units, structural trends and the selection of areas for future exploration and seismic acquisition.

CONCLUSIONS

In underexplored frontier basins, like the Canning Basin, integrated interpretation of 'vintage' quality seismic data in conjunction with AGG data has demonstrated the value of 2.5D gravity modelling of geological cross sections along seismic lines. The key to enabling a more complete interpretation of 'vintage seismic data' with few constraints was the validation by gravity modelling with AGG data. By gravity modelling multiple seismic traverses the 3D understanding of the structure, stratigraphy and tectono-sedimentary evolution of the basin can be better understood. This ultimately leads to more informed exploration decisions, such as targeted seismic surveys and drilling locations.

ACKNOWLEDGMENTS

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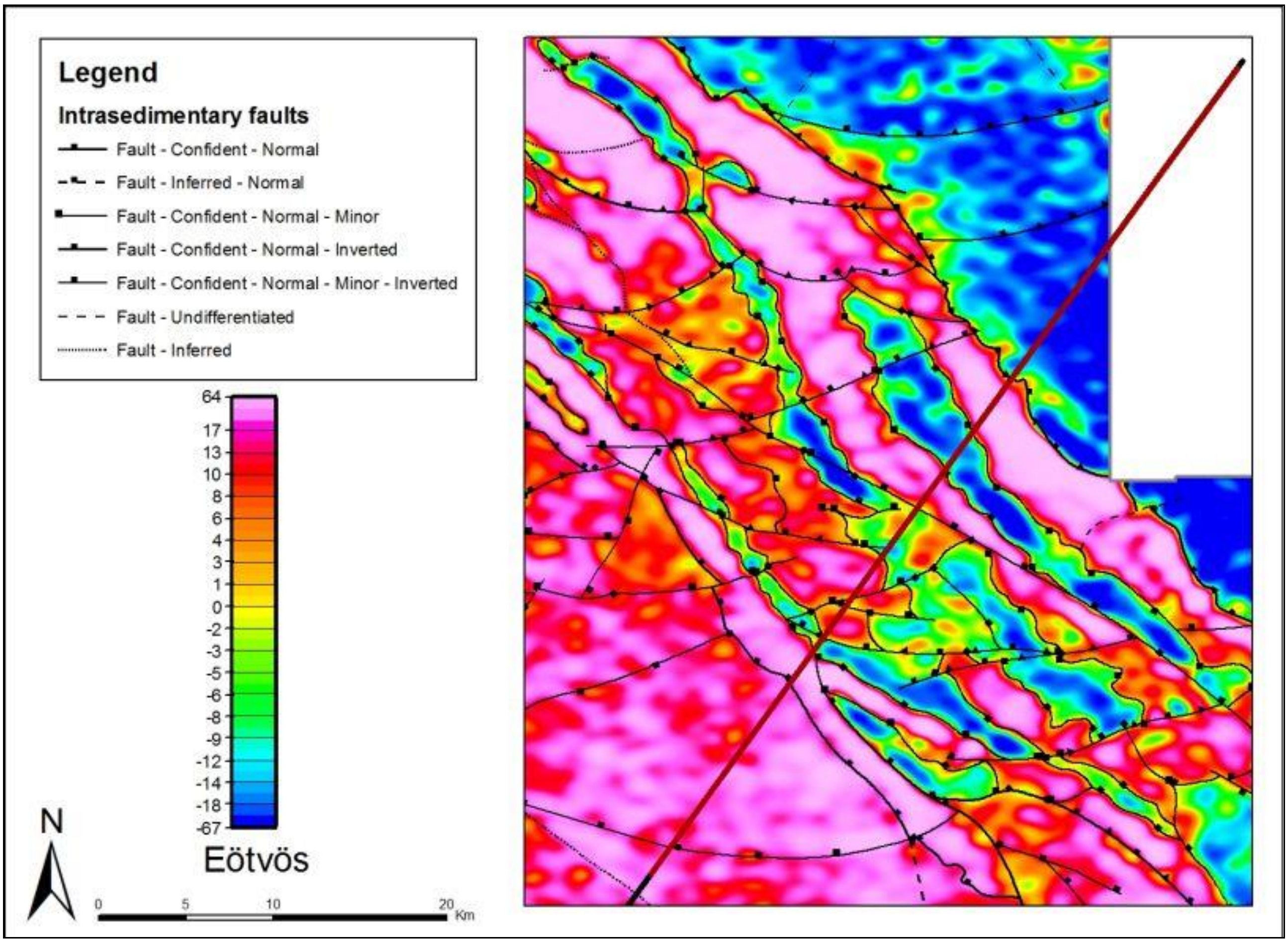

Figure 2. Integrated structural interpretation of the AGG data in the vicinity of the traverse shown in figures 3 to 5. The mapped faults are overlain on the image of GDD. The extent of he modelled traverse shown in figures 3 to 5 is depicted in red.

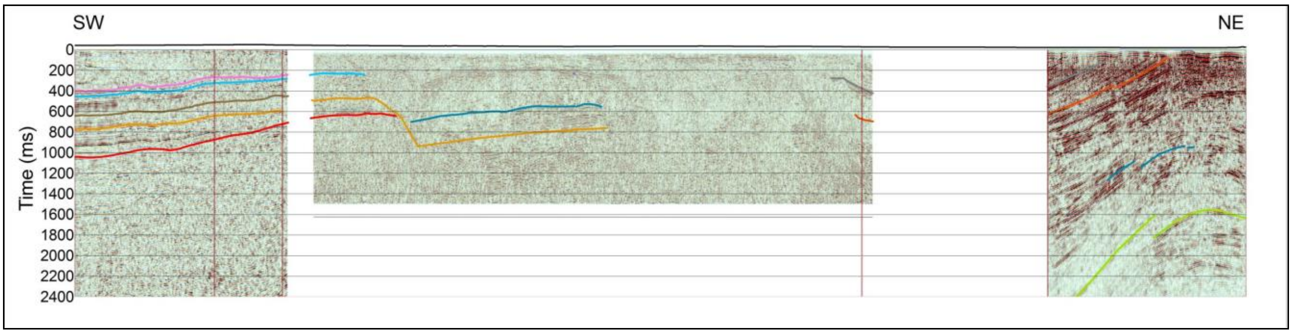

Figure 3. Seismic data along the modelled traverse shown in figures 4 and 5. Note the very different quality of the each of the seismic lines along this part of the traverse. The original seismic interpretation of this 'vintage' seismic data is also shown on this figure.

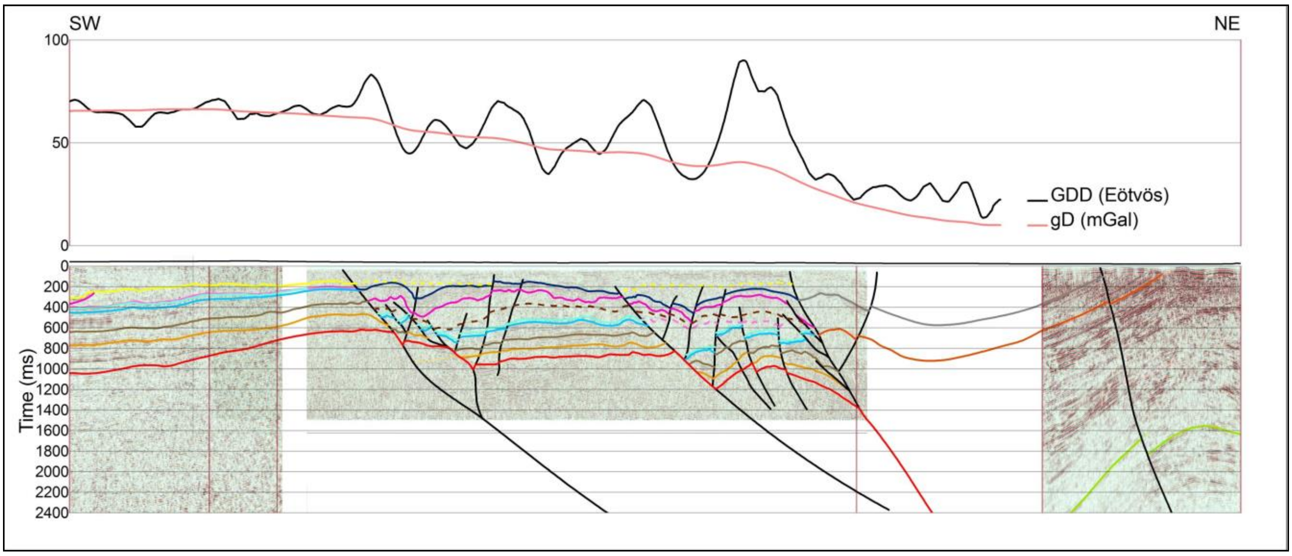

Figure 4. Final interpretation of the seismic traverse. This interpretation was produced using the conceptual geological model developed by the interpretation of the AGG data with the other available datasets. Profiles of the G_{DD} and g_D, also used to construct the position of faults and gravitational features on this traverse, are shown above.

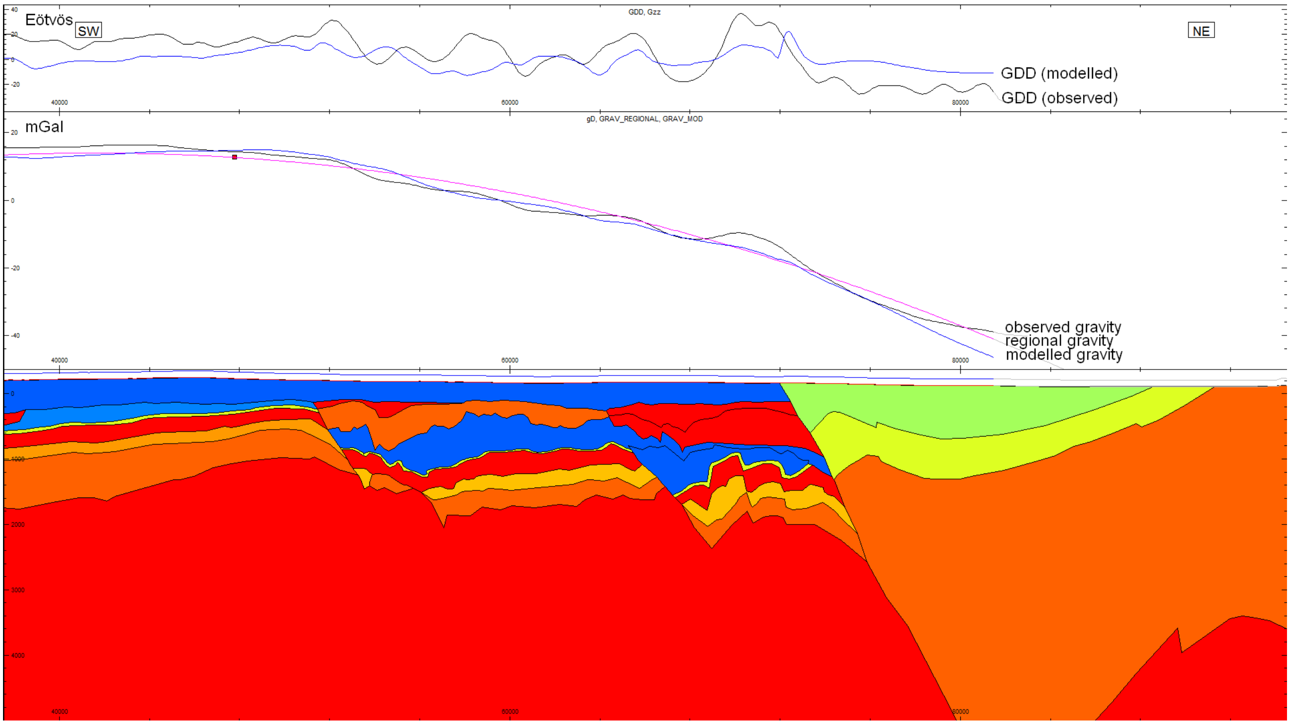

Figure 5. Final result of gravity modelling of the traverse shown in the figures 2 to 4. The vertical scale of the section is in meters. Each colour shown in the modelled section represents a different density applied in the final model (in order of decreasing densities: red = 2.7 g/cm^3, orange = 2.65 g/cm^3, light orange = 2.6 g/cm^3, yellow = 2.55 g/cm^3, light green = 2.52 g/cm^3, light blue = 2.37 g/cm^3 and dark blue = 2.35 g/cm^3).