Using FALCON® Airborne Gravity Gradiometer data to assist the interpretation of 2D seismic: an example from the Canning Basin, Australia

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Summary

Many frontier basins have widely spaced, vintage 2D seismic data available. The often poor quality of this vintage seismic makes it difficult to derive any meaningful geological information. By using additional complementary datasets, interpretation of the seismic data is often possible. Here we show how FALCON® Airborne Gravity Gradiometer (AGG) data combined with magnetic and other geological data has enabled a geological model to be constructed and vintage seismic to be interpreted. A workflow involving integrated interpretation of AGG, magnetic and seismic data is described using an example from the Canning Basin in northern Western Australia.

Introduction

The Canning Basin in northern Western Australia is an under explored frontier basin. Available data is generally restricted to vintage 2D seismic, few wells and regional magnetic and gravity data. The Buru Energy Joint Venture conducted a FALCON® Airborne Gravity Gradiometer survey over the southern margin of the Fitzroy Trough covering parts of the Jurgarra, Mowla and Barbwire Terraces and the Broome and Crossland Platforms (Figure 1). The survey covered almost 40,000 km^2 with 1,000 m spaced north/south lines. The main objective of the survey was to understand the 3D geology of the survey area to assist in the planning of further 2D and 3D seismic surveys.

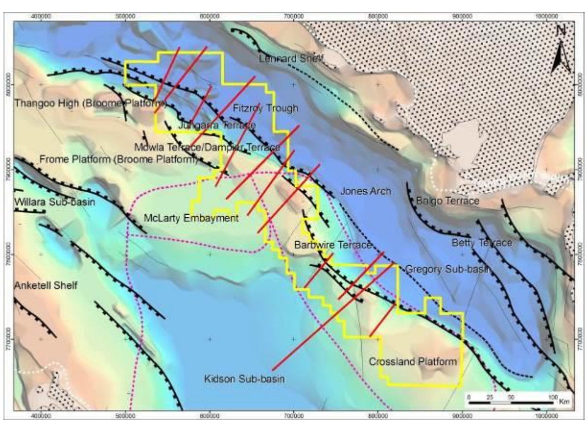

Figure 1: Location of the AGG survey (yellow outline) and the traverses modelled in this study. Background image is the OZ SEEBASE basement topography image (FrOG Tech, 2006).

All available vintage data has been combined with the newly acquired AGG and magnetic data to produce an integrated interpretation. After an initial integrated structural interpretation, reinterpretation of selected seismic traverses and subsequent 2.5D gravity modelling was completed. These modelled traverses were then used to produce a 3D geological model of the northern part of the survey area.

Integrated Interpretation Method

Integrated interpretation of all available complementary datasets enables the construction of robust geological models. The workflow described here is an iterative approach and prior steps are reviewed at the completion of subsequent steps. The integrated approach is as follows:

1. Integrated geological interpretation of AGG, magnetic, seismic and geological data produced an initial structural element map (Figure 2). Structures at different levels were interpreted using different combinations of data. Magnetic data was predominantly used to produce a structural interpretation of magnetic basement. AGG data was used to interpret intrasedimentary structure and significant density contrasts (Figure 3). The seismic data was used to identify the nature of the density contrasts (high density

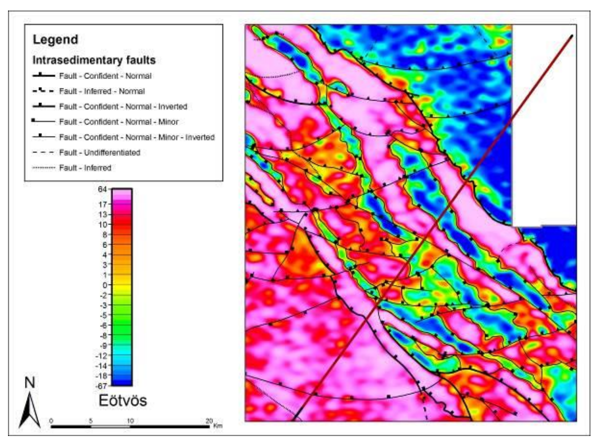

Figure 2: Integrated structural interpretation of the AGG, magnetic and seismic data. Background image is the GDD. Red line shows the location of the seismic traverse shown in subsequent images.

areas were generally due to carbonates at either shallow or deeper levels within the sediments) and the AGG was used

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to extrapolate away from the seismic lines to provide a much better understanding of the 3D geology. Magnetic data was also used to identify intrasedimentary intrusives.

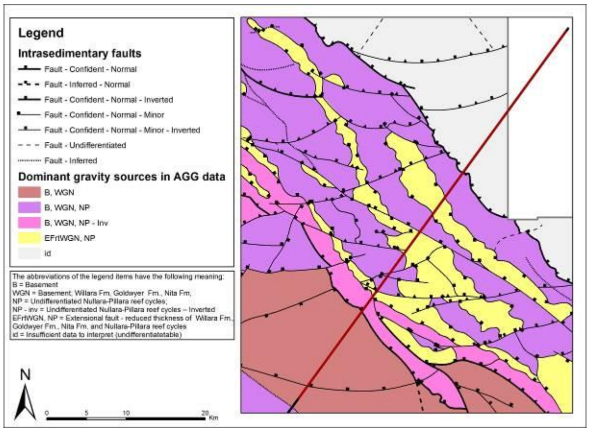

Figure 3: Interpretation of the distribution of gravity sources identified by the integration of seismic and AGG data.

2. Werner (Werner, 1953) and Euler (Reid et al., 1990) methods applied to the line magnetic data produced a depth to magnetic basement map. Typically, magnetic basement coincides with crystalline basement however, intrasedimentary intrusives are interpreted and parts of the basement are comprised of non-magnetic sediments making the derivation of a continuous, robust crystalline basement surface from the magnetic data very difficult.

3. Previous interpretation of the seismic data is evaluated. In general the previous seismic interpretation had extracted as much information as possible from the vintage seismic data (Figure 4).

4. Using the conceptual geological model developed in steps 1-3, the vintage seismic was reinterpreted. Sixteen traverses were interpreted across the survey area some of which were composites of several seismic lines. Images of the AGG data, AGG profile data and the integrated structural interpretation were combined with the seismic data to constrain fault locations and the thickness and distribution of the units (Figure 5). As geological knowledge was gained during this step it was iteratively fed back into the integrated interpretation completed in step 1 and maps at all levels were updated.

5. Reinterpretation of the seismic lines was completed in the time domain. CGG-LCT software was used to depth convert the interpretation using scattered wells in the area.

6. 2.5D gravity modelling of each of the sections was undertaken to validate the interpretation. Where appropriate, modifications were made to either the density or the geometry of the traverses, until an acceptable fit was obtained (Figure 6). Any modification to the traverses was applied to the structural and lithological interpretation completed in prior steps resulting in an updated conceptual geological model consistent with the multiple datasets used in the interpretation.

7. A 3D geological model was constructed by extrapolating between interpreted traverses using GOCAD® SKUA® (Figure 7). An initial fault network was used to constrain key horizons within the model (Figure 8). The model was then converted to a voxel model and the forward gravity response calculated (Figure 9). The match to the acquired data was reasonable and an unconstrained inversion was completed using VPmg to further constrain the densities.

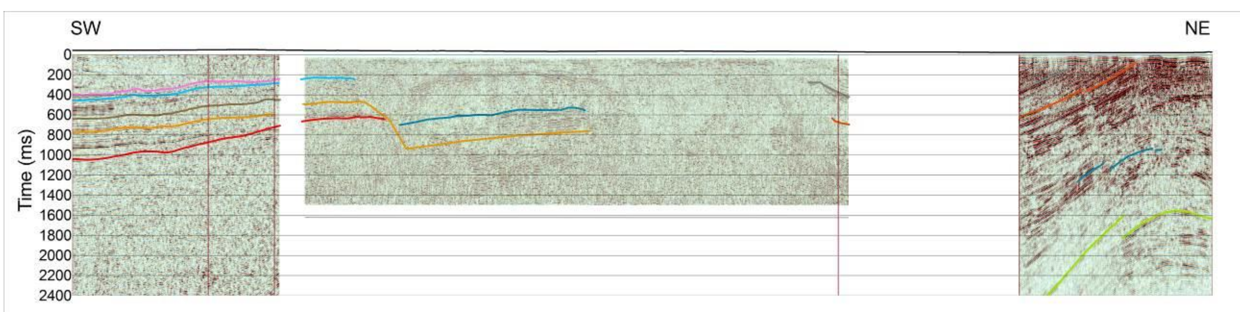

Figure 4: Example of vintage seismic data traverse (shown by red line in Figure 2) with interpretation. Note that this traverse is made up of three segments of seismic data.

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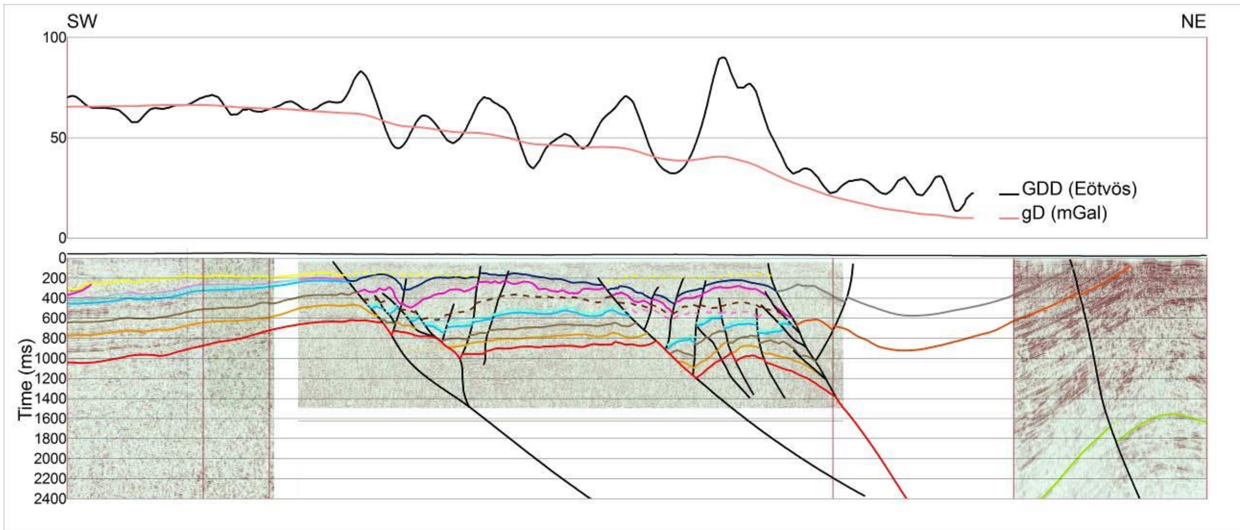

Figure 5: Integrated interpretation of traverse shown by red line in Figure 2. Note the additional level of detail compared to the original interpretation of only the seismic data (Figure 4). Top panel includes GDD (black line) and gD (red line).

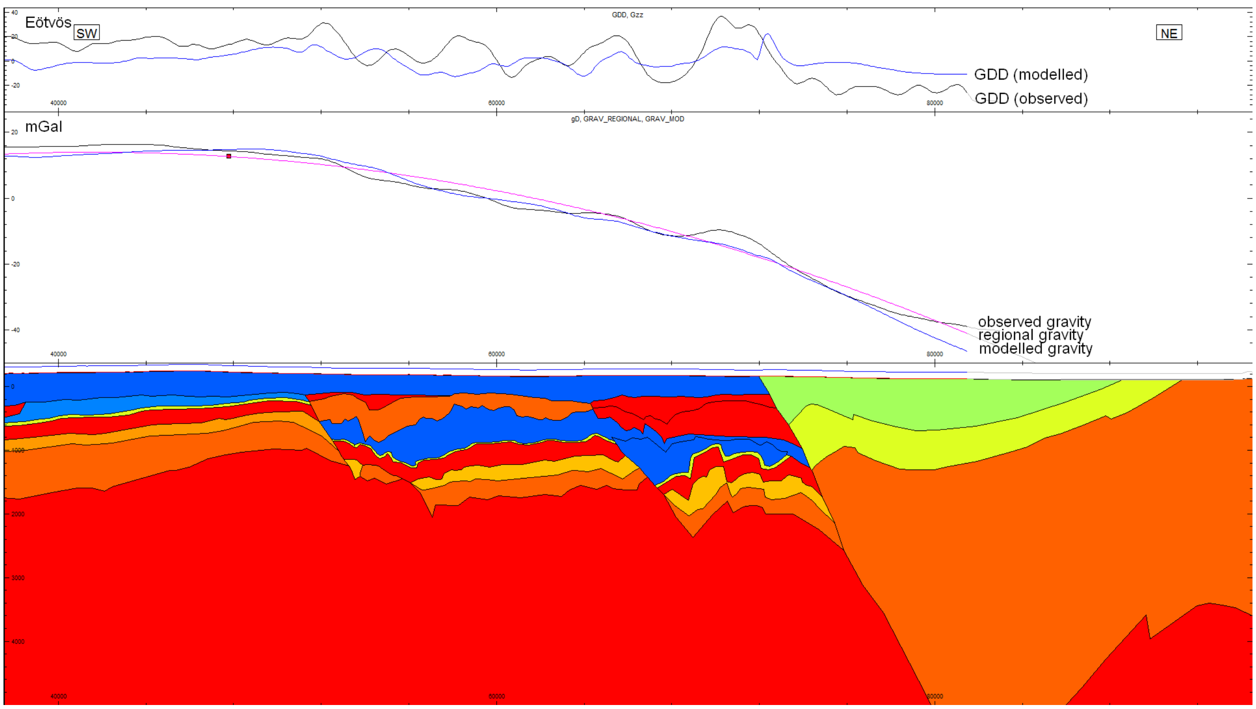

Figure 6: Gravity model of seismic traverse shown in Figure 2. The vertical scale of the section is in meters. Each color shown in the modelled section represents a different density applied in the final model (in order of decreasing densities: red = 2.7 g/cm^3, orange = 2.65 g/cm^3, light orange = 2.6 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).

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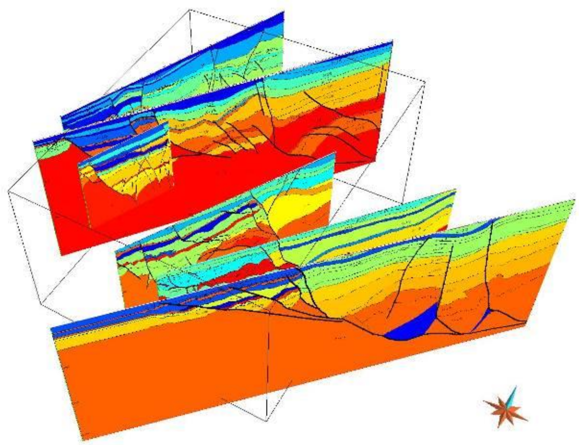

Figure 7: Six traverses through the northern part of the survey area. Colors represent density although are not the same from section to section. 6x vertical exaggeration.

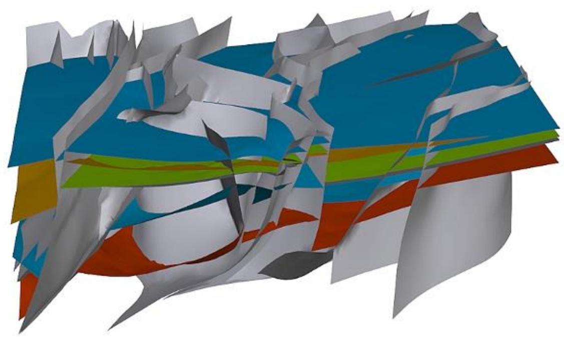

Figure 8: 3D Fault network (faults in grey) and horizons (colored surfaces) from GOCAD SKUA model for the northern part of the survey area.

Conclusions

Maximizing the information derived from existing vintage 2D seismic can not only speed up the exploration cycle but can also reduce the overall cost. By undertaking integrated interpretation of the available vintage seismic data combined with AGG data, conceptual geological models can be developed. These models can be tested by 2.5D gravity modelling of the seismic interpretation which can then be extrapolated to produce 3D geological block models.

Acknowledgments

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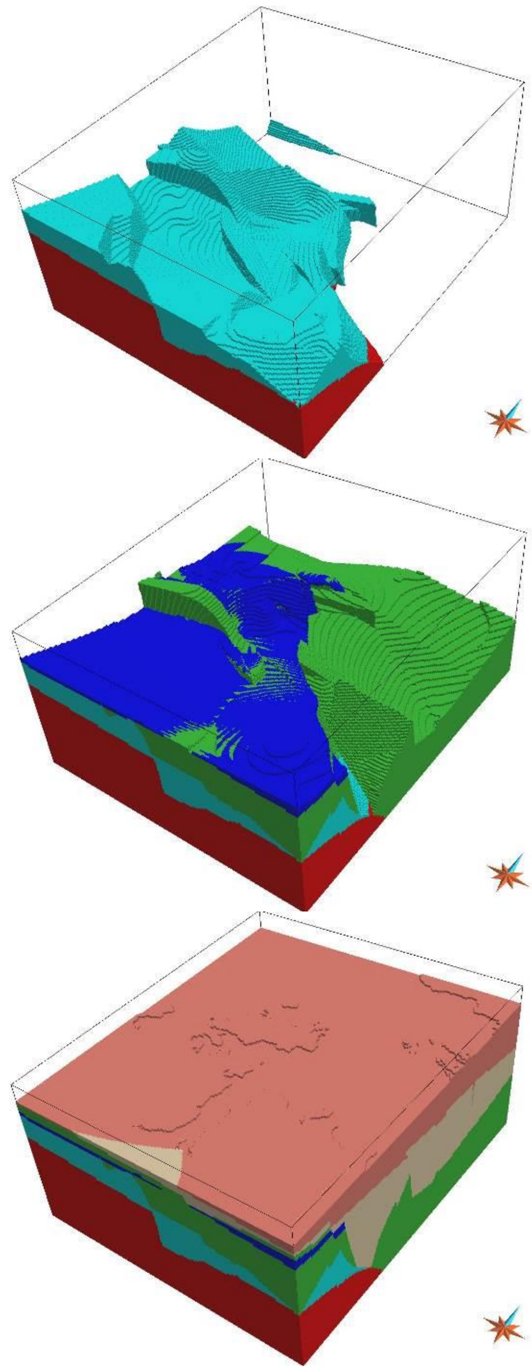

Figure 9: 3D block models for the northern part of the survey area. Basement (Red), top Nita Fm. to top metamorphic basement (light blue), top Laurel Fm. to top Nita Fm. (green), Nullara and Pilara Fms. (dark blue), Poole Fm./top Grant Fm. to top Laurel Fm. (beige) and surface to Poole Fm./top Grant Fm. (pink).

EDITED REFERENCES

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