3D Modelling of the Merlinleigh Sub-basin

Description of the project

This case history shows the application of Intrepid Geophysics' data processing software *Intrepid*© combined with the geological and geophysical modelling package *GeoModeller*© to create a 3D geological model that honours the observed magnetic and gravity data available for this area.

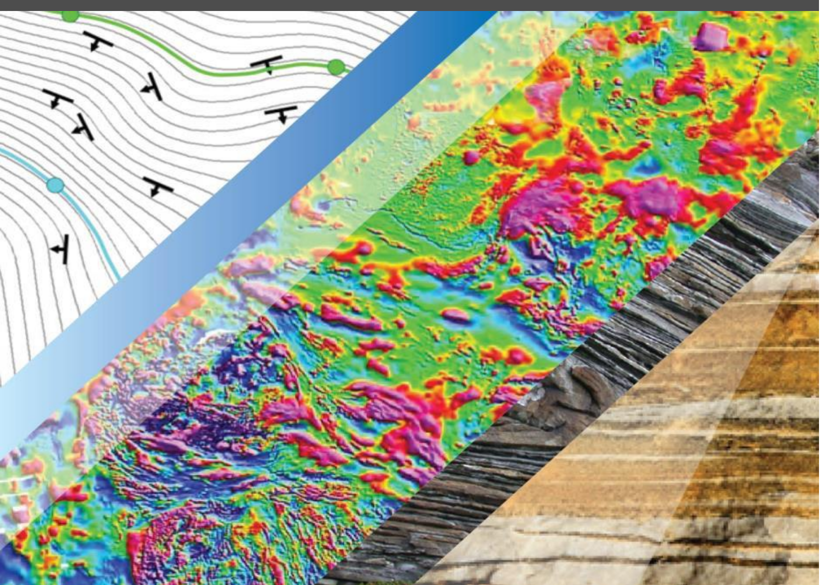
Software used

GeoModeller 2013 is a software tool for 3D geological modelling: for building complex, steady state, 3D geology models and performing forward and inverse geophysical modelling directly from solid 3D geology.

INTREPID© is a software package with extensive capabilities in airborne, ground, and marine magnetics, terrestrial and marine gravity, and 256 channel radiometrics data processing and interpretation.

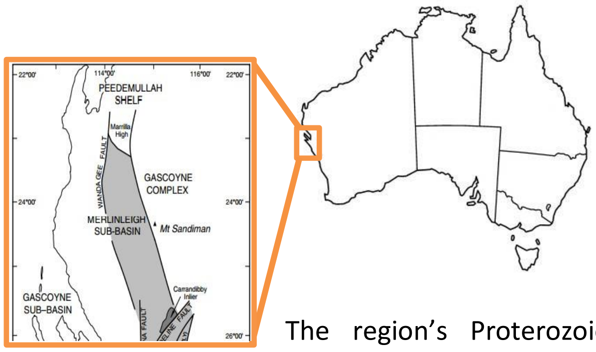
Author

C.Burney, J.Sumpton , GeoIntrepid 16 Sept 2013



Case History

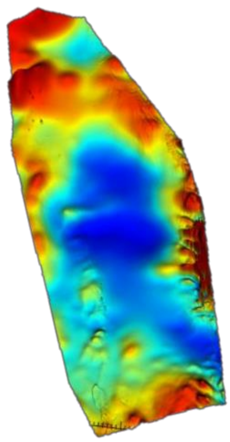
The Merlinleigh Sub-basin is part of the onshore Carnavon basin in Western Australia.



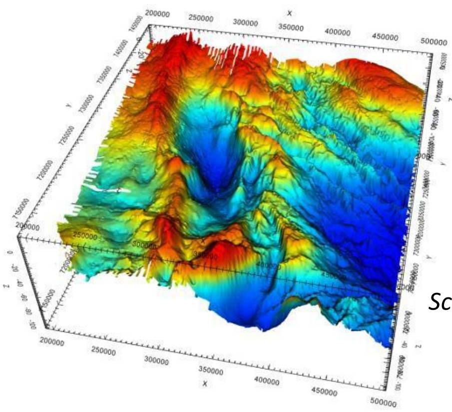
The region's Proterozoic basement is overlain by a sedimentary succession up to 8000m thick.

As part of the Petroleum Initiatives program conducted by the Geological Survey of Western Australia (GSWA) high-resolution aeromagnetic and semi-detailed helicopter-supported gravity surveys were conducted in 1995 to assist with the structural interpretation of the Merlinleigh Sub-basin.

The line data were gridded using *Intrepid* with a cell size of a quarter of the traverse line spacing. Those grids were used in the following process of interpretation and Inversion.

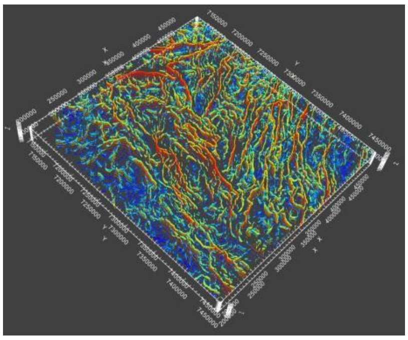


TMI grid (cell size 106 m)



Terrain Corrected Scalar gravity anomaly grid (cell size 250m)

Magnetic and gravity data interpretation



3D view of the gravity Worms

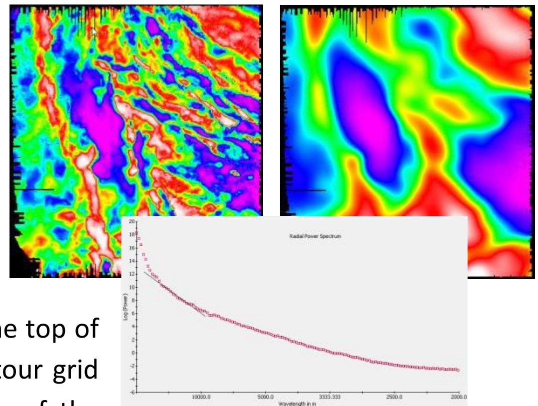
Using *Intrepid*, several processing steps were performed on the magnetic and gravity data to complete the interpretation and the 3D modelling of the basin.

Multi scale edge enhancement (WormE)

WormE is used to highlight the edges of the geophysical features. Both gravity and magnetics "worms" were imported into *GeoModeller* to support the geological modelling.

Spectral depth determination

Using the power spectrum calculated from the grids we were able to filter the residual anomalies (shallower depth) from the regional anomalies with deeper sources. The two output grids were used for comparison with the inversion results and to separate the signal of the basement from the sedimentary cover.



Gravity grid power spectrum, Left residual signals, right regional signal

Murthy and Roa Depth to basement

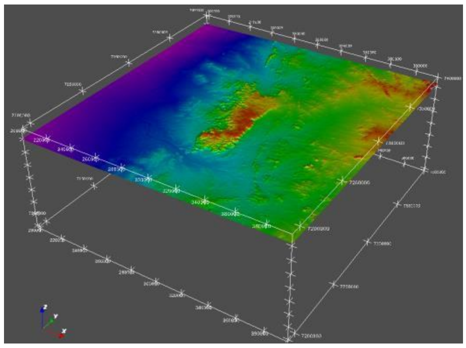
Gravity inversion (Murthy & Rao, 1970) gives a depth estimate to the top of the basement surface below each gravity anomaly. The depth contour grid was imported into *GeoModeller* and used to refine the modelling of the basement.

3D Geological Modelling

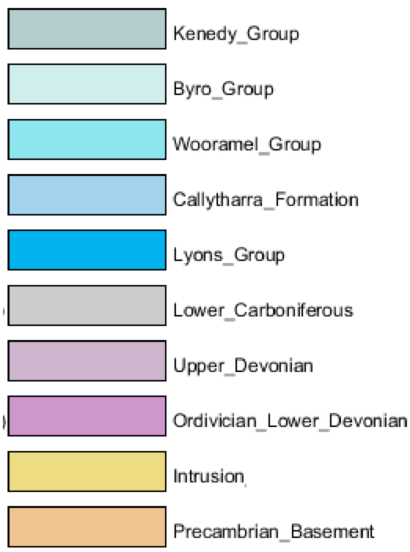
A 3D geological model of the Merlinleigh sub-basin was created using *GeoModeller*.

The software uses a 3D potential field approach (mathematical model) calculated from sparse geological data that can be imported or digitised manually. Data can include drill holes, contact and orientation data and cross-sections.

For this project the terrain was modelled using the SRTM 90m data from CGIAR-CSI (directly imported into *GeoModeller*).



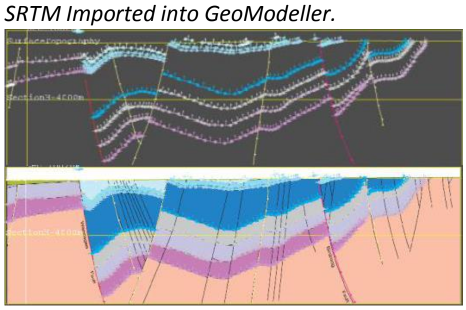
SRTM Imported into GeoModeller.



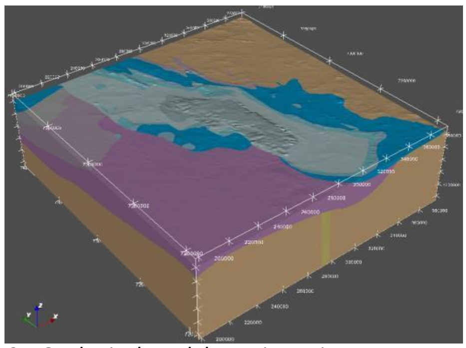
Stratigraphic pile of the Model.

The geology of the Merlinleigh basin was created and constrained using geological surface maps and interpreted seismic cross-sections from the report : "Structure and petroleum potential of the southern Merlinleigh sub-basin Carnarvon basin" produced by the government of Western Australia.

This interpreted geological model was then tested against the gravity and magnetic grids in a stochastic lithology Inversion.



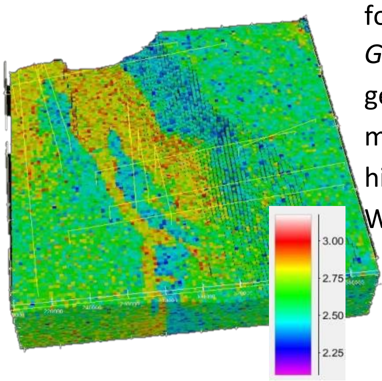
Interpreted seismic cross-section.



3D Geological Model post inversion.

Gravity and Magnetic Inversion

Properties optimisation

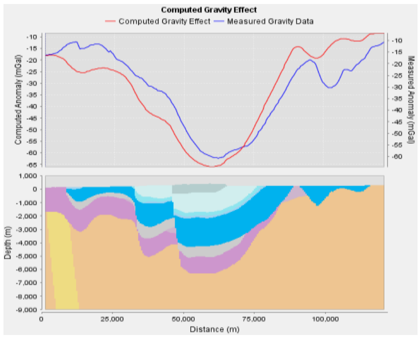


Because of an uncertainty on the densities and the susceptibilities values for each formation, the first step of the process was to run a property optimisation in *GeoModeller*. The property optimisation consists of an inversion of the model on geophysical properties only. The magnetic optimisation reveals a main magnetisation of the basement as predicted. However the gravity results show a high density body (around 2.8) in the basement (average density of 2.65) along the Wandagee fault.

With this result the original geological model was modified and an intrusion of density 2.82 was introduced along the fault.

Forward Modelling 2D and 3D

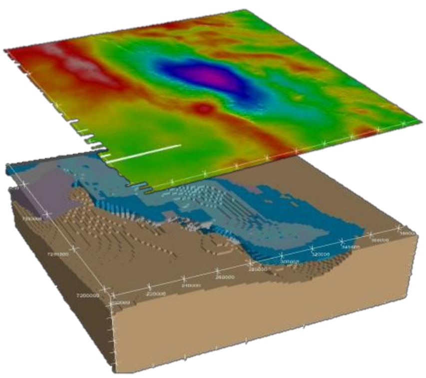
Before starting a full 3D Inversion the geological model was first tested against the observed magnetic and gravity data in a set of 2D and 3D forward models using *GeoModeller*.



Computed and measured signal on 2D section.

Gravity and Magnetic 3D Inversion

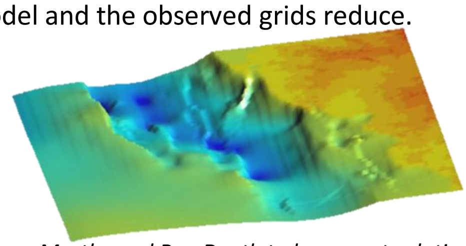
All information going into the creation of a 3D geological model has some error and the knowledge of geology usually decreases at larger depth. Inversion uses the geophysical information to refine the 3D model.



Voxelized Geological model and gravity grid.

At the start of inversion the initial geological model is voxelised into 3D cells (2000(X) x 2000(Y) x 250(Z) m. Each cell is attributed with a lithology, a density and a susceptibility value. During inversion these attributes of the cell are modified until the misfit between the gravity and magnetic response from the model and the observed grids reduce.

The final model from the inversion shows a slight change mainly in the basement.



Murthy and Roa Depth to basement solution

Conclusion

Using *Intrepid* (WormE and various depth to basement tools) and *GeoModeller*, a 3D geological model that honours the known geological data, and explains the gravity and magnetic data has been constructed.

References

- Spector, A., and Grant, F.S. (1970), Statistical methods for interpreting aeromagnetic data, Geophysics 35, pp 293–302
- Mosegaard and Tarantola (1995), and developed in 2D by Bosch et al. (2001).
- Murthy & Rao (1970), from Computers & Geosciences, Vol 15 No. 7 pp 1149-1156

Suite 110, 3 Male Street
Brighton, VIC 3186, Australia
Tel: +613 9593 1077
Fax: +613 9592 4142
Email: info@intrepid-geophysics.com
www.intrepid-geophysics.com