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Potential field interpretation and modelling in the deep-water Otway Basin

Yvette Poudjom Djomani
Geoscience Australia

Australian Government
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Introduction

Contrary to the onshore and shallow-water Otway Basin, where hydrocarbons have been discovered, the deep-water offshore basin is underexplored, as there have been sparse data in the past. The 2020 Otway Basin Seismic Program (OBSP) acquired 2D seismic, and over 8,200 line-kilometers of gravity and magnetic data (Fig.1).

Wavelength filtering of the newly acquired magnetic and gravity data provides valuable information on the geometry and the spatial extent of igneous rocks in the deep-water basin. Low-pass filtering of gravity data shows large positive anomalies correlating with major basement highs interpreted from seismic data. 2D modelling of the newly acquired magnetic data provides additional constraints on the size and extent of igneous rocks across the basin. Such modelling in the south eastern part of the basin shows large magnetic bodies at a depth of 12-19km, and a shallow body, 3.1km thick, at about 6km depth.

2020 Otway Basin Seismic Program

As part of the OBSP survey, gravity and magnetic data were acquired along all 2D seismic lines (Fig. 1). The magnetic data were merged with public domain survey data (Meyer *et al.*, 2017) to produce seamless magnetic maps of the combined onshore and offshore parts of the Otway Basin (Fig. 2). Similarly, the gravity data were merged with public domain satellite data (Sandwell and Smith, 2009) to produce gravity images (Fig. 3).

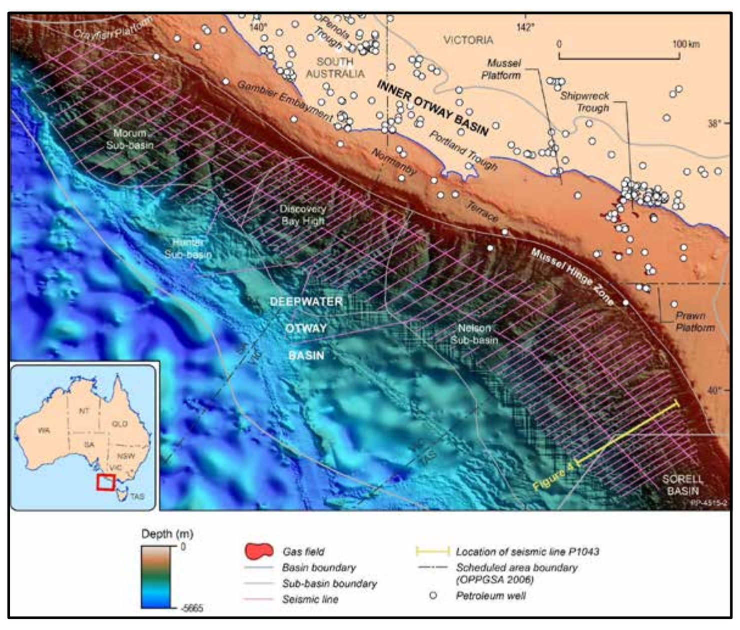

Figure 1. Map of the Otway Basin showing the location of petroleum wells and the Otway Basin Seismic Program seismic lines along which gravity and magnetic data were also acquired. The background image is a merge of the swath bathymetry (from the OBSP) and public-domain topography.

Enhancement processing of magnetic and gravity data

The merged gravity and magnetic data sets were further enhanced to better highlight some buried features.

Tilt angle of magnetic data

The tilt angle is a quantity derived from the ratio of vertical to total horizontal derivative and is defined by Miller and Singh (1994) as:

$$tilt\ angle = tan^{-1}\left(\frac{vertical\ component\ of\ gradient}{horizontal\ component\ of\ gradient}\right)$$

The tilt angle tends to normalise anomaly amplitudes and is positive over vertically-sided anomaly sources. Therefore, positive tilt angles can be used to help identify source bodies irrespective of magnetisation direction (Morse, 2010). Tilt angle for the merged magnetic grid of the Otway Basin is shown in Figure 2. The image shows some narrow magnetic highs that correlate with igneous rocks identified in wells in the onshore Otway Basin. For example, 25 m of igneous rocks were intersected in Casterton 1 at 2400 m depth. This correlation can be used to predict the location of igneous rocks in the inshore. A similar correlation between magnetic anomalies and igneous rocks in wells was seen in the Browse Basin on Australia's North West Shelf (Hackney *et al.*, 2015). The correlation between the magnetic tilt anomalies and igneous rocks onshore suggests that this magnetic filter may be used to map the distribution of such rocks in the Deep-water Otway Basin.

High pass filtering of gravity data

Figure 3 shows a 150 km high pass filter of the combined gravity data over the Otway Basin. This filter emphasizes anomalies with wavelengths less than 150 km and is useful to map the Continent-Ocean Boundary and areas of basement highs or exhumed mantle, within the basin. It should be noted that the new gravity data has higher resolution than the satellite-derived data.

The interpretation of seismic lines has identified some basement highs in the outer margins of the basin (Nicholson *et al.,* 2022). These highs correlate well with the positive gravity anomalies as seen on the high-pass 150 km filtered data. This correlation suggests that the enhanced gravity data is a good tool to use for mapping major structural elements across the Deep-water Otway Basin and is valuable in resolving structural trends across the seismic coverage.

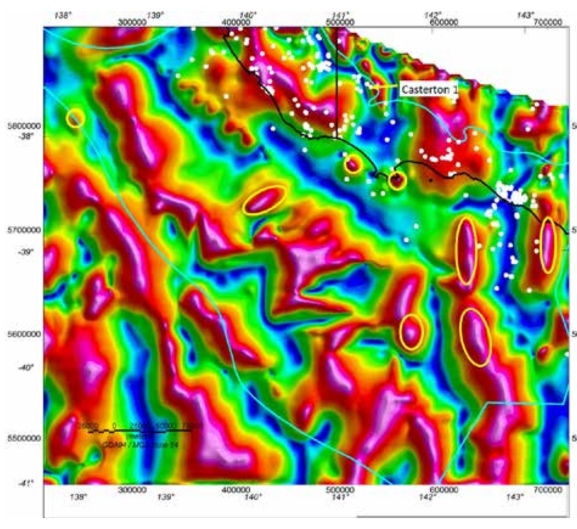

Figure 2. Tilt derivative image of the merged public-domain and magnetic data acquired during the Otway Basin Seismic Program. The coastline is shown in black for reference. The cyan line is the outline of the Otway basin. Note the location of the onshore Casterton 1 petroleum well which correlates with a positive magnetic anomaly and where igneous rocks were intercepted at 2400m depth.

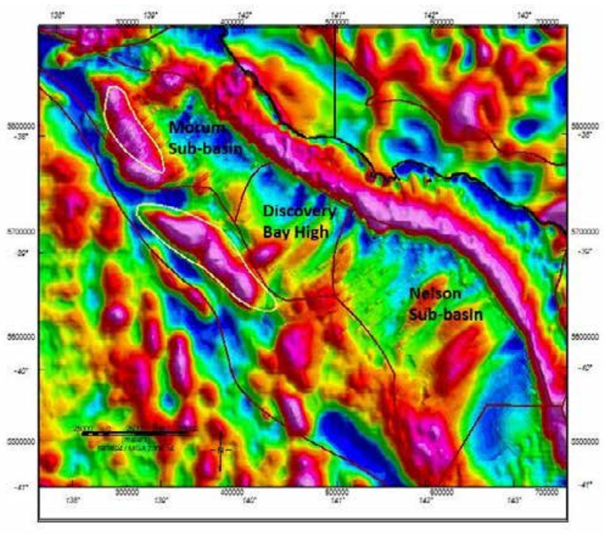

Figure 3. This image shows the 150 km high-pass filter of the merged gravity grid overlain by polygons representing outer margin basement highs (large yellow polygons) derived from the interpretation of seismic data. Note the correlation between the outer margin basement highs and large positive gravity anomalies. The brown labelled polygons are the major structural elements of the Otway Basin (Nicholson et al., 2022).

Magnetic data modelling

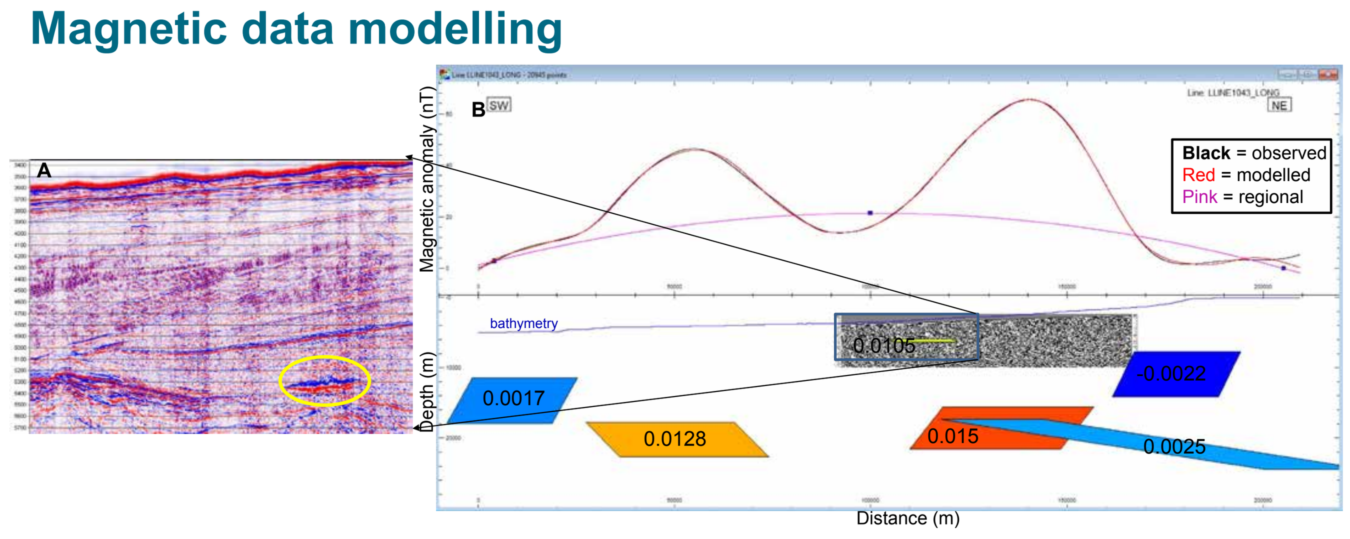

Figure 4. Magnetic modelling of seismic line P1043 (location in Figure 1). A) part of seismic line P1043 (Schenk *et al.*, 2021) showing an interpreted igneous body at 5 km depth (marked by the yellow ellipse). The seismic image was used as backdrop for the modelling. B) 2D magnetic modelling of line P1043. The top part shows the observed (black) and modelled (red) magnetic anomalies. The pink line is the regional magnetic response computed from the data. The bottom part is the depth section showing a series of tabular magnetic bodies labelled with their susceptibilities. The red line is the modelled combined effect of these bodies. Most bodies are at a depth of 12-19 km. The igneous occurrence from Fig 4A is modelled with a susceptibility of 0.010 S.I on the flank of a large positive magnetic anomaly.

Conclusions

The new gravity and magnetic data, acquired during the 2020 Otway Basin Seismic Program, were processed and integrated with existing open-file data to produce a merged dataset for the onshore and offshore Otway Basin. Enhancement processing of the data provides valuable information on basement structure and the possible distribution of igneous rocks. For example, tilt angle of the magnetic data shows narrow magnetic highs that correlate with igneous rocks identified in wells in the onshore Otway Basin. This correlation suggests that the tilt filter grid can be used to predict the distribution of such rocks in the deep-water areas where there are no wells. The newly acquired seismic data reveals basement highs that correlate well with the positive gravity anomalies evident in the high-pass 150 km filtered data. This correlation suggests that the enhanced gravity data is a good tool to use for mapping large-scale structural elements within the deep-water areas. Magnetic data modelling suggests large magnetic bodies within 12-19 km depth. While the seismic interpretation predicts the position of the igneous body at 5 km depth, the magnetic modelling provides information on its size (3.1 km).

The information on this poster is available for download from Geoscience Australia's product catalogue website (https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/146433) and via this QR code.

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For Further Information: Dr Yvette Poudjom Djomani
Email: yvette.poudjomdjomani@ga.gov.au
Ph: +61 2 6249 9224 **Web:** www.ga.gov.au