



Aeromagnetic investigation of the source to the Dunkley Magnetic Anomaly, Western Tasmania

By

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1. Introduction

This project involves the characterisation of the source to the Dunkley Magnetic Anomaly in the Rayne Tenement of Western Tasmania through forward modelling of magnetic data.

The **Dunkley Magnetic Anomaly (DMA)** (Figure 1) is a positive magnetic anomaly, located in the northeast of the Rayne Tenement. The anomaly covers an area of approximately 6 km² and has a relative maximum amplitude of ~1000 nT above regional magnetic values, the lowest of which form an arcuate magnetic trough to the southeast (Figure 1).

Superimposed on the DMA is a small-scale circular magnetic anomaly, labelled as "**peak anomaly**" (Figure 1), that measures approximately 500 m in diameter and has an amplitude of up to 650 nT (relative to regional magnetic values). It has been made clear to me that this anomaly is currently of keen interest as having economic potential and as such the nature of the source to this small-scale anomaly is also a focus of this project (Tom Whiting, Pers. Comm.).

The DMA comprises a series of magnetic ridges (Figure 1) which are oriented approximately north-south but at their southern ends appear to be slightly folded towards the west. These ridges may be the magnetic expressions of structural undulations of the surface of a magnetic source body, e.g. hinges of gentle, open upright folds or fault slices or may be due to discrete linear magnetic source bodies.

1.1 Local geology and previous exploration

Kilpatrick (1985) describes the local stratigraphy, structure and mineralisation, which can be summarised as follows:

Basement (>700 m thick), comprises Precambrian Oonah quartzites and slates, later mudstones, siltstones, dolomites with minor lava and volcanic breccias. Basement is overlain by the (>820 m thick) **Lower Cambrian Success Creek Group (SCG)** sandstones and polymict conglomerate, quartz sandstones and siltstones and later black mudstone, siltstone and sandstone. Conformably overlying the SCG is the Cambrian **Crimson Creek Formation (CCF)**, a thick (i.e. >1000 m) sequence of tuffaceous siltstones, greywackes and clastic sediments. The Ordovician-Silurian **Eldon Group** is locally faulted against the CCF but does not occur in the vicinity of the Dunkley Magnetic Anomaly, where only the SCG and CCF outcrop and are likely to be in fault contact with each other.

Local structure is dominated by gentle to moderate open folding (Devonian Tabbarabbaran Orogeny) of flat-lying stratigraphy which is overprinted by

widespread steep to moderately-dipping normal faults, juxtaposing CCF against the SCG in outcrop at the surface. Granite bodies which intruded during the Tabbarabbaran Orogeny occur at basement depths (i.e. 500-1200 m depth). Elsewhere locally, these granite bodies have been interpreted as sources to positive magnetic anomalies in the area (Adrian Rigg, Pers. Comm.).

Economic mineralisation is believed to have been produced by mineralising hydrothermal fluids associated with orogenic granite emplacement. Mineralisation occurs as thin (<20 m thick) stratabound dolomite-siderite-carbonate horizons which occur at the top of the SCG and at the base of the CCF, through carbonate replacement and skarn-derived deposits. This mineralisation is also thought to occur along associated feeder faults.

1.2 Rock properties and other modelling constraints

Drilling was previously undertaken to test the source to the “peak anomaly” (Kilpatrick (1985); Figure 1). This drillhole (S1200) was drilled to a depth of 598.6 m and penetrated only non-magnetic Cambrian CCF rocks from collar to end of hole. The drillhole begins ~120 m to the east of the maximum amplitude of the peak anomaly and has an average westward dip of ~60°, therefore intersects rocks directly beneath the peak anomaly at a depth of approximately 200 m (Kilpatrick, 1985). Hence, the source to the peak anomaly of the DMA must occur at depths greater or less than ~200 m (i.e. this magnetic source was not penetrated by drillhole S1200). The geological log of Drillhole S1200 is honoured in forward modelling of magnetic profiles for this project.

Magnetic susceptibility measurements were taken at one metre intervals along the length of drillcore extracted from drillhole S1200 (Kilpatrick, 1985). Results show that the bulk magnetic susceptibility of Cambrian sediments (CCF) is negligible. No magnetic rocks were intercepted by the drillhole.

In contrast, rock properties given by Leaman and Webster (2002) show that the Cambrian sediments (CCF and SCG) have a magnetic susceptibility of greater than 0.01 SI; that Precambrian basement (e.g. the Oonah Quartzites etc) has a bulk rock magnetic susceptibility of 0.0025-0.0060 SI; and that Devonian granites and granodiorites have a magnetic susceptibility of ~0.0025 SI. This magnetic susceptibility seems low however, given that the same report discusses the “magnetic” nature of Devonian granites in the Renison and Zeehan areas adjacent to the study area, especially with respect to associated magnetic metamorphic aureoles.

Local stratigraphy, depths to lithological contacts and structure as indicated by the stratigraphic column and summary of geology provided in Kilpatrick (1985) are honoured in forward models for this project. For the purposes of modelling, lithological units have been simplified into groups with similar magnetic susceptibilities.

1.3 Project aims

- 1) To characterise the source of the Dunkley Magnetic Anomaly in terms of geometry, depth and magnetic susceptibility.
- 2) To characterise the source of the “peak anomaly” superimposed upon the Dunkley Magnetic Anomaly.

2. Methodology

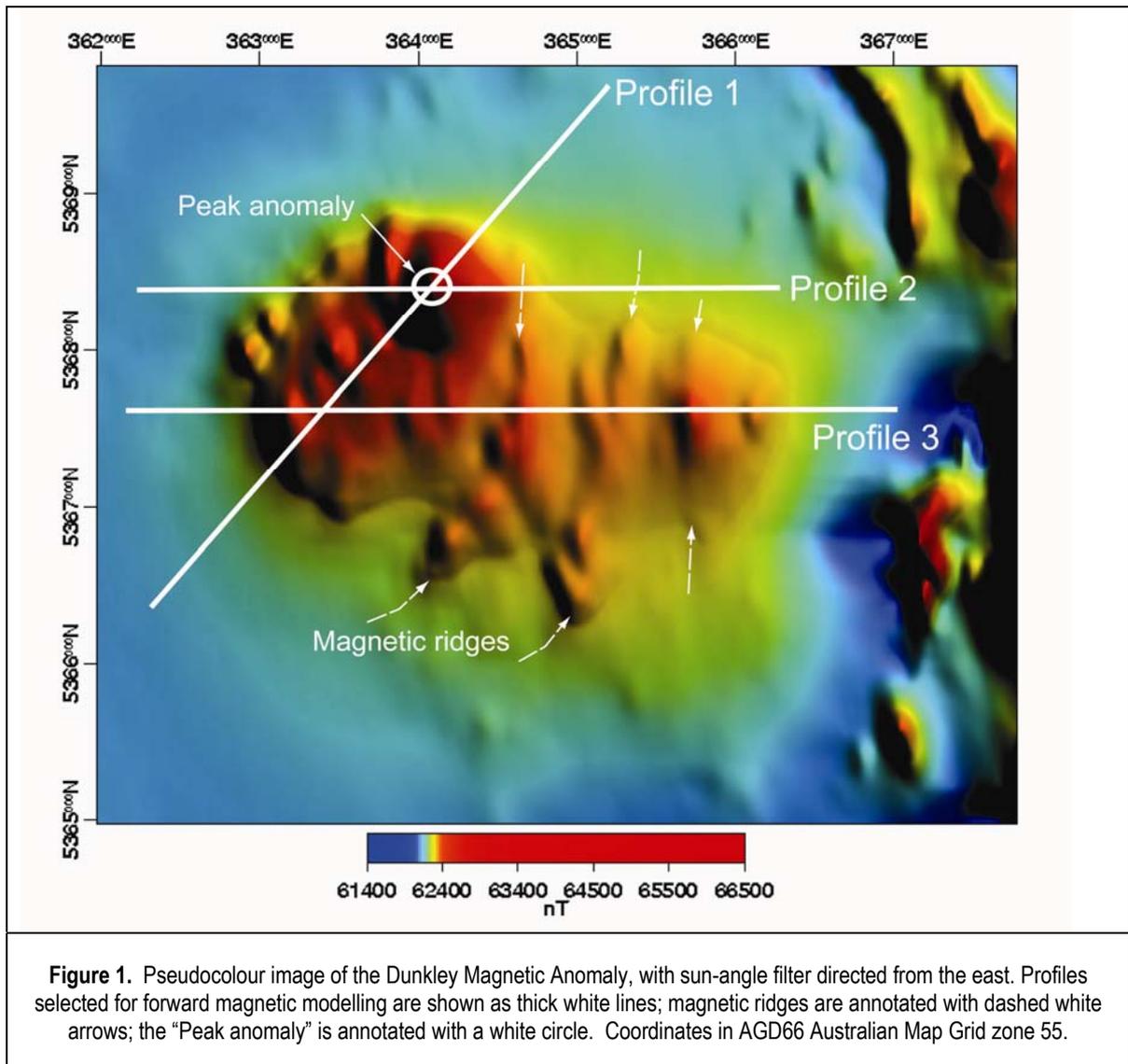
2.1 Gridding and grid stitching of magnetic datasets

The 2001 West Tasmania (WTRMP Area C) dataset with a flight line spacing of 200 m was used as a regional dataset onto which datasets of smaller area and generally higher resolution were stitched to form a composite grid. The final magnetic grid from which magnetic profiles were extracted is a composite of the following aeromagnetic grids:

- 2001 West Tasmania (WTRMP Area C) with a flight line spacing of 200 m
- 2002 WTRMP Mount Read Volcanics with a flight line spacing of 200 m
- 1985 CSR Cuni (relevelled dataset) with a flight line spacing of 100 m
- 1995 CSR Zeehan Area 2 with a flight line spacing of 80 m

This composite grid is imaged in Figure 1.

A fifth ungridded dataset, the 1993 CRA Melba Flats dataset was found to contain six bogus outlier data points (with E,N coordinates of (999999.0,9999999.0)) causing initial gridding problems. Each of these points was deleted before a successful grid could be made. However the final grid produced showed that the data had been poorly levelled and is therefore not sensible in its current form, for use in extracting profiles to forward model. Further, the Melba Flats grid was situated in the same location as the Cuni dataset. For these reasons, the Melba Flats dataset has not been used in this project.



2.2 Extraction of magnetic profiles

The location of Profile 1 (Figure 1) was selected to provide a northeast-southwest oriented perspective through the western-most part of the DMA as well as intersecting the “Peak anomaly”. The location of Profile 2 (Figure 1) was selected to provide an east-west oriented perspective through the northern-most part of the DMA as well as intersecting the “Peak anomaly”. The location of Profile 3 (Figure 1) was selected to provide an east-west oriented perspective through the central, widest extent of the DMA as well as passing orthogonally through the north-south oriented magnetic ridges.

Forward modelling was carried out using the following magnetic field specifications for Zeehan, Tasmania:

Magnitude H: 18 978 nT

Inclination I: -72.236°

Declination D: 13.030°

(Source: Geoscience Australia website)

Forward modelling of magnetic data along these profiles was initially conducted on the premise that the broader DMA may be the magnetic expression of a Devonian granite at basement depths (i.e. >500 m depth) and that the “peak anomaly” may be the magnetic expression of a discrete, smaller-scale magnetic body situated at depths shallower than basement. Interpretations of this smaller-scale magnetic body may include: a slice of ultramafic material or a skarn/dyke/flat-lying pyrrhotite body that may be associated with the contact between the CCF and the SCG or a fault structure. It has been indicated to me that this type of magnetic body may exist at depths of ~300 m (Tom Whiting, Pers. Comm.). Magnetic ridges evident in the pseudocolour image of the DMA (Figure 1) may be the magnetic expression of faulted or folded magnetic granite.

In order to obtain a three dimensional interpretation of the DMA, each profile is modelled to be consistent with where it intersects with the other two profiles.

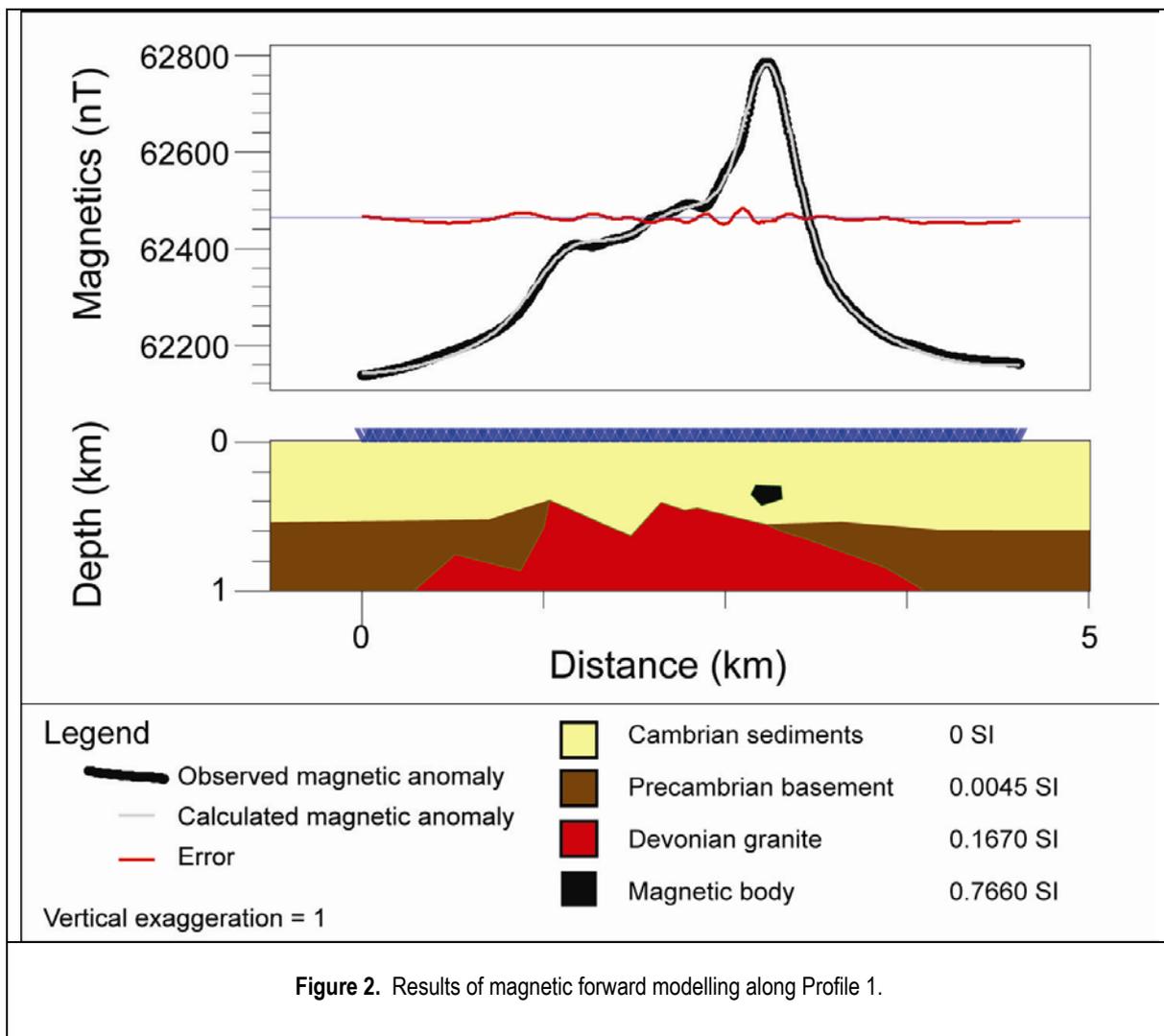
3. Results of forward modelling

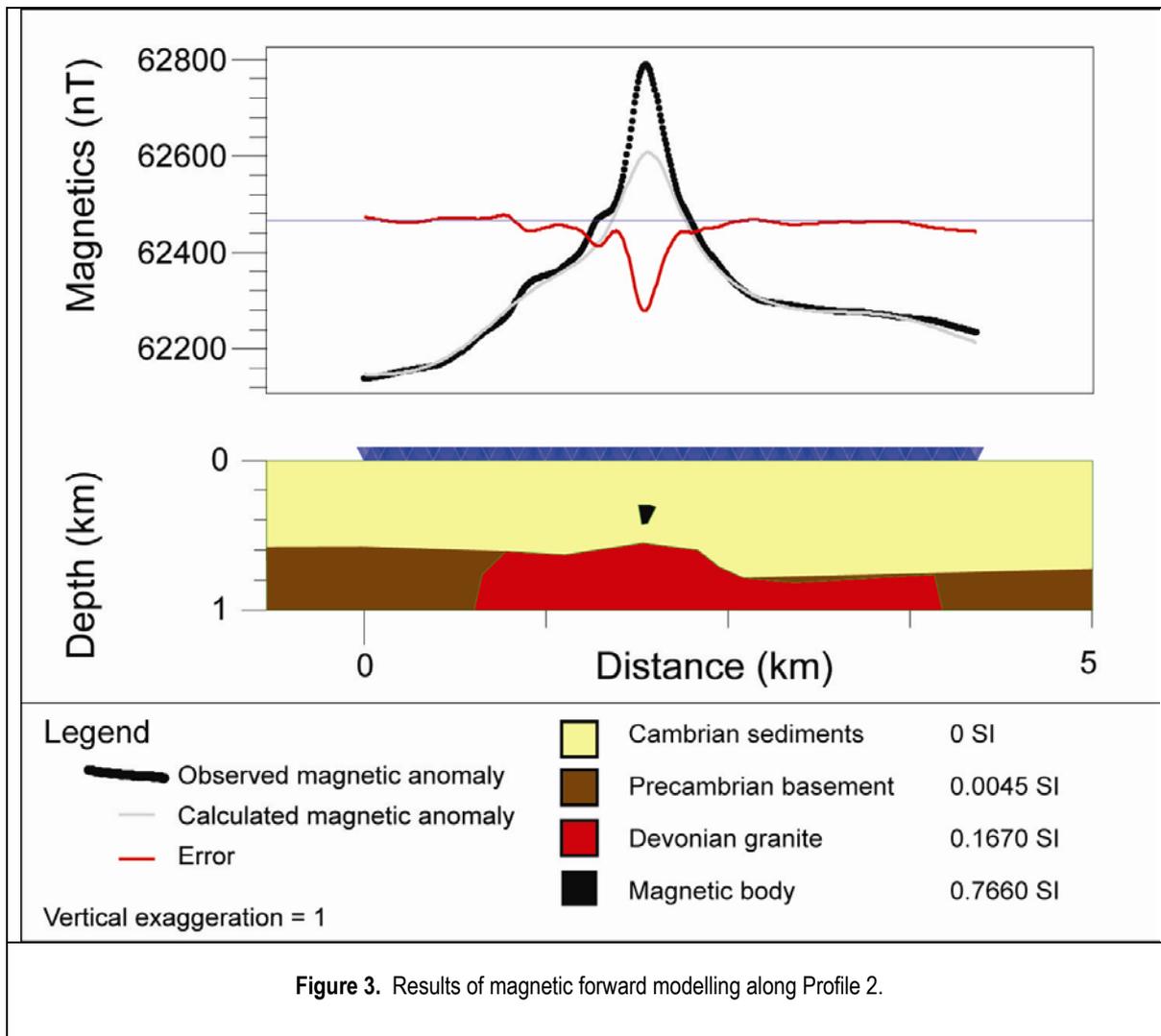
In all three modelled profiles (Figures 2-4), Precambrian basement at depths of greater than 500 m and having relatively low (0.0045 SI) magnetic susceptibility is responsible for the regional magnetic field. The source to the DMA is a body of higher magnetic susceptibility (0.1670 SI), which is enclosed within basement. This basement body is modelled to be ~2.5 km wide in a northeast-southwest direction along Profile 1, ~2.9 km wide along east-west Profile 2 and ~3.5 km wide along east-west Profile 3 and is interpreted as an intrusive, magnetic (relative to basement) Devonian granitoid.

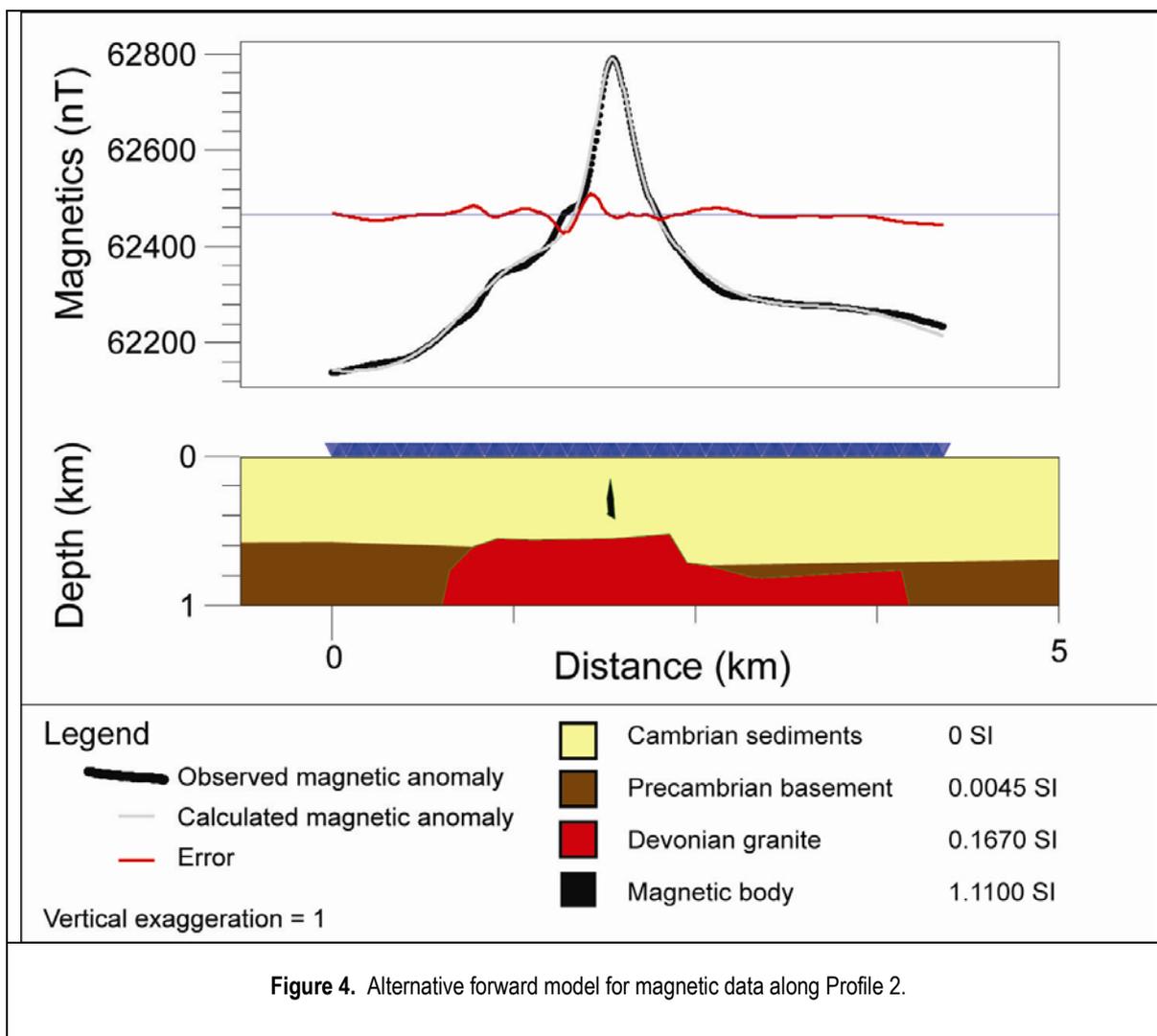
The source to the “peak anomaly” is modelled in Profiles 1 and 2 (Figures 2 and 3) as being ~100 m wide in both the NE-SW direction (Profile 1) and the E-W direction (Profile 2). This body is also modelled to be just over 100 m in depth extent (extending from ~300 to ~400 m deep) and is therefore relatively symmetrical in three dimensions. This modelled body possesses an unrealistically high magnetic susceptibility of 0.7660 SI. However when modelled to have a lower susceptibility, the body must be much shallower and wider, therefore contradicting geological information given by Drillhole S1200. As such, this shallow option is rejected and it is concluded that the unreasonably high magnetic susceptibility modelled for the source to the peak anomaly may be due to the bulk regional susceptibilities of surrounding rocks being underestimated. For Profile 2 (Figure 3), the calculated effect of the same magnetic source body (e.g. modelled to have the same susceptibility and geometry as in Profile 1) is not

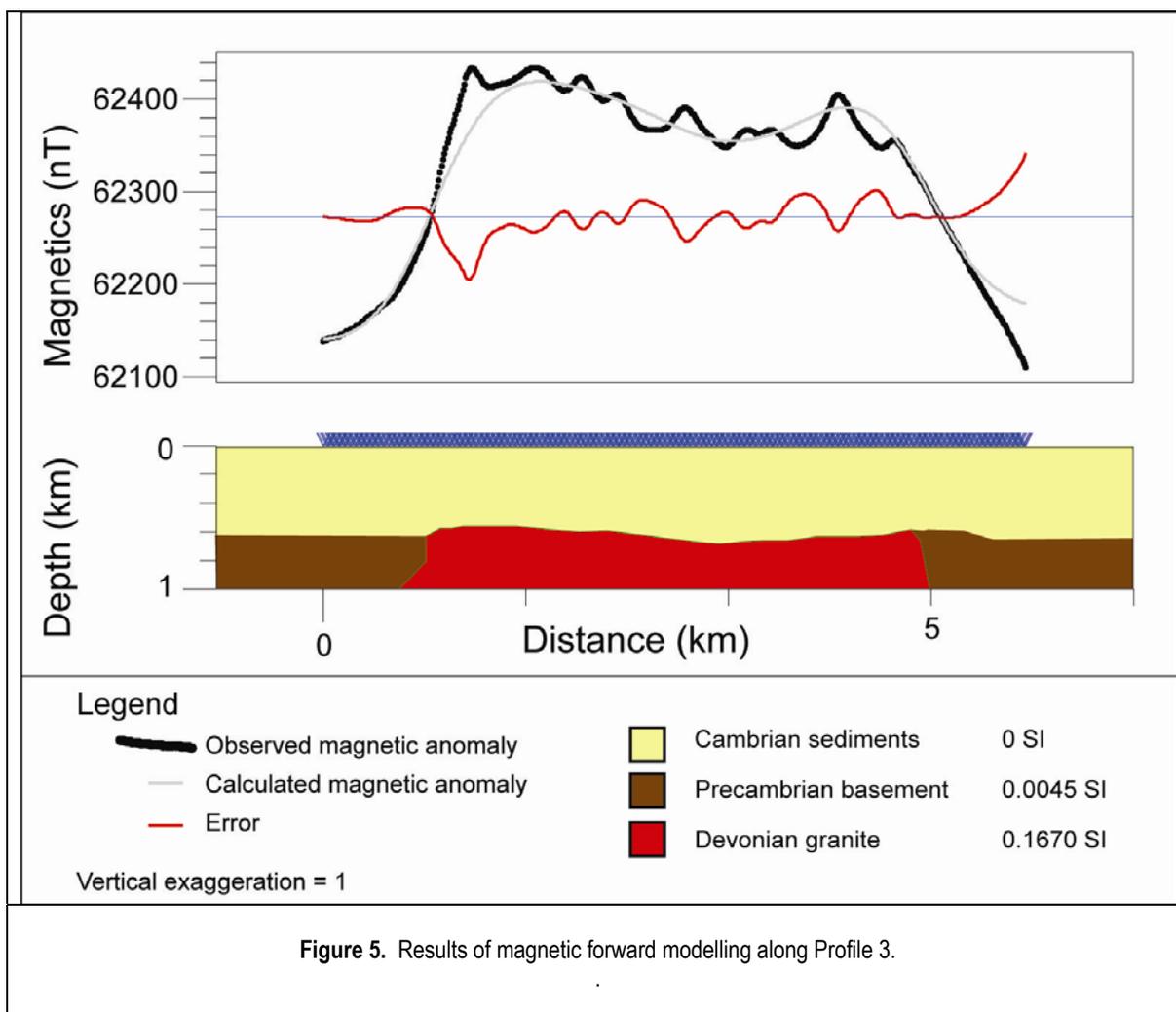
high enough in amplitude to honour the observed magnetic data. An alternative model for Profile 2 (Figure 4) shows the magnetic source body of the “peak anomaly” to extend from ~150 to ~400 m depth and is only about 500m in width. Moreover, this alternative body has an even higher magnetic susceptibility of 1.1100 SI. This model has a calculated effect that matches the amplitude of the “peak anomaly”, however given that Drillhole S1200 did not penetrate a magnetic body of any kind (at a depth of ~200 m), this alternative model should be rejected on the grounds that it contradicts existing geological data.

Figure 5 shows the forward model of Profile 3. The magnetic ridges superimposed upon the DMA may not be reconciled by modelling undulations in the surface of the (interpreted) magnetic Devonian granite within basement rocks as the short wavelengths require a much shallower (probably near-surface) source. Further modelling may be undertaken to determine the sources to these magnetic ridges, if required.









4. Conclusions

The best-fit, constrained forward modelled results show that:

- Precambrian basement at depths of greater than 500 m has a relatively low (0.0045 SI) magnetic susceptibility and is responsible for the regional magnetic field.
- A possible source to the Dunkley Magnetic Anomaly is a magnetic (relative to basement) body enclosed within Precambrian basement at depths of greater than ~500 m. This modelled body is ~2.5 km wide in a northeast-southwest direction along Profile 1, ~2.9 km wide along east-west Profile 2 and ~3.5 km wide along east-west Profile 3 and is interpreted as an intrusive magnetic (relative to basement) Devonian granitoid.

- The source to the “peak anomaly” can be modelled as a body that is ~100 m wide in both the NE-SW and E-W directions as well as being just over 100 m in depth extent (extending from ~300 to ~400 m deep) and is therefore relatively symmetrical in three dimensions. This modelled body is extremely magnetic relative to all other lithologies modelled.
- ~N-S oriented magnetic ridges have short wavelengths that cannot be reconciled by magnetic bodies at basement depths but are probably the expression of near-surface magnetic bodies.

References and acknowledgements

Kilpatrick, D.J., 1985. Open file report book 85/2450, Renison Ltd.

Leaman, D.E. and Webster, S.S., 2002. Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program. Tasmanian Geological Survey Record 2002/15.

All aeromagnetic data were obtained from the Department of Infrastructure, Energy and Resources, Tasmania (Mineral Resources Tasmania) website: <http://www.mrt.tas.gov.au>

Geomagnetic reference values were obtained from the Geoscience Australia website: <http://www.ga.gov.au/oracle/geomag/agrfform.jsp>

Tom Whiting and Adrian Rigg (Stellar Resources) provided useful background information concerning this project.

Supplementary notes to be appended to PGN Report 2/2008 for Stellar Resources, January 2008.

For the Dunkley Magnetic Anomaly project, I had assumed that the original modeling (undertaken for report 85-2450) had been done along an E-W profile (i.e. Line 600S, shown as roughly E-W oriented on page 22 of Report 85-2450).

However Drillhole S1200 was actually drilled along a WSW bearing and I now understand that Line 600S does not run E-W but is parallel with the drillhole (i.e. WSW).

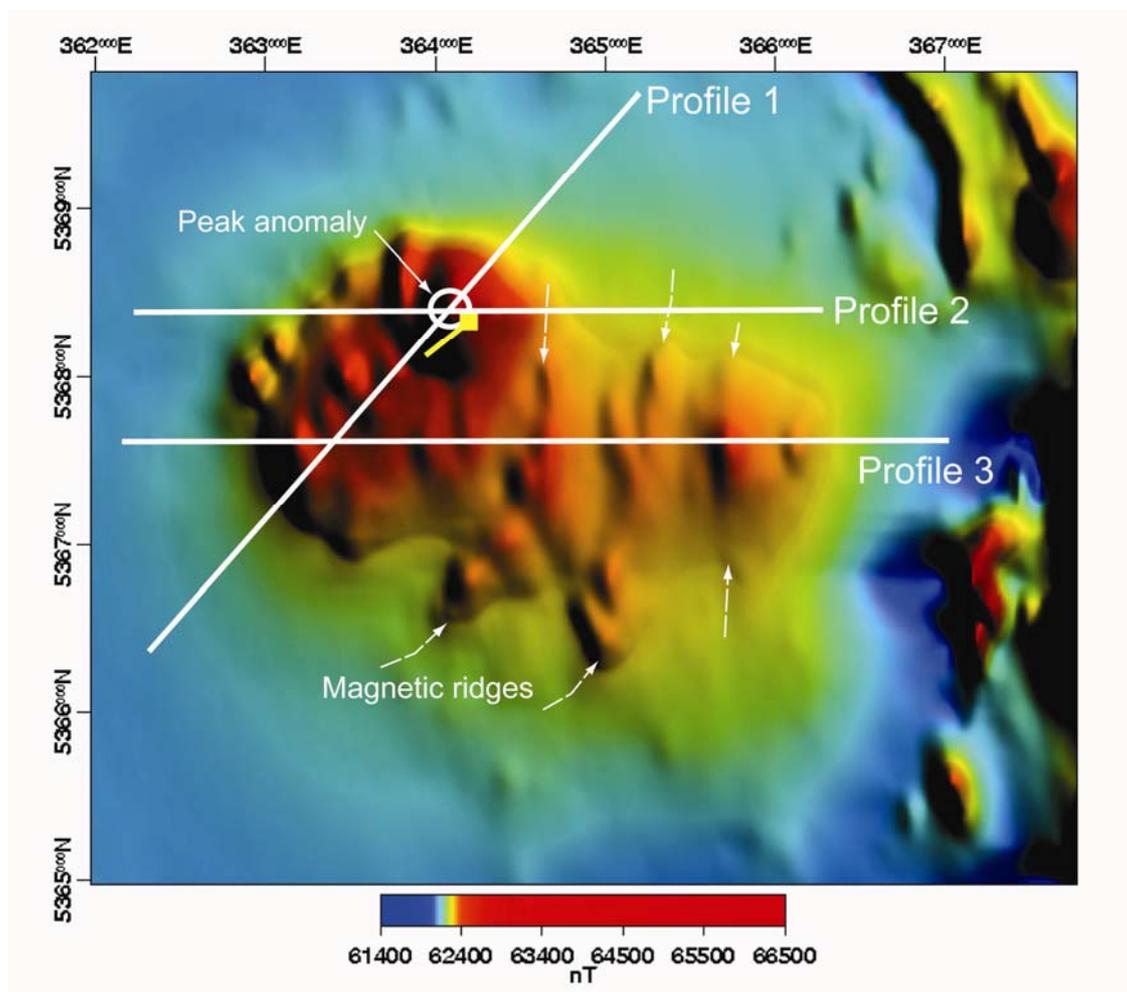


Figure 1: Dunkley Magnetic Anomaly with “peak anomaly” and profile locations relative to Drillhole S1200. Yellow square denotes where drillhole begins; yellow line denotes lateral trajectory of drillhole.

Drillhole S1200 (shown as yellow square while the lateral distance drilled is shown as a yellow line; Figure 1) actually begins at AGD66 (zone 55) coordinates of: 364208mE, 5368338mN and continues to the ~WSW for 324 m lateral distance (as shown in map view Fig 1) to a vertical depth of 496 m below the surface (equating to a downhole depth of 598 m). At this location the drillhole does not intersect with the peak anomaly (Fig. 1).

Therefore, Drillhole S1200 does not actually intersect with either of my models Profile 1 or Profile 2 but rather begins ~140 m southeast of Profile 1 and ~60 m south of Profile 2 (though Profile 1 does run approximately parallel with the bearing of the drillhole).

Figure 2 shows Drillhole S1200 if projected (140 m towards the NW) onto modeled Profile 1. The drillhole would begin at 2.72 km along Profile 1 and run along a bearing parallel to the profile. Drillhole S1200 would intersect with Profile 2 above the surface of the Earth.

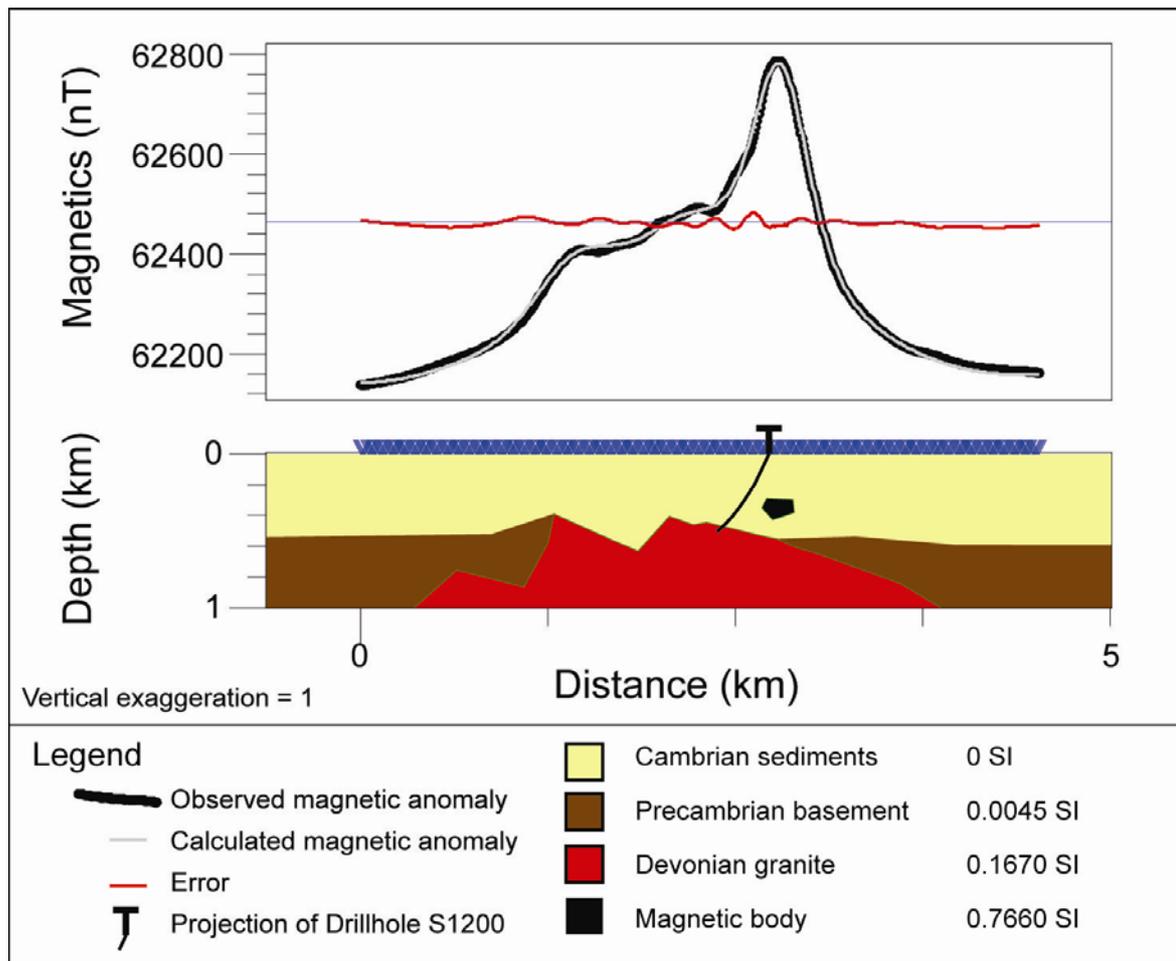


Figure 2: Results of forward magnetic modeling along Profile 1 with the projection (from ~140 m SE; parallel to the profile) of Drillhole S1200.

So if we were to honour the geological data interpolated from the drillhole, there would be obvious problems with Profile 1 (e.g. surface of the granite is too shallow) and this would need to be re-modelled.

As an alternative, I could model a new profile of data that runs exactly along the trajectory of Drillhole S1200 (NB: this would not intersect with the “peak anomaly” (Fig. 1) but may help to constrain the magnetic expression of any magnetic body that may exist directly beneath the new profile).

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