Magnetic mentor

David Pratt
Tensor Research
E david.pratt@tensor-research.com.au

Increasing depth perception with pseudo-gravity

I have dedicated this edition of the *Magnetic mentor* to Richard Lane as he stimulated discussions on this topic following a visit with Clive Foss to Geoscience Australia. Richard invited us to a meeting with a regional mapping group who were using ModelVision to validate their geological section interpretations. The near surface geology was constrained by magnetic data while the lower resolution gravity data was used to investigate alternative structural interpretations in the deeper regions of their sections. In the October edition of the *Magnetic mentor*, I demonstrated how the basement immediately below the bedrock unconformity dominates the magnetic information and it is difficult see beyond the unconformity. This leads us to a discussion on the possible use of the pseudo-gravity transformation for greater depth of investigation.

Pseudo-gravity as an integration

Pseudo-gravity is computed using a FFT transformation to perform a reduction to the pole (RTP) and vertical integration of the anomalous magnetic intensity field (AMI). I am introducing the AMI term to differentiate it from total magnetic intensity or the abbreviation TMI. AMI is the residual magnetic intensity after subtraction of the IGRF. The transform also assumes that all anomalies are induced, and no significant magnetic remanence is present that will shift the magnetisation vector away from the expected IGRF direction.

The transformation uses a fundamental relationship between the magnetic and gravity gradient fields known as the Poisson relation. A proportionality constant C_p that defines the relationship between them is defined by $C_p = \frac{kFC_m}{\rho\gamma}$, where ρ is the density contrast, k is magnetic susceptibility, F is the scalar amplitude of the total magnetic field and γ is the universal gravitational constant (Blakely 1995). C_m is a constant used to manage the difference between SI and cgs-emu units.

I presented this concept to the 2004 Sydney ASEG conference (Pratt and Shi 2004) where we were able to demonstrate the presence of a deep, high magnetic susceptibility intrusion beneath a granite. We were awarded Best Minerals Paper, and the extended abstract has proved to be very popular on ResearchGate.

In this context, you can model and invert pseudo-gravity data using conventional gravity modelling tools where the density is treated as pseudo-density. **Figure 1** illustrates the change in character of the first vertical derivative (FVD), anomalous magnetic intensity (AMI) and gravity over a range of simple geological shapes along a west to east profile. The magnetic field inclination is -60 degrees and declination zero. The FVD has the most detail and picks up the edges of the shallow bodies while the AMI is much smoother. The gravity data is symmetric and smoother where the width of the anomalies has increased relative to the AMI trace. Each field parameter is seeing a different proportion of the magnetic material beneath the unconformity where Gravity > AMI > FVD. See ***Magnetic mentor* – Depth of penetration** for a more detailed explanation of the AMI and FVD case.

The concept of an equivalence between magnetic susceptibility and density is not all that intuitive. Think of it as a function of the magnetite content per cc instead of grams/cc. The magnetite content is not linearly related to density because there is a logarithmic relationship between magnetic susceptibility and magnetitecontent.

Amadeus Basin continued

In the October *Magnetic mentor* article, I showed you how to use monochrome to enhance depth variations in magnetic images and the limitations of depth of penetration. In this article we use the pseudo-gravity image to look deeper. **Figure 2** shows the FVD (b), RTP (d), pseudo-gravity(c) and Bouguer gravity (e) images over a large section of the Amadeus Basin with an interpretive outline of the basin from Geoscience Australia. All grids used for creating the images (**Figure 2**) were downloaded from the Geoscience Australia GADDS website. The regional scale pseudo-gravity grid is automatically clipped to your area of interest which means you don't have to run the pseudo-gravity transformation. When using a subset of a TMI grid, long wavelength artifacts are introduced due to integration of the padding zone during the FFT phase transformation procedure. The paper by Pratt and Shi (2014) shows you how to reduce or remove the long wavelength artifacts to enhance shallow targets for minerals exploration.

In this example, the FVD has the best match with the basin boundary because it is suited to imaging the near surface geology or basement. The pseudo-gravity image exhibits a high over most

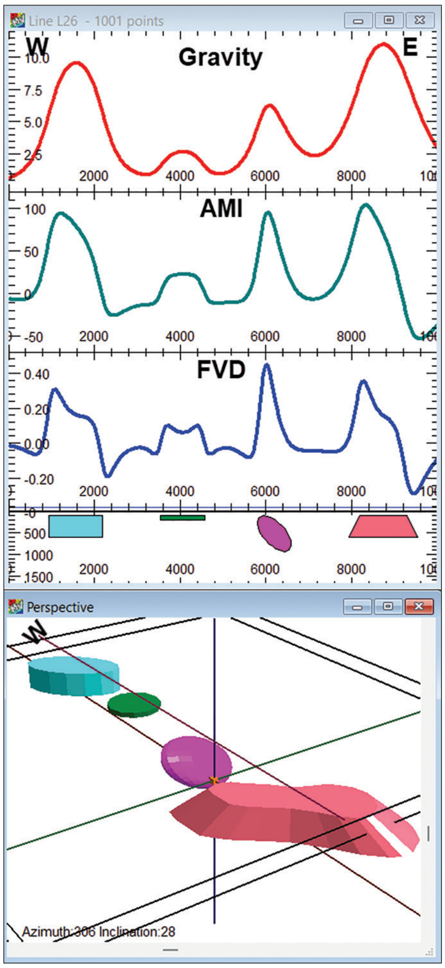

Figure 1. *1VD, AMI and gravity model results over different geological model shapes (pipe, sill, ovoid and frustum shaped intrusions).*

of the basin area which is attributed to the early Neoproterozoic rift volcanics. The northern side of the basin abuts the Arunta Complex, and it appears to be associated with a steep faulted margin. The sharp gradient in pseudo-gravity on the south-west side of the basin is well outside the mapped basin boundary and most likely associated with the Woodroffe Thrust that has created the thin sliver of the amphibolite-facies Mulga Park Zone (Howard *et al*. 2011). The RTP image hints at the overthrust, but it is much more obvious in the pseudo-gravity image. The high zone crosses the south-east edge of the basin where it continues into the Pedirka Basin which in turn is beneath the Eromanga Basin. You can see a very steep north-east trending edge to the pseudo-gravity which is parallel to the local Bouguer gravity trend.

I want to thank my colleague Blair McKenzie for his insight and contributions to this article on pseudo-gravity interpretation. See the ***Magnetic Mentor* series** link to download data and related information for this and previous editions.

References

Blakely, R.J. 1996. *Potential theory in gravity and magnetic applications*. Cambridge University Press 1996

Howard, H. M., R. H. Smithies, P. M. Evins, C. L. Kirkland, M. Werner, M. T. D. Wingate and F. Pirajno. 2011. Explanatory notes for the west Musgrave Province, Record 2011/4. Geological Survey of Western Australia, Perth.

Pratt, D. A. and Z. Shi. 2004. An improved pseudo-gravity magnetic transform technique for investigation of deep magnetic source rocks, ASEG Extended Abstracts, 2004:1, 1-4, DOI:10.1071/ASEG2004ab116

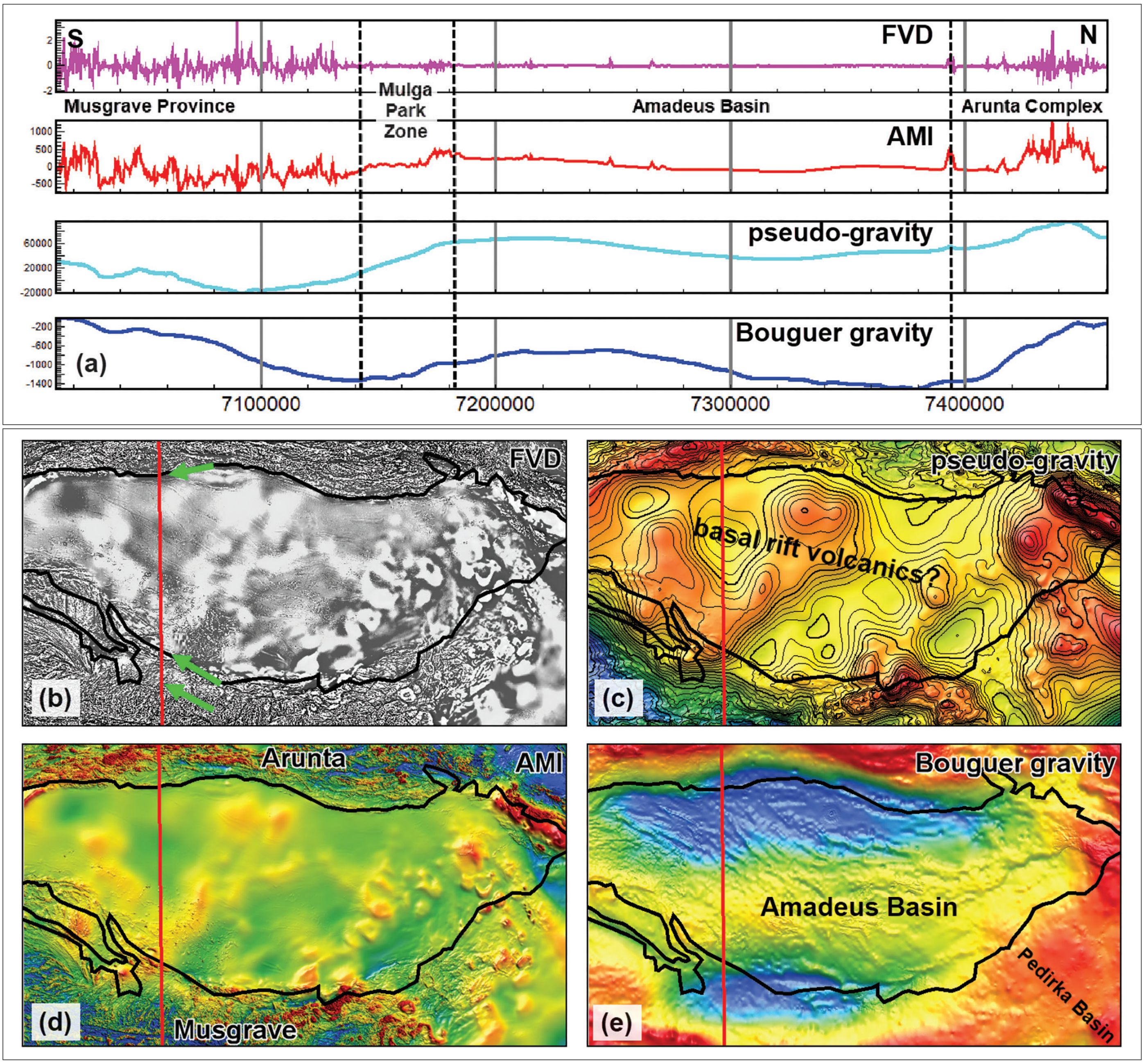

Figure 2. *An integrated image and muti-track graph (a) of a north-south profile across the four grid images of FVD (b), pseudo-gravity (c), reduction to pole (RTP) (d) and spherical cap Bouguer gravity (e). All grid images use a clipped, linear colour stretch. The dashed lines on the graph and green arrows on image (b) show the boundaries of the major geological domains.*