10.1071/PVv2012n157p42

The constrained magnetic modelling of the Wallaby gold deposit, Western Australia

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This article reports on Sasha Banaszczyk's Honours project, which was sponsored by the ASEG Research Foundation. Sasha's project was supervised by Mike Dentith at The University of Western Australia and Yvonne Wallace and Lee Sampson at Barrick (Australia Pacific).

Project summary

With minerals exploration becoming reliant on understanding the deeper subsurface in detail, the development of 3D geophysical inversion is becoming essential. Due to the non-uniqueness of inversion an infinite number of solutions can be found to fit original potential field data; however, this can be overcome by applying geological and mathematical constraints within an inversion.

A Sparse Constraint Model Builder (Model Builder) developed for use with the University British Columbia – Geophysical Inversion Facility code (UBC-GIF) aims to facilitate the supply of direct constraints to mediate the inversion process (Williams, 2008). The Model Builder can be used to create factual 3D physical property models from surface sample measurements, drilling property measurements and outcrop or basement geology maps. Buffers are also applied to the physical property model to allow measurements to be extrapolated into surrounding regions where there are less or no constraints. This physical property model then provides a reference model or bounds model for a UBC-GIF inversion to use as a constraint, therefore incorporating a degree of geological knowledge during the model building process.

The Wallaby gold deposit is located 25 km southwest of Laverton in the Eastern Goldfields Superterrane, Western Australia, and is a satellite deposit within Barrick Gold Limited's Granny Smith mine property. Gold mineralisation at Wallaby is hosted within a mafic conglomerate, intruded by a south plunging (50°) magnetite-actinolite altered syenite pipe. Features of the magnetic Wallaby anomaly are the amplitude (910 nT) and twin peaks central to the broad 'bullseye' anomaly. Gold mineralisation at Wallaby is associated with zones of lower to moderate magnetic susceptibility (Coggon, 2003; Neilson, 2005). This relationship can be modelled using magnetic data to infer further regions of mineralisation. The Model Builder was used to create a 3D physical property model of the magnetic susceptibility distribution from measurements taken along diamond drill core. Utilising this as a constraint enabled a UBC-GIF inversion to resolve detail laterally away from the alteration pipe, and below the known depth (1200 m) of the Wallaby deposit.

The aims of this research were:

- to test whether inversion methods constrained by a physical property model built using the Model Builder can improve on previous magnetic modelling and create a reliable and geologically realistic magnetic inversion from aeromagnetic data;
- to use these improved models of magnetic susceptibility to better understand the internal structure of the Wallaby system, and to identify areas of low magnetic susceptibility as a proxy for Au lodes.

The process for creating the physical property model and constrained inversions of the Wallaby deposit was iterative, reliant on visual assessment of the model and forward/residual calculations. These were used to determine the most realistic representation of the magnetic susceptibility distribution within the alteration pipe that showed the characteristic central low and outer high magnetic susceptible zones (Coggon, 2003).

It was found that the physical property model itself provided a very useful exploration tool, defining the magnetic susceptibility distribution within the alteration pipe. Interpretation of this model found zones of mineralisation that correlated with low to moderate zones of magnetic susceptibility, and the plunge of the alteration pipe and major structural features were clearly defined (Figure 1(b)).

In the initial stages of the constrained inversions a coarse mesh was used to enable refinement of the physical property model and inversion parameters (Figure 1(c) and (d)). Once a realistic model, based on the known geology of the Wallaby deposit was resolved, the final physical property model and inversions were built using a fine mesh (Figure 1(e) and (f)).

The constrained inversions of the Wallaby gold deposit were useful in accurately identifying extensions of known gold lodes in shallow regions of the models (Figure 1(e) and (f)). At depth and in regions with limited constraints, however, the resolution of detail decreased. The southward plunge of the alteration pipe and detail within the central low and outer high magnetic susceptible zones were resolved. Similar low magnetic susceptible features were identified in the bounds model inversion, also seen in the reference model inversion (Figure 1(e) and (f)).

The bounds model inversion resolves a large zone of high magnetic susceptibility on the northern edge of the Wallaby pipe that is not resolved in the coarse mesh inversions. The main magnetic alteration within the Wallaby deposit is known to be contained within the alteration pipe (Coggon, 2003; Miller, 2010), so it is unlikely that a large intense region of alteration extends to depth on the northern side of the deposit. The constraining physical property model is not accurately representing the magnetic response of the magnetic alteration, so the inversion is compensating by resolving a northern high magnetic susceptible zone where limited constraints are available. The reference model inversion, however, produces a more realistic model consistent with the known geology of the area, where the outer magnetic high susceptibility on the northern and southern edges of the pipe is clearly resolved. A magnetic source is also defined at depth which constrains deeper zones of mineralisation.

Project outcomes

1. The Model Builder provides a useful tool for creating geologically realistic constrained potential field inversions from the UBC-GIF inversion code. The constrained magnetic inversion of the Wallaby gold deposit was useful in confirming further regions of gold mineralisation outside the Wallaby alteration pipe.

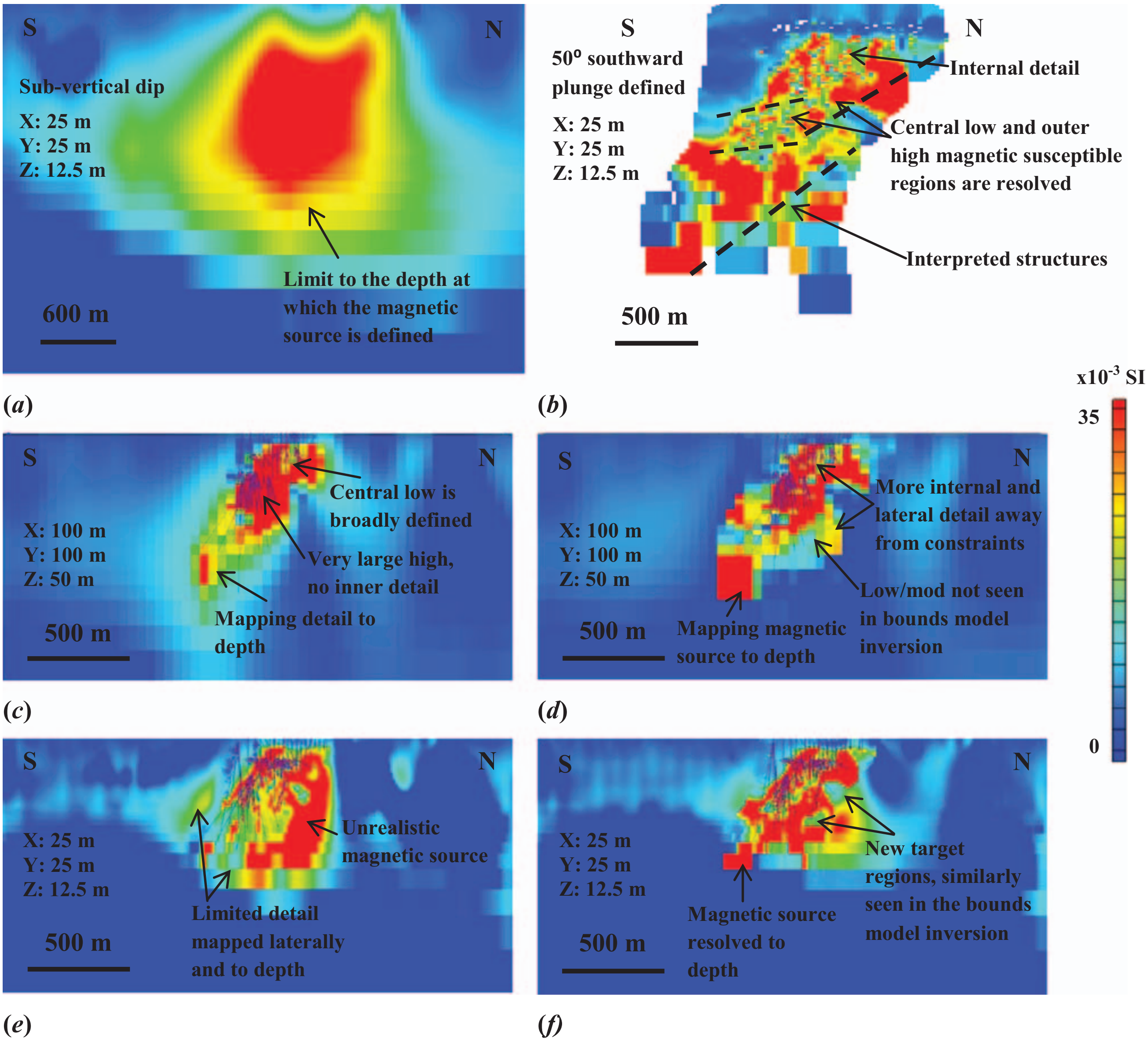

Fig. 1. *Comparisons between (a) an unconstrained UBC-GIF inversion of the Wallaby gold deposit; (b) Model Builder fine mesh physical property model (buffered) showing the magnetic susceptibility distribution within the alteration pipe; (c) UBC-GIF coarse mesh inversion constrained with a coarse physical property model applied as a bounds model; (d) UBC-GIF coarse mesh inversion constrained with a coarse physical property model applied as a reference model; (e) UBC-GIF fine mesh inversion constrained with (b) applied as a bounds model; and, (f) UBC-GIF fine mesh inversion constrained with (b) applied as a reference model.*

2. Higher resolution detail can be resolved when more constraints are available for creating a physical property model.
3. A compromise needs to be made dependent on the number of physical property measurements available, the number of cells in the inversion mesh, and the level of detail required from the inversion. A relatively large cell size provides an efficient model for defining large features and may be all that is needed depending on the exploration requirements.
4. The bounds model inversion and reference model inversion show some similarities and ideally, should be interpreted in conjunction to provide a more accurate exploration tool than using one model over the other.
5. It is recommended that the dynamic range from forward/residual calculations of the physical property model be very close to the original aeromagnetic data before attempting to use the physical property model to constrain an inversion.

References

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