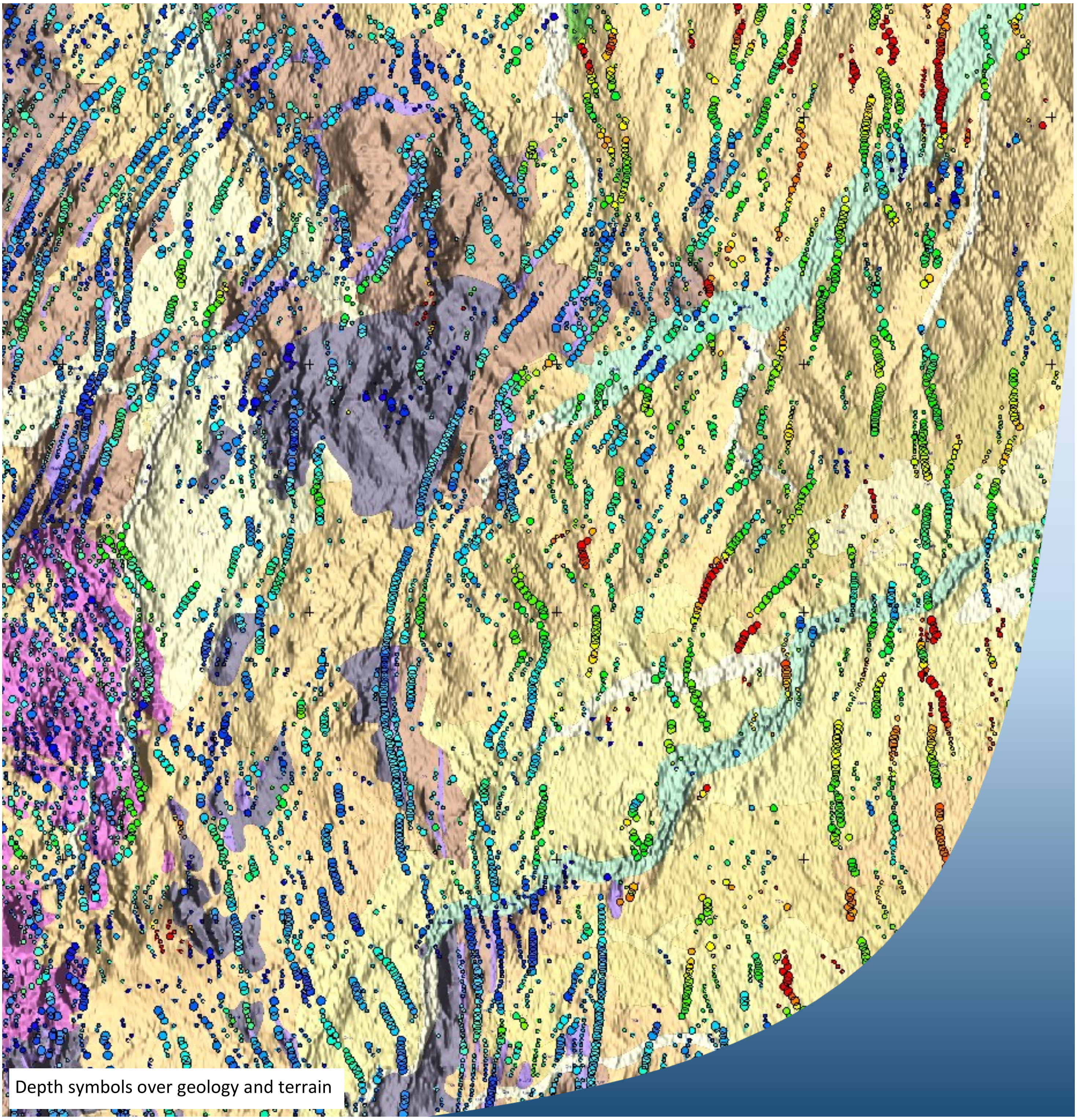
Tensor Research

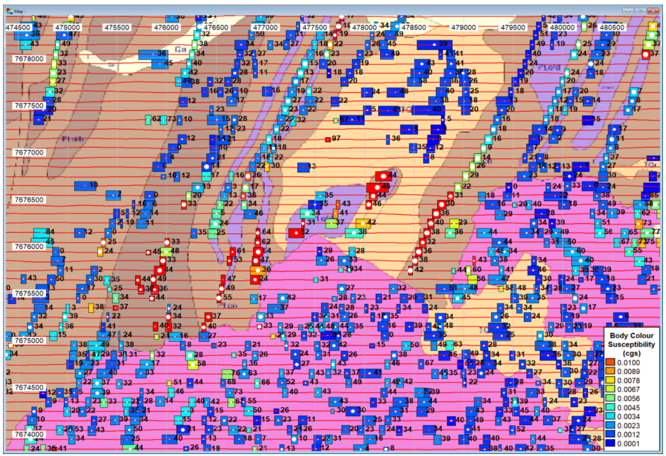
RPD Mapping

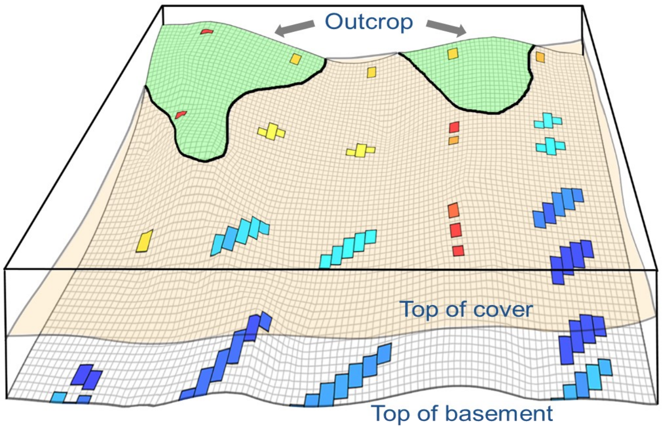
Rock property and depth mapping research

Large scale bedrock mapping from FTMG and TMI surveys



Depth symbols over geology and terrain



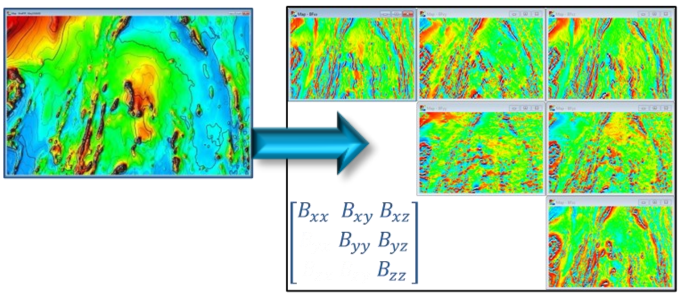


Supracon FTMG Sensor System

Measure FTMG

$$\begin{bmatrix} B_{xx} & B_{xy} & B_{xz} \\ & B_{yy} & B_{yz} \\ & & B_{zz} \end{bmatrix}$$

Convert TMI to FTMG



What is RPD Mapping?

RPD Mapping was developed to turn full tensor magnetic gradient (FTMG) and total magnetic intensity (TMI) surveys into large scale, 3D magnetic geology maps of the bedrock surface. The process creates both a model and an attributed point dataset suitable for use in mapping and GIS software. The model can be used in ModelVision for further refinement of important geological targets.

It is not a voxel model. RPD Mapping builds a segment model of the bedrock surface where every anomaly on every line above a specified threshold has an associated segment. Each segment becomes part of a constraining geological model that plays an important role during inversion to ensure coherency and continuity of the geological units. The segment model has 3D attributes which make it suitable for 3D visualisation and importantly, the whole model is always visible because it does not require the use of isosurfaces to segment the model.

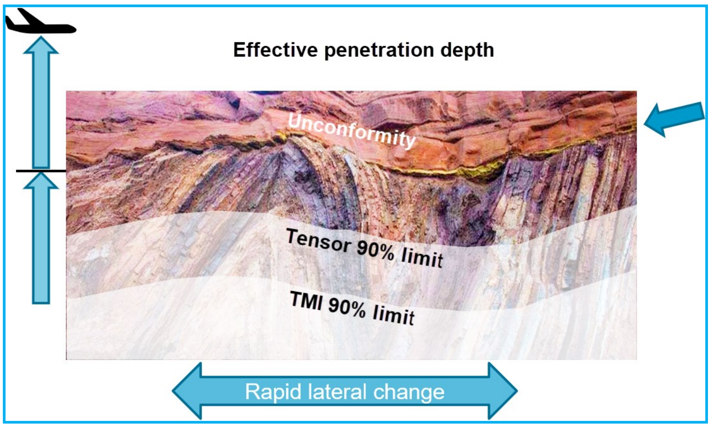
Each segment has approximately 200 attributes that are created by the AI expert system with a much smaller subset being used for most exploration applications.

Spatial	Magnetic	Source shape
X, Y	Susceptibility	Pipe
Elevation	Magnetisation vector	Pluton
Depth BG	Jres, Ires, Dres	Formation, dyke
Width	ARRA	Edge
Strike length	(Rotation angle)	Elliptic
Azimuth	Quality	(IOCG)

DIAS Airborne is operating commercial FTMG surveys, and there is an increasing interest in tools to interpret the data. RPD Mapping is a research service provided by Tensor Research for FTMG survey clients and conventional high resolution TMI surveys.

TMI to FTMG Conversion

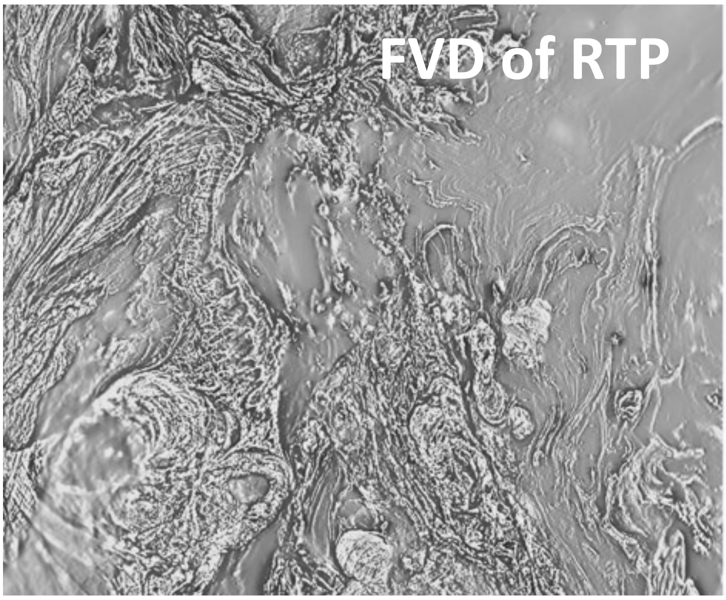
FTMG data can be generated from TMI surveys using a special suite of Filters in ModelVision. The Depth Module also uses the FTMG data in QuickDepth where a complete set of tensor line data and grids is produced automatically during the data preparation stage and saves many manual steps. Of course, the measured tensor will contain significantly better data for the cross line components for the same line spacing and flying height. This advantage improves even further in low field inclinations and rugged terrain.

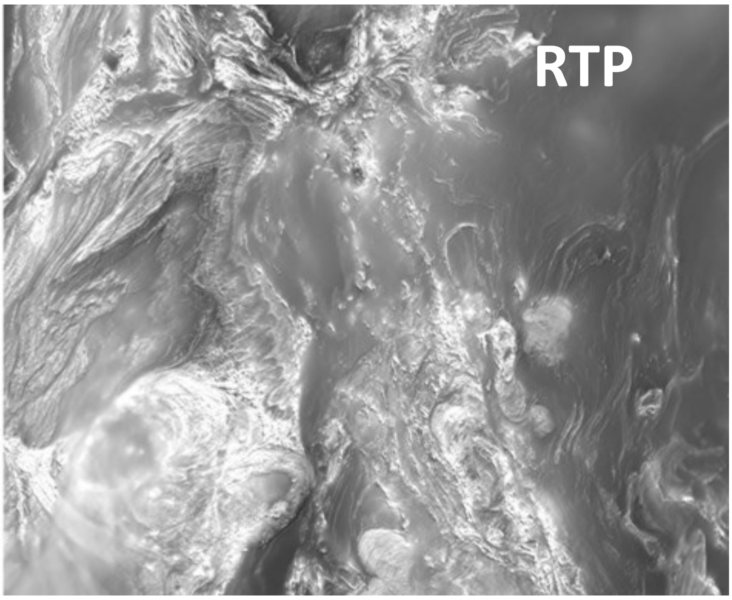


A schematic model of the depth of penetration for tensor and TMI data where the shaded areas shows the 90% cutoff levels.

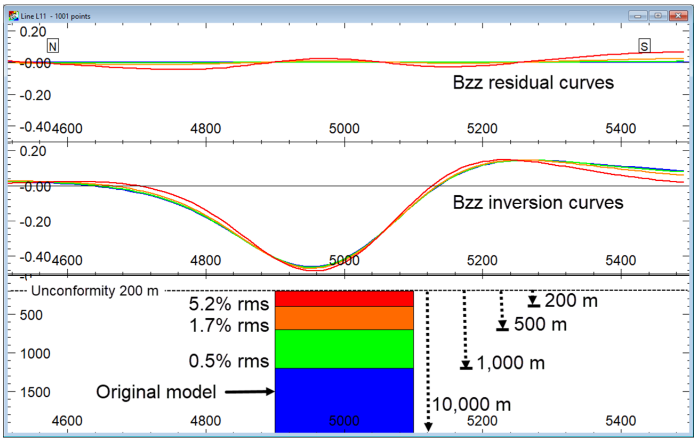
Why does the unconformity dominate?

The magnetic bedrock unconformity provides an important geological constraint for building large scale rock property and depth models. Truncated, dipping formations generate the largest anomalies and this structural style is common in many Paleozoic, Proterozoic and Archean terranes. Deeper magnetic units must have much higher susceptibilities before they dominate the shallower anomalies. This example from the Cloncurry region shows first vertical derivative and RTP images that highlight the unconformity surface over a depth range from outcrop to > 1 km. There are very few instances of a deeper anomaly being seen through the unconformity suite of anomalies.



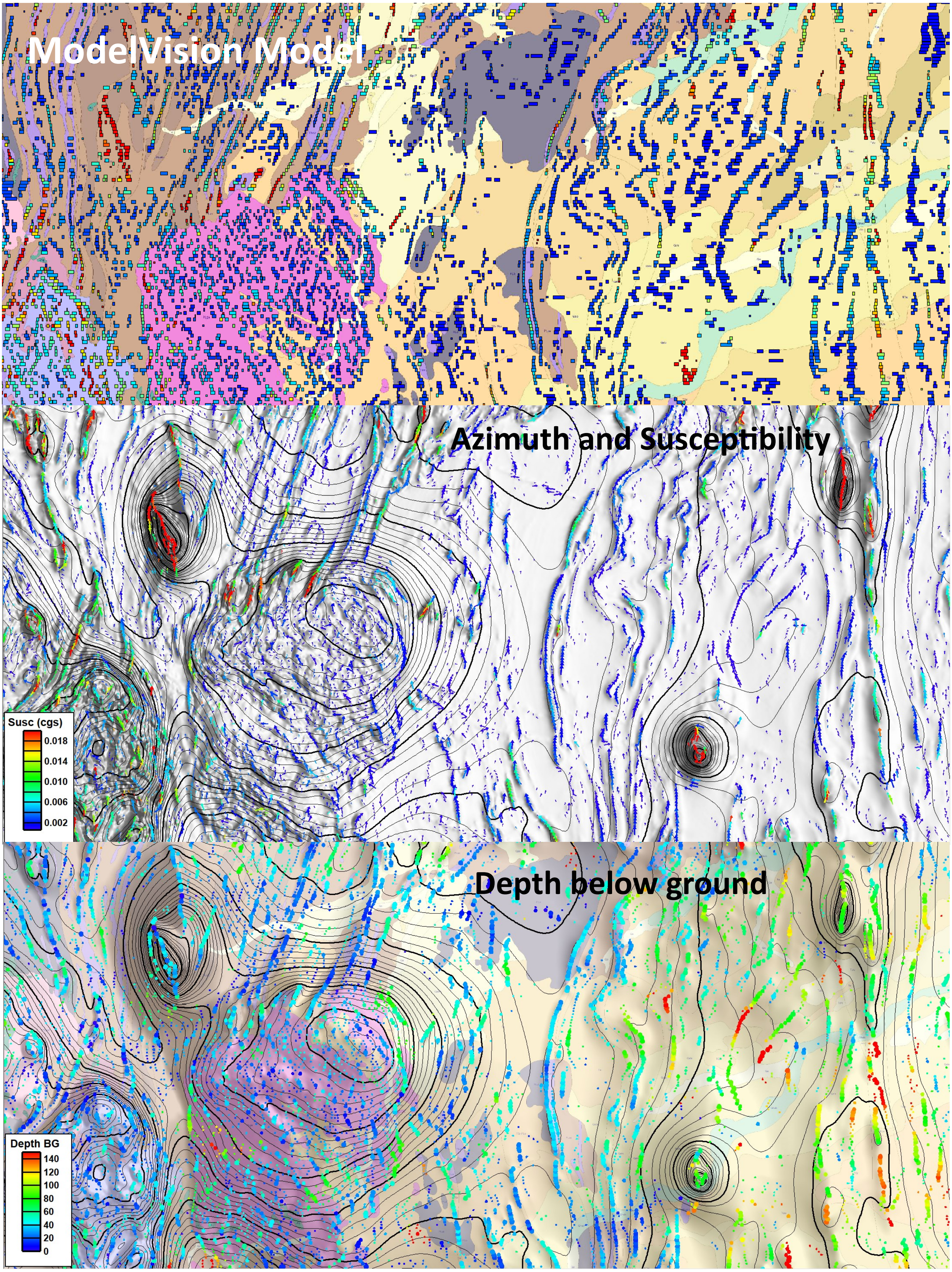


Bzz RMS	Top	Extent	Lower
Model	200	10,000	10,200
0.5%	200	1,000	1,200
1.7%	200	500	700
5.2%	200	200	400

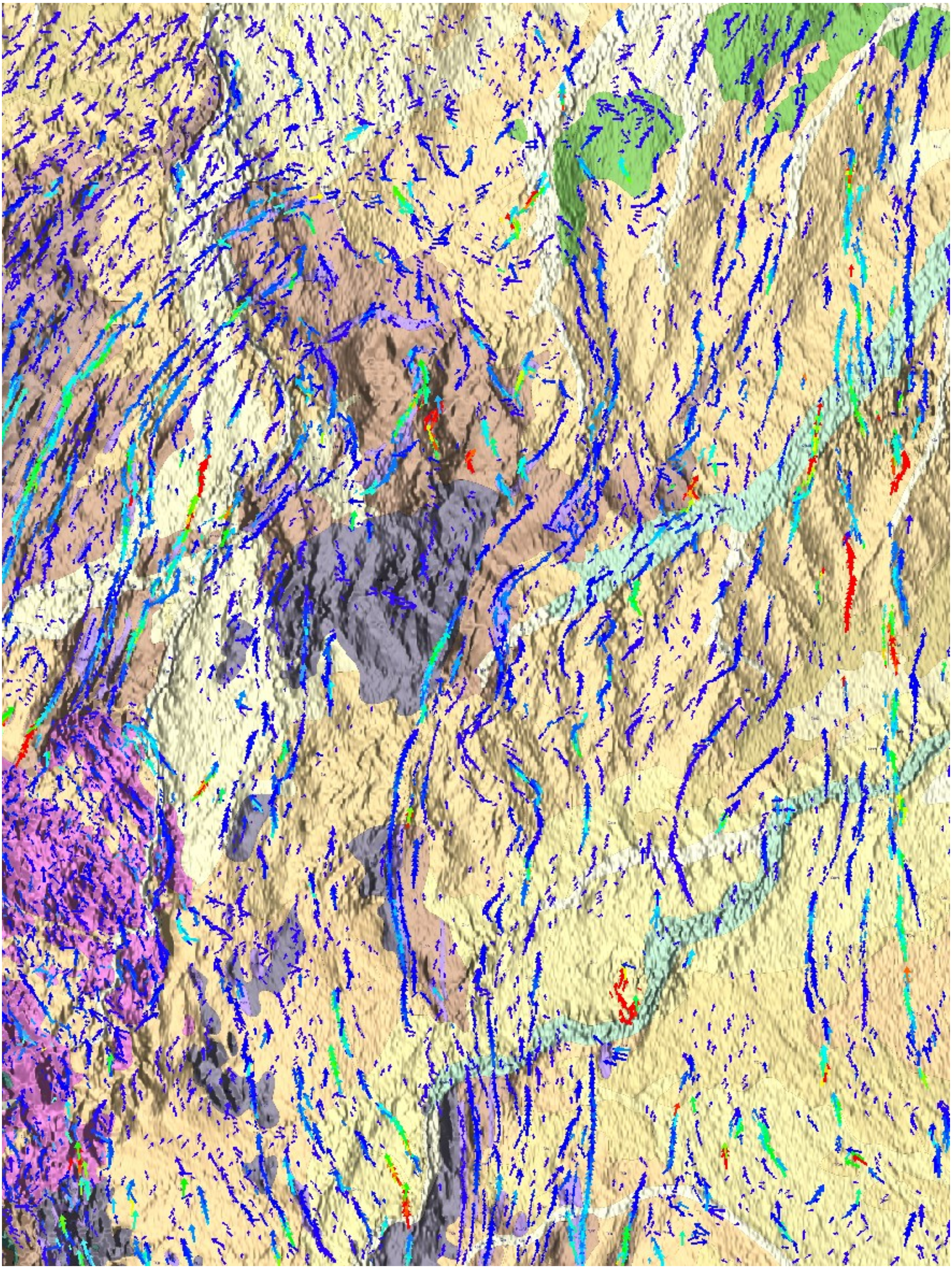


Section , Bzz and Bzz residual model response curves after inversion of the variable depth extent formation for magnetic susceptibility.

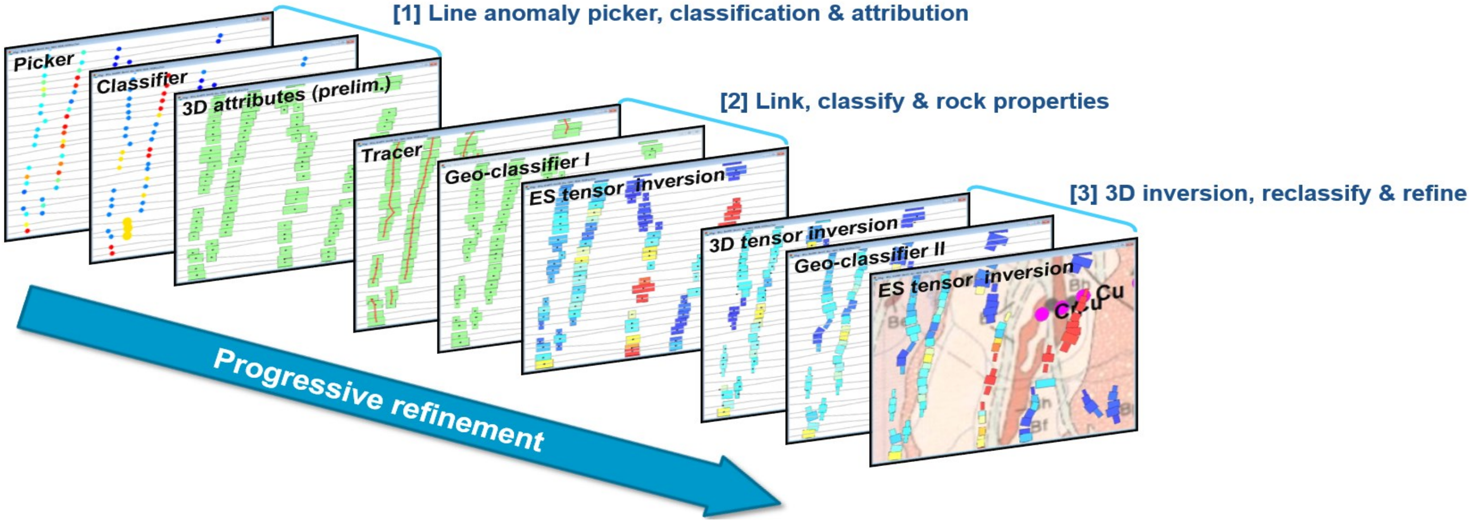
The first vertical derivative of TMI is similar to the Bzz tensor component and is used extensively for geological map interpretation by geologists. We tested the unconformity model dominance on tensor data with the Bzz results shown in the ModelVision cross-section display. The initial model starts at a depth of 200 m below the magnetic sensor with a depth extent of 10,000 m. New models were created with depth extents of 1,000, 500 and 200 m and we inverted the models against the original 10,000 m model data. Only magnetic susceptibility changed in each inversion where the RMS shows only small changes for each extent. Where the depth extent of 200 m matches the distance from the sensor to the unconformity, the RMS of the residual difference curve is just 5.2%. This demonstrates that the tensor data is focused on a thin sliver of rocks immediately beneath the unconformity and is also a useful proxy for a geological map of the unconformity. The Bzz tensor component is shown in the track above the model and the top track shows the residual Bzz anomaly at the same scale. The shallower penetration of the tensor and FVD (TMI) is caused by the faster amplitude drop-off of $1/r^{n+1}$ compared with $1/r^{n}$ for TMI data where n = structural index.


ModelVision Model
Azimuth and Susceptibility
Susc (cgs)
0.018
0.014
0.010
0.006
0.002
Depth below ground
Depth BG
140
120
100
80
60
40
20
0

Azimuth, Susceptibility and Estimated Quality

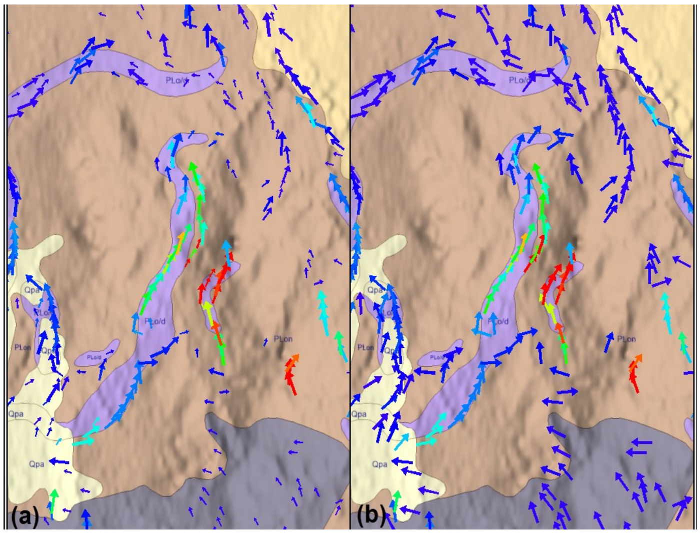


What is the function of the AI System?



RPD Mapping uses a three-stage process for building a magnetic lithology model of the magnetic bedrock surface which progressively refines the model by applying simple geological principles at each stage. Stage 1 builds an initial segment model for every anomaly on every flight line using the 3D information inherent in the magnetic tensor (Pratt et al. 2019). Stage 2 links the segments into a coherent suite of formations or isolated bodies. In Stage 3, the geological model is used to constrain the parameter ranges and the regularisation of formation trends during inversion of the magnetic tensor data.

Importantly, the AI system collects information that detects interference and noise that affects the quality of the final inversion parameters. We call this depth quality because depth is a very important parameter and it can be used to control the size of map symbols that are used to display any of the final important rock property estimates. This provides immediate visual feedback to geologists and geophysicists regarding confidence levels without having to look at the underlying numeric values.



Example images with (a) and without (b) symbol size controlled by the "Quality" AI parameter. The visual coherence improves with size encoding of the quality parameter.

Recommended Reading

Clark, D.A., 2014, Methods for determining remanent and total magnetization of magnetic sources – a review: Exploration Geophysics, 45, 271–304.

Foss, C.A., Pratt, D.A. and McKenzie, K.B. 2023, Sweet-spots for estimation of source magnetization direction. AEGC 2023, Brisbane Extended Abstracts, 6pp.

Pratt, D.A., McKenzie, K.B. and White, A.S., 2014, Remote reman -ence estimation (RRE): Exploration Geophysics, 45(4), 314-323.

Pratt, D.A., McKenzie, K.B. and White, A.S. 2019 An AI approach to automated magnetic formation mapping beneath cover: ASEG Extended Abstracts, 2019:1, 1-9.

Pratt, D.A. and Shi, Z., 2004, An improved pseudo-gravity magnetic transform technique for investigation of deep magnetic source rocks: Extended Abstracts, ASEG 17th Geophysical Conference and Exhibition, Sydney 2004.

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