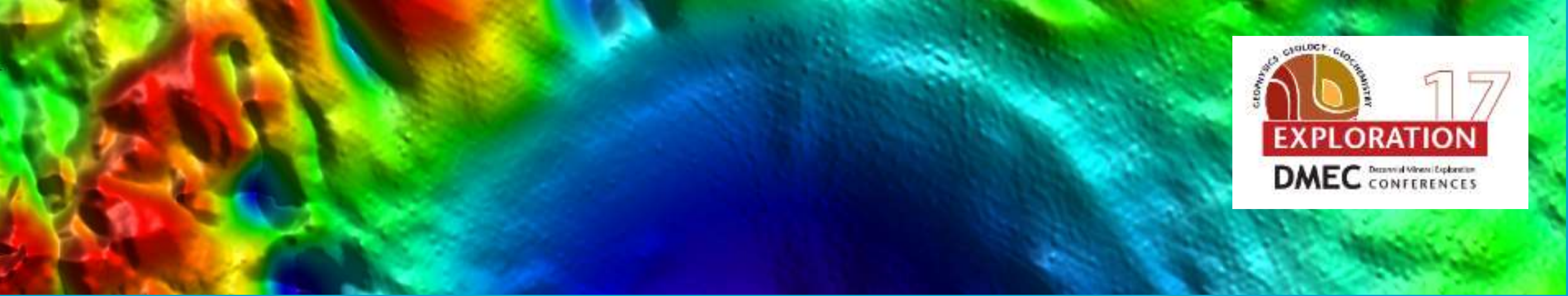
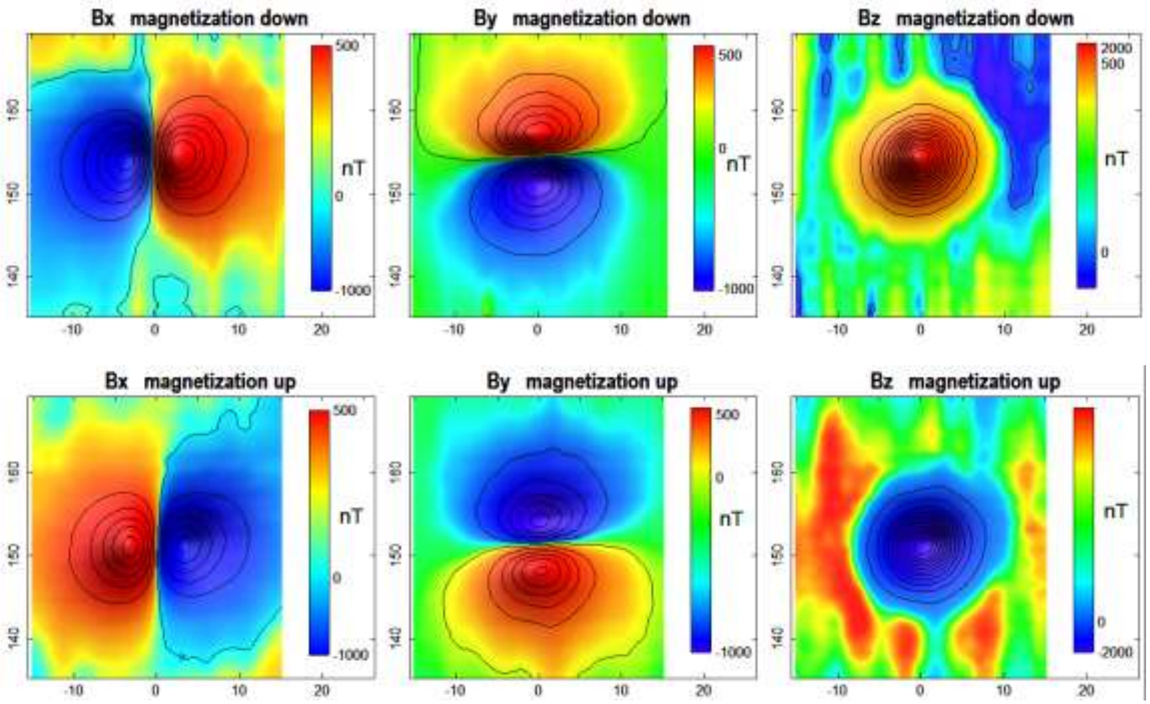


A practical guide to estimating magnetization direction from magnetic field data

Clive Foss
12 October 2017

Mount Harcus Sample Magnetic Field Scans



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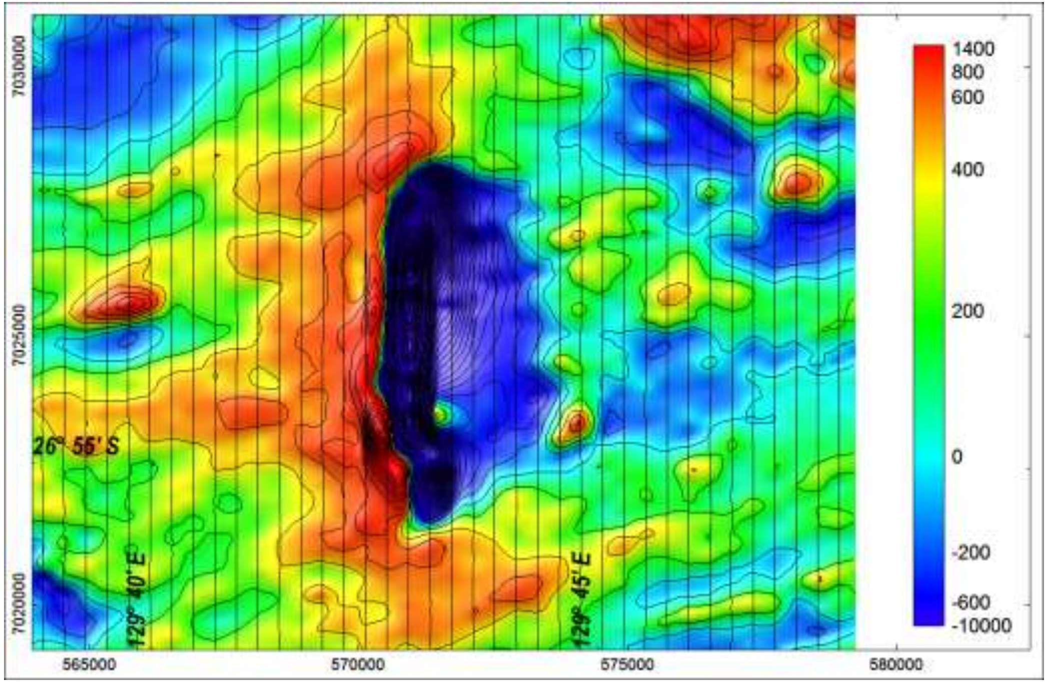
Mount Harcus Anomaly, central Australia



Background field c. 55400 nT

Anomaly > 10,000 nT

Age of intrusion
c. 1070 My

Sample

K= .45 SI
Remanence = 295 Amperes/m
Q = 15

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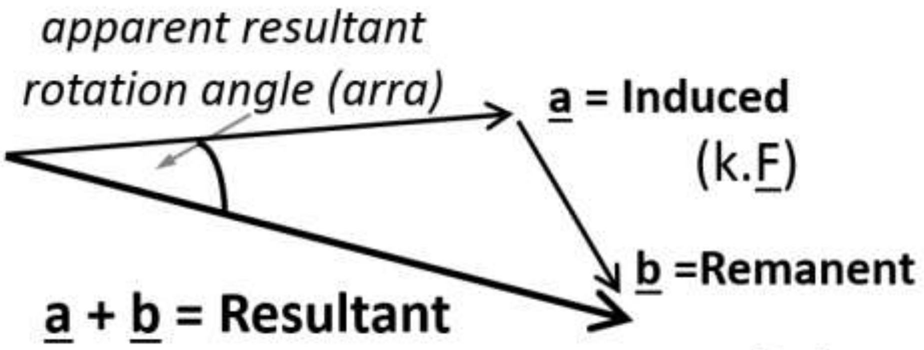
Outline

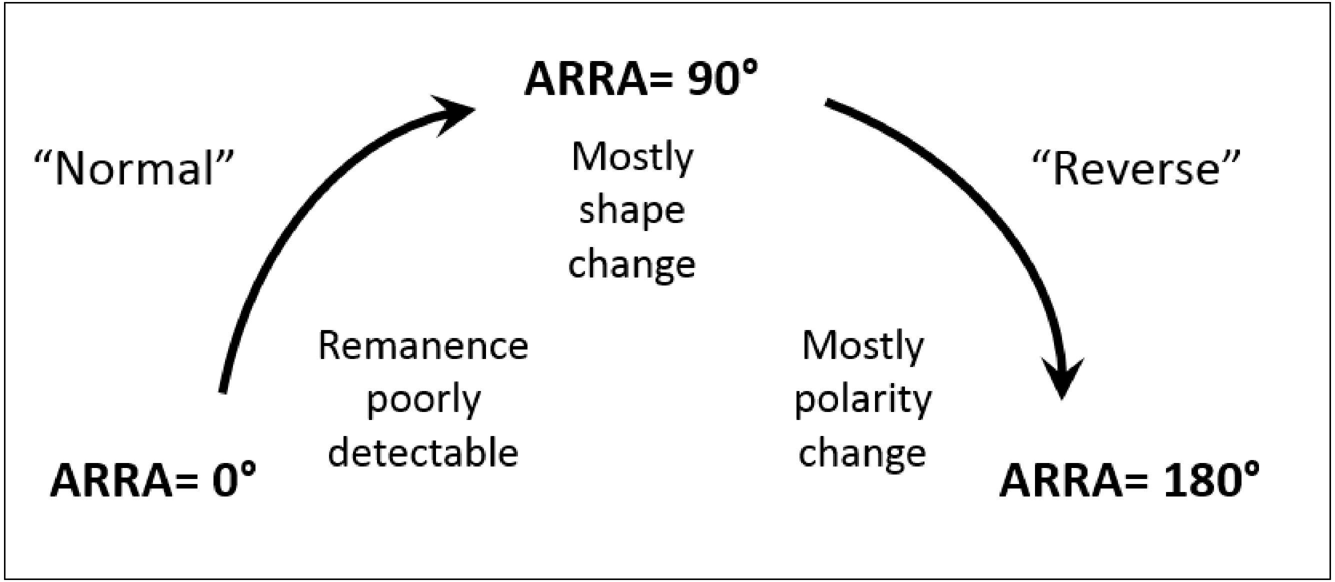
- Resultant magnetization magnetic field interpretation
- Expression of remanence in Canadian + Australian TMI data
- Recognition of remanence in TMI imagery
- Remanence and RTP/ Total gradient
- Helbig's magnetic moment analysis
- Insensitivity to source shape for compact sources
- Anomaly isolation
- Conclusions and recommendation

Resultant Magnetization



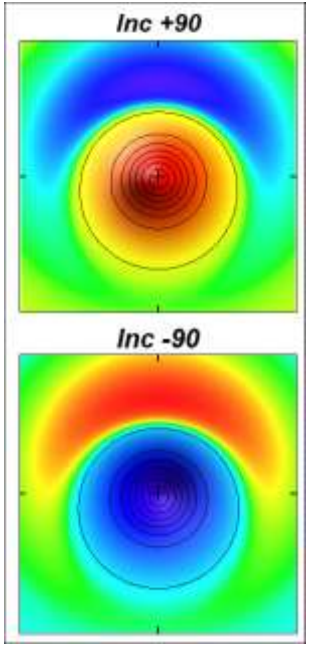
Koenigsberger ratio $Q = \frac{|\underline{b}|}{|\underline{a}|}$

Resultant magnetization magnetic field interpretation

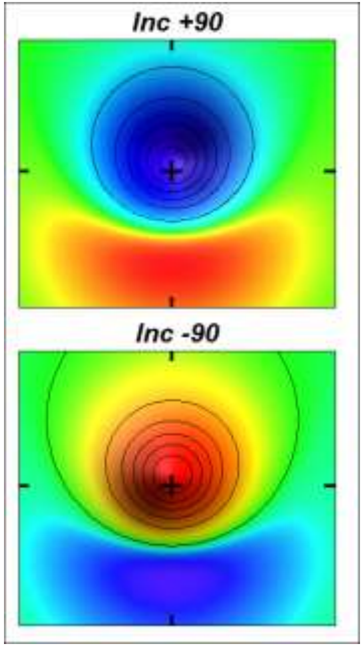


TMI anomalies for vertical magnetization in a high inclination field

Canada



Australia



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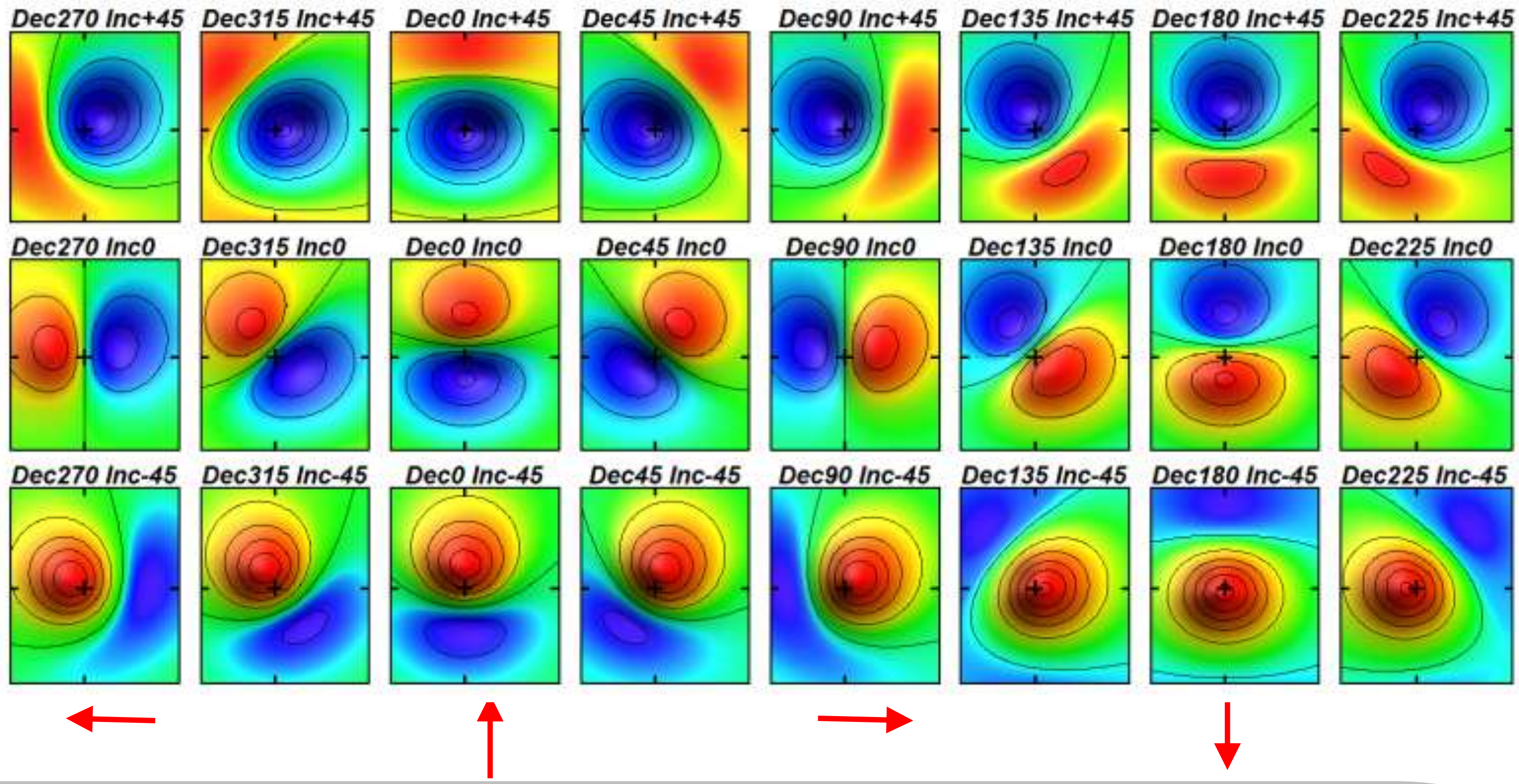
Australian TMI dipole anomalies



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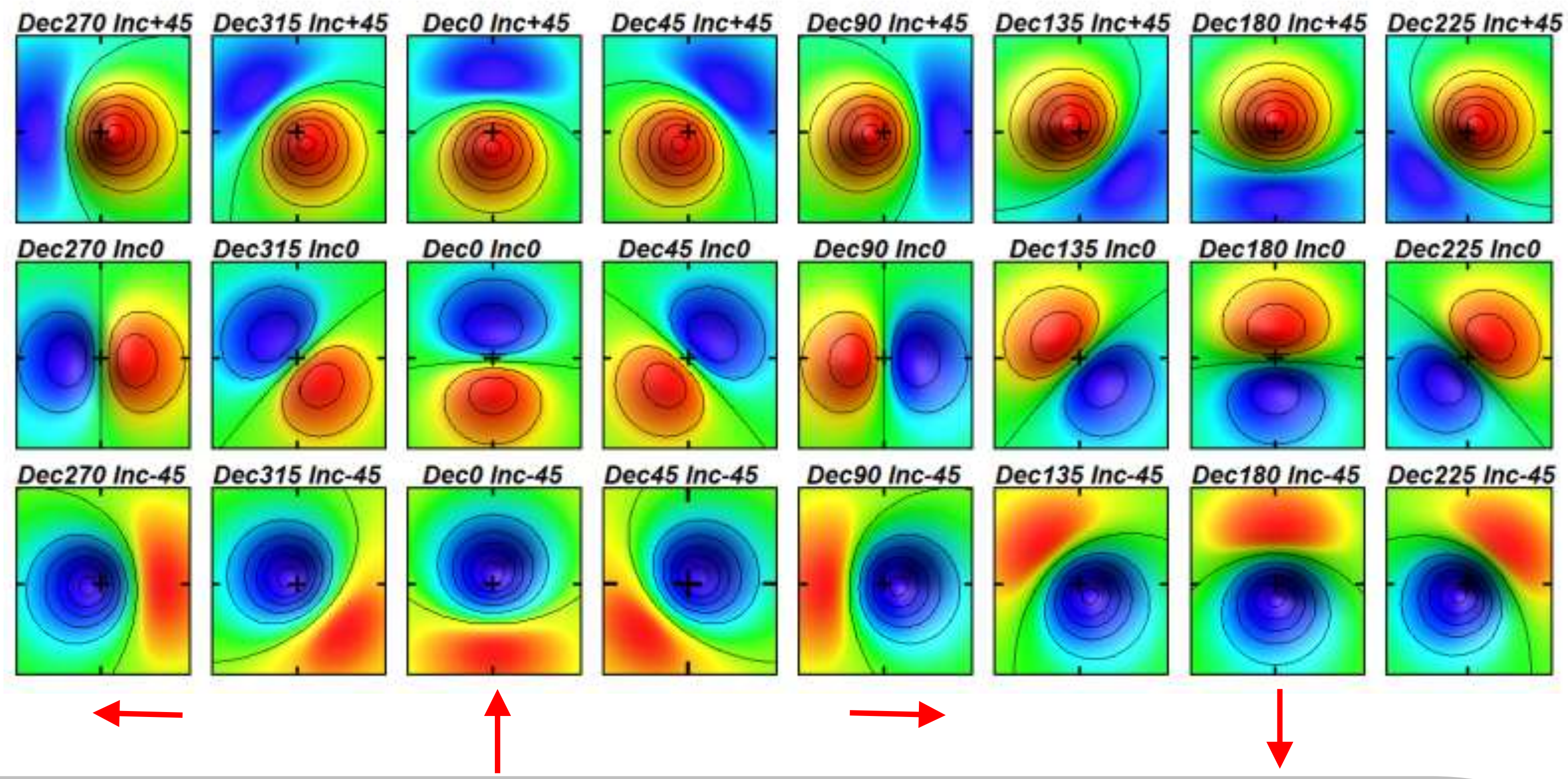
Canadian TMI anomalies



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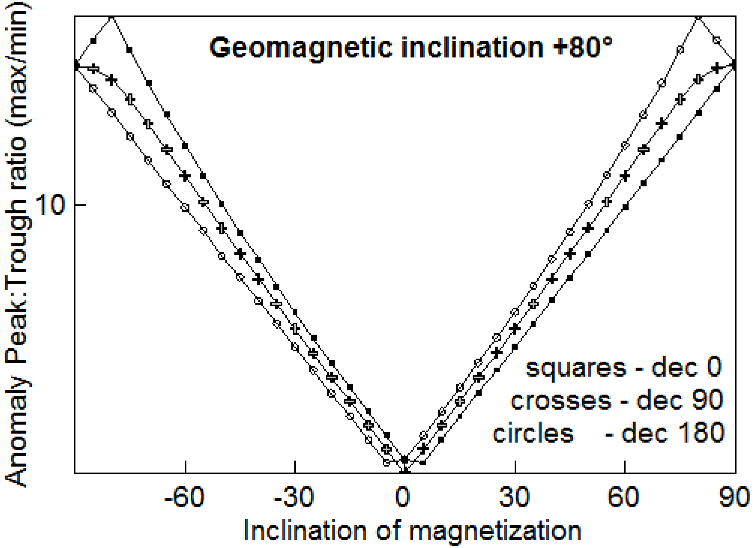
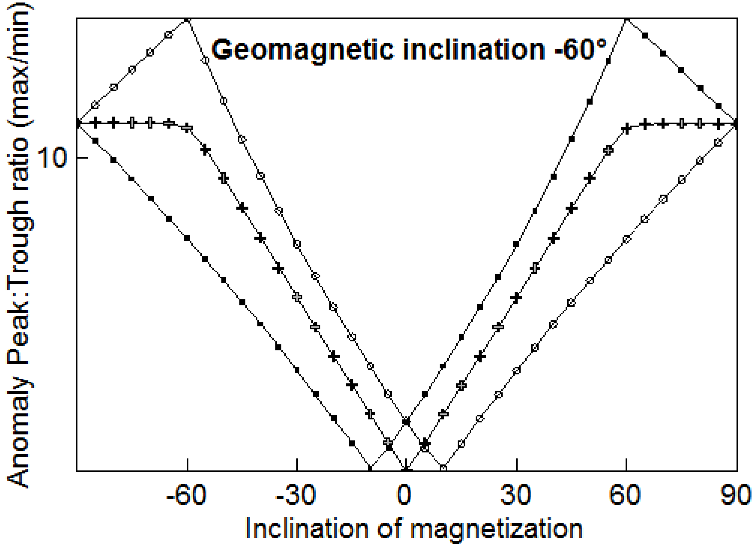
TMI peak-to-trough ratios



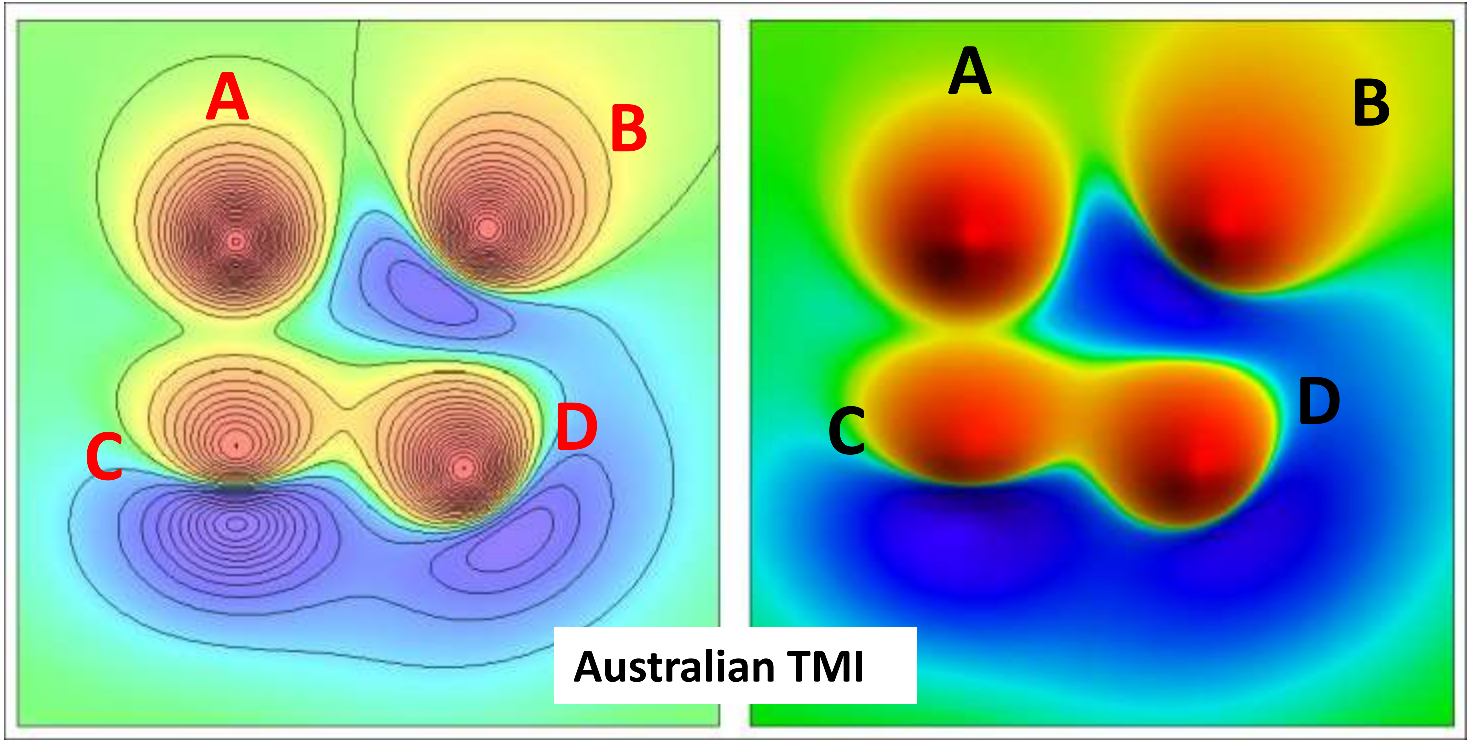
Canada



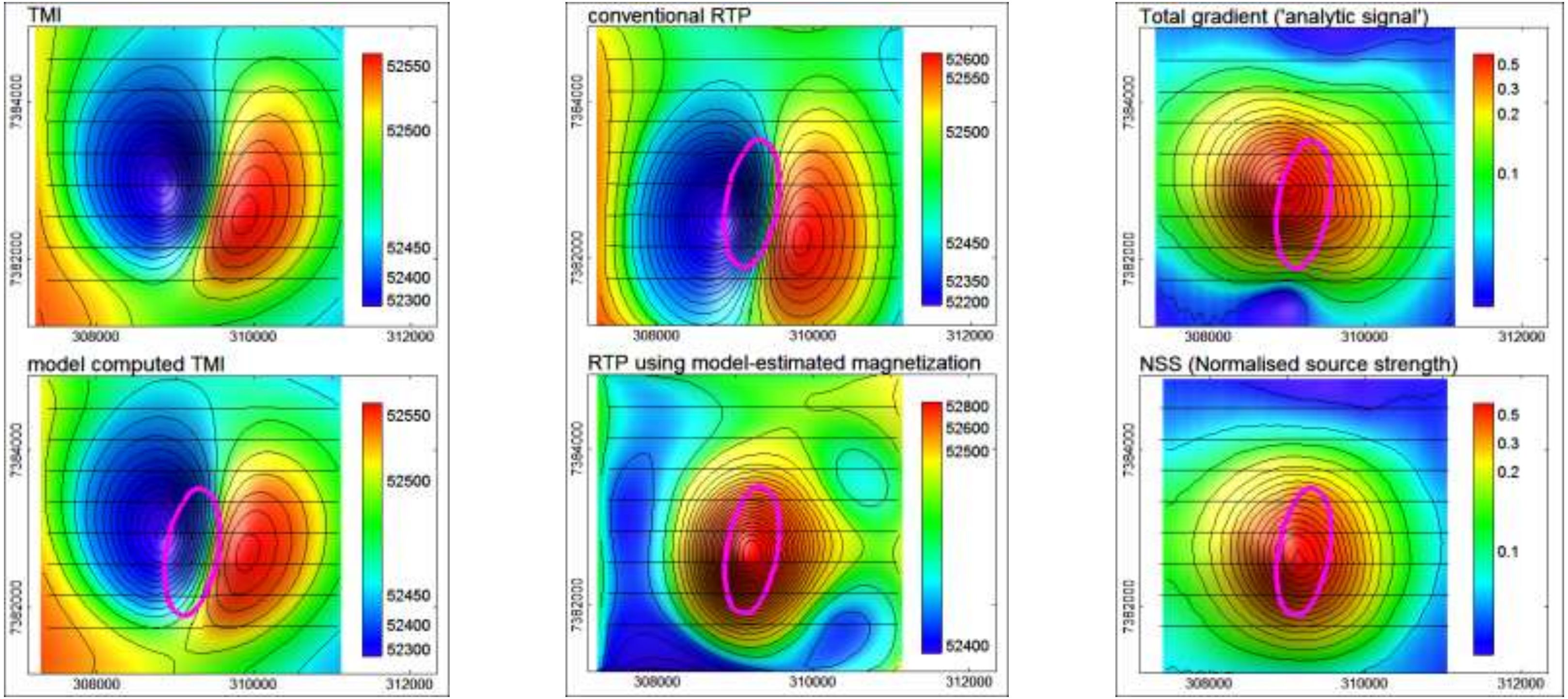
Australia

Recognising the expression of remanence in TMI anomalies

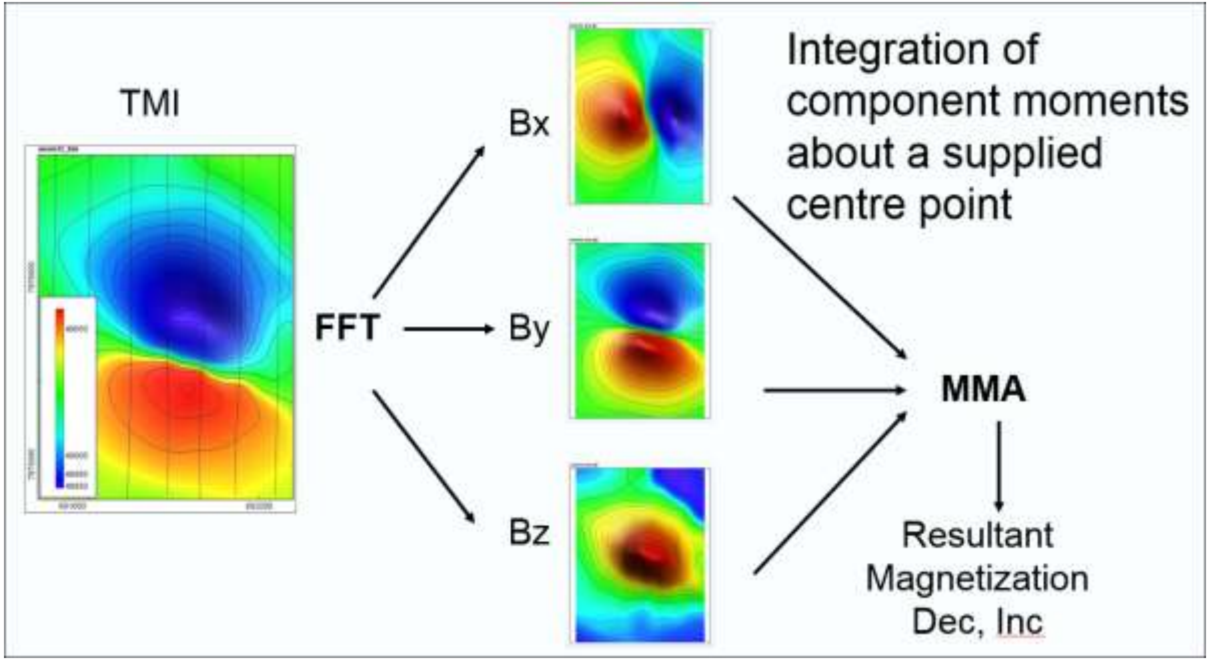
	Dec	Inc
A	000	-90
B	045	-45
C	000	-10
D	315	-45



RTP and remanent magnetization



Helbig's magnetic moment analysis



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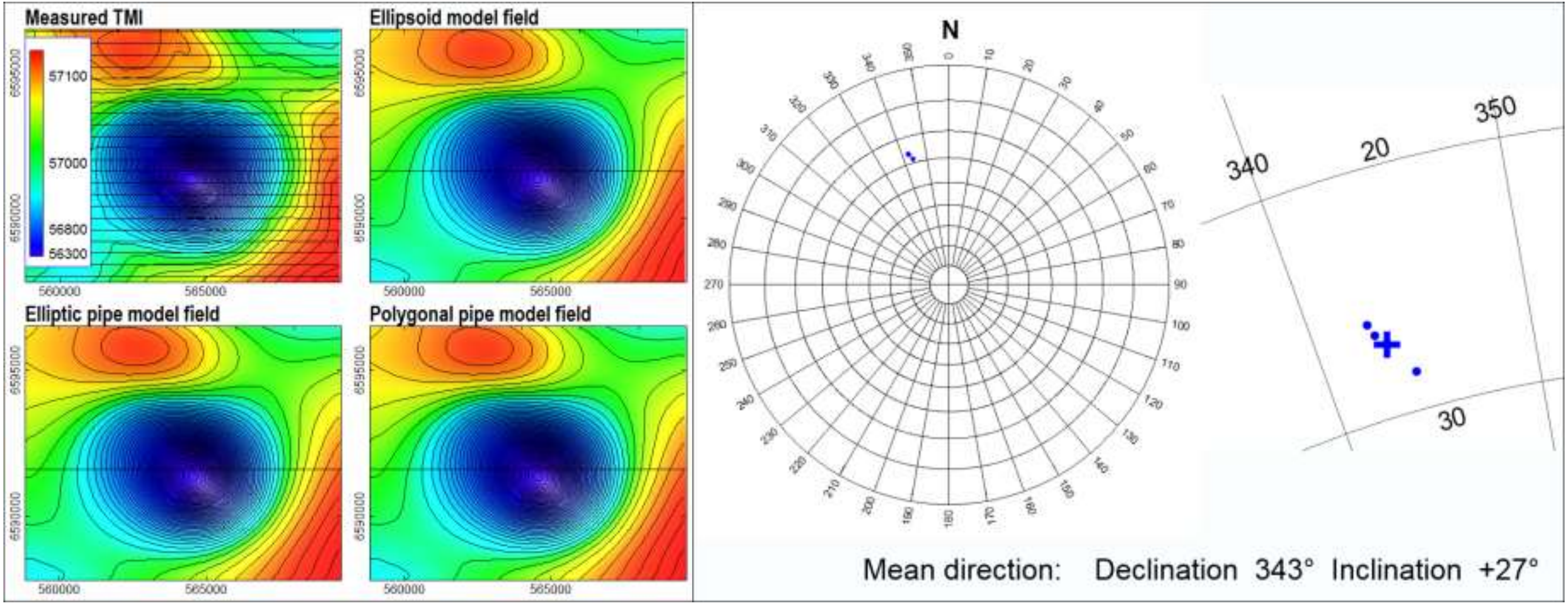
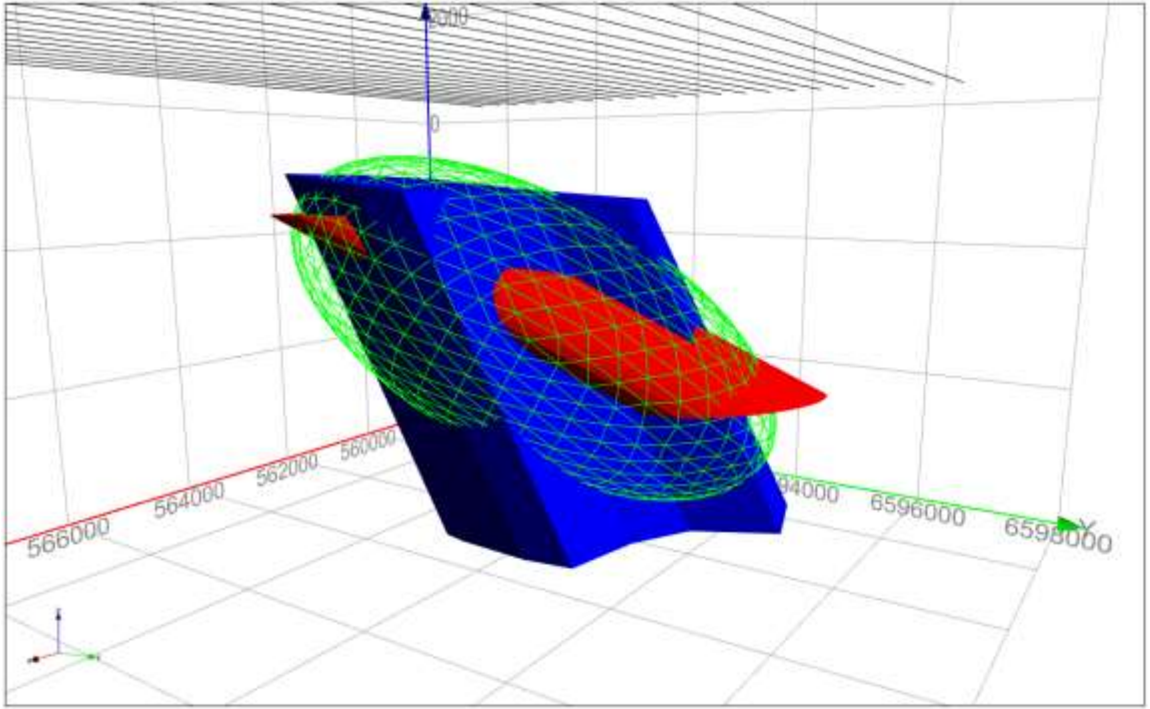
Insensitivity to shape for compact sources



CSIRO

Insensitivity to shape for compact sources



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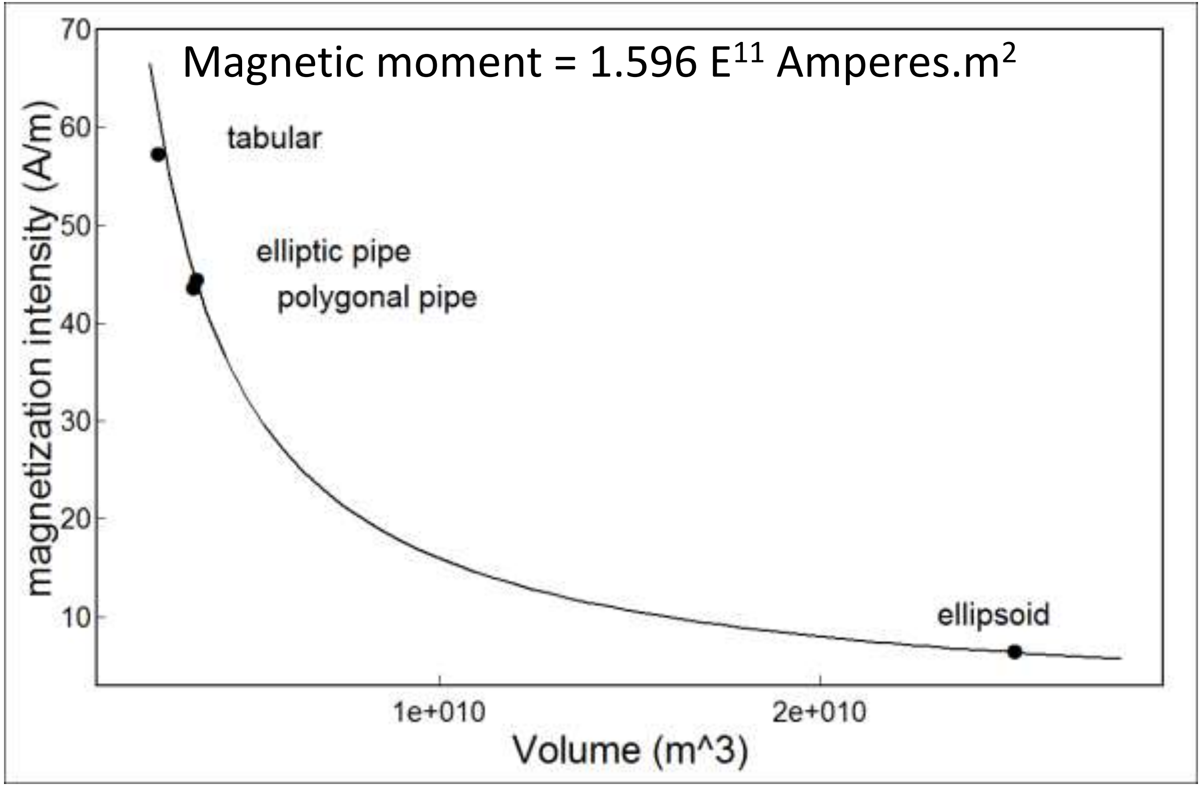
Anomaly 266 model magnetic moments



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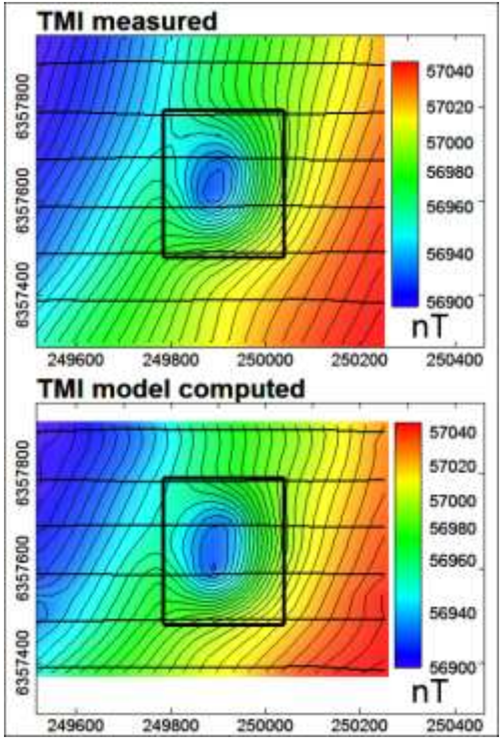
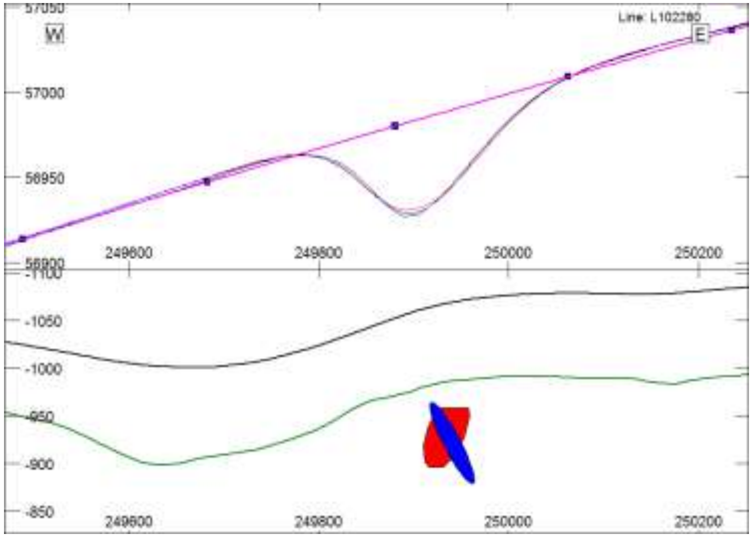
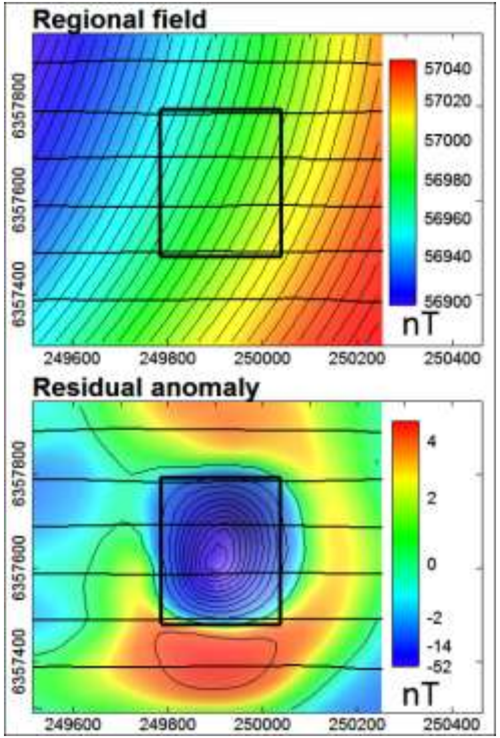
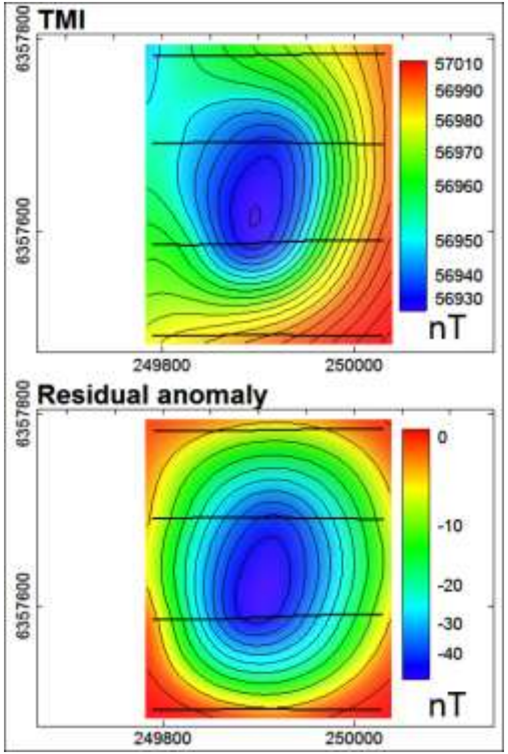
Anomaly separation

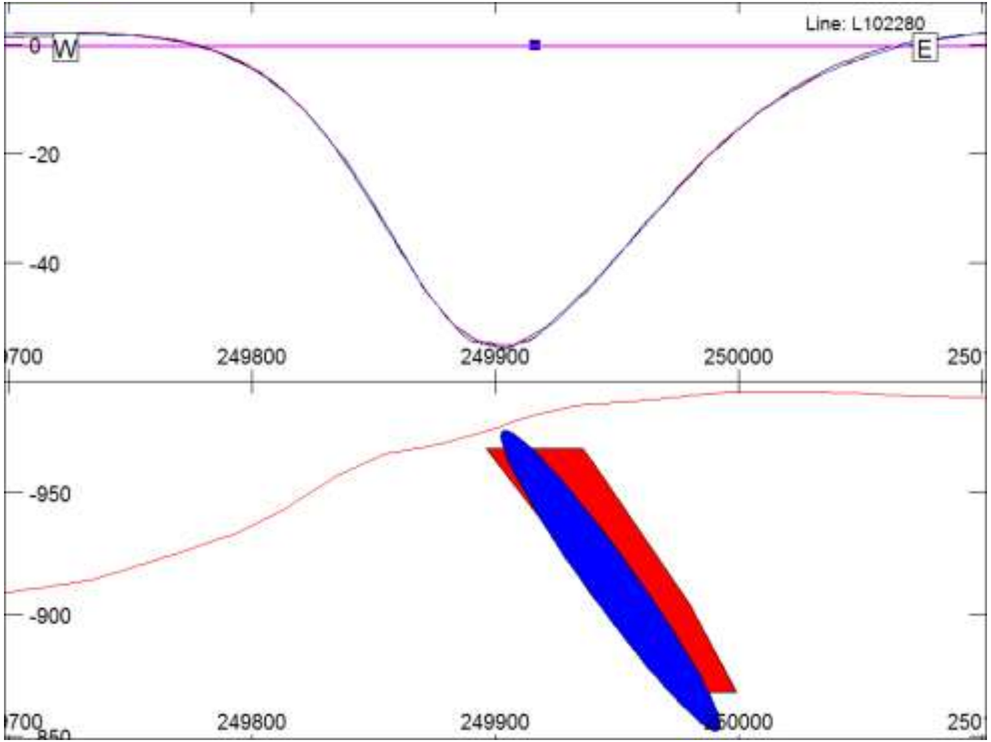




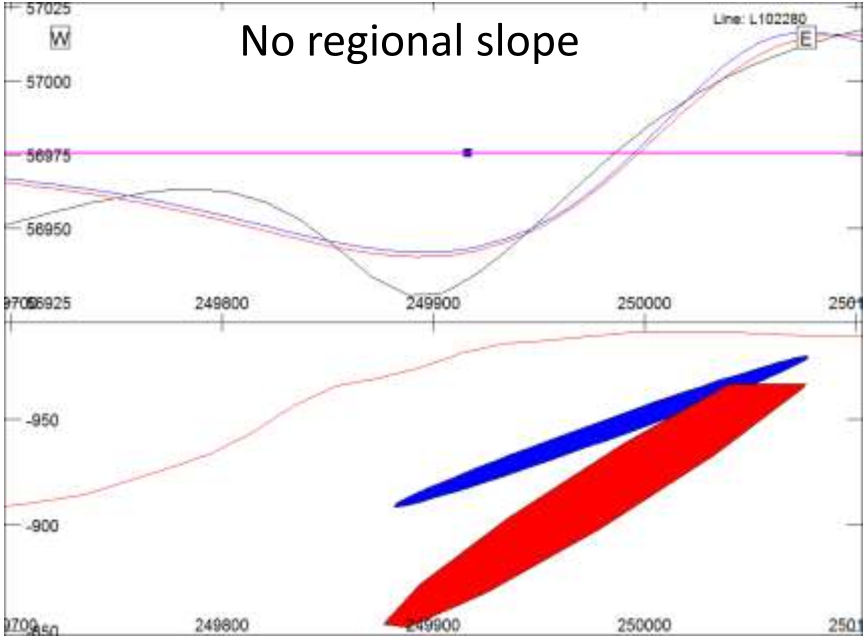


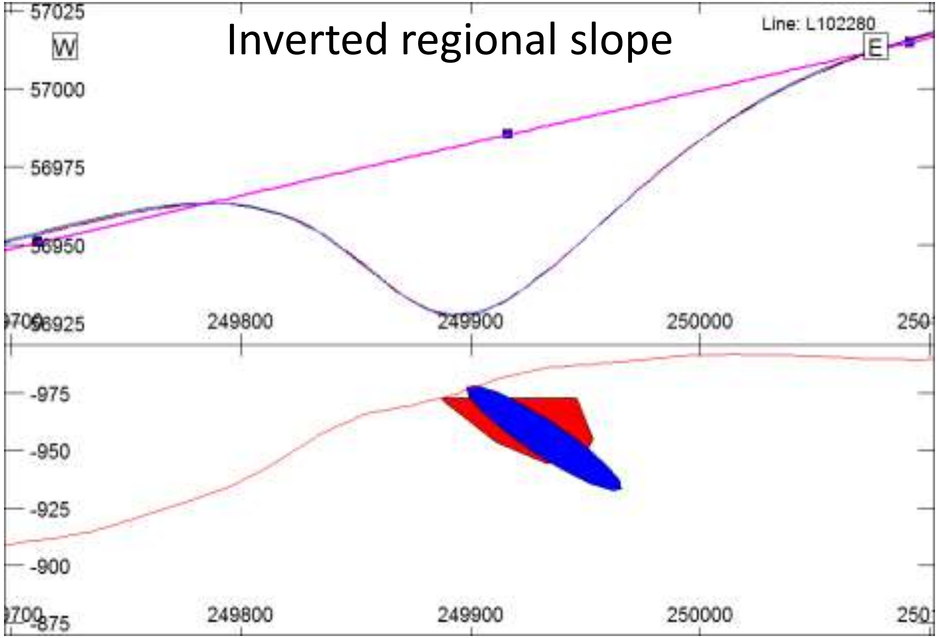
Regional stripped in anomaly window



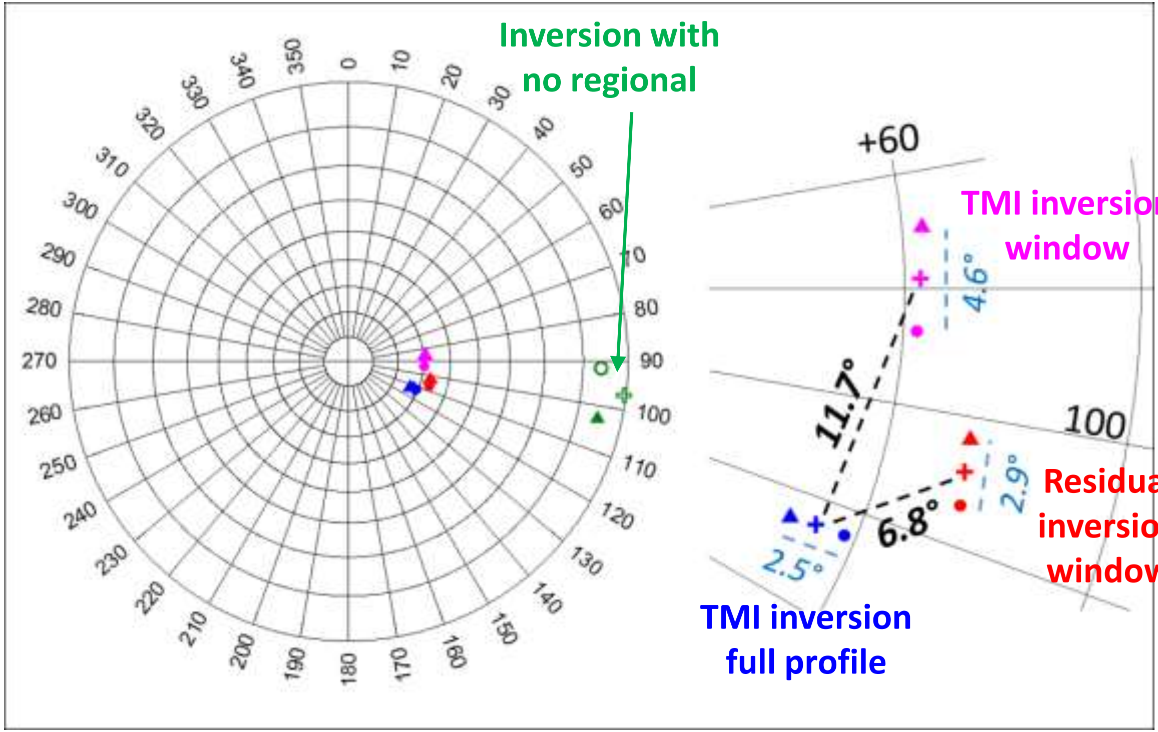


Free Regional in anomaly window





Recovered Magnetization Directions



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Conclusions

1	The external magnetic field of a body is a function of its resultant (remanent plus induced) magnetization.
2	Koenigsberger ratio values calculated from rock magnetic measurements suggest that remanent magnetization contribute substantially to most measured magnetic field variations.
3	Many, and possibly most measured magnetic anomalies are due to magnetizations with some departure from the local geomagnetic field direction.
4	For magnetic field studies of magnetization, the Koenigsberger ratio should be supplemented with a measure of the angular rotation of magnetization away from the local geomagnetic field, here termed the apparent resultant rotation angle (ARRA).
5	Helbig's 1963 proof that the direction of a dipole magnetization can be recovered from magnetic field analysis is the fundamental basis for investigation of the magnetization direction of any compact source.
6	Extension of Helbig's proof to studies of geological magnetizations requires reliable isolation of an anomaly from overlapping fields, accurate determination of the center of magnetization, and appropriate correction for any influence of shape and plunge.
7	At steep geomagnetic inclinations the peak to trough azimuth and amplitude ratio indicate magnetization direction. These characteristics are more clearly expressed in magnetic field images with subdued sun-shading and contour overlays.
8	The standard RTP is invalid for magnetizations not in the geomagnetic field direction, but the transform can be adjusted to accept other magnetization directions.

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Conclusions

9	The total gradient transform has low sensitivity to magnetization direction, and the Normalized Source Strength (NSS) has even less.
10	The exact distribution of a compact magnetization has little effect on estimation of its magnetization direction.
11	Because shape detail is relatively unimportant, parametric and voxel inversions of identical anomaly separations should provide essentially identical resultant magnetization direction estimates.
12	Position and estimated magnetization direction of a compact source are closely linked. In inversion, an error in one causes an error in the other, but for well-defined anomalies both position and magnetization direction can both be resolved.
13	Anomaly (regional-residual) separation is commonly the most critical aspect in determining magnetization direction.
14	Where inversion has itself been used to perform an anomaly separation it is important to review images of the regional and residual fields to ensure that the separation is acceptable.
15	Estimation of magnetization direction is relatively robust because it is a bulk characteristic rather than a detail (such as depth to top, or shape), and also because it does not have a particularly close pairing with any other parameter or parameter set (as for instance do intensity of magnetization and volume, which are so closely paired that there is generally little sensitivity to either value, only to their product).

Thank you

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