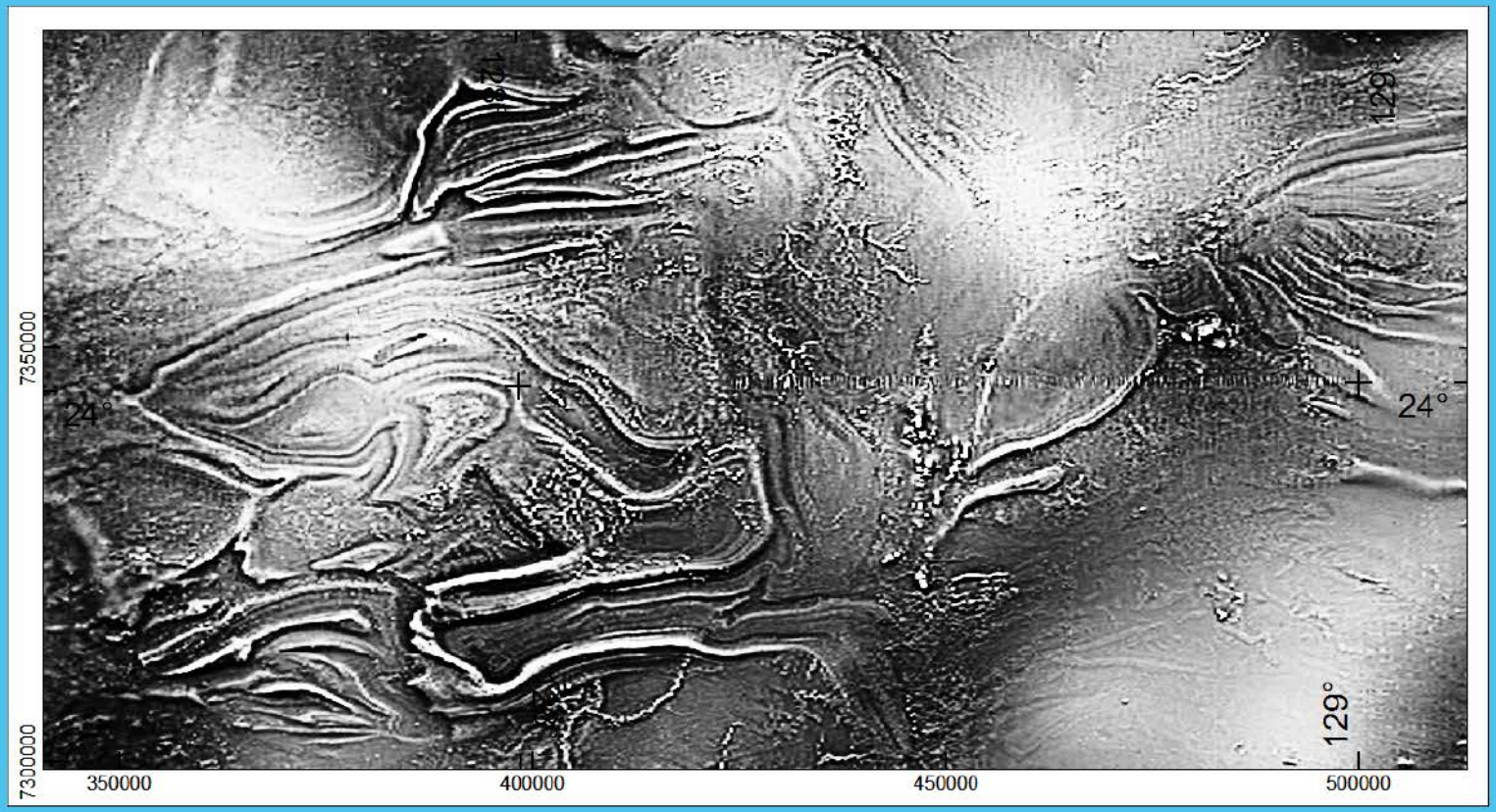


Uncovering with magnetics

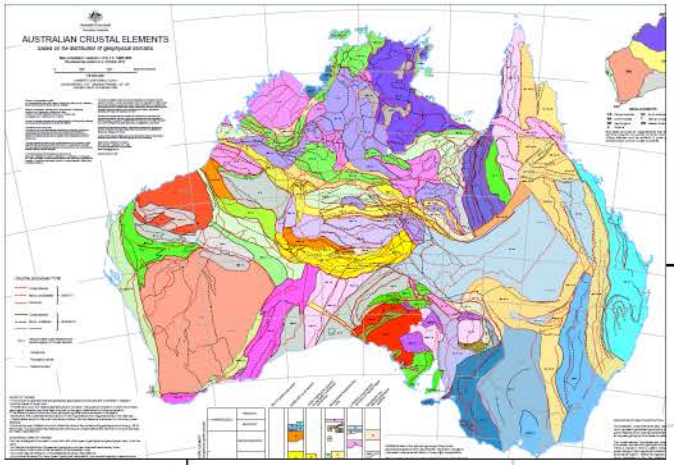
Clive Foss

Directions

1. Introduce the geophysical method in mapping cover thickness down to 1 km over a 5×5 km area
2. Discuss resolution of the method
3. Discuss how uncertainty is assessed
4. Provide an overview of the strengths and weaknesses of the method through case study examples

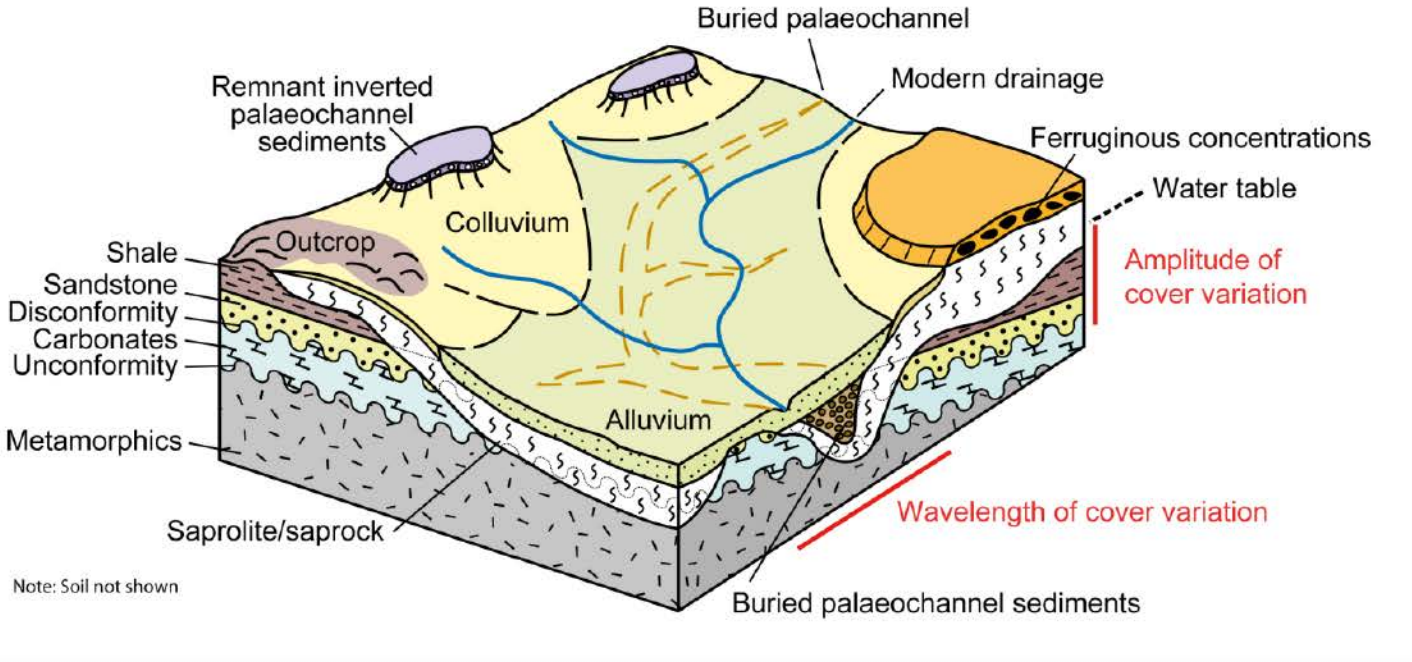
1) The Magnetic Method

Magnetics ~~Reveals~~ Defines Australian Geology



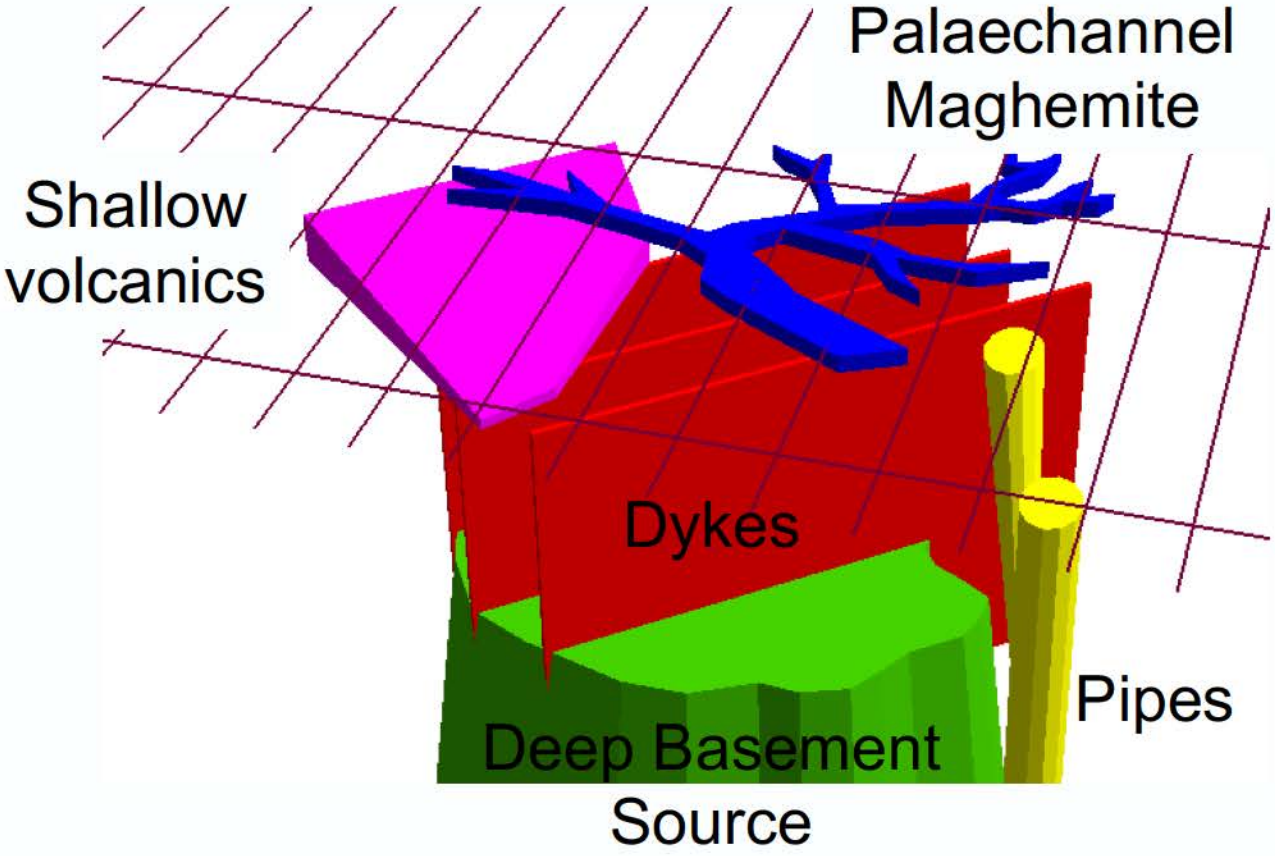
Australian Crustal Elements Map
by Geoscience Australia

Shallow Geology Schematic

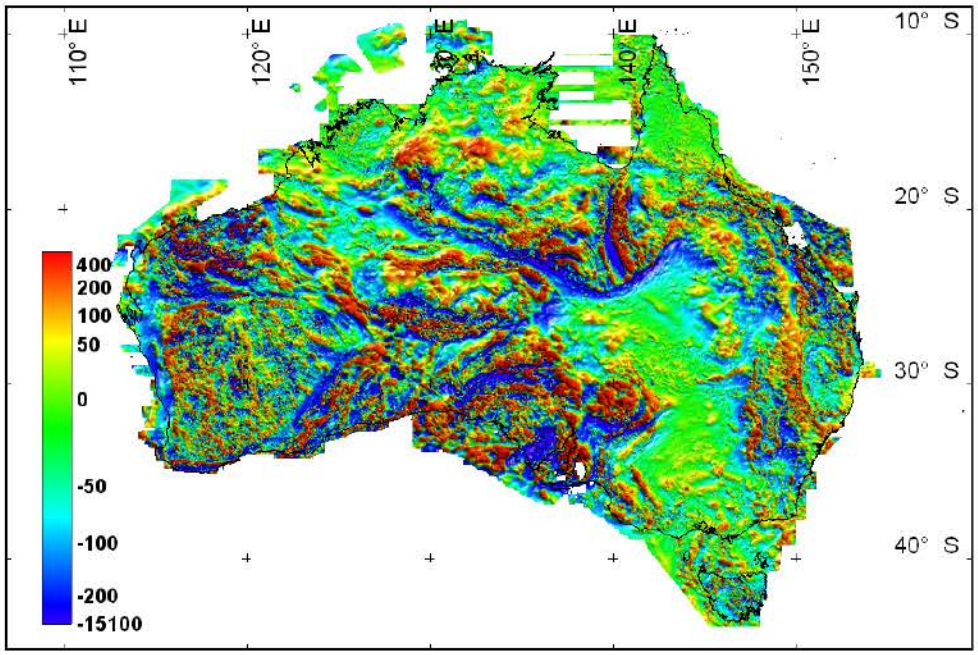


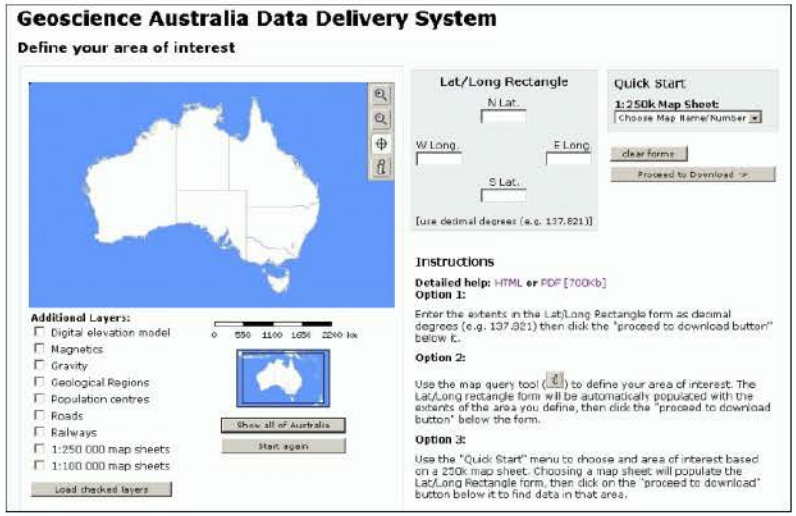
Most of these features can produce magnetic field variations detectable by low-level hi-resolution aeromagnetic and ground magnetic surveys. In any area generally only the strongest magnetizations can be mapped.

Most Common Magnetic Sources



GADDS – Australia's Geophysical Crown Jewels



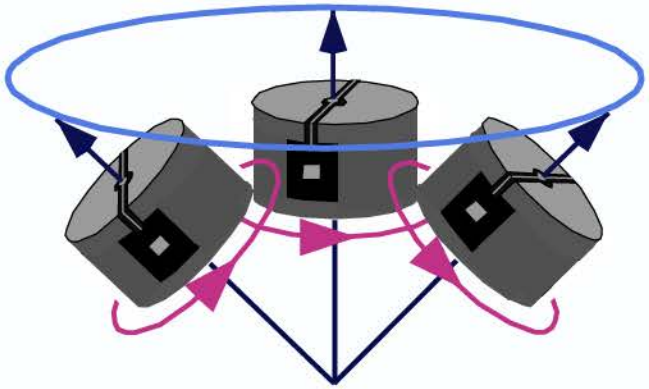


Wing Tip Gradiometry

- Slight incremental cost to reduce effective line spacing
- Use of wing-tip gradiometry is a cultural issue
  - Canada – the default choice
  - Australia – rarely used FOR NO GOOD REASON
- The advantages are similar for regional and detailed surveys

Airborne Magnetic Tensor Gradiometry

- Anglo and De Beers are flying magnetic tensor gradiometry using low-temperature SQUIDs



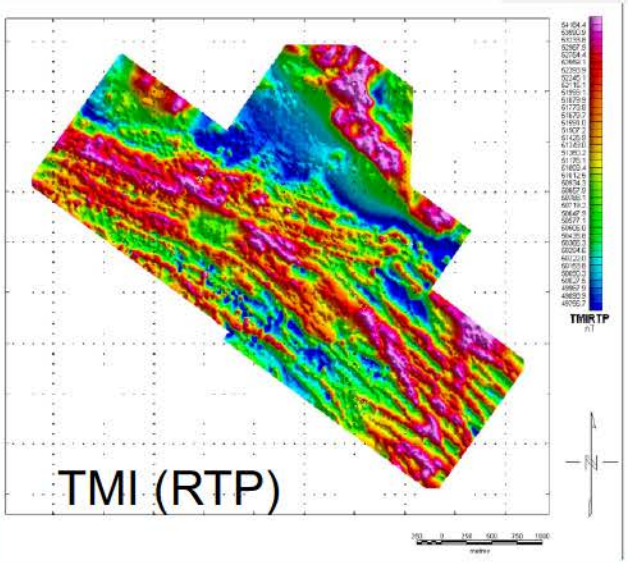
- CSIRO has a 2/3rd developed high-temperature SQUID magnetic tensor gradiometry (developed largely with defence funding for submarine detection)

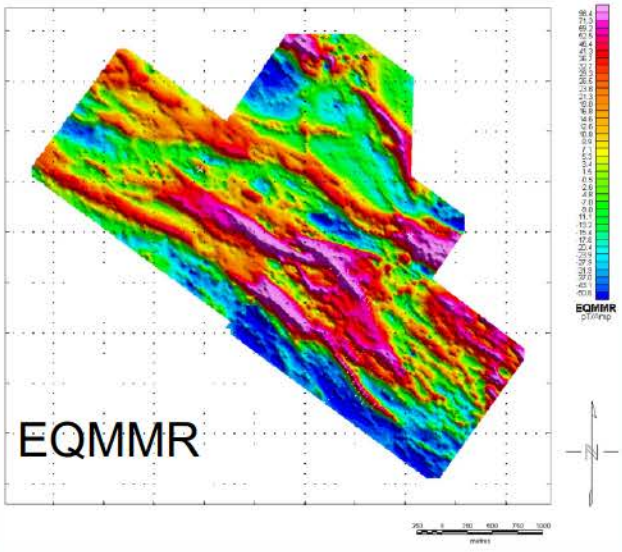
- Magnetic tensor gradiometry is unlikely to displace TMI as the 'work-horse' aeromagnetic method – but may find application in high-resolution mapping

SAM – Sub-audio Magnetics

Developed by GAP Geophysics http://www.gapgeo.com/

Gap Geophysics Australia





- Ground or heli- surveys
- More expensive than standard magnetics – but provides new mapping of an independent physical property

Ultra-lights and Drones

- Do we want ultra-lights? - they may provide a cheap survey platform but can safety levels be ensured?
- Drones are an inevitable development and should provide lower cost aeromagnetic surveys

Medium size drone to fly tenement scale surveys (and possibly larger)

Small scale drone for brown-fields and production applications monitoring stockpiles or mapping mine benches

Ground surveys

There will always be a place for high resolution ground surveys (by foot or quad-bike)

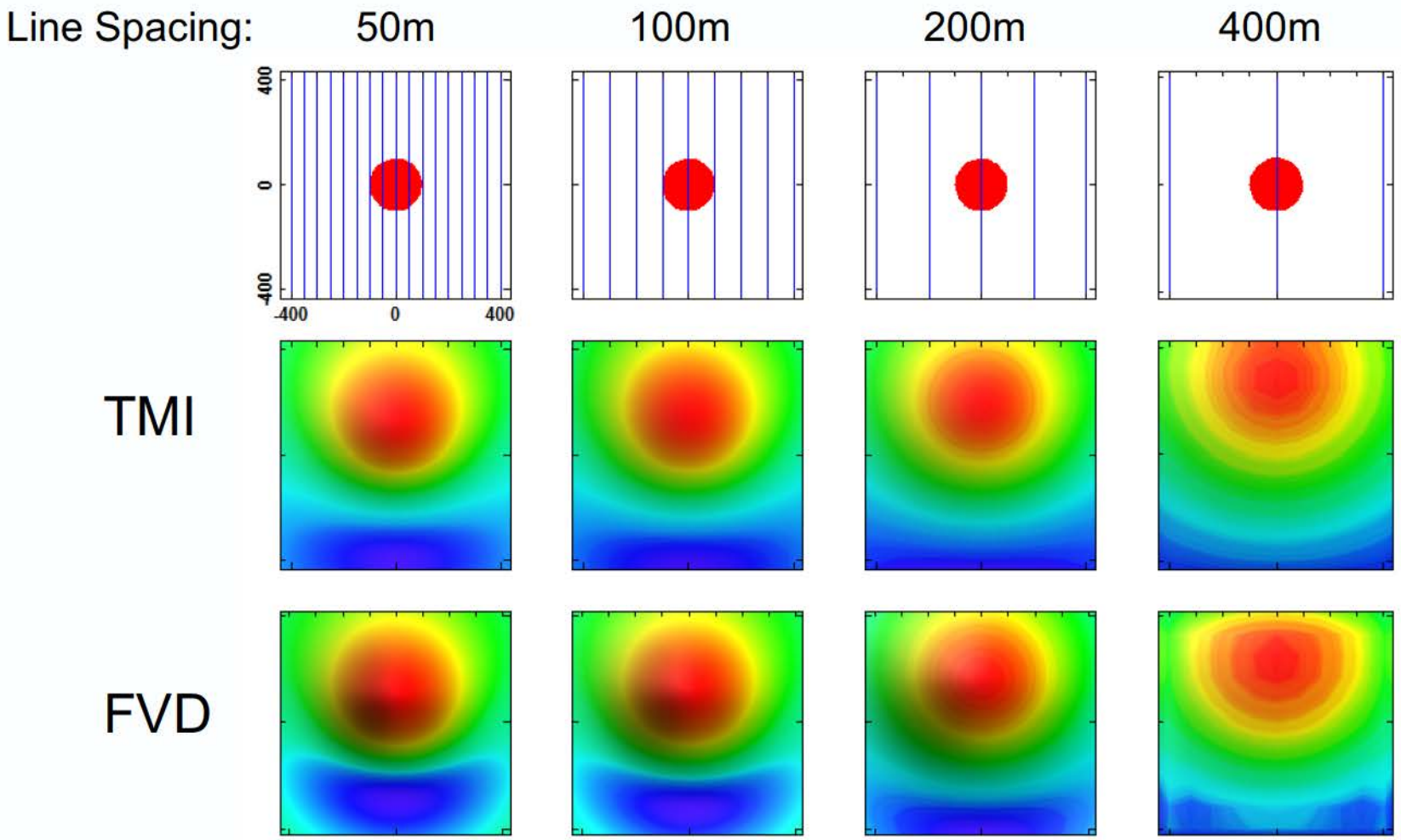
Boreholes

- Down-hole Susceptibility Logging
- National Physical Property Database
- Down-hole TMI and component surveys
- CSIRO DETCRC tensor down-hole probe

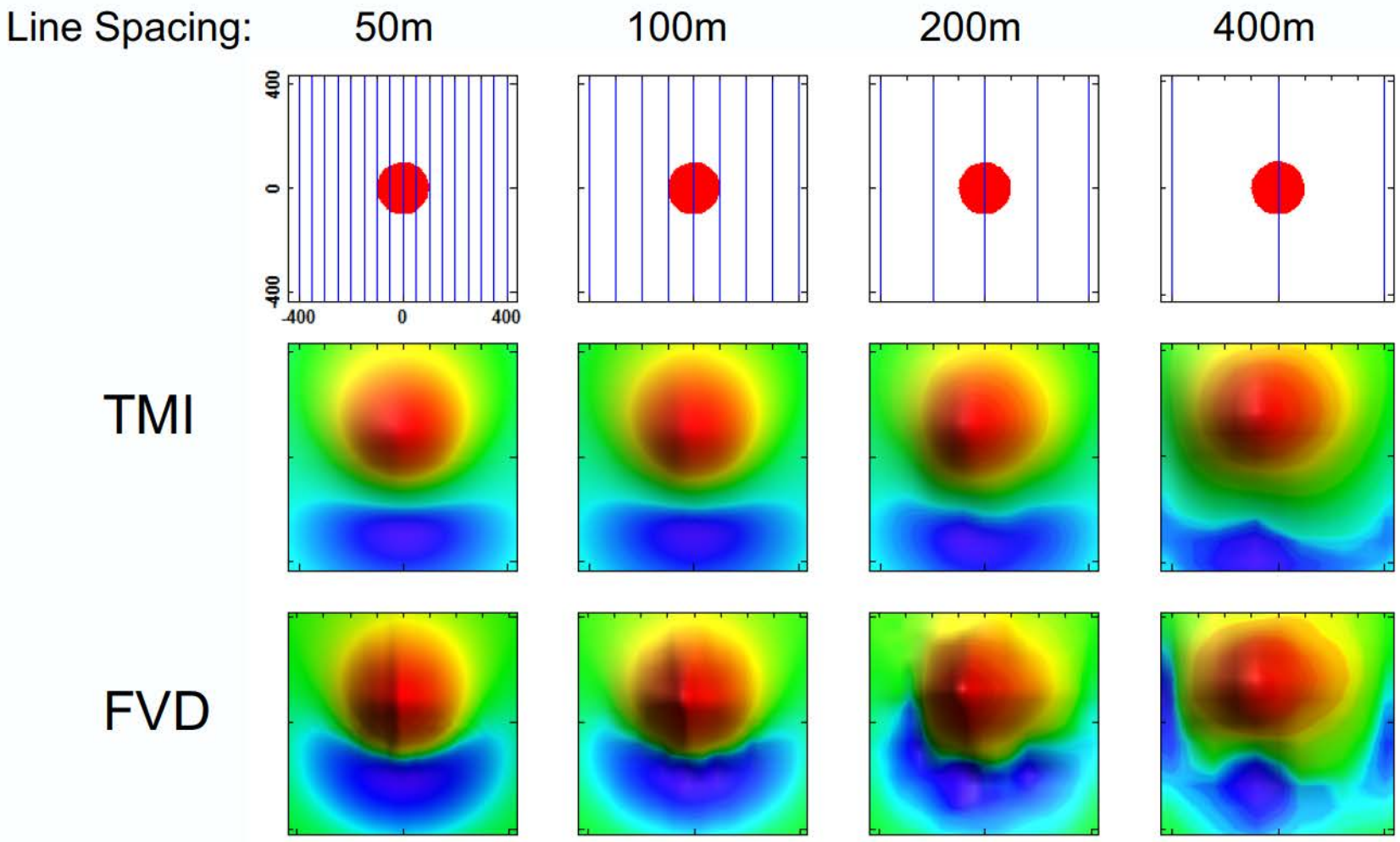
DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

2) Resolution

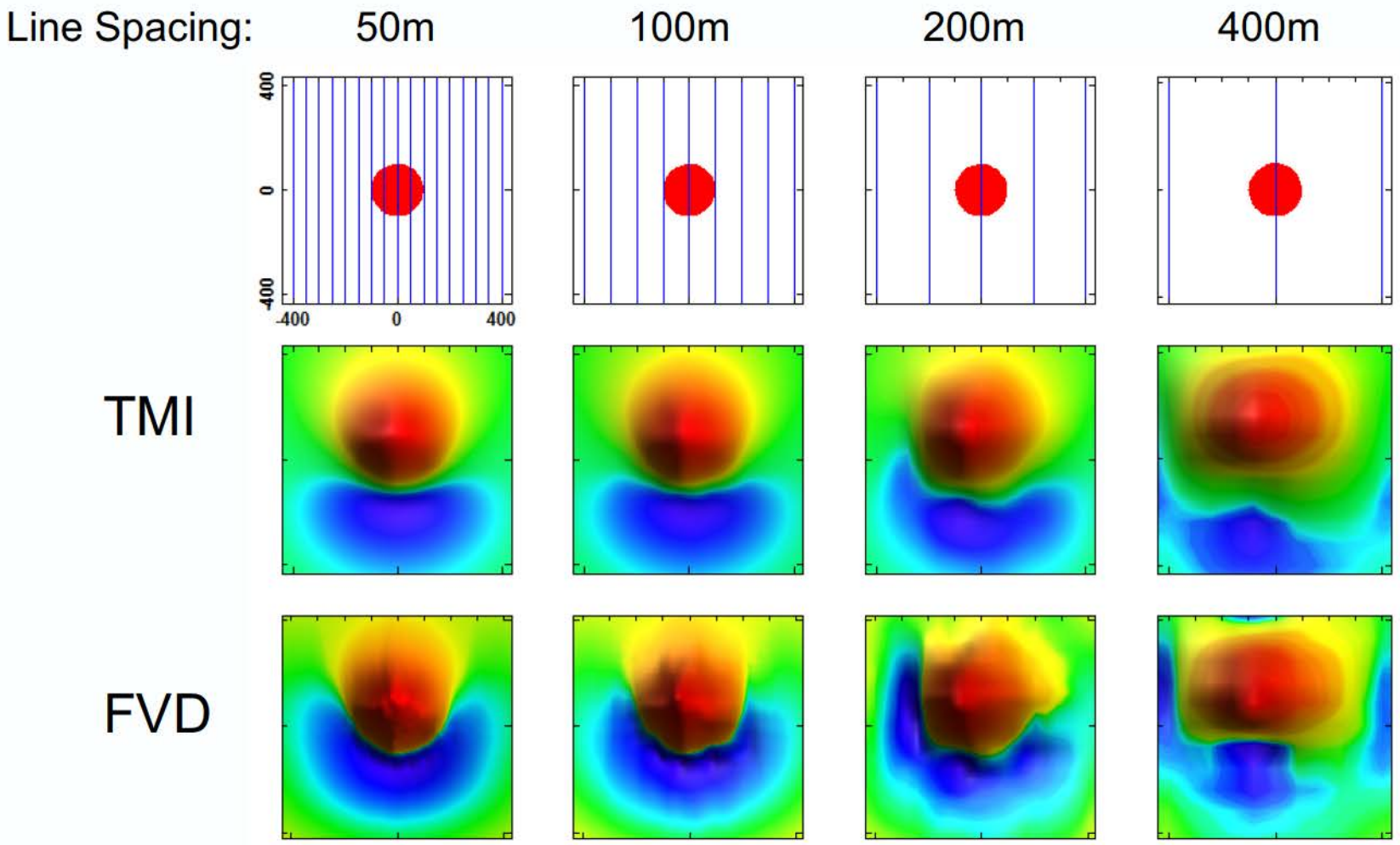
Source diameter 2titim, depth 3titim



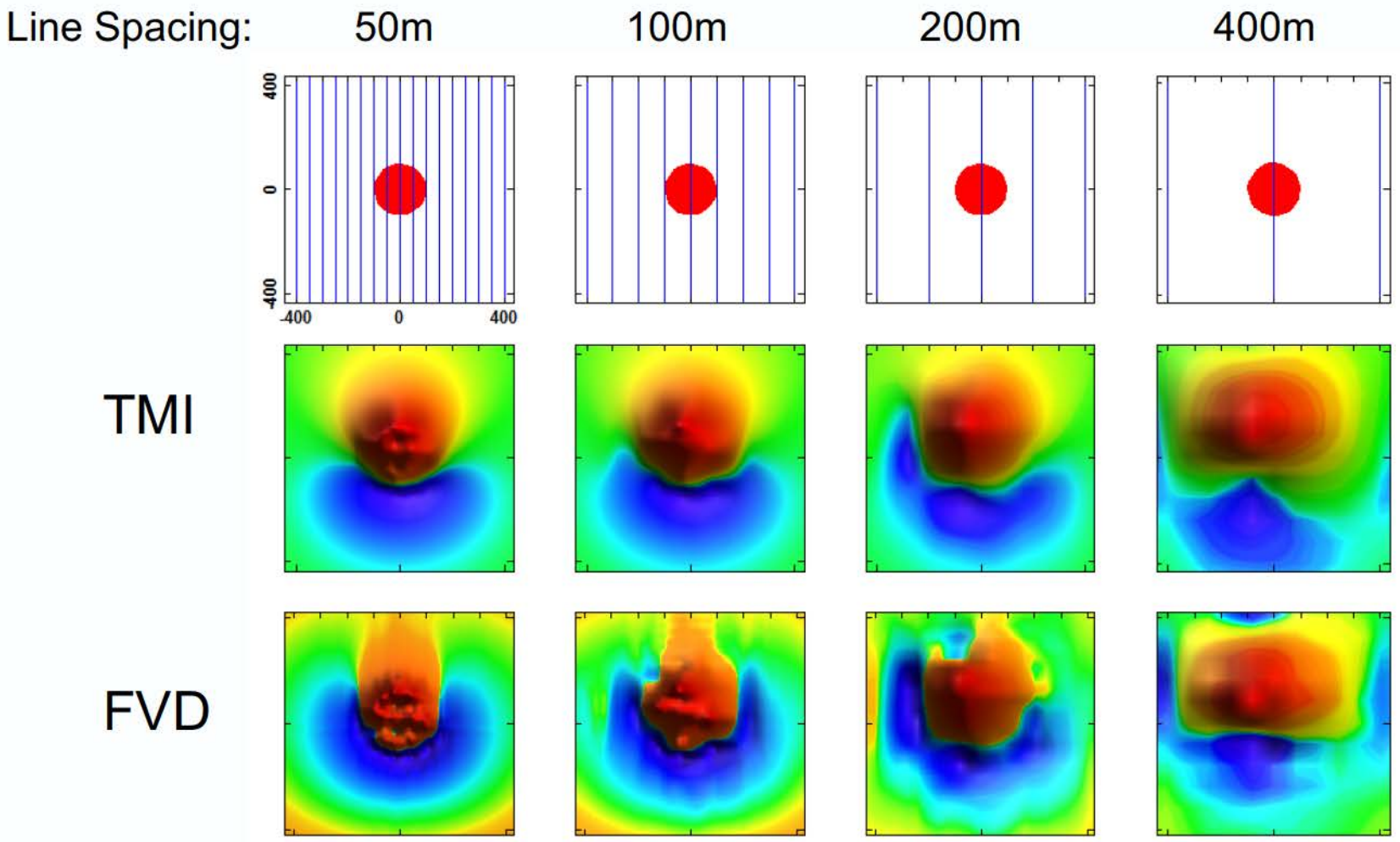
Source diameter 2tititim, depth 2tititim



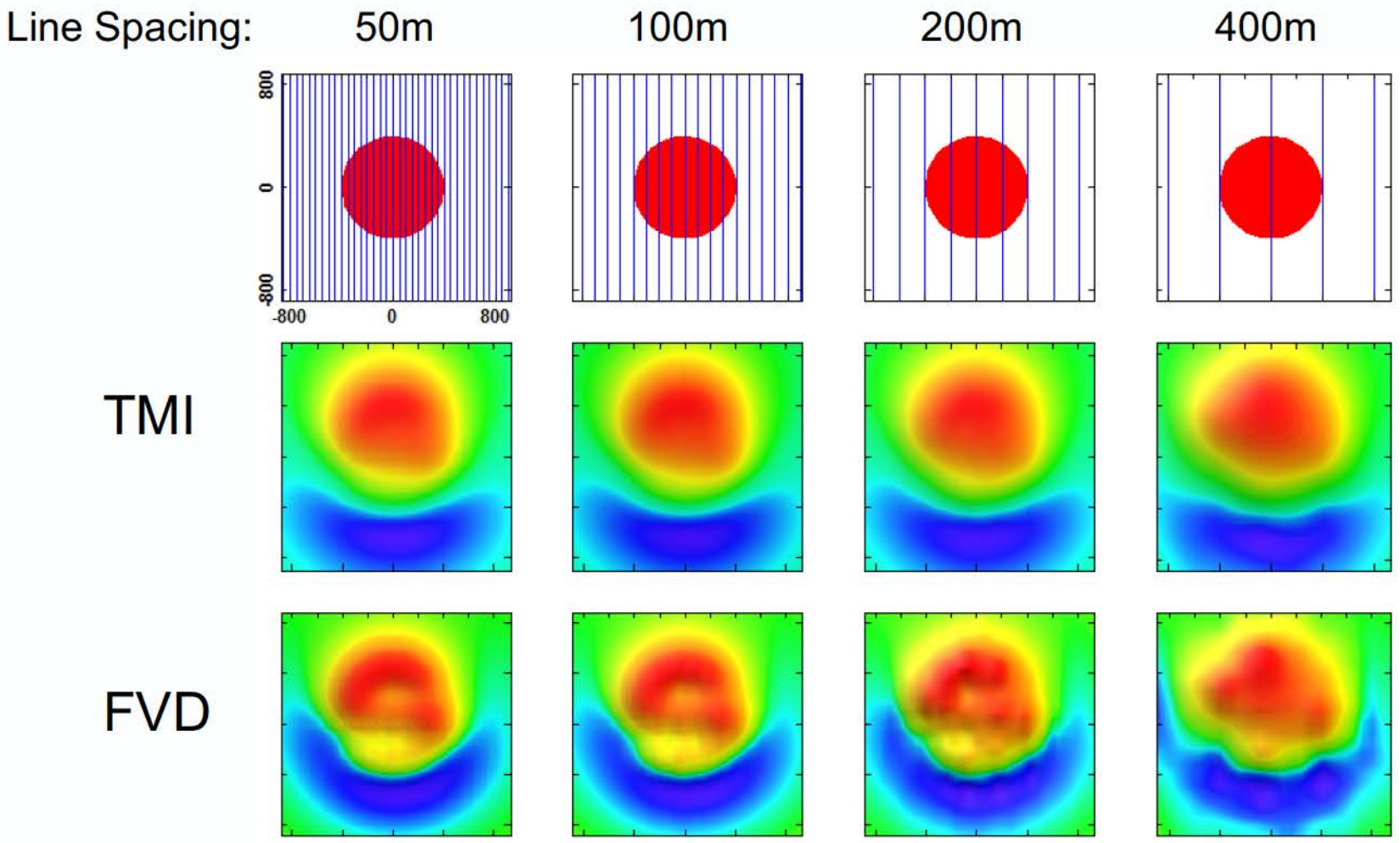
Source diameter 2titim, depth 1titim



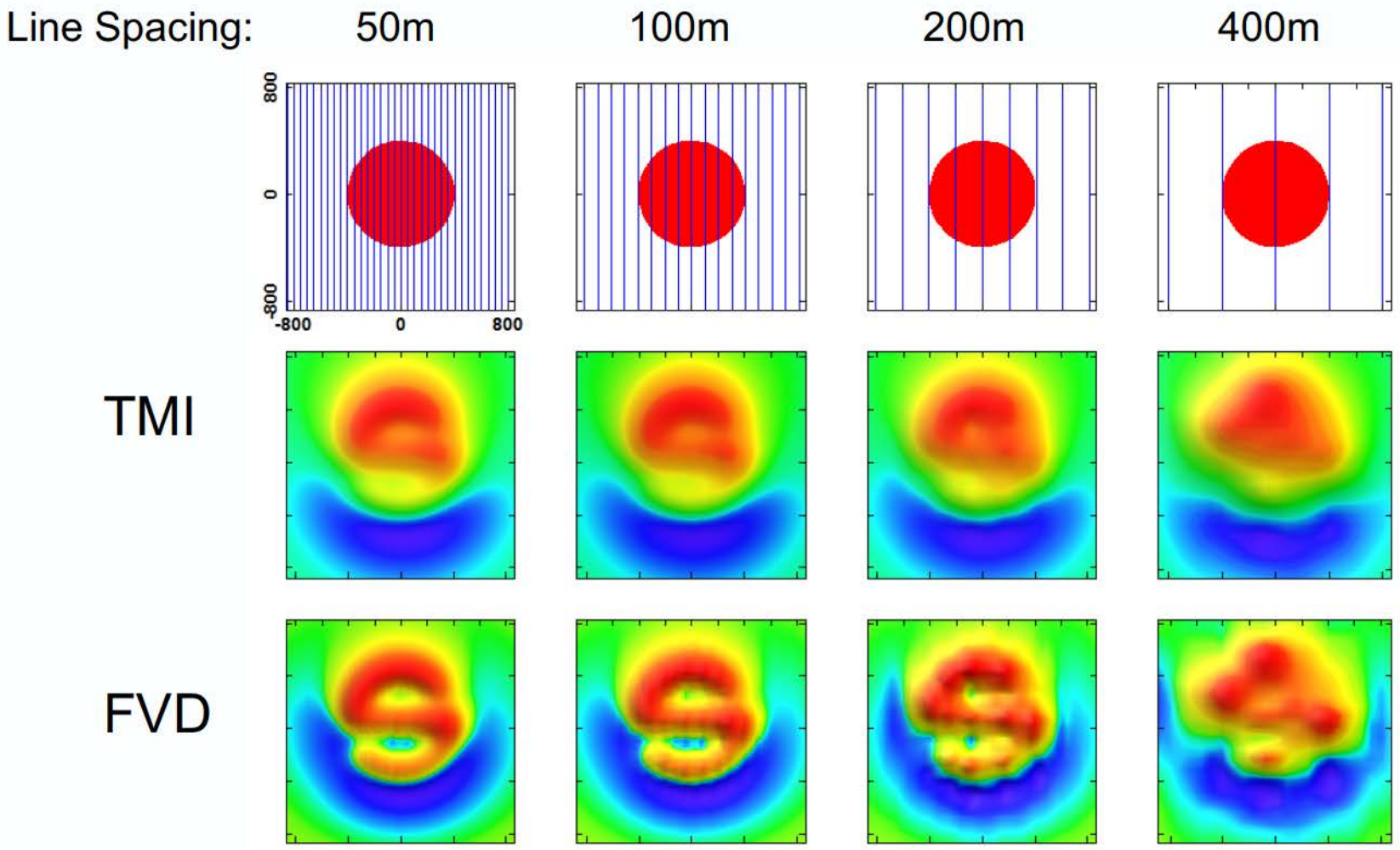
Source diameter 2titim, depth 5tim



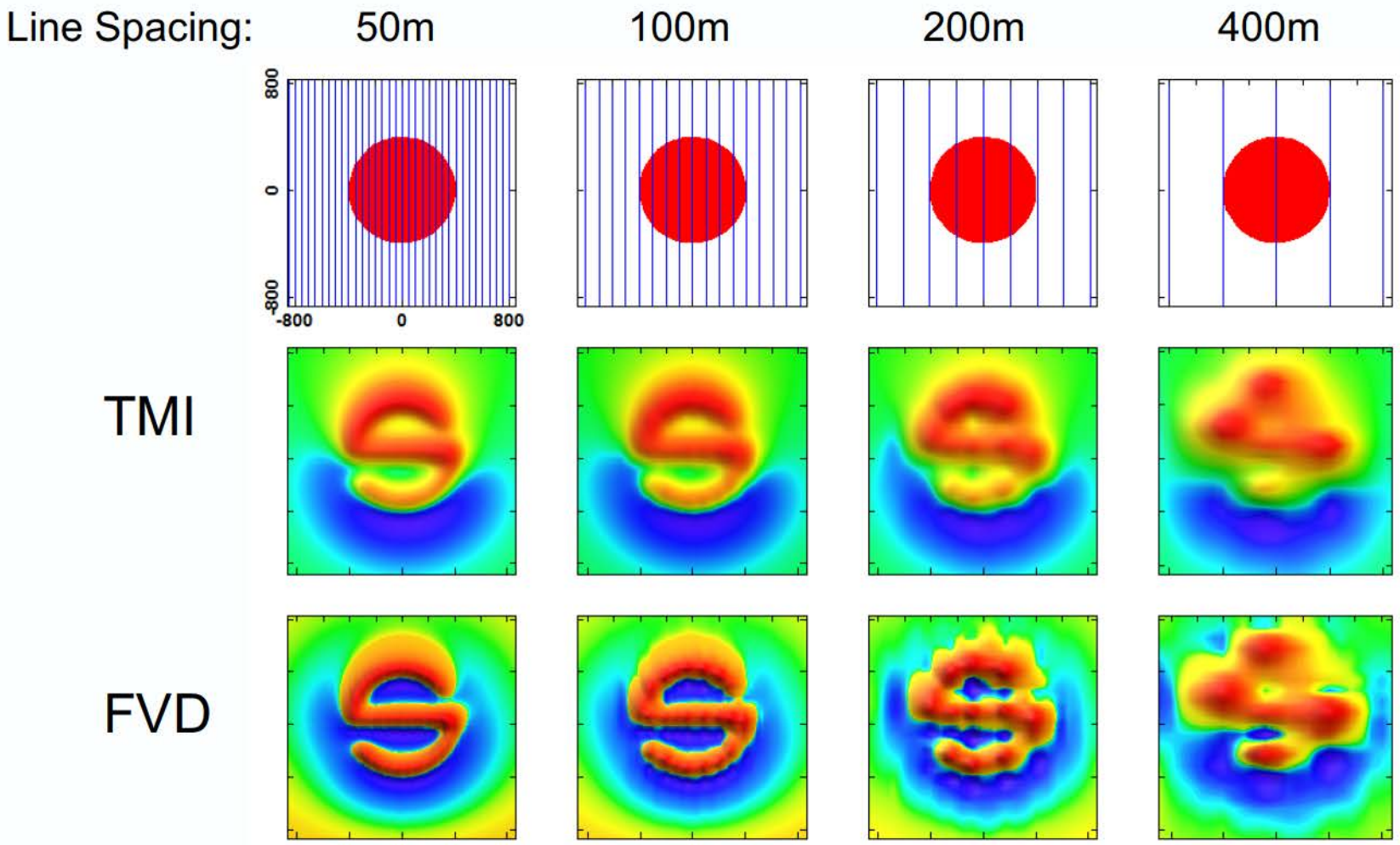
Source diameter 8titim, depth 3titim



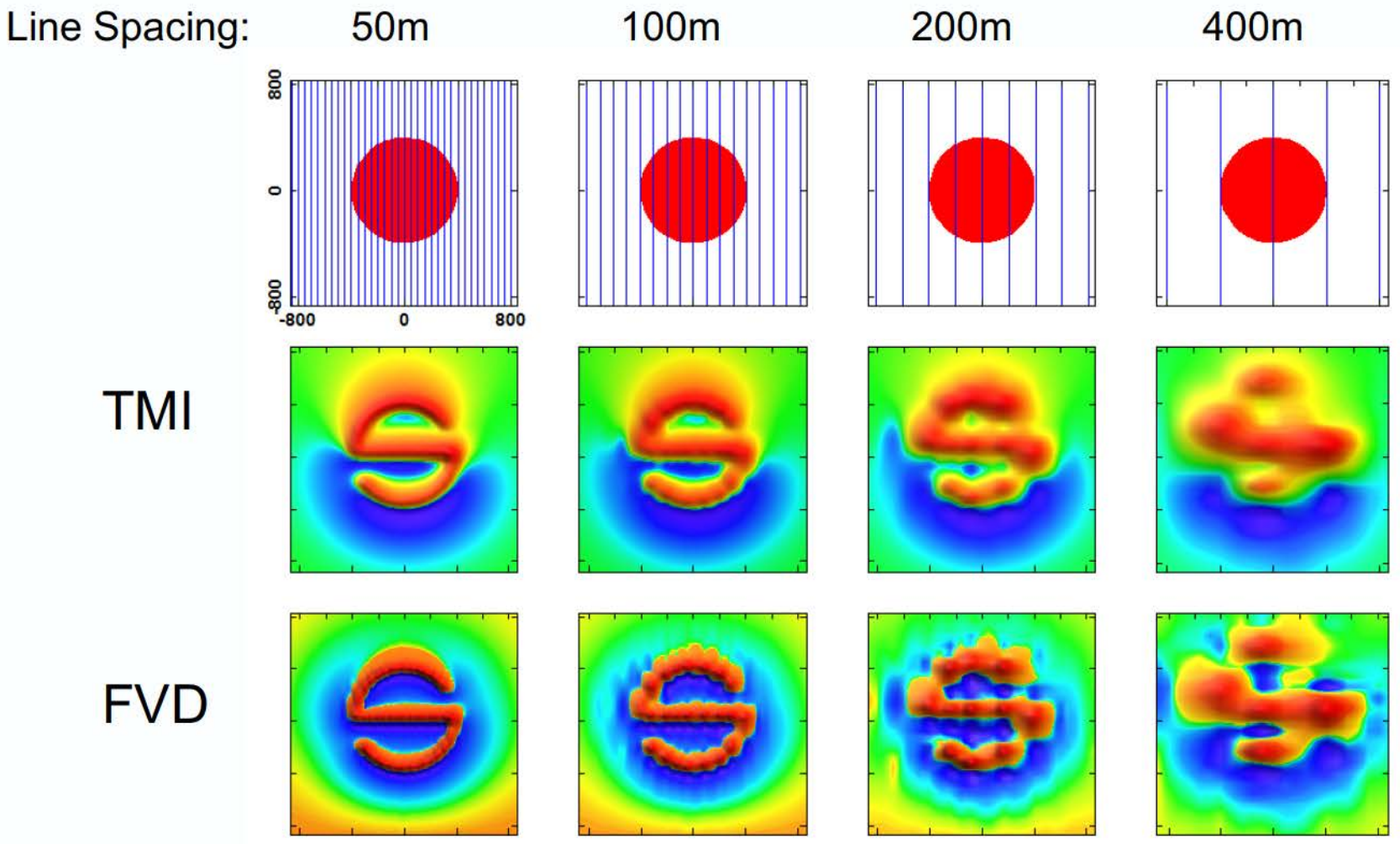
Source diameter 8titim, depth 2titim



Source diameter 8titim, depth 1titim



Source diameter 8titim, depth 5tim



Will we acquire closer line-spaced data?

- This decision is made on budget considerations
- Depends on the relevance of the magnetic bodies to mineralisation

Will closer line-spaced data provide significant new information?

- Depends on depth to the magnetic sources
- Depends on the scale of the geological structures

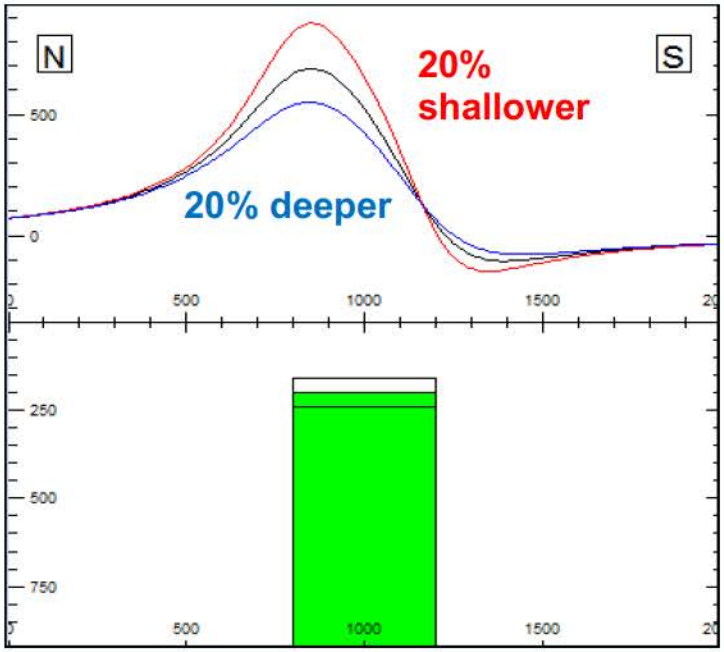
As a general rule, if an area is worth exploring, has regional magnetic coverage at 400 metre line spacing and sources <200 below surface, it should be worthwhile infilling to 100 or 50 metre spacing.

3) How is Uncertainty Assessed?

This Slide Intentionally Blank

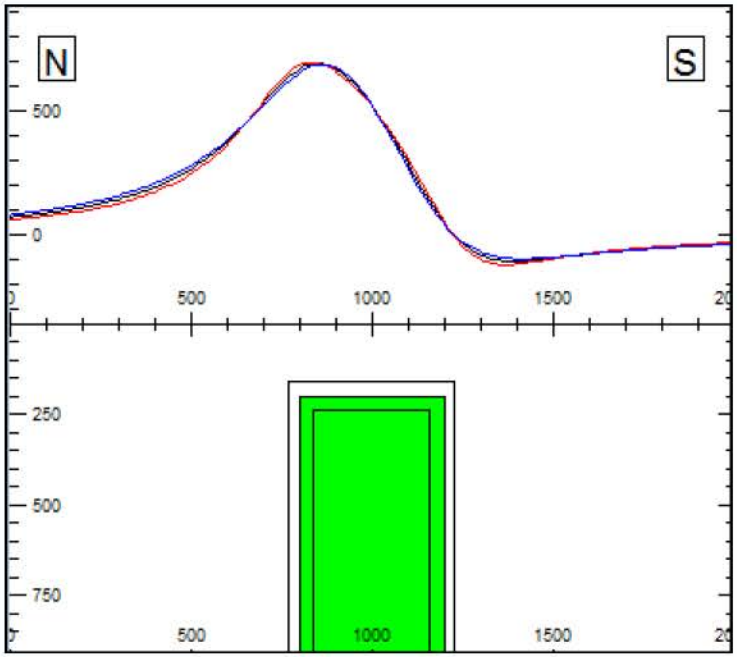
Sensitivity to source depth

Depth offset for identical sources
(appropriate to looking for a known source)



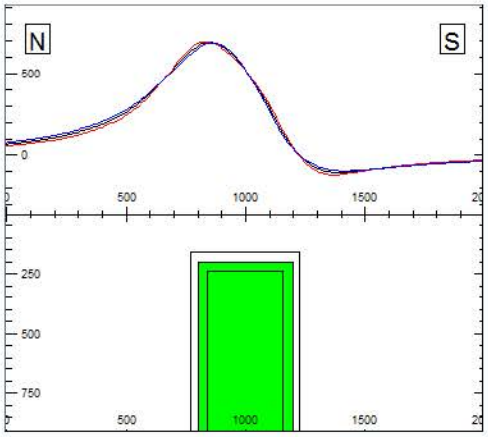
Sensitivity to source depth

Depth offset inversion-matched sources
(appropriate to looking for an unknown source)



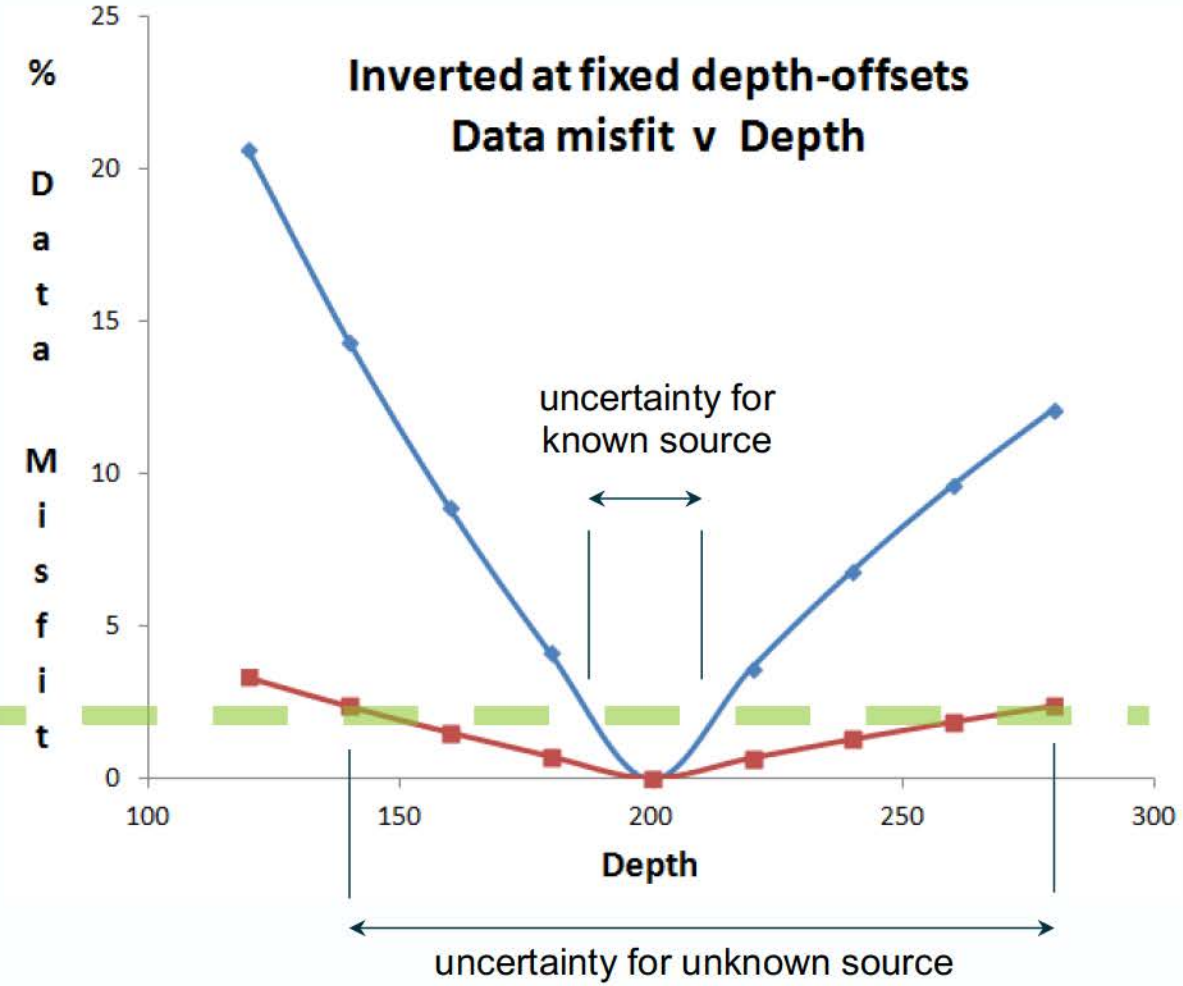
Anomaly changes due to depth variation can be mostly compensated by changes in other parameters – especially susceptibility and thickness

Evaluating sensitivity to depth



Depth offset of an unknown source model

Level at which the misfit is proposed to be significant (interpretational)



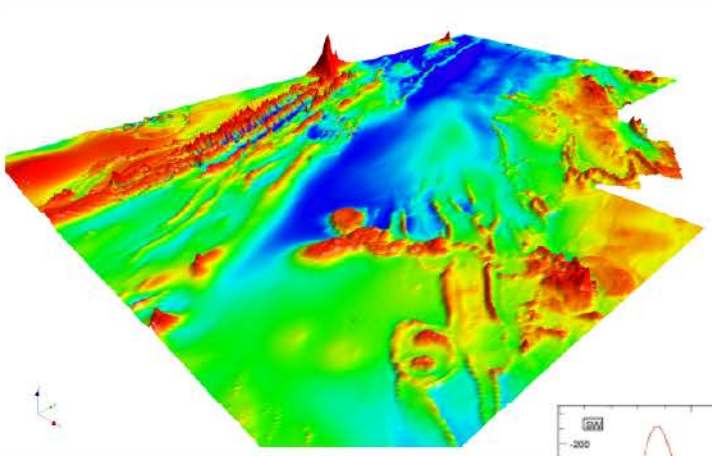
An Australian Magnetic Source Database ?

- Magnetic source depth estimation doesn't cut it
  – we need dedicated inversion of isolated anomalies

- CSIRO and Geoscience Australia have investigated suitable work-flows and have the necessary skills to generate a national database of inverted source solutions with associated parameter attributes and sensitivity estimates

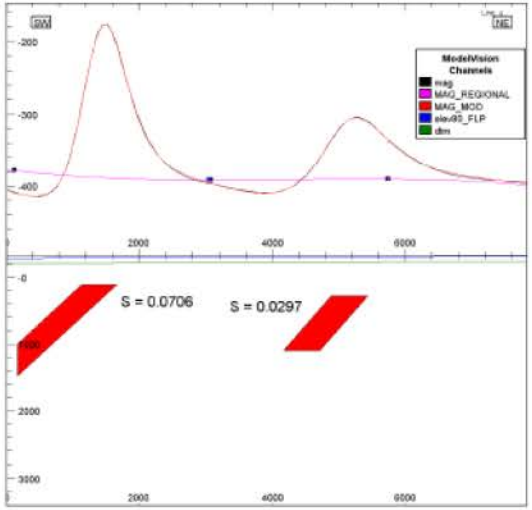
4) Examples Illustrating Strengths and Weaknesses

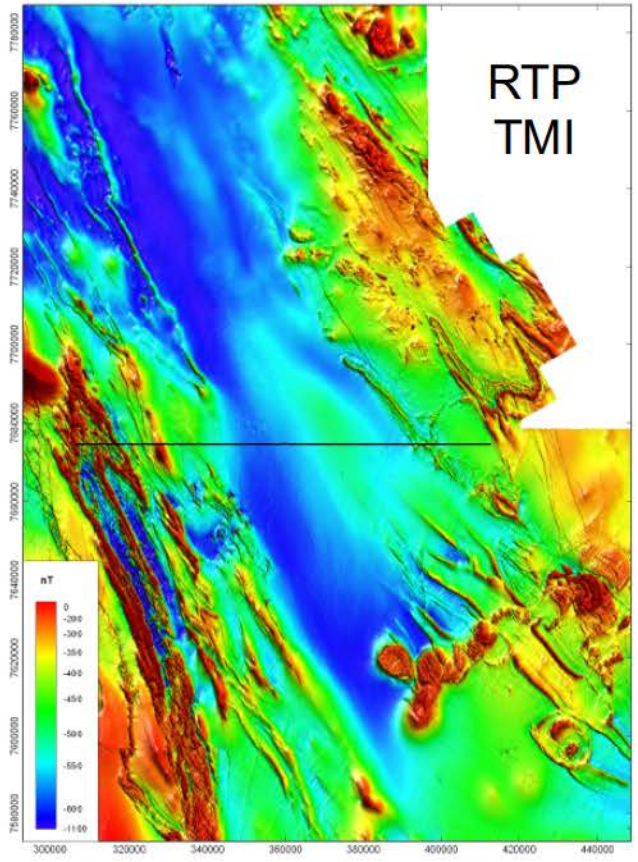
Case Study (strength) Waukarlycarly Basin, WA



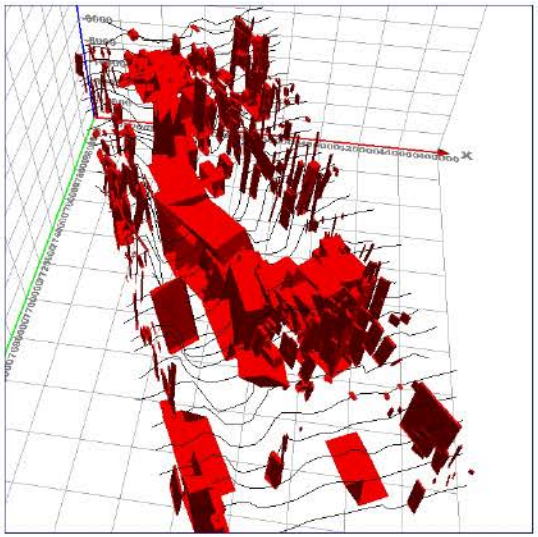
RTP
TMI

Selected profile inversions

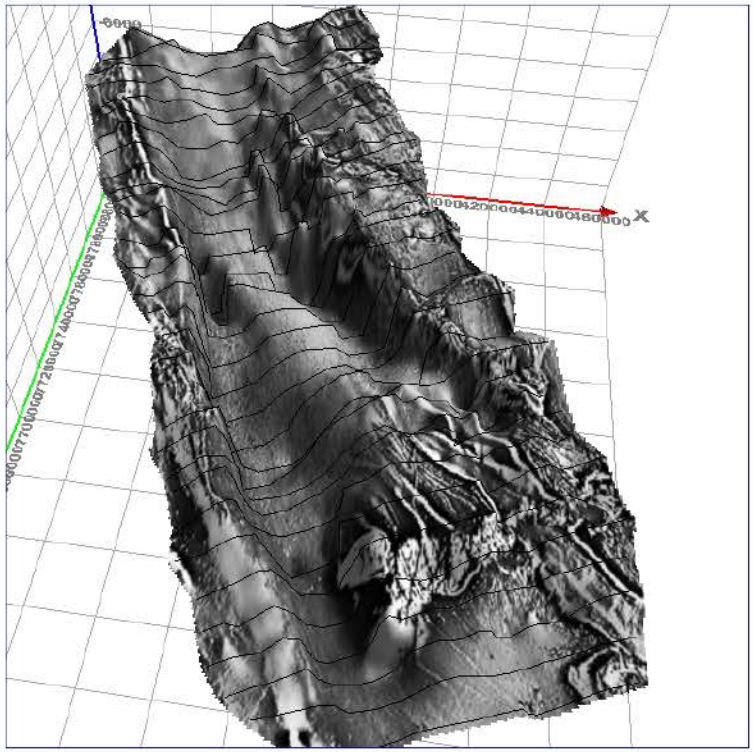




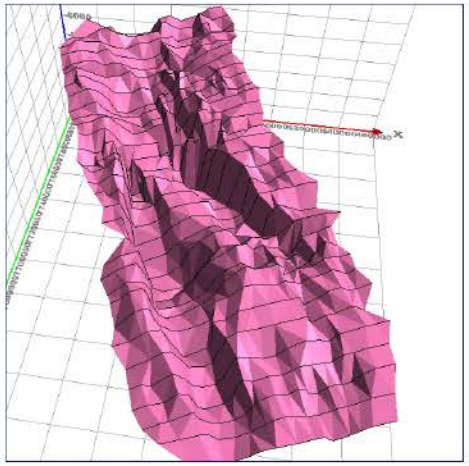
Waukarlycarly Basin, WA



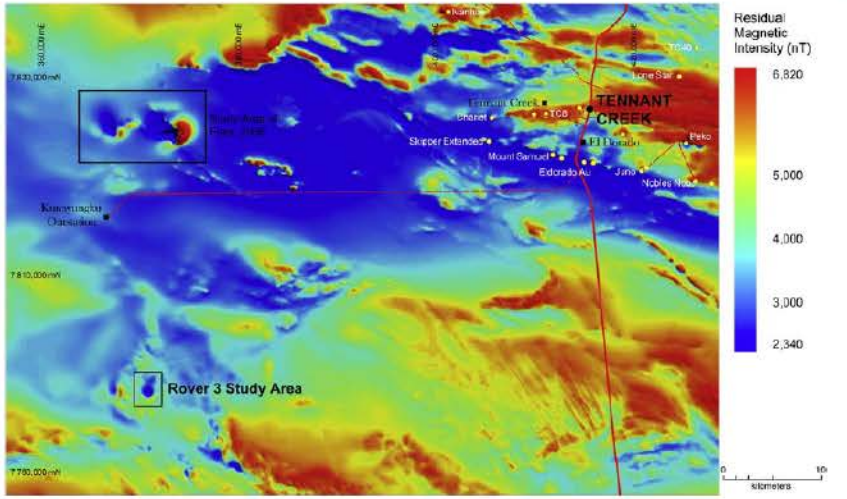
Solutions



Depth surface

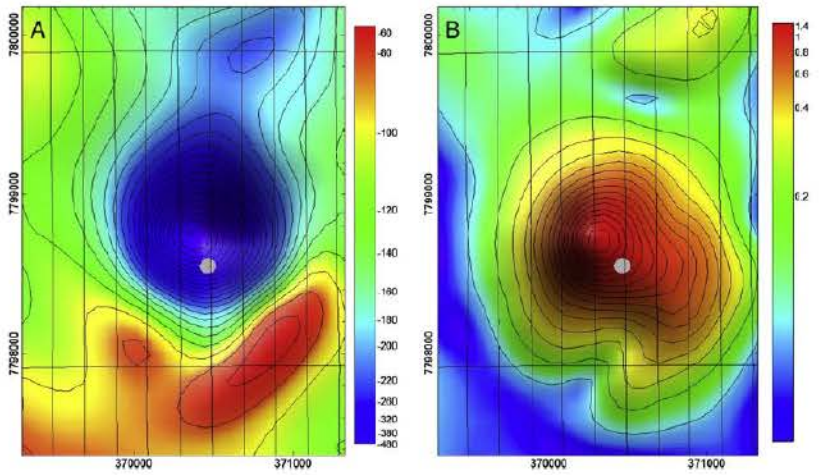


Case Study (weakness)
Rover 3 Tennant Creek

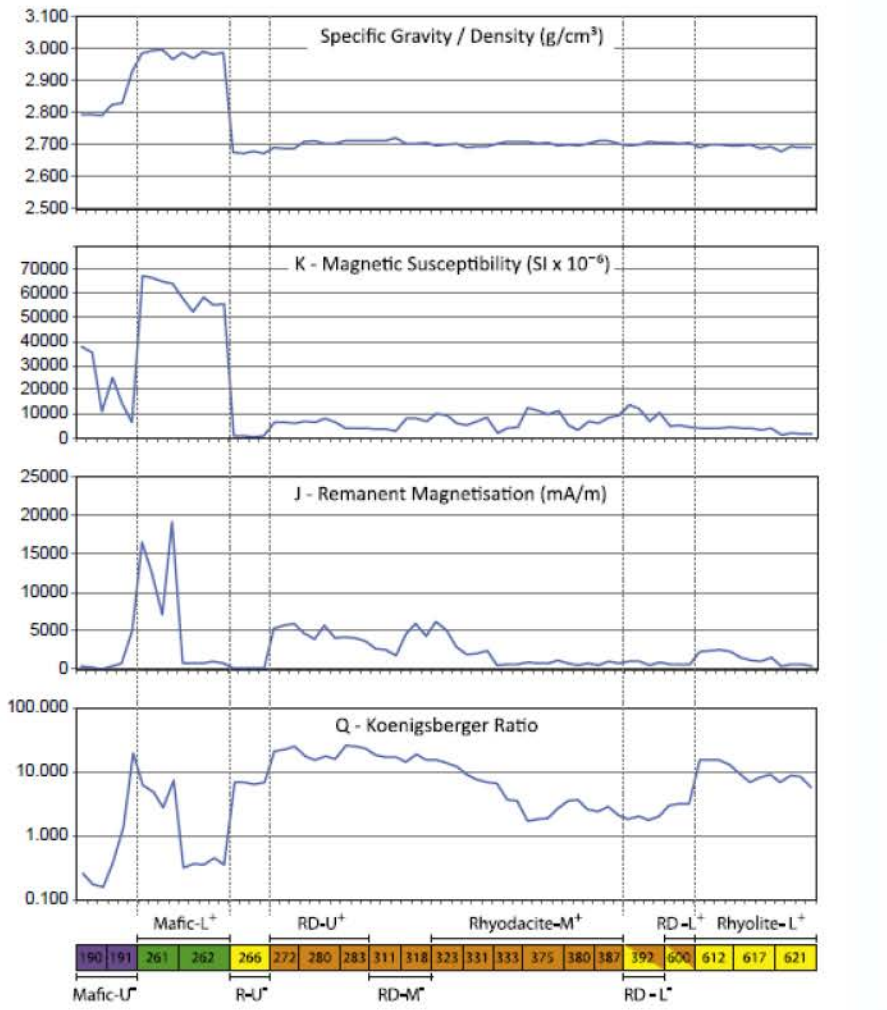


TMI anomaly

Total Gradient anomaly



Rover 3 Tennant Creek



- Estimated depth 250 metres (a good estimate)
- Magnetization was only tested with a susceptibility meter
- Q factor of the most significant shallow magnetization is up to 10
- Drilling continued to a depth of 738 metres

Journal of Applied Geophysics 104 (2014) 121–133

Contents lists available at ScienceDirect

Journal of Applied Geophysics

journal homepage: www.elsevier.com/locate/jappgeo

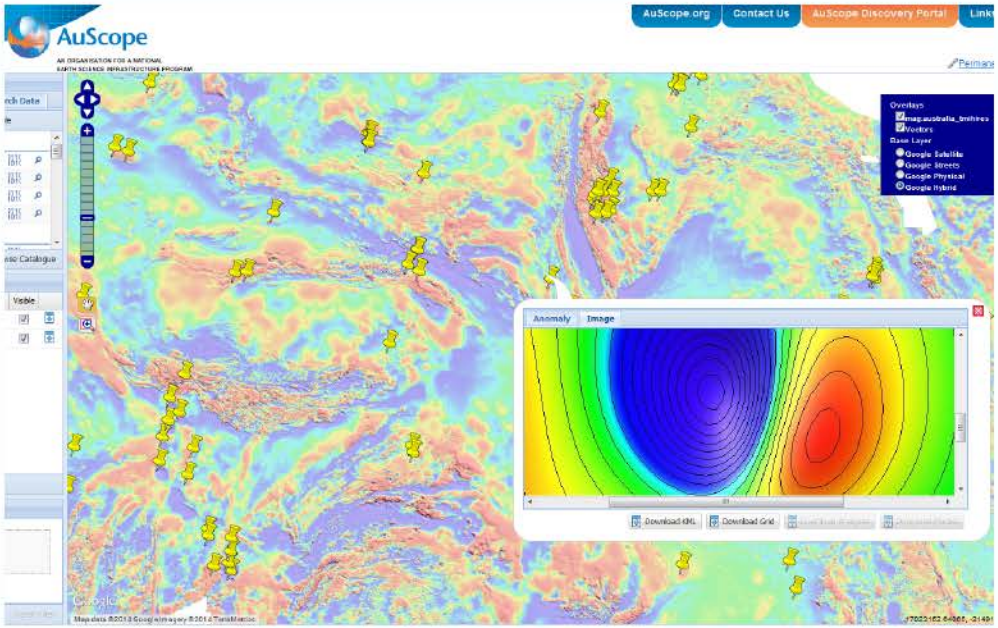
The Paradox of Scale: Reconciling magnetic anomalies with rock magnetic properties for cost-effective mineral exploration

James R. Austin [1,*], Clive A. Foss

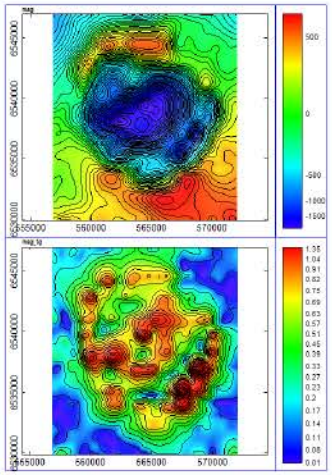
CSIRO Earth Science and Resource Engineering, PO Box 136, North Ryde, NSW 1670, Australia

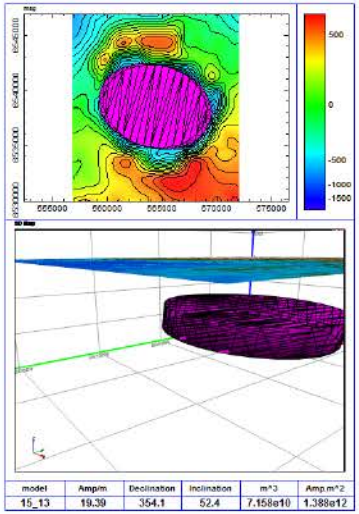
The Australian Remanent Anomalies Database

- A joint CSIRO – Geoscience Australia initiative available through the AuScope Portal (link at: www.magresearch.org)



Example grid download





Example model download

Conclusions

- Magnetic Field Studies are crucial for exploration beneath cover
- We need tenement-scale high-resolution magnetic surveys
- We need to value-add to the existing regional datasets
  - The National Remanent Anomalies Database (available through the AuScope portal)
  - A suggested national magnetic source database (this will require funding)

www.magresearch.org

Thank you

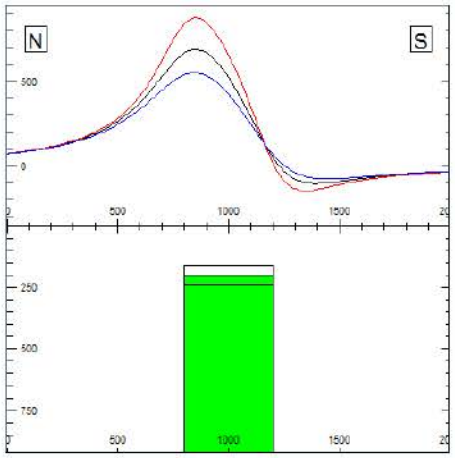
CSIRO Earth Science and Resource Engineering

Minerals Down Under Flagship

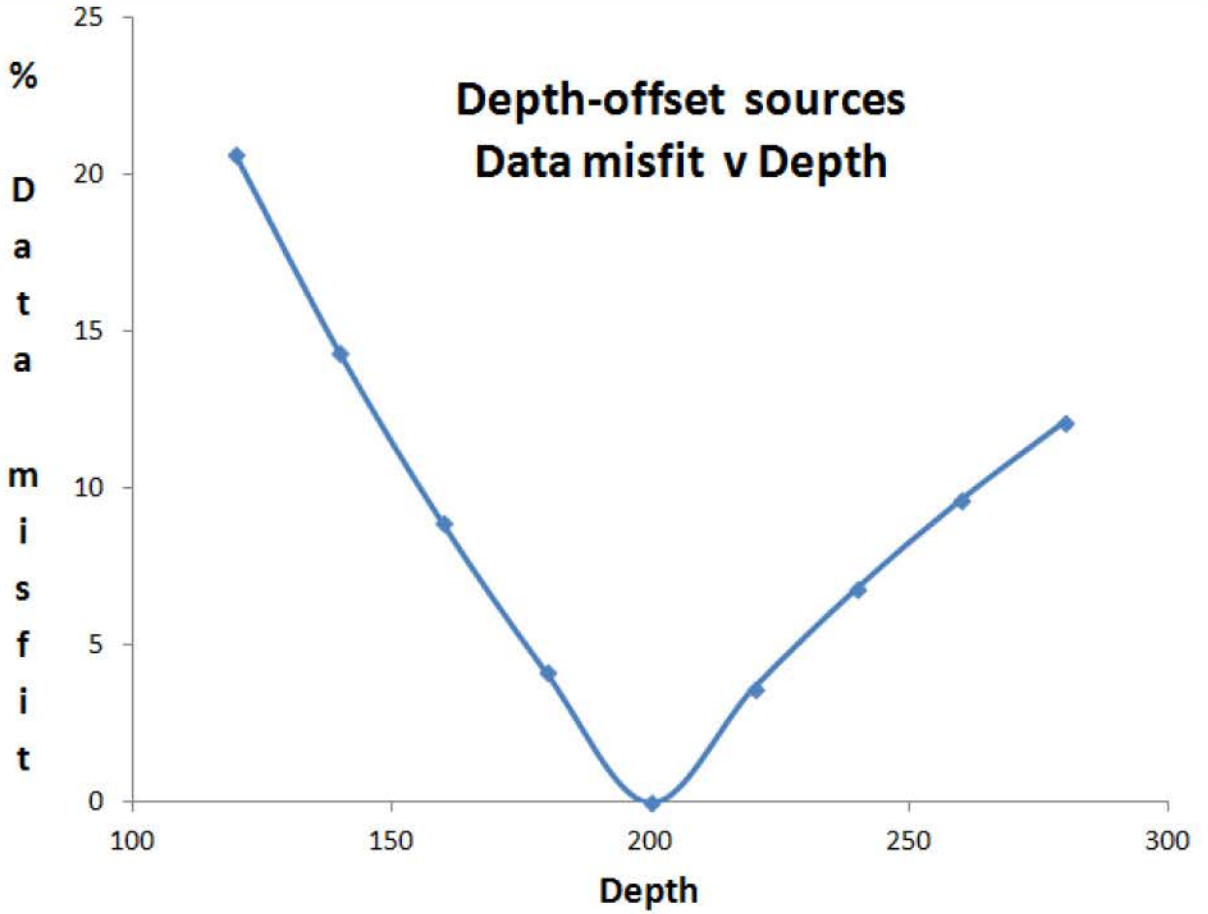
Clive Foss

t +61 2 949ti 8713
e clive.foss@csiro.au

Evaluating sensitivity to depth



Depth offset of a known source model



Data misfit = % rms difference between curves, normalised to the measured curve