Industry requirements for undercover exploration

A geophysical perspective

Charles Funk – Senior Geologist

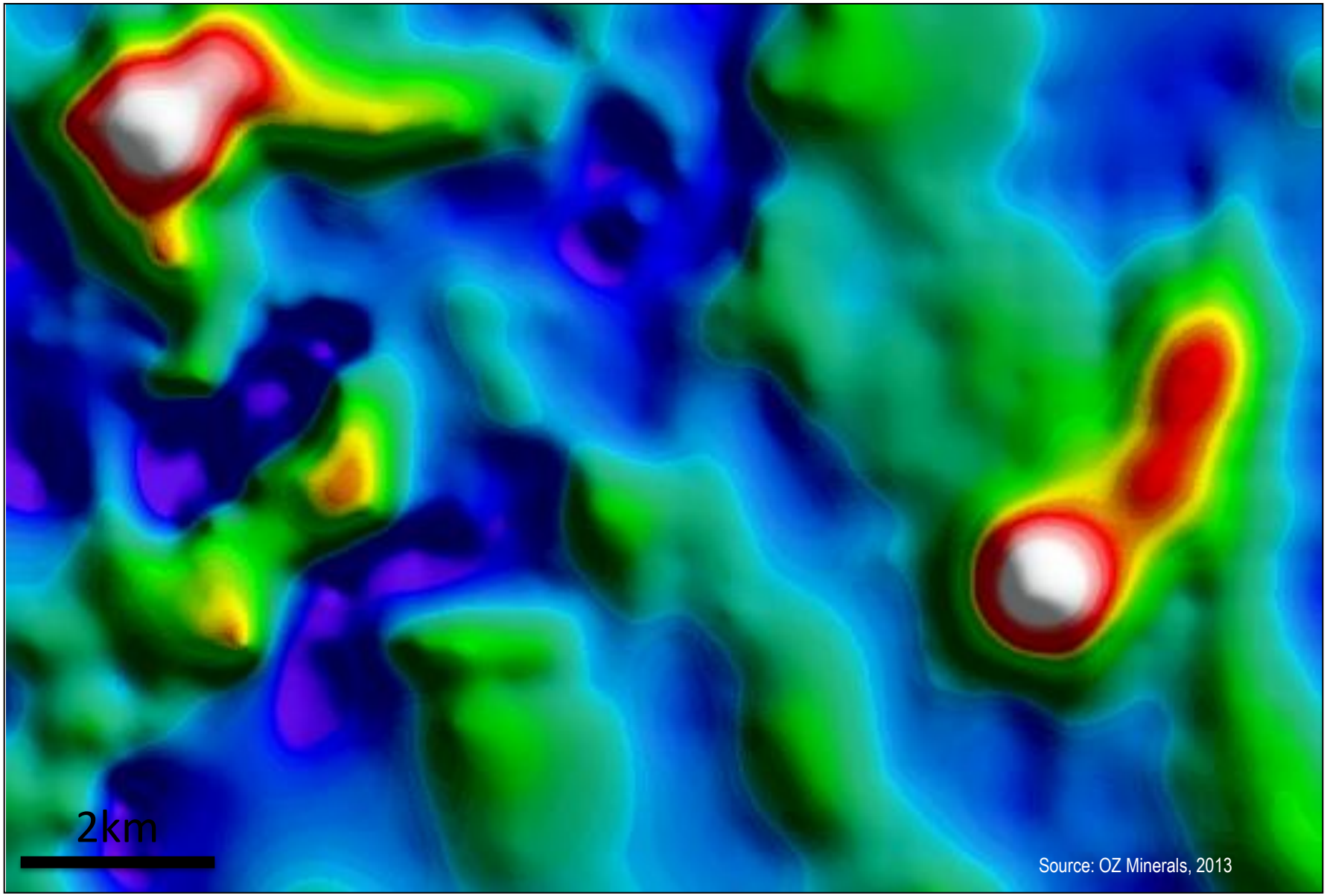
UNCOVER
AUSTRALIAN EXPLORATION GEOSCIENCE RESEARCH

Summary

- **Geophysics role.**
- **The extent of the challenge.**
- **Two approaches**
  - - Direct detection
  - - Weights of evidence
    - - Regional scale
    - - Tenement scale
- **Mapping the unconformity**
- **Seismic in hard rock environments**

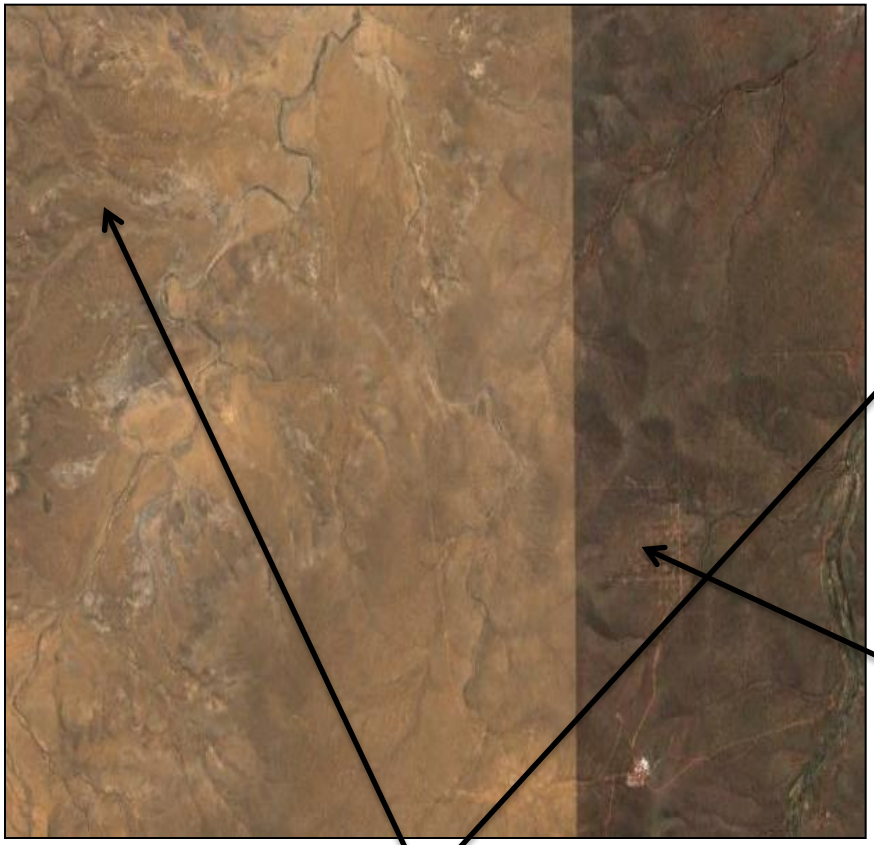
The challenge

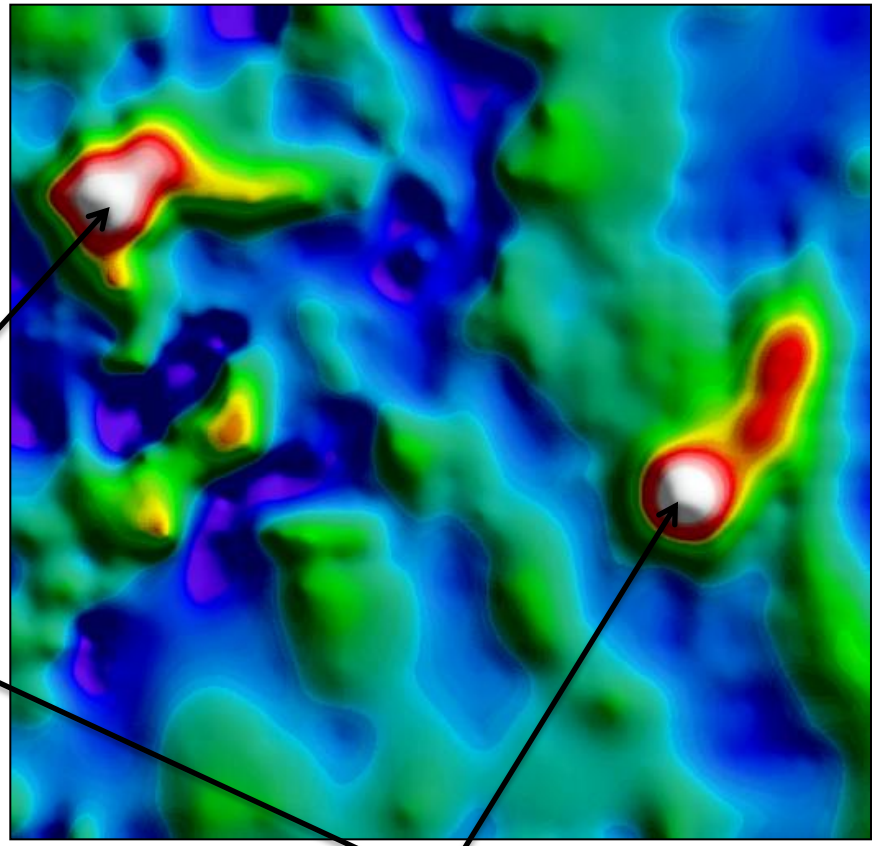
The challenge



The challenge

- 400-600m of transported cover
- 200m spaced gravity survey





Khamsin:
701m @ .83% Cu and .24g/t Au.

Carrapateena:
800Mt @ 0.8%Cu, 0.3 g/t Au and 3.3 g/t Ag.

Geophysics Role

- Has a fundamental advantage over other geological observations as it is the only method that **remotely senses rock properties**.

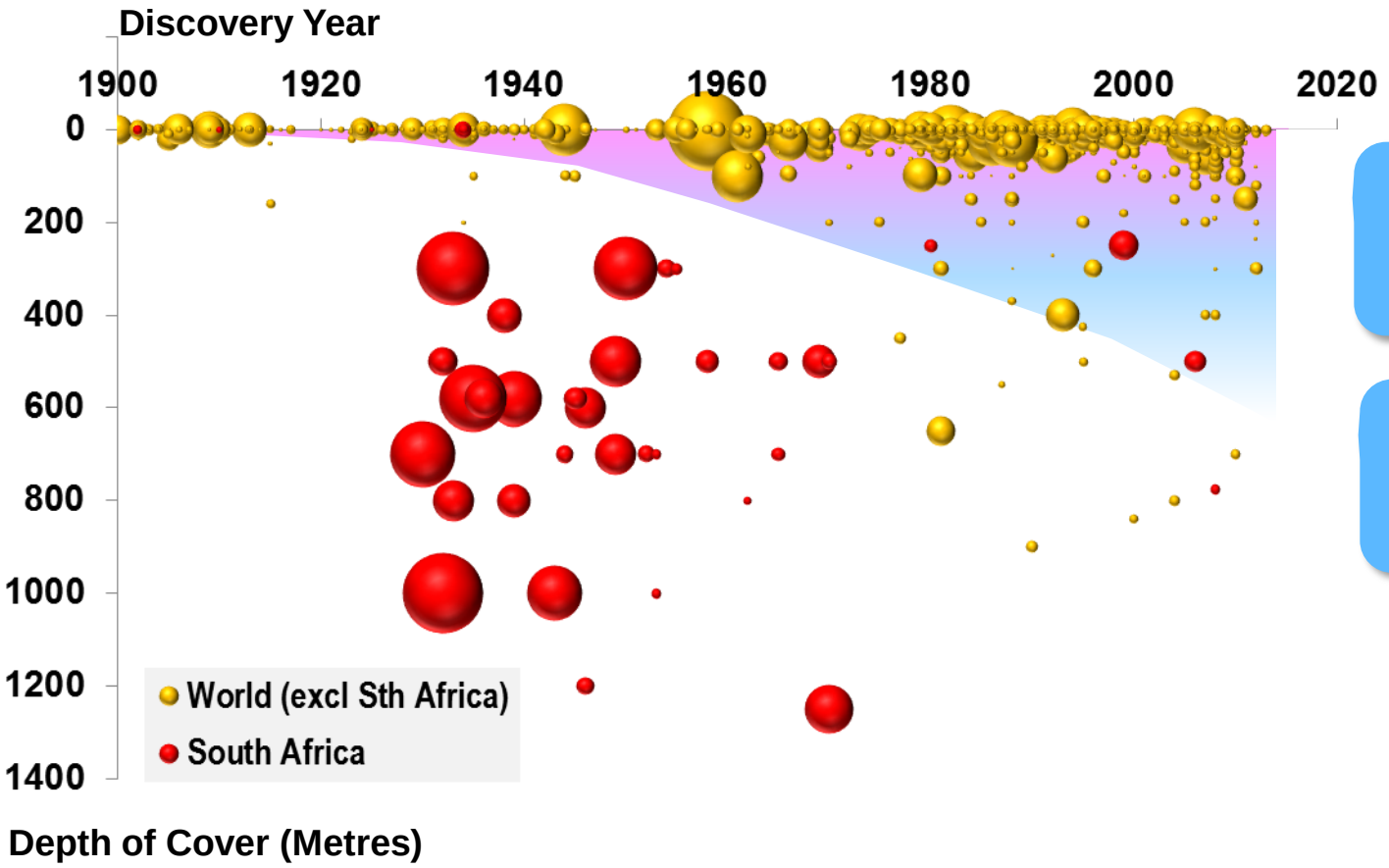
- Physical rock properties need to be interpreted within a geological framework to be useful.

- A much more **cost effective** method to map beneath the surface than drilling.

- Downsides principally due to decreasing resolution as depth increases. Also at best rock properties can only act as a proxy for assay results

The trend towards deeper discoveries

Depth of cover for GOLD discoveries in the World: 1900-2013



While the depth of cover is increasing it is a gradual trend

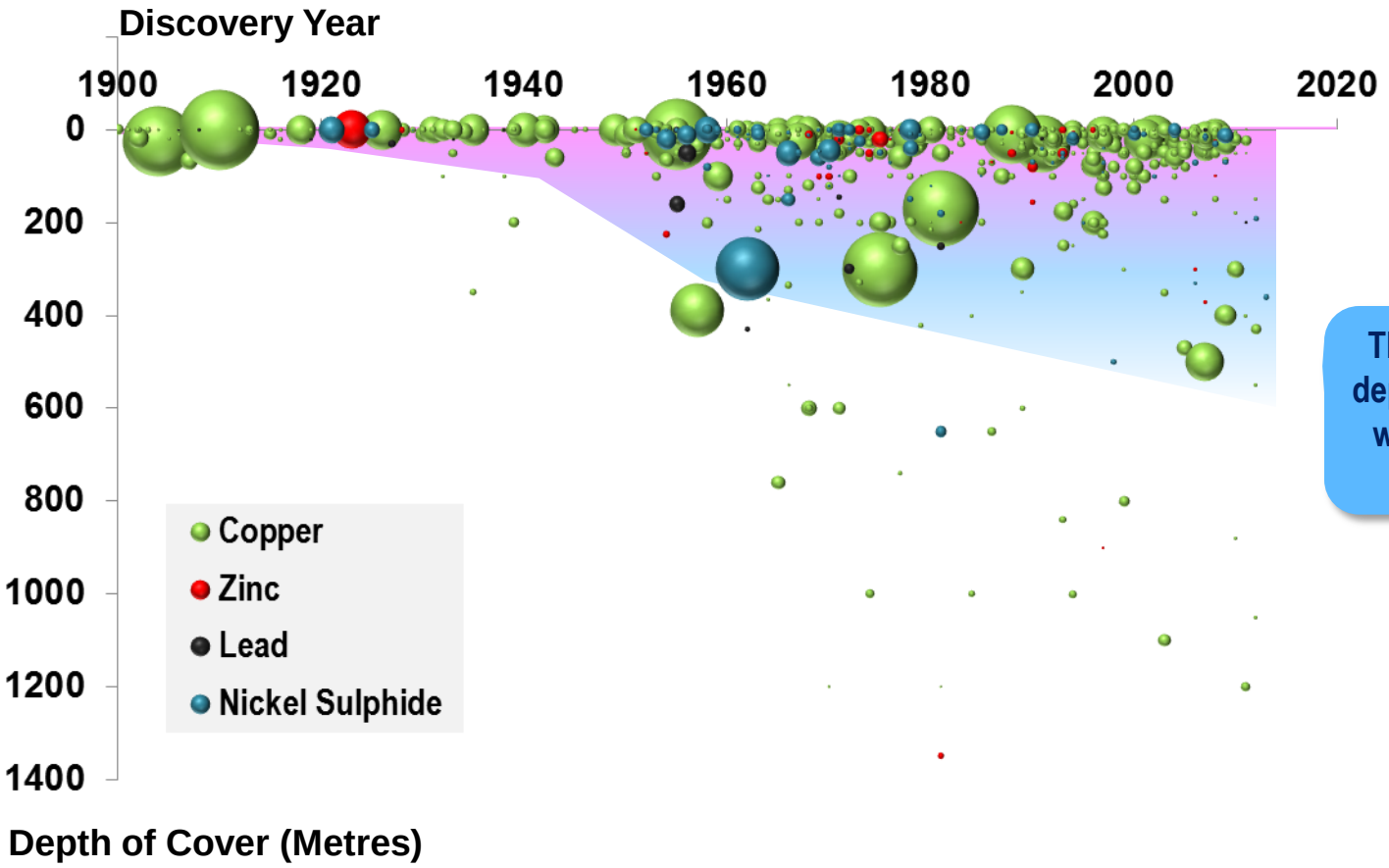
Most of the gold discoveries are still being made under shallow cover

Note: Primary gold deposits > 0.1 Moz. Bubble size refers to Moz of pre-mined Resource
Excludes satellite deposits within existing Camps.

Source: MinEx Consulting © November 2013

The trend towards deeper discoveries

Depth of cover for BASE METAL discoveries in the World: 1900-2013

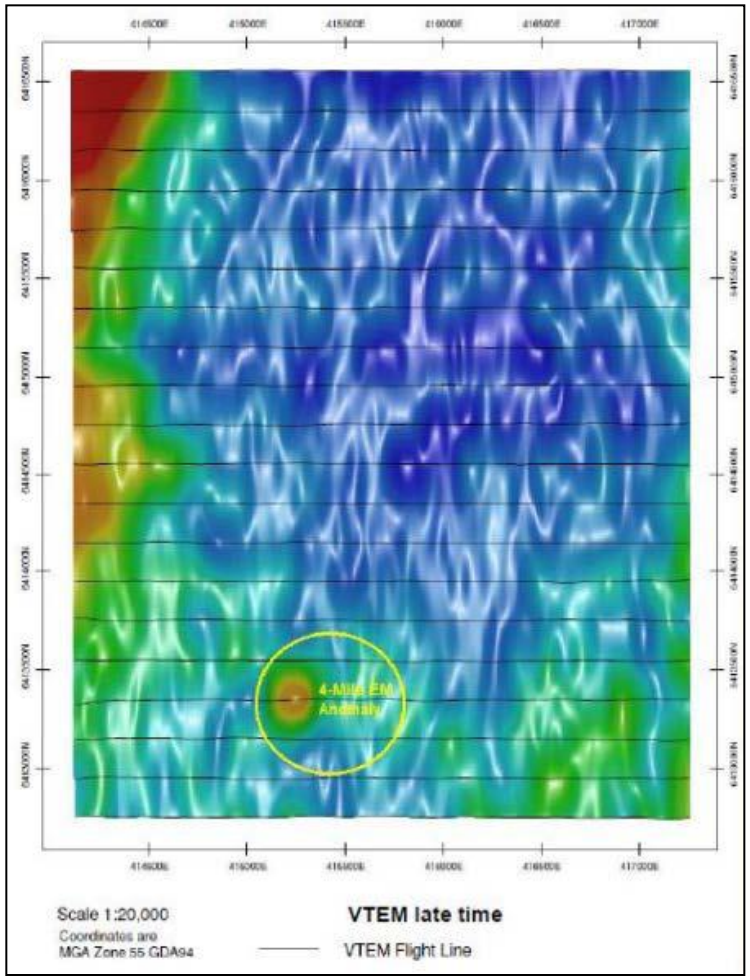


The step increase in the depth of cover (post 1945) was due to innovations in geophysics

Note: Primary Cu, Zn, Pb and Ni deposits > 0.1 Mt Cu-equivalent
Bubble size refers to Mt Cu-eq of pre-mined Resource, as calculated using the average metal price for 2011-2013
Excludes satellite deposits within existing Camps. Excludes nickel laterite deposits

Direct detection and weights of evidence

- **Direct detection of orebodies from geophysical data**
  - - Density (Olympic Dam, Prominent Hill)
  - - Magnetics (Cannington, Ernest Henry)
  - - Electrical Methods (Nova, Mallee Bull)
- **Weights of evidence**
  - Most discovery's involve the combination of geology, geochemistry, structural mapping and geophysics.

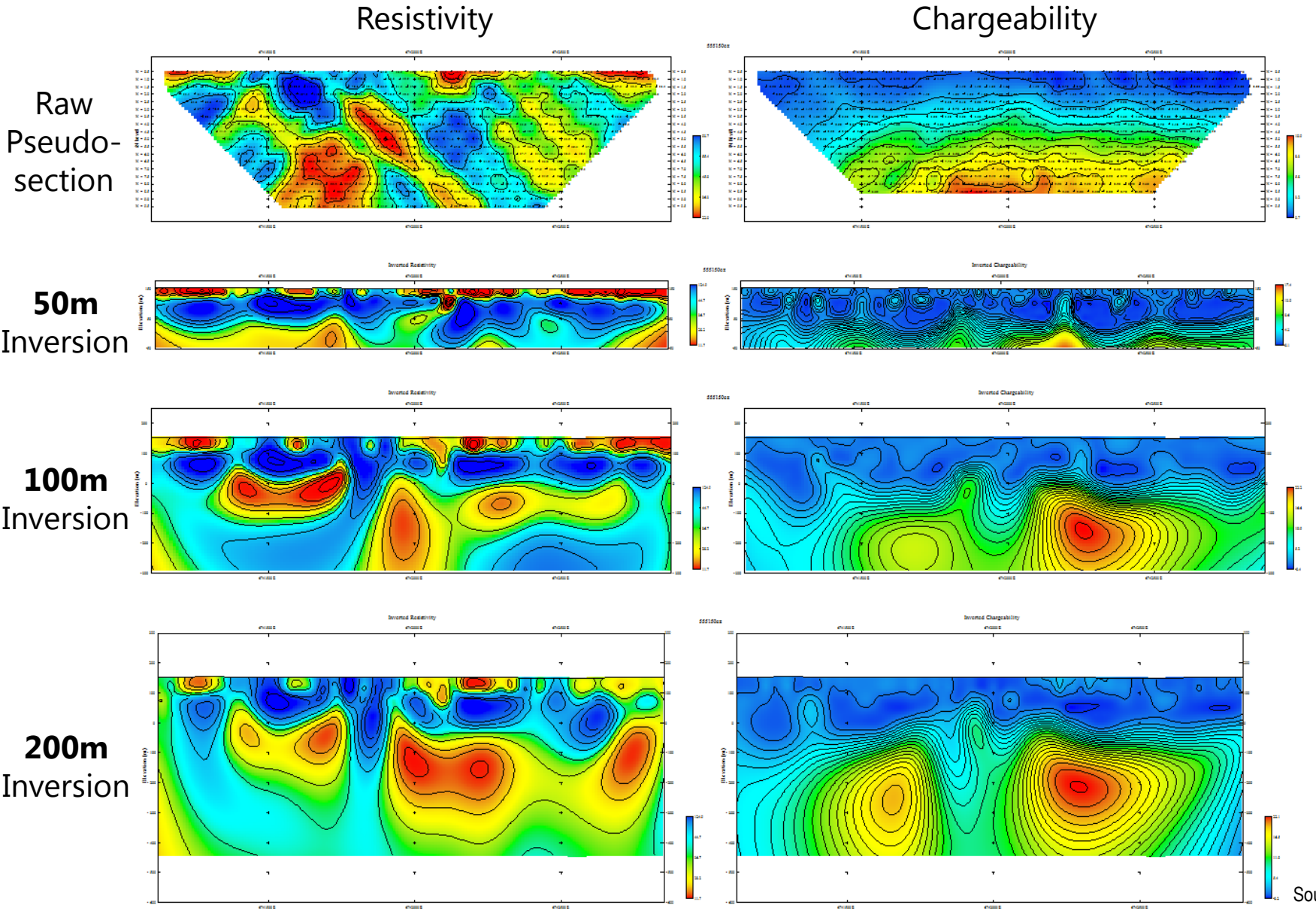


Mallee Bull deposit – Peel Mining

Direct detection

- **Industry needs improved equipment that increases resolution at depth, covers more area and does so cheaply.**
  - Larger 3D IP arrays with greater sensitivity.
  - Lower frequencies in AEM data.
  - Cheaper hard rock seismic
- **More knowledge to interpret the data all ready collected**
  - Better interpretation/processing of airborne gravity gradient data.
  - Improved AEM inversion. Integrated and constrained inversion.
  - More published, modern examples of orebody signatures.

Direct detection

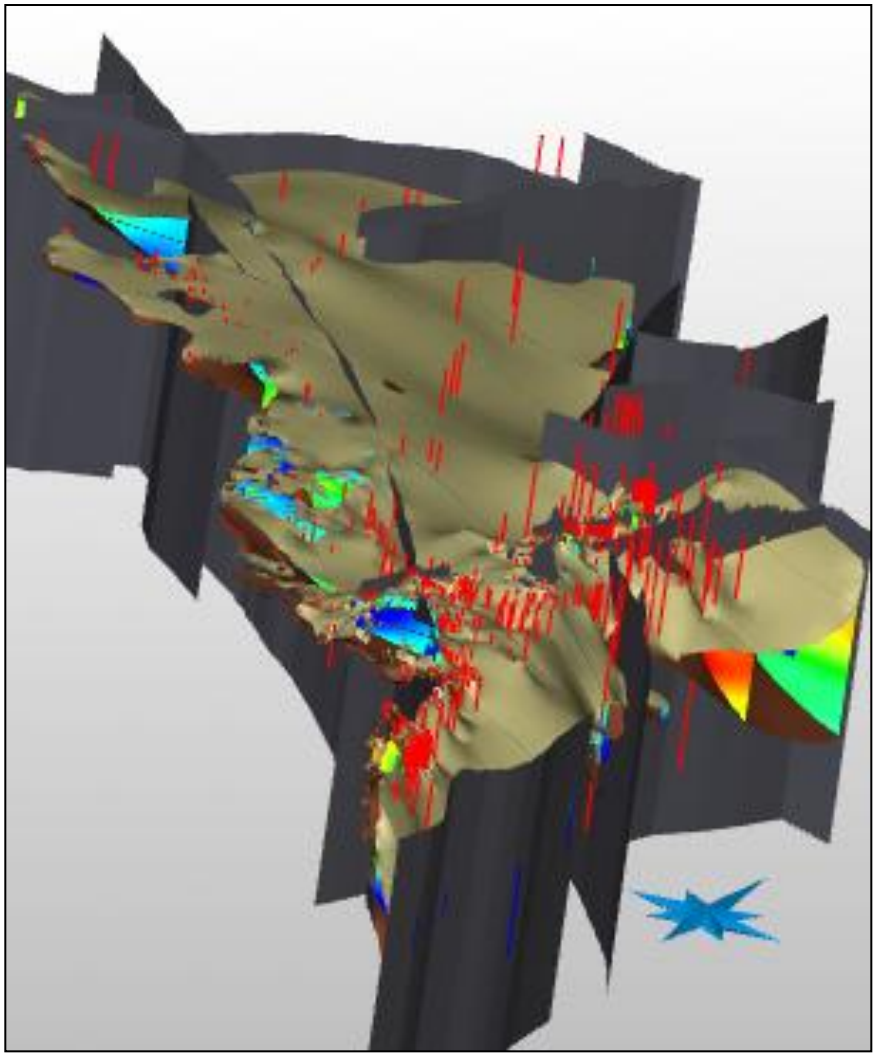


Source: Funk, 2013

Weights of evidence

Regional Scale

- Government has a strong record of success here - regional gravity and magnetics, seismic traverses, some AEM surveys, etc.
- Industry uses this data to define metallogenic belts undercover – map greenstones, accreted porphyry arcs, uranium sources and traps, etc.
- Next step to support industry is to map the unconformity above prospective basement.

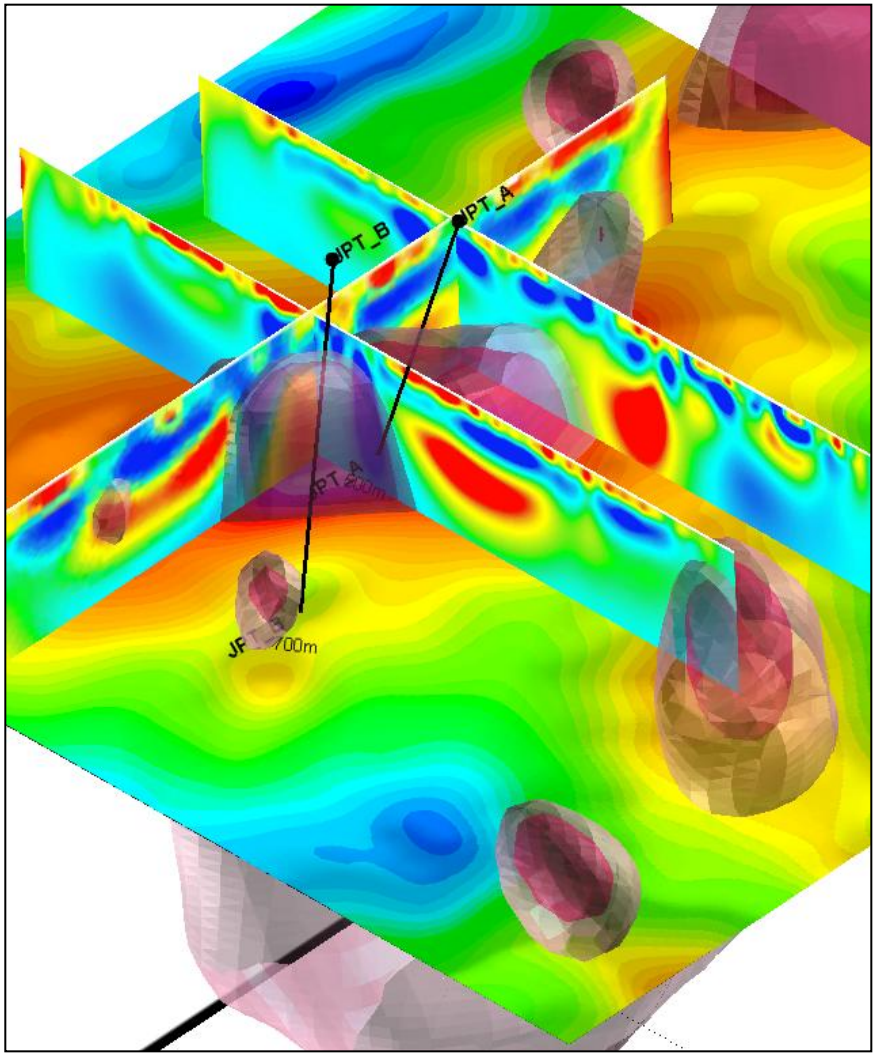


Carriewerloo Basin – DMITRE

Weights of evidence

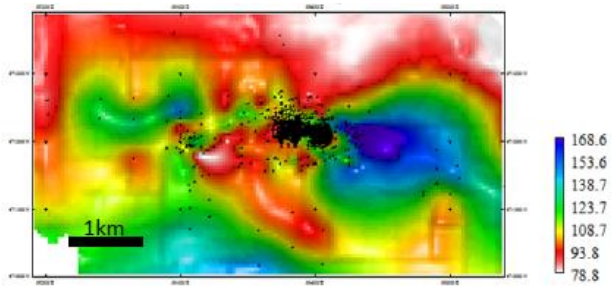
Tenement Scale

- Structural interpretation from geophysical datasets.
  - Greenstone belt faults.
  - Basin margins, etc.
- Coincident geochemical and geophysical anomalies.
- Informs geological models.
- Mapping of the unconformity at high resolution.
  - Corrects geophysical models.
  - Improves geochemical cover modelling

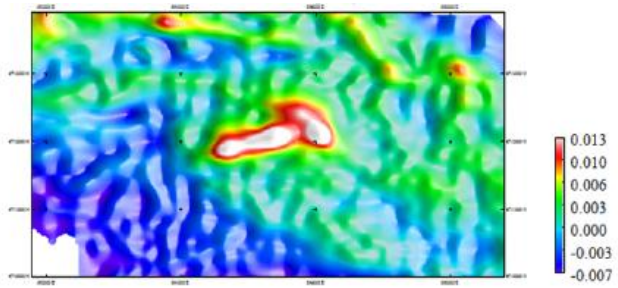


Mapping the unconformity

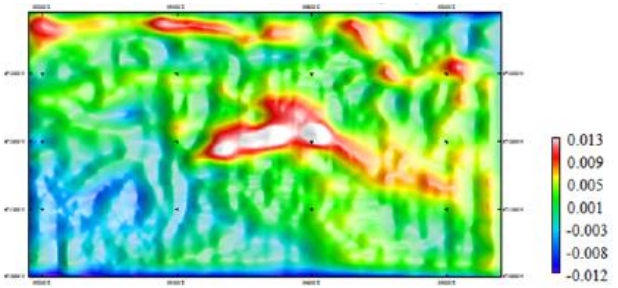
Prominent Hill – Cover depth



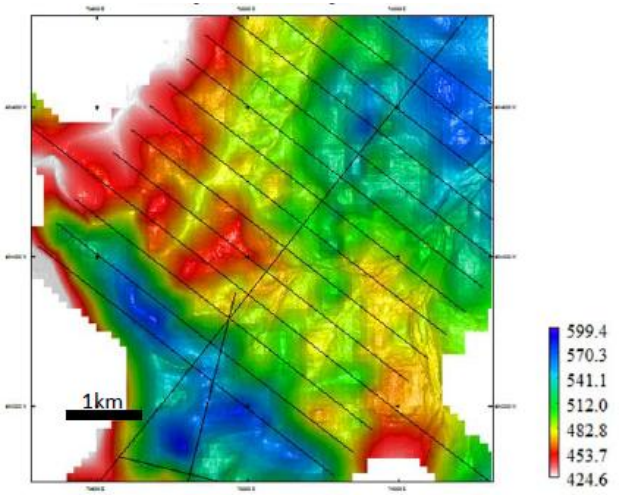
Prominent Hill – 1VD gravity



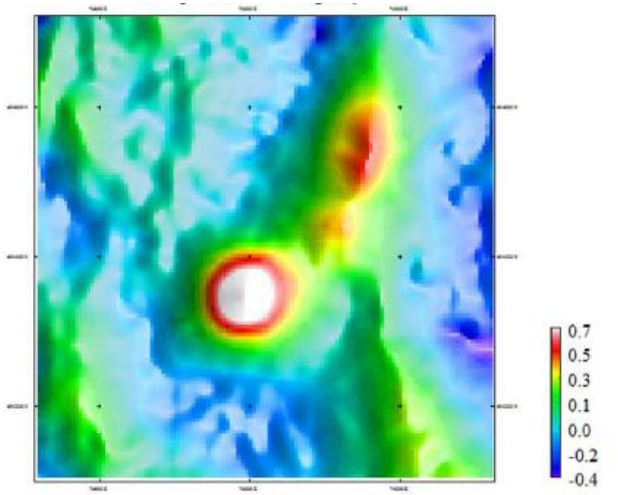
Prominent Hill – Basement corrected 1VD gravity



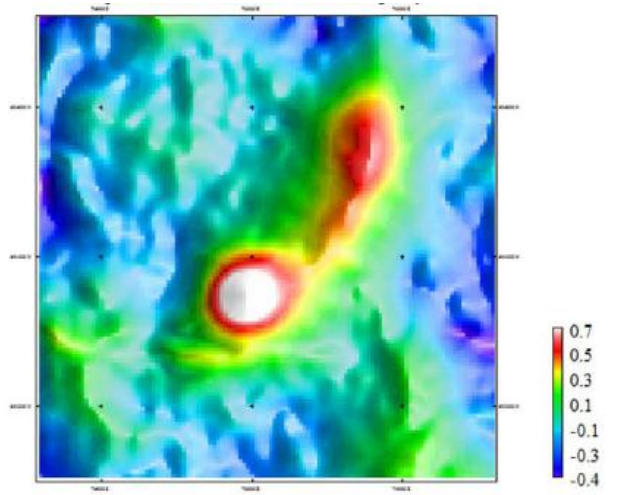
Carrapateena – Cover depth



Carrapateena – Residual gravity

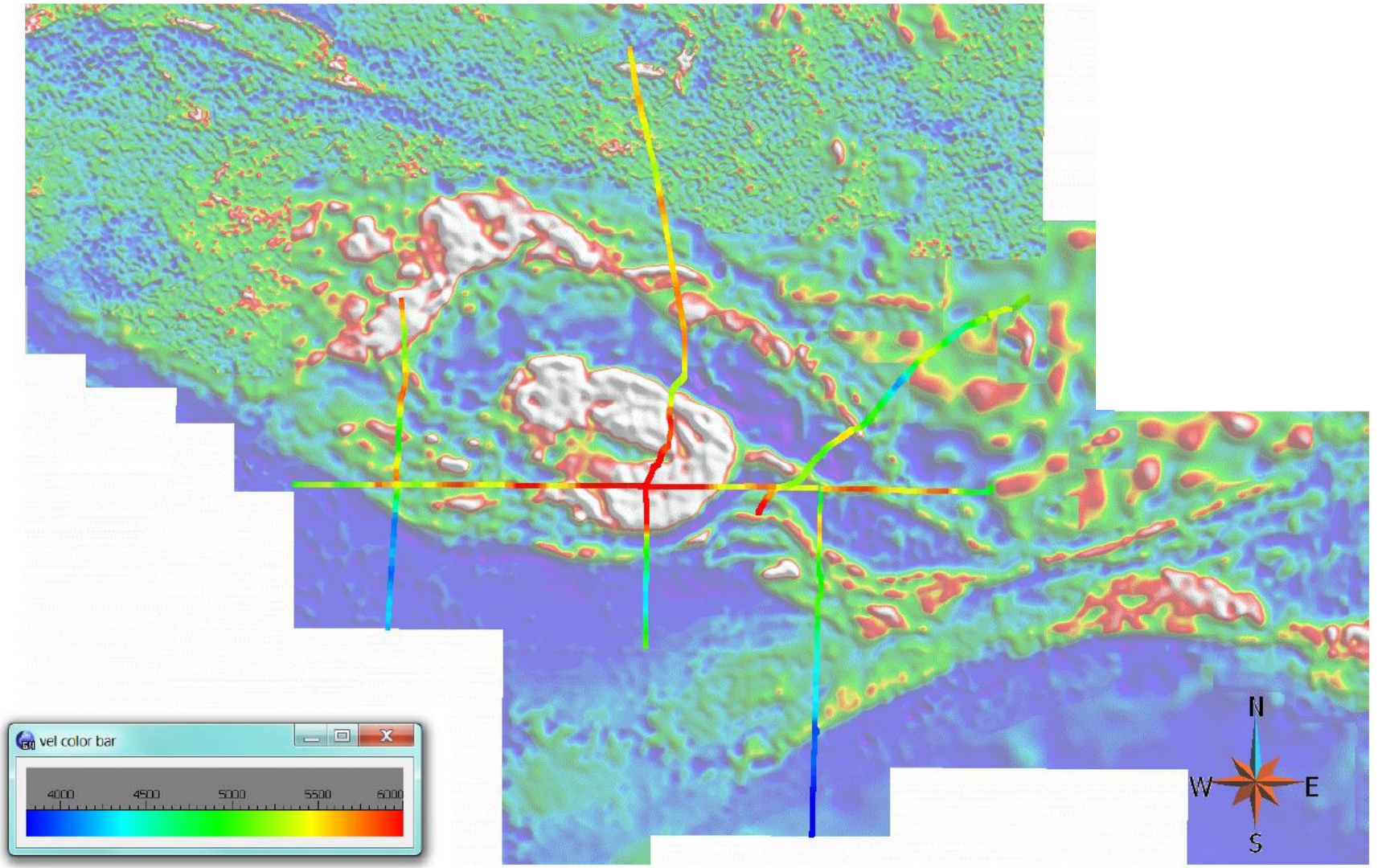


Carrapateena – Basement corrected residual gravity



Source: Funk, 2013

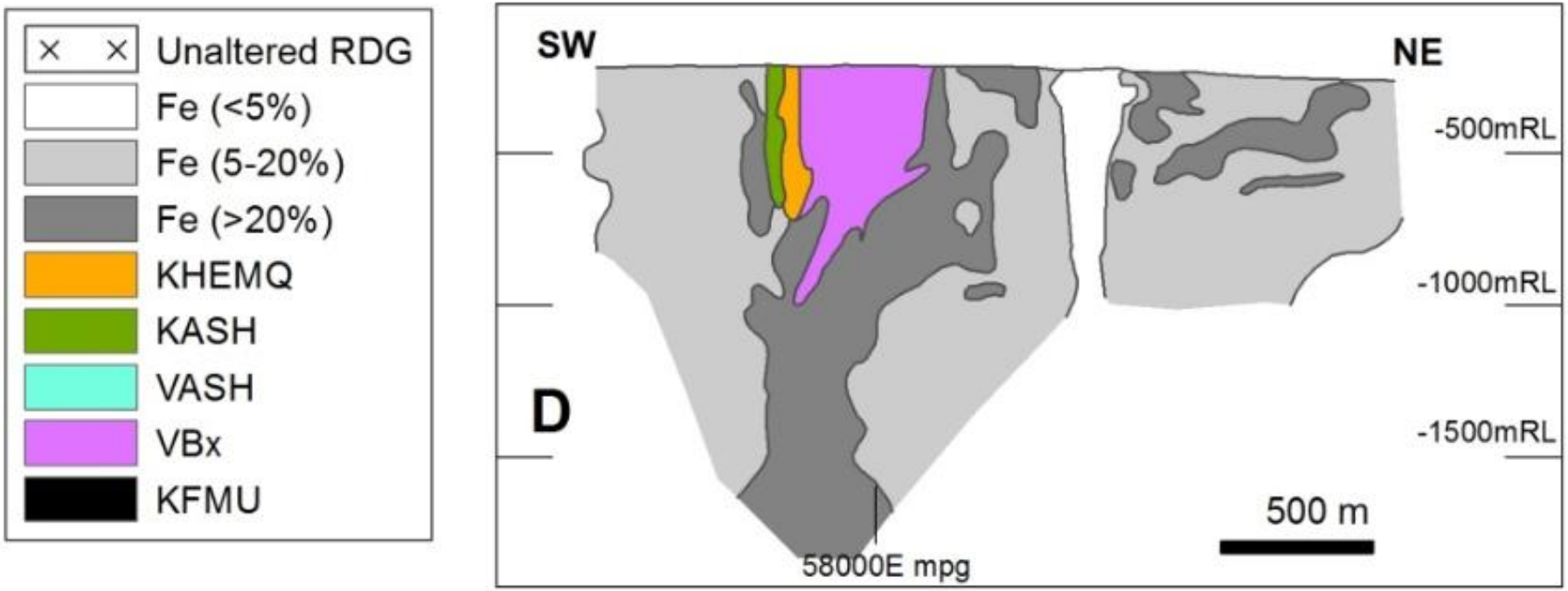
Mapping the unconformity



Source: Funk, 2013

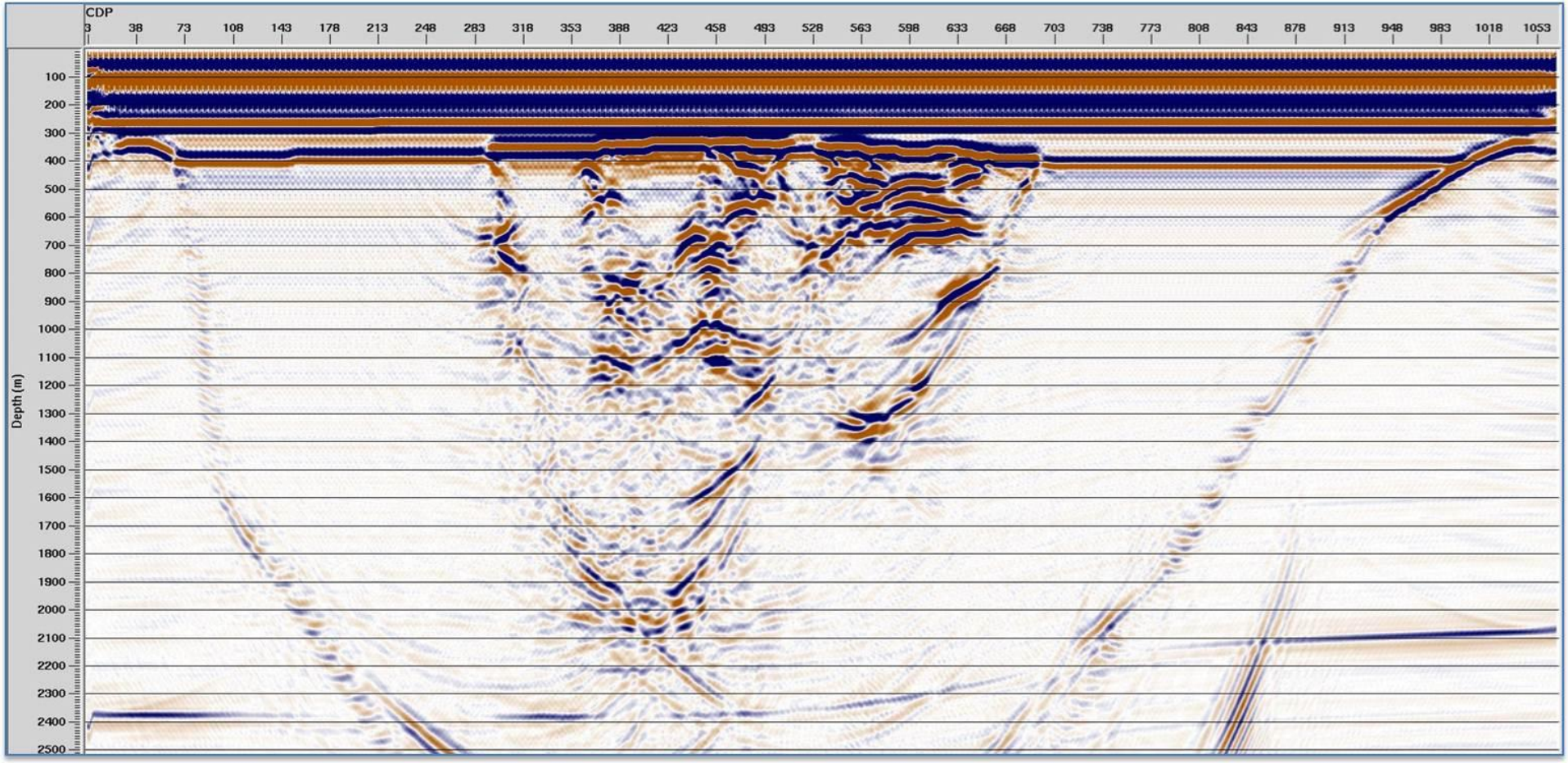
Seismic in hard rock environments

Olympic Dam (Ehrig et al., 2013)



Source: HiSeis, 2014

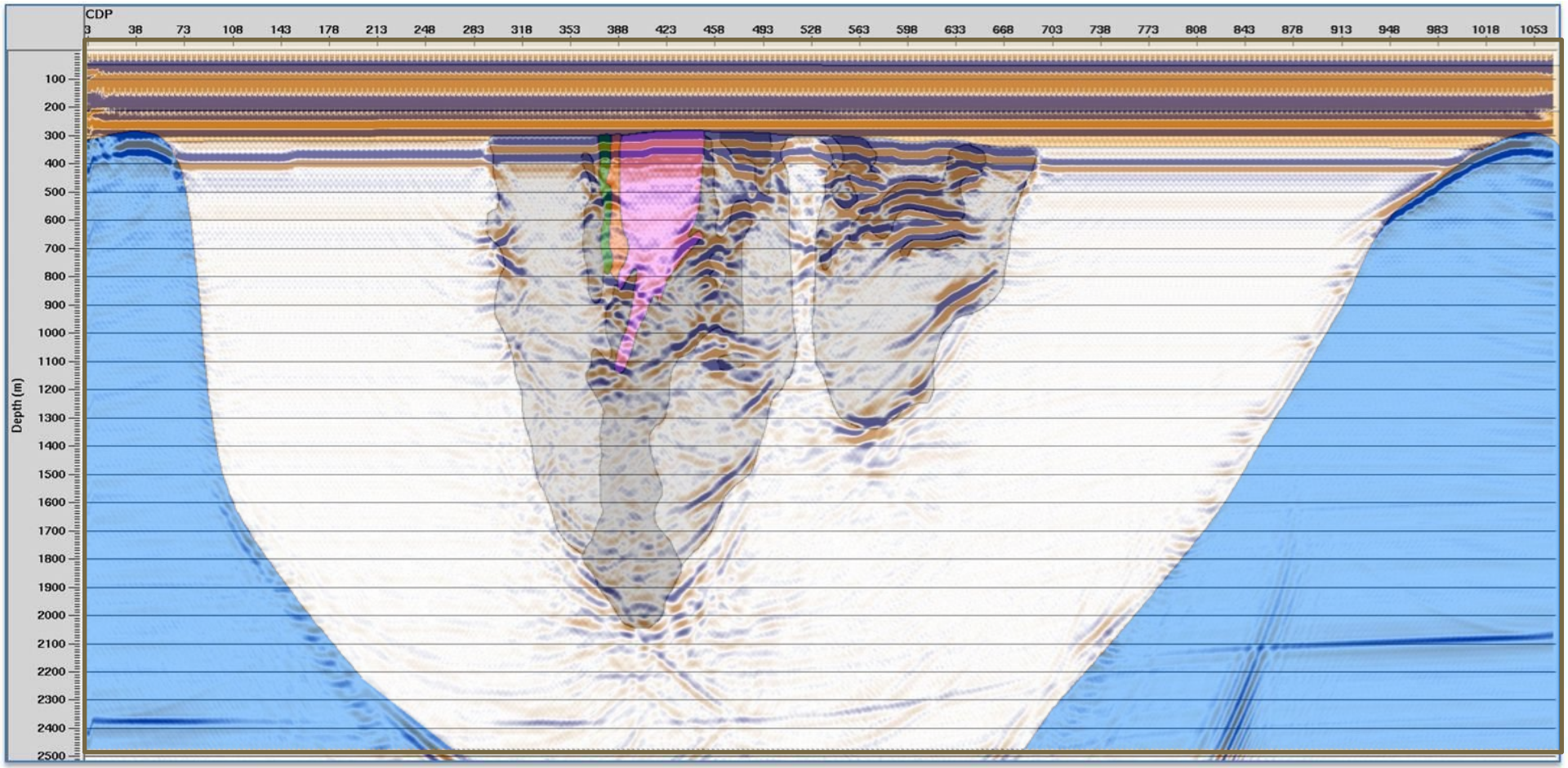
Line D, migrated stack overlain on model



Source: HiSeis, 2014

Seismic in hard rock environments

Line D 350m cover, migrated stack



Source: HiSeis, 2014

Industry needs – Discussion

Considerations

- Surveys that cover larger areas with greater resolution.
- Knowledge to improve interpretation of the existing data.
- Government can support by mapping unconformity surface at large scales.
- Improve on existing links between Industry, Universities and Government to attempt new science.
- Hard rock seismic can be the next breakthrough tool for minerals exploration.

Acknowledgments

- Thankyou to;
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