MINERAL EXPLORATION UNDER DEEP COVER

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The problem

"Discovery rates, especially of world-class deposits, have fallen significantly over the past 15-20 years, despite increased exploration expenditure, a wide range of new science and technology, and unparalleled access to virtually all parts of the globe"

Etheridge, M.A., SEG Conference, Perth 2004

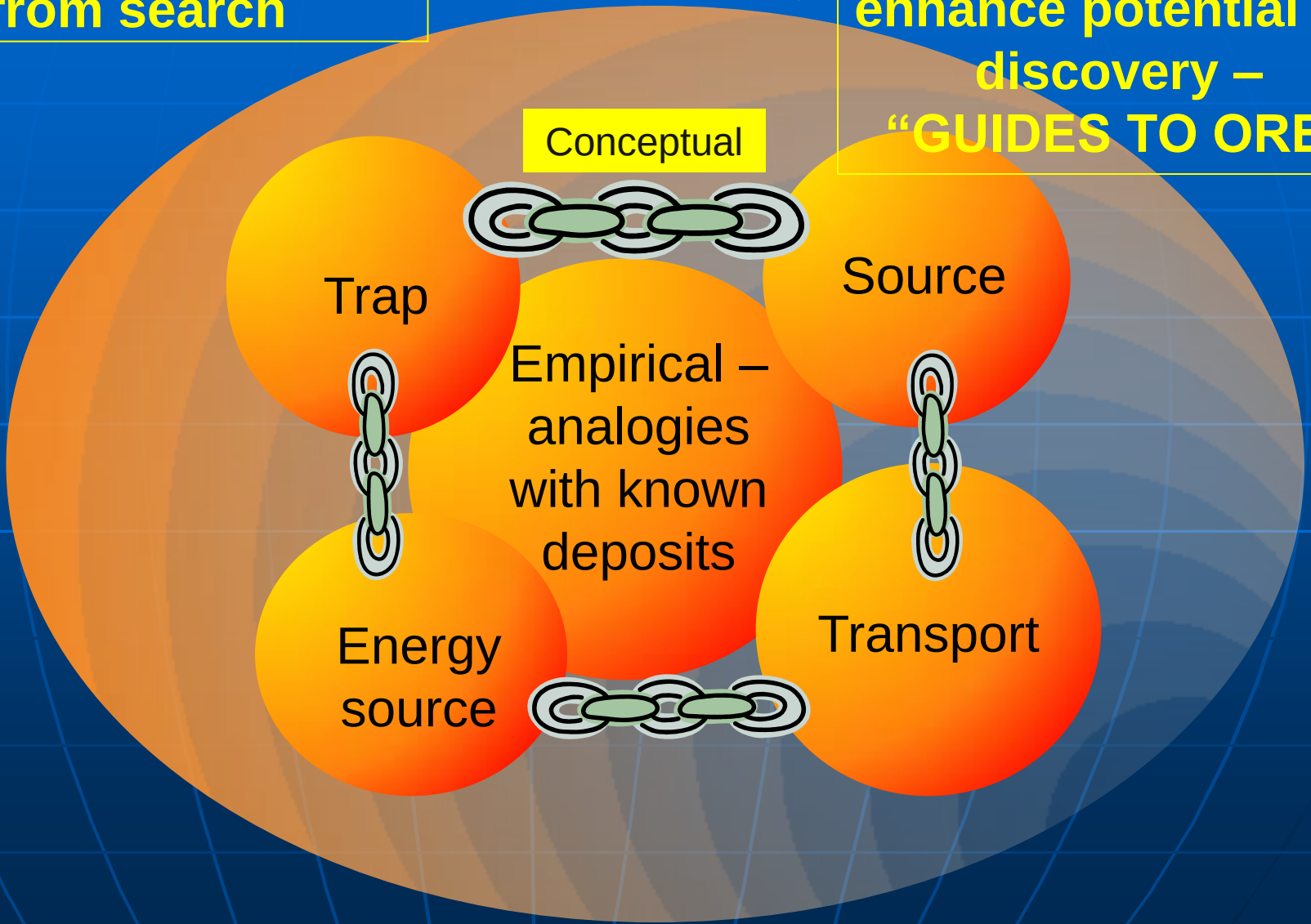
Outline

- Mineral-exploration – the process
  - Exploration models
  - Ground selection
  - Drill target selection
  - Drill testing
- Impediments to exploration due to deep cover
- The Olympic Dam discovery – a successful deep cover exploration case study
- Challenges

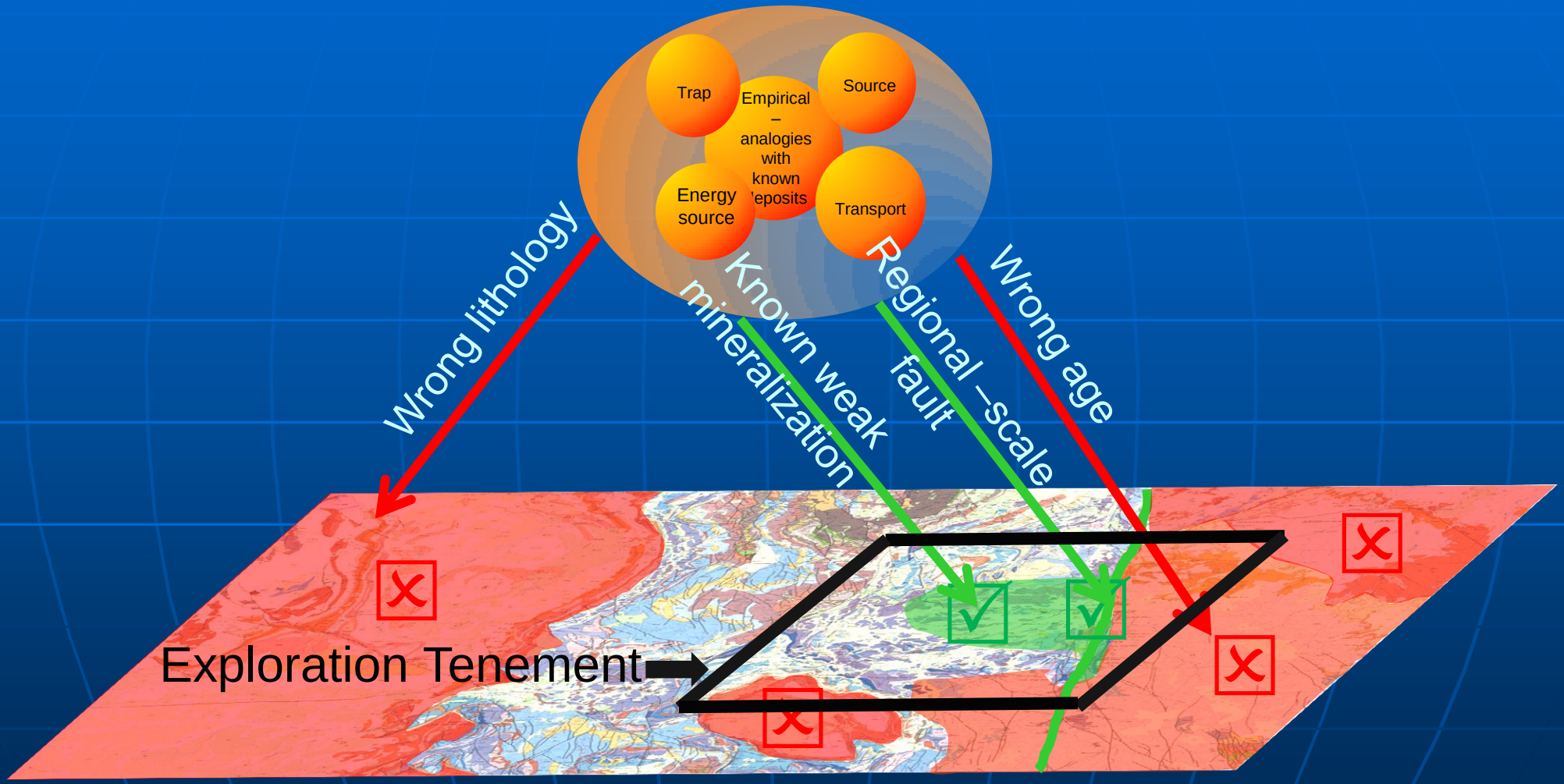
Mineral exploration models

Features that eliminate areas from search

Features that enhance potential for discovery – "GUIDES TO ORE"



Mineral exploration – ground selection



1:250K regional geology map sheet (~175km x 110km)

Drill target selection

- Geological mapping
- Geochemical sampling – stream, rock, soil, botanical
- Airborne geophysics – magnetics, radiometrics, electromagnetics, gravity gradiometry
- Ground geophysics – magnetics, gravity, induced polarisation, electromagnetics, near-infrared infrared (NIR) spectroscopy, reflection seismology

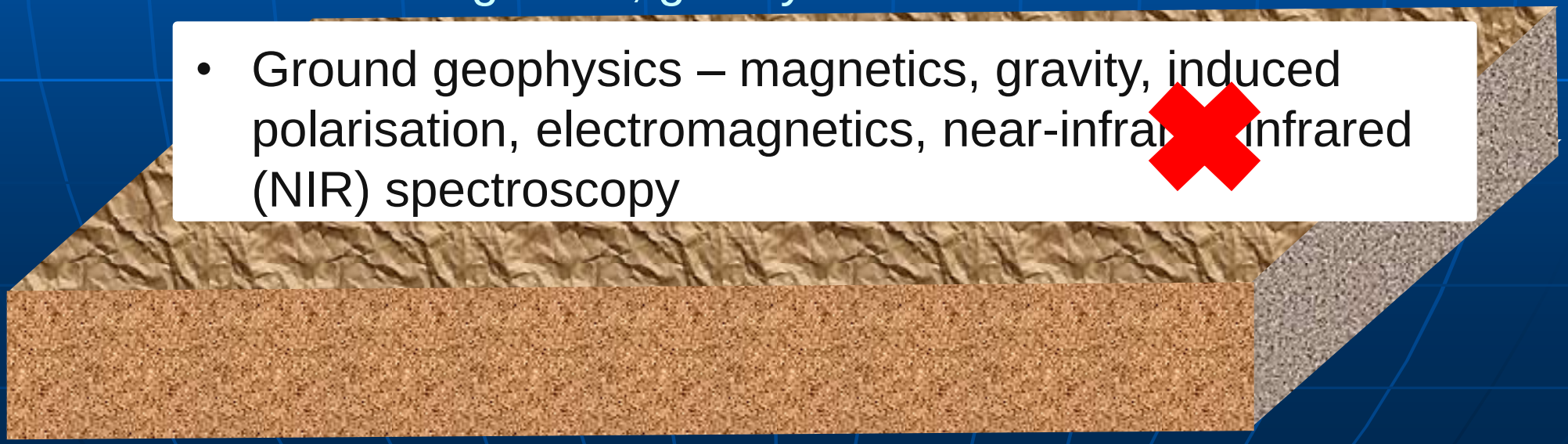
Drill testing

Photo- detcrc.com.au/about/why-was-det-crc-created/

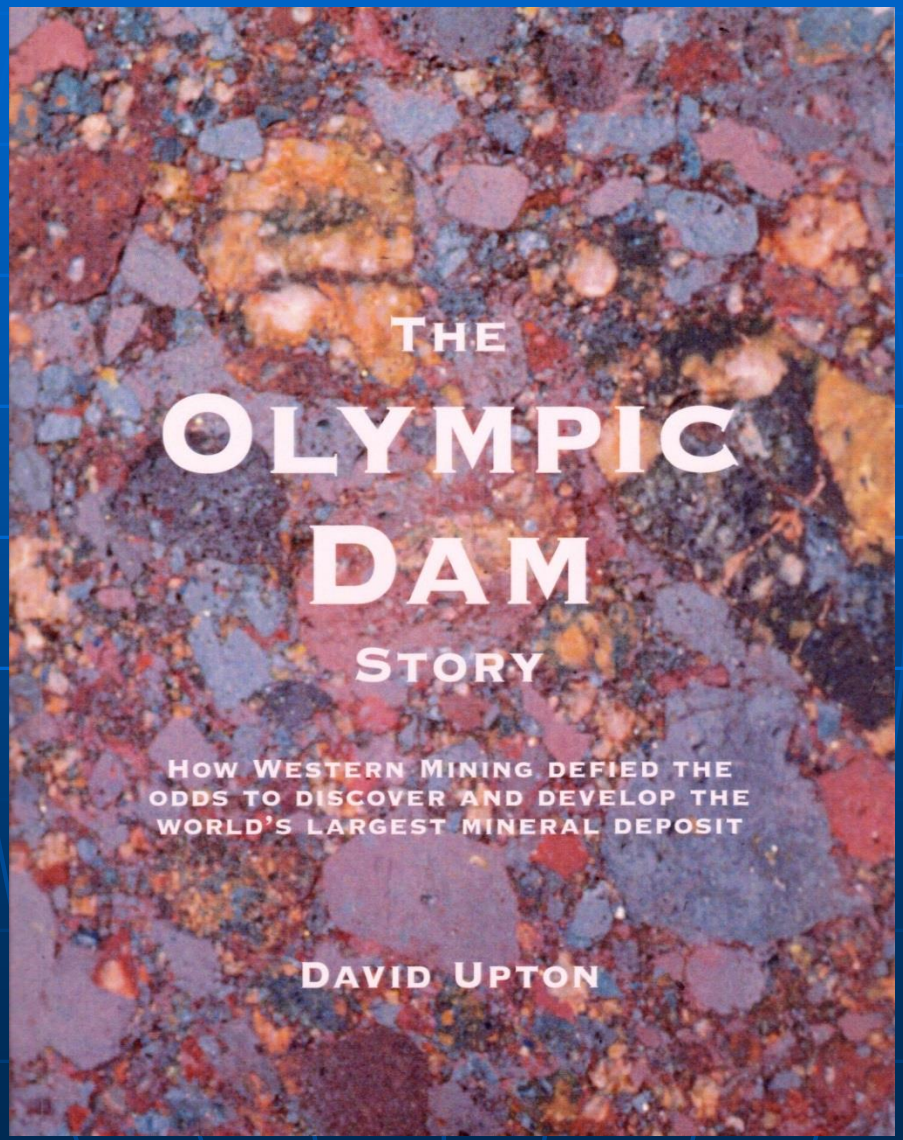
Photo courtesy of Geoscience Australia

What happens when we have deep (>300m) cover?

- Ground selection – no geology to guide selection
- Drill-target selection –
  - Geological mapping
  - Geochemical sampling – stream, rock, soil, botanical
  - Airborne geophysics –magnetics, radiometrics, electromagnetics, gravity
  - Ground geophysics – magnetics, gravity, induced polarisation, electromagnetics, near-infrared (NIR) spectroscopy

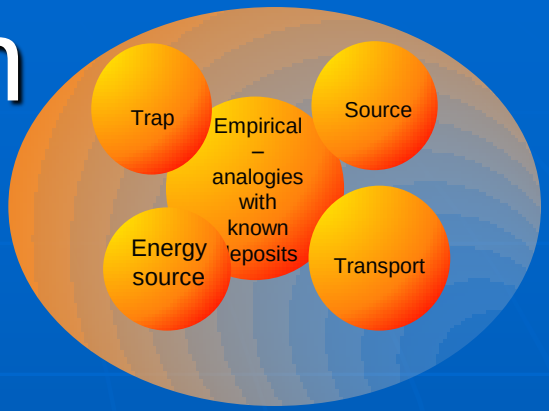


An example of successful exploration under deep cover



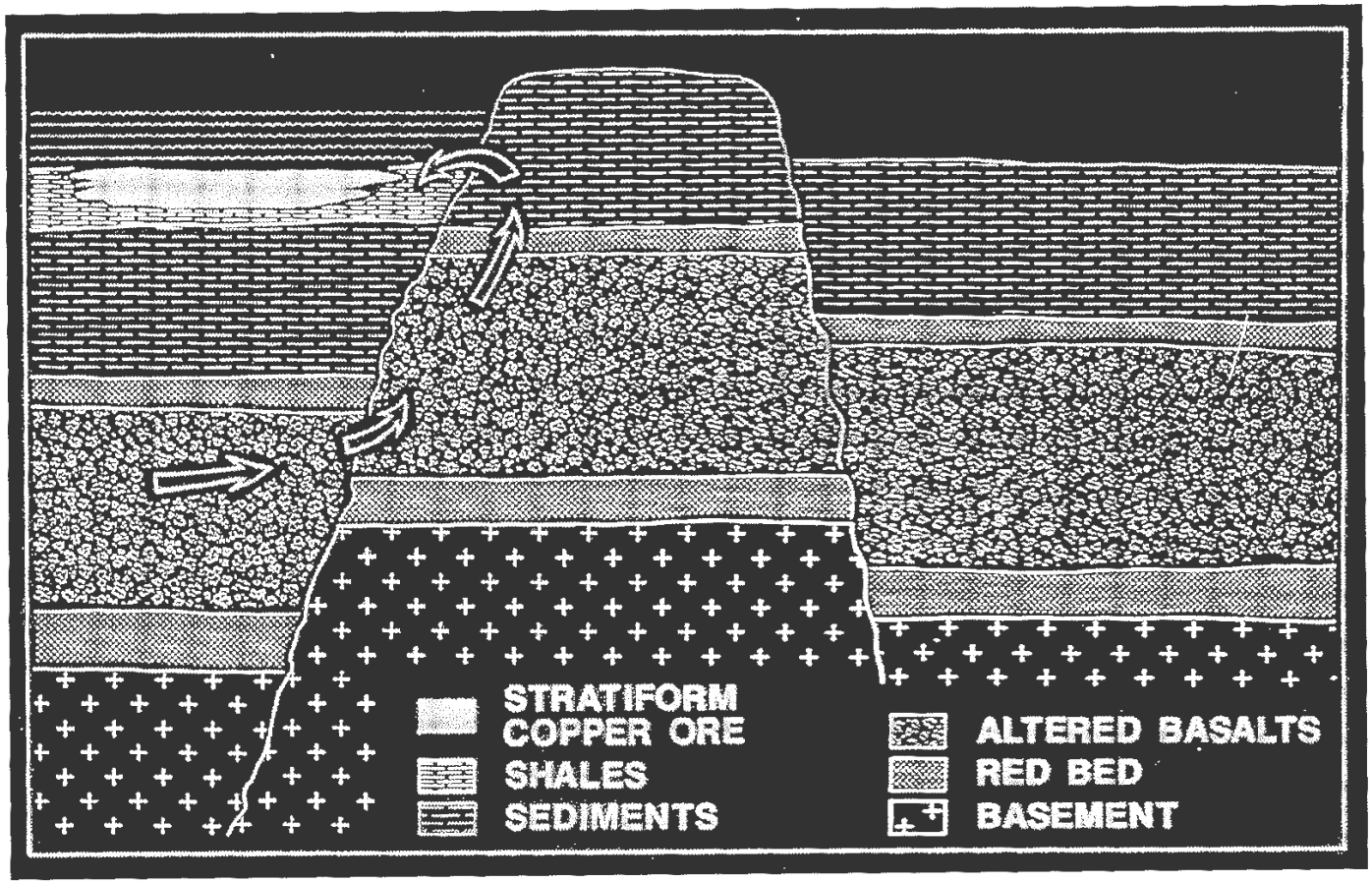
Upton, D., 2010

The Olympic Dam exploration model (1)



- Leadership: Roy Woodall - WMC
- Author: Doug Haynes – WMC
- Target: an African Copper Belt style sediment-hosted stratiform copper deposit in Neoproterozoic sediments– a large Mt Gunson look-alike.
- Key elements:
  - Abundant source rocks at depth – altered Proterozoic tholeiitic flood basalts depleted in copper (likely to be associated with coincident gravity and magnetic highs)
  - Reduced sediments adjacent to major faults that “trapped” hydrothermal fluids emanating from the underlying source rocks
  - A favorable lineament – tectonic setting (Tim O’Driscoll & Roy Woodall)

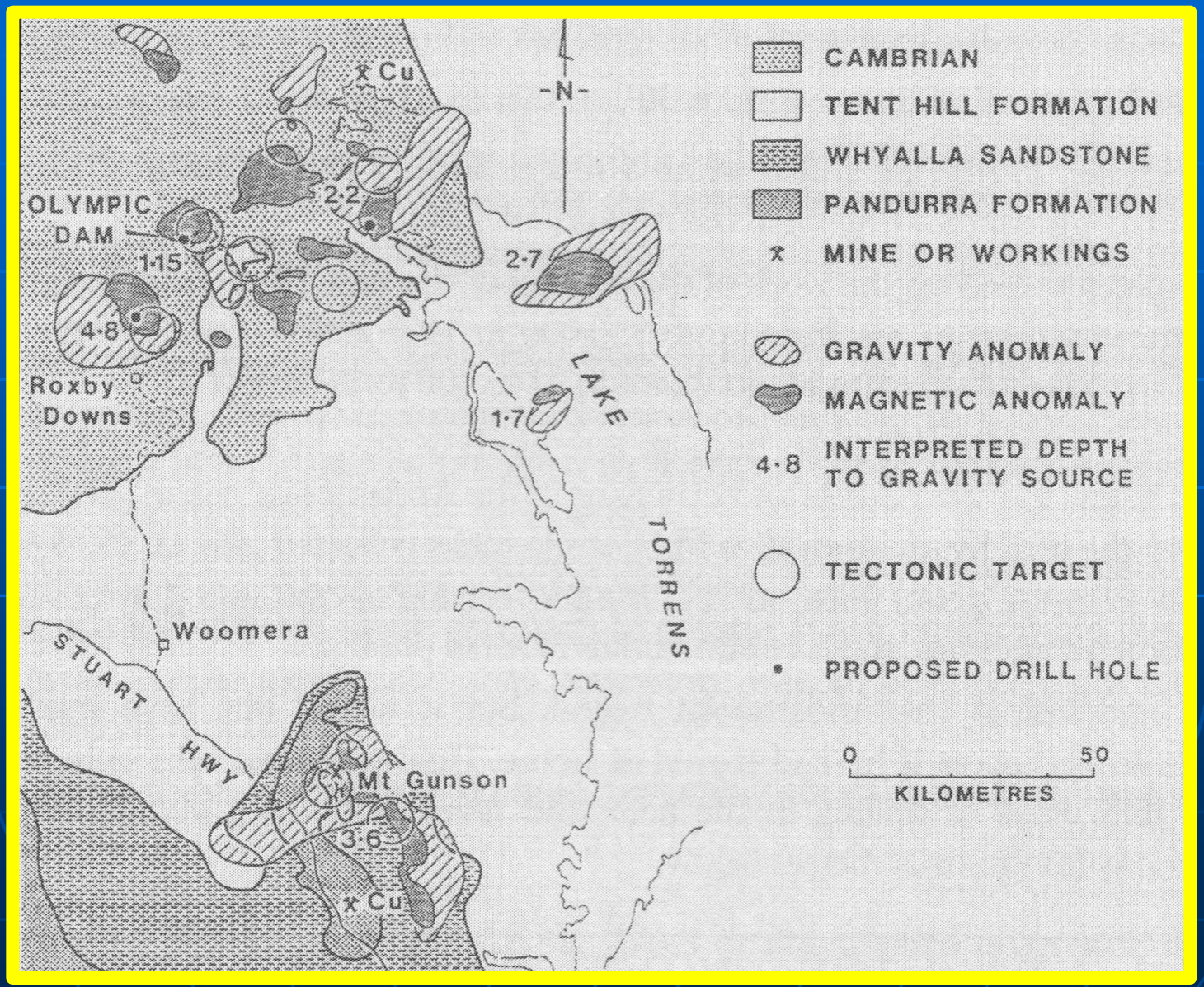
The Olympic Dam exploration model (2)



A graphic of Western Mining's altered basalt model for stratiform copper deposits, from a company presentation several years after the discovery.

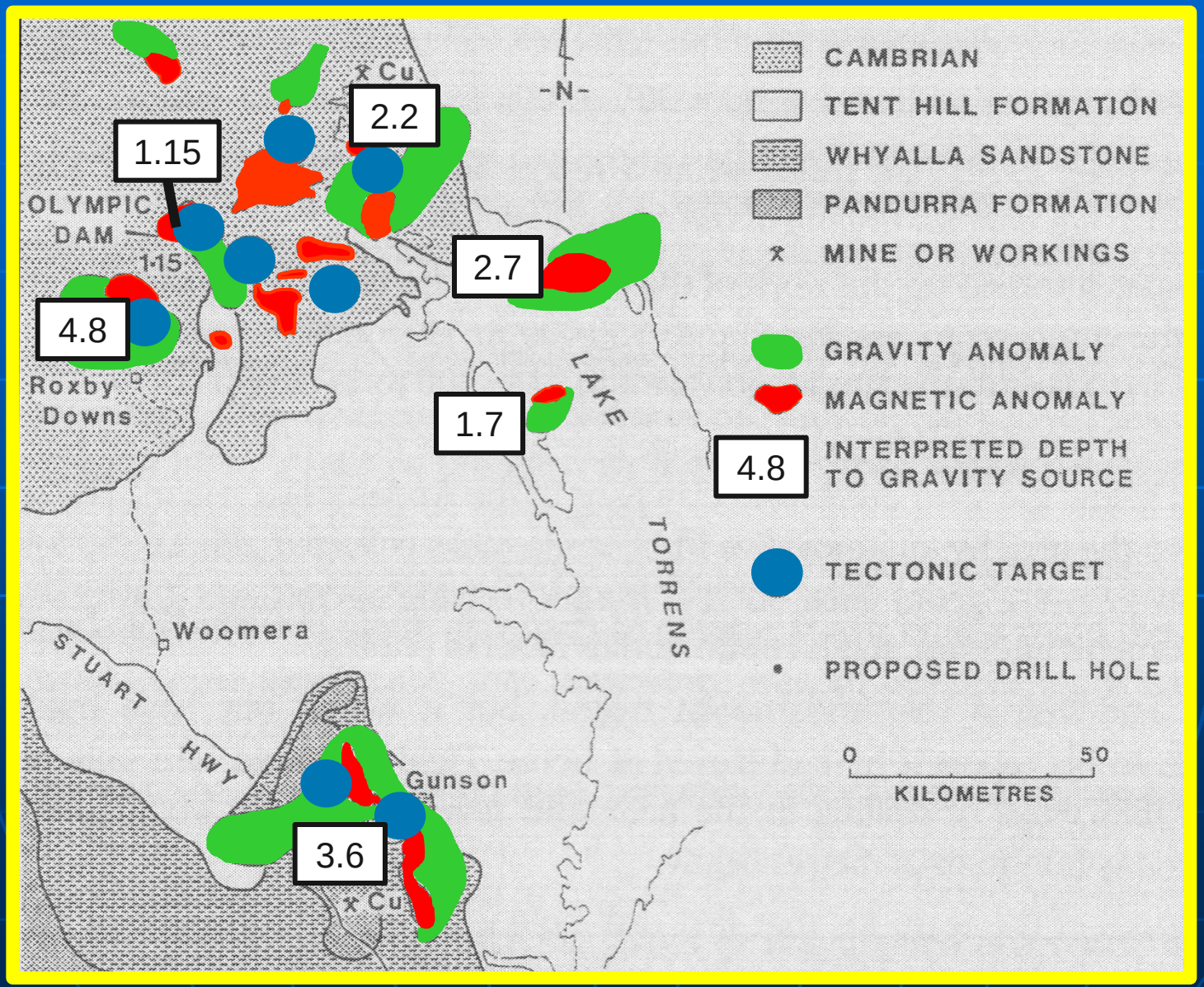
Upton, D., 2010, p.62

Ground Selection – Sept 1974 (1)



Upton, D., 2010, p.86

Ground Selection – Sept 1974 (2)



Upton, D., 2010, p.86

OUTCOME

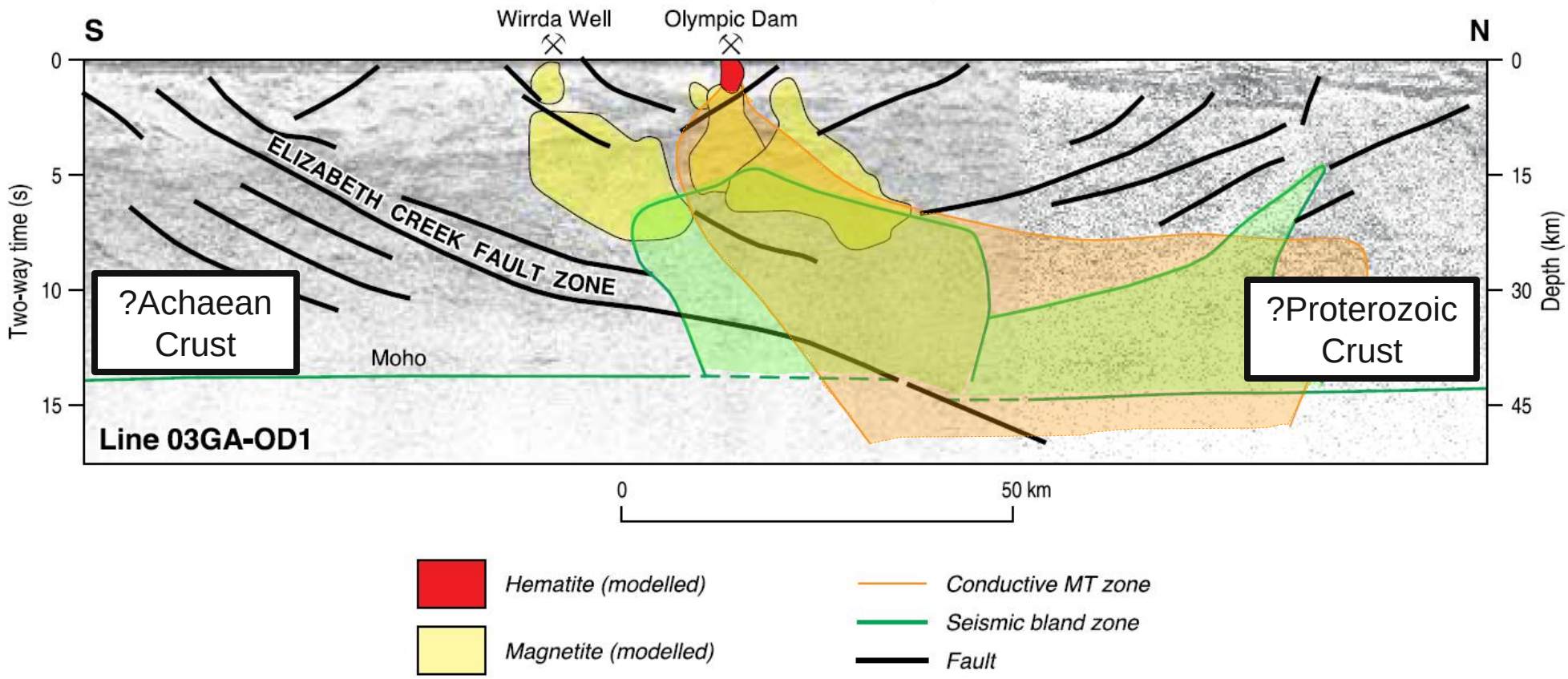
World's: largest uranium resource

3rd largest gold resource

5th largest copper resource

- Discovery Hole – RD10 Nov 1976 – beneath 350m of cover
- A new deposit type – IOCG or "Olympic Dam type"
- The OD gravity anomaly was the shallowest
- Mineralization is in the basement to the Neoproterozoic sediments
- Geophysical anomalies appear not to be due to tholeiitic flood basalts
- O'Driscoll's WNW lineament delineates the main ore zone more precisely than the original gravity and magnetic data
- A serendipitous discovery?

North-South Seismic Section, Olympic Dam, (Looking West)

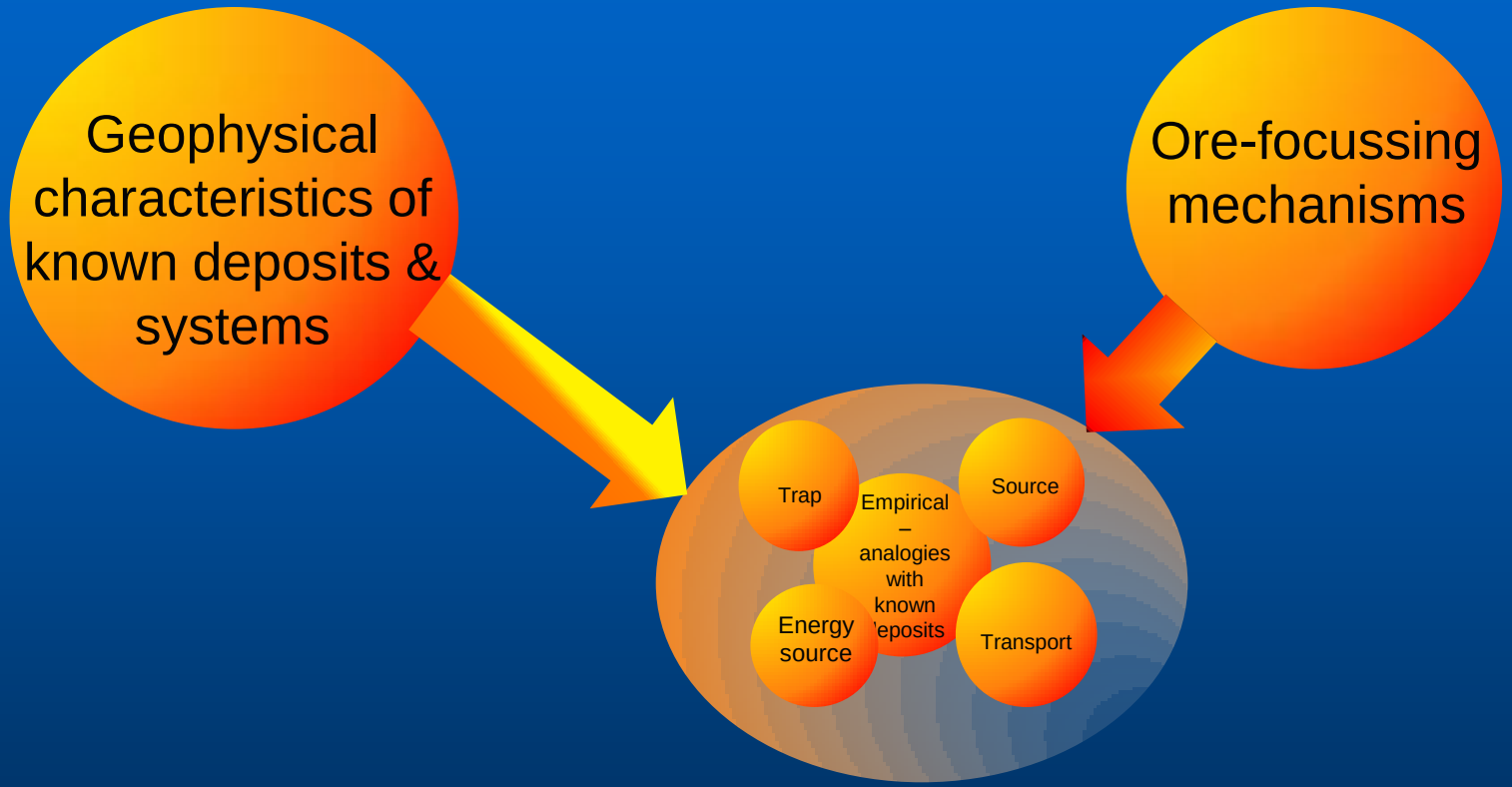


Shaping a Nation, 2012. Geoscience Australia, Fig. 8.21

Mineral exploration under deep cover – Lessons from the Olympic Dam discovery

1. An exploration model is an essential starting point for deep under-cover exploration.
2. In the absence of regional geological information, regional geophysical data sets are necessary to guide ground selection
3. Target generation under deep cover is also dependent on geophysical data and on interpretations of those data
4. Using regional magnetic and gravity data sets to interpret basement & target geology is very difficult.

Challenges (1) – Better exploration models are needed for deep exploration under cover



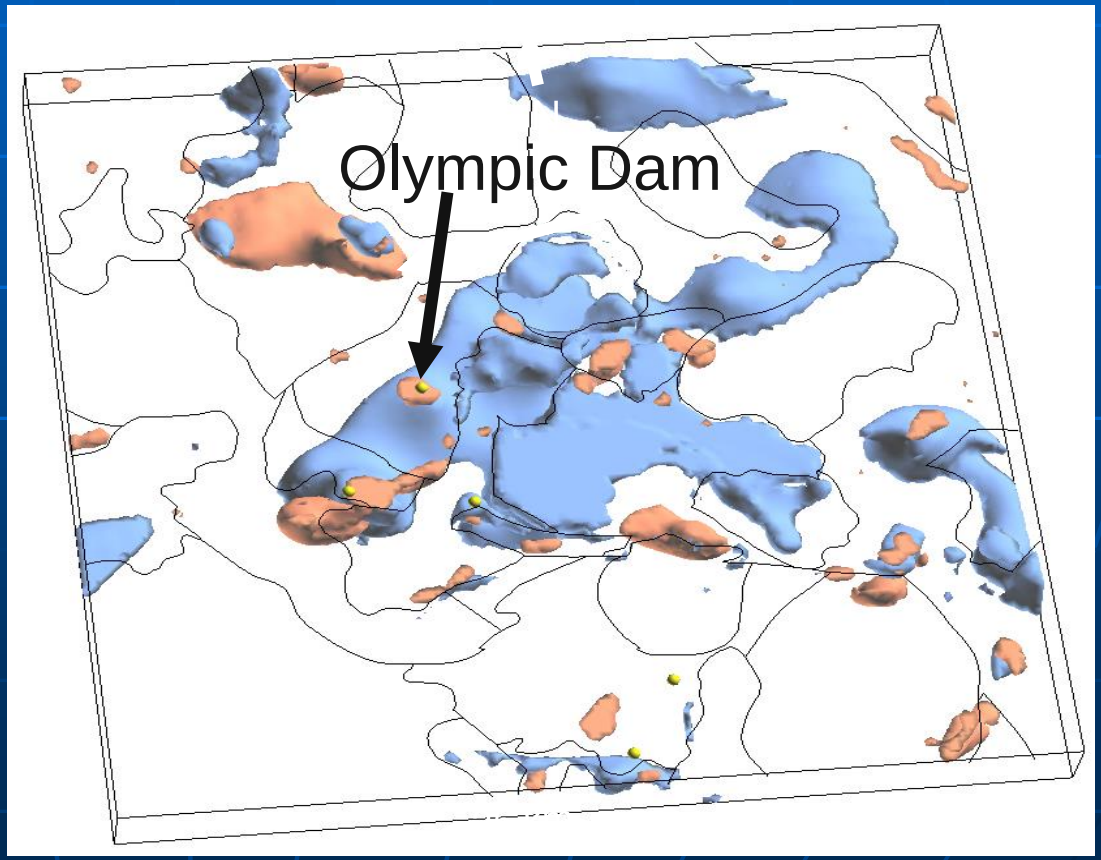
Exploration models need a sharper focus on ore-focussing mechanisms and the geophysical signatures of ore-forming systems

Challenges (2)

Ground selection and drill-targeting methods need refinement using better geophysical data inversion methods to accurately describe the geology of the Earth's crust in four dimension to enable the location of deep mineralization to be reliably predicted.

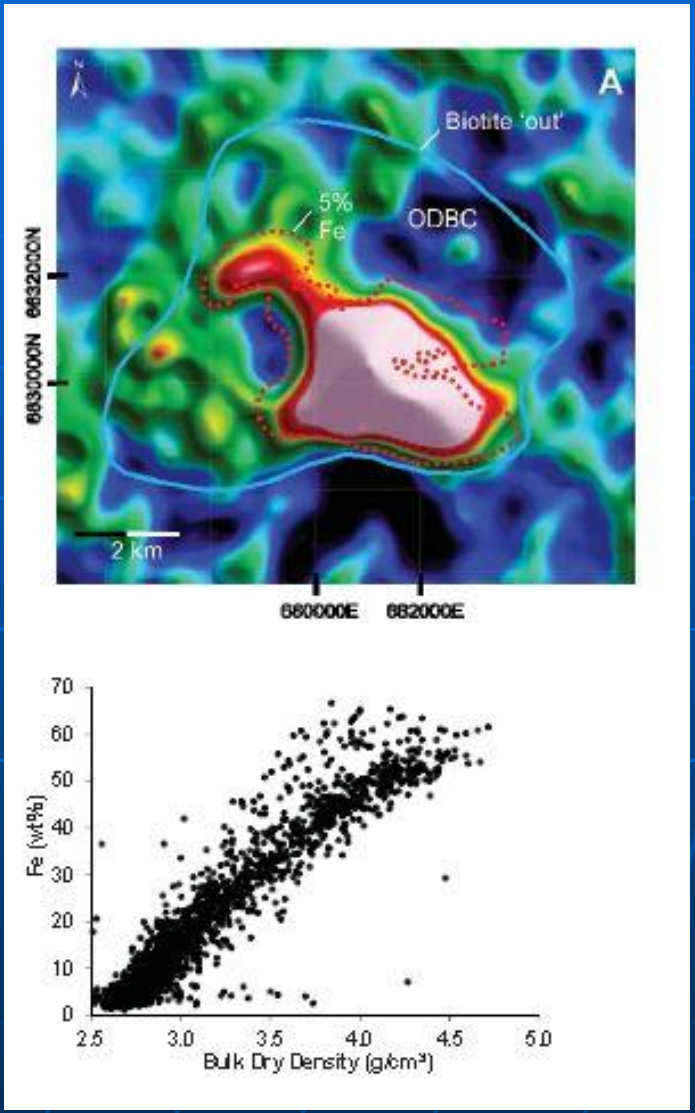
1.5% "magnetite"
Includes all susceptible minerals as their magnetite equivalent

0.5% "haematite"
Includes haematite, sulphides, gold, other dense minerals, and remanent magnetisation



Challenges (3)

New and improved of geophysical tools are needed to directly detect different types of mineralization at depth. This will need a comprehensive understanding of the geophysical characteristics of mineral-deposit types comparable to the understanding we have today of the geology, mineralogy and geochemistry of the main mineral-deposit types.



After Ehrig, K., McPhie, J., and Kamenetsky, V., 2013, SEG – Sillitoe Volume

Challenges (4) - Drill testing

Photo- detcrc.com.au/about/why-was-det-crc-created/

- Faster and cheaper drilling technologies
- New and improved down-hole geochemical and geophysical tools

Photo courtesy of Geoscience Australia

THANK YOU

…..and I wish all deep undercover explorers every success!