Australian Government

Geoscience Australia

New insights into some of Australia's giant deposits through seismic reflection surveys: Exploration implications

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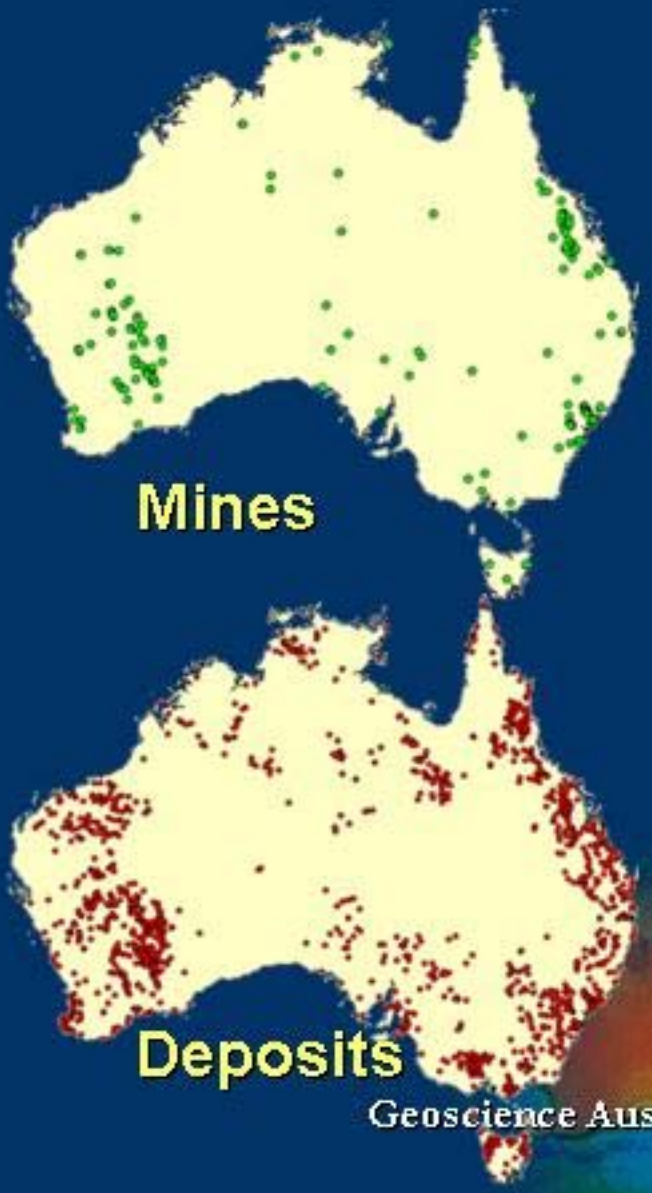
PDAC 2005

Australia's Mineral Endowment

- Australia is in the top 6 producers in world for 20 mineral commodities
- Large reserves of
  - Bauxite
  - Nickel
  - Lead,
  - Mineral sands
  - Silver
  - Tantalum
  - Uranium
  - Zinc



Most known deposits are at or near surface

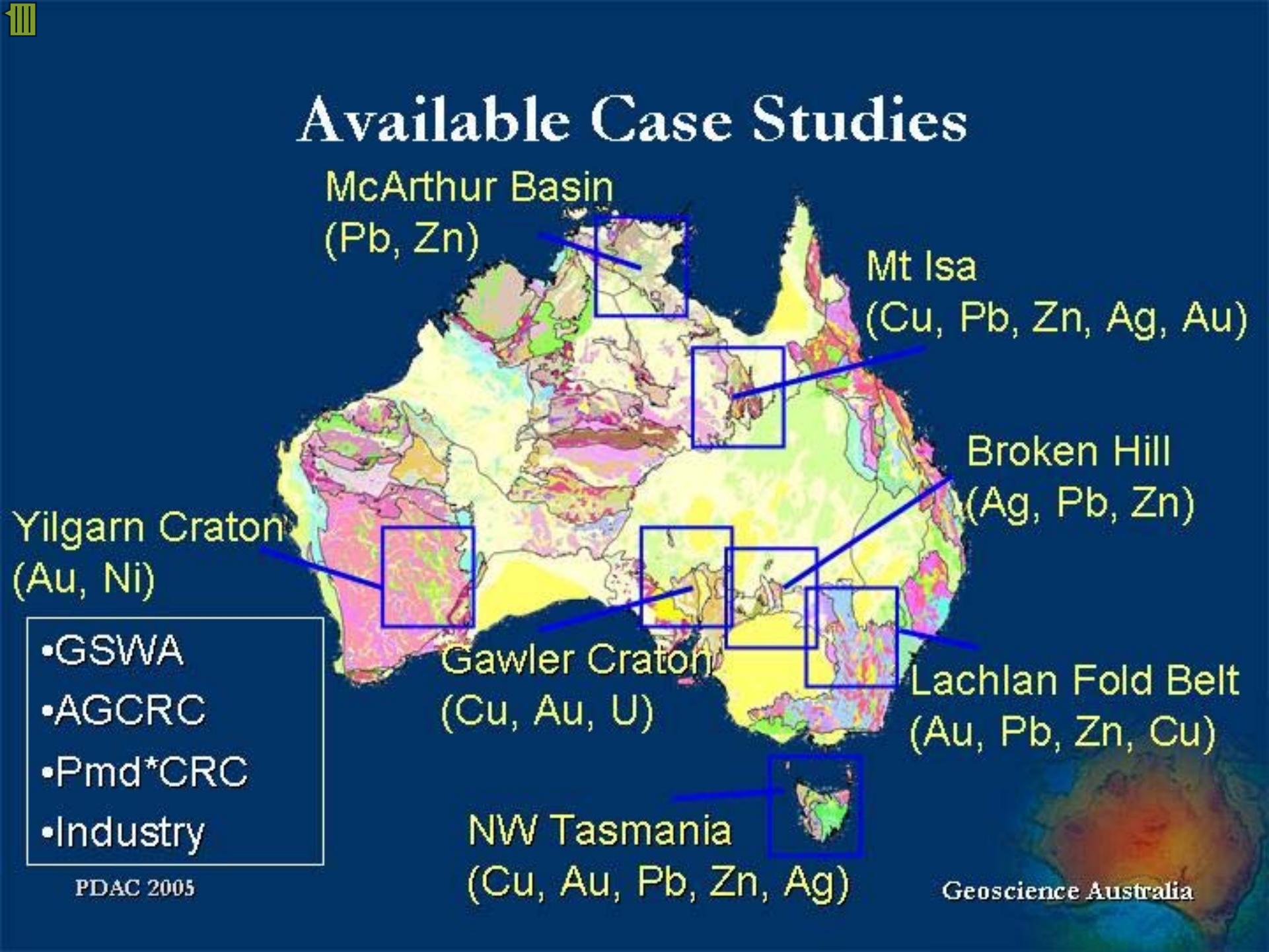
How well do we know the geology in 3D?

McArthur Basin Seismic Survey

Seismic Imaging Approach

- Don't try to image ore bodies
- Do what the petroleum industry does:
  - Find the environment that is conducive to mineralisation
  - Image the structures and pathways
  - Imaging an ore body is a bonus (flat spots)
- Need to predict settings and what they will look like
- Mineralising fluids leave a trail!

Available Case Studies



- GSWA
- AGCRC
- Pmd*CRC
- Industry

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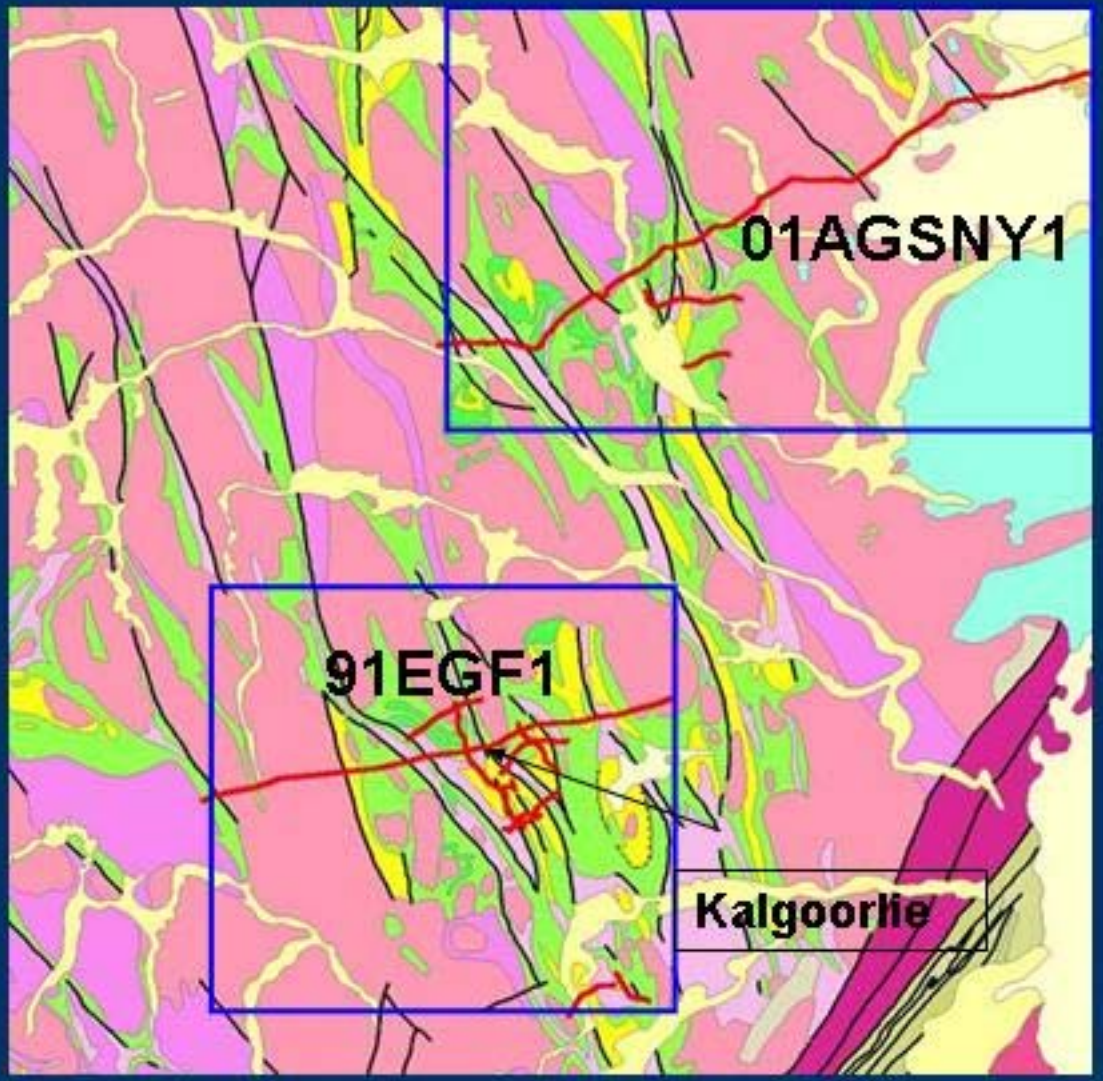
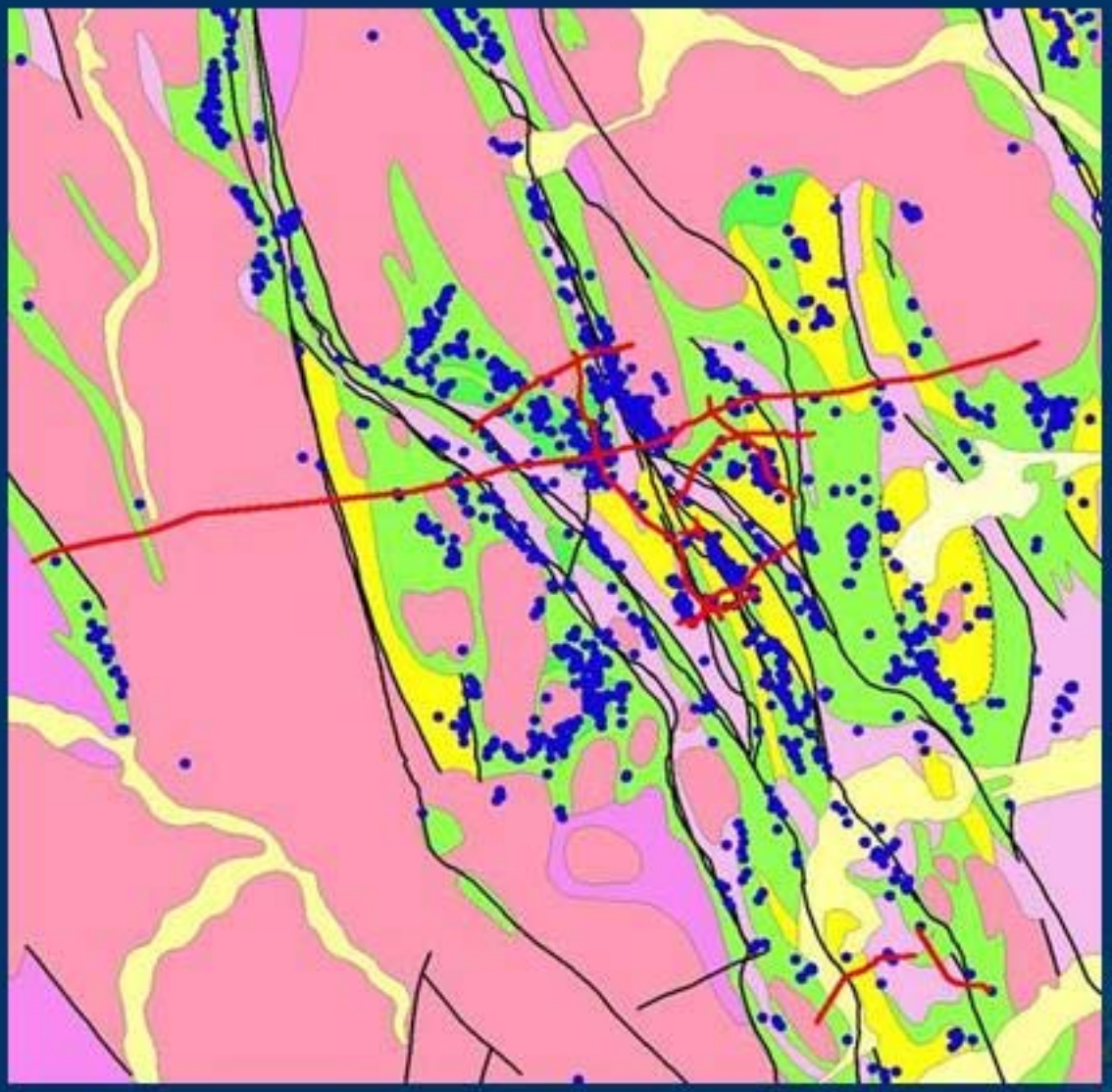
Geology



Gold Endowment

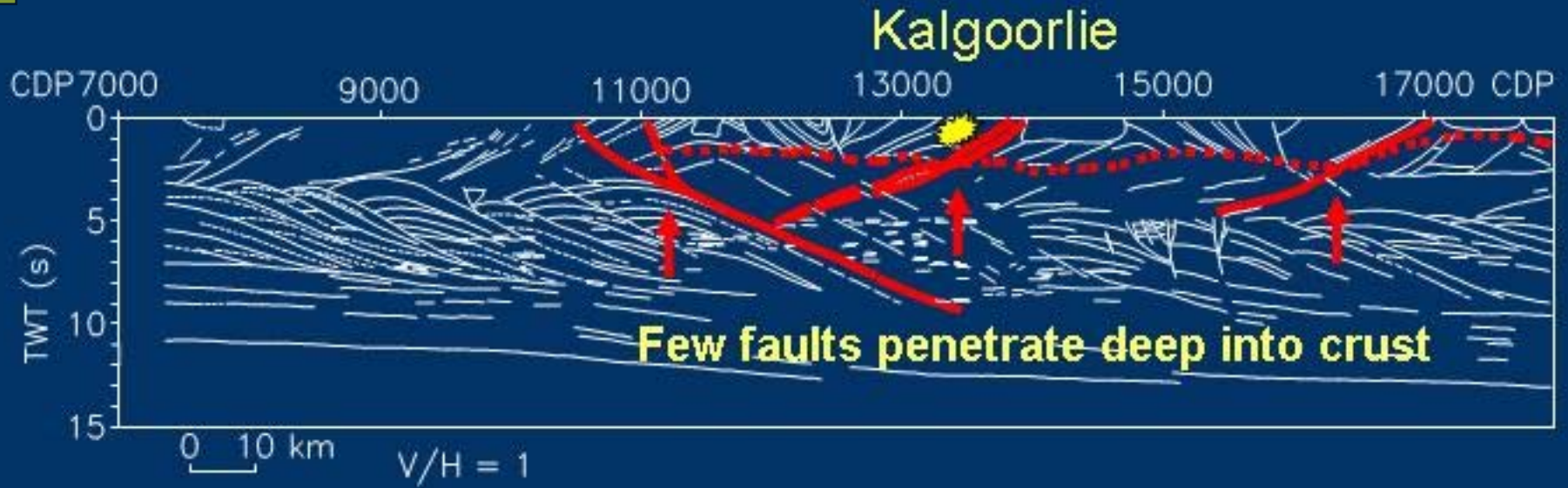


Present Day Geometry

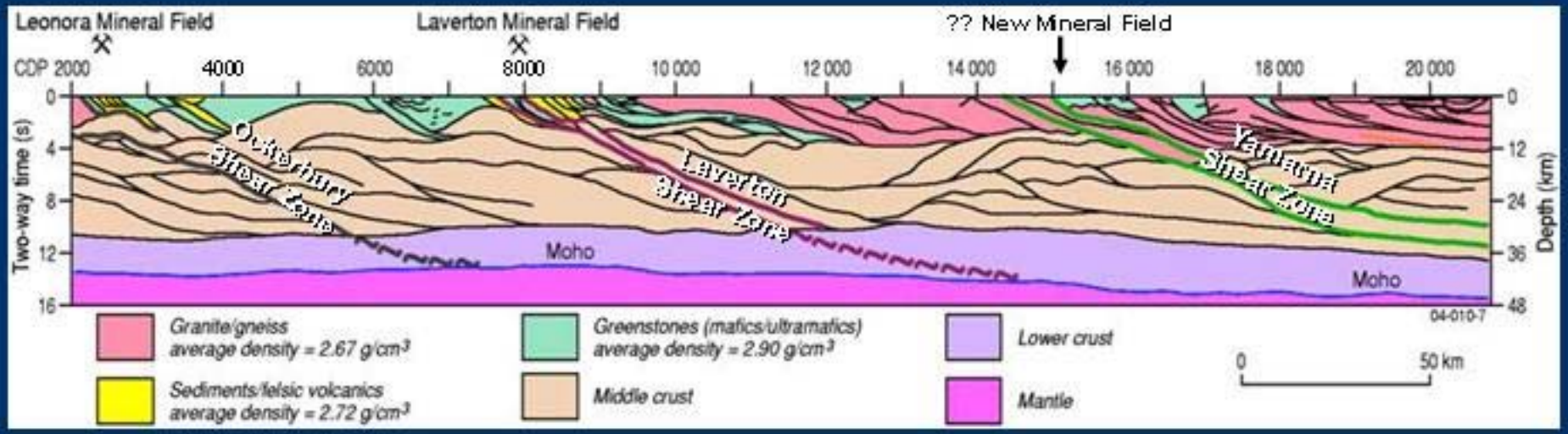
W E

213x45km

91EGF1


Kalgoorlie
CDP 7000
9000
11000
13000
15000
17000 CDP
0
5
10
15
TWT (s)
Few faults penetrate deep into crust
0 10 km
V/H = 1

Northeastern Yilgarn Seismic Transect

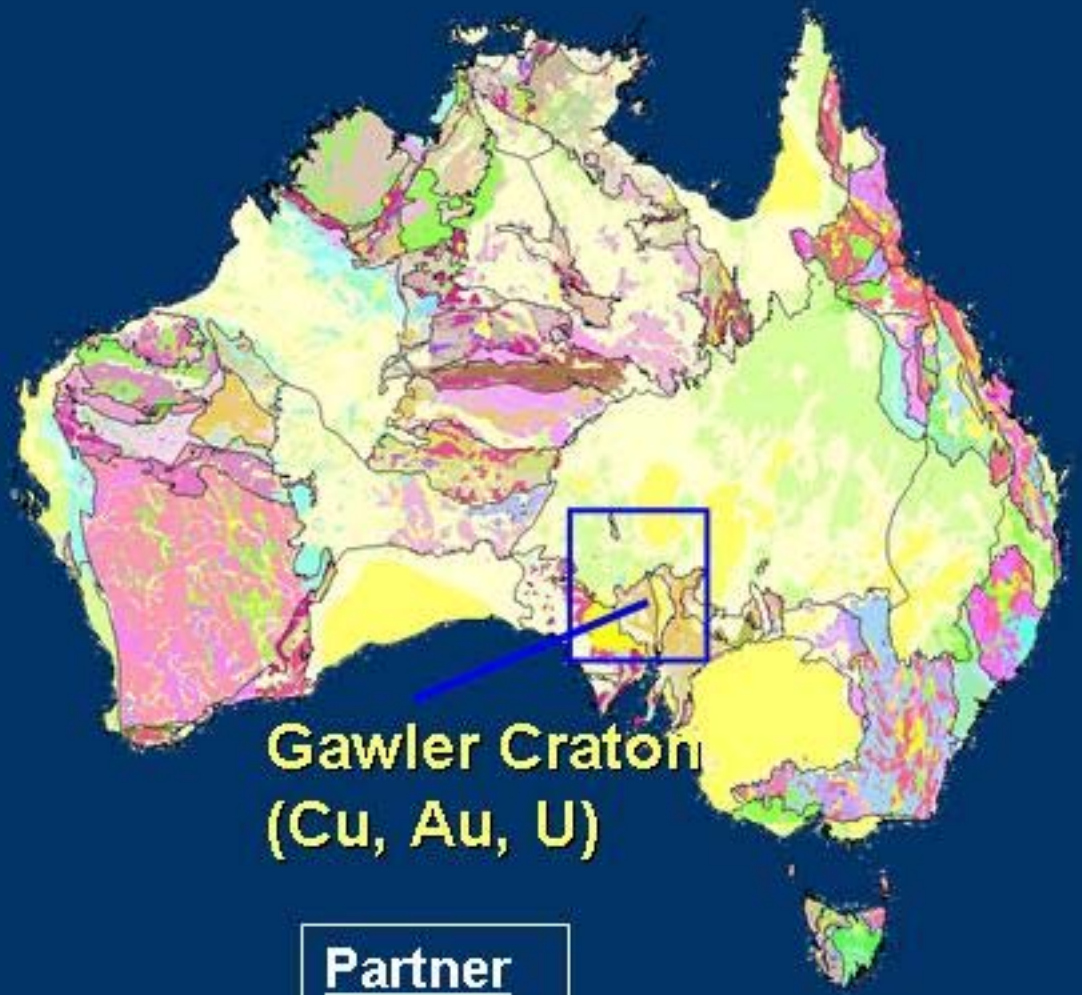


- Moho deepens to east
- three broad crustal layers
- prominent low-angle east dip (thrust belt)
- 3 deep-penetrating?? shear zones

Findings

- Signature of most crustal deformation events can be seen in the seismic image
  - Fault zone reflectivity due to alteration (phyllosilicates)
  - Alteration caused by fluids at time of deformation
- Analogy with modern orogens suggests detachment controlled by fluid "ponding" at brittle/ductile transition zone
- (Few) faults that penetrate the detachment into the deeper crust focus fluid flow between the lower and upper crust

Available Case Studies



Partner

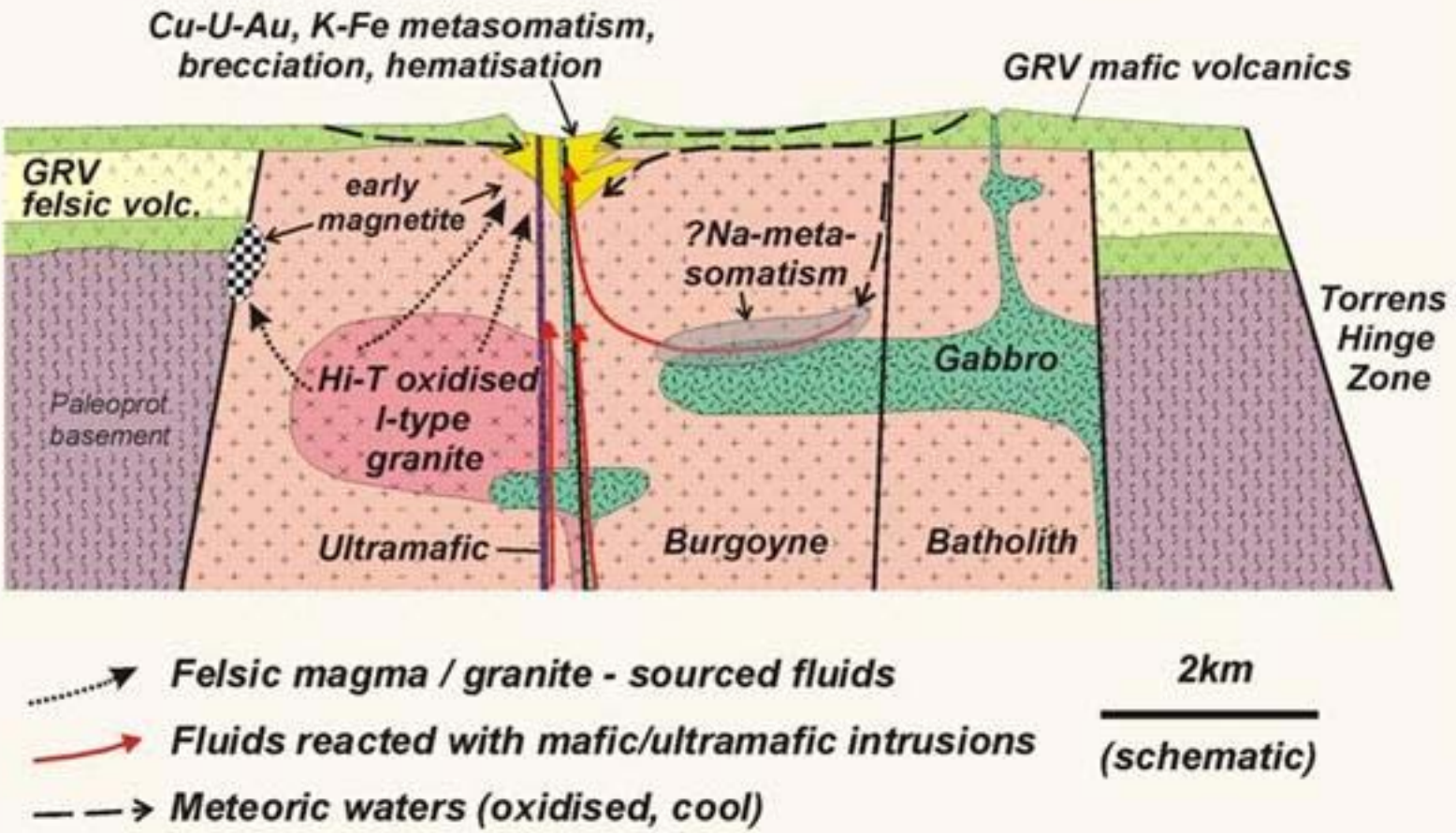
PIRSA

Gawler Craton Seismic Survey 2004

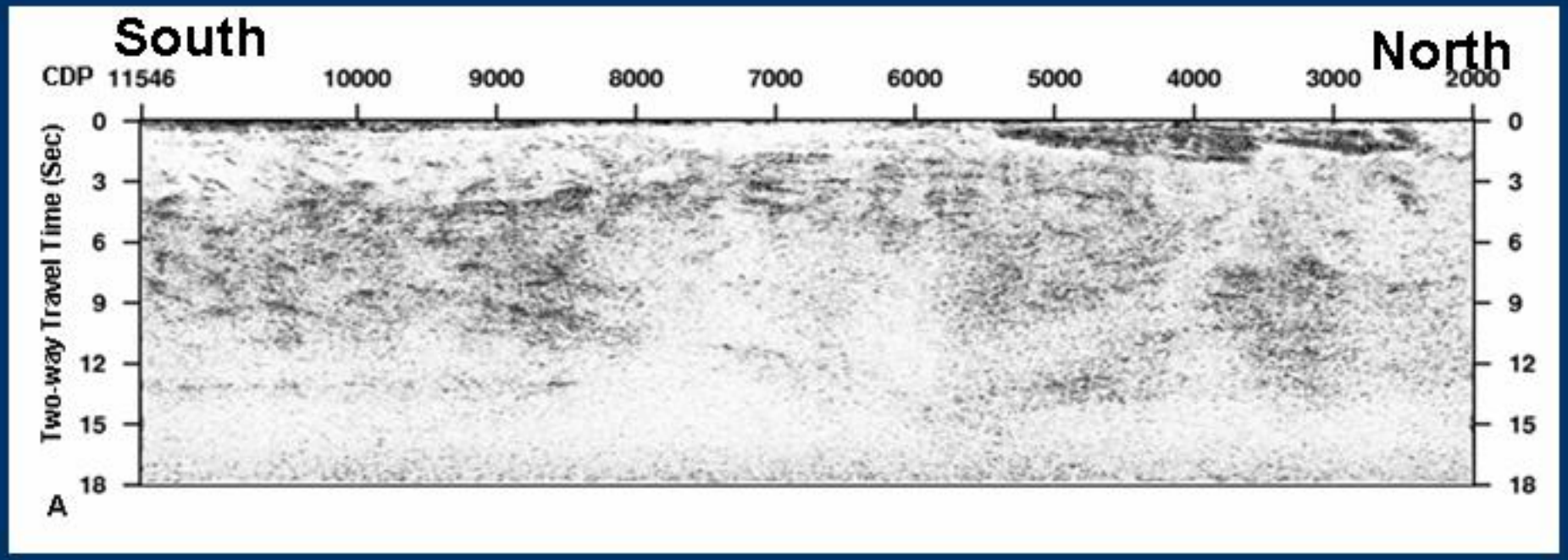
250 km of deep crustal seismic

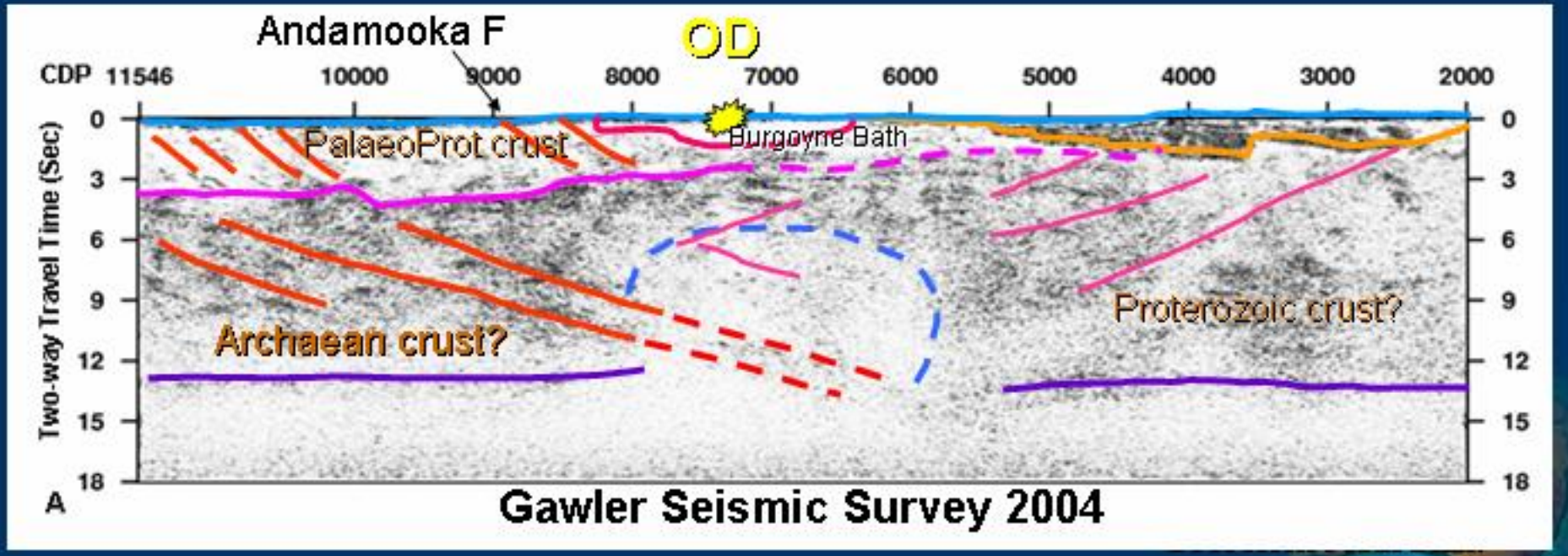
Aim:
Define the 3D structure of the Gawler Craton near Olympic Dam

OLYMPIC DAM - STYLE CU-AU SYSTEM



Geology partly based on Reeve et al. (1990) & Haynes et al. (1995)

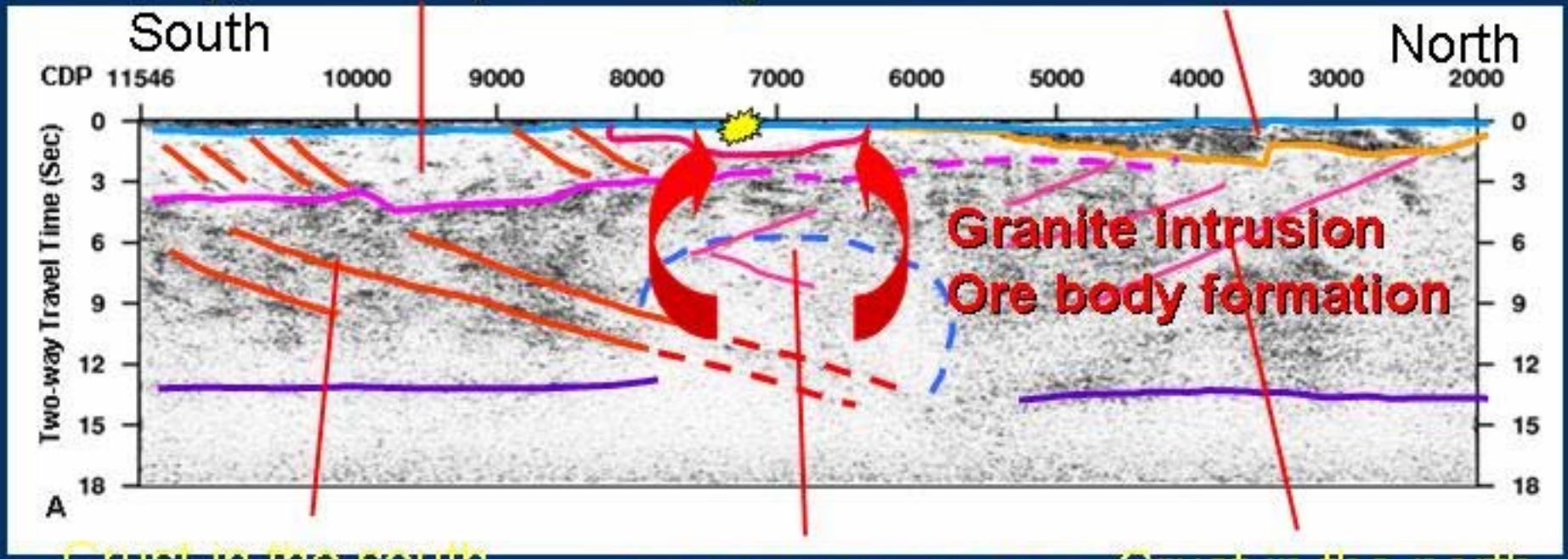

South
North
CDP 11546
10000
9000
8000
7000
6000
5000
4000
3000
2000
Two-way Travel Time (Sec)
0
3
6
9
12
15
18
A


Andamooka F
OD
CDP 11546
10000
9000
8000
7000
6000
5000
4000
3000
2000
Two-way Travel Time (Sec)
0
3
6
9
12
15
18
A
PalaeoProt crust
Burgoyne Bath
Archaean crust?
Proterozoic crust?
Gawler Seismic Survey 2004

Tectonic Setting

Pre-ore body extension
?Syn-ore body shortening

Post-ore body extension to create this basin

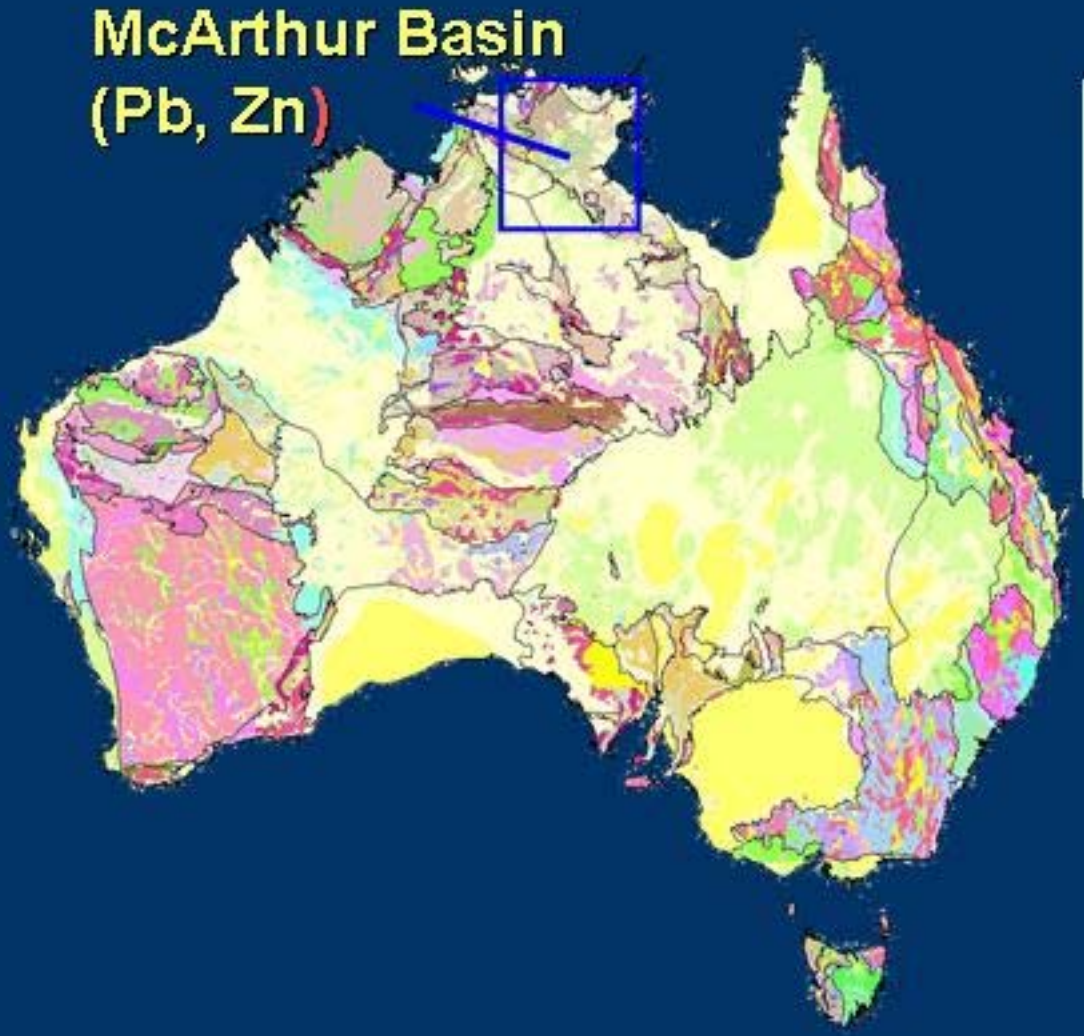


Crust in the south
- Shortened
- Same time as upper crust?

Crust in the middle
- Anomalous
- ?Overprinted
- ?Depleted

Crust in the north
- Shortened
- Same time as upper crust?

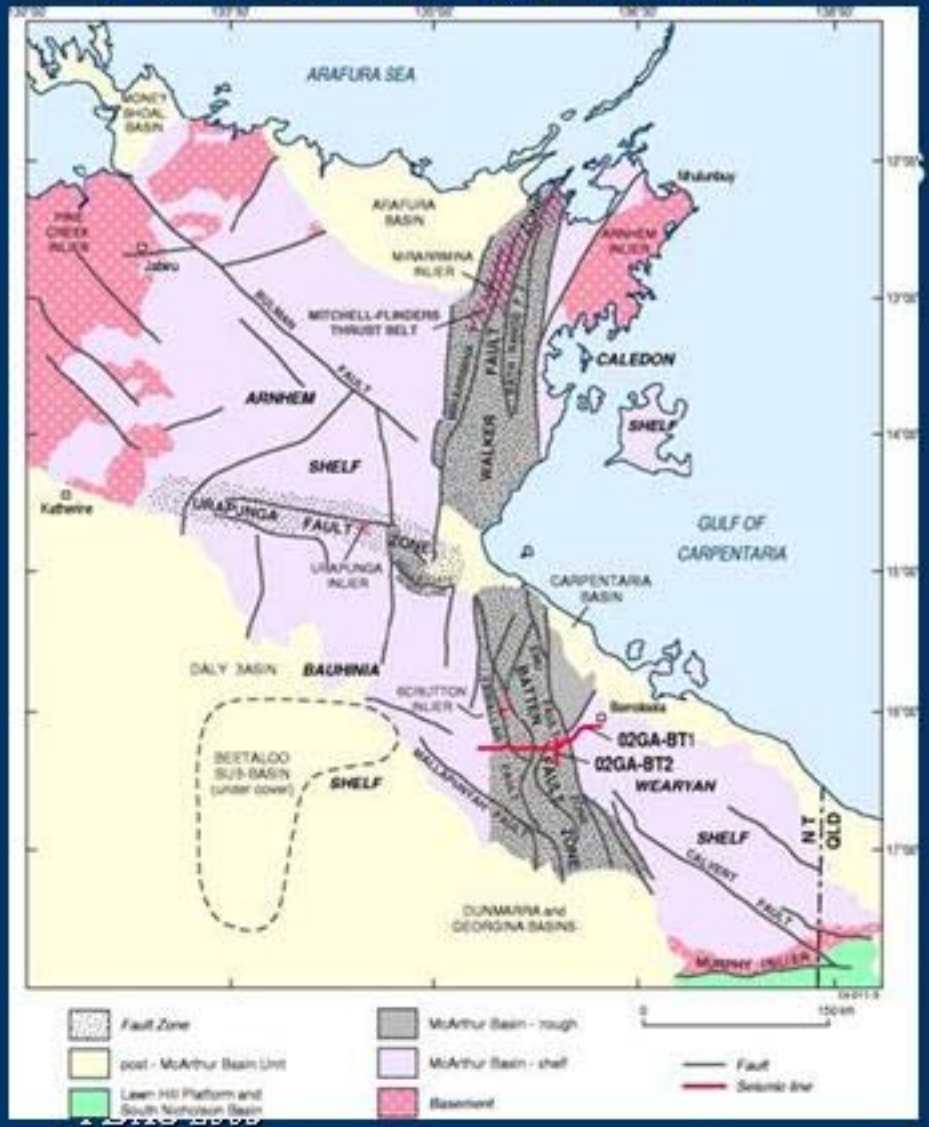
Available Case Studies

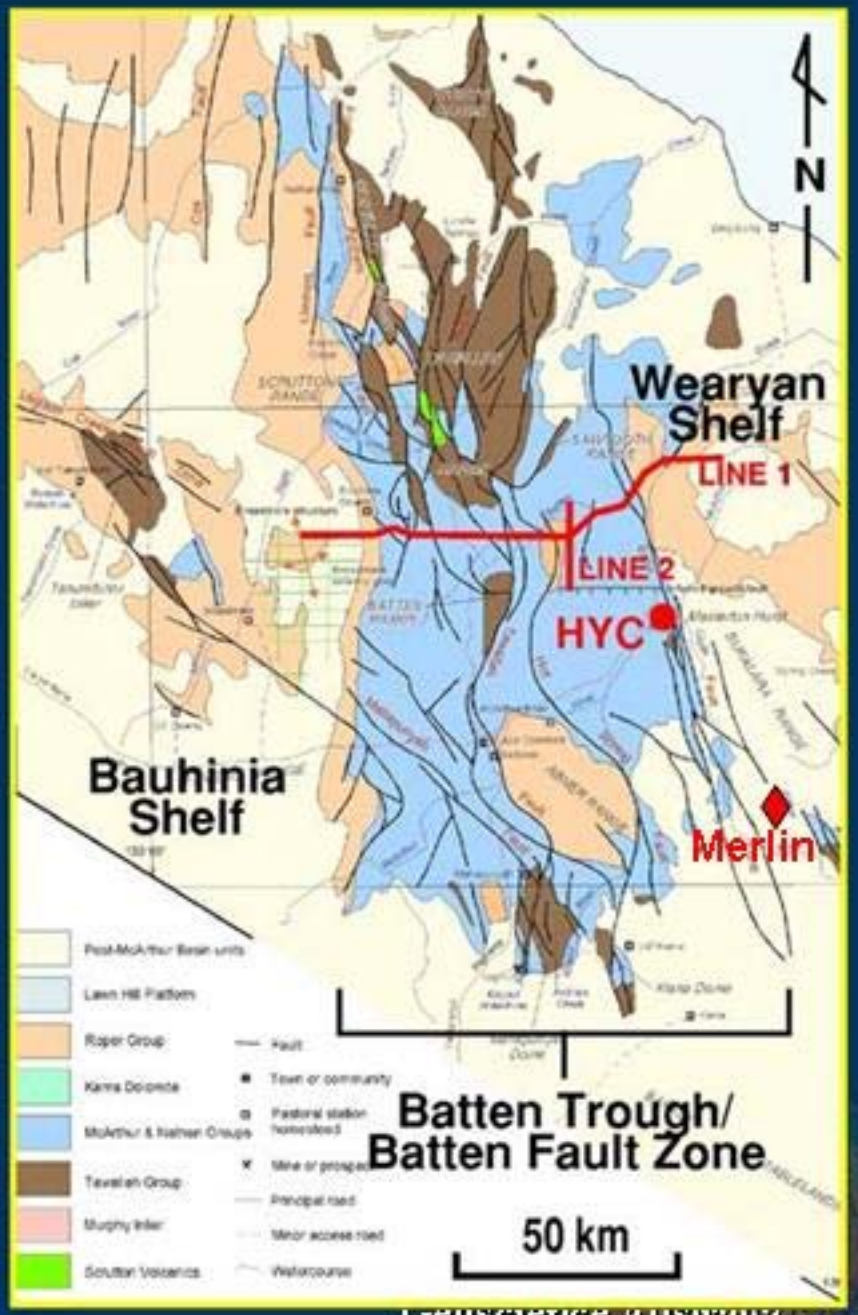


Partners

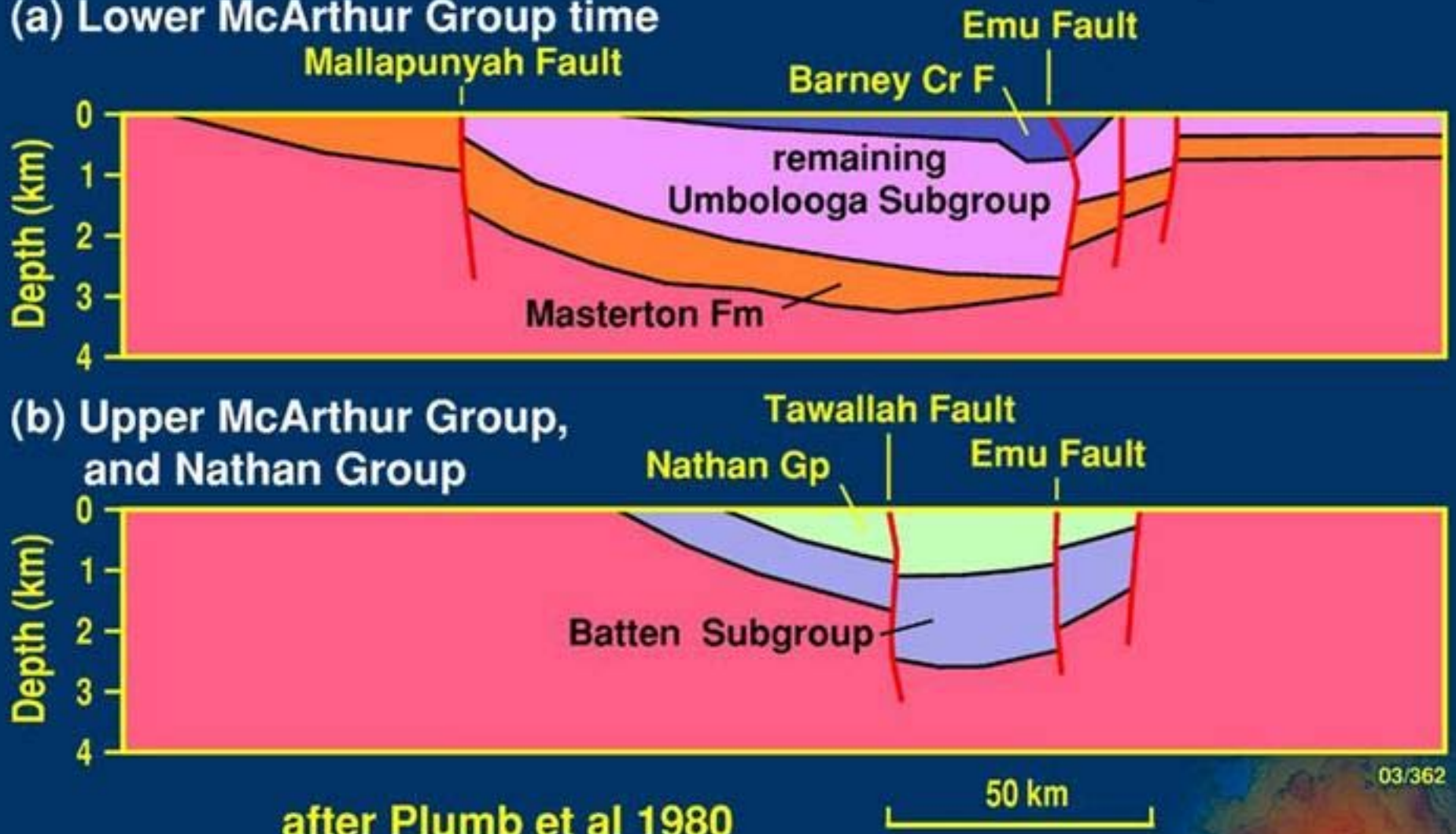
- NTGS
- Pmd*CRC
- Anglo-American

Tectonic elements in the McArthur Basin

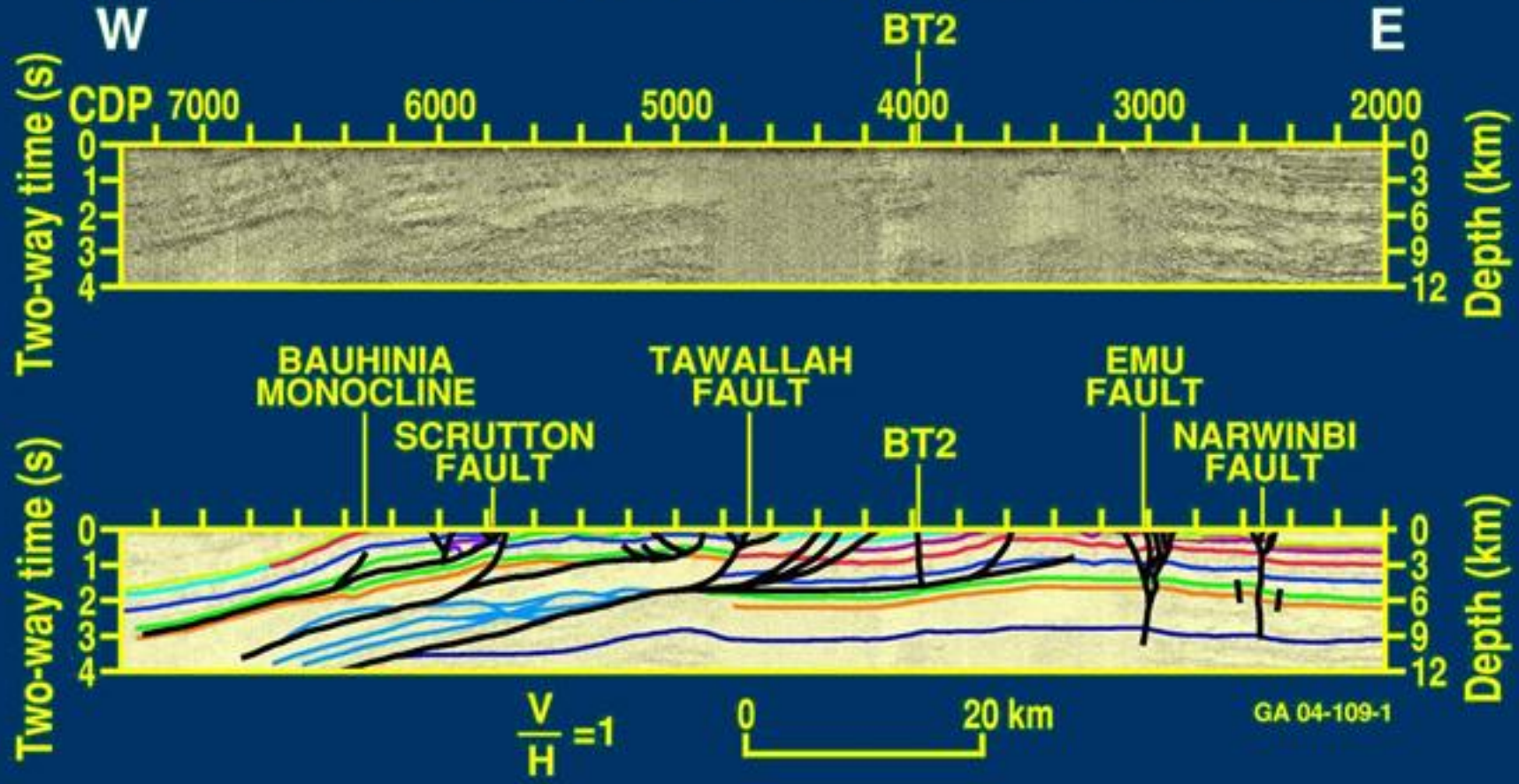




Early interpretations for Batten Trough



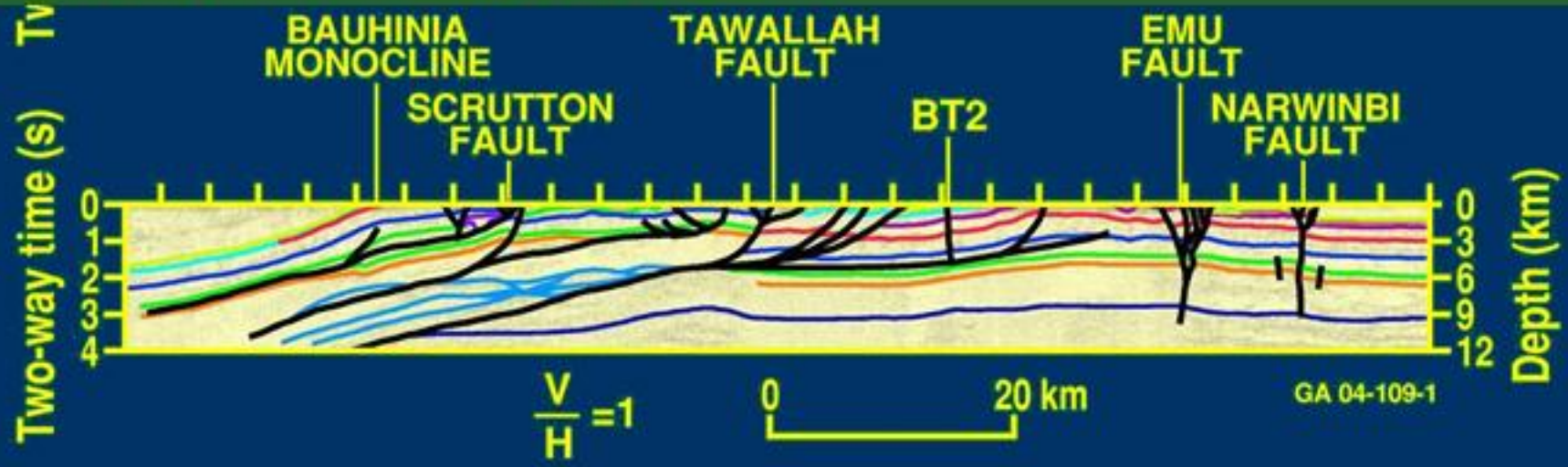
McArthur Basin seismic line 02GA-BT1



- base Roper Gp
- base Nathan Gp
- base Stretton Sst
- base Yalco Fm
- intra-McArthur (? Barney Cr)
- base McArthur Gp
- base of U Tawallah Gp
- base of M Tawallah Gp
- base of Tawallah Gp
- basement reflection
- Fault

Implications for Mineralisation

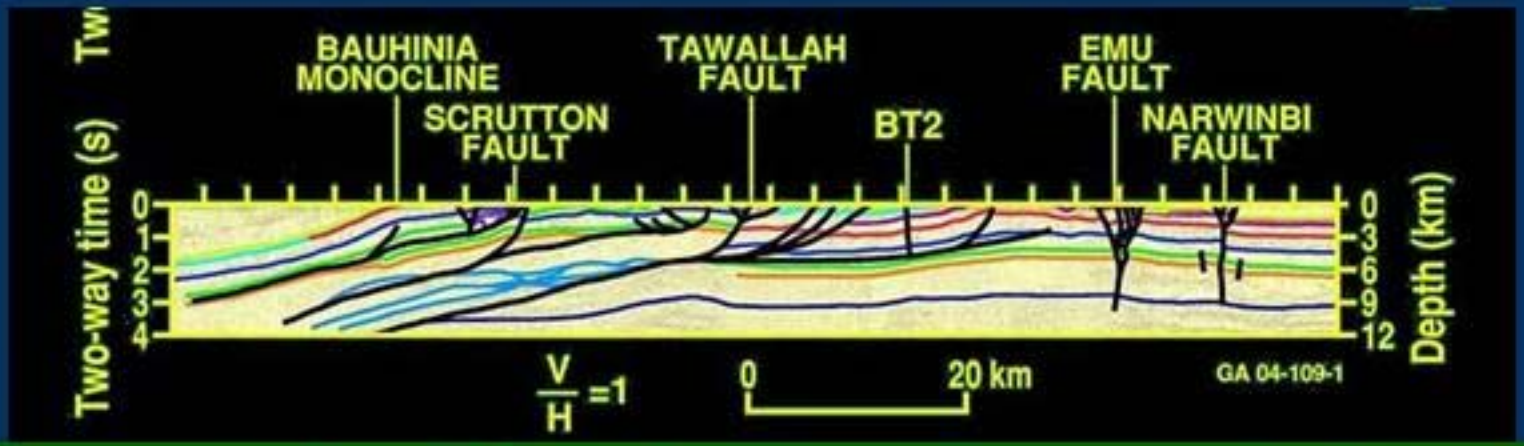
- McArthur R deposit not at boundary of depositional basin
- Tawallah Fault dips gently to west and aquifer is mostly below fault – need a new fluid circulation model
- Increased potential for McArthur-style deposits along Emu Fault Zone in areas under cover



- Younger major thrust belt – possible foreland basin type deposits (MVTs) – topographically driven fluids??
- In core of thrust belt (orogen) to west - potential for orogenic gold deposits under cover?

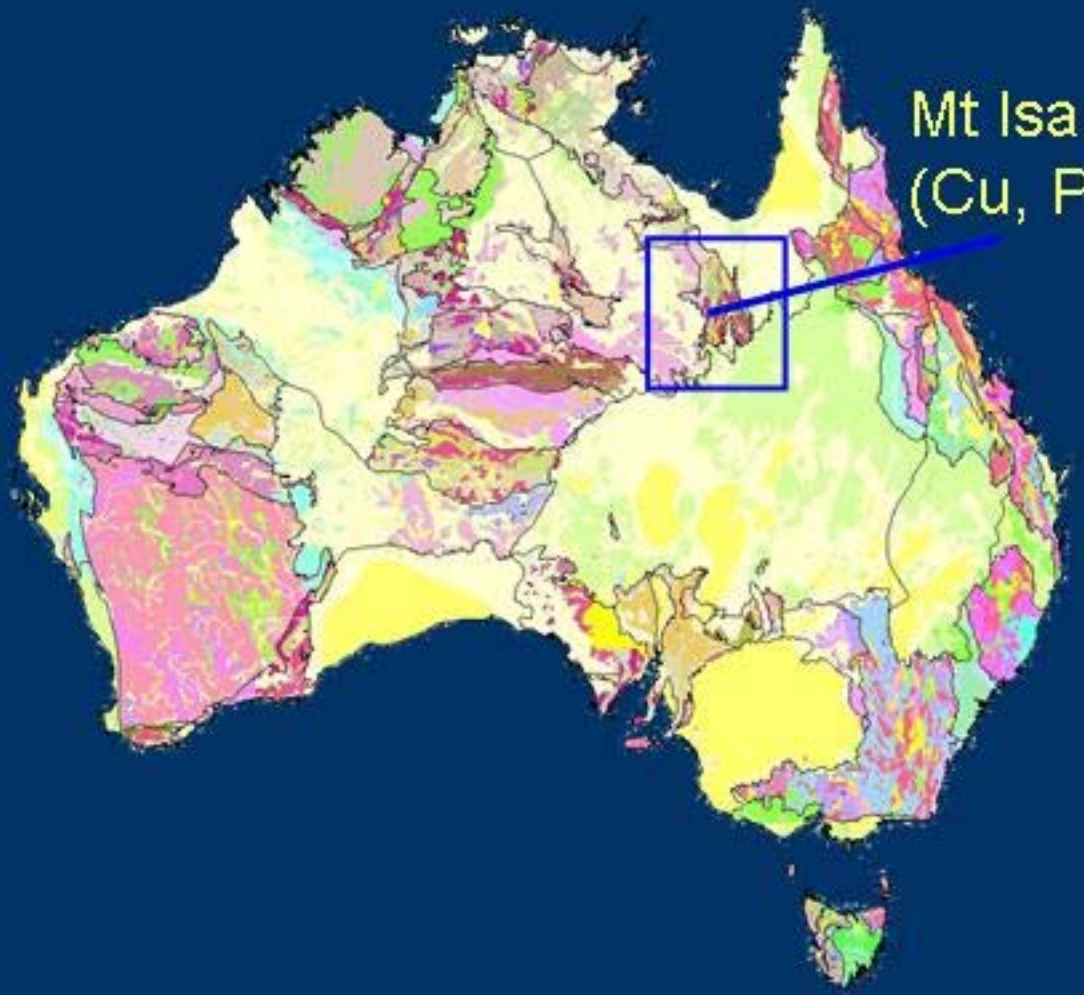
Korsch et al, 2004

Sediment-hosted stratiform McArthur-style

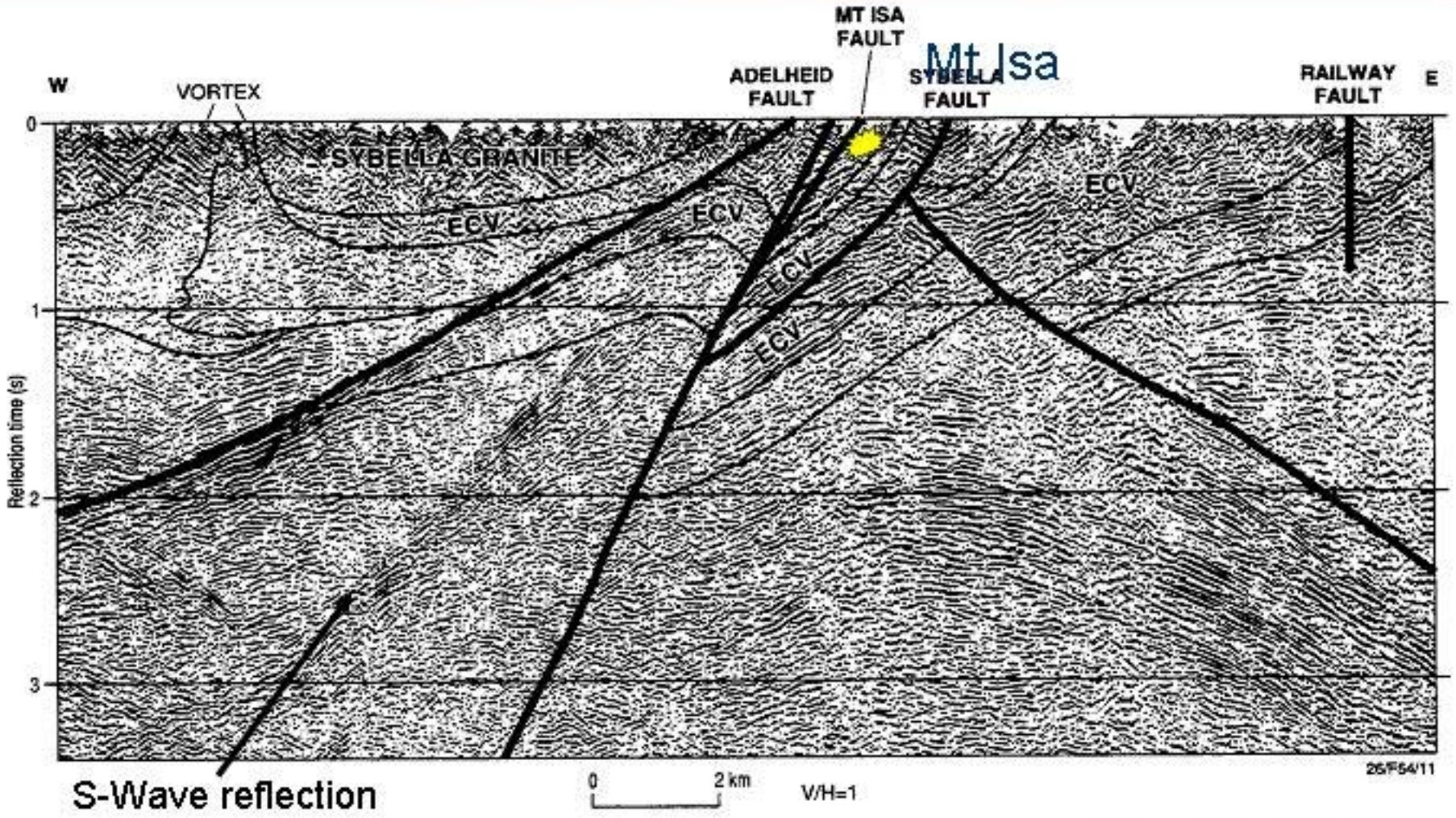


- Steep geometry of Emu Fault permits access to deep basinal brines
- Potential for other sub-basins along strike-slip Emu Fault
- Thick McArthur Group east of Emu Fault – prospective?
- The convective fluid flow system not essential
  - fluids could be derived from deeper, older part of Tawallah Formation
  - fluids possibly hotter (up to 300 deg C supported by biomarkers in the mineralisation-related organic material)
  - (high T means higher solubility of lead and zinc)

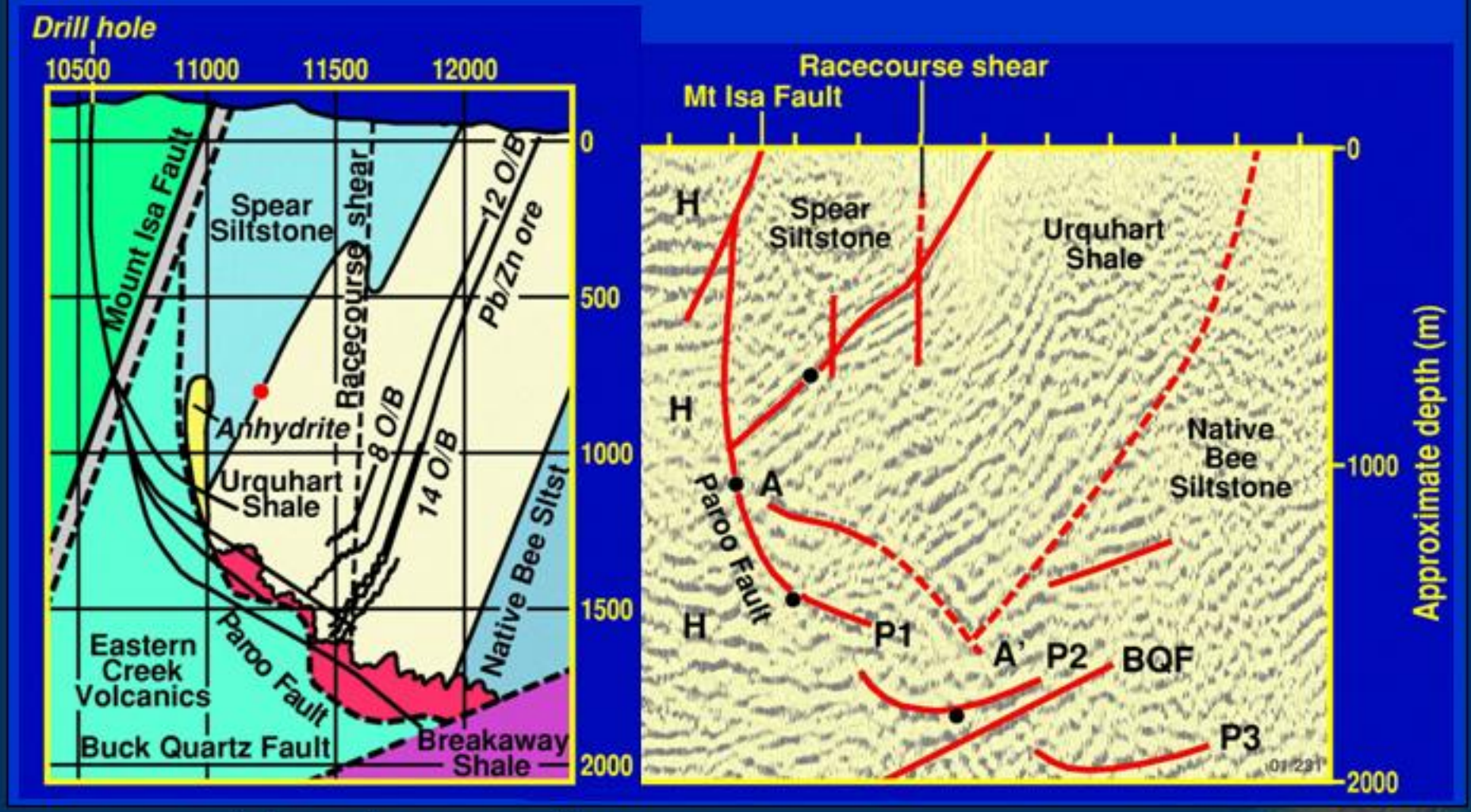
Mt Isa Seismic



1994 Mt Isa Seismic Transect – Mt Isa Mine portion



1994 Mt Isa Seismic Transect – mine scale seismic



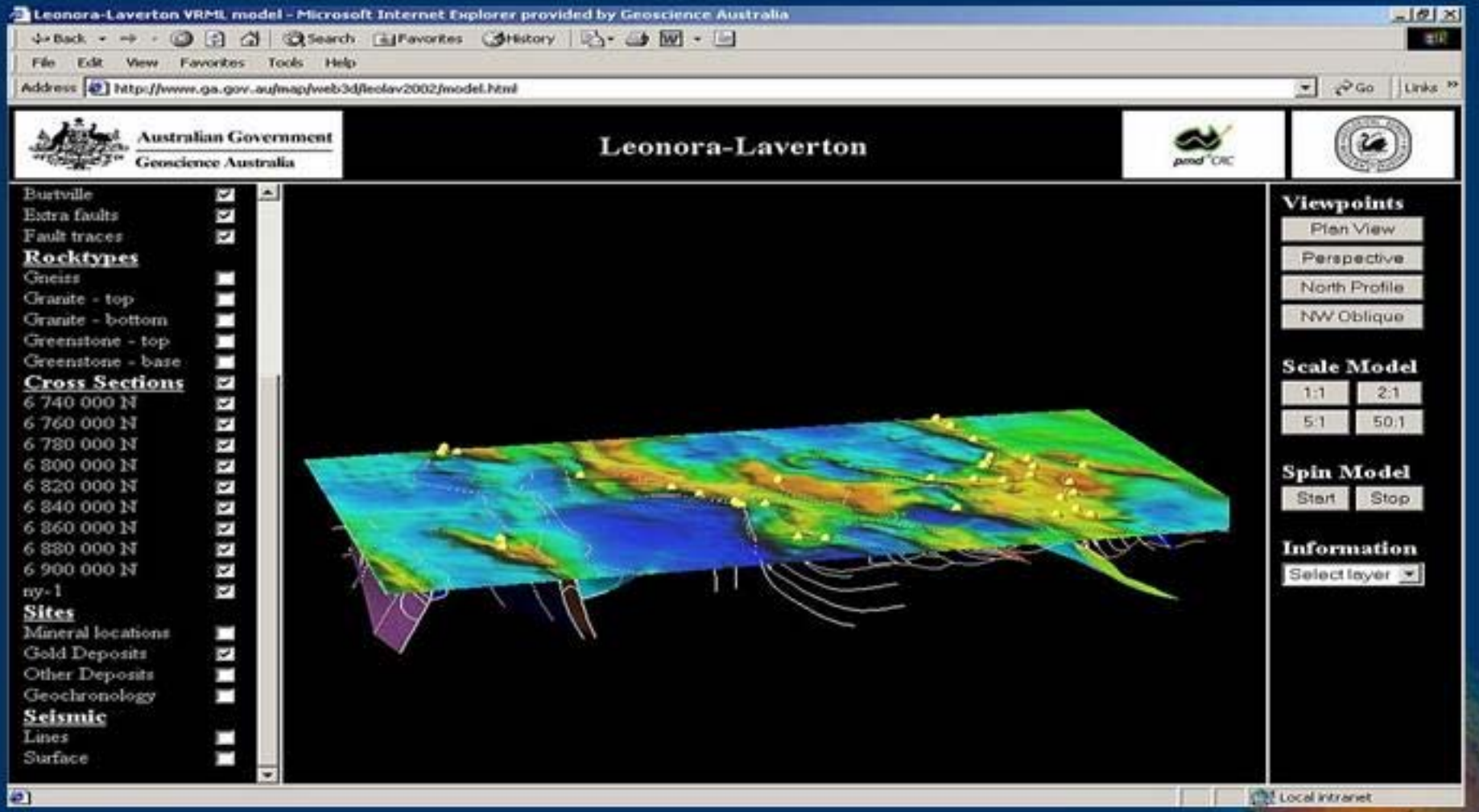
Schematic cross section across the Mount Isa Cu-Pb-Zn Mineral Field, coincident with seismic traverse 94ISA-03

Lessons from Seismic

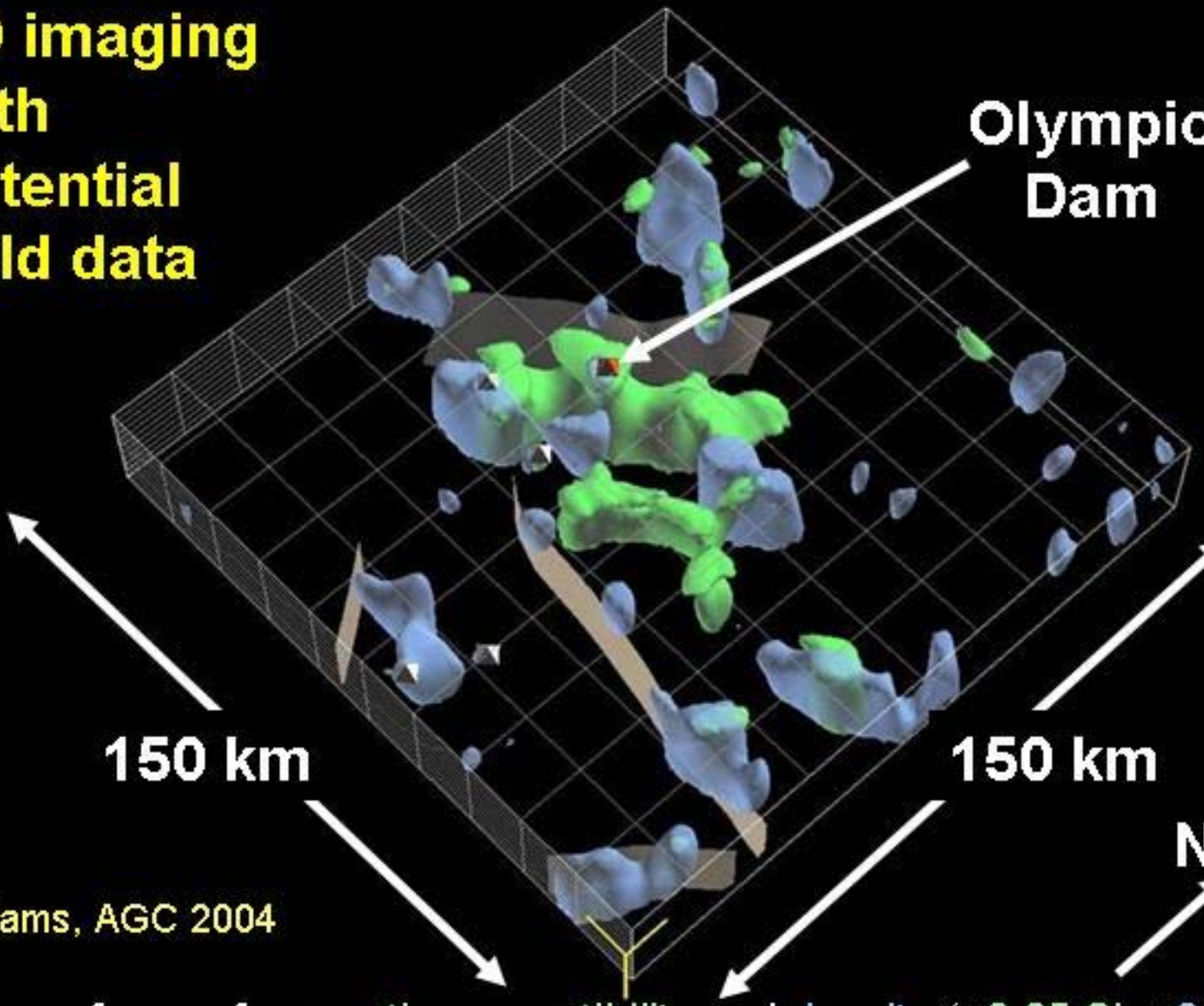
- Seismic can image structures in ore controlling/influencing mineralisation, e.g.
  - crustal penetrating long-lived faults active during change from compression to strike-slip(?) in the case of Archaean gold;
  - basin margin faults in strata bound deposits.
- Zones that have had fluid movement are reflective
  - alteration changes rock density and seismic wave speed
  - faults have anisotropy caused by the alignment of phyllosilicate minerals
- At deposit scales, high resolution data show the environment around the ore deposit
  - Elements for local exploration strategy
  - Maps fluid signatures (e.g. alteration front etc) rather than the ore body.

BUT

3D Geological Models



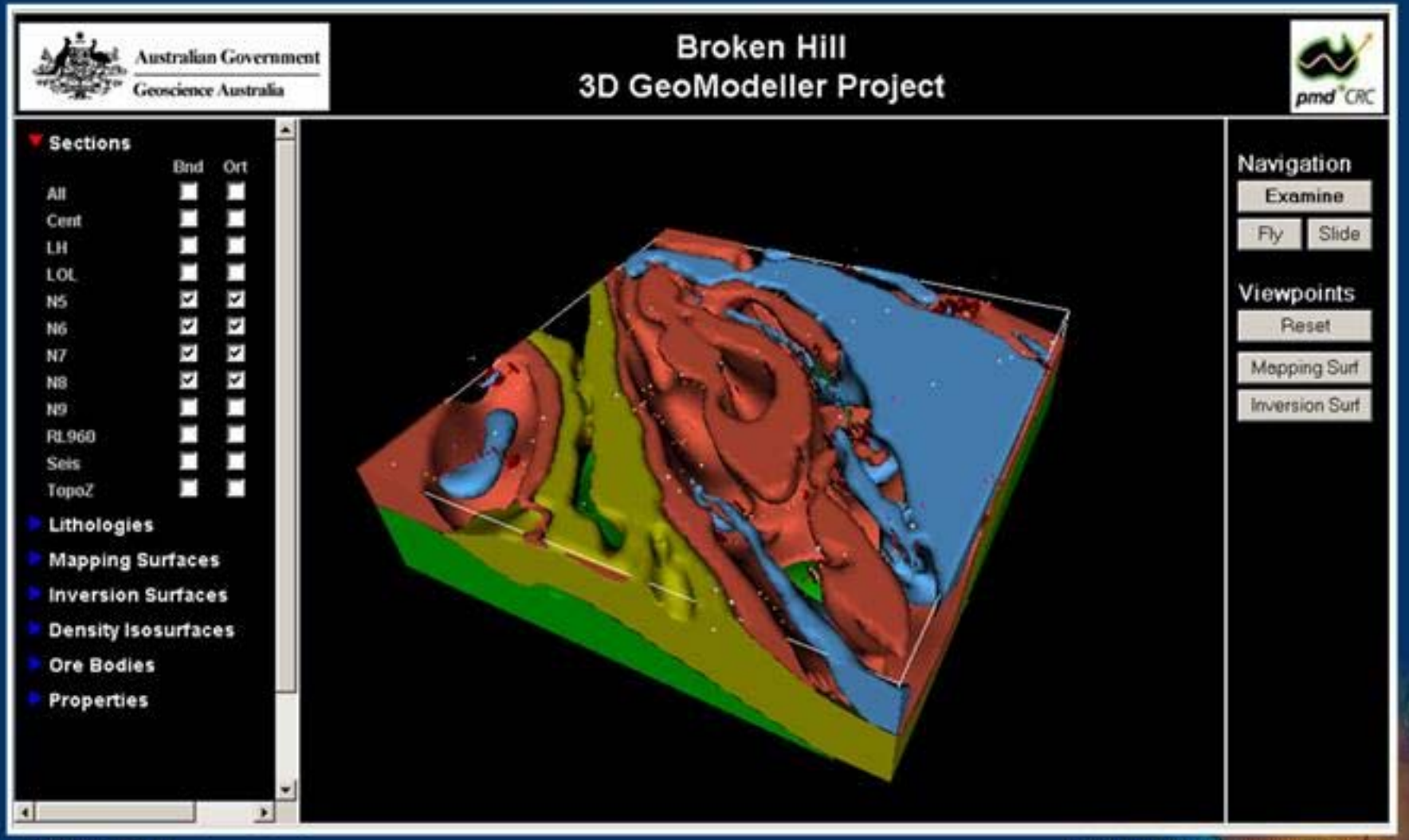
3D imaging with potential field data



Williams, AGC 2004

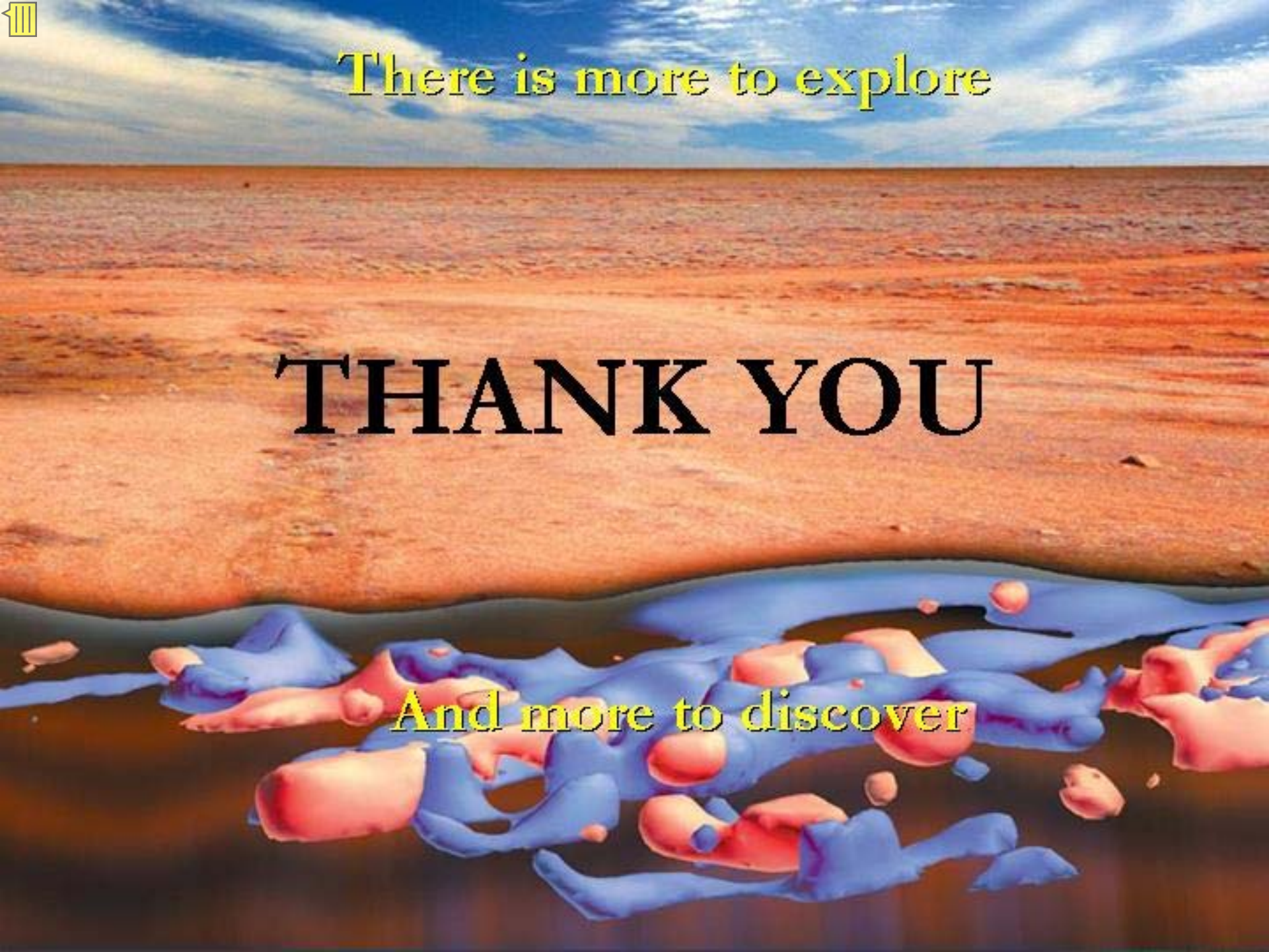
Iso-surfaces of magnetic susceptibility and density (>0.05 SI, >0.3 g/cm^3)

Geomodeller Project Broken Hill VRML display



Conclusions – Exploration Implications

- Seismic surveys revealing 3D structure of crust in mineral provinces
- Geology as not well known in 3D as we think
  - Seismic has challenged 'known geology' is each province it has been used
  - Some mineral deposit models based on old geology need re-examination/revision
- Crustal architecture key to determining regional scale controls on mineralisation
- Most major deposits lie at major crustal boundaries/breaks
- New mineral potential opened up by seismic (or 3D models)


There is more to explore
THANK YOU
And more to discover