



Minerals @ GA Update Forum

2 September 1:00 – 5:00 Raggatt Theatre

Cnr Jerrabomberra Ave & Hindmarsh Drive, Symonston

Geoscience Australia is holding a free Minerals Open Afternoon at its Canberra Headquarters. Please join us to hear about our exciting new products and Geoscience Australia's UNCOVER projects being conducted across Australia.

RSVP's to Nicole.manning@ga.gov.au by 27th August

1.00 - The Minerals programme at GA: an UNCOVER overview

Theme 1. Cover

1.15 - Towards a national cover thickness map using data mining: a model-based predication of cover thickness

1.30 - Airborne electromagnetic (AEM) – cover thickness, cover character, advanced processing, interpretations and case study exemplars.

1.45 - Geophysics applied to variable cover: benchmarking multiple methods to known depths.

Theme 2. Architecture

2.00 - The magnetotelluric method to map near surface to deep lithosphere: case studies and new developments.

2.15 - The seismic database of Australia: a continent in cross section.

2.30 - Bringing it all together: The Australian Architecture Reference Model (AusARM)

2.45 - Refreshments

Theme 3. Geodynamics and mineral system evolution

3.00 - Australia through time: the U-Pb database of Australia, ASUD, GA's geochronology capability.

3.15 - Isotope geochemistry to map architecture and fertility: Sm-Nd, Pb and Hf.

3.30 - Mineral systems as an area selection method at the national and regional scales: examples of magmatic Ni-PGE, IOCG and salt lakes.

Theme 4. Footprints and toolkits

3.45 - Update in regional stratigraphic drilling projects: Staveland and Thomson.

4.00 - Lowering the entry level to big data and big compute: the Virtual Geophysical Laboratory and its future development.

4.15 - Data delivery and discoverability: Rock Properties, Geoscience Portal, GADDS.

4.30 - Discussion



Australian Government
Geoscience Australia



Minerals @GA: an UNCOVER overview



Richard.Blewett@ga.gov.au

Mineral Systems Branch Head



Australian Government
Geoscience Australia



Minerals @GA: an UNCOVER overview



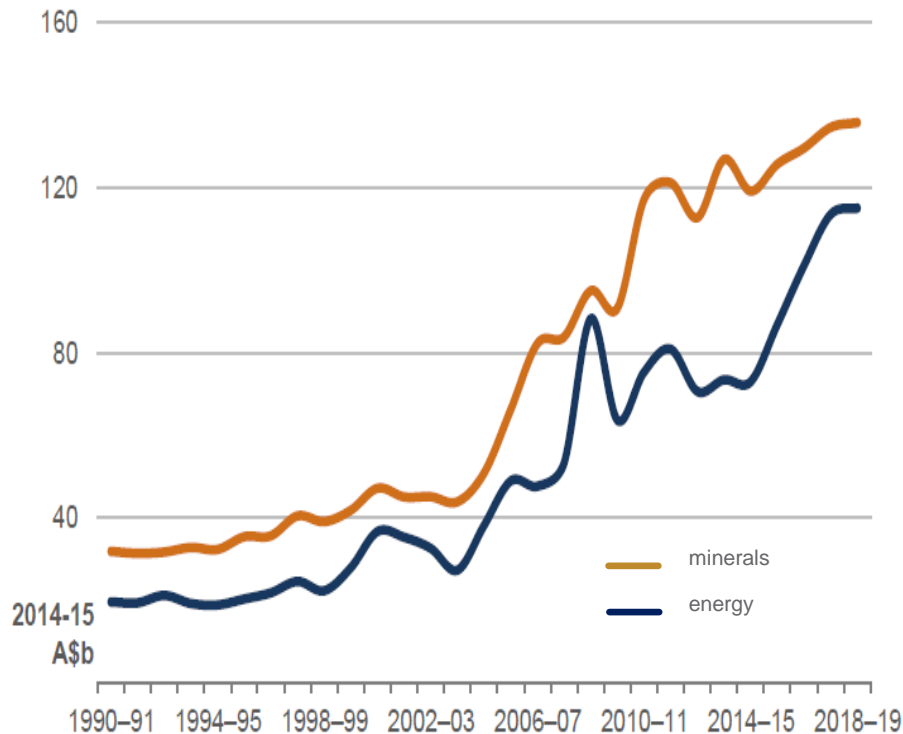
Richard.Blewett@ga.gov.au

Mineral Systems Branch Head

GA's minerals-related activities

- Pre-competitive minerals data acquisition, processing, interpretation and delivery
- Custodians national databases and maps (mineral resources, geology, geophysics, stratigraphy, geochemistry, geochronology)
- Work with states/NT across borders on seamless geoscience products
- Lead innovations nationally (eg. high-performance computing, data integration, 3-4D)
- Set standards for the service providers (eg. Geophysics), which benefits all users including industry
- Advice to Government
- Lead *Australia Minerals* to promote a minerals prospectus for 'united Australia' at international investment attraction meetings like China Mining, Prospectors & Developers Association Canada (PDAC)
- **But why do we do what we do?**

Minerals and energy export earnings

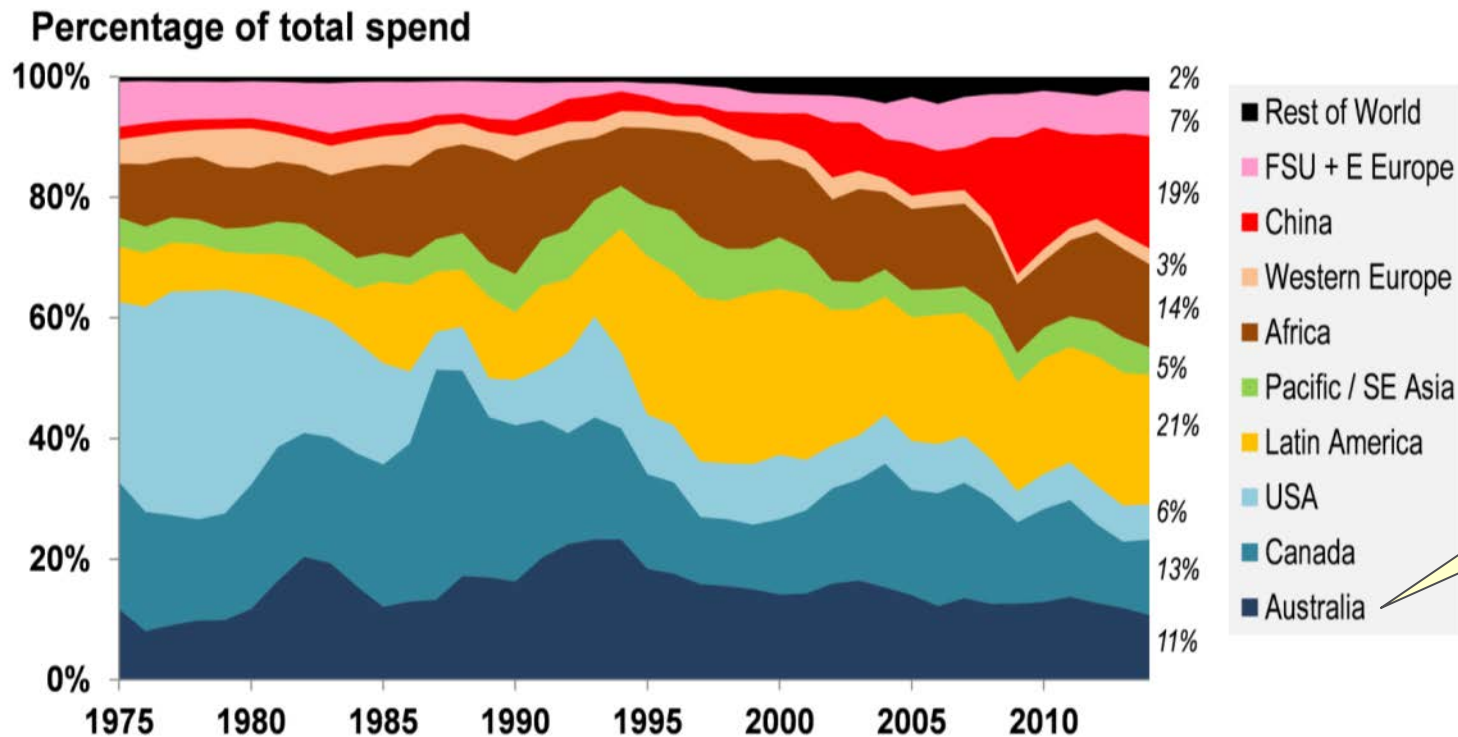


Sources: BREE, ABS

2013-14 \$195 billion
 \$124 billion – minerals
 \$71 billion – energy

2014-15 \$192 billion

New discovery requires new exploration

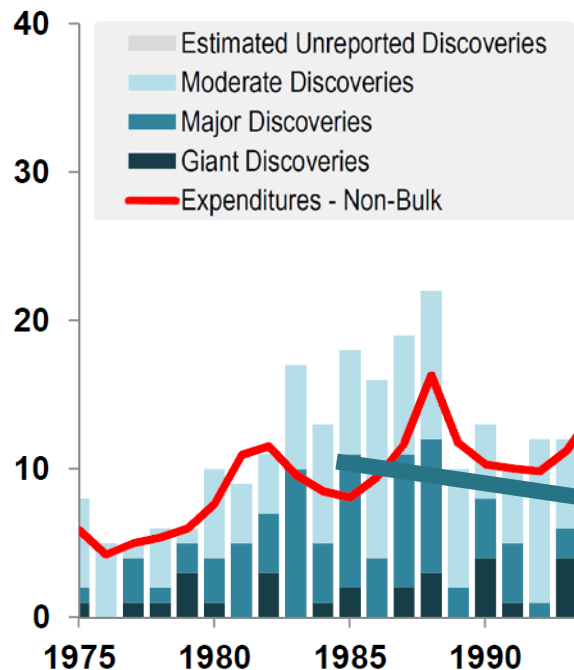


Australia's share has dropped from 21% to 11% since 1996

Source: MinEx Consulting estimates June 2015

Despite exploration increase, discoveries not followed

Number of Discoveries



The rate of discovery moves in-line with expenditure

.... With a slow decline over time

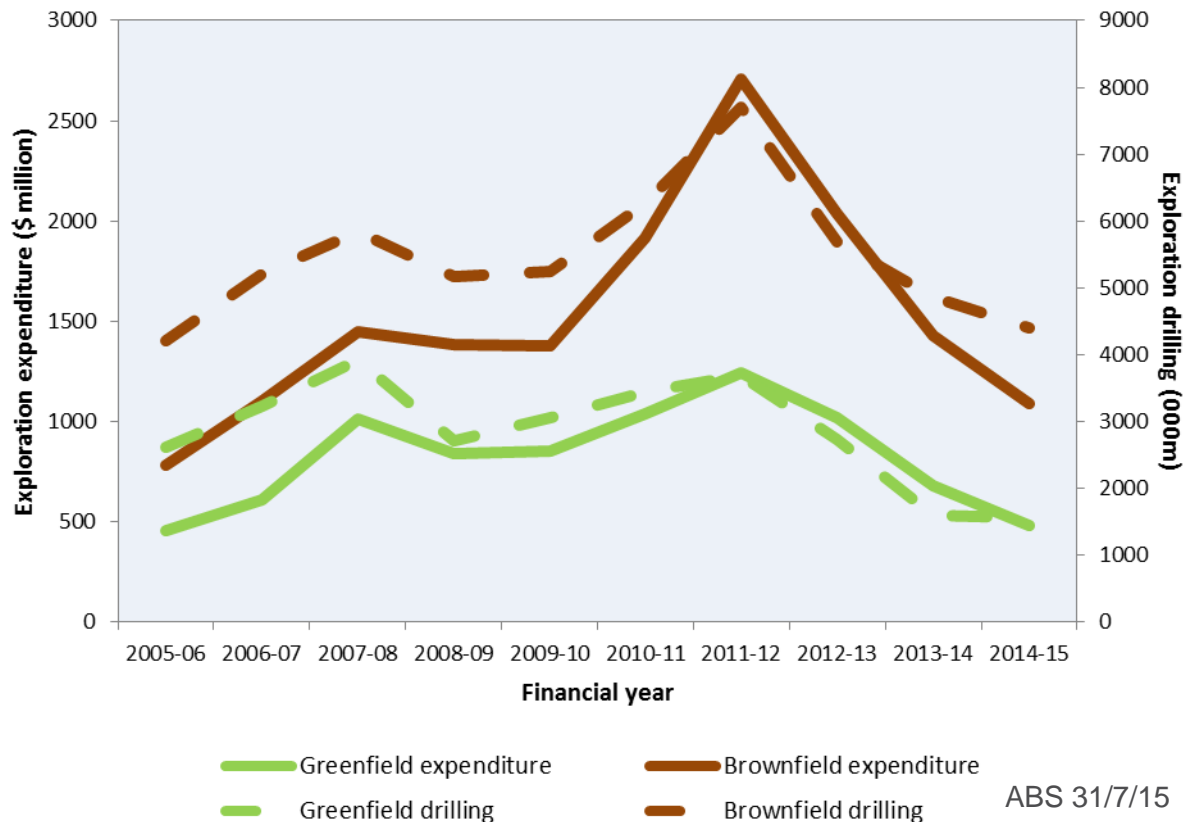
Total expenditure
June 2015 A\$B

\$4
\$3
\$2
\$1
\$0

1975 1980 1985 1990 1995 2000 2005 2010 2015

MinEx consulting June 2015

A worrying trend!



Mining exploration dips by 76pc in three years

Tess Ingram

Australian mining exploration expenditure hit a near-decade low of \$384 million in the three months to March, down 76 per cent in three years. The total national investment in exploration slumped 13.4 per cent during the March quarter, according to the seasonally adjusted data from the Australian Bureau of Statistics.

This is the lowest estimated total spend the bureau has reported since September 2006, when investment was \$380 million. It is down more than 60 per cent from the high of \$1 billion invested in the industry in March 2012.

During the quarter, Queensland led the decline across the states, down 32 per cent, or \$11 million. Western Australia dropped \$30 million, or 12 per cent, led by a substantial drop in iron ore expenditure.

modity was on coal exploration, down more than 44 per cent, or \$34 million.

Industry experts have warned the reduction in exploration expenditure could be detrimental for the industry if maintained in the long term.

Earlier this year Association of Mining and Exploration Companies chief executive Simon Bennison highlighted the importance of continued exploration, given the long lead time between exploration and production. Mr Bennison said it often took companies seven to 10 years to progress from an initial exploration application to first production at a project.

The downturn also has repercussions for contractors; some have been forced to diversify into other industries.

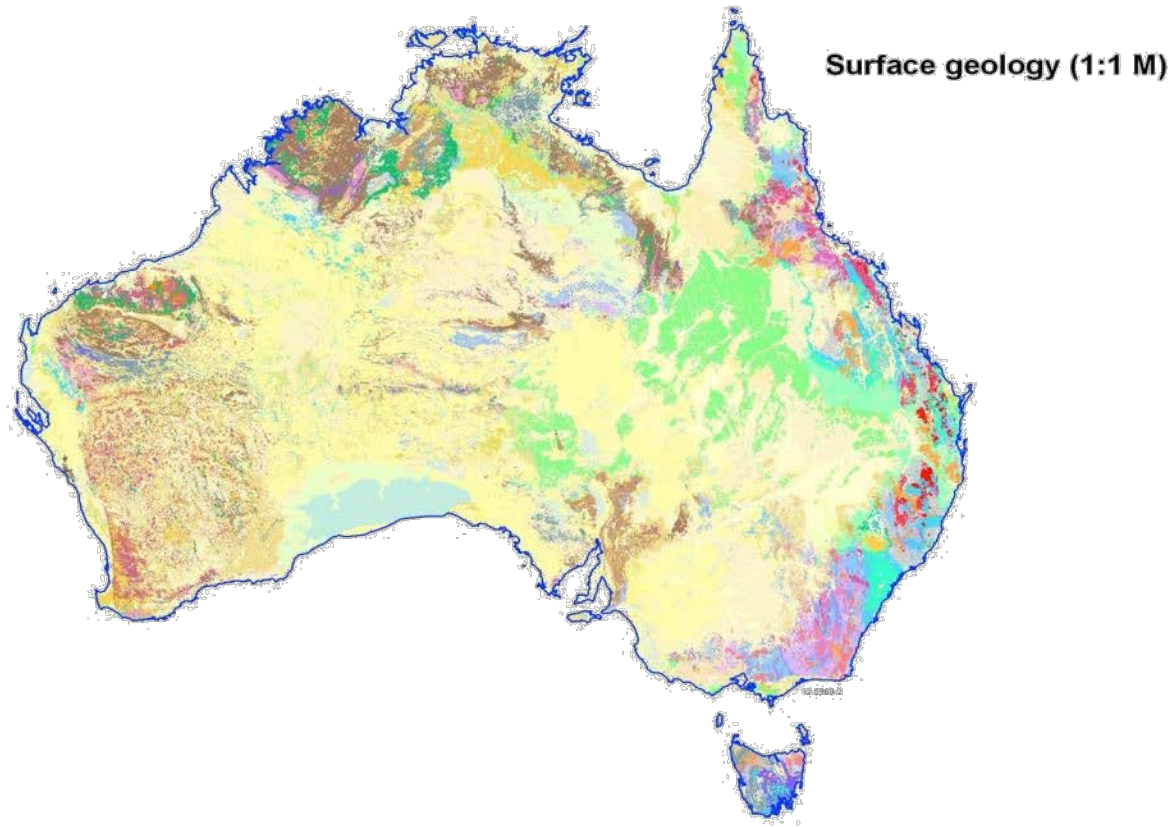
Grain farmer Dan Cooper told Fairfax Media in April he was using mineral exploration drills to search for water on his property because that

The exploration drillers are looking for work so they're heading to [agriculture].

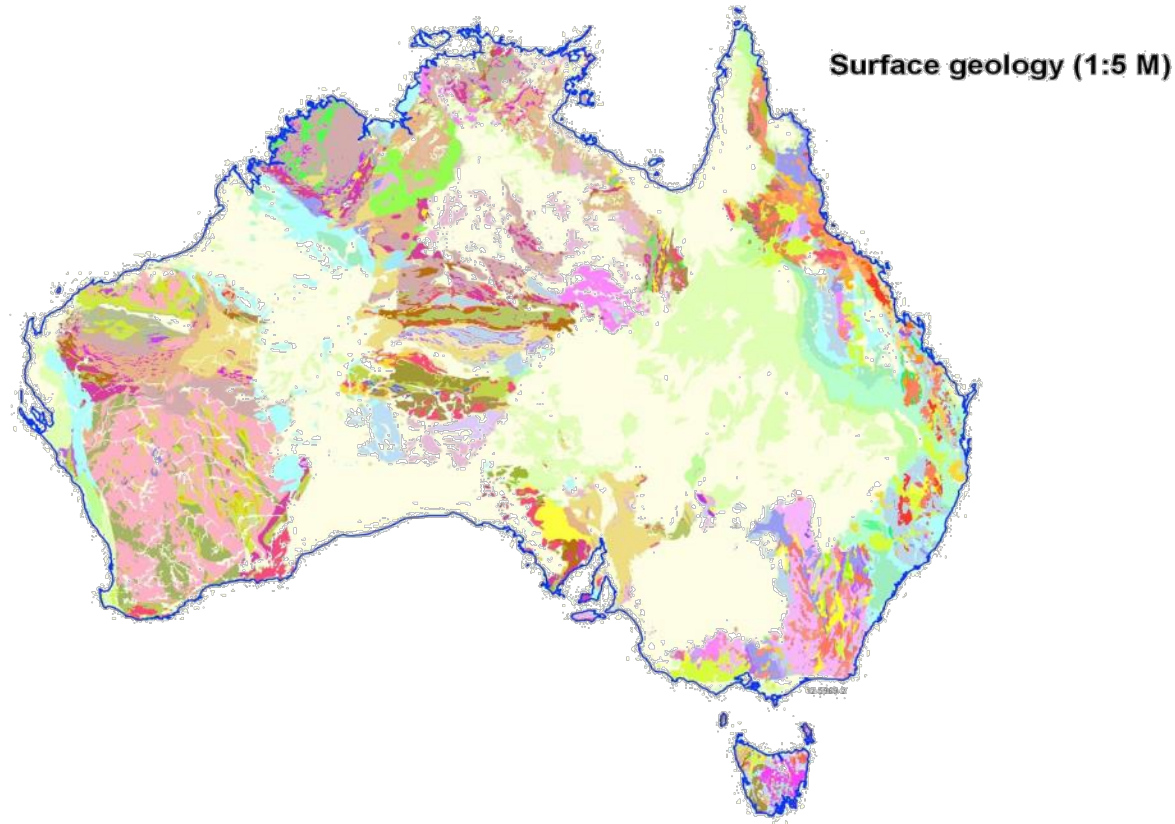
Dan Cooper, grain farmer

Australian Financial Review
2 June 2015

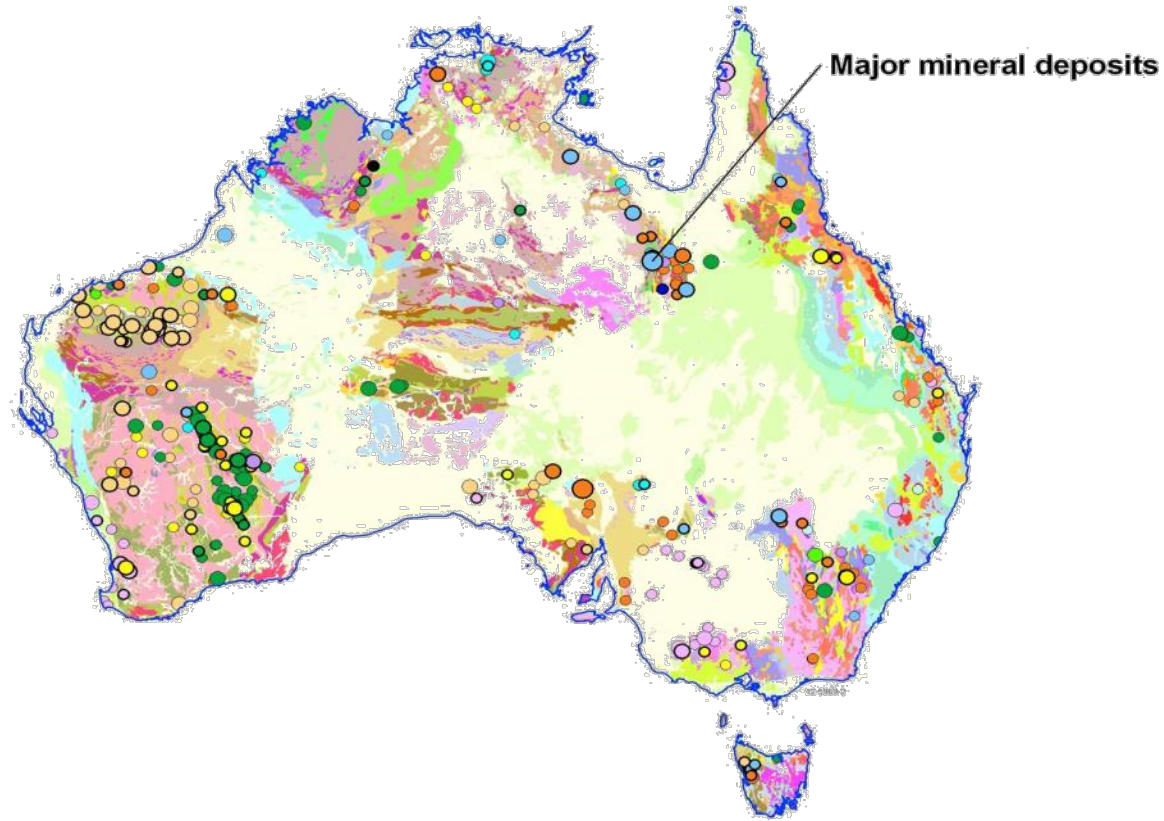
Australia's undercover mineral potential



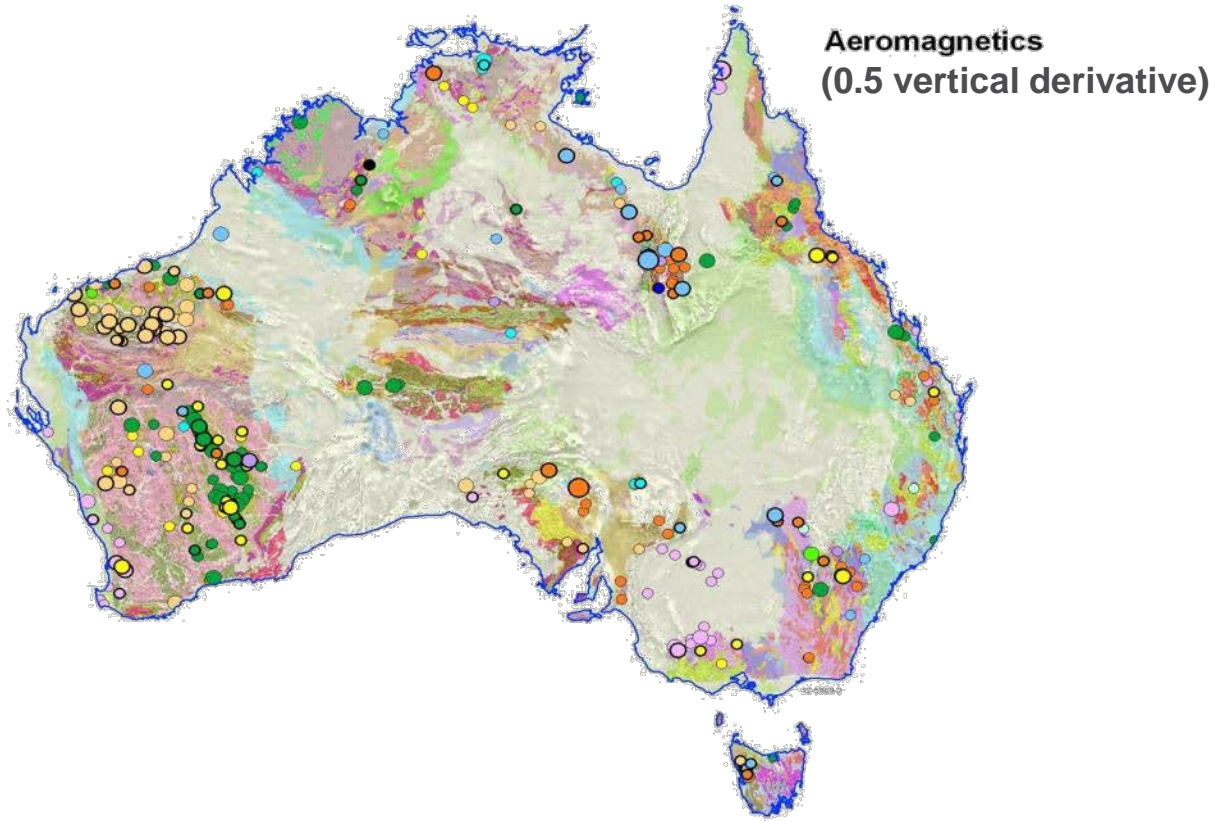
Australia's undercover mineral potential



Australia's undercover mineral potential



Australia's undercover mineral potential

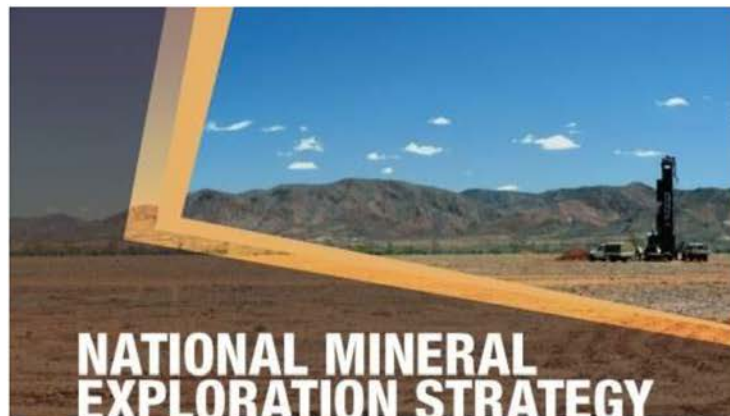


The challenge and the opportunity

- Continent is ~80% covered
- How to see through the cover?
- and seize the opportunity



Government response to the challenge and opportunity



VISION:

Unlocking Australia's hidden resource potential.

MISSION:

To address greenfield exploration challenges, stimulate new discoveries, ensure continuity of the pipeline of mineral resource investments, and the longevity of Australia's mineral resources industry.

SCOPE OF THE STRATEGY

This National Mineral Exploration Strategy focuses on the acquisition and delivery of pre-competitive geoscience, applied geoscience research initiatives to assist exploring undercover and a mineral exploration investment attraction plan. Supporting activities associated with the strategy aimed at cross-jurisdictional collaboration on regulatory reform are also underway. The strategy will not address the financial challenges facing the minerals sector.

THE THREE ELEMENTS OF THE NATIONAL MINERAL EXPLORATION STRATEGY ARE:

PRE-COMPETITIVE
GEOSCIENCE INFORMATION

MINERAL EXPLORATION
INVESTMENT ATTRACTION PLAN

NATIONAL GEOSCIENCE
RESEARCH INITIATIVE



UNCOVER Initiative (www.uncoverminerals.org.au)

... an innovative, structured and nationally coordinated strategic venture that will bring competitive advantage to Australian mineral exploration ...

Partners

- Mineral exploration industry
- METS industry
- GA, Geological surveys & CSIRO
- Research (Unis)

Science themes

1. Cover
2. 3D architecture
3. Geodynamics & Mineral system evolution
4. Distal Footprints of ore bodies

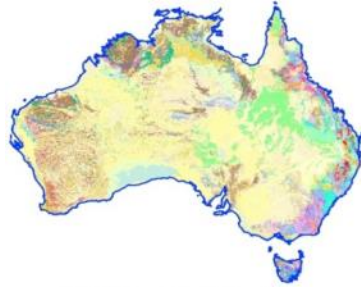


UNCOVER Roadmap priorities

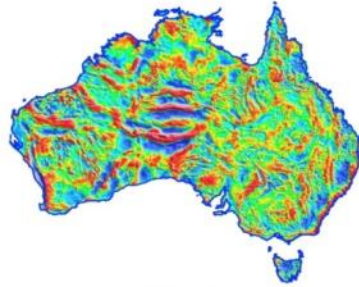
	Focus Area Themes	
Highest Priority	1.1	Understand type age, depth of cover. Compile and produce 3D Geological & Paleosurface Maps & Layers
	4.3	Characterise and mapping whole mineral system footprint signatures. Proximal to Distal through data compilation of Geology, Geochemistry & Geophysics
	4.1	Improve understanding and develop definitions of mineral systems across scales for different model/deposit types and commodities
	2.1	Compile and integrate models and data to build 3D architecture and composition of Australian whole lithosphere (mantle-crust-surface) from current data and knowledge
	1.8	Depth-to-basement and cover-characteristics, imaging from new targeted airborne National (20km) EM surveys.
	2.4	Acceleration and completion of national AusLamp long period MT (55km spacing) program

- List of the **Highest** priorities from the 45 Roadmap activities

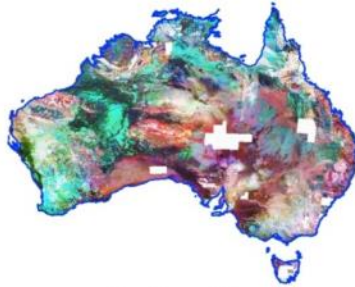
Custodians of the national database



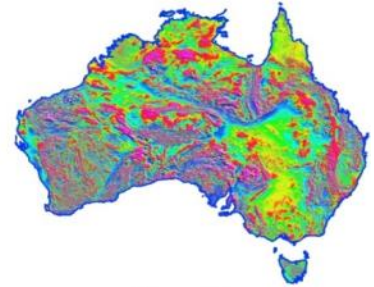
1:1M Surface Geology



Gravity



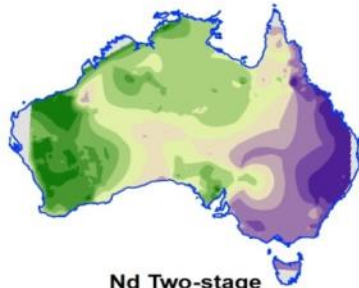
Radiometrics



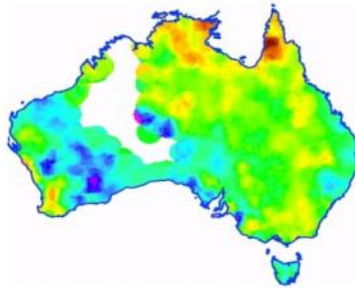
Magnetics



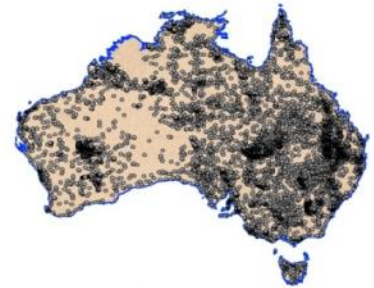
Onshore Seismic Lines



Nd Two-stage
Depleted Mantle Model



National Geochemical Survey



Water bores

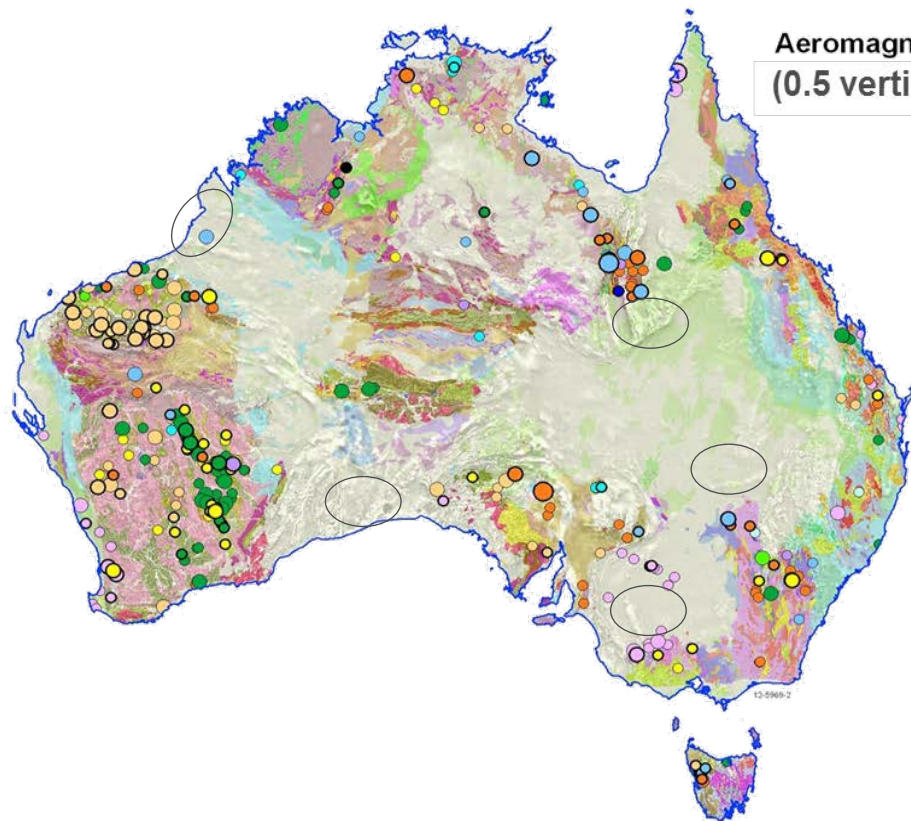
Bore
holes

14-8099-5

Data from Geoscience Australia and State/NT geological surveys

- quality-assured and delivered FREE incl. major investment from States/NT

Continuing to build on national maps



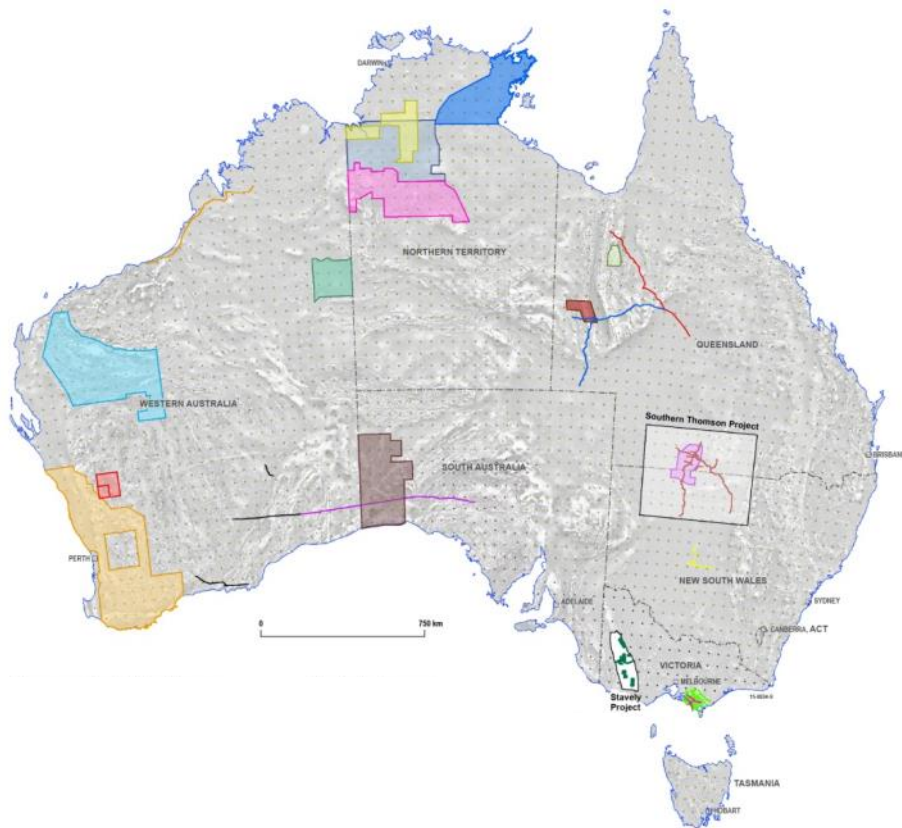
Aeromagnetics
(0.5 vertical derivative)

Precompetitive data program with collaborative projects with States/NT geological surveys:

- airborne magnetic-radiometric
- gravity
- AEM
- Seismic/MT transects
- AusLAMP
- Regional drilling (Thomson)
- Geochronology and stratigraphy

**Greenfields focus of combined
Government efforts**

Continuing to build on national maps



Precompetitive data program with collaborative projects with States/NT geological surveys:

- airborne magnetic-radiometric
 - gravity
 - AEM
 - Seismic/MT transects
 - AusLAMP
 - Regional drilling (Thomson)
 - Geochronology and stratigraphy
- Greenfields focus of combined Government efforts**

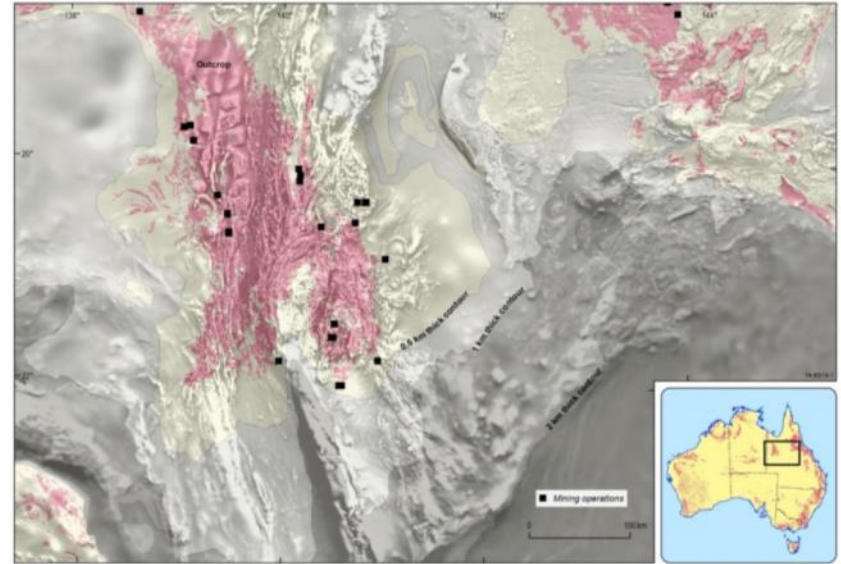
Theme 1: Cover

Science problem: ~80% of the continent is covered by post mineralisation material which poses a major exploration challenge and opportunity.

What is the thickness and character of cover at my drill site?

Solutions:

- a) Harness legacy data
- b) Benchmark methods of cover-thickness estimation
- c) Develop new techniques of cover characterisation
- d) New predictive maps





Australian Government
Geoscience Australia



Towards a national cover thickness map using data mining: a model-based predication of cover thickness



John Wilford, Karol Czarnota, Tony Meixner, Patrice de Caritat

John.Wilford@ga.gov.au

Cover characterisation

Drilling and associated lithological descriptions – points of truth?

- A. Harness legacy data (drilling; remote sensing – geophysics)
- B. Building national databases
- C. Drill hole interpretation
- D. Interpolation/modelling between drillholes – building surfaces.



Cover characterisation

Building point depth database and surfaces (national coverage)

National prediction of Chronostratigraphic era

- ← Cenozoic
- ← Mesozoic
- ← Paleozoic
- ← Proterozoic
(Neoproterozoic/
Meoproterozoic)
- ← Paleoproterozoic/Archean

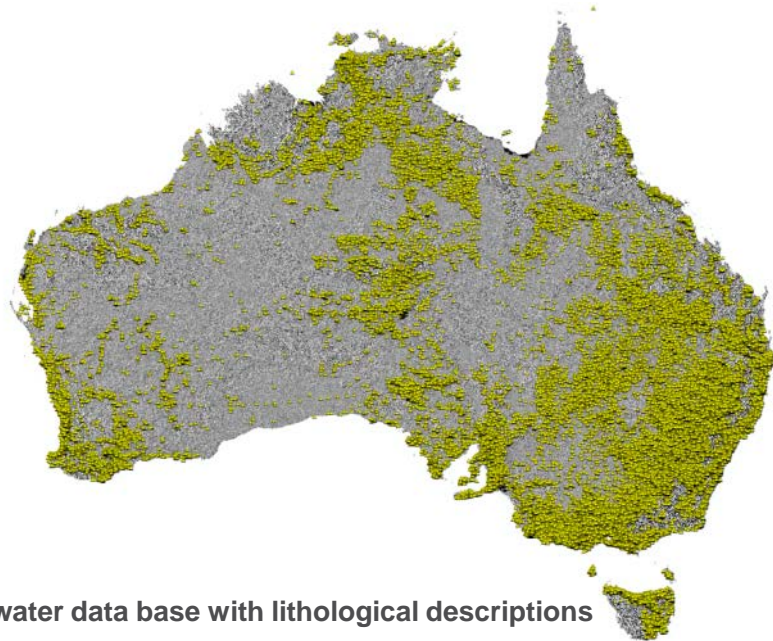


Depth of oxidation



Harnessing legacy data – drillholes and remotely sensed depths

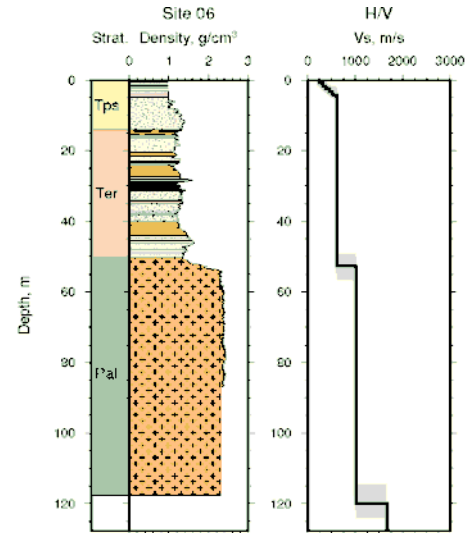
- Designing point-cloud database of cover-thickness estimates (borehole, seismic, magnetic, AEM, AMT, etc...) with chronostratigraphic attributes



● Bores (~365,000)
98% < 200m



Remotely sensed



Groundwater data base with lithological descriptions

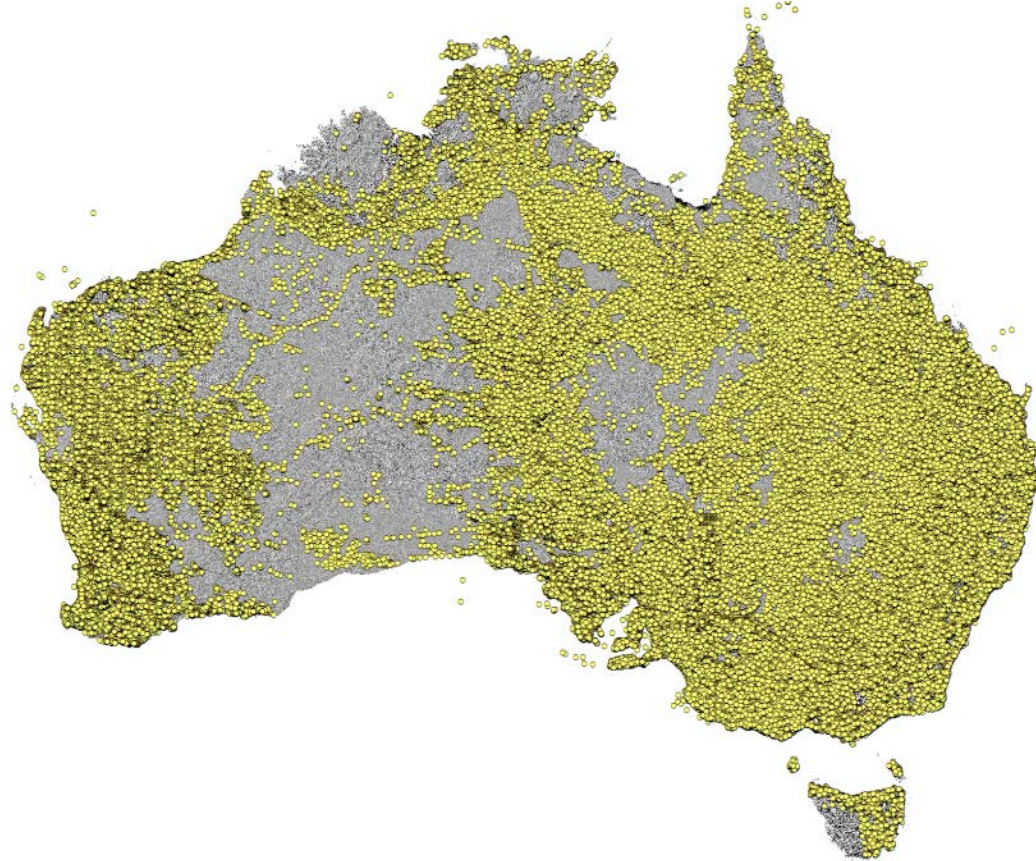
Data interpretation and assessing confidence

1. Drillhole descriptions poor and inconsistent; spatial inaccuracies prior to GPS < 1990.
2. Automatic lithology and lithology 'like' text matching.
3. Tagging drill depth descriptions that are at odds with our understanding of weathering and geomorphic processes or from other datasets (e.g. radiometrics; DEM, more reliable drilling).



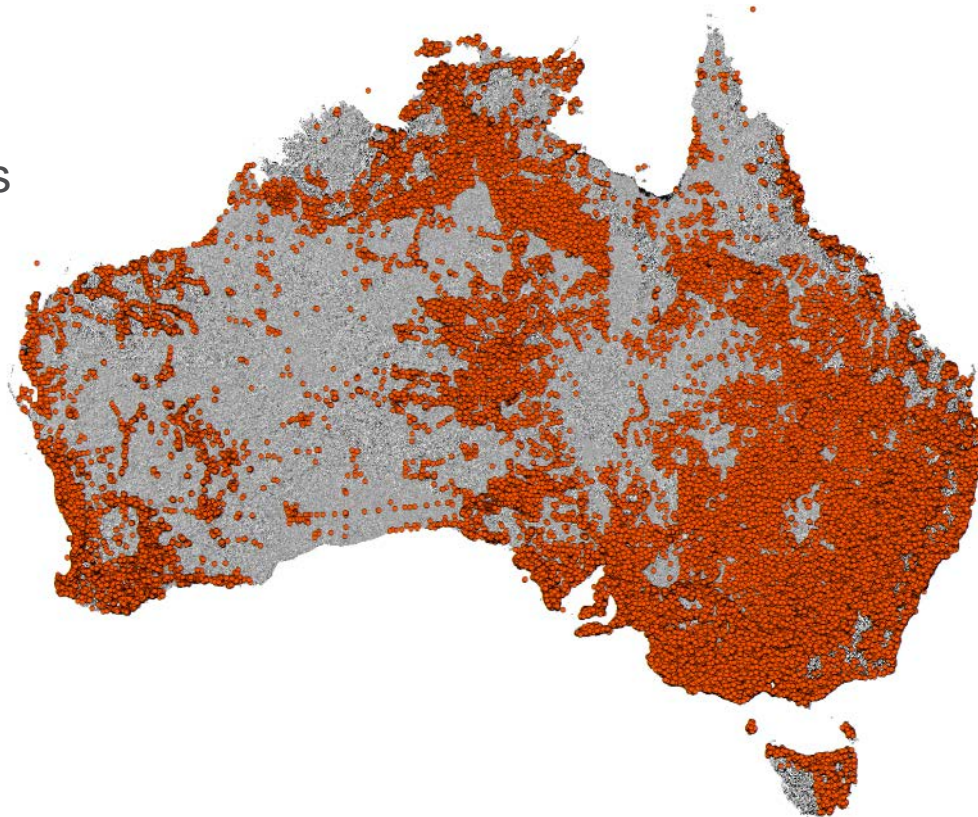
National Groundwater database

> 800 000 drill holes



National Groundwater database

~ 350 000 drill holes
with lithology



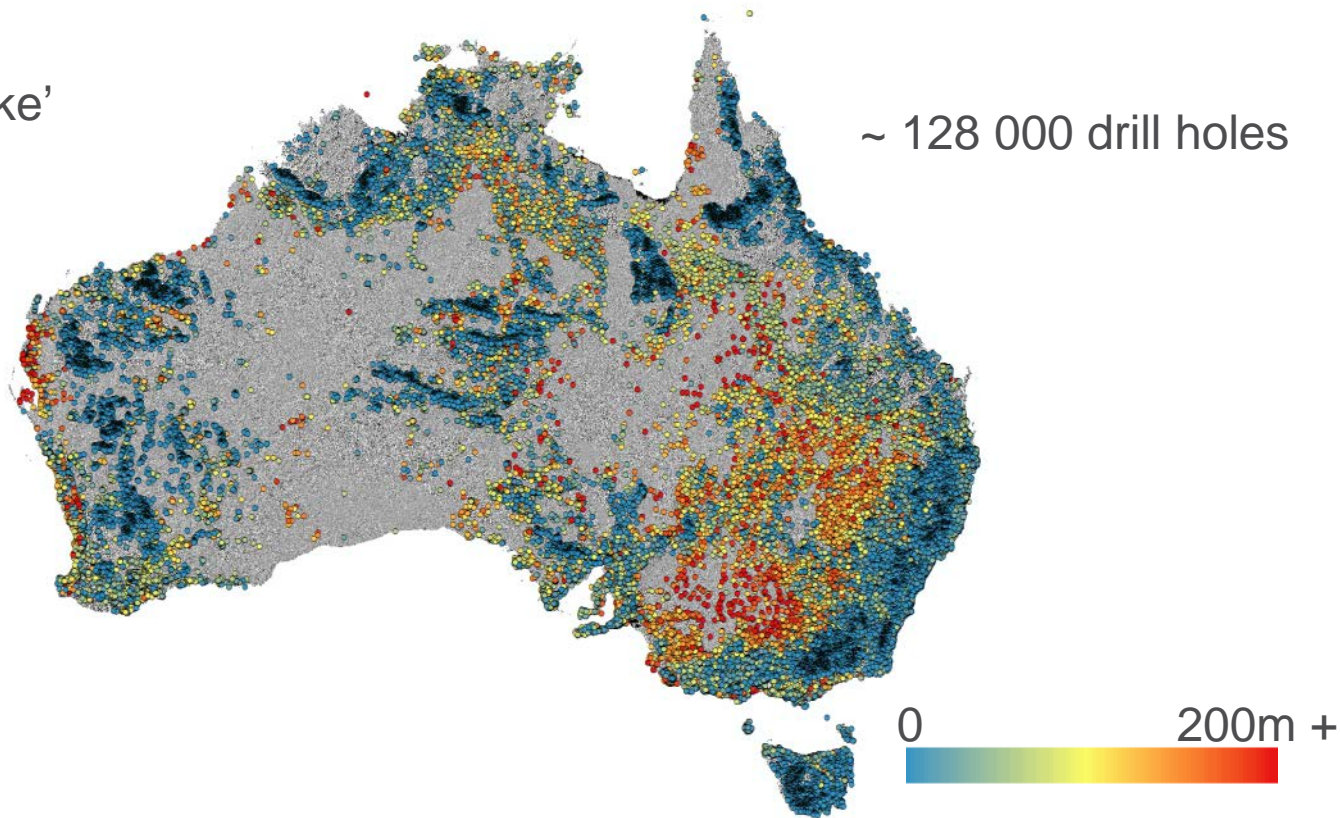
National Groundwater database

Lithology and lithology 'like'
text matching

granod
granodi
granodio
granodioite
granodionite
granodior
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granodiorite
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granodorite
Granodylt

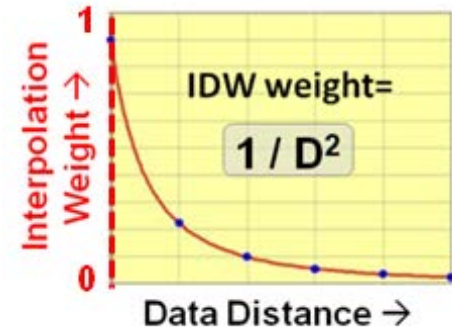
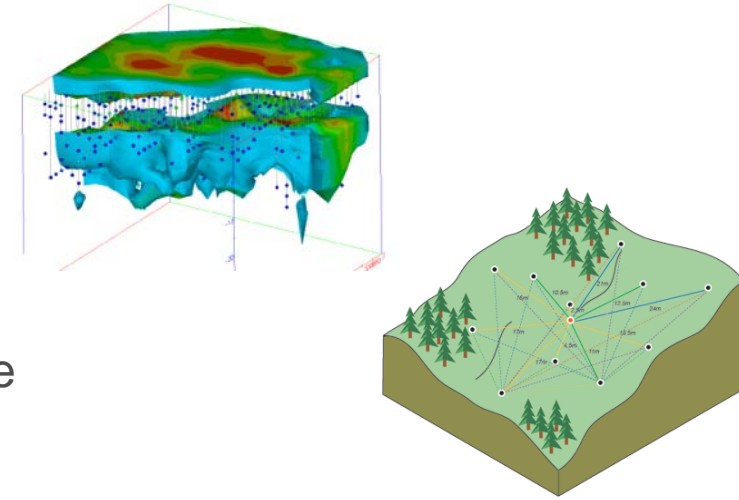
→ Bedrock depth

~ 128 000 drill holes



Points to surface predictions

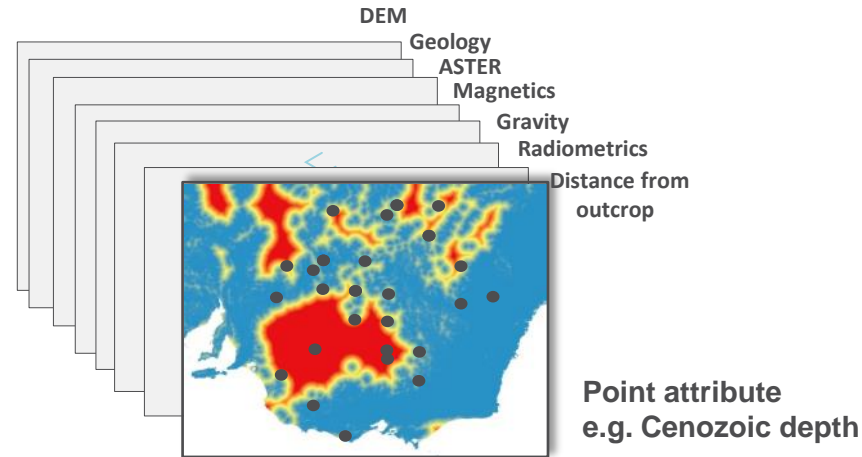
1. Interpolation between points. Based on auto correlation between points – “nearby things are more alike than distant things” e.g. Inverse distance weighted (IDW) interpolation and kriging (variogram).
2. Covariate modelling supported by supplementary data using data mining techniques



Points to surface predictions using environmental correlation

Environmental correlation uses covariates or predictive datasets coupled with statistical methods for correlation and regression to predict cover depth/geochemistry. Cubist data mining – consists of a decision-based classification tree with nested linear regression models (regression trees).

Covariate datasets



Cubist model structure

1) If (conditional statement based on decision tree splits)

Distance from outcrop < 200m

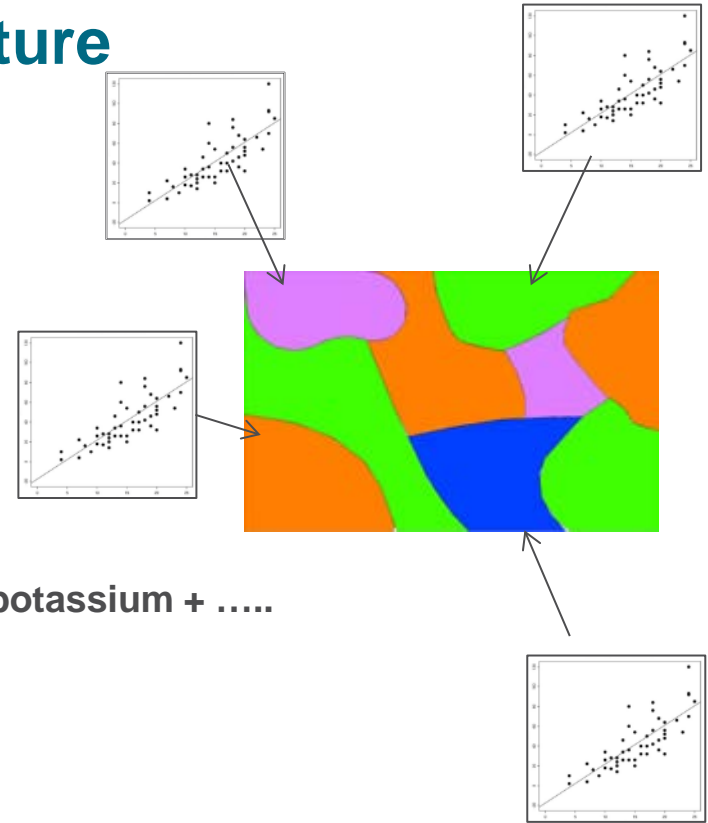
and

Lithology = (p, q, r)

(2) Then (linear model)

Property = c_1 * magnetic intensity + c_2 * gravity + c_3 * gamma potassium +

where a , c_1 , c_2 , c_3 are constants, p, q, and r are classes, and property = target variable.

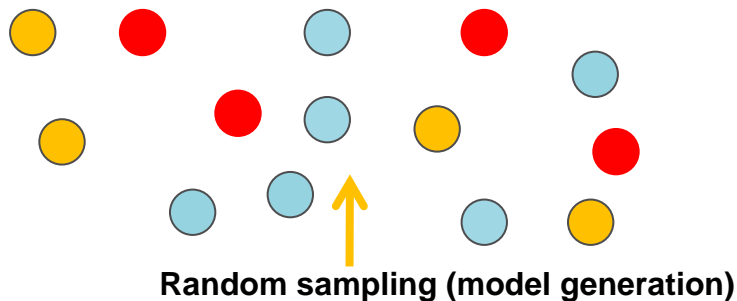
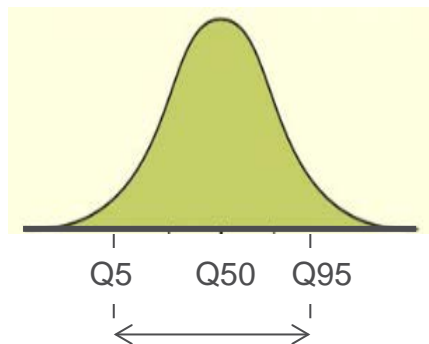


Cubist implementation

Sample stratification - bootstrapping (with sample replacement) or K-fold x-validation.

Sample stratification used to generate many model predictions from which median values are calculated and associated uncertainties.

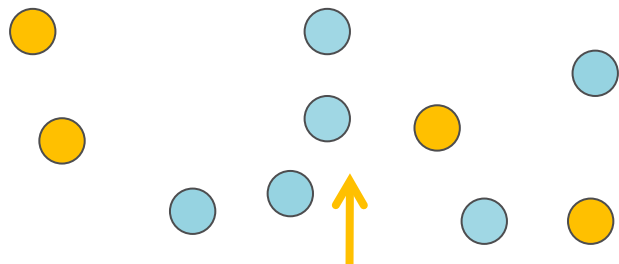
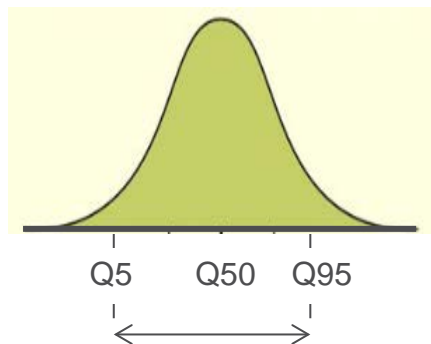
Out of sample validation



Cubist implementation

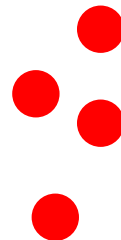
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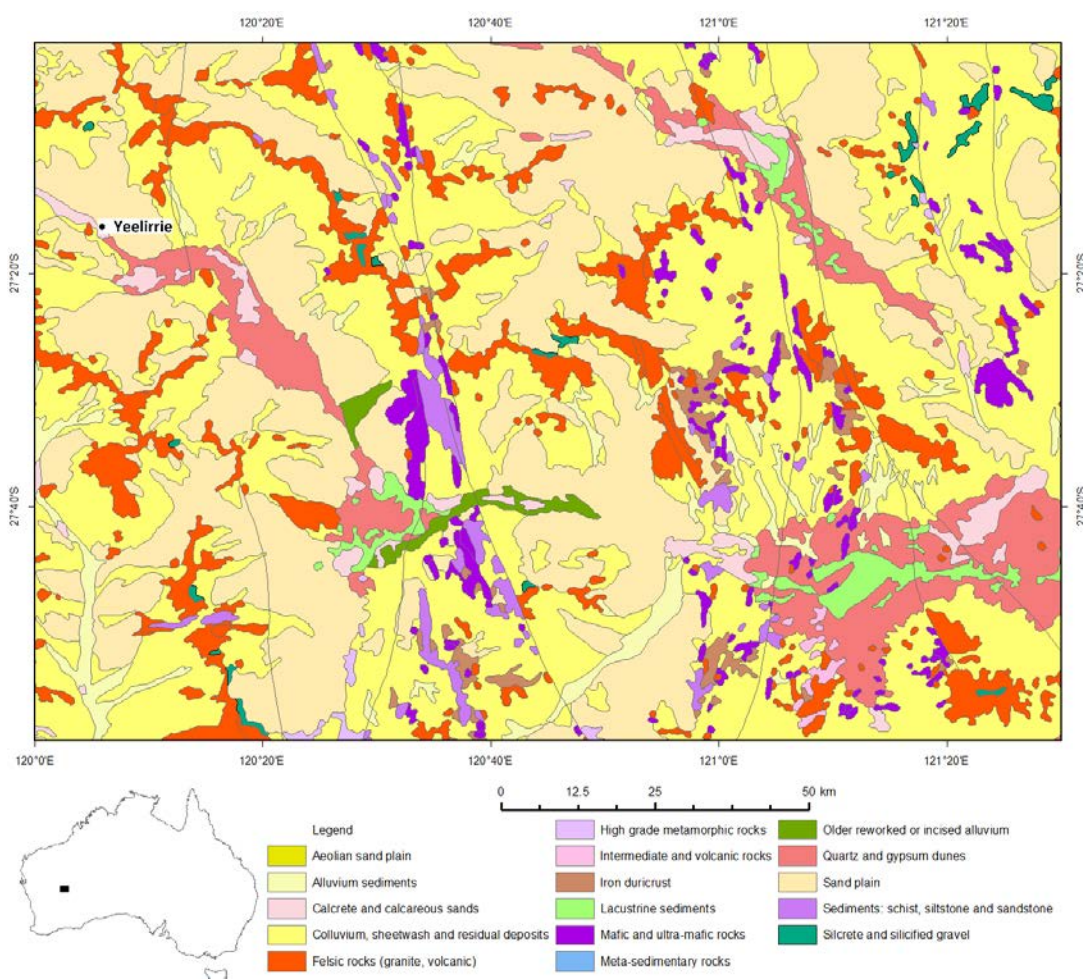
Random sampling (model generation)

Out of sample validation



Modelling surface geochemistry

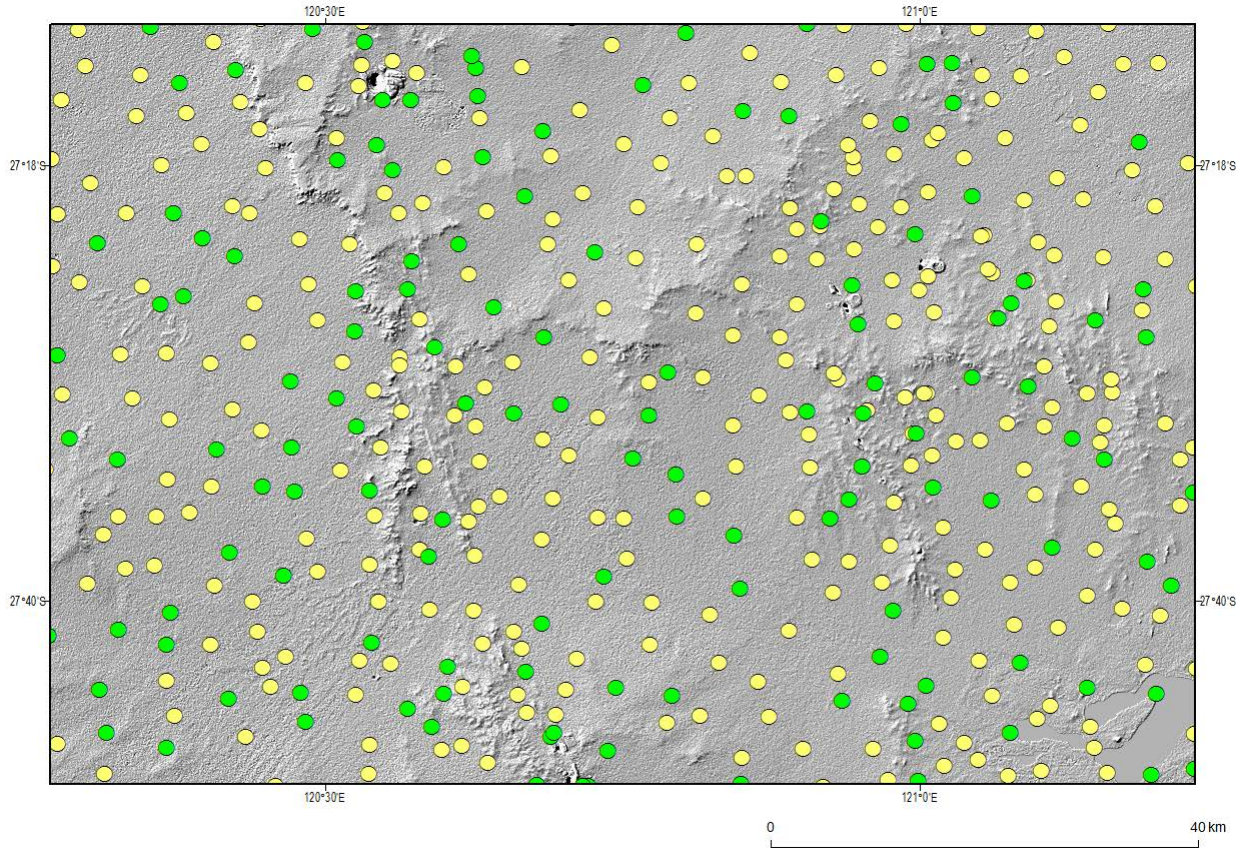
Sir Samuel 1:250 000 map
sheet area



Geochemical Sample locations

Sir Samuel 1:250 000
map sheet area

Yellow = training (66%)
Green = validation (33%)

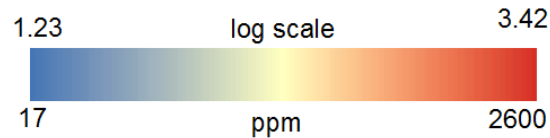
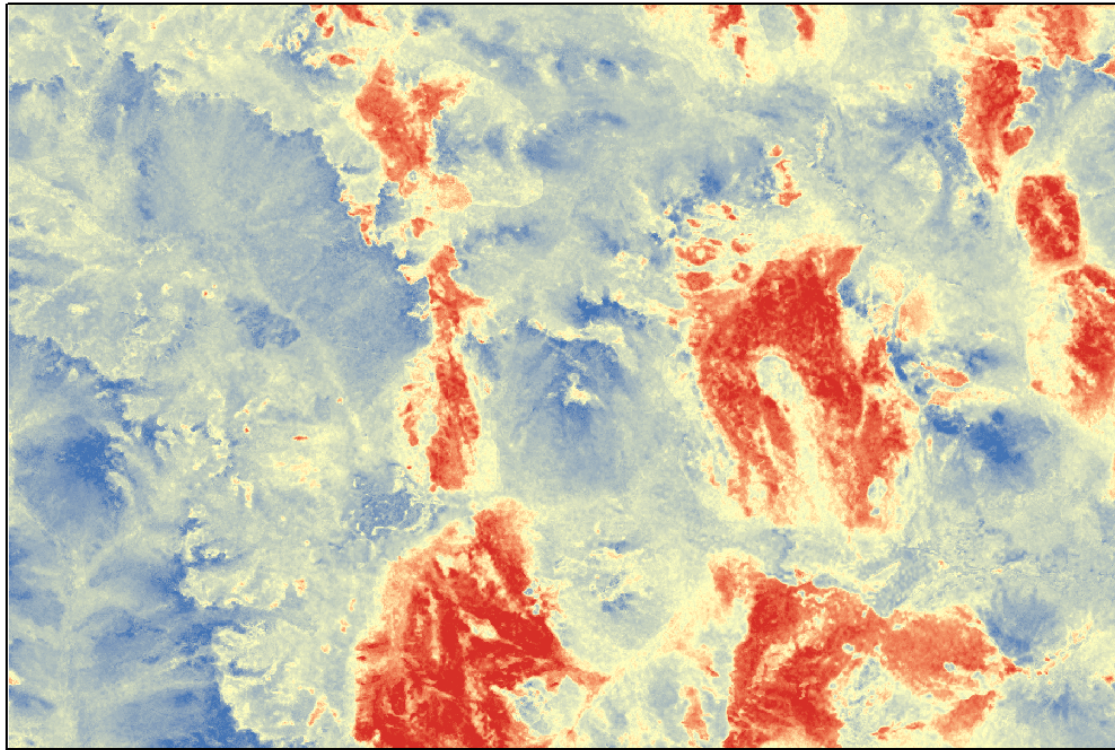
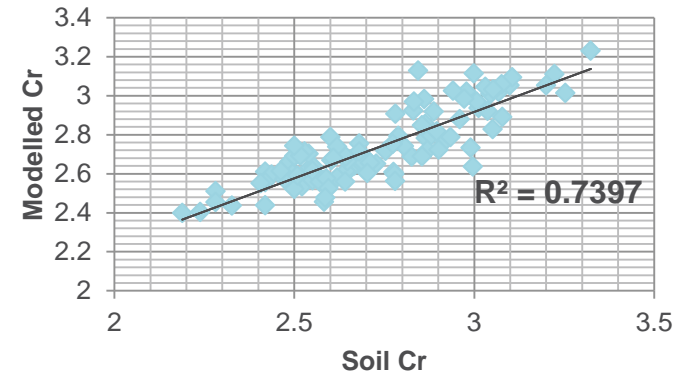


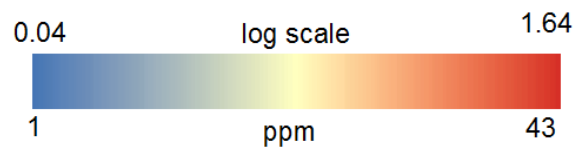
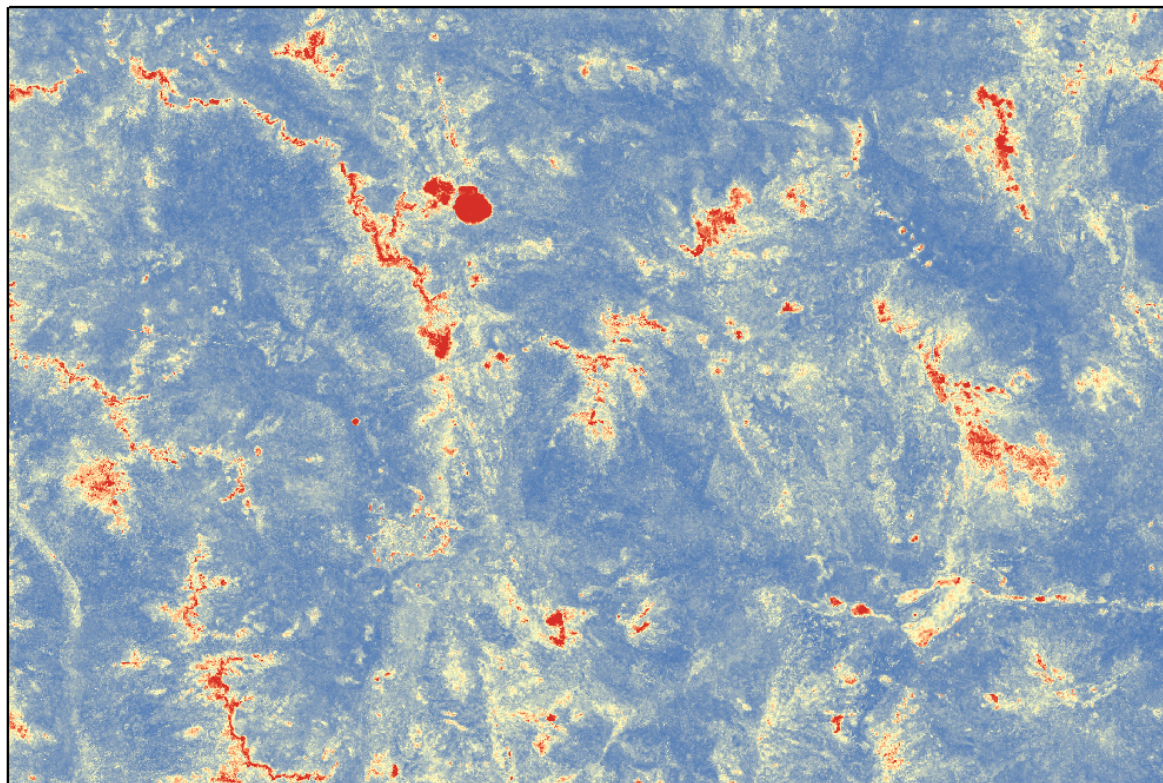
Cr concentration using environmental correlation

Important predictors

- Gamma-ray
- MODIS satellite
- Gravity
- Terrain
- Magnetics

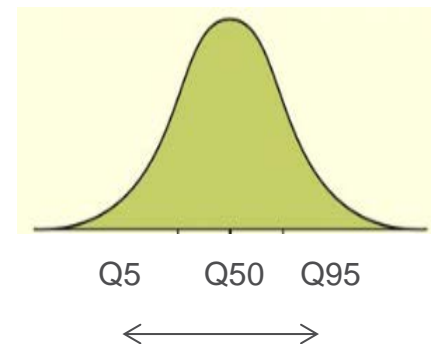
Cr modelled vs soil geochemistry



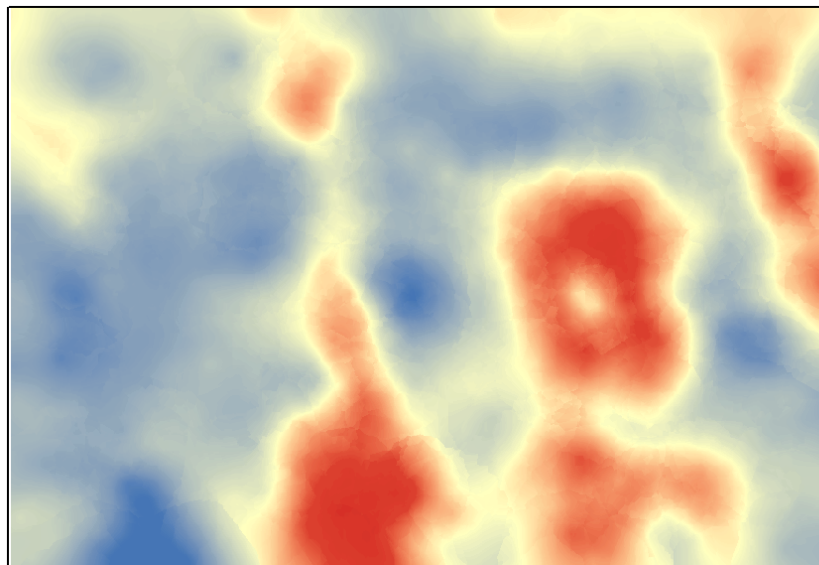


Cr prediction uncertainties

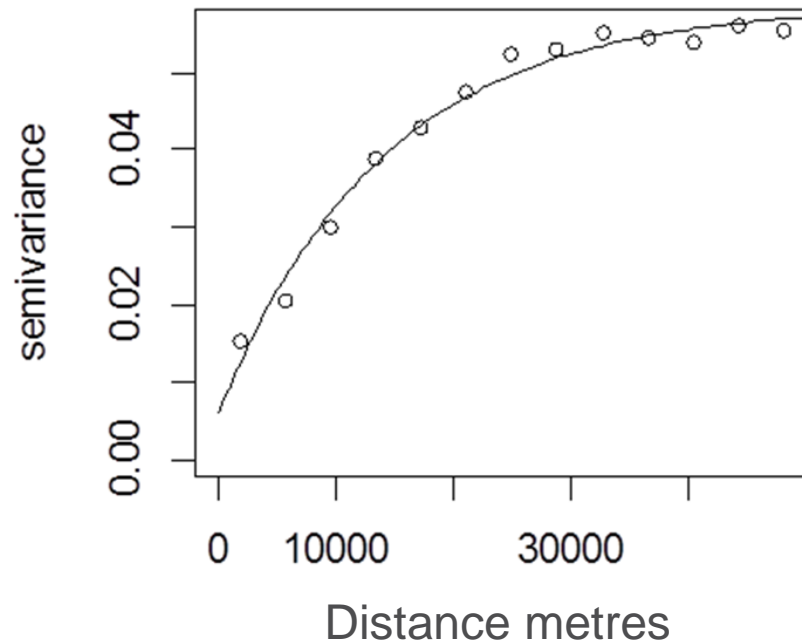
(Q95-Q5/Q50)



Kriged Cr concentration

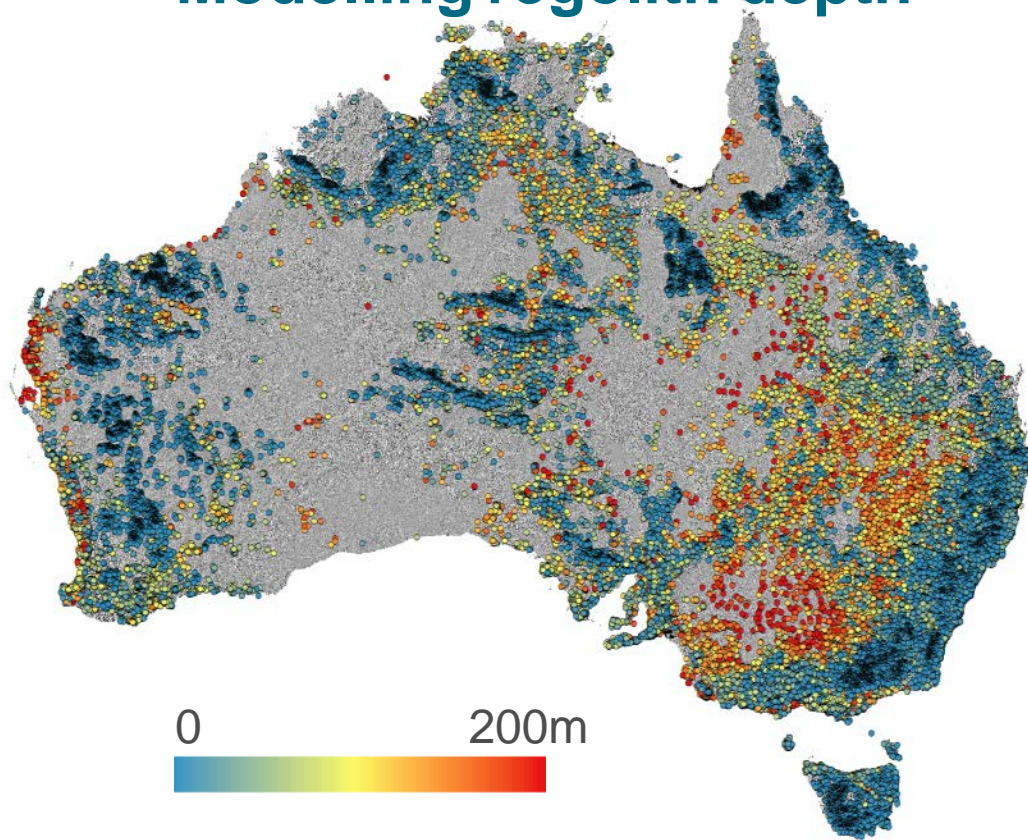


1.42 log scale 3.26
26 ppm 1819

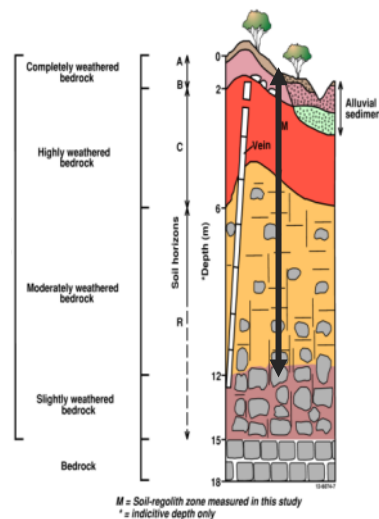


$$R^2 = 0.70$$

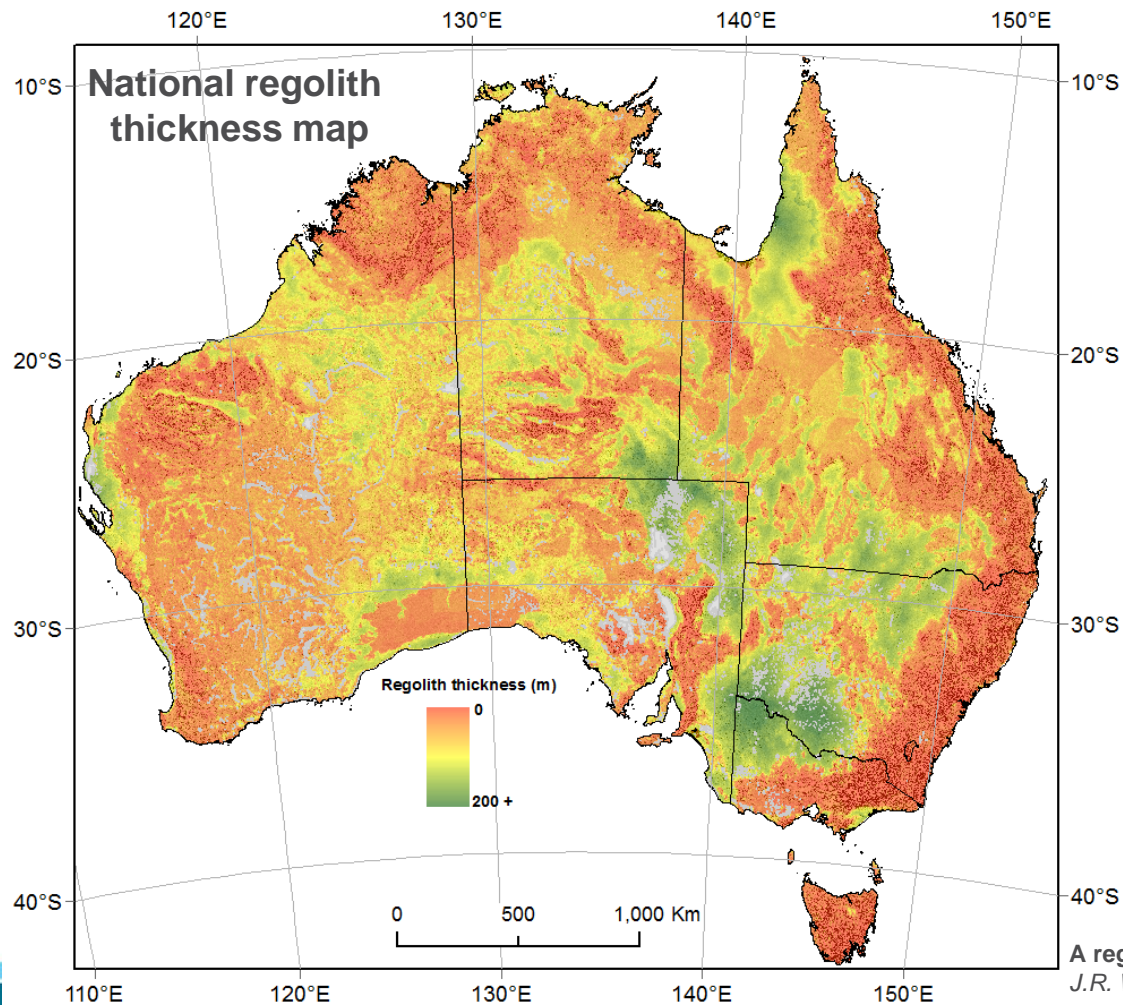
Modelling regolith depth



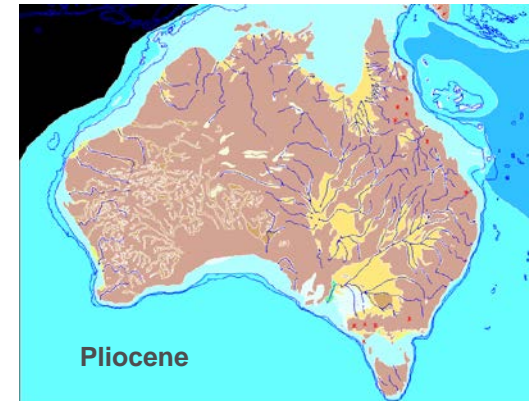
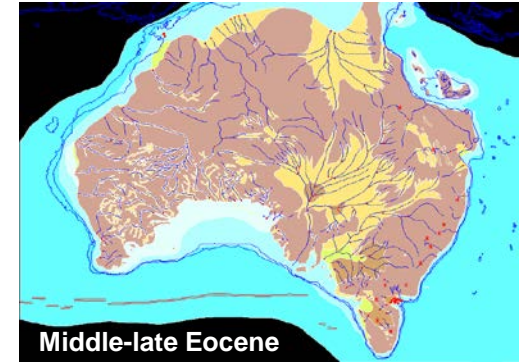
Lithology and lithology 'like' text matching



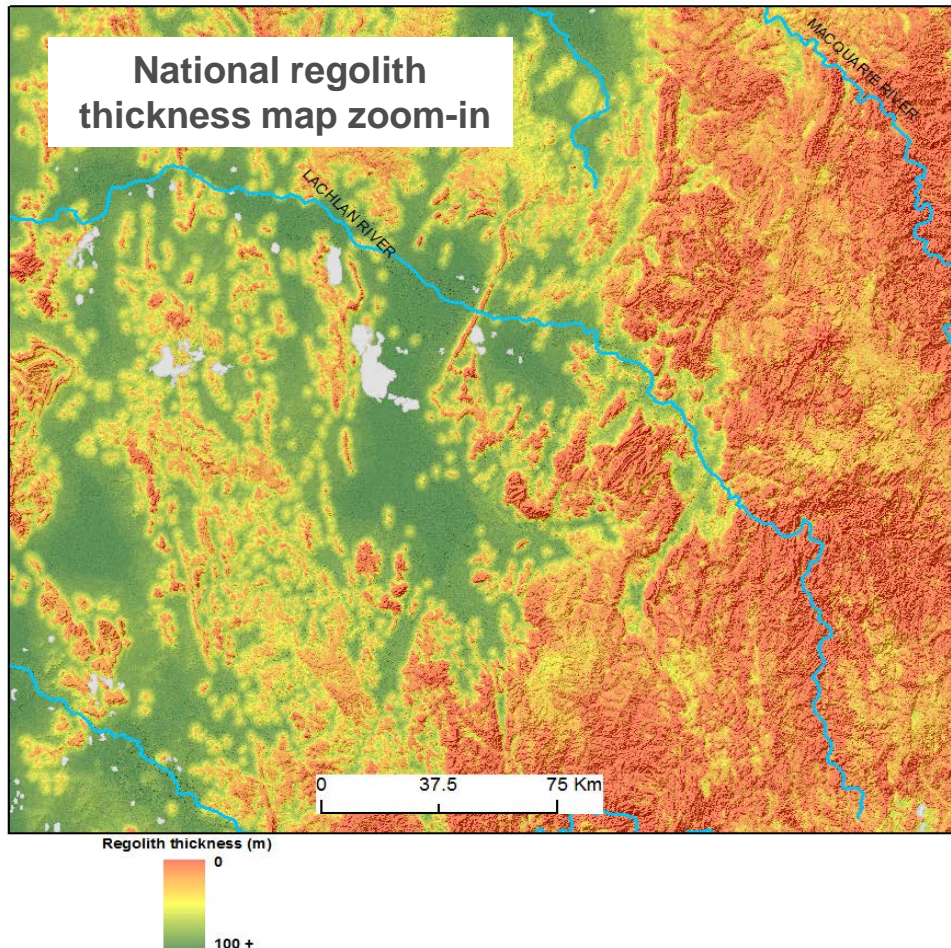
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granodiotite
granodorite
Granodylt



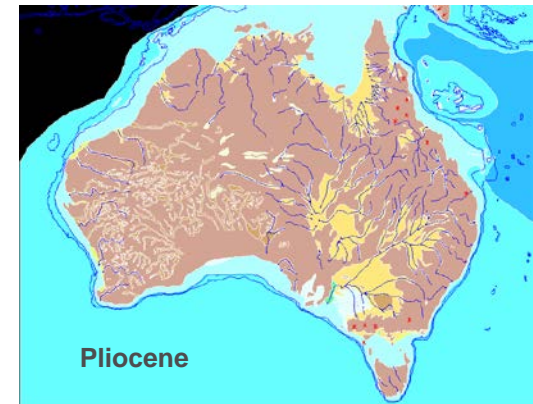
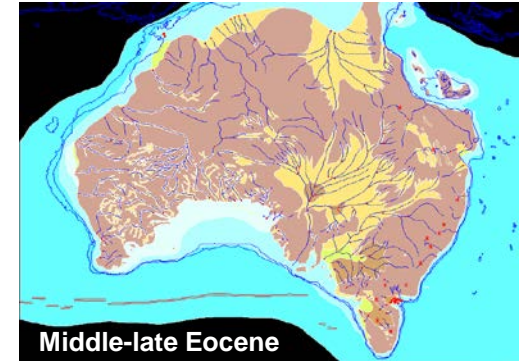
Cenozoic time periods



A regolith depth map of the Australian continent. In prep
J.R. WILFORD, R SEARLE, M. THOMAS, D. PAGENDAM, M.J. GRUNDY

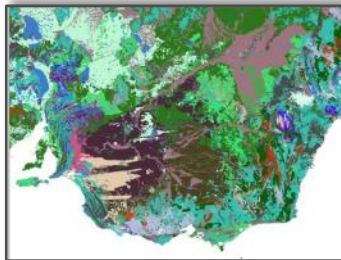


Cenozoic time periods

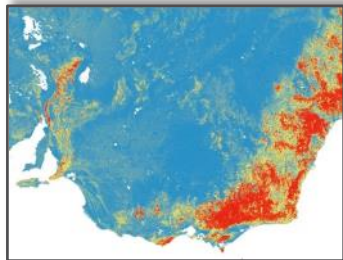


Predictive maps of cover thickness – Murray Basin

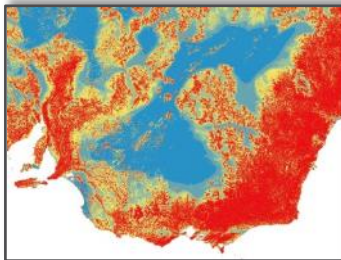
Surface geol.



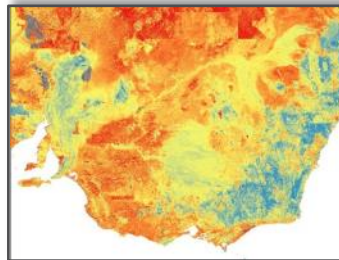
Topo. relief



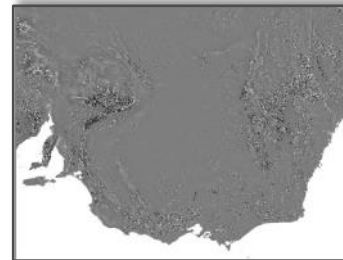
Valley flatness index



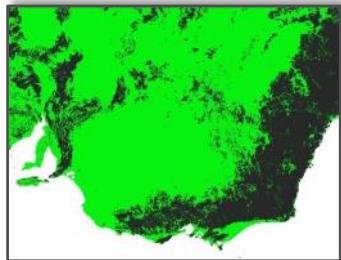
Weathering intensity



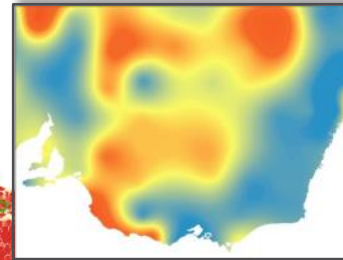
RTP TMI



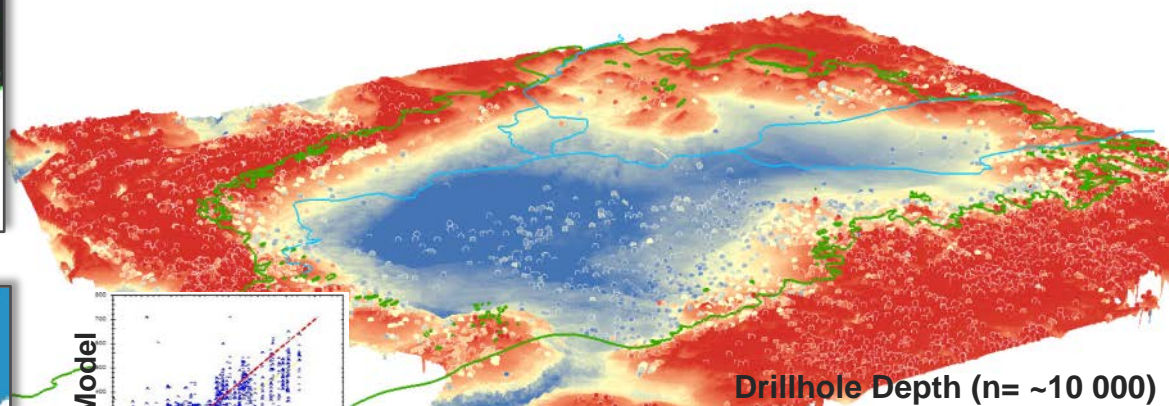
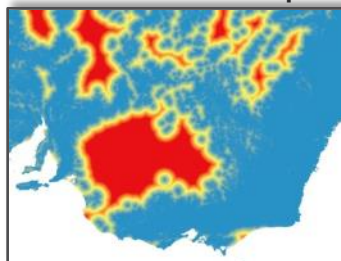
Cenozoic geology



Filtered tilt est.



Distance from outcrop

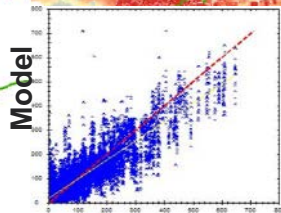
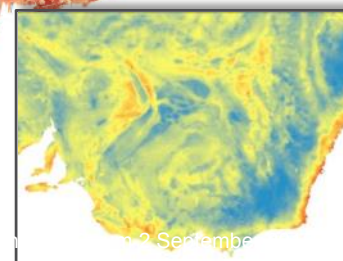


Drillhole Depth (n= ~10 000)

0 650 m



Bouguer gravity

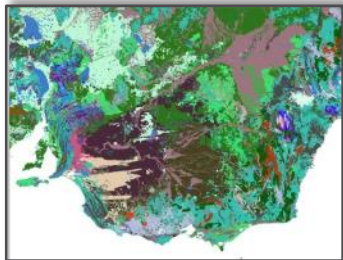


Observed

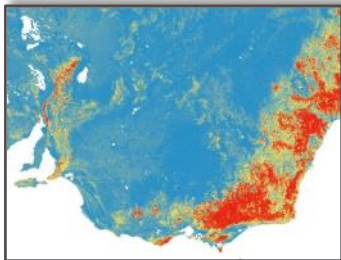
2 September

Predictive maps of cover thickness – Murray Basin

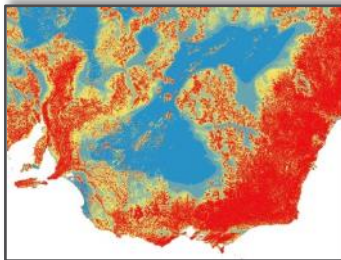
Surface geol.



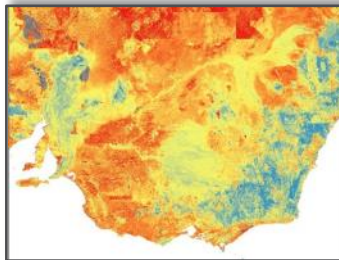
Topo. relief



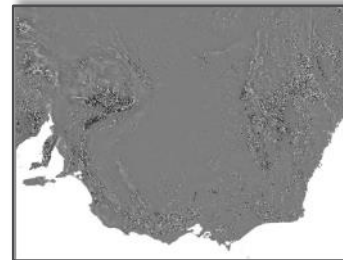
Valley flatness index



Weathering intensity



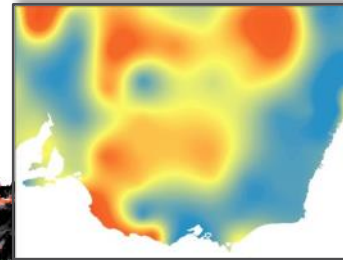
RTP TMI



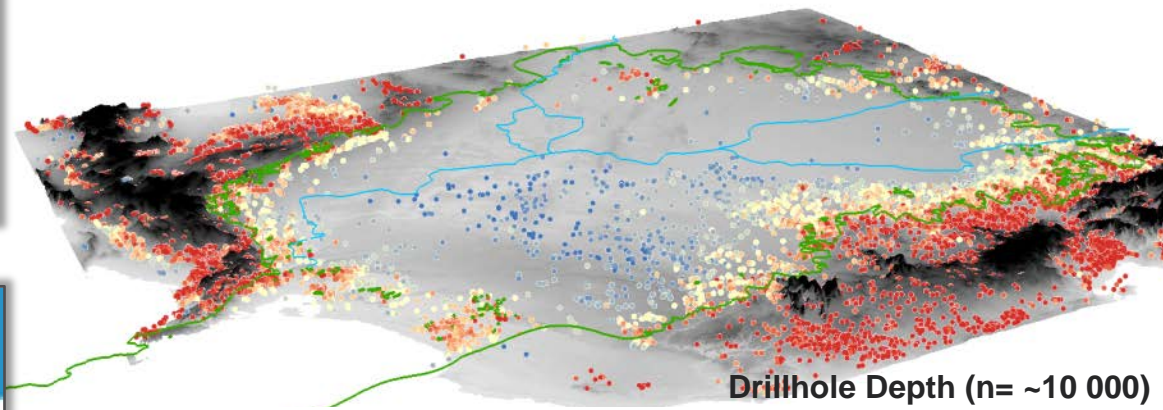
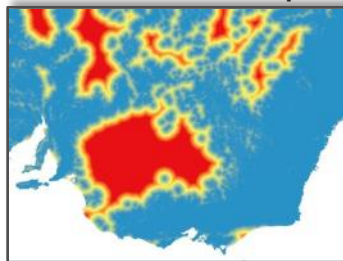
Cenozoic geology



Filtered tilt est.

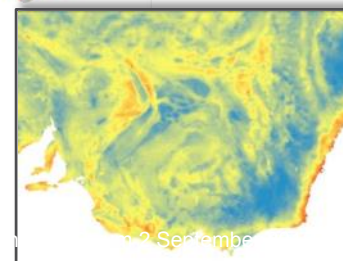


Distance from outcrop



Drillhole Depth (n= ~10 000)

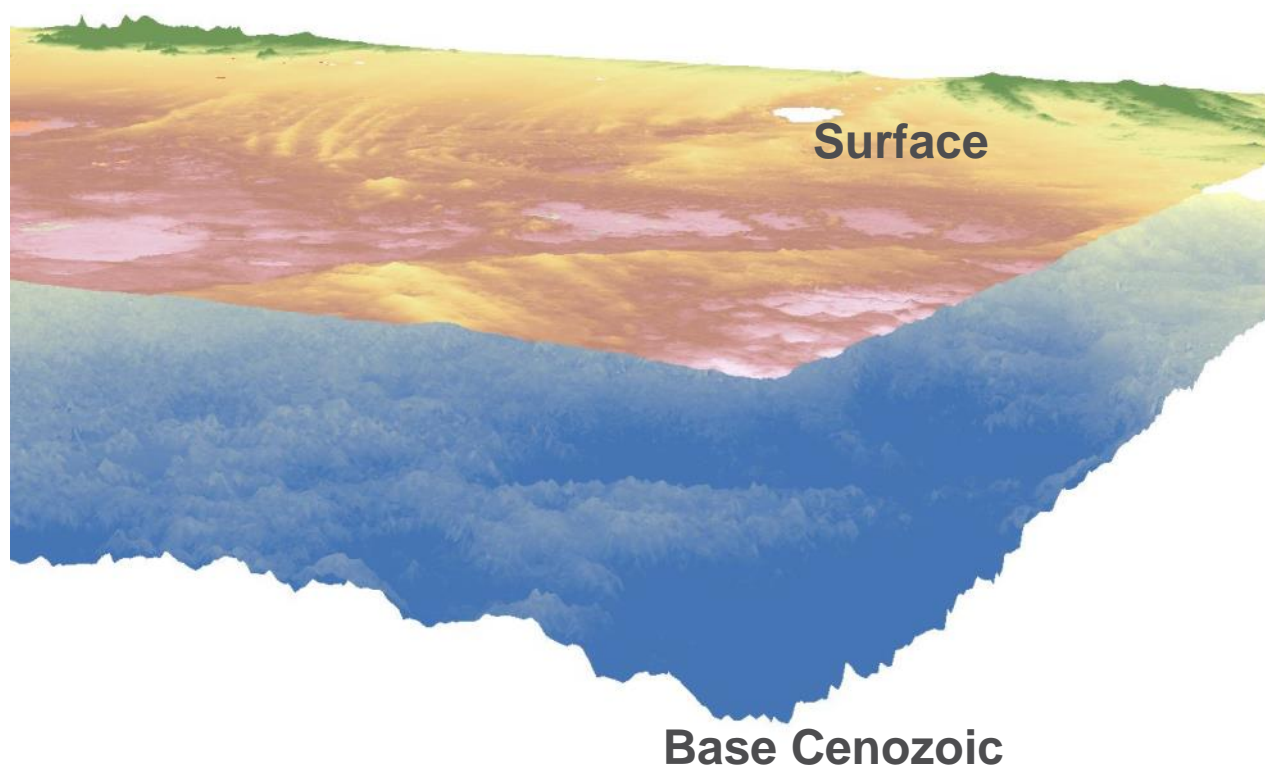
Bouguer gravity



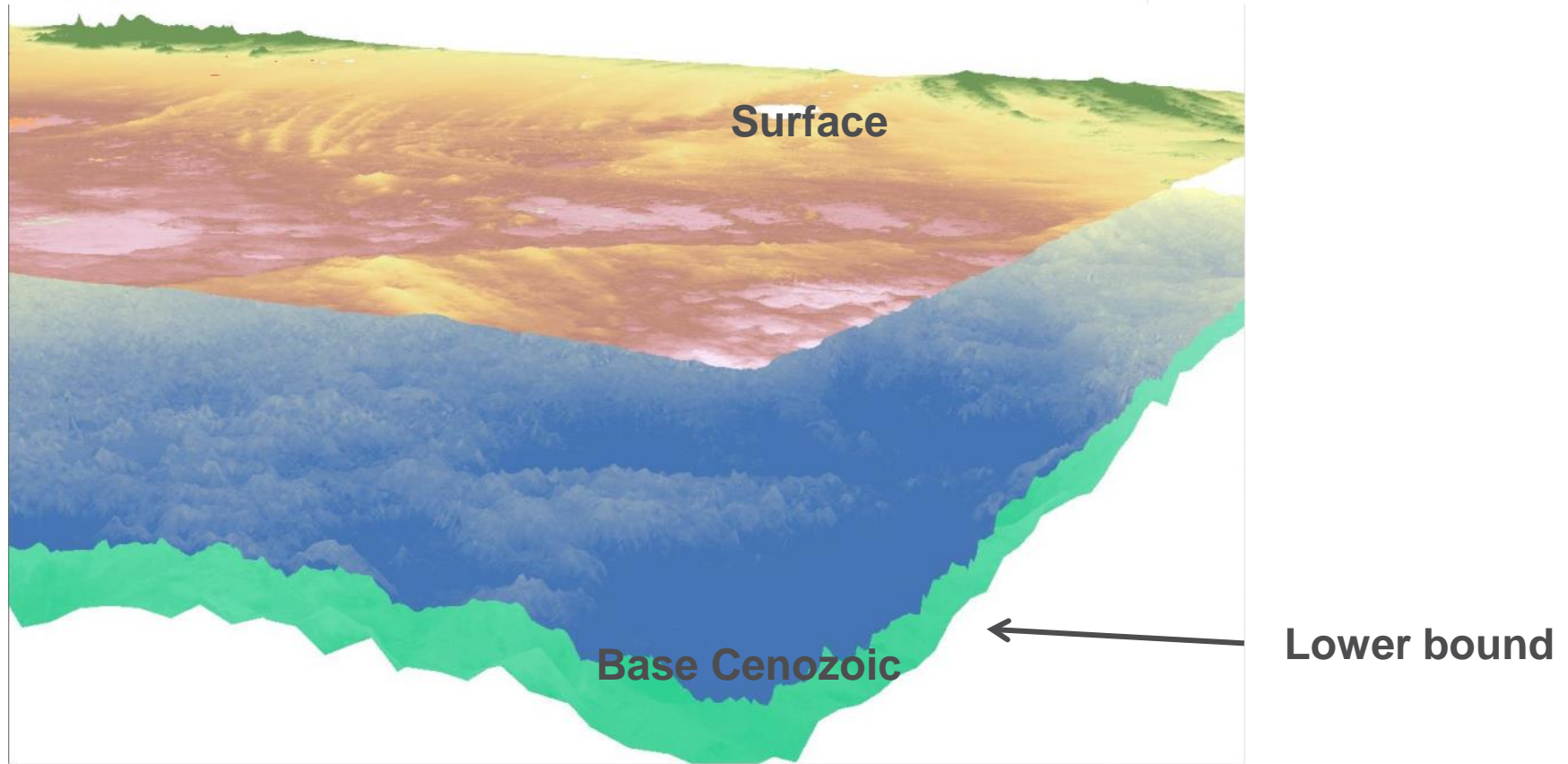
0 650 m



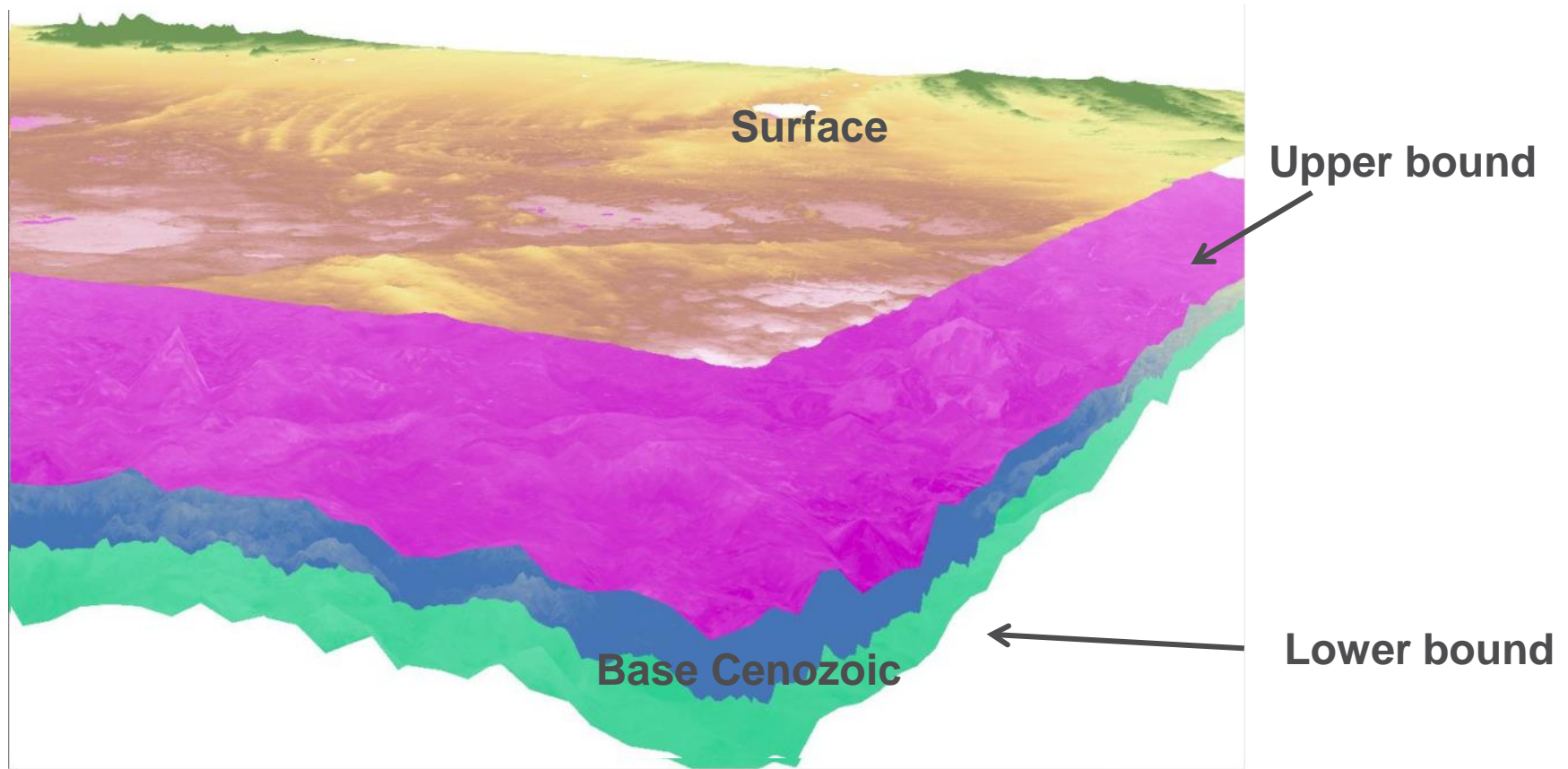
Cenozoic depth boundary with uncertainties - Murray Basin



Cenozoic depth boundary with uncertainties - Murray Basin

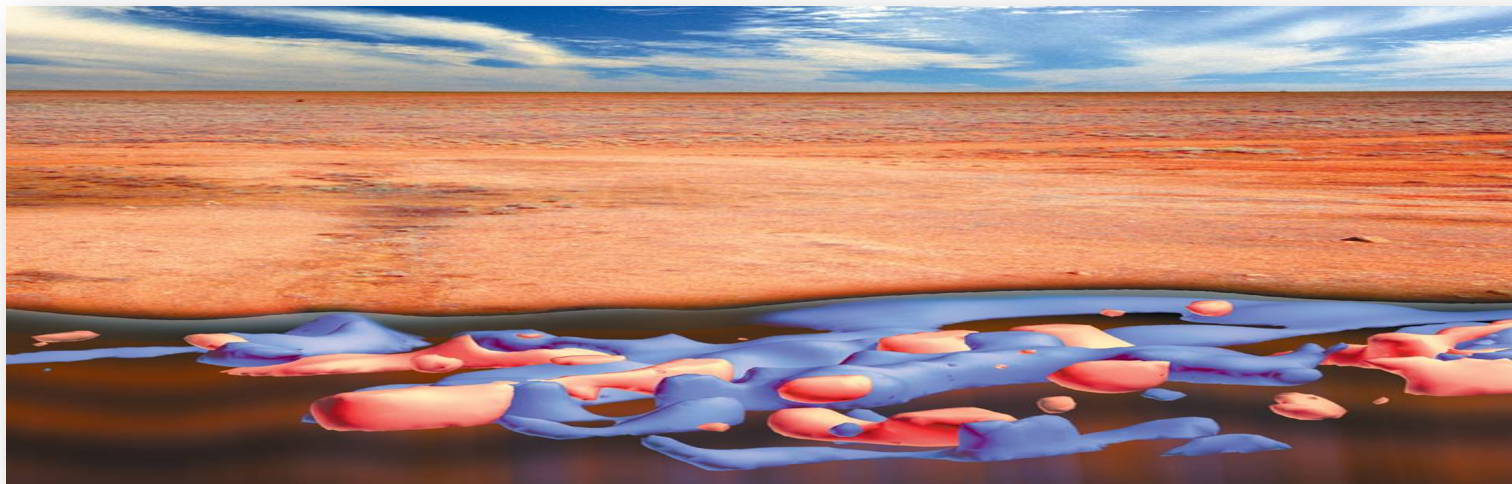


Cenozoic depth boundary with uncertainties - Murray Basin



Conclusions

- Compiling legacy data (drilling; remote sensing – geophysics)
- Building robust databases of primary depth estimates (with degrees of confidence)
- Developing and testing different techniques to generate predictive maps of cover thickness and surface geochemistry (with uncertainties).



Mapping Geology with Airborne Electromagnetics

- Introduction
- AEM Systems
- AEM at GA
- AEM discoveries
- GA AEM Impacts
- GA AEM Innovations

Marina.Costello@ga.gov.au



AEM

Characterises the depth and nature of cover

Characterise and detect distal footprints of ore deposits

One geologist's cover is another geologist's basement

“Cover” and “basement” depend on the commodity sought

Today's examples are only a few from GA's AEM survey work

Highlighting some of the science outcomes and industry impacts

AEM systems on the Geoscience Australia Deed



SPECTREM
GPX

A twin-engine turboprop aircraft with a white base paint and blue and red accents. The word 'SPECTREM' is visible on the side of the fuselage. It is flying over a landscape of green fields and brown patches.




SKYTEM
SkyTEM Australia

A helicopter is shown in flight, pulling a large, rectangular, metal frame structure behind it. The structure is suspended by cables and appears to be a large-scale geophysical survey instrument.



TEMPEST
CGG

A twin-engine turboprop aircraft with a white base paint and red accents on the wings and tail. It is flying over a blue sky.



VTM
Geotech
Airborne
Surveys

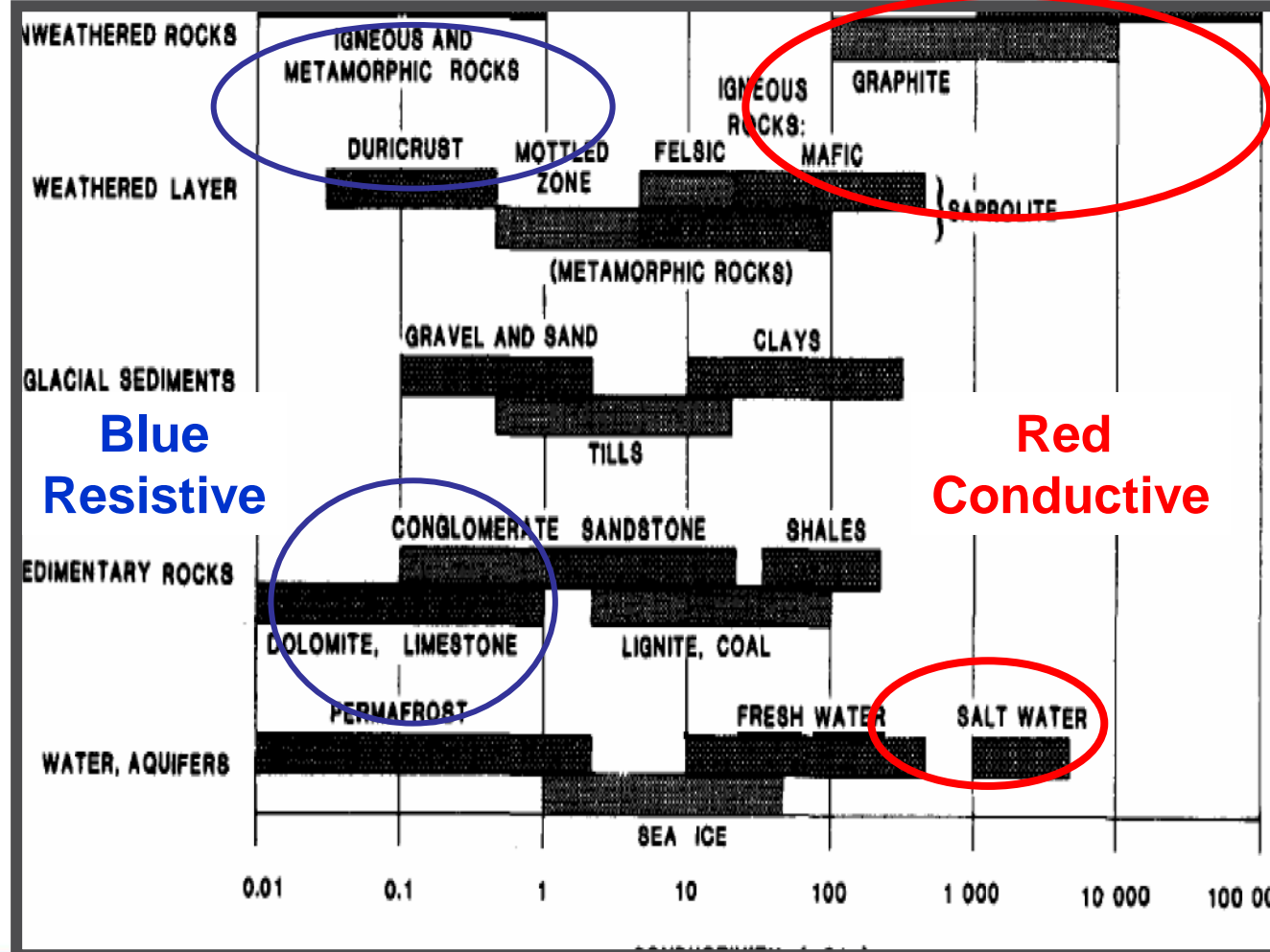
A helicopter is shown in flight, pulling a large, rectangular, metal frame structure behind it. The structure is suspended by cables and appears to be a large-scale geophysical survey instrument.

AEM 1.01

Typical ranges of electrical conductivities for common earth materials

Conductivity contrasts can help us map under-cover geology

Palacky (1993)



Government funded AEM surveys

G.A. AEM surveys

Paterson: 2007-2008
Area: 47,600 km²
Line km: 28,200

**WA Govt
Capricorn: 2013-2014**
Area: 146,300 km²
Line km: 30,123

**WA Govt
Bryah Basin: 2012**
Area: 146,300 km²
Line km: 2,025

Pine Creek: 2008-2009
Area: 73,700 km²
Line km: 29,900

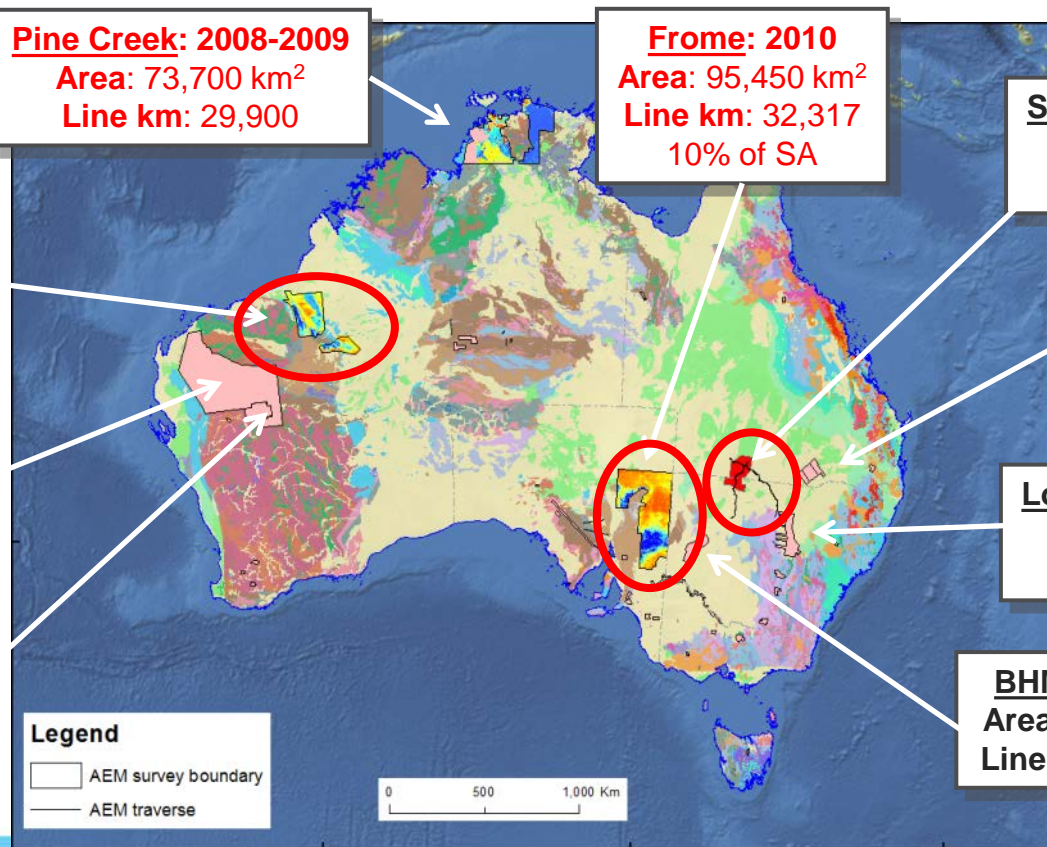
Frome: 2010
Area: 95,450 km²
Line km: 32,317
10% of SA

Southern Thomson: 2014
Area: 16,000 km²
Line km: 4,200

Lower Balonne: 2001
Area: 8,880 km²
Line km: 28,882

Lower Macquarie: 2007
Area: 13,000 km²
Line km: 35,189

BHMAR: 2009
Area: 7,541 km²
Line km: 31,834



AEM at Geoscience Australia

- Precompetitive AEM released
- Very large regional surveys
- Risk reduction
- Increased/new investment – surveys paid for themselves
- Good quality – archived – re-useable
- Value add product development
- Value add expert interpretation



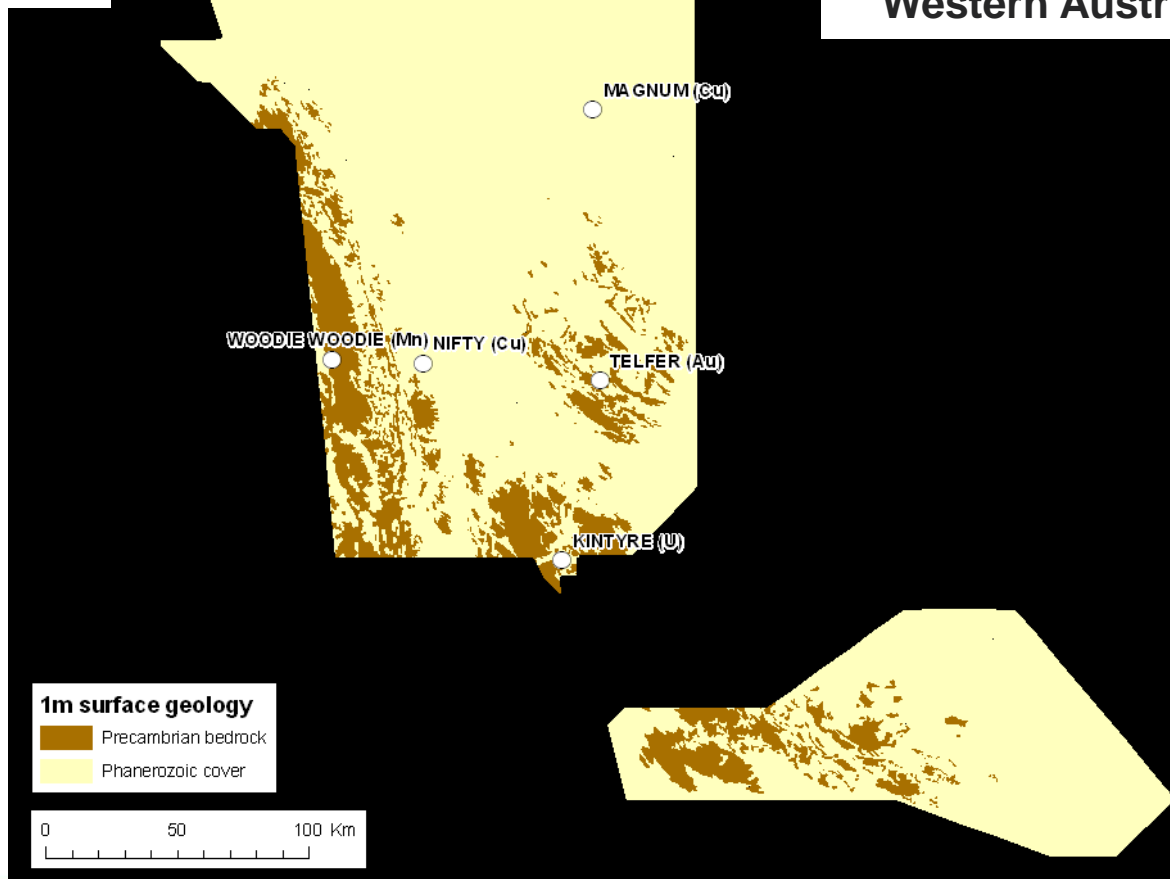
Mapping under cover

84% cover in the AEM survey area

Lateral continuity of conductivity patterns with mapped surface geology

- Extensions of geology under cover
- Potential rock types under cover

Paterson AEM survey Western Australia

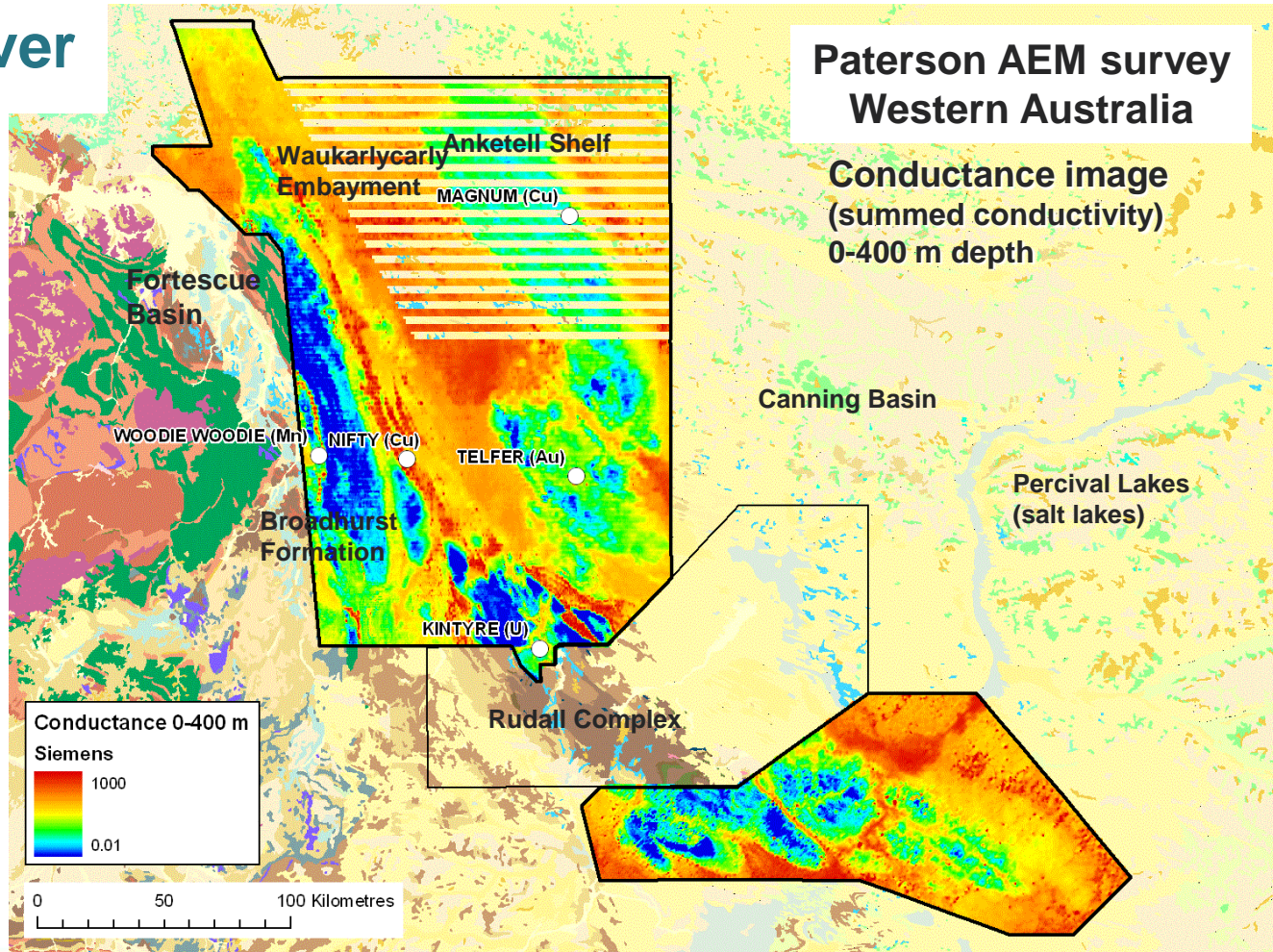


Mapping under cover

84% cover in the AEM survey area

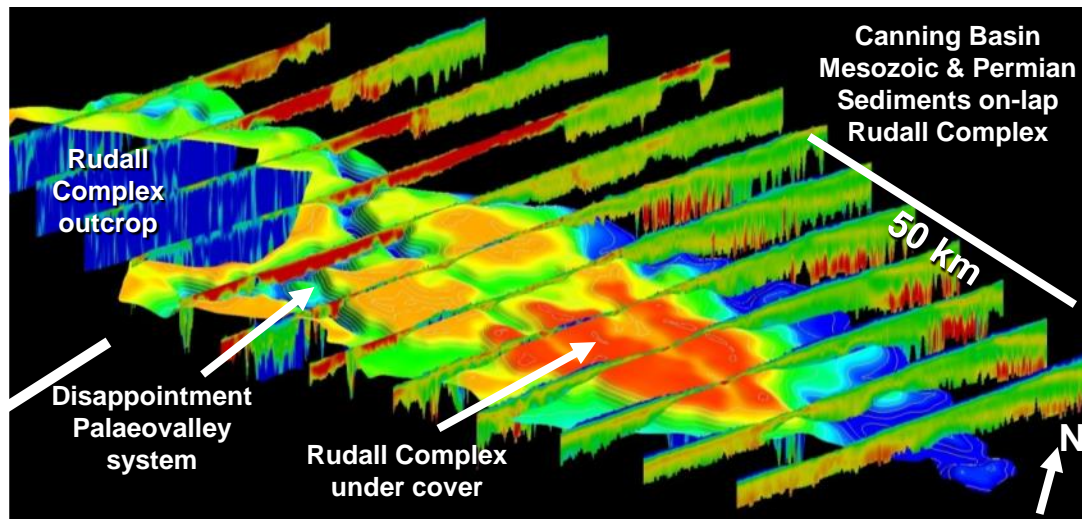
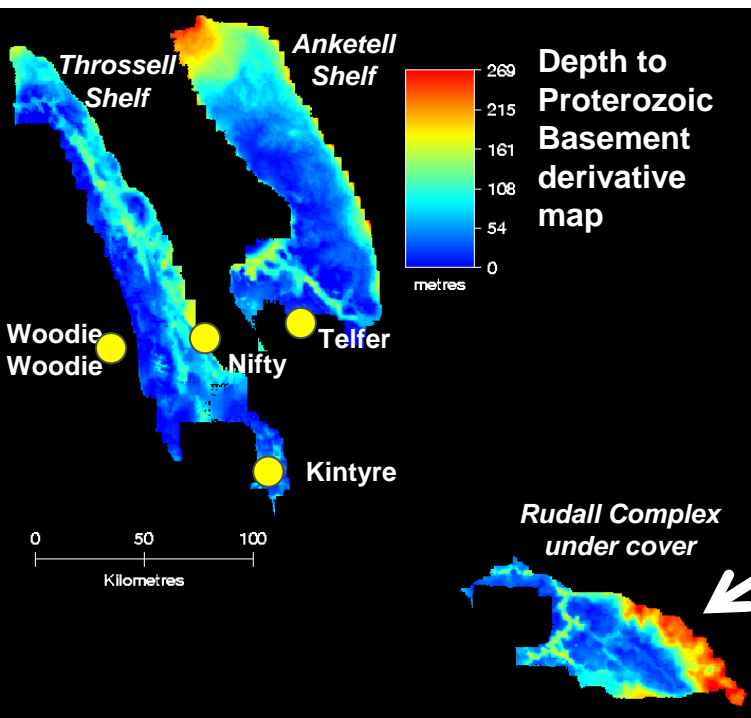
Lateral continuity of conductivity patterns with mapped surface geology

- Extensions of geology under cover
- Potential rock types under cover



“Just tell us how thick the cover is!”

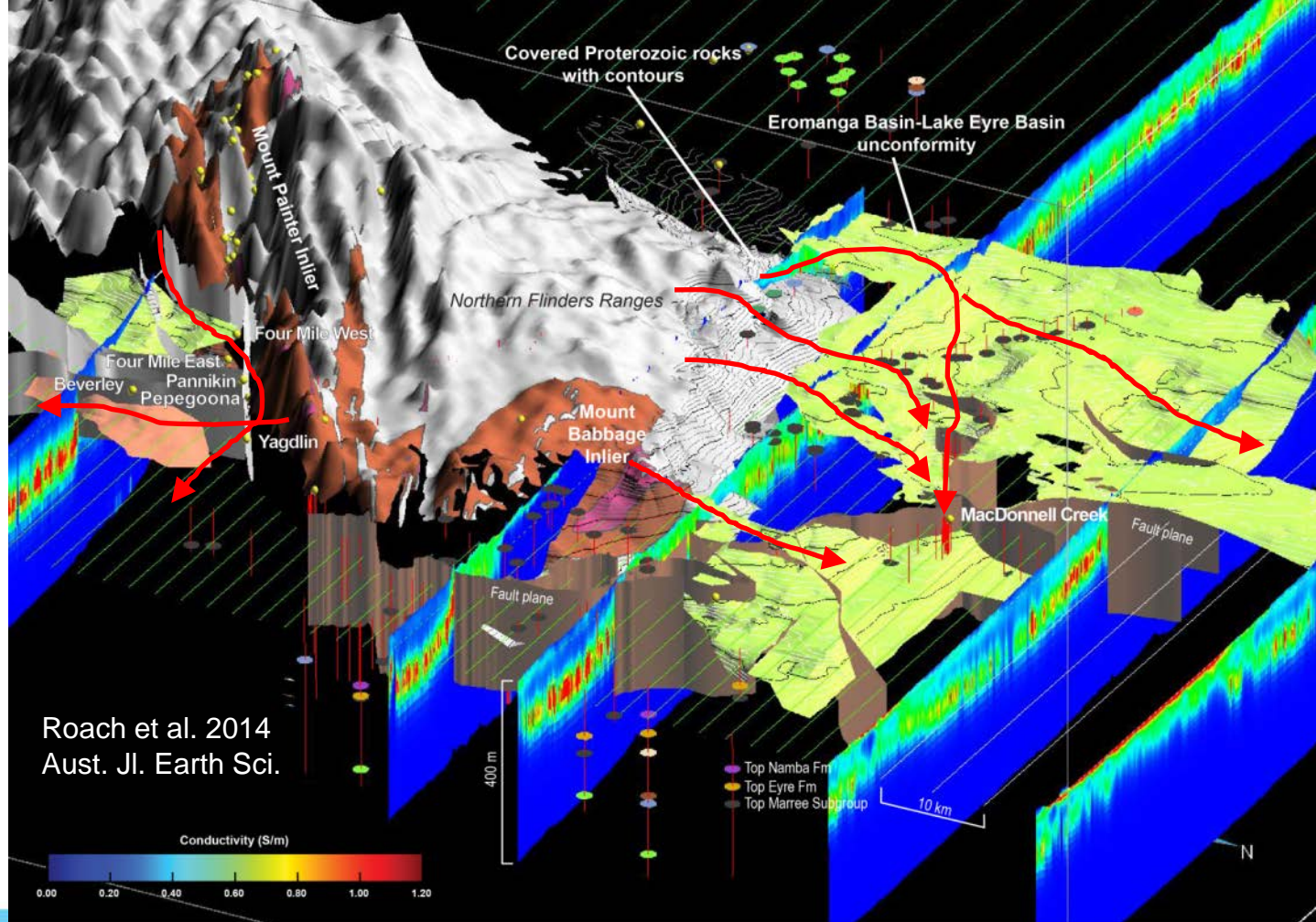
Excellent results in mapping regional cover thickness and extent of under-cover high-prospectivity terrains – Paterson W.A.



Mapping under cover Frome S.A.

Mapping the
sources, transport
pathways and
sinks of uranium in
the northern
Flinders Ranges

Tectonic controls
on preservation of
uranium traps



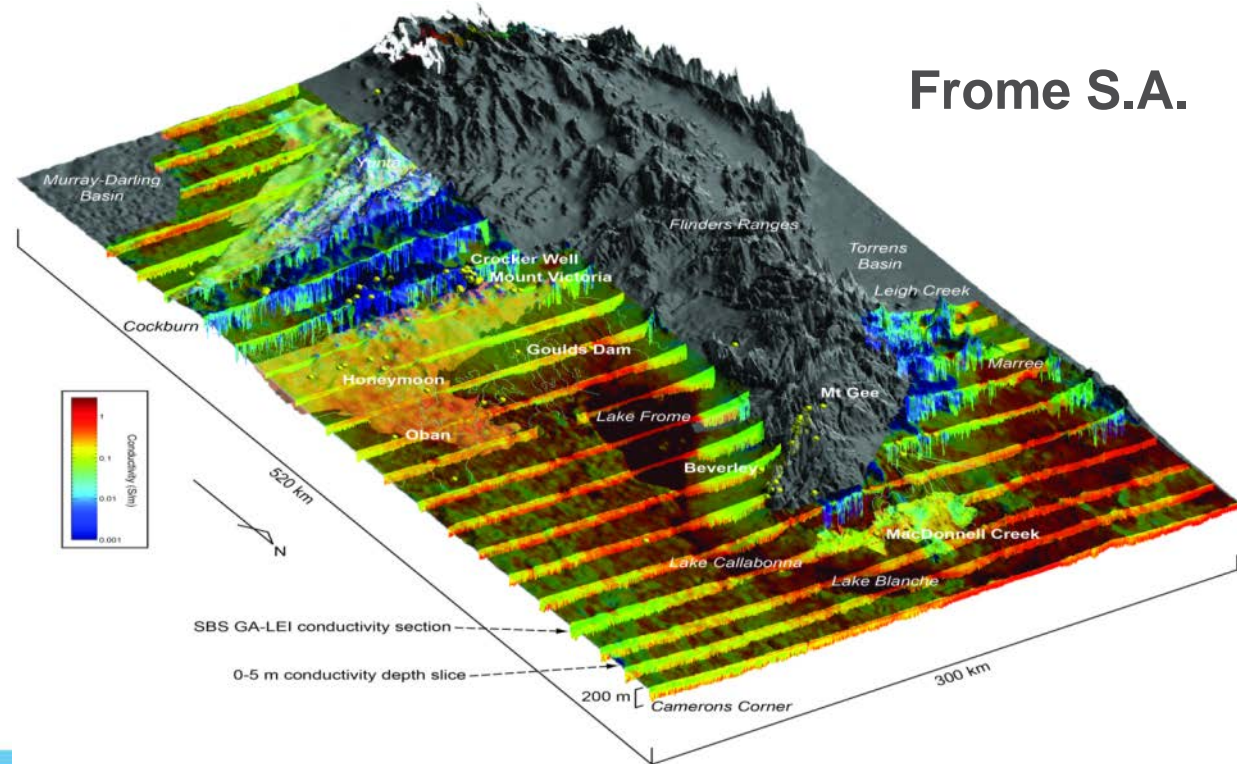
GA AEM Impacts: Regional Mapping

Regional understanding of U systems and their settings

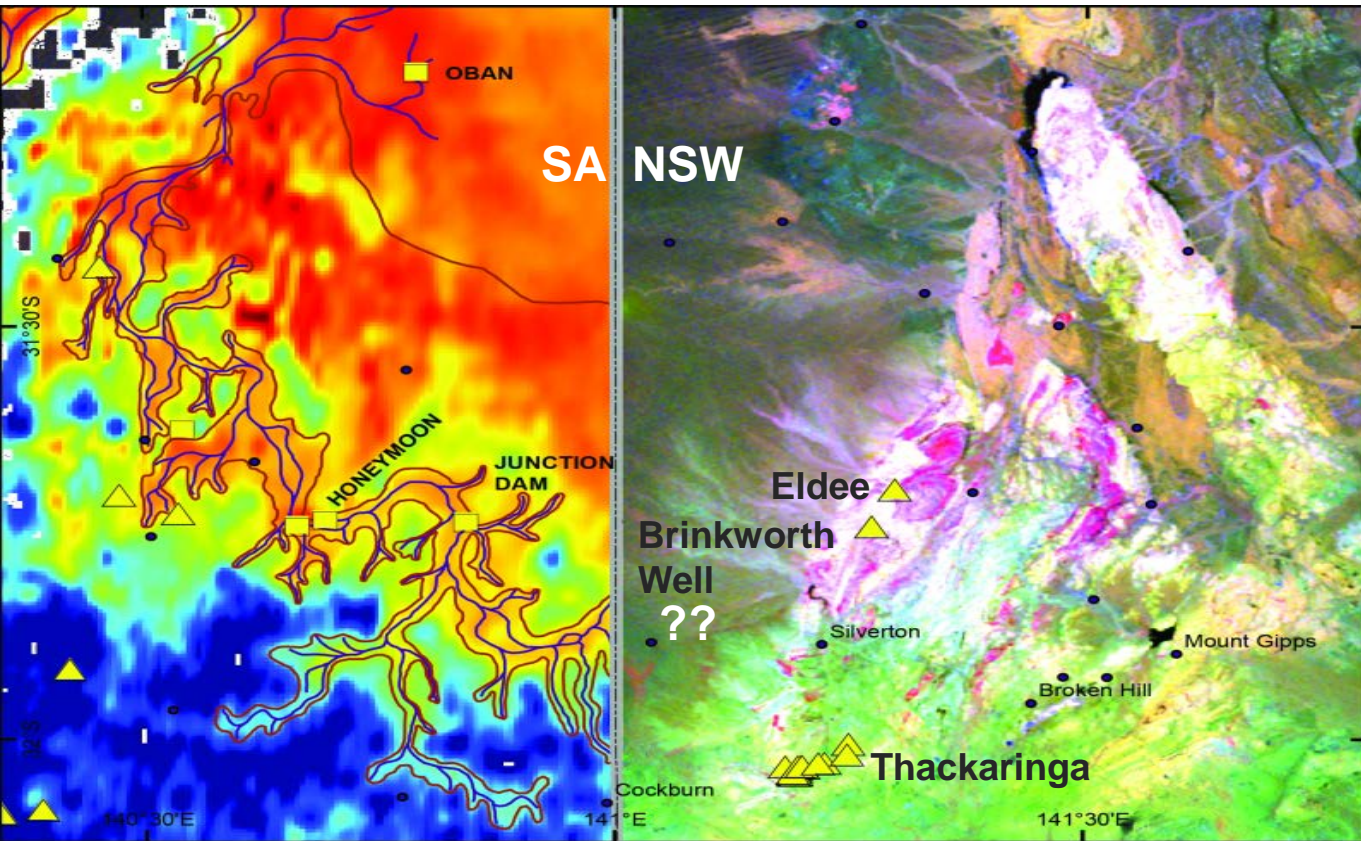
Model palaeosurfaces

More precise depth
to target information

Map alteration zones

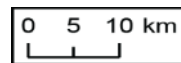
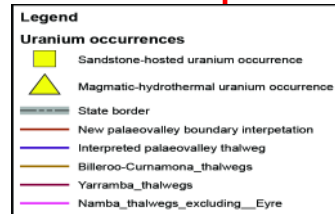


Where does that palaeovalley go?



Remapped

- Yarramba Palaeovalley
- Billeroo-Curnamona
- Lake Namba
- **Uranium Prospectivity**



GA AEM Impacts: Under Cover

Mapping cover thickness in search of NEW targets

- United Uranium
- Outback Metals
- Uranium Exploration Australia
- Territory Uranium (Green Ant)

New discovery: Thunderball uranium prospect (Thundellara Exploration)

The AEM interpretation in Figure 3, coupled with the coherent geochemical anomaly depicted in Figure 2, make this target an excellent resource development priority for the start of TUC's busy exploration season.

*Reference: Lally, J.H., & Bajwah, Z., 2005; Uranium Deposits of the Northern Territory, Report 20, August 2005, Northern Territory Geological Survey; Northern Territory Government.

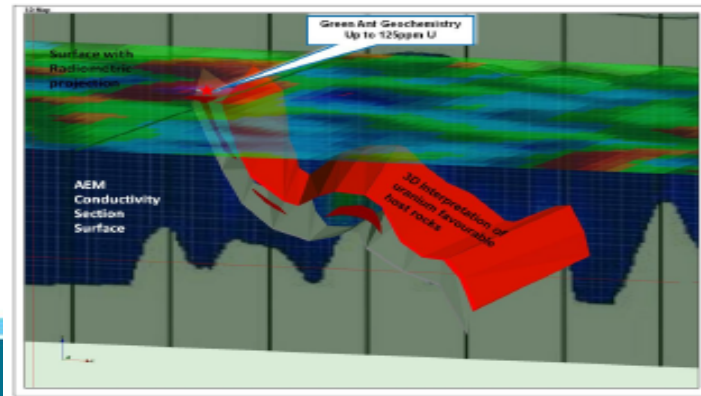
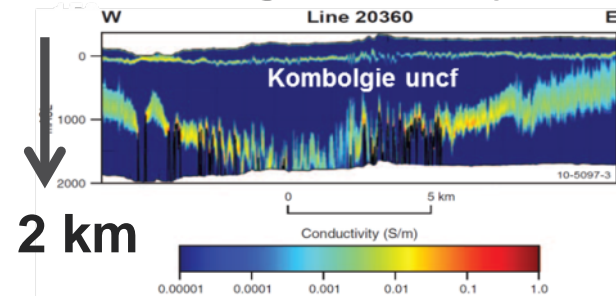


Figure 3— 3D Interpretation of uranium favourable host rocks beneath the Green Ant Prospect. Information used for drill targeting.

Territory Uranium
Company Ltd ASX
Announcement
11 March 2010

VTEM Kombolgie Survey



RC Drilling Commences at 'Green Ant' Unconformity Related Uranium Prospect (Pine Creek Project, Northern Territory).

The Company has planned a programme of approximately 4.6 RC holes at its Green Ant Prospect in the Pine Creek Project. The prospect is located in a highly prospective region next to historic uranium mines and new uranium prospects as shown in Figure 1.



Initially, 500m of drilling is planned to test an interesting and well defined uranium soil and rock chip anomaly which was outlined in 2009 TUC's June 2009 Quarterly Activities Report. Geochemical results of up to 125ppm U are identified proximal to the uranium prospective eroded unconformity (Figure 2).

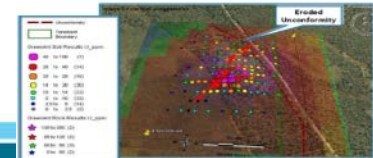


Figure 2 - Green Ant Prospect and geochemistry on radiometric background



ASX Code: TUC

31 March 2010
ASX Announcement

Registered Office
Suite 5, 387 York Street
Subsidiary Pty Ltd
Tel: 08 9380 6261
Fax: 08 9382 1766
E: info@territoryuranium.com.au
W: www.territoryuranium.com.au
ABN: 94 115 770 226

Service (Main) Office
Unit 2/19 Immersie Road
Winnah NT 0650
Tel: 08 9947 0944
Fax: 08 9947 1517
E: info@territoryuranium.com.au
W: www.territoryuranium.com.au

Company Management
Peter Harold
Non-Executive Chairman
Ian Rotherham
Managing Director
Russell Stanley
Non-Executive Director
Peter Stanley
Non-Executive Director
Michael Jackson
Non-Executive Director
Kathleen Breen
Company Secretary

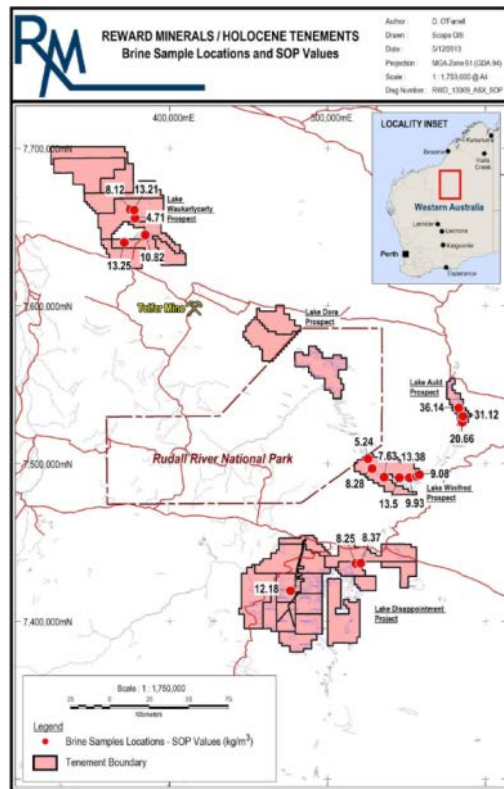
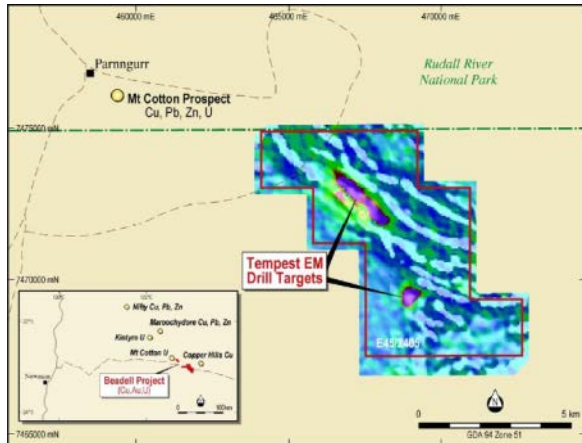
March 2015

GA AEM Impacts: Discoveries

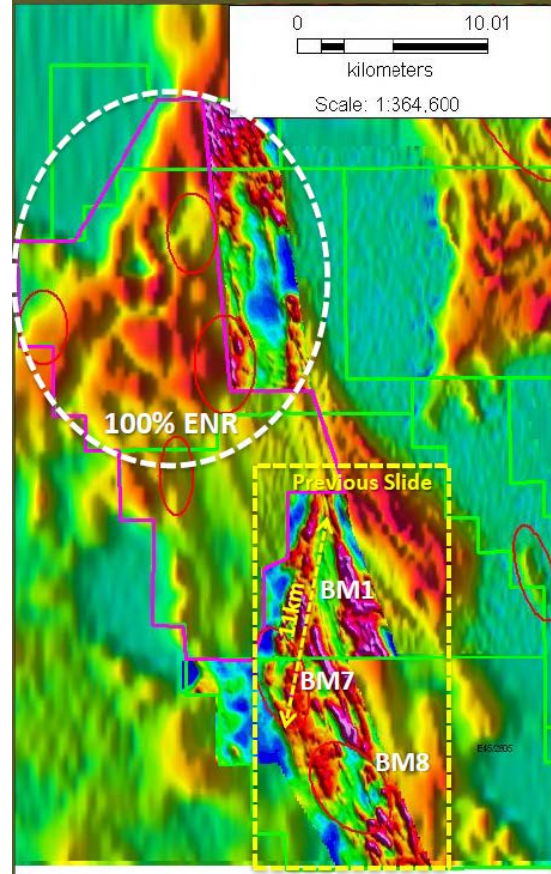
Target generation:

- Yeneena Cu-Co, Mn, Cu-Zn
- Beadell Cu-Pb-Zn-Au
- Further U, Cu-U mineral systems around Kintyre
- Salt lakes potash

GA TEMPEST
AEM image,
Beadell Cu
prospect.
Cauldron
Energy Ltd ASX
announcement
1 Nov 2010



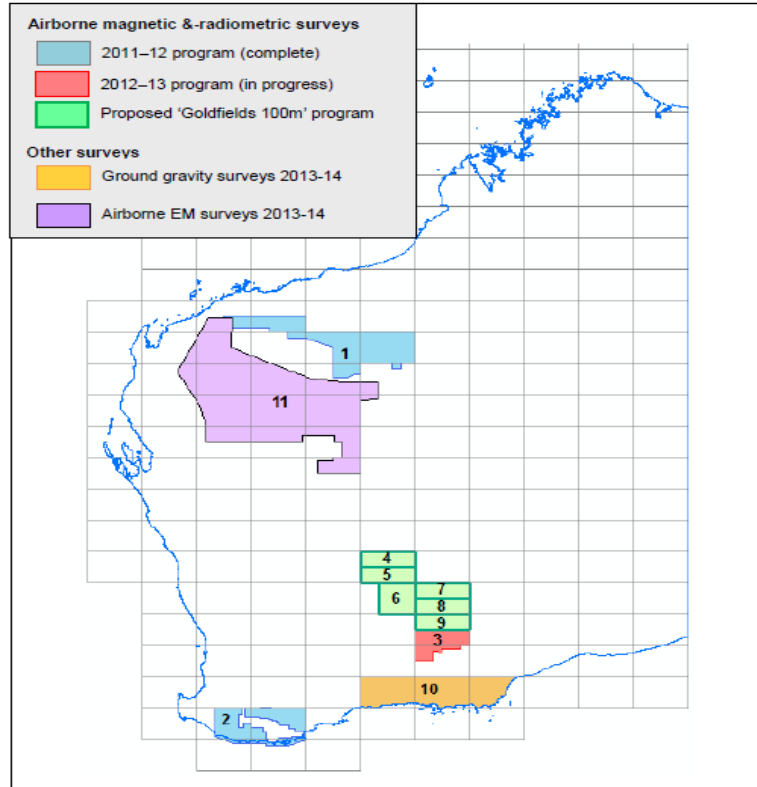
Reward Minerals Ltd potash tenements



GA TEMPEST and VTEM AEM image,
Yeneena Cu prospect. Encounter Resources
Ltd, RIU Sydney 14 May 2013

GA AEM Impacts: Government Investments

GSWA regional geophysics survey program update — May 2013



Survey outline shapefiles available online at www.dmp.wa.gov.au/geophysics.

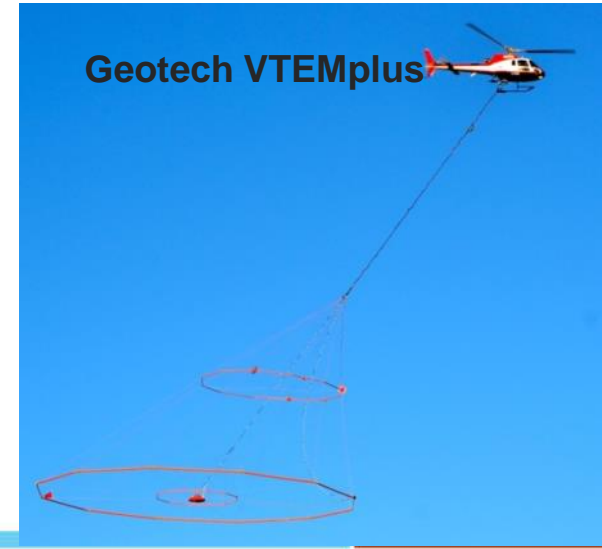
- Bryah Basin 2012 (GSWA)
- Capricorn Orogen 2014 (GSWA)
- Mt Isa AEM (GSQ)
- Water for Food Initiative
- Musgraves (GSSA)
- Spike in co-funding AEM (NTGS)

Equivalent investment by Industry

- infill geophysical surveys
- logging
- drilling
- mapping

GA AEM Impacts: AEM industry

- Influencing system development
- Increasing the scope of AEM beyond “traditional uses”
- Improving technical specifications
- Demonstrate mapping techniques
- Consultants selling value add prospect scale analysis
- Introducing new inversion algorithms (NCI, VGL)



GA AEM Innovation:

Computational Science



Featured Layers

Search: Visible

Geoscience Australia (6 Items)

GOCAD Models

GA Geophysics Projects

Paterson Airborne Electromagnetic Survey

Rum Jungle Airborne Electromagnetic Survey

Woolner Airborne Electromagnetic Survey

Australian Point Gravity

1011

1011

1011

1011

1011

1011

Geoscience Australia (4 Items)

1011

1011

1011

1011

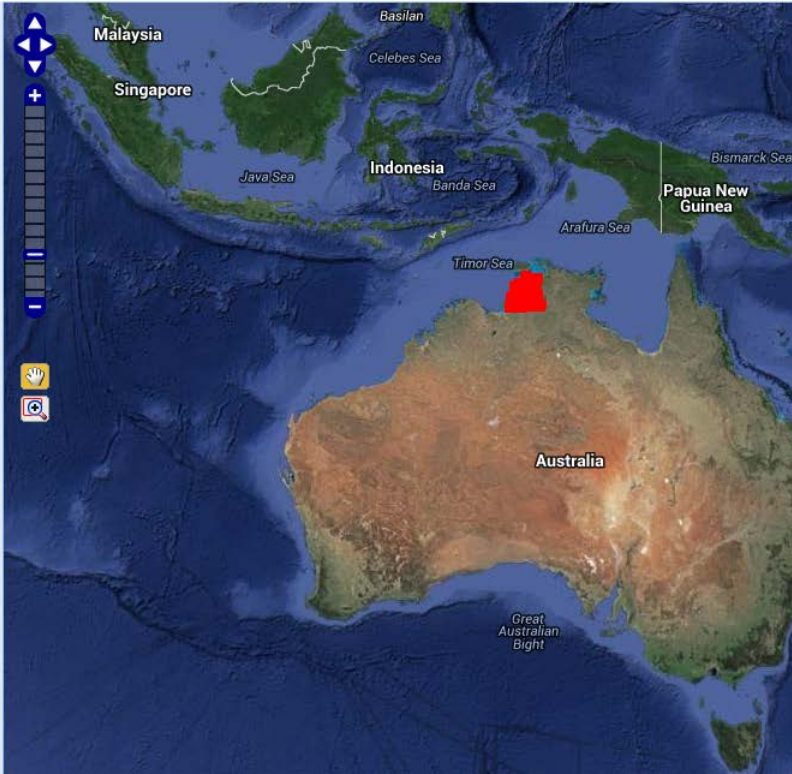
Filter

WMS Properties

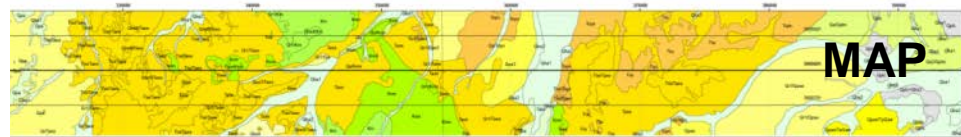
Opacity:

Add to Map

Reset Filter

Active Layers

GA AEM Innovation: Inversions



CROSS-SECTION

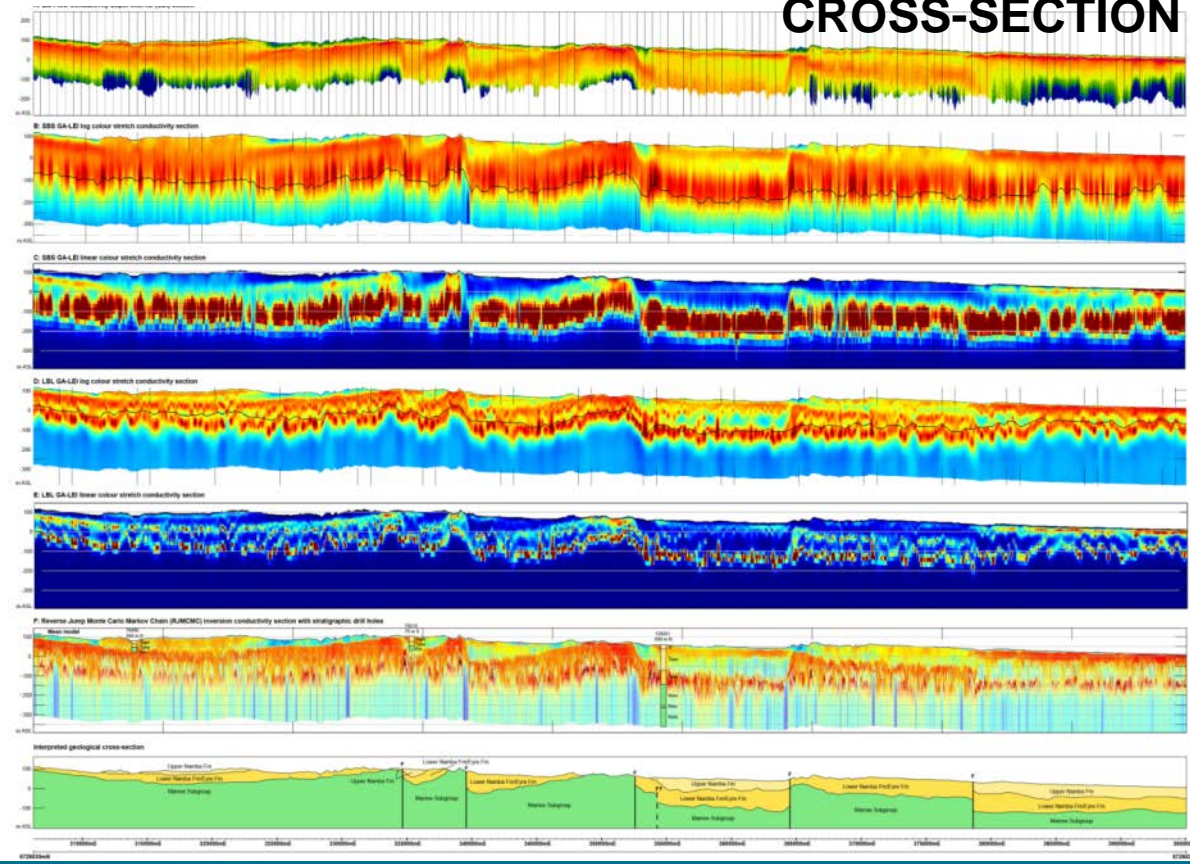
EM FlowTM

GALEISBS

GALEILBL

GA RJ MC MC

Interpretation



Evolution of airborne electromagnetic inversion techniques at Geoscience Australia

Geoscience Australia is a leading developer of airborne electromagnetic inversion algorithms.

Examples here show the progress from commercial solutions through the Geoscience Australia Layered Earth inversion (GA-LEI) to the latest Reversible Jump Markov chain Monte Carlo (RJ-MCMC) inversion.

The RJ-MCMC inversion is still in development, but promises to add a new level of detail to calibrated, quantitative airborne electromagnetic data, improving interpretability over previous inversion techniques.

The RJ-MCMC inversion uses the resources of the National Computational Infrastructure (NCI) to calculate hundreds of thousands of models for each sounding. This method quantifies uncertainty in the final inversion model, rather than using a pre-conceived geo-electrical model.

Example sections at left are of the 200901 from the Prime AEM Survey, including:

- A: Contractor-supplied EM FlowTM test approximate Inversion Conductivity Depth Interval (CDI) section.
- B: A Sample-by-Sample GA-LEI conductivity section displayed using a logarithmic colour stretch.
- C: A Sample-by-Sample GA-LEI conductivity section displayed using a linear colour stretch.
- D: A Line-By-Line GA-LEI conductivity section displayed using a logarithmic colour stretch.
- E: A Line-By-Line GA-LEI conductivity section displayed using a linear colour stretch.
- F: A Reversible Jump Markov chain Monte Carlo inversion conductivity section displayed using a logarithmic colour stretch.

Stratigraphic drill hole legend

Geological units: T1a, T1b, T2a, T2b, T3a, T3b, T4a, T4b, T5a, T5b, T6a, T6b, T7a, T7b, T8a, T8b, T9a, T9b, T10a, T10b, T11a, T11b, T12a, T12b, T13a, T13b, T14a, T14b, T15a, T15b, T16a, T16b, T17a, T17b, T18a, T18b, T19a, T19b, T20a, T20b, T21a, T21b, T22a, T22b, T23a, T23b, T24a, T24b, T25a, T25b, T26a, T26b, T27a, T27b, T28a, T28b, T29a, T29b, T30a, T30b, T31a, T31b, T32a, T32b, T33a, T33b, T34a, T34b, T35a, T35b, T36a, T36b, T37a, T37b, T38a, T38b, T39a, T39b, T40a, T40b, T41a, T41b, T42a, T42b, T43a, T43b, T44a, T44b, T45a, T45b, T46a, T46b, T47a, T47b, T48a, T48b, T49a, T49b, T50a, T50b, T51a, T51b, T52a, T52b, T53a, T53b, T54a, T54b, T55a, T55b, T56a, T56b, T57a, T57b, T58a, T58b, T59a, T59b, T60a, T60b, T61a, T61b, T62a, T62b, T63a, T63b, T64a, T64b, T65a, T65b, T66a, T66b, T67a, T67b, T68a, T68b, T69a, T69b, T70a, T70b, T71a, T71b, T72a, T72b, T73a, T73b, T74a, T74b, T75a, T75b, T76a, T76b, T77a, T77b, T78a, T78b, T79a, T79b, T80a, T80b, T81a, T81b, T82a, T82b, T83a, T83b, 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Conclusions

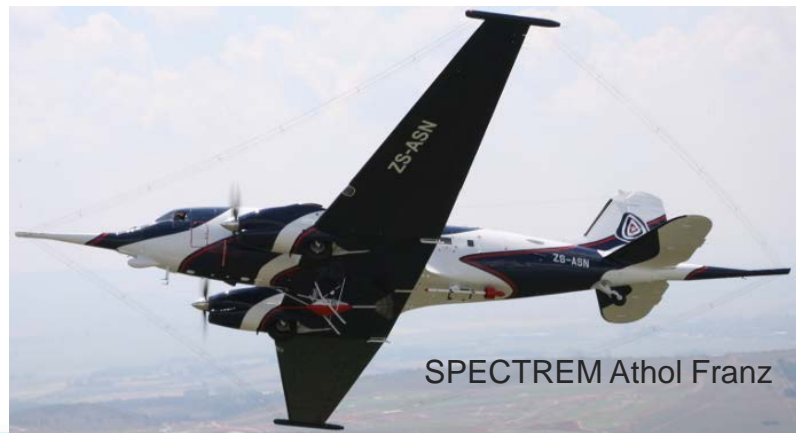
Regional AEM data bridge the gap between where outcrop stops and where other geophysical models start

AEM data join the dots between sparse drillholes

AEM data can model the all-important basement-cover interface

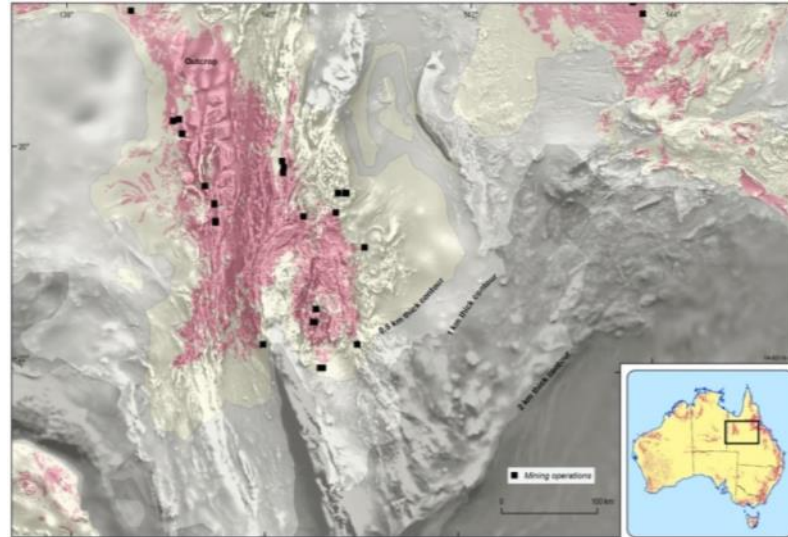
AEM data are ideally suited to exploration in the top ~300 m of the Earth's surface; explorable depths within easy reach of current drilling technology

Regional AEM data reduce exploration risk and stimulate investment by government and industry



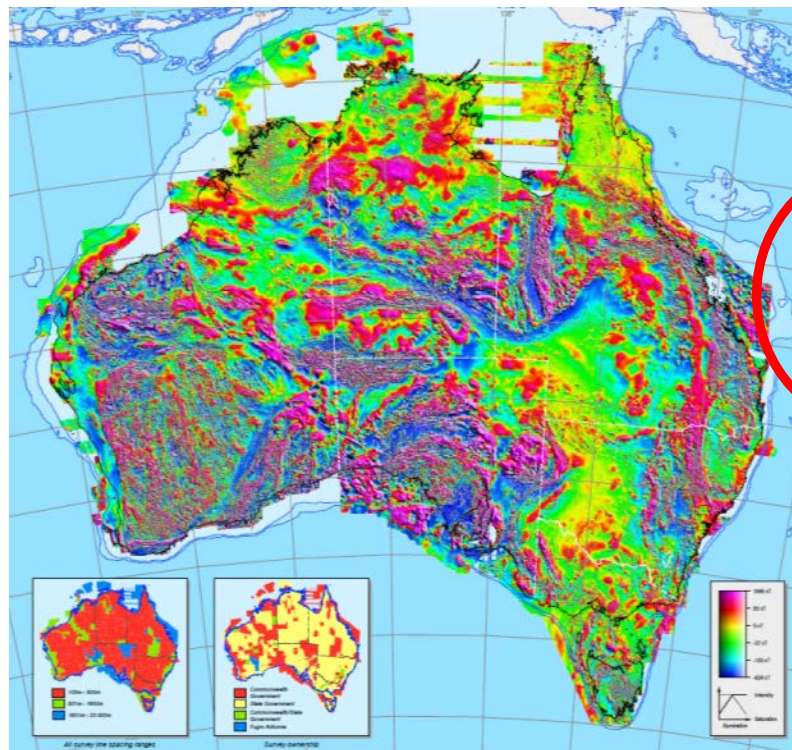


Geophysics applied to variable cover: benchmarking multiple methods to known depths



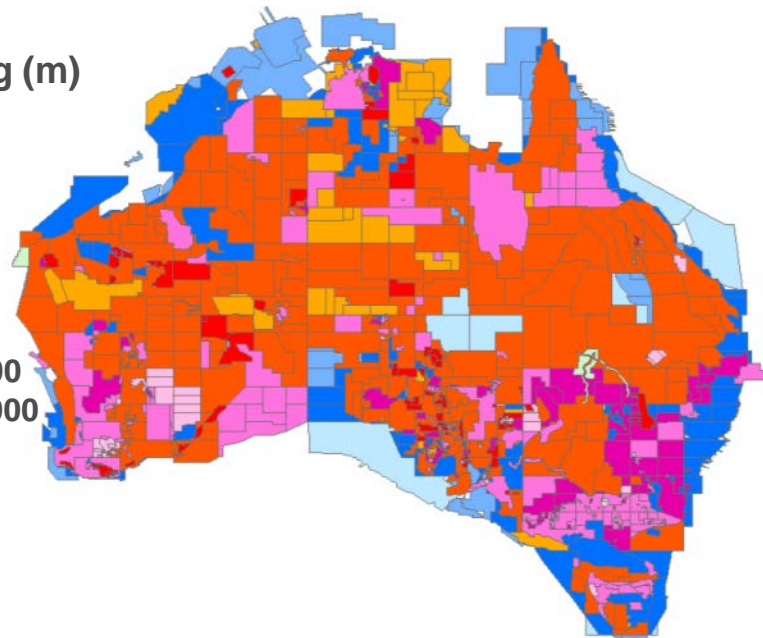
Tony Meixner, Aki Nakamura, Karol Czarnota, Alexei Gorbatov, Sarlae McAlpine,
James Goodwin and Malcolm Nicoll
tony.meixner@ga.gov.au

Magnetic anomaly map of Australia

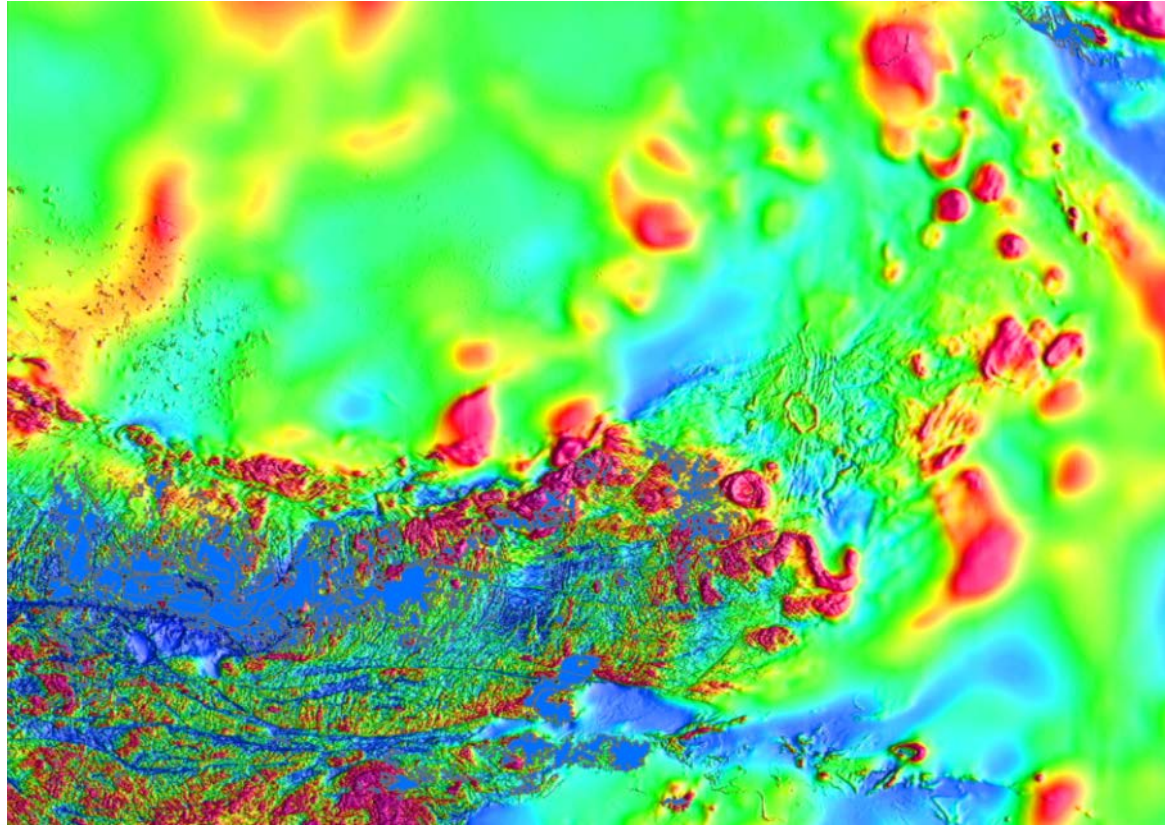


Line spacing (m)

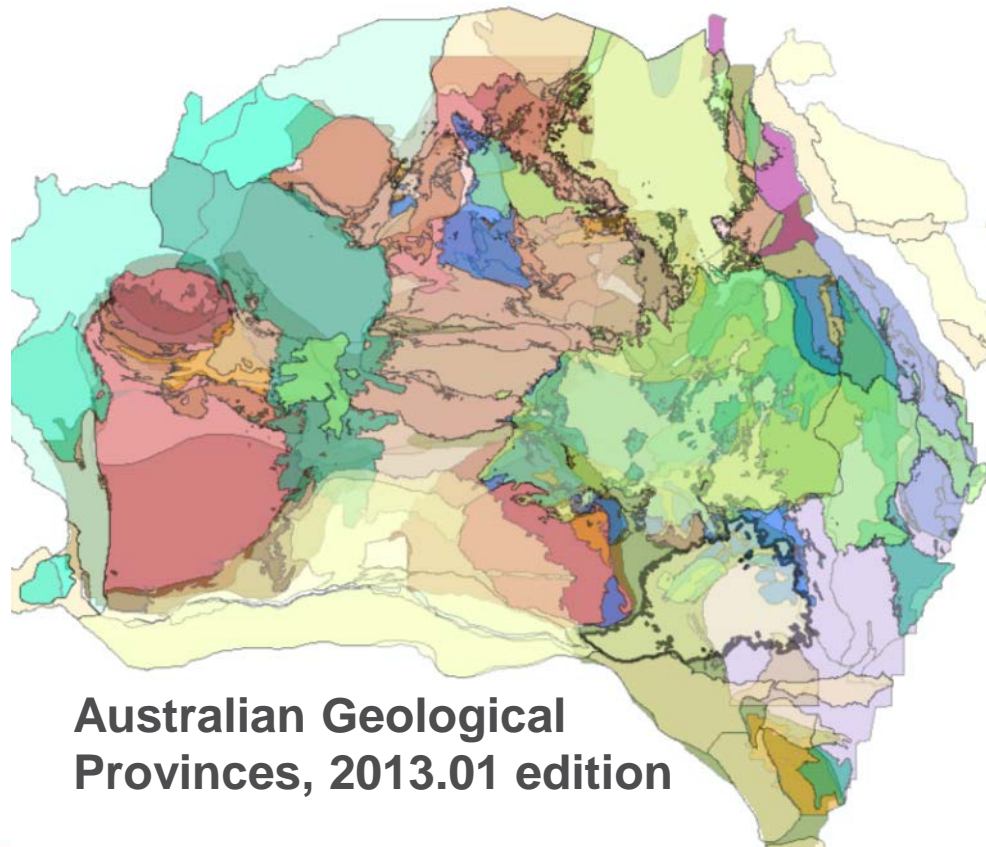
- 100
- 150, 200
- 250
- 300
- 400
- 500
- 600 to < 2000
- 2000 to < 4000
- >= 4000



Magnetic anomaly attenuation with depth



Benchmarking magnetic methods against drill-holes

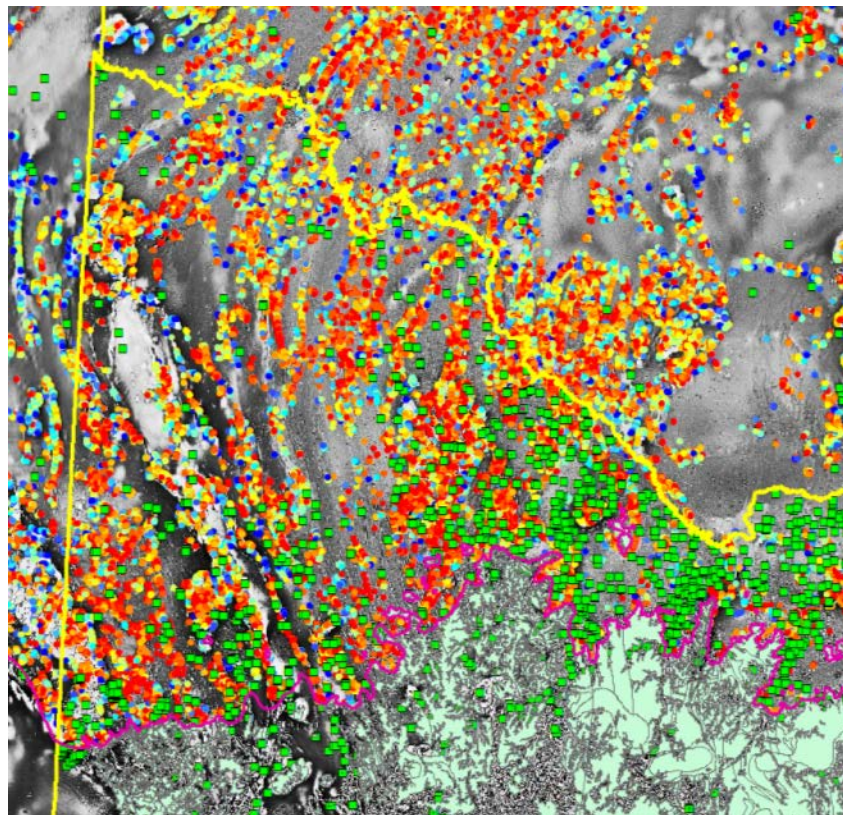


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Depth to magnetic source method

- Targeted Inversion Modelling
- Naudy method
- Tilt depth
- Euler deconvolution
- (Spectral method)

Benchmarking: Magnetic tilt-depth estimates against drill-holes

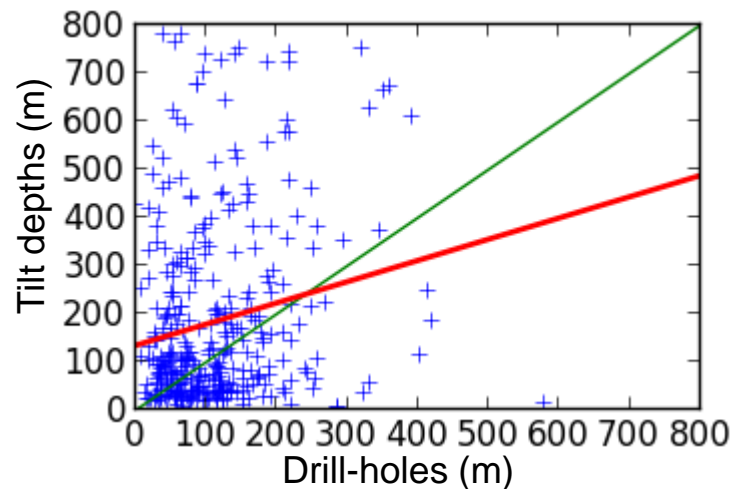


■ Basement intersecting
Drill-holes

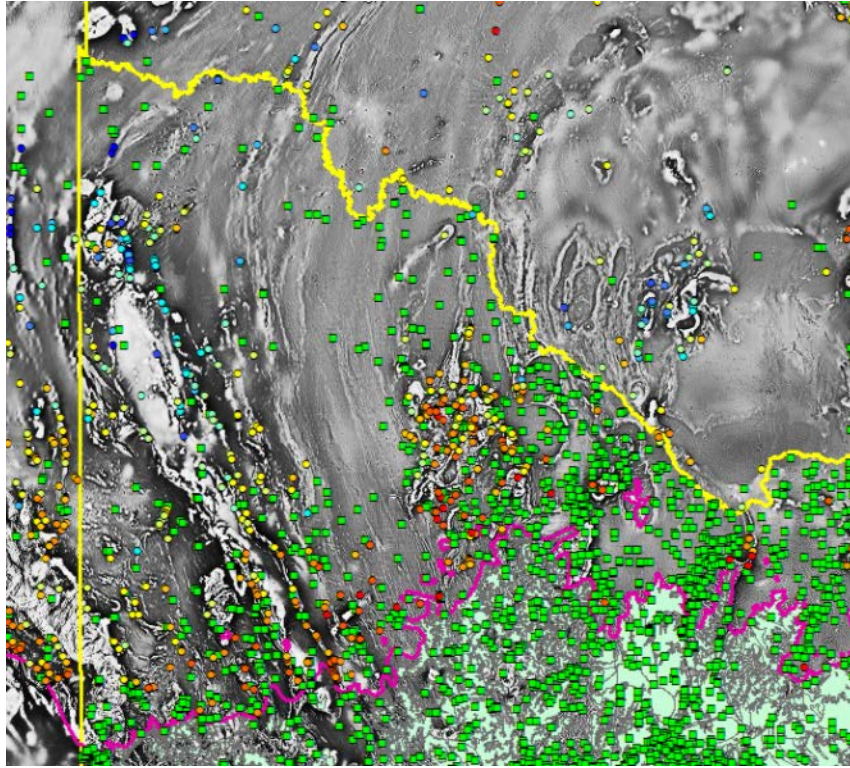
Tilt depths

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650

**Highly automated
method:
 $R^2 = 0.04$**



Benchmarking: Naudy depth estimates against drill-holes

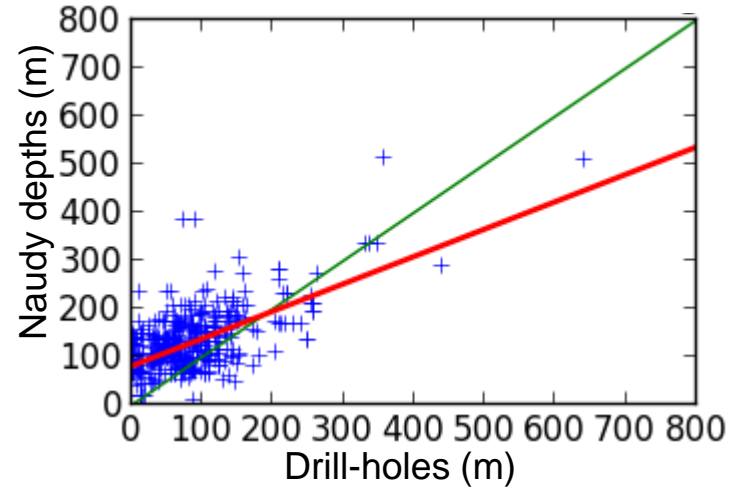


■ Basement intersecting
Drill-holes

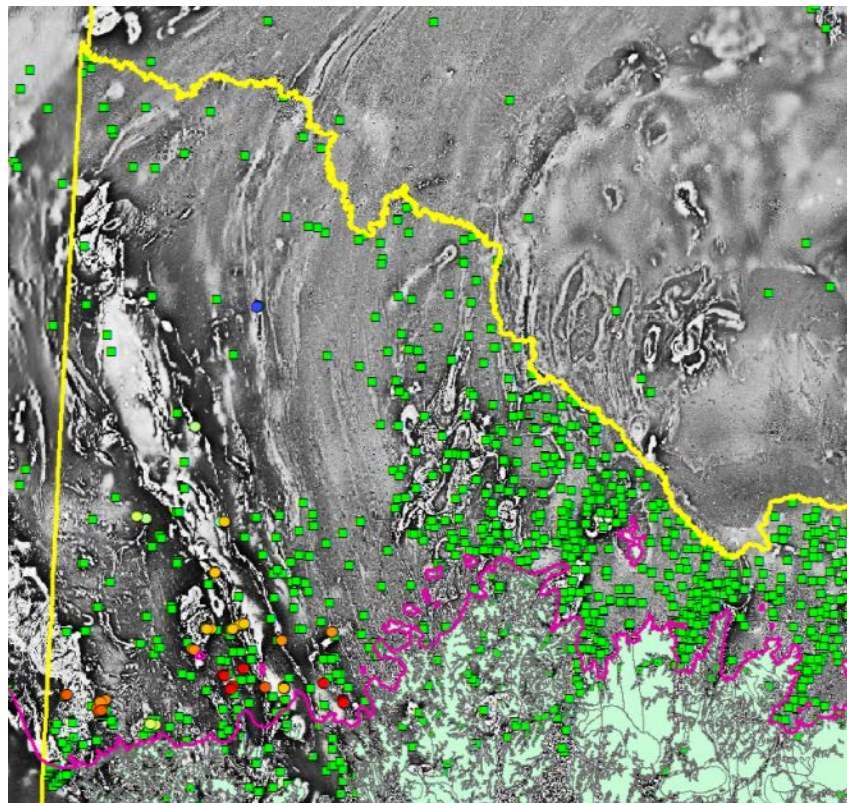
Naudy depths

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650

**moderately automated
method:
 $R^2 = 0.42$**



Benchmarking: Targeted inversion modelling against drill-holes

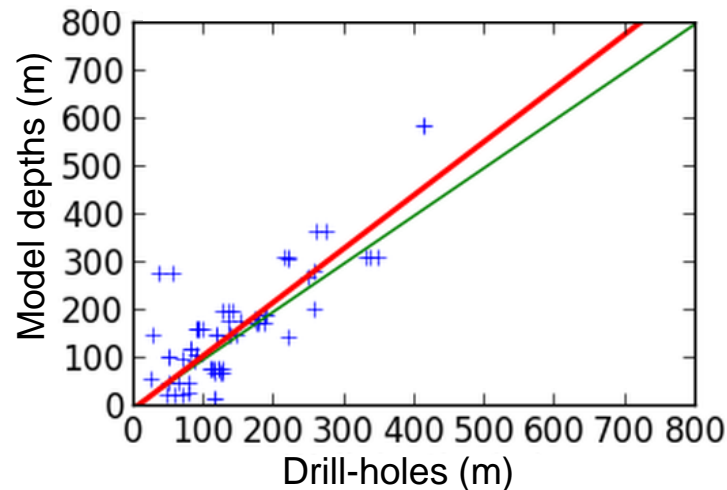


■ Basement intersecting
Drill-holes

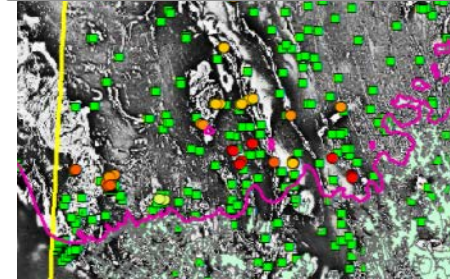
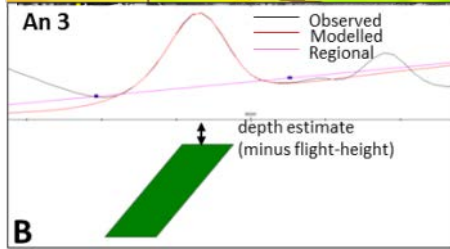
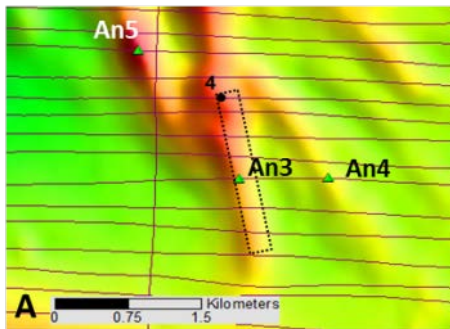
Model depths

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650

**Hands on
method:
 $R^2 = 0.68$**



Benchmarking: Targeted inversion modelling against drill-holes

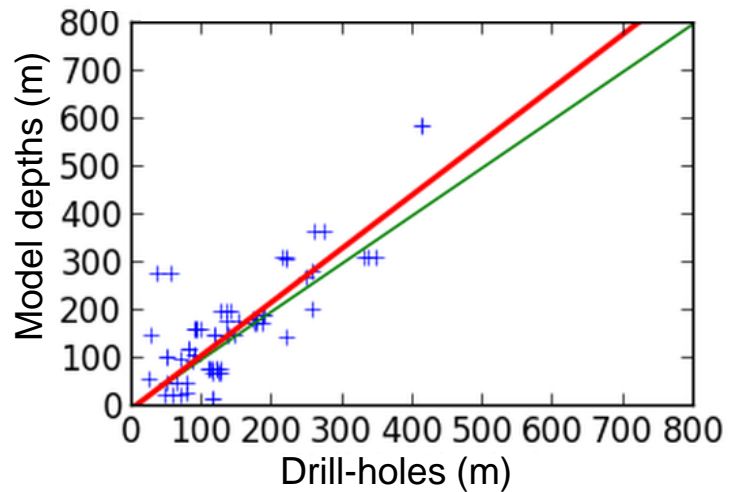


■ Basement intersecting Drill-holes

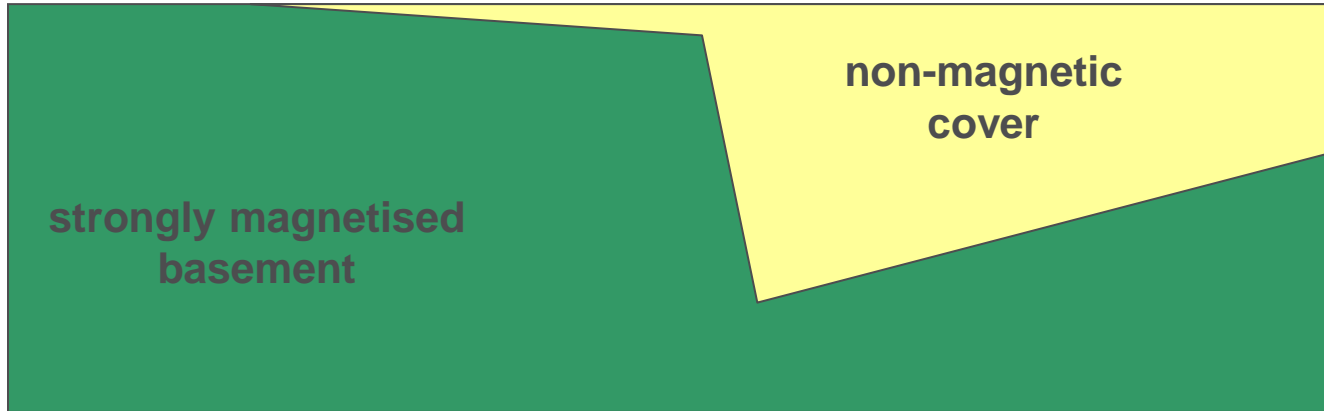
Model depths

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650

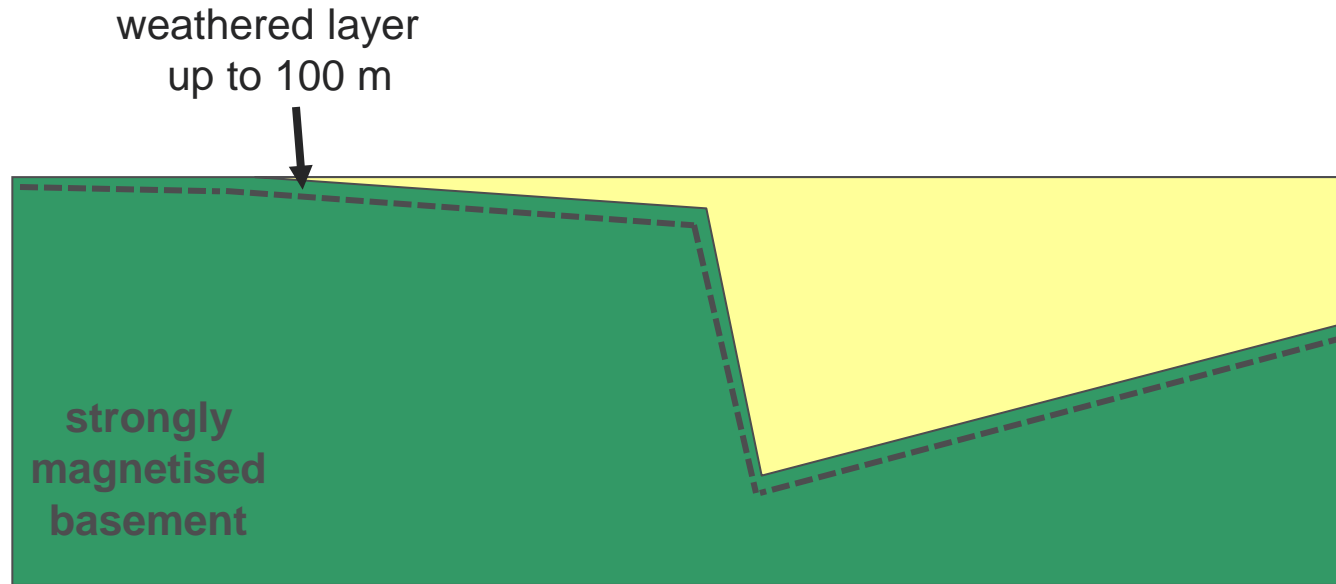
**Hands on
method:
 $R^2 = 0.68$**



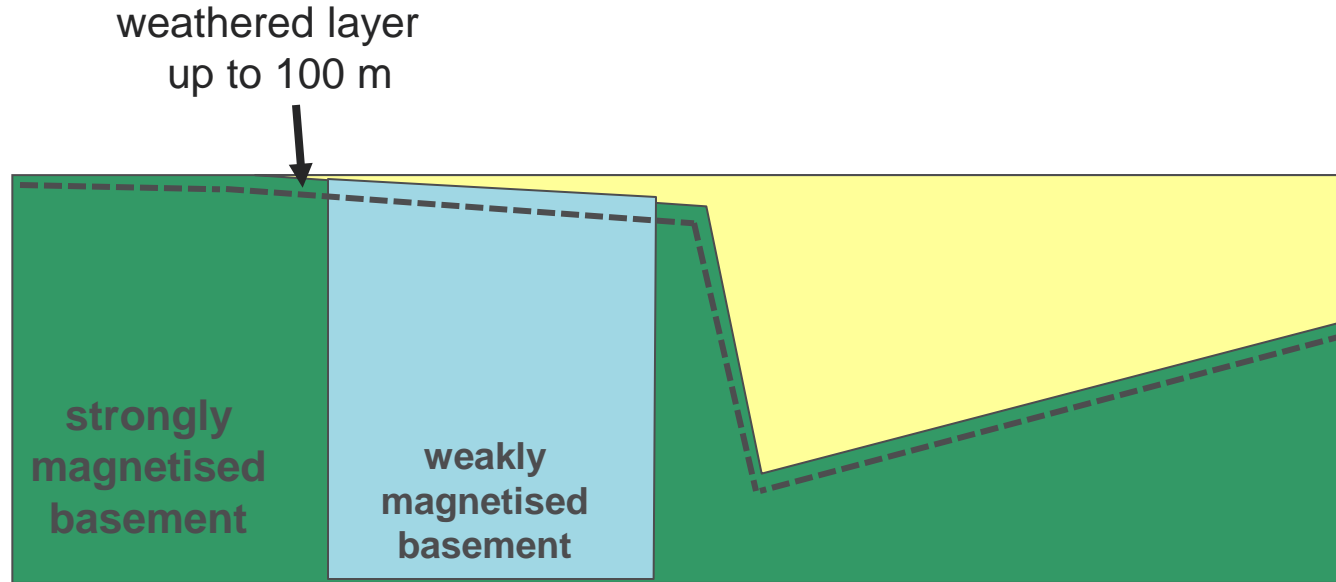
Geological attributing



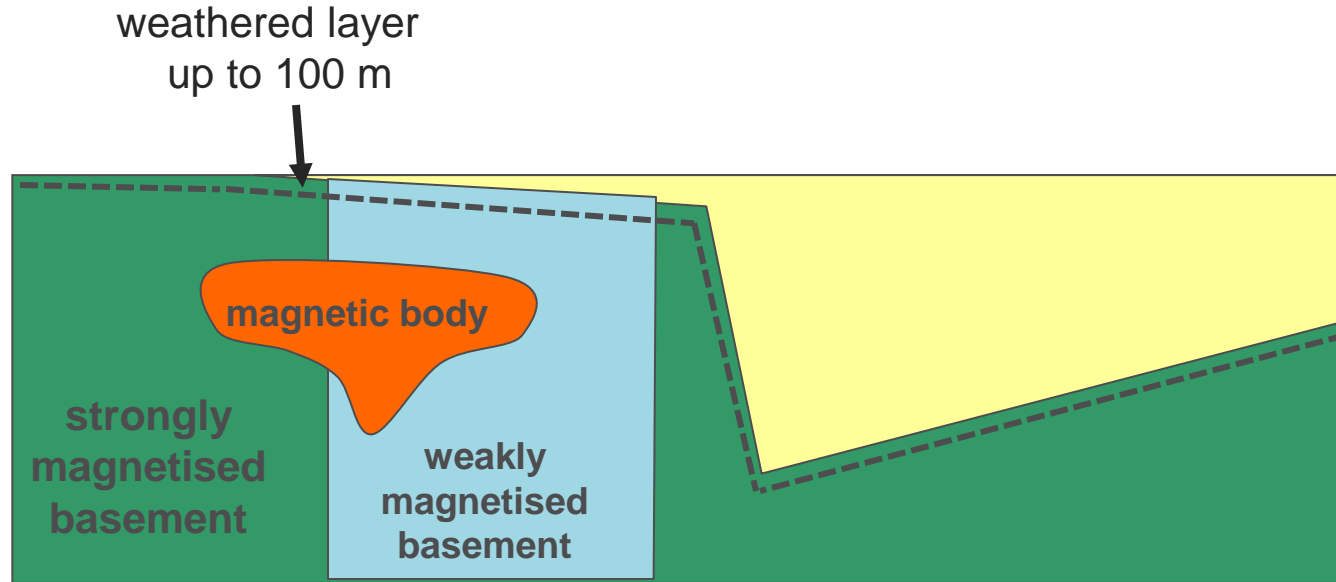
Geological attributing



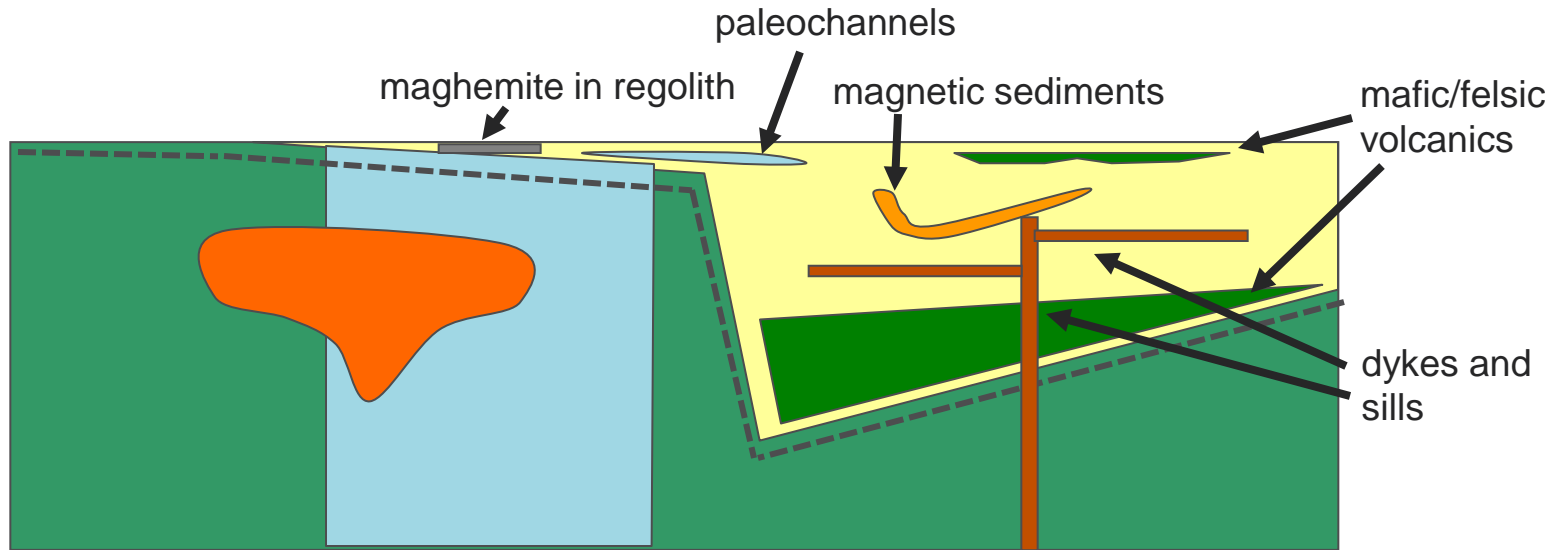
Geological attributing



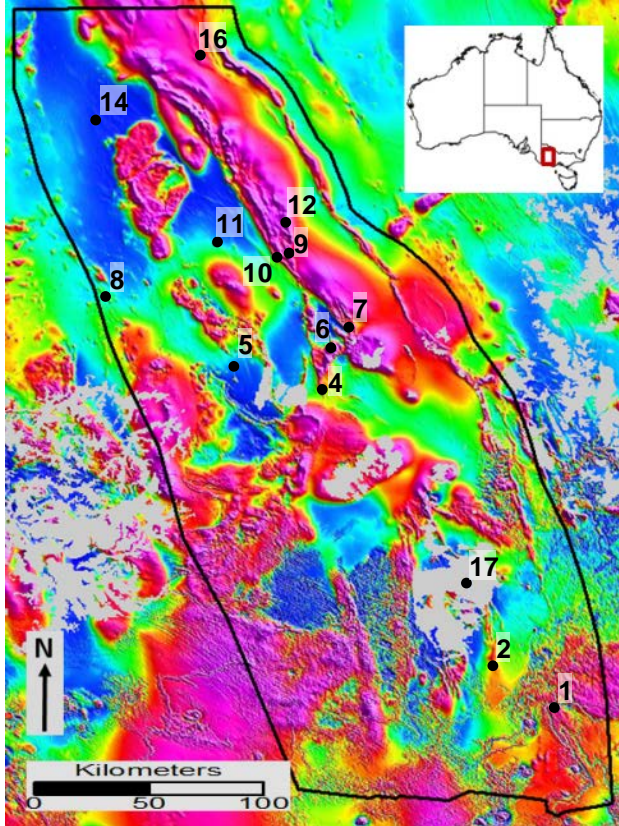
Geological attributing



Geological attributing



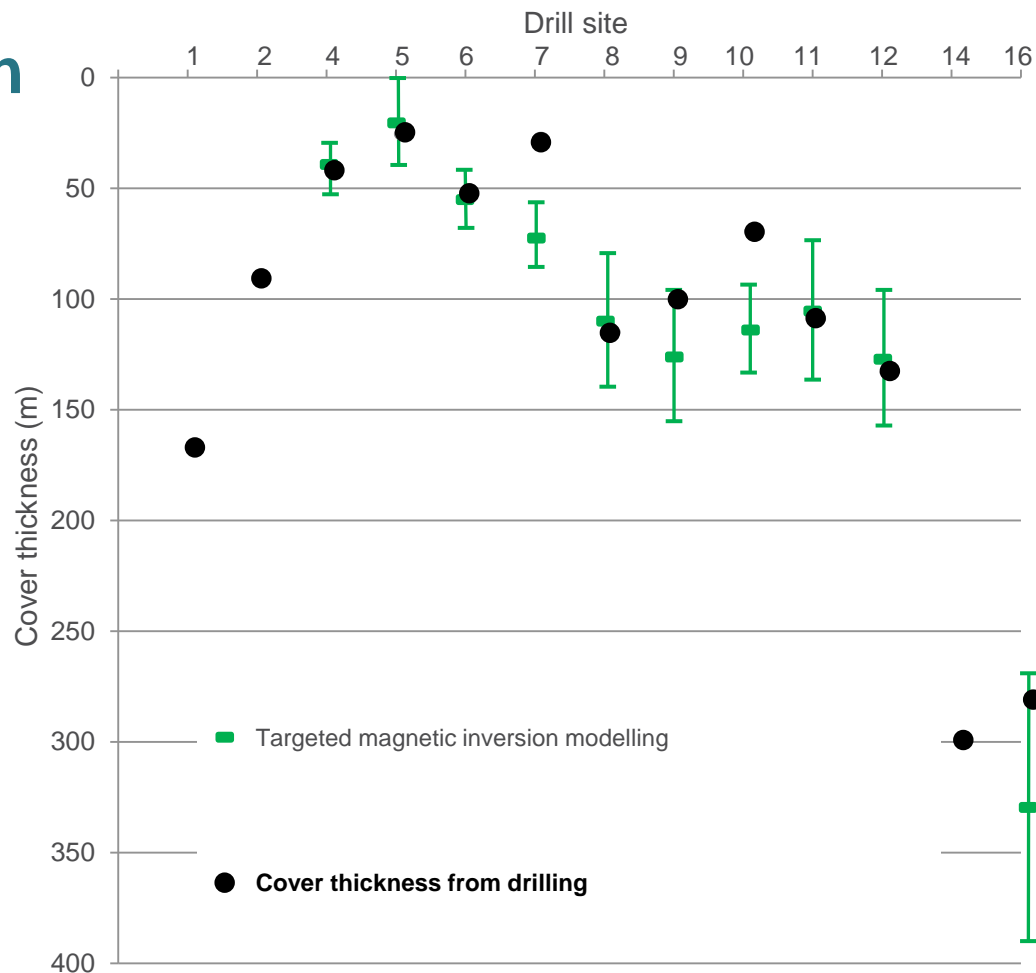
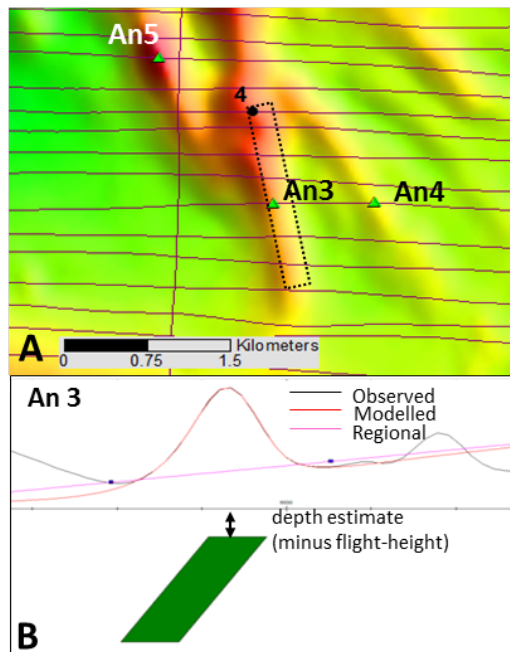
Staveland drilling project: pre-drilling geophysics



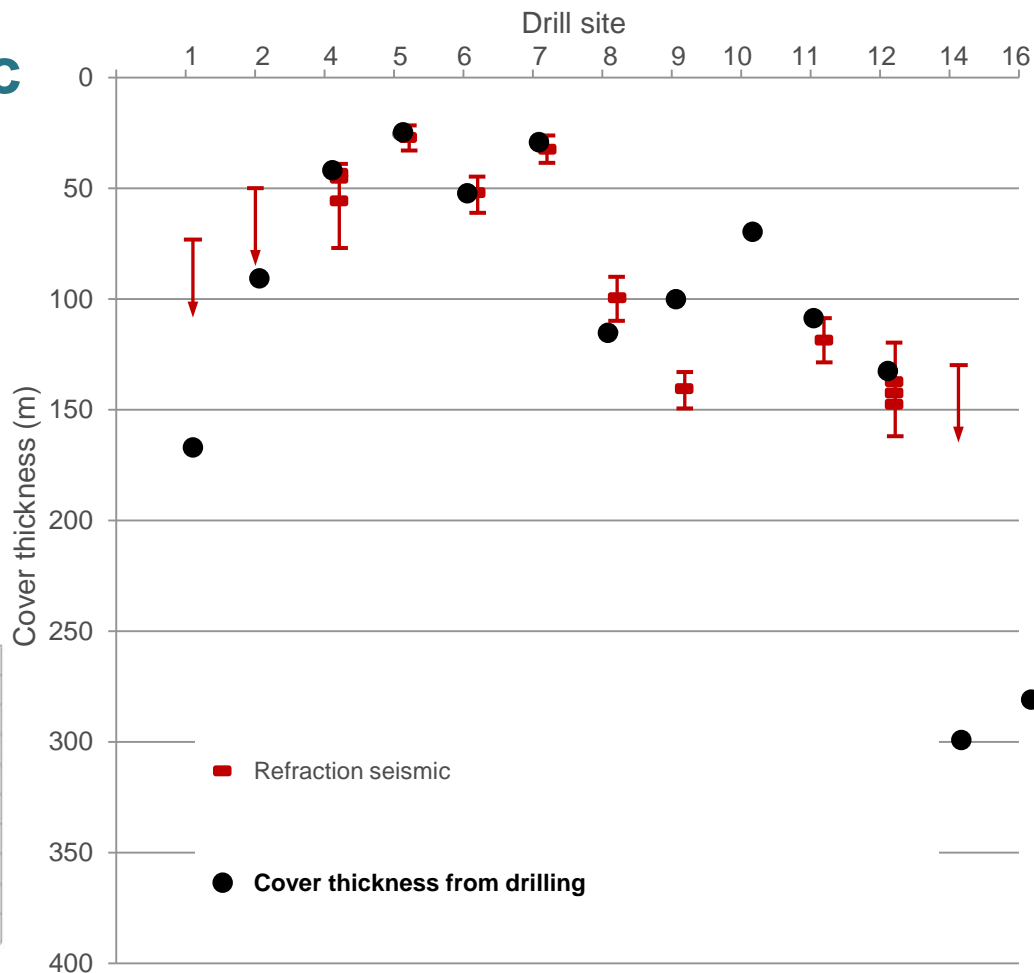
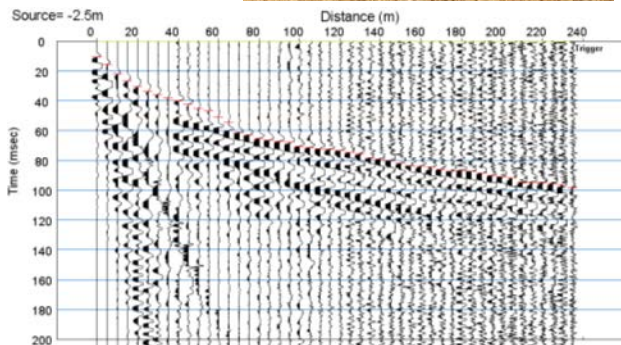
Objectives:

1. Estimate cover thickness – reduce the risk of drilling
2. Investigate a range of geophysical techniques – to provide a ‘tool kit’ for the explorer to delineate cover thickness in greenfield regions.

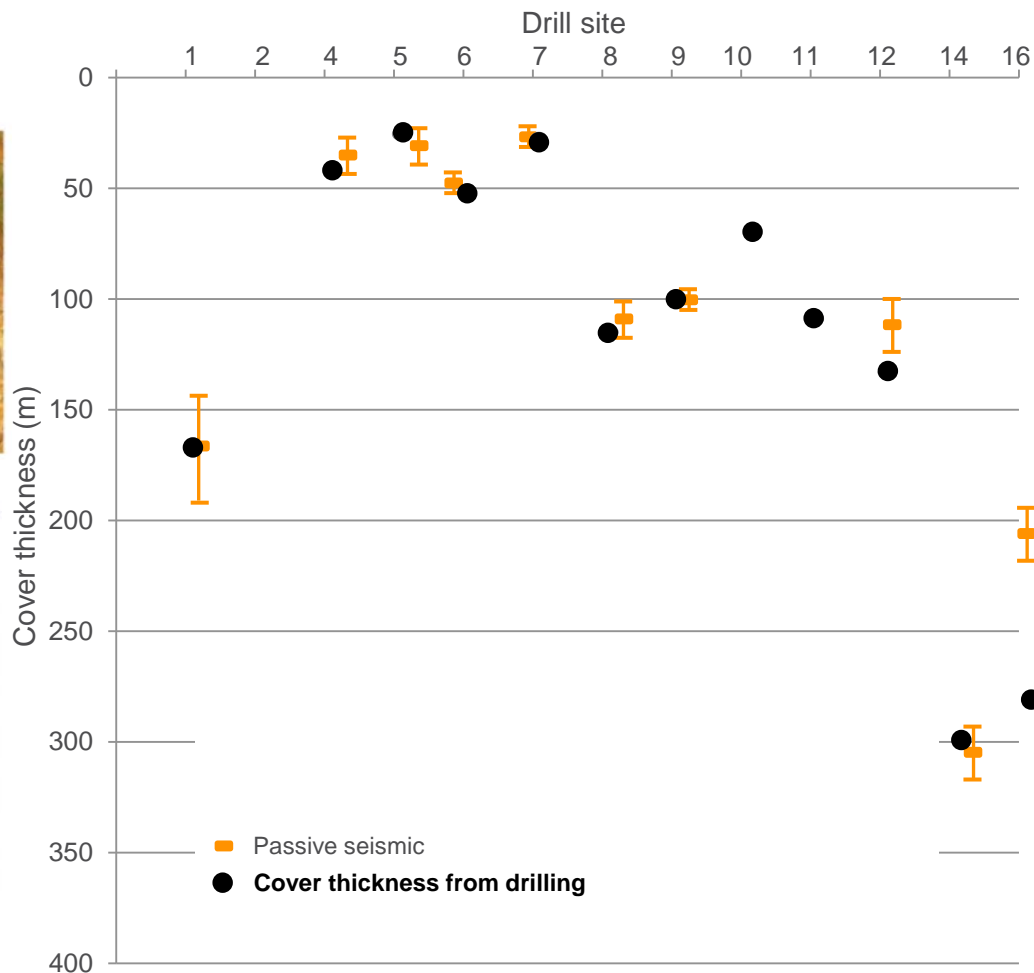
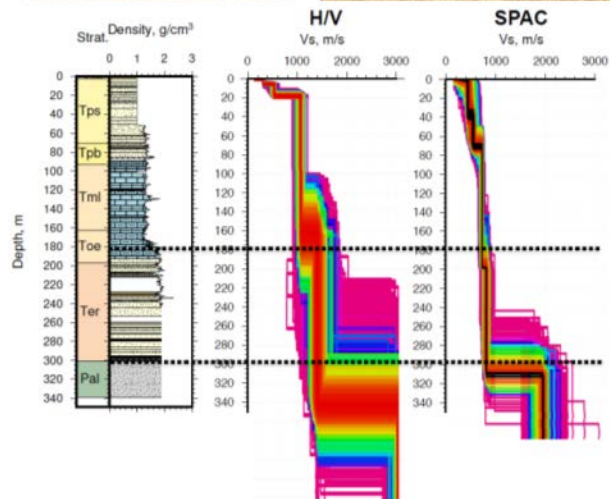
Targeted Inversion Modelling



Refraction seismic

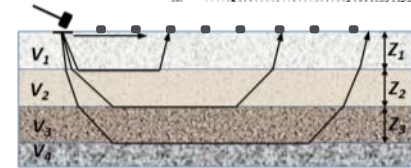
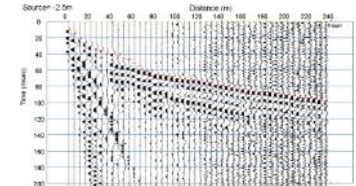
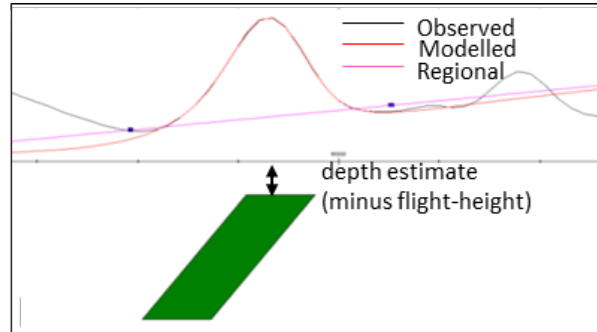


Passive seismic



Conclusions

- Depth to magnetic source methods can provide cover thickness estimation across most of Australia
- Grid based methods produce low reliability results - flight-line based methods produce higher reliability results
- Magnetic depth estimates must be geologically attributed
- If need to know cover thickness accurately (e.g. prior to drilling) use local scale geophysical acquisition (refraction seismic, passive seismic, electrical resistivity, audio magnetotellurics)



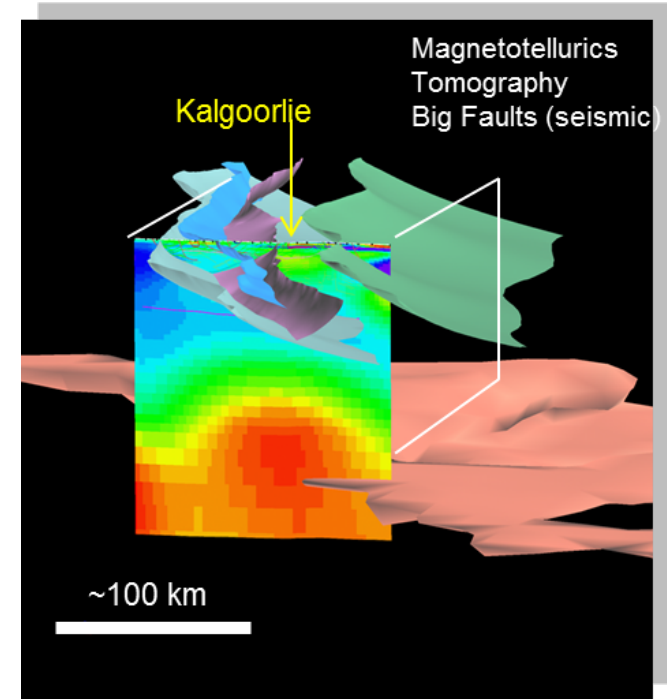
Theme 2: 3D architecture

Science problem: World class mineral deposits result from efficient focussing of metal, fluid and energy through the lithosphere into the upper crust.

What is the architectural record of these fluxes, especially under cover?

Solutions:

- a) Map the lithospheric architecture
- b) Define the crustal architecture
- c) Integrate towards national 3D model





Magnetotellurics:

Illuminating Australia's deep earth using all natural sources of electrical data



Jingming Duan, Leijung Wang, Millicent Crowe, Sarah Buckerfield, Tristan Kemp, *Richard Chopping*
richard.chopping@ga.gov.au

Talk outline

What is MT

How it relates to other electrical methods

Geoscience Australia's MT work, with examples

- Transects to complement seismic sections
- AMT augmenting AEM
- AusLAMP: Illuminating Australia's deep earth

Wrapping up – what about vectors to mineralisation?

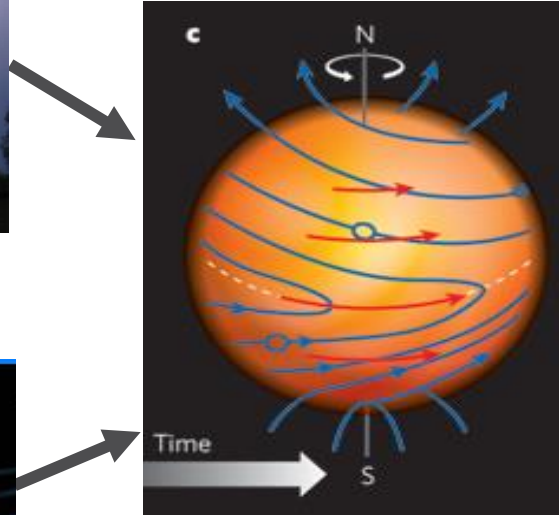


What is MT: the source of signals

1. Lightning



2. Solar wind



Black box - Earth

>1 Hz from
Spherics,
generated by
world-wide
thunderstorms

$F > 1\text{ Hz}$

$F < 1\text{ Hz}$

<1 Hz from
Earth's
magnetic
field
variations
with solar
wind
interactions

Measure time
variations of electric
(E) and magnetic (H)
fields at the Earth's
surface.

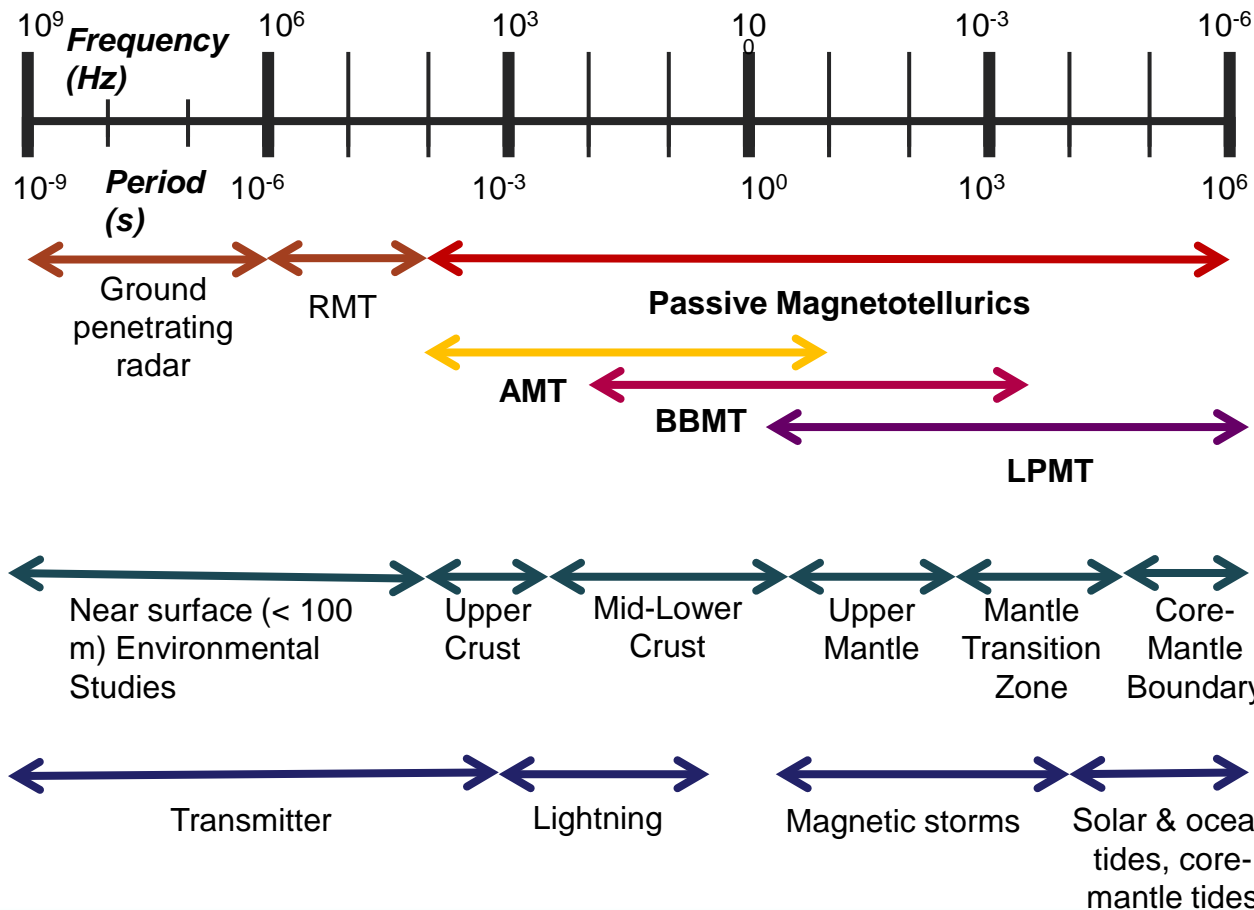
MT DATA

Objective: derive
the geoelectric
structures and
relate it to
geological
structures and
tectonics

THE INPUT

THE OUTPUT

What is MT: the different flavours



Frequency
Period

Techniques

RMT: Radiomagnetotellurics

AMT: Audiomagnetotellurics

BBMT: Broadband magnetotellurics

LPMT: Long-period magnetotellurics

Areas of investigation

Signal sources

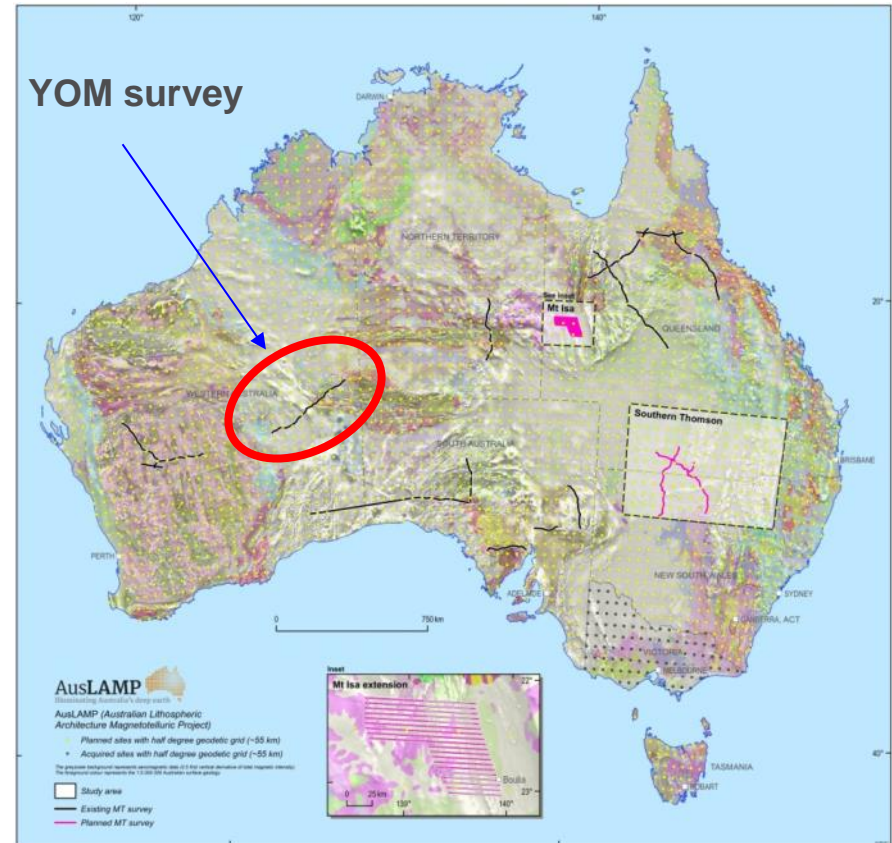
Geoscience Australia's MT program



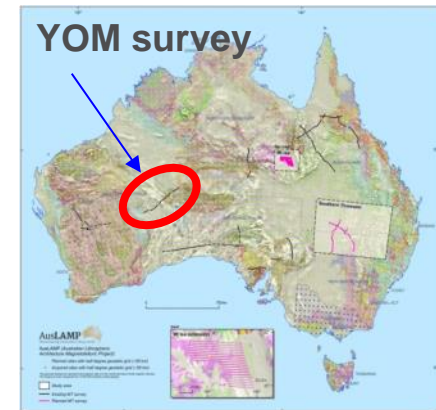
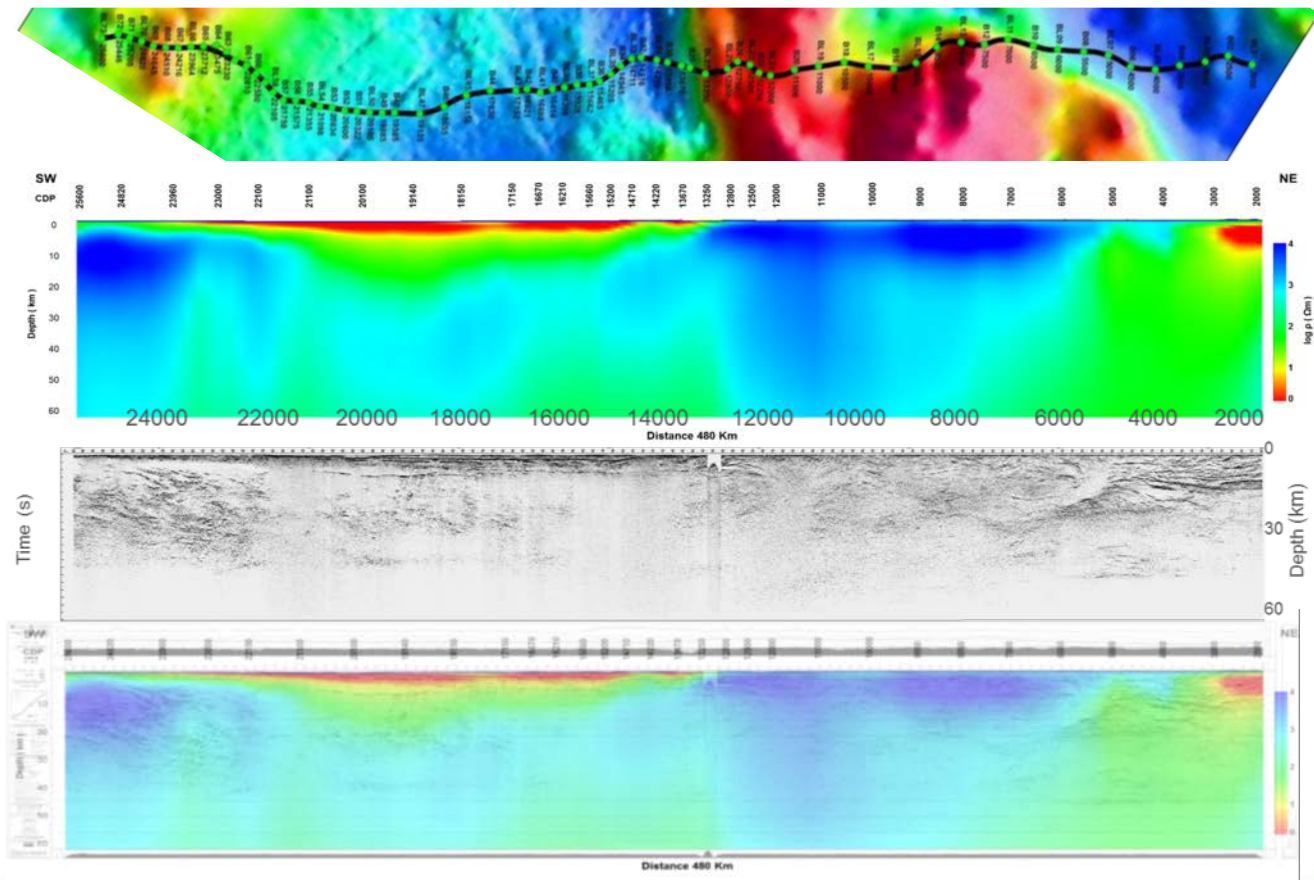
- Large-scale regional and national MT surveys to investigate crustal and lithospheric architectures in Australia
- 16 regional surveys (more than 3000 sites) across potential mineral provinces and frontier sedimentary basins
- The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP) is a collaborative national survey for acquiring LPMT data at approximately 2800 sites with a ~50 km grid spacing

MT complementing deep reflection seismic transects

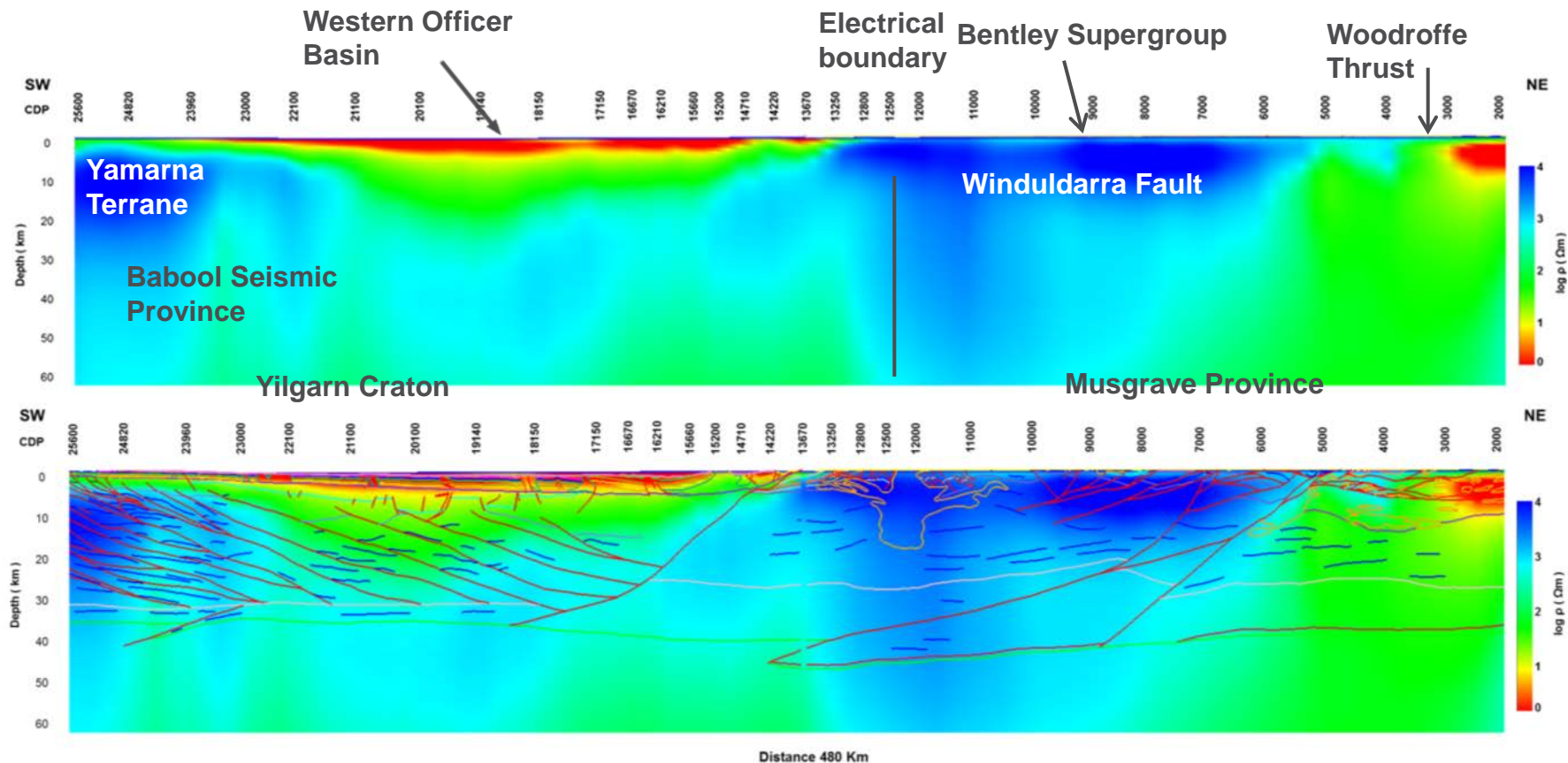
- Yilgarn Craton, western Officer Basin and western Musgrave Province (YOM) MT survey results released to public in 2013
- 73 broadband (BBMT) and 31 long-period (LPMT) sites
- These MT data complement other datasets



MT complementing deep reflection seismic transects

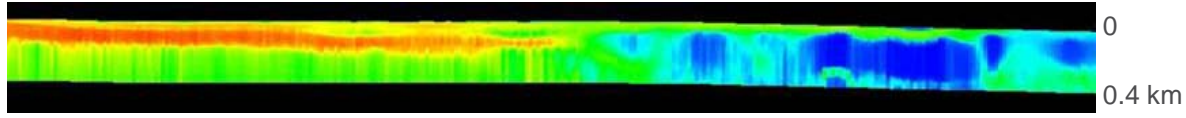


MT complementing deep seismic transects

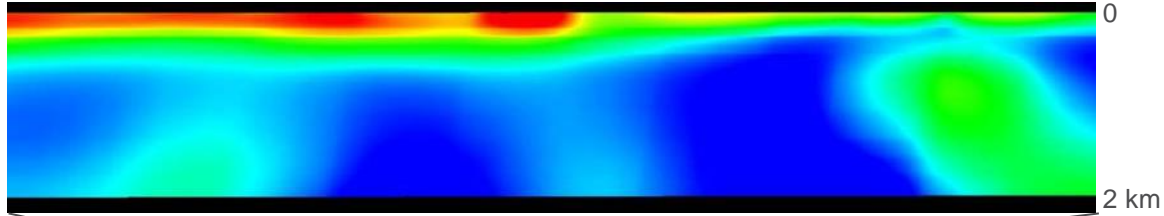


MT to augment AEM

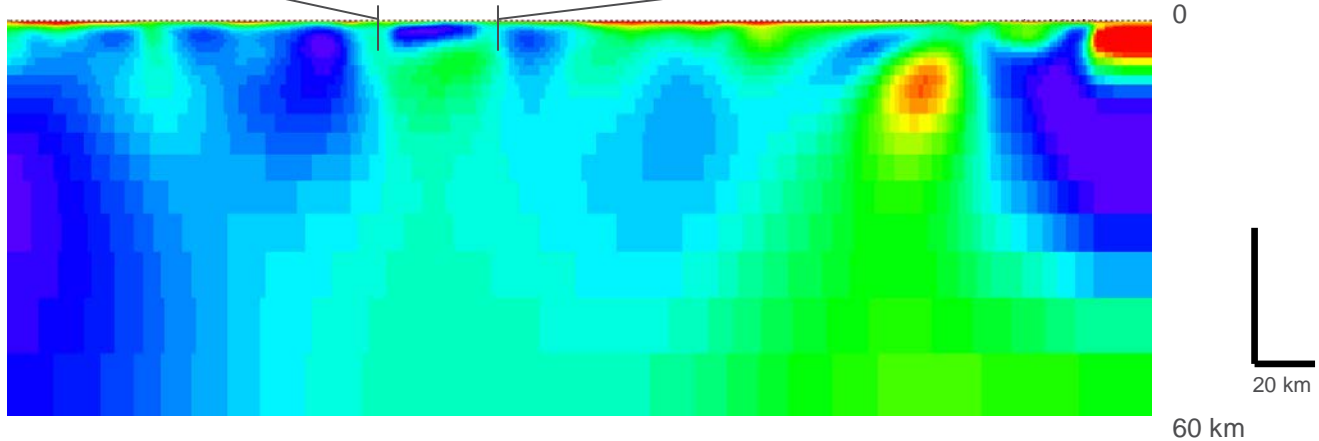
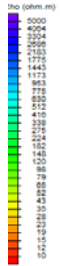
AEM



AMT



BBMT

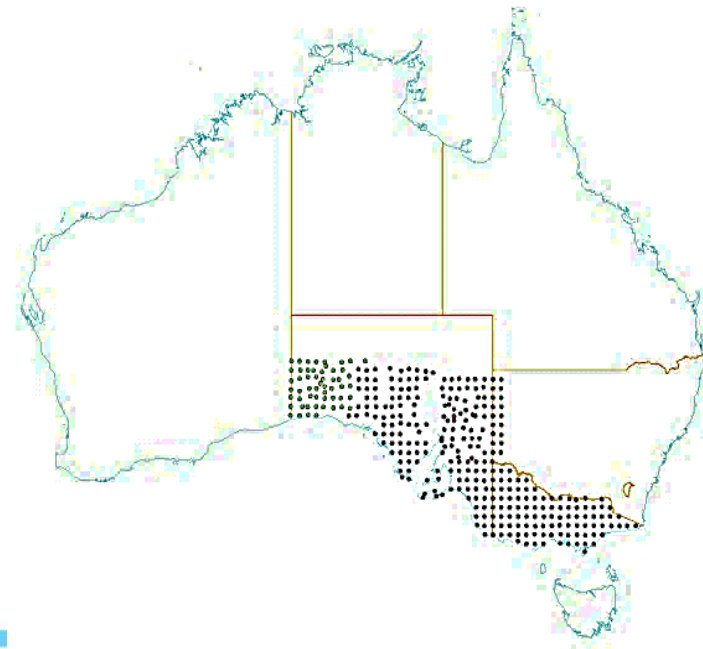
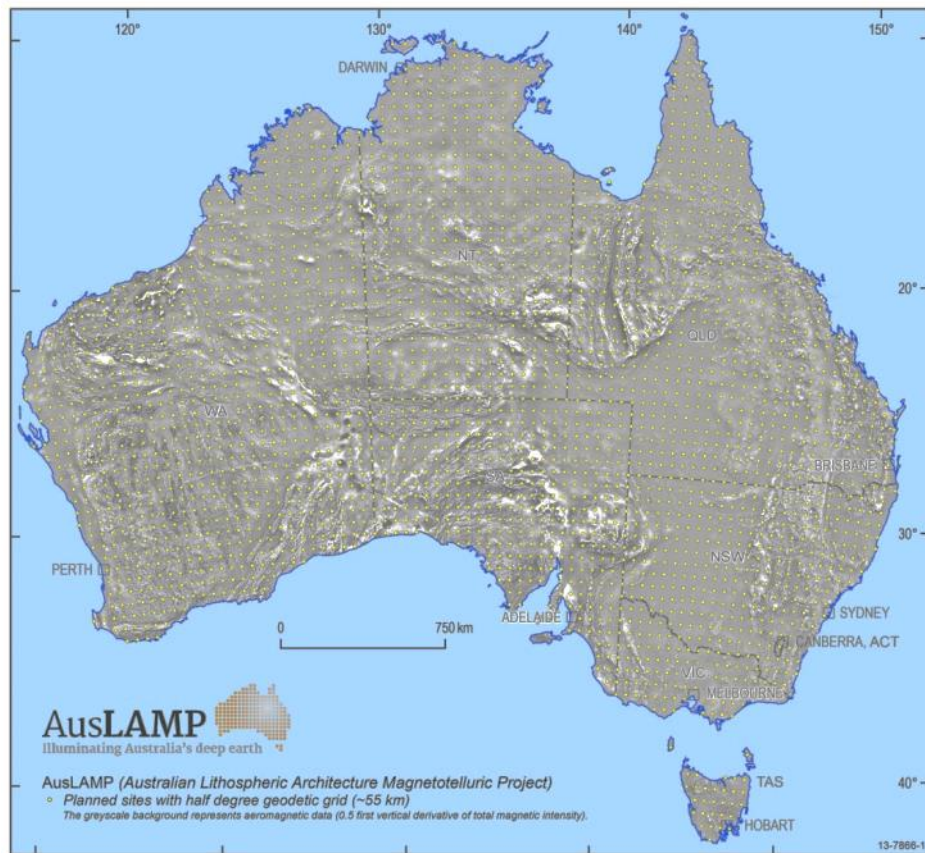


AusLAMP

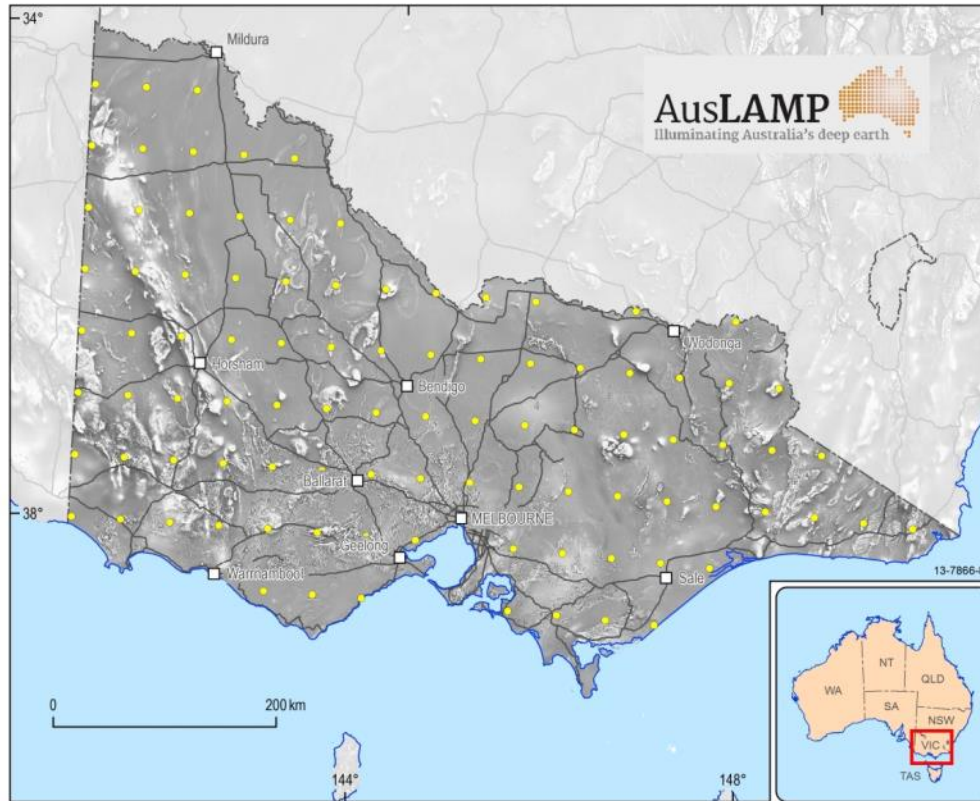
The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP), aims specifically to illuminate Australia's deep electrical structure

LPMT ~2800 sites with a ~50 km grid spacing

AusLAMP-VIC is the first survey for the project.

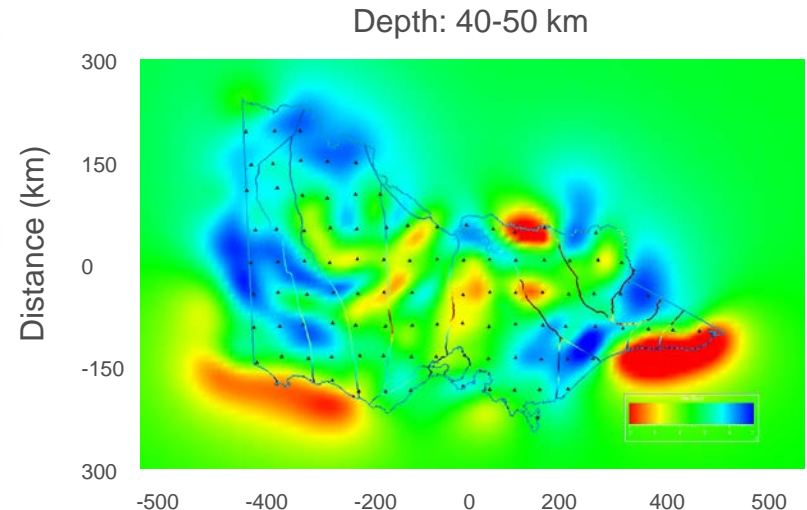


AusLAMP: Victoria

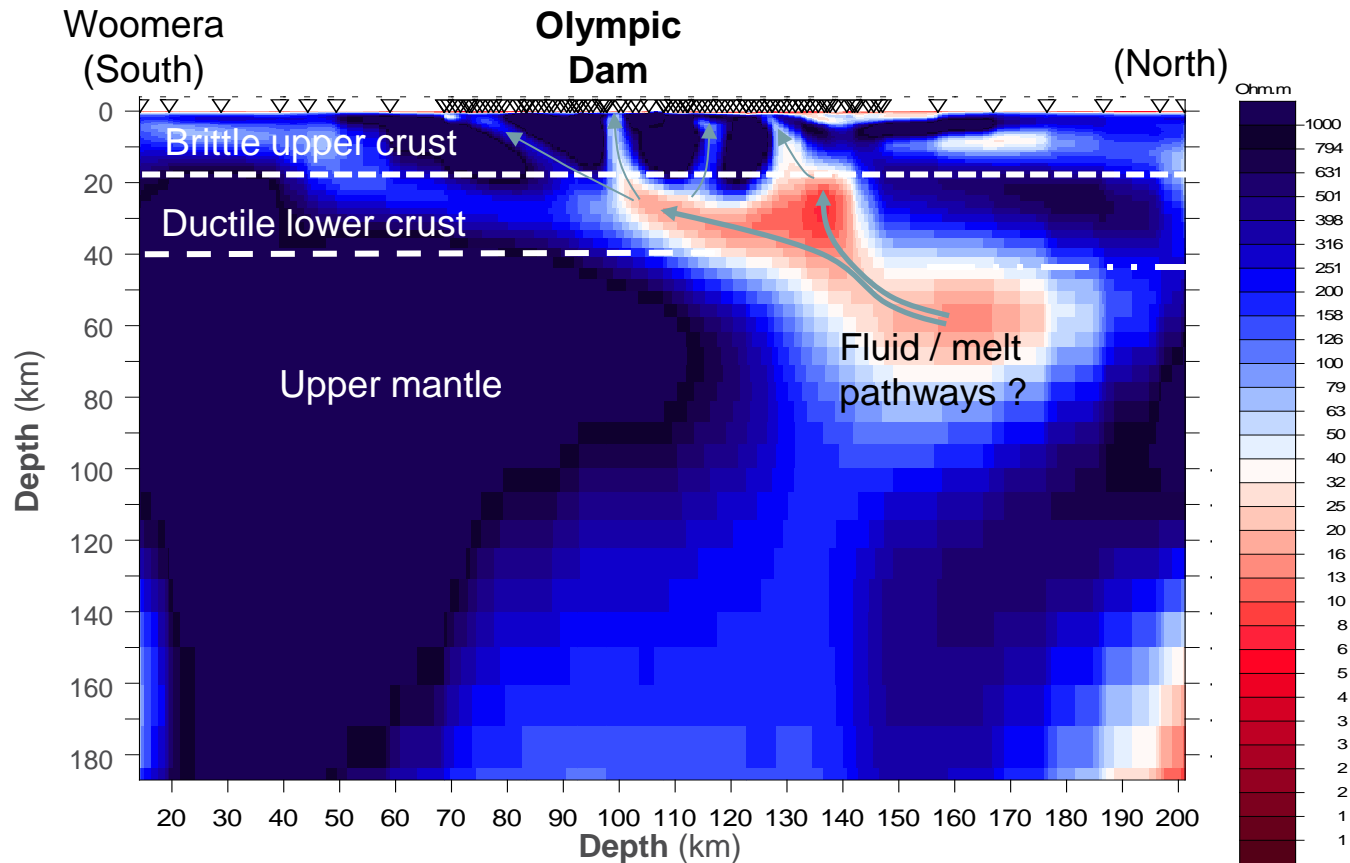


AusLAMP (Australian Lithospheric Architecture Magnetotelluric Project)
● Planned sites with half degree geodetic grid (~55 km)
The greyscale background represents aeromagnetic data (0.5 first vertical derivative of total magnetic intensity).

- 7 months for data acquisition
- 4 months for data processing
- Data analysis and modelling are in progress
- Data release due very shortly!



MT and mineralisation...



Example from Graham Heinson,
University of Adelaide

High resolution LPMT
across the Stuart Shelf

Highlights alteration
pathways in the lithosphere
beneath Olympic Dam

Although the LPMT
deployments for AusLAMP
cannot reach this
resolution in the upper
crust, they can resolve the
broad scale features that
are indicative of
mineralised terranes

GA MT work program 2015-2016

AusLAMP is our priority going forwards for the broadest scale electrical structures across Australia

Working with states to acquire more regional scale broadband data as required, e.g. Cloncurry and Southern Thompson regions

Working with research organisations on further developments to processing and modelling

- Standards for MT products
- Better utilisation of high-performance computing for MT

Web based delivery of data and model products

In short: lots of stuff to do, lots of good stuff to come from it!

Conclusions

MT adds considerable knowledge to the structure of Australia

MT results are directly comparable with other datasets

Our final unknown property is conductivity

AusLAMP well underway with Victoria and 50% of SA completed (70% by EoY)

Potential to map structures unobserved in other datasets

Contact us for further info: richard.chopping@ga.gov.au or magnetotelluric@ga.gov.au





Australian Government
Geoscience Australia



The seismic database of Australia: A continent in cross section



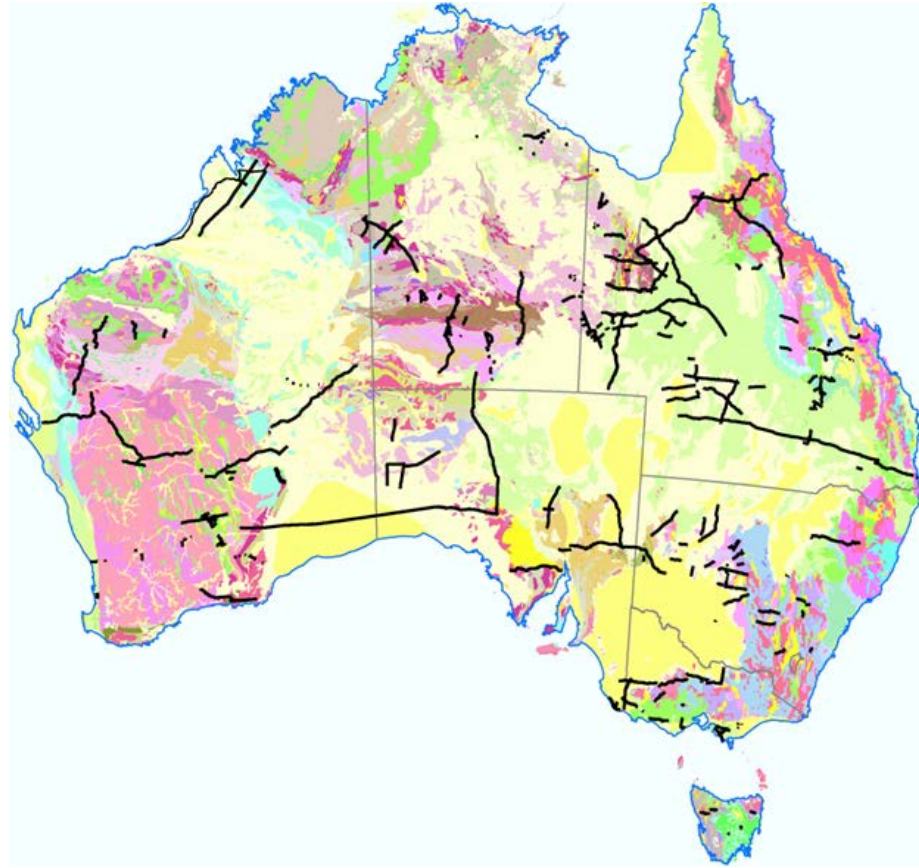
Onshore Seismic and MT Section

Ross.Costello@ga.gov.au

The Deep Crustal Seismic Data

**Deep Crustal Seismic
(Refraction and
Reflection) since
1950's**

**Digital recording of
Reflection Seismic
Lines collected by
BMR/AGSO/GA in
collaboration with
state geological
surveys
1976 – 2015**



Surveys

Deep Crustal

Reflection Seismic

Lines

Explosives

1976-1999 —

Vibroseis

1999-2013 —

2013-2015 —



Surveys

Deep Crustal Reflection
Seismic

Energy Source

Pre 1999 – Explosives



Georgina Basin 1977



Eastern Lachlan 1997



Surveys

Deep Crustal Reflection
Seismic

Energy Source

From 1999 – Vibroseis



The Deep Crustal Seismic Data

Progress of
acquisition and
processing

BMR91-EGF1
(explosives)

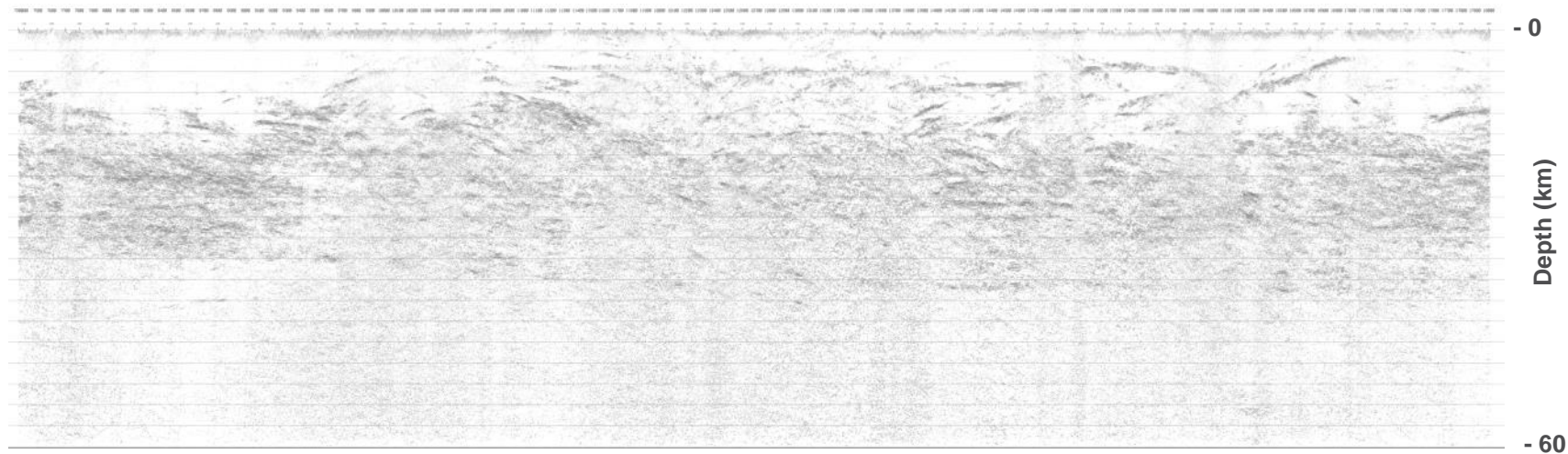
01AGS-NY1
(vibroseis)

10GA-YU2
(vibroseis)



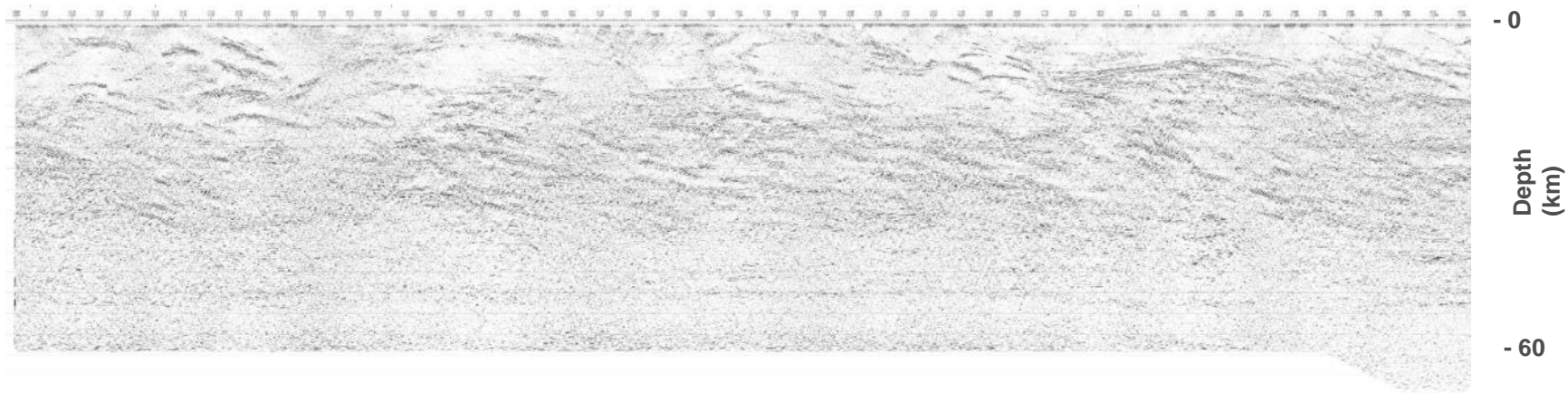
Surveys

BMR91-EGF1 96 Channels



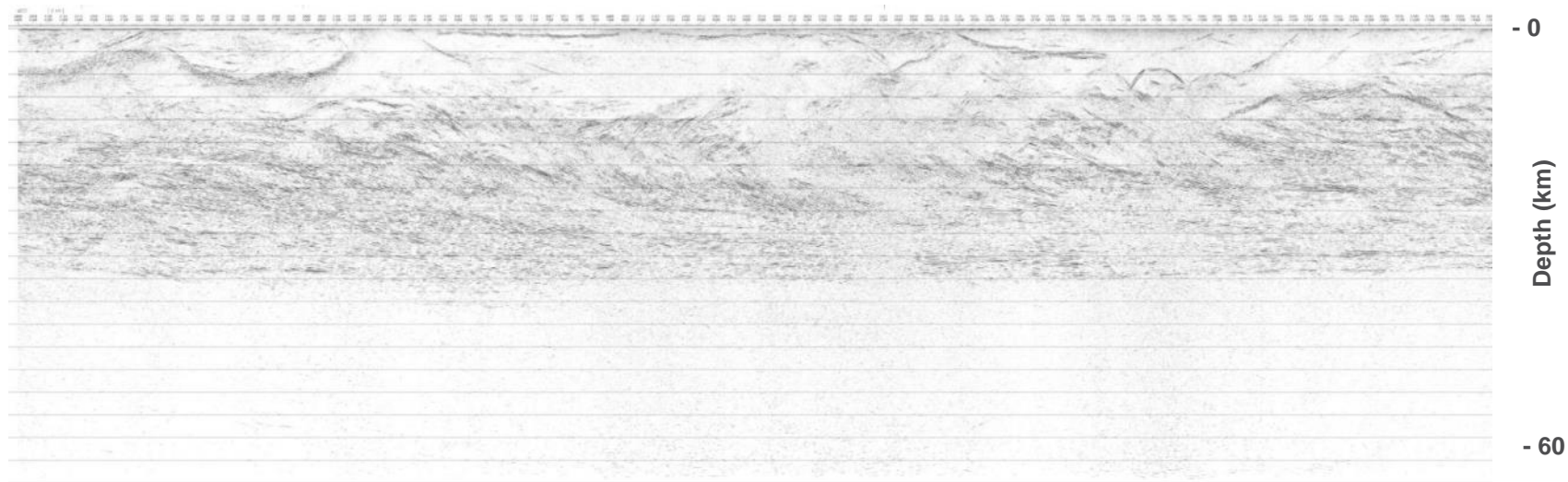
Surveys

01AGS-NY1 240 Channels



Surveys

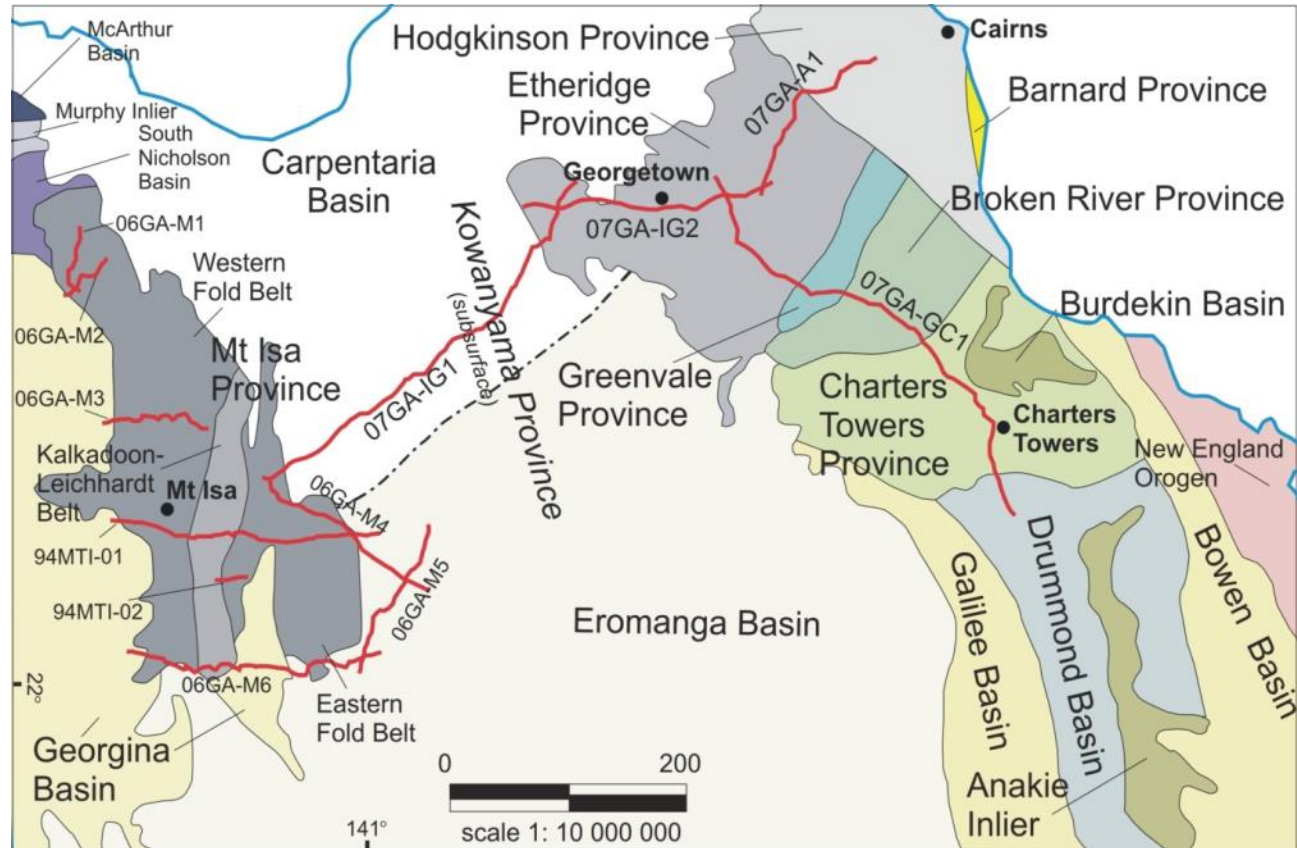
10GA-YU2 300 Channels



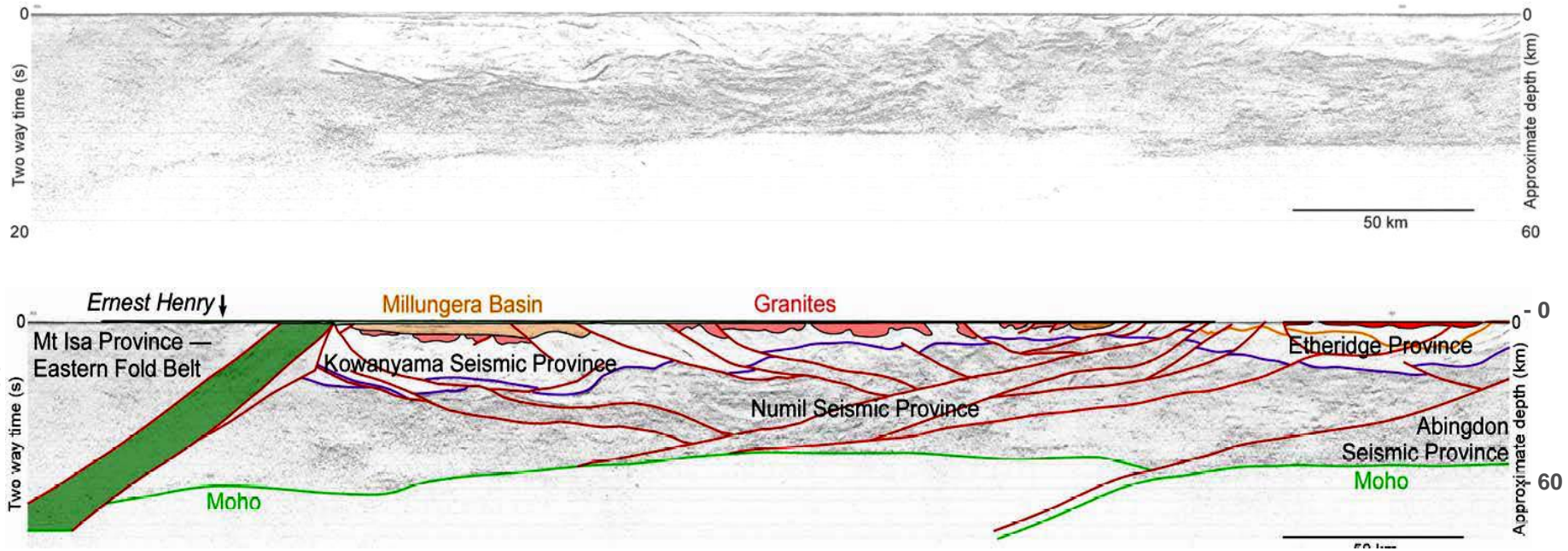
Surveys

07GA-IG1

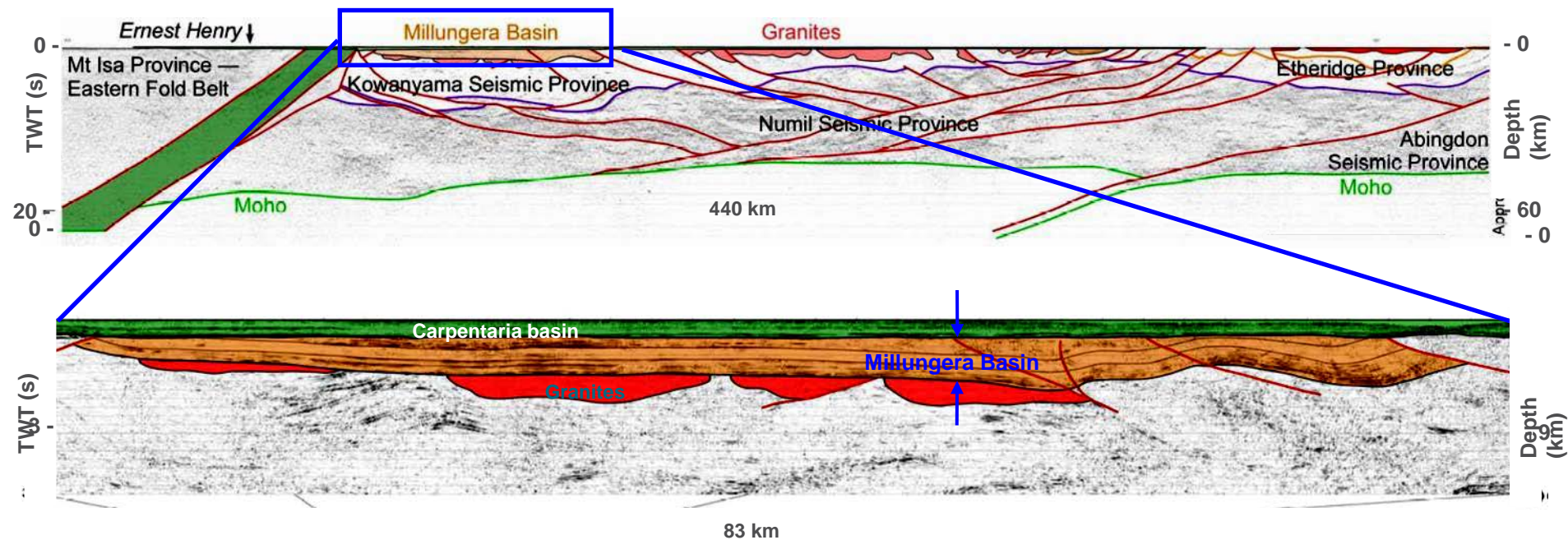
GA/GSQ



Survey Isa-Georgetown 07GA-IG1



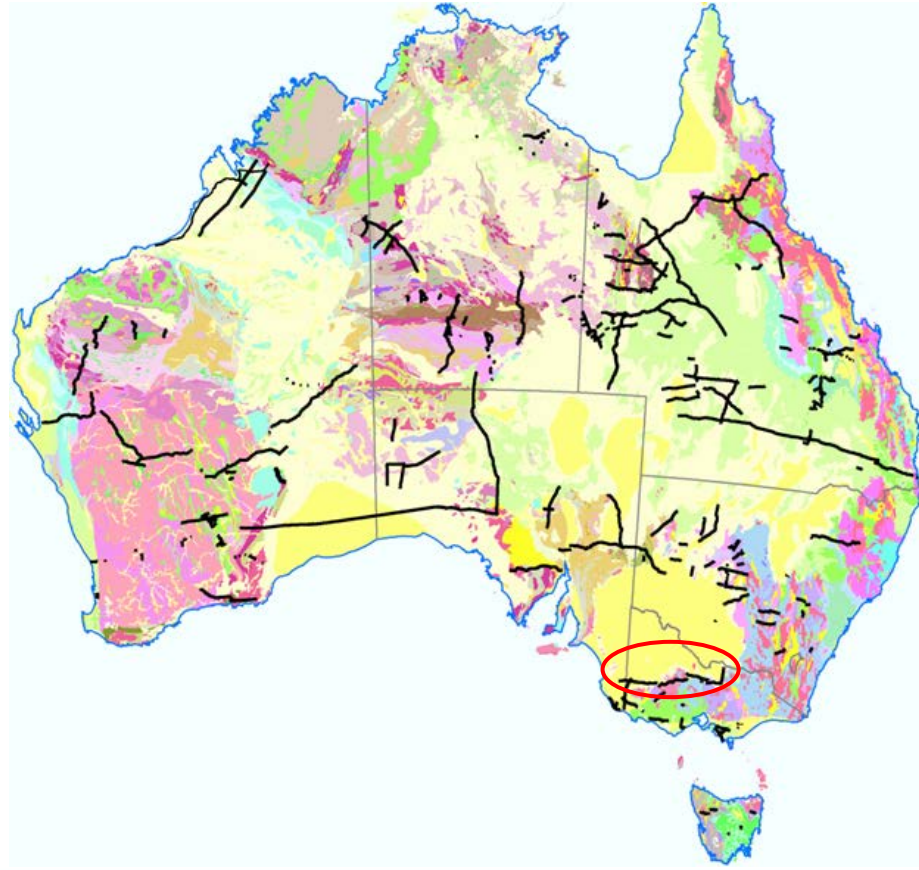
Survey Isa-Georgetown 07GA-IG1



The Deep Crustal Seismic Data

2006 Central Victoria
Survey

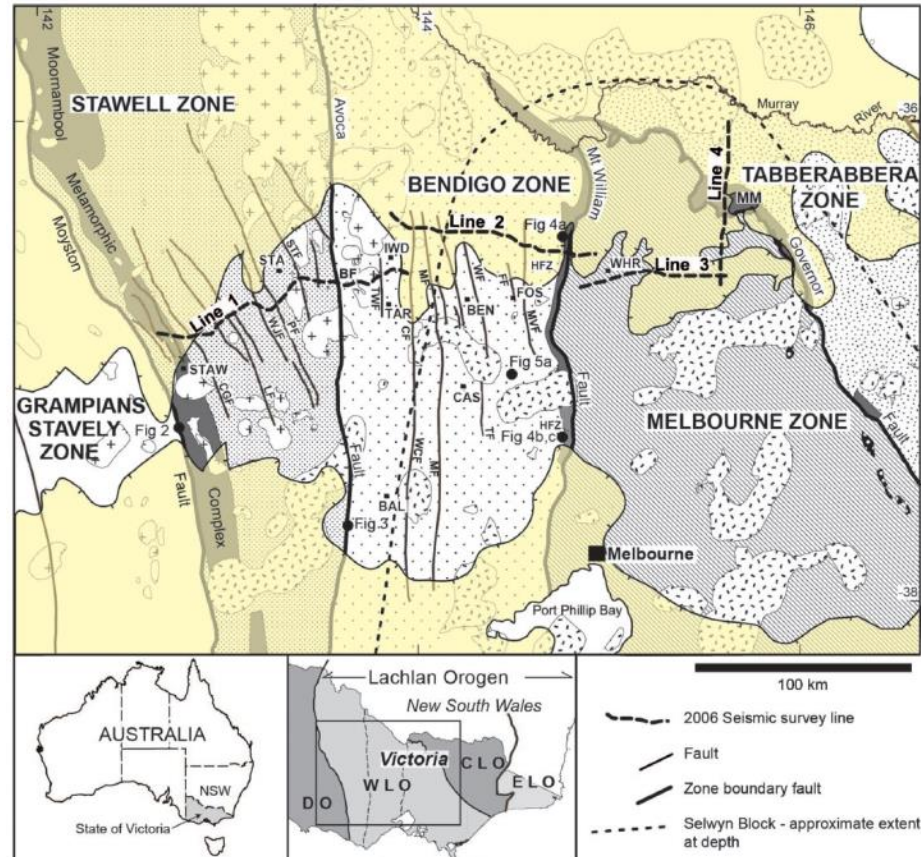
GA/GSV



The Deep Crustal Seismic Data

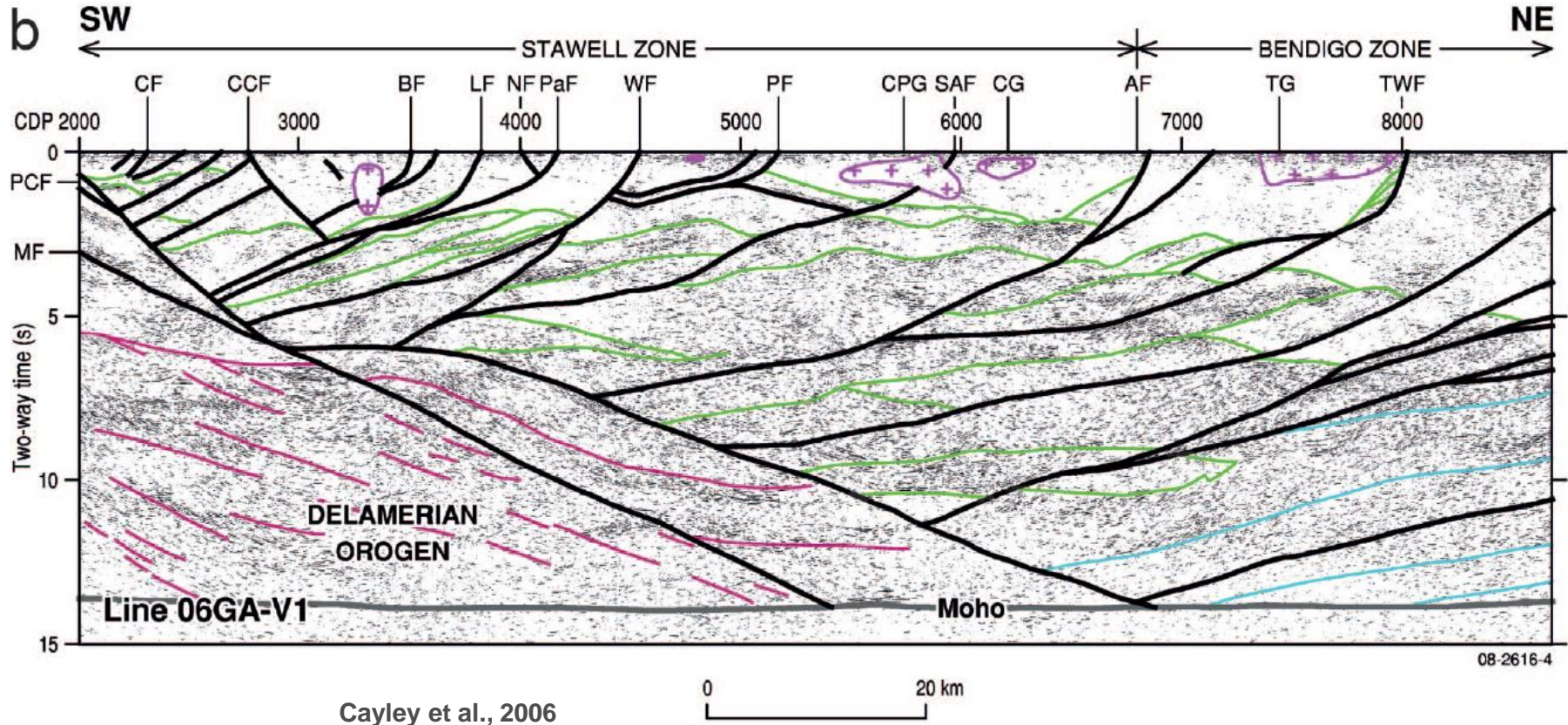
2006 Central Victoria Survey

GA/GSV

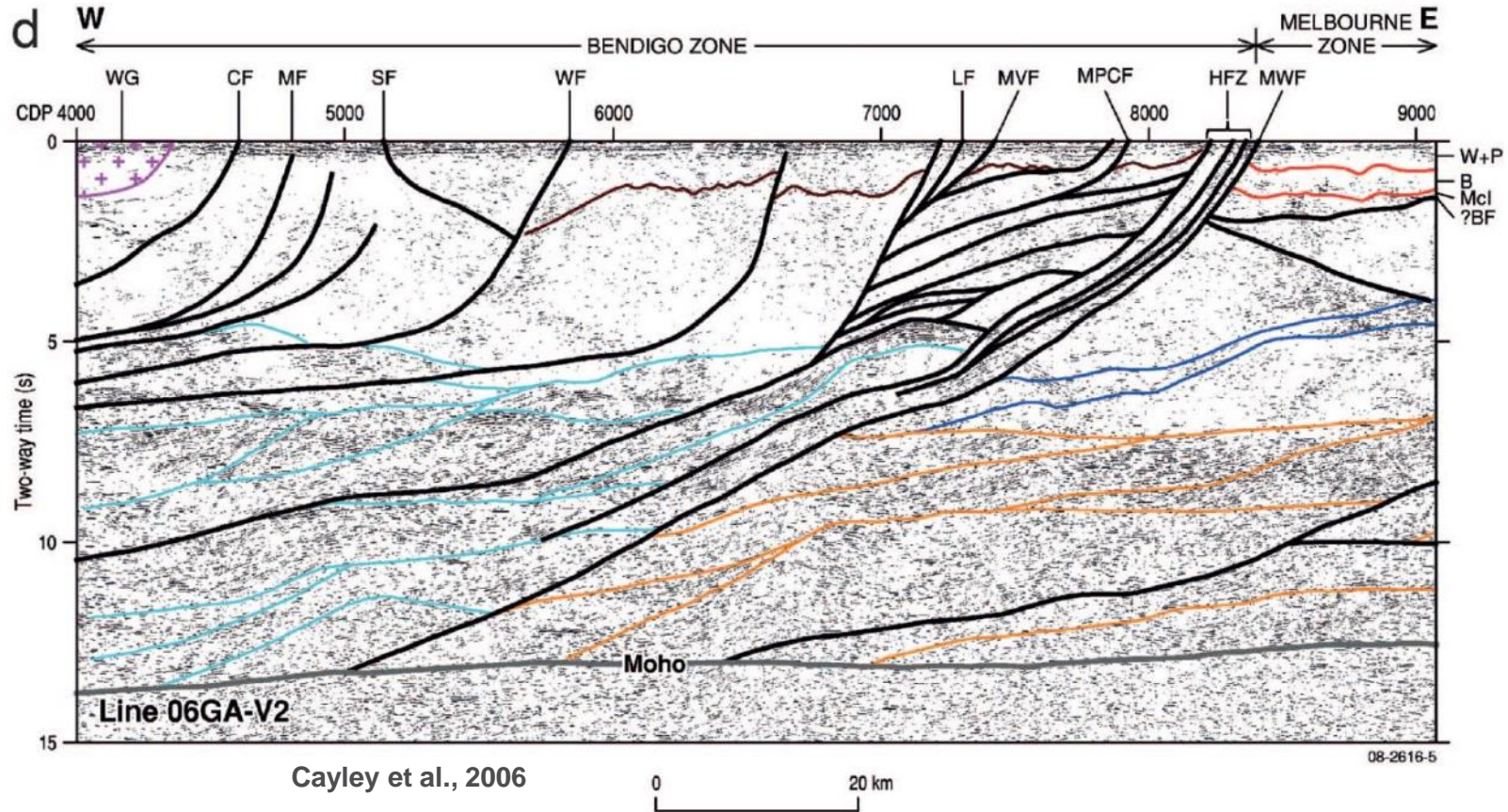


Cayley et al., 2006

The Deep Crustal Seismic Data

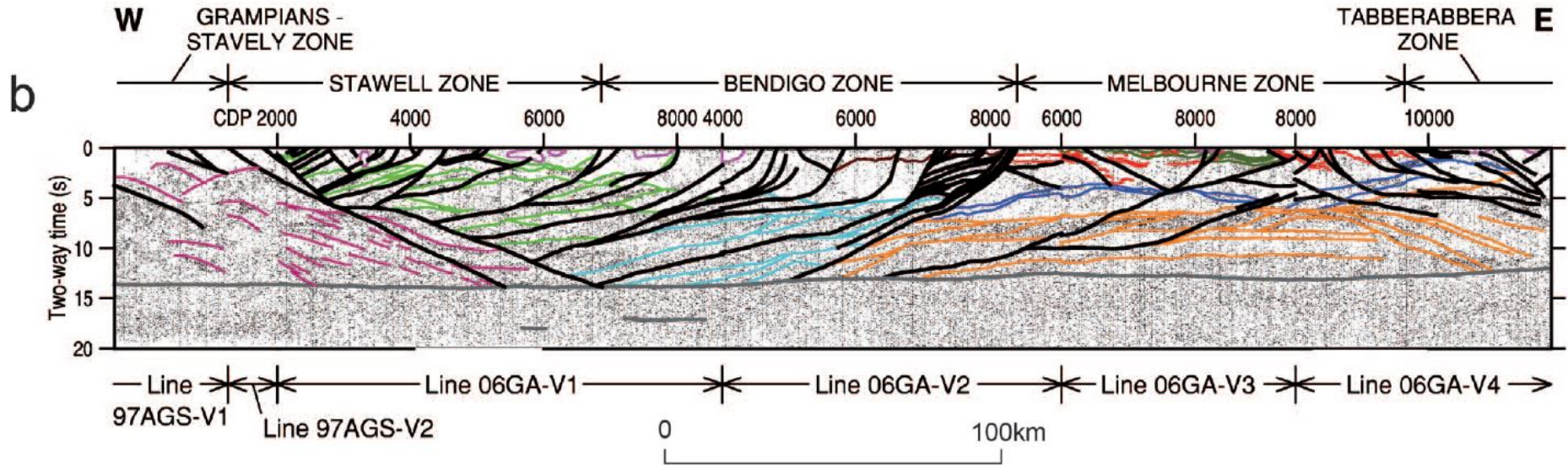


The Deep Crustal Seismic Data



The Deep Crustal Seismic Data

2006 Central Victoria Survey



Cayley et al., 2006

The Deep Crustal Seismic Data – Recent Surveys

**SA (Eucla-Gawler)
GA/DMITRE**

**Collected 2013/14
374 km @ 20 seconds**

Release September 2015



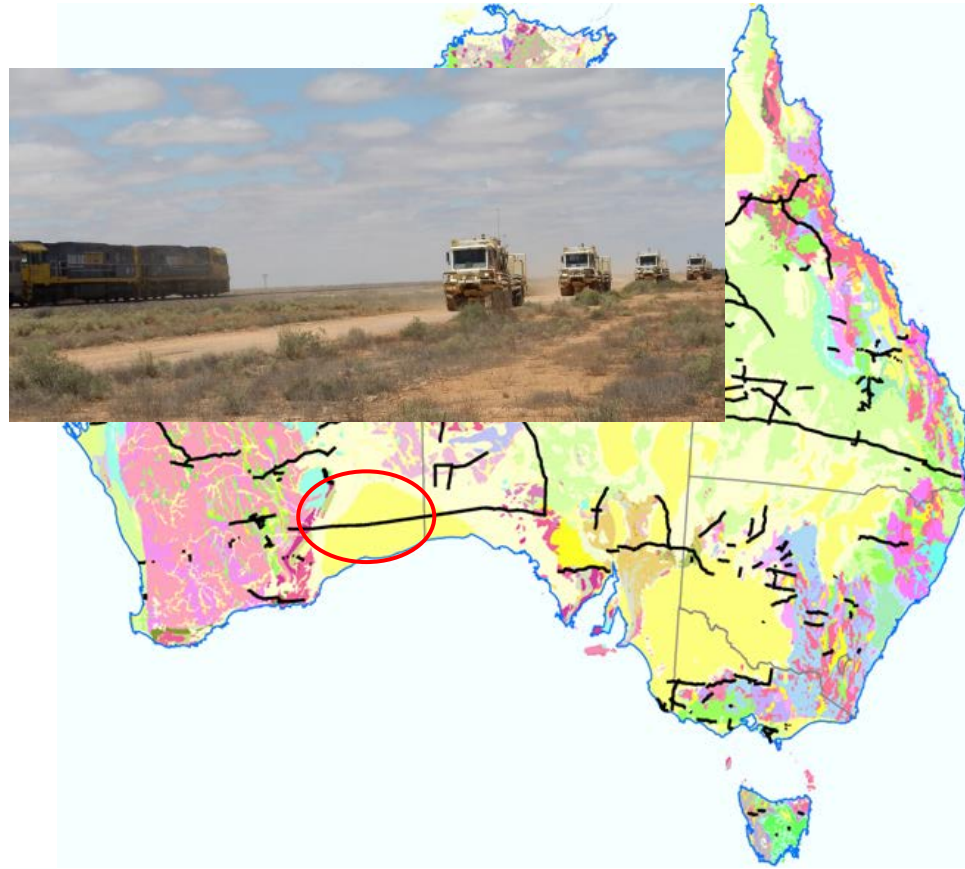
The Deep Crustal Seismic Data – Recent Surveys

**WA (Eucla-Gawler)
GA/GSWA**

**Collected 2013/14
460 km @ 20 seconds**

**Image beneath Eucla
Basin – relation between
Yilgarn/Albany-
Fraser/Gawler**

Release June 2016



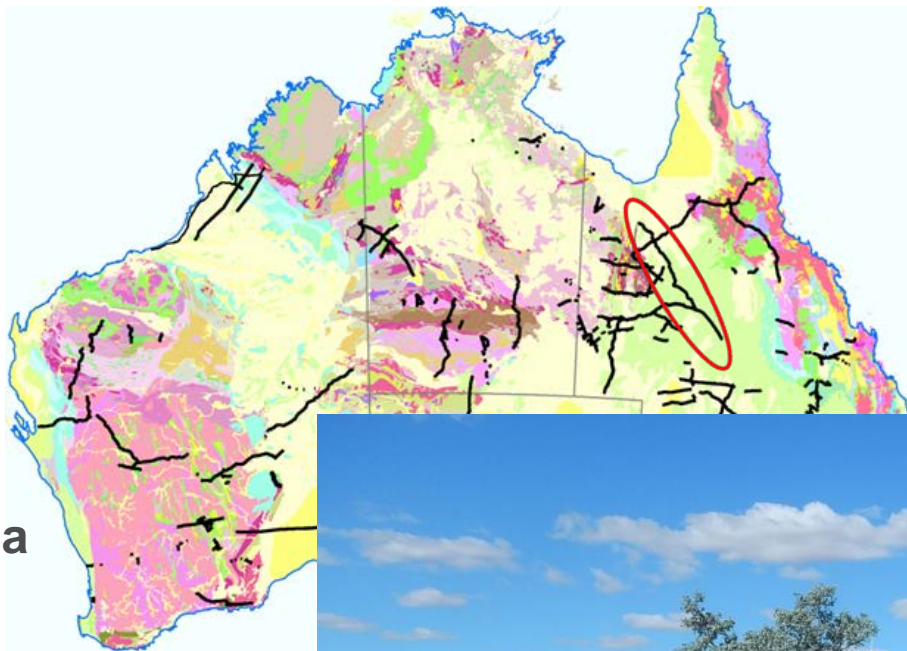
The Deep Crustal Seismic Data

**Southeastern Mt Isa
GA/GSQ**

**Collected 2014
670 km @ 20 seconds**

**Cork Fault
Relation to overlying basins
Millungera, Galilee, Eromanga**

Release September 2015



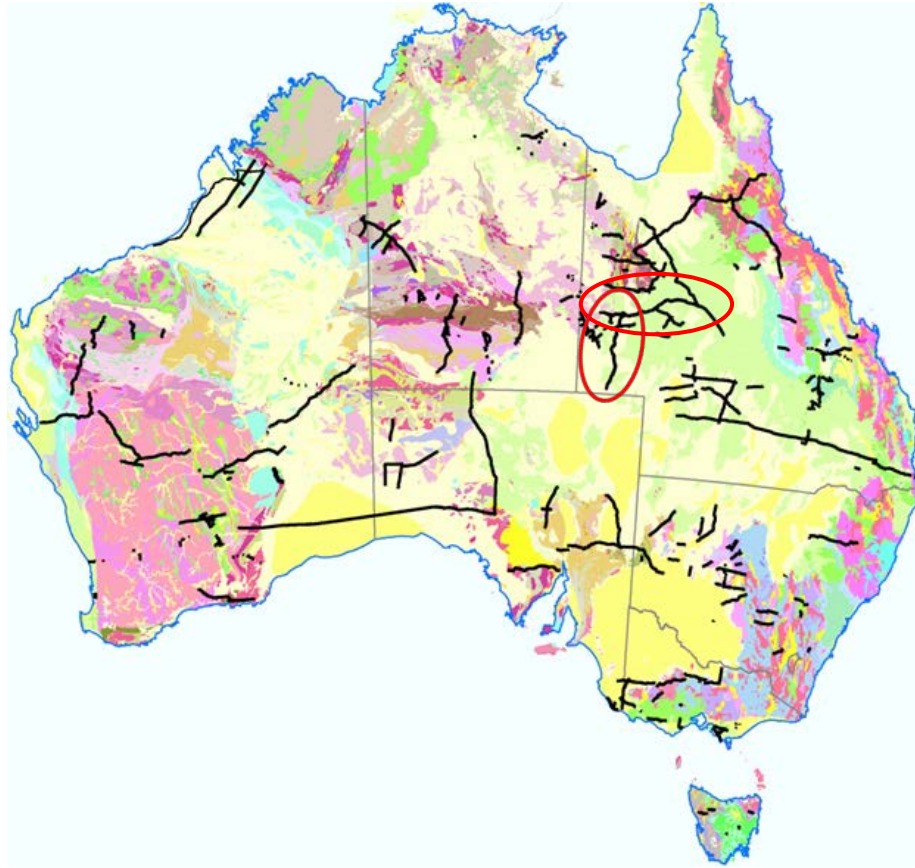
The Deep Crustal Seismic Data

**Boulia and Boulia Extension
GA/GSQ**

**Collected 2015
847 km @ 20 seconds**

**Cork Fault
Mount Isa Inlier
Thomson Orogen
Galilee, Eromanga Basins**

**Release September 2015
Early 2016 (processed)**



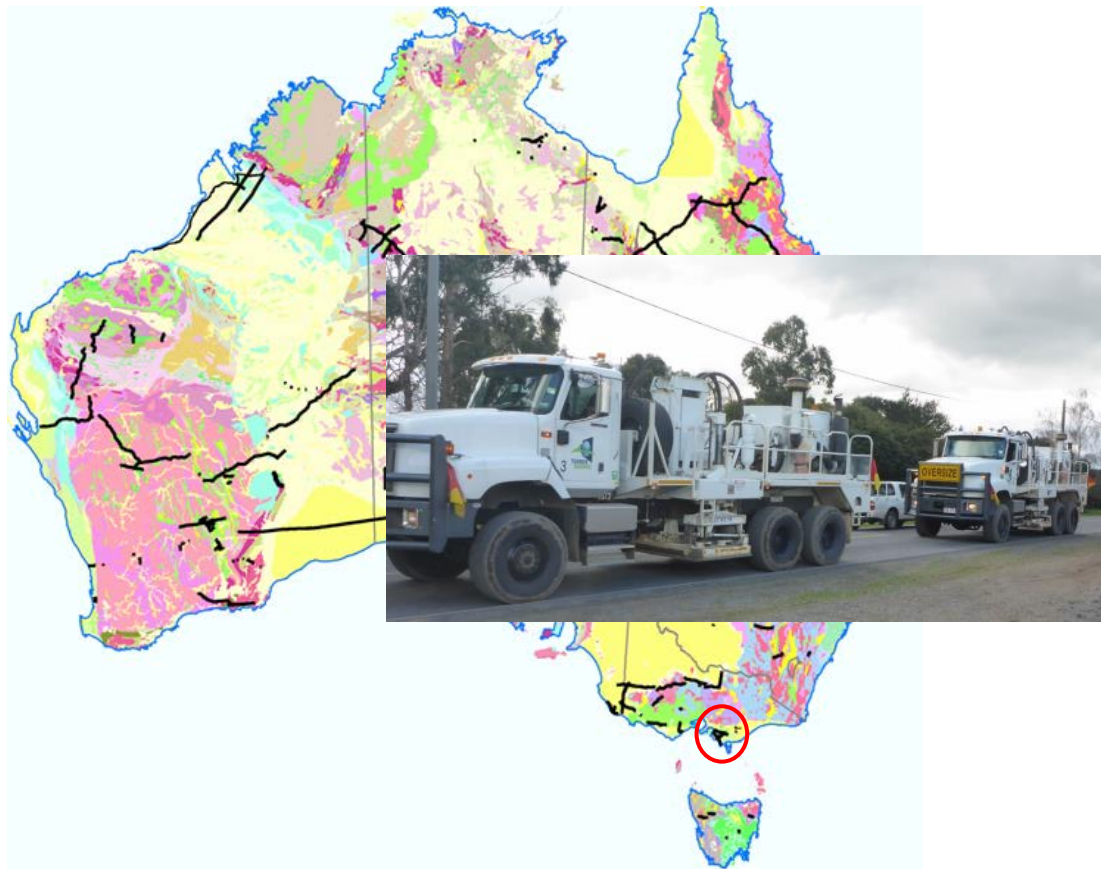
The Deep Crustal Seismic Data

**South Gippsland
GA/GSV**

**Collected 2015
203 km @16 seconds**

**Geometry of Strzelecki
Group,
Gippsland Basin
Architecture of Basement**

Release Early 2016



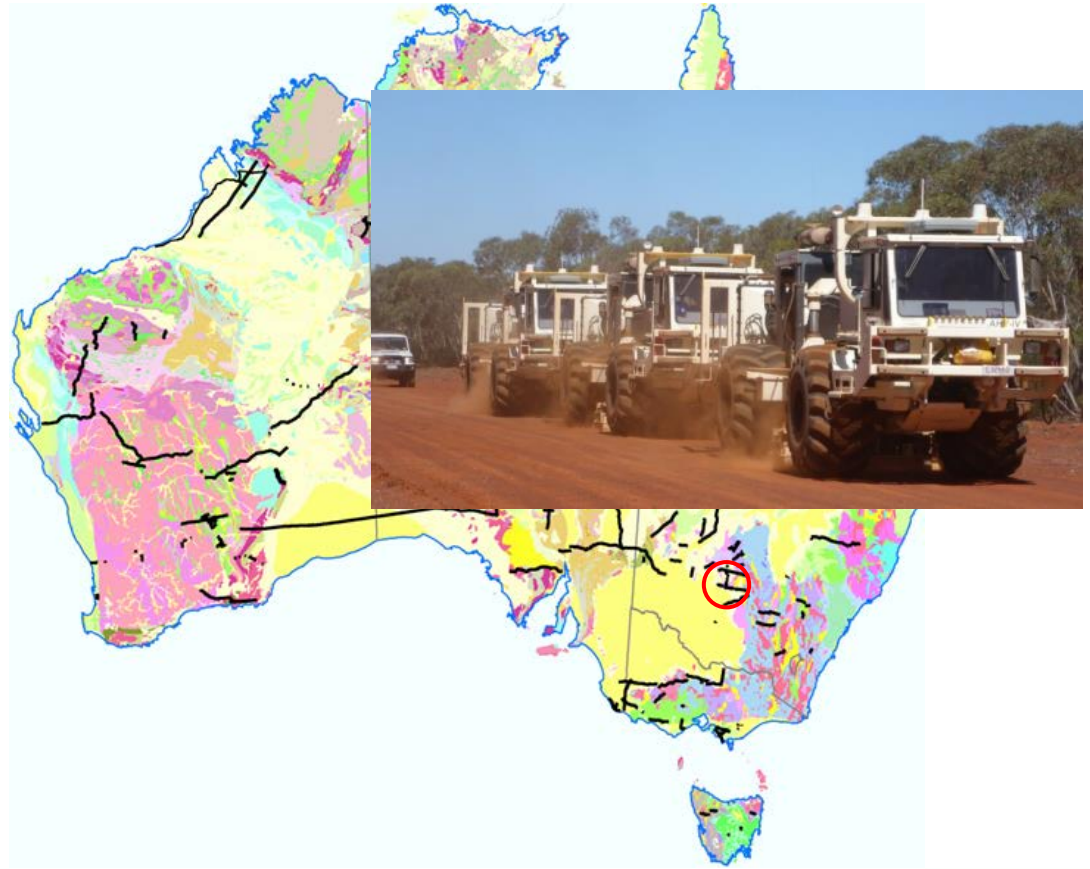
The Deep Crustal Seismic Data

**Yathong Trough
GA/GSNSW**

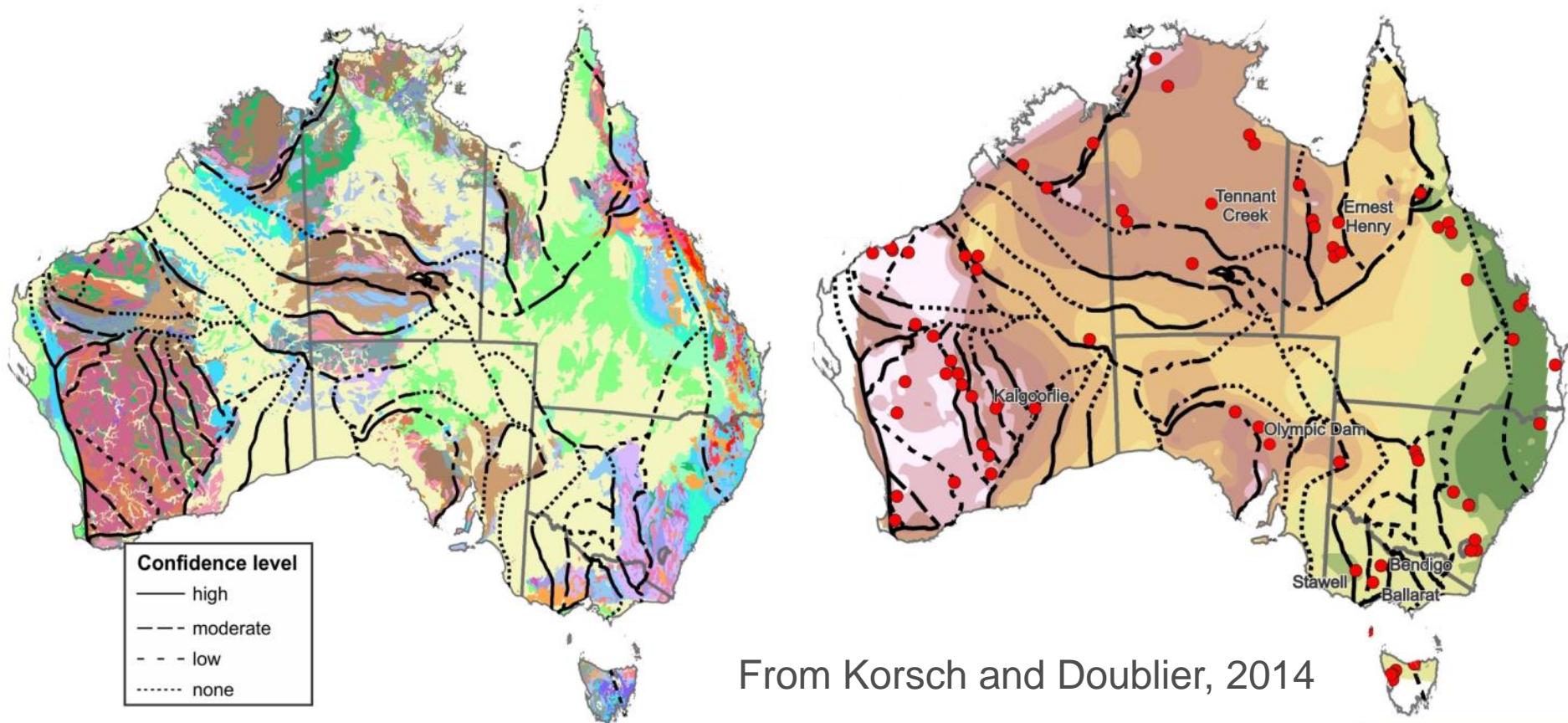
**Collected 2013
230 km @ 22 seconds**

**Geometry of Yathong
Trough part of the Darling
Basin**

Release 2015

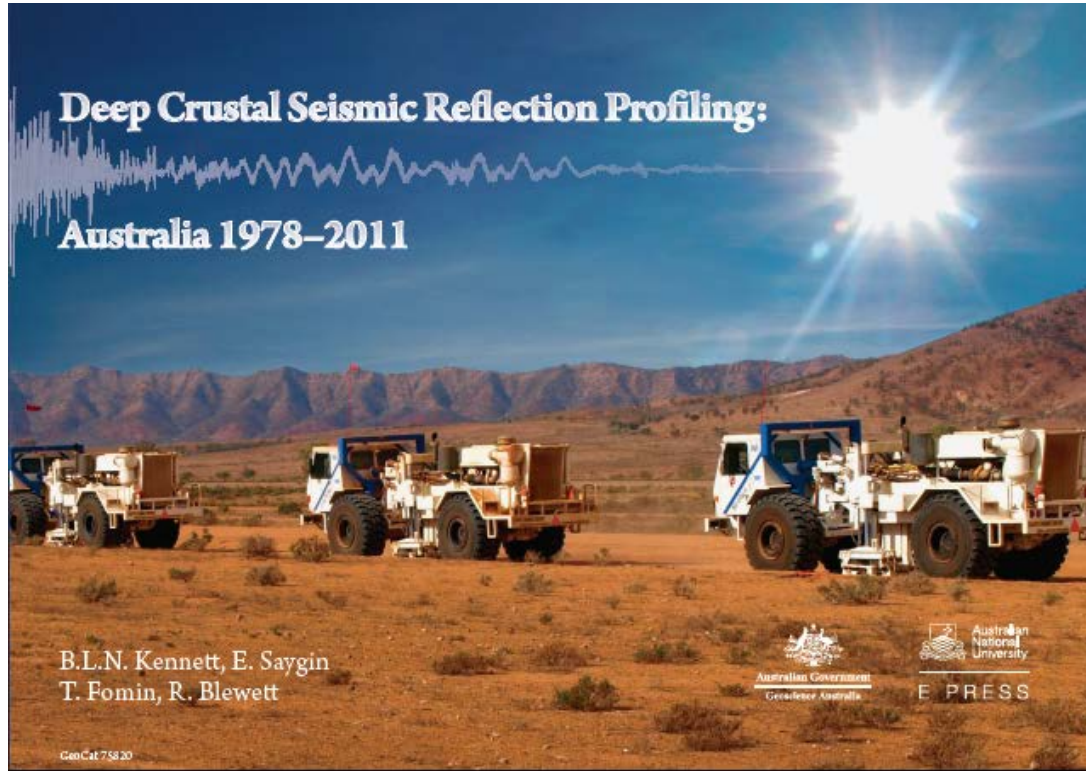


The Deep Crustal Seismic Data

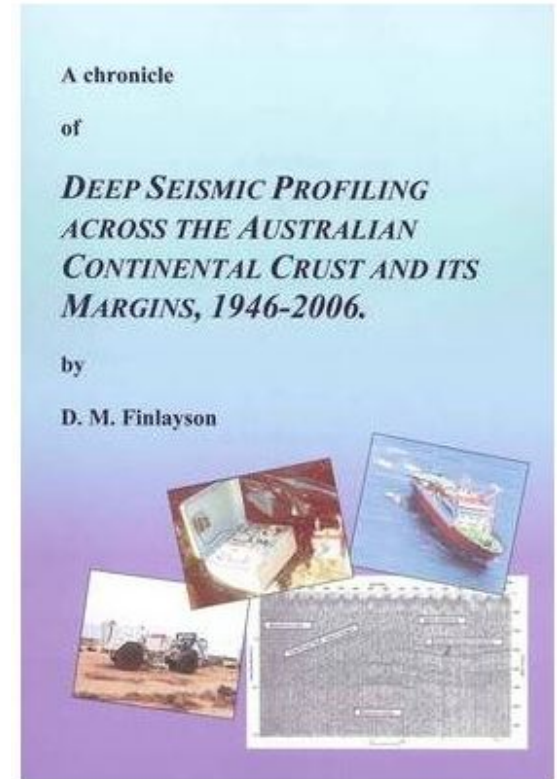


From Korsch and Doublier, 2014

The Deep Crustal Seismic Data



<http://press.anu.edu.au/?p=249881>



Conclusions

Deep crustal seismic can

- Image major crustal boundaries and faults
- Indicate potential fluid flow pathways
- Image under cover

Processed data and images available from GA website

<http://www.ga.gov.au/about/what-we-do/projects/minerals/current/seismic>

Data

Home > Data and Publications Search >

Australian Government
Geoscience Australia

Data and Publications Search

Quick Links

Map View Split View List View

Distance Measure Map Layers Reset Map

Lat 1.017°, Long 105.375°

What:
deep crustal seismic

The deep seismic structure of Precambrian terranes within the West Australi...

The deep seismic structure of Precambrian terranes within the West Australian Craton and implications for crustal formation and evolution. This paper outlines initial results of the received function analysis.

Deep Seismic Reflection Profiling in the NE Yilgarn: Implications for the Yilga...

Deep-seismic reflection data have provided information on the crustal architecture of several highly mineralised regions within the Archaean northeastern Yilgarn Craton, Western Australia. These seismic data are characterised by several prominent features and include 1) a change in the thickness of the crust across the northeastern Yilgarn Craton, 2) subdivision of the crust into three broad ...

Crustal structure of the Olympic Dam region: Constraints from deep seismic ...

Two nearly orthogonal deep seismic reflection profiles acquired in the northern Stuart Shelf, and centred on the Olympic Dam Fe oxide Cu-U-Au deposit, clearly image the cover successions and the structure of the cratonic basement around the deposit. Along the line of the profiles, sequences of the Pandurra Formation, Adelaide Rift Complex, and the Stuart Shelf have total thicknesses varying fro...

Investigation of advanced seismic processing techniques; improving the reso...

Heath, C.J., Goleby, B.R., Fomin, T., 2004. Investigation of advanced seismic processing techniques; improving the resolution of near surface seismic data derived from deep crustal reflection seismic surveys. Unpublished pmd*CRG report, 39p.

L200 Southern Carnarvon Deep Crustal Seismic Survey, WA, 2011 Stacked ...

Processed Stacked and Migrated SEG-Y seismic data and section images for the Southern Carnarvon Deep Crustal Seismic Survey. This survey was conducted under a National Geoscience Agreement with the Western Australia Geological Survey. Funding was through the Onshore Energy Security Program. The objective of the survey was to image the Byro Sub-basin of the onshore Carnarvon Basin. Data are sup...

L201 Albany Fraser Orogen Deep Crustal Reflection Seismic Survey, WA 20...

Geoscience Australia conducted the Albany Fraser Orogen 2D Seismic Survey in 2012. The survey involves the acquisition of seismic reflection and gravity Data over the Yilgarn Craton margin and the Albany Fraser Orogen of Western Australia. The survey consisted of four lines, totalling 677kms. The project is a collaborative project between Geoscience Australia and the Geological Survey of Western...

L192 Georgina-Arunta Deep Crustal Seismic Survey, NT, 2009 Stacked and ...

Processed Stacked and Migrated SEG-Y seismic data and section images for the Georgina - Arunta Deep Crustal Seismic Survey. This survey was primarily funded through the Onshore Energy Security Program and was acquired in collaboration the Northern Territory Geological Survey. The objectives of the survey were to image the Georgina and Amadeus basins to enhance the knowledge of their petroleum p...

L095 Braidwood Tiddinbilla deep crustal seismic reflection survey (Murrumb...

Geoscience Australia conducted the Braidwood Tiddinbilla deep crustal seismic reflection survey in 2012. The survey involves the acquisition of seismic reflection and gravity Data over the Braidwood Tiddinbilla region of the Murrumbidgee Basin, New South Wales. The survey consisted of four lines, totalling 677kms. The project is a collaborative project between Geoscience Australia and the Geological Survey of Western...

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Australian Government
Geoscience Australia



Bringing it all together: The Australian Architecture Reference Model (AusARM)



Malcolm Nicoll, *Karol Czarnota* Karol.Czarnota@ga.gov.au

EarthSci

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Scene Bookmarks x1

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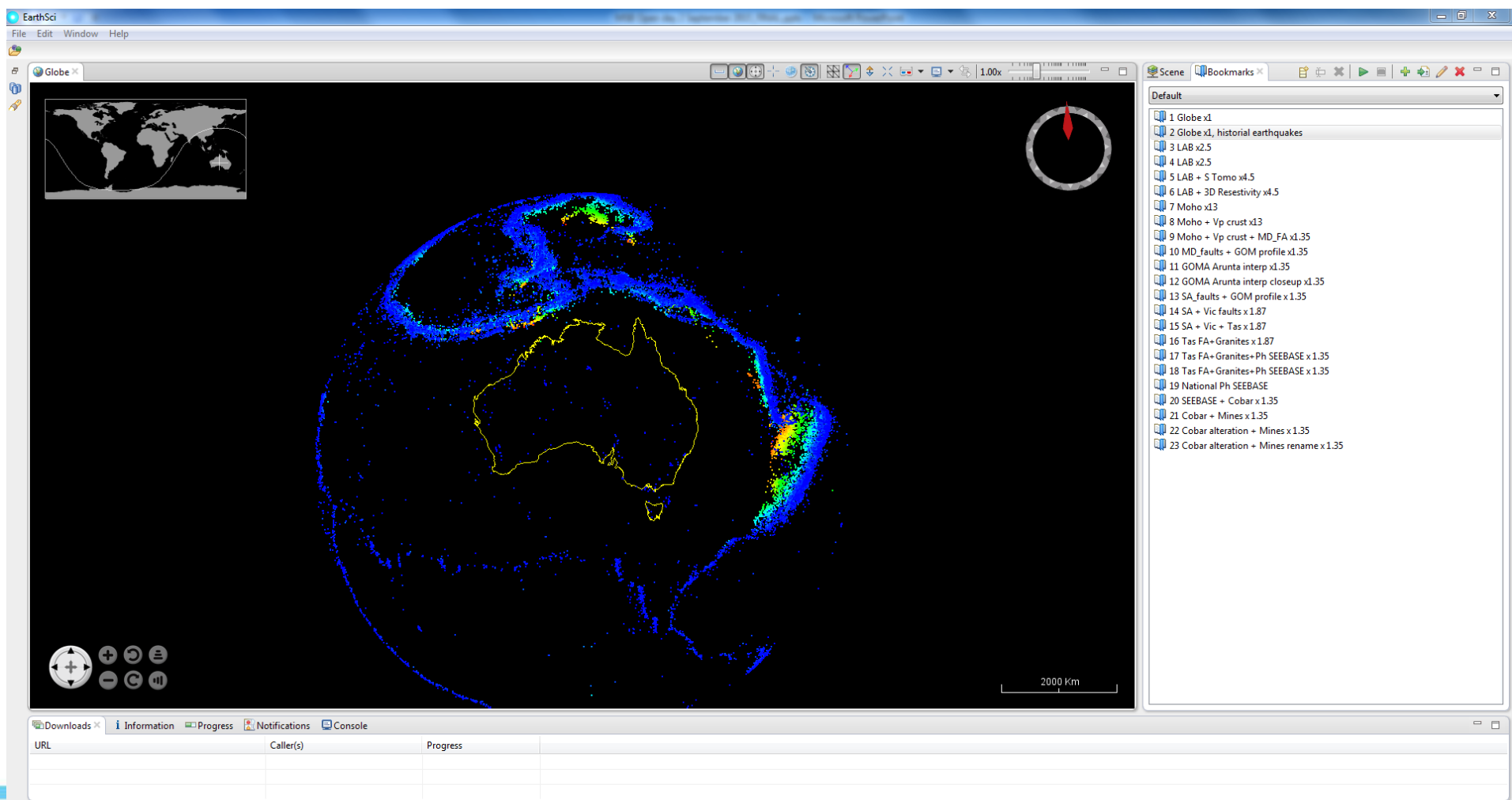
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- 2 Globe x1, historical earthquakes
- 3 LAB x2.5
- 4 LAB x2.5
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- 6 LAB + 3D Resistivity x4.5
- 7 Moho x13
- 8 Moho + Vp crust x13
- 9 Moho + Vp crust + MD_FA x1.35
- 10 MD_faults + GOM profile x1.35
- 11 GOMA Arunta interp x1.35
- 12 GOMA Arunta interp closeup x1.35
- 13 SA_faults + GOM profile x1.35
- 14 SA + Vic faults x1.87
- 15 SA + Vic + Tas x1.87
- 16 Tas FA+Granites x1.87
- 17 Tas FA+Granites+Ph SEEBASE x1.35
- 18 Tas FA+Granites+Ph SEEBASE x1.35
- 19 National Ph SEEBASE
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- 21 Cobar + Mines x1.35
- 22 Cobar alteration + Mines x1.35
- 23 Cobar alteration + Mines rename x1.35

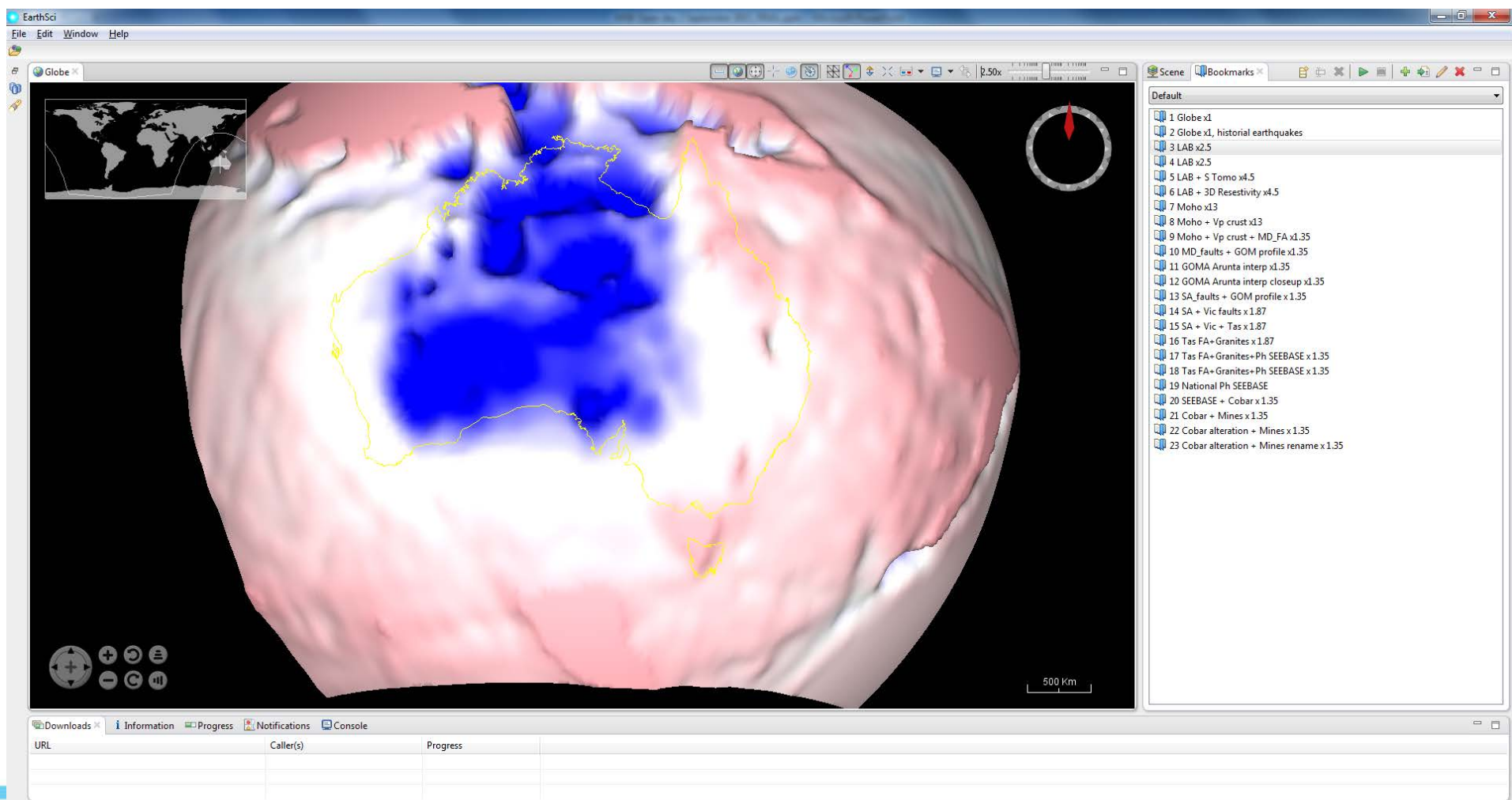
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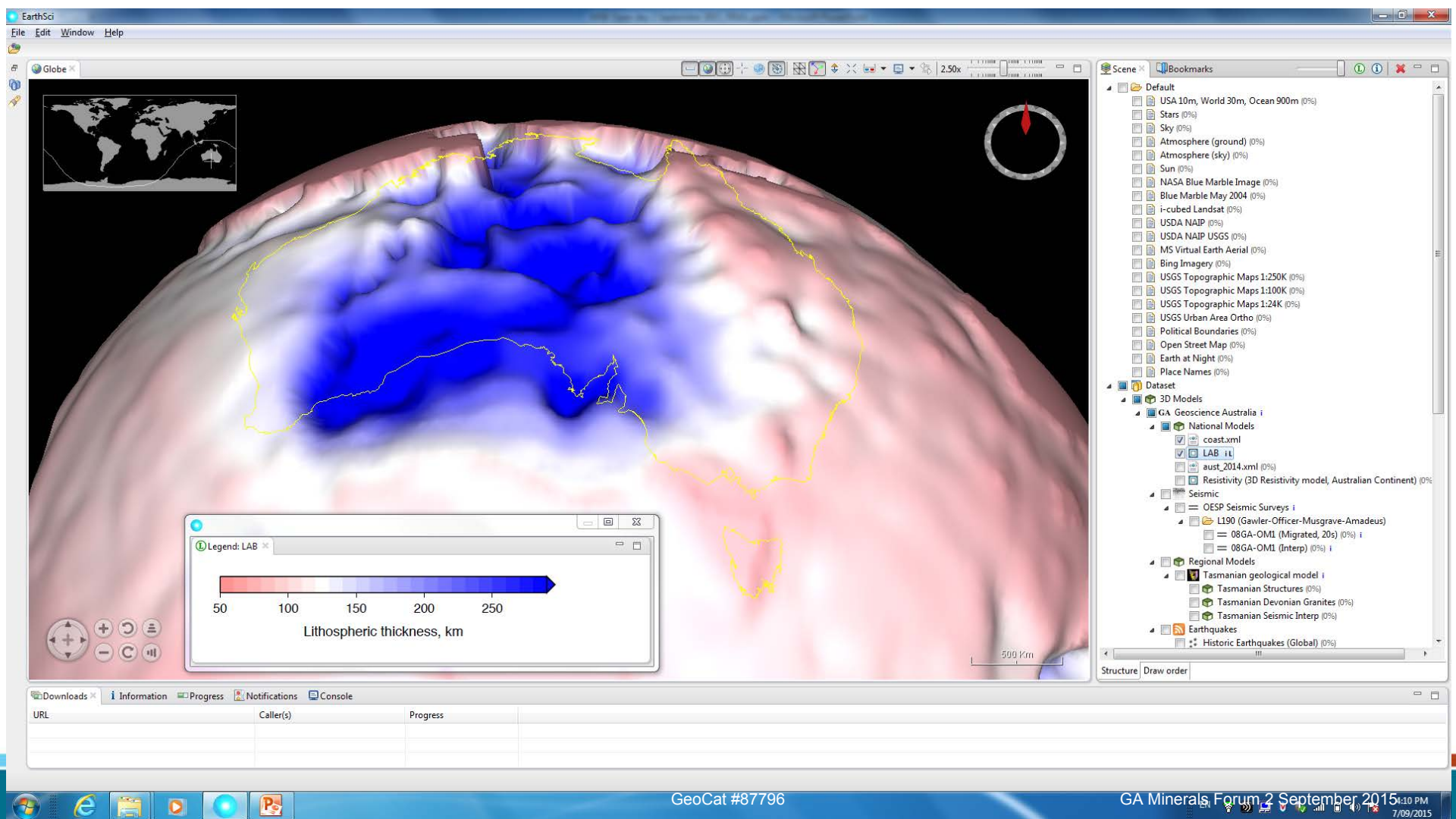
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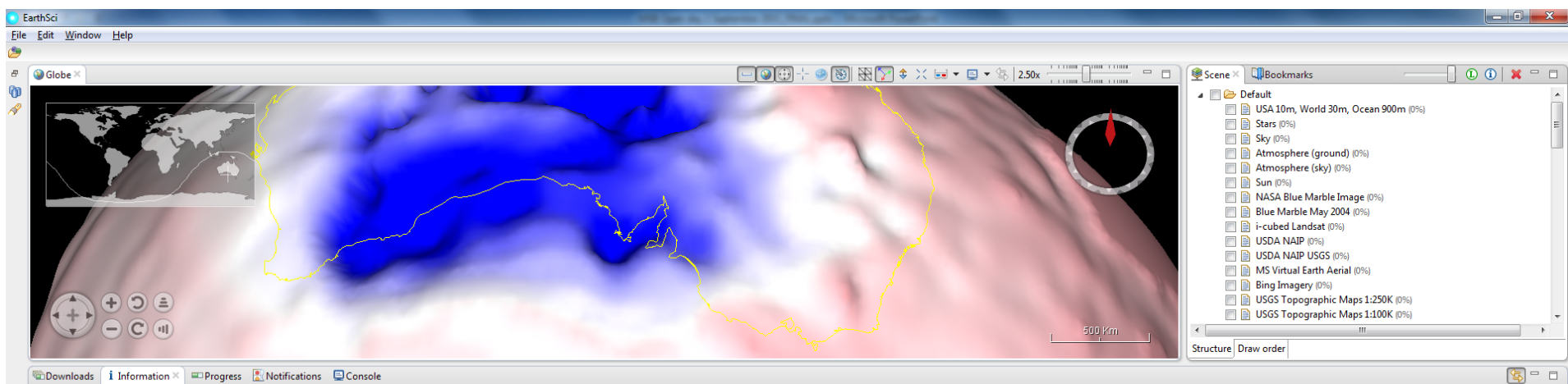
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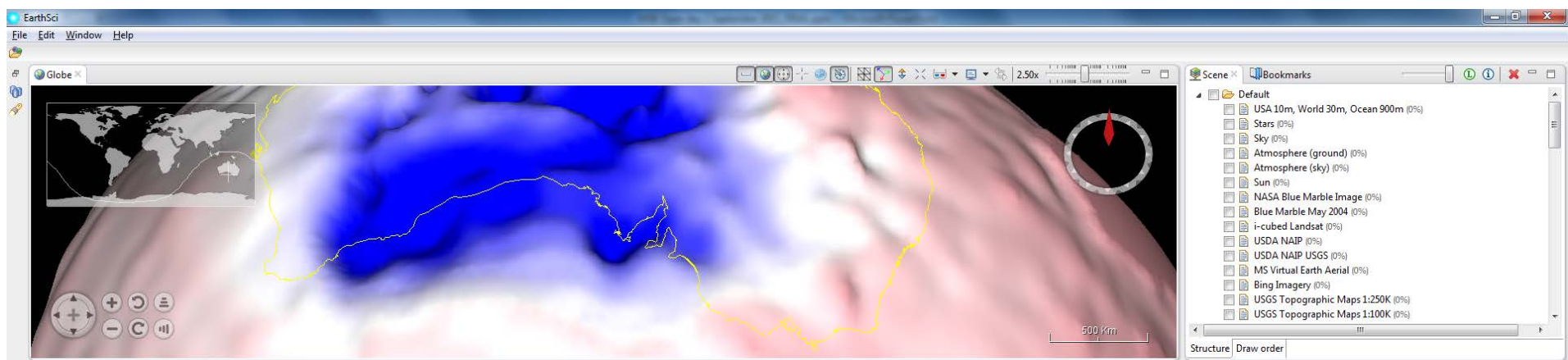


Australian lithosphere–asthenosphere boundary

Australian lithosphere–asthenosphere boundary from Czarnota et al. (2014) based on a surface wave tomography model by Fishwick and Rawlinson (2012) using parametrisation by Priestley and McKenzie (2006).

References

Czarnota, K., G. G. Roberts, N. J. White, and S. Fishwick (2014), Spatial and temporal patterns of Australian dynamic topography from River Profile Modeling, *Journal of Geophysical Research: Solid Earth*, 119(2), 1384-1424, doi:10.1002/2013JB010436.
<http://onlinelibrary.wiley.com/doi/10.1002/2013JB010436/full> Fishwick, S., and N. Rawlinson (2012), 3-D structure of the Australian lithosphere from evolving seismic datasets, *Australian Journal of Earth Sciences*, 59(6), 809-826. Priestley, K., and D. McKenzie (2006), The thermal structure of the lithosphere from shear wave velocities, *Earth and Planetary Science Letters*, 244(1-2), 285-301.



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Research Article

Spatial and temporal patterns of Australian dynamic topography from River Profile Modeling

K. Czarnota, G. G. Roberts, N. J. White, S. Fishwick

First published: 18 February 2014 [Full publication history](#)

DOI: 10.1002/2013JB010436 [View/save citation](#)

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Volume 119, Issue 2
February 2014
Pages 1384–1424

Abstract

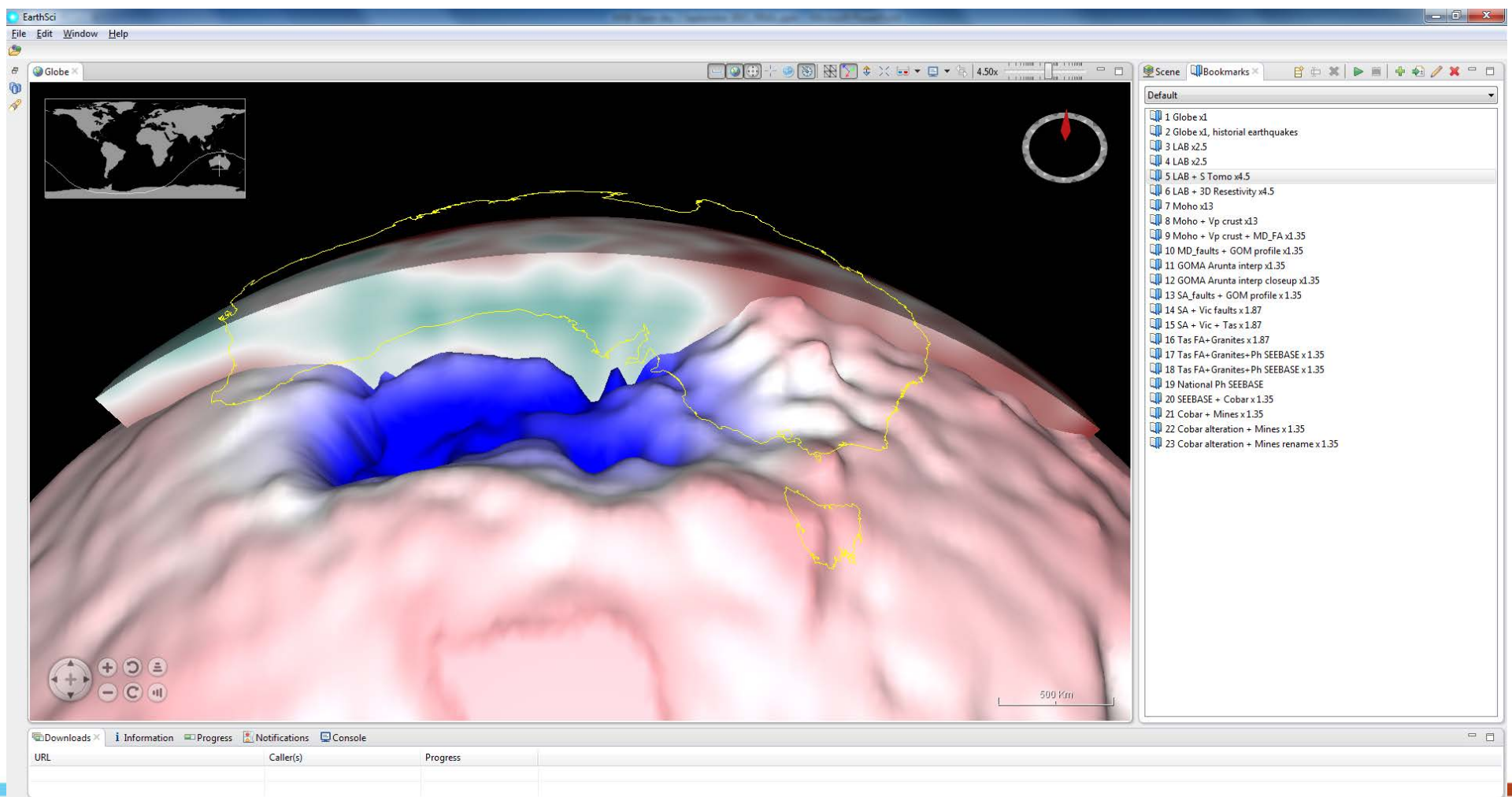
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- 2 Geophysical and Geologic Constraints
- 3 Drainage Patterns
- 4 Uplift Histories From River Profiles
- 5 Discussion
- 6 Conclusions

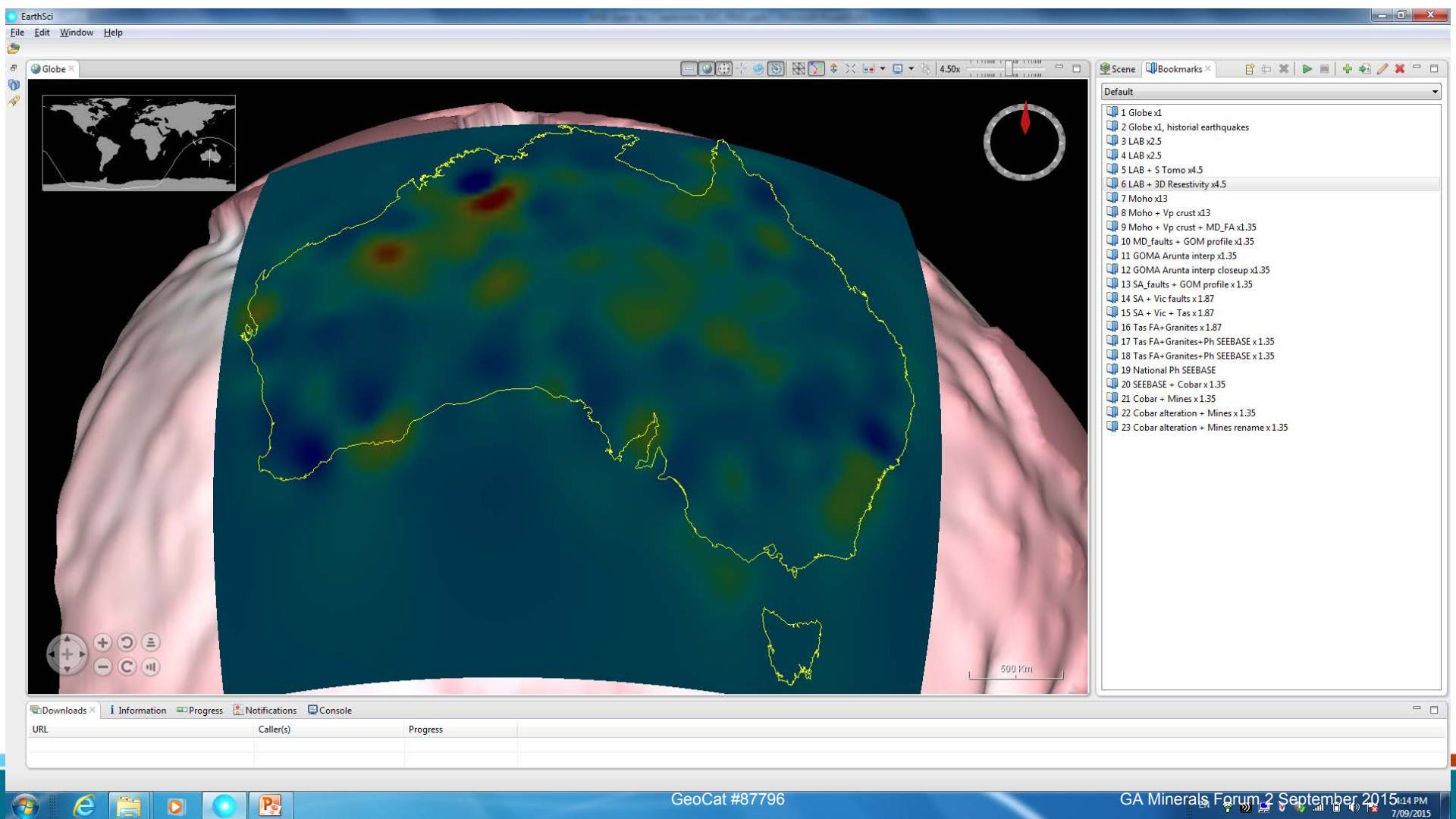
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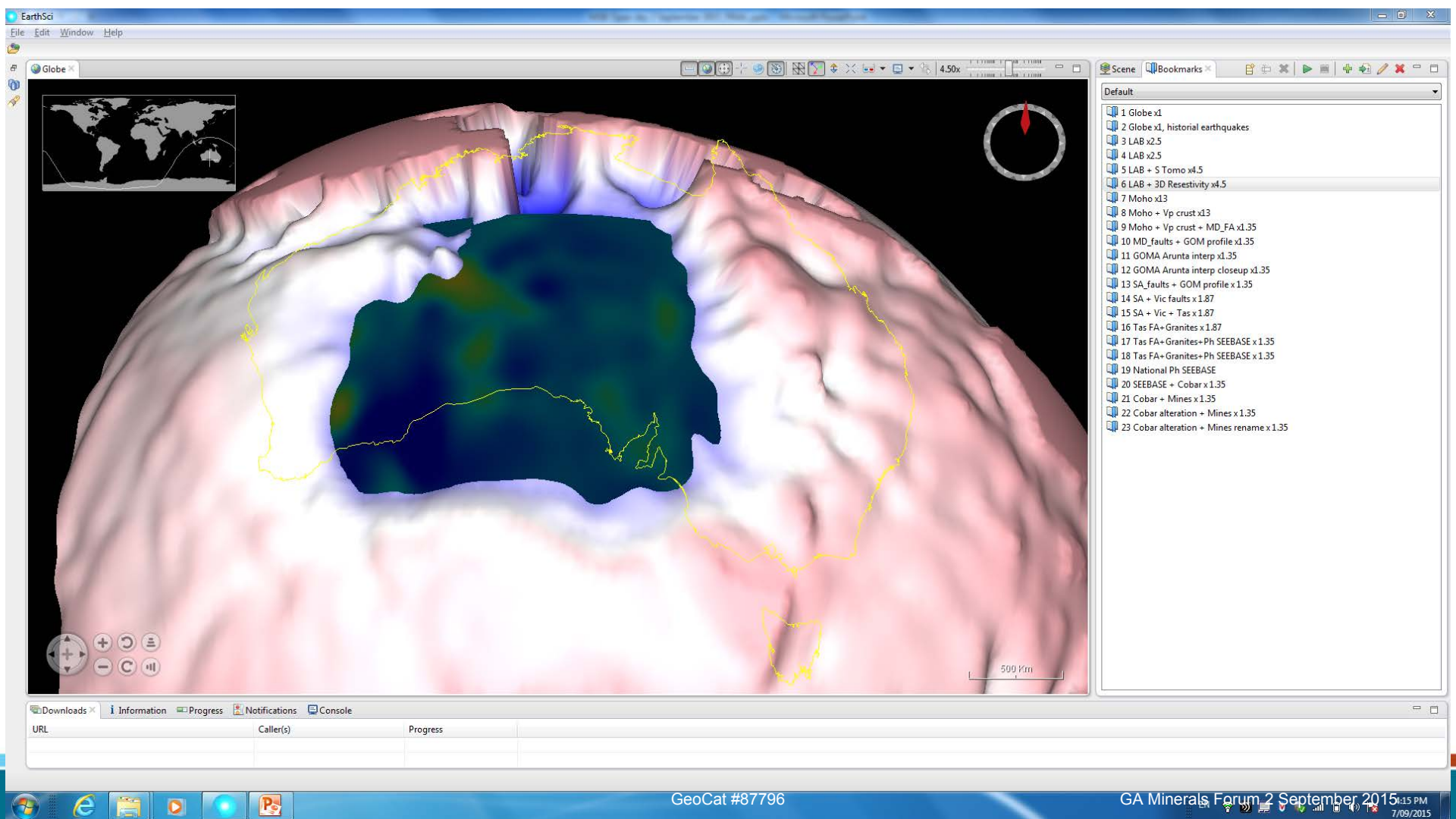
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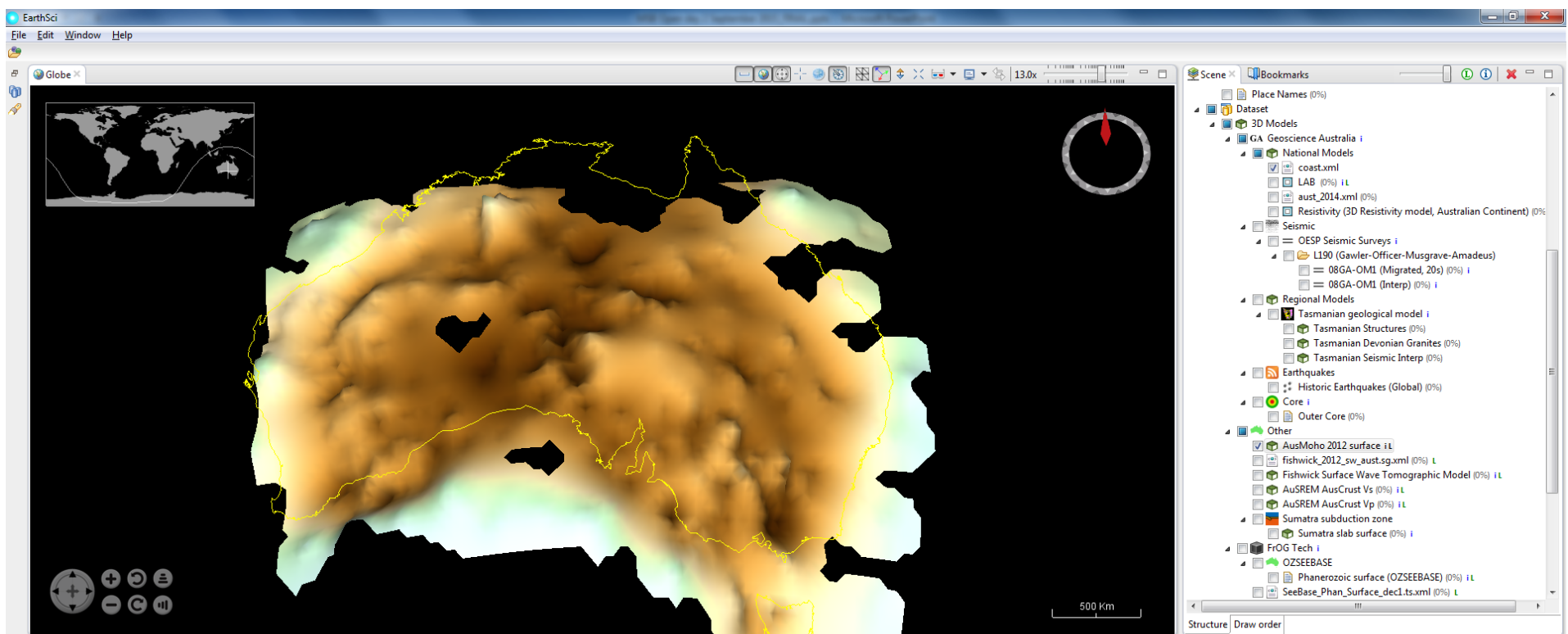
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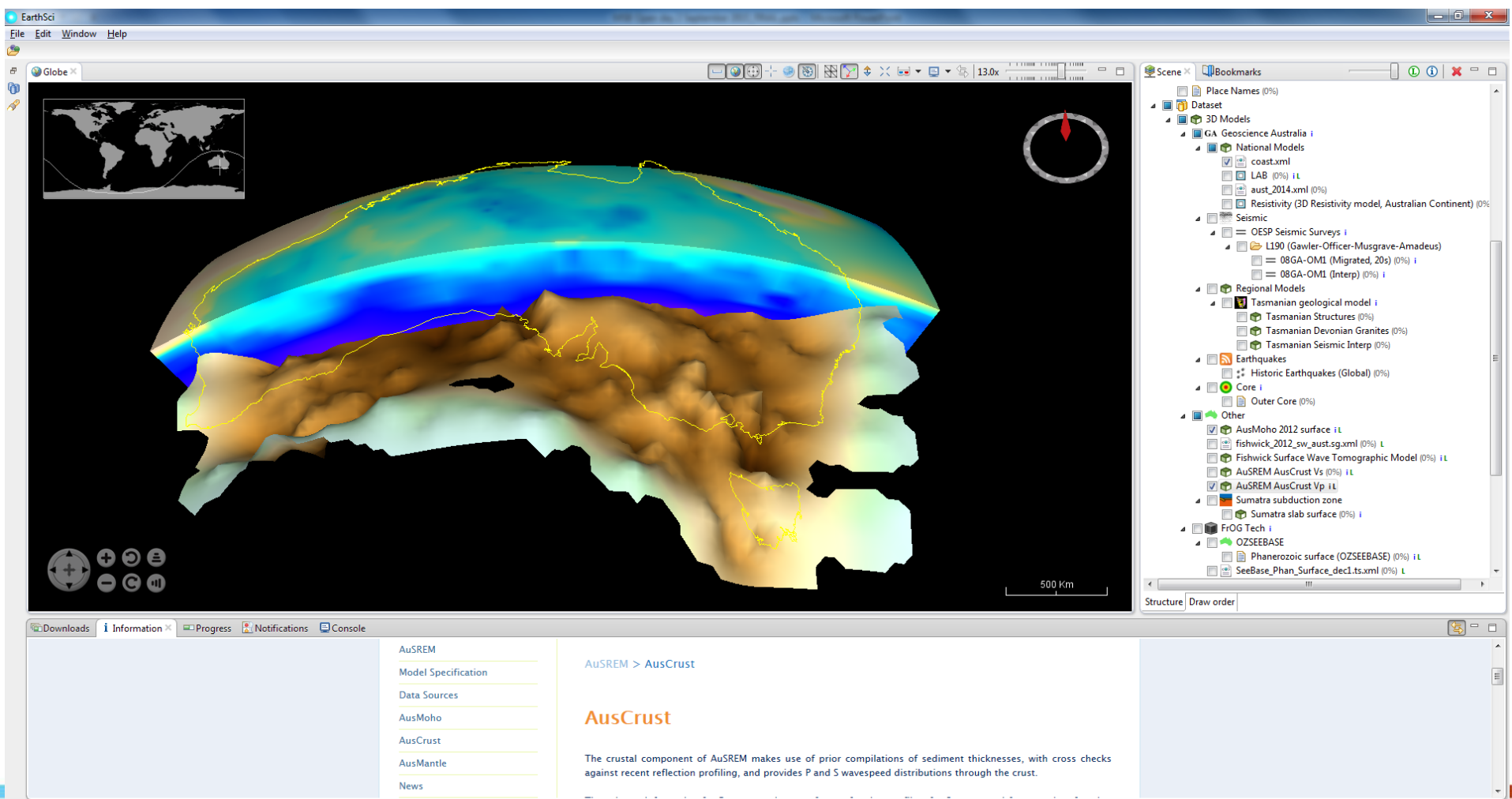
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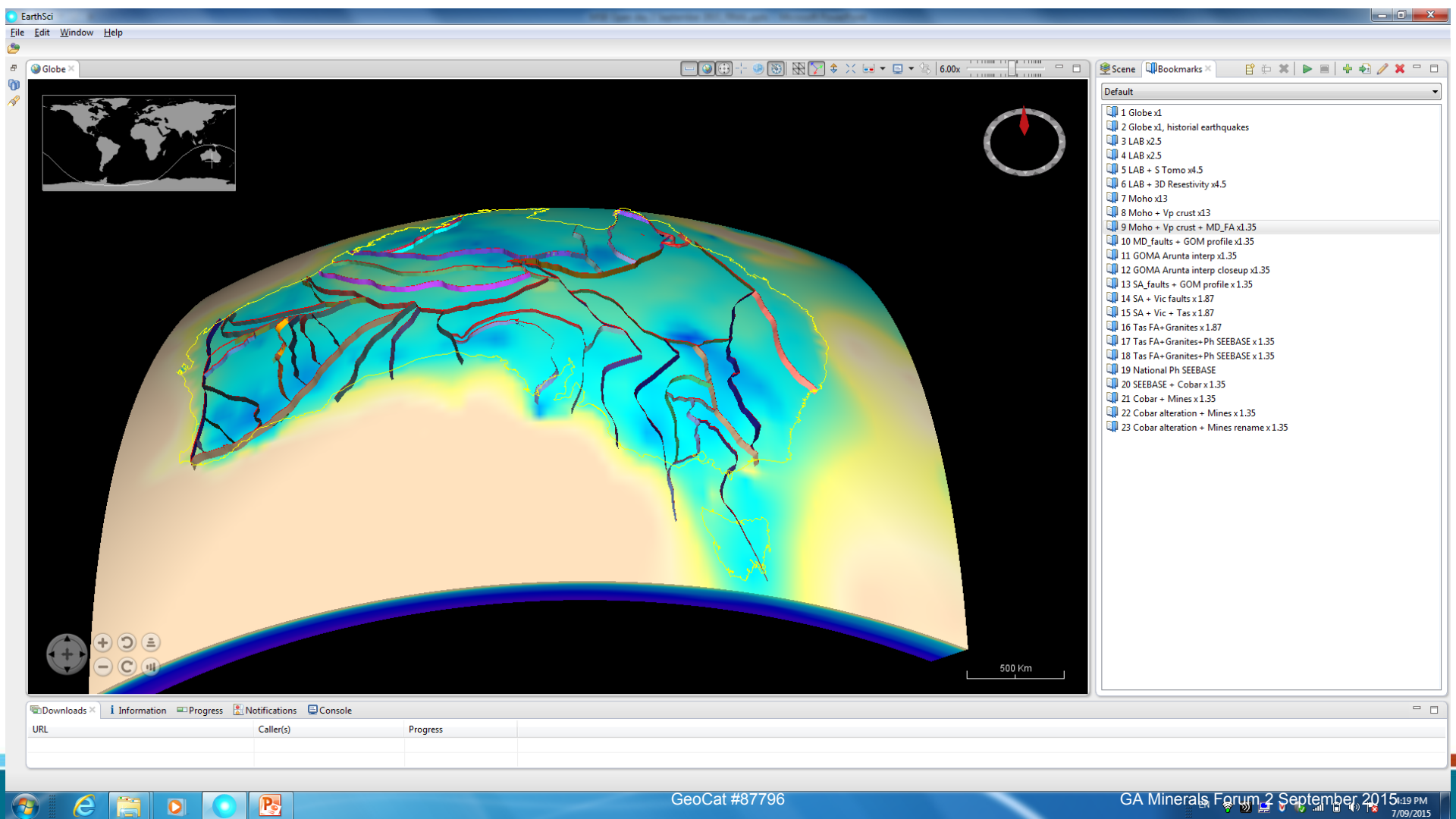


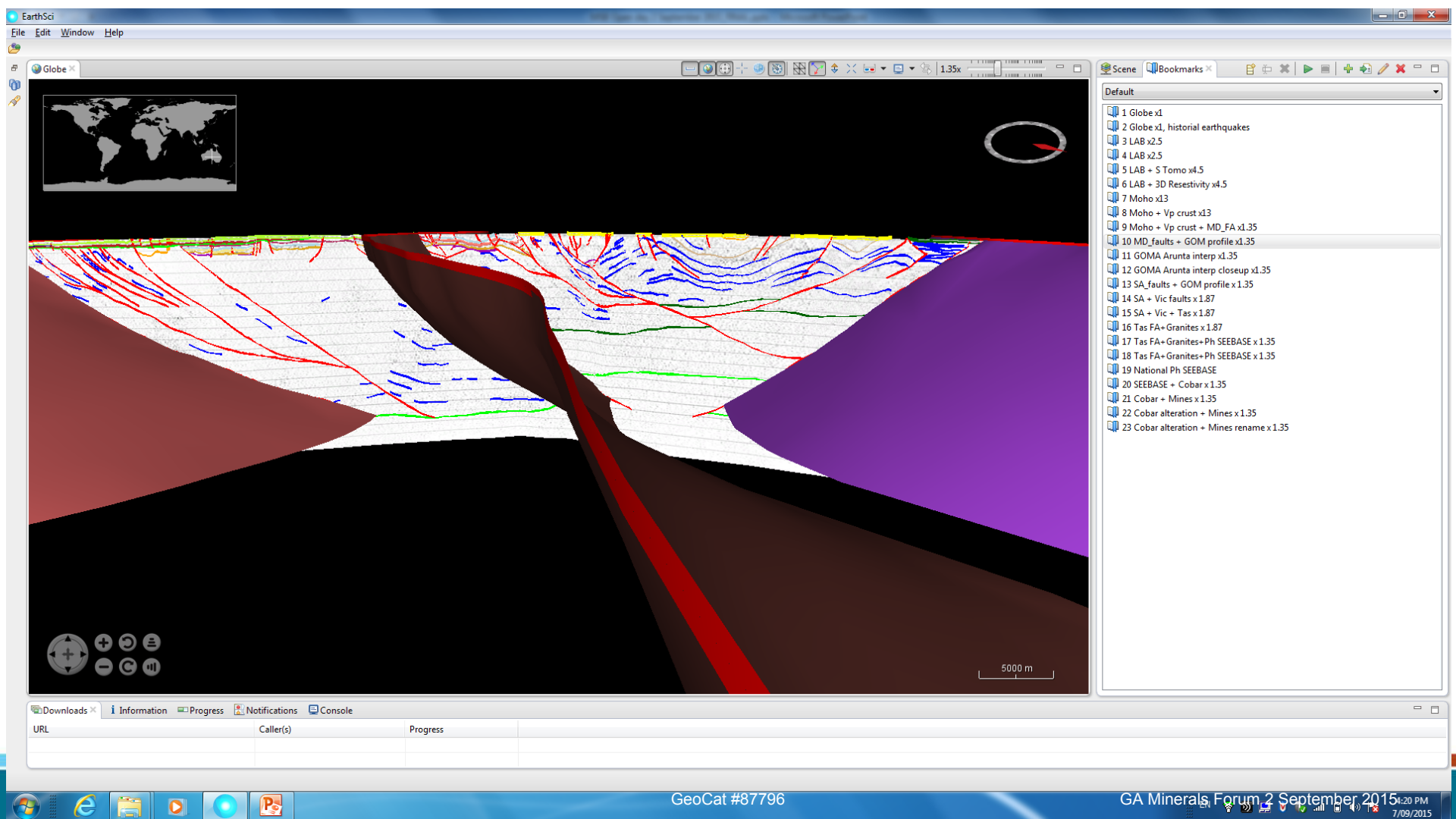


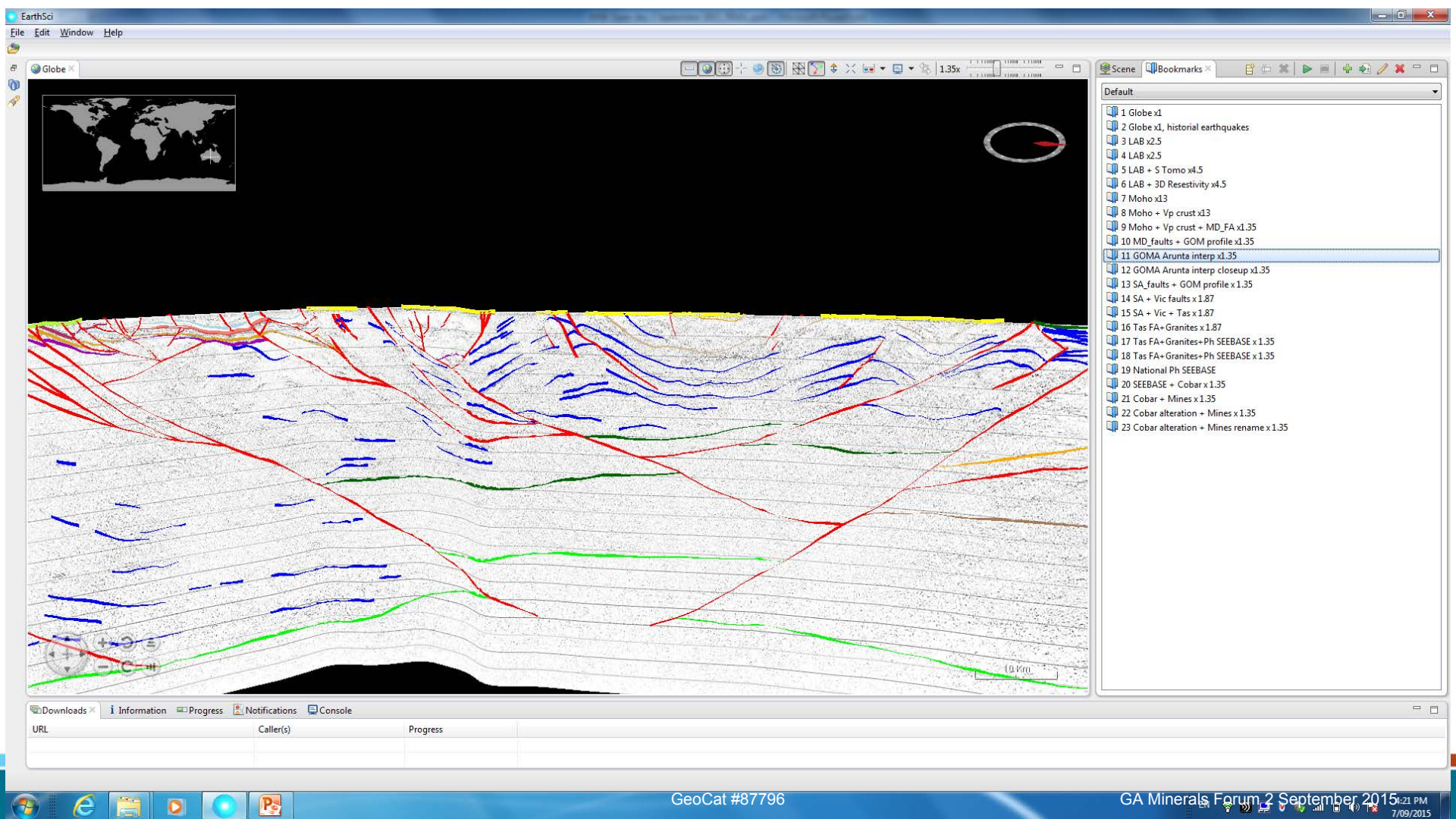


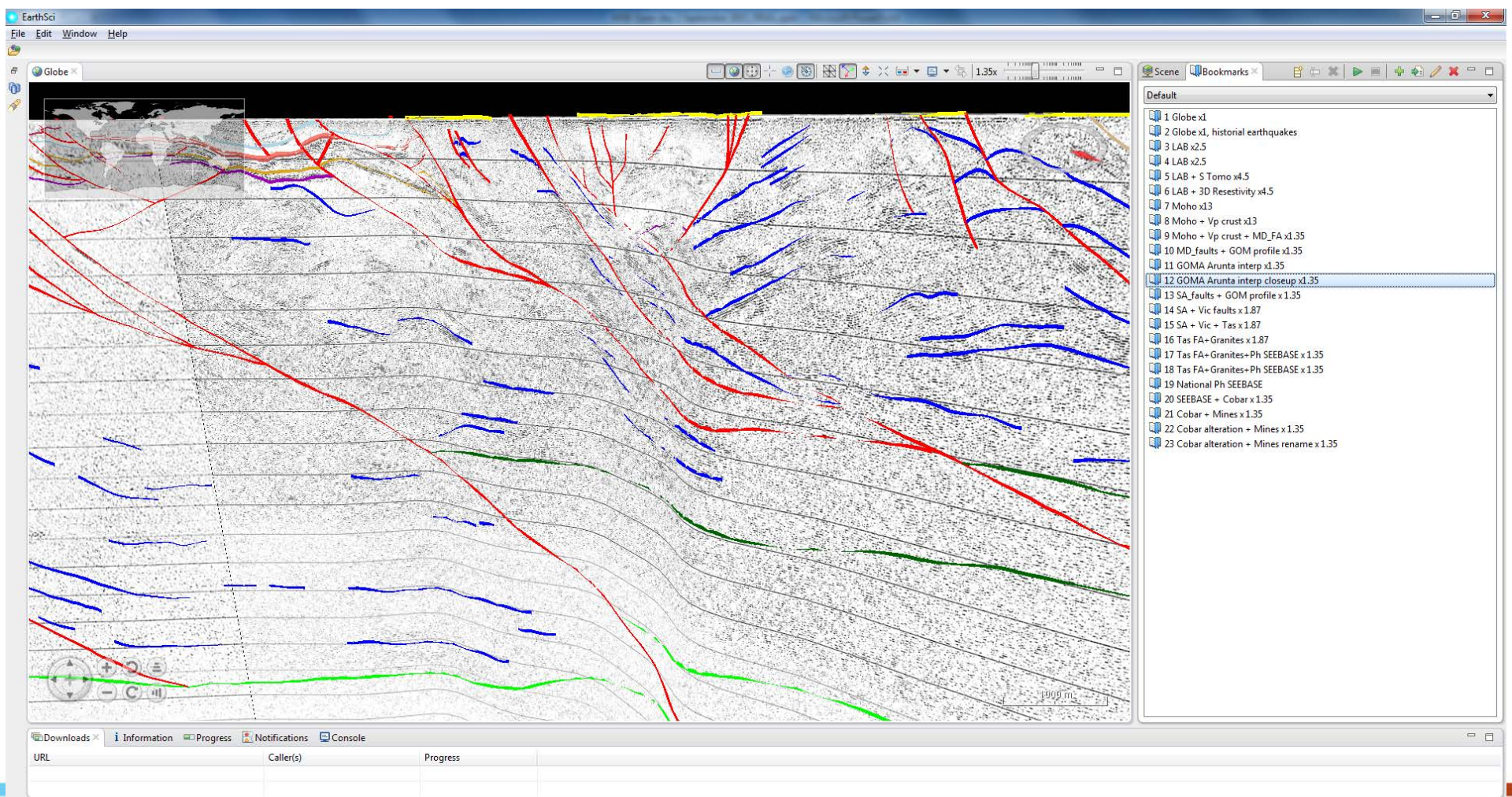


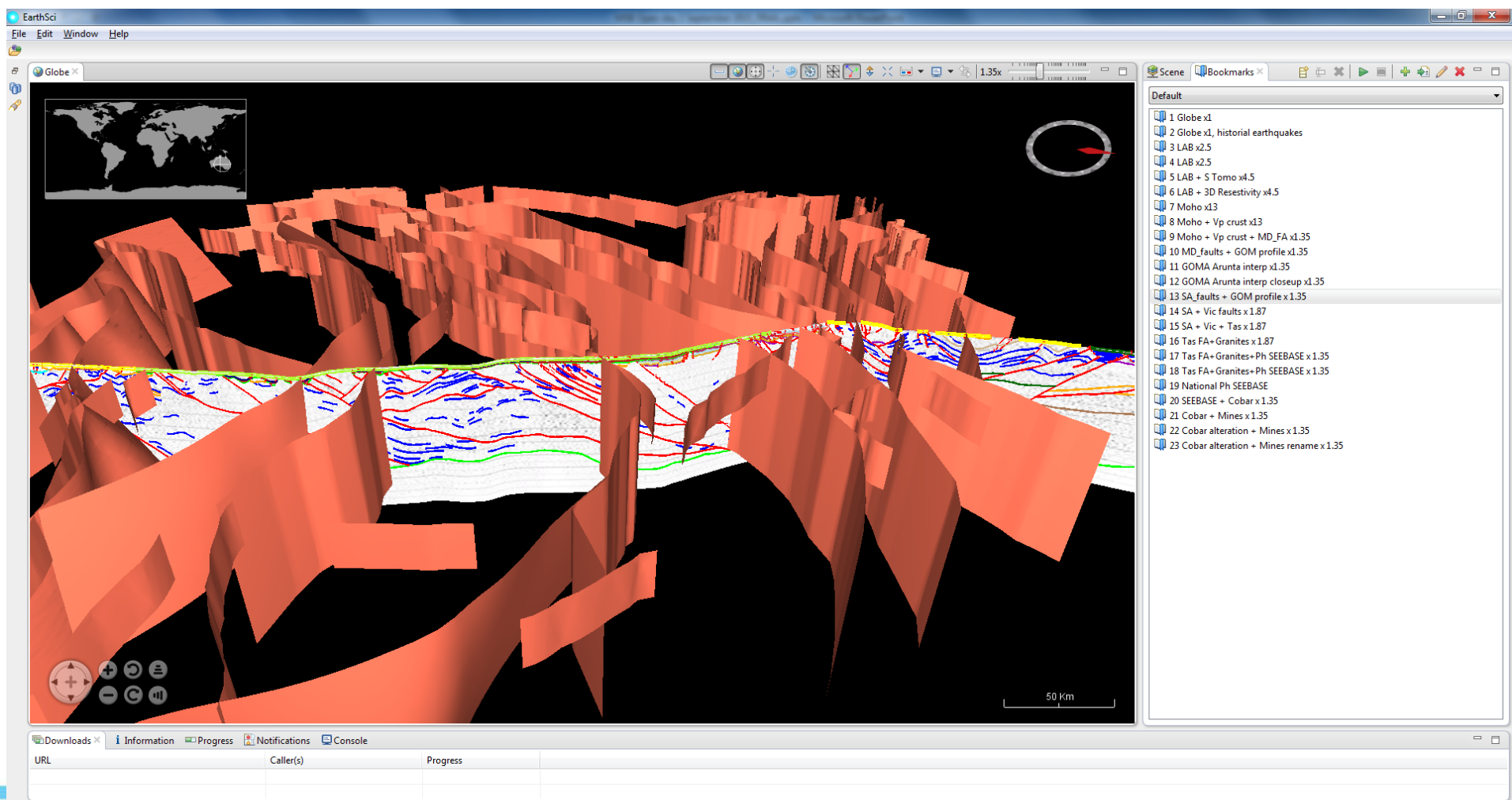


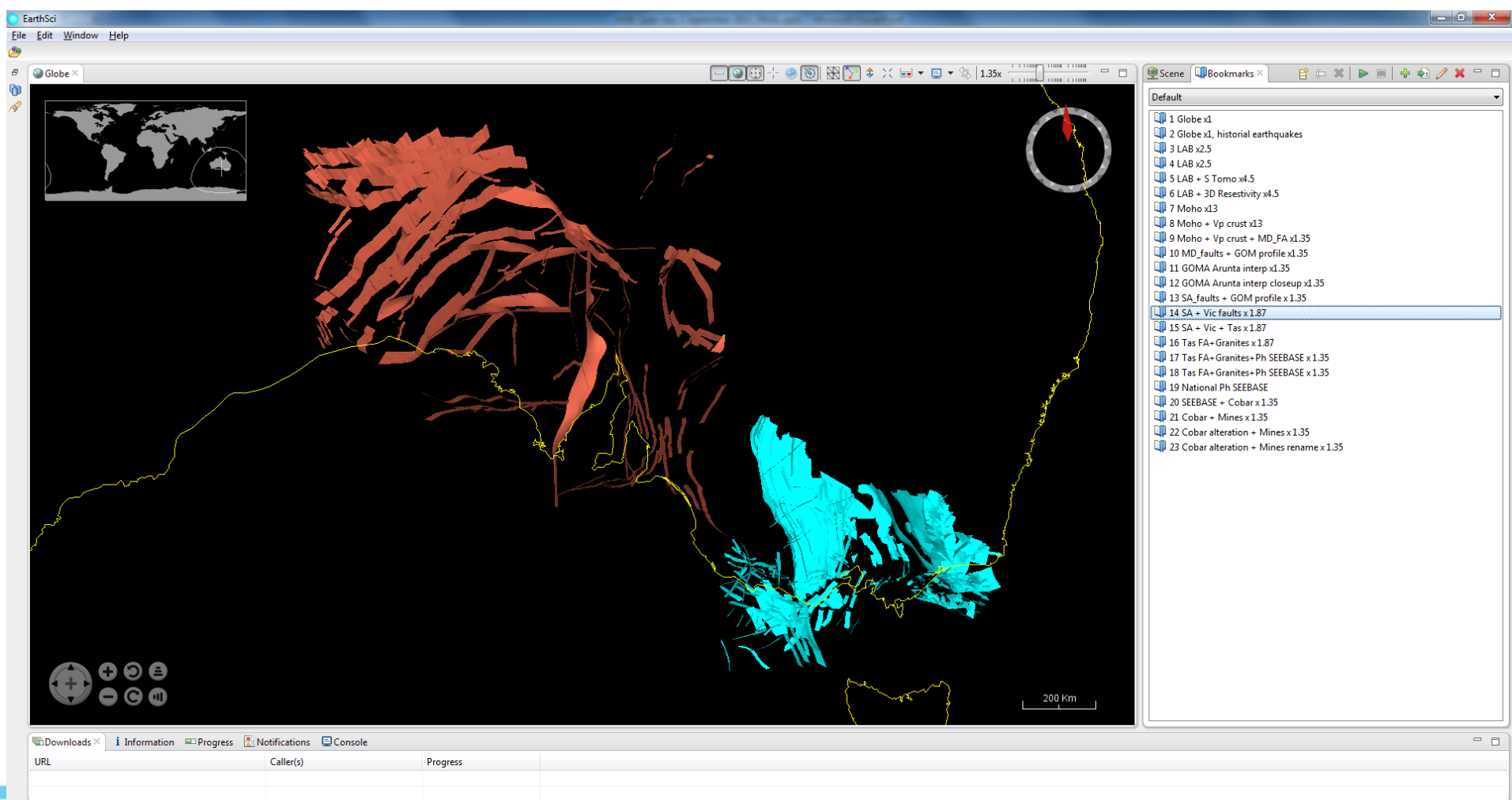


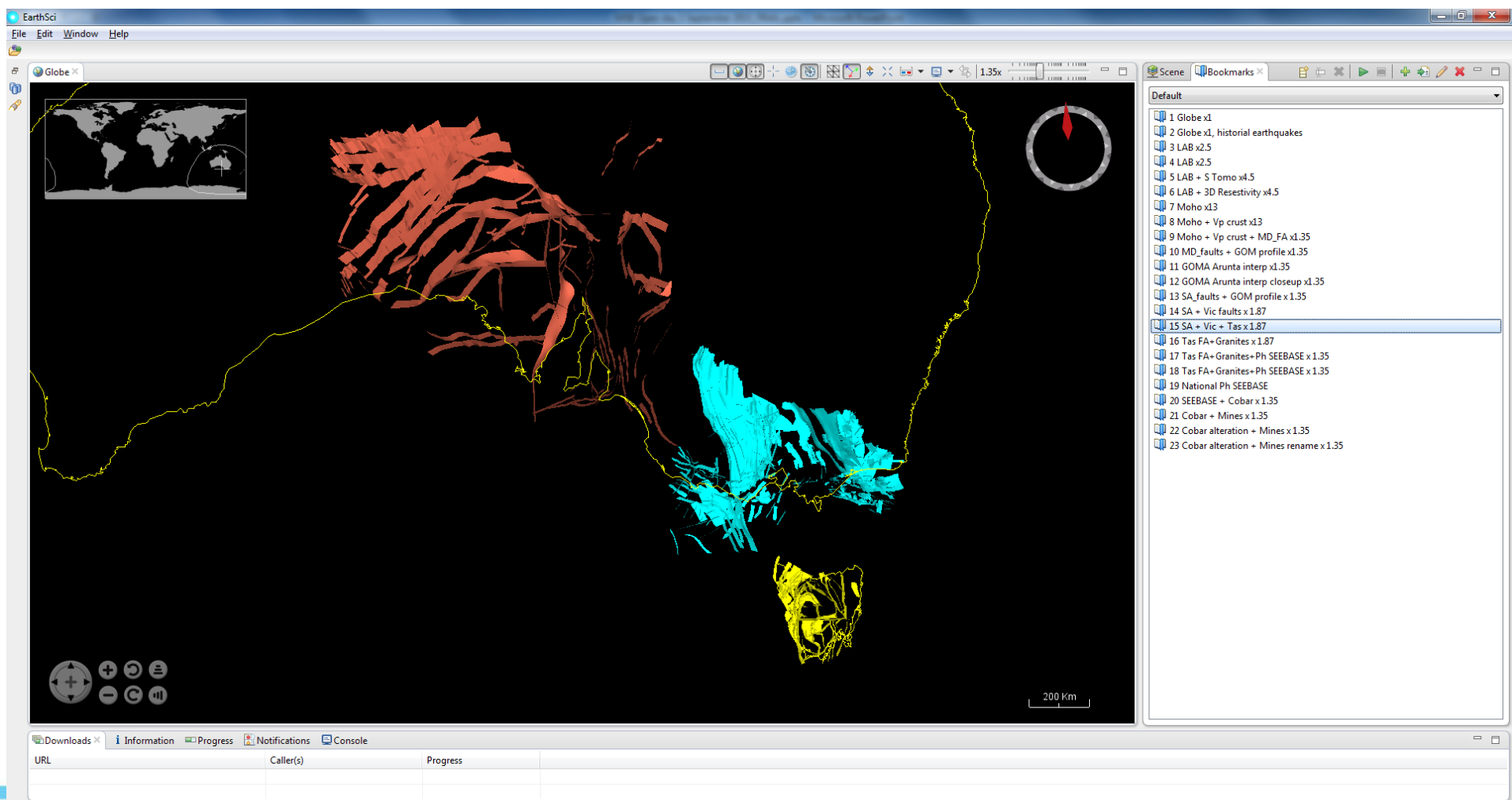


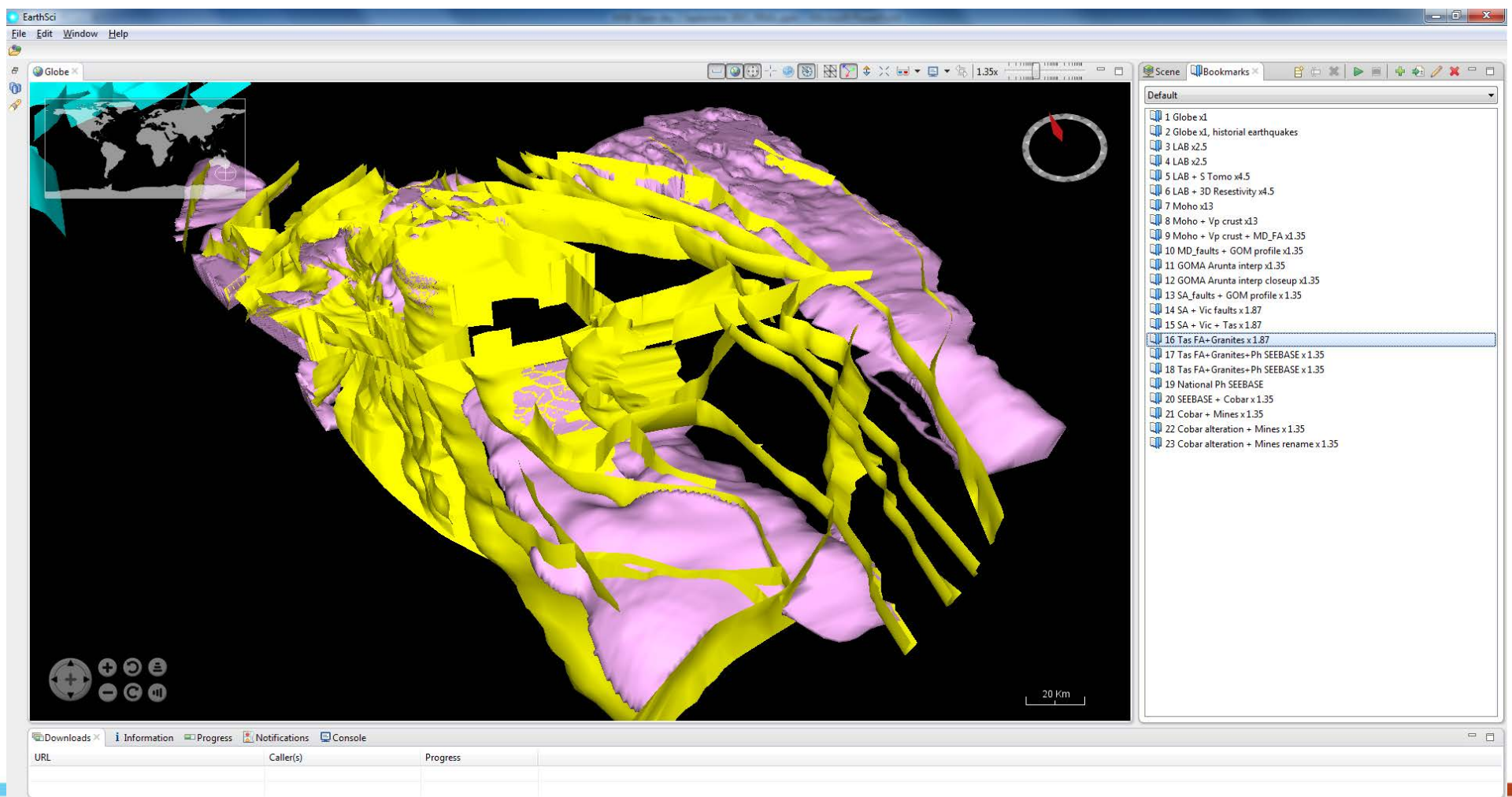


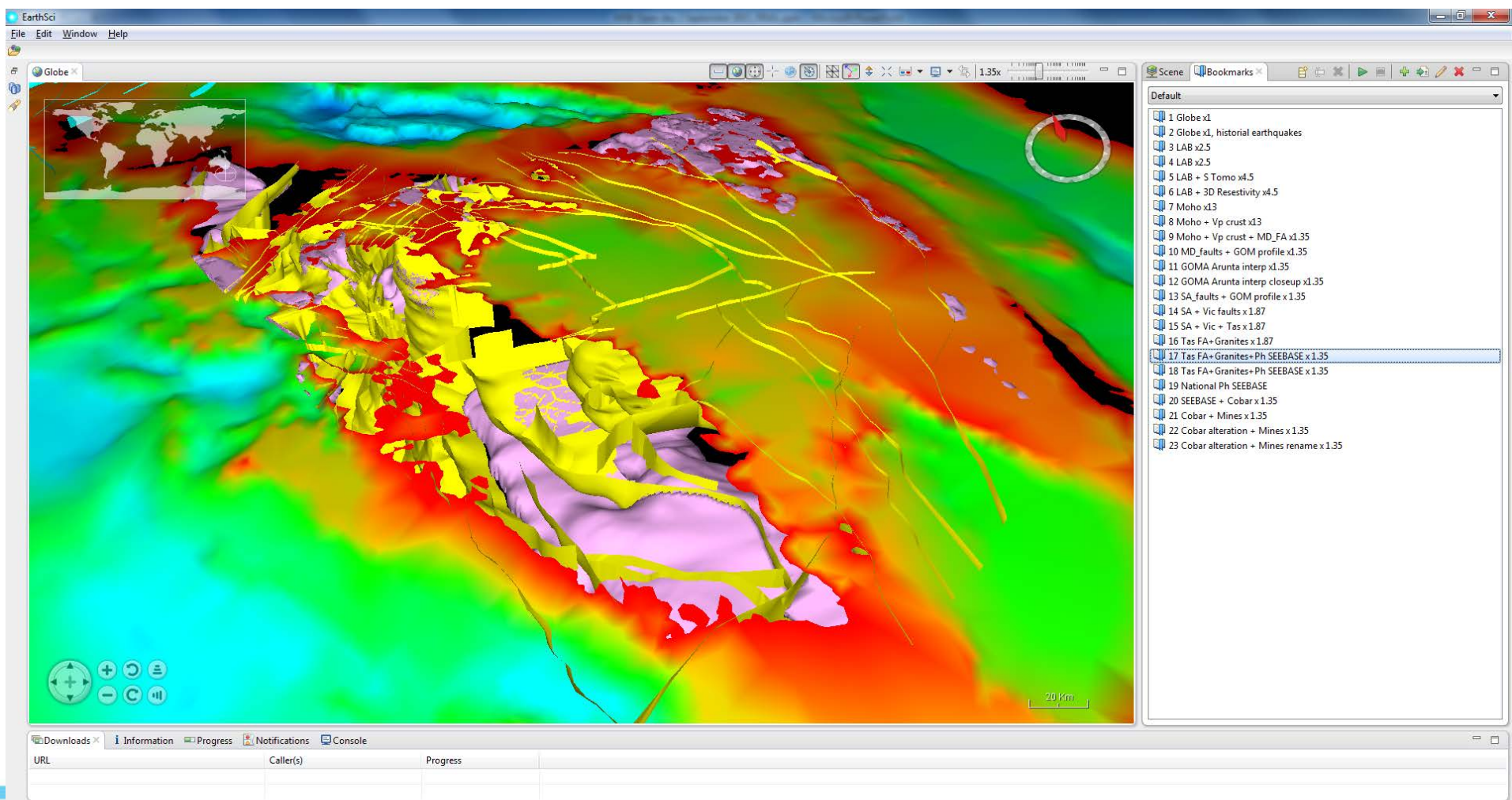


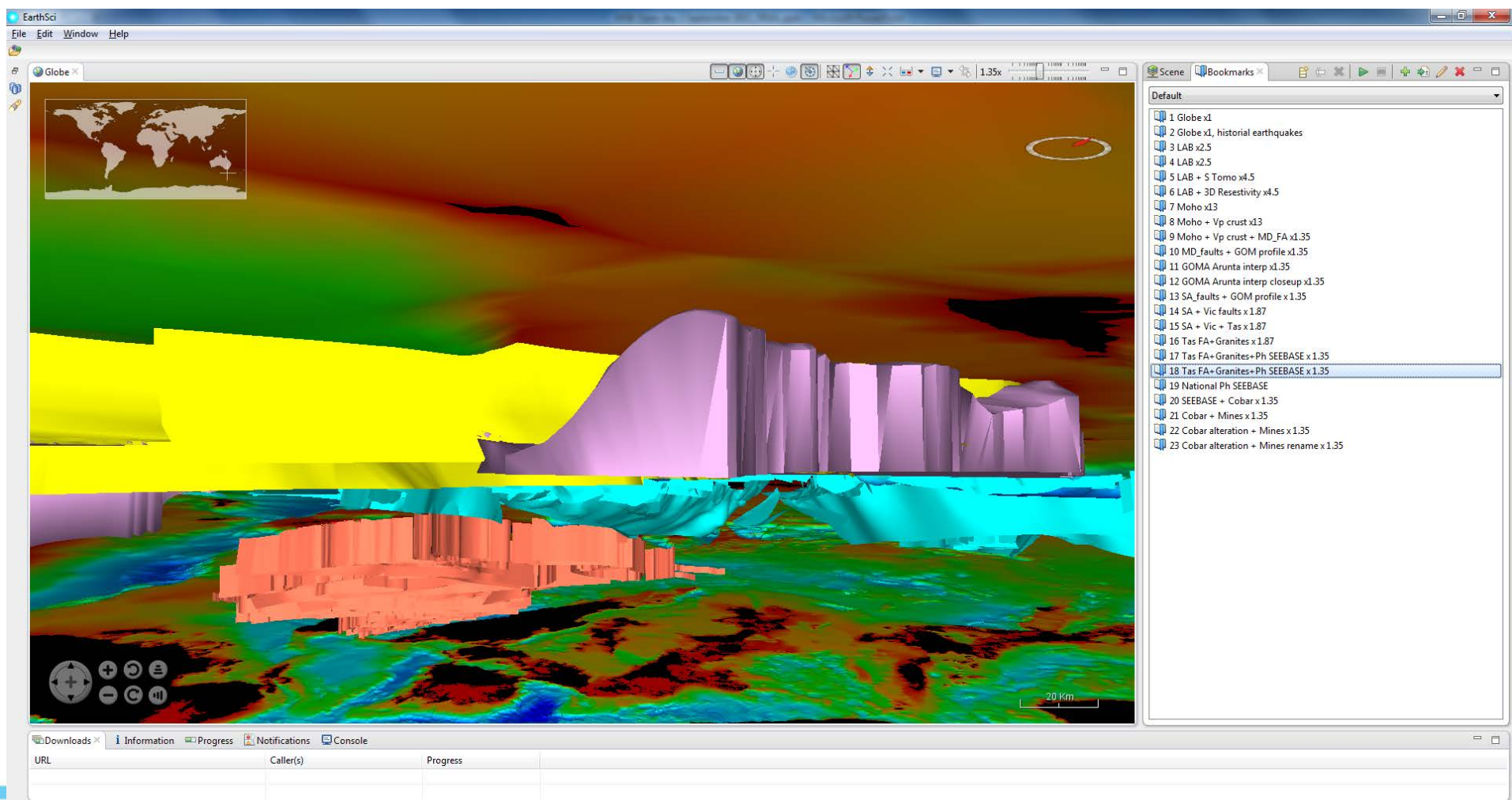


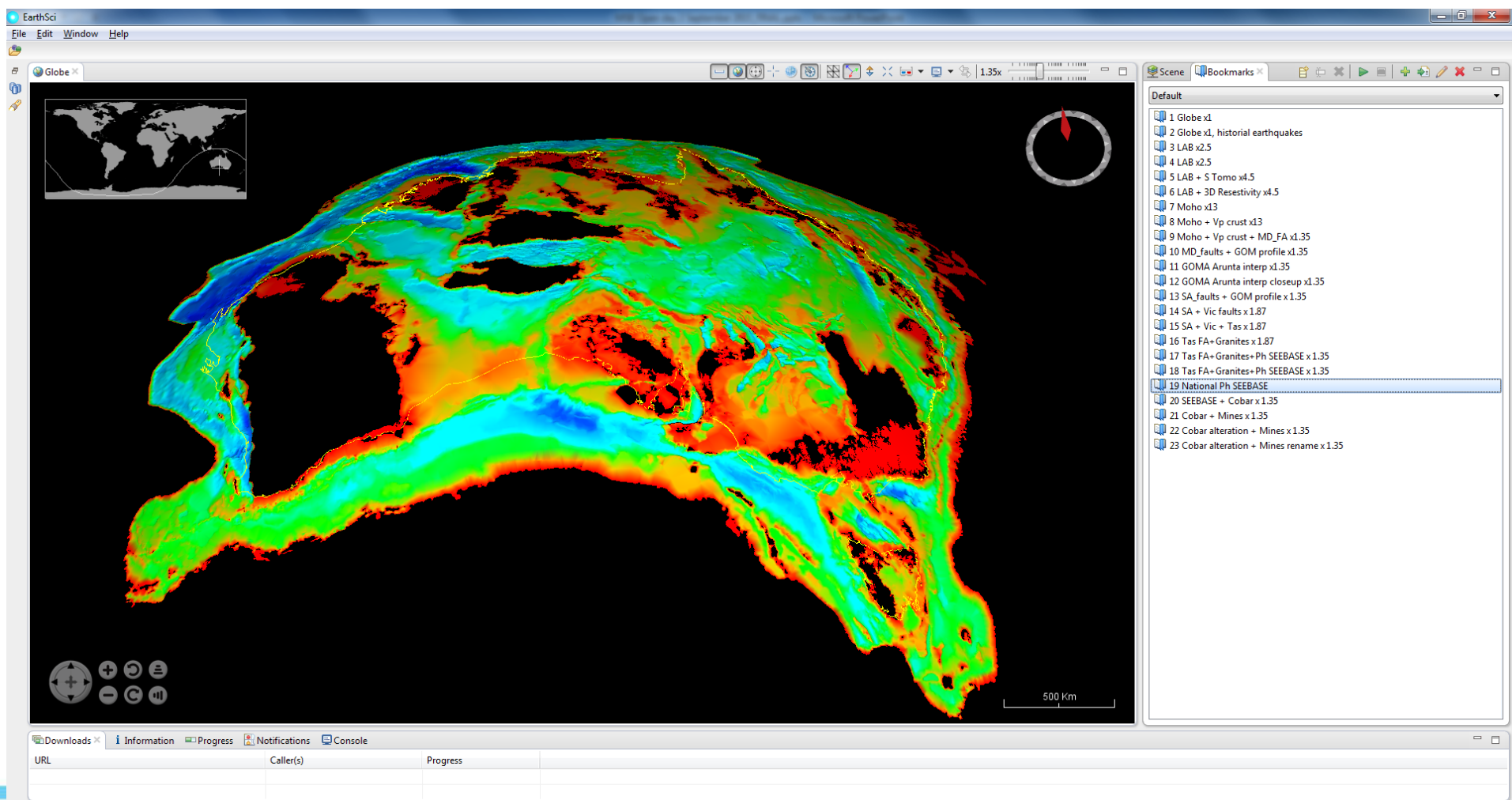


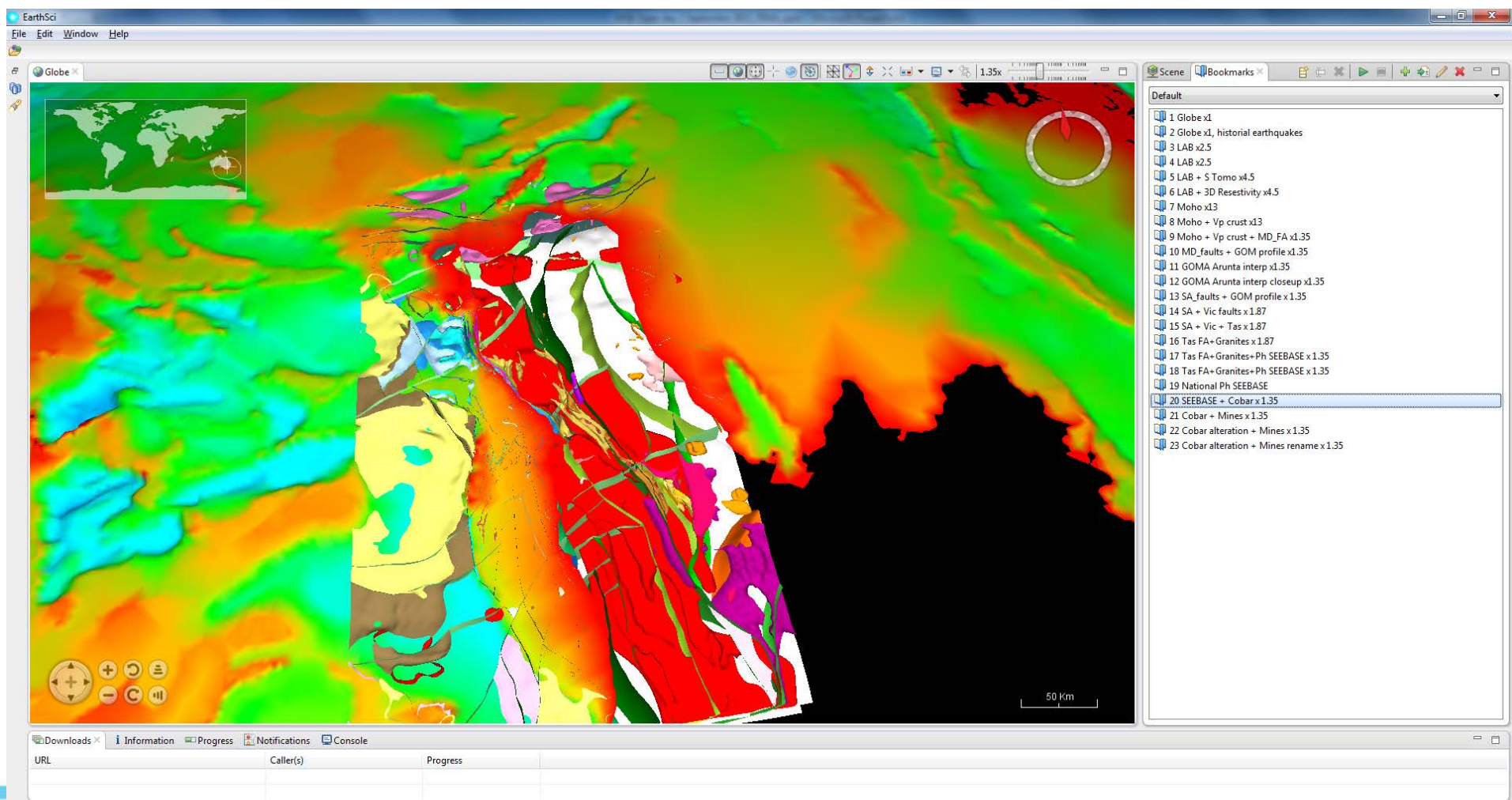


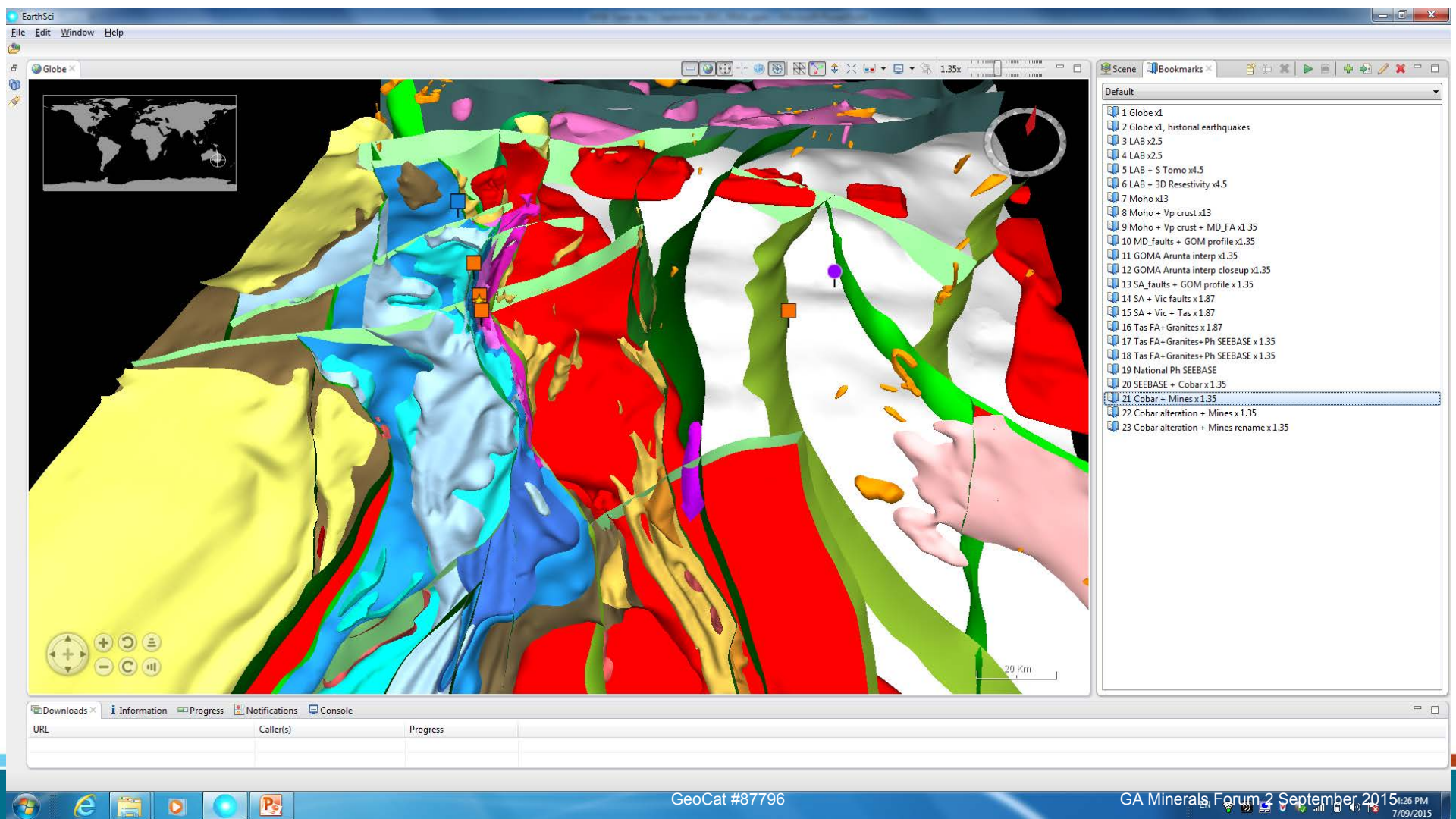


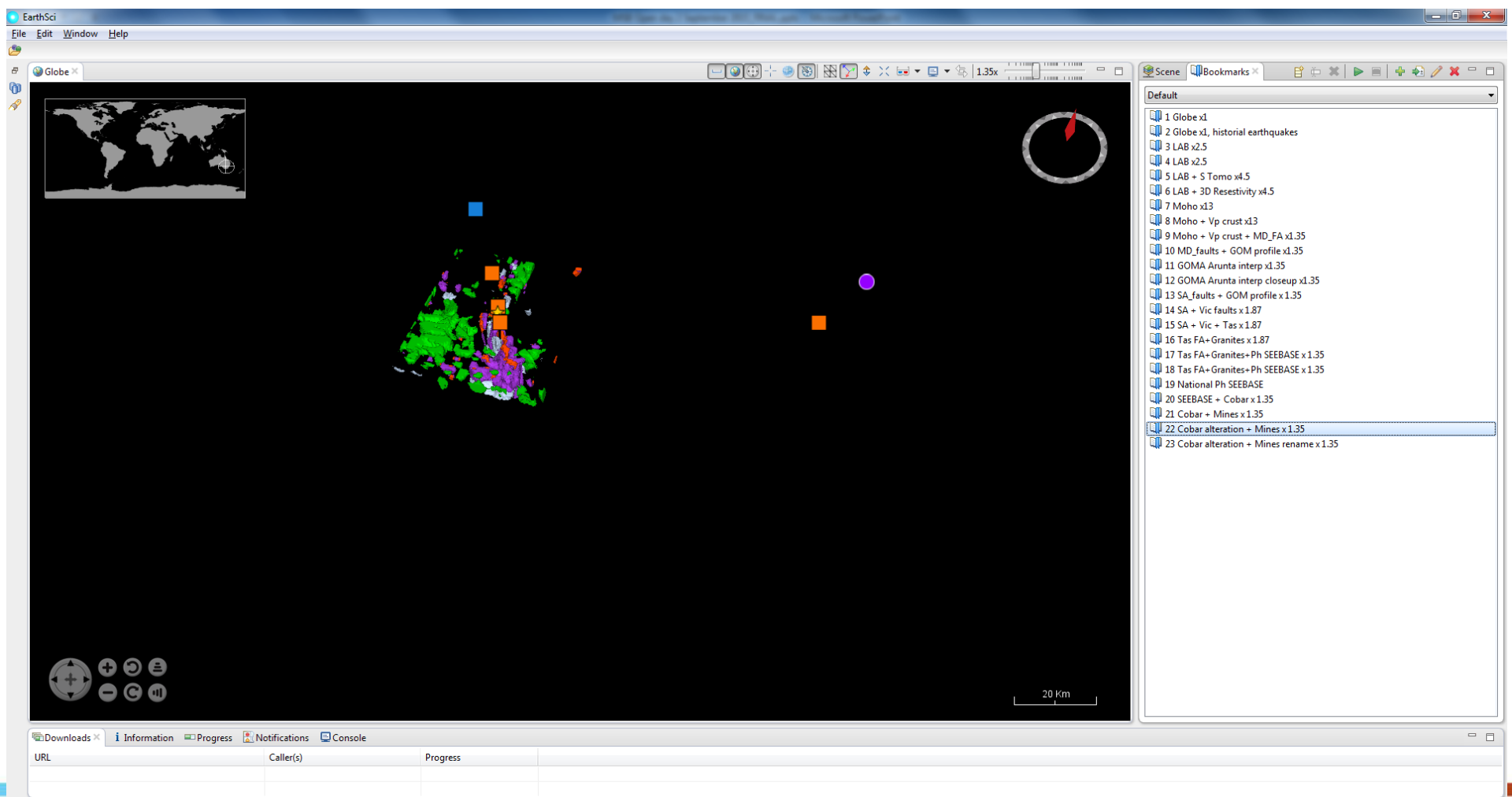


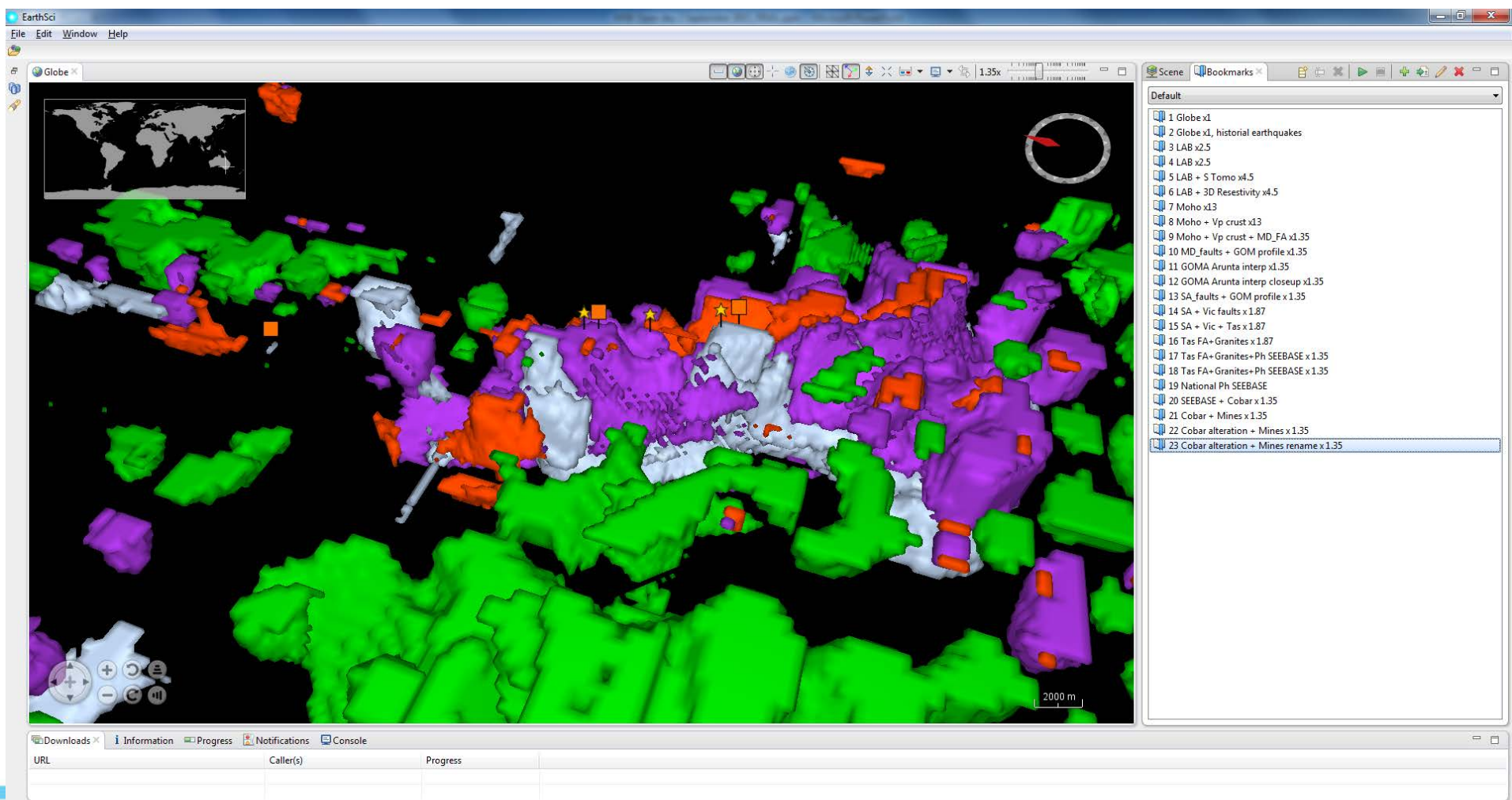












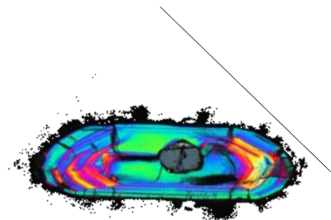
Theme 3: Geodynamics & mineral system evolution

Science problem: Most major ore deposits formed during specific time periods, linked to stages in supercontinent cycles.

Australia is endowed with a >3.8 billion year rock record, but where are the favourably-aged rocks hosting mineral deposits?

Solutions:

- a) New determinations of geological ages (stratigraphy, rocks, events, mineral deposits, etc)
- b) Translating theory into practical maps for exploration area selection
- c) Assessments of Australia's mineral potential, greenfields and under cover



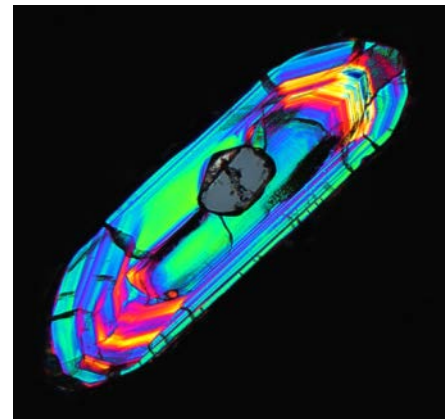


Australian geology through time:

**The Australian Stratigraphic Units Database (ASUD)
GA's geochronology capability and program**

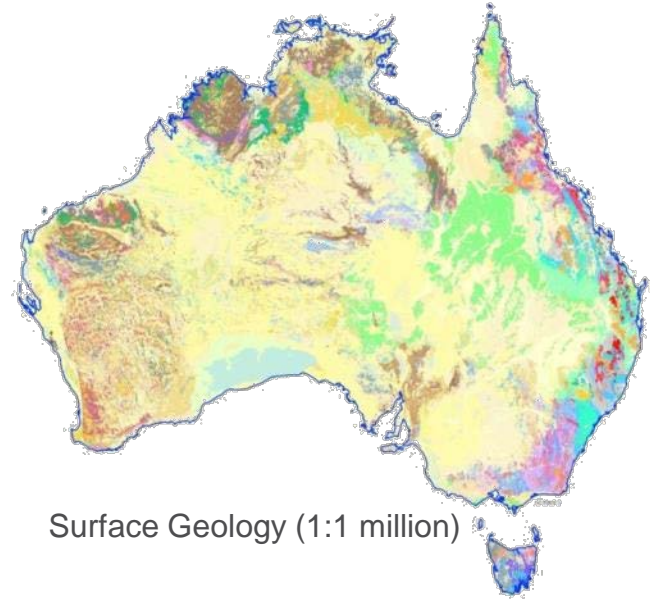
Geoff.Fraser@ga.gov.au

*Geochronology & Stratigraphy Section
Mineral Systems Branch, Resources Division*



The Australian Stratigraphic Units Database (ASUD)

- >14,000 geological units
- names
- lithologies
- relationships
- ages
- references



Surface Geology (1:1 million)

Australian Stratigraphic Units Database (ASUD)

- where to find it?
 - ga.gov.au
 - stratigraphic unit searches
- But that's not all...
- name reservation forms
 - unit definition forms
 - guides to stratigraphic nomenclature (incl. igneous units)

The screenshot shows the Australian Stratigraphic Units Database (ASUD) website. The header includes the Australian Government Geoscience Australia logo and the title "Australian Stratigraphic Units Database". The main content area displays the entry for "Mount Ainslie Volcanics", which is highlighted with a red box. The entry includes fields for "Current: Yes", "Category: Variation of published name", "Originator: Abell, R.S. (after Opik 1958)", "Replaced by:", "Description: Dacitic ignimbrite, minor ashstone, agglomerate and shale; porphyry", "Comments: BMR Bulletin 233. Approved by A. Walther 17-MAY-1990", "Geological province: Lachlan Orogen", "Type state: NSW", "Reference section type:", "Maximum thickness:", "Minimum thickness:", "Unit Age", "Event: eruption", "Top of unit -", "Minimum age: Wenlock", "Maximum age:", "Base of unit -", "Minimum age:", "Maximum age: Wenlock", "Stratigraphic Hierarchy (current units only)", "Rank", and "Status".

Field	Value
Mount Ainslie Volcanics	
Current:	Yes
Category:	Variation of published name
Originator:	Abell, R.S. (after Opik 1958)
Replaced by:	
Description:	Dacitic ignimbrite, minor ashstone, agglomerate and shale; porphyry
Comments:	BMR Bulletin 233. Approved by A. Walther 17-MAY-1990
Geological province:	Lachlan Orogen
Type state:	NSW
Reference section type:	
Maximum thickness:	
Minimum thickness:	
Unit Age	
Event:	eruption
Top of unit -	
Minimum age:	Wenlock
Maximum age:	
Base of unit -	
Minimum age:	
Maximum age:	Wenlock

Stratigraphic Hierarchy (current units only)

Stratigraphic Hierarchy (current units only)	Rank	Status
• Douro Group	Group, Suite	Formal
- Deakin Volcanics	Formation, beds	Formal
- Mugga Mugga Porphyry Member	Member, phase	Formal
- Glenisla Volcanics	Formation, beds	Formal
- Goobarragandra Volcanics	Formation, beds	Formal
- Hawkins Volcanics	Formation, beds	Formal
- Bango Limestone Member	Member, phase	Formal
- Ledgeworth Facies	Member, phase	Informal
- Vale View Facies	Member, phase	Informal
- Illunlie Volcanics	Formation, beds	Formal
- Laidlaw Volcanics	Formation, beds	Formal
- Mount Ainslie Volcanics	Formation, beds	Formal
- Mount Painter Volcanics	Formation, beds	Formal
- Walker Volcanics	Formation, beds	Formal
- Yanawe Formation	Formation, beds	Formal
- Euralie Limestone Member	Member, phase	Formal

Geoscience Australia's geochronology program:

- core capability is in-house SHRIMP laboratory
- other in-house expertise (but not in-house analytical facilities):
ID-TIMS U-Pb, Ar-Ar, K-Ar, Re-Os, (Nd, Pb, O, Hf)

Geological Events we can (and do) date:

- Igneous
- Metamorphic
- Fluid alteration/mineralisation
- Sediment provenance
- Geological timescale calibration



SHRIMP

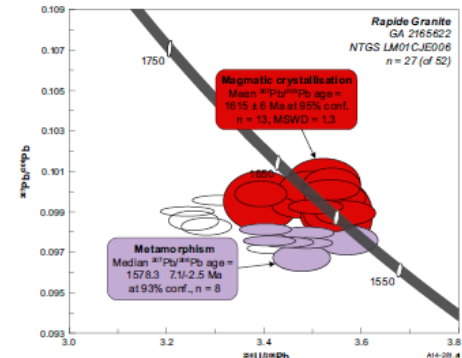
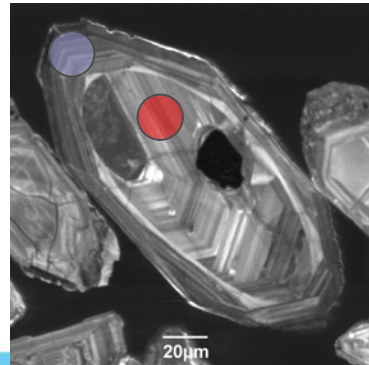
- U-Pb zircon (monazite, titanite)
- ~120 samples per year
- supporting GA projects
- ongoing collaborations with:

- NTGS
- GSQ
- GSNSW
- GSSA
- GSV



Big instrument ... > 5 metres

Small targets... ~300 micron zircon grains



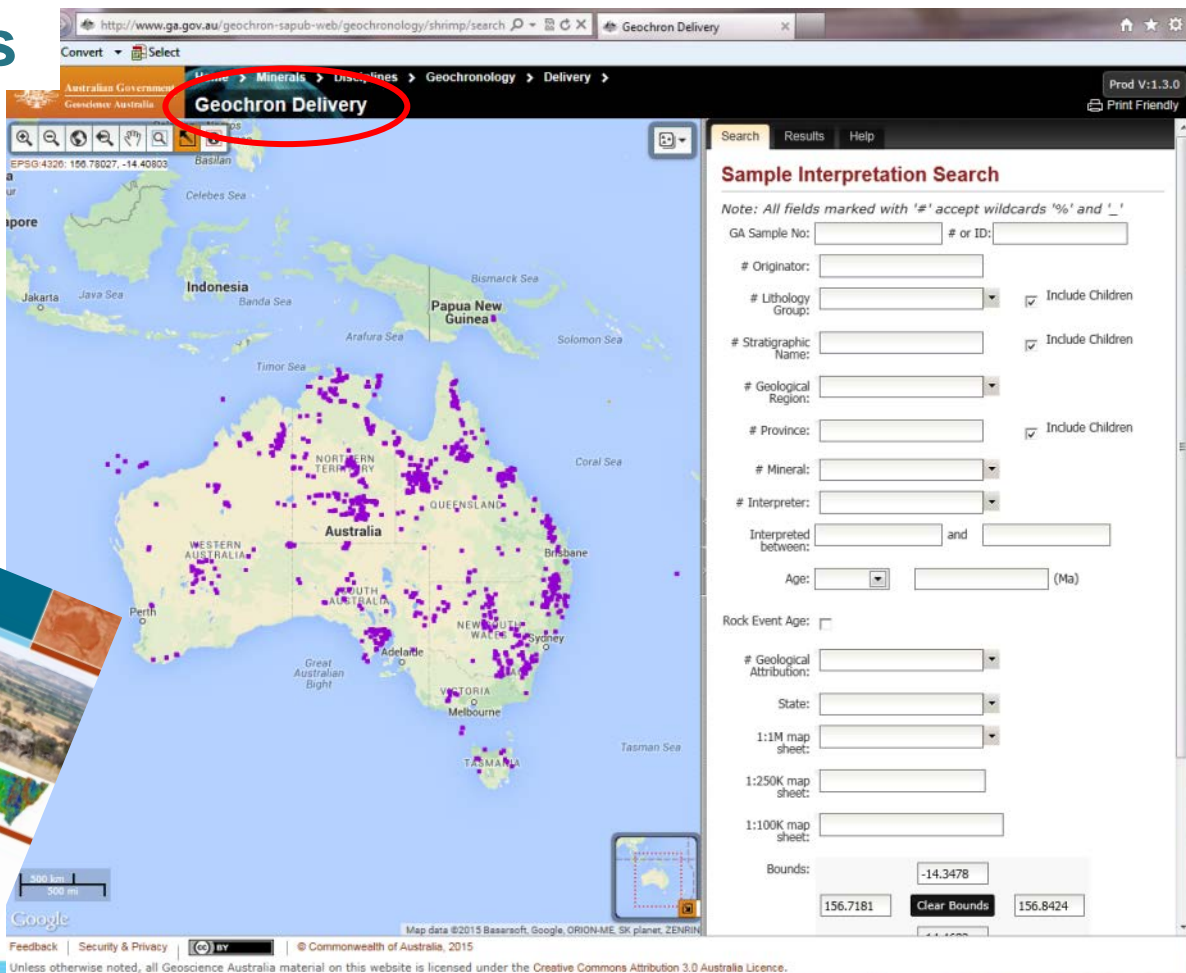


Mineral Separation & Sample Preparation

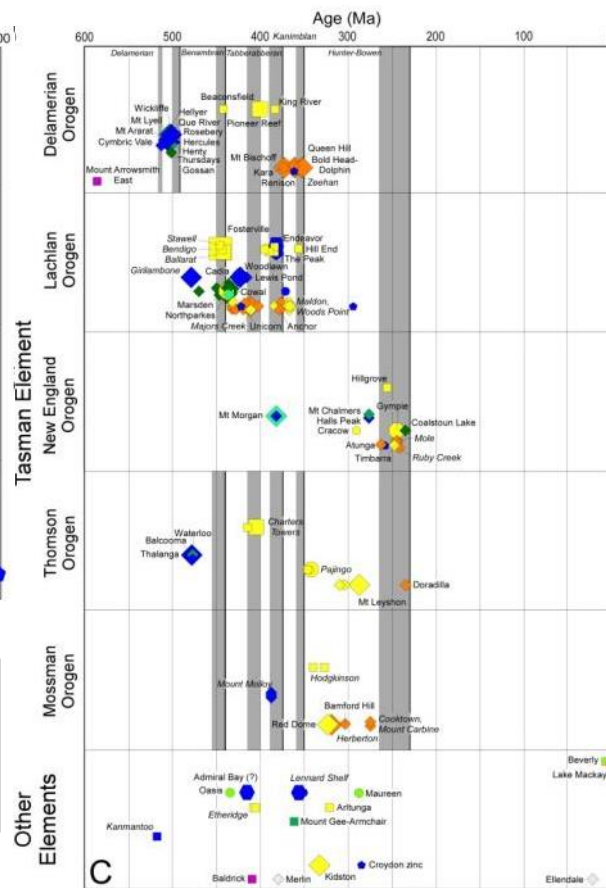
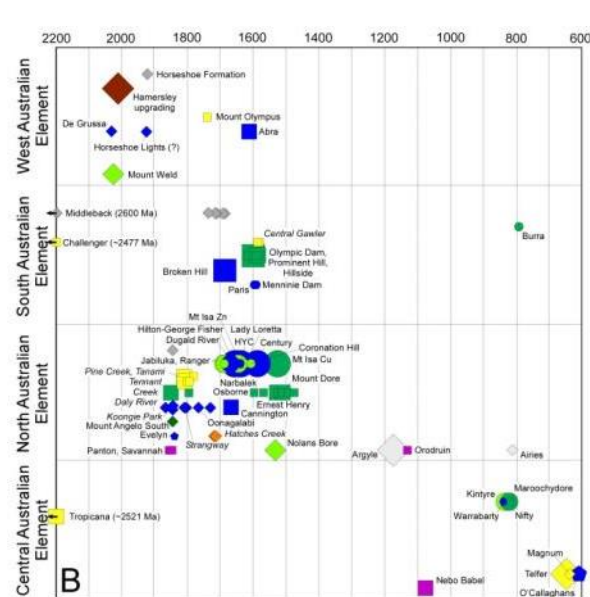
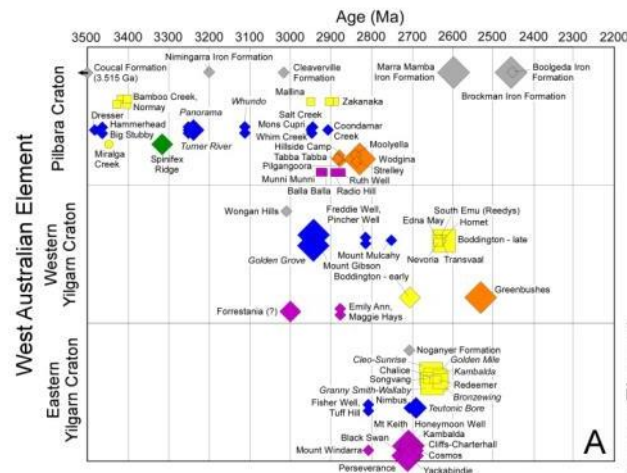


Geochronology results

- Geological reports
- Journal papers
- Online data delivery
 - >1300 samples from GA laboratory



Datasets: ages of Australian ore deposits – a new synthesis



Convergent margins

Initial stage: subduction

- Komatiite-associated Ni-Cu-PGE
- VHMS Zn-Pb-Cu; high sulphidation Cu-Au
- Porphyry Cu-Au-Mo; calc-alkaline and alkaline
- Epithermal Au, Ag-Pb-Zn

Final stage: post-orogenic extension

- Iron ore enrichment
- Iron-oxide Cu-Au-U
- Granite-related Zn-W-Cu-Sn
- Granite-related Sn-Ta, Mo-W
- Intrusion-related Au

Intermediate stage: orogenesis

- Mississippi Valley-type Zn-Pb
- Epigenetic Cu-Au; Zn-Pb-Ag
- Orogenic Au

Intraplate

- Sandstone-hosted U; surficial U-V
- Orthomagmatic Ni-Cu, PGE and V-Ti-Fe
- Salt-lake hosted K

Divergent margins

Initial stage: initiation and rifting

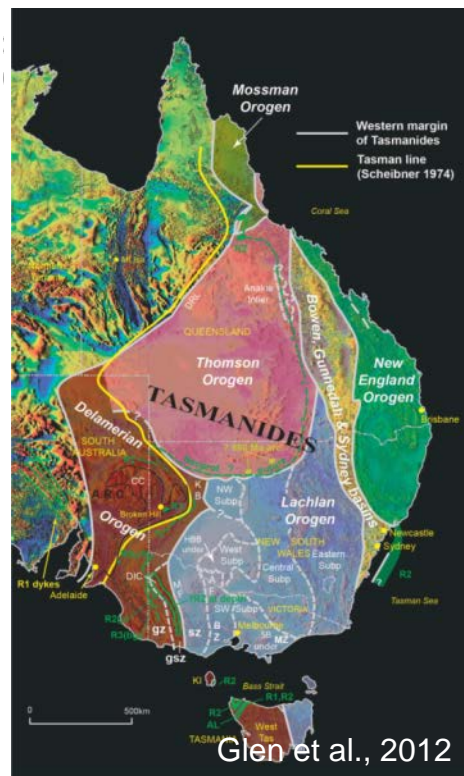
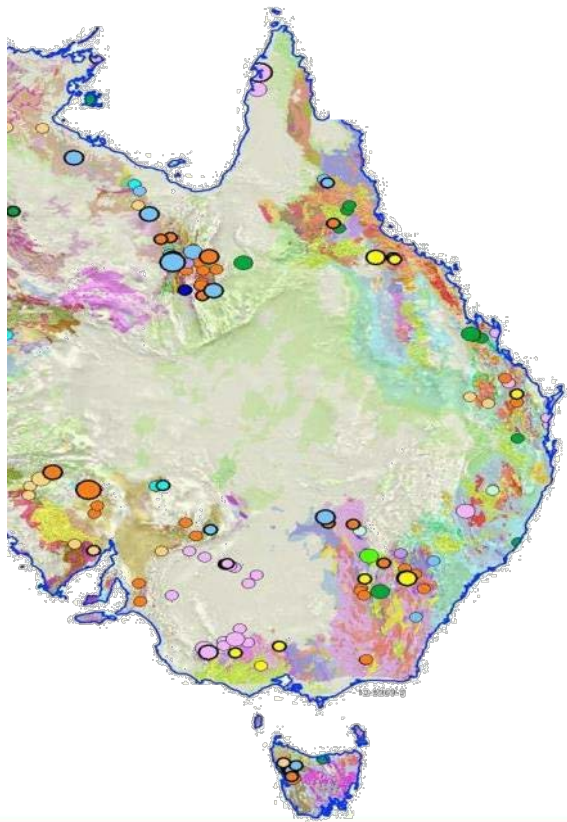
- Diamond
- Alkaline-related REE-P-Th-U
- Siliciclastic-mafic Zn-Pb-Ag

Final stage: basin sag, passive margins and inversion

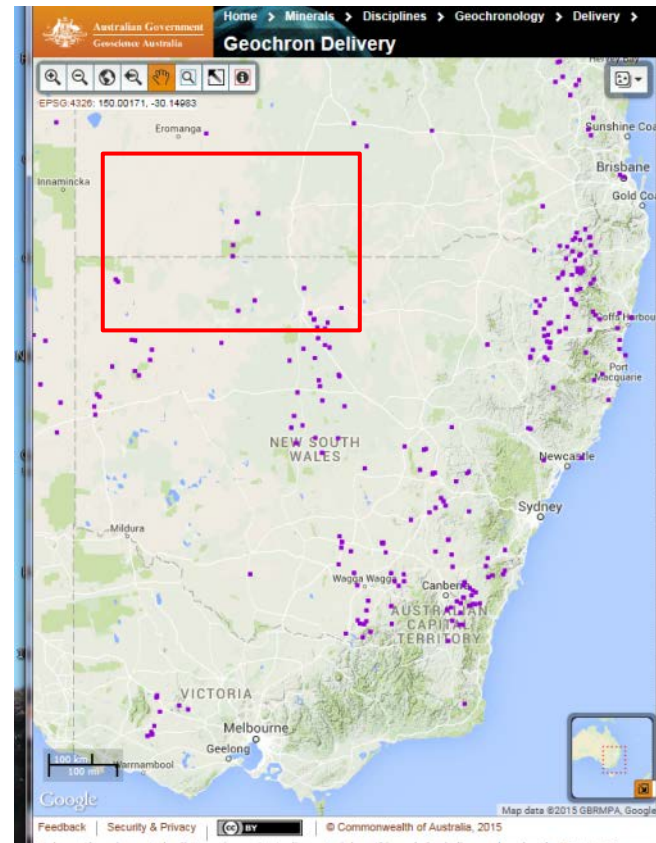
- Shale-hosted Cu
- Unconformity-related U
- Banded-iron formation (undifferentiated)
- Siliciclastic-carbonate Zn-Pb-Ag

(from Huston et al., in press)

Work in progress: southern Thomson Orogen



Glen et al., 2012



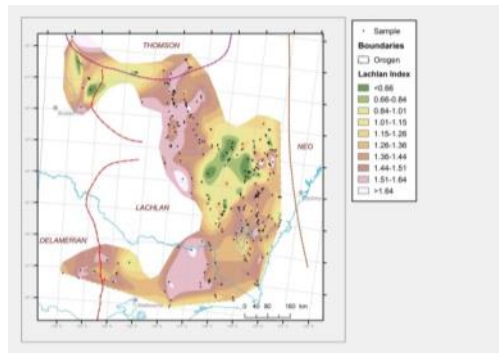
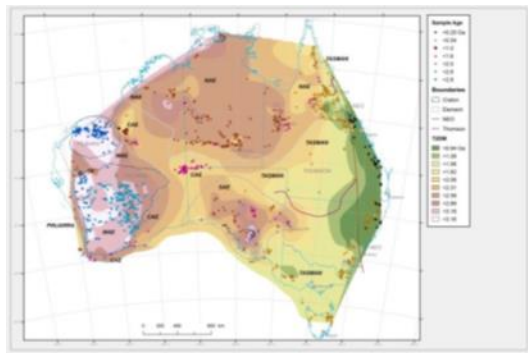
Contact us.....

stratnames@ga.gov.au
geochronology@ga.gov.au





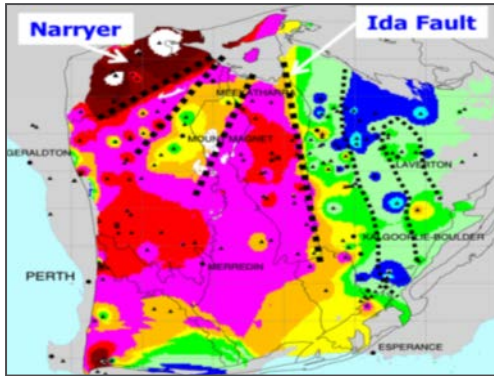
Isotope geochemistry: a tool to map crustal architecture and fertility



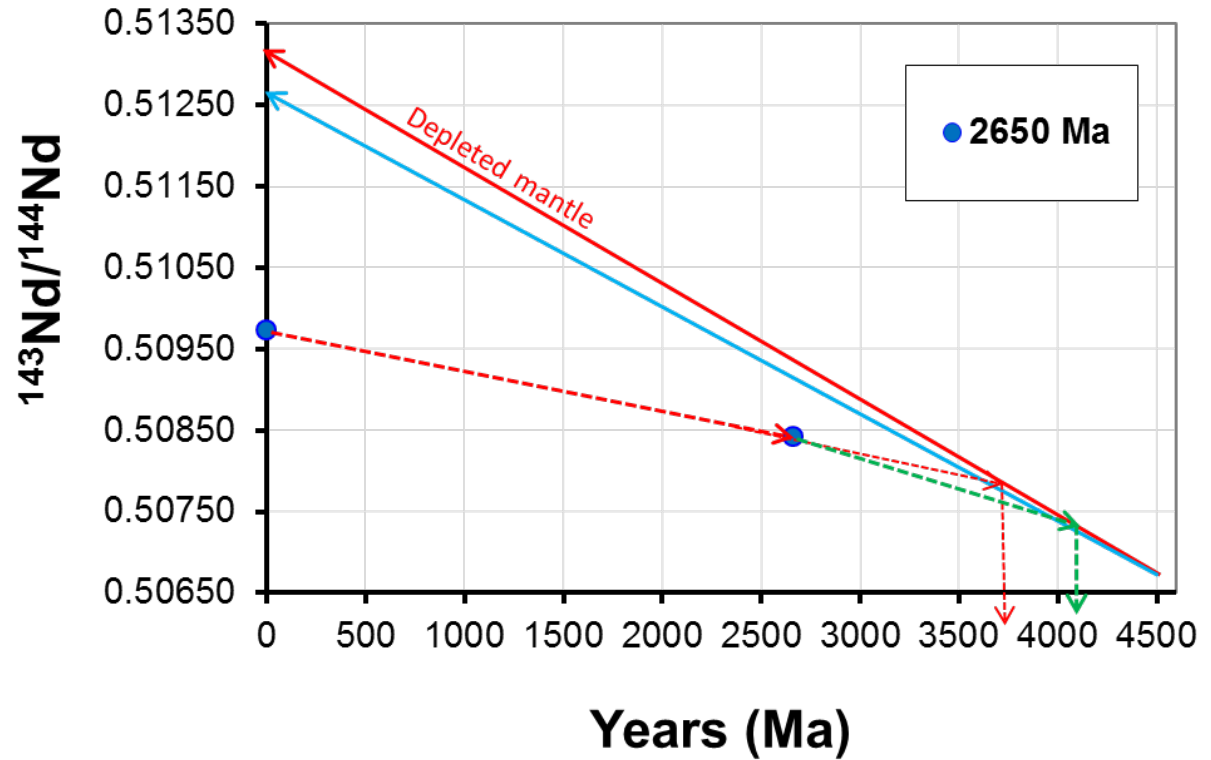
Kathryn Waltenberg, David Champion, David Huston
Kathryn.Waltenberg@ga.gov.au

4D metallogenic evolution: big boundaries in Sm-Nd and Pb

Yilgarn T_{DM} map

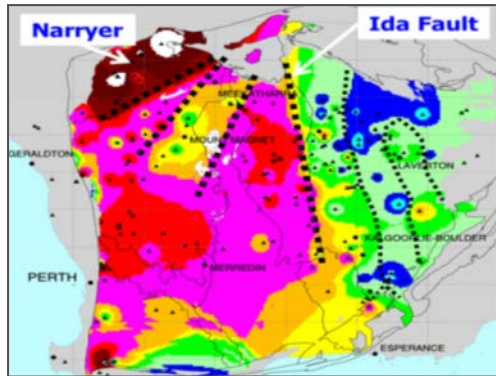


Champion & Cassidy, 2004

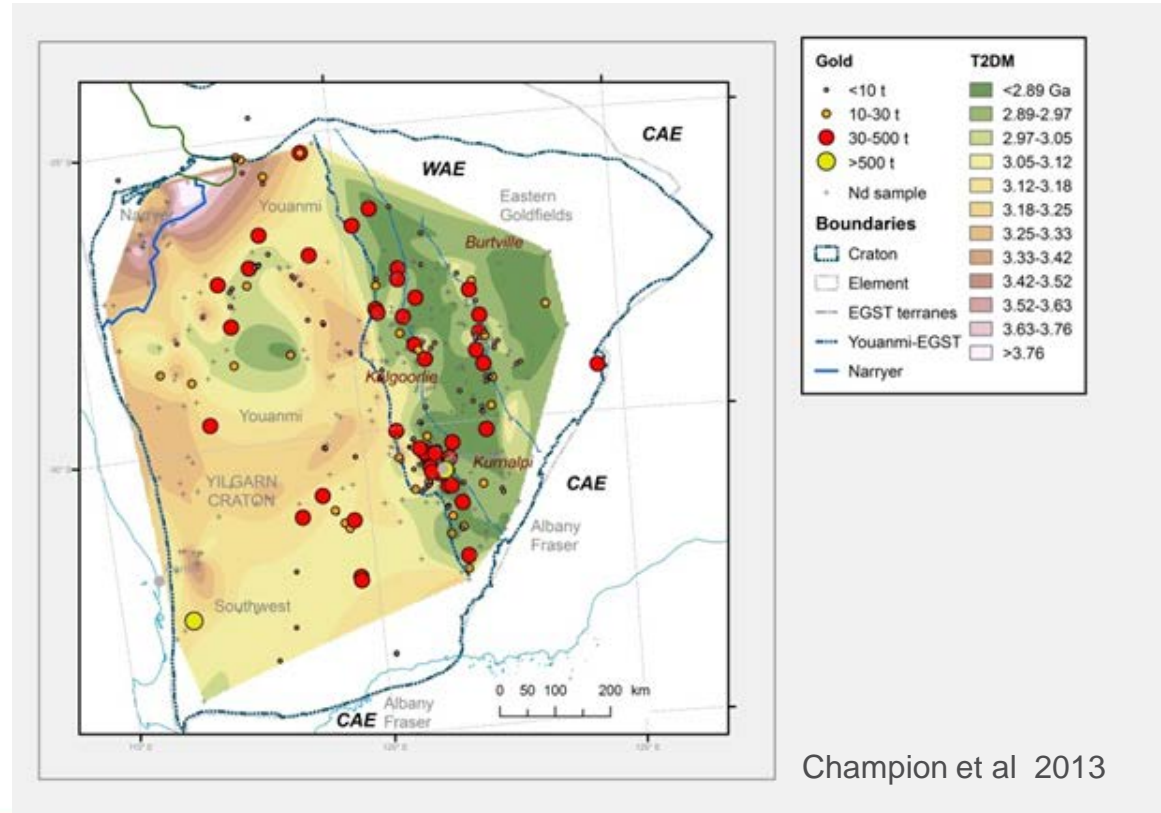


4D metallogenic evolution: big boundaries in Sm-Nd and Pb

Yilgarn T_{DM} map



Champion & Cassidy, 2004



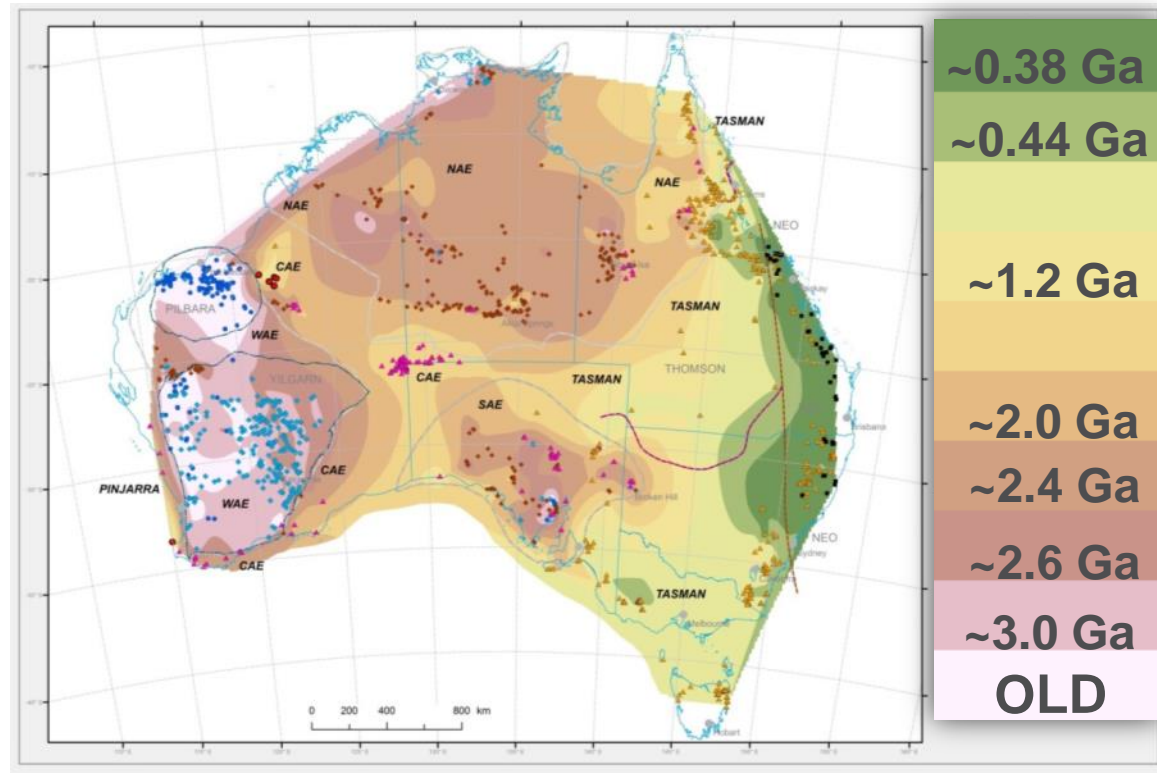
Champion et al 2013

Sm-Nd model age map of Australia

- Look 'through' the granite to date its source
- ~Timing of crust 'extraction' from mantle

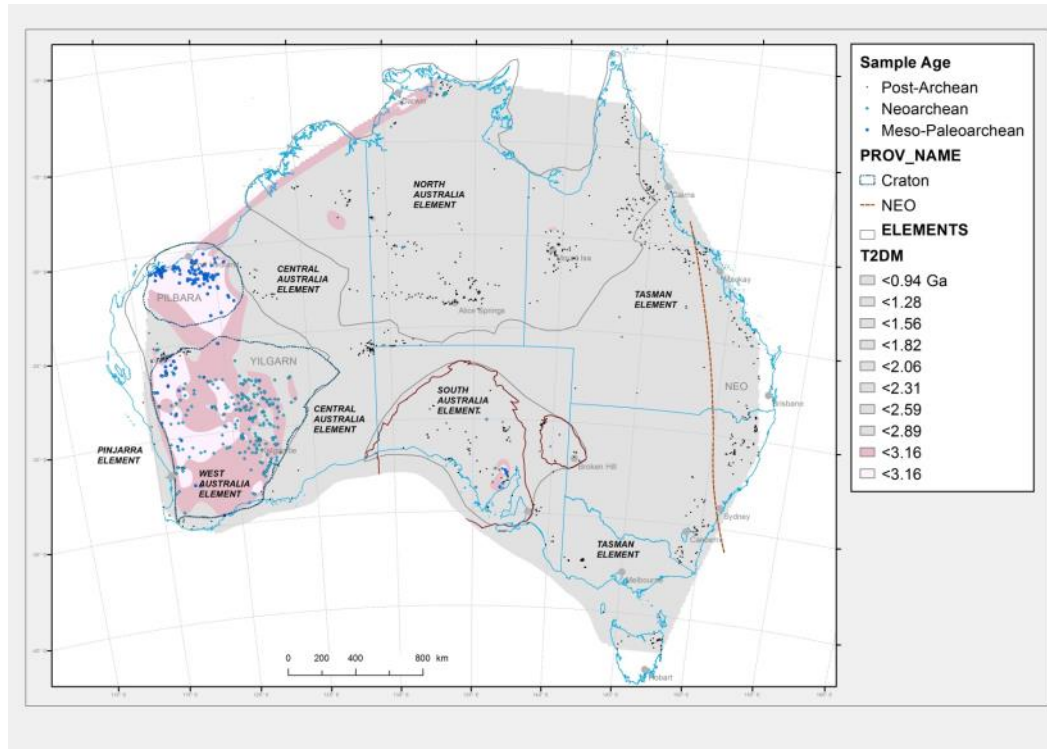
Model ages:

- Approximation of the bulk age of the crust
- Best used in relative terms and at regional scales



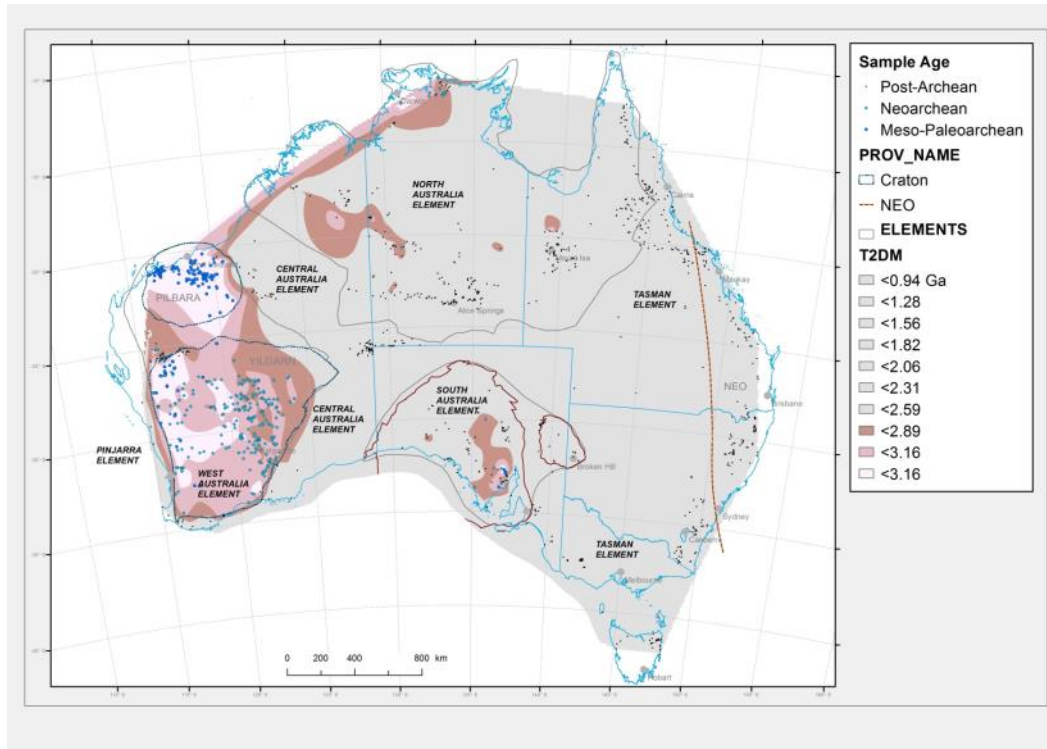
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



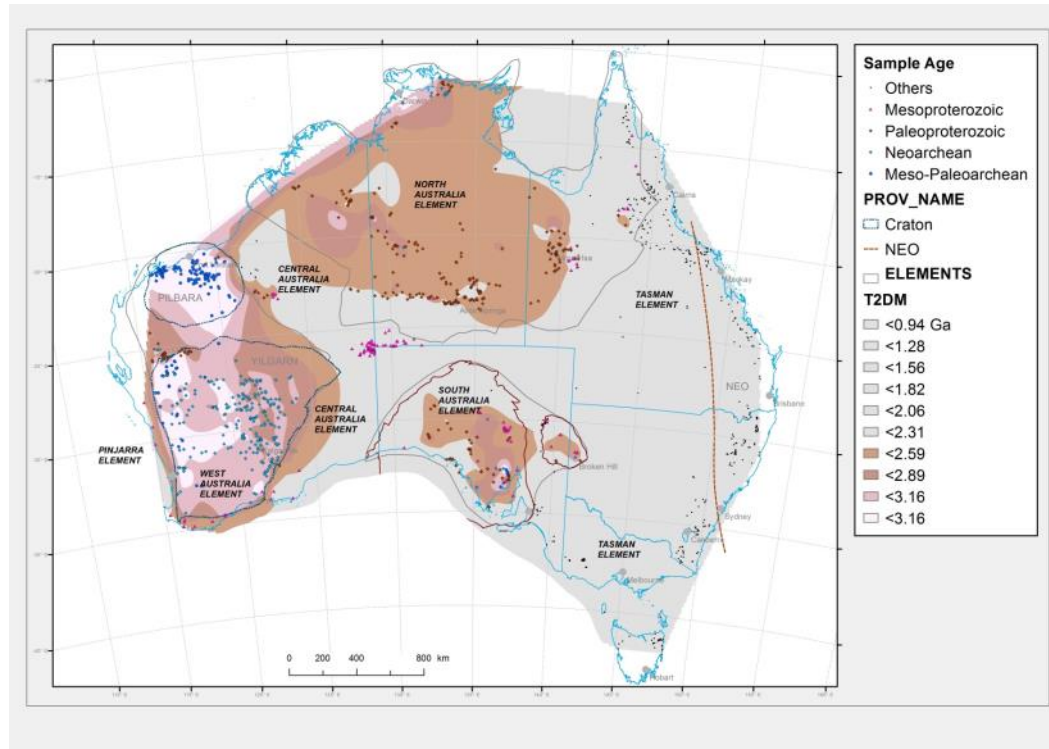
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



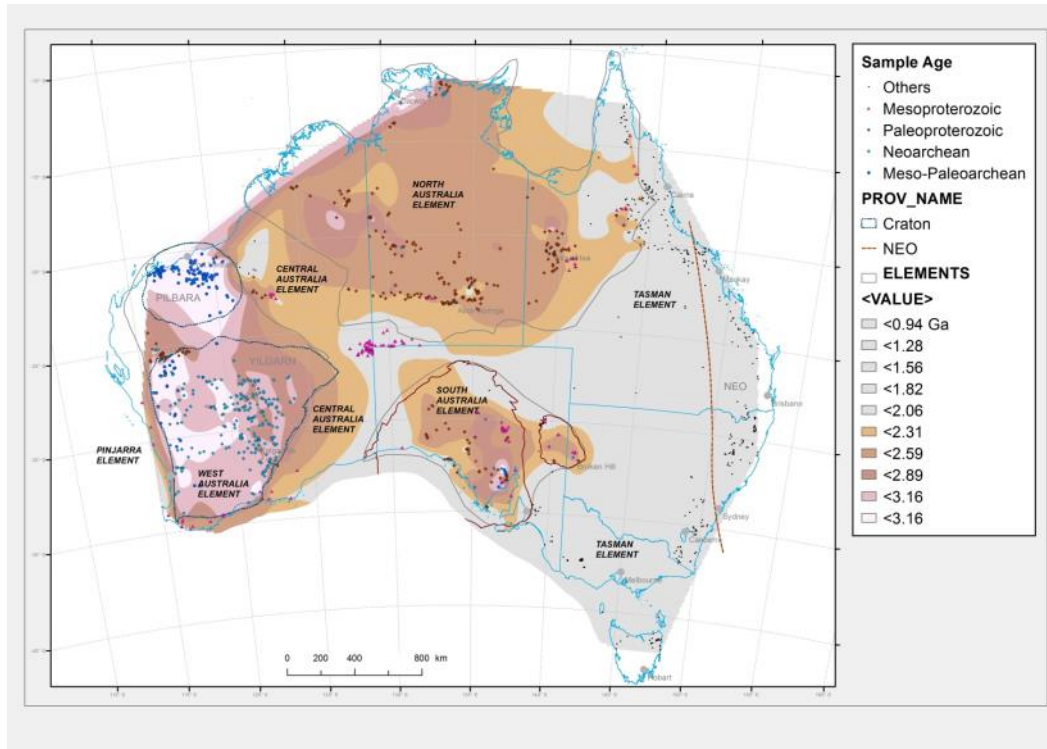
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



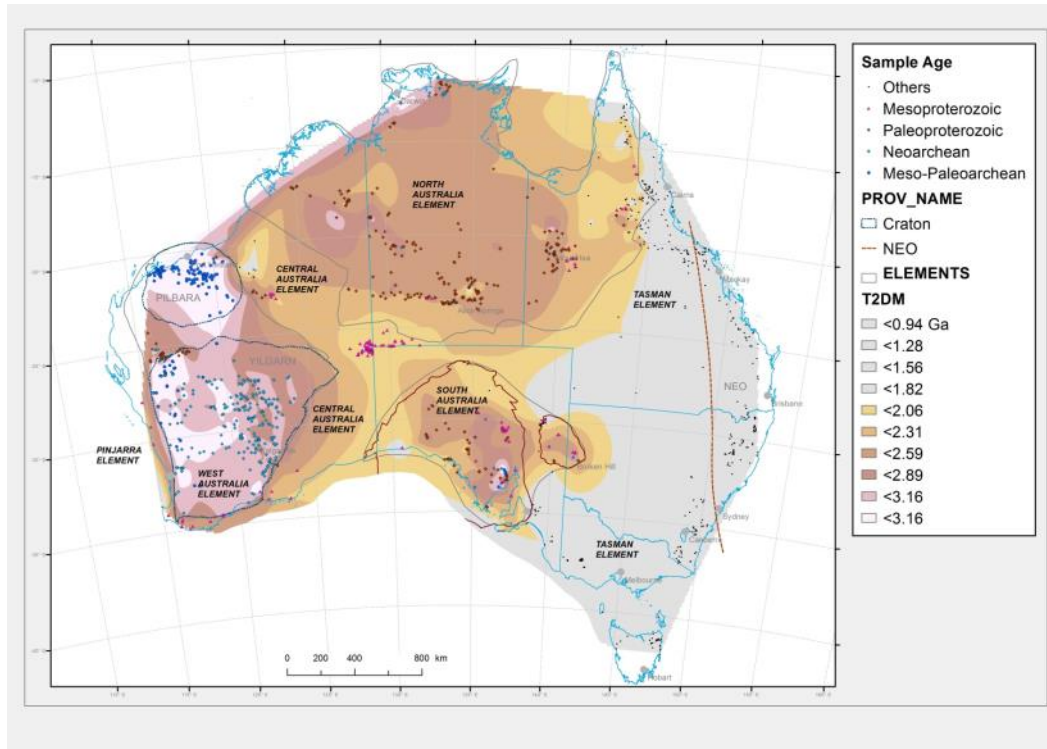
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



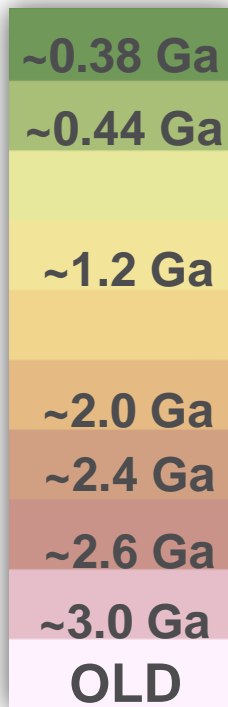
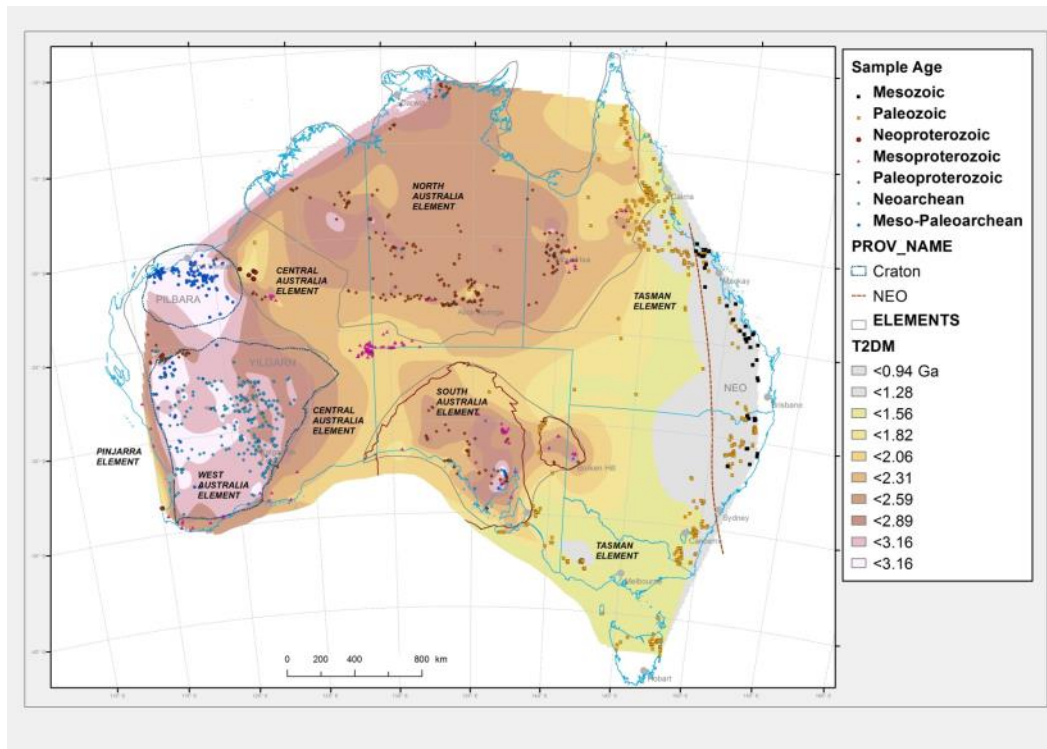
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



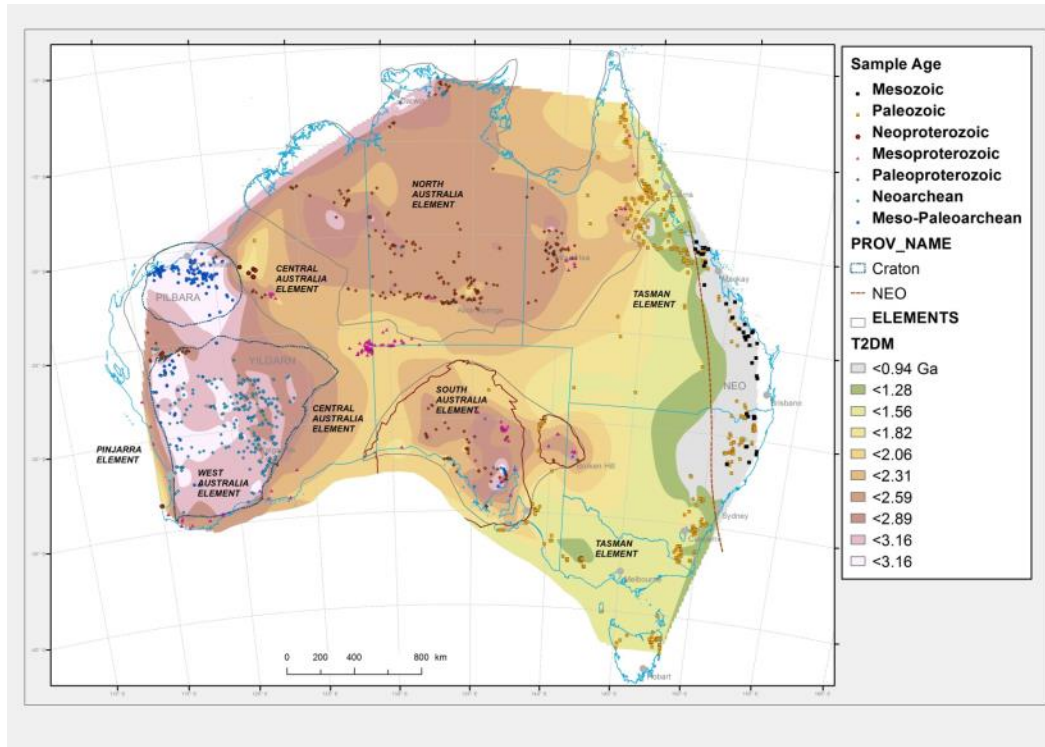
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



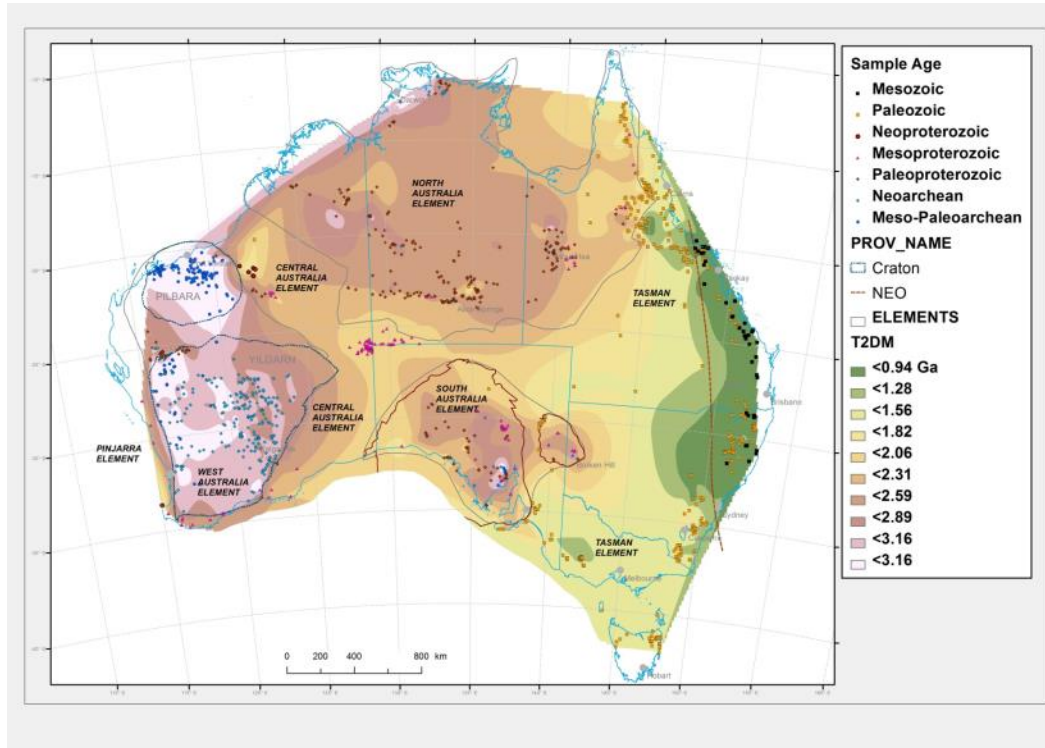
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



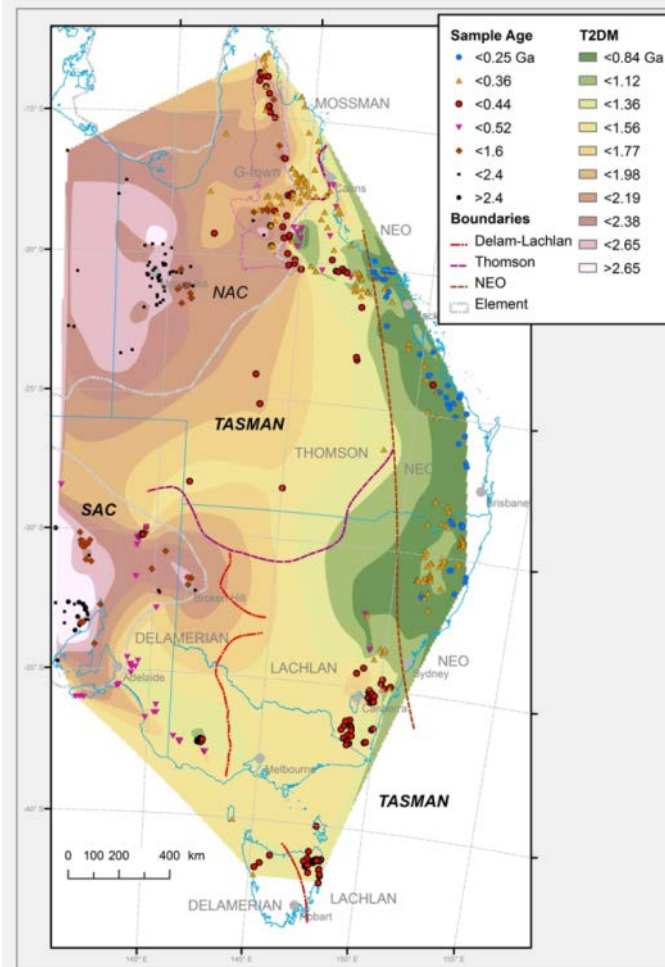
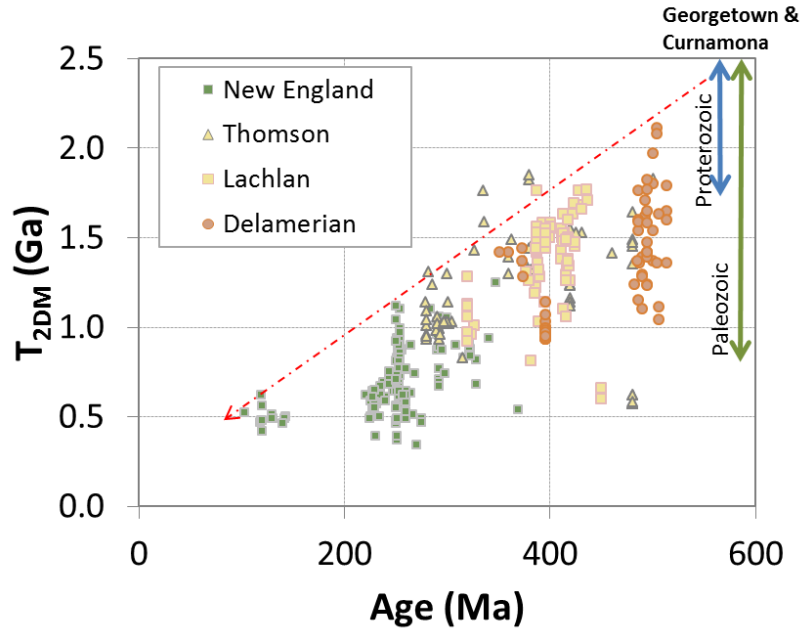
Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Sm-Nd model age map of Australia: building a continent



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Sm-Nd: Eastern Australia



Lead (Pb) isotopes

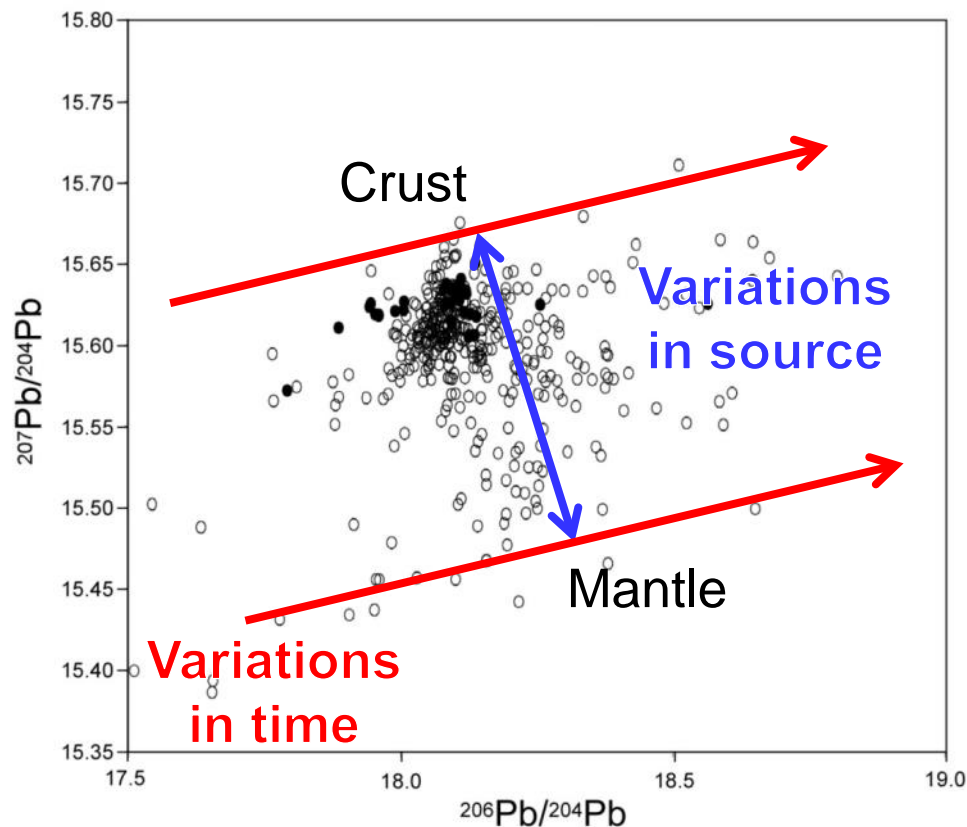
- Similar concept to Sm-Nd, but utilises Pb-rich, U-free minerals (e.g. galena, feldspar)
- Best when the age of the system is independently known
- Pb isotopes in feldspar can represent bulk-crust/mantle composition through time
- Pb isotopes in galena provide direct information about crust/mantle input during mineralisation events



Rob Lavinsky, iRocks.com

Lead isotopes in Lachlan: $^{206}\text{Pb}/^{204}\text{Pb}$ vs $^{207}\text{Pb}/^{204}\text{Pb}$

- Similar concept to Sm-Nd, but utilises Pb-rich, U-free minerals (e.g. galena, feldspar)
- Best when the age of the system is independently known
- Pb isotopes in feldspar can represent bulk-crust/mantle composition through time
- Pb isotopes in galena provide direct information about crust/mantle input during mineralisation events



Lead isotopes in Lachlan: mineralising processes

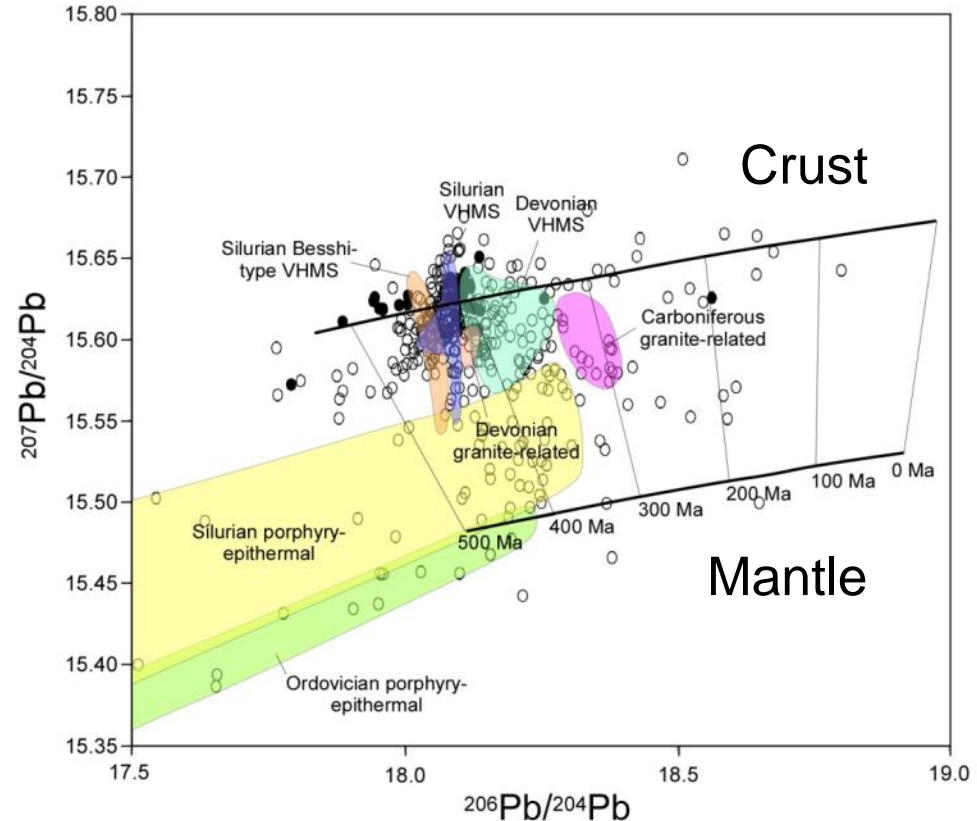
Different mineralising processes generate different Pb-isotope signatures

Crustal:

VHMS

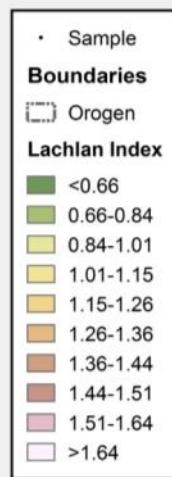
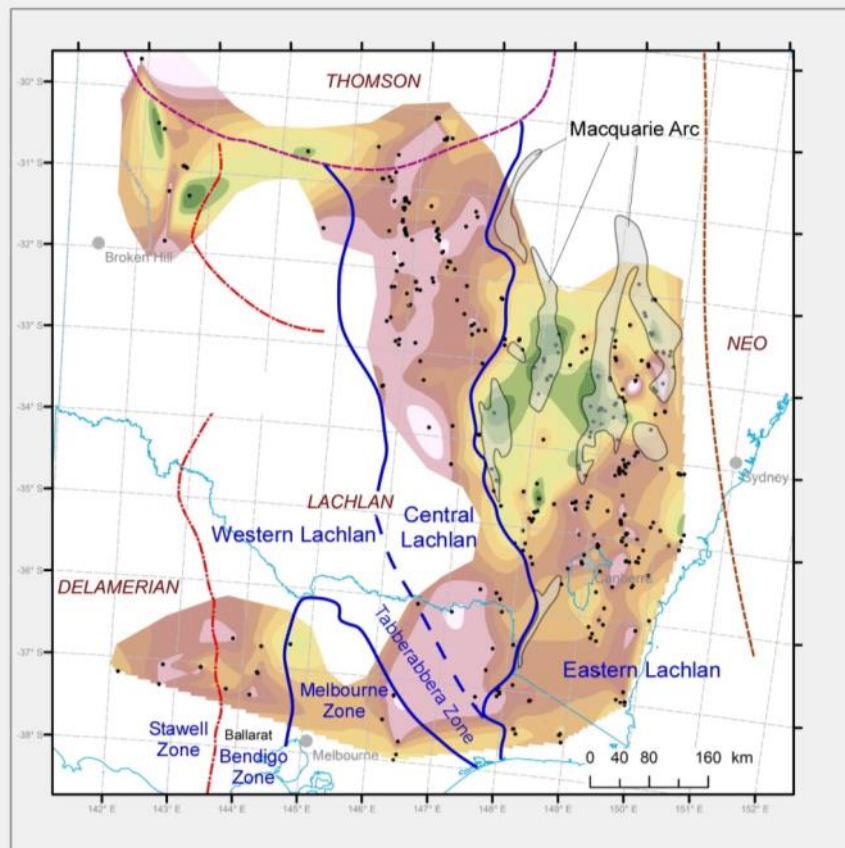
Mantle:

Porphyry-epithermal



Fields and evolution curves from Carr et al. (1995)

Lead isotopes in Lachlan: Lachlan Lead Index



Juvenile

↕

Evolved

Strong correlations
between isotope
signatures and
subprovince
boundaries

Huston, D.L., et al., in press. Metallogensis and geodynamics of the Lachlan Orogen: New (and old) insights from spatial and temporal variations in lead isotopes. *Ore Geology Reviews*.

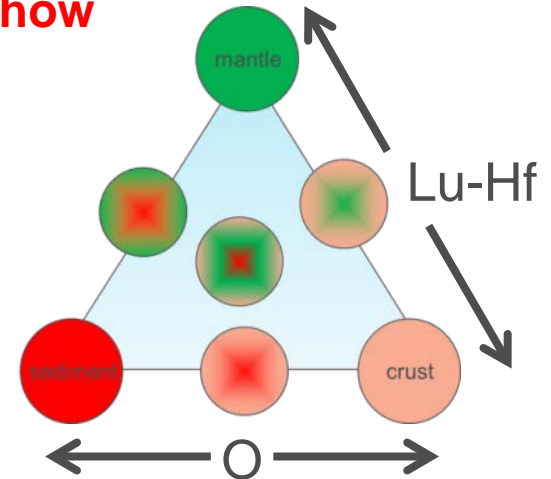
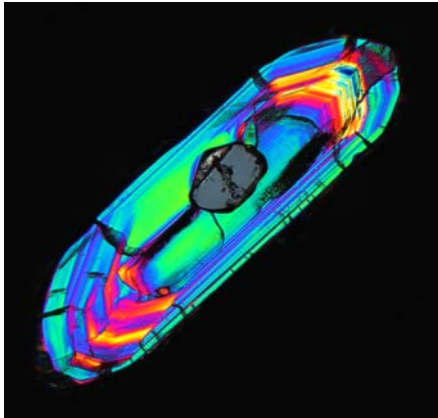
<http://dx.doi.org/10.1016/j.oregeorev.2015.07.005>

Lu-Hf and O isotopes

Zircons lock in Hf-isotope composition at time of crystallisation

O-isotopes record metasomatism (e.g. during subduction)

U-Pb + Lu-Hf + O = when + (from) where + (maybe) how



Hf-isotope data: compilation and database

Existing literature:

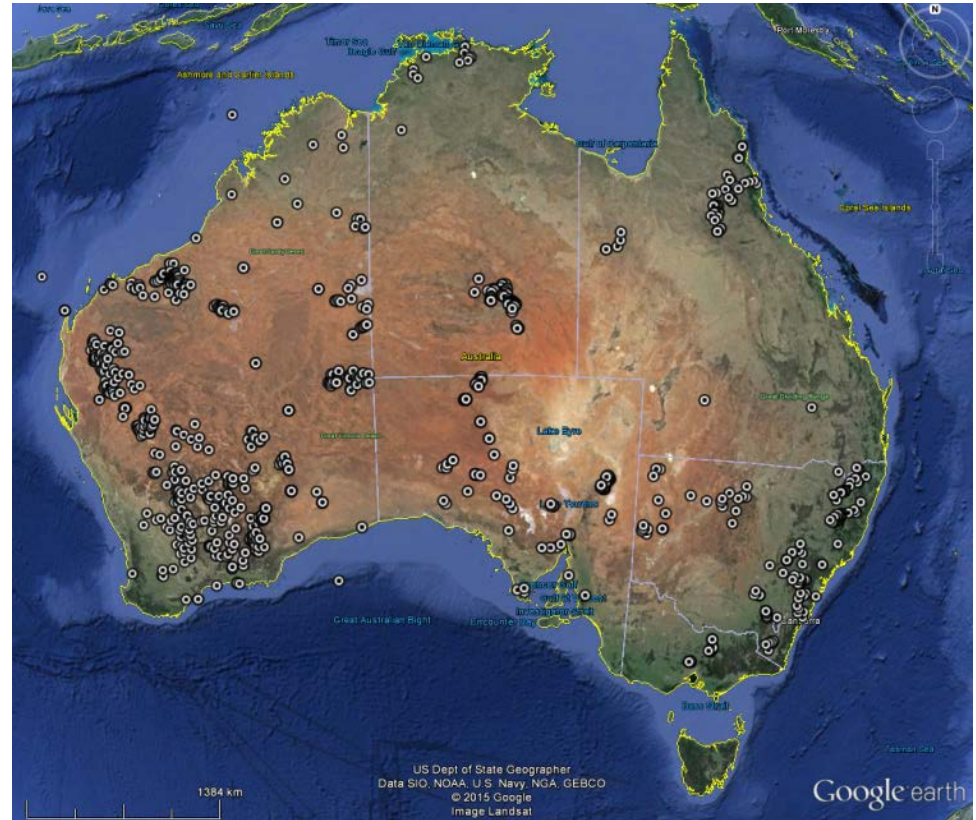
>17 000 analyses

>1200 samples

>150 publications

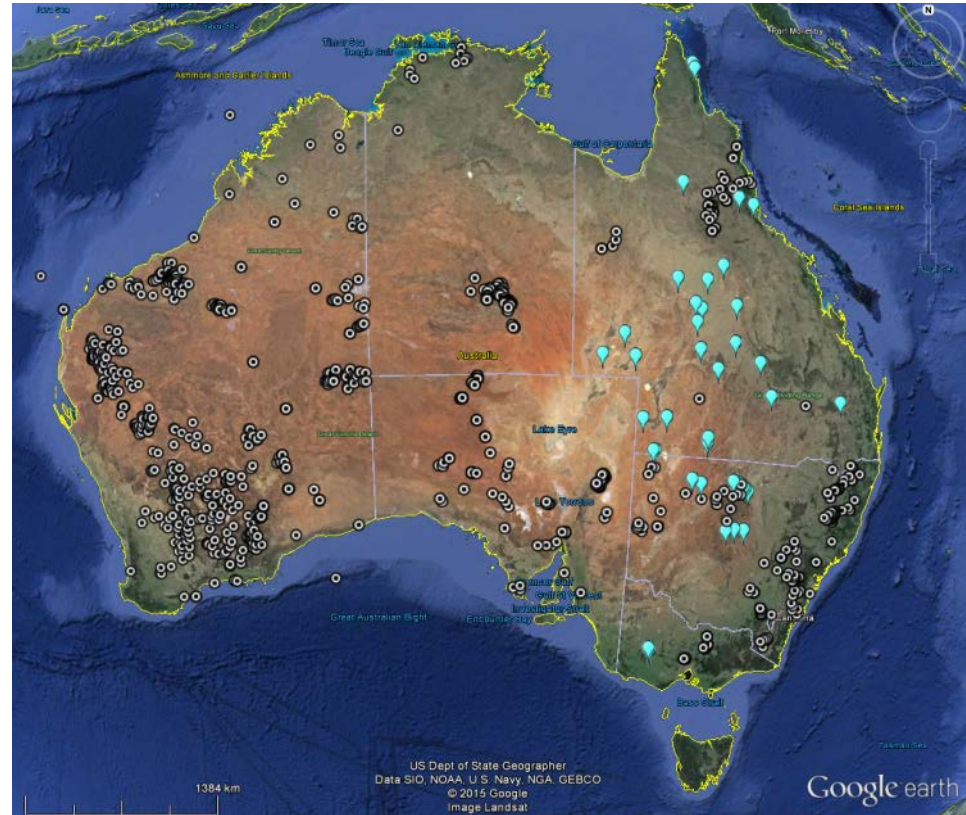
Only 75% of samples properly located!

Database to store both Lu-Hf and O isotope data: long-term project



Hf-isotope data: new work (GA and State partners)

- Staveland Region, in support of Staveland drilling program with GSV
- In Queensland, collaboration with GSQ
- Thomson-Lachlan boundary, in support of southern Thomson drilling program with GSNSW and GSQ



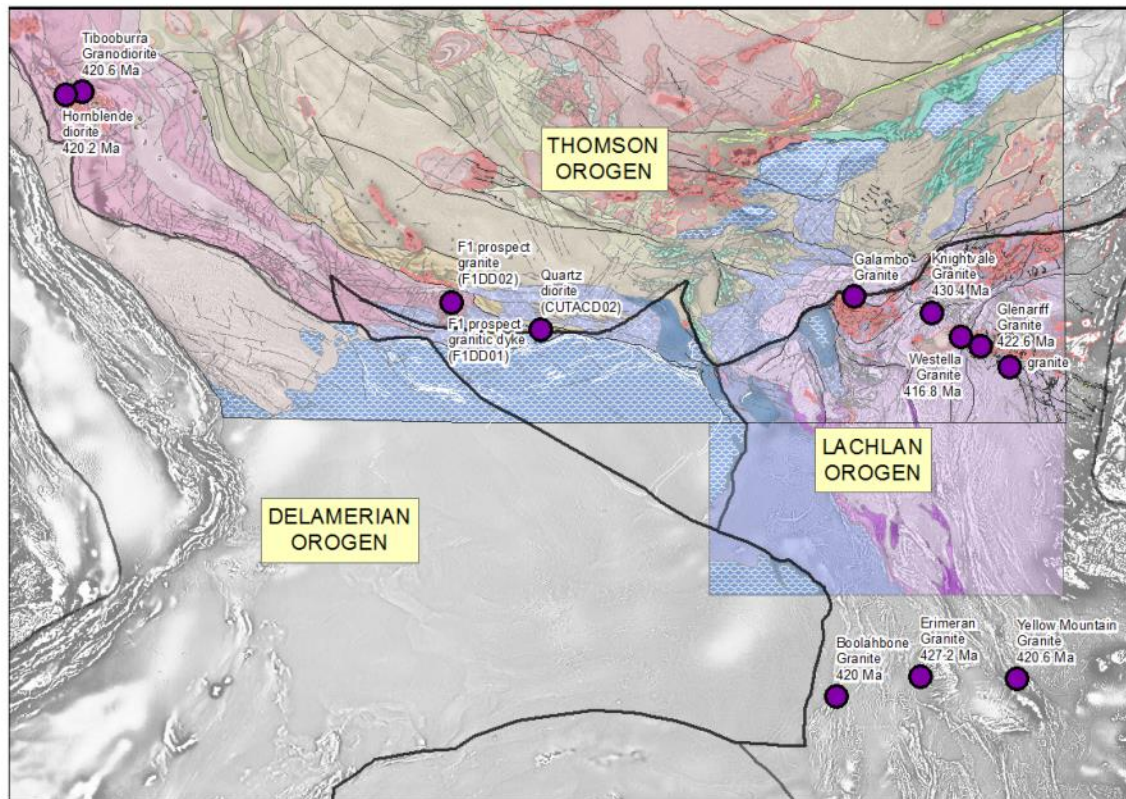
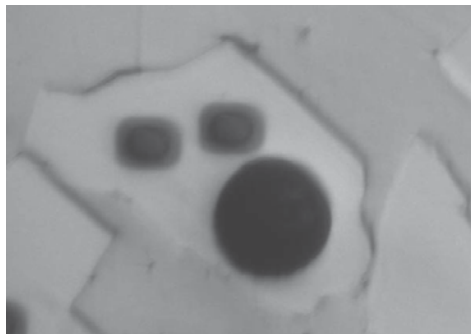
Hf + O isotopes across Thomson–Lachlan boundary

New isotopic information
from archived collections

Existing SHRIMP U-Pb

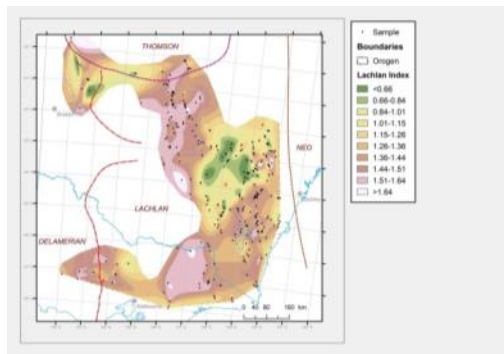
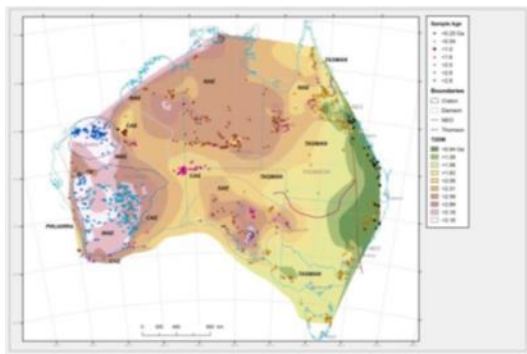
+ SHRIMP O-isotopes

+ MC-ICP-MS Hf-isotopes



Contacts

- Sm-Nd isotopes: David Champion David.Champion@ga.gov.au
- Pb isotopes: David Huston David.Huston@ga.gov.au
- Lu-Hf + O isotopes: Kathryn Waltenberg Kathryn.Waltenberg@ga.gov.au



Champion, D.C., 2013. *Neodymium depleted mantle model age map of Australia: explanatory notes and user guide*. Record 2013/044. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2013.044>

Huston, D.L. et al., in press. Metallogensis and geodynamics of the Lachlan Orogen: New (and old) insights from spatial and temporal variations in lead isotopes. *Ore Geology Reviews*. <http://dx.doi.org/10.1016/j.oregeorev.2015.07.005>



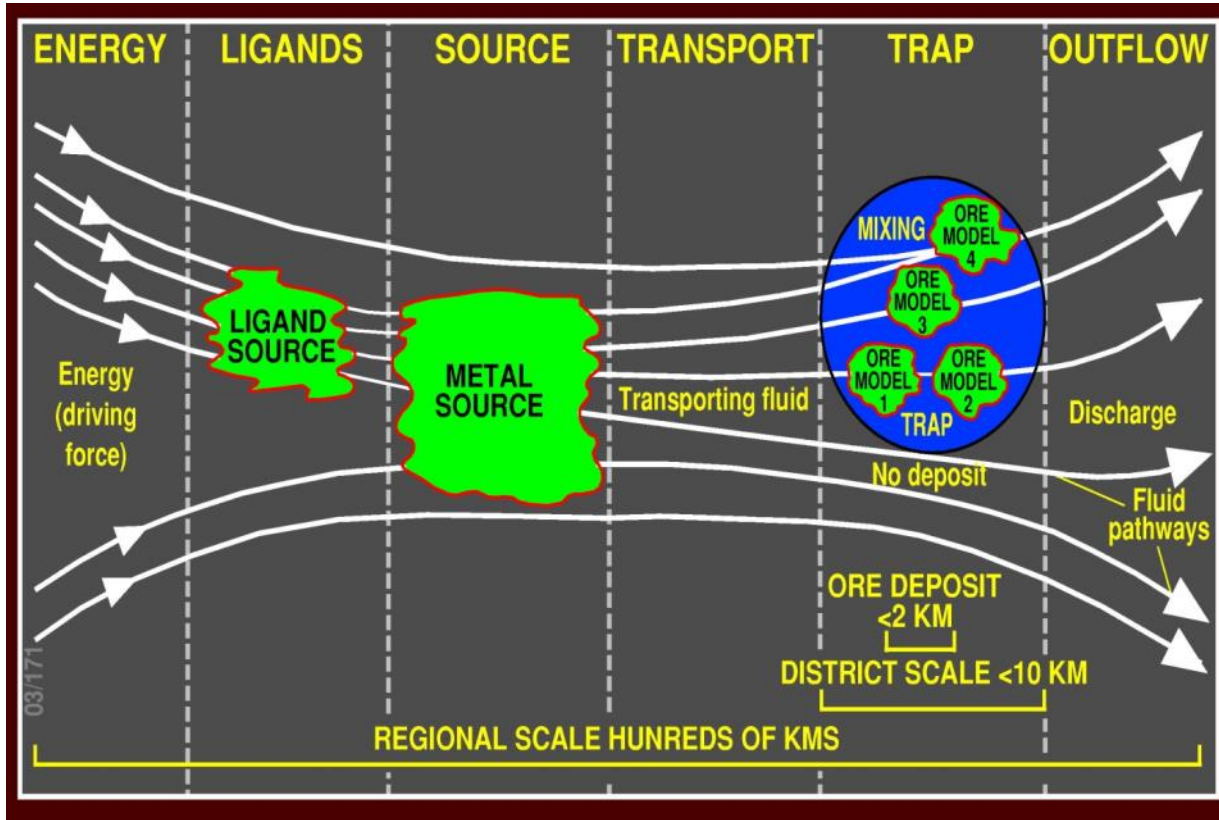
Mineral systems as an area selection method at the regional and national scales: examples of IOCG and magmatic Ni-Cu-PGE systems



R Skirrow, H Dulfer, J Thorne, D Champion, A Schofield, DL Huston*

*David.Huston@ga.gov.au

Mineral systems – the beginnings



Wyborn et al. (1994)

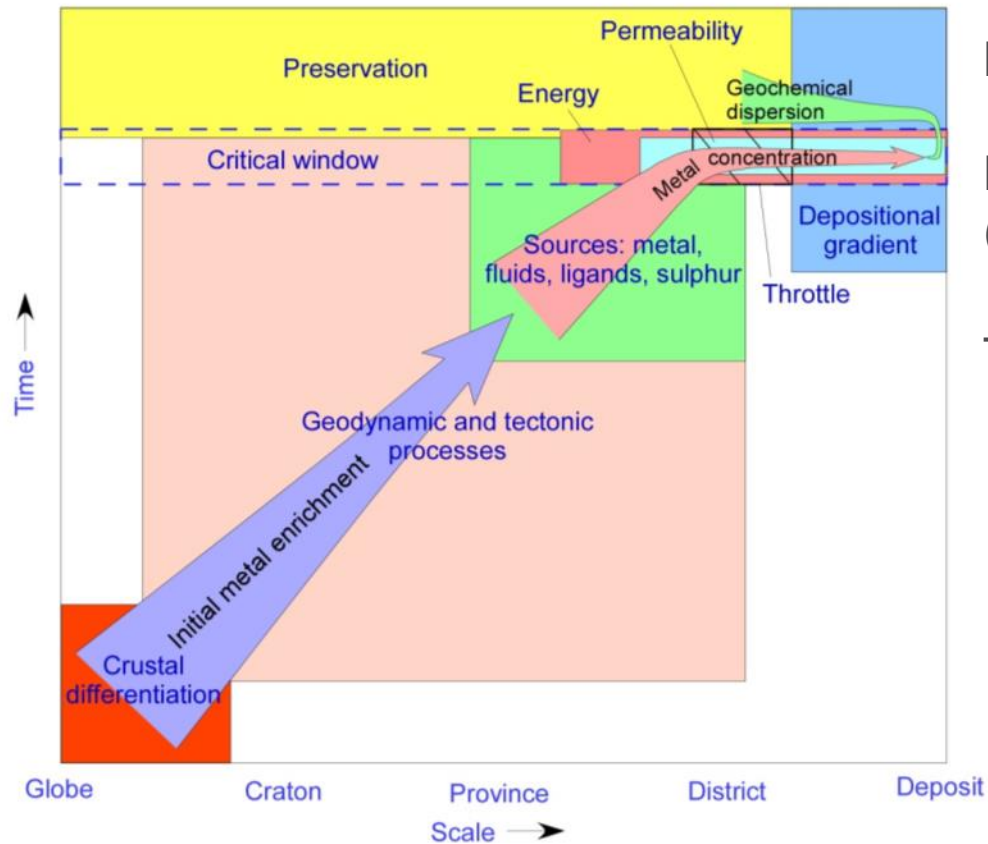
Modelled after petroleum system concept (developed in 1970s)

Source – transport – trap

Mineral system is much larger than ore deposit

Mineral system concept can be predictive

Mineral systems – evolution of a concept

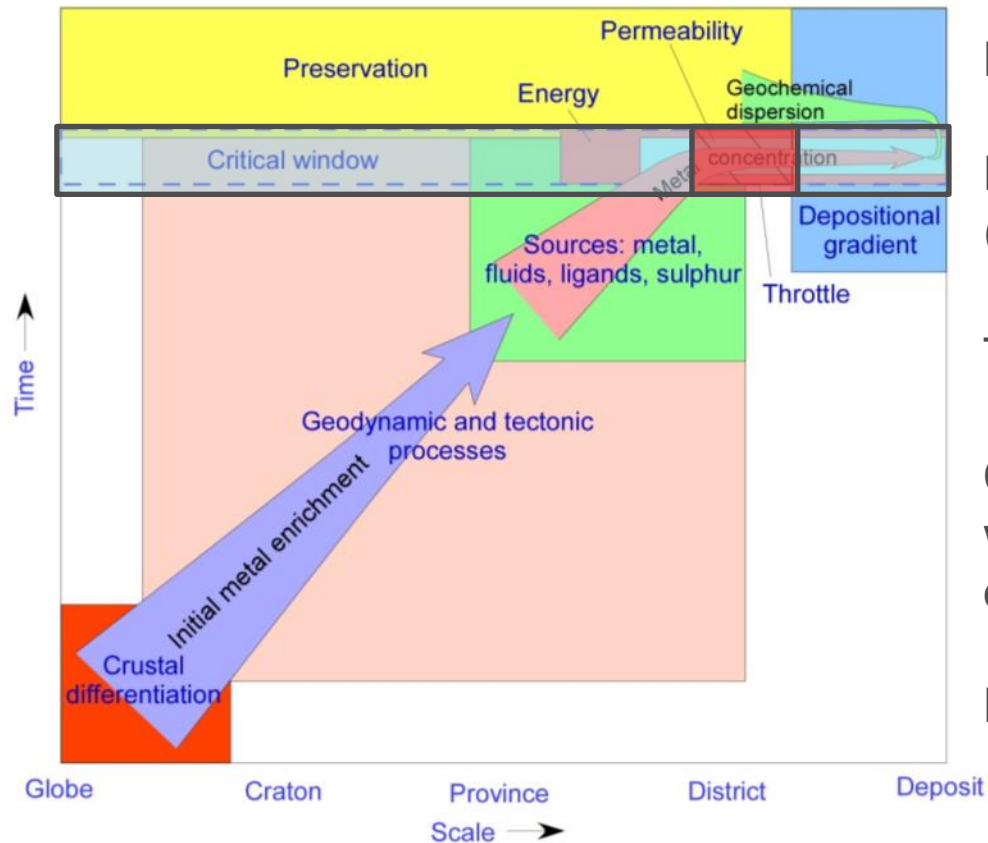


Mineral system concept has evolved

Number of different versions around (GA, UWA and consultants)

Time component recognised

Mineral systems – evolution of a concept



Mineral system concept has evolved

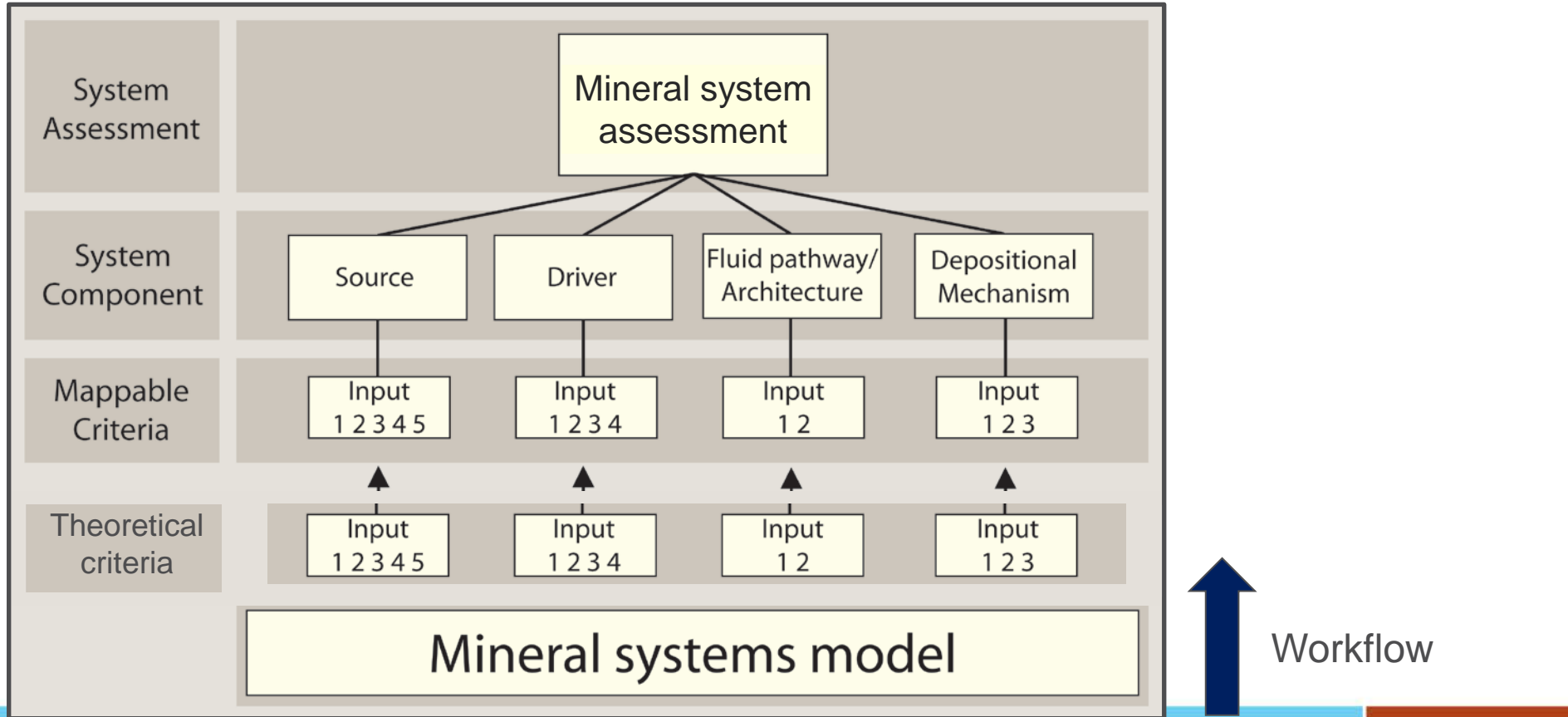
Number of different versions around (GA, UWA and consultants)

Time component recognised

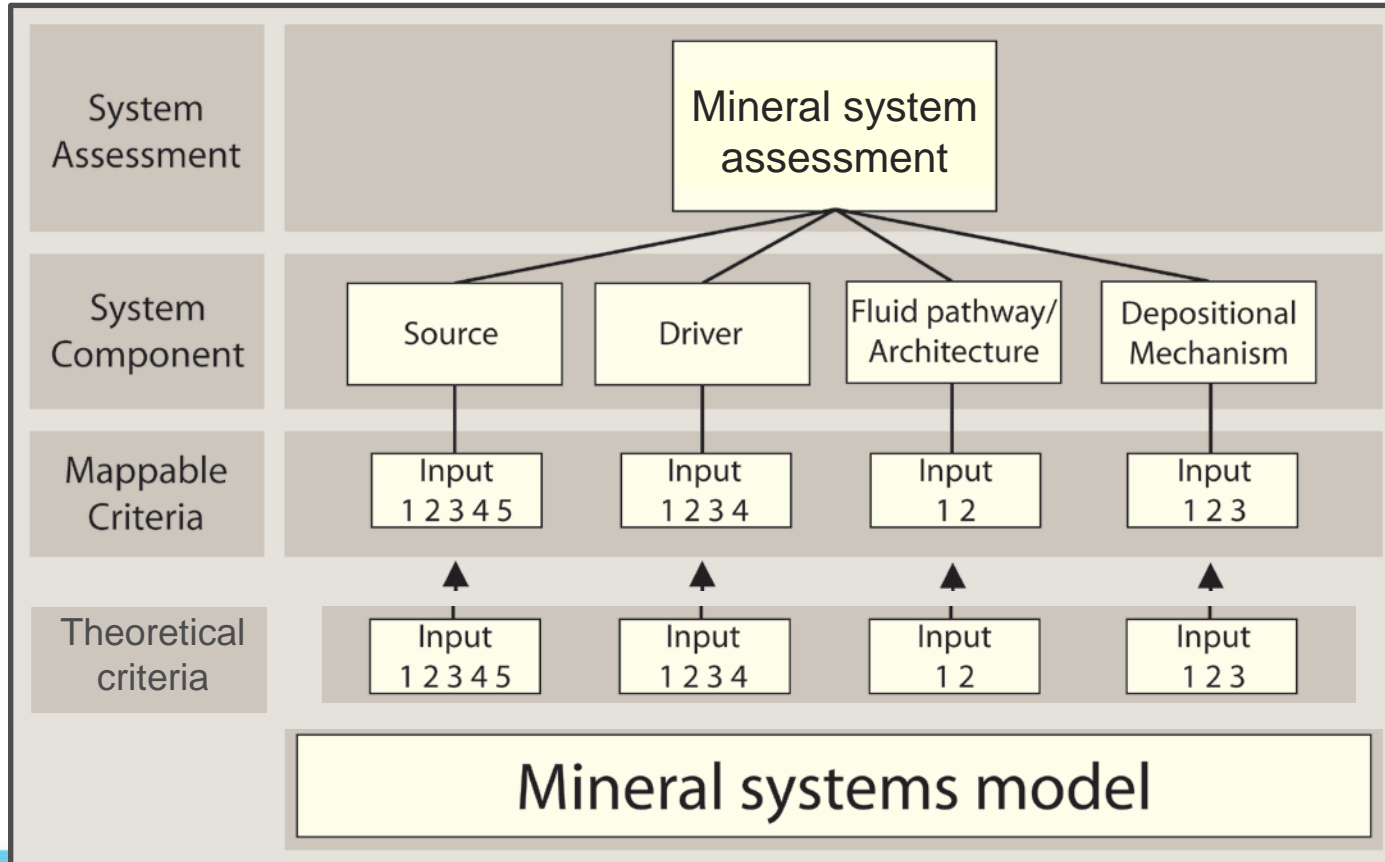
Concepts of trigger (in time - critical window) and throttles (in space) developed

Linkages to tectonic systems

GA's methodology of mineral potential mapping



GA's methodology of mineral potential mapping

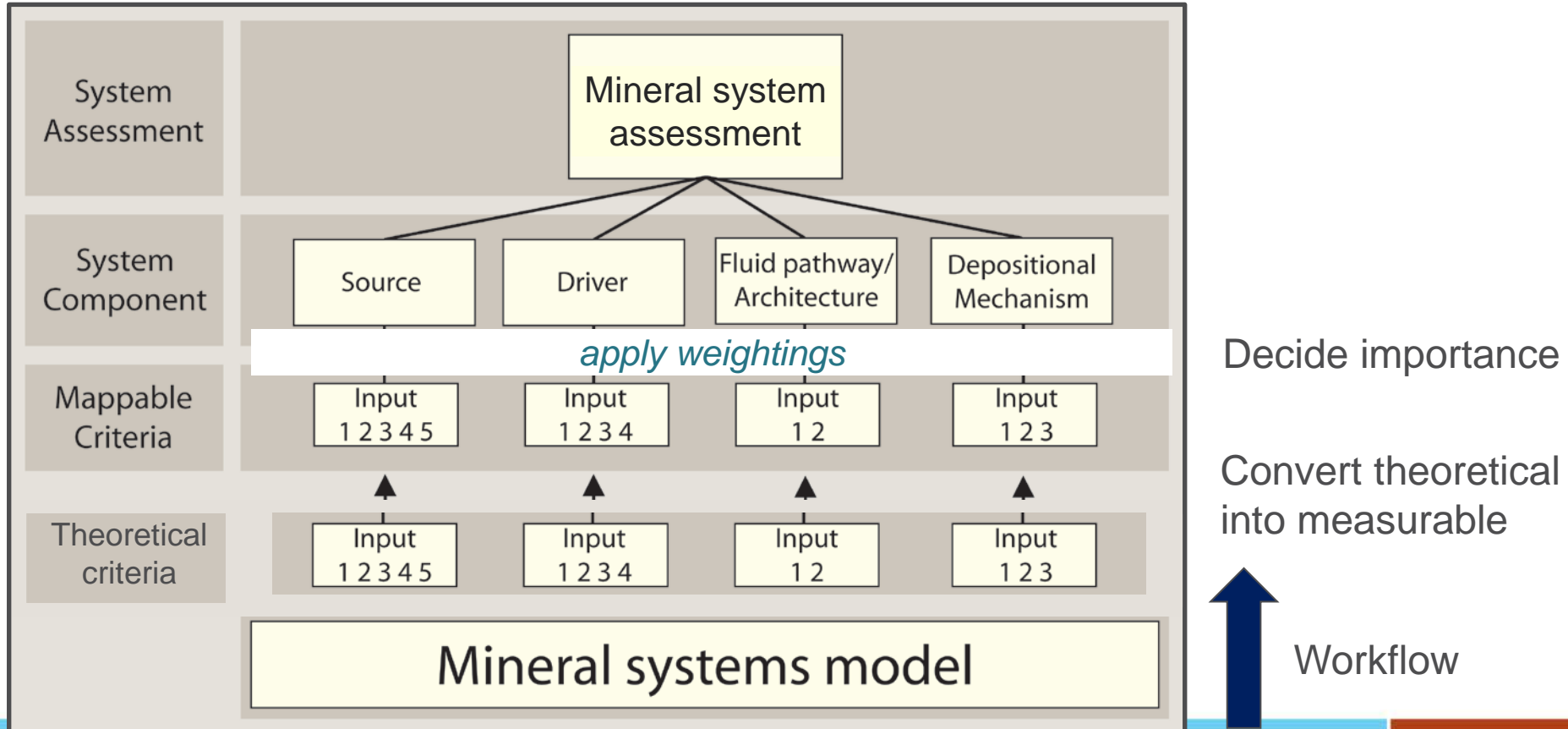


Convert theoretical
into measurable

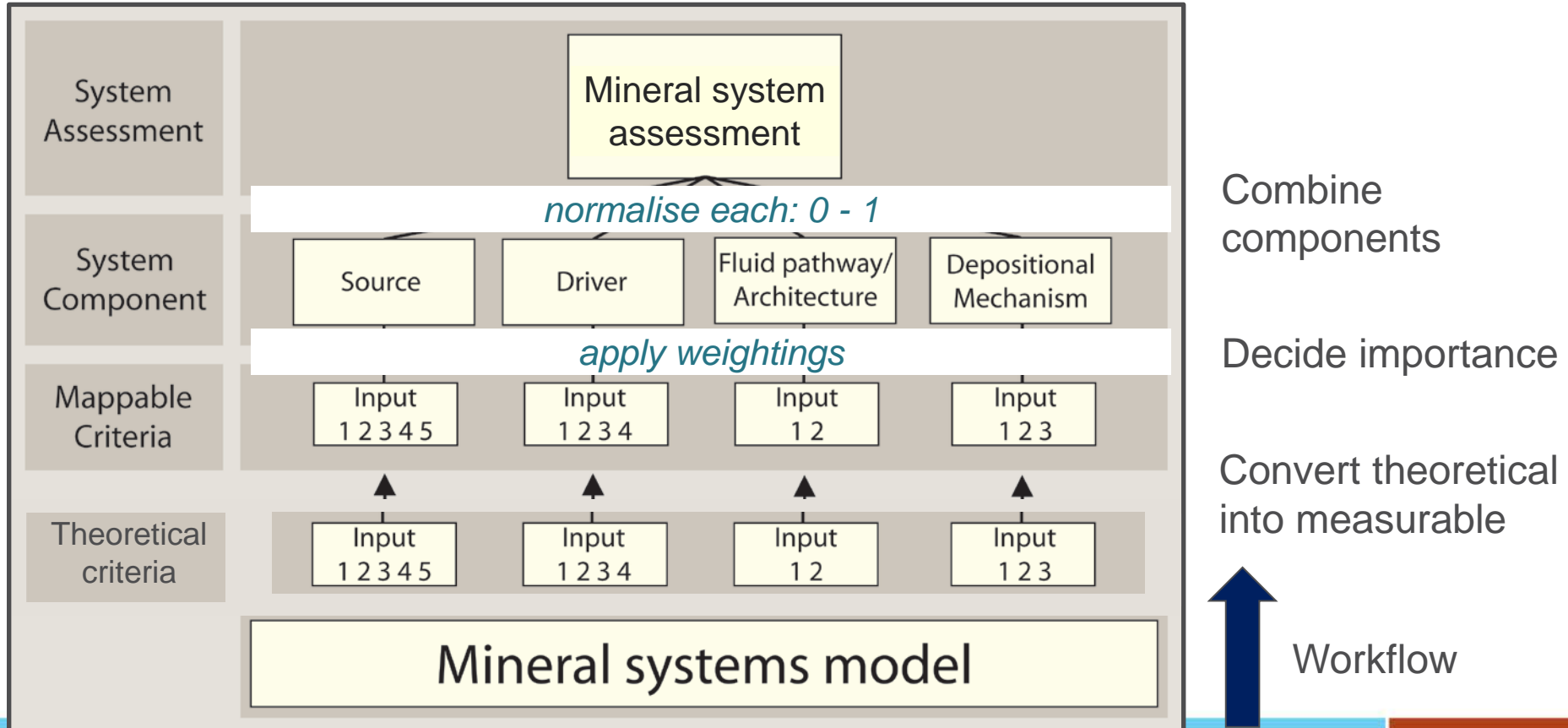


Workflow

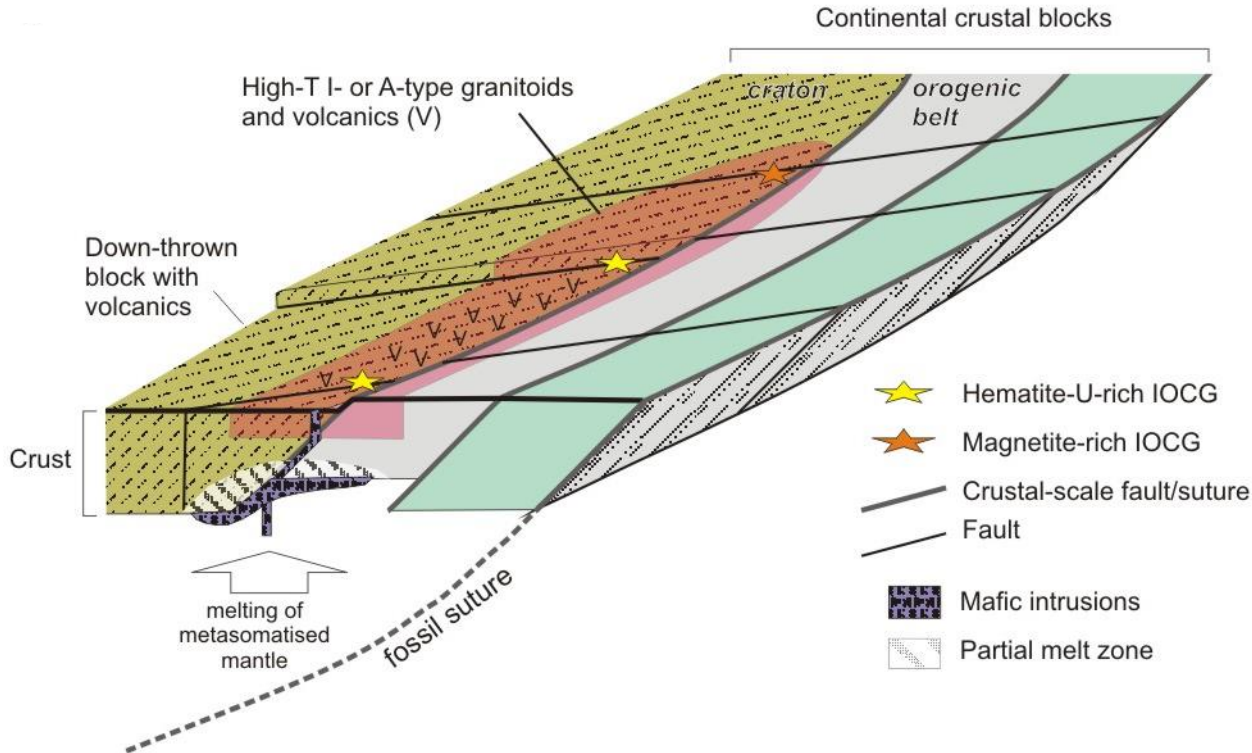
GA's methodology of mineral potential mapping



GA's methodology of mineral potential mapping

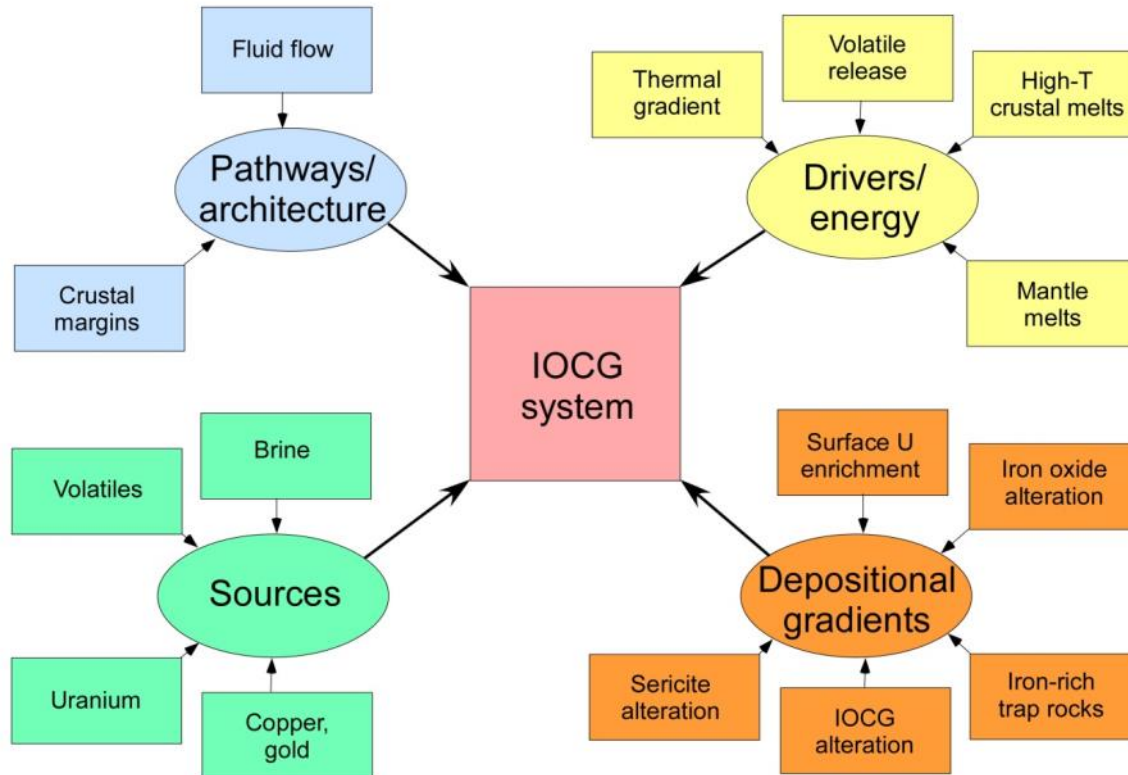


IOCG deposits – system model

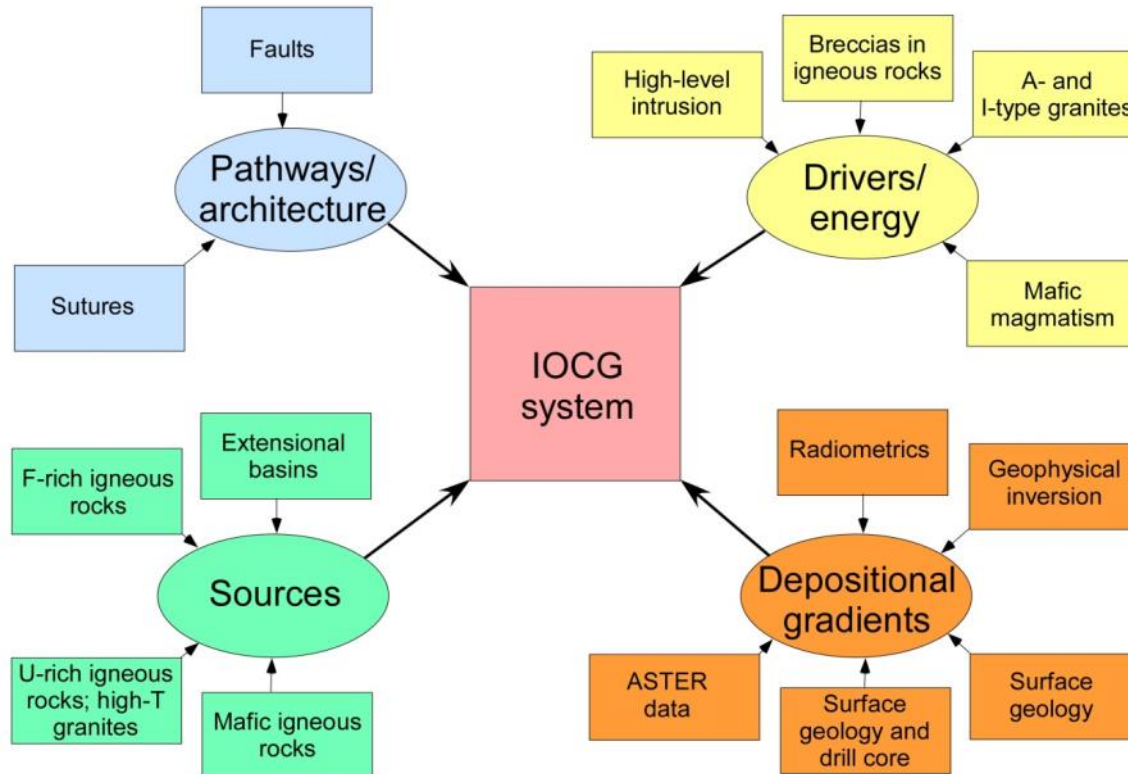


- Associated with sutures
- Associated with extension following contraction
- Associated with cross structures
- Related to high-T crustal magmatic rocks
- High level intrusive rocks
- Regional and local alteration: Fe, Na-Ca, K

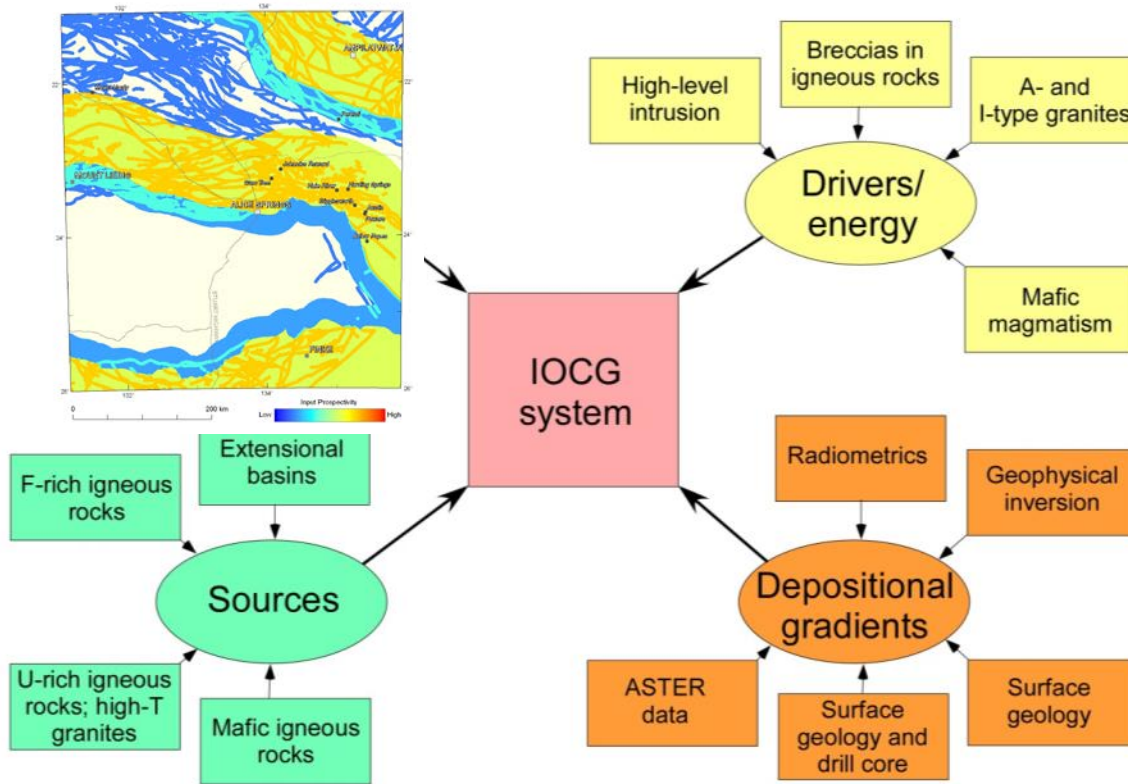
Arunta IOCG potential – theoretical criteria



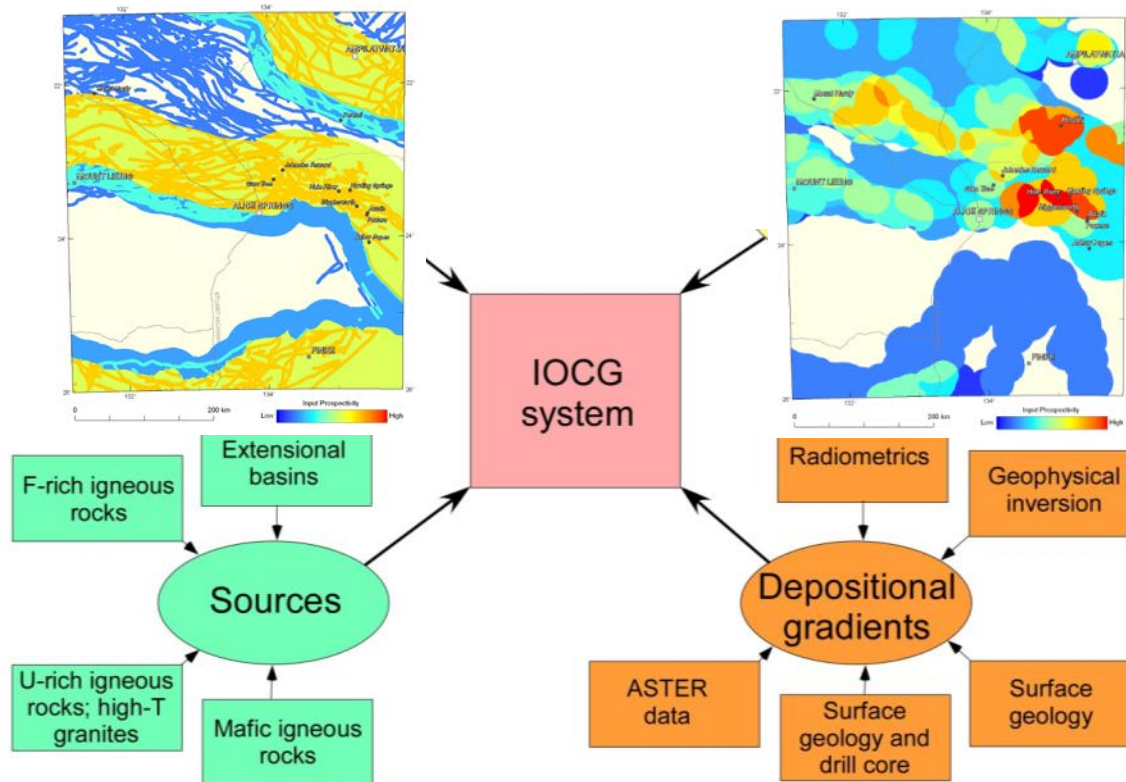
Arunta IOCG potential – mappable criteria



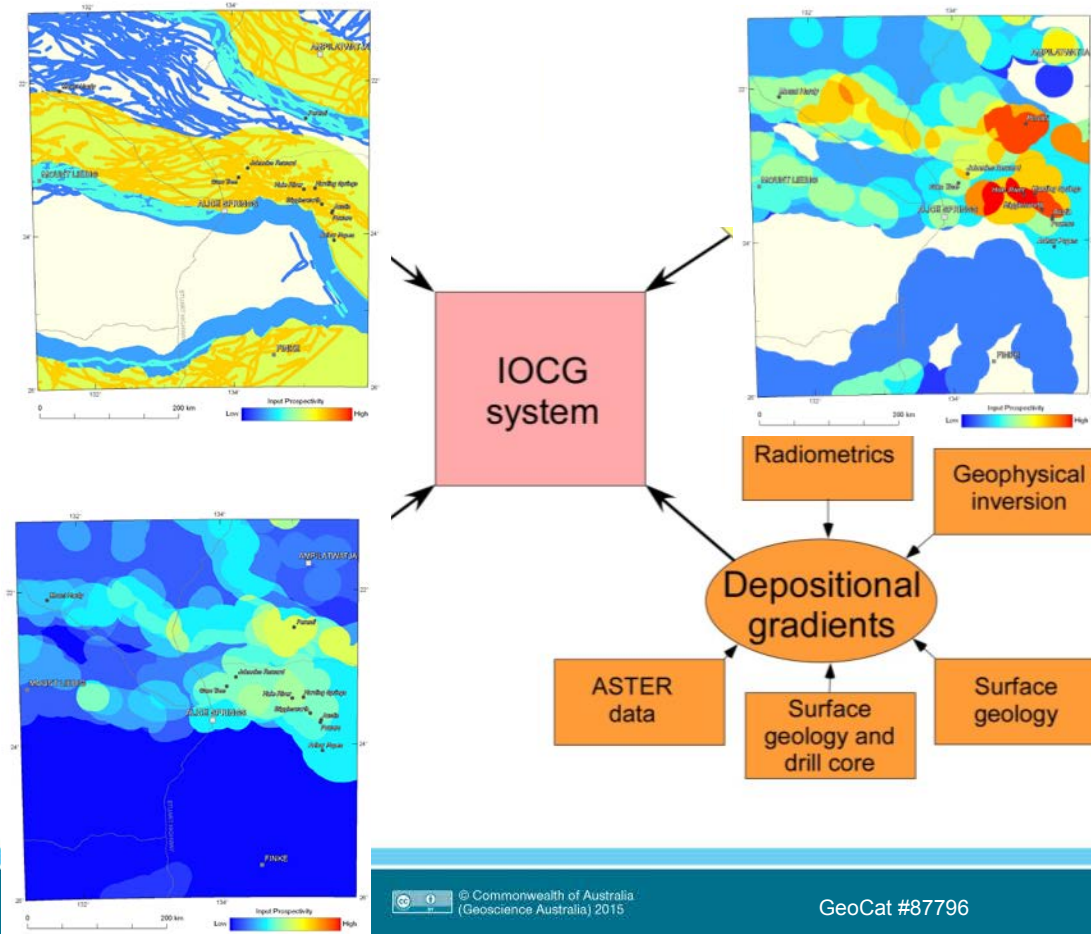
IOCG deposits in Arunta – results



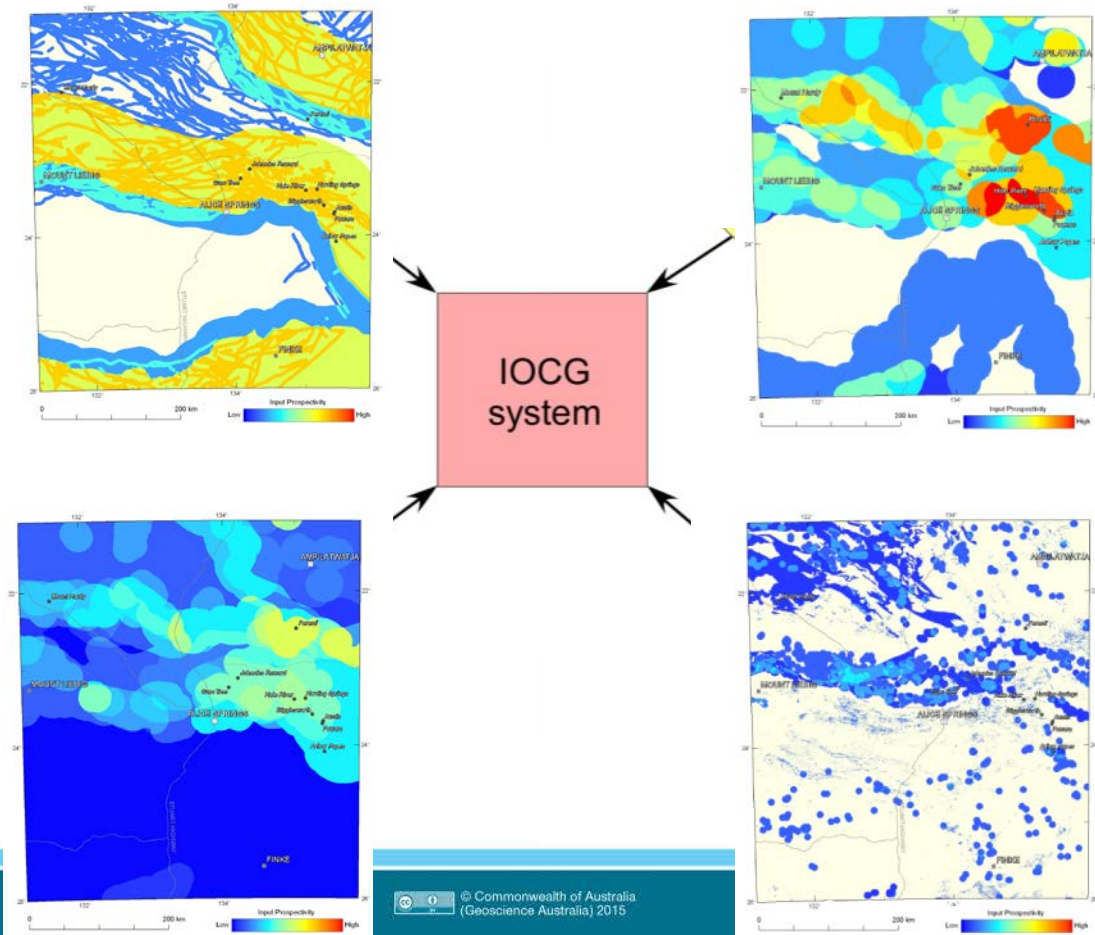
IOCG deposits in Arunta – results



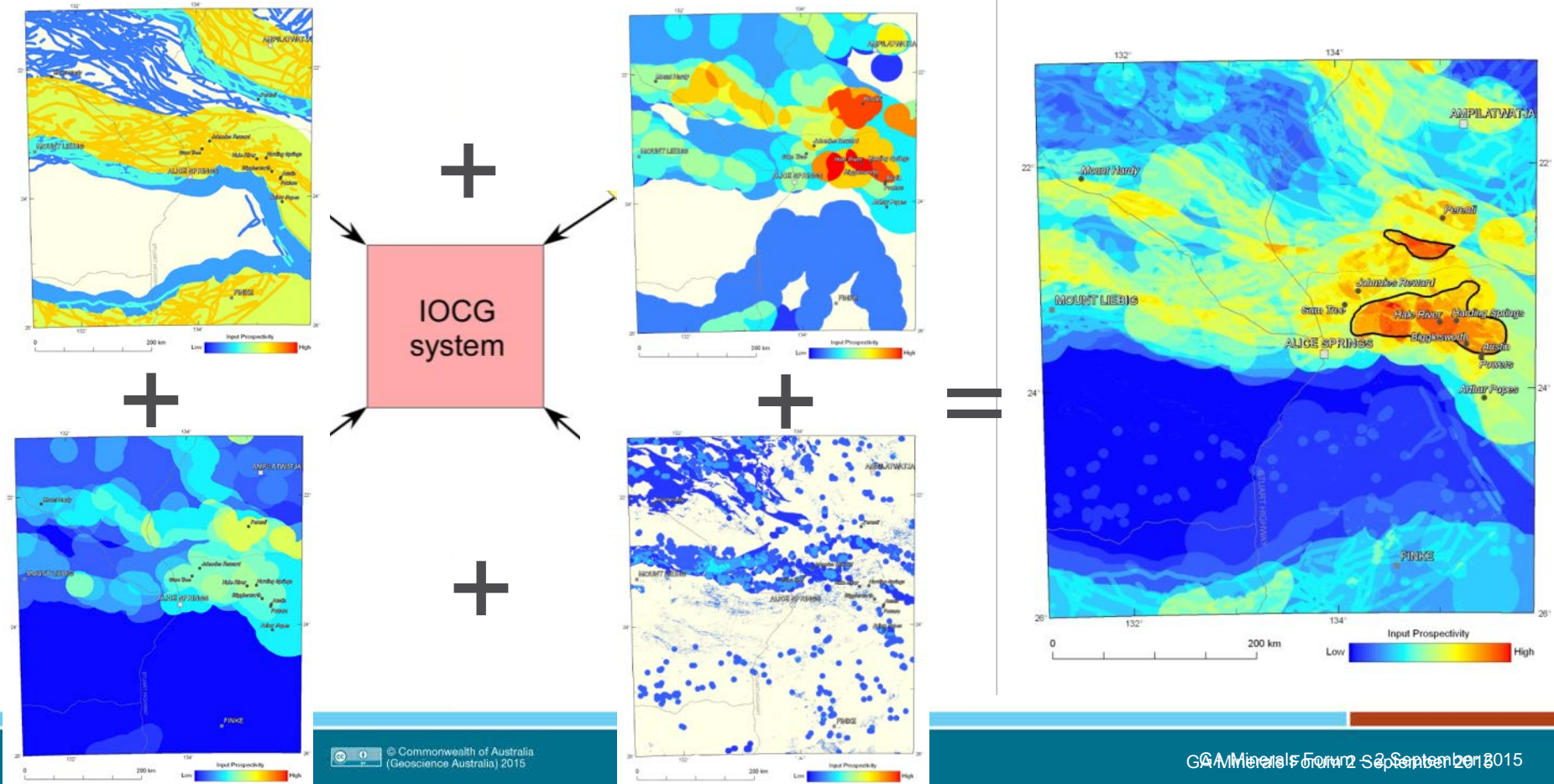
IOCG deposits in Arunta – results



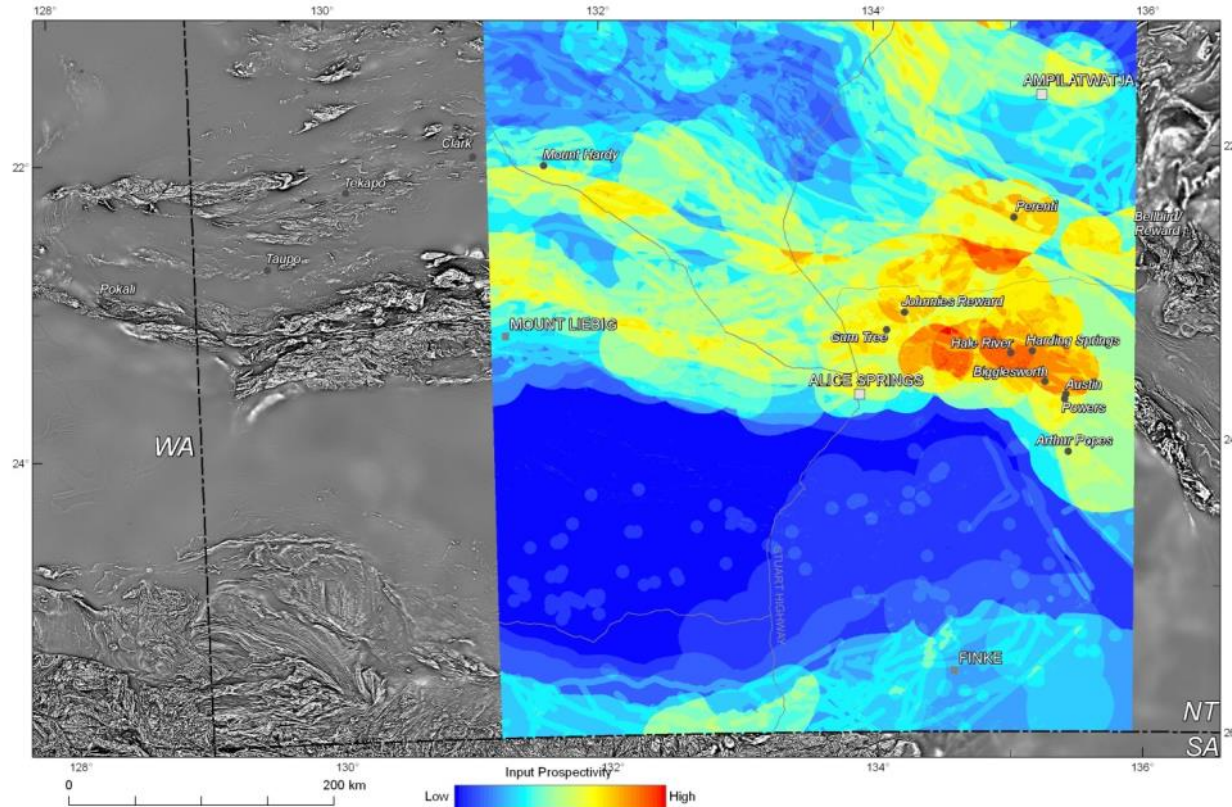
IOCG deposits in Arunta – results



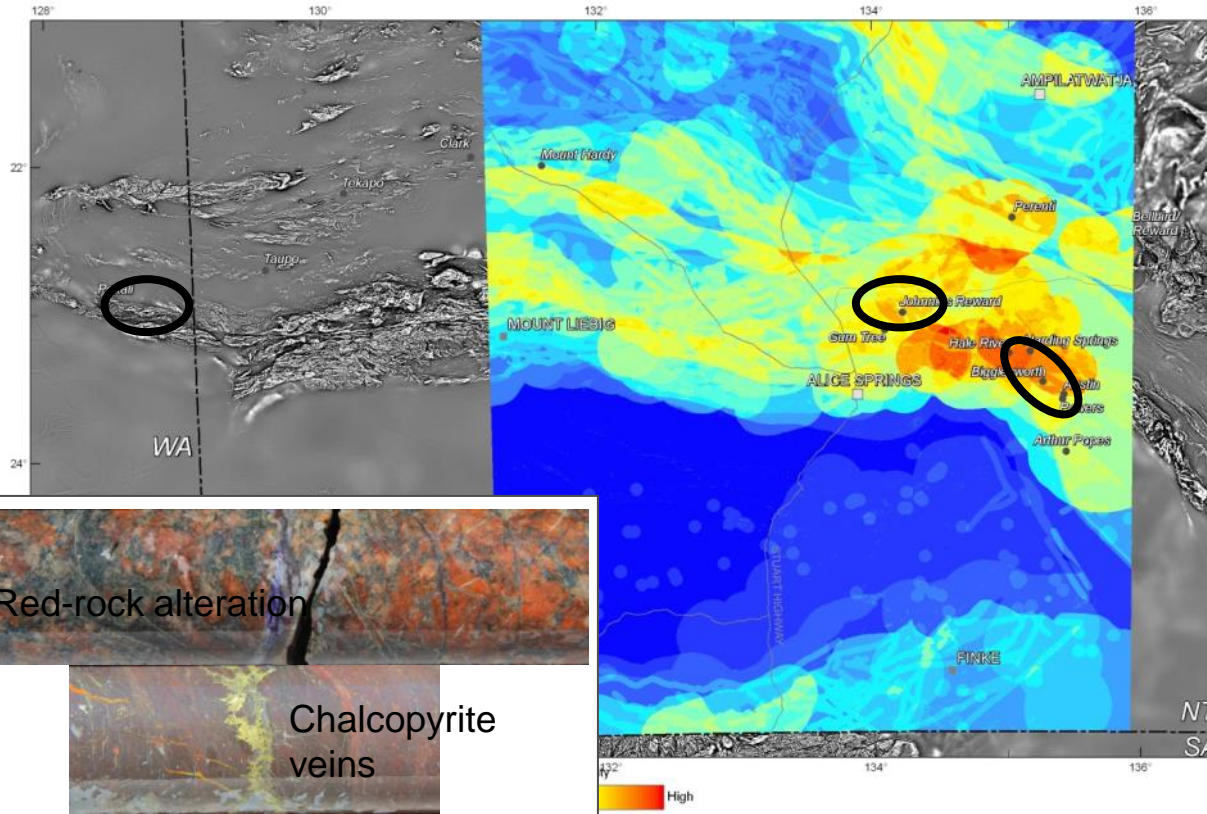
IOCG deposits in Arunta – results



IOCG deposits in Arunta – final results



IOCG deposits in Arunta – final results



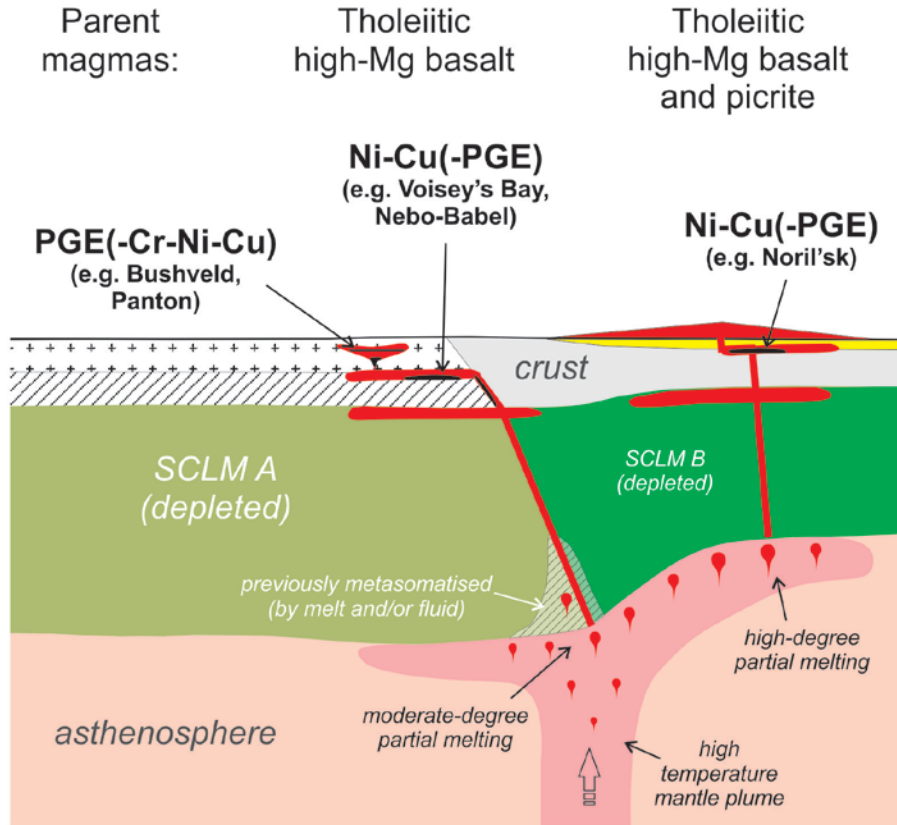
78m @ 0.26% Cu
(Ashburton Minerals ASX
release, 19 July 2012)

34m @ 3.83 g/t Au, 0.44%
Cu (Transol ASX release, 26
July 2012)

Extensive hematite-fluorite
alteration (Whelan et al.,
2012)

Rock chip results of up to
4.5% Cu, 0.2 g/t Au, 2.3 g/t
Ag (Mithril Resources ASX
release, 29-11-2011)

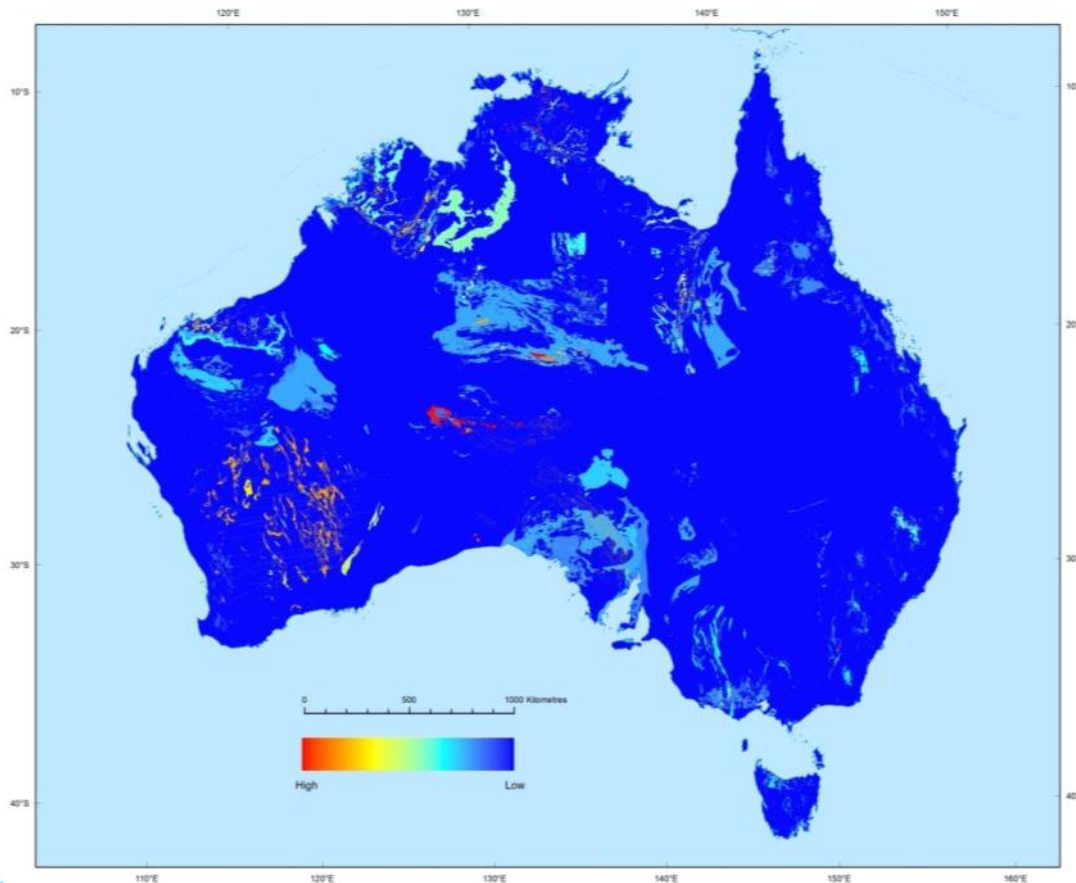
National magmatic Ni-Cu-PGE – system model



- Plume ascends through the mantle
- Moderate to high degree partial melting
- Melt travels along trans-crustal and trans-lithospheric weaknesses
- Nickel sulphide ore formation at mid- to upper-crustal levels due to sulphur saturation

Source: Naldrett (2004), Arndt et al. (2005) Barnes and Lightfoot (2005), Hoatson et al. (2006), Begg et al. (2010) Schulz et al. (2010), Griffin et al. (2013) and Arndt (2013).

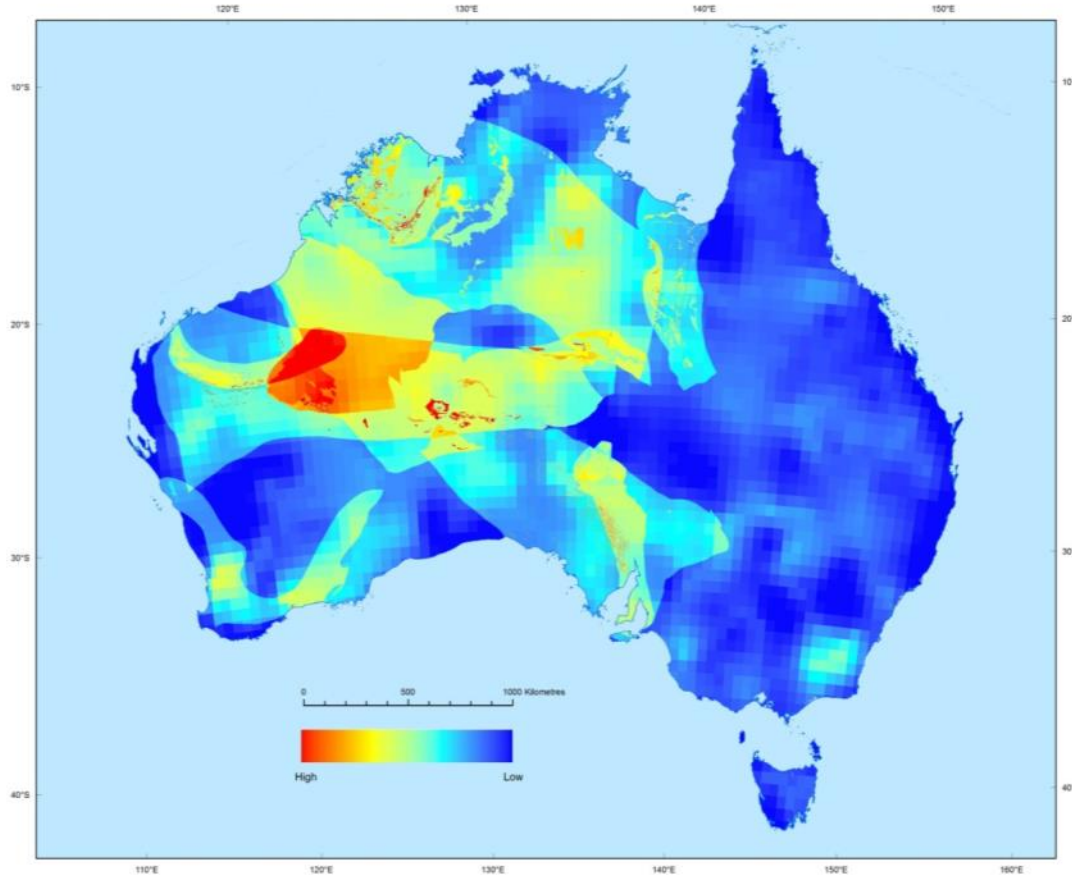
National magmatic Ni-PGE – sources



Datasets used

- Distribution of mafic and ultramafic rocks (MUM synthesis and OZchem)
- Distribution of tholeiitic rocks (OZchem)
- High Ni-Cu-PGE abundances in mafic-ultramafic rocks (OZchem)

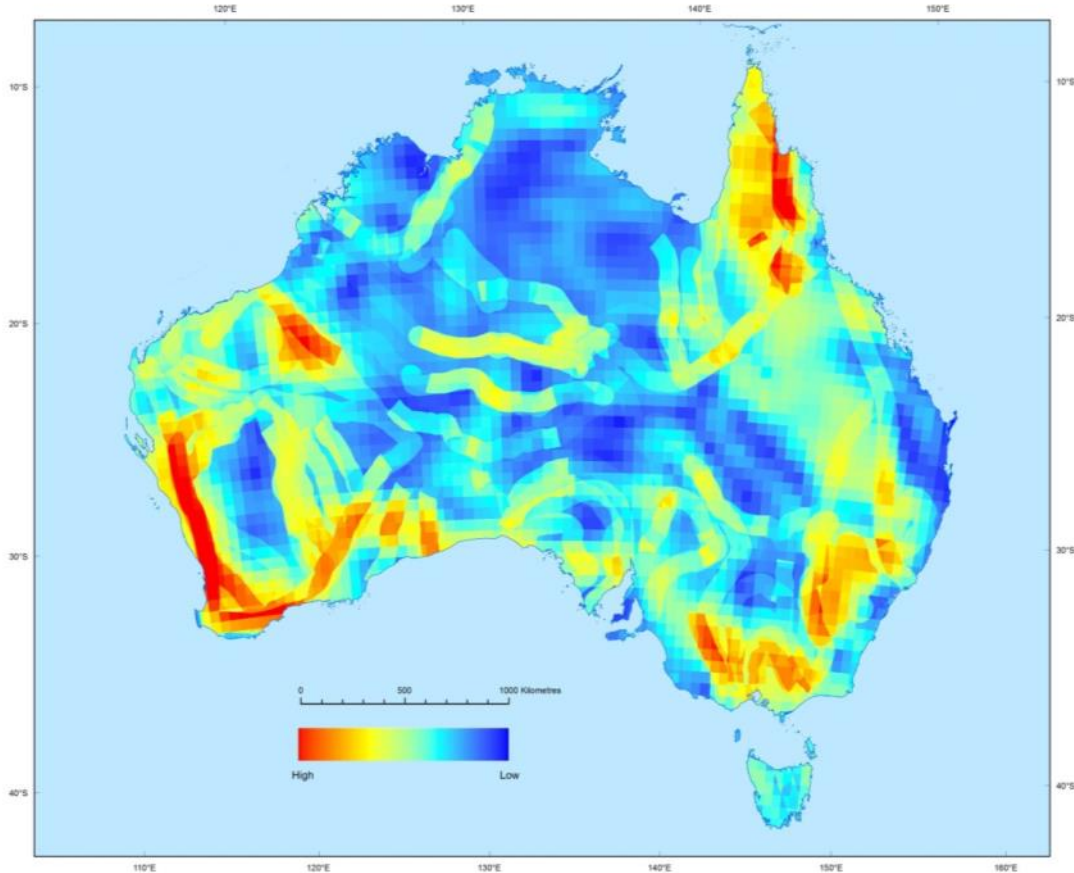
National magmatic Ni-PGE – driver



Datasets used

- Distribution of Proterozoic large igneous provinces (from MUM synthesis)
- Thickness of mafic rocks in the crust (from seismic velocity data)

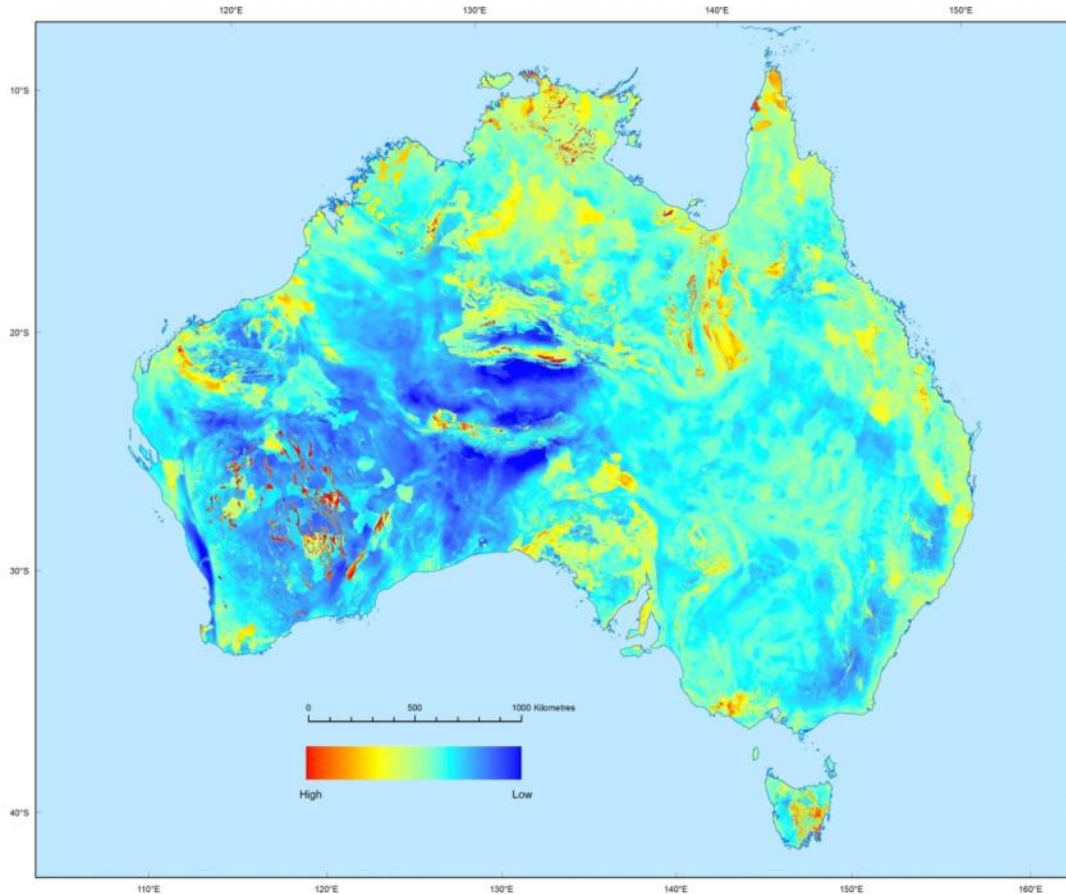
National magmatic Ni-PGE – pathway/architecture



Datasets used

- Seismic velocity tomography (AusREM)
- Crustal boundaries from seismic data
- Crustal boundaries from radiogenic (Sm-Nd) data

National magmatic Ni-PGE – deposition



Datasets used

- Local Ni, Cu and PGE depletion (OZchem)
- Sulphur saturation – high S (OZchem)
- Erosional dispersion of magmatic Ni-Cu (NGSA)
- Mineral occurrence locations (MINLOC)
- Presence of shallow mafic-ultramafic bodies (gravity and aeromagnetic data)

Conclusions and the future

- GA has developed a robust, repeatable methodology for mineral potential analysis based on the mineral system paradigm
- This methodology works at both the national and province scale
- The methodology has been used for a number of different mineral system types
- The methodology effectively identifies the location of known deposits (not used in analysis)
- The datasets used at the national and province scales are very different, reflecting the importance of different essential ingredients
- Results will influence GA's upcoming program of regional drilling

Theme 4: distal footprints & toolkits

Science problem: Ore deposits are small, and are often under cover.

How do we see the larger signals (footprints) of mineral systems to reduce risk in selected regions?

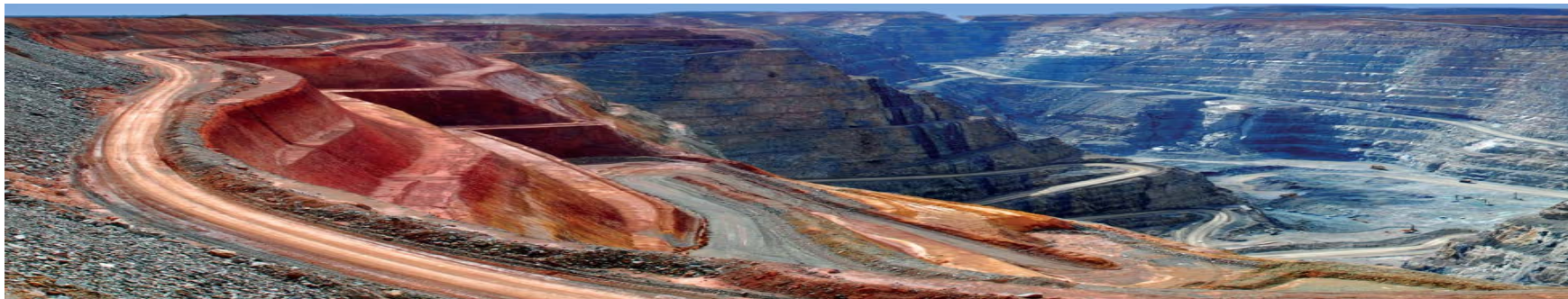
Solutions:

- a) Collect new data to map prospective fairways under cover (drilling)
- b) Maximise the knowledge: develop new exploration toolkits at a range of scales
- c) Deliver products including data





Regional stratigraphic drilling projects: Staveland and Southern Thomson



Anthony Schofield (anthony.schofield@ga.gov.au)

Ian Roach (ian.roach@ga.gov.au)

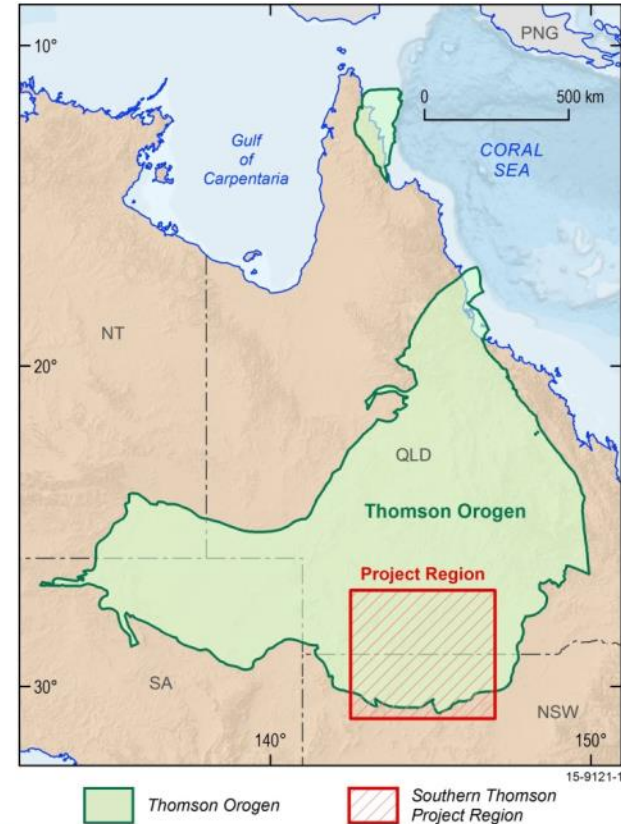
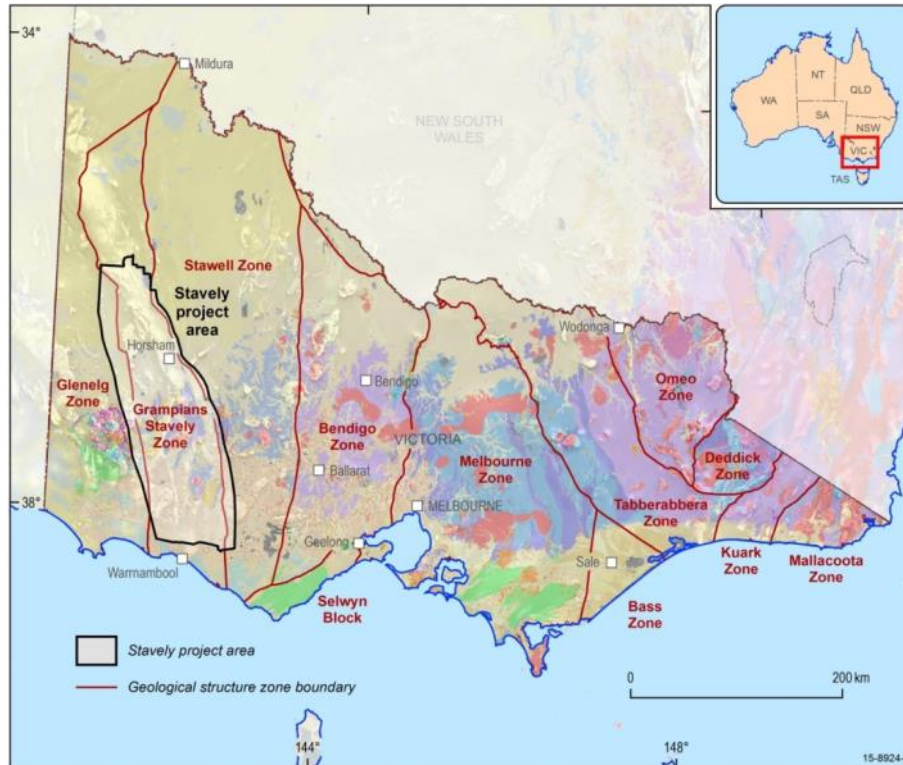
Why regional drilling projects?

To lead the discovery of a new mineral province(s) in under cover Australia through:

- 1) Development of **tool kits** which help explorers **determine the thickness and nature of cover** materials in a range of geological environments
 - 2) **Collection and integration** of a range of **datasets and samples**
- **improved understanding of the regional geology and mineral systems in under cover areas**

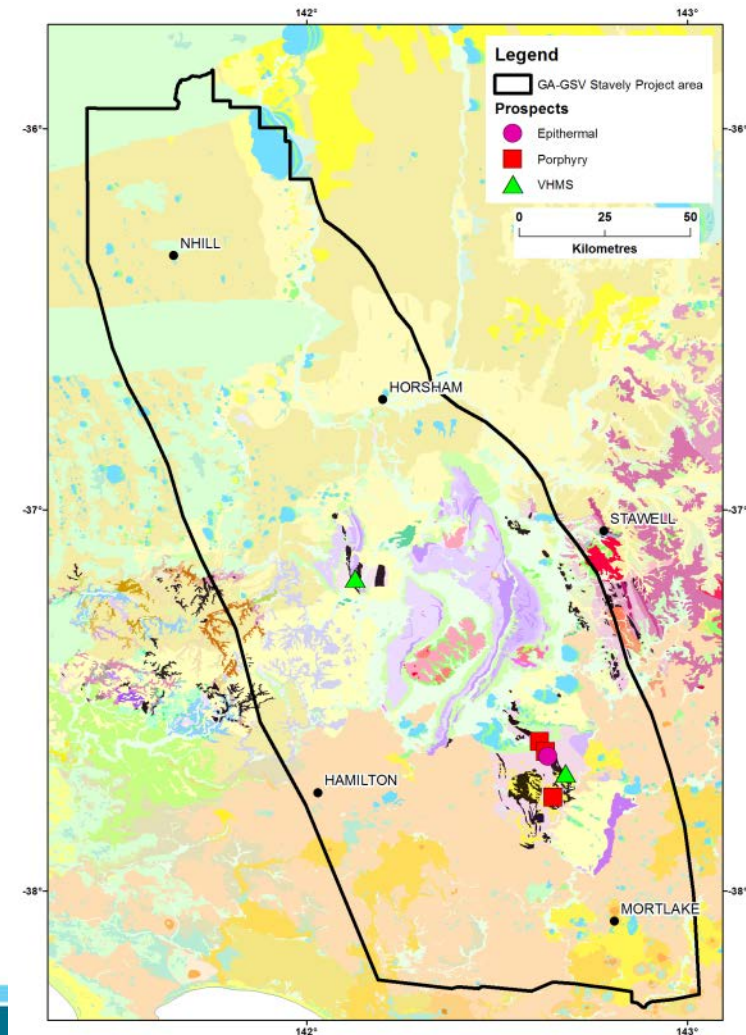


Regional drilling projects at Geoscience Australia



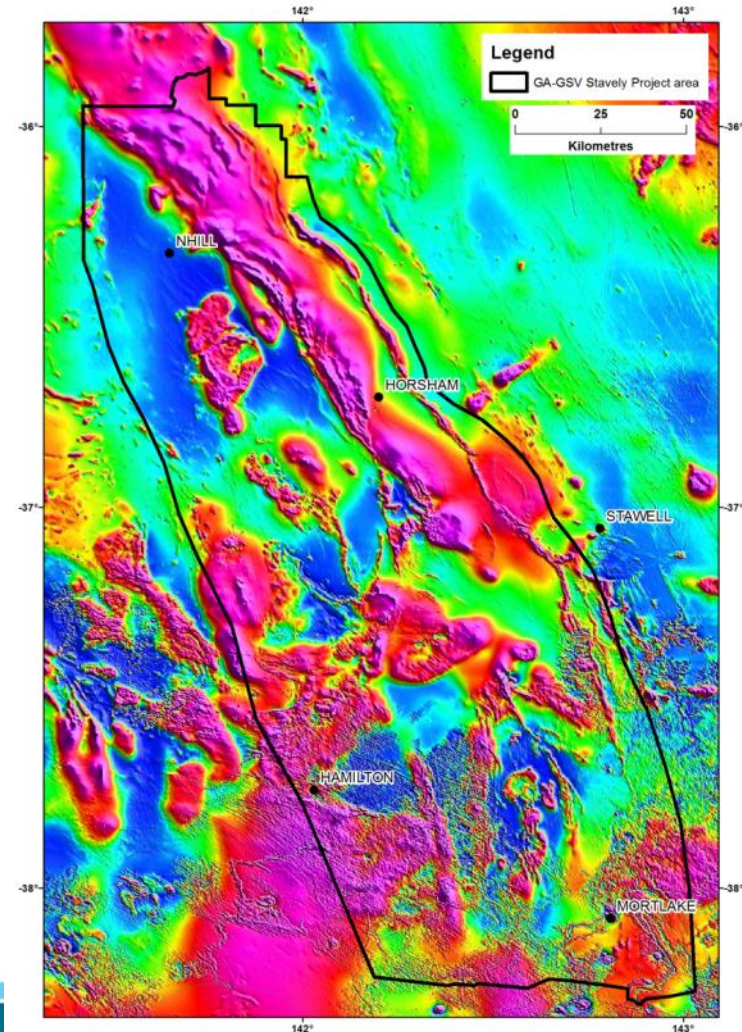
Stavely Project

- Geoscience Australia-Geological Survey of Victoria collaborative project
- Porphyry-epithermal and VHMS potential within largely buried Cambrian Arc package (Stavely Arc)
- Pre-competitive stratigraphic drilling of prospective rock packages with DET CRC
- New data acquisition



Stavely Project

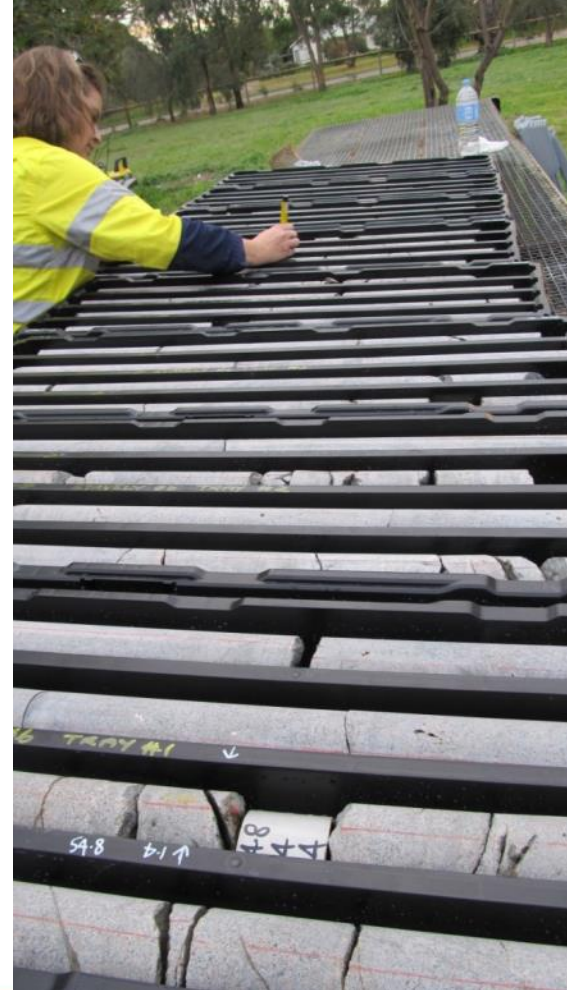
- Geoscience Australia-Geological Survey of Victoria collaborative project
- Porphyry-epithermal and VHMS potential within largely buried Cambrian Arc package (Stavely Arc)
- Pre-competitive stratigraphic drilling of prospective rock packages with DET CRC
- New data acquisition



Drilling in the Stavely region

14 fully-cored stratigraphic drill holes

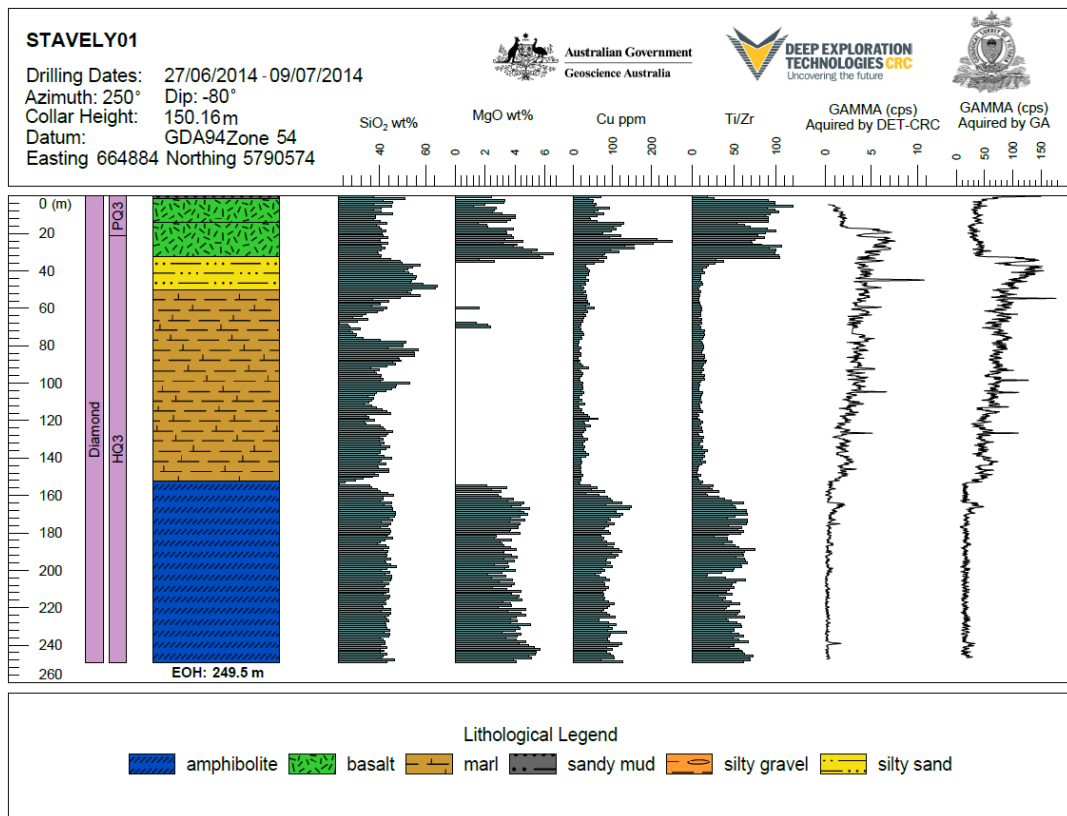
- April-September 2014
- 2708 m total (1152 m sonic, 1556 m diamond)
- Included deepest sonic hole drilled in Australia (212 m)
- Prospective arc rocks intersected
- Cover depths relatively shallow (typically <150 m)



Deploying new drilling technologies

DET CRC technologies deployed during drilling

- Lab-at-Rig[®] (geochemistry)
- AutoSonde[™] (geophysics)
- Helps detect lithological changes and distal signatures of mineral systems

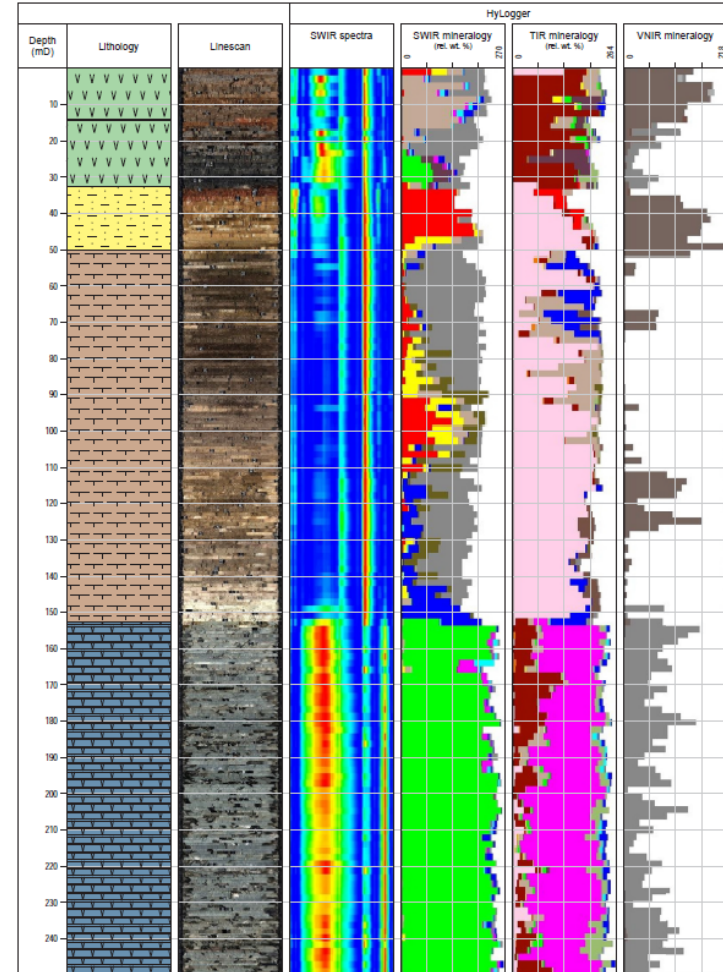


New data acquisition

Newly-acquired data helping to understand the geology and mineral systems potential of the Stavelly Arc

- Down-hole geophysics
- Rock properties
- HyLogger™ hyperspectral data
- Whole rock geochemistry and isotope analysis
- Geochronology

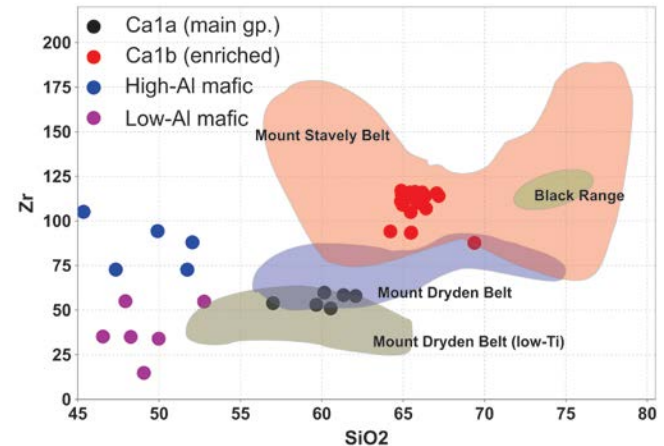
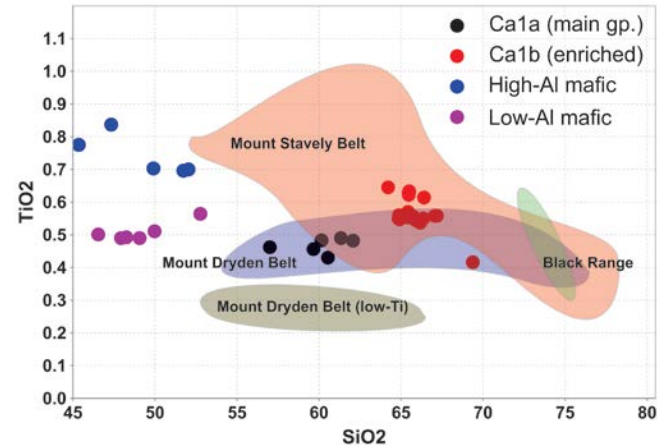
Partnerships with AuScope, University of Melbourne, GSSA, ANU, UTAS



Mapping drilling results to outcrop

New geochemical data expanding the prospective fairway in the Stavely Arc

- Groups identified in drilling correlate with outcropping belts with known prospectivity
- Results consistent with a mature arc setting



Stavelly Project delivery

Field data released July 2015

Upcoming releases:

- HyLogger™ hyperspectral data
- Lithological logs
- Petrophysical data
- Geochronology and geochemistry

Regional synthesis and Explorer's Guide to be delivered in early 2016



Australian Government
Geoscience Australia





Record 2015/13 | GeoCat 83147

Regional geology and mineral systems of the Stavelly region, western Victoria

Data release 1 – Stratigraphic drilling field data

Schofield, A., Cayley, R.A., Barton, T., Taylor, D.H., Nicoll, M. and Cairns, C.P.

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

www.ga.gov.au

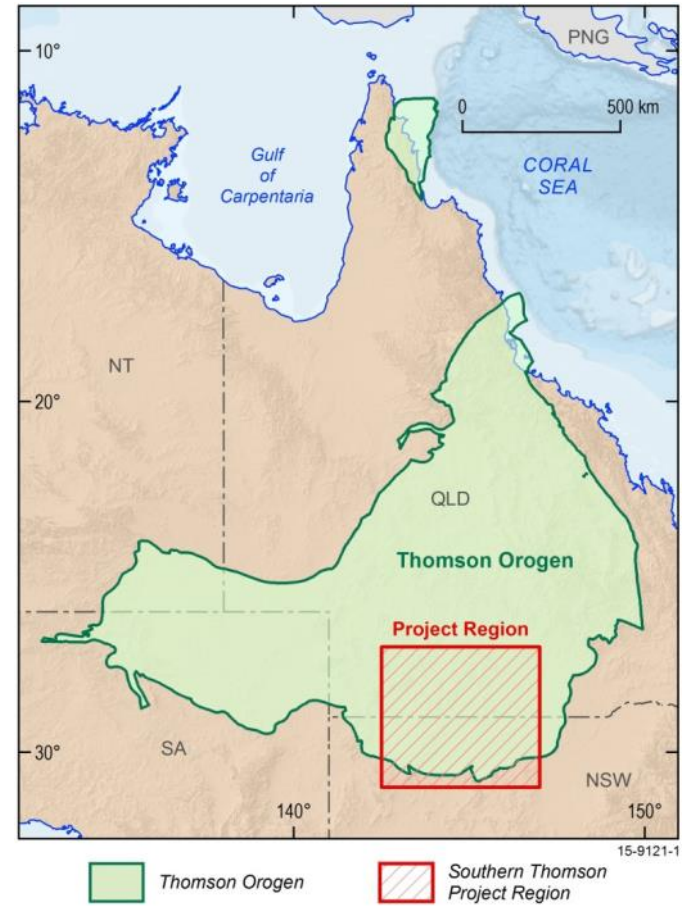
The Southern Thomson Project

The southern Thomson Orogen is a frontier area:

- << 1% outcrop, Mesozoic and Cenozoic cover
- Poor geological knowledge
- Poor mineral potential understanding

The southern Thomson Project:

- Joint project between GA, GSNSW and GSQ
- New geophysical, geochemical and geochronological data acquisition
- Drilling campaign in 2015/16 to test solid geology and mineral potential models



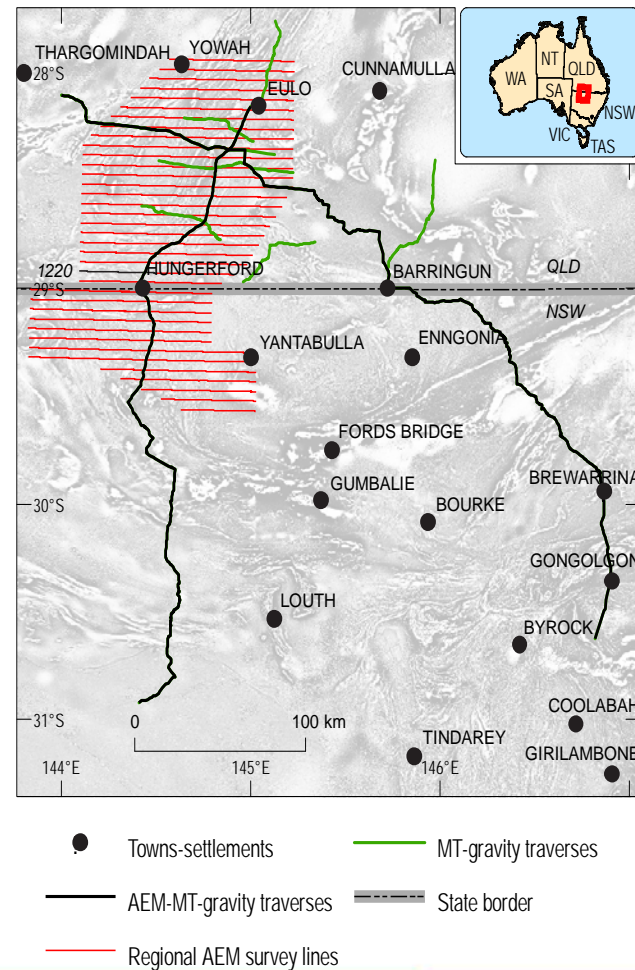
New geophysical data acquisition

Program of airborne and ground geophysical data acquisition:

- Airborne electromagnetics (released 2014 via GA website)
- Gravity traverses (released 2014 via GADDs)
- Broadband and audio magnetotelluric traverses
- Site-specific ground geophysics to support drilling program

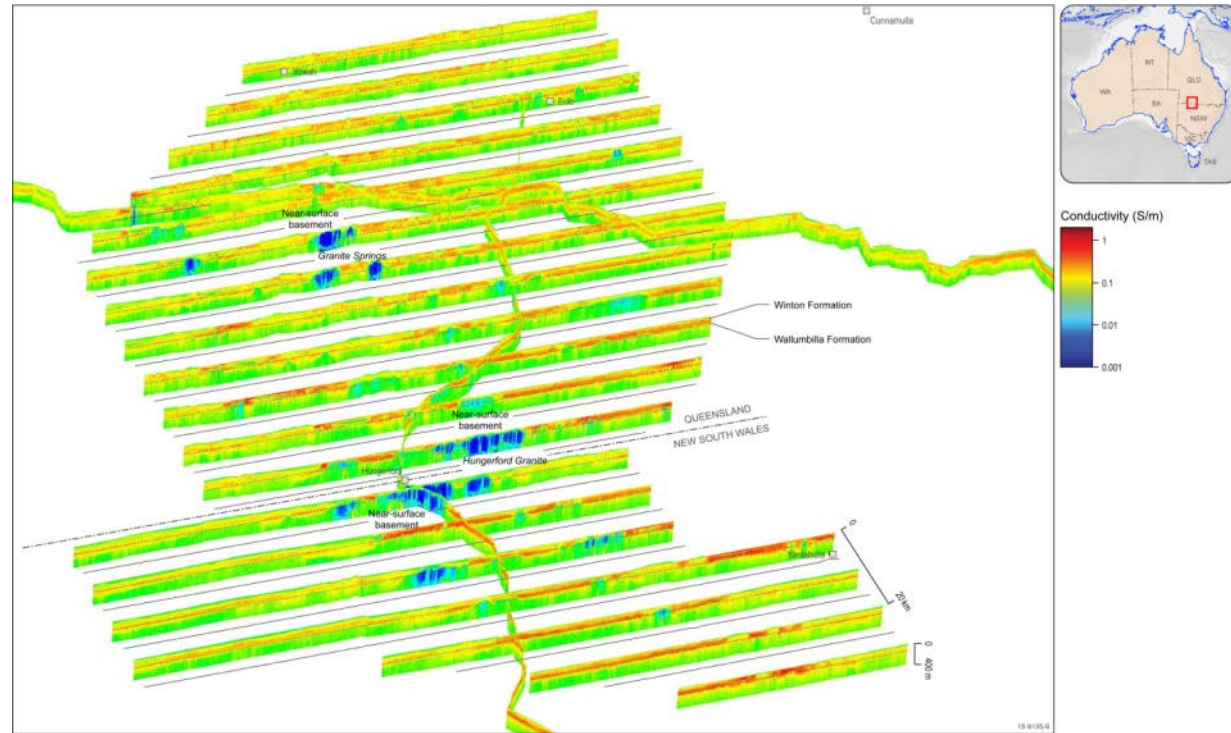
New data acquisition to support:

- Depth To Basement (DTB) mapping
- Under-cover geological mapping
- Model boundary between Thomson/Lachlan orogens
- Drill site targeting



AEM survey

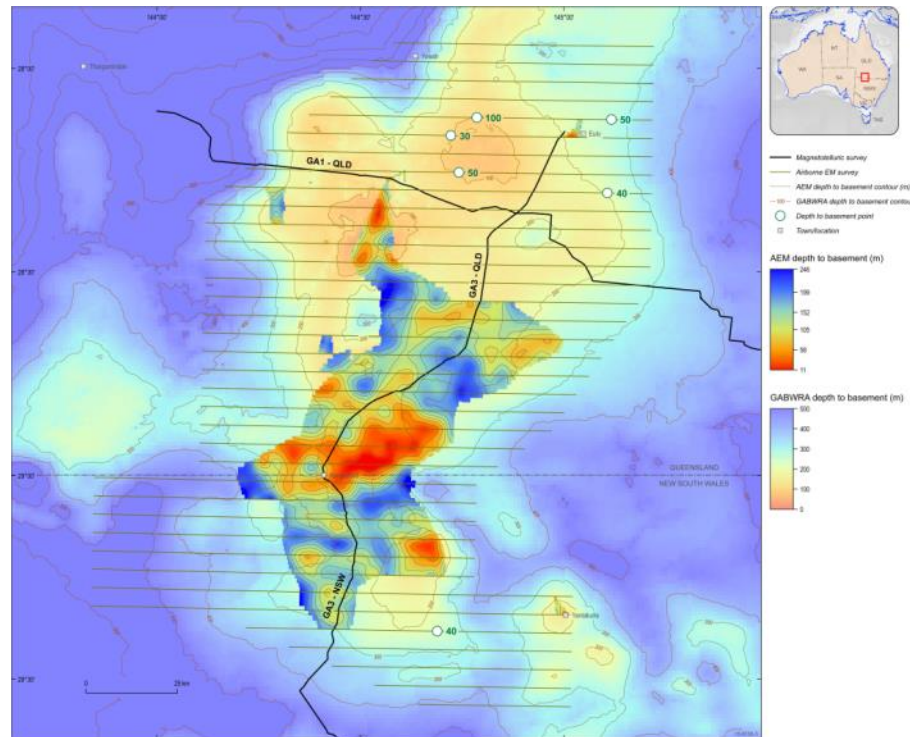
Flown 25 March-5 May 2014 using Geotech Ltd VTEM_{plus}[®] system



AEM survey

Flown 25 March-5 May 2014 using Geotech Ltd VTEM_{plus}[®] system

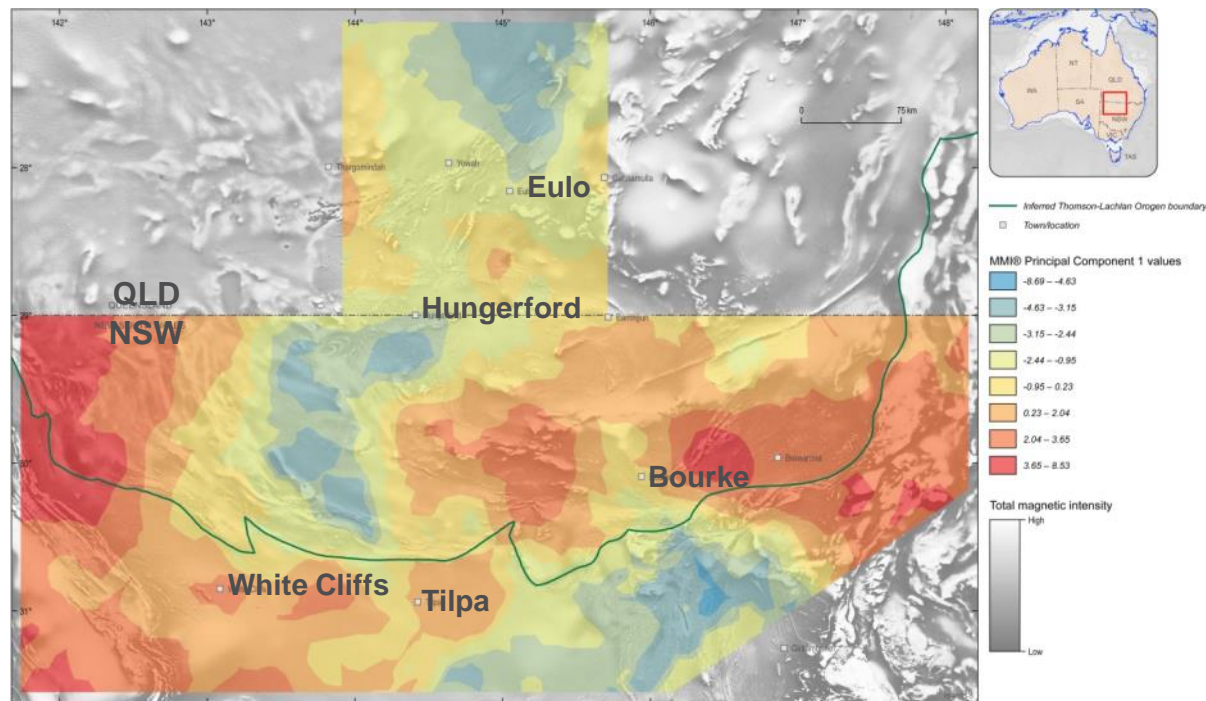
- Successfully map > 3440 km² of under-cover Eulo Ridge
- Map extensive electrically resistive basement terrains under cover
- Map unrecognised basement 'islands' under shallow cover
- High resolution hydrostratigraphic mapping
- Introduce new inversion algorithm
- Highlight the benefit of correct system selection by forward modelling



Regolith geochemistry

Mobile Metallic Ion[®] Principal Component 1 results of drainage catchment outlet sediments:

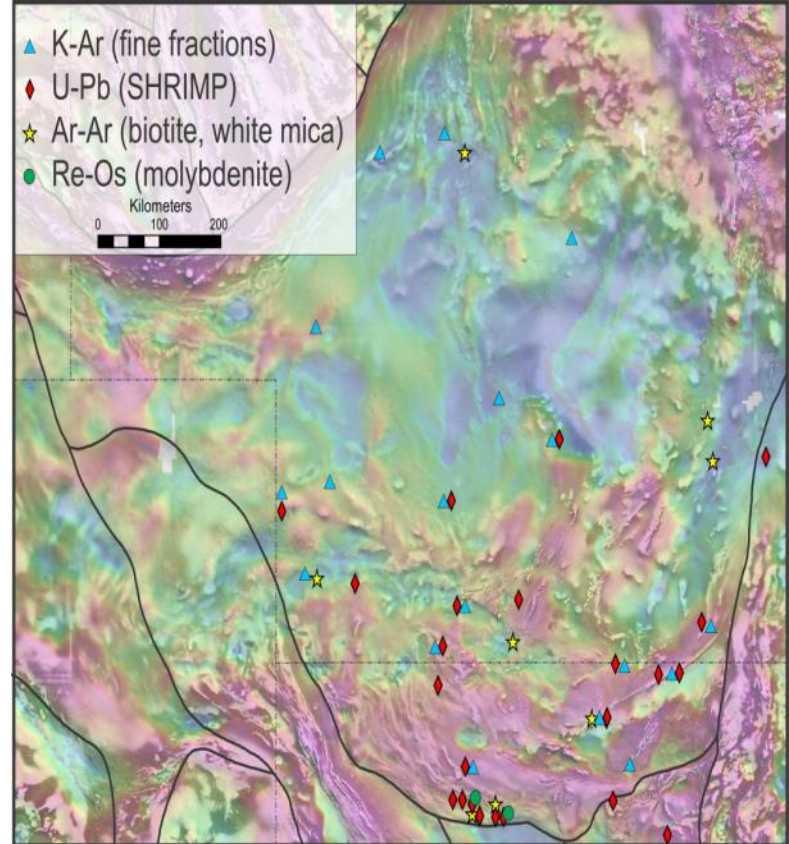
- Kriged MMI[®] PC1 map
- Cool colours – REEs associated with resistate minerals
- Warm colours – Ca, Sr, Mg, Cu, Au, Mo, Ni associated with calcrete and potential mineralisation



Geochronology

New data on magmatic, metamorphic and mineralisation ages:

- Builds on recent NGA geochronology in NSW and QLD
- New U-Pb SHRIMP mounts from industry drill core: magmatic ages
- New Ar-Ar, K-Ar ages, XRD on mineral separates for age of metamorphism on Culgoa Lineament
- New S & Pb isotopic data on mineralisation
- Release ages as a new GA Record on southern Thomson-northern Lachlan 2015



New isotopic age samples

Conclusions

Pre-competitive drilling aims to:

- Understand and develop new solid geology products
- Assess regional prospectivity
- Reduce exploration risk
- Encourage the discovery of a new minerals province

Drilling in the Staveland region uncovering prospective arc rocks

The southern Thomson Orogen is a true greenfields area. Drilling to commence in 2015





Australian Government
Geoscience Australia



Lowering the Entry Level to Big Data & Big Compute:

The



Virtual Geophysics Laboratory

and its future development

Carina Kemp, *James Goodwin*, Murray Richardson and Richard Chopping
james.goodwin@ga.gov.au

Big Data

There is an estimated **3 Petabytes** of publically funded geoscience data in Australia, and the majority of this data is held by Geoscience Australia.

In terms of geophysics this includes nationwide datasets of:

- Gravity
- Magnetics
- Radiometrics
- Seismic
- Magnetotellurics
- Airborne Electromagnetics (AEM)
- Satellite derived data

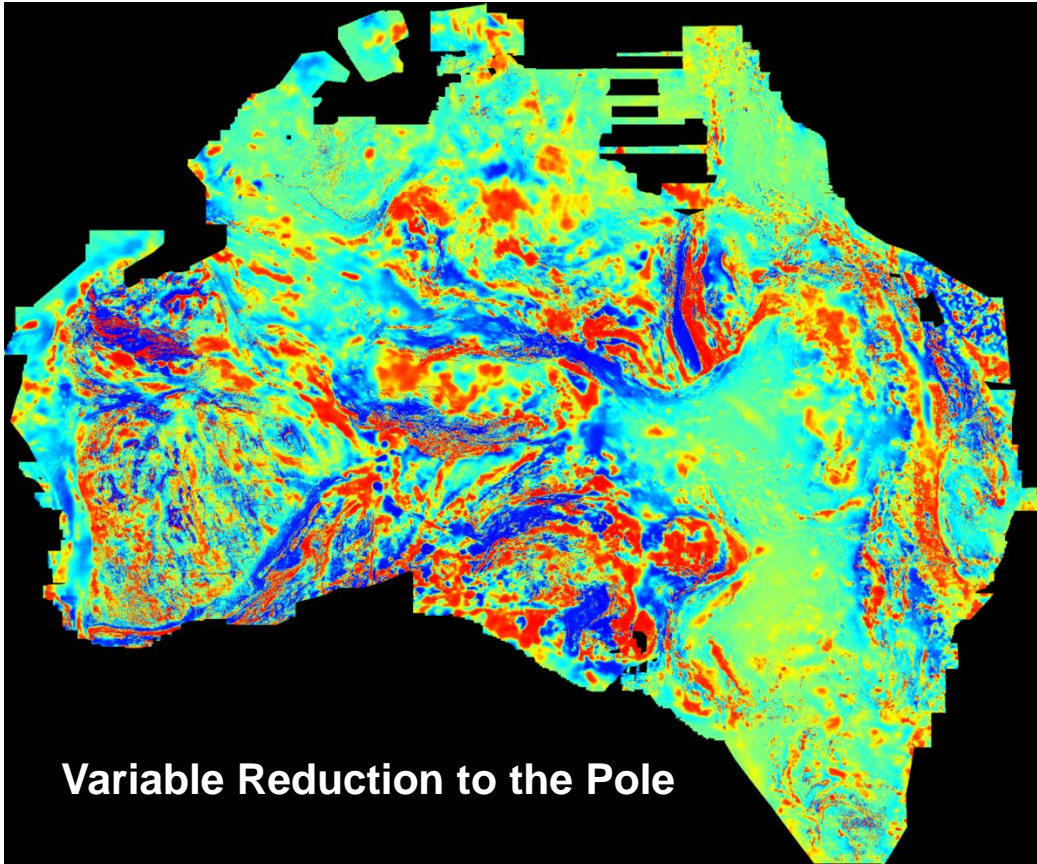
Big Compute: National Computational Infrastructure



RAIJIN

- 57,472 computer cores
- > 10 petabytes Research Data Storage Infrastructure (RDSI)
- Peak performance of 1.2 PFlops
- Ranked 38th most powerful computer system in the world
- Virtual labs (VLs)

Magnetic Anomaly Map of Australia 2015



- 80 × 80 m cell size
- Variable Reduction to the Pole produced using GA codes.
- Only possible using the NCI

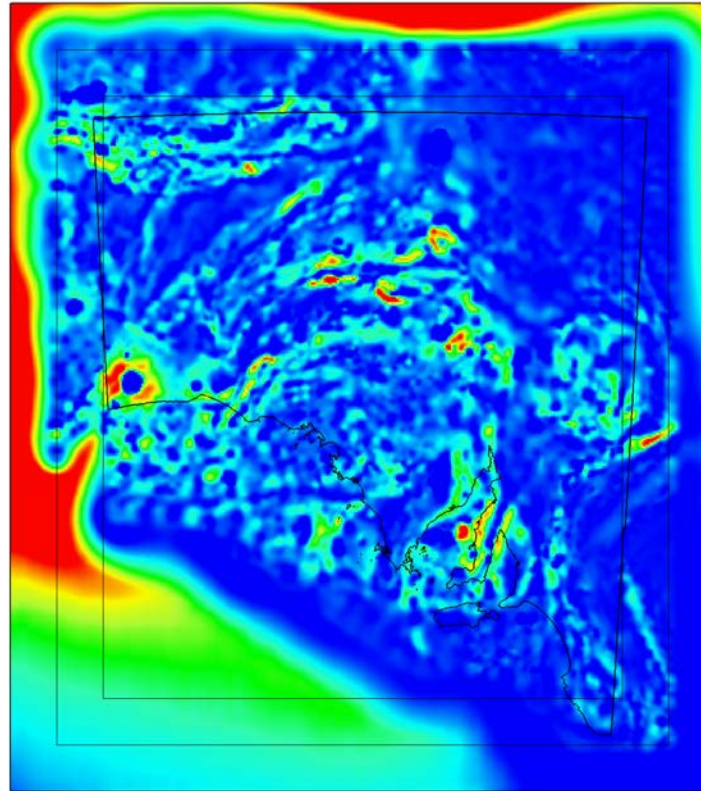
Magnetic Inversion Model – Gawler Craton, S.A.

1500 km x 1700 km
(4 km cell size)

~ 8 Million cells total

Inversion result
took 9 hours to run
using 128 CPU

Only possible using the
NCI



Horizontal Section
Z = -10,000 mRL



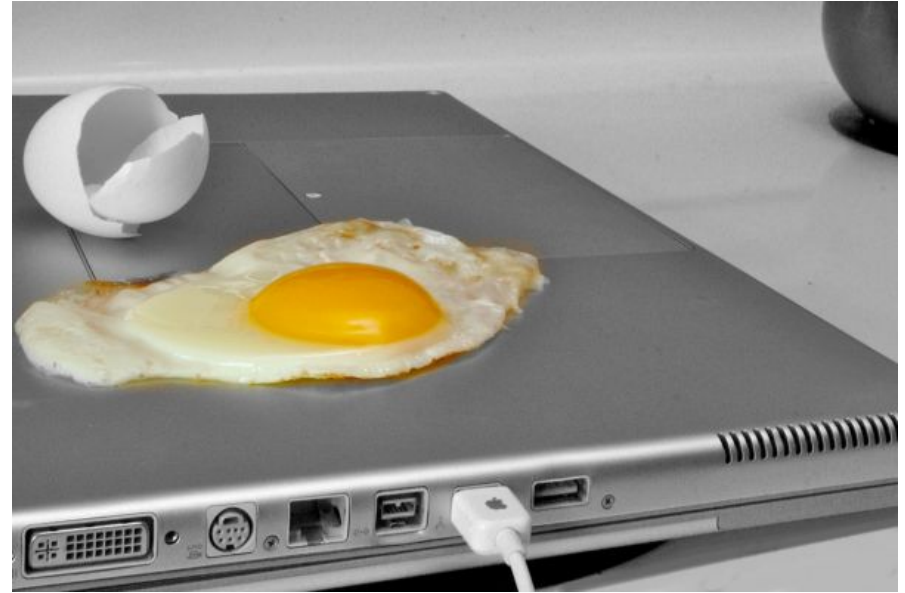
Results courtesy of the
Geological Survey of South
Australia (Simon van der
Weilen et al.)

Magnetic Susceptibility (SI)

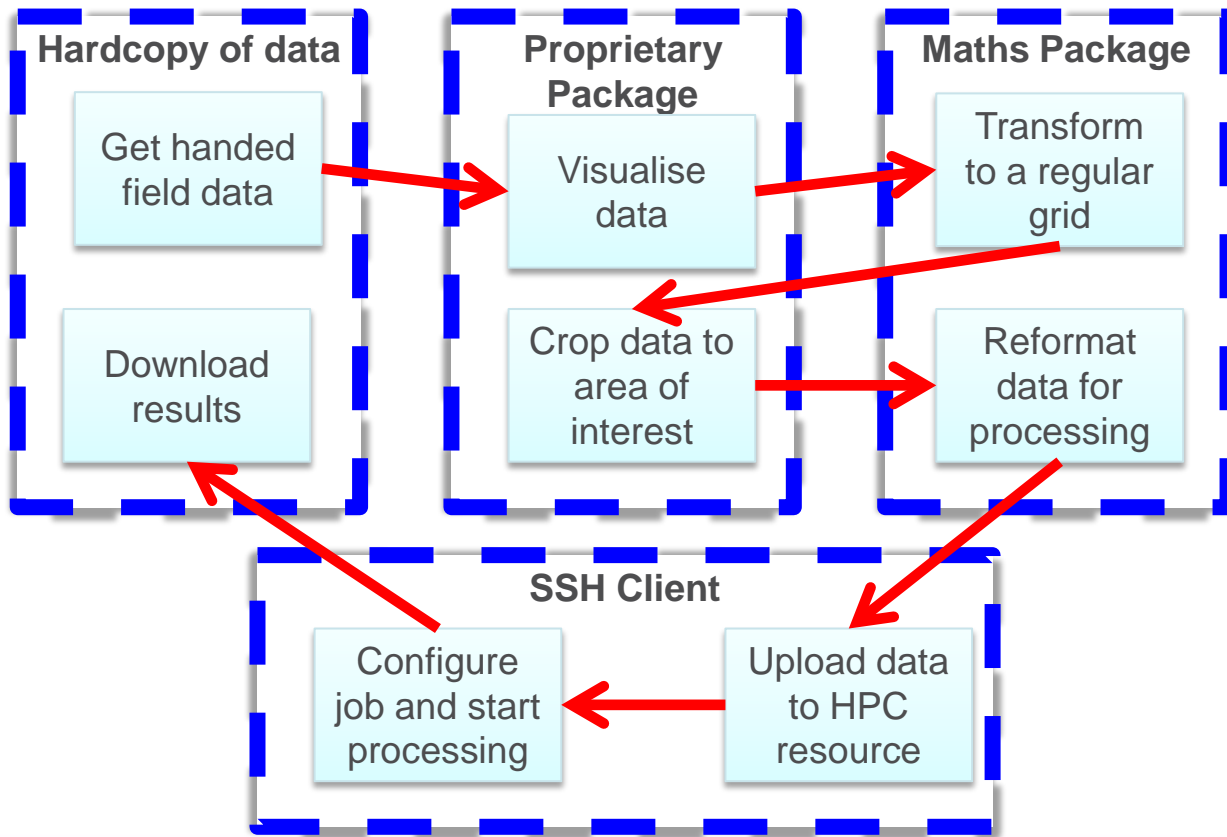
0 0.005 0.01 0.015 0.02 0.025 0.03 0.035 0.04 0.045 0.05 0.055 0.06 0.065 0.07 0.075 0.08

What is the problem?

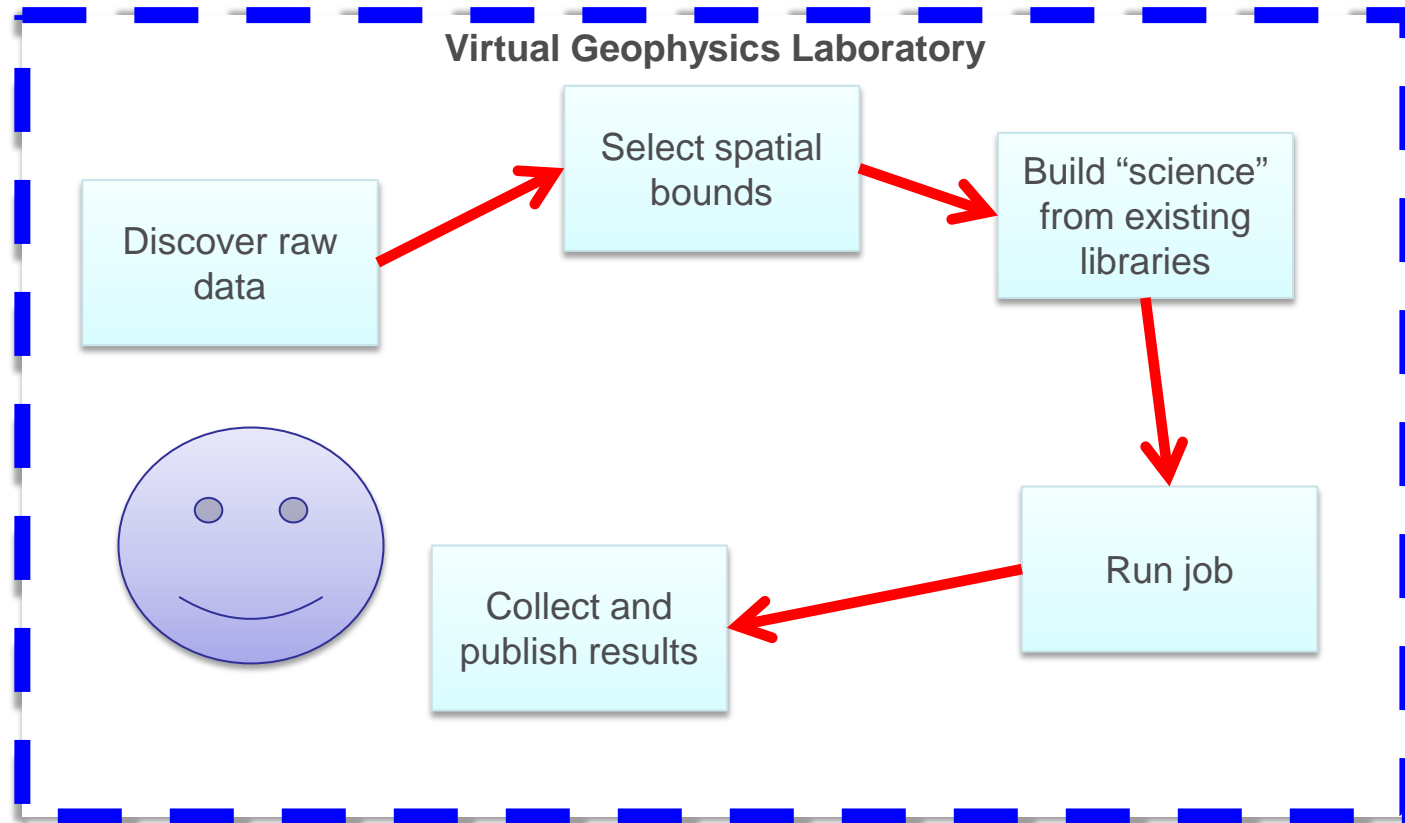
- Access to Big Data
- Access to Big Compute
- Complex geophysical scientific workflows



From this..

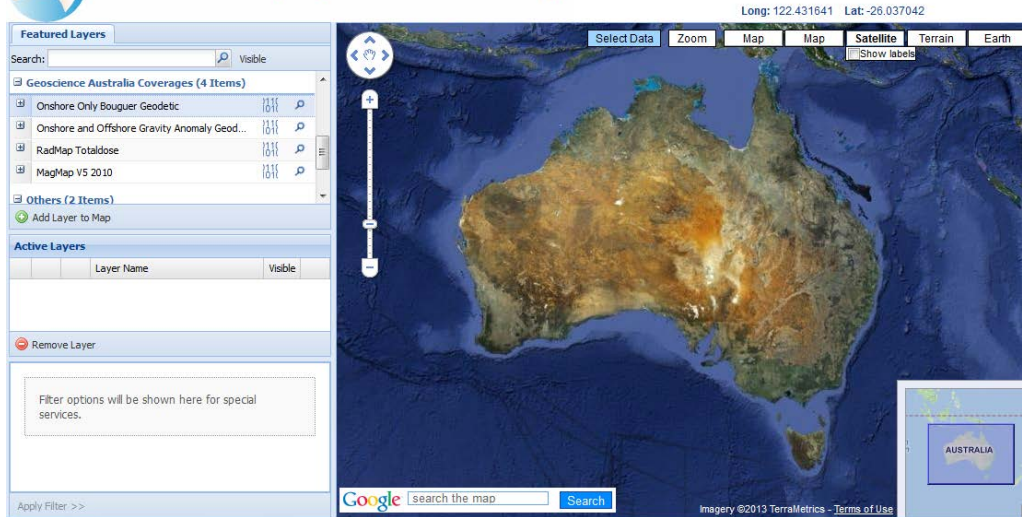


...to this: A Virtual Laboratory in the Cloud.



The Virtual Geophysics Laboratory

Contributing to the high performance computing evolution



<http://vgl.auscope.org>

Currently open for all for research and beta testing ..

Funded by:



This is what VGL looks like.



Featured Layers

Search:

Geoscience Australia Coverages (4 Items)

- ☒ Onshore Only Bouguer Geodetic
- ☒ Onshore and Offshore Gravity Anomaly Geod...
- ☒ RadMap Totaldose
- ☒ MagMap V5 2010

Others (2 Items)

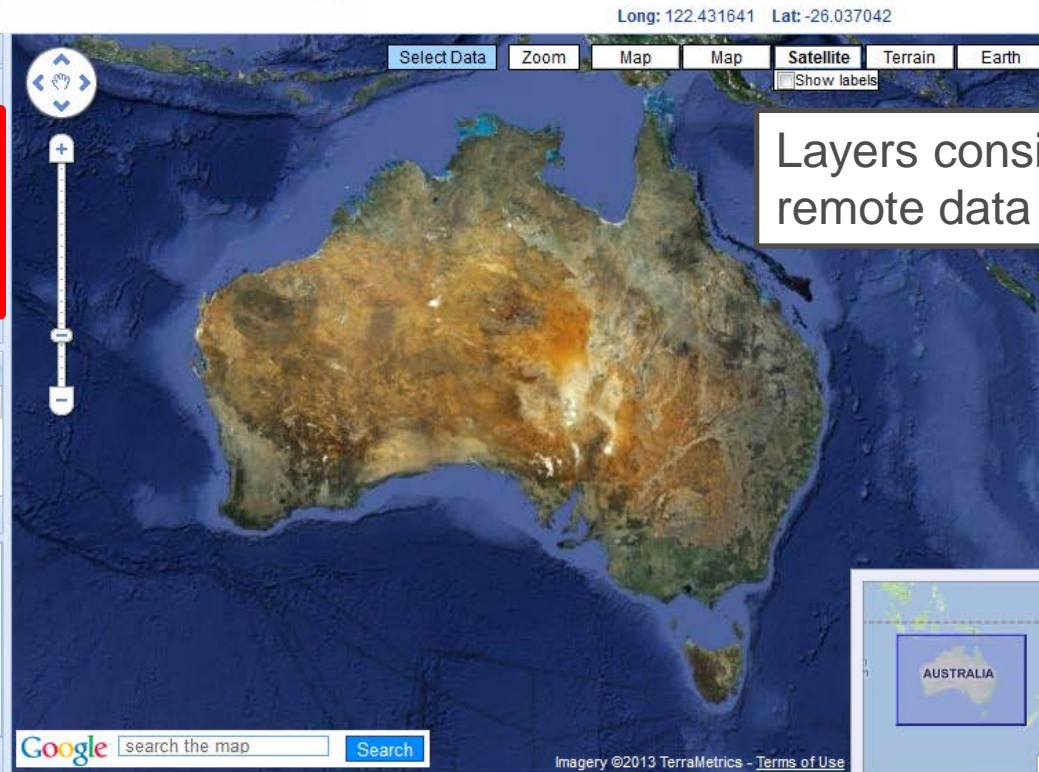
☒ Add Layer to Map

Active Layers

	Layer Name	Visible
<input checked="" type="button" value="Remove Layer"/>		

Filter options will be shown here for special services.

Apply Filter >>



Layers consist of numerous remote data services

This is what VGL looks like.



Help VGL Portal Submit Jobs Monitor Jobs Login

Long: 122.431641 Lat: -26.037042

Select Data Zoom Map Map Satellite Terrain Earth Show labels

Featured Layers

Search: [] Visible

Geoscience Australia Coverages (4 Items)

- Onshore Only Bouguer Geodetic
- Onshore and Offshore Gravity Anomaly Geod...
- RadMap Totaldose
- MagMap V5 2010

Others (2 Items)

Add Layer to Map

Active Layers

Layer Name	Visible

Remove Layer

Filter options will be shown here for special services.

Apply Filter >>

Google search the map

Layers consist of numerous remote data services

Service Information

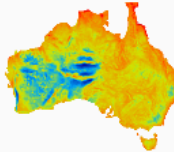
OGC Web Coverage Service 1.0.0 (1 Item)

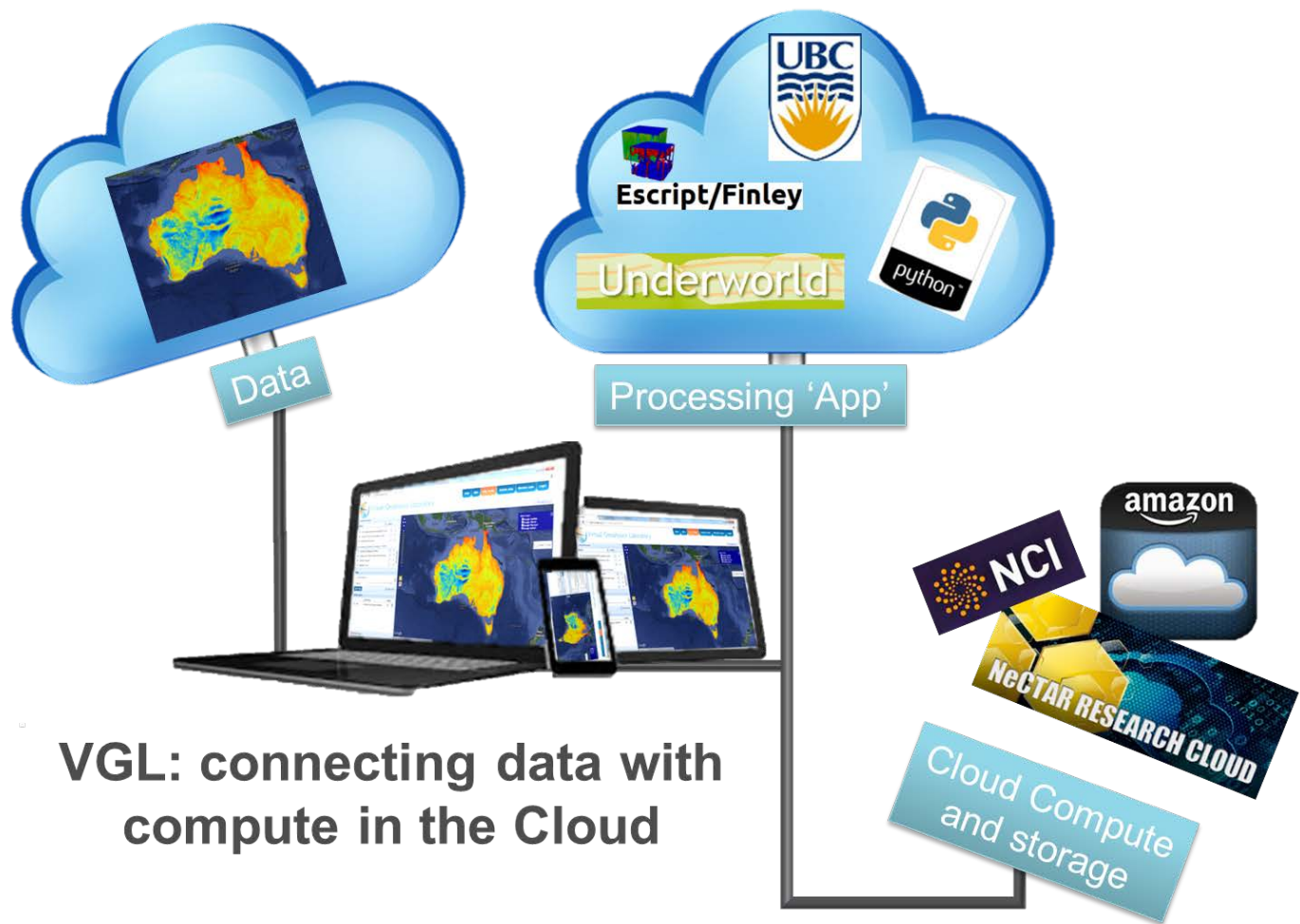
onshore_only_Bouguer_geodetic
http://sis2.anu.edu.au/thredds/wcs/ga/gravityMap/onshore_only_Bouguer_geodetic_fixed2.nc
onshore_only_Bouguer_geodetic

[DescribeCoverage respo...](#)

OGC Web Map Service 1.1.1 (1 Item)

onshore_only_Bouguer_geodetic
http://sis2.anu.edu.au/thredds/wms/ga/gravityMap/onshore_only_Bouguer_geodetic_fixed2.nc
onshore_only_Bouguer_geodetic





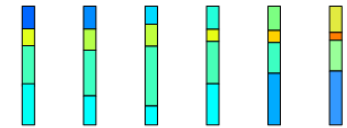
Key Virtual Geophysical Laboratory features

- Access to precompetitive **geophysical data** online
- Access to **cloud computing** and **storage**
- Access to geophysical data **workflows** ('apps')
- Capture **Metadata**
 - (ISO 19115) 'provenance record' enabling transparency of the results.
 - Share your results and search for other published results.

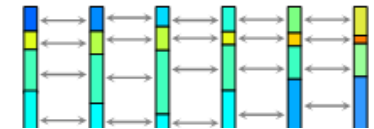
Airborne Electromagnetics (AEM) Inversion

- All codes developed at GA in platform independent C++
- Our inversions code is based on layered earths (1D not 3D)
- Deterministic Gradient Based
 - GALEISBS - sample by sample
 - our main production algorithm
 - GALEILBL - line by line
 - used occasionally
 - HOLISTIC - survey at a time
 - frequency domain only
- Codes released via VGL and open source

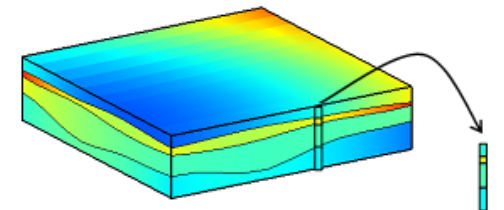
Sample by sample (SBS)
many completely independent 1D models



Laterally constrained (LCI)
many 1D models linked along line by covariance

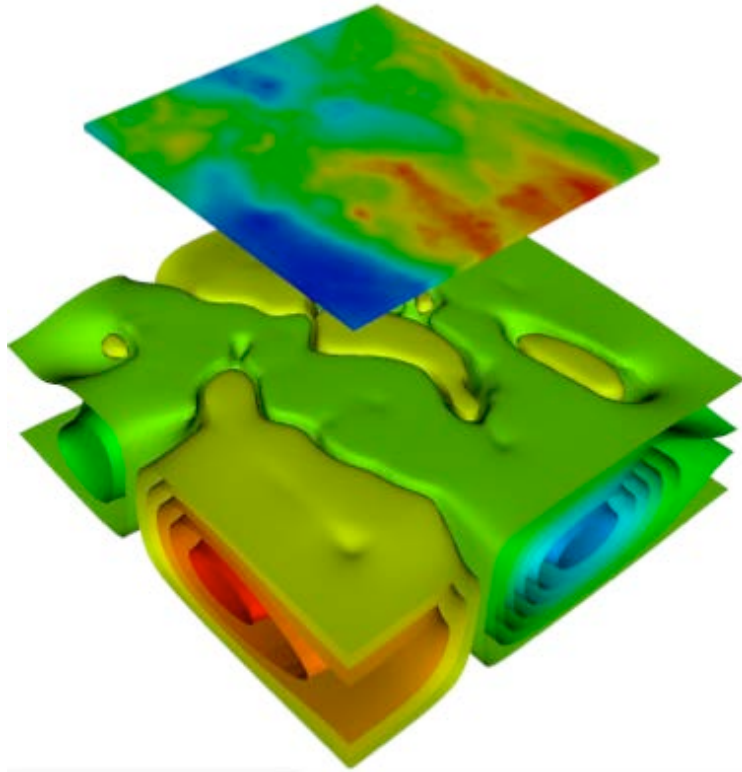


Holistic
one smooth continuous 3D model

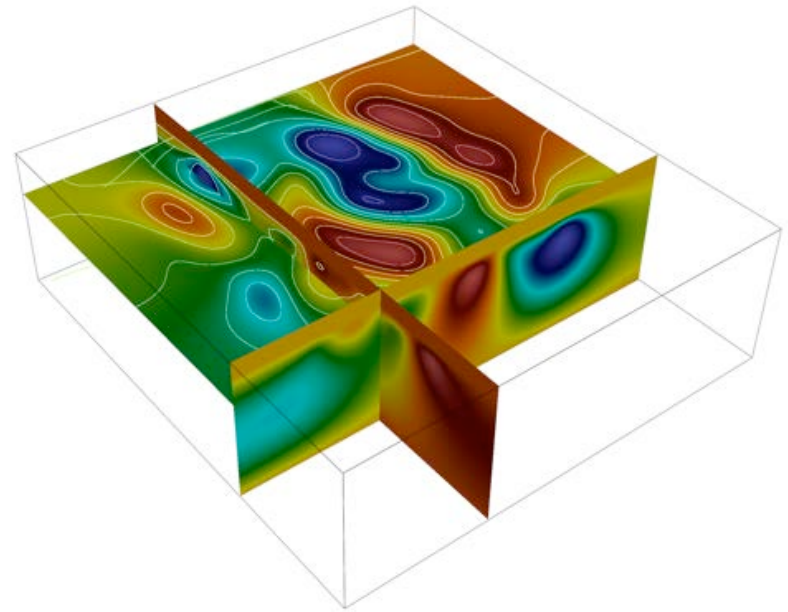


1D models extracted for forward modelling
Courtesy of R. Brodie

A VGL Result: escript.downunder



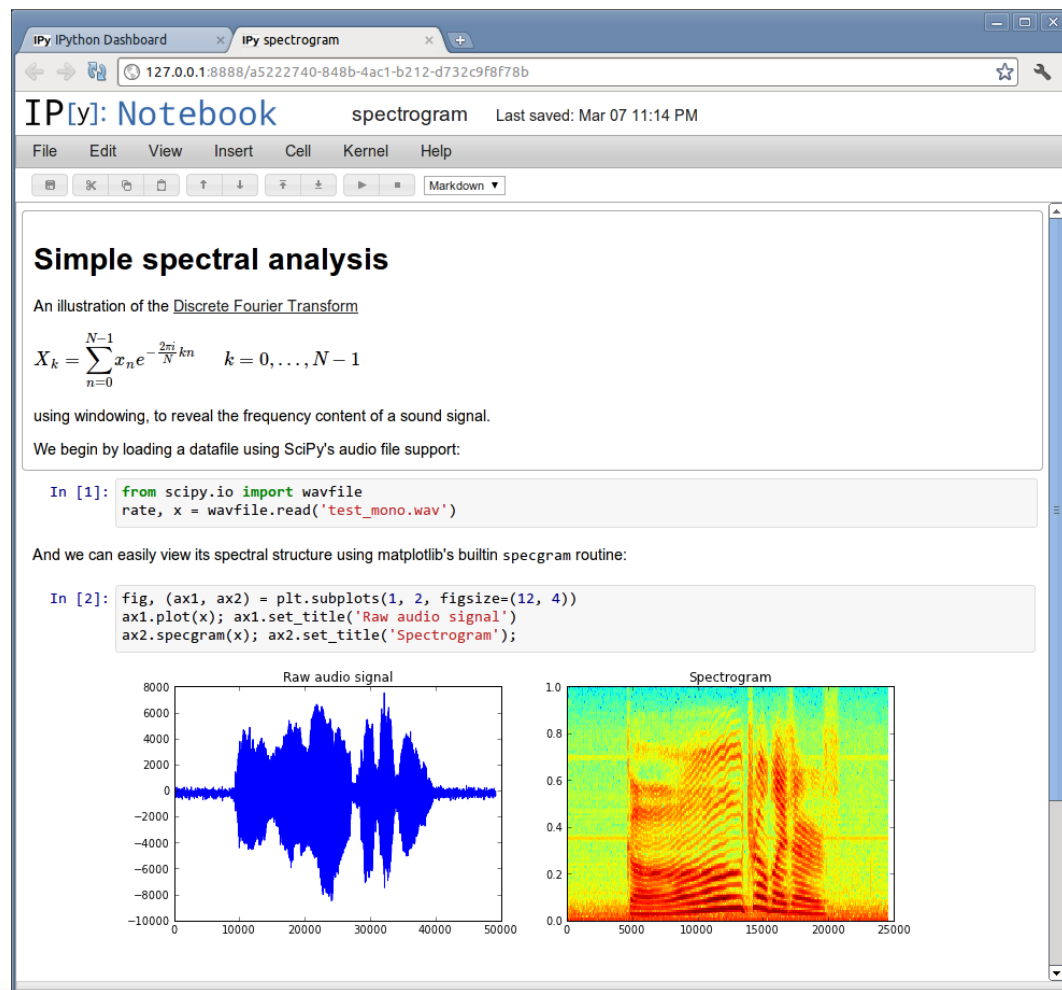
Inversion of gravity anomaly data



Joint inversion of gravity and magnetic data. ~ 100km by 100km by 30km depth showing magnetic susceptibility variation.

The iPython Notebook

Interactive computational environment that provides a platform for reproducible results.



The High Performance Computing Evolution

Virtual Laboratories remove the technical barriers

- Open access to data,
- Open access to scientific workflows
- Open access to and transparency in the scientific results.

More Information on VGL can be found at:

<https://www.nectar.org.au/virtual-geophysics-laboratory>

ANVGL coming soon.

VGL is free for research use:

<http://vgl.auscope.org>

Phone: +61 2 6249 9228

Web: www.ga.gov.au

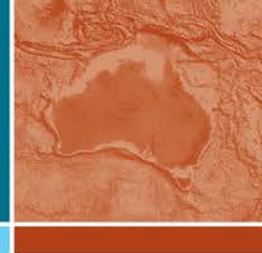
Email: carina.kemp@ga.gov.au; richard.chopping@ga.gov.au;
james.goodwin@ga.gov.au

Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609

Postal Address: GPO Box 378, Canberra ACT 2601



Australian Government
Geoscience Australia



Advances in Geoscience Information Access



Ollie Raymond oliver.raymond@ga.gov.au

Advances in Geoscience Information Access

Data as Web Services

- What is an OGC Web Service?



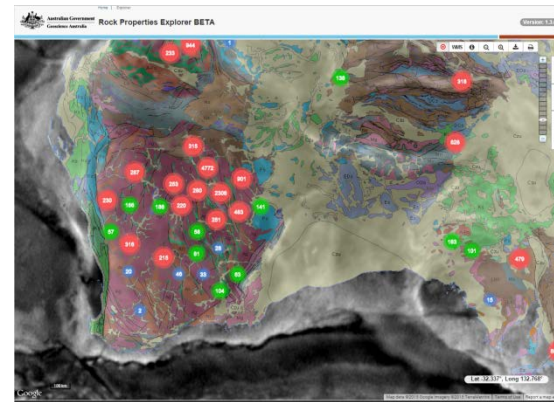
GA Geological Data as Web Services

Australian Geoscience Information Network

- Geoscience Portal redevelopment
- GADDs redevelopment

Geoscience Data Standards and Australia's Role

- GA and GGIC



MineralTenementML

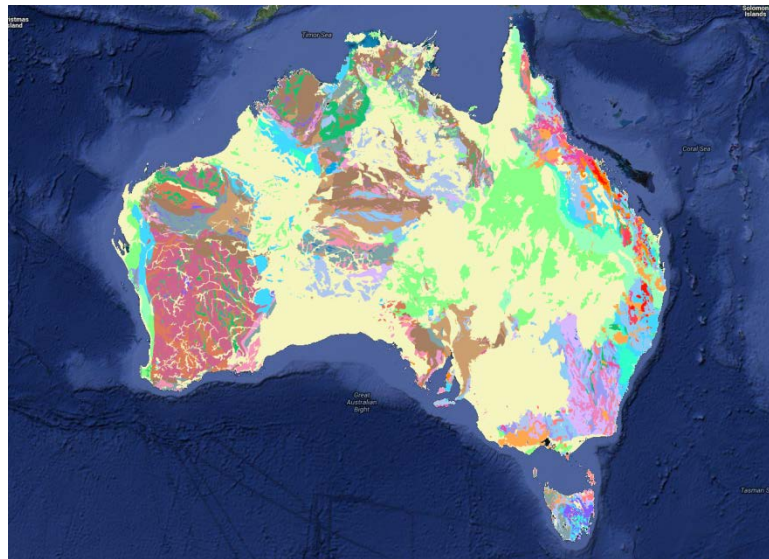


Data as Web Services

What are “OGC Web Services”?

Maps and data broadcast over the internet , like streaming TV, using international standard protocols developed by the Open Geospatial Consortium (OGC).

- **WMS (Web Map Service)**
- **WFS (Web Feature Service)**
- **WCS (Web Coverage Service)**



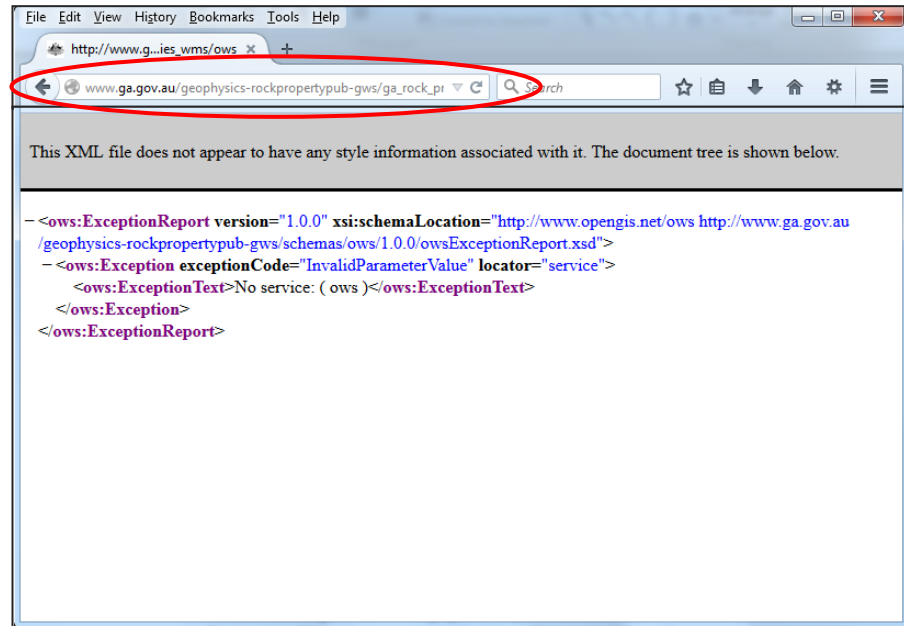
Data as Web Services

What are “OGC Web Services”?

- Web services are accessed via a URL “endpoint”

e.g: http://www.ga.gov.au/geophysics-rockpropertypub-gws/ga_rock_properties_wms/ows

- the endpoint URL will not resolve in a standard browser address bar!



Data as Web Services

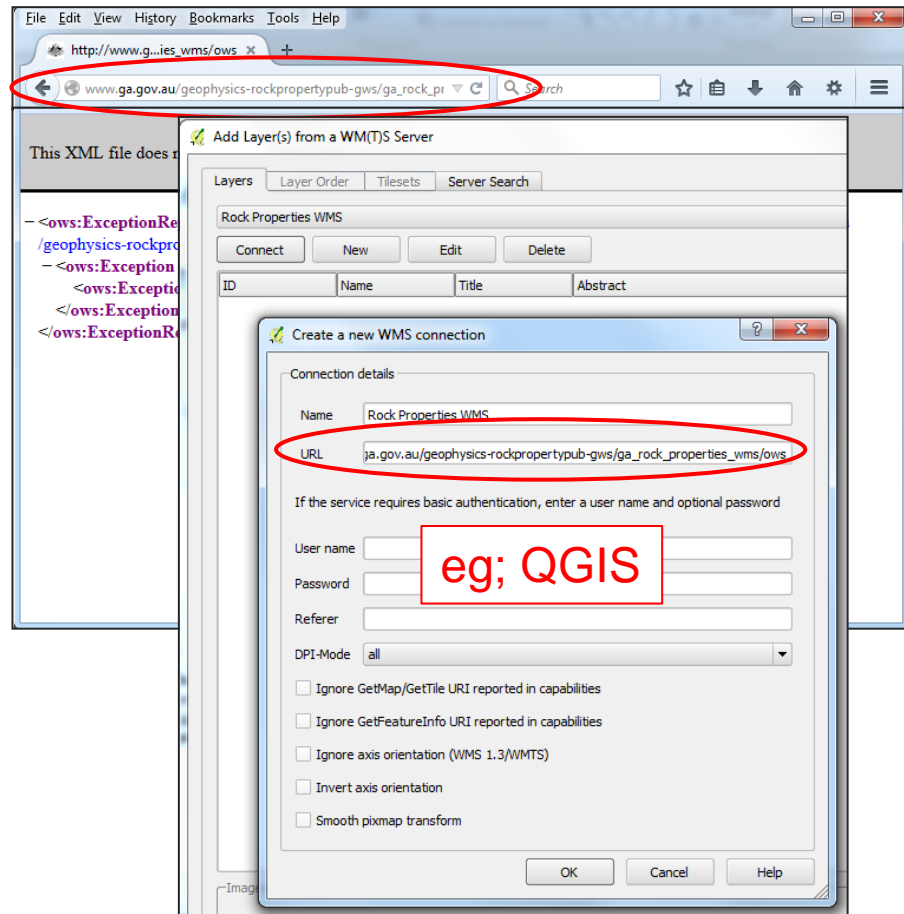
What are “OGC Web Services”?

- Web services are accessed via a URL “endpoint”

e.g: http://www.ga.gov.au/geophysics-rockpropertypub-gws/ga_rock_properties_wms/ows

- the endpoint URL will not resolve in a standard browser address bar!
- the URL is consumed by GIS applications, web portals, and other analytical applications built to consume OGC web services
- GA website has instructions for using web services in some common GIS applications

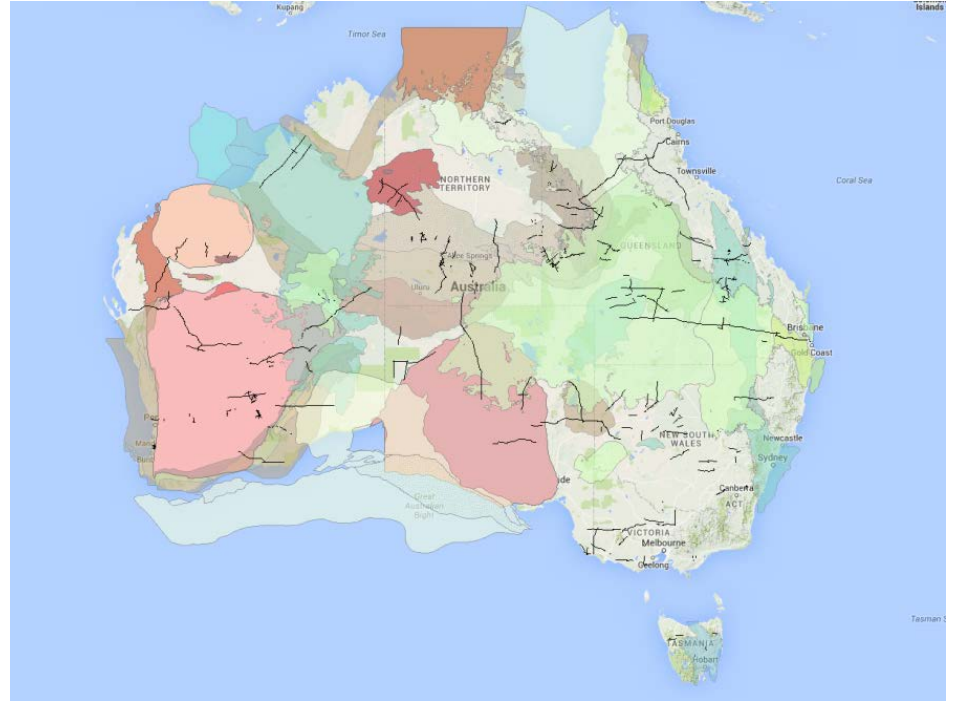
<http://www.ga.gov.au/data-pubs/web-services#heading-2>



Data as Web Services

WMS (Web Map Service)

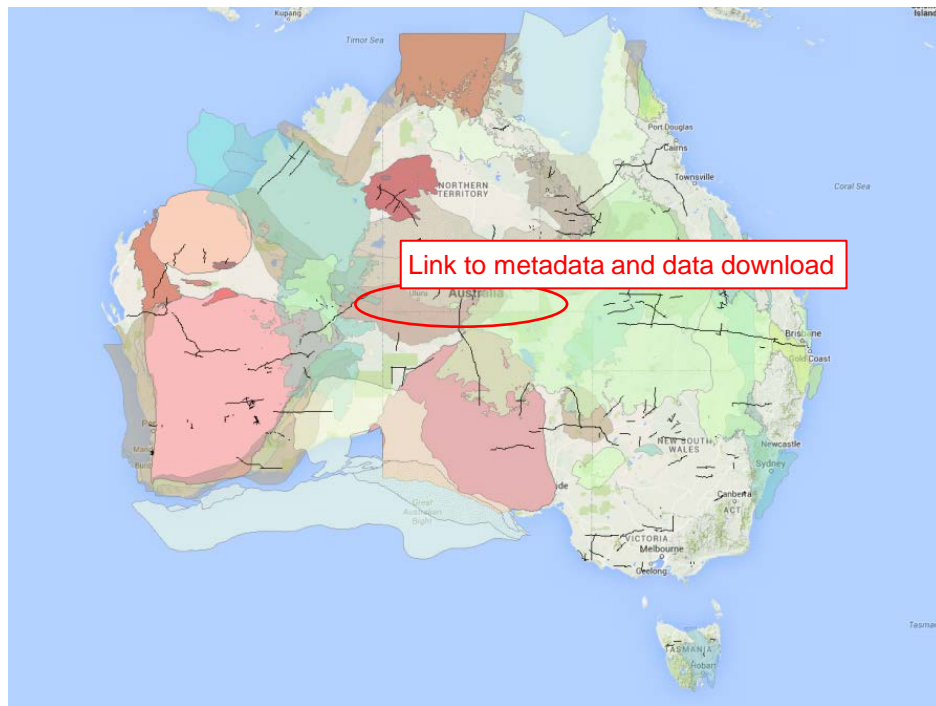
- delivers map data as an image



Data as Web Services

WMS (Web Map Service)

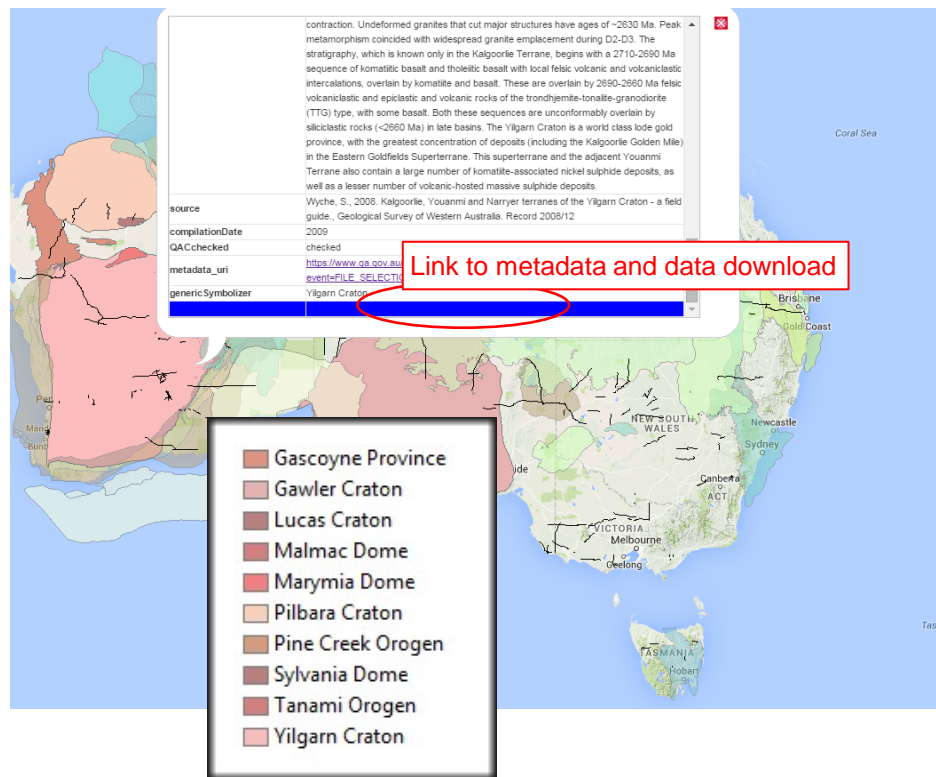
- delivers map data as an image
- they can be queried online



Data as Web Services

WMS (Web Map Service)

- delivers map data as an image
- they can be queried online
- the data behind the WMS can be accessed if a link is provided in the WMS to a downloadable file
- typically, symbolisation/legend is delivered with the WMS map
- WMS maps are primarily used as queryable backdrops in your GIS analysis

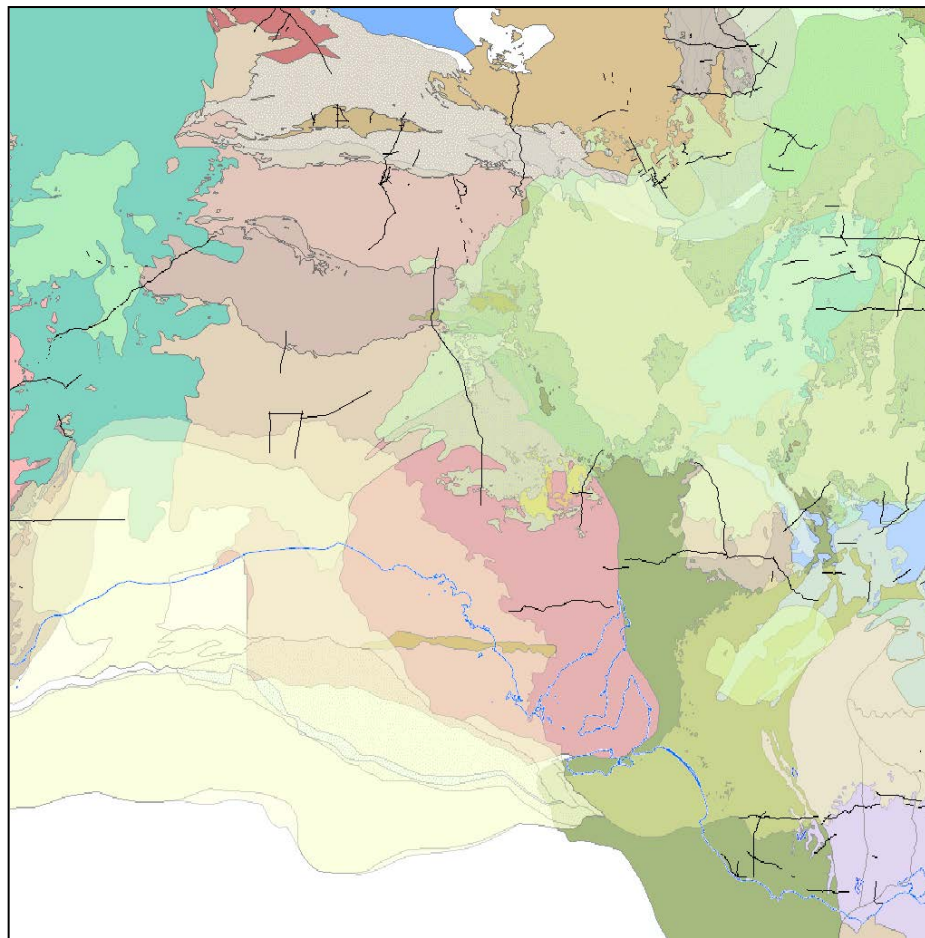


Data as Web Services

An example of a GA WMS,

GA's Onshore Seismic Surveys WMS

- i. a map of survey locations,

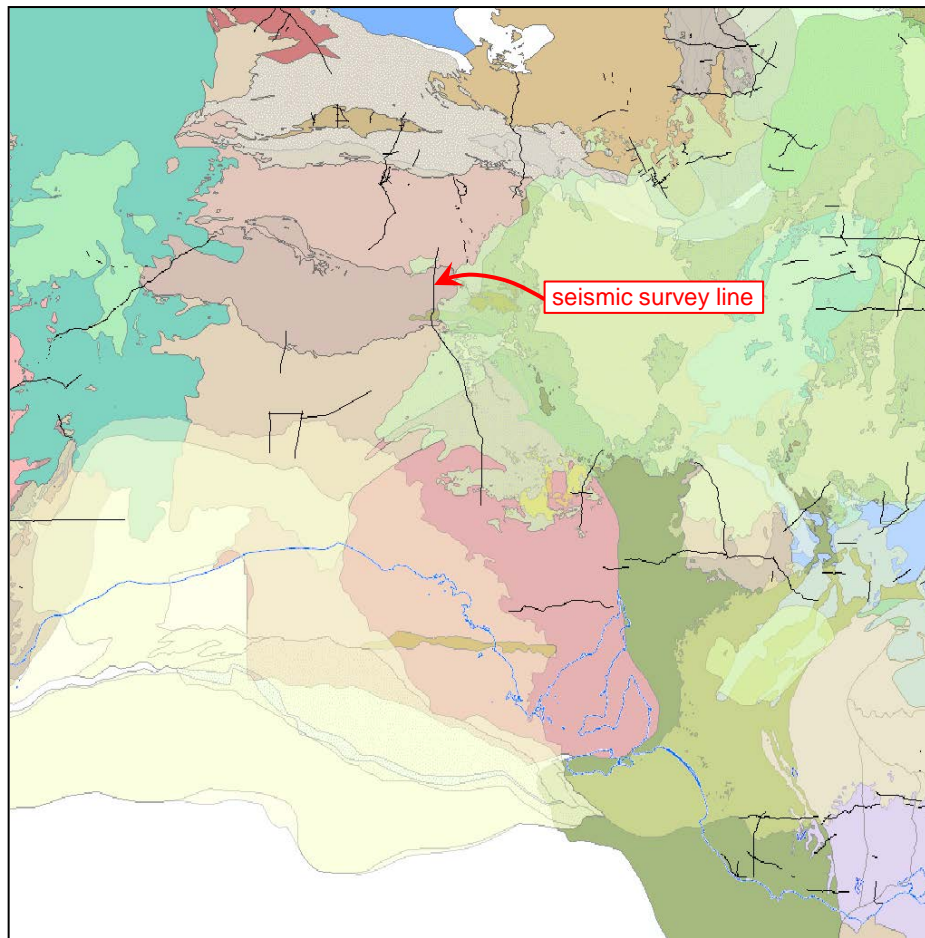


Data as Web Services

An example of a GA WMS,

GA's Onshore Seismic Surveys WMS

- i. a map of survey locations,
- and
- ii. a link to the seismic data

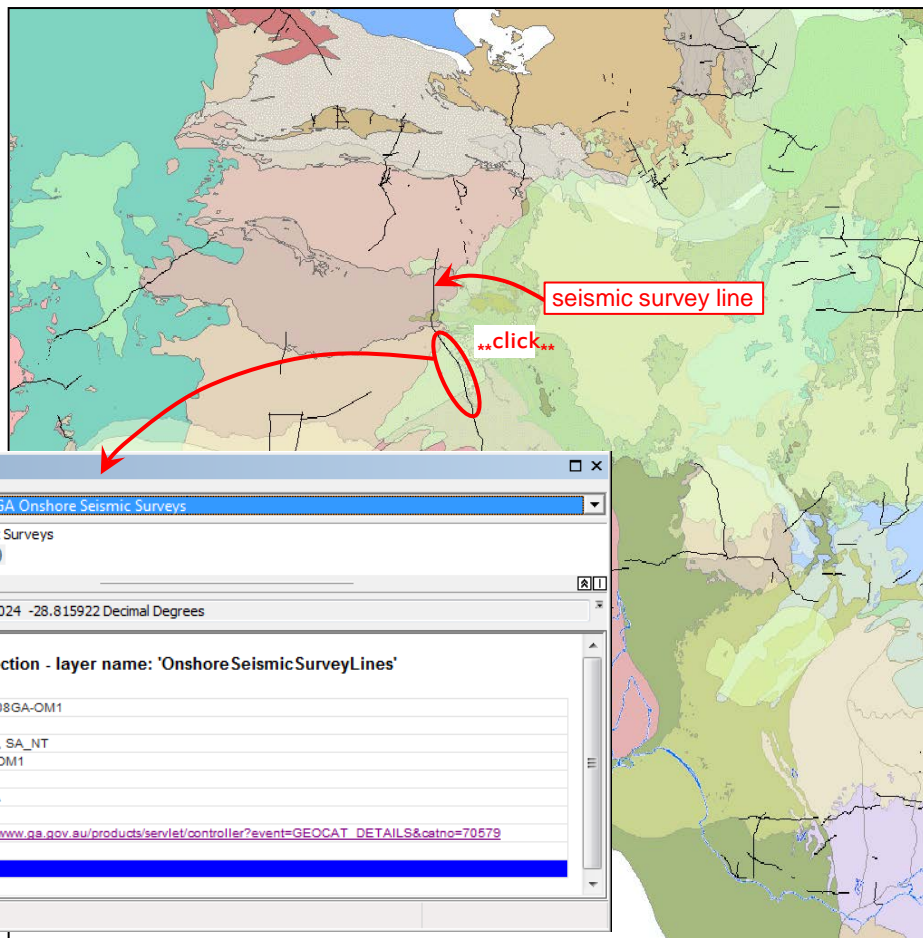


Data as Web Services

An example of a GA WMS,

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- a map of survey locations, and
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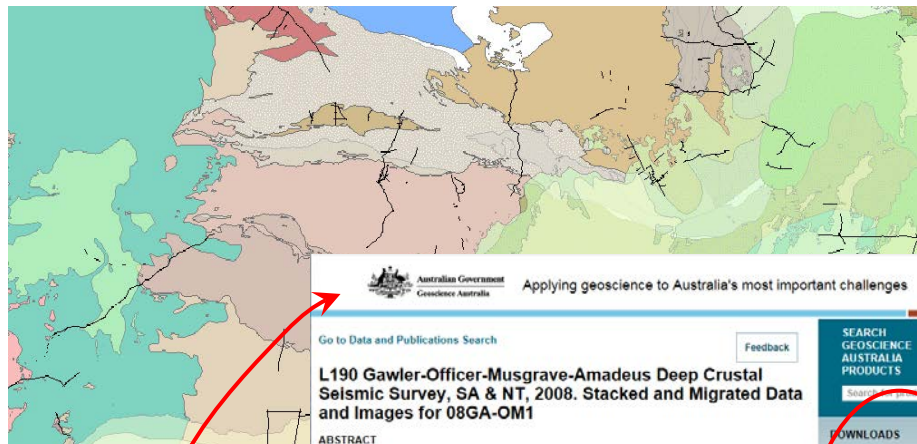


Data as Web Services

An example of a GA WMS,

GA's Onshore Seismic Surveys WMS

- a map of survey locations,
- and
- a link to the seismic data



Identify

Identify from: ☐ GA Onshore Seismic Surveys

☐ GA Onshore Seismic Surveys
WMS Feature(s)

Location: 134.336024 -28.815922 Decimal Degrees

FeatureInfoCollection - layer name: 'Onshore Seismic Surveys'

uri	surveyNo	surveyName	lineName	length	state	year	url	urlNci
L190_08GA-OM1	L190	GOMA_SA_NT	08GA-OM1	634.52	NT_SA	2008	https://www.ga.gov.au/products/servlet/controller?event=GIS	Null

Identified 1 feature

Australian Government
Geoscience Australia

Applying geoscience to Australia's most important challenges

Go to Data and Publications Search

Feedback

L190 Gawler-Officer-Musgrave-Amadeus Deep Crustal Seismic Survey, SA & NT, 2008. Stacked and Migrated Data and Images for 08GA-OM1

ABSTRACT

Processed seismic data (SEG-Y format) and TIFF images for the Gawler-Officer-Musgrave-Amadeus (GOMA) Deep Crustal Seismic survey (L190) acquired by Geoscience Australia (GA) in collaboration with AusScope and Primary Industries and Resources South Australia (PIRSA). Stack and migrated data for line 08GA-OM1 as well as CDP coordinates data. This 634 line km traverse follows the Alice Springs to Adelaide railway line beginning near Eridunda in the Northern Territory and finishing near Tarcool in the South Australia.

PRODUCT TYPE/SUB TYPE

dataset - Seismic Data - seismic survey

CONSTRANTS

license
Creative Commons Attribution 4.0 International Licence

IP OWNER

Commonwealth of Australia (Geoscience Australia)

AUTHOR(S)

Maher, J.L.

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GEOSCIENCE
AUSTRALIA
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08GA-OM1 Interpreted Seismic Sections (23 MB)
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08GA-OM1 Migrated Data part 1 of 2 (166 MB)
08GA-OM1 Stacked Data part 2 of 2 (166 MB)
08GA-OM1 Stacked Data part 1 of 2 (166 MB)
08GA-OM1 Images 300dpi (178 MB)
08GA-OM1 Images 150dpi (178 MB)
08GA-OM1 Images 75dpi (178 MB)

For information on acquiring this product, please contact Geoscience Australia Client Services via:

email:
clientservices@ga.gov.au;
fax:
+61 2 6249 9960; or
phone:
1800 800 173 (within Australia);
+61 2 6249 9966 (outside Australia)



Data as Web Services

WFS (Web Feature Service)

- streams data as XML

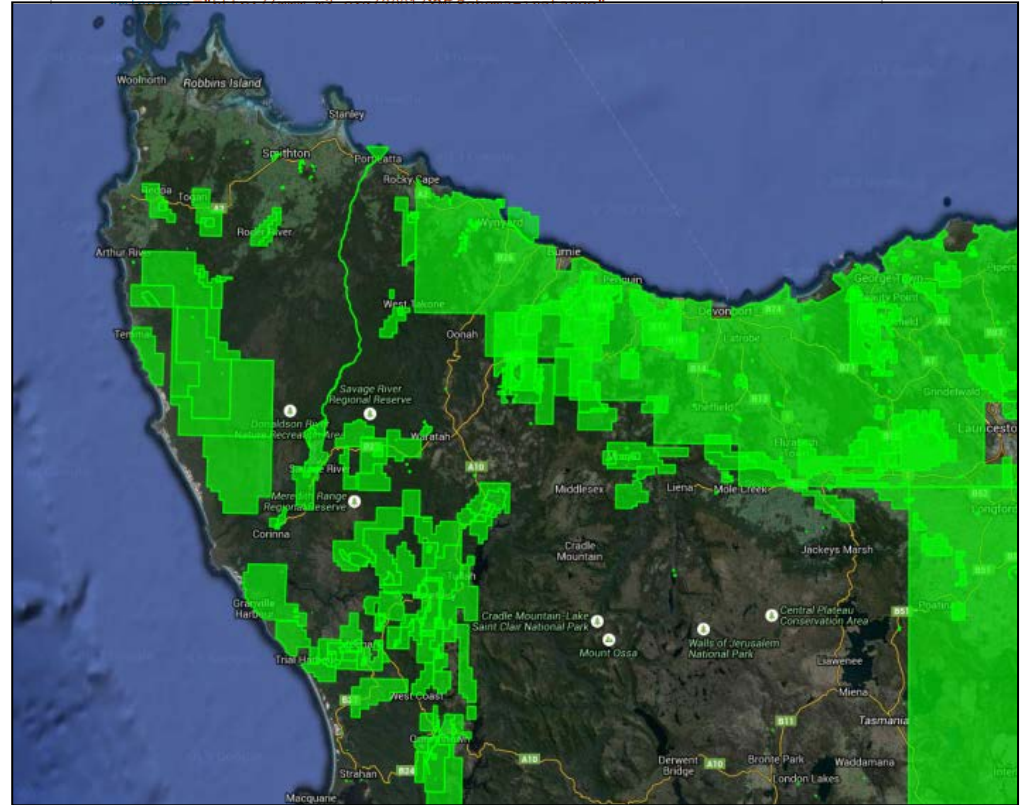
```
<mt:MineralTenement
  xmlns:mt="http://xmlns.geoscience.gov.au/mineraltenementml/1.0"
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  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:gml="http://www.opengis.net/gml"
  xsi:schemaLocation="http://xmlns.geoscience.gov.au/mineraltenementml/1.0
    http://schemas.geoscience.gov.au/MineralTenementML/1.0/mineral
    http://data.myagency.gov.au/resource/feature/mya/mineraltenement/12"
  <mt:identifier>http://data.myagency.gov.au/resource/feature/mya/mineraltenement/12
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  <mt:owner>Geo Exploration Pty Ltd</mt:owner>
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  <mt:jurisdiction_uri>http://www.myagency.gov.au/</mt:jurisdiction_uri>
  <mt:shape>
    <gml:Polygon srsDimension="2" srsName="http://www.opengis.net/def/crs/EPSSG/0/4"
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        <gml:LinearRing srsDimension="2">
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            145.306965906809 -41.87937754399609
            145.336680620719 -41.87941383898959
            145.278660993645 -41.85236731493909</gml:posList>
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        </gml:exterior>
      </gml:Polygon>
    </mt:shape>
  </mt:MineralTenement>
```

```
<mt:MineralTenement
  xmlns:mt="http://xmlns.geoscience.gov.au/mineraltenementml/1.0"
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  xlink:href="http://www.w3.org/1999/xlink"
  ...
```

Data as Web Services

WFS (Web Feature Service)

- streams data as XML
- the live XML feed can be rendered, filtered, and queried by a mapping application

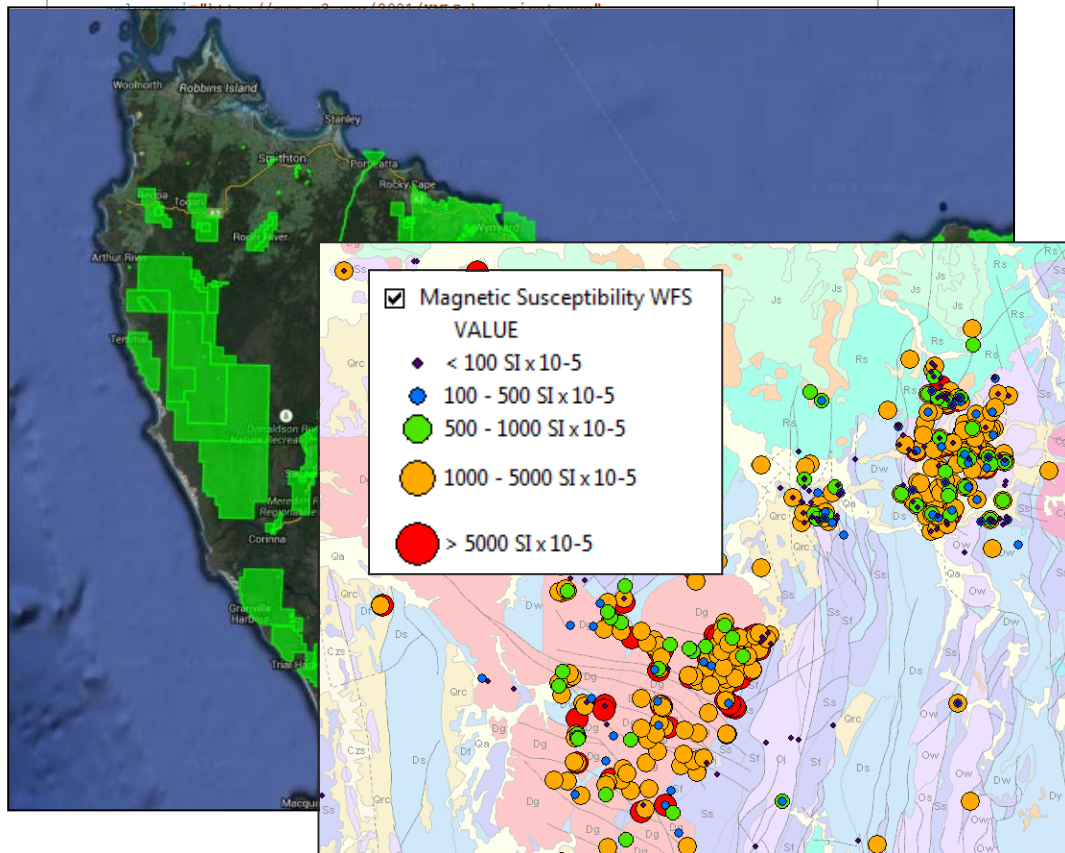


Data as Web Services

```
<mt:MineralTenement
  xmlns:mt="http://xmlns.geoscience.gov.au/mineraltenementml/1.0"
  xmlns:xlink="http://www.w3.org/1999/xlink"
```

WFS (Web Feature Service)

- streams data as XML
- the live XML feed can be rendered, filtered, and queried by a mapping application
- or, it can be consumed on-the-fly by analytical and modelling applications

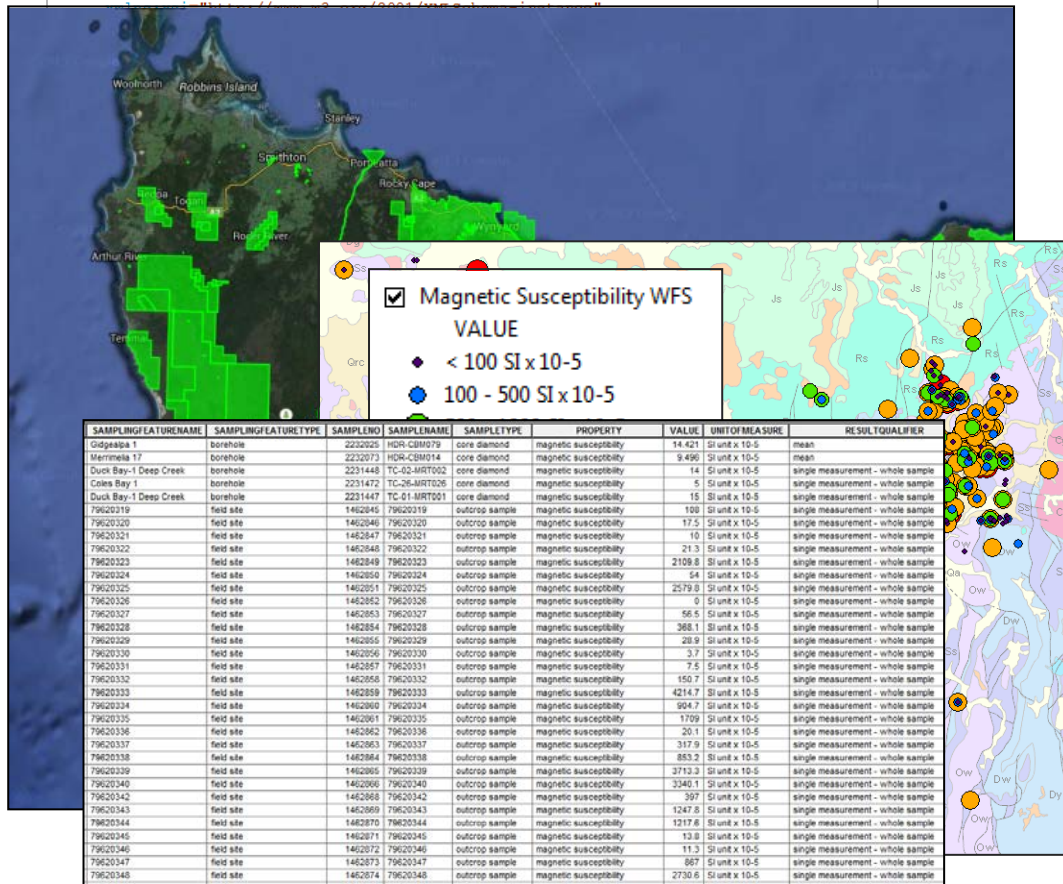


Data as Web Services

WFS (Web Feature Service)

- streams data as XML
- the live XML feed can be rendered, filtered, and queried by a mapping application
- or, it can be consumed on-the-fly by analytical and modelling applications
- or, it can be downloaded in various formats to your local PC (eg, CSV, shapefile, gdb)

```
<mt:MineralTenement
  xmlns:mt="http://xmlns.geoscience.gov.au/mineraltenementml/1.0"
  xmlns:xlink="http://www.w3.org/1999/xlink"
```



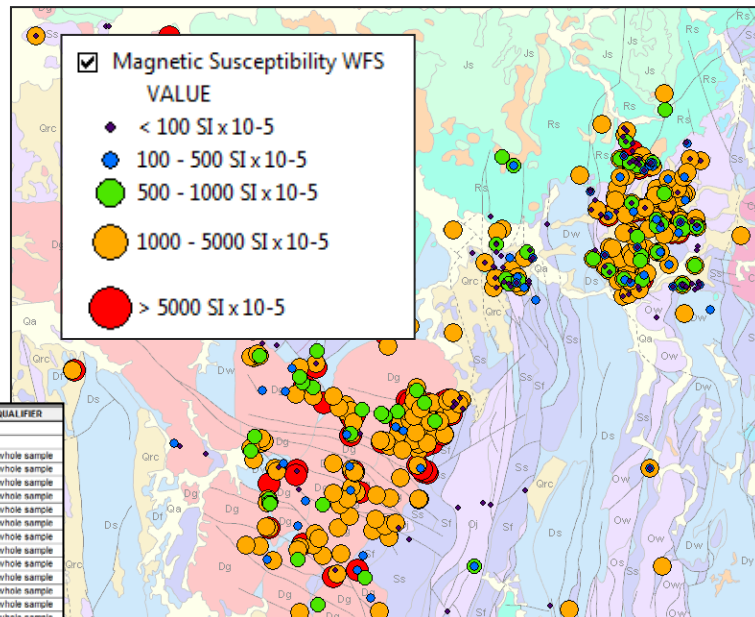
Data as Web Services

WFS (Web Feature Service)

Geoscience Australia's Rock Properties

<http://www.ga.gov.au/explorer-web/rock-properties.html>

SAMPLINGFEATURENAME	SAMPLINGFEATURETYPE	SAMPLFNO	SAMPLFNAME	SAMPLFTYPE	PROPERTY	VALUE	UNITOFMEASURE	RESULTQUALIFIER
Gidgenalpa 1	borehole	2232026	HDR-CBM070	core diamond	magnetic susceptibility	14.421	SI unit x 10 ⁻⁵	mean
Merrimela 17	borehole	2232073	HDR-CBM014	core diamond	magnetic susceptibility	9.496	SI unit x 10 ⁻⁵	
Duck Bay-1 Deep Creek	borehole	2231448	TC-02-MRT002	core diamond	magnetic susceptibility	14	SI unit x 10 ⁻⁵	single measurement - whole sample
Coles Bay 1	borehole	2231472	TC-06-MRT026	core diamond	magnetic susceptibility	5	SI unit x 10 ⁻⁵	single measurement - whole sample
Duck Bay-1 Deep Creek	borehole	2231447	TC-01-MRT001	core diamond	magnetic susceptibility	15	SI unit x 10 ⁻⁵	single measurement - whole sample
79620319	field site	1462845	79620319	outcrop sample	magnetic susceptibility	108	SI unit x 10 ⁻⁵	single measurement - whole sample
79620320	field site	1462846	79620320	outcrop sample	magnetic susceptibility	17.5	SI unit x 10 ⁻⁵	single measurement - whole sample
79620321	field site	1462847	79620321	outcrop sample	magnetic susceptibility	10	SI unit x 10 ⁻⁵	single measurement - whole sample
79620322	field site	1462848	79620322	outcrop sample	magnetic susceptibility	21.3	SI unit x 10 ⁻⁵	single measurement - whole sample
79620323	field site	1462849	79620323	outcrop sample	magnetic susceptibility	2109.8	SI unit x 10 ⁻⁵	single measurement - whole sample
79620324	field site	1462850	79620324	outcrop sample	magnetic susceptibility	54	SI unit x 10 ⁻⁵	single measurement - whole sample
79620325	field site	1462851	79620325	outcrop sample	magnetic susceptibility	2579.8	SI unit x 10 ⁻⁵	single measurement - whole sample
79620326	field site	1462852	79620326	outcrop sample	magnetic susceptibility	0	SI unit x 10 ⁻⁵	single measurement - whole sample
79620327	field site	1462853	79620327	outcrop sample	magnetic susceptibility	56.5	SI unit x 10 ⁻⁵	single measurement - whole sample
79620328	field site	1462854	79620328	outcrop sample	magnetic susceptibility	368.1	SI unit x 10 ⁻⁵	single measurement - whole sample
79620329	field site	1462855	79620329	outcrop sample	magnetic susceptibility	20.9	SI unit x 10 ⁻⁵	single measurement - whole sample
79620330	field site	1462856	79620330	outcrop sample	magnetic susceptibility	3.7	SI unit x 10 ⁻⁵	single measurement - whole sample
79620331	field site	1462857	79620331	outcrop sample	magnetic susceptibility	7.5	SI unit x 10 ⁻⁵	single measurement - whole sample
79620332	field site	1462858	79620332	outcrop sample	magnetic susceptibility	150.7	SI unit x 10 ⁻⁵	single measurement - whole sample
79620333	field site	1462859	79620333	outcrop sample	magnetic susceptibility	4214.7	SI unit x 10 ⁻⁵	single measurement - whole sample
79620334	field site	1462860	79620334	outcrop sample	magnetic susceptibility	904.7	SI unit x 10 ⁻⁵	single measurement - whole sample
79620335	field site	1462861	79620335	outcrop sample	magnetic susceptibility	1709	SI unit x 10 ⁻⁵	single measurement - whole sample
79620336	field site	1462862	79620336	outcrop sample	magnetic susceptibility	20.1	SI unit x 10 ⁻⁵	single measurement - whole sample
79620337	field site	1462863	79620337	outcrop sample	magnetic susceptibility	317.9	SI unit x 10 ⁻⁵	single measurement - whole sample
79620338	field site	1462864	79620338	outcrop sample	magnetic susceptibility	853.2	SI unit x 10 ⁻⁵	single measurement - whole sample
79620339	field site	1462865	79620339	outcrop sample	magnetic susceptibility	3713.3	SI unit x 10 ⁻⁵	single measurement - whole sample
79620340	field site	1462866	79620340	outcrop sample	magnetic susceptibility	2340.1	SI unit x 10 ⁻⁵	single measurement - whole sample
79620341	field site	1462867	79620341	outcrop sample	magnetic susceptibility	397	SI unit x 10 ⁻⁵	single measurement - whole sample
79620342	field site	1462868	79620342	outcrop sample	magnetic susceptibility	1247.8	SI unit x 10 ⁻⁵	single measurement - whole sample
79620343	field site	1462869	79620343	outcrop sample	magnetic susceptibility	1217.6	SI unit x 10 ⁻⁵	single measurement - whole sample
79620344	field site	1462870	79620344	outcrop sample	magnetic susceptibility	13.8	SI unit x 10 ⁻⁵	single measurement - whole sample
79620345	field site	1462871	79620345	outcrop sample	magnetic susceptibility	11.3	SI unit x 10 ⁻⁵	single measurement - whole sample
79620346	field site	1462872	79620346	outcrop sample	magnetic susceptibility	387	SI unit x 10 ⁻⁵	single measurement - whole sample
79620347	field site	1462873	79620347	outcrop sample	magnetic susceptibility	2730.6	SI unit x 10 ⁻⁵	single measurement - whole sample
79620348	field site	1462874	79620348	outcrop sample	magnetic susceptibility			

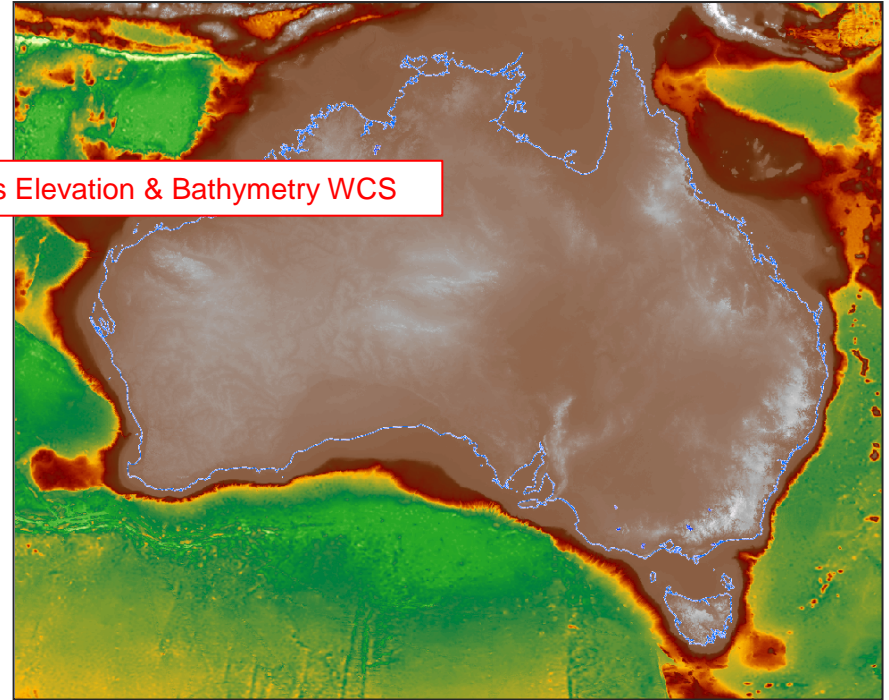


Data as Web Services

WCS (Web Coverage Service)

- delivers gridded (raster) data
- delivers the real data values, not just RGB pixel values

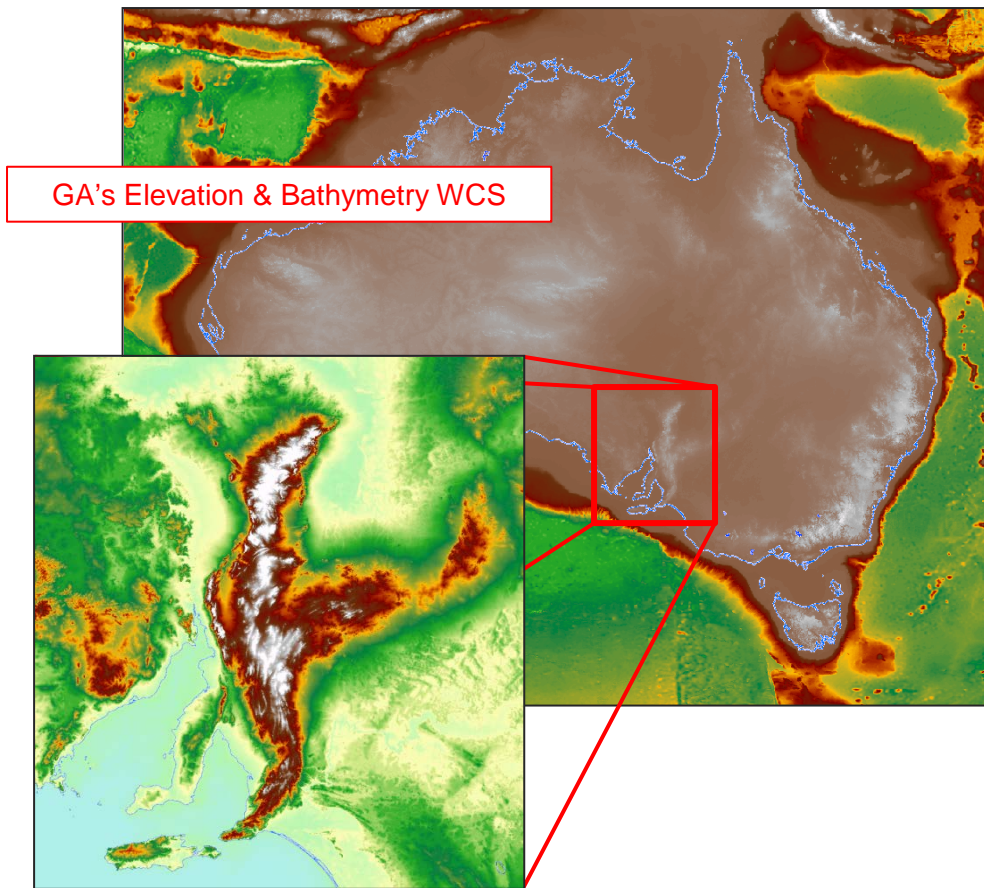
GA's Elevation & Bathymetry WCS



Data as Web Services

WCS (Web Coverage Service)

- delivers gridded (raster) data
- delivers the real data values, not just RGB pixel values
- data can be queried and consumed for data processing online
- data can be re-stretched by your mapping application
- can be downloaded in various formats (eg, NetCDF, geoTIFF)



Data as Web Services

Geoscience Australia Web Services

- Surface Geology of Australia (1:2.5M & 1:1M) - WMS
 - Geological Provinces - WMS
 - National Geophysical Grids - WMS
 - Onshore Seismic Surveys - WMS
 - Rock Properties - WMS & WFS
 - Elevation and Bathymetry - WMS & WCS
 - Topography and Infrastructure - WMS & WFS
- ...and over 100 more - just type “web services” into the GA website search tool**

Geoscience Portal redevelopment

www.geoscience.gov.au

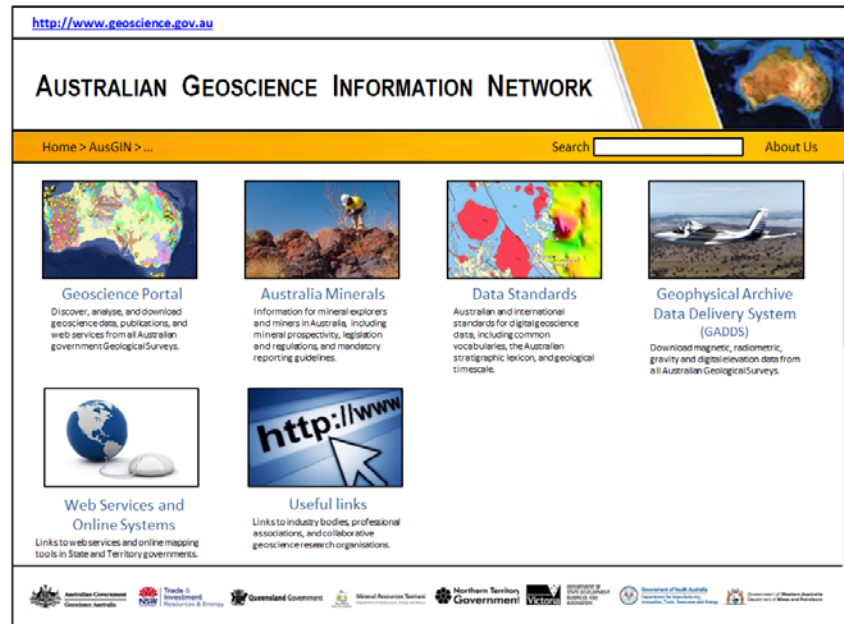
- owned by all Australian geological surveys
- hosted by Geoscience Australia



Geoscience Portal redevelopment

www.geoscience.gov.au

- owned by all Australian geological surveys
- hosted by Geoscience Australia
- new look and feel - **AusGIN**
- same URL



Geoscience Portal redevelopment

www.geoscience.gov.au

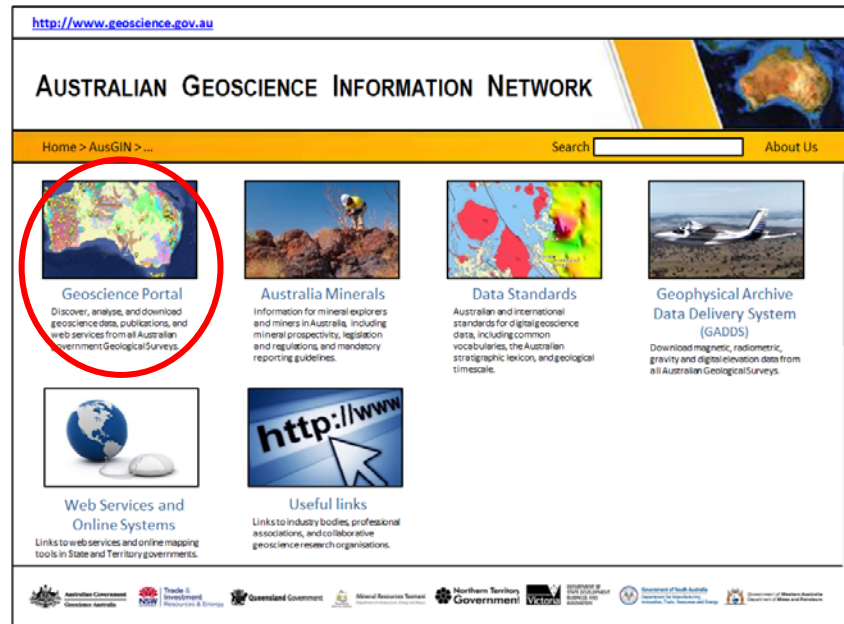
- owned by all Australian geological surveys
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- same information for mineral explorers, under the “Australia Minerals” banner
 - eg; regulations, reporting guidelines



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 - eg; regulations, reporting guidelines
- and a **new Geoscience Portal**, building on and improving the AuScope Portal technology
 - a single data portal for access to all government geoscience information



Geoscience Portal redevelopment

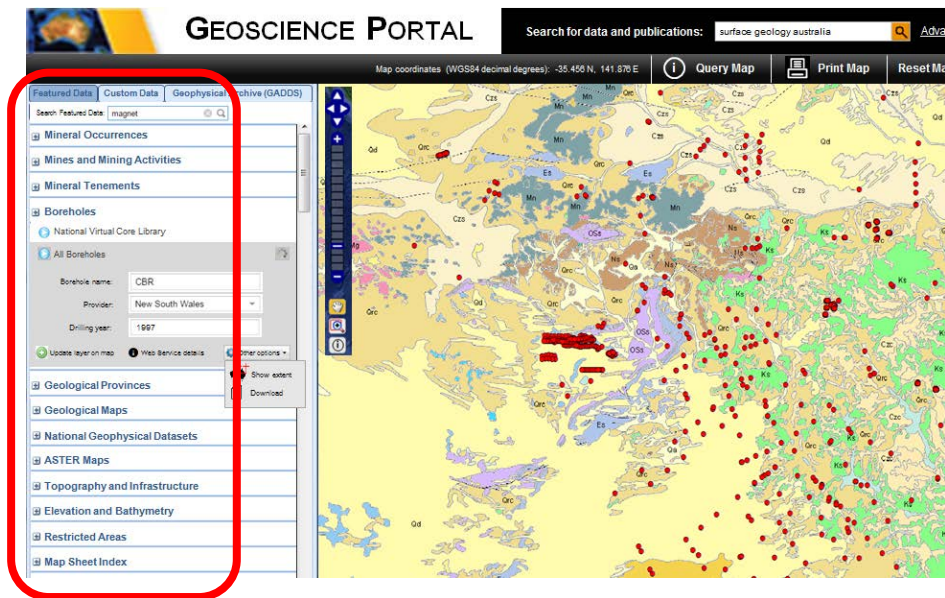
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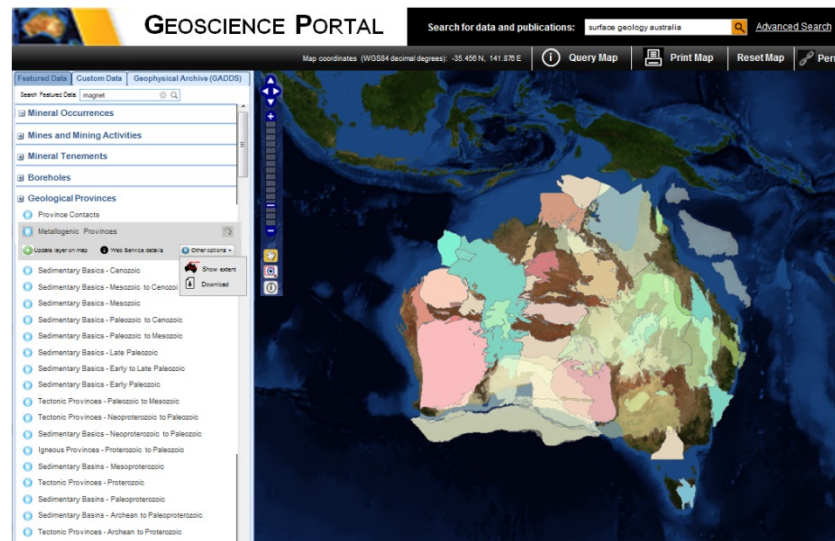
Geoscience Portal redevelopment

- new Geoscience Portal
- featured web services for mineral explorers
 - mines and mineral occurrences
 - mineral tenements
 - boreholes



Geoscience Portal redevelopment

- new Geoscience Portal
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 - geological maps



Geoscience Portal redevelopment

- new Geoscience Portal
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 - boreholes
 - geological maps
 - geophysical images and data
 - topography & infrastructure
 - restricted access areas, and more...



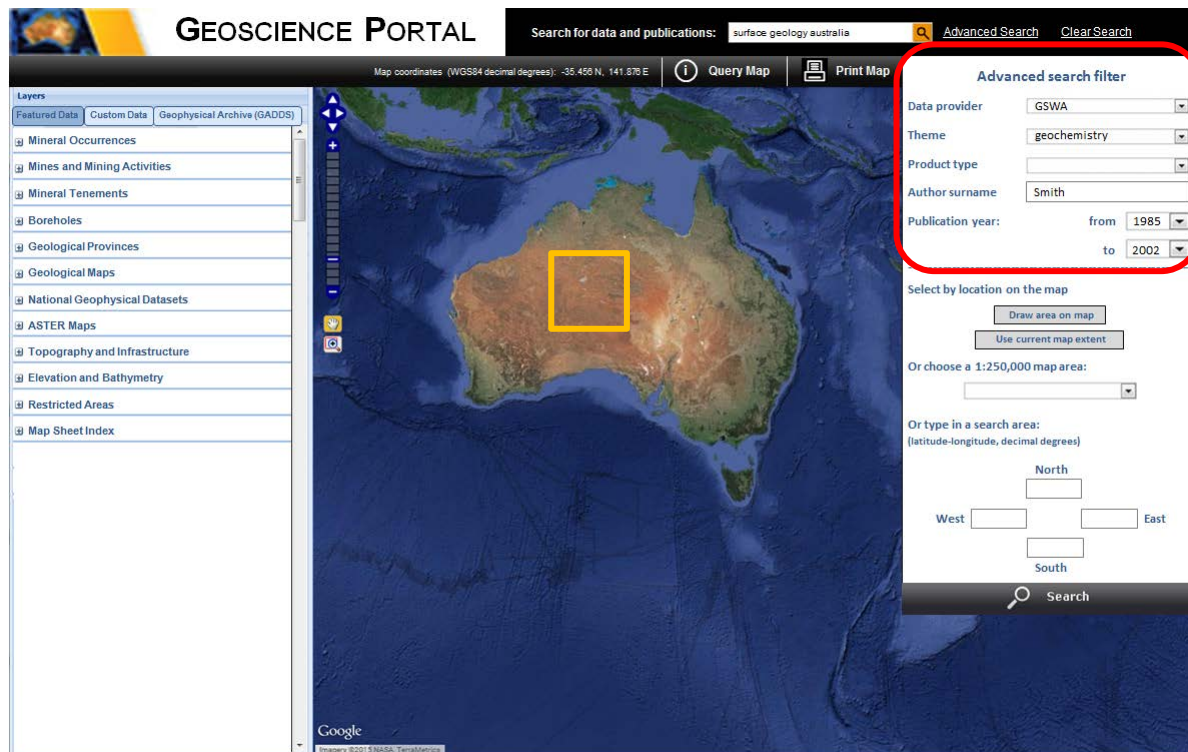
Geoscience Portal redevelopment

- new Geoscience Portal
- featured web services for mineral explorers
 - mines and mineral occurrences
 - mineral tenements
 - boreholes
 - geological maps
 - geophysical images and data
 - topography & infrastructure
 - restricted access areas, and more...
- sourced from all Australian geological surveys
- query and download data layers



Geoscience Portal redevelopment

- Multi-agency data discovery
- search data and publication catalogs from all State, Territory and Commonwealth geological surveys



Geoscience Portal redevelopment

- Multi-agency data discovery
- search data and publication catalogs from all State, Territory and Commonwealth geological surveys
- download data and publications via links to the geological surveys' data repositories

The screenshot displays the Geoscience Portal interface. At the top, the header reads "GEOSCIENCE PORTAL" with a search bar containing "surface geology australia". Below the header, a map of Australia is visible with coordinates (WGS84 decimal degrees): -35.496 N, 141.576 E. A sidebar on the left shows "Layers" with options like "Featured Data", "Custom Data", and "Geophysical Archive (GADDOS)". The main content area displays "Search Results" for the criteria "surface geology australia", showing 50 of 121,646 results. A red circle highlights the "Info and download" link for the "Surface Geology of Australia data package 2012 edition". A detailed view of this package is shown on the right, including its source (Geological Survey of Western Australia), abstract, and download links. The package is a 1:2.5M scale geology of Australia data documents the distribution and age of major stratigraphic, tectonic and medium to high-grade metamorphic rock units of western Australia. This edition contains the same spatial content as the previous edition, but its geological attribute data is more complete than the 2010 edition. The dataset was compiled to use at scales between 1:2.5 million and 1:5 million inclusive. Show full abstract

Surface Geology of Australia data package 2012 edition

DATA SOURCE
Geological Survey of Western Australia

ABSTRACT
The 1:2.5M scale geology of Australia data documents the distribution and age of major stratigraphic, tectonic and medium to high-grade metamorphic rock units of western Australia. This edition contains the same spatial content as the previous edition, but its geological attribute data is more complete than the 2010 edition. The dataset was compiled to use at scales between 1:2.5 million and 1:5 million inclusive. Show full abstract

DOWNLOADS
Download the file (100,122 MB)
Download the file (100,122 MB)
Download the file (100,122 MB)

RELATED LINKS
View data in MacConnect online
Metadata tool

This product is available for purchase for \$99.00
To purchase it, complete the order form (PDF 45 KB) and submit it to the Geoscience Australia Sales Centre via:
email: customers@ga.gov.au
fax: +61 2 6249 9960 or
phone: 1800 888 173 (within Australia)
+61 2 6249 9966 (outside Australia)
Please note that support hours are 9 am to 5 pm weekdays

PRODUCT TYPE/SUB TYPE
dataset - GIS Dataset - National

CONSTRAINTS
License: Creative Commons Attribution 3.0 Australia License

IP OWNER
Geological Survey of Western Australia

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WEB SERVICES
[Web Map Service](#)
[Web Feature Service \(GML/GeoJSON\)](#)
[Web Feature Service \(GeoJSON\)](#)

Geoscience Portal redevelopment

- Multi-agency data discovery
- search data and publication catalogs from all State, Territory and Commonwealth geological surveys
- download data and publications via links to the geological surveys' data repositories

The screenshot displays the Geoscience Portal interface. At the top, there is a search bar with the text 'surface geology australia' and buttons for 'Advanced Search' and 'Clear Search'. Below the search bar, a map of Australia is visible with coordinates (WGS84 decimal degrees): -35.458 N, 141.876 E. The left sidebar shows a 'Layers' panel with 'Featured Data', 'Custom Data', and 'Geophysical Archive (GADDOS)'. The main content area displays search results for 'Surface geology of Australia data package 2012 edition'. The results list includes 'GA', 'Web service', 'Show extent', and 'Info and download' links. A red circle highlights the 'Info and download' link. Below the search results, there is a section for 'Surface geology of Australia 1:1M scale (2012 edition)' and '1:2 500 000 Geological Map of Western Australia 1998'. The right sidebar shows a 'DATA AND SOFTWARE CENTRE' section with a list of data sources and links to download data.

Geoscience Portal redevelopment

- Multi-agency data discovery
 - search data and publication catalogs from all State, Territory and Commonwealth geological surveys
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[illegible]

Geoscience Portal redevelopment

- **GADDS**

- a refit into the new Geoscience Portal
- ability to download recently acquired AEM data
- ability to filter surveys by year

The screenshot displays the Geoscience Portal interface. At the top, the 'GEOSCIENCE PORTAL' logo is visible alongside a search bar containing 'surface geology australia'. Navigation tabs include 'Featured Data', 'Custom Data', and 'Geophysical Archive (GADDS)'. The main map area shows Australia with a grid overlay. A sidebar on the left provides information about the GADDS system and instructions for downloading data. A modal window titled 'Geophysical Archive Data Delivery System (GADDS)' is open, allowing users to select data type (Vector or Raster), theme (Elevation, Magnetics, Radiometrics, or Gravity), and survey year (from/to). The 'National datasets only' checkbox is checked. A 'Next' button is at the bottom right of the modal.

Geoscience Portal

Search for data and publications: [Advanced Search](#) [Clear Search](#)

Map coordinates (WGS84 decimal degrees): -35.498 N, 141.878 E [Query Map](#) [Print Map](#) [Reset Map](#) [Permanent Link](#) [Help](#)

Geophysical Archive Data Delivery System (GADDS)

This system provides magnetic, radiometric, gravity and digital elevation data from Australian National, State and Territory Government geophysical data archives.

To display national geophysical images on the map, choose layers from the list of "Featured Data" layers.

INSTRUCTIONS TO DOWNLOAD GEOPHYSICAL DATA

STEP 1: Select an area of Australia to search

Either: [Click here to draw a search area on the map](#)

Or: Enter the extents of your search area in Latitude/Longitude decimal degrees (e.g. 137.85)

NORTH
-28.6

WEST 127.35 **EAST** 136.8

SOUTH
-36.0

Or: Choose a 1:250,000 scale map sheet from the list below.
[Choose Map Name/Number](#)

STEP 2: Click here [Proceed to download](#)

[Click here](#) for more detailed GADDS help.

Geophysical Archive Data Delivery System (GADDS)

Select data type and theme

Data type: ☒ Vector - line data ☐ Raster - grid data

Theme: ☒ Elevation ☐ Magnetics ☐ Radiometrics ☐ Gravity

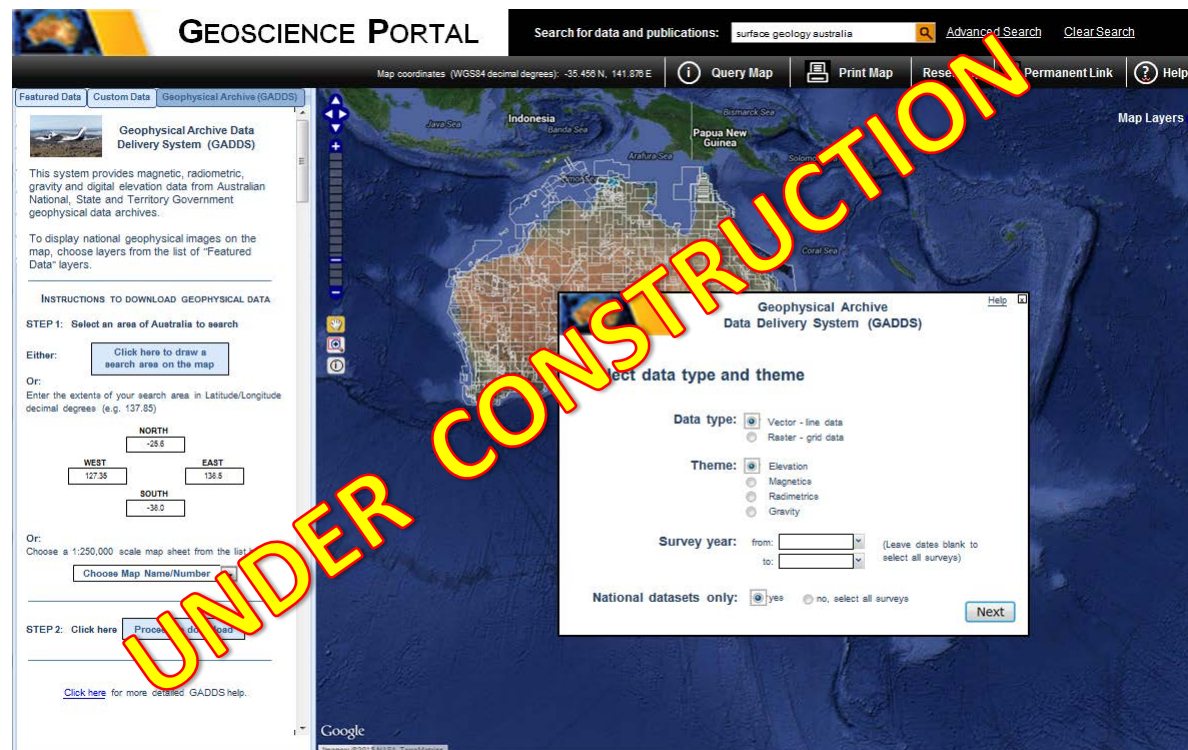
Survey year: from: to: (Leave dates blank to select all surveys)

National datasets only: ☒ yes ☐ no, select all surveys [Next](#)

Geoscience Portal redevelopment

- **GADDS**

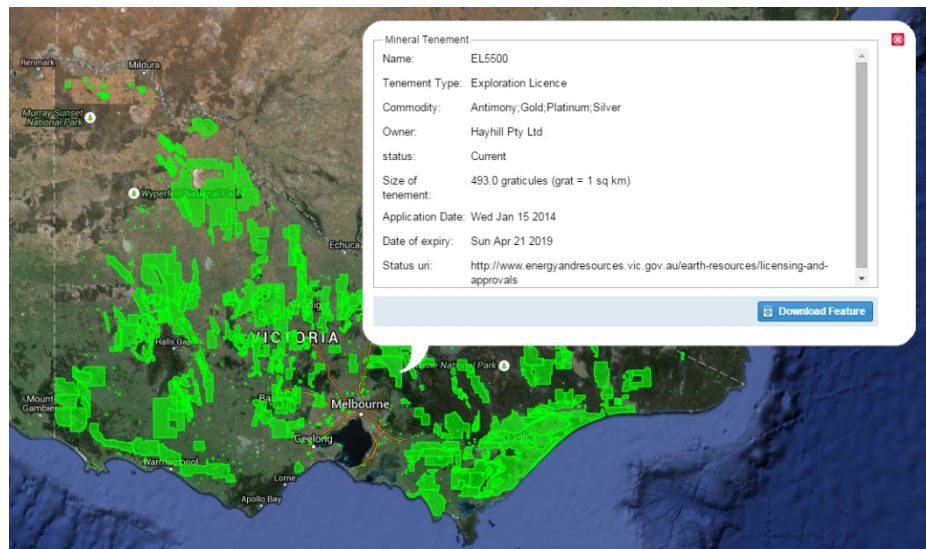
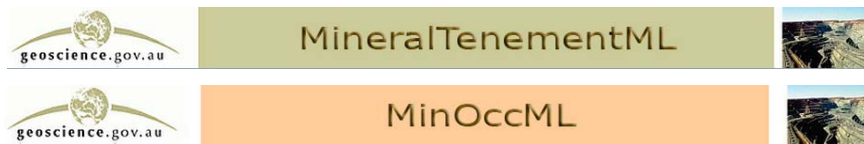
- a refit into the new Geoscience Portal
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Geoscience Data Standards

Data Transfer Standards

- In Australia, GGIC recently published WFS/WMS data transfer standards for mineral tenements and mineral occurrences
 - currently being tested to deliver data in the AuScope Portal
 - best practice use of these standards is still being refined in the Australian geological surveys
 - the way of the future for delivery of mineral tenement, mineral occurrence, mine, and borehole data



Geoscience Data Standards

Data Transfer Standards

- Internationally, Geoscience Australia currently chairs the GeoSciML Standards Working Group, and the OneGeology Executive Board
 - considerable Australian influence on global standard data structures, and in the promotion of best practice in geoscience data delivery
 - there is still some way to go to get global data standards implemented as normal practice in all of the Geological Survey agencies



Conclusions

- Geoscience Australia (and all the other Australian Geological Surveys) are moving towards publishing all of their fundamental geoscience data as standard web services
- GA publishes over 100 web services of geological, geographic, and other spatial data
- Virtually all GIS applications (both free and costly) can now consume web services
 - at least WMS and simple WFS services
- The redeveloped Geoscience Portal will greatly enhance the ability of the geological community to find, analyse, and download government geoscience data





Australian Government
Geoscience Australia



Minerals @GA: Impacts



Richard.Blewett@ga.gov.au

Mineral Systems Branch Head

Impact of GA pre-competitive work: operating mine

In the 1960s and early 70s GA collected magnetics, gravity and geochemistry data across the remote Stuart Shelf of South Australia

In 1975–6 Western Mining Corporation discovered Olympic Dam by using the precompetitive data, resulting in a \$1T in ground value of U, Cu, Au and Rare Earths

Stuart Shelf



Olympic Dam plant



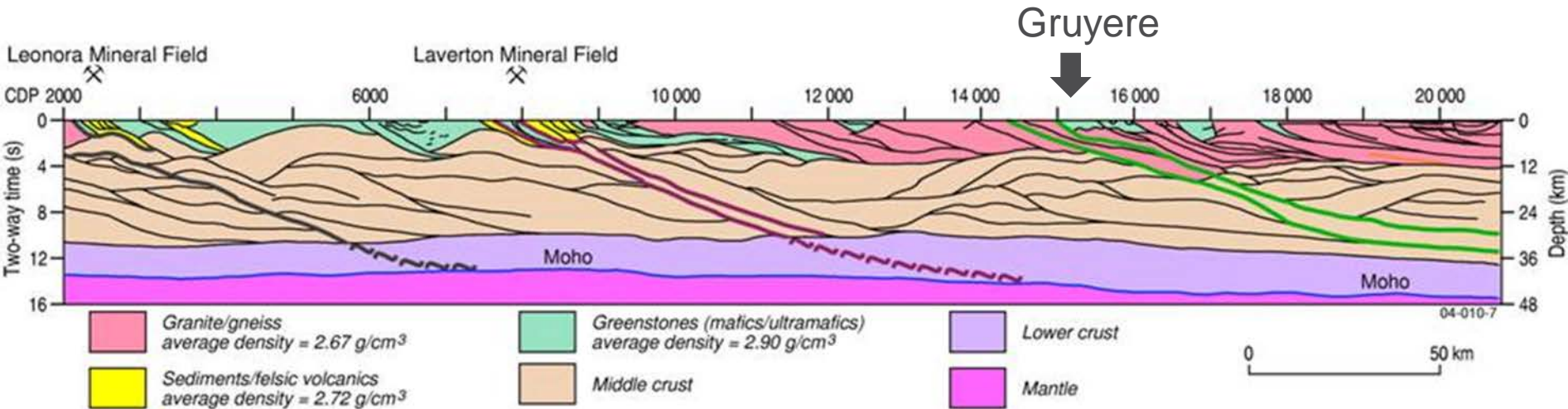
Roxby Downs



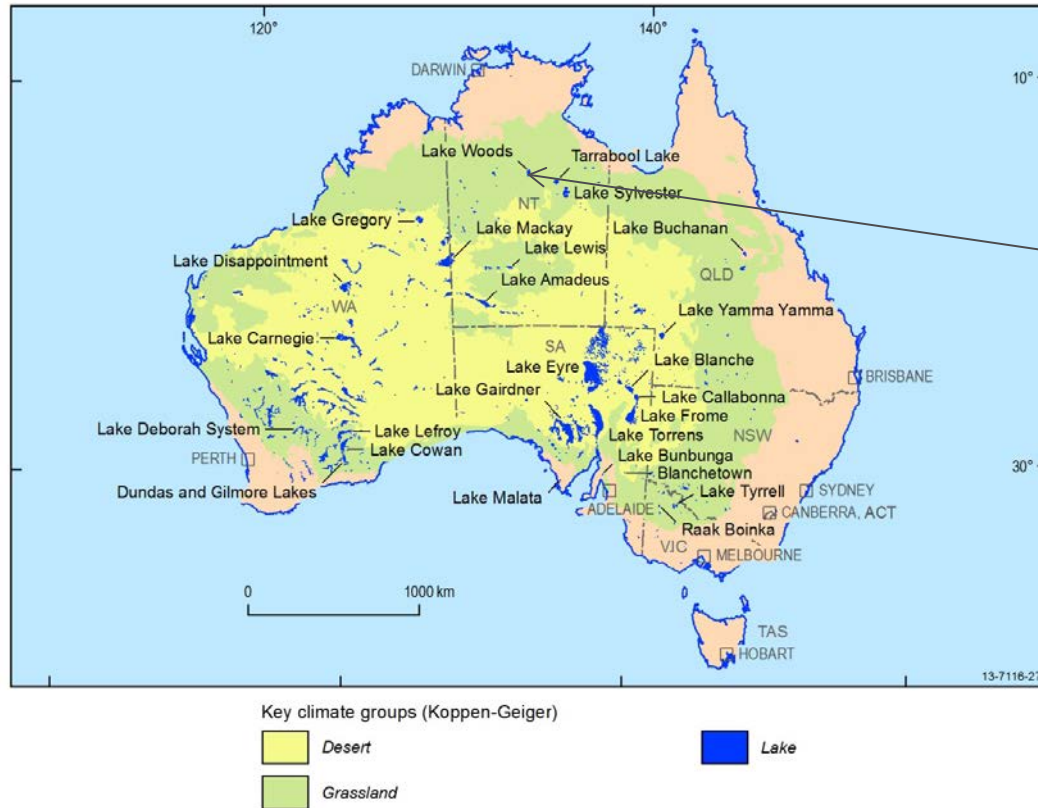
Impact of GA pre-competitive work: new discovery

In 2001 GA collected seismic data (below) and predicted this belt as prospective for new world-class gold deposits

In 2014 Gold Road Resources discovered the Gruyere gold deposit in the Yamarna Belt, which is a 5+ Million oz greenfields discovery in WA's Eastern Goldfields



Impact of GA pre-competitive work: new provinces



In 2013, GA delivered a national assessment of salt lake potential for K, Li, U, B.

Lake Woods (NT) was one region predicted as being prospective for potash (K)

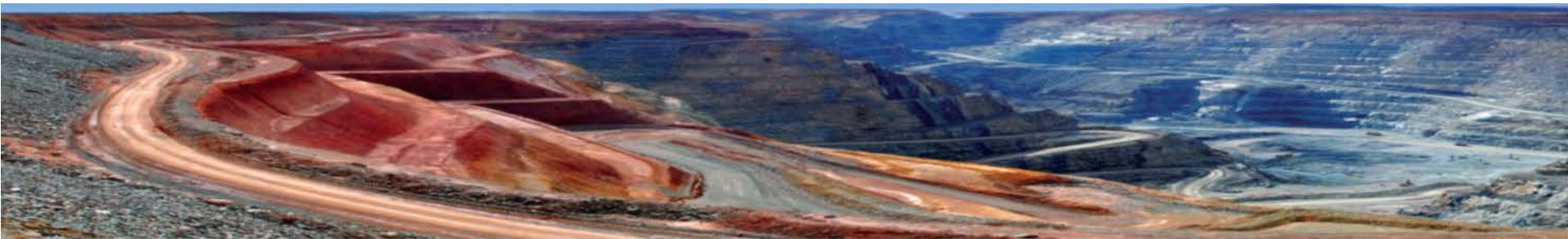
In 2014–15 Frontline Resources took up potash exploration tenements on the basis of these predictions and data

Two pertinent quotes

There are two basic ways a nation can derive more wealth from mining:

- 1) *tax existing mines; and/or*
- 2) *discover new mines*

Alan Trench MiningNewsnet.com 2015



Mineral industry users of geoscience data are almost unanimous in their view that government geoscience increases exploration efficiency and effectiveness ...

J.M. Duke, Prospectors and Developers Association of Canada, 2010