Australian Government
Geoscience Australia

Exploring for the Future
minerals | energy | groundwater

Exploring for the Future: realising the resource potential of the NW Mineral Province (and beyond)

Dr Richard Blewett – Branch Head Mineral Systems



- **WHAT** Major $100.5M investment in pre-competitive geoscience from the Commonwealth Government (2016–2020).
- **WHY** Build a resource prospectus of mineral, energy, and groundwater to support northern Australia's future economic prosperity.
- **WHO** Geoscience Australia in collaboration with State and Northern Territory government agencies, industry contractors and universities.
- **HOW** Through innovative and integrated new data and knowledge generation to understand our geological resources in under-explored regions.



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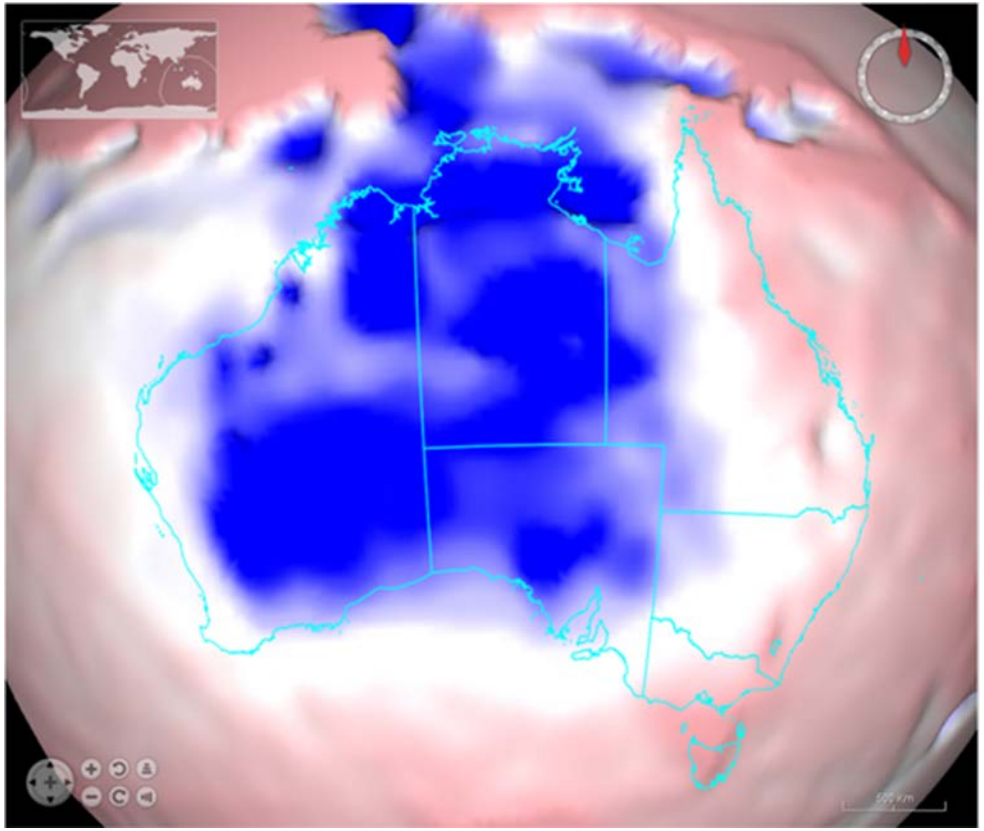
NW Minerals Province: it has deep roots



~160 km contour
of the lithosphere

Czarnota et al., 2016

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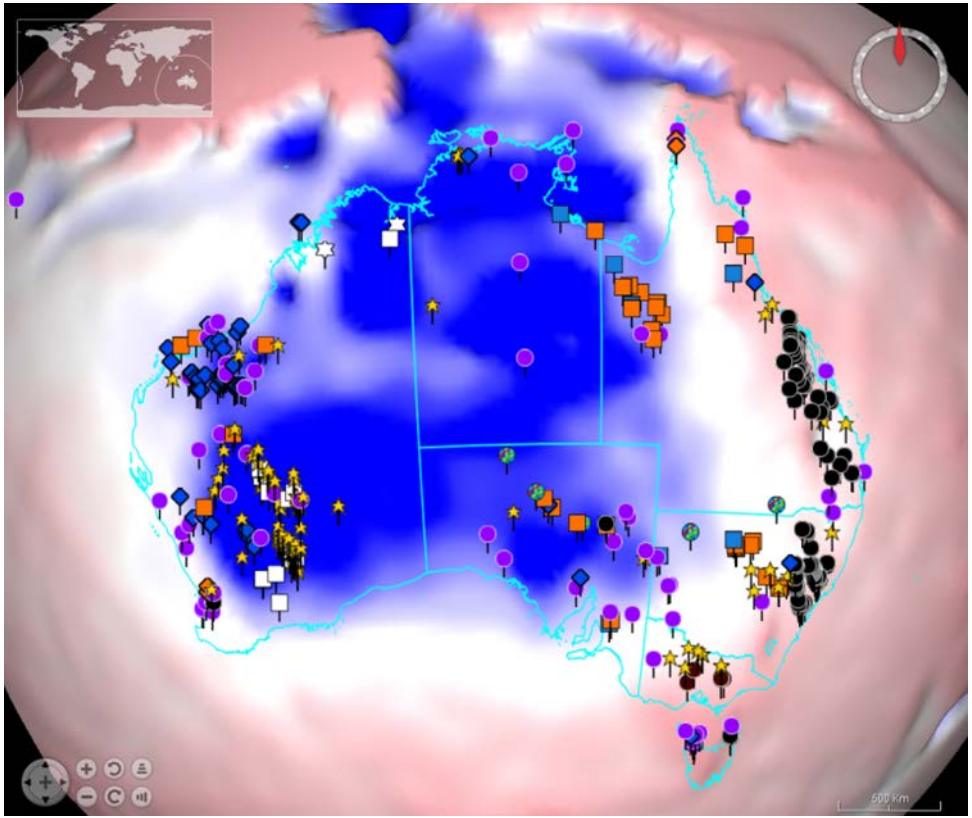
NW Minerals Province: it has deep roots



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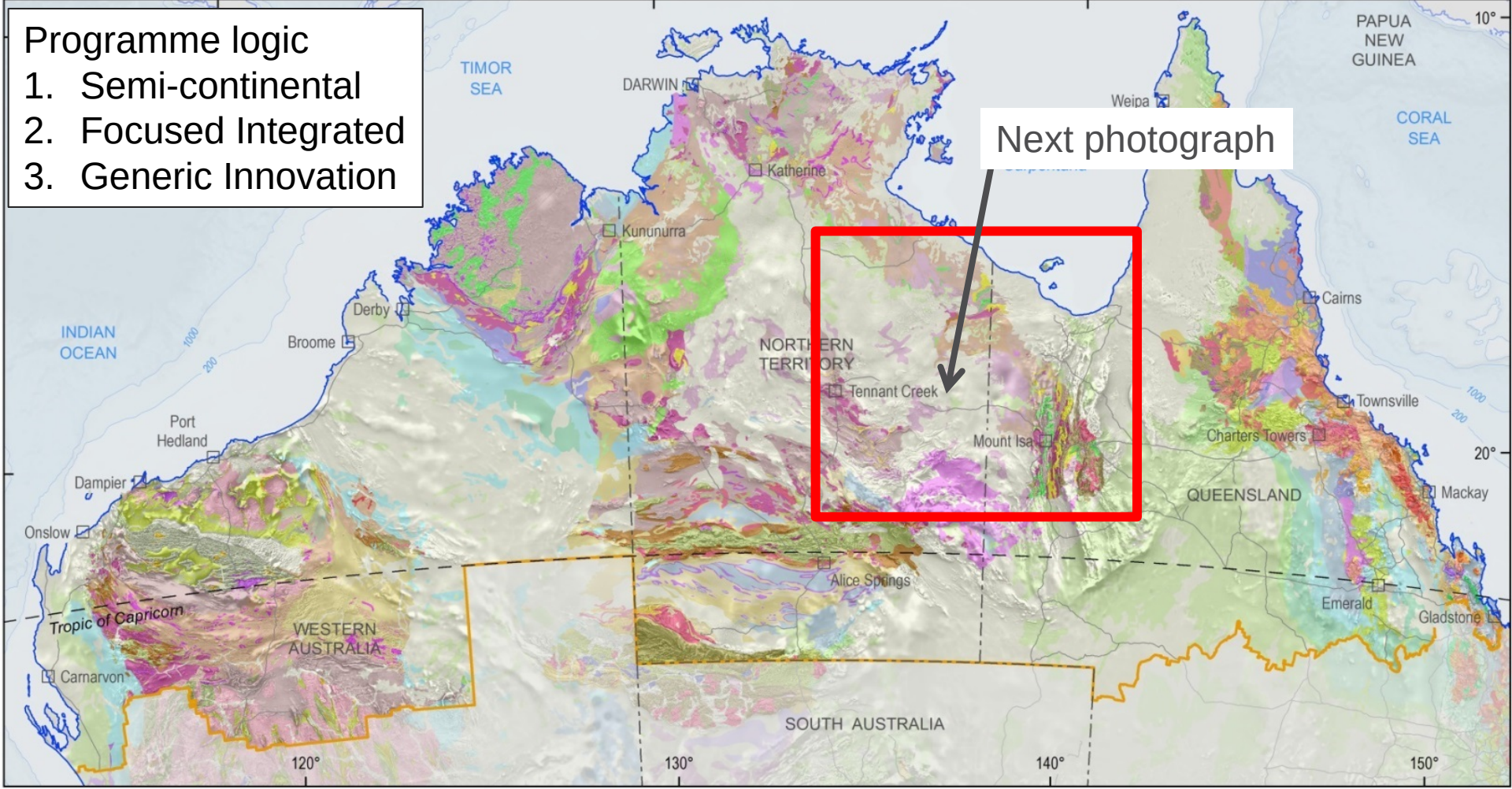

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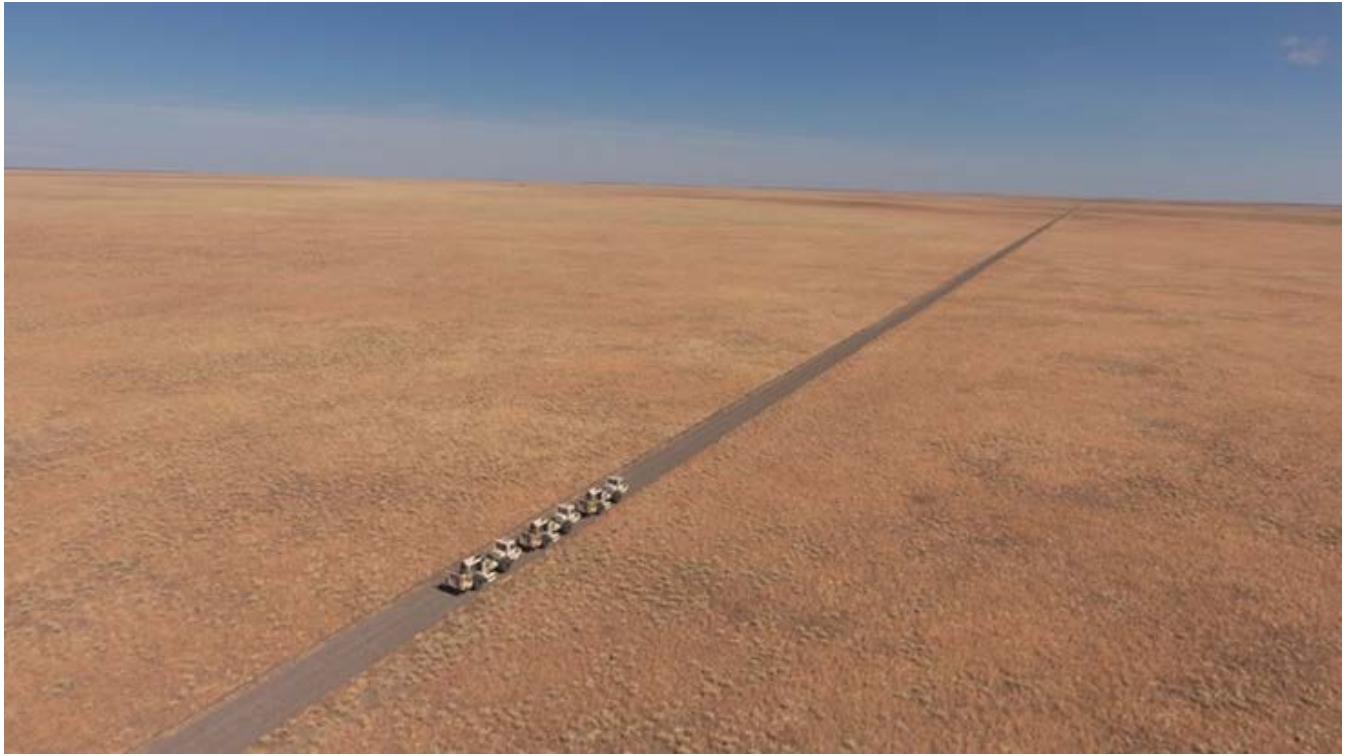
The great unknown

~75% of Australia



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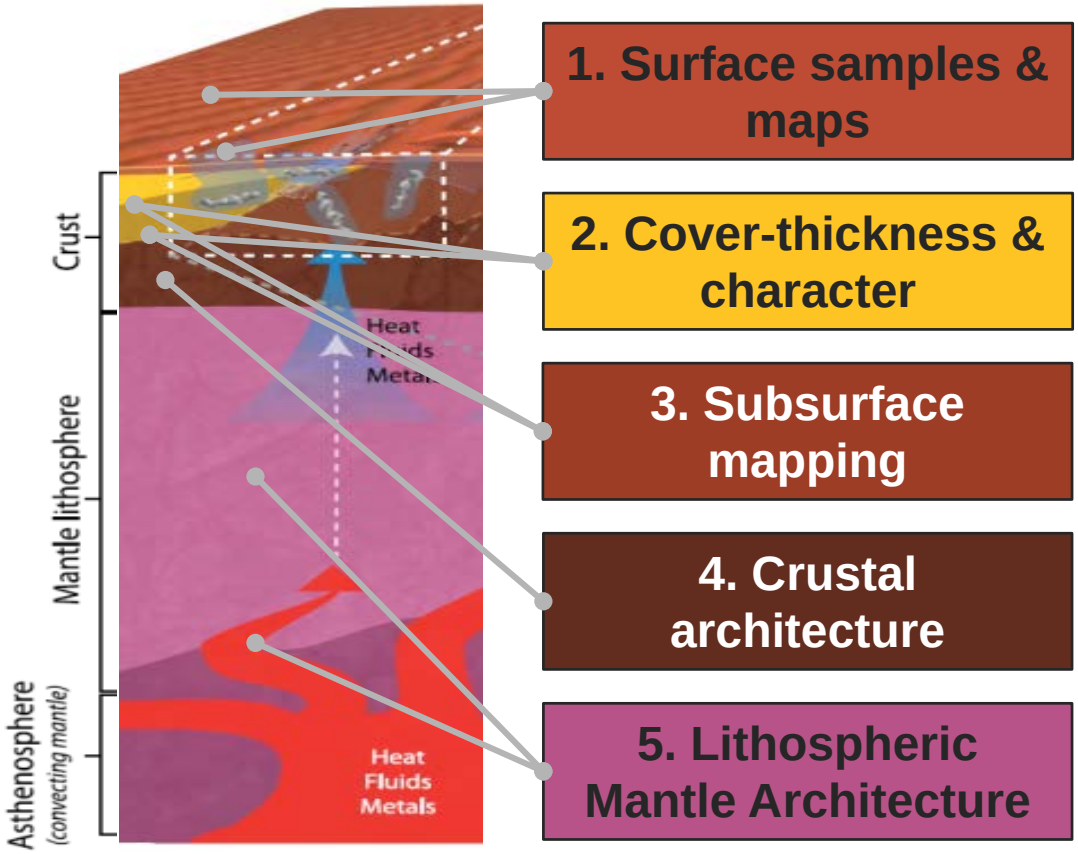
Mapping Australia together



1. Surface samples & maps
2. Cover-thickness & character
3. Subsurface mapping
4. Crustal architecture
5. Lithospheric Mantle Architecture

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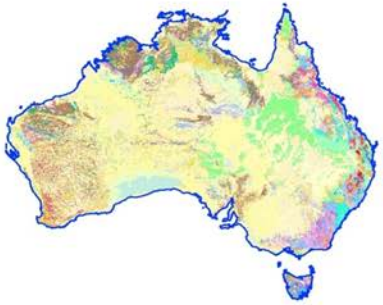
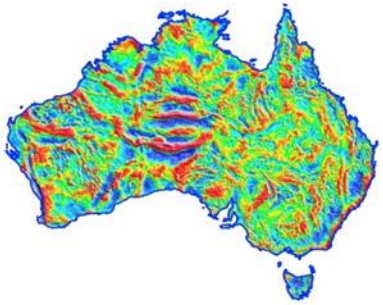
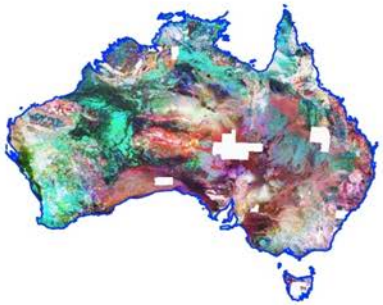
Building on the national datasets and databases



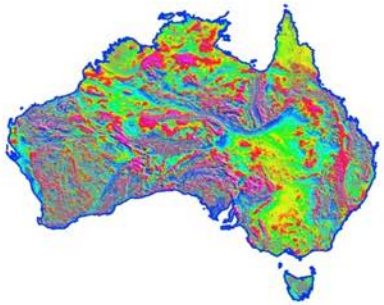
1:1M Surface Geology



Gravity

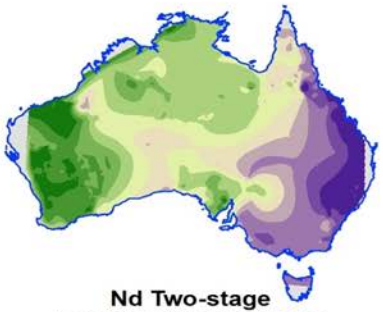


Radiometrics

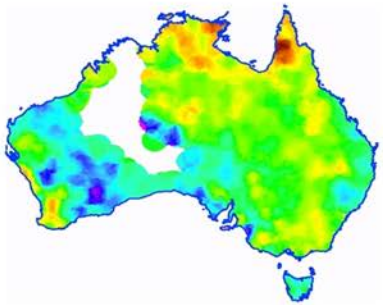


Magnetics

Onshore Seismic Lines



Nd Two-stage
Depleted Mantle Model



National Geochemical Survey

National MT

16-9908-8

Data from Geoscience Australia and State/NT geological surveys

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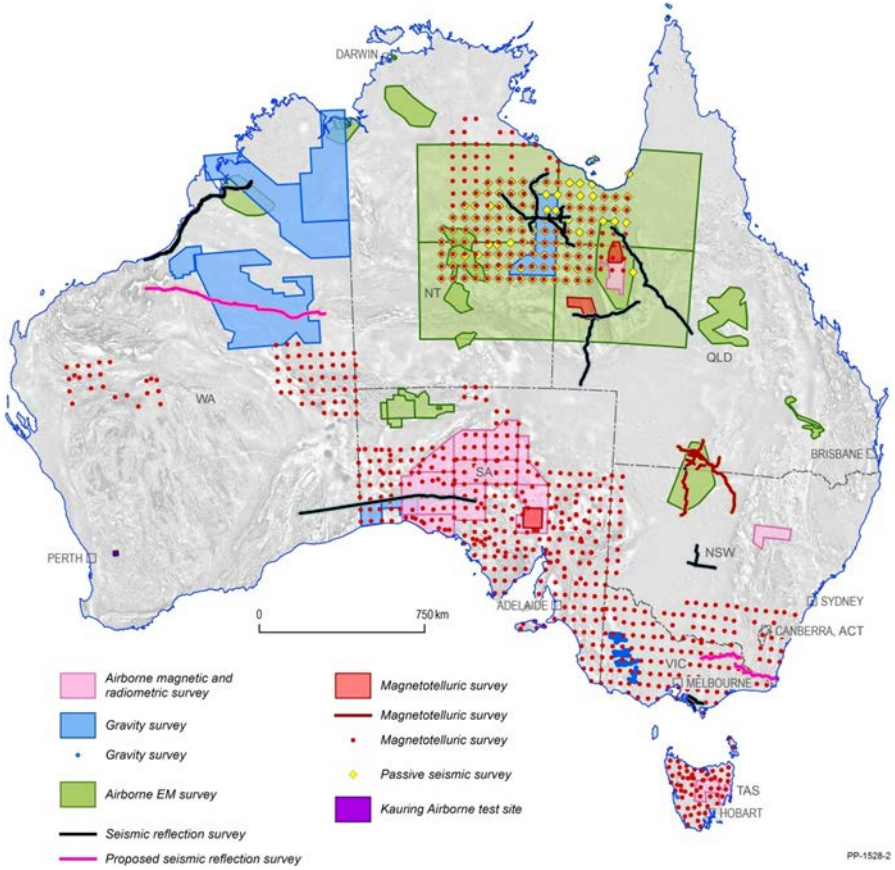
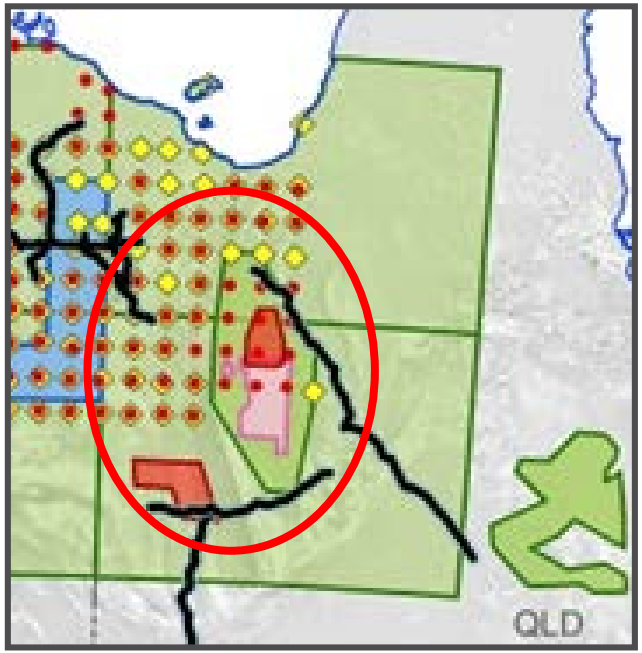
Building on the national datasets and databases

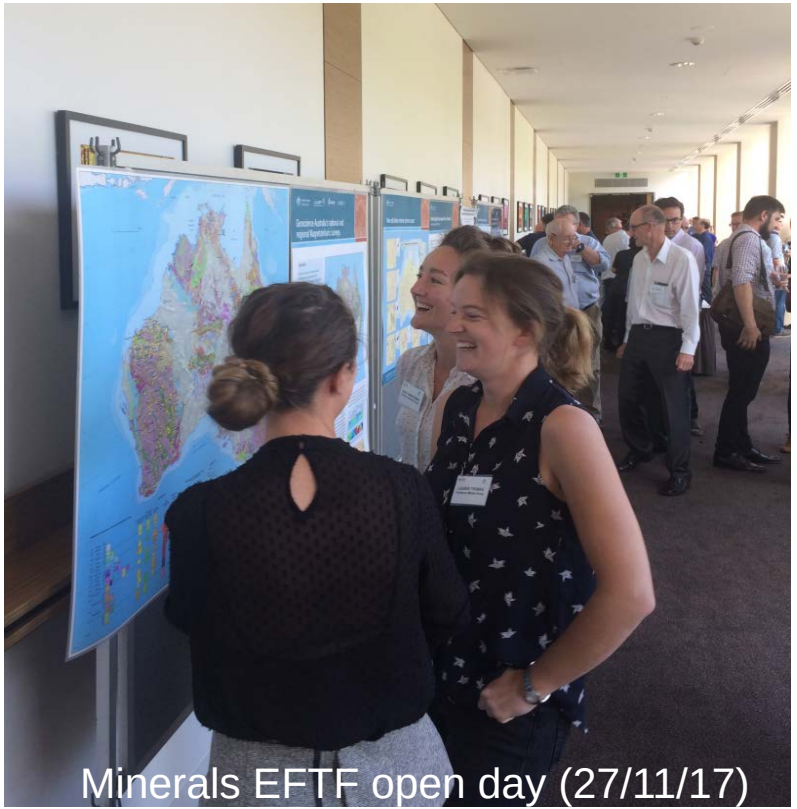




GA doing lots of work with GSQ in NW

Working with geol surveys, industry & academia

Basin-hosted minerals workshop (28/11/17)


Minerals EFTF open day (27/11/17)

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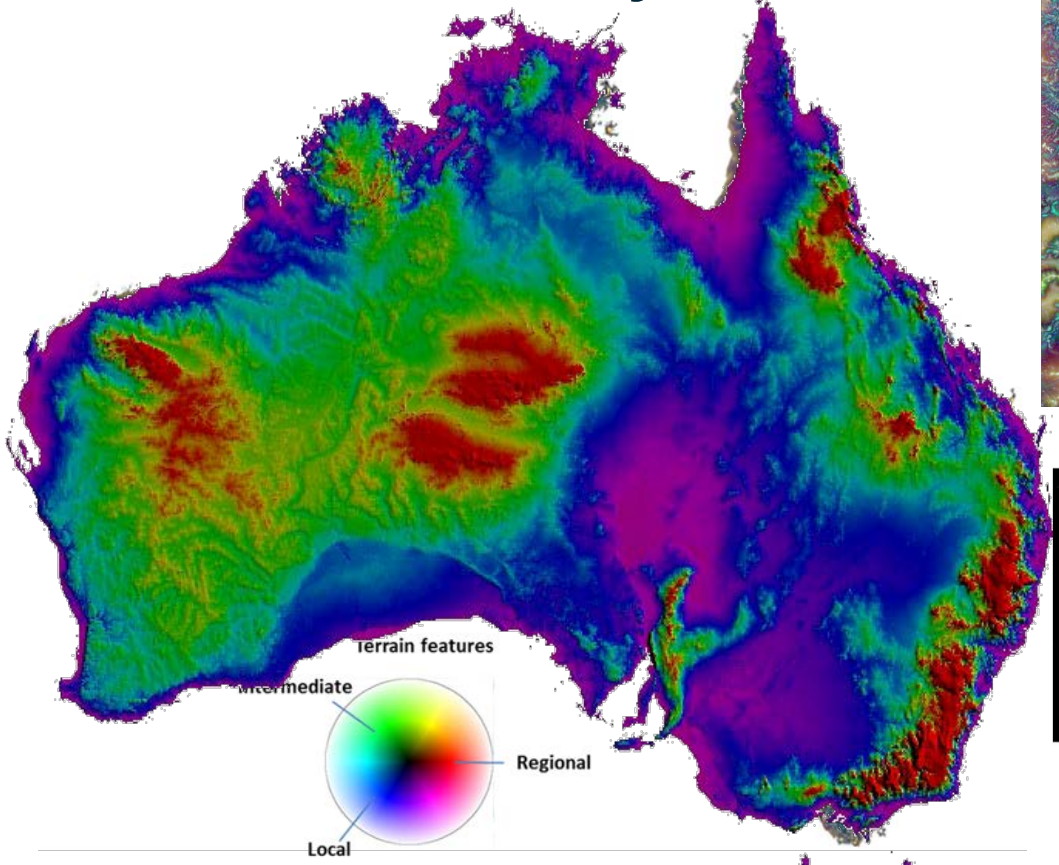
Working with people and protecting the environment

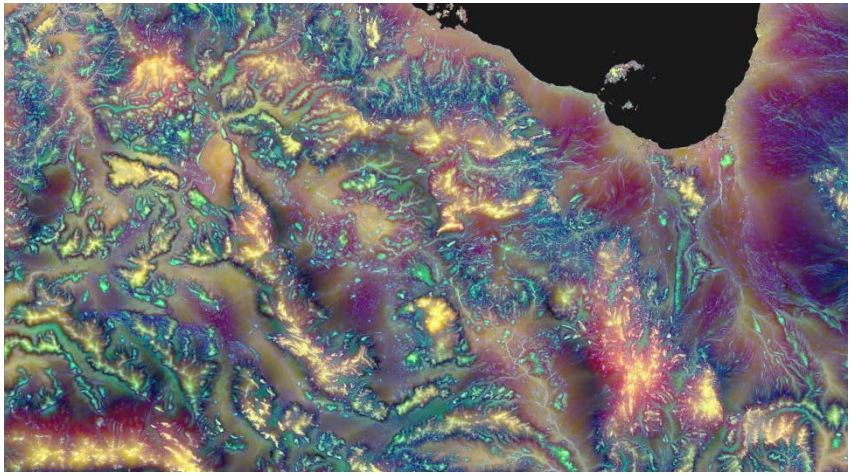
Courtesy Bruce Goleby

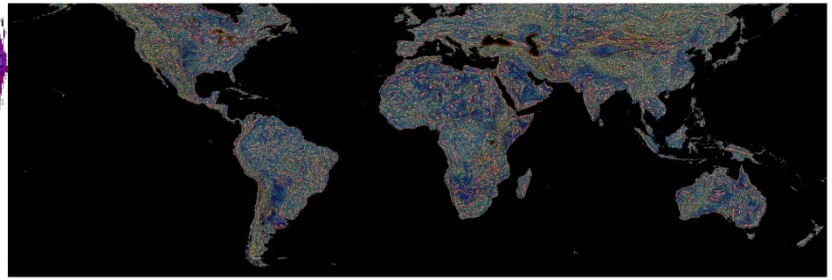
Courtesy Ian Roach

Semi-continental

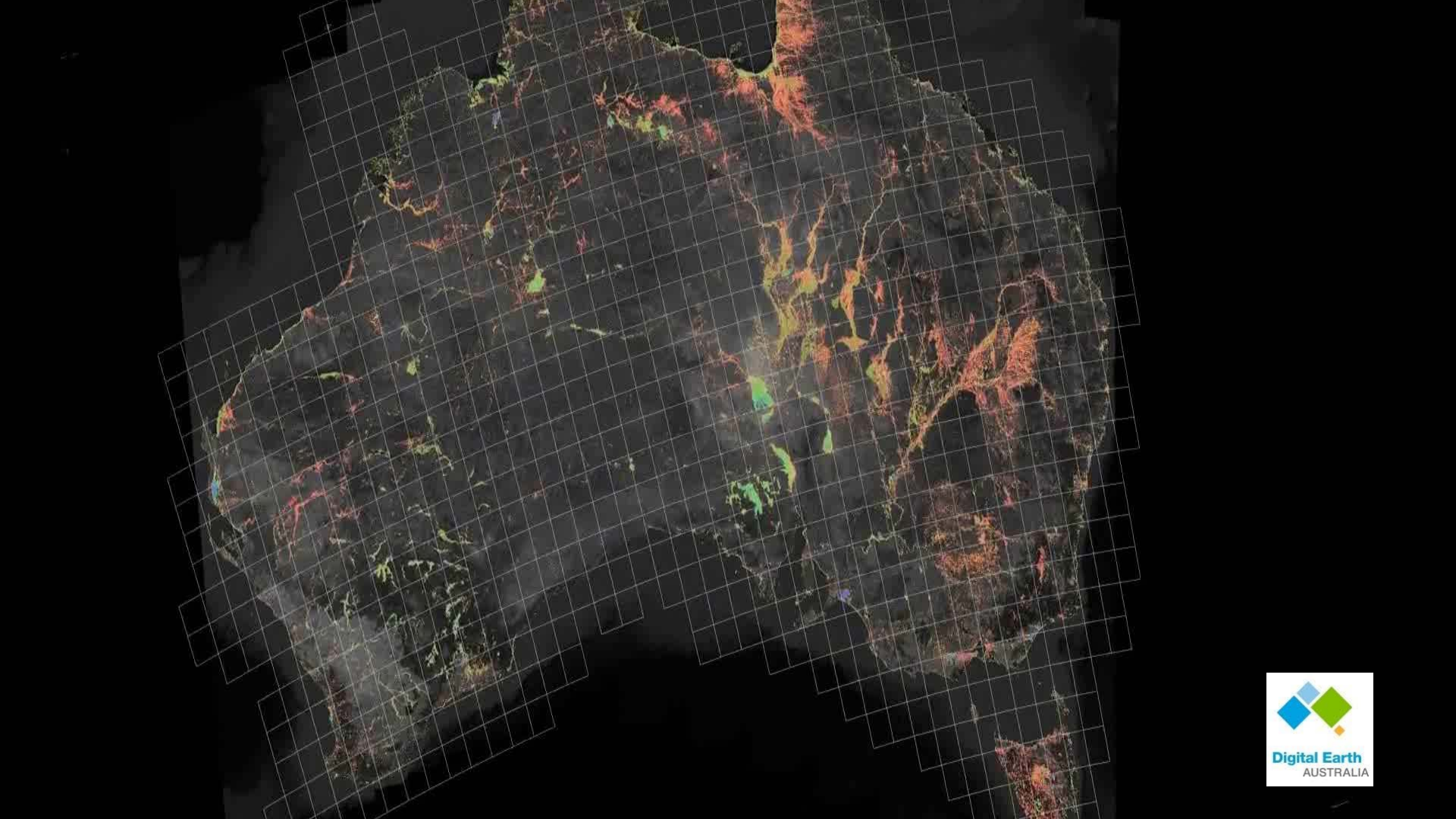
Novel terrain analysis



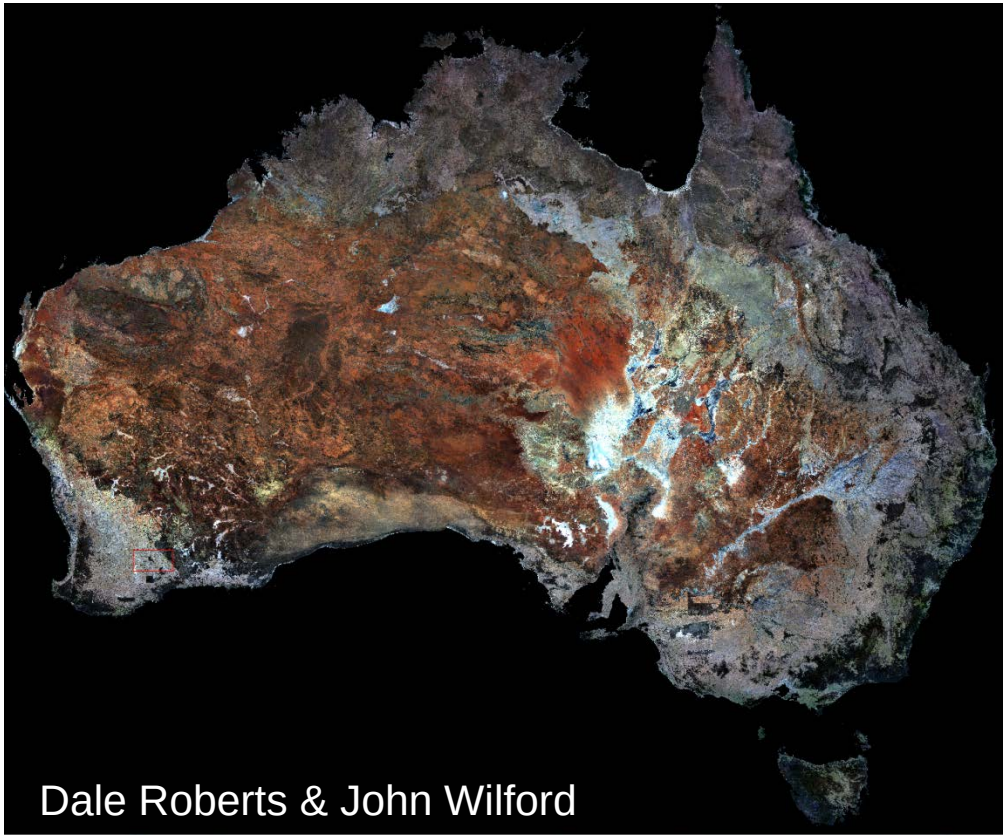


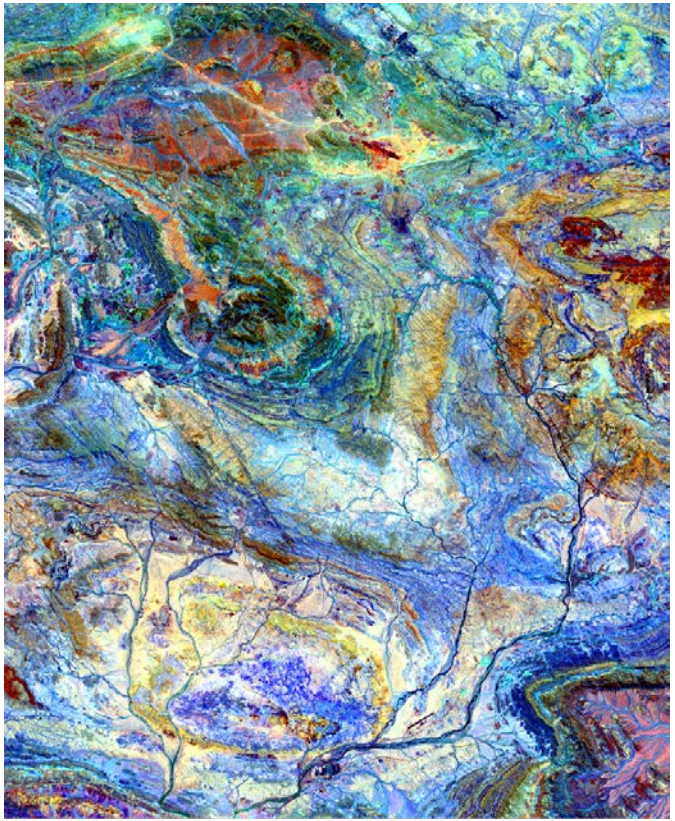


John Wilford & Sudipta Busak


Digital Earth
AUSTRALIA

Bare(st) Earth Australia and mineral mapping





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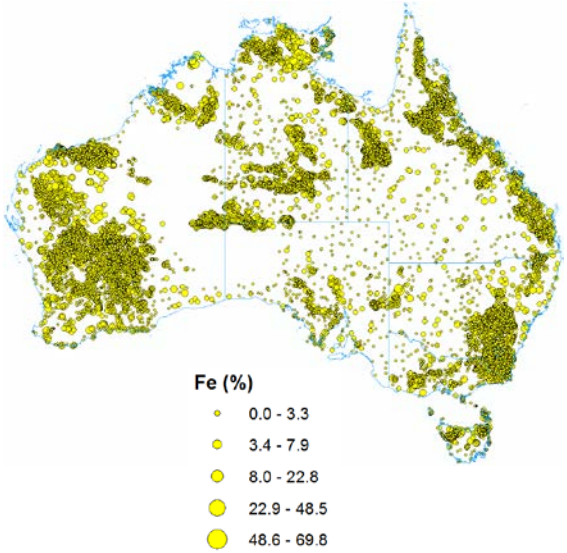
Mapping Australia: Fe surface model (RandomForest)

N = 32,800

r^2 .69

0.1 5 >10%

Database (Ozchem, NGSA) regolith and rock samples



All major elements being mapped

John Wilford

What is ‘cover’ what is regolith?

Chronostratigraphic

Cenozoic

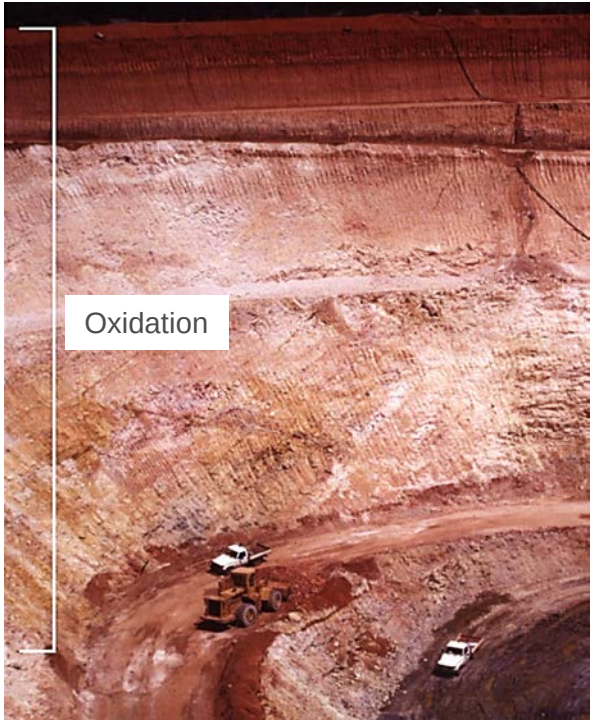
Mesozoic

Palaeozoic

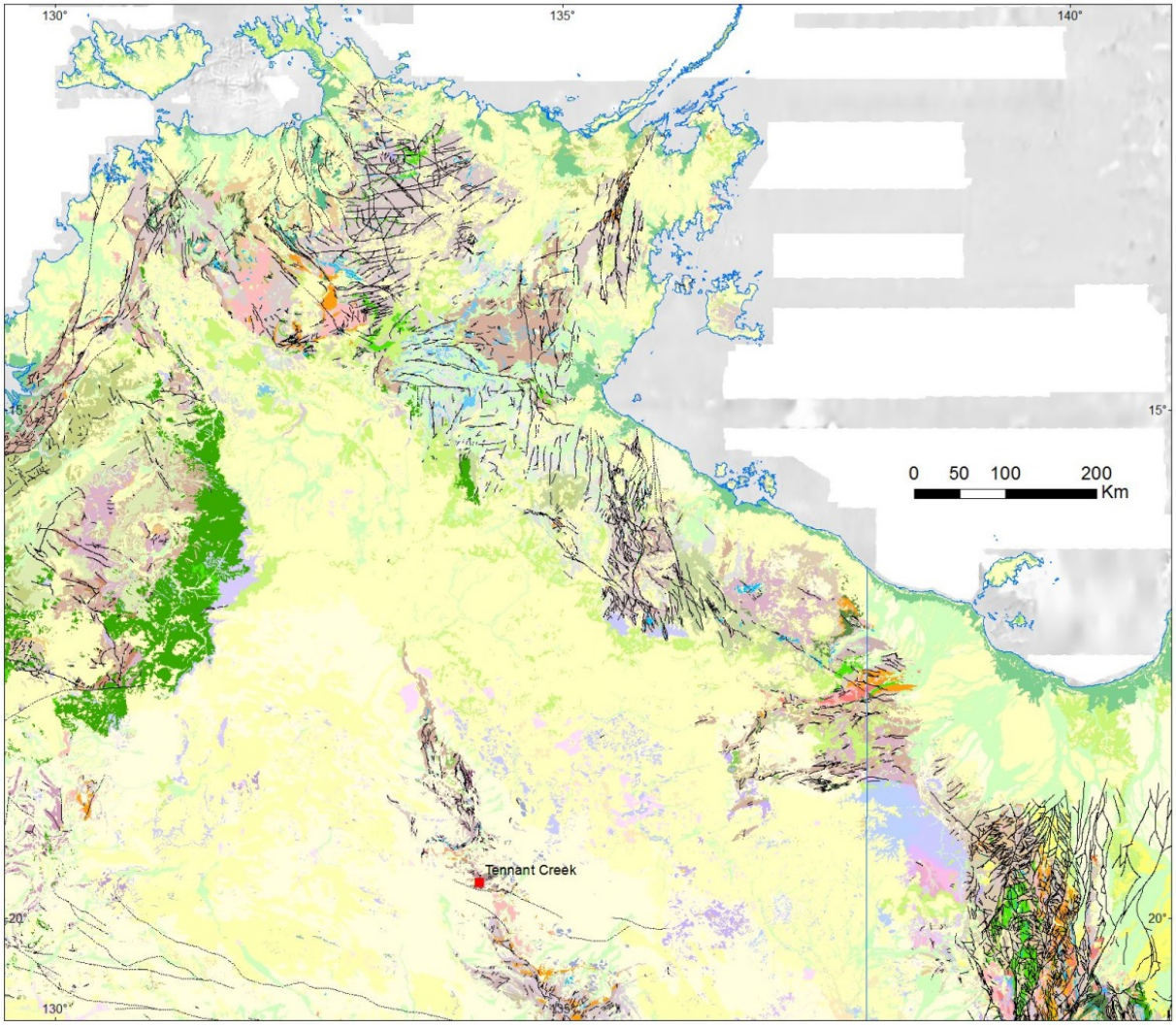
Proterozoic (Neoproterozic/ Meoproterozoic)

Palaeoproterozoic / Archaean

Depth of oxidation



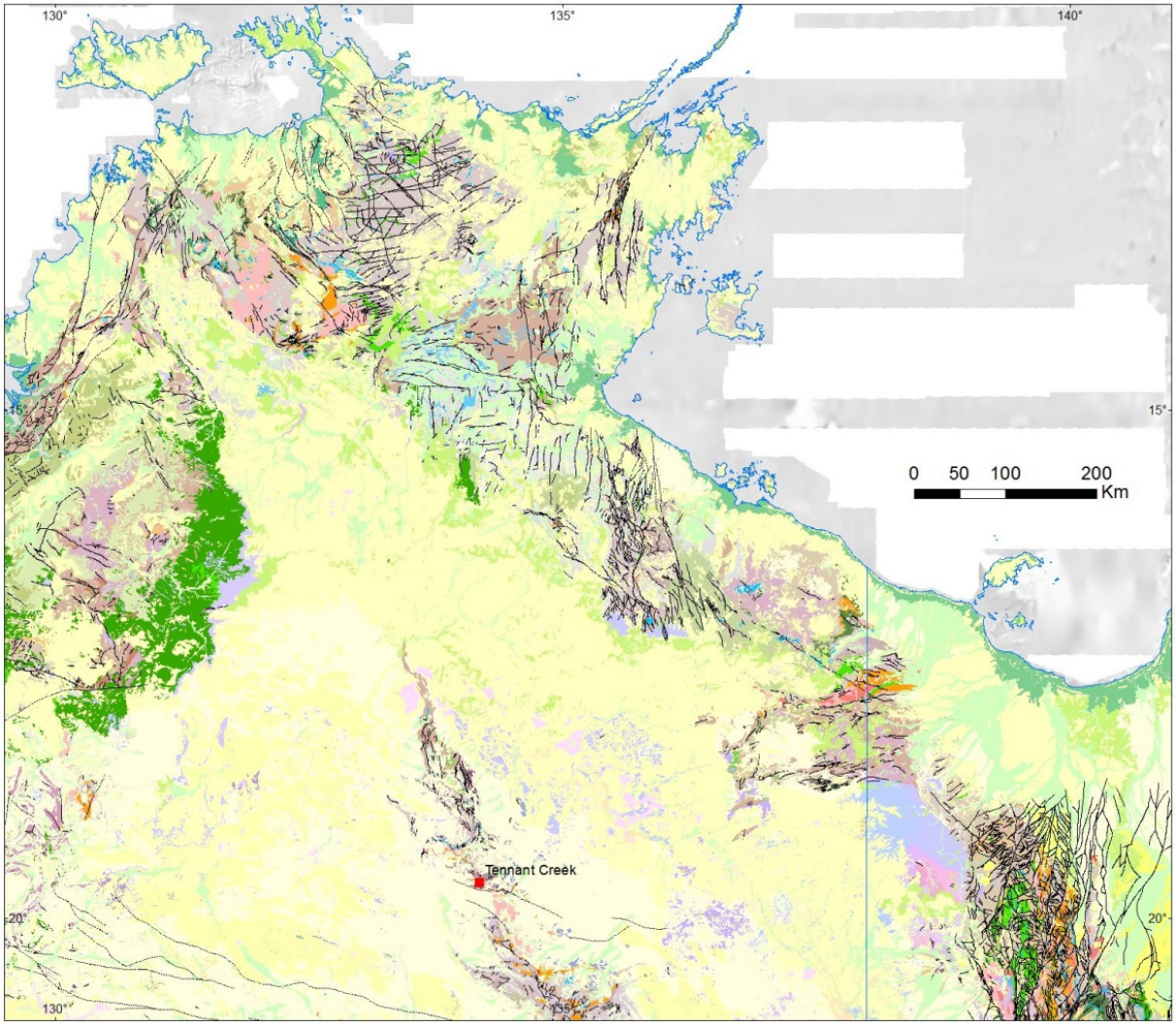
Source: Bronzewing open cut (WA). Ravi Anand



Towards 3D: Solid Geology by time – Surface Geology (2012)

Outcrop geology including Cenozoic

Alastair Stewart and Songfa Liu



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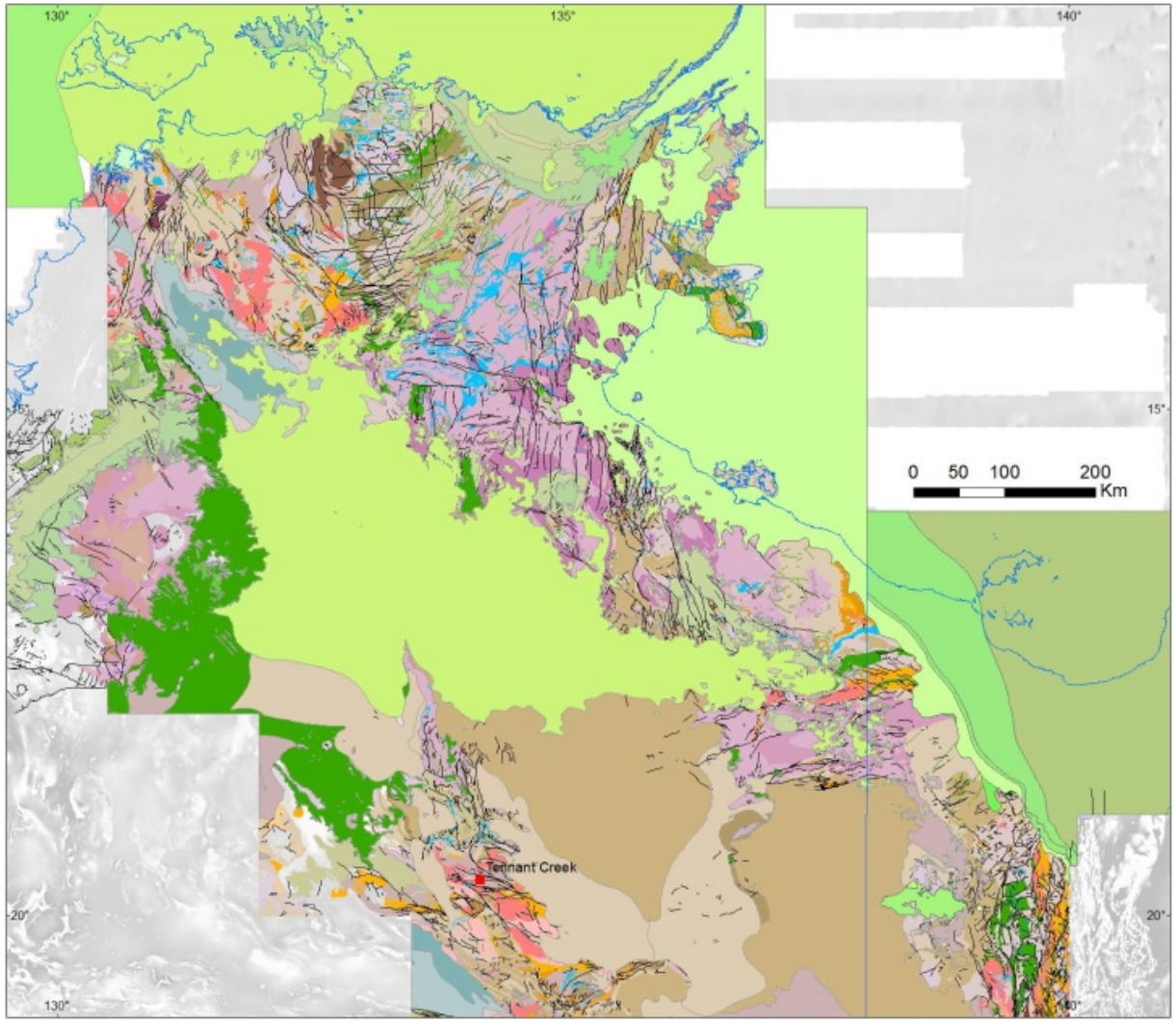
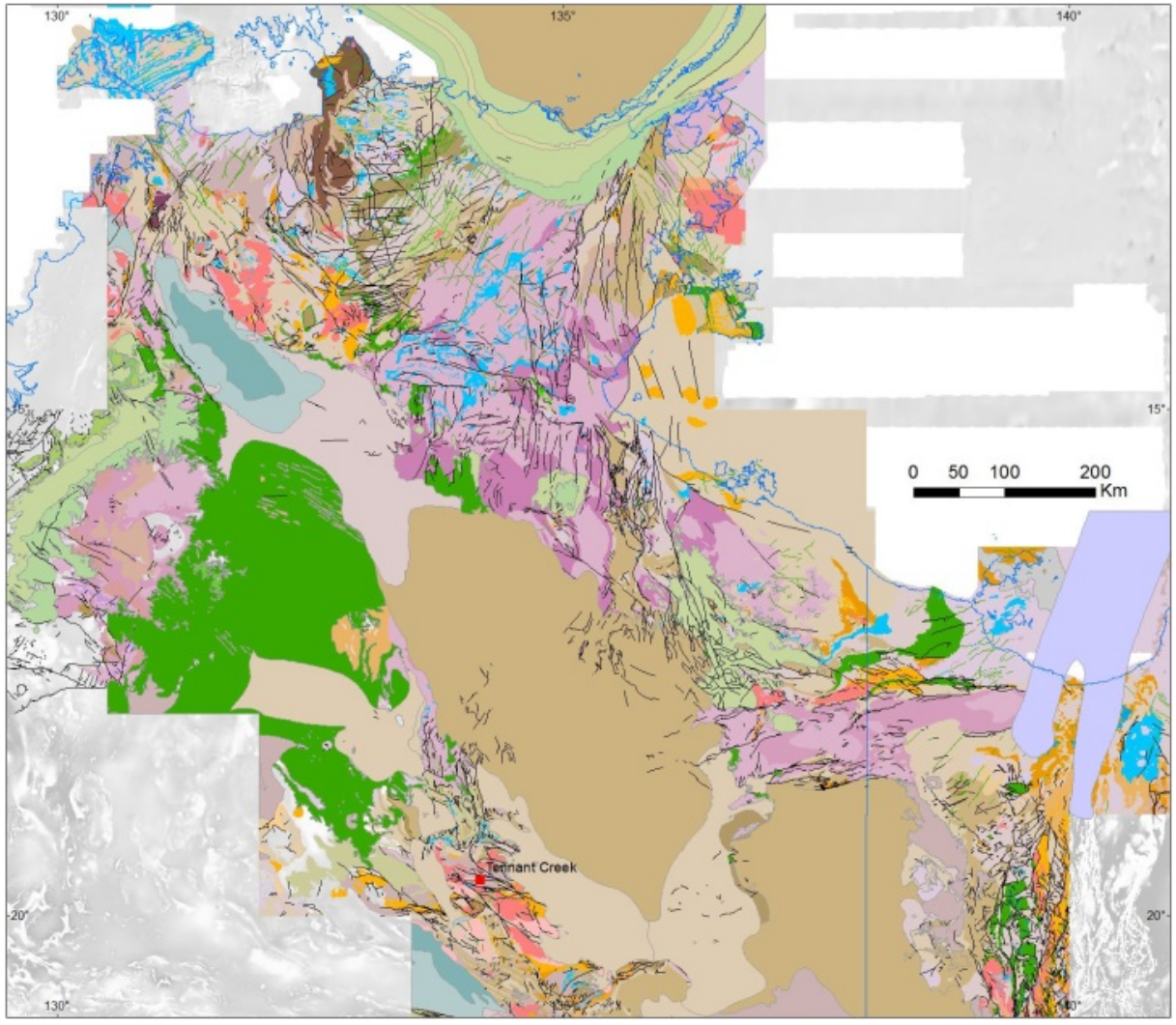


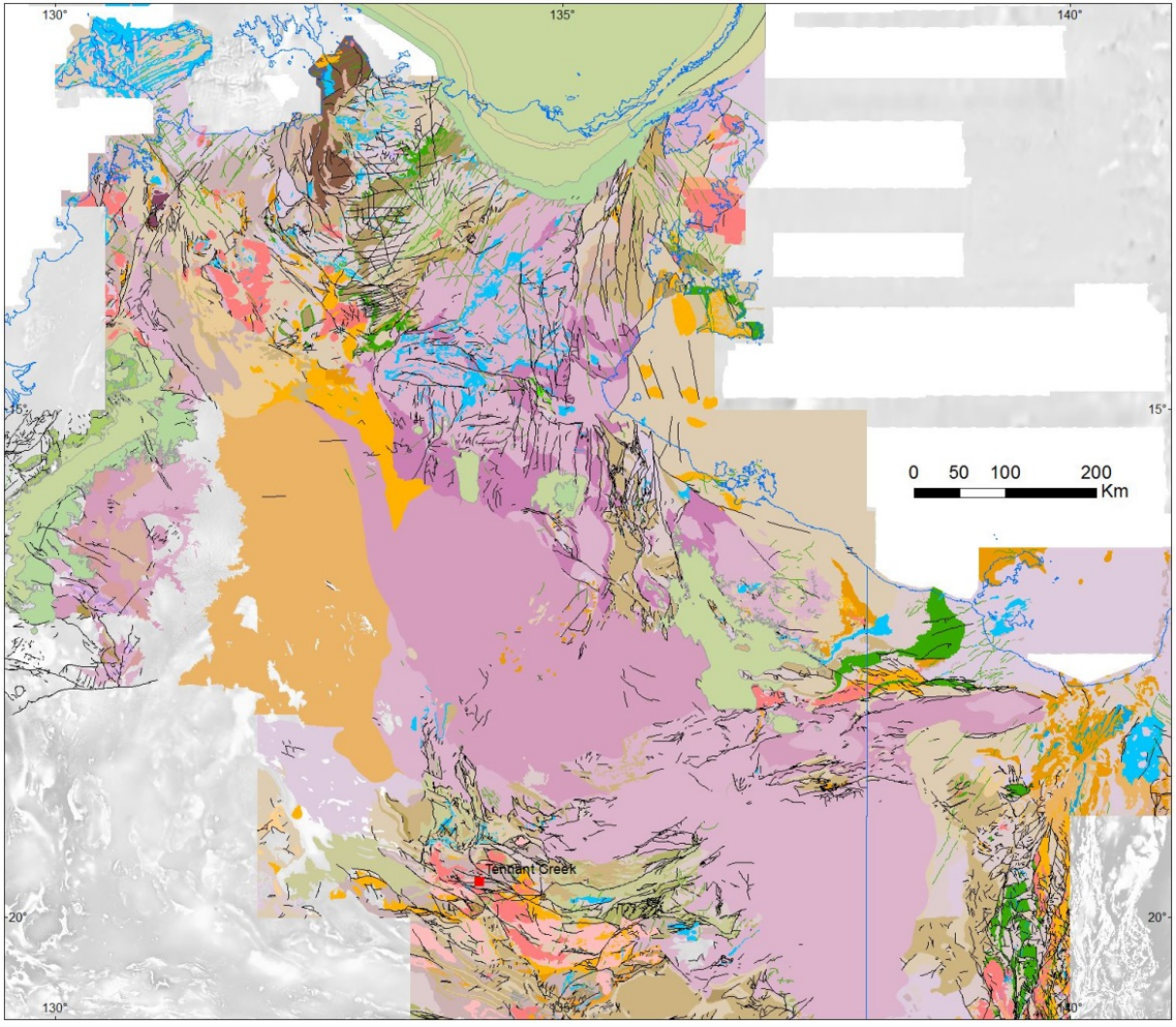
Towards 3D: Solid Geology by time – pre-Cenozoic over Magnetics

Alastair Stewart and Songfa Liu



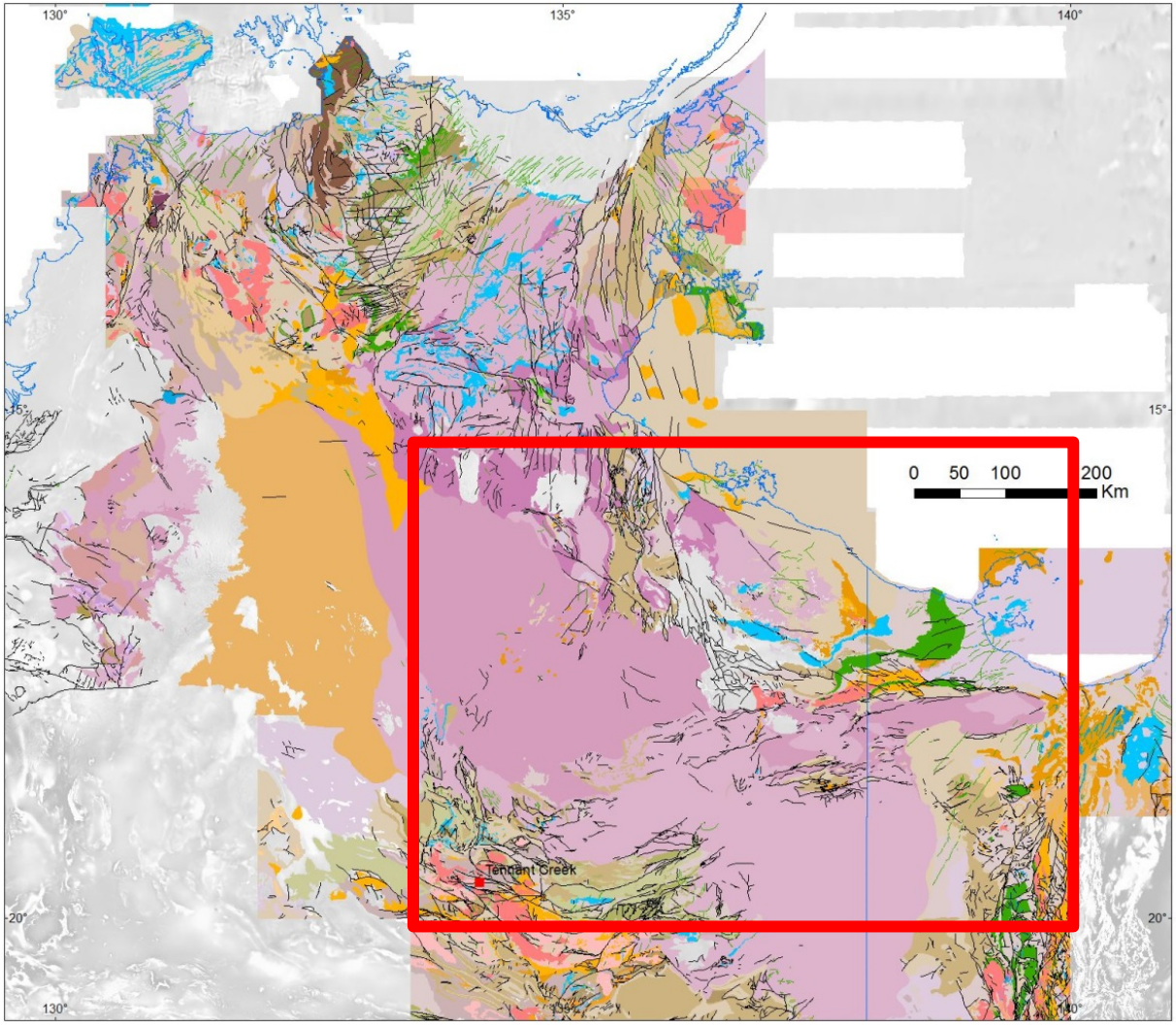
Towards 3D: Solid Geology by time – pre-Mesozoic over Magnetics

Alastair Stewart and Songfa Liu



Towards 3D: Solid Geology by time – pre-Palaeozoic over Magnetics

Alastair Stewart and Songfa Liu

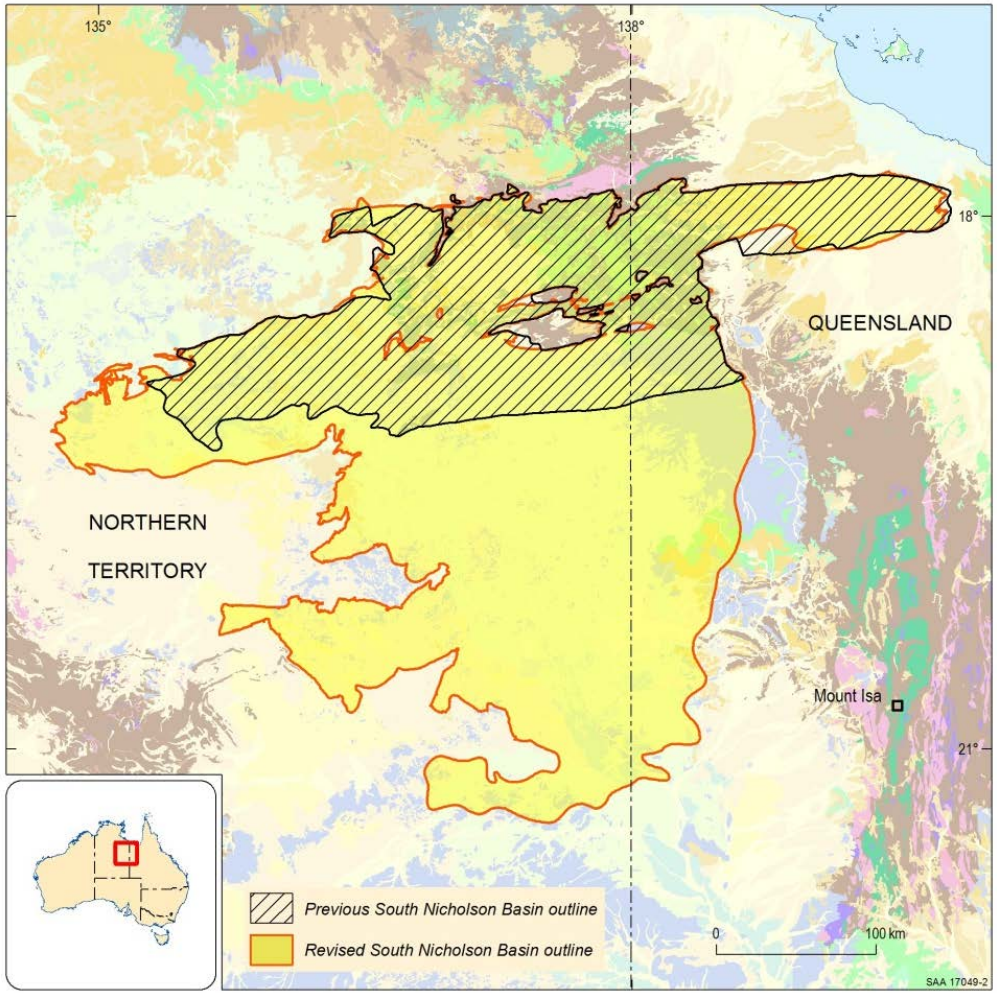


Towards 3D: Solid Geology by time – pre-Neoproterozoic over Magnetics

- **GIS release of revised Geological Provinces 2018**
- **GIS release of Tennant Creek – Mt Isa solid geology**

Alastair Stewart and Songfa Liu

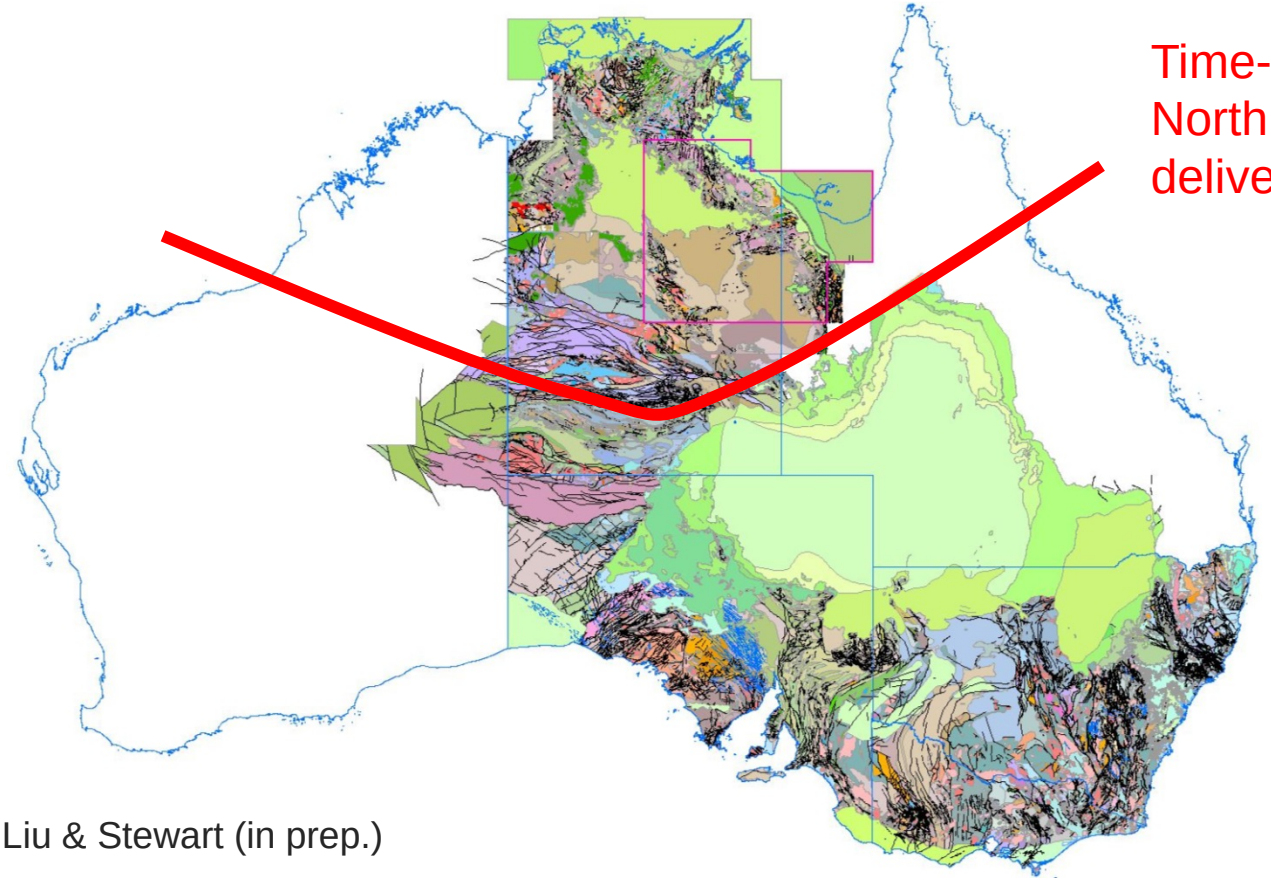
The impact of mapping in 3D



- Redefined the prospective South Nicholson Basin under cover
- The area 3x enlarged
- Defined using existing drill hole reports and geophysics

Alastair Stewart

Towards a national Pre-Cenozoic seamless map



Time-series maps of North Australia to be delivered

Stewart (2018), Liu & Stewart (in prep.)

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Repository of cover-thickness estimates: EGGS

(**E**stimates of **G**eological and **G**eophysical **S**urfaces)

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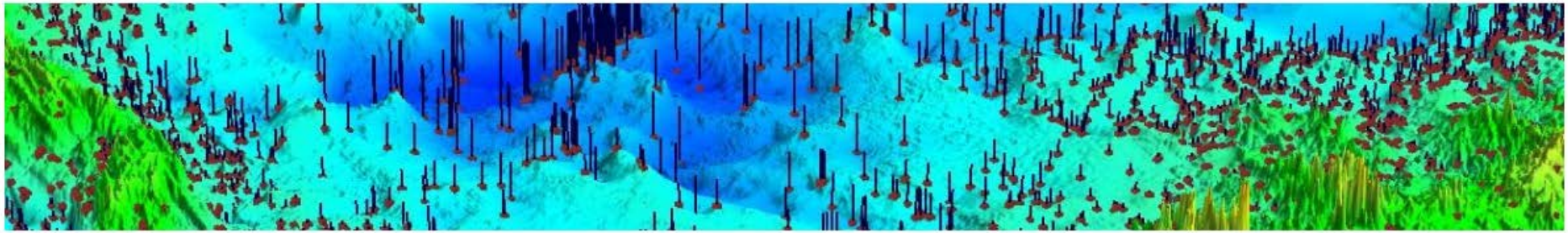
EGGS database - stores fundamental depth data

Estimates of Geological and Geophysical Surfaces (EGGS)

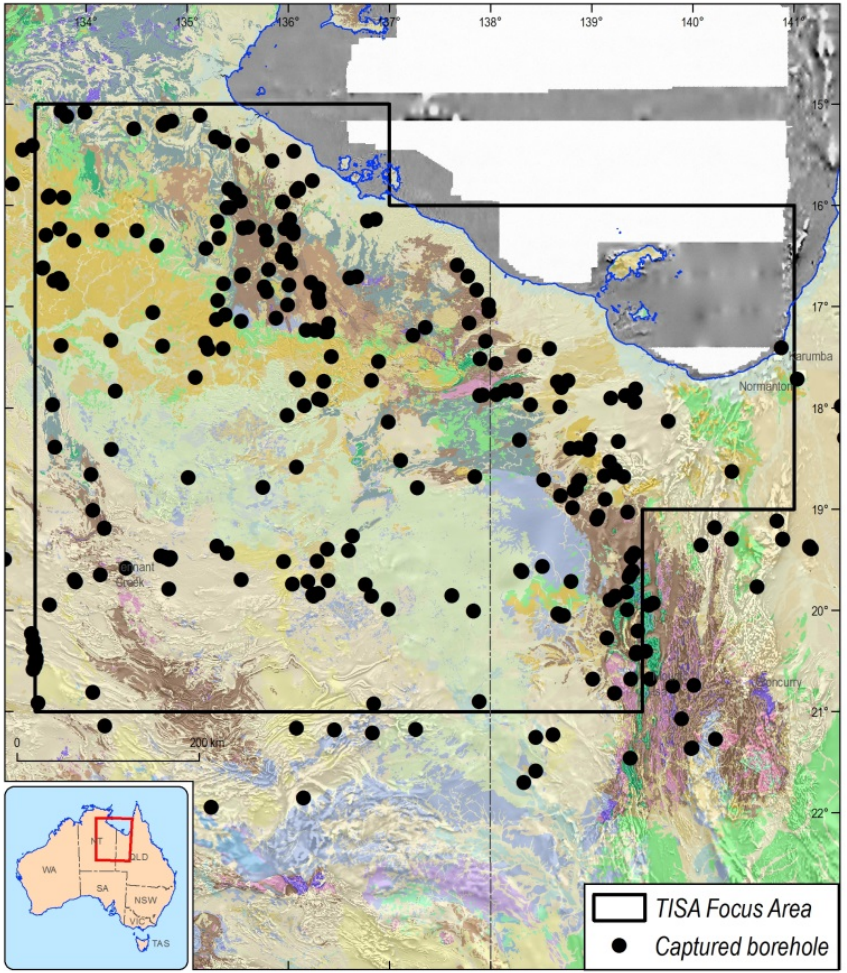
Boreholes	Magnetics	AEM	Seismic Reflection	Data Extraction
MT	Seismic Passive	Seismic Refraction	Administration	Bulk Upload



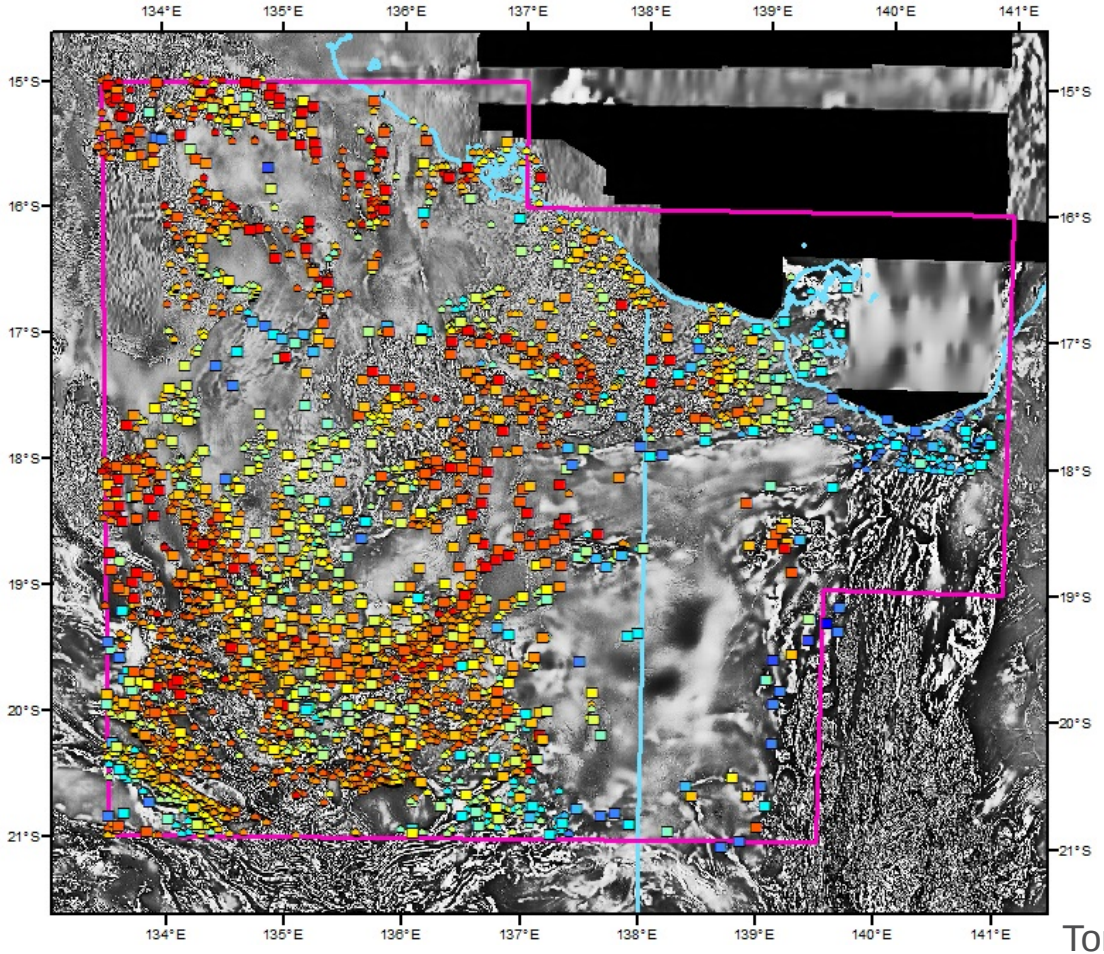
Emma Mathews, Tony Meixner, Yusen Ley Cooper, Malcolm Nicoll

Compile existing drilling

- Compilation of borehole logs from historic drilling
- Control points (depth & lithology) for ‘solid geology’
- Input to EGGS
- Re-analysis of legacy material



Distribution of compiled boreholes (Liam Pitt)



All depths to top of magnetic source

Depth (m)

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 400
- 401 - 500
- 501 - 750
- 751 - 1000
- 1001 - 2000
- 2001 - 5000
- 5001 - 20000

Type of estimate

- Naudy (N = 4214)
- Targeted Inversion (N = 603)

Background Image = Magnetics 1st vertical derivative

Tony Meixner

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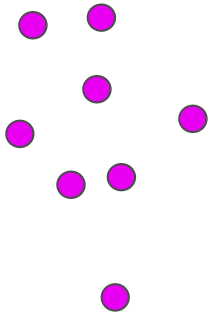
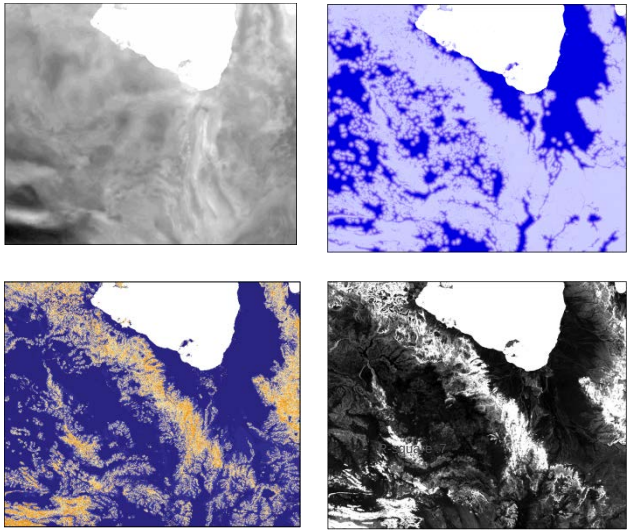
Points to 3D surfaces: UncoverML machine learning

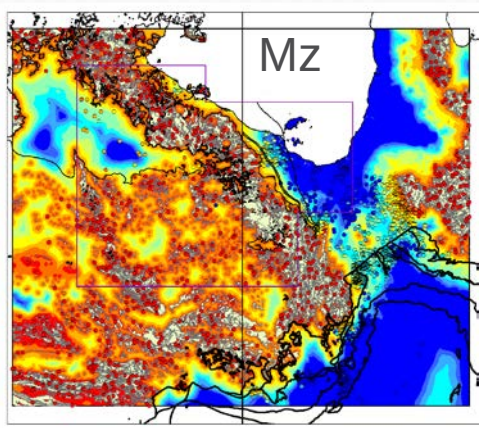
Covariates

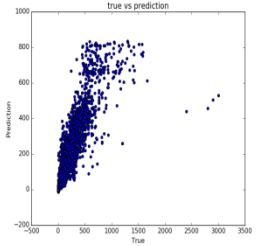
depths

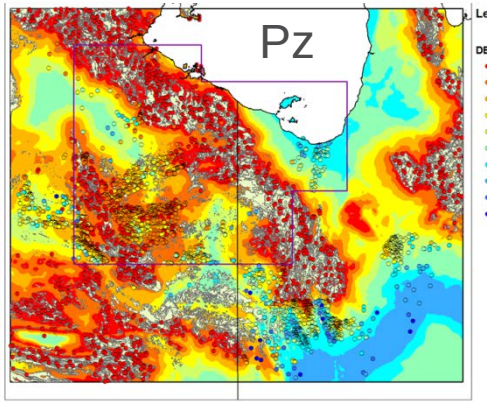


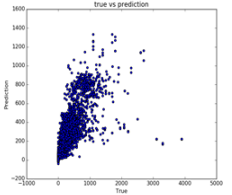


UncoverML - Machine learning code finding predictive relationships between cover depths and covariates









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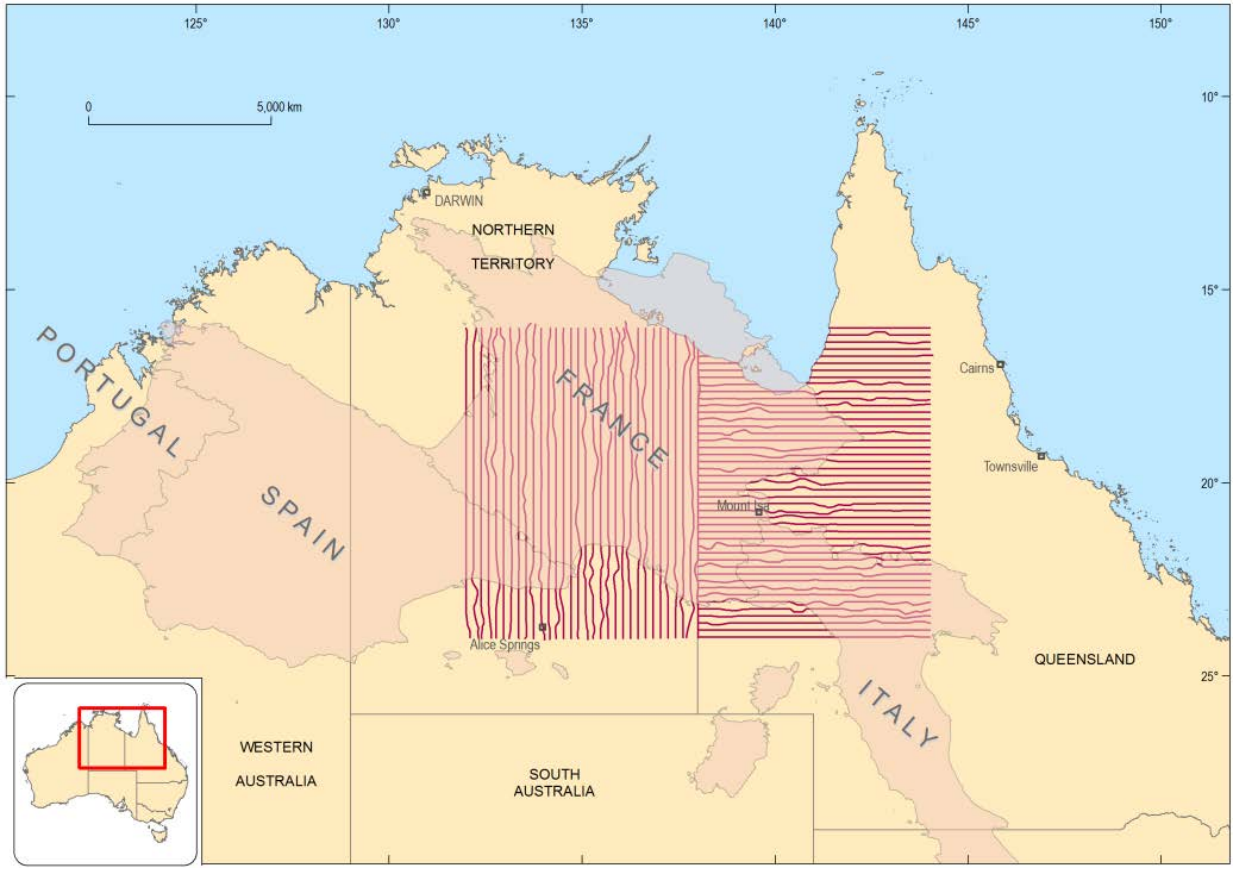
Acquisition of AEM data at an unprecedented scale



- Provide a 20 km spaced national framework for AEM surveys
- Map:
  - cover-thickness
  - cover-character
  - direct-detection
- Reduce exploration risk and stimulate investment

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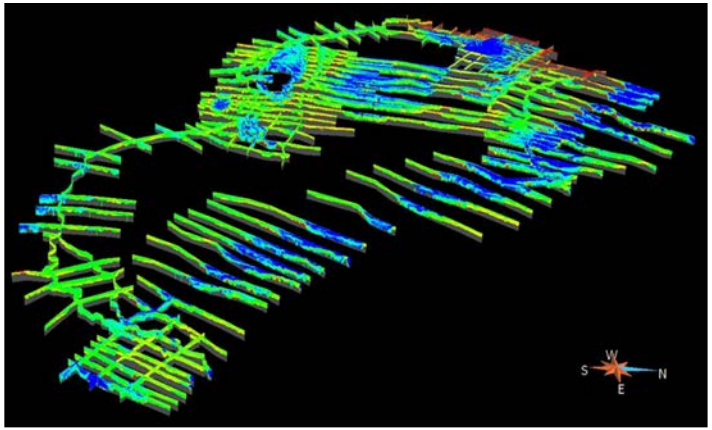
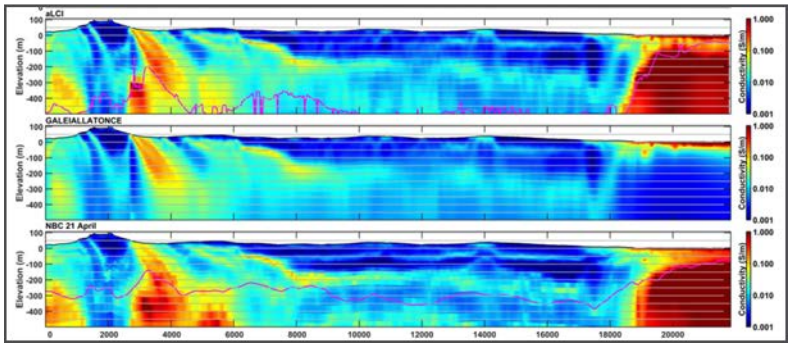
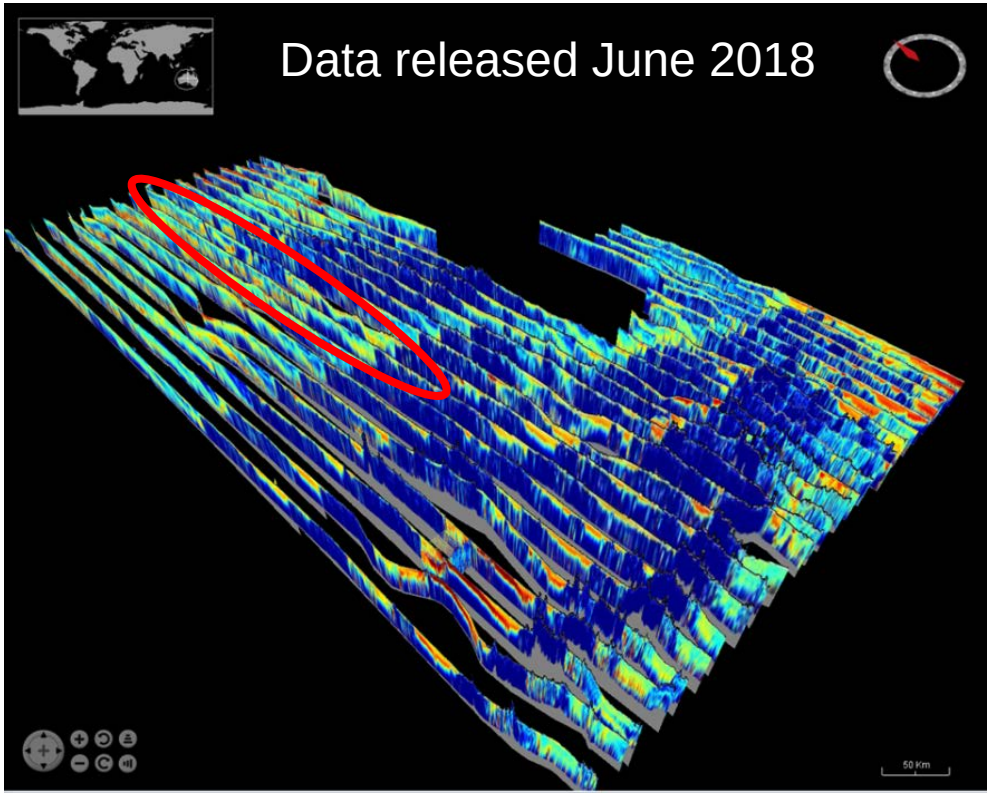
Mapping the top 500 m: targeted AEM and AusAEM





20 km



1000 km

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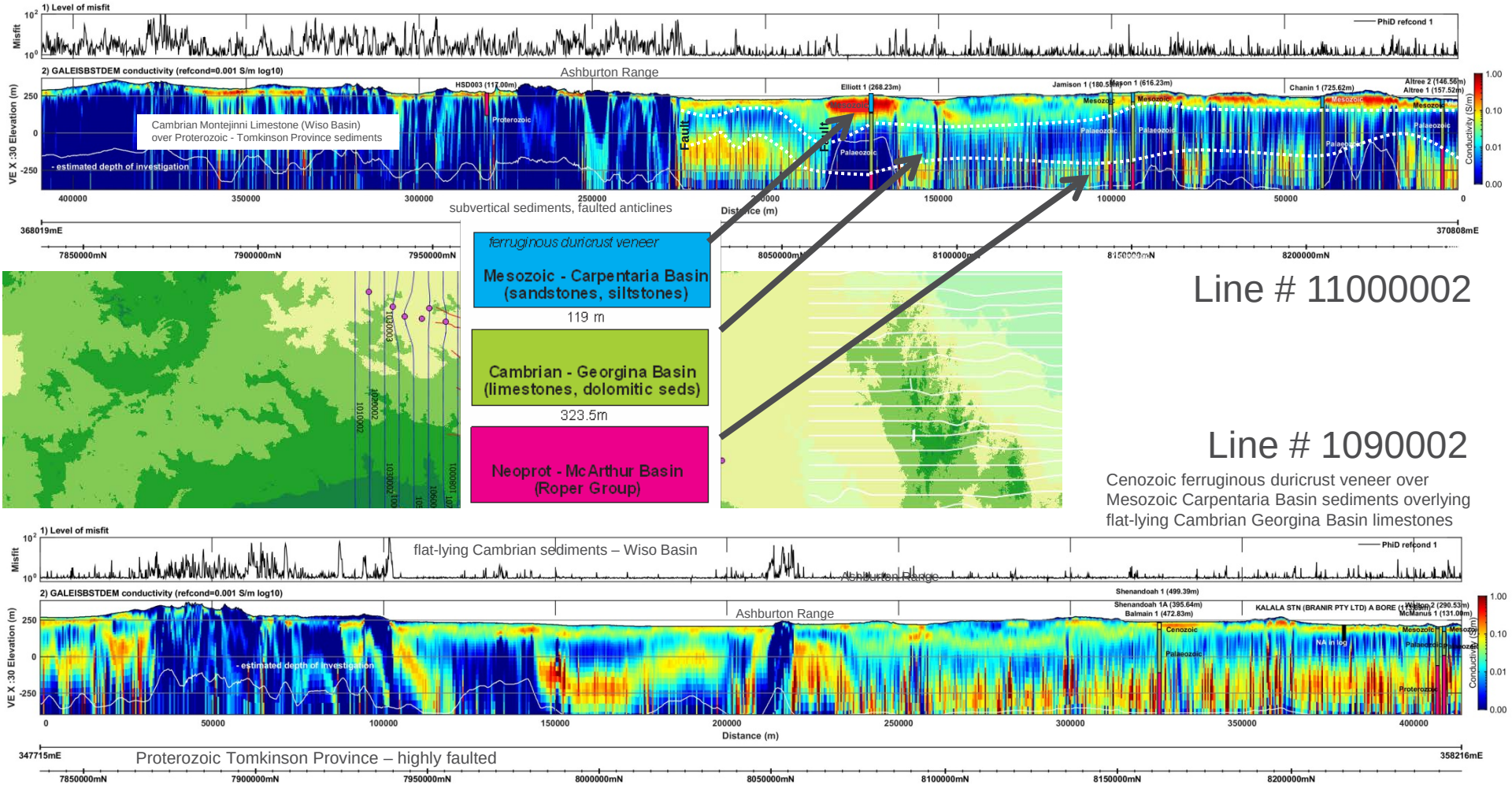

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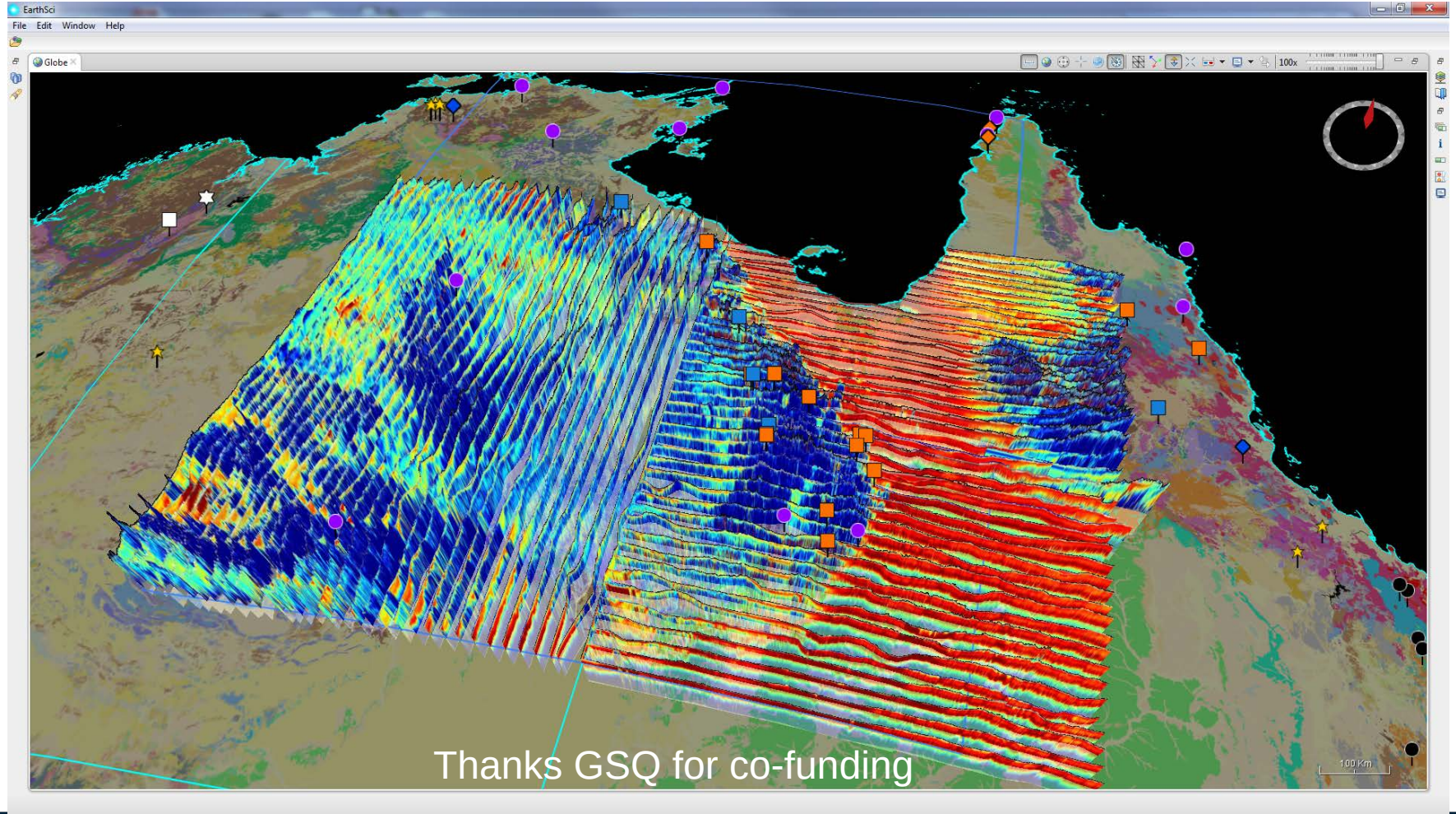

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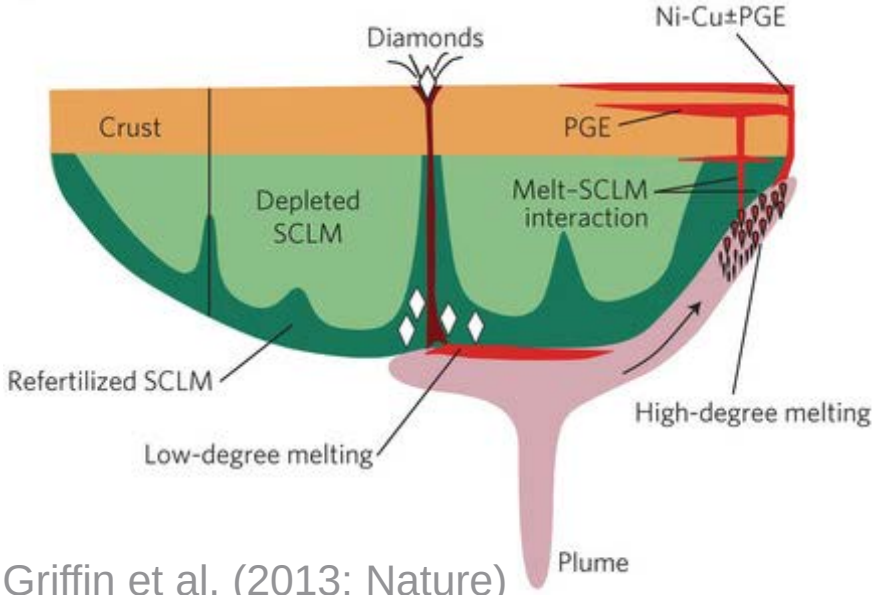
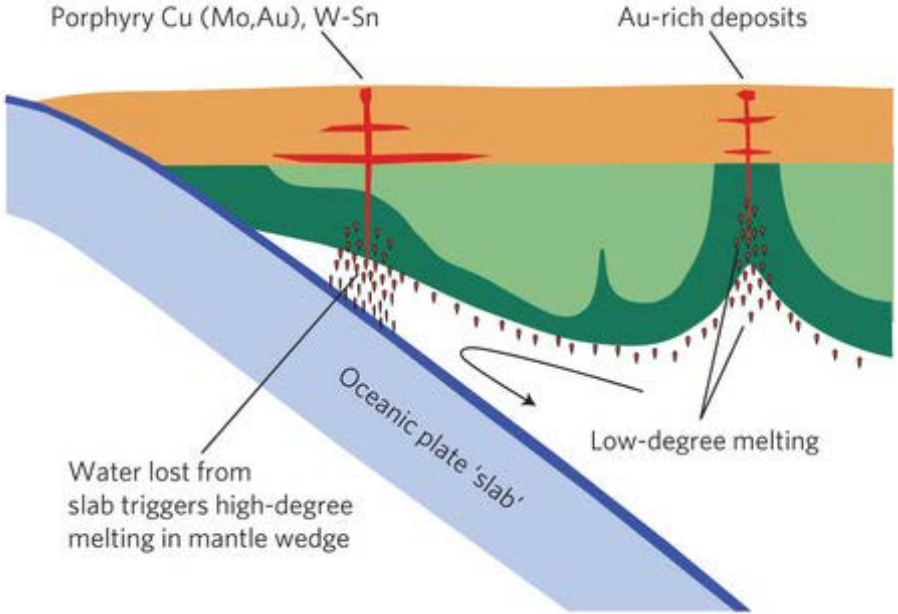
Map the metasomatised mantle: AusLAMP & AusARRAY

- Pathways to giants -> define deep crust and mantle structure and fertility
- Long-period magnetotellurics (LPMT), passive seismic integrated with xenolith and mantle-melt chemistry



Griffin et al. (2013; Nature)



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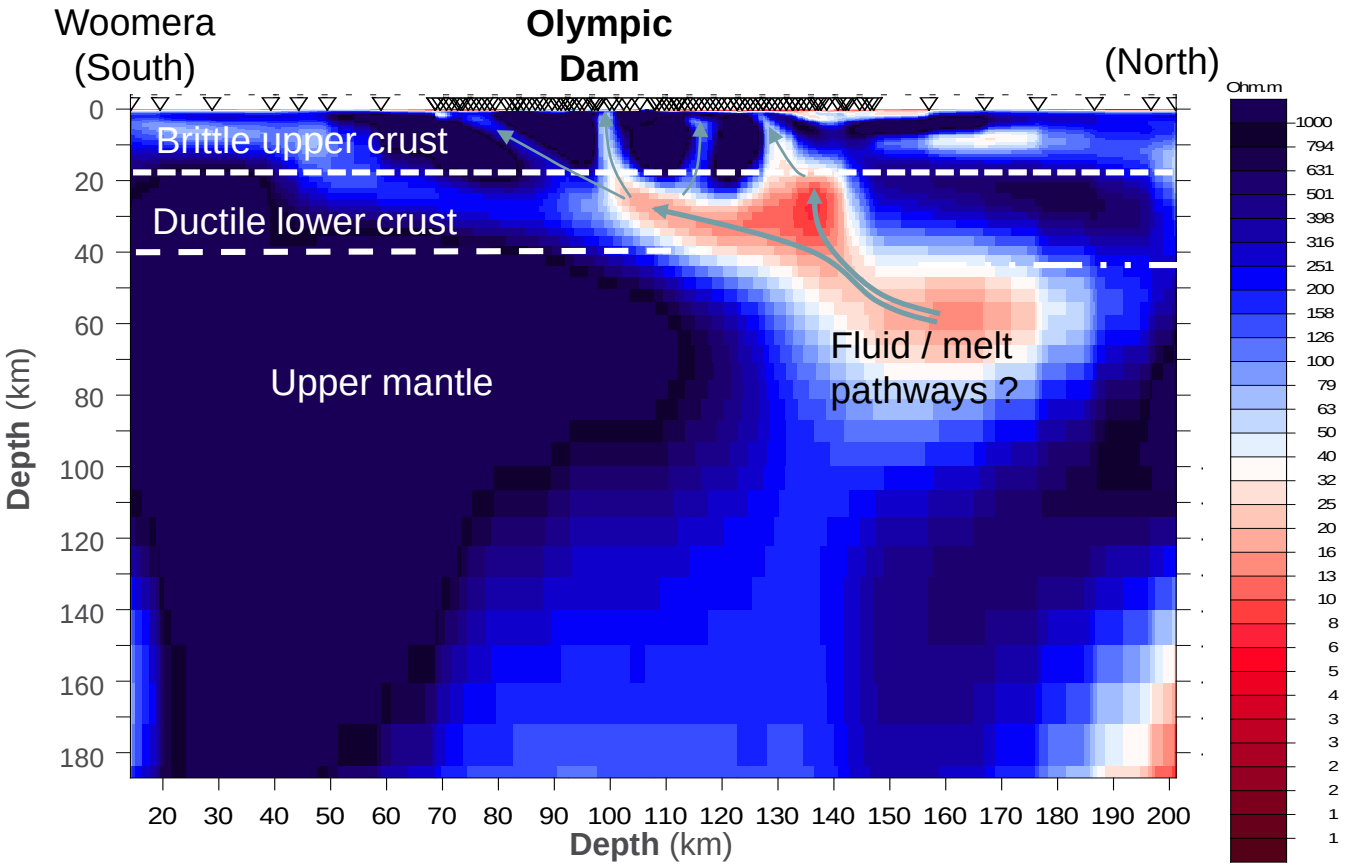
The motivation for deep conductivity constraints…



Example from Graham Heinson, Uni of Adelaide

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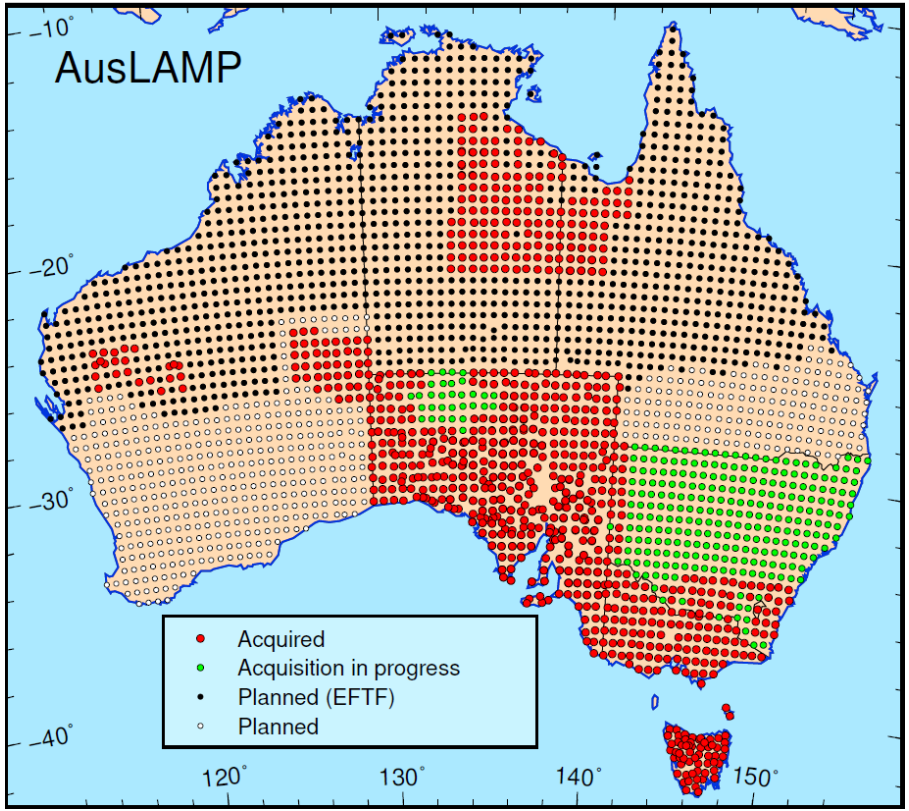
AusLAMP: Deep architecture and fluid pathways



- Plan to acquire data at approximately 2800 sites with half degree grid spacing
- Acquired data at ~800 sites (~28% completed)
- Included ~150 sites for EFTF in NT and QLD
- Mapping deep architecture and fluid pathways

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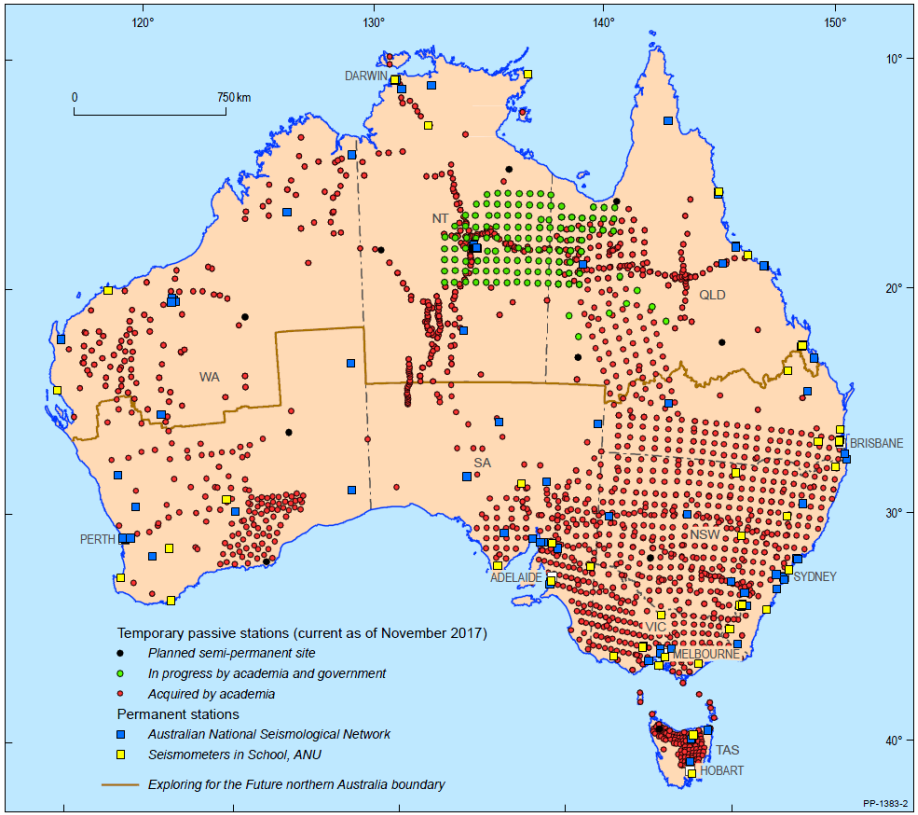
AusARRAY passive seismic: cover thickness and deep structure

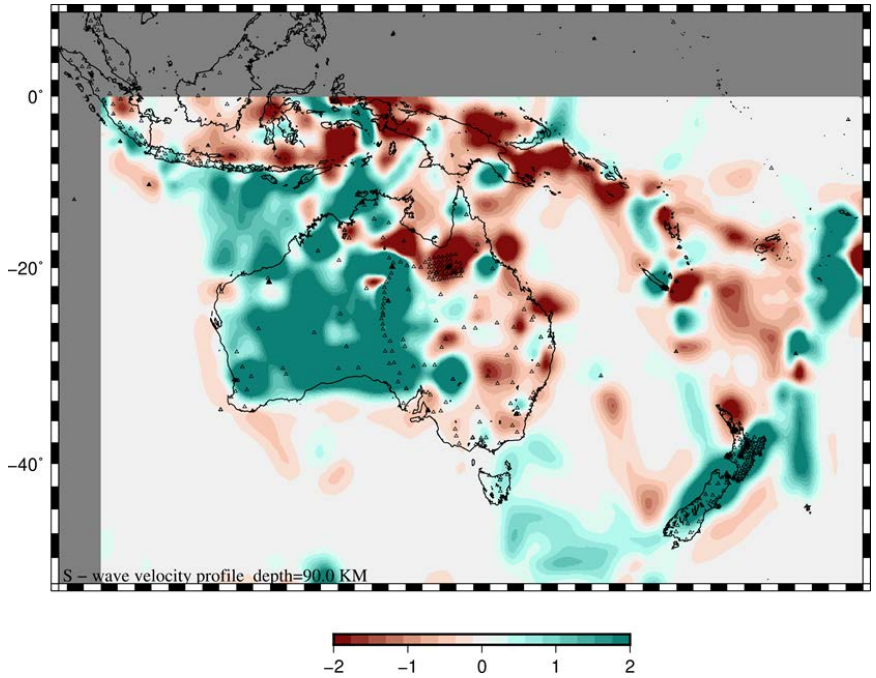
- Moving array of 120 seismometers for 12 months at each site
- First deployment completed in Oct 2017
- Mapping cover thickness, deep structure and background seismicity
- New national tomography model end-2018



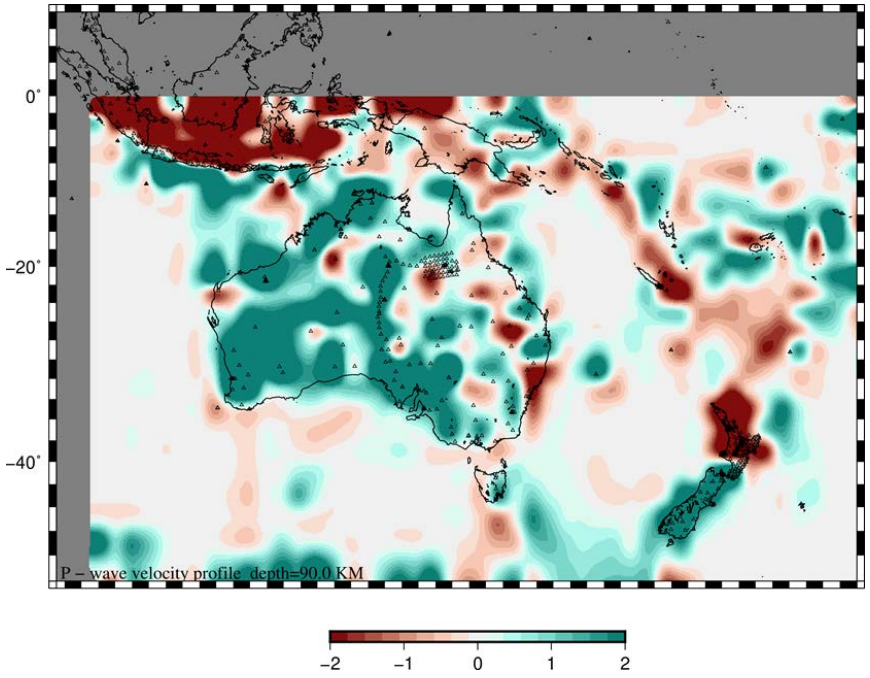
Alexei Gorbatov

Passive seismic P and S wave tomography - FWI

S-wave (90 km depth)



P-wave (90 km depth)



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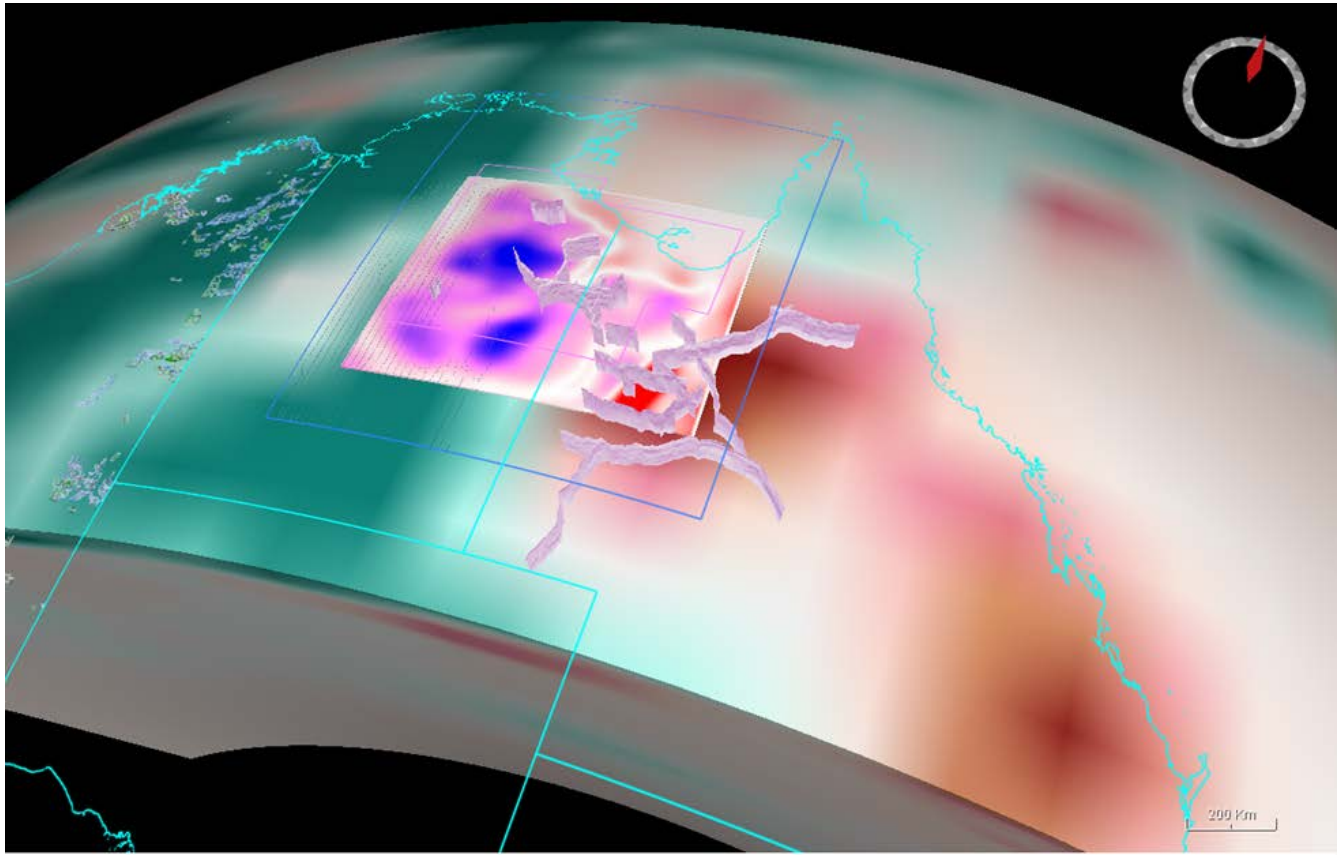
Integrating seismic, passive seismic and MT



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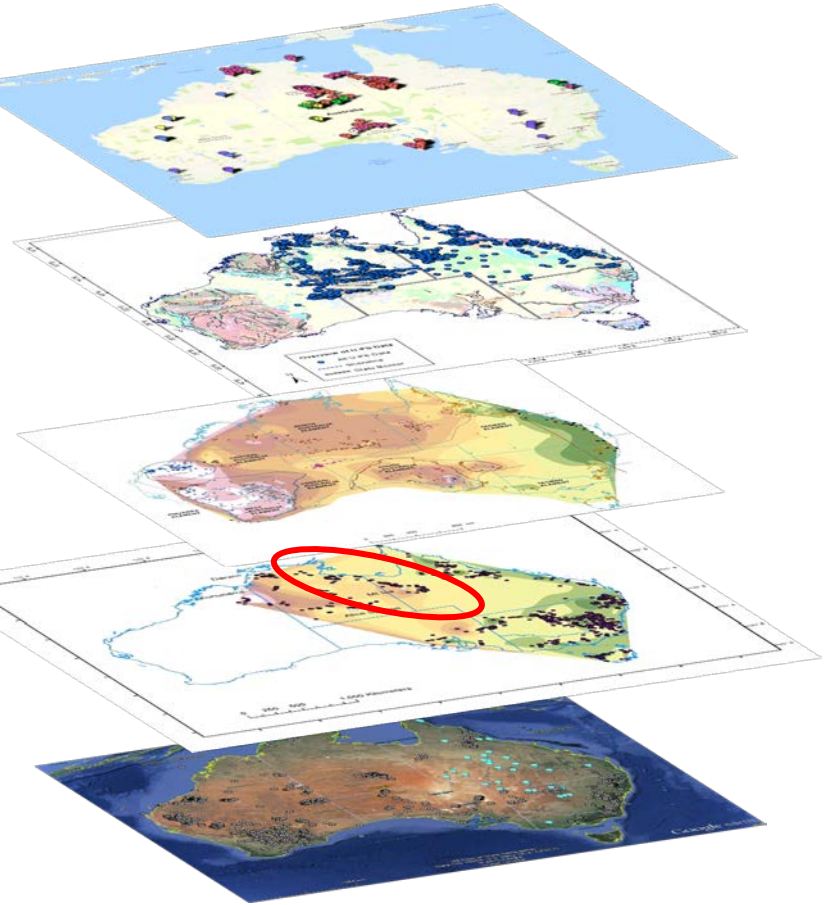

Ar-Ar ages

U-Pb ages

Nd-isotopes

Pb-isotopes

Hf-isotopes

ISOTOPIC

ATLAS

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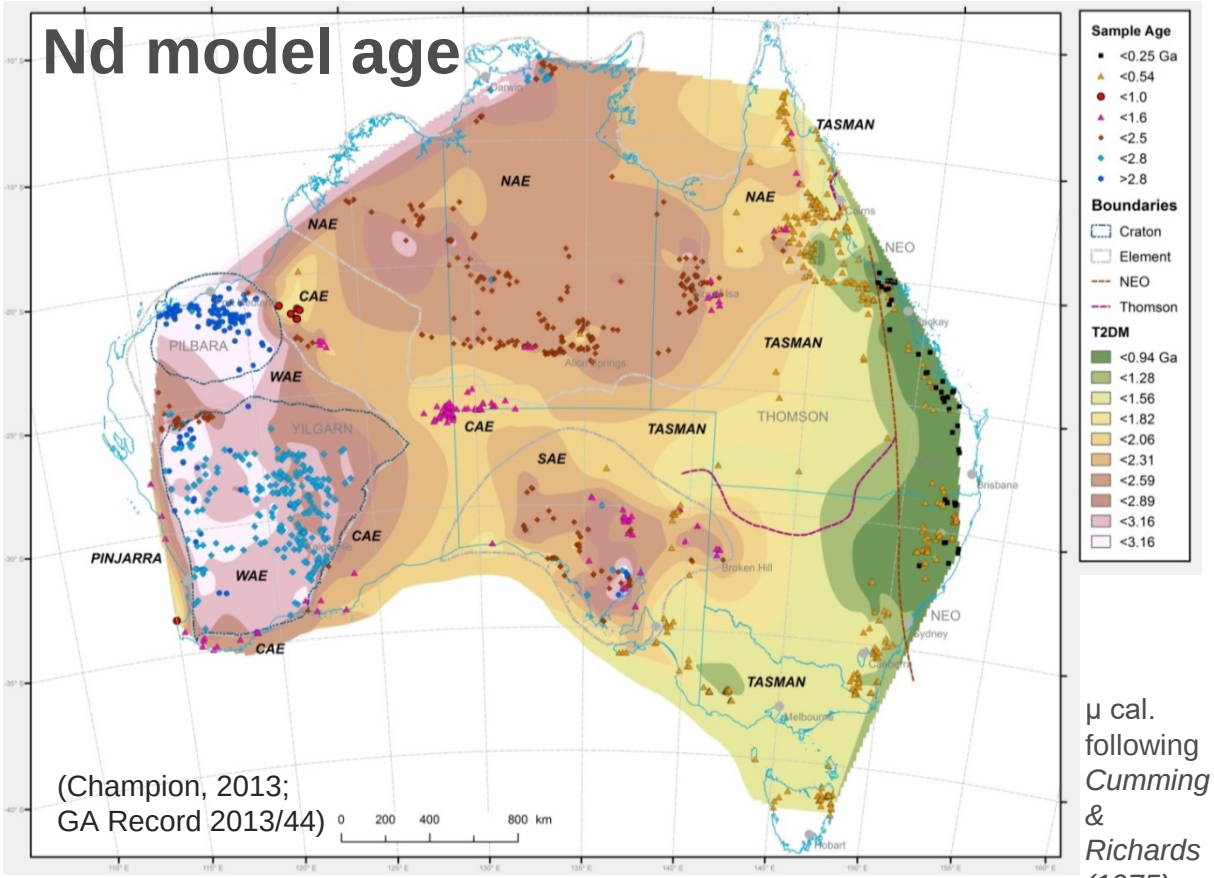
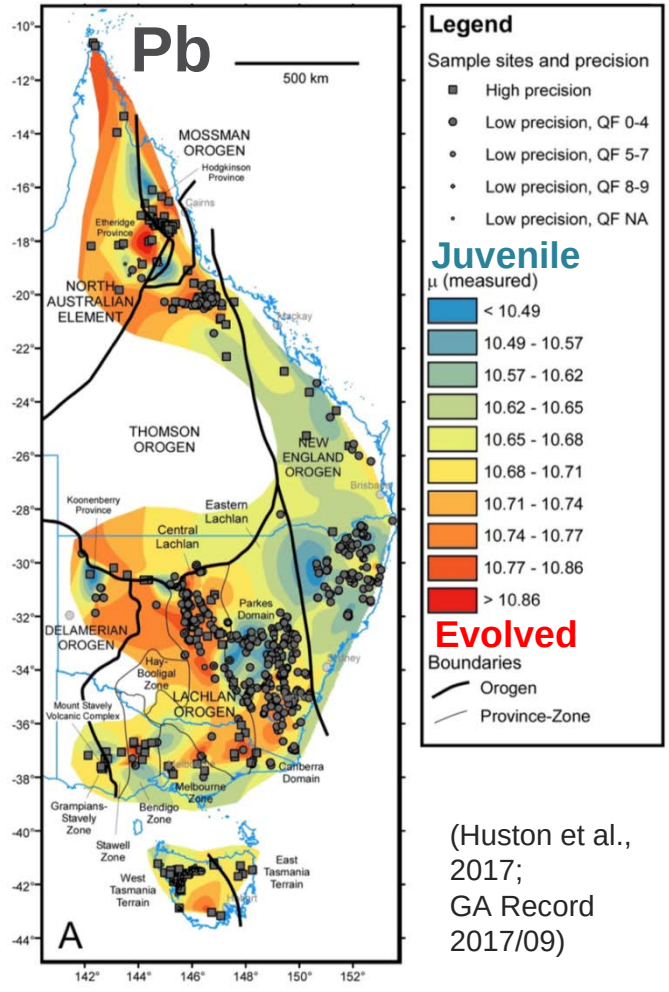
Mapping Australia: isotopes



(Champion, 2013;
GA Record 2013/44)

μ cal. following *Cumming & Richards (1975)*



(Huston et al., 2017;
GA Record 2017/09)

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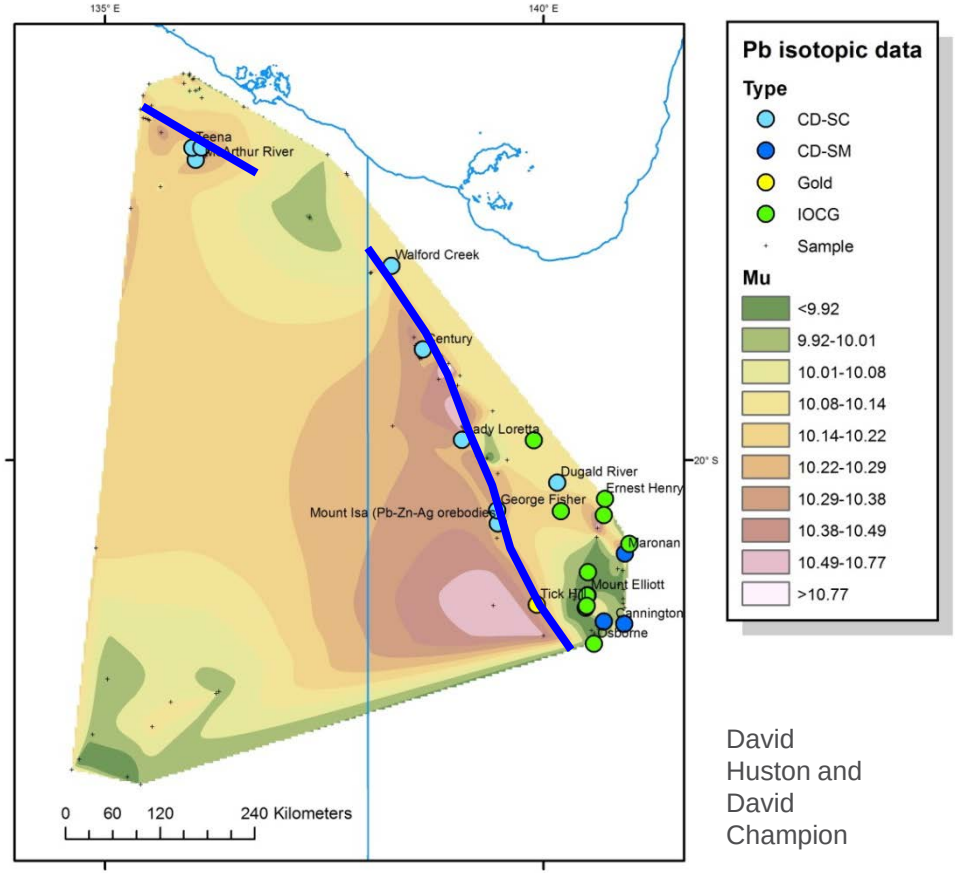
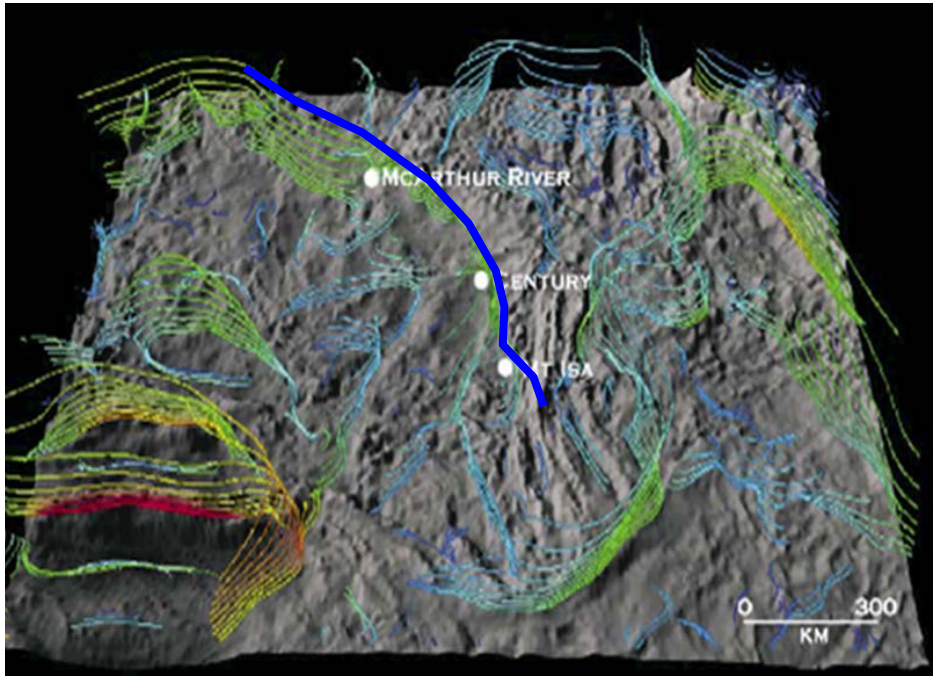
Pb – isotope mapping



David Huston and David Champion

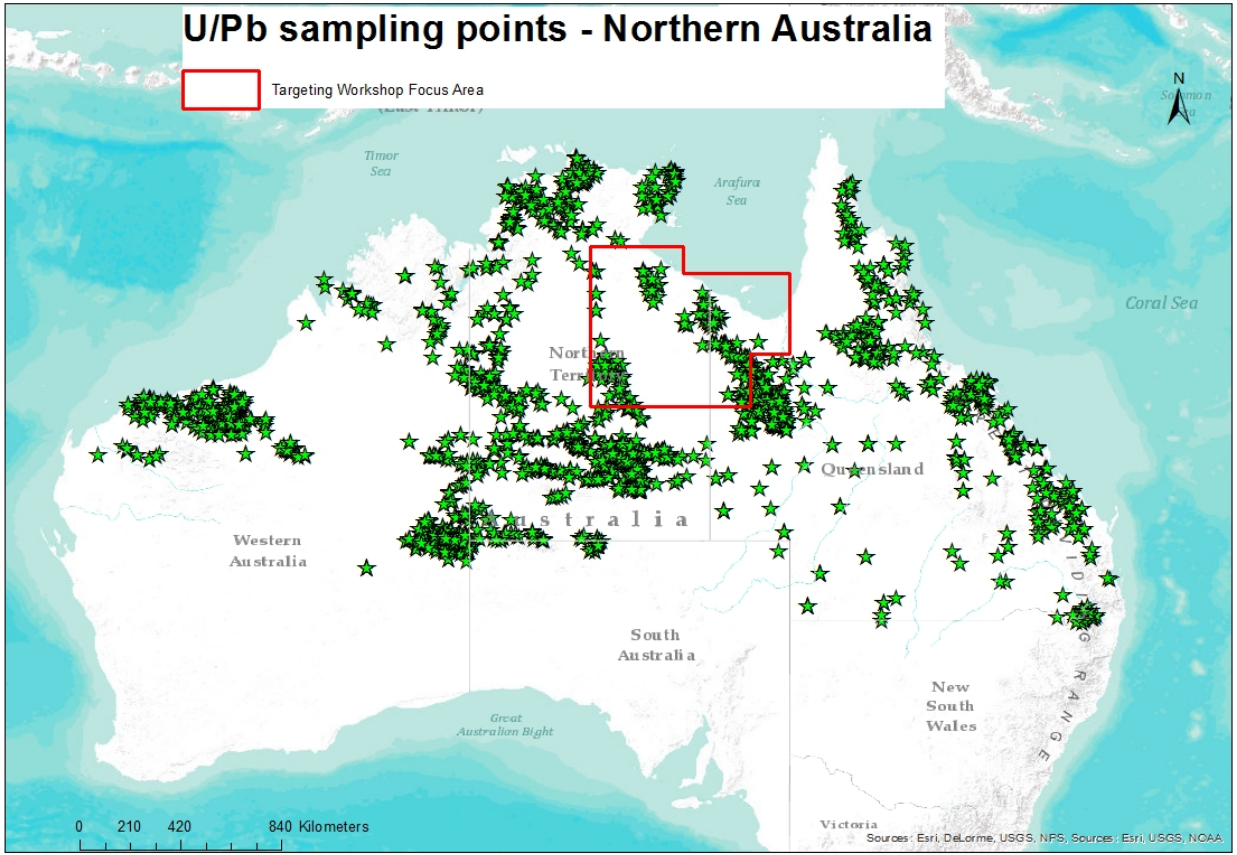
Is this the isotopic expression of the “Barramundi Worm”?

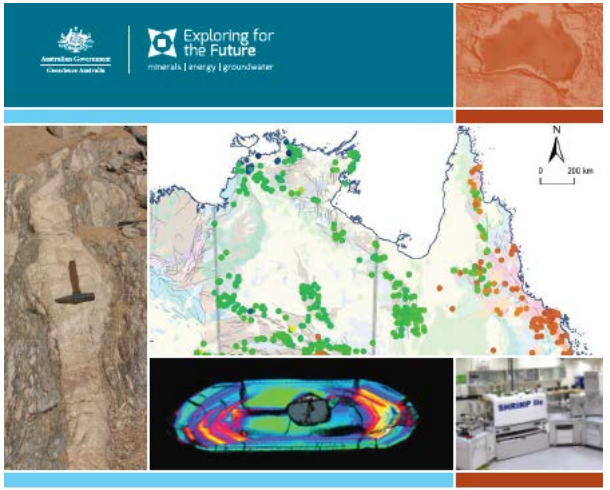


Phanerozoic Pb-isotopes is out as GA record

Proterozoic Pb-isotopes due end 2018

Compilation of U-Pb geochronology





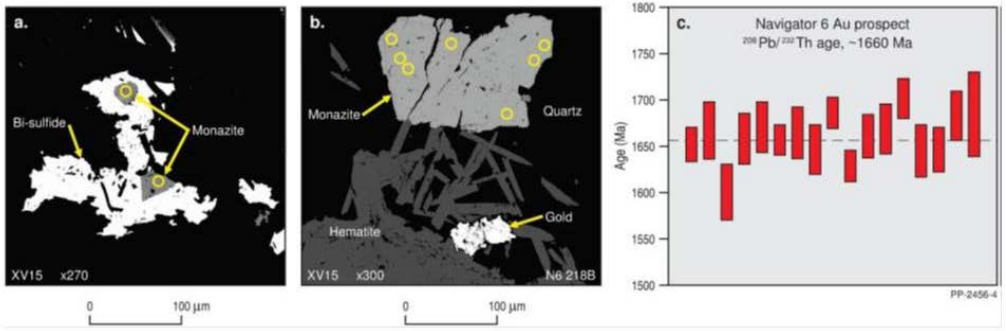
Record 2017/22 | eCat 115184

A U–Pb geochronology compilation for northern Australia

Version 1, November 2017

J.R. Anderson, G.L. Fraser, S.M. McLennan and C.J. Lewis

Targeted dating



- Confirm new gold event at 1650 Ma at Tennant Creek
- Potentially opens up 200 Myr new stratigraphical search space

- Xenotime in South Nicholson
- Mt Isa basement search

Roger Skirrow & Andrew Cross

Focused Integrated Studies

TISA extras

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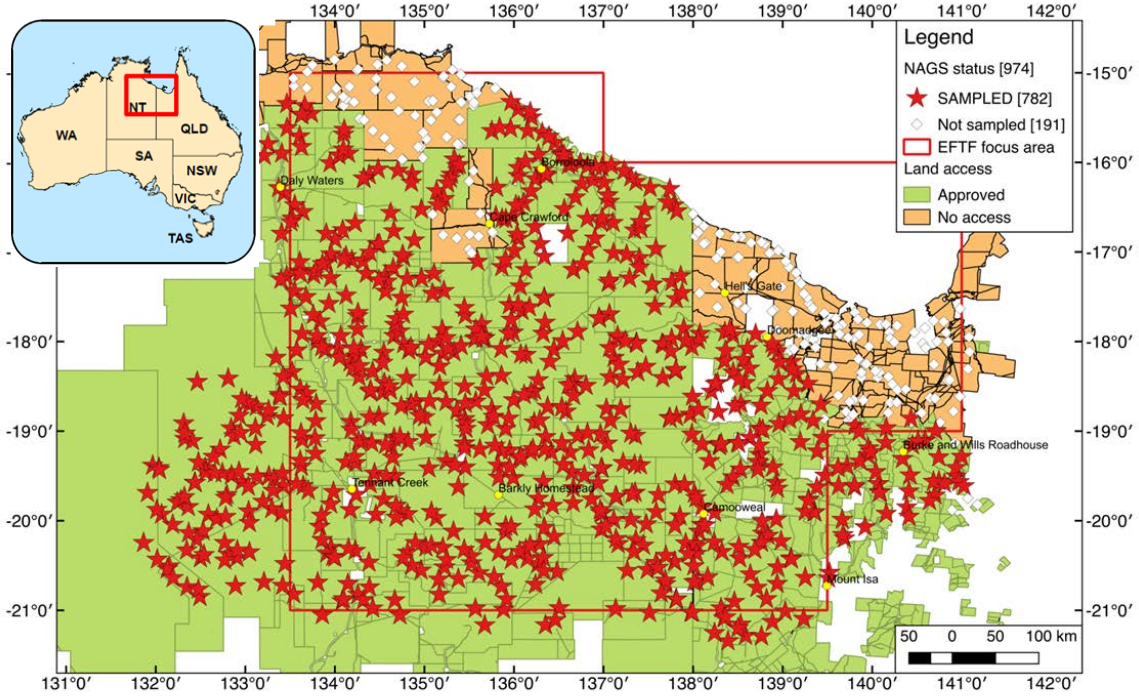
Soil geochemistry for baseline and distal footprints

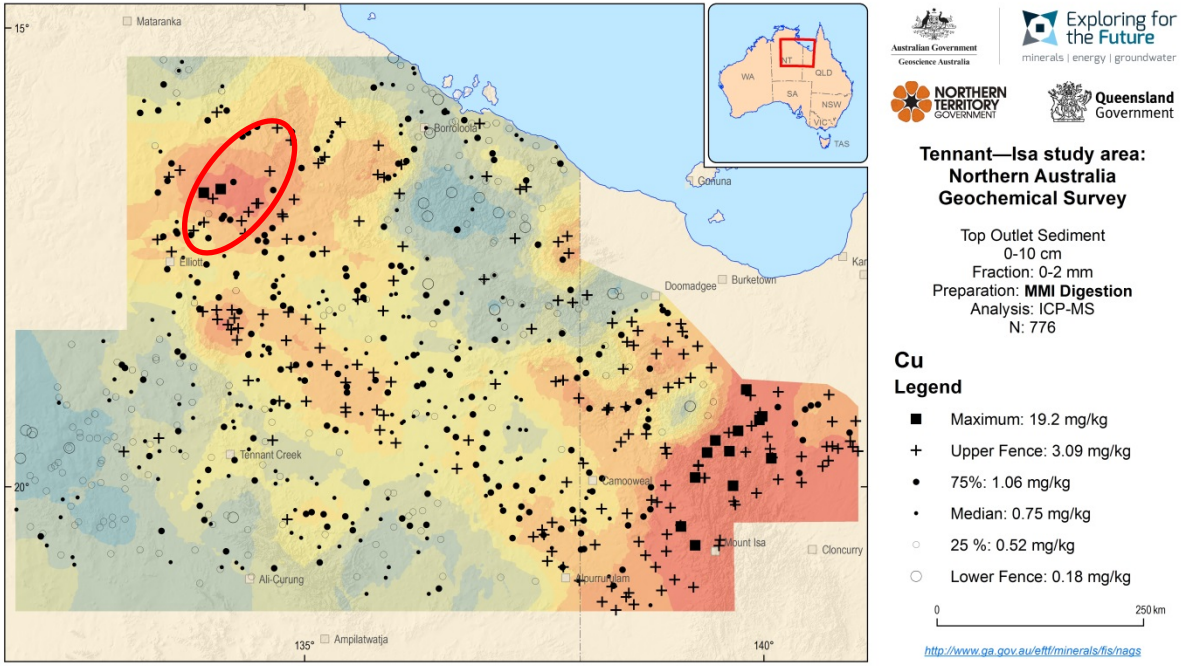
- 780 samples collected at ~20 km spacing (0–10 cm depth).
- Biome characterisation underway
- Data released:
  - Metadata, Ph, EC, Colour
  - MMI
  - Fine fraction full digest



Collaboration with NTGS and GSQ

Evgeniy Bastrakov and Phil Main

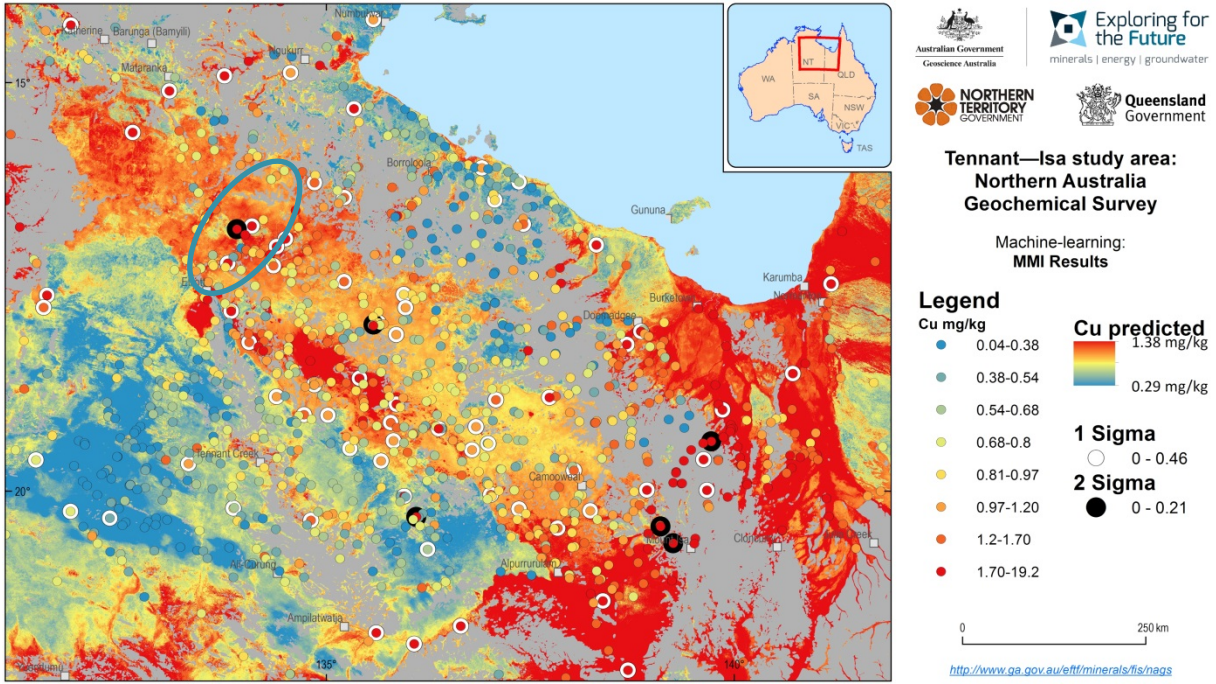
MMI (<2 mm): Cu



Have 56 elements mapped – incl fertiliser elements (K, P)

Evgeniy Bastrakov and Phil Main

Machine learning: MMI Cu



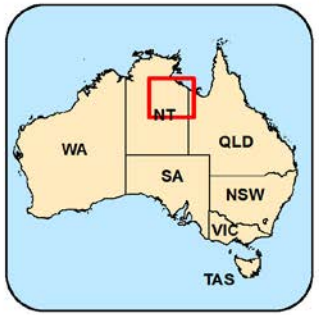
Evgeniy Bastrakov and Phil Main

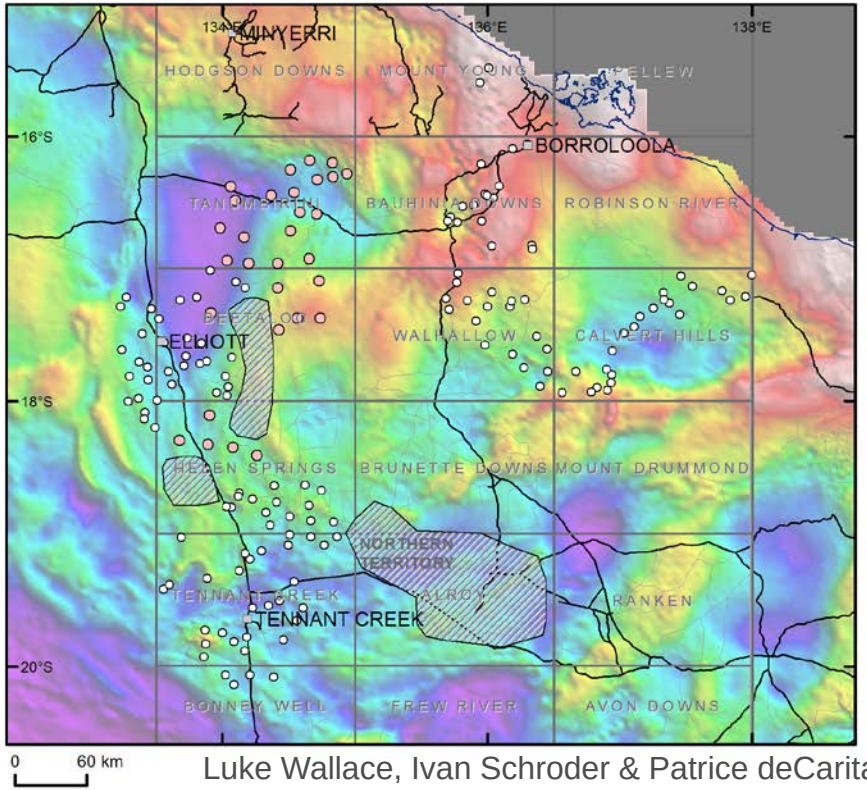
Hydro-geochemistry for baseline and distal footprints

Sampling water bores for

- Distal footprints mineral exploration
- Baseline environmental data

- 2017 - 136 bores
- 2018 – 31 bores (so far)
- Data release of 2017 = Oct 2018

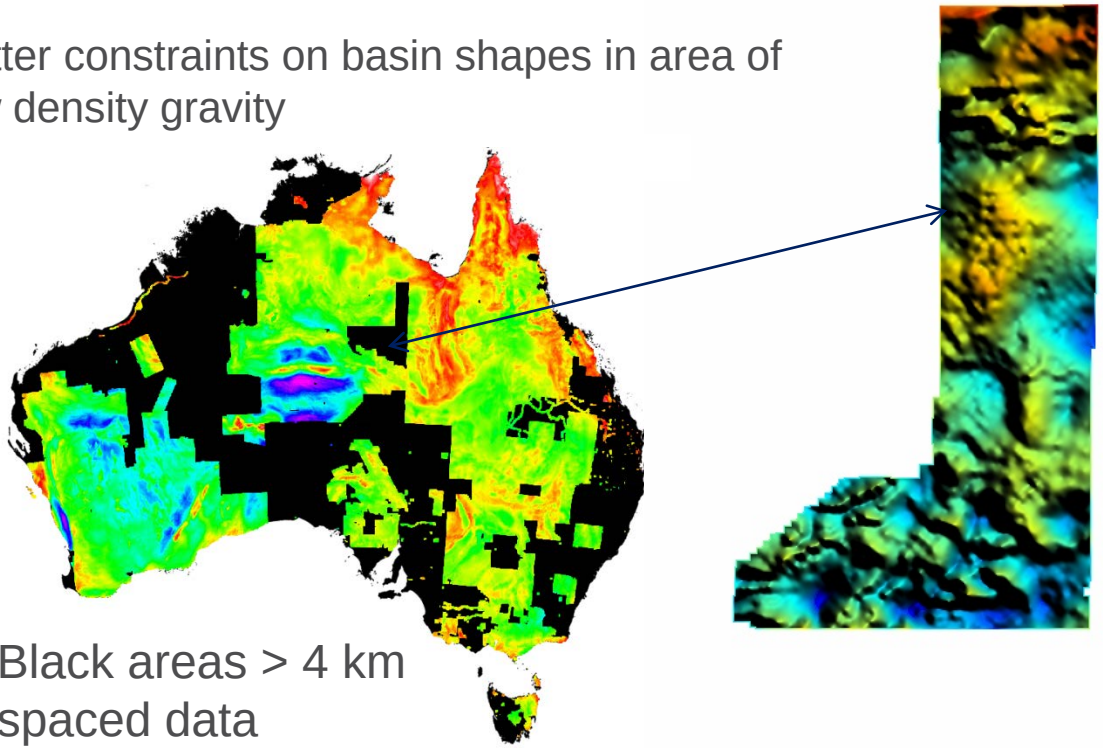




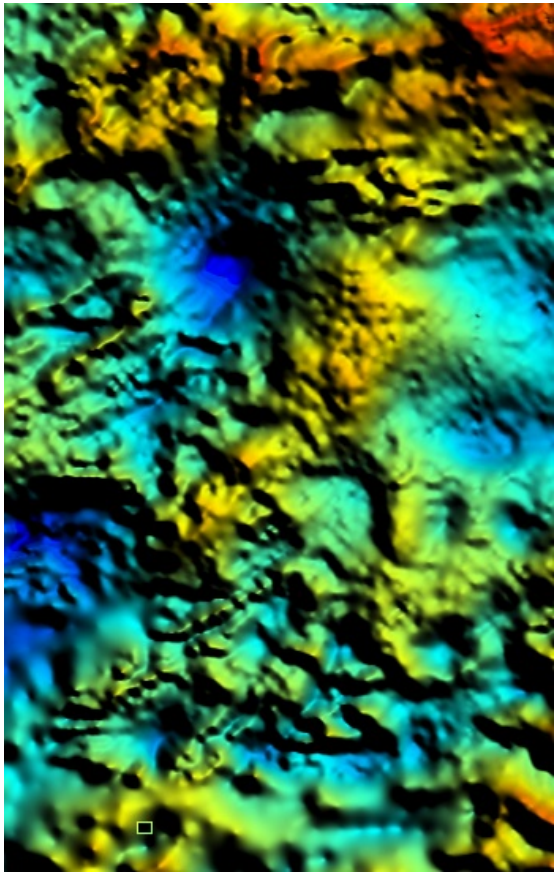
Luke Wallace, Ivan Schroder & Patrice deCaritat

AusGrav: 4 km spaced gravity infill

- Completed – data released 15th Sep 2017
- Better constraints on basin shapes in area of low density gravity



Black areas > 4 km spaced data



Phillip Wynn

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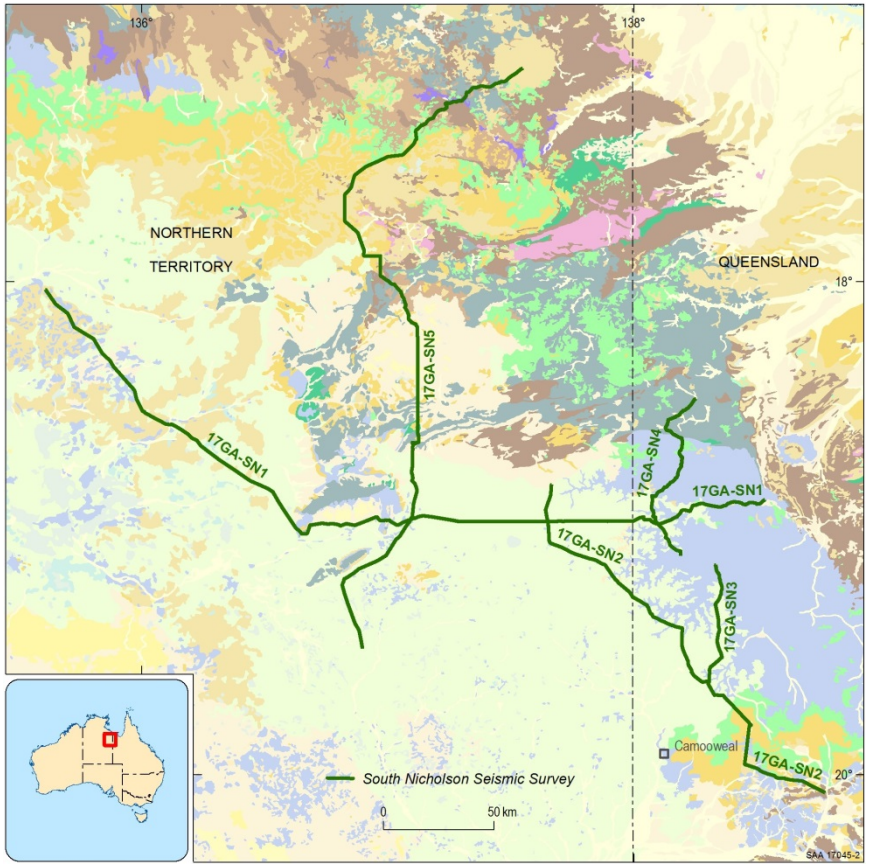
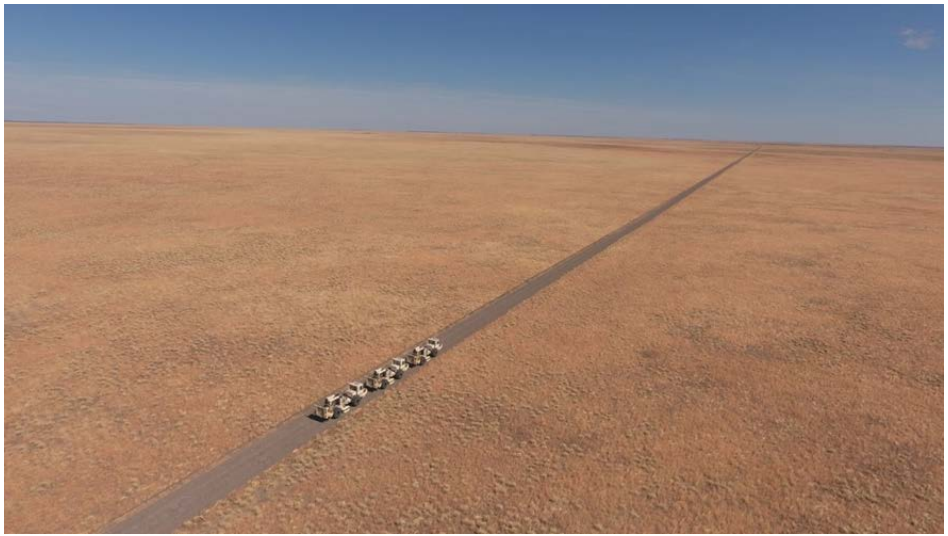
2D deep crustal seismic reflection



1100 km new data in collaboration with the NTGS and GSQ - AuScope

Link to existing deep seismic



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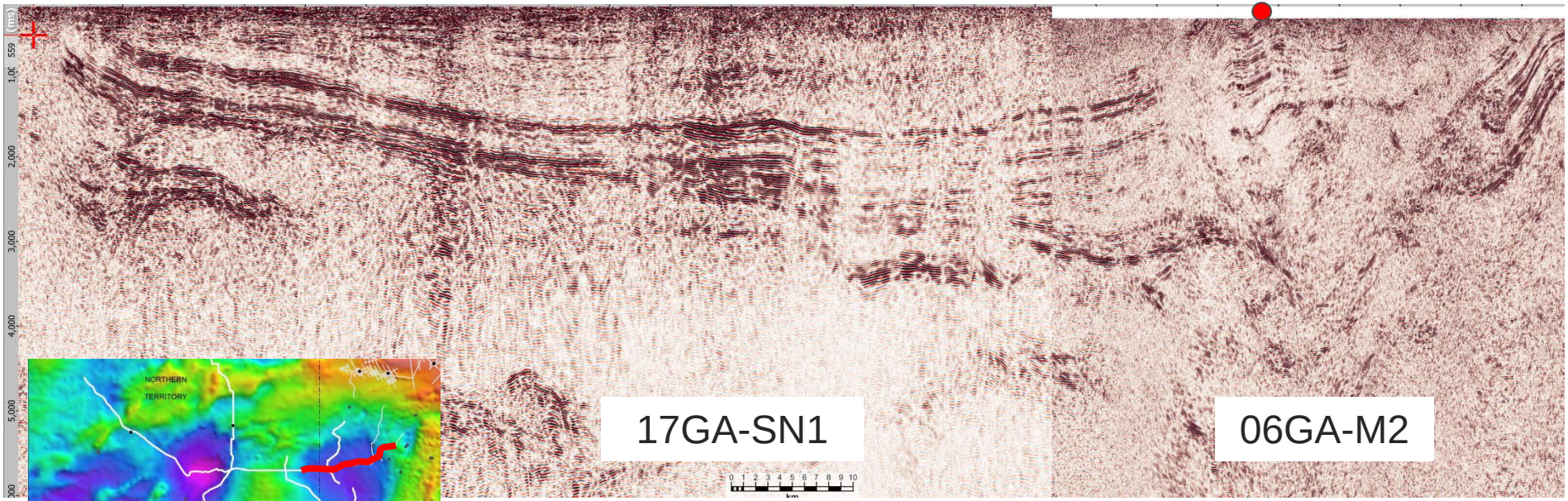
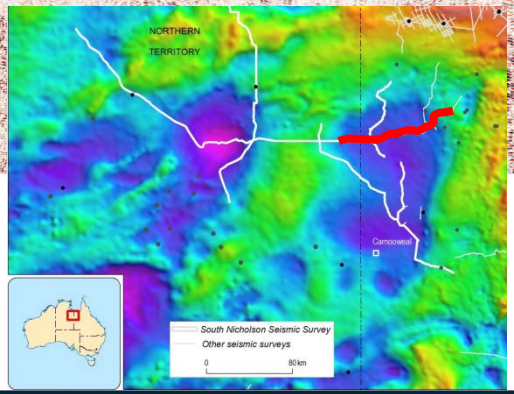
Interim PreSTM 17GA-SN1 and 06GA-M2

W

Century Mine

E





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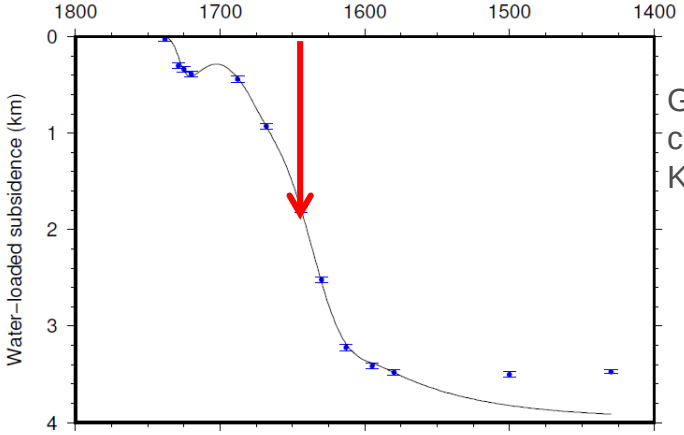
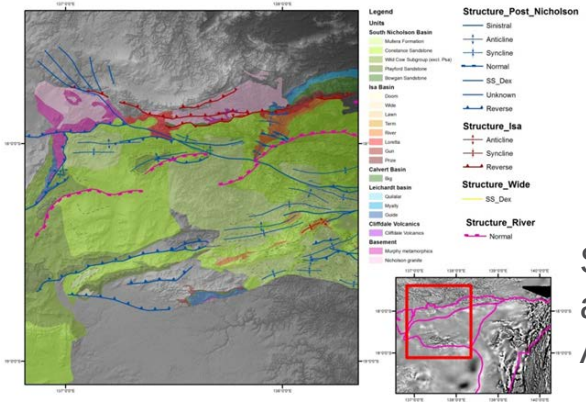
2D deep crustal seismic reflection

Basin analysis approach to mineral system targeting

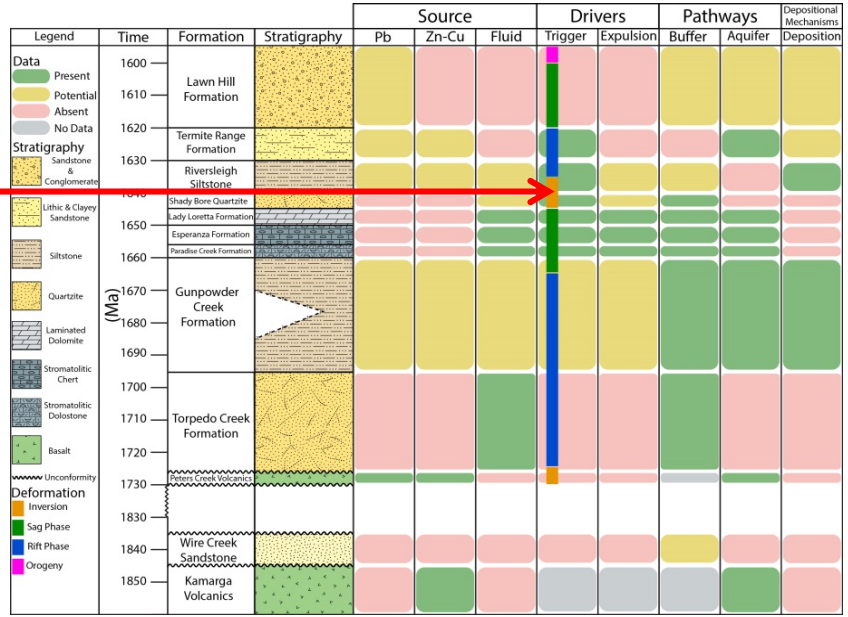


Geodynamic controls
Karol Czarnota



Structural architecture
Andy Clark

Initial mineral potential assessment for SE Lawn Hill Platform



1D analysis (David Huston and Jane Thorne)

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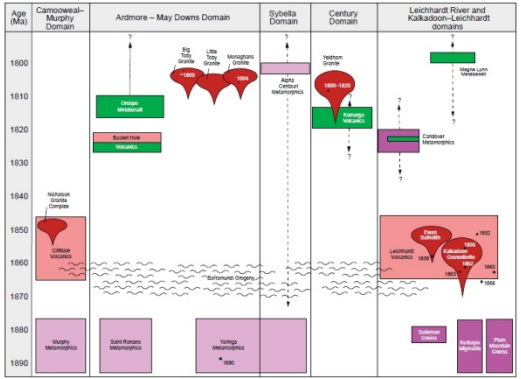
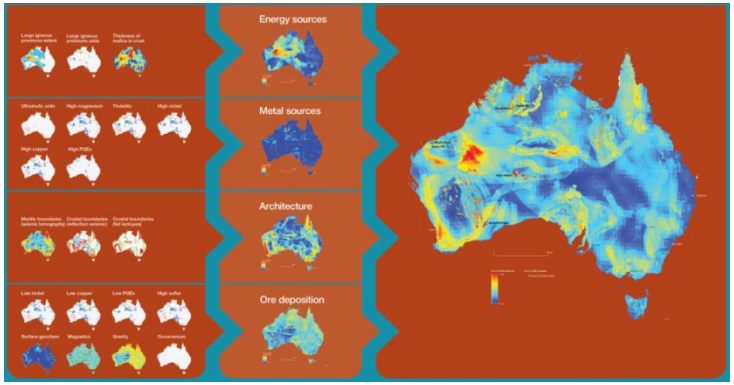
Integrated approach to targeting

Regional stratigraphic + events framework



Map mineral systems under cover



- AusAEM
- AusLAMP
- AusArray
- Cover mapping
- Geochronology

- NAGS
- Hydrogeochem
- Solid geology
- Isotopes
- Architecture

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Drilling greenfield frontiers: Coompana beneath Nullarbor

- No known exposures of basement rocks
- Extensive cover sediments
- Very limited prior drilling
- Very little known about cover thickness

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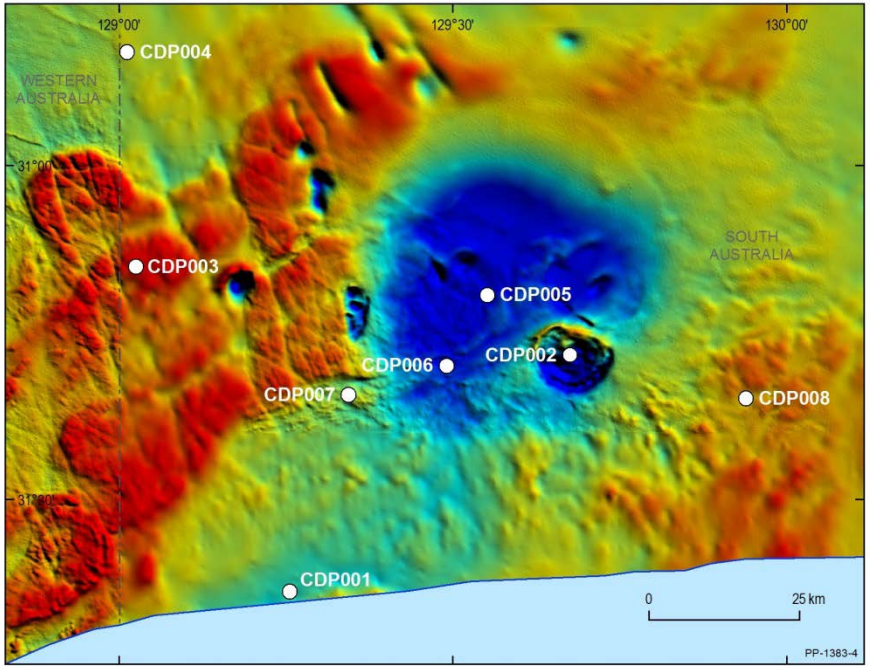
Stratigraphic Drilling

- 8 drill holes completed on 10th September 2017
- A total of 4560m drilled, incl. > 1600m of new crystalline basement core
- Multiple intrusive phases intersected in the basement drill core

Representative granitic gneiss from CDP001



Sun-shaded RTP total magnetics

○ *Completed borehole*

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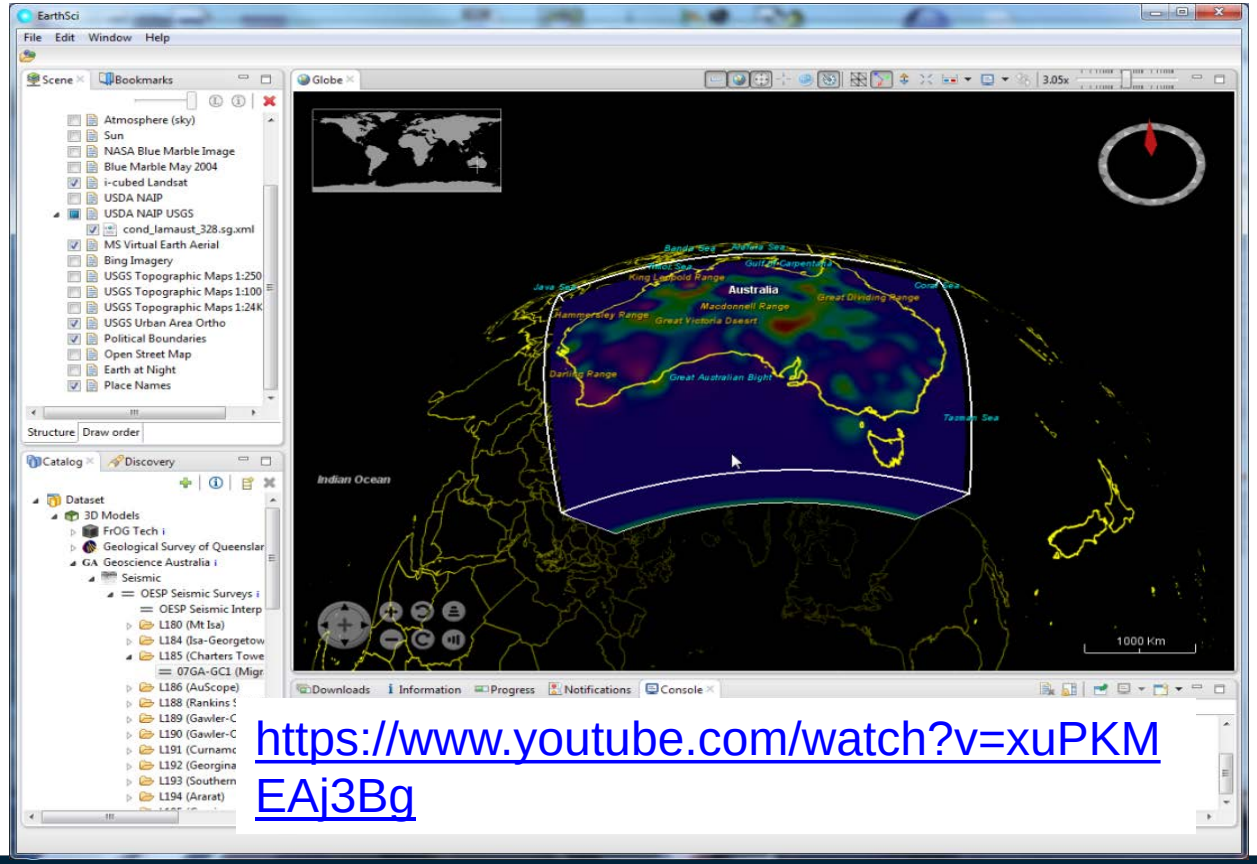
Generic innovation and applications

Richard.Blewett@ga.gov.au

Earth*Sci* to visualise, integrate and deliver



https://www.youtube.com/watch?v=xuPKMEAj3Bg

- GA developed 2D and 3D visualisation tool
- supports integration & visualisation wide range data types
- runs on normal PCs & Macs with reasonable graphics card

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Precompetitive geoscience tools

Virtual lab: codes, data and ‘compute’

4 software developers on the team

Some codes in progress

uncoverML:
https://github.com/GeoscienceAustralia/uncover-ml

Machine learning for the Geoscience Australia uncover project, regression and classification models for ground cover thickness and geochemical modelling. Currently evaluating deep learning frameworks

passive-seismic:
https://github.com/GeoscienceAustralia/passive-seismic

Seismic inversion, tomography products, large scale data migration curation of seismic events and waveforms data

mtpy: https://github.com/GeoscienceAustralia/mtpy2

Magnetotelluric (MT) Data Processing, Analysis, Modelling and Visualisation

geo-sampling:
https://github.com/GeoscienceAustralia/geo-sampling

Collection of advanced sampling methods used in geoscience

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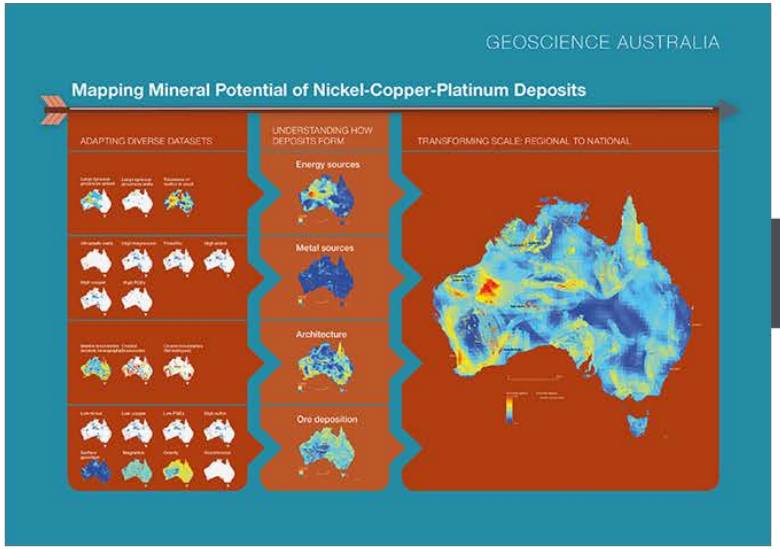
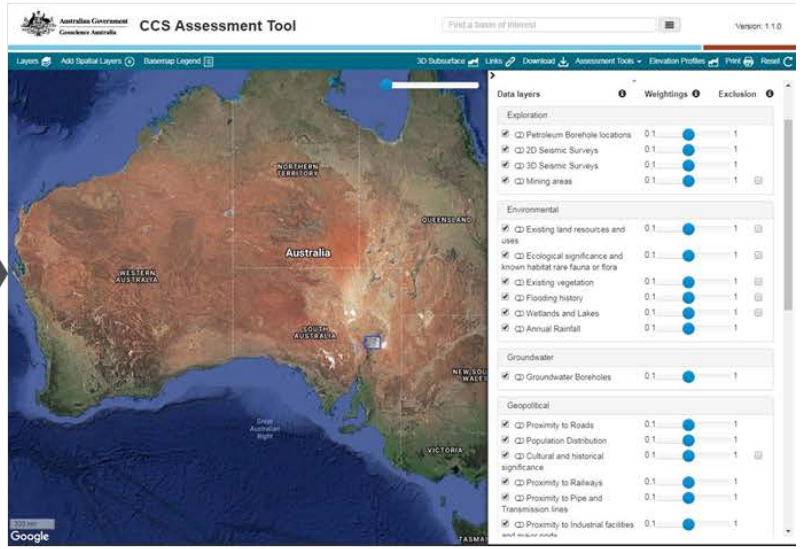
Integrated product suite: multi-criteria decision support

GIS based multi-criteria assessment



- Requires specialist GIS software
- Requires GIS expertise
- Transparent but static

Online multi-criteria assessment tool



- Available to anyone with internet access
- Requires **no** GIS software or expertise
- Interactive, repeatable and transparent

Beta version of portal and toolbox release at AGCC (October)

Richard.Blewett@ga.gov.au

Australian Government
Geoscience Australia

Exploring for the Future
minerals | energy | groundwater

Take home message

- Exciting program of unprecedented scale, scope and integrated skills
- Revolutionise understanding of northern Australia's resource potential
- Short-term success – deliver the program (new insights and new jobs)
- Medium-term success – change industry behaviour and attract significant new resource exploration and development investment
- Long-term success –exploration leads to new Tier 1 mineral/energy discovery and agricultural development that creates inter-generational wealth for all Australians.

AGCC Australian Geoscience Council Convention

BIG ISSUES AND IDEAS IN GEOSCIENCE

14–18 OCTOBER 2018 | Earth Science Week

Adelaide Convention Centre

AGC

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AGIA

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Supporting Geoscientists

Australian Society of Exploration Geophysicists

AusIMM THE MINERALS INSTITUTE

GEOLOGICAL SOCIETY OF AUSTRALIA

IAH AUSTRALIA

PESA

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