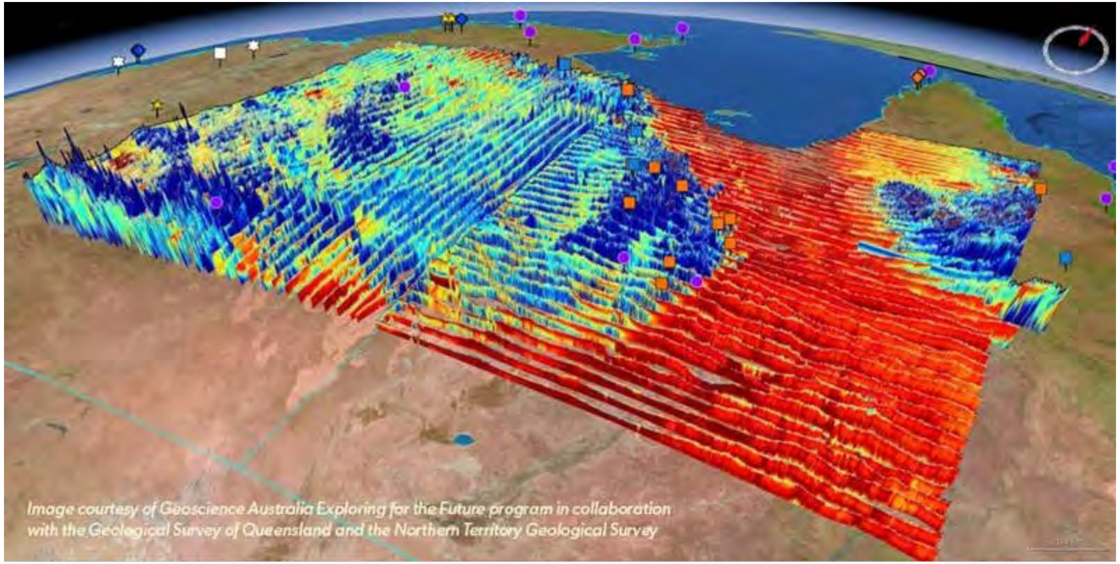
Science in the Surveys 2019

Tuesday 26 March 2019



AUSTRALIA MINERALS

Club Maitland City, Rutherford

Session Two

Chair: ***Kevin Ruming***

11:00 Exploration research towards Australia's future mineral production

Sandi Occhipinti, *CSIRO*

11:25 20 years of precompetitive geoscience data in the Capricorn Orogen: the link between mineral systems and crustal evolution

Simon Johnson, *Geological Survey of Western Australia*

11:50 Enabling data-driven exploration in north west Queensland

Helen Degeling, *Geological Survey of Queensland*

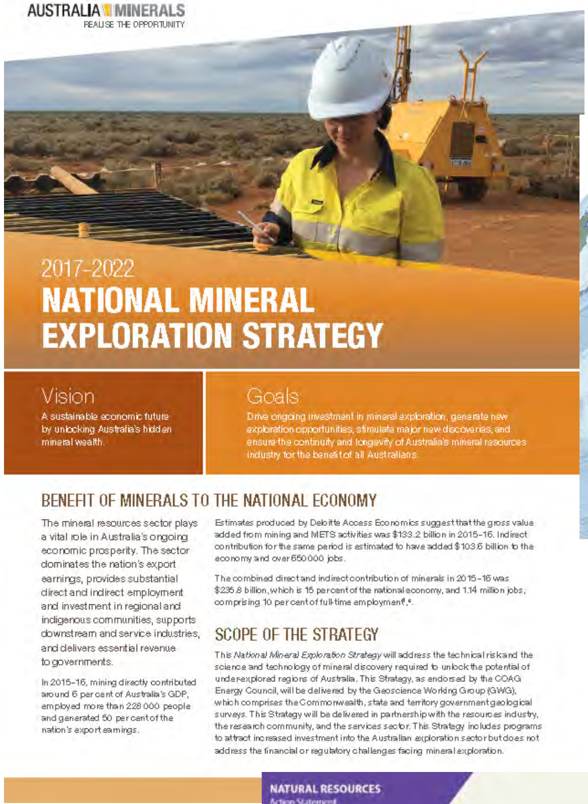
12:15 Shoring up the framework – Tasmanian geology and mineralisation

Andrew McNeill, *Mineral Resources Tasmania*

12:40 **Lunch**

Exploration research towards Australia's future mineral production

Sandra Occhipinti, CSIRO


AUSTRALIA MINERALS
REALISE THE OPPORTUNITY

2017-2022
NATIONAL MINERAL EXPLORATION STRATEGY

Vision
A sustainable economic future by unlocking Australia's hidden mineral wealth.

Goals
Drive ongoing investment in mineral exploration, generate new exploration opportunities, stimulate major new discoveries, and ensure the continuity and longevity of Australia's mineral resources industry for the benefit of all Australians.

BENEFIT OF MINERALS TO THE NATIONAL ECONOMY

The mineral resources sector plays a vital role in Australia's ongoing economic prosperity. The sector dominates the nation's export earnings, provides substantial direct and indirect employment and investment in regional and indigenous communities, supports downstream and service industries, and delivers essential revenue to governments.

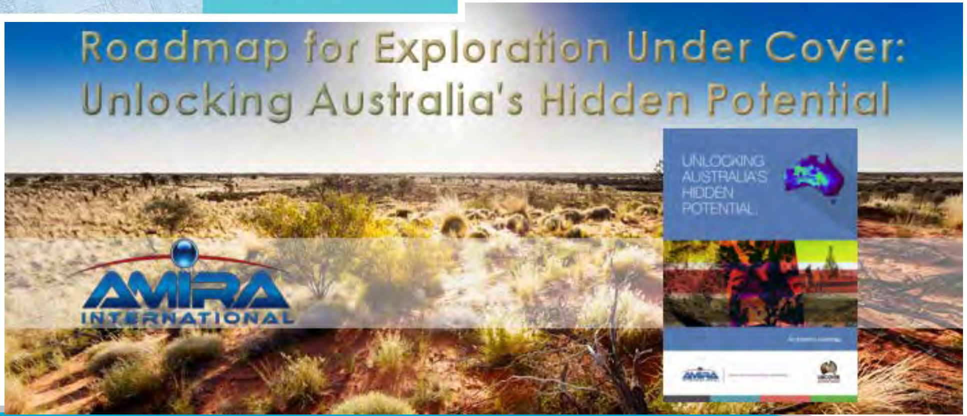
In 2015-16, mining directly contributed around 6 per cent of Australia's GDP, employed more than 228 000 people and generated 50 per cent of the nation's export earnings.

Estimates produced by Deloitte Access Economics suggest that the gross value added from mining and METS activities was $133.2 billion in 2015-16. Indirect contribution for the same period is estimated to have added $103.6 billion to the economy and over 650 000 jobs.

The combined direct and indirect contribution of minerals in 2015-16 was $235.8 billion, which is 15 per cent of the national economy, and 1.14 million jobs, comprising 10 per cent of full-time employment[1],[4].

SCOPE OF THE STRATEGY

This *National Mineral Exploration Strategy* will address the technical risk and the science and technology of mineral discovery required to unlock the potential of underexplored regions of Australia. This Strategy, as endorsed by the COAG Energy Council, will be delivered by the Geoscience Working Group (GWG), which comprises the Commonwealth, state and territory government geological surveys. This Strategy will be delivered in partnership with the resources industry, the research community, and the services sector. This Strategy includes programs to attract increased investment into the Australian exploration sector but does not address the financial or regulatory challenges facing mineral exploration.




NATURAL RESOURCES
Action Statement

ATSE

Increasing mineral discovery success

March 2018

Investment in low-impact, cost-effective technologies will assist in addressing the urgent need to increase the success rate of discovering new, internationally competitive Australian mineral deposits in increasingly challenging geological, environmental and social conditions.

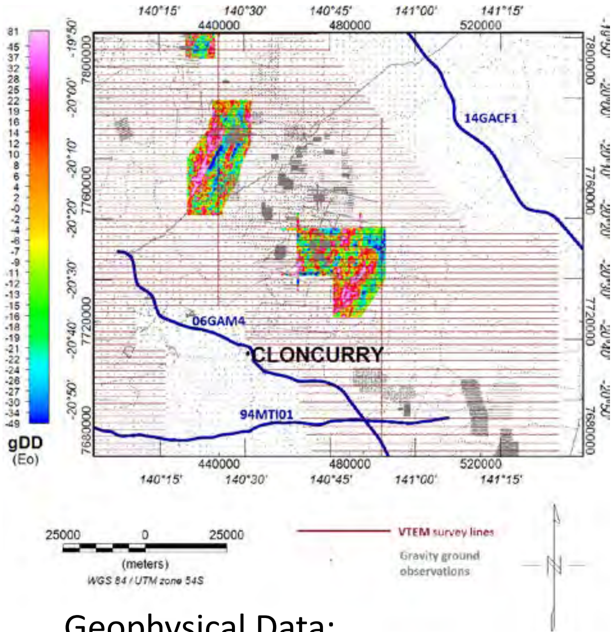
CSIRO

Exploration Undercover

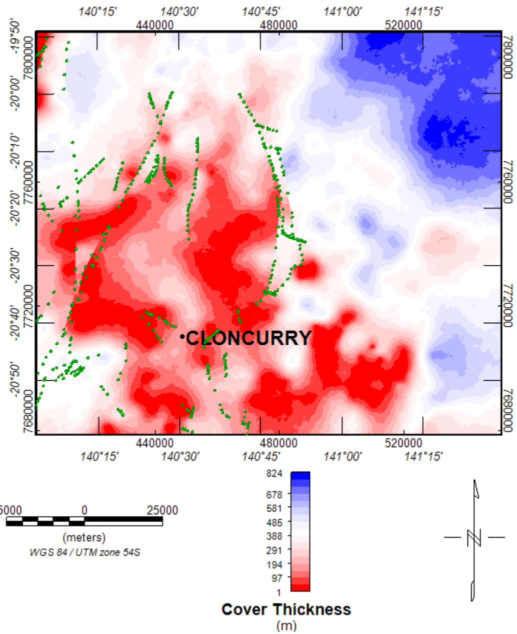
- Defining new search space/s
- Using a mineral systems approach
- Eliminating – spurious elements from analyses
- Using data analytics/machine learning
- Interdisciplinary & multidisciplinary approach to teams
- Collaborating
- Listening
- Taking risks

Base line, cover thickness & uncertainty mapping?

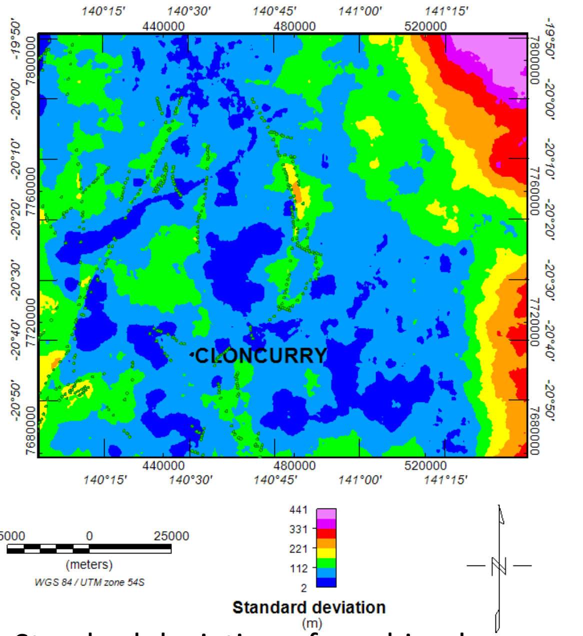
Jelena Markov & Gerhard Visser
Deep Earth Imaging, FSP



Geophysical Data:
Ground Gravity
Seismic lines
VTEM (EM) survey lines
AGG (airborne gravity gradiometry grids
& other data.....



Distribution of cover thickness (sediments)
Faults displayed, where observed in field
In some areas faults control thickness distribution



Standard deviation of combined thickness estimate from distribution of cover thickness. Measures uncertainty of results
Useful for ground-truthing

Ore deposits – McArthur River (HYC)

Sam Spinks et al., AGES

NT.GOV.AU

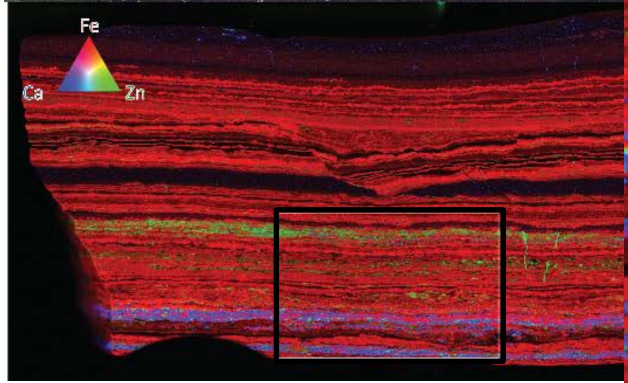
Stripping back through paradigms of ore deposit models and getting to the real story

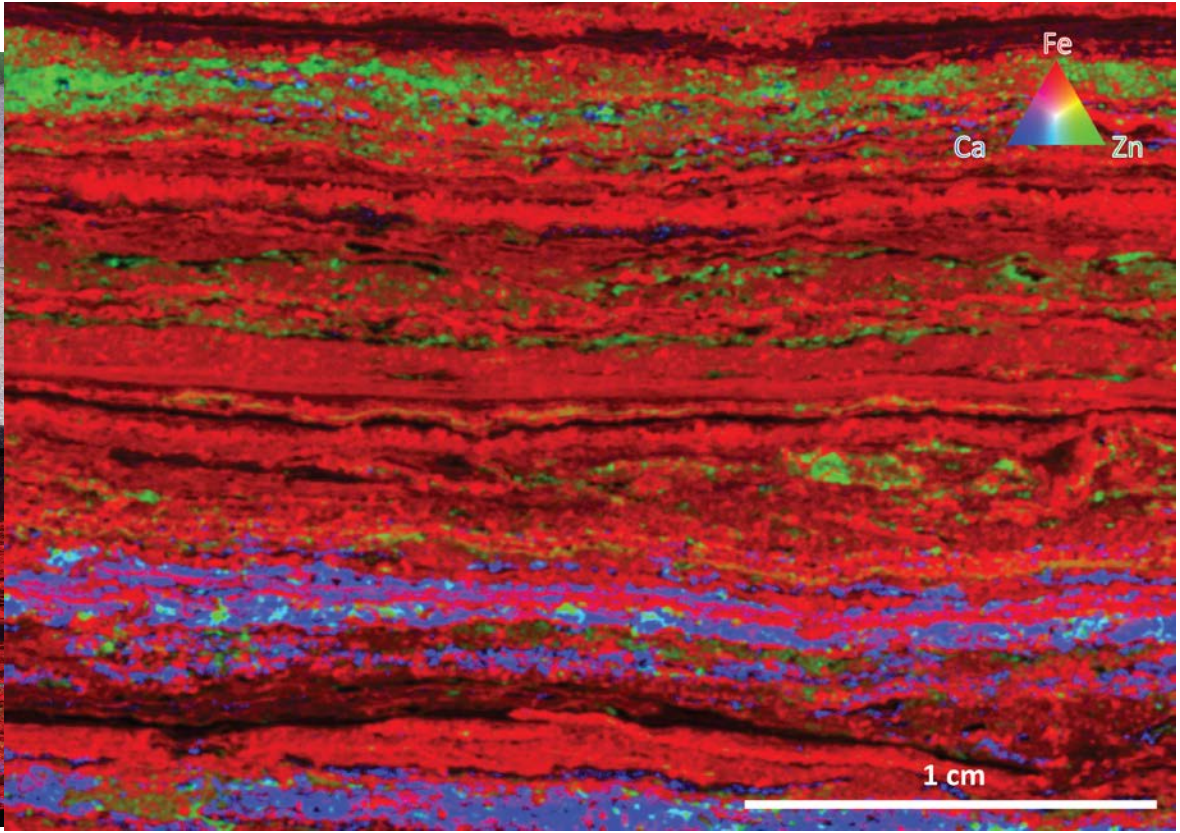
Observation	Syndepositional Model	Diagenetic-epigenetic model
Laminated ore textures	Consistent with deposition from water column	Can be produced by replacement of sedimentary (carbonate) layering
Timing of sphalerite and galena mineralization	Not consistent	Deposition of base metal sulfides after latest diagenetic pyrite indicate diagenetic-epigenetic model
Lithogeochemical haloes (Tl)	Enrichment of Tl up to 200 m above ore zone could result from low-T fluid after main-stage mineralization	Enrichment of Tl up to 200 m above ore zone *indicate* fluid flow well after deposition of ore-hosting sediments low-T fluid after main-stage mineralization

After Huston et al. 2006; Econ. Geol.

McArthur River (HYC)- Carbonate Replacement

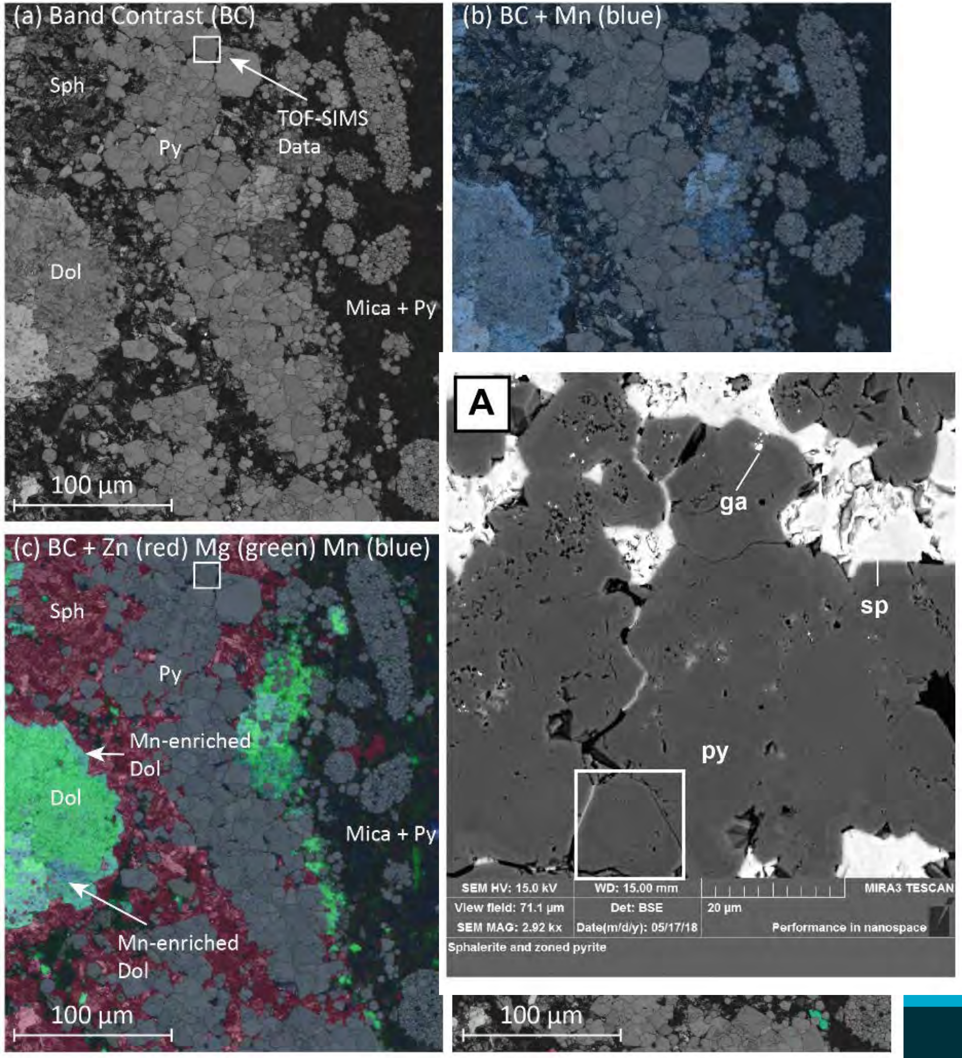
Sam Spinks et al., AGES

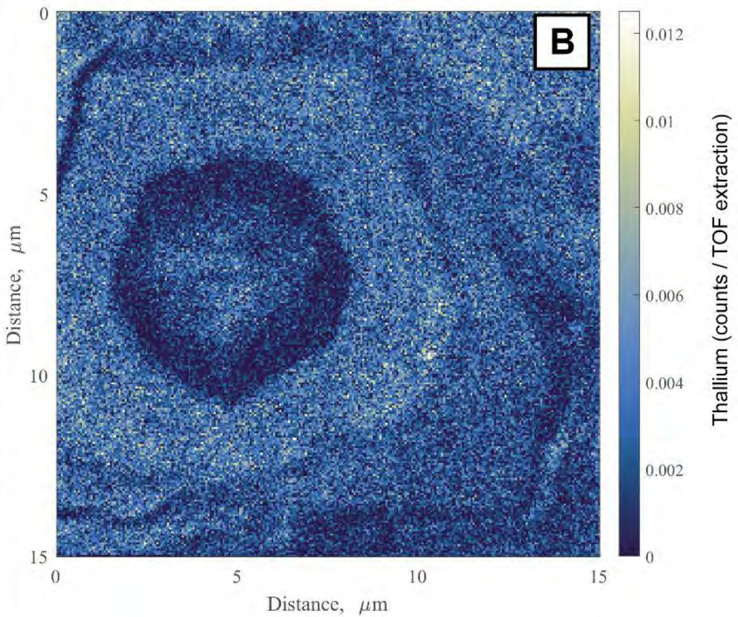




Sam Spinks et al., AGES

McArthur River (HYC)- Carbonate & Zinc & Thalium relationship

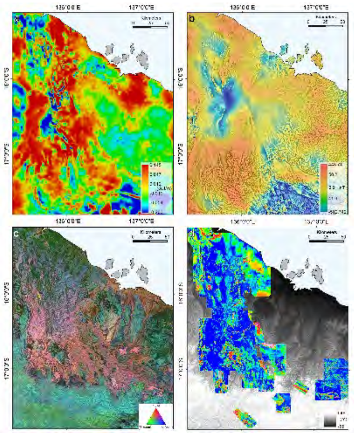


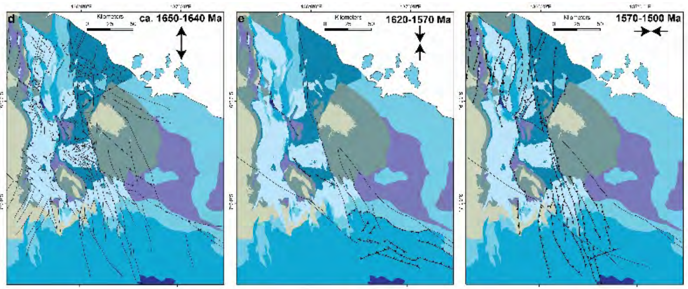


McArthur Basin: Geophysical interpretation and modelling

Northern Territory Government

Teagan Blaikie et al., AGES

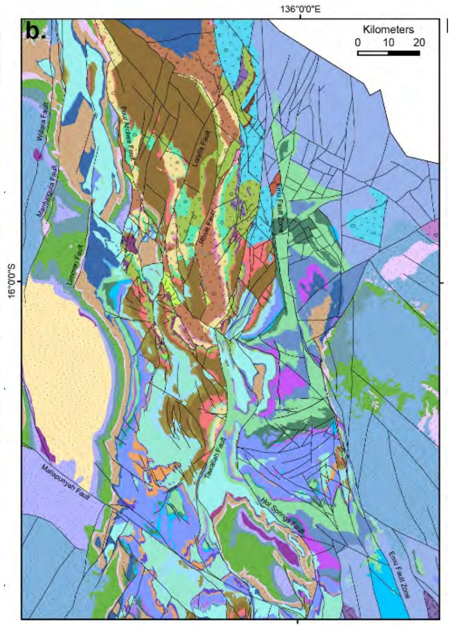




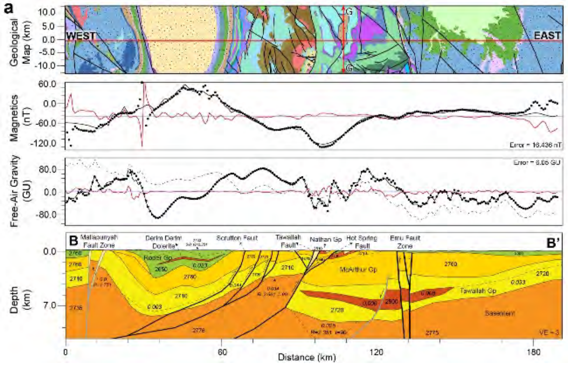
Middle McArthur Group
(Isa Superbasin)

Upper McArthur/Nathan Groups
(Early Isan Orogeny)

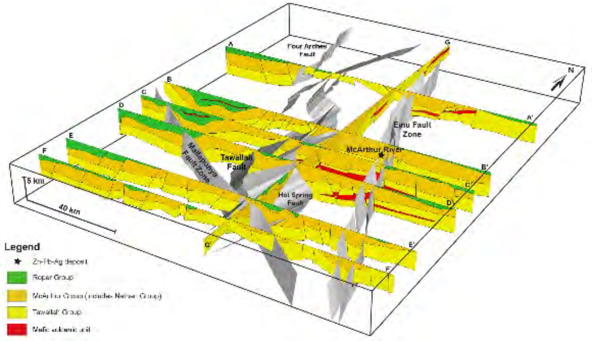
Deformation and erosion
(Late Isan Orogeny)



Solid geology and fault event interpretation



Geophysical modelling of basin architecture

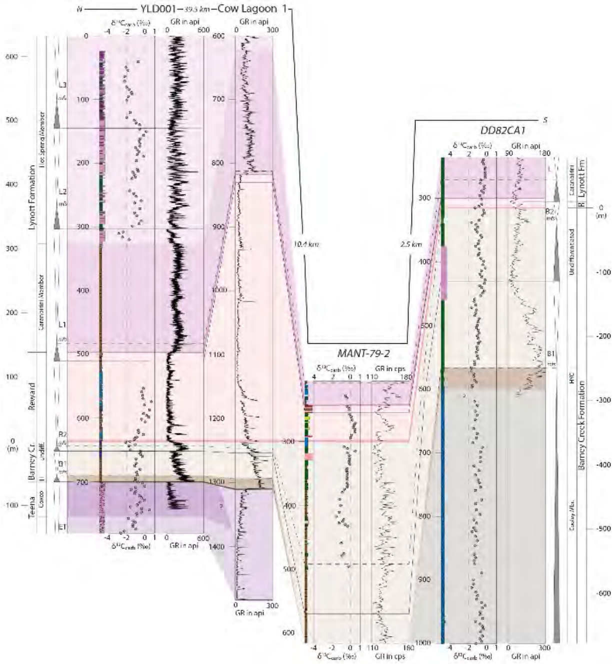


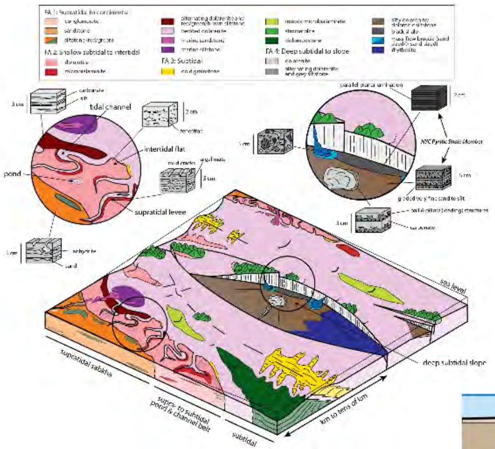
Architecture & time

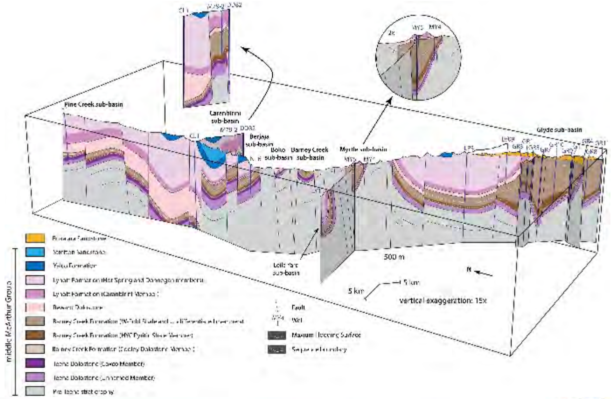
CSIRO

Integrating structural interpretation with Basin analysis *to develop region-specific targeting concepts for sediment-hosted mineral systems – Marcus Kunzmann*

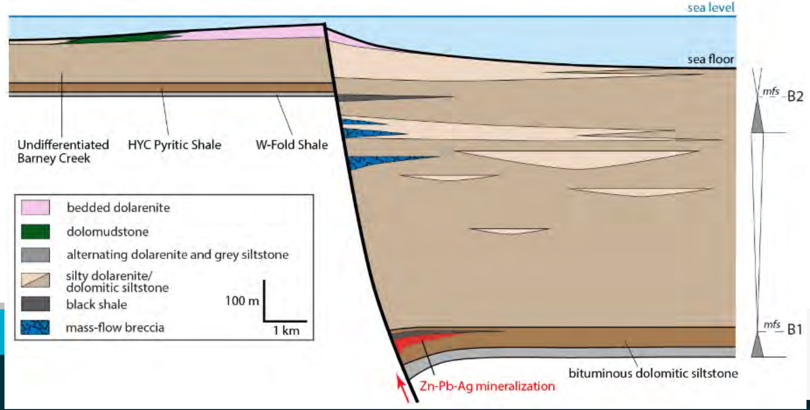
- Facies analysis, sequence stratigraphy, chemostratigraphy, tectonostratigraphy







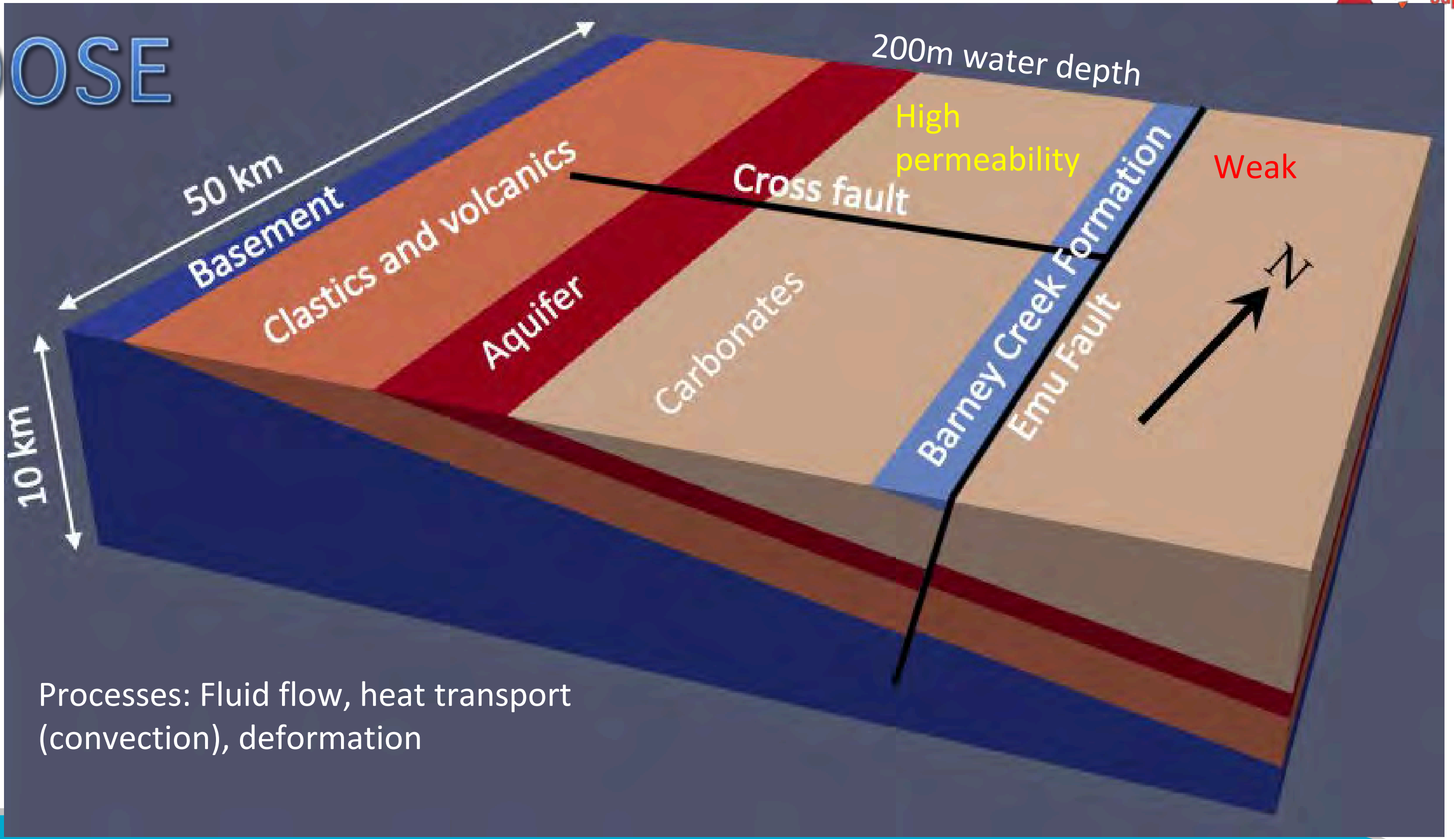
Fertility & Architecture



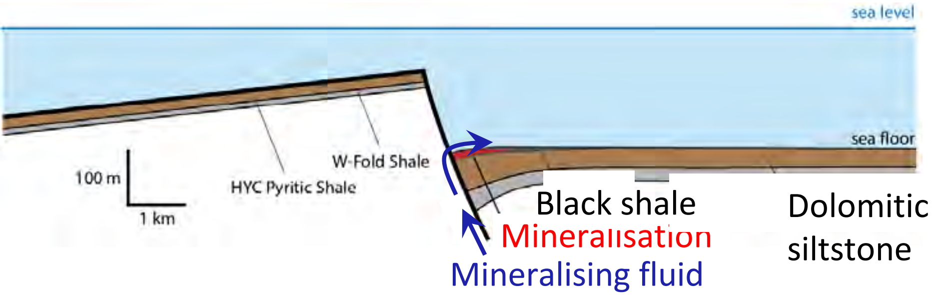
e.g., Kunzmann et al., 2019, Ore Geology Reviews

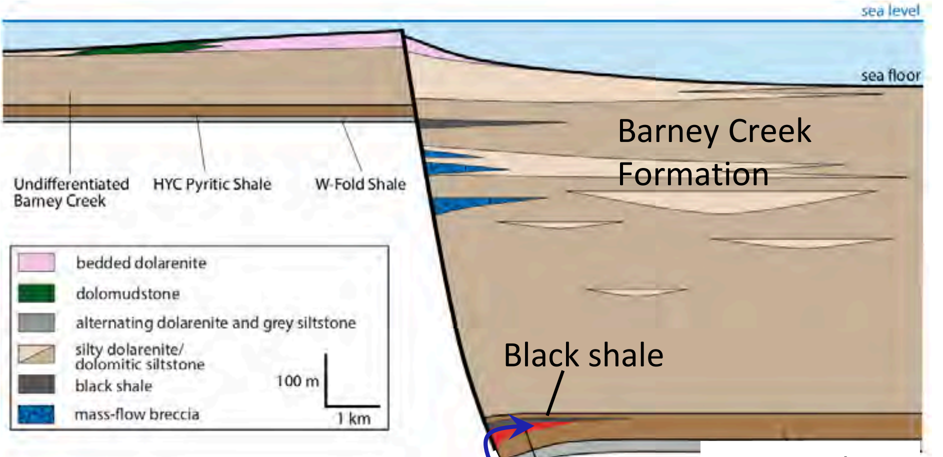
Numerical model – *testing what we think is going on*

Heather Sheldon et al., AGES



Stratigraphic interpretation

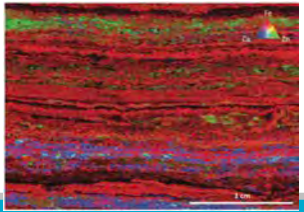




Kunzmann et al. 2019

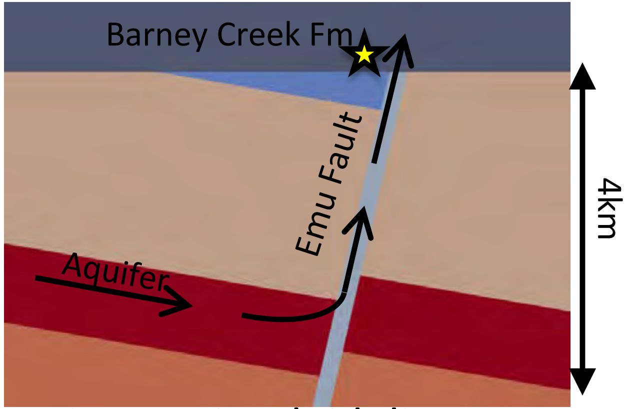
Syngenetic scenario: black shale = chemical trap on seafloor

Diagenetic scenario: black shale = seal, diverting fluids into BCF

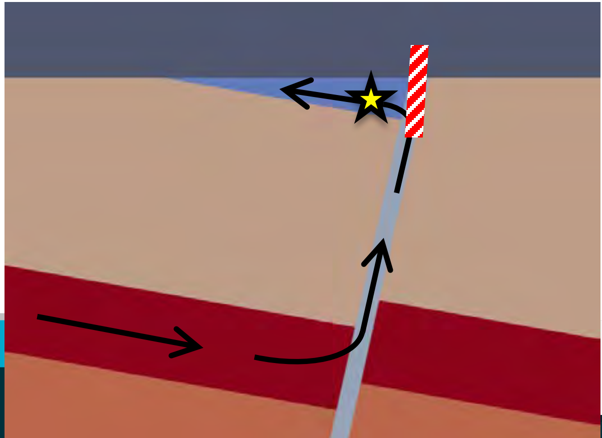


Spinks et al. 2019

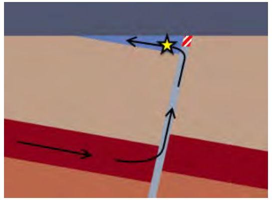
Syngenetic: Fluid flows up Emu Fault to seafloor



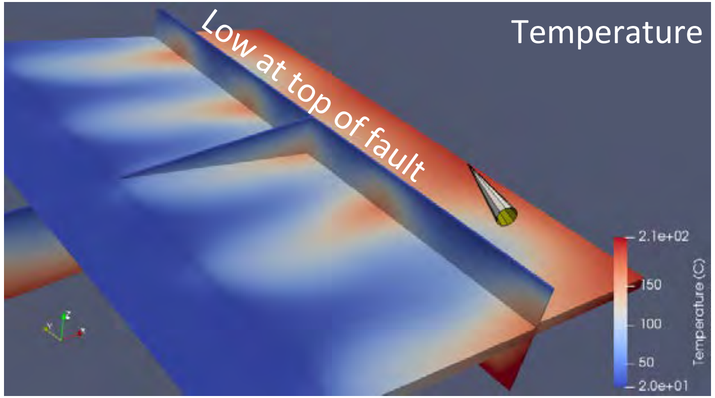
Diagenetic: Fluid diverts out of Emu Fault into BCF

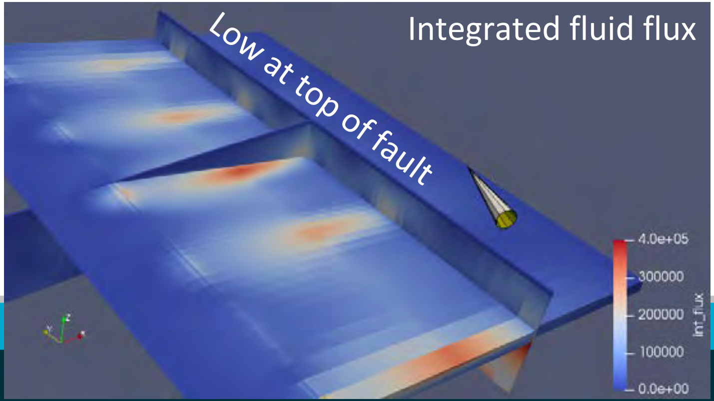


Results: Thermal convection, diagenetic scenario

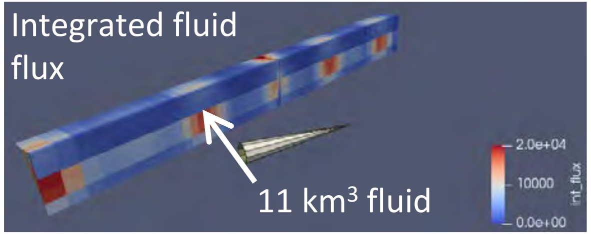


Aquifer and faults





Barney Creek Fm
(vertical exaggeration x10)



Note, no deformation

Next steps

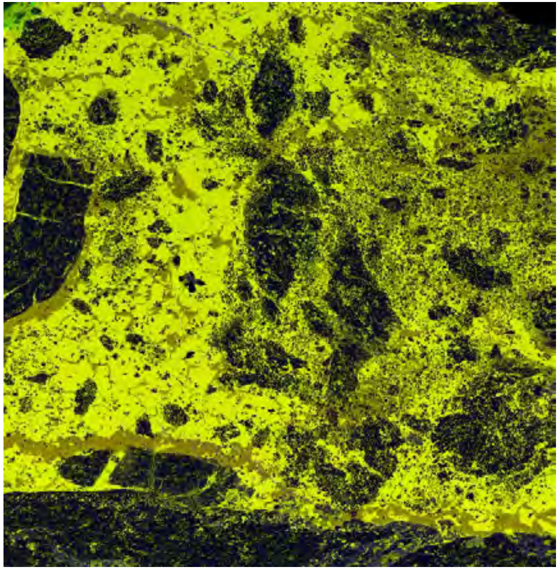
- Apply more realistic geometry/architecture to assist in exploration targeting (Sheldon,Schaubs, Blaikie)
- Application to another area (Sheldon, Schaubs, Blaikie, Schmid)
- Introduction of salinity into models – investigating relative importance of salinity & temperature in driving fluid flow (Sheldon, Schaubs, Poulet)
- Update permeability with deformation (Poulet, Sheldon, Schaubs)
- Introduce reactive transport into the models, testing ideas about geochemistry & reactions that take place in the system (Mei, Lui, Spinks, Schmid, Sheldon, Poulet et al)

MRIWA Project xxxx with companies: For more information, contact Peter Schaubs: peter.Schaubs@csiro.au

R+ postdoc applications, May 2019

Strategic Projects – Discovery, CSIRO

Characterising breccia-hosted mineral systems – *an exploration to resource calculation & mine operations project…. In development*



Maia mapper image, breccia ore

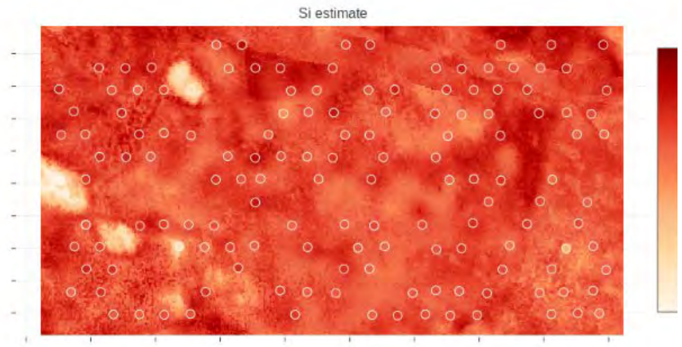
Understand the role of breccia in mineral systems:

- establish criteria for recognising distal fringes of breccia-hosted systems
- develop optimal strategies for imaging and chemically analysing breccia ores at multiple-scales
- establish protocols for meaningful geostatistical evaluation and delineation of mineral resources in breccia-dominated systems
- Determine ore deportment, hardness, metallurgical constraints (partnering with Mining & Processing)

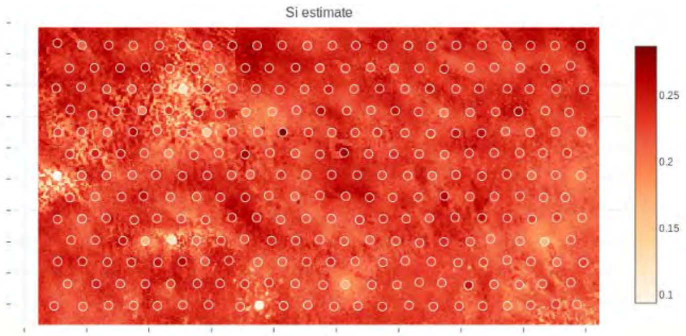
Barnes, Poulet, Pearce, Vernon et al

Innovation in the SAMPLING approach

- SMART SAMPLING… how many samples are needed and where do you collect them
- In this example we could have done 50% less, big economic savings
- This is a rough example – it could be much better, we should achieve the same with 80% less samples, using the algorithm to guide next sample selection



50% samples removed at random



100% samples

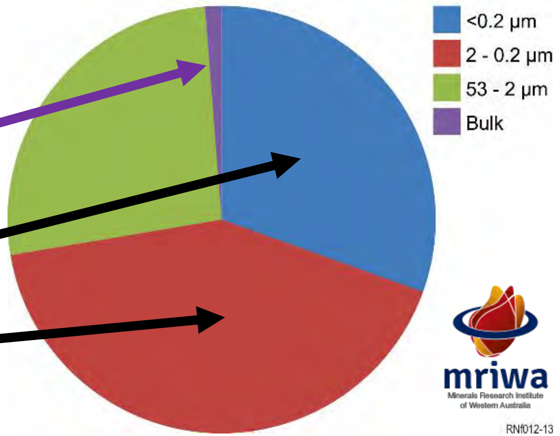
Exploration through cover

- M462 - Multi-scaled near surface exploration using ultrafine soils

Mineral	Diameter (µm)	Surface/exchange area (m^2/g)
Sand	50-2000	0.04
Silt	2-50	0.1
Clays	**< 2**	**5 - 800**

Why are we mainly sampling this?

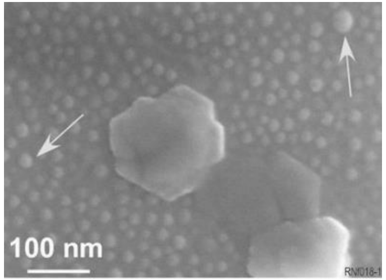
Average total gold by size in dune sands n=14



Benefits of fine fraction concentration

- Enhance concentrations from dune sands to 10s ppb
- <u>More reproducible/reliable</u>
- Big upside for detection, reproducibility and exploring through cover for subtle Au, Cu, Zn signatures

Ryan Noble



soils commercialised workflow

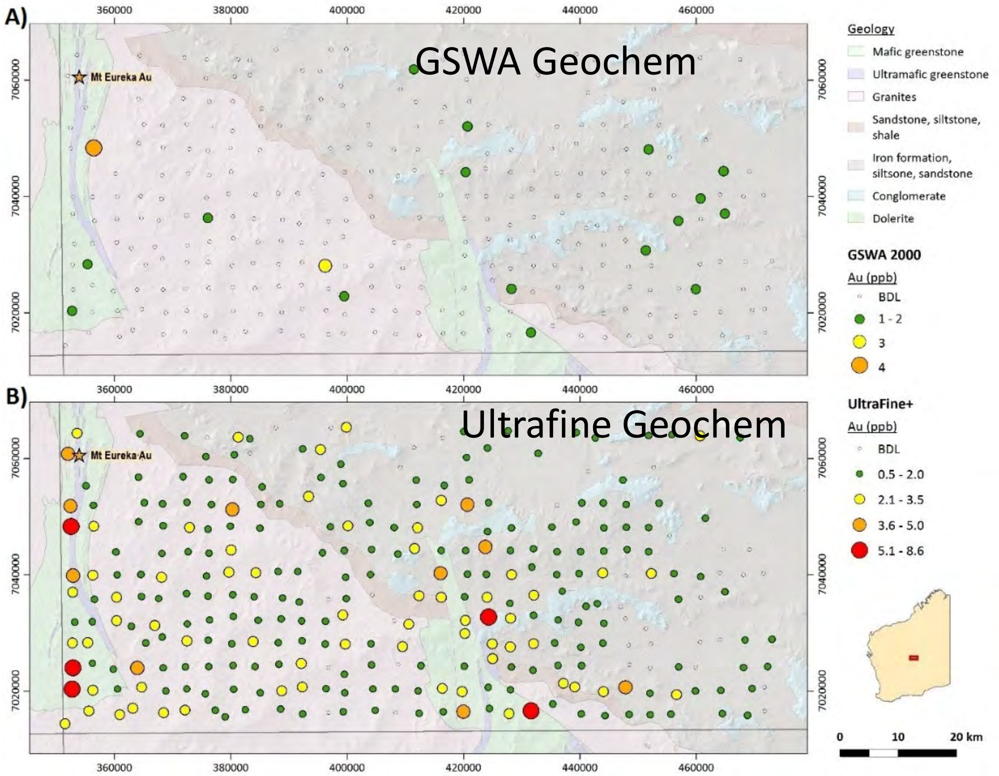
A) Original sampling and analysis by GSWA (2000)

- <180 µm/80 mesh, milled. 18 of 300 with Au

B) Same samples using UltraFine+

Additional spectral and physical properties

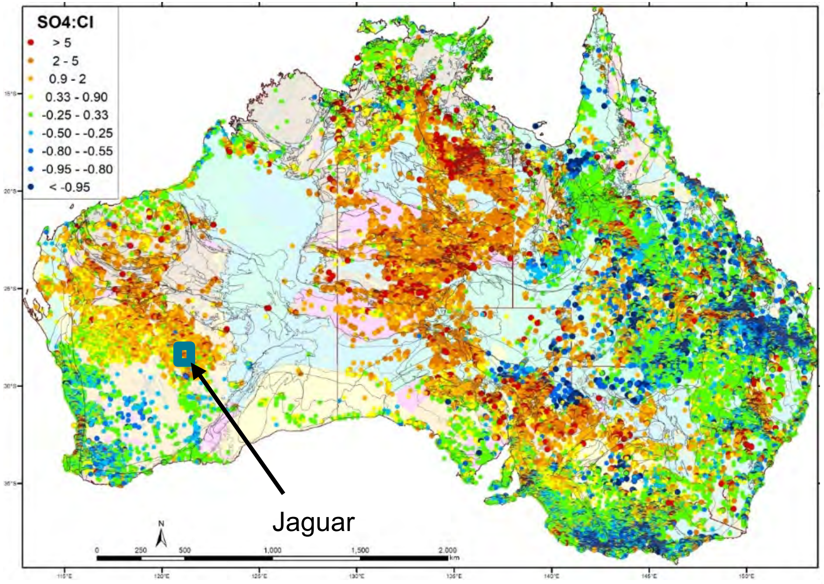
Future will be Machine learning/uncertainty maps for industry at a click of a button to come

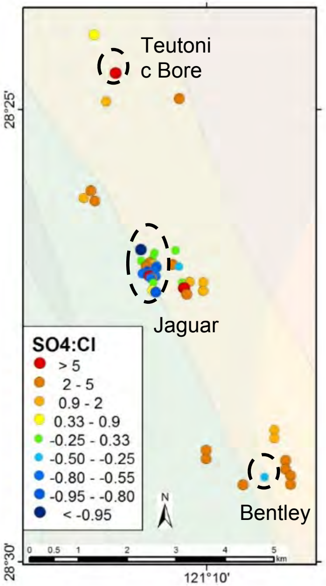


Gray, Reid, Thorne et al

Hydrogeochemistry of scale

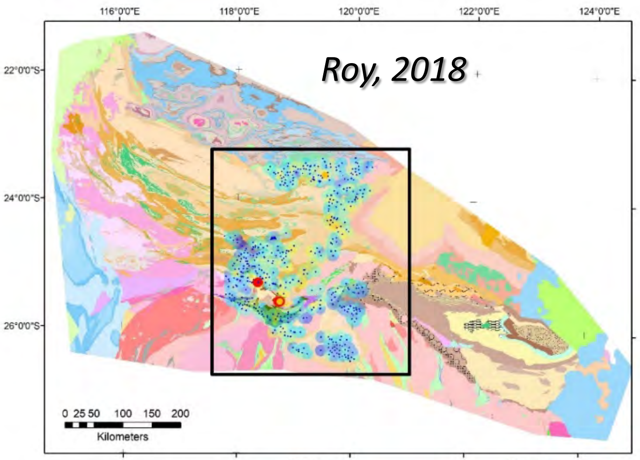
Continental scale can provide major lithological information
Deposit scale can identify anomalies linked to weathering sulfides

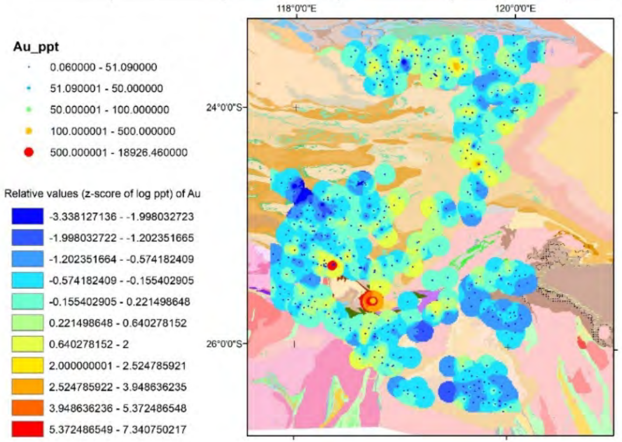


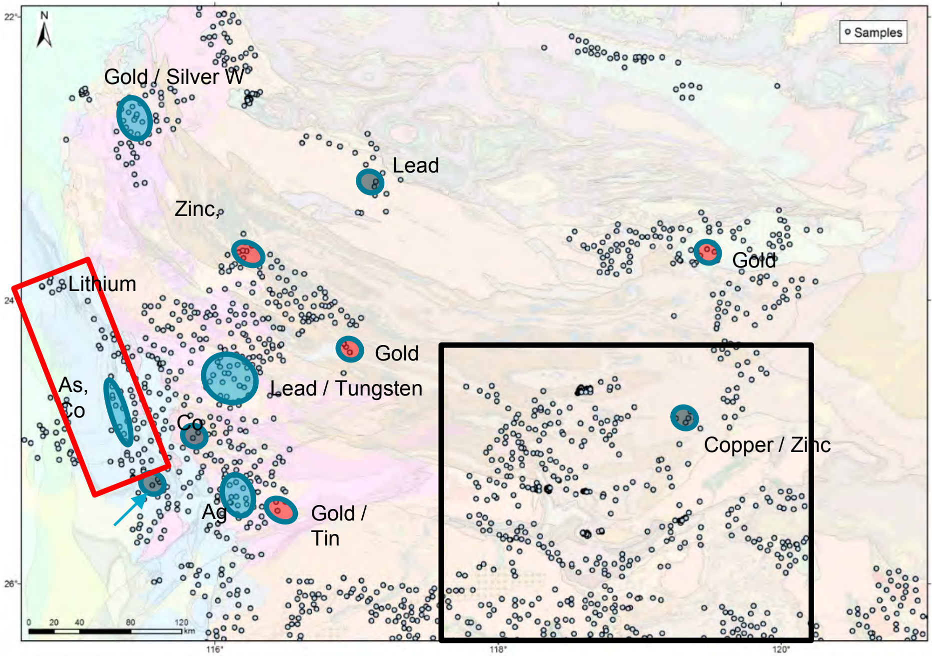


Hydrogeochemistry to 'see' and detect through cover

Reid, Thorne, Roy, Gray et al







120 km

- New targets

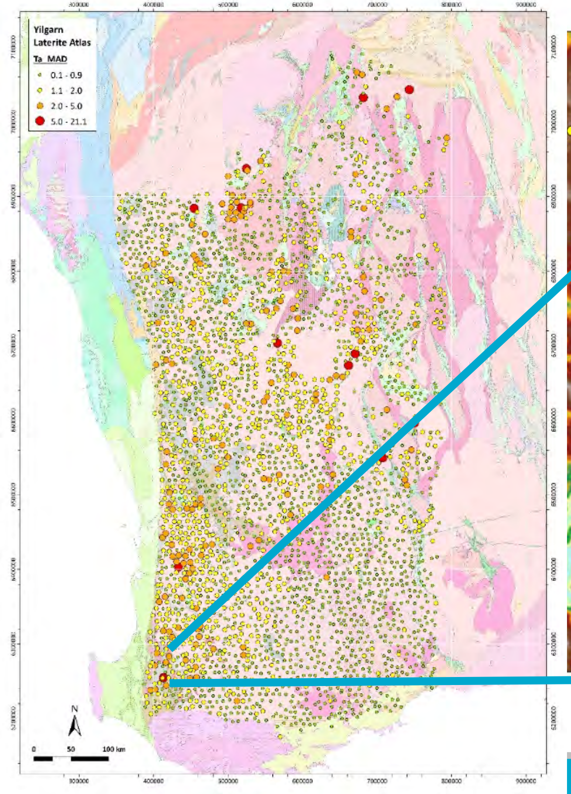
Capricorn
DISTAL FOOTPRINTS

CSIRO

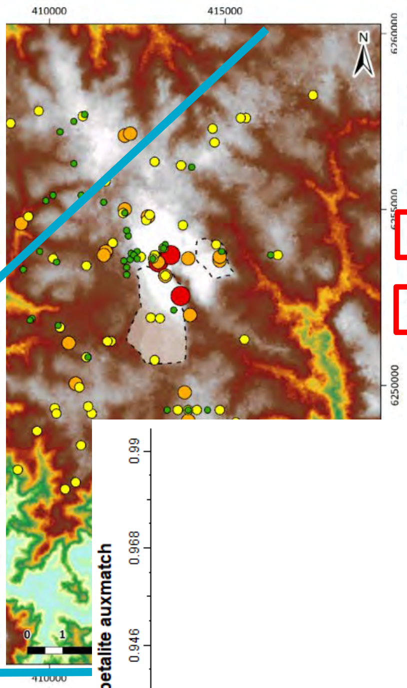
Old samples, new targets/opportunities?

LeGras, Laukamp, Anand

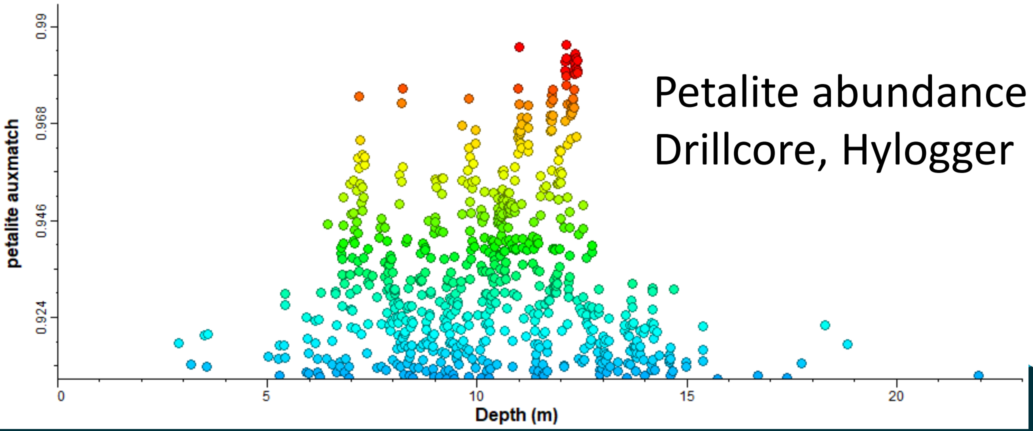
Ta in Fe pisoliths



Li in Fe pisoliths over Greenbushes

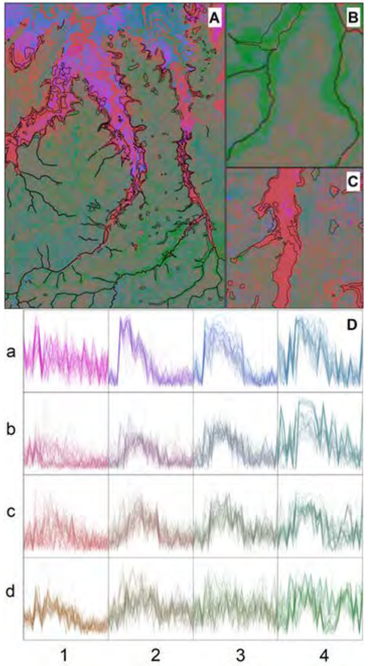


	Formula	SWIR 1200 - 2500 nm	TIR 6000 – 14500 nm
Amblygonite	$LiAl(PO_4)F$		x
Elbaite	$Na(Al_{1.5}Li_{1.5})Al_6(Si_6O_{18})(BO_3)_3(OH)_3(OH)$	x	x
Eucryptite	$LiAlSiO_4$		x
Hectorite	$Na_{0.3}(Mg,Li)_3Si_4O_{10}(F,OH)_2 \cdot nH_2O$	x	x
Lepidolite	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	x	x
Lithiophilite	$LiMn^{2+}(PO_4)$		x
Neptunite	$KNa_2LiFe^{2+}{}_2Ti_2Si_8O_{24}$		x
Petalite	$LiAlSi_4O_{10}$		x
Polylithionite	$KLi_2AlSi_4O_{10}F_2$	x	x
Spodumene	$LiAlSi_2O_6$		x
Zinnwaldite	$K(Al,Fe,Li)_3(Si,Al)_4O_{10}(OH)F$	x	x

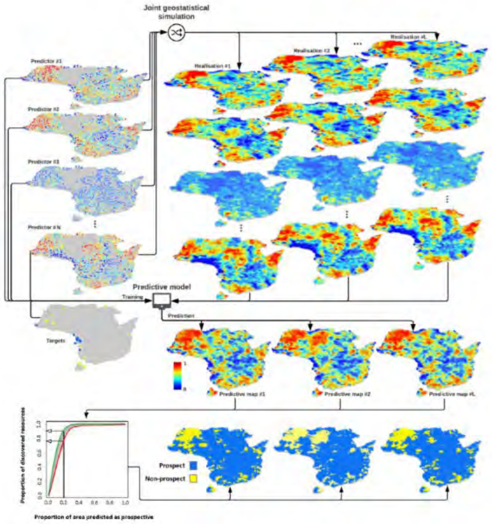


Petalite abundance
Drillcore, Hylogger

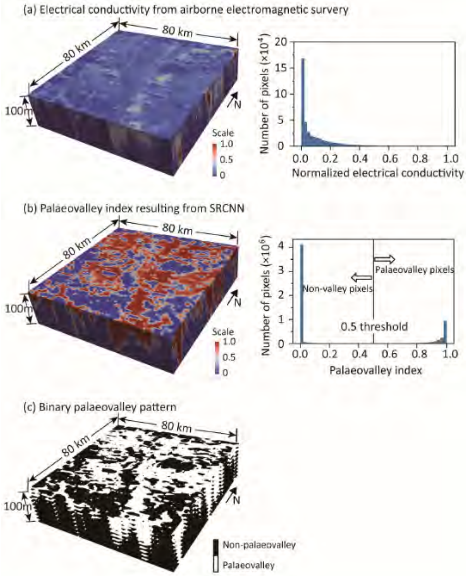
Data assimilation and value of information



Castellazzi:
GDE identification from SAR



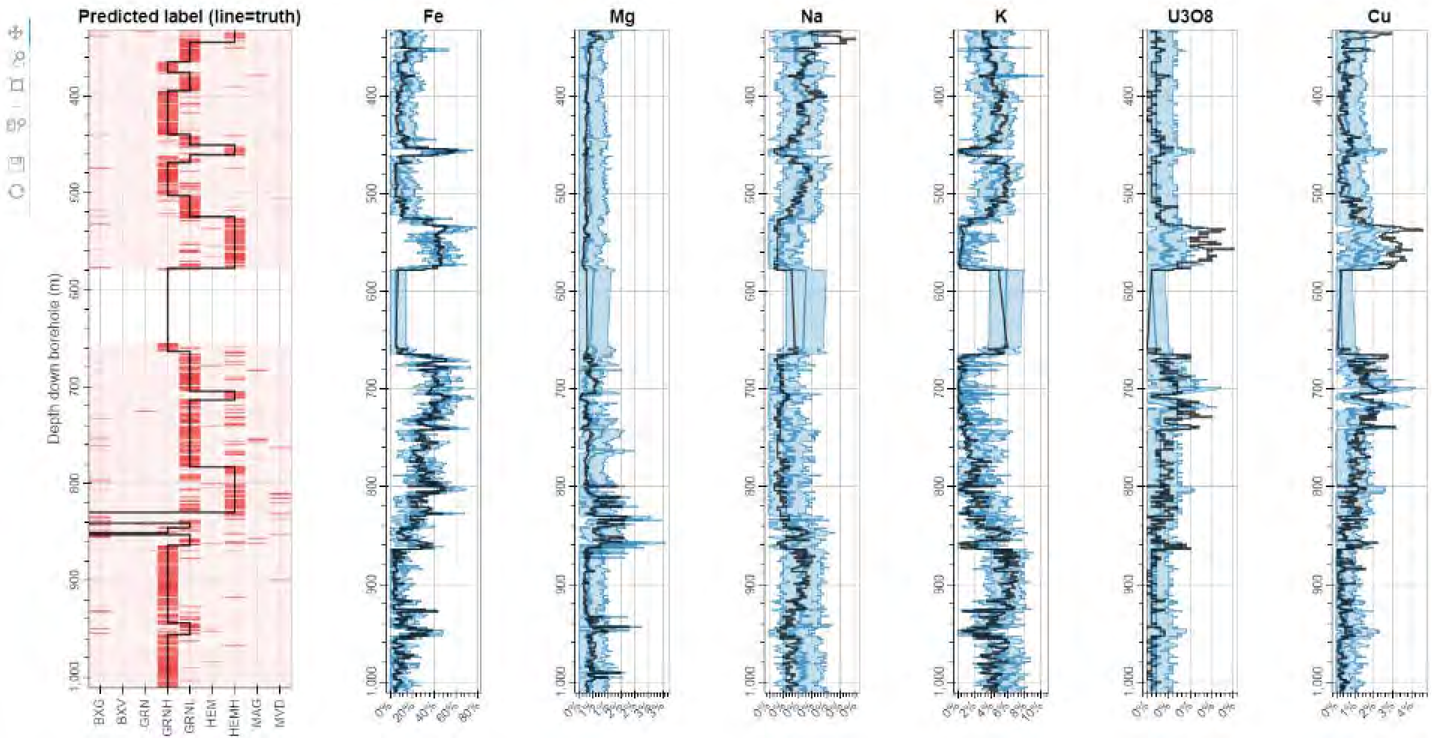
Talebi:
Joint geostat + ML for gold prospectivity



Jiang:
ML to identify
paleochannels from AEM

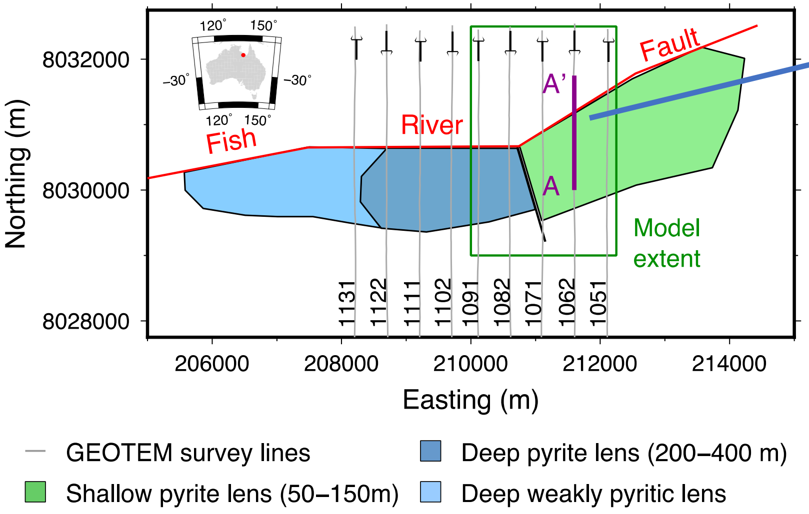
Rosetta – Predictive analytics

- **Outcome:** From hyperspectral images, we can probabilistically predict lithological labels, *modal* chemistry and mineralogy



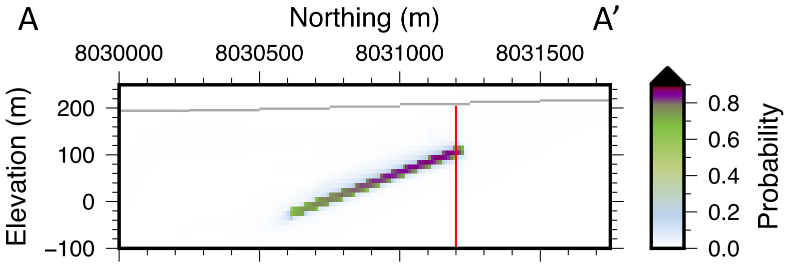
Probabilistic inversion for a basement conductor

Inverting multiple survey lines for a single basement conductor



Legacy GEOTEM data from Walford Creek, Queensland, Australia

Cross-section through the probability to intersect the target



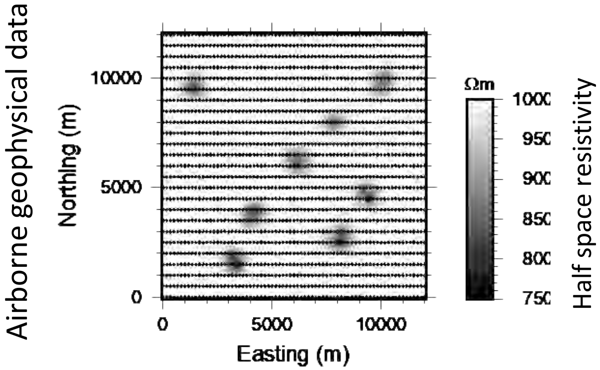
- Geologically plausible target is to the south of the fault
- Identification of a shallow drillable target
- Quantifying the possibility of a larger target

Hauser, J., J. Gunning, and D. Annetts, 2016, Probabilistic inversion of airborne electromagnetic data for basement conductors: Geophysics, 81, E389 - E400.

Contact: Juerg.Hauser@csiro.au

Objective target ranking for greenfield exploration using AEM data

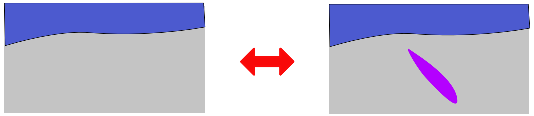
Which conductivity anomalies are potentially economic basement conductors?



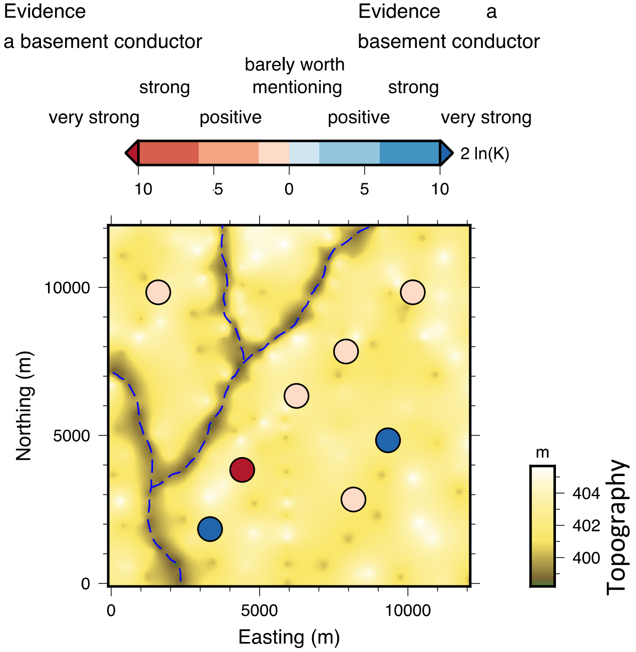
Apply Bayesian model selection concepts to quantify the likelihood

No “economic” basement conductor

An “economic” basement conductor



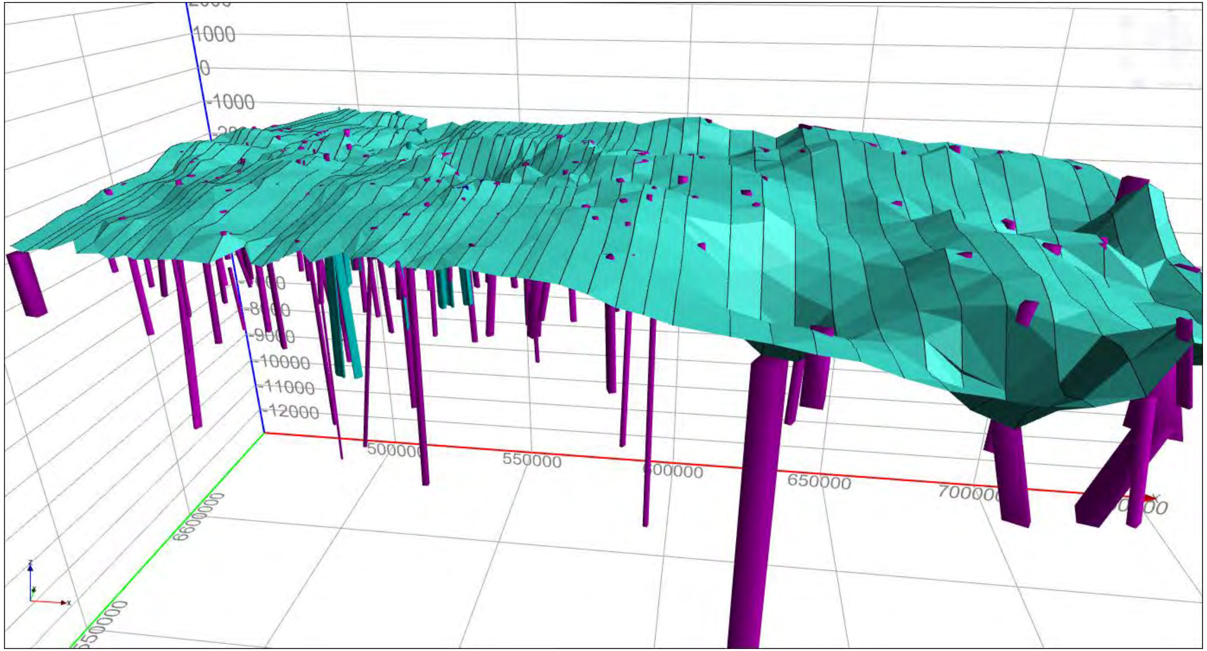
Focus the exploration program on anomalies that are likely to be caused by basement conductors



Contact: Juerg.Hauser@csiro.au

Jim Austin et al.,

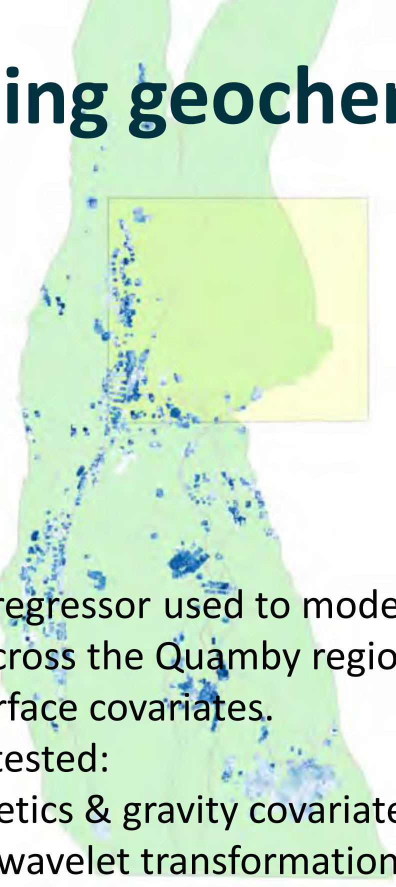
Construction of basement surface from high quality magnetic source depth estimates



Coompana basement surface

Predicting geochemistry/prospectivity using ML

Cole et al.

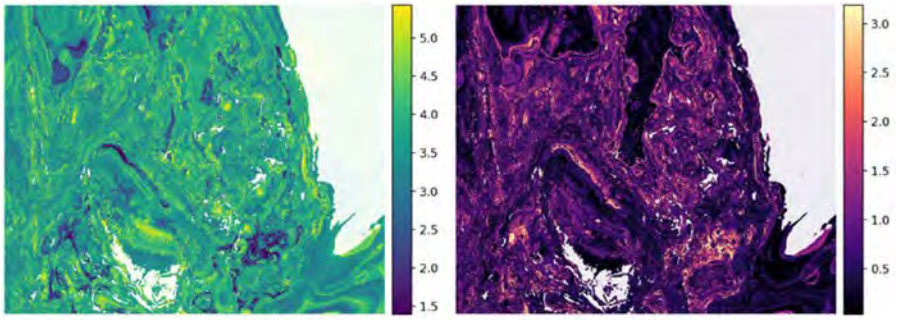


Random forest regressor used to model geochemistry across the Quamby region based on subsurface covariates.

2 models were tested:

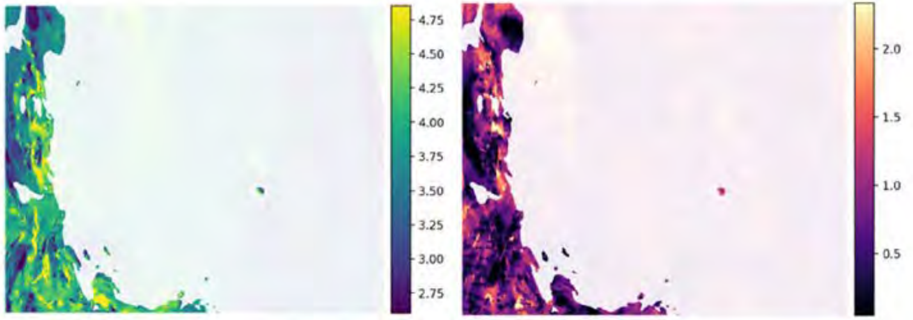
a. using magnetics & gravity covariates;
b. addition of wavelet transformations

Figure 9.1.: Geochemistry model training points (showing Cu values) over larger east succession and Quamby region outline.



(a) log(Cu) prediction.

(b) log(Cu) uncertainty.



(a) log(Cu) prediction.

(b) log(Cu) uncertainty.

Figure 9.7.: Quamby Cu prediction/uncertainty (magnetics and gravity covariates with wavelet features masked by covariate shift).

AuScope

Virtual Research Environment (AVRE) — Data, Visualisation & Analytics

Welcome to the AuScope Virtual Research Environment (AVRE), Australia's home of geoscience data and tools that help scientists place the next pieces of our giant, continental puzzle.

The AVRE is a rich ecosystem of Findable, Accessible, Interoperable and Reusable (FAIR) data and tools contributed to by a diverse range of Australian research organisations, government

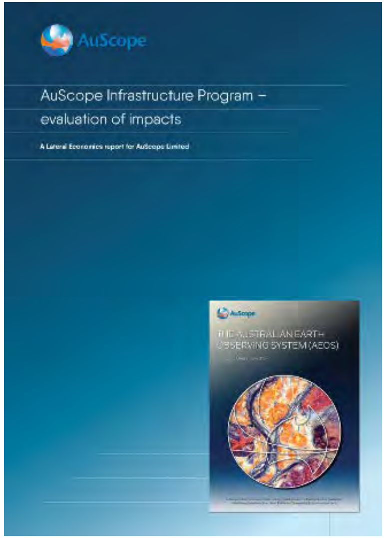
- NVCL
- Mobile Petrophysical Laboratory (Infrastructure)
- Thermodynamic Infrastructure
- FAIMS – adaptable field mission planning templates

Impact

AVRE has improved the availability and accessibility of comprehensive geoscientific data in Australia. Key impacts include $912M of realised value to mineral exploration, as well as $458M in gold discoveries and $35M per annum in mining efficiencies.

Aside from the key findings by Lateral Economics and CSIRO, the AVRE has been recognised by BOM in the Information Platform for Bioregional Assessments Phase One Information Architecture report (20-12-2012).

1 — Lateral Economics, 2016
2 — CSIRO, 2014



CSIRO

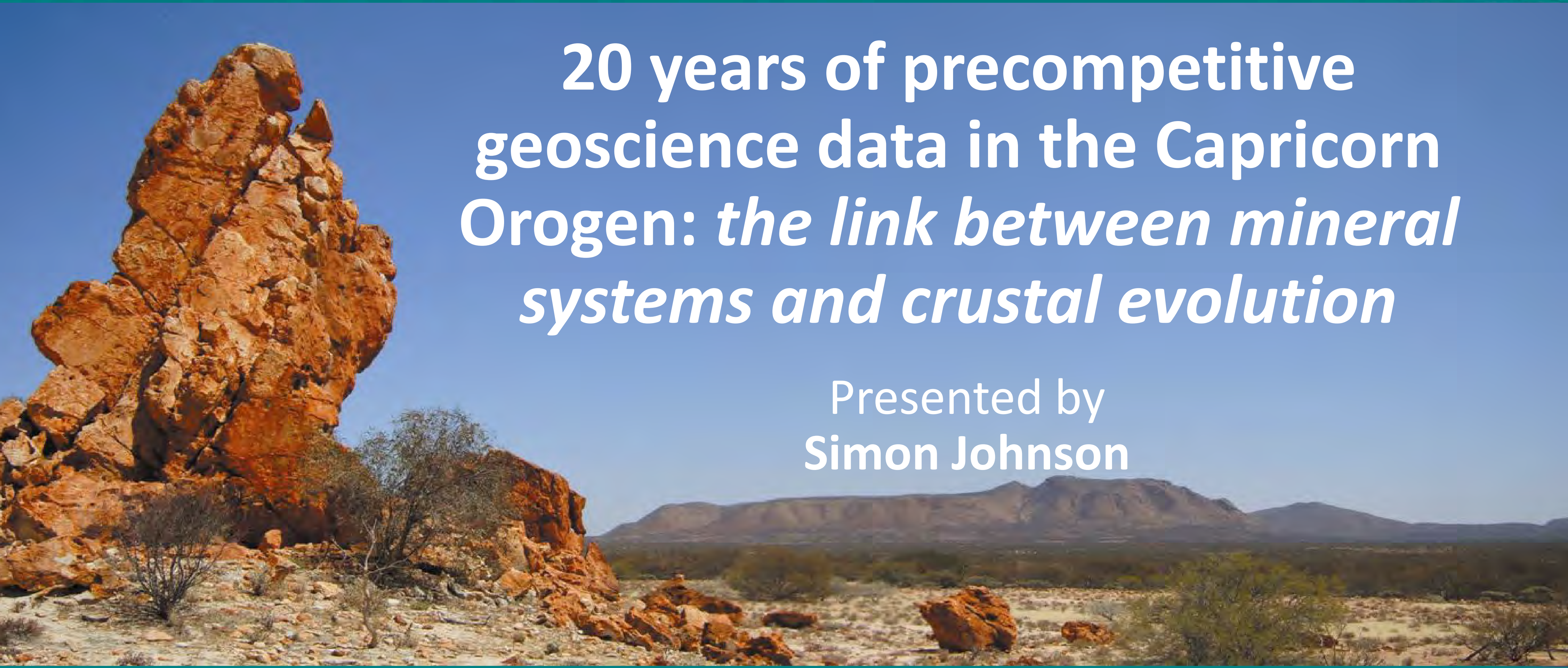
Industry Led Agenda

- Opening up new search spaces
- Working with Universities, GA, State Surveys & Industry

Discovery

Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**
Geological Survey of Western Australia

20 years of precompetitive geoscience data in the Capricorn Orogen: *the link between mineral systems and crustal evolution*



Presented by

Simon Johnson

Precompetitive geoscience data and geological surveys

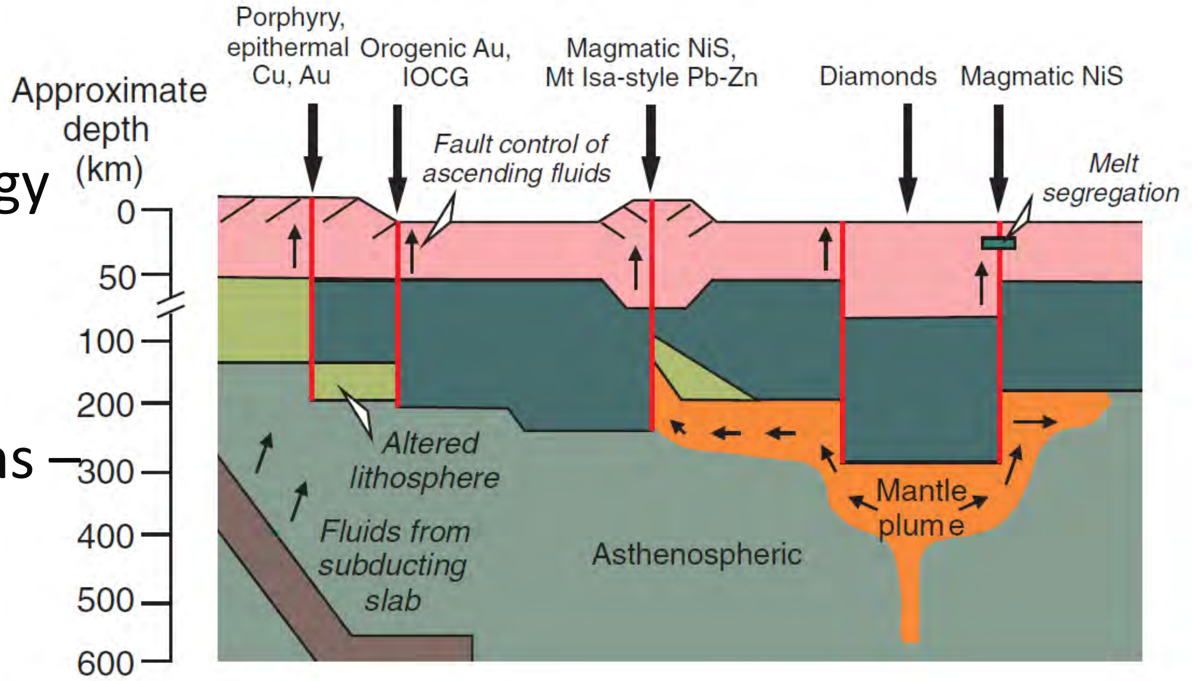
Reduce financial risk to explorers – better use of exploration expenditure – target smaller, more prospective regions for investigation

Free and FAIR (**f**indability, **a**ccessibility, **i**nteroperability, and **r**eusability) geoscience data

State geological surveys:
Mapping, geophysics, geochemistry, geochronology

Next step to link data to exploration strategy:

Craton to province-scale drivers of mineral systems – crustal architecture, geodynamic and tectonic processes, timing of mineralization



20 years of mapping in the Capricorn Orogen

1st edition mapping of the State at 1:250k scale complete by late 1970s

Invention of the SHRIMP (high-precision geochronology) drove State remapping at 1:100k scale in the late 1980s

1:100k scale mapping in the Capricorn Orogen started in 1998 – finished exactly 20 years later (55 map sheets)

- analytical advances during mapping led to an 'Enhanced Geochronology' program
- geophysical advances – vibroseis seismic reflection, passive seismic, ASTER, LANDSAT

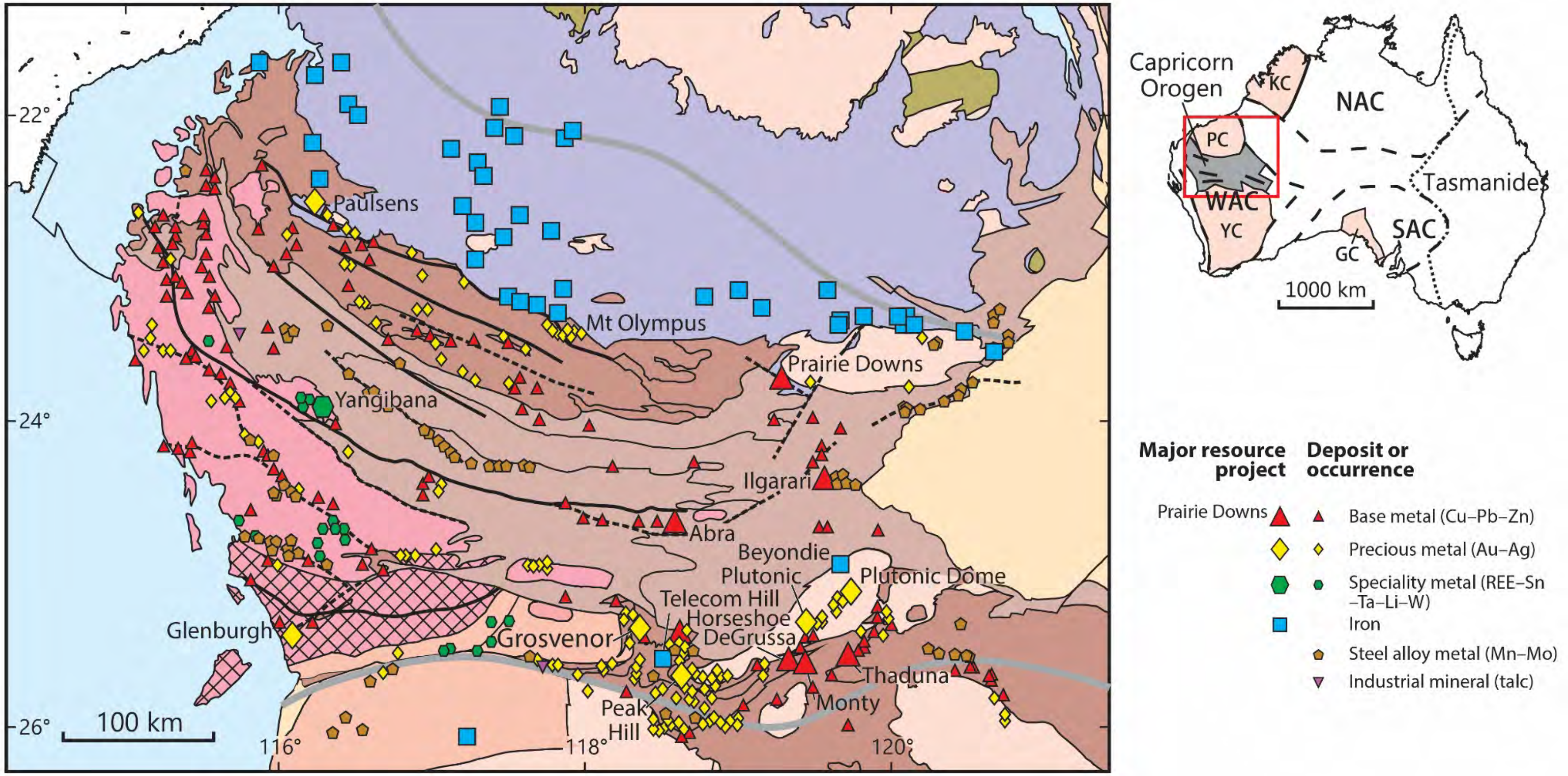
Maps in more detail but the real value is the **revolution in understanding**!

Capricorn Orogen

Proterozoic orogen between the Archean Pilbara and Yilgarn Cratons and Glenburgh Terrane

Sutures the cratons to form the West Australian Craton

Well endowed with multiple commodities



Geological history and geodynamic setting

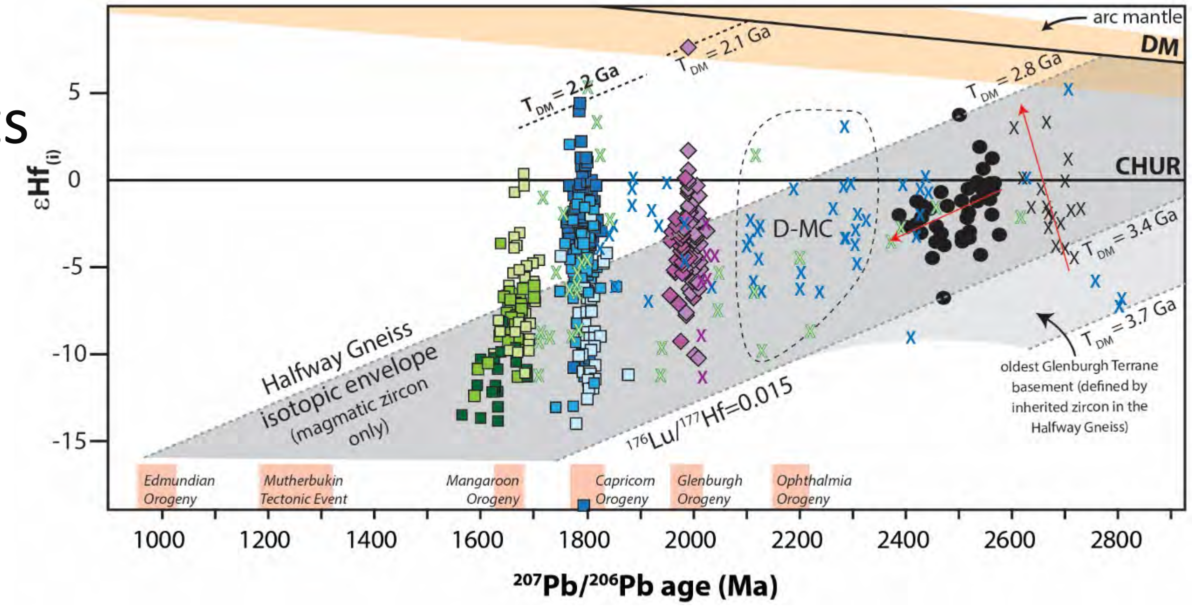
Defined by all mapped components

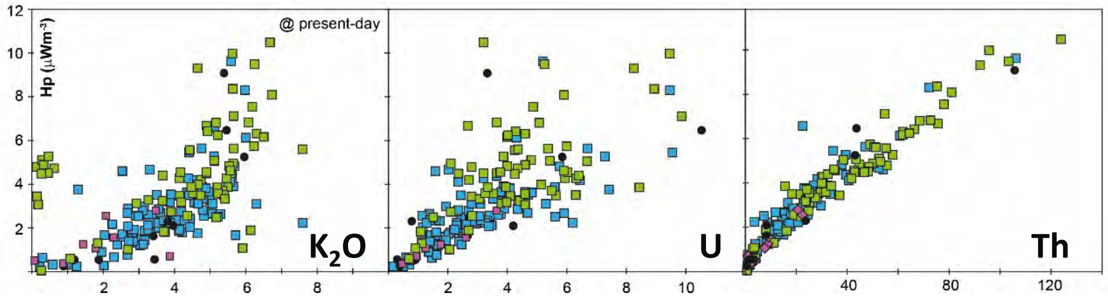
Geochemistry

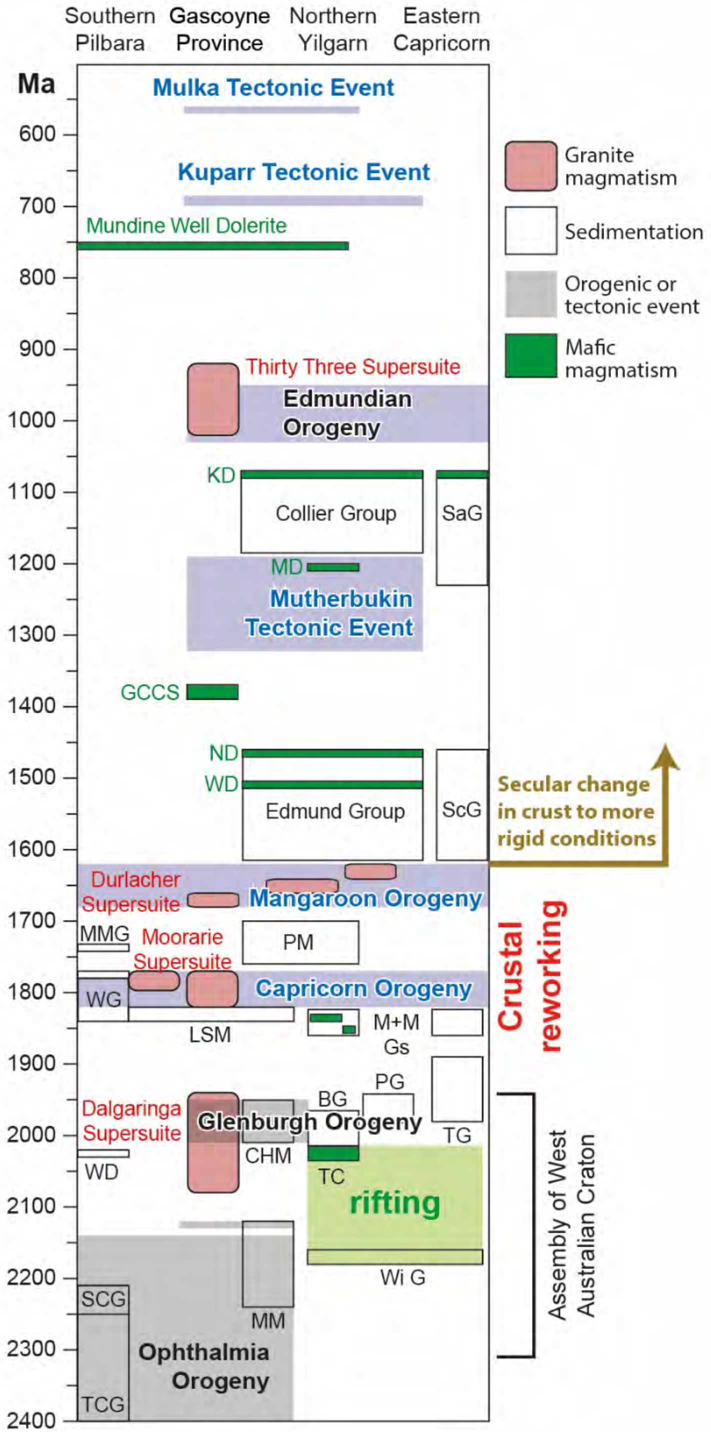
Geochronology

Whole rock and mineral isotopes

Structure







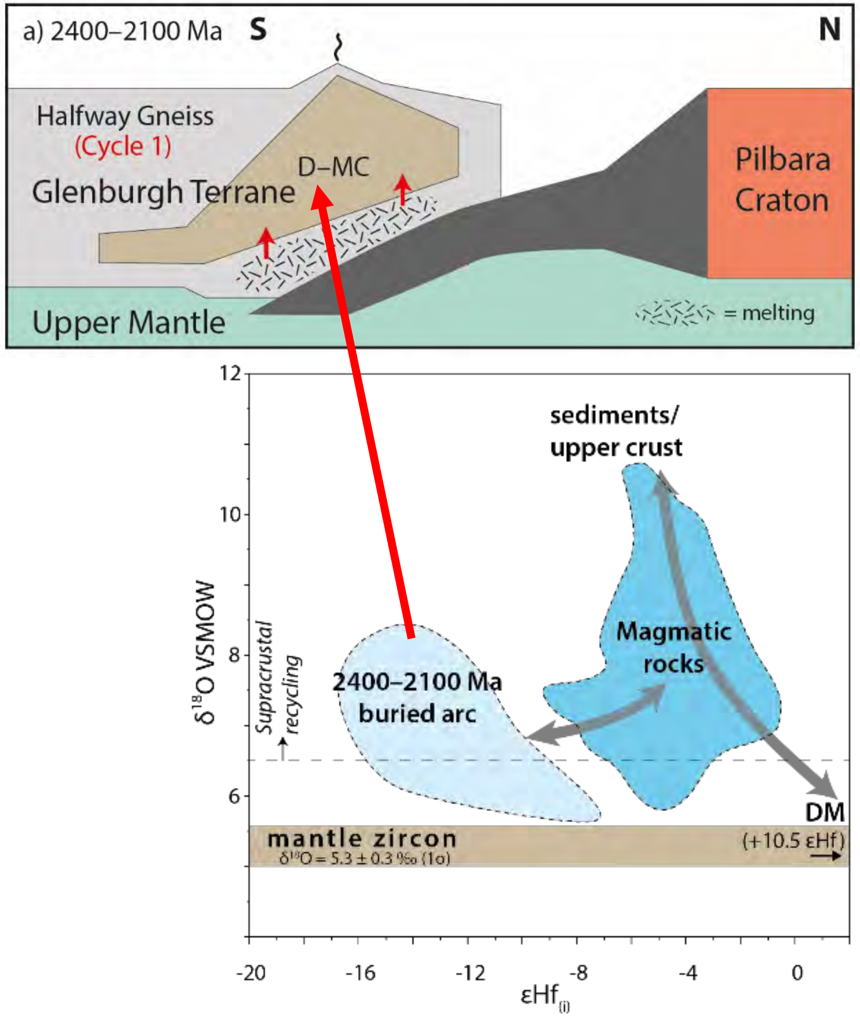
Geodynamic setting - collision

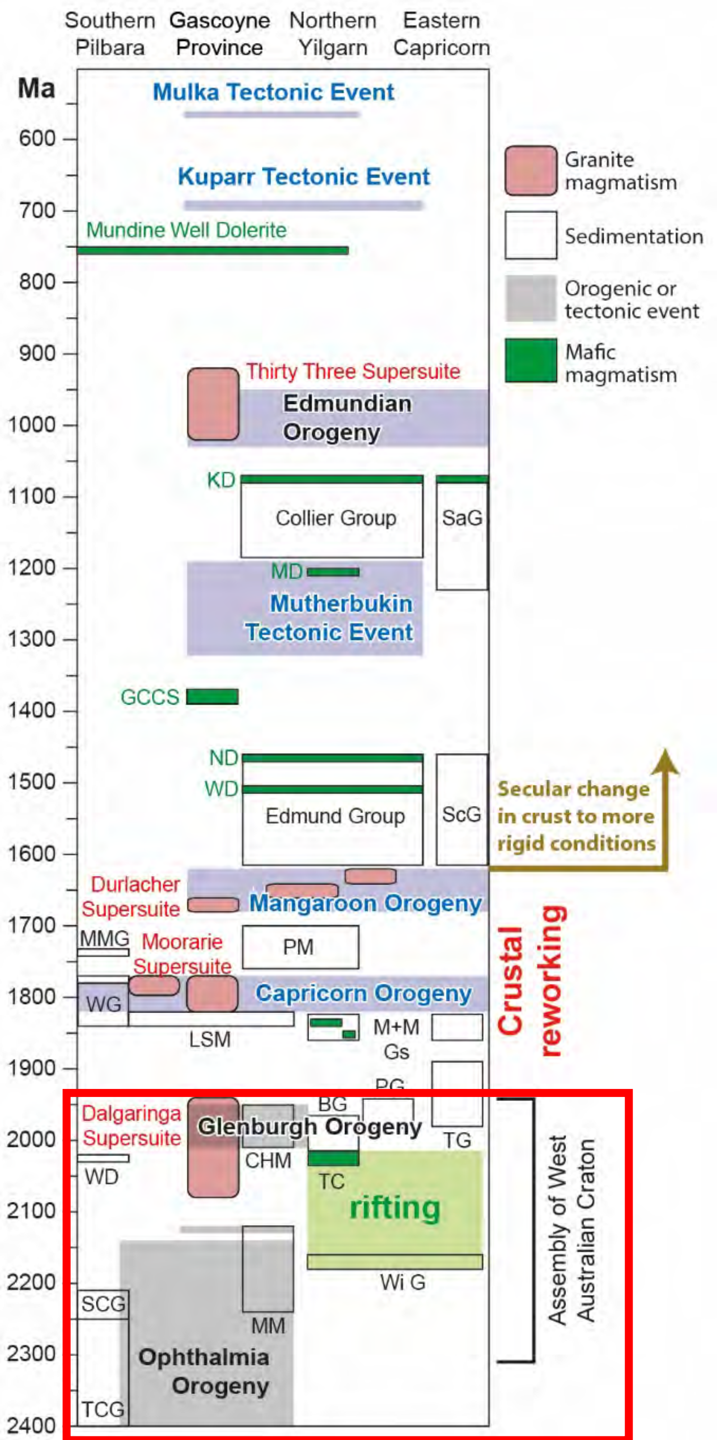
Assembly of the West Australian Craton

Punctuated two-stage assembly

Collision/accretion of the Glenburgh Terrane to the Pilbara Craton during the 2400–2145 Ma Ophthalmia Orogeny

Cryptic Ophthalmian-aged magmatic arc – defined by Hf and O isotopes in inherited zircons

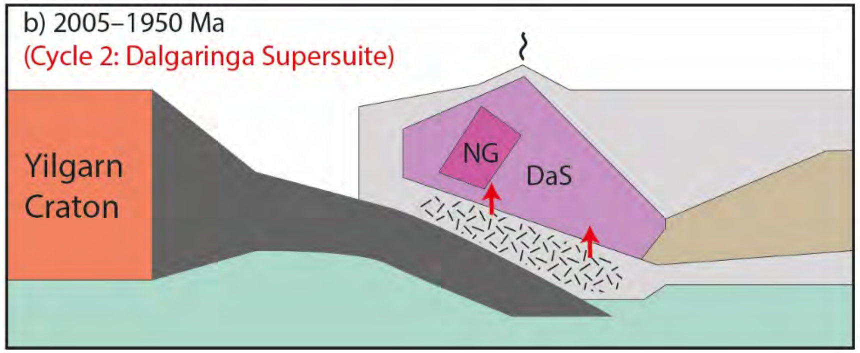




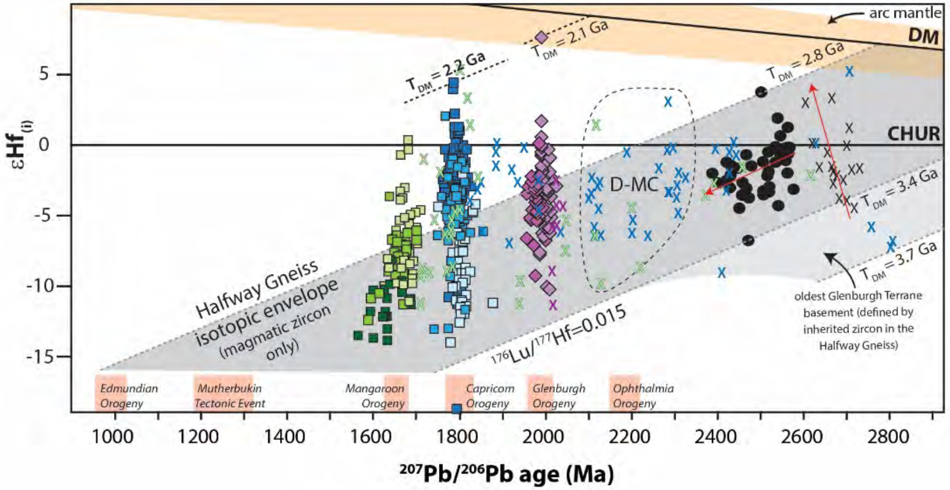
Geodynamic setting - collision

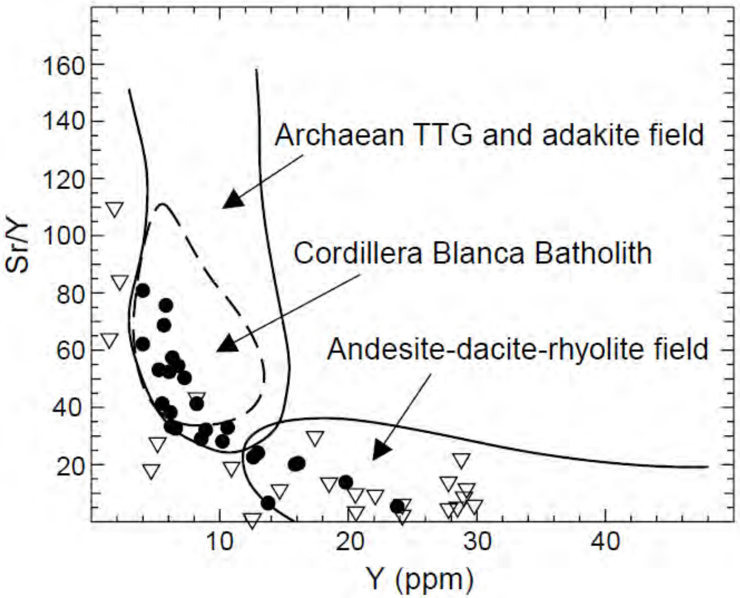
Assembly of the West Australian Craton

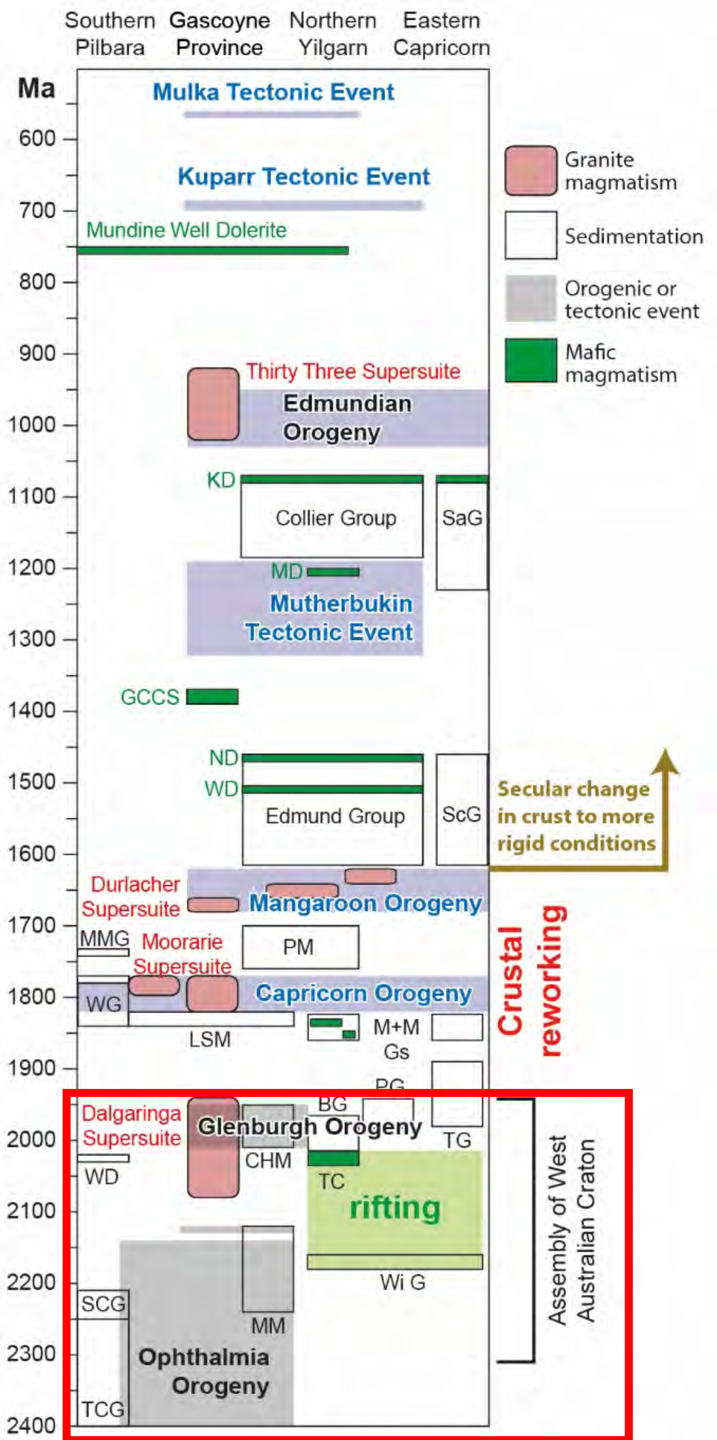
Collision of the Glenburgh Terrane—Pilbara Craton with the Yilgarn Craton during the 2005–1950 Ma Glenburgh Orogeny to form the WAC



continental margin magmatic arc



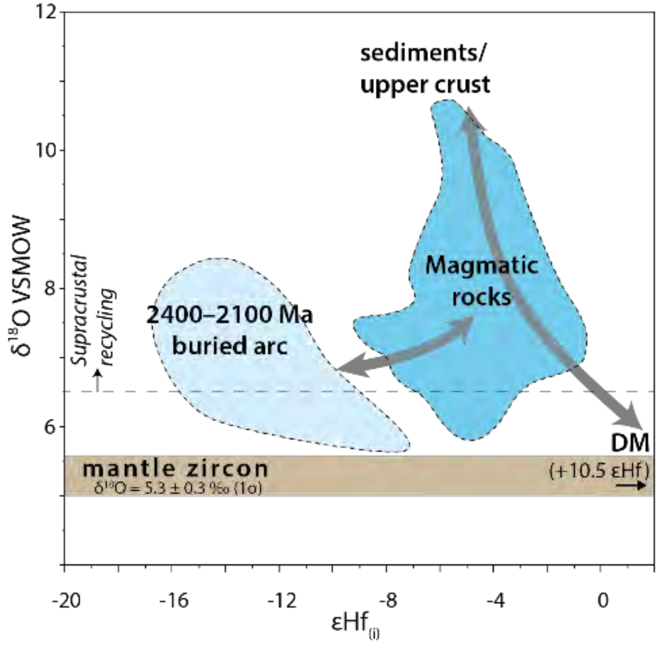


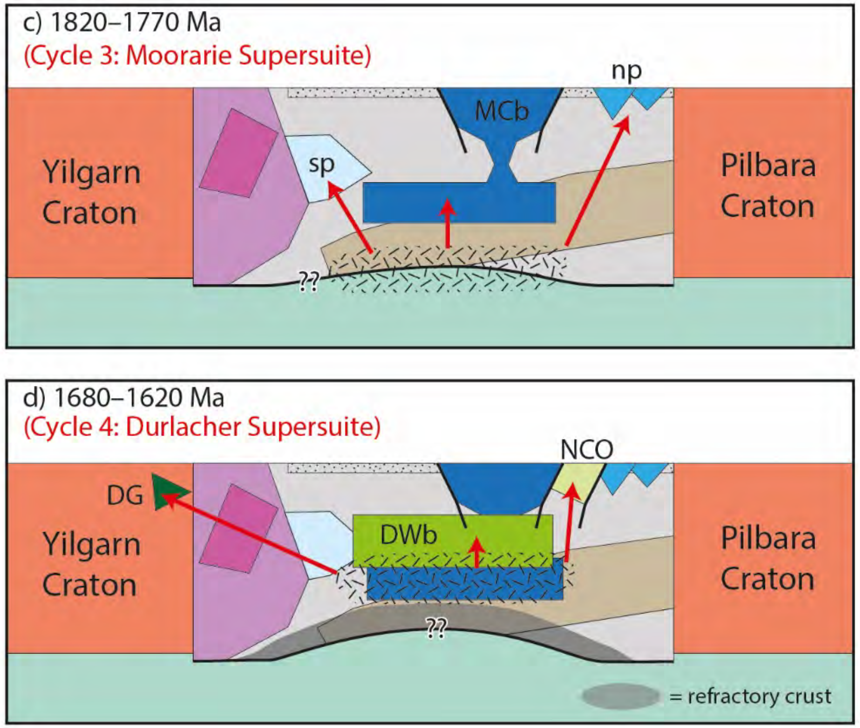


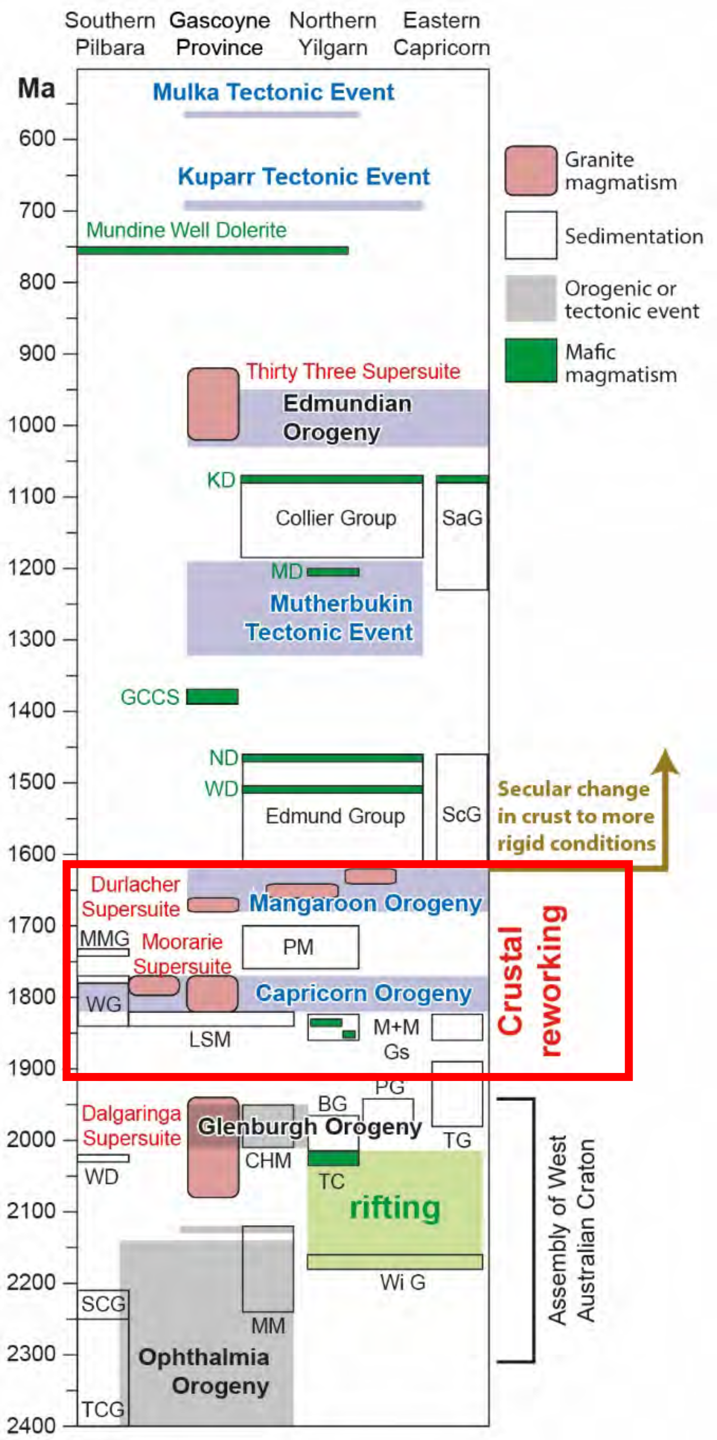
Geodynamic setting – reworking

Over 1 billion years of coaxial intracratonic crustal reworking

Deformation, metamorphism, magmatism, sedimentation







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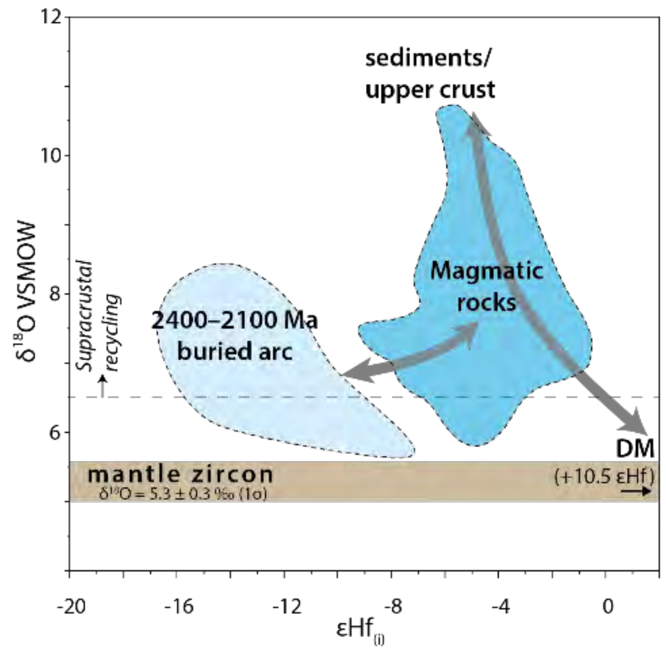
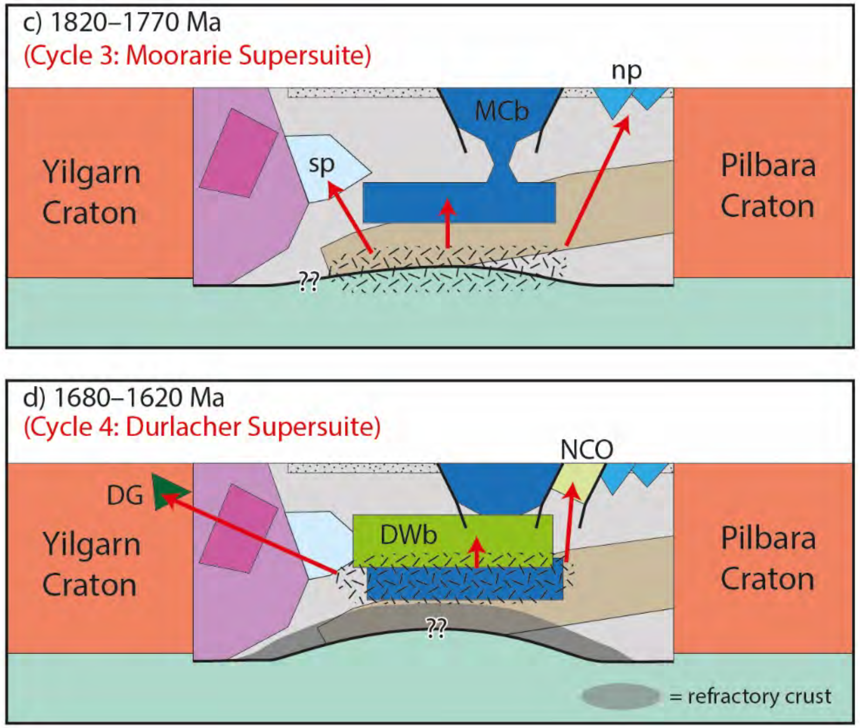
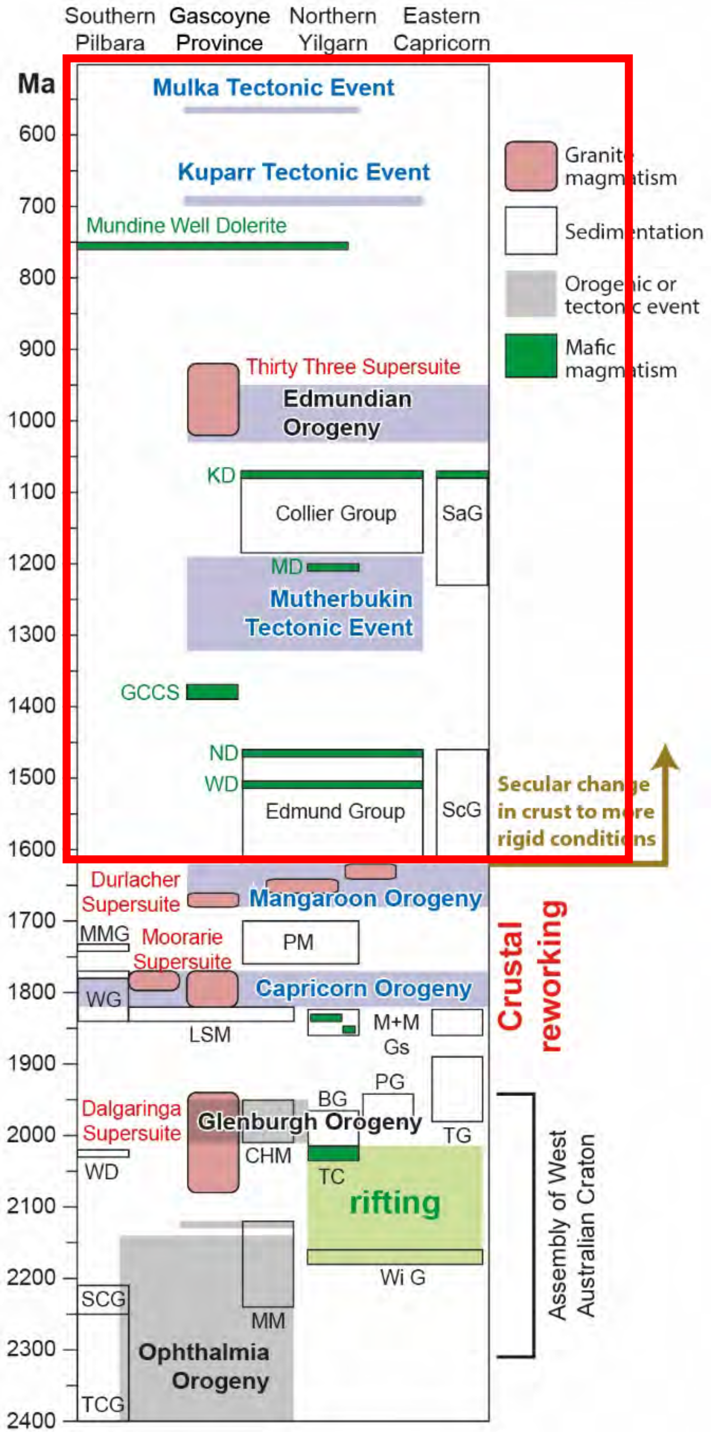




Change in crust to cold and brittle

Formation of intracontinental basins

Shear zone and fault reactivation

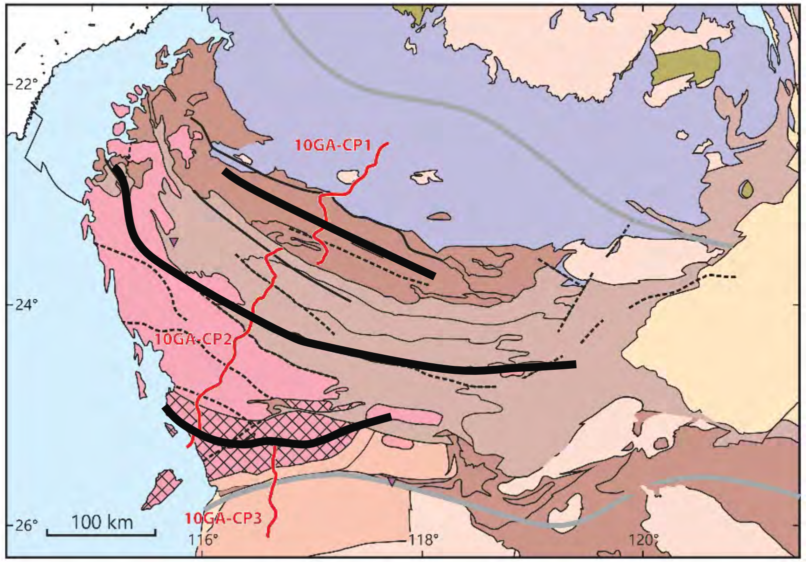


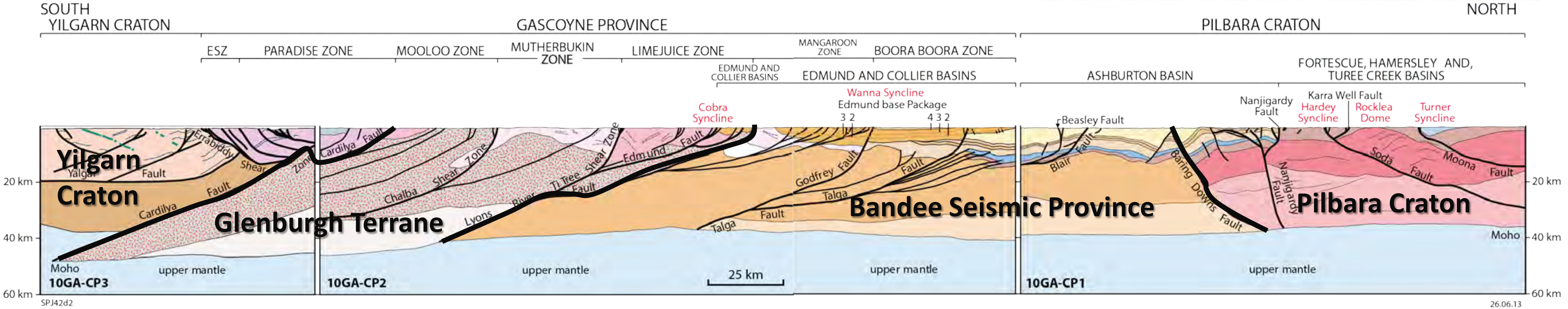
Lithospheric architecture

In 2010 – 581 km vibroseis-source reflection seismic

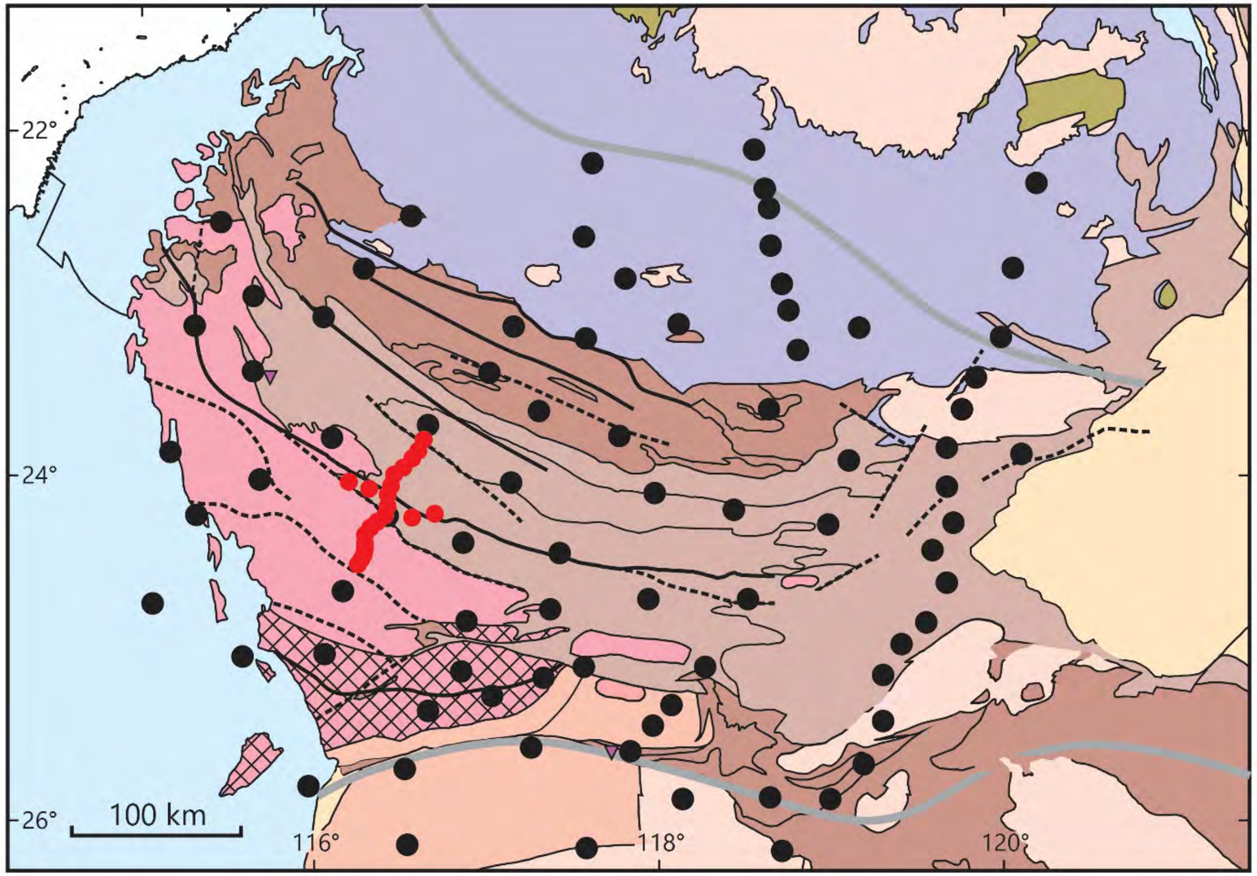
Well-known (mapped) surface geology – interpreted at depth

Define four crustal blocks and three suture zones





Passive seismic array (COPA)



Two complementary broadband passive source surveys 2014–2017

COPA (black dots) – orogen-scale structure, 88 stations deployed over 3 years

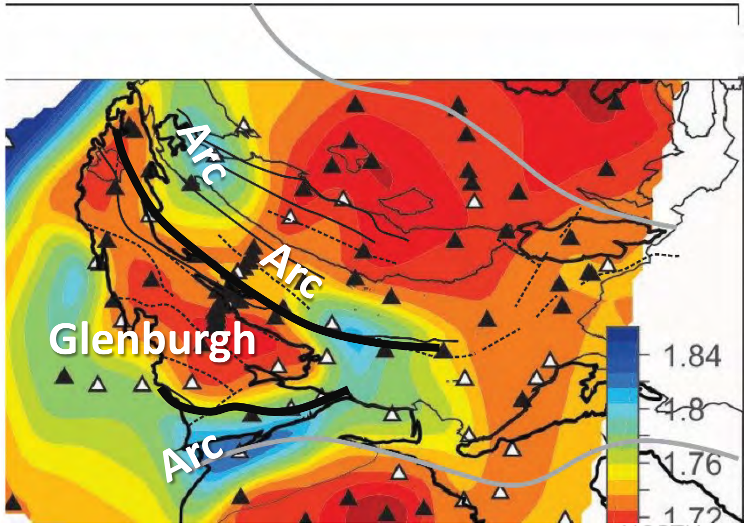
HPS (red dots) – high density array, 25 stations over 200 km along the 10GA–CP2 seismic line (2–8 km spacing) – compare passive and active source data

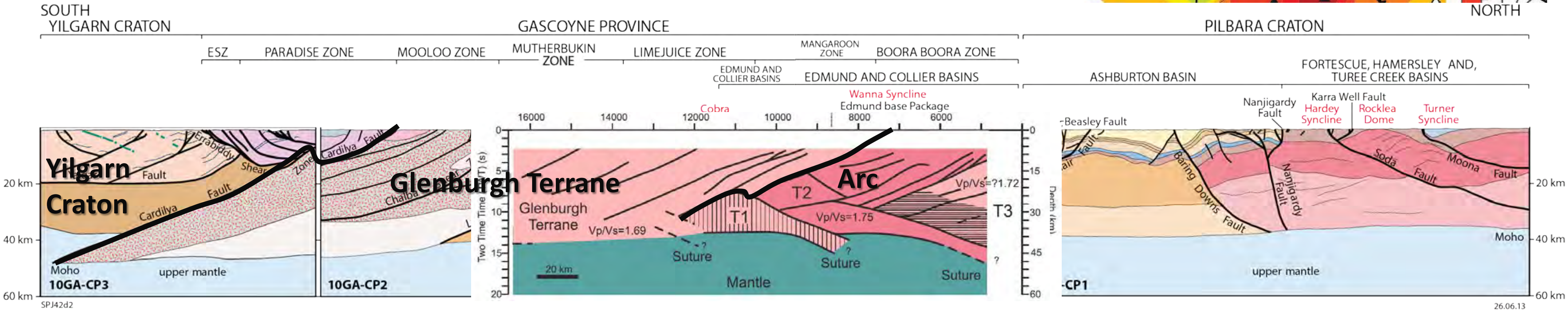
Lithospheric architecture (HPS array)

The HPS array helped re-interpret parts of 10GA-CP2

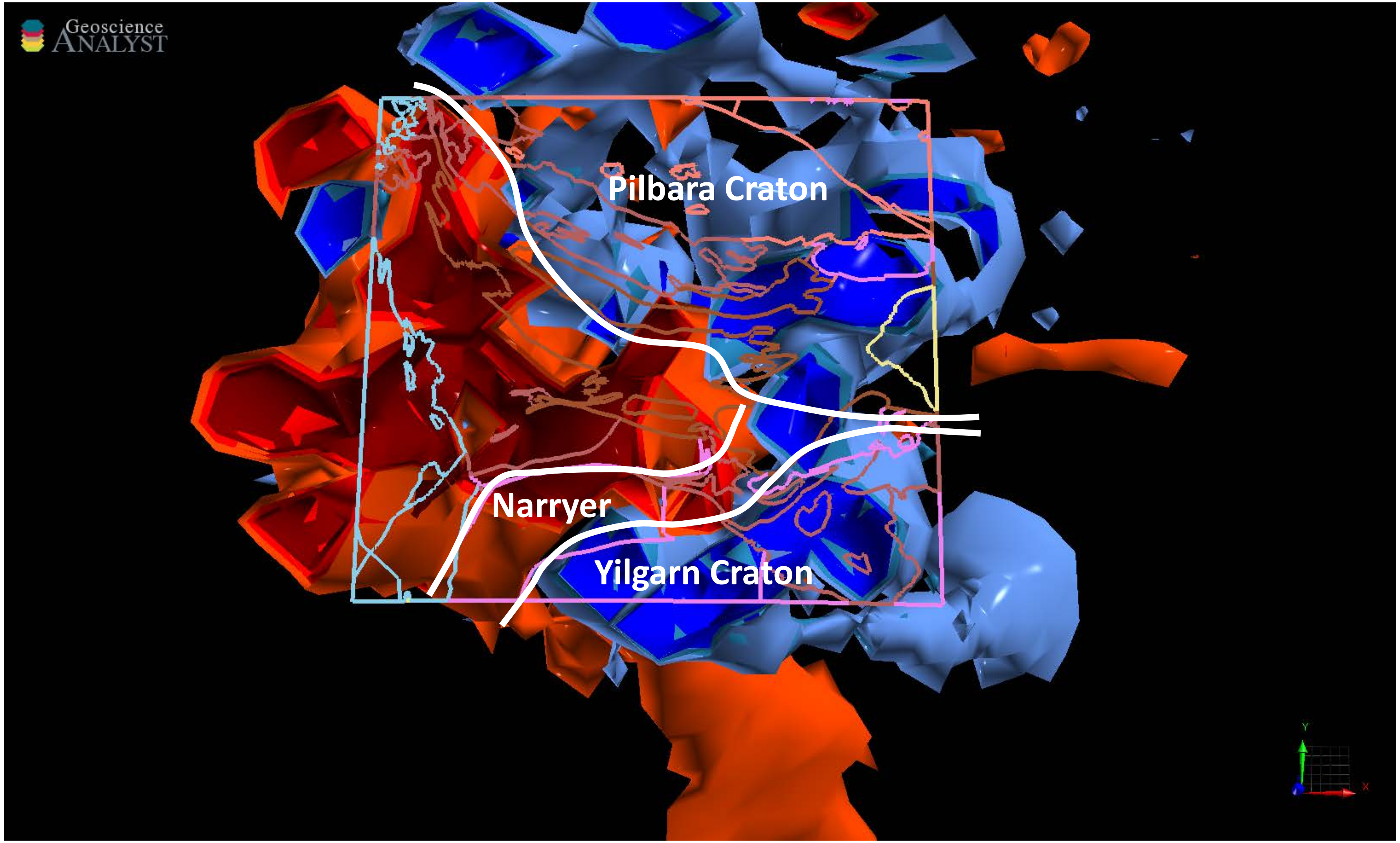
Ambient noise shear wave velocity structure highlights compositional contrasts in the crust – reflected in bulk crustal Vp/Vs ratio

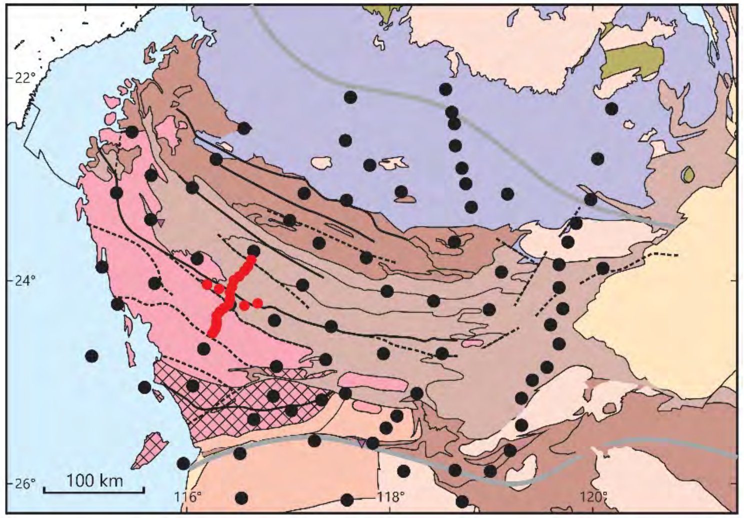
Imaged the buried Ophthalmian Arc





Lithosphere–asthenosphere architecture



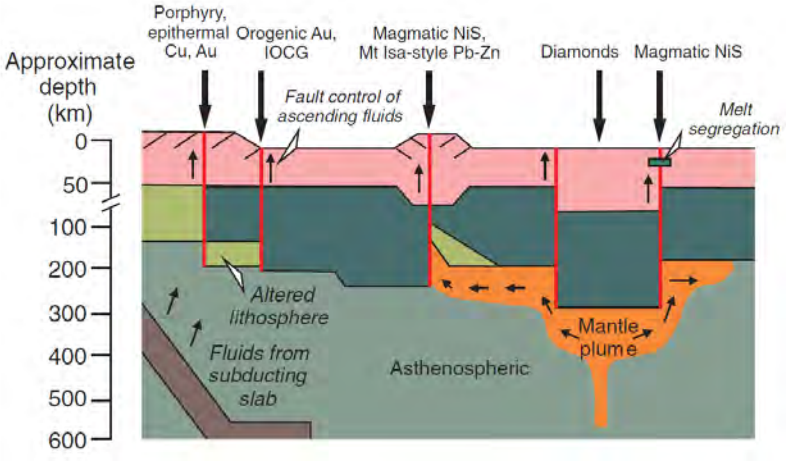


Ambient noise bodywave tomography (COPA)

Red – hydrated, altered mantle
Blue – refractory mantle

Critical for understanding mantle–crust interactions

Linking geology to mineral systems

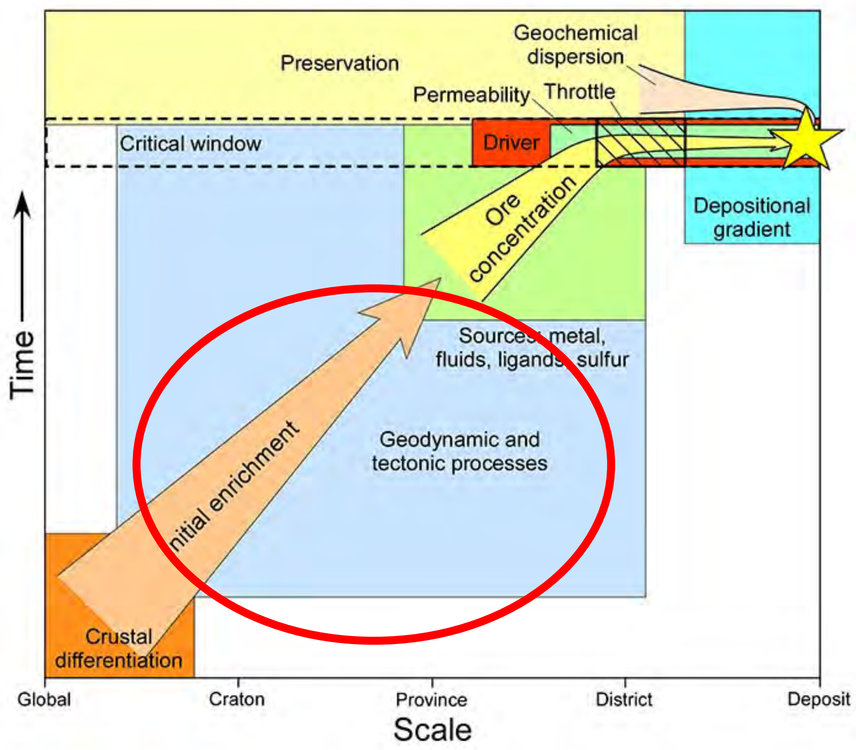


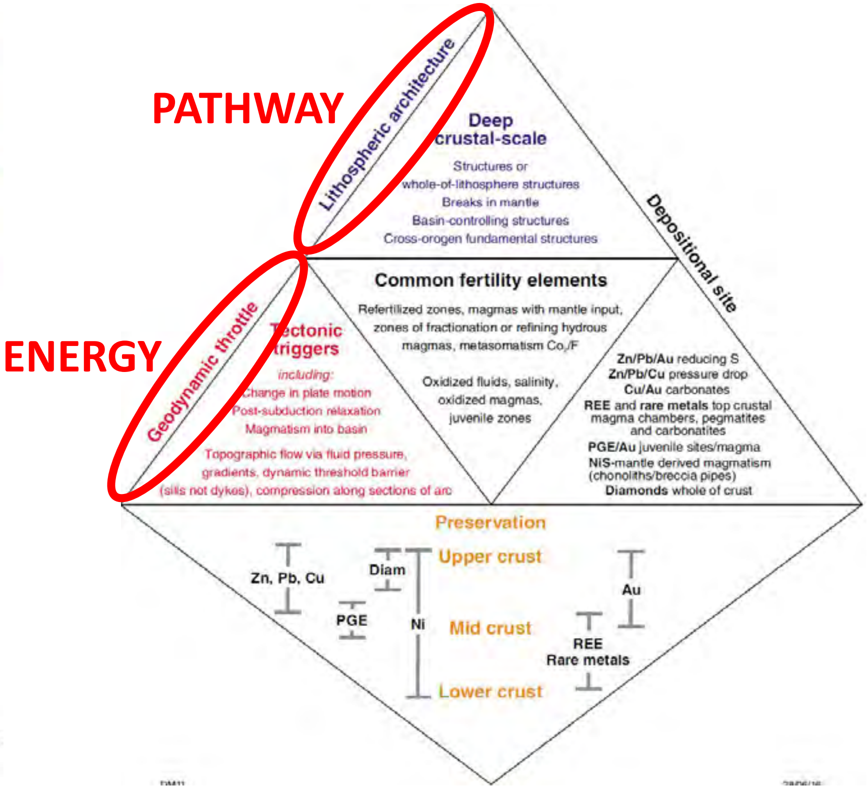
Craton–Province scale

Mineral system defined by two critical elements:

Pathway – architecture

Energy – geodynamic throttle

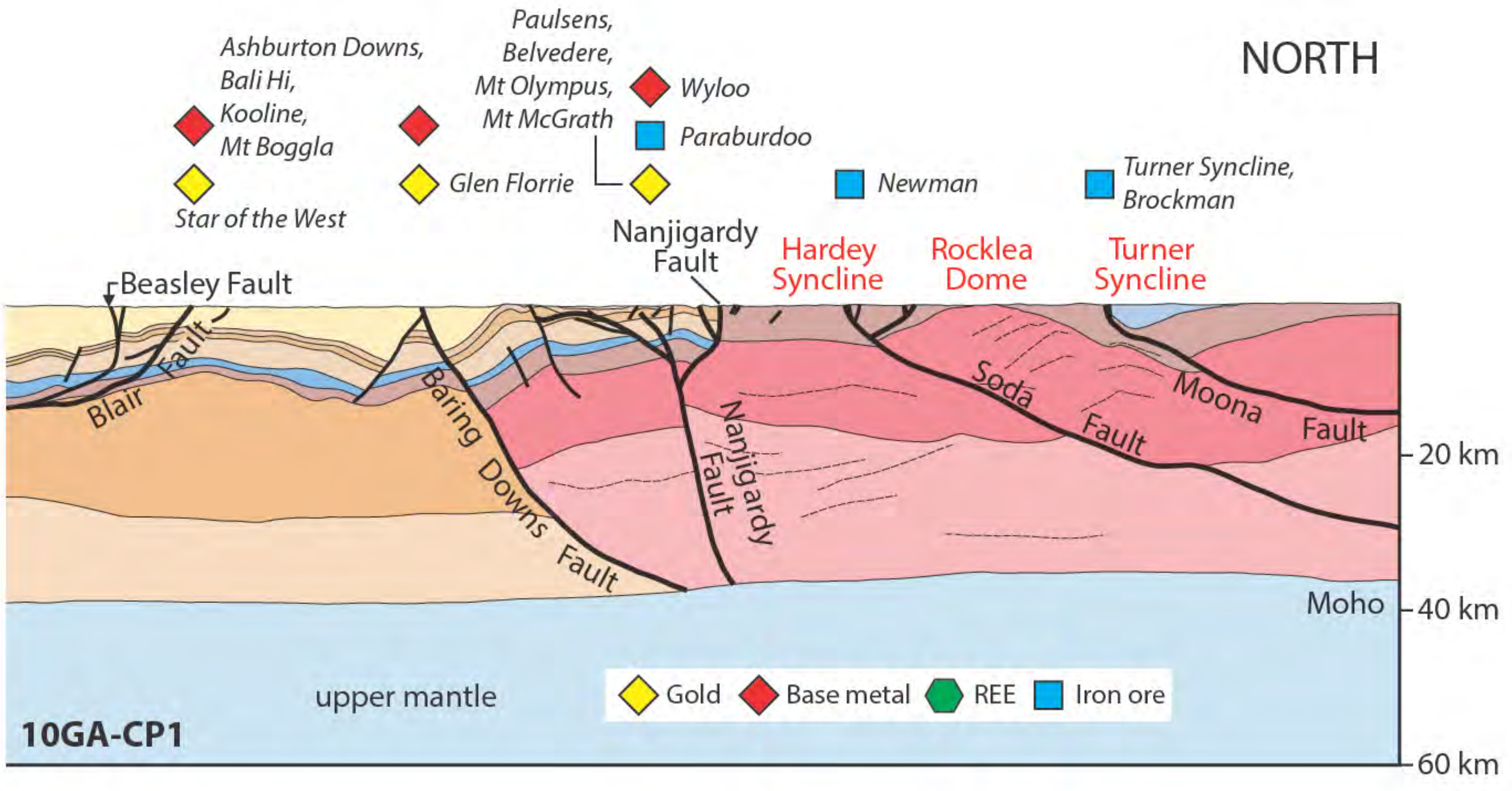




Lithospheric architecture – northern Capricorn

The majority of gold and base metal deposits lie on major mantle-tapping shear zones or their secondary structures

Nanjilgardy Fault the most endowed

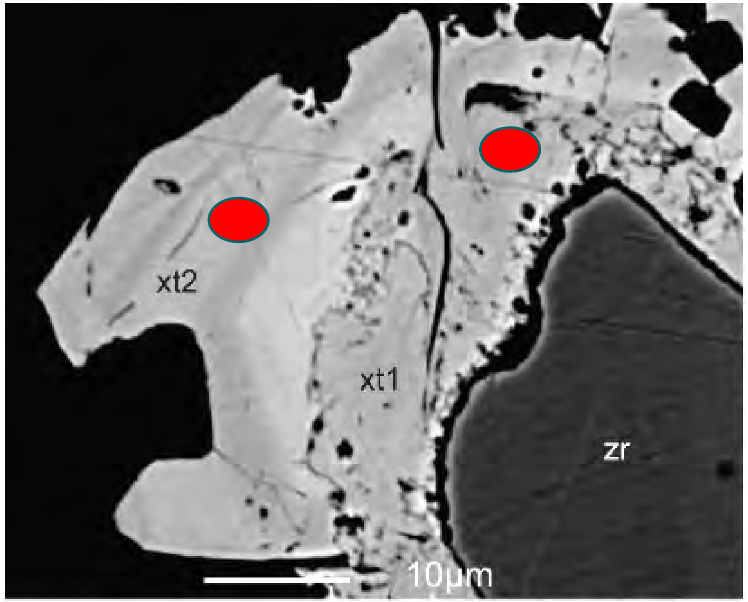


Geodynamic throttle (energy=timing)

Link crustal architecture and known tectonic evolution to fluid flow events

Precise timing of mineralization

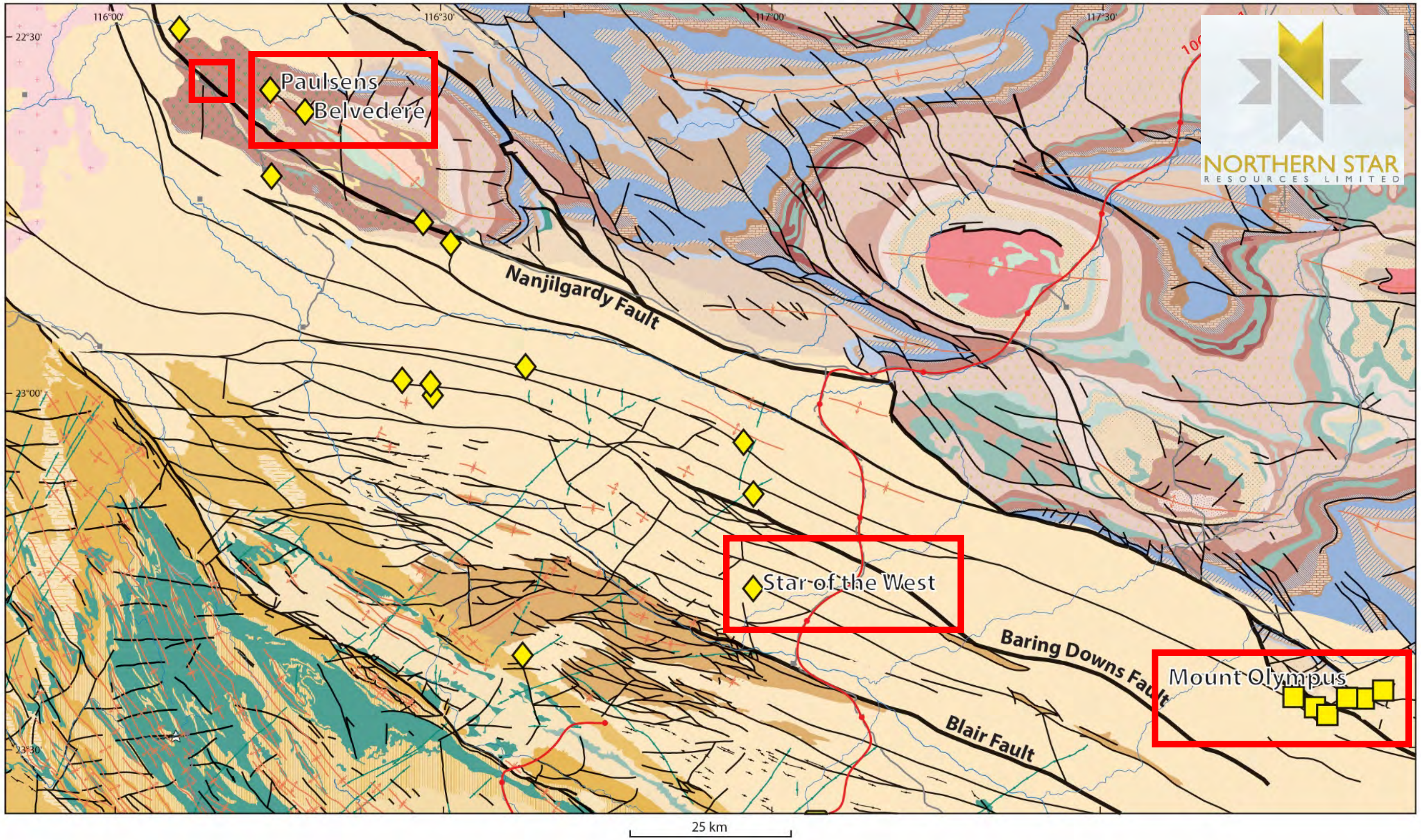
- xenotime YPO_4 and monazite $(La,Ce)PO_4$
  - common in hydrothermal systems
  - resilient to isotopic resetting
  - dissolution-reprecipitation reactions
- in situ SIMS (SHRIMP) dating
  - preserve the textures
  - small analysis spot



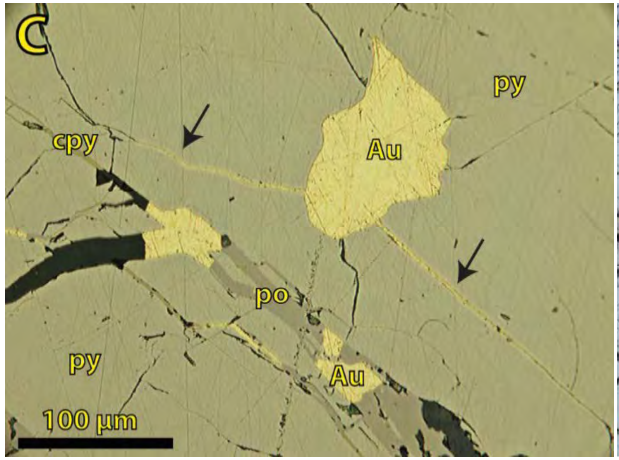
Timing of gold mineralization – northern Capricorn

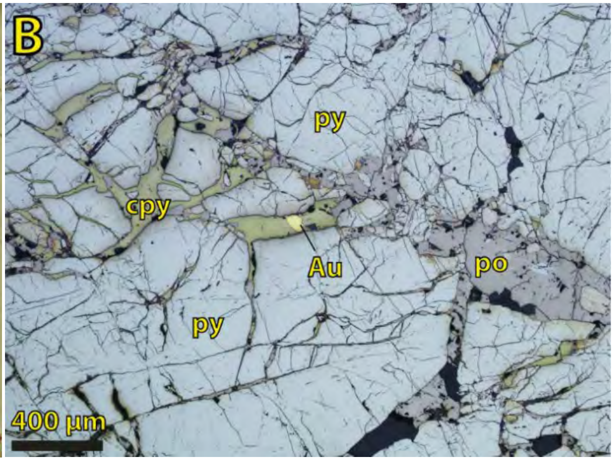
Precisely dated the timing of gold mineralization at four deposits

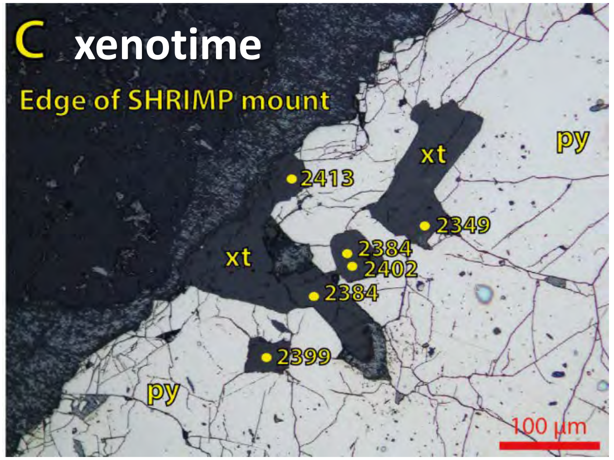
Precisely date the timing of shear zone movement and hydrothermal fluid flow

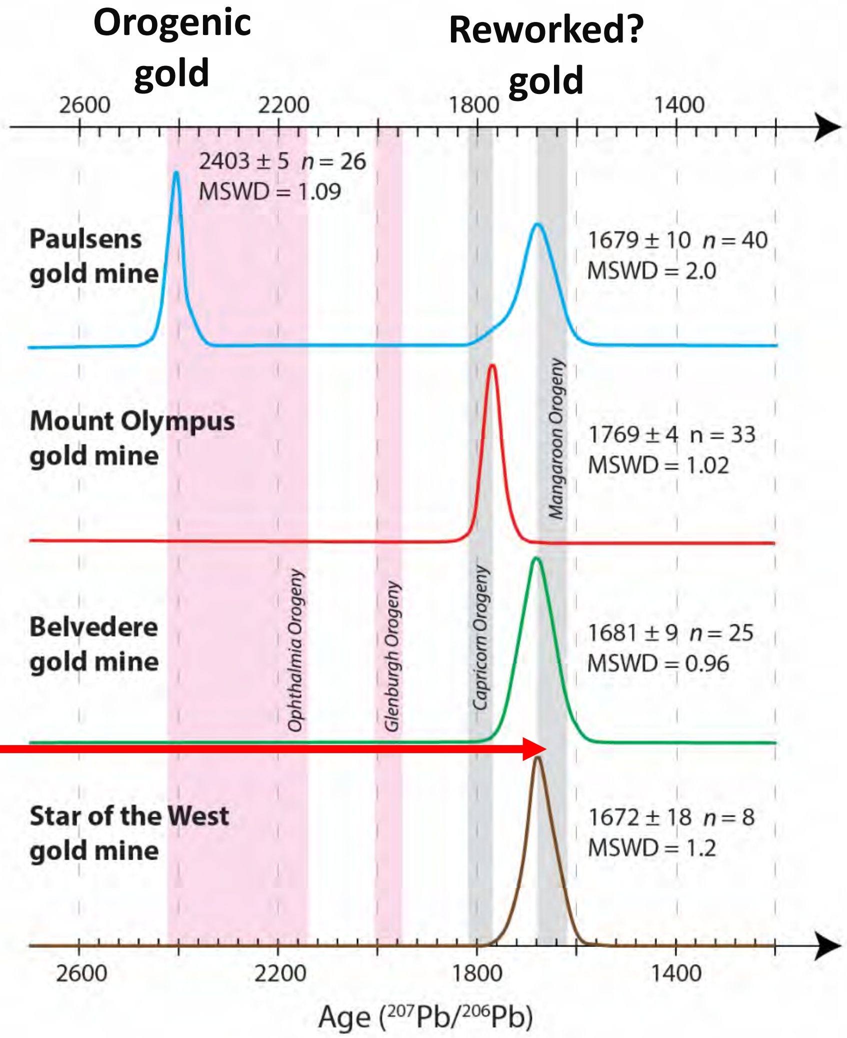


Timing of gold mineralization – northern Capricorn









NORTHERN STAR RESOURCES LIMITED

Gold mineral system – northern Capricorn

PATHWAY - Gold is hosted on the major crustal (mantle-tapping) structures or their 1st/2nd order splays

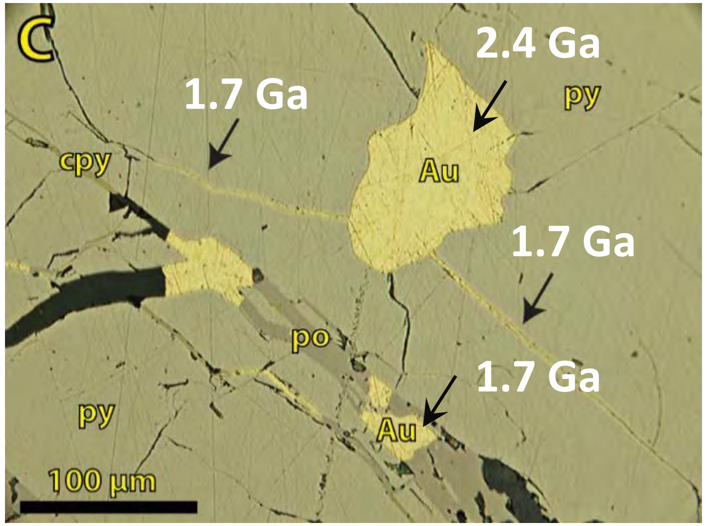
ENERGY - Driven by orogenic events in the mid/deep crust

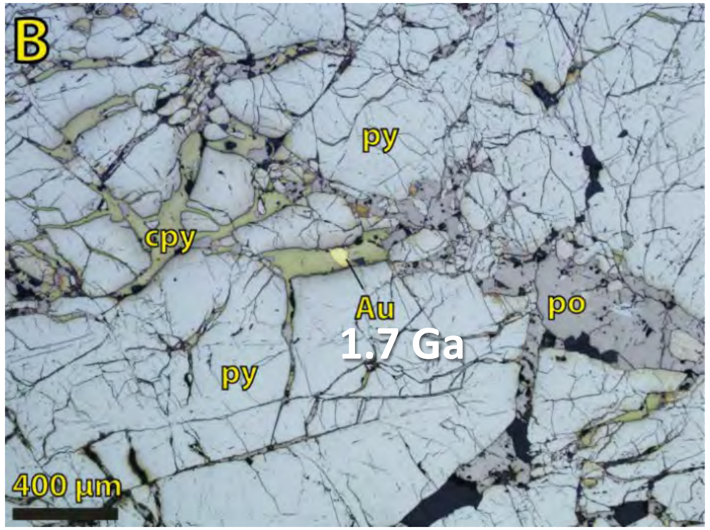
- link between regional metamorphism and deformation, and hydrothermal fluid flow/mineralization
- barren and mineralized hydrothermal fluids flux during faulting

One large orogenic gold deposit (Paulsens) during accretionary orogenesis

reworked during successive events into smaller deposits

One large deposit and minor secondary gold events



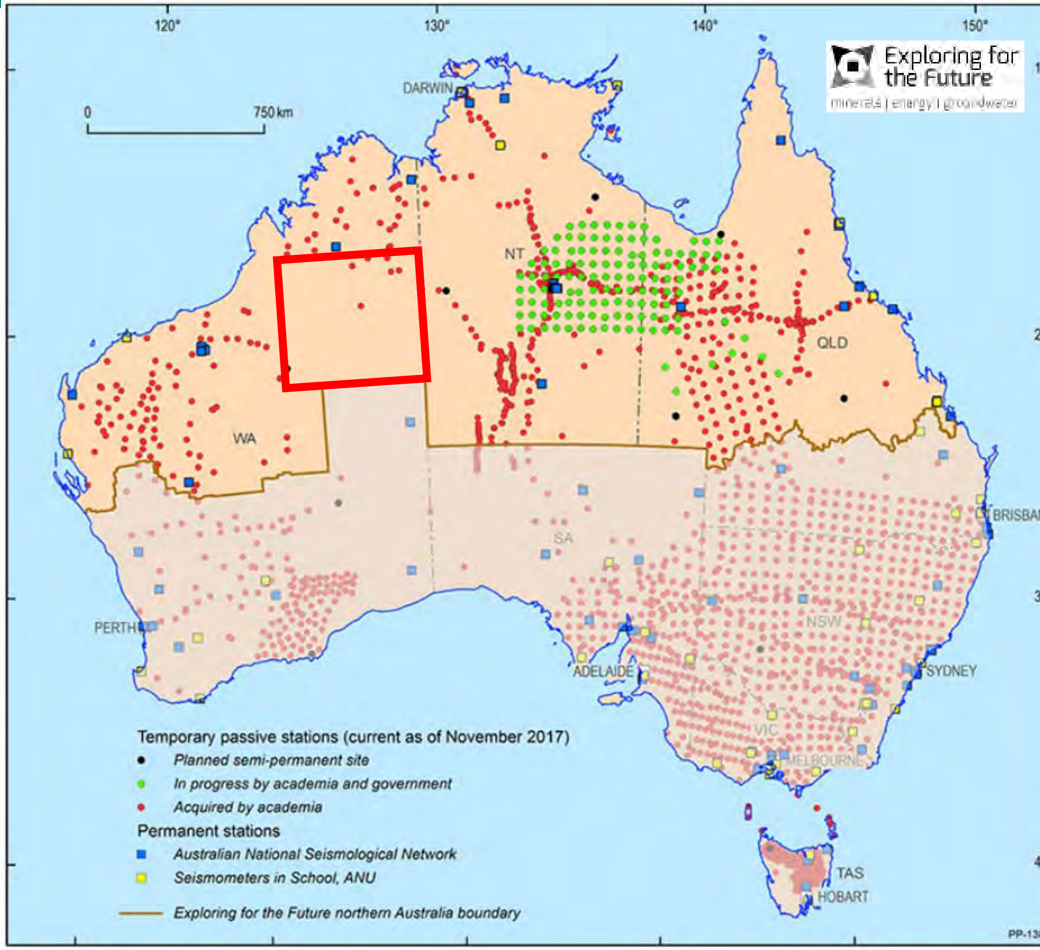


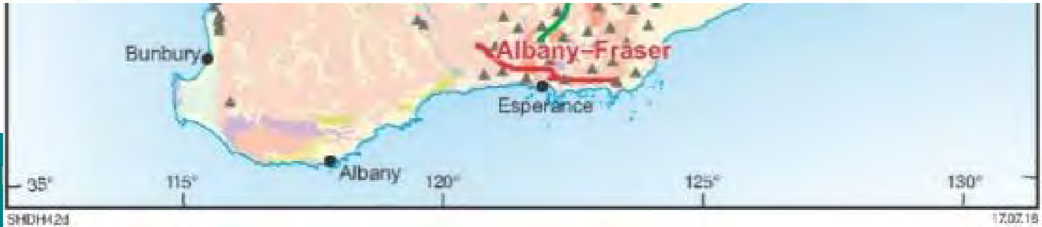
Summary

20 years of geological and geophysical 'mapping' in the Capricorn – unique understanding of the crustal evolution and architecture through time

Critical pre-competitive data can be used to directly inform the craton to province-scale drivers of mineral systems

Where to go from here?





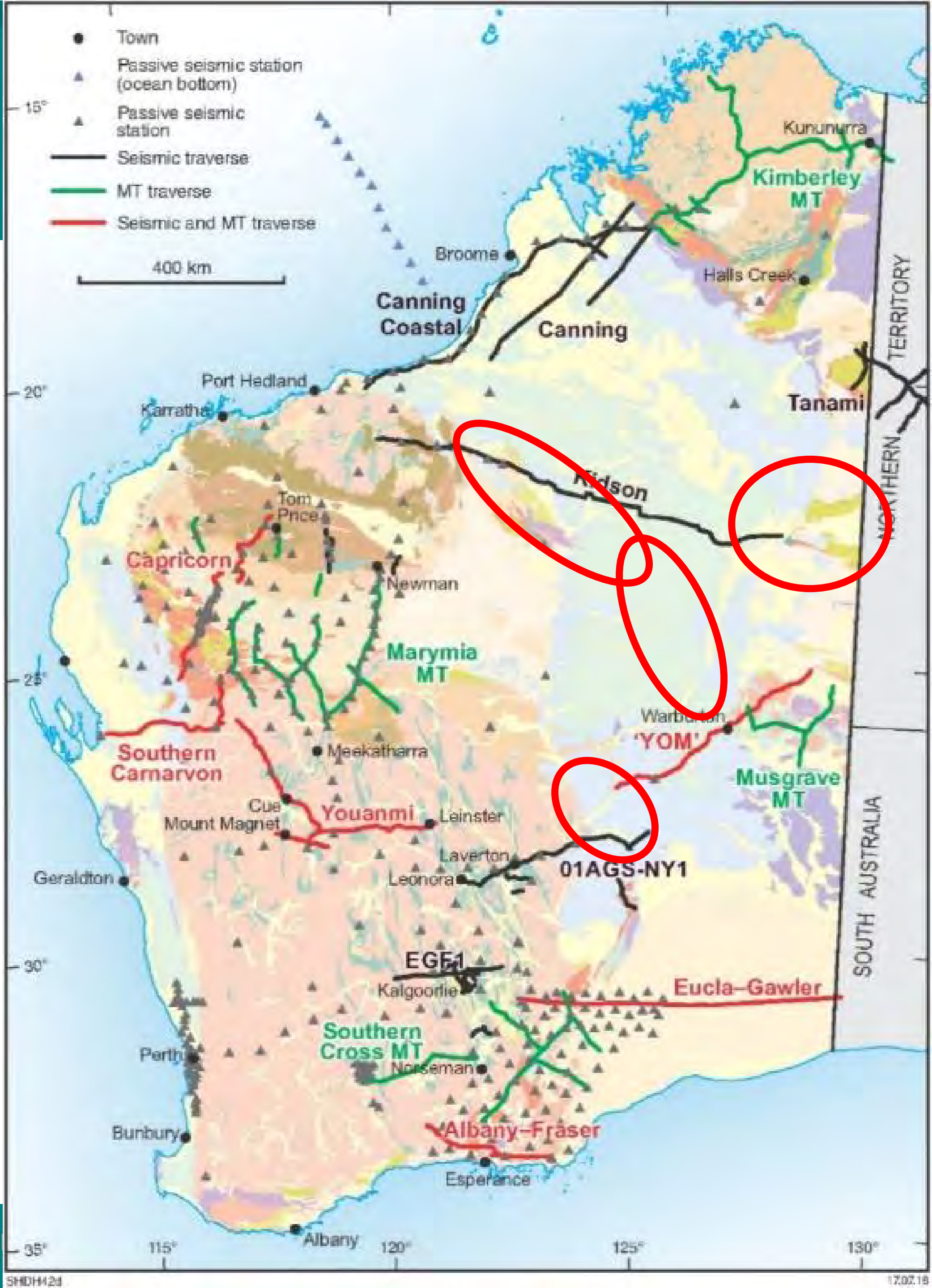
Summary

20 years of geological and geophysical 'mapping' in the Capricorn – unique understanding of the crustal evolution and architecture through time

Critical pre-competitive data can be used to directly inform the craton to province-scale drivers of mineral systems

Where to go from here?

National Drilling Initiative (NDI) – apply it to the 'Gap' – Proterozoic margins under shallow cover



Cooperative research

Capricorn DISTAL FOOTPRINTS

John de Laeter Centre

CCFS

GEMOC

CSIRO

SCIENCE AND INDUSTRY ENDOWMENT FUND

mriwa

Australian Government
Geoscience Australia

Geological Survey South Australia

MACQUARIE University
SYDNEY·AUSTRALIA

Centre for EXPLORATION TARGETING

NORTHERN STAR
RESOURCES LIMITED

Australian National University

AuScope

Curtin University

THE UNIVERSITY OF WESTERN AUSTRALIA

Australian Government
Australian Research Council

DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

Department of Natural Resources, Mines and Energy

GSQ's New Discovery Program

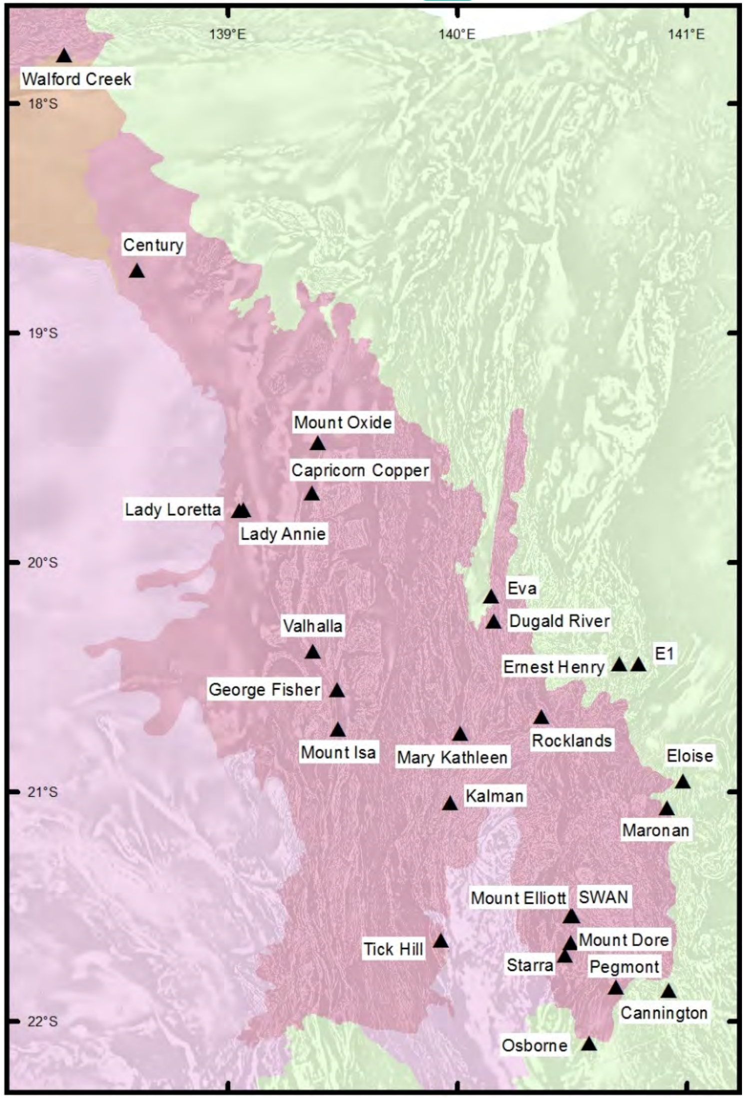
Enabling data-driven exploration in NW Queensland

Science in the Surveys
26th March 2019

Queensland Government

Focus on NW Qld

- NW Mineral Province: **highest value** mineral province in Qld
- Significant **exploration investment** from major international companies
- **Key focus** area for Qld Govt and GSQ:
    - NW Minerals Province Strategic Blueprint
    - Qld Mineral and Coal Exploration Guideline
    - GSQ's **Strategic Resources Exploration Program**, and
    - GSQ's **New Discovery Program**



GSQ Projects and Funding

Strategic Resources Exploration Program

2017-2021 SREP

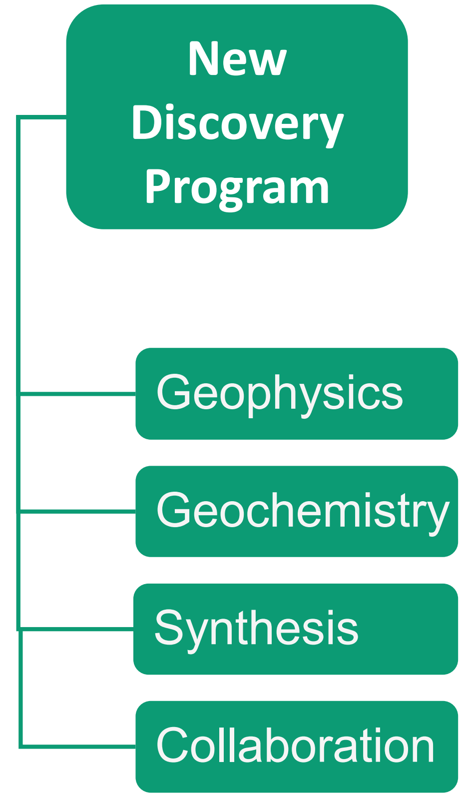
- Geoscience Data Modernisation — $7.125M
- New Discovery Program — $11.6M
- Collaborative Exploration Initiative — $3.6M
- Industry Engagement — $1.2M
- Frontier Basin Gas Exploration — $3.6M

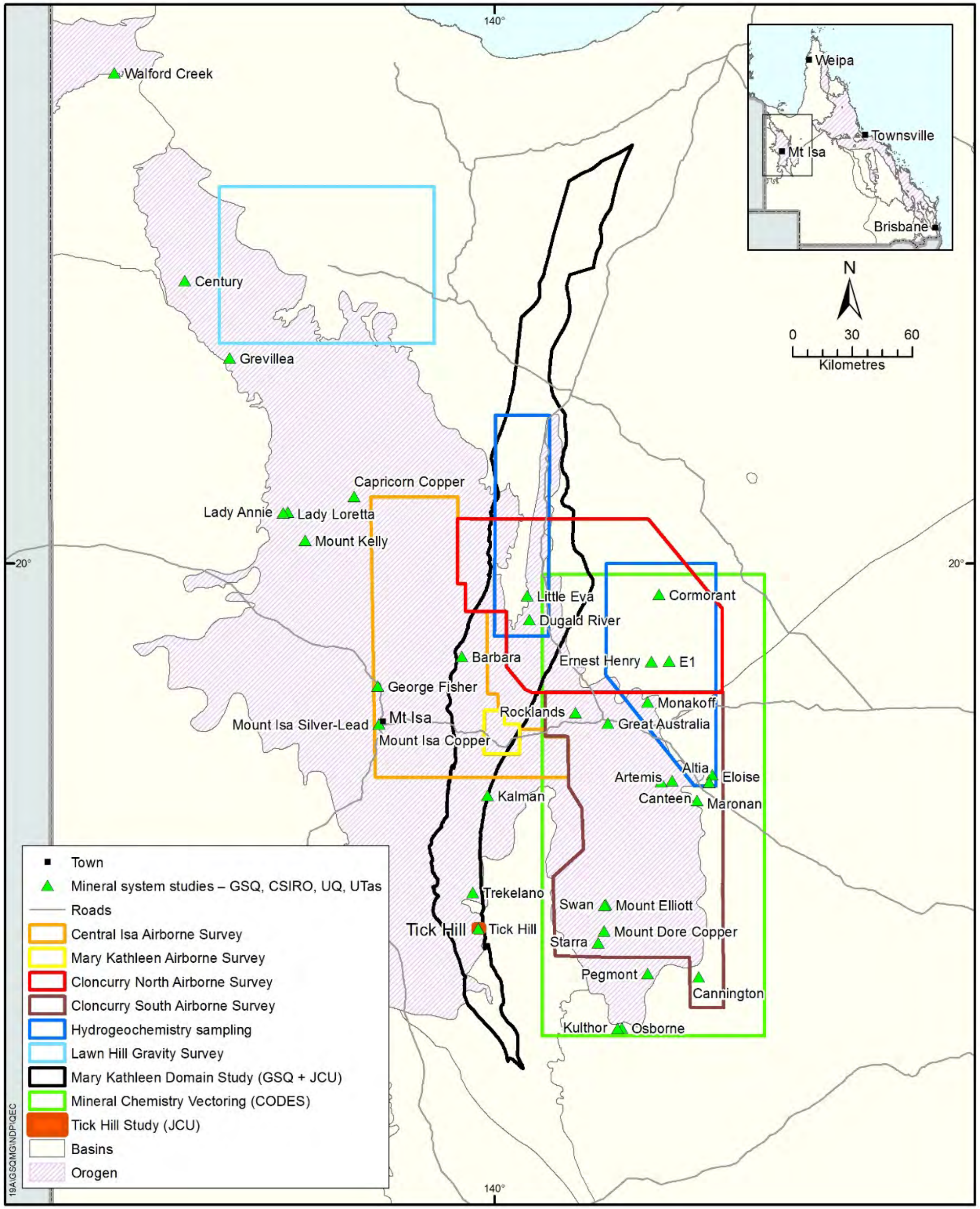
New Discovery Program:

- Geophysics — New geophysical surveys
- Geochemistry — Surveys, case studies, research
- Synthesis — Compilations, research
- Collaboration — Collaborative contributions

New Discovery Program

- New data and research – support exploration and discovery
- Strategic collaborative partnerships with key public geoscience agencies – BRC, CODES, EGRU, CSIRO, Geoscience Australia
- Individual projects (>20) – aiming to maximise synergies and collaboration



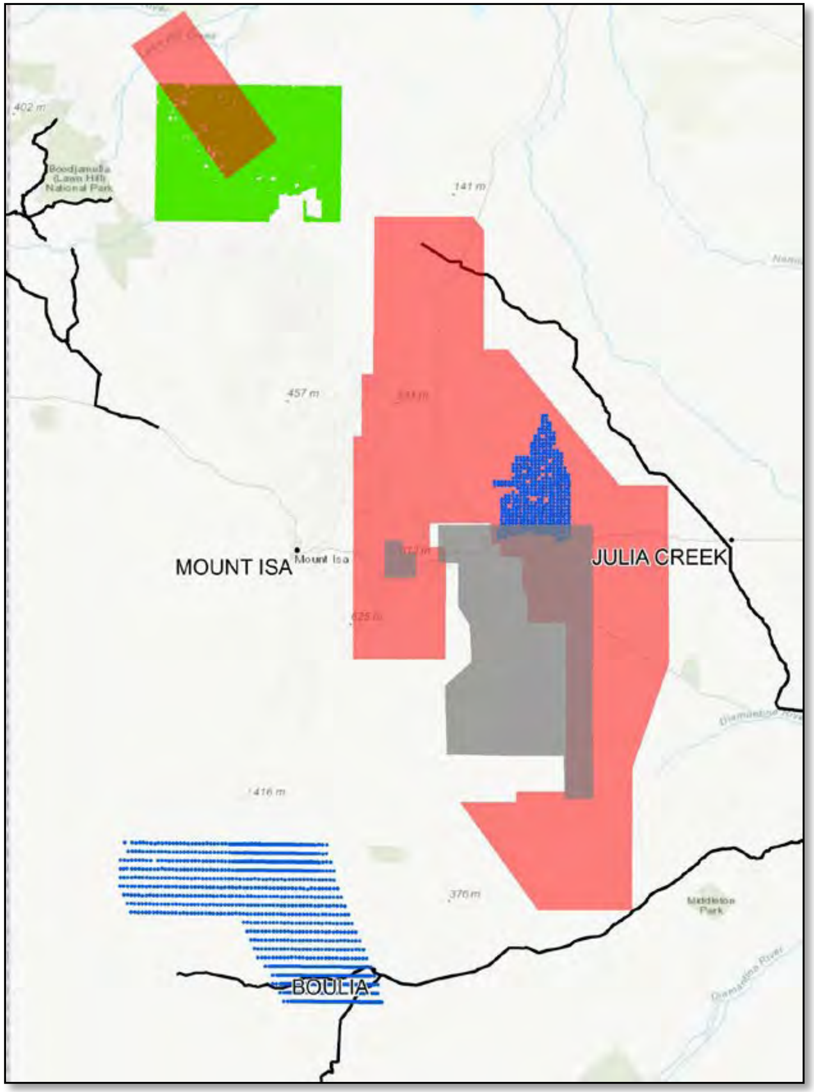


Coverage of the New Discovery Program

Recently Completed Geophysics

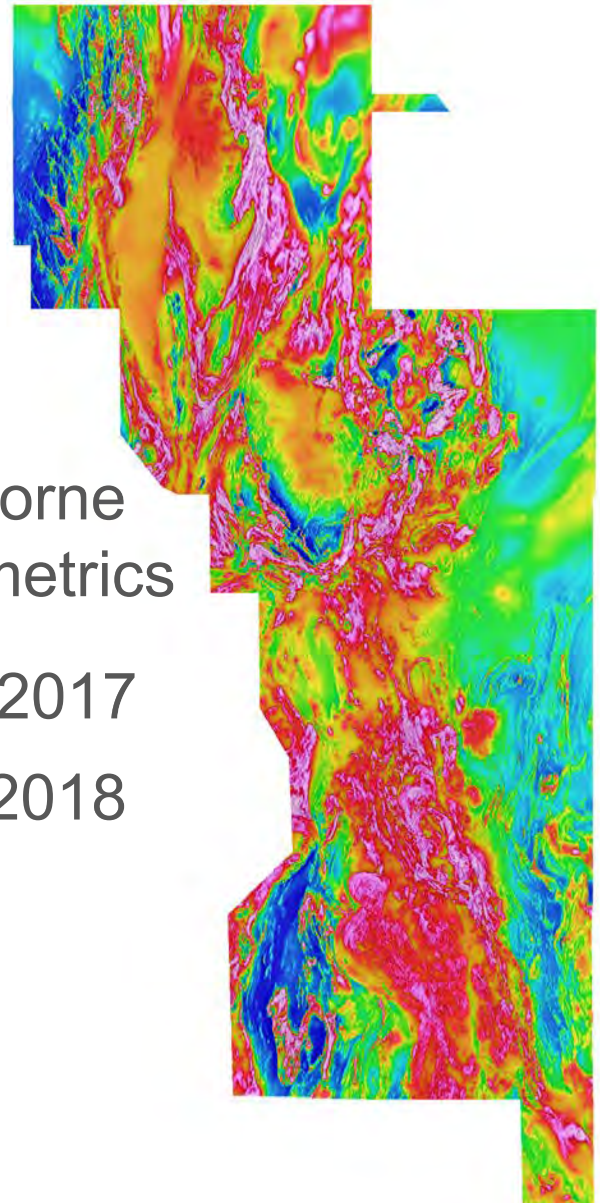
- $4.3M under New Discovery Program

- Airborne EM (≤ 2.5 km)
- Magnetotelluric (≤ 2.5 km)
- 1 km ground gravity
- High resolution magnetics (≤100 m)
- Deep crustal seismic



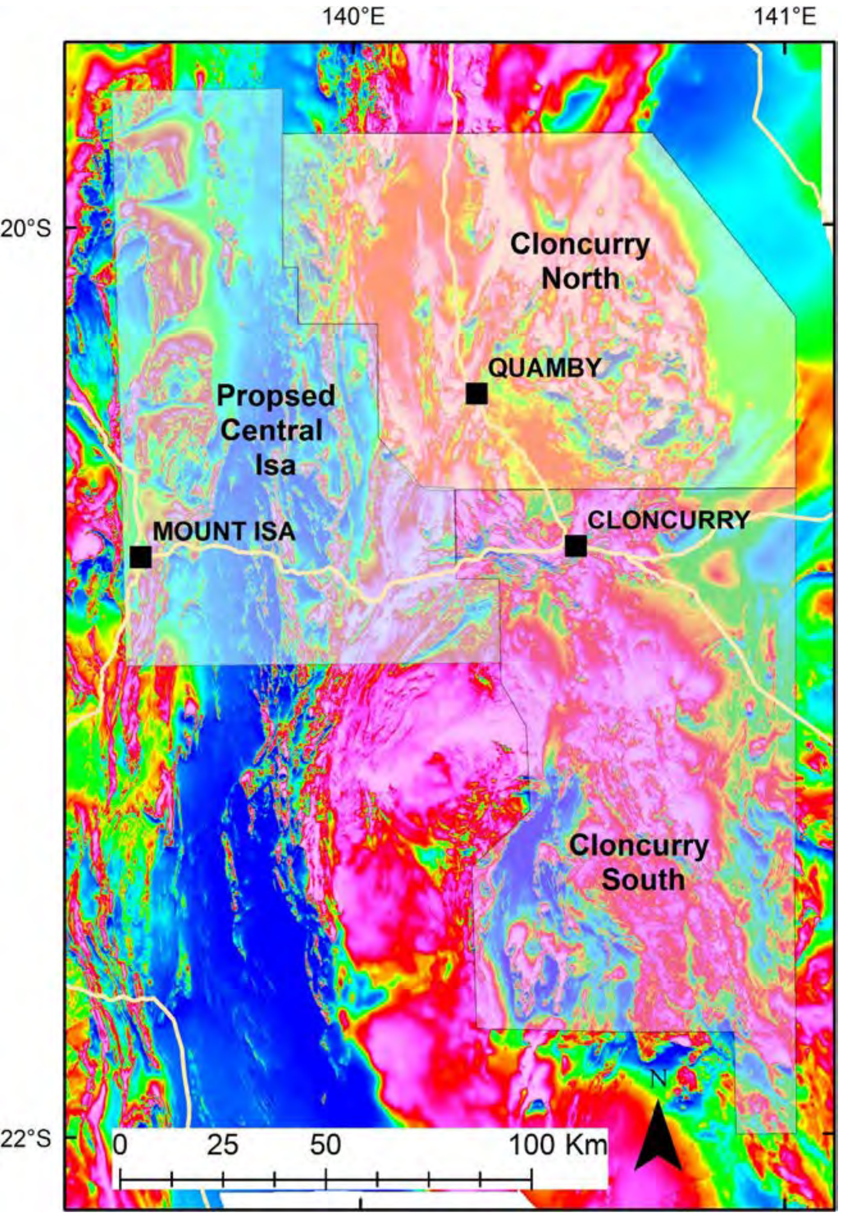
All released data available at QDEX Data http://qdexdata.dnrm.qld.gov.au

High Resolution Mag



- Expanding 100m airborne magnetics and radiometrics
  - Cloncurry South – 2017
  - Cloncurry North – 2018
  - Central Isa – 2019

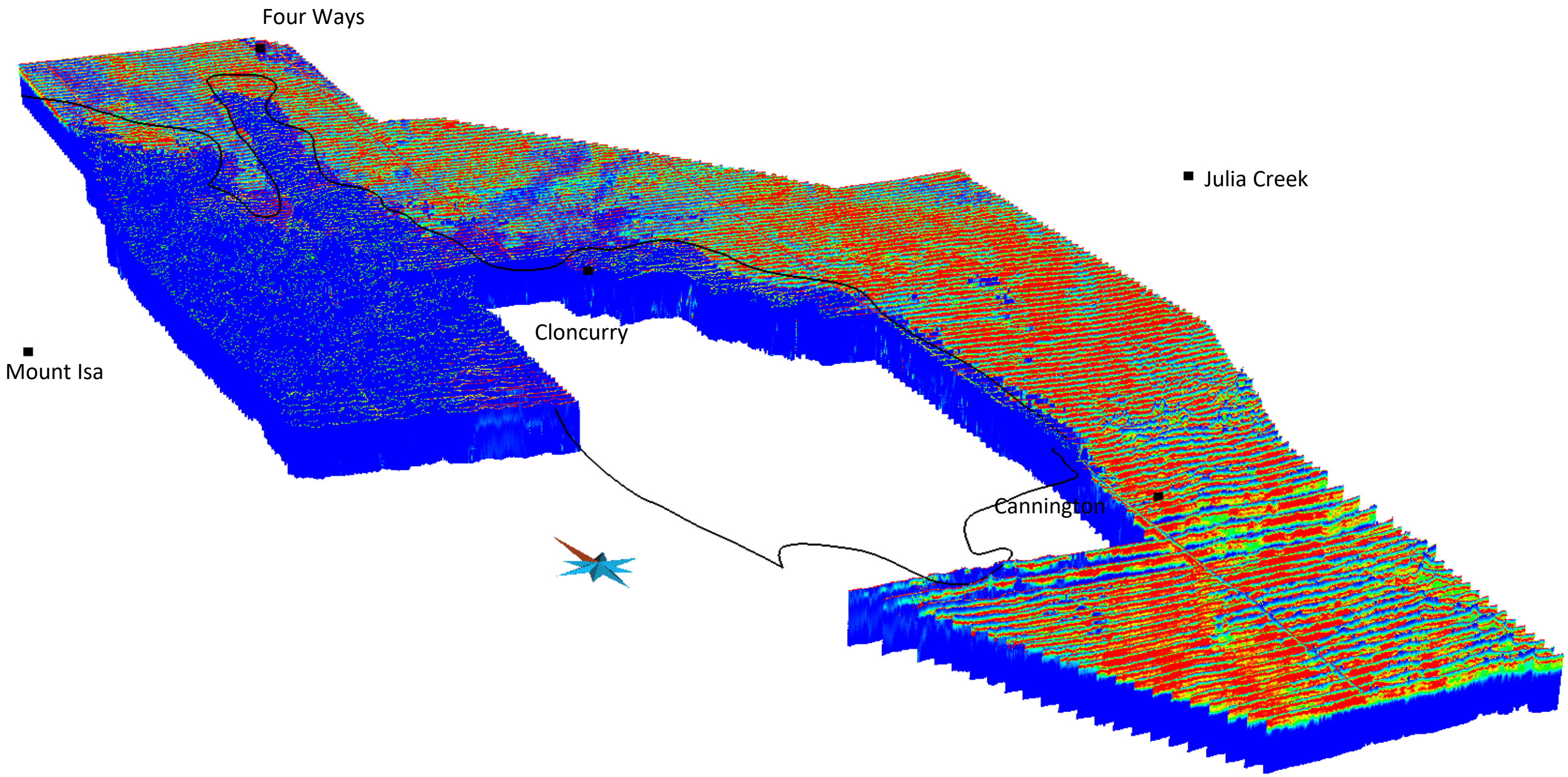
Central Isa Survey



- Approximately 85,000 line km
- Start date mid-April
- 3 surveys combined to create a large high resolution merge of region
- ~28,000km^2 covered by 3 surveys

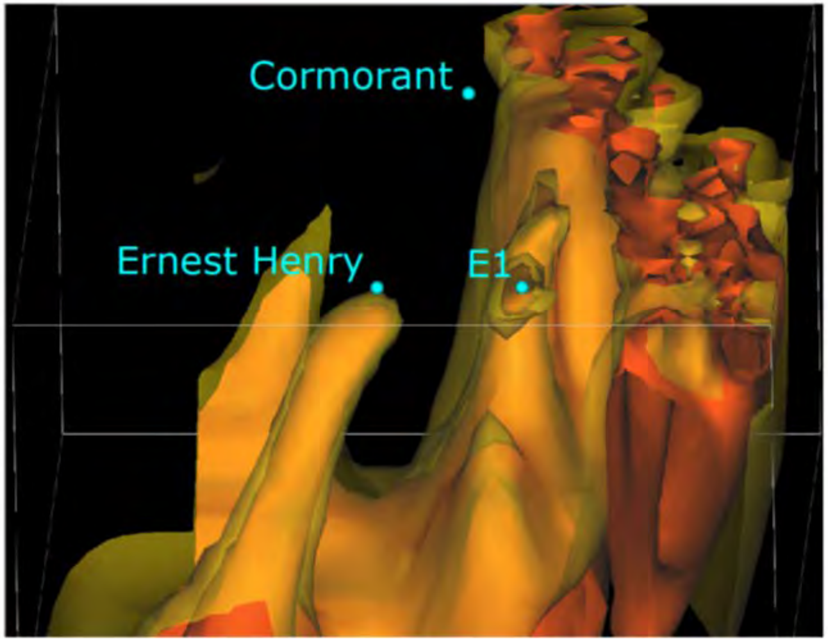
Airborne AEM

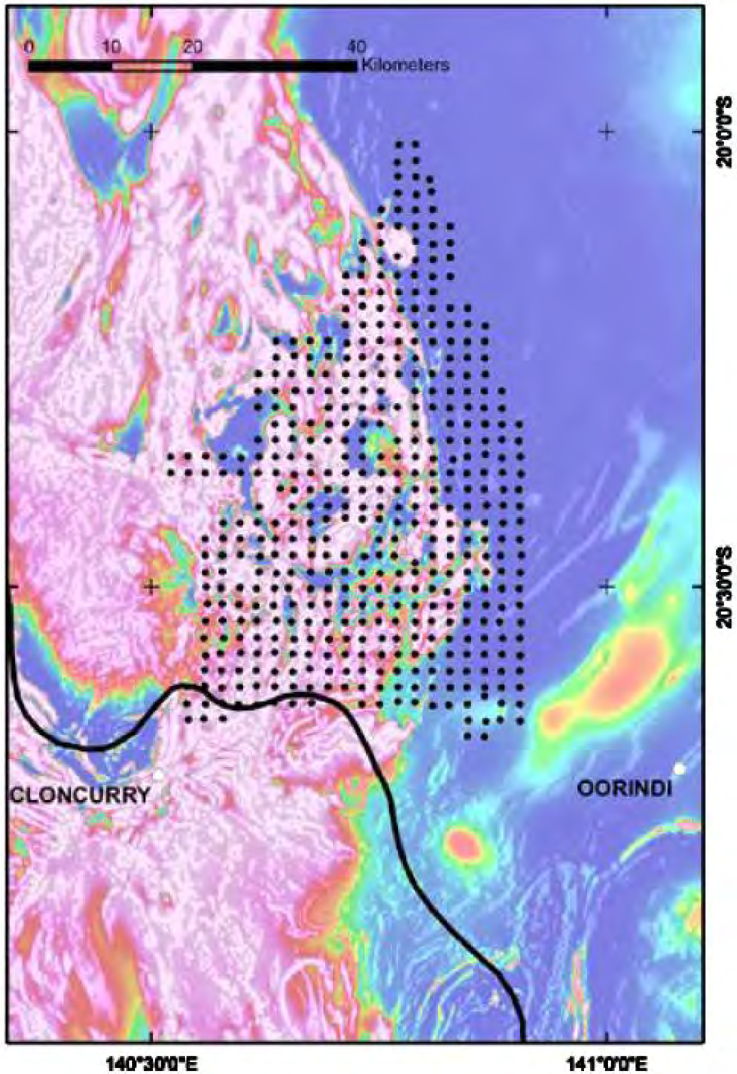
- GSQ AEM – VTEM, acquired in 2016-17
- Future targeting AEM planned for FY 2019-2020
  - Targeting Western Succession
  - AusAEM results to drive area selection



Magnetotellurics (MT)

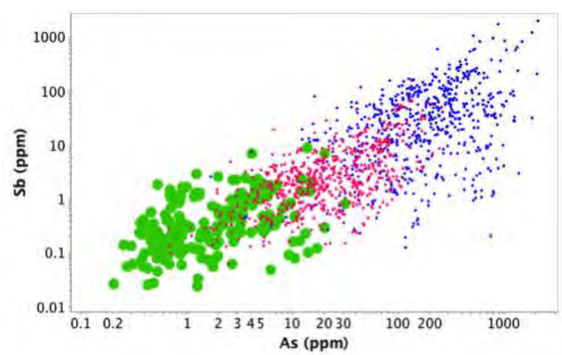
- MT grid surveys – S of Mt Isa and N of Cloncurry (incl Ernest Henry)
- Planning new survey area for collection in 2019

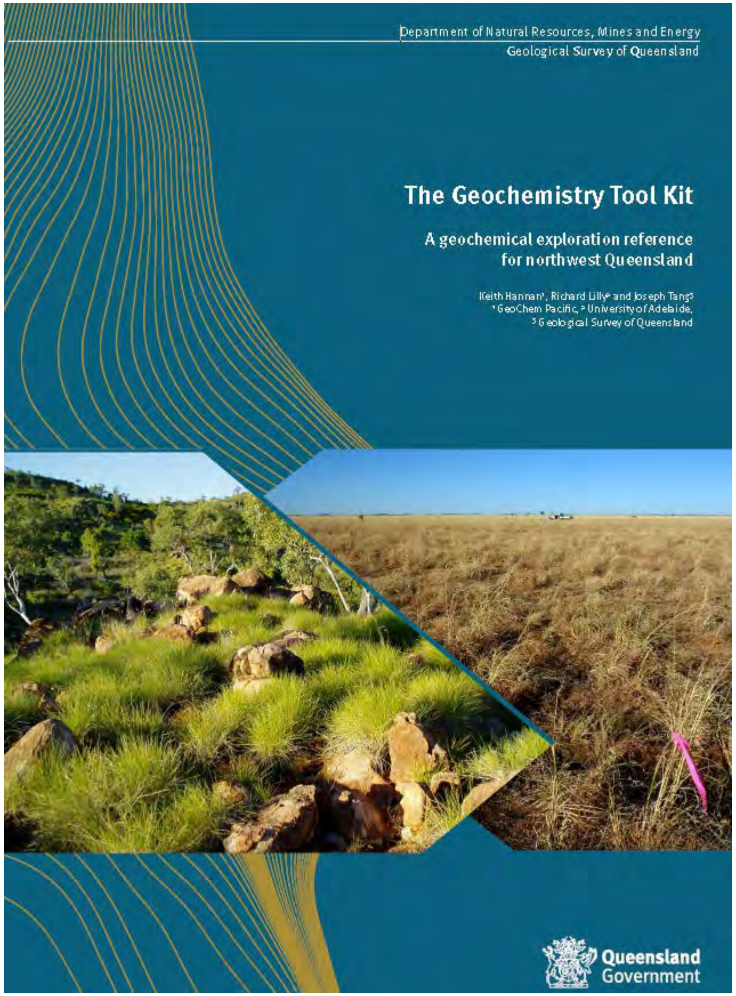




Geochemistry

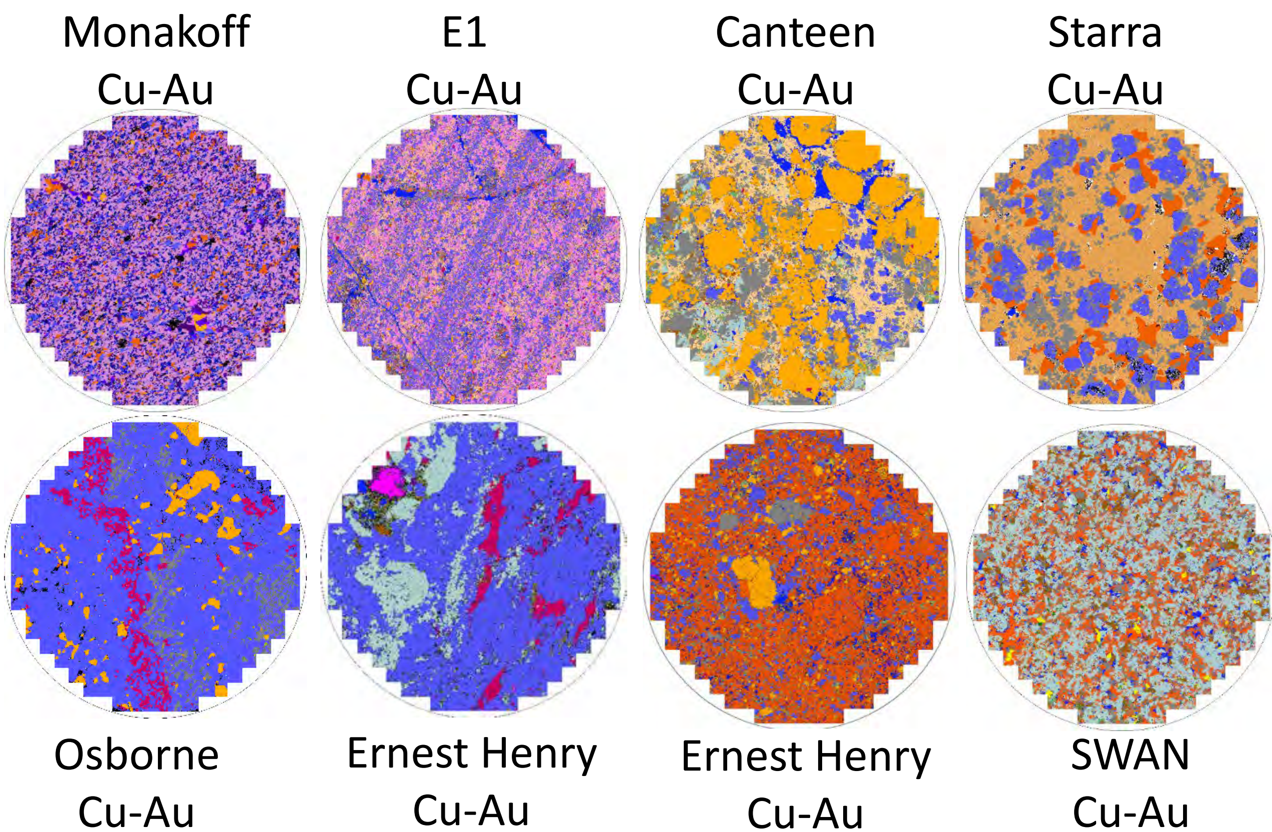
- **Geochemical Toolkit** for explorers
  - Adelaide Uni - GeoChem Pacific-GSQ – **released 2018**
- **Hydrogeochemistry** of the Mt Isa Province - GSQ-CSIRO
- **Mineral chemistry vectoring**
  - CODES
  - Footprints of major IOCG and sediment-hosted Cu, Zn, Pb, Ag deposits





Geochemistry

- **Fingerprinting mineral deposits** - CSIRO
  - Geophysical, structural and mineralogical signatures of the Cloncurry Mineral System

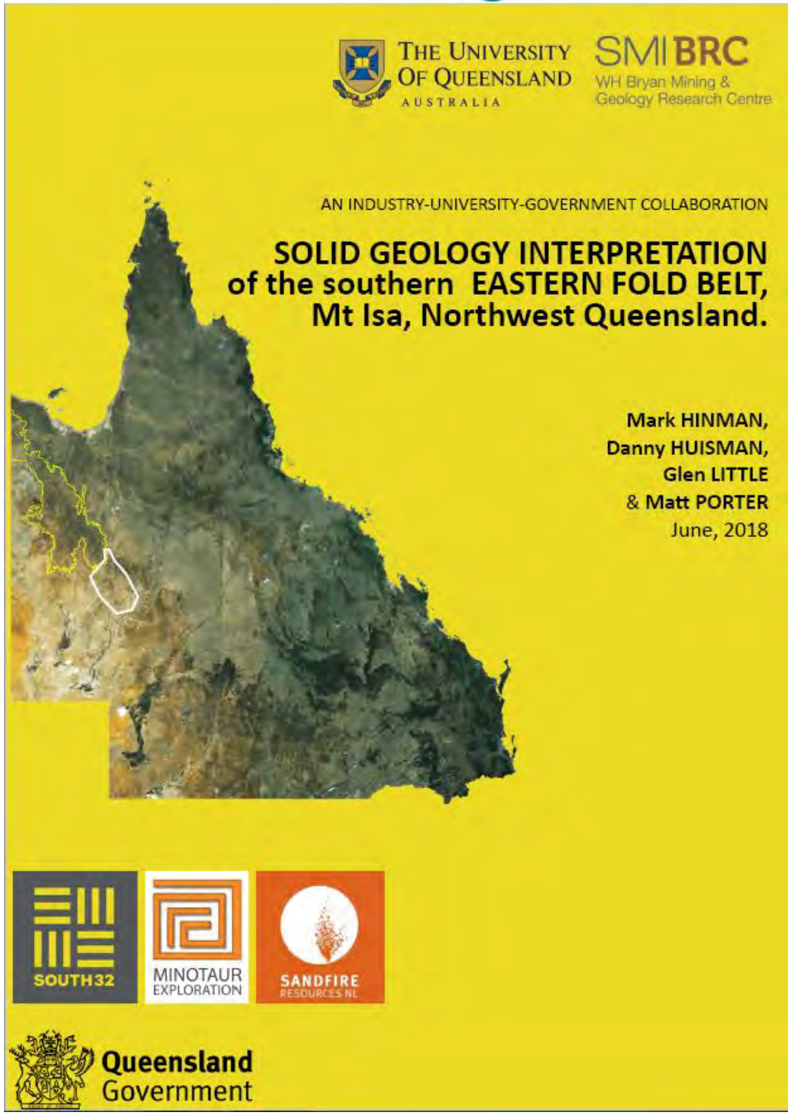


TIMA images

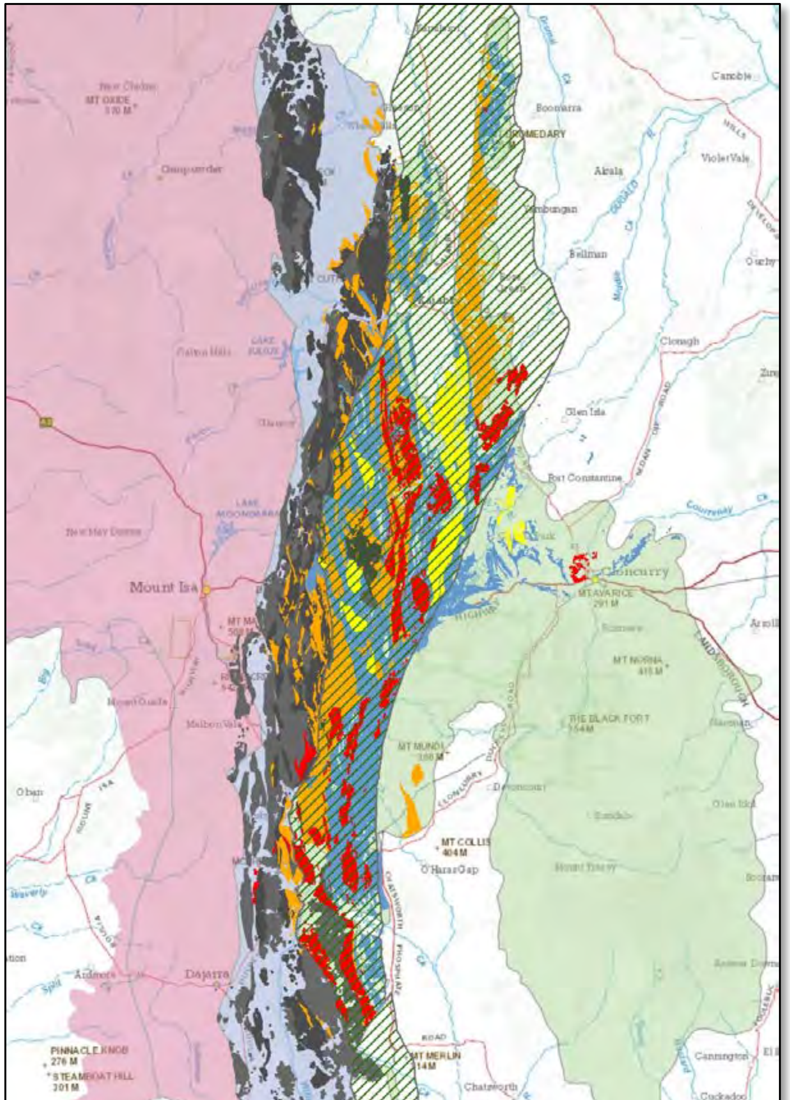
Combining…..
- Paleomagnetics
- Mineralogy
- Geochemistry
- Hyperspectral
- Conductivity
- Density
- Mag susceptibility
- Mag remanence
- Radiometrics

Geology/Mineral Synthesis

- Compilation of historic research (BRC/UQ-GSQ **completed**)
- Machine Learning pilot (DATA61/CSIRO **completed**)
- Co & HREE mineral systems (Ken Collerson **completed**)
- Tick Hill gold deposit (PhD, EGRU)
- Mary Kathleen Domain magma fertility (EGRU)



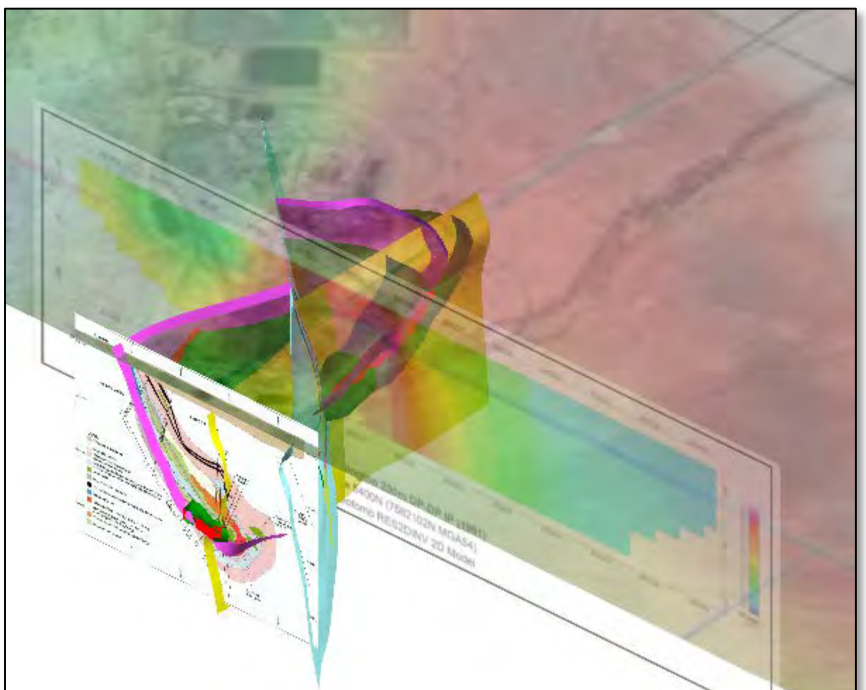
Mary Kathleen Domain Geology

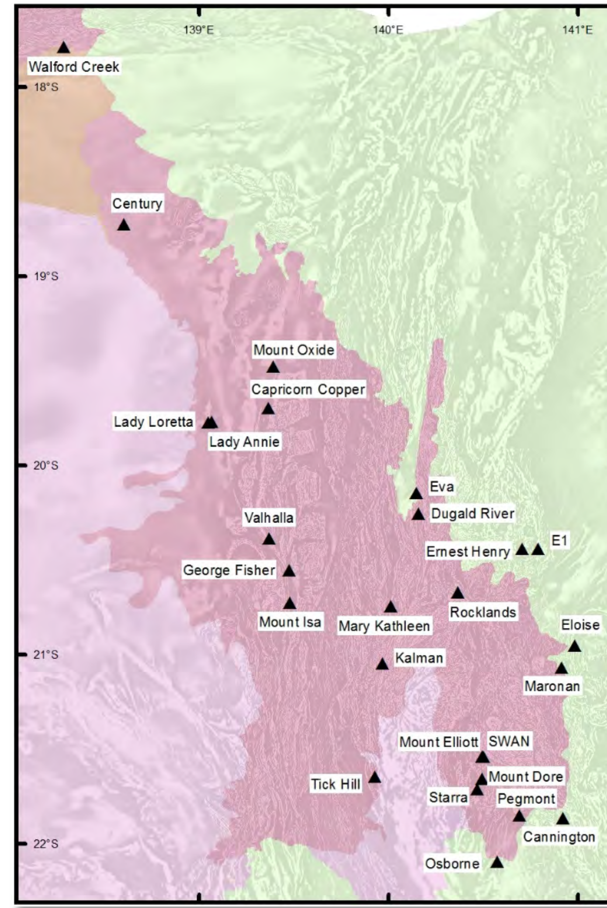


- Important mineral deposits:
  - Mary Kathleen, Little Eva, Dugald River, Tick Hill
- Test association of mineralisation with felsic and mafic magmatism
  - 1540-1500 Ma (similar to IOCGs in Eastern Succession)
- Poorly constrained in the MKD

Deposit Atlas

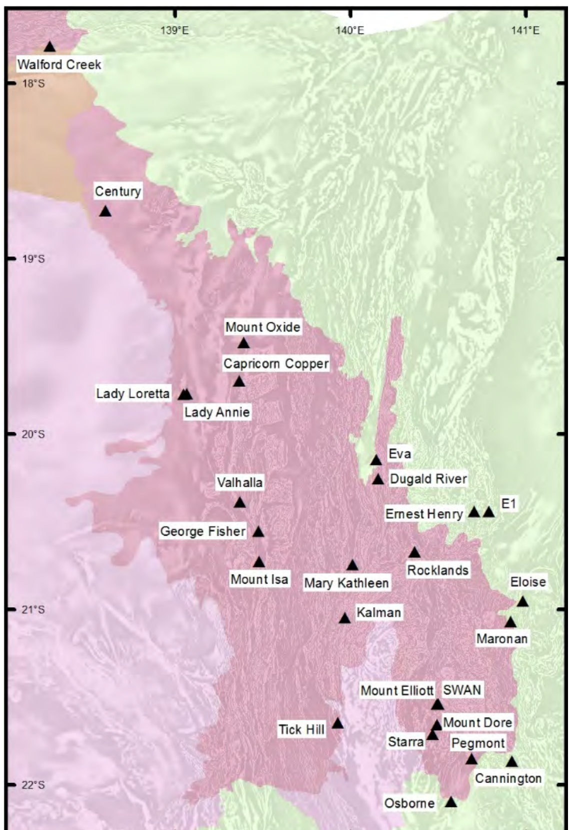
- Deposit atlas of NW Qld
  - UQ collaboration, Rick Valenta
  - Compilation of all open file data for major or significant deposits in the NW Minerals Province

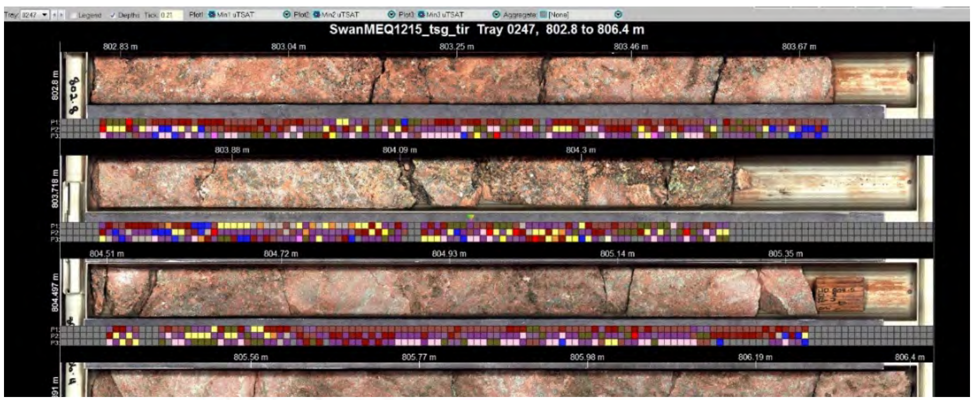


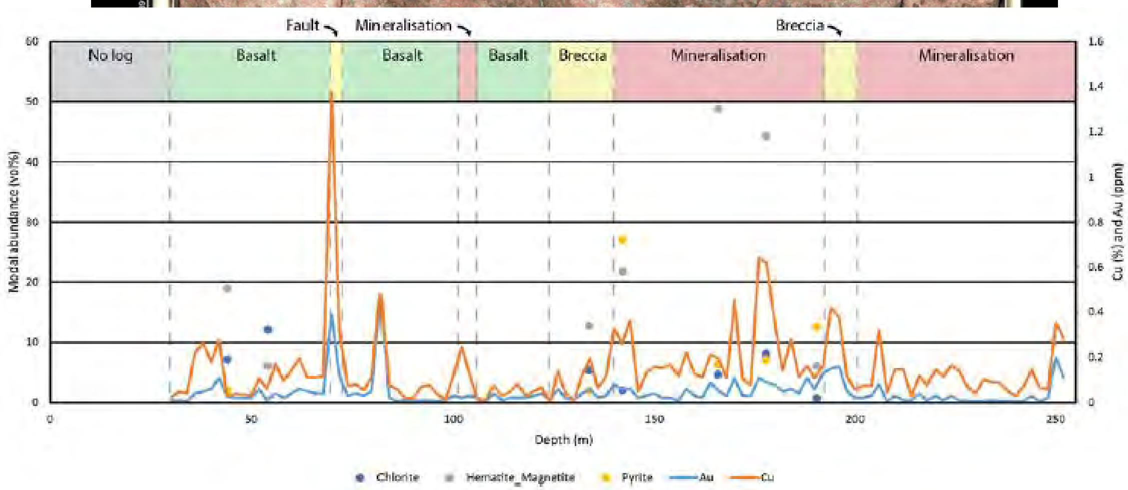


Reference Collection

- Digital core library for key deposits in the NW
- Complements Deposit Atlas
- Compile and enhance drill hole data

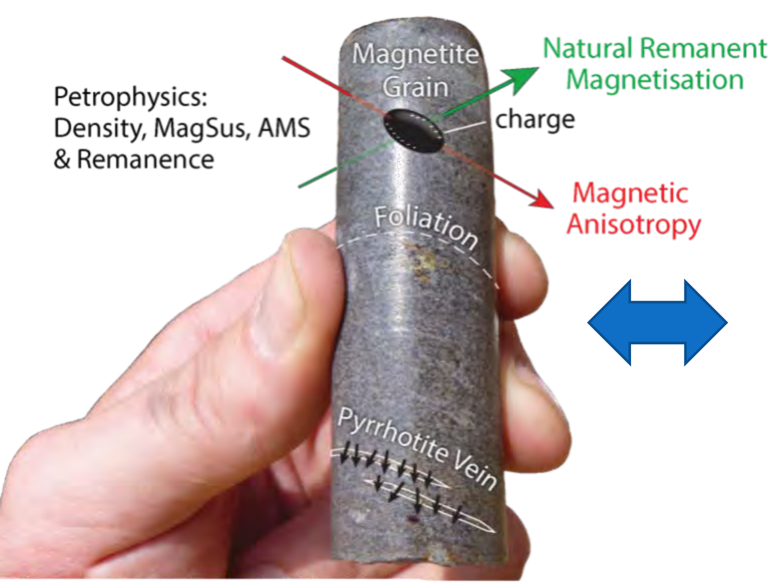


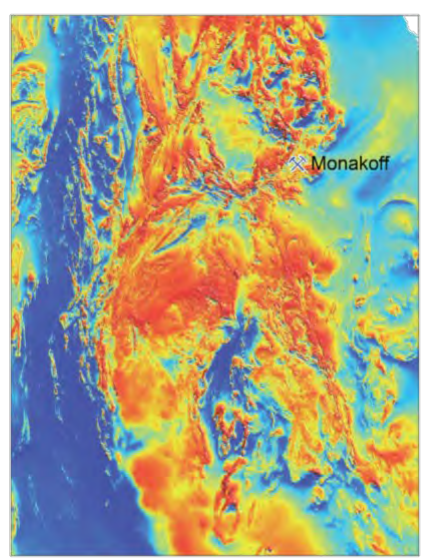


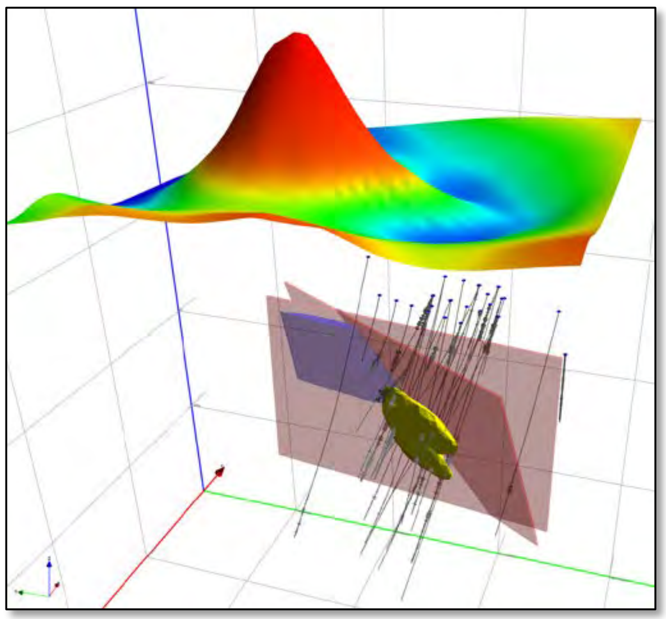


Geoscience Data Modernisation

- Data “Integration”
- Entering a new era of data-driven “science”, but
- Huge problems with data integration in geoscience
- Differing datasets that were never designed to be integrated
- Geoscientific data is different from most other data:





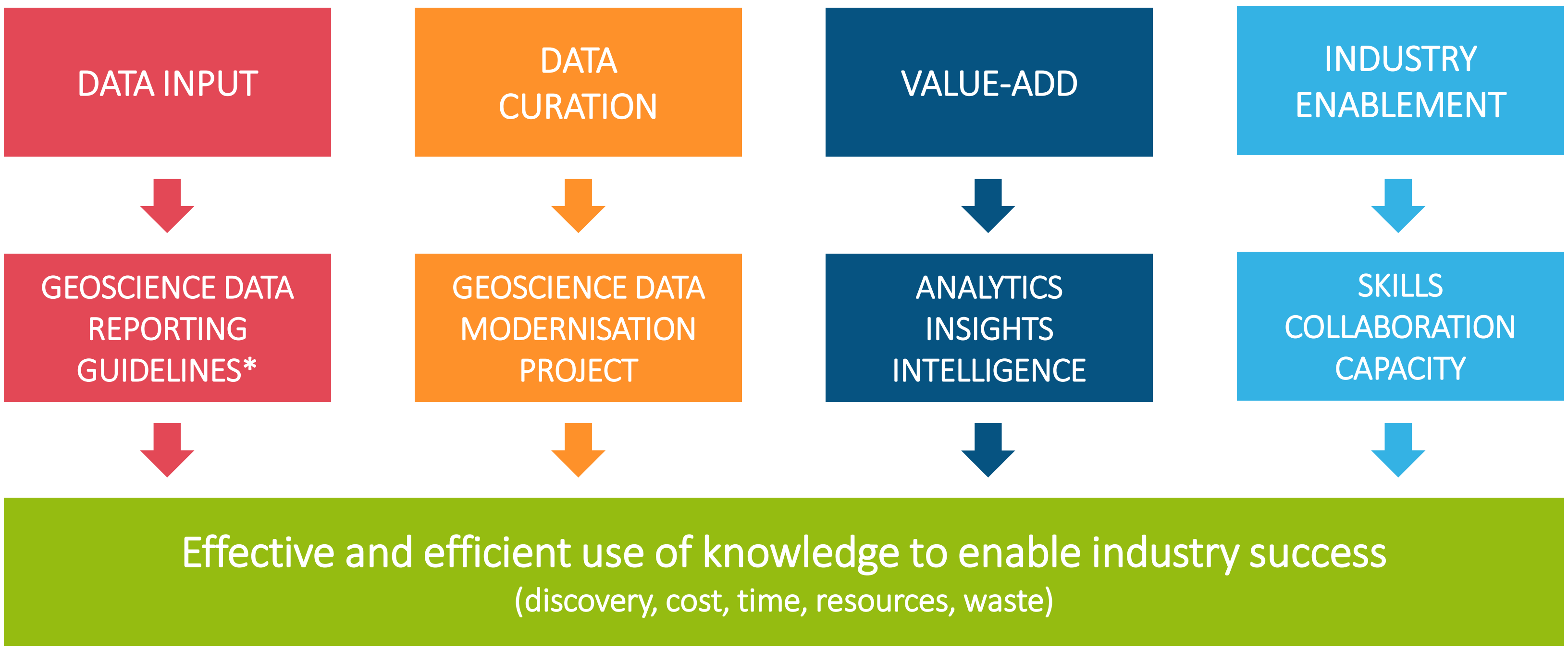


Geoscience Data Modernisation

- In Qld, real problems with data storage and data quality
- These affect:
  - Data discoverability
  - Data useability
- Ultimately hampering exploration success

Geoscience Data Modernisation

Data-Driven Exploration



* Draft Mineral & Coal Reporting Guidelines available for Industry feedback after 29th March 2019

Disparate systems into One

Unsupported technology	MERLIN Borehole, Surface Geology, EDC
Unsupported technology	QDEX Reports
Duplicative system, expensive data storage	QDEX Data
Duplicative system	GEM
Unsupported technology	Discoverer BI
Redundant	Mines DB
Significant cost savings from reduced data volume	GSQ Data (NAS)

→ GSQ Data Lake

Data Lake

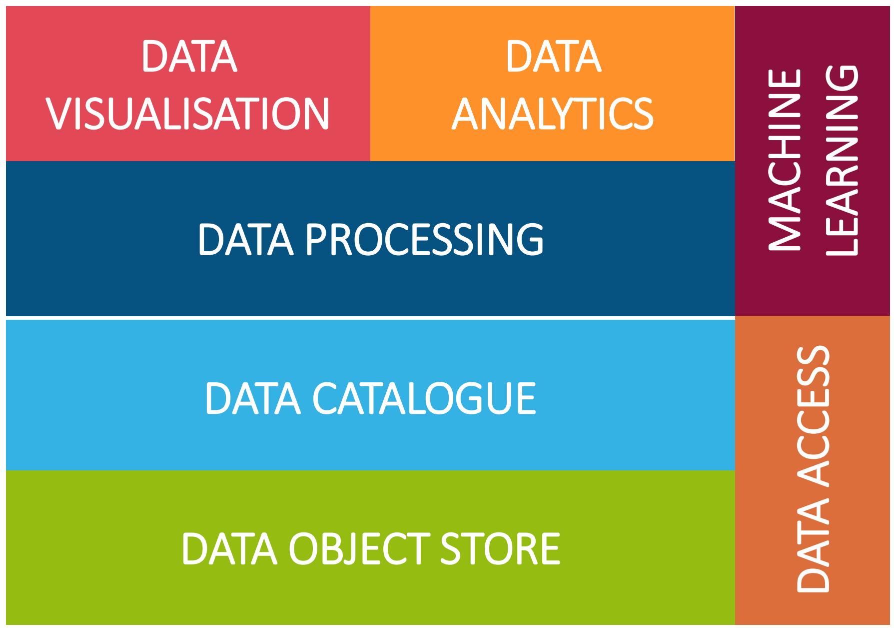
Find insights in data

Interact with the data via spatial, textual, graph, 3D

Optimise, enhance, cleanse & curate data

Index all digital & physical data

Store every piece of data as an object



AI that learns from data, and identifies patterns & insights

Human, computer & cloud data access

Pilot Progress to Date

RECEIVE/ GENERATE | VALIDATE | STORE | CATALOGUE | DISCOVER | EXTRACT/ ANALYSE

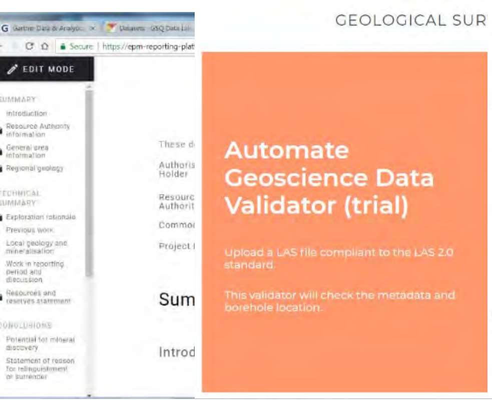
EPM report form prototype

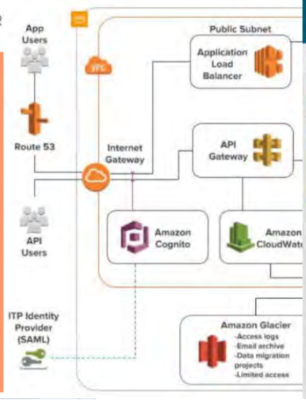
LAS file validator

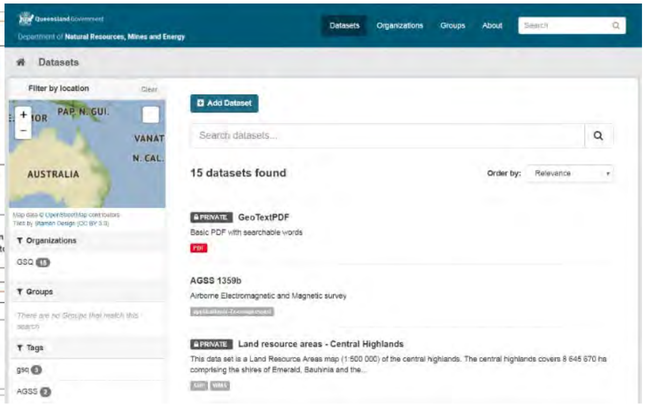
Pilot data lake

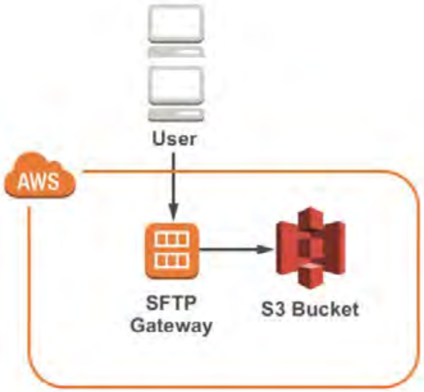
CKAN data catalogue
Vocabulary manager

File transfer test









Summary

- **New Discovery Program**
  - Collaborative research projects from 2017-2021
  - Geophysics, geochemistry, geology, data integration
  - Aiming to boost exploration discovery in NW Qld

- **Geoscience Data Modernisation Project**
  - Takes a wholistic approach to geoscience data
  - Aiming to make ‘data driven exploration’ a reality

Presented by Andrew McNeill
Mineral Resources Tasmania
26 March, 2019

Shoring up the framework: Tasmanian geology, mineralization, and hazards

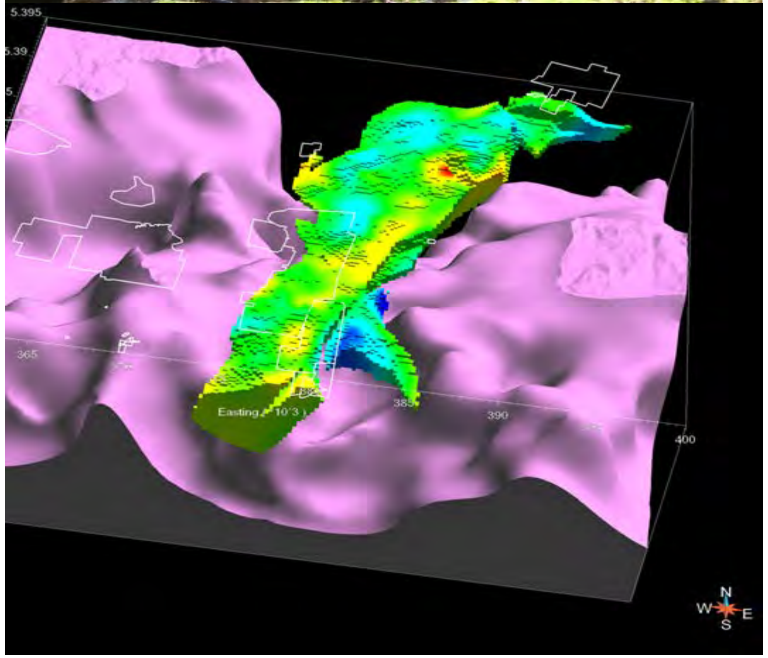
Department of State Growth

Tasmanian Government

Introduction

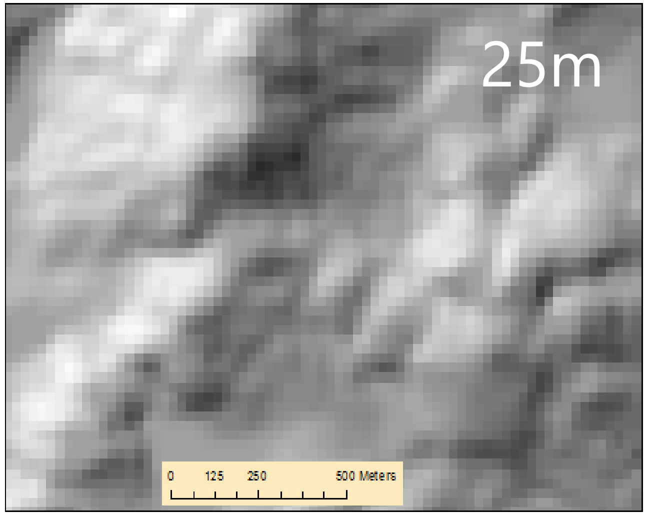
- One of MRTs main roles is to reduce investment and land use risk by developing a robust geological framework for the State

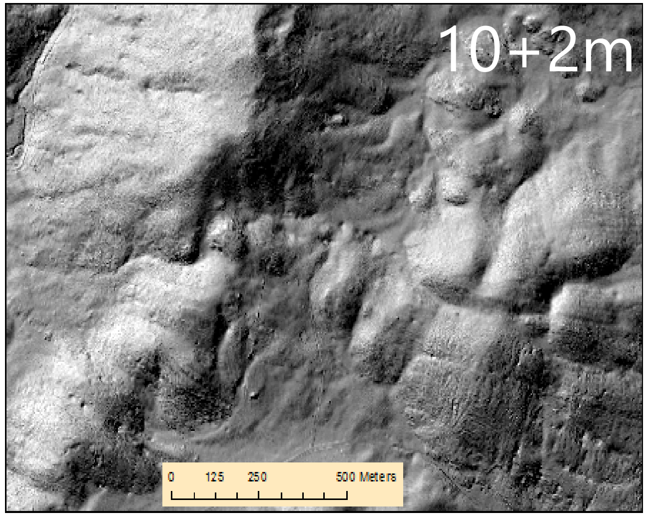
- “Removing” the vegetation – LiDAR and new DEMs
- Establishing the geological framework – mapping
- Establishing the geological framework – magnetics, gravity, MT, passive seismic – will only discuss gravity
- Shoring up the framework 1 - geochronology
- The third dimension – geophysically corroborated 3D modelling
- Shoring up the framework 2 – natural hazards
  - Landslip
  - Debris flow
  - Tsunami

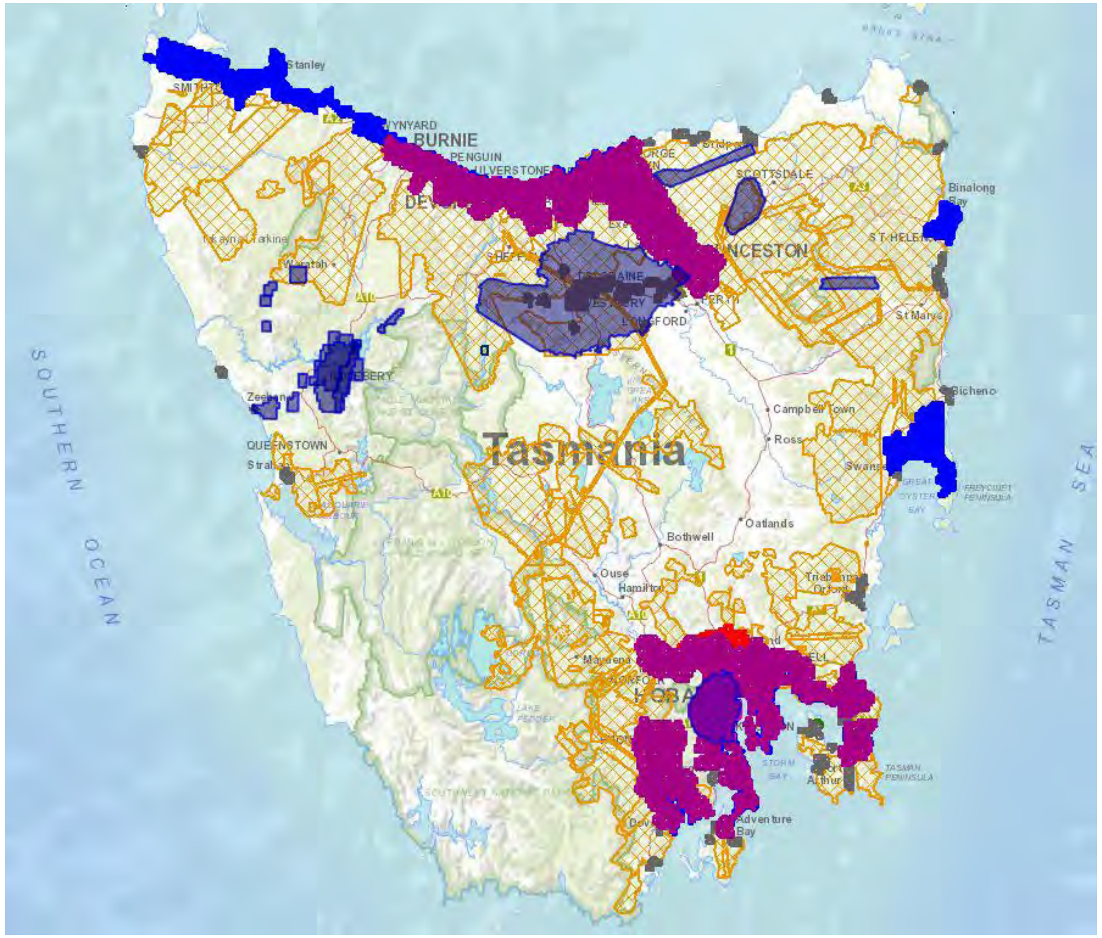


Removing the vegetation

- 54% of state covered by LiDAR (of varying quality); coverage of north and east to be completed in 2019
- 25m state-wide DEM >20 years old – not being revised by State mapping
- Have produced state-wide 10m and 10+2m DEMs

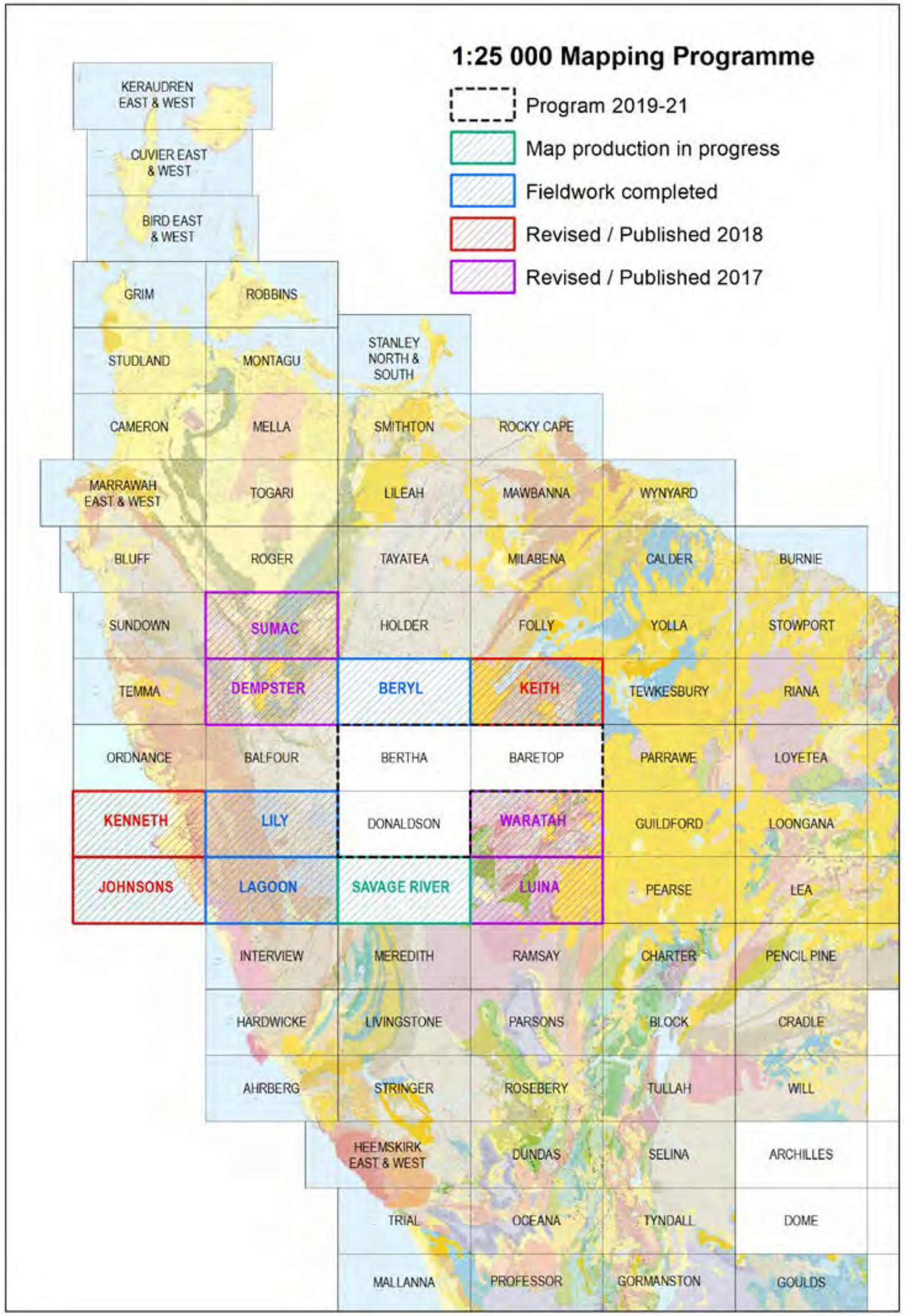






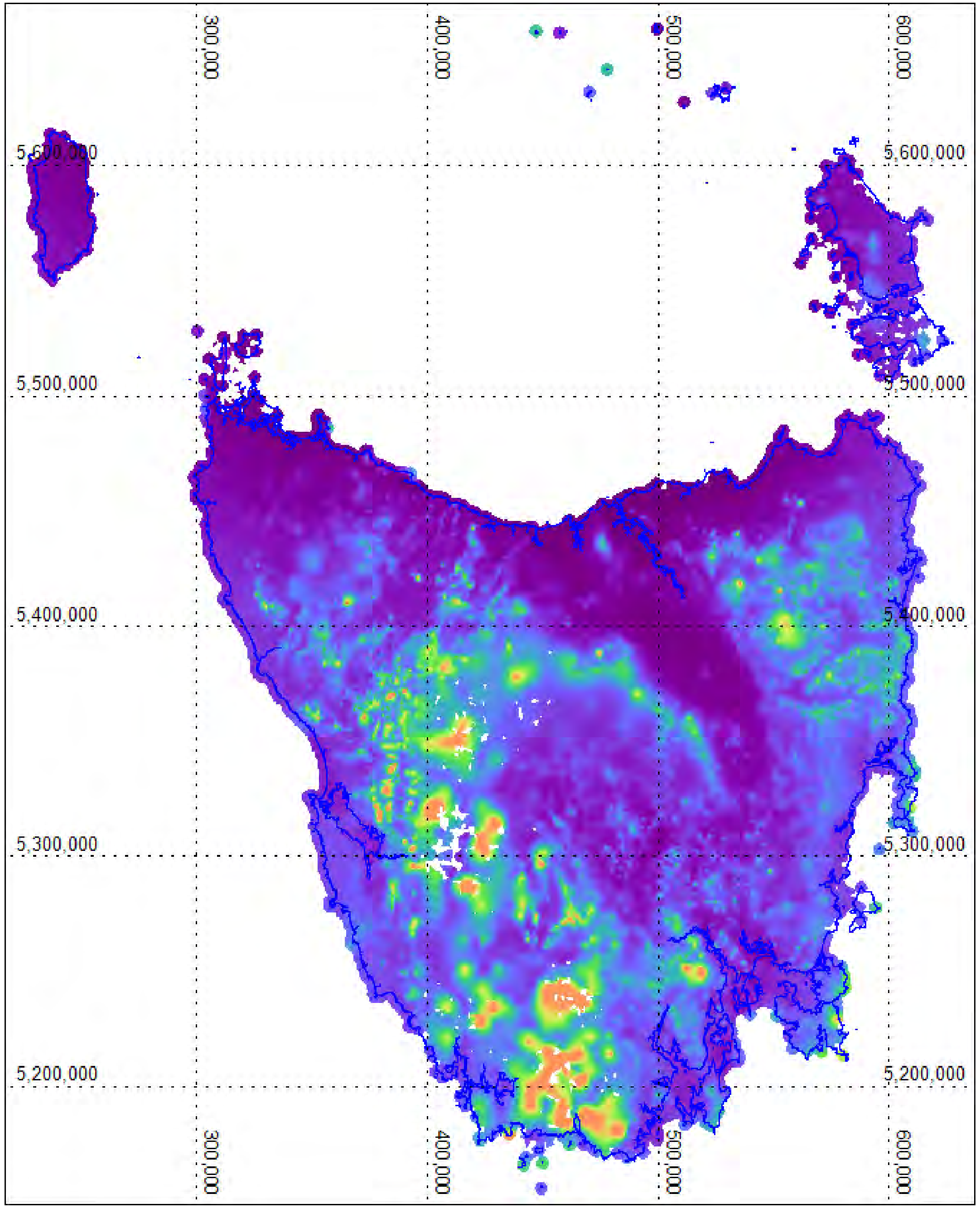
Establishing the framework - mapping

- Digital seamless 1:250K geology complete and being maintained
- Digital seamless 1:25K geology >54% complete (>88% in highly mineralised areas)
- Program:
  - o Complete 1st generation 1:25k coverage in NW Tasmania
  - o Developing improved data model
  - o Updating existing mapping as opportunities arise
  - o Integrating LiDAR into workflow (where possible)



Establishing the framework - geophysics

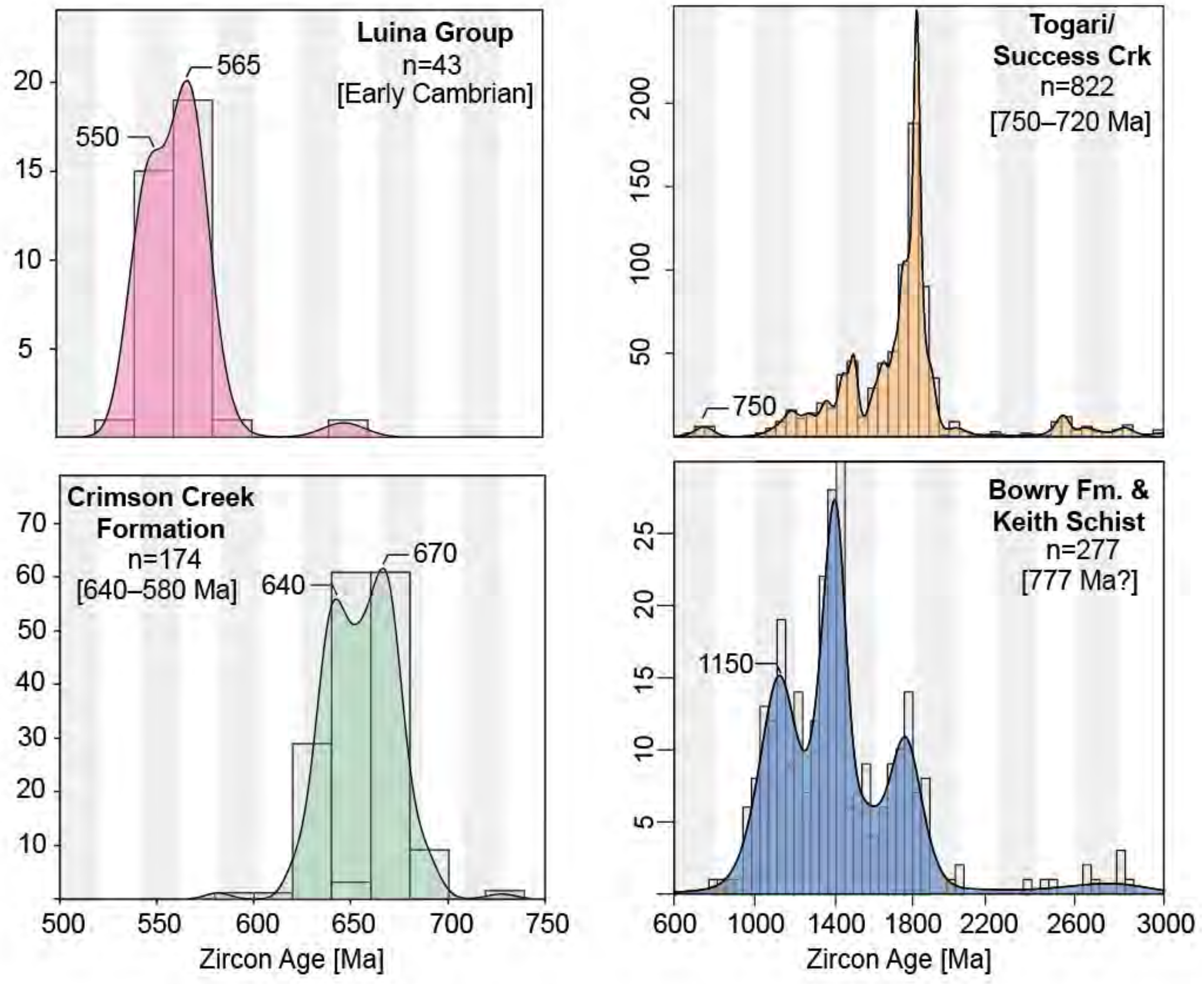
- Terrain correction update for all gravity data
  - On- and off-shore topography significant
  - Previously corrections done manually to 22 km
  - Replaced by automatic correction from 2-167 km
  - Use improved quality DEMs (including bathymetry)
  - Earth curvature correction now used (significant effect)
  - Add continental slope effect (minor effect only)
  - Highest correction now 40.6 mGal (11.6 mGal greater than in previous corrections).
  - Updated dataset available on-line



Shoring up the framework 1 - geochronology

- Joint projects with GA, UTas, UMelb, Boise State U, UBC, U Sth Florida
- Supports regional mapping and addresses specific problems
- Direct dating of mineralisation (Re-Os on molybdenite and U-Pb in cassiterite)
- How robust are our geochemically and petrographically based correlations?

Detrital zircon reference database



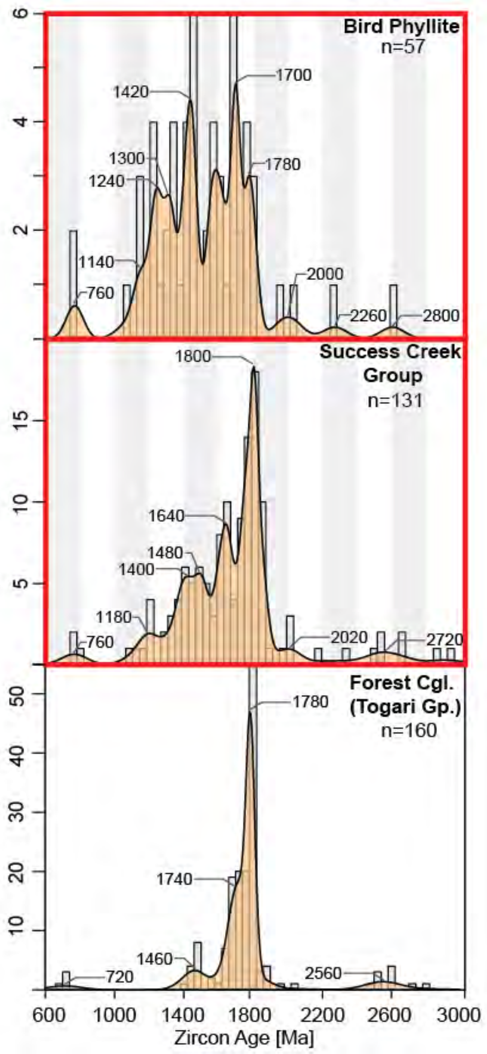
Geochronology - Neoproterozoic

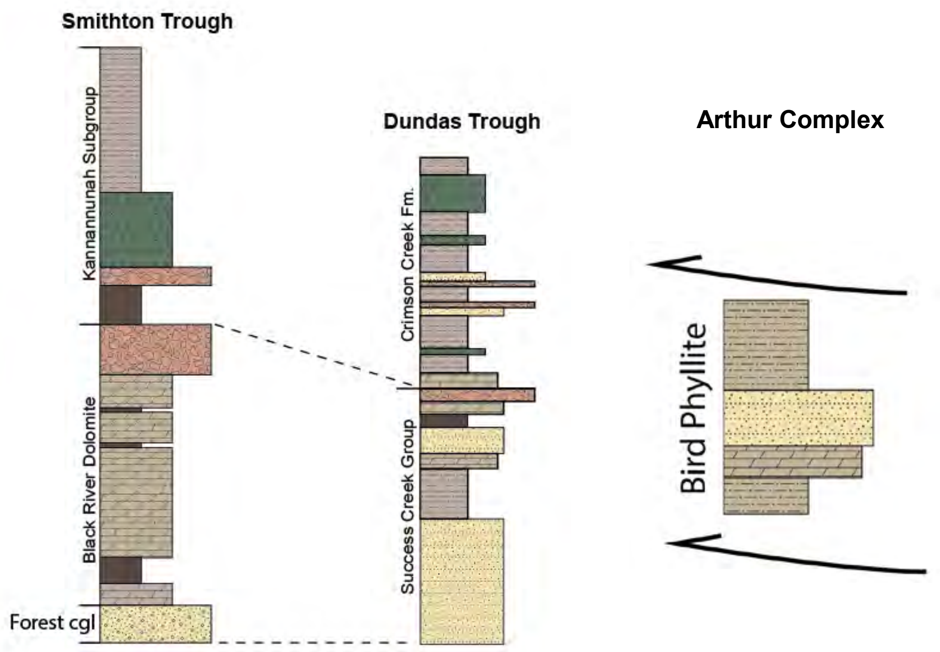
Detrital zircons in Neoproterozoic to ?early Cambrian sequences

Project with UTas and UMelb.

Fault bounded sequences of varying metamorphic grade – how do they correlate?

In this example the Success Creek Group and Bird Phyllite share similar DZ provenance to the lower parts of Togari Group (Forest Conglomerate), supporting correlations through the Smithton and Dundas Troughs and the Arthur Metamorphic Complex.



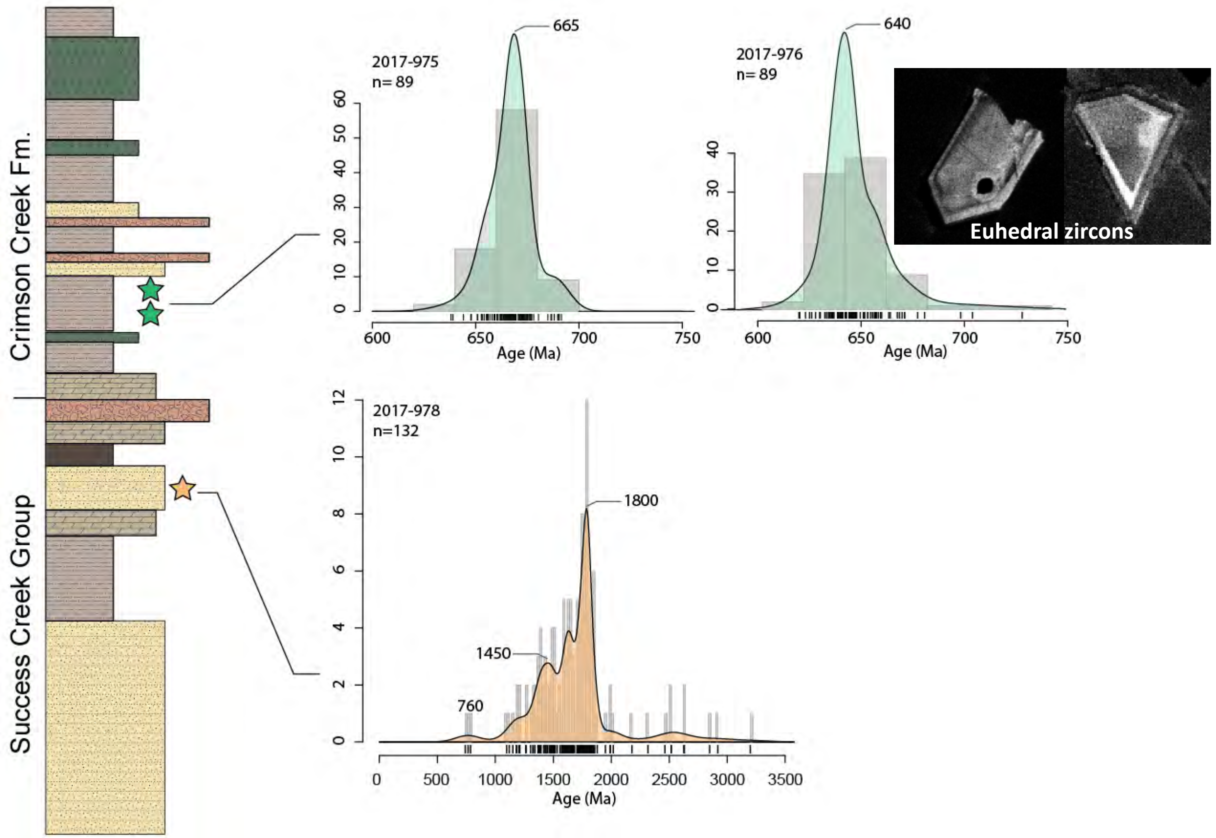


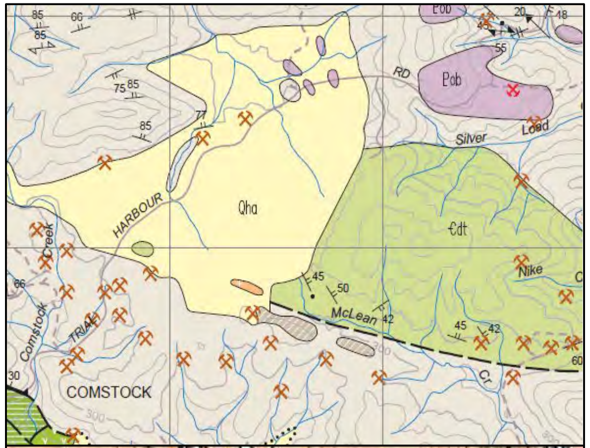
Geochronology - Neoproterozoic

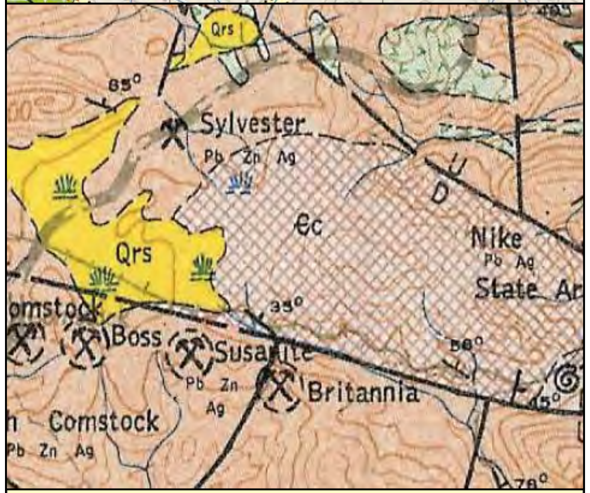
Zeehan area:

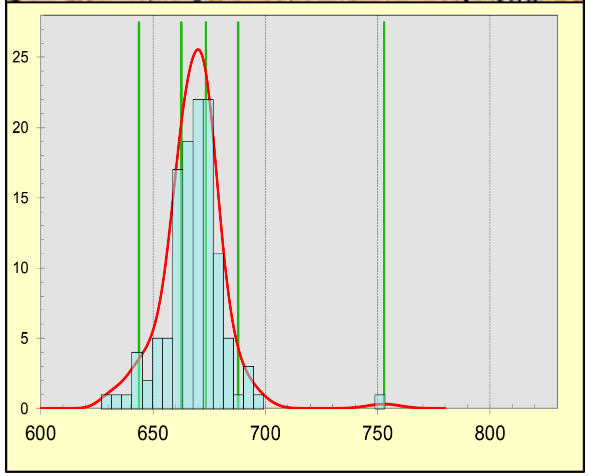
Sediments mapped as either Neoproterozoic (prospective) or Middle Cambrian (un-prospective) by MRT

LA-ICPMS dating of detrital zircons suggests correlation with the Neoproterozoic Crimson Creek Formation



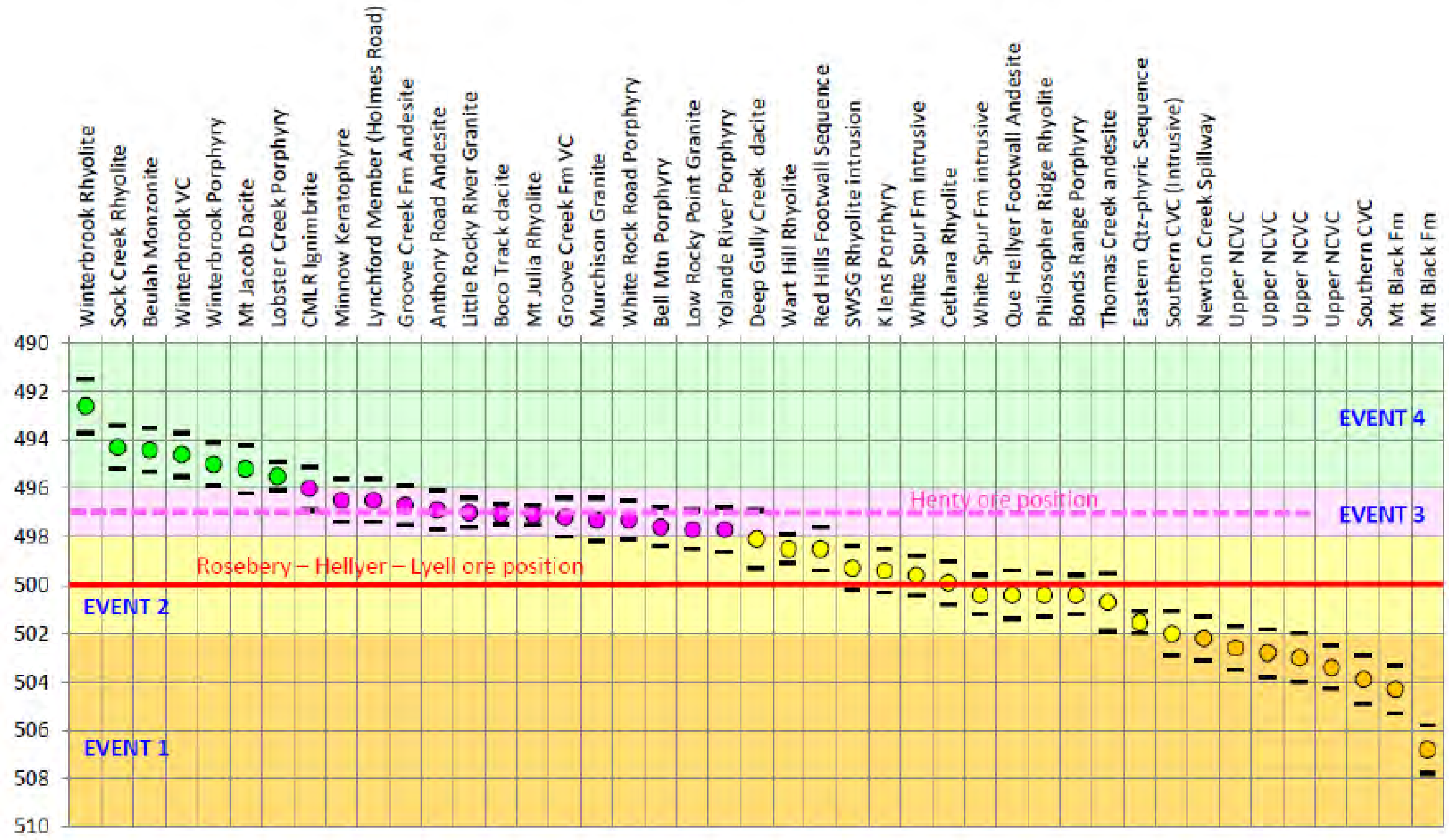






Geochronology – Mount Read Volcanics (MRV)

- What is the age of the VHMS mineralisation – is there a holy Host?
- Can we us our current volcanological and lithochemical correlations to define prospective horizons?
- Project with UTas and UBC:
  - o acquired 49 zircon ages
  - o CA-TIMS, errors of <1.0 Ma
  - o Couldn't obtain good dates for all samples
  - o Age range is 506.8 – 492.6 Ma



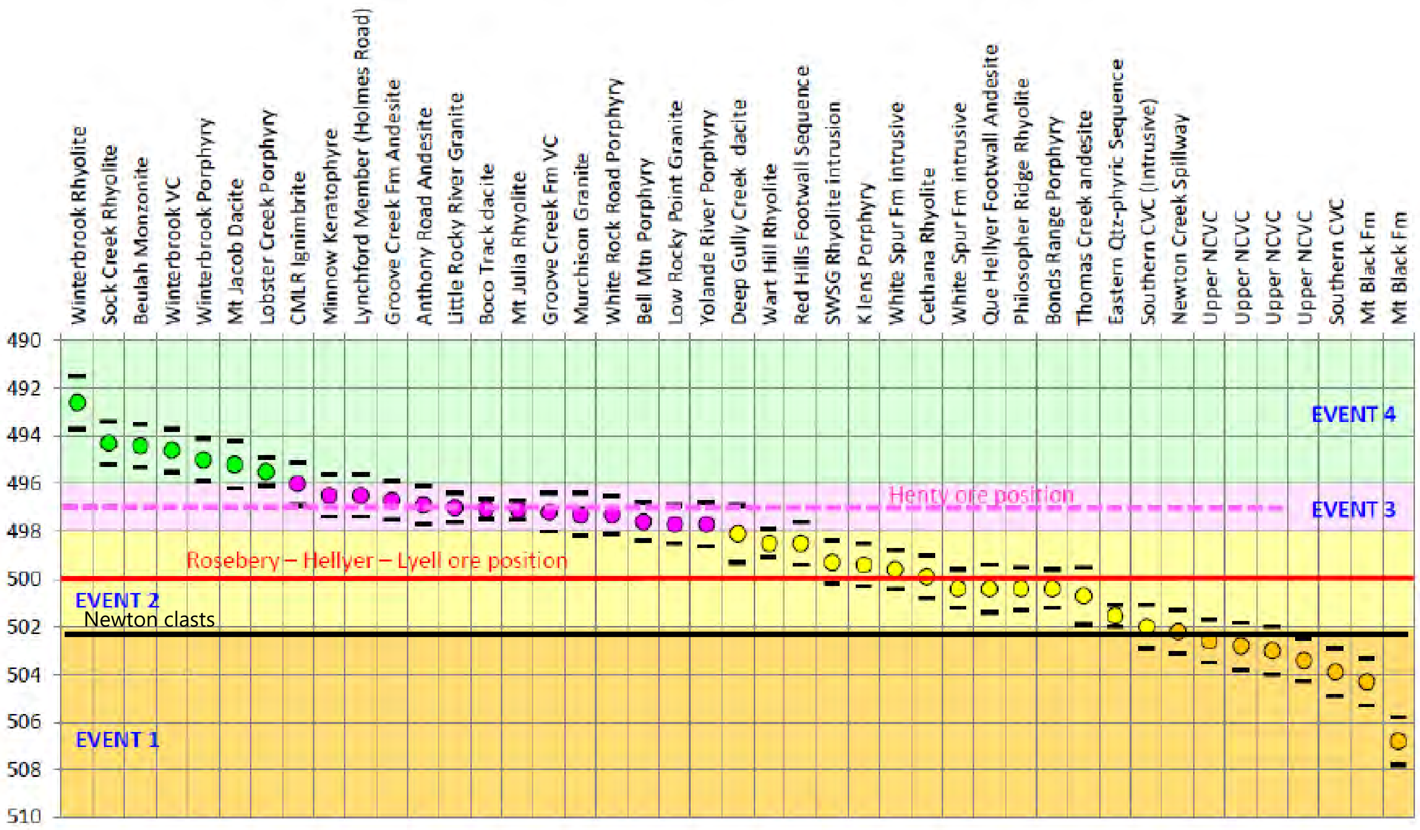
Geochronology – Mount Read Volcanics (MRV)

Deposit	Ore	Method	Footwall	Hangingwall
Wart Hill	*?*		*498.5±0.6 Ma*	*496.5±0.8 Ma*
Thomas Creek	?		500.7±1.2 Ma	?
Prince Lyell	500.4±2.3 Ma	Re-Os (moly)	500.4±0.6 Ma	?
Crown Lyell	491.2±2.5 Ma	Re-Os (moly)	500.4±0.6 Ma	?
Newton clasts	?		502.2±0.9 Ma	502.1±1.0 Ma
Henty	*?*		*~497 Ma*	
Red Hills	*?*		*498.5±-0.6 Ma*	
Rosebery	?		502.8±0.7 Ma	499.4±0.6 Ma
Hellyer	500±23 Ma	Re-Os (WR)	500.4±0.7 Ma	499.3±0.5 Ma

Data: Mortensen et al (2015), Champion et al (2009), Vicary et al (in prep.), Huston et al (in prep.)

Geochronology – Mount Read Volcanics (MRV)

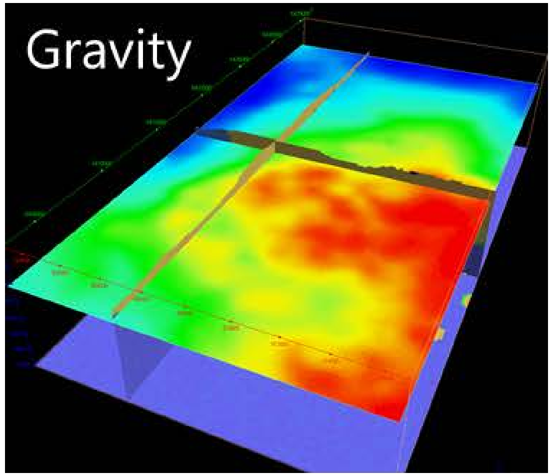
- Major Pb-Zn mineralisation at ca 500 Ma; sub-economic mineralisation both older and younger
- Cu-Au Mineralisation starts at ca 500 Ma and may occur over period of several million years (not just at Lyell)
- Issues with previous lithological/geochemical correlations:
- Lynchford Tuff equivalents span 2.2 Ma – implies not just one eruption; CVC at Red Hills has Tyndall Group age; Elliott Point Porphyry (496.3 Ma) vs Bonds Range Porphyry (500.4 Ma)

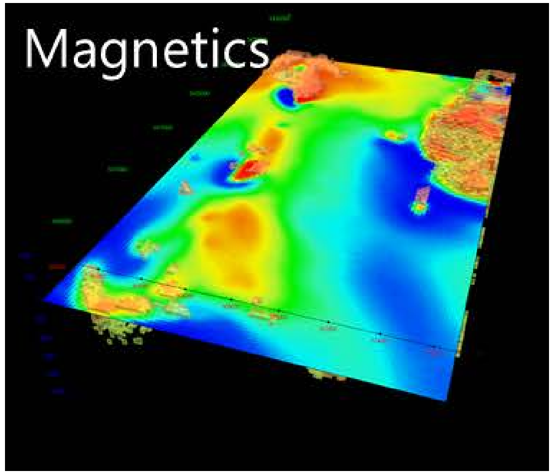


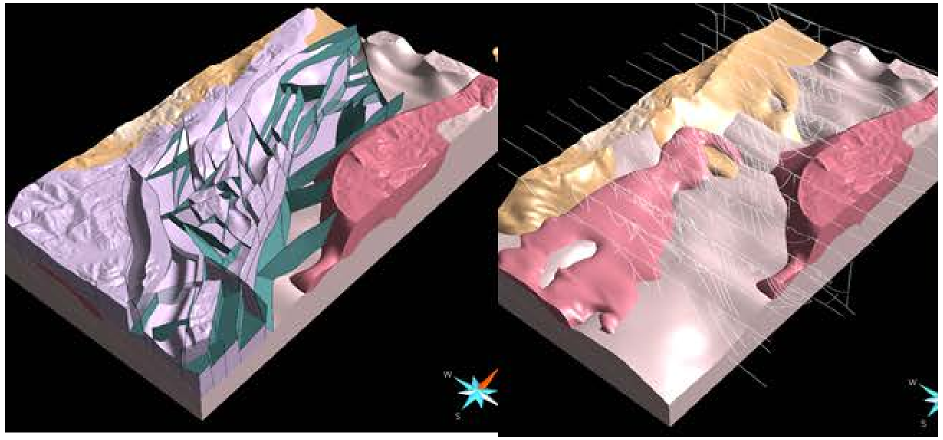
The Third dimension - geophysically corroborated 3D modelling

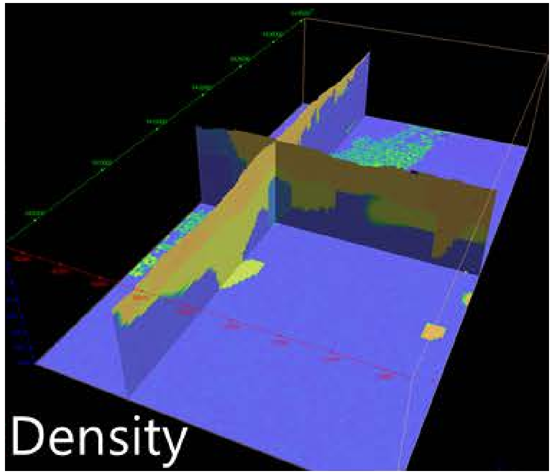
- Semi-regional scale
- Based 1:25,000 mapping and x-sections constructed using geology and drilling data.
- Gravity and magnetic datasets curated by MRT
- Physical properties database curated by MRT

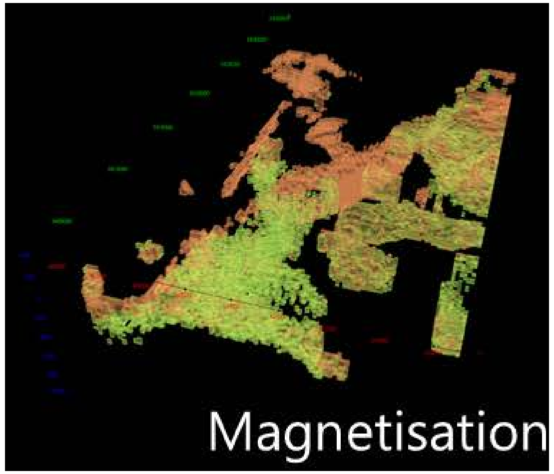
Alberton-Mathinna goldfield, NE Tas







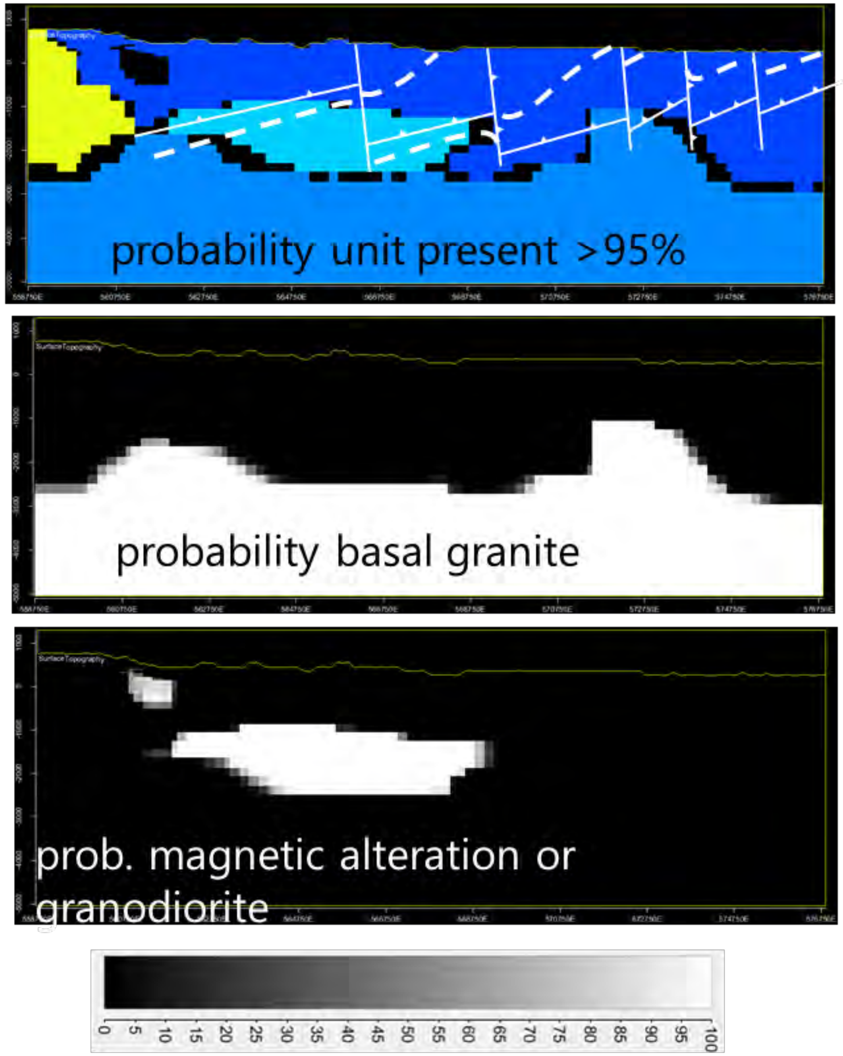


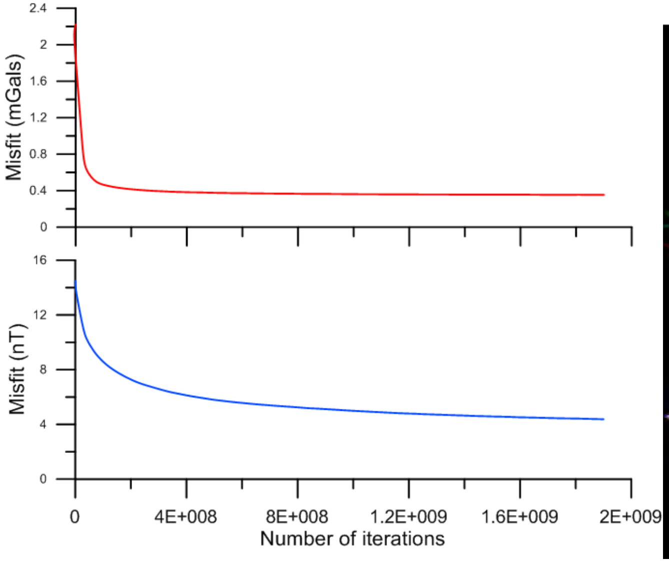


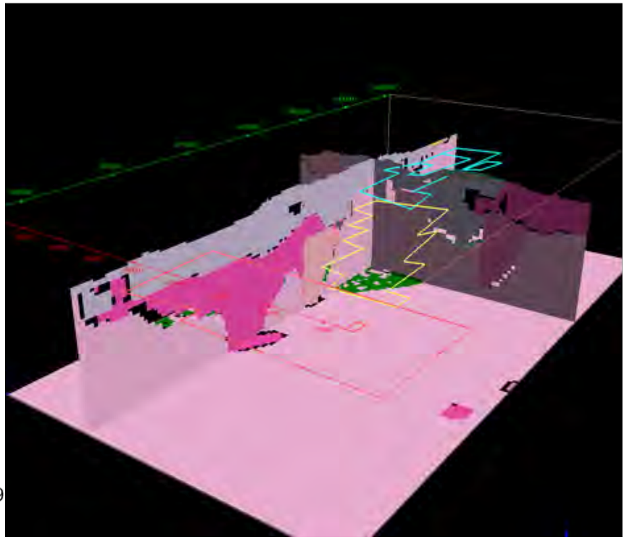
The Third dimension - geophysically corroborated 3D modelling

- With probabilistic interpretation using Geomodeller
- Reference model constructed – inversions of both gravity and magnetics.
- Iteratively vary individual voxels until error is minimised (burn-in)
- For this model required 200 million iterations for gravity and approx. 1 billion for magnetics.

Alberton-Mathinna goldfield, NE Tas



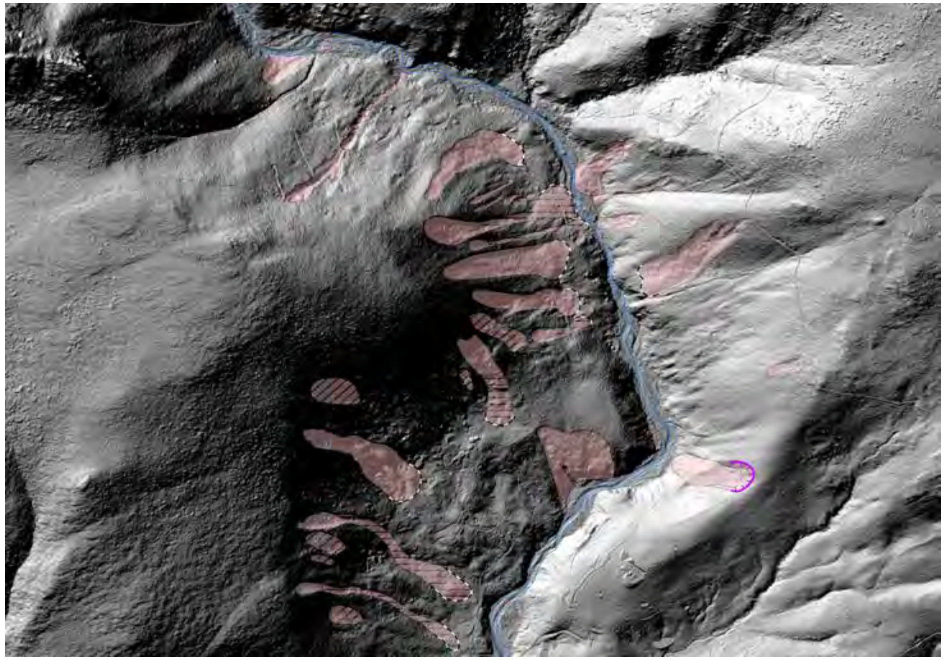




Natural hazards – landslip

C Mazengarb, M Stevenson, N Roberts

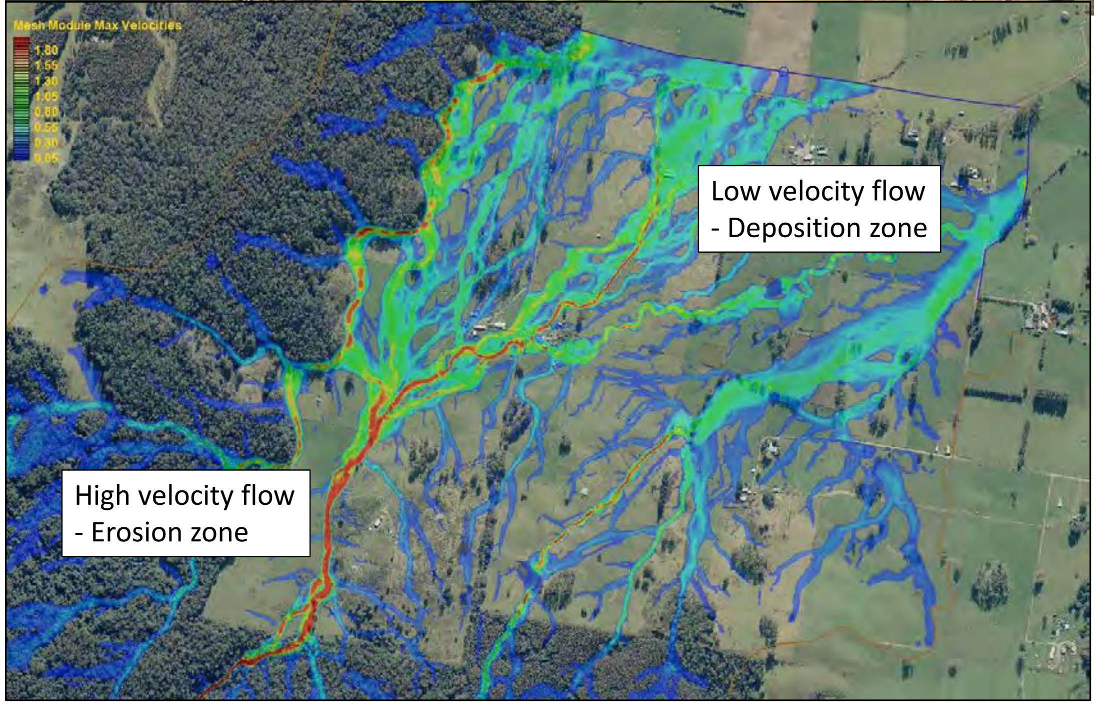
- MRTs role is to provide advice to other agencies.
- Since 1960s more than $12 million paid in compensation for damage to dwellings; cost to repair other infrastructure not recorded.
- Re-activation of landslides after 2016 rain event – currently 4 houses severely damaged Tamar Valley.
- Can be cryptic in landscape – use LiDAR to locate and catalogue
- Use identified slips, underlying geology and topography to define Hazard banding
- Currently:
  - Identifying landslips re-activated after 2016 event
  - Updating state-wide hazard banding.
  - Investigating use of InSAR (RADAR interferometry) to measure movement rates.



Natural hazards – debris flow

C Mazengarb, C Kain, M Stevenson

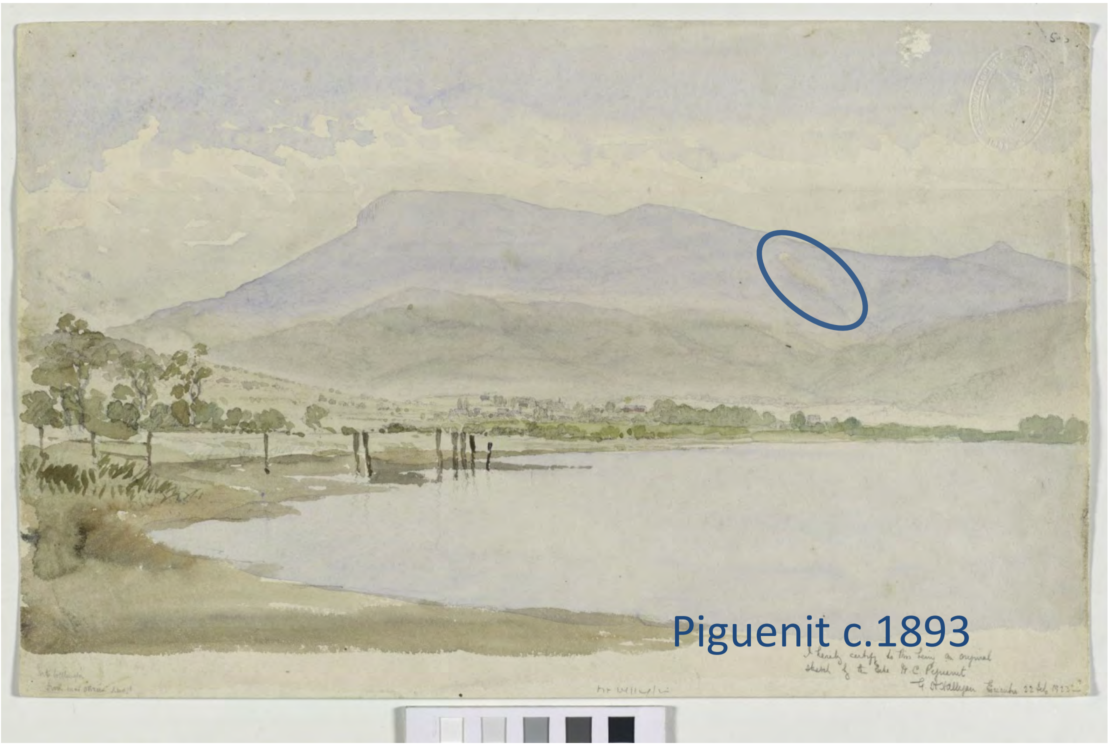
- Rare, locally high impact events after high rainfall
- 2011 and 2016 Caveside flows
- Model using RiverFlow 2D

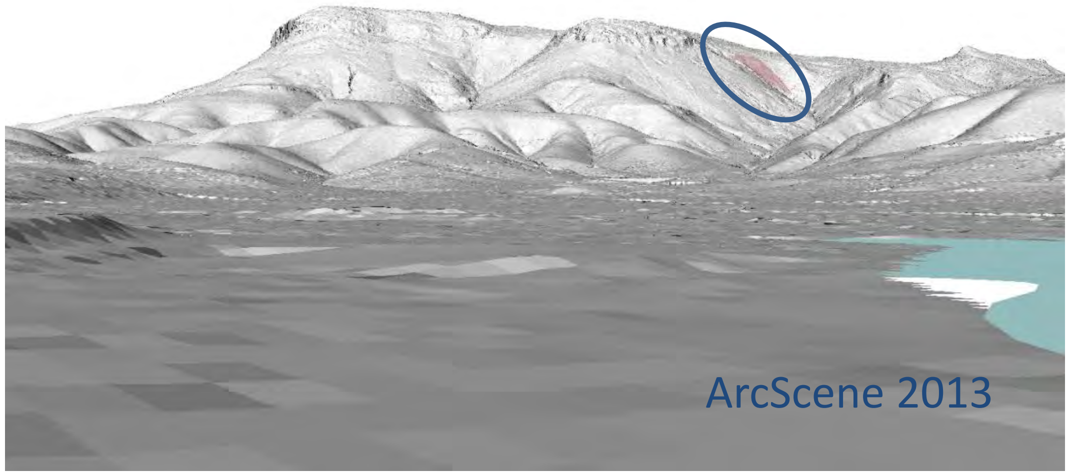


Natural hazards – debris flow

C Mazengarb, C Kain, M Stevenson

- Glenorchy 1872 event
- Historic research
- Much of Mt Wellington area, above Hobart, shows evidence of historic debris flows
- Flo-2D modelling of 1872 event gives good agreement – can use elsewhere?





Natural hazards – tsunami risk

C Kain and C Mazengarb

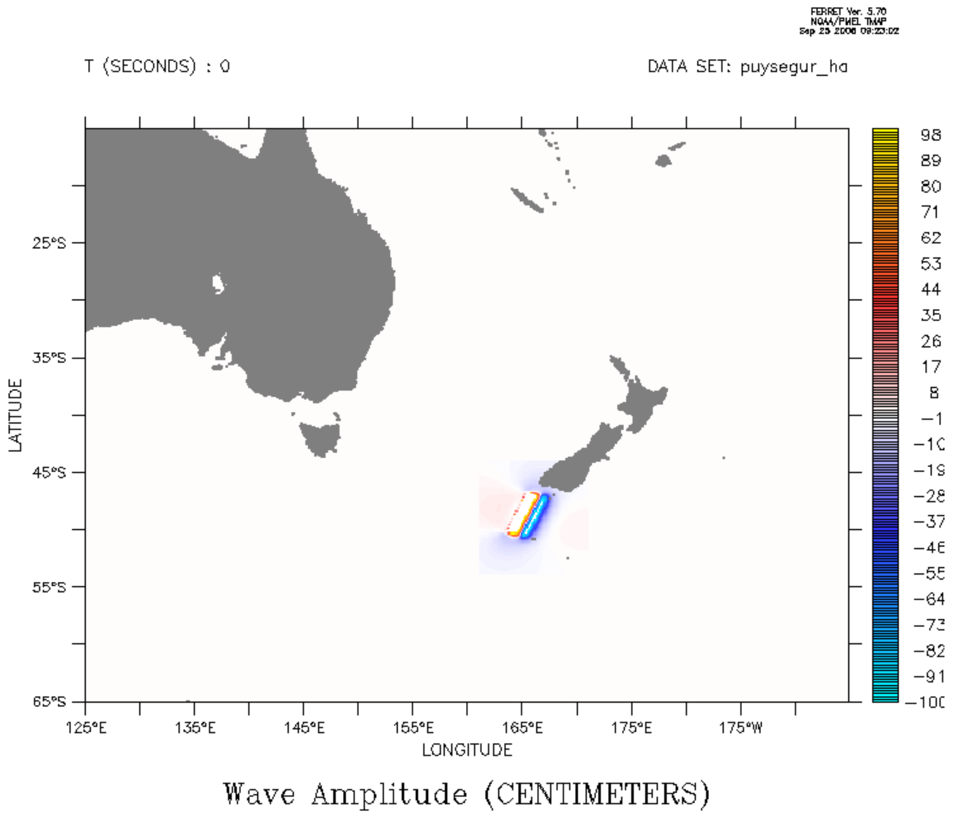
Why:

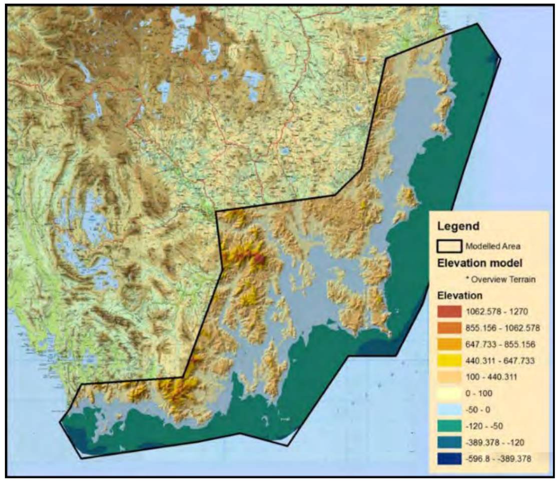
- Travel time < 2 hours, warning time even less
- Tsunami is a hazard with low probability but high, poorly understood consequence
- SES requested for management and evacuation planning

Method:

- Worst case: 8.7 Mw earthquake off SW New Zealand, high astronomical tide (HAT)
- Elevation model with surface roughness and land cover
- Use ANUGA hydrodynamic model

- Won State level Natural Disaster Resilience Grant Programme (NDRGP) award
- Funded to extend modelling to remainder of eastern Tasmania



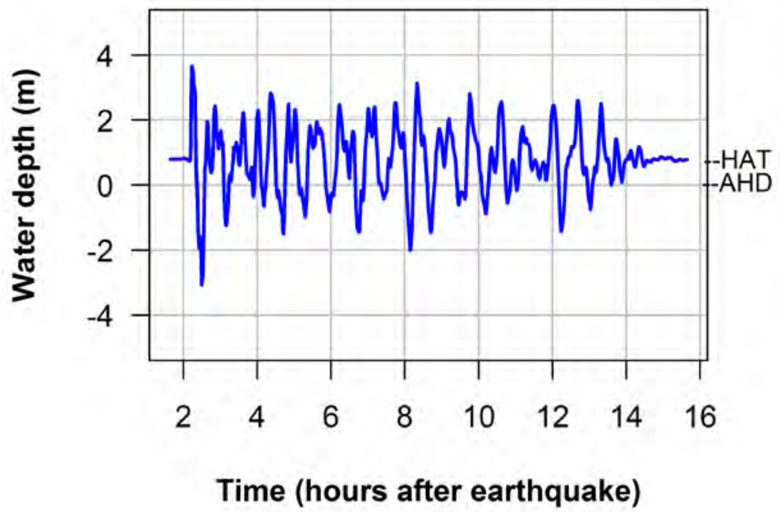


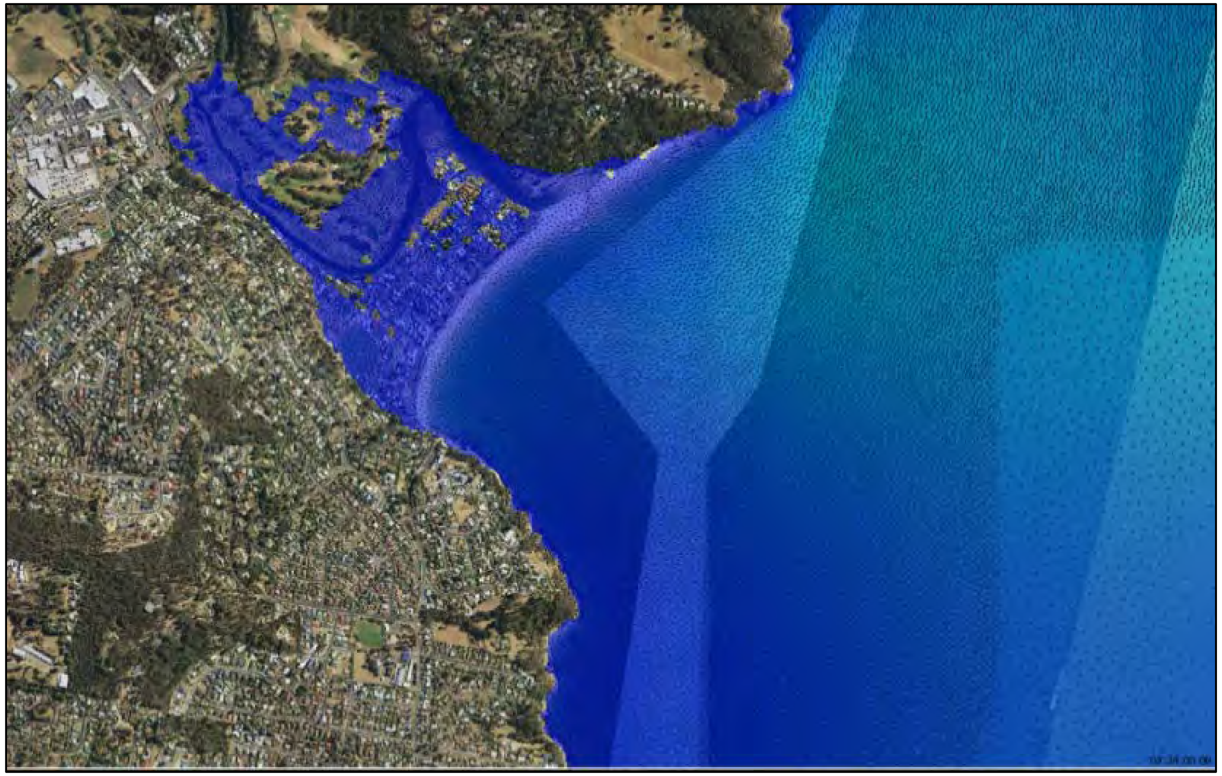
Modelling domain

Natural hazards – Tsunami Risk

Results:

- Significant inundation in exposed eastern locations:
  - o Tasman Peninsula
  - o Bruny Island
  - o Kingston Beach
  - o Orford (70 houses)
- Moderate inundation in other places along shores of Derwent Estuary
- Hobart Airport is protected by the dune line, even with the recent lowering
- Evacuation of vessels from ports not likely to be feasible with a tsunami arrival time of 1.5-3 hours post-earthquake
- Need to re-examine potential effects on RHH - include buried Hobart rivulet (not in current model)





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