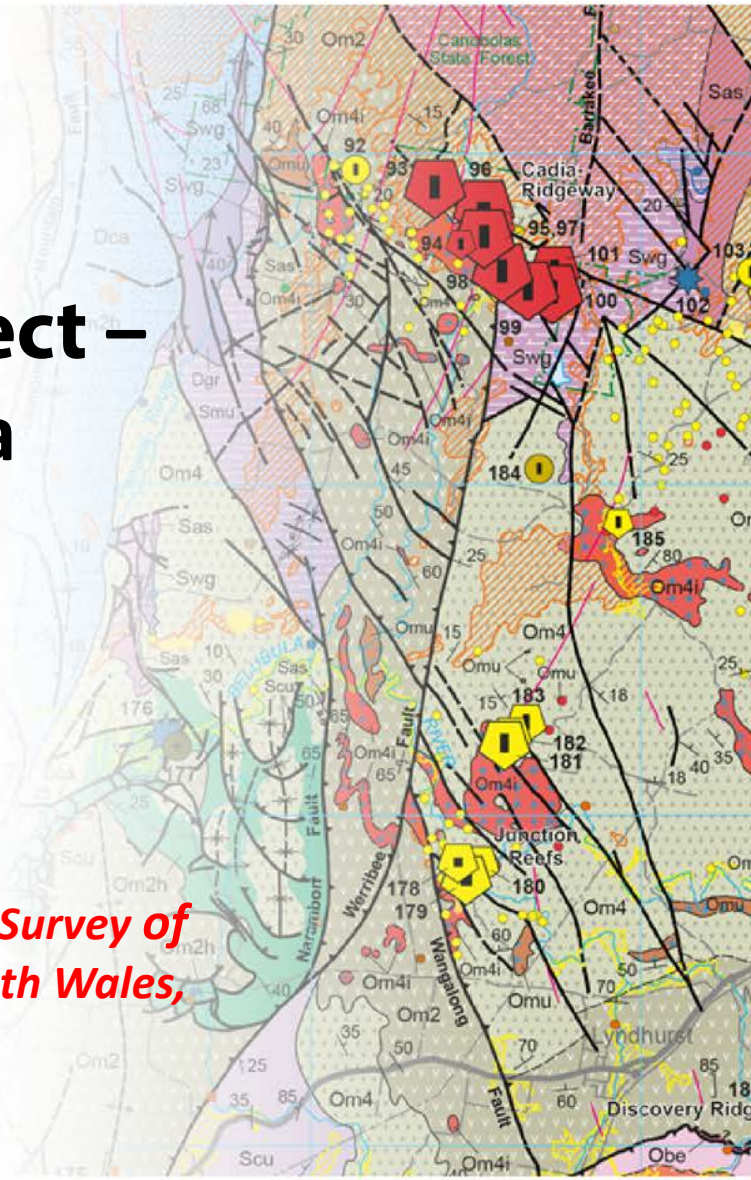
Department of Industry
Resources & Energy

new frontiers
new south wales

The Southern Thomson Project – Looking into the basement of a new frontier terrane

Rosemary Hegarty
Geological Survey of New South Wales



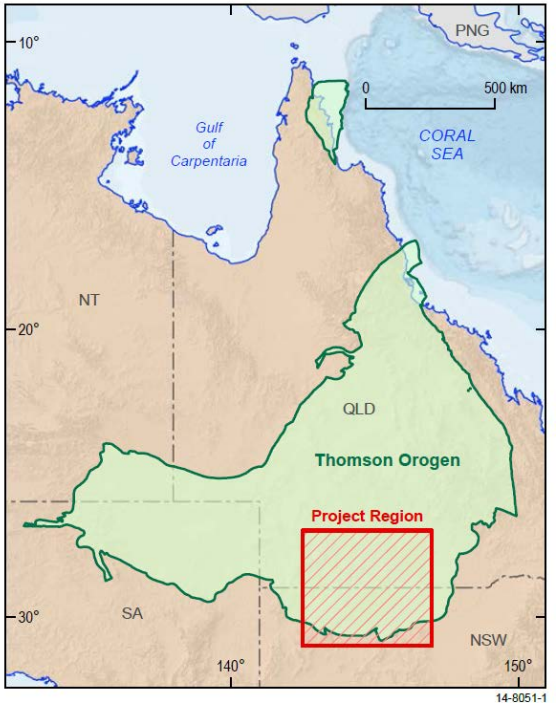
Acknowledgements to: Geoscience Australia, Geological Survey of Queensland, colleagues at Geological Survey of New South Wales, Newcastle University staff & students, and to industry contributors.

GSNSW is participating in two separate collaborative projects underway in the southern Thomson Orogen. These share an aim to increase the exploration potential for those covered basement rocks.

1. **Southern Thomson NCF Project**: data acquisition and synthesis

Impact: *To provide the mineral exploration industry with pre-competitive data, and knowledge that reduces risk and encourages investment in the region.*

- Looking at solid geology, geochronology, and structural geology (geochemistry)
- mineral systems results
- geophysical surveys (AEM results)



2. ARC LINKAGE research projects: complement the NCF investigations

- testing tectonic models
- coordinated academic studies underway

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Why the interest?

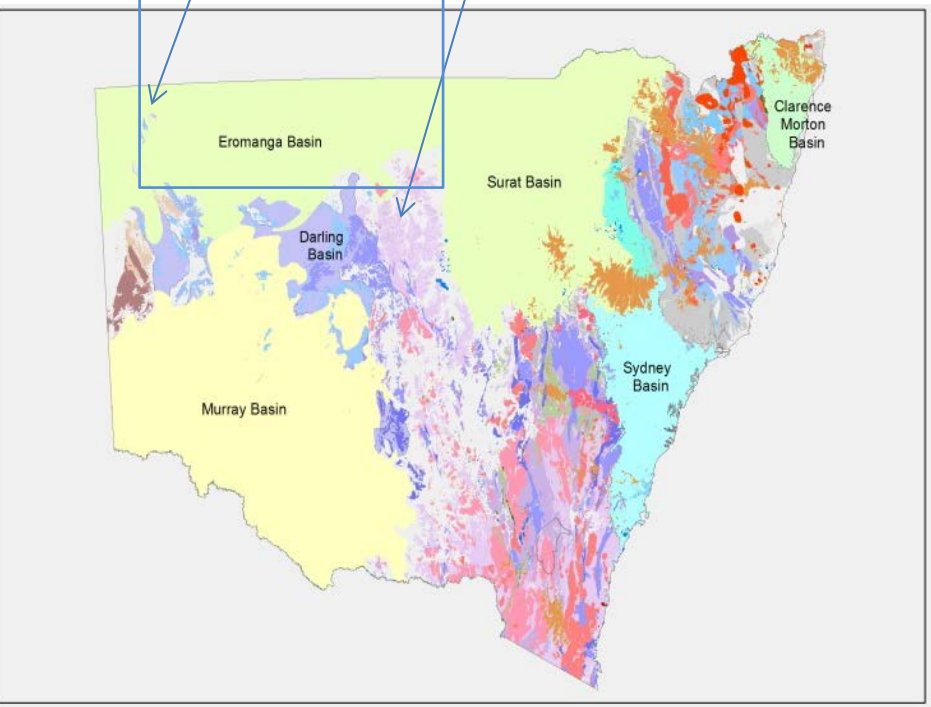
- Totally hidden prospectivity
- Improvements in DTB, stratigraphy & structure
- Improved mineral systems understanding

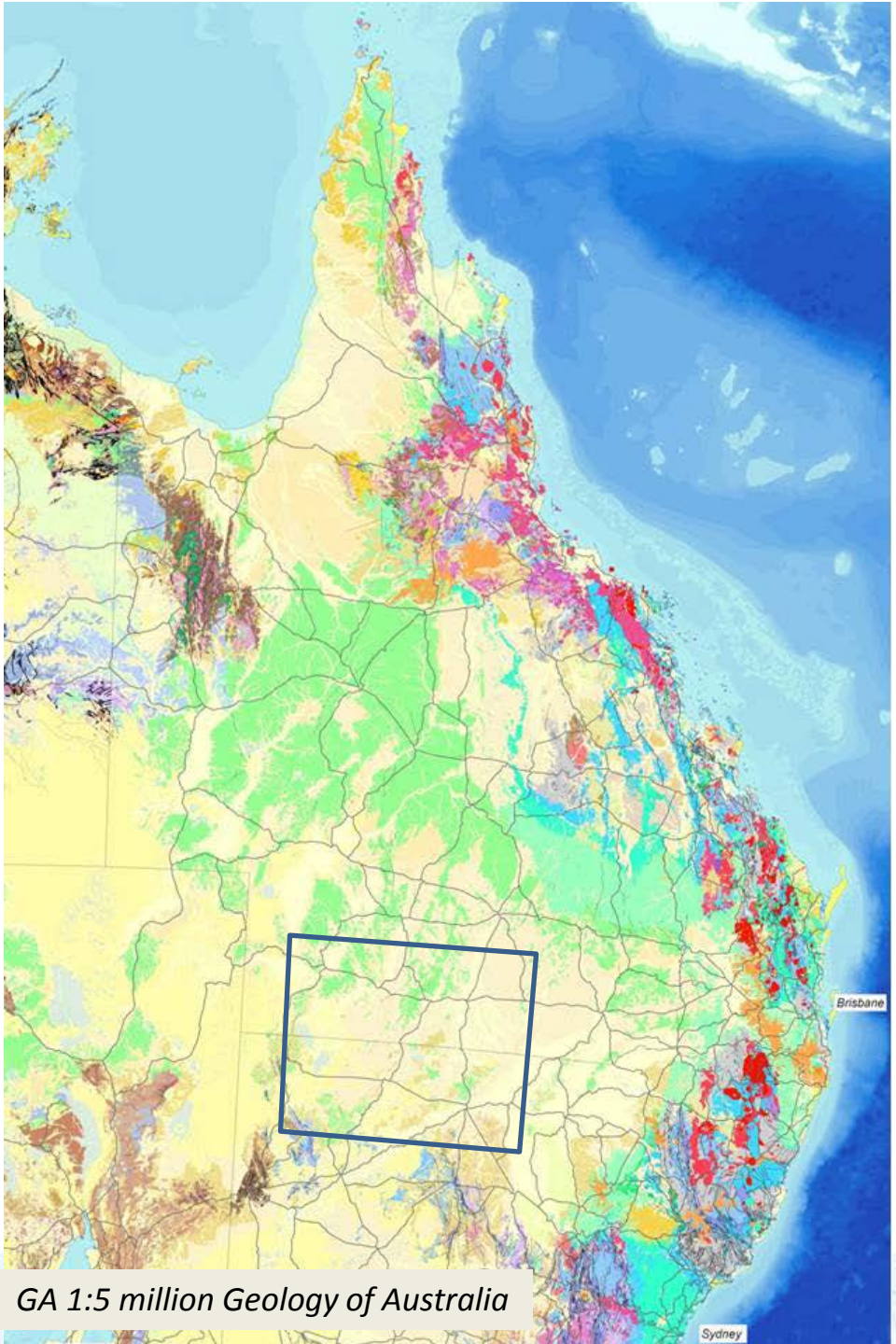
What is it prospective for?

- Initially
- Potential

Orogenic gold

VAMS, Cobar-styles





GA 1:5 million Geology of Australia

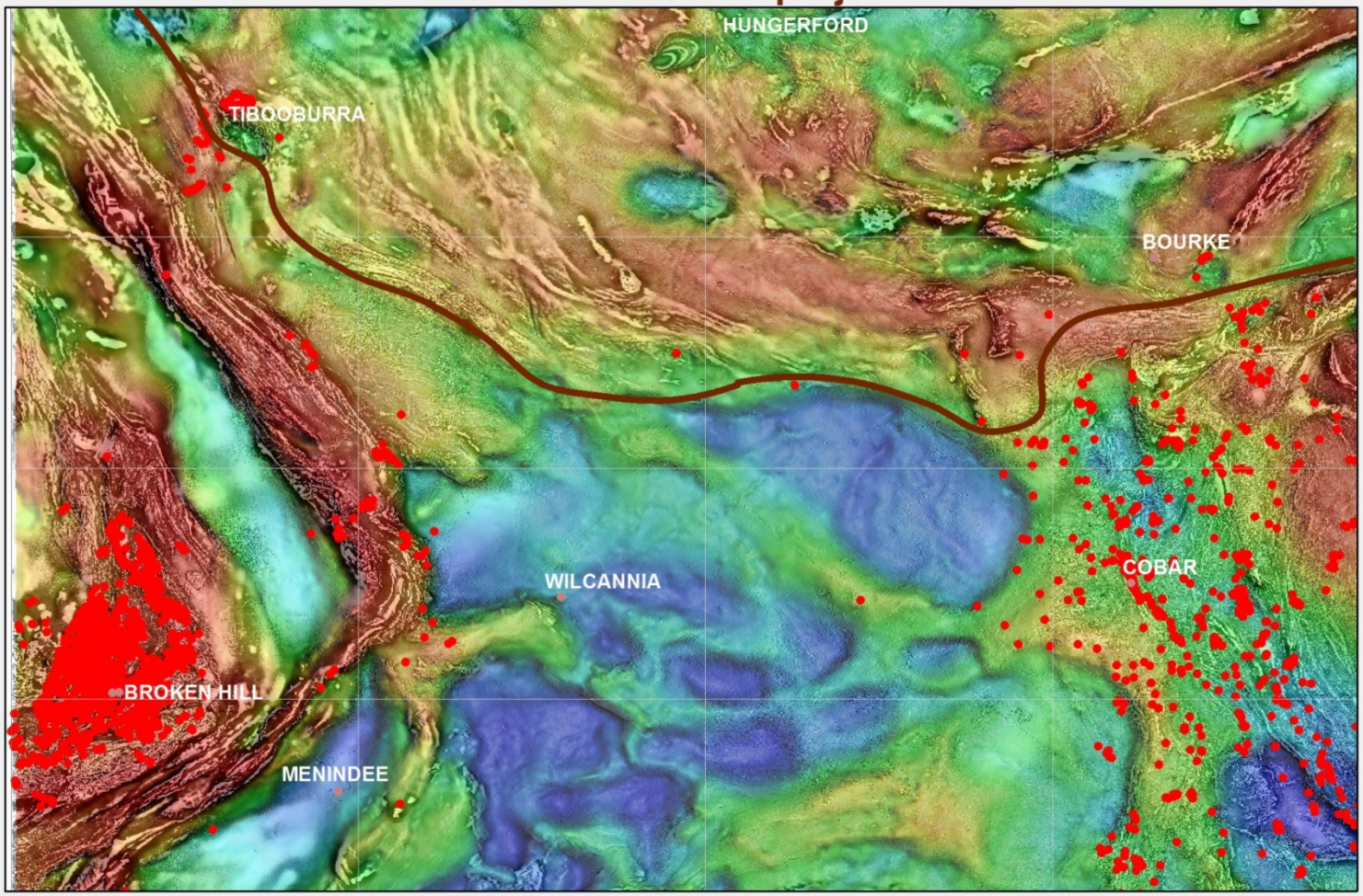
COVER!

70km north of Bourke

TFB006A 453.9m

UNDERCOVER

Southern Thomson project area - NSW



MINERAL OCCURRENCES • 0 50 100 200 km 1VD TMI RTP on GRAVITY

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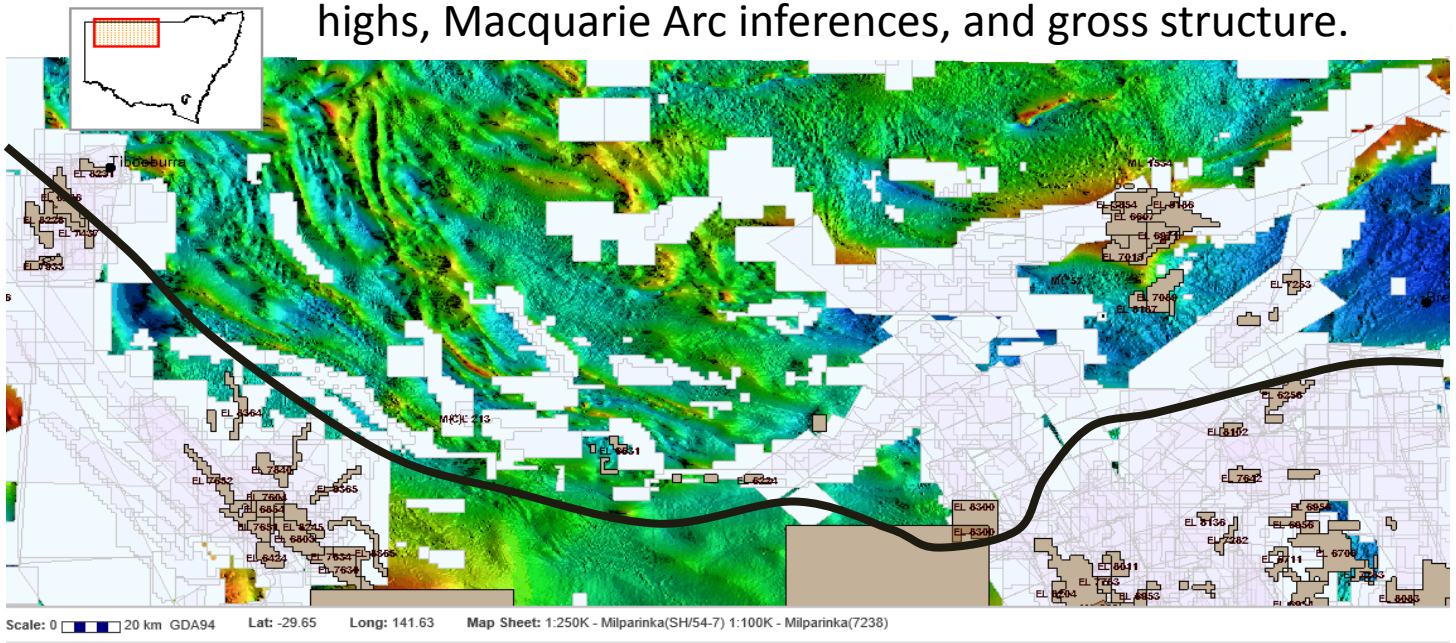
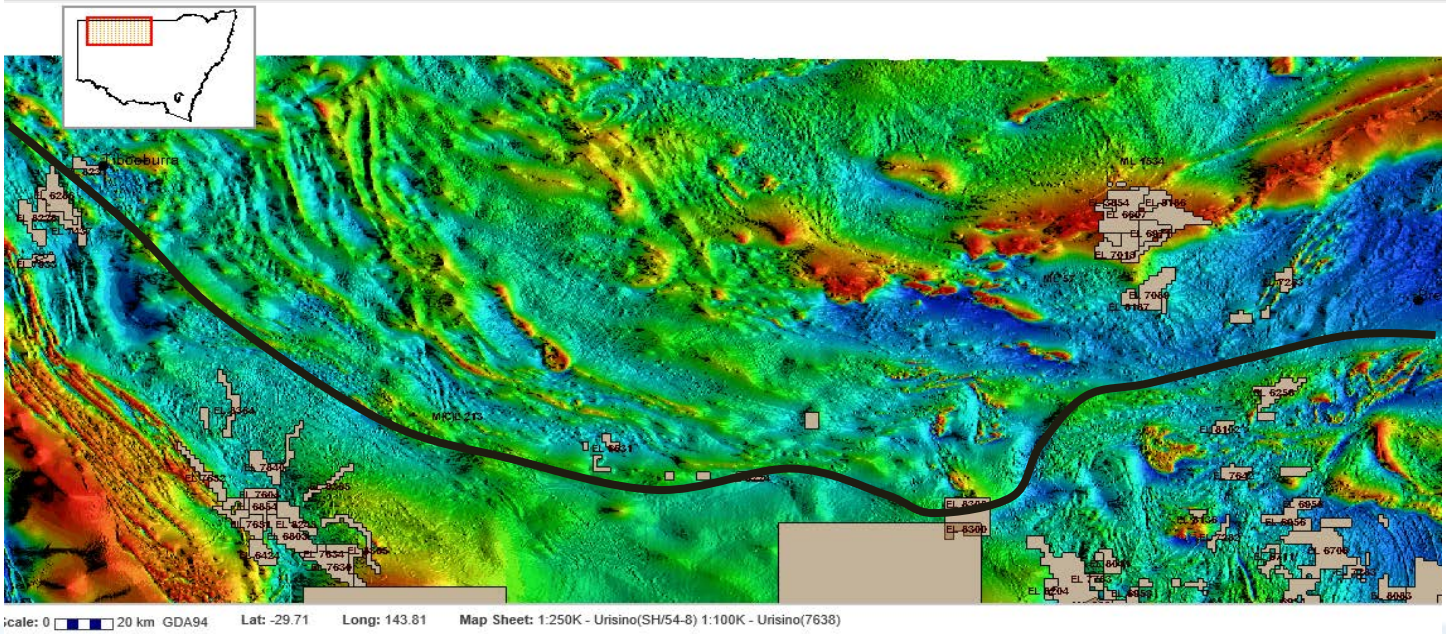
Exploration targets based mainly on aeromagnetic highs, Macquarie Arc inferences, and gross structure.

ALL HISTORICAL MINERAL EL's



CURRENT MINERAL EL's Sept 2015



Since 2005, good exploration work has taken place but the tides of finance are fickle.

The legacy is valuable samples now available for analysis from tested targets (largely magnetic).

Governments are acting on their role to build the framework and understanding of the area, and connecting with the 4 themes of the UNCOVER vision.

What are the solutions in southern Thomson region?

Collaborative NCF between Geoscience Australia, GSNSW and GSQ commenced Dec 2013

Australian Government Geoscience Australia

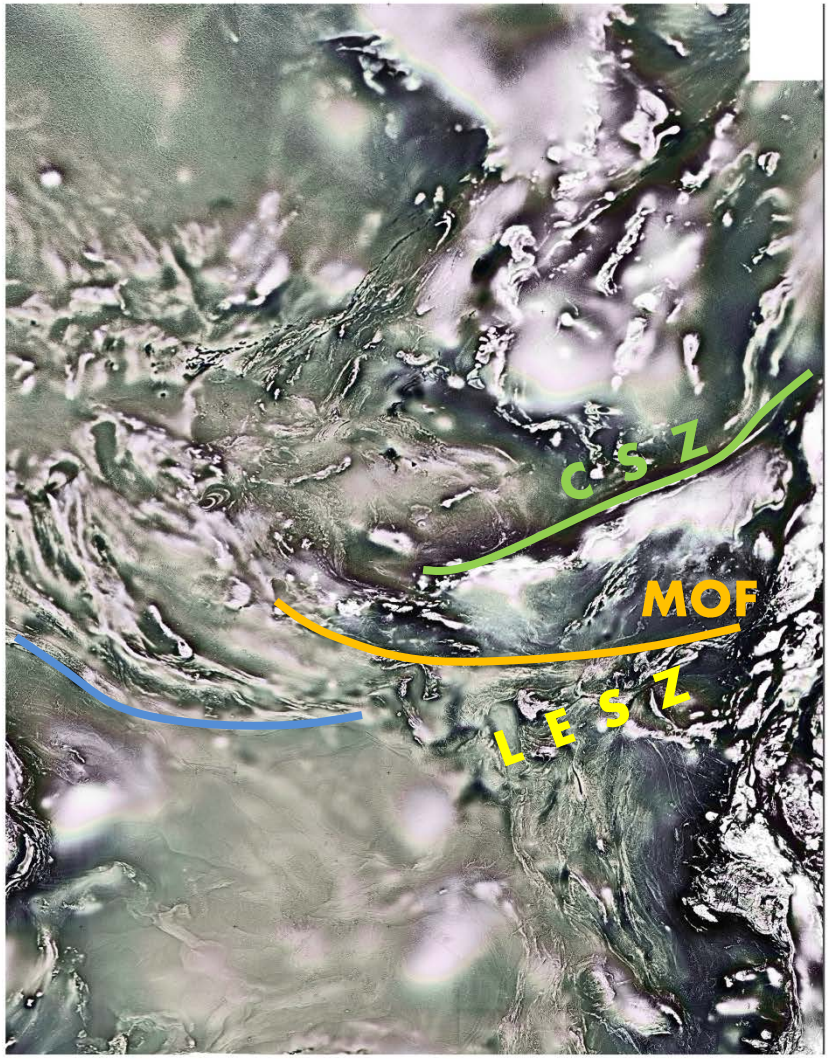
NSW Trade & Investment Resources & Energy

Queensland Government Department of Natural Resources and Mines

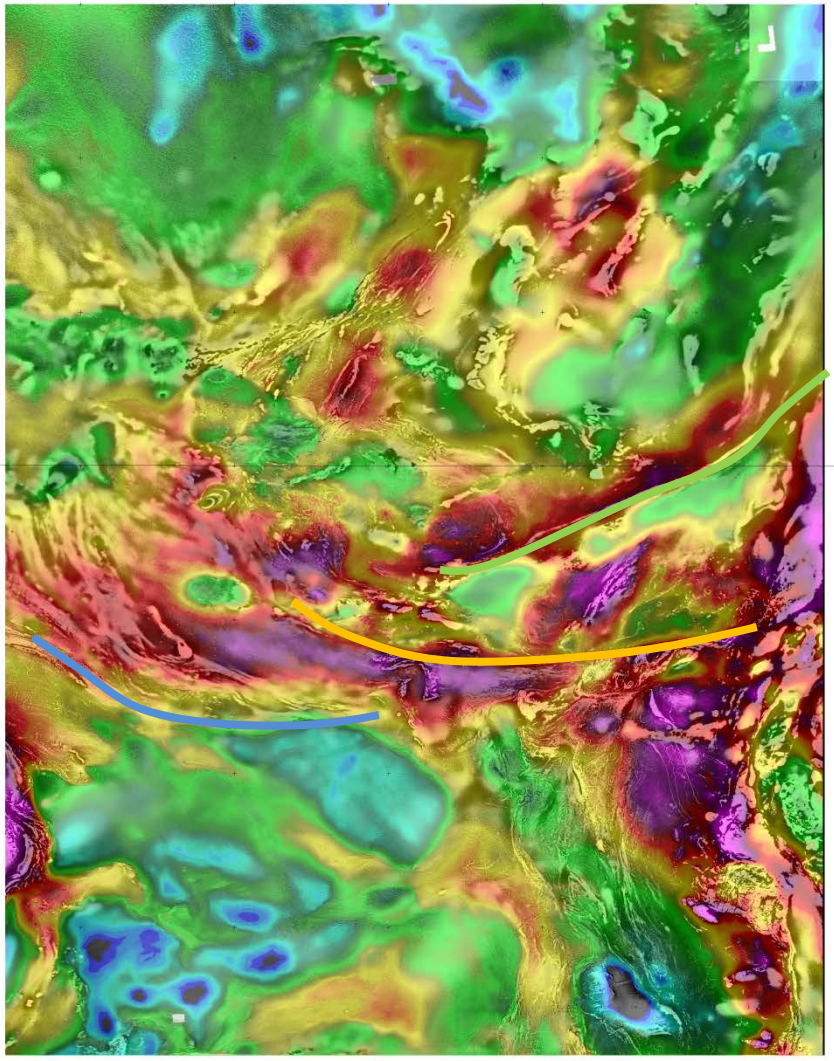
- **Solid geology map compilation**
- **Geochronology**
- **Mineral systems study**
- Structural synthesis
- Geochemistry survey
- **New geophysical acquisition**

“Southern Thomson Orogen”

A complex structural history (ductile, rotation, transtension, brittle ….)



1VD & TMI

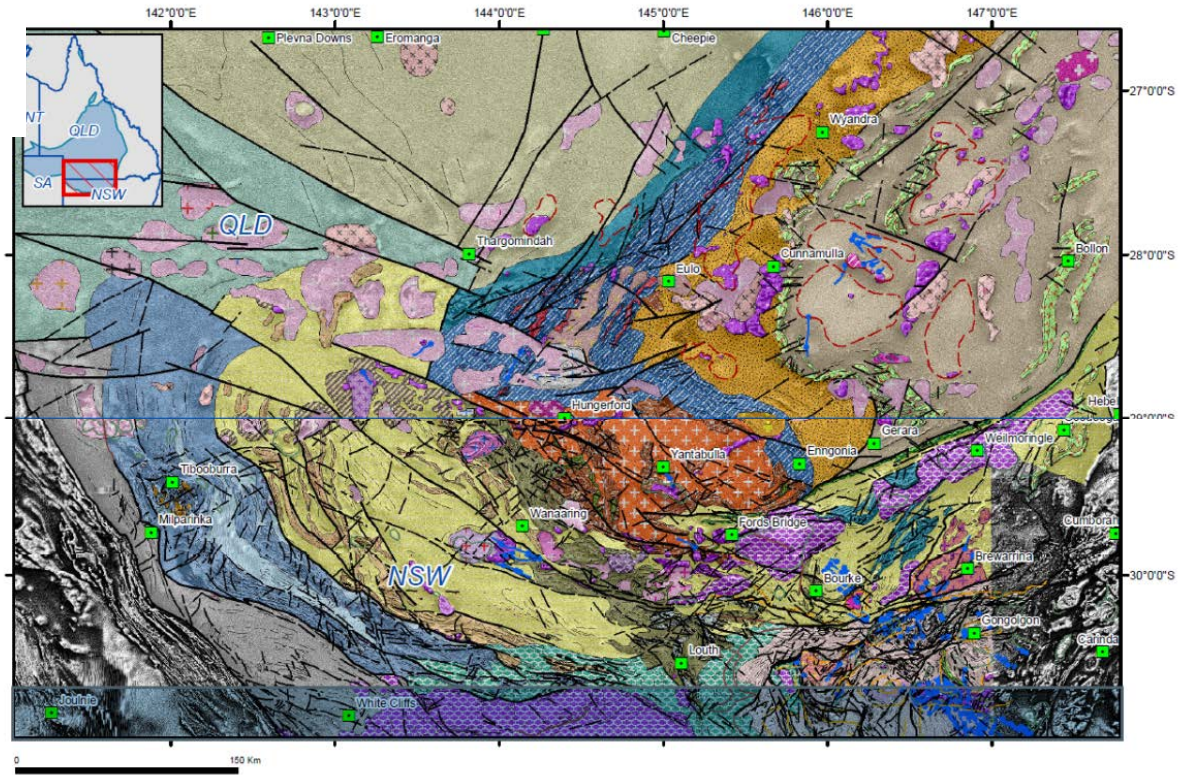


1VD TMI on Gravity

Olepoloko Fault | Louth-Eumarra Shear Zone | Mount Oxley Fault | Culgoa Shear Zone

Solid Geology for NSW + QLD

- Merged geophysical–geological interpretation across border
- Development of unit descriptions and naming, in spite of the lack of lithologic information and few age dates
- Expanded our concepts of “complex”, but also improves broader perspective on major trends
- Provides structural framework for kinematic studies, defining ductile zones and brittle fault sets
- Inclusion of prospective rocks in NSW (Late Silurian & Early Devonian), even with poor geophysical contrast



146°E

147°E

27°S

28°S

29°S

30°S

31°S

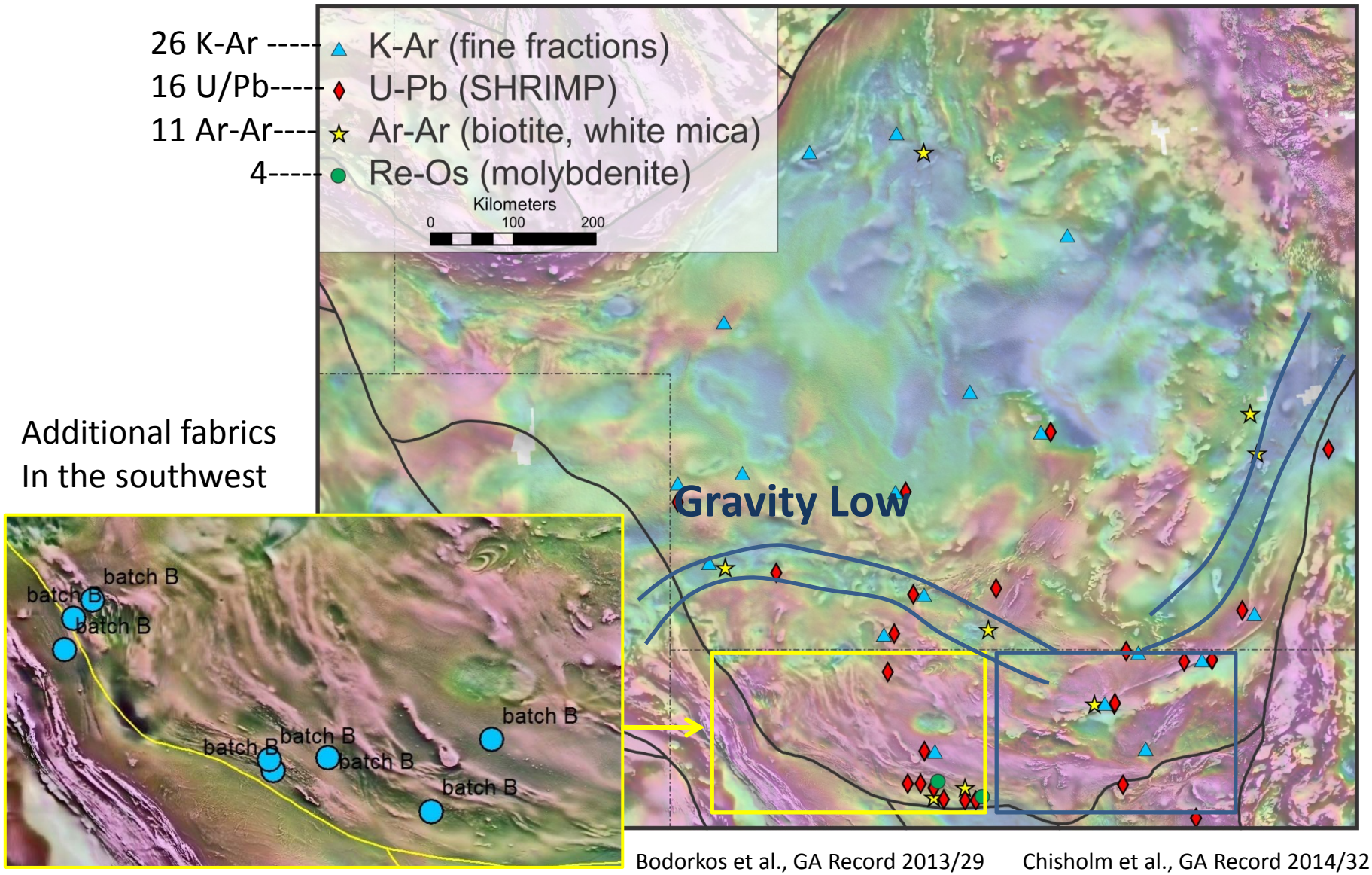
Werewilka formation
(no lithology or
samples)

Waratta Group
(MDA 500 Ma peaks)
Siliciclastics with dolerite/gabbro
Slaty cleavage

Tongo association
(no lithology or samples)

Metasedimentary units
with range of maximum
detrital provenance ages

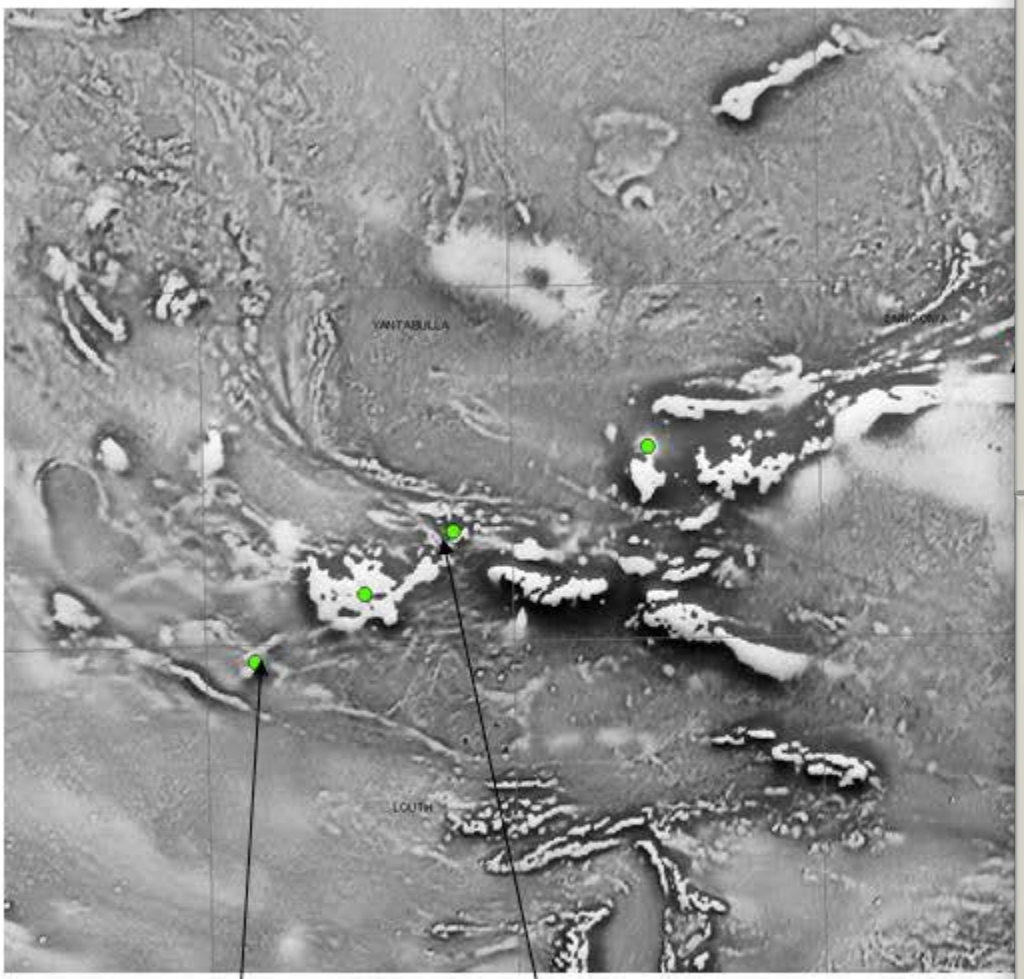
Sampling & isotopic analysis at GA for geochronology and major deformational events



Additional fabrics
In the southwest

Bodorkos et al., GA Record 2013/29
Fraser et al., GA Record 2014/53

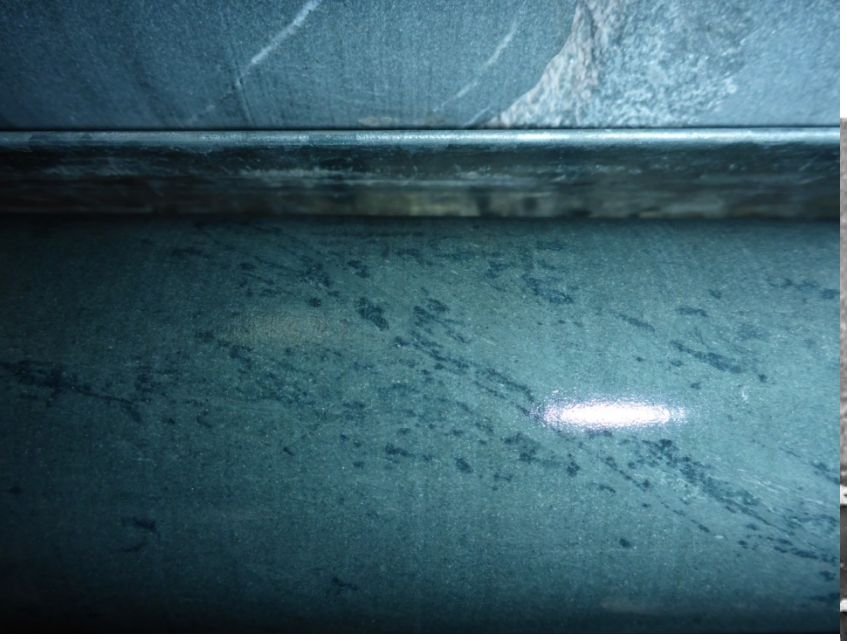
Chisholm et al., GA Record 2014/32
Cross et al., Qld Geol Record 2015/01

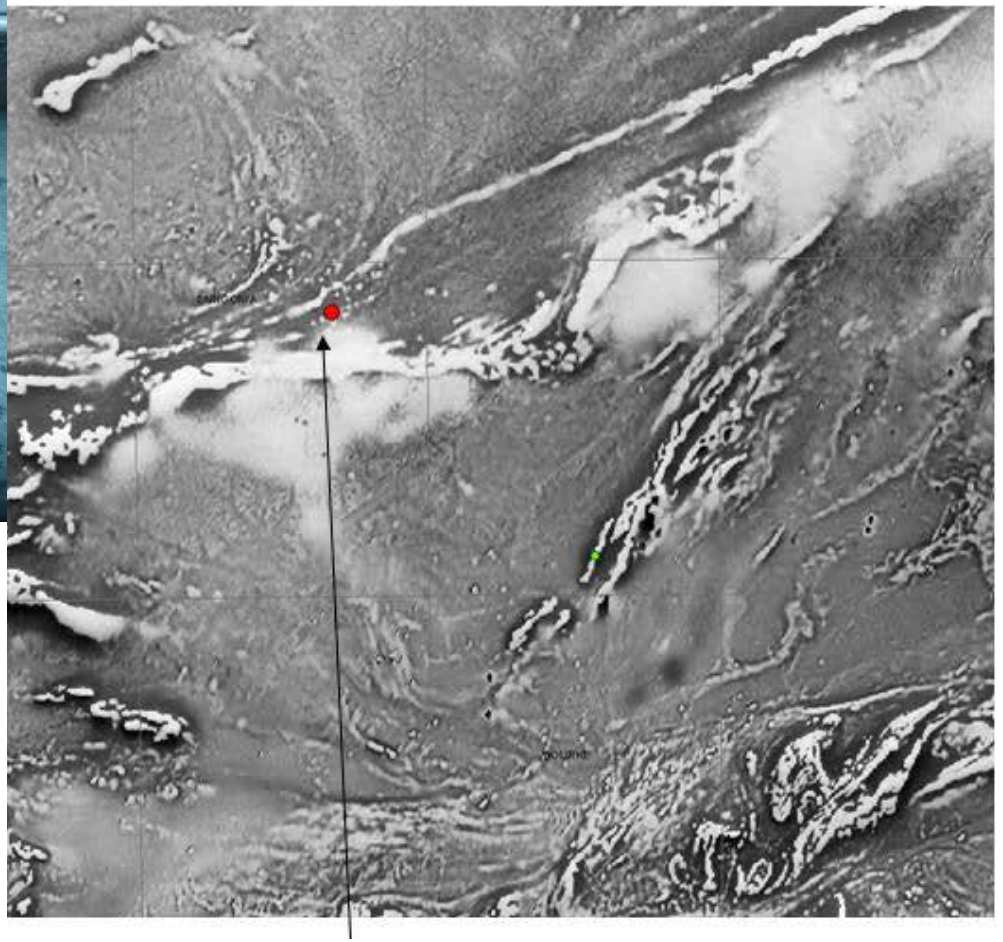


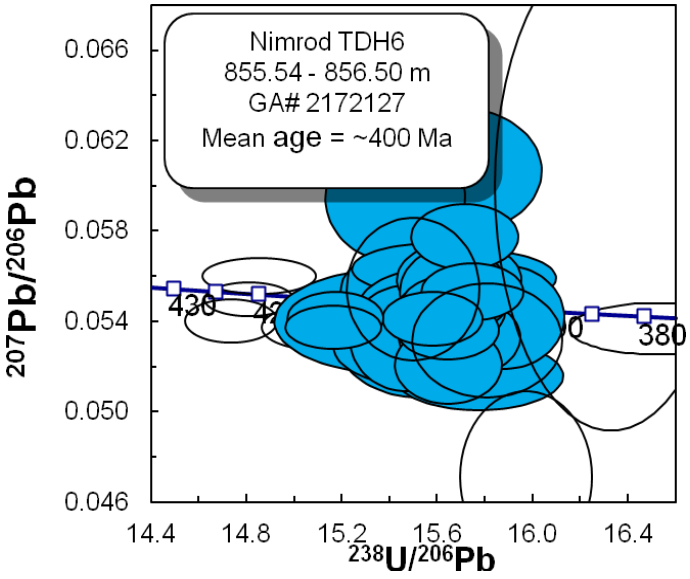
Tinchelooka quartz diorite (402 Ma[1])
at 306m/310m/320m (top)

Conlea porphyry (398 Ma[2])
at 316m/329m/366m/434m (lower)

[1]Bodorkos et al., GA Record 2013/29
[2]Fraser et al., GA Record 2014/53





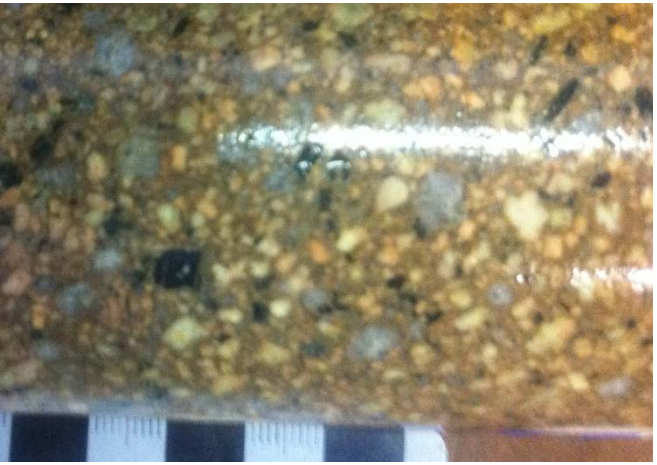


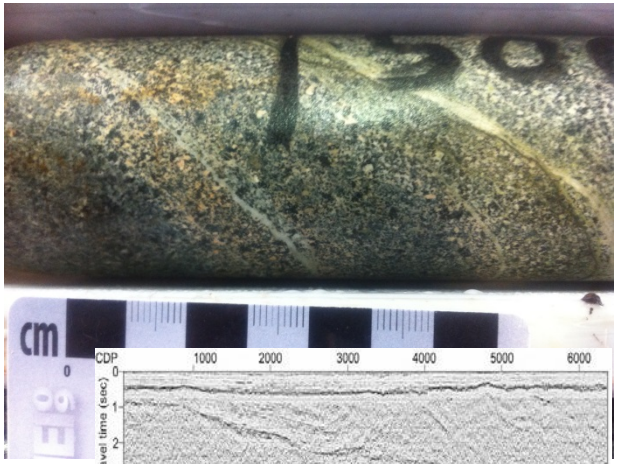
TDH6 (minor "green" beds within thick redbed sequence)

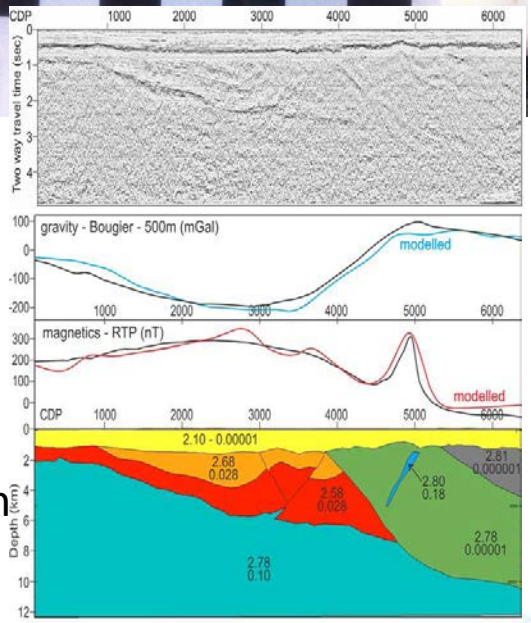
- Contains abundant zircon of igneous origin without appreciable working: volcaniclastic in T/S,
- volcaniclastic zircon age ~400 Ma ~400 Ma (7 inherited & 21 close)

We know the age of likely shallow intrusion and associated volcanism, but not much else…

Still need to define the igneous petrology and geochemistry of the variations within (and between) the 4 cored drill holes, and look at alteration on contact zone and within the igneous units.







So SHRIMP dating has helped compare/relate the diorites and porphyry to the volcaniclastic rocks in Tuncoona rift/formation.

How does this compare/relate to units of similar age in NSW or Qld?

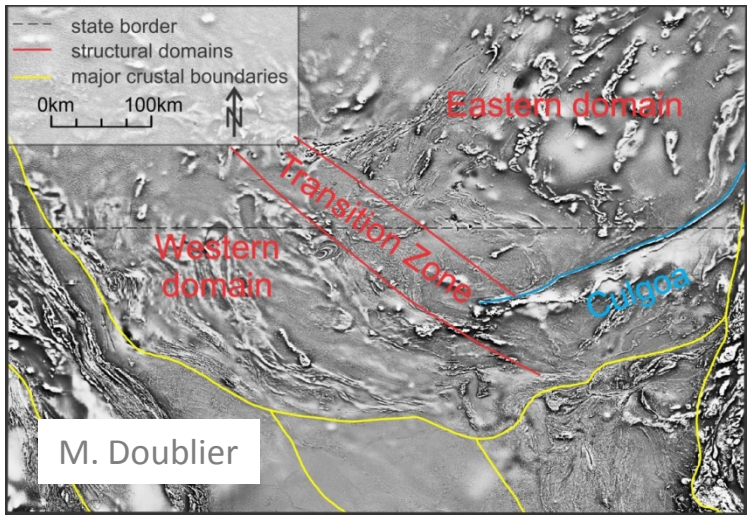
- Possibly extension and rifting (deposition of the basal Paka Tank Trough units) is initiating at roughly the same time the Cobar Basin is sag phase/winding down?

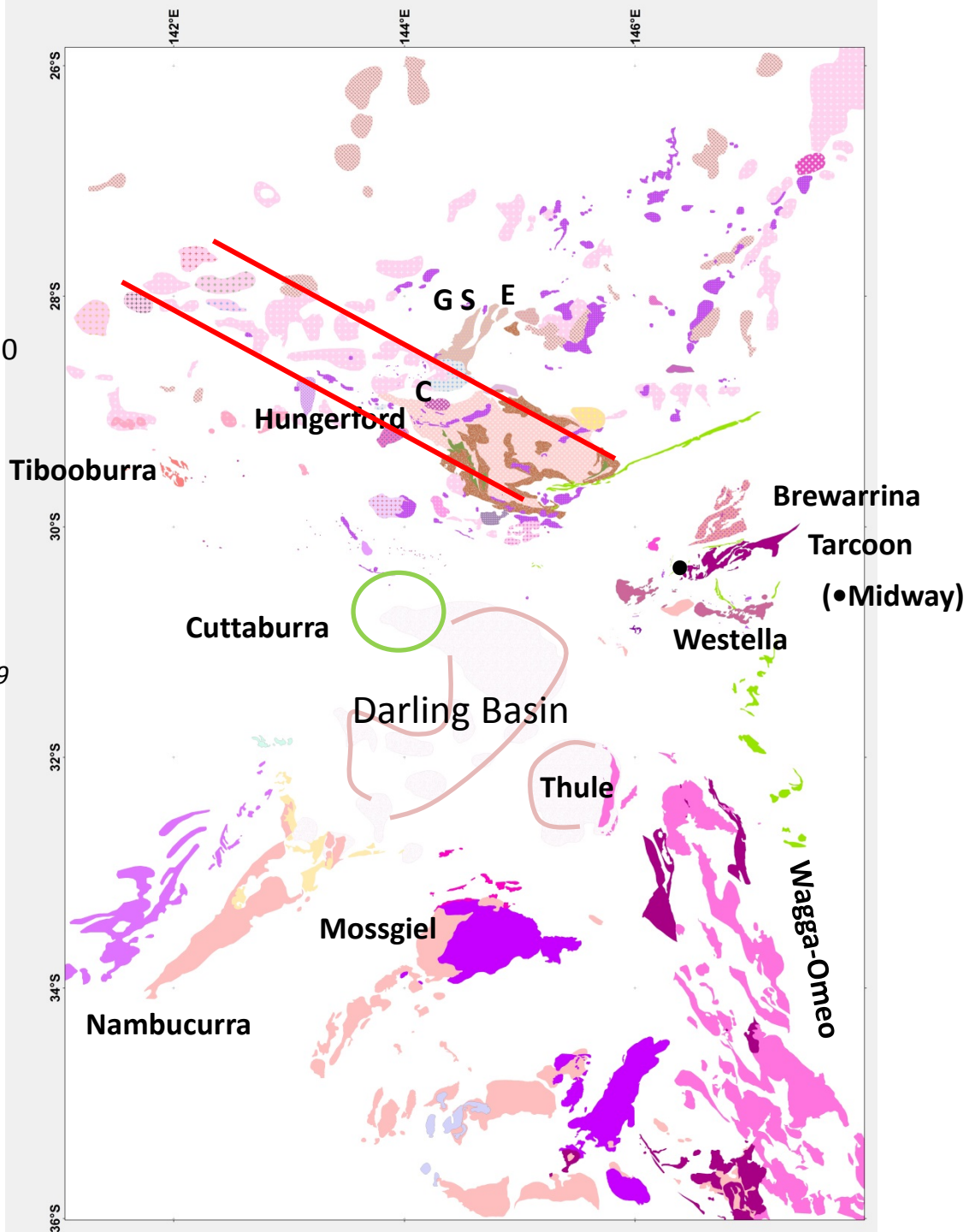
Basement Granites – extent interpreted from geophysics

Granite emplacement is settling into age patterns….

Recent dates such as the Brewarrina, Galambo and Cuttaburra intrusions are 430 – 420 Ma. Other suites and plutons at 416 – 408 Ma.

But others vary:
Granite Springs Granite: 456.3 ± 3.9 Ma
Currawinya Granite: 381.5 ± 2.4 Ma
Both in Cross et al., Queensland Geological Record 2015/01
Eulo Granite: 385.0 ±2.5 Ma
Cross et al., 2012 Queensland Geological Record 2012/19
Midway Granite: 325 Ma
Burton et al., GSNSW Quarterly Notes No 125



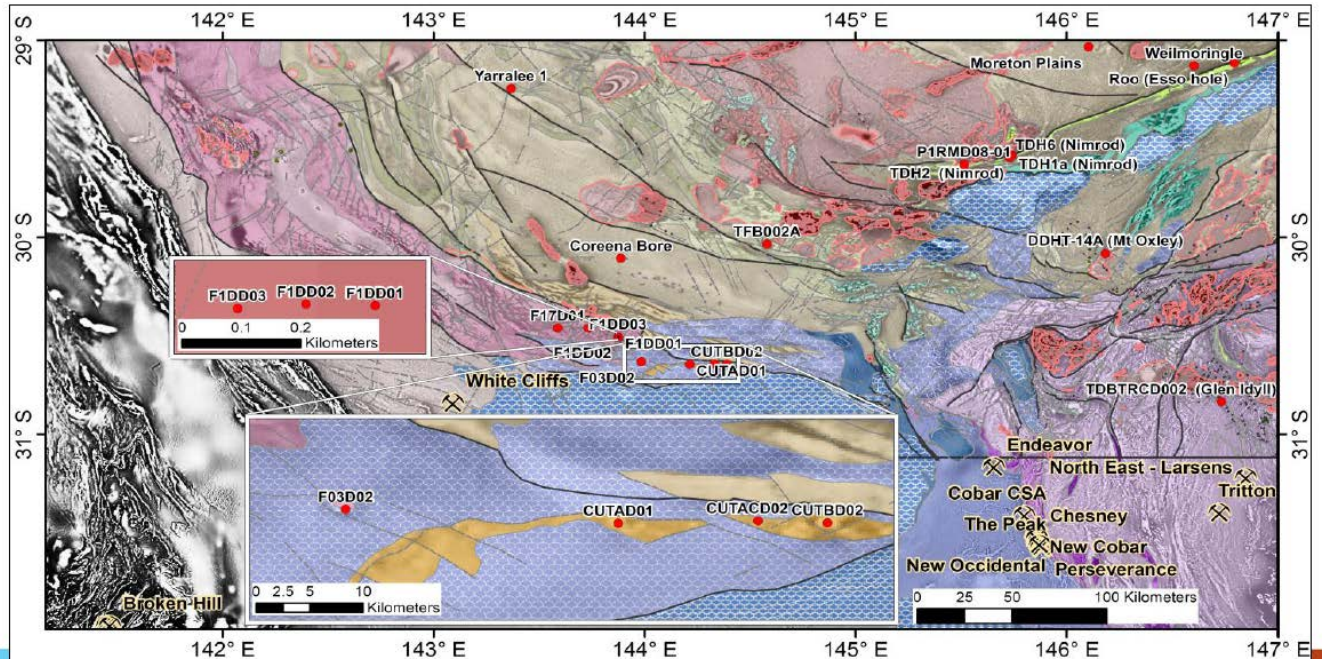


Mineral Systems

Assessing prospectivity of the southern Thomson Orogen based on new isotopic data and structural interpretations:

- Petrography & SEM, major & trace elements for 12 samples from Pirelli ultramafic intrusion on Culgoa lineament for PGEs and compare other ultramafic rocks in the region, including the Fifield Complex
- Explore links between W-Mo and Au-basemetal mineral systems in Cobar and Lachlan Orogen and southern Thomson Orogen: Re-Os
- Intensive study of drill cores from two undercover prospects to understand style and timing of mineralisation. Exploration drilling reported by Thomson Resources Limited (Rothery 2013, 2014) found indications of Au, Mo and W mineralisation associated with hydrothermally veined and altered metasedimentary rocks and disseminated within I-type granite.

(R. Skirrow, D. Huston, S. Armistead, M. Doublier, D. Champion and others)



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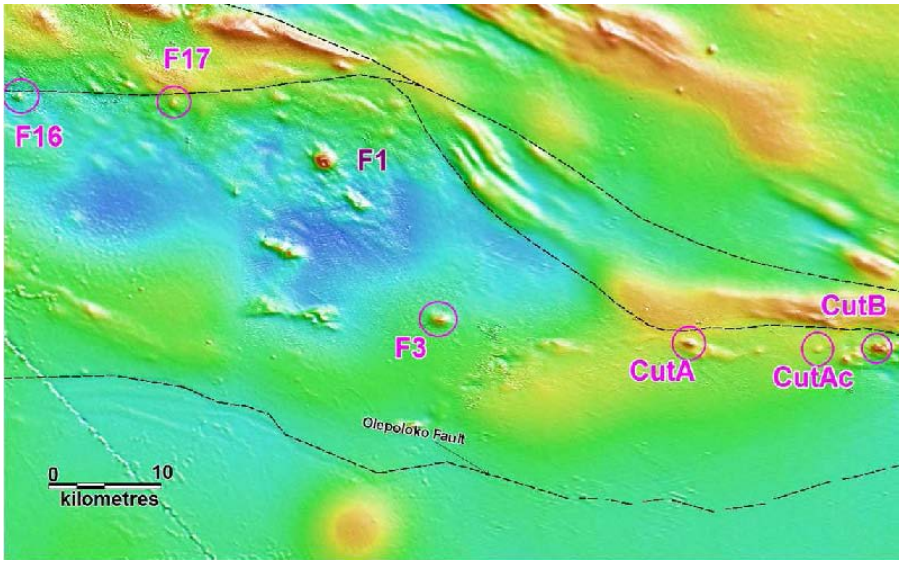
Zn Cu Pb Sn W within altered basement rocks

Drill core from 2 prospects:

Cuttaburra:	**F1:**
CUTAD01	F1DD03
CUTACD02	F1DD02
CUTBD02	F1DD01



- Geochemical analysis of assay data
- Thin section petrography
- Wholerock geochemistry
- Sulfur isotope studies
- Pb isotope data

Geochronology data

- Re-Os molybdenite
- Ar-Ar muscovite
- U-Pb cassiterite U-Pb zircon (Chisholm, 2013; Armistead and Fraser, GA Record 2015/20)

http://www.thomsonresources.com.au/components/com_reports/rfiles/TMZ_AR_27_Sept_12.pdf

(Geophysics at last!)

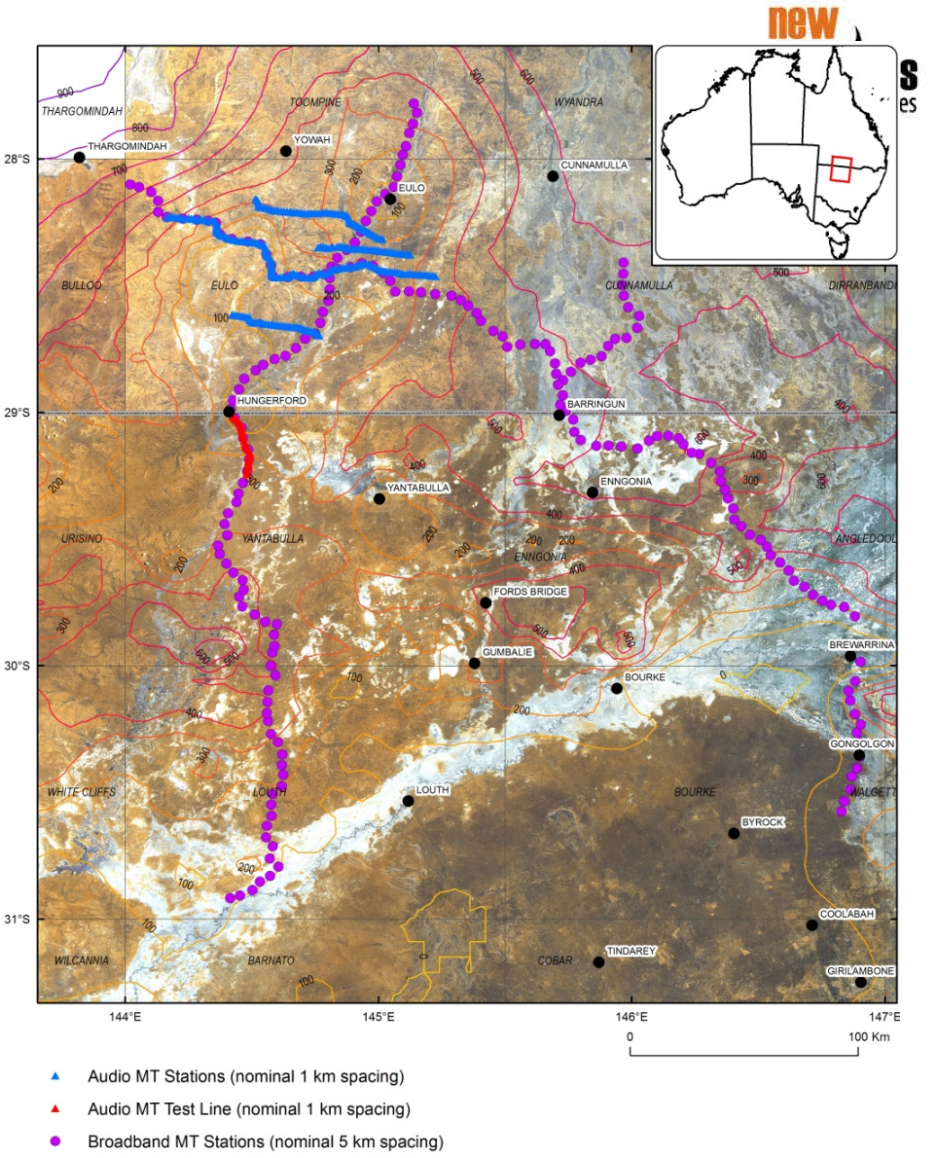
Magnetotelluric (MT) & Gravity surveys

Acquisition now complete

- Broadband MT (lithospheric depth)
- Some Audio MT (high-resolution, near-surface)
- Gravity along traverses @ 333 m spacing ~3600 new gravity stations

Combined AEM, MT & gravity data will provide the deep conductivity picture down to >100 km depth along these lines.

They will be used to model Thomson-Lachlan boundary and lithospheric architecture.



I. Roach, Digging Deeper 2014

Airborne electromagnetic survey completed

New AEM data:

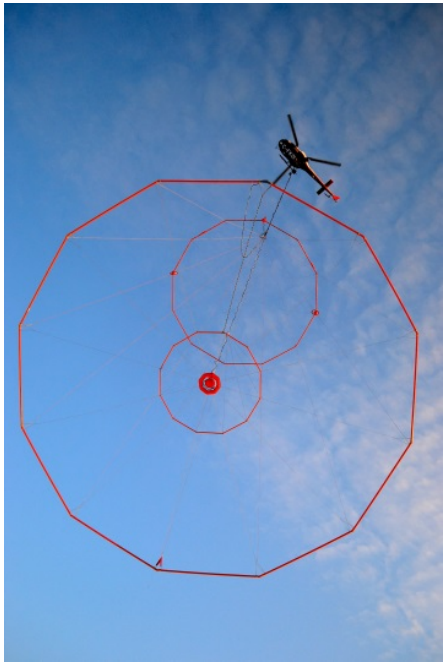
- Regional survey at 5 km line spacing over the Eulo Ridge
- Single lines along the MT-gravity traverses

Phase 1 (Contractor-supplied) data released 18 August 2014

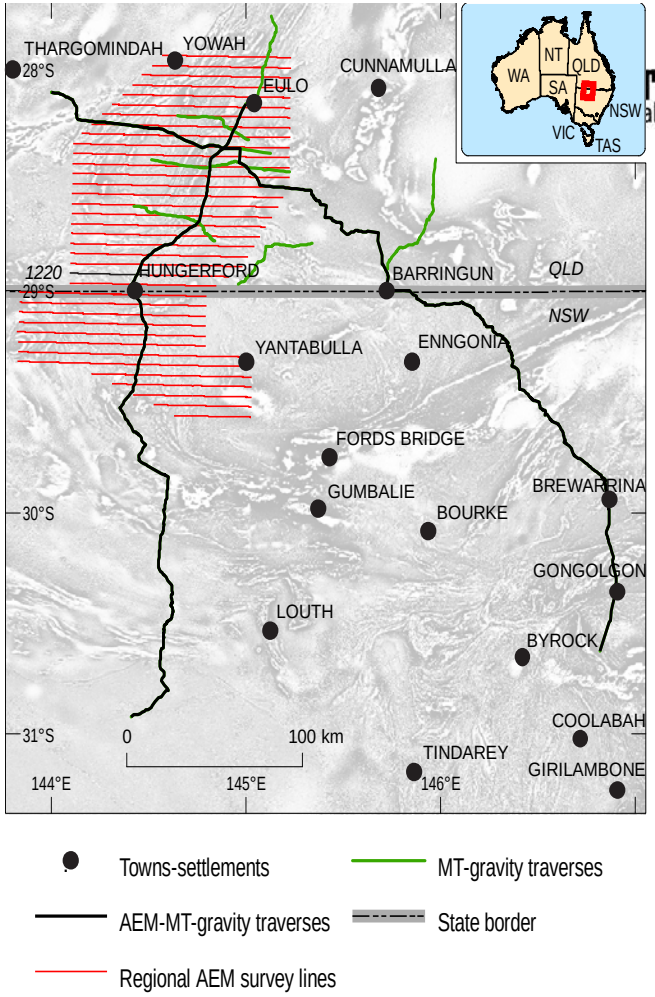
Phase 2 (GA inversions) data released December 2014

Comprehensive report to document and interpret data due next month

All data are available from the Geoscience Australia website: www.ga.gov.au



GeoTech Airborne Ltd: VTEM plus®



I. Roach, Digging Deeper 2014

AEM inversion algorithms

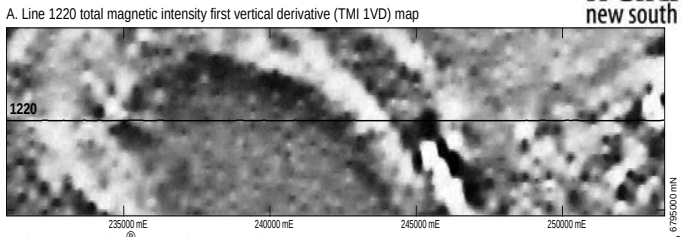
New AEM inversion algorithms developed at GA:

- GA Layered Earth Inversion
- GA Monte Carlo inversion

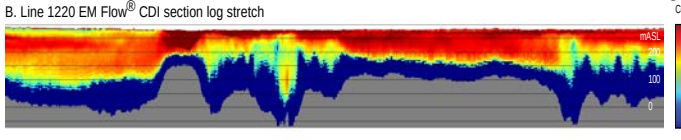
Extend understanding of the contractor-delivered data

Clearer inversions, clearer interpretations, greater risk reduction in regional assessment

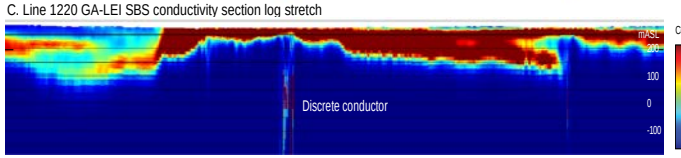
TMI 1VD map



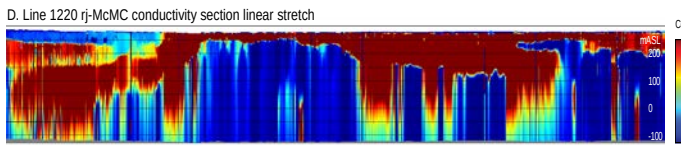
EM Flow®



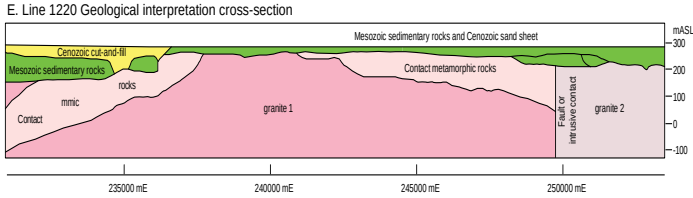
GA-LEI SBS



Rj-McMC



Interp



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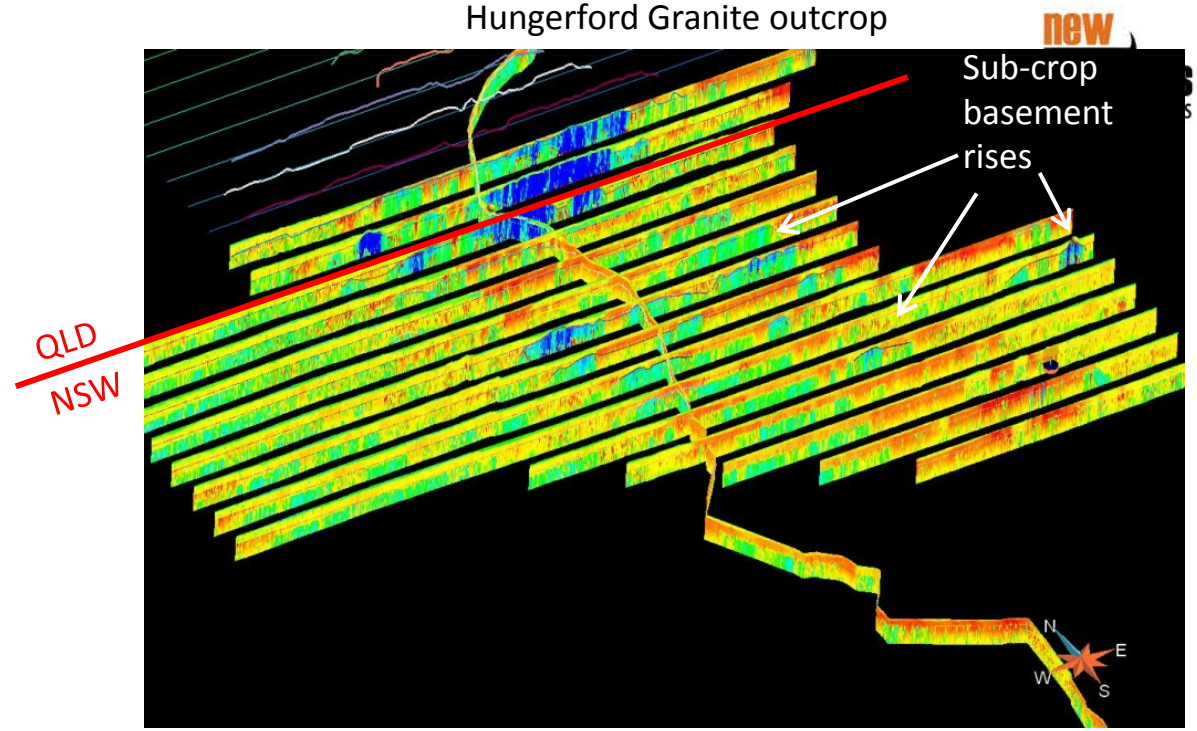
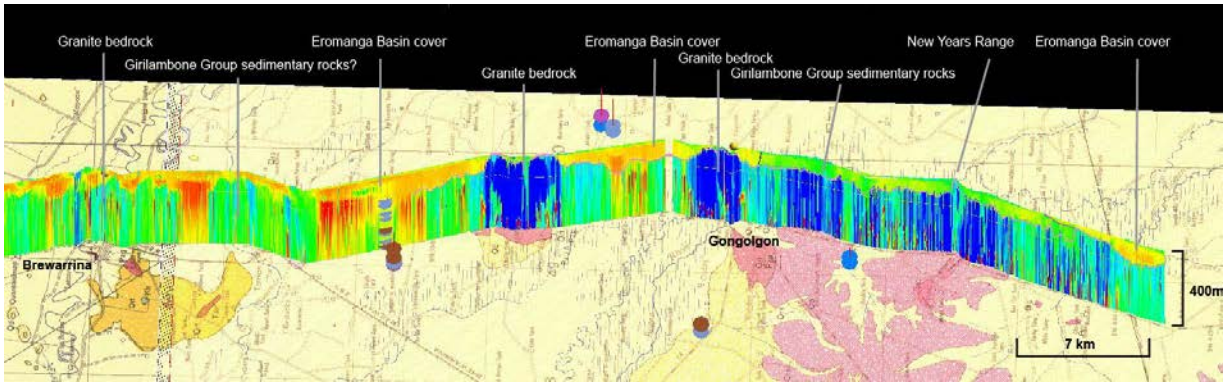
Regional AEM survey results

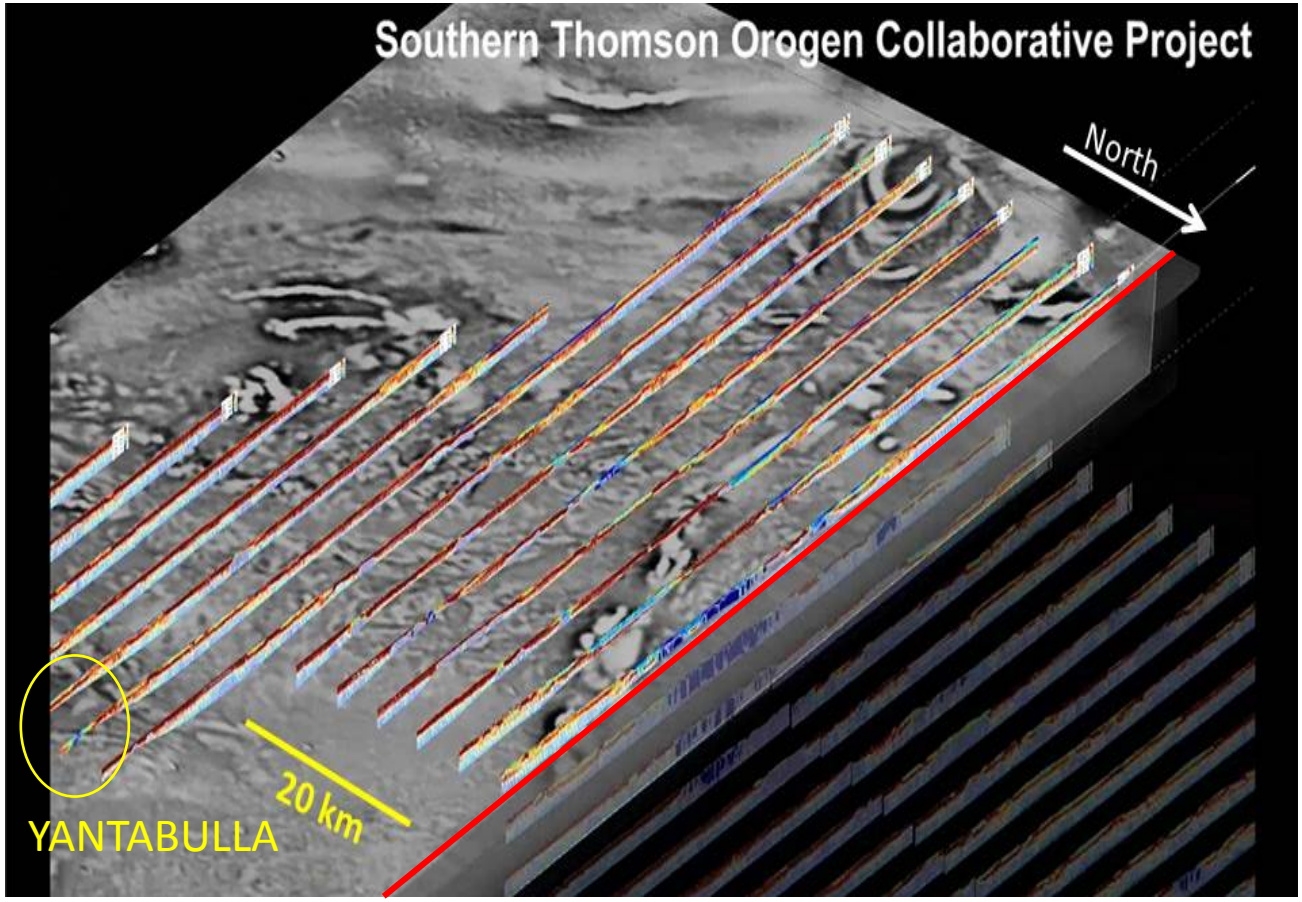
Regional AEM survey:

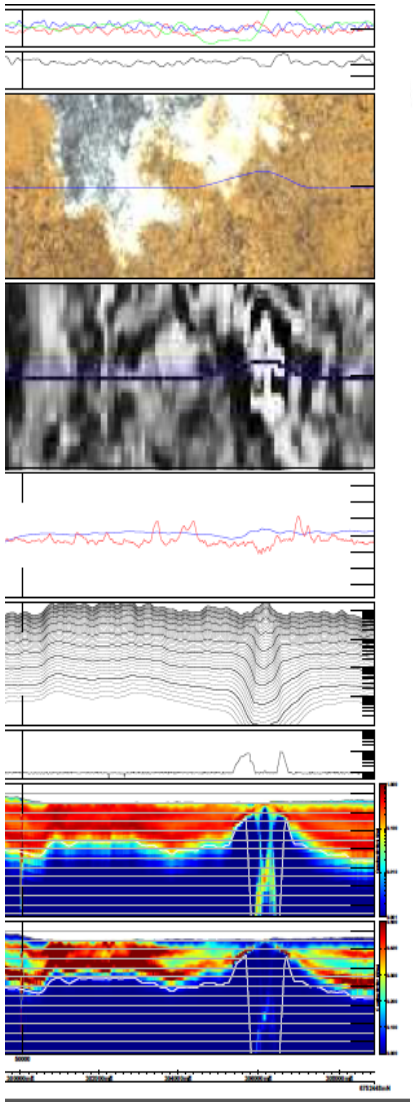
- Depth of cover mapping over Eulo Ridge
- Identify unmapped resistive and conductive basement terrains
- Risk reduction for further EM and drilling





AEM identifies basement highs in NSW



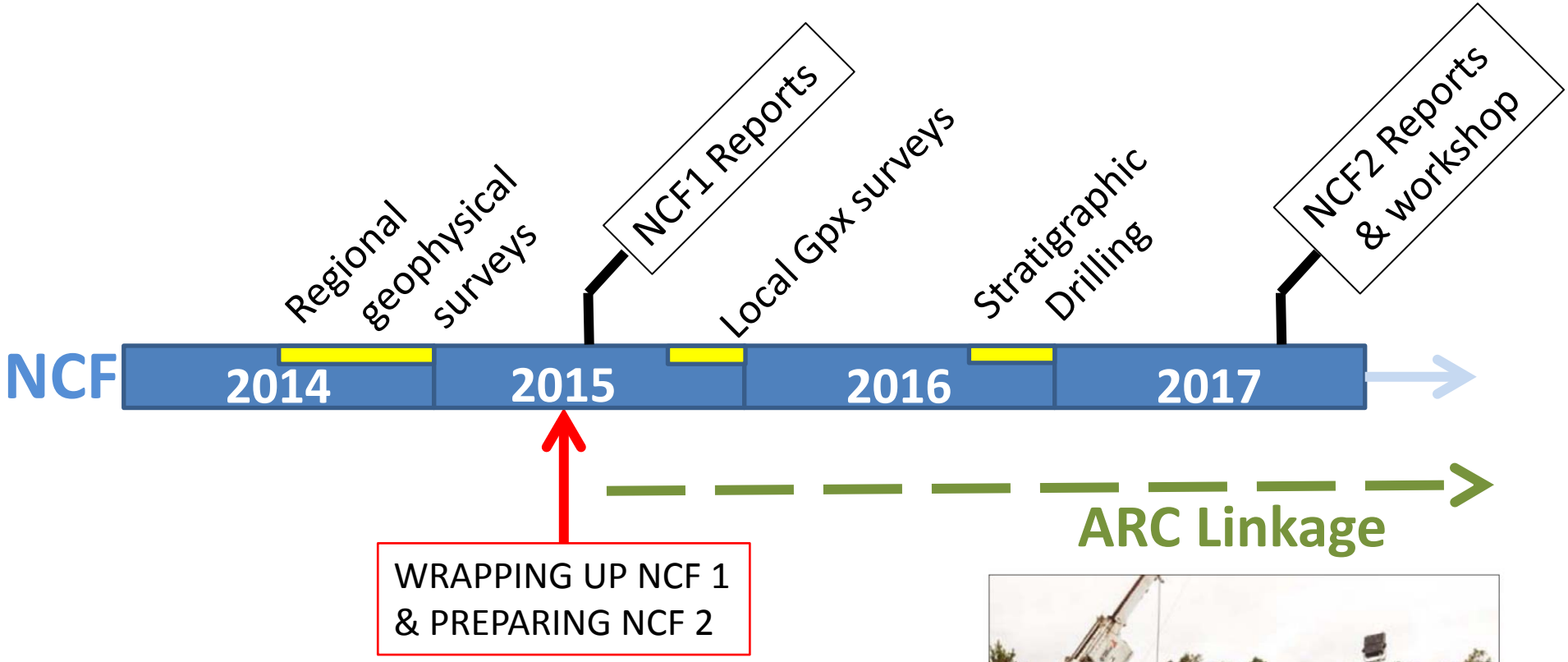


YANTABULLA

- DTB variability means 5 km line spacing is too wide for gridding in this zone
- Yantabulla example coincident with water bore bedrock granite at <10m

I. Roach, Digging Deeper 2014

NCF Project Plans looking forward…



Planned stratigraphic drilling program can potentially incorporate developments from DET CRC e.g. downhole tools, solids recovery (SRU) & lab at rig (LAR)

Brukunga DET CRC site

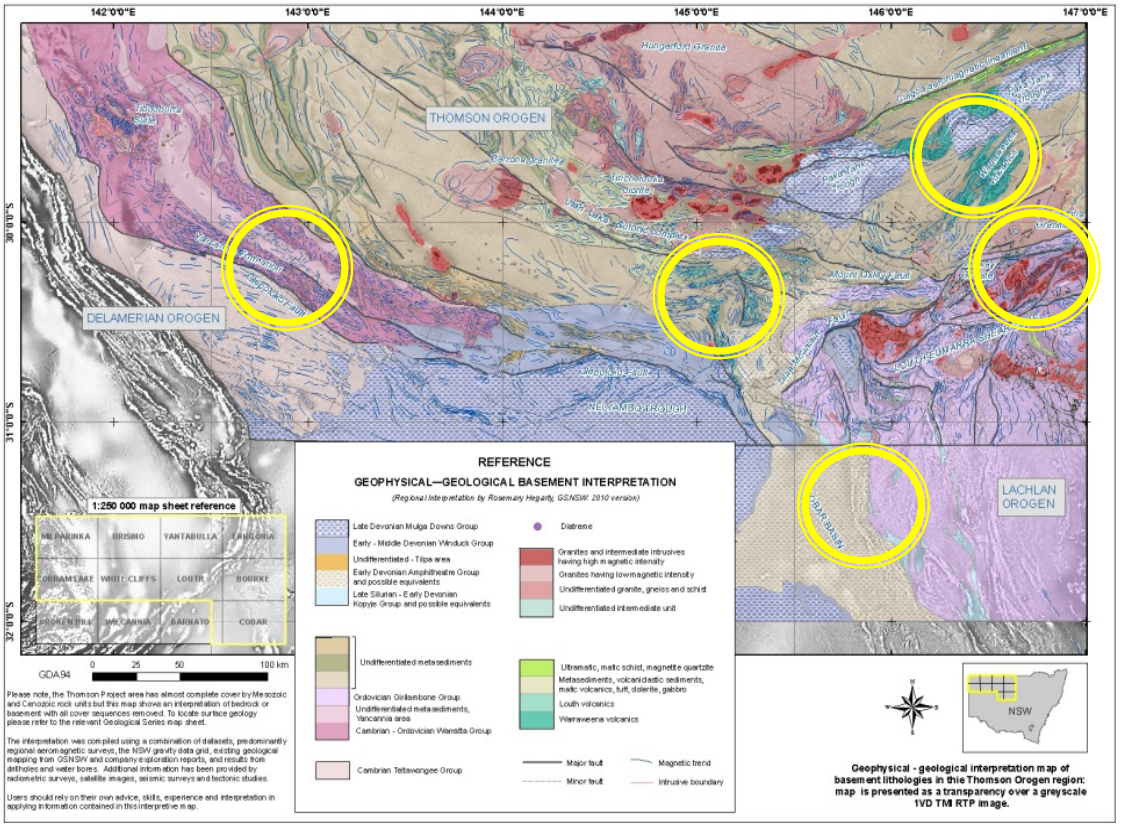
ARC Linkage Collaborative Research Agreement
- funded, signed & commencing 2015

"The southern Thomson Orogen – a missing link in the Tasmanides"

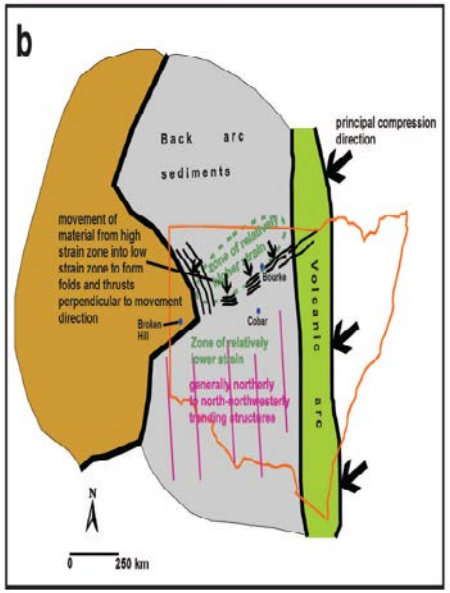
Chief Investigators - **University of Newcastle (Prof Bill Collins)**
Also – **University of Queensland, Queensland University of Technology**
Partner Investigators – **GSQ, GSNSW**

Designed to increase understanding of key aspects and sites

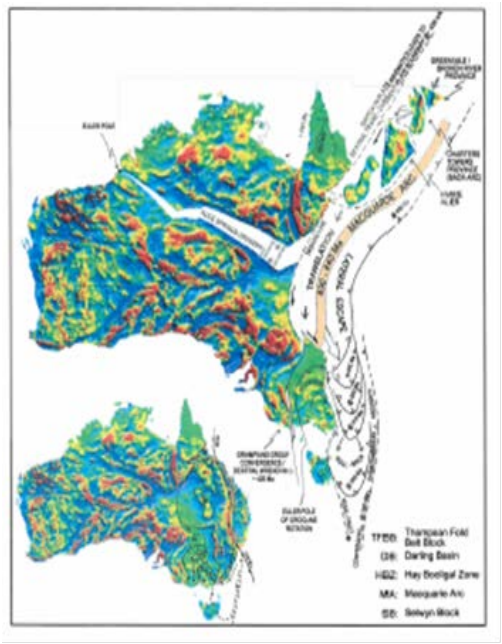
1. Systematic age determination of key lithostratigraphic units across the STO, both sedimentary, igneous and metamorphic;
2. Detrital zircon age spectra of major sedimentary units for provenance analysis;
3. Kinematic analysis and Ar-Ar age determination of major fault structures and syn-kinematic intrusions, where possible;



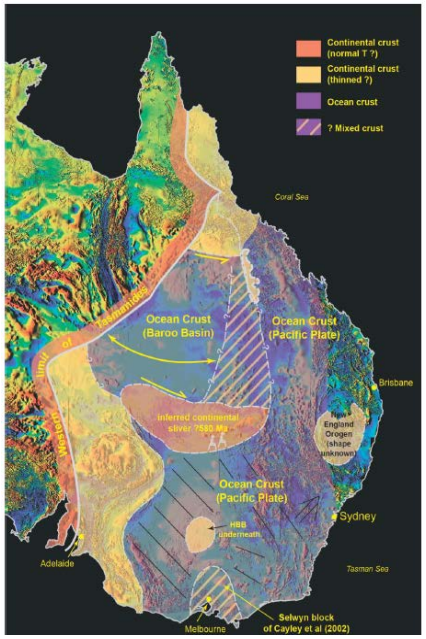
"Understanding STO origin and evolution is thus critical to understanding Tasmanides geodynamics"



2009 Formation of the E-W trending segment of the STO by "Benambran" ENE-WSW compression at 440-430 Ma. According to this model, Cambro-Ordovician turbidites were squeezed against the Precambrian salient of the Curnamona block, and extruded south (Burton, 2009).



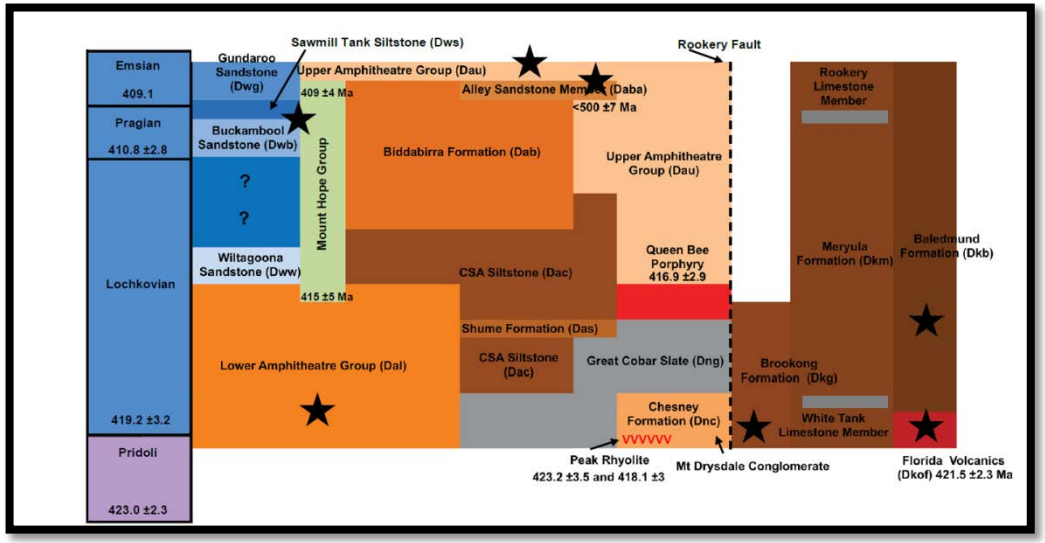
2012 Paleozoic oroclinal deformation (Cayley, 2012). According to this scenario, the entire Lachlan Orogen was folded into a Z-shaped orocline that more than doubled its width.



2013 An E-W oriented dextral strike-slip fault system at the southern margin of a westward retreating subduction margin (Glen et al., 2013). This geodynamic setting was dictated by the geometry of a Neoproterozoic backarc system.

Focus: to expand on the exact character of detrital provenance for Cobar Super Supergroup so that Southern Thomson investigations can compare with confidence.

"Age and provenance of the Cobar Supergroup" *(results in prep for publication)*
Honours thesis completed by Matthew Parrish, 2014, at University of Newcastle

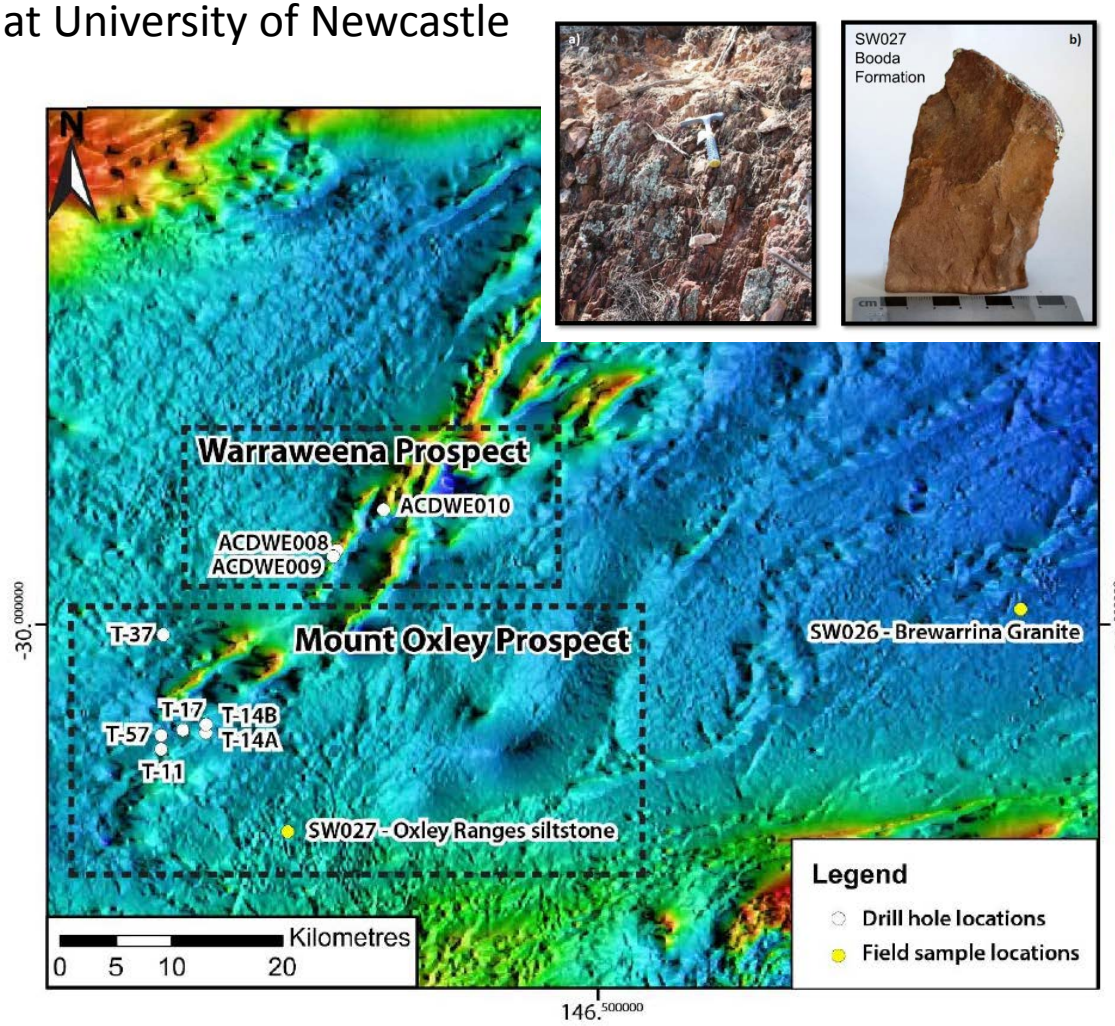


- Investigated max dep ages and provenance using LA_ICP_MS
- Seven samples selected to represent a section through stratigraphy in the local Cobar area, including Florida Volcanics
- Useful conclusions on methodology of LA-ICP-MS, including inheritance, and grainsize limitations
- Considered the provenance through time, comparing rift stage with basin sag infill and tying in with previous results

Focus on Warraweena Volcanics and surrounding sedimentary basement rocks

"Uncovering the Southern Thomson Orogen, NSW: Geodynamic Significance of Warraweena Volcanics and Related Rocks" *(results in prep for publication)* Hons thesis completed by Sarah Whalan, 2014, at University of Newcastle

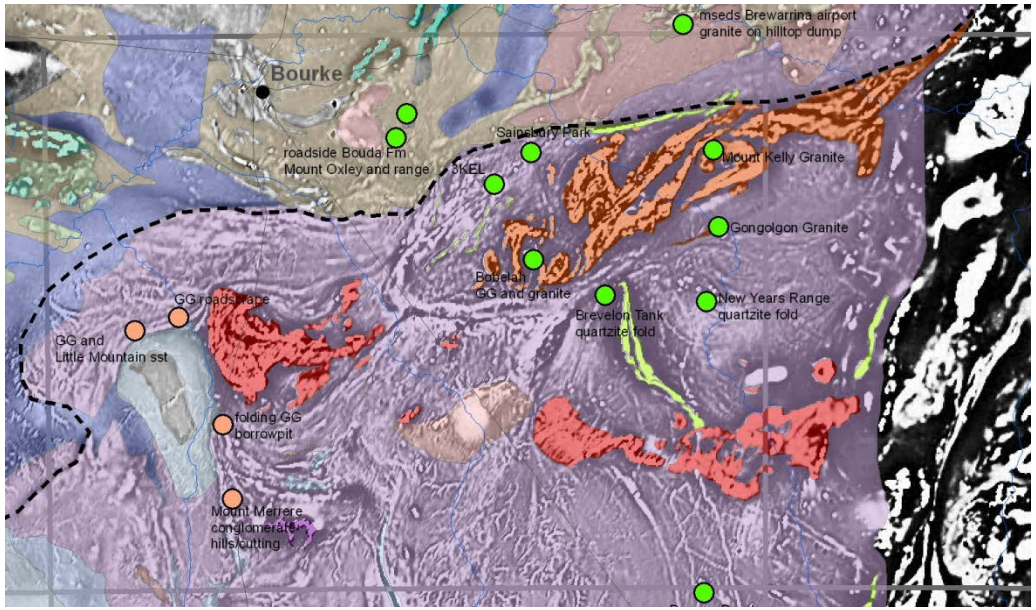
- Comparison of ICP_MS with shrimp dating of zircons from S-type Brewarrina Granite
- Sm Nd isotope chemistry of the igneous rocks (granite, volcs and tuff)
- Investigated max dep ages and provenance using LA_ICP_MS
- Included trace element composition for source: Yb/Sm
- Concluded by comparing these samples with detrital spectra from others obtained in the STO region in NSW



Focus: to understand the varied deformational fabrics and their timing moving north from Girilambone towards the Mount Oxley Fault

"Structure and kinematics of the Louth-Eumarra Shear Zone (north-central New South Wales, Australia) and implications for the geodynamics of the Thomson-Lachlan boundary" *(thesis submitted June 2015. University of Queensland)*

- detailed local mapping and thin section studies from drill core in a complex structural area



Also underway, Rasheed Hussain has commenced a PhD at University of Queensland studying deep seismic character and basement structure.
Ryan Dwyer has commenced a study of the Louth Volcanics to understand the geochemistry, petrology, lithological relationships and ages of those rocks.

In conclusion – what are the benefits to explorers?

Finding ways to reduce drilling expense and risk by

- Defining cover thickness and character
- Testing techniques for accurate depth to basement mapping
- To aid target generation by increased understanding of basement rocks (determining ages and age constraints)
- Recognising structures and mineral system potential.
- To formulate geological histories and geochemical characteristics which can underpin tectonic understanding.

To summarise Southern Thomson activities

1. The NCF collaboration phase 1 (2014 – 2015) has released new precompetitive data and developed/tested new concepts. Reporting on AEM and Mineral systems studies have been completed – to be released soon (?October/November).

2. The second phase NCF agreement (2015 – 2018) has commenced to undertake ground geophysics later this year. It aims to drill stratigraphic samples and results for analysis, helping to define basement units and recognise prospectivity.

3. The ARC linkage projects have already provided solid results in key areas. Two projects are current, and more projects await students through UoN, UQ and QUT.

THIS ALL TAKES TIME!

THANK YOU AND STAY TUNED