New mineralisation windows in East Riverina: Results from the five-year mapping project

26 September 2019

Contents

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Introduction

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East Riverina mapping project

5-year project (mapping 2014 to 2018)

- finalisation of line work, data and reports in 2019.

Update geological knowledge

- previous maps mostly from 1960–70s at 1:250 000
- increasing land use pressures.

Multi-disciplinary approach

- ‘Boots on the ground’ mapping with specialist input.

Applied research projects

- e.g. Uni of Newcastle, Lachlan Orogen ARC.

Local engagement

- professionals and community.

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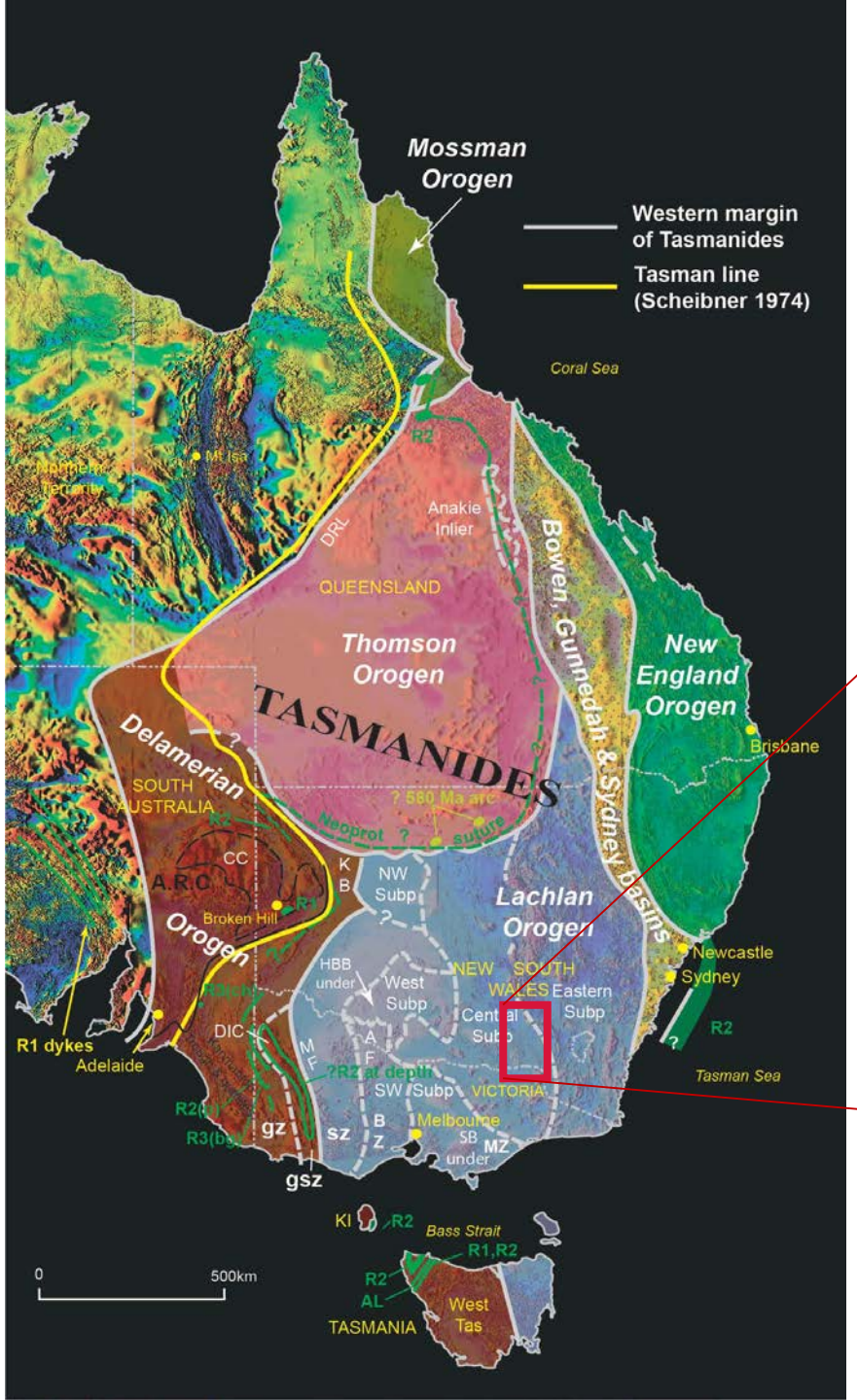
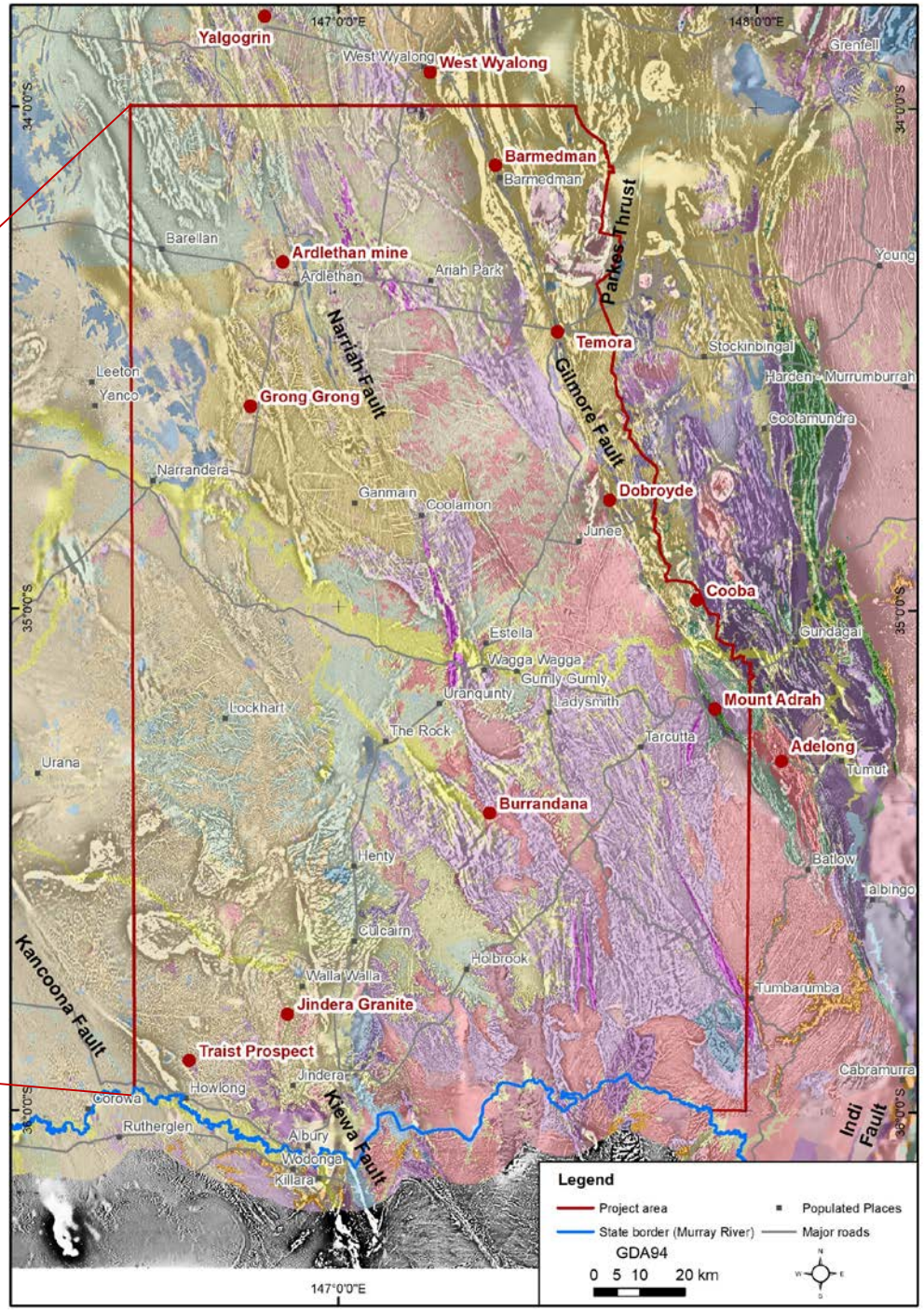
GOAL 1

A growing and diverse economy

Direction 12: Sustainably manage mineral resources



Surface geology from NSW Seamless Geology over 1vd TMI



Source: Glen 2013

New data

>7250 new observations & measurements (FieldObs)

- available in MinView
- includes photos, sample and analytical information.

~200 new age determinations

- >100 new isotopic:
  - SHRIMP (Geoscience Australia)
  - Ar–Ar (UoM, ANU), LA ICPMS (UoN, JCU, MU)
- >90 new palaeontological:
  - conodonts, graptolites, fish and invertebrates.

Australian Government
Geoscience Australia

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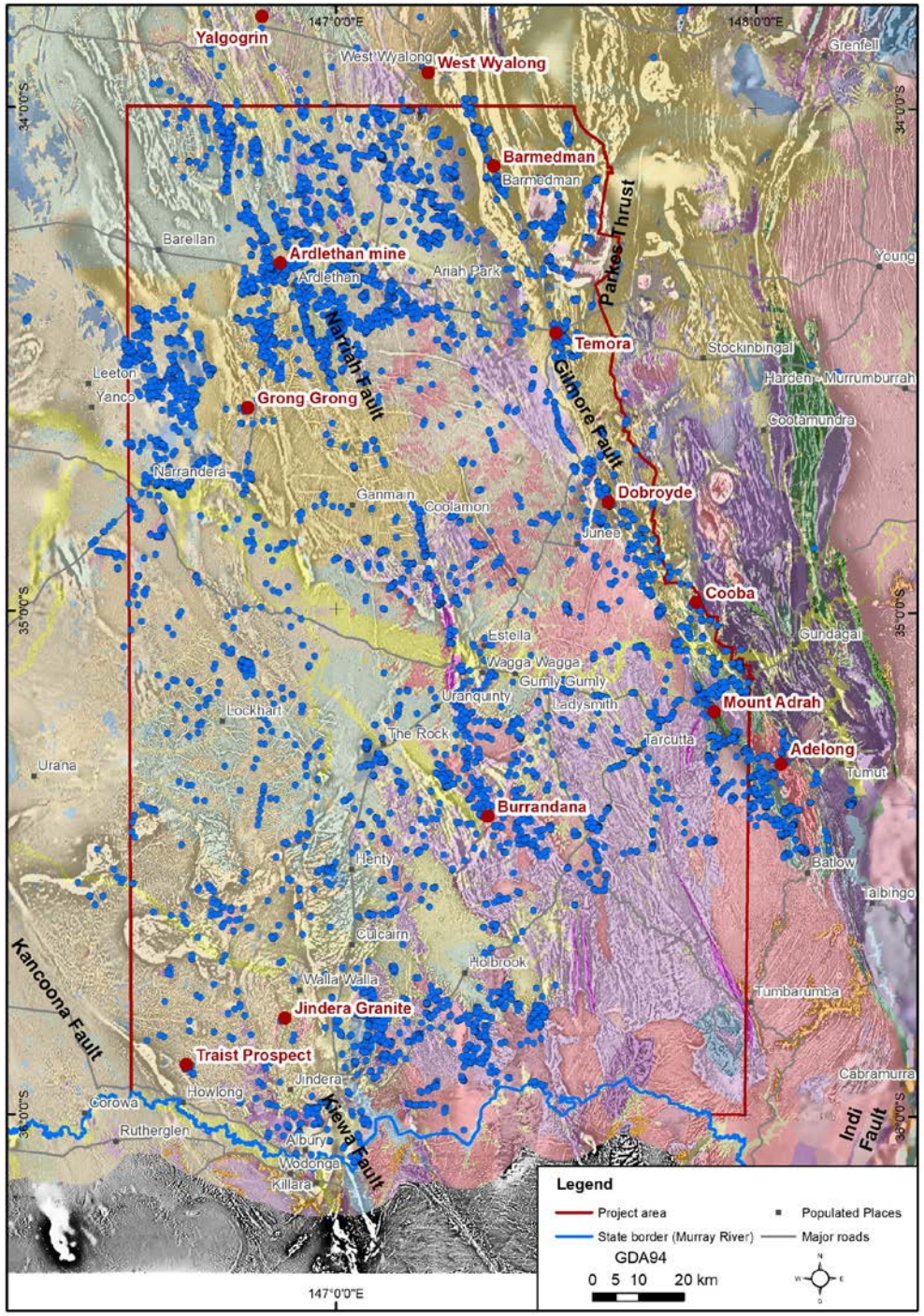


FieldObs with surface geology
(NSW Seamless Geology over 1VD TMI).

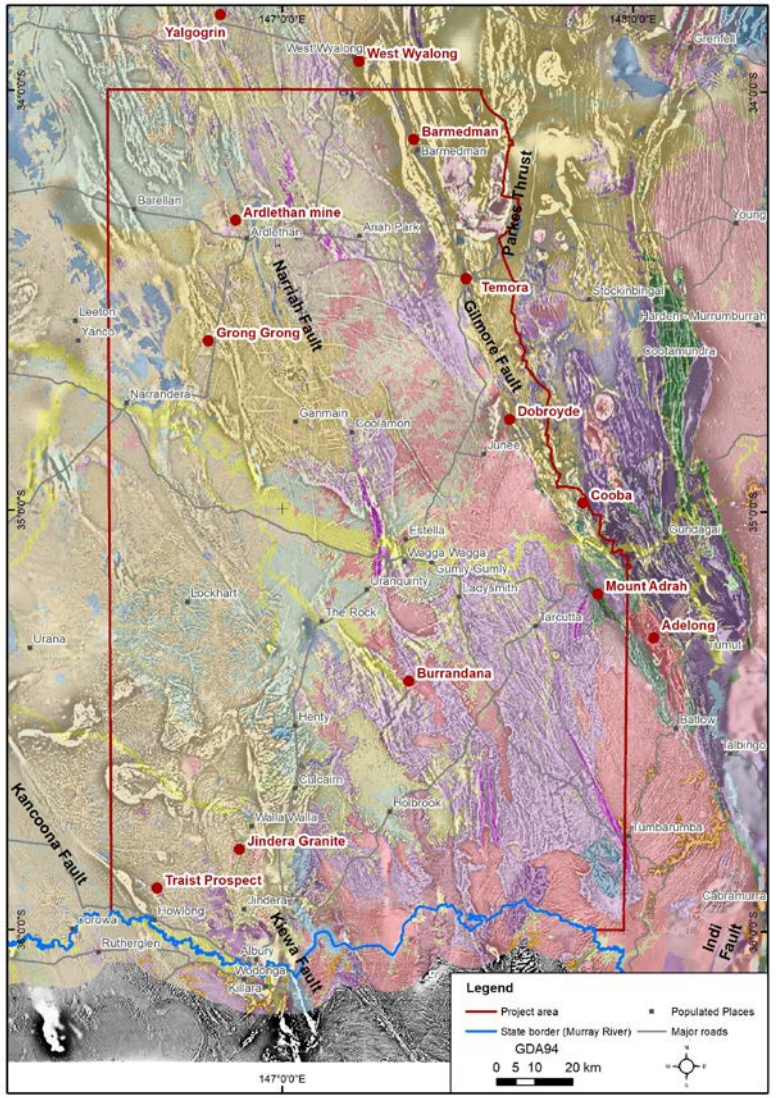
New linework

Into Seamless Geology

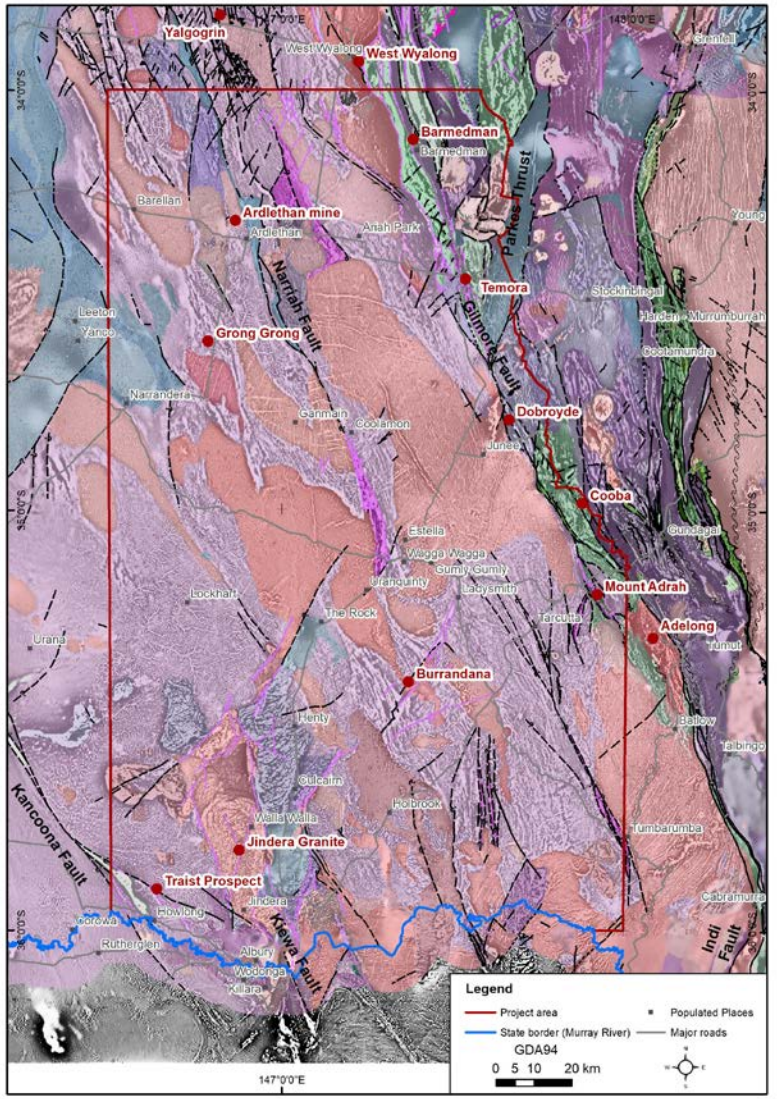
Four provinces:

- Lachlan Orogen (LAO)
- Western Devonian Basins (WDB)
- Cenozoic Igneous Province (CIP)
- Cenozoic Sedimentary Province (CSP).

Surface Geology (all provinces)
(NSW Seamless Geology over 1VD TMI).



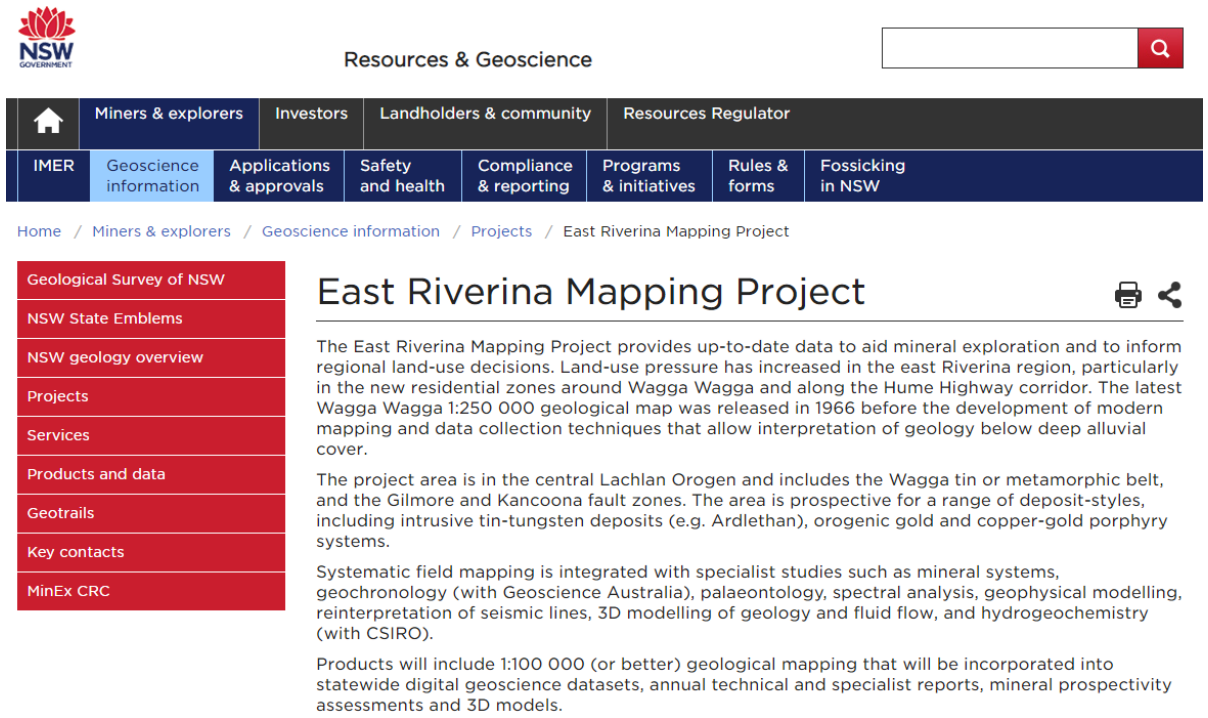
LAO and WDB
(NSW Seamless Geology over 1VD TMI).



New ideas

Available via East Riverina webpage:

- 18 x GS reports – field work
- 2 x GS reports – palaeontology
- 6 x GS reports – SHRIMP U–Pb (co-branded as Geoscience Aust. records)
- 2 x GS reports – LA ICPMS U–Pb
- 1 x GS report – mineral systems
- 1 x GS report – hydrogeochemistry (CSIRO)
- GS report, QN, paper – remote sensing (RMIT).



- 2 x Masters thesis, 2 x Honours thesis (UoN)
- Various conference posters, abstracts, talks

- Plus more reports coming soon
  - e.g. mineral systems and synthesis reports.

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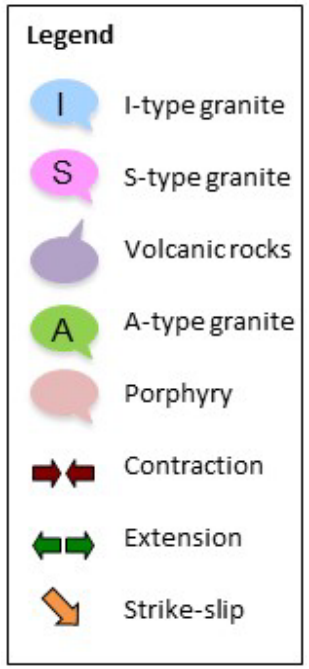
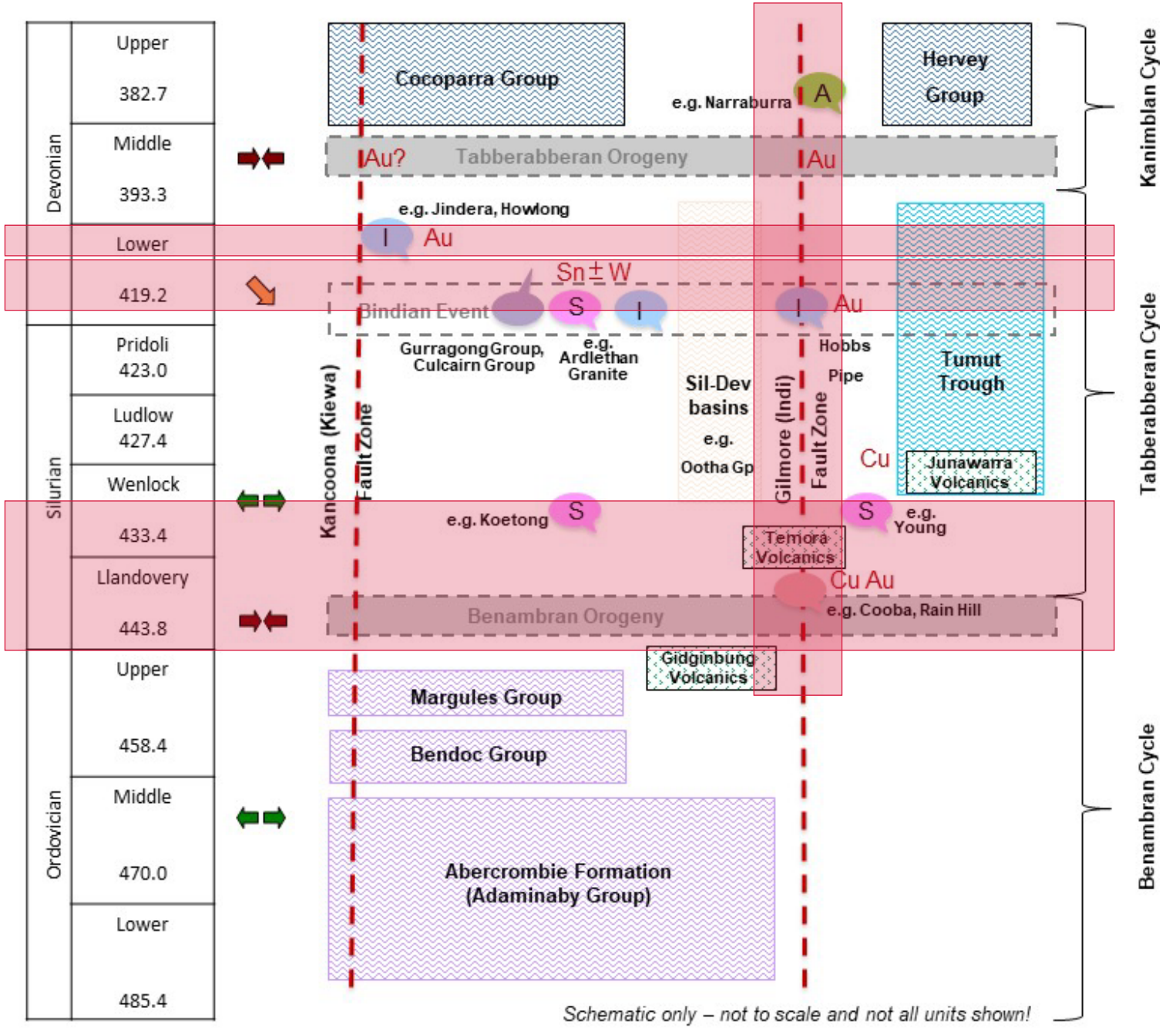
Today’s focus

Mineral systems associated with Siluro-Devonian magmatism and deformation





Early Silurian epithermal–porphyry systems

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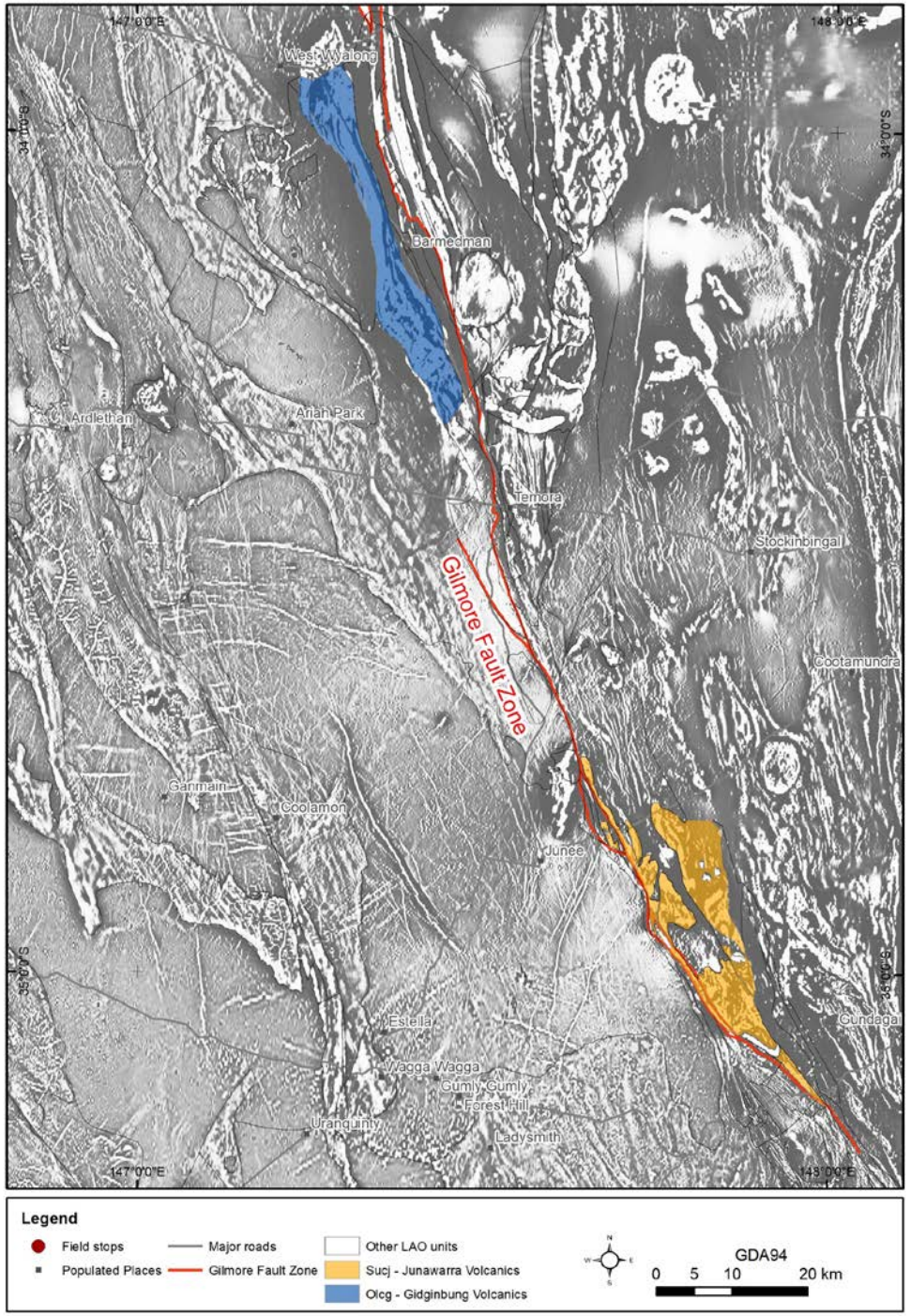
Epithermal–porphyry systems

Magnetic linears along Gilmore Fault Zone associated with intermediate to mafic rocks

Previously interpreted as:

- Continuation of the Junee–Narromine Volcanic Belt of the Macquarie Igneous Province (Benambran Cycle);
- Associated with opening of the Tumut Trough (Tabberabberan Cycle);
- Of uncertain or mixed origin.

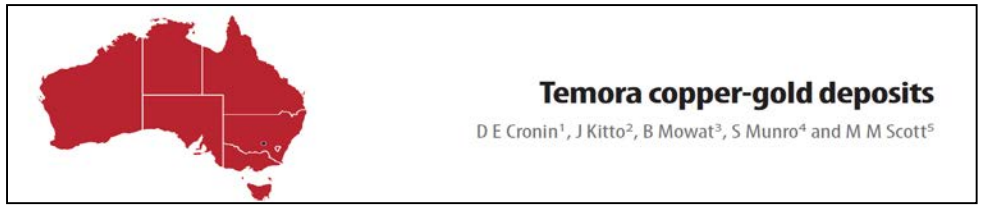


LAO geology (ERIV) over 1VD TMI.

Epithermal–porphyry systems

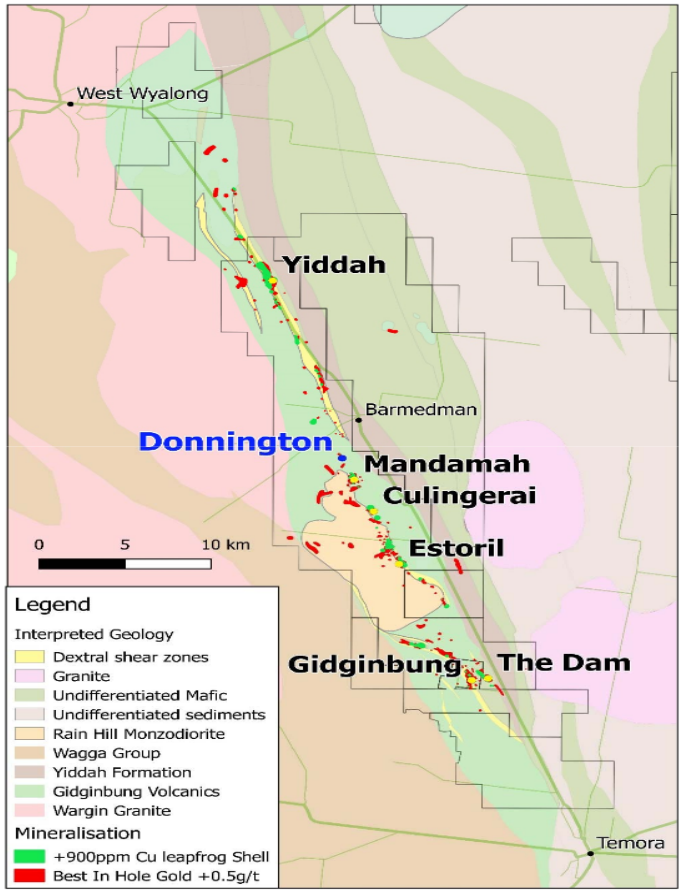
Gidginbung–Temora belt

- Part of Junee–Narromine Volcanic Belt (MIP)
- Late Ordovician – Early Silurian
- Epithermal mineralisation
  - e.g. Gidginbung
- Porphyry mineralisation
  - e.g. Donnington

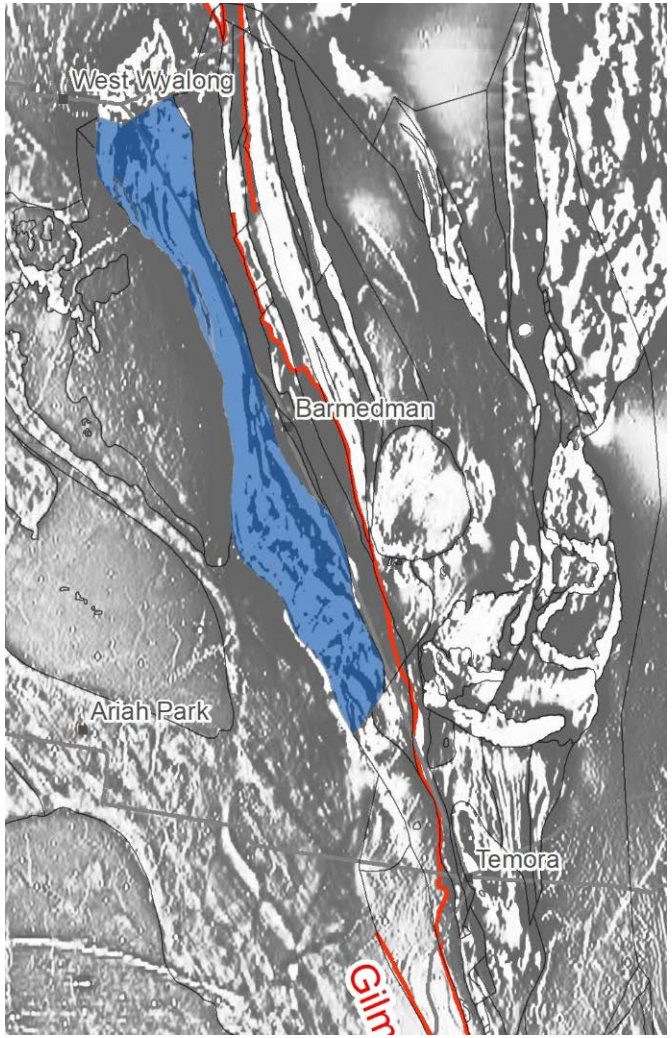


Temora copper-gold deposits

D E Cronin[1], J Kitto[2], B Mowat[3], S Munro[4] and M M Scott[5]



Source: Sandfire Resources, Cronin et al. (2017)

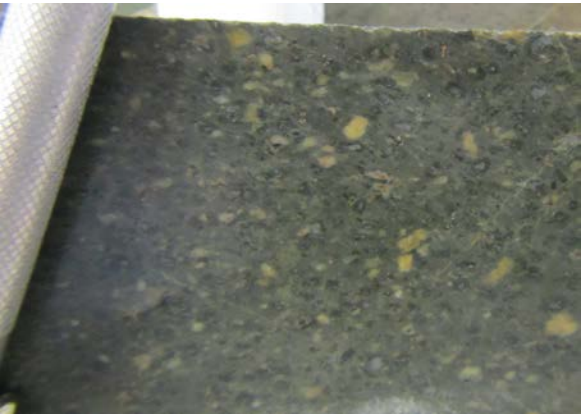


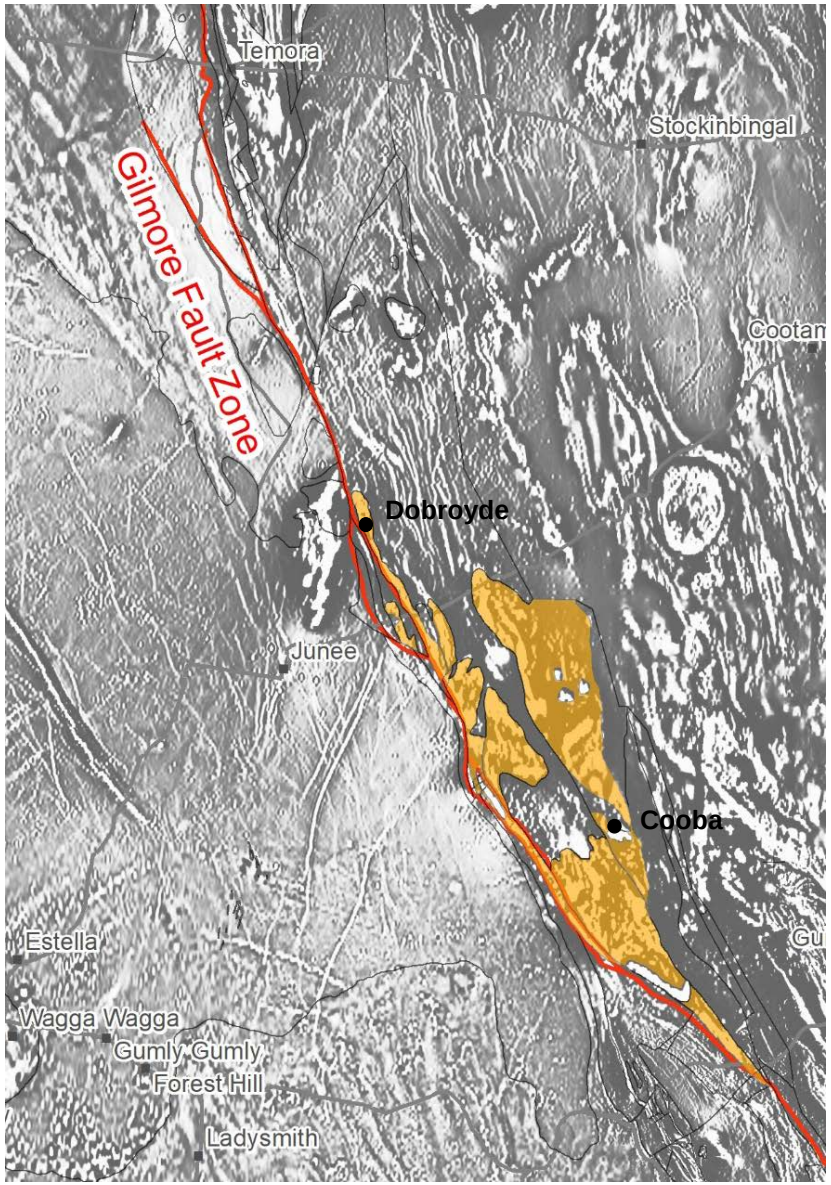
LAO geology (ERIV) over 1VD TMI.

Epithermal–porphyry systems

Junawarra Volcanics

- Associated with high sulfidation epithermal and carbonate base-metal mineralisation at Dobroyde (Diemar and Hughes 2018).
- First U–Pb geochronology
  - 431.1 ± 1.8 Ma for a porphyritic andesite at Dobroyde
  - 432 Ma (prelim.) for an autoclastic andesitic breccia to south.
- Tholeiitic affinity, with trace element characteristics indicative of a non-subduction setting (Eastlake 2018).
- New mapping of ‘jasper’ overlying mafic rocks
  - evidence of hydrothermal fluids associated with eruption.





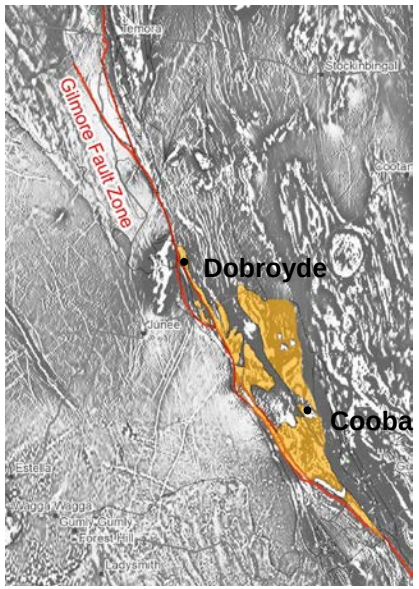
LAO geology (ERIV) over 1VD TMI.

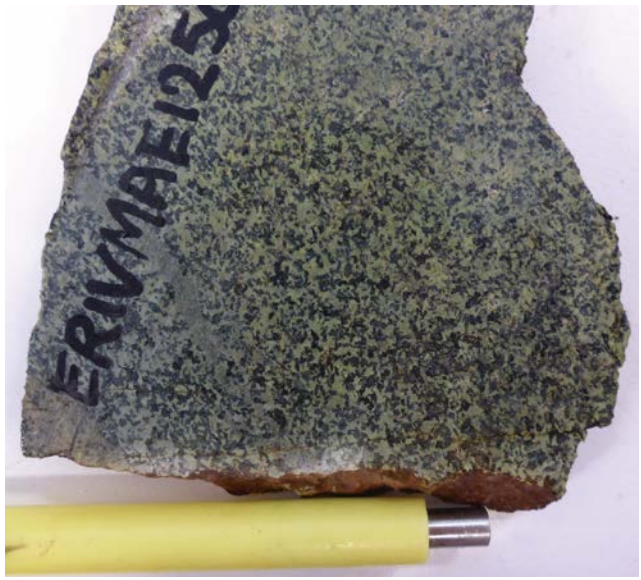
Source: Waltenberg et al. 2019, Bodorkos et al. in prep., ERIVKSH0112, ERIVMAE1221, Eastlake (2018) GS2018/0255.

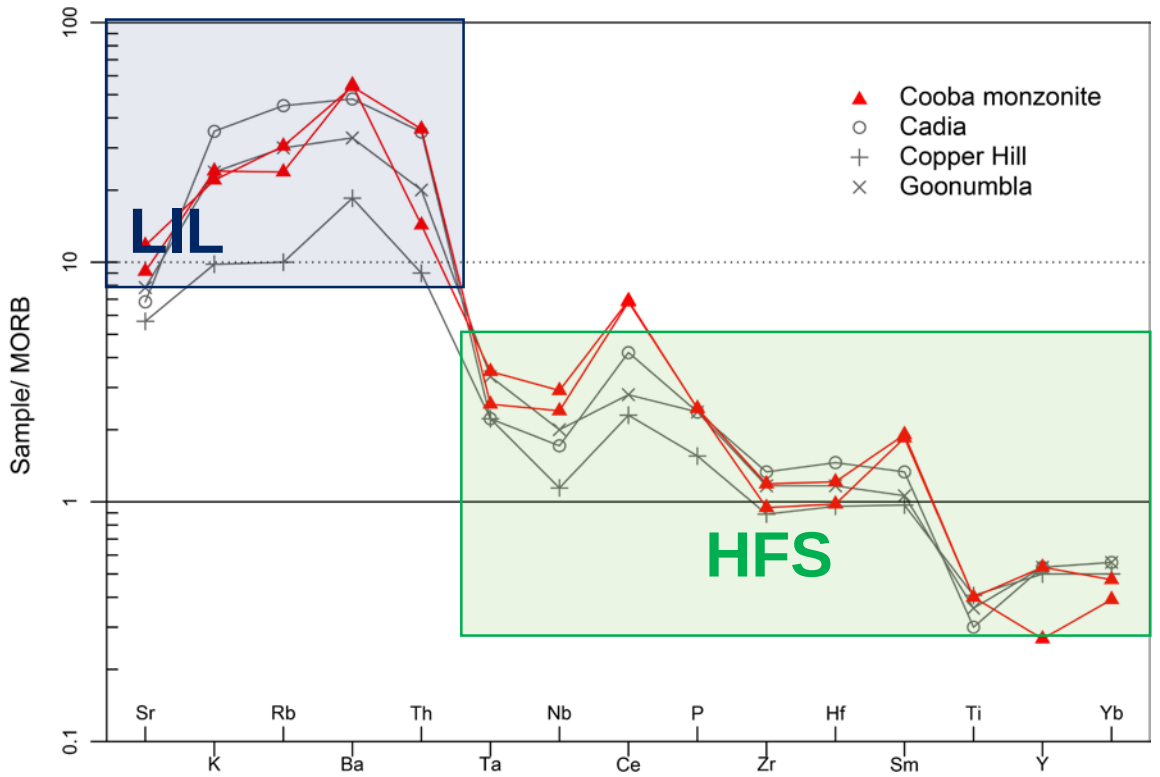
Epithermal–porphyry systems

Cooba monzonite

- High-K, subduction-related monzonite identified
  - 439 Ma (prelim. age, Bodorkos et al. in prep.)
- Similar age and geochemical affinity to mineralised intrusions at Cadia and Goonumbla
- Associated with historical copper workings.





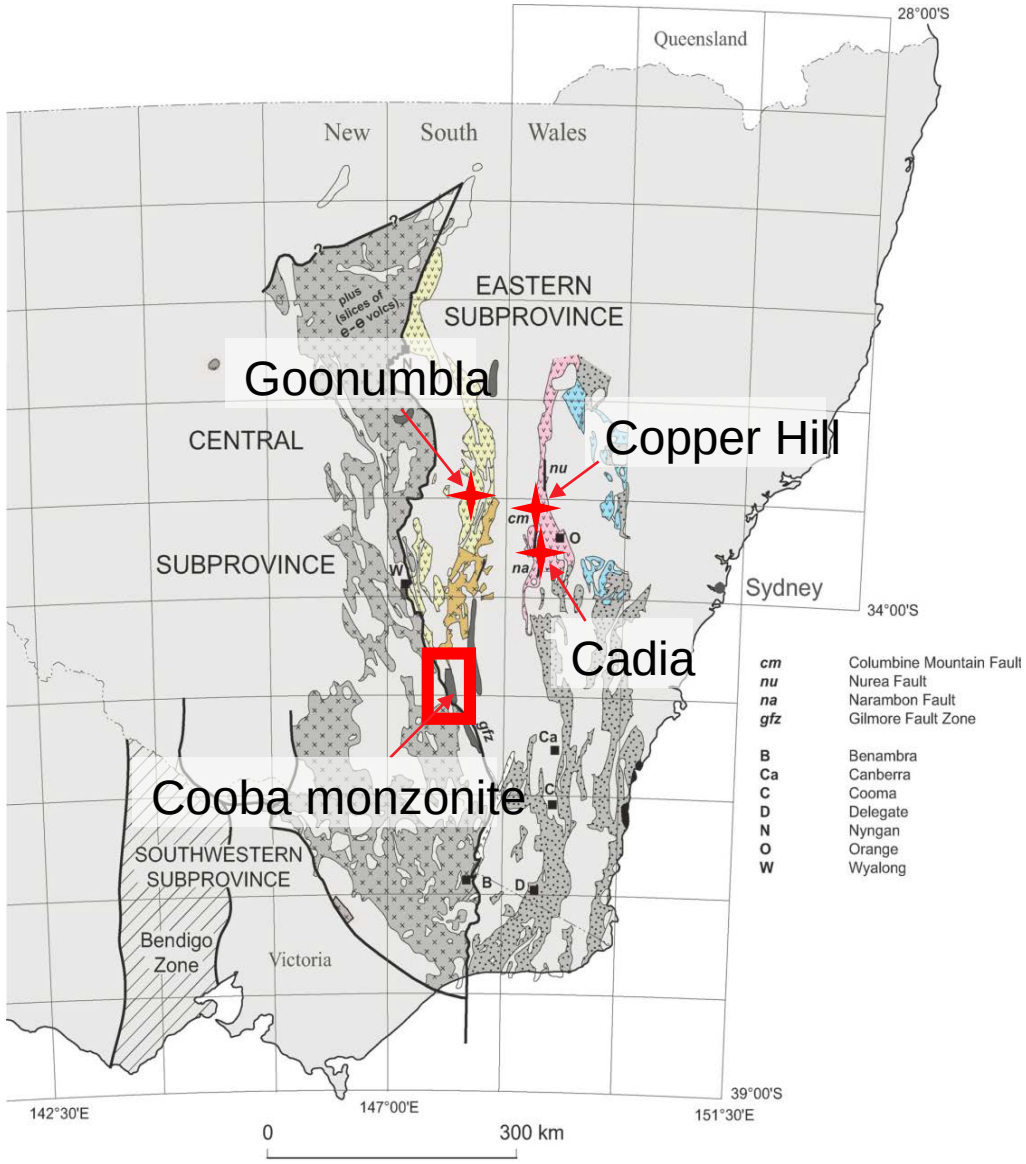


Source: Eastlake (2018) GS2018/0255,
including data from Blevin (2002) and plot of Pearce (1983).

Epithermal–porphyry systems

Implications:

- Junawarra Volcanics younger (~432 Ma) with tholeiitic geochemical affinity
  - o Represent opening of Tumut Trough
  - o Contemporaneous with S-type granites.
  - o Associated with Dobroyde and hydrothermal activity
- Monzonite at Cooba has similar age and geochemistry to Cadia and Goonumbla
  - o Extends ~439 Ma Phase 4 Macquarie Igneous Province to south.



Source: Eastlake (2017) after Crawford et al. (2007)

Early Devonian intrusion-related systems

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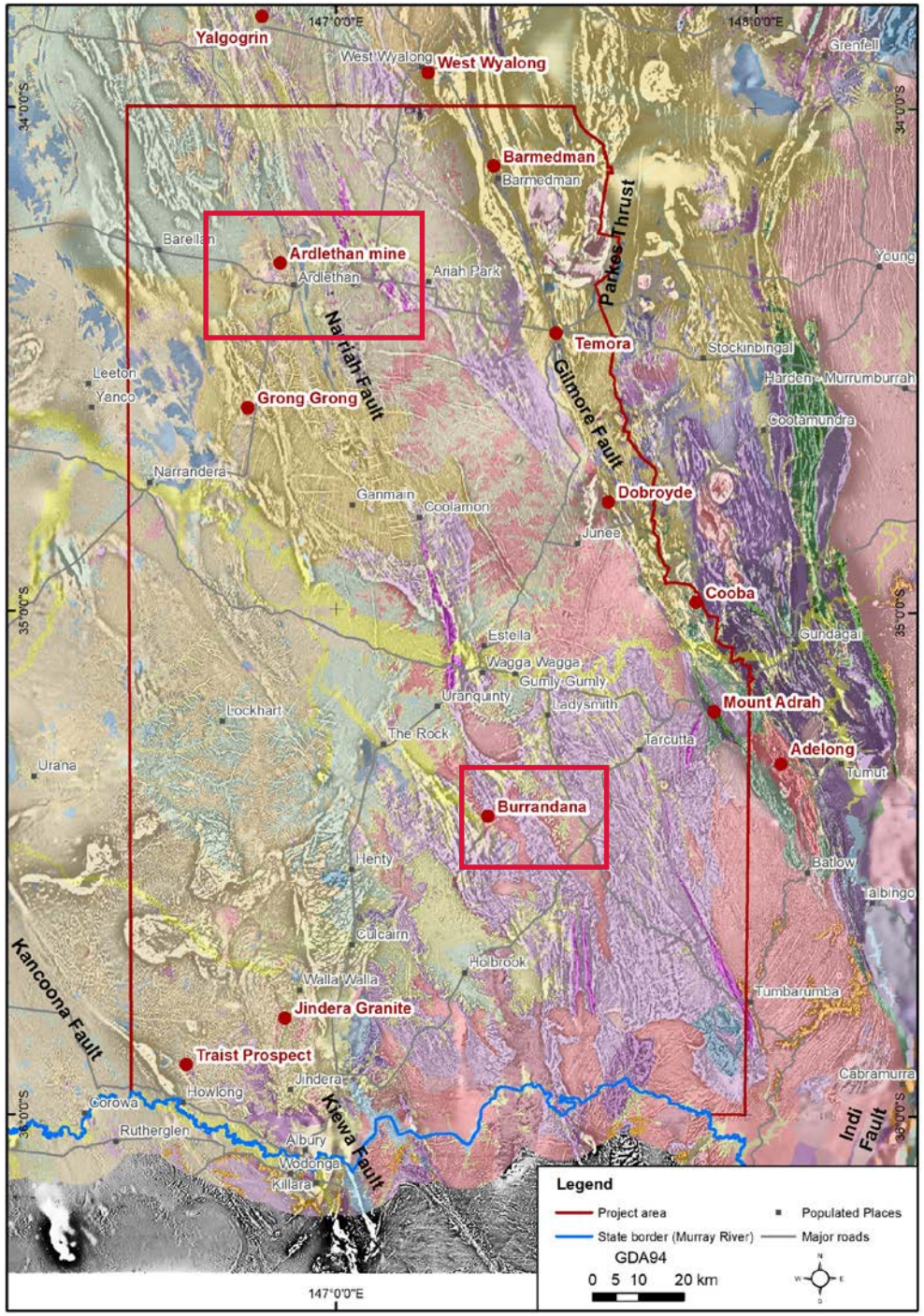
Intrusion-related tin

The southern part of the ‘Wagga Tin Belt’.

Largest resource in ERIV at Ardlethan with hard-rock mining (1965–1986) until world tin price collapsed.

- Unmined total resource (tailings, waste, hard rock) of 66,500 t of contained tin.

Also tin–tungsten at Burrandana.



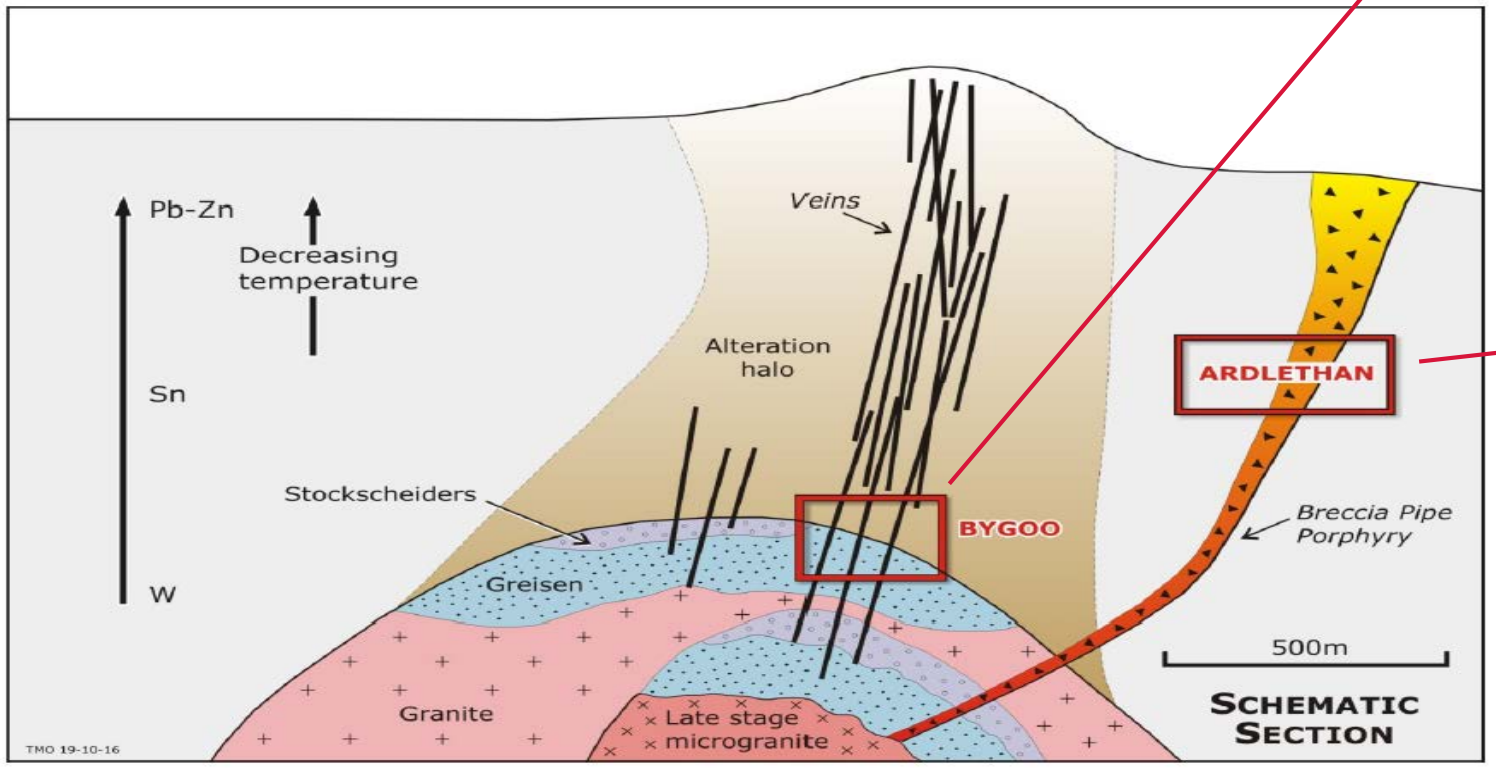
Surface geology (NSW Seamless Geology) over 1VD TMI.

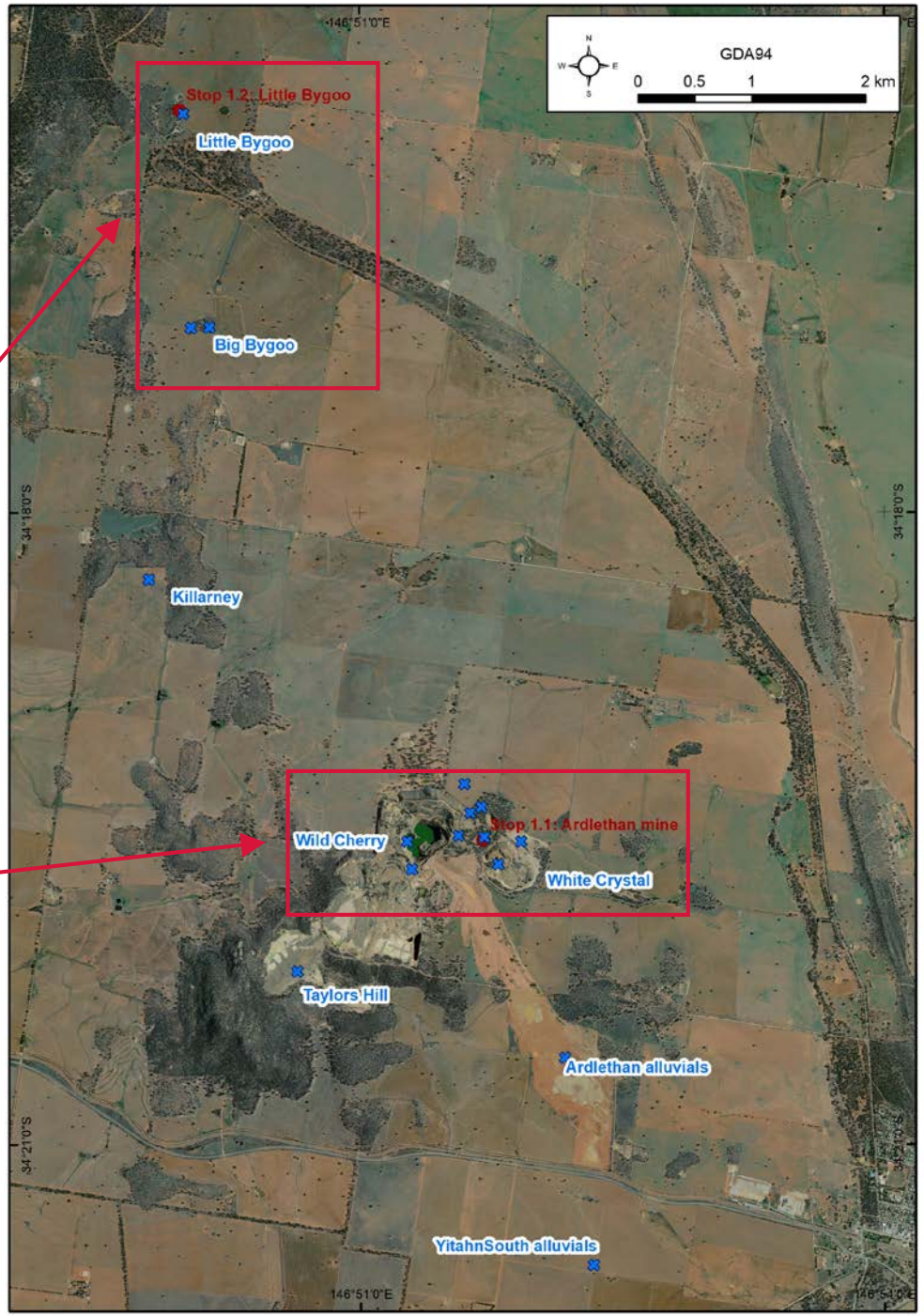
Source: Australian Tin Resources, Thomson Resources

Intrusion-related tin

Ardlethan area

- Breccia pipes (e.g. Ardlethan mine)
- Tin-bearing greisen zones and veins (e.g. Bygoo).



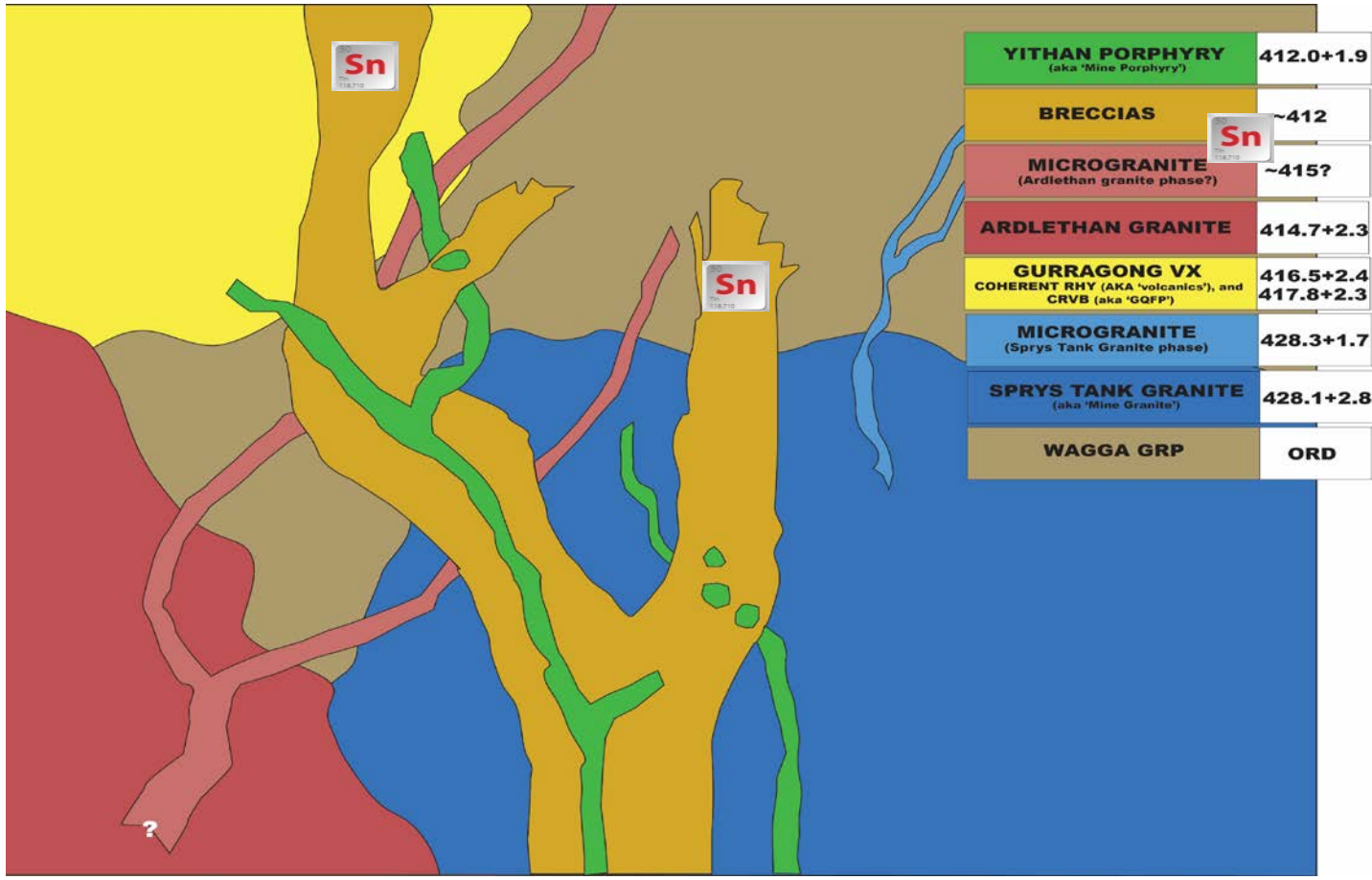


Source: Thomson Resources after Blevin (1998)

Intrusion-related tin

What age is mineralisation?

- Previously assumed to relate to the S-type, ~430 Ma Koetong Supersuite
- Though Ardlethan thought to be younger (Blevin 2010)
- New mapping, petrography and geochronology have differentiated magmatic history.
- Tin mineralisation is younger
  - ~414 Ma.

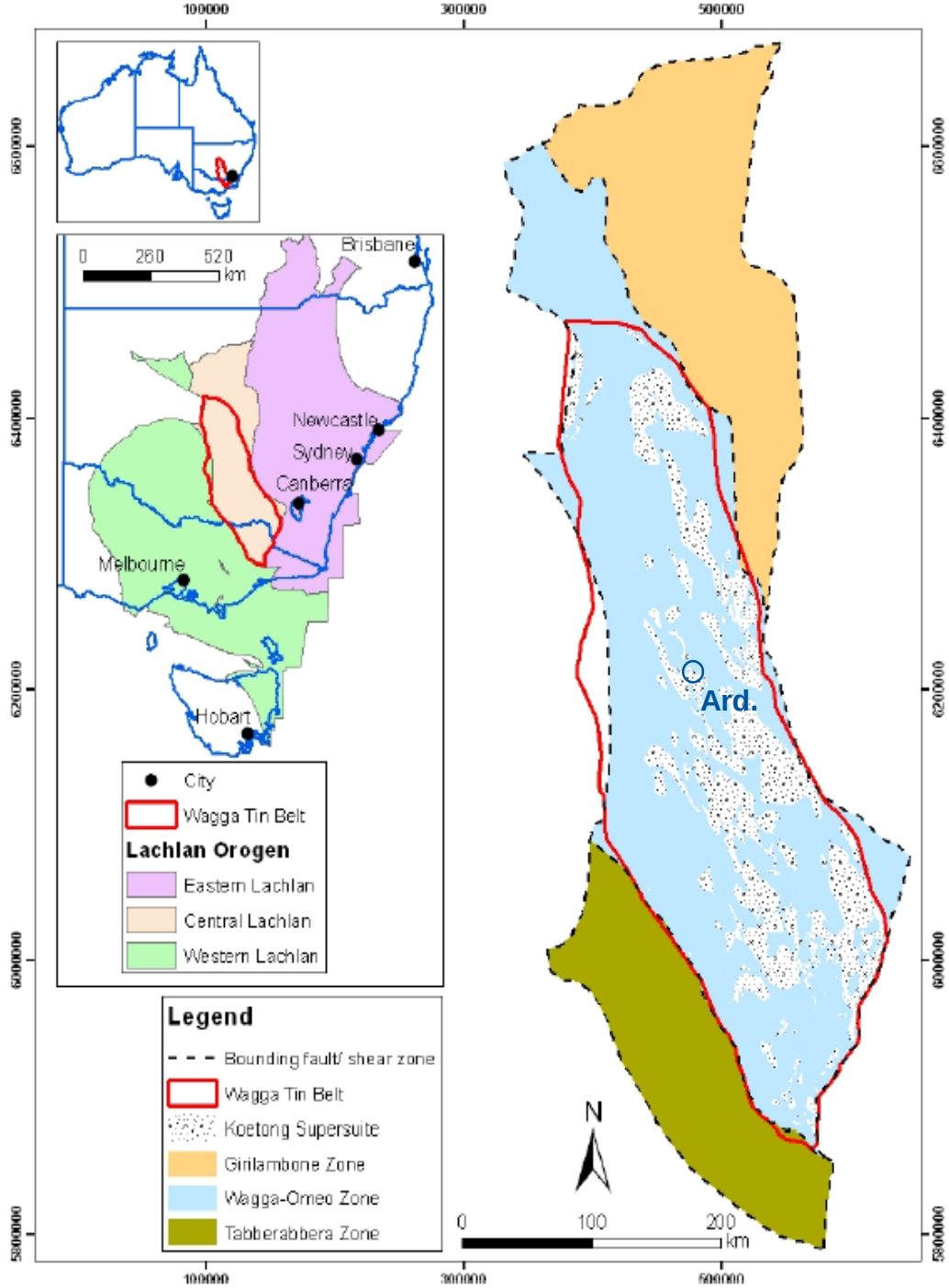


Source: Bull & Blevin (2016)

Intrusion-related tin

Implications:

- Tin prospectivity study completed pre-East Riverina mapping project
  - ~430 Ma Koetong Supersuite was a key theme in weights of evidence approach
  - Now know that tin mineralisation is associated with Early Devonian magmatism (~414 Ma)
- Upcoming exploration model and mineral potential mapping for intrusion-related tin in zone 55 west
  - Will incorporate new data and ideas
- Mapping has constrained exploration search space.



Source: Guj & Mamuse (2013)

Intrusion-related gold

Hobbs Pipe (near Mount Adrah) focus

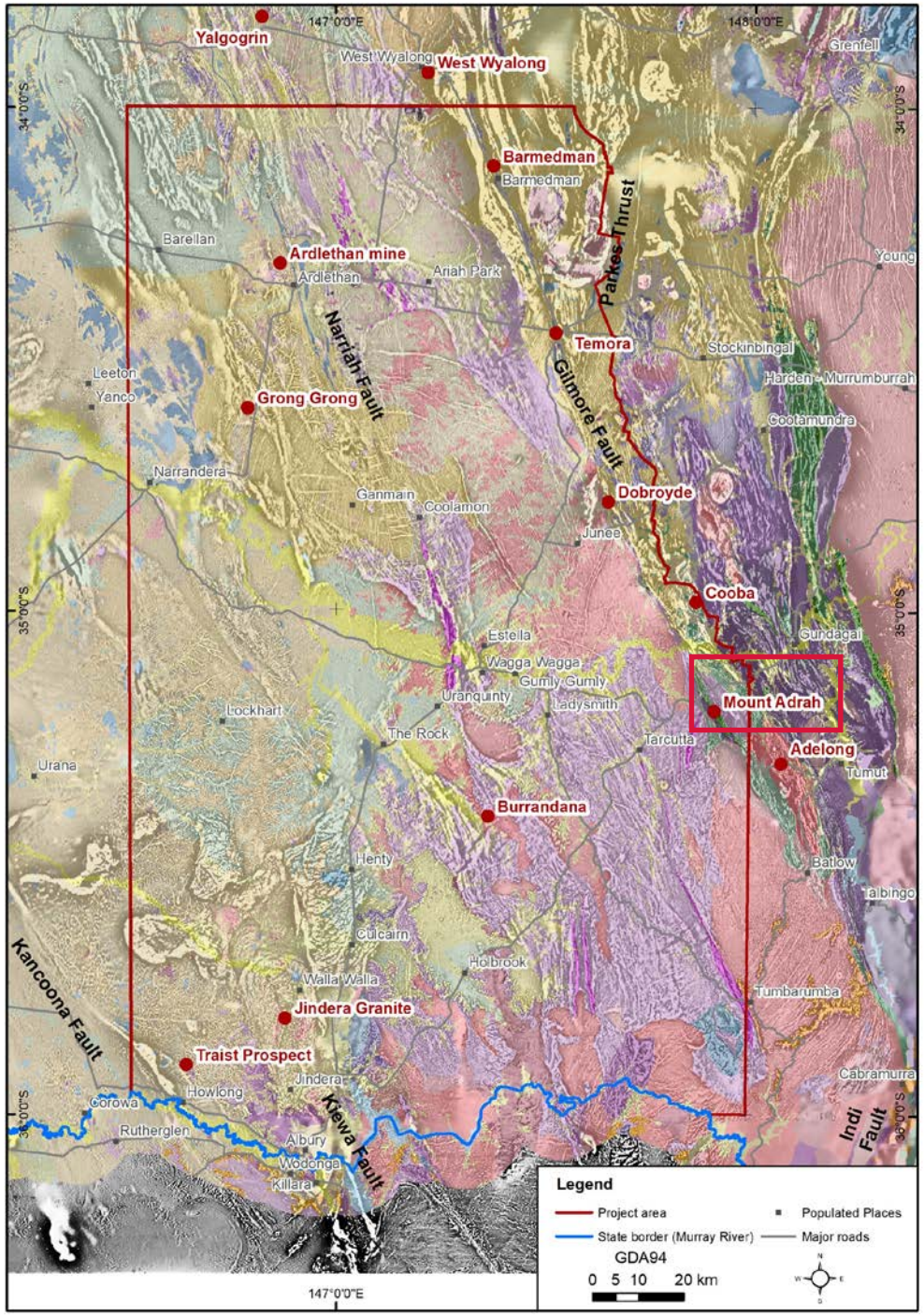
- 20.1 Mt @ 1.12 g/t Au for 727,727 oz Au.

Several quartz monzonite to monzodiorite intrusions identified in Ordovician Abercrombie Formation country rock

- Hobbs Pipe dated at 414.7 ± 2.6 Ma, SHRIMP U–Pb zircon (Waltenberg et al. 2015).

Gold mineralisation:

- Disseminated within Hobbs Pipe intrusive body
- Quartz reefs in Abercrombie Formation.



Source: White (2013), 0.50 g/t cut off

Surface geology (NSW Seamless Geology) over 1VD TMI.

Intrusion-related gold

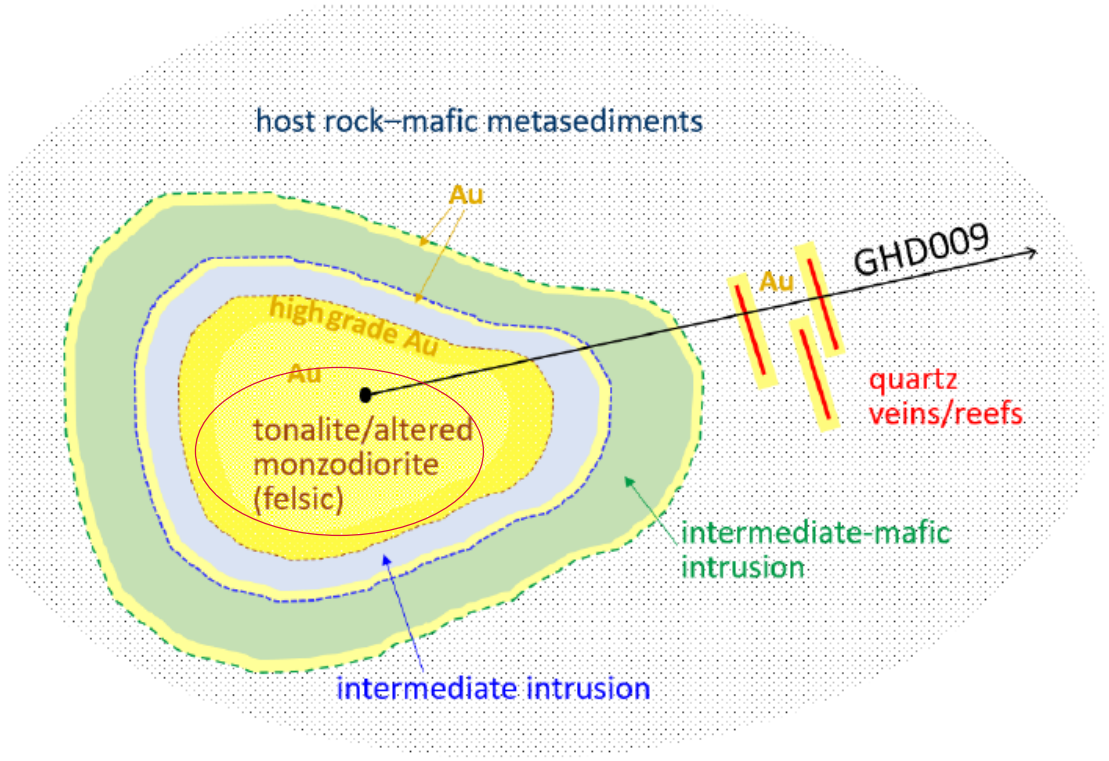
New GS report by Wang et al. (in prep.)

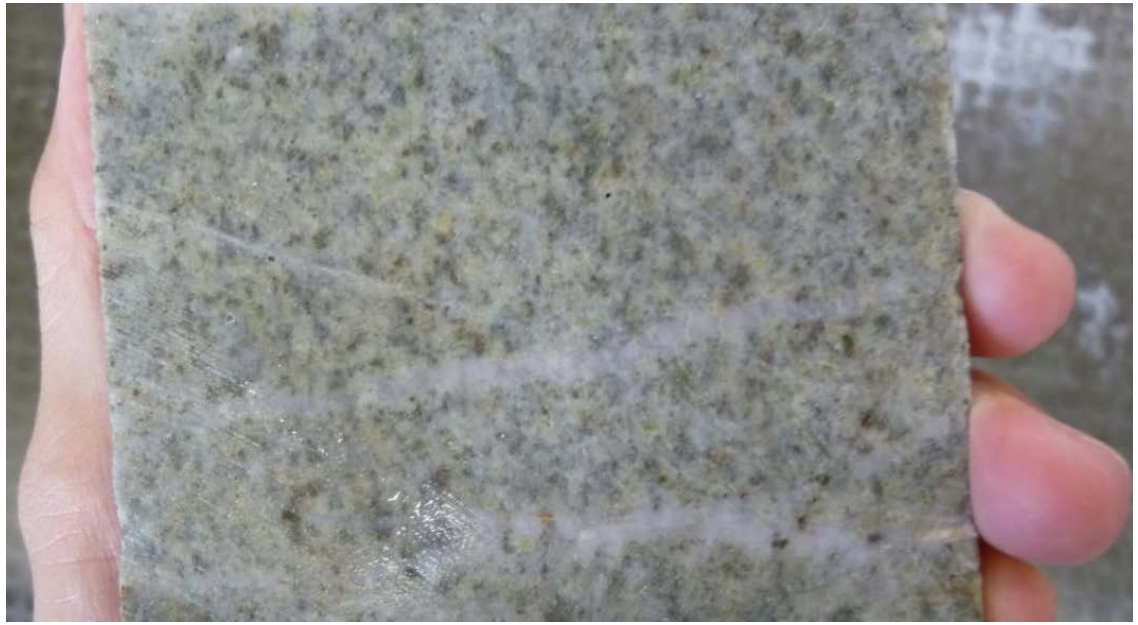
- Integration of HyLogger™ data, petrography, sulfur isotopes
- Confirms intrusion-related gold genesis.

Sericite–calcite–leucoxene–pyrite–arsenopyrite alteration:

- Associated with gold mineralisation in the intrusion
- Within margins of high-grade gold-bearing reefs in host rocks
- Overprints regional foliation.

Sulfur isotopes indicated magmatic-dominated source.





Source: Waltenberg et al. 2015, Wang et al. (in prep.)

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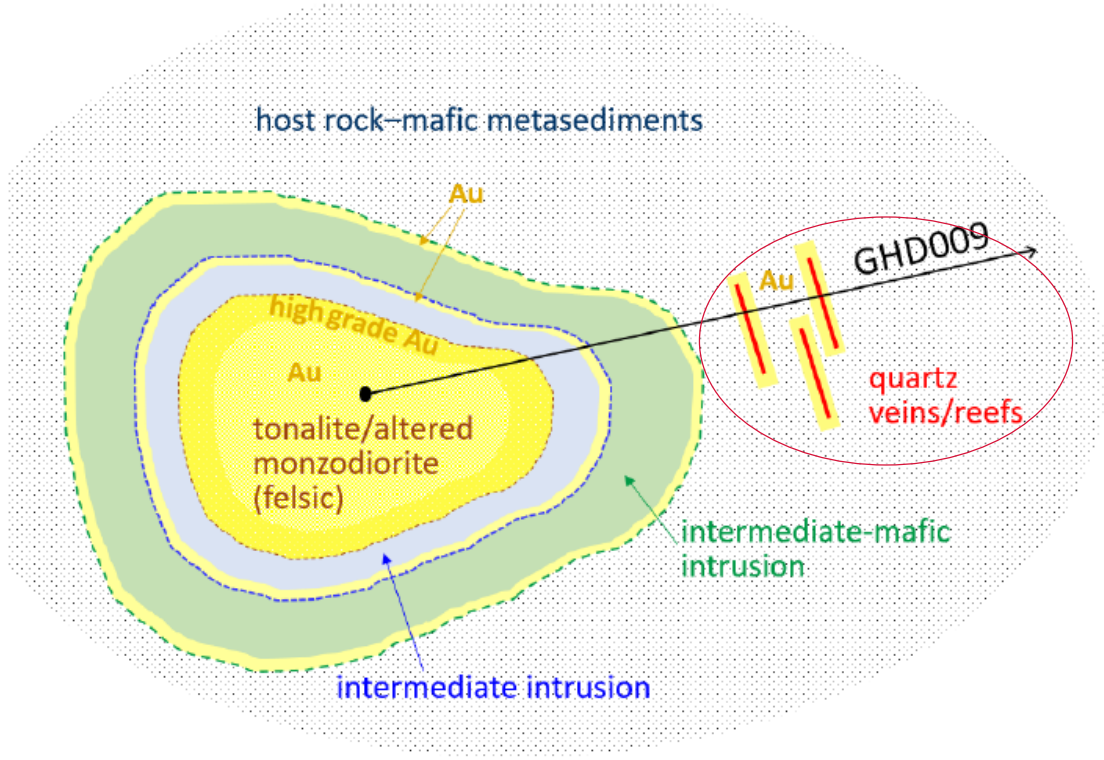
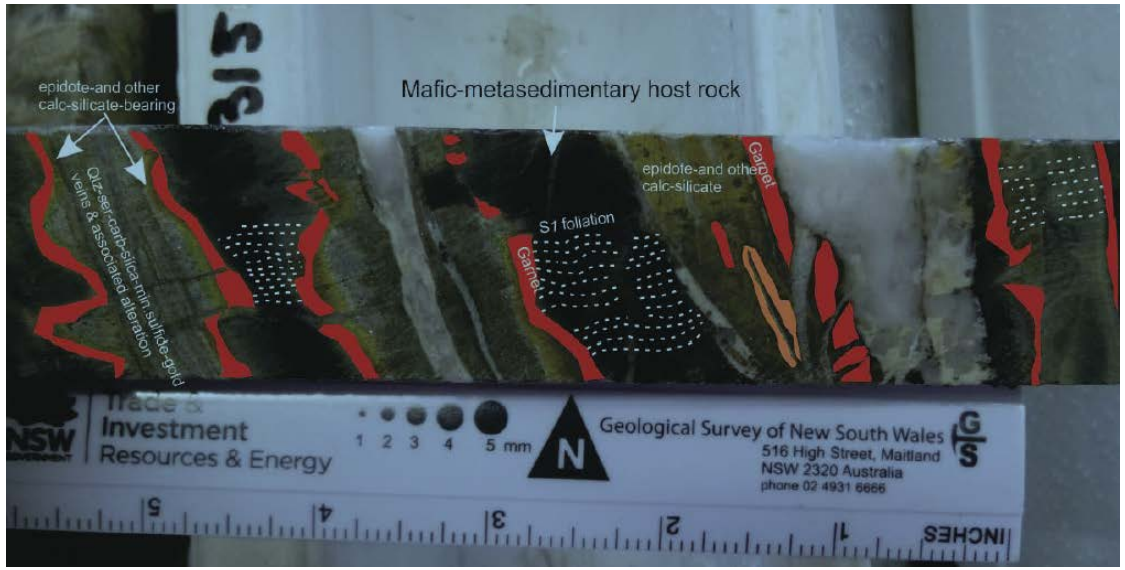




Source: Waltenberg et al. 2015, Wang et al. (in prep.)

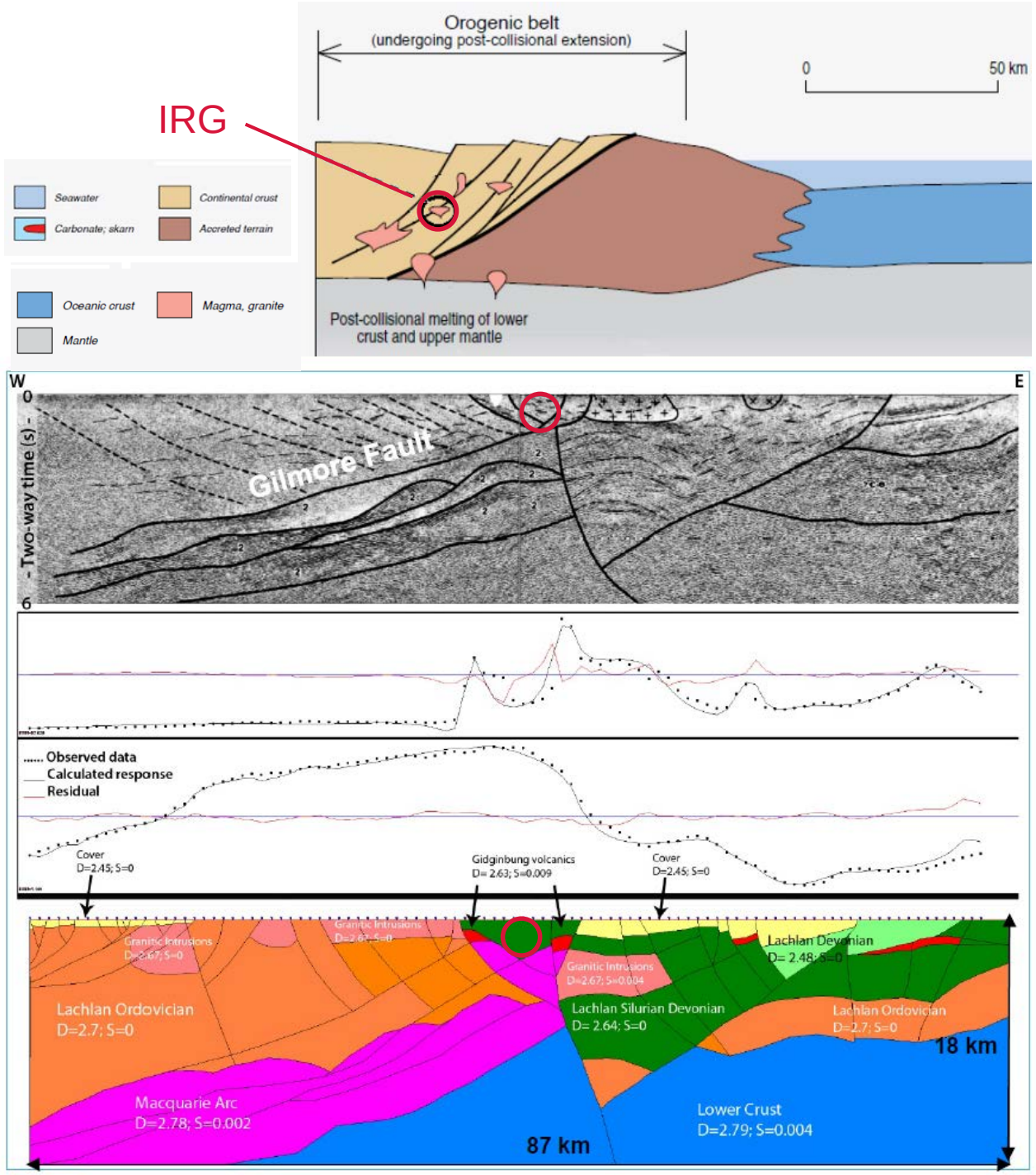
Intrusion-related gold

Implications:

- Intrusion driver for mineralisation
  - o Intrusion
  - o Country rock.

- Hobbs Pipe is exposed mineralised ~415 Ma intrusion in hanging wall of the Gilmore Fault Zone.

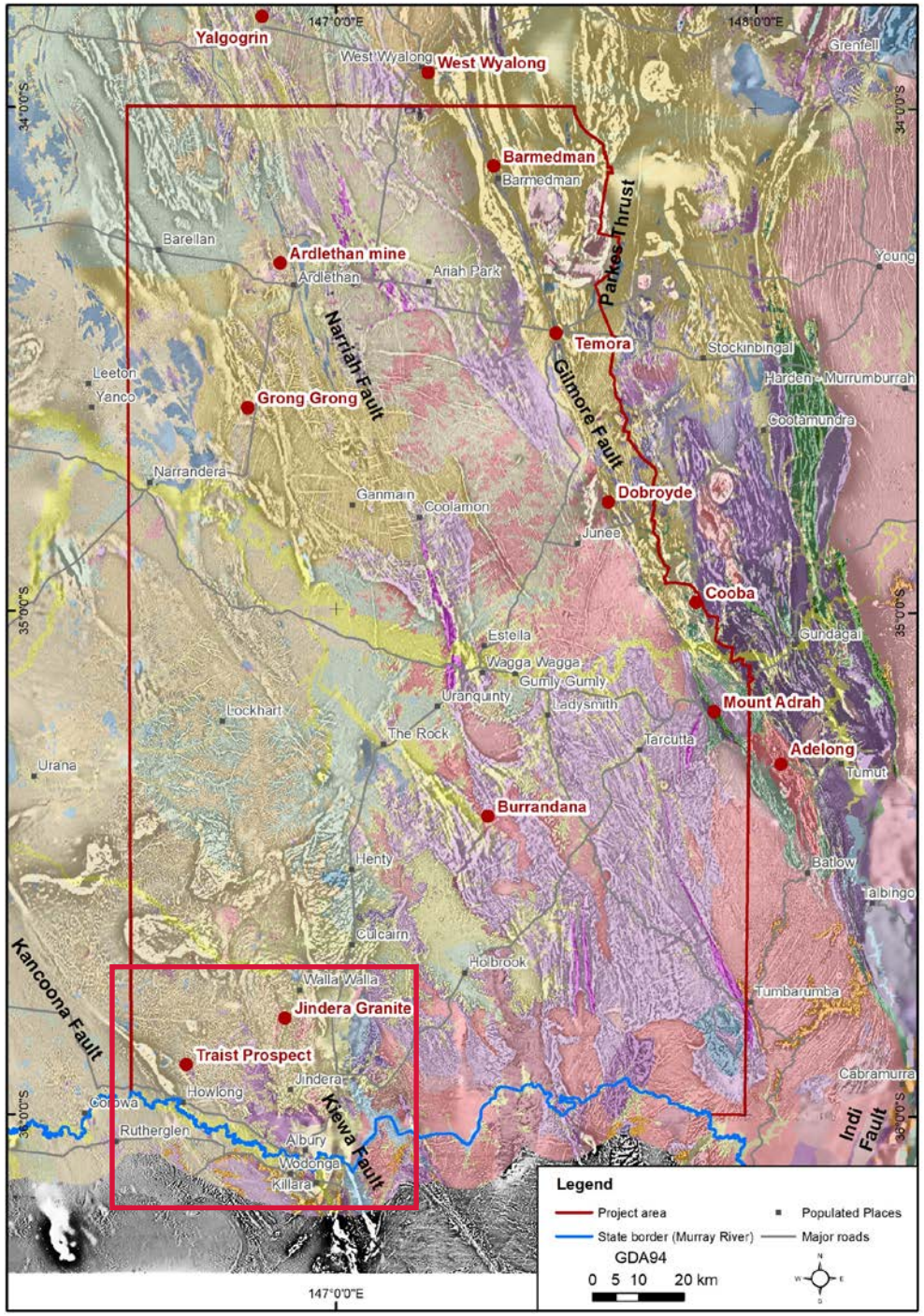
- Other blind intrusions in same structural setting?
  - o Leucoxene as vector?



Source: Geoscience Australia, Spampinato (2018) – GS2018/0576,

Porphyry–epithermal gold

Focus on the Traist prospect in Howlong area



Surface geology
(NSW Seamless Geology) over 1VD TMI.

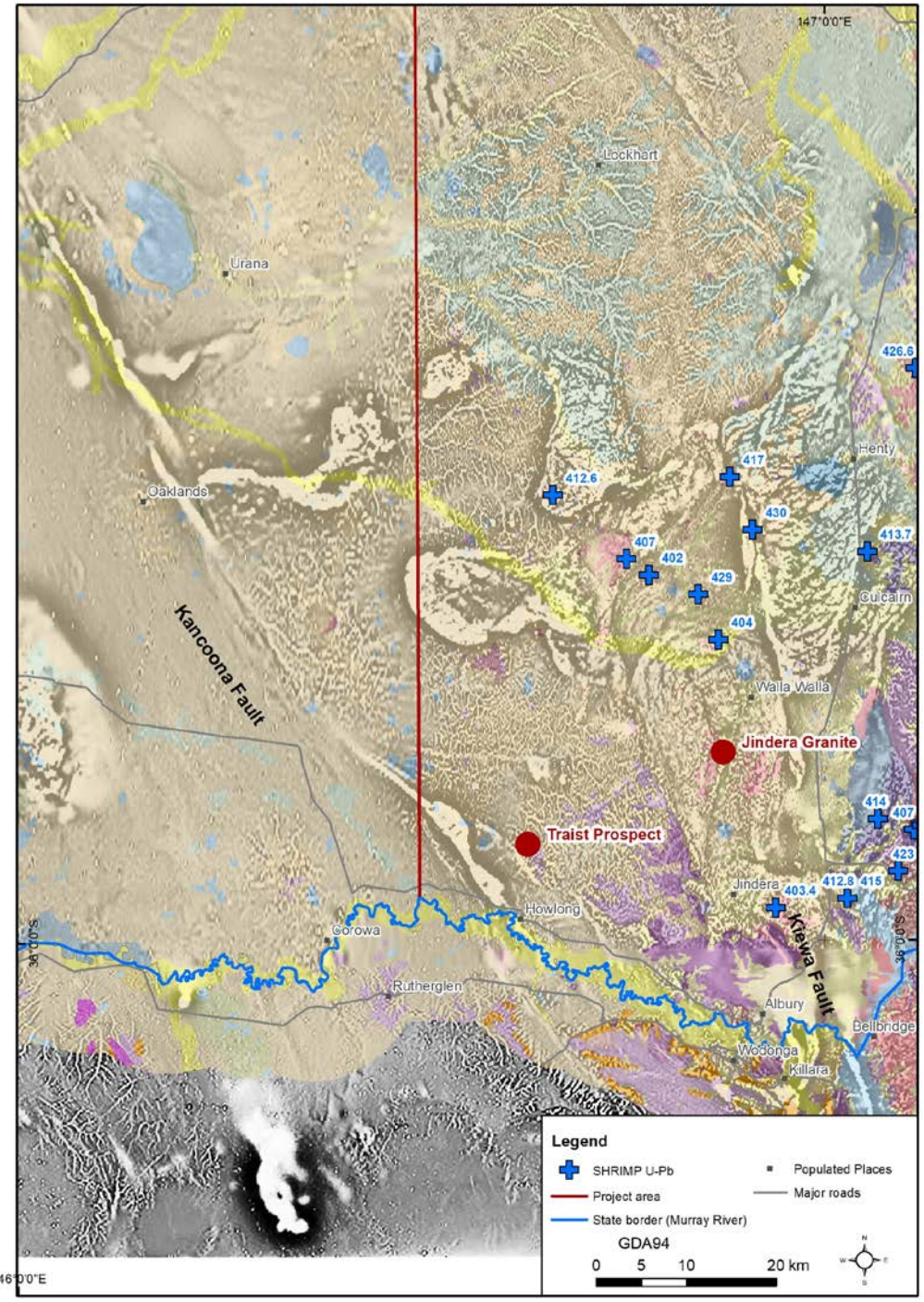
Porphyry–epithermal gold

Porphyritic intrusions along a splay of the Kancoona Fault.

- Gold mineralisation hosted by porphyritic intrusions and Ordovician Abercrombie Formation country rock.
- Dextral strike-slip movement interpreted from aeromagnetic imagery
- Consistent with kinematic history of Kancoona–Kiewa fault zone in Victoria.

New mapping, petrography and geochronology for Jindera Granite.

- Series of metaluminous, highly fractionated, I-type lobes younging to the south (Bull 2017)
- ~407 to ~403 Ma (Bodorkos et al. 2015, in prep.).



Surface geology (NSW Seamless Geology) over 1VD TMI.

Source: Bull 2017 – GS2017/149,
Bodorkos et al. 2015 – GS2015/0002.

Porphyry–epithermal gold

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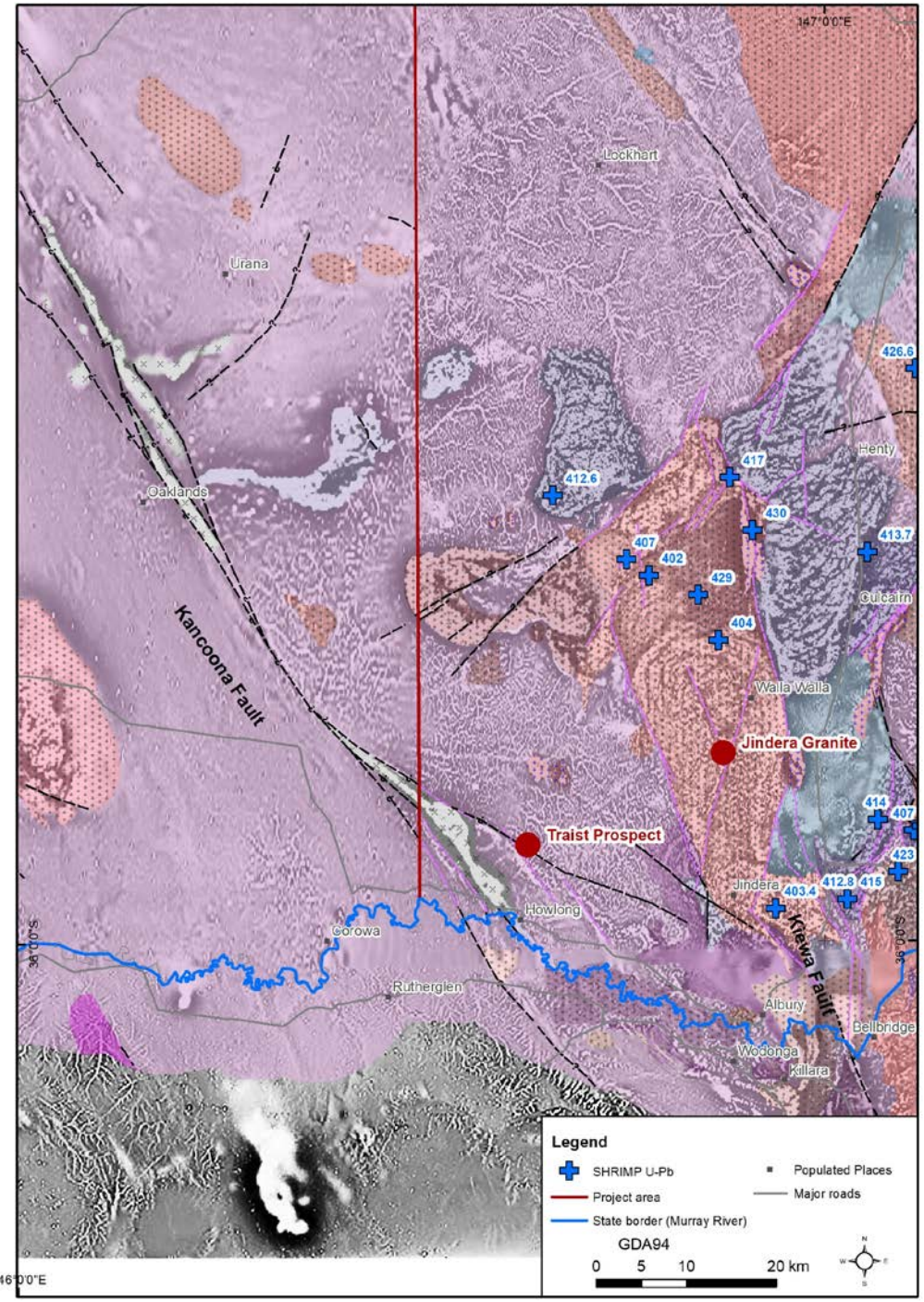


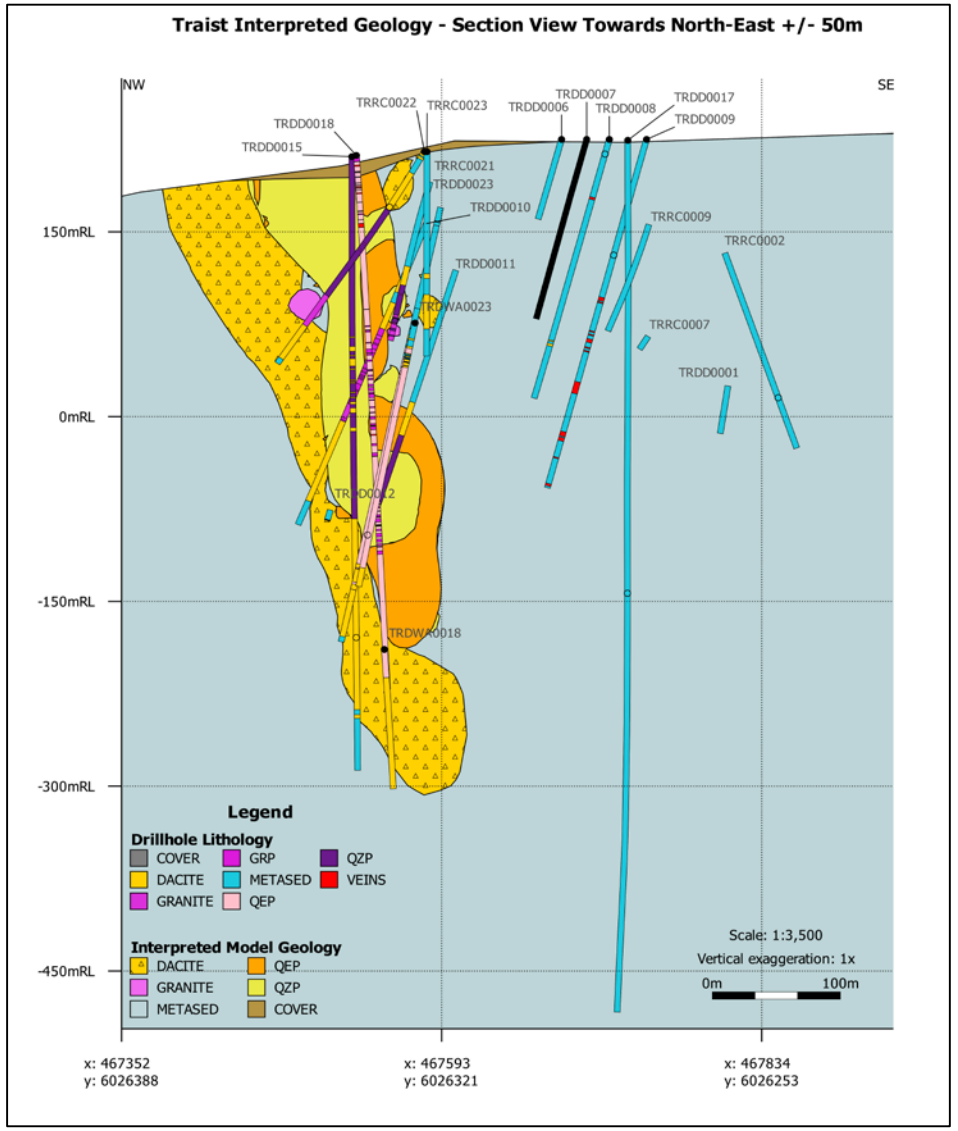
Source: Bull 2017 – GS2017/149,
Bodorkos et al. 2015 – GS2015/0002.

LAO geology
(NSW Seamless Geology) over 1VD TMI.

Porphyry–epithermal gold

New GS report by Forster et al. (in prep.):

- Integration of HyLogger™ data, petrography, geochronology, sulfur and lead isotopes
- New Re–Os age of molybdenite of 404.4 ± 1.5 Ma at Traist – within error of the Jindera Granite
- S isotopes – magmatic-dominated sulfur source
- Pb isotopes – typical Lachlan Orogen Early Devonian granite signature
- Concludes that mineralisation at Traist is epithermal carbonate base-metal–gold mineralisation.

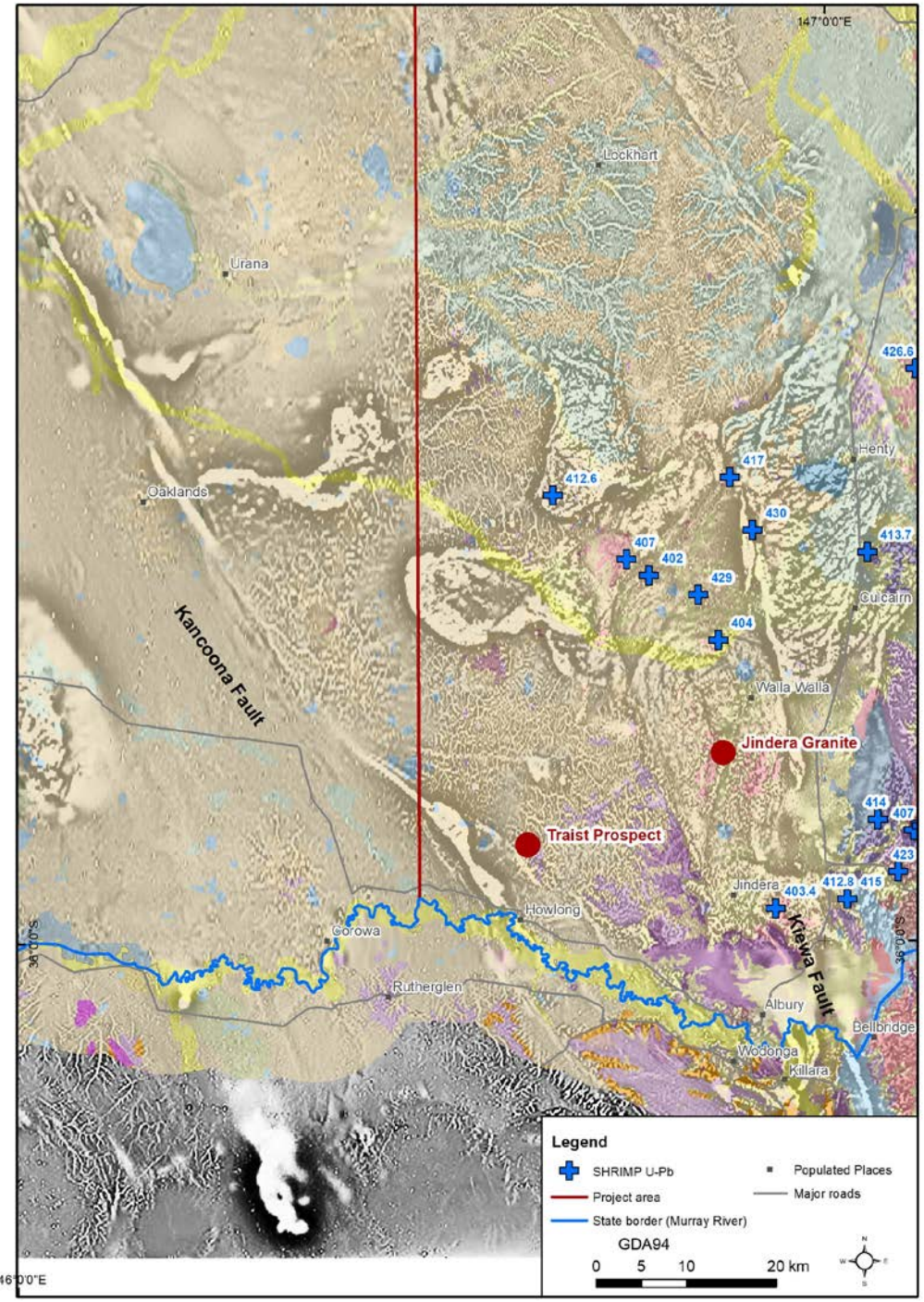


Source: Forster et al. (in prep.)

Porphyry–epithermal gold

Implications:

- Newly recognised ~405 Ma magmatic event with gold mineralisation
- Intrusions along splays of major fault system
  - o Kancoona (Boothagandra)–Kiewa FS
- Poor exposure
  - o Traist porphyry is only intrusion exposed.



Surface geology (NSW Seamless Geology) over 1VD TMI.

Early to Middle Devonian structurally controlled low sulfidation gold mineralisation

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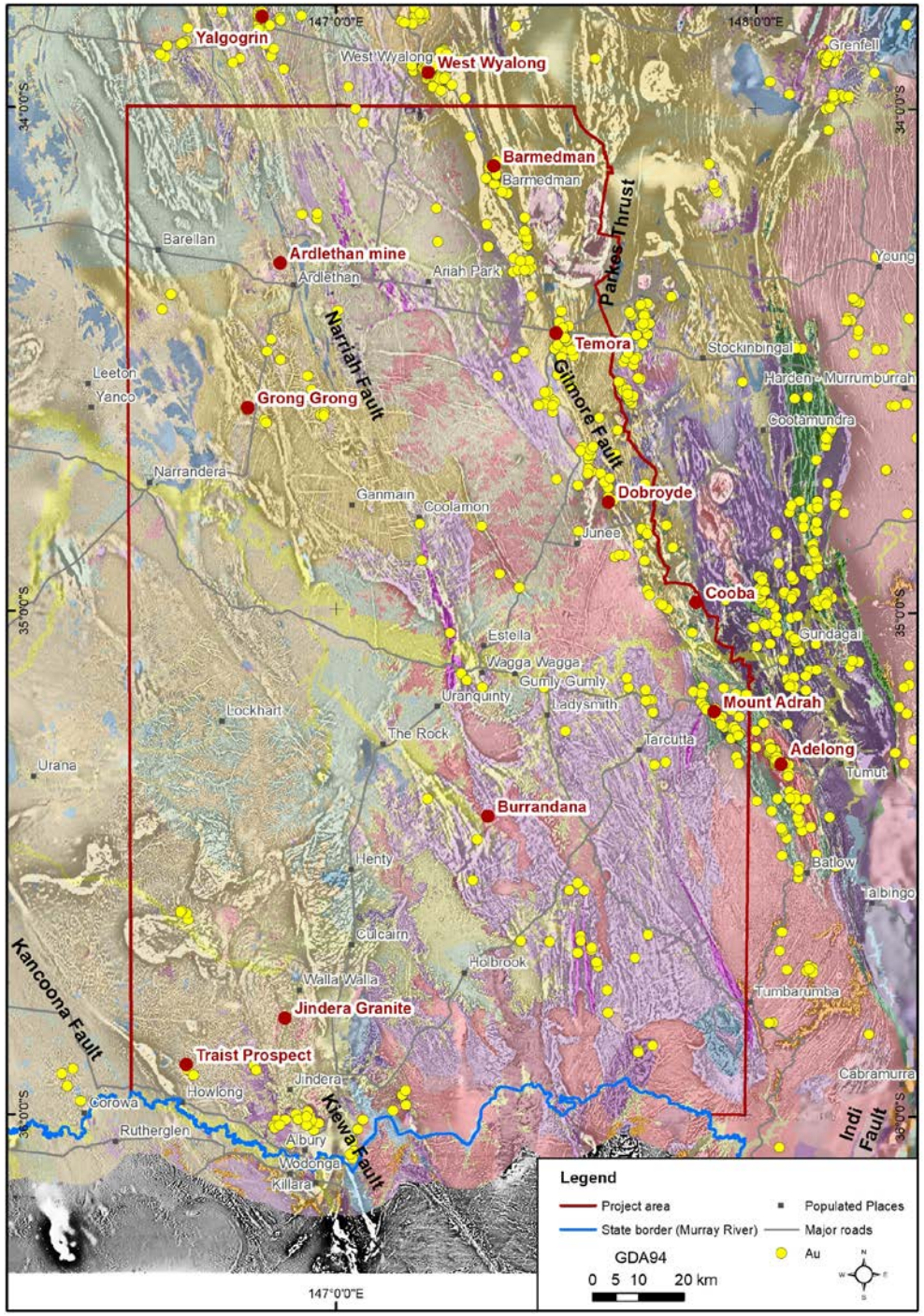
Structurally controlled gold

Gold mineralisation along Gilmore Fault Zone

- Plus parallel faults and related faults.

New GS report (Stuart et al. in prep.) reviewed individual goldfields in a regional context

- >500 occurrences with 32.2 t (1.14 Moz) Au
- Gold is hosted by range of Ord–Sil–Dev lithologies
- Timing Early (Bindian) to Middle Devonian (Tabberabberan) – though little direct dating.

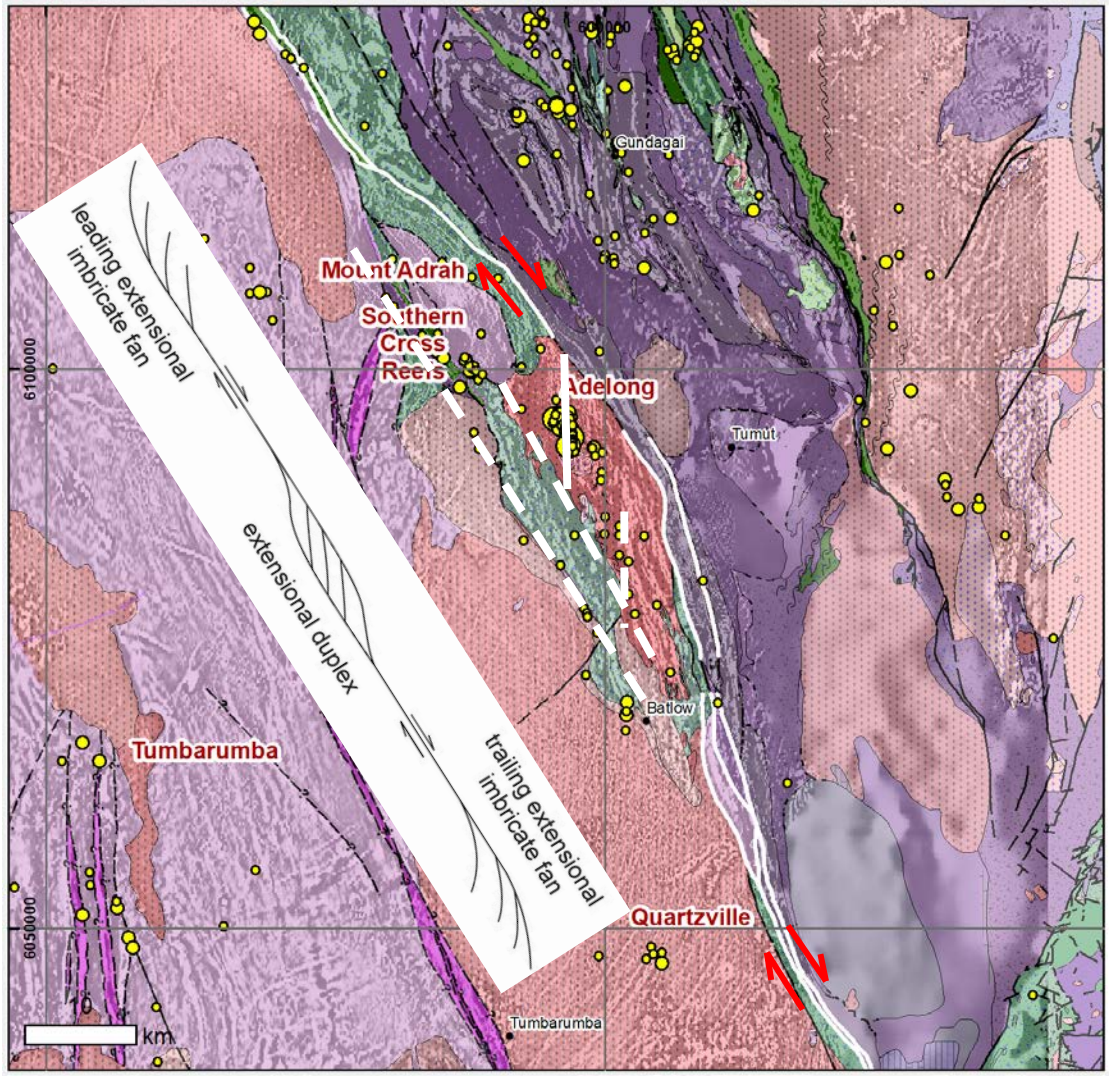


Gold occurrences (MetIndEx) with surface geology (NSW Seamless Geology) over 1VD TMI.

Structurally controlled gold

Three main settings …

1. Narrow vein arrays within relatively competent rock types adjacent to second or third order splays of the GFZ and parallel structures.
    - e.g. Adelong, West Wyalong.



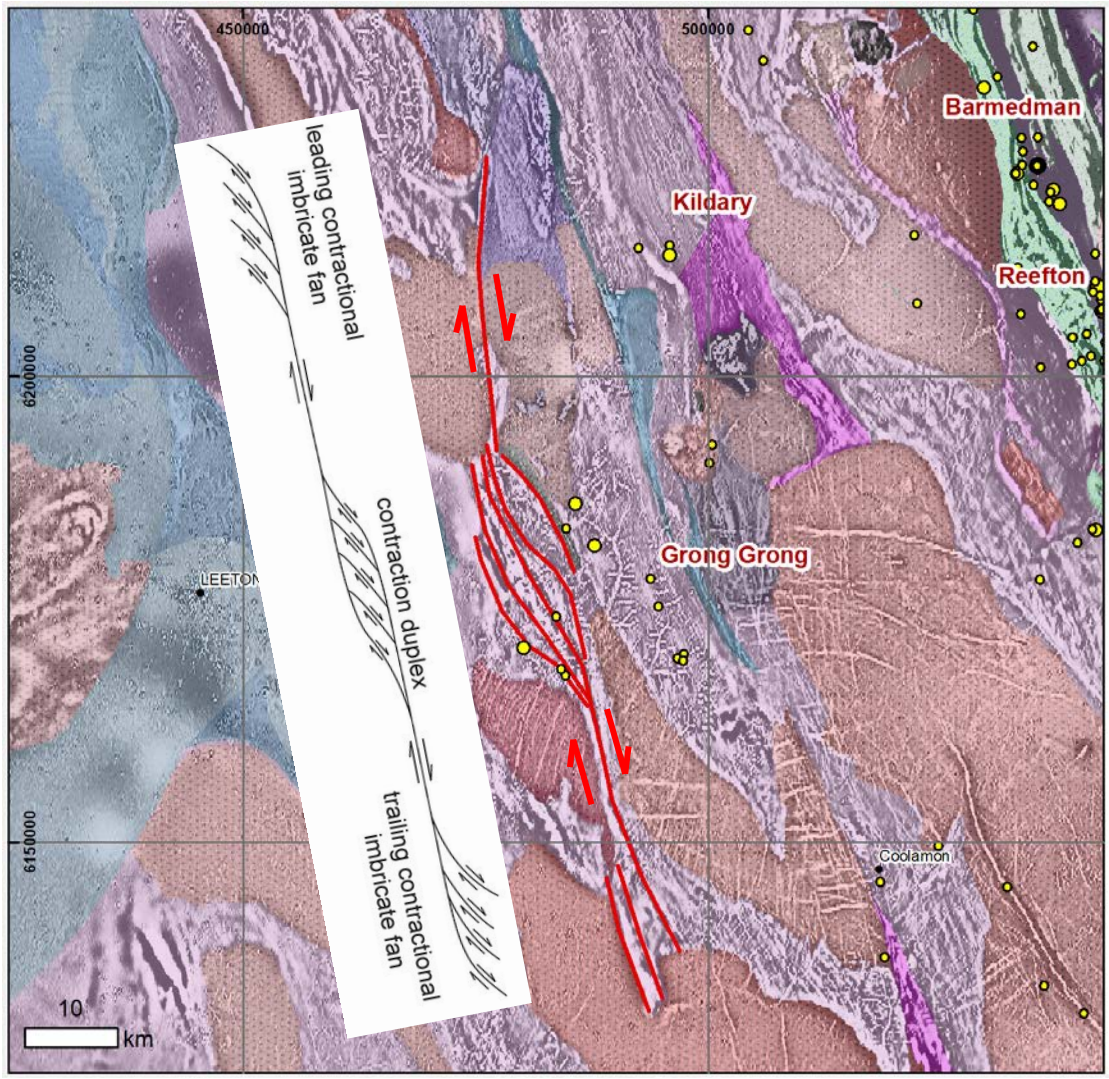
Source: Stuart and Ricketts (2019) from Stuart et al. (in prep.). After Woodcock & Fischer (1986).

Gold occurrences (MetIndEx) with LAO geology (NSW Seamless Geology) over 1VD TMI.

Structurally controlled gold

Three main settings …

2. Along contacts between granites and metasedimentary country rock, or in pressure shadows near granites, where fluids have been focussed along contacts or around competent bodies.
   - e.g. Grong Grong.



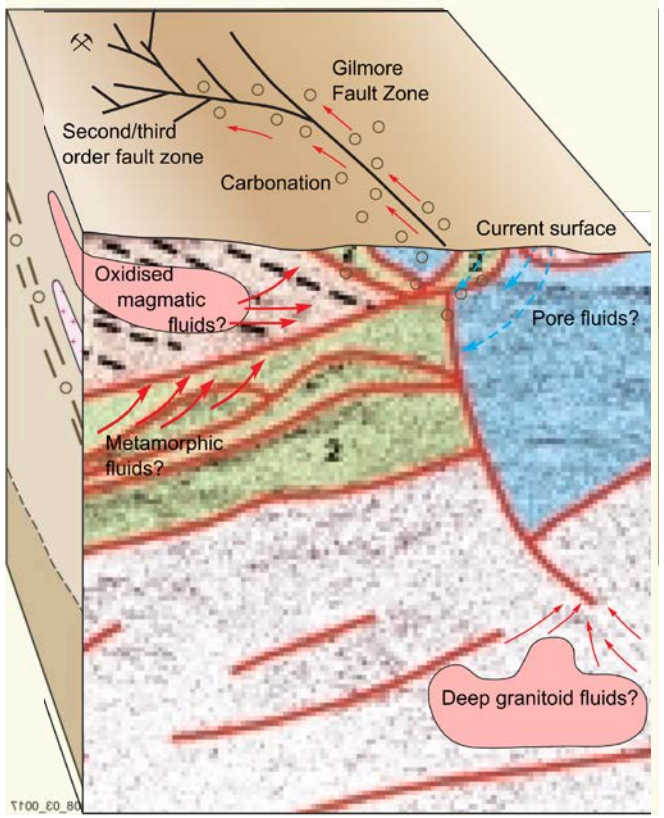
Source: Stuart and Ricketts (2019) from Stuart et al. (in prep.). After Woodcock & Fischer (1986).

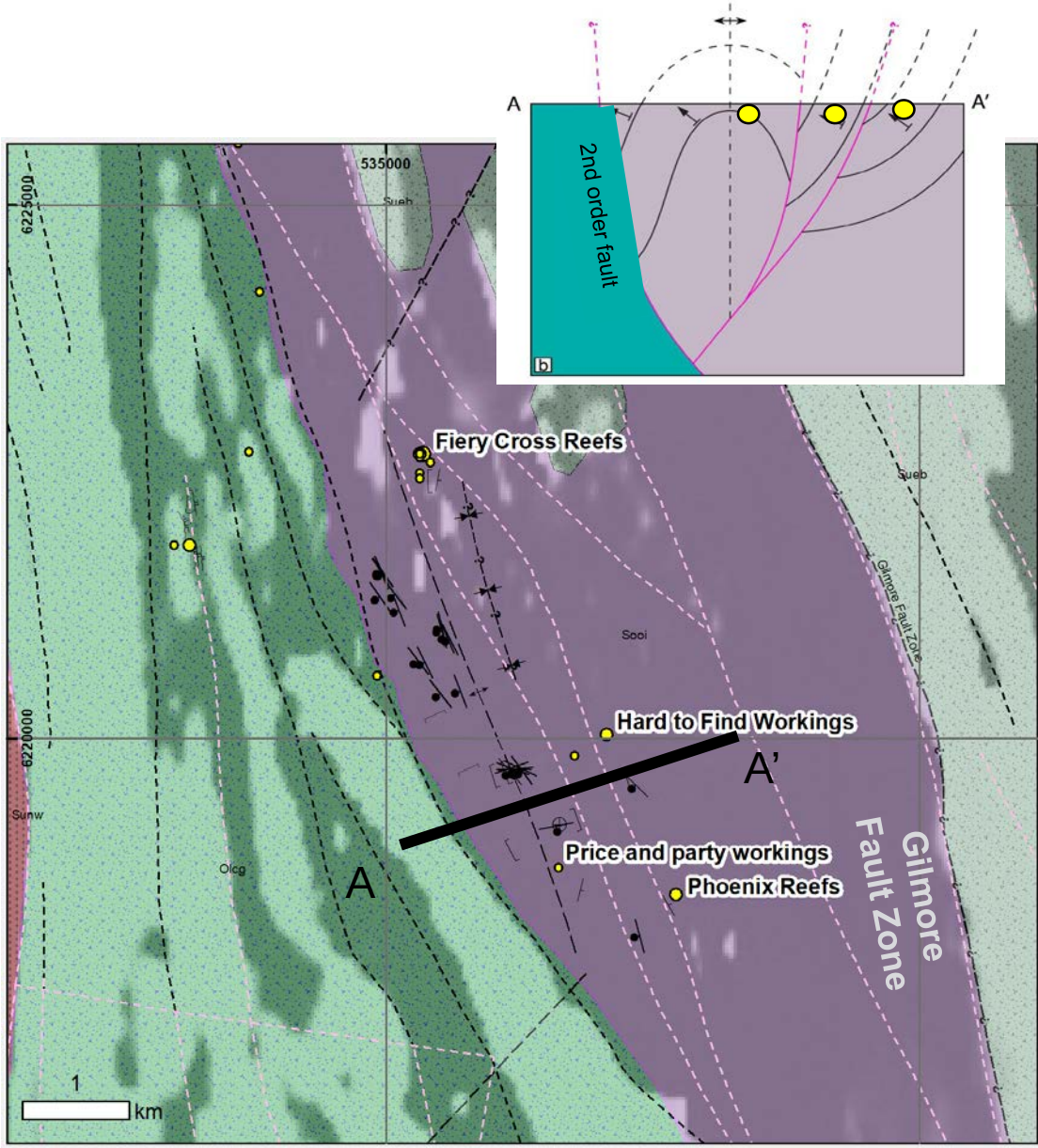
Gold occurrences (MetIndEx) with LAO geology (NSW Seamless Geology) over 1VD TMI.

Structurally controlled gold

Three main settings …

3. Gold associated with folding adjacent to the GFZ.
    - e.g. Barmedman.





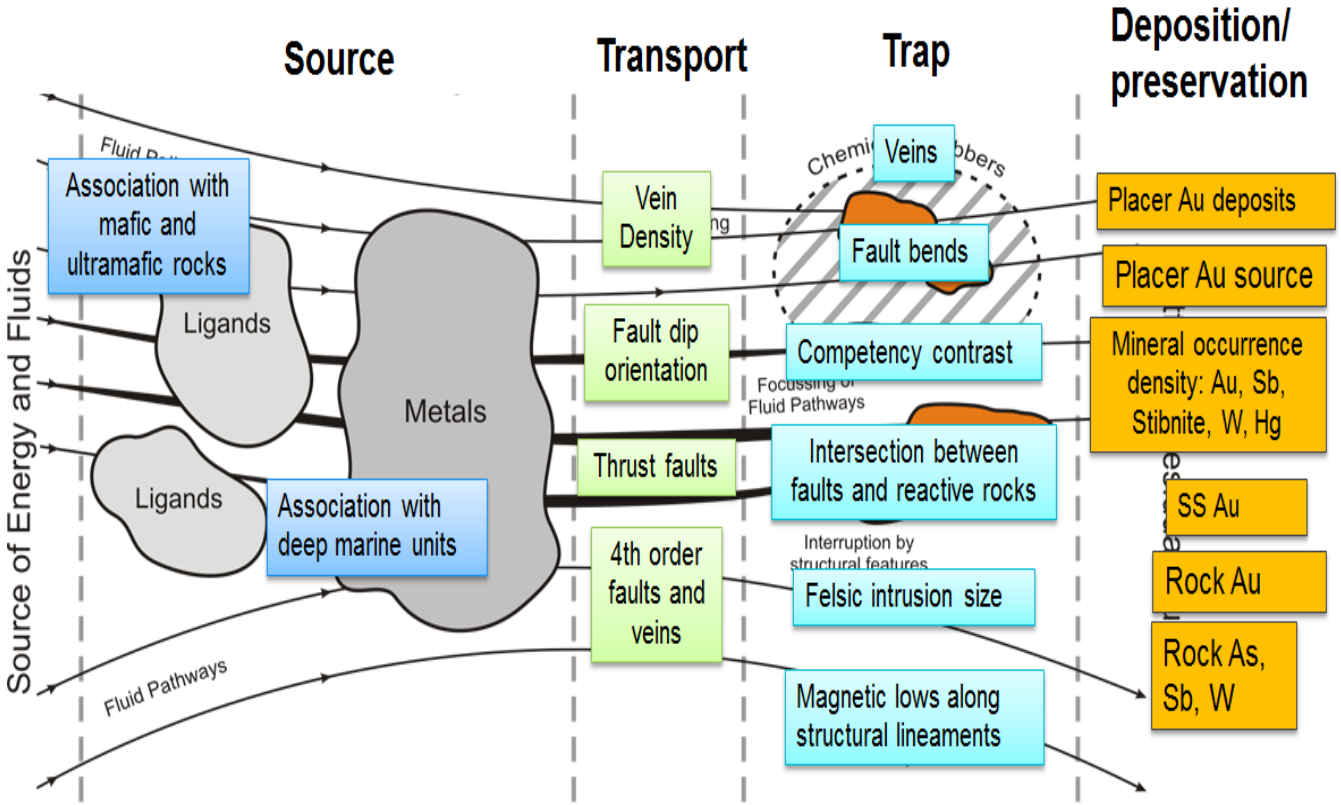
Source: Stuart and Ricketts (2019) from Stuart et al. (in prep.) after Eastlake (2016), Lewis and Downes (2008)

Gold occurrences (MetIndEx) with LAO geology (NSW Seamless Geology) over 1VD TMI.

Structurally controlled gold

Implications:

- Structural setting key
  - o Crustal scale and associated faults
    - – geometry and kinematics
  - o Lithology of host not as critical as inflections, contrasts, contacts etc.
- Multiple Devonian gold-forming events
- Importance of quality mapping to identify key criteria for mineral potential mapping.



Key mappable criteria – orogenic gold (zone 55 east)

Source: Orogenic gold mineral potential mapping (Kenex Pty Ltd), after Knox-Robinson and Wyborn (1997)

Conclusions

NSW GOVERNMENT

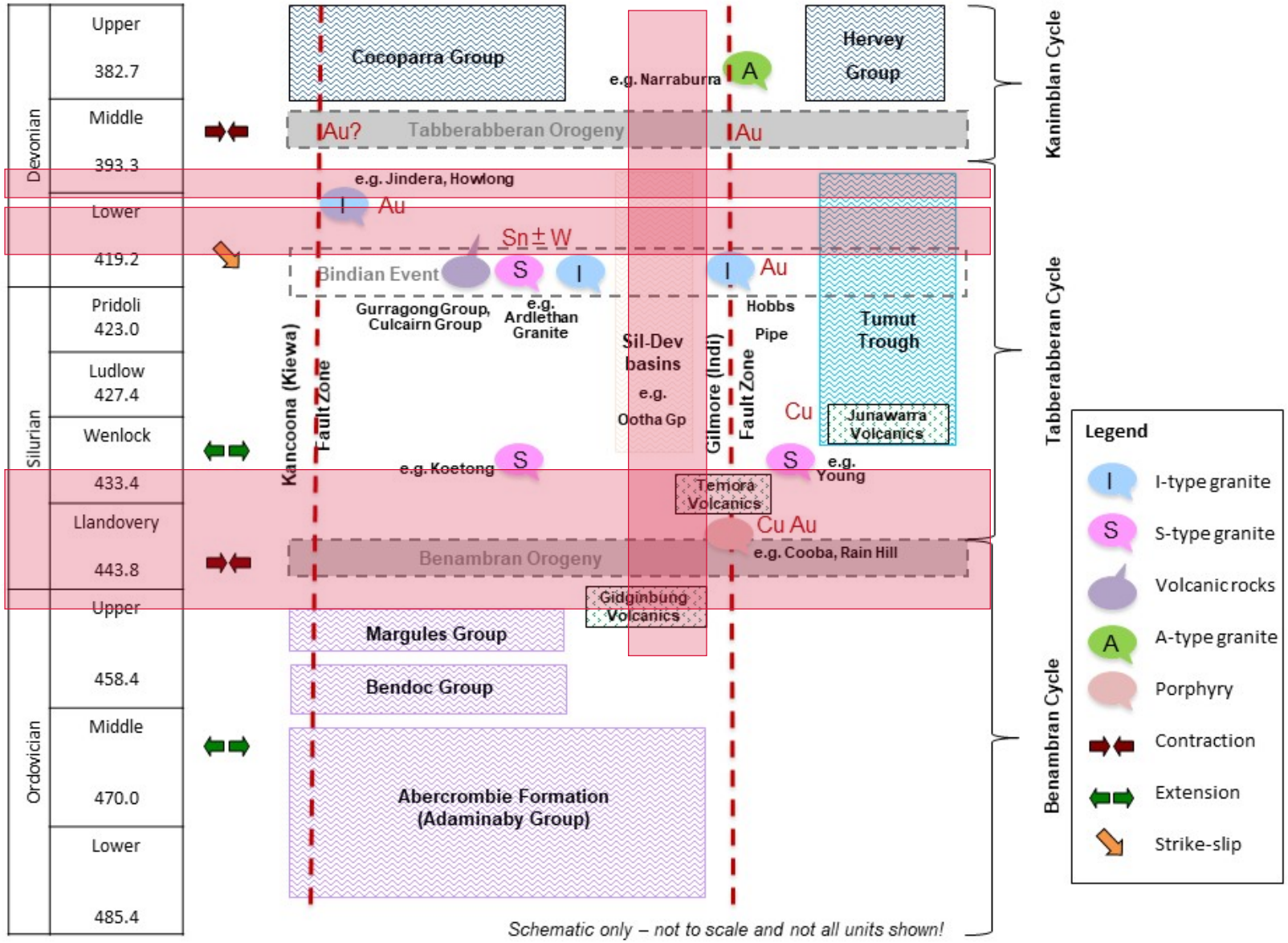
Conclusions

New data, line work and ideas from mapping project

Increased understanding of:

- Siluro-Devonian magmatic history
- Structural framework, kinematics and history.

Implications for mineral systems and exploration



The work of many!

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