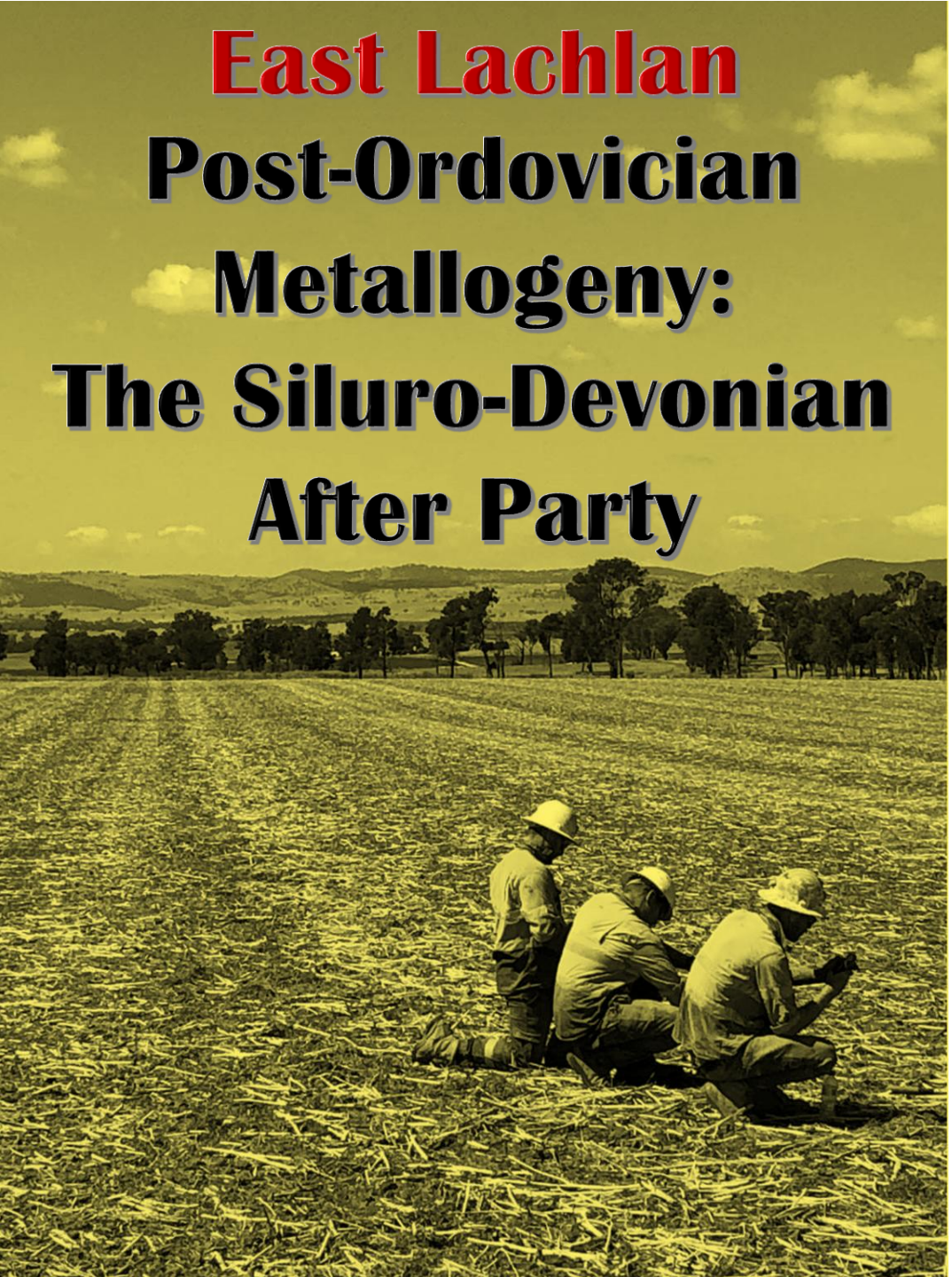
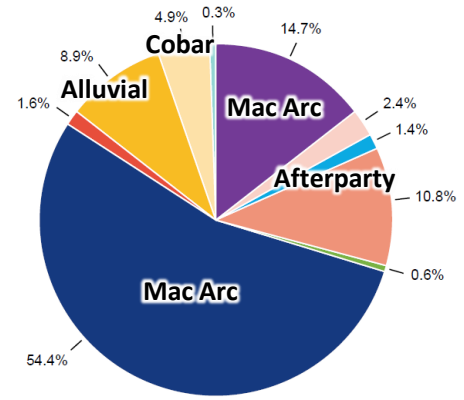
East Lachlan

Post-Ordovician Metallogeny: The Siluro-Devonian After Party



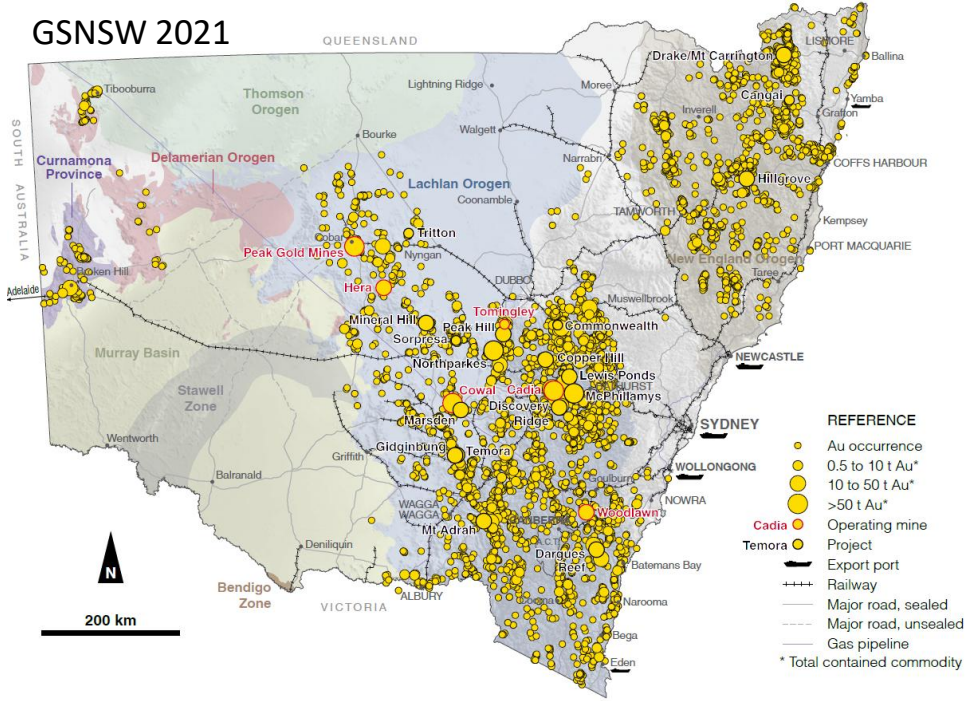
Gold endowment (past production + resources) for NSW, classified by deposit type

Total endowment >3280 t / 106 Moz
Current resources >2120 t / 68 Moz



- Epithermal
- Porphyry
- Skarn
- Granite-related
- VAMS
- Alluvial/eluvial
- Orogenic Au
- Distal intrusion-related Cu–Au
- BHT
- Orogenic base metal

GSNSW 2021



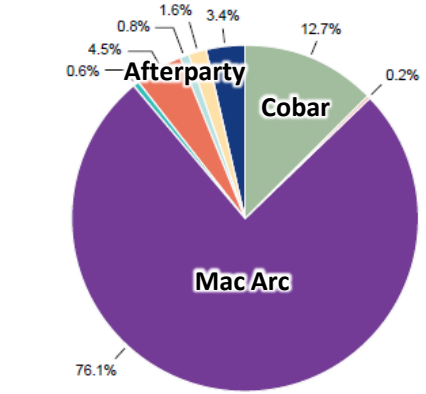
REFERENCE

- Au occurrence
- 0.5 to 10 t Au*
- 10 to 50 t Au*
- >50 t Au*
- Cadia — Operating mine
- Temora — Project
- Export port
- Railway
- Major road, sealed
- Major road, unsealed
- Gas pipeline

* Total contained commodity

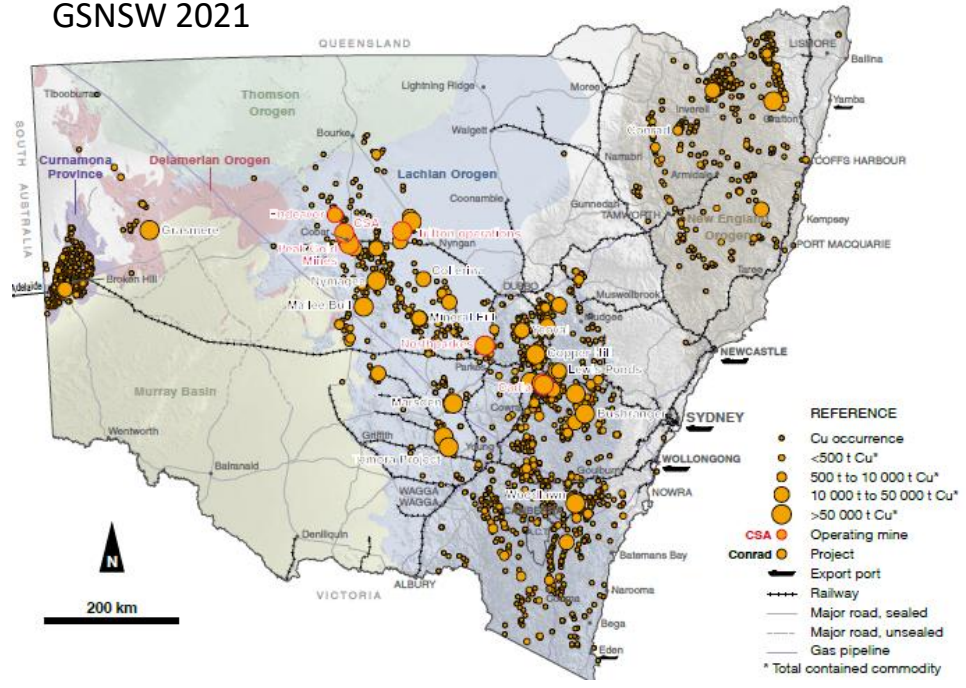
Copper endowment (past production + resources) for NSW, classified by deposit type

Total endowment >19.1 Mt; current resources >15.0 Mt



- Distal intrusion-related Cu–Au
- Orogenic base metal
- SHMS
- Intrusion-related
- Porphyry
- Skarn
- Epithermal
- VAMS

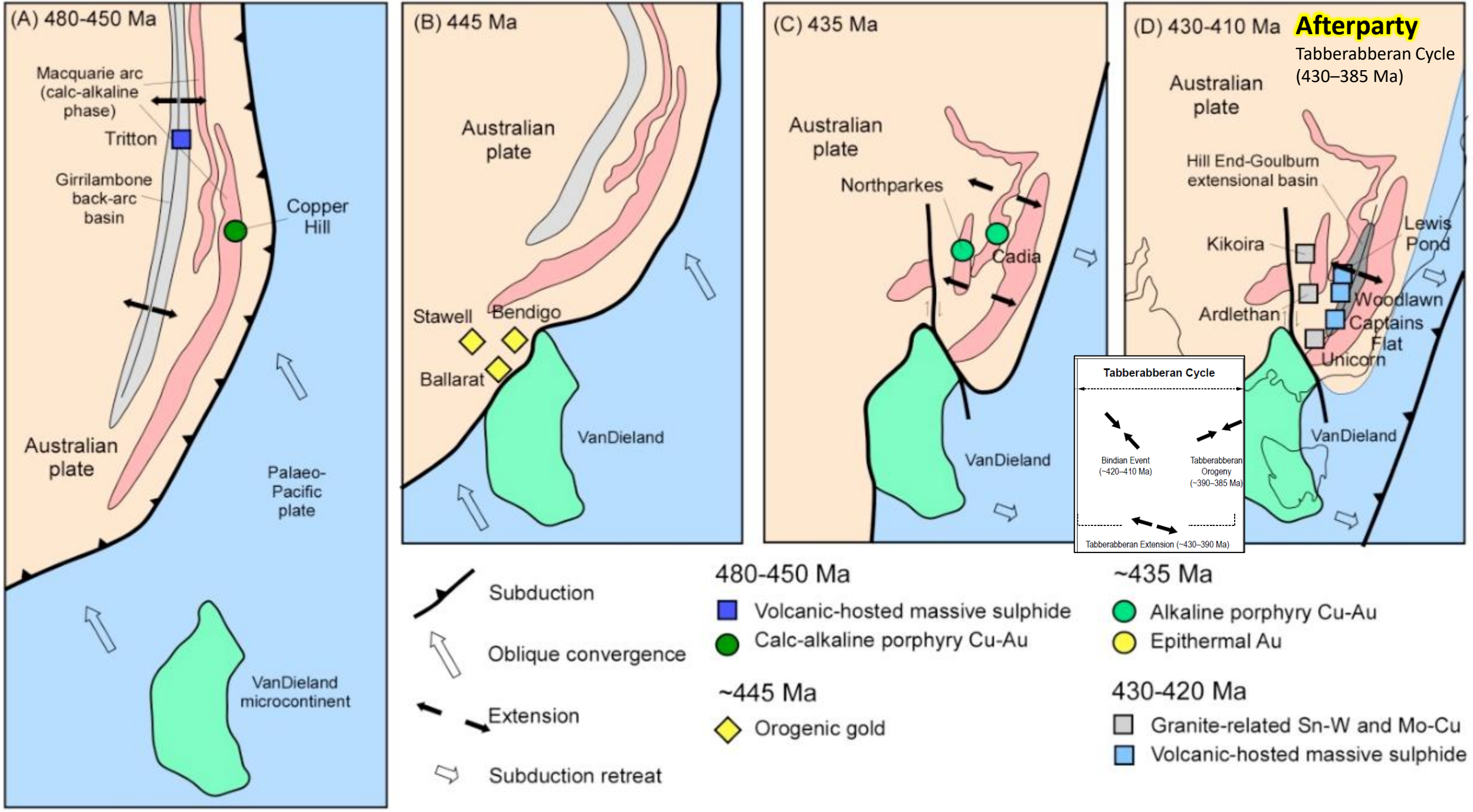
GSNSW 2021



REFERENCE

- Cu occurrence
- <500 t Cu*
- 500 t to 10 000 t Cu*
- 10 000 t to 50 000 t Cu*
- >50 000 t Cu*
- CSA — Operating mine
- Conrad — Project
- Export port
- Railway
- Major road, sealed
- Major road, unsealed
- Gas pipeline

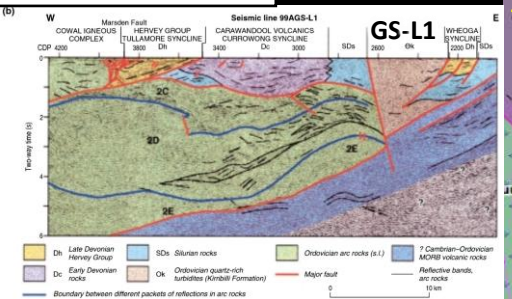
* Total contained commodity

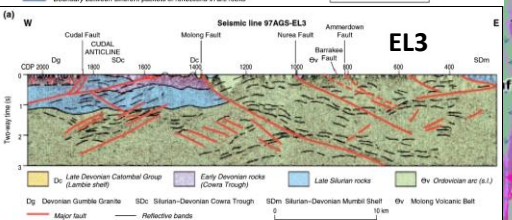


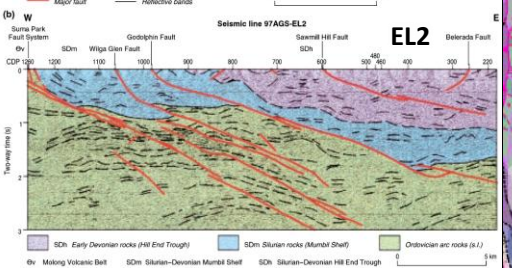
Huston et al. 2015: Metallogenesis of the Lachlan Orocline

East Lachlan Afterparty Au-Cu-Ag-(Pb-Zn) deposits (north)

Glen et al. 2002







early- to mid Devonian

mid- to late Silurian

Mid-late Silurian
Browns Creek 431 Ma
McPhillamys 423 Ma
Kempfield 420 Ma
Commonwealth 420 Ma
Lewis Ponds 417 Ma

Early-mid Devonian
Yeoval 409 Ma
Mt Leadley 405 Ma
Wirrinya 404 Ma
Mt Aubrey 401 Ma
London-Victoria 400 Ma
Tomingley 392 Ma

Tomingley
Au 2.9 Moz

Commonwealth
Au 0.1 Moz
Ag 3.3 Moz
Cu 30 Kt

Mt Leadley

Yeoval
Cu 50 Kt

Mt Aubrey
Au 0.1 Moz

CL25-L1

EL3

London-Victoria
Au 0.1 Moz

EL2

Lewis Ponds
Au 0.5 Moz
Ag 21 Moz
Cu 30 Kt

McPhillamys
Au 2.1 Moz

Browns Ck
Au 1 Moz
Ag 0.4 Moz
Cu 7 Kt

GS-L1

Wirrinya

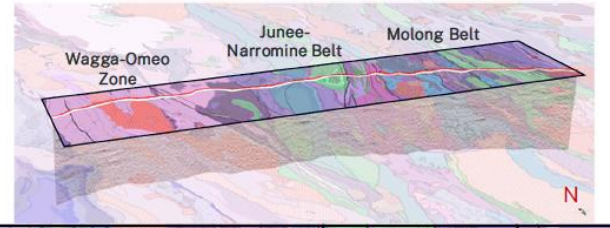
Kempfield
Au 0.1 Moz
Ag 66 Moz

Bumbaldry
Au 0.02 Moz
Cu 0.3 Kt

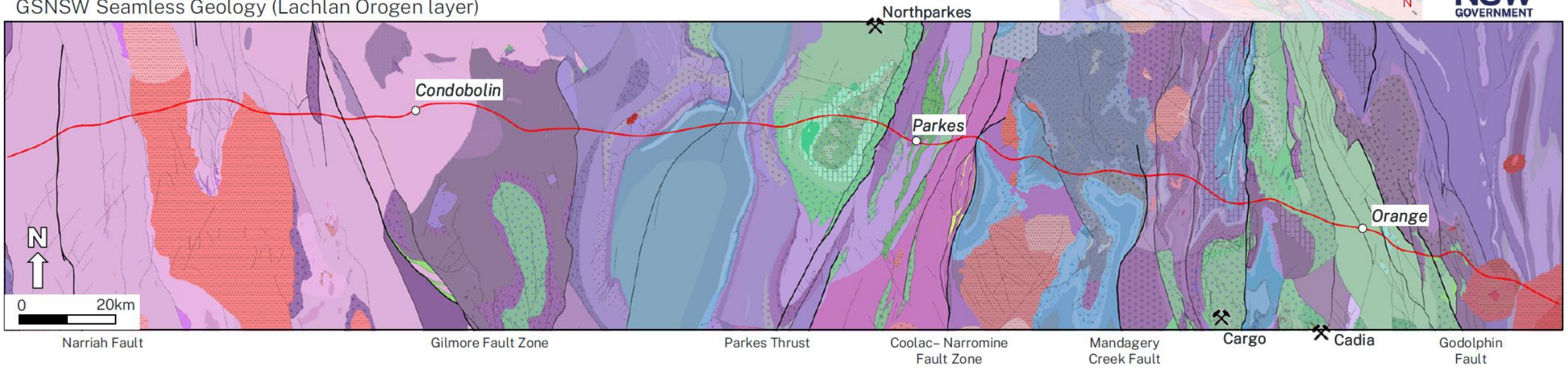
20 km

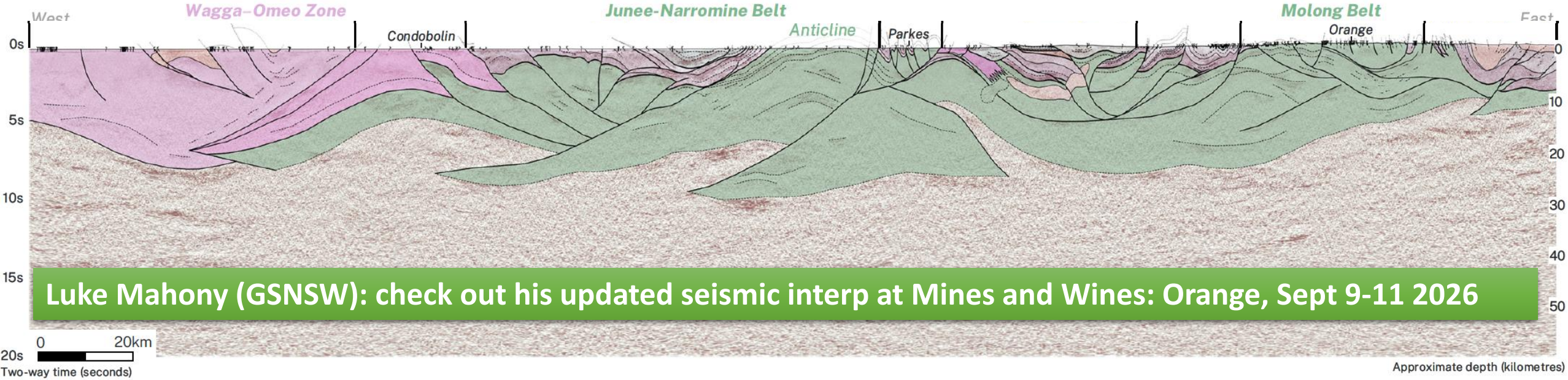
Seismic interpretation: CL25 Line 1

GSNSW Seamless Geology (Lachlan Orogen layer)



NSW GOVERNMENT





Luke Mahony (GSNSW): check out his updated seismic interp at Mines and Wines: Orange, Sept 9-11 2026

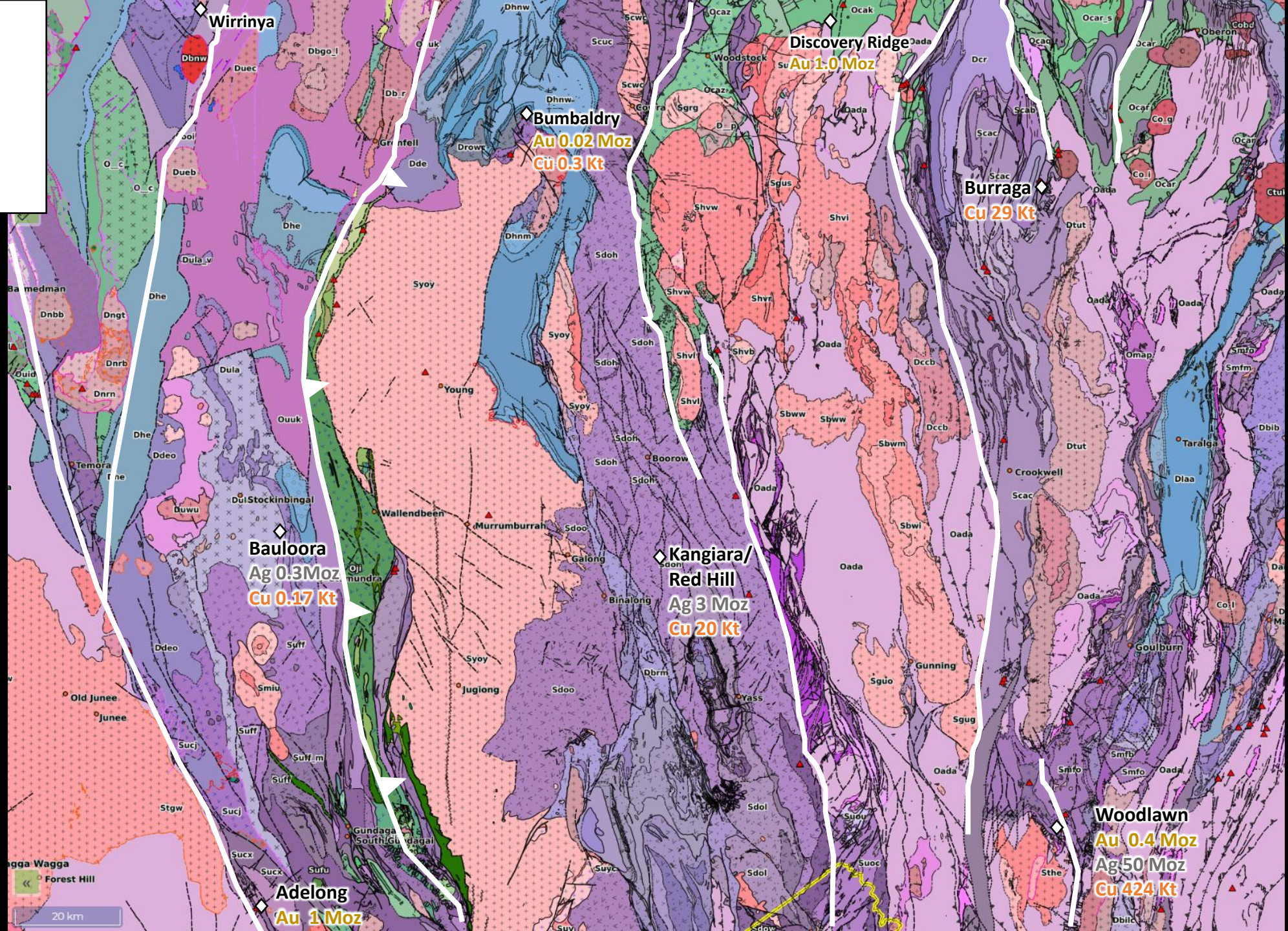
East Lachlan Afterparty Au-Cu-Ag-(Pb-Zn) deposits (south)

Mid-late Silurian

Discovery Ridge 434 Ma
Kangiara 430 Ma
Woodlawn 423 Ma
Burraga 421 Ma

Early-mid Devonian

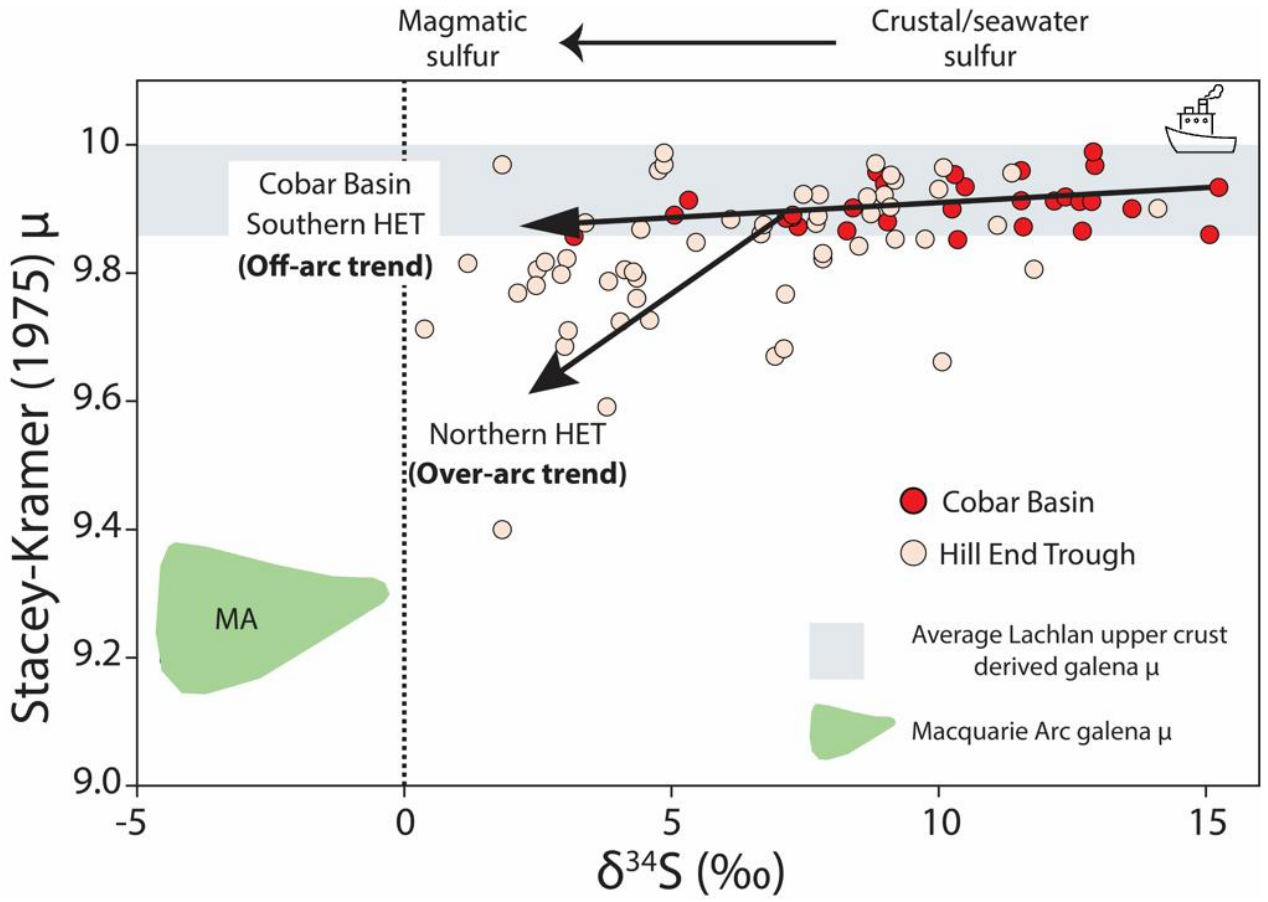
Bauloora 416-380 Ma
Wirrinya 404 Ma
Bumbaldry 390 Ma
Adelong 396 Ma

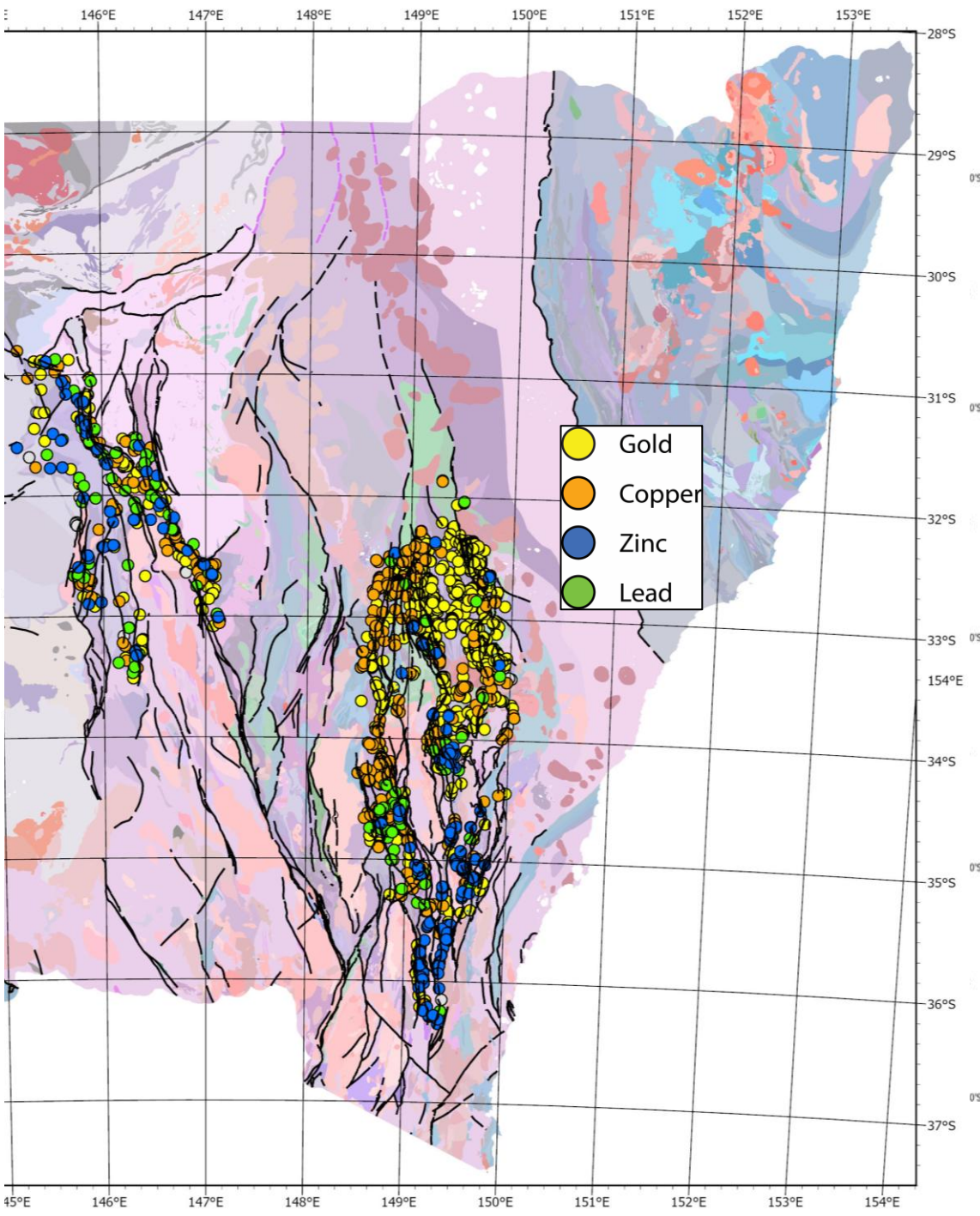


Joel Fitzherbert (GSNSW)

Check out his updated project at Mines and Wines: Orange, Sept 9-11 2026

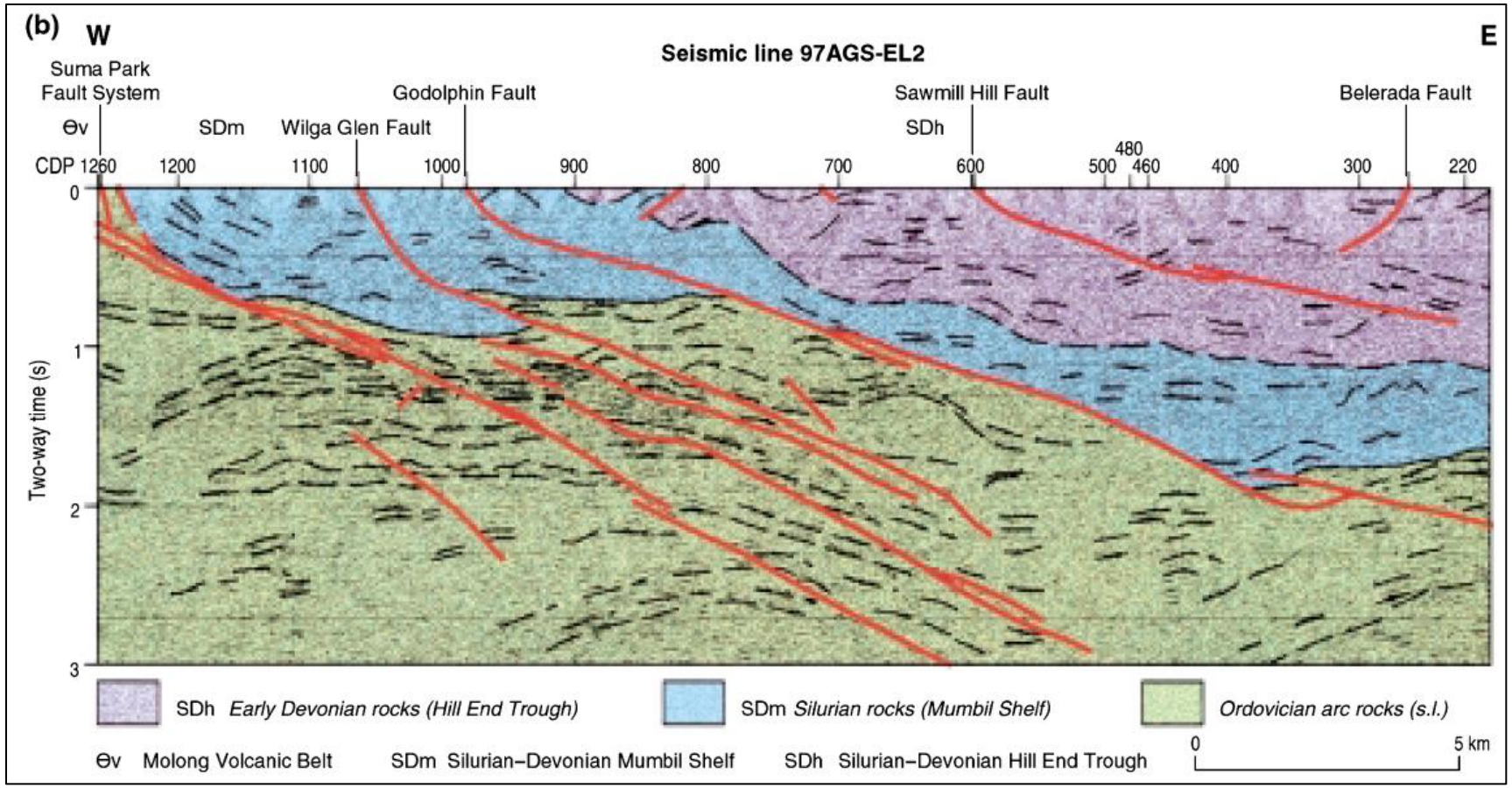
Successor basin galena paired average μ Versus $\delta^{34}S$

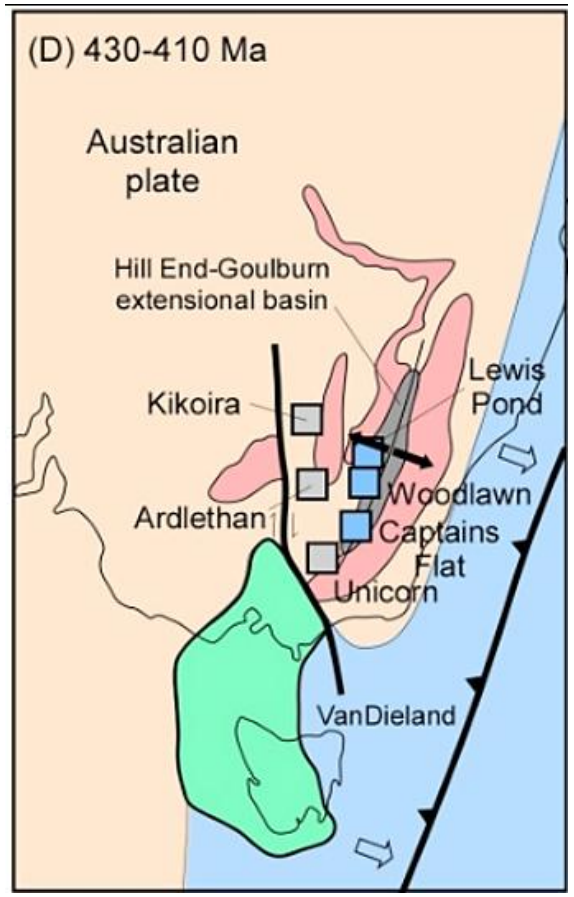




Geodynamic controls on mid- to late-Silurian Afterparty mineralisation

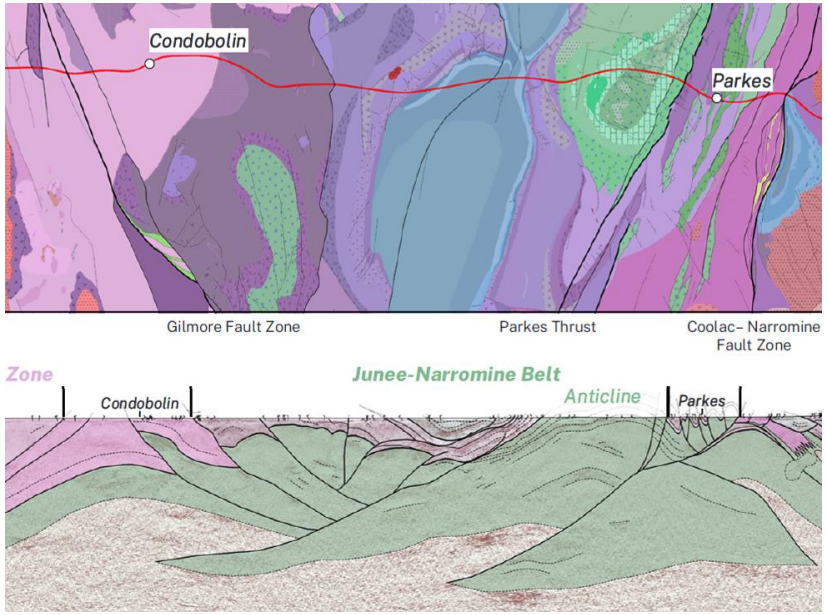
- Active transtension-extension: rift basins initiating along Mac Arc margins.
- Heat insulated by rapid basin formation: throttle on hydrothermal fluids.
- Heat/fluids focussed along growth faults: exploration search space.
- Goulburn Basin- Melting of Ordovician turbidite producing S-type batholith: **base metal** flavour.
- Hill End Trough- Reactivated growth faults carry Mac Arc-influenced ore fluids: **gold-copper** flavour.

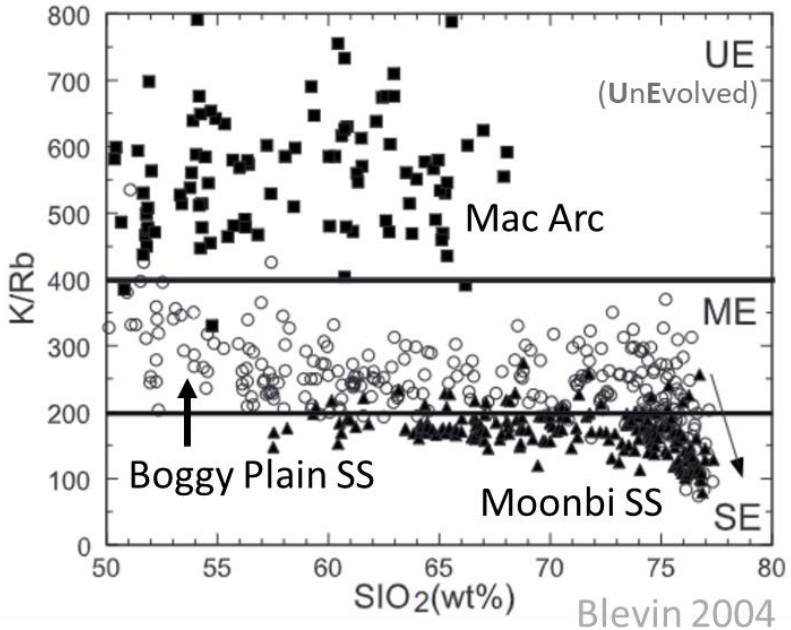


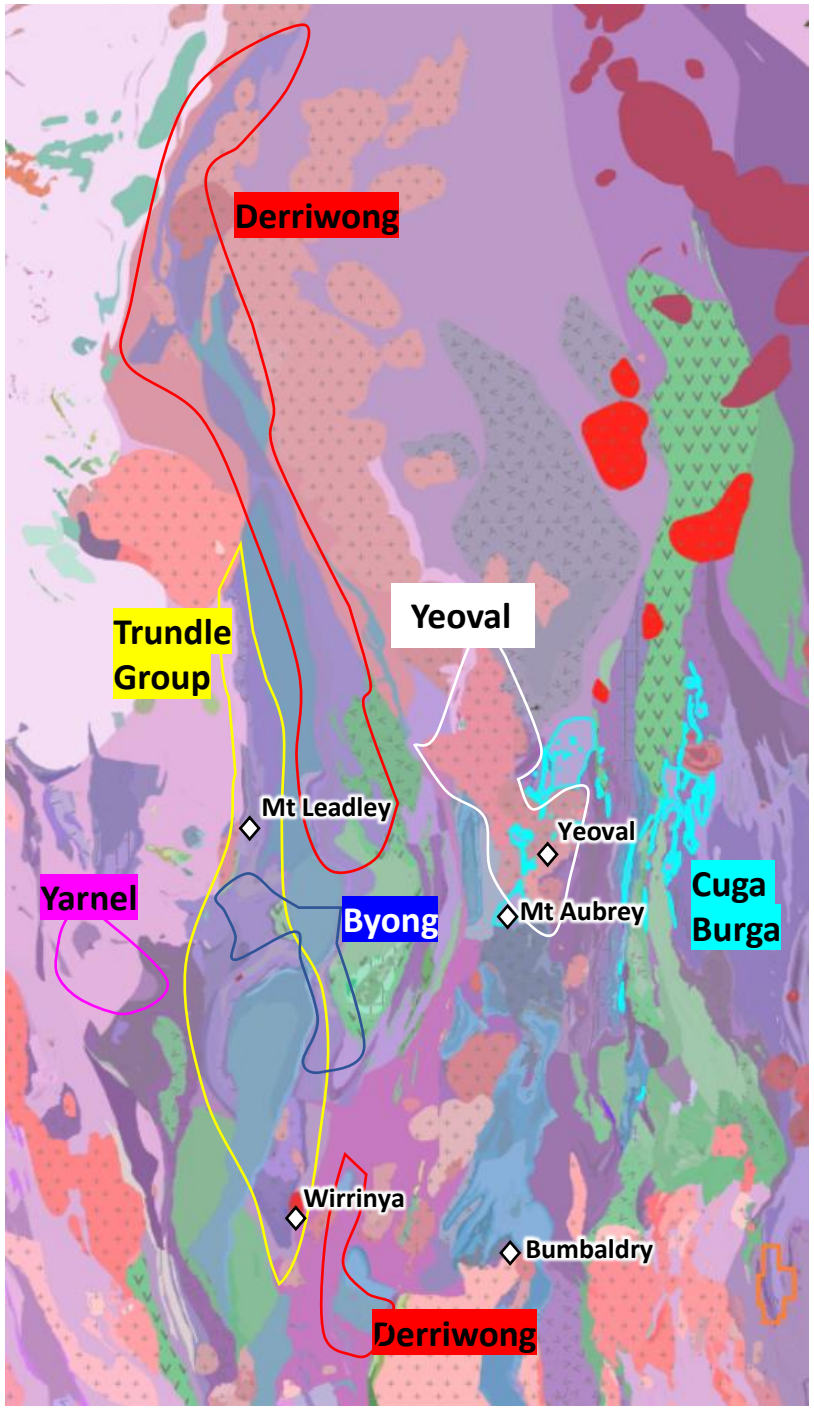


Distribution of Early Devonian Afterparty rocks in the NE Lachlan

- Plutonism focused west of Molong Belt (**Boggy Plain Supersuite, Eugowra granites**) and Junee-Narromine Belt (**Wagga Batholith**).
- Volcanism focused along Jemalong Shelf (margins of Junee-Narromine Belt) as well as **Cuga Burga Volcanics**.
- Jemalong Shelf dominated by Derriwong Group (incl. **Byong, Meloola, Femoy volcanics**) and **Yarnel Volcanics**
- Jemalong Shelf also includes slightly younger and Trundle Group: **Carawandool** and **Kadungle volcanics**.
- Flank, intrude and/or unconformably overlie Mac Arc sequences.







Early Devonian Afterparty: Yeoval Suite and Cuga Burgas

- Early Devonian Yeoval+Nallawa suites (Boggy Plain Supersuite):
  - gabbro-granite-granodiorite-diorite, high-K, CA I-type, moderately evolved.
- Porphyry mineralisation (no Py), low grade high tonnage Cu resource (50Kt Cu, 2.6Kt Mo).
- ε_{Nd} values (+4.8 to +7.0) within the range of Mac Arc, suggesting a mantle-derived source (either directly or re-melted).
- Cuga Burga Volcanics: basalt-andesite-rhyolite high-K, CA I-type, spatially and geochemically associated with Yeoval Suite, marine to emergent. Propylitic to advanced argillic alteration.
- Cuga Burgas/Mac Arc share low levels of HFSE, Ti, Nb, Zr, and Y, and med-high levels of the large-ion-lithophiles e.g. Ba, Sr, K.

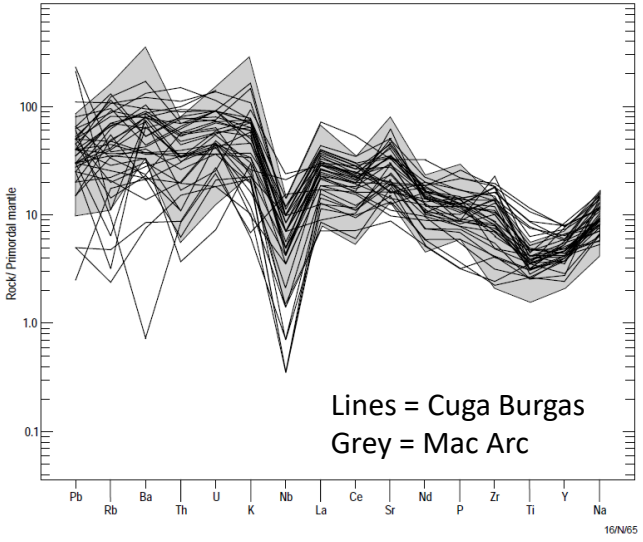
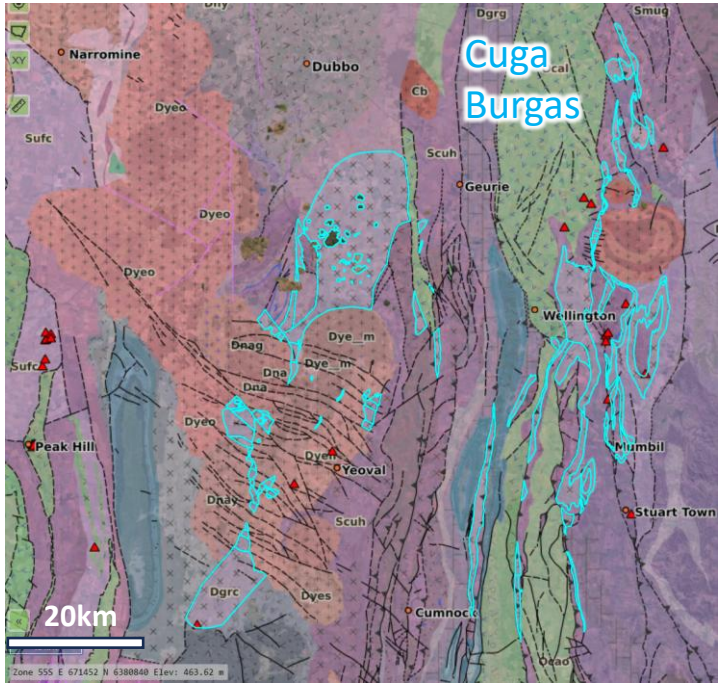
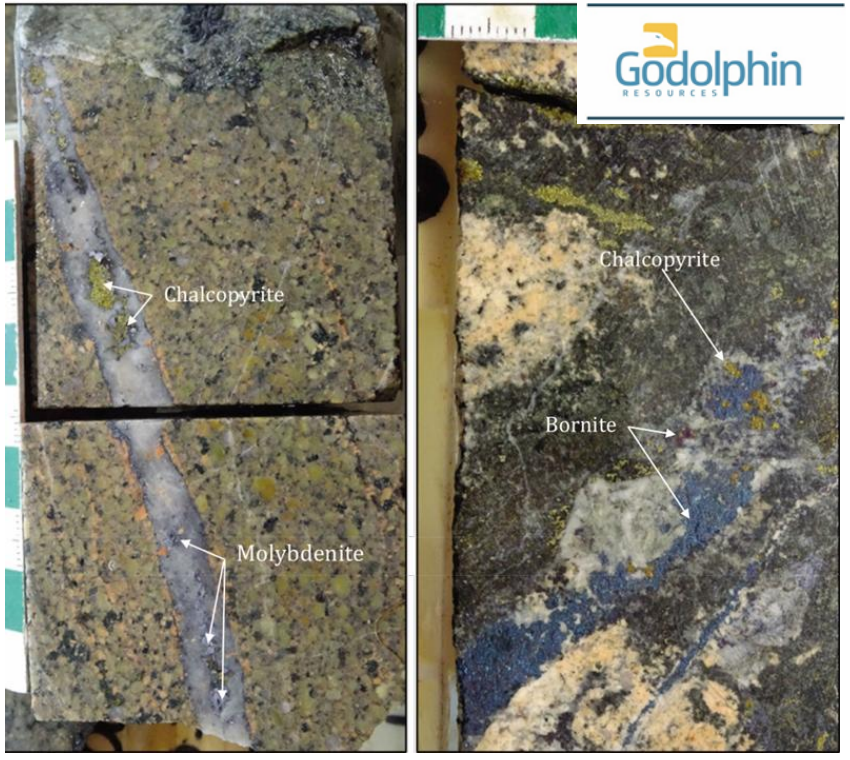


Fig. 9. Spidergram plot comparing basalts and andesites of the Lower Devonian Cuga Burga Volcanics with Ordovician igneous rocks of similar SiO_2 content (shaded area).

GA_Record_2001_09

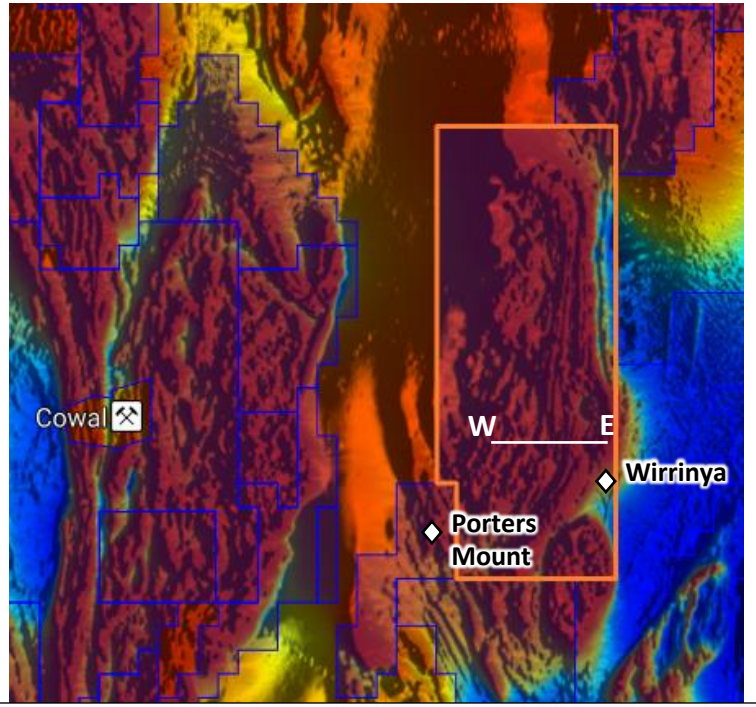
Raymond & Sun, 1998



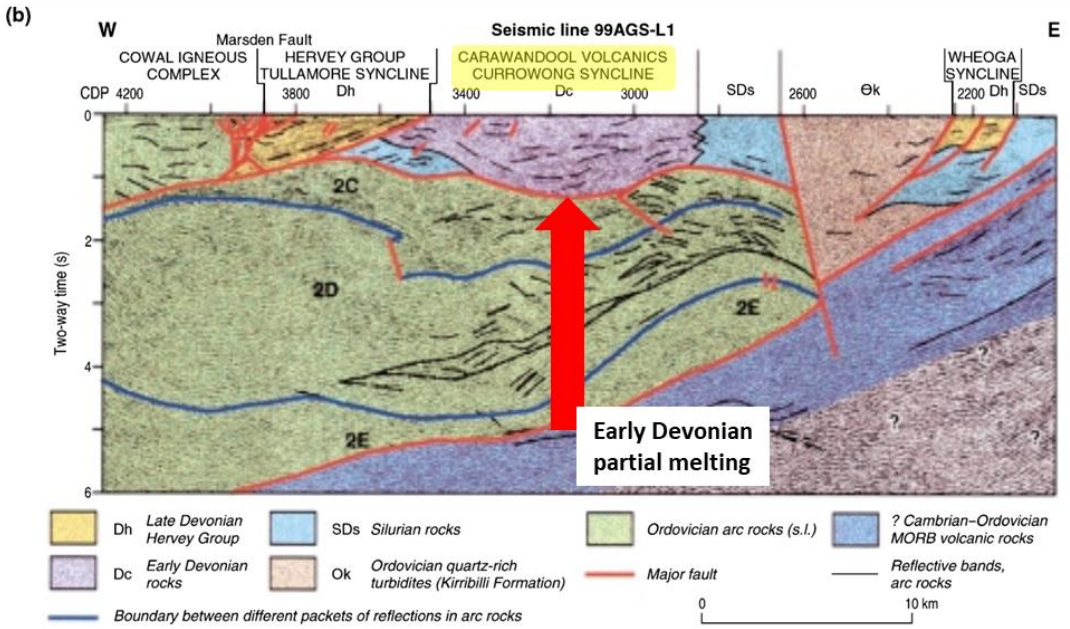


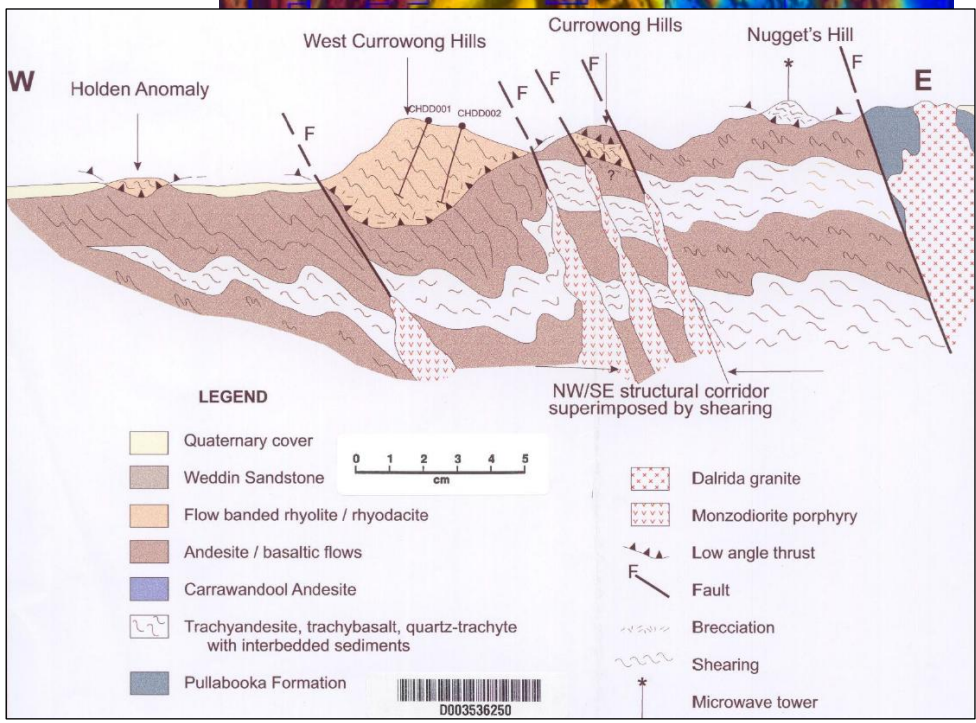
Wirrinya

- Primarily felsic volcanics with lesser basaltic and Hbl-andesitic lavas and breccias; trachy-equivalents.
- Early Devonian age (403.8 ± 2.1 Ma), SiO2 mostly above 65%, ε_{Nd} +8.1, (Porters Mount +6.5).
- Higher HFSE and show fractionation trends more akin to younger Palaeozoic and Cenozoic intraplate magmatic rocks in the LFB.
- Generally lower levels of LIL elements and do not show calc-alkaline characteristics.
- PGE data available for the mafic Carawandool Volcanics shows low levels of Pt and Pd.
- Newcrest interpreted Currowong Hills as an advanced argillic lithocap above a porphyry deposit.
- Drilling revealed elevated Ag, Cu and Mo at Currowong Hills and Porters Mount Qtz Diorite (+Au).



GS-L1 Seismic line (Glen 2002)



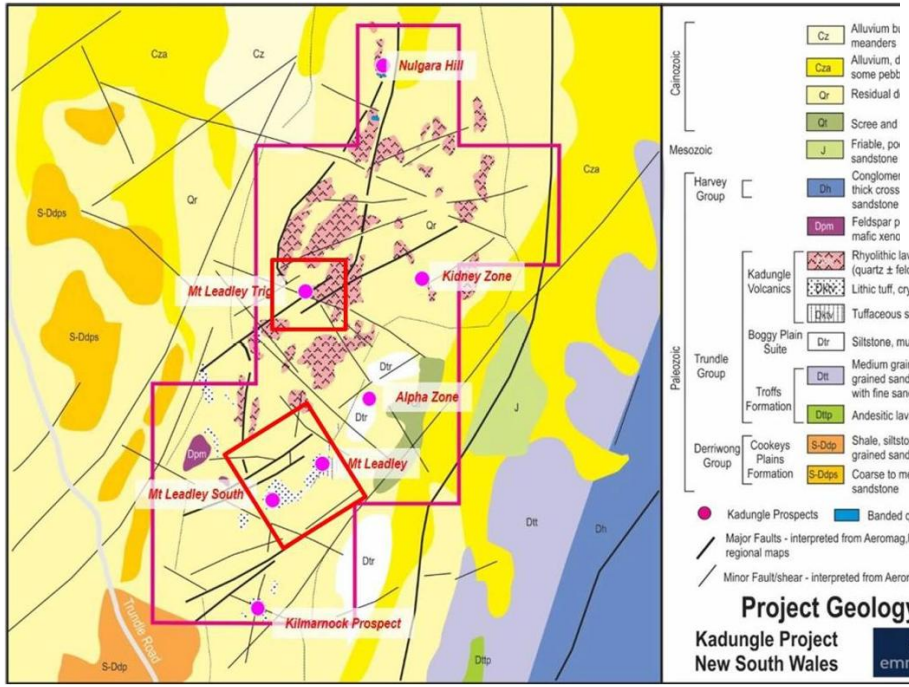


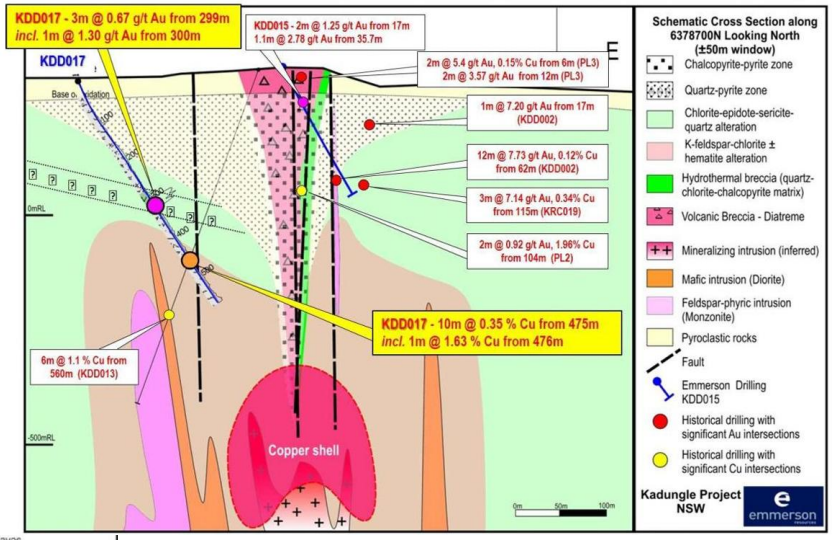
Wirrinya and Porters Mount alteration/vein styles

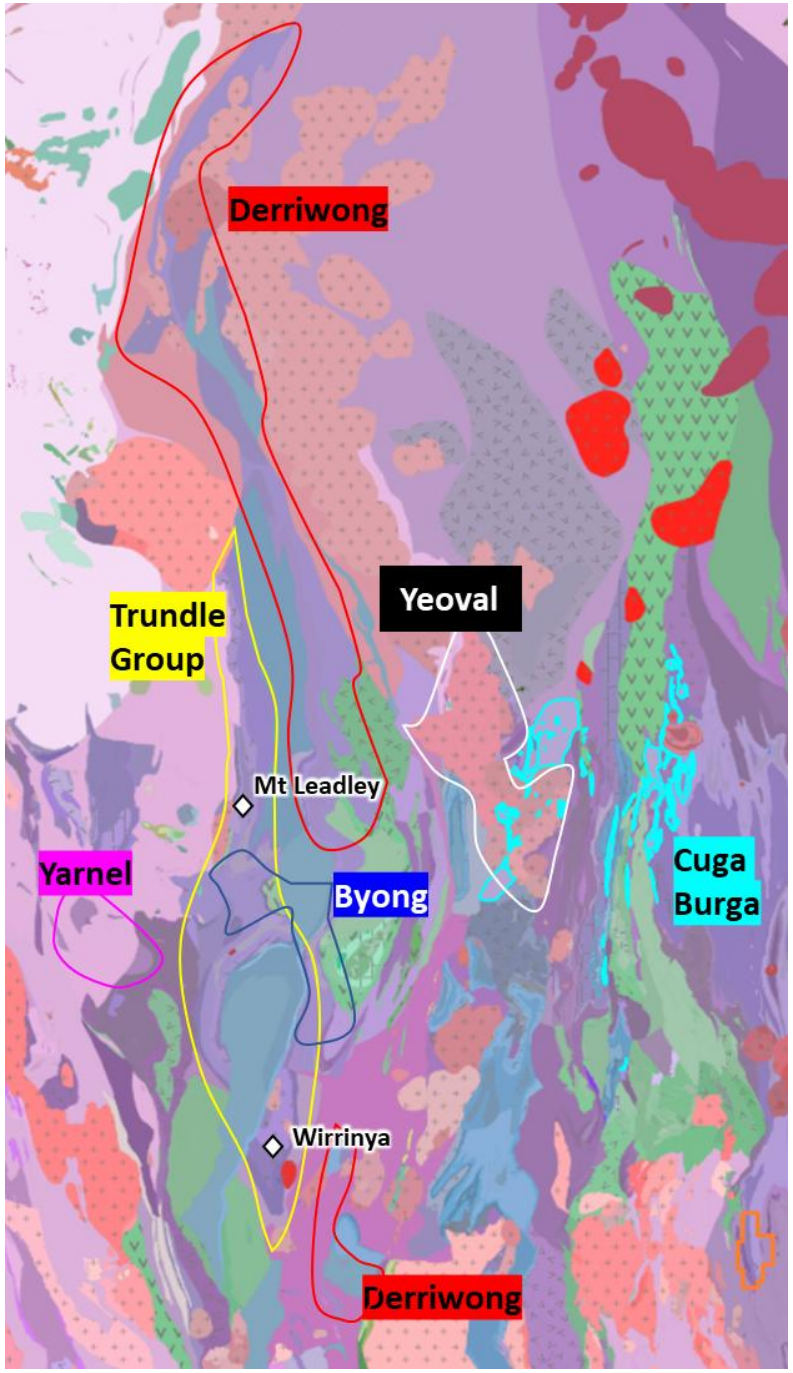
Mount Leadley

- Epithermal quartz-gold-silver-copper vein style mineralisation (e.g. 12m at 7.73 g/t gold).
- Deeper disseminated chalcopyrite ± bornite ± molybdenite.
- Hosted in mid Devonian I-type rhyolite-andesite Kadungle Volcanics with comagmatic Gobondery Granite nearby.
- Early Devonian Fermoy Volcanics (Derriwong Gp) lower in sequence.

ERM ASX: 18 July 2017

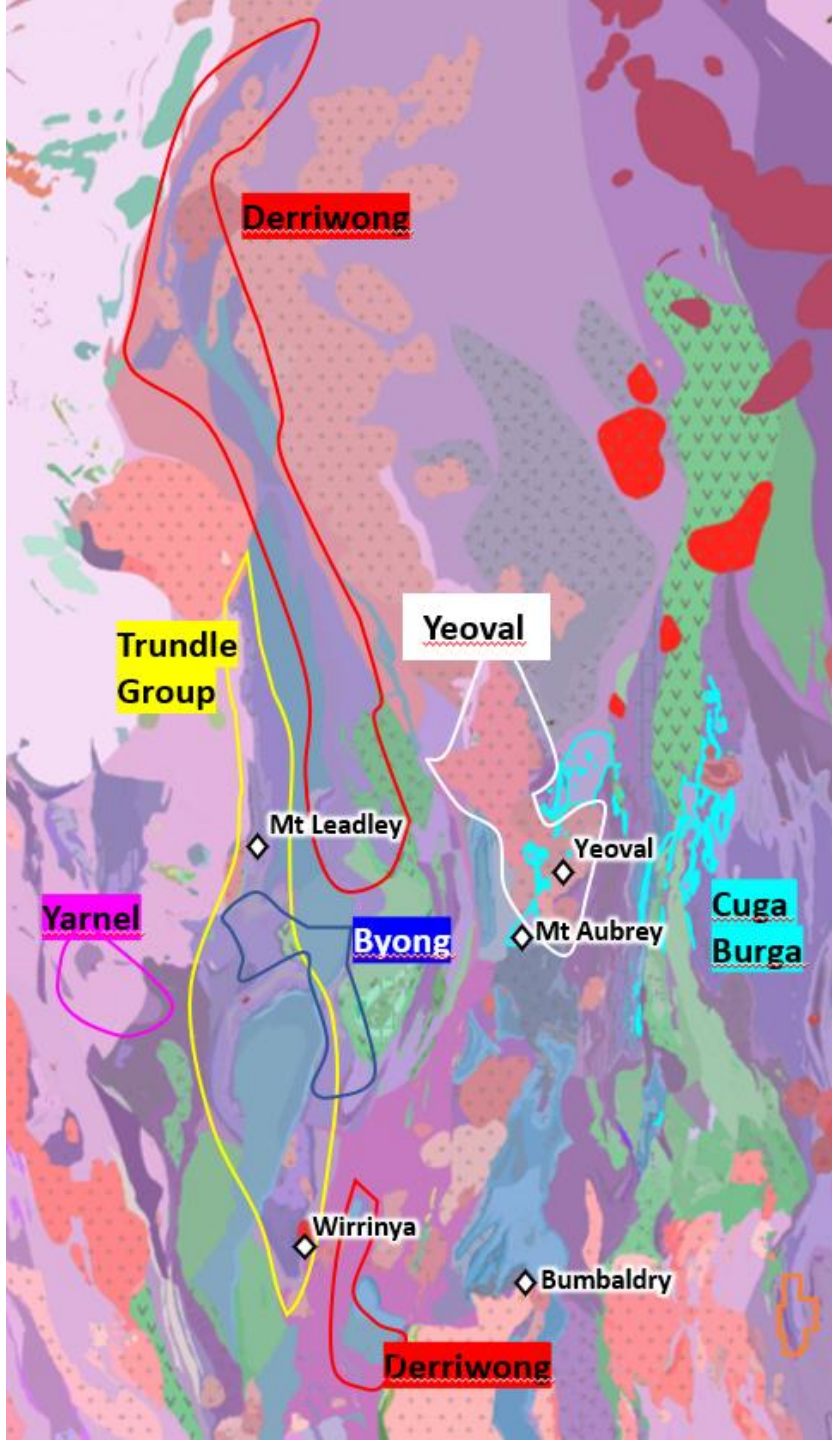






Mac Arc (Junee-Narromine Belt) vs. Early-mid Devonian Afterparty

	Mac Arc	Afterparty
Intermediate volcanics (basalt to andesite)	✓	✓
If preserved: oxidised, acidic alteration, lithocap	~	✓
I-Type, oxidised, unevolved, hydrous magmas	✓	~
Calc-alkaline to alkaline geochemistry	✓	~
Strong magnetic signature (High Fe_2O_3/FeO)	✓	✓
Strongly positive ε_{Nd} isotopic signature (+3 to +8)	✓	✓
Depleted mantle Pb-isotope signature	✓	✓
Silica saturated magmatism and mineralisation	✓	✓
Can include carbonate-base metal veining	✓	✓
High total alkalies ($Na_2O + K_2O > 5\%$)	✓	✓
High K_2O/Na_2O (>1)	✓	✓
High Ba, Rb, Th, P, Sr, Pb, light REE (La, Ce, Nd)	✓	✓
Depletion in TiO_2 (<1%), Nb and Ta	✓	✓
High PGE concentrations	✓	~
Rhyolite rare	✓	✗
Porphyry vein mineralisation	✓	✗



High pressure hydrous melts (Mac Arc) VS Lower pressure mid-crustal melts (Afterparty)

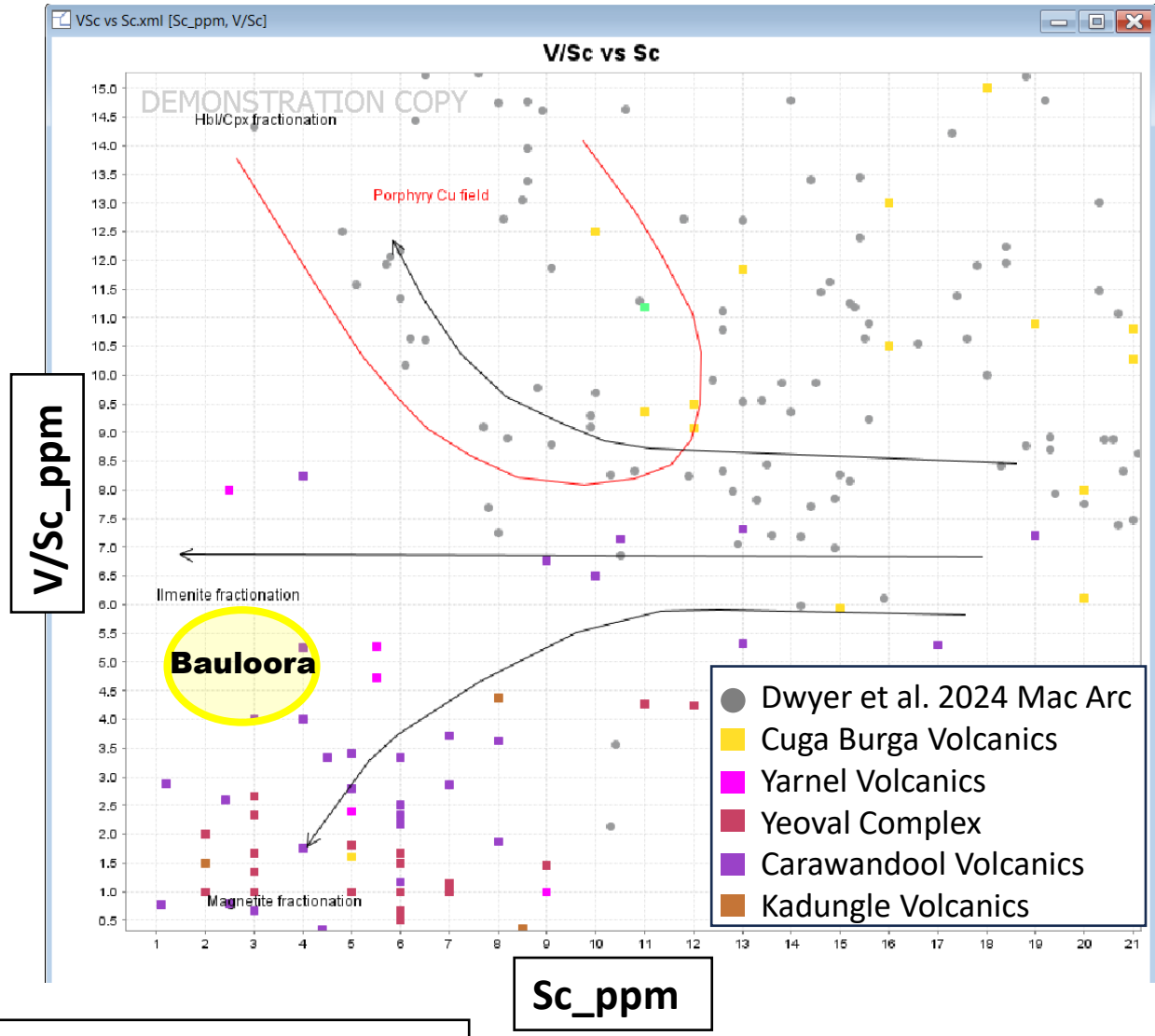
Scott Halley:

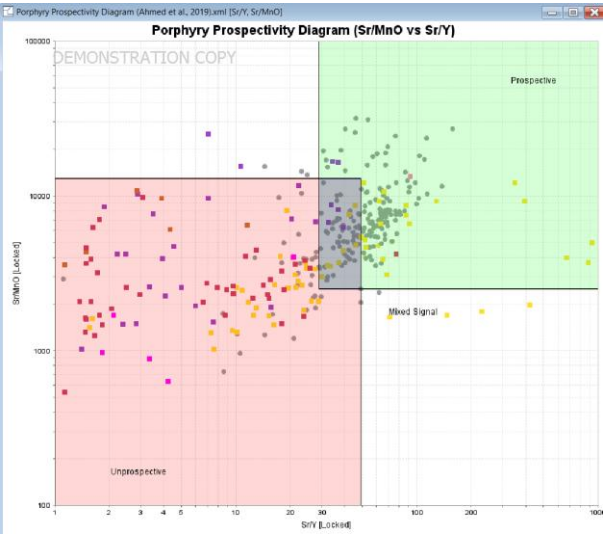
- Scandium partitions into magnetite in silicate melts.
- High pressure hydrous melts fractionate hornblende before cooling below the magnetite liquidus (>V/Sc).
- low pressure mid-crustal melts begin crystallizing magnetite early (<V/Sc).

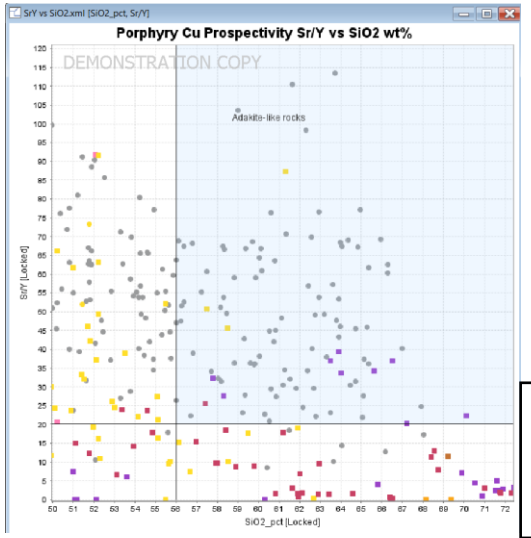
This results in less-oxidised melts that will reach sulphide saturation early- no beers at the after party!

https://www.scotthalley.com.au/

Dwyer et al. (2024) https://doi.org/10.1144/SP551-2024-65







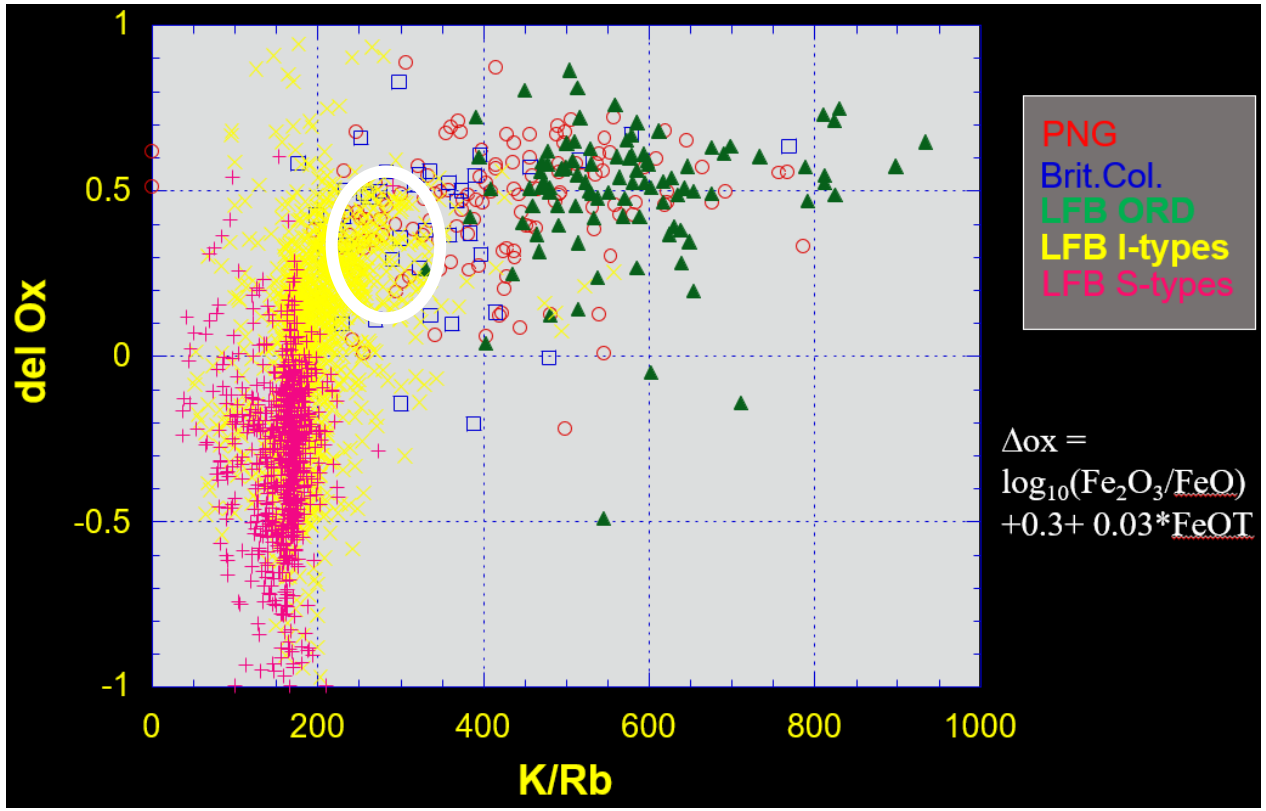
Bob Loucks would agree…high Sr/Y picking high P melting of plagioclase in hydrous environment – ie. subducting slab

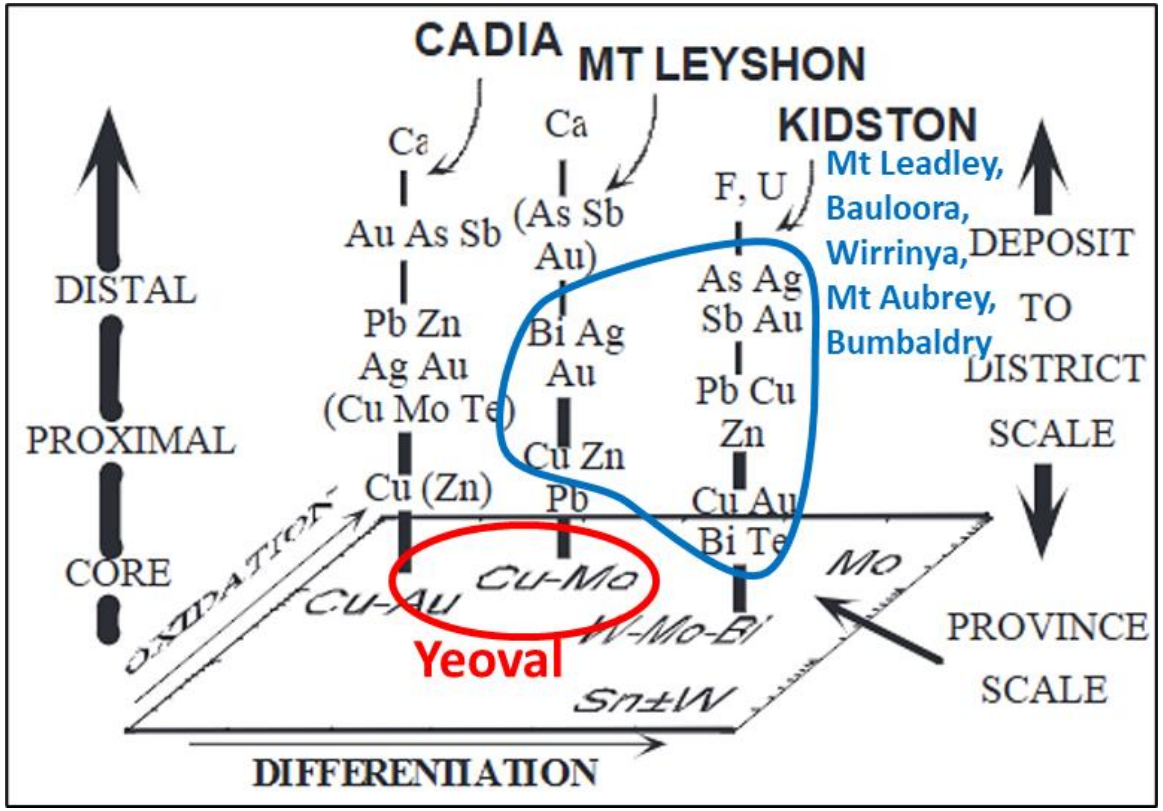
Back to Blevin (2004) for more insights…

Early-mid Devonian Afterparty plutons may deport gold into mineral system peripheries

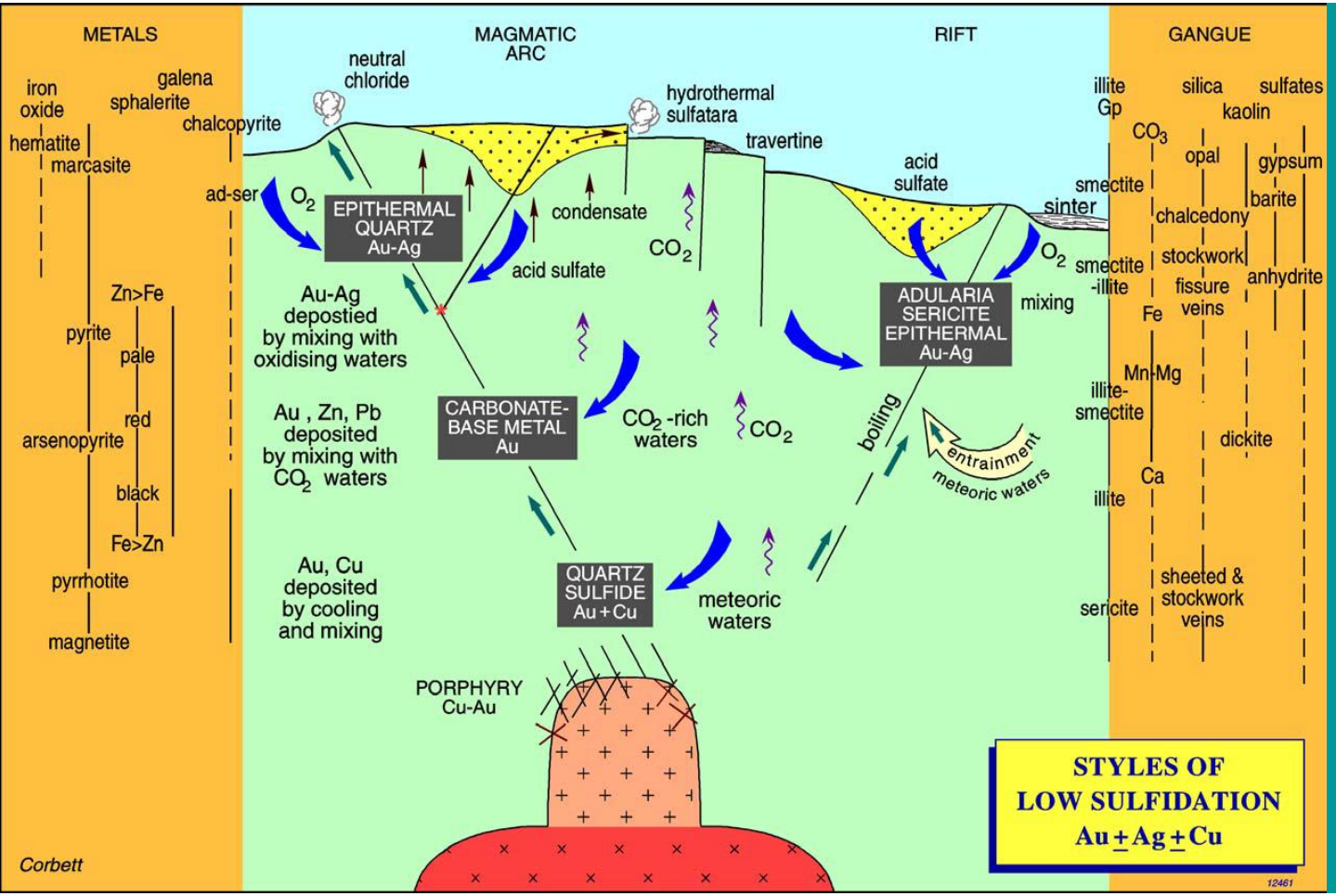
For moderately oxidised/evolved granites:
“the Au-rich portion of granitoid-related mineral deposits may be located distant from the high-T core of the hydrothermal system”

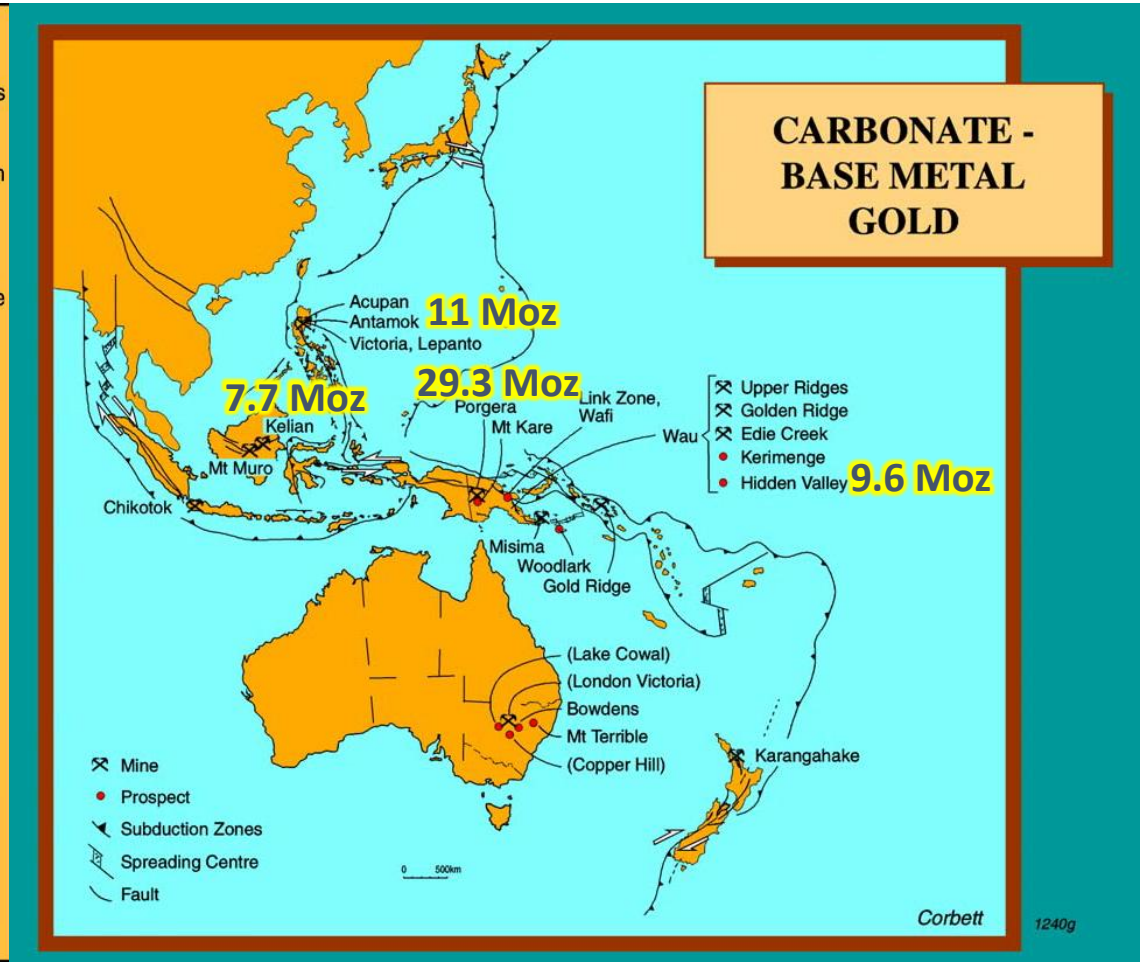
Most early-mid Devonian Au-Cu-Ag prospects are:
- Hosted in volcanics with similar age and geochemistry.
- Show intermediate- to low-sulphidation epithermal vein styles.





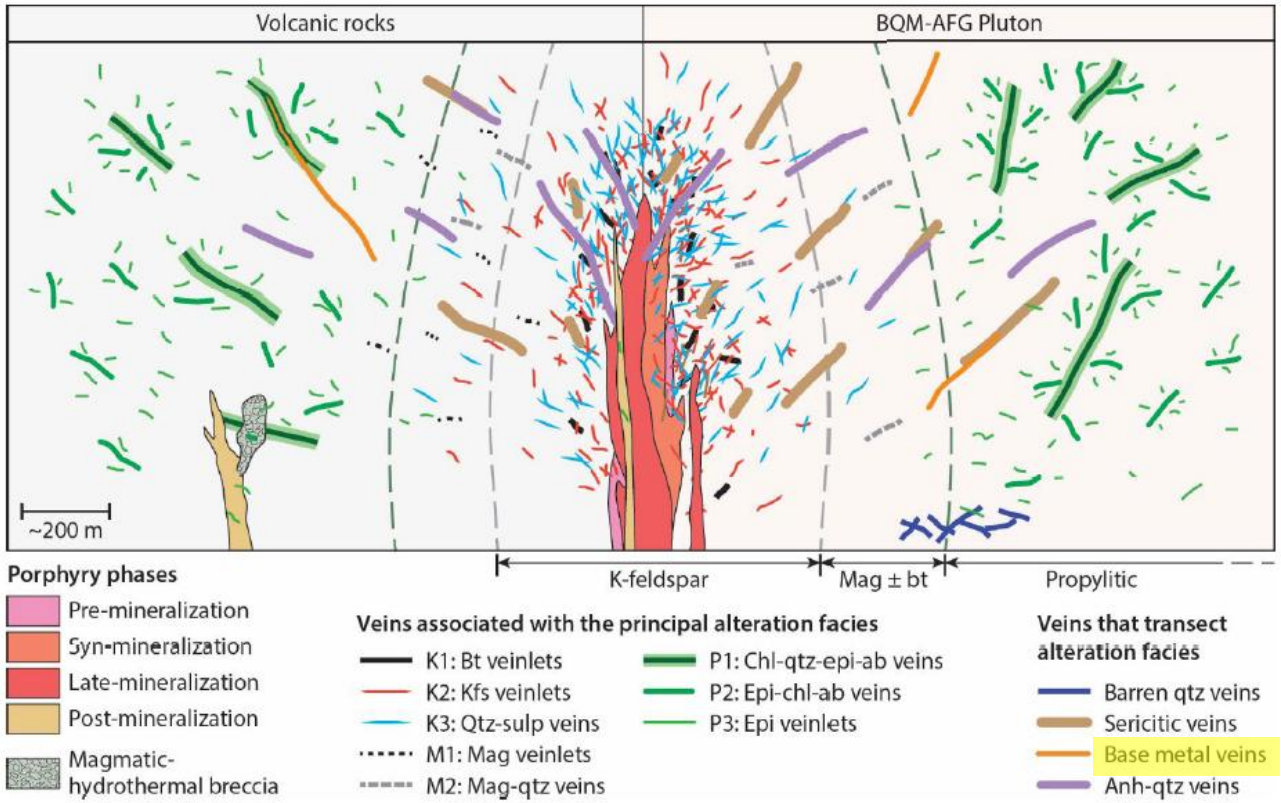
Carbonate-Base Metal setting and examples

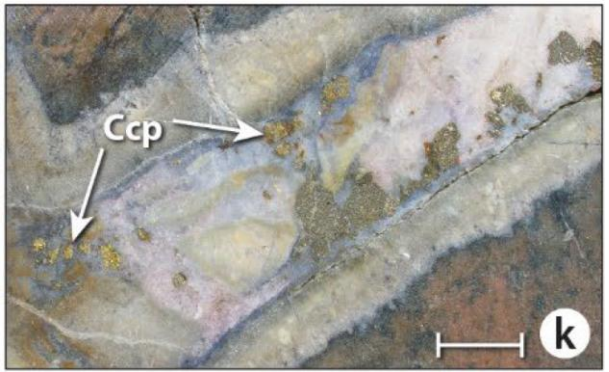


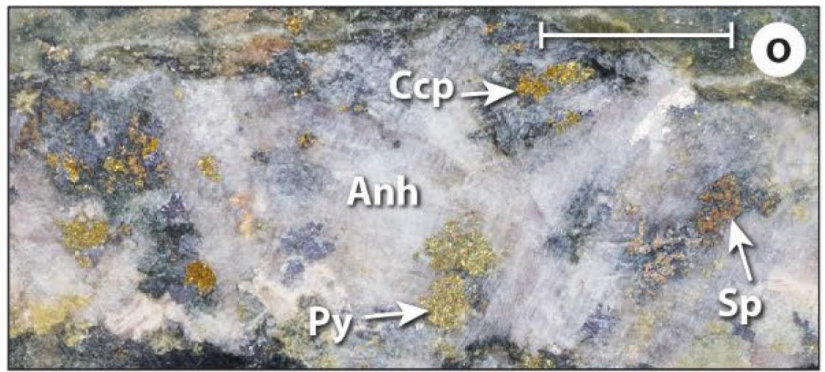


CBM veins in the Mac Arc: Northparkes and Cowal

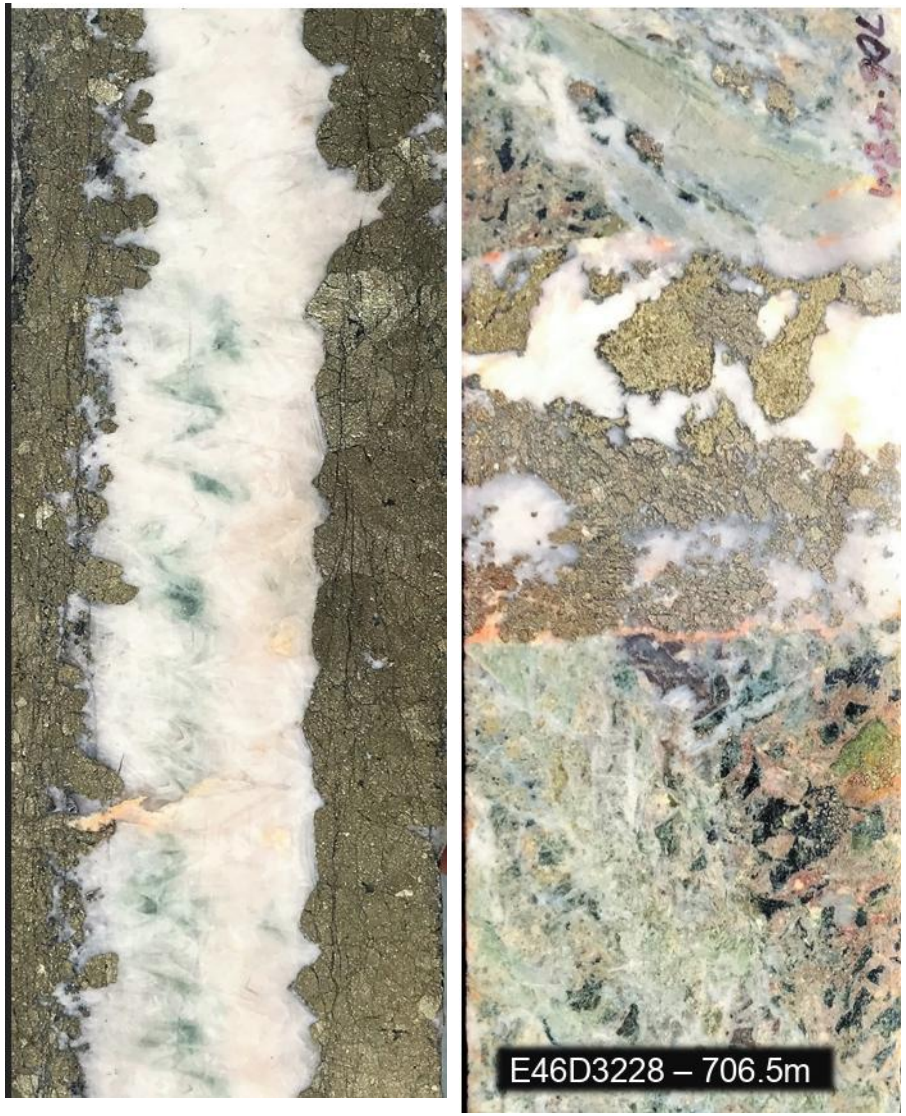
Northparkes: <u>CBMs not economic</u> (Pacey 2019)



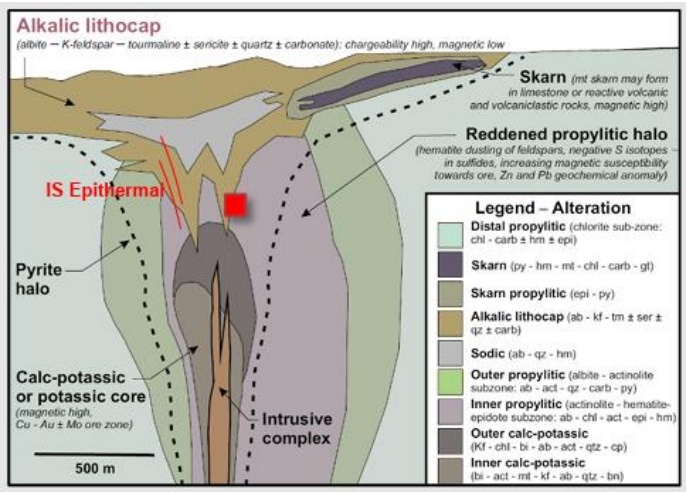


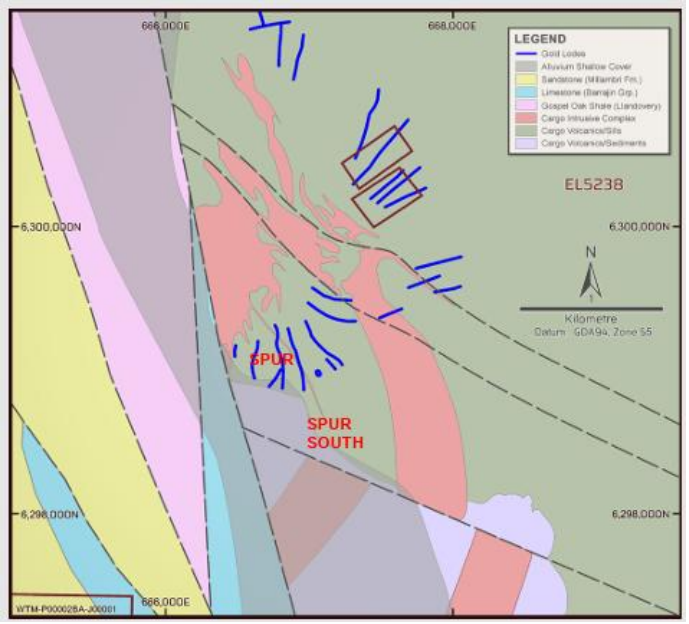


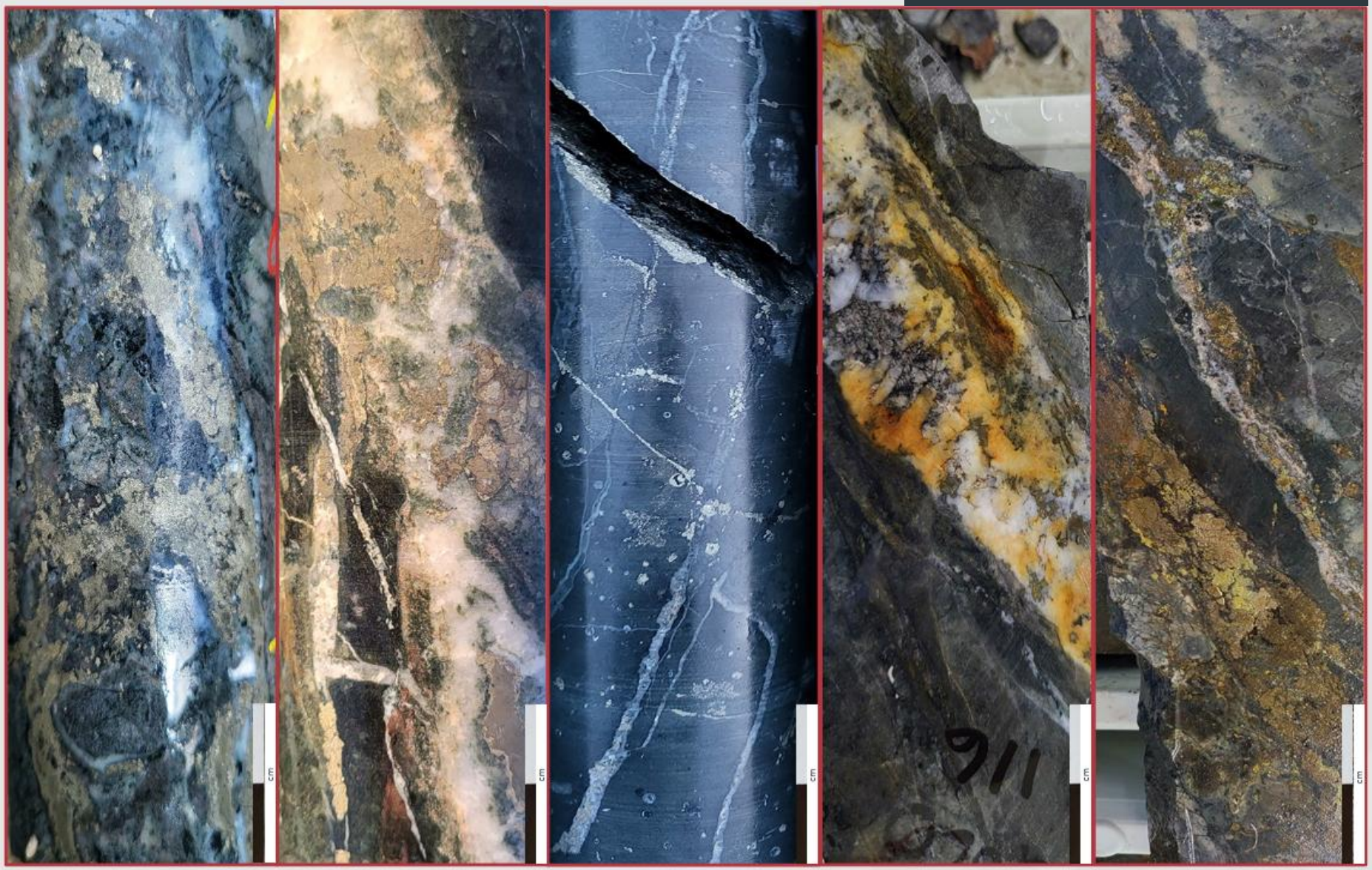
Cowal: <u>CBMs economic</u> (Leslie 2017)



Spur: CBMs economic







SPD003 – 361.8m, subvertical pyrite stringers, 22g/t Au, 0.12% Cu (Epithermal)

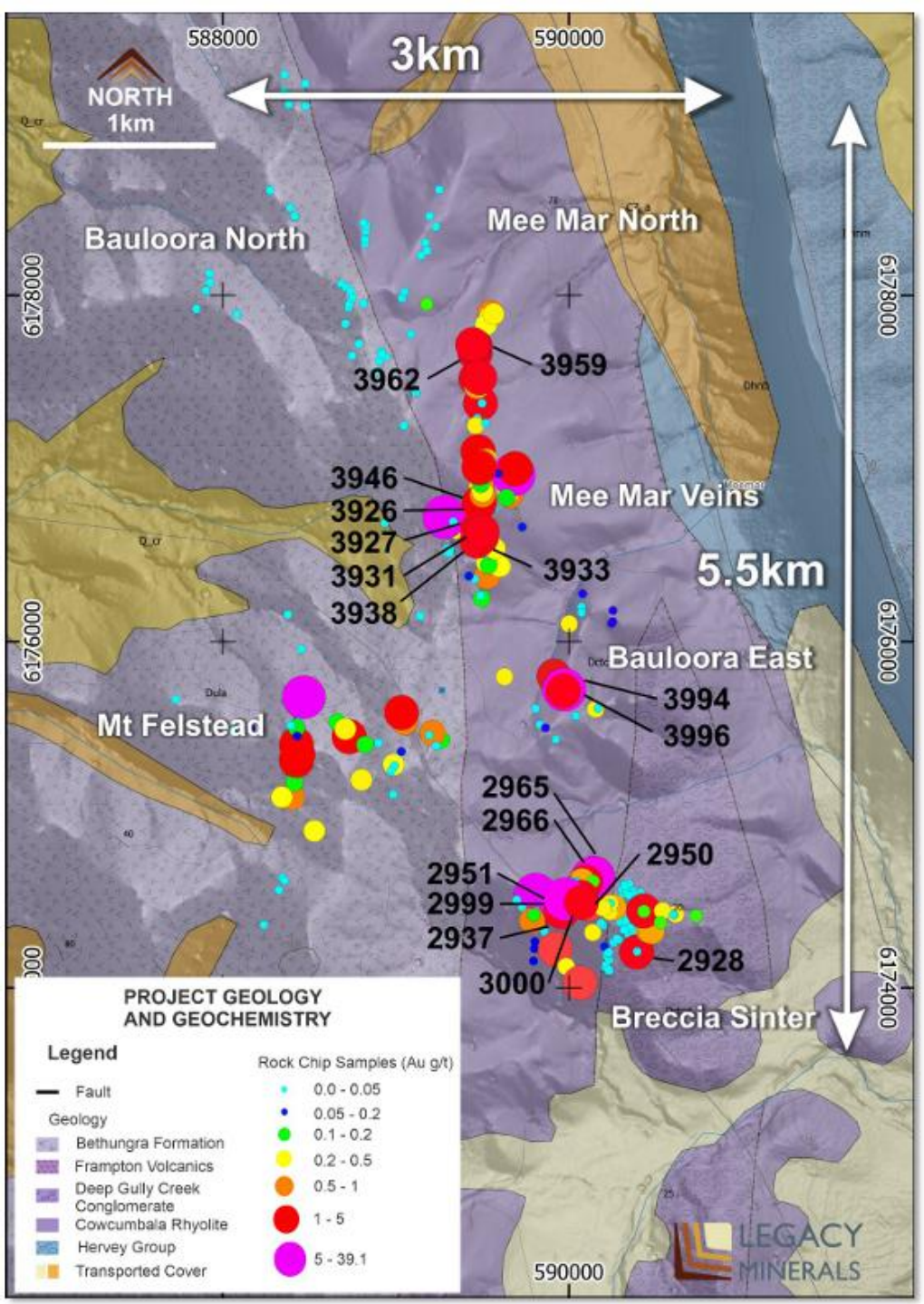
SPD001 – 221.3m, discrete narrow quartz + magnetite + pyrite vein, 3.6g/t Au (Epithermal)

SPD003 – 419.8m, pyrite stringer stockwork/multiple vein sets associated with silica alteration, 1.42g/t Au (Epithermal)

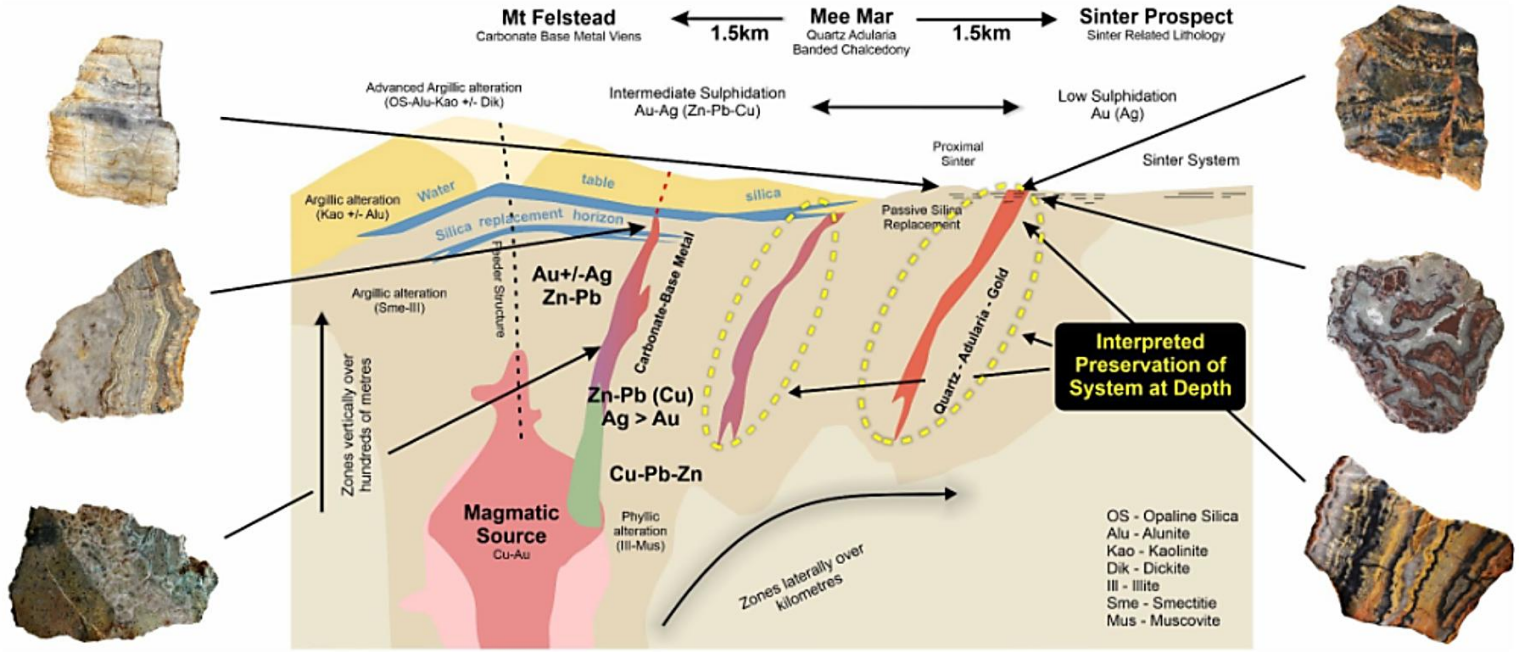
SD010 – 115.3m, quartz + ankerite + pyrite vein, 3.6g/t Au, 0.2% Cu (Epithermal)

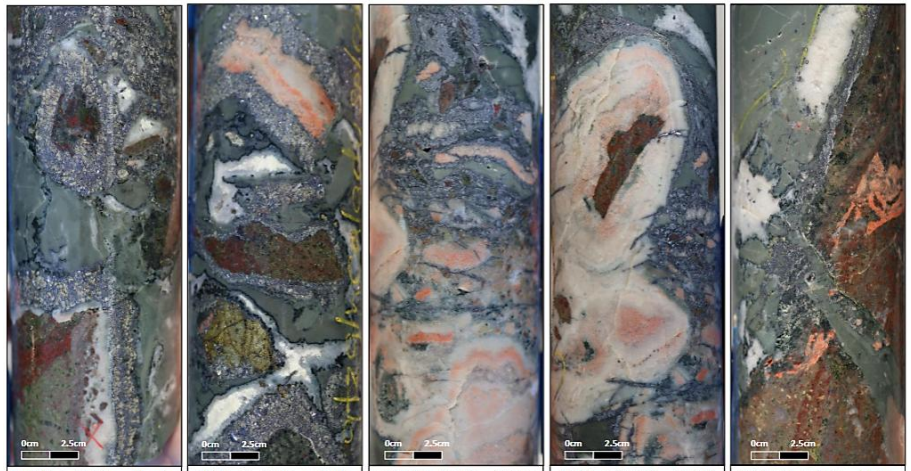
SD010 – 137.5m, pyrite - chalcopyrite, sub vertical stringers, 124g/t Au, 1% Cu (Epithermal)

Bauloora LS-IS Epithermal: CBMs economic



Epithermal Exploration Model for the Bauloora Project





ML001 at 149.8m - Quartz-galena-sphalerite-chalcopyrite-adularia-chalcedony cockade breccia.

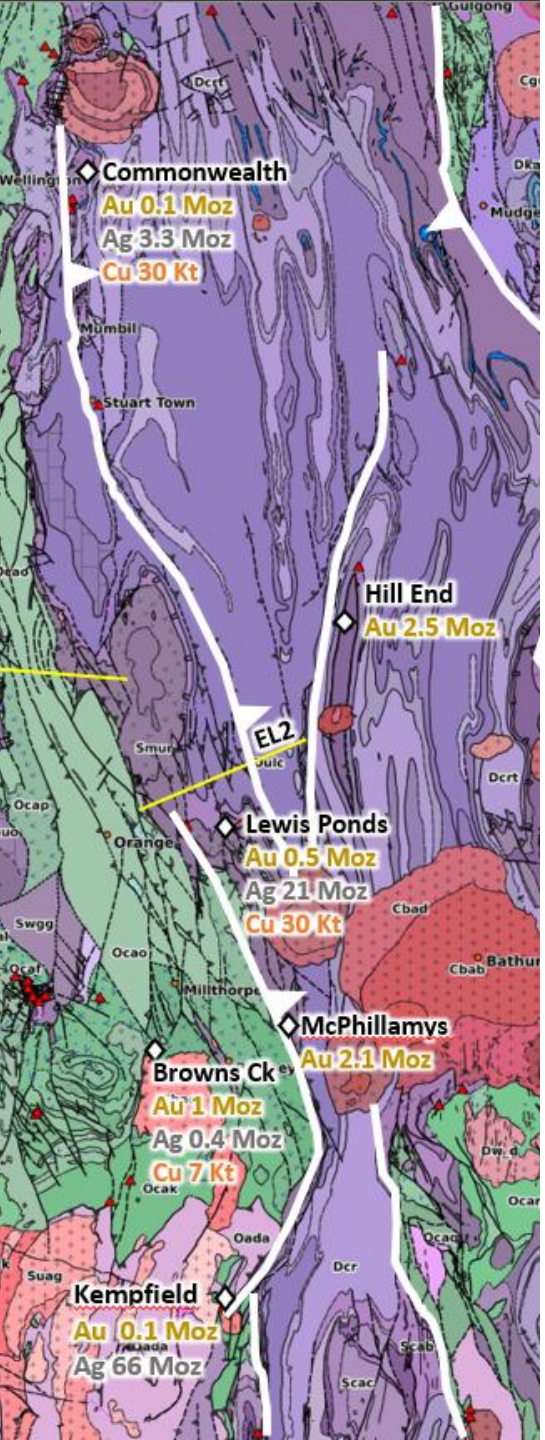
ML001 at 151m - Quartz-galena-sphalerite-chalcopyrite-adularia-chalcedony cockade breccia.

ML001 at 152.7m - Quartz-galena-sphalerite-adularia-chalcedony cockade breccia.

ML001 at 152.7m - Quartz-galena-sphalerite-adularia-chalcedony cockade breccia.

ML001 at 154.8m - Quartz-galena-sphalerite-adularia breccia with quartz-chalcedony matrix.

Figure 5: Diamond drill core photos of quartz vein textures at the Moonlite Prospect.



Summary

- Economic gold (~10Moz), copper (~640Kt) and silver (~152Moz) deposits were formed in the Eastern Lachlan Orogen during the Siluro-Devonian.
- The majority of this endowment was formed in the mid to late Silurian, hosted in extensional rift basins, along growth faults flanking exposed Macquarie Arc belts.
- Early to mid Devonian afterparty suites reflect back-arc partial melting of tectonically-thickened Macquarie Arc volcanics at the base of the crust. Melting reactions were dominated by dehydration of biotite and amphibole, not hydrous high pressure melting of plagioclase , characteristic of fertile Ordovician magmas.
- These magmas reached sulphur saturation early and were therefore unable to carry as much copper or gold in the melt.
  They did not bring beers to the afterparty!
- However, there is potential for economic Au-Cu-Ag deposits related to high K, moderately oxidized/evolved I-type granitoids, with Au-Ag likely to be focused in intermediate to low sulphidation settings distal from system centres.