Geology and geochronology of the Two-Thirty Prospect NSW

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Australian Government

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Presentation Outline

- Overview of the Macquarie Arc
- Geology of the Northparkes district
- Two-Thirty prospect geology
- Evidence for multiple hydrothermal overprints
- Geochronology of the Two-Thirty prospect
- Conclusions

K-feldspar – pyrite – chalcopyrite – calcite – fluorite cemented breccia

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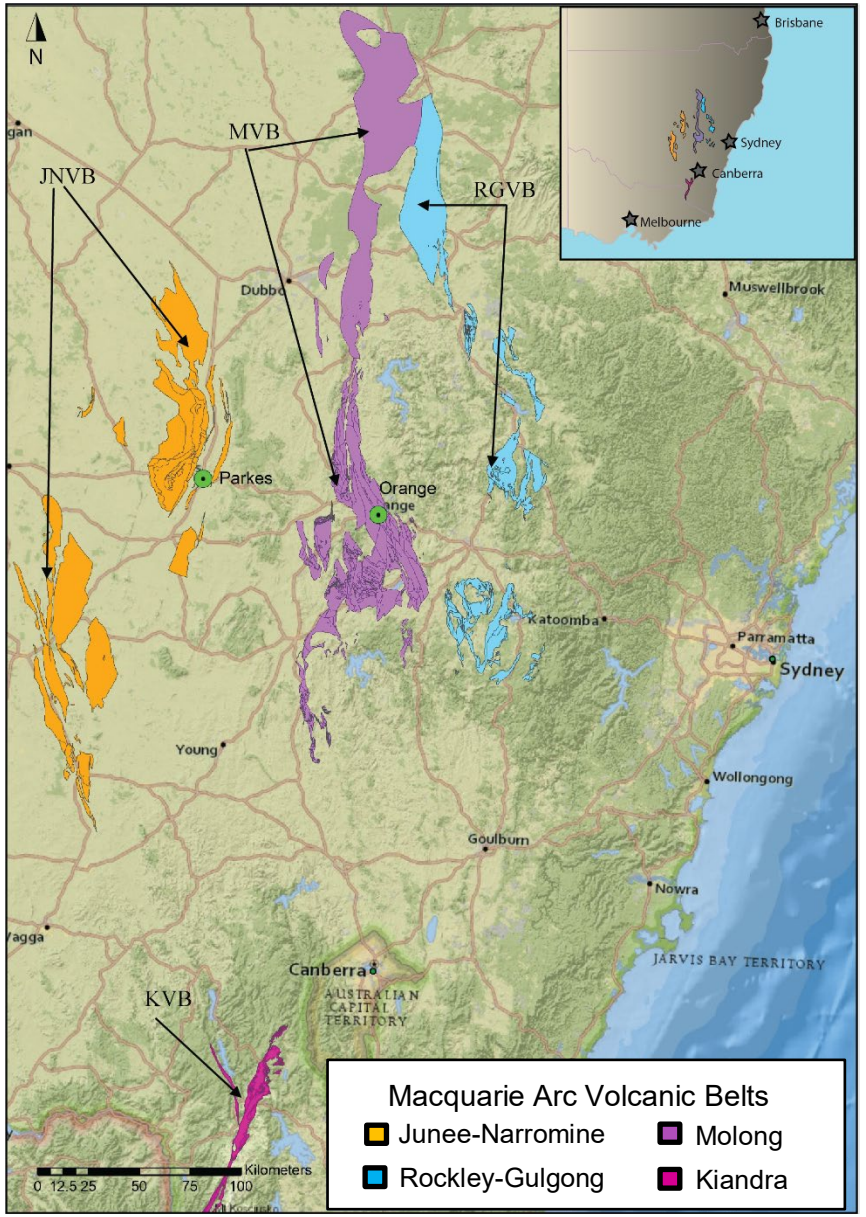
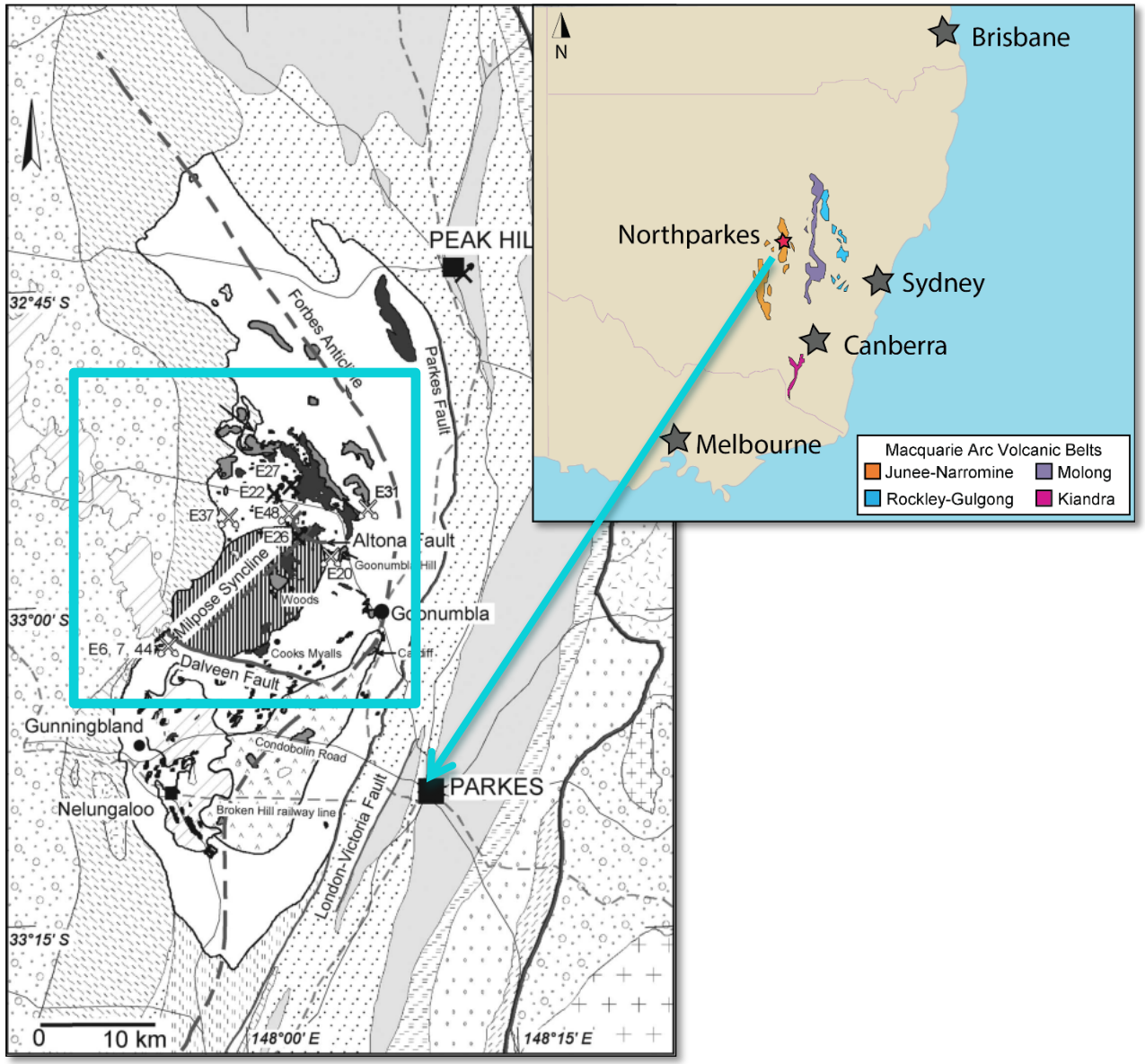
Overview of the Macquarie Arc

- Four Ordovician volcanic belts
- Separated by turbidite sequences
- Economic porphyry mineralisation in the western and central belts
- Numerous skarn and epithermal mineral deposits and prospects
- Complex geometry and contact relationships



Northparkes District

- Located ~350 km WNW of Sydney
- Mineralisation first reported in the 1800s
- Hosted by the Ordovician Goonumbla Volcanic Complex



Northparkes porphyry Cu-Au district. Modified after Lickfold et al. (2007)

Goonumbla Volcanic Complex

- Located ~350 km WNW of Sydney
- Mineralisation first reported in the 1800s
- Hosted by the Ordovician Goonumbla Volcanic Complex

Wombin Volcanics
439 Ma – 444 Ma

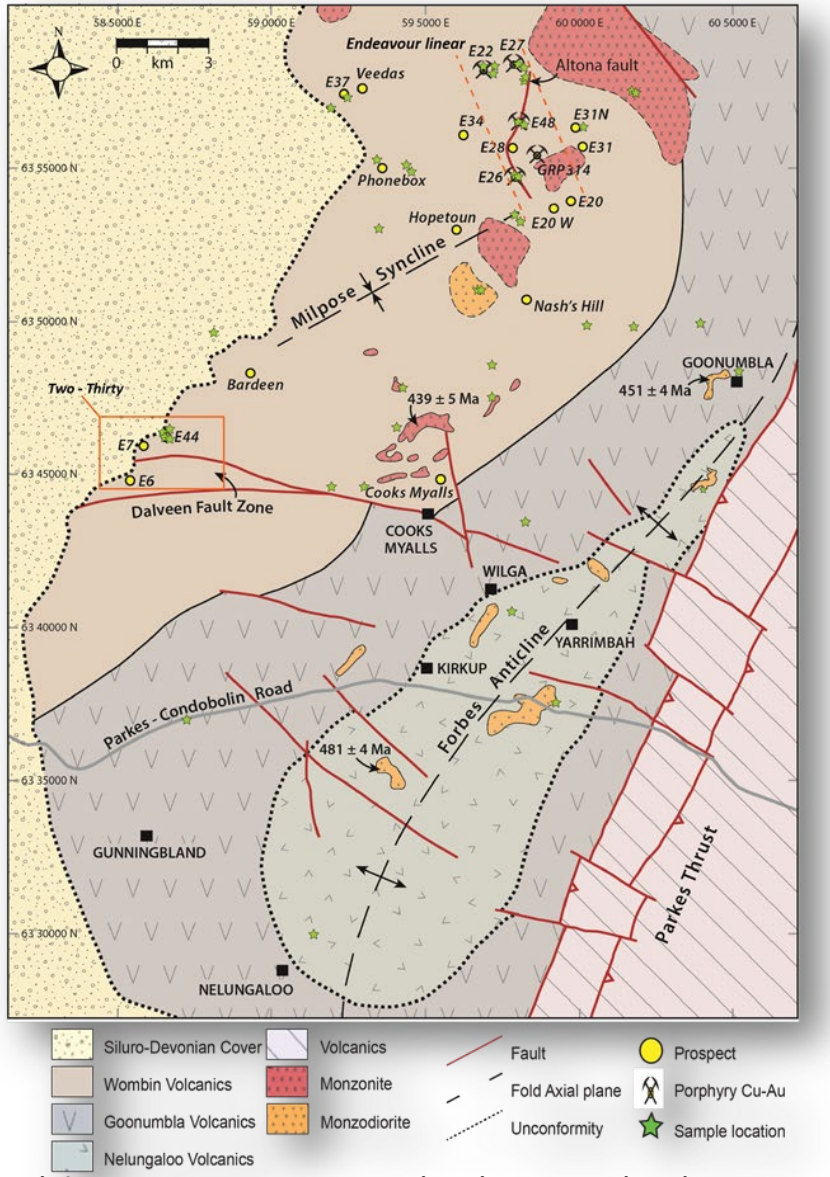
Goonumbla Volcanics
444 Ma – 455 Ma

Nelungaloo Volcanics
476 – 496 Ma

Krynen et al. (1990), Lickfold et al. (2007)

Northparkes Porphyries

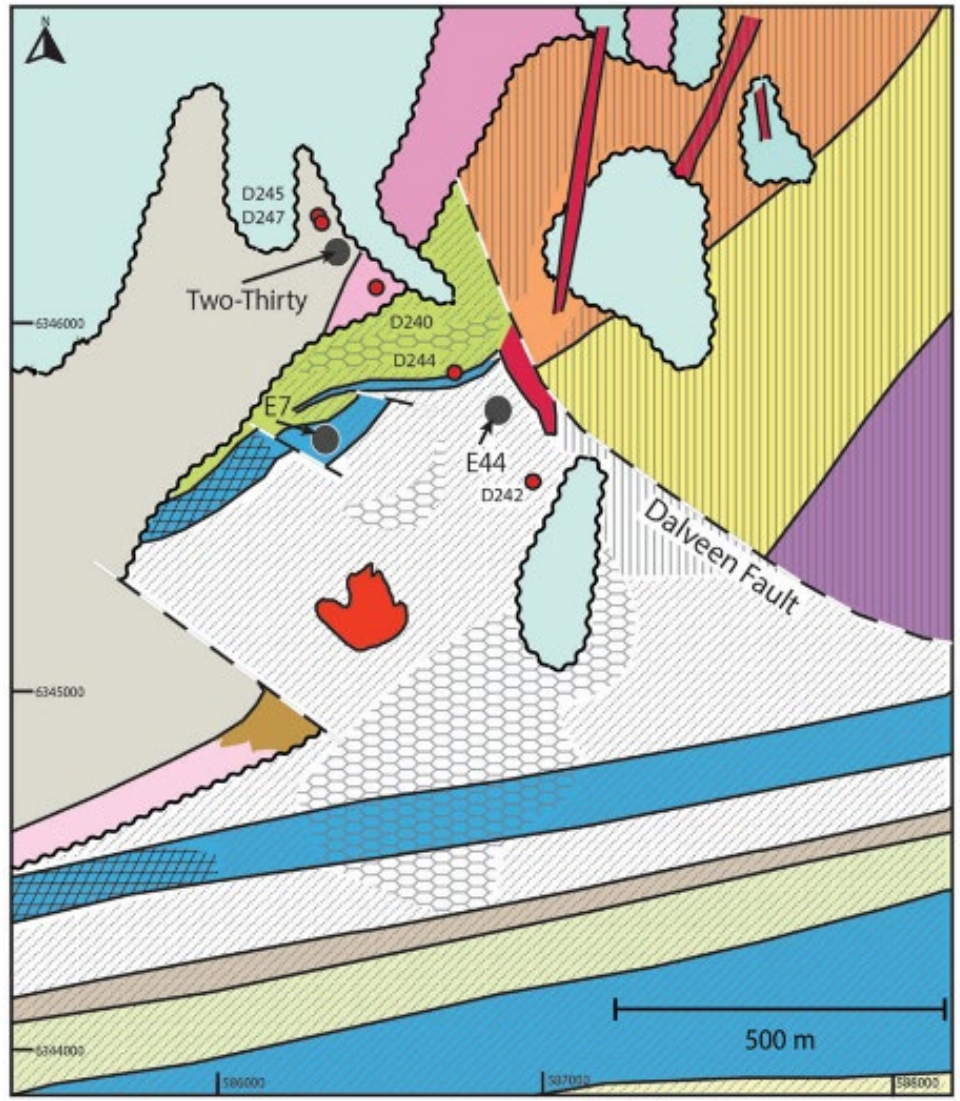
- Five major porphyry centres occur on a 6 km ~NW/SE linear
- At least seven intrusive phases identified across the district
- Alkalic and transitional calc-alkalic porphyry systems
- Two discrete phases of mineralisation



Modified after Pacey (2016) from mapping by Simpson et al (2005) Heithersay (1996) and Arundell (1998)

Two-Thirty Prospect Geology

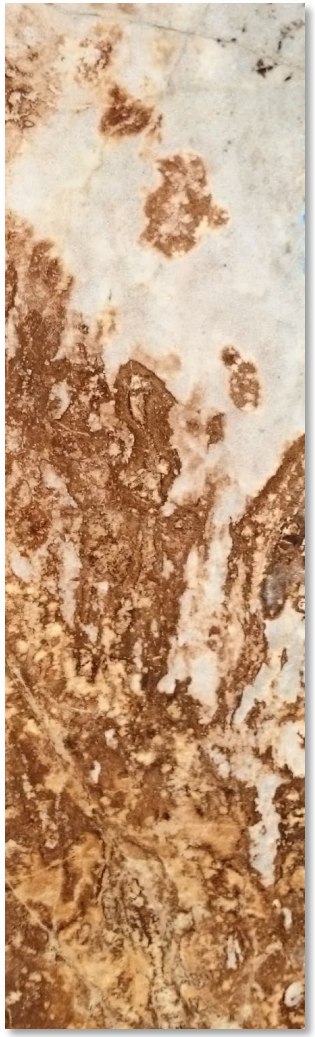
- Single pro-grade – retrograde skarnoid assemblage associated with micro-syenite
- Au and tellurides in retrogressed domains
- Fractionated oxidised, alkalic fluid source
- S isotopes -3.8 and -5.3 ‰
- 14 – 19 wt% NaCl from inclusions
- Skarn is a passive host for Au(?)



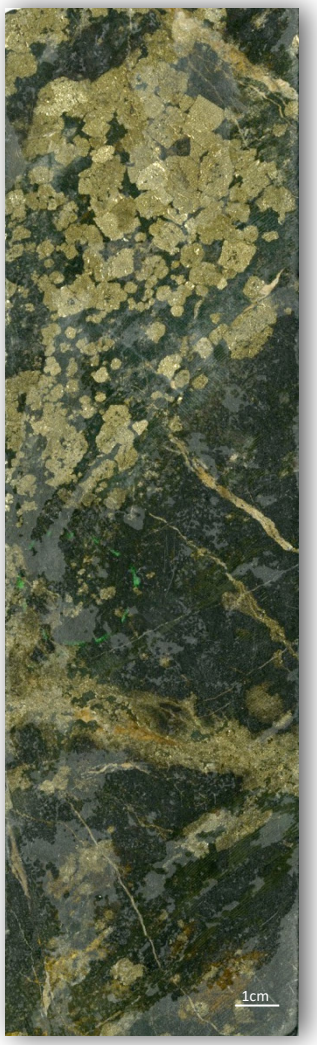
Modified after Jones (1991)

Two-Thirty Prospect Geology

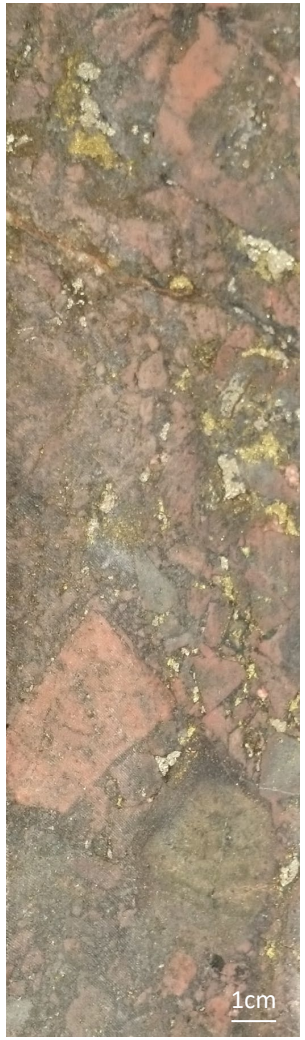
- Moderately dipping (60°/~120°) Late Ordovician basal Goonumbla volcanics host the Two-Thirty prospect
- Comprised of a series of:
  - Andesite – basaltic andesite sandstones and siltstones
  - Volcaniclastic breccias
  - Discontinuous limestones
  - Syn-depositional latite lavas



Garnet skarn



Massive magnetite skarn

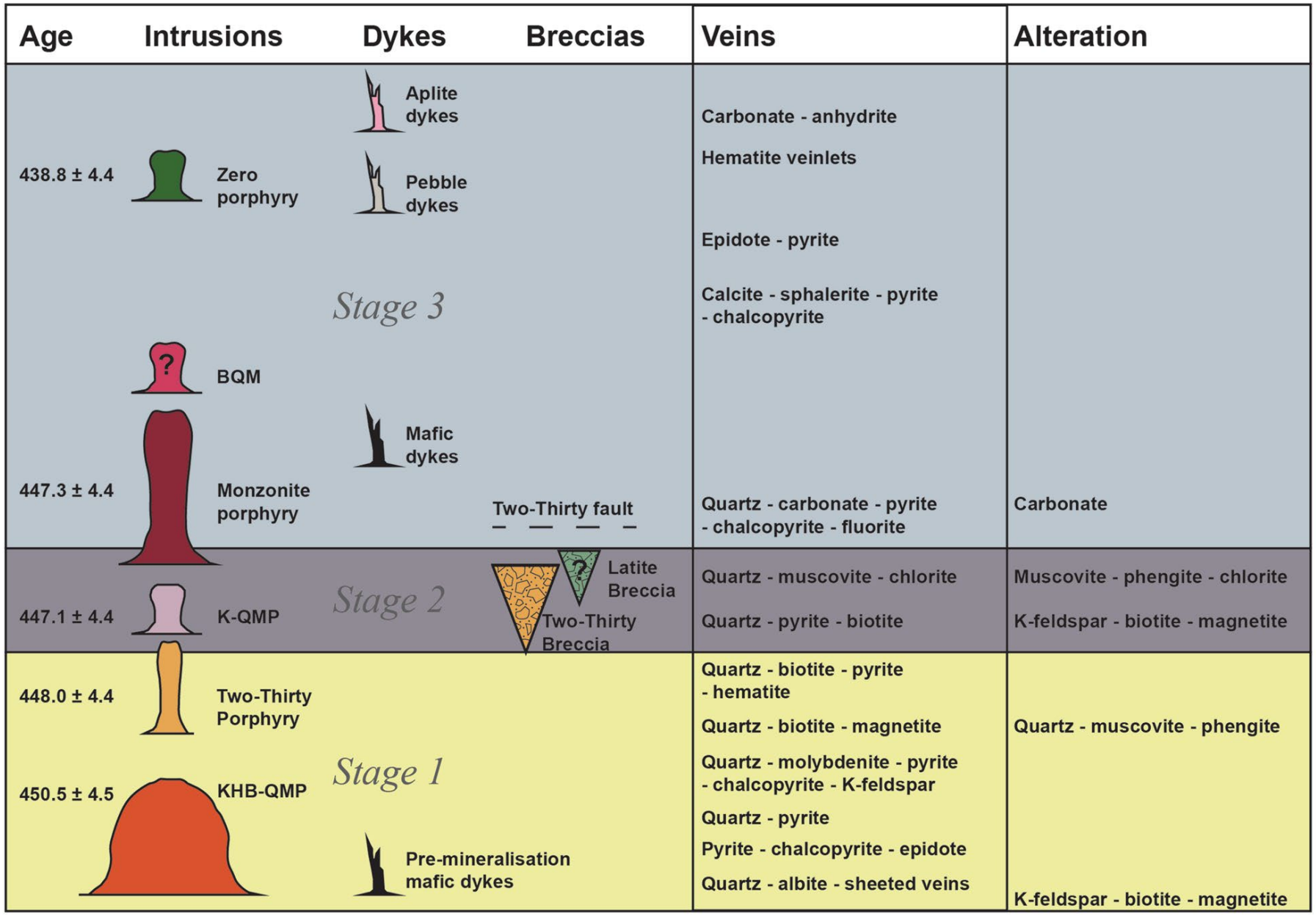


Chaotic-matrix supported, polymict breccia

K-feldspar – pyrite – chalcopyrite – aplite cemented breccia

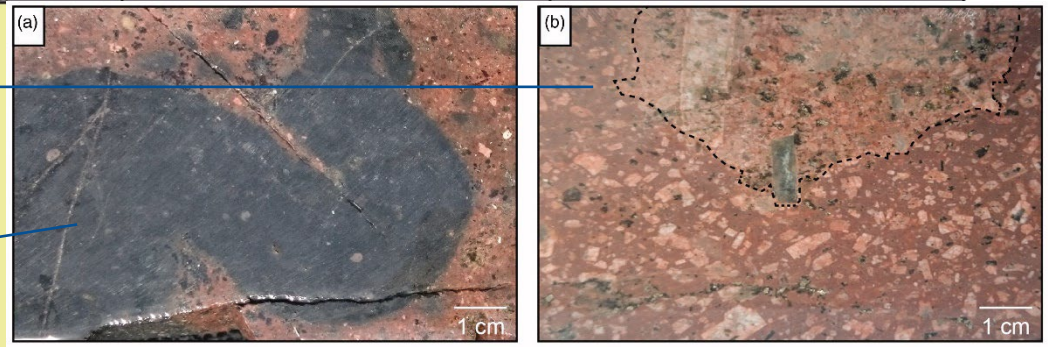
Two-Thirty porphyry

Two-Thirty Prospect Geology

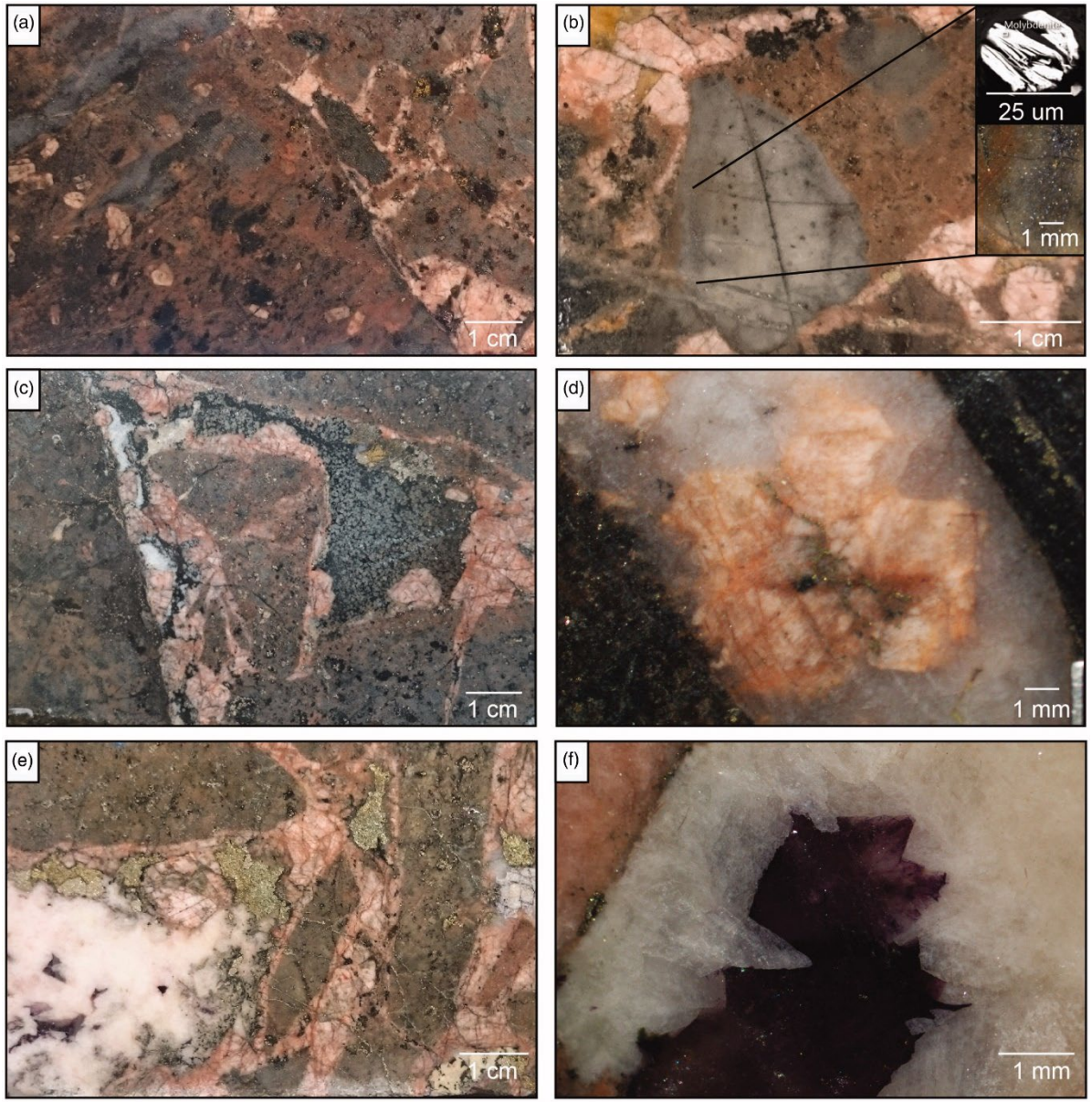


Two-Thirty Prospect Geology

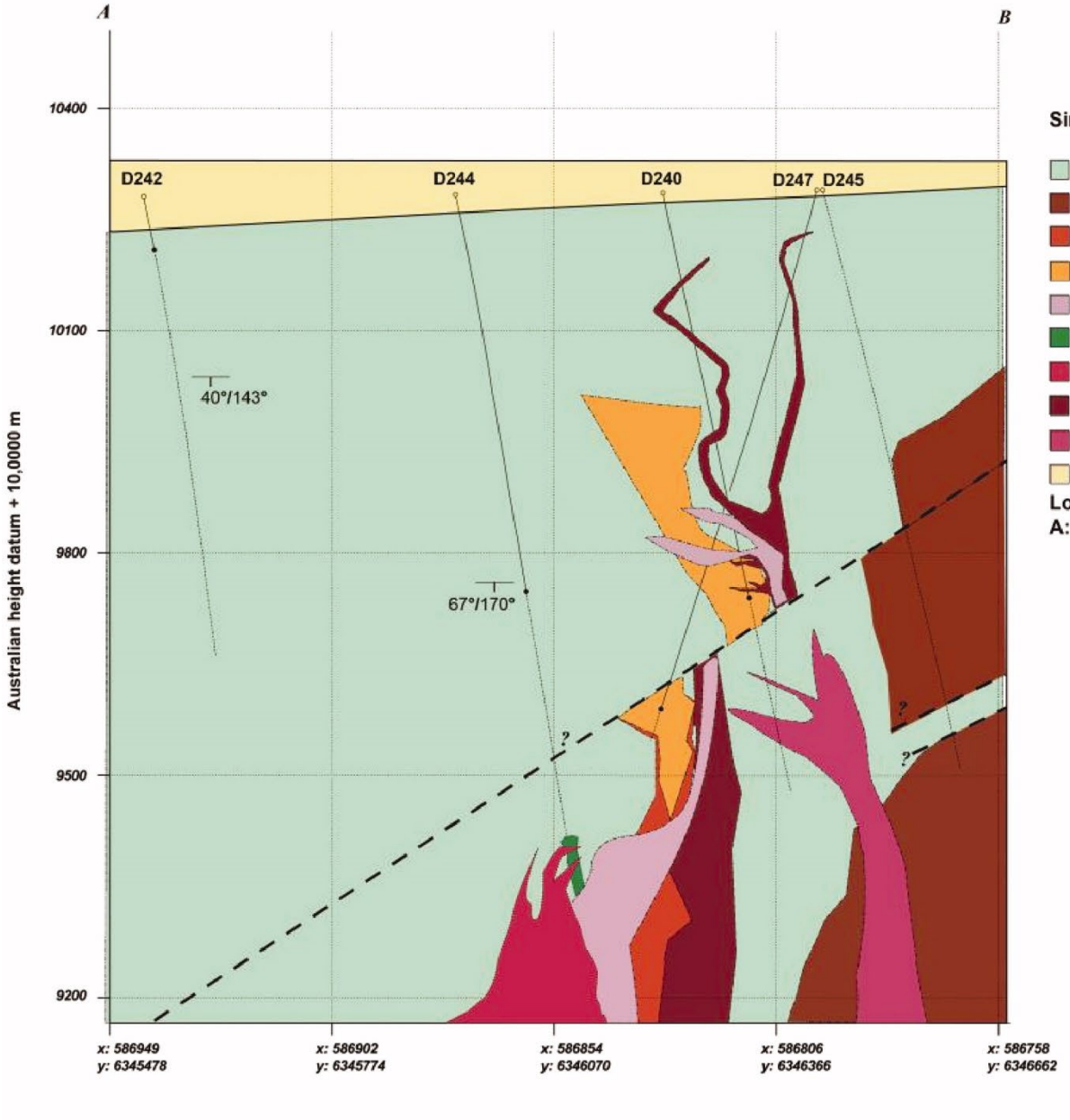
Age	Intrusions	Dykes	Breccias	Veins	Alteration
		Aplite dykes		Carbonate - anhydrite	
438.8 ± 4.4	Zero porphyry	Pebble dykes		Hematite veinlets	
				Epidote - pyrite	
	Stage 3			Calcite - sphalerite - pyrite - chalcopyrite	
	BQM				
447.3 ± 4.4	Monzonite porphyry	Mafic dykes	Two-Thirty fault	Quartz - carbonate - pyrite - chalcopyrite - fluorite	Carbonate
			Latite Breccia	Quartz - muscovite - chlorite	Muscovite - phengite - chlorite
447.1 ± 4.4	K-QMP	*Stage 2*	Two-Thirty Breccia	Quartz - pyrite - biotite	K-feldspar - biotite - magnetite
448.0 ± 4.4	Two-Thirty Porphyry				
450.5 ± 4.5	KHB-QMP	*Stage 1*	Pre-mineralisation mafic dykes		



Two-Thirty Prospect Geology



Two-Thirty Prospect Geology



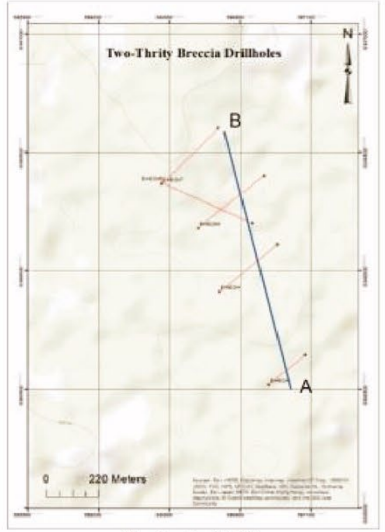
Simplified Geology of the Two-Thirty Prospect

- Undifferentiaed Goonumbla Volcanic Complex
- KHB-QMP
- Two-Thirty Porphyry
- Two-Thirty Breccia
- K-QMP
- Latite Breccia
- BQM
- Monzonite porphyry
- Zero porphyry
- Cover Sequence

Symbols

- Fault
- Bedding
- Drill Collar
- Drill Trace
- Intercept with section
- Drill trace beyond section

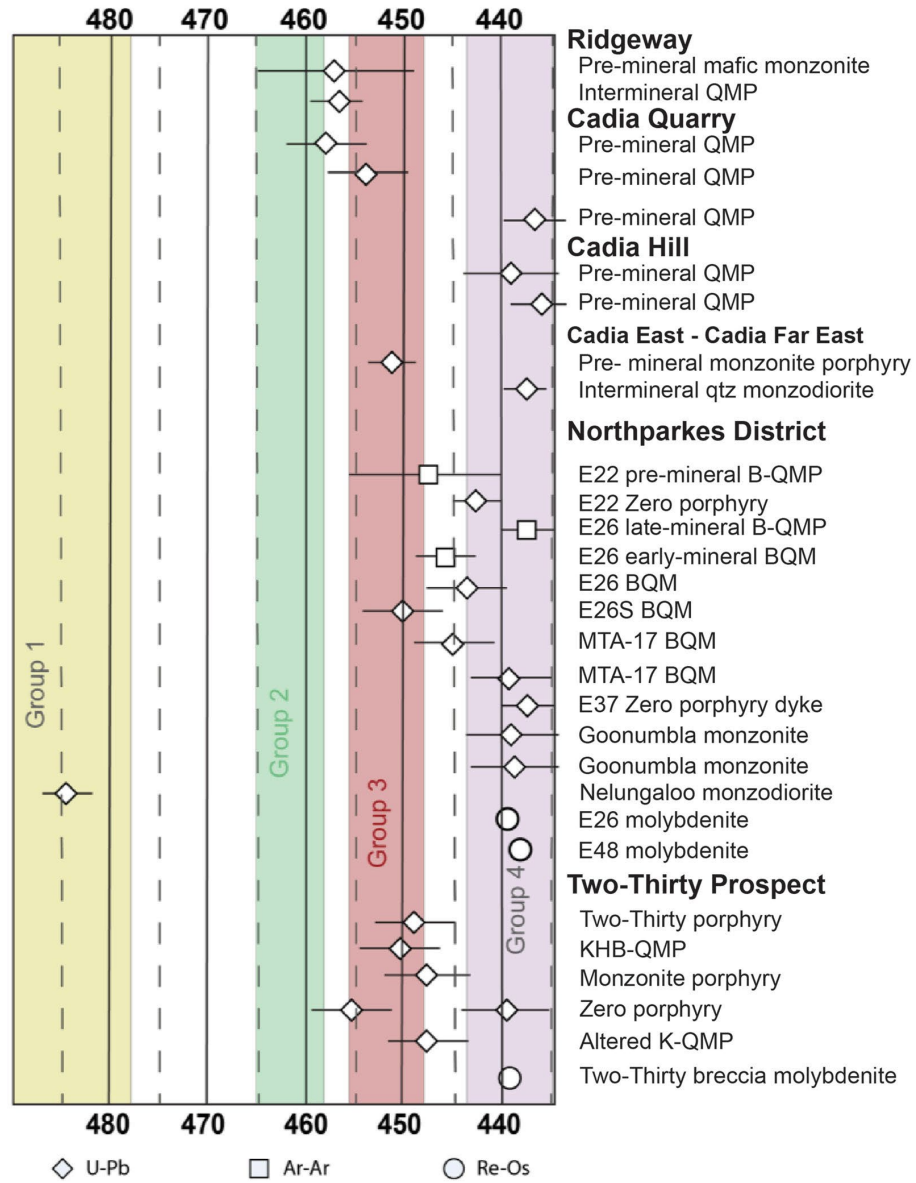
Location: UTM
A: E586949, N63455478 - B: E586707, N6346978



Scale: 1: 5,500
Vertical exaggeration: 1x

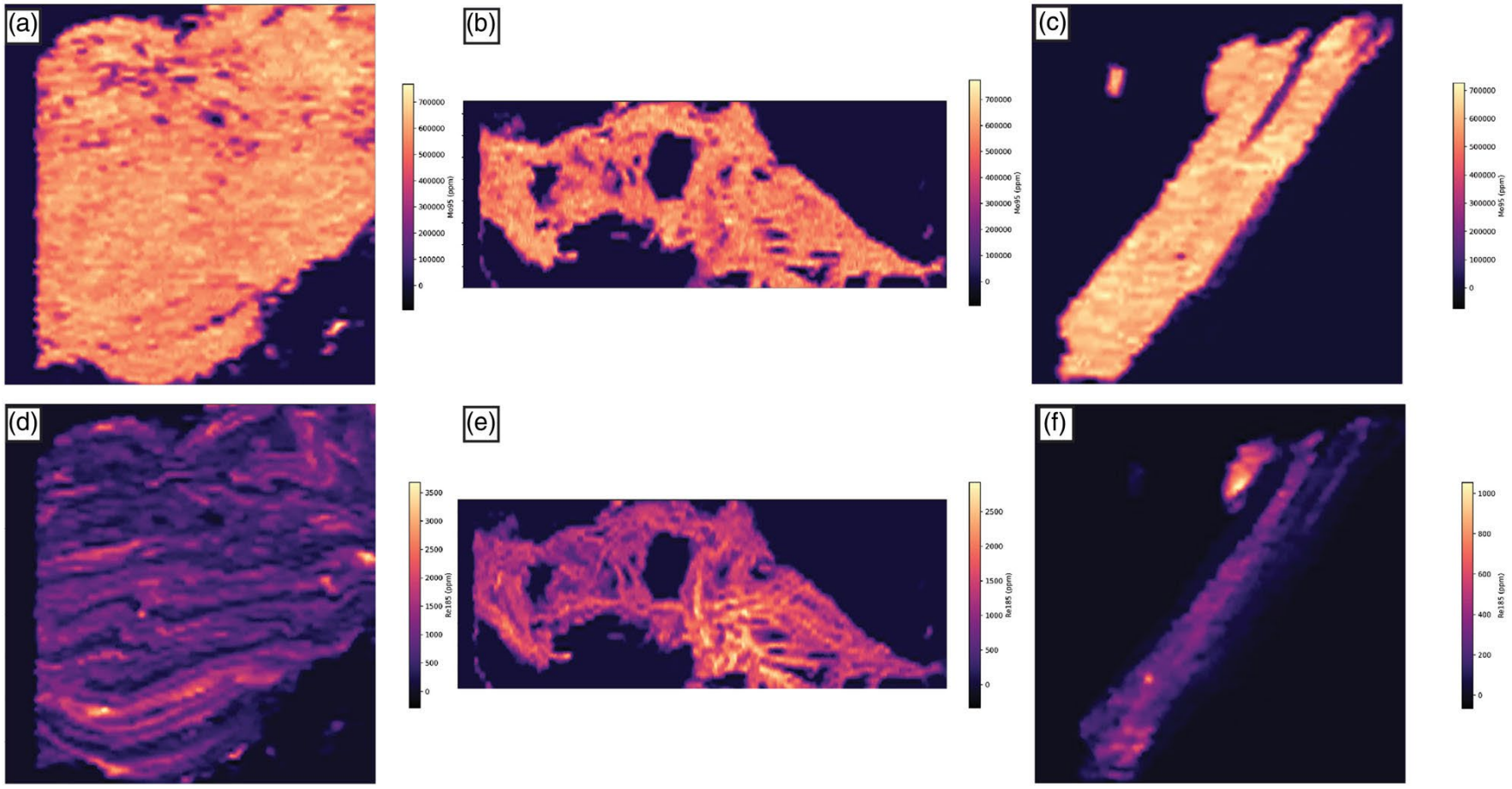
Geochronology in a Regional Framework

- The KHB-QMP and Two-Thirty porphyry pre-date mineralisation at Northparkes
- Emplacement of KHB-QMP similar timing to the BQM at E26
- Molybdenite dates from E26, E48, and E44 indicate similar mineralisation timing
- Two phases of ore-formation are proposed at E44 based on the disparity between the Two-Thirty porphyry and molybdenite dates
- Molybdenite deposition timing broadly similar to Cadia East and Cadia Hill mineralisation
- Two age populations in zero porphyry



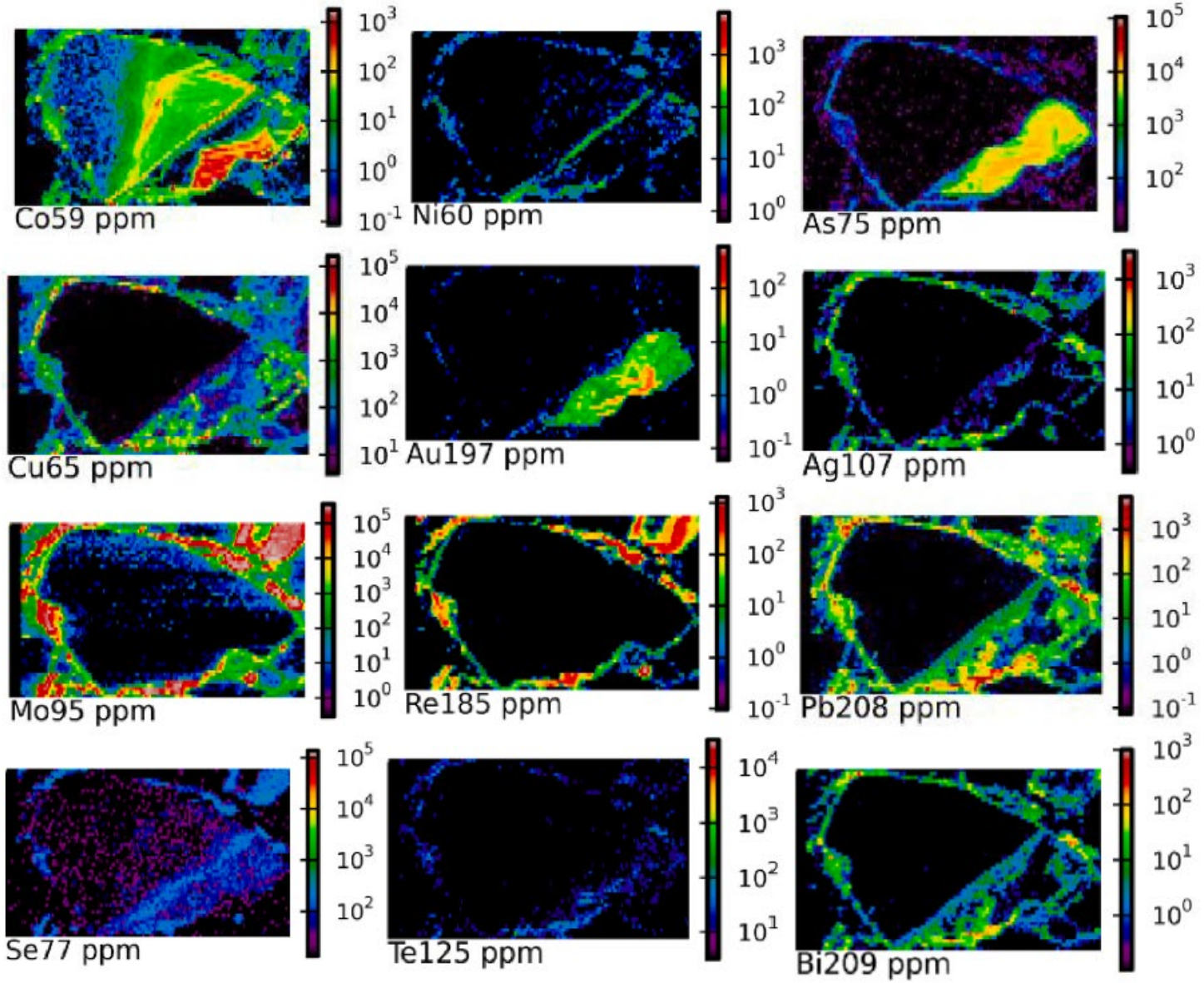
Distribution of Mo and Re in Molybdenite

- Two-Thirty molybdenite has the lowest Re ~ 280 ppm compared to ~1200 ppm at E48 and E27
- Re distribution is concentrically zoned from high in the core to low on the rim in molybdenite from E44
- Re from E48 has oscillatory variation due to the fibrous habit



Distribution of Pyrite Trace Elements

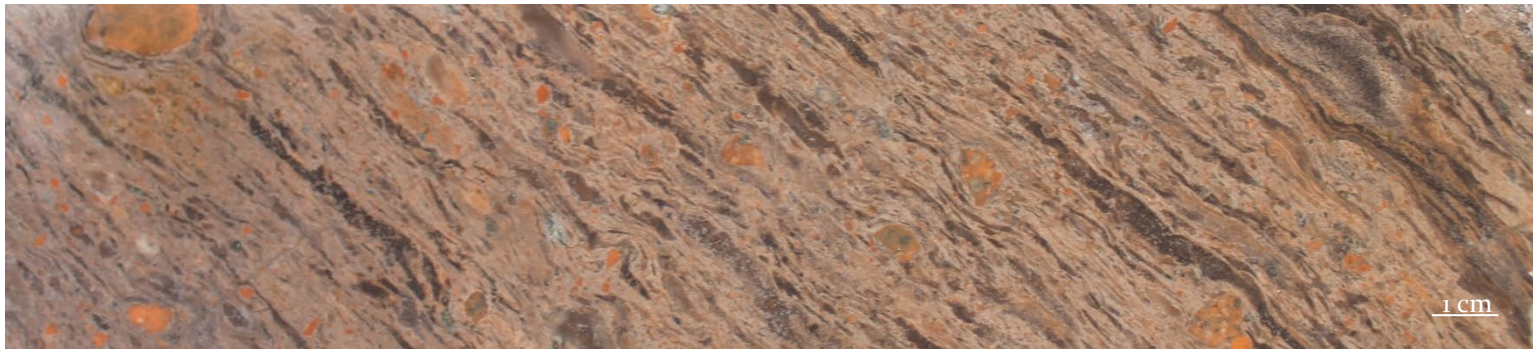
- Early high temperature Co rich core – porphyry related
- Au, and As + Co as part of a subsequent low-temperature epithermal overprint
- Cu an Mo mantle pyrite indicating late timing related to main stage mineralisation at Northparkes
- Multiple pulses of hydrothermal activity with different fluid sources



Steadman et al., (2021)

Conclusions

- Two-Thirty is a mineralised magmatic hydrothermal breccia complex, related to the 448 ± 4.4 Ma emplacement of the Two-Thirty porphyry
- Emplacement of syn-mineralisation porphyries pre-dates Northparkes porphyry systems
- Post-mineralisation dykes and molybdenite at Two-Thirty are coeval with Northparkes
- LA-ICPMS maps of sulfide indicate a complex paragenesis with multiple fluid sources
- Source of high grade, low – intermediate sulfidation mineralisation remains unresolved



Acknowledgements

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References

Arundell, M. C. (1998). *The geology and mineralisation of the E31 copper-gold prospect, Goonumbla, N.S.W. Unpub. Masters of Economic Geology*. University of Tasmania, 82 p.

Cooke, D. R., Wilson, A. J., House, M. J., Wolfe, R. C., Walshe, J. L., Lickfold, V., & Crawford, A. J. (2007). Alkalic porphyry Au – Cu and associated mineral deposits of the Ordovician to Early Silurian Macquarie Arc, New South Wales. *Australian Journal of Earth Sciences*, *54*(2–3), 445–463.

Heithersay, P. S., & Walshe, J. L. (1995). Endeavour 26 North; a porphyry copper-gold deposit in the Late Ordovician, shoshonitic Goonumbla volcanic complex, New South Wales, Australia. *Economic Geology*, *90*(6), 1506–1532. Jones, B. M. (1991). *Geological setting and genesis of the Endeavour 44 Au, Pb, Zn skarn, Parkes, NSW, B.Sc Honours*. Australian National University, 143 p.

Lickfold, V., Cooke, D. R., Smith, S. G., & Ullrich, T. D. (2003). Endeavour Copper-Gold Porphyry Deposits, Northparkes, New South Wales: Intrusive History and Fluid Evolution. *Economic Geology*, *98*(8), 1607–1636

Lickfold, V., Cooke, D. R., Crawford, A. J., & Fanning, C. M. (2007). Shoshonitic magmatism and the formation of the Northparkes porphyry Cu-Au deposits, New South Wales. *Australian Journal of Earth Sciences*, *54*(2–3), 417–444.
Rush, J. A. (2013). Geology of the Marsden Cu-Au Porphyry, NSW, Unpub. B.Sc Honours. University of Tasmania.

Simpson, C. J., Cas, R. A. F., & Arundell, M. C. (2005). Volcanic evolution of a long-lived Ordovician island-arc province in the Parkes region of the Lachlan Fold Belt, southeastern Australia. *Australian Journal of Earth Sciences*, *52*(6), 863–886.

Steadman, J. A., Large, R. R., Olin, P. H., Danyushevsky, L. v., Meffre, S., Huston, D., Fabris, A., Lisitsin, V., & Wells, T. J. (2021). Pyrite trace element behaviour in magmatic-hydrothermal environments: An LA-ICPMS imaging study. *Ore Geology Reviews*, *128*(July 2020), 103878.

Wells, T. J. (2016). *Geology and genesis of the Two-Thirty prospect, Northparkes, NSW; Unpub. BSc. Honours*.

Wells, T. J., Cooke, D. R., Baker, M. J., Zhang, L., Meffre, S., Steadman, J., Norman, M. D., & Hoye, J. L. (2021). Geology and geochronology of the Two-Thirty prospect, Northparkes district, NSW. *Australian Journal of Earth Sciences*, *68*(5), 659–683.

Wilson, A. J., Cooke, D. R., Stein, H. J., Fanning, C. M., Holliday, J. R., & Tedder, I. J. (2007). U-Pb and Re-Os geochronologic evidence for two alkalic porphyry ore-forming events in the Cadia District, New South Wales, Australia. *Economic Geology*, *102*(1), 3–26.

Zukowski, W. (2010). *Geology and Mineralisation of the Endeavour 41 Gold Deposit, Cowal District*, NSW, Australia; Unpub. PhD thesis. University of Tasmania.