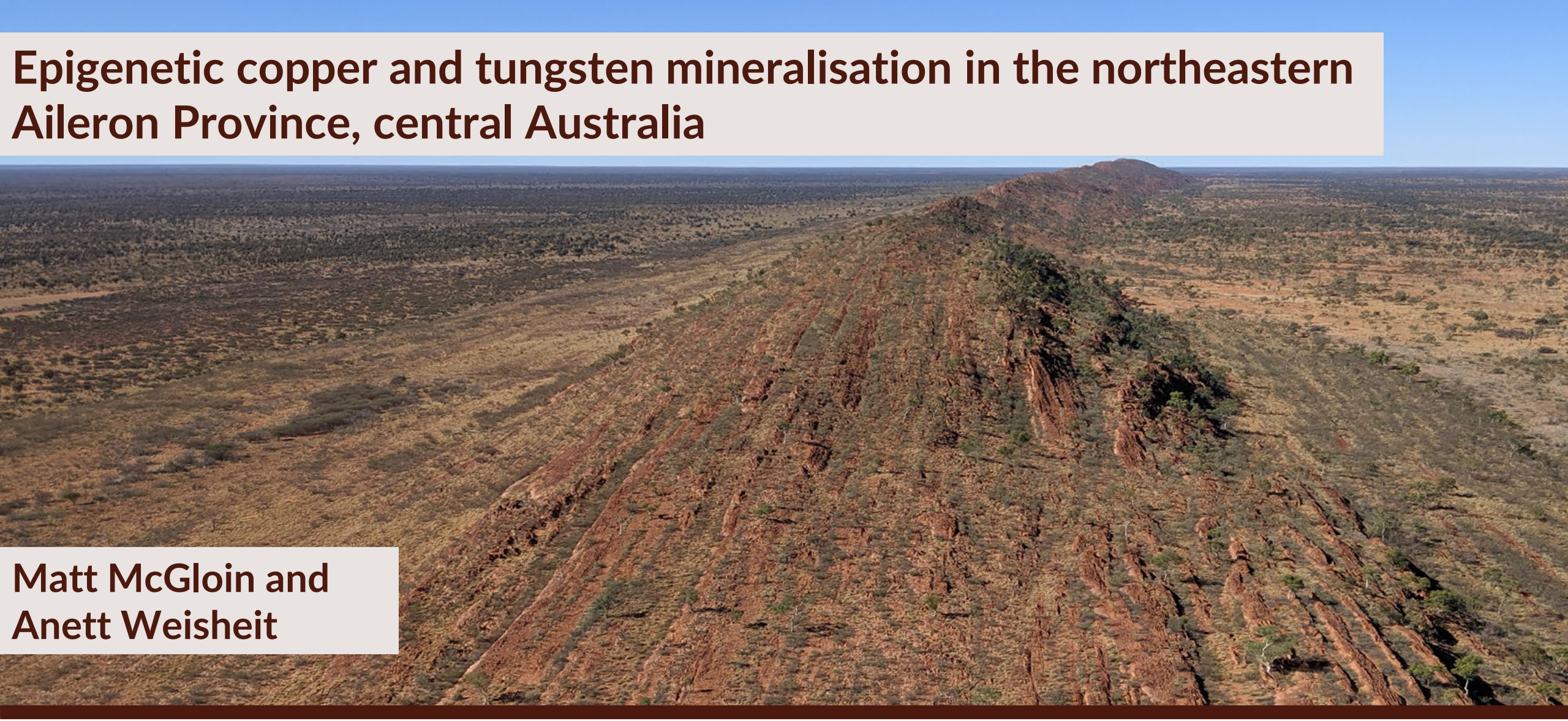
Epigenetic copper and tungsten mineralisation in the northeastern Aileron Province, central Australia

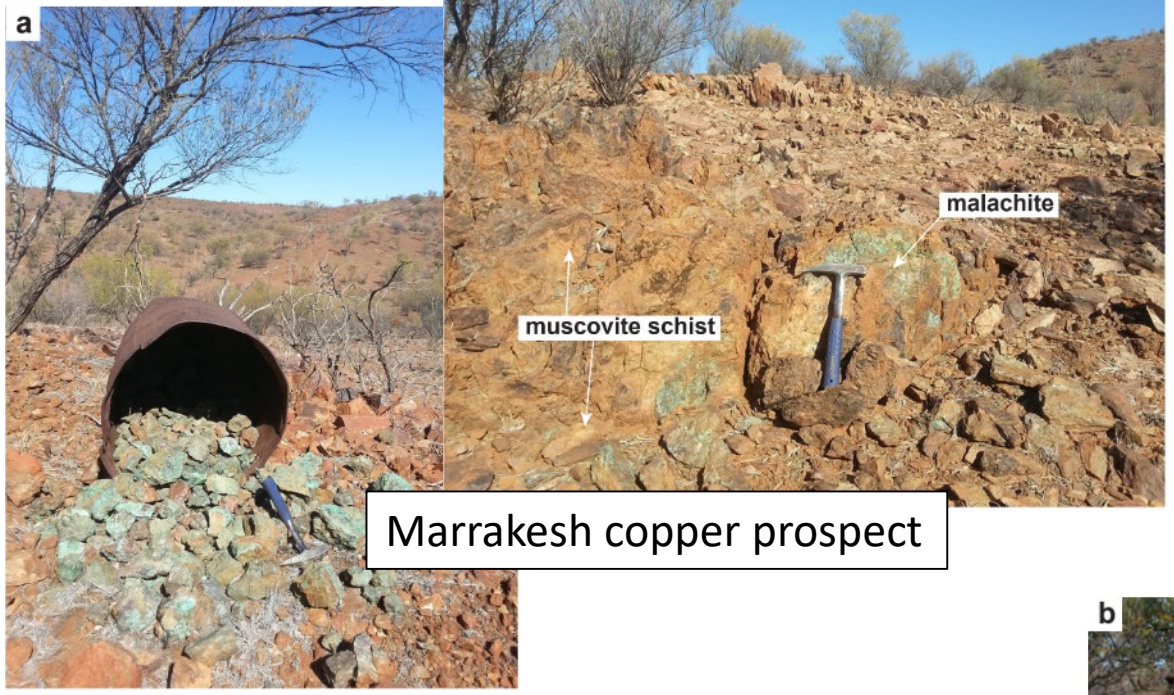


Matt McGloin and
Anett Weisheit

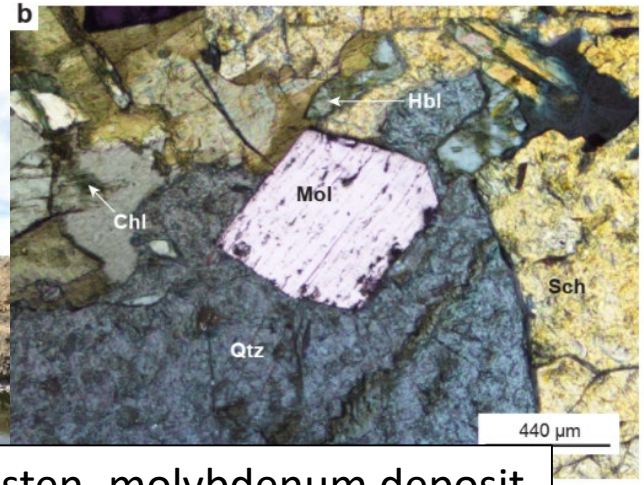
NORTHERN TERRITORY GOVERNMENT

NORTHERN TERRITORY GEOLOGICAL SURVEY
AGES2021
ANNUAL GEOSCIENCE EXPLORATION SEMINAR
20–21 April 2021, Alice Springs, Northern Territory

Epigenetic copper and tungsten mineralisation in the northeastern Aileron Province, central Australia



Marrakesh copper prospect

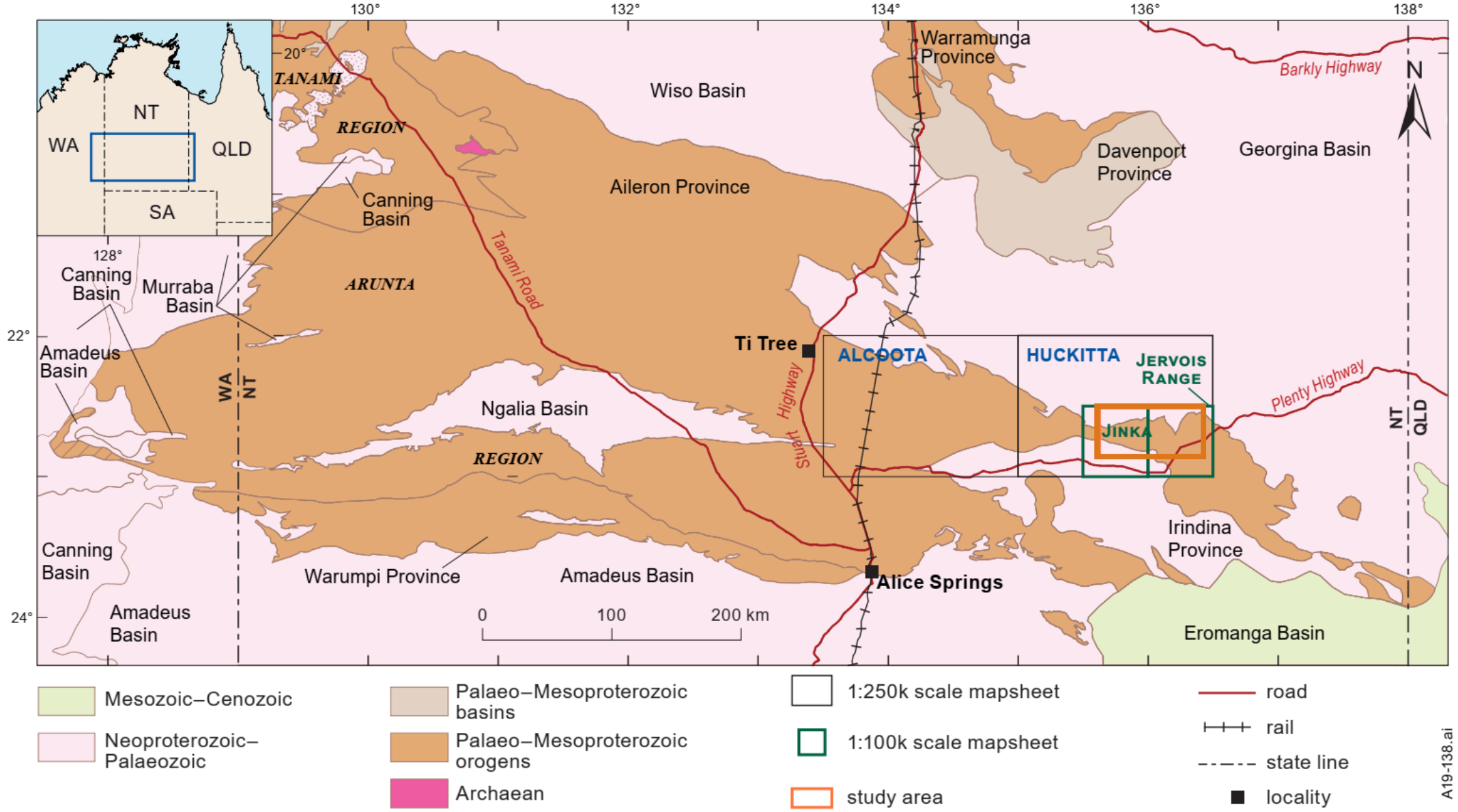


Molyhil tungsten–molybdenum deposit

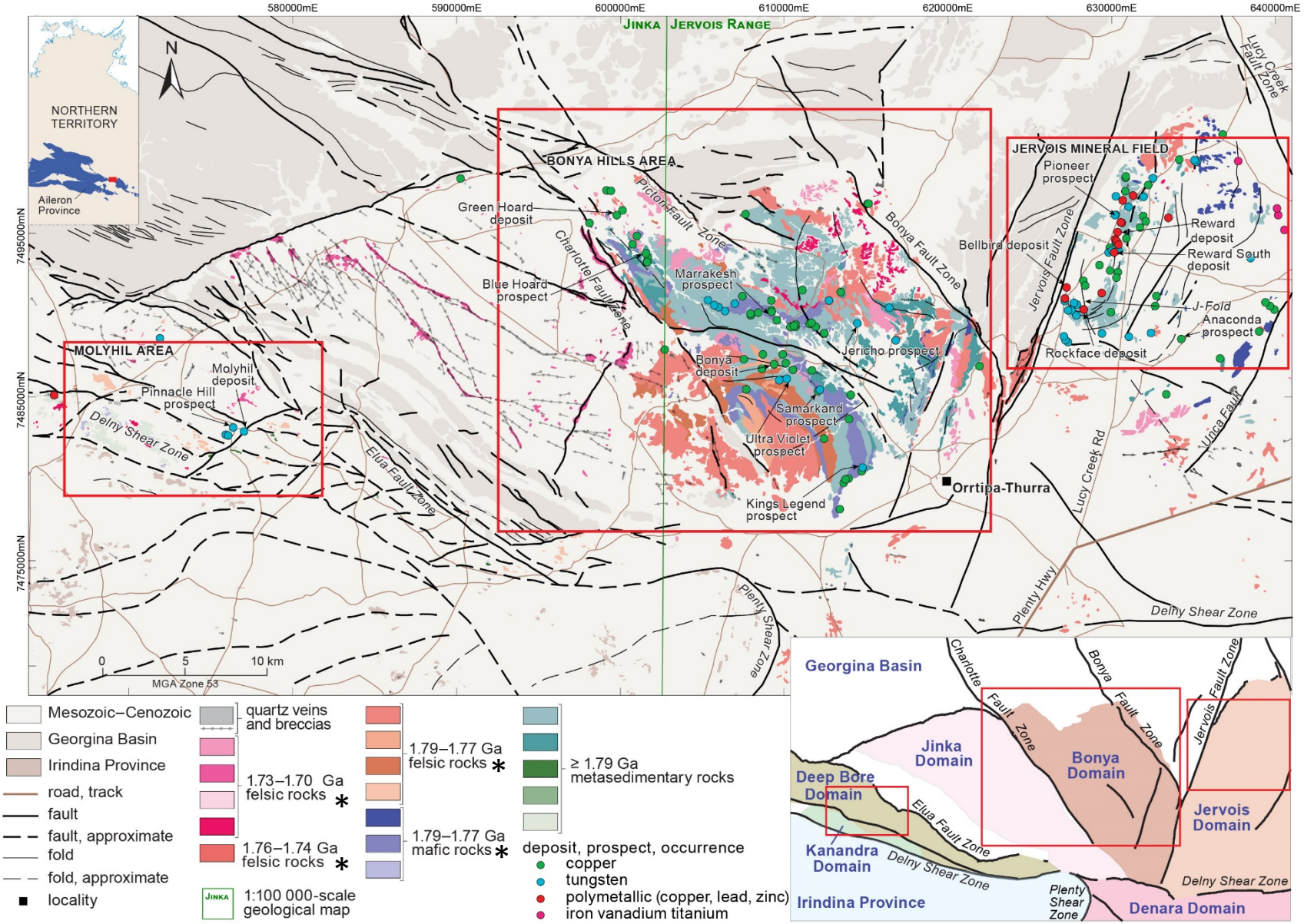
Bonya copper deposit

McGloin MV and Weisheit A, in prep. Epigenetic copper and tungsten mineralisation in the Aileron Province, central Australia: examples from Molyhil, Bonya Hills, and the Jervois mineral field. *Northern Territory Geological Survey, Record* 2021-0XX.

➢ Location of study area



➢ Location, aims, and methods



Epigenetic Cu and W mineralisation

As part of NTGS framework study

>130 Cu and W mineralisation were visited:

- Precise location
- Mineral assemblages
- Temporal and spatial relationship
- Geochemical character
- Sources of ore forming elements
- Mineralising processes

Two styles of mineralisation:

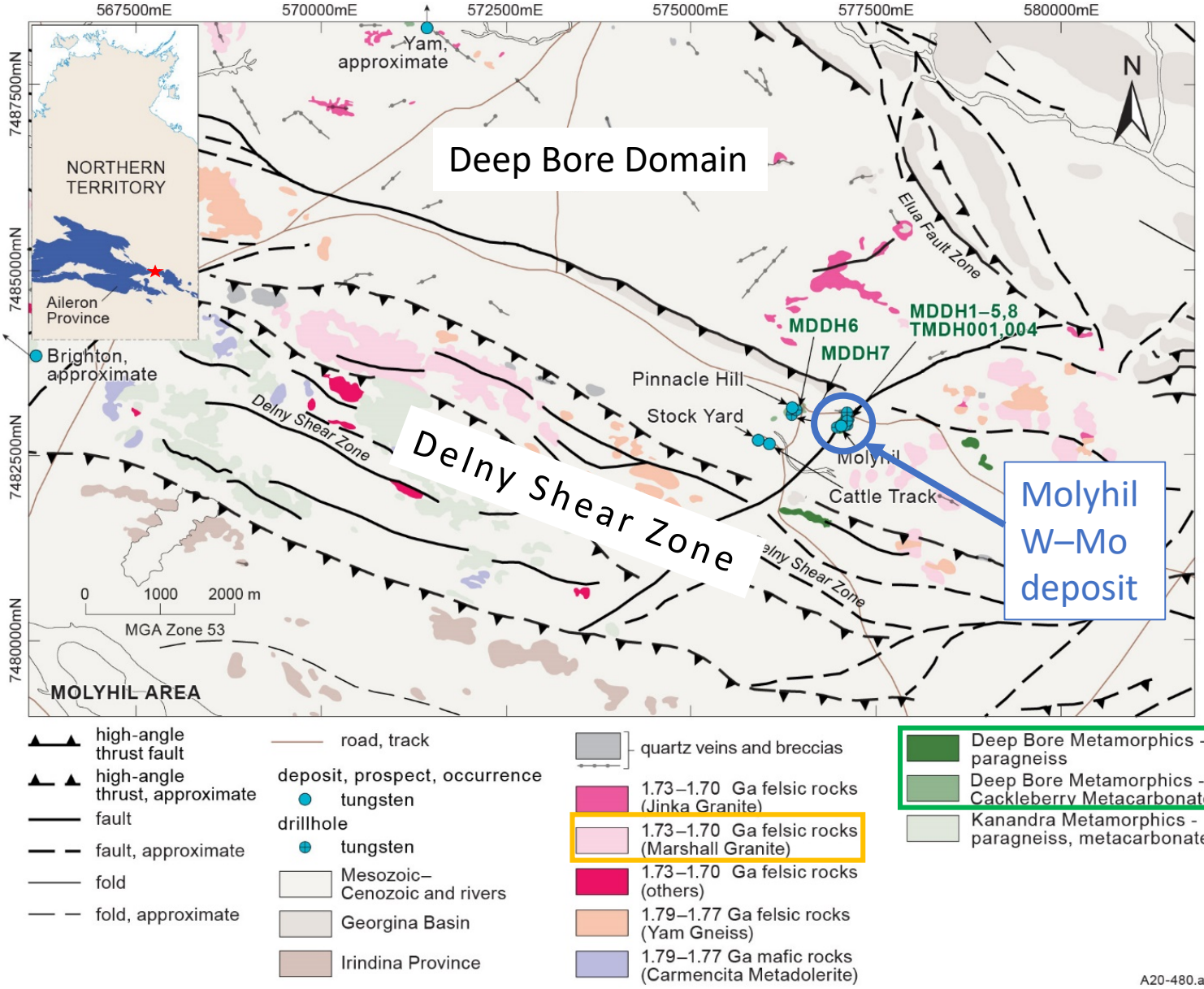
➢ Pre- to syn-tectonic, stratabound, syngenetic, polymetallic base metal mineralisation only in the Jervois mineral field

➢ Wide-spread post-tectonic, epigenetic Cu–W mineralisation spatially associated with meta-mafic and post-tectonic felsic rocks (this study)

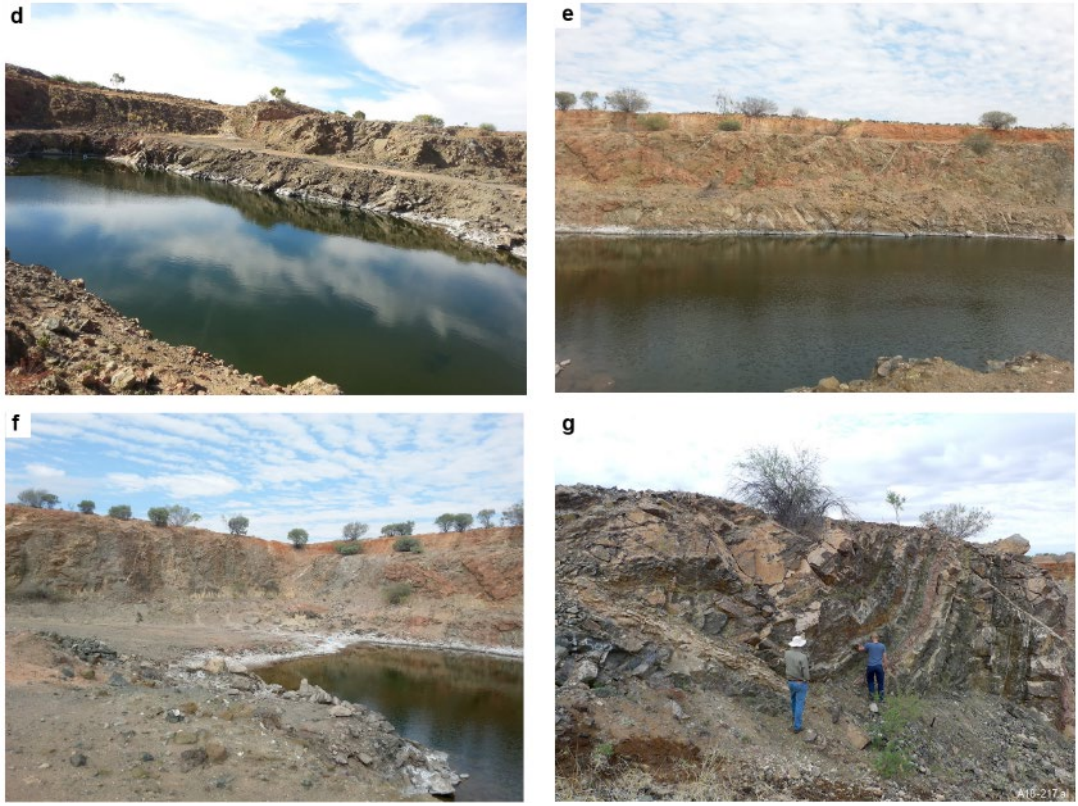
See last slide for list of references

*see **Beyer and Whelan, AGES2021**

➢ Molyhil W–Mo deposit: local geology

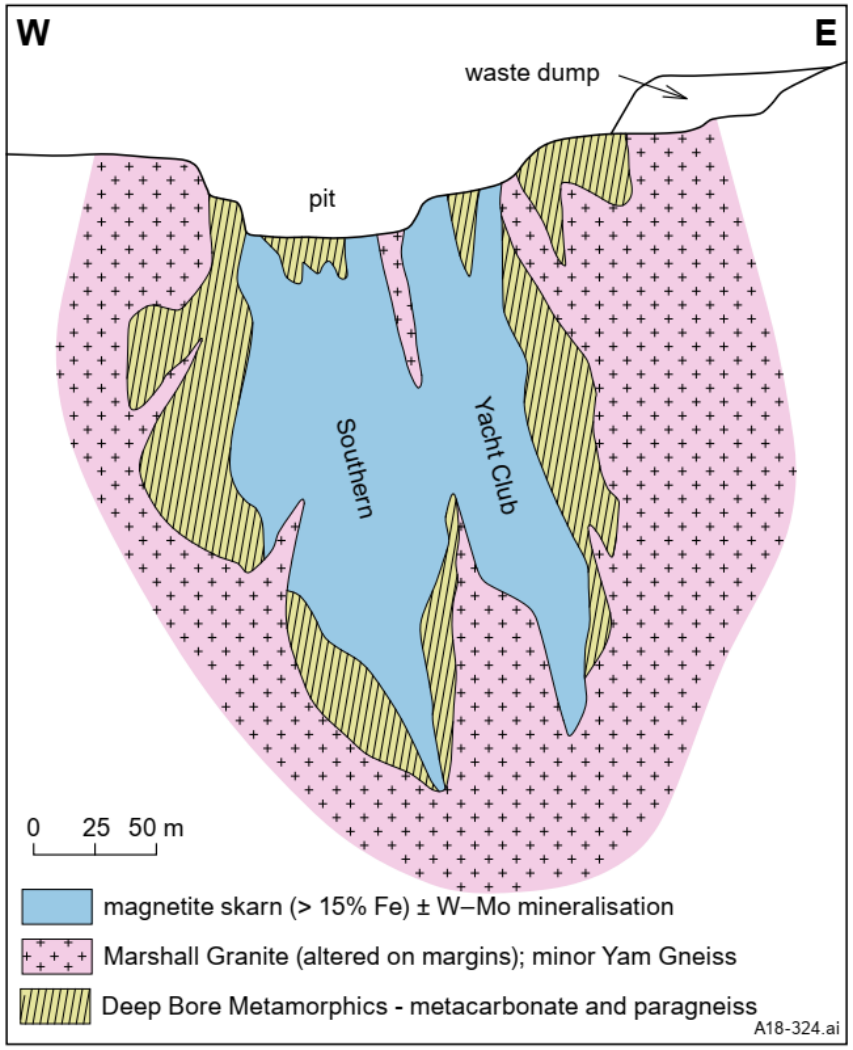


Epigenetic Cu and W mineralisation



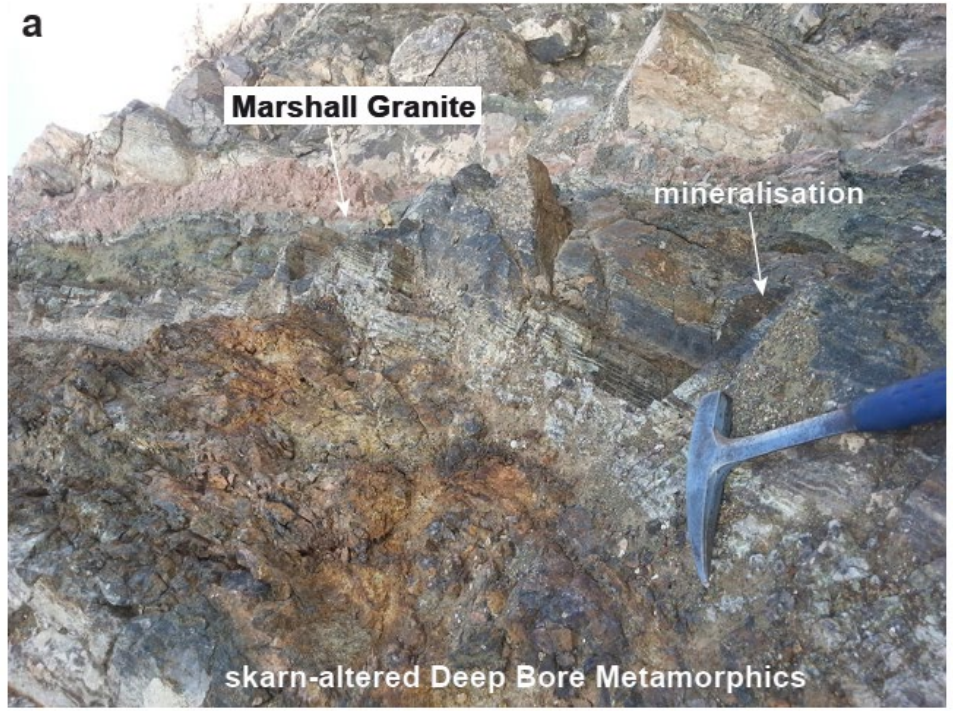
- North of the Delny Shear Zone in the Deep Bore Domain
- Two N–S-trending bodies (Yacht Club and Southern) exposed in 10 m deep pit
- Mineralisation at contact between ca 1.79 Ga metacarbonate rocks, paragneiss, and ca 1.73–1.72 Ga Marshall Granite (endoskarn, exoskarn)

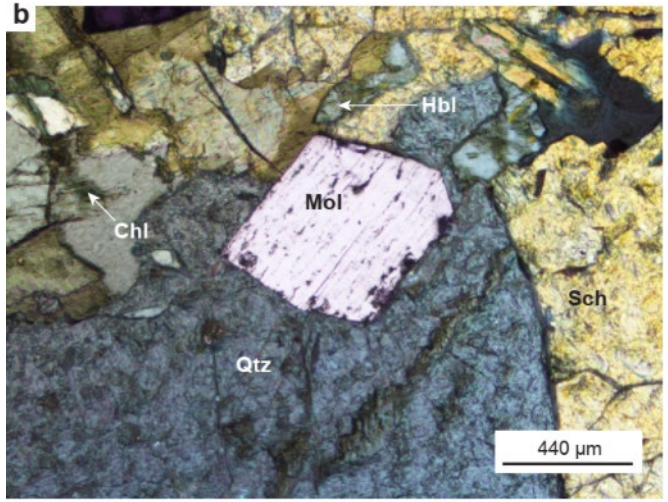
➢ Molyhil W–Mo deposit: mineralisation

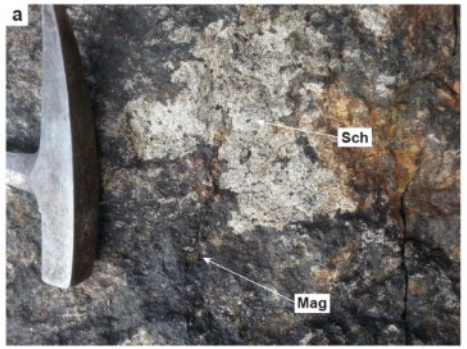


adapted from: McGloin MV and Bradey RS, 2017. Molyhil tungsten–molybdenum deposit: in Phillips NP (editor). *'Australian Ore Deposits'. AusIMM Monograph* 32, 565–566.

Epigenetic Cu and W mineralisation





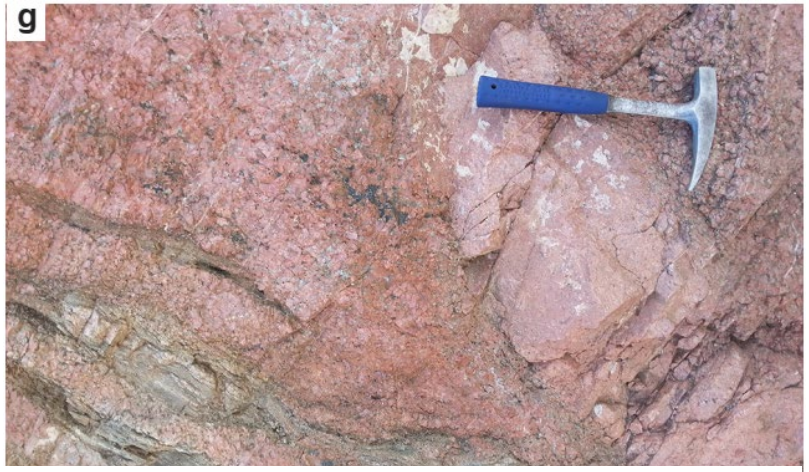


- massive and disseminated scheelite, powellite, and molybdenite together with magnetite; minor pyrite, pyrrhotite, chalcopyrite
- Gradational iron-alteration associated with Marshall Granite (iron-skarn, andraditic hornfels)
- Muscovitisation, chloritisation, K-feldspar–quartz alteration

→ oxidised, weakly acidic (pH ~5–6), high-T (≥400°C) ore-forming fluids

➢ Molyhil W–Mo deposit: age

Epigenetic Cu and W mineralisation



Deformed phase of Marshall Granite: 1732±4 Ma (ICP–MS U–Pb apatite)

Reno BL, McGloin MV, Thompson JM and Meffre S, in prep. Summary of results. Laser ablation ICP–MS in situ apatite geochronology of the Molyhil tungsten–molybdenum deposit and Prospect D. *Northern Territory Geological Survey, Record*.

Re–Os dating molybdenite model age: 1721 ± 8 Ma

Cross A, 2009. *SHRIMP U–Pb xenotime geochronology and its application to dating mineralisation, sediment deposition and metamorphism.* PhD thesis, Australian National University, Canberra.

^{40}Ar–^{39}Ar hornblende cooling below 480°C: 1702 ± 5 Ma for a sample from molybdenite-mineralised skarn (see **Reno *et al*, AGES2021**)

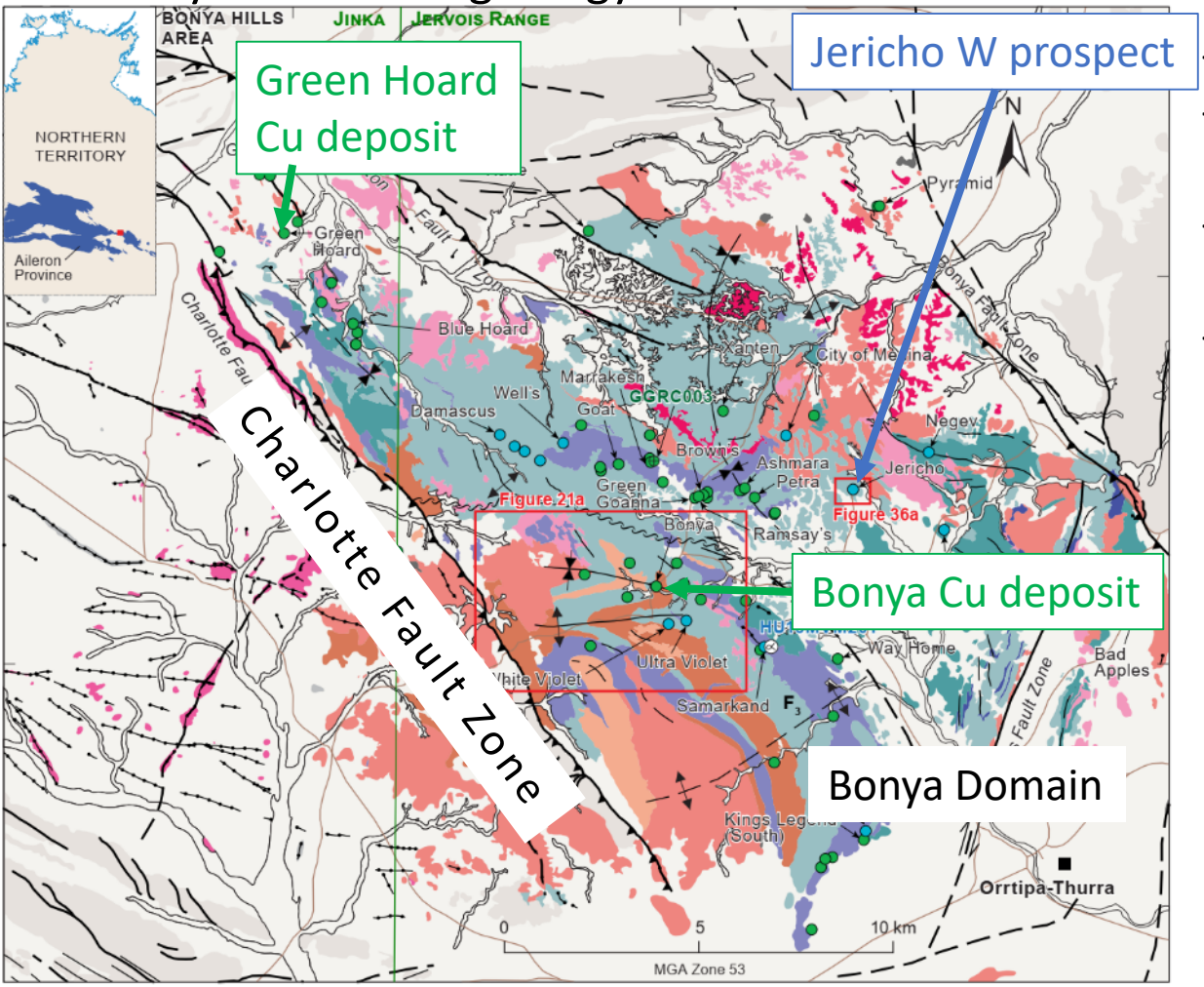
Reno BL and Fraser GL, 2021. Summary of results. Joint NTGS–GA geochronology project: Constraining cooling and deformation in the eastern Aileron Province through 40Ar/39Ar step-heating of hornblende, muscovite, and biotite. *Northern Territory Geological Survey, Record* 2021-001.

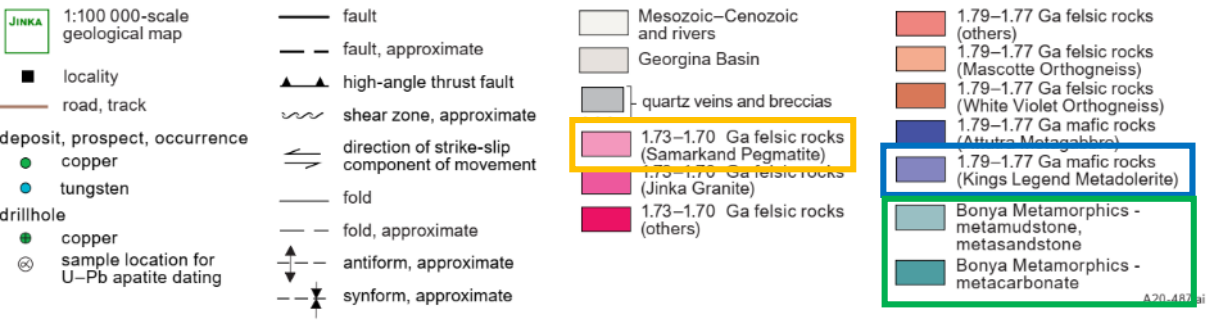
→ mineralisation formed between ca 1.72–1.70 Ga

Undeformed aplite dyke of Marshall Granite: 1720±18 Ma (SHRIMP U–Pb zircon)

Kositcin N, McGloin MV, Beyer EE, Reno BL and Weisheit A, 2018a. Summary of results. Joint NTGS–GA geochronology project: Base metal and tungsten mineralisation, and skarn alteration in the Aileron Province, July 2017–June 2018. *Northern Territory Geological Survey, Record 2018-009*.

➢ Bonya Hills: local geology



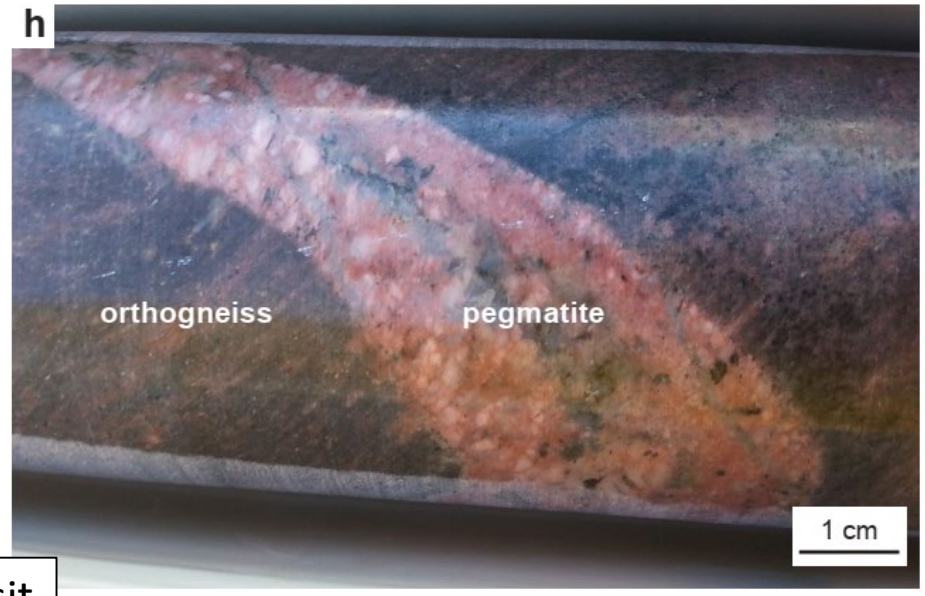


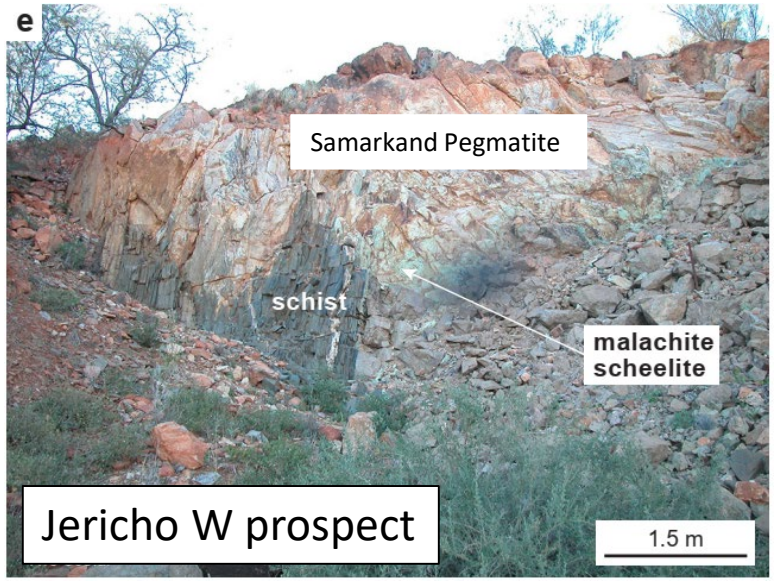
- East of the Charlotte Fault Zone in the Bonya Domain
- Over 60 deposits/prospects of vein-hosted Cu mineralisation and skarn-hosted W mineralisation
- Hosted in ca 1.79 Ga Bonya Metamorphics and felsic igneous rocks
- Commonly in the hinge of F_3 folds and proximal to outcrops of ca 1.79 Ga Kings Legend Metadolerite and ca 1.73–1.70 Ga tourmaline-bearing dykes and quartz-veins of Samarkand Pegmatite

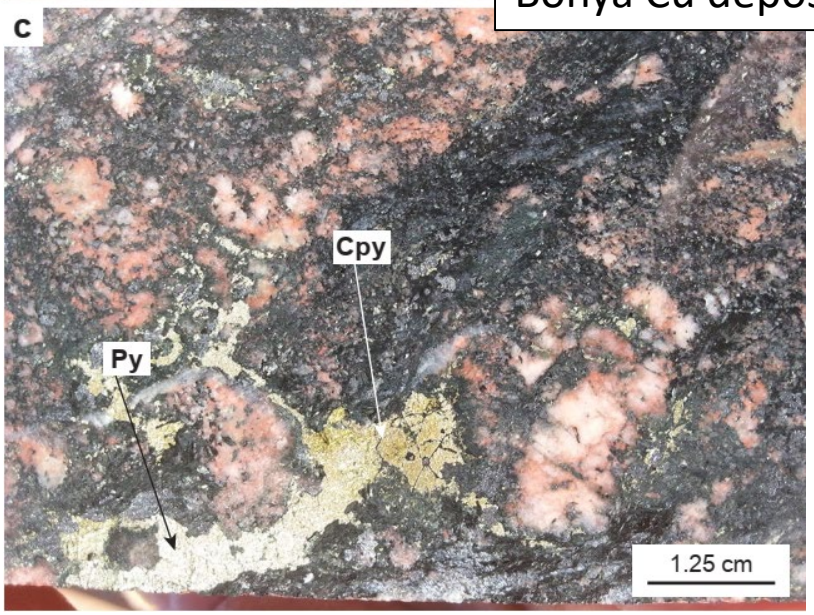
➢ Bonya Hills: mineralisation

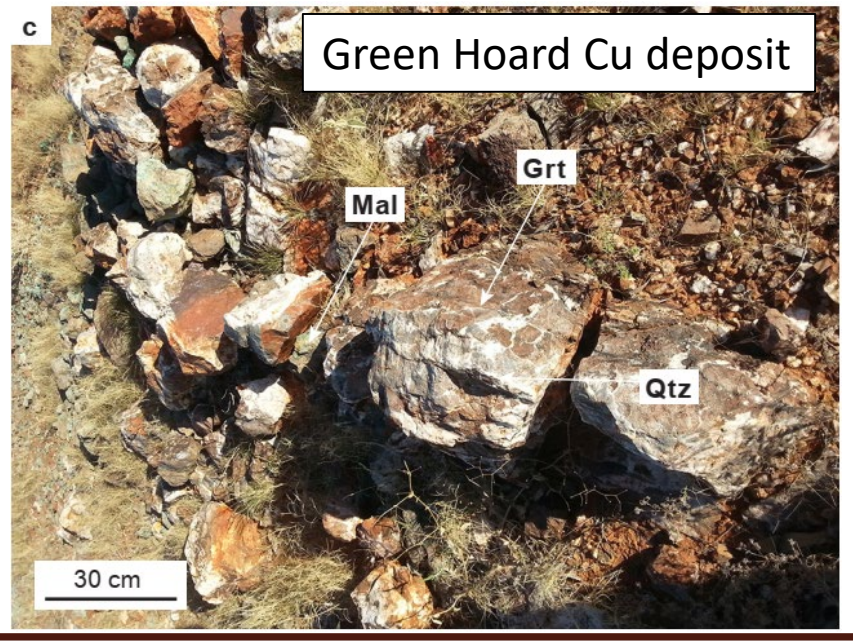
Epigenetic Cu and W mineralisation

Bonya Cu deposit





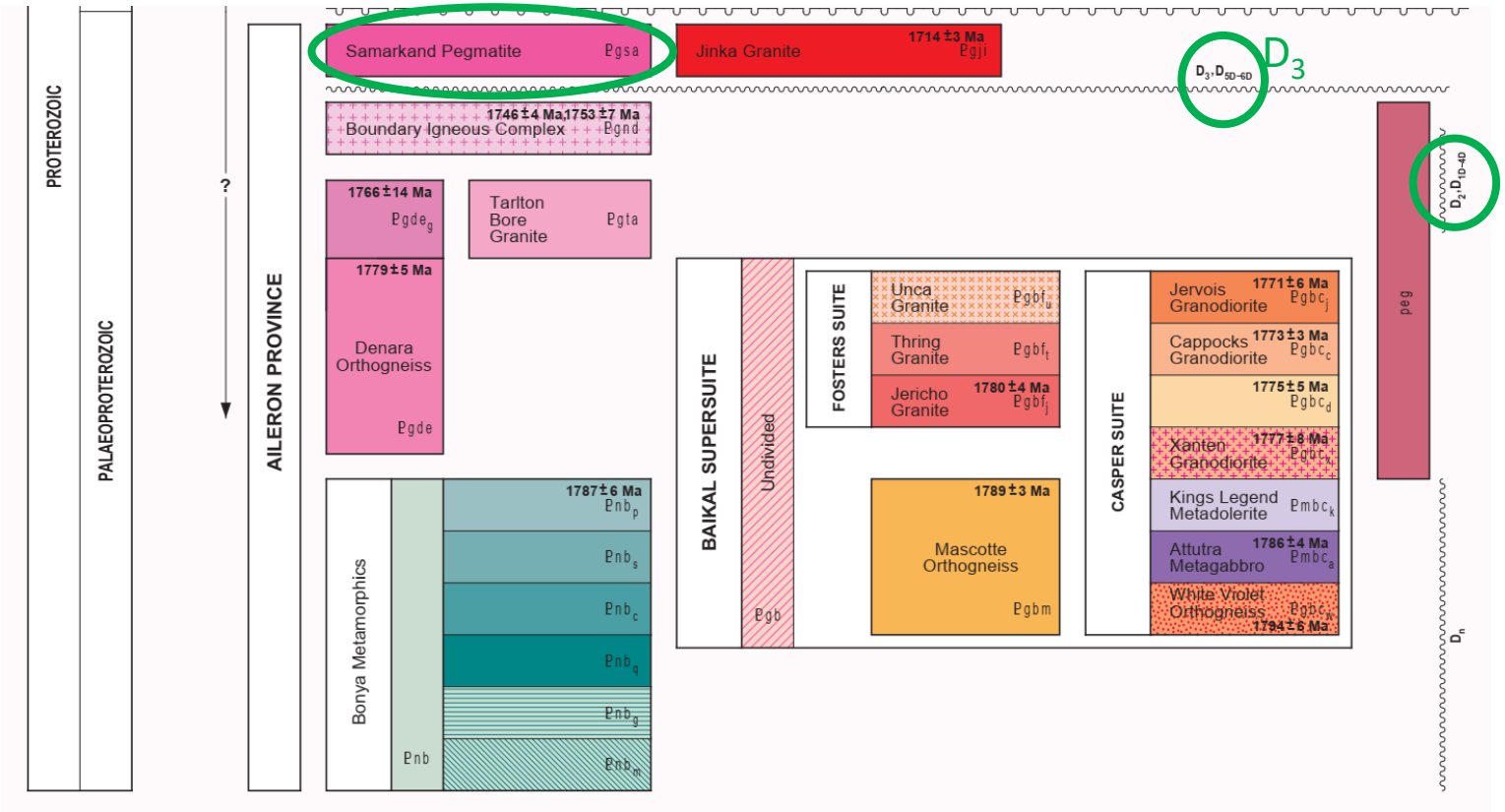




- Mineralisation: in and at quartz-veins, stockworks, pegmatites (malachite, scheelite, powellite, chrysocolla, azurite, hematite; chalcopyrite, pyrite)
- Alteration at veins: quartz, tourmaline, garnet, epidote, chlorite
- Skarn alteration: quartz, epidote, clinopyroxene, garnet, vesuvianite, actinolite, calcite, minor wollastonite

→ Brittle conditions; magmatic-hydrothermal fluids ≥300°C, oxidised, weakly acidic and saline

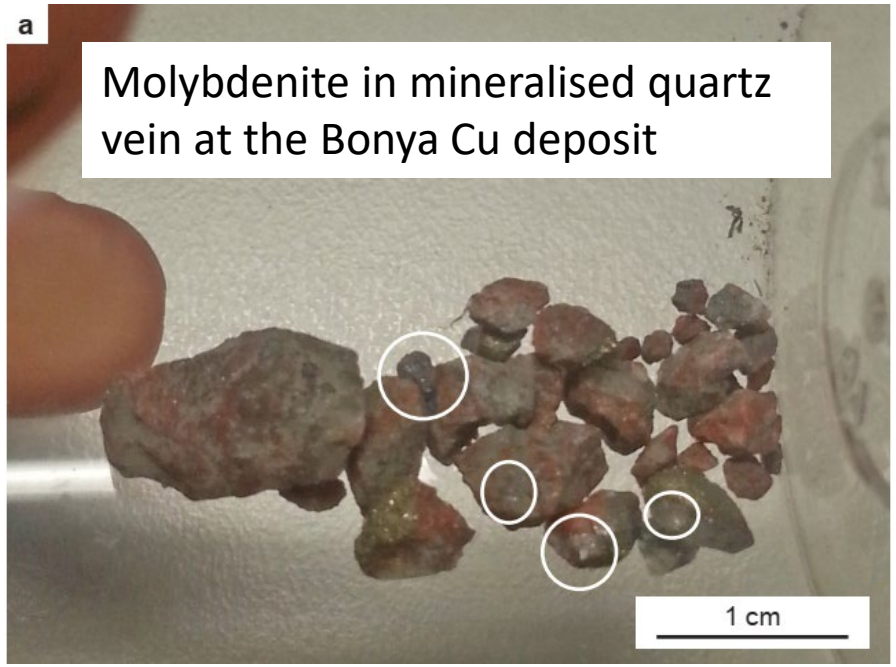
➢ Bonya Hills: age



Reno BL, Weisheit A, Beyer EE, Whelan JA and Kraus S, 2019. *Jervois Range Special, Northern Territory (First Edition). 1:100 000 geological map series, 6152*. Northern Territory Geological Survey, Darwin.

- Post-dates ca 1.75 Ga main foliation S_2 and asymmetric folds F_3
- Associated with veins and dykes of ca 1.7 Ga Samarkand Pegmatite

McGloin MV, Whelan JA, Reno BL, Beyer EE, Weisheit A, Thompson JM, Meffre S and Zhukova I, 2018. Summary of results. NTGS LA–ICP–MS geochronology project: Jervois mineral field, Bonya Hills and Jinka Plain in HUCKITTA, Aileron Province, May 2014–December 2015. *Northern Territory Geological Survey, Record* 2018–012.



Re–Os molybdenite isotopic age:
1726±8 Ma (this study)

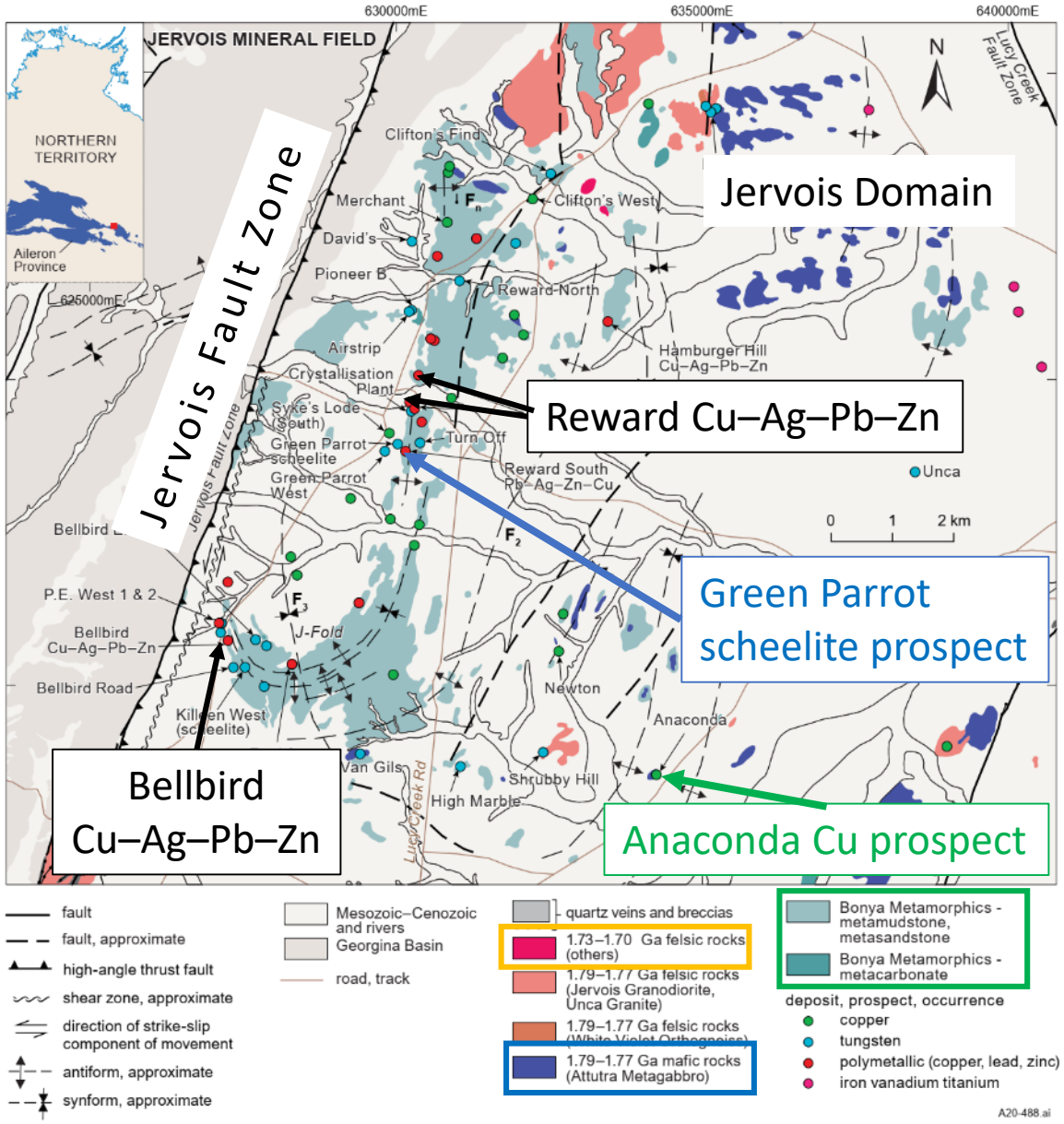
→ mineralisation formed at/after ca 1.73 Ga

Epigenetic Cu and W mineralisation

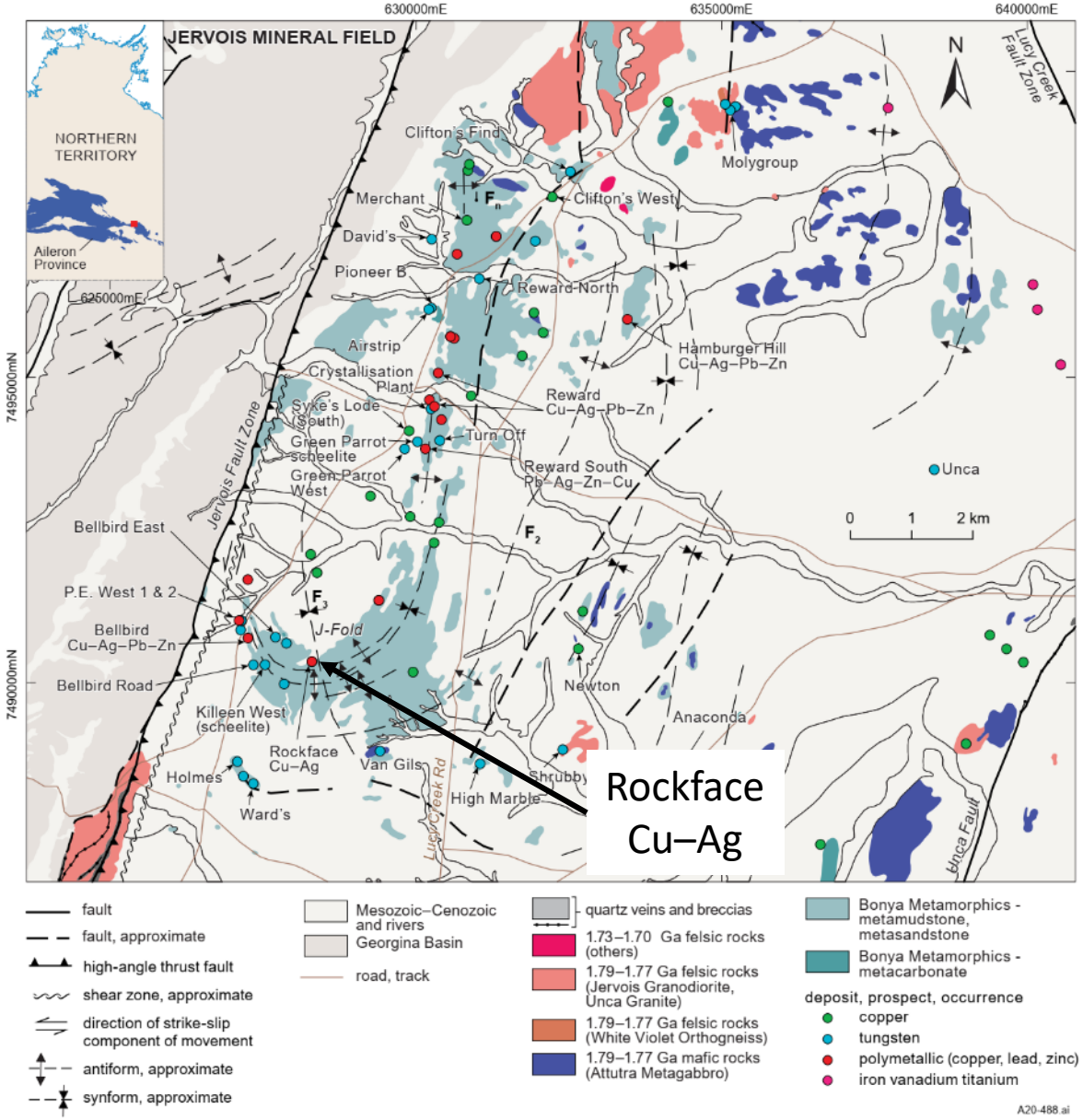
- Sparse epigenetic Cu- and W-mineralisation similar in style to that in the Bonya Hills
- hosted in ca 1.79 Ga Bonya Metamorphics and associated with ca 1.79 Ga Attutra Metagabbro and ca 1.73–1.70 Ga Samarkand Pegmatite
- Post-deformational, concentrated in F_3 hinge zones

→ mineralisation possibly at 1.73–1.70 Ga

- Spatial overlap with pre- and syn-deformational polymetallic base-metal mineralisation (see **Morgan, AGES2021**)



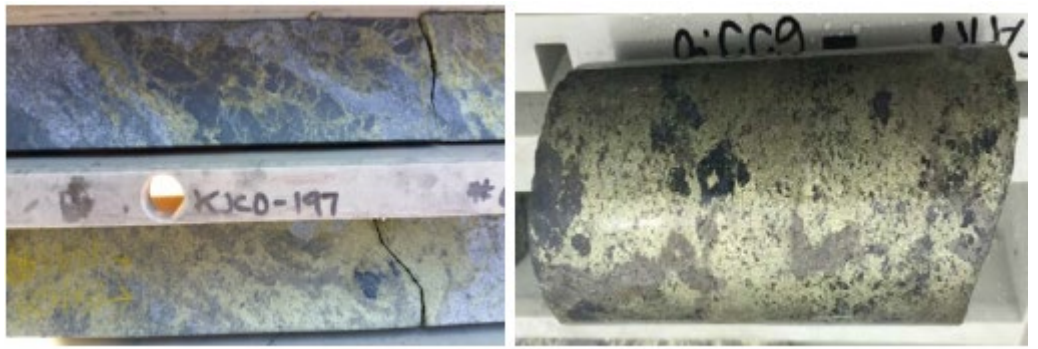
➢ Hybrid deposits – Rockface in the Jervois mineral field



Epigenetic Cu and W mineralisation

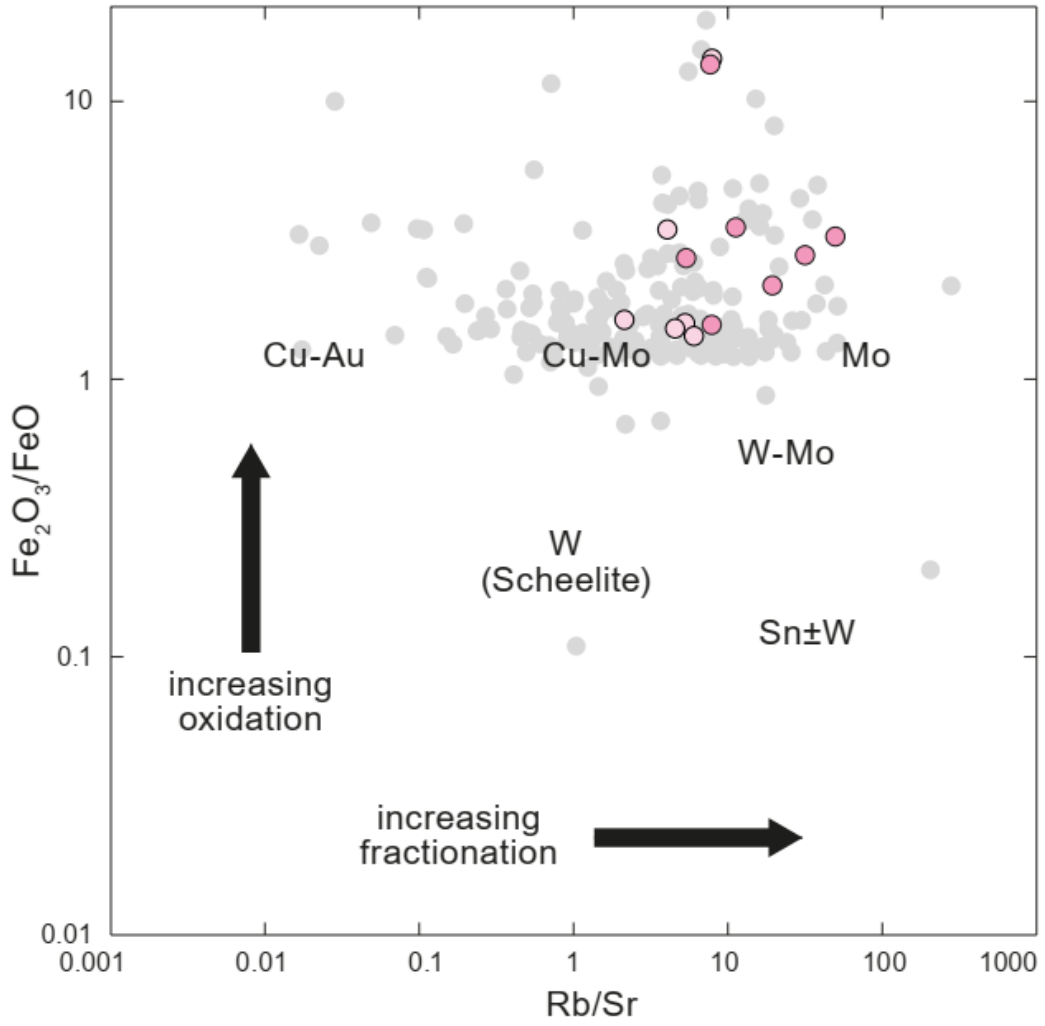
- Cu–Ag mineralisation crosscuts S_2 foliation and is concentrated in hinge of F_3 J-Fold
- Unusual massive magnetite–chlorite alteration possibly indicating Cu-rich epigenetic fluids interacted with garnet–biotite-rich meta-exhalites

garnet–biotite → magnetite–chlorite–biotite



magnetite–chalcopyrite–pyrite–quartz → chalcopyrite–pyrite

➢ Felsic igneous source rocks



Ca 1.73–1.70 Ga Marshall Granite & Samarkand Pegmatite:

- weakly peraluminous
- oxidised
- fractionated

→ support active sourcing of W, Mo (Au, U, and S)

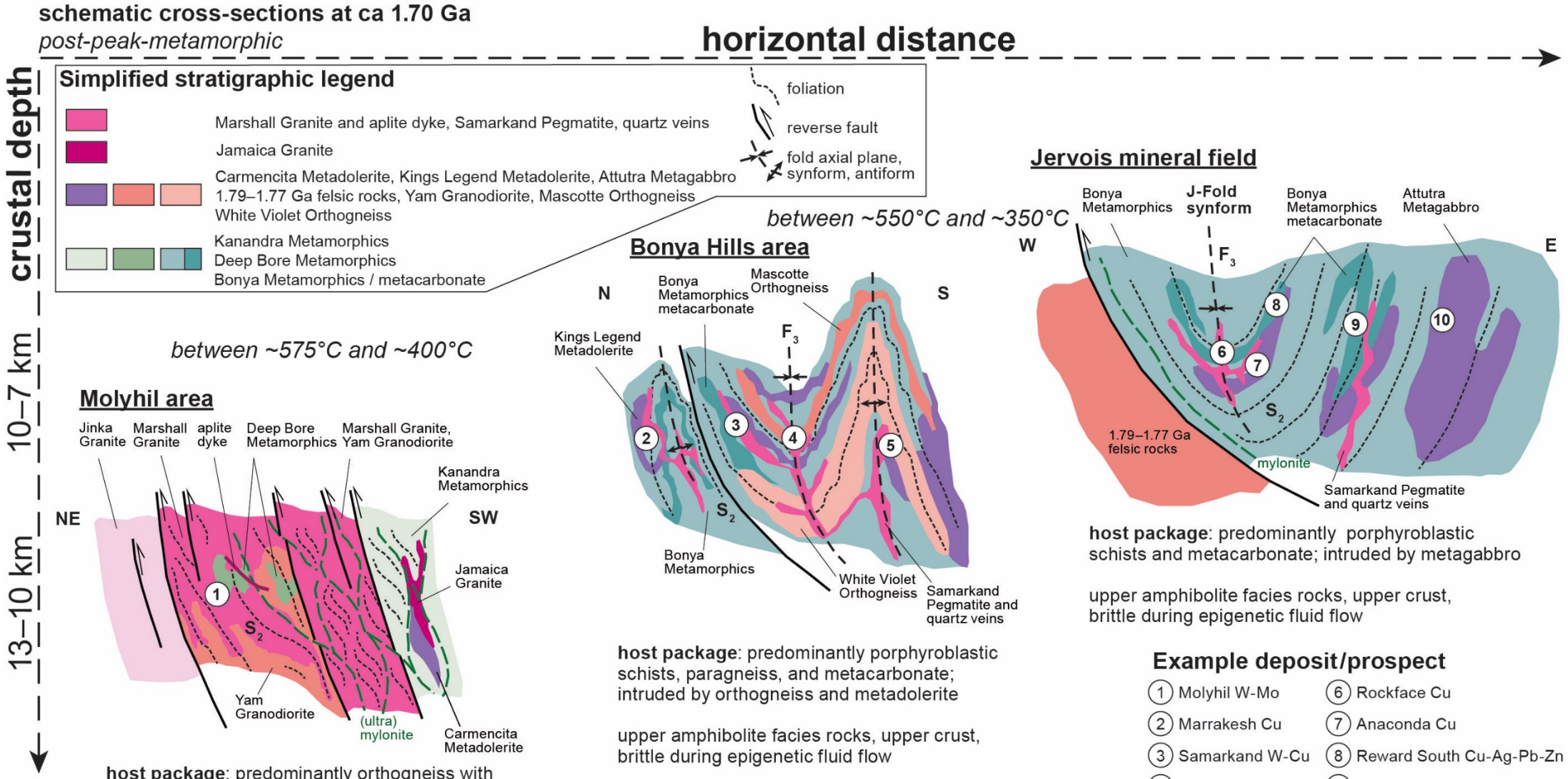
→ support exolution of highly-saline, magmatic-hydrothermal fluids that can leach and transport Cu, S, Se, Bi, Fe e.g. from mafic country rocks (ie ca 1.79 Ga Attutra Metagabbro and Kings Legend Metadolerite)

→ fluid focussing and mineralisation:

- chemical traps (e.g. metacarbonate rocks)
- structural traps (e.g. S_2 foliation, F_3 fold hinges)
- cooling and decompression

→ mineralisation potential for similar settings throughout the Aileron Province (e.g. in ALCOOTA) and in nearby provinces (e.g. Davenport and Warramunga provinces): **see eg McGloin, AGES2017; Farias et al, AGES2021; Beyer and Whelan, AGES2021**

Model of formation of epigentic Cu–W mineral systems in the northeastern Aileron Province



Epigenetic copper and tungsten mineralisation in the northeastern Aileron Province, central Australia

Selected references of local and regional mineralisation studies

- Barraclough D, 1979. Geological investigations at the Molyhil scheelite mine, central Australia. *Northern Territory Geological Survey, Technical Report* GS1979-016.
- Dobos S, 1978. *Phase relations, element distributions and geochemistry of metamorphic rocks from eastern Arunta Block, NT*. PhD Thesis, Macquarie University, Sydney.
- Freeman MJ, 1990. Molyhil scheelite–molybdenite deposit. *Australian Institute of Mining Engineers Monograph* 16, 875–877.
- Huston DL, Maidment D and Hussey K, 2006. Regional geology and metallogeny of the eastern Aileron and Irindina Provinces: a field guide. *Geoscience Australia, Record* 2006/13.
- Johannsen LA, 1971. Reports on AP 3113 Bonya Plains. *Northern Territory Geological Survey, Open File Company Report* CR1971-0175
- Mackie AM, 2005. EL 2239 Molyhil Huckitta 1:250K map sheet, Third Annual Report, *Northern Territory Geological Survey, Open File Company Report* CR2005-248
- Mason H, 1978. Annual Report for E.L.1727 (West Molyhil), Huckitta, Northern Territory. Anaconda Australia Inc. Report IR F53/11/3 (1). *Northern Territory Geological Survey, Open File Company Report* CR1979-065
- McGloin MV and Bradey RS, 2017. Molyhil tungsten–molybdenum deposit: in Phillips NP (editor). '*Australian Ore Deposits*'. *AusIMM Monograph* 32, 565–566
- Price LA, 1996. Final report on exploration activities for exploration licences (ELS) 6993 Bonya Creek, 7287 Mt Cornish and 7505 Twins Bore for the period 09/11/90 to 02/01/96, Eastern Arunta Project. Normandy Exploration Limited, Report Number 20267. *Northern Territory Geological Survey, Open File Company Report* CR1996-0283.
- Raith JG, Riemer N and Meisel T, 2004. Boron metasomatism and behaviour of rare earth elements during formation of tourmaline rocks in the eastern Arunta Inlier, central Australia. *Contributions to Mineralogy and Petrology* 147, 91–109.
- Ransom DM, 1978. The scheelite prospects of the Jervois Range, Bonya Creek and Molyhil areas. *Northern Territory Geological Survey, Open File Company Report* CR1978-0186
- Riemer S, 2000. *Petrology and geochemistry of scheelite-bearing calc-silicate rocks, Bonya Block, Arunta Inlier, central Australia.* Masters Thesis, Institute of Geological Sciences, University of Leoben, Austria
- Schmid S and Schaubs P, 2015. The Jervois Cu-Pb-Zn deposit–A hybrid SEDEX–VMS mineralizing system, Northern Territory, Australia. Poster P082: in '*SEG 2015: World-Class Ore Deposits: Discovery to Recovery; 27–30 September 2015; Hobart, Tasmania, Australia.*' Society of Economic Geologists

  Schöner N, 2000. *Tourmalinisation associated with strata-bound scheelite mineralisation, Bonya Block, Arunta Inlier, central Australia*. Masters Thesis, Institute of Geological Sciences, University of Leoben, Austria.
- Shaw RD, Warren RG, Offe LA, Freeman MJ and Horsfall CL, 1984. Geology of Arunta Block in the southern part of the Huckitta 1: 250 000 sheet area – Preliminary data, 1980 survey. *Bureau of Mineral Resources, Geology and Geophysics, Record* 1984/3.
- Stewart AJ and Warren RG, 1977. The mineral potential of the Arunta block, central Australia. *Bureau of Mineral Resources Journal of Australian Geology and Geophysics* 2, 21–34.
- Warren RG, Stewart AJ and Shaw RD, 1974. Summary of information on mineral deposits of the Arunta Complex, Alice Springs area, NT. *Bureau of Mineral Resources, Geology and Geophysics, Record* 1974/117, 55p.
- Warren RG 1980. The Arunta Block in the Huckitta 1:250 000 Sheet area: a review of data to June 1980. *Bureau of Mineral Resources, Geology and Geophysics, Record* 1980/045.
- Watson DP, 1972. The Attutra copper lead and scheelite deposits, Jervois Range, Northern Territory, Petrocarb Exploration NL. *Northern Territory Geological Survey, Open File Company Report* CR1973-033.
- Watson DP, 1975. Attutra copper lead and scheelite zone, Jervois Range: in Knight CL (editor). '*Economic Geology of Australia and Papua New Guinea*'. *Australasian Institute of Mining and Metallurgy. Monograph Series* 1(1), 447–449.
- Ypma PJ, Boorder HD, Gils V, Kehrens P, Ormsby W, and Peters M, 1984. *Geology and mineralisation of the Jervois range, NT.* Darwin Conference 1984, Australasian Institute of Mining and Metallurgy, Melbourne, 319–321.