Late Paleozoic gold mineral systems in north-east Queensland

Recent geochronology and metallogenic research

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Outline

- Summary of geochronological and metallogenic research of the past 5-7 years (mostly funded by GSQ)
- Focus – on Carboniferous to Permian gold metallogeny of north-east Queensland
Acknowledgements

Summary of work, performed or funded by GSQ, in collaboration with:

- Klondike Exploration (Gregg Morrison)
- Terra Search (Simon Beams and staff)
- JCU (Zhaoshan Chang, Paul Dirks, staff, post-docs and students)
- Geoscience Australia (U-Pb and Re-Os geochronology)
- ANU (Ar-Ar geochronology – G. Lister, M. Forster)
- University of Alberta, Canada (Re-Os geochronology – Rob Creaser)
- Scottish Universities (O isotopes)
- Multiple companies across the region (access to sites; co-funding research students)
North-eastern segment of the North Australian Craton

Along the cratonic margin

- Neoproterozoic-Ordovician Thomson Orogen
- Silurian to Devonian Mossman Orogen
- Devonian to Triassic New England Orogen (NEO)

In Carboniferous-Permian, all provinces N and W of NEO were affected by felsic magmatism of the Kennedy Igneous Association (KIA)
KIA – extensive felsic magmatism, north and inboard from NEO

Several epochs – from ~345 Ma to 265 Ma:

(i) early Carboniferous (345-330 Ma) - restricted

(ii) late Carboniferous (325-290 Ma) – most volume

(iii) early to mid-Permian (285-265 Ma) – widest spatial extent; main magmatism in the E and N
Diverse C-P mineralisation – mostly coinciding in age with KIA (345-280-265 Ma)

- **Au**(-Ag), **Sn**, **W**, Zn, Cu, Fe, U
- Veins, breccias, skarns; orogenic, low- and high-S epithermal, IRGD, etc.
- Pre-2014 – paucity of geochronology on mineralisation away from several major deposits

**Kennedy Igneous Association – C-P mineral province**

- U-Pb (zircon; SHRIMP – GA) >20
- Re-Os (molydenite) >25
- Ar-Ar >65
- U-Pb (zircon; LA - JCU) >150
- K-Ar (Terra Search) >40
Carboniferous-Permian mineral systems

- Diverse C-P mineralisation – mostly coinciding in age with KIA (345-280-265 Ma)
- **Au**(-Ag), **Sn**, **W**, Zn, Cu, Fe, U
- Veins, breccias, skarns
- The largest (and best studied) deposits – in the south
- Least understood – at Cape York
Relatively minor historic goldfields (2 – with current exploration projects):

- Horn Island (~0.8 t Au production; 15 t Au resource)
- Coen (~1.5 t Au)
- Ebagoola (~800 kg Au)
- Yarraden (~550 kg Au)
- Alice River

Minor Sn-W (mostly alluvial):

- Archer River (314 t Sn)
Horn Island gold mine (800 kg Au production, 15 t Au resource)

- Until recent geochronological work by GSQ (and GA), both igneous rocks and Au assumed to be early Permian or “Permo-Carboniferous”
Horn Island gold deposit

- Horn Island gold mine (800 kg Au production, 15 t Au resource)
- Until recent geochronological work by GSQ, both igneous rocks and Au assumed to be early Permian or “Permo-Carboniferous”
- Dominant mineralisation – Qtz-Py-Ga-Sp-Au veins in granite (with sericite alteration), rare Qtz-Mo veins; late-stage carbonate-fluorite and epithermal quartz veins
Horn Island gold deposit

- U-Pb (SHRIMP) on host granites – 343-344 Ma
- Re-Os on Qtz-Mo veins – 342-344 Ma
- Ar-Ar on sericite alteration and veins (with Qtz-Ga-Sp-Au) – ~315-320 Ma
- $\delta^{18}\text{O}_{VSMOW}(\text{Qtz}) = 11\%$ (magmatic source?)
- U-Pb (SHRIMP) on (mostly) barren rhyolite dyke – 310 Ma
- Main Au – late Carboniferous, unrelated to host granites (and associated minor Mo-W-Bi-Te mineralisation)

New geological interpretation (incorporating above results) – in ASX announcement of Alice Queen Ltd (31 May 2019)
C-P gold mineral systems – Cape York

Relatively minor historic goldfields (2 – with current exploration projects):

- Horn Island (~0.8 t Au production; 15 t Au resource)
- Coen (~1.5 t Au)
- Ebagoola (~800 kg Au)
- Yarraden (~550 kg Au)
- Wenlock (~150 kg Au)
- Alice River

Minor Sn-W (mostly alluvial)

- Archer River (314 t Sn)
Gold mineral systems – Coen region

- Qtz-Py-Asp-Au(±Ga) veins in PR metamorphics, D granites and rhyolite dykes; sericite alteration; Au-Ag-As±Sb(Pb-Zn) geochemistry

- “Shear-hosted”? D and P-C?

- Until recent geochronological work by GSQ, no reliable age constraints on gold mineralisation
Geochronology – Coen region

- U-Pb SHRIMP on felsic dykes hosting Au – 283-285 Ma
- Broadly synchronous with the Wolverton Granite (280.4 ± 1.5 Ma) and a rhyolitic plug at Spion Kop (281.6 ± 3.9 Ma)
- Ar-Ar on pervasive sericite in rhyolite dykes with Au mineralisation – ~280Ma
- Ar-Ar on muscovite in Au and W veins – ~275 Ma
- $\delta^{18}O_{\text{VSMOW}}(\text{Qtz}) = 0\%$-$5\%$ (meteoric) to 13%-$15\%$ (distal magmatic?)
- Early Permian metallogenic event – correlating with epithermal Au at Georgetown and Mt Carlton
C-P gold mineral systems – Cape York

Two distinct mineral systems:

- Late Carboniferous (~315 Ma)
  IRGS at Horn Island
- Early Permian (~275 Ma)
  Epithermal Au in the Coen region
Diverse C-P mineralisation – mostly coinciding in age with KIA (345-280-265 Ma)

- **Au** (-Ag), **Sn**, **W**, **Zn**, **Cu**, **Fe**, **U**

- The largest C-P gold deposits NE QLD
Orogenic gold – Mossman Orogen

- Multiple orogenic Au deposits – in the Hodgkinson and Broken River provinces
- Qtz-Py-Asp-(Sb)-Au veins and stockworks (Au-As-Sb-W geochemistry)
Orogenic gold – Ar-Ar geochronology

15 Ar-Ar dates on sericite alteration indicate Carboniferous age:

- ~330-350 Ma (refractory Au-Sb)
- 300-310 Ma (Au-Qtz vein)
- 280 Ma (minor Au-Qtz vein) – one deposit ‘off-trend’
- Age span and episodes – the same as the KIA
Au-Cu and Zn-Cu-Pb-Zn mineral systems – Chillagoe district

Carboniferous Zn-Cu skarns, Au-Cu porphyry – genesis, relationships?

Peter Illig (PhD), 2016-
Mungana Au and Zn-Cu-Pb-Zn mineral systems

- Zn-Cu skarn – 335 Ma
- Au porphyry (IRGD) – 317 Ma

Peter Illig, 2017
Gold mineral systems – Georgetown

- A variety of styles (and previously often assumed ages)
- Devonian orogenic Au; Carboniferous IRGS; Carboniferous (?) porphyry Cu; Permian (?) epithermal Au
Gold mineral systems – Georgetown

Morrison, Mustard, Cody, 2017
Most deposits – Devonian ‘plutonic’ (≡ orogenic); Au-Bi-Te-Pb-Zn-As – suggesting magmatic inputs

Intrusion-related: early Carboniferous (Kidston) and early Permian

Epithermal – early Permian (Agate Creek)
Two distinct Au mineral systems, distinguishable by geochemistry:

- Devonian orogenic (Au-Ag-Pb-Zn-Cu)
- Carboniferous intrusion-related (Au-As-Te-Bi-Cu-Pb-Zn-Ag-Sb(Mo-W), km-scale zonation)
Extensive new geochronology confirmed distinct metallogenic events:

- Porphyry Cu-Mo (~425 Ma)
- Orogenic Au (~415 Ma)
- Intrusion-related Au (330-320 Ma in the W; 310-290 Ma in the E)

Beams, Morrison, 2017
Gold mineral systems – northern Bowen Basin and Urannah

Isaac Corral, 2017
Gold mineral systems – northern Bowen Basin
High- and Low-sulphidation deposits – Mt Carlton district

- Herbert Creek East: 270 ± 7 Ma
- MCU: 278 ± 6 Ma
- MCU: 285 ± 7 Ma
- Boundary: 254 ± 5 Ma
- Mt Carlton: ~283; 279-277 Ma
- Capsize: Mo 286±1 Ma
- Castle: 266 ± 6 Ma
- Strathmoore: 267 ± 7 Ma
- Ortiz: 256 ± 6 Ma
- Powerline: 239 ± 5 Ma
- Powerline: 235 ± 5 Ma
- Mt. Herbert East: 262 ± 6 Ma

Isaac Corral, 2017
The Paleozoic Mount Carlton Deposit, Bowen Basin, Northeast Australia: Shallow High-Sulfidation Epithermal Au-Ag-Cu Mineralization Formed During Rifting

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Abstract

Mount Carlton is a Paleozoic high-sulfidation epithermal deposit located in the northern segment of the Bowen Basin, northeast Queensland, Australia. The deposit is hosted in Early Permian volcanic and sedimentary rocks, and an open-pit mining operation includes the Au-rich V2 pit in the northeast and the Ag-rich A39 pit in the southwest. Mineralization at Mt. Carlton occurred during active rifting, partly contemporaneously with the deposition of volcanic sediments in localized half-grabens and graben basins. Steep normal faults and fracture
Orogenic, intrusion-related and epithermal Au (and Sn-W) mineral systems across NE Queensland – diverse manifestations of the same regional thermal and magmatic events driving the Kennedy Igneous Association

- 350-335 Ma - IRGS (Kidston); epithermal Au (Pajingo); orogenic Au (Hodgkinson Province), Sn (Kangaroo Hills)
- 325-290 Ma – orogenic Au (HP); IRGS (Ravenswood, Mungana – Au, Mt Leyshon, Horn Island); Sn (Herberton); Bi-Mo-W
- 285-275 Ma – widespread Au (epithermal – Mt Carlton, Agate Creek, Cape York Peninsula) and local Sn-W deposits (Mt Carbine)
- 265-235 Ma – low-sulphidation epithermal Au in the northern Bowen Basin