Late Paleozoic gold mineral systems of north-east Queensland

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Outline

- Overview of Carboniferous to Permian gold metallogeny of north-east Queensland

- Summary of geochronological and metallogenic research of the past 5-7 years (mostly funded by GSQ)

- Orogenic, intrusion-related and epithermal Au (and Sn-W) deposits across NE Queensland – related synchronous mineral systems
Diverse Carboniferous to Permian mineralisation – **Au**(-Ag), **Sn, W**; **Zn, Cu, Fe, U**

- Major gold deposits of various types and styles (veins, breccias, stockworks, skarns)
  - **Intrusion-related (IRGS)** – Kidston (5 Moz), Ravenswood (7 Moz), Mt Leyshon (3.5 Moz), Mt Wright, Red Dome, Mungana
  - **Epithermal** – Mt Carlton, Agate Creek, parts of Woolgar
  - **Orogenic** – deposits in the Mossman Orogen
  - Poorly characterised vein Au deposits of Cape York

- Nature, timing and relationships between gold (and base metal) mineral systems?
IRGS – variety of styles (veins, breccias, skarns); geochemical zonation; Bi-Te-W-Mo-(Pb-Zn-Cu-Ag-As-Sb); magmatic fluids (Kidston, Ravenswood, Mt Leyshon)

Epithermal – variable relationships with magmatism; Ag-As-Sb; meteoric to magmatic fluids (Mt Carlton; Agate Creek; Woolgar)

Orogenic – no clear relationship with magmatism; regionally persistent characteristics; As-Sb-(W-Pb); metamorphic fluids (Northcote, Tregoora)

Carboniferous-Permian gold mineral systems
IRGS – a general conceptual model

- Au-rich systems formed by (mostly) magmatic fluids
- A range of deposit models / styles
- Geochemical zonation around causative intrusions

Hart, 2005
IRGS in NE Queensland

- Au-rich systems formed by (mostly) magmatic fluids
- A range of crustal levels: plutonic - porphyry - epithermal
- A range of styles – depending on crustal level, fluid pressure and properties of host rocks
- Geochemical zonation

Morrison, 2017
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 north and west of NEO were affected by felsic magmatism of the Kennedy Igneous Association (KIA)
KIA – extensive Carboniferous to Permian felsic magmatism, north and inboard from NEO

Several epochs – ~345 Ma to 265 Ma:

- early Carboniferous (345-330 Ma)
- late Carboniferous (325-290 Ma)
- early to mid-Permian (285-265 Ma)
- Kennedy Igneous Association

**Kennedy Igneous Association**

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Recent metallogenic research

Since 2014, extensive new metallogenic research (GSQ, Terra Search, JCU), including:

- Regional studies – Charters Towers, northern Bowen Basin, Georgetown, Mossman Orogen, Cape York
- Deposit studies (4 PhD, MSc, Honours - JCU)
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- Deposit studies (4 PhD, MSc, Honours - JCU)
- Geochronology:
  - U-Pb (zircon; SHRIMP – GA) >20
  - Re-Os (molybdenite) >25
  - Ar-Ar >65
  - U-Pb (zircon; LA – JCU) >150
  - K-Ar (Terra Search) >40
Carboniferous-Permian 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)
- Alice River
- Minor Sn-W
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Horn Island gold deposit

- Horn Island gold mine (800 kg Au production, 15 t Au resource)
- Qtz-Py-Ga-Sp-Au veins in granite (with sericite alteration); rare Qtz-Mo veins; late-stage carbonate-fluorite and epithermal quartz veins
- Historically, both igneous rocks and Au assumed to be early Permian or “Permo-Carboniferous”
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
- U-Pb (SHRIMP) on (mostly) barren rhyolite porphyry dyke – 310 Ma
- $\delta^{18}O_{VSMOW}(Qtz) = 11\%$ (magmatic source)
- Main Au – late Carboniferous IRGS, genetically unrelated to host granites (and minor Mo-W-Au-Bi-Te mineralisation)
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 / or P-C?
Gold mineral systems – Coen region

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- “Shear-hosted”? D and / or P-C?
Geochronology – Coen region

- U-Pb SHRIMP on felsic dykes hosting Au – 283-285 Ma
- Ar-Ar on pervasive alteration sericite and vein muscovite – ~275-280 Ma
- $\delta^{18}O_{VSMOW}(Qtz) = 0\%$-5\% (meteoric) to 13\%–15\% (distal magmatic?)
- Early Permian metallogenic event – correlating with epithermal Au at Georgetown and Mt Carlton
Two distinct mineral systems:

- Late Carboniferous (~315 Ma) IRGS at Horn Island
- Early Permian (~275 Ma) epithermal Au / distal IRGS? in the Coen region
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:

- ~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 (and other mineral systems)
Carboniferous Zn-Cu skarns, Au-Cu porphyry – genesis, relationships?

Peter Illig (PhD), 2016-2019
Mungana Au and Zn-Cu-Pb-Ag 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 et al., 2019 – QDEX Report No. 114062
Most deposits – Devonian ‘plutonic’ (≡ orogenic); Au-Bi-Te-Pb-Zn-As – suggesting magmatic inputs

IRGS: early Carboniferous (Kidston) and early Permian

Epithermal (LS) – early Permian (Agate Creek)
Gold mineral systems – Charters Towers Province

Carboniferous to Permain mineral deposits
- Major gold deposits (>1 Moz Au)
- Orogenic Au
- Intrusion-related and Epithermal Au
- Cu, Zn, Pb
- Sn, W

Kennedy Igneous Association
- 255-265 Ma
- 325-350 Ma
- 350-335 Ma
- Undifferentiated

Structural Framework
- Late Permian - Cenozoic Basins
- Devonian - Carboniferous Basins
- New England Orogen
- Moseman Orogen
- Thomson Orogen
- North Australian Craton
- Towns

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

Isaac Corral, 2017
Gold mineral systems – northern Bowen Basin

Isaac Corral, 2017
High- and Low-sulphidation deposits – Mt Carlton district

- Herbert Creek East: 270 ± 7 Ma
- MCU: 285 ± 7 Ma
- Boundary: 254 ± 5 Ma
- Mt. Herbert East: 262 ± 6 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

Isaac Corral, 2017
Carboniferous and Permian metallogenic events

- **350-335 Ma** - IRGS (Kidston); epithermal Au (LS - Pajingo); orogenic Au (Hodgkinson Province); Sn (Kangaroo Hills); Zn (Mungana)
Carboniferous and Permian metallogenic events

- **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) and Bi-Mo-W
Carboniferous and Permian metallogenic events

- **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)
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285-275 Ma – widespread Au (epithermal – Mt Carlton, Agate Creek, Cape York Peninsula) and local Sn-W deposits (Mt Carbine)

Mineral systems across NE Queensland – diverse manifestations of the same regional thermal and magmatic events
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