

# Synchronous Carboniferous orogenic and intrusion-related gold mineral systems in north-east Queensland

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**KLONDIKE**

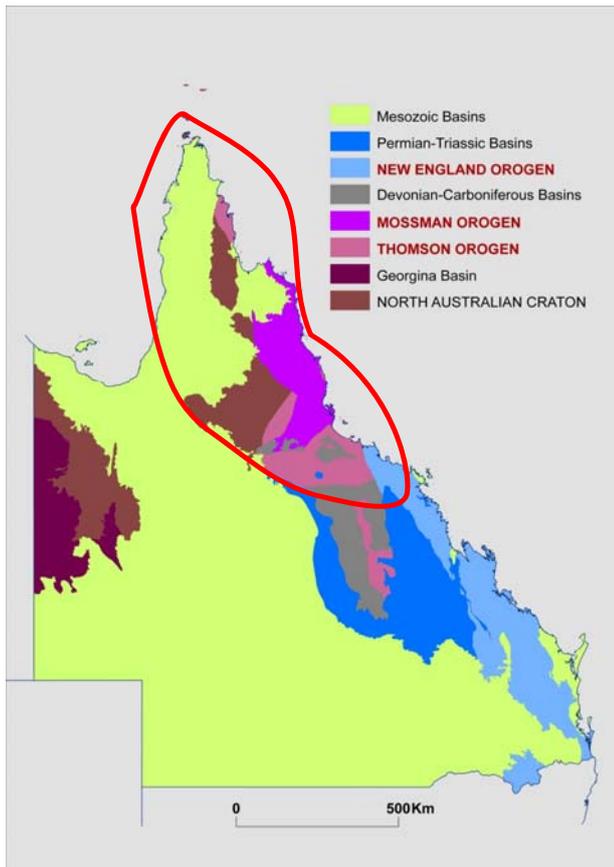
Townsville, 8 December 2017



## Outline

- Intrusion-related and orogenic gold deposits – end members in relation to magmatism (direct metal source vs. no apparent genetic relationship)
- In NE QLD during 350-300 Ma, IRGS and orogenic Au-Sb deposits formed in separate non-overlapping domains
- Timing and genetic links between IRGS and orogenic Au systems (as well as Sn-W and epithermal Au) in NE QLD?

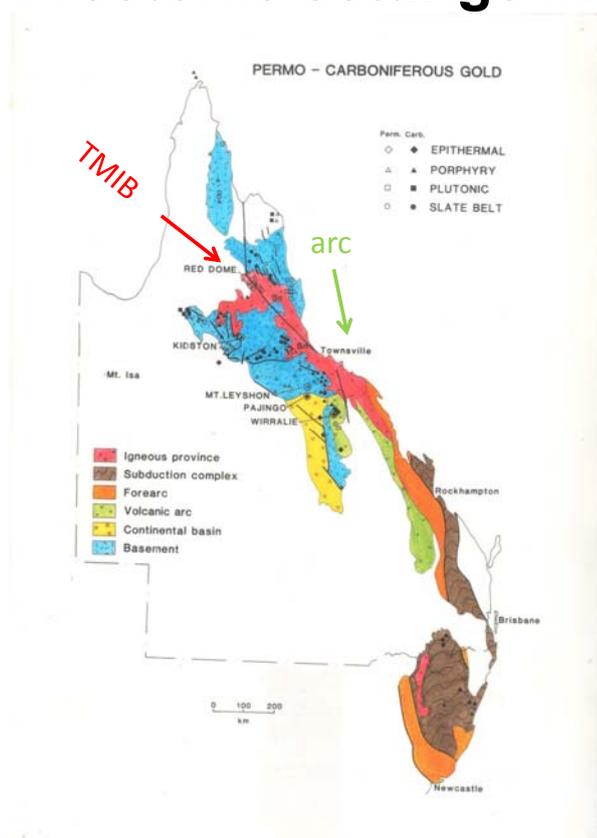
# Geological setting of NE QLD



- North-eastern segment of the North Australian Craton
- Along the cratonic margins:
  - the Neoproterozoic-Ordovician Thomson Orogen
  - Silurian to Devonian Mossman Orogen
  - Devonian to Triassic New England Orogen (NEO)
- In Carboniferous and Permian, all the provinces north and inboard of NEO were affected by extensive felsic magmatism of the Kennedy Igneous Association (KIA)

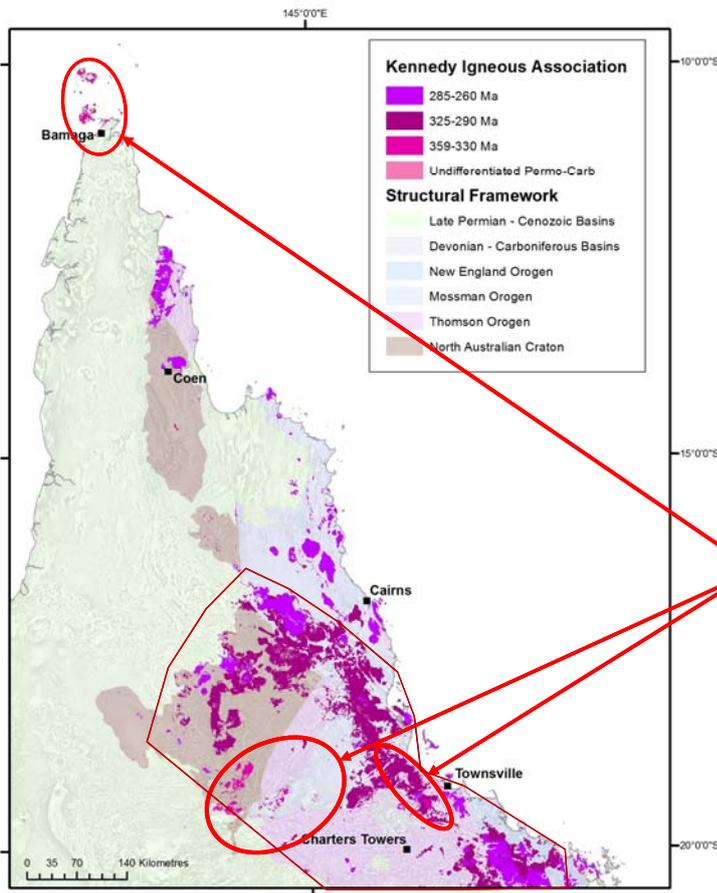
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## Tectonic settings in Carboniferous - Permian



- NEO – belt of intermediate volcanism, Cu-Mo-Au metallogeny
- KIA – extensive felsic magmatism, north and inboard from NEO, Au-Sn-W-Mo metallogeny
- A cluster of diverse Au, Sn, W Permo-Carboniferous deposits - related to Kennedy Igneous Association

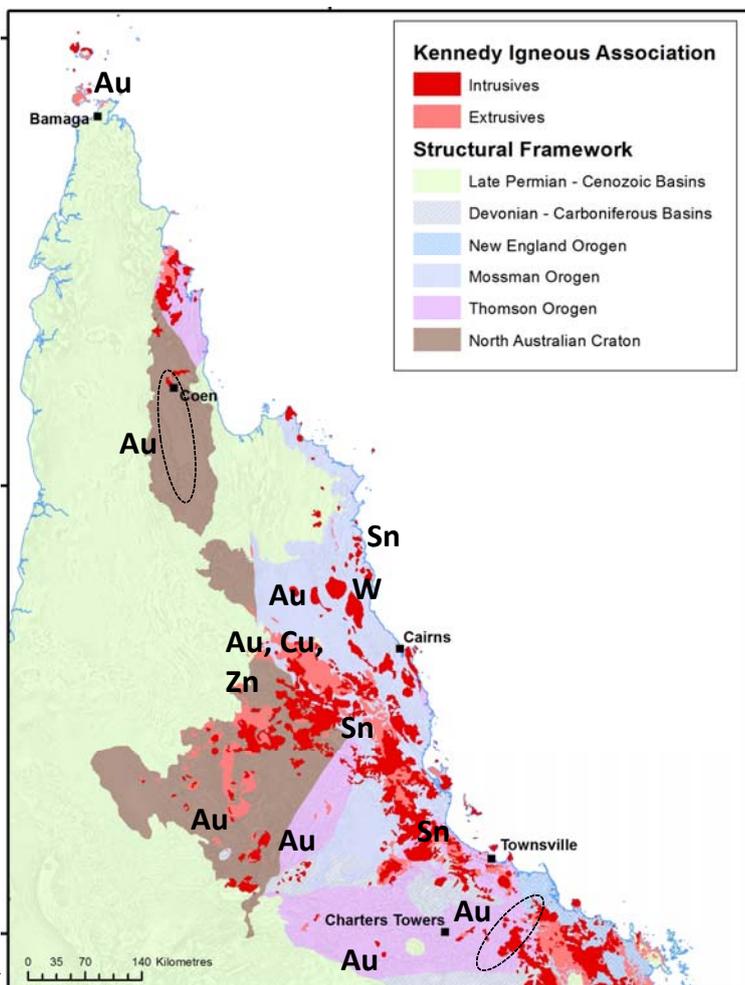
***NQ Permo-Carboniferous is an IRGS Province in an off-arc setting***



## Kennedy Igneous Association

- 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

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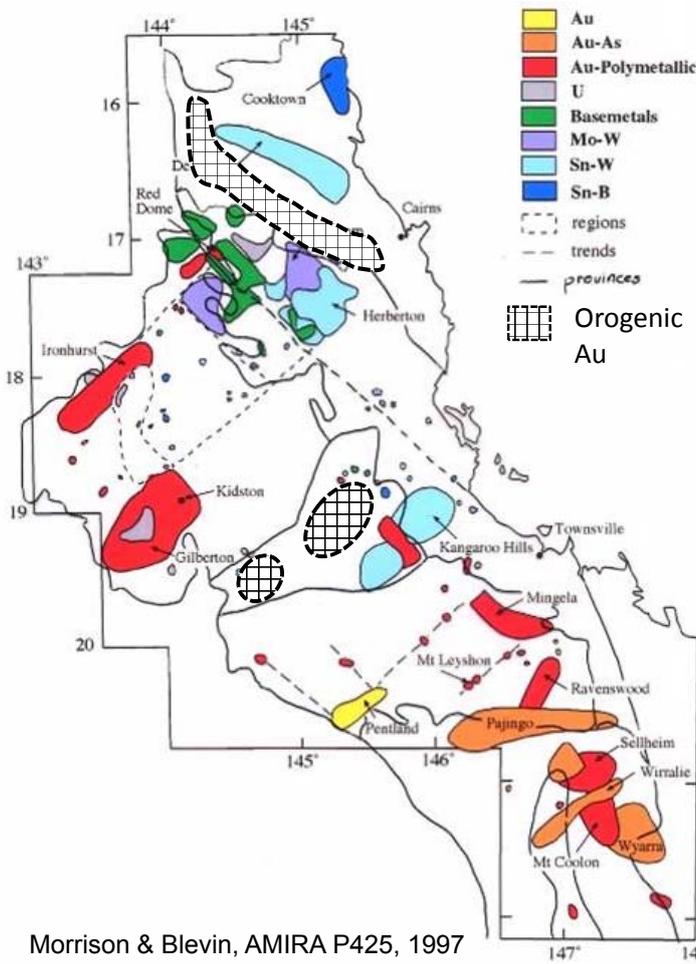


## Kennedy Igneous Association – C-P mineral province

- Diverse C-P mineralisation – coinciding in age with KIA (**345-280-265 Ma**)
- **Au(-Ag), Sn, W, Zn, Cu, Fe, U**
- Veins, breccias, skarns
- Most are demonstrably related to magmatism – but some are not (orogenic Au)
- The largest deposits – in the south

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# Permo-Carboniferous mineral systems



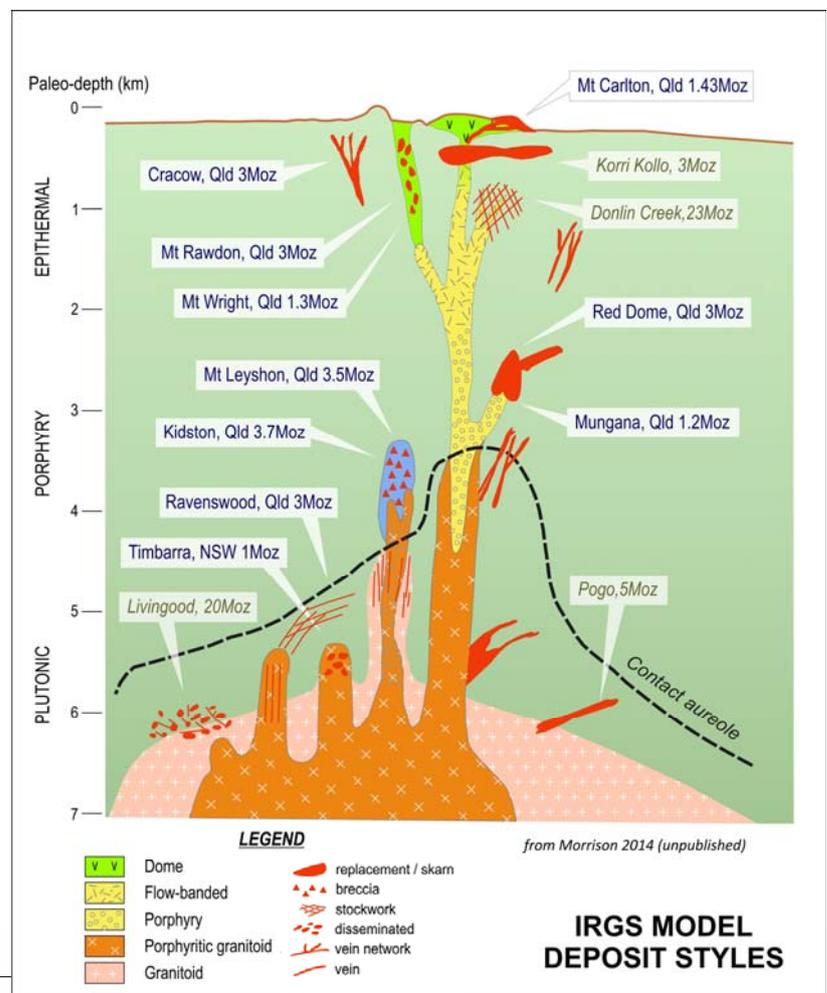
Morrison & Blevin, AMIRA P425, 1997

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- Systems with demonstrable magmatic links – reviewed by AMIRA P425
- Au-dominant systems – in the S and W, on igneous and metamorphic protolith
- Sn-W – mostly in the sedimentary Mossman Orogen
- No porphyry Cu deposits
- Orogenic Au(-As-Sb) - in the sedimentary Mossman Orogen

## Intrusion-related metal systems (IRMS) of North Queensland

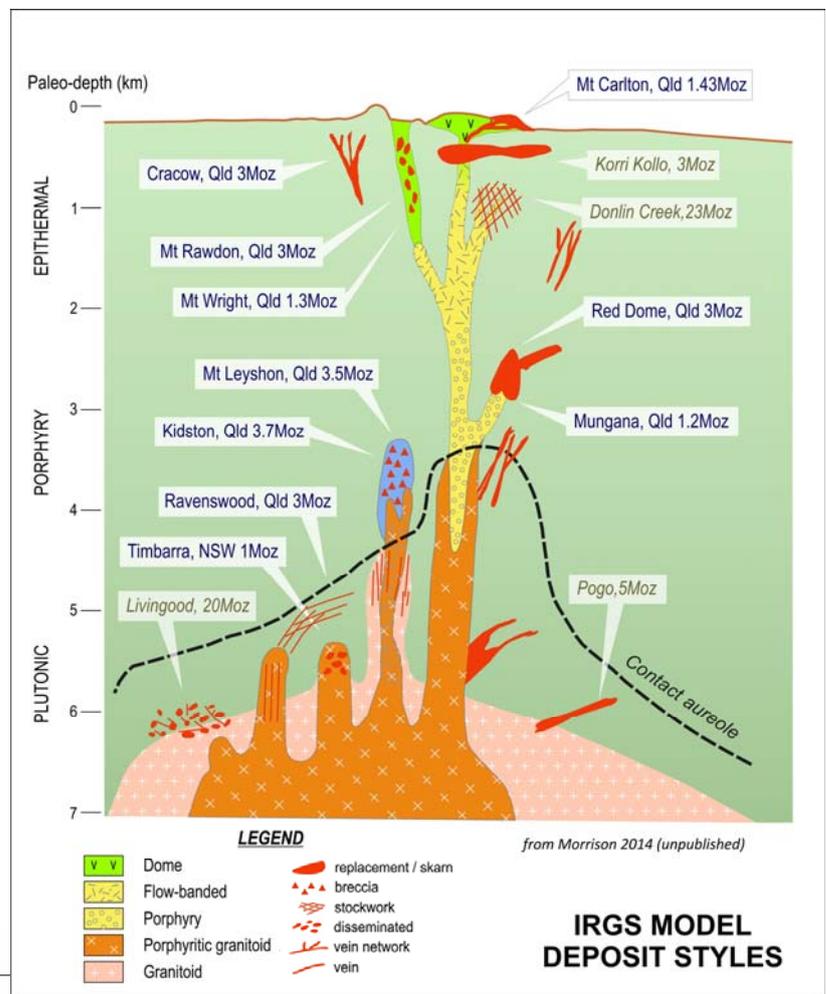
- IRMS – groups of coeval mineral systems formed by (dominantly?) magmatic fluids
- Main commodity (Au, Sn, W, Cu, Zn...) – function of magma chemistry, controlled by overall geology
- A range of crustal levels and deposit styles
- Porphyry Cu - IRCS, formed at a porphyry level



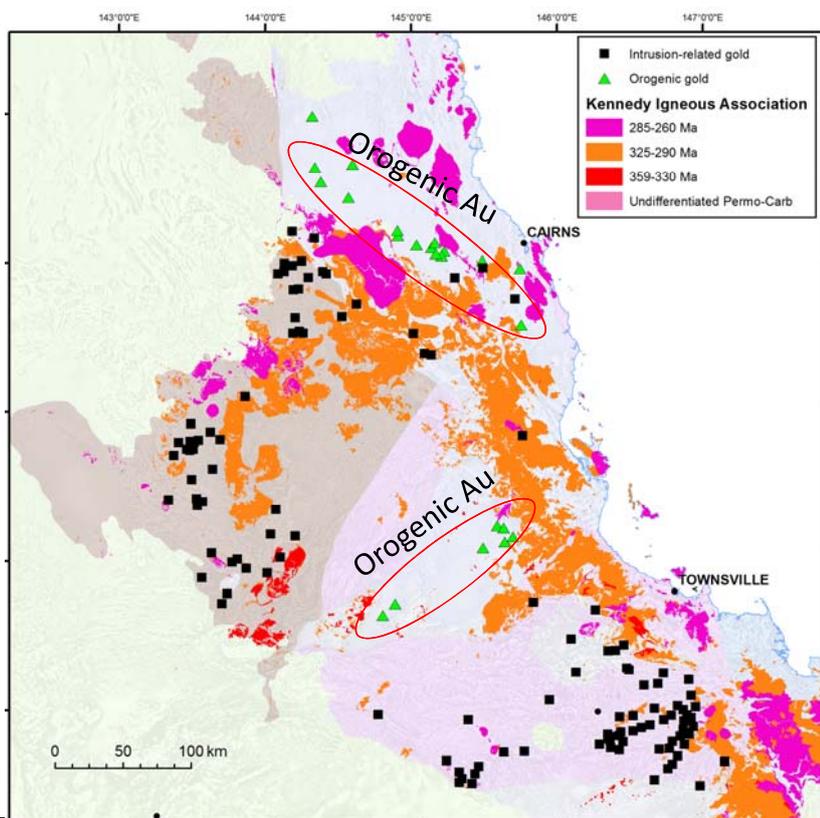
**IRGS MODEL  
DEPOSIT STYLES**

## Intrusion-related gold system (IRGS) of North Queensland

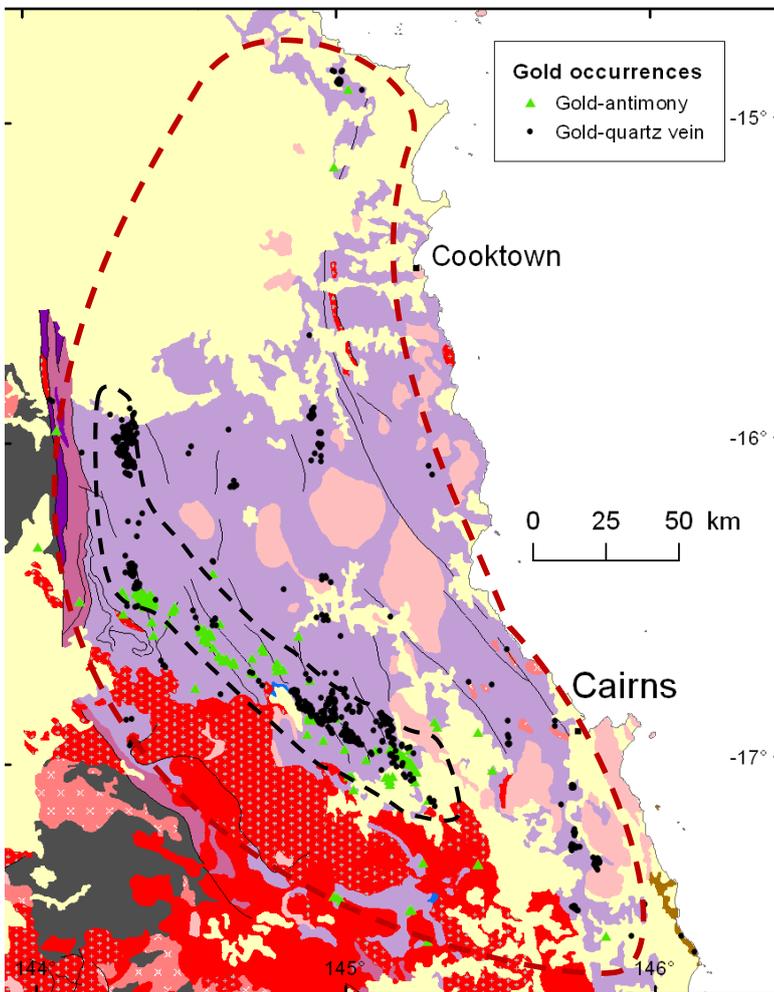
- IRGS – Au-dominated IRMS
- Form at a range of crustal levels – from plutonic, through porphyry, to epithermal
- A range of styles (vein, stockwork, breccia, skarn) – depending on crustal level, fluid pressure and properties of host rocks
- Most in QLD – at the porphyry level



## Permo-Carboniferous Au systems – orogenic Au vs IRGS



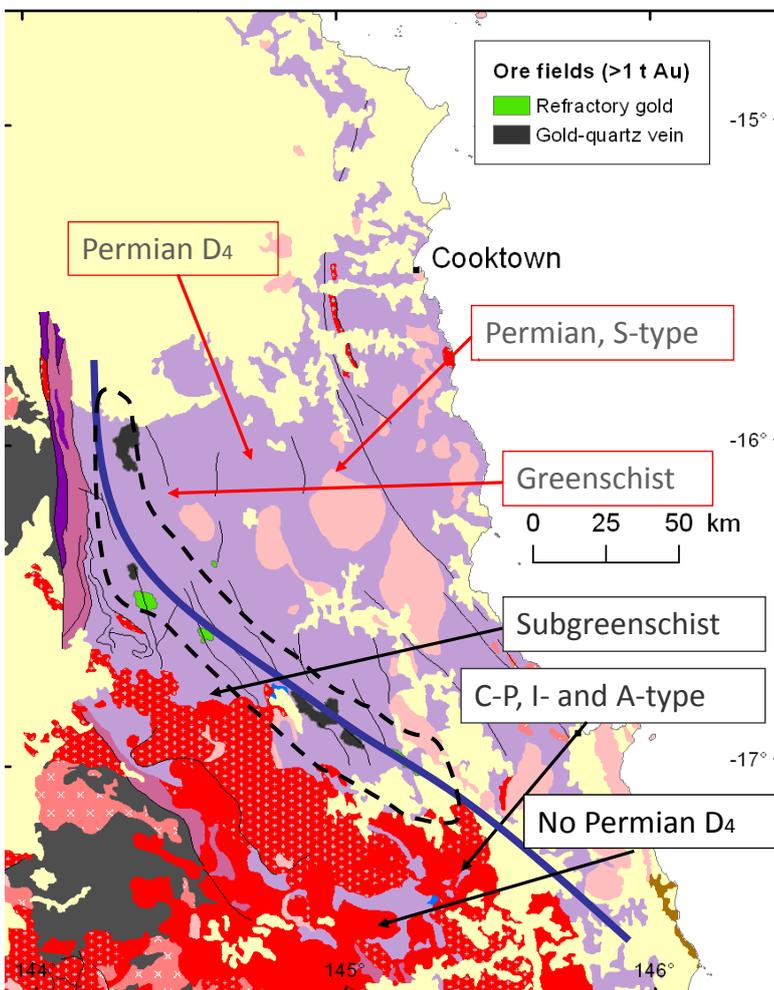
- Most IRGS – in igneous-metamorphic provinces (Etheridge, Charters Towers)
- IRGS - with subvolcanic complexes, away from main batholiths and volcanic cauldrons
- Orogenic Au – only in the sedimentary Mossman Orogen



## Hodgkinson Province – orogenic Au

- Devonian turbidites, on older Paleozoic and Proterozoic basement
- I- and A-type (340-300, ~280 Ma), magmatism in the SW – S-type (280-265 Ma) in the NE
- Orogenic Au - the entire province
- But best deposits – in a narrow belt

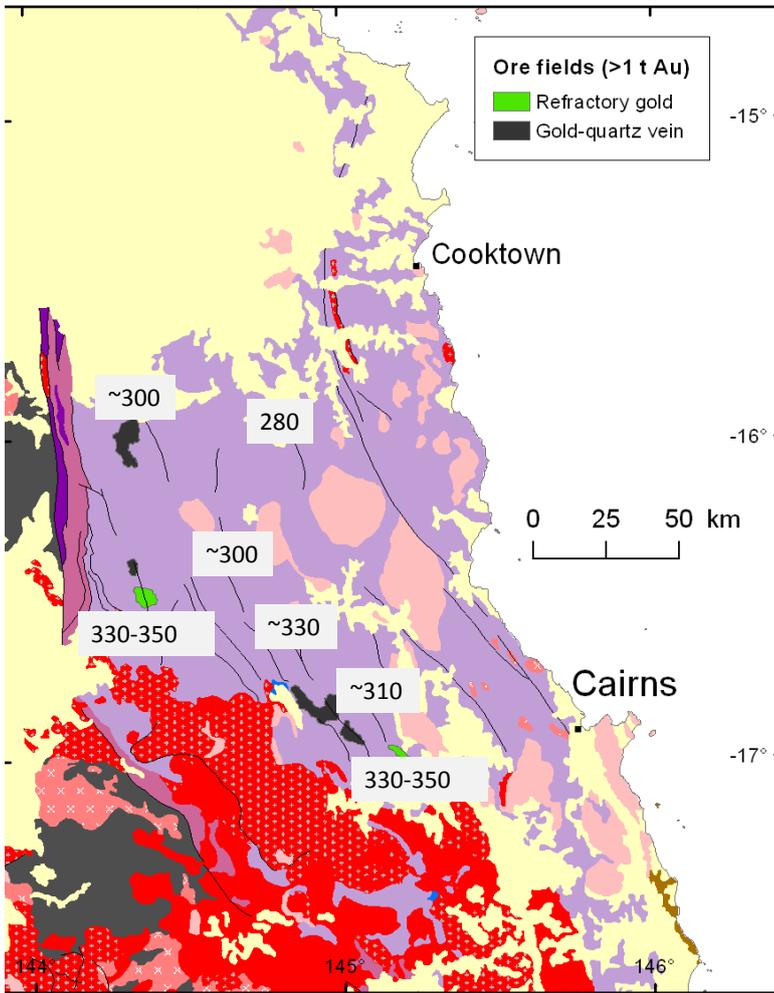
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## Hodgkinson Province – orogenic Au

- All fields with >1 t Au – in one narrow belt
- It represents a major crustal domain boundary
- Zone of high fluid flow - and magmatic heat driving devolatilisation?

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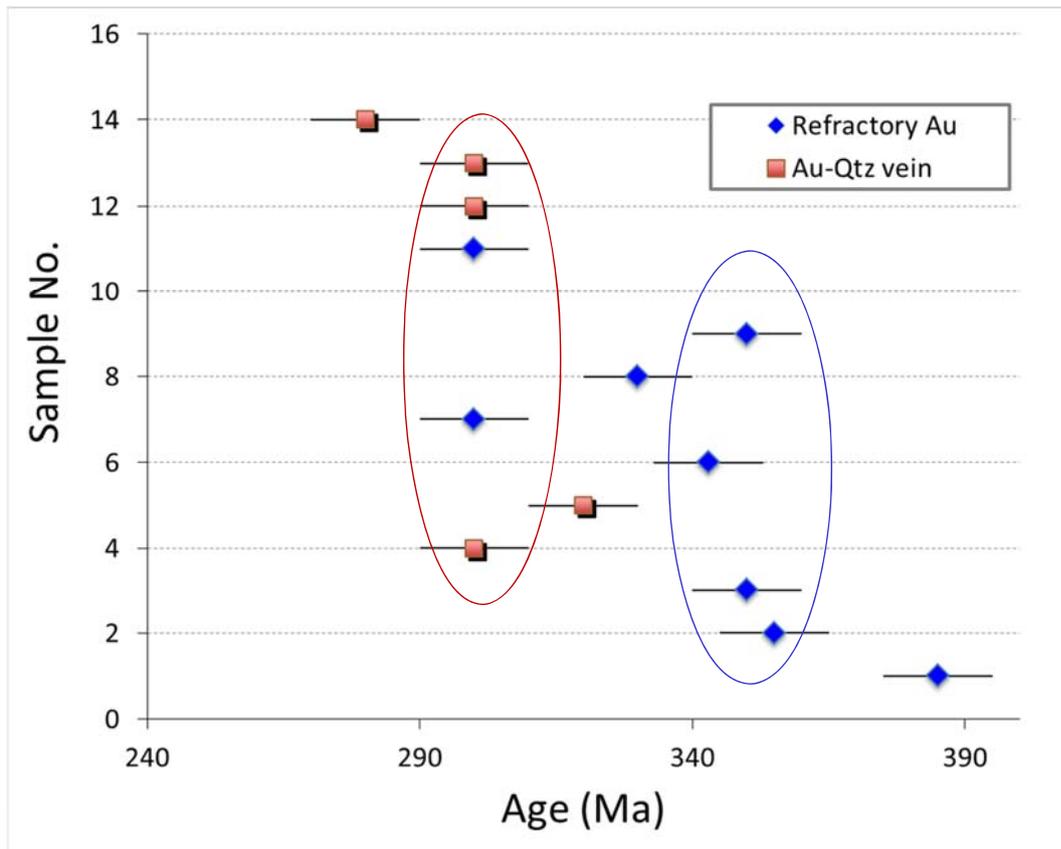
## Orogenic Au – timing

Several apparent age groups:

- ~330-350 Ma (**refractory Au-Sb**)
- 300-310 Ma (**Au-Qtz**)
- 280 Ma (minor Au-Qtz) – one deposit ‘off-trend’
- Age span and epochs – the same as the KIA

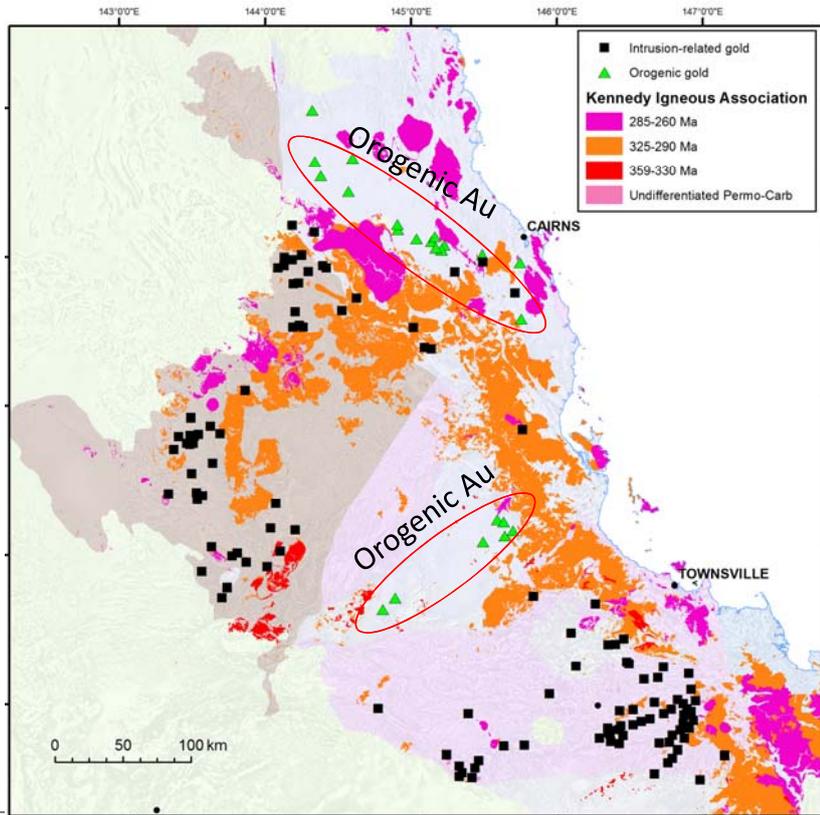
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## Orogenic Au – timing



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# Timing of orogenic Au vs KIA magmatism



➤ ~330-350 Ma (orogenic Au-Sb) – first epoch of KIA (at surface - isolated and distal from orogenic Au-Sb)

➤ 300-325 Ma (orogenic Au) – extensive I-type magmatism in SW Hodgkinson – and other parts of NE QLD

➤ ~280 Ma (minor orogenic Au?) – main magmatism in Hodgkinson and Cape York, widespread (but mostly minor) elsewhere

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## Summary – timing of magmatic and metallogenic events in NE QLD

- Orogenic and intrusion-related Au (and epithermal Au and Sn-W) mineral systems across NE Queensland – diverse manifestations of the same regional thermal and magmatic events driving KIA
- **350-335 Ma** - **IRGS** (Kidston); **epithermal Au** (Pajingo); orogenic Au (Hodgkinson Province), Sn (Kangaroo Hills)
- **325-290 Ma** – orogenic Au (HP); **IRGS** (Ravenswood, Chillagoe; Mt Leyshon); **Sn** (Herberton); Bi-Mo-W
- **285-275 Ma** – widespread Au (**epithermal** – Mt Carlton, Agate Creek, minor orogenic?) and local Sn, **W** (Mt Carbine) deposits – including Au (Sn, W) deposits of the Cape York Peninsula

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# Summary – IRGS and orogenic Au in NE QLD

- Orogenic and intrusion-related gold deposits – formed in spatially separate domains, but during the same magmatic epochs
- Both are driven by major episodes of crustal heating and melting
- Deep crustal melting **created** IRGS – and could also drive metamorphic devolatilisation in the Mossman Orogen and associated orogenic gold systems
- Metamorphic and magmatic processes across NE QLD overlap in time and space and are part of the common broad tectono-magmatic (and associated metallogenic) evolution of the region in the Carboniferous – early Permian