

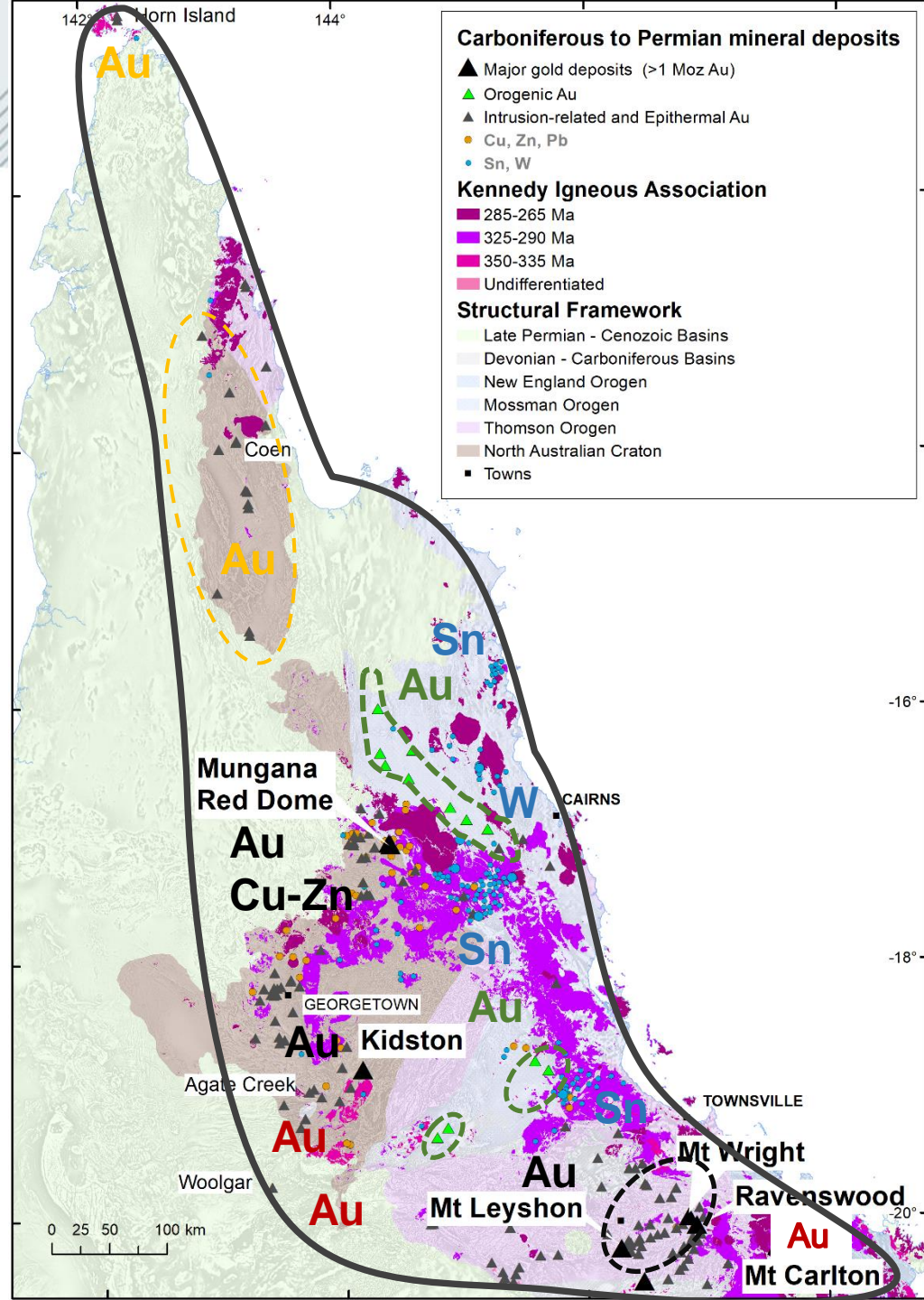
Late Paleozoic gold mineral systems of north-east Queensland

Vladimir Lisitsin, Courteney Dhnaram
Geological Survey of Queensland

Outline

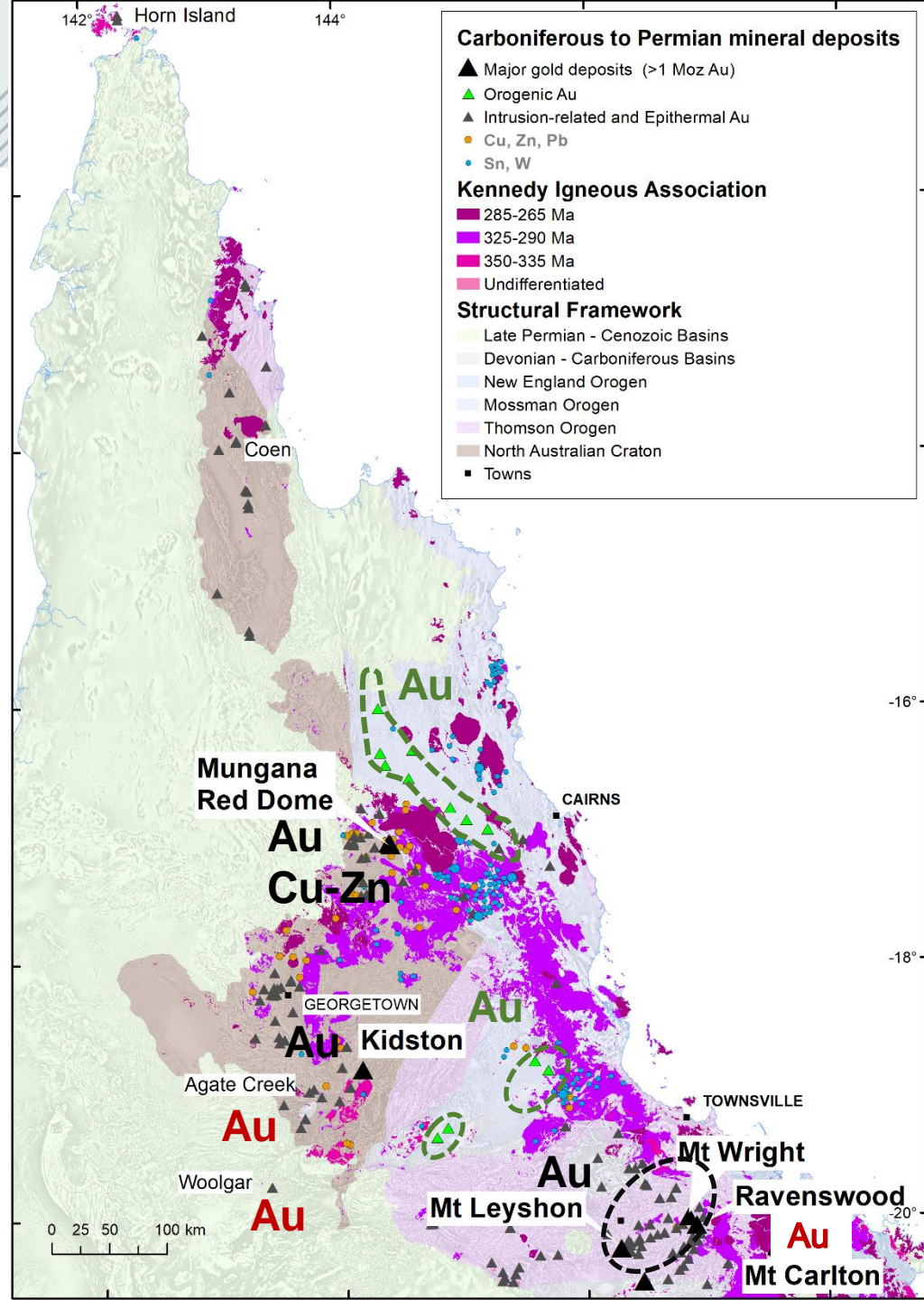
- Overview of Carboniferous to Permian gold metallogeny of north-east Queensland
- Summary of geochronological and metallogenic research of the past 5-7 years (mostly funded by GSQ)
- Orogenic, intrusion-related and epithermal Au (and Sn-W) deposits across NE Queensland – related synchronous mineral systems

North-east QLD gold province



- 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?

Carboniferous-Permian gold mineral systems

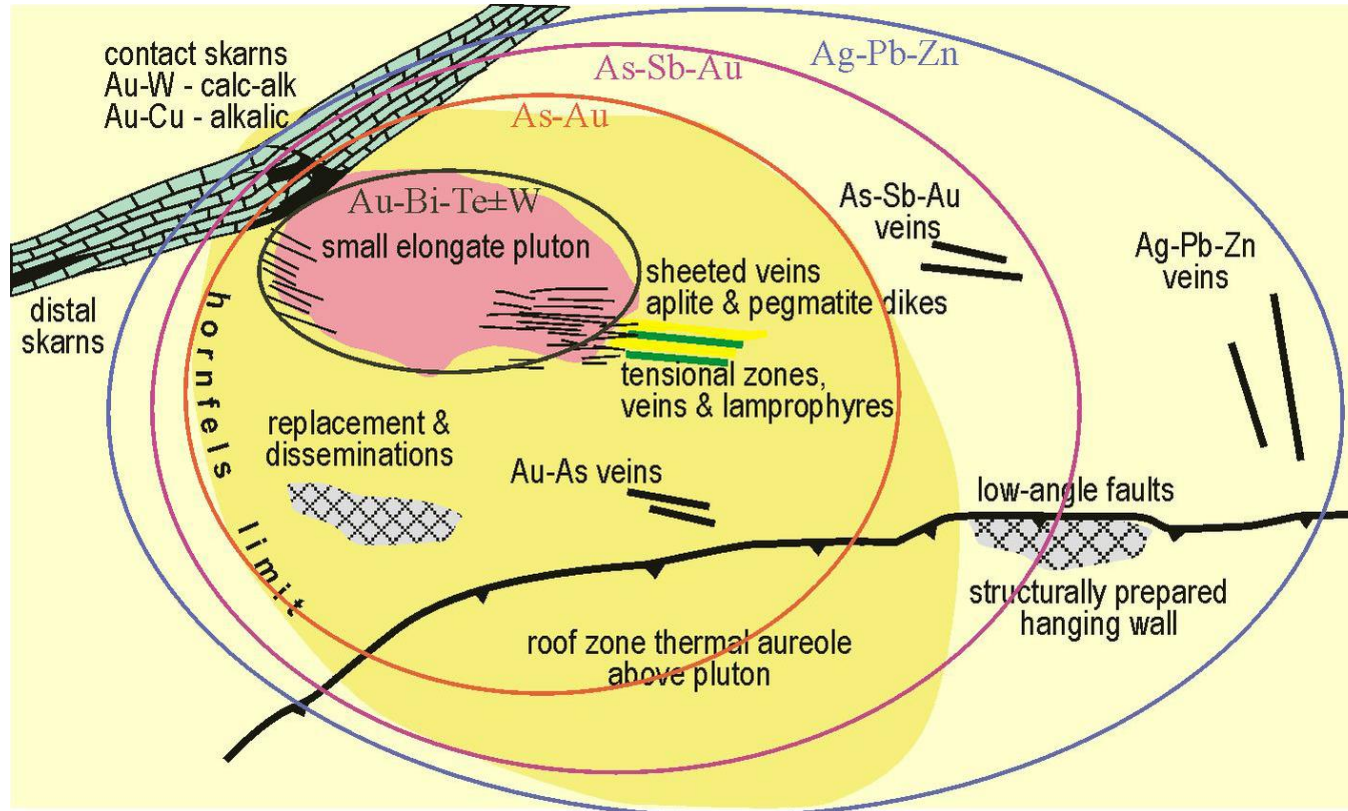


➤ **IRGS** – variety of styles (veins, breccias, skarns); geochemical zonation; Bi-Te-W-Mo-(Pb-Zn-Cu-Ag-As-Sb); magmatic fluids (**Kidston, Ravenswood, Mt Leyshon**)

➤ **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**)

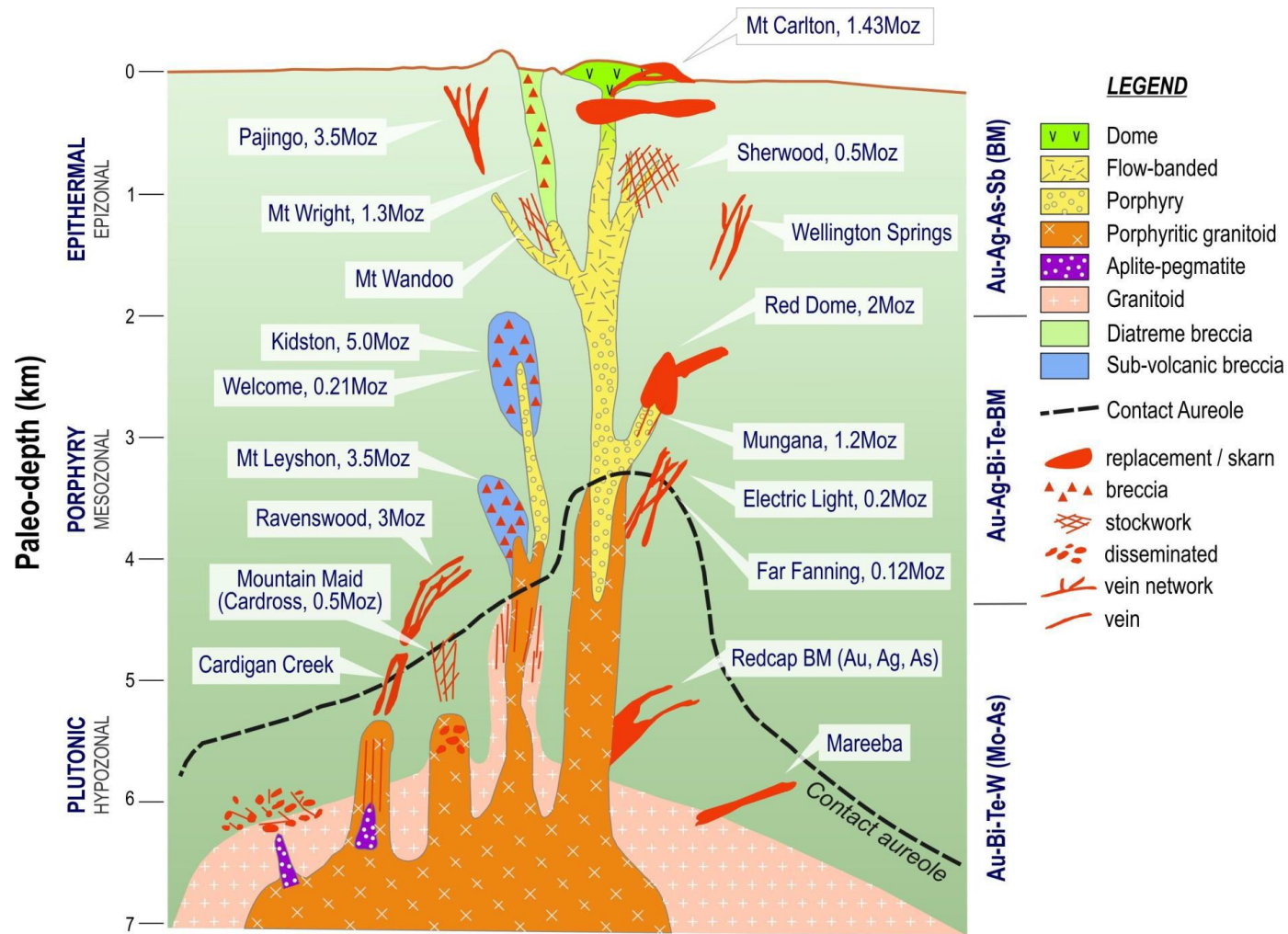
IRGS – a general conceptual model



Hart, 2005

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

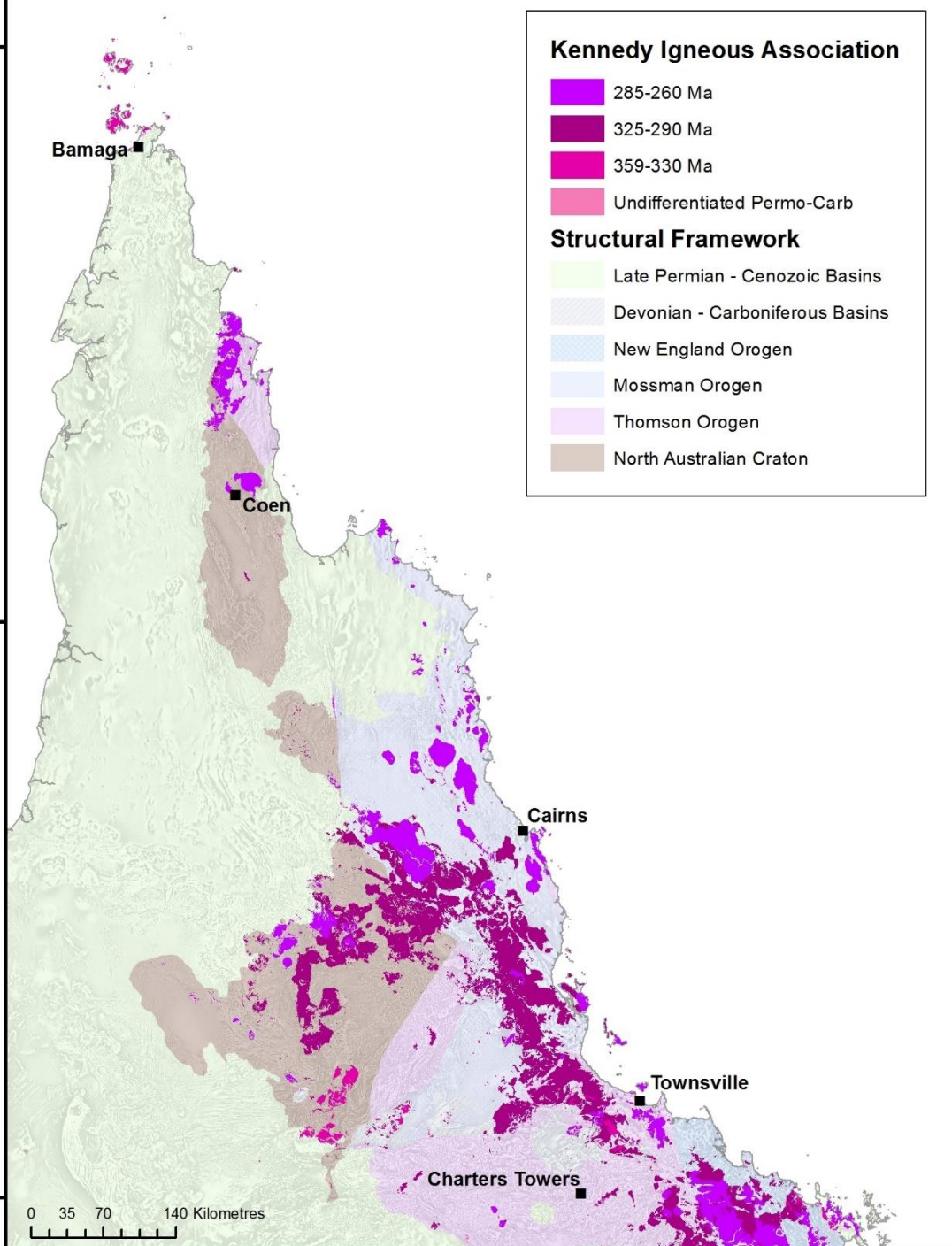
IRGS in NE Queensland



Morrison, 2017

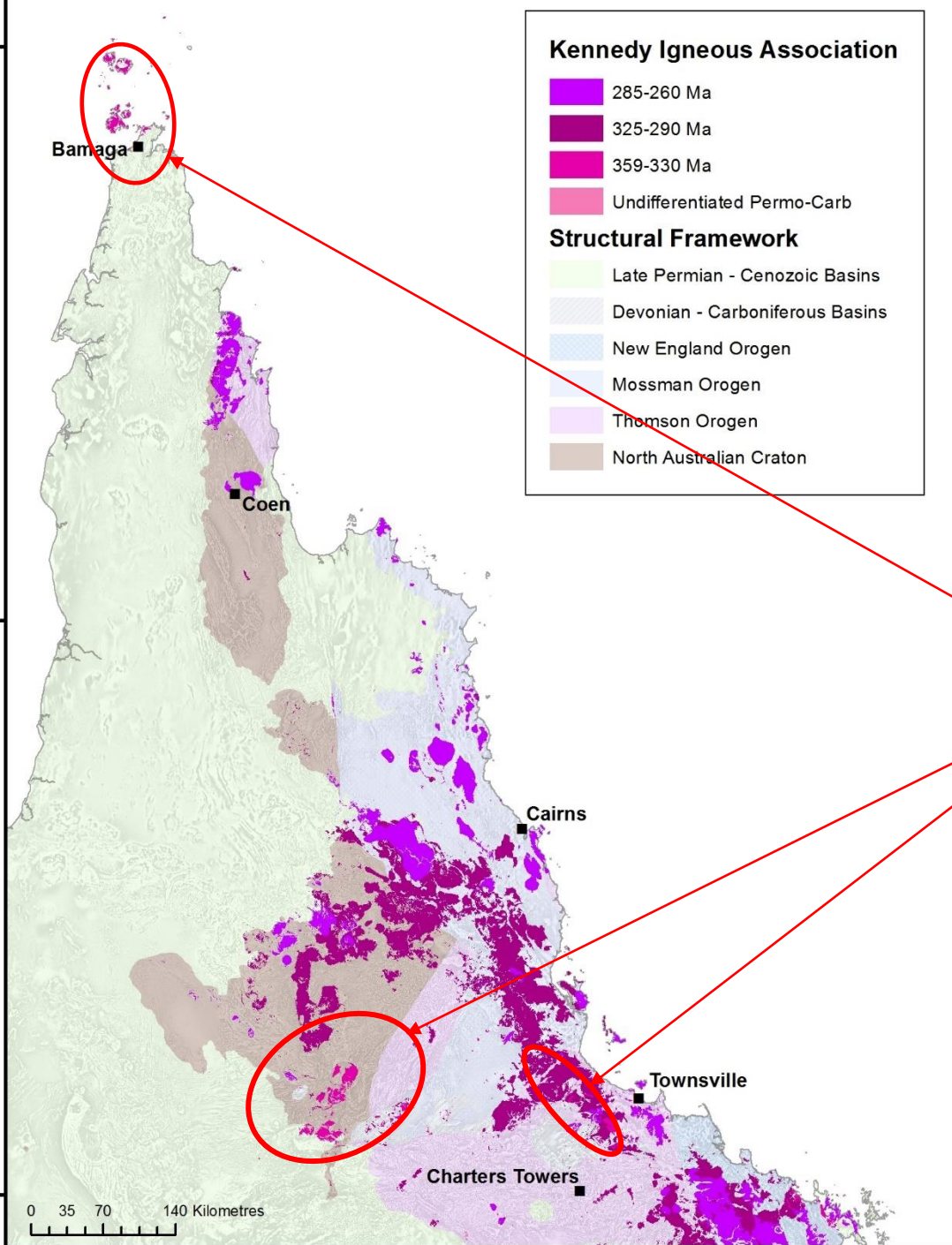
- Au-rich systems formed by (mostly) magmatic fluids
- A range of crustal levels: plutonic - porphyry - epithermal
- A range of styles – depending on crustal level, fluid pressure and properties of host rocks
- Geochemical zonation

Geological setting of NE QLD



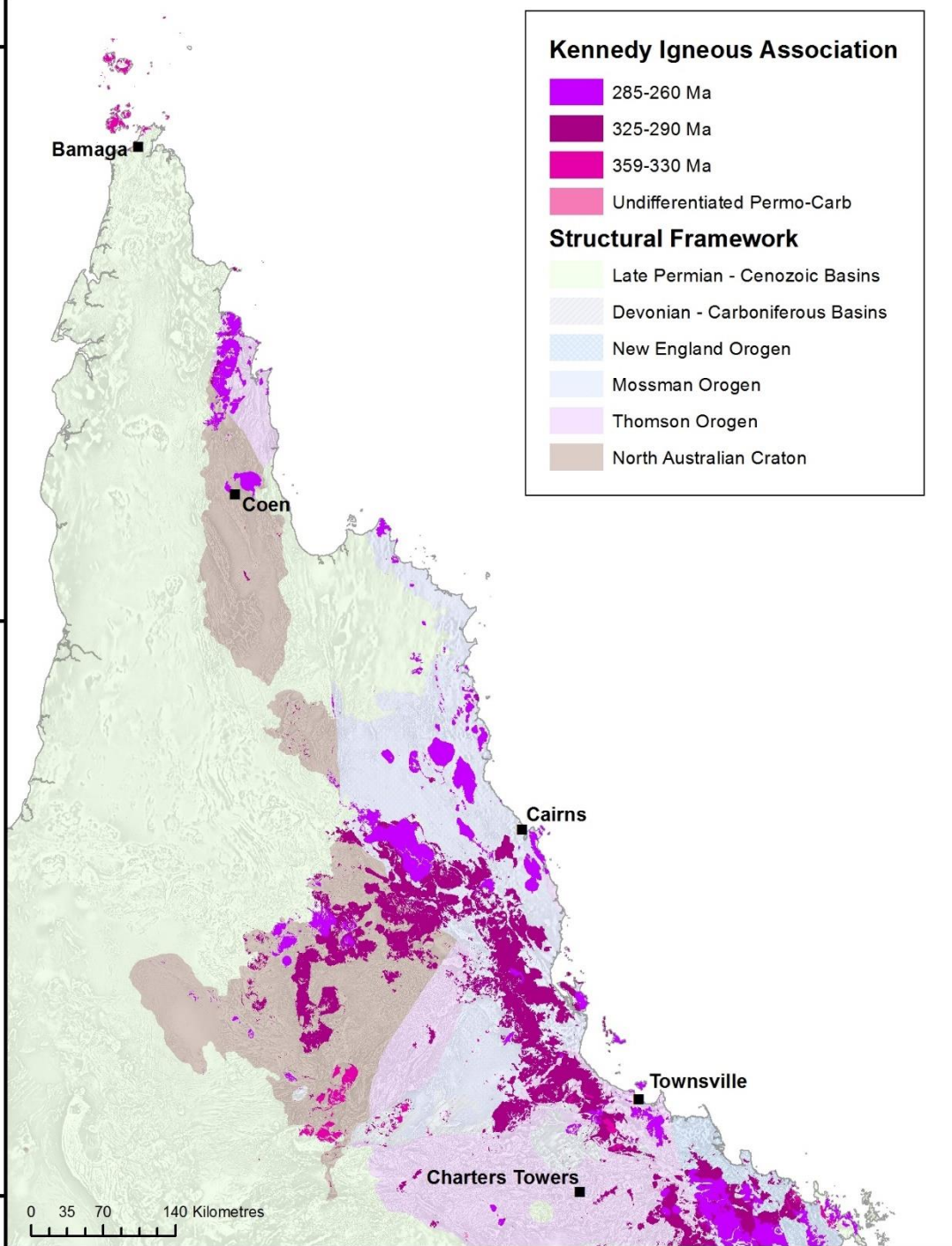
- North-eastern segment of the North Australian Craton
- Along the cratonic margin
 - Neoproterozoic-Ordovician Thomson Orogen
 - Silurian to Devonian Mossman Orogen
 - Devonian to Triassic New England Orogen (NEO)
- In Carboniferous-Permian, all provinces north and west of NEO were affected by felsic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

Kennedy Igneous Association



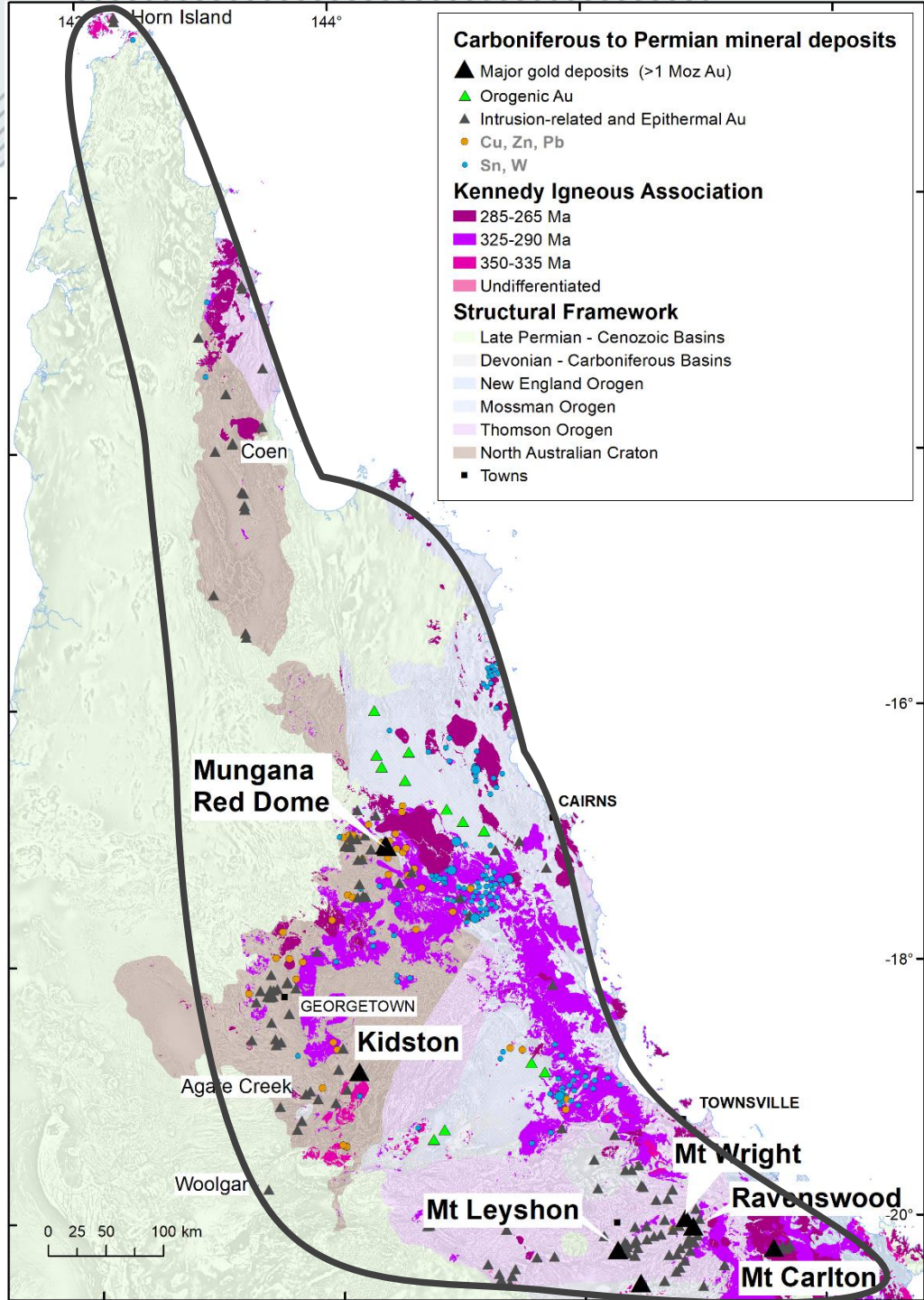
- KIA – extensive Carboniferous to Permian felsic magmatism, north and inboard from NEO
- Several epochs – ~345 Ma to 265 Ma:
 - early Carboniferous (345-330 Ma)
 - late Carboniferous (325-290 Ma)
 - early to mid-Permian (285-265 Ma)

Kennedy Igneous Association



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- Spatial extent and timing of KIA – similar to late PZ mineral systems

Kennedy Igneous Association

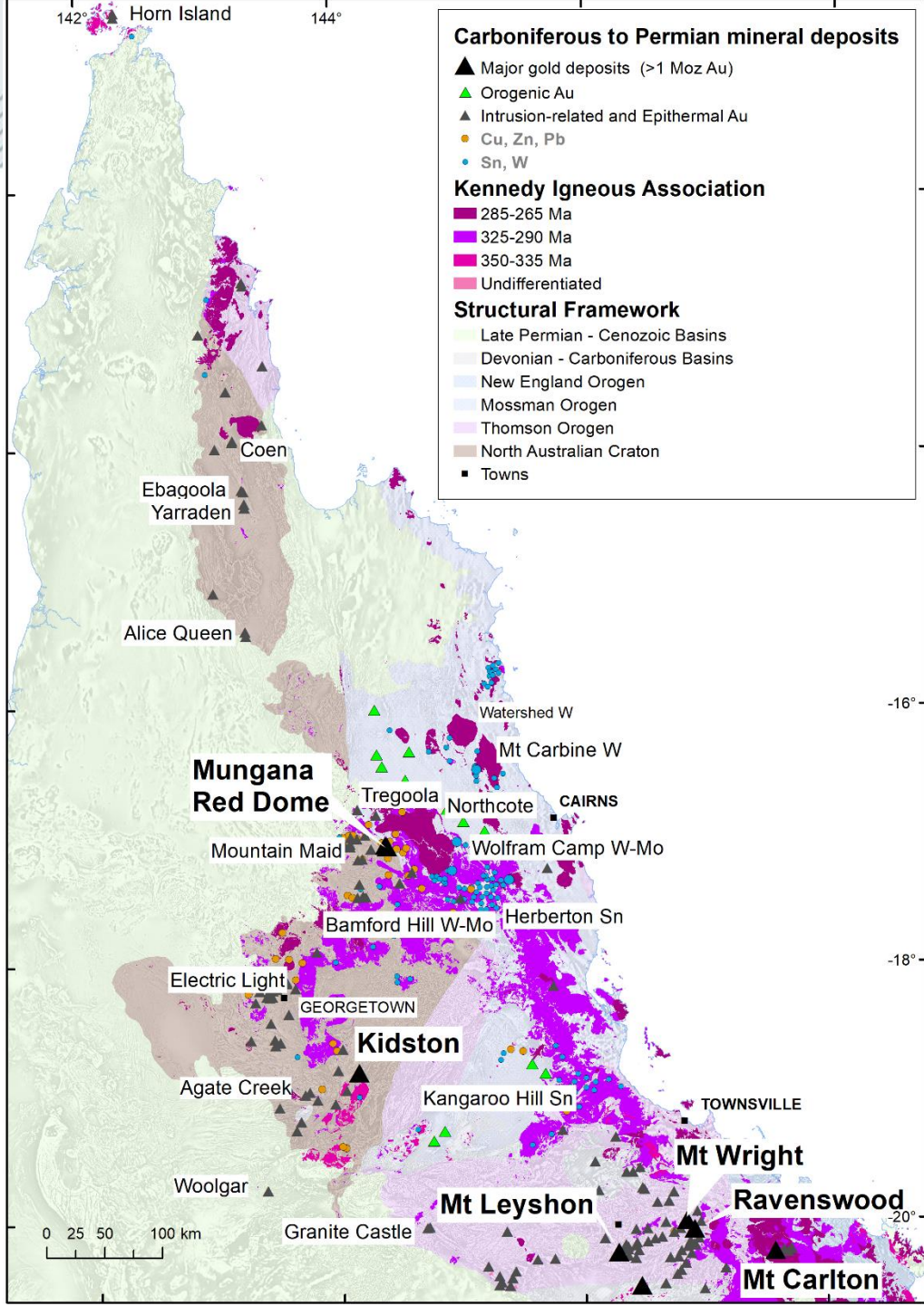


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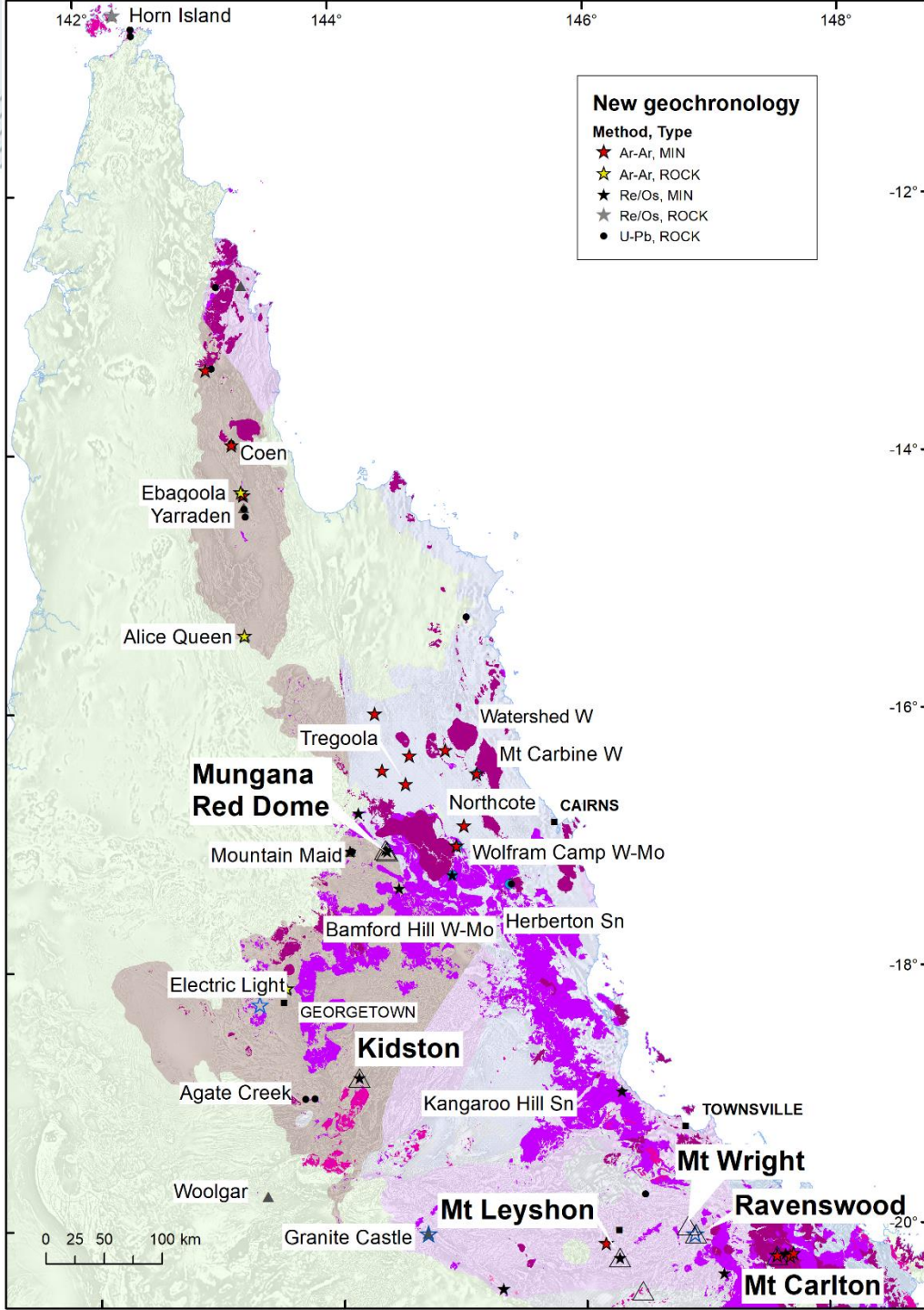
Recent metallogenic research

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)



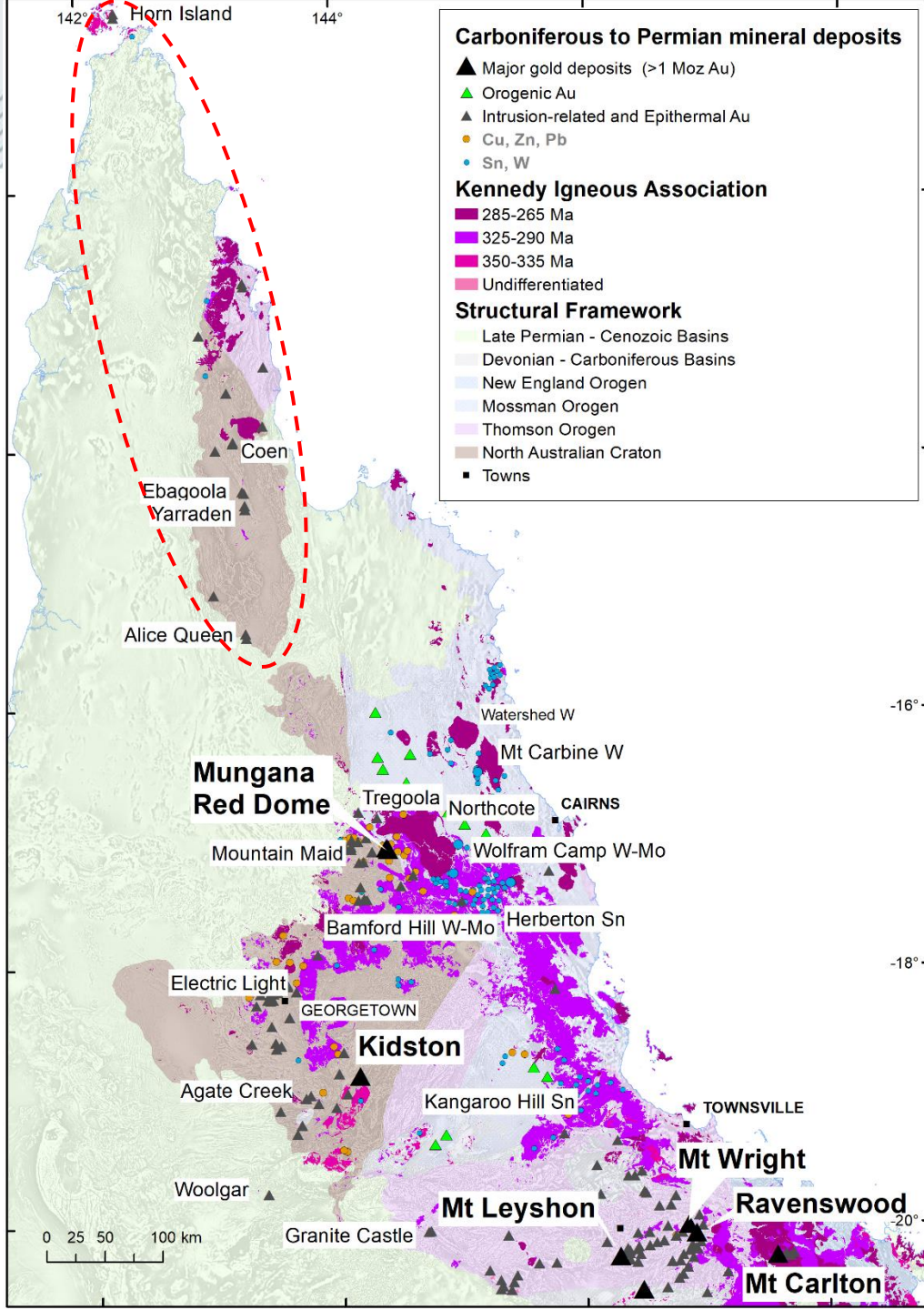
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- Regional studies – Charters Towers, northern Bowen Basin, Georgetown, Mossman Orogen, Cape York
- Deposit studies (4 PhD, MSc, Honours - JCU)
- Geochronology:
 - U-Pb (zircon; SHRIMP – GA) >20
 - Re-Os (molybdenite) >25
 - Ar-Ar >65
 - U-Pb (zircon;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

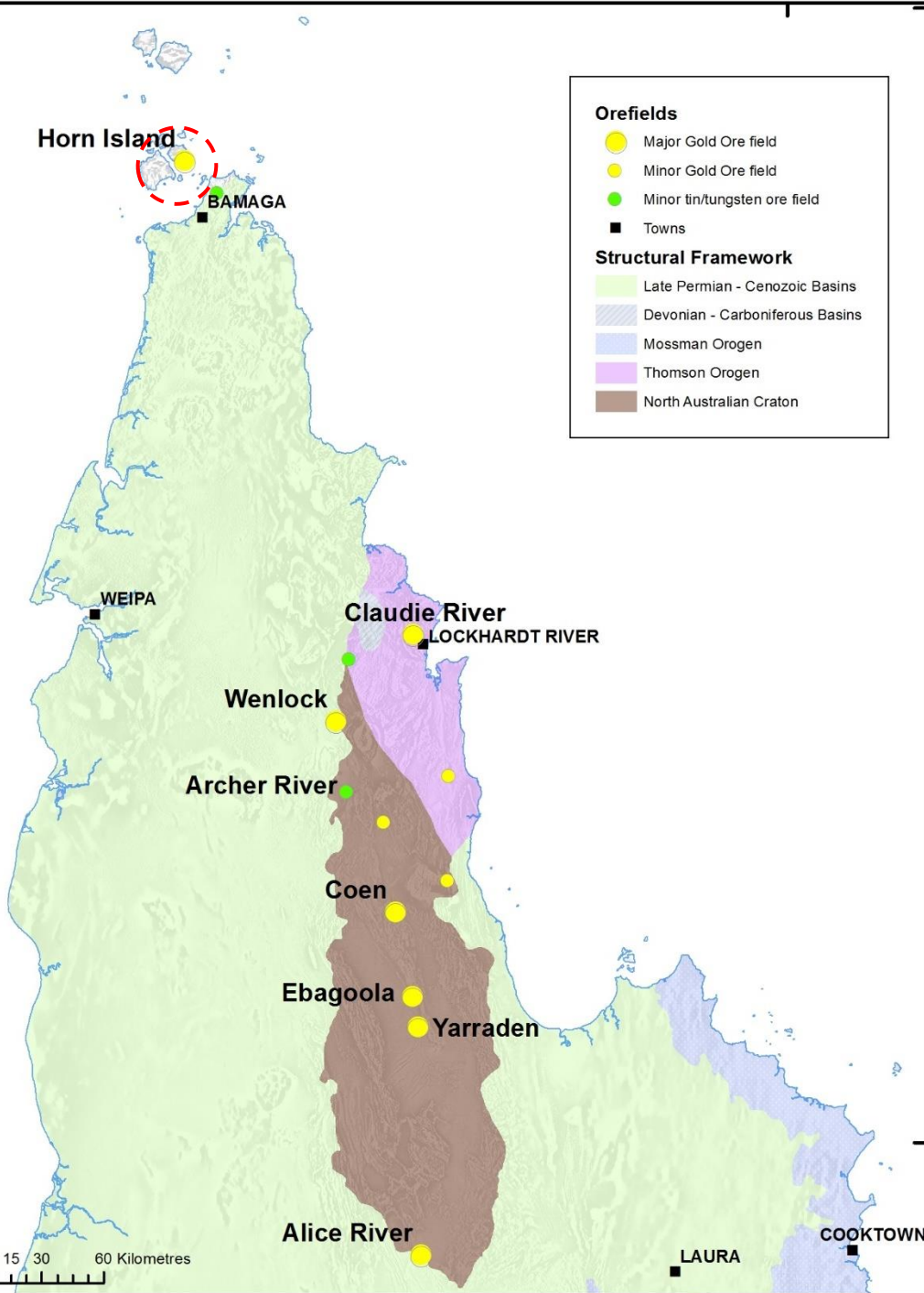
Carboniferous-Permian mineral systems – Cape York



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

Carboniferous-Permian mineral systems – Cape York

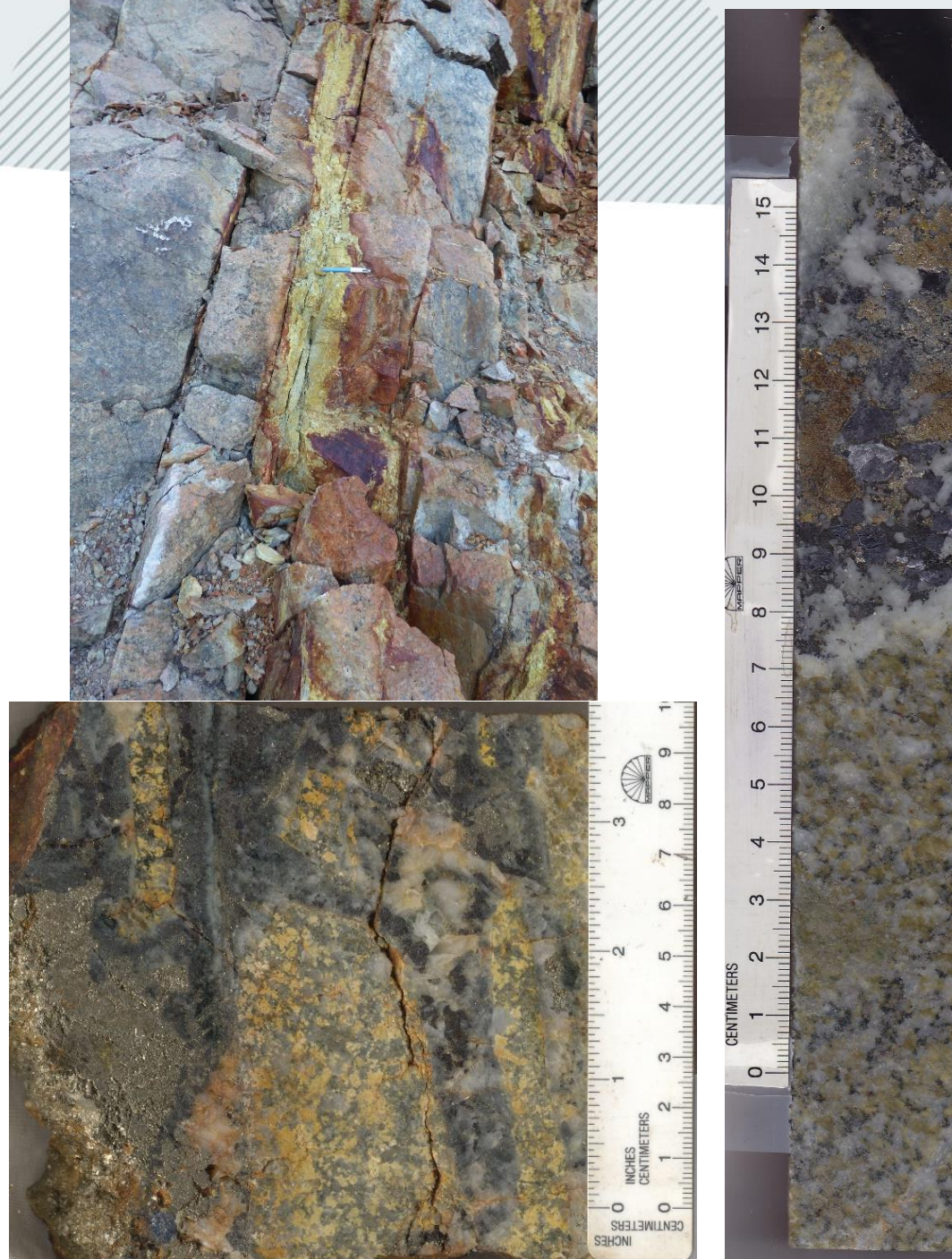


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Horn Island gold deposit

- 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”

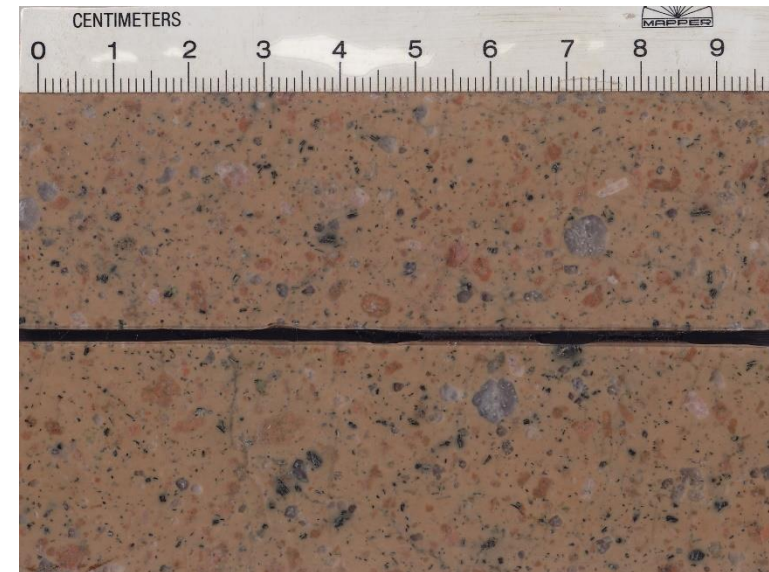


Horn Island gold deposit

- 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
- $\delta^{18}\text{O}_{\text{VSMOW}}(\text{Qtz}) = 11\text{‰}$ (magmatic source)
- **Main Au – late Carboniferous IRGS, genetically unrelated to host granites (and minor Mo-W-Au-Bi-Te mineralisation)**



Qtz-Mo



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)

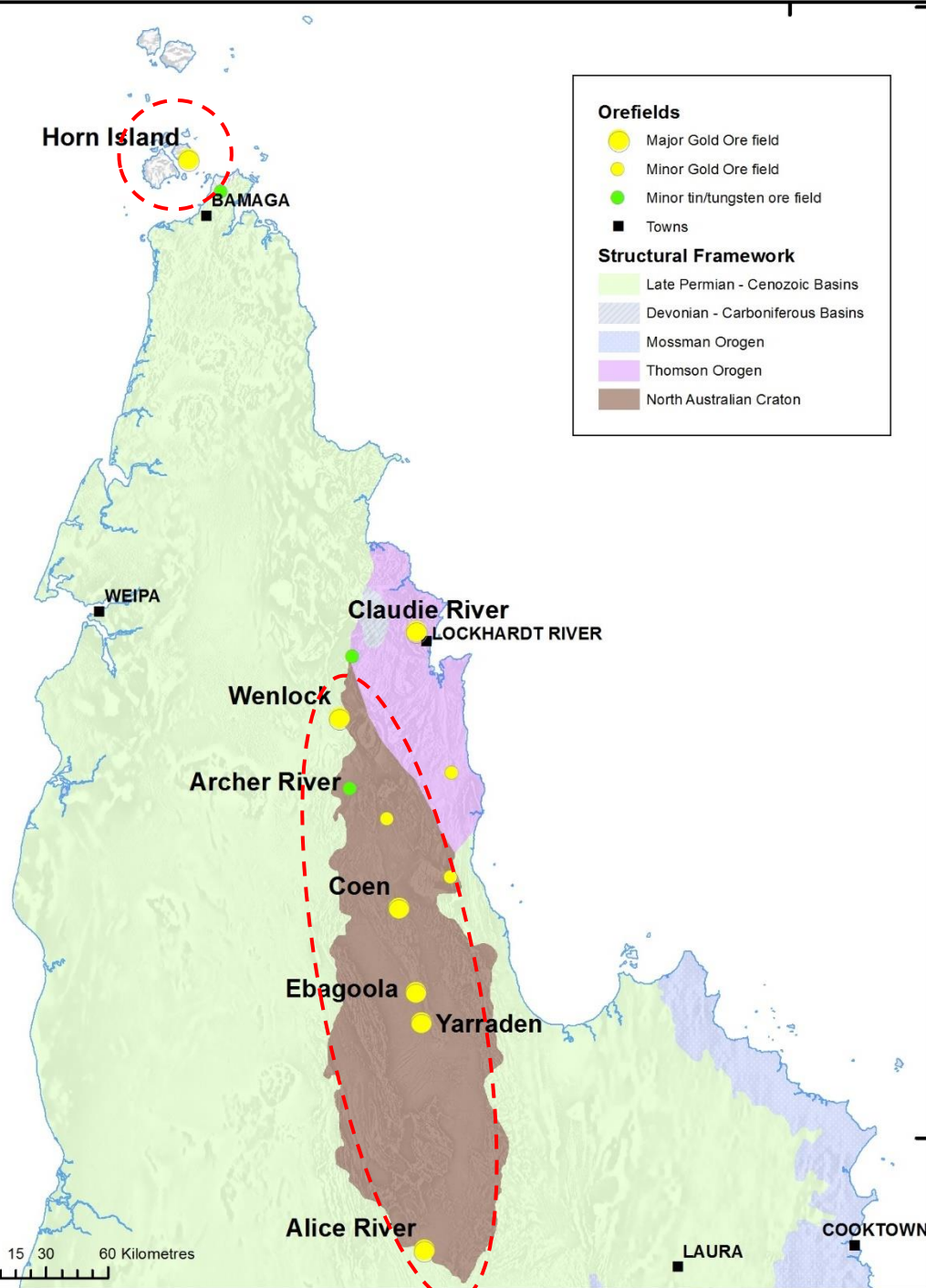
➤ Yarraden (~550 kg Au)

➤ Wenlock (~150 kg Au)

➤ Alice River

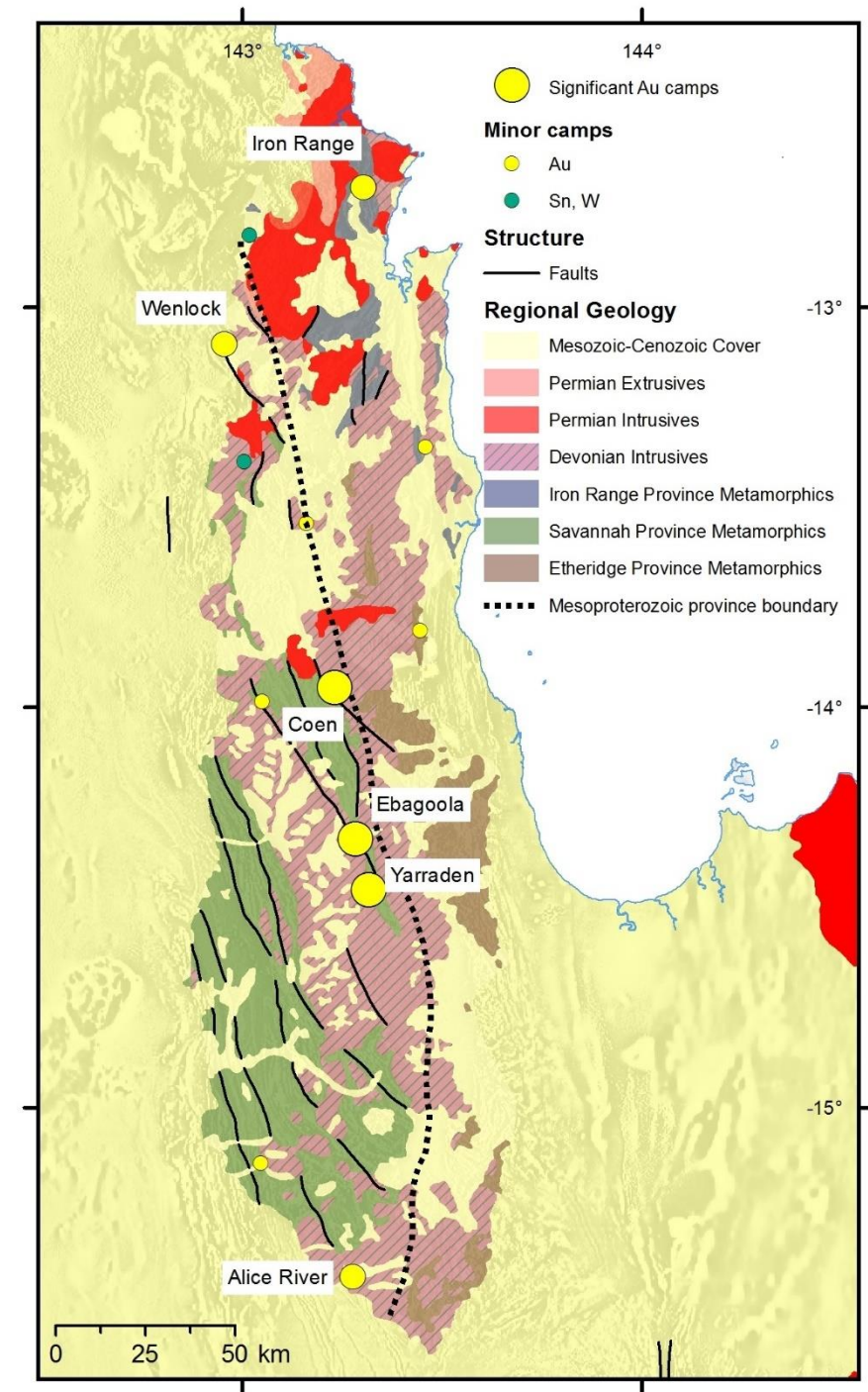
Minor Sn-W (mostly alluvial)

➤ Archer River (314 t Sn)



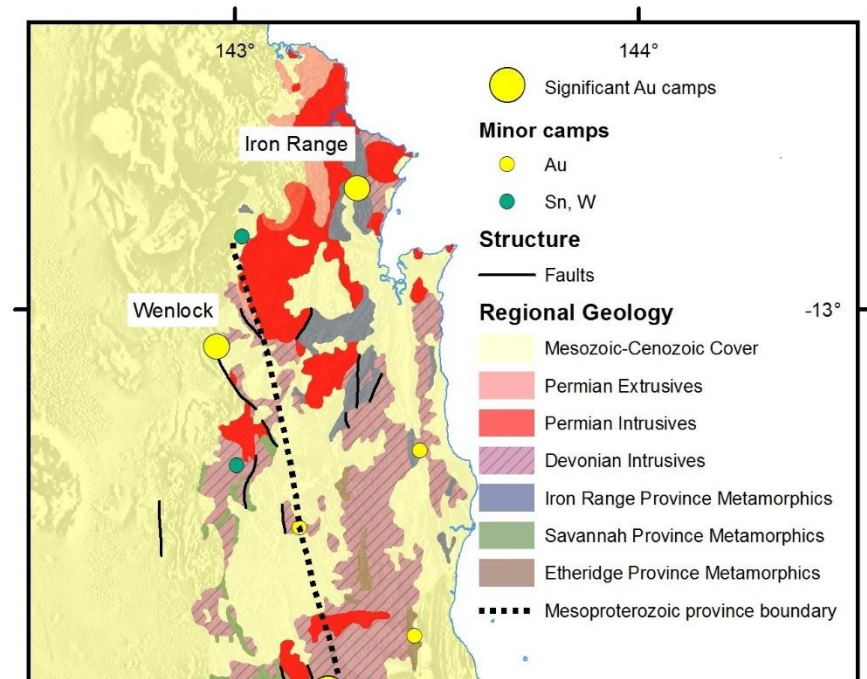
Gold mineral systems – Coen region

- Qtz-Py-Asp-Au(\pm Ga) veins in PR metamorphics, D granites and rhyolite dykes; sericite alteration; Au-Ag-As \pm Sb(Pb-Zn) geochemistry
- “Shear-hosted”? D and / or P-C?



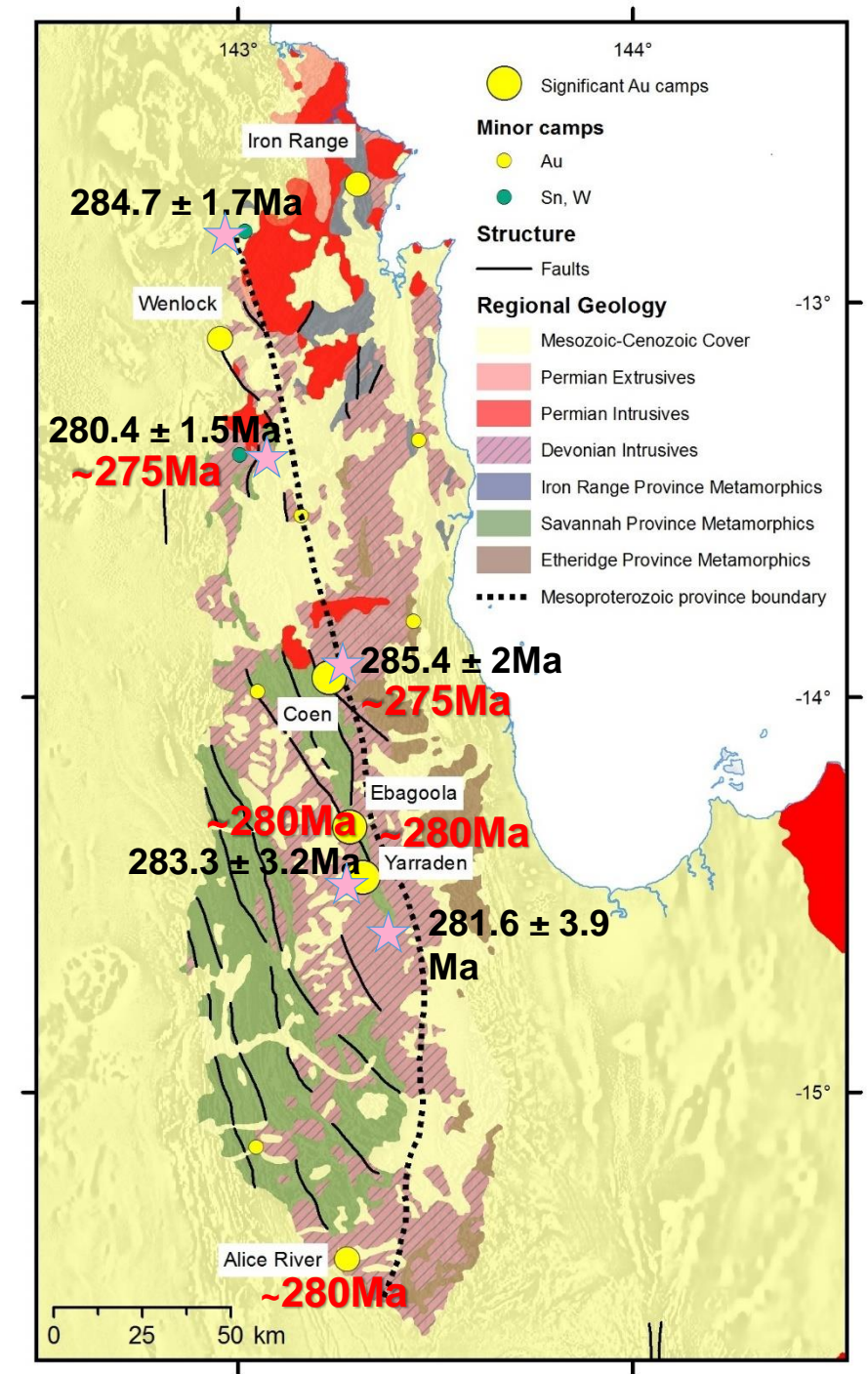
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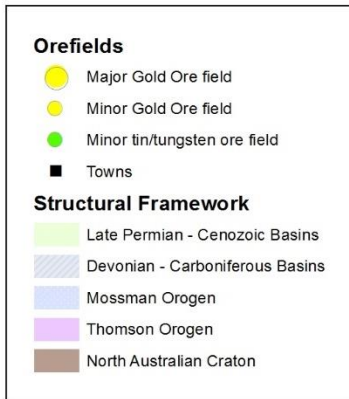
Geochronology – Coen region

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



Gold mineral systems – Cape York

Late Carboniferous Au (IRGS)



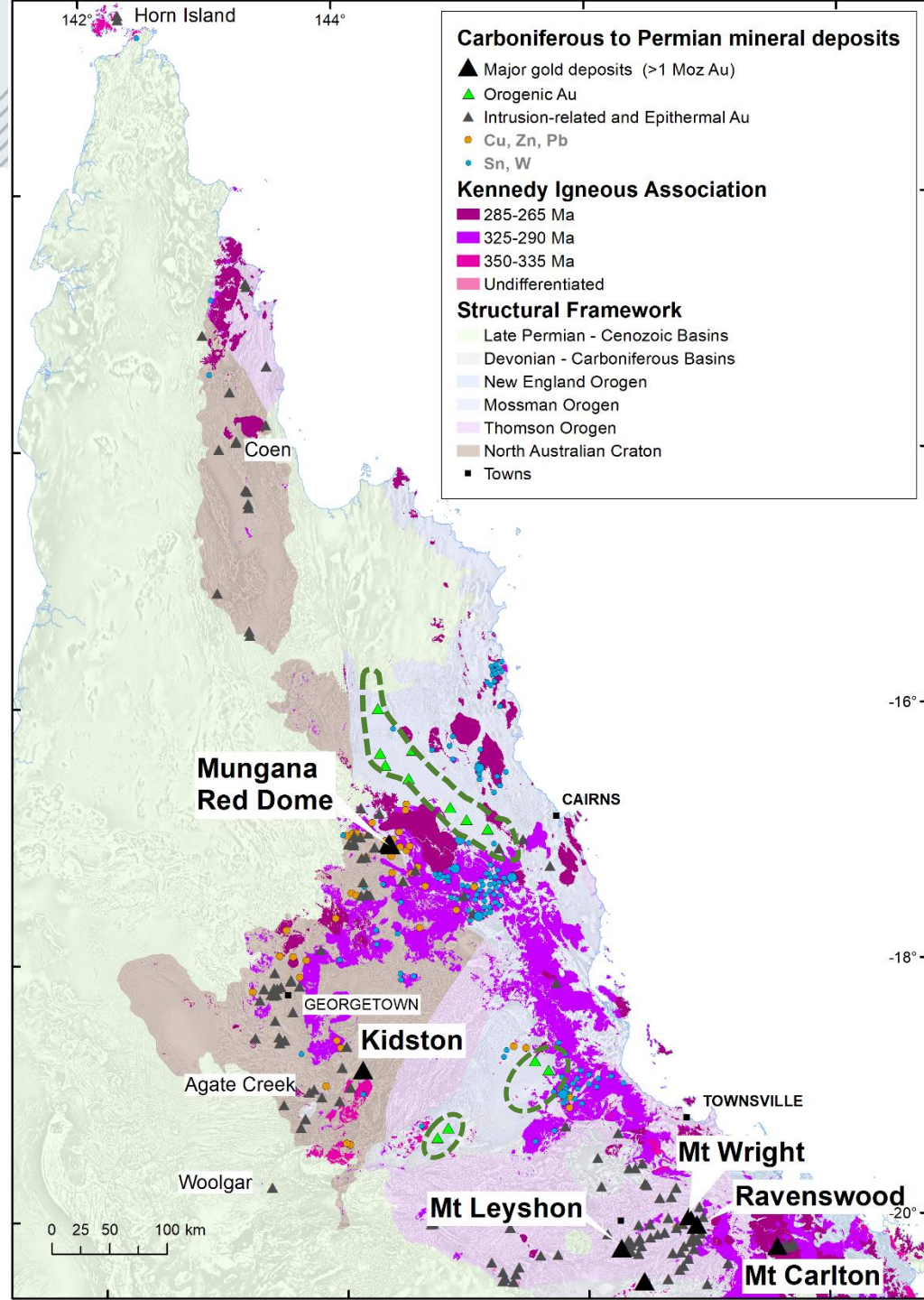
Early Permian Au (epithermal / distal IRGS?)

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

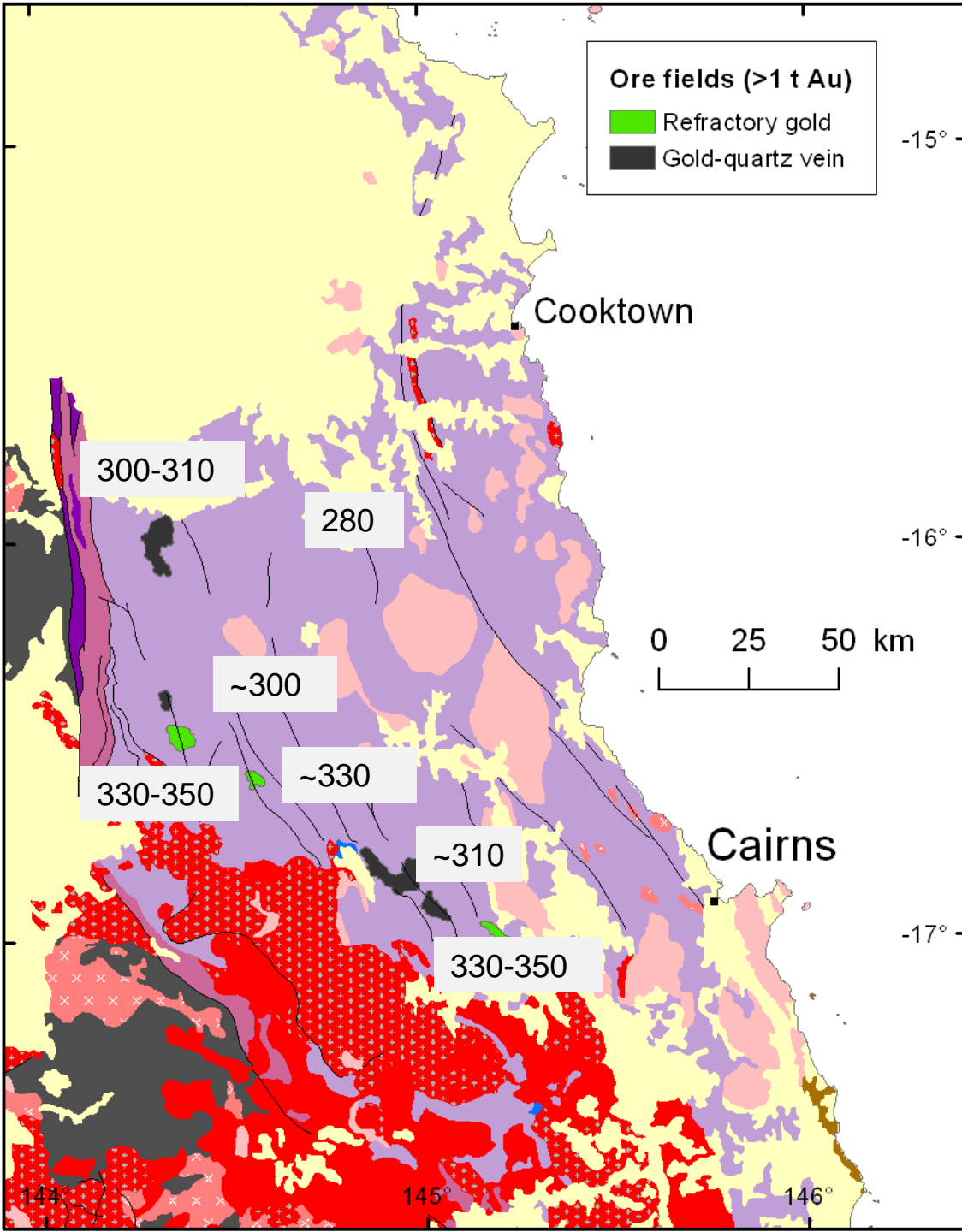
- Multiple orogenic Au deposits – in the Hodgkinson and Broken River provinces
- Qtz-Py-Asp-(Sb)-Au veins and stockworks (Au-As-Sb ± W geochemistry)



Orogenic gold – Ar-Ar geochronology

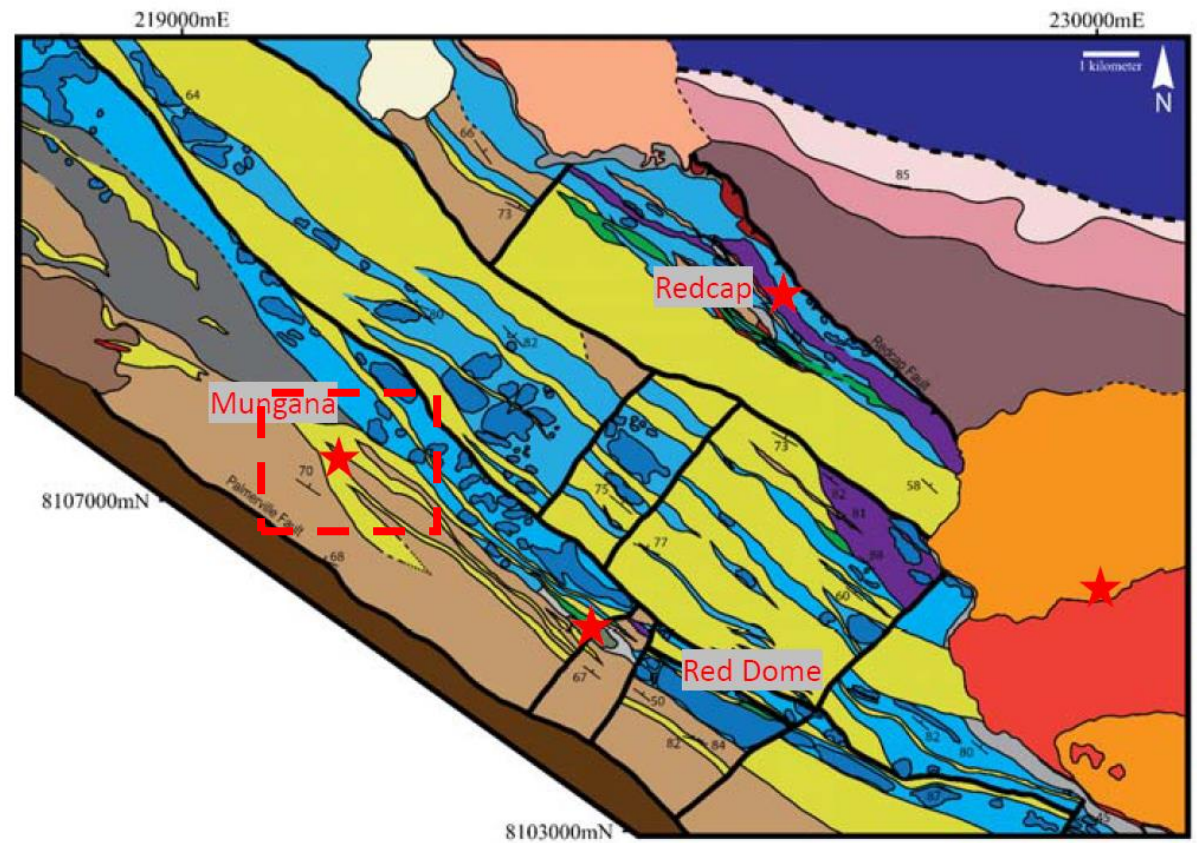
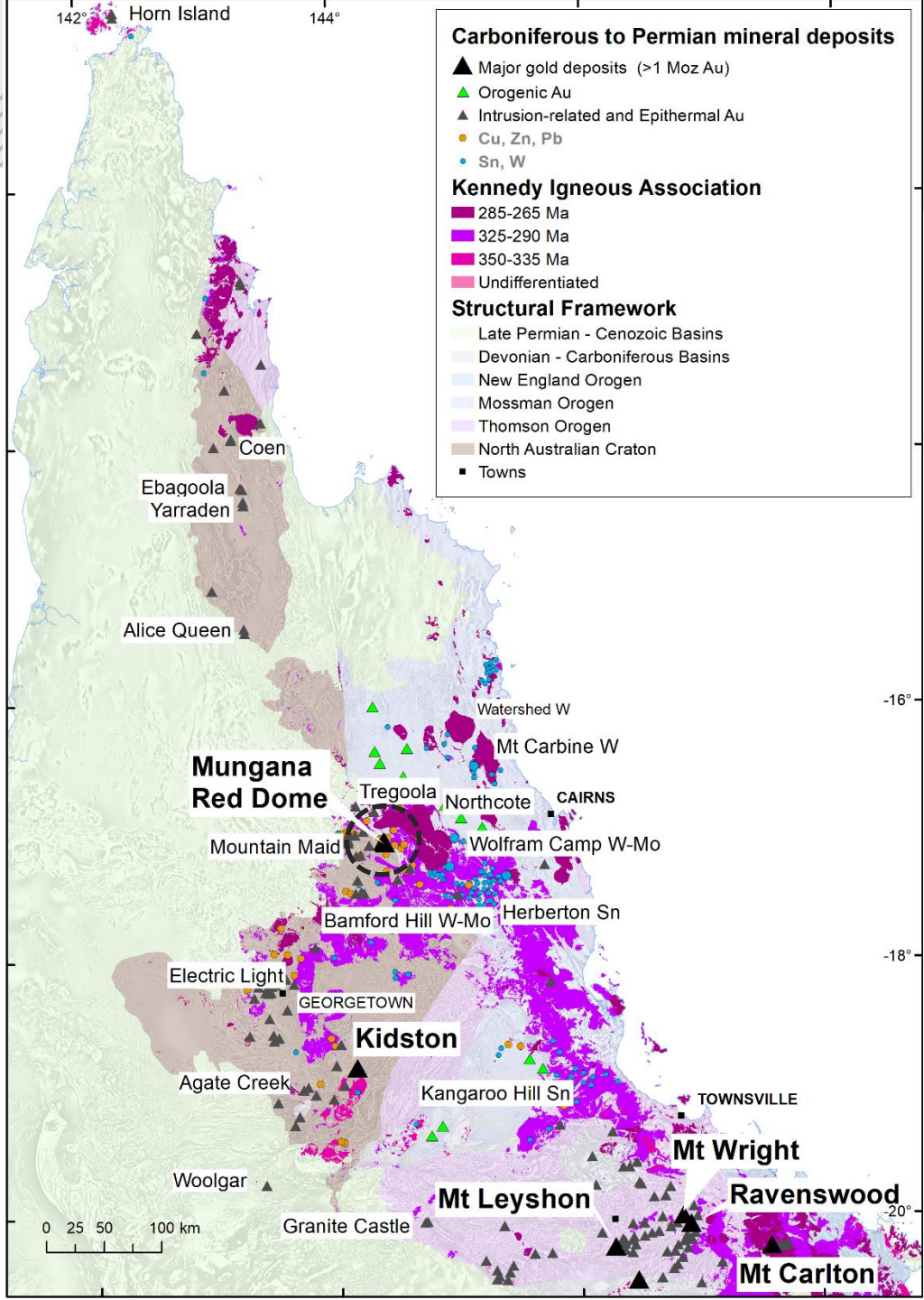
15 Ar-Ar dates on sericite alteration:

- ~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)



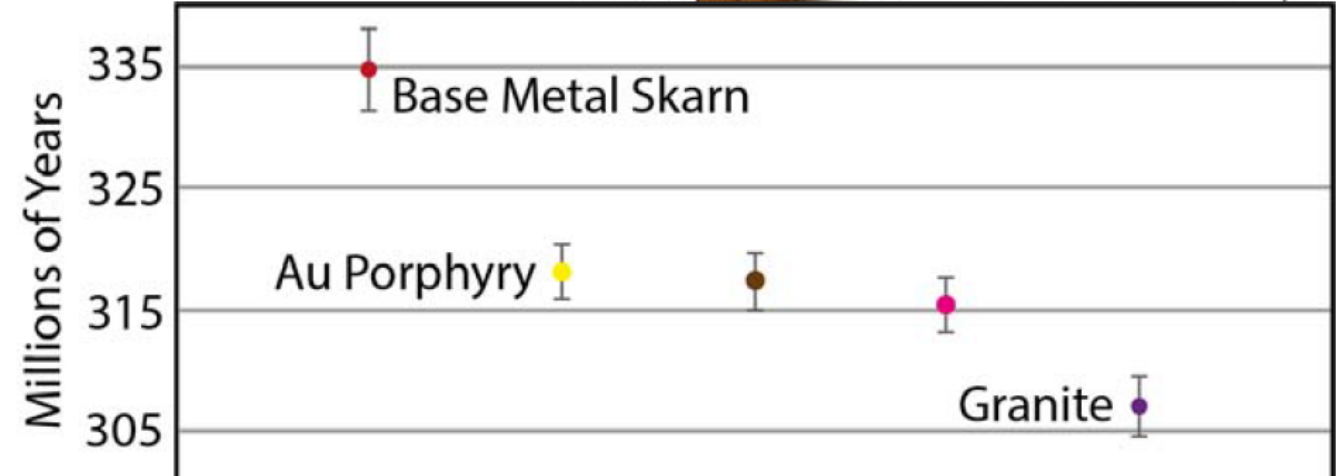
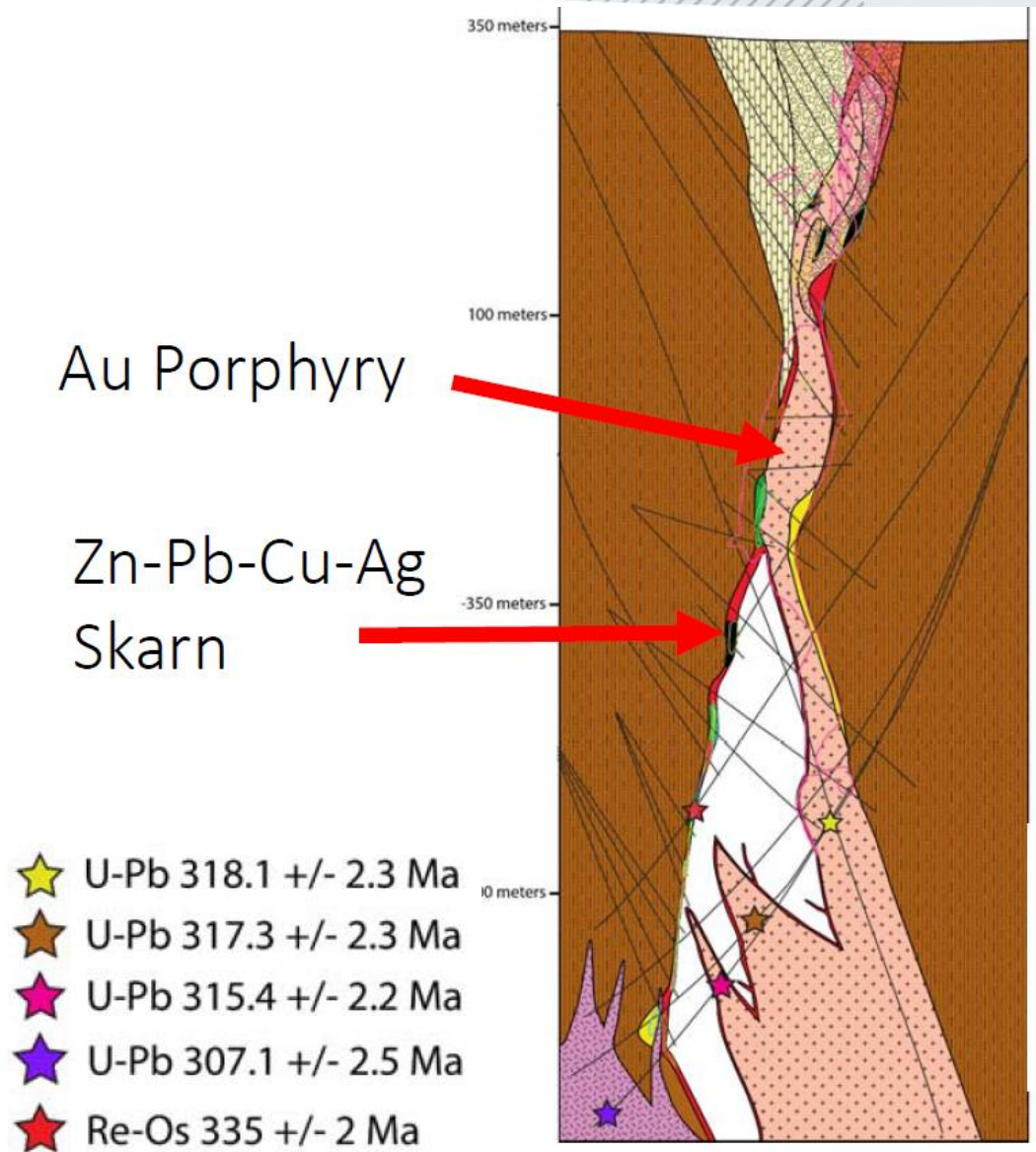
Au-Cu and Zn-Cu-Pb-Zn mineral systems – Chillagoe district

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



Peter Illig (PhD), 2016-2019

Mungana Au and Zn-Cu-Pb-Ag mineral systems



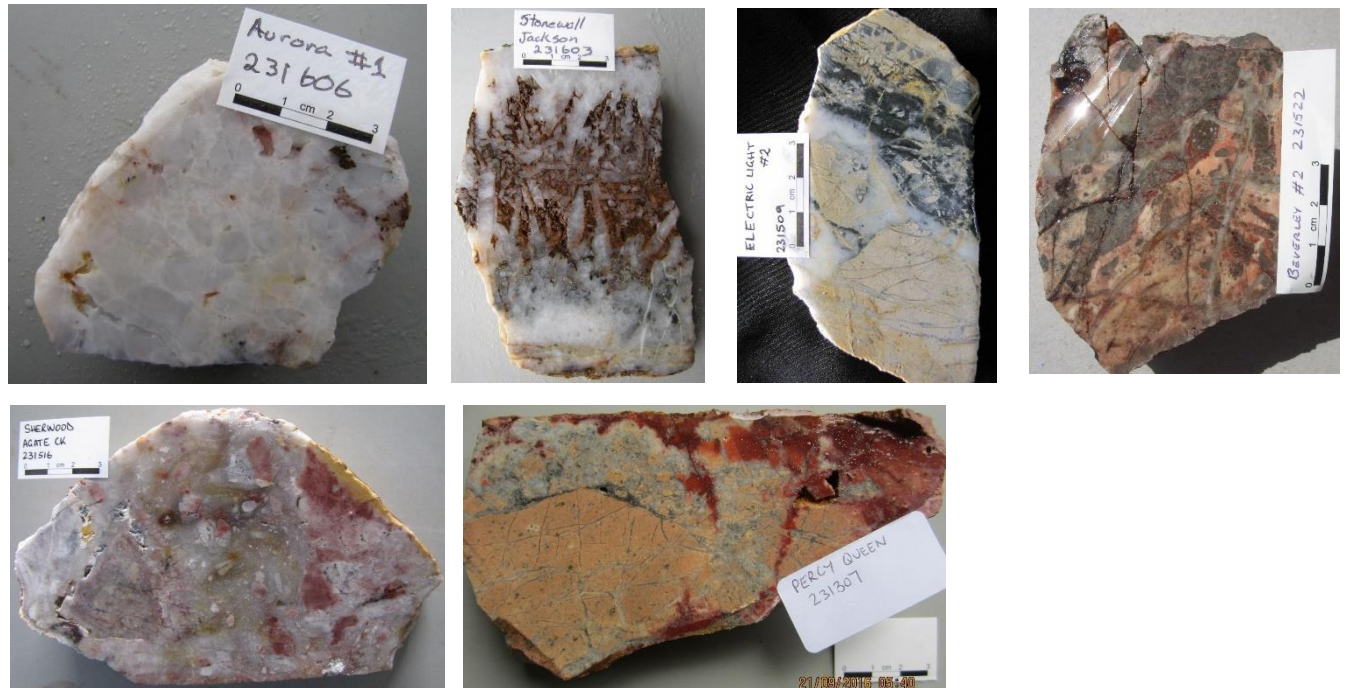
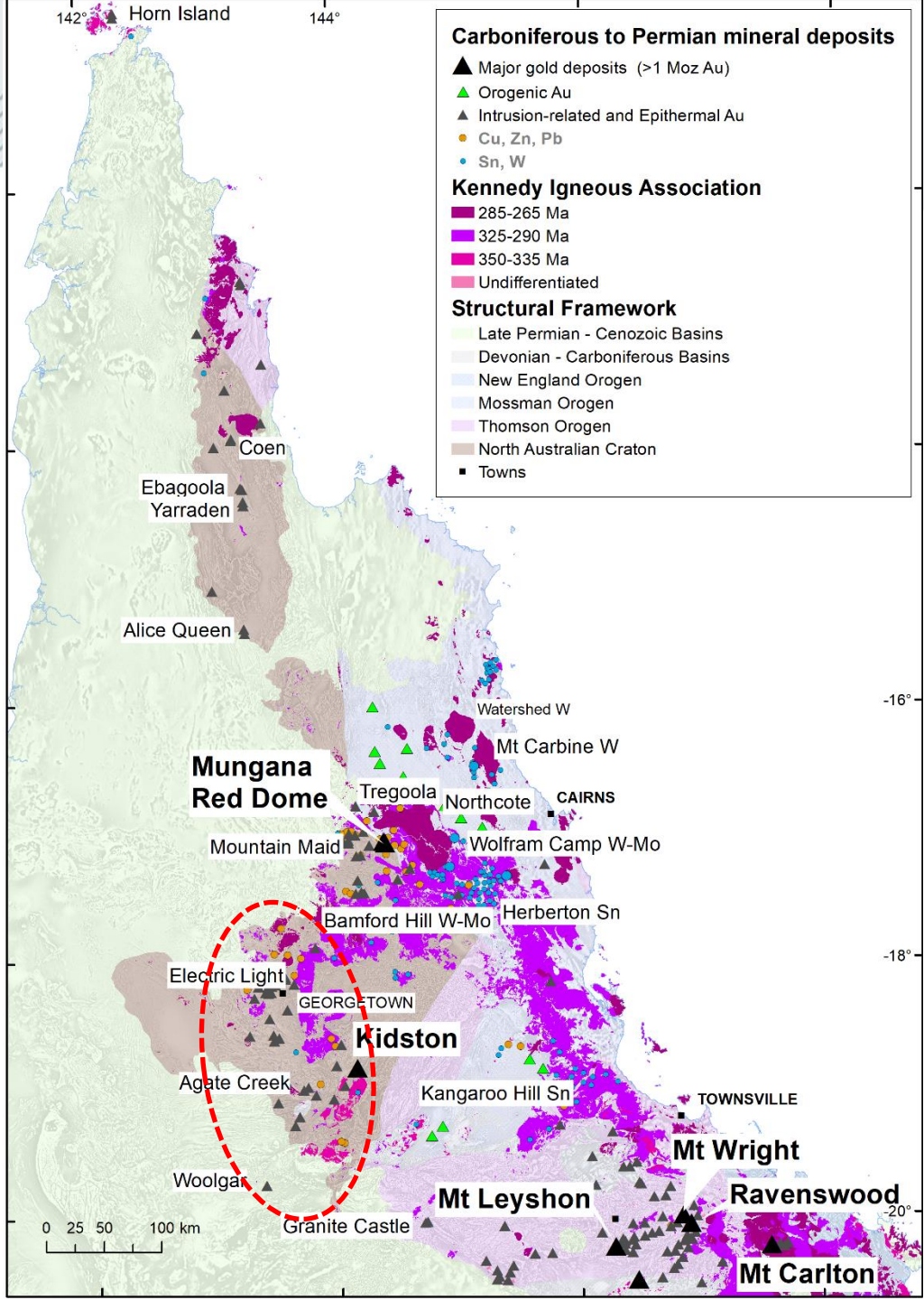
- Zn-Cu skarn – 335 Ma
- Au porphyry (IRGD) – 317 Ma

Peter Illig, 2017

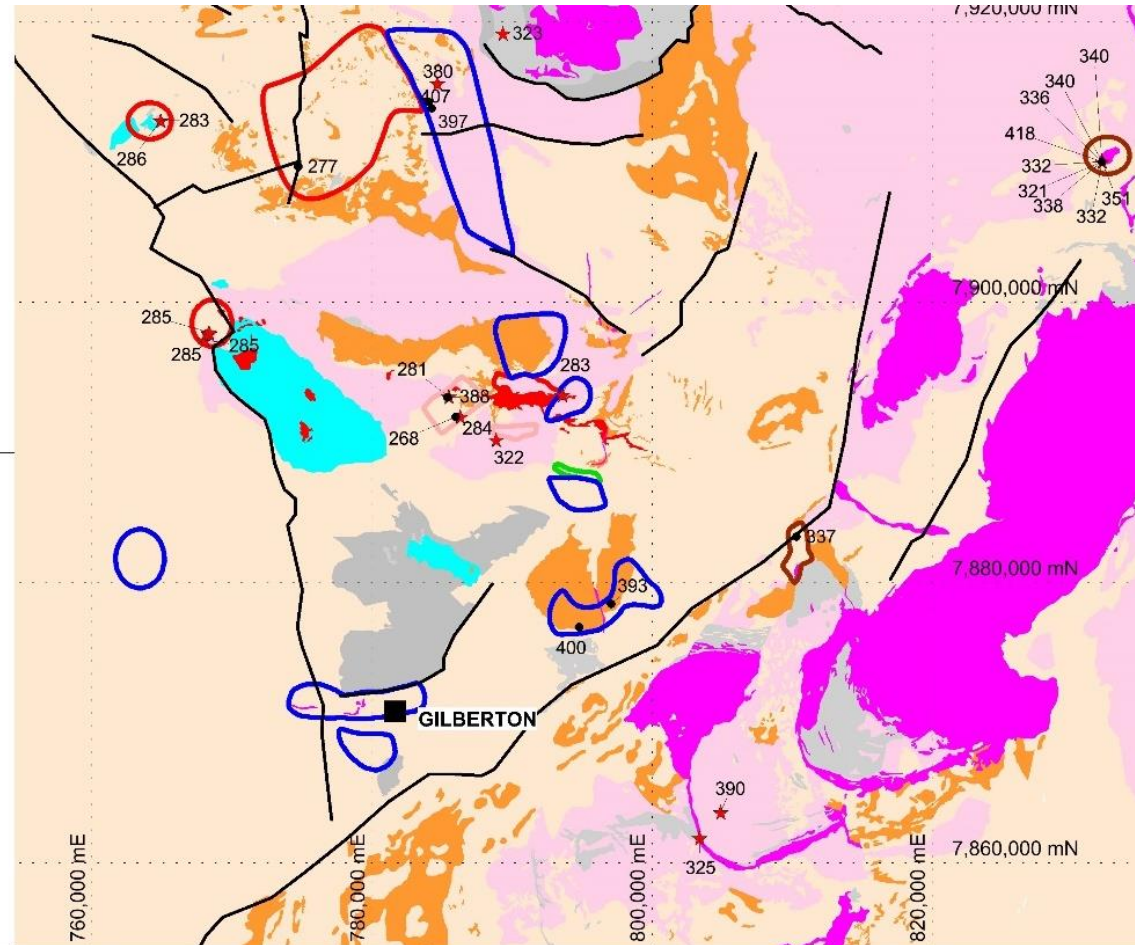
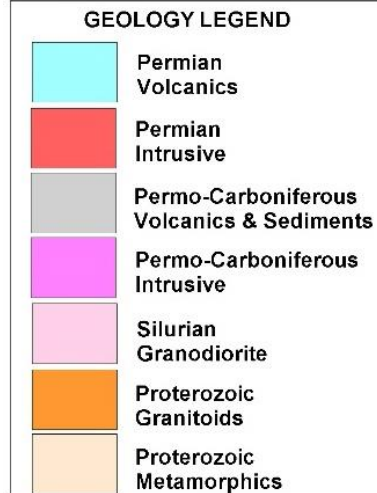
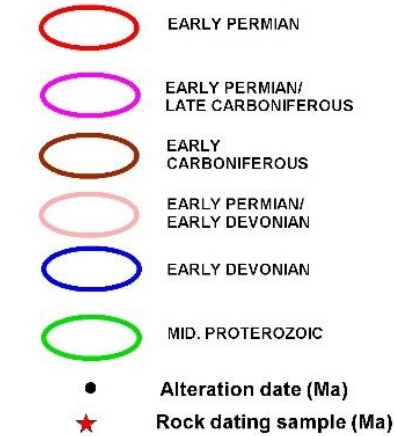
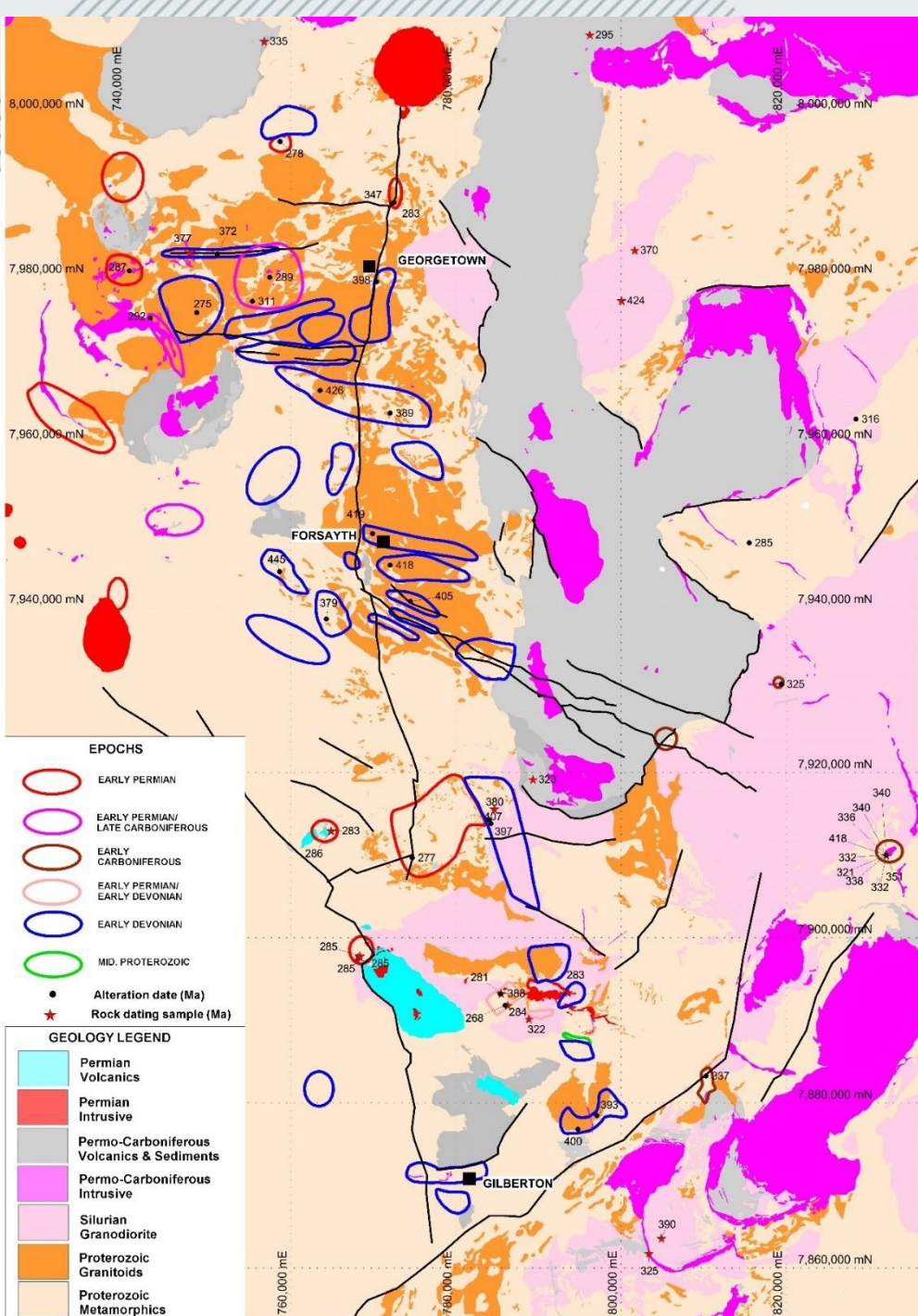
Gold mineral systems – Georgetown

➤ A variety of styles (and previously often assumed ages)

➤ Devonian orogenic Au; Carboniferous IRGS; Carboniferous(?) porphyry Cu; Permian(?) epithermal Au

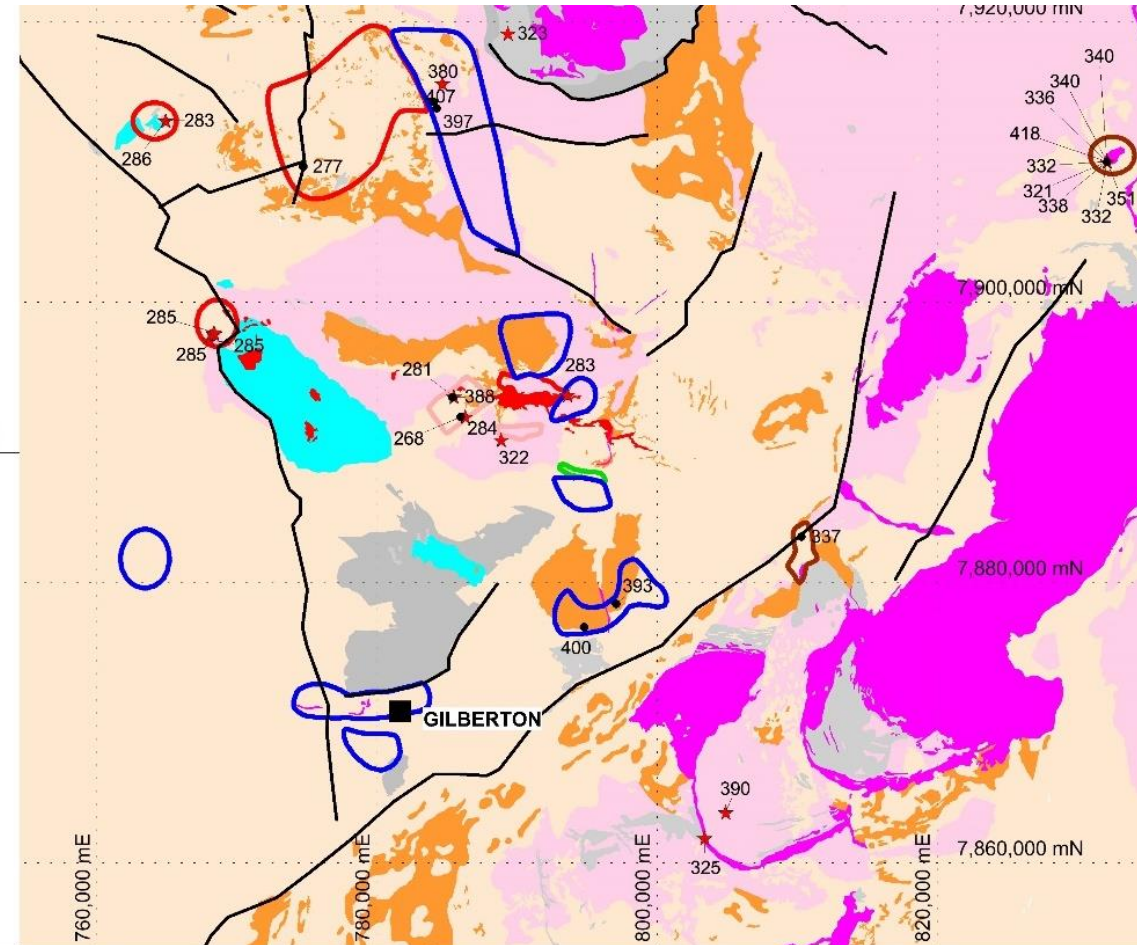
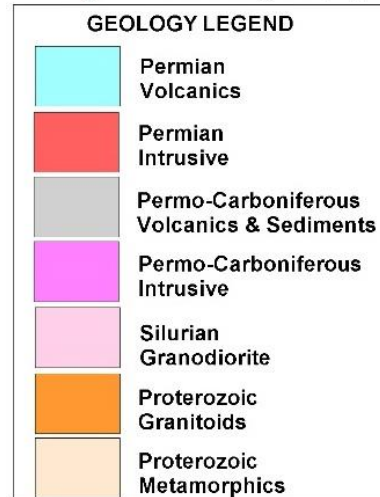
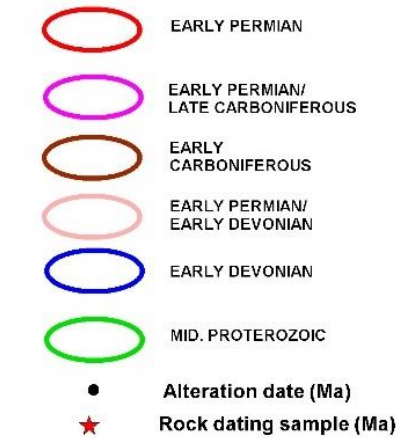


Gold mineral systems – Georgetown

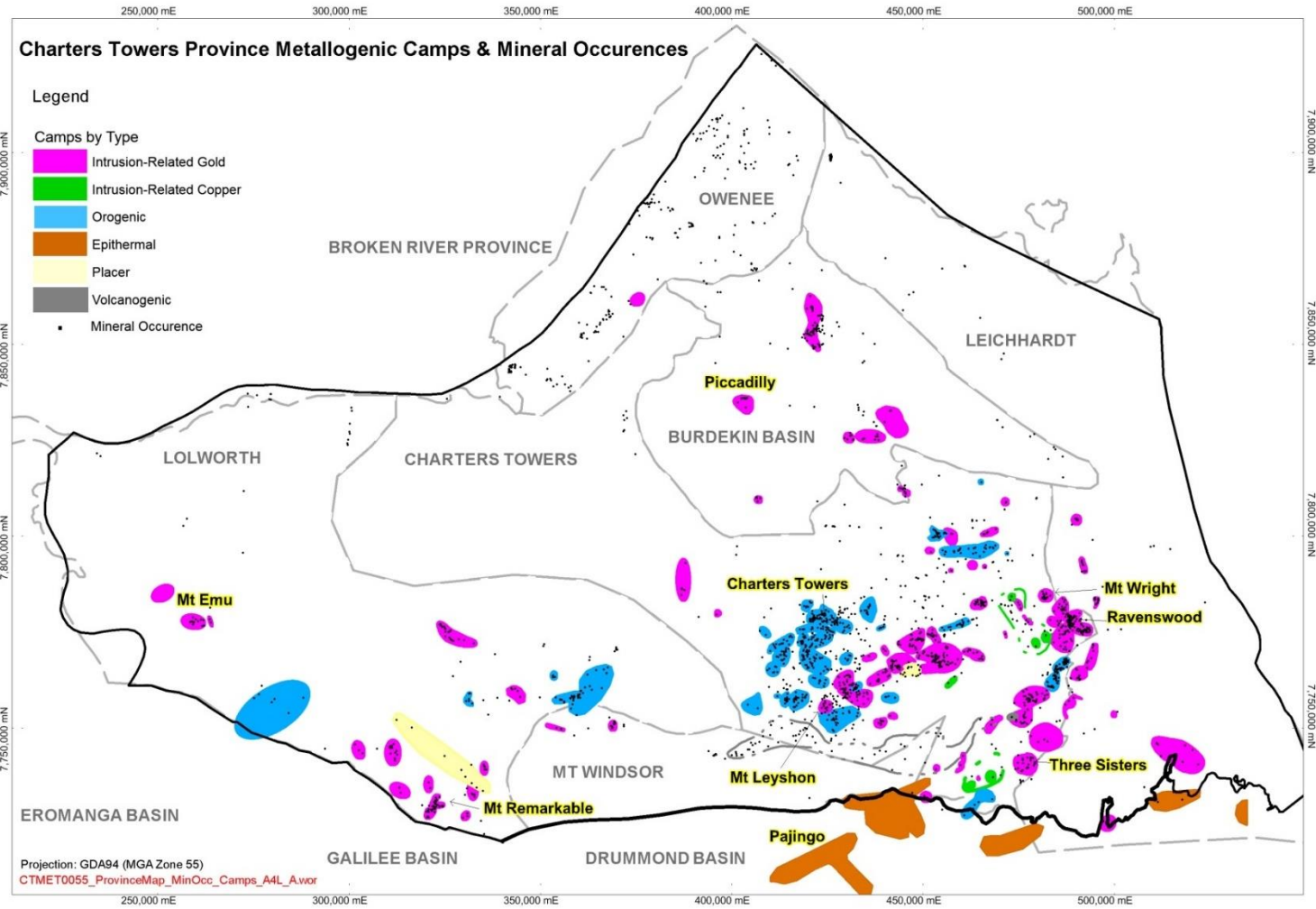
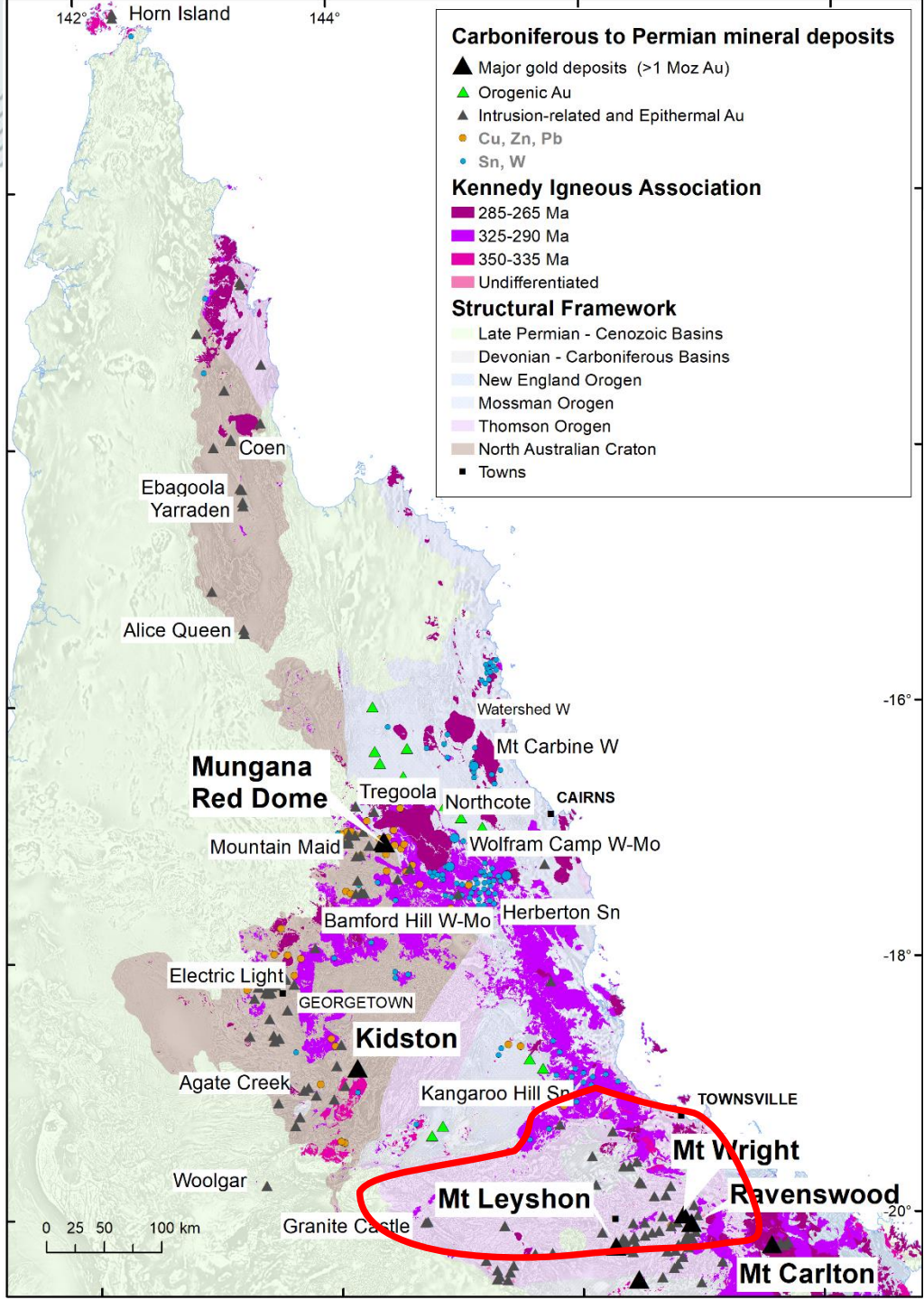


Gold mineral systems – Georgetown

- 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



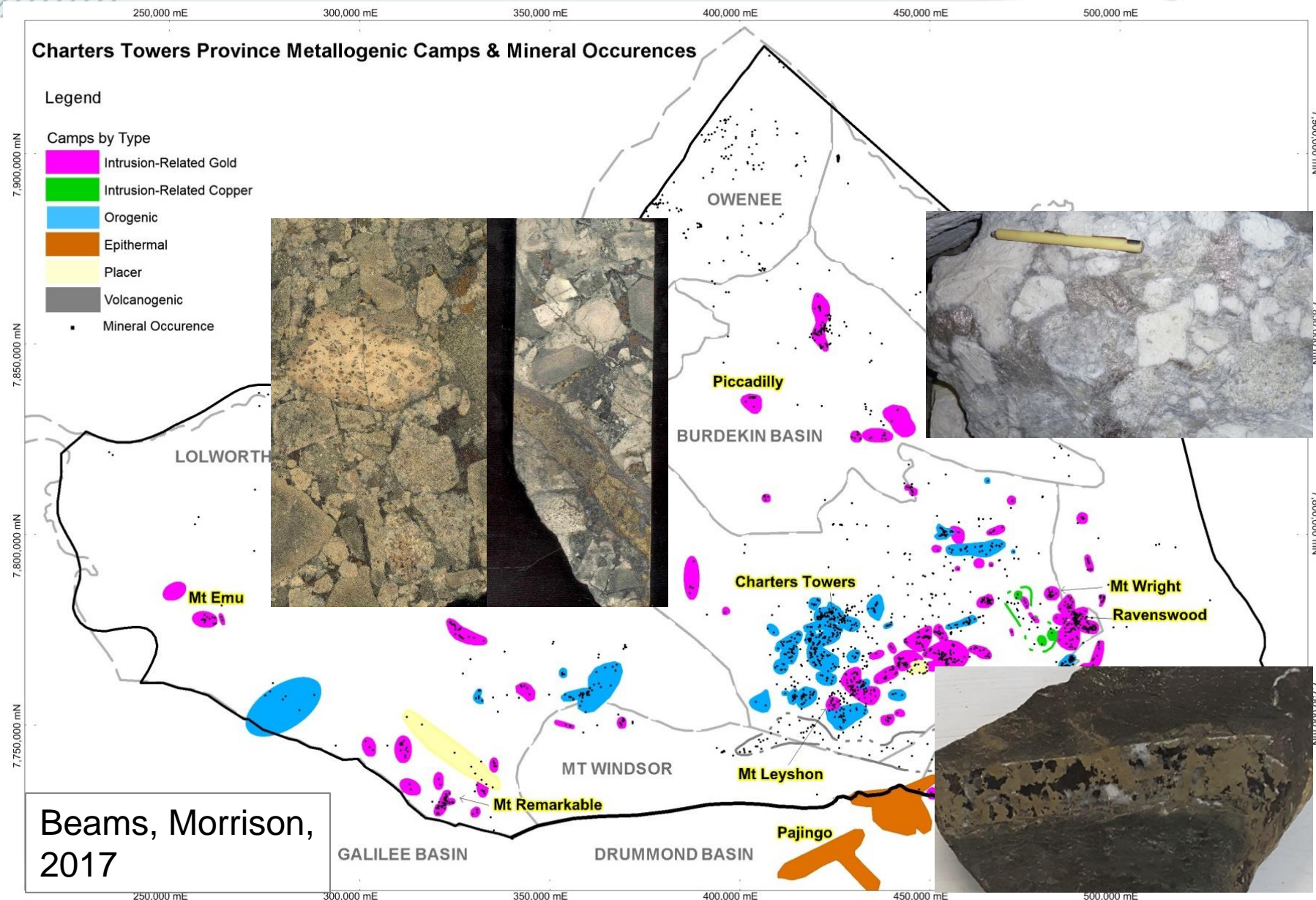
Beams, Morrison,
2017

Gold mineral systems – Charters Towers Province

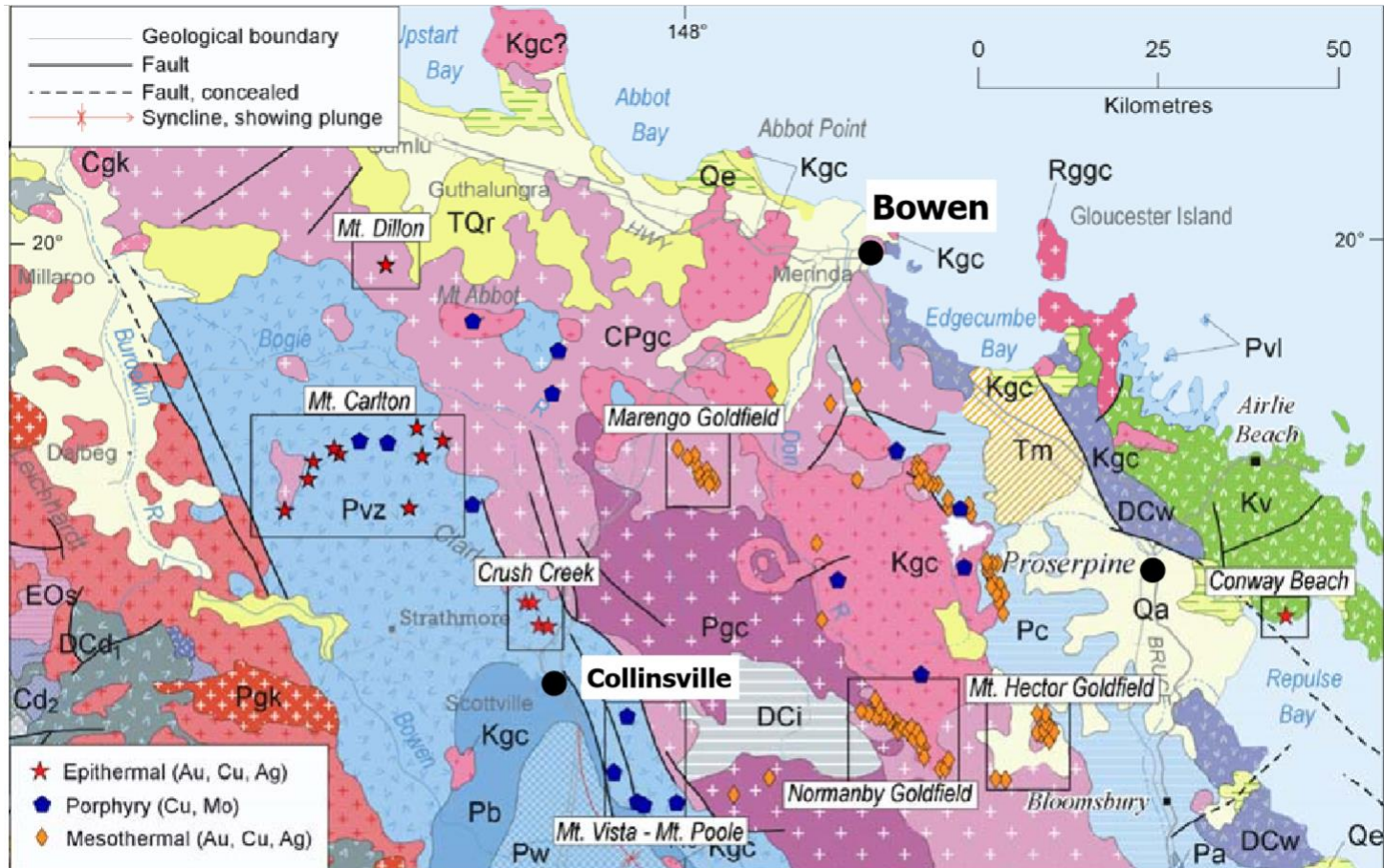
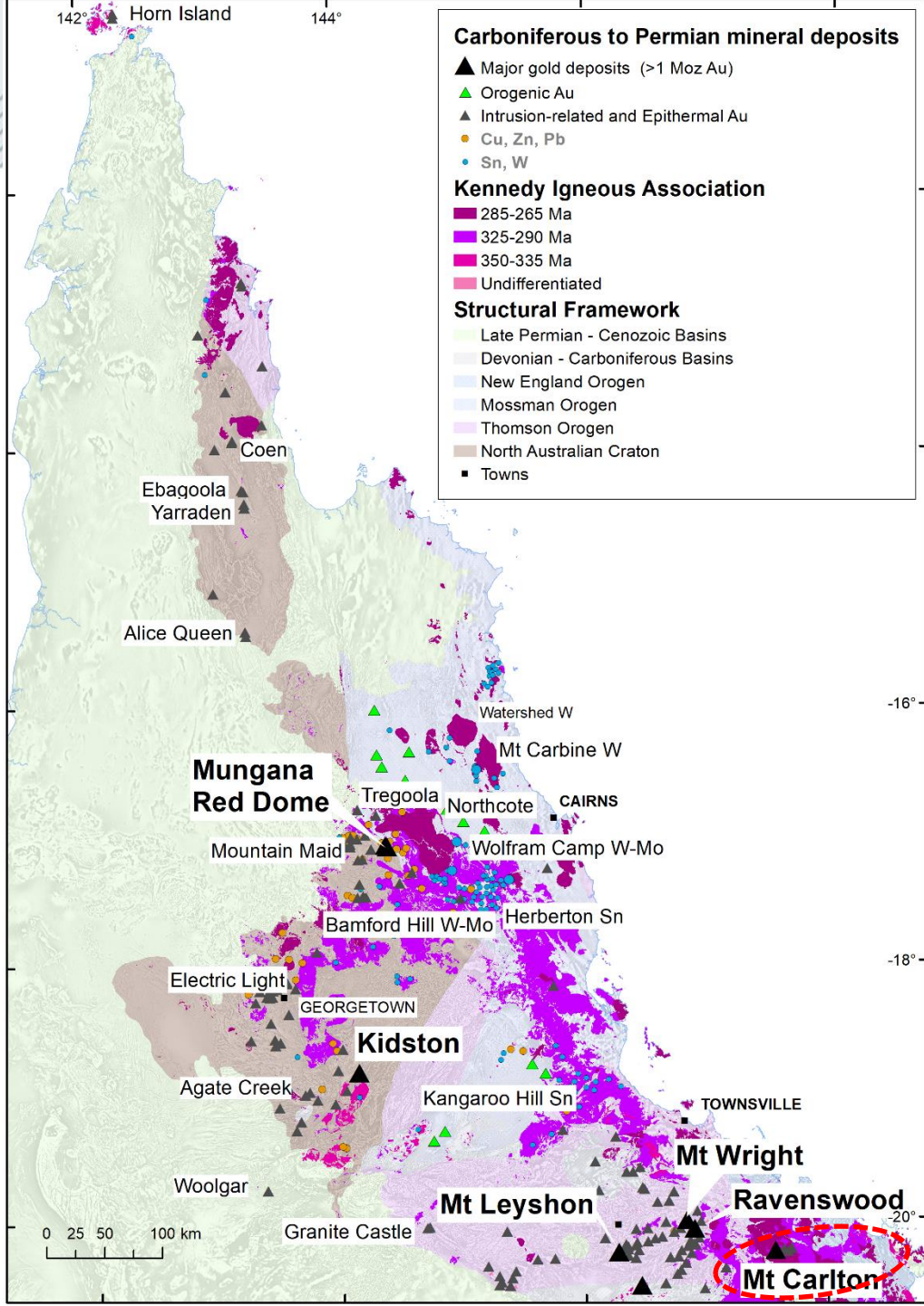
Two distinct Au mineral systems, distinguishable by geochemistry:

➤ Devonian orogenic (Au-Ag-Pb-Zn-Cu)

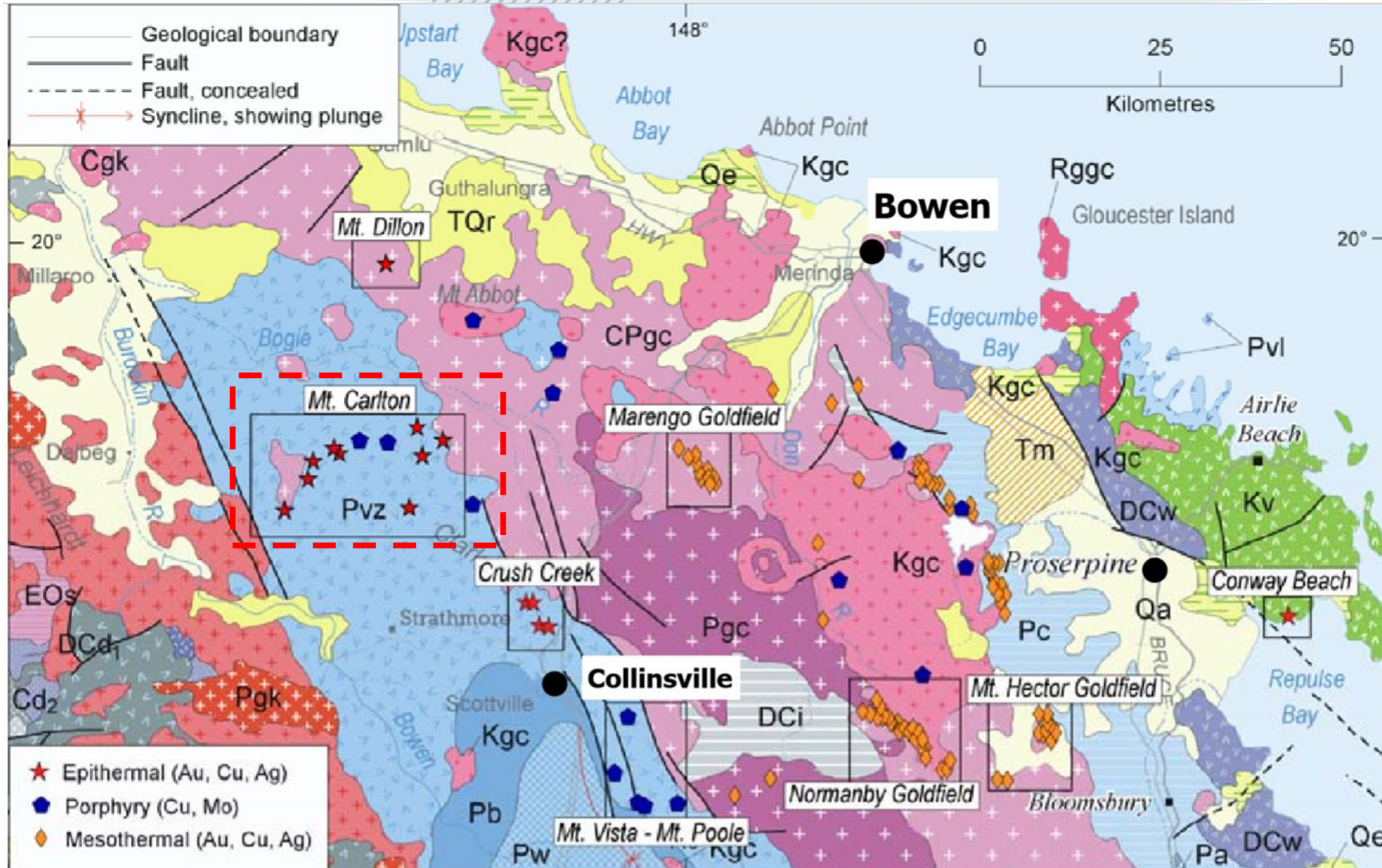
➤ Carboniferous intrusion-related (Au-As-Te-Bi-Cu-Pb-Zn-Ag-Sb(Mo-W), km-scale zonation)



Gold mineral systems – northern Bowen Basin and Urannah Batholith

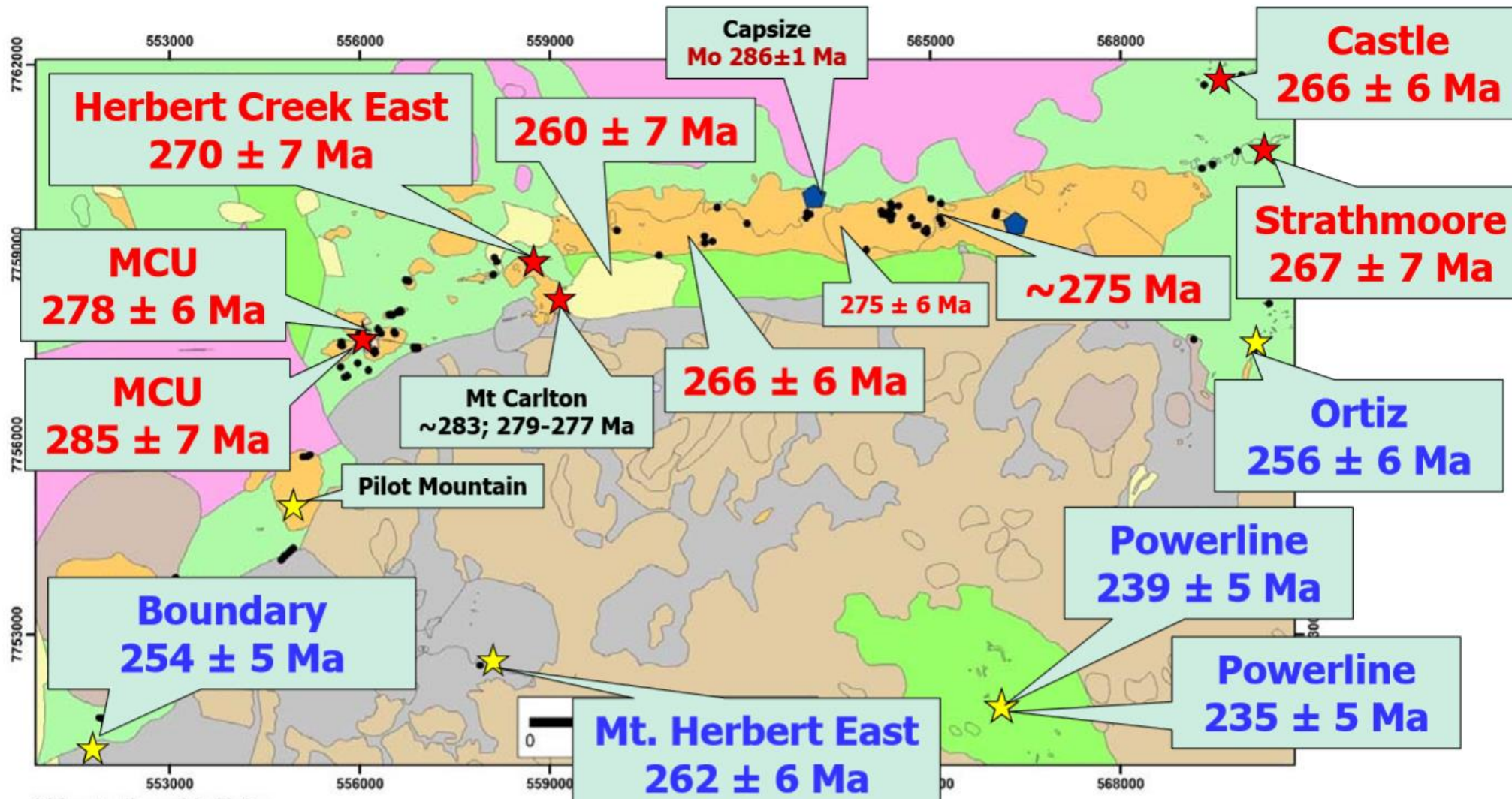


Gold mineral systems – northern Bowen Basin



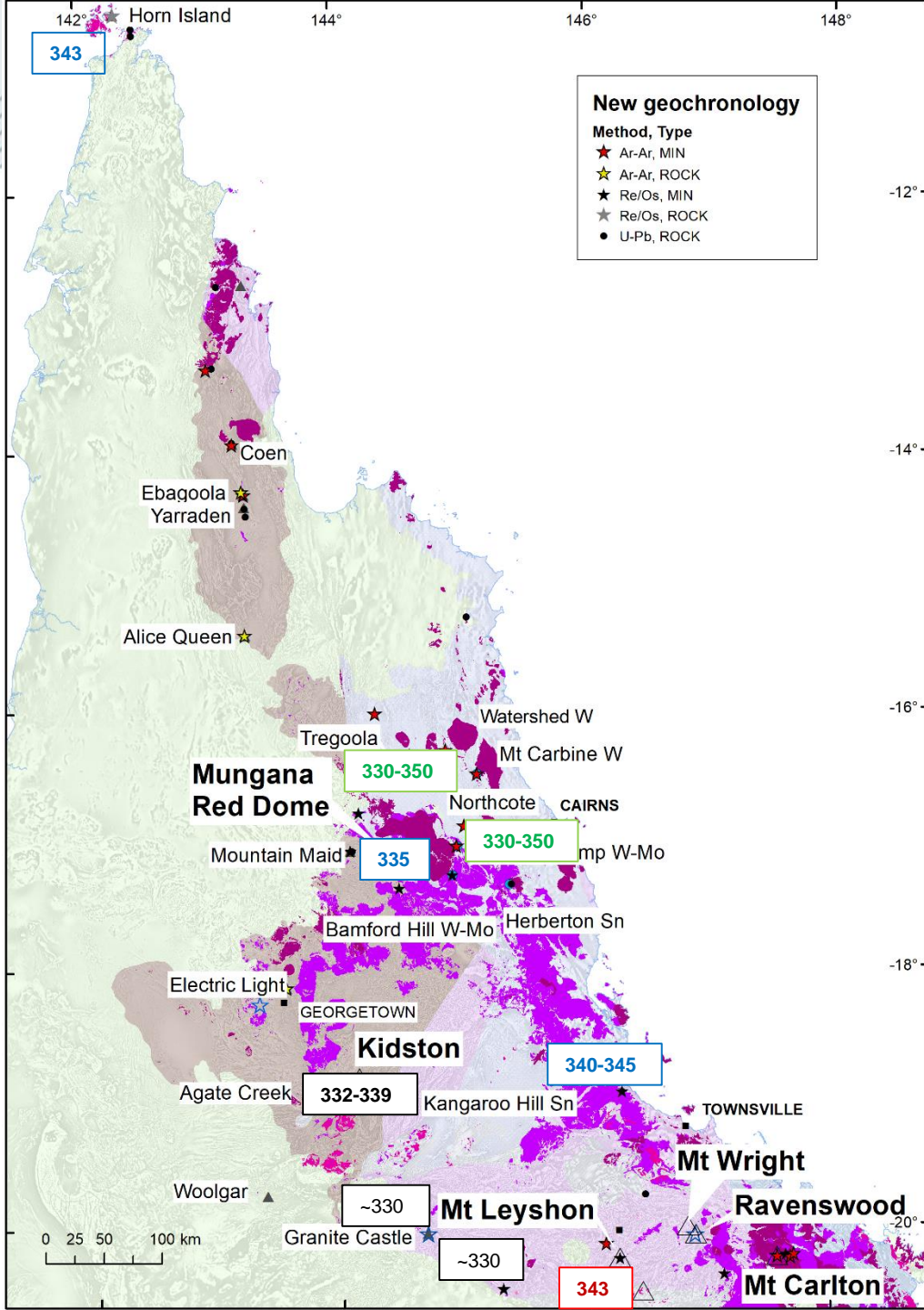
Isaac Corral, 2017

High- and Low-sulphidation deposits – Mt Carlton district



Carboniferous and Permian metallogenic events

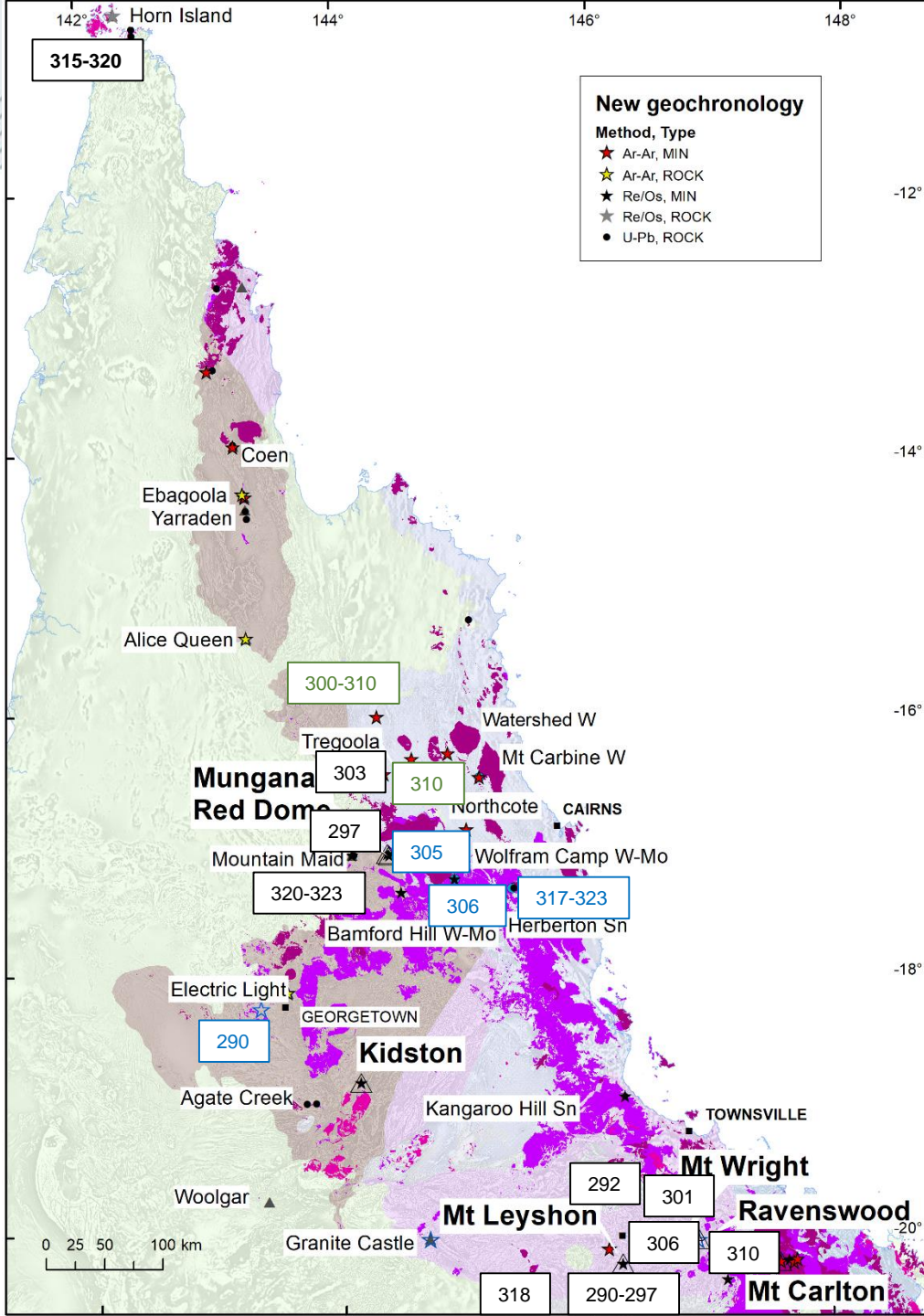
- **350-335 Ma - IRGS** (Kidston); epithermal Au (LS - Pajingo); orogenic Au (Hodgkinson Province); Sn (Kangaroo Hills); Zn (Mungana)



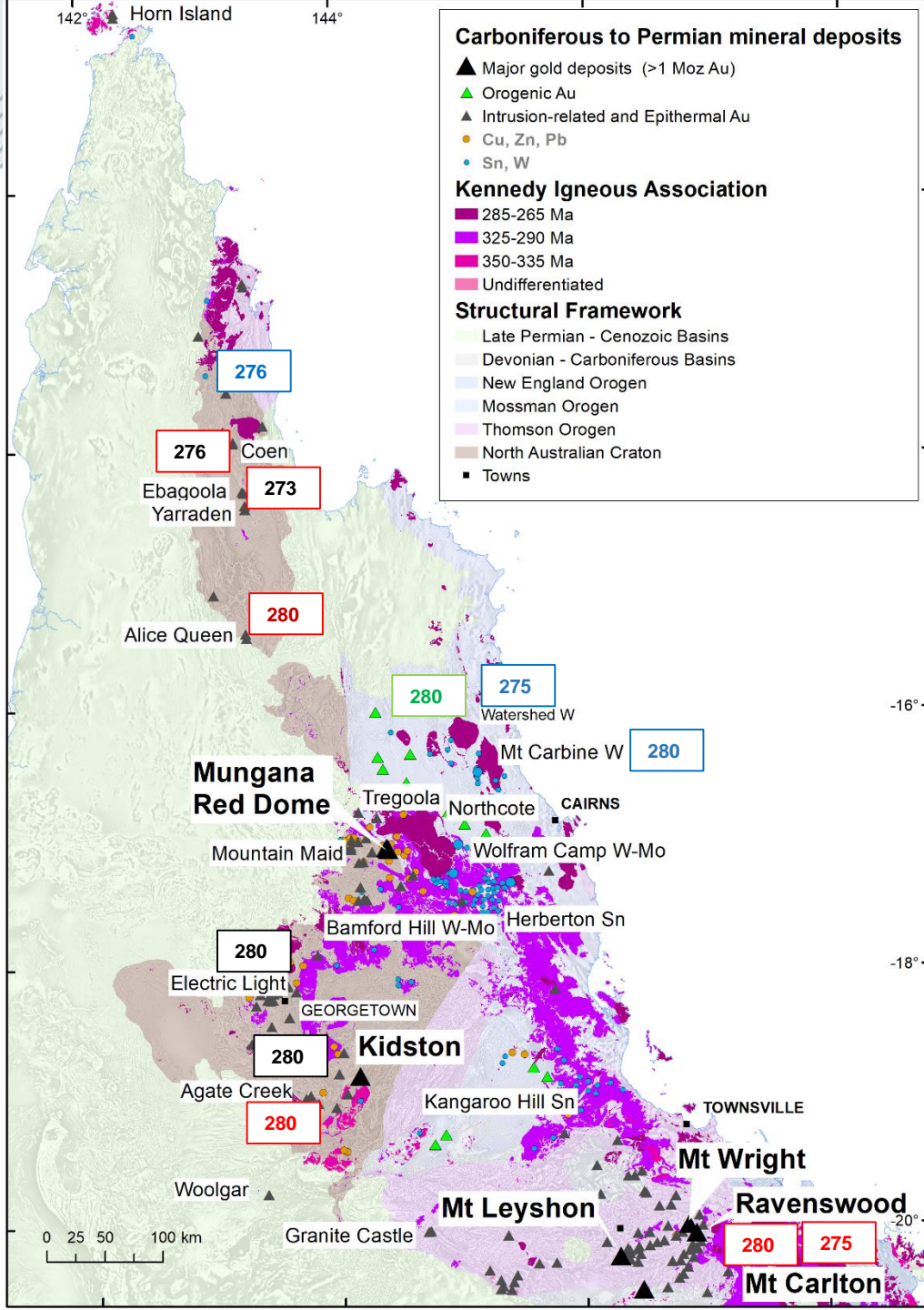
Carboniferous and Permian metallogenic events

➤ 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



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➤ **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)

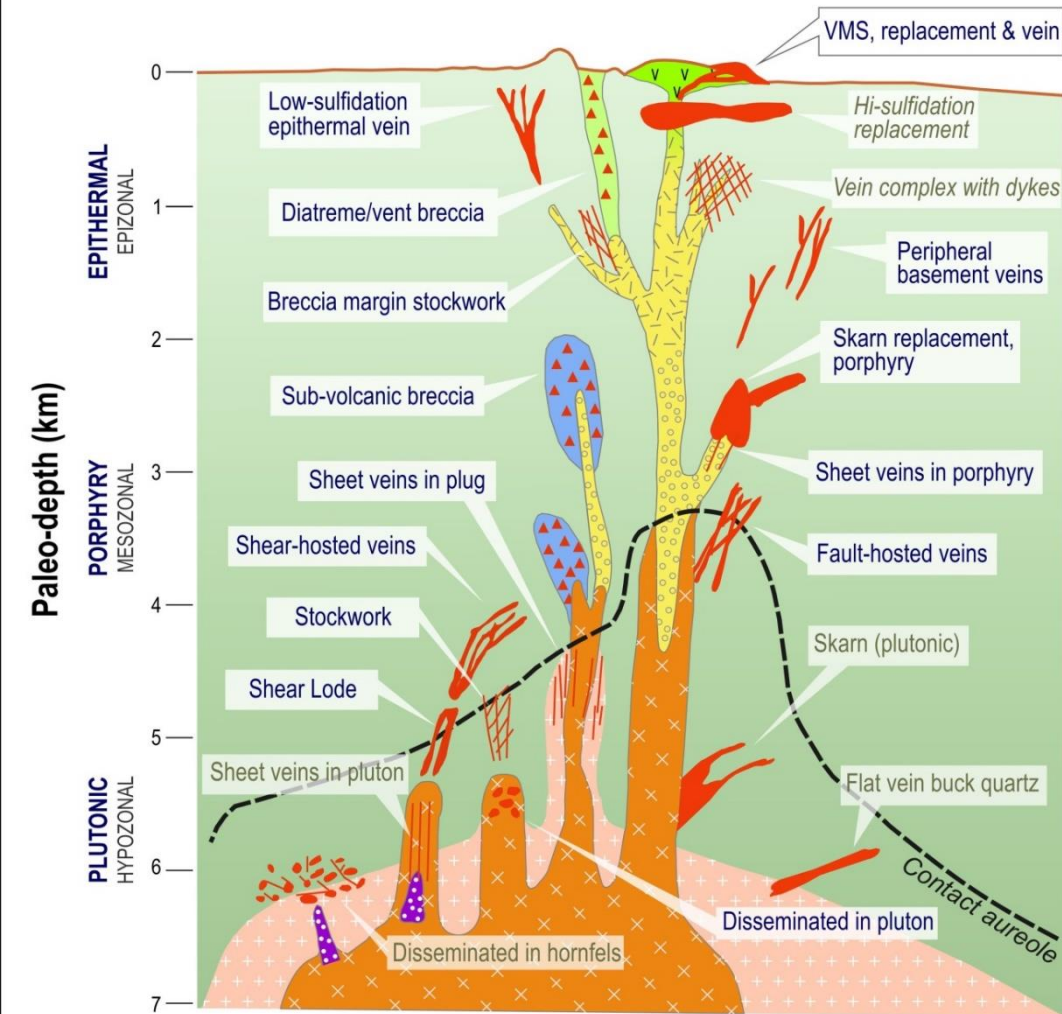
Relationships between distinct mineral systems

➤ **350-335 Ma - IRGS** (Kidston); **epithermal Au** (Pajingo); orogenic Au; Sn (Kangaroo Hill)

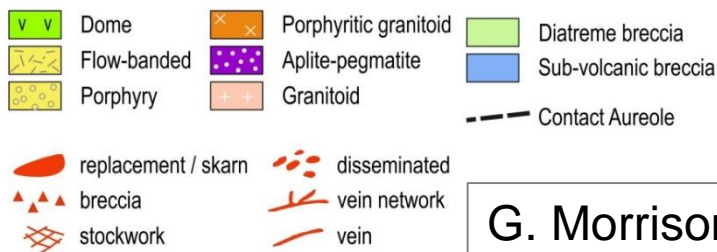
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➤ Mineral systems across NE Queensland – diverse manifestations of the same regional thermal and magmatic events



LEGEND



G. Morrison, 2014

Acknowledgements

- 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 – Adrian Boyce)
- Multiple companies across the region (access to sites; co-funding research students)

