

# Intrusion-related minerals systems of north Queensland

Courteney Dhnaram (Geological Survey of Queensland)

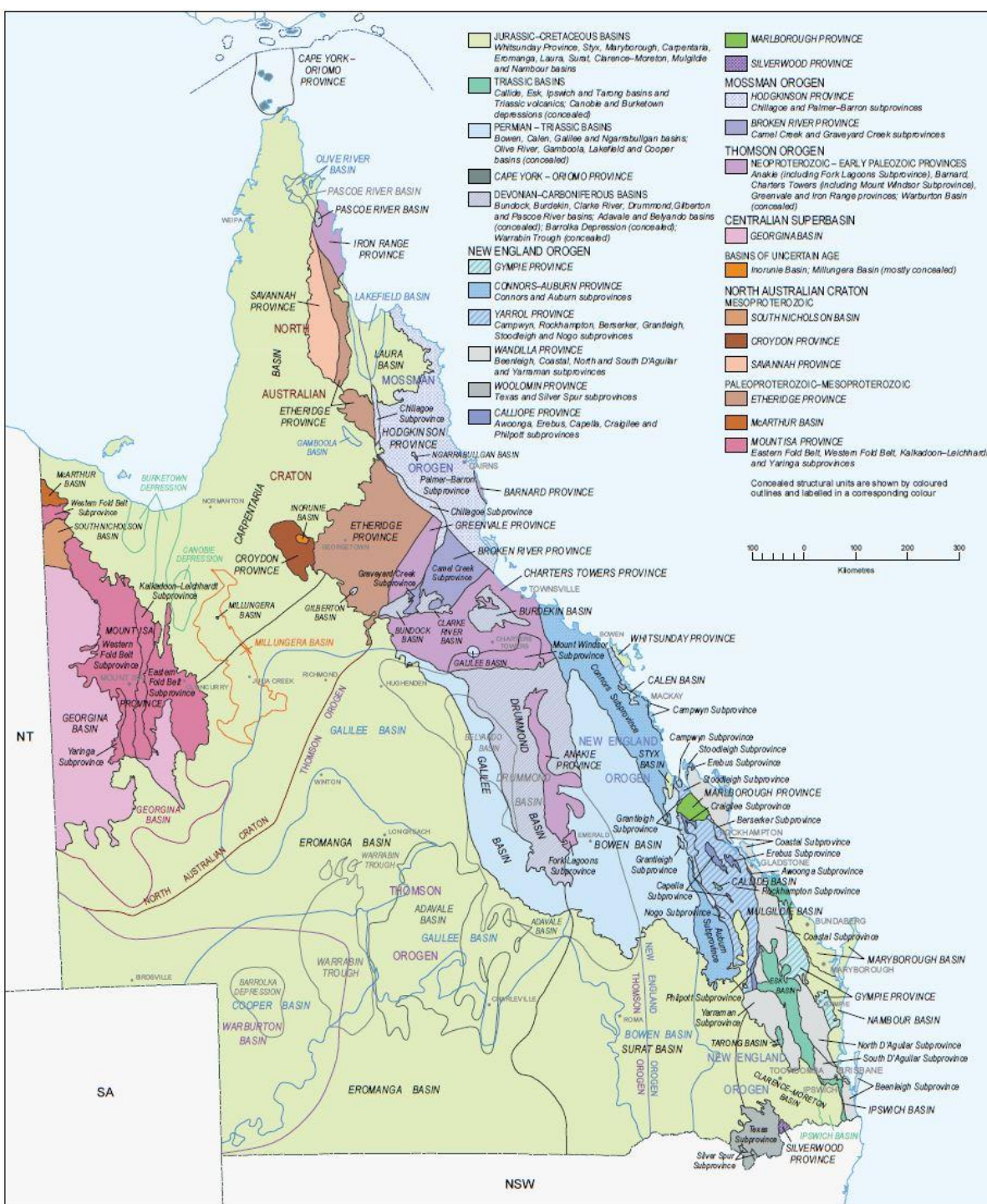
# Outline

- The bulk of this presentation was prepared by Vladimir Lisitsin (GSQ) - but the conceptual framework of the discussed project had been defined through extensive consultations involving many people – most notably, from JCU, Terra Search and Klondike Exploration
- Most sample- to deposit-scale illustrations of intrusion-related gold deposits were provided by Gregg Morrison (Klondike Exploration)

# Outline

- Major late Palaeozoic mineral systems of north-east Queensland – an overview
- Geological problems and questions
- Proposed solutions – 3-year collaborative research project
- Current GSQ projects

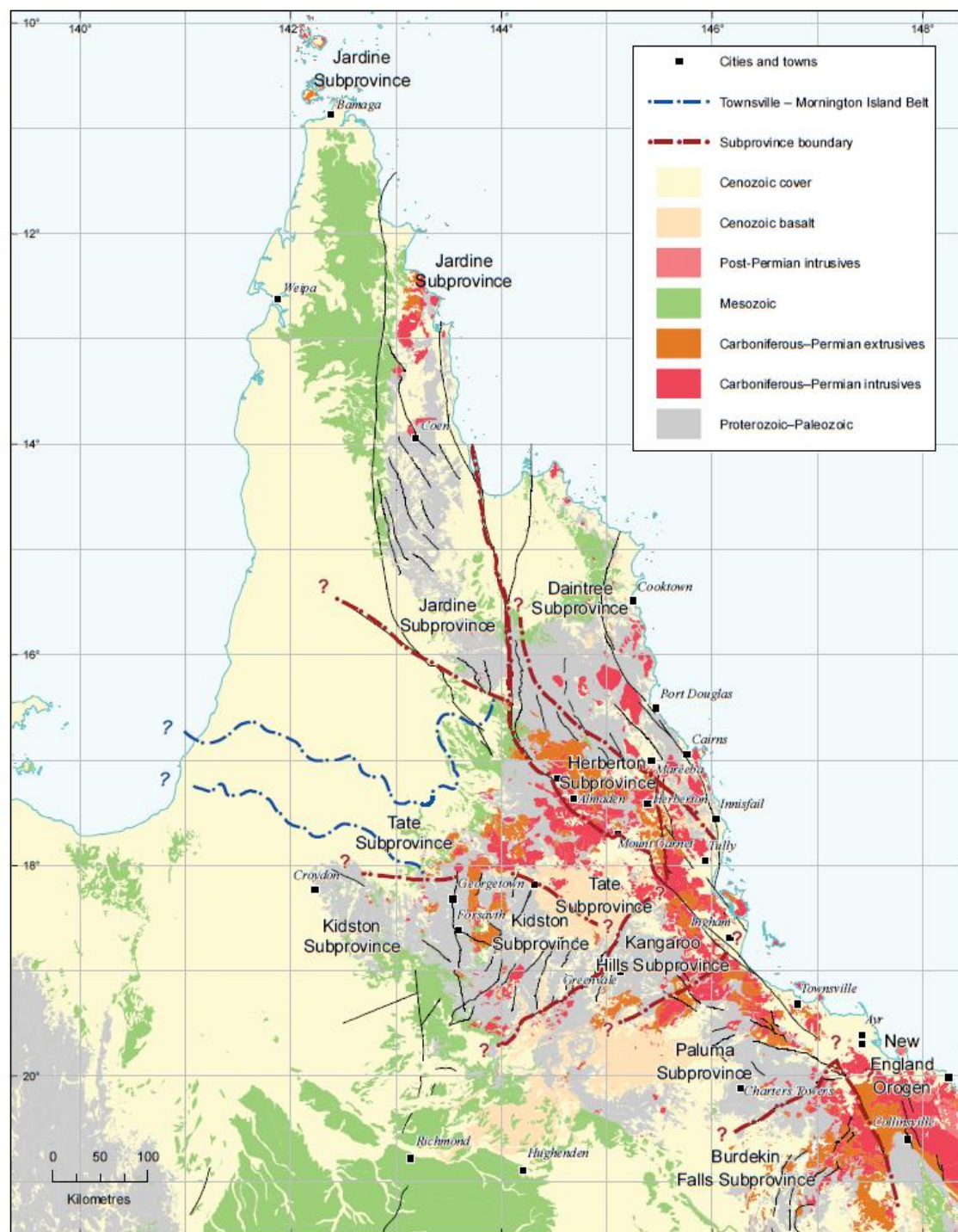
# Geological Setting



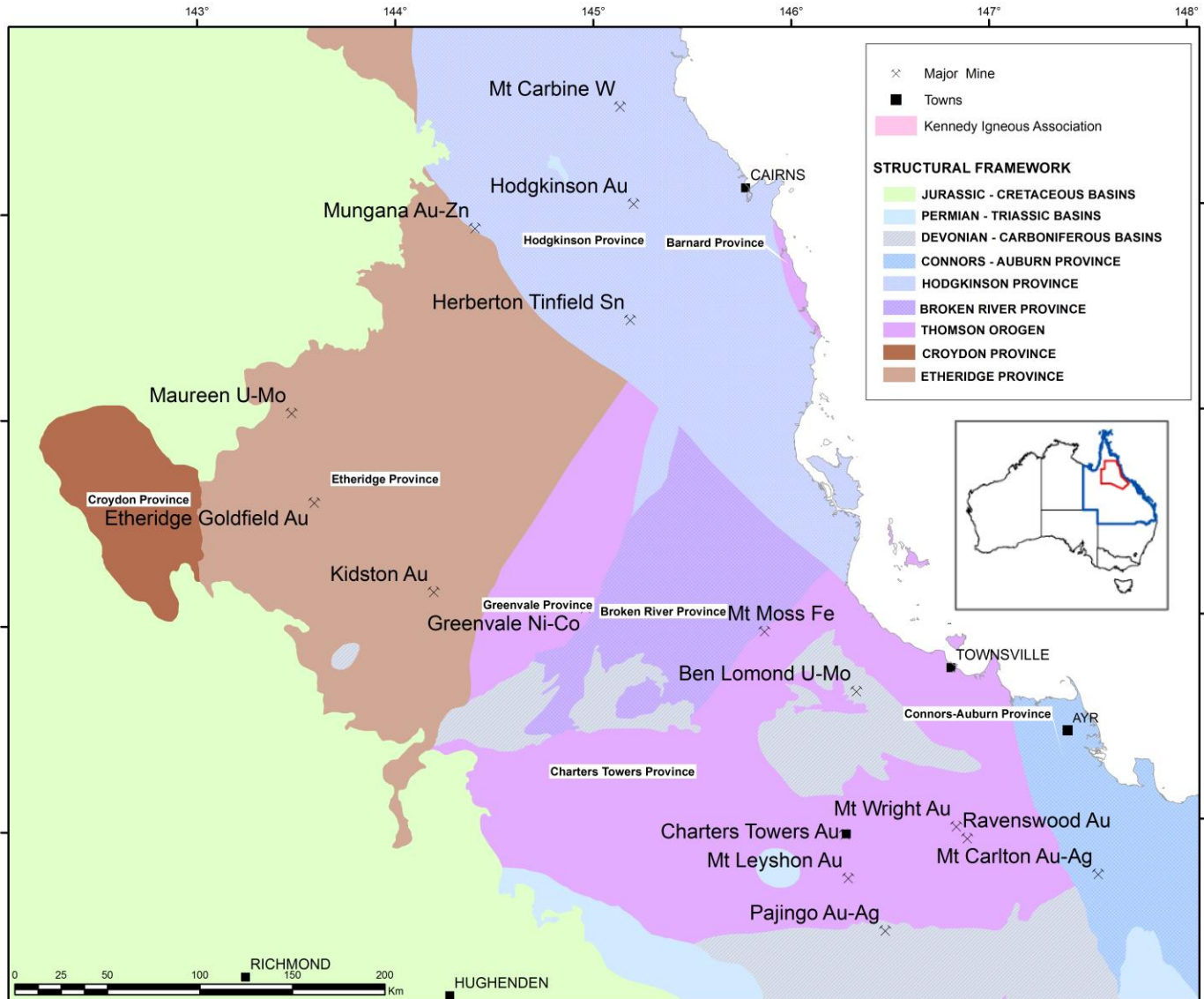
- Project is located in north-east Queensland, from the northern Drummond Basin to the southern boundary of the Laura Basin
- The felsic Permian – Carboniferous Kennedy Igneous Association is linked to intrusion-related mineral systems in the region and will be focussed on in this talk

# Geological Setting

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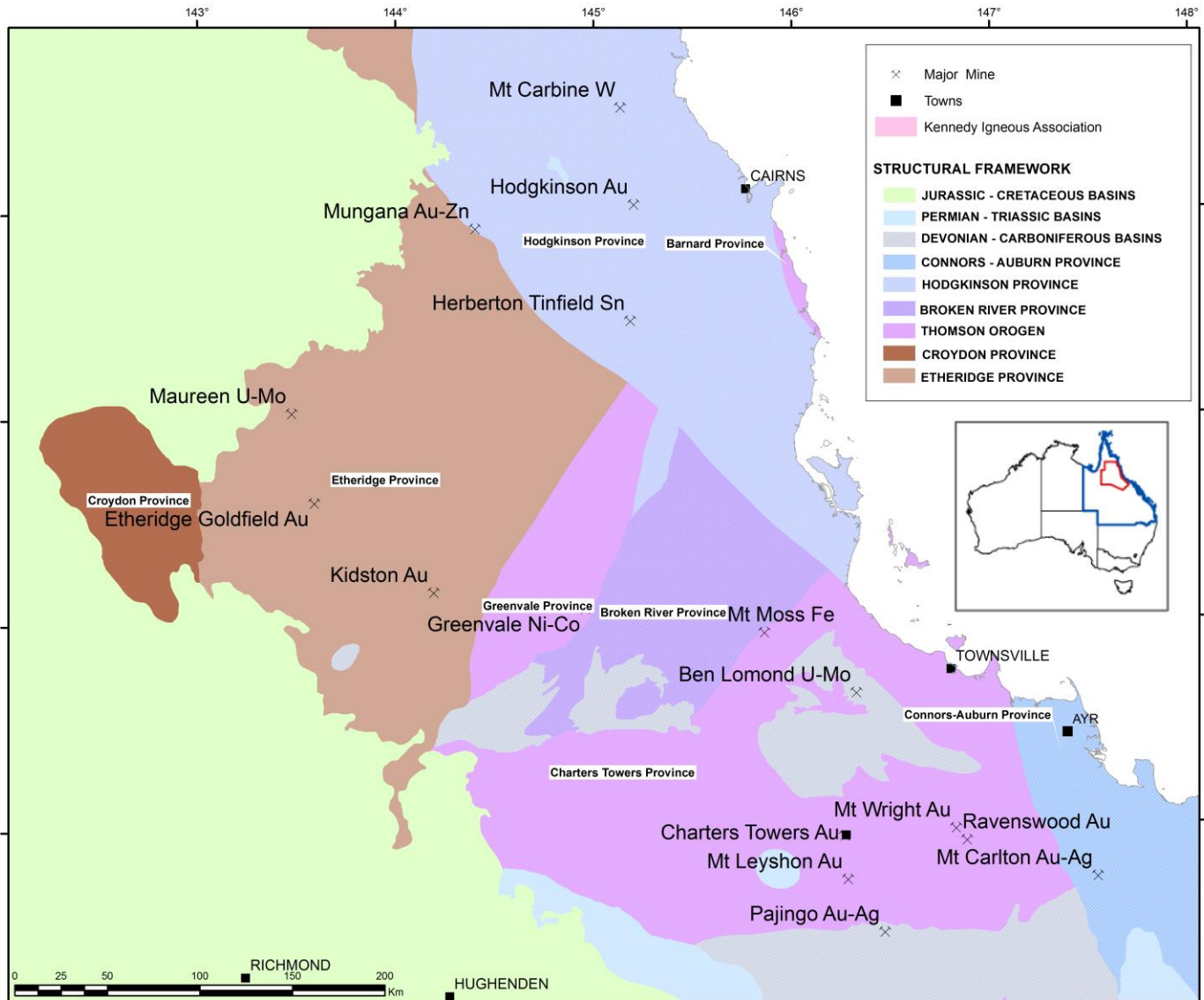
# North-east Queensland – significant mineral endowment



• Significant historic production and remaining resources of various commodities:

- Gold – Charters Towers (6.5 Moz), Kidston (5 Moz), Pajingo (5 Moz), Ravenswood (4 Moz), Mungana – Red Dome (4 Moz), Mt Leyshon (3.5 Moz), Mt Carlton (>2.2 Moz Au eq.), Mt Wright (1.3 Moz)

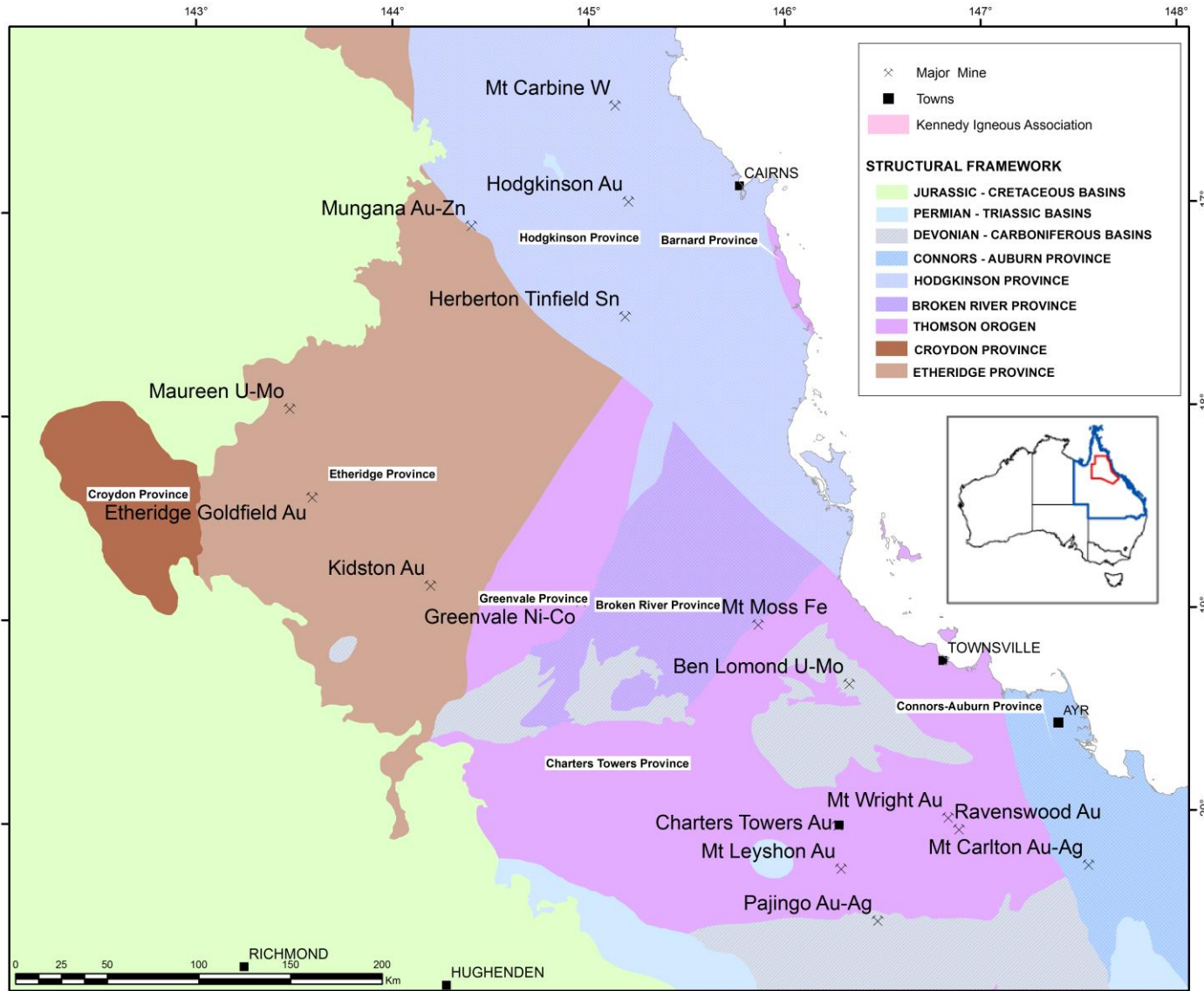
# North-east Queensland – significant mineral endowment



• Significant historic production and remaining resources of various commodities:

- Tin, tungsten – Herberton, Mt Carbine
- Uranium – Ben Lomond, Maureen
- Nickel – Greenvale

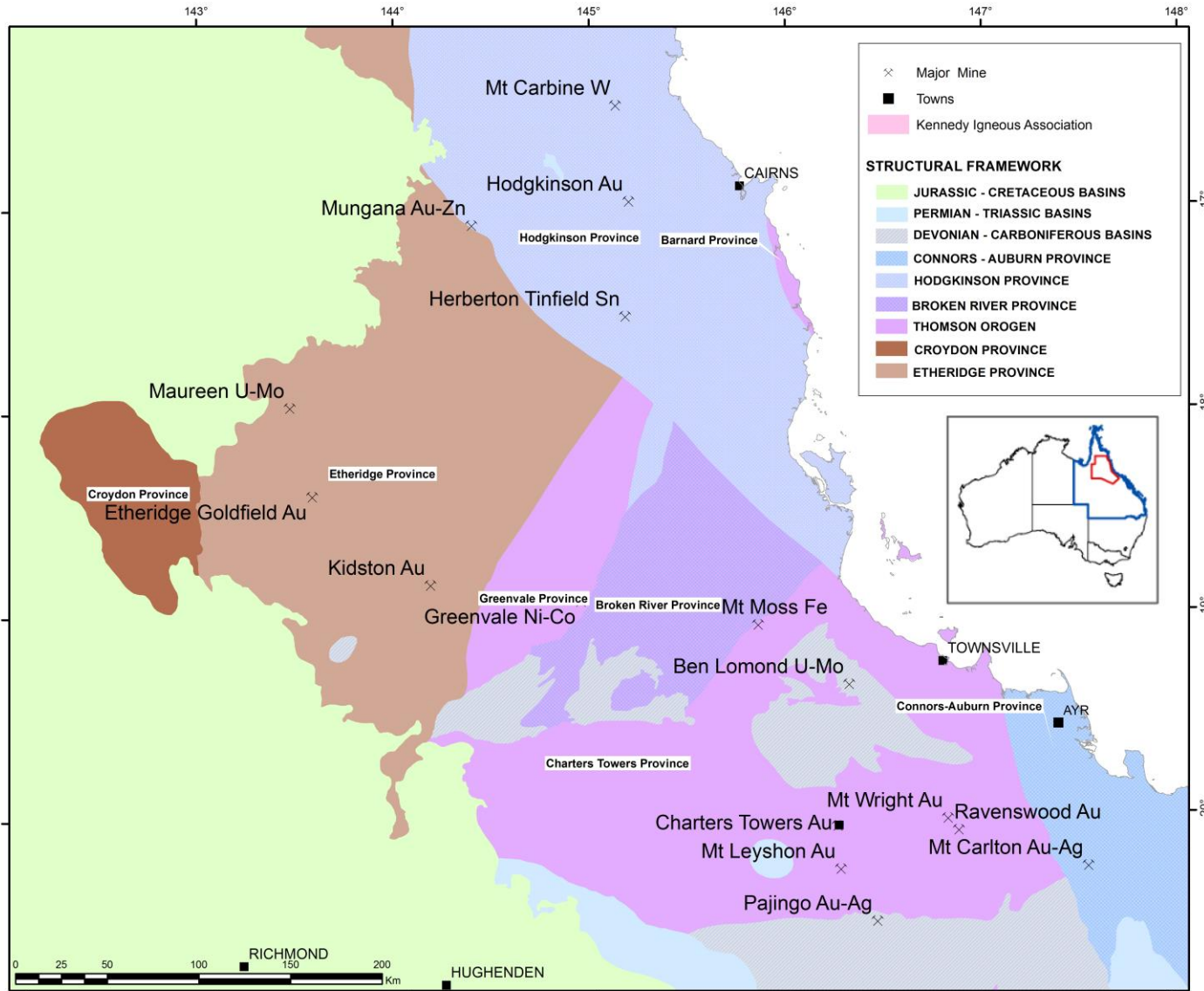
# North-east Queensland – rare recent discoveries



- Few significant recent discoveries
- Ran out of deposits – or ideas?
- What exploration strategies worked in the past – and what may work now?

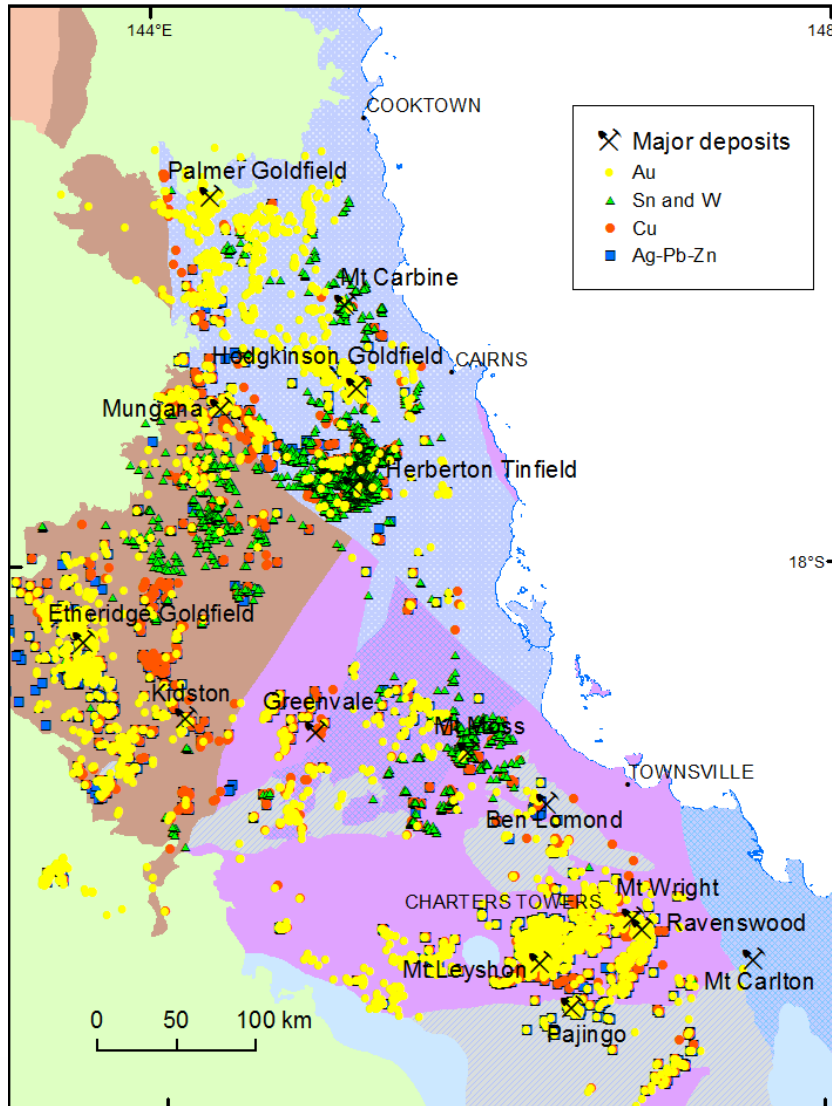


# North-east Queensland – rare recent discoveries



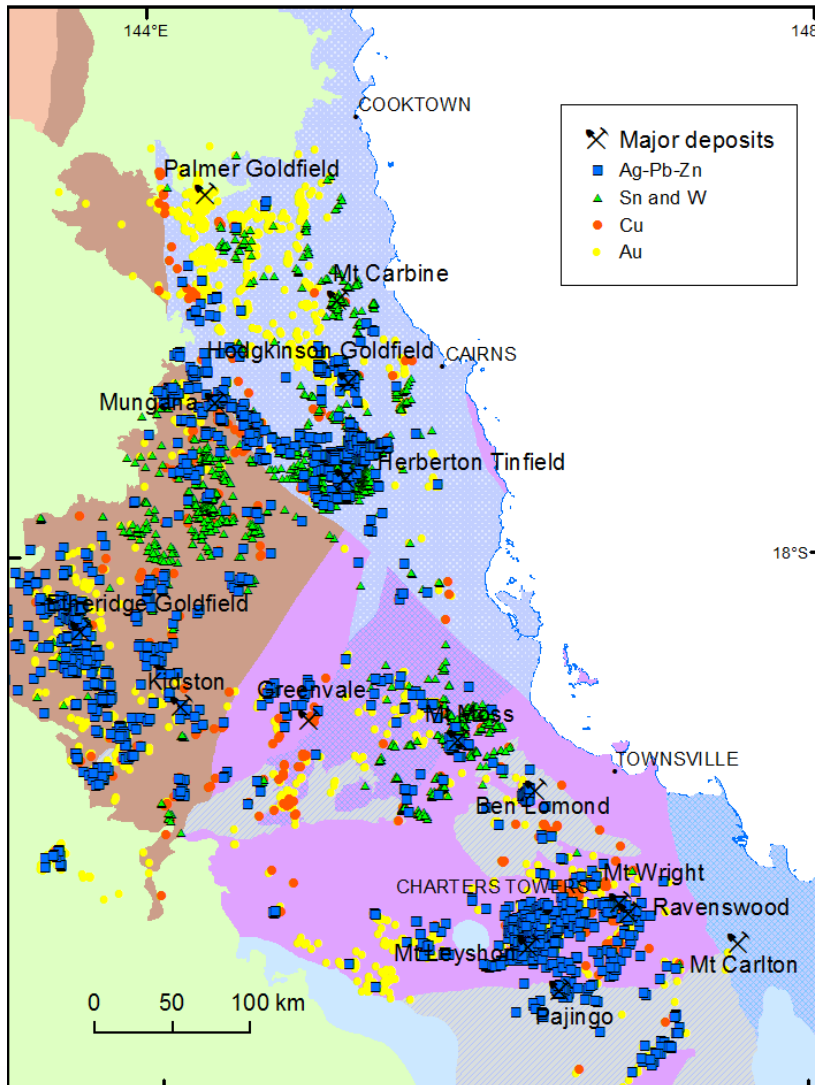
- Need to re-evaluate mineral prospectivity of the region – and find ways to unlock it
- Need better understanding of regional metallogenic processes and their camp-scale expressions

# North-east Queensland – various commodities over a large region



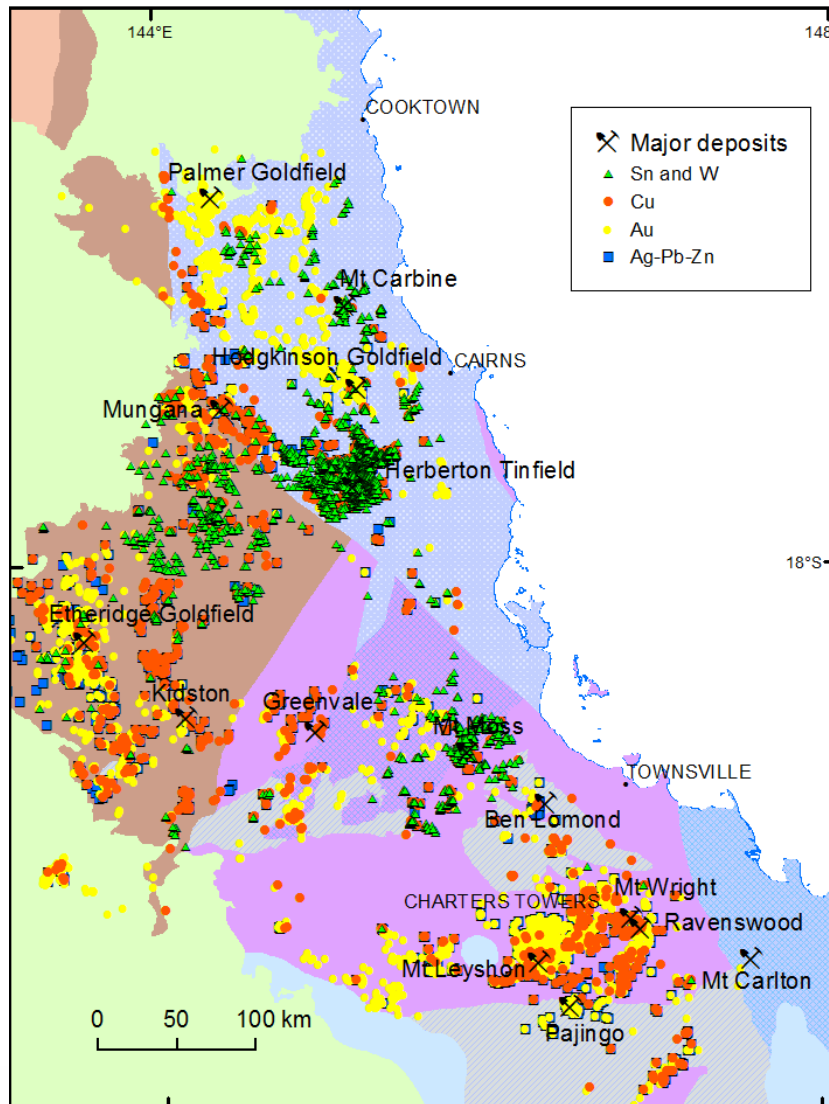
- Occurrences of different commodities over large areas – **Au-Ag**, **Sn-W**, Zn-Pb-Ag, Cu
- Significant overlaps of different commodities – particularly Au-Ag, but also Au-Sb, Cu-Au, Au-Sn-W

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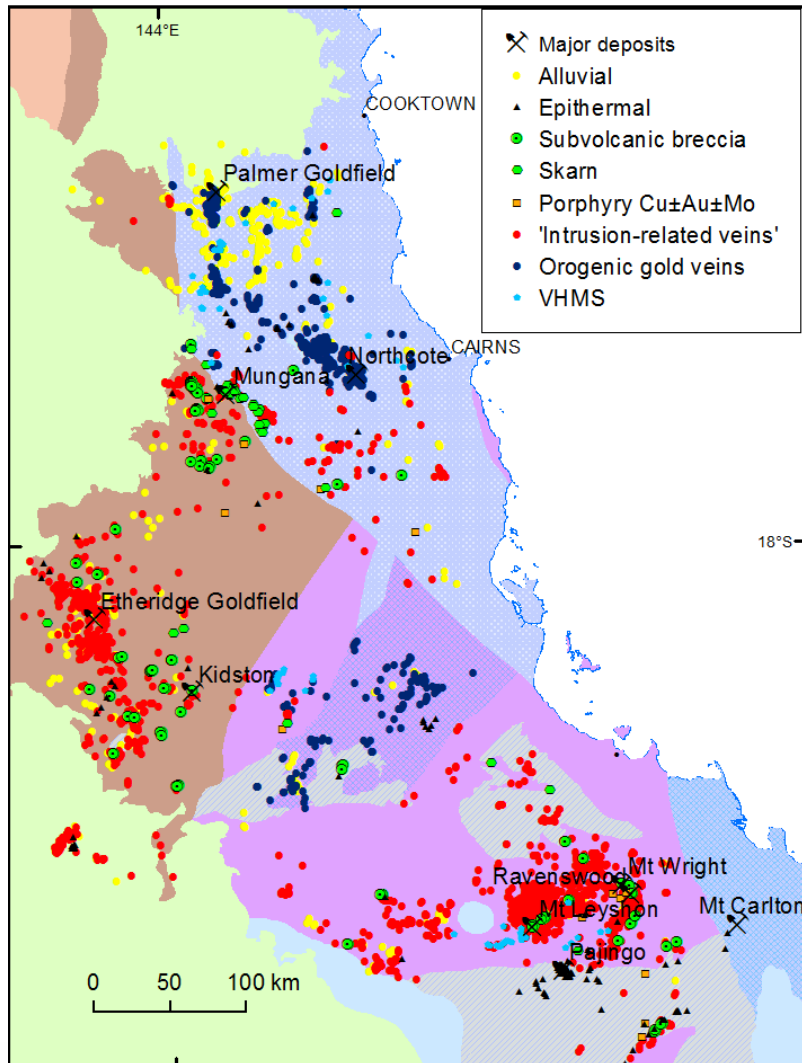
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# North-east Queensland – occurrences of various commodities over a large region



- Occurrences of different commodities over large areas – **Au-Ag**, **Sn-W**, Zn-Pb-Ag, Cu
- Significant overlaps of different commodities – particularly Au-Ag, but also Au-Sb, Cu-Au, Au-Sn-W
- Difficult to analyse, incomplete data, no information under cover

# North-east Queensland – gold mineralisation of various styles



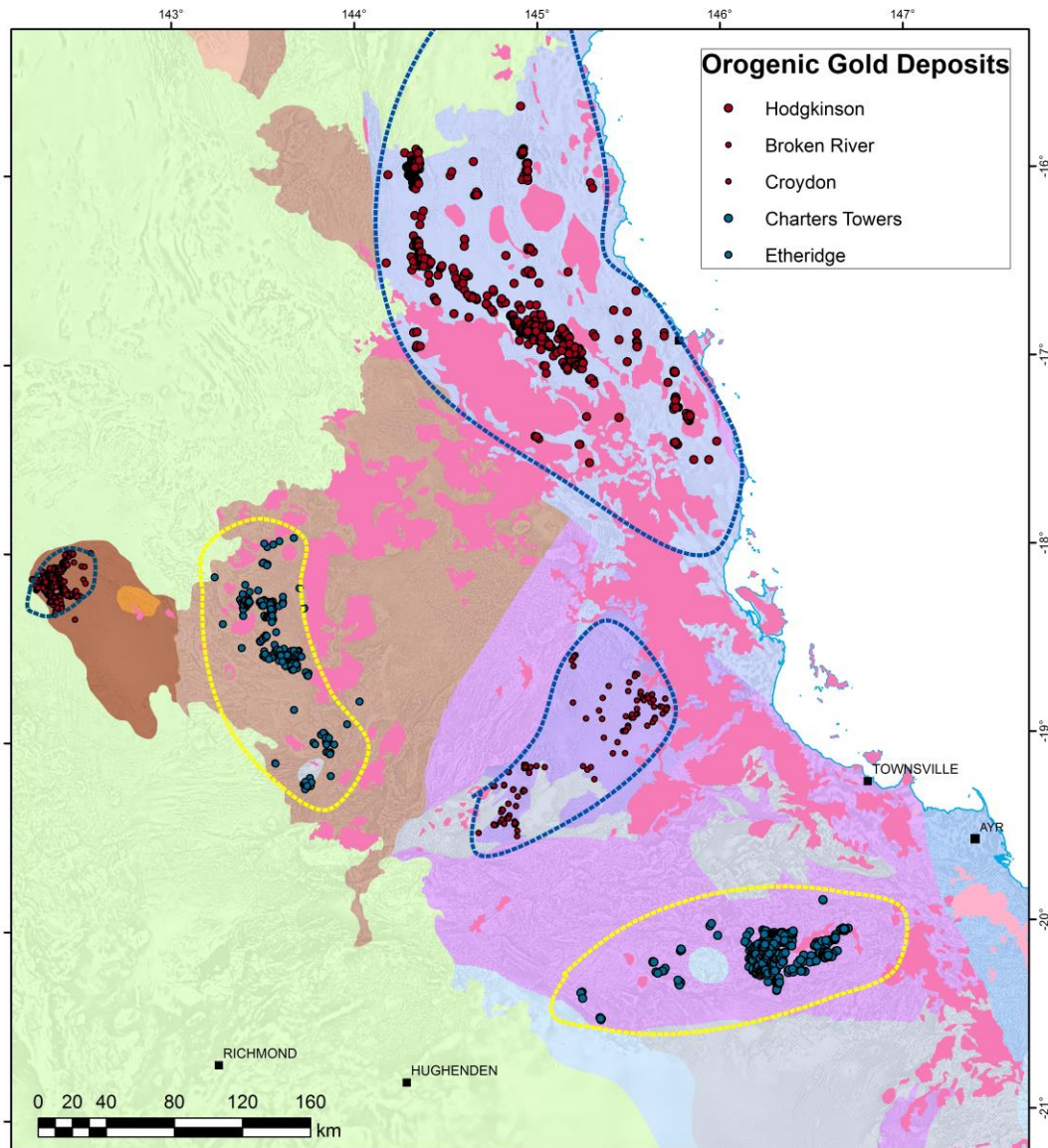
Gold-bearing occurrences represent multiple deposit types and styles:

- Ordovician VHMS
- Early Devonian 'intrusion-related veins'
- Carboniferous to Permian orogenic gold veins
- Carboniferous to Permian epithermal, porphyry, skarn, subvolcanic breccia and 'intrusion-related veins'
- Cainozoic alluvial

# North-east Queensland – regional-scale mineral systems

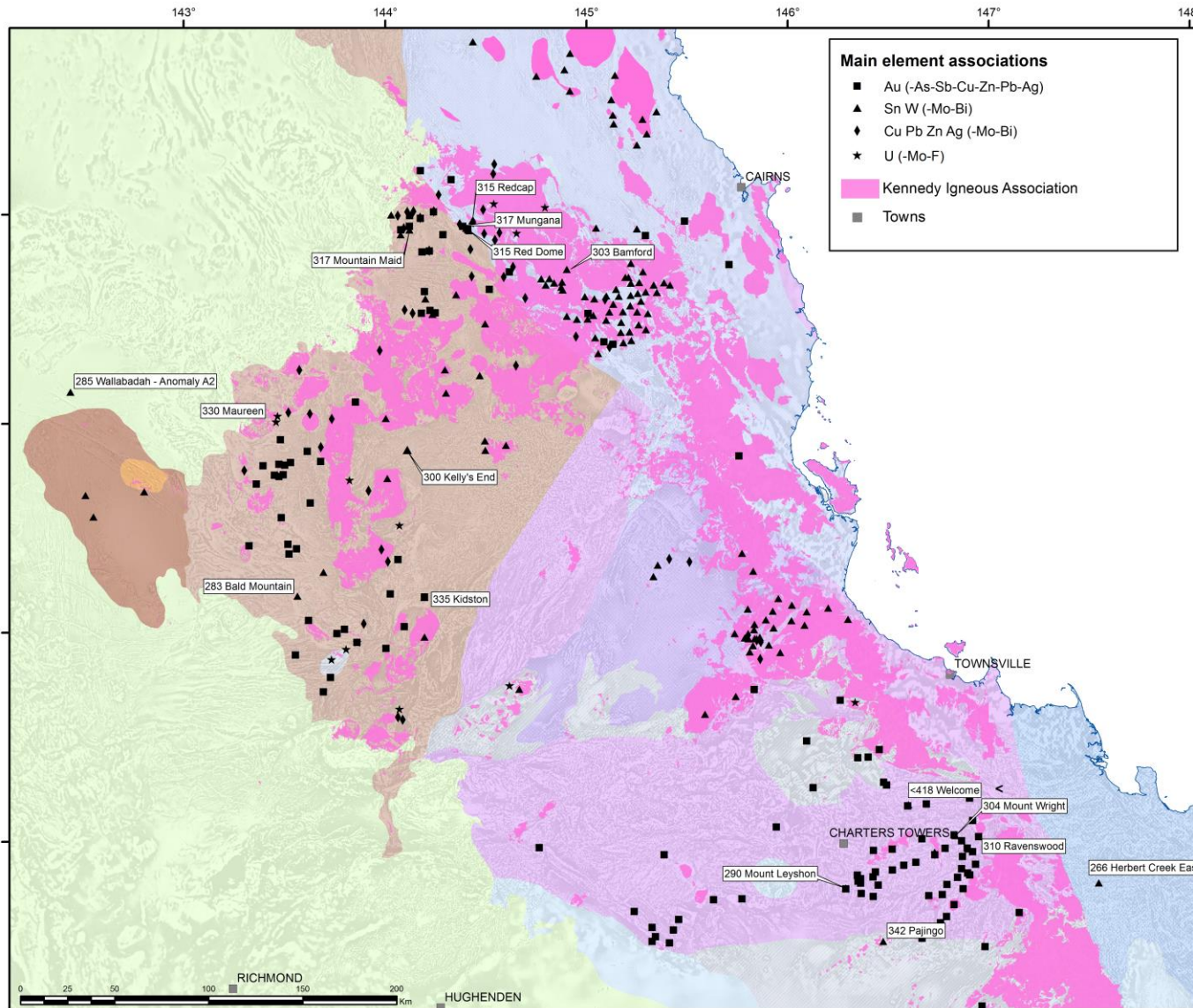
- Two major families of mineral systems:
  - Orogenic gold – both sediment and intrusion-hosted, regionally uniform geochemistry and mineralisation styles
  - Intrusion-related hydrothermal (Au, Sn, W, Cu, Zn, U, Mo, etc.) – clear magmatic links, geochemical zonation, variety of mineralisation styles

# Orogenic gold mineral systems – north-east Queensland



- Major orogenic gold mineral systems:
- Early Devonian
  - Charters Towers
  - Etheridge
- Carboniferous to Early Permian
  - Hodgkinson
  - Broken River
  - Croydon

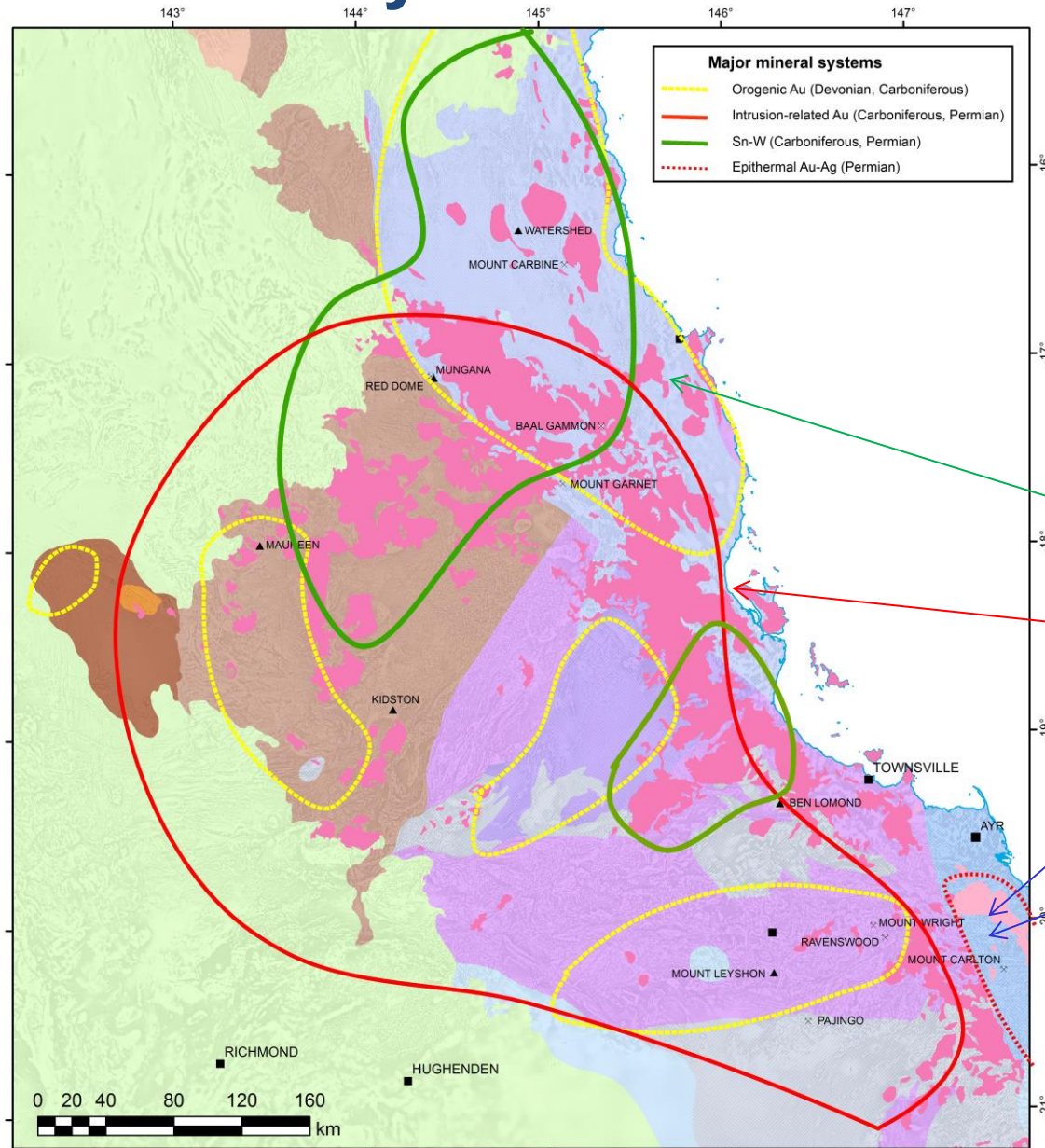
# Permo-Carboniferous intrusion-related hydrothermal mineral systems



- Diverse deposit styles with close genetic relationships to Permo-Carboniferous magmatism
- Au, Sn, W, Cu, Zn, U, Fe
- Regional domains of geochemically similar deposits
- Geochemical zonation within camps and individual deposits
- Evidence of emplacement at different crustal levels



# Permo-Carboniferous intrusion-related hydrothermal mineral systems

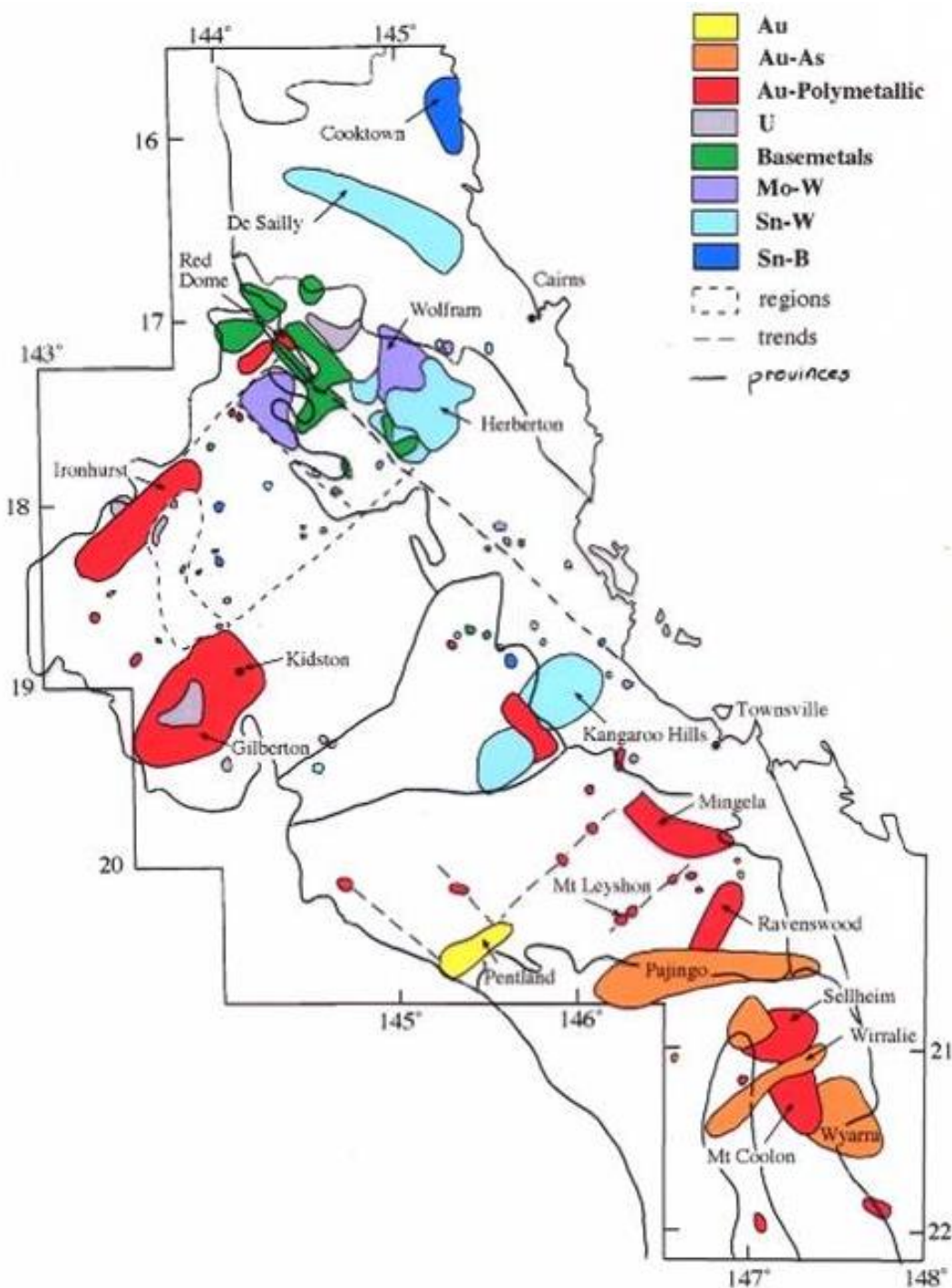


• Several distinct partially overlapping intrusion-related hydrothermal mineral systems:

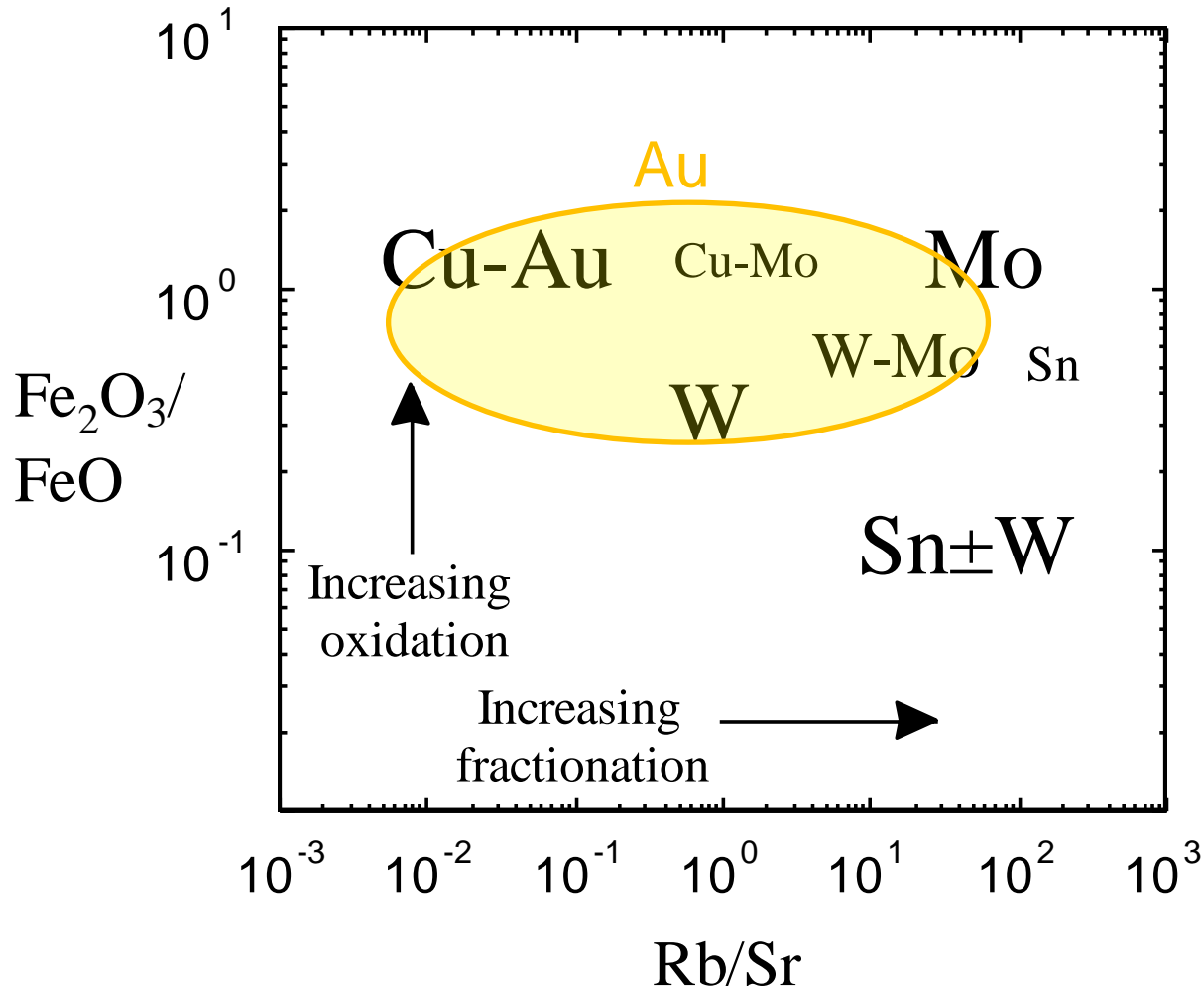
- Sn-W
- Intrusion-related Au
- Epithermal Au-Ag
- Porphyry Mo-Cu

# Permo-Carboniferous intrusion-related hydrothermal mineral systems

- Metallogenic specialisation of major Permo-Carboniferous magmatic complexes is defined by their dominant geochemistry



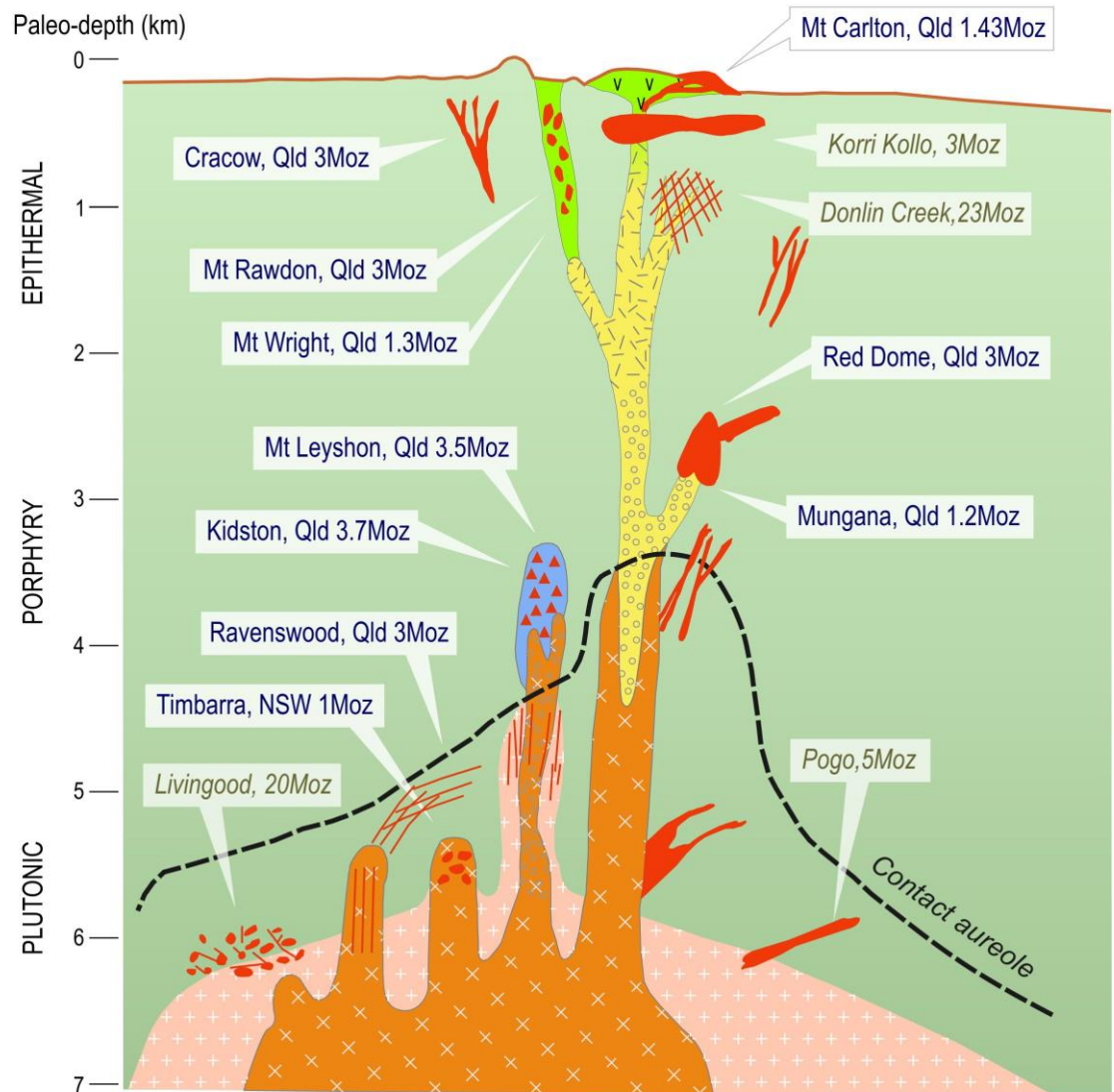
# Magma chemistry – key metallogenic factor










Blevin et al. (1996)

# Intrusion-Related Gold Systems

- Wide range of deposit styles
- Depth of emplacement spans >7 km
- Deposit style – function of depth
- Commodities (Au, Sn-W or Mo-W) – function of magma chemistry



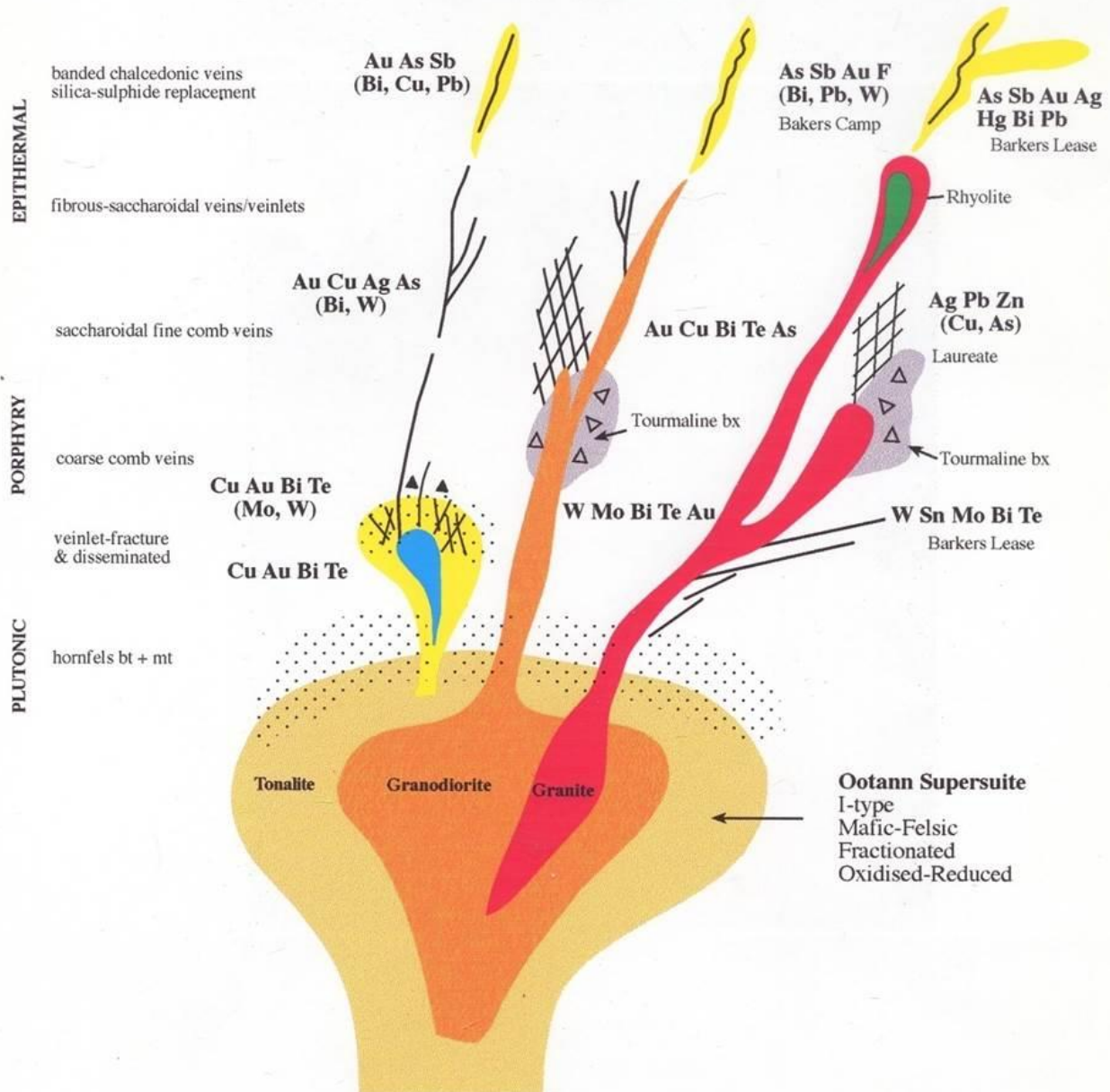
## LEGEND

	Dome		Contact Aureole
	Flow-banded		Ore body
	Porphyry		
	Porphyritic granitoid		
	Granitoid		

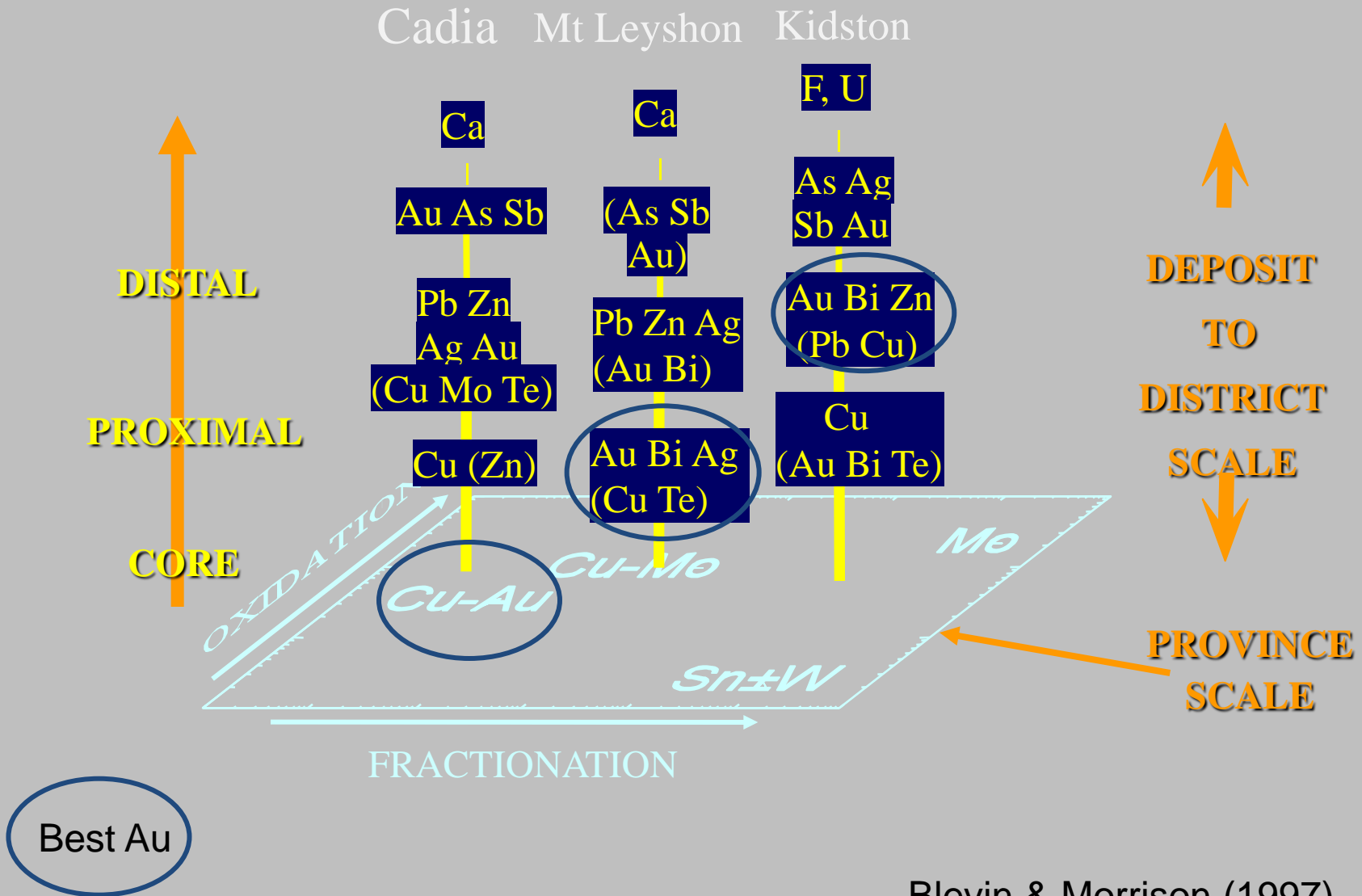
from Morrison 2014 (unpublished)

**IRGS MODEL  
DEPOSIT STYLES**

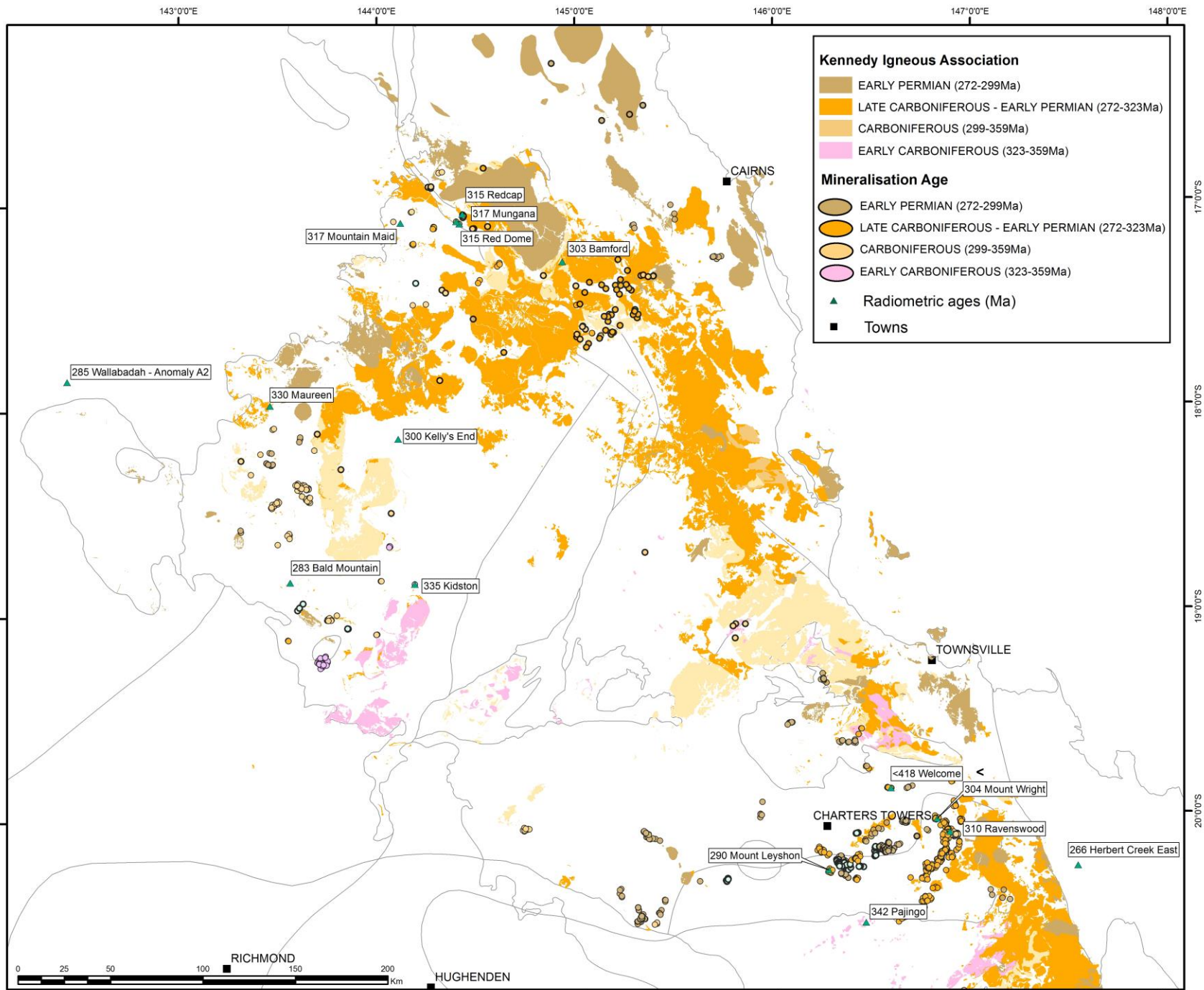
# District-scale metal zoning



# METAL ZONING PATTERNS AND ORE POSITION FOR PORPHYRY HYDROTHERMAL SYSTEMS



Blevin & Morrison (1997)

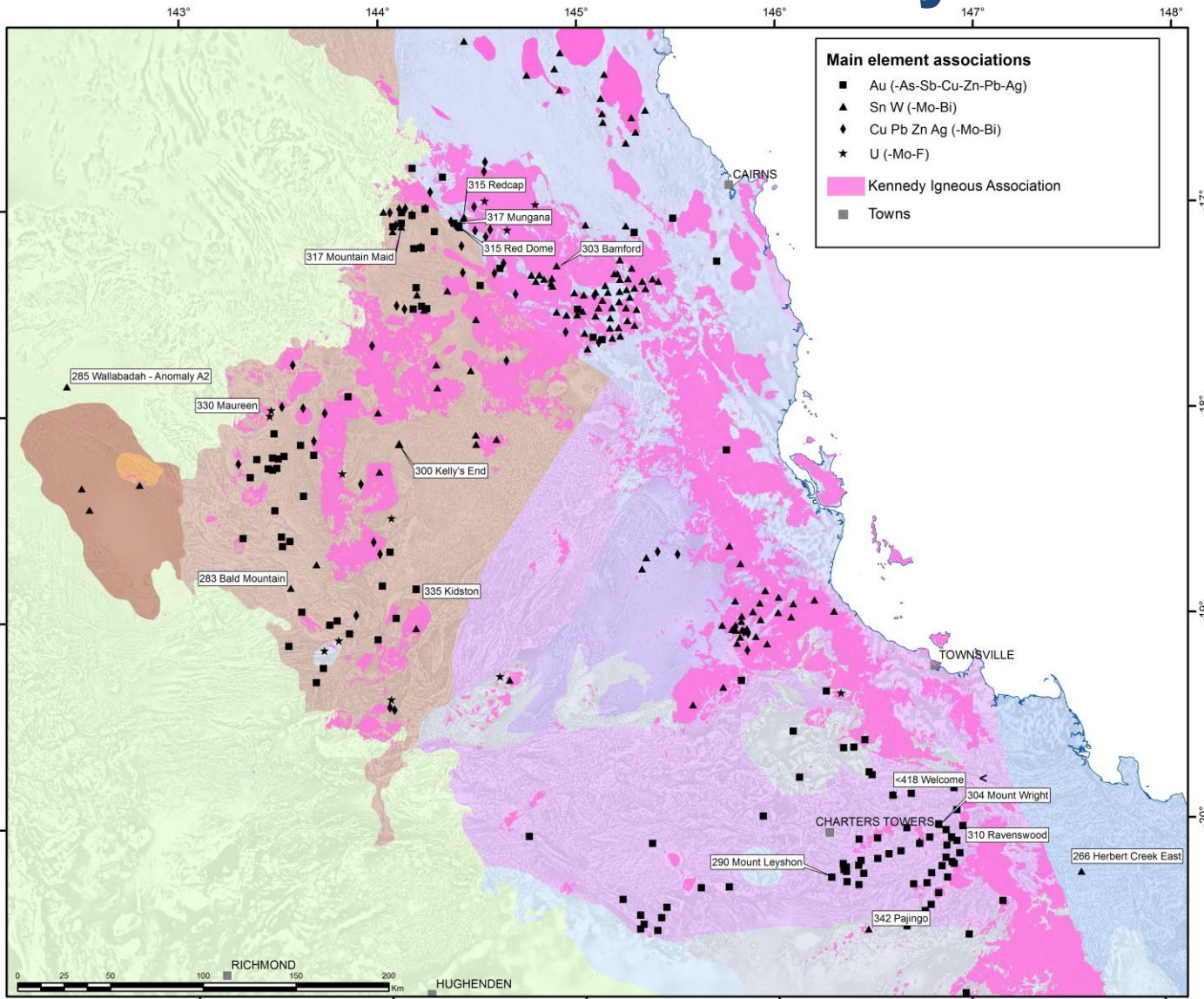


# Questions and problems

- Spatial extents of specific intrusion-related mineral systems – and their geochemical variants?
- Geochronology of metallogenic and associated magmatic events across the region?
- Distinguishing barren, poor and rich systems and districts?
- Recognising potential at depth?
- Mineralogical and geochemical alteration signatures – early recognition of hydrothermal alteration?
- Geophysical expressions in regional and more detailed datasets?
- Consistent validated regional metallogenic datasets – geochemistry, shallow intrusions, solid geology?
- Exploration targeting – strategies, tools and targets?



# Permo-Carboniferous intrusion-related mineral systems



- Permo-Carboniferous intrusion-related mineral systems remain poorly understood
- A collaborative 3-year project between GSQ, JCU, Terra Search and Klondike Exploration commenced in July 2014

# Prospectivity of intrusion-related mineral systems of north-east Queensland

## **Funding:**

\$2.5 million over 3 years from GSQ, plus in-kind contributions from the collaborative partners and additional funding from industry

## **Industry support:**

Evolution Mining, Carpentaria Gold, Vital Metals, Glencore - Copper

## **Implementation:**

11 related sub-projects (JCU, Terra Search, Klondike Exploration, GSQ)

# Project structure

Title	Responsible group
1. Magma-related hydrothermal mineral systems of the northern Bowen Basin	JCU
2. Geology of the Mt Carlton high-sulfidation epithermal deposit	JCU
3. Magma fertility, petrogenesis and geodynamic setting of Carboniferous and Permian magmatic complexes	JCU
4. Updated geology of the Charters Towers region	TS-K
5. Metallogeny of the Charters Towers Province	TS-K
6. Metallogeny of the Permo-Carboniferous mineral systems of the Georgetown region	TS-K
7. Metallogeny of Sn-W-Mo-Cu mineral systems	JCU
8. Exploration geophysical signatures of intrusion-related deposits in the Charters Towers region	TS-K
9. Comprehensive prospectivity analysis	JCU - GSQ
10. Regional alteration mapping using remote sensing methods	JCU
11. Geochemical signatures of intrusion-related mineral systems	JCU - TS-K

# Progress – James Cook University

- Dedicated research team in place: 3 postdocs, 3 PhD students, 1 MSc student, 5 EGRU staff
- Several projects commenced - Mt Carlton epithermal district, Sn-W metallogeny, magma fertility, geochemistry, prospectivity analysis

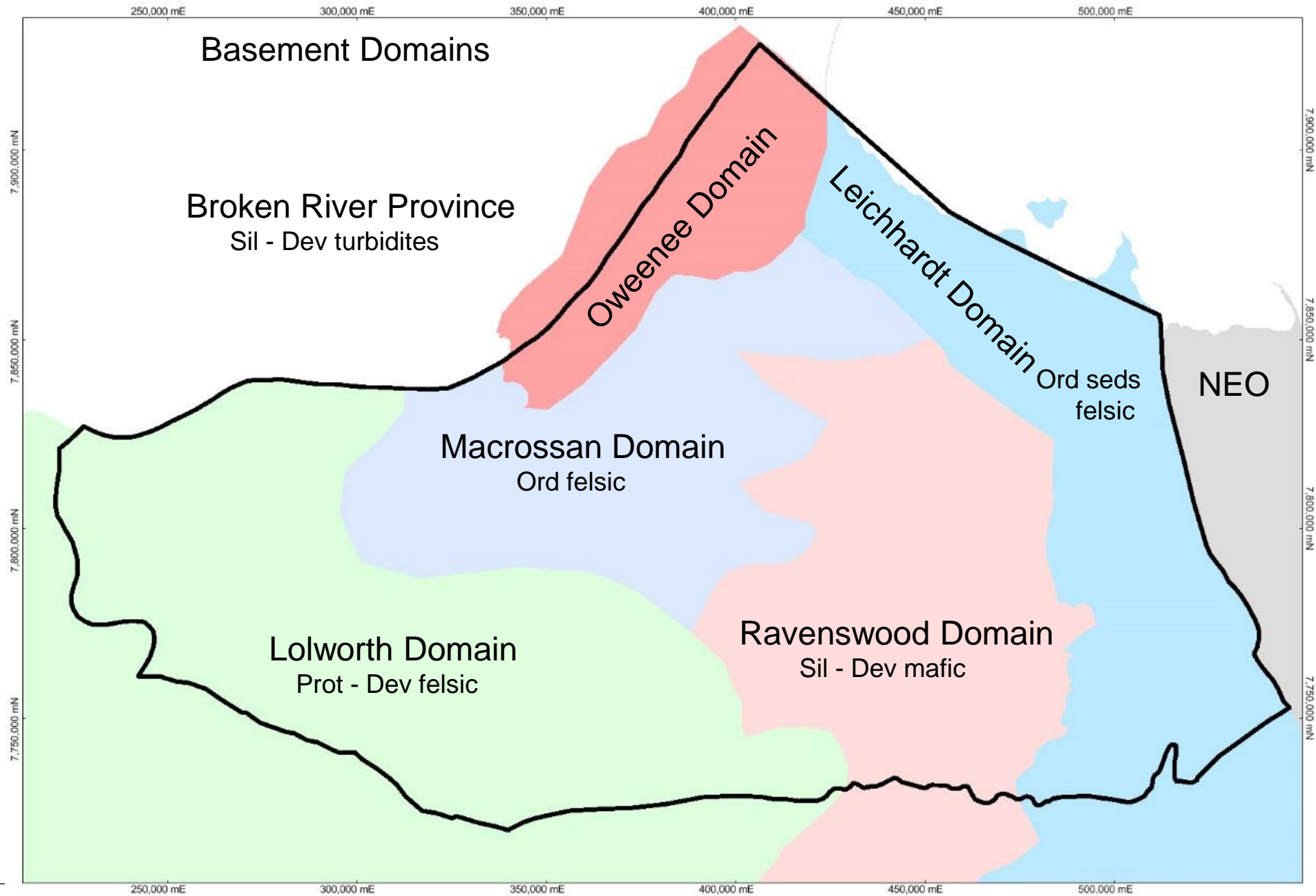
# Progress – James Cook University

Early results from the Mount Carlton and northern Bowen Basin study:

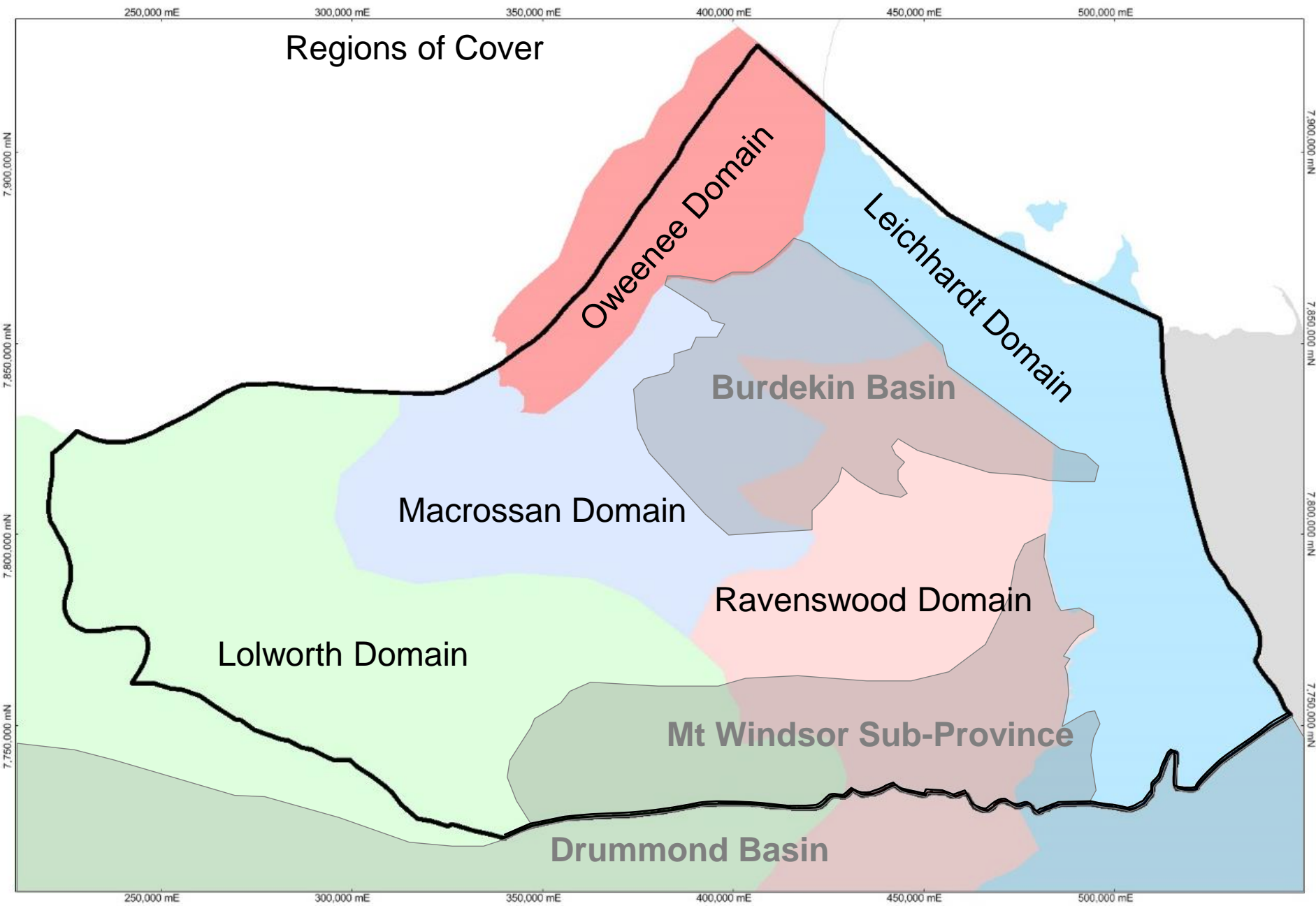
- Geochronology was completed on zircons (U-Pb), alunite from Mt Carlton (Ar-Ar), and molybdenite from the Capsize porphyry (Re-Os).
  - Alunite from Mt Carlton gave a date of  $284.3 \pm 2.0$  Ma.
  - Molybdenite from Capsize gave a date of around  $285.7 \pm 1.2$  Ma.

[http://www.jcu.edu.au/egru/public/groups/everyone/documents/newsletter/jcu\\_149235.pdf](http://www.jcu.edu.au/egru/public/groups/everyone/documents/newsletter/jcu_149235.pdf)

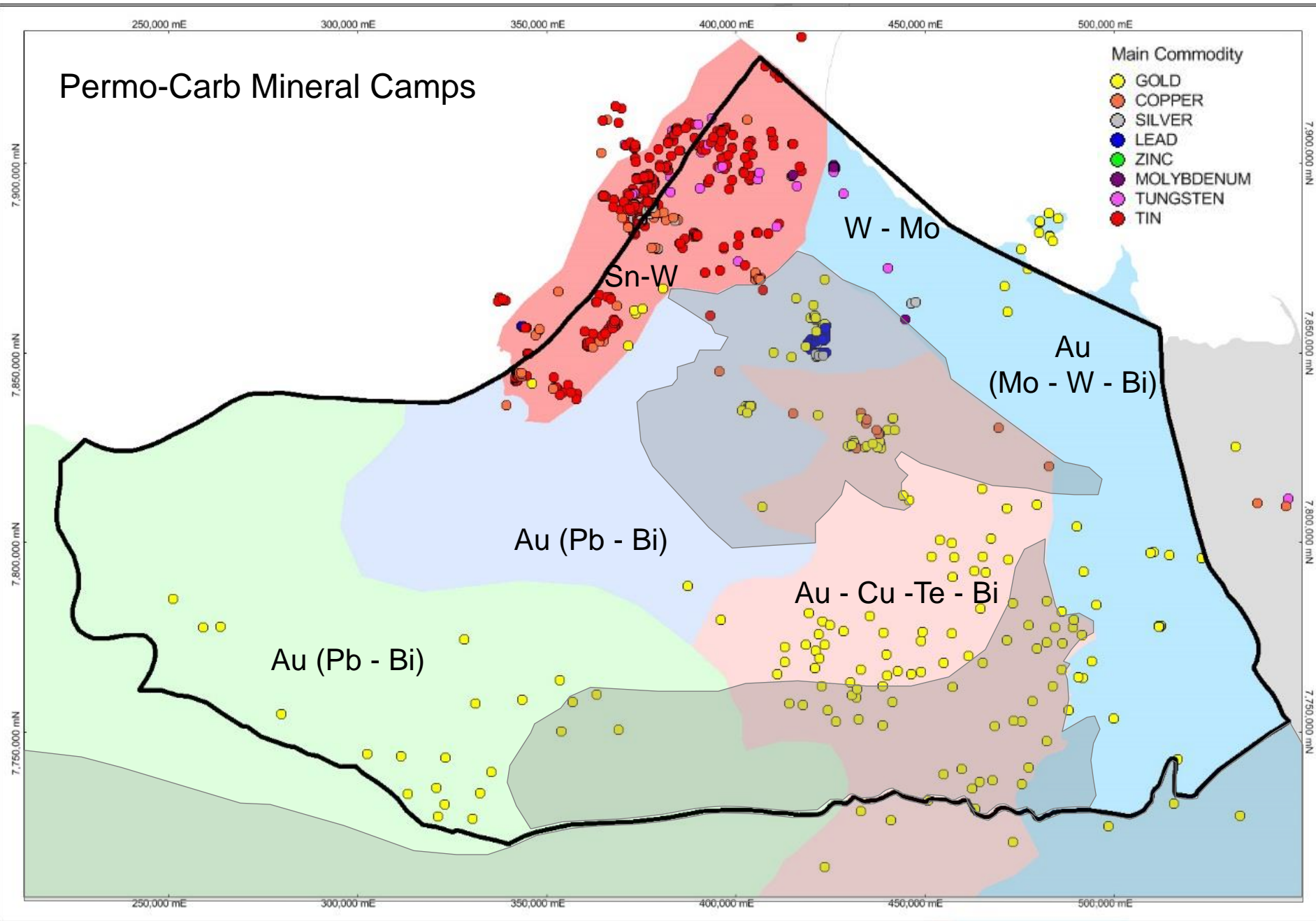
# Progress – Terrasearch/Klondike Exploration



# Regions of Cover



# Permo-Carb Mineral Camps

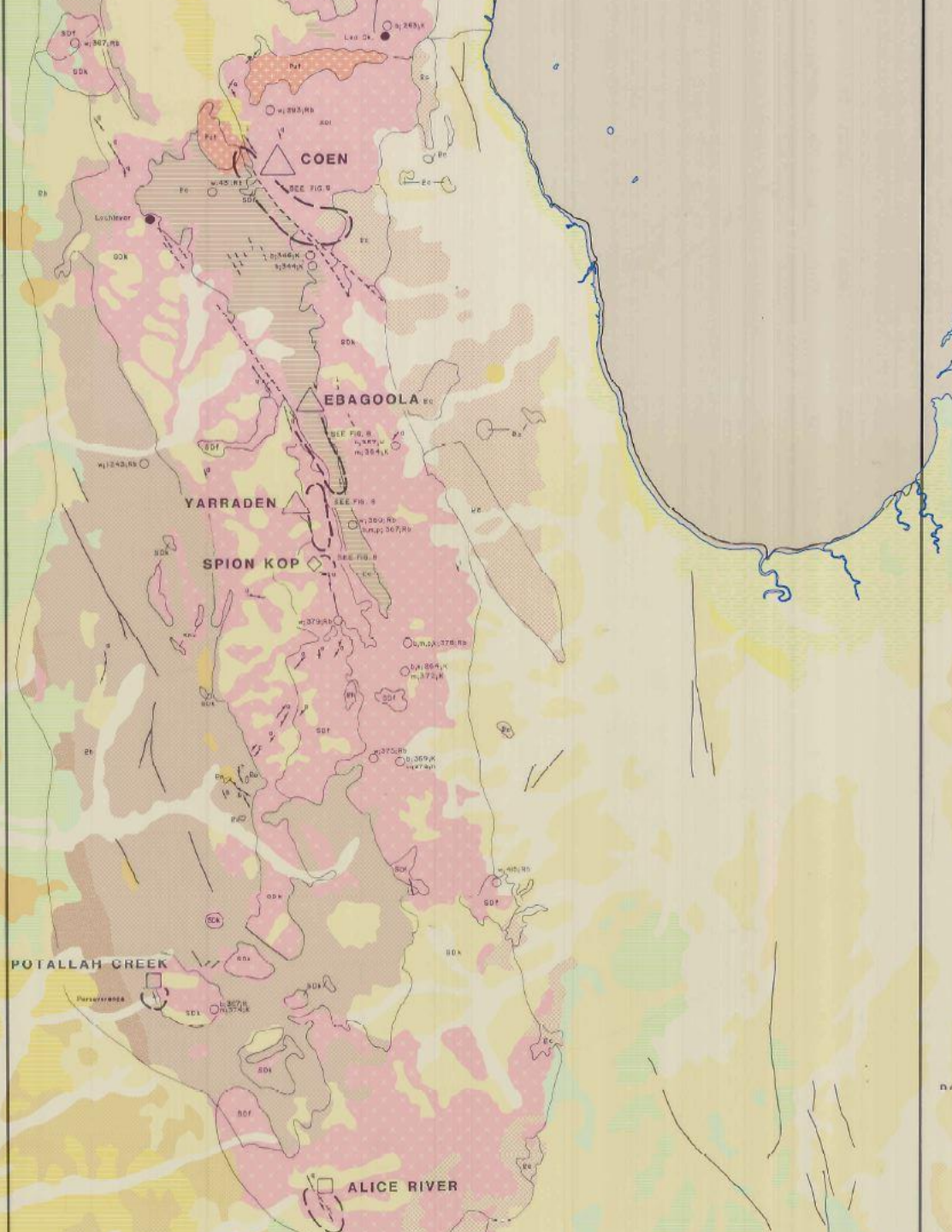




# Current GSQ Projects

## Cape York Mineral Resource Assessment

- Continuation of rationale behind North Queensland Magmatic Systems Study
- Infilling the previous National Geochemical Survey of Australia (NGSA)
- Focusing on the gold and tin-tungsten fields and their relationship with the Kennedy Igneous Association



- No systematic studies undertaken over the area, with no age dating undertaken on either the Au and Sn-W mineralisation
- Preliminary results from Alice River (southern most goldfield in the study) with a rhyolite associated with Au mineralisation gives a SHRIMP age of ~285.
- Follow up rhyolite dykes from the Coen and Ebagoola goldfield and the tip of Cape York are waiting dating
- Ar/Ar and Re/Os dating ongoing

# Summary

- Diverse intrusion-related mineral systems of north-east Queensland have a significant potential for major new discoveries (Au, Sn, W, Cu)
- A 3-year collaborative study (GSQ, JCU, Terra Search, Klondike Exploration) to evaluate mineral potential of the region and facilitate new discoveries (2014-2017)