## 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

#### JURASSIC-CRETACEOUS BASINS MARLBOROUGH PROVINCE 0 Whitsunday Province, Styx, Maryborough, Carpentaria, CAPE YORK-Eromanga, Laura, Surat, Clarence-Moreton, Mulgildie SILVERWOOD PROVINCE ORIOMO PROVINCE TRIASSIC BASINS MOSSMAN OROGEN Callide, Esk, Ipswich and Tarong basins and HODGKINSON PROVINCE Triassic volcanics; Canobie and Burketown Chillagoe and Palmer-Barron subprovinces depressions (concealed) BROKEN RIVER PROVINCE PERMIAN - TRIASSIC BASINS Carnel Creek and Graveyard Creek subprovinces Rowen Calen Galilee and Noarrabulloan basins: Olive River, Gamboola, Lakefield and Cooper OUVERIVER basins (concealed) NEOPROTEROZOIC - EARLY PALEOZOIC PROVINCES Anakie (including Fork Lagoons Subprovince), Barnard, CAPE YORK - ORIGMO PROVINCE Charters Towers (including Mount Windsor Subprovince), - PAS COE RIVER BASIN DEVONIAN-CARBONIFEROUS BASINS Greenvale and Iron Range provinces; Warburton Basin lundock, Burdekin, Clarke River, Drummond, Gilberton PASCOERIVER BASIN and Pascoe River basins; Adavale and Belyando basins CENTRALIAN SUPERBASIN (concealed); Barrolka Depression (concealed); GEORGINA BAS IN Warrabin Trough (concealed) - IRON RANGE NEW ENGLAND OROGEN PROVINCE BASINS OF UNCERTAIN AGE GYMPIE PROVINCE Incrunie Basin; Millungera Basin (mostly concealed) CONNORS-AUBURN PROVINCE NORTH AUSTRALIAN CRATON SAVANNAH LAKEFIELD BASIN Connors and Auburn subprovinces MESOPROTEROZOIC PROVINCE SOUTH NICHOLS ON BASIN Campwyn, Rockhampton, Berserker, Grantleigh NORT Stoodleigh and Nogo subprovinces CROYDON PROVINCE WANDILLA PROVINCE eenleigh, Coastal, North and South D'Aguilar BASIN SAVANNAH PROVINCE and Yarraman subprovinces MOSSMAN PALEOPROTEROZOIC-MESOPROTEROZOIC WOOLOMIN PROVINCE AUSTRALIAN Texas and Silver Spur subprovinces ETHERIDGE PROVINCE ETHERIDGE CALLIOPE PROVINCE Subprovince PROVINCE Awoonga, Erebus, Capella, Craipilee and HODGKIN SON Philpott subprovinces PROVINCE - NGARRABULLGAN BASIN Eastern Fold Belt, Western Fold Belt, Kalkadoon-Leichhardt and Yaringa subprovinces OROGEN 0, CRATON Concealed structural units are shown by coloured - BARNARD PROVINCE outlines and labelled in a corresponding colour Western Fold Belt - Chille one Sub novince GREENVALE PROVINCE BASIN BROKEN RIVER PROVINCE CROYDON PROVINCE CHARTERS TOWERS PROVINCE BURDEKIN BASIN CALEN BASIN Campwyn Subprovince GEORGINA BASIN GALILEE BASIN Stoodleigh Subprovince Yaringa. MARIBOROUGH PROVINCE Craiglee Subprovince Berseiker Subprovince EROMANGA BASIN BOWEN BASIN - Erebus Suborovince HOMSON ADAVALE BASIN GALLE MARYBOROUGH BASIN OROGEN WARRAB BARROLKA COOPER BASIN NAMBOUR BASIN WARBURTON BOWEN BASIN North D'Aquillar Subprovince SURAT BASIN - South D'Aguillar Subprovince Been leigh Subprovince FROMANGA BASIN IPSWICH BASIN NSW

# Geological Setting

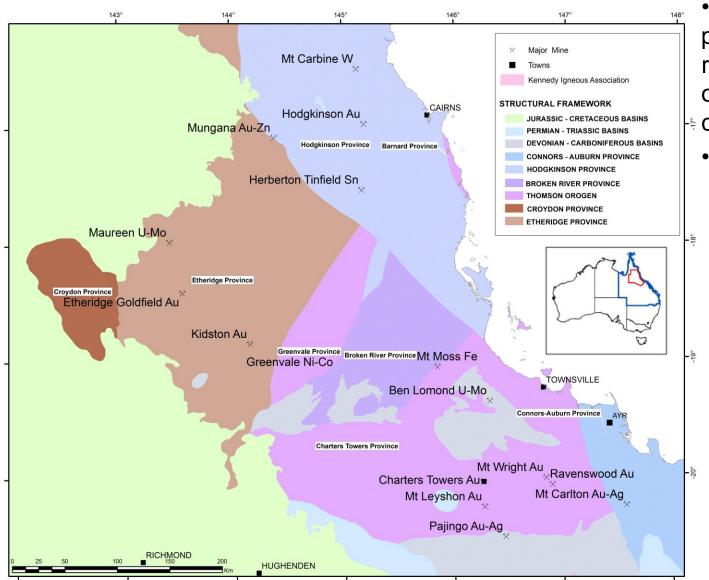
- Project is located in north-east Queensland, from the northern Drummond Basin to the southern boundary of the Laura Basin
- The felsic Permian –
   Carboniferous Kennedy
   Igneous Association is
   linked to intrusion-related
   mineral systems in the
   region and will be
   focussed on in this talk

#### **Jardine** Subprovince Townsville - Mornington Island Belt Subprovince boundary Cenozoic cover Cenozoic basalt Jardine Post-Permian intrusives Subprovince Mesozoic Carboniferous-Permian extrusives Carboniferous-Permian intrusives Proterozoic-Paleozoic Daintre'e Jardine Subprovince Subprovince Kidston Subprovince Subprovince Falls Subprovince

# Geological Setting

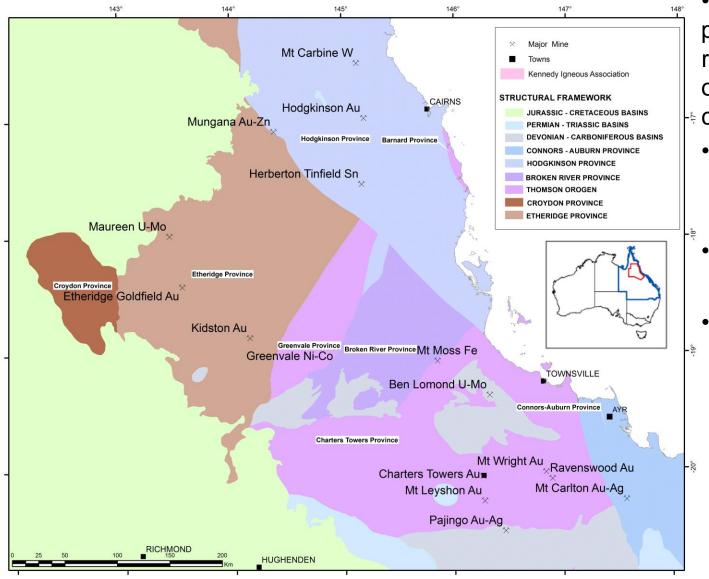
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### North-east Queensland – significant mineral endowment



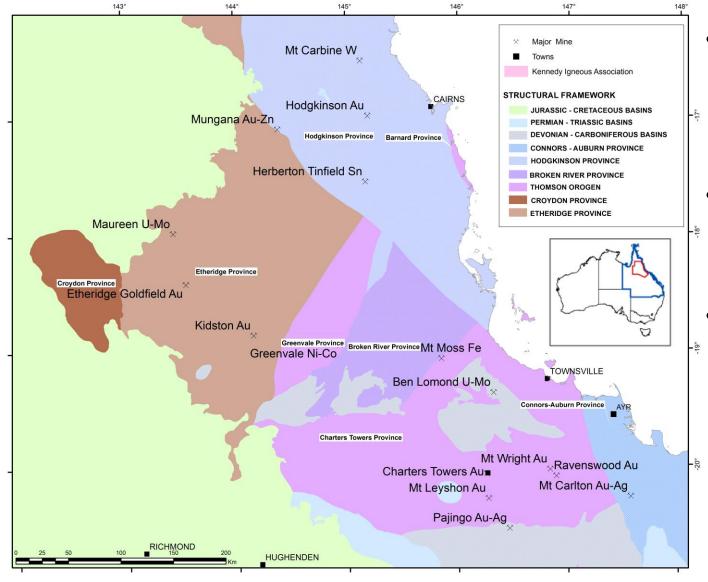
- Significant historic
   production and
   remaining resources
   of various
   commodities:
  - Gold Charters
    Towers (6.5 Moz),
    Kidston (5 Moz),
    Pajingo (5 Moz),
    Ravenswood (4
    Moz), Mungana –
    Red Dome (4
    Moz), Mt Leyshon
    (3.5 Moz), Mt
    Carlton (>2.2 Moz
    Au eq.), Mt Wright
    (1.3 Moz)

### North-east Queensland – significant mineral endowment



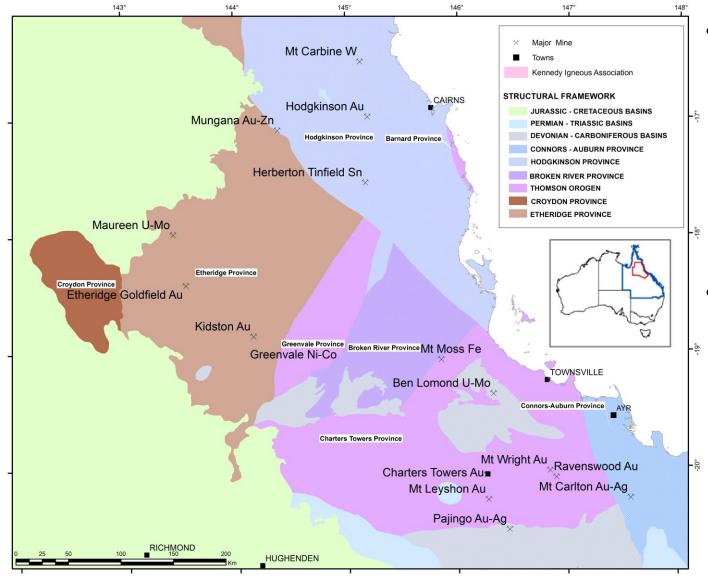
- Significant historic production and remaining resources of various
   commodities:
  - Tin, tungsten Herberton, Mt Carbine
  - Uranium Ben Lomond, Maureen
- Nickel –Greenvale

### North-east Queensland – rare recent discoveries



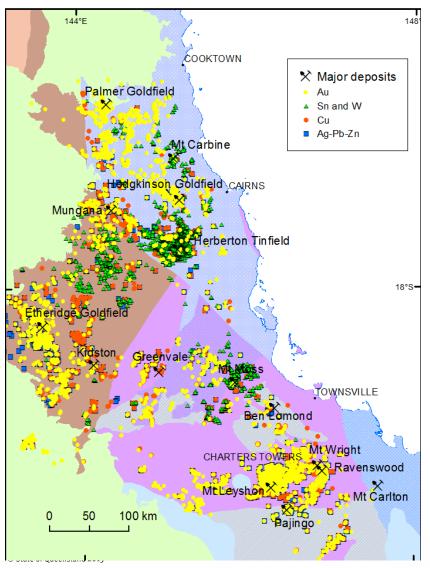
- Few significant recent discoveries
- Ran out of deposits – or ideas?
  - What exploration strategies worked in the past and what may work now?

### North-east Queensland – rare recent discoveries



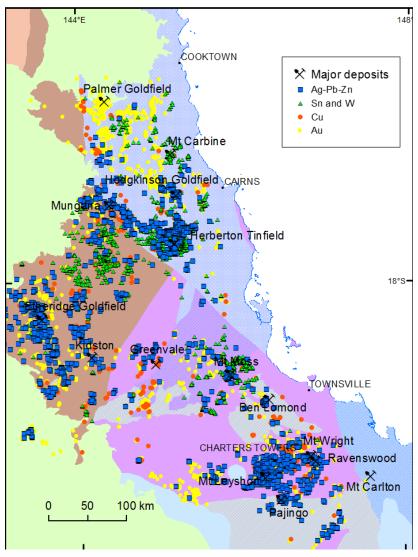
- Need to reevaluate mineral prospectivity of the region – and find ways to unlock it
  - Need better understanding of regional metallogenic processes and their campscale expressions

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



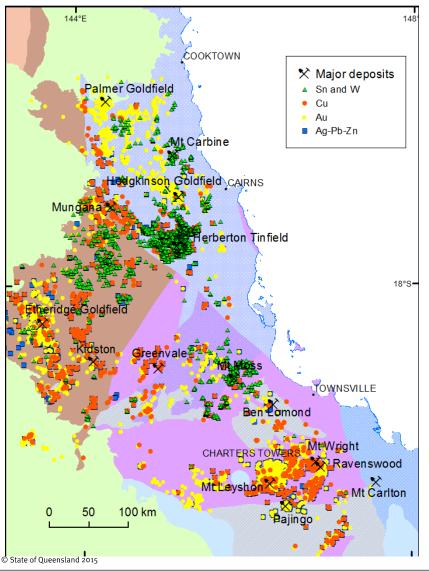
- Occurrences of different commodities over large areas – Au-Ag, Sn-W, Zn-Pb-Ag, Cu
- Significant overlaps of different commodities – particularly Au-Ag, but also Au-Sb, Cu-Au, Au-Sn-W

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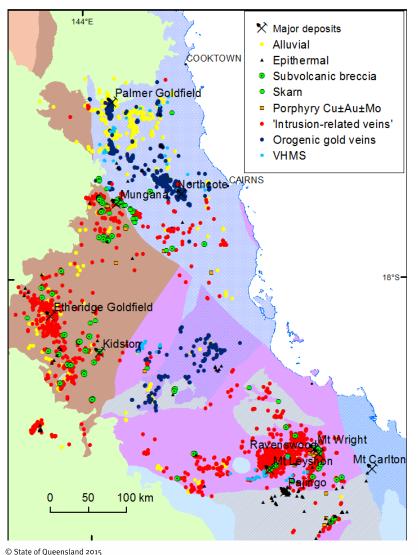
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# North-east Queensland – occurrences of various commodities over a large region



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- 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



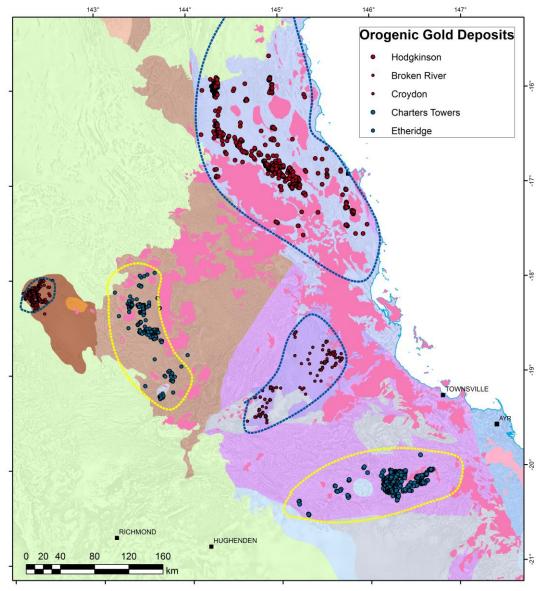
Gold-bearing occurrences represent multiple deposit types and styles:

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

### North-east Queensland – regionalscale mineral systems

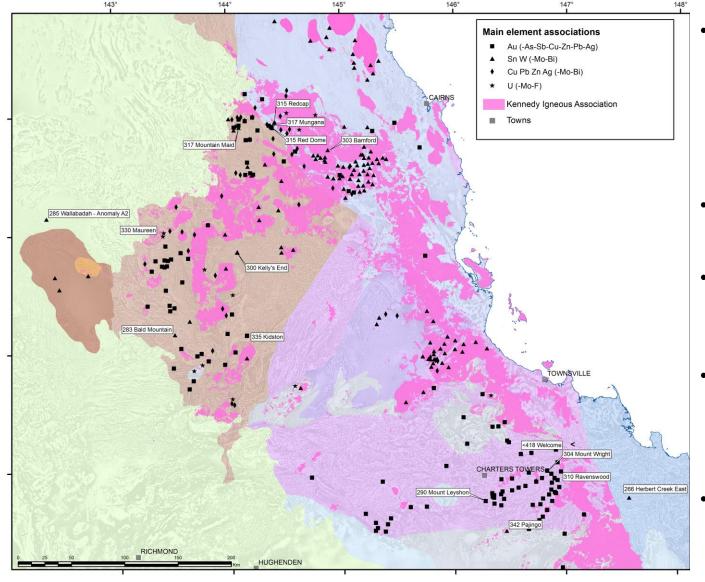
- •Two major families of mineral systems:
- Orogenic gold both sediment and intrusion-hosted, regionally uniform geochemistry and mineralisation styles
- Intrusion-related hydrothermal (Au, Sn, W, Cu, Zn, U, Mo, etc.) – clear magmatic links, geochemical zonation, variety of mineralisation styles

### Orogenic gold mineral systems – north-east Queensland



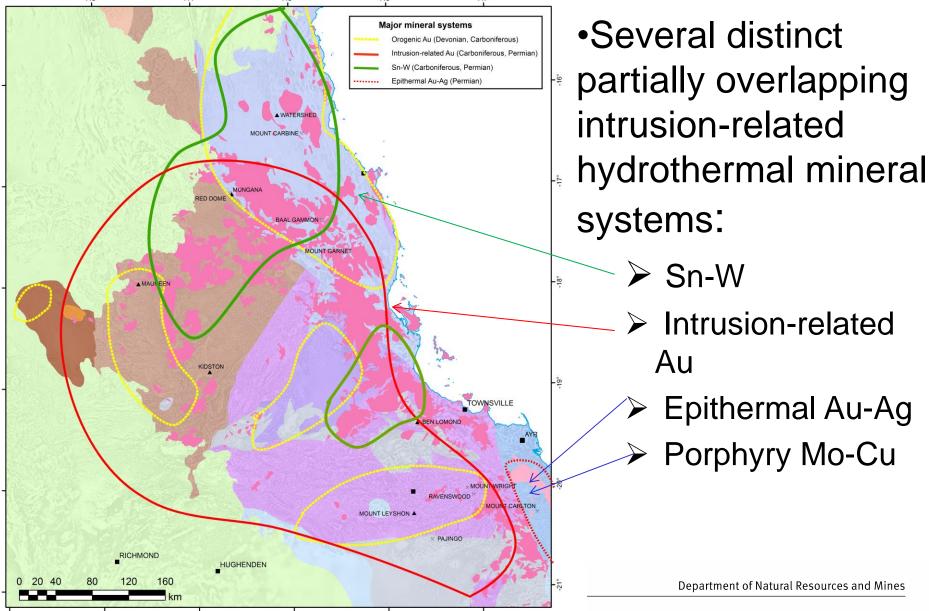
- Major orogenic gold mineral systems:
- Early Devonian
  - Charters Towers
  - > Etheridge
- Carboniferous to Early Permian
  - ➤ Hodgkinson
  - ➤ Broken River
  - > Croydon

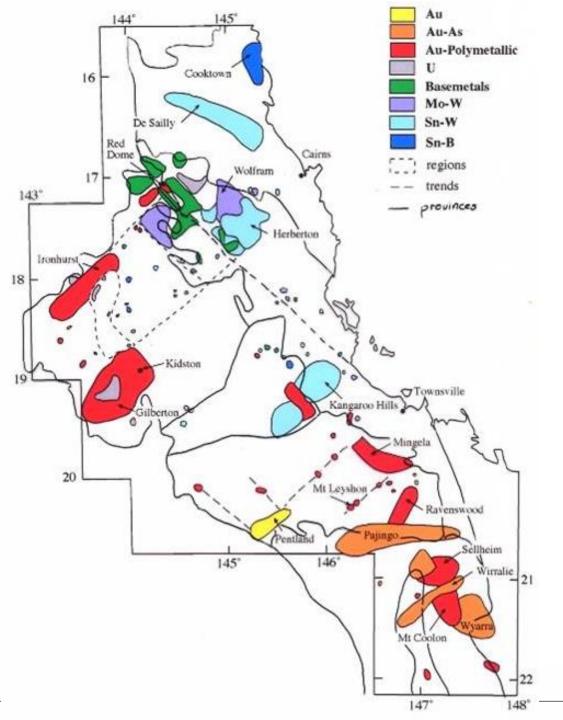
# Permo-Carboniferous intrusion-related hydrothermal mineral systems



- 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

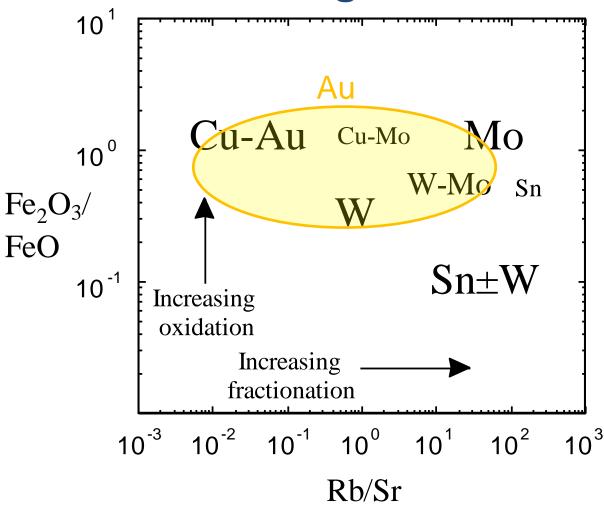




### Permo-Carboniferous intrusion-related hydrothermal mineral systems

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

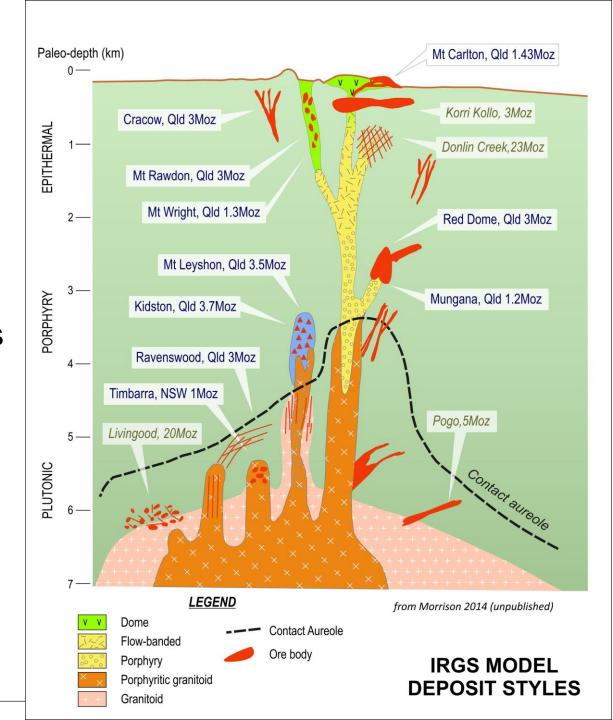
# Magma chemistry – key metallogenic factor



Blevin et al. (1996)

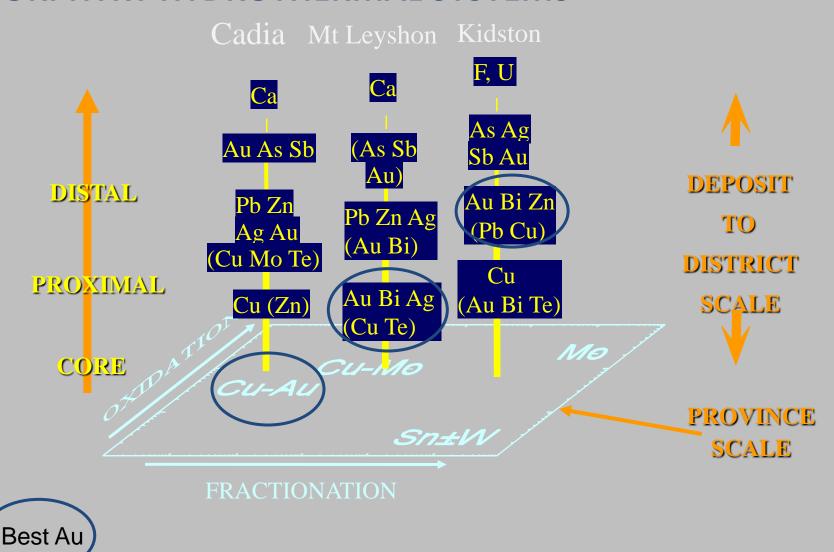
### Intrusion-Related Gold Systems

- 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

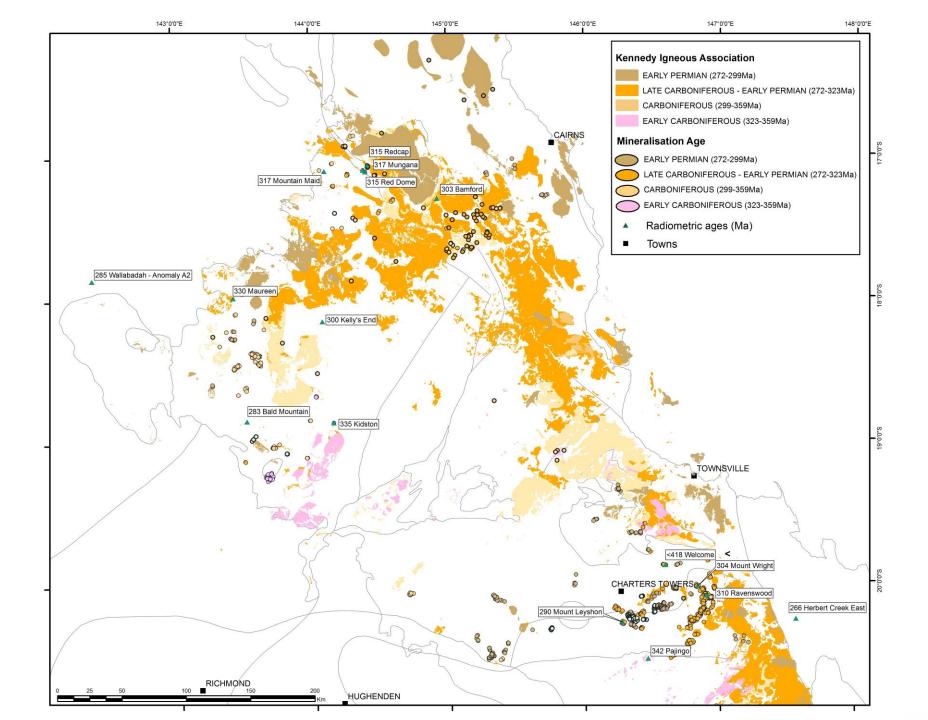


#### District-scale metal zoning Au As Sb As Sb Au F banded chalcedonic veins (Bi, Cu, Pb) silica-sulphide replacement (Bi, Pb, W) As Sb Au Ag EPITHERMAL Hg Bi Pb Bakers Camp Barkers Lease Rhyolite fibrous-saccharoidal veins/veinlets Au Cu Ag As (Bi, W) Ag Pb Zn (Cu, As) Au Cu Bi Te As saccharoidal fine comb veins Laureate PORPHYRY Tourmaline bx Tourmaline bx coarse comb veins Cu Au Bi Te (Mo, W) W Mo Bi Te Au W Sn Mo Bi Te veinlet-fracture Barkers Lease & disseminated Cu Au Bi Te PLUTONIC hornfels bt + mt **Ootann Supersuite Tonalite** Granodiorite Granite I-type Mafic-Felsic Fractionated Oxidised-Reduced

### METAL ZONING PATTERNS AND ORE POSITION FOR PORPHYRY HYDROTHERMAL SYSTEMS



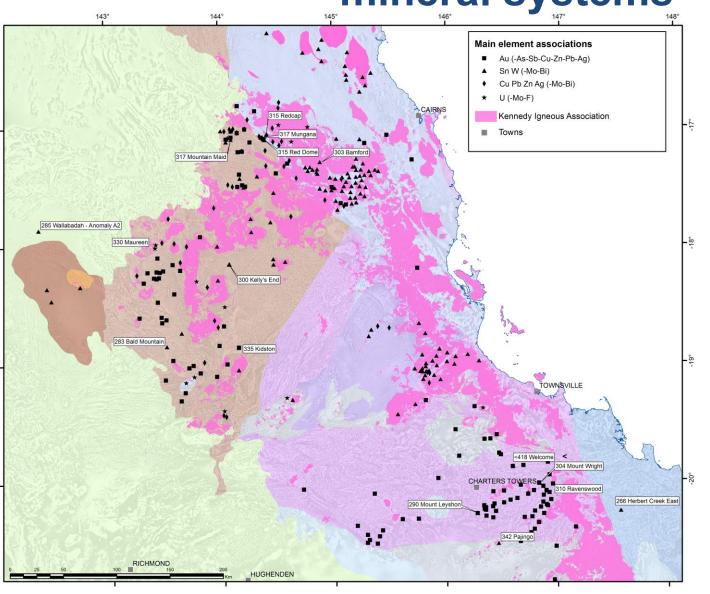
Blevin & Morrison (1997)



#### **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

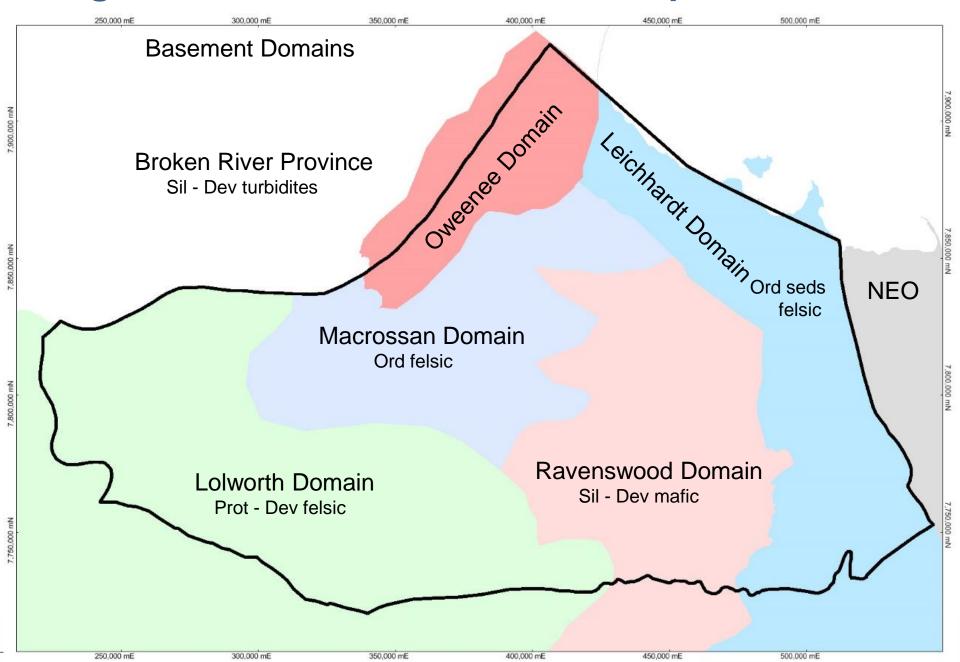
#### **Progress – James Cook University**

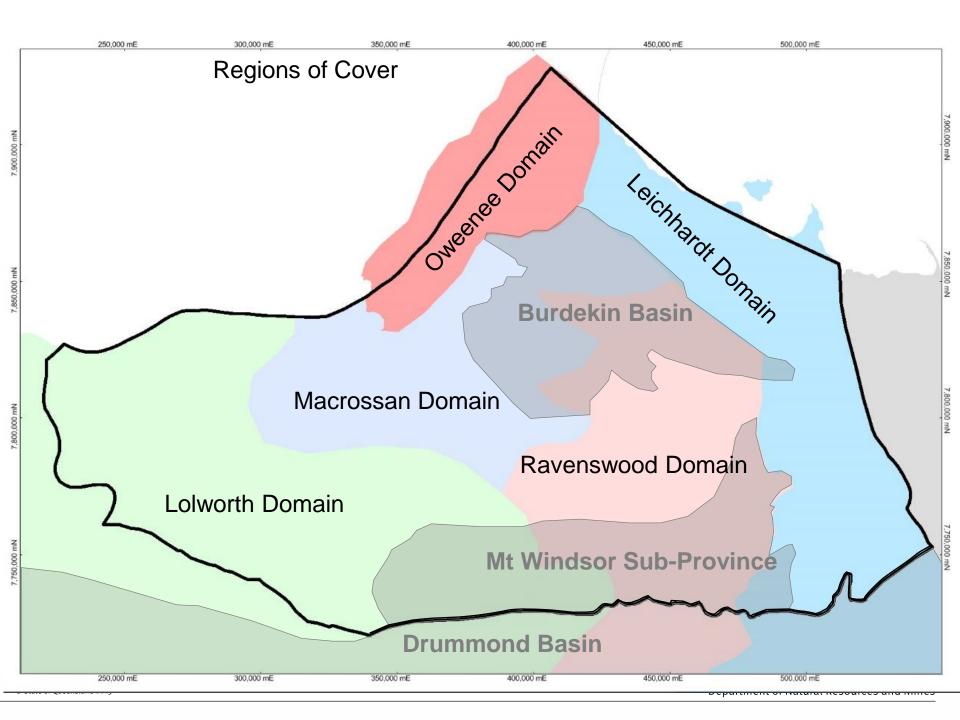
Early results from the Mount Carlton and northern Bowen Basin study:

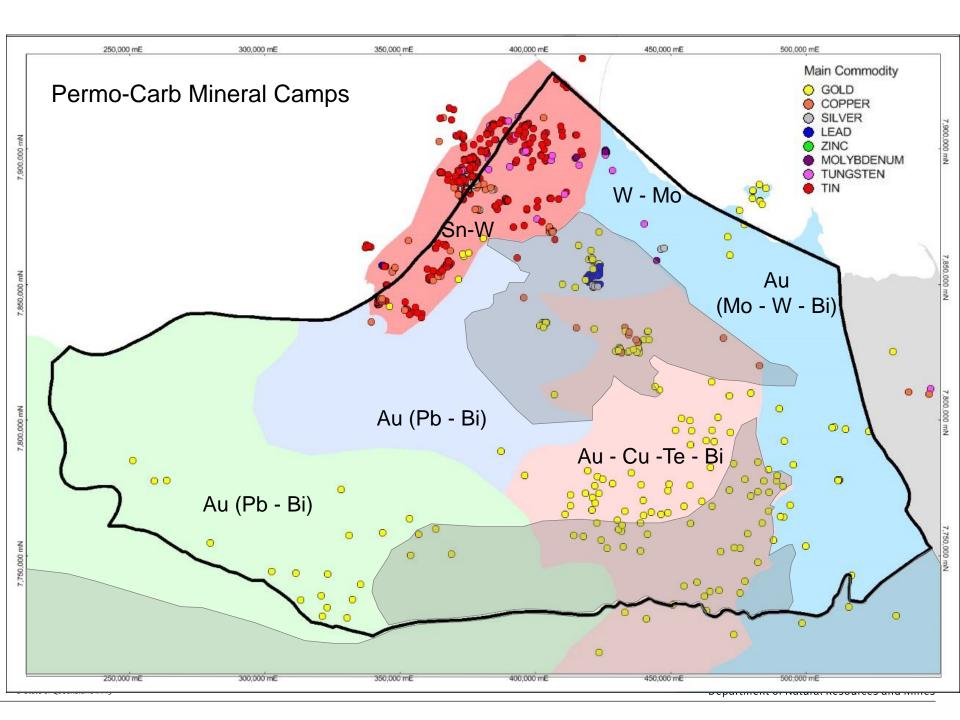
- Geochonology was completed on zircons (U-Pb), alunite from Mt Carlton (Ar-Ar), and molybdenite from the Capsize porphyry (Re-Os).
  - Alunite from Mt Carlton gave a date of 284.3  $\pm$  2.0 Ma.
  - Molybdenite from Capsize gave a date of around 285.7 ± 1.2 Ma.

http://www.jcu.edu.au/egru/public/groups/everyone/documents/newsletter/jcu\_149235.pdf

#### **Progress – Terrasearch/Klondike Exploration**



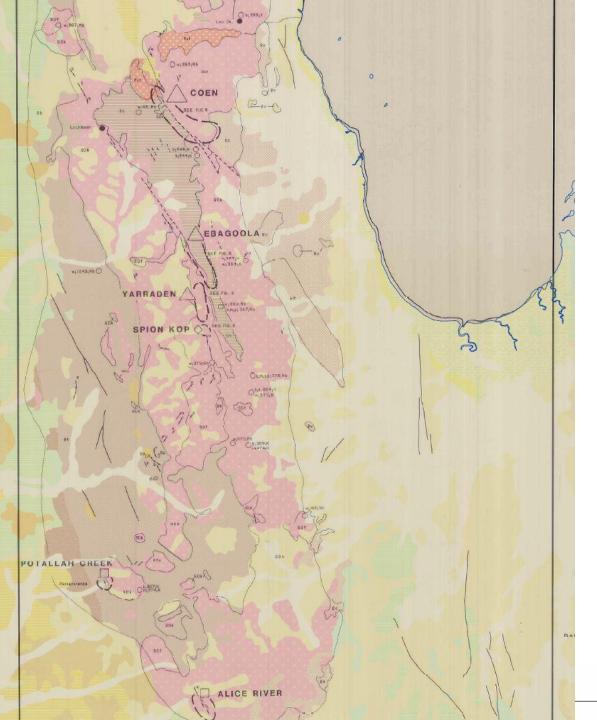




#### **Current GSQ Projects**

#### 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)