Intrusion-related minerals systems of north Queensland

Courteney Dhnaram (Geological Survey of Queensland)
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.**
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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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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
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

Department of Natural Resources and Mines
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

Increasing fractionation
Increasing oxidation

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
METAL ZONING PATTERNS AND ORE POSITION FOR PORPHYRY HYDROTHERMAL SYSTEMS

Best Au

Cadia  Mt Leyshon  Kidston

Core  Proximal  Distal

DEPOSIT TO DISTRICT SCALE

PROVINCE SCALE

FRACTIONATION

Cu-Au  Cu-Mo  Mo

Sn±W

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 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

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<td>2. Geology of the Mt Carlton high-sulfidation epithermal deposit</td>
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<td>3. Magma fertility, petrogenesis and geodynamic setting of Carboniferous and Permian magmatic complexes</td>
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<td>10. Regional alteration mapping using remote sensing methods</td>
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<td>11. Geochemical signatures of intrusion-related mineral systems</td>
<td>JCU - TS-K</td>
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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
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 ± 2.0 Ma.
  - Molybdenite from Capsize gave a date of around 285.7 ± 1.2 Ma.
Progress – Terrasearch/Klondike Exploration

Basement Domains

Broken River Province
Sil - Dev turbidites

Lolworth Domain
Prot - Dev felsic

Macrossan Domain
Ord felsic

Oweenee Domain

Leichhardt Domain
Ord seds felsic

Ravenswood Domain
Sil - Dev mafic

NEO

Progress – Terrasearch/Klondike Exploration
Permo-Carb Mineral Camps

- Au (Pb - Bi)
- Au - Cu - Te - Bi
- W - Mo
- Sn-W
- Au (Mo - W - Bi)

Main Commodity:
- GOLD
- COPPER
- SILVER
- LEAD
- ZINC
- MOLYBDENUM
- TUNGSTEN
- TIN
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)