Intrusion-Related Gold Deposits in North Queensland

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GSQ Project final meeting
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<table>
<thead>
<tr>
<th>CLAN</th>
<th>TOTAL Moz</th>
<th>Deposit Moz</th>
<th>DEPOSIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRGS</td>
<td>19.8</td>
<td>5.1</td>
<td>Kidston</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.0</td>
<td>Ravenswood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5</td>
<td>Mt. Leyshon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1</td>
<td>Red Dome</td>
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<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>Mungana</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>Mt. Wright</td>
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<tr>
<td>Epithermal</td>
<td>8.9</td>
<td>3.6</td>
<td>Pajingo</td>
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<tr>
<td></td>
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<td>2.2</td>
<td>Mt. Carlton</td>
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<td></td>
<td></td>
<td>1.1</td>
<td>Wirralie</td>
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<tr>
<td>Orogenic granite-hosted</td>
<td>8.6</td>
<td>6.8</td>
<td>Charters Towers</td>
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<td></td>
<td></td>
<td>1.0</td>
<td>Croydon</td>
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<tr>
<td>Orogenic turbidite-hosted</td>
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<td></td>
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<tr>
<td>Placer (estimated)</td>
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<td>1.6</td>
<td>Palmer River alluvials</td>
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<tr>
<td>VMS total</td>
<td>0.3</td>
<td></td>
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</tbody>
</table>

17 deposits +1Moz in Qld
12 deposits +1Moz in NQ
>40Moz total endowment NQ
>19 Moz in IRGS

In all ~130 IRGS in NQ

Some bi-product Cu
But no major Cu deposits is unusual

So NQ has a concentration of IRGS
c.f. Yukon-Alaska Cretaceous
The INTRUSION-RELATED CAMP

**IR**
= intrusion intimate to hydrothermal system and deposit

**IRGD**
Intrusion-Related Gold Deposit
*Gold only commodity*

**CAMP**
All magmatic & hydrothermal features related to an intrusive centre

**DEPOSIT**

**INTRUSION**

**BRECCIA & ALTERATION**

**MLBX**

**MPBXf**

**MPBXc**

**Southern Porphyry**

**Basement raft**

**CAMP IS WHOLE THING**
IRGS NQ: IRGS Mineral System Model with NQ Examples

Legend:
- Dome
- Flow-banded
- Porphyry
- Porphyritic granitoid
- Aplitic-pegmatite
- Granitoid
- Diatreme breccia
- Sub-volcanic breccia
- Contact aureole
- Replacement/skarn breccia
- Stockwork disseminated
- Vein network
- Vein

Key Sites:
- Mt Carlton, 1.43 Moz
- Pajingo, 3.5 Moz
- Mt Wright, 1.3 Moz
- Wellington Springs
- Kidston, 5.0 Moz
- Welcome, 0.21 Moz
- Mt Wandoor
- Red Dome, 2 Moz
- Mungana, 1.2 Moz
- Electric Light, 0.2 Moz
- Far Fanning, 0.12 Moz
- Mountain Maid (Cardross, 0.5 Moz)
- Ravenswood, 3 Moz
- Cardigan Creek
- Redcap BM (Au, Ag, As)
- Mareeba

Depth (km):
- Paleo-depth

Zones:
- Epithermal
- Porphyry
- Mesozone
- Plutonic

Contact aureole
Cluster of IRGS in north Qld
Permo-Carboniferous age
Related to Kennedy Igneous Association

Townsville Mornington Island Belt is oblique to the arc
Cauldron subsidence => extension
Rhyodacite composition
Au-Sn-W-Mo metallogeny

Connors arc extensive under Bowen Basin
Andesite stratovolcanoes
Cu-Mo-Au metallogeny

So NQ Permo-Carboniferous is an IRGS Province in an off-arc setting
NQ metallogenic districts

NORTH QUEENSLAND MINERAL DISTRICTS BY METAL ASSOCIATION

NORTH QUEENSLAND MINERAL DISTRICTS BY CORE ASSOCIATION

Morrison & Blevin 1997, AMIRA P425
Early Carboniferous to mid Permian (345-260ma)
- Dominated by cauldron subsidence complexes i.e. extension in continental crust
- I-type throughout with Permian A +/- S-type
- High SiO₂ K₂O & LILE, strongly fractionated
- Derived from homogeneous mainly Proterozoic lower crust with limited mantle input, variations due to fractionation
- Distinct from NEO of same age which has andesitic stratovolcanoes and is more conventional arc
- Metallogeny is Au Sn W U not Cu-Mo-Au like NEO
Fractionation represented by Rb/Sr vs SiO₂

Increases with SiO₂, K and volatile elements

Au is with the less fractionated intrusions, but favours the volatile phase in any system

Therefore is best at moderate fractionation in mafic suites

This figure is of a continental suite with limited mafic members, so the gold is in Cu-Mo and Mo-W-Bi associations
NQ Au deposits are in intrusive suites that have moderate fractionation and slightly oxidised to slightly reduced geochemistry. Most deposits are in magmatic-hydrothermal systems with Cu-Mo or Mo-W Bi cores.
**Deposit Classification**

**Mesozonal veins and breccias dominate**

**Polymetallic systems but only 1-2 commodities**

**Bi-Te diagnostic of Permo-Carb IRGS**

<table>
<thead>
<tr>
<th>Environment &amp; style</th>
<th>n</th>
<th>ENDOWMENT t Au</th>
<th>Element Class</th>
<th>Core</th>
<th>Example</th>
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</thead>
<tbody>
<tr>
<td>Epizomal Vein</td>
<td>8</td>
<td>0.26</td>
<td>Au PM Bi +/-Te</td>
<td>Cu-Mo</td>
<td>Wellington Springs</td>
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<td>Epizomal Stockwork</td>
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<td>0.15</td>
<td>Au As Bi Te</td>
<td>Mo-W-Bi</td>
<td>Mt Wandoop</td>
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<tr>
<td>Epizomal Breccia</td>
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<td>32</td>
<td>Au BM Bi Te</td>
<td>Mo-W-Bi</td>
<td>Mt Wright</td>
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<tr>
<td>Mesozonal Skarn</td>
<td>2</td>
<td>66</td>
<td>Au PM Bi Te</td>
<td>Mo-W-Bi</td>
<td>Red Dome</td>
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<tr>
<td>Mesozonal Lode</td>
<td>5</td>
<td>0.5</td>
<td>Au PM Bi</td>
<td>Mo-W-Bi</td>
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<td>200</td>
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<td>variable</td>
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<td>2.3</td>
<td>Au PM Bi Te</td>
<td>Cu-Mo</td>
<td>Upper Cape</td>
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<tr>
<td>Mesozonal Breccia</td>
<td>26</td>
<td>270</td>
<td>Au PM Bi Te</td>
<td>ALL</td>
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<td>Au As (BM)</td>
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<td>Hypozonal Vein</td>
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<td>Au PM Bi</td>
<td>Mo-W-Bi</td>
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<td>Hypozonal Stockwork</td>
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<td>16</td>
<td>Au PM Bi</td>
<td>Mo-W-Bi</td>
<td>Mountain Maid (Cardross)</td>
</tr>
</tbody>
</table>

BM (basemetal) = Cu-Zn-Pb; PM (polymetallic) = Cu-Pb-Zn+/- Bi, Te, Mo, W, Sn, As, Sb.
IRGS NQ  NQ Examples on IRMS model

- Pajingo, 3.5Moz
- Mt Wright, 1.3Moz
- Kidston, 5.0Moz
- Welcome, 0.21Moz
- Mt Leyshon, 3.5Moz
- Ravenswood, 3Moz
- Mountain Maid (Cardross, 0.5Moz)
- Cardigan Creek
- Mt Wando
- Sherwood, 0.5Moz
- Wellington Springs
- Red Dome, 2Moz
- Mungana, 1.2Moz
- Electric Light, 0.2Moz
- Far Fanning, 0.12Moz
- Redcap BM (Au, Ag, As)
- Mareeba

**Legend**
- Dome
- Flow-banded
- Porphyry
- Porphyritic granitoid
- Aplite-pegmatite
- Granitoid
- Diatreme breccia
- Sub-volcanic breccia
- Contact aureole
- Replacement / skarn breccia
- Stockwork
- Disseminated
- Vein network
- Vein

**Contact aureole**
IRGS NQ  System identification & interpretation

SYSTEM FINDERS

1. Geology interp of Minocc
2. ‘Jetrex’ topo silica + rhyol
3. Reverse mag anomalies
4. In-district geochem including alluvials

SYSTEM INTERPRETERS

1. drill, drill, drill & interpret
2. Ore control domains especially permeability
3. Metal zoning

Kidston- Morrison 2007
Two parallel districts sit inside the gravity & mag boundary. Disrupted by NE fault
One driven by diorite on batholith side with Cu-Te geochem core (Ravenswood)
and other by rhyolite in Ordovician metaseds with Mo-W-Bi core (Mt Canton)
IRGS NQ: Cardross region deposits wide range of metal associations
IRGS NQ: Cardross metal variability relates to intrusion composition & zoning
A profound reverse anomaly is ascribed to hydrothermal magnetite in the contact aureole of the mother intrusion pre-ore. The reverse mag epoch (~320-280Ma) is useful thru NQ.
IRGS NQ  Mt Wright soil and rock metal zoning

3km diameter soil anomaly Zn, Bi, Au only 5ppb on hill

1km tall system, well zoned Au 0.1ppm at surface, Best Au ore 500-800m below
IRGS NQ  *Piccadilly: vein → system → zoning → opportunity*

- Au vein only to start
- More vein sets isolated
- Mag shows intrusive centre
- Geochem shows zoned system

→ Only seeing ¼ of system!
• A distinct NQ IRGS province with +20Moz
• Existing work defines >130 systems
• ~30 explored well
• In current climate good targets can be identified in system interpretation
• Especially via system facies geometry & multi-element geochemical zoning