‘New insights into the Architectural Development of the southern Cloncurry IOCG Terrain - Controls and Timing of Mineralization’

Mark Hinman
DMQ Project - southern Cloncurry Belt

‘Prospectivity - Mineability - Viability’
Overall aims to reduce risk of exploring for large, mass-mineable deposits at depth in the southern Cloncurry Belt.

Reported here:
(1) Updated **solid geology, structural, & tectono-stratigraphic interpretation** which builds on the published GSQ 100K solid geology, utilizing the smaller scale prospect geology & detailed geophysics made available by Chinova

(2) Some resource-scale examples of **timing and controls** on IOCG-style mineralisation

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Acknowledgements

Chinova ... data including detailed geophysics, detailed prospect mapping & project ddh databases
GSQ ... pre-release 100K mapping (Selwyn, Mount Angelay), geochron database
Historic Mapping ... Leishman, 1970s-80s; Searl, 1952; ... & others
Personal ... understanding gained during contract work for Ivanhoe, Inova & Chinova, 2011-2015
Deep Mining Queensland Project Location
Eastern Fold Belt between Cloncurry & Osborne
approx 180x50km
Regional vs Detailed Magnetics

Very significant difference in resolution

... has allowed a high fidelity interpretation

> package continuity
> package architecture
> faulting and fine structure

GA Mag tmi-rtp v6 (2015) 80m grid

Chinova detailed Mag merge vrmv-2vd (201x) 10m grid
KEY POINTS

DMQ southern Cloncurry IOCG Belt

• IOCG-style mineralisation focuses within late Isan (D3-4), brittle, fracture-breccia networks that are controlled by local competency contrast & strain partitioning.

• D3-4 structuring comprises short-strike / small-displacement faults, and localised reactivation of older structures …. in contrast with, D2 faults which are regional in strike & commonly juxtapose packages of contrasting lithology & age.

  (Dichotomy: D2 structure well imaged (mapping, seismic, geophysics ..) cf. D3-4 structures, likely highly seismic, but generally not well imaged!)

• In D3-4 time, crystallising granites (that drive the high temp, IOCG fluid systems) themselves locally play roles in strain partitioning which drives the brittle failure focusing IOCG mineralisation.

• Pre-orogenic architectures likely play critical roles in the geometries of intrusion, brittle deformation, IOCG fluid circulation, & the localisation of ore formation.
Tectono-Stratigraphic Development of Eastern Fold Belt

Updated 2000 NWQMP Tx Chart
to reflect current understanding of EFB package relationships & latest geochronology (Withnall-Parsons, 2007-2009; NWQMEP, 2011)

Re-built EFB Solid Geology
highlighting packages & deformation events that impact their geometry
~1775-1765Ma

Bulonga

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
Marraba-Mitakoodi-Double Crossing Meta

~1765-1755Ma

Marraba-Mitakoodi-DCM

Bulungo
Argylla

Kalkadoon
Leichardt Volcs

Barramundi

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
Corella

~1755-1740 Ma

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
~1740Ma

**WONGA Extension**

~1740-1745Ma

**Mount Fort Constantine Volcanics**

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
APWP for the Palaeo-MesoProterozoic of Northern Australia (Idnurm, 2000)

~1710Ma

OP1 Deformation

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
~1715-1710Ma
Staveley

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
**~1710Ma**

**Roxmere**

FRF = Fountain Range Fault  
PFZ = Pilgrim Fault Zone  
HT = Highway Thrust  
OF = Overhang Fault  
CF = Cloncurry Fault
Kuridala-Starcross-Llewelyn

~1710-1680Ma

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
New Hope-Mt Norna

~1680-1690Ma

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
<table>
<thead>
<tr>
<th>Location</th>
<th>Age (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer-Toole Creek</td>
<td>~1690-1650</td>
</tr>
</tbody>
</table>

**Diagram:**
- **Answer-Toole Creek**
- **New Hope-Mt Norna**
- **Kuridala-Starcross-Ulewelyn**
- **Barramundi**
- **Bulonga-Marraba-Mitakoodi-DCM**
- **Argylla**
- **Wonga MFCV**
- **Kalkadoon Leichardt Volcs**

**Map:**
- **TICK HILL**
- **PHOSPHATE HILL**
- **MT ELLIOTT**
- **VEREY MOUNT DORE**
- **STARRA**
- **OSBORNE KULTHOR**
- **CANNINGTON**
- **ERNEST HENRY**
- **ROCKLANDS**
- **CLONJURRY COPPER**
- **MARY KATHLEEN**
- **SAWN TOOLE CREEK**

**_scale:** 0 to 25 km
~1650Ma

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
~1590-1575Ma
Isan D1 Folding & Thrusting
THIN-SKINNED

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
Isan D2 Folding
THICK-SKINNED

~1555-1535 Ma

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
~1555-1535Ma
Isan D2 Faulting
THICK-SKINNED

~1545Ma
Maramunnggee

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
~1515-1500Ma
Williams Suite
~1515-1500Ma
D3-4 shortening
~1515-1500Ma

Williams Suite

~1515-1500Ma
early D3-4 Faulting

Cu-Au, Au-Cu, Mo-Cu

Barton & Johnson (2004), Williams et al. (2005), Williams et al. (2010)
~1515-1500Ma
**Williams Suite**

~1515-1500Ma
**early D3-4 Faulting**

???? Ma

**Quamby**

Cu-Au, Au-Cu, Mo-Cu

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Surficial ± Formational Fluid Source IOCG Model

*Source: Barton & Johnson (2004)*

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**Williams**

- Saxby
- Maramungee

**Quamby**

- D3-4
- D2
- D1

- Answer-Toole Creek
- New Hope-Mt Norna
- Kuridala-Starcross-Ulewelyn
- Roxmore
- OP1
- WONGA
- Marraba
- Marraba-Mitakoodi-DCM
- Bulonga
- Argilla

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**Kalkadoon Leichardt Volcs**

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**Barramundi**

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**Fracture Zones**

- FRF = Fountain Range Fault
- PFZ = Pilgrim Fault Zone
- HT = Highway Thrust
- OT = Overhang Fault
- CF = Cloncurry Fault

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**Quamby**

Cu-Au, Au-Cu, Mo-Cu

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**Barton & Johnson (2004), Williams et al. (2005), Williams et al. (2010)**
~1545Ma
Williams Suite
~1555-1535Ma
late D3-4 Faulting
???? Ma
Quamby
Cu-Au, Au-Cu, Mo-Cu
Surficial ± Formational Fluid Source IOCG Model

Williams Suite - HEAT source - circulation driver
Isan D3-D4 - BRITTLE, shallow crustal deformation
Quamby Basin - continental, oxidised, evaporitic?

>> IOCG Mineralisation

Barton & Johnson (2004), Williams et al. (2005), Williams et al. (2010)
<1500Ma post Isan Faulting widespread

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
<1500Ma post Isan Faulting widespread & appears to reflect ....

.... older, pre-orogenic architectures ‘significant crustal penetration & persistance’

**NE architecture**
Wonga-reactn>MFCV margin Mitakoodi culmination D2 folding D1 & D2 deformation partitioning post-Williams reactn

**NW architecture**
Williams margins D2 deformation partitioning post-Williams reactn

**older NNW architecture**
post-Williams reactn

>>> significant influence on IOCG mineral system geometry and ultimate sites of metal accumulation

FRF = Fountain Range Fault
PFZ = Pilgrim Fault Zone
HT = Highway Thrust
OF = Overhang Fault
CF = Cloncurry Fault
Starra-Merlin-Mount Dore
DMQ Interpretation (2016)

- unconformable onlap of Answer Slate
- D1 N’ward overthrust of Staveley over Answer
  > EW F1 folds; highly attenuated/folded MIF-HIF
  > preserves FW block architecture
- D2 folding of D1 overthrust into vertical
  > F1 fold sub-vertical vs sub-horiz F2 folds
- D3-4 shortening: transpressive BRITTLE reactivation
  > at Starra, footwall architecture contribution to fract-bx
  > at Merlin-Mt Dore, strain intensification
- post-mineral reverse faulting of MDG over M-MD

Mount Dore Granite
D3-4
D2
D1

Answer Slate
Kuridala Fm
Roxmlere Quartzite
Staveley Fm
OP
WONGA
Double Crossing Meta

Gin Creek Granite

Eastern Fold Belt Timespace
Starra Line - Long Section

2012 Resource Model - mined/probable
Mount Dore-Merlin
Gradational stratigraphy:
Staveley-Roxmere-(SF)-Kuridala
Kuridala: carb silt dominant

D3 Faulting:
complex, curvilinear, anastomosing

Brittle, fracture & breccia
Damage Zones ...
... in carbonaceous silts
& along reactivated contacts
.. host Cu mineralisation

D3 Faults ... small throws!
NOT Regional Structures

Granite Reverse Fault
highly planar, post-mineral, significant throw
Gradational stratigraphy: Staveley-Roxmere-(SF)-Kuridala
Kuridala: phyllite dominant

D3 Faulting: complex, curvilinear, anastomosing brittle in calc-silicate, carb silt ductile (mylonitic) in phyllite

Brittle, fracture & breccia zones host Mo minz ...
.. along reverse fault where calc-silicate & carbonaceous silt are brecciated, and .. where normal calc-silicate / carb silt contact is brecciated in FW & HW of reverse fault

D3 Faults ... small throws! NOT Regional Structures

Granite Reverse Fault highly planar, significant throw, post-mineral > reactivation > Mo-matrix breccias ...
Mount Elliott - SWAN
Close proximity to D1 structure

... juxtaposes, with significant HW truncations, strong mag-character package against benign Staveley-Kuridala packages
SWAN 0.75eq%Cu
Long Section ... looking SW through SWAN

- post-mineral D3-4 Faults
- family cuts Squirrel Hills Granites
CONCLUSIONS

DMQ southern Cloncurry IOCG Belt

• Reliable geochronology suggests IOCG-style mineralisation forms during late orogenic, shallow-crustal, brittle, deformation (Isan D3-4)

• IOCG-style mineralisation forms via a complex interplay in the geometries of thermally-driven, circulation of (?basinal) brines, and the contemporaneous Isan D3-4 patterns of brittle, fracture-breccia deformation

• Ore deposition is focused within brittle, breccia/fracture networks that are ubiquitously post-peak metamorphic

• Local competency contrasts & strain partitioning play critical roles in the geometries of brittle failure & ore localisation

• D3-4 faulting comprises short-strike / small-displacement faults, and localised reactivation of older structures

• Contrasts with D2 faults which are regional in strike & commonly juxtapose packages of contrasting lithology & age

(Dichotomy: D2 structure well imaged (mapping, seismic..) cf. D3-4 structures, likely highly seismic, but generally not well imaged!)

• In D3-4 time, crystallising granites (that drive the high temp IOCG fluid systems) themselves locally play roles in strain partitioning which drives the brittle failure that focuses IOCG mineralisation

• Subtle pre-orogenic, (potentially depositional), architectures play critical roles in: (1) (Isan) deformation partitioning, (2) intrusion geometry, and (3) IOCG-forming, fluid circulation patterns ... and therefore, strongly impact on localisation of IOCG ore formation

DMQ Project going forward, aims to tease these controls & interplays into 3D!