



# Intrusion-Related Gold Systems of north Queensland & new ideas from Charters Towers Province

*Gregg Morrison & Simon Beams*

***Intrusion-Related Gold Deposit (IRGD)***

*A deposit spatially and temporally related to an intrusion where Au (Ag) is the only commodity*

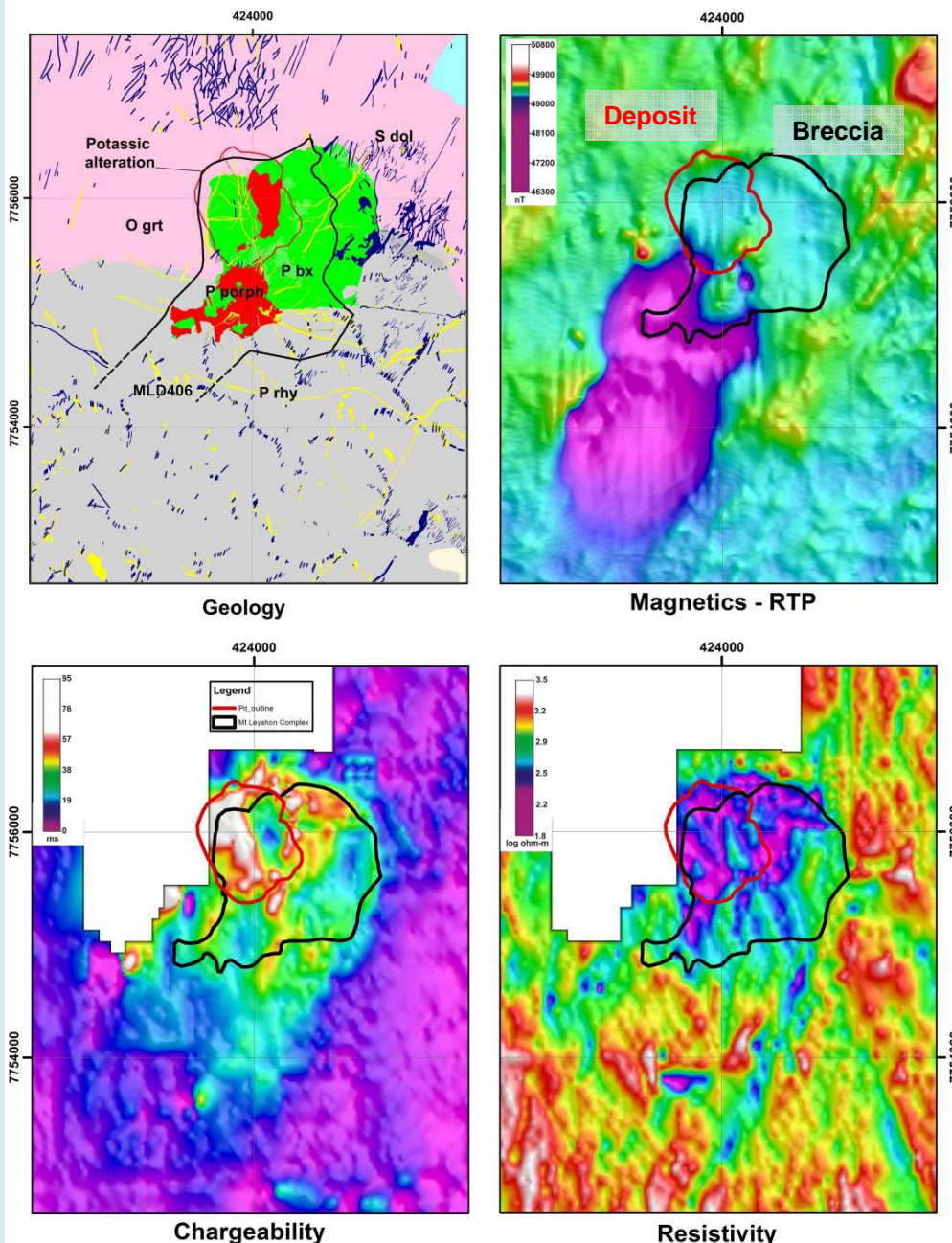
***Intrusion-Related Gold System (IRGS)***

*The area of intrusions and hydrothermal features (alteration, breccias, mineralisation) that may enclose a deposit*

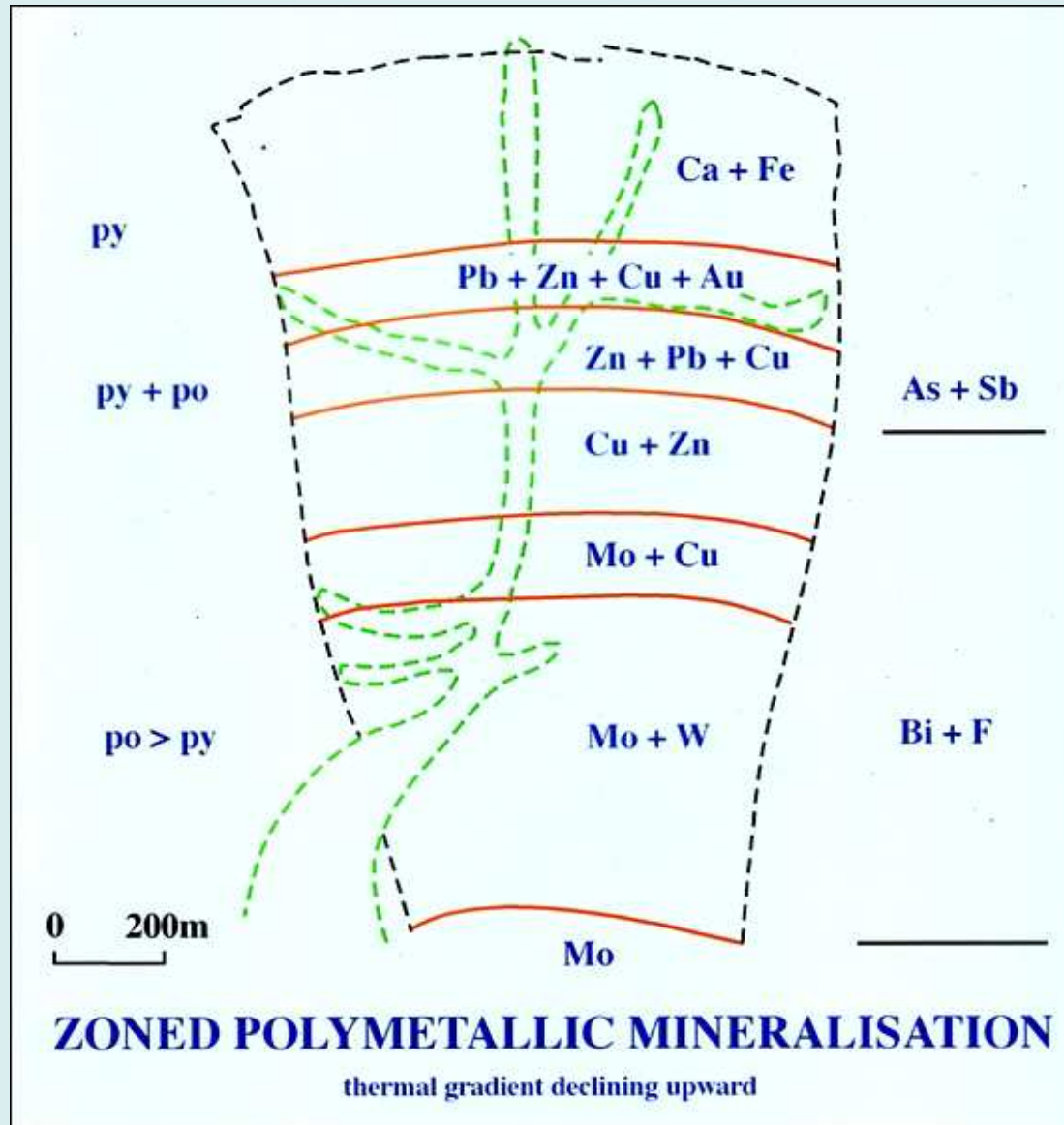
***Intrusion-Related Mineral System (IRMS)***

*The clan of magmatic hydrothermal systems with a variety of metals (Cu Mo W Sn)*

# System Components Mount Leyshon



- 1km diameter deposit 3.5Moz
- 2km diameter breccia pipe with multi-phase intrusions and mineral occurrences
- 3km reverse magnetic anomaly magnetite-biotite alteration on an inferred diorite stock
- 4km long chargeability anomaly due to pyrite - sericite alteration
- 4km x 2km intrusion-centred magmatic-hydrothermal system all components 290+/-5 Ma
- ***Systems more common than deposits***



## *Metal Zoning (Kidston)*

- Polymetallic system
- Classical zoning on a Thermal gradient
- Au only in one zone with Pb-Zn-Cu
- Mo-W-Bi Core
- Exposed distal BM

**CLASSIFY**

**PINPOINT AU**

# IRGS NQ : *metal zoning patterns for different core associations*

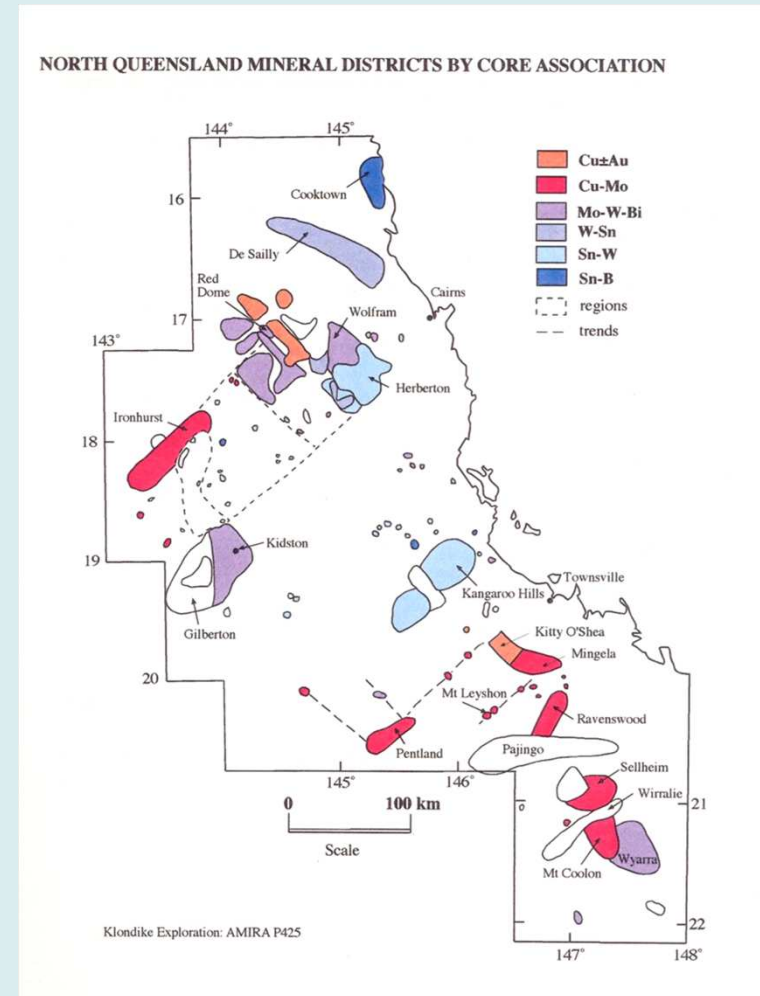
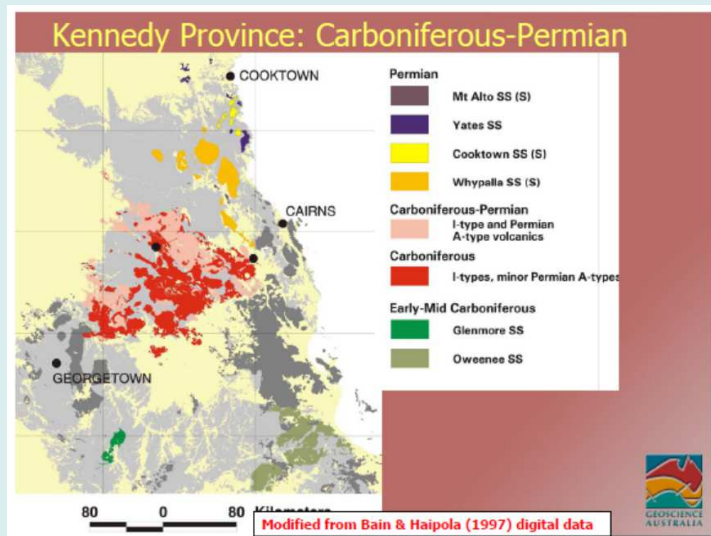
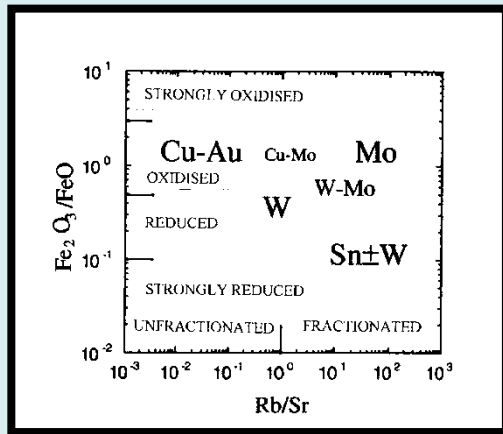
| METAL ZONING         | general     | Cu-Au                     | Cu-Mo             | Mo-W-Bi        | Sn-W             | Sn-B         |
|----------------------|-------------|---------------------------|-------------------|----------------|------------------|--------------|
| <b>MARGINAL</b>      | Ca, F       | Ca                        | Ca                | F, U           | F, Ba, Se, Hg, U | F            |
| <b>DISTAL (As)</b>   | As Sb       | Au As Sb                  | (As, Sb, Au)      | (As Ag Sb Au)  | As (Au)          | As           |
| <b>DISTAL (BM)</b>   | Pb, Zn, Ag, | Pb Zn Ag Au<br>(Cu Mo Te) | Pb Zn Ag (Au, Bi) | Zn Cu Pb Bi Au | Pb Ag Zn         | Zn Pb Ag     |
| <b>PROXIMAL (BM)</b> | Cu Mo       | Cu (Zn)                   | Cu Au Ag (Bi Te)  | Cu (Au Bi Te)  | Cu Mo Bi         | Cu Bi Mo (W) |
| <b>CORE</b>          | core        | Cu Au (Te)                | Cu Mo             | W Mo Bi        | Sn W             | Sn B (W)     |
| <b>Example</b>       |             | Goonumbla                 | Mount Leyshon     | Kidston        | Herberton        | Cooktown     |

- Broadly similar patterns of metal zoning **core → Cu → Zn-Pb → As-Sb → Ca**
- Progression of core associations siderophile to lithophile, mafic to felsic
- Diagnostic metals **Te mafic, Bi-Te intermediate, Bi felsic, Sn-W min melt**
- Best gold is more distal in zoning for more lithophile associations

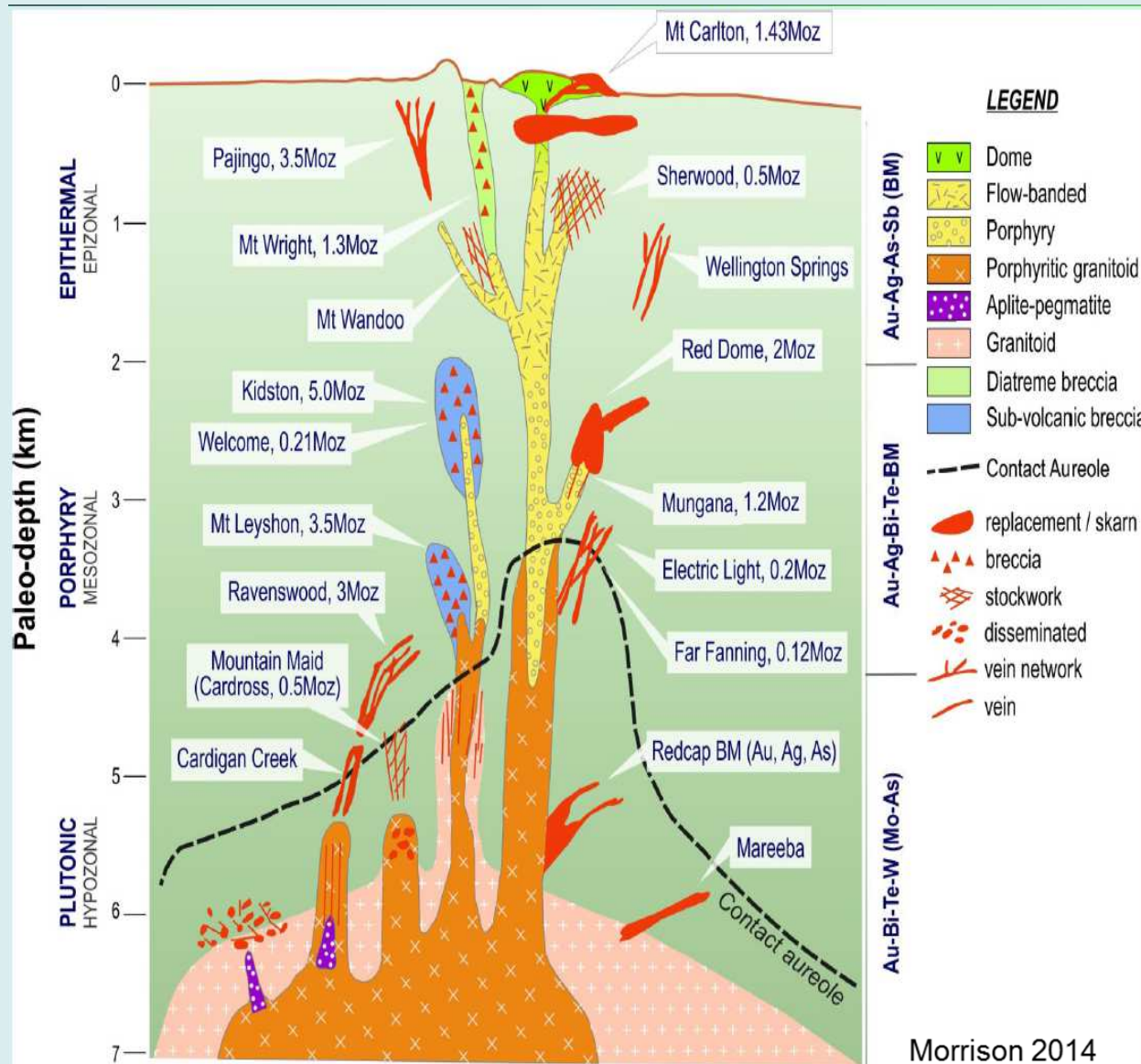


# IRGS NQ : *igneous type - core metal mapping*

Phil Blevin redox-fractionation plot links igneous rock type to core associations  
 Dave Champions maps show the distribution of igneous types  
 → Maps that identify prospective areas for core metal associations



# IRGS NQ: wide range of emplacement levels & styles



## NQ IRGS MODEL

*Crustal range for levels of emplacement reflected in intrusion form*

*Porphyry level dominant in NQ*

*Plutonic level in Yukon & Braidwood*

*Vein & breccia styles dominant reflects qz-fs basement*

*3 metal associations reflect fluid conditions*

# IRGS NQ

# NQ Au *total and >1Moz deposits*

| CLAN                      | TOTAL Moz   | Deposit Moz | DEPOSIT                |
|---------------------------|-------------|-------------|------------------------|
| IRGS                      | <b>19.3</b> |             |                        |
|                           |             | 5.0         | Kidston                |
|                           |             | 4.8         | Ravenswood             |
|                           |             | 3.5         | Mt. Leyshon            |
|                           |             | 2.1         | Red Dome               |
|                           |             | 1.1         | Mungana                |
|                           |             | 1.1         | Mt. Wright             |
| Epithermal                | <b>8.9</b>  |             |                        |
|                           |             | 3.6         | Pajingo                |
|                           |             | 1.4         | Mt. Carlton            |
|                           |             | 1.1         | Wirralie               |
| Orogenic granite-hosted   | <b>8.6</b>  |             |                        |
|                           |             | 6.8         | Charters Towers        |
|                           |             | 1.0         | Croydon                |
| Orogenic turbidite-hosted | <b>1.3</b>  |             | Hodgkinson             |
| Placer (estimated)        | <b>~4</b>   |             |                        |
|                           |             | 1.6         | Palmer River alluvials |
| VMS total                 | <b>0.3</b>  |             |                        |

## For NQ

>40Moz total endowment

Nearly half IRGS

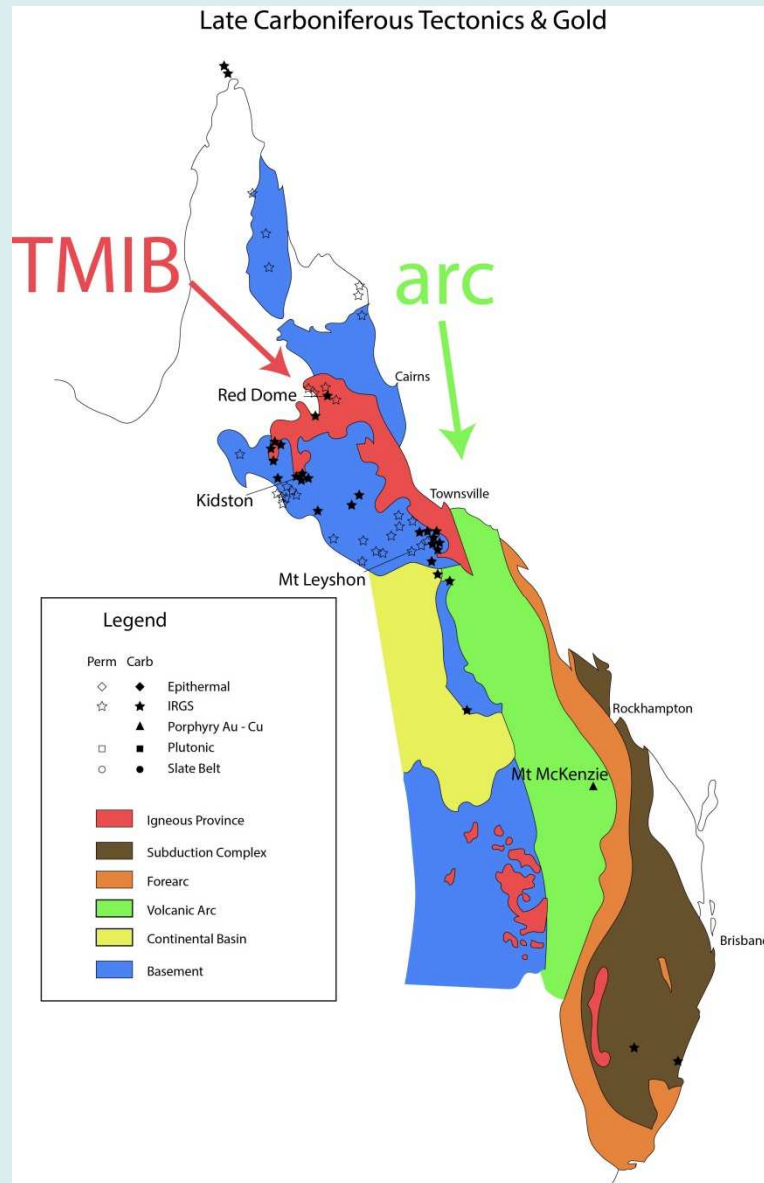
Mostly since 1985

Some bi-product Cu

But no major Cu deposits

***So NQ is an IRGS Province  
one of only a few  
in the world***



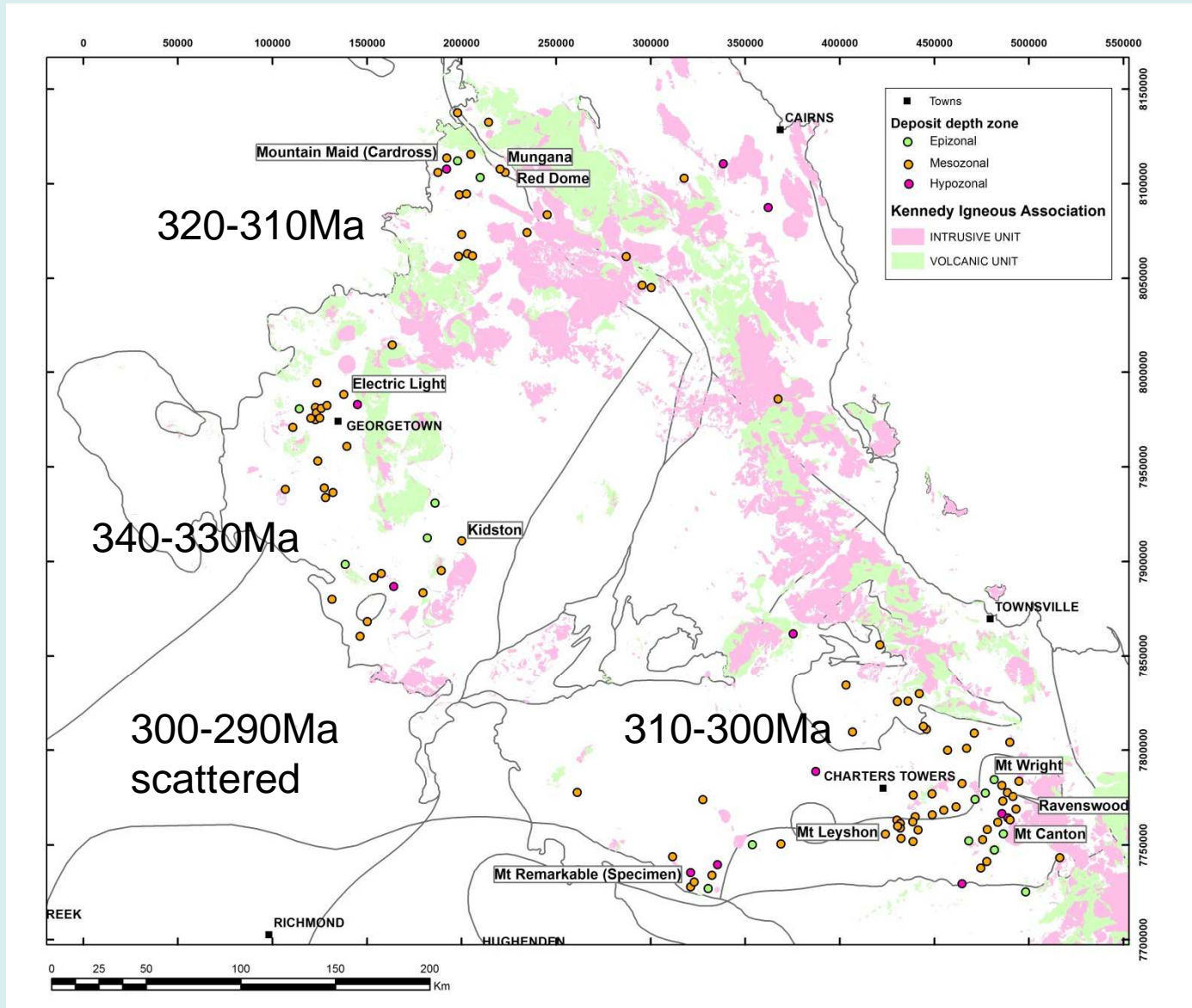


Townsville Mornington Island Belt

is oblique to the arc  
 Cauldron subsidence => extension  
 K-rich rhyodacite magma  
 Crustal melts by under-plating  
 Au-Sn-W-Mo-U metallogeny  
 IRGS dominant

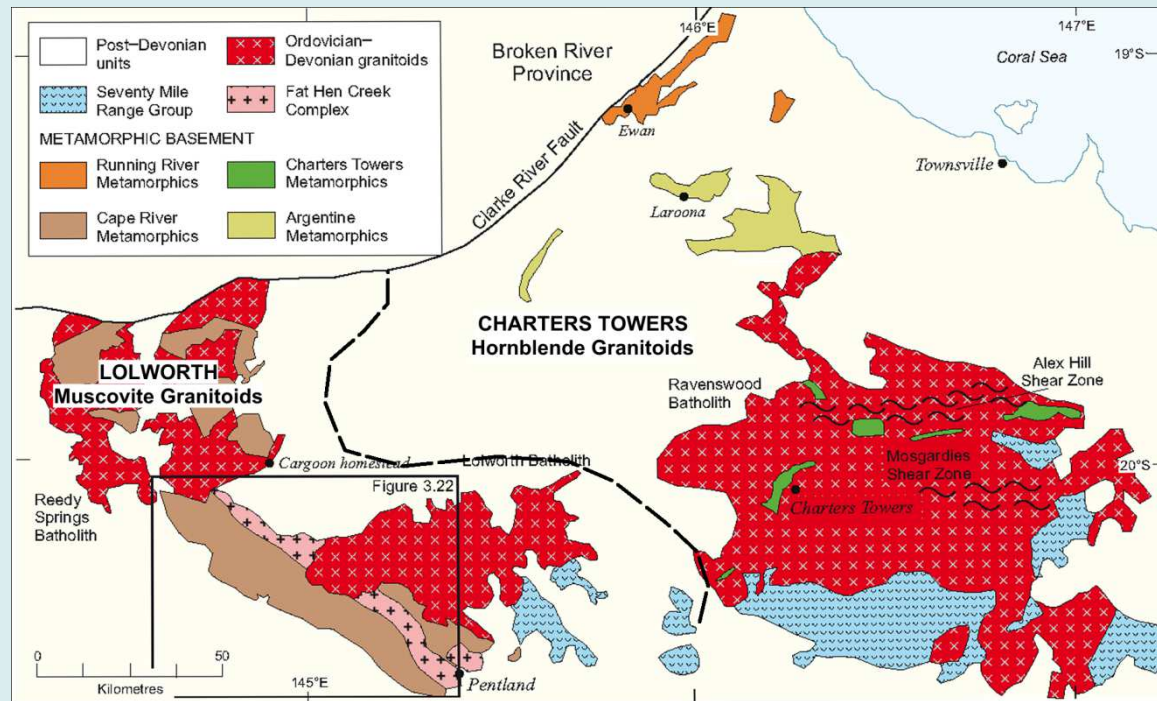
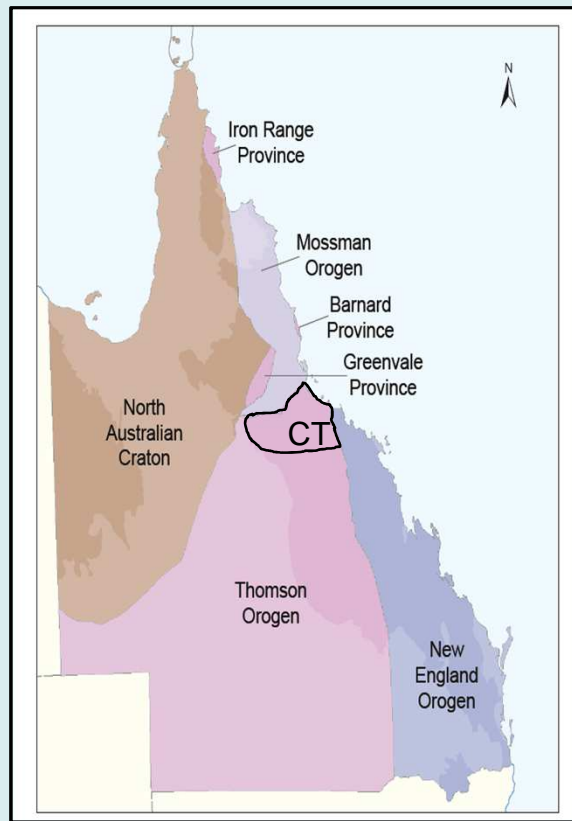
Connors arc

extensive under Bowen Basin  
 Andesite stratovolcanoes  
 Cu-Mo-Au metallogeny  
 Porphyry Cu dominant



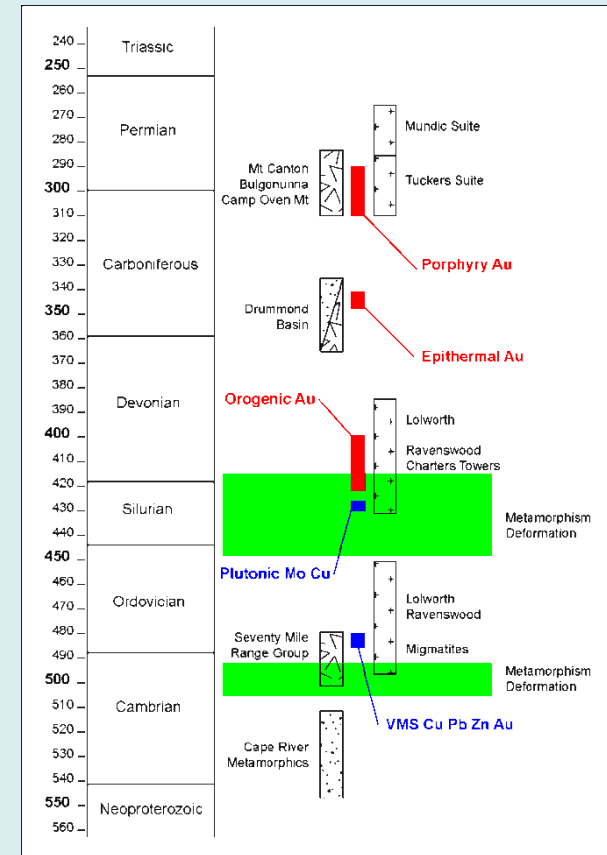
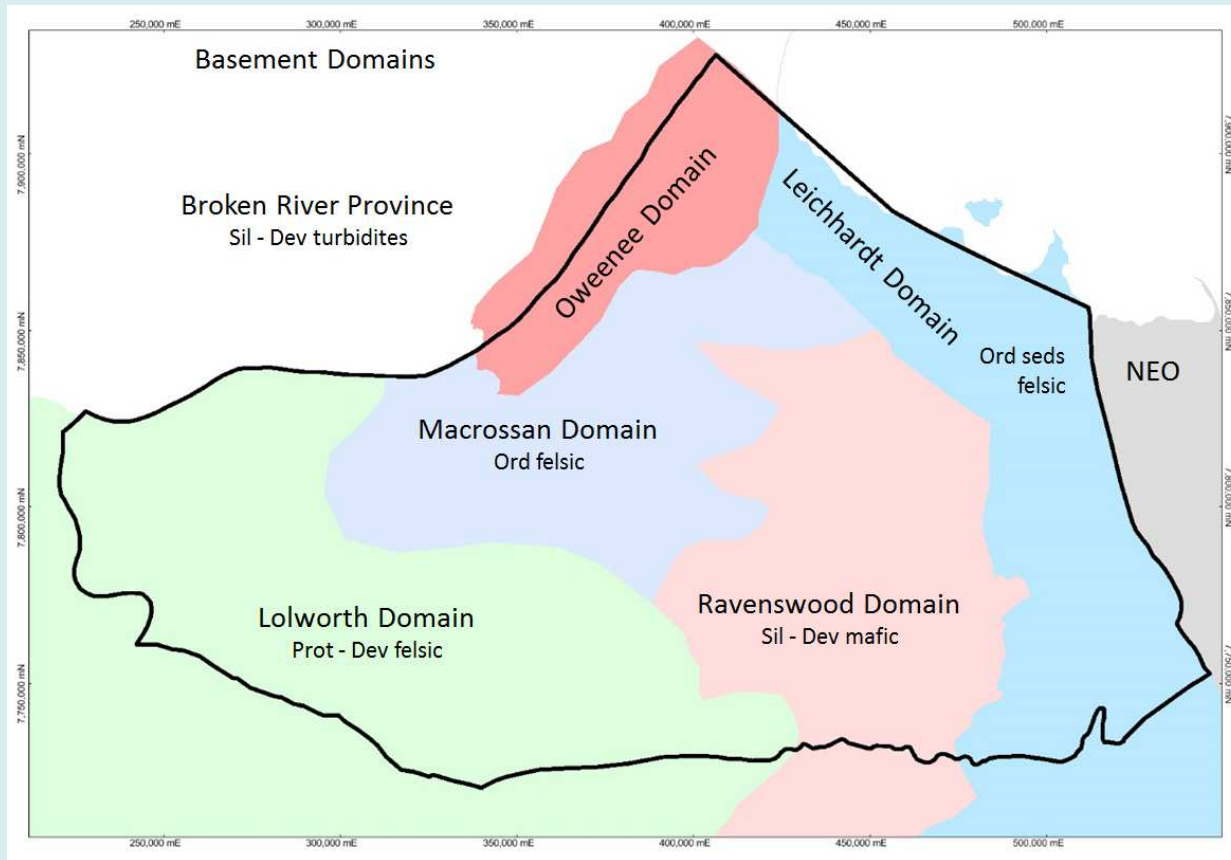
# CT IRGS: *Setting of Charters Towers Province*

- CT is the best exposed part of the Cambro-Ordovician Thomson Orogen
- Proterozoic metased basement under TO & Mossman Orogen to north
- Cambro-Ordovician sediments, felsic volcanics & felsic granitoids
- Siluro – Devonian granitoids
- boundary faults to Dev-Carboniferous basins
- E boundary tectonic obscured by Carb-Permian Kennedy Province



# CT IRGS: *basement geology domains*

Separate Ordovician and older felsic granitoids and meta-sediments  
From Siluro-Devonian granodiorite in Ravenswood domain

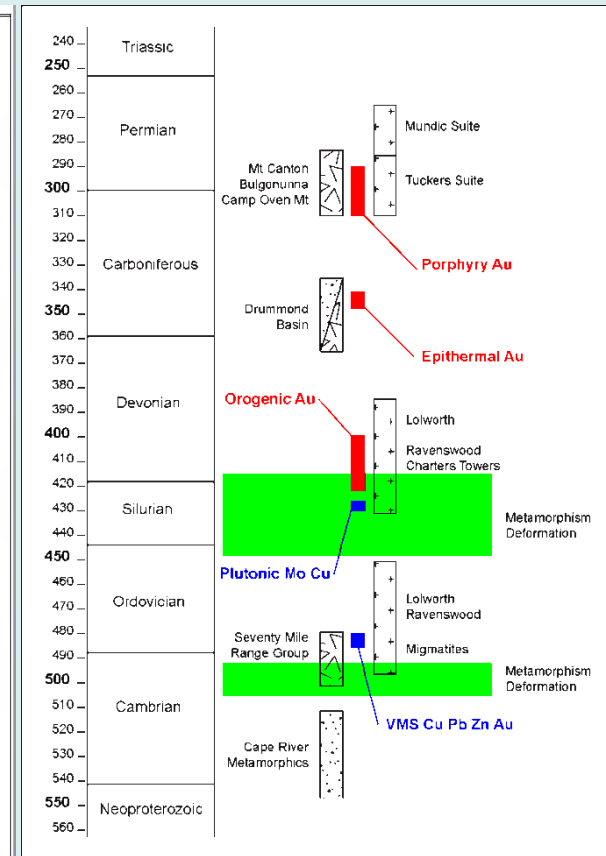
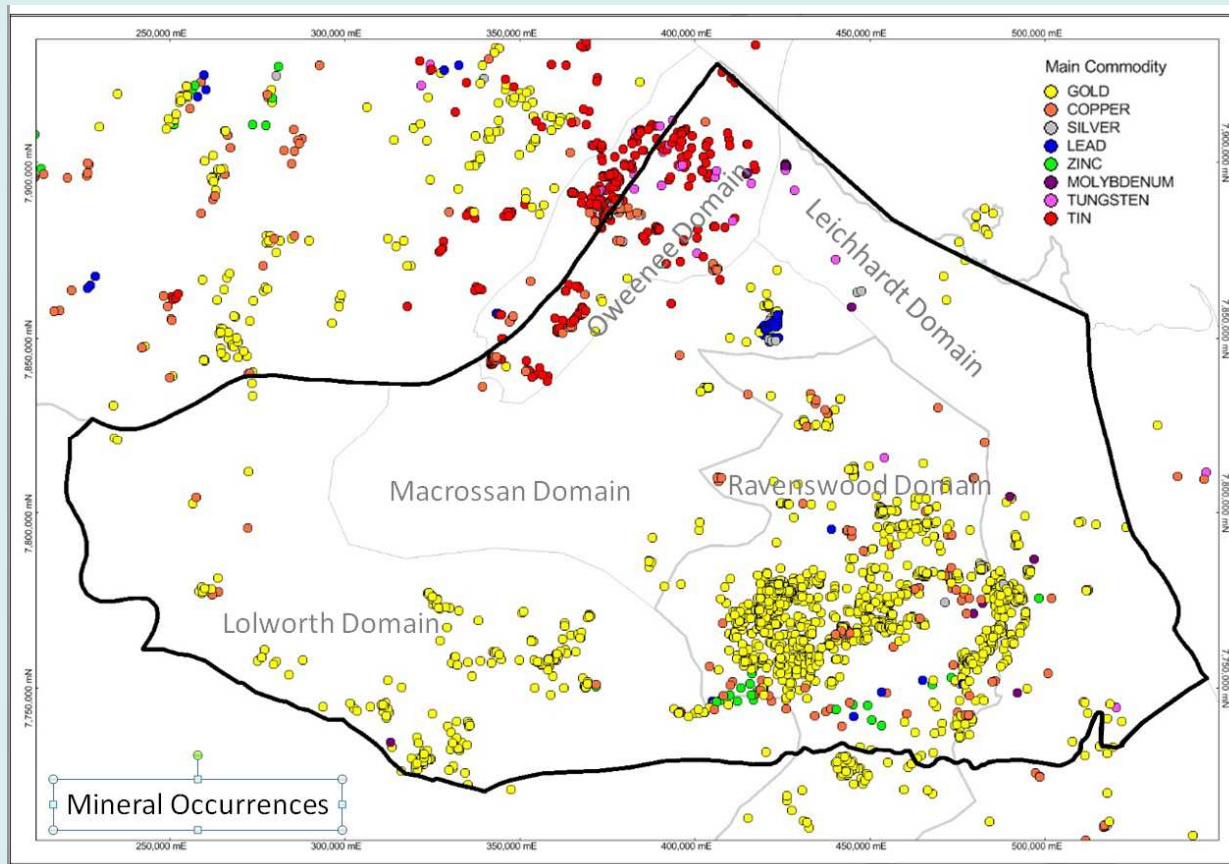




CT IRGS:

# MINOCC by commodity

Concentrated Au & basemetals in Ravenswood Domain (Sil-Dev granodiorite)  
Basemetal Mt Windsor belt (Ord) & Cu-Mo porphyry in Ravenswood (Dev)  
Oweenee stitching pluton brings Sn-W(Carb)

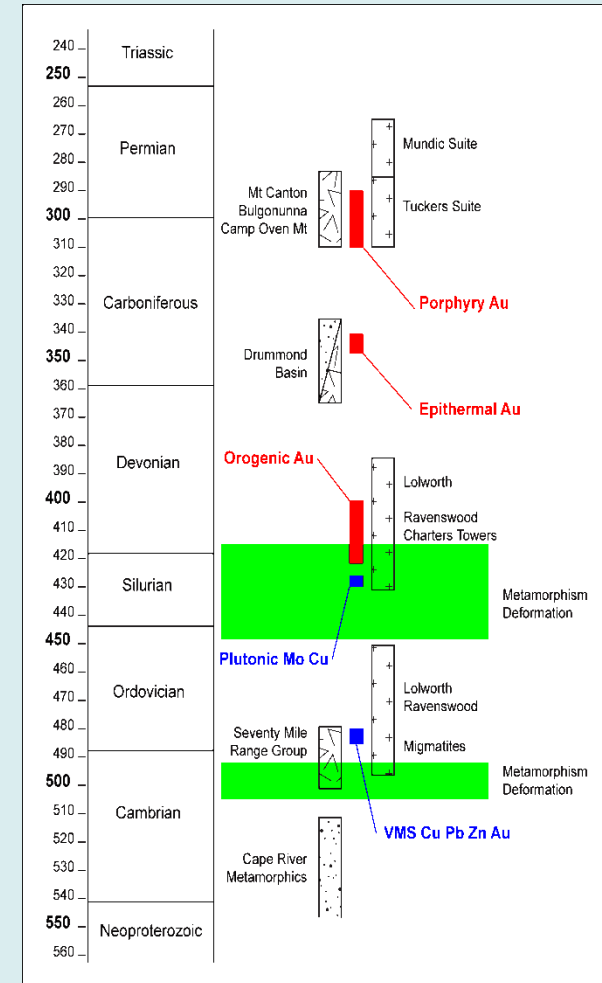




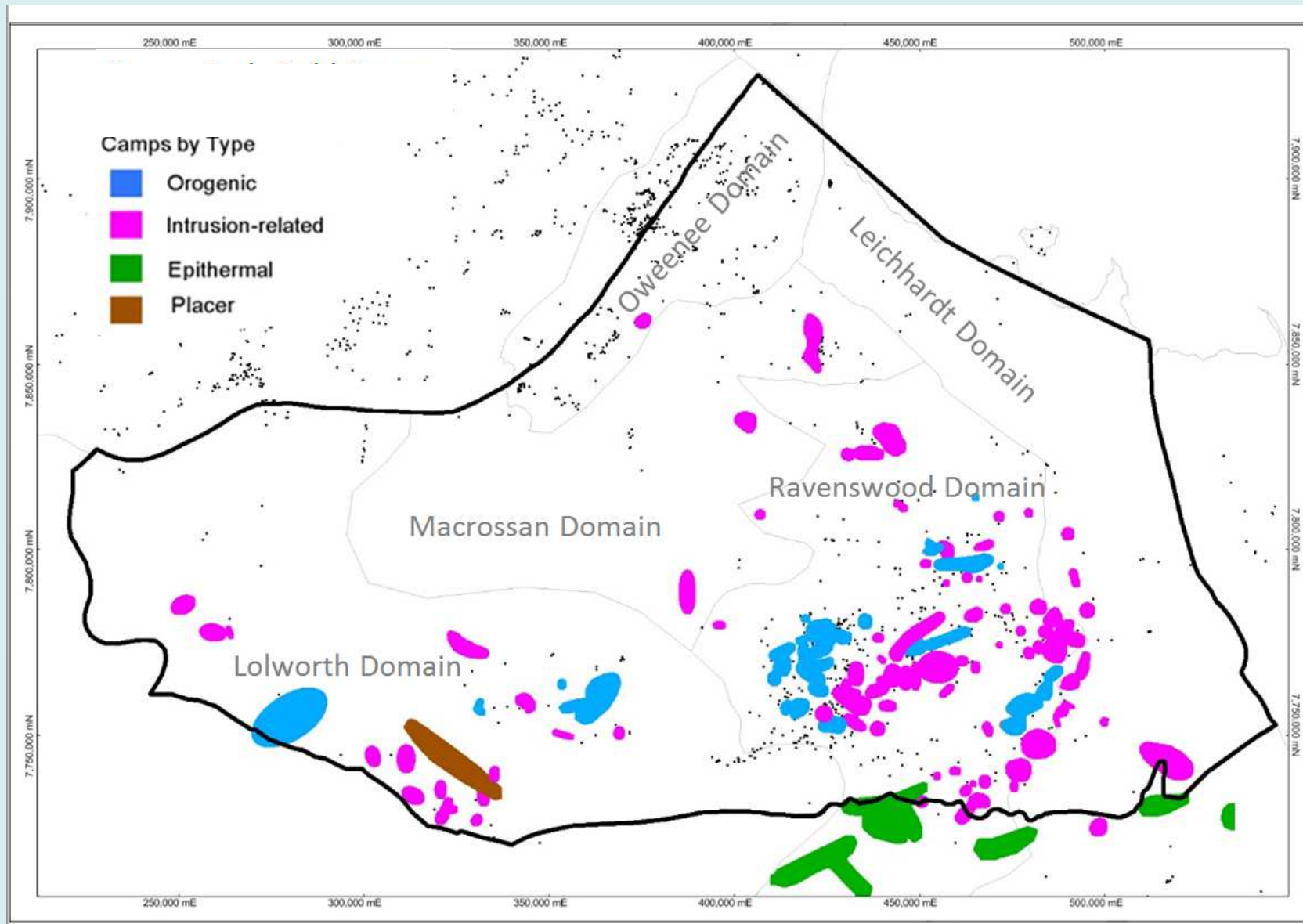
# CT Metallogenic:

# Mineral System Classification

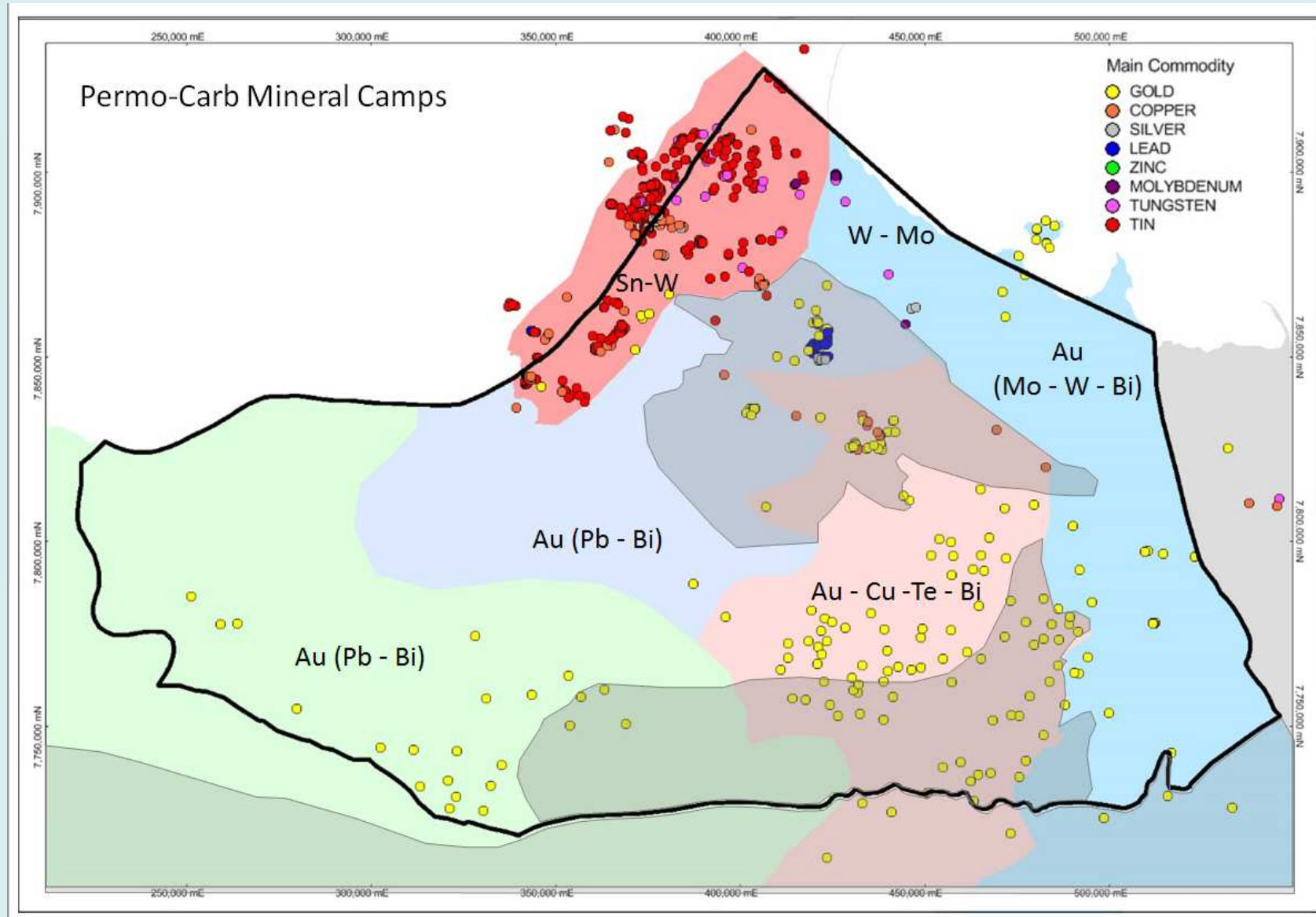
| CLAN                               | DEPOSIT TYPE                        | GEOCHEM TYPE        | EPOCH | TYPE EXAMPLE       |
|------------------------------------|-------------------------------------|---------------------|-------|--------------------|
| <b>Orogenic (granitoid hosted)</b> | lode hypozonal                      | Au-BM-As            | S-D   | Hadleigh Castle    |
|                                    | lode mesozonal                      | Au-BM               | S-D   | Charters Towers    |
| <b>intrusion-related (reduced)</b> | vein hypozonal                      | Au-PM-Te            | C-P   | Brookville         |
|                                    | lode mesozonal                      | Au-PM-Te            | C-P   | Ravenswood         |
|                                    | breccia mesozonal                   | Au-PM-Bi            | C-P   | Mt Leyshon         |
|                                    | breccia epizonal                    | Au-As               | C-P   | Antimony Dam       |
|                                    | Vein network epizonal               | Au-PM-Bi            | C-P   | Far Fanning        |
|                                    | vein epizonal                       | Au-PM-Bi            | C-P   | Wellington Springs |
|                                    | <b>intrusion-related (oxidized)</b> | stockwork hypozonal | Cu-Mo | S-D                |
| High-sulfidation epith.            |                                     | Au-PM-Bi            | P-Tr  | Mt Carlton         |
| <b>Epithermal</b>                  | Low-sulfidation vein                | Au-BM               | C-P   | Pajingo            |
|                                    | Low-sulfidation hotspring           | Au-As               | C-P   | Wirralie           |
| <b>Volcanogenic</b>                | Au-rich VMS pipe                    | Au-BM               | E-O   | Highway            |
|                                    | Au-rich VMS stratiform              | Au-PM               | E-O   | Thalanga           |
| <b>Placer</b>                      | Alluvial                            | Au                  | Rec   | Leyshon view       |



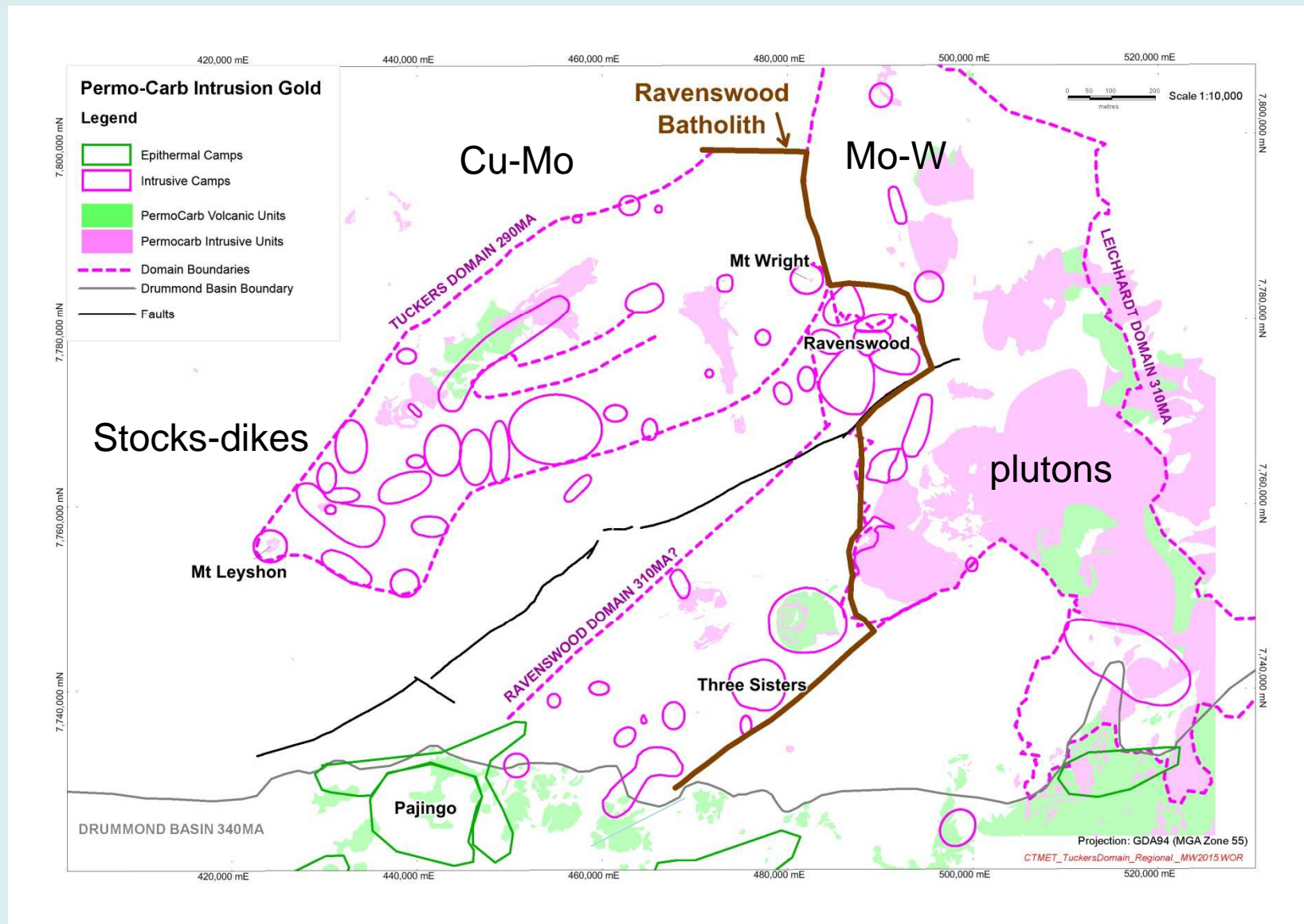
# CT IRGS: *Gold Camps by Clan*



# CT IRGS: *main commodity for Permo-Carb Camps on Domains*

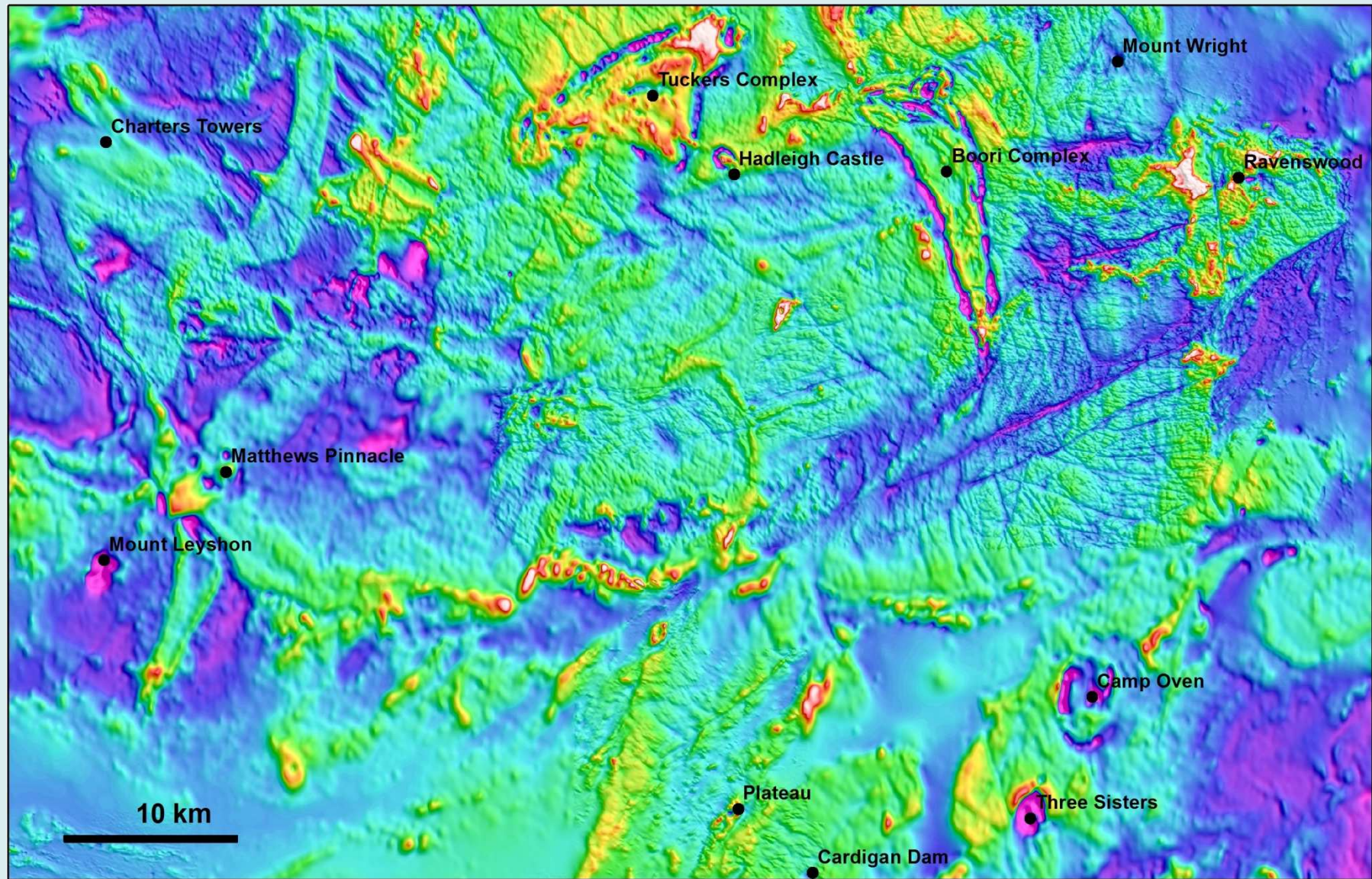


# CT IRGS: *Basement domains control IRGS type*



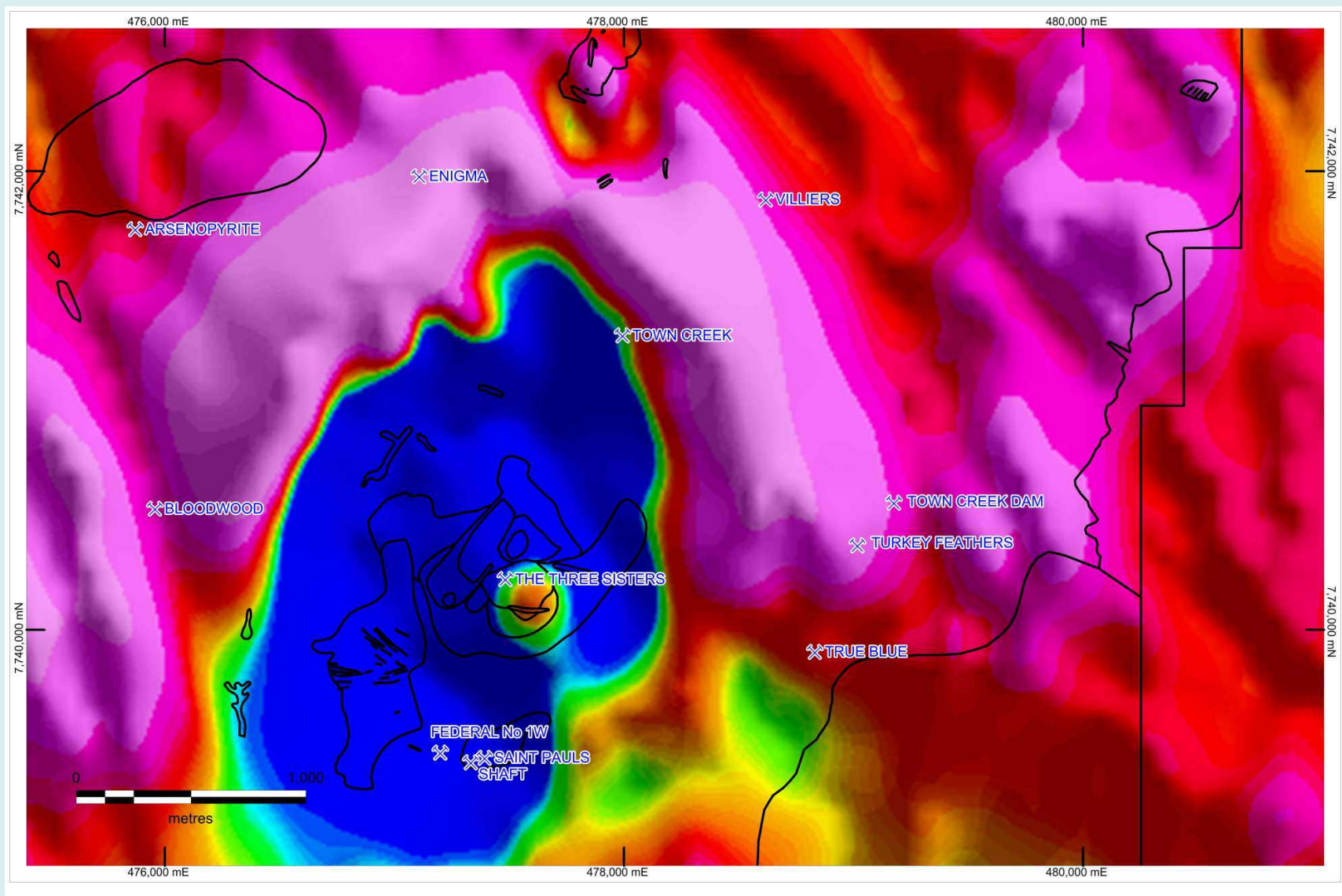


# CT IRGS: *Reverse mag anomalies*





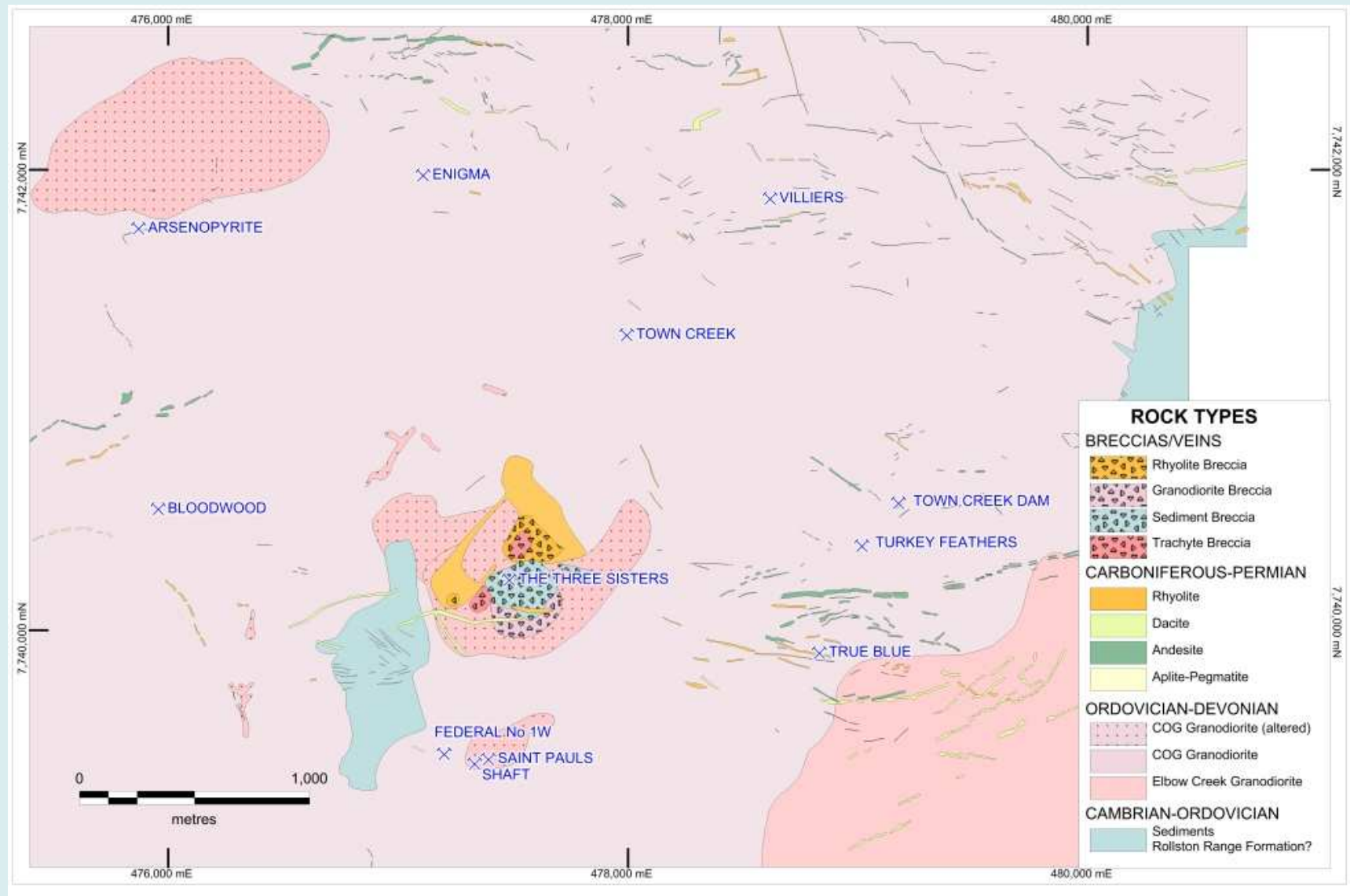
Three Sisters System reverse magnetic anomaly  
*Related to biotite- magnetite alteration around an inferred dioritic intrusion*



N Lisowiec, Resolute Mining

**KLONDIKE**

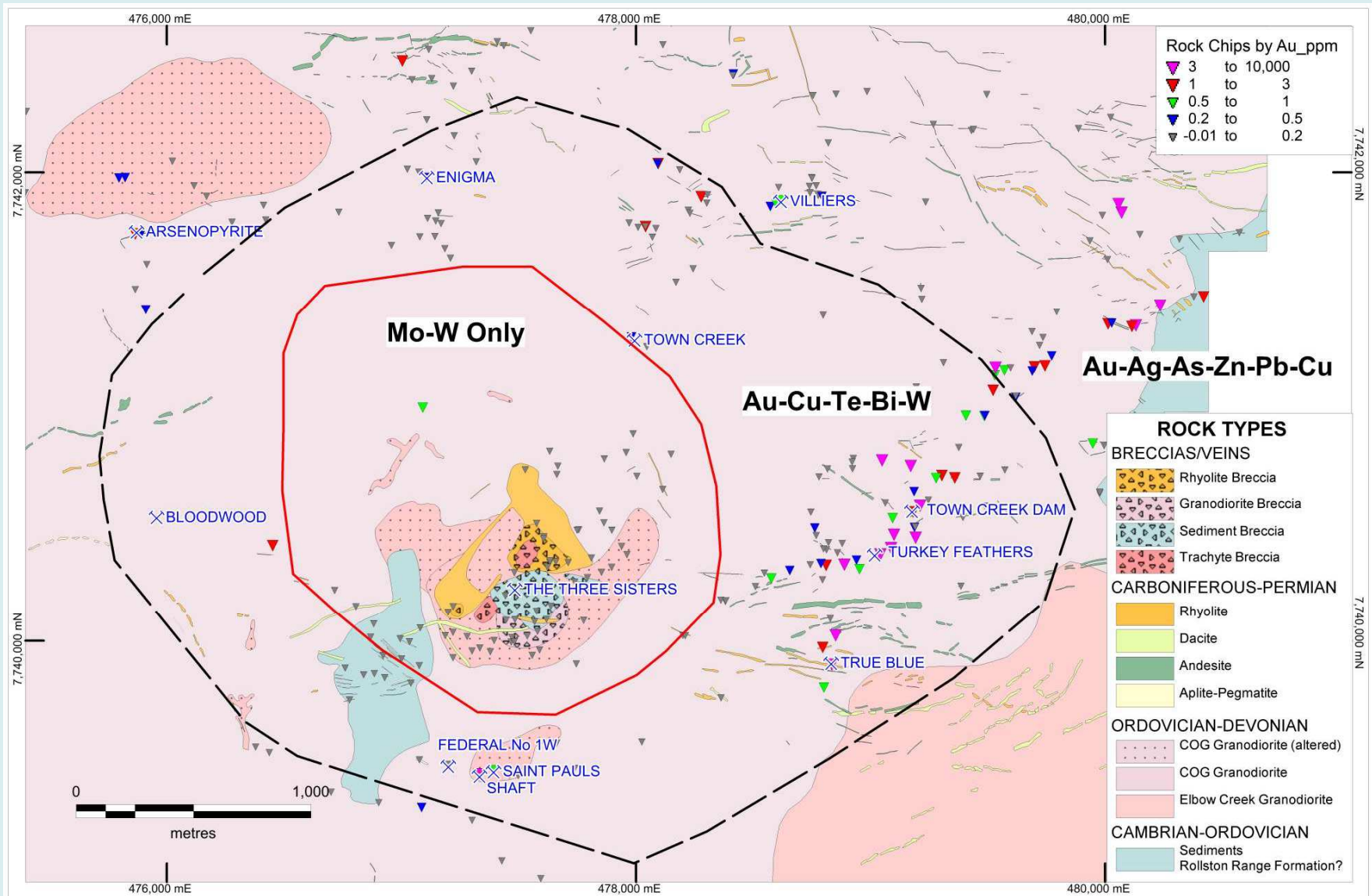
# IRGS CT: *Three Sisters geology*



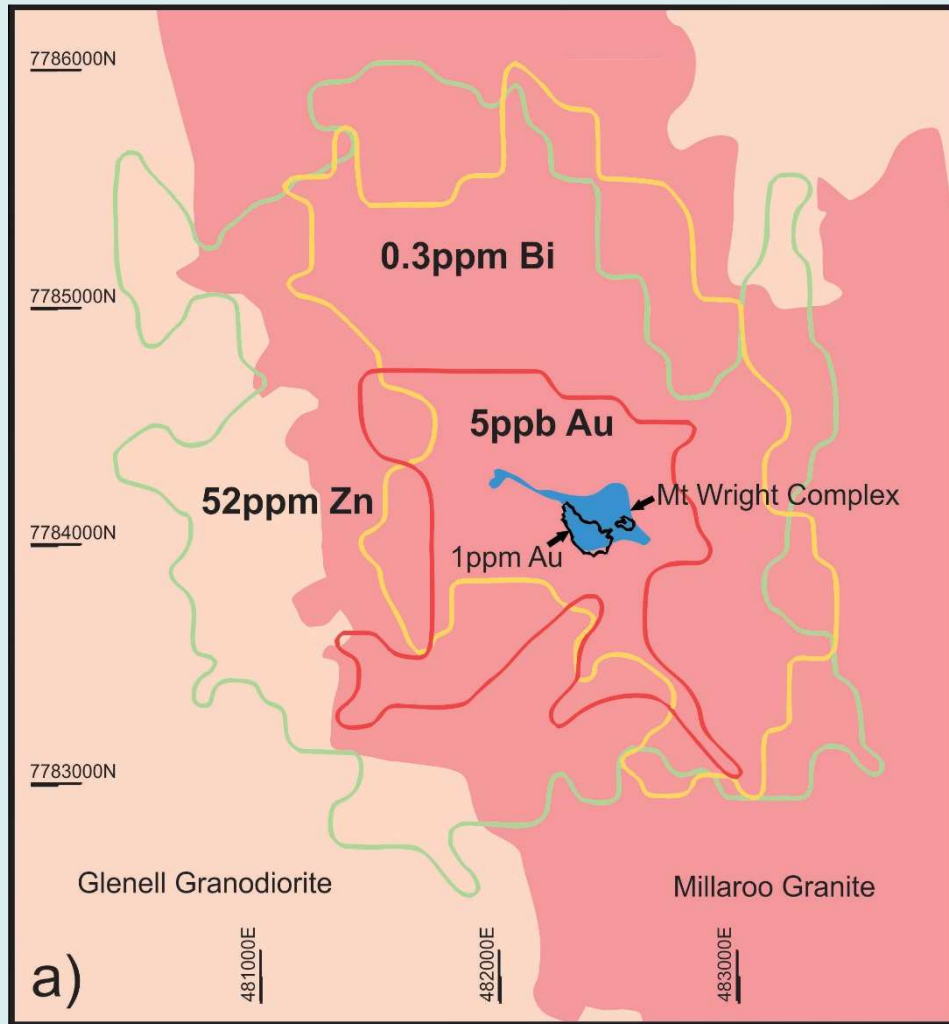
N Lisowiec, Resolute Mining

**KLONDIKE**

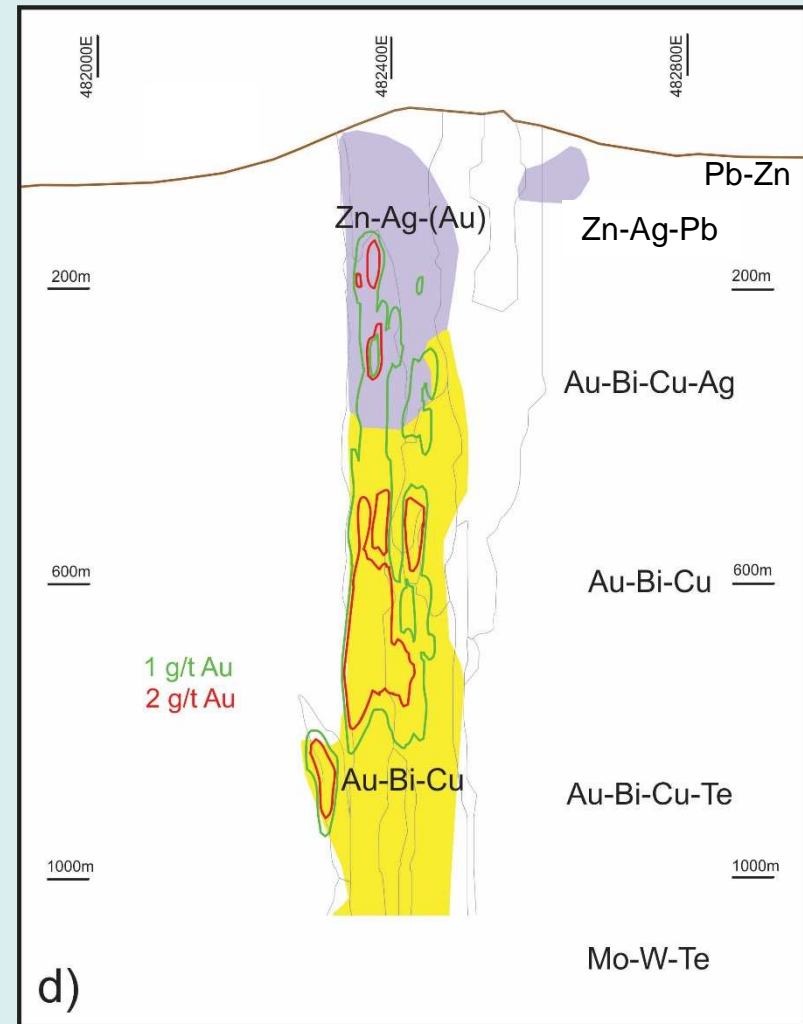
# IRGS CT: *Three Sisters metal zoning*







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

Based on 13 metal set Au Ag As Sb Pb Zn Cu Bi Te Mo W Sn  
 Normalised to host or related intrusion  
 Classified in terms of relative enrichment  
 Scheme based on ~100 examples from Charters Towers region

**CLASSIFICATION SCHEME**

|                                |  |
|--------------------------------|--|
| <b>AU+BM (NO BI +/-AS, TE)</b> | OROGENIC GRANITE-HOSTED TYPE e.g. Charters Towers                  |
| <b>AU BI TE AS SB (+/-BM)</b>  | PLUTONIC IRGS TYPE and or mafic intrusion e.g. Ravenswood          |
| <b>AU-BI-BM +/-TE</b>          | PORPHYRY AU TYPE and or intermediate intrusion e.g. Mt Leyshon     |
| <b>AU BI MO W +/- BM</b>       | PORPHYRY AU TYPE with felsic intrusion e.g. Mt Remarkable, Kidston |
| <b>AU AG TE</b>                | LOW SULFIDATION EPITHERMAL VEINS e.g. Pajingo                      |
| <b>AU AG AS</b>                | EPITHERMAL HOTSPRING DEPOSITS e.g. Wirralie                        |
| <b>AU AG TE AS +/- BM</b>      | HI-SULFIDATION EPITHERMAL e.g. Mt Carlton                          |



- A distinct NQ IRGS province with +20Moz
- Existing work defines >150 systems
- ~30 explored well
- In current climate good targets can be identified in system interpretation
- Especially via system facies geometry & multi-element geochemistry