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Magnetite and Hematite Alteration Proxies from 3D Gravity and Magnetic Inversion

Mapping IOCG-related alteration

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NORTHERN TERRITORY GOVERNMENT

Queensland Government

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

Mineral Systems Approach

The aim of this study is to predict the presence of **hydrothermal alteration systems** associated with iron-oxide-copper-gold (IOCG) deposits.

Host rocks in the vicinity of an IOCG deposit will display **hydrothermal alteration** along a spectrum in which the dominant iron oxide is either **magnetite** or **hematite** (Williams *et al.*, 2005).

Contact zones between magnetite- and hematite-rich alteration are highly favourable for the formation of higher grade copper-gold mineralisation (Bastrokov *et al.*, 2007).

Alteration Cone

Magnetite

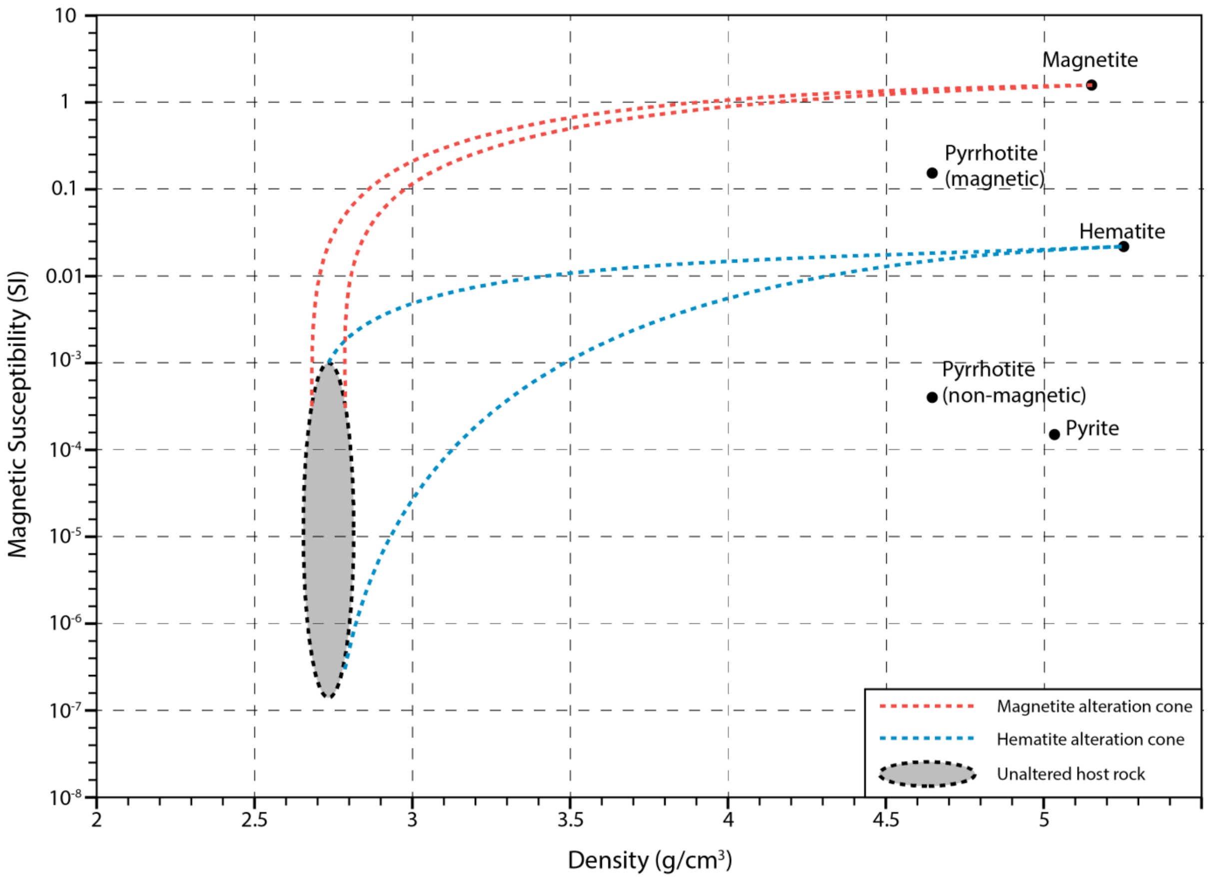
- Relatively dense and magnetic

Hematite

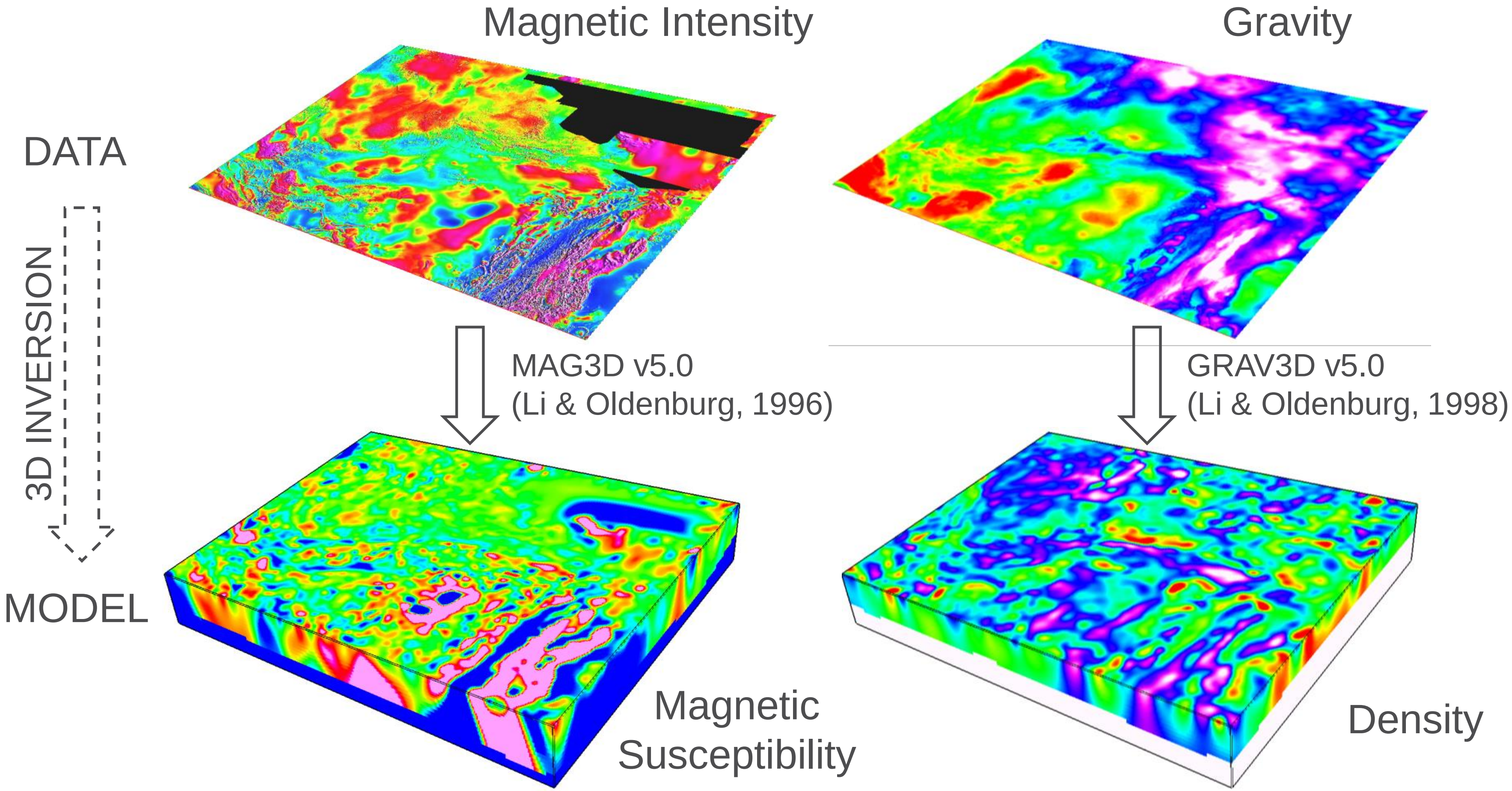
- Relatively dense but less magnetic

Alteration Cone Theory

- Chopping, 2007
- Williams and Chopping, 2009
- Chopping and van der Wielen, 2009



Modified from Williams and Chopping 2009


Magnetic Intensity
Gravity
DATA
3D INVERSION
MAG3D v5.0
(Li & Oldenburg, 1996)
GRAV3D v5.0
(Li & Oldenburg, 1998)
MODEL
Magnetic
Susceptibility
Density

Previous Work

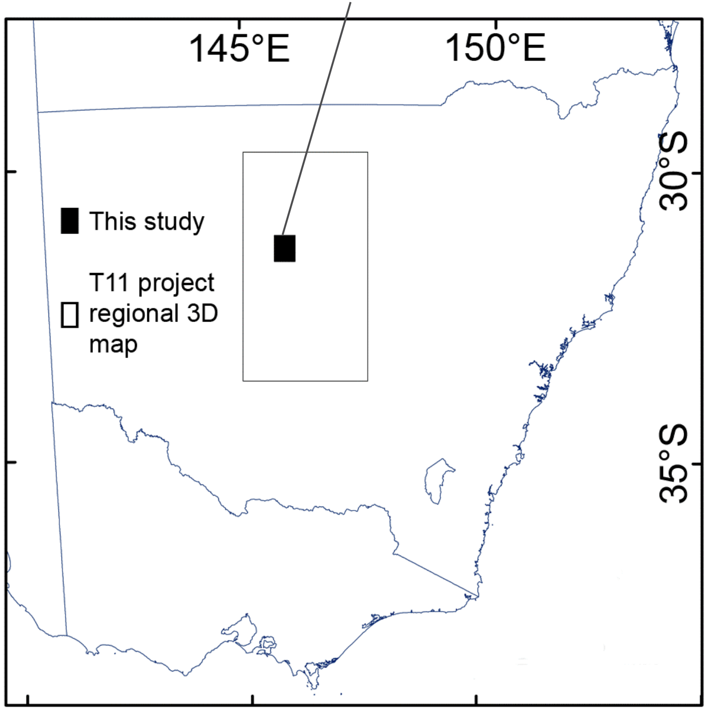
Olympic Dam region, SA

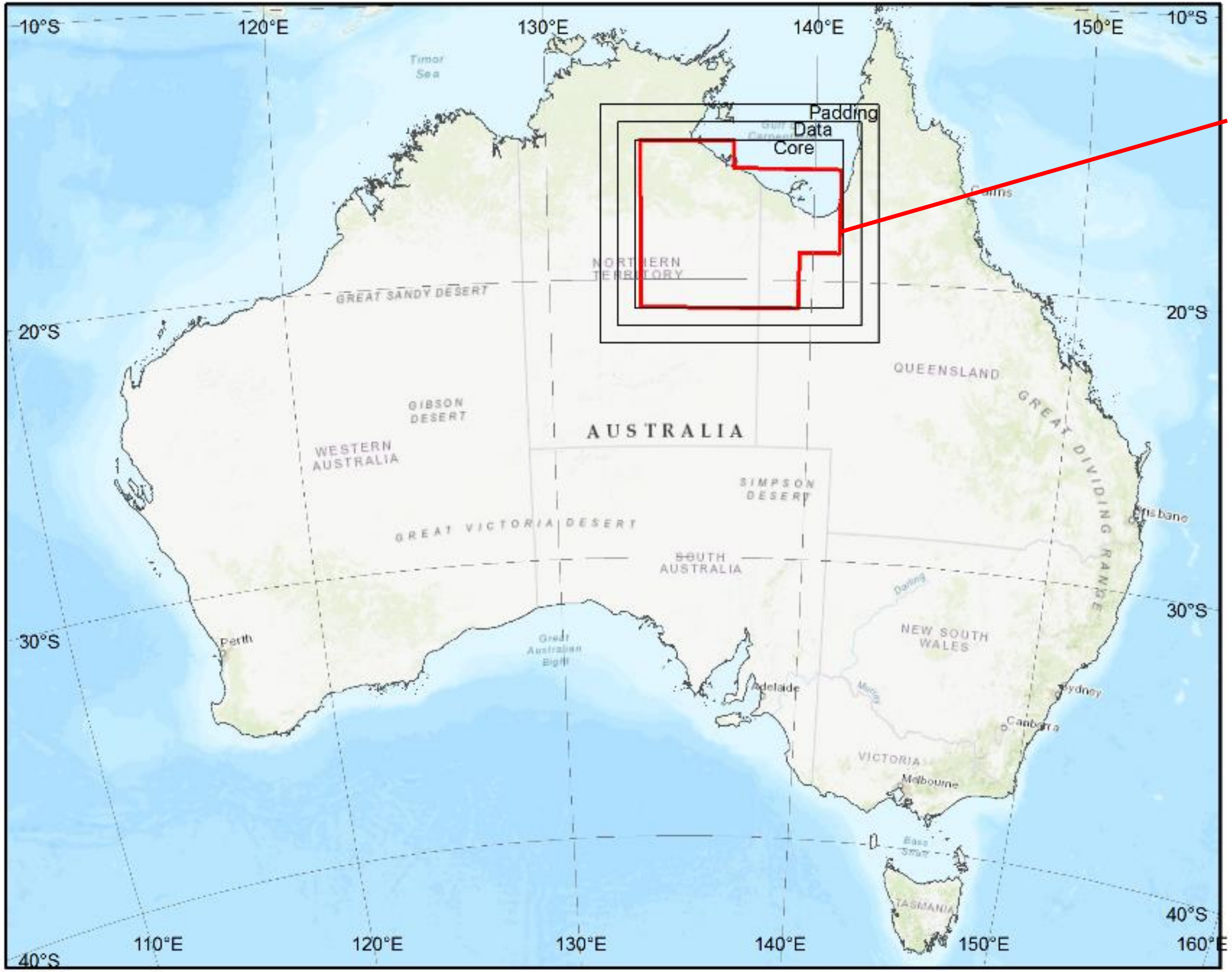
- Williams *et al.*, 2004
- Williams and Dipple, 2007
- Skirrow *et al.*, 2007
- Hayward and Skirrow, 2010

Cobar region, NSW

- Chopping, 2008
- Chopping and van der Wielen, 2009

e.g. Cobar region study
40 x 50 x 16 km
(Chopping and van der Wielen, 2009)





Tennant Creek - Mount Isa Project Area

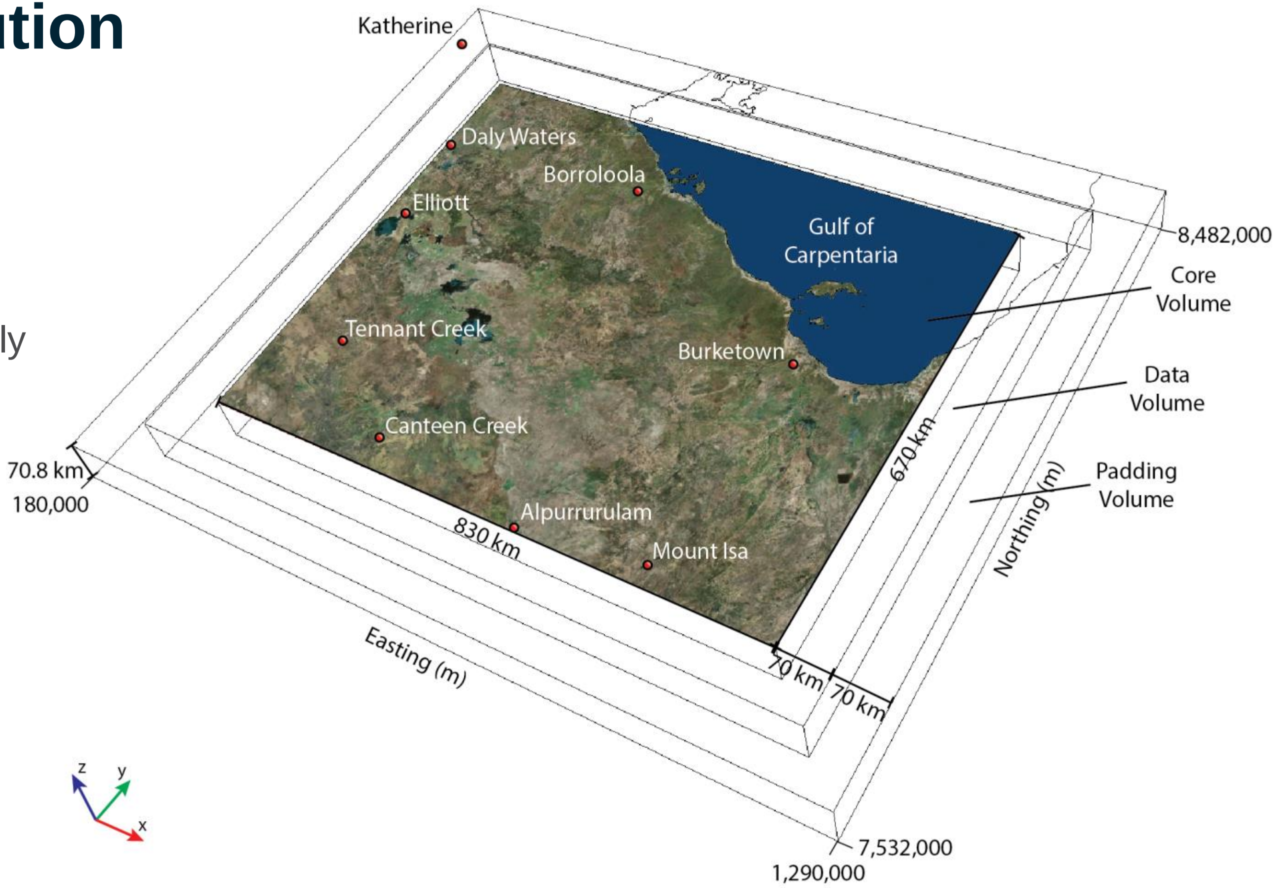
Scale and Resolution

Core Volume
- 830 km x 670 km x 70 km

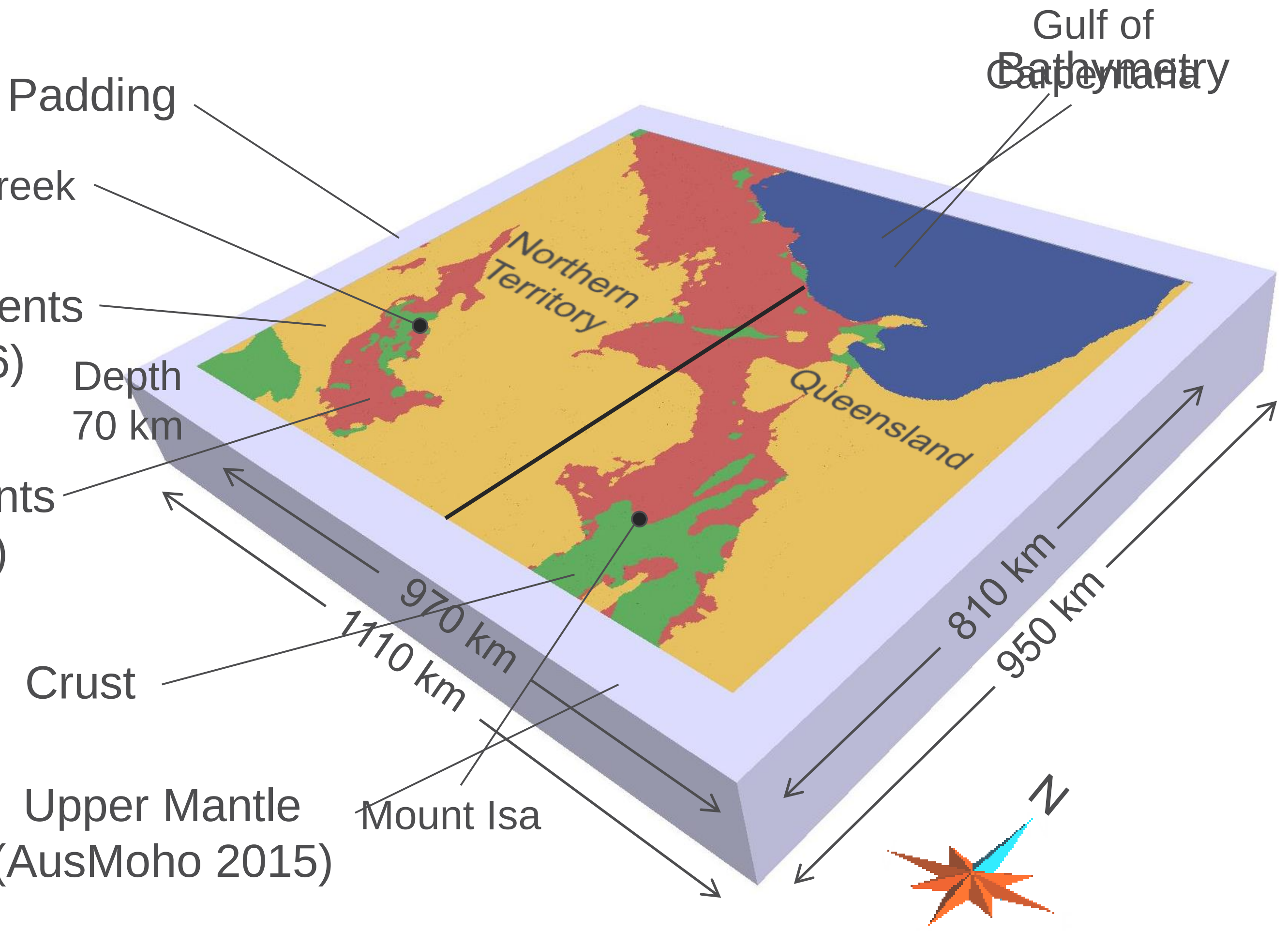
Resolution
- 2 km x 2 km cells horizontally
- Variable cell size vertically

Number of Cells
- ~12.7 million

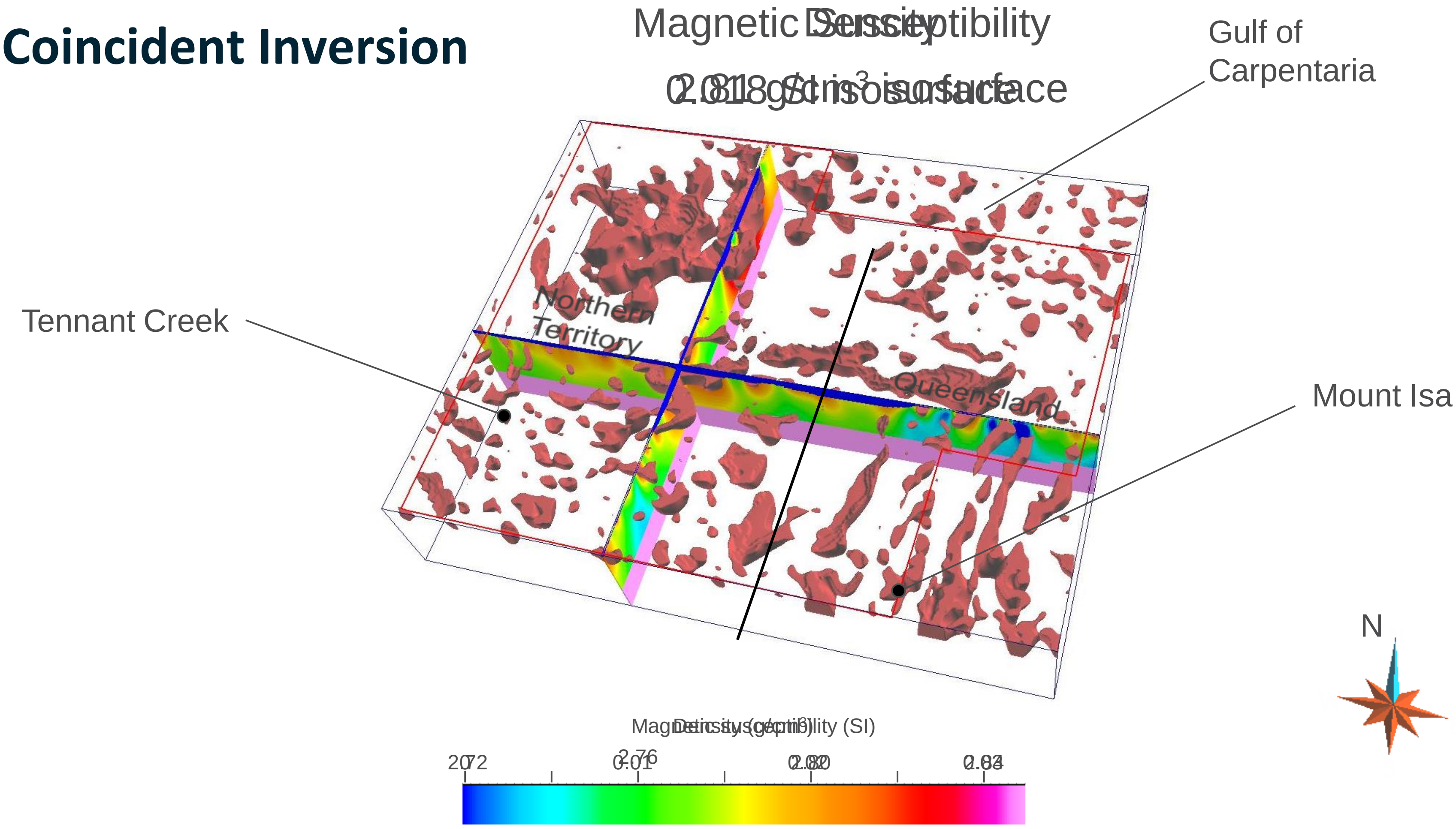
Method
- UBCGIF 3D inversion
  - MAG3D v5.0
  - GRAV3D v5.0
- Coincident models
- NCI supercomputer



Constraints



Coincident Inversion



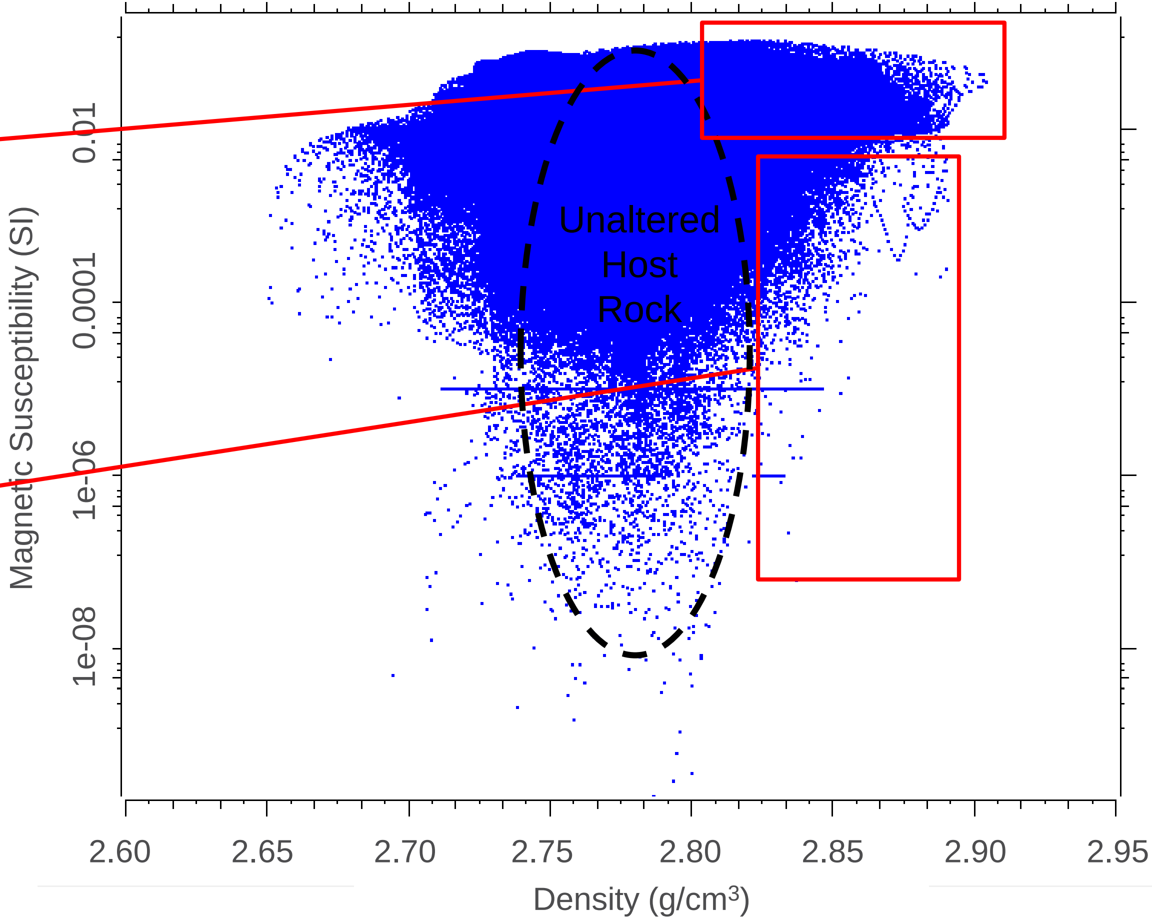
Alteration Proxies

Magnetite Proxy

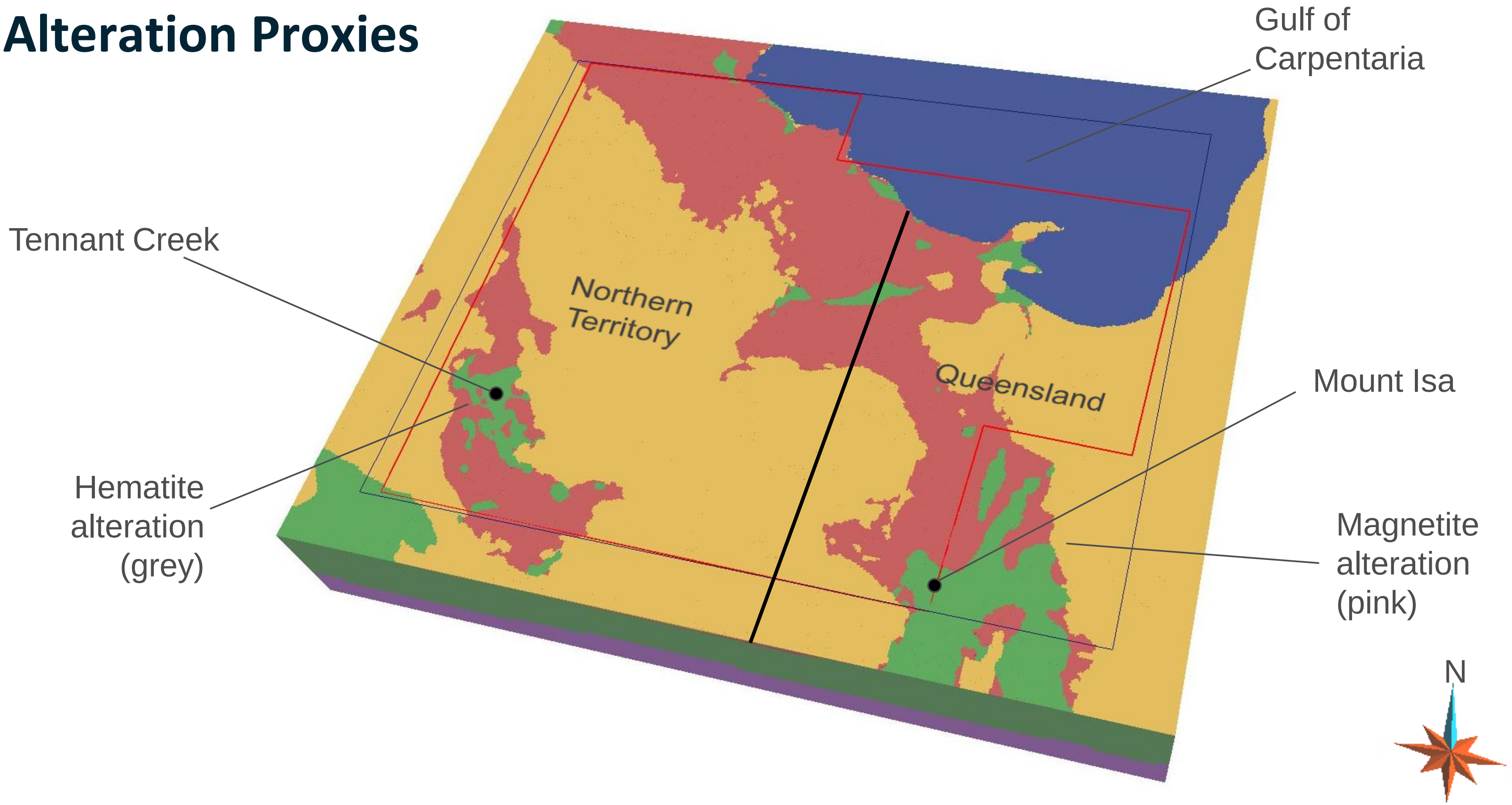
- High magnetic susceptibility (> 0.015 SI)
- High density (> 2.81 g/cm^3)

Hematite Proxy

- Low magnetic susceptibility (< 0.01 SI)
- High density (> 2.82 g/cm^3)



Alteration Proxies



Tennant Creek – Mount Isa Region

Magnetite Proxy

Den > 2.83
Mag Sus > 0.025

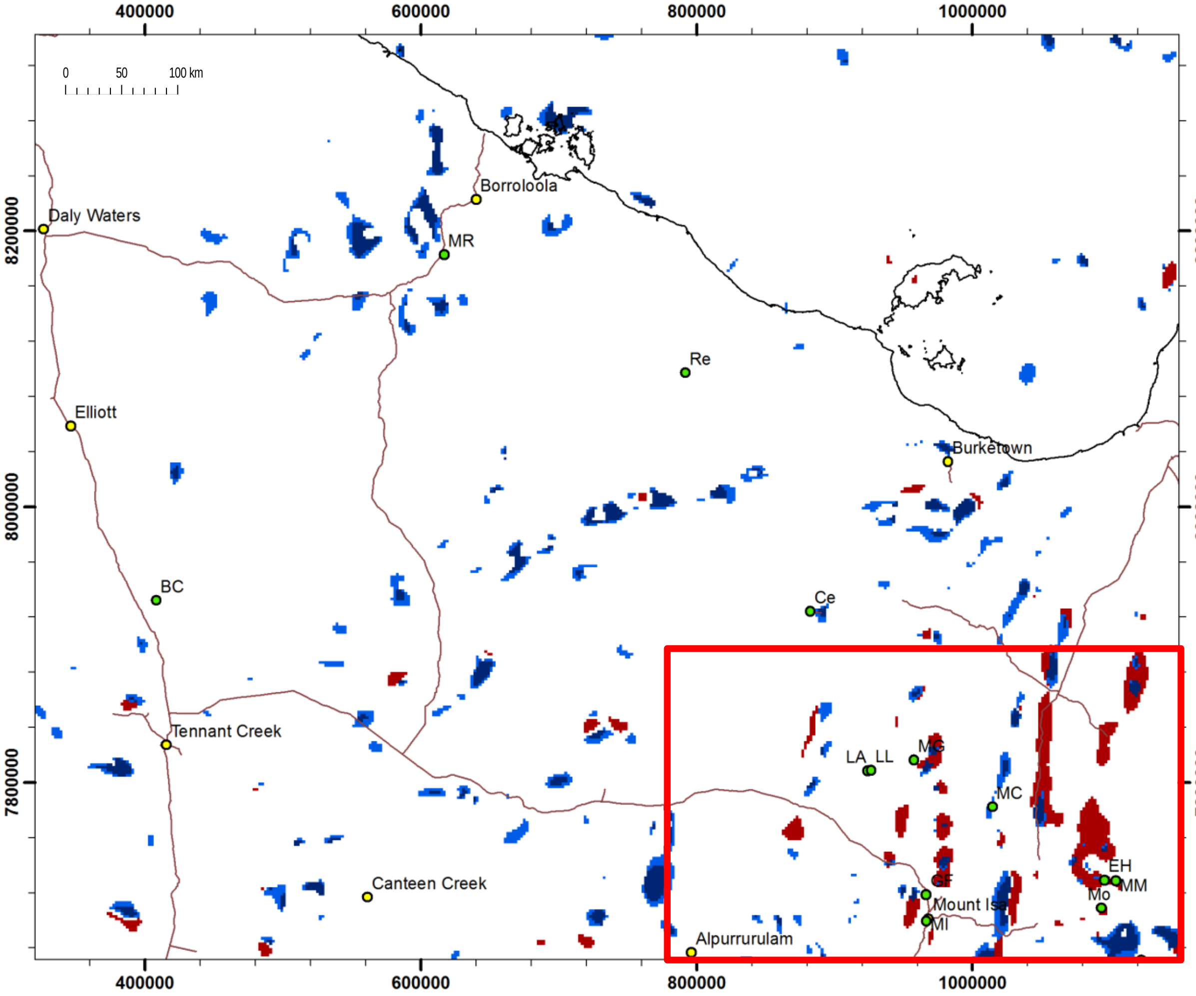
Hematite Proxy

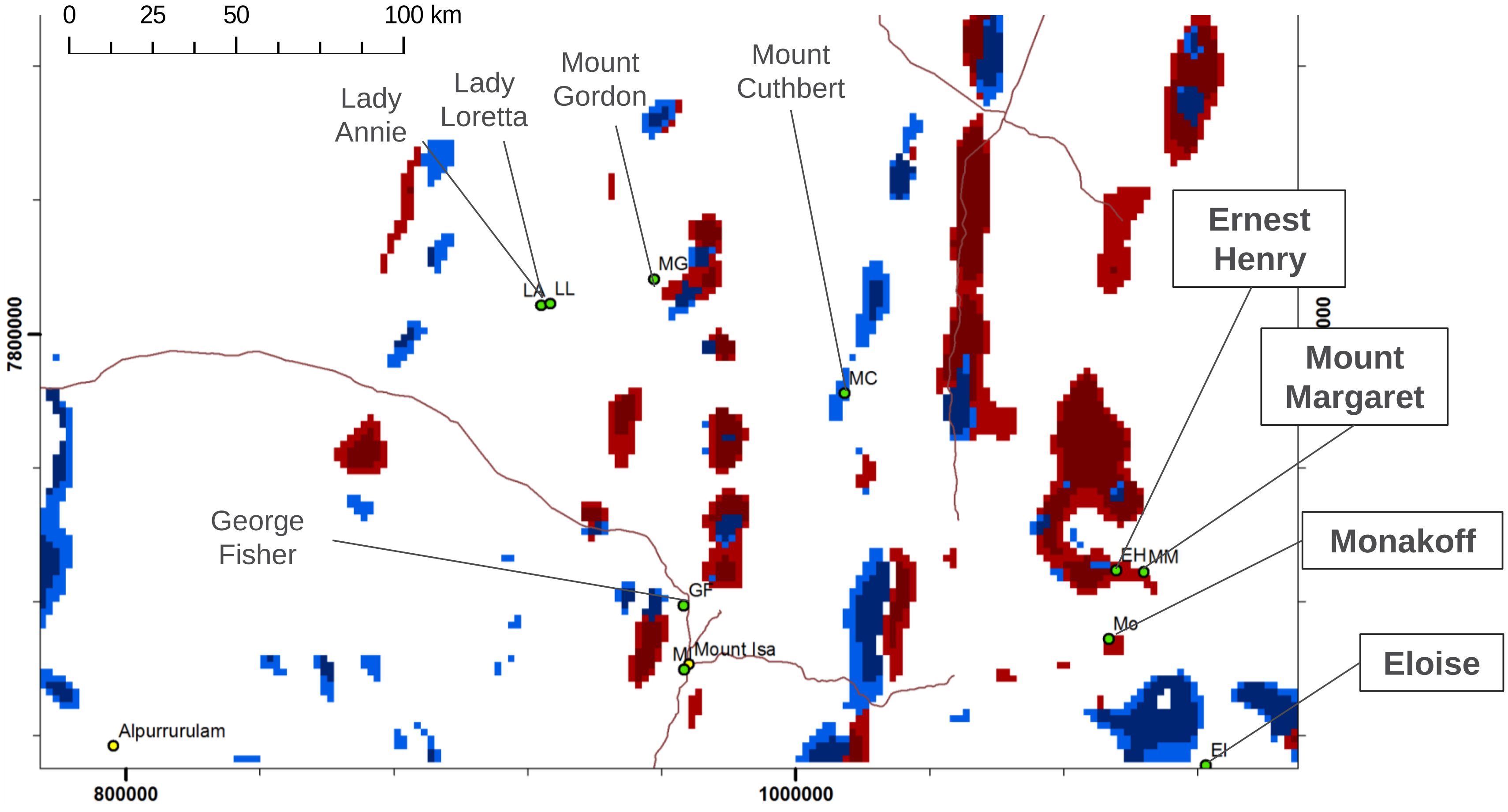
Den > 2.84
Mag Sus < 0.01

Towns/cities

Operating mines

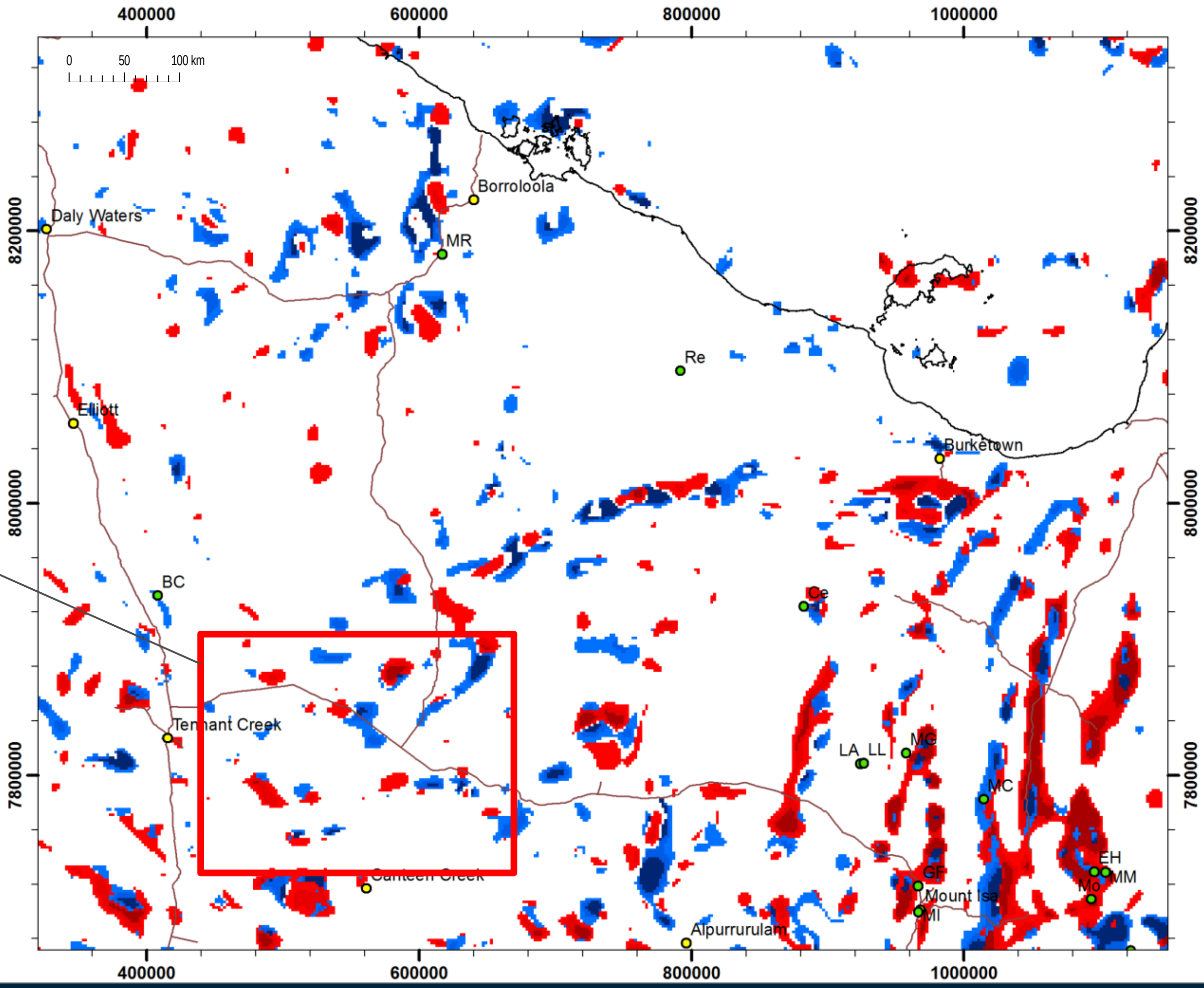
Major roads




0
25
50
100 km
7800000
800000
1000000
Lady Annie
Lady Loretta
Mount Gordon
Mount Cuthbert
Ernest Henry
Mount Margaret
Monakoff
Eloise
George Fisher
LA
LL
MG
MC
EH
MM
Mo
El
GF
MI
Mount Isa
Alpurrurulam

Tennant Creek – Mount Isa Region

East Tennant Region



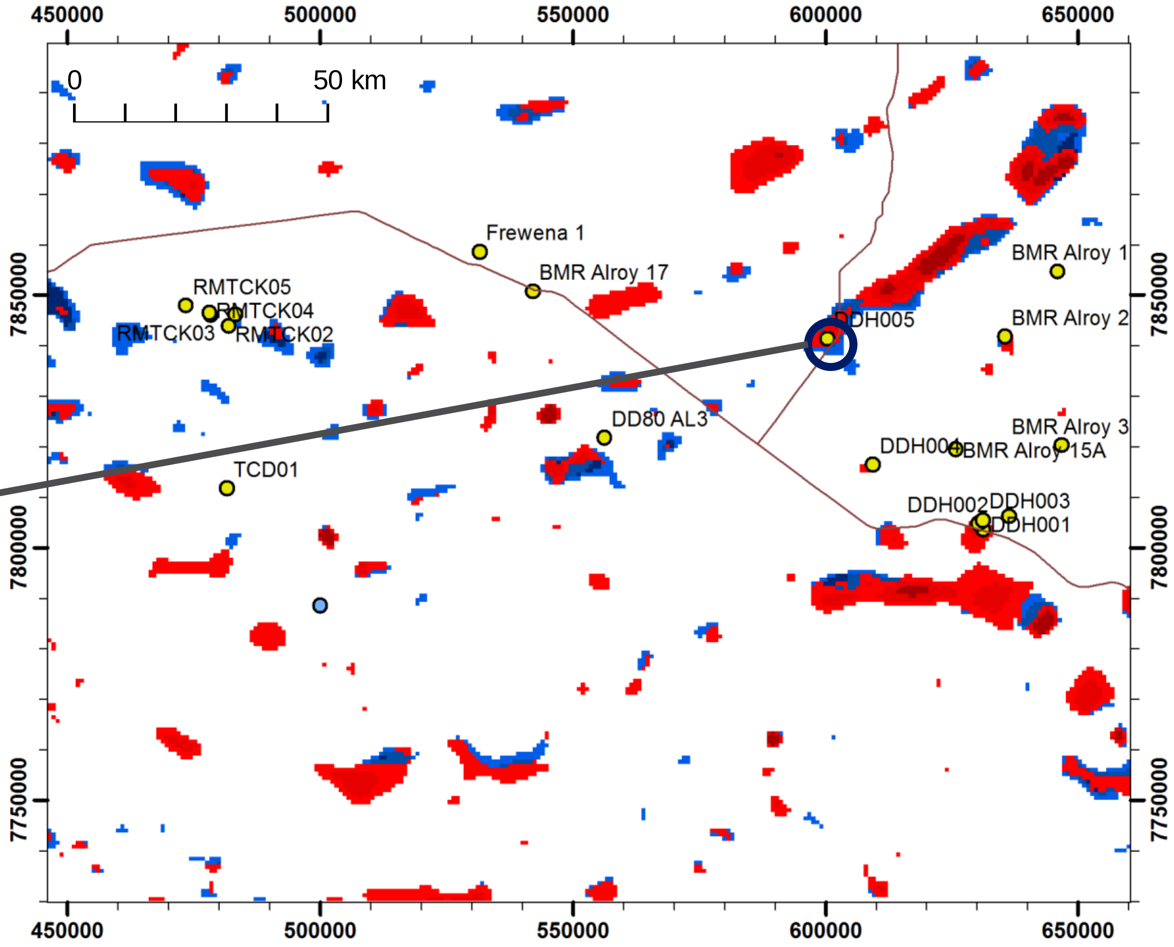
- Towns/cities
- Operating mines
- Major roads

East Tennant Region

East Tennant Model

- 800 m x 800 m cells horizontally

Borehole DDH005



DDH005 Host Rocks

Upper: biotite-qtz-fs-cordierite-sillimanite banded gneiss

Middle: graphite-Fe-Mg-Si-rich and Al-rich laminated metasediments

Lower: Metasomatized Carbonates with pyroxenes, pyrite and pyrrhotite

Slide courtesy of James Murr

DDH005 Paragenesis

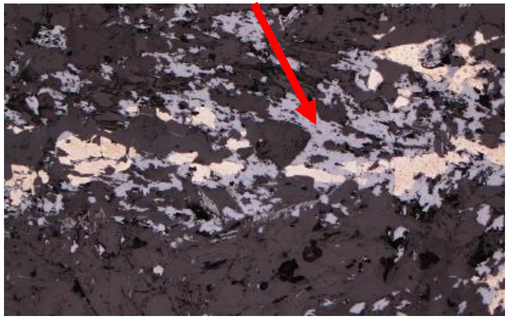
(0) Iron rich laminated mud/siltstones, probably of a sub-marine sedimentary facies

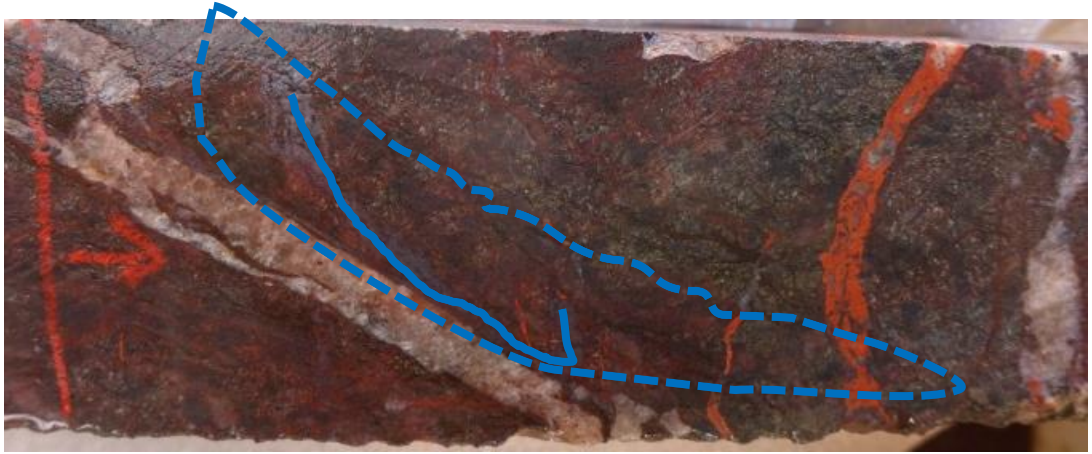
(1) Retrogression and/or hydrothermal alteration at upper greenschist/lower amphibolite facies, magnetite replacement of protolithic hematite and veining with introduced magnetite/pyrite/amphibole/biotite.

(2) Brittle deformation, hydrothermal veining and alteration at low-medium temp (150°-250°C?) by chlorite/sericite-hematite-pyrite-carbonate-chalcopyrite-titanite

(3) Late low temp (<150°C?) veins of hematite-dusted chalcedony & quartz and gypsum

DDH005 Middle 2018339549
(1) Hematite altered magnetite with relict magnetite





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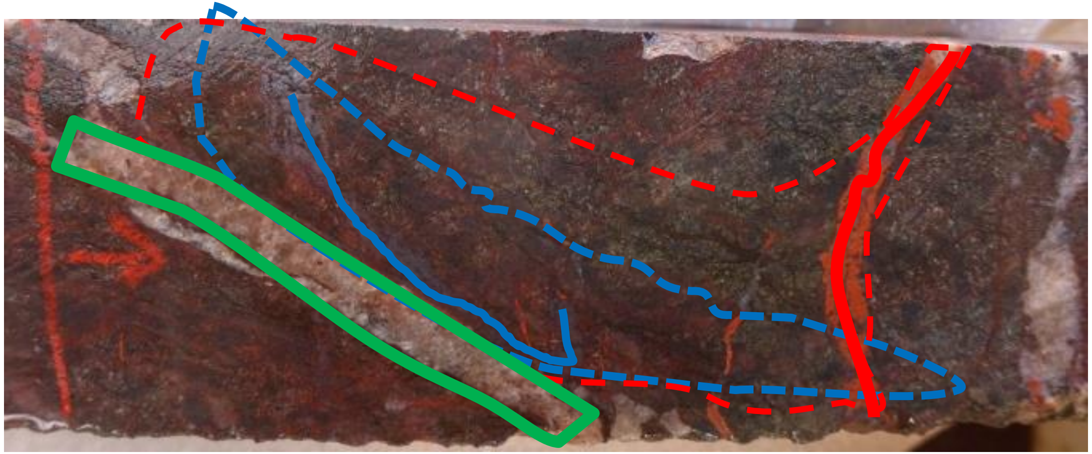
(3) Late low temp (<150°C?) veins of hematite-dusted chalcedony & quartz and gypsum

DDH005 Middle 2018339549
(2) Chlorite/ser-hematite (probably remobilized)-pyrite-chalcopyrite vein (XPL)



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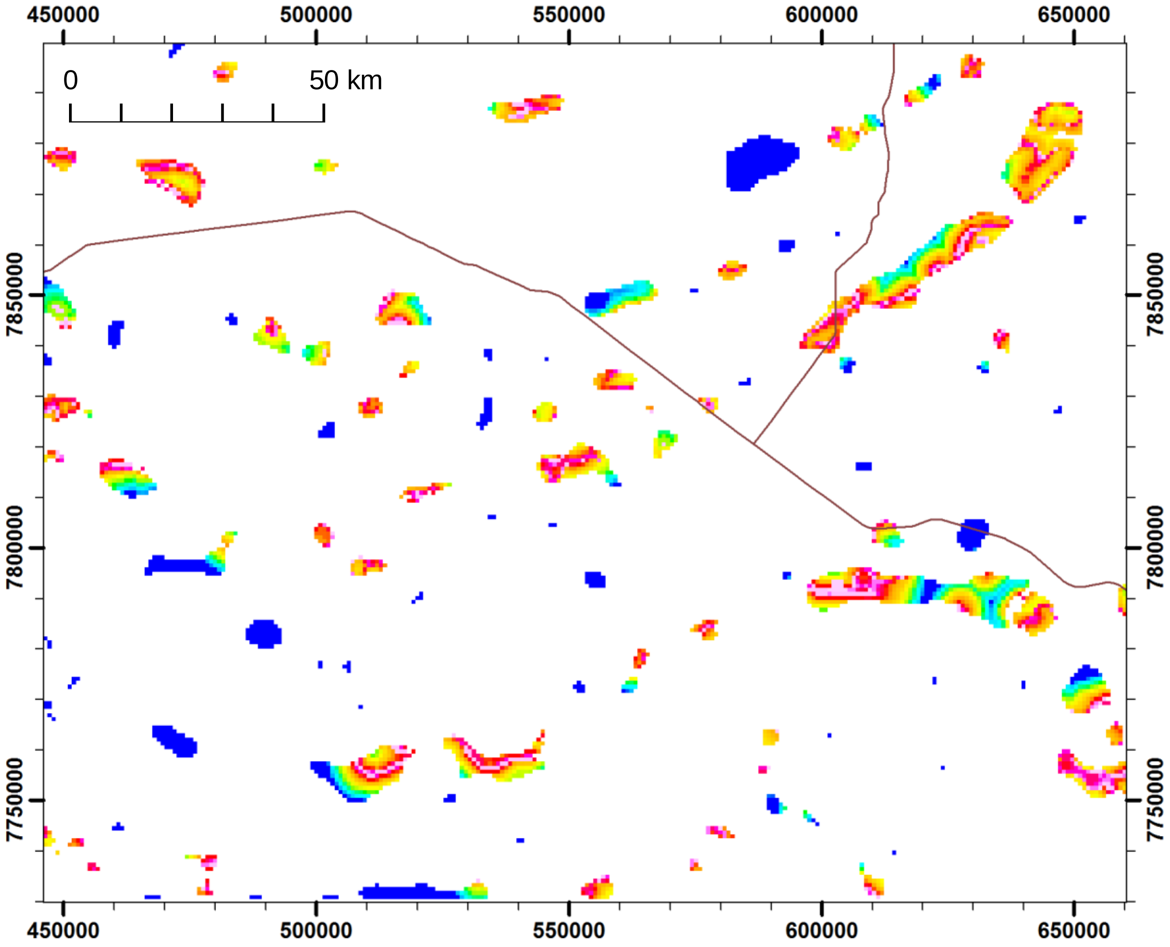
East Tennant Region

Contact zones between magnetite- and hematite-rich alteration are highly favourable for the formation of higher grade copper-gold mineralisation.

(Bastrokov *et al.*, 2007)



Limitations and Uncertainty

- Resolution of the models
- Prior geological knowledge (e.g. reference model constraints)
  - Integration with other datasets is essential (deep seismic reflection, AEM, solid geology, etc.)
- Overlap with unaltered geological units / other alteration minerals
- Remnant magnetisation
  - Compare with the analytic signal
  - Magnetic Vector Inversion (MVI; MacLeod and Ellis, 2013)

Producing Magnetite and Hematite Alteration Proxies using 3D Gravity and Magnetic Inversion

Goodwin and Skirrow, 2019

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