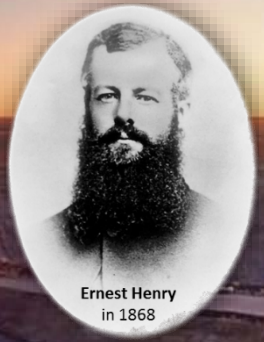
Geophysics of the Ernest Henry IOCG Deposit: a Geologists Perspective



Richard Lilly, NExUS Program Leader, University of Adelaide

Richard.lilly@adelaide.edu.au

Acknowledgements to Terry Harvey (MIM)

Evolution MINING

ERNEST HENRY

NExUS
National Exploration Undercover School

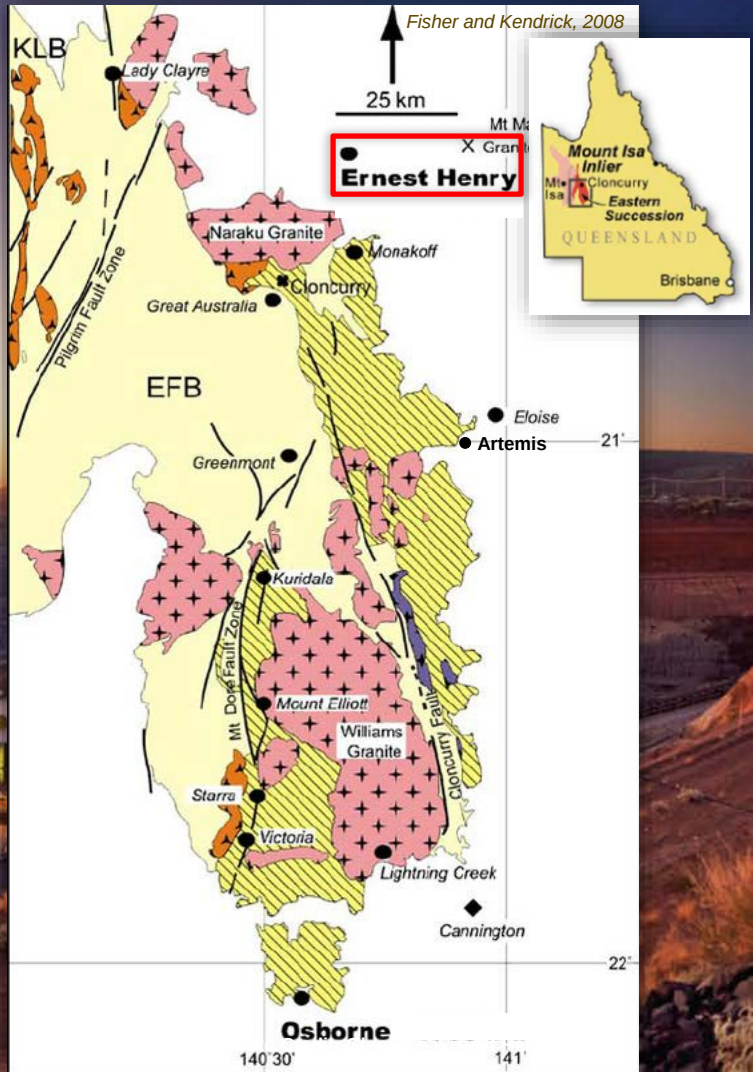
ERNEST HENRY IOCG

'Some of the most metasomatised rocks on the planet'

(M. Rubenach pers comm)

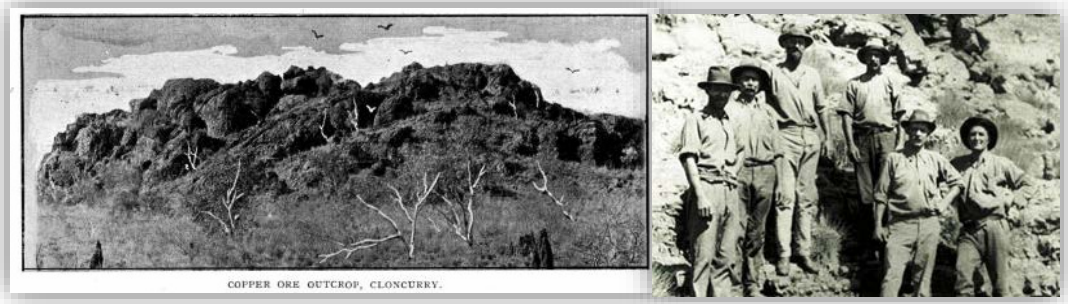
- 'Classic' IOCG terrain with well established ore deposit models and yet every year somebody discovers something different…
- Strong mineral endowment in a variety of commodities

  (Cu, Au, Pb, Zn, Ag, Co, REE)

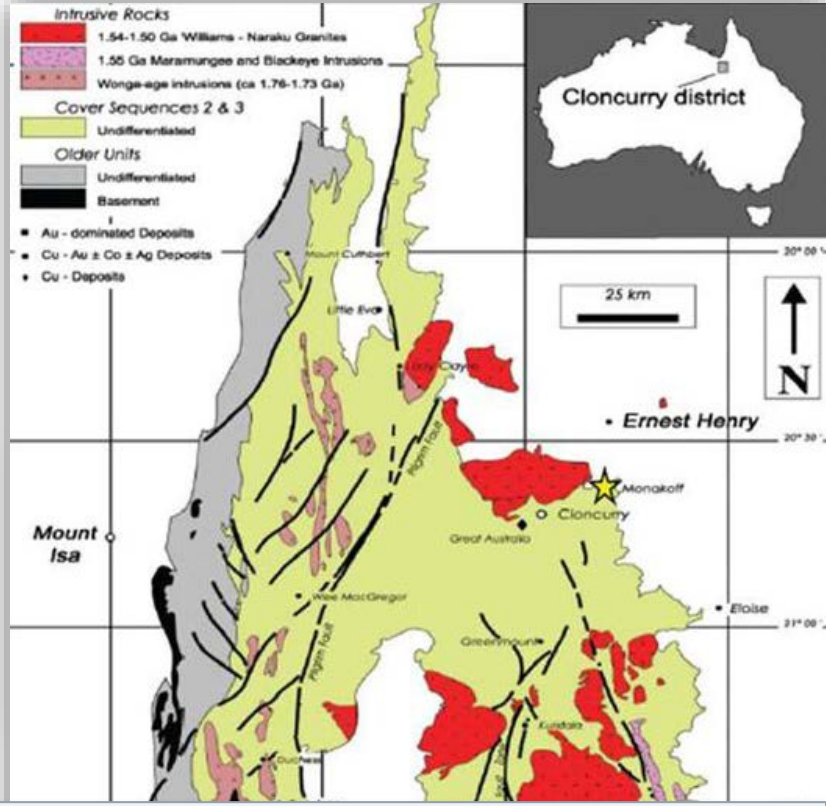


Mount Isa Inlier: Eastern Succession

- Eastern part of the Proterozoic Mount Isa Inlier, north-west Queensland
- Over 150 years of mining and exploration history (First discovery, Gt. Australia, Cloncurry 1867).



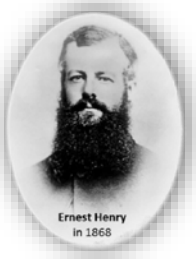
- Deposited during a long lived palaeo-mesoproterozoic extension and basin forming period (ca. 1800-1600 Ma)
- Majority of the rocks of the Eastern Succession were formed between 1780 and 1500 Ma



- **Recognised for its abundance and diversity of mineralisation styles including:**
- **Strong mineral endowment in Cu, Au, Zn, Pb, etc**

ERNEST HENRY Cu-Au

- Discovered 1992 (Mag-TEM)
- Cu-Au ore hosted by brecciated and altered intermediate volcanic rocks (1750Ma)
- Pipe-like breccia body dipping SSE at 30-50°
- 2017 UG Resource 87.1 million tonnes at 1.18% Cu with 0.6 g/t Au
- LOM to 2027



Acknowledgement to EHM Geology Team

ERNEST HENRY Cu-Au

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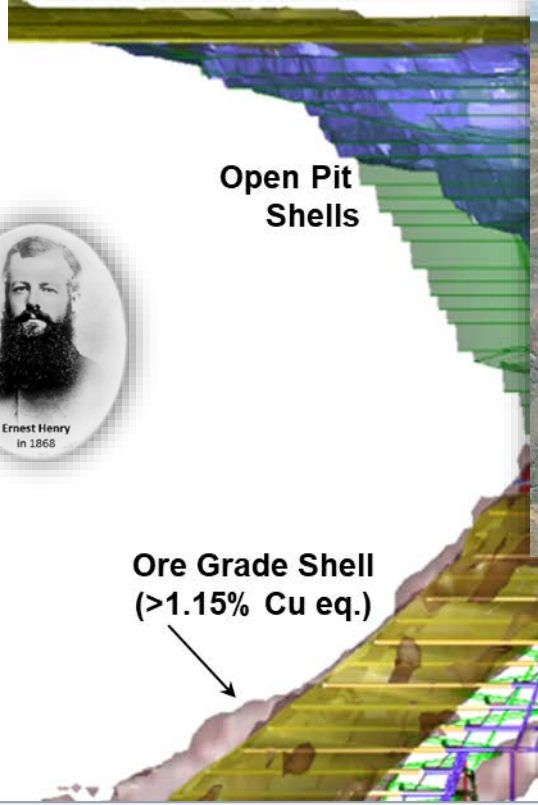
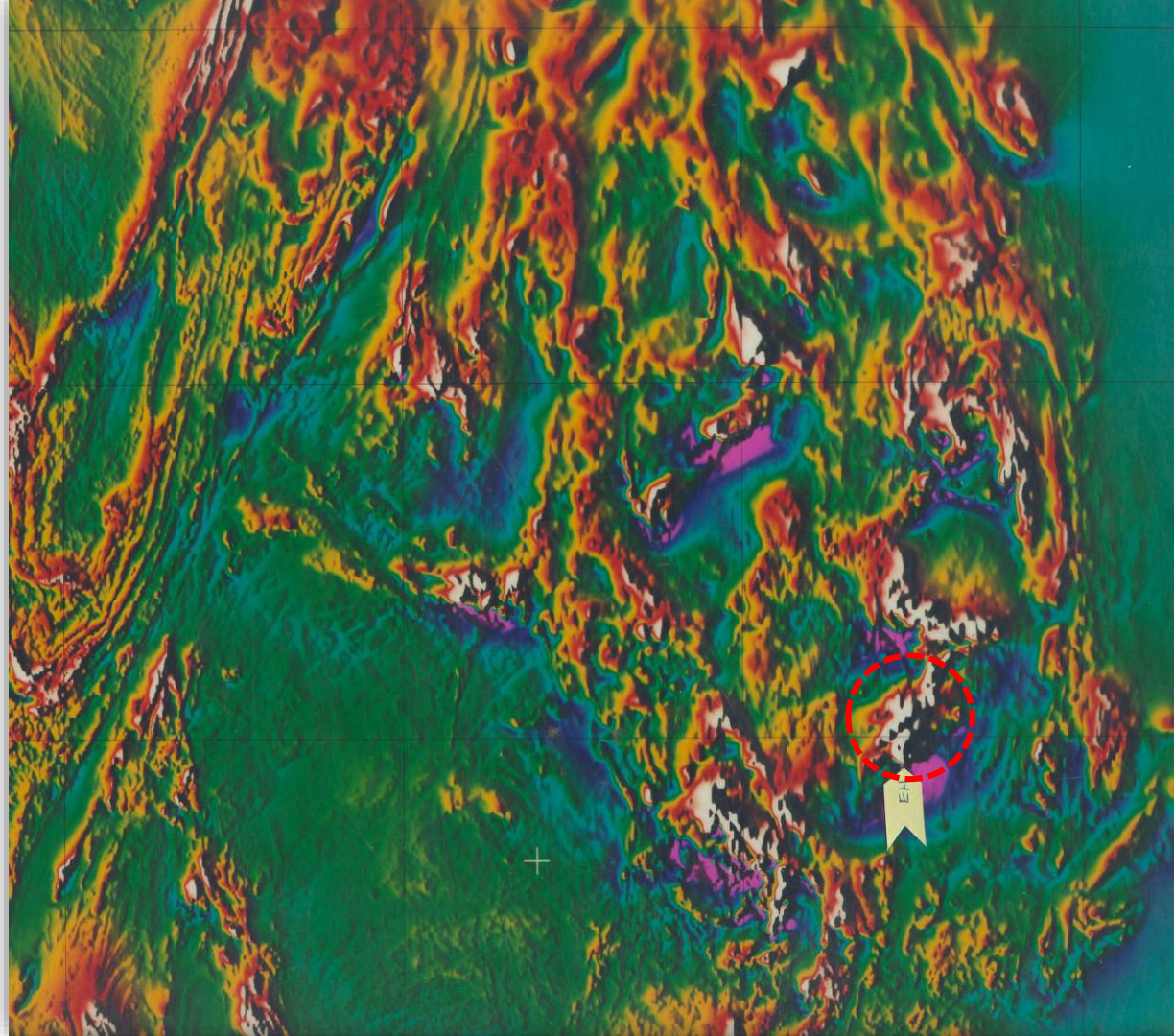


- **In 2016 Evolution signed to buy 100% of the Au credits from Glencore**
- **In Nov 2021 Evolution completed full ownership (~$1 Bn)**
- **In <18 months Evolution LOM extended to 2040** (Underground resource at 77.4Mt, June 2023)

The Exploration Challenge: Ernest Henry before... and after...

Ernest Henry IOCG Deposit - Discovery

- No natural surface outcrop - covered by 30-60m Mesozoic sediments
- Early exploration targeted role front uranium in the cover sequence
- **Savage Exploration** pegged major aeromagnetic anomalies in the region for a magnetite resource in 1974.
- **BHP** explored the area from 1984-1986 targeting the largest untested magnetic anomalies in the Isa Block. Specifically targeted magnetite skarn or BIF related base metals.
- **BHP** defined a total of 28 targets, 8 of which were excluded for follow up because they fell within Savage ML's



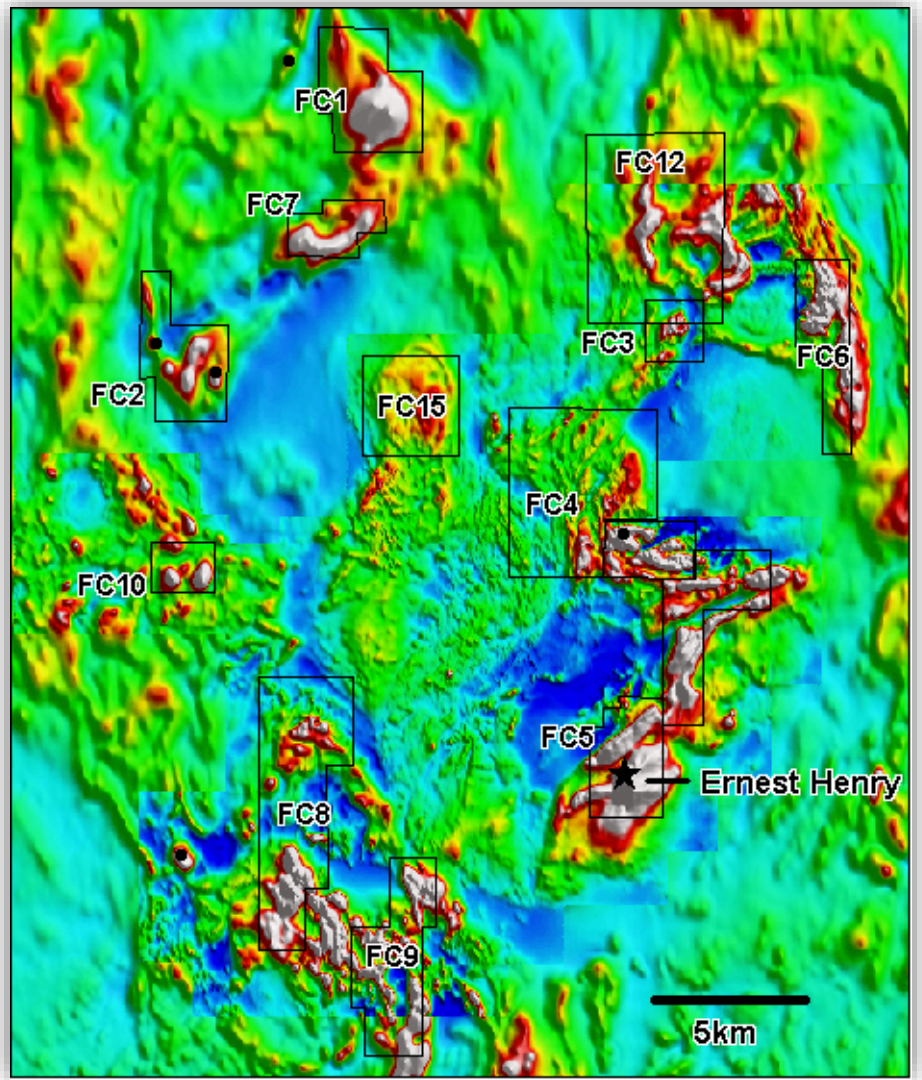
Ernest Henry IOCG Deposit - Discovery

- In the late 1980's -1990 WMC targeted magnetic anomalies (FC Targets)

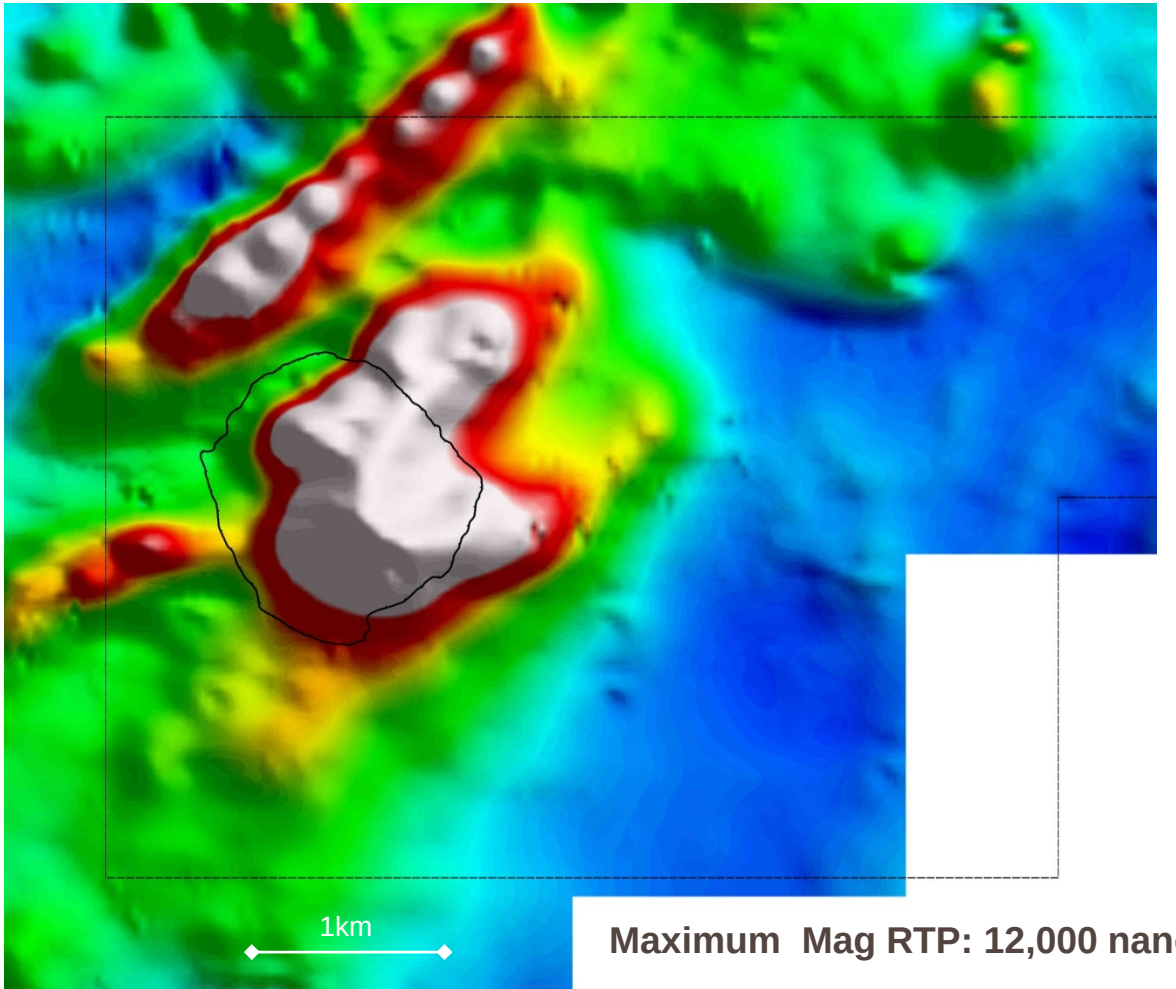
- Exploring for Starra style Fe-stone hosted Cu-Au deposits and skarn related gold.

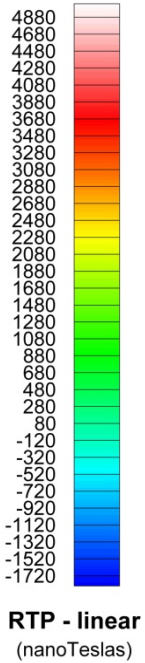
- Also recognised potential for Olympic Dam style Cu-Au-U mineralisation.

- Transient Electromagnetic (TEM) conducted over FC5 in 1991



Ernest Henry RTP Magnetics 1992 airborne survey

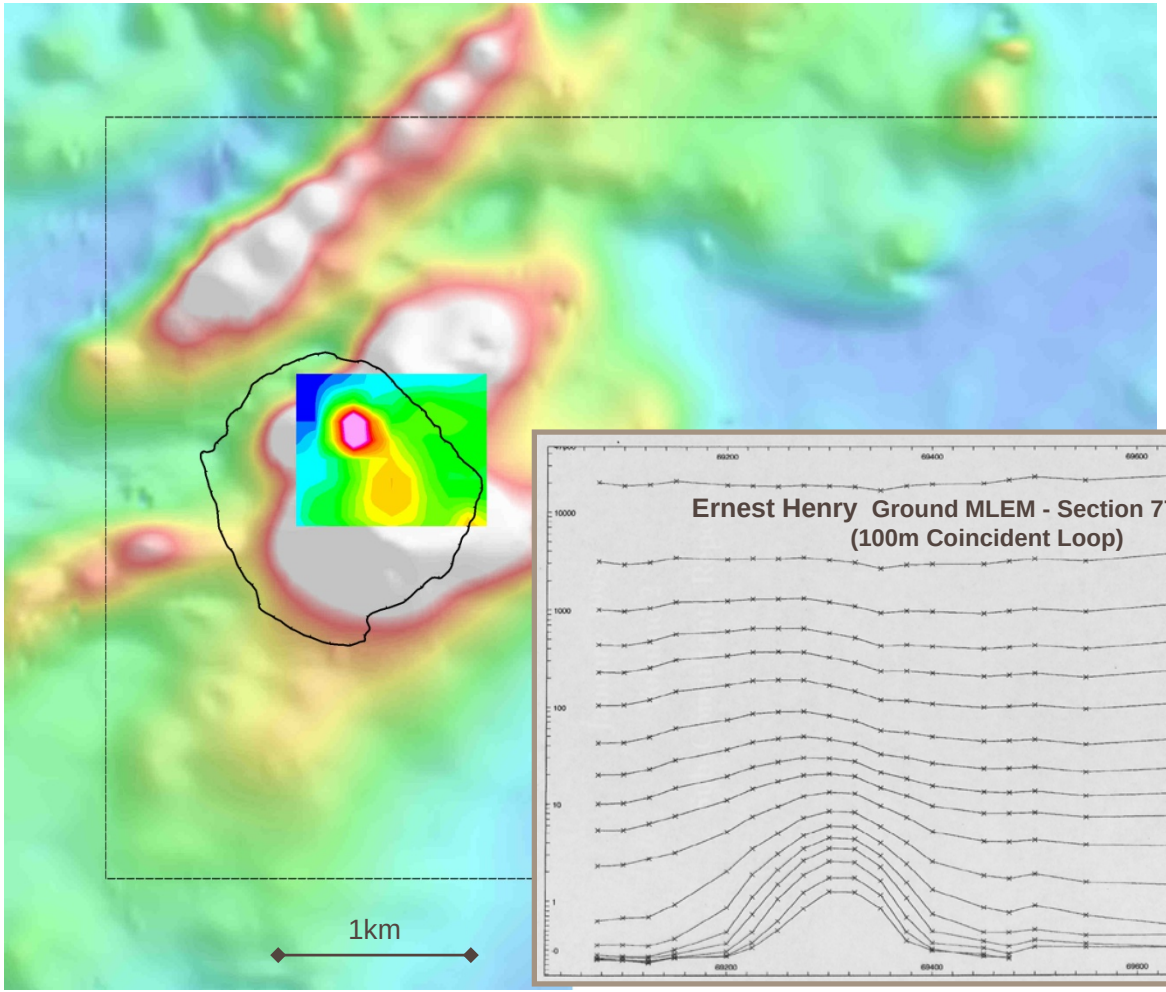




Maximum Mag RTP: 12,000 nanoteslas

Acknowledgements to Terry Harvey (MIM)

Ernest Henry Discovery TEM over 1992 RTP magnetics



Acknowledgements to Terry Harvey (MIM)

Ernest Henry IOCG Deposit - Discovery

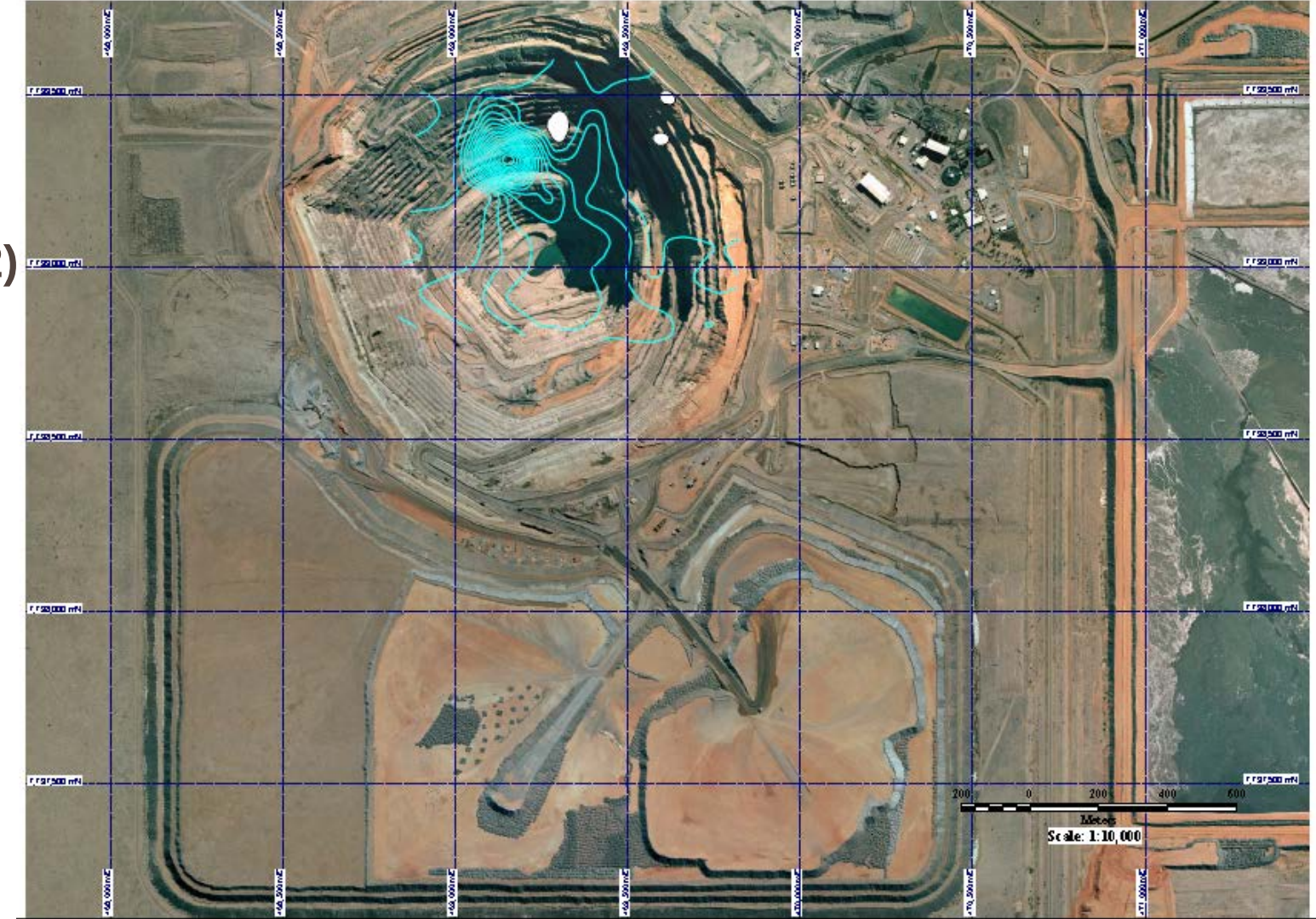
- Discovery hole drilled in 1991 targeted on ground-derived EM anomaly.
- Anomaly response from small supergene chalcocite blanket
- Discovery Hole intersected;

  7.1m @ 4.95% Cu, 0.8 g/t Au from 97.35 m, and

  114.2m @ 1.75% Cu, 0.9g/t Au from 120.5m

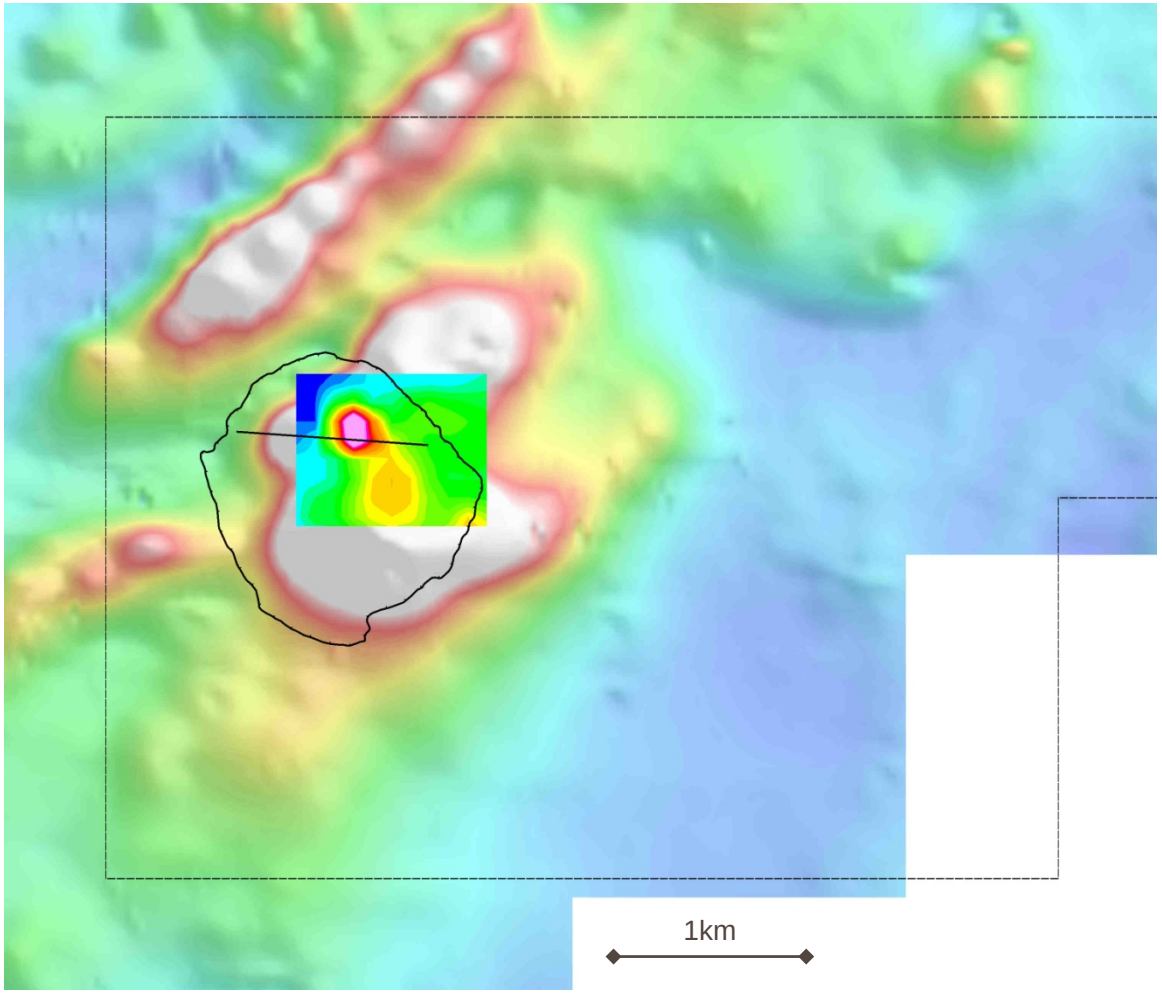
- Ground magnetic, gravity and induced polarisation methods were used to help guide early delineation drilling
- In 1993 the deposit was determined to lie within Mining Lease 2671, owned by Savage Exploration
- MIM Holding Limited purchased 51% of Savage Exploration
- Pre-strip commenced 1996

Gridded MLEM over Ernest Henry open pit (2012)



Acknowledgements to Terry Harvey (MIM)

Ernest Henry Discovery TEM over 1992 RTP magnetics IP Follow-up



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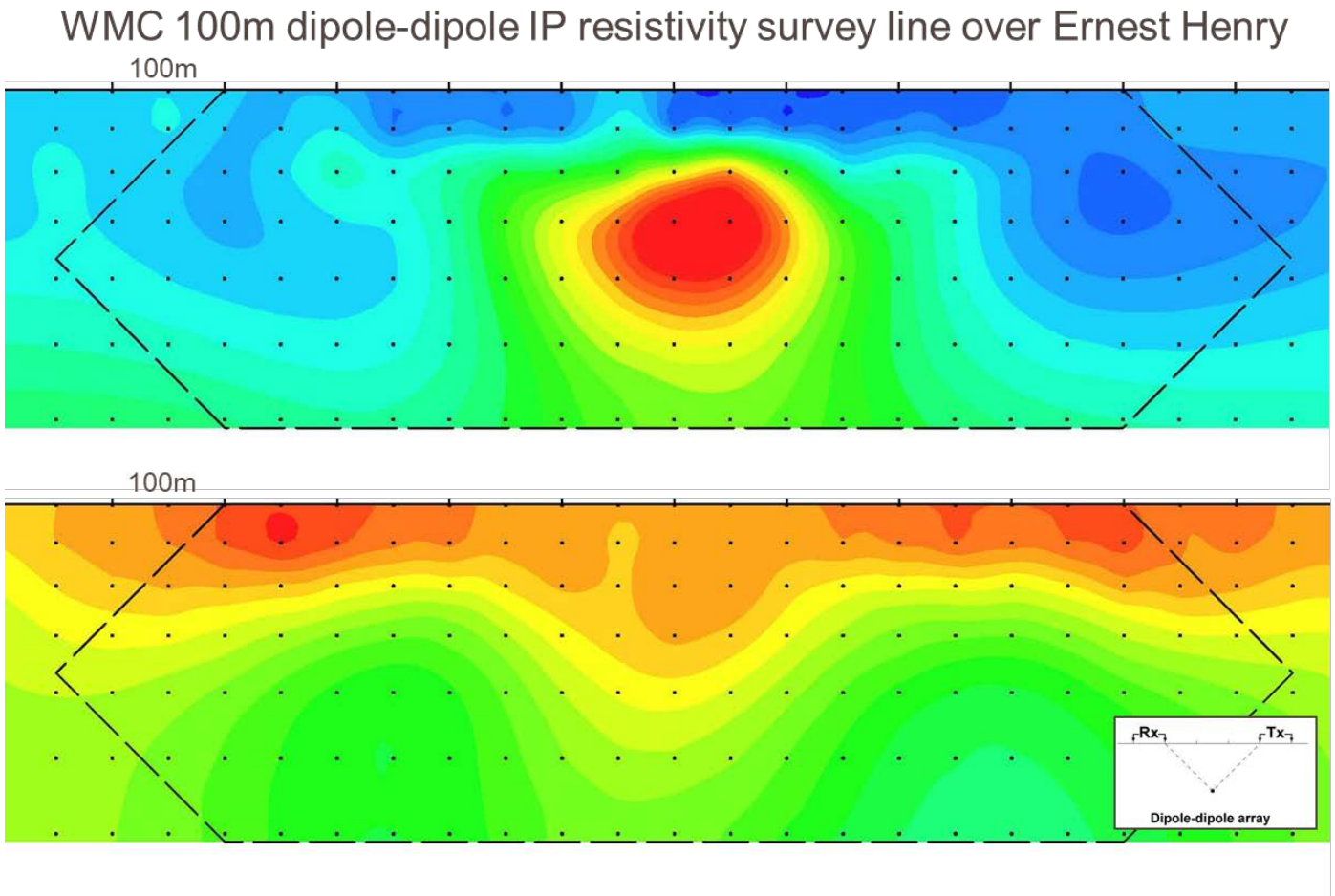
Ernest Henry IOCG Deposit - Discovery



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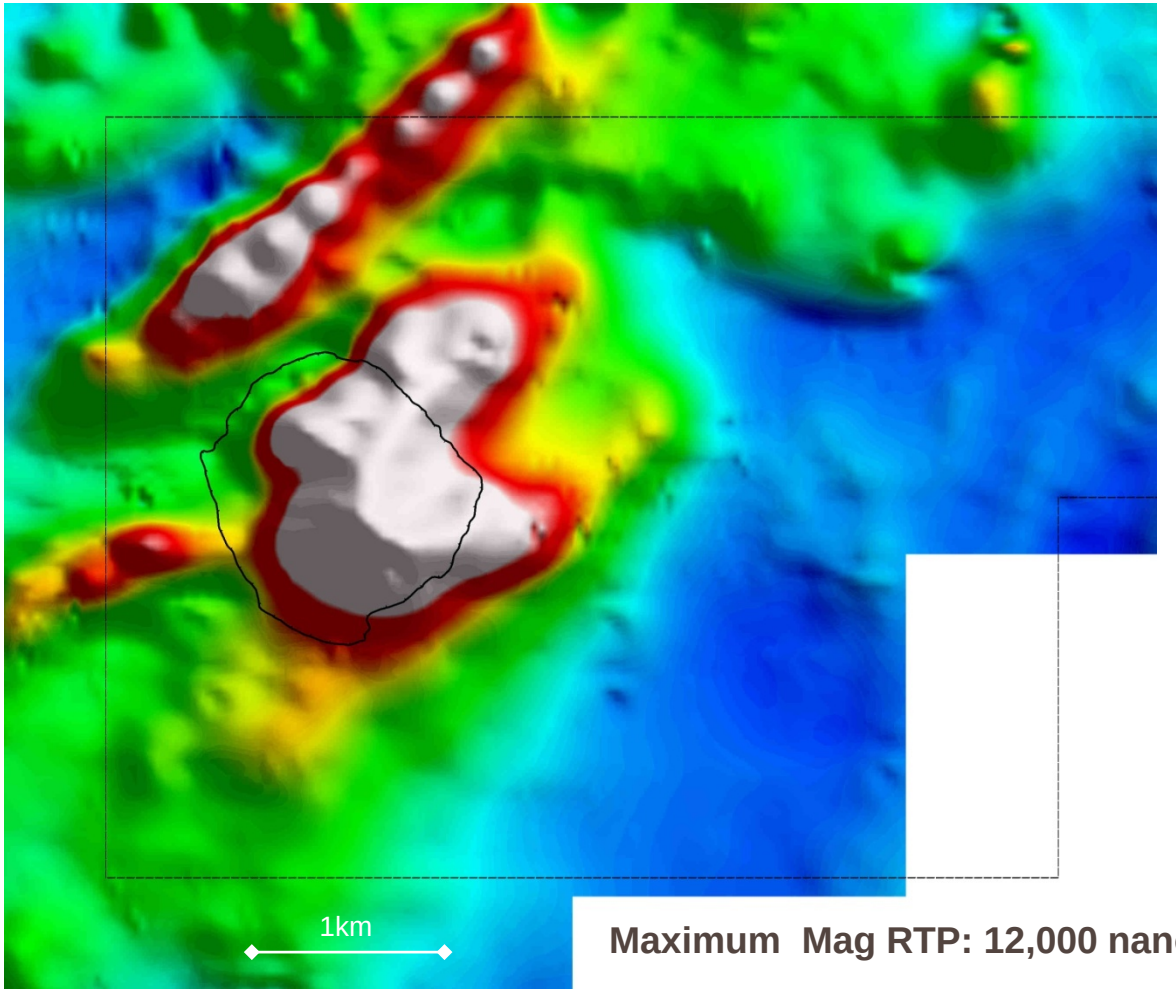
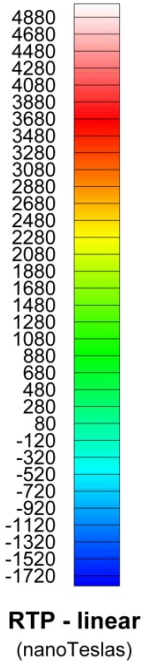
Ernest Henry RTP Magnetics 1992 airborne survey



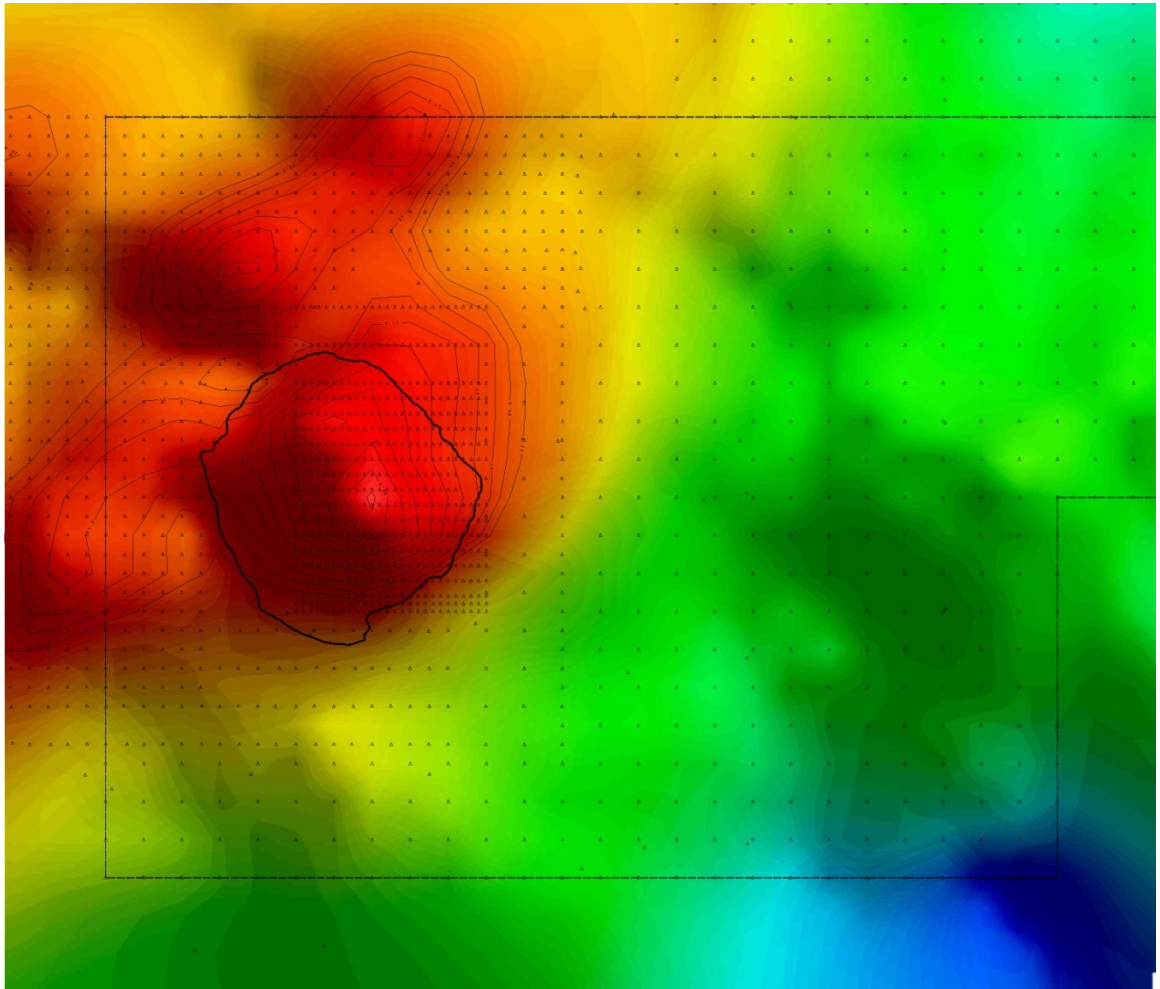


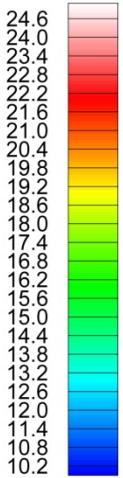
Maximum Mag RTP: 12,000 nanoteslas

Acknowledgements to Terry Harvey (MIM)

Ernest Henry WMC Ground Gravity 1993-1995 surveys

Maximum Gravity: 3 milligals above the level of the more extensive gravity complex

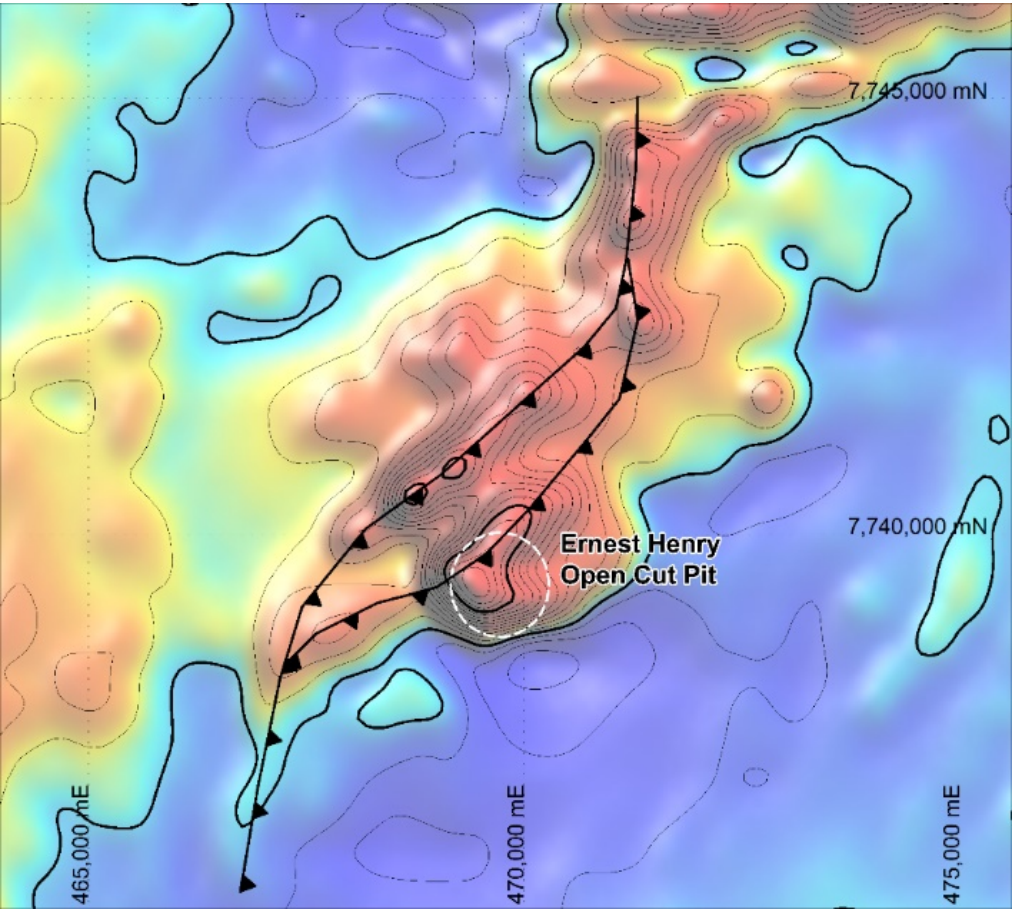




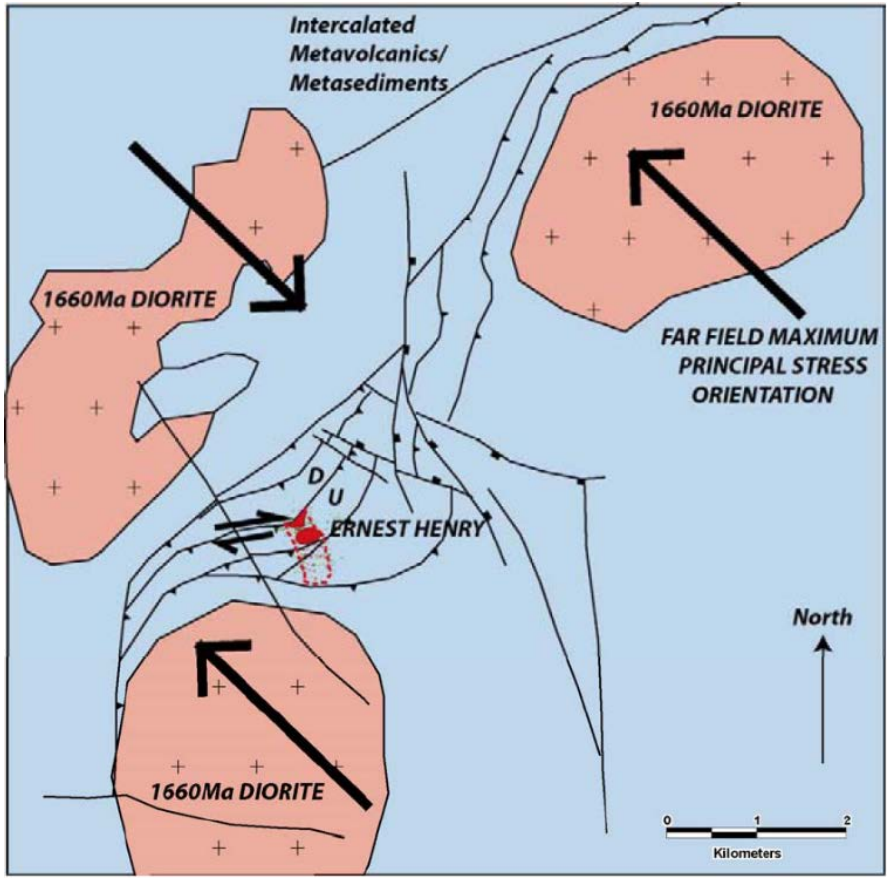
WMC Gravity - linear
(milliGals)

Acknowledgements to Terry Harvey (MIM)

Ernest Henry Structural Controls



Magnetics TMI

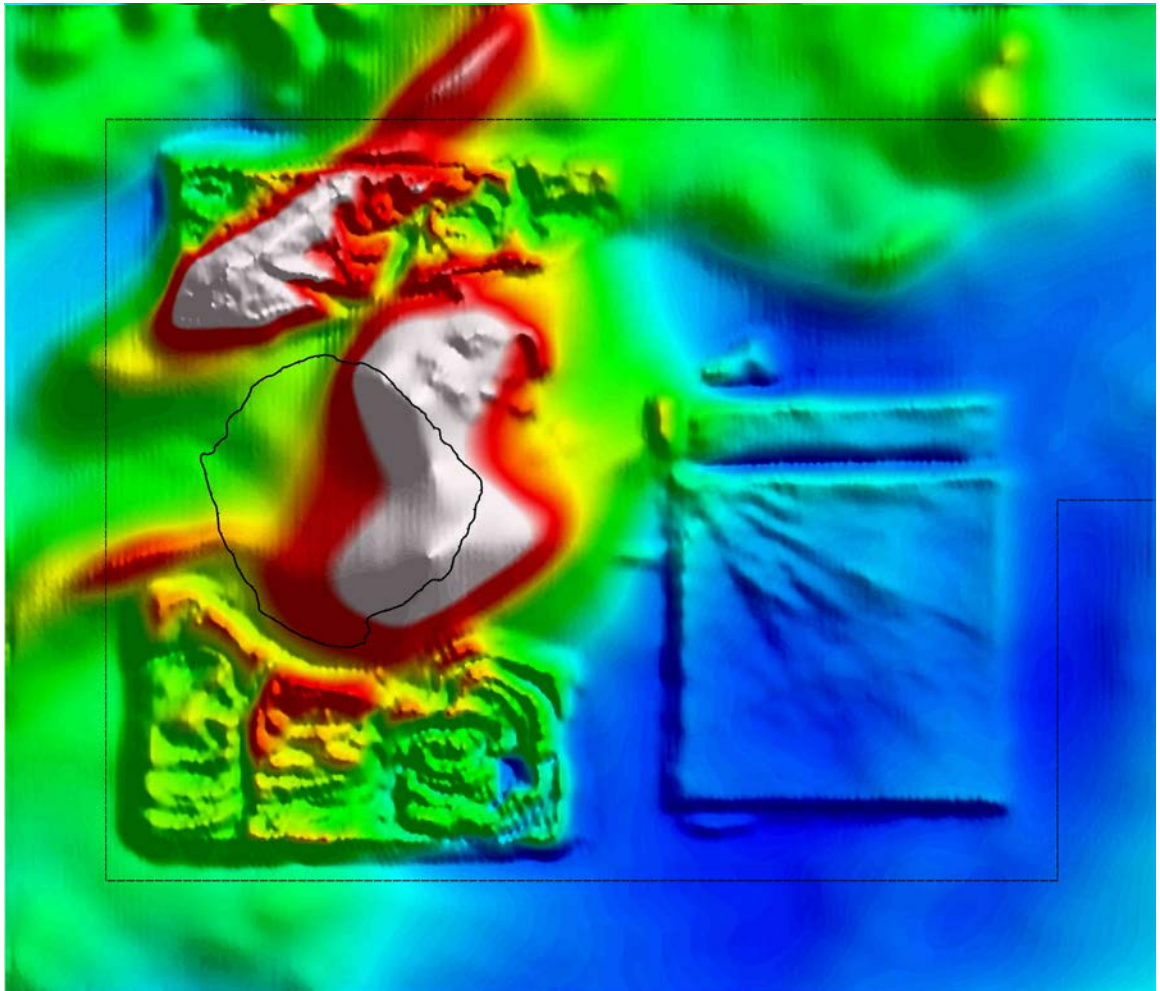


Attributed to Valenta, 2000

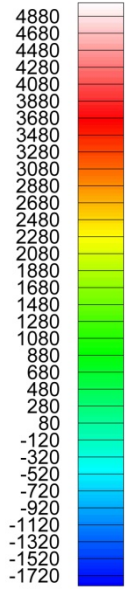
Ernest Henry Geophysical Discovery Summary

- **Magnetics** - Highly magnetic (~10,000nT anomaly)
  - Strong correlation between Cu and magnetite
  - Excellent for mapping lithology/structures under cover
- **TEM** - Identified supergene cap (but failed to detect disseminated sulphides)
- **IP-resistivity** - Effective in identifying disseminated sulphide mineralisation
  - Effective in seeing basement through 100m of cover in area
  - Resistivity effective in mapping out, structures, basement, weathering and conductive lithologies
- **Gravity** - helped to discriminate the mineralised system within the generally magnetic environment

Ernest Henry RTP Magnetics 1992-2012 airborne survey



2012 airborne survey: magnetics picks waste dumps and tailings

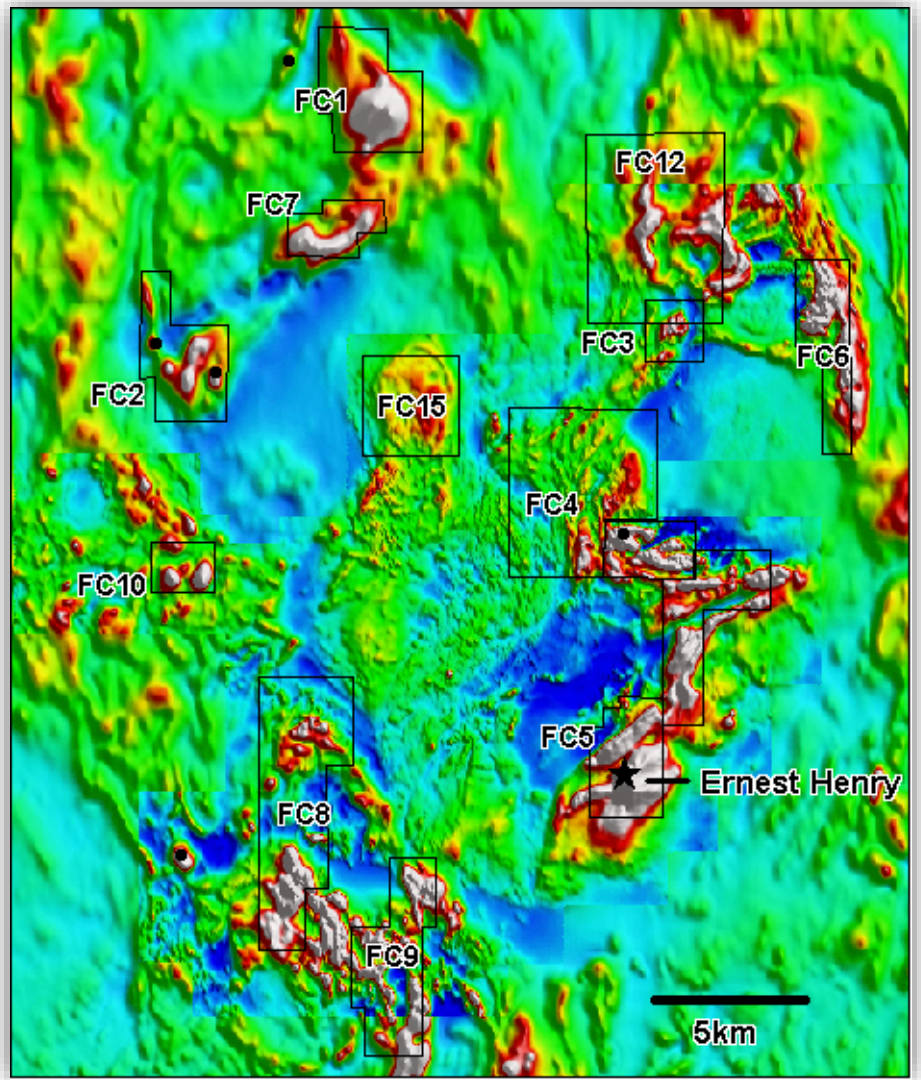


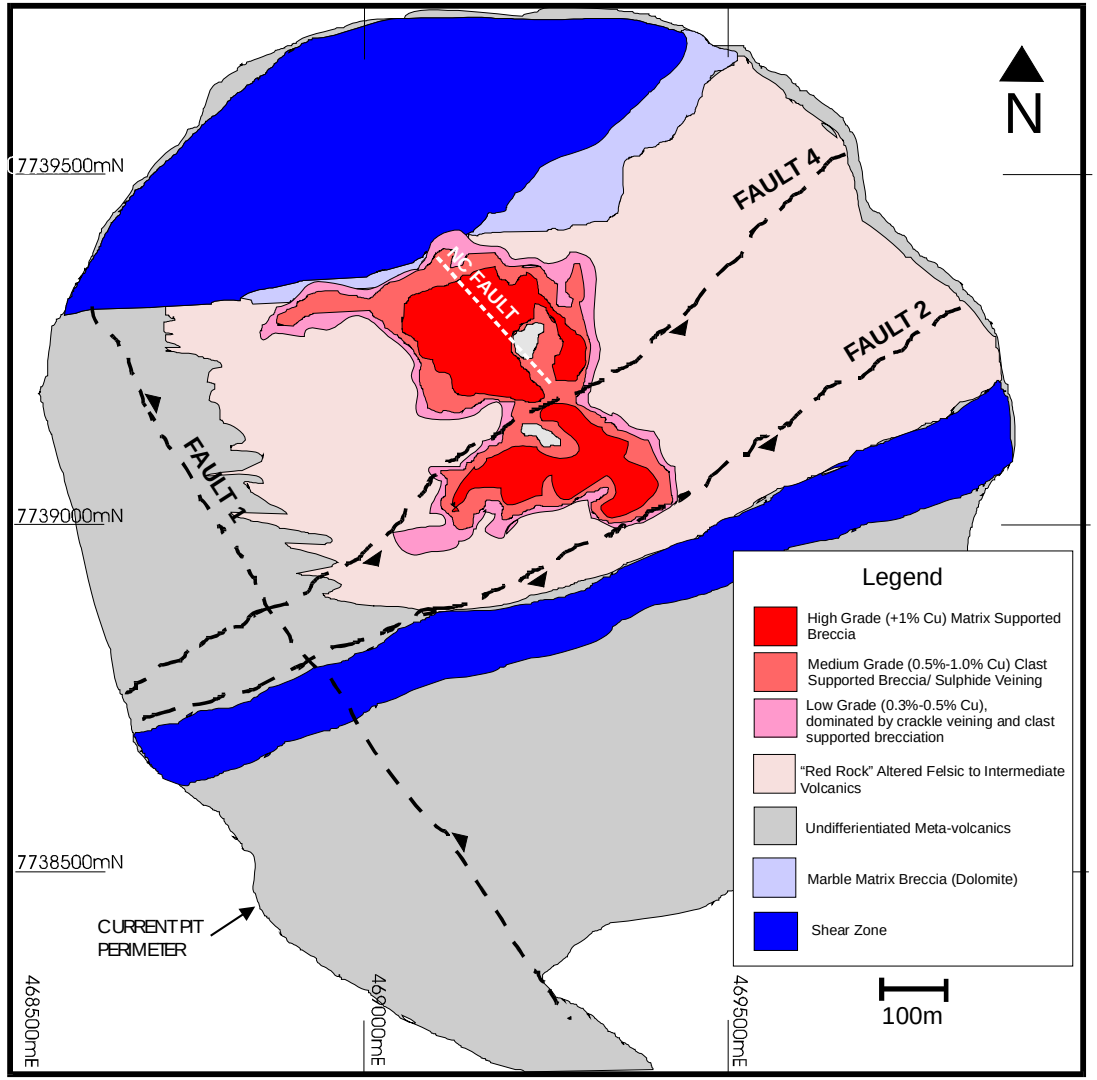
RTP - linear
(nanoTeslas)

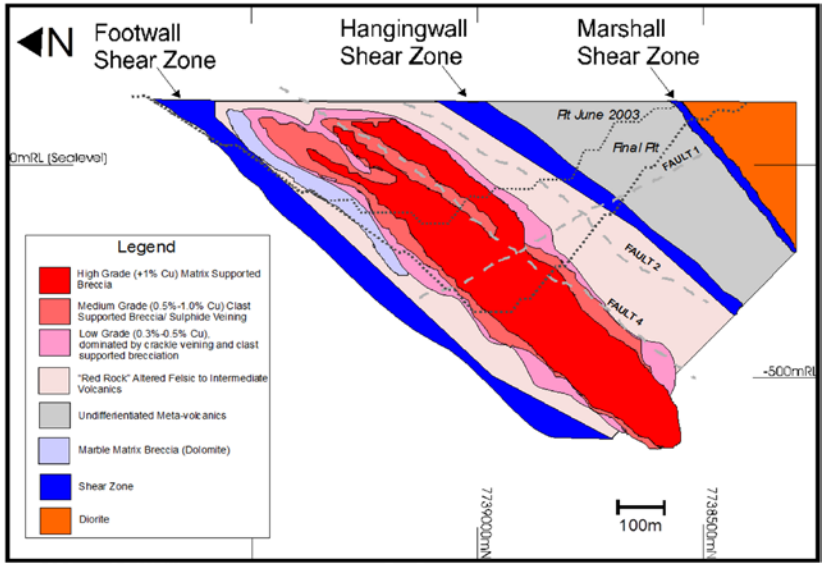
Acknowledgements to Terry Harvey (MIM)

Ernest Henry IOCG Deposit - Discovery

- **Since the discovery of Ernest Henry, almost every other mag high in the district has now been drilled…(important in the discoveries of Cannington, Osborne)**
- **But why are so many of the magnetic highs barren?**




N
7739500mN
7739000mN
7738500mN
FAULT 4
NC FAULT
FAULT 2
FAULT 1
CURRENT PIT PERIMETER
468500mE
469000mE
469500mE
Legend
High Grade (+1% Cu) Matrix Supported Breccia
Medium Grade (0.5%-1.0% Cu) Clast Supported Breccia/ Sulphide Veining
Low Grade (0.3%-0.5% Cu), dominated by crackle veining and clast supported brecciation
"Red Rock" Altered Felsic to Intermediate Volcanics
Undifferientiated Meta-volcanics
Marble Matrix Breccia (Dolomite)
Shear Zone
100m


N
Footwall Shear Zone
Hangingwall Shear Zone
Marshall Shear Zone
Pit June 2003
Final Pit
FAULT 1
FAULT 2
FAULT 4
0mRL (Sealevel)
-500mRL
Legend
High Grade (+1% Cu) Matrix Supported Breccia
Medium Grade (0.5%-1.0% Cu) Clast Supported Breccia/ Sulphide Veining
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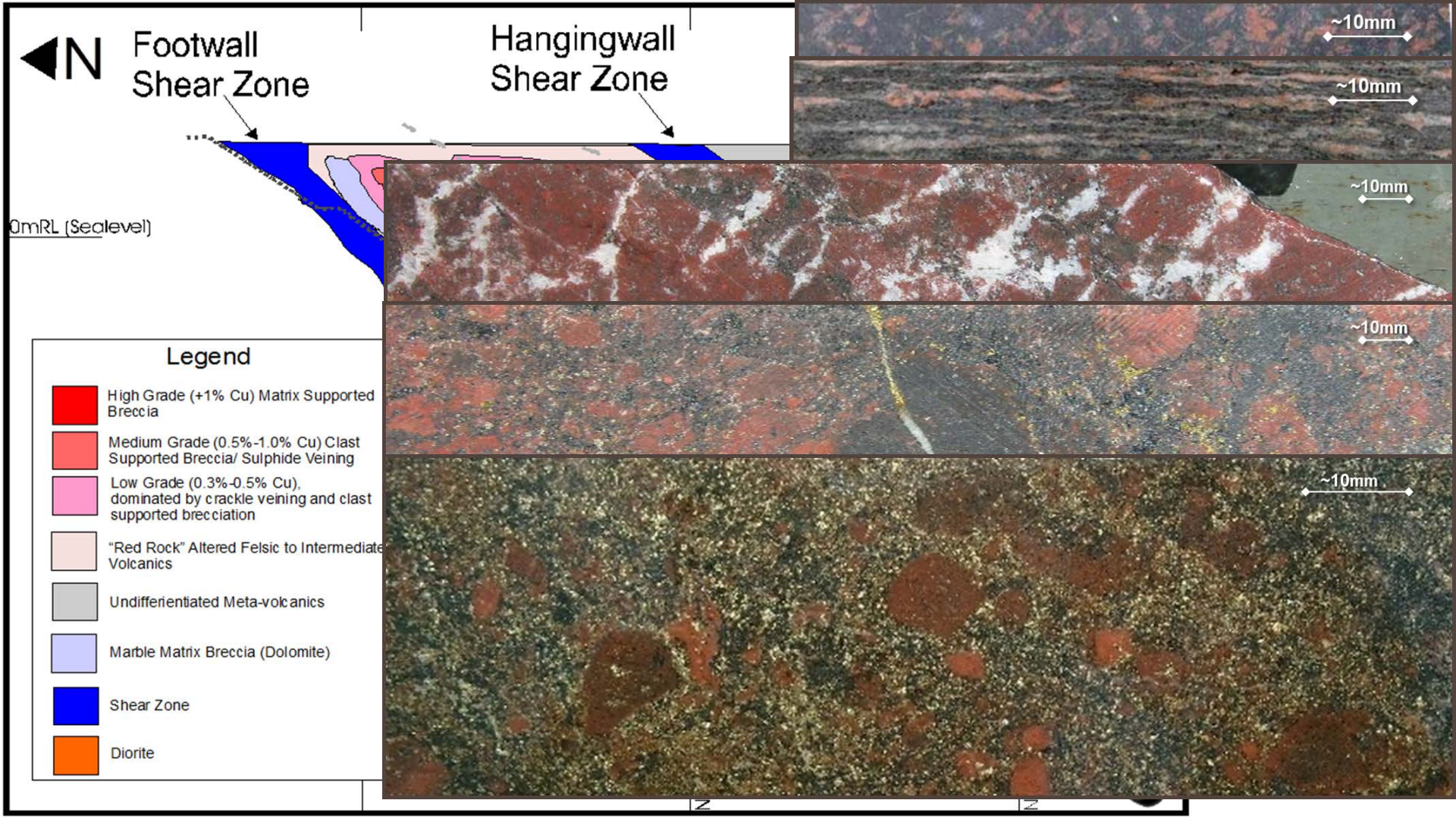
"Red Rock" Altered Felsic to Intermediate Volcanics
Undifferientiated Meta-volcanics
Marble Matrix Breccia (Dolomite)
Shear Zone
Diorite
7739000mN
7738500mN
100m


N
Footwall
Shear Zone
Hangingwall
Shear Zone
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Legend
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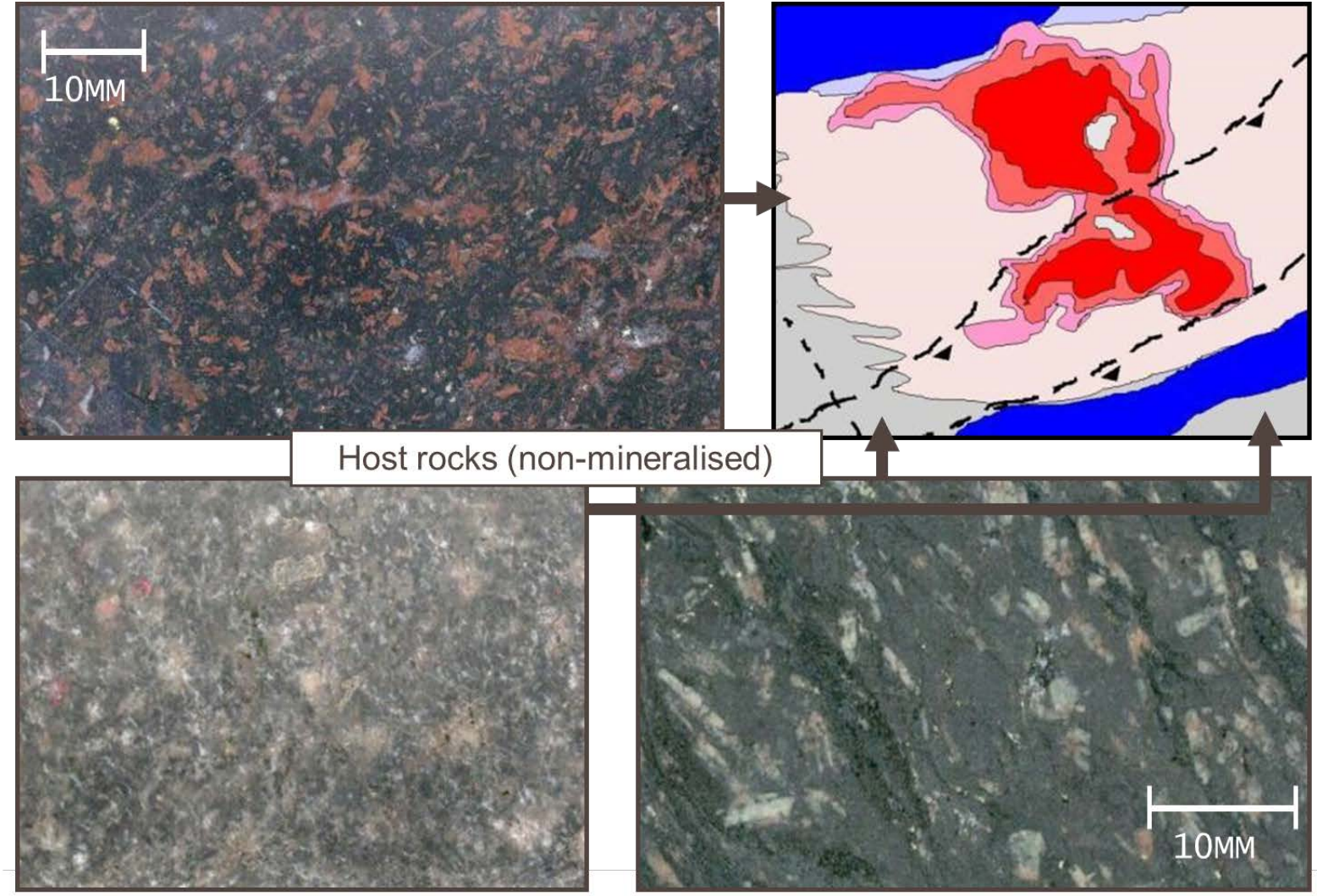
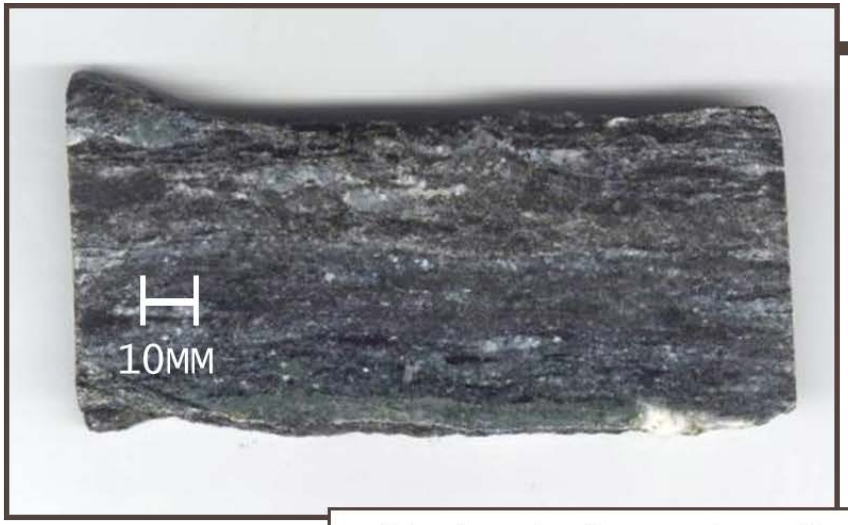
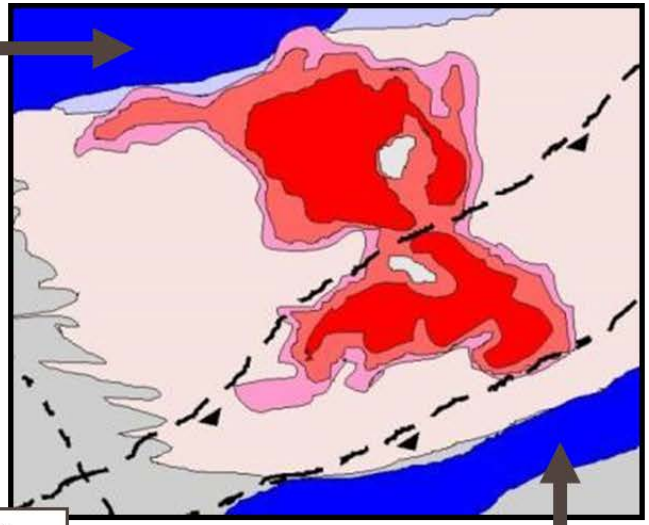
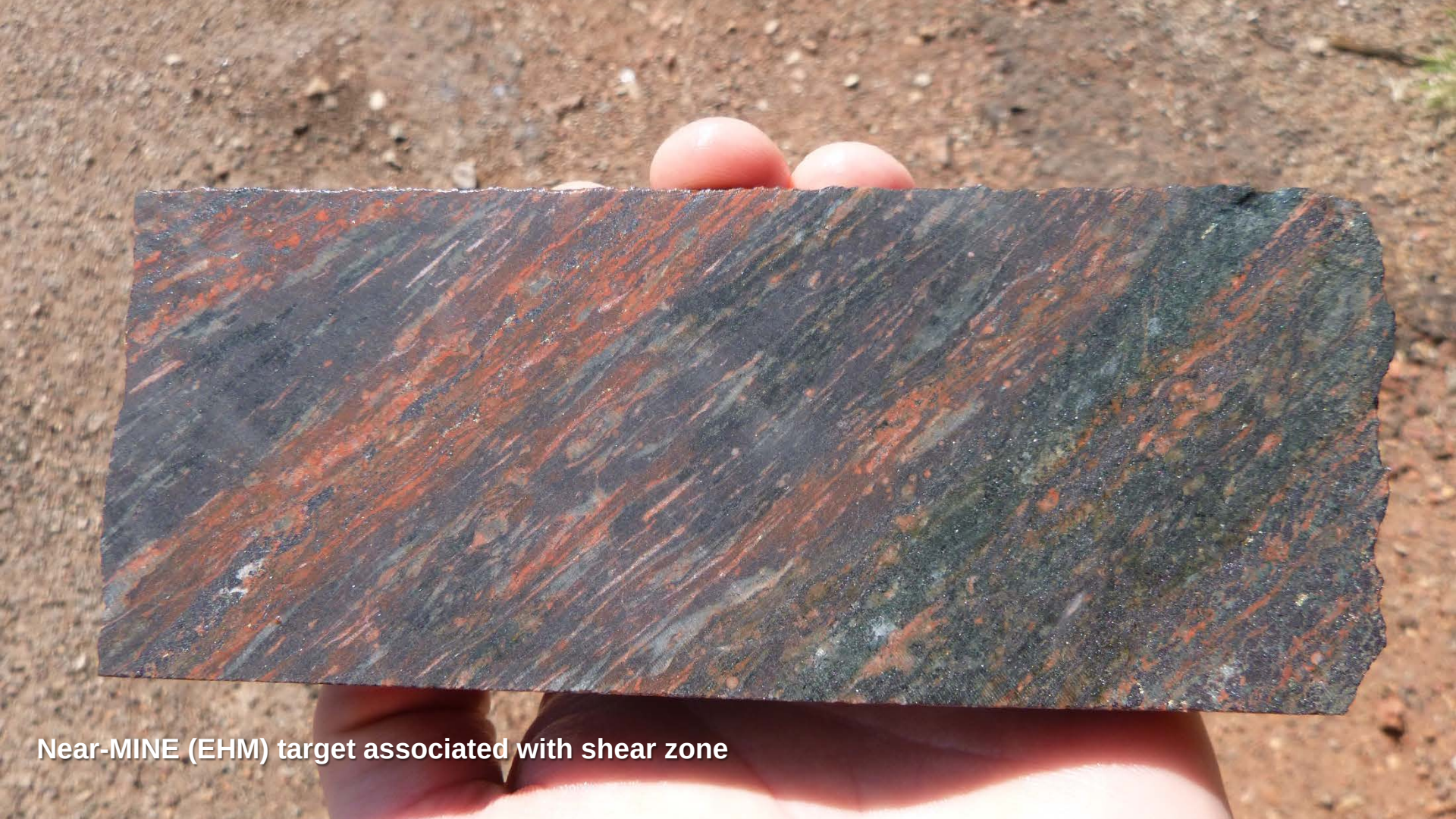
Marble Matrix Breccia (Dolomite)
Shear Zone
Diorite
~10mm
~10mm
~10mm
~10mm
~10mm


10MM
Host rocks (non-mineralised)
10MM



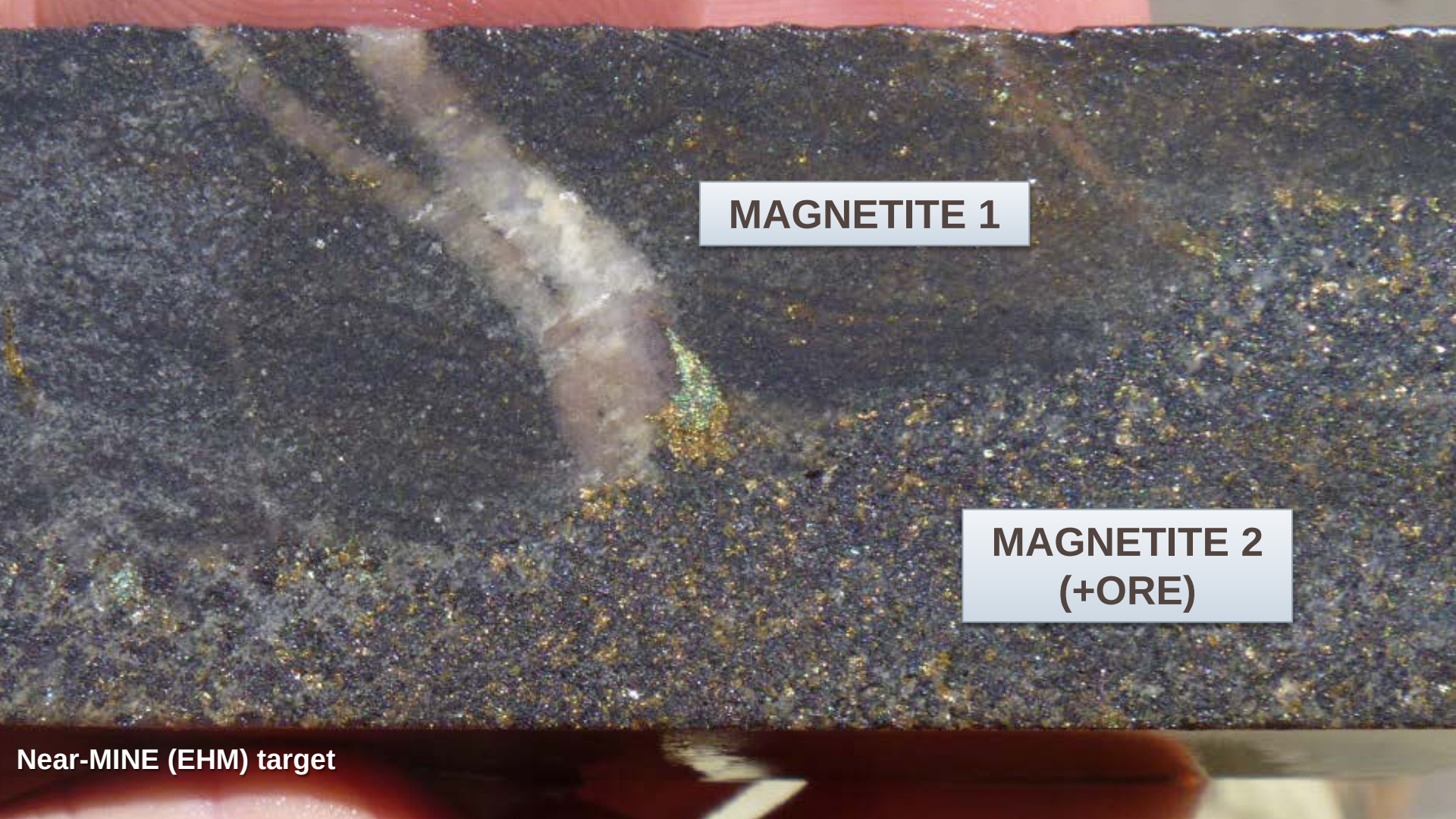


Host rocks (non-mineralised)

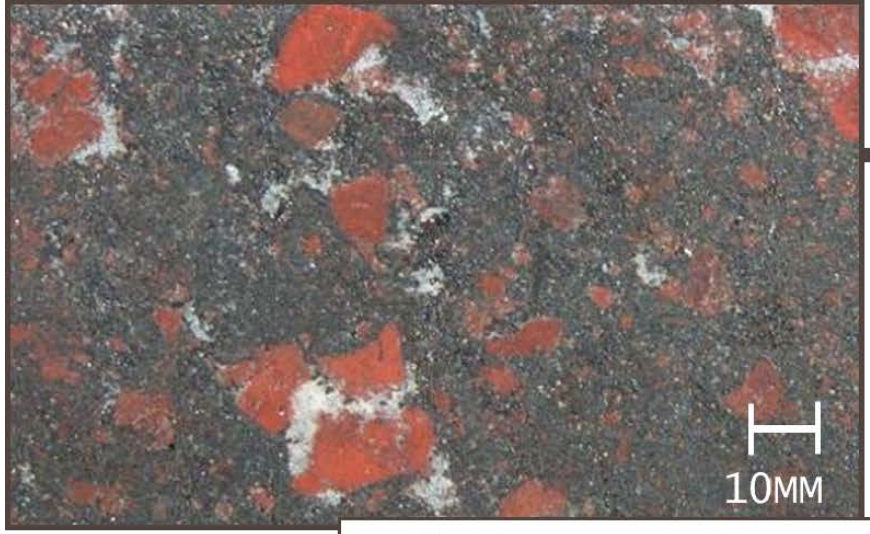


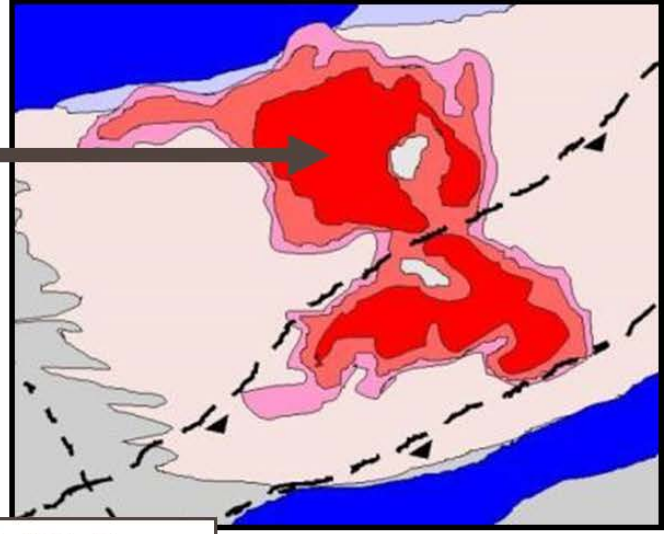
Near-MINE (EHM) target associated with shear zone

Near-MINE (EHM) target associated with shear zone

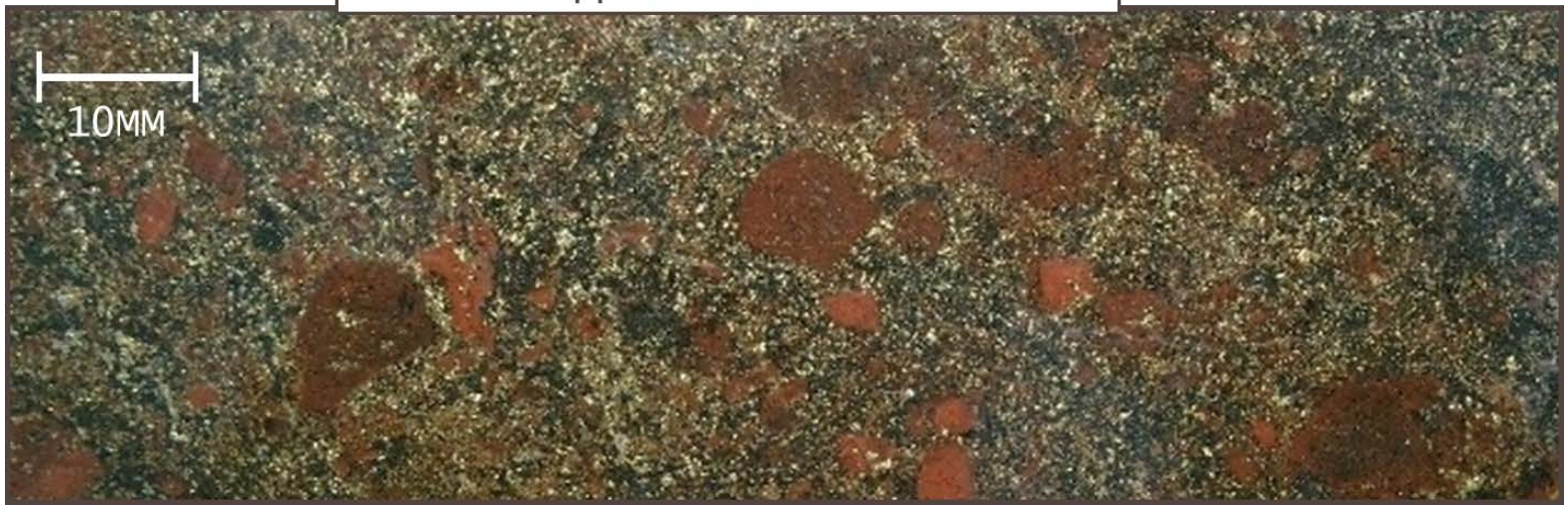


Near-MINE (EHM) target





Matrix supported breccia +1.0% Cu



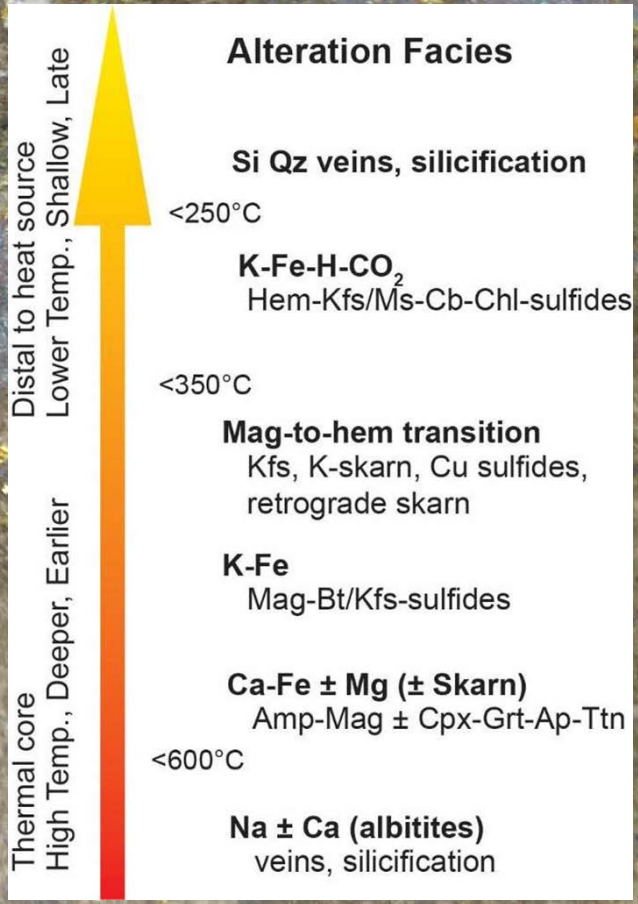
IOCG ALTERATION:

- **Most IOCG deposits display a variably complex pre-ore down-temperature alteration assemblage** (POTENTIALLY SEPERATED BY MILLIONS OF YEARS!)

1. **Na-Ca** — **Red Rock**
   - REGIONAL, potentially savaging metals (albitisation and scapolite)

2. **Fe-Mg-K** — **Dark Rock**
   - Magnetite-amphibole-biotite-Kspar
   - More localized, overprinting

3. K-Fe-SULPHIDES (normally about last) — **ORE STAGE!**



Corriveau et al. 2016, *Economic Geology*

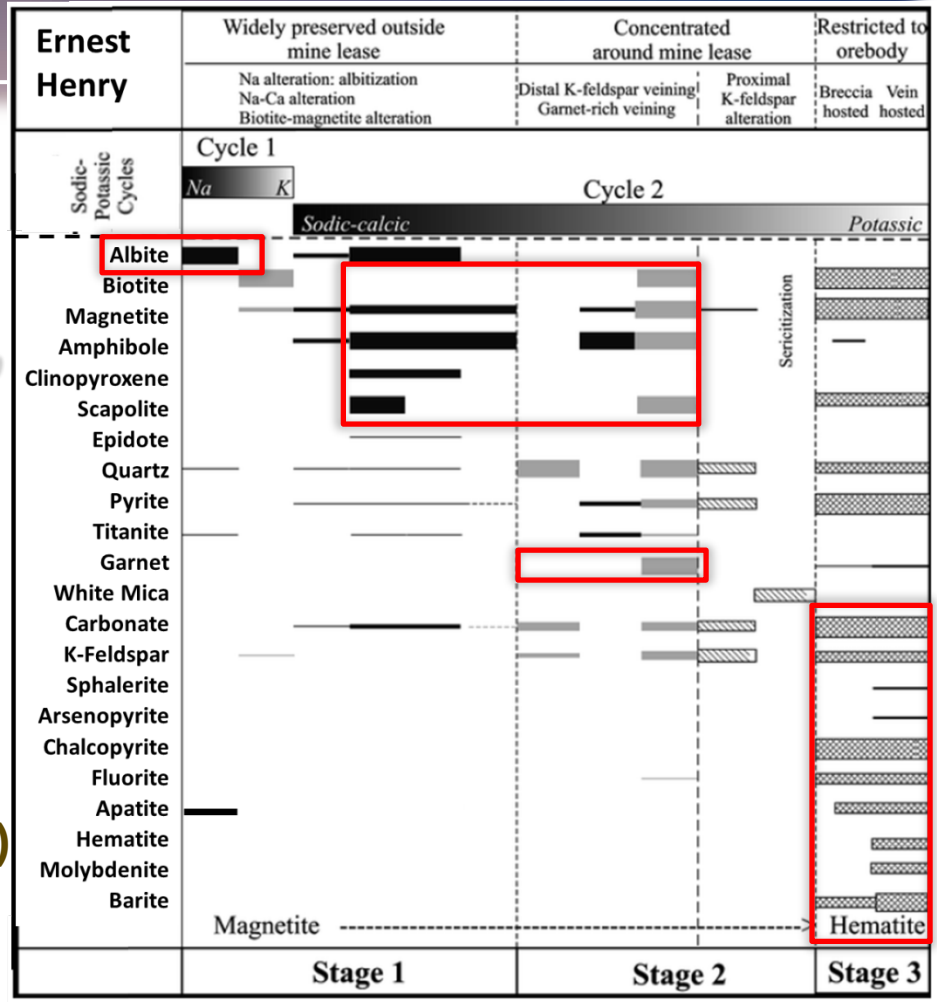
Ernest Henry Paragenesis

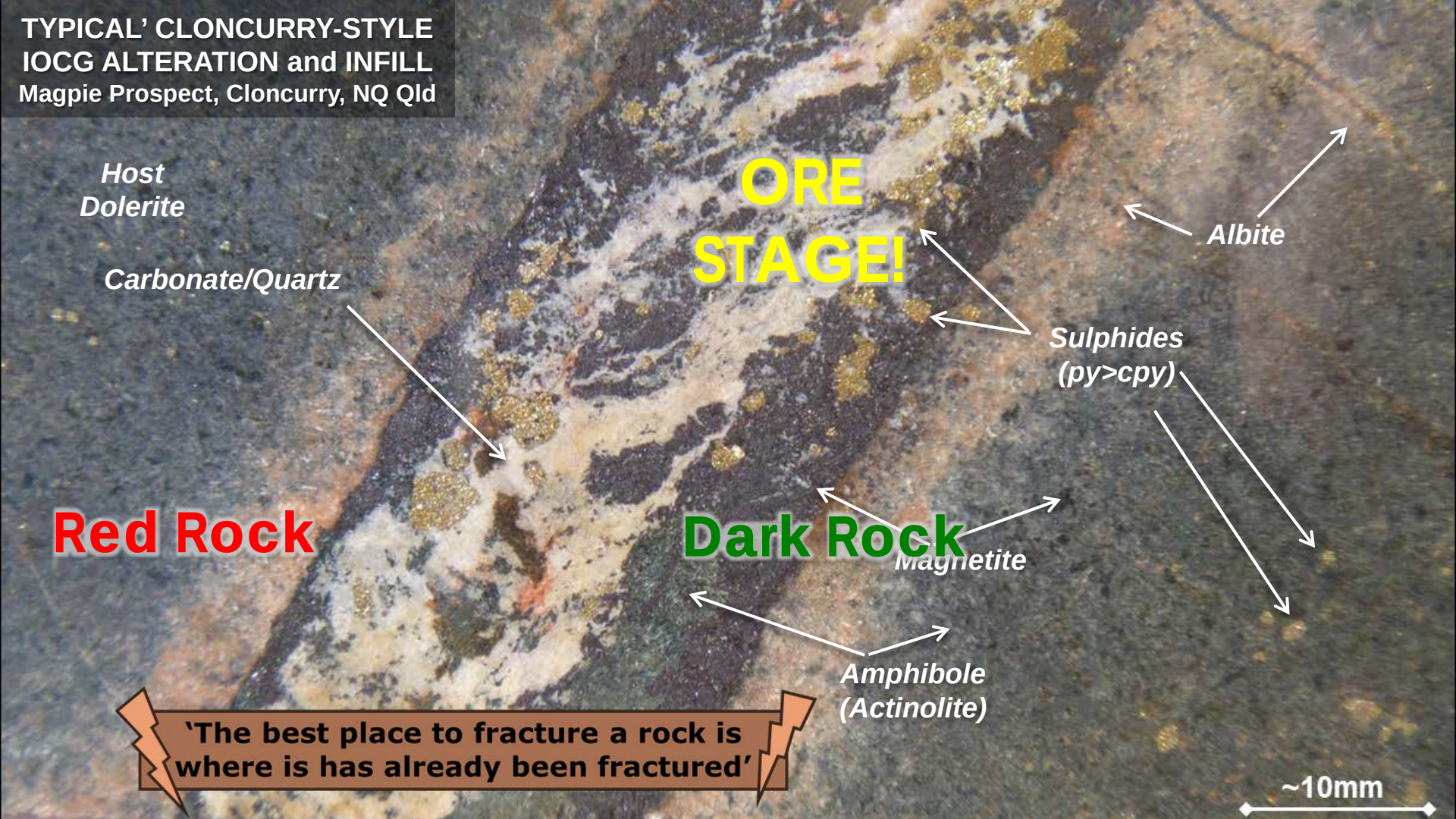
- Stage 1: Regional Na-Ca
  - Albite/Scapolite **(+ *apatite ~1580Ma*)**

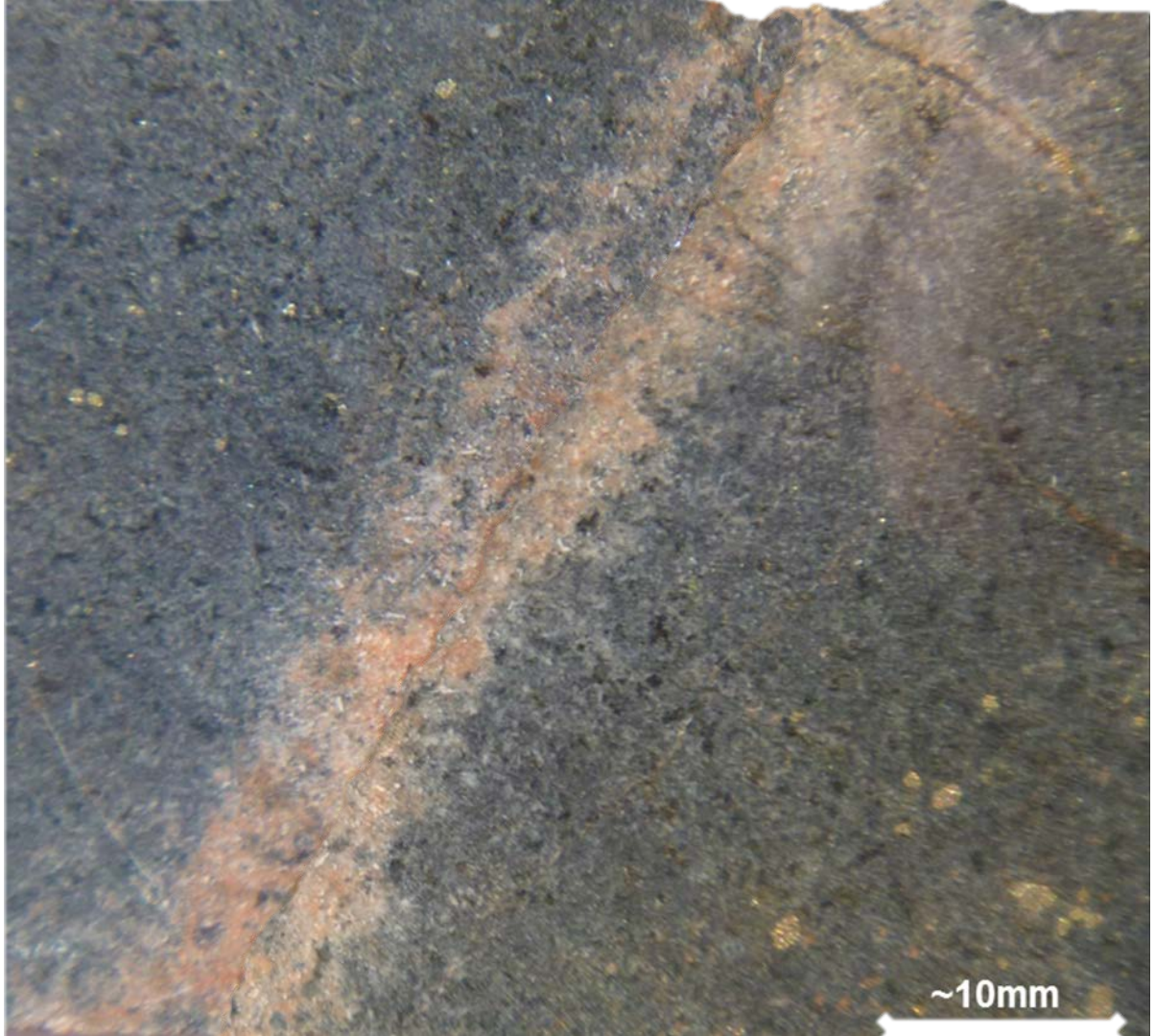
‘Red Rock’

- Stage 2: ‘Dark Rock’ **‘Dark Rock’**
  - Biotite-magnetite (K-spar)
  - + some garnet (interlens)

- Stage 3: Mineralisation
  - K-spar-magnetite **ORE STAGE!**
  - Chalcopyrite-pyrite-Ca-Qz- ***(~1510Ma)***
- Post-min carb/qtz (marble matrix breccia) ±fluorite/barite




TYPICAL' CLONCURRY-STYLE
IOCG ALTERATION and INFILL
Magpie Prospect, Cloncurry, NQ Qld
Host
Dolerite
Carbonate/Quartz
ORE
STAGE!
Albite
Sulphides
(py>cpy)
Red Rock
Dark Rock
Magnetite
Amphibole
(Actinolite)
'The best place to fracture a rock is
where is has already been fractured'
~10mm

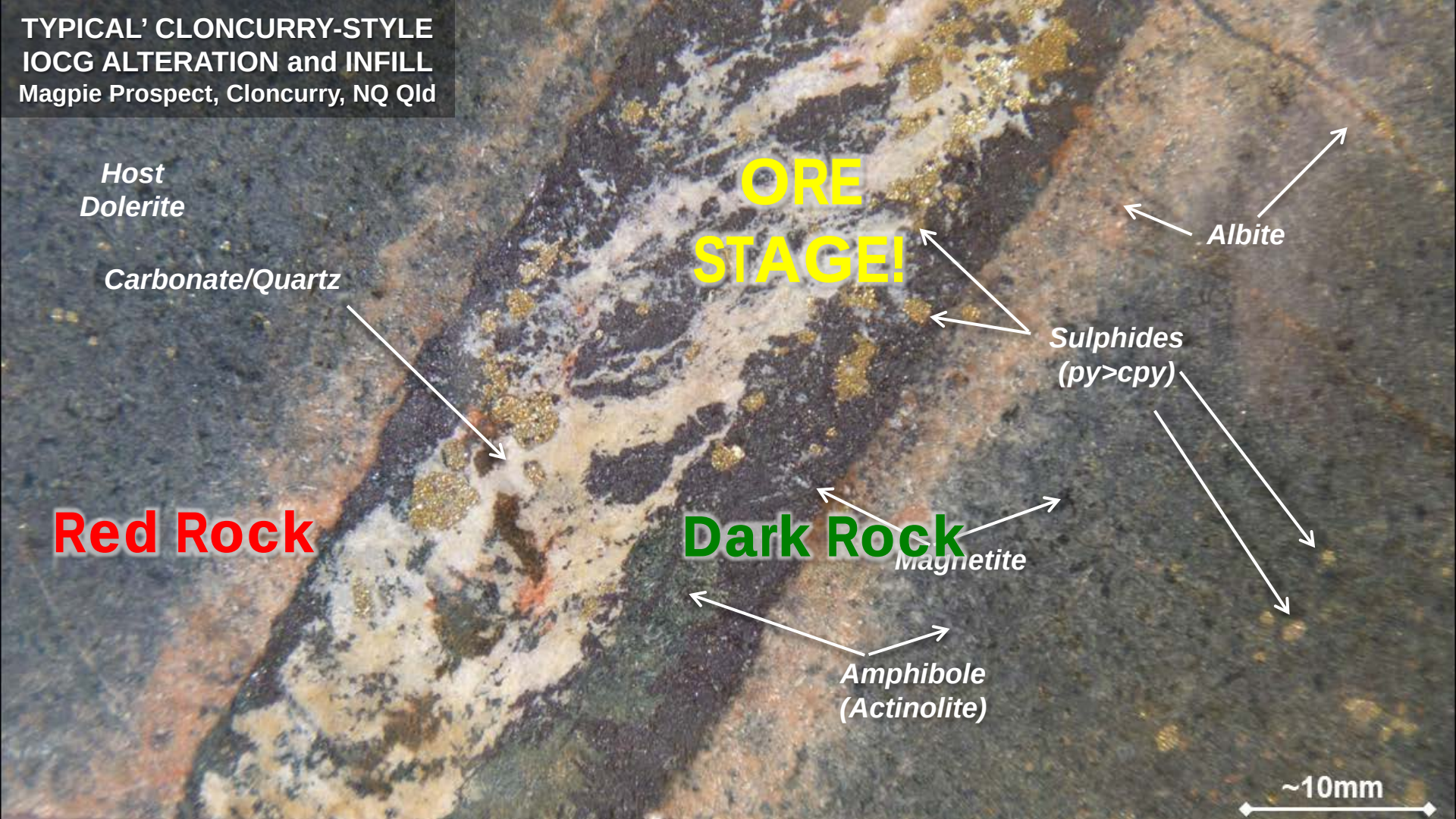

~10mm


~10mm

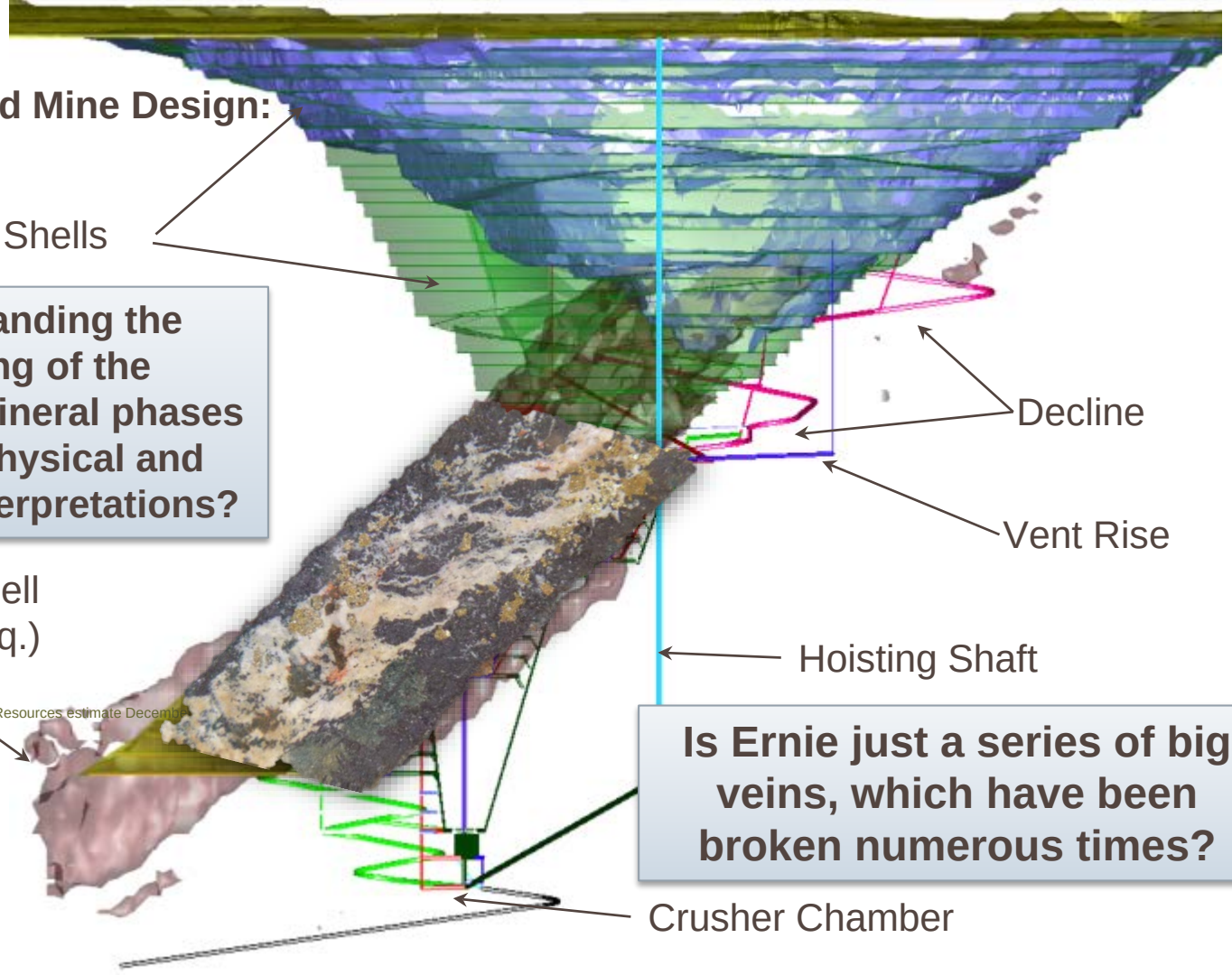

~10mm


~10mm


~10mm


TYPICAL' CLONCURRY-STYLE
IOCG ALTERATION and INFILL
Magpie Prospect, Cloncurry, NQ Qld
Host
Dolerite
Carbonate/Quartz
ORE
STAGE!
Albite
Sulphides
(py>cpy)
Red Rock
Dark Rock
Magnetite
Amphibole
(Actinolite)
~10mm

Current Underground Mine Design: Sub-Level Cave



Thank You

Does understanding the relative timing of the introduction of mineral phases affect the geophysical and petrophysical interpretations?

Richard Lilly, NExUS Program Leader, University of Adelaide

Richard.lilly@adelaide.edu.au

Acknowledgements to Terry Harvey (MIM)

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