Advanced Understanding of Structural and Geochemical Controls on Mineralisation in the Eastern Mt Isa Inlier Using Innovative Techniques for Exploration

A GSQ funded Industry Priorities Initiative

A New Approach to Understanding Deformation and Mineralisation 'A Critical Tool in the Exploration Process'

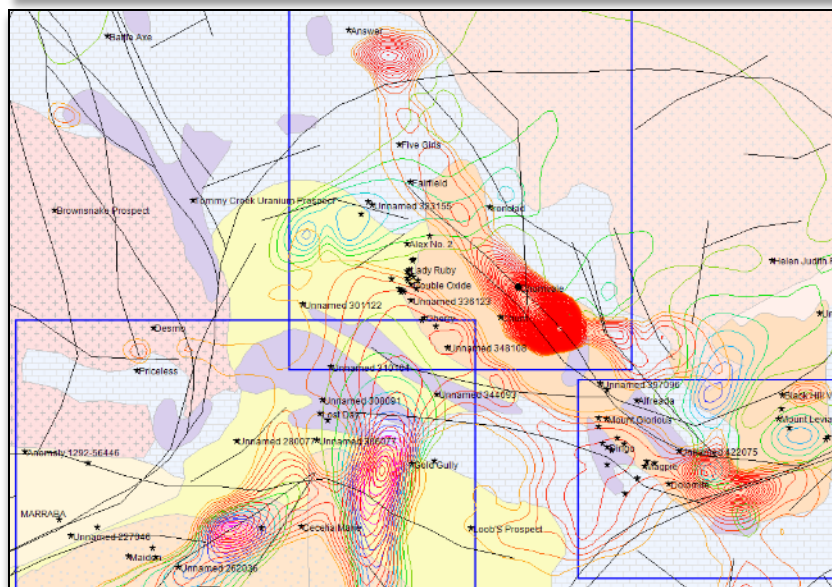
John McLellan

Acknowledgments

- Queensland Exploration Council - Industry Priorities Initiative
- Geological Survey of Queensland and the Queensland Government for funding the project
- Dr Hassan Baghian for geochemical and technical expertise
- Many Industry Personnel, in particular Trevor Shaw (Exploration Manager at Glencore)
- Other personnel at Glencore, Chinnova, ActiveX, Cudeco, Exco, Hammer Metals, GBM and Chinnalco for assistance, data and ground access.
- ALS laboratories, Imdex (pxrf)

Outline

- Project
- Exploration 'current state of play'
- Structural Controls and Deformation
- Discrete Element Modelling
- Regional Eastern Mt Isa Modelling
- Local Scale Modelling
- Summary



Project Background

PROJECT TEAM: John McLellan (GMEX) Mat Brown (MBC) Nick Oliver (HCOV Global)

PROJECT OVERVIEW: To provide novel and alternative datasets for industry to revitalize their targeting strategies. This will be done by using innovative techniques of a combination of geomechanical modelling with a geochemical and structural field focus.

WORKFLOW: The cornerstone of the workflow will be the selection of areas of focus using map-based geomechanical models that simulate the passage of mineralizing fluids during faulting, and fusion of these areas of focus with other datasets, including regional geochemical datasets generated by major explorers (and augmented by our program) in the region in the last 20 or so years.

- This project is innovative and introduces new concepts to highlight the mineral potential in the eastern Mt Isa Block
- The team has extensive experience in the district, and also in prior collaborations, and has a collective skill set optimised for this project.
- The project outputs will benefit companies with a major interest in exploration for new Cu, Cu-Au (including IOCG) and Au-only deposits, but also others looking for structurally controlled deposits of any style.
- Access to this data is now freely available as digital maps and spatial (GIS based) information

Exploration Success

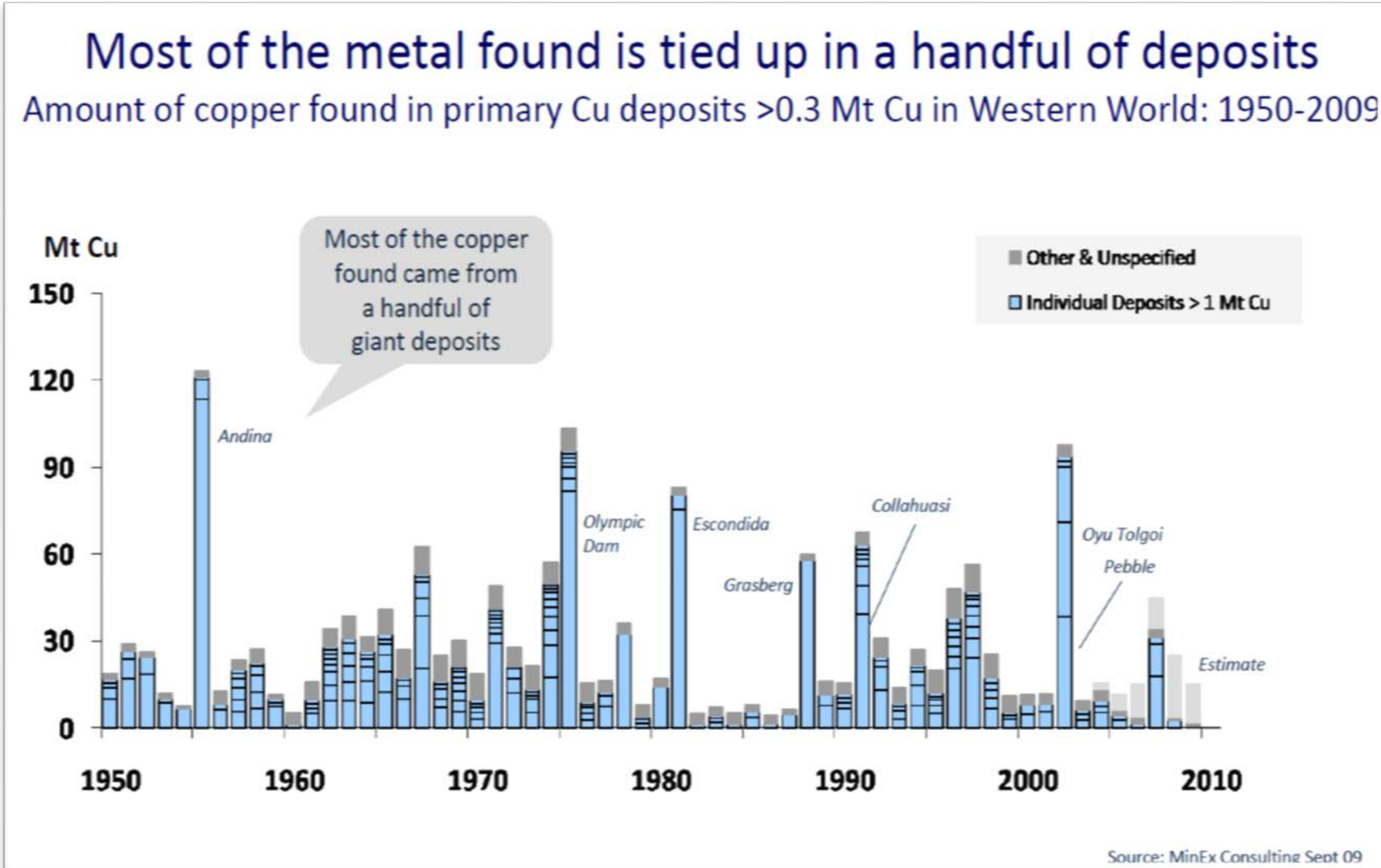
- NW Queensland has a significant problem
- Mines are closing or in depletion (Osborne/Century/Cannington/Eloise)
- Long term projects with resources not in production (Swan, Merlin, Dugald River)
- 8-9 year lag time between Discovery and Production
- No significant discoveries in last 15 years

- Why are few deposits being found?

Either:

a) They've all been found or b) The techniques being used are no longer as effective

Exploration Success



Project Background

- The current exploration methodology no longer works
- Low hanging fruit has been picked
- No real advancement in geochemistry or geophysics in this time
- Geochemistry - more accurate/precise assaying but we are still using the same sampling methods (with a few exceptions)
- Geophysics – putting more power into the ground and improving noise to signal ratios, maybe some funky processing but we are still measuring the same six physical parameters.

Where is the 'step change' coming from?

IOCG Mineralisation in Mt Isa Block: What Do We Know?

1. We know deformation events and mineralisation are linked
2. Deformation provides fluid pathways and fluid focussing
3. Structural Controls are one of the most important aspects of these deposits

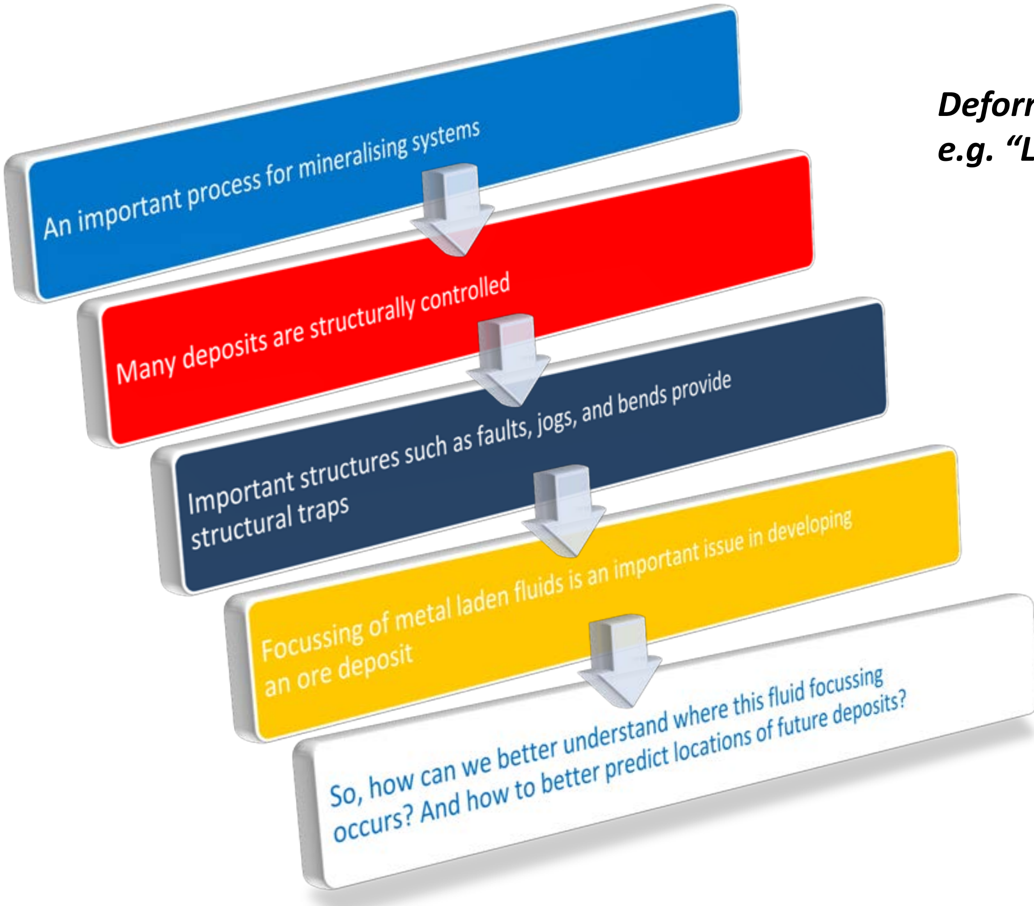
Structural Controls of Mineralisation

- This term means many things to many people (stress, strain, styles of failure, timing in relation to deformation)
- It can change readily with scale (mine scale to regional scale)
- People tend to scale up or scale down and expect the same controls at all scales – not always the case
- Stress rotation is real and difficult to determine (needs lots of measurements in lots of places)
- Applying regional conditions to large scale areas often results in complexities at the smaller scale

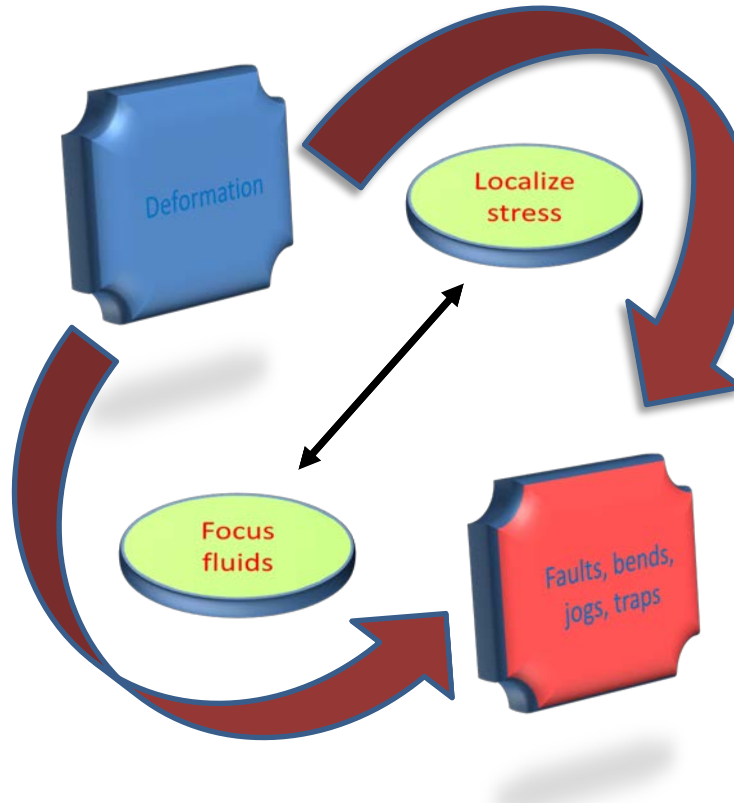
Structural Controls, Prospectivity Analyses and Targeting

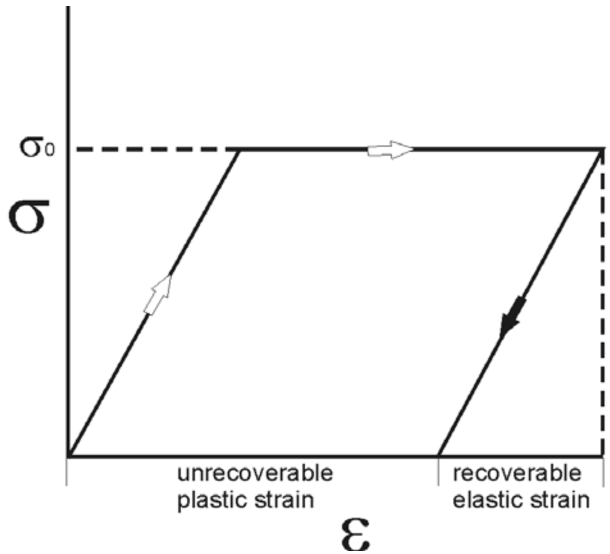
- Mostly a large database of structural measurements and stereonets to explain trends
- Interpretation leads to generalisations of what orientations of faults are most related to mineralisation
- These generalisations are then often weighted /ranked as critical parameters in prospectivity analyses
- Are they really explaining the multi-scale parameters of geology?
- How do we quantify this and use it to be predictive?

Understand the Geomechanics



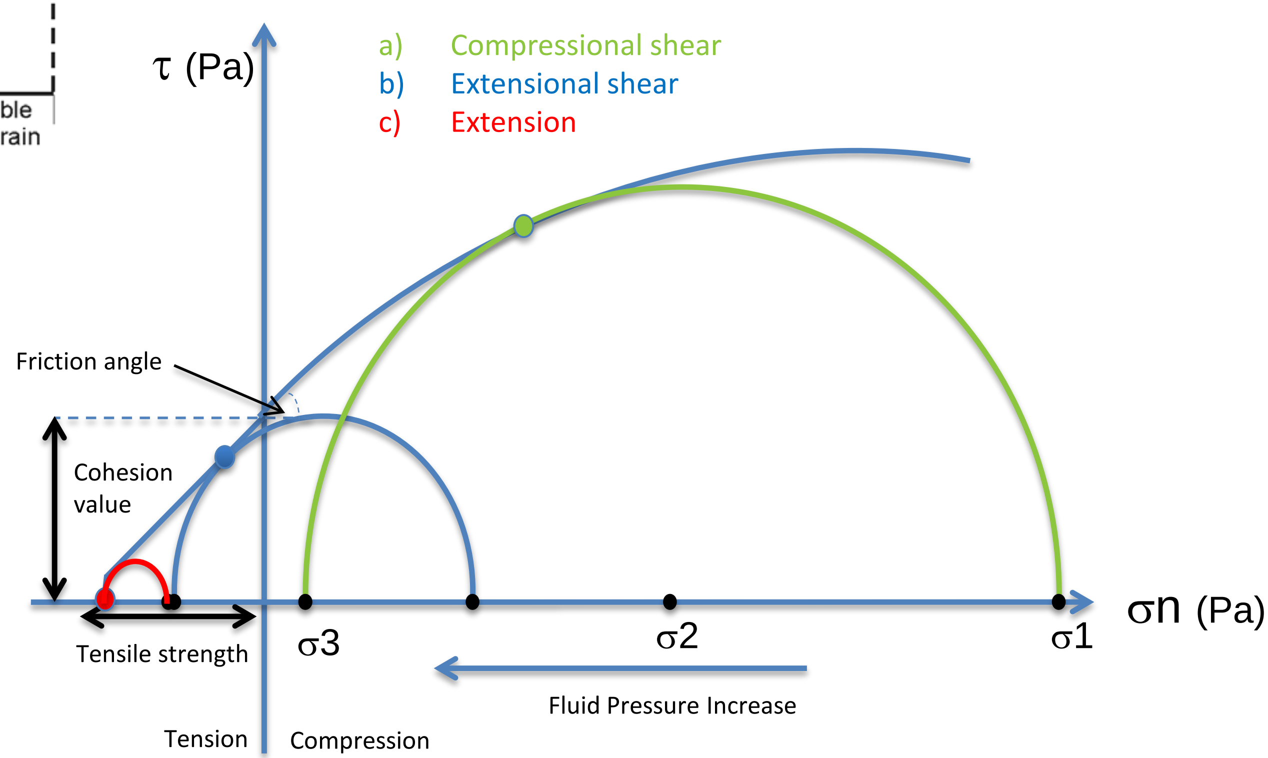
Deformation is generally coupled with fluid e.g. "Law of effective stress"





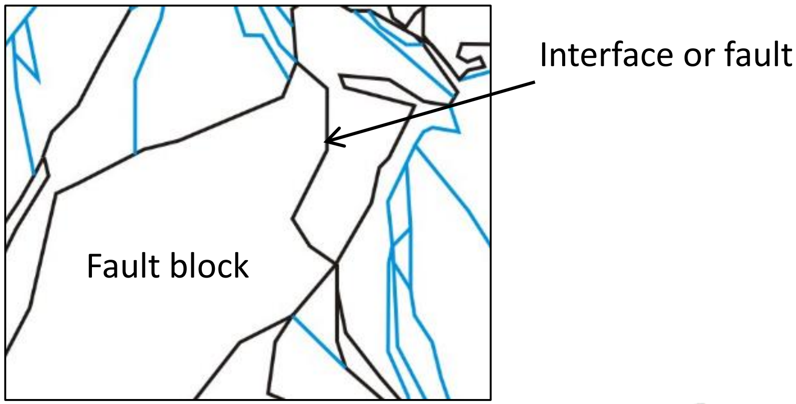
Given specific criteria e.g. rock properties, failure criteria, fluid pressures, we can deduce when a rock will fail in either

a) Compressional shear
b) Extensional shear
c) Extension

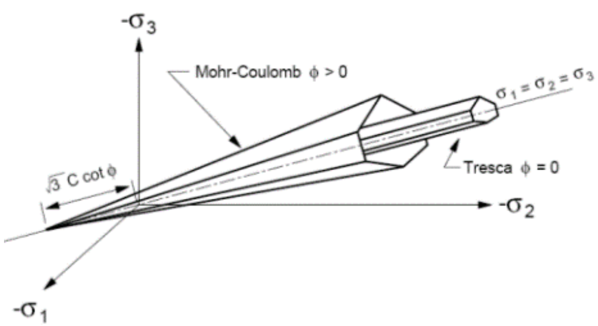


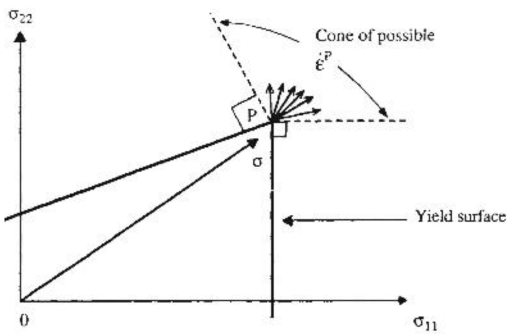
Discrete Element Modelling

- A method to simulate the behaviour of discrete blocks and their interfaces
- Represents discontinuous deformation where fault movement transfers stress into country rock
- Stress and strain calculated in both fault block material and at contacts/interfaces (faults)
- Strike slip movement in 2d can result in stress transfer into fault blocks that condition for failure
- We can predict areas with the most favourable conditions for failure based on mechanics
- These favourable locations are important as they are potential zones of mineralisation



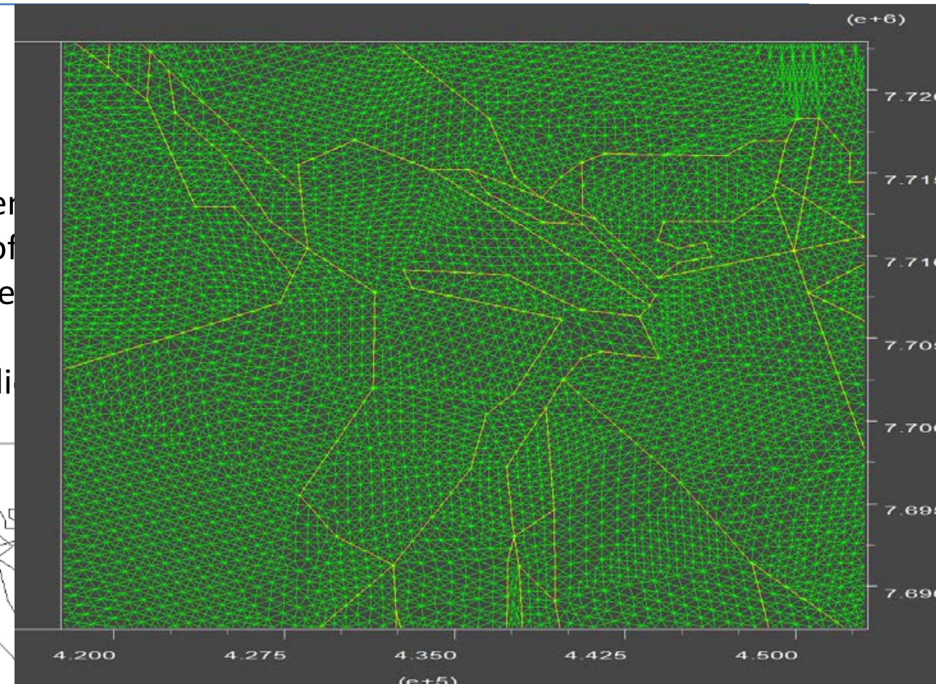
• DEM method therefore has to consider both the behaviour of the block material (rock) and the contacts (faults)
• That behaviour is driven by an underlying constitutive theory (Mohr-Coulomb) which determines how stress/strain is partitioned and failure criteria applied

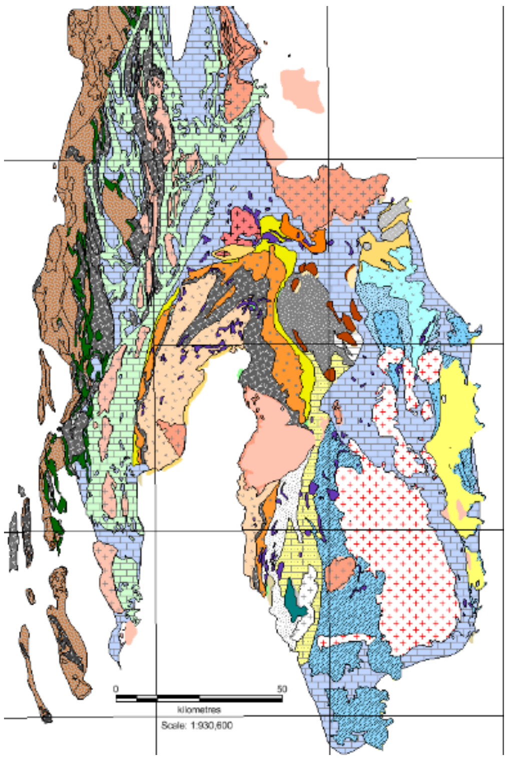


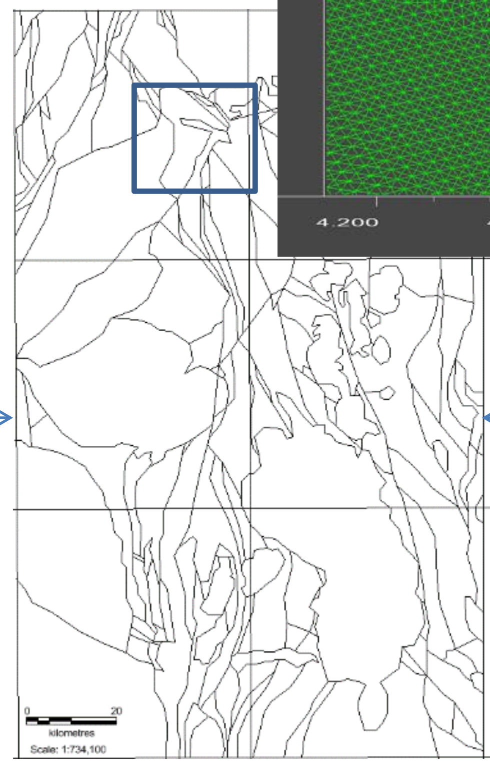


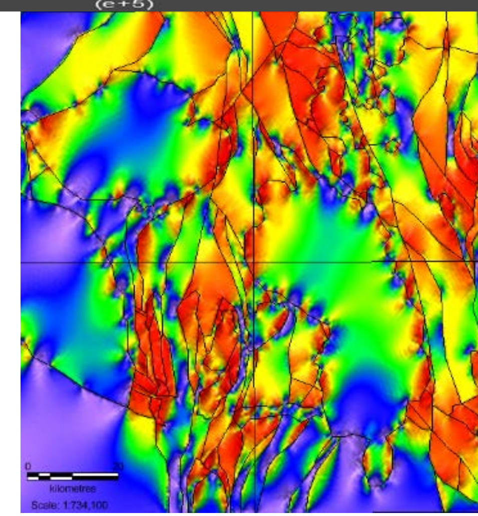
DEM Methodology

- 2d conceptual model derived from the geology
- Models are constructed and meshed into discrete eler
- Elements and Architecture represent faulted blocks of
- Stress is applied commensurate with deformation eve
- Models are interpolated and anomalies highlighted
- Anomalies represent predictive targets to be field vali



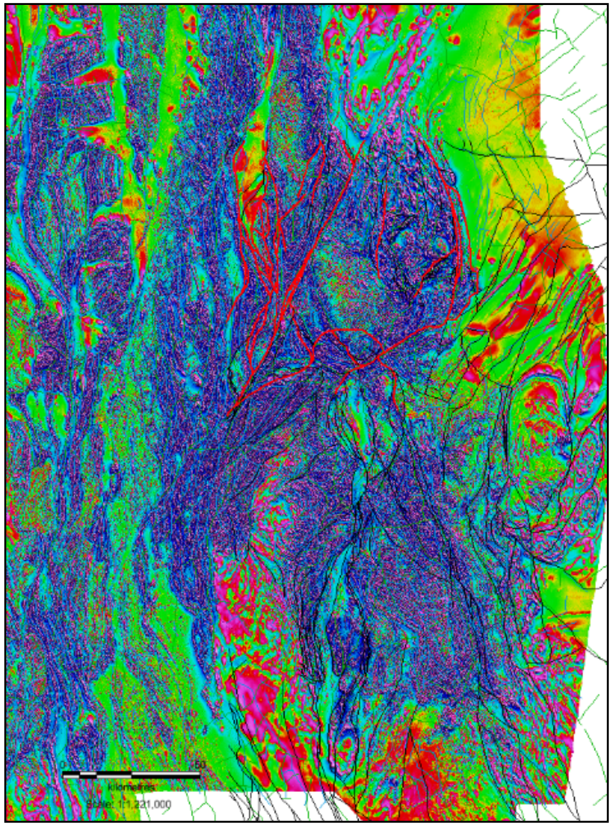


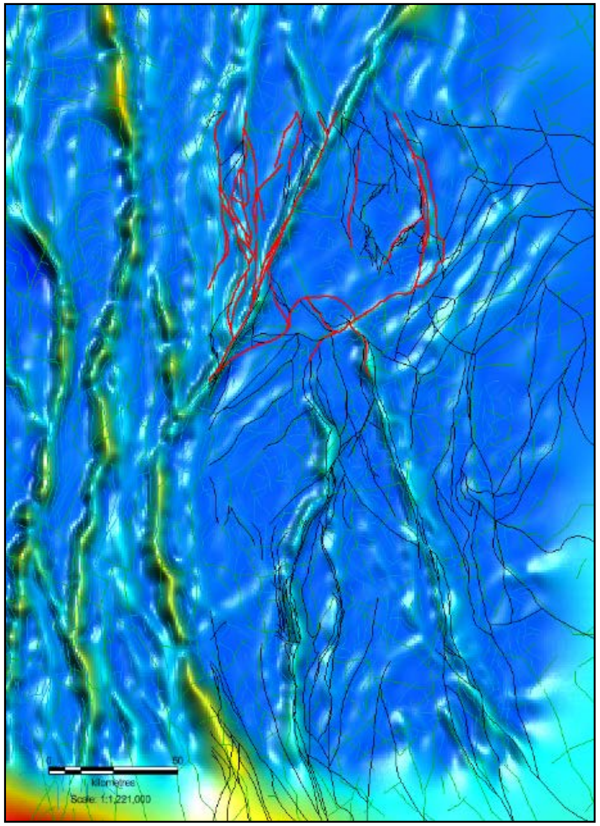




Model Input data

- Published geological mapping (250k, 100k and local scale)
- GSQ data including mapping and 3D models (Quamby and Mt Dore)
- Industry confidential datasets (mapping and geophysics)
- Mapping (this project for local scale modelling)
- Geophysics and Gravity data (RTP 1VD, Worm data from pmd*CRC)



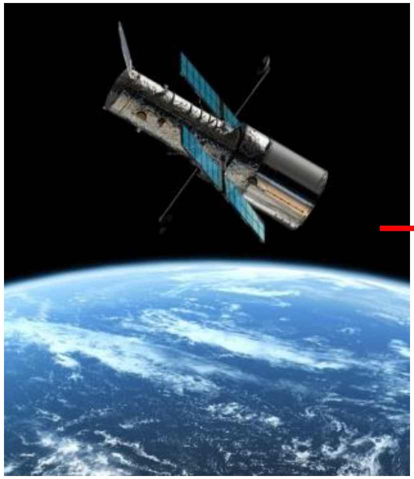


Scales for Scales

Important:

This process is iterative and scalar, a large-scale model will give you large or broad scale targets!

To refine the detail you need to undertake small-scale models

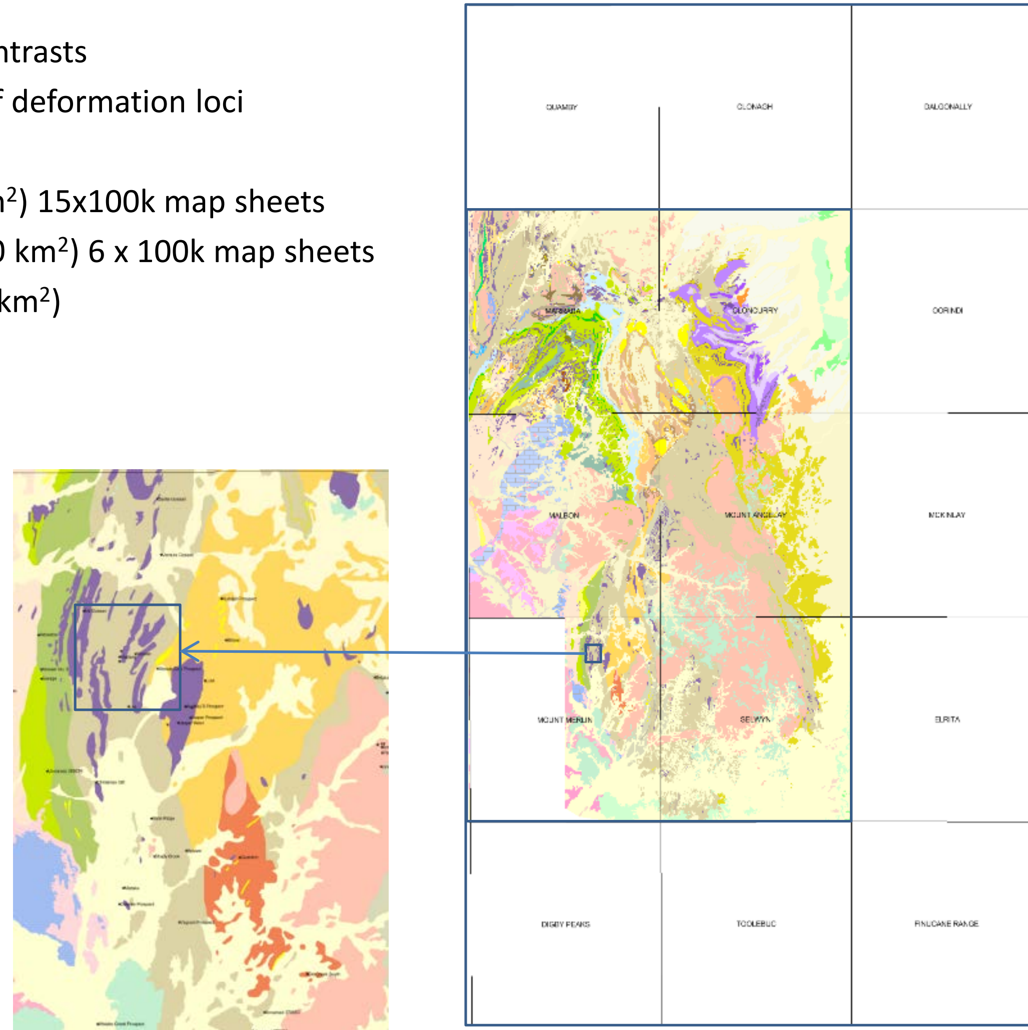


Eastern Mt Isa Block–Modelling Scales

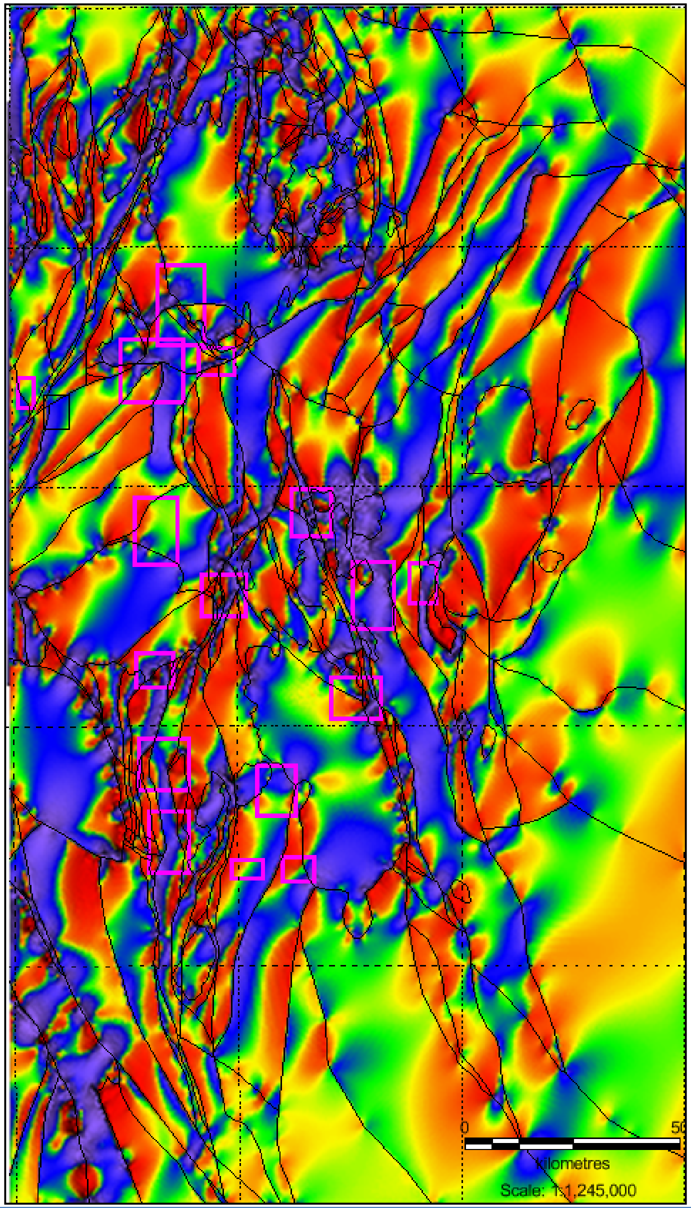
- Structurally controlled mineralisation
- Fault controlled system with competency contrasts
- Aim: to identify the most favourable areas of deformation loci

Three scales of interest:

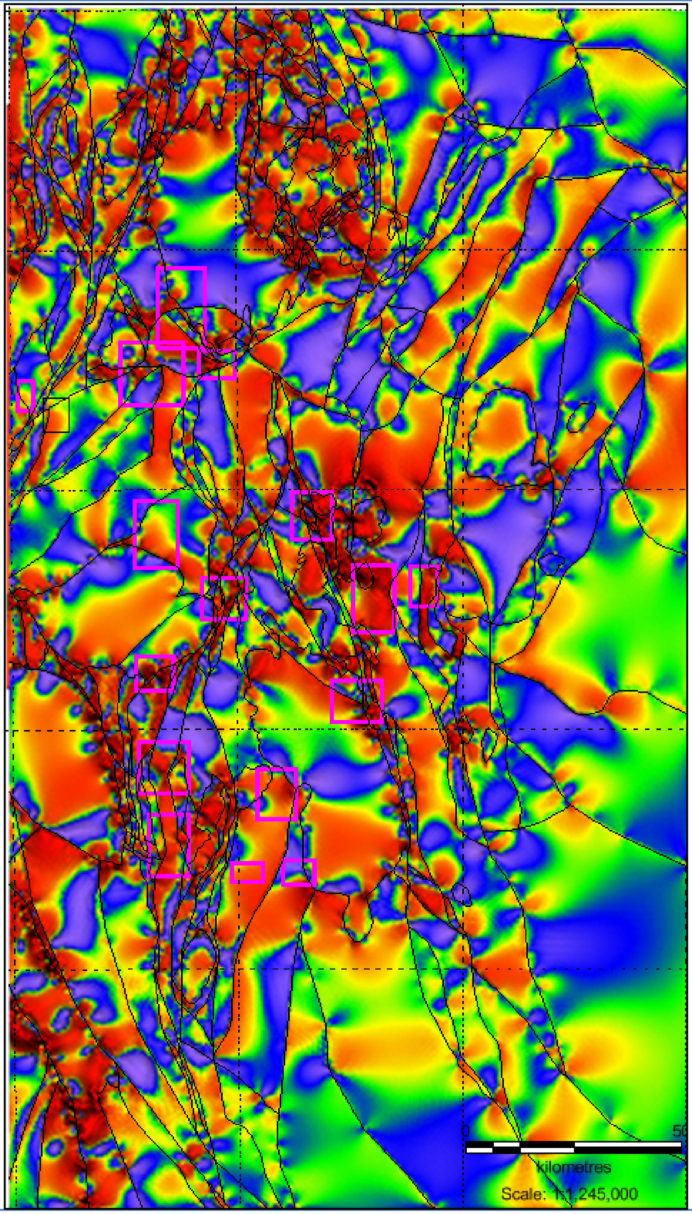
1. Large Scale Regional Modelling (~43,000 km^2) 15x100k map sheets
2. Medium Scale Regional Modelling (~ 17,000 km^2) 6 x 100k map sheets
3. Small Scale Local Modelling (between 0-25 km^2)



Large Scale

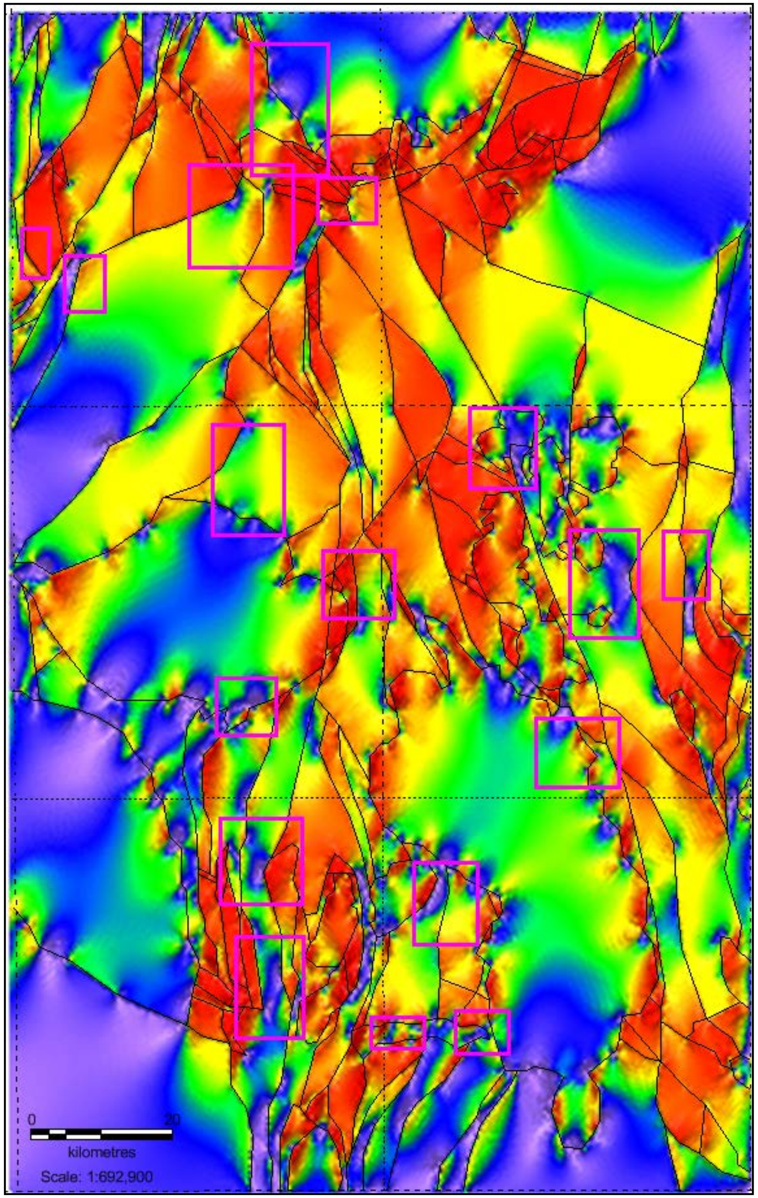


$\sigma 3$

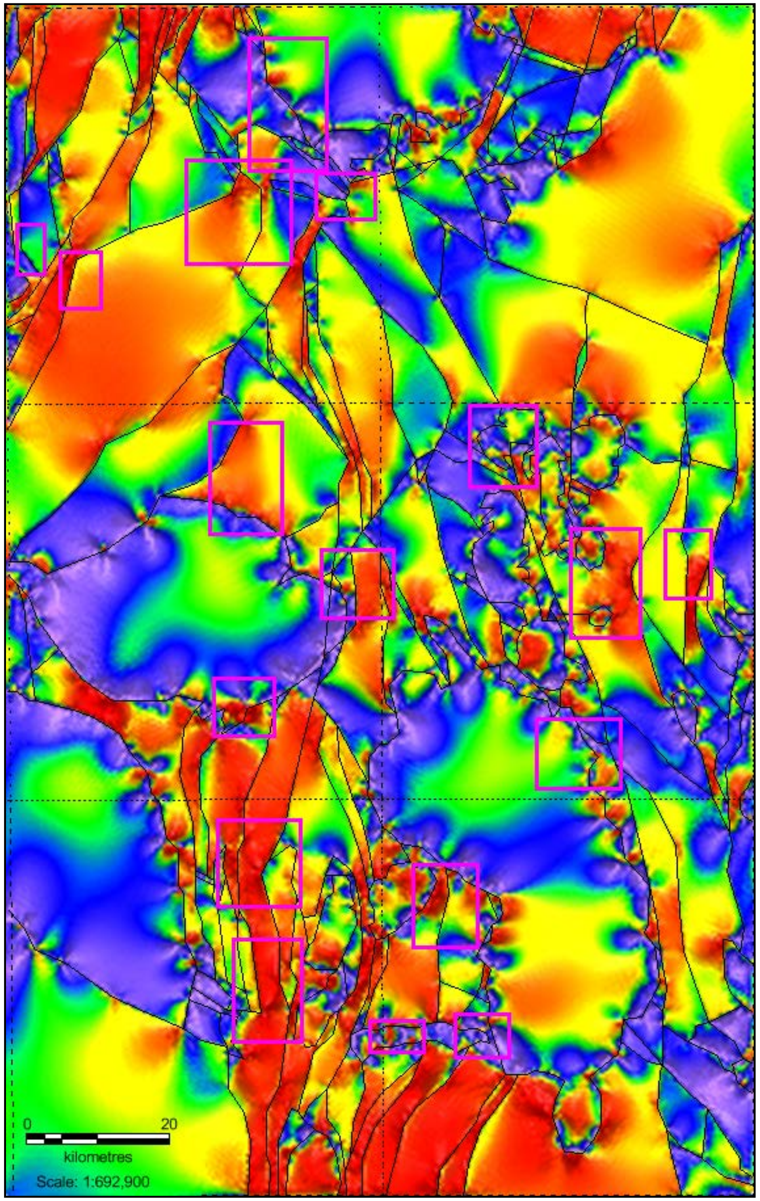


$\Delta\sigma$

Medium Scale

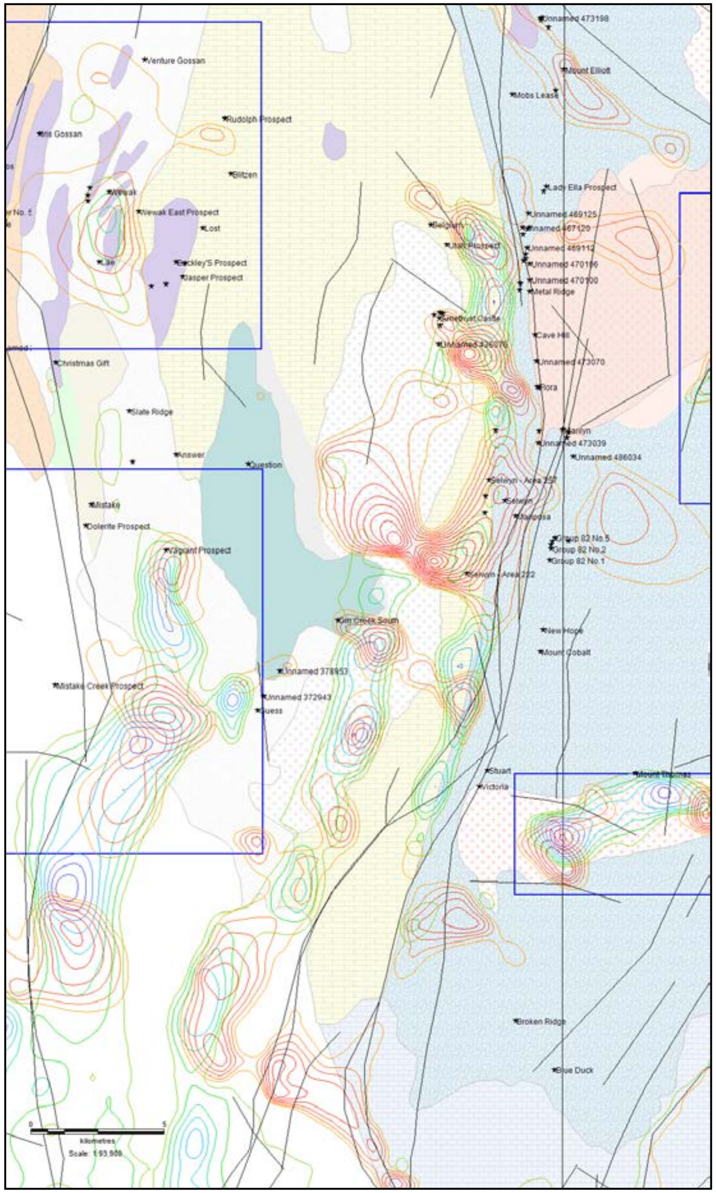


σ3

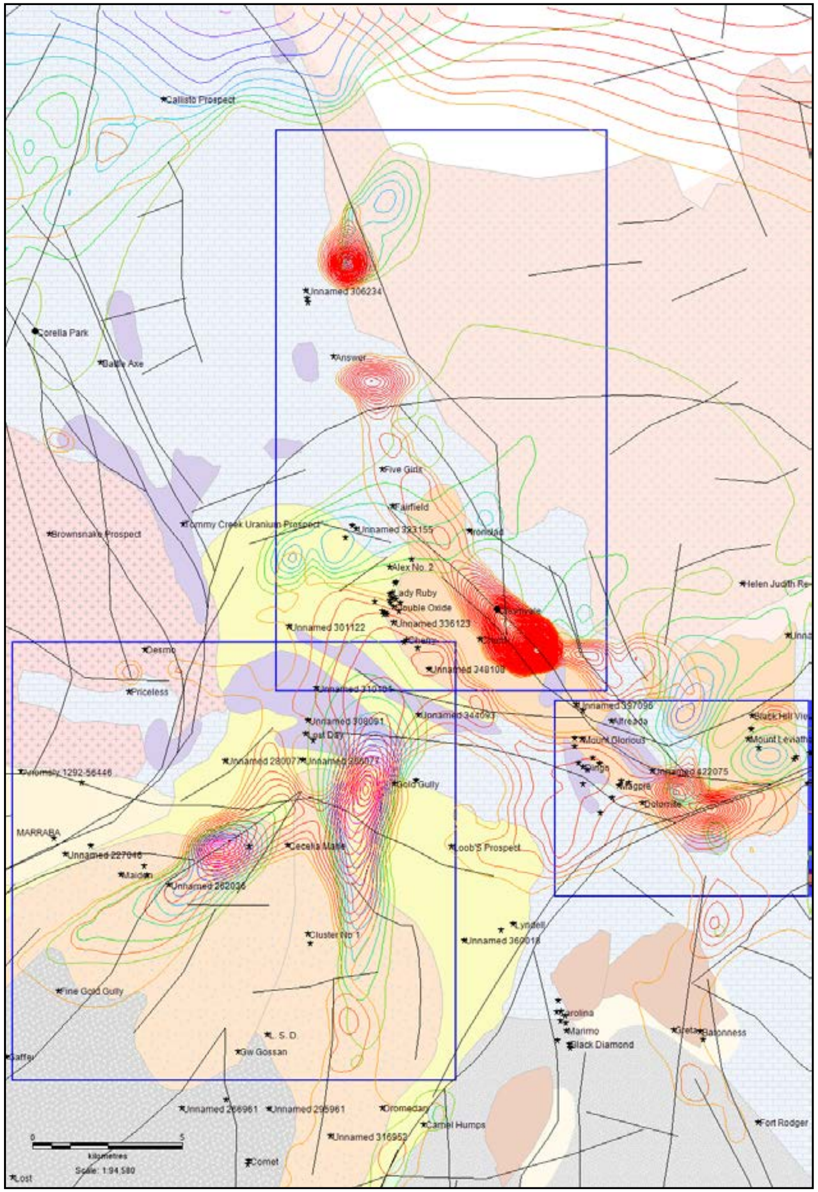


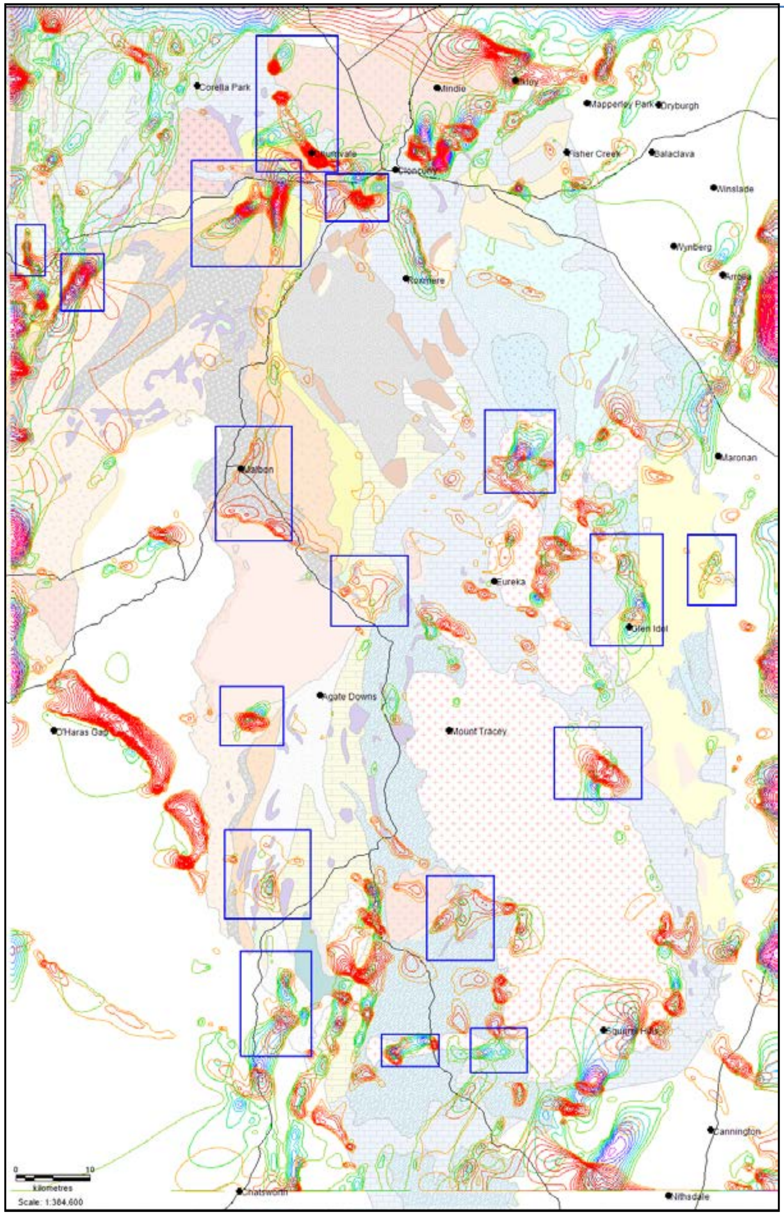
Δσ

Location: Selwyn Corridor



Location: Cloncurry/Chumvale





Areas of Interest:

A desktop exercise was undertaken to ascertain the most prospective areas for ground truthing based upon several criteria, namely:

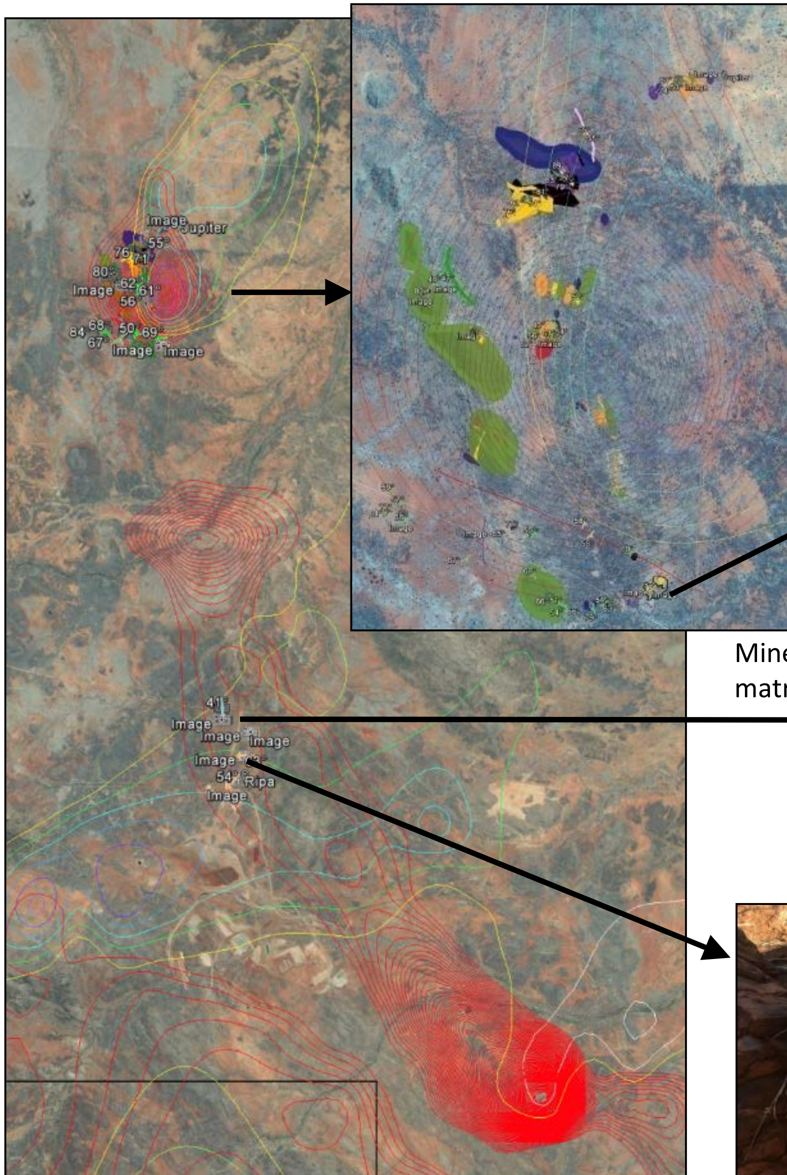
1. Geomechanical suitability (low minimum principal stress and high differential stress)
2. Favourable geology based on fault architecture and competency contrasts
3. Geophysical signatures
4. Geochemical signatures (or lack of geochemical data)
5. Tenement Access and physical locality

Initially approximately seventeen areas were highlighted; however, this was reduced to nine main areas following a reduction process which was primarily attributed to both physical access and field time constraints. The areas selected covered both the northern and southern areas of the region.

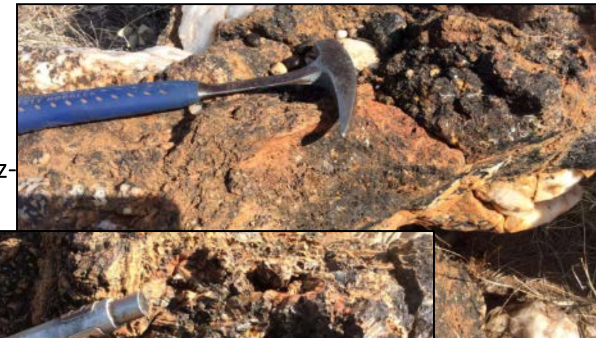
1. Ironclad
2. Kingfisher
3. Magpie
4. Elaine Dorothy
5. Brown Eye
6. Wewak
7. Mistake
8. Mort
9. Yellow Waterhole

Location 1: Ironclad

Location 1: Ironclad



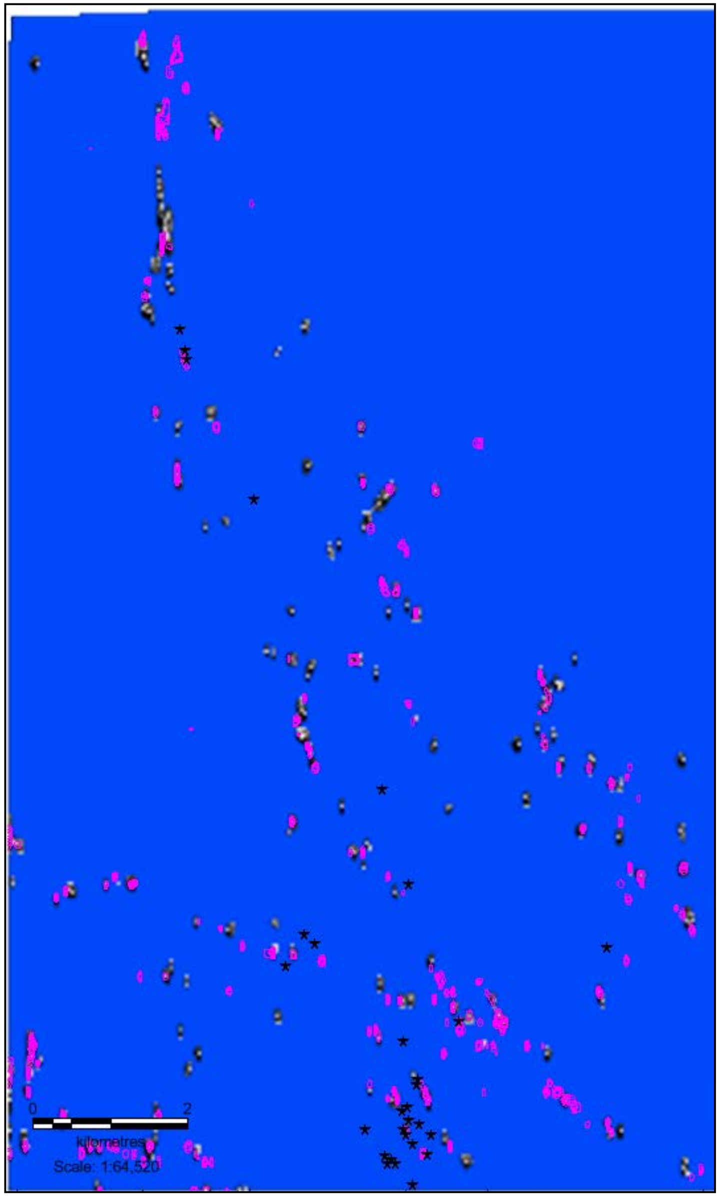
Copper Mineralisation (sulphides & Oxides in a quartz-tourmaline veins



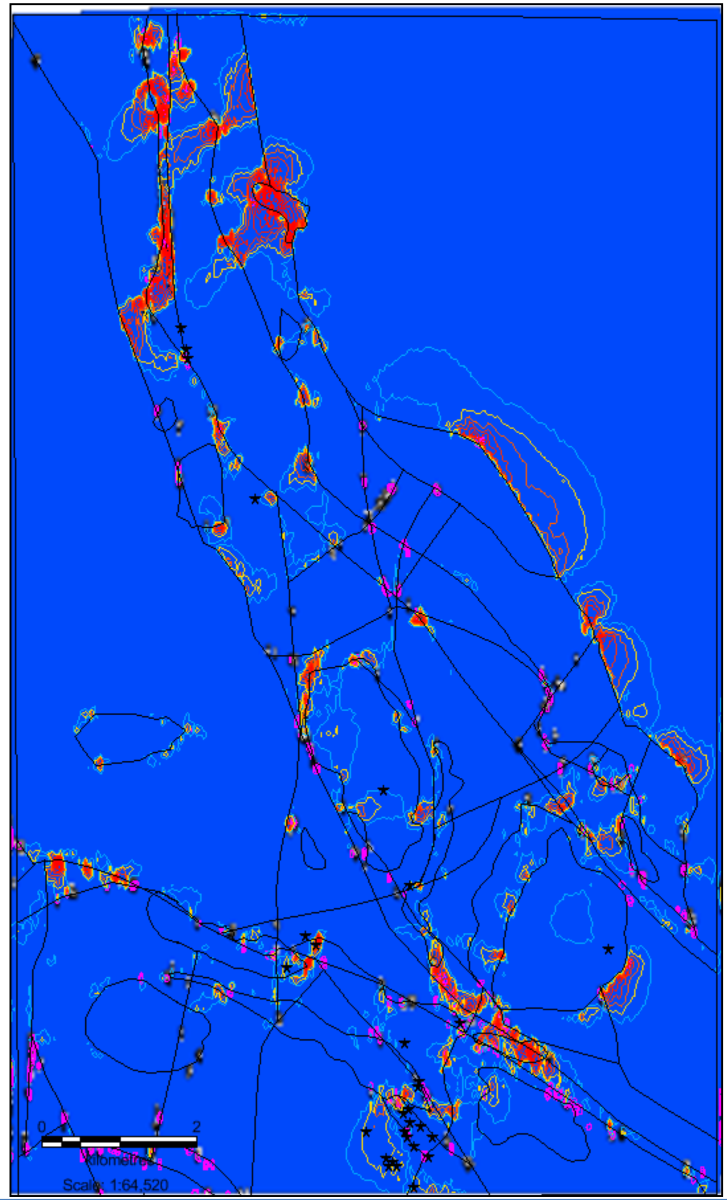
Mineralised breccia. Semi rounded Quartz and calcsilicate fragments in a matrix of actinolite hematite

Folding in Overhang Jasperlite

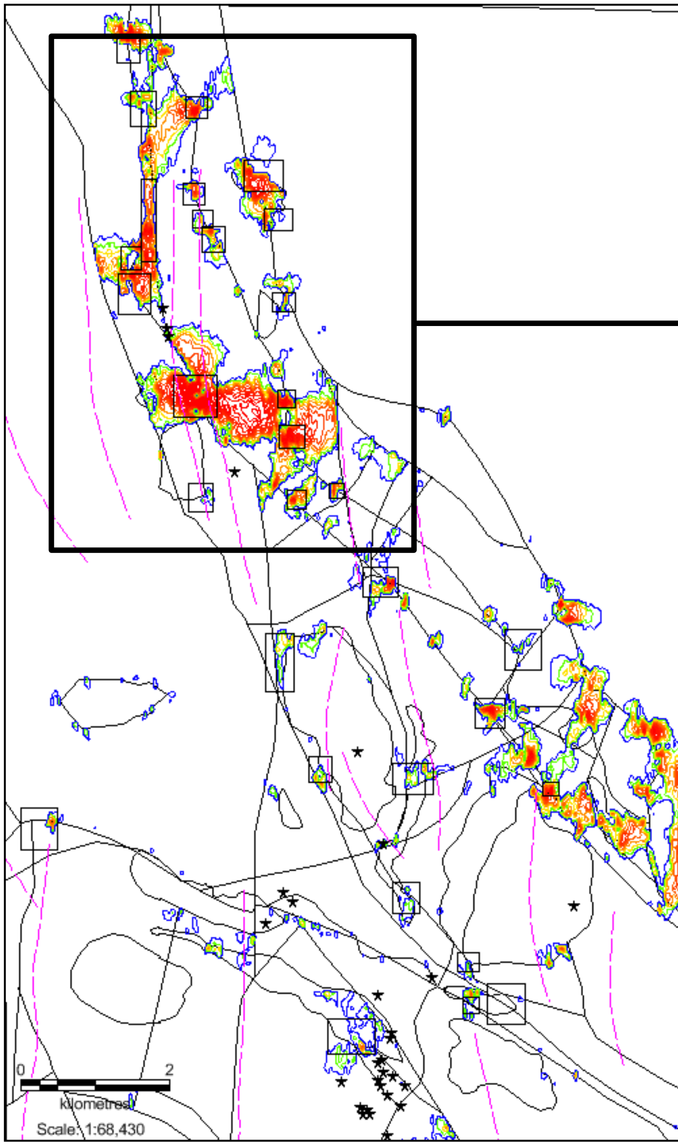
Location 1: Ironclad



State
NE-Pink
ESE-Gold



NE $\Delta\sigma$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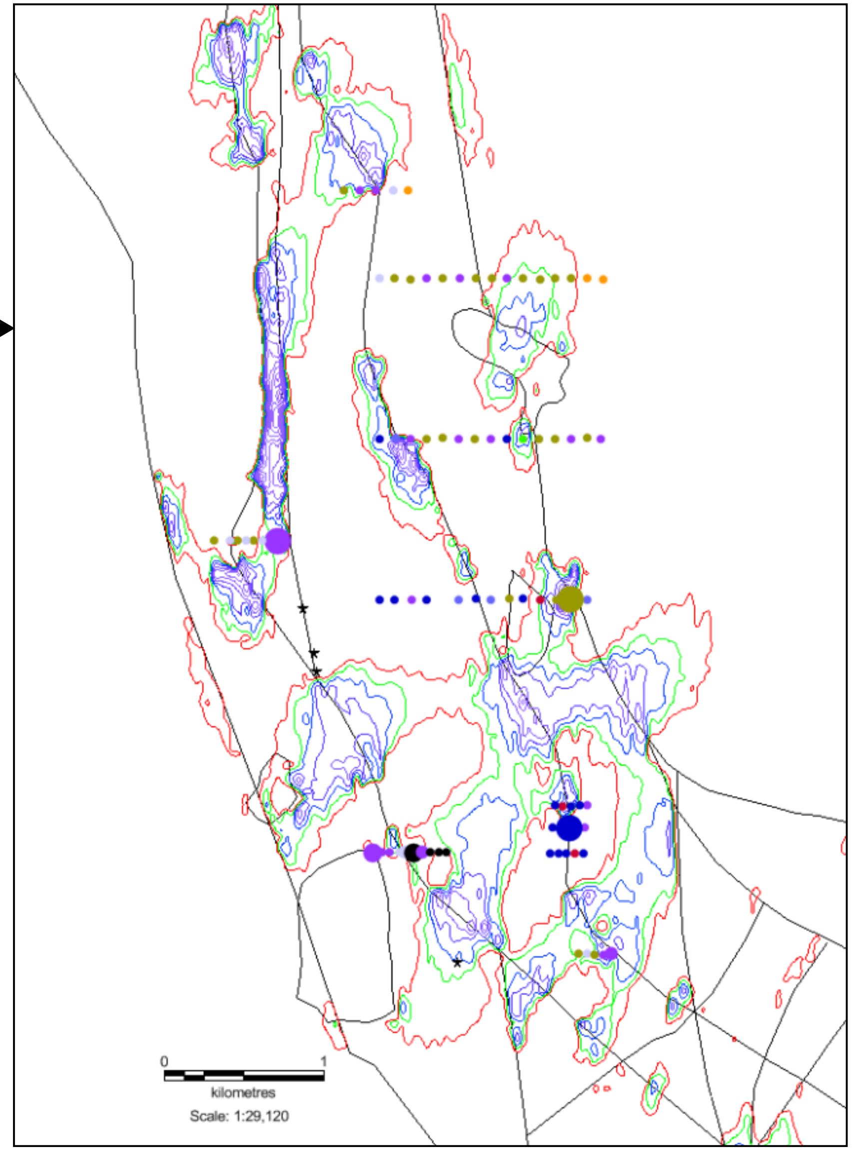
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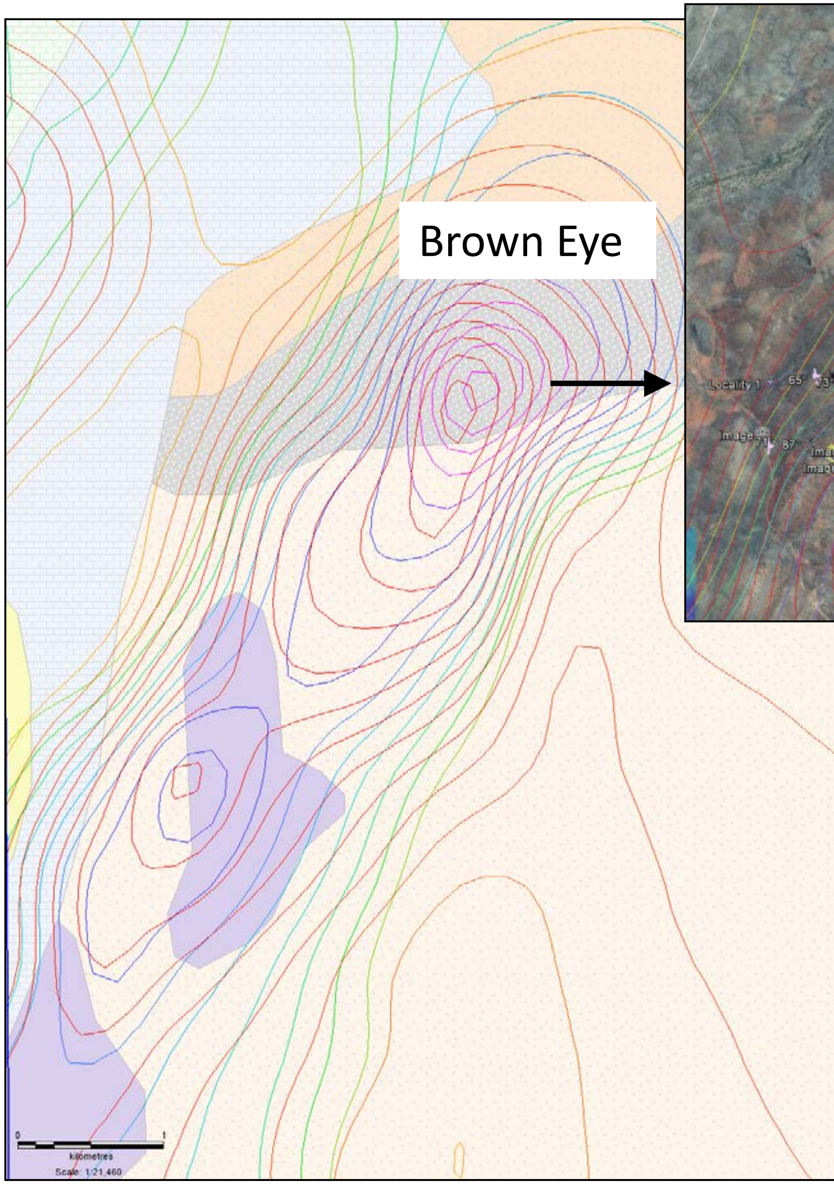
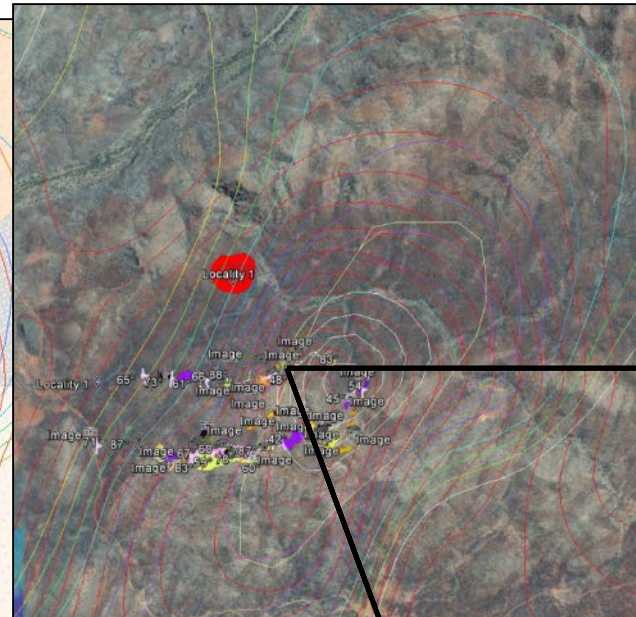
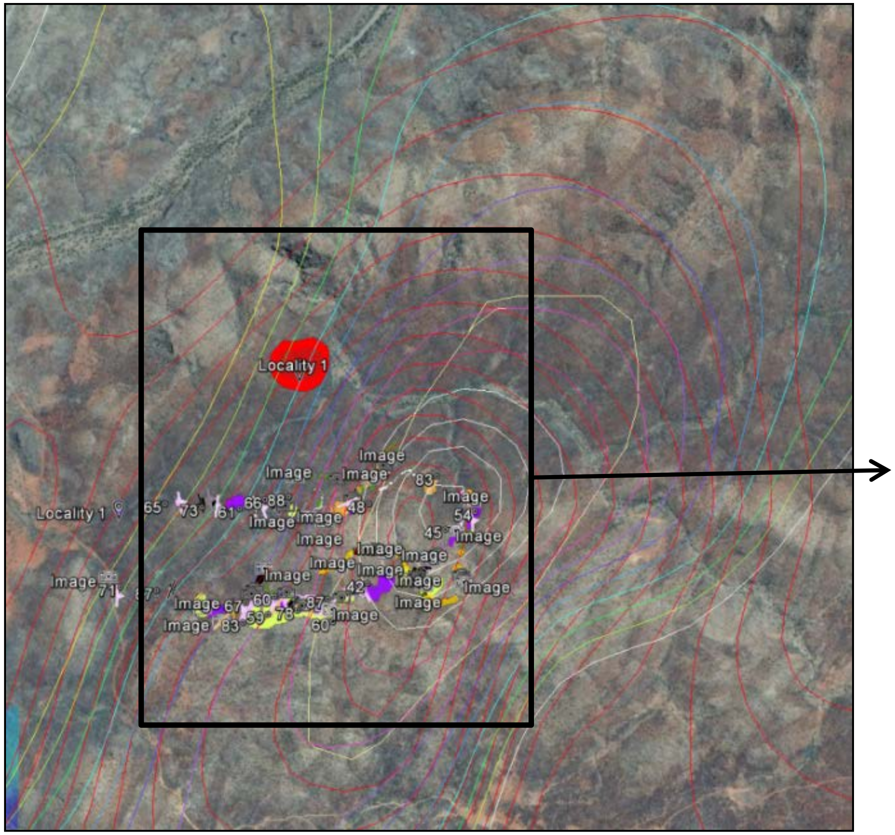


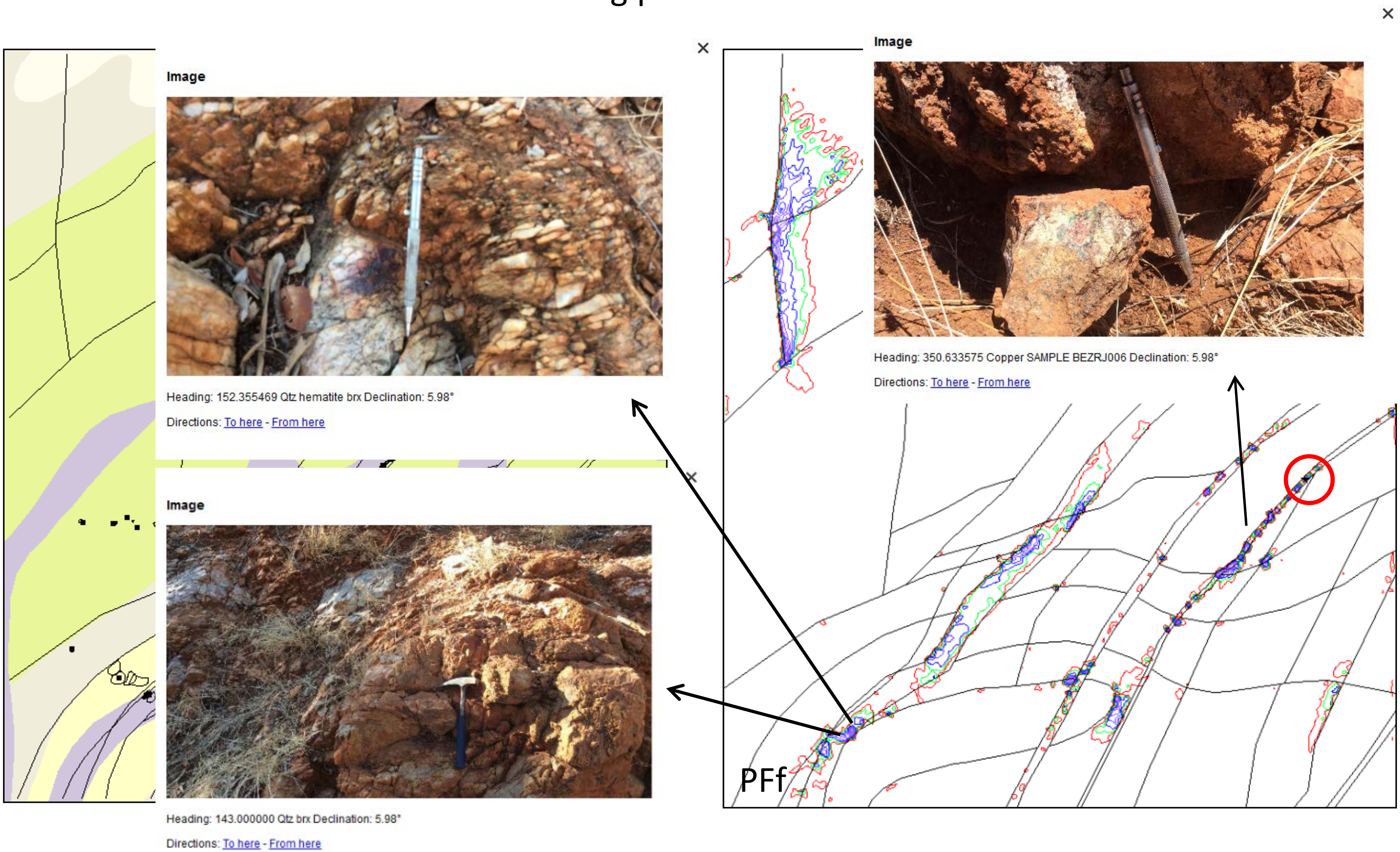


Cu-rich quartz hematite breccias

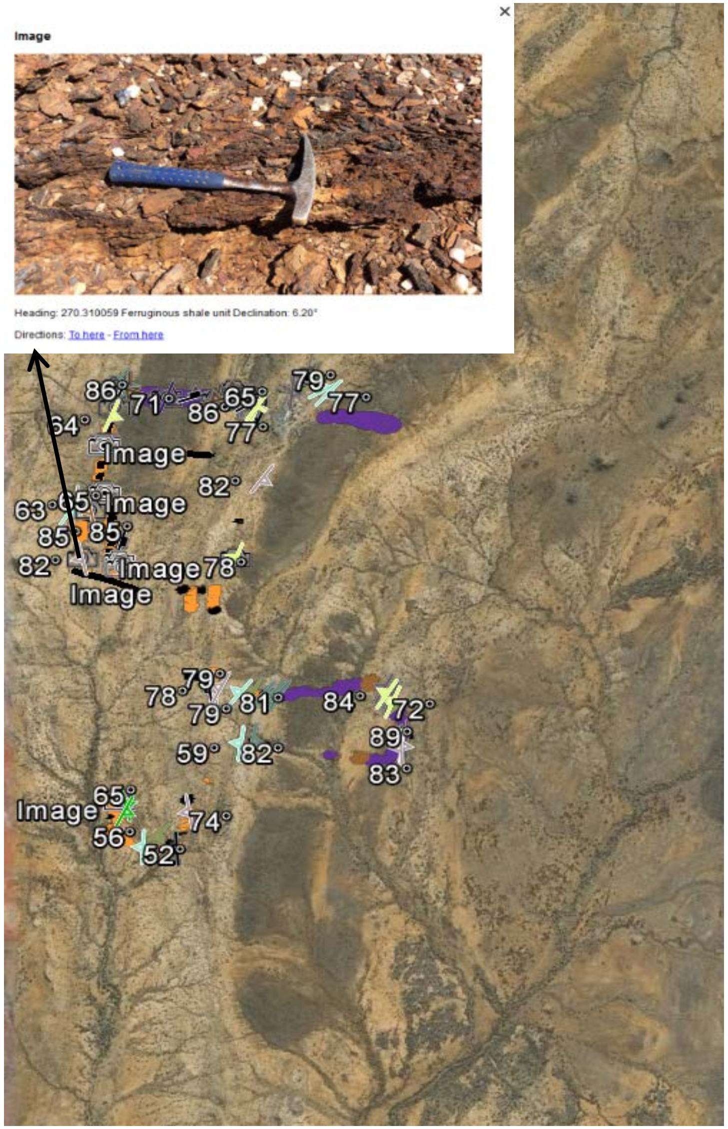
Local scale Geomechanical Modelling post fieldwork

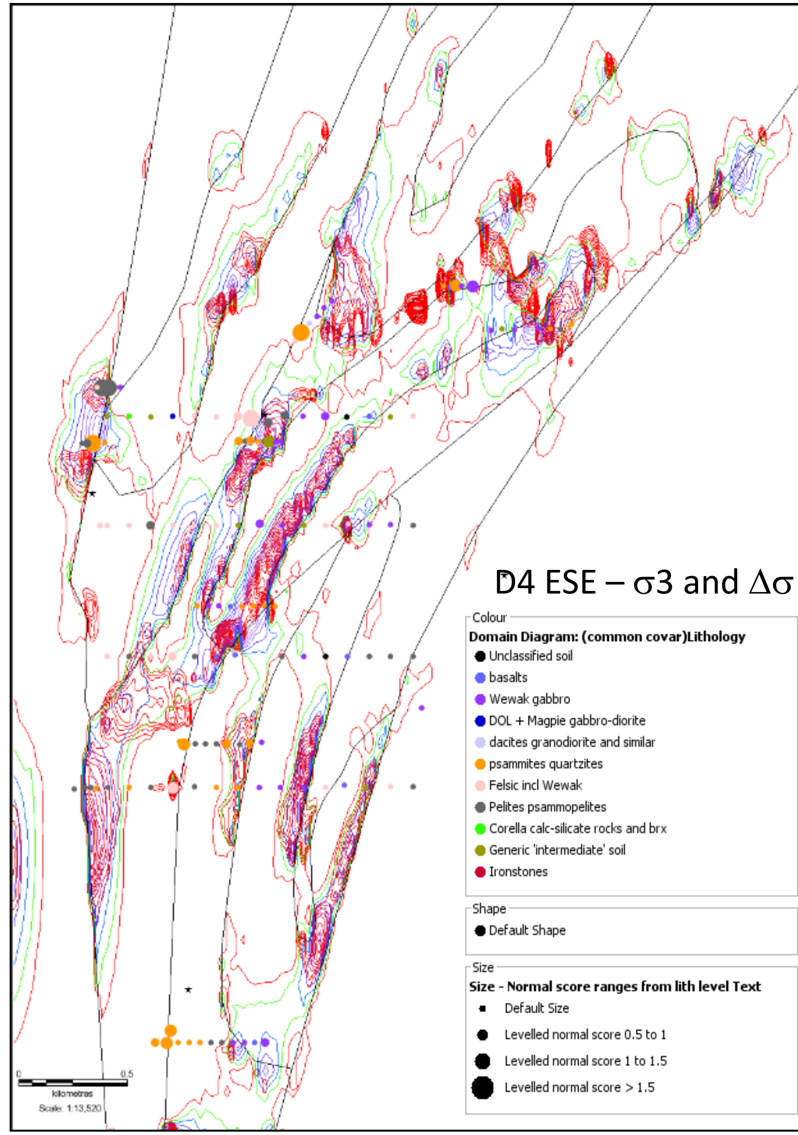


Local scale Geomechanical Modelling post fieldwork



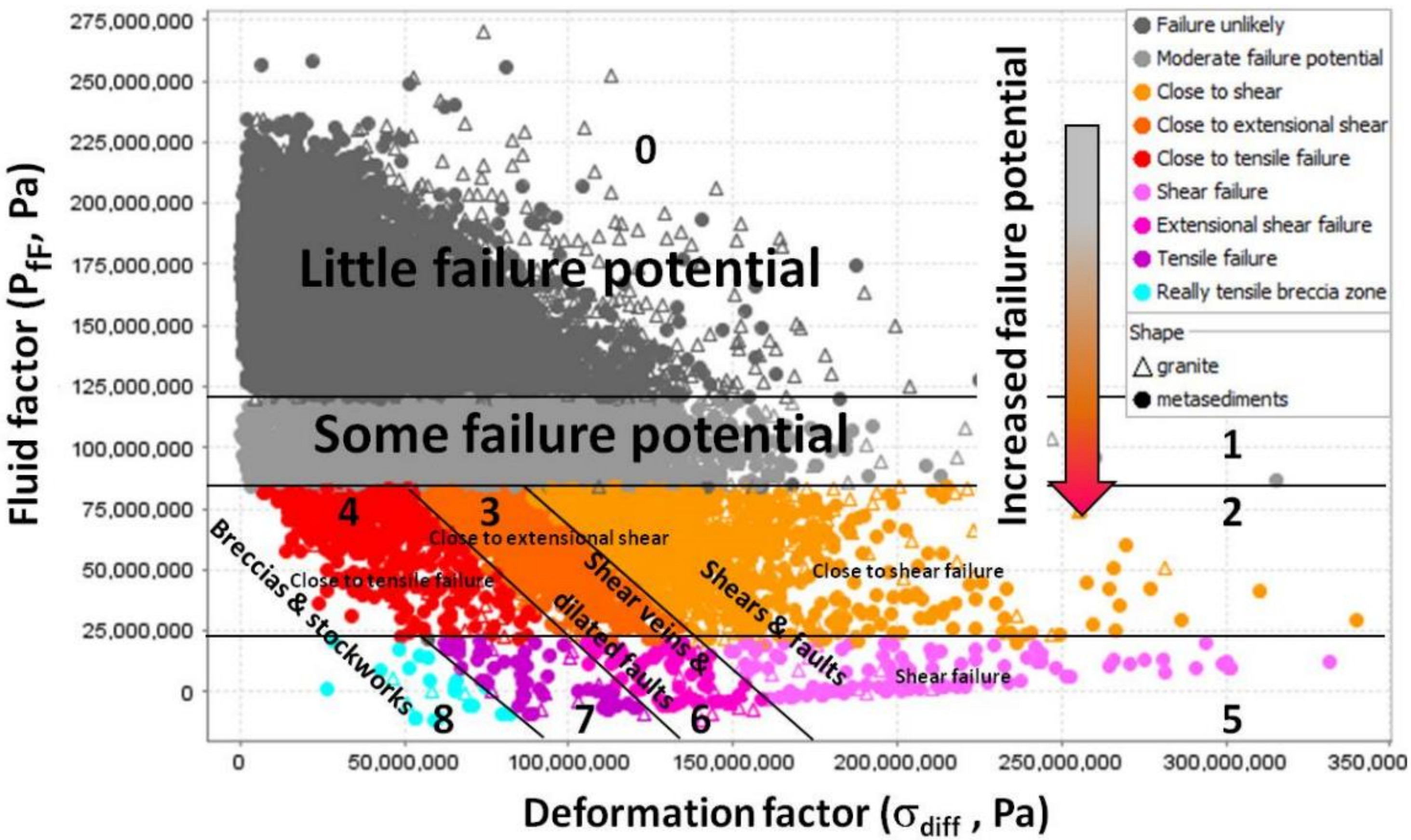
Local scale Geomechanical Modelling post fieldwork





Modelling outputs as Predictor Maps

Predictor Maps have been generated using IOGAS. These are based on the geomechanics and highlight areas most likely to fail based on material parameters and fluid pressures



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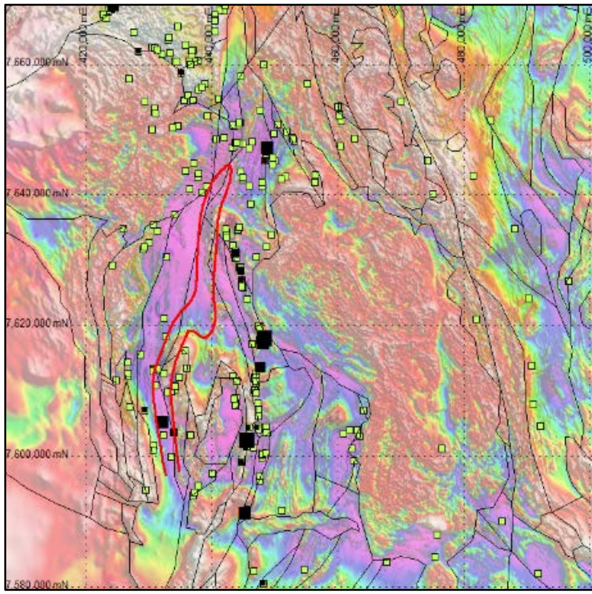

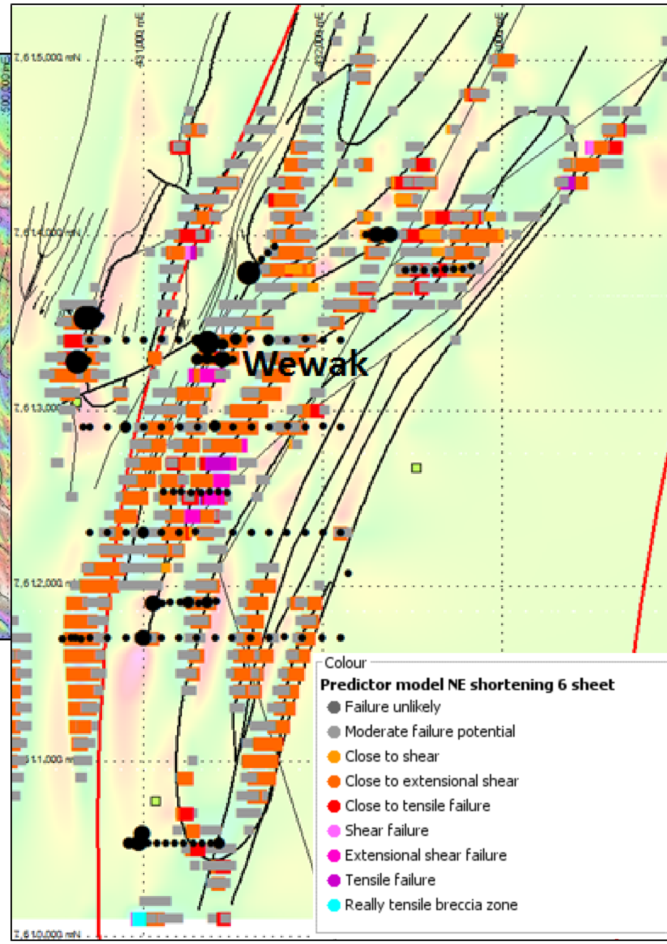

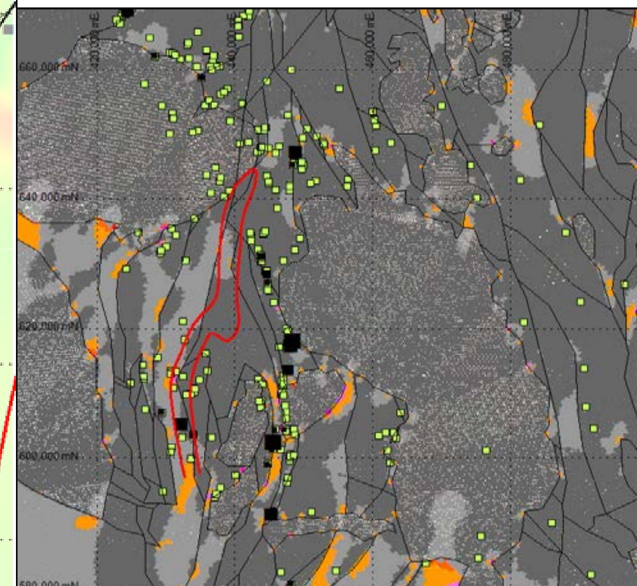

The ‘hits’ and ‘misses’ are now apparent but we have some basis for deciding on further work and/or drilling. You can see the original (red) Isa/Calvert Superbasin regional targeting lines, the (grey) angular lines from the regional rock boundaries in the 6-sheet geological model, and the (black) geology lines used to build a local UDEC model that relates to the Predictor coloured dot output.

Geomechanical Summary

- Lowest values of both minimal principal stress and fluid pressure required for failure, areas of failure and high values of differential stress provide a good combination of variables for selecting geomechanical targets

- Not all geomechanically suitable areas contain known mineralisation, however, the premise of this work was to highlight the most structurally favourable sites as a data rich layer for prosectivity analayses

- The favourable geomechanical areas that have been ground truthed and validated, where outcrop was available high level deformation was clearly evident (e.g faulting, veining, shearing and brecciation)

- Many of these areas of prediction returned evidence of copper mineralisation

Modelling Outputs

- Outputs from the geomechanical modelling component of the project will consist of:

1. Raw output data for all areas modelled (regional to local scales)
2. Collated grid files that can easily be imported into many GIS environments
3. Information layers in Mapinfo formats
4. Brief guide to Geomechanics is also prepared to assist industry with understanding and using the data

QDEX Reports and DATA available at http://bit.ly/2k0shrr