SMI BRC
WH Bryan Mining & Geology Research Centre

DMQ Wrap-up – May 2017

Prospectivity Analysis

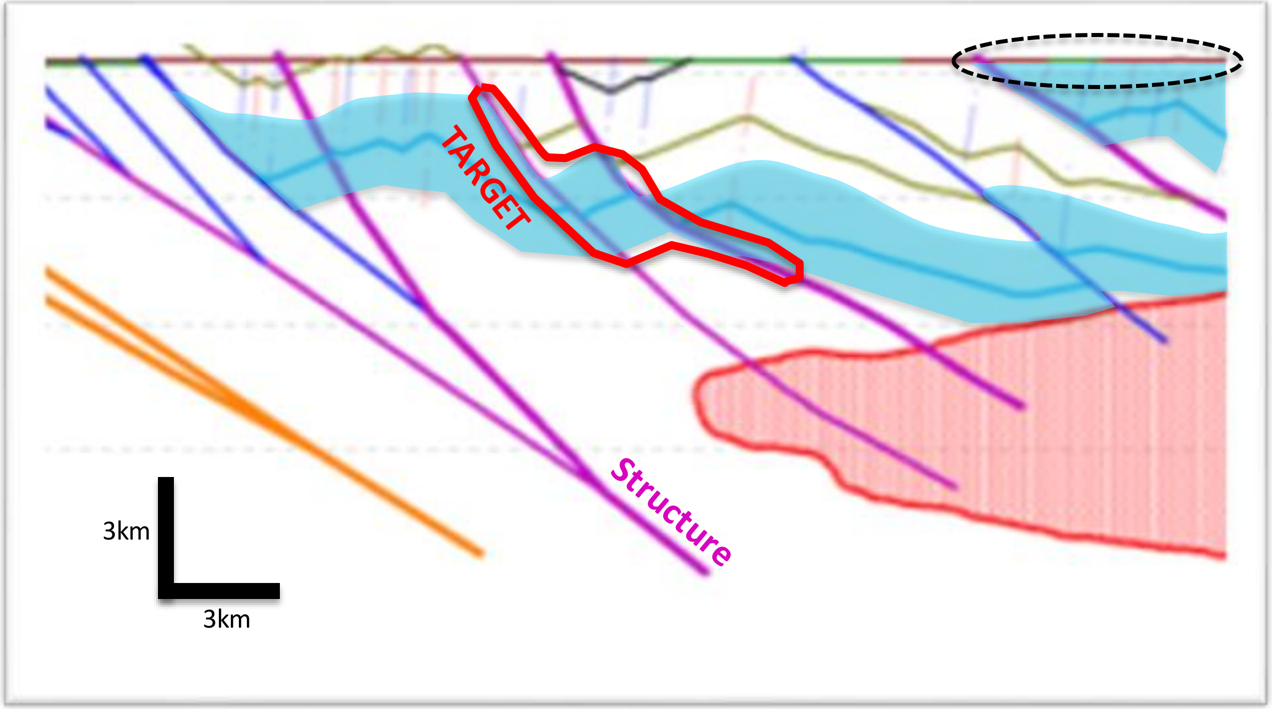
Brisbane, Queensland

16th May, 2017

The University of Queensland Australia

The Case for 3D Prospectivity Analysis

We don't live in a 2D world!



WOFE Inputs from here = barren

Host sequence

Intrusives

Geological Criteria Determining Prospectivity

Recapping : Cloncurry Cu-Au Essential Ingredients

- **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**
- 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**

Preferential Host Package

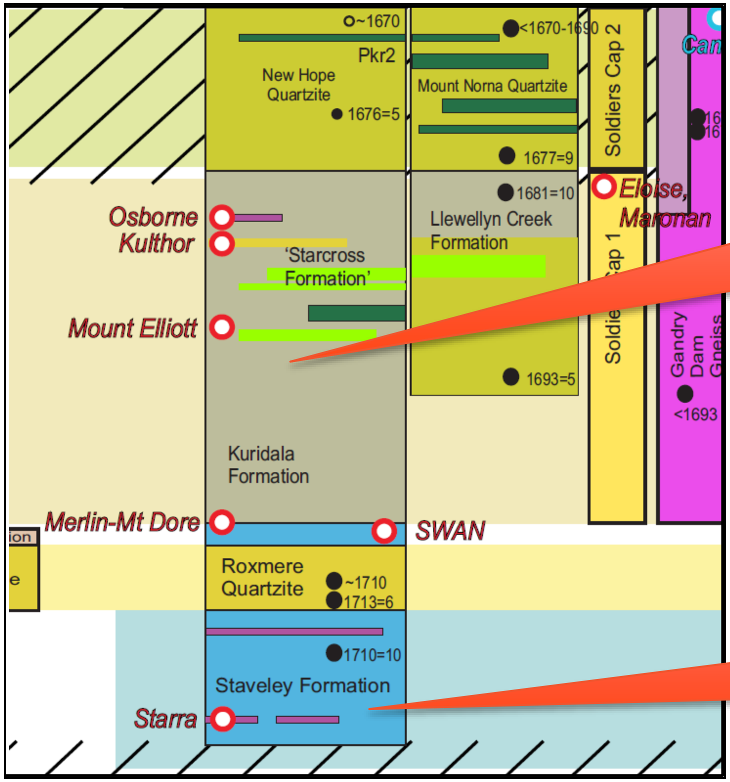


Figure 5.1 Excerpt of the Time-Space Chart (Figure 3.5) showing deposit localities relative to stratigraphy.

Metals precipitate when fluids interact with reduced (carbon or magnetite-bearing) host rocks

Oxidised and brittle calc-silicate sequence allows transport of metals and sulphate in oxidised saline brine

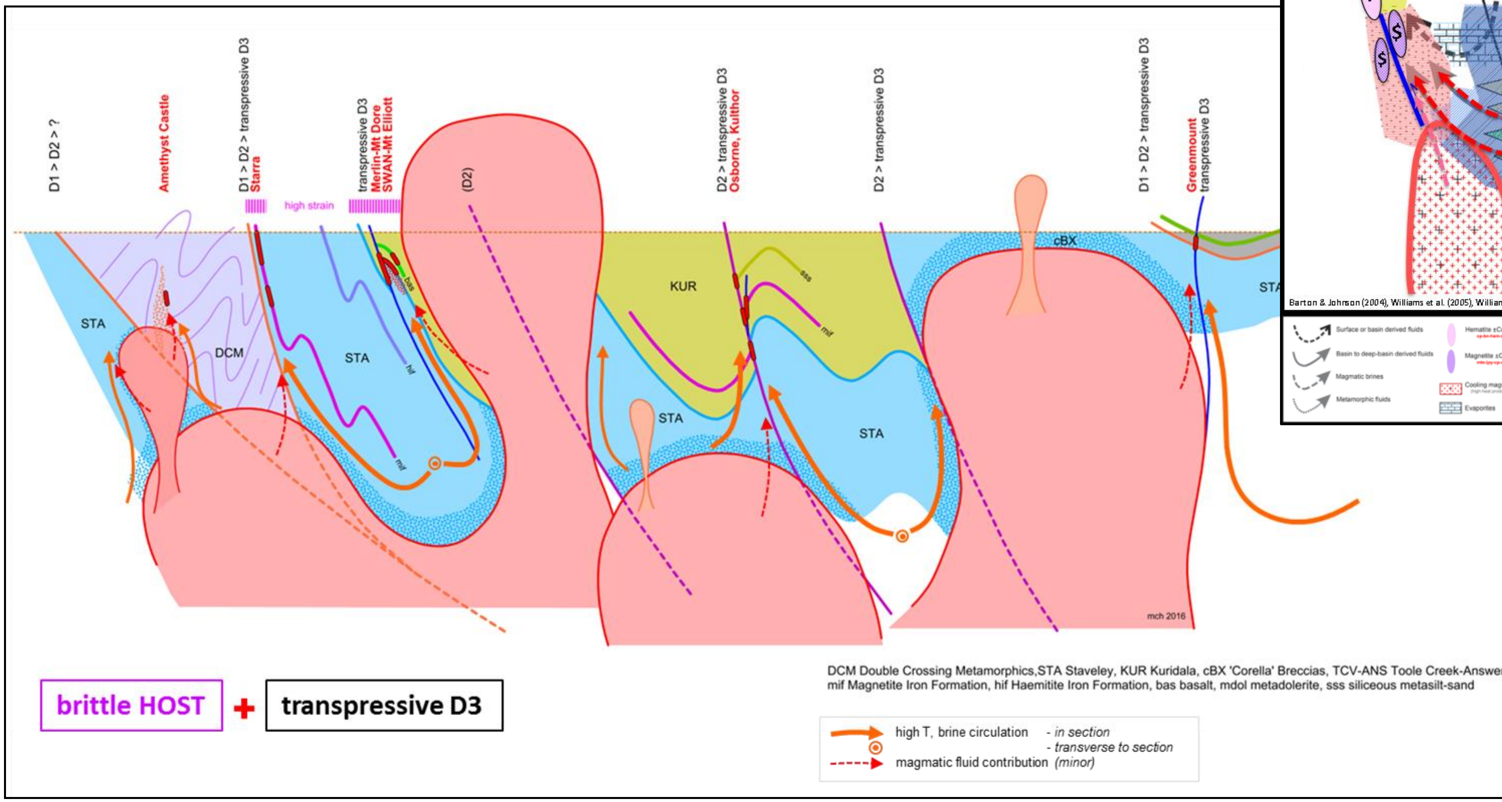
Groups by Deposit-style

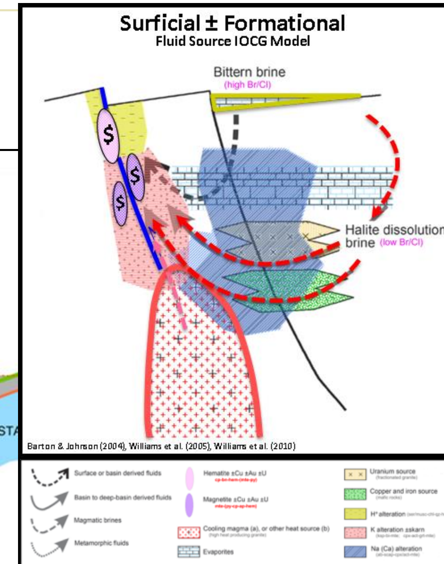
1. Deposits Hosted Within the Upper Staveley/Lower Kuridala Stratigraphy.
    - Rheological contrast between Calc-silicates, Roxmere Quartzite, and Kuridala schists seen as a focus for deformation and exploited during mineralization in late D3.
    - ‘Other’ rigid bodies at this stratigraphic position, e.g. SWAN Diorite, offer further rheological contrast and focusses brecciation/secondary permeability and potential to host mineralization if within a fluid cell.
    - Redox potential of Staveley in contact with overlying reduced rocks (Figure 5.2) inferred as an important ingredient.
    - Presence of ironstones yields discrete targets within this broader stratigraphic package.
    - E.g. Osborne-Kulthor, Mt Elliott-SWAN, and Merlin-Mt Dore deposits.

2. *Structural juxtaposition of Staveley with Other (Reduced) Packages.*
    - Likely to be evidently structurally-controlled/hosted
    - Greater potential expected where Staveley is in structural contact with reduced packages such as Answer Slate/Toole Creek Formation.
    - Focussing relationship of early structural features, likely reactivated basement structures.
    - E.g. Starra line of deposits.

3. *Deposits hosted in Overlying Sequences, but Related to Staveley:Granite:Fault Association at Depth.*
    - Highly variable deposit-style possible.
    - Deposits may be structurally-focussed or within broader breccia bodies.
    - Intrusion of granite into the Staveley calcareous sequence inferred as driver for brecciation (CO_2 release).
    - E.g. EH, Eloise

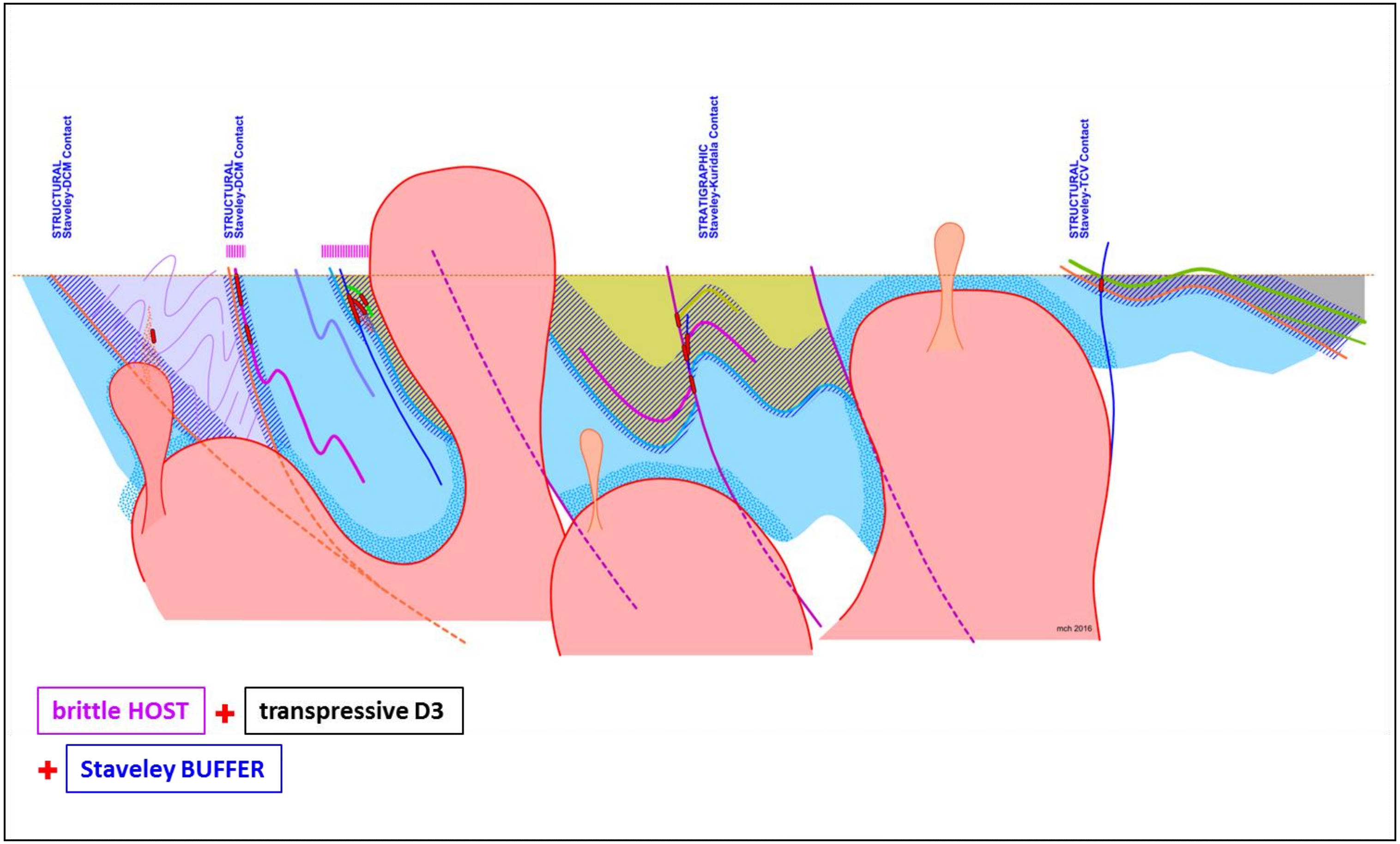
Schematic Section – Deposit controls



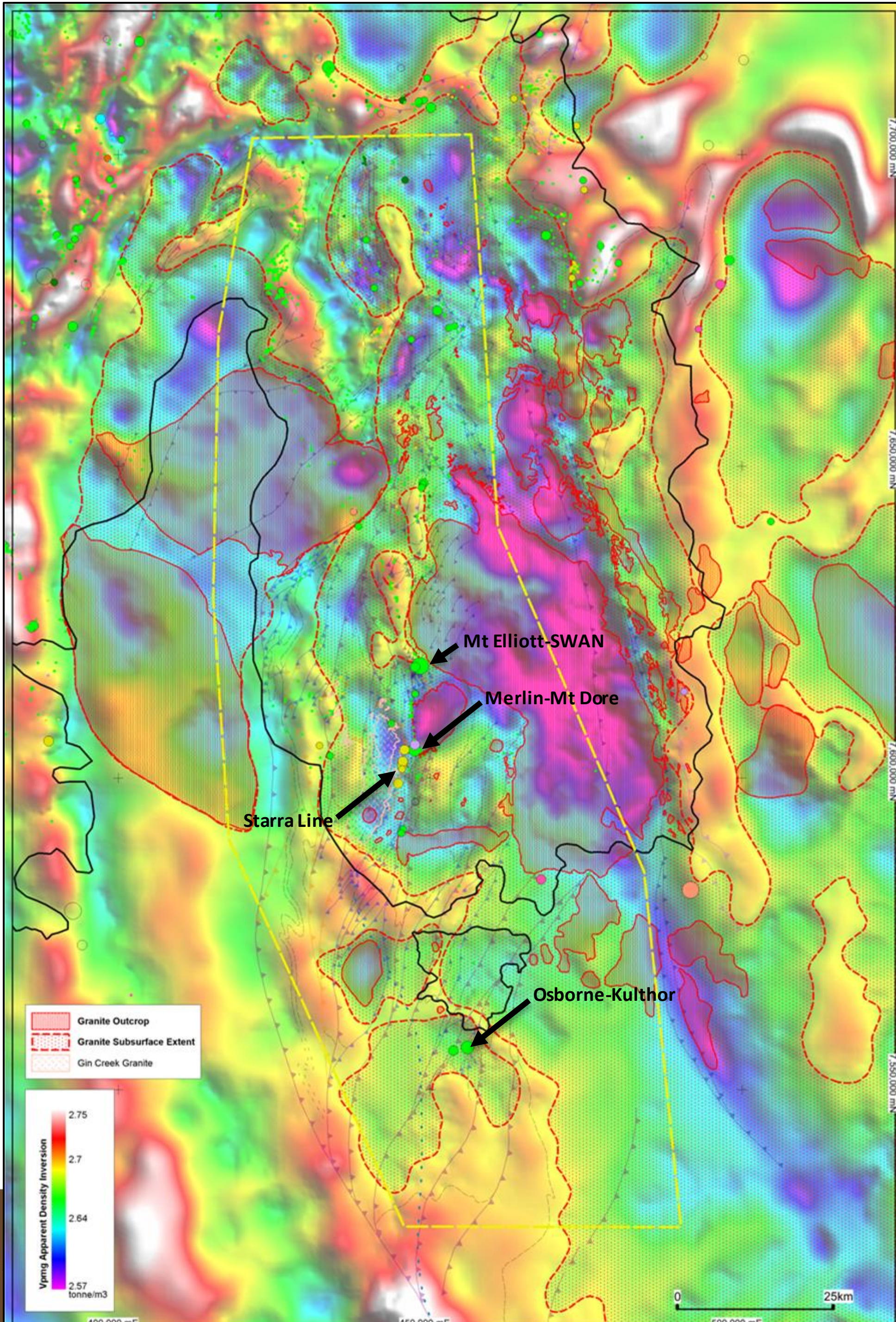


Schematic cross-section illustrating inferred controls on deposit styles in the DMQ project area. Essential ingredients required for each of the identified deposit styles. Orange arrows represent high temperature brine circulation, red arrow represent magmatic fluid contribution.

Schematic Section – Stratigraphic Buffering



Schematic cross-section illustrating the asymmetric buffer around the upper Staveley stratigraphic contact, and buffering of structural juxtaposition of Staveley against other stratigraphy. These buffer zones conceptually encompass the bulk of deposit locations in the belt.

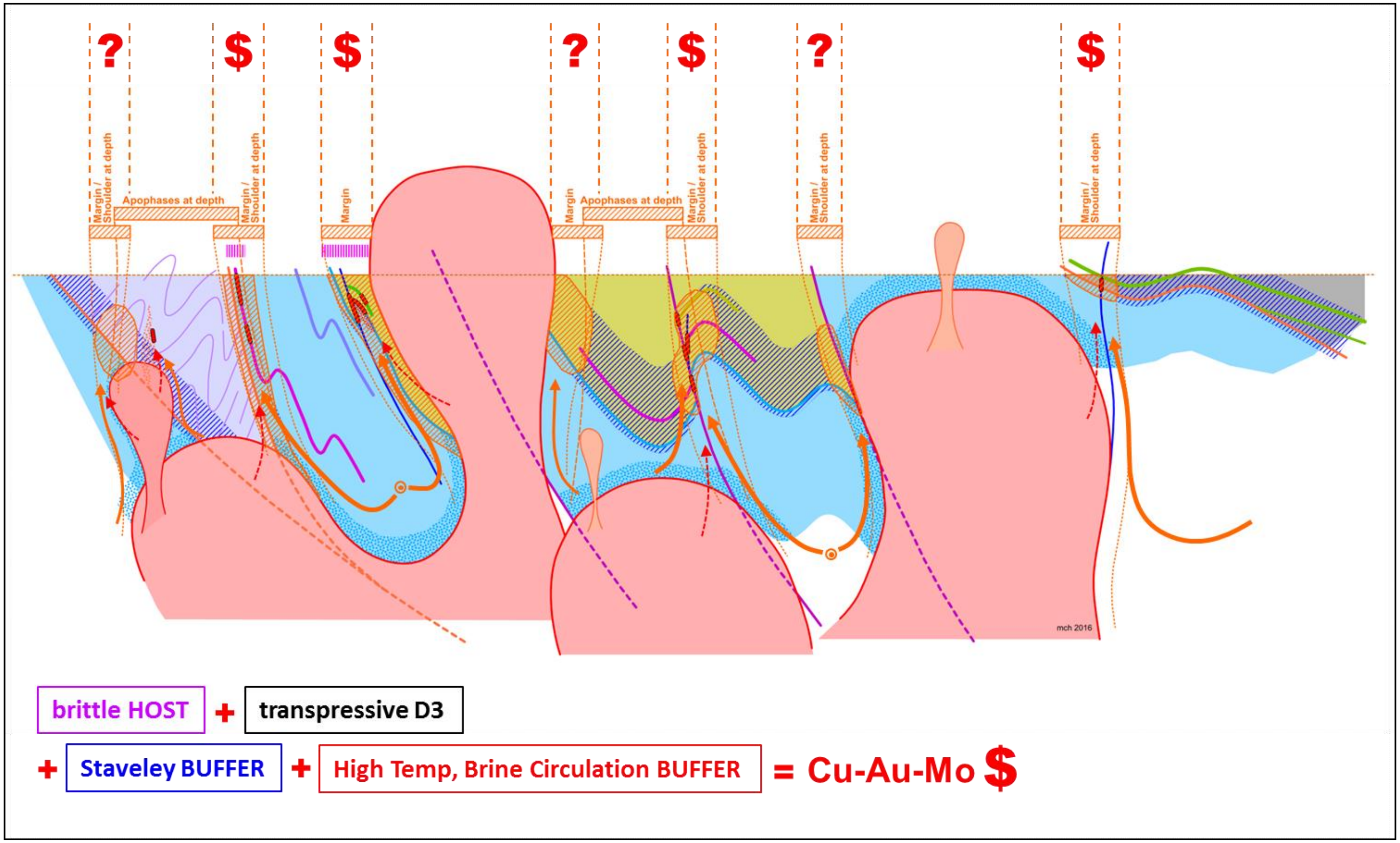


Apparent Density Model overlain with DMQ structural interpretation and GSQ Mineral occurrences.

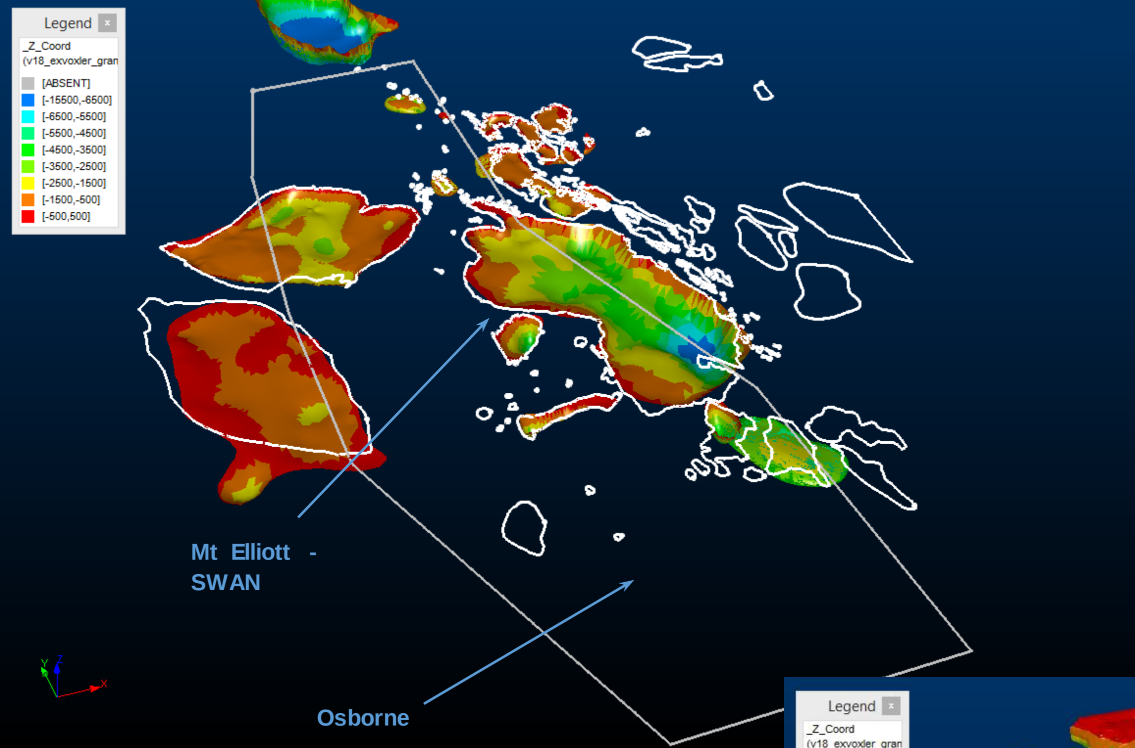
Highlights significant spatial relationships with shoulder and margins of low density domains. Cu green; Au yellow; Mo mauve

Key takeaway….the felsic intrusives are important!

Schematic Section – Prospectivity



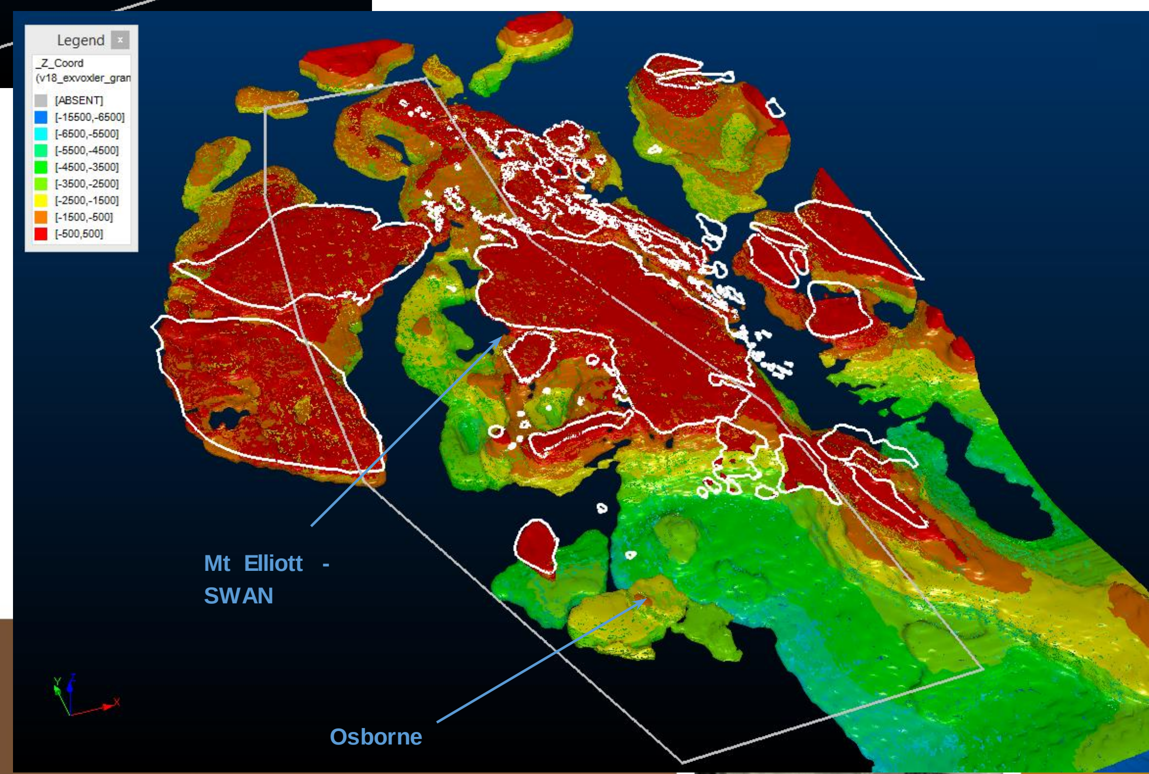
Schematic cross-section illustrating buffers specific to the role of granite morphology in convective focussing of fluid into favourable litho-structural sites. Granite morphology is considered critical in driving convective fluid movement, and as such, will determine prospective corridors



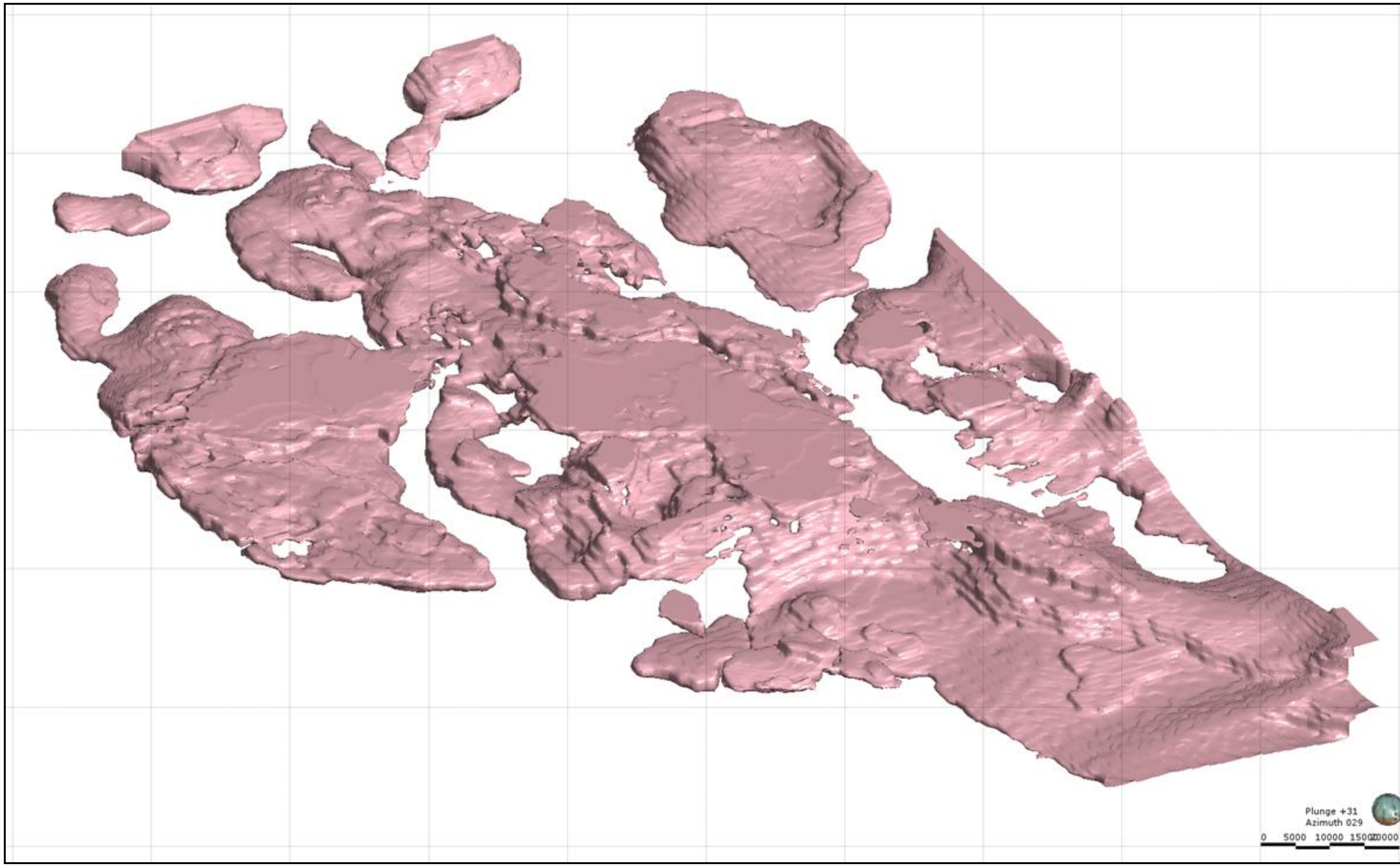
If granites are that important, then we need good approximation of the 3D subsurface geometry and distribution

(Mira Geoscience, 2011)

(DMQ, 2017)

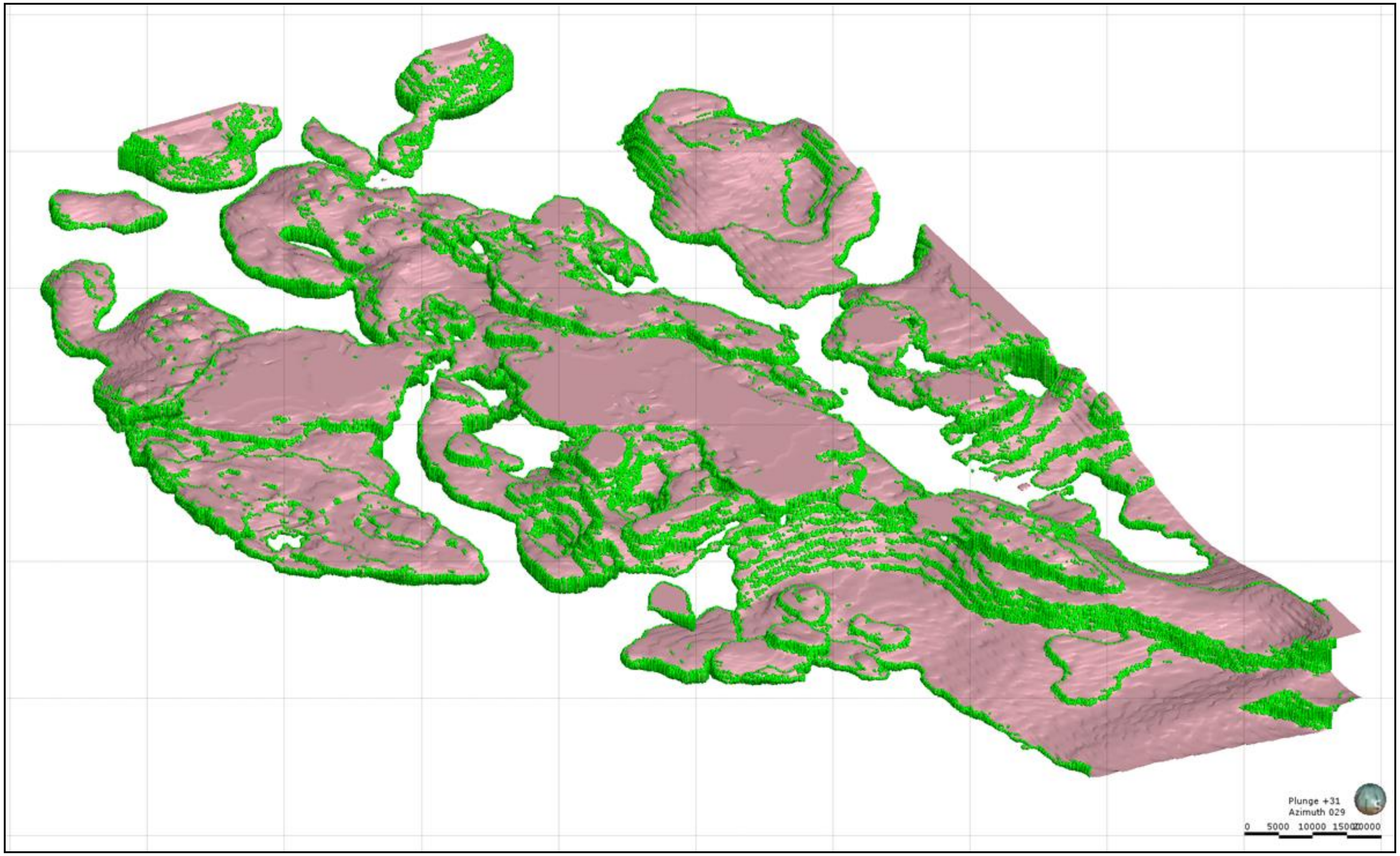


3D Intrusives



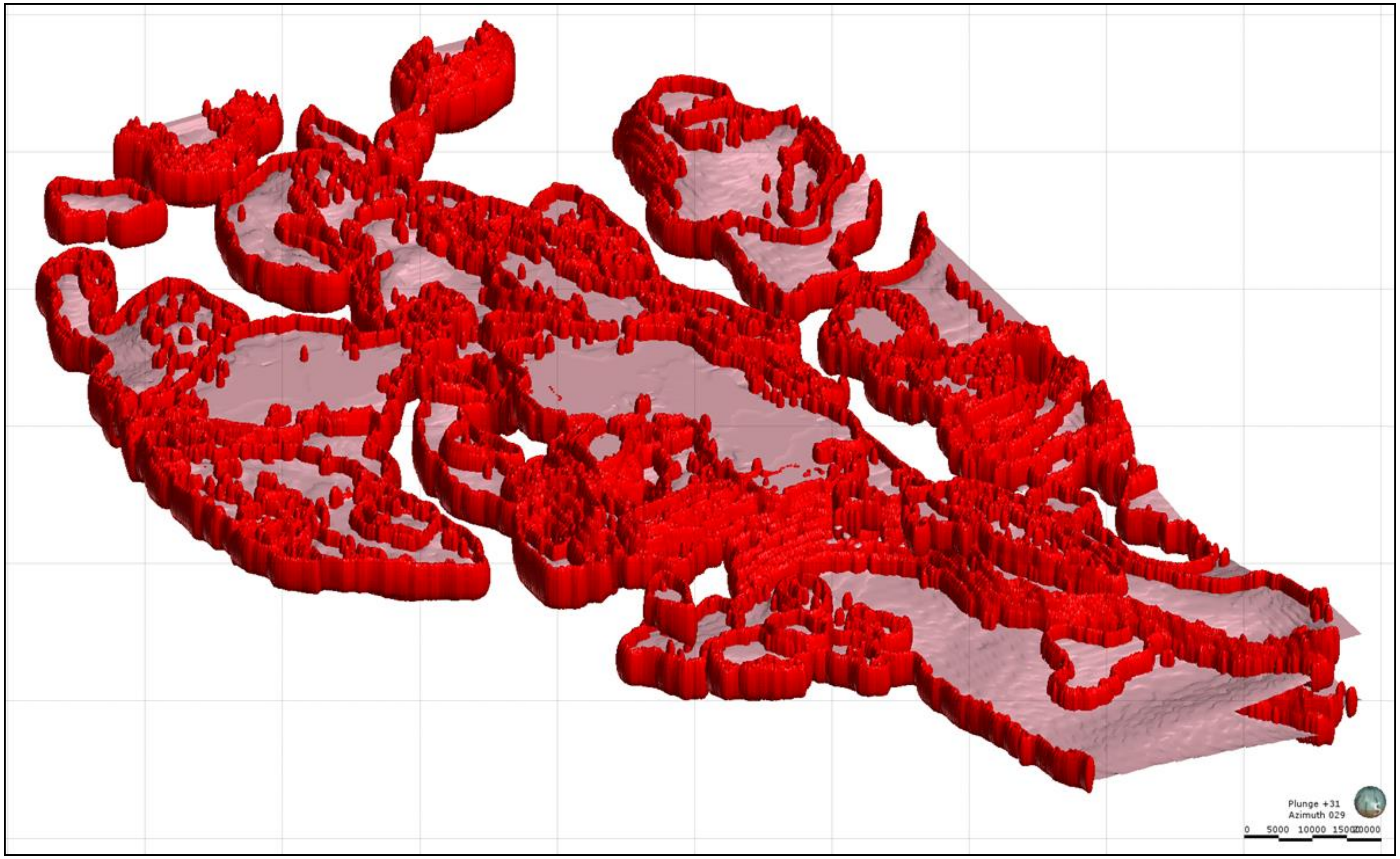
3D view of the Williams-age felsic intrusions in the study area, as determined through geologically-constrained gravity inversion. Looking northeast.

3D Intrusives – Edge Detection



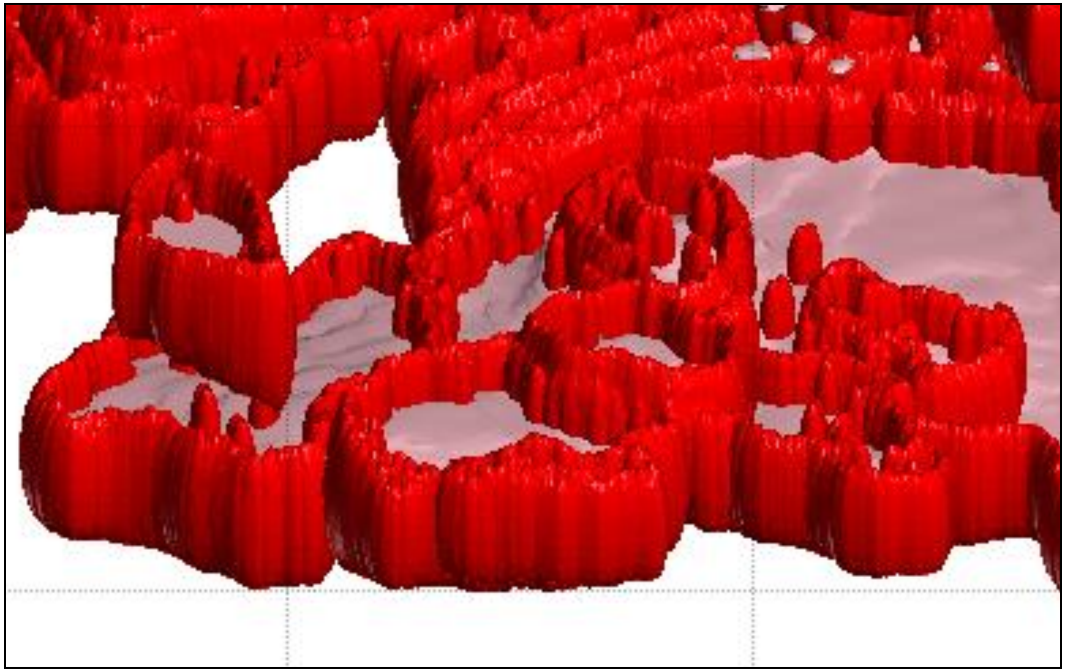
Edges of intrusive bodies with higher dip (>50°) identified in green.

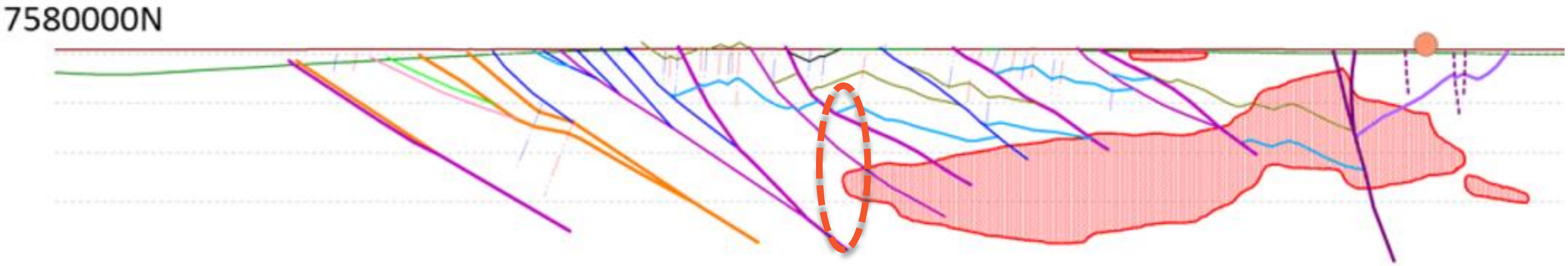
3D Intrusives - Buffering



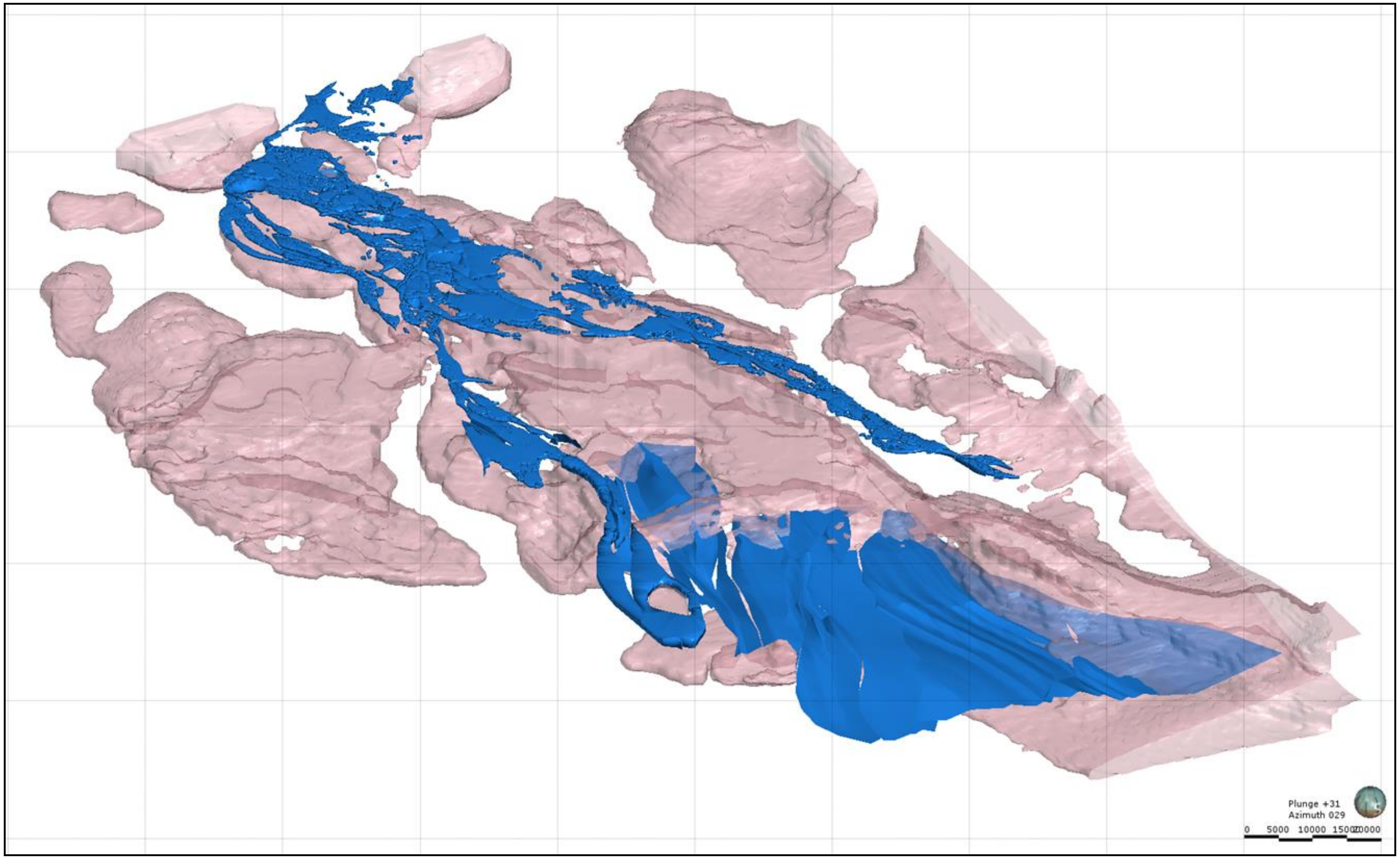
Anisotropic buffer applied to the 3D felsic intrusive geometry.

3D Intrusives – Buffering (in detail)



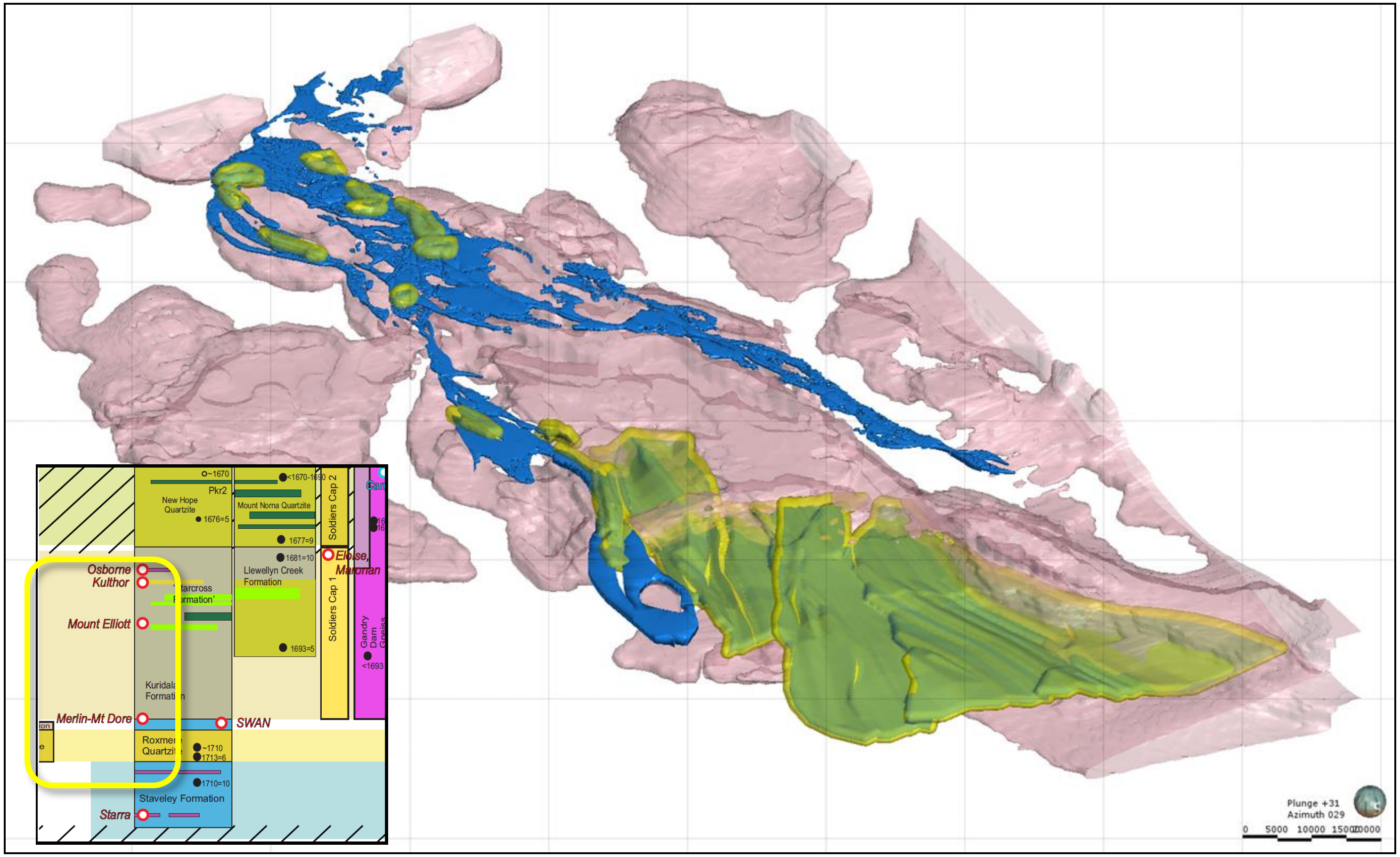


3D Host-rock distribution



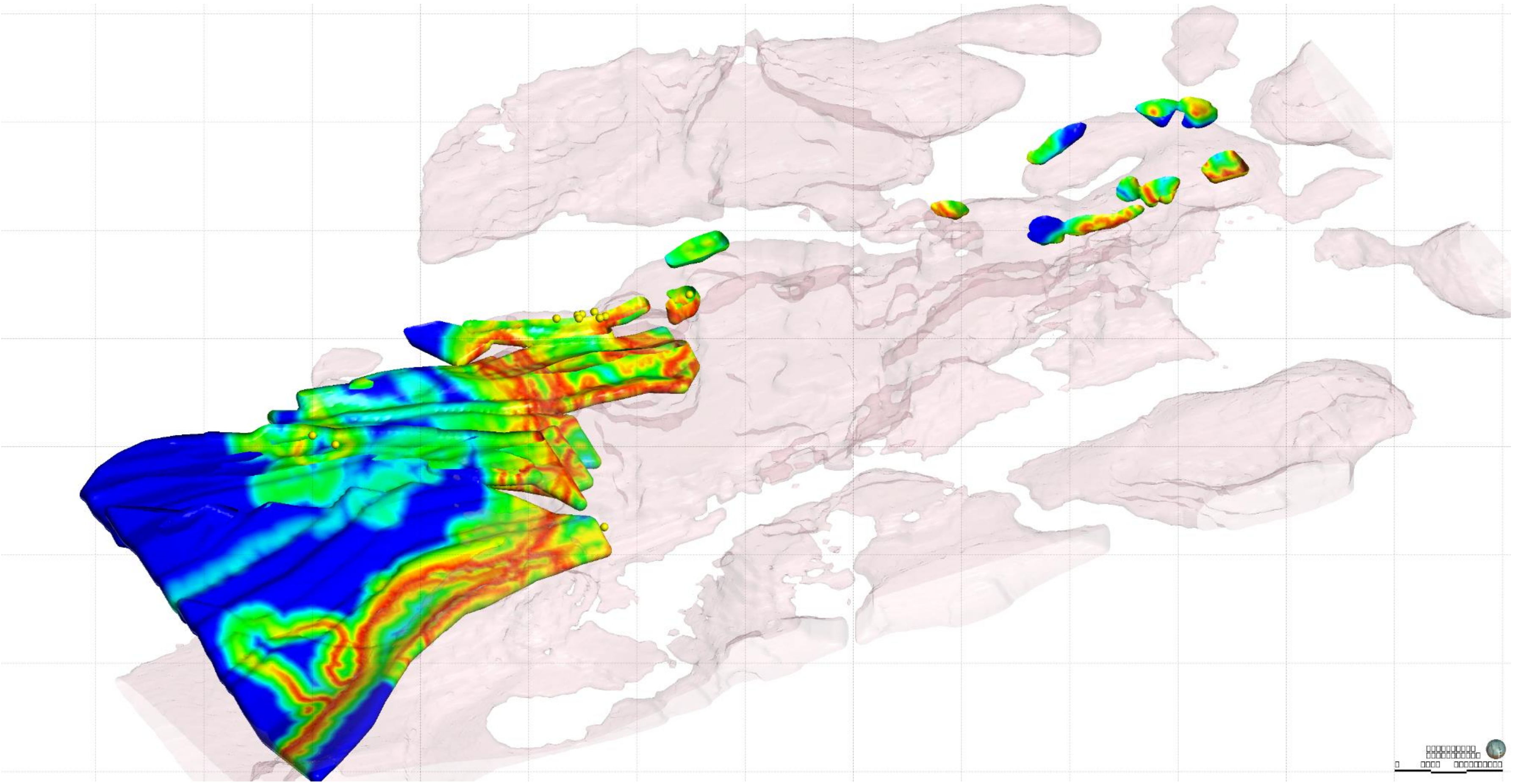
Top of Staveley Formation stratigraphic surface (blue) in bottom right hand corner of image (south), and outcropping Staveley Formation and equivalents represented by blue solid in the top left of image (north).

3D Host-rock Distribution - Buffered

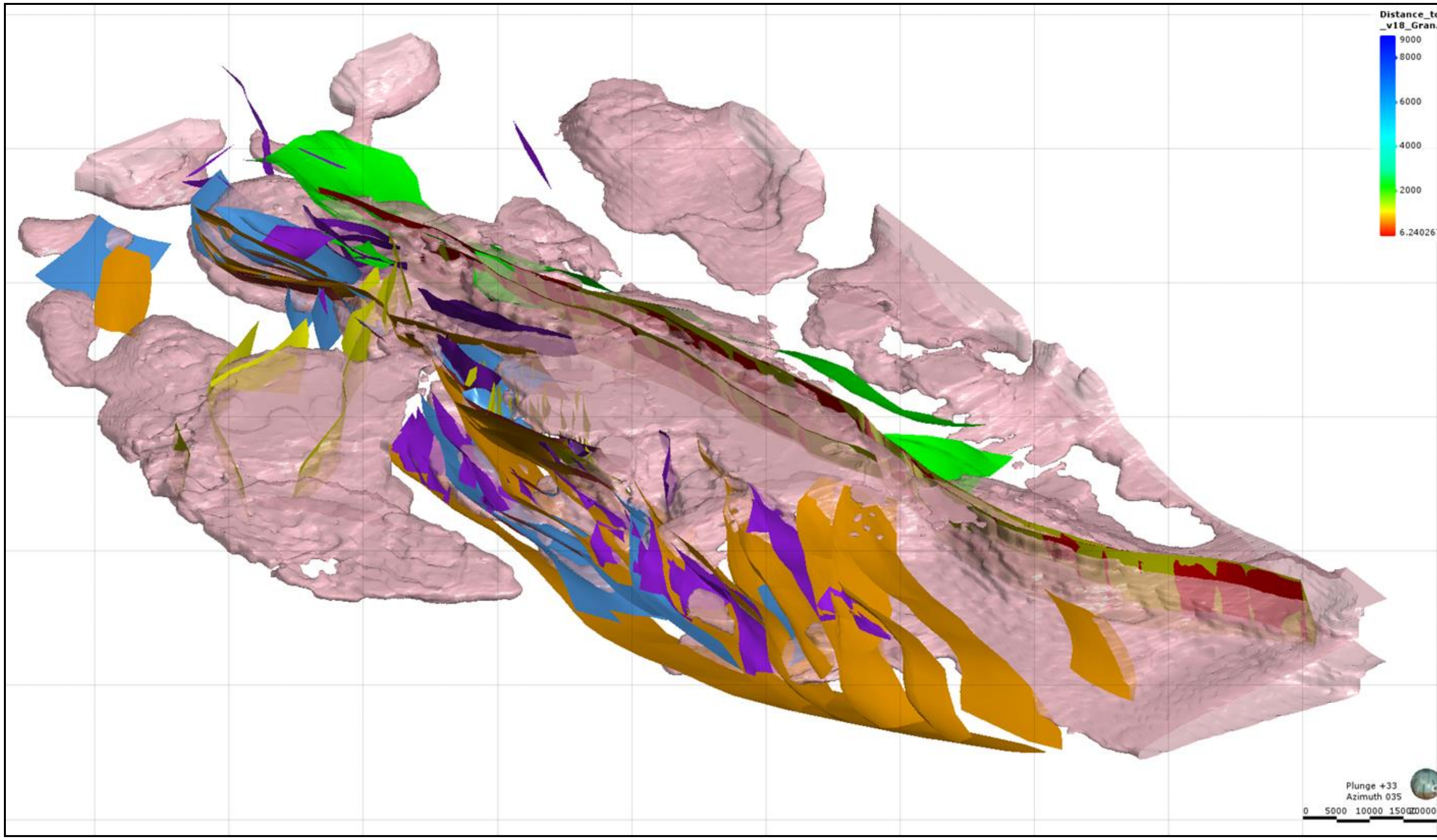


Asymmetric buffering (yellow) of the Top of Staveley Formation stratigraphic surface (-300m/+1500m).

Staveley Buffer Coloured by Proximity to Granite Edges

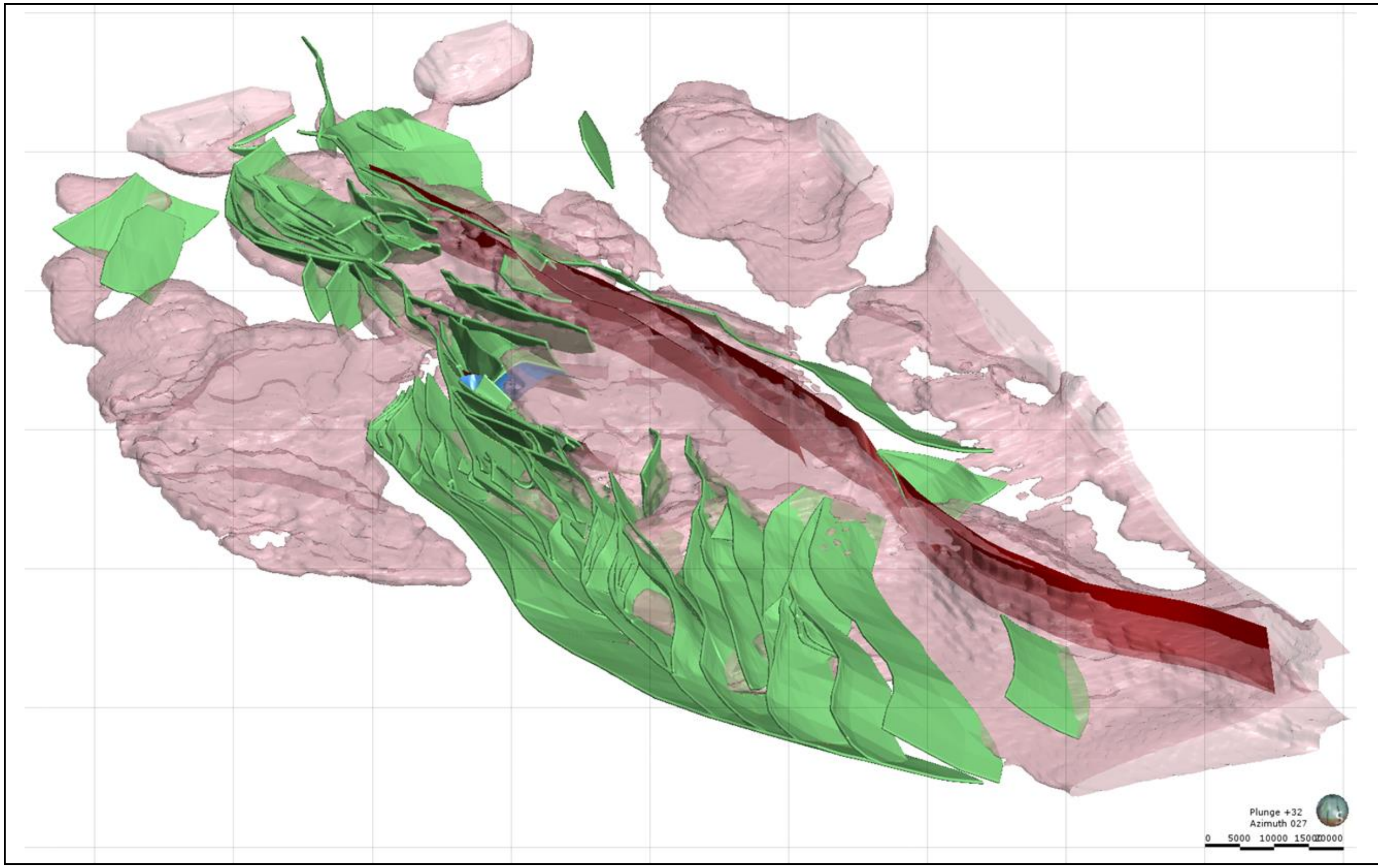


3D Structure



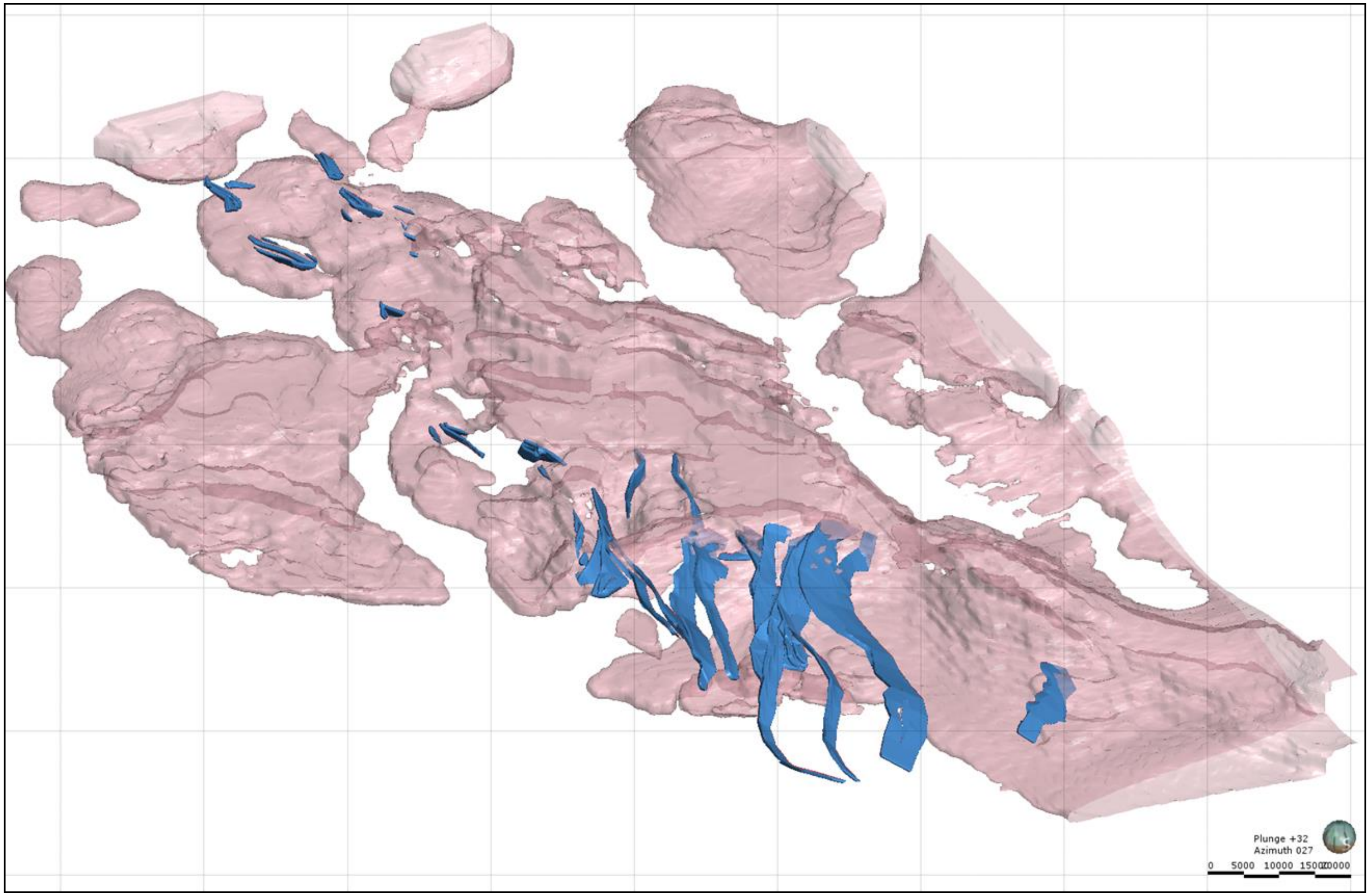
Modelled faults displayed as coloured surfaces. D1 faults: blue, D2 faults: orange, D3 faults: navy, early-D4 faults: purple, late-D4 faults: red/yellow.

3D Structure - Buffered



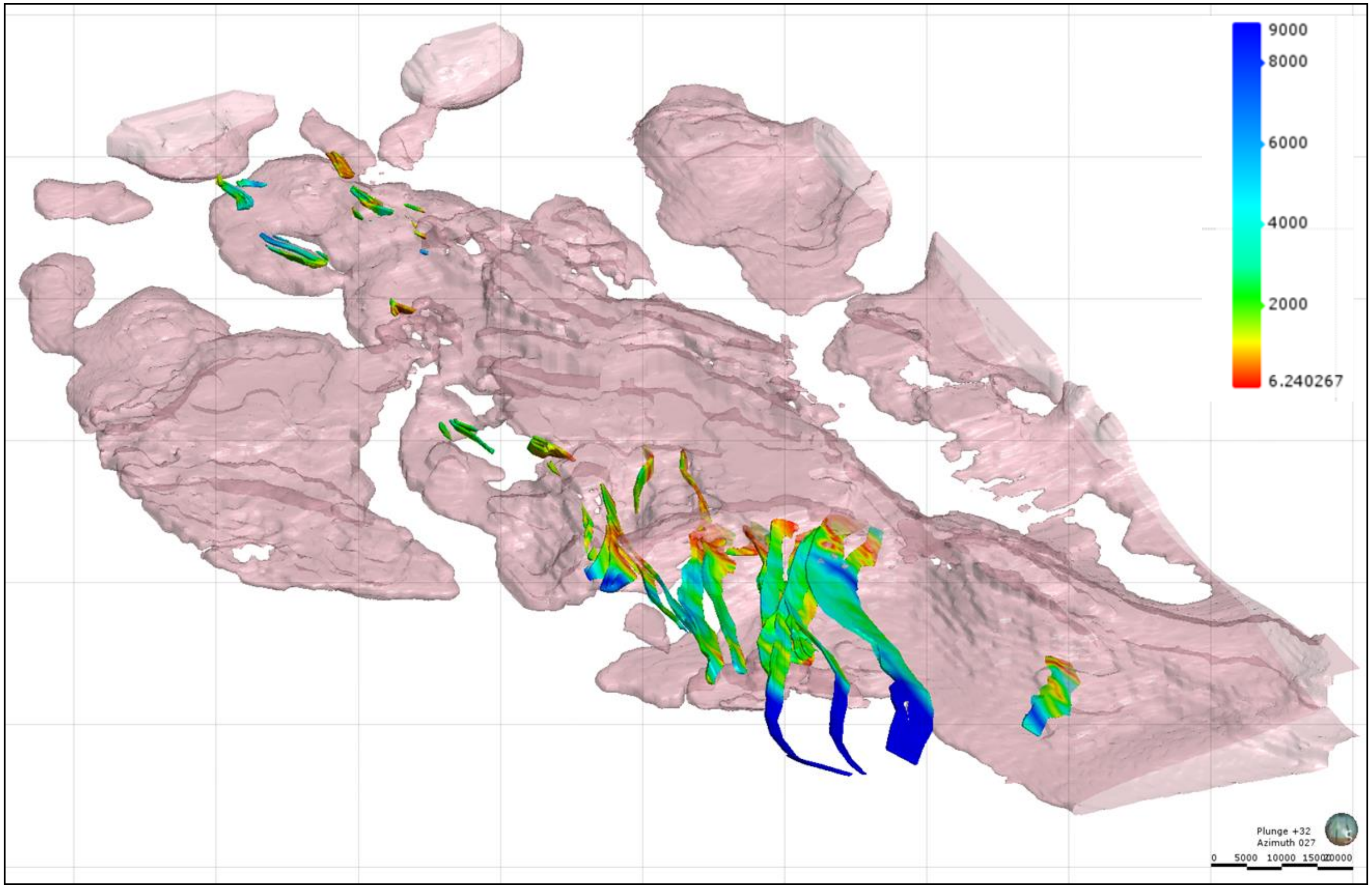
Buffered faults (green) where interpreted to predate the latter stages of D4. The green buffer is ±250m each side of the modelled faults.

3D Structure and Strat Buffer Intersection



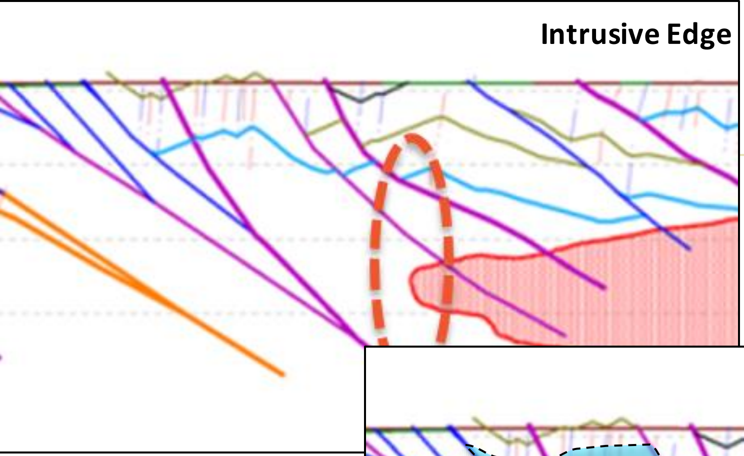
Resultant volumes after intersection of structural and stratigraphic buffer domains.

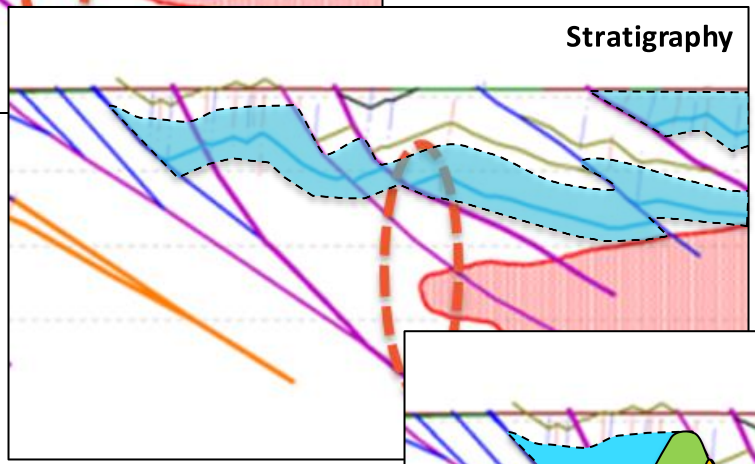
3D Structure and Strat Buffer Intersection

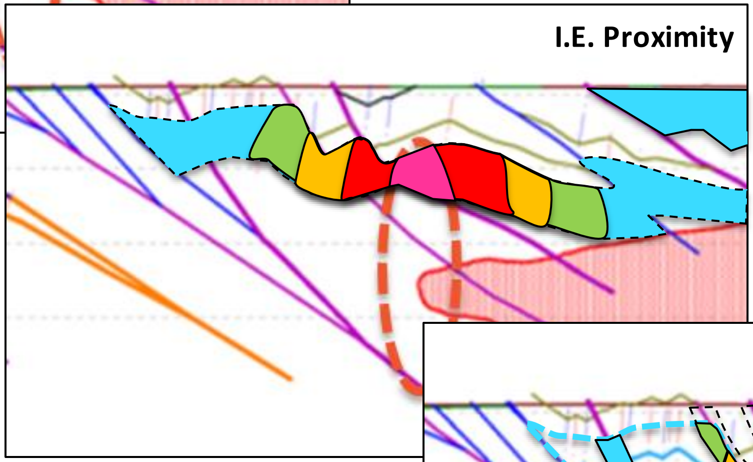


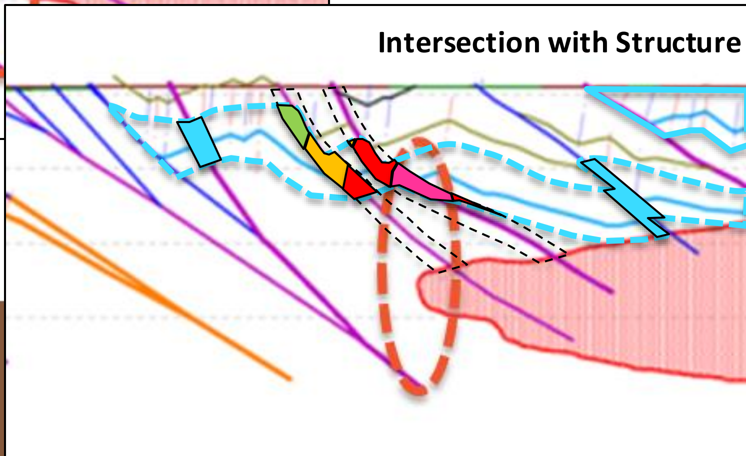
Coloured by proximity to intrusive buffer zones (as per legend).

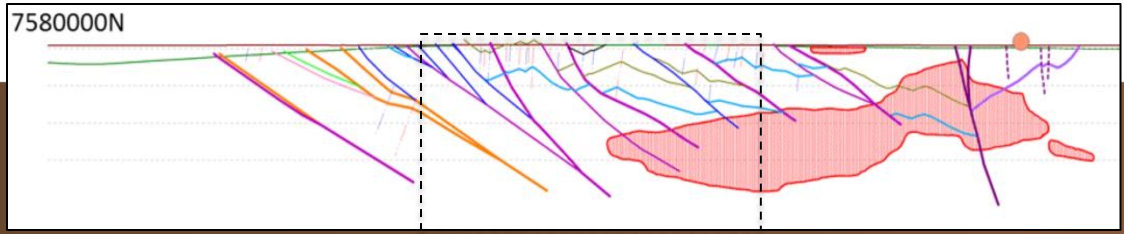
Buffering Process (Osb/MtD/SWAN) - Schematics

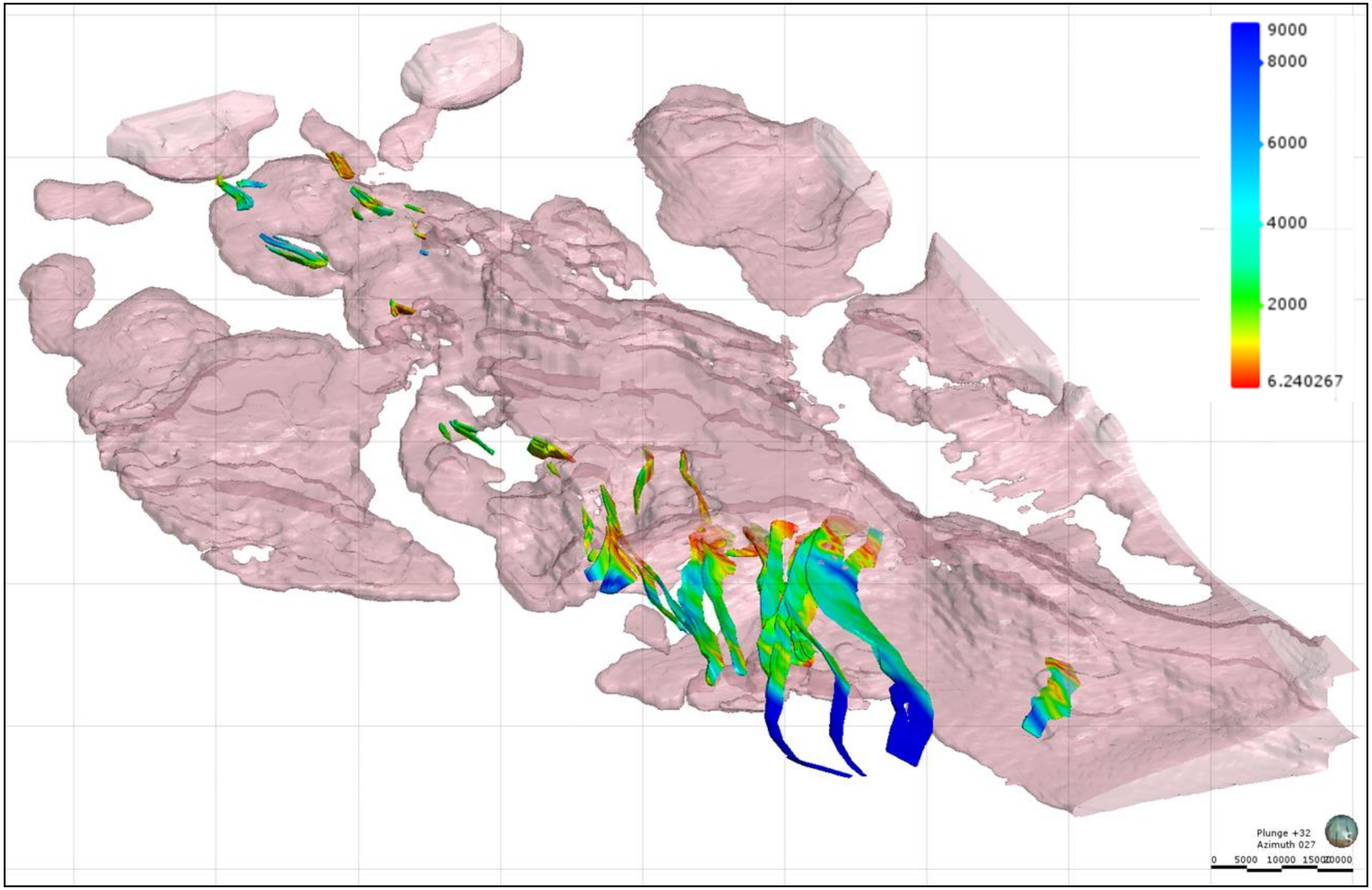






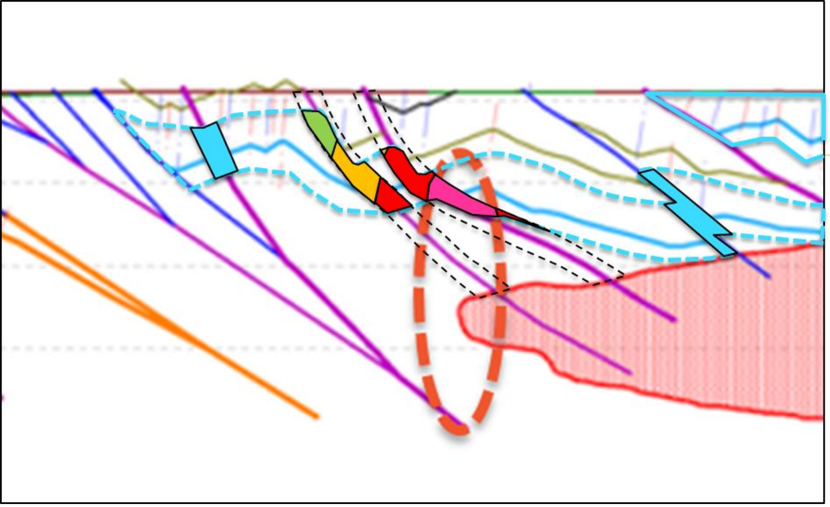


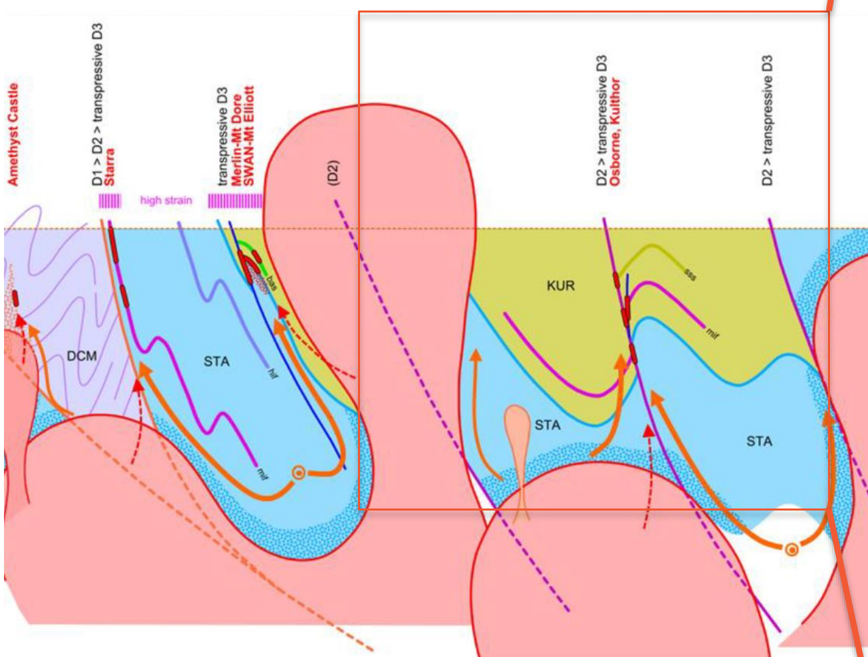


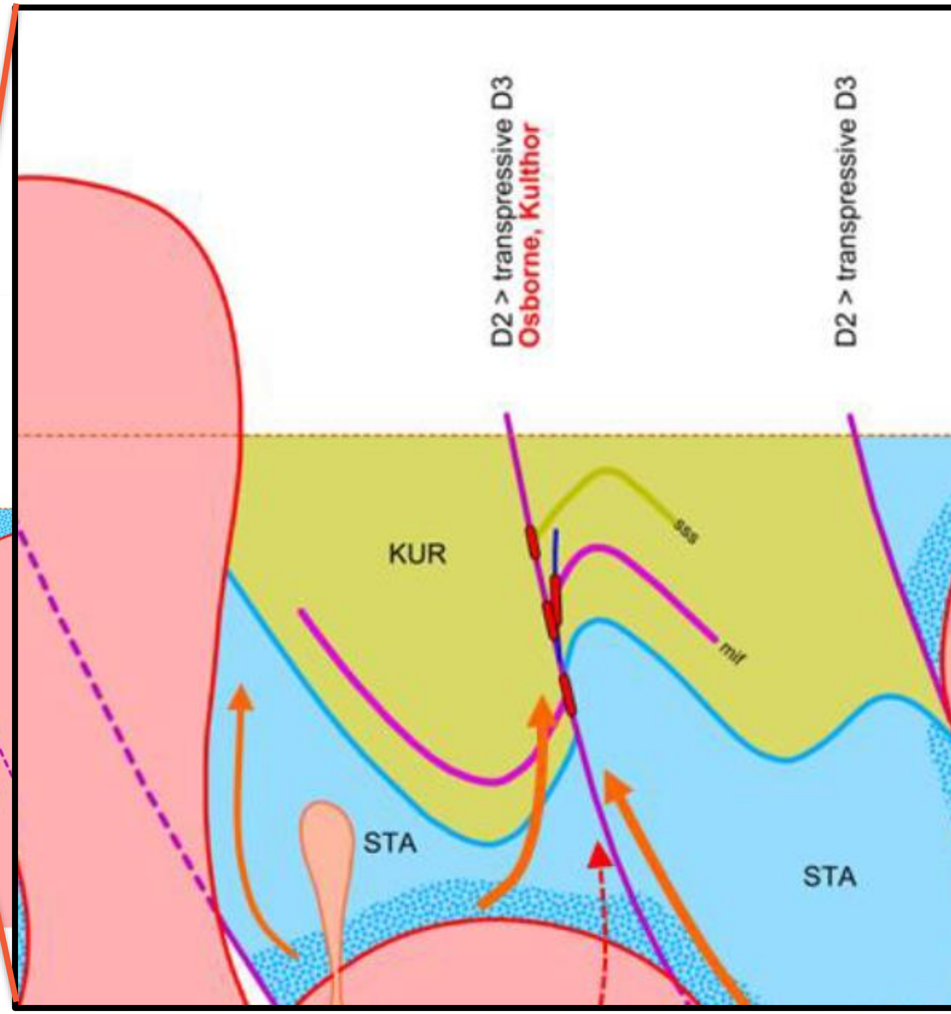


Structure and stratigraphic buffer intersection coloured by proximity to intrusive buffer zones (as per legend).

Osborne - Kulthor



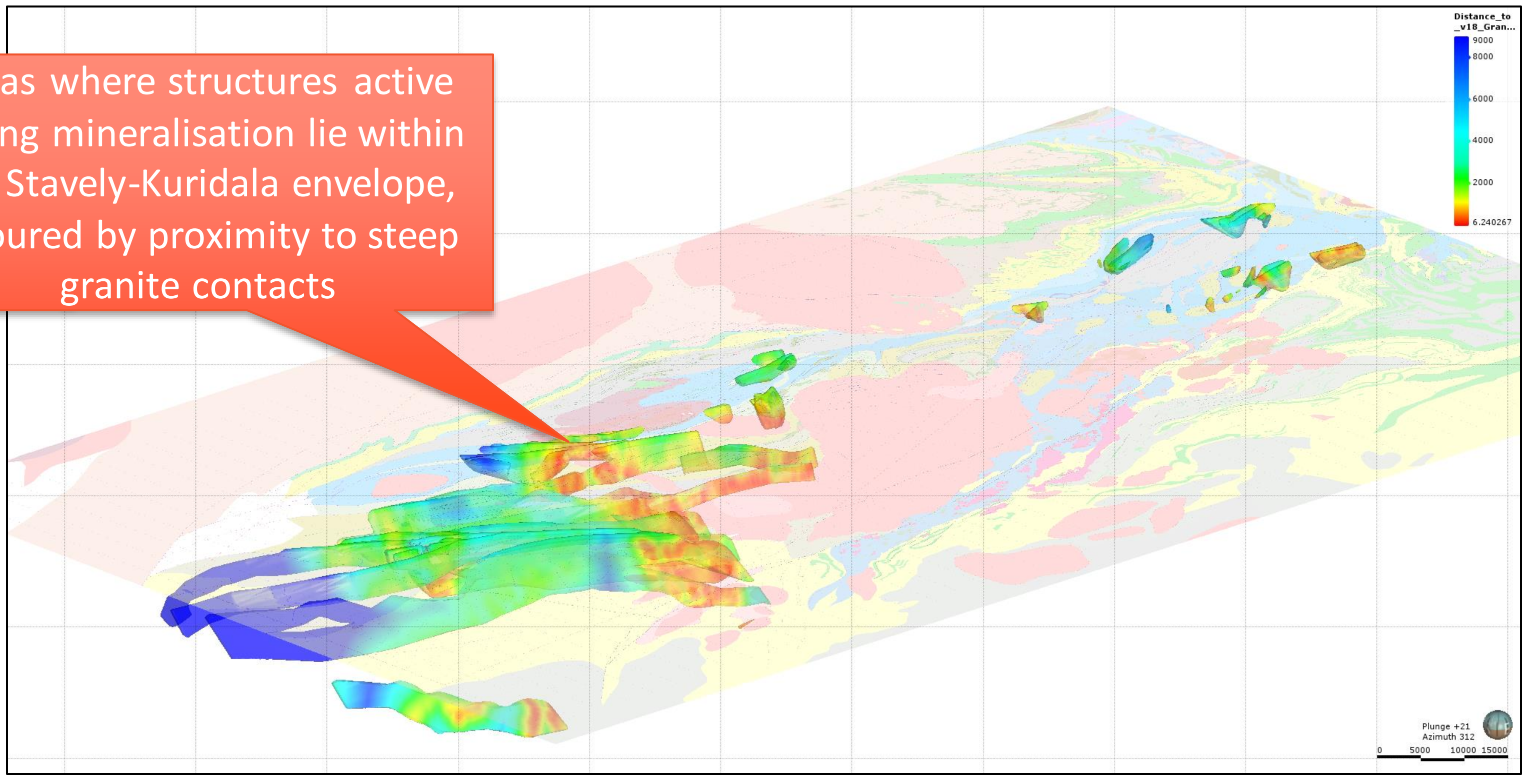




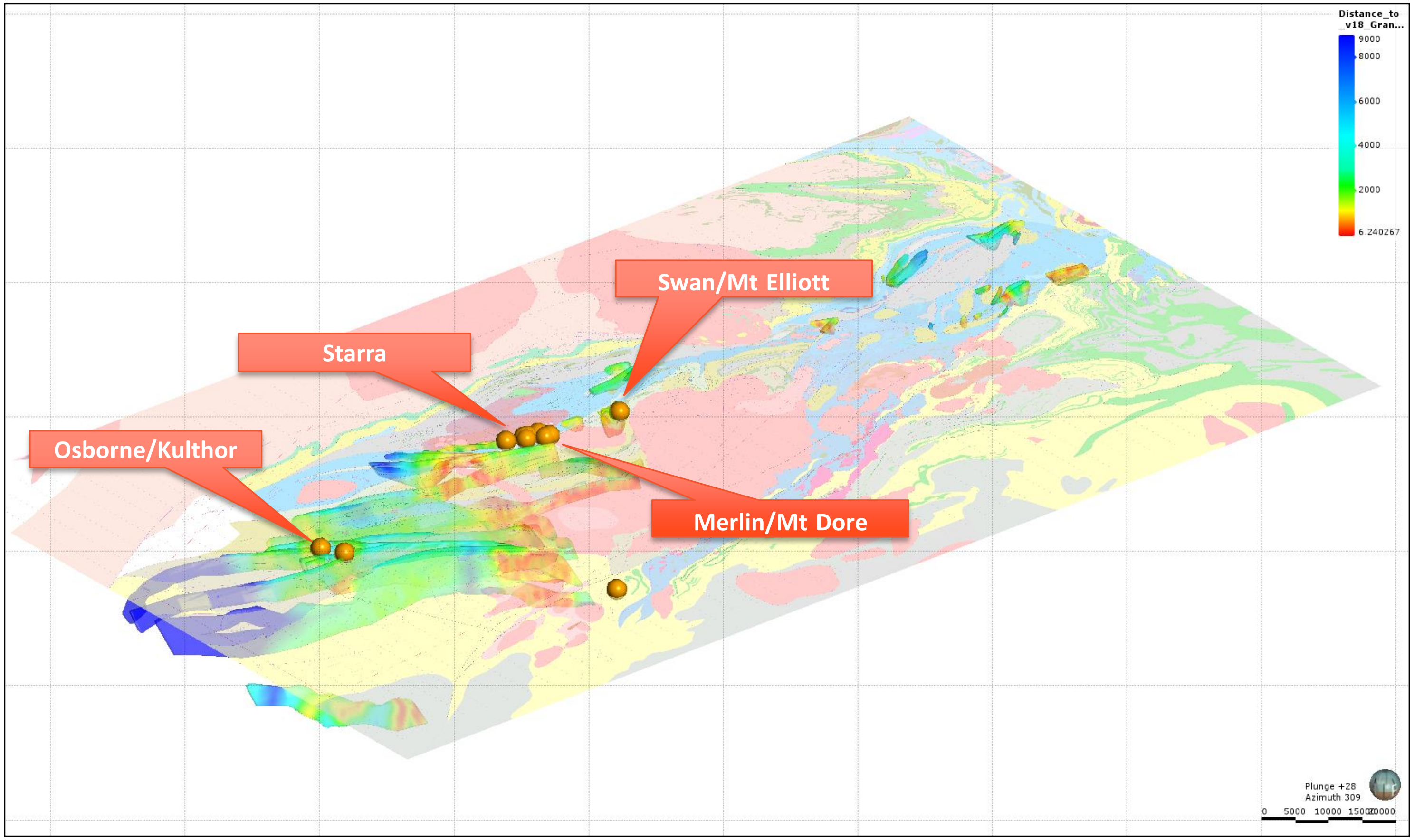
Applying Criteria to the District Model

- Proximity to Stavely contact (not including structural Staveley contacts)
- Within 250m of a D3 or earlier structure
- Hotter colours show proximity to steep granite edges

Areas where structures active during mineralisation lie within the Stavely-Kuridala envelope, coloured by proximity to steep granite contacts

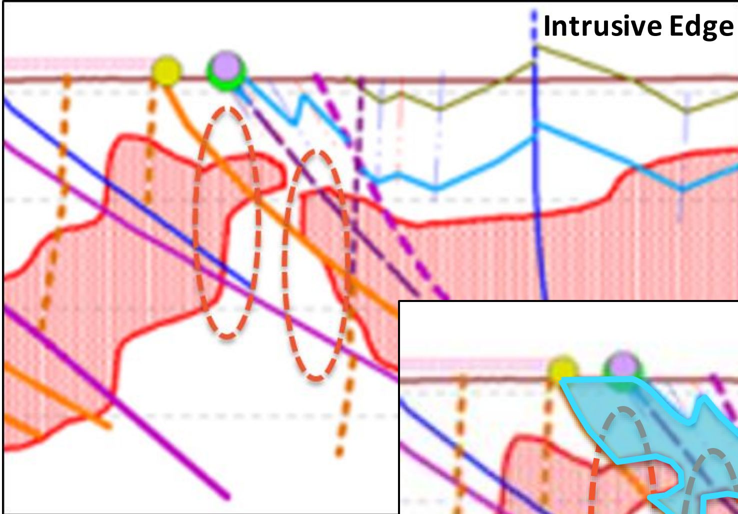


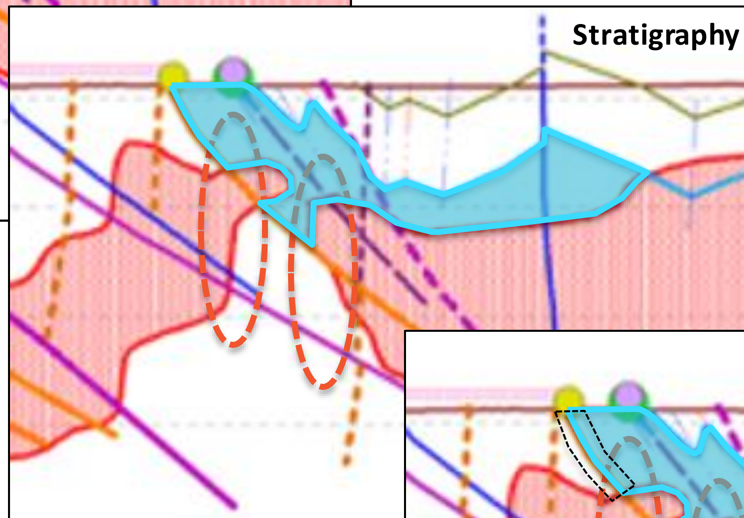
Applying Criteria to the District Model

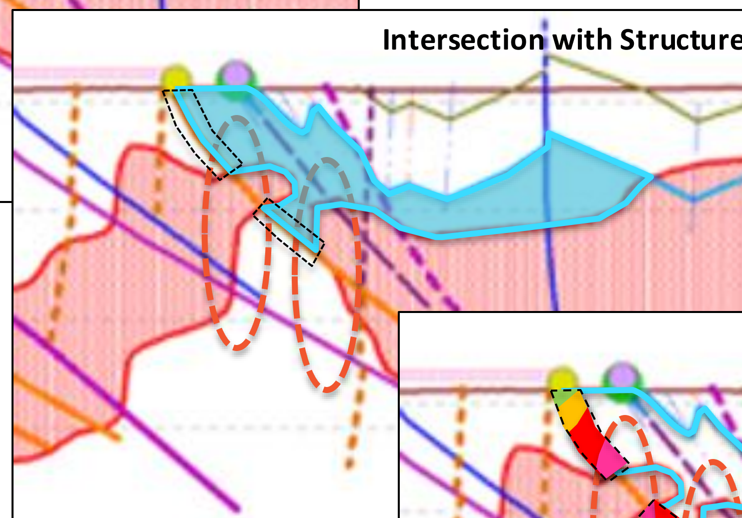


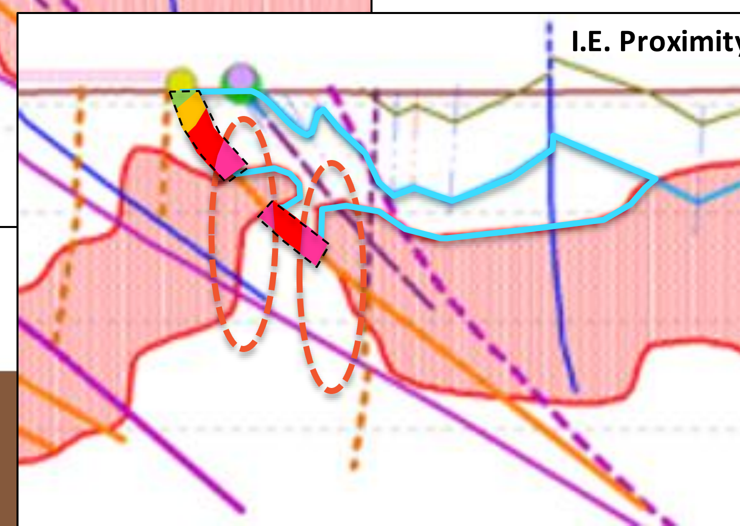
Location of significant deposits and mines relative to the inferred areas of enhanced prospectivity.

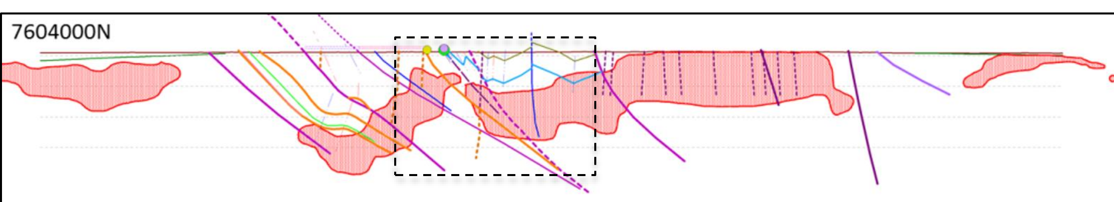
Buffering Process (Starra) - Schematics



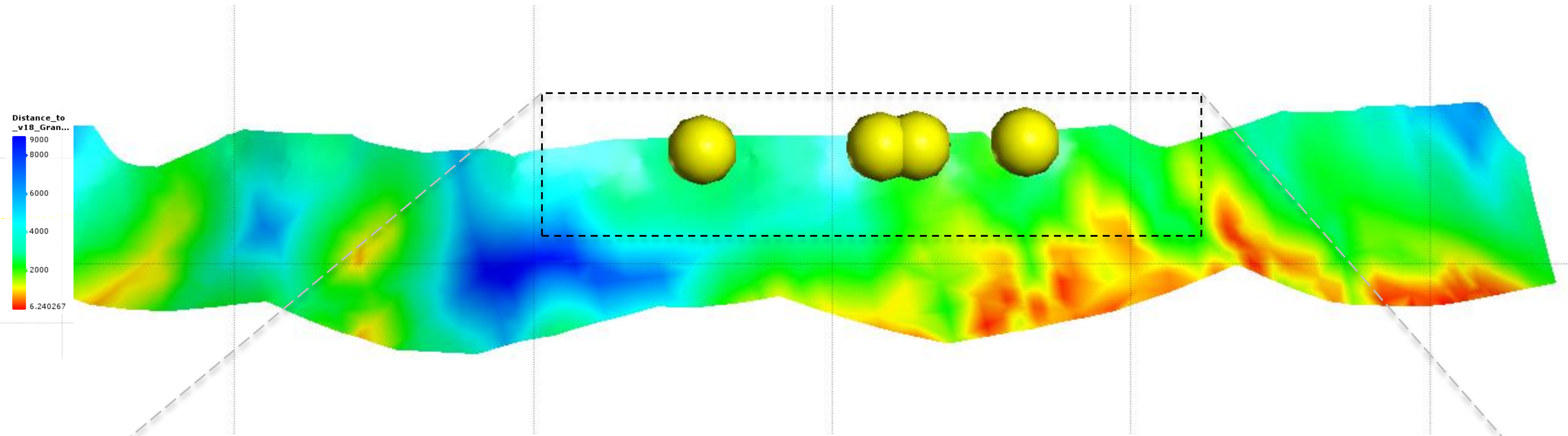


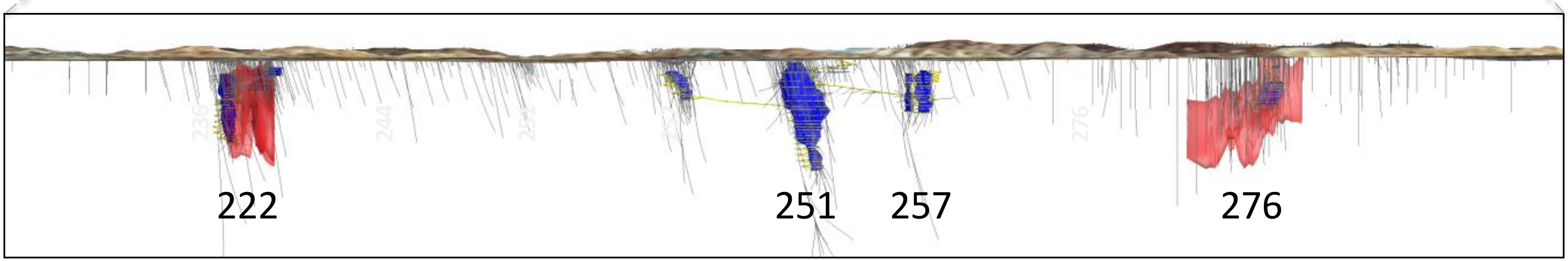






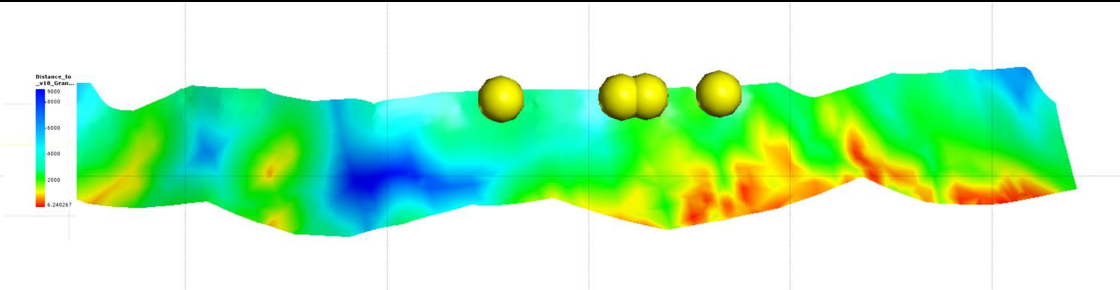
Starra Line

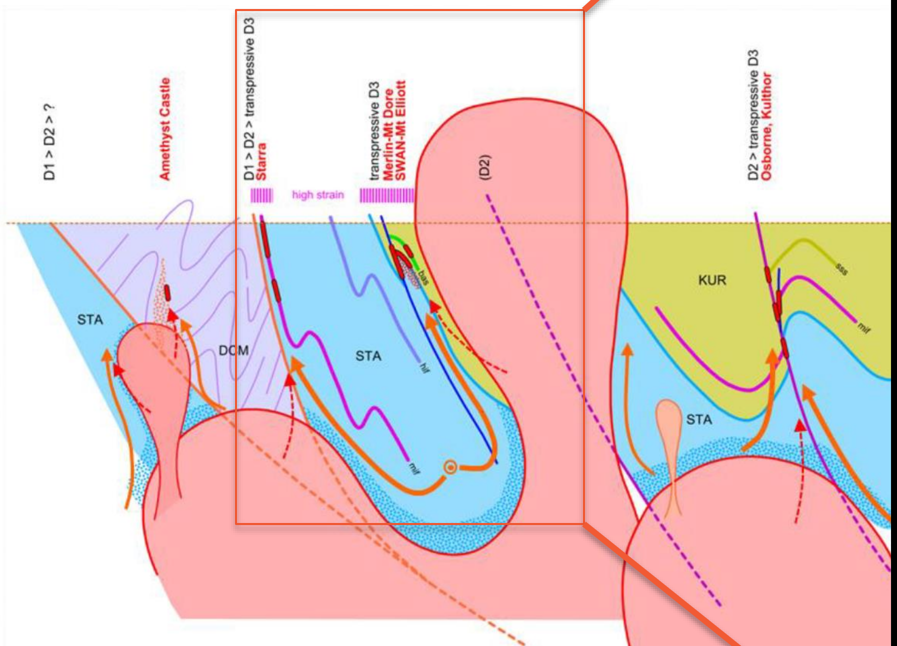




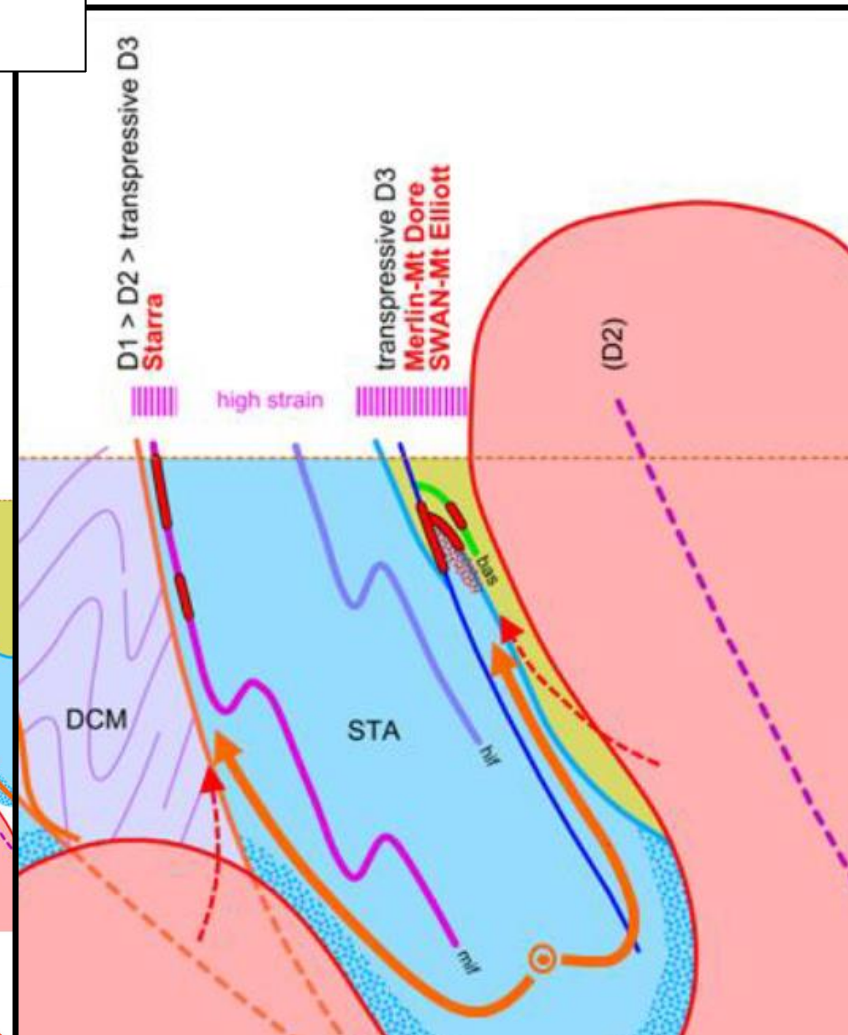
Courtesy – Chinova Resources. Longitudinal Projection – looking West

Starra



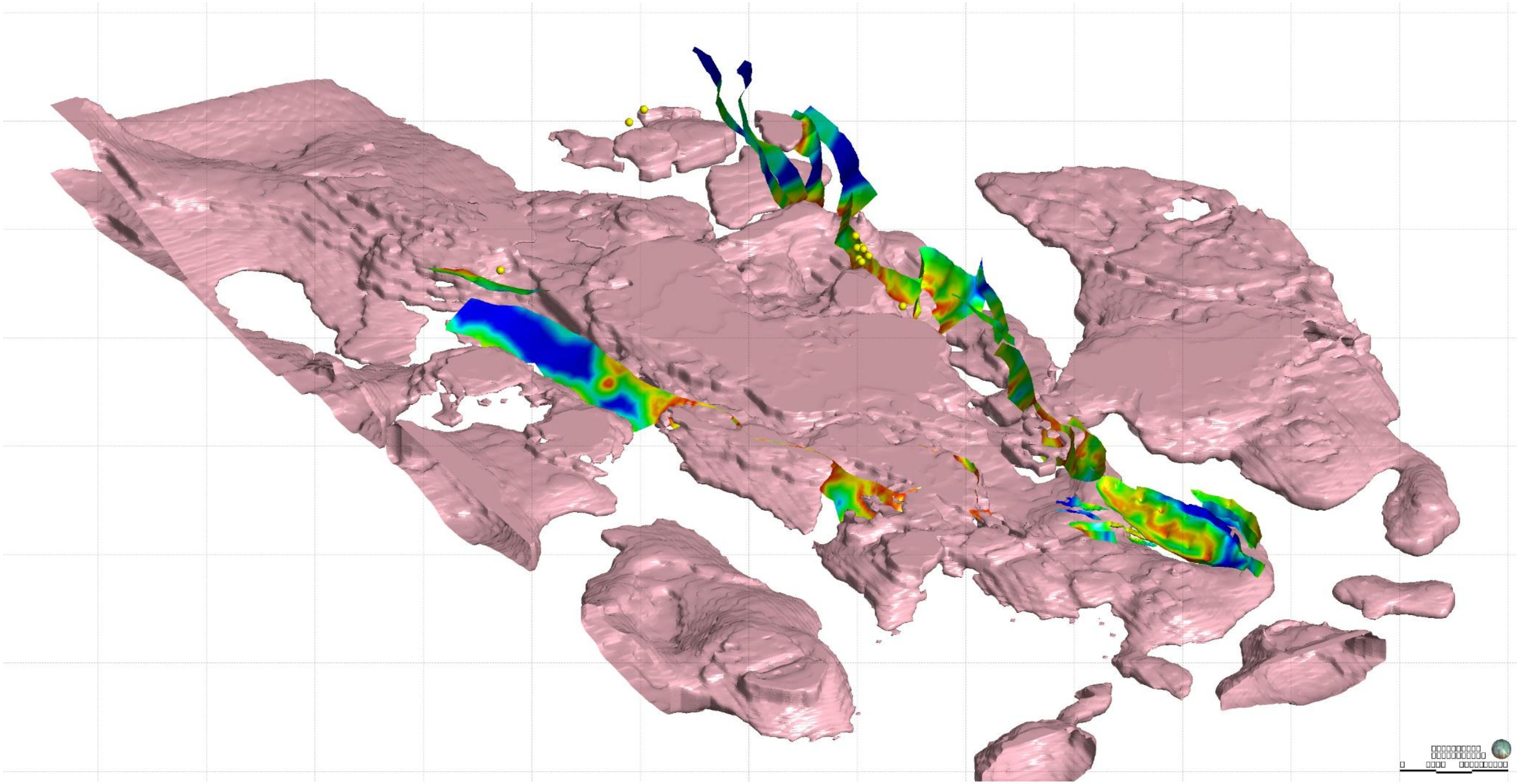


D1 > D2 > ?
Amethyst Castle
D1 > D2 > transpressive D3
Starra
high strain
transpressive D3
Merlin-Mt Dore
SWAN-Mt Elliott
(D2)
D2 > transpressive D3
Osborne, Kulthor
KUR
STA
DCM
STA
hif
mif
bas
STA

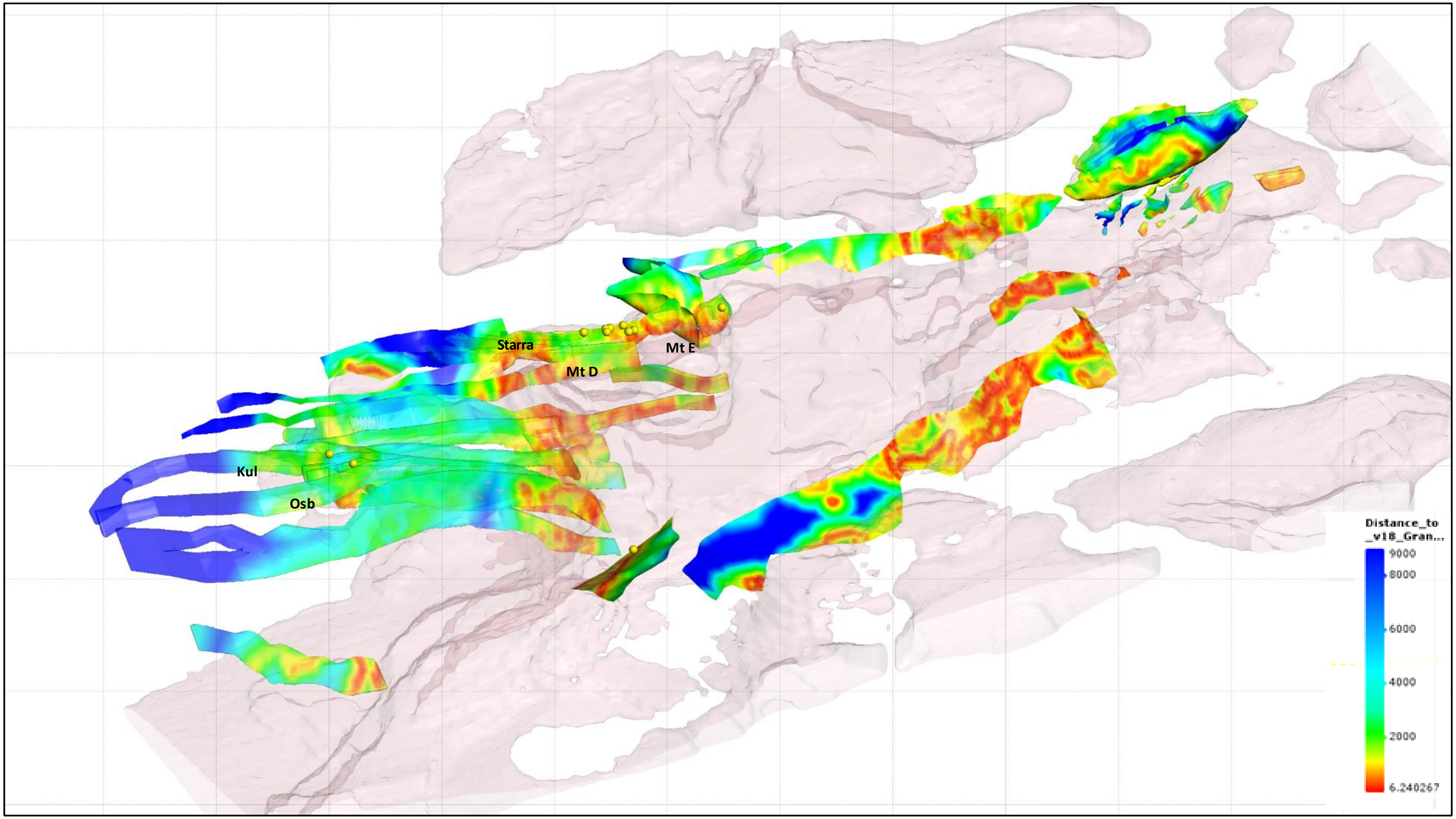


D1 > D2 > transpressive D3
Starra
high strain
transpressive D3
Merlin-Mt Dore
SWAN-Mt Elliott
(D2)
DCM
STA
hif
mif
bas

‘Starra-style Structural Juxtaposition Target’ Prospectivity



Combined Target Types – More Upside!



Prospectivity Conclusions

- 2D prospectivity analysis does not inform as to the depth potential for discovery of new mineral deposits.

- Understanding of the key factors required for Cloncurry-style Cu-Au deposit formation, coupled with 3D representations of critical geological features; translates to a process and workflow for spatial 3D prospectivity analysis.

- The DMQ model has not tried to be overly quantitative…..geological intuition is required for deep exploration. This is borne from comprehensive understanding of the deposit-forming conditions, host-rocks, structure, and dynamic partitioning of strain (hence the reason why none of these deposits look the same!)

- As with any Prospectivity Analysis, the determinant of success is the ability to 'rediscover' known deposits. The current models achieve this.

DMQ Summary

Aiming to reduce the risk profile of exploring at depth in the Cloncurry district by identifying tracts of ground which are:

- prospective for large, mass-mineable mineral deposits, i.e. **<u>fertility</u>**
- comprise geotechnical, geothermal, geographical conditions which are technically amenable to mass-mining methods, i.e. **<u>mineability</u>**, and
- comprise all of the above, but with the prospect of positive financial outcomes….subject to internal & external factors, i.e. **<u>viability</u>**.