SMI BRC
WH Bryan Mining &
Geology Research Centre

# DMQ Wrap-up – May 2017

## Target & Prospect Evaluation

Brisbane, Queensland

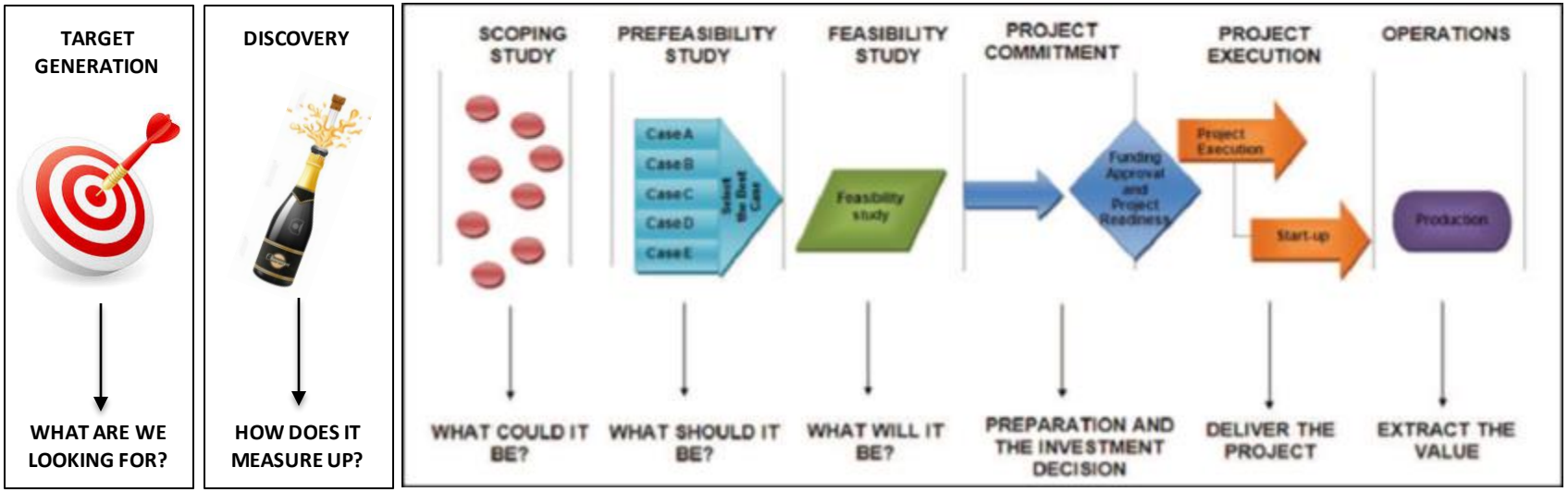
16th May, 2017

The University Of Queensland
AUSTRALIA

# Evaluation by Project Stage

Pre- Concept/Scoping-Study Evaluation

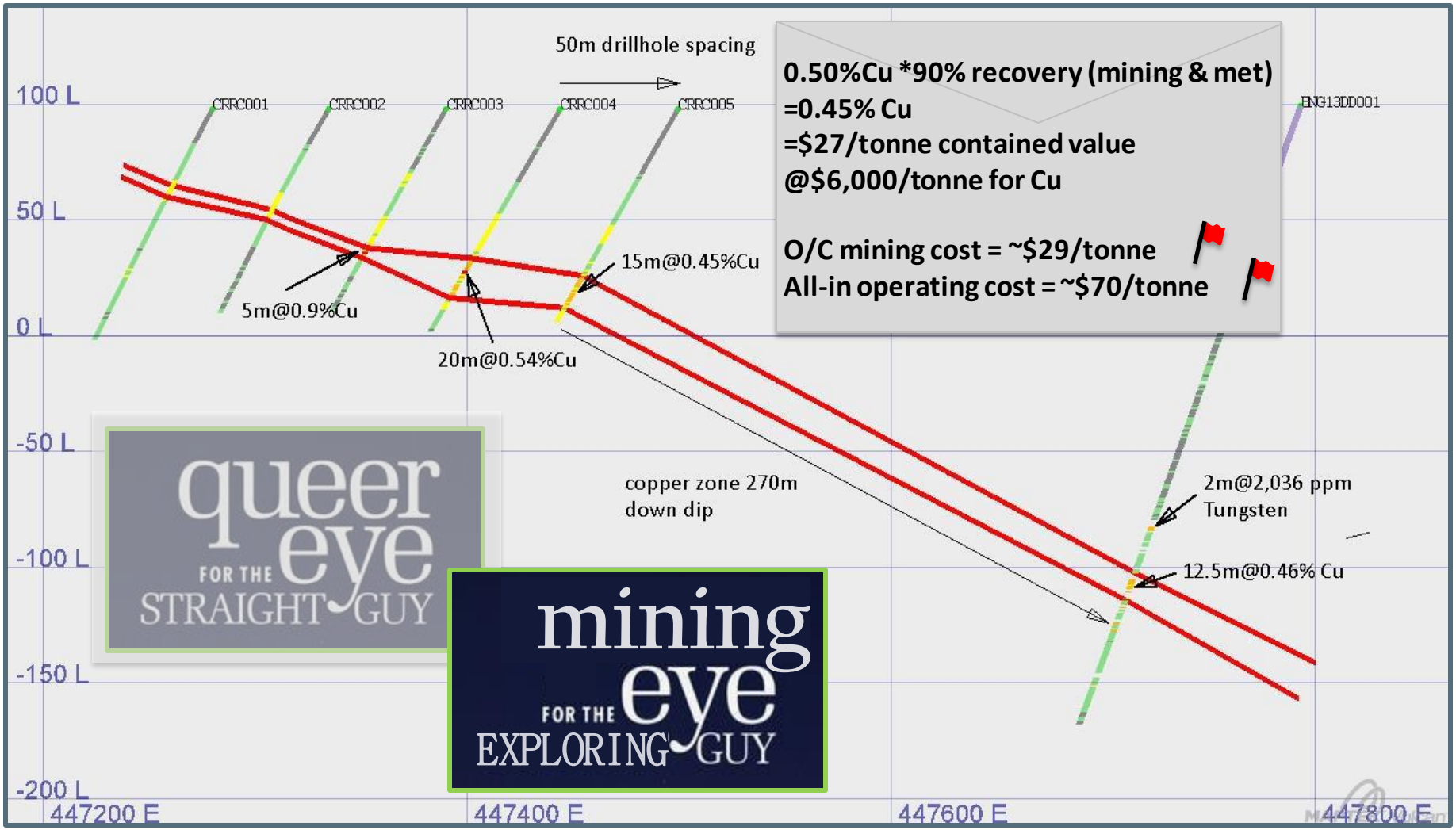
Multidisciplinary Project Evaluation




**The progress of studies for mineral projects** (Source: AusIMM Cost Estimation Handbook, 2nd ed.)

Company-specific practices

Established Processes and Guidelines




"…infill drilling…" "…open-cut potential…" "…skarns…associated with Grasberg…"

## Figure 3: Queensland's new resources and mineral intersections map

**1 COALSTOUN — Copper**

Significant Intersections
- 21 m at 0.81% Cu from 15 m
- 17 m at 0.65% Cu from 42 m

Activex Limited — www.activex.com.au

**2 COPPER CANYON — Copper**

Significant Intersections
- 37 m at 0.78% Cu, 0.5 g/t Au 976 ppm Co from 54 m including 8 m at 2.27% Cu, 1.61 g/t Au and 1237 ppm Co from 59 m
- 67 m at 0.52% Cu, 0.24 g/t Au 767 ppm Co from 34 m including 10 m at 0.83% Cu, 1.61 g/t gold and 847 ppm Co from 84 m

Queensland Mining Corporation Limited — www.qmcl.com.au

**3 DOMAIN 81 — Copper, Gold**
- 3 m at 1.3% Cu, 0.8 g/t Au from 216 m
- 22.4 m at 2.2% Cu, 1.2 g/t Au from 280 m
- 31 m at 1.9% Cu, 1.2 g/t Au from 383 m

Chinova Resources Limited — www.inovaresources.com

**4 ESK — Copper**

Significant Intersection
- 12 m at 0.9% Cu 0.1 g/t Au from 300 m

Activex Limited — www.activex.com.au

**5 KAISER BILL — Copper, Gold**

Significant Intersections
- 11 m at 1.46% Cu 0.29 g/t Au from 29 m
- 9 m at 1.23% Cu 0.12 g/t Au from 142 m
- 30 m at 1.03% Cu 0.17 g/t Au from 157 m
- 24 m at 1.25% Cu 0.28 g/t Au from 201 m

Consolidated Tin Mines Ltd — www.csdtin.com.au

**6 MEGELLI ZONE — Copper, Gold**

Significant Intersections
- 14 m at 2.2% Cu, 2.9 g/t Au from 108 m
- 22 m at 0.9% Cu, 0.5 g/t Au from 61 m
- 15 m at 1.4% Cu, 0.9 g/t Au from 92 m

Chinova Resources Limited — www.inovaresources.com

**7 NATIVE COMPANION — Copper, Gold**

Significant Intersections
- 12 m at 0.73% Cu, 0.32 g/t Au from 68 m
- 34 m at 0.75% Cu, 0.21 g/t Au from 54 m

Chinalco Yunan Copper Resources Ltd — www.cycal.com.au

**8 OVERLANDER NORTH AND SOUTH — Copper, Gold**

Indicated Resource
- 253 000 t at 1.35% Cu, 254 ppm Co

Inferred Resource
- 1.518 Mt at 1.17% Cu, 476 ppm Co

Hammer Metals Limited — www.hammermetals.com.au

**9 QUESTION MINE — Copper, Gold**

Significant Intersections
- 18 m at 1.32% Cu, 0.24 g/t Au from 96 m
- 23 m at 1.42% Cu, 0.19 g/t Au from 61 m

Chinova Resources Limited — www.inovaresources.com

**10 SLATE RIDGE — Copper, Gold**

Significant Intersections
- 43 m at 4.66% Cu, 1.1 g/t Au from 51 m
- 29 m at 2.45% Cu, 1.42 g/t Au from 69 m

Chinova Resources Limited — www.inovaresources.com

**11 THALANGA FAR WEST — Polymetallic**

Measured Resource
- 81 000 t at 1.5% Cu, 1.3% Pb, 4.6% Zn, 0.2g/t Au, 30g/t Ag

Indicated Resource
- 691 000 t at 1.6% Cu, 1.7% Pb, 5.5% Zn, 0.3g/t Au, 44 g/t Ag

Inferred Resource
- 873 000t at 1.9% Cu, 2.3% Pb, 6.6% Zn, 0.2g/t Au, 53 g/t Ag

Red River Resources Limited — www.redriverresources.com.au

**12 WEE MACGREGOR — Copper**

Inferred Resource (based on historical data)
- 1.65 Mt at 1.6% Cu

Argosy Minerals — www.argosyminerals.com.au

**13 YOUNG AUSTRALIAN — Copper**

Significant Intersections
- 6 m at 1.07% Cu from 144 m
- 18 m at 0.51% Cu from 92 m

Queensland Mining Corporation Limited — www.qmcl.com.au

**14 CHLOE JACKSON — Zinc, Lead, Silver**

Significant Intersection
- 11 m at 4.7% Zn 2.1 % Pb and 32.1 g/t Ag from 163 m

Consolidated Tin Mines Ltd — www.csdtin.com.au

**15 KING VOL NORTH — Zinc**

Significant Intersections
- 33.2 m at 5.6% Zn from 99 m
- 13 m at 4.6% Zn from 71 m

Auctus Chillagoe Pty Ltd — www.athertonresources.com.au

**16 MARONAN — Lead, Silver with a copper gold zone**

Inferred resource
- 30.8 Mt at 6.50% Pb and 106 g/t Ag using a 3% lead cut-off grade

Inferred resource
- 19.2 Mt at 1.24% Cu and 0.6 g/t Au using a 0.5% copper cut-off grade (fresh and weathered)

Red Metal Limited — www.redmetal.com.au

**17 REDCAP — Zinc, Copper**

Significant Intersections
- 3 m at 20.5% Zn, 2.9% Cu from 289.7 m
- 5 m at 9.4% Zn, 0.9% Cu from 268.4 m
- 2.4 m at 13.6% Zn, 1.9% Cu from 212.6 m
- 3.7 m at 8.7% Zn, 2.1% Cu from 326 m

Auctus Chillagoe Pty Ltd — www.athertonresources.com.au

**18 AGATE CREEK — Gold**

Indicated resource
- 5.0 Mt at 1.6 g/t Au

Inferred resource
- 3.2 Mt at 1.2 g/t Au

Laneway Resources Limited — www.lanewayresources.com.au

**19 CHOUGH — Gold**

Significant Intersection
- 82 m at 0.106 g/t gold from 20 m

Orion Gold NL — www.oriongold.com.au

Queensland's significant mineral mines, advanced mineral projects and new intersections (July 2016)
www.dnrm.qld.gov.au

Some nice intersections reported…..

Any mining eye FOR THE EXPLORING GUY contenders?

As explorers, how do we know when we have something with potential?

What is the effect of exploring deeper?

# Introduction to PEET-UG

***PROSPECT ECONOMIC EVALUATION TOOL - UNDERGROUND***

Interactive, spread-sheet based tool, for prospect/target evaluation (Pre-'Concept level' analysis) in relative terms.


3 key purposes:

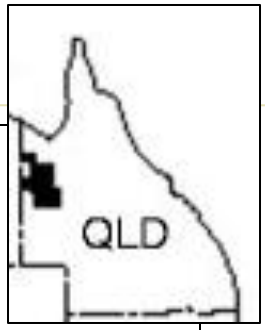
1. Where should I be exploring? …..mining constraints on prospectivity utilized in exploration strategy development.

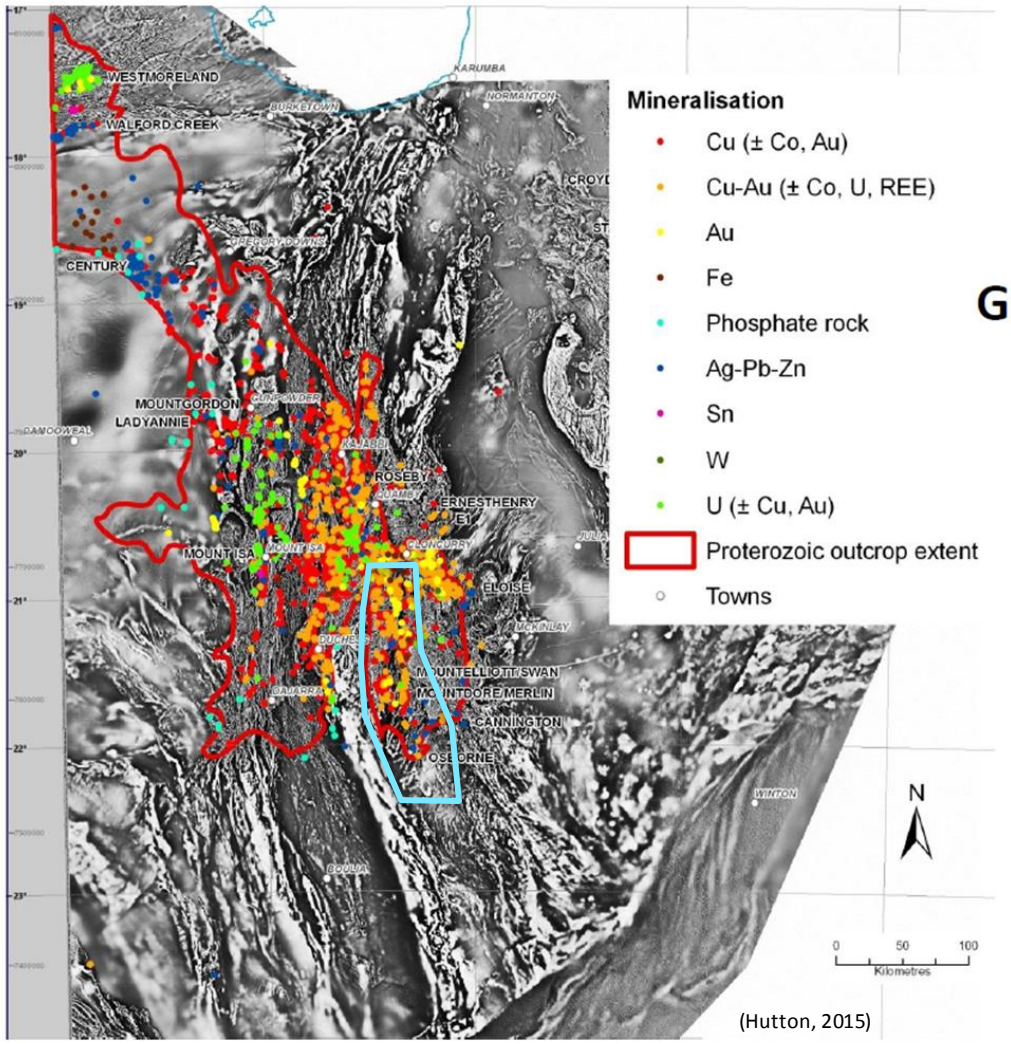
2. Amongst my portfolio of targets/prospects, which of these has the potential to sustain a mining operation? Tool for ranking geological targets in terms of potential viability.

3. Tool for stage-gating the exploration process: is the prospect worth continued effort/expenditure?

**The evaluative tool has been constructed to determine relative value of deposits amenable to underground mining, and as a standalone operation.**

# Venturing off the outcrop



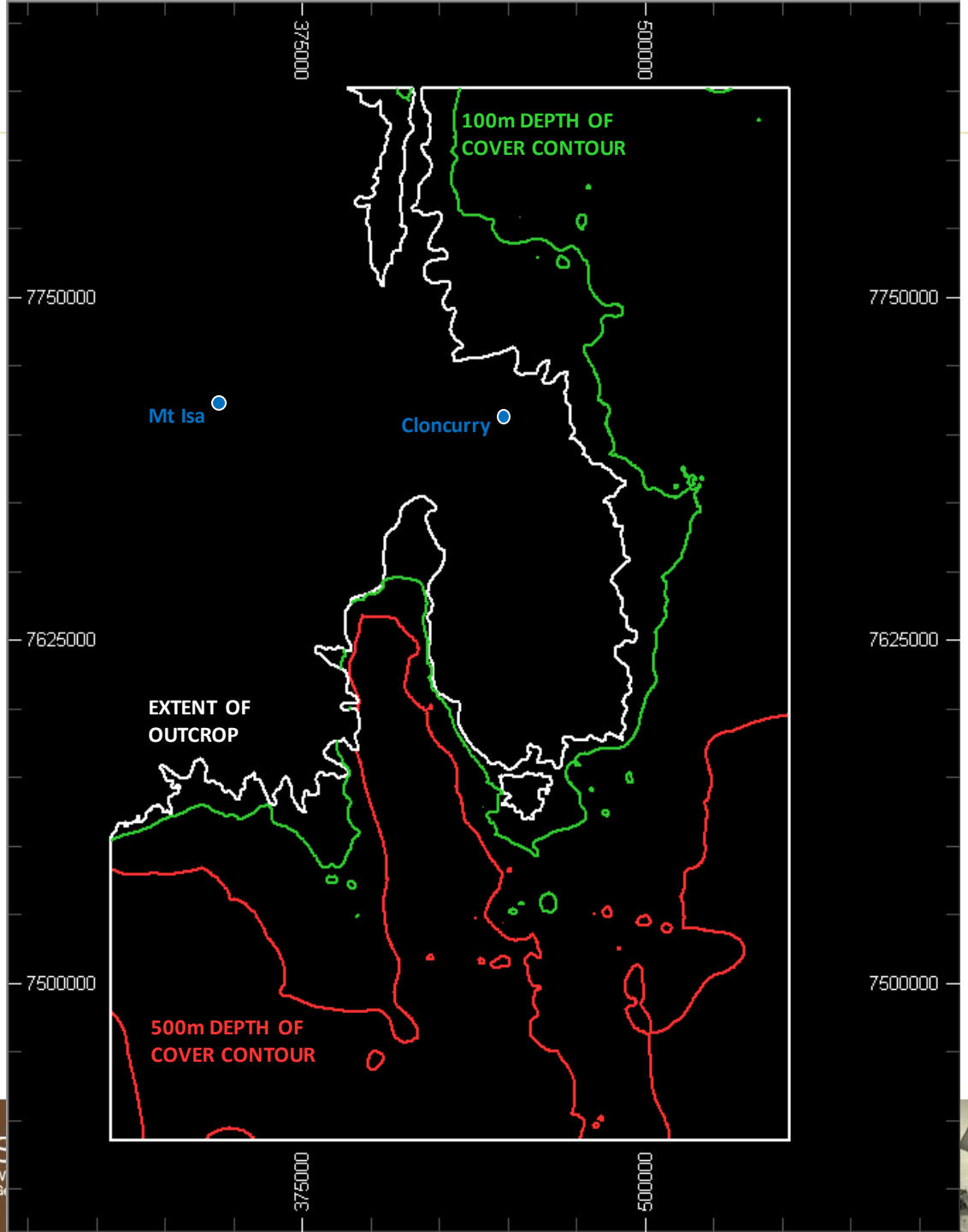



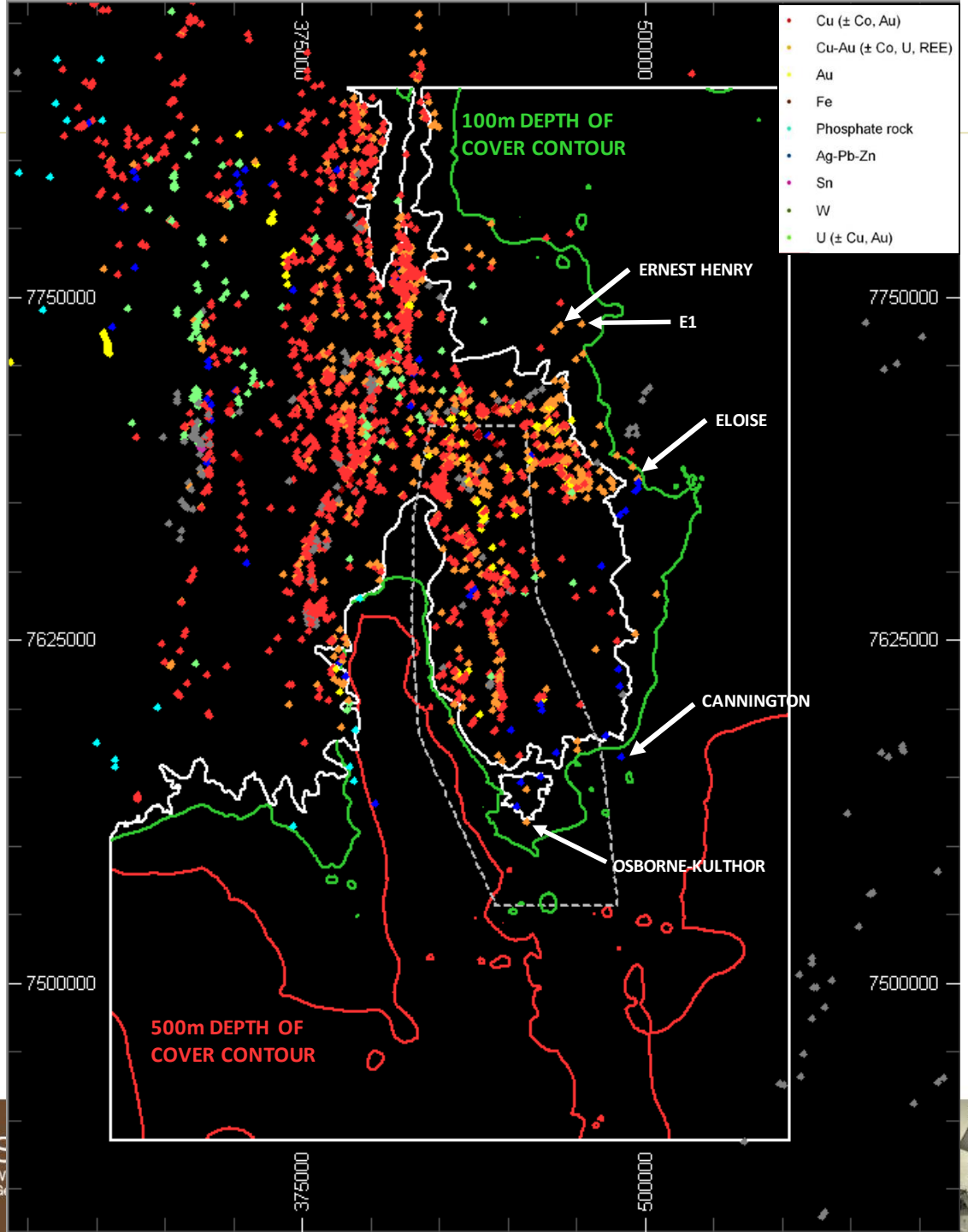

(Hutton, 2015)

Magnetic Image - 1st vertical derivative

## Mt Isa Inlier Greenfields Potential

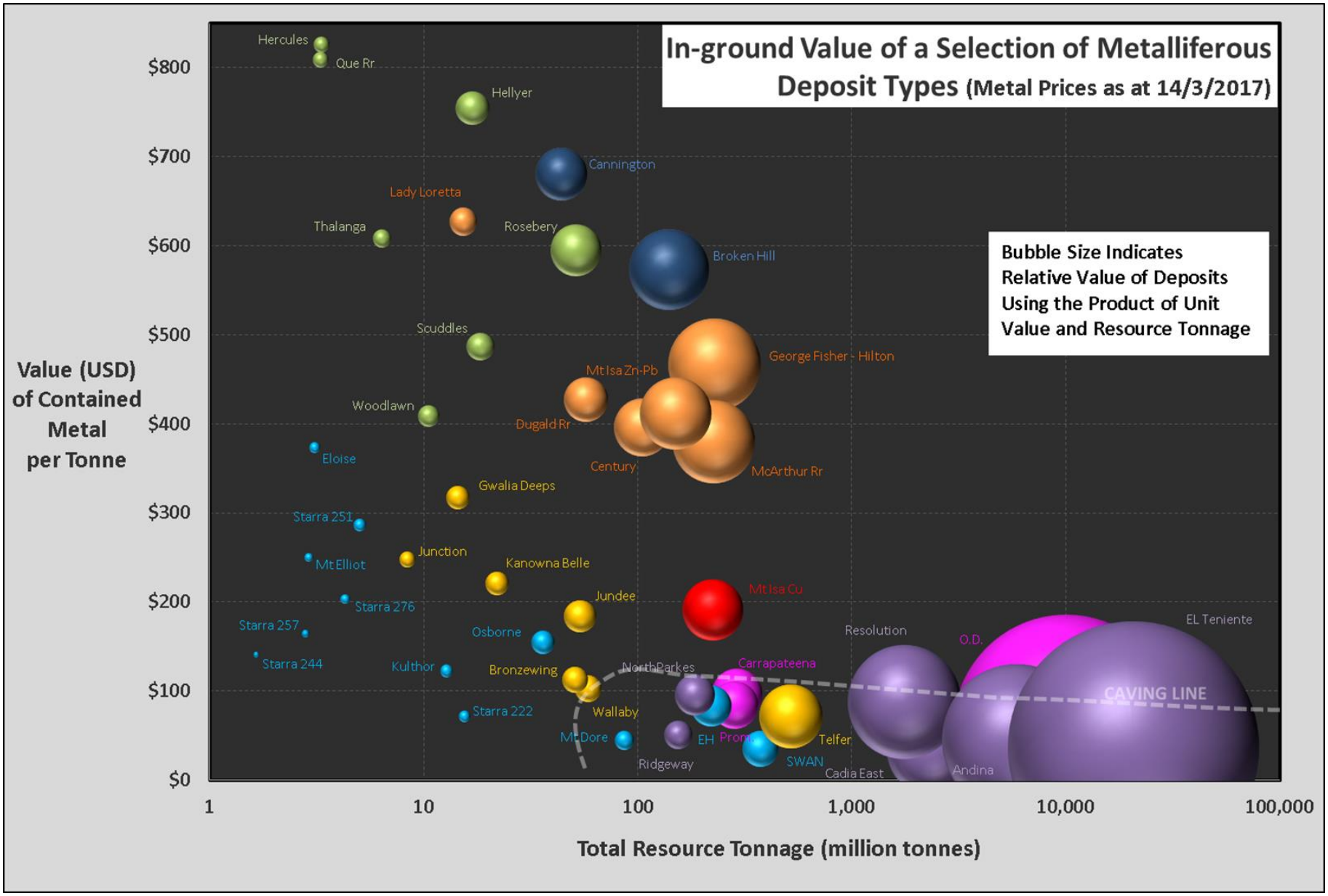
**>70 % is under cover and virtually unexplored**

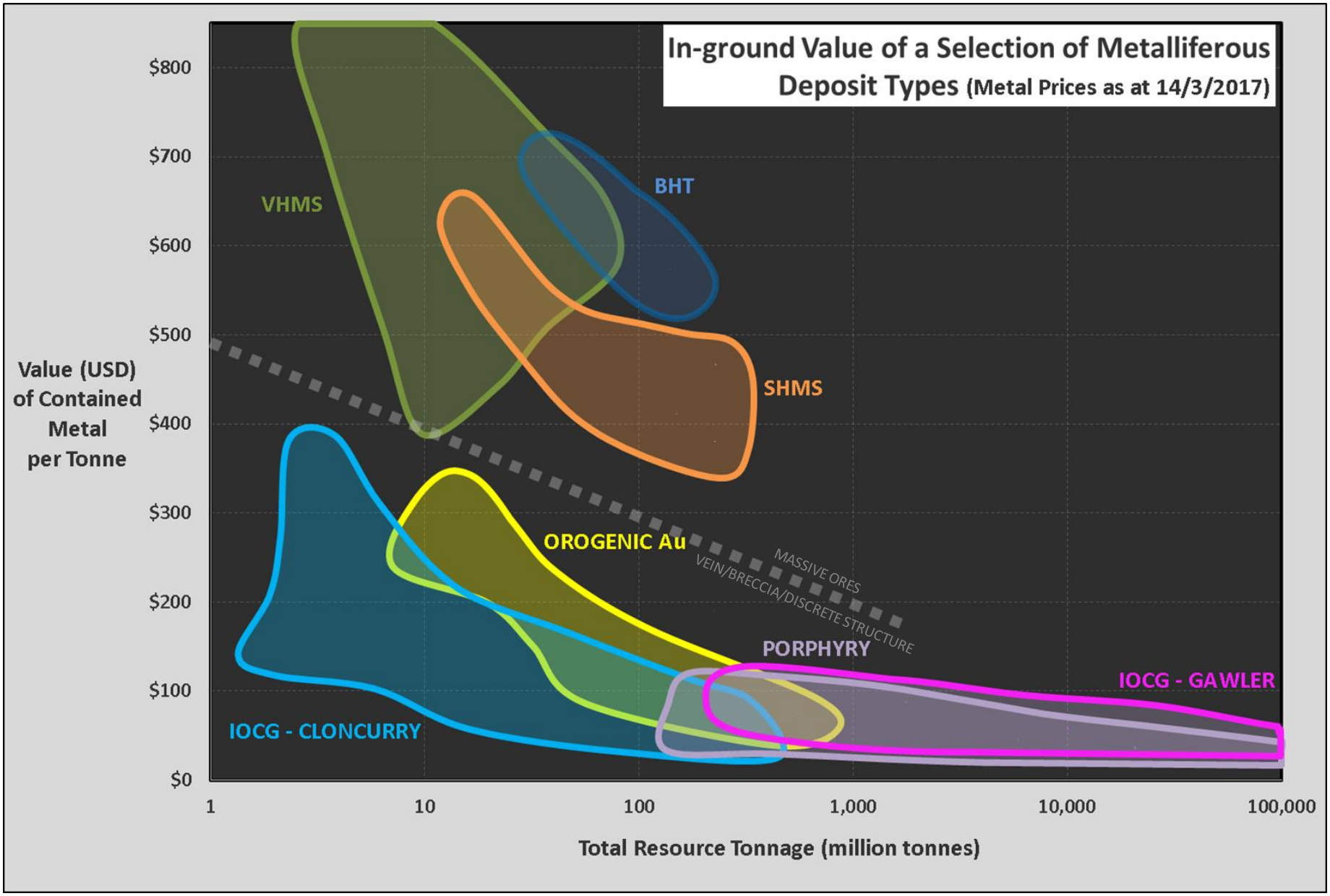

375000
500000
100m DEPTH OF COVER CONTOUR
7750000
7750000
Mt Isa
Cloncurry
7625000
7625000
EXTENT OF OUTCROP
7500000
7500000
500m DEPTH OF COVER CONTOUR
375000
500000


Cu (± Co, Au)
Cu-Au (± Co, U, REE)
Au
Fe
Phosphate rock
Ag-Pb-Zn
Sn
W
U (± Cu, Au)
100m DEPTH OF COVER CONTOUR
500m DEPTH OF COVER CONTOUR
ERNEST HENRY
E1
ELOISE
CANNINGTON
OSBORNE-KULTHOR
375000
500000
7750000
7625000
7500000

What do we need to find at 500m depth in order to establish a viable mining operation?

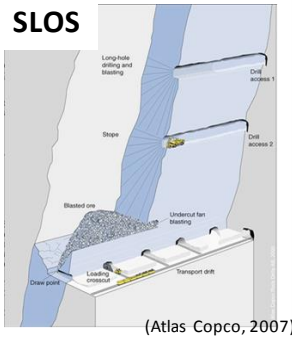
Is this reasonable in the context of known deposits in the area we are exploring?


In-ground Value of a Selection of Metalliferous Deposit Types (Metal Prices as at 14/3/2017)
Bubble Size Indicates Relative Value of Deposits Using the Product of Unit Value and Resource Tonnage
Value (USD) of Contained Metal per Tonne
$0
$100
$200
$300
$400
$500
$600
$700
$800
1
10
100
1,000
10,000
100,000
Total Resource Tonnage (million tonnes)
Hercules
Que Rr
Hellyer
Cannington
Lady Loretta
Thalanga
Rosebery
Broken Hill
Scuddles
George Fisher - Hilton
Mt Isa Zn-Pb
Woodlawn
Dugald Rr
Century
McArthur Rr
Eloise
Gwalia Deeps
Starra 251
Junction
Mt Elliot
Kanowna Belle
Mt Isa Cu
Jundee
Starra 276
Starra 257
Osborne
Resolution
O.D.
EL Teniente
Starra 244
Kulthor
Bronzewing
North Parkes
Carrapateena
CAVING LINE
Starra 222
Wallaby
Mt Dore
EH
Prom
Telfer
SWAN
Ridgeway
Cadia East
Andina


In-ground Value of a Selection of Metalliferous Deposit Types (Metal Prices as at 14/3/2017)
Value (USD) of Contained Metal per Tonne
$800
$700
$600
$500
$400
$300
$200
$100
$0
1
10
100
1,000
10,000
100,000
Total Resource Tonnage (million tonnes)
VHMS
BHT
SHMS
OROGENIC Au
MASSIVE ORES
VEIN/BRECCIA/DISCRETE STRUCTURE
PORPHYRY
IOCG - GAWLER
IOCG - CLONCURRY

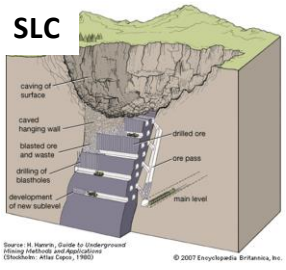
# Extraction Options at Depth – Operating Costs

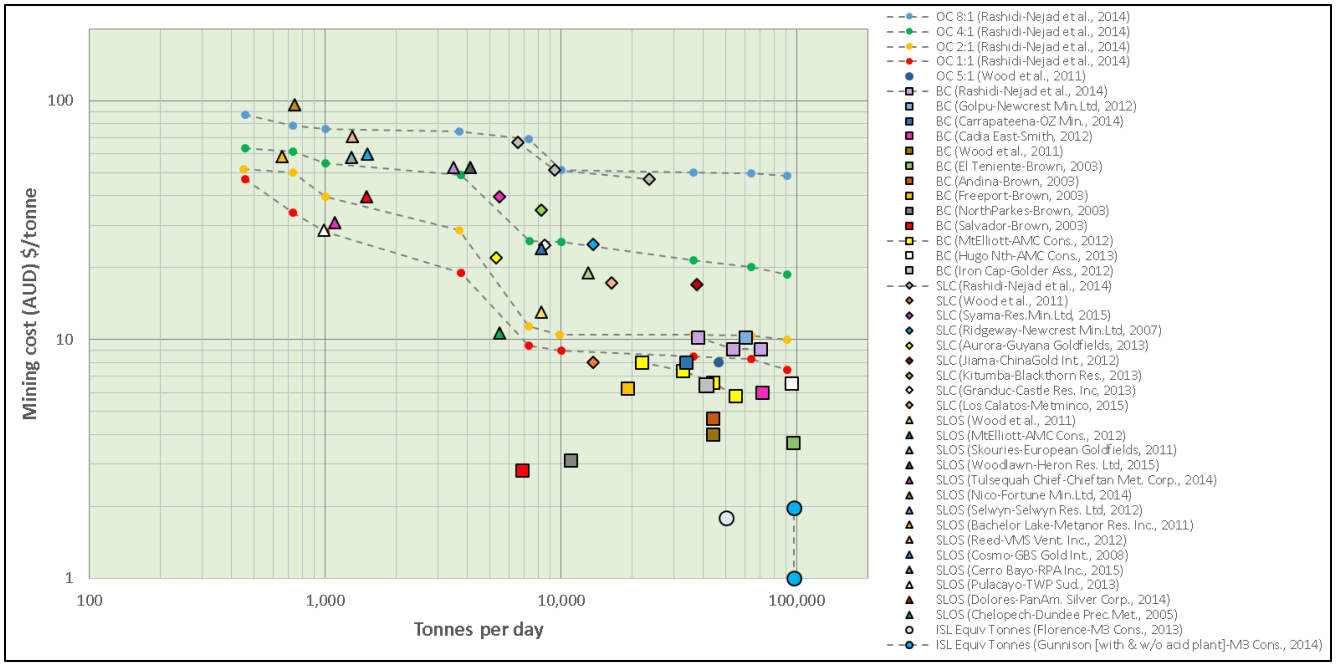
**SLOS**



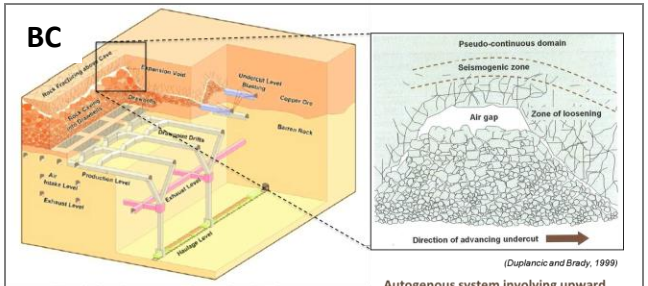

(Atlas Copco, 2007)

**SLC**



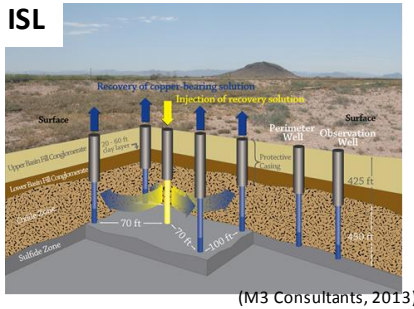

**BC**




Resolution Copper – schematic mine layout
(http://resolutioncopper.com/the-project/mine-plan-of-operations/)

Autogenous system involving upward migration of the seismogenic zone

**ISL**




(M3 Consultants, 2013)

# Extraction Options at Depth – Operating Costs

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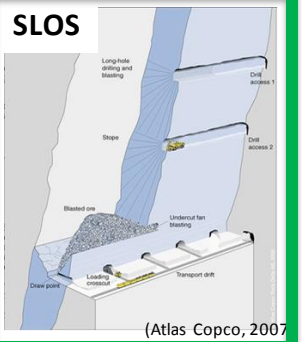


(Atlas Copco, 2007

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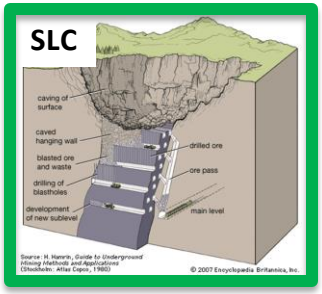
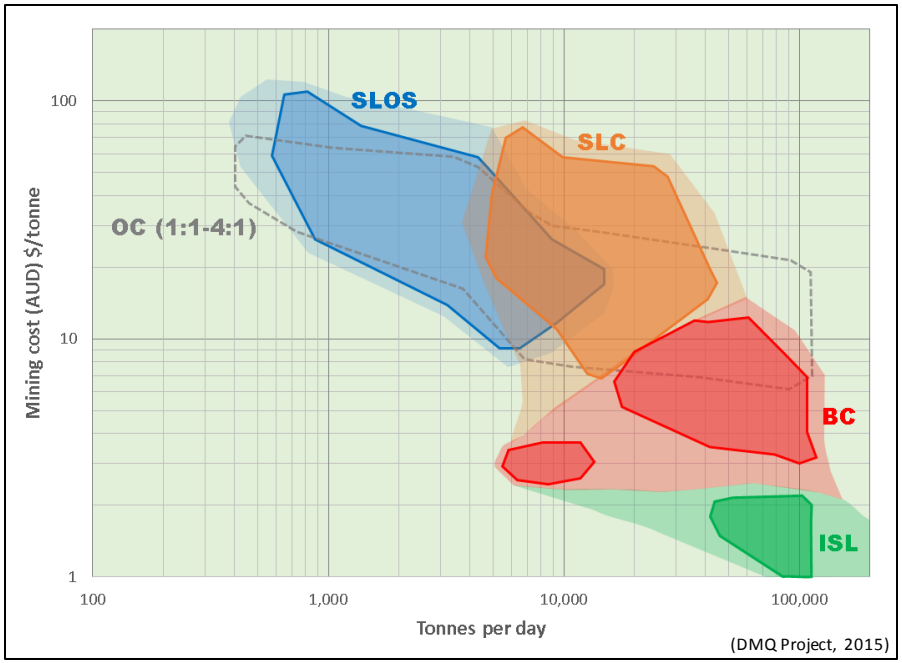


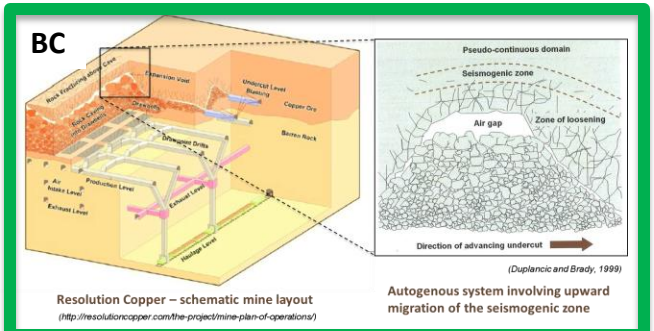




(DMQ Project, 2015)

**PEET Options**

✓

**BC**

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Autogenous system involving upward migration of the seismogenic zone

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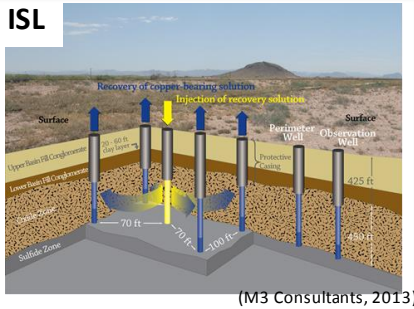



(M3 Consultants, 2013)

***Not* PEET Option**

✗

# Key workings of PEET-UG

**1. Inputs & Assumptions**

- Grade Distribution
- Depth of Cover
- Down-dip Extent
- Length of new road required
- Grade
- Dip
- Width
- Strike-length
- Discount rate
- Metal prices
- Distance to transport hubs
- S.G.
- Mining & Met. recovery
- Exchange rate

**2. Derived Quantities**

- Tonnage
- In-ground value
- Tonnes/vertical metre
- Mine capex estimates
- Contained metal
- Mining rate potential
- Mining advance rate
- Haulage distances
- Opex estimates (Mining + Geology + Processing + Admin)

**3. Mining Method Selection**

- Potential mining block height
- SLOS vs SLC vs BC determined by deposit geometry, dip , min. block height, in-ground 'ore' value
- Truck vs Conveyor test (determined by depth below surface and production rate)

**4. Project & Prodtn. Schedule**

- Mine development by year
- Schedule of ore processed and recovered metal
- Production by year
- Schedule of concentrate produced (tonnes and grade)

# Key workings of PEET-UG (cont'd)

**5. Revenue Schedule**

- Payable metal by year
- Realisation costs by year
- Refining charges per year
- Total Gross Revenue by year

**6. Capex Estimate Models**

- Declines
- Vertical development
- Fixed plant and Infrastructure
- Processing Plant
- Lateral development
- Mobile equipment
- Infrastructure and services
- Sustaining capex
- Total capex
- Tax deduction for capex

**7. Opex Estimate Models**

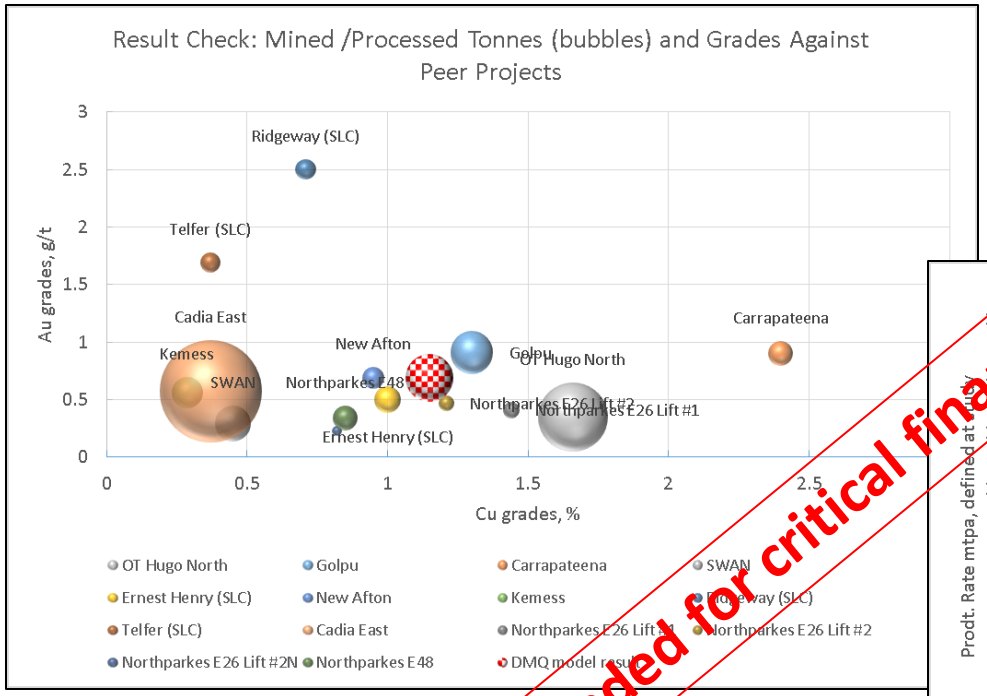
- Mining costs assuming steady state production
- Processing costs " "
- General & Admin costs by year

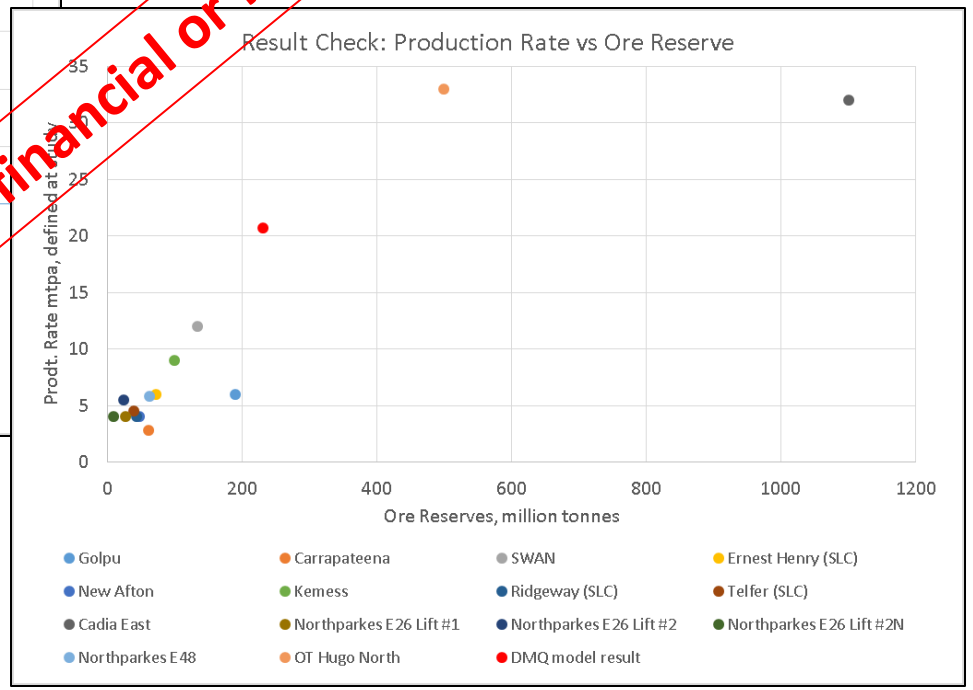
**8. Evaluation Model**

- Collated revenue, capex, opex
- IRR calculation
- Maximum negative cash position
- NPV calculation
- Time to payback
- EBITDA
- Net Cashflow

# Results: comparison with peer projects

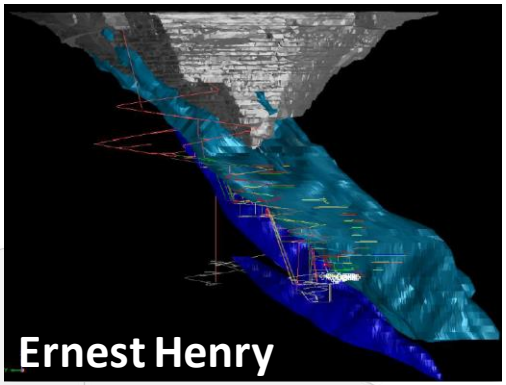

Collated key inputs and outputs on single sheet

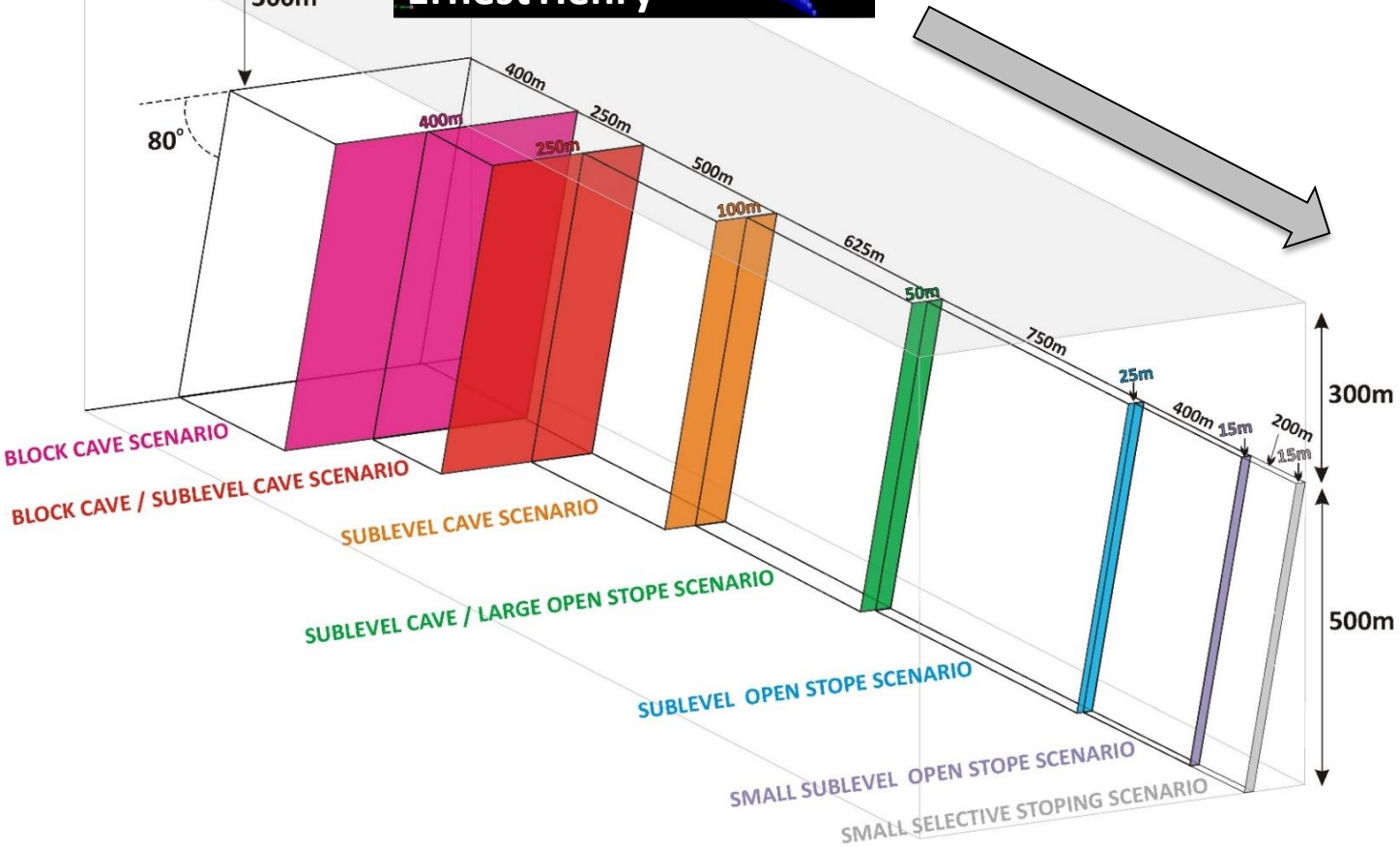


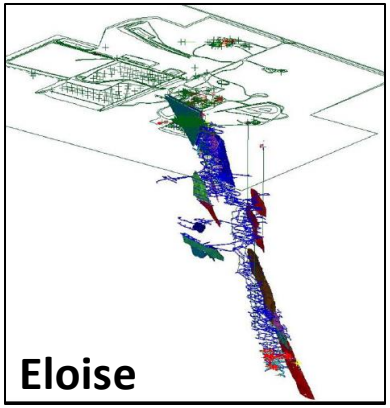




Not intended for critical financial or feasibility analysis

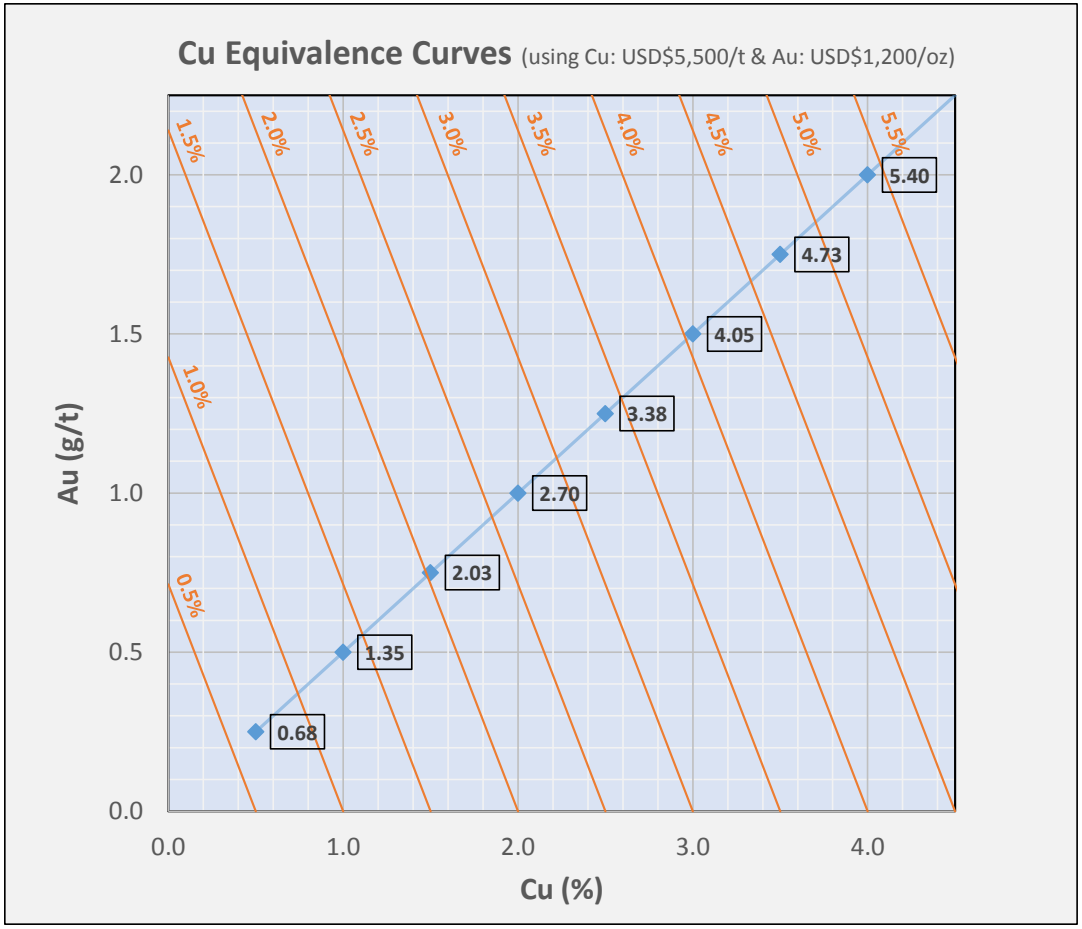
# PEET-UG used in anger…..on simulated data



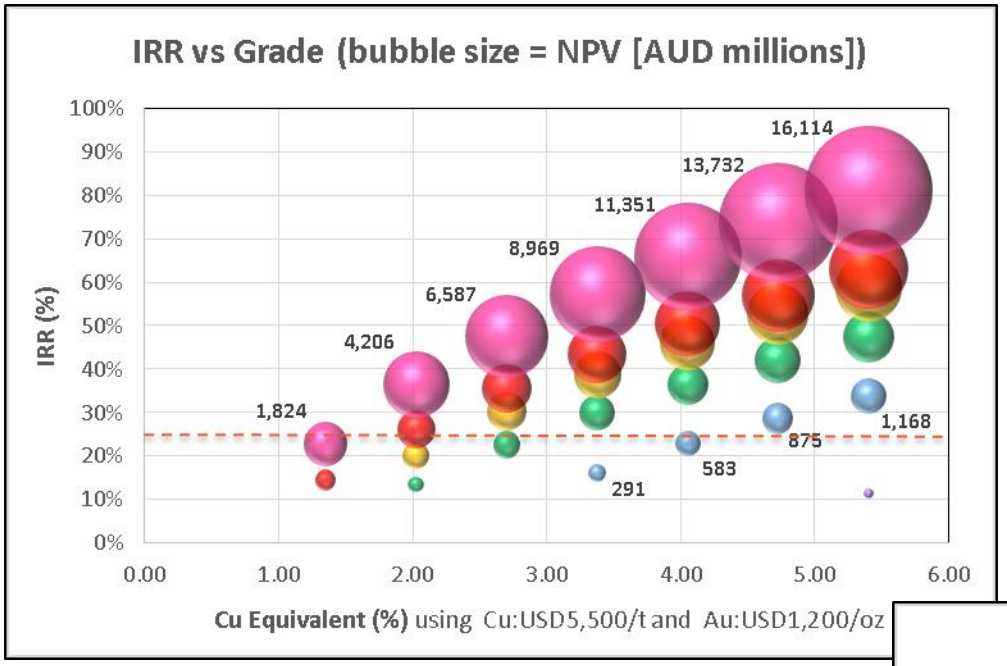



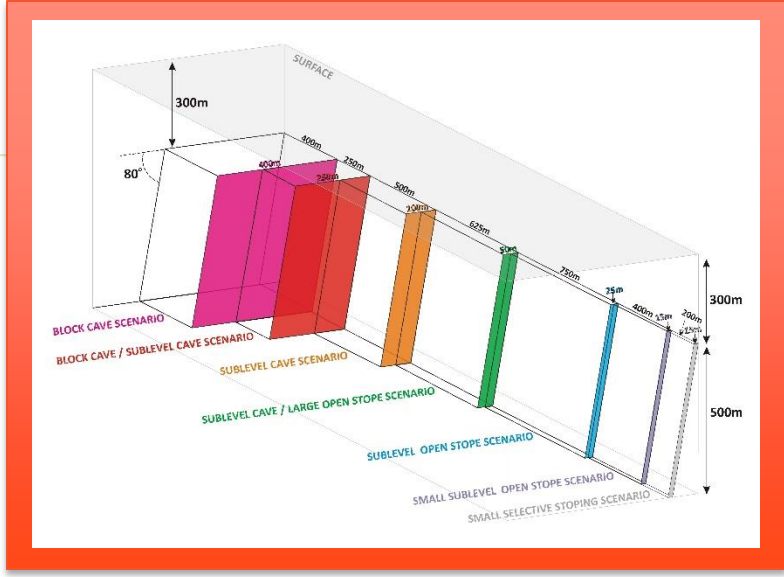

# Copper Equivalence




CuEq (%) = ($value contributed from both Cu and Au) / Cu price.

# Financial measures vs grade/-tonnage/geometry (mining method)



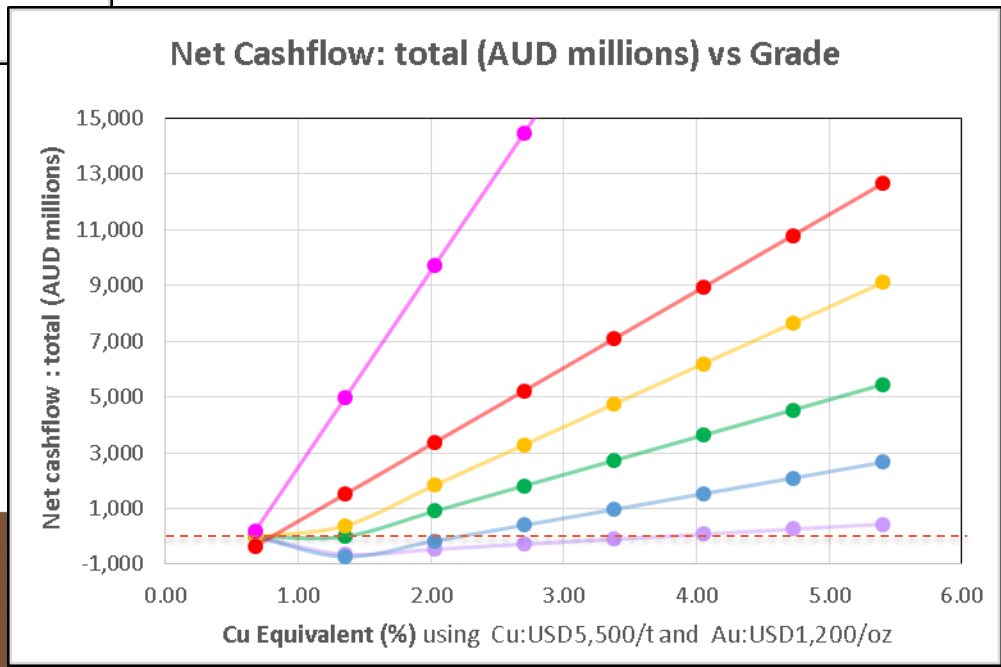




Below, net-cashflow (total) vs grade. Dashed line = 0 cashflow. SLOS methods achieve negative cashflows at grades where caving methods are profitable.

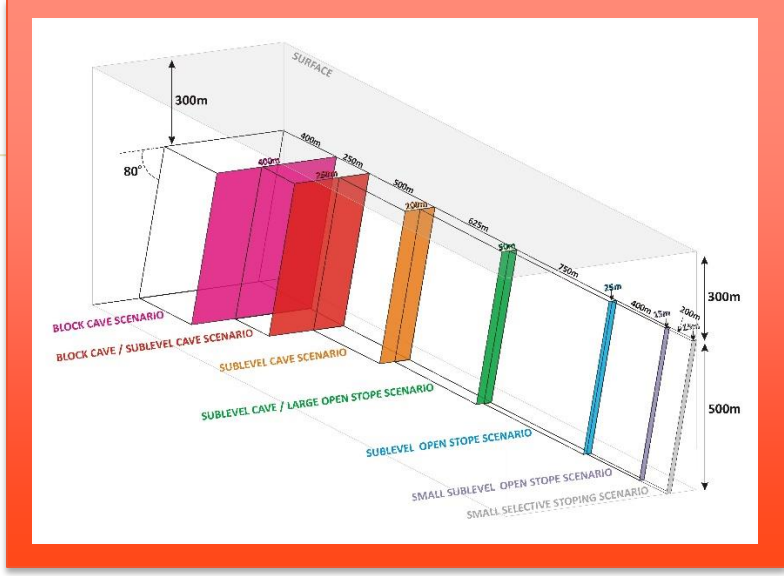
Above, Internal rate of return (IRR) vs grade. Bubble colour corresponds with geometry/mining-block (see image in top RH corner of slide). Bubble size is proportional to NPV, some annotated. Bigger target = more tonnes = higher value. Dashed line represents the 25% IRR 'target' outcome (AP pers. comms, 2016).

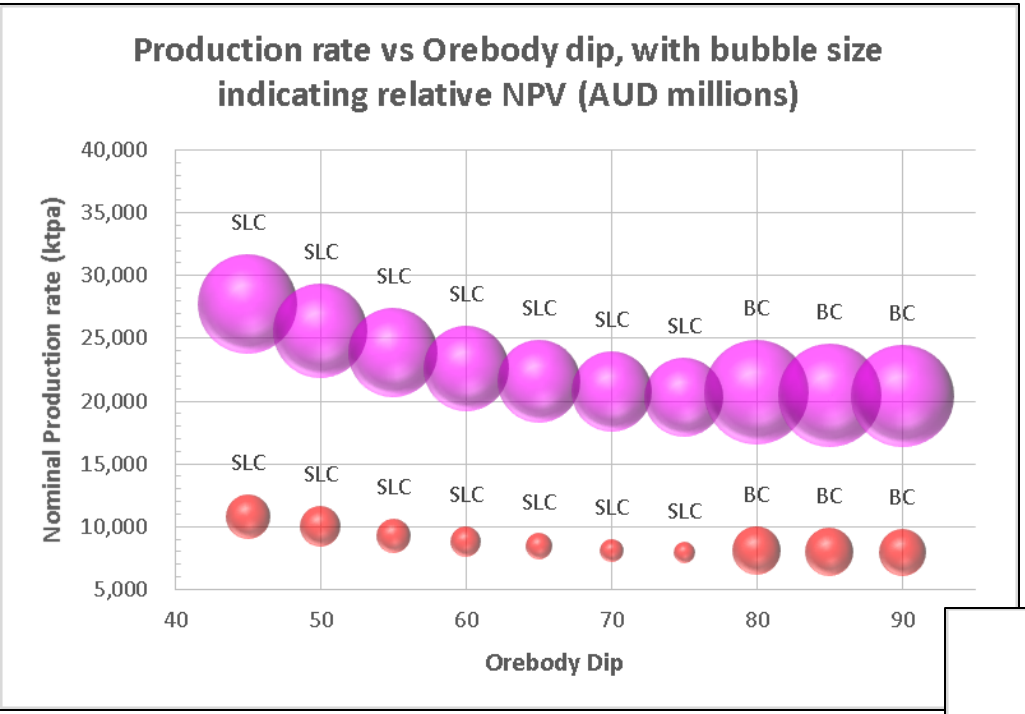
*Parameters:*

- *300m depth to top of deposit*
- *80 degree dip*
- *CuEq calculation assumed Cu at USD$5500/t, and Au at USD$1200/oz, and a 20k:1 ratio of Cu:Au, as broadly observed in IOCG systems.*



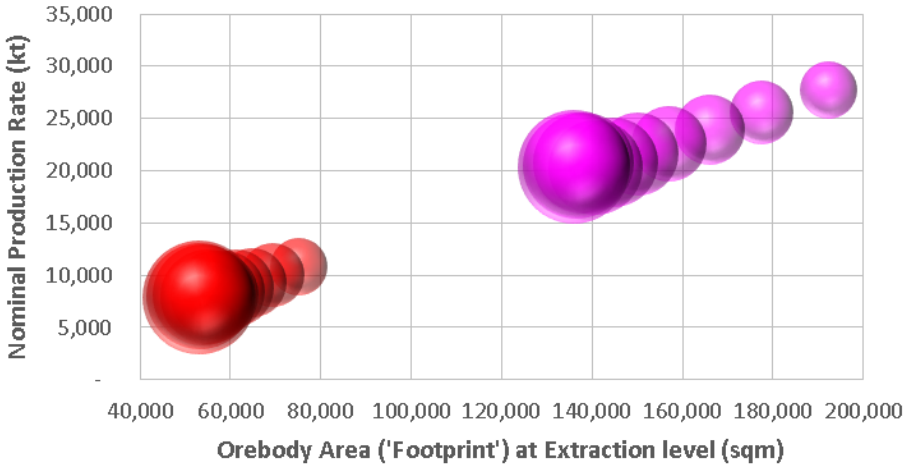
# Impact of Orebody Dip and Geometry on Mining (& Financial) performance




Below, the effect of dip on horizontal area ('footprint') available for extraction. Production rate is higher at gentler dips. Other technical challenges relating to flow of material and stresses impact on mineability, but are deposit-specific and not dealt with at this early stage assessment.

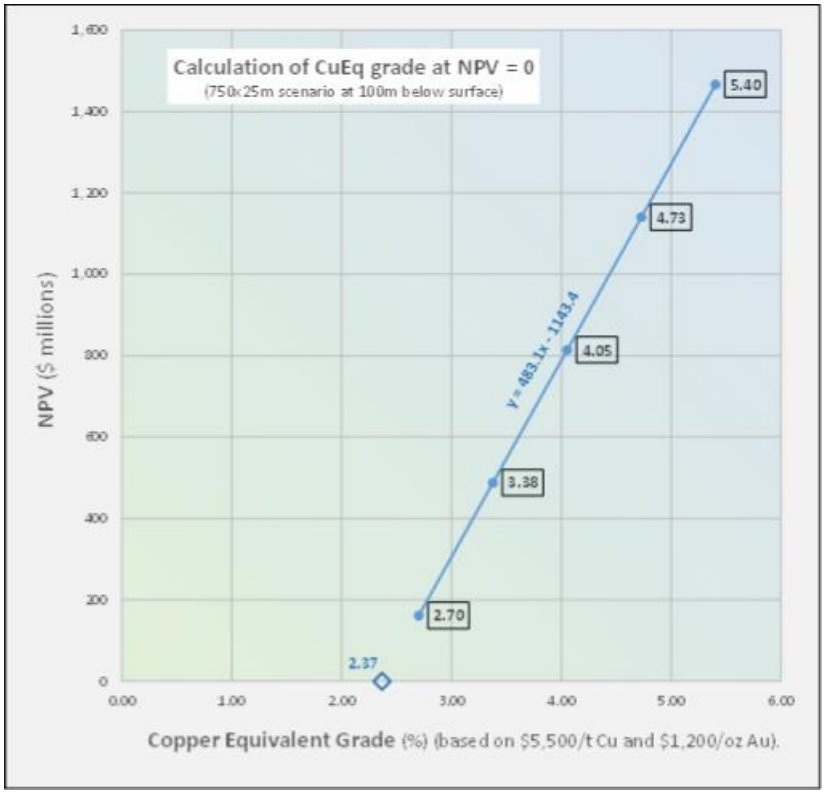
Above, orebody dip erodes NPV through reduction of footprint (access for extraction) and reducing metal content in the 500m vertical high mining block. An 80deg imposed threshold on Block Caving limits its application, but arrests the reduction in NPV and production rate. An interesting phenomenon from the above chart is that NPV is maximised where these mining methods are at their technical limit, i.e. the lowest dip achievable.




*Parameters:*

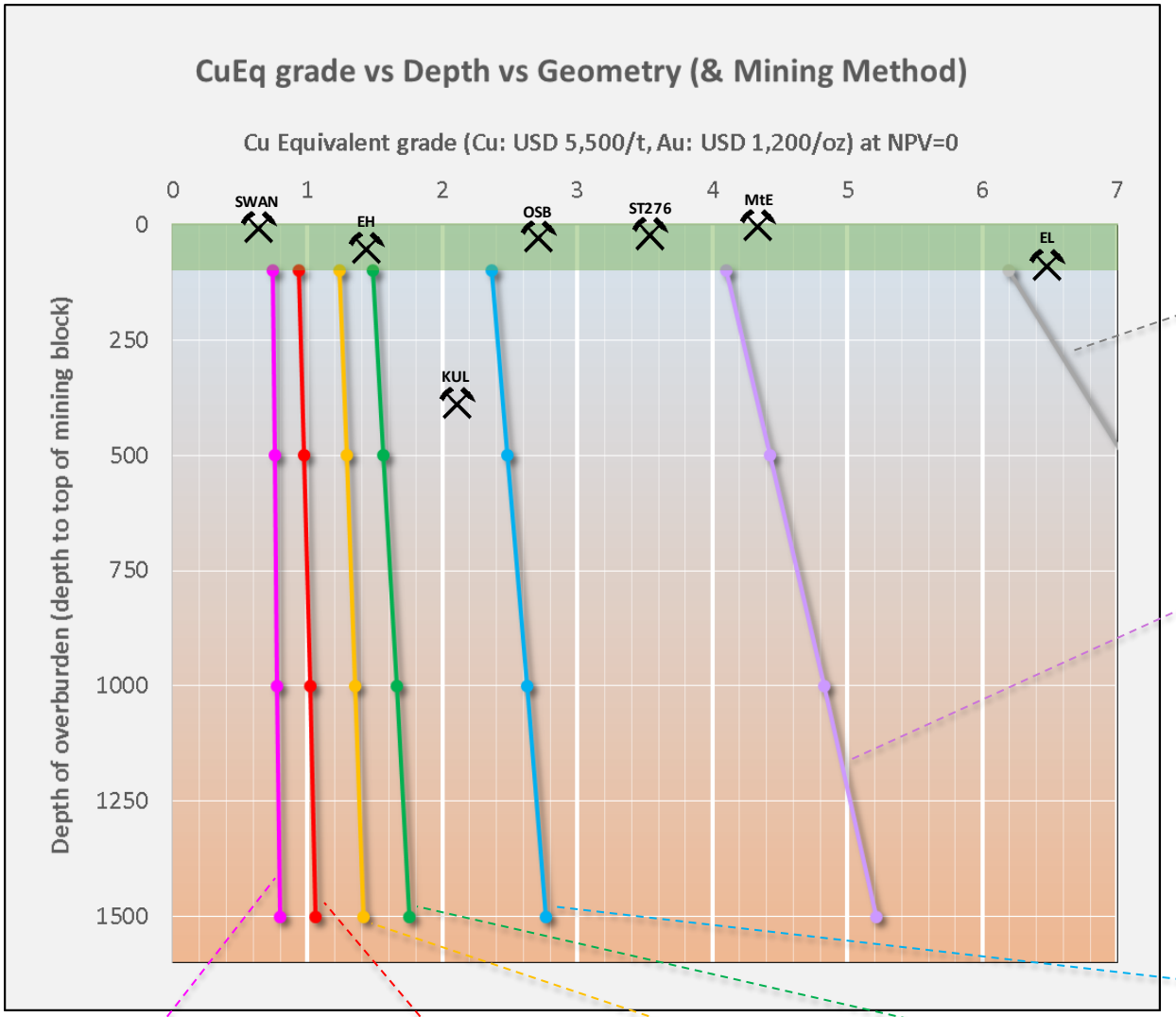
- *300m depth to top of deposit*
- *Cu grade of 1.0% and Au grade of 0.5g/t*
- *500m mining block height*

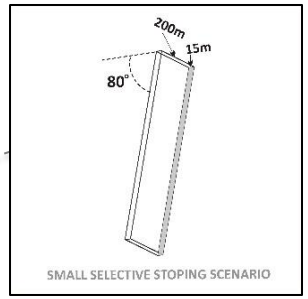
# Comparing apples with apples…..NPV=0

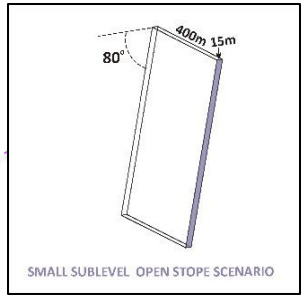


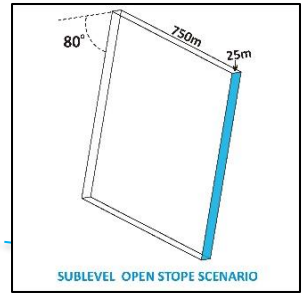

NPV=0 does not mean that the project has no value, but implies that it offers no greater realisation of value than other investment options, or benefits outweighing the cost of capital.

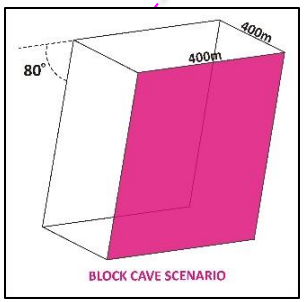
At NPV=0, project risk would be a determining factor in investment choice.

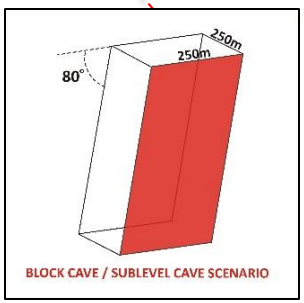


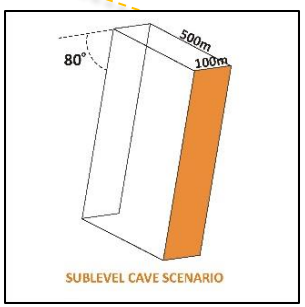



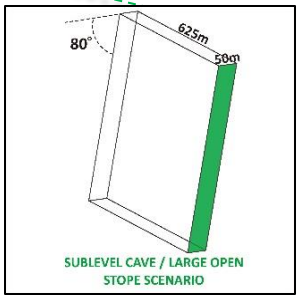



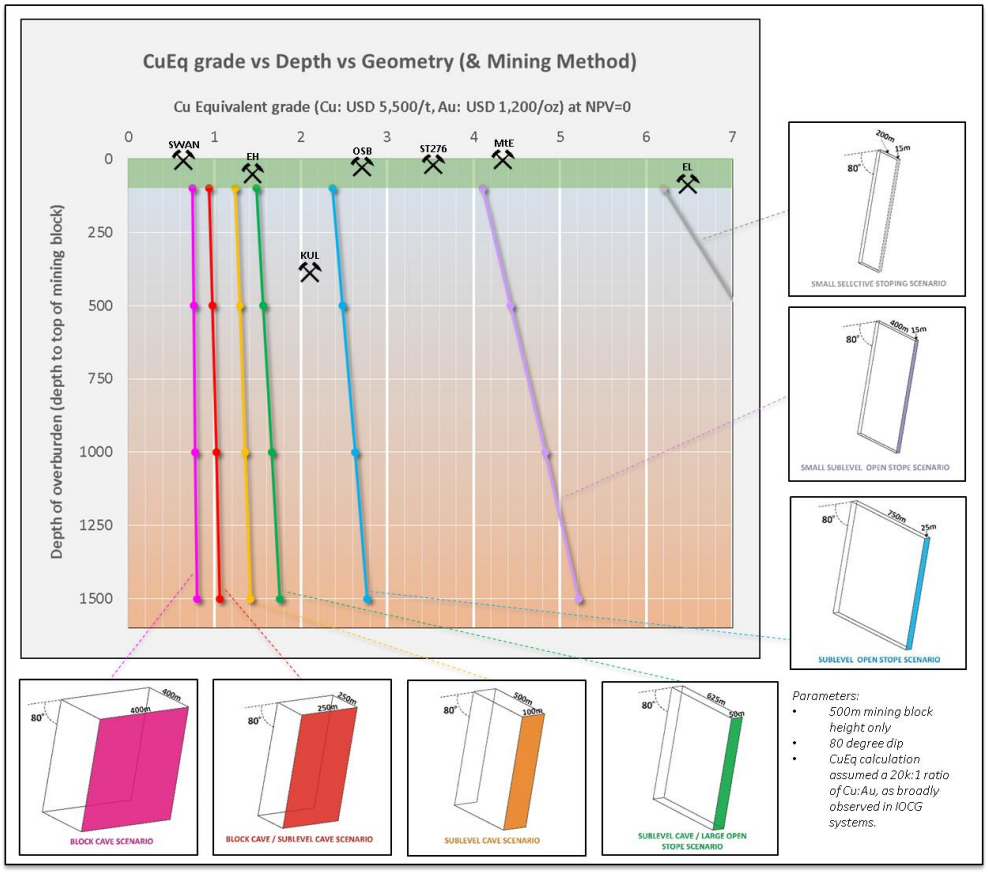




*Parameters:*

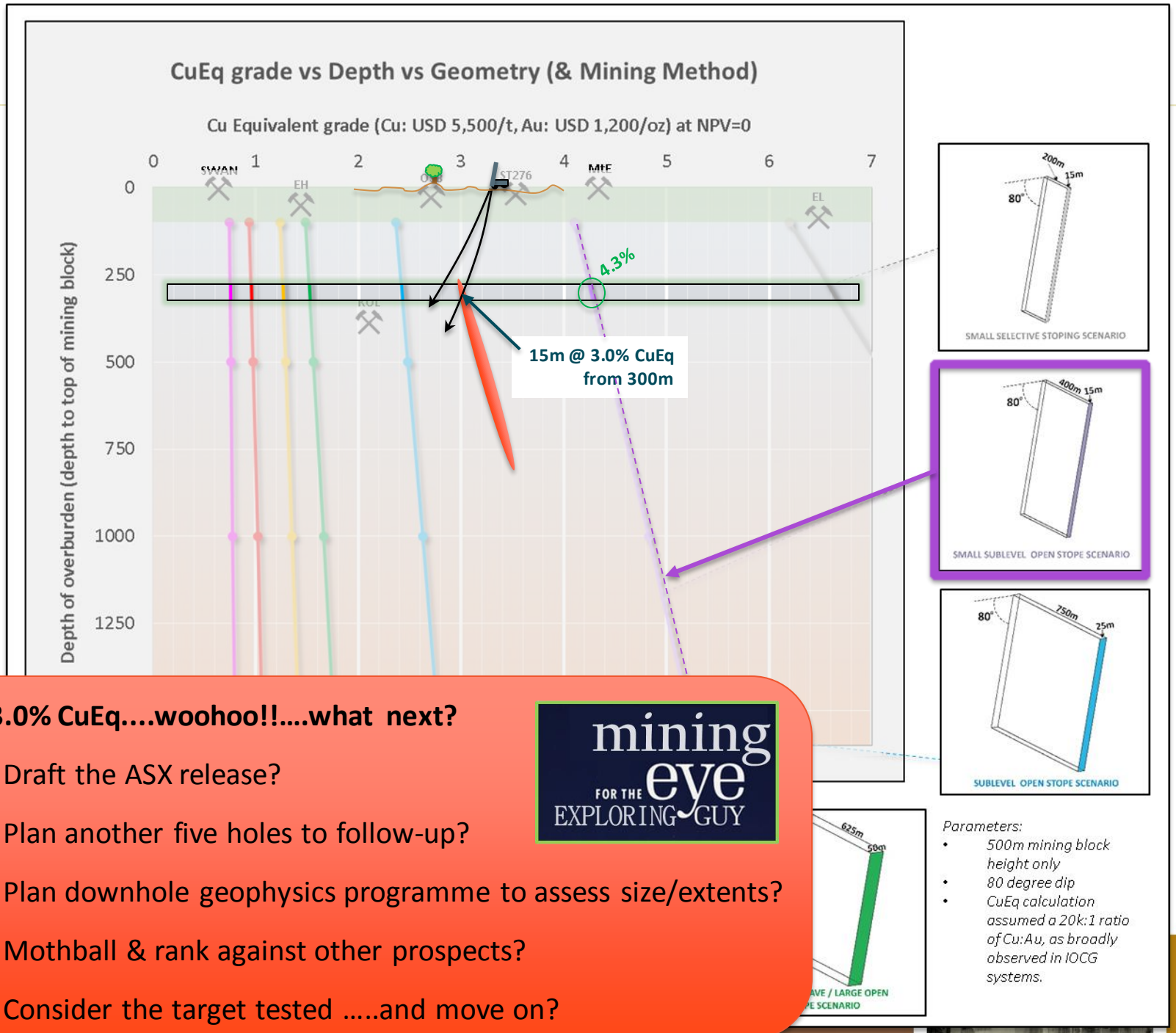
- *500m mining block height only*
- *80 degree dip*
- *CuEq calculation assumed a 20k:1 ratio of Cu:Au, as broadly observed in IOCG systems.*

# Indicative ‘cut-off’ grades by mining method/orebody geometry




## Key observations:

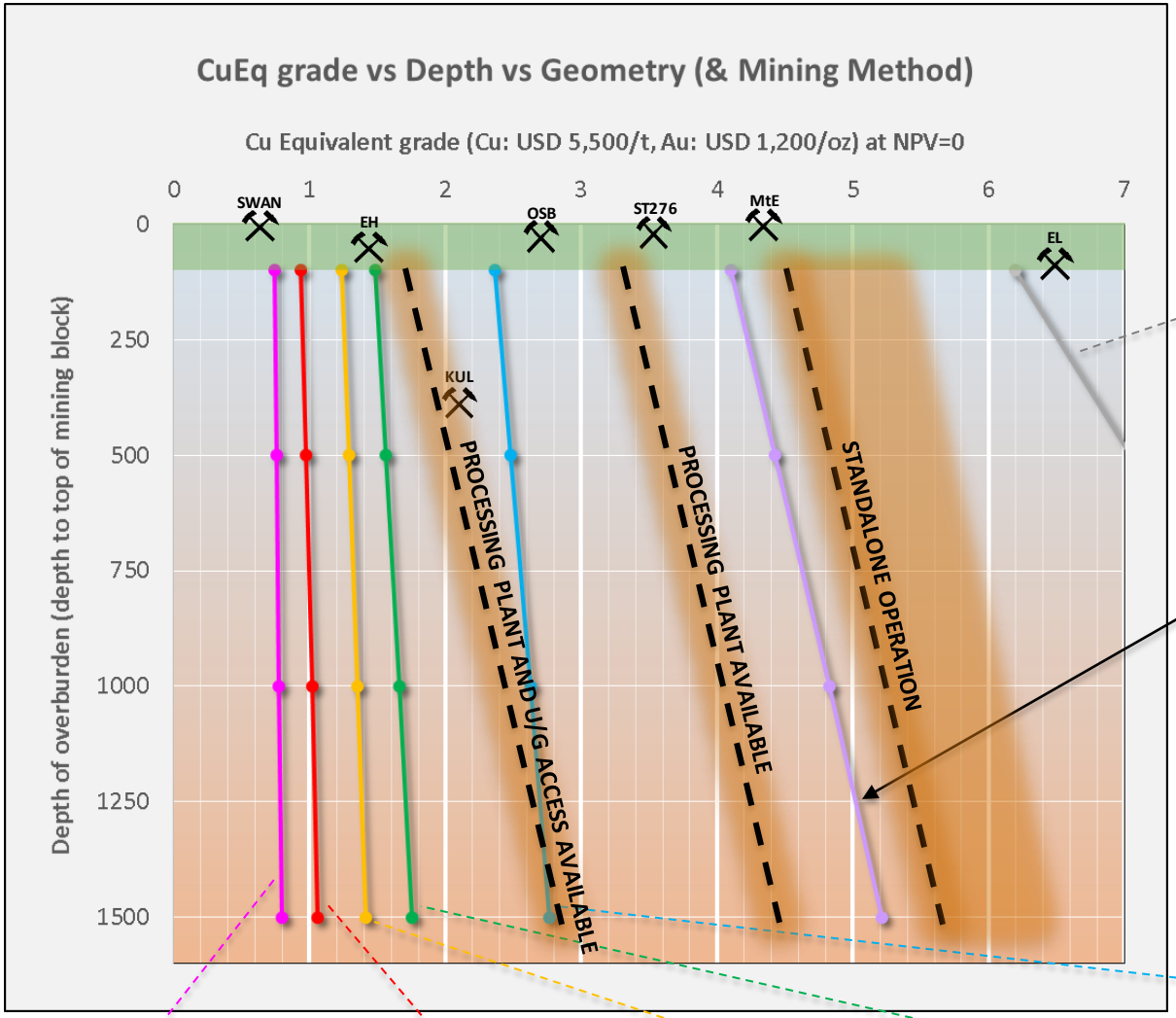
- Depth insensitivity of Block and Sub-level Caving scenarios.
- SWAN occurs left of its corresponding geometry curve (orange) and is uneconomic in the assumed price environment
- Eloise, despite being significantly higher grade, would likely be sub-economic if the top of the ore-reserve was 250m below surface.
- The more selective and development intensive (per tonne of mined ore) stoping methods have a shallower gradient to their CuEq vs Depth curve. Extensions to these mines with depth, carries additional costs; and these costs are amortised across fewer tonnes mined and metal produced.
- Kulthor is well to the left of its corresponding geometry curve (purple) and was economically extracted as it was an incremental expansion of an existing mine and utilized existing processing facility. Discovery of a Kulthor-analogue away from this infrastructure would likely be sub-economic.

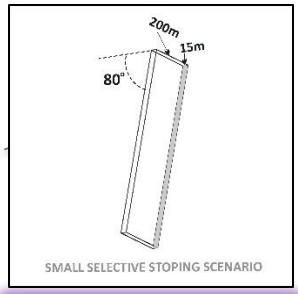


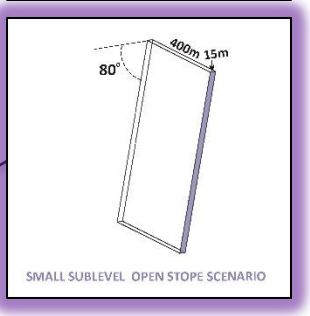

**15m @ 3.0% CuEq....woohoo!!....what next?**

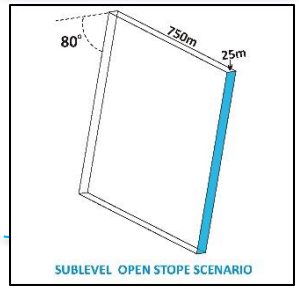
- Draft the ASX release?
- Plan another five holes to follow-up?
- Plan downhole geophysics programme to assess size/extents?
- Mothball & rank against other prospects?
- Consider the target tested .....and move on?

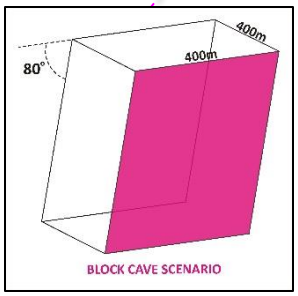
mining eye FOR THE EXPLORING GUY

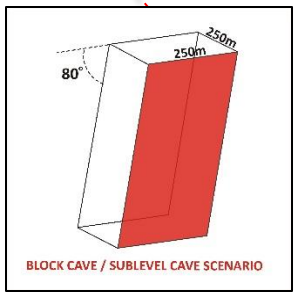


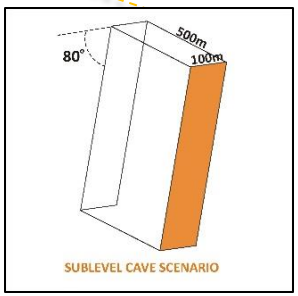



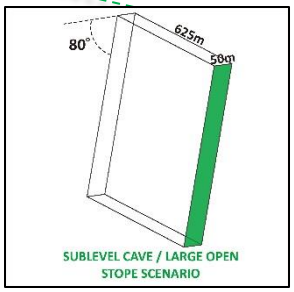



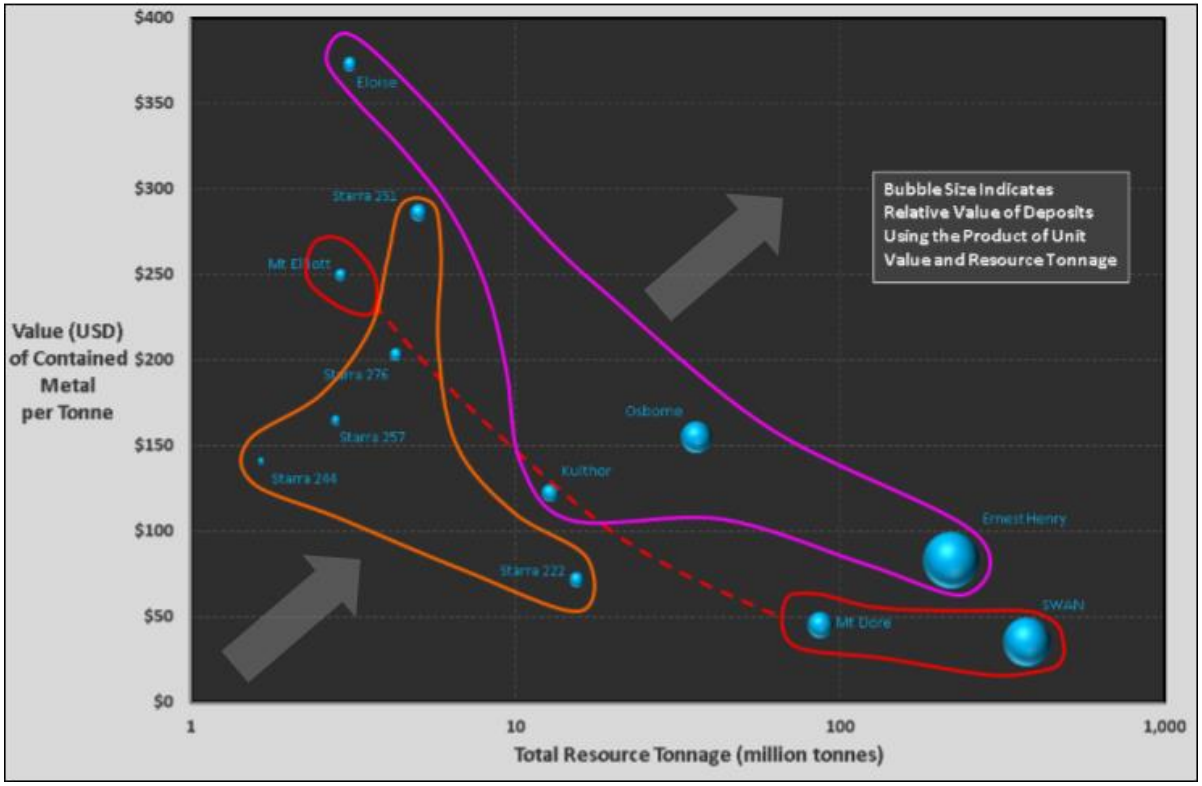




*Parameters:*

- *500m mining block height only*
- *80 degree dip*
- *CuEq calculation assumed a 20k:1 ratio of Cu:Au, as broadly observed in IOCG systems.*

# Are some Cloncurry Cu-Au deposits more prospective than others?




Unit-value per tonne of ore for Cloncurry Cu-Au deposits grouped by deposit-style. Polygons represent grouping of Cloncurry Cu-Au deposits based on the following deposit-styles: Orange polygon: Structural juxtaposition with Staveley Fmn; red polygon: Staveley/Kuridala contact domain, magenta polygon: deposits well into the hangingwall of the Staveley Fmn. Grey arrow indicates the preferred direction, i.e. higher value and higher tonnage.

- The average value per tonne for Cloncurry Cu-Au deposits is $161, with larger deposits (>10Mt) averaging $85/t.
- The smaller deposits have average contained value of $236/t.
- This equates to CuEq of 1.5% for the >10Mt deposits and 4.1% for the remainder of deposits, which are generally <5Mt.

It is apparent that the successful mining of Cloncurry Cu-Au deposits as underground mines has largely been possible due to precursor open-cut mines at the same operation. In other words, the initial extraction method was via open-cut mining and this has covered costs of site access and infrastructure (processing plant, power, water, offices, camp, and tailings storage facility).



# 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. **fertility**
- comprise geotechnical, geothermal, geographical conditions which are technically amenable to mass-mining methods, i.e. **mineability**, and
- comprise all of the above, but with the prospect of positive financial outcomes….subject to internal & external factors, i.e. **viability**.