SMI BRC
WH Bryan Mining & Geology Research Centre

The University of Queensland
AUSTRALIA

(Osborne Headframe – March 2015)

GSQ-Digging Deeper 2016

Exploring Deeper: What are you looking for? What do you need to find?

Travis Murphy

19th August, 2016

Queensland Government
Department of Natural Resources and Mines
Geological Survey of Queensland

chinova resources

DATAMINE

Fullagar Geophysics

Deep Mining Queensland (DMQ)

DMQ Project Team

Dr Travis Murphy (Exploration and Mine Geology)

Dr Mark Hinman (Exploration and Mine Geology)

Dr Mark Pirlo (Exploration Geochemistry)

John Donohue (Exploration Geophysics)

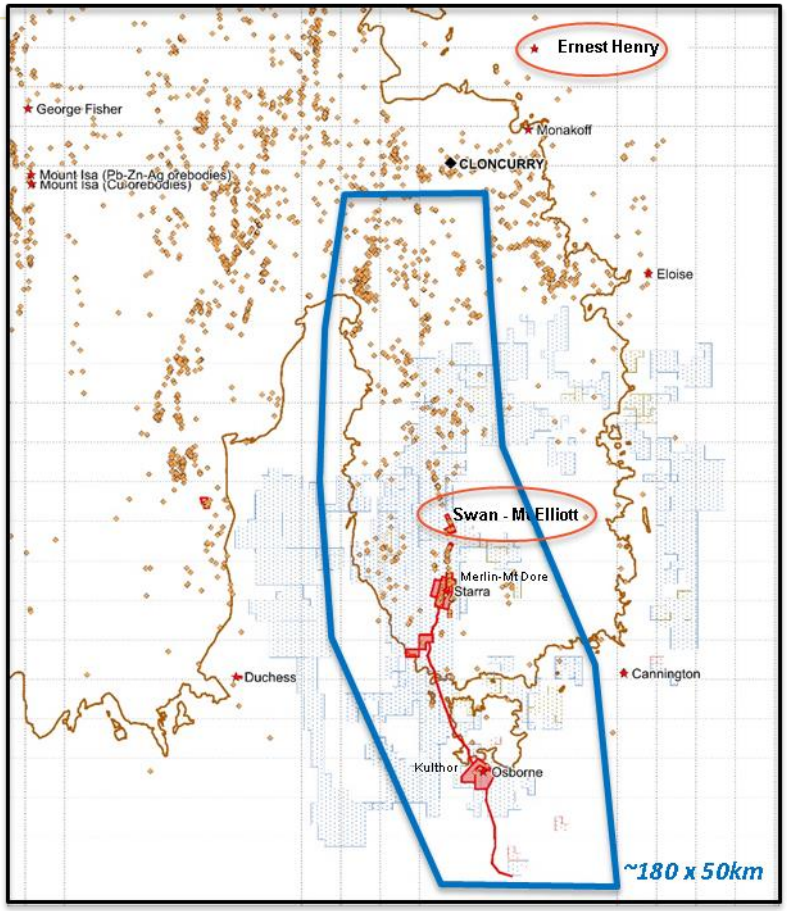
Mark Jones (Software Engineering & Database Support)

Adrian Pratt (Consultant Mining Engineer)

Collectively >100 years mining industry experience

Mining Informed Targeting/Prospectivity

- The research project is centred on part of the Eastern Fold Belt encompassing the Osborne-Kulthor Cu-Au mine, Starra line of Au-Cu deposits and mines, Mt Dore Cu deposit, Merlin Mo deposit, Mt Elliott Cu-Au complex (SWAN, Domain 81, Corbould, Mt Elliott) and numerous historic mining operations and prospects.
    - District with multiple Cu-Au mines, lots of smoke, yet only one large mass-mineable deposit (Ernest Henry), and a large prospective resource (SWAN – *Mt Elliott*).
- What are the prospects for discovery of additional mass-mineable deposits if we deepen the search space to 2km below surface?.....and what would a mineable deposit need to look like at this depth?



	Mt	Cu (%)	Au (g/t)
Ernest Henry[1]	220	1.1	0.5
Swan[2]	375	0.44	0.25

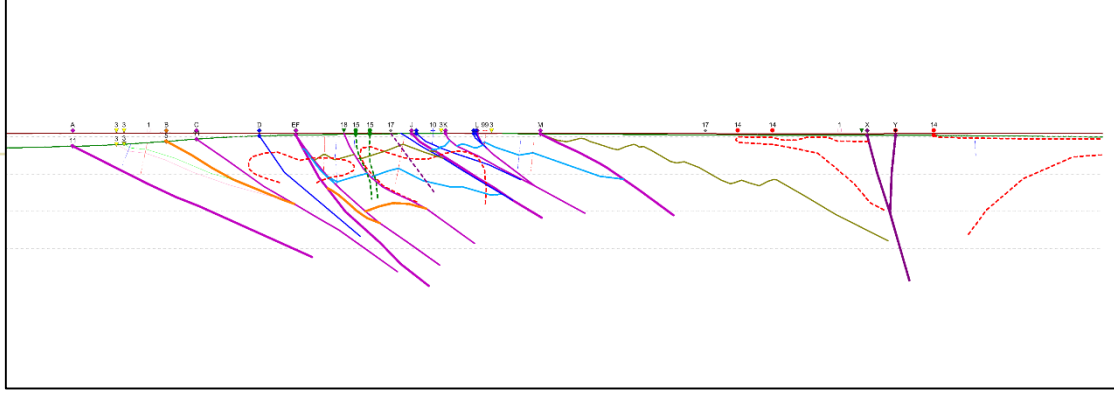
[1] Glencore Reserves & Resources, 2014 [2] AMC – Mt Elliott Scoping Study, 2012

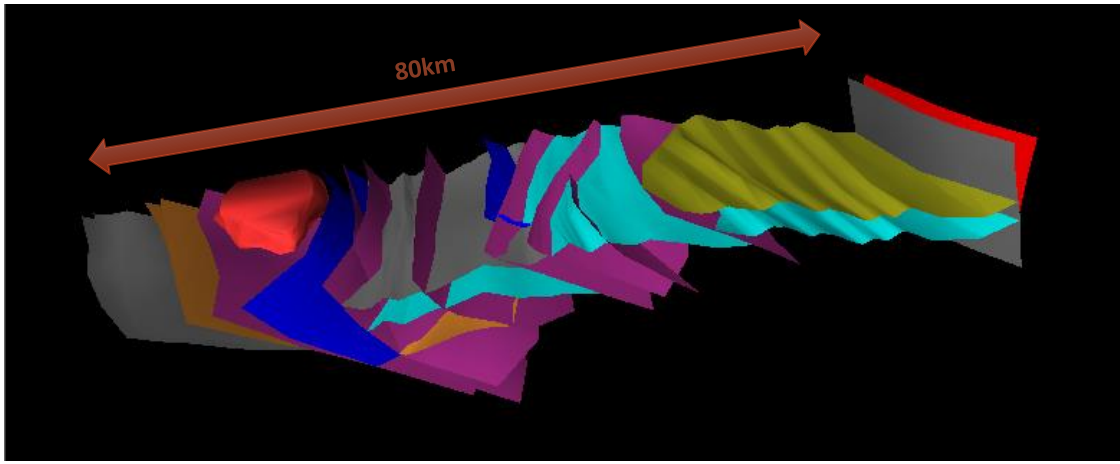
DMQ aims to reduce the risk of deep exploration in the Cloncurry Cu-Au district through:

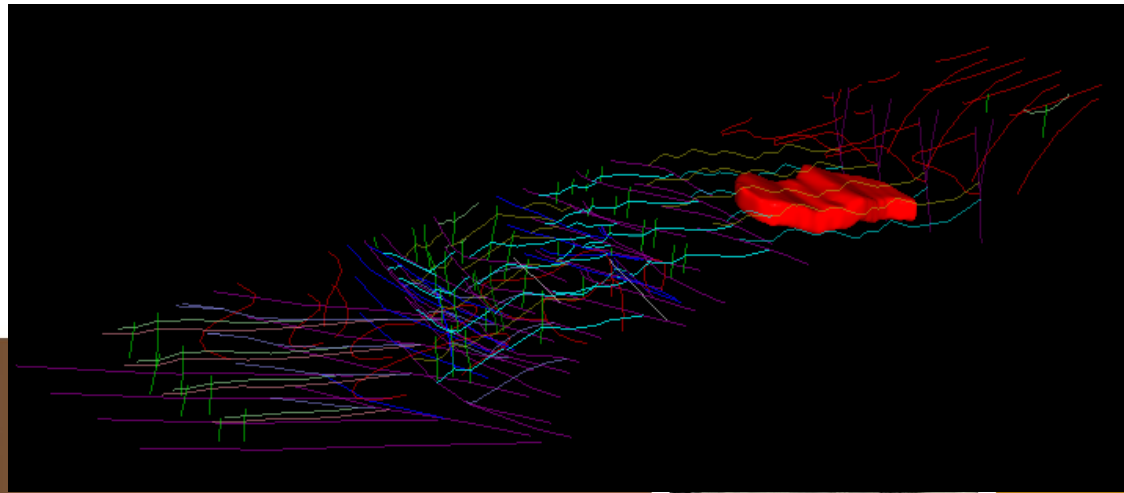
- Detailed geological understanding, informed by comprehensive analysis of geological, geophysical and geochemical datasets

- Considered interpretation of the controls on known orebody location, geometry, and tenor

- Insights into economic viability as affected by variations in deposit size, geometry, grade, depth, and proximity to transport and services infrastructure.







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:

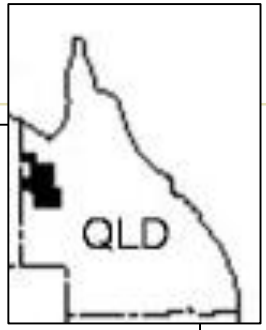
1. Where should I be exploring? …..mining constraints on prospectivity utilized in exploration strategy development.

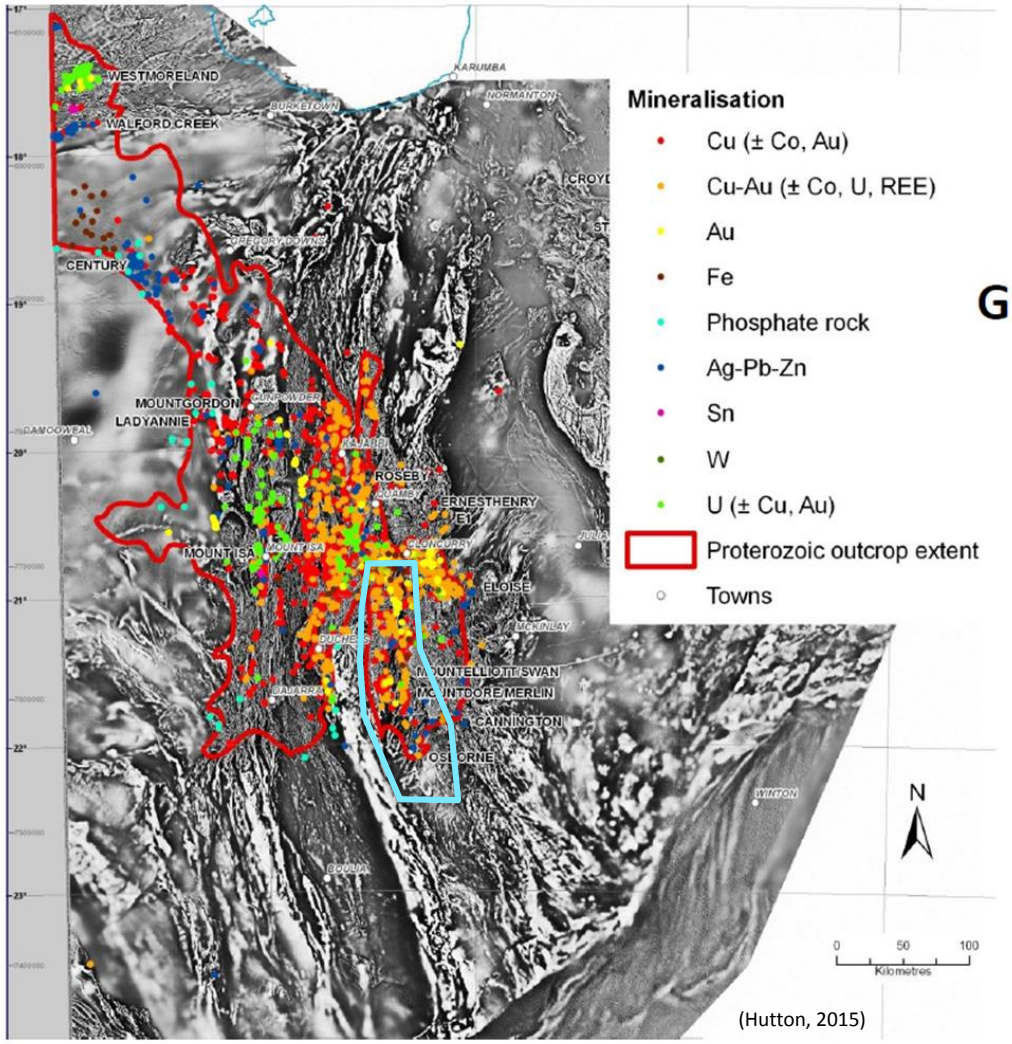
2. Amongst my portfolio of targets/prospects, which of these has the potential to sustain a mining operation? Tool for ranking geological targets in terms of potential viability.

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



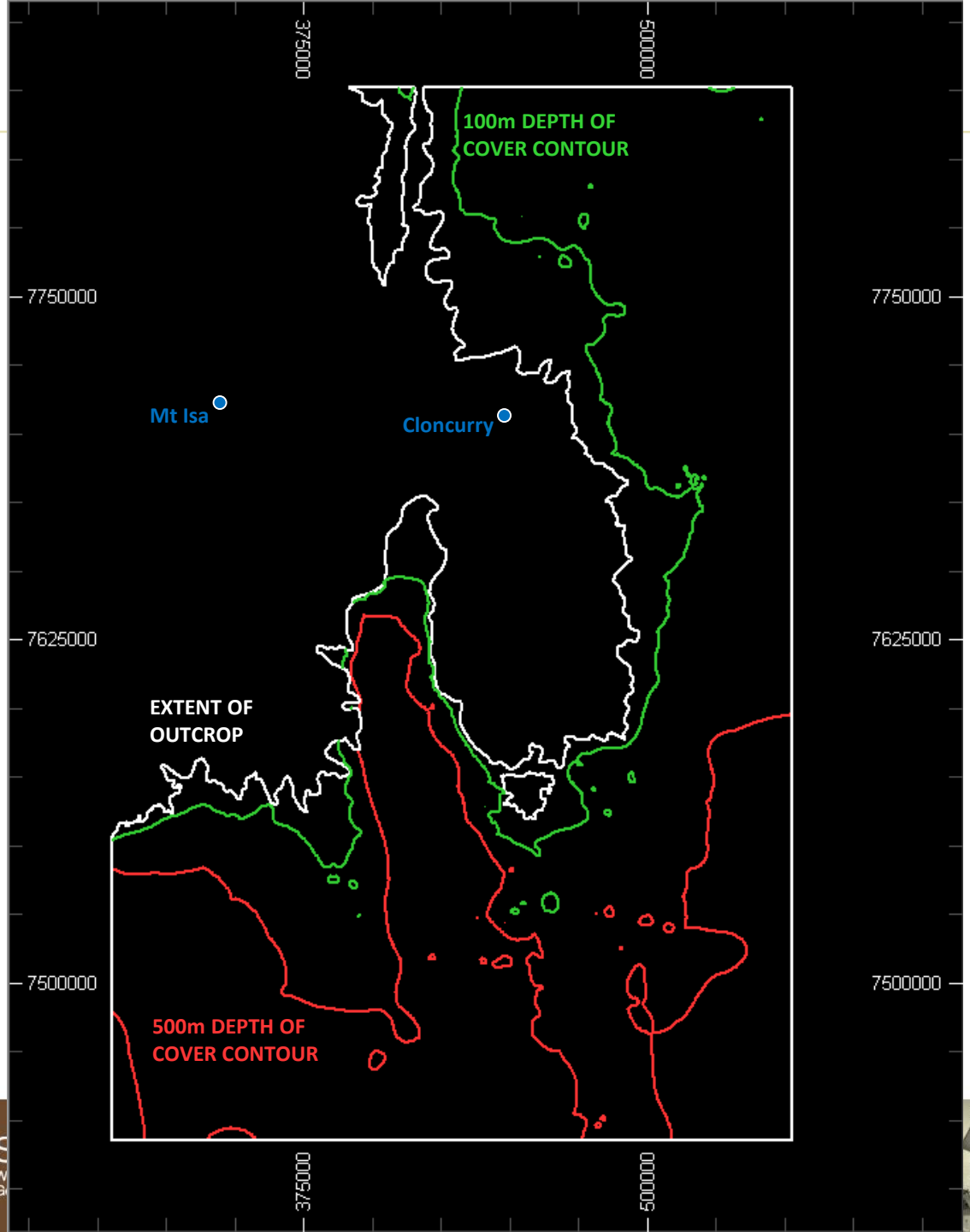


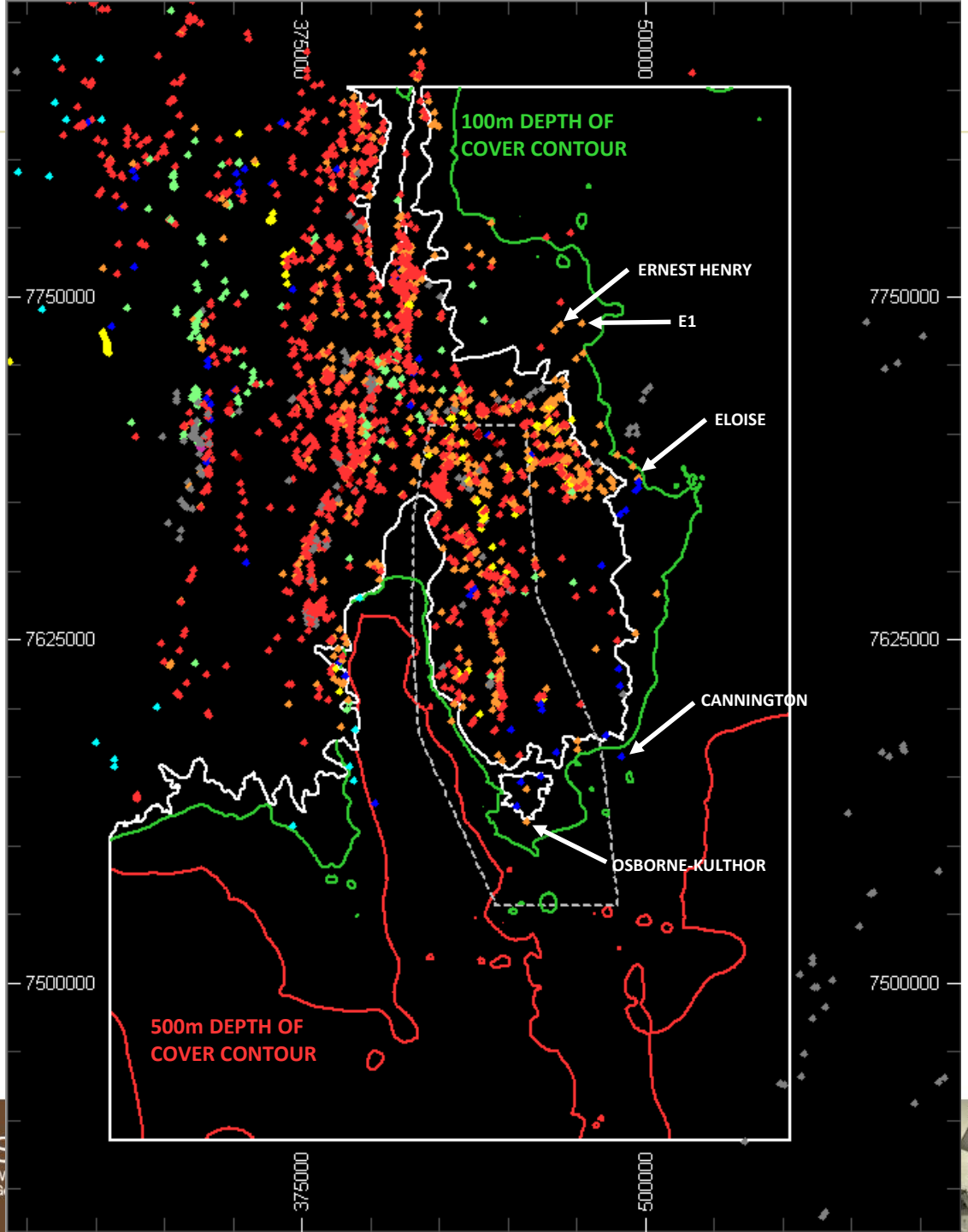
(Hutton, 2015)

Magnetic Image - 1st vertical derivative

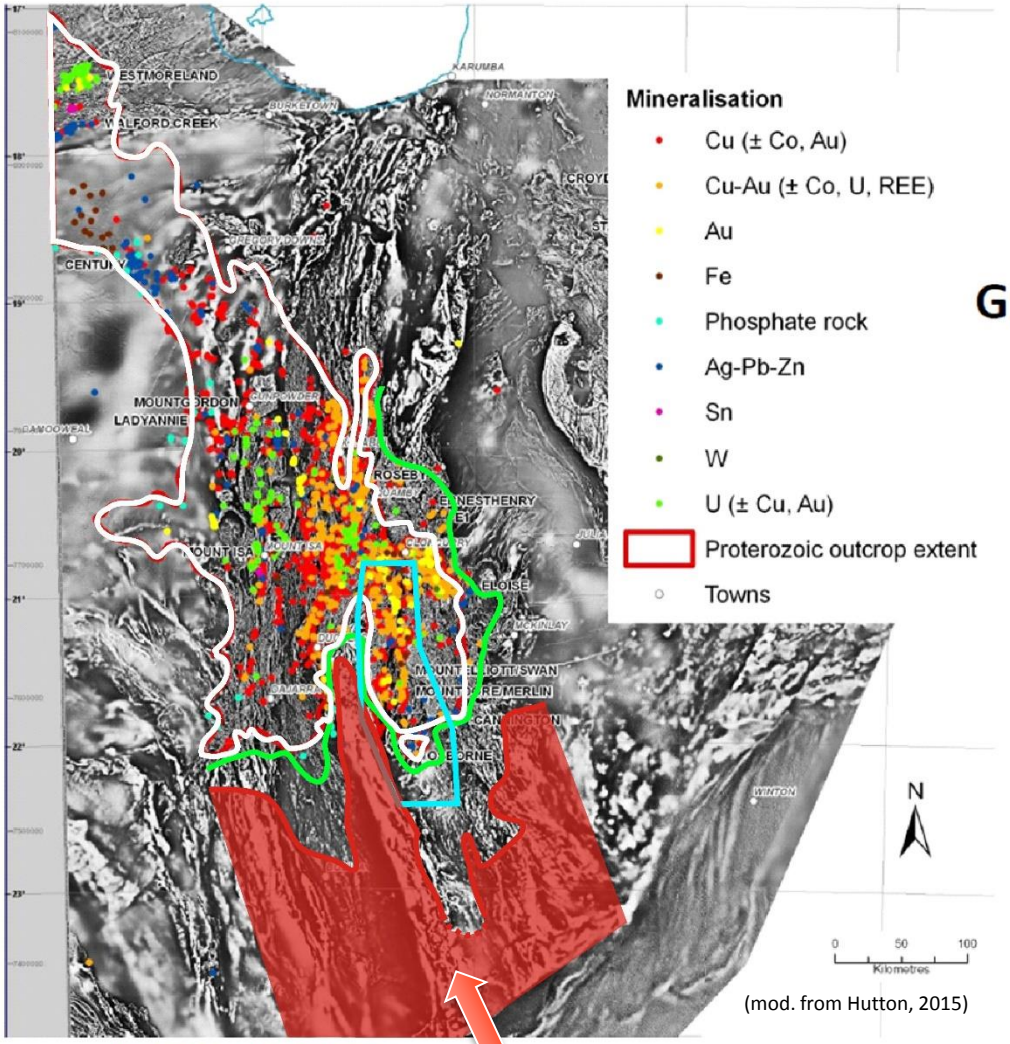
Mt Isa Inlier Greenfields Potential

>70 % is under cover and virtually unexplored


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



Mineral occurrences coloured as per legend on slide 6 & 9

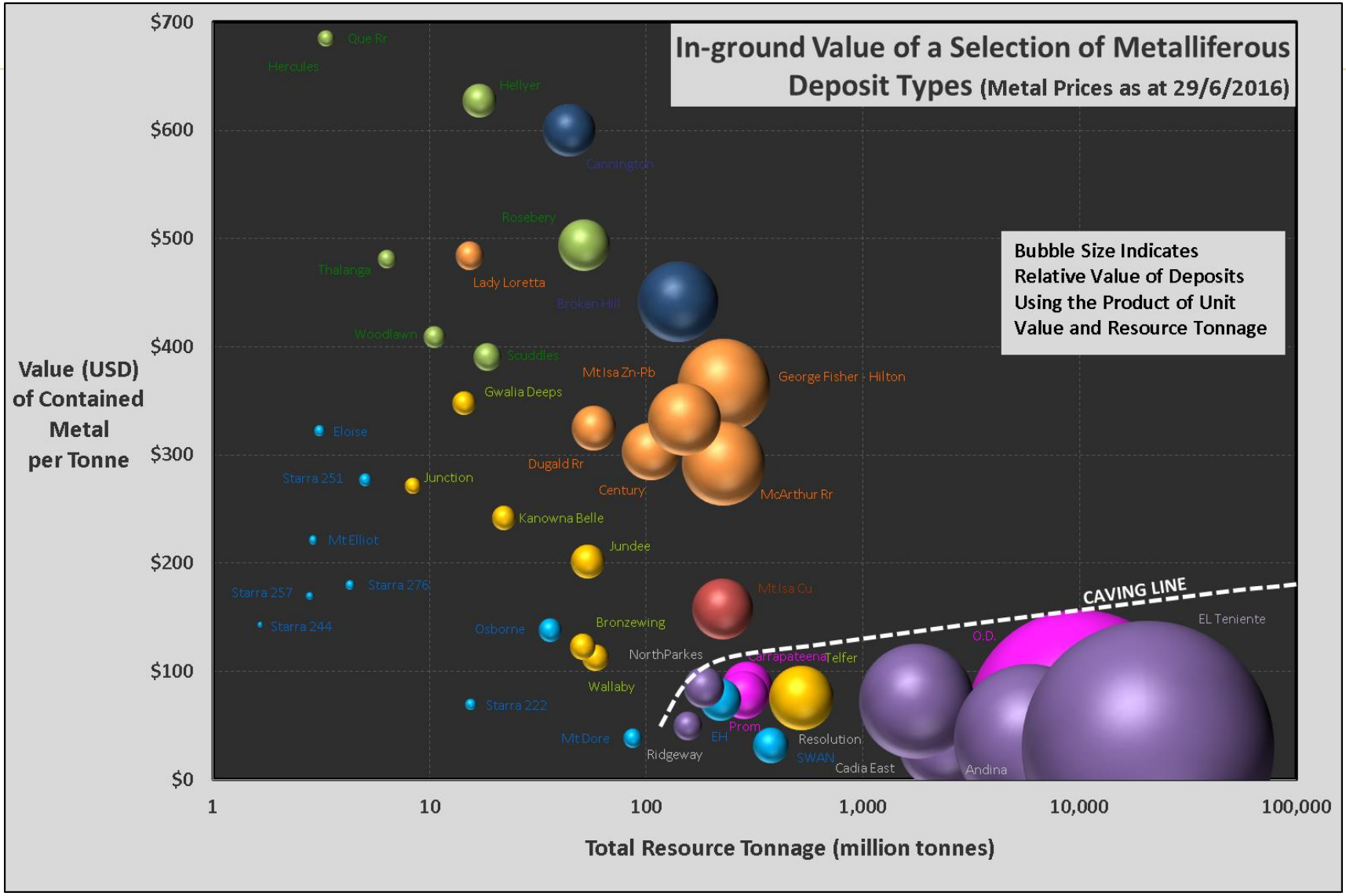


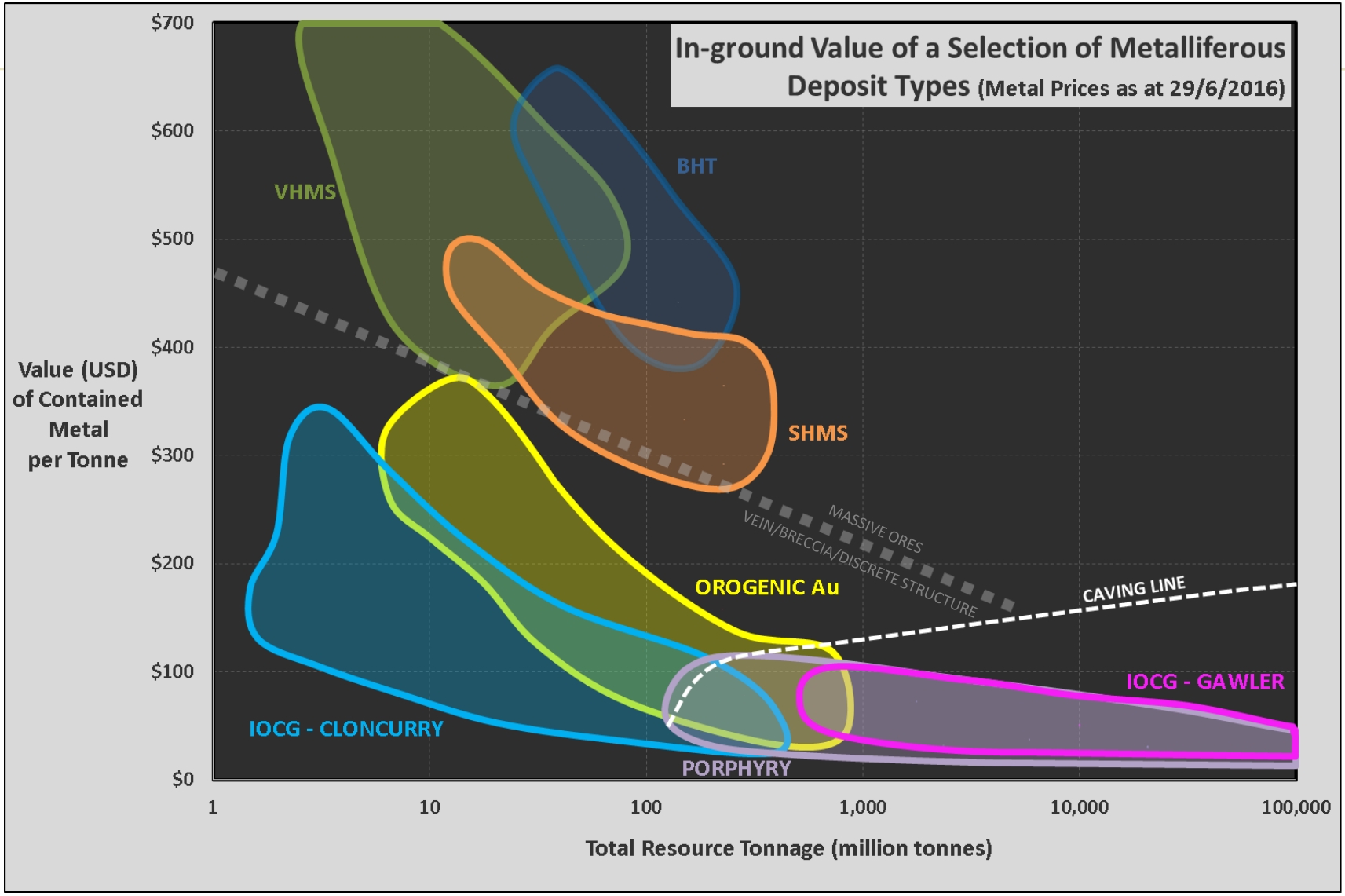
Greenfields Potential

>70 % is under cover and virtually unexplored

No-go zone for EFB-style Cu-Au?

However, not all ore deposit-types are created equally…..


In-ground Value of a Selection of Metalliferous Deposit Types (Metal Prices as at 29/6/2016)
Bubble Size Indicates Relative Value of Deposits Using the Product of Unit Value and Resource Tonnage
Value (USD) of Contained Metal per Tonne
$700
$600
$500
$400
$300
$200
$100
$0
1
10
100
1,000
10,000
100,000
Total Resource Tonnage (million tonnes)
Que Rr
Hercules
Hellyer
Cannington
Rosebery
Thalanga
Lady Loretta
Broken Hill
Woodlawn
Scuddles
Mt Isa Zn-Pb
George Fisher - Hilton
Gwalia Deeps
Eloise
Dugald Rr
Century
McArthur Rr
Starra 251
Junction
Kanowna Belle
Mt Elliot
Jundee
Starra 257
Starra 276
Starra 244
Mt Isa Cu
CAVING LINE
EL Teniente
O.D.
Osborne
Bronzewing
NorthParkes
Carrapateena
Telfer
Wallaby
Starra 222
Prom
EH
Mt Dore
Ridgeway
Resolution
SWAN
Cadia East
Andina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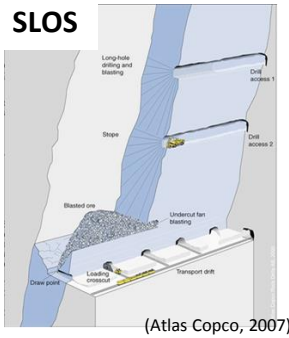
$700
$600
$500
$400
$300
$200
$100
$0
1
10
100
1,000
10,000
100,000
Total Resource Tonnage (million tonnes)
VHMS
BHT
SHMS
OROGENIC Au
IOCG - CLONCURRY
IOCG - GAWLER
PORPHYRY
MASSIVE ORES
VEIN/BRECCIA/DISCRETE STRUCTURE
CAVING LINE

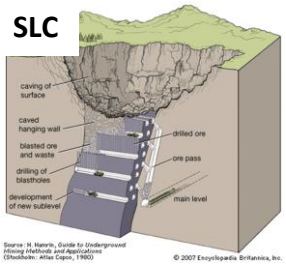
Extraction Options at Depth – Operating Costs

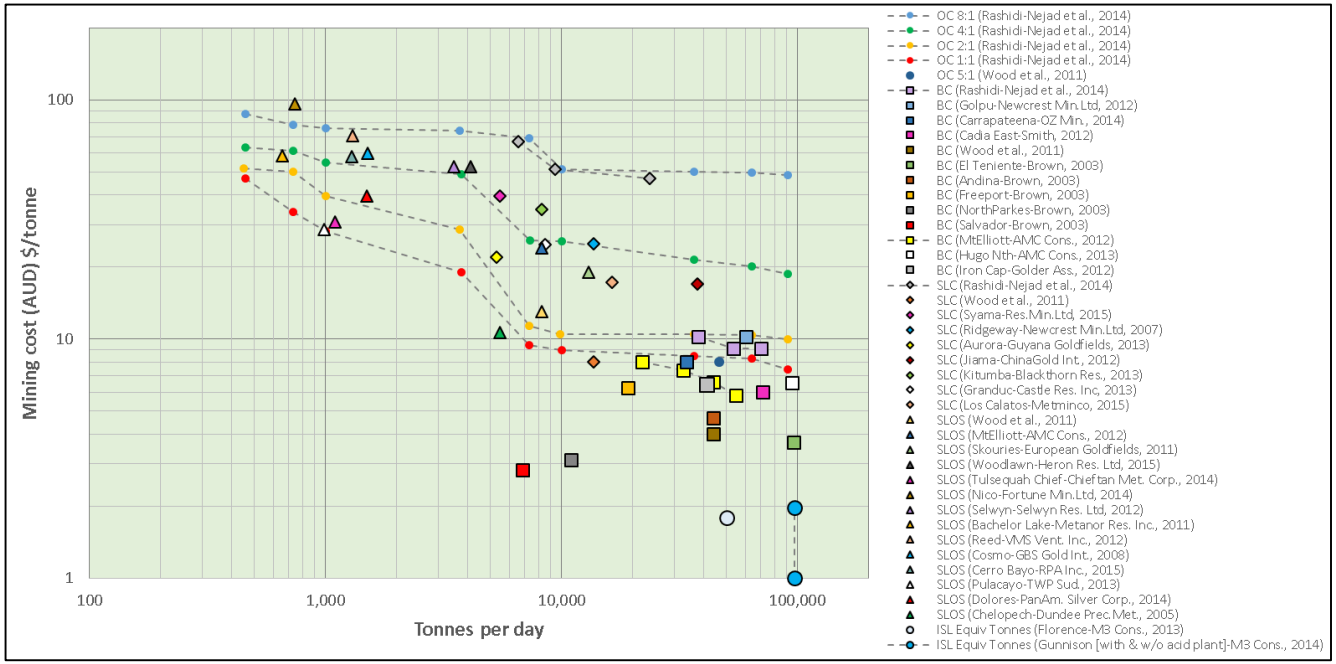
SLOS



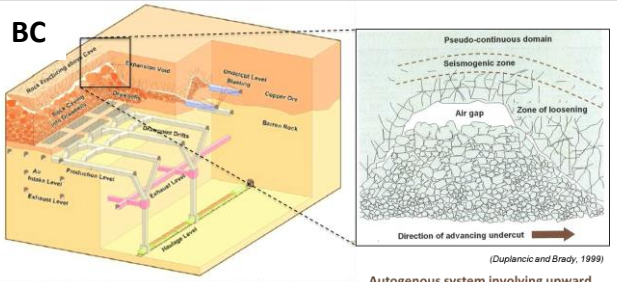
(Atlas Copco, 2007)

SLC





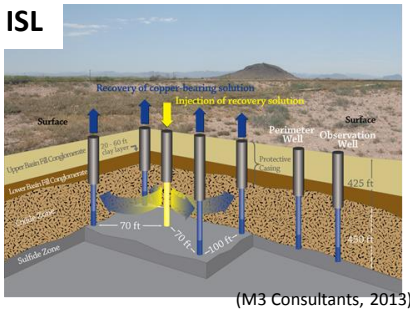
BC



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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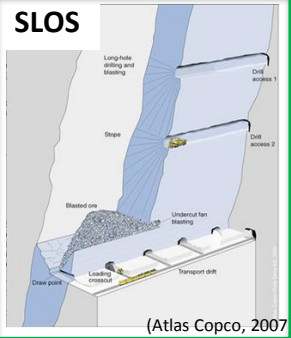
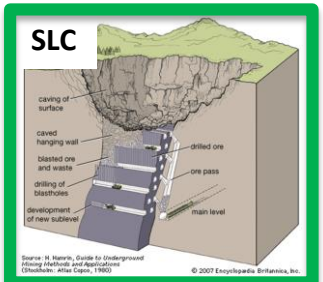
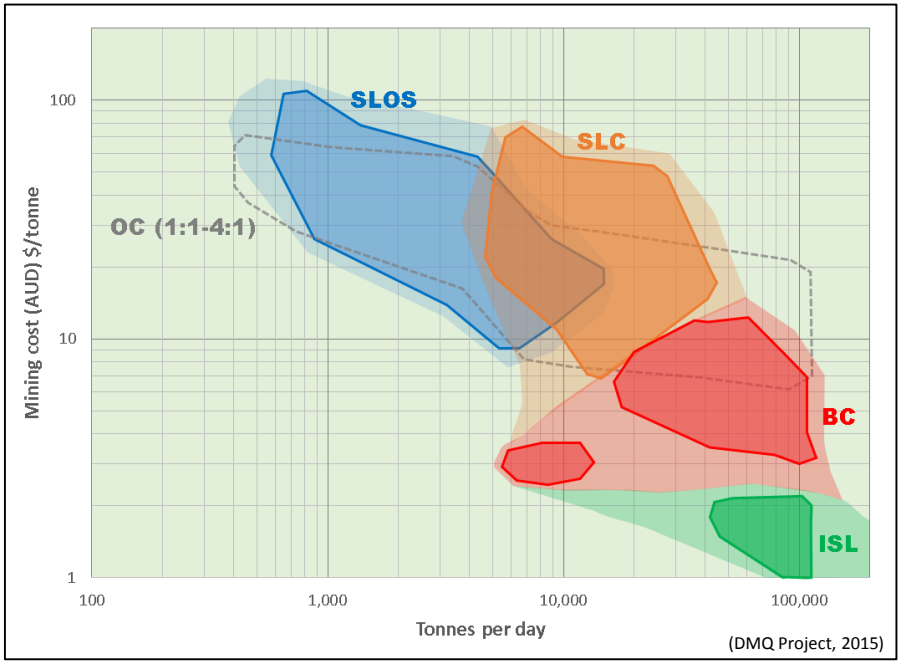


(Atlas Copco, 2007

SLC



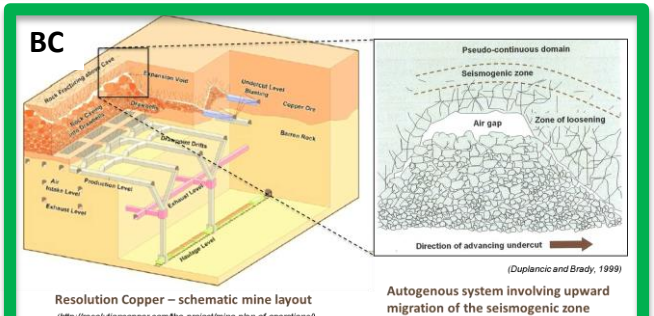


(DMQ Project, 2015)

PEET Options

✓

BC



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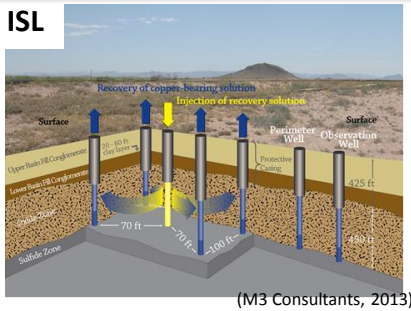


(M3 Consultants, 2013)

***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

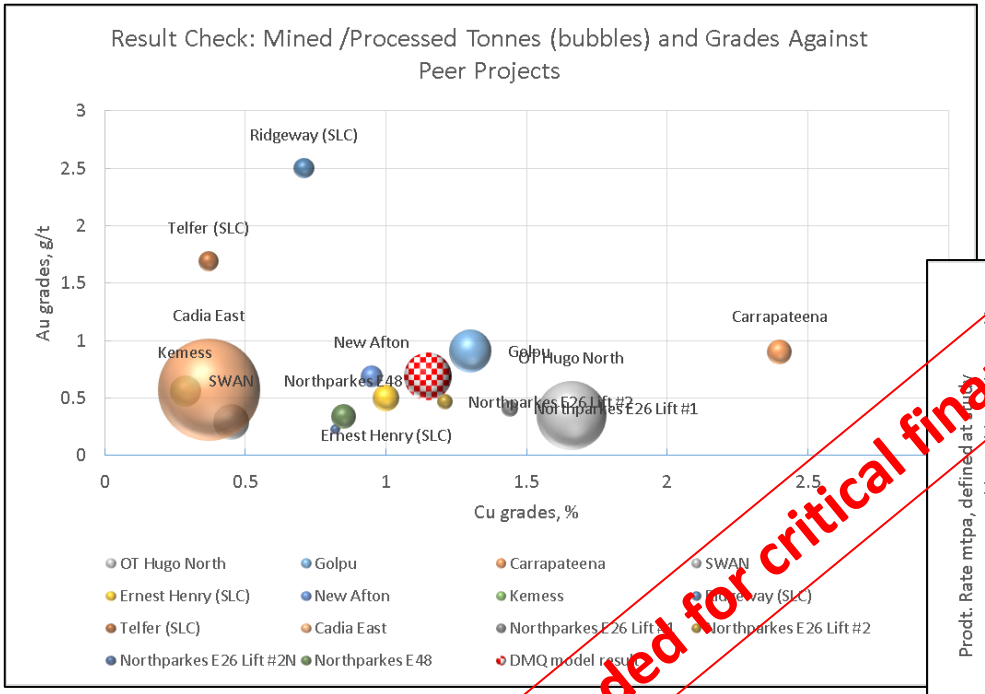
- Mining costs assuming steady state production
- Processing costs " "
- General & Admin costs by year

8. Evaluation Model

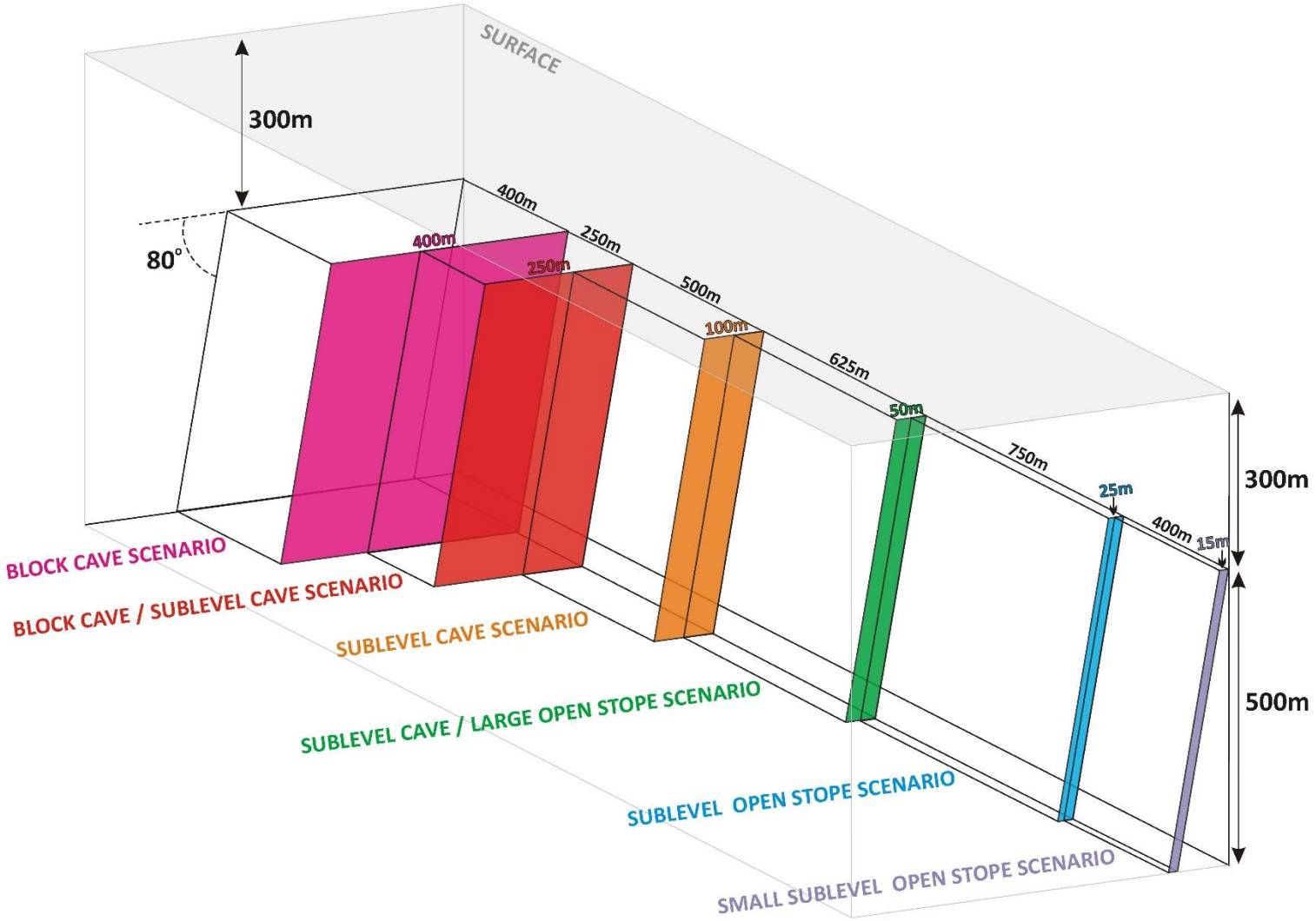
- Collated revenue, capex, opex
- IRR calculation
- Maximum negative cash position
- NPV calculation
- Time to payback
- EBITDA
- Net Cashflow

Results: comparison with peer projects

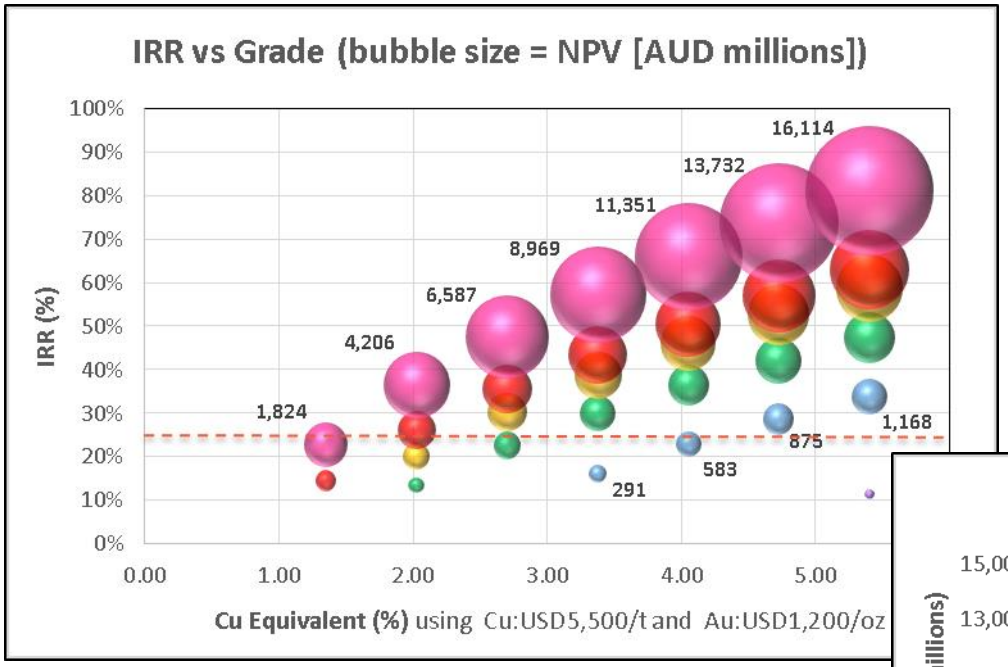
Collated key inputs and outputs on single sheet

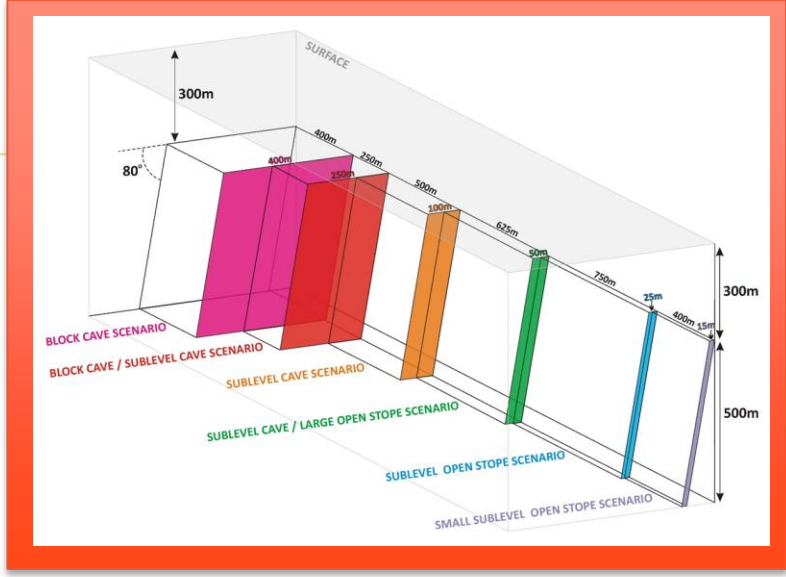


PEET-UG used in anger…..on simulated data



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

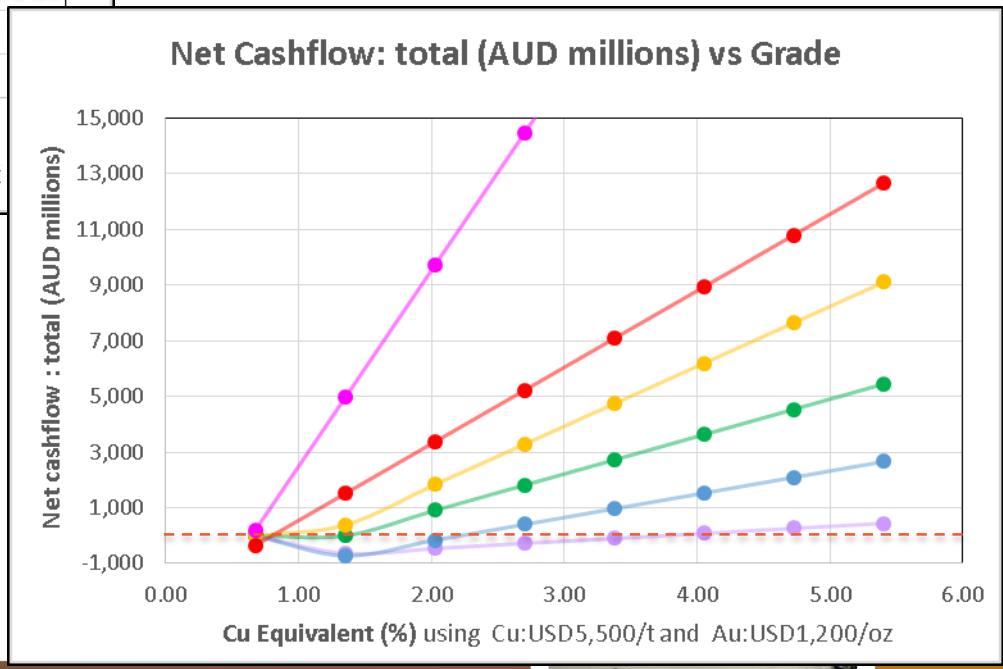




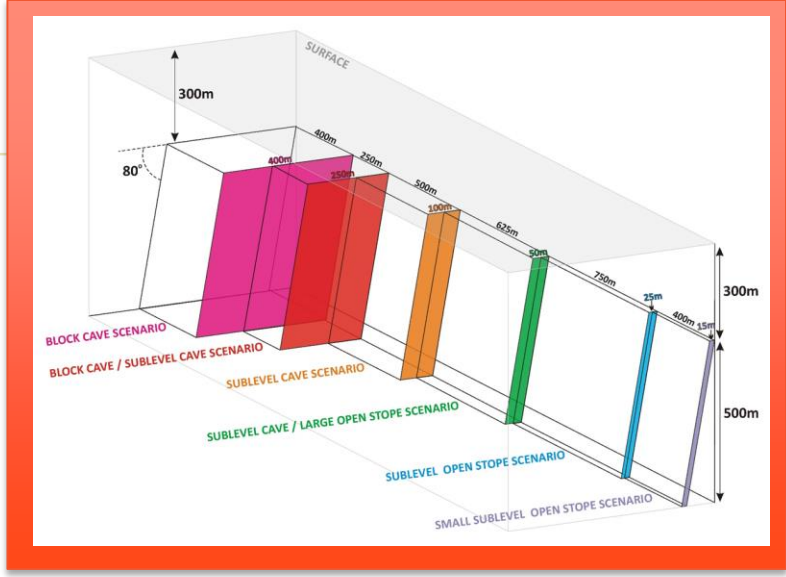
Above, Internal rate of return (IRR) vs grade. Bubble colour corresponds with geometry/mining-block (see image in top RH corner of slide). Bubble size is proportional to NPV, some annotated. Bigger target = more tonnes = higher value. Dashed line represents the 25% IRR 'target' outcome (AP pers. comms,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

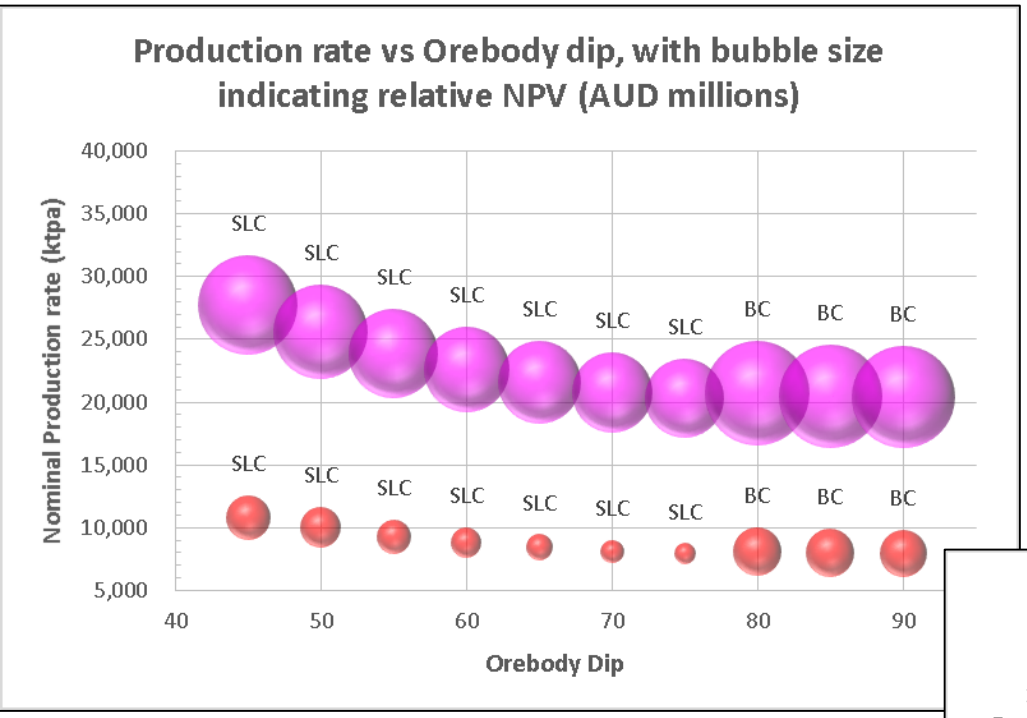
Parameters:

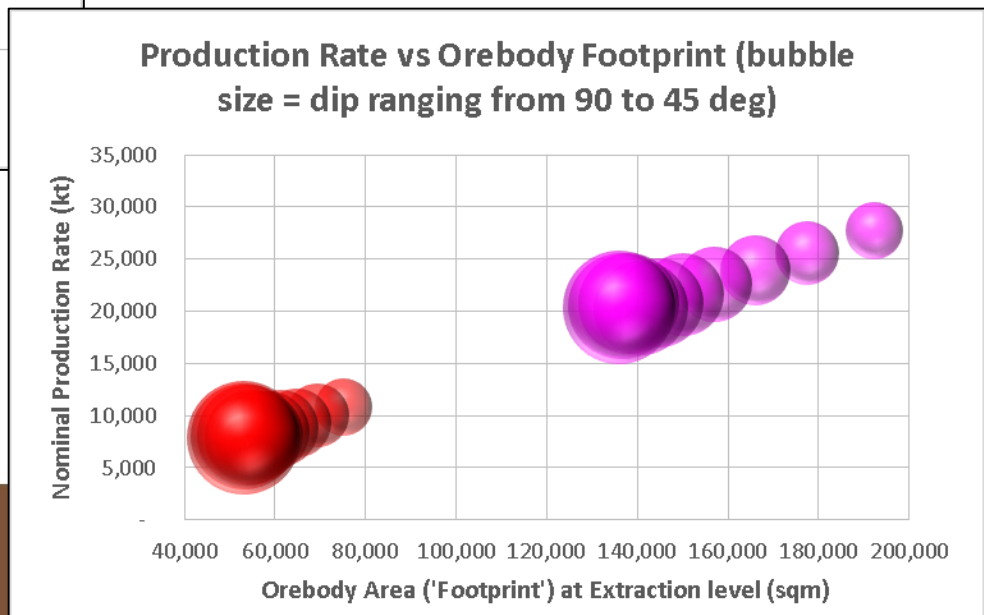
- *300m depth to top of deposit*
- *80 degree dip*
- *CuEq calculation assumed Cu at USD$5500/t, and Au at USD$1200/oz, and a 20k:1 ratio of Cu:Au, as broadly observed in IOCG systems.*



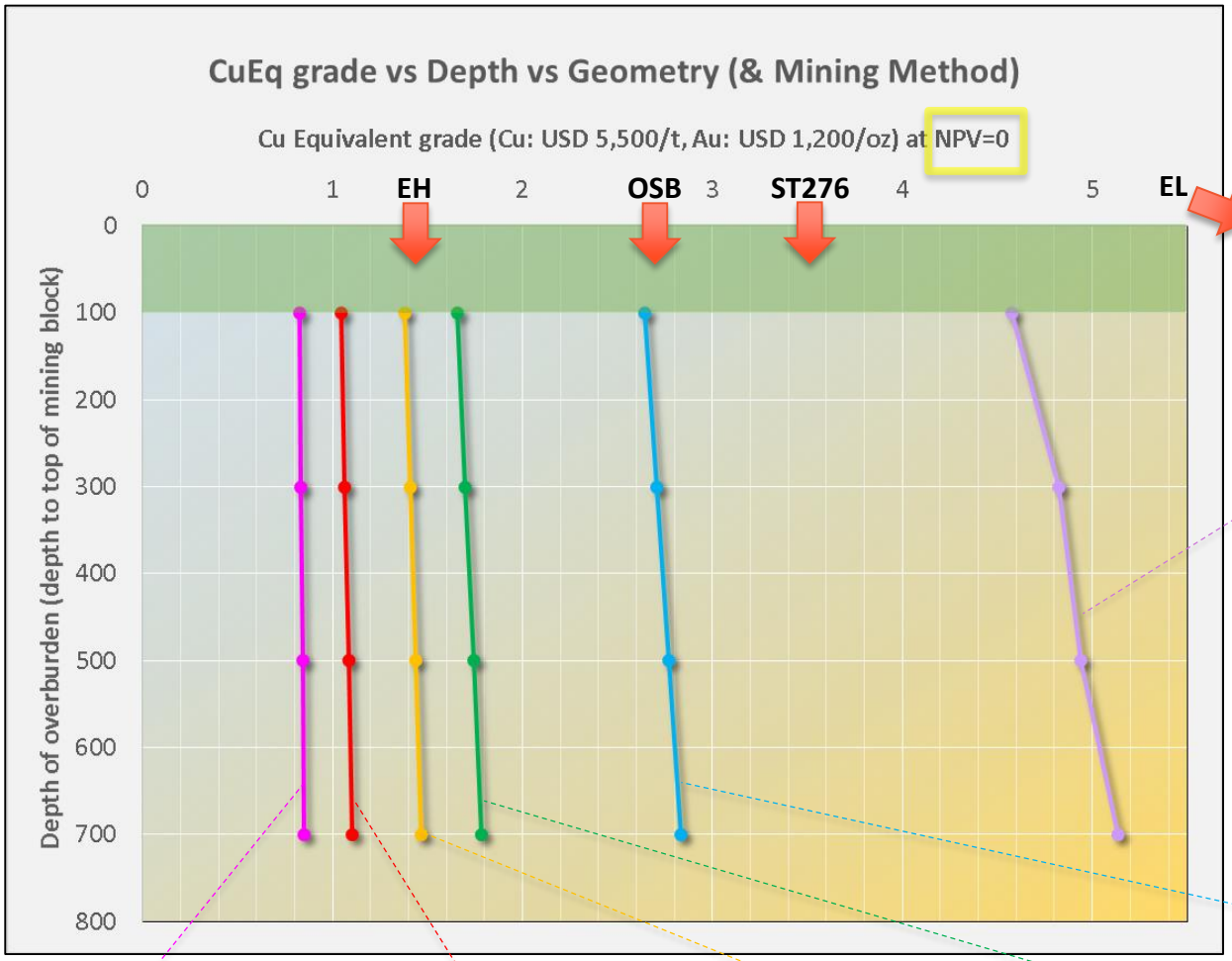
Impact of Orebody Dip and Geometry on Mining (& Financial) performance

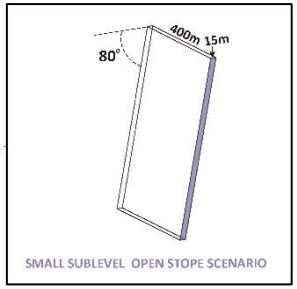


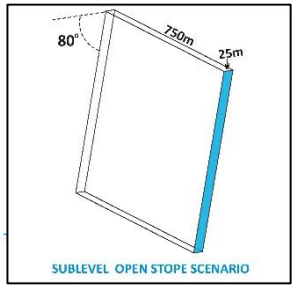


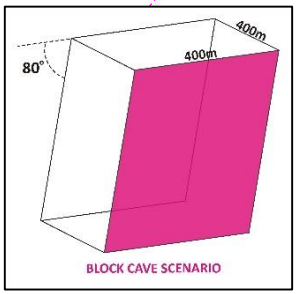


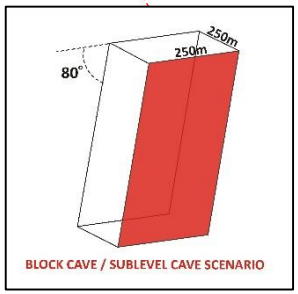
Indicative ‘cut-off’ grades by mining method/orebody geometry

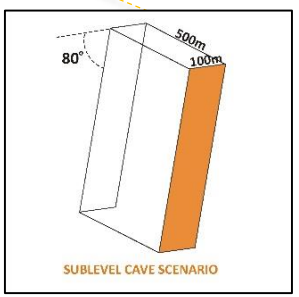


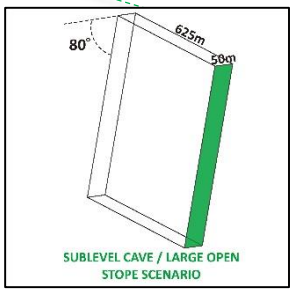












Parameters:

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

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**.

More info? See the DMQ posters on display here at 'Digging Deeper', and visit www.brc.uq.edu.au/brc-projects