

SMI BRC

WH Bryan Mining &
Geology Research Centre



Digging Deeper 2015

“Deep Mining Queensland (DMQ)
Project....where Exploration meets
Mass Mining”

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 Queensland Government
Department of Natural Resources and Mines

Geological Survey of Queensland

chinova
resources

Fullagar
Geophysics  Pty Ltd

DMQ Project Team

Dr Travis Murphy (Exploration and Mine Geology)

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Dr Mark Pirlo (Exploration Geochemistry)

John Donohue (Exploration Geophysics)

Mark Jones (Software Engineering & Database Support)

~75 years mining and exploration geoscience experience



BRC: the Mass-Mining Research Niche

- Mass-mining research : Benchmarking, Technology, & Innovation

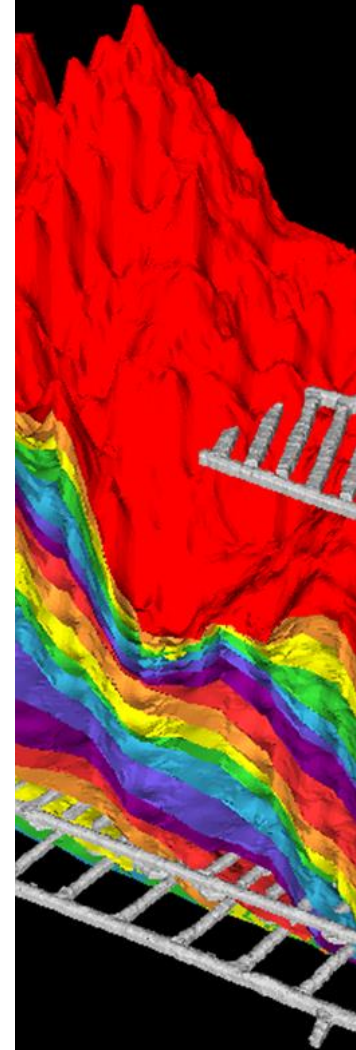
- *'International Caving Study'*,
- *'Mass Mining Technology 1-3'*,
- *'Supercaves'*,
- *'Next Generation Cave Mining'*

- The role of Geology in Mass-Mining: retrospective analysis feeding innovative predictive models

- *'Geology and Mass Mining'*

- Mass-Mining - 'informed' exploration

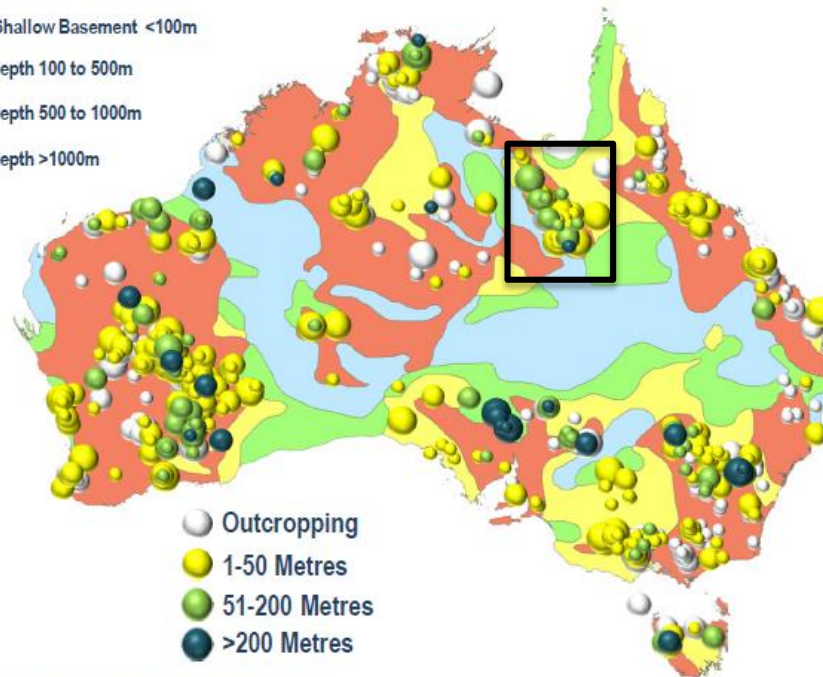
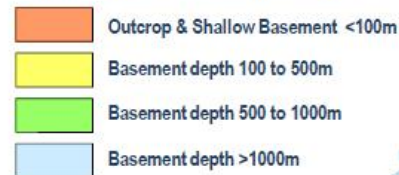
- *'Deep Mining Queensland' (DMQ)*



Why Deep?....by Necessity!

Estimated depth to basement for non-bulk mineral deposits in Australia

INDICATIVE DEPTH OF COVER



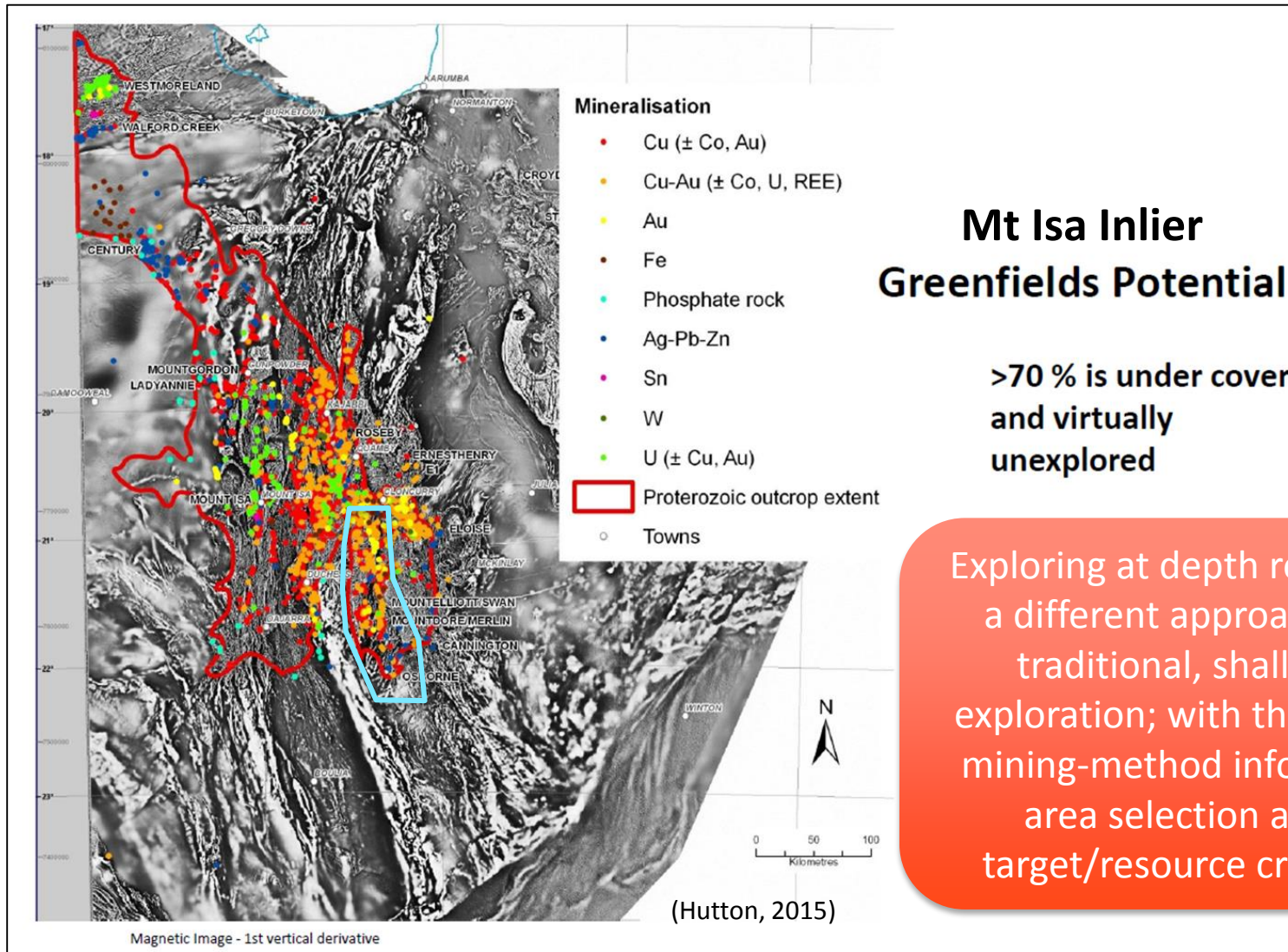
Note: Excludes Bulk Minerals (such as Bauxite, Coal, and Iron Ore)
Bubble-size refers to size of deposit

"Moderate" >100koz Au, >10kt Ni, >100kt Cu equiv, 250kt Zn+Pb, >5kt U₃O₈
"Major" >1Moz Au, >100kt Ni, >1Mt Cu equiv, 2.5Mt Zn+Pb, >25kt U₃O₈
"Giant" >6Moz Au, >1Mt Ni, >5Mt Cu equiv, 12Mt Zn+Pb, >125kt U₃O₈

Sources: MinEx Consulting © September 2014
Geoscience Australia



Why Deep?....Opportunity!

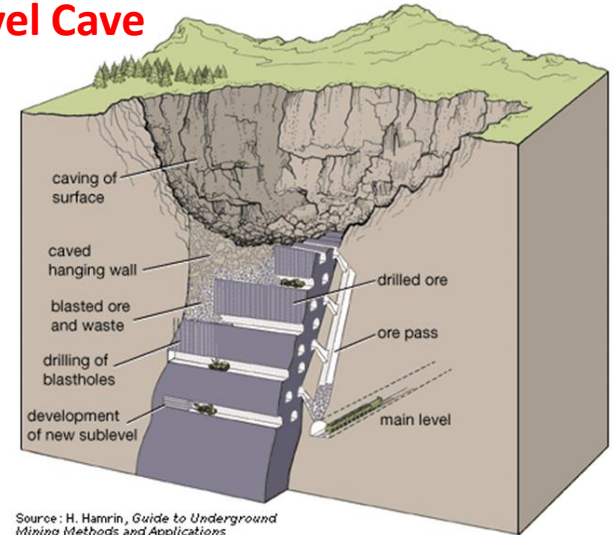


Mining Method Selection - Fundamentals

- Geometry/orientation
- Tonnage/production potential
- Required production rate
- Rock mass characteristics
- Depth below surface
- Stress conditions
- Economics: Recoverable metal vs Capital + Operating costs

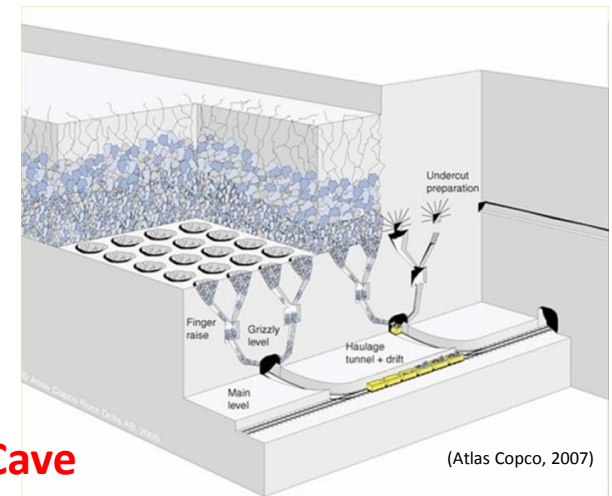
Reduced optionality if deposit is deep and large and/or low grade

Sublevel Cave



Source: H. Hamrin, *Guide to Underground Mining Methods and Applications* (Stockholm: Atlas Copco, 1980)

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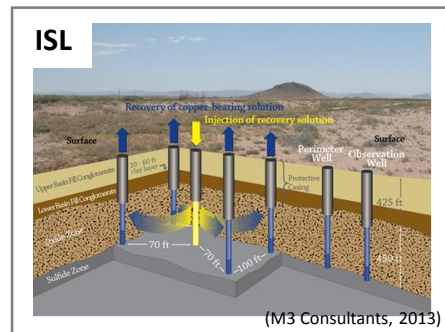
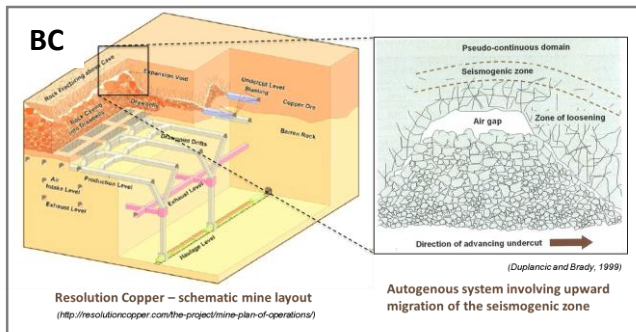
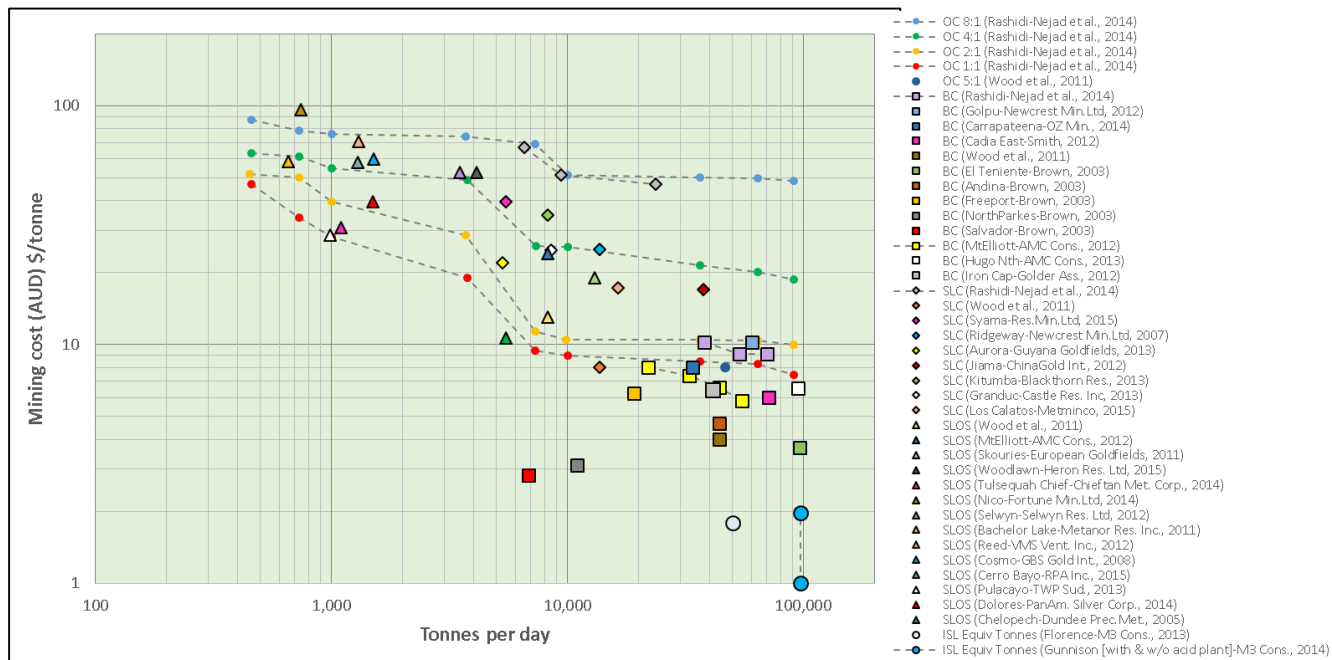
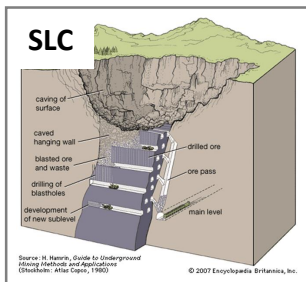
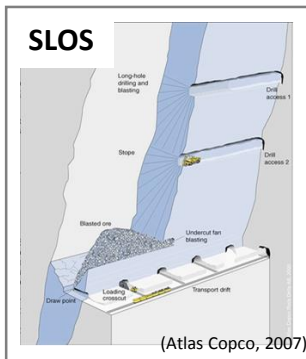


Block Cave

(Atlas Copco, 2007)



Extraction Options at Depth – Operating Costs



The lower cost extraction methods are less flexible and carry higher technical risk!



Technical Factors Affecting Deep Mass-Mineability

- Orebody geometry/continuity & orientation are critical
- Stress.....works with us in cave mining, but needs to be managed
- Geothermal gradient
- Caveability of the orebody and overburden
- Characteristics of the orebody and overburden:
 - Reactivity (spontaneous combustion, swelling minerals)
 - Solubility (re-cementing of fragments, groundwater contamination)
 - Rapid oxidation (negative impact on recovery)
 - Health and safety of workers (radioactive, fibrous, chemical hazards)
 - Clay/fines generation (risk of mud-rushes and dilution)
 - Downstream processing effects (deleterious elements)
- Effects, and management, of subsidence on surface land-use.

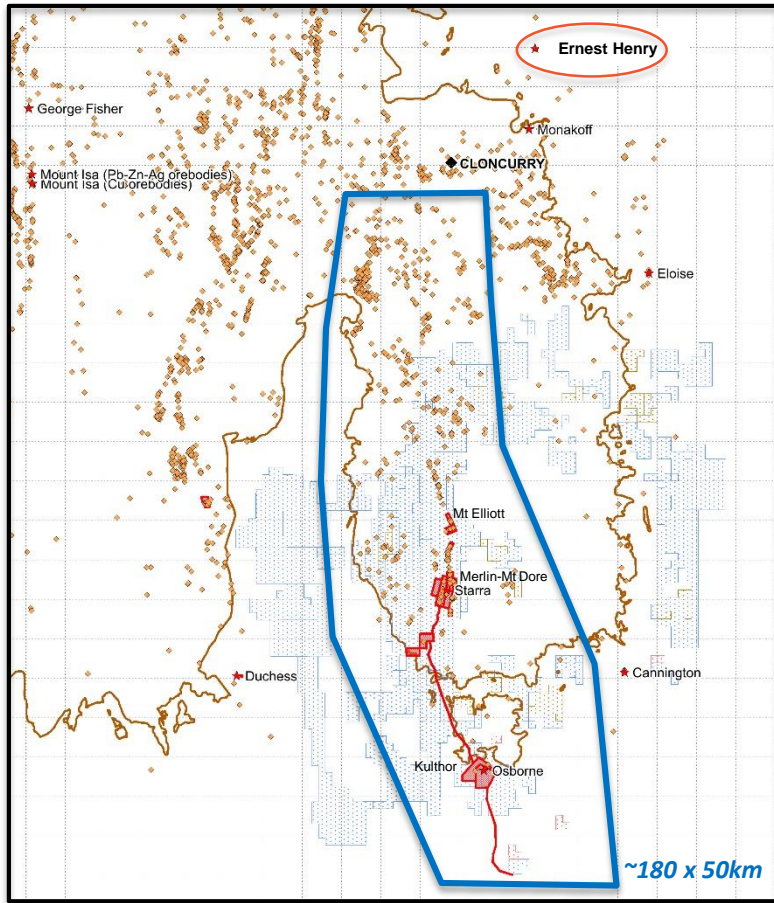
Technical factors are key in method selection. Geology informs the selection criteria.



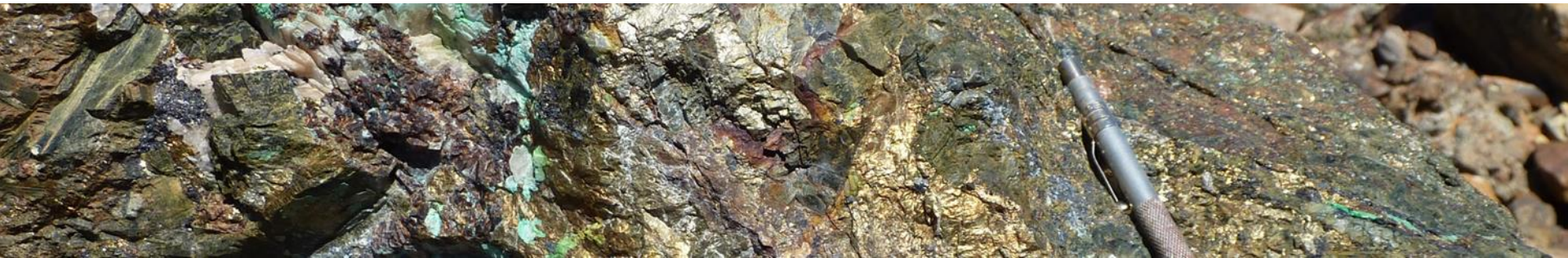
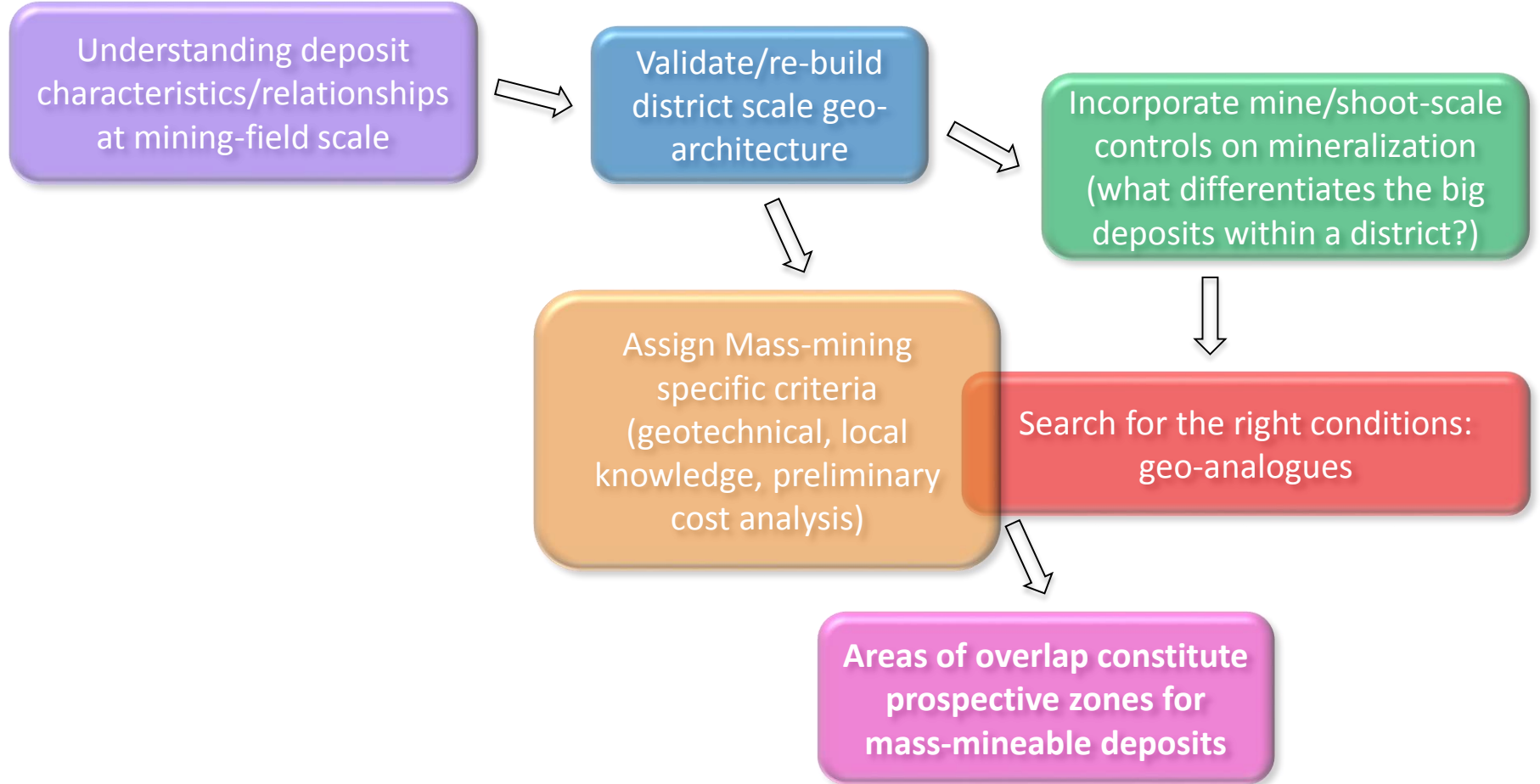
Mining Factors as Input into Targeting/Prospectivity

DMQ: 'MINING-INFORMED EXPLORATION'

- District with multiple Cu-Au mines, lots of smoke, yet only one large mass-mineable deposit (Ernest Henry).
- What are the prospects for discovery of additional mass-mineable deposits if we deepen the search space to 2km depth?.....and what would a mineable deposit need to look like at this depth?
- What does history tell us about mining in the district in terms of stress conditions, rock characteristics, geothermal gradient, potential deposit size/grade/orientation/-geometry?



DMQ



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.

