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Stope Optimisation in Critical & Key Minerals: Conceptual to LOM Case Studies

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Stope Optimisation – Introduction

- Developed by Chris Alford, Alford Mining Systems and defined as:

  *"Mineable Shape Optimiser (**MSO**) is a strategic mine planning tool that automates the design of stope shapes for a range of stoping methods for underground mines. Using constraints, detailing mining method and design parameters MSO provides the optimal stope shape design to maximise the value of an orebody"*

- Advanced functionality and parameter definition from early "floating stope" and "mineable reserve optimiser (MRO)
- Present a number of critical mineral case studies showing some key functionality.

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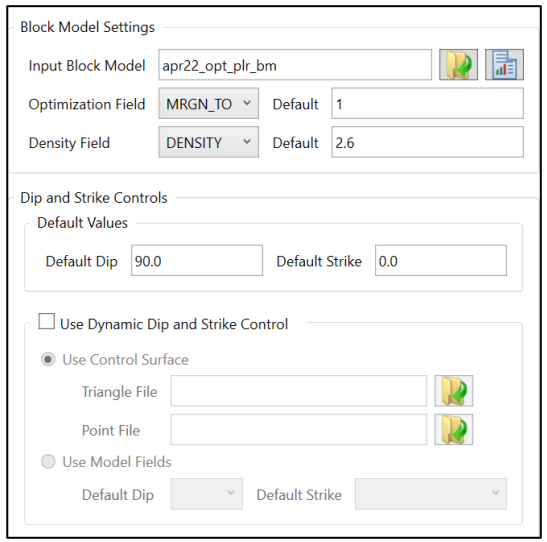
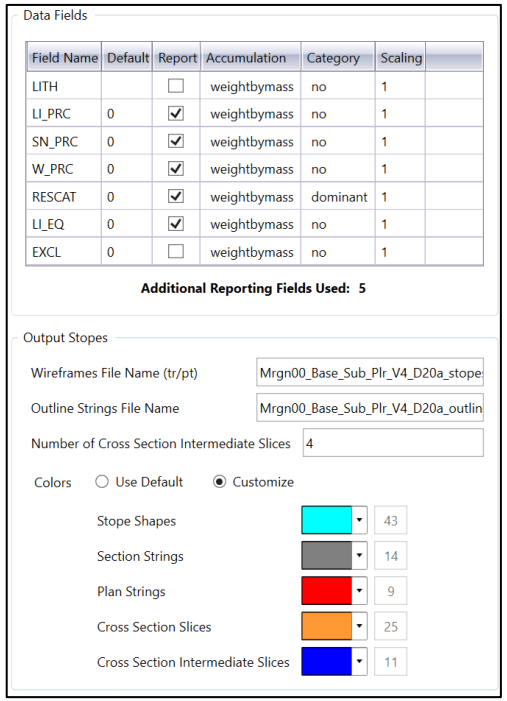
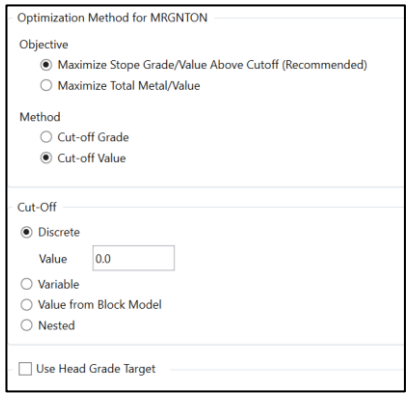
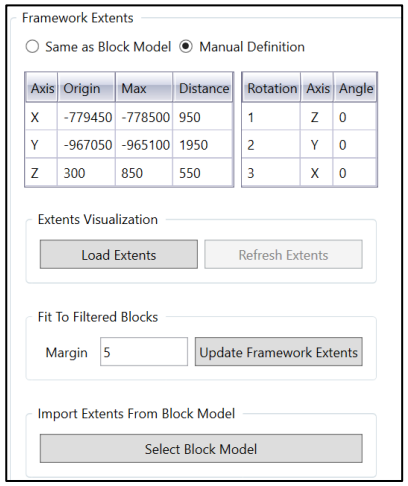
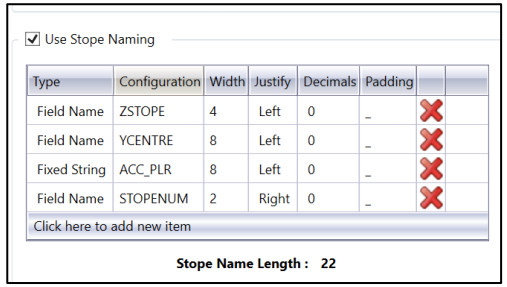
Stope Optimisation – Key Features

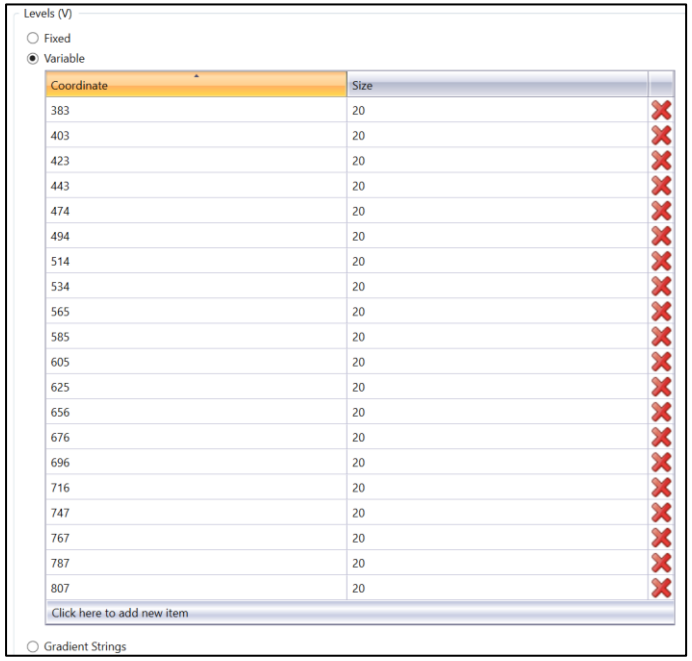


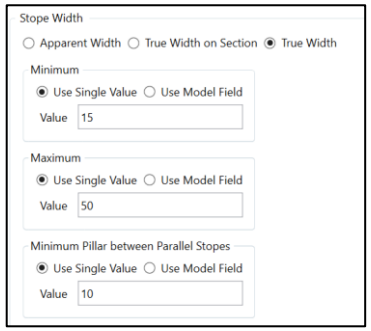


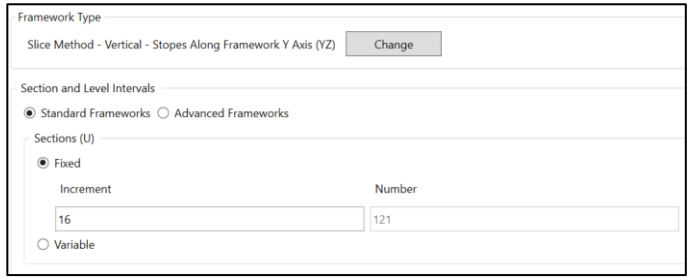






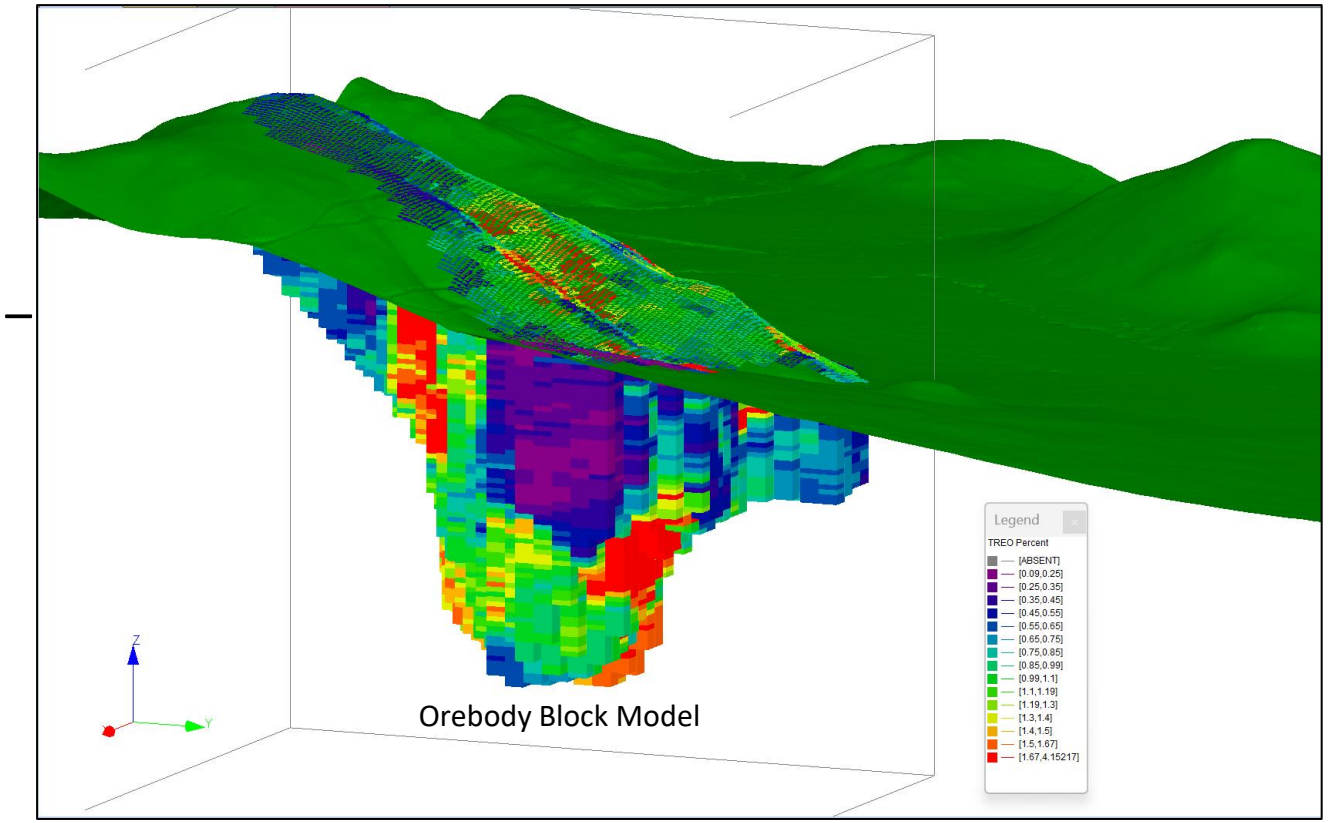






Stope Optimisation – Case Study 1

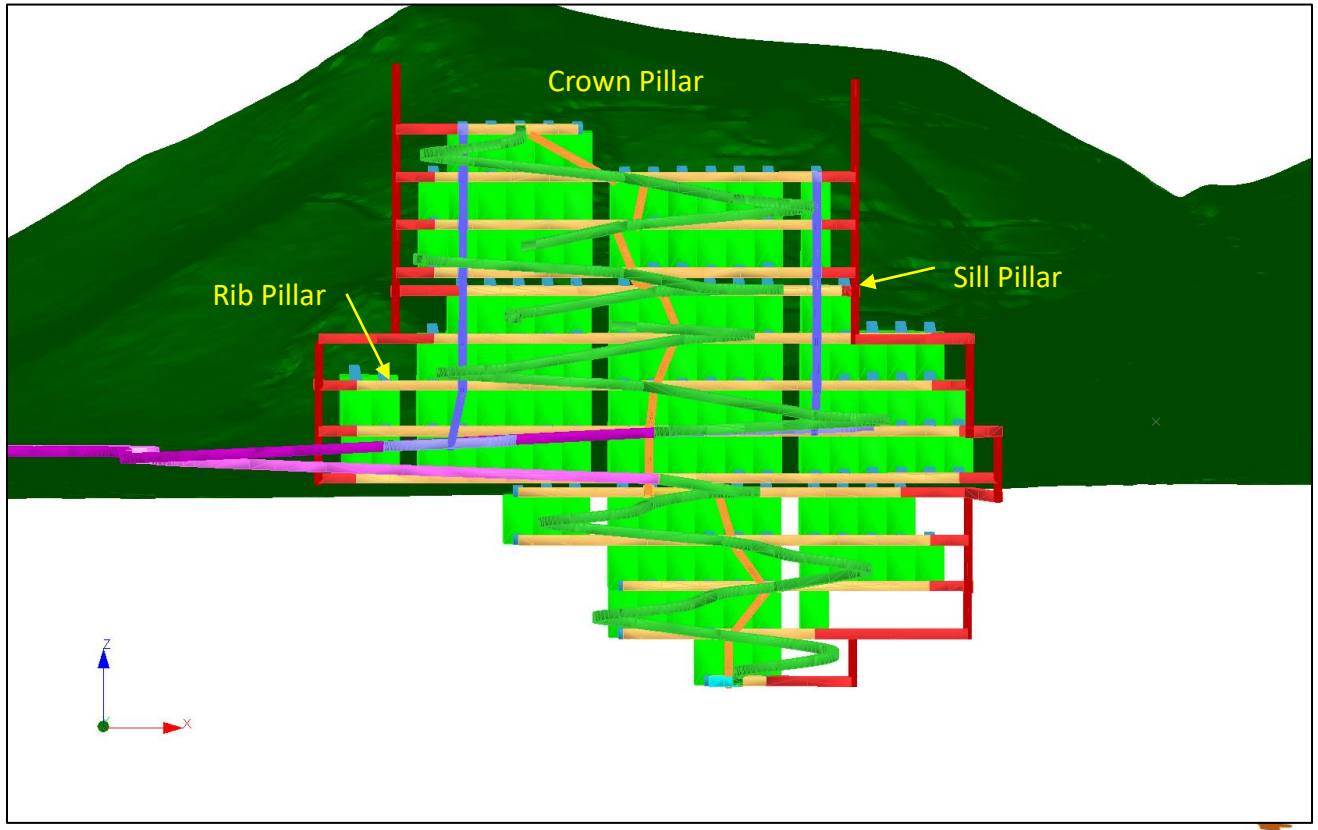
- Minerals: REE
- Where: Southern/Central Africa
- Study Level: Scoping/Conceptual
- Project Background: Completed OP DFS – conceptual/scoping study to cross-check UG option
- Key Aspects:
  - 2 ore types
  - 1 processible other not
  - 2 cut-off grades



Orebody Block Model

Stope Optimisation – Case Study 1

- Optimisation Parameters:
  - LHOS (25m H, 15m W & to 50m L) – NS
  - 10m rib pillar every 90m
  - 10m sill pillar (max 4 stopes)
  - 20m crown pillar
  - 5m barrier pillar (longitudinal stopes)
  - Full stopes
  - Exclude 2nd ore type but allow as dilution (10-20%)
  - 2 cut-off scenarios (0.6 & 0.8% TREO)



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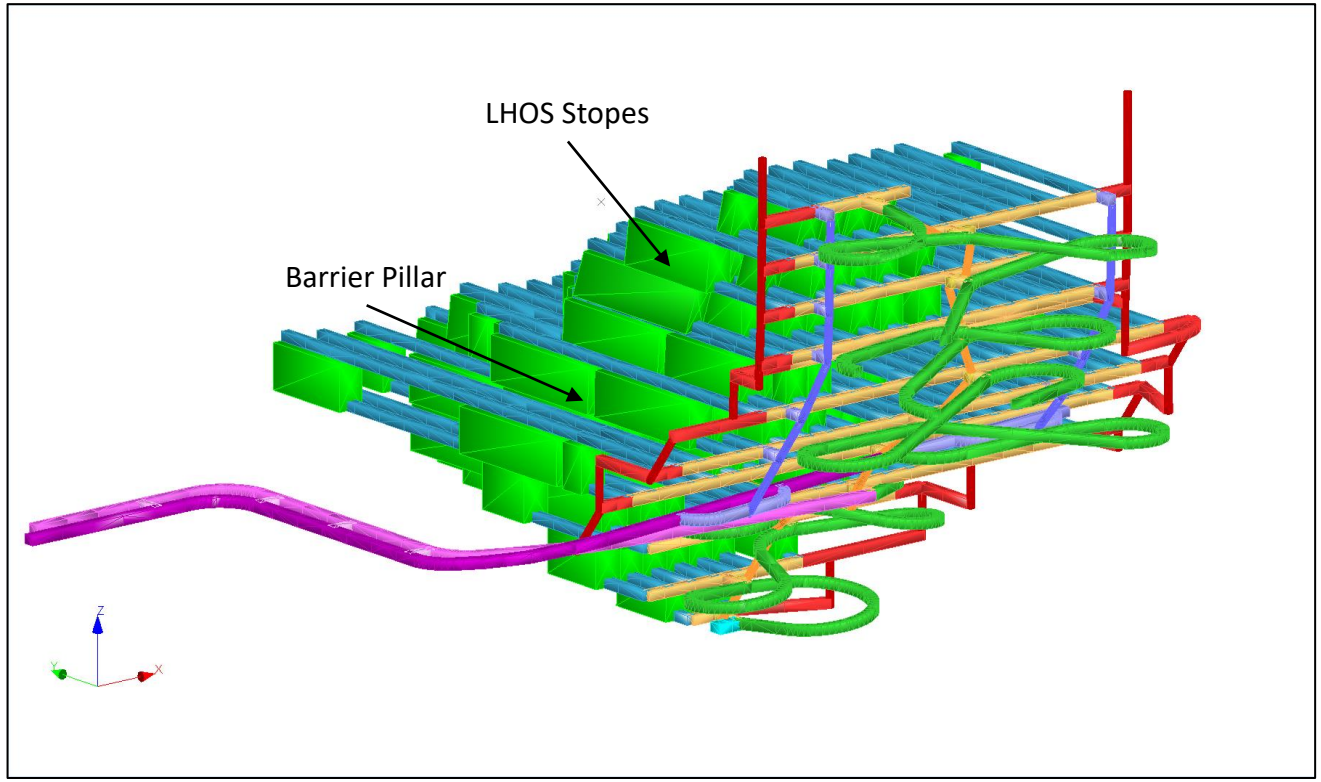
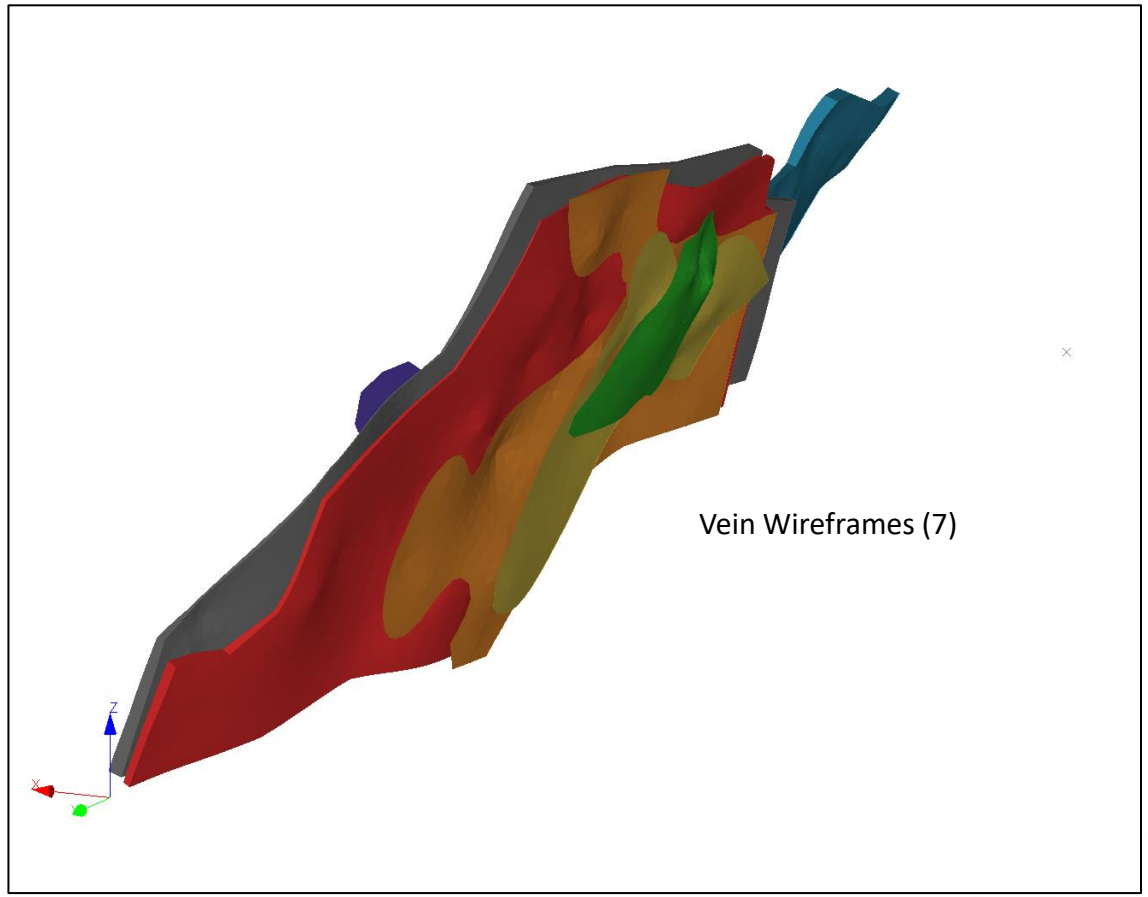
Stope Optimisation – Case Study 1

- Outcomes:
  - Better Mn/Mg ratio than OP
  - No OB removal
  - Minimal un-processible ore type (dilution)
  - Matched pit grade but lower tonnage



Stope Optimisation – Case Study 2

- Minerals: Sn – with Cu/Pb/Zn/Ag
- Where: Central Africa
- Study Level: Scoping
- Project Background: Assess minimum mining width for equipment selection & identify potential Inferred stopes – existing mine
- Key Aspects:
  - Crown pillar/weathering zone
  - Multiple veins - 7
  - Incremental dilution options/cut-off grades
  - Rotated model
  - Steep narrow veins



Vein Wireframes (7)

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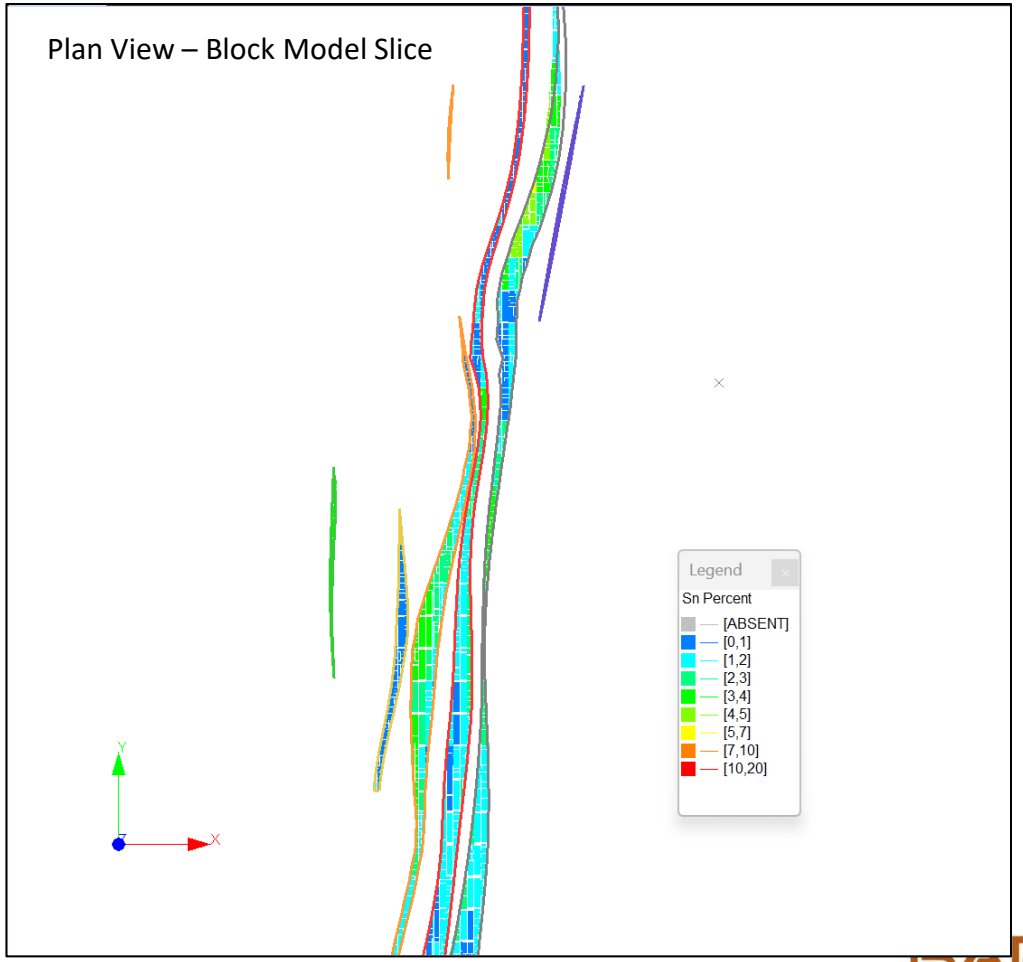
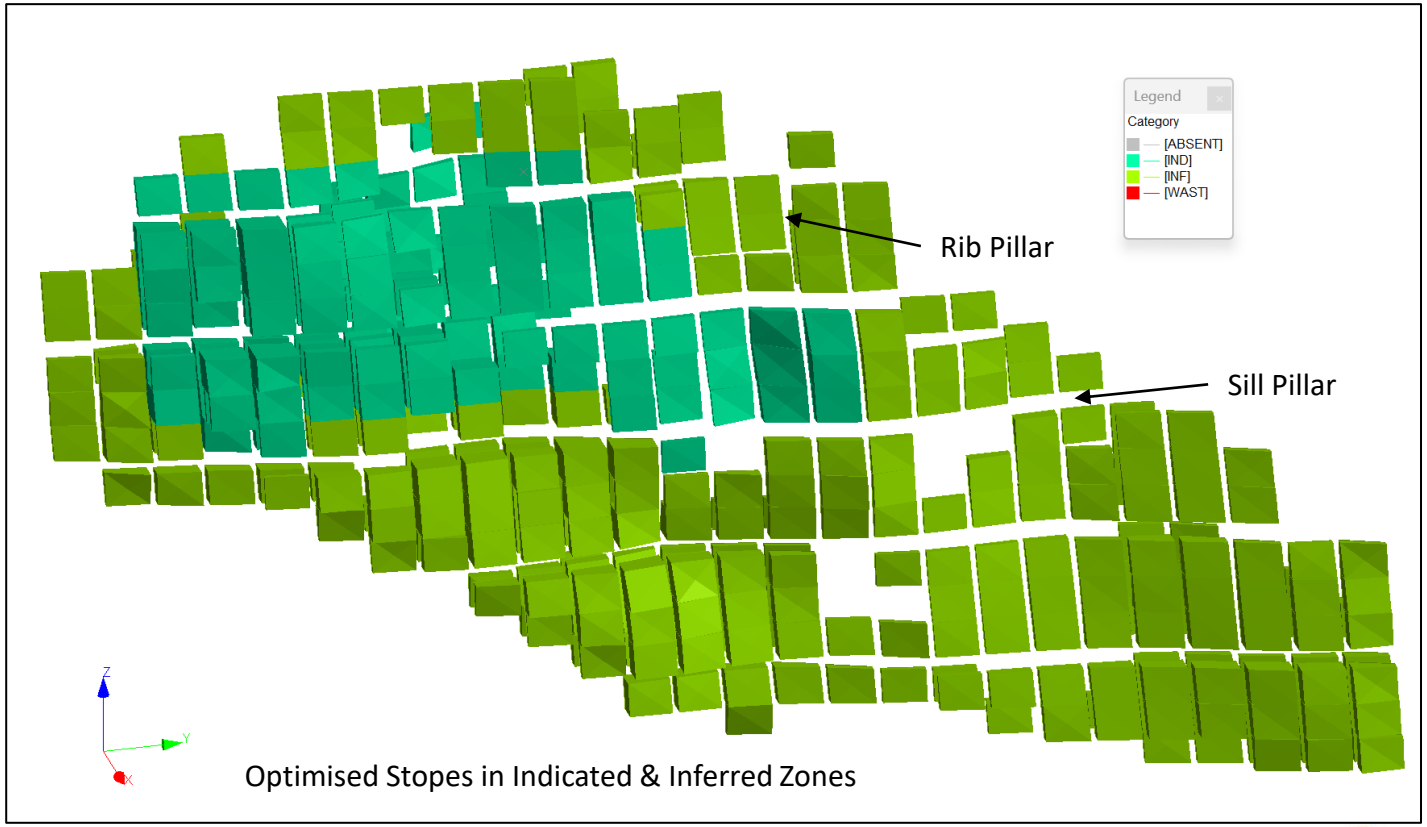
Stope Optimisation – Case Study 2

- Optimisation Parameters:
  - Minimum mining width – 2.5m & 4m
  - 0.25m dilution skins
  - Incremental maximum dilution (10% increments)
  - 4 Cut-off grades (0.6, 0.7, 0.8, 1.0% Sn)
  - Stope length – 30m
  - Stope height – 15m
  - Rib pillar – 5m every stope
  - Sill pillar – 8m every 3 stopes
  - 40m weathering exclusion



Stope Optimisation – Case Study 2

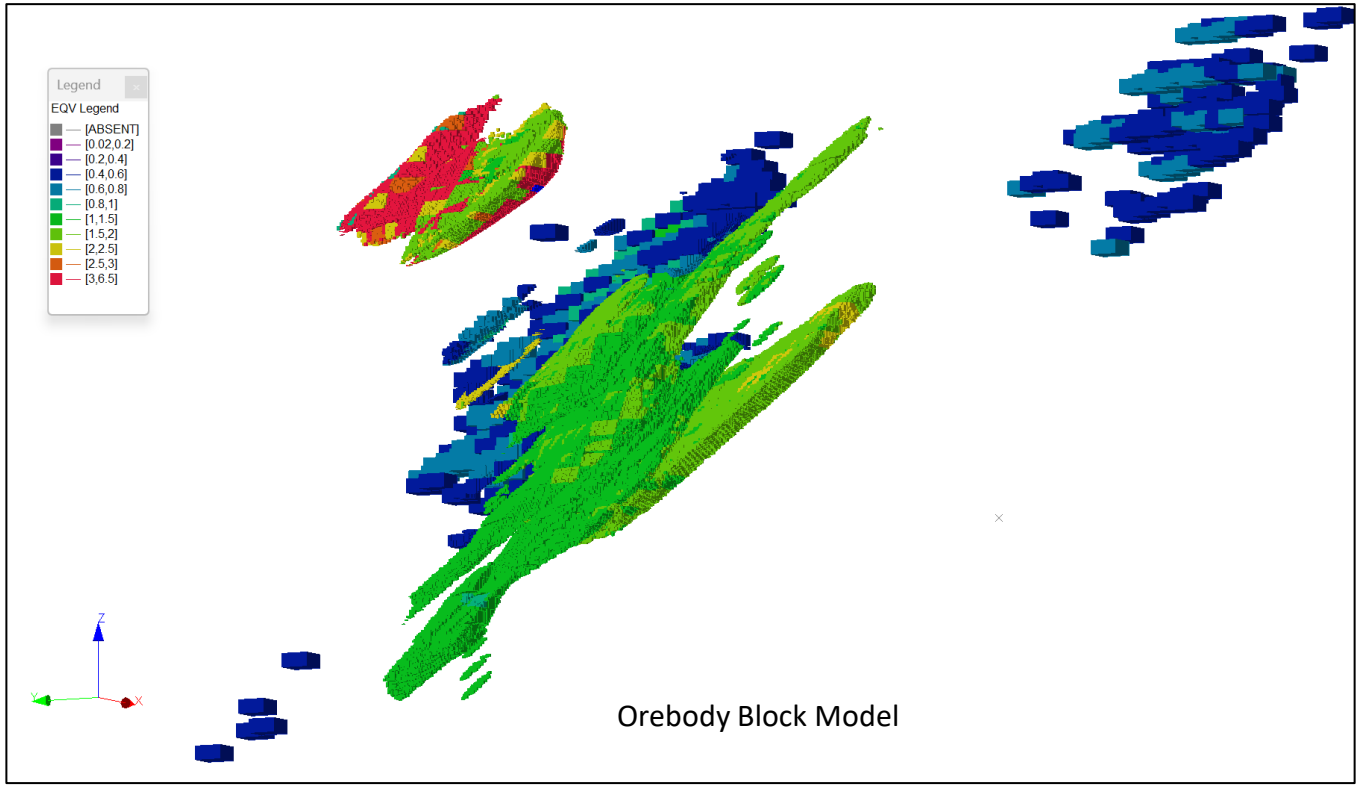
- Outcomes:
  - 2.5m minimum mining width
  - Current sized fleet (other deposit)
  - 1.0% cut-off
  - Up to 80% dilution
  - Identified Inferred stope potential



Optimised Stopes in Indicated & Inferred Zones

Stope Optimisation – Case Study 3

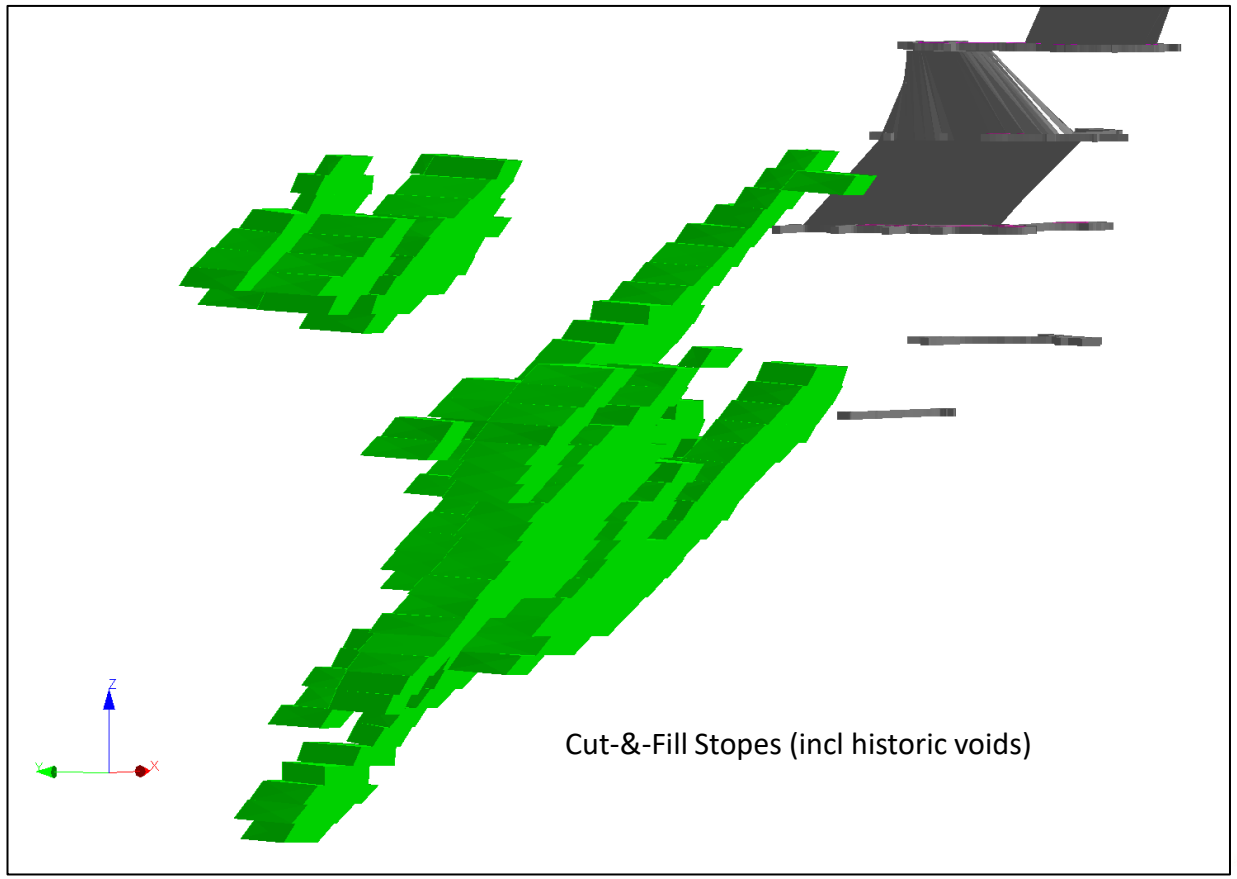
- Minerals: Vn – with Cu/Pb/Zn/Ag
- Where: Southern Africa
- Study Level: Scoping
- Project Background: Assess mining method (LHOS or C&F); dilution impacts
- Key Aspects:
  - Limit model extent (shadow zones)
  - Dilution increments for both methods
  - 45° dip



Orebody Block Model

Stope Optimisation – Case Study 3

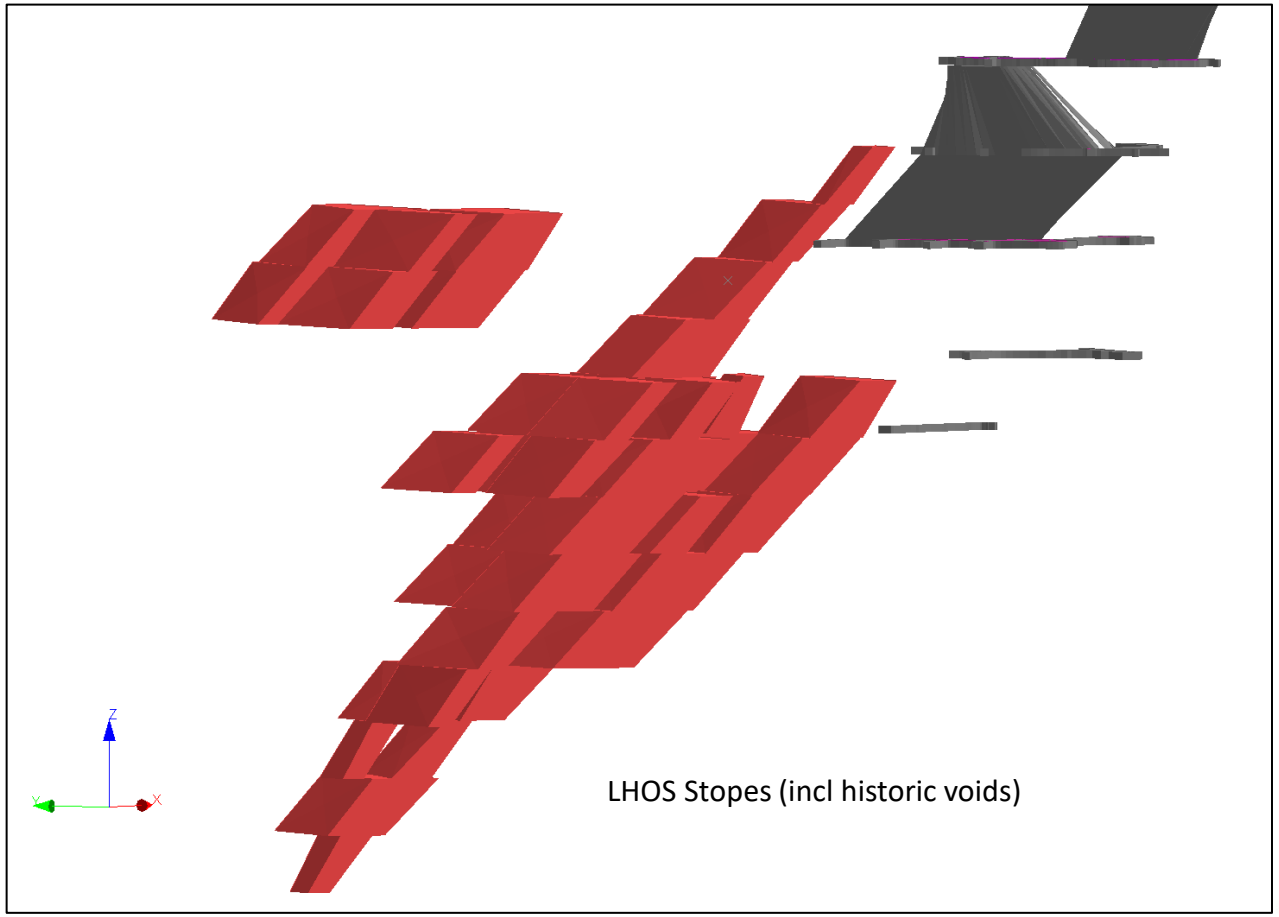
- Optimisation Parameters:
  - Cut-&-Fill:
    - Cut-Off V_2O_5 EQV – 0.46%
    - Cut height – 5m (15m sub-levels)
    - Min width – 4m
    - Dilution skin – 0.2m
  - LHOS:
    - Cut-Off V_2O_5 EQV – 0.38%
    - Stope height – 15m
    - Min width – 4m
    - Dilution skin – 0.5m
  - Both:
    - 10% dilution increments
    - Model extent restricted to main ore zone



Cut-&-Fill Stopes (incl historic voids)

Stope Optimisation – Case Study 3

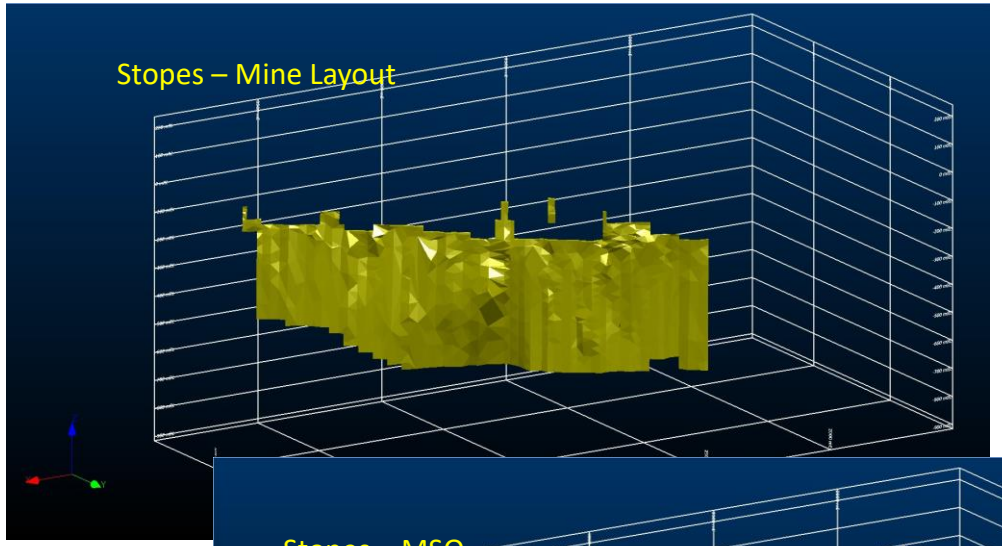
- Outcomes:
  - MSO & cost modelling of each dilution value
  - LHOS at max 70% dilution best result

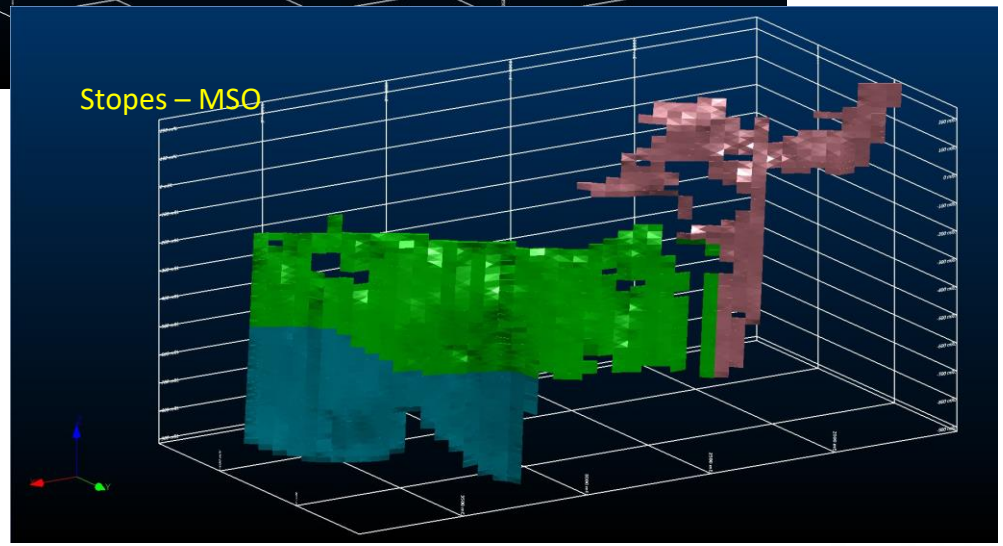


LHOS Stopes (incl historic voids)

Stope Optimisation – Case Study 4

- Minerals: Cu – with Co
- Where: Central Africa
- Study Level: DD
- Project Background: Check stoping designs using MSO: and ID potential extensions
- Key Aspects:
  - 3 working mines
  - SLC, VCR & MCR (mechanised continuous retreat)
  - Using same parameters
  - Comparative assessment





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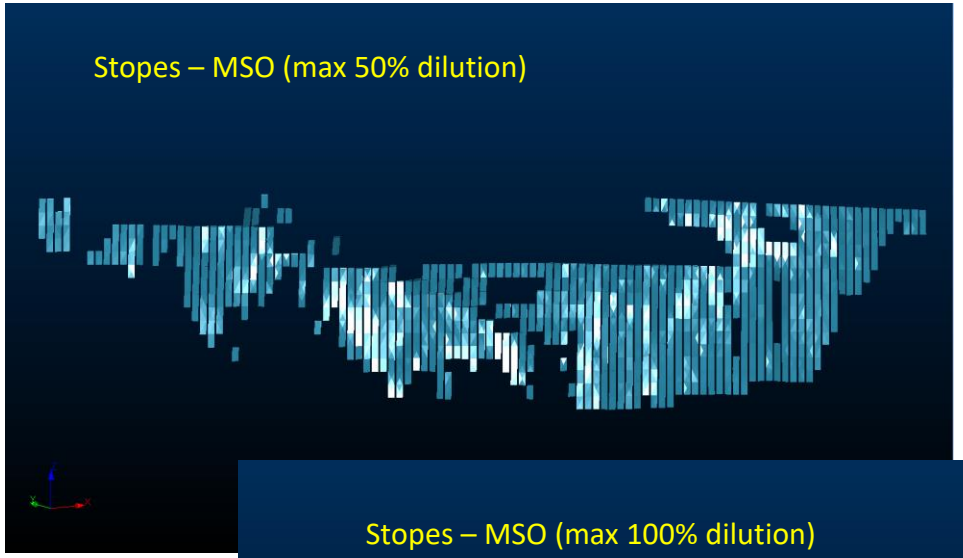
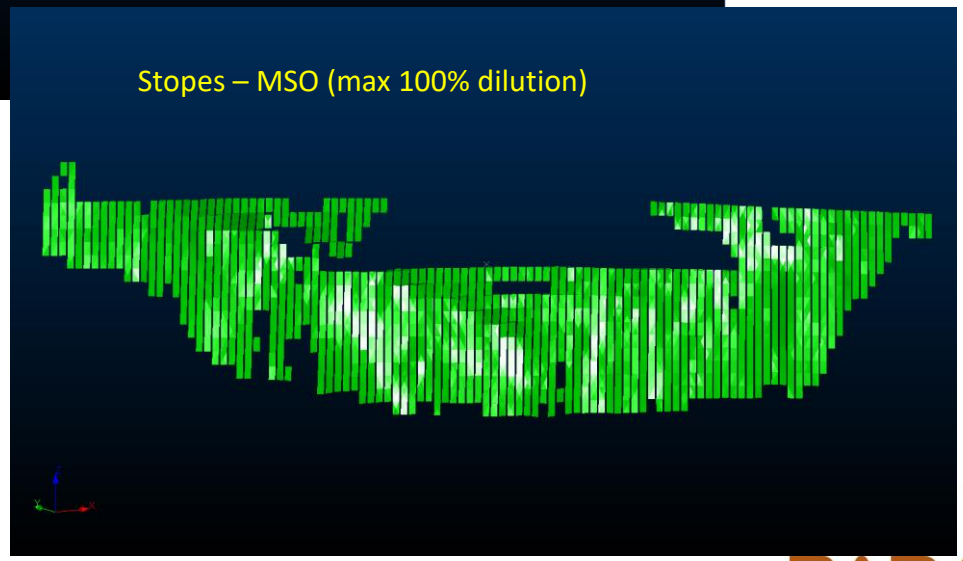
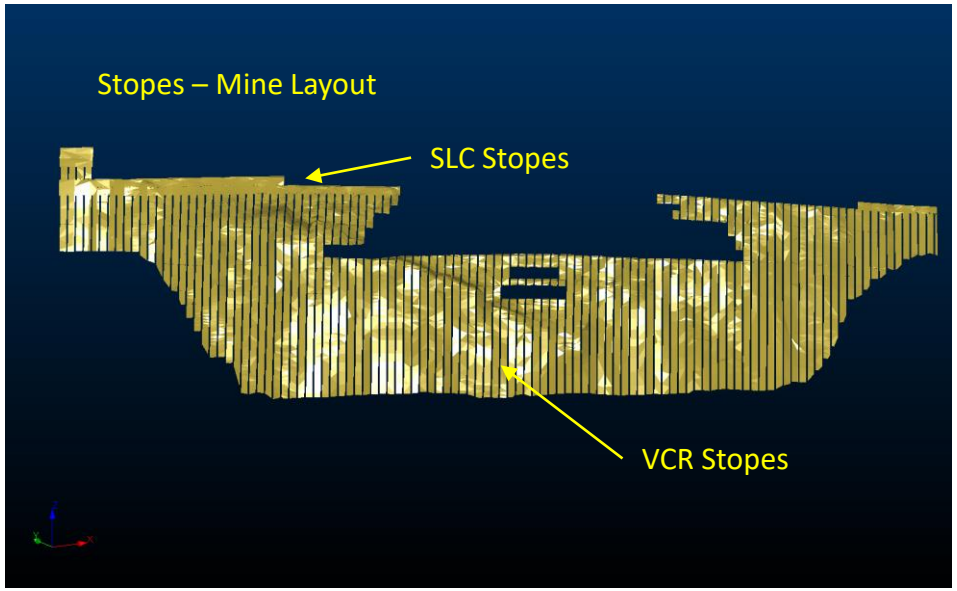
Stope Optimisation – Case Study 4

- Outcomes:
  - MSO & mine stope design generally match at gross scale (local differences)
  - Identify potential extensions/upside

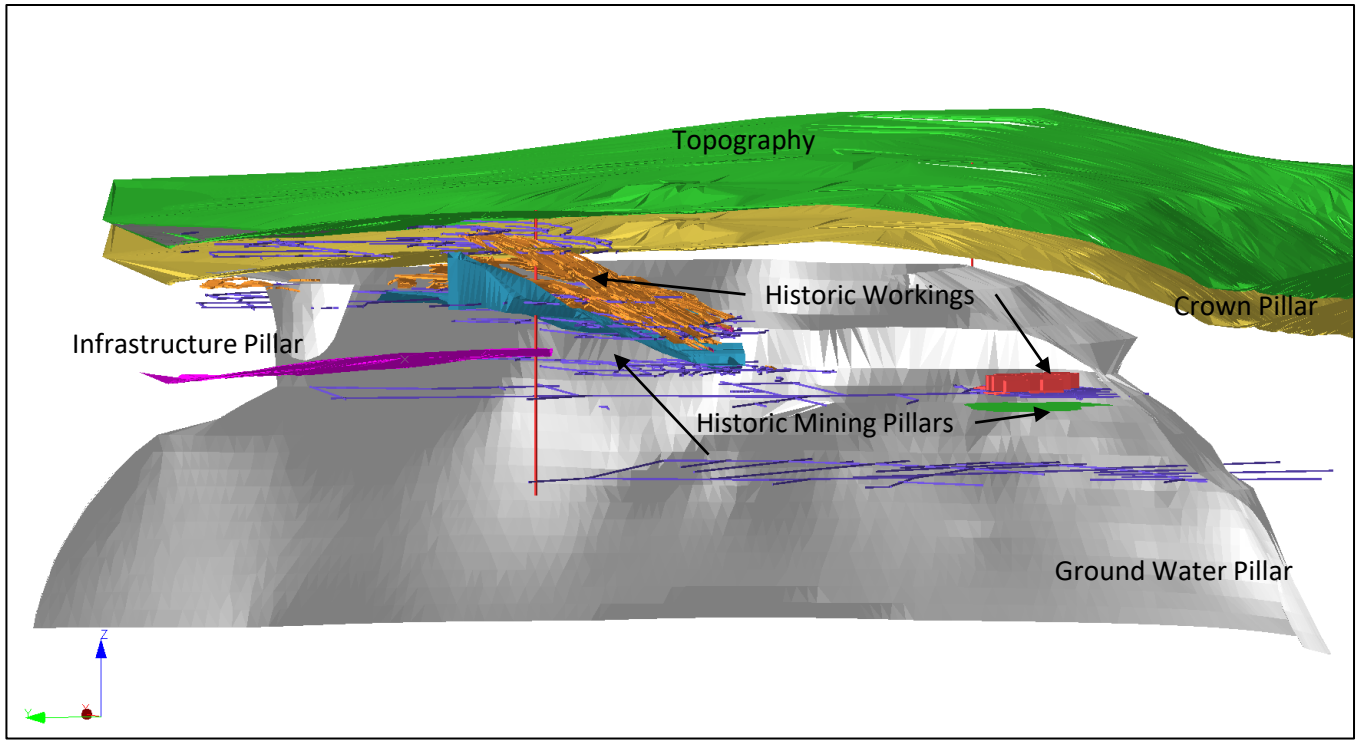






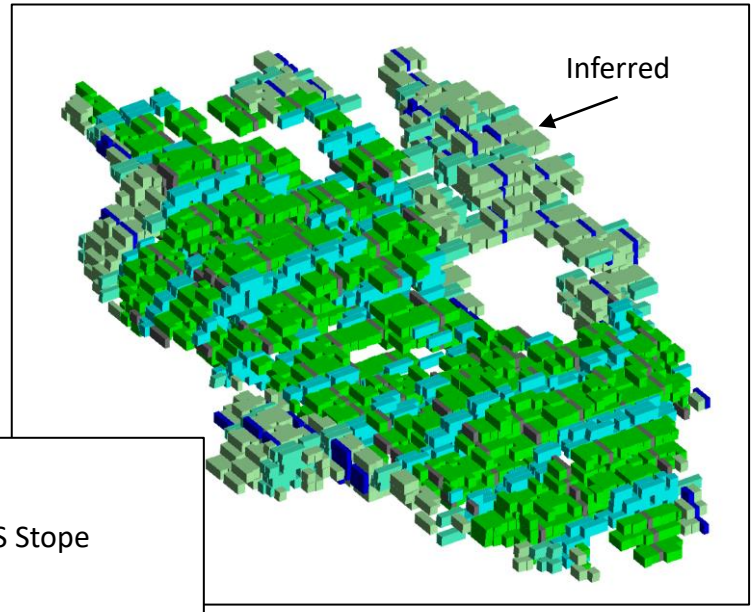
Stope Optimisation – Case Study 5

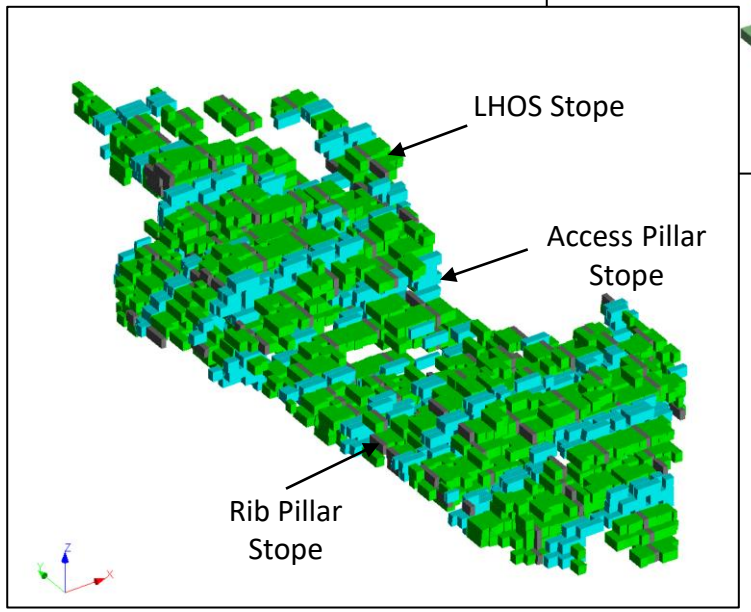
- Minerals: Li – with Sn/W
- Where: Central Europe
- Study Level: PFS / DFS
- Project Background: DFS & LOM design/schedule; expansion option (Inferred)
- Key Aspects:
  - Multiple exclusion zones – border, crown, surface infra, historic workings (x2), ground water barrier
  - Historic workings & surface infrastructure
  - Different MSO directions
  - ESG limitations



Stope Optimisation – Case Study 5

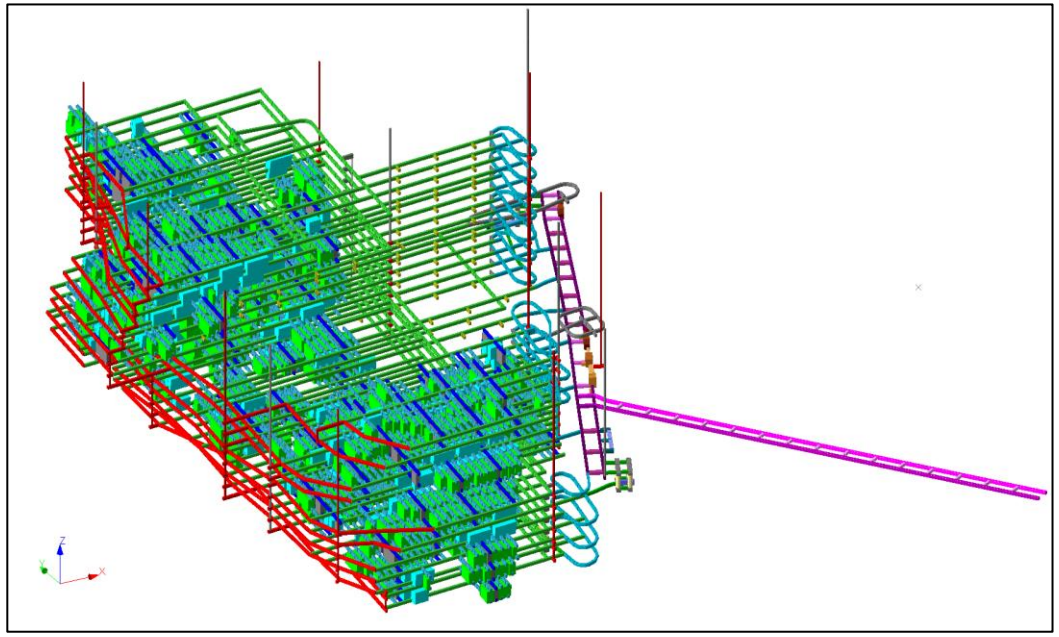
- Optimisation Parameters:
  - Cut-Off – based on a Margin
  - Longitudinal (NS - stopes & rib pillars) & Transverse (WE - access pillars) direction
  - LHOS – 20m H x 16m W x 50m L (max)
  - Rib pillar every 5 stopes (10m W) - remove
  - Sill pillar every 4 stopes – leave
  - 5m Barrier pillar after 50m length
  - Partial stope option – 10% increments down to ½ width – keep height
  - Access pillar stopes as per LHOS
  - Exclusion zones – non-mining areas

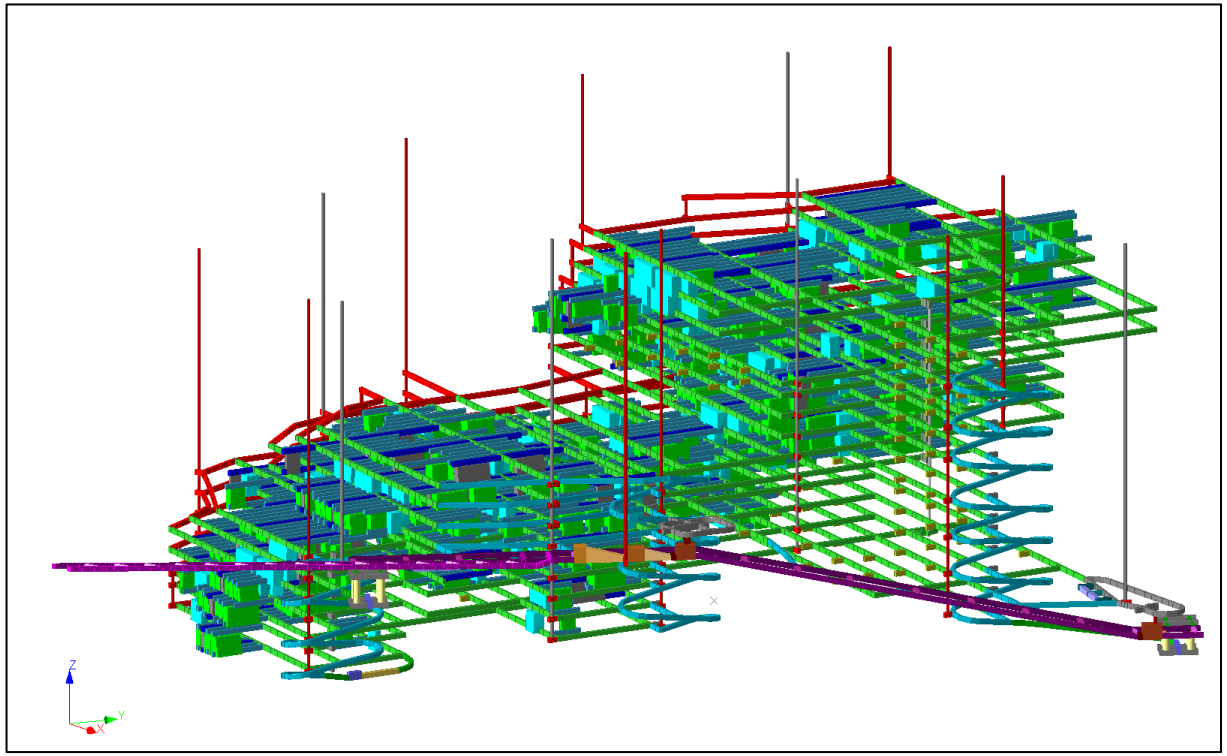




Stope Optimisation – Case Study 5

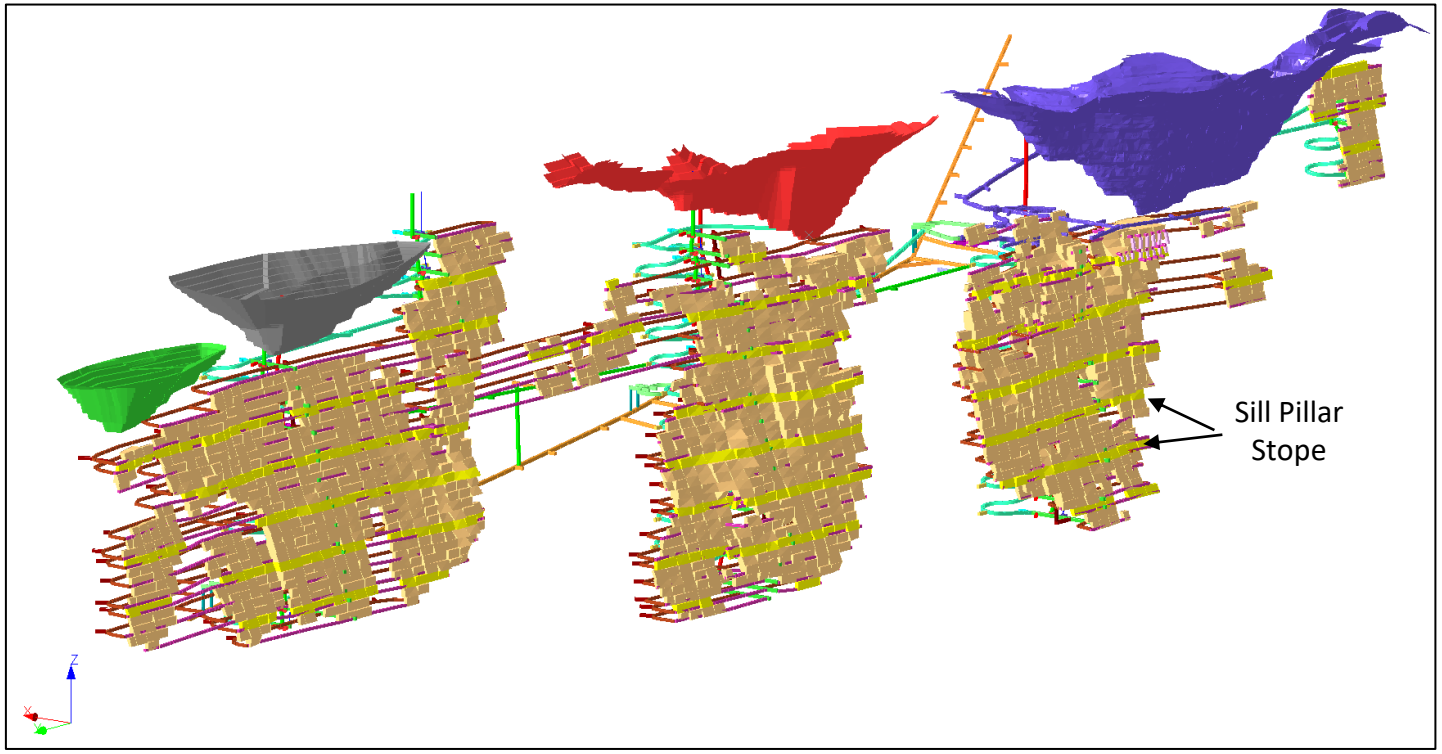
- Outcomes:
  - Full LOM stopes defined including extractable pillars
  - Inferred (future) stopes defined & catered for





Stope Optimisation – Other Cases

- Minerals: Au/Ag
- Where: SE Europe / West Africa
- Study Level: PFS / Scoping
- Project Background: various Au mines or projects – OP vs UG or OP to UG
- Key Aspects:
  - Test OP cuts vs. UG option
  - Extend mining from OP to UG
  - UG alternative to OP – surface issues restricting OP



Stope Optimisation – Summary

- Useful tool for definition & assessment:
  - All project levels – early resource/potential to LOM/operational design
  - Comparative assessments – DD or OP vs UG
  - Scenario assessments easily & quickly – equipment, cut-off, dilution, mining method, mining widths/dimensions, etc.
  - Can be used in OP not just UG – complex orebodies & define mineable ore blocks within pit shell (dilution)

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