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PIONEERING PROGRESS : THE FUTURE OF ROCK ENGINEERING

Improved Stope Design and Sequencing at Big Gossan Mine, Indonesia

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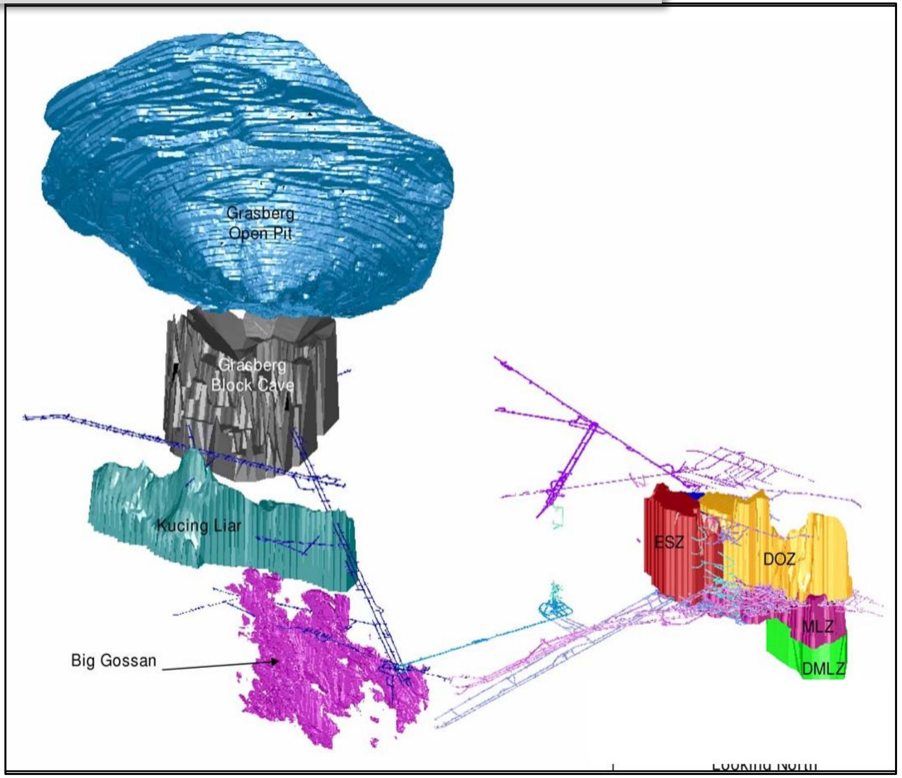
Presentation Outline

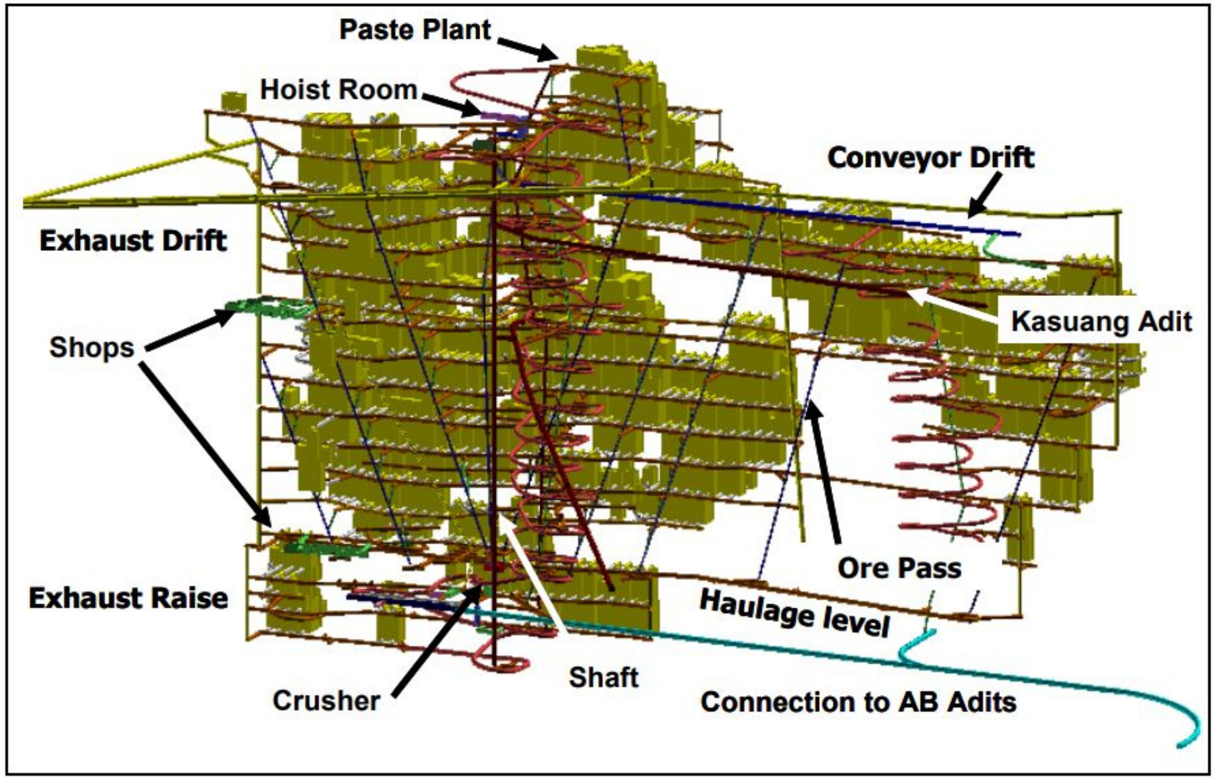
INTRODUCTION	STOPE STABILITY ASSESSMENT	UNDERCUTTING SEQUENCE	CONSLUSION
✔ Mine Overview ✔ Objectives of the study ✔ Geotechnical Challenges ✔ Analysis Tools	✔ MSG Evolution ✔ Stability Insights ✔ Design Implication	✔ Safety Concern ✔ Undercutting Sequence ✔ Stability of Undercutting Method ✔ Design Efficiency	✔ BG Modified Stability Graph ✔ Undercutting Sequence Method

Work Location

Mine Overview

Underground PTFI mine Layout





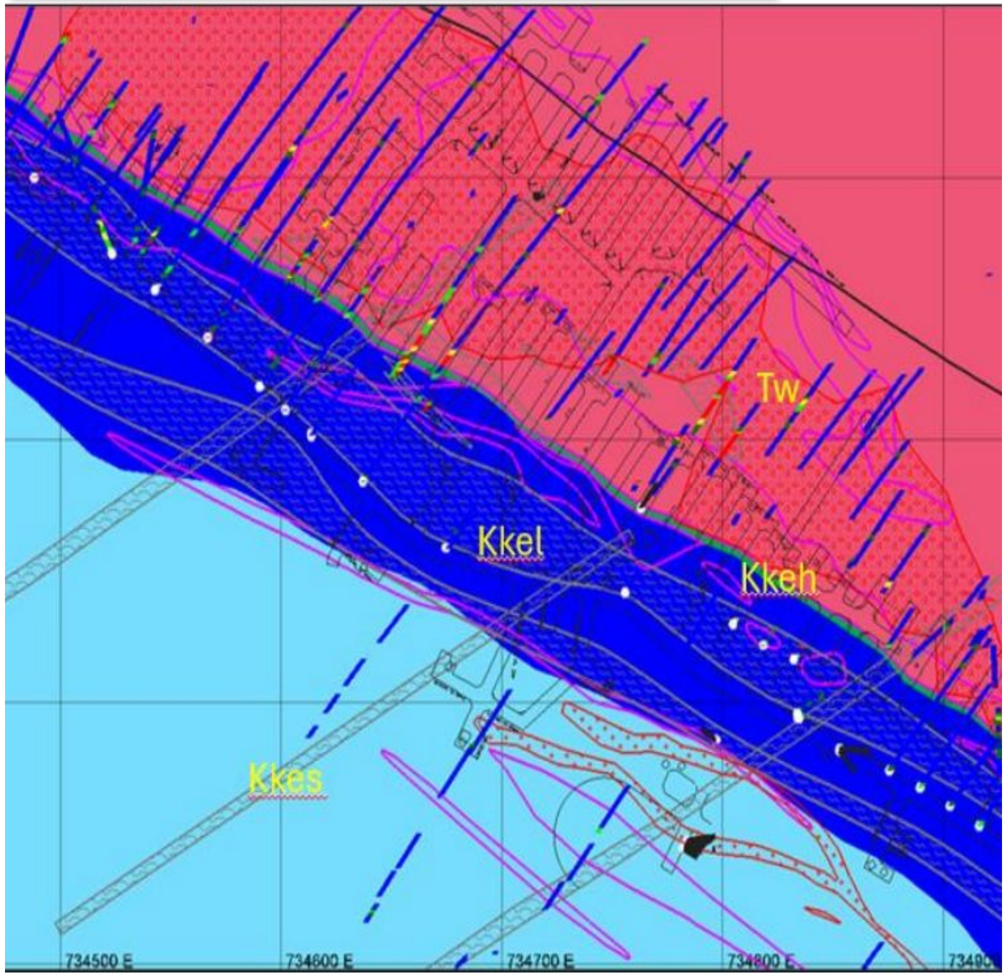
<u>**Key Highlight**</u>

- Open Pit (Grasberg); Cave Mines (GBC, Kucing Liar,DMLZ & PB4), Stope Mine (Big Gossan)
- PTFI production rate : 300k Tpd (PTFI)

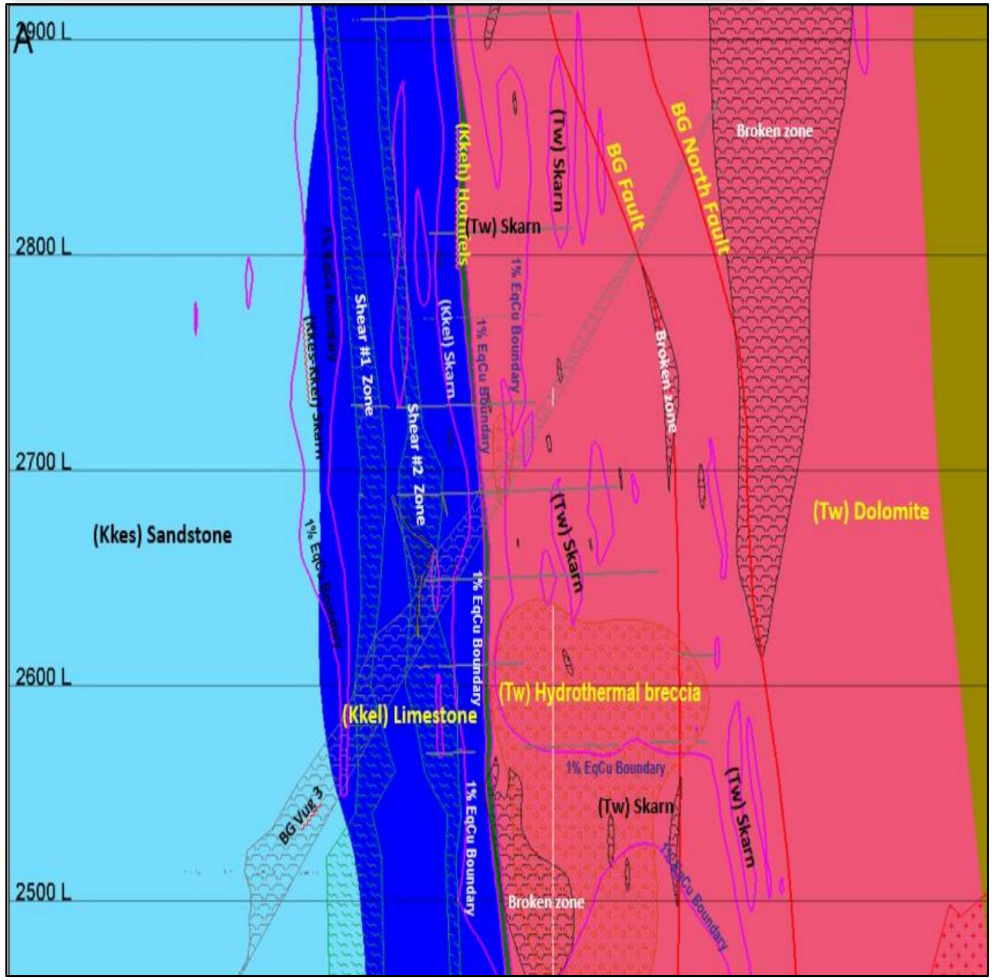
- Mining Method : Sub Level Open Stope with CPF paste filled
- Stope Dimension : 15m (Wide) x 40m (height) x up to 60m (transverse length)
- Current production rate : 8.500-10.000 Tpd (BG)`

Geological Setting

Big Gossan Geological Map (Planview)



Big Gossan Geological map overview (Section View



Key Highlight

- Skarn type deposit, in formation of TW-Skarn. Mineralization copper, gold, and silver
- The Orebody is narrow vertical, approximately 60m wide, 1.500m on strike and 400m in depth from surface

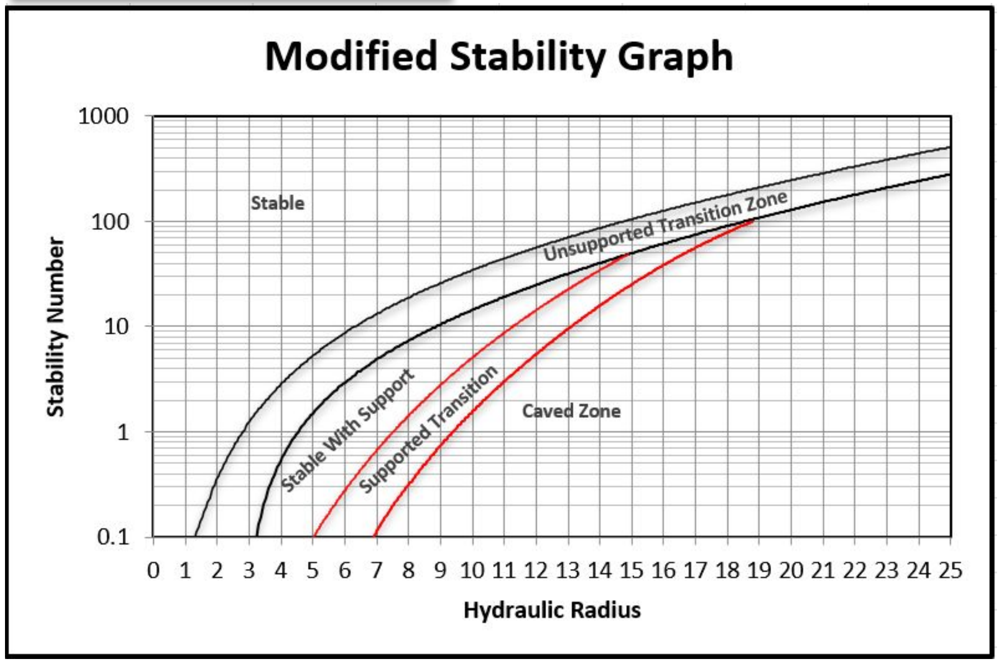
Big Gossan Stability Assessment

Stability Graph (Mathews,1981)

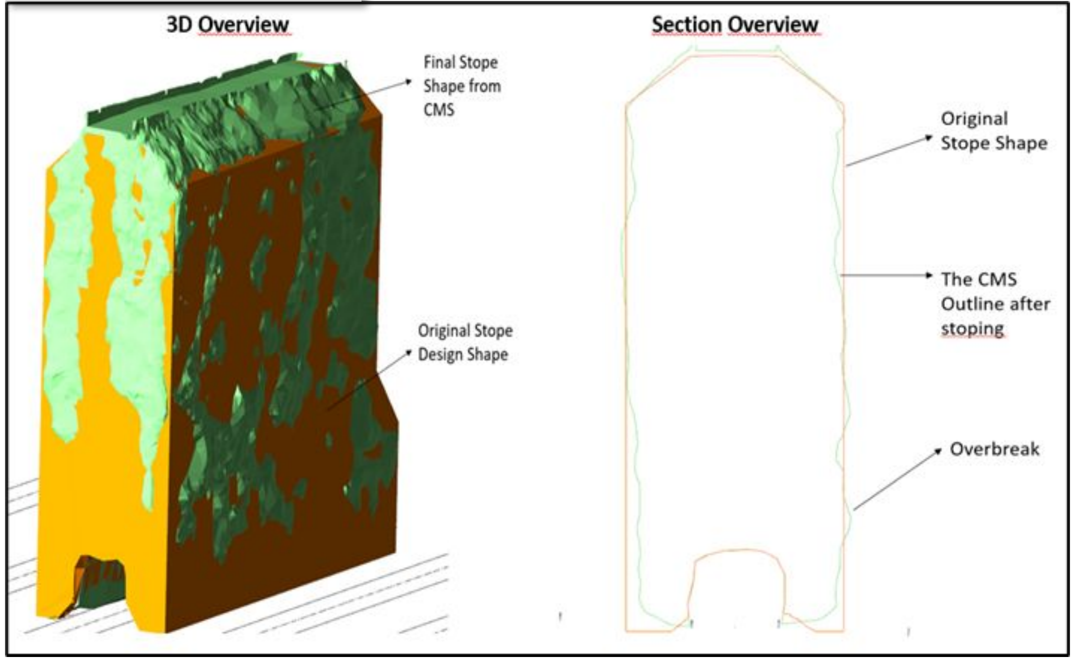
Modified Stability Graph (Potvin,1988 Nickson,1992)

Modified Stability Graph (Big Gossan, 2024)

MSG (Potvin 1988,Nickson 1992)



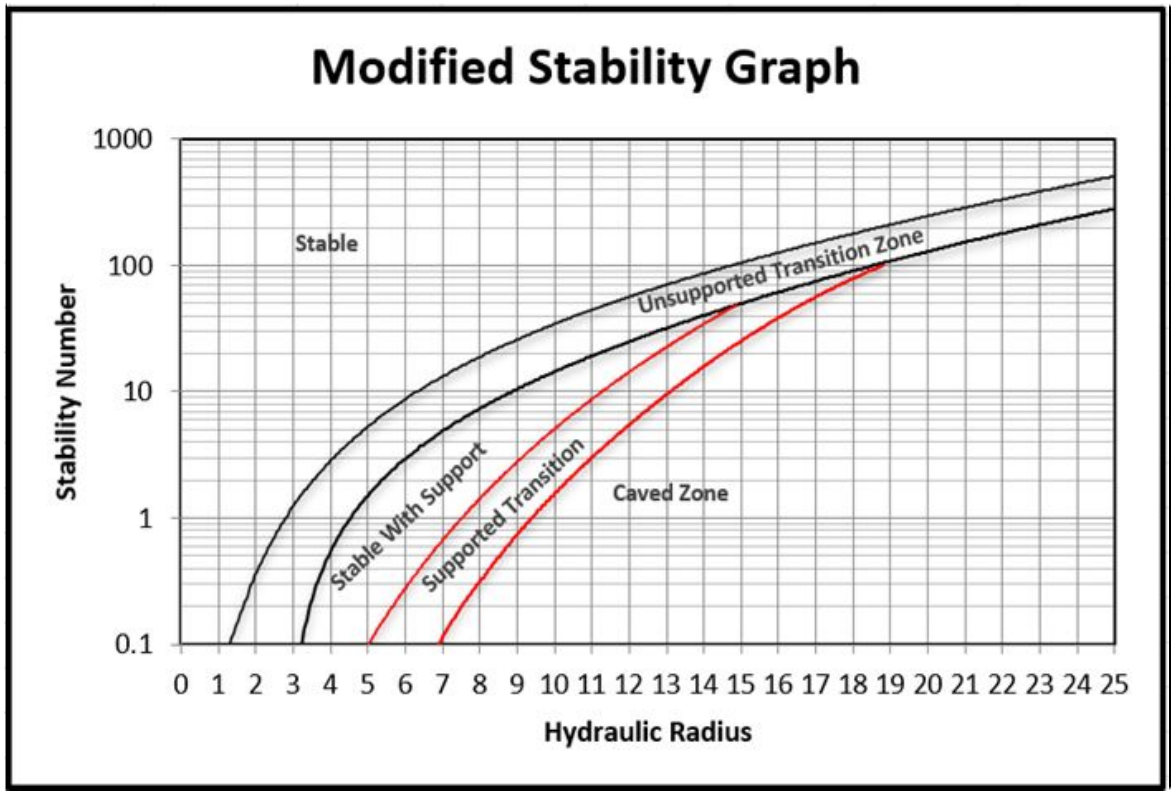
Cavity Monitoring Survey

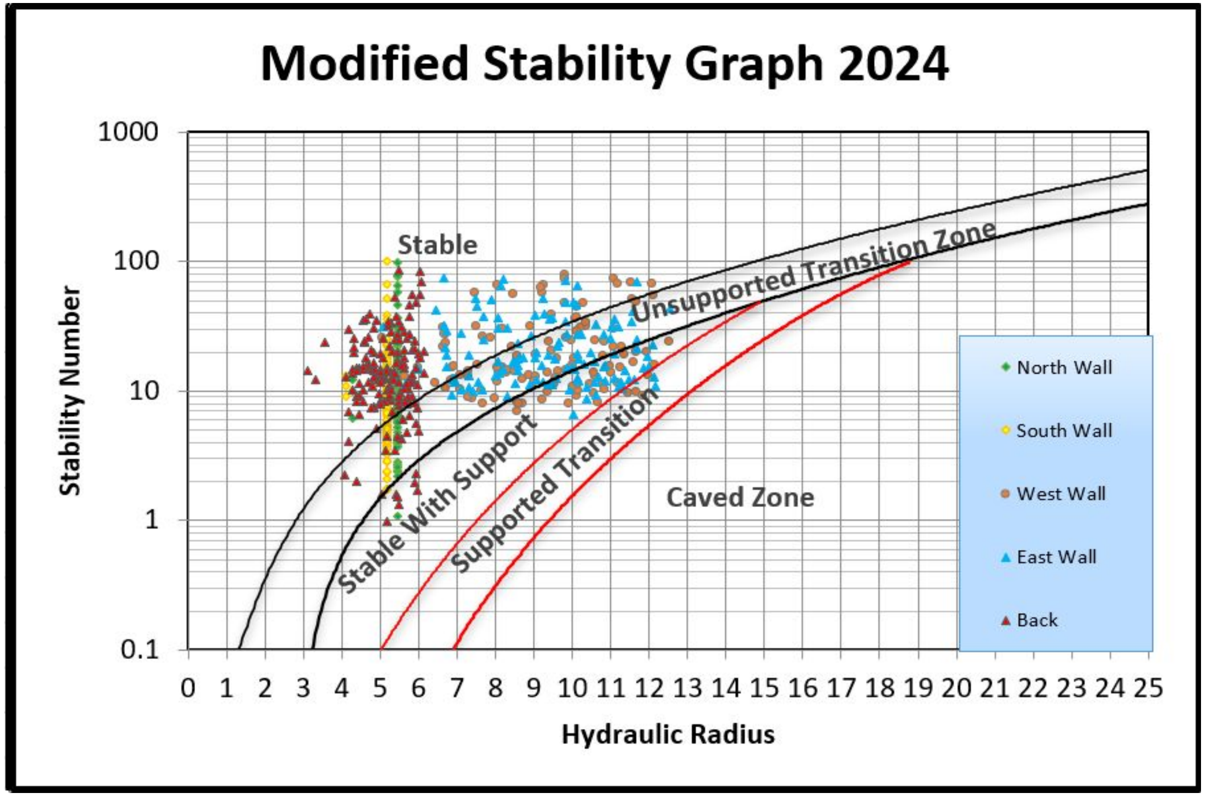


Key Highlight

- MSG used to assess stope stability at Big Gossan.
- Parameters optimized from Nickson to BG conditions.
- Challenge : Geological Structure & Stress Environment
- CMS used to validate stope stability through reconciliation process

Modified Stability Graph



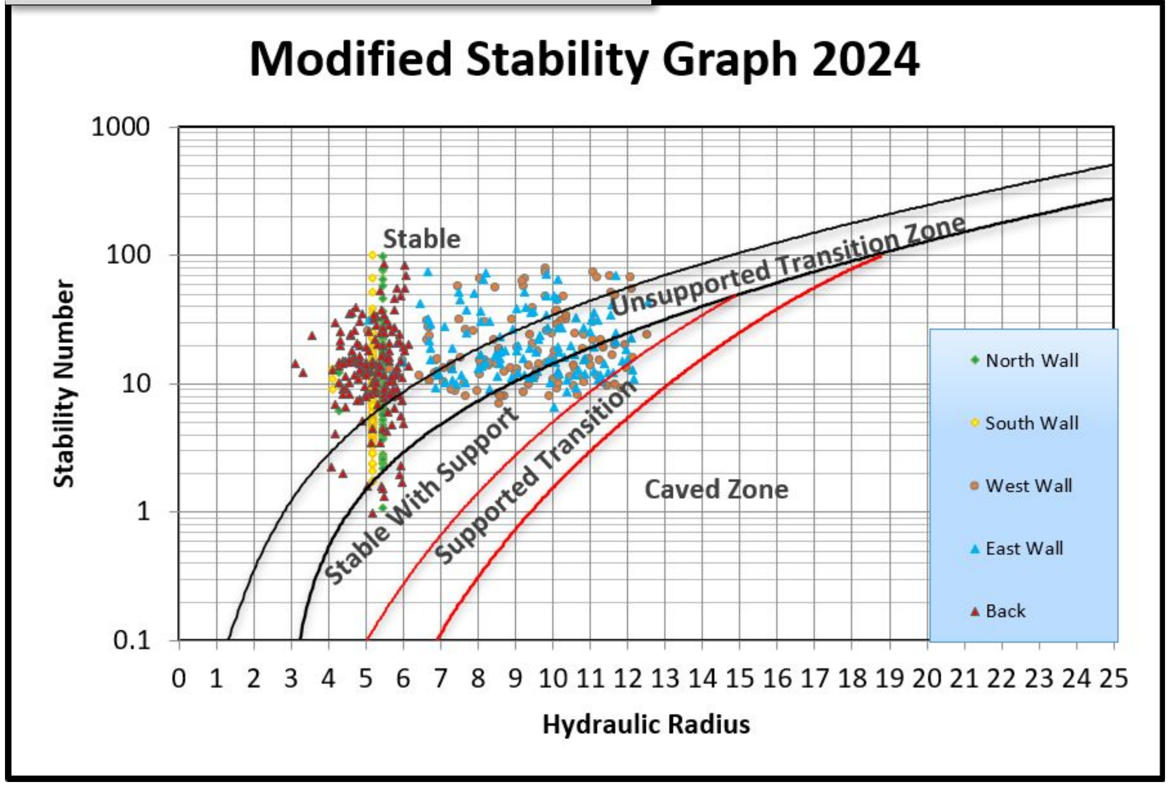


Key Highlight

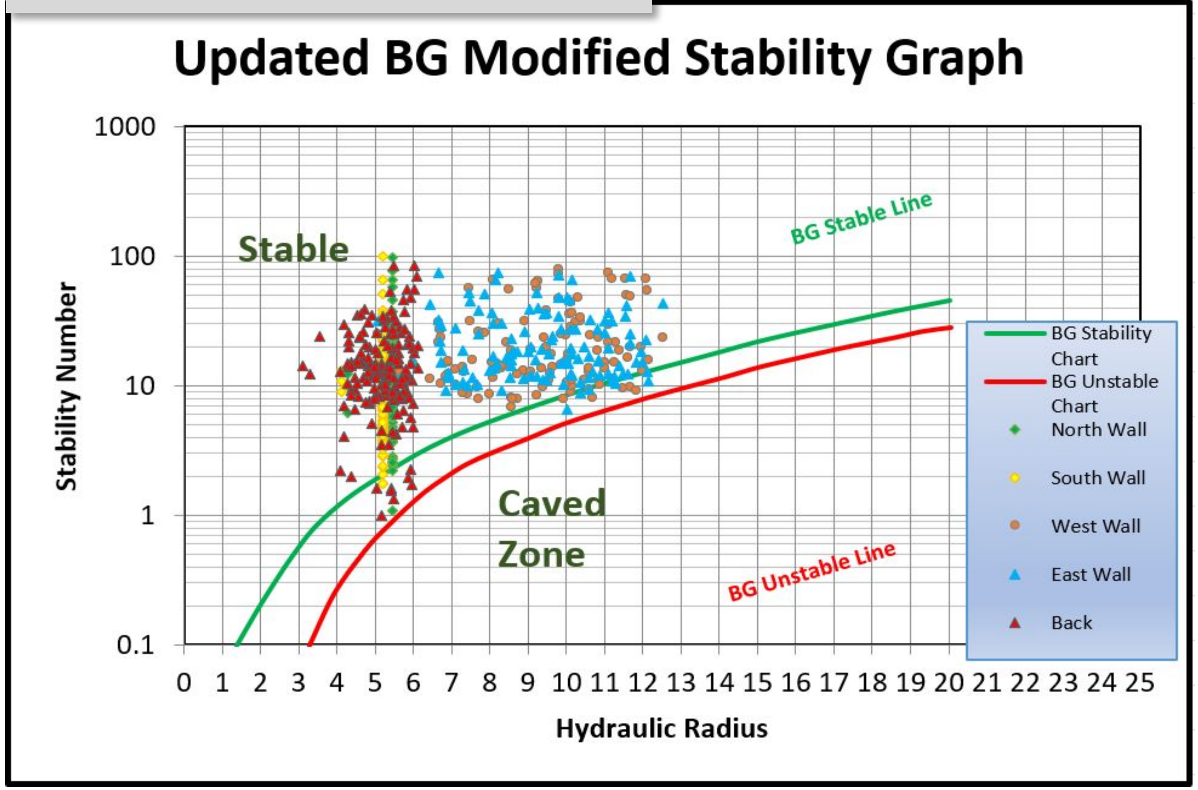
- Stability data plotted using Nickson (1992) zones.
- General: All stopes stable without support.
- Data indicated that the site specific need to be update.

Extending Big Gossan Modified Stability Graph

MSG (Potvin, 1988; Nickson, 1992)



MSG (Big Gossan, 2024)

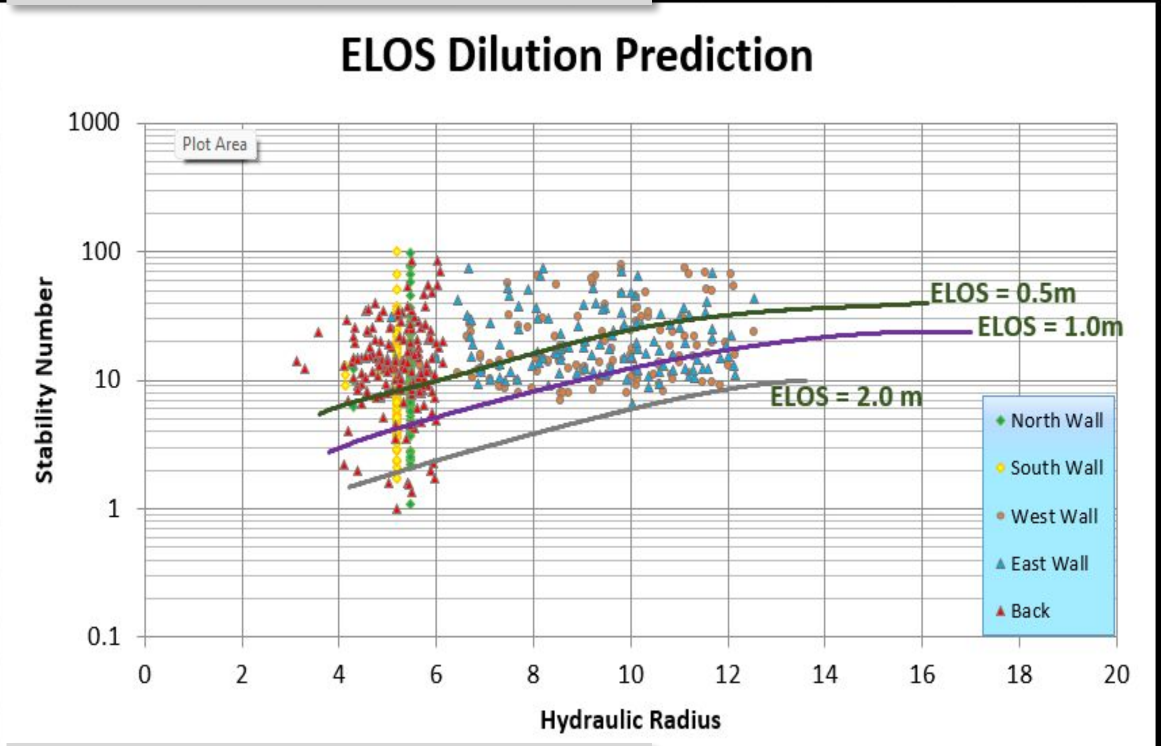


<u>Key Highlight</u>

- Several walls located at stable with supported zone (MSG Nickson,1992), but all stopes remain stable without extra support.
- Plotted data on MSG BG 2024 to identify trends and refine stability zones.
- New zoning for stable and unstable zone was updated

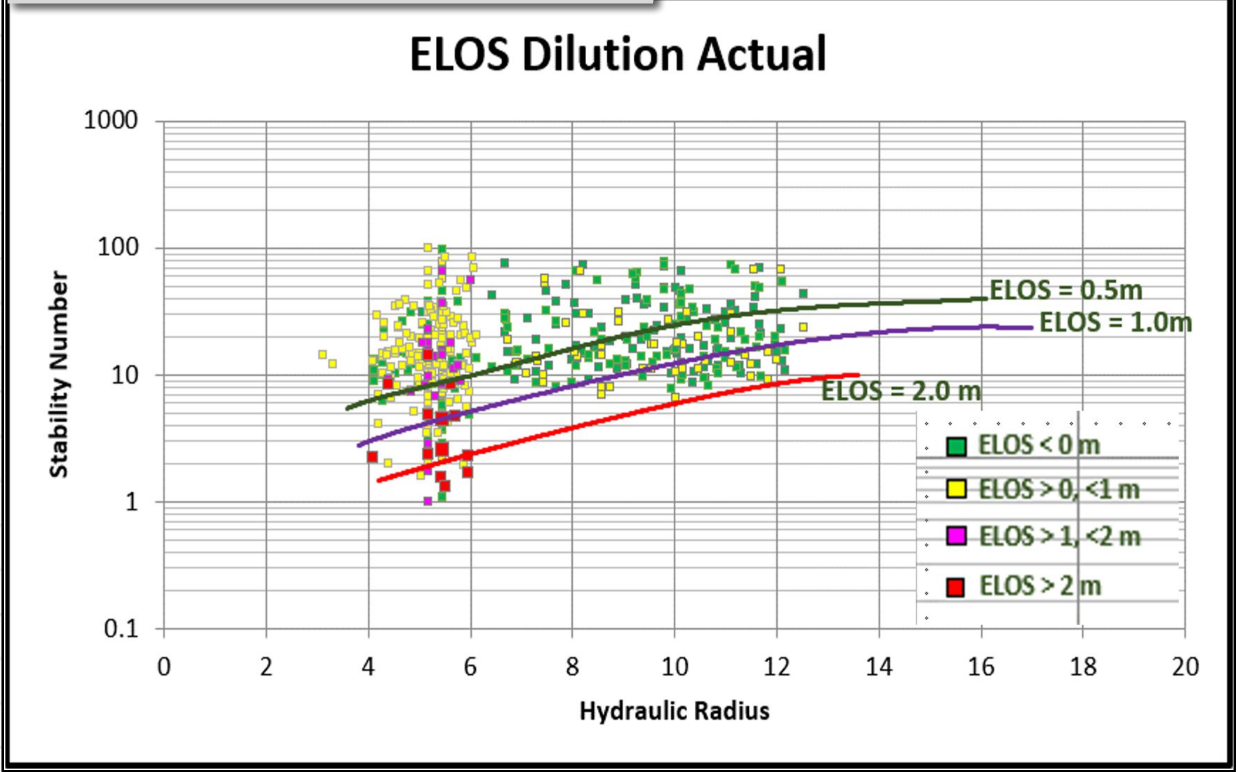
Stability Insights

BG ELOS Prediction, 2024



Clark and Pakalnis in 1997

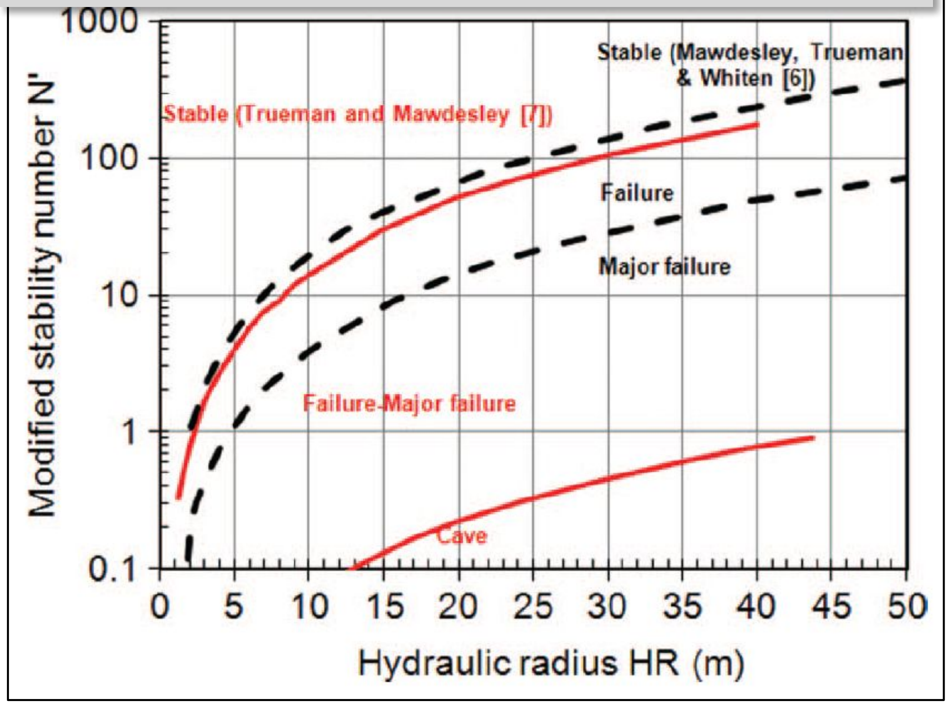
BG ELOS Actual, 2024

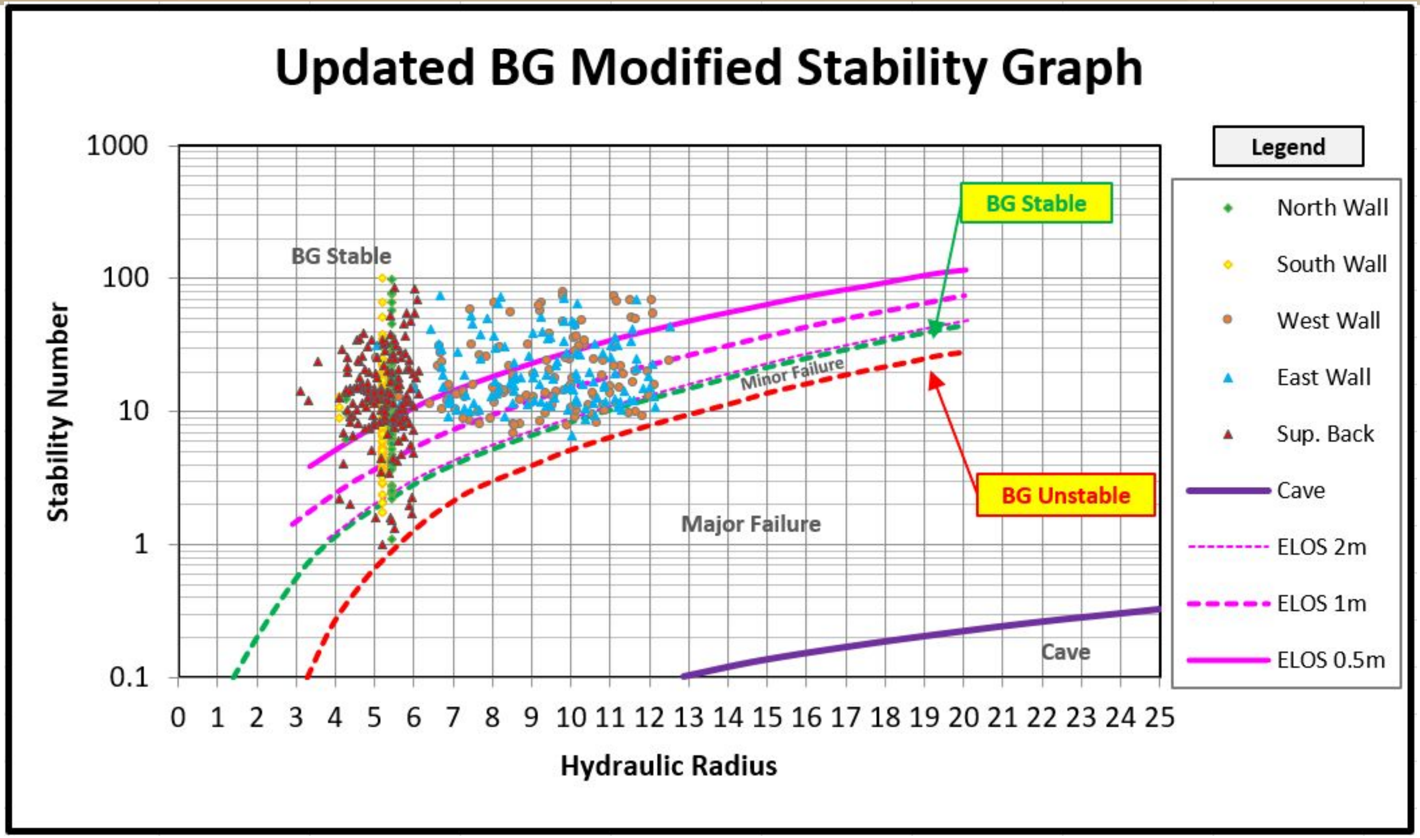


Key Highlight

- CMS done for 171 stopes, overbreak mostly observed at North, South, and Back wall
- East and West walls generally stable
- Most Overbreak attributed to blasting inaccuracies, but limited to geological structure and stress environment

Updated BG Modified Stability Graph



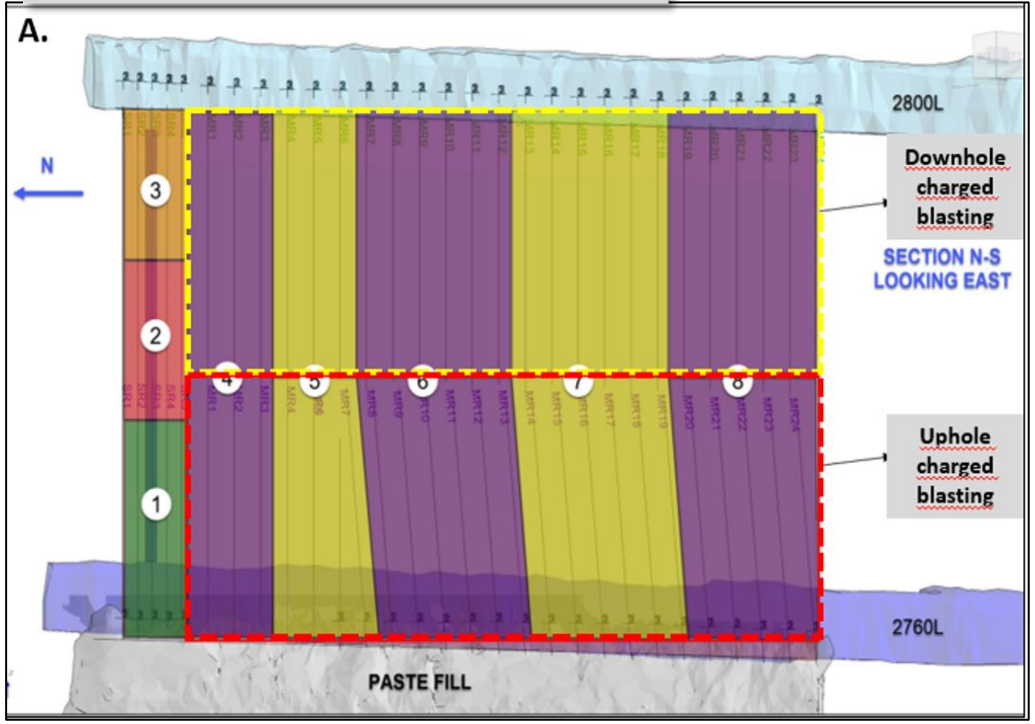


Key Highlight

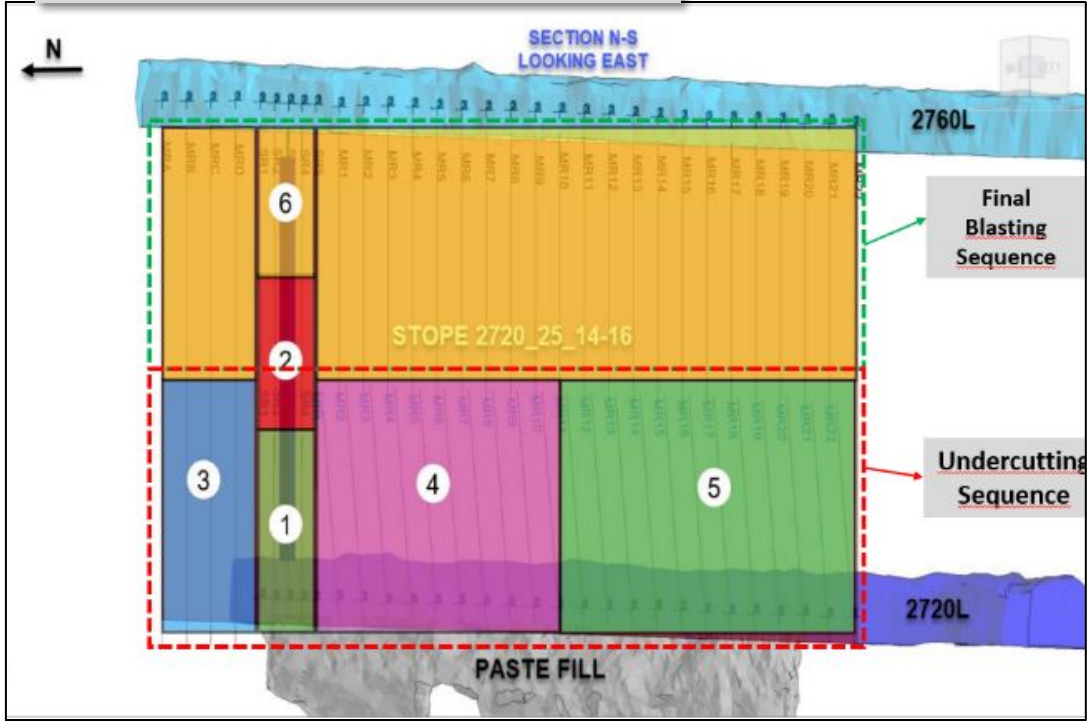
- 171 Stope data points collected between 2010 and 2024
- MSG confirmed by Equivalent Linear Overbreak/Slough (ELOS)
- New Zoning for stability & ELOS graph areas in the updated BG MSG ; Stope design more effective
- Design implication: Maximum HR ≈ 20; Maximum Stope Height ≈ 80 m

Undercutting Sequence

Original Blast Design



Updated Blast Design

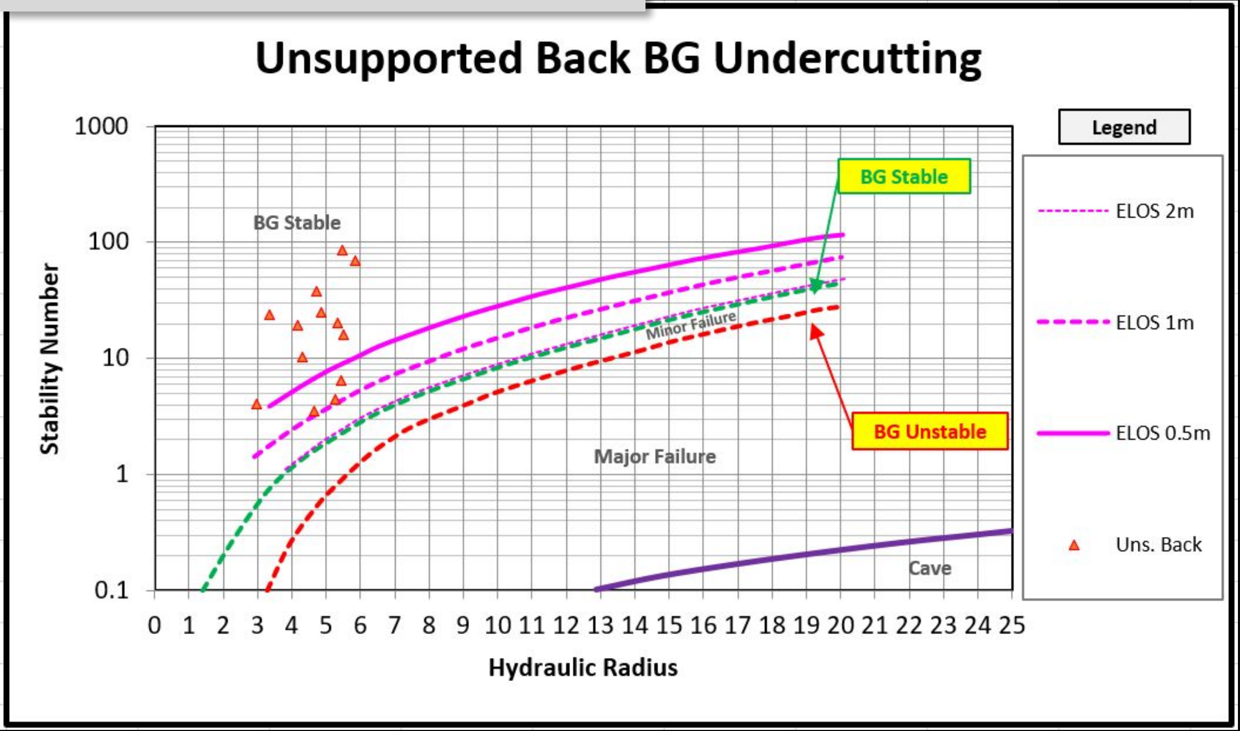


Key Highlight

- Concern: Large voids & Productivity
- Updated blast design has Unsupported Back
- Geotechnical consideration:
  - ❑ The length and span of the unsupported back.
  - ❑ The duration for which an unsupported back will remain stable

Undercutting Sequence Stability

Unsupported Back Undercutting Sequence



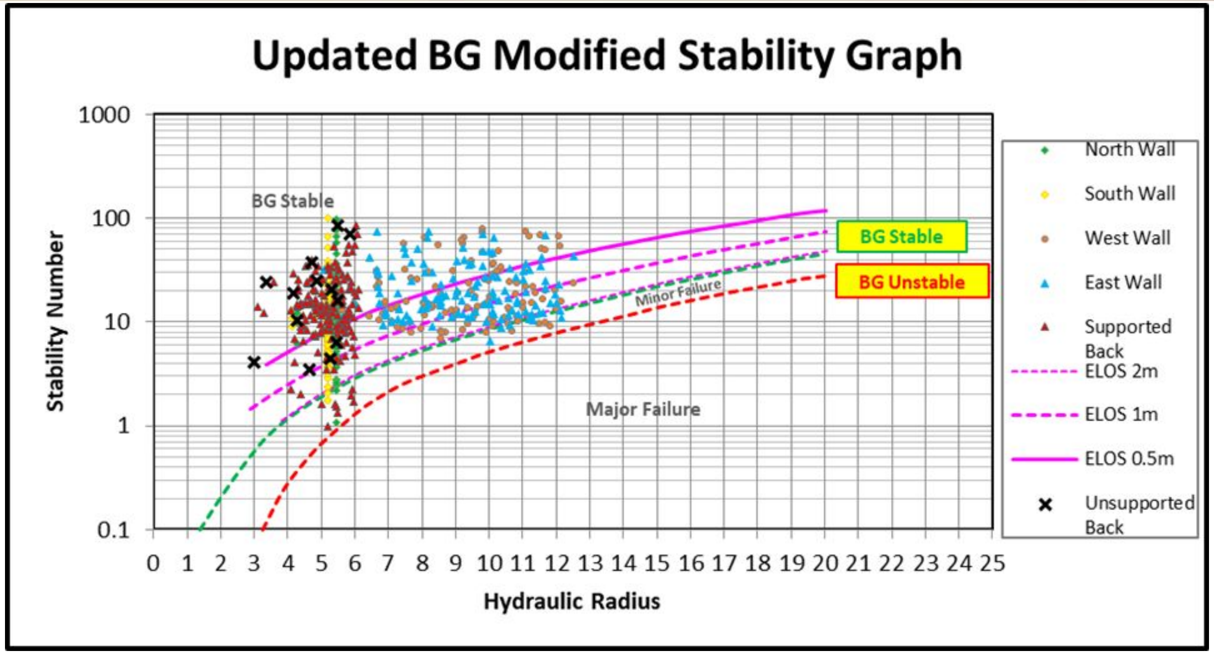
Actual ELOS & Stability for Undercutting Sequence

Stope Id	Dimension				Ground Condition (RMR)	Q-Value	Ground Condition	Elos Calculation		
	Width	length	Height	Undercutting				Elos (Meter)	Status	Stability
2940_23_16	15	65.2	40	54.2	83	33.75	Good Ground	0.22	overbreak	Stable
2940_19_18	15	41.2	40	40.72	78	30	Good Ground	0.35	overbreak	Stable
2860_24_15	15	65	40	56.7	73	10	Fair to Good Ground	0.36	overbreak	Stable
2860_20_15	15	64	40	53.45	75	19.8	Good Ground	1.04	overbreak	Stable
2860_39_11	15	55	40	40.92	73	8.75	Fair Ground	0.74	overbreak	Stable
2720_25_14	15	65.5	40	55.8	80	30	Good Ground	0.38	overbreak	Stable
2720_19_16	15	51	40	44.64	80	30	Good Ground	0.22	overbreak	Stable
2640_18_13-14	15	45.1245	40	41.2	74	13.2	Good Ground	0.33	overbreak	Stable

Key Highlight

- Several empirical methods were evaluated to determine stability
- 69 undercutting sequences across 22 stope was implemented/ monitored
- Rock Mass Condition: Good
- No signs of instability
- Conclusion: Strong correlation found between final stope back (supported) and unsupported stope back (crown pillar) stability. The stability of unsupported back can be effectively assessed using MSG Method

Conclusion



- **The geotechnical assessment** gave insights on stope stability, undercutting, and MSG effectiveness
- **New Zoning for stable/unstable** areas in the updated BG MSG ; Stope design more effective
- **Unsupported pillar backs are stable,** showing similar MSG and ELOS trends as supported backs, indicating that the final stope back and intermediate stope back data sets could be correlated. The stability of **unsupported back can be effectively assessed using MSG Method**
- Overall, this study underscores **the importance of controlled blasting techniques and continuous refinement of geotechnical models in optimizing stope design**

THANK YOU

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