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Investigating the impacts of caving mining methods on open pit bench stability at Nchanga Mine, Zambia

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Presentation lay out

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Introduction

- Nchanga Mine in Zambia employs a combination of underground caving mining methods and open pit mining operations to extract valuable copper ore.
- The caving mining method involves the gradual collapse of the surrounding rock mass to extract ore, resulting in subsidence zones and voids.

Problem background

- The implementation of underground caving mining methods can have significant impacts on the flow of caved materials and the overall stability of the mine's surroundings.
- Ensuring the stability of open pit benches is crucial for safe and efficient mining operations, as any instability can lead to slope failures, jeopardising personnel, equipment, and production.
- Likewise, maintaining the stability of waste dumps is vital to preventing environmental hazards such as soil erosion and the release of hazardous materials.

Materials and Methods

To assess the surface ground response to underground mining caving the impact on open pit bench stability, the following study variables and methods shown in Table 1 were used:.

Table 1: Study variables for ground conditions

Study Variables	**Methods**	**Other parameters**
1. classification Rock mass systems 2. Rock quality 3. Discontinuity 4. Ground Water condition 5. Joints condition	1. Rock mass rating, 2. Rock quality designation, 3. Q- Classification, 4. Laubscher's rock mass classification system	Other rock mass classification methods

Continuation

Table 2 Study variables

Study Variables	Methods	Other parameters
1. Caved mass flow analysis 2. Surface subsidence Deformation 3. Slope stability 4. Slope angles	1. Slope Stability Radar (SSR) analysis 2. Satellite imagery	Empirical designs 1. Laubscher (1994), 2. Laubscher (1990)

Slope Stability Radar (SSR)

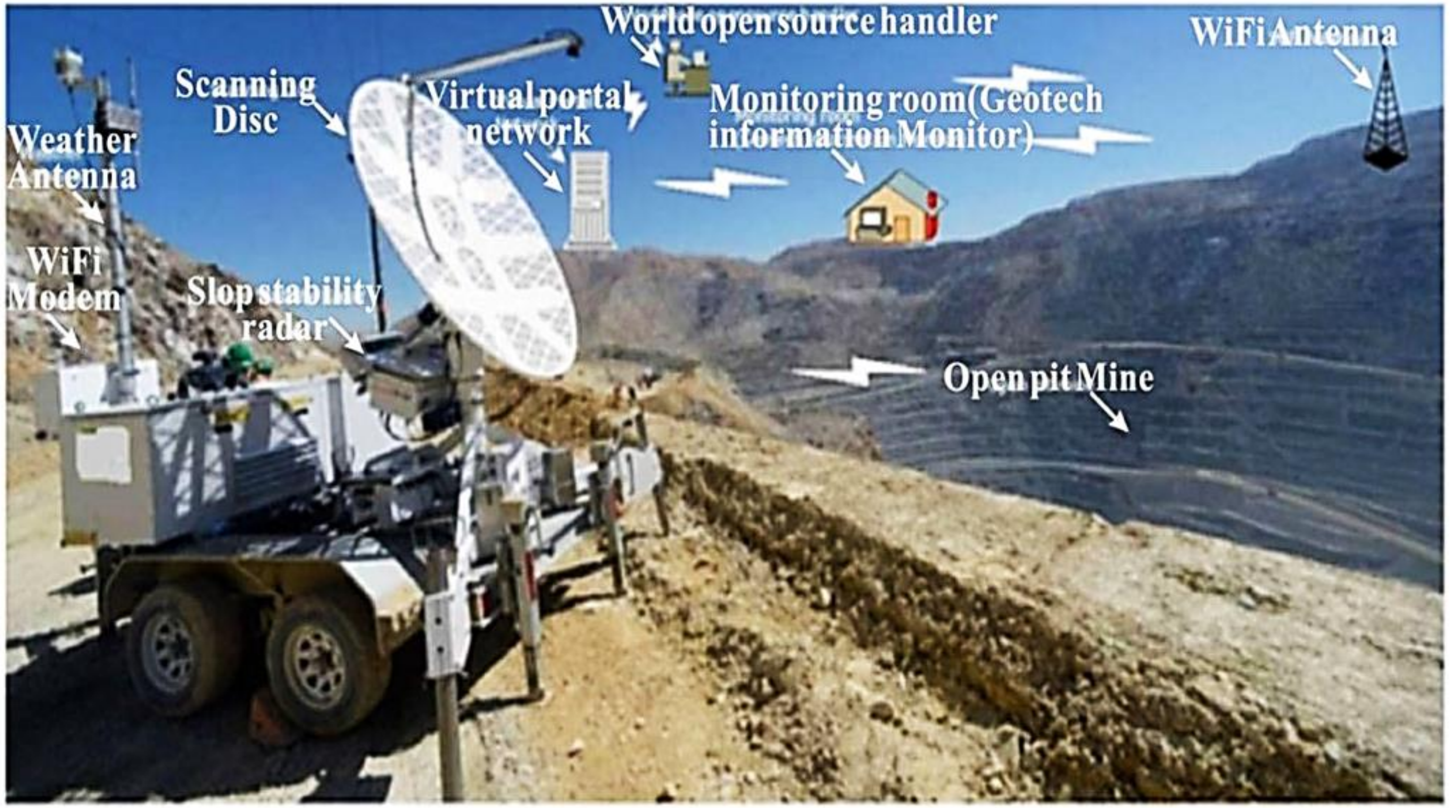

Figure 1 :Slope stability radar field deployment at Nchanga open pit (KCM, 2014)

Results and Discussion

Table 3: Calculation and classification of RQD

Rock type	RQD=115-3.3J_v	J_v= $1/s_1+1/s_2+1/s_3$	Class
Upper Banded Shale - UBS	25.24%	27.2	Poor
The Feldspathic Quartzite - TFQ	35.25%	24.2	Poor
Banded Sandstone Upper-BSSU	46.25%	20.8	Poor
Pink Quartzite - PQ	60.55%	16.5	Fair
Banded Sandstone lower- BSSL	42.95%	21.8	Poor
LBS	32,50%	25.0	Poor
Transitional Arkose- TRARK	47.90%	20.3	Poor
Arkose- ARK	39.10%	23.0	Poor
Nchanga Red Granite - NRG	50.65%	19.5	Fair

Hydraulic Radius for Trough Drives

Hydraulic radius is the ratio of the area of a span to be caved to the wetted perimeter of the same span.

The undercut above a scraper drift for Nchanga mine has the following dimensions: Length = 64.0 m; width = 9.6 m. Therefore, the resulting hydraulic radius is:

$$Hydraulic\ radius\ (HR) = \frac{Area}{perimeter} = (9.6\,m x\,64.0\,m)/[2x9.6\,m + 64.0m = 4.2\,m$$

Various rock types and Hydraulic radius

Rock type	MRMR	Hydraulic radius
NRG	63	below 23m hydraulic radius-stable, above 40m hydraulic radius- caving
ARKOSE	55	below 18m hydraulic radius- stable, above 32m hydraulic radius –caving
TRARK	< 3	caving will start as low as 4.2m hydraulic radius
PQ	14	caving will start as low as 4.2m hydraulic radius
BSSU	< 3	caving will start as low as 4.2m hydraulic radius
TFQ	18-40	below 10m hydraulic radius -stable, above 20m hydraulic radius –caving
UBS	< 9	caving will start as low as 4.2m hydraulic radius

SSR Analysis

- The investigation has unveiled a progressive bottom-up failure in the footwall slope, primarily driven by the weakening of the rock unit at the base.
- This discovery provides essential insights for designing effective footwall slopes at Nchanga mine.

Conclusion

- Significant portion of the rock units at Nchanga mine are in the fair to poor category
- These results emphasize the need for a comprehensive understanding of the geological and geotechnical aspects when planning underground mining activities
- The SSR has established the pattern of displacements near the toe of the slope which is attributed to the undercutting of weak rock units in the underground production areas.

Recommendation

- The analysis of slope stability due to block caving is a multifaceted process.
- Empirical methods offer insights into general slope behavior, while rock mass classification with MRMR provides specific stability and caving criteria for different rock types.
- It is recommended to apply all these approaches in order make informed decisions regarding slope stability and potential caving effects to ensure safe and efficient mining operations.

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The End

Thank you for attention