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Development of a Multi-Stage Large Excavation Crusher Chamber at Palabora Mining Company

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AfriRock Conference

Define tomorrow.

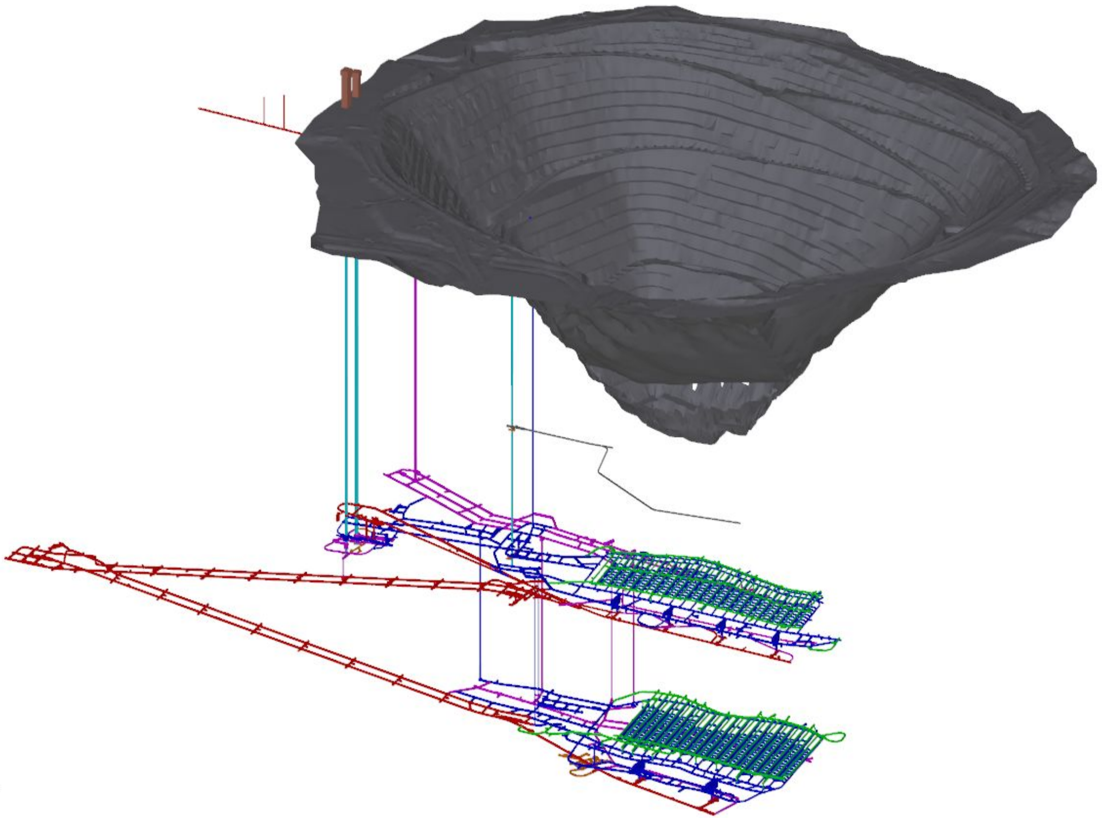
Table of Contents

Introduction

PILLARS OF MoU BETWEEN PMC & UNISA			
#	**Pillar Type**	**Pillar Description**	**Pillar Update**
1	Research and Development for Postgraduate Studies	Support and enable PMC employees to partake in industry-based research through MSc & PhD studies	10 Employees for MSc 1 Employee for PhD
2	Work Integrated Learning (WIL)	Assist UNISA students gain practical work experience	3 Mining Eng Students on-boarded in 2024 & for 2025 plan is 4 1 Mine Survey Student on-boarded in 2024
3	Short Learning Programs (SLP) at above NQF Level 4	Accelerate development of employees by elevating their knowledge and skills	3x SLP's 80% complete (Management Essentials, Mining & Mineral Processing)
4	Higher Certificate in Supervisory Development (NQF Level 5)	Enable Supervisors to properly lead, inspire and guide their teams	Programme may start in Jan 2028
5	Recognition of Prior Learning (RPL)	Provide opportunities for employees who have gained experience with no qualification to obtain formal qualification	16 employees admitted through RPL
6	**Collaboration in Research, Innovation, Commercialization and Technical Support**	**Drive business sustainability to build strong technical pipeline or internal pool of experts**	** 4 papers accepted in different journals** ** 1 JRP call between SA/China (through NRF)**
7	**Exchange of educators, learners, administrators and advisors to participate in conferences, symposia and seminars**	**Provide platform for professional development and networking**	**SAIMM LimpopoTech Event (2024 / 2025) - 3 / 2 PMC & 10/2 UNISA presentations respectively** **Digital Transformation in Mining Conf (2025) – 1 PMC & 1 UNISA presentations**

Introduction

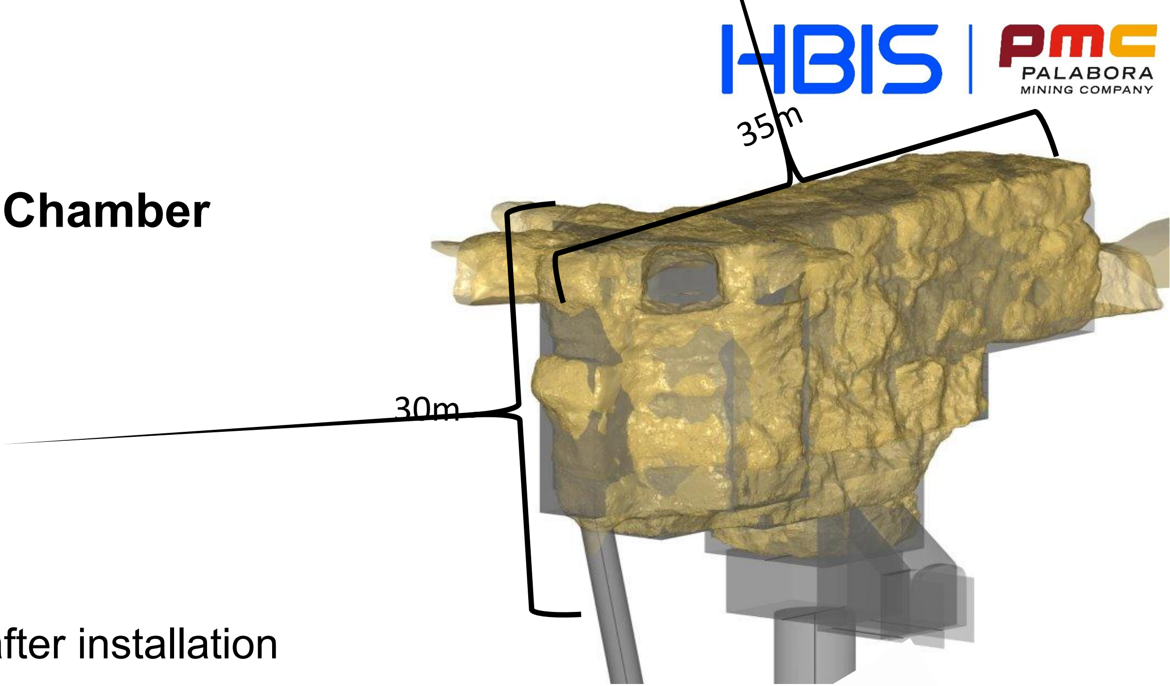
- Located in Phalaborwa, Limpopo Province
- Has been in operation since 1960
- **Twin** decline access system
- Recently replaced In-pit vent shaft
- **6** inter-Lifts Vent passes
- **40km** of Development
- **15.1** hectares of undercutting
- **434** drawpoints/**217** drawbells
- **2** large Jaw-Gyratory Crushers



Introduction

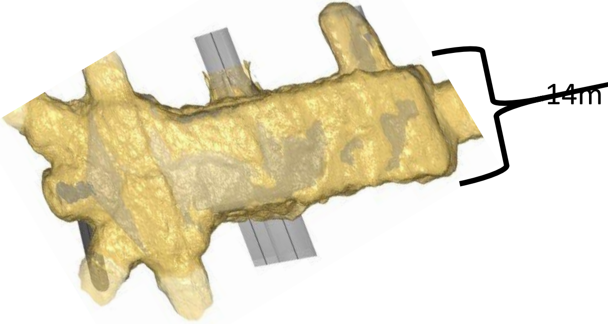
Quick facts about the Crusher Chamber

- 45m High (15 Stories)
- 14m Wide
- 35m Long
- 55kt of Material moved
- 2000tph Capacity of the crusher after installation



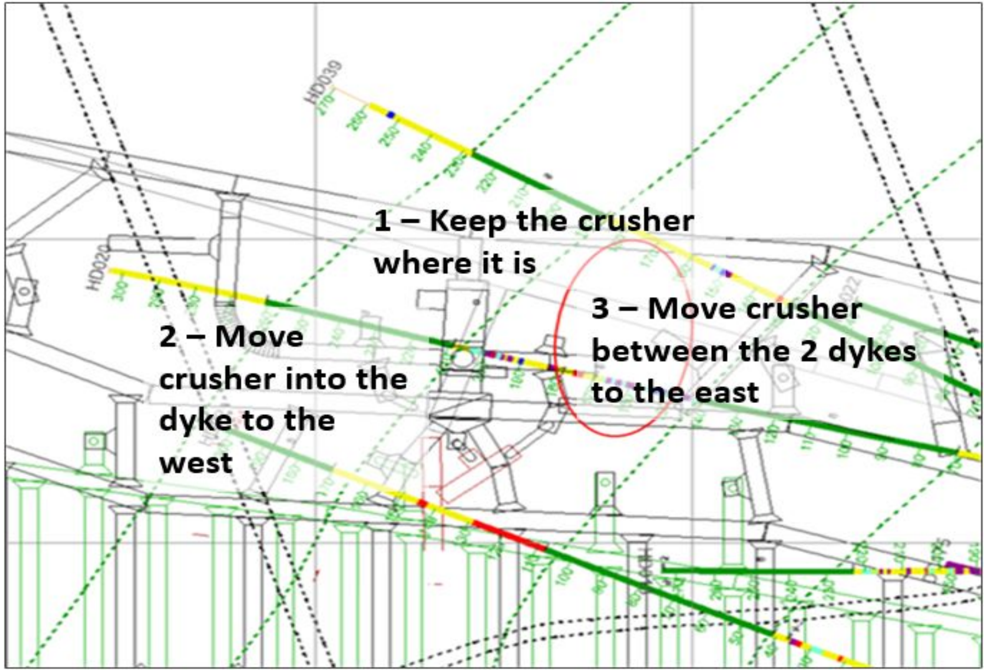
PURPOSE:

This work provides valuable insights into the planning, excavation, and ground control of large underground chambers. This is to serve as a replicable framework for similar large excavations, especially in South Africa, where such developments are rare.



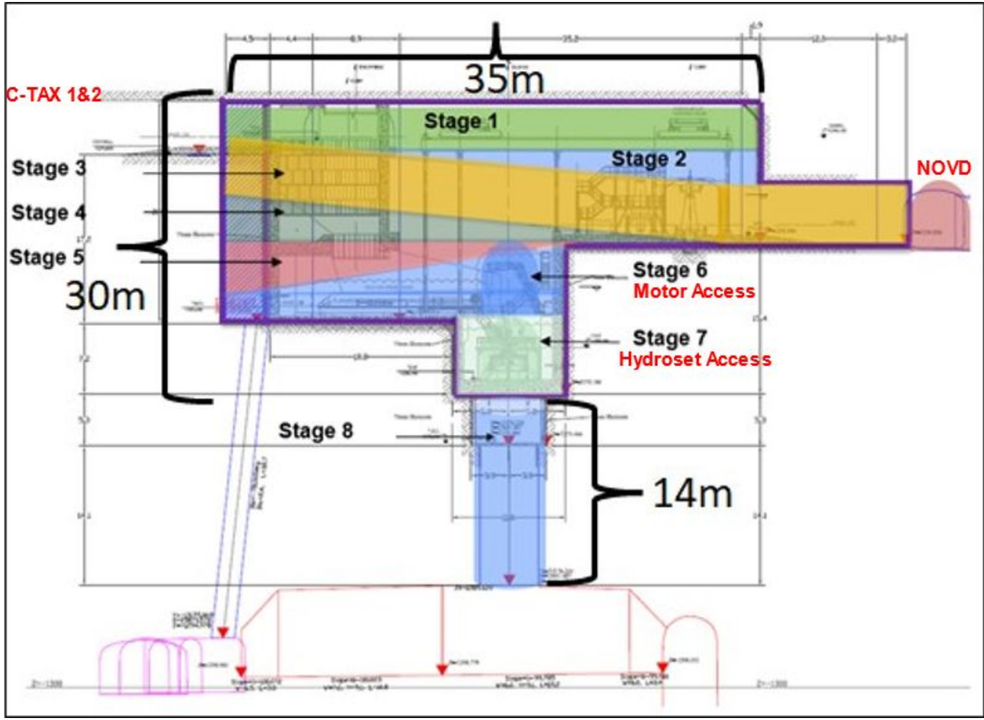
Mining Approach and Sequence

- Positioning of the excavation:
  - Exploration holes for the Lift II cave were drilled from Lift I, ensuring complete coverage of the Lift II footprint.
  - The original mine design positioned the chamber within a *Dolerite Dyke* and *Foskorite* contact – **1**
  - Earlier mining experience suggested that *Dolerite Dyke* contacts might function as weak planes, increasing the risk of seismic activity and displacement.
  - Numerical modelling identified a secure location for the crusher chamber, ensuring it remains clear of abutment stress effects



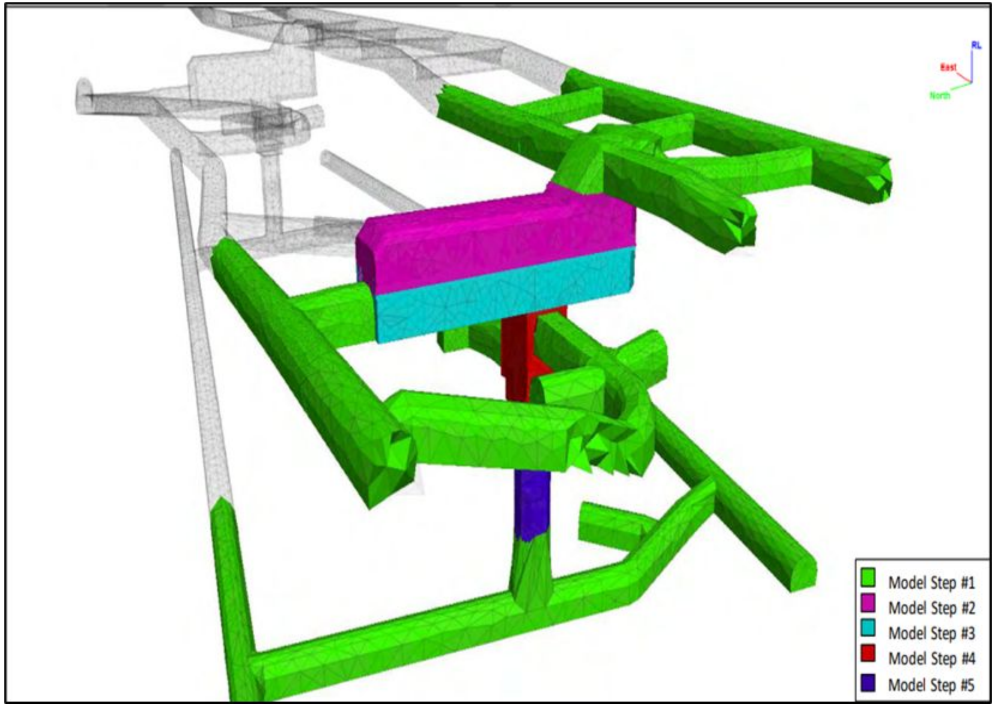
Mining Approach and Sequence

- Excavation sequence:
  - The excavation of the crusher chamber was performed in a top-down sequence to minimise unsupported spans and ensure ground stability.
  - The excavation process was divided into multiple stages to allow for systematic support installation and reduce the risk of ground instability during mining.
  - The final stage involved the excavation of the Crusher silo using drop-raising techniques, creating a 6m diameter and 14m long silo.



Numerical Modelling – Mining Sequence

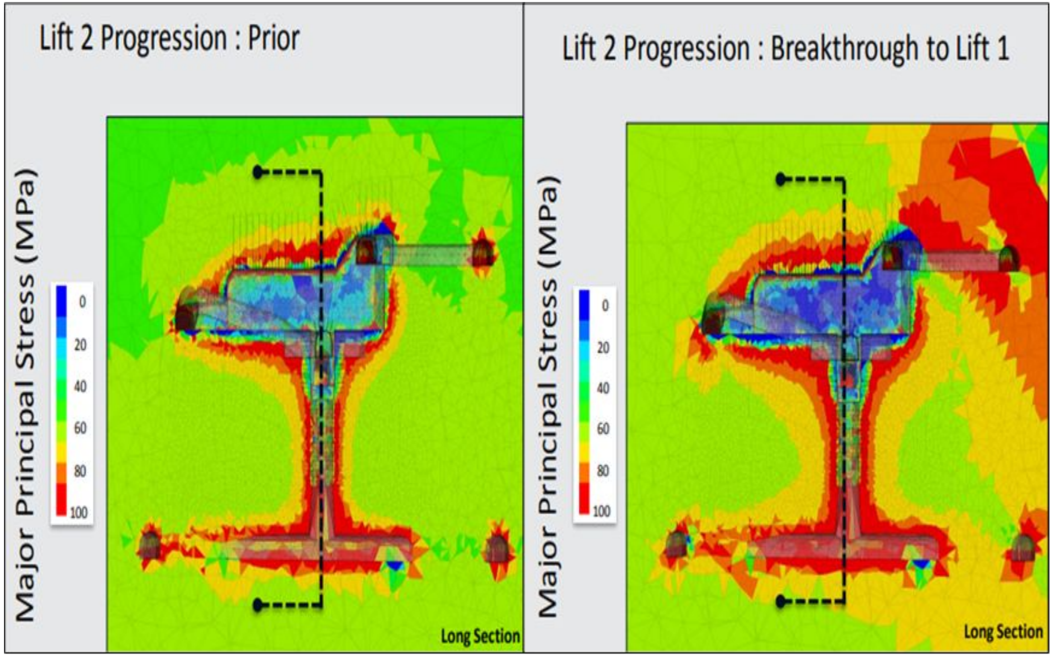
- Excavation sequence:
  - The sequence for excavating the crusher chamber was included in the numerical model.
  - As each bench of the crusher chamber is excavated, ground support was installed in a consecutive manner
  - After the crusher chamber was finished, the propagation of Lift II cave was also simulated progressively in several stages.



Numerical Modelling - Stress

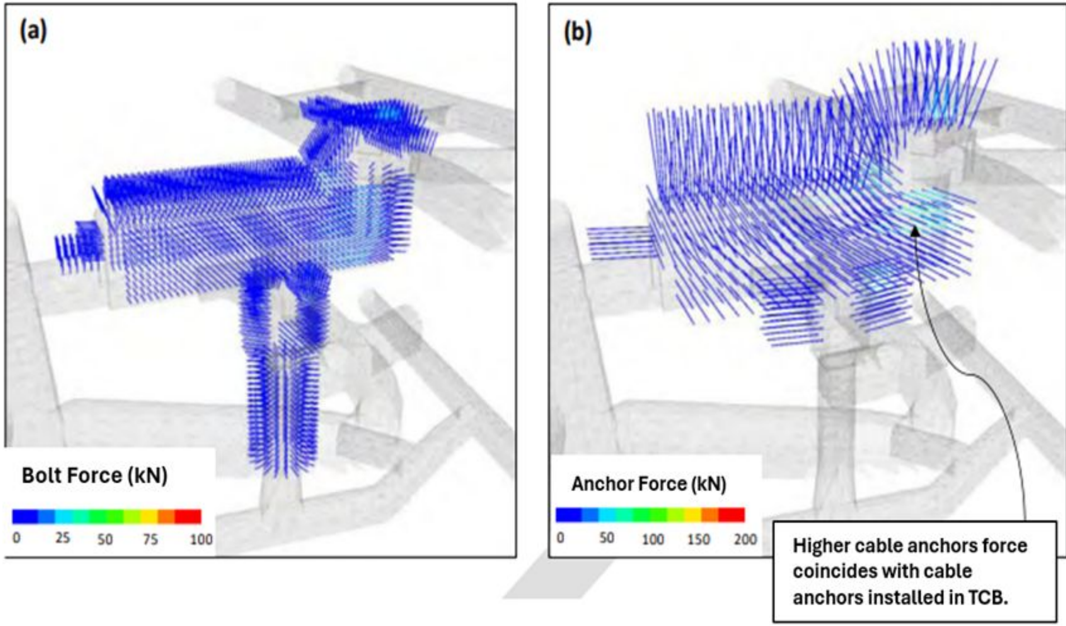
 Stresses around excavation:

- Key parameter used when modelling was the stress changes in the chamber during three key stages: ***before undercutting***, ***during the undercutting*** phase, and at ***the initiation*** of cave formation.
- Progression of maximum principal stress and rock mass damage around the crusher chamber, both before and after cave propagation.
- Areas beyond the immediate vicinity of the excavation exhibited high magnitudes of maximum principal stress, ranging between 80 and 90 MPa.
- The depth of yielding in the sidewalls was estimated to range from 2.5 to 3.0 meters.



Numerical Modelling - Support

- Ground support performance:
  - As cave propagation progressed, the force exerted by the solid rebar roof bolts did not exceed 30 kN, and the force from the twin-strand cable anchors did not exceed 90 kN.
  - The yield capacities for the solid rebar roof bolts and twin-strand cable anchors were 210 kN and 400 kN, respectively.



Recommendations

Feature	Span	Cable Anchor Spacing	Cable Anchor Length	Support Spacing	Bolt Length	Welded Mesh	Shotcrete Type & Thickness
Crusher Chamber	14.0 m	2.0 m	12.0 m	1.4 m	2.4 m	2.0 m x 4.0 m x 5.6 mm	FRS 50 -150 mm

The support system recommended for the Lift I crushers, and adapted for Lift II, included:

- 100 mm of fiber-reinforced shotcrete (Fibre-crete) with 45 MPa strength.
- 2.4 m long 20 mm resin rebar bolts installed at 1 m spacing in the roof and sidewalls.
- 12 m long cable anchors in the sidewalls at 2 m spacing.

Challenges

- Ground conditions:
  - Over-breaking and under-breaking due to unexpected joints were exposed.
  - Over-breaking and under-breaking related incorrect charging up practices.
  - Manual installation of the 12m long cable anchors.
  - Mining layout deviations related to marking and drilling.
  - Equipment(TMM) breakdowns due to age.

Conclusion

- Comprehensive planning is vital and includes careful choice of equipment, careful design of support systems, and extensive geological study.
- Mining sequence to be defined clearly to the execution team.
- The stability of the chamber and the safety of the workers, particularly when the crusher is in operation, depend on strong support systems like shotcrete, cable bolts, and roof bolts.
- Regular inspections and stringent quality control measures during excavation are necessary to maintain operational standards and resolve challenges quickly.
- Timely decision-making and smooth operations depend on effective communication and collaboration among all disciplines involved.
- Installation of monitoring systems to detect ground movement and deformation.

Pictures

Acknowledgements

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Thank You