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Utilisation of drone technology to monitor blasting performance for the undercutting of Lift 2 block cave at Palabora Mining Company

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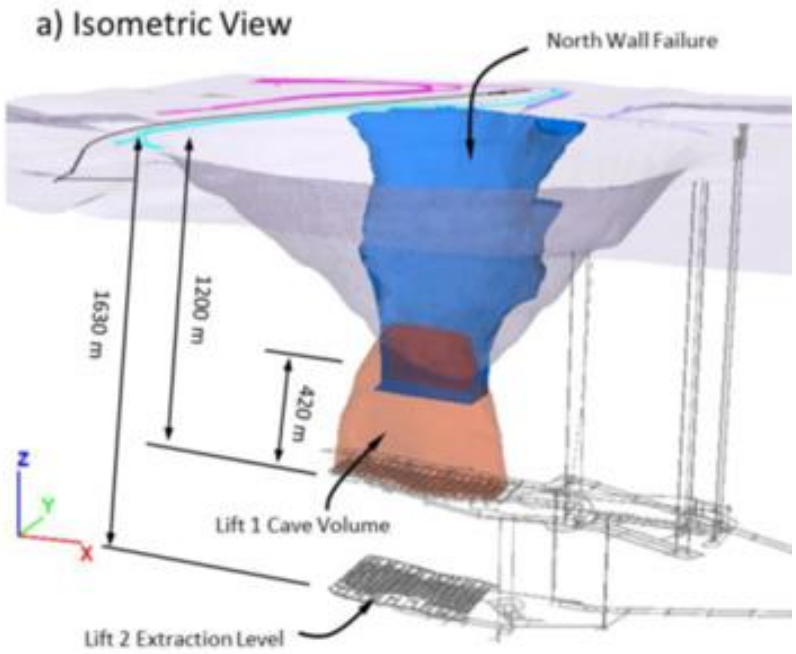
4TH DIGITAL TRANSFORMATIONIN MINING CONFERENCE

Define tomorrow.

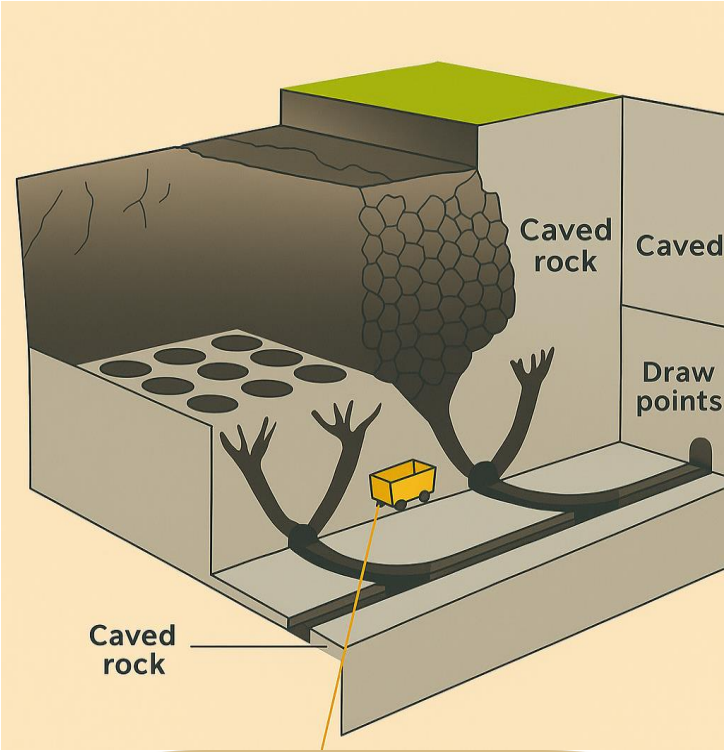
Introduction Palabora Mine (PMC)

- Located in Limpopo, South Africa
- Carbonatite-hosted copper deposit of global significance
- Transition to block caving (2002) from open-pit operation.
- Lift 1: 20 years of production, now depleted.
- Lift 2: Operating at 1400 m depth under high-stress conditions.
- Host rocks: Phoscorite, carbonatite, intersected by dolerite dykes.



Block Caving: Method Overview and Undercut Importance

- High-tonnage, gravity-driven underground mining method
- Cave initiated by blasting a horizontal undercut slot
- Undercutting controls cave shape and ore flow
- Requires precise blasting to avoid overbreak, underbreak, and pillars
- Poor blasting leads to dilution, blockages, and instability



Undercut Blasting Challenges at Lift 2 PMC

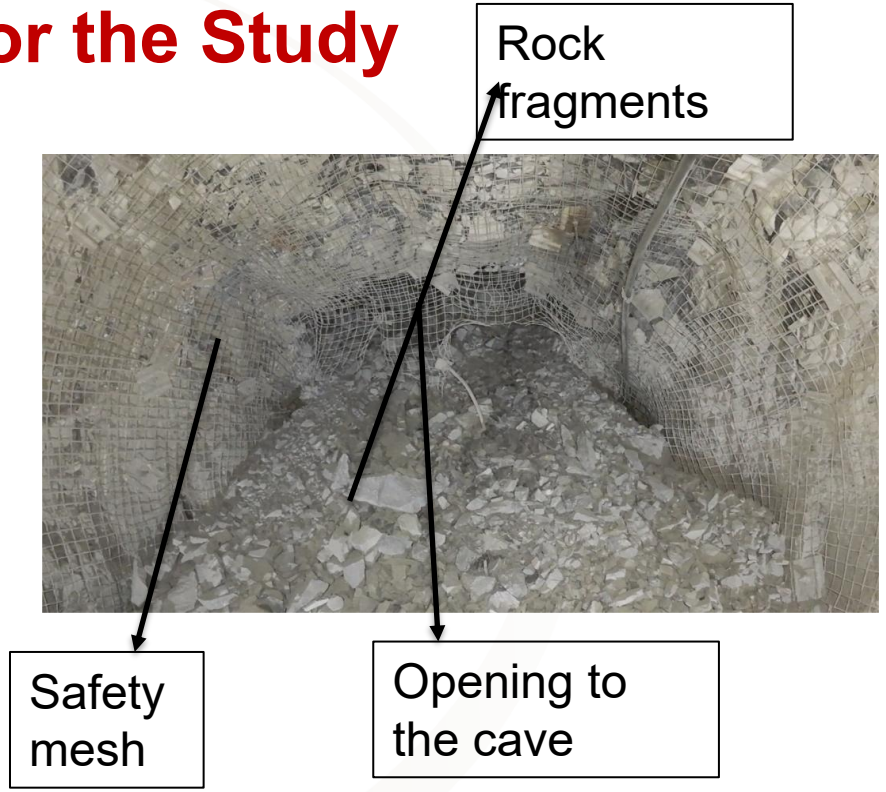
- Undercut height at Lift 2: 4.8 m
- **Overbreak**: Excessive charge leads to instability and dilution
- **Underbreak**: Insufficient energy leaves unfragmented rock
- **Pillar formation**: Unblasted zones block ore flow and cave growth
- Poor fragmentation increases risk of draw point hang-ups
- Quick, precise post-blast scanning is essential for feedback

Research Aim

- Evaluate the effectiveness of the Elios 3 drone for monitoring blasting performance during undercutting
- Compare drone-based scans to traditional CMS scans at Palabora Lift 2
- Assess ability to detect:
  - Overbreak
  - Underbreak
  - Pillar formation
  - Analyse operational efficiency and safety improvements

Motivation for the Study

- Accurate undercut blasting is essential for block cave success
- CMS Scanner to monitor the undercutting
- CMS at Palabora has key limitations:
  - Limited visibility
  - Close-range operation exposes personnel to risk
  - Clear 50% of the fragments
- Need for faster, safer, and more accurate monitoring



Elios 3 Drone vs CMS Scanner for Blast Monitoring

Elios 3 Drone

- Designed for confined, GPS-denied environments
- Equipped with LiDAR, 4K camera, and thermal imaging
- 180° camera tilt and collision-tolerant cage
- Hover time: 9–12.5 minutes
- Operated remotely (15–50 m from cavity)
- Minimal setup, quick deployment
- Captures high-resolution 3D point clouds

CMS Scanner (Geosight NX-150)

- Static LiDAR using time-of-flight technology
- Mounted on a boom, operated ~15 m from cavity
- Limited field of view; prone to shadowing
- Requires cleared drawpoints for access
- Operator exposed to hazardous zones
- Lower scan density and less coverage

Data Acquisition Using Elios 3 Drone

- Conducted 3 post-blast flights, each lasting ~6 minutes
- Reference discs used for geo-referencing scans
- Acquired LiDAR point clouds, thermal images, and visual data
- Captured full 3D cavity geometry within ~20 minutes
- No need to access or clear draw points during scanning
- All flights were conducted remotely from safe zones

Data Acquisition Using CMC Scan

- CMS scans performed post-blast at multiple cavities
- Scanner mounted on a boom, operated from ~15 m away
- Draw point access required for setup and debris clearing
- Each scan took approximately 40 minutes, including setup
- Operator remained nearby during scans for equipment control

Geo-Referencing and Quality Assurance

Control Setup

- Control points established using total station or reference discs
- Both CMS and drone scans aligned to mine grid (UTM → mine coordinates)

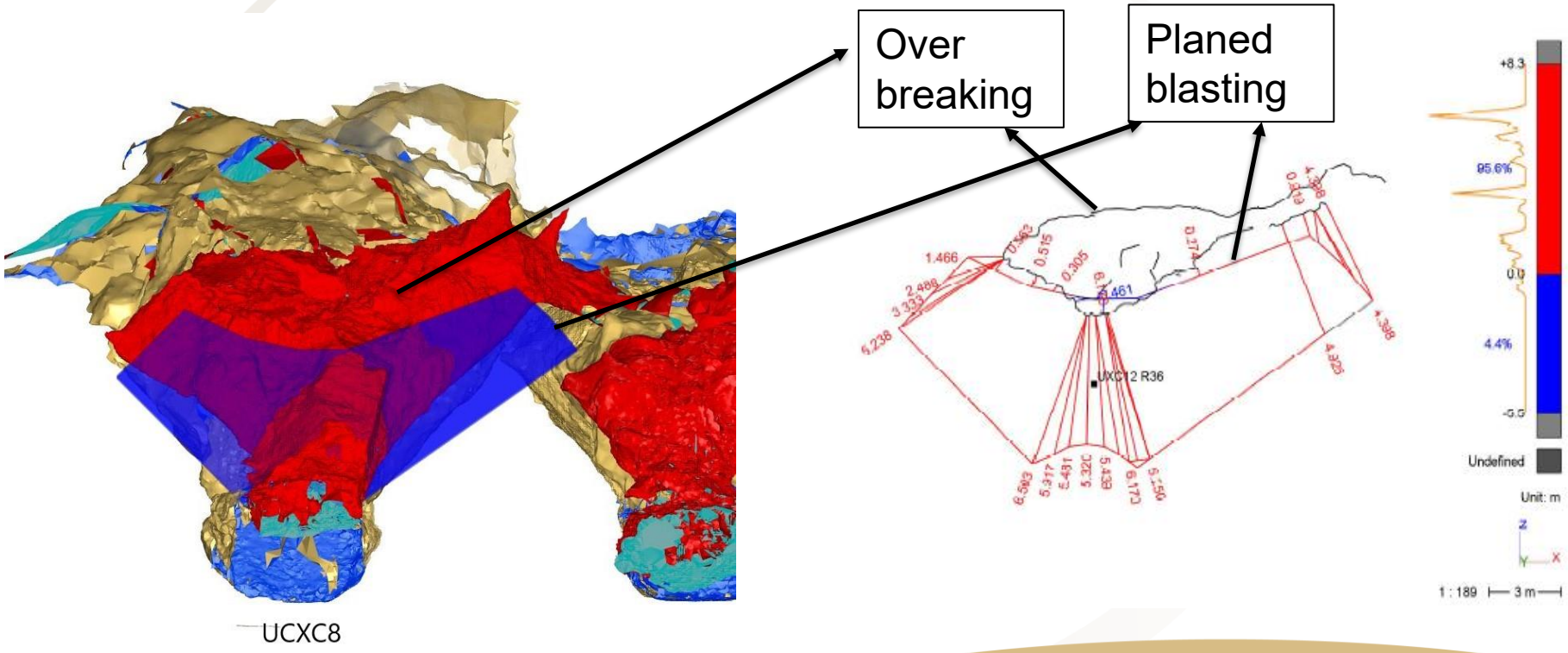
Software Used

- FARO Connect and Leica Cyclone 3DR for point cloud registration

Validation Steps

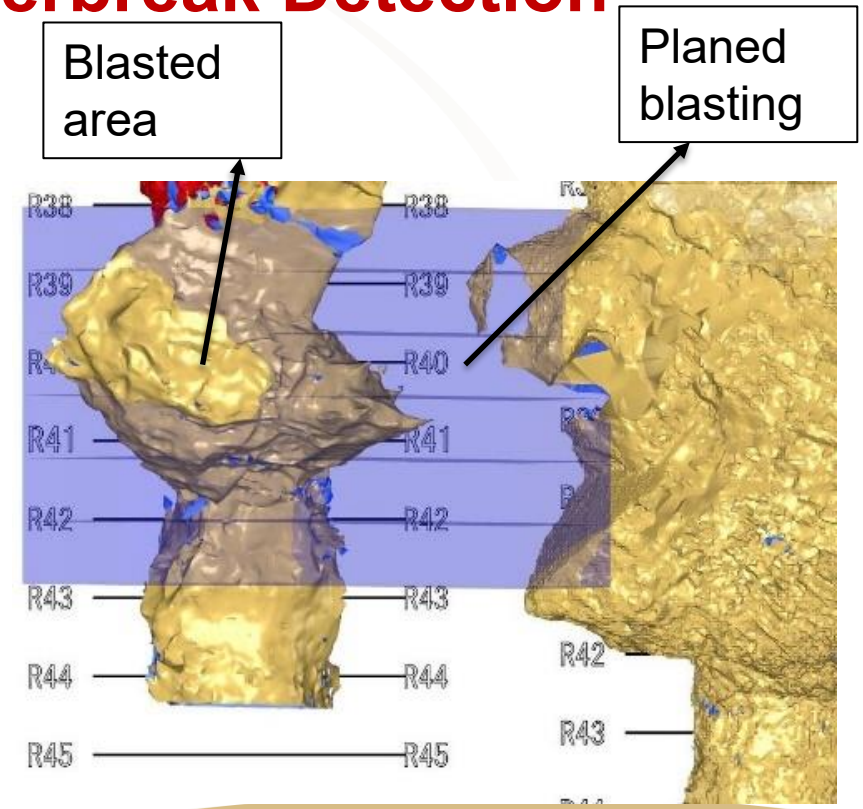
- Corrected alignment errors
- Minimized spatial deviations
- Verified against planned undercut geometry

Drone-Based Overbreak Detection



Drone-Based underbreak Detection

- Significant underbreak between R39 and R43
- Indicates poor energy distribution or spacing issues
- Impacts:
  - Creates intact rock blocks
  - Leads to ore hang-ups and reduced cave growth
  - Requires secondary blasting → increased cost and delay



Pillar Formation – Drone Detection

Highlights large intact zones post-blast

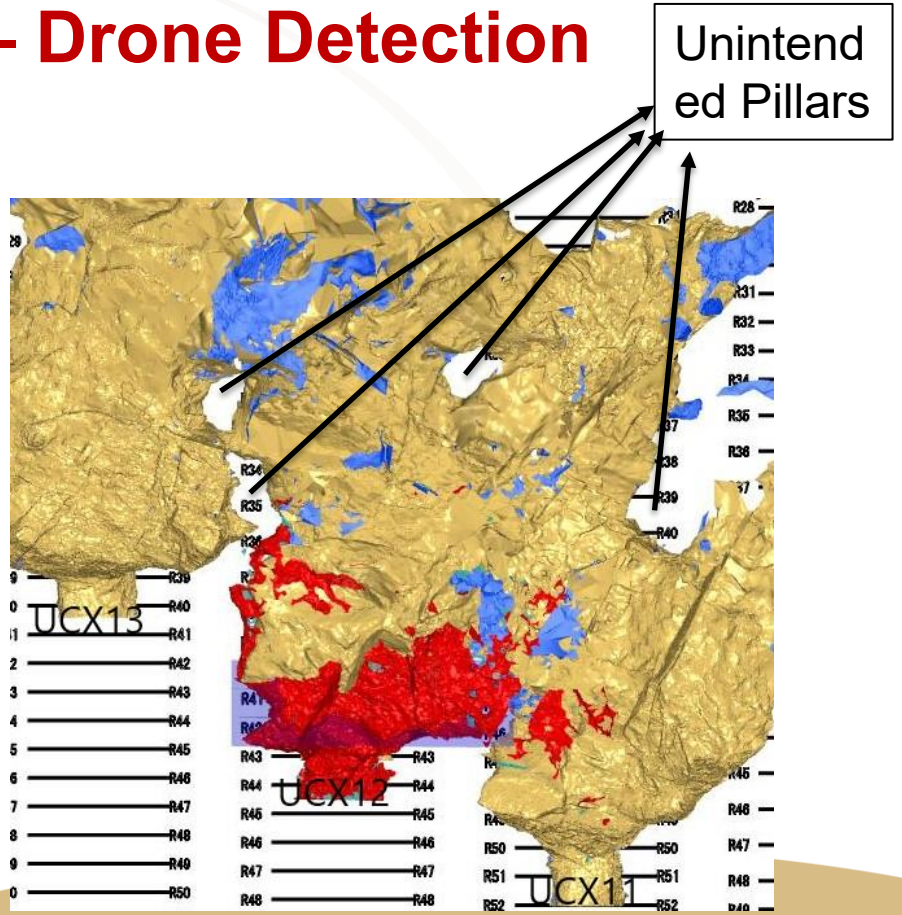
- Unintended pillars detected near R31, R32, R35, and below UCX11

Causes:

- Insufficient charge energy
- Design flaws or poor blast execution

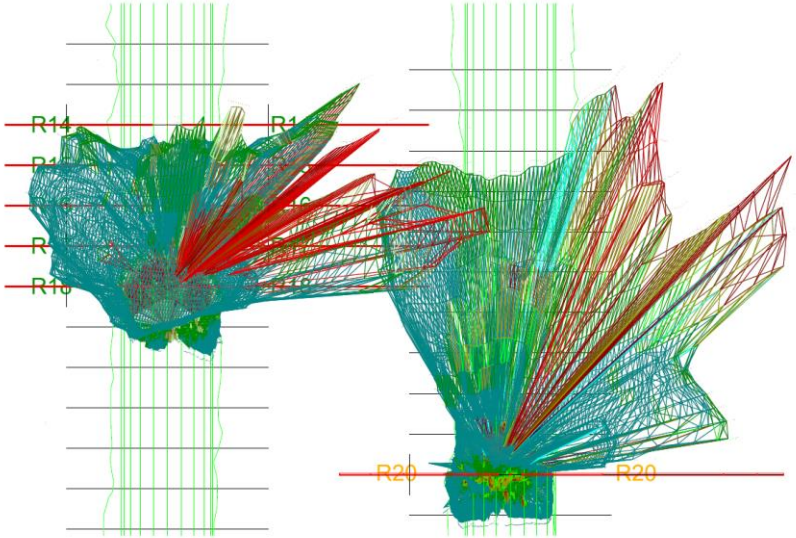
Consequences:

- Blocked ore flow
- Stress build-up and increased seismic risk

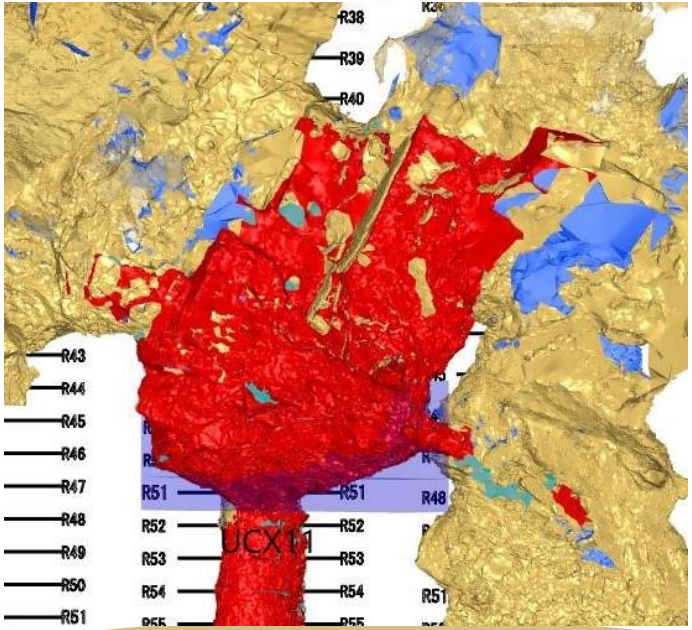


Scans Comparison

CMS Scans



Drone Scan



Comparison of Safety and Operational Efficiency

Aspect	Elios 3 Drone	CMS (NX-150 Scanner)
Operator Distance	15–50 m (remote control)	~15 m (near cavity)
Drawpoint Access	Not required	Must be cleared >50%
Setup Time	Minimal (ready in minutes)	~40 minutes per scan setup
Scan Duration	< 15 minutes (3 flights × 6 min)	≥ 40 minutes include setup
Mobility	High – can fly through confined areas	Static – limited by boom reach
Shadowing	Low – drone navigates blind spots	High – limited line of sight
Training Needed	Basic drone pilot + site safety protocols	Specialised CMS scanner training
Operator Exposure	Low – minimal time in hazard zone	High – prolonged proximity to void

Conclusion, Limitations and Recommendations

Conclusion

- Elios 3 drone successfully monitored undercut blast performance in Lift 2

Limitations

- Battery life limits continuous flight duration (9–12.5 minutes) LiDAR calibration required before each deployment
- Post-blast dust may reduce visibility and data clarity
- Limited performance in areas with severe air turbulence or narrow voids
- Requires skilled visual interpretation during data analysis

Recommendations

- Use Elios 3 for routine post-blast scans in undercut areas
- Reserve CMS for inaccessible or structurally complex zones

Acknowledgements

- Palabora Mining Company (PMC)
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Thank You