The use of Varistem® Stemming Plugs, Machine Learning and Artificial Intelligence, to optimise blasting and reduce environmental impacts

Presenter: Ruan Els

Event: Explosives and Blasting Workshop
Birchwood Hotel and OR Tambo Conference Centre

30 July 2025

Agenda

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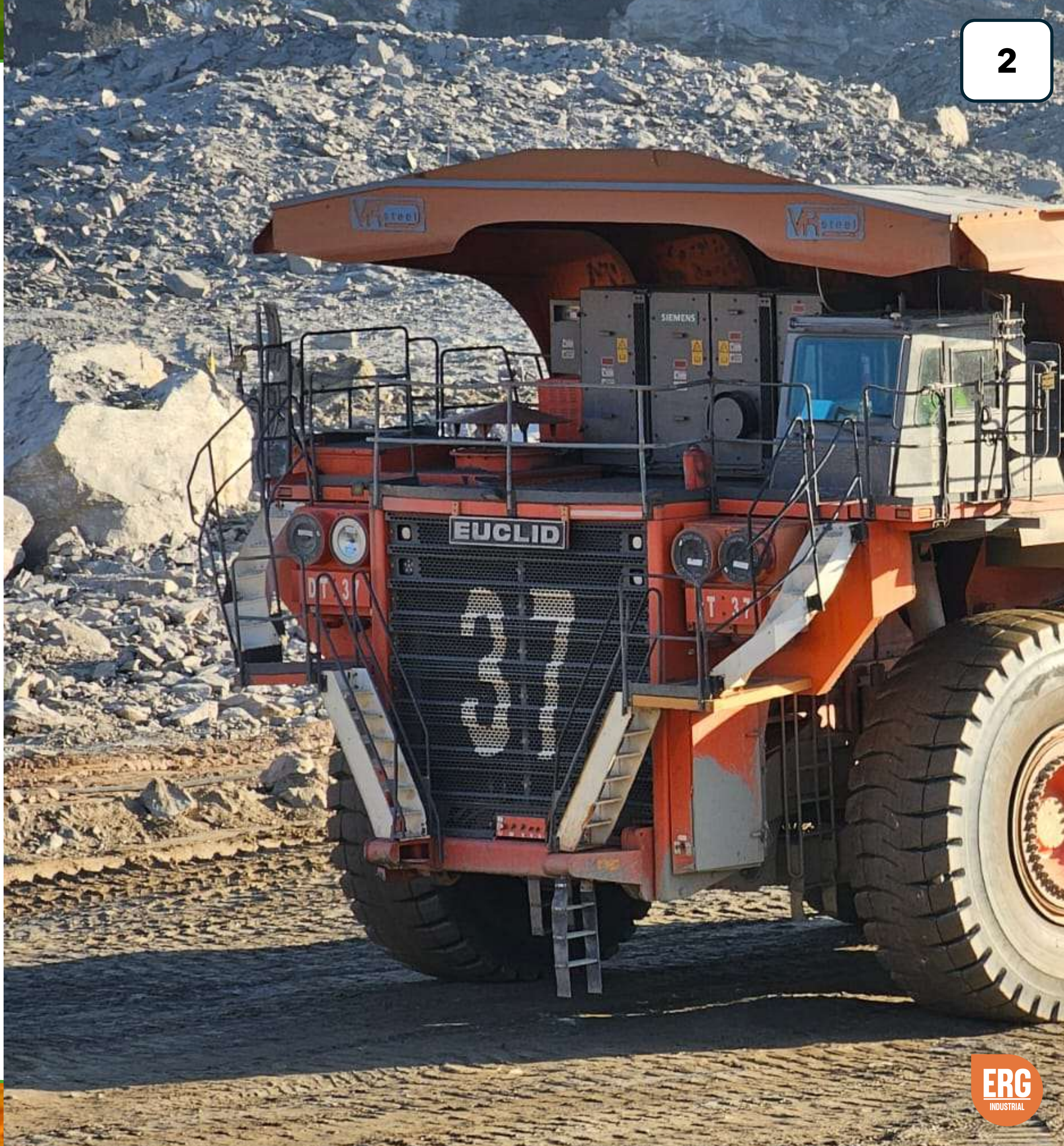
   i. Who is Ruan Els?
   ii. Who is ERG Industrial?
2. Background to Research Study
3. SA Case Studies
4. UK Case Studies
5. Research Findings
6. Conclusions



Introduction – Who is Ruan Els?

- Currently enrolled to complete a Masters in Mining Engineering by 2025

(University of Pretoria, South Africa)

- Worked as an academic instructor and researcher at the University of Pretoria (4 Years).
- Worked as an independent consultant: drill and blast training and consulting, feasibility studies, optimisation studies and rock engineering (2 Years).

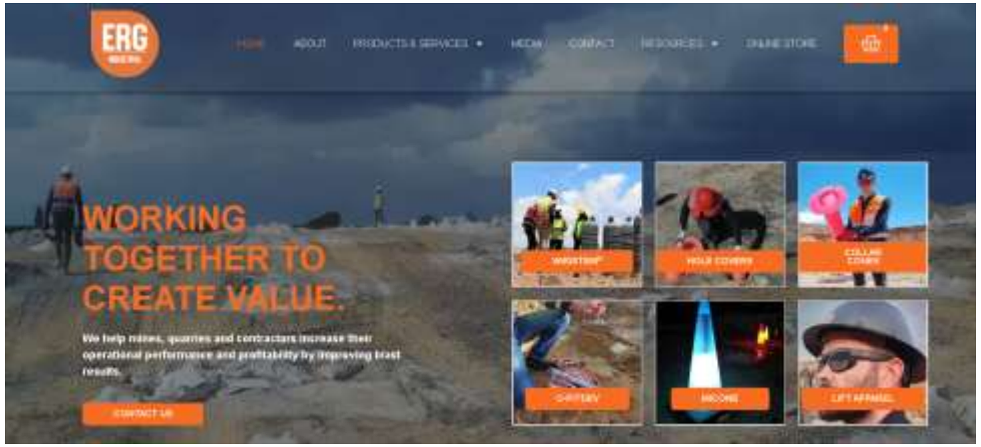
(Private Consulting)

- Joined ERG Industrial in June 2023 and gained invaluable in-field experience in drill and blast optimisation, using advanced stemming solutions.

Introduction – Who is ERG Industrial?

ERG Industrial is a global goods and services provider to the mining, quarrying, civil and construction industries. With head offices in Johannesburg and Dublin; manufacturing and warehousing in USA, South Africa, UK, Taiwan & Australia; we currently serve a customer base spanning across 58 x countries globally.

Our products portfolio comprises of six main product lines, all focused on producing value within the drill & blast and safety domains.



Our engineering consulting services are predominantly aimed at creating sustainable value within the drill and blast domain.

Background on Research Study

Partnership to advance research into technology applications in the mining, quarrying and civil industries with the objective of creating exceptional value and reduced environmental impact.

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GEARS
GROUND ENGINEERING APPLIED RESEARCH SERVICES

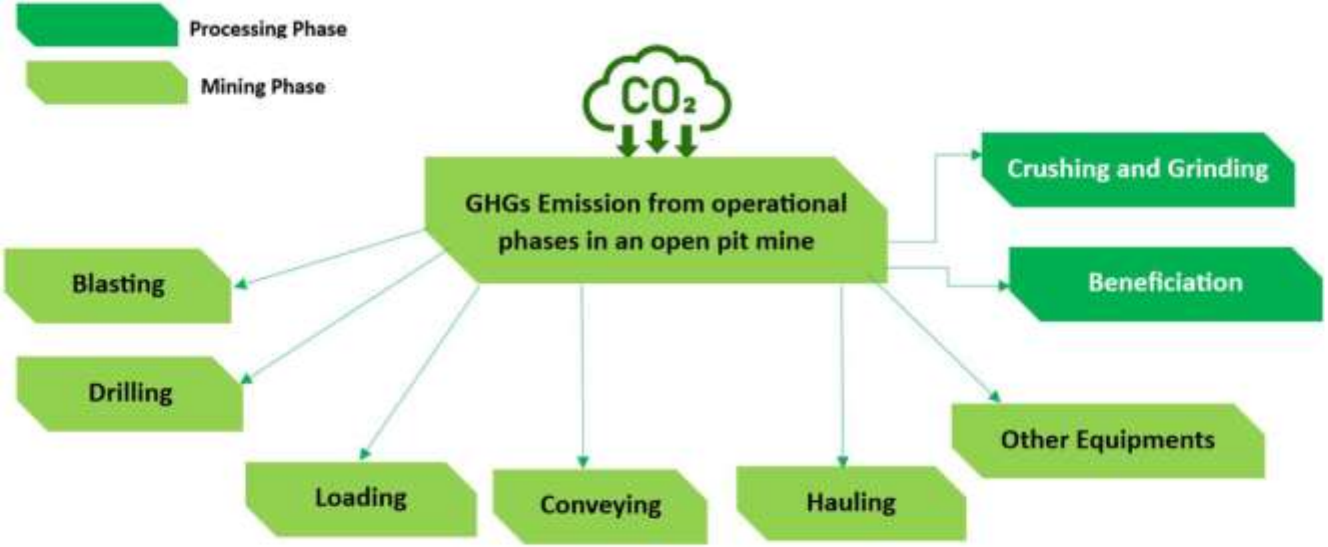
Background on Research Study

Case studies were conducted on mines and quarries in both South Africa and the United Kingdom with the key research objectives being:

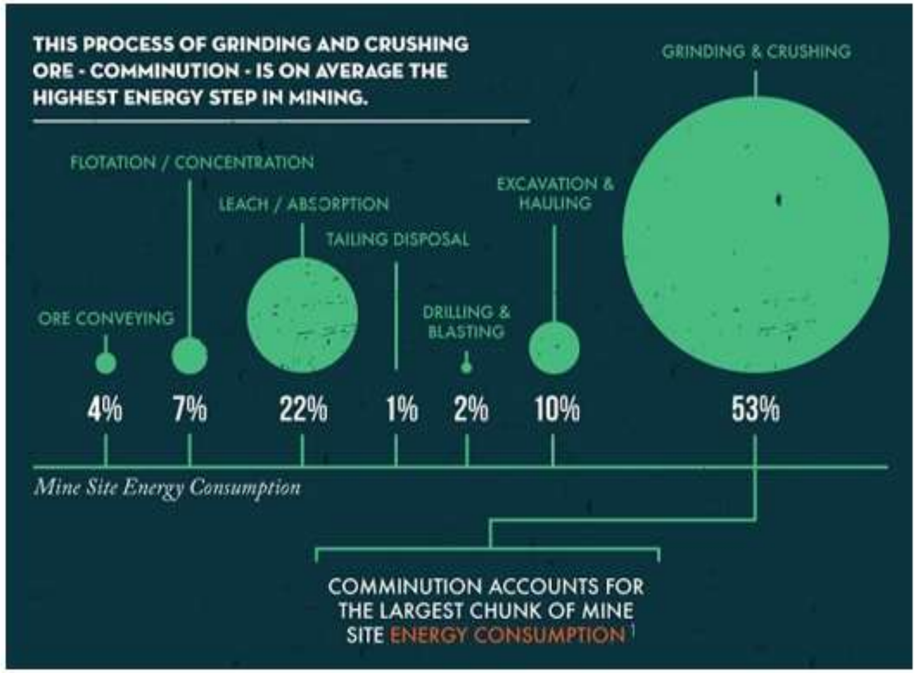
- Investigate the impact of using Varistem® Stemming Plugs on blast outcomes and environmental impact
- Investigate the financial impact of using Varistem® Stemming Plugs
- Investigate the potential for the use of ML and AL to capture and process data to track impact of blasting activities

Background on Research Study

MINE TO MILL CONCEPT (M2M)



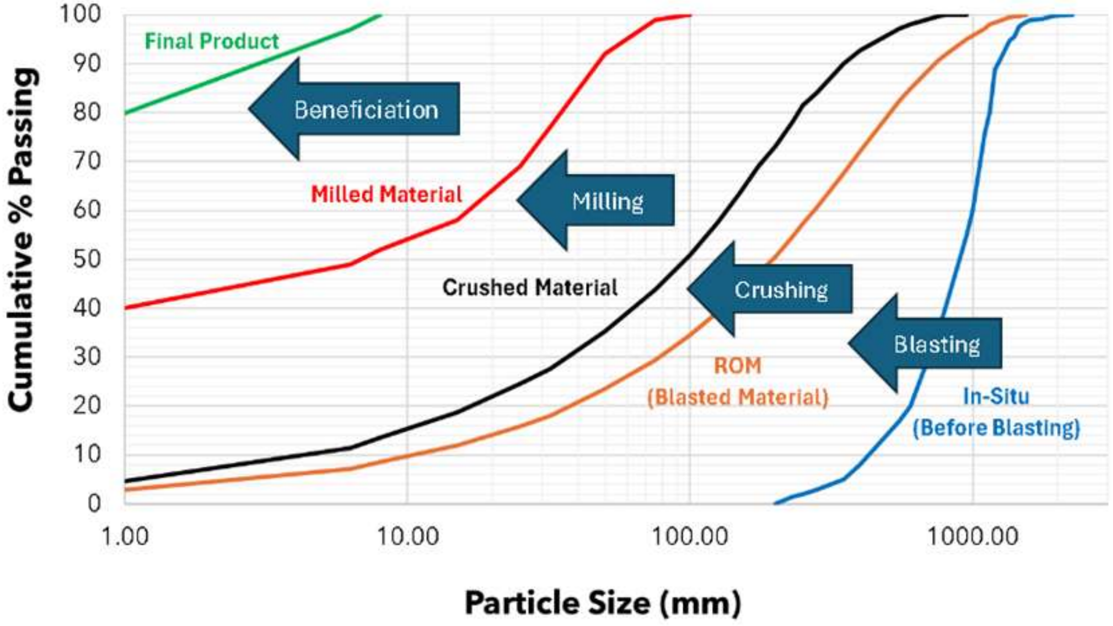
(Onifade, et al., 2024)

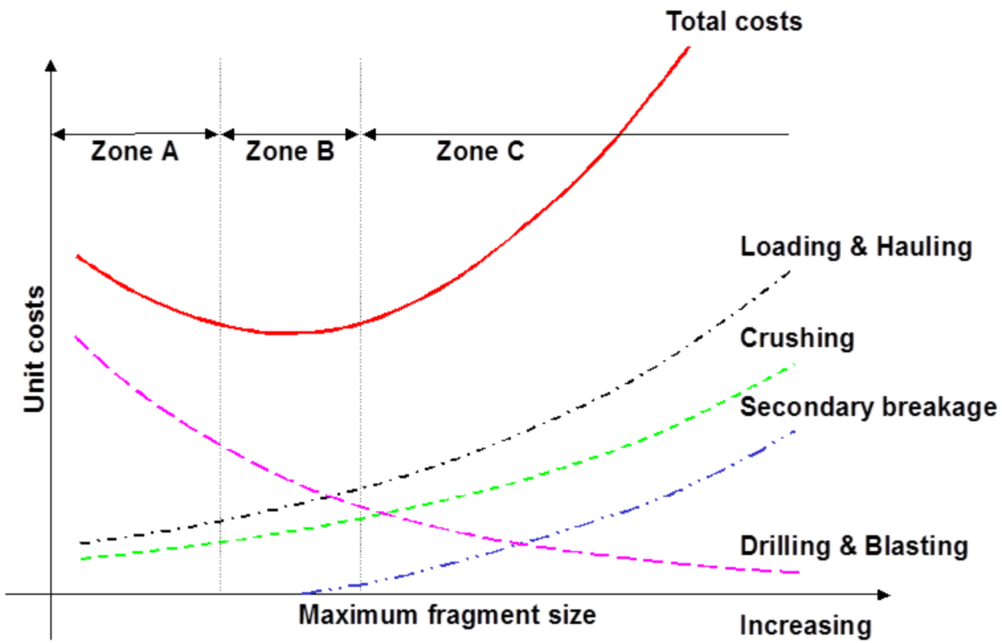


(CEEC, 2015)

Background on Research Study

MINE TO MILL CONCEPT (M2M)

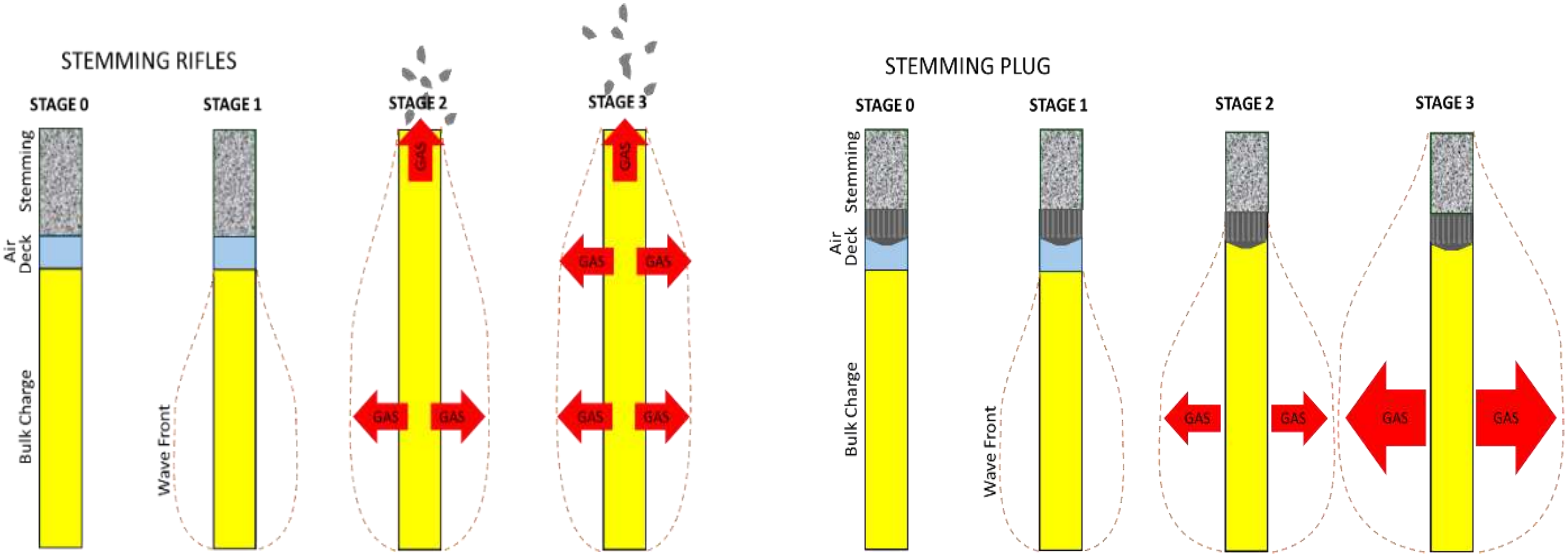




(After University of Pretoria, 2020)

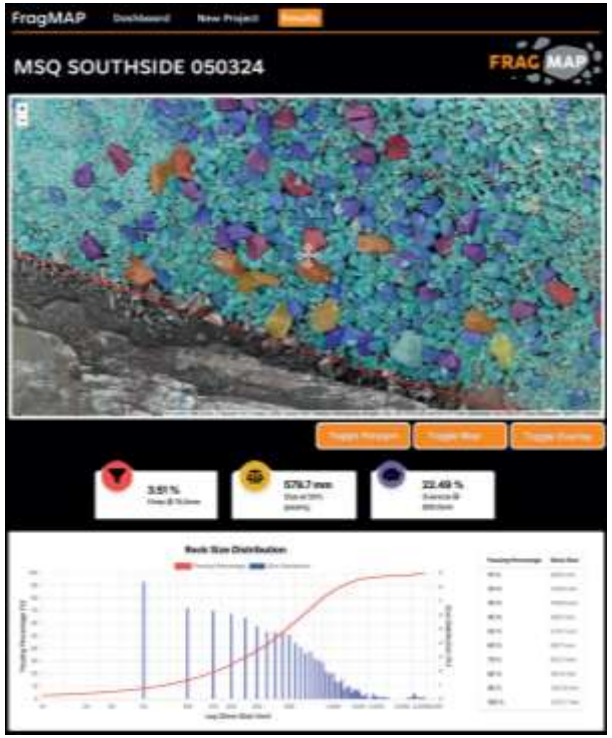
Background on Research Study

MINE TO MILL CONCEPT (M2M) – Varistem Stemming Plugs



Background on Research Study

MINE TO MILL CONCEPT (M2M) – Machine Learning & Artificial Intelligance



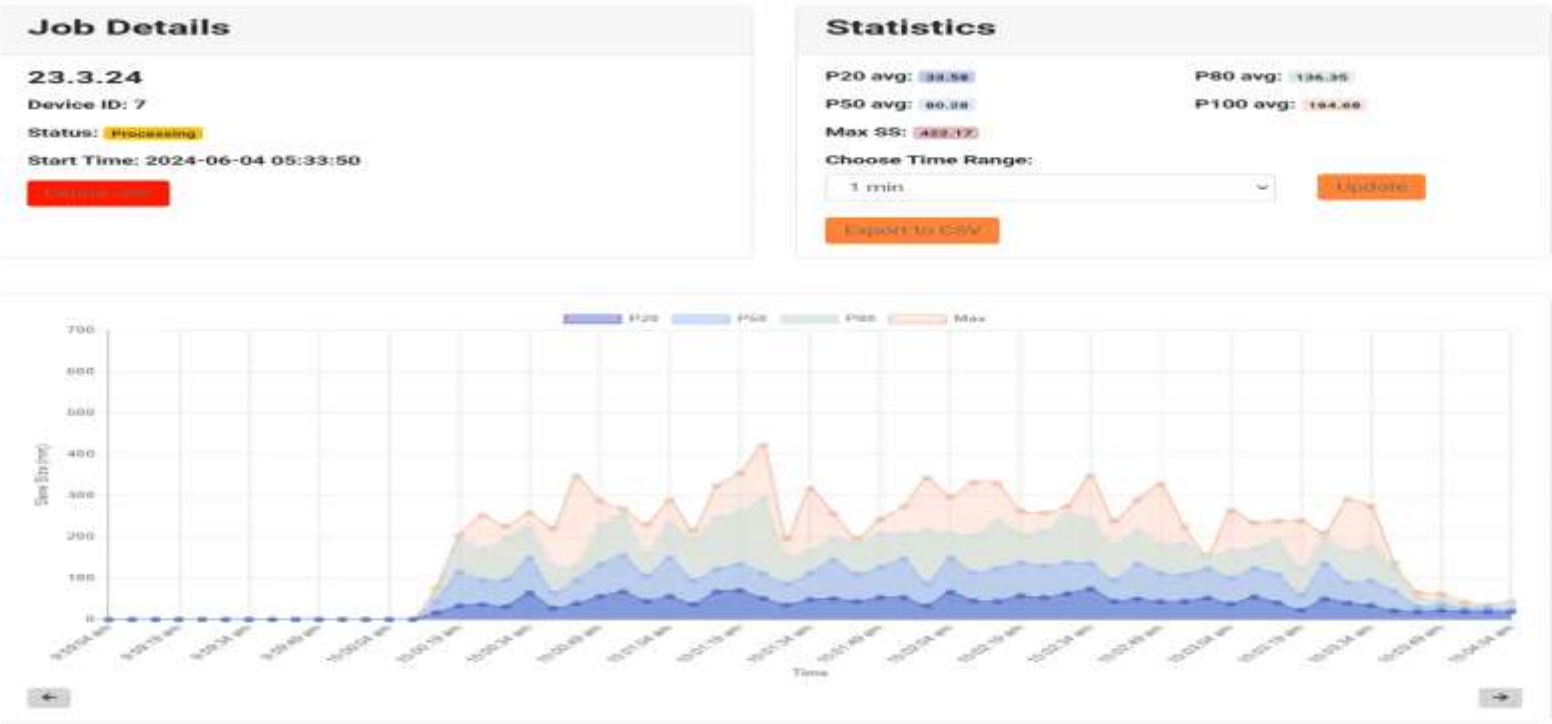
- The Internet of Things (IOT) market has the potential to add $14 trillion US dollar to the global economy by 2030 (World Economic Forum, 2018)

- Largest trend is researchers identifying ways to use AI and ML to not only conduct repetitive tasks, quicker and faster, but to interpret complex datasets and make predictions using behavioural trends identified.

- Example of the study conducted at Mountsorrel Quarry in the UK where GEARS, in collaboration with New Gradient and Tarmac, won the IQ Emerald Challenge Award for their work in monitoring the impact of CO2 due to poor blasting quality.

Background on Research Study

MINE TO MILL CONCEPT (M2M) – Machine Learning & Artificial Intelligance



GEARS GROUND ENGINEERING APPLIED RESEARCH SERVICES · BLAST FRAG · BLAST WAVE · FRAG MAP · AGG CAM · M2M MINE TO MILL

Background on Research Study

- **Blast induced impacts reviewed in case studies:**
  - Noise (dB)
  - Airblast Overpressure (kPa)
  - Flyrock
  - Fragmentation (PSD)
  - CO2 footprint

- **Technology reviewed in case studies:**
  - Varistem® Stemming Plugs
  - Software and equipment enabled with ML and AL to collect and interpret complex data

SA CASE STUDY 1: Quarry

- **Problem:** Surrounded by communities and sensitive structures were struggling to blast within the SA legal noise limit for blasting (>134dB).

- **Objective:** Investigate if Varistem stemming plugs could reduce the airblast and noise readings to within acceptable limits. Two monitoring stations were placed at 250m (station A) and 290m (station B) away from the blast. The vibration and noise readings were monitored with the airblast pressure converted from the measured data.

- **Methodology:** Monitoring of blasts using 2 monitoring stations, one at 250m (station A) and the other at 290m (station B) away from the blast.

SA CASE STUDY 1: Quarry

Hole Diameter: 102mm
Bench Height: 10m
Burden: 2.4
Spacing: 2.6
Stemming Type: Aggregate stemming material and Varistem Stemming Plugs

SA CASE STUDY 1: Quarry

- **Results:** The vibration and noise readings were monitored with the airblast pressure converted from the measured data:
  - ✓ a **noise reduction of 7%-10%** was measured
  - ✓ **60-77% reduction in airblast overpressure** was calculated from the measured data
  - ✓ The vibration data was close to historic data and still within acceptable legal limits for most types of structures (>12.5mm/s).

- After the writing of this IOM3 paper, additional trials reinforced these findings as similar impacts on noise and airblast overpressure was noted at:
  - ✓ **A Coal Mine in South Africa:** Average noise reduction of 6.6% and reduced airblast overpressure of 63%. (Based on a total of 21 Varistem blasts out of 65 blasts reviewed)
  - ✓ **A Platinum Mine in South Africa:** Reduction in max noise reading of 14.3%, relating to an overpressure reduction of 89.9% in airblast overpressure. (Based on a 3-month Varistem trial in a 10-month review window)

More details available on the ERG Industrial Website: www.ergindustrial.com

SA CASE STUDY 2: Coal Mine

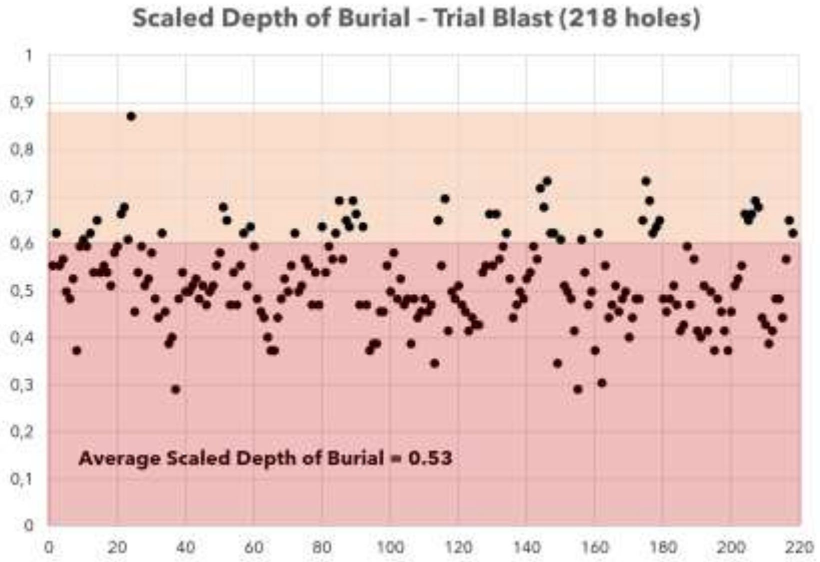
- **Problem:** Surrounded by communities and sensitive structures and had challenges with flyrock going beyond the mining boundary.

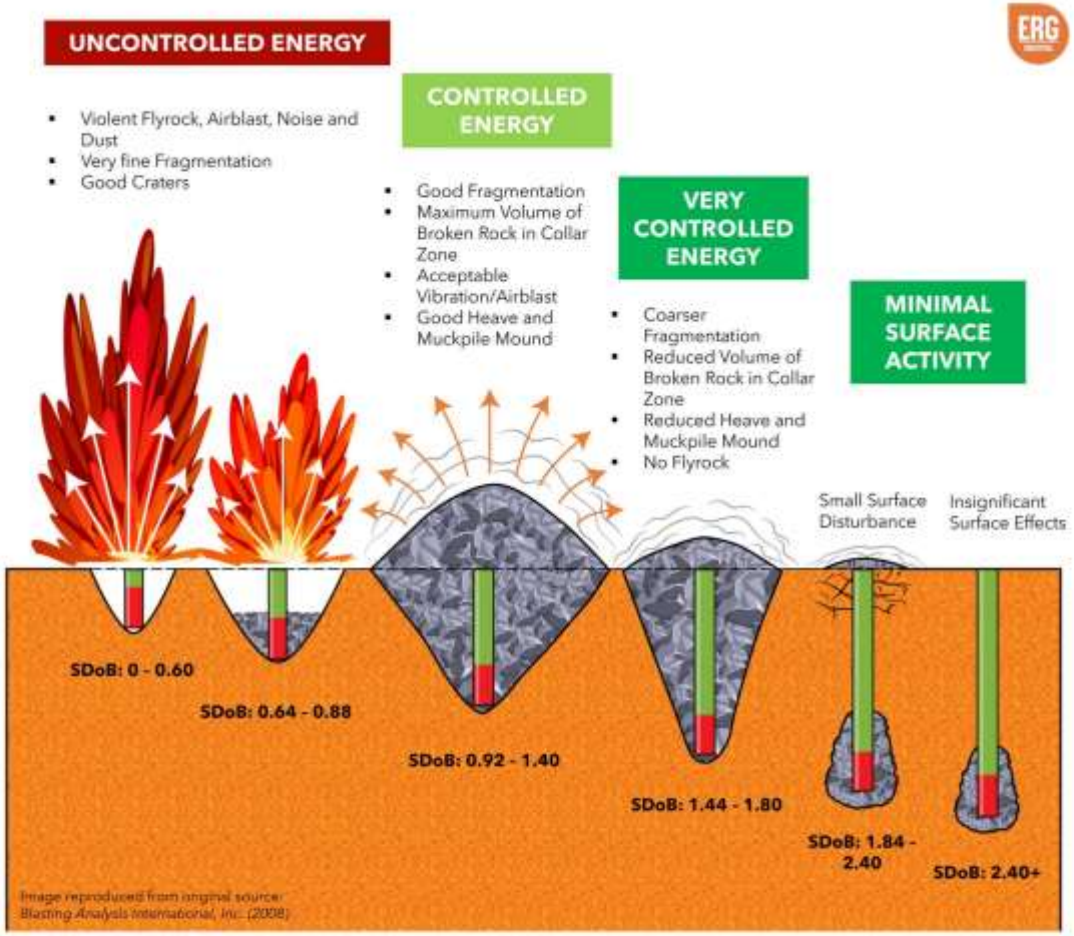
- **Objective:** Investigate if Varistem stemming plugs can assist with mitigating flyrock. There was a total of 218 holes at a diameter of 171mm and an average stemming height of 1.04m. The average Scaled Depth of Burial (SDoB) was 0.53 based on the in-field data measured on the bench, which falls within the uncontrolled energy category of SDoB. Violent flyrock, adverse airblast, excessive noise were all predicted.

- **Methodology:** The design of the blast was not adjusted with the only addition being the Varistem stemming plug. A video analysis as done to review the blast outcome in terms of the stemming ejection and the flyrock distance.

SA CASE STUDY 2: Coal Mine

Number of holes:	218
Average drill depth: *[shortest hole 0.4m]*	**2.08m**
Average stemming height:	1.04m
Hole Diameter:	**171mm**





SA CASE STUDY 2: Coal Mine

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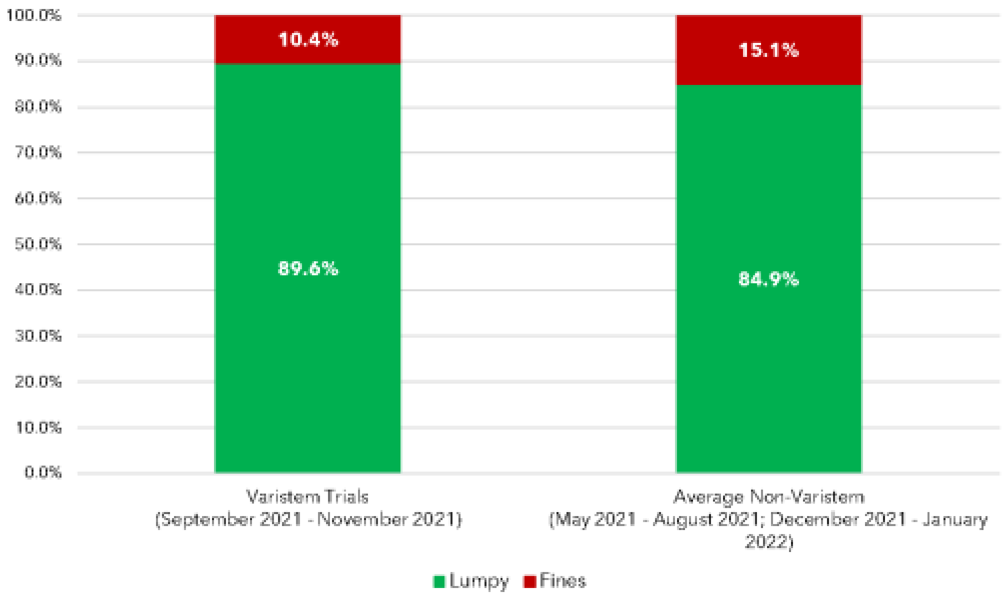
- **Results:** With the use of the Varistem plug, the post-blast measurements indicated an approximated **80% flyrock distance reduction** based on the pre-blast predicted outcomes (from more than 500m predicted to within 100m actual measured). These measurements were done using visual analysis from drones based on markers placed at 50m intervals.

SA CASE STUDY 3: Manganese Mine

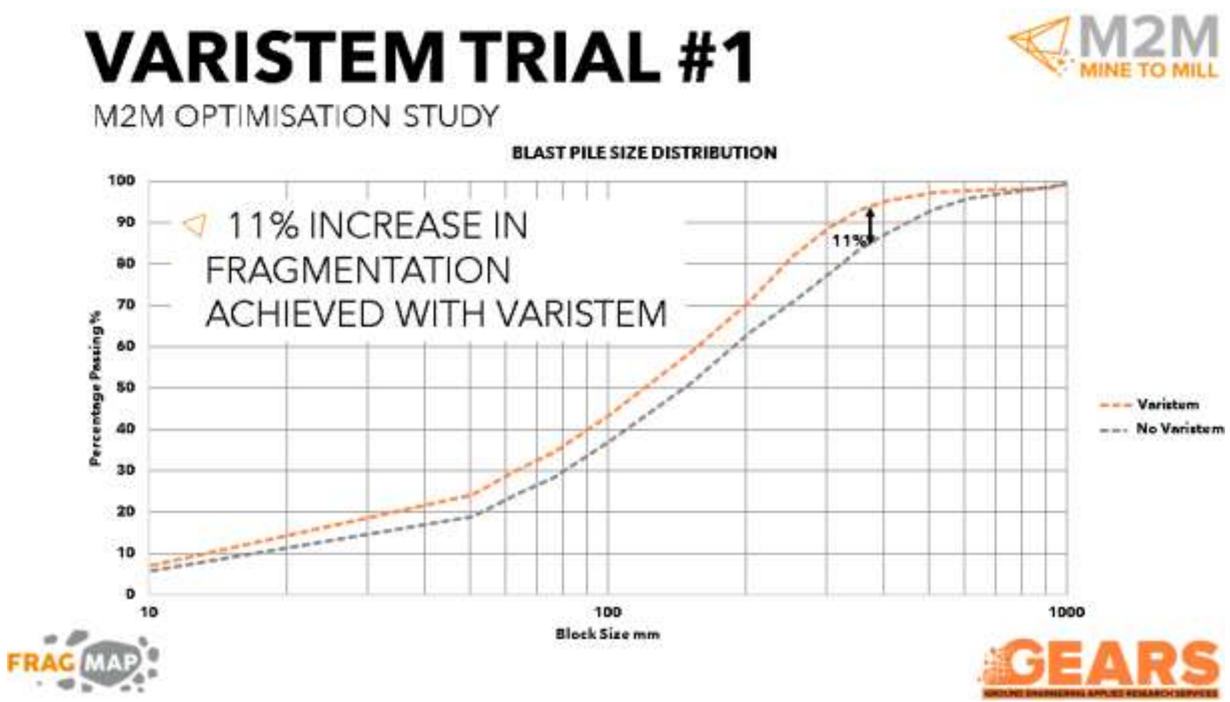
- **Problem:** This client experienced challenges with ore losses due to excessive fines. This not only affects the amount of sealable product but the overall price package of the ore itself as well.
- **Objective: I**nvestigate if Varistem stemming plugs could assist in improving the fragmentation distribution/uniformity, to reduce oversize material whilst also reducing excessive fines.
- **Methodology:** The impact of the Varistem plugs were tracked over a 3-month period looking at the cumulative % passing (material measured at the processing stages) and compared to a 3-month data window where the Varistem plugs were not used.

SA CASE STUDY 3: Manganese Mine

- **Results:** The data indicated when using the Varistem stemming plugs, the fines reduced from 15.1% of the blasted material to only 10.4% (**4.7%. Difference**)
- An improved fragmentation distribution was realized due to the Varistem stemming plugs which improved not only fragmentation distribution, but also ensured improved lumpy-ore price valuation. The predicted value-add was estimated at **$10m p.a. nett gain** due to the improved blast outcomes.

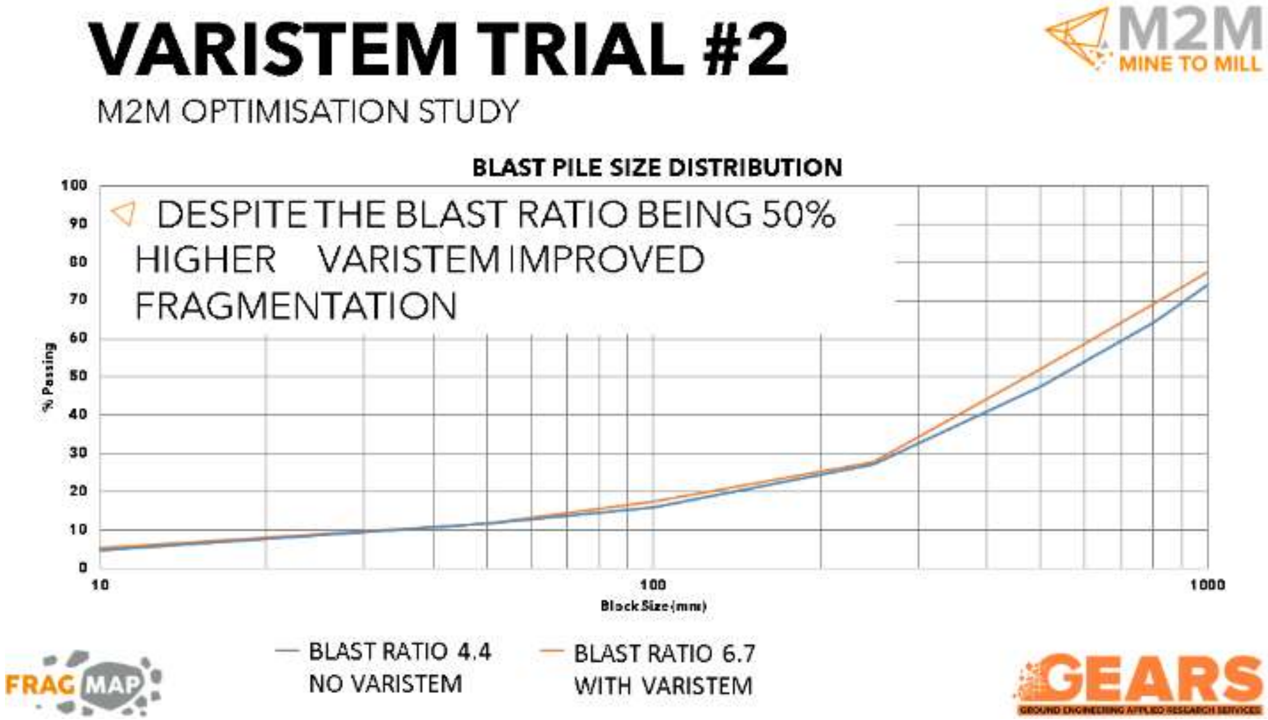


UK CASE STUDY 1: Dolomite Quarry



UK CASE STUDY 1: Dolomite Quarry

UK CASE STUDY 2: Limestone Quarry



Trial Specifications:

- Hole diameter: 90mm
- Target Blast Ratio: 5.1
- Burden: 3.2m
- Spacing 3.2m
- Stemming height: 2.6m
- Number of rows: 3

UK CASE STUDY 2: Limestone Quarry

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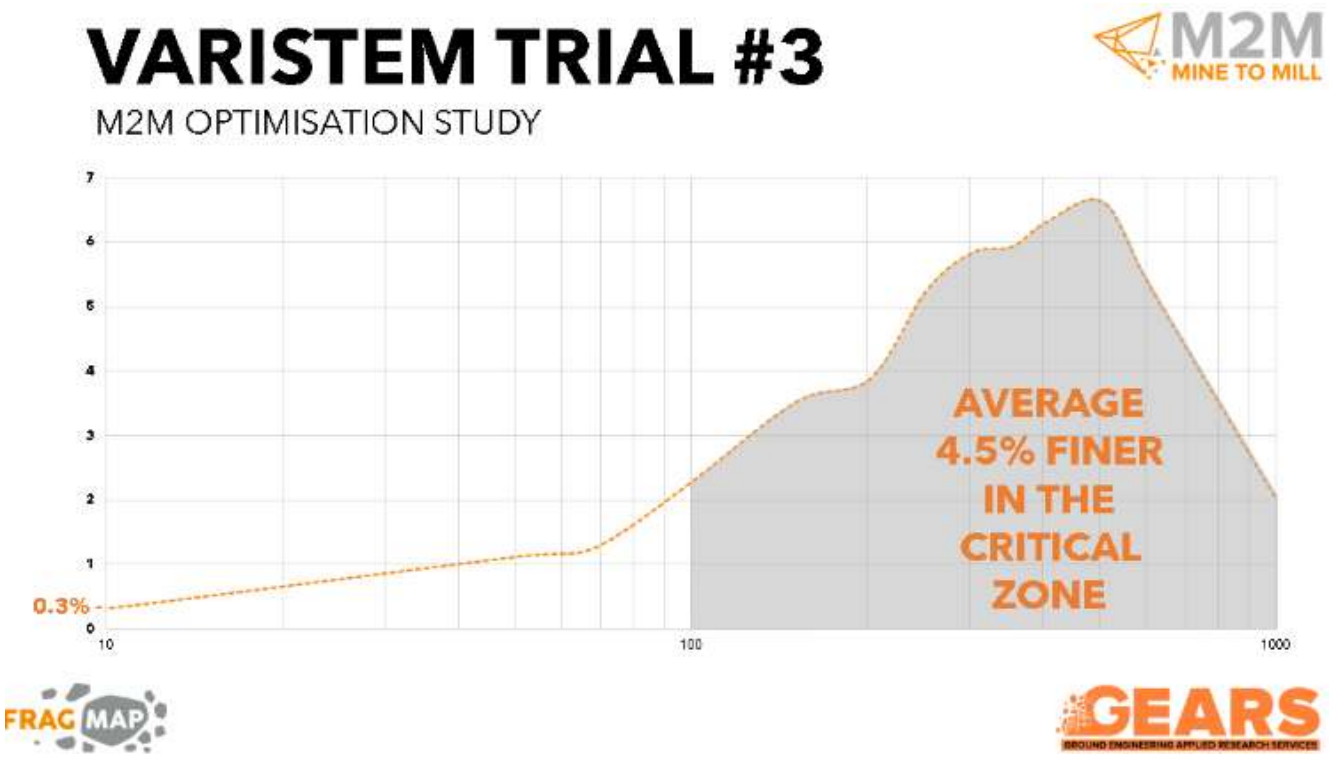
UK CASE STUDY 3: Quartz-Dolerite Quarry

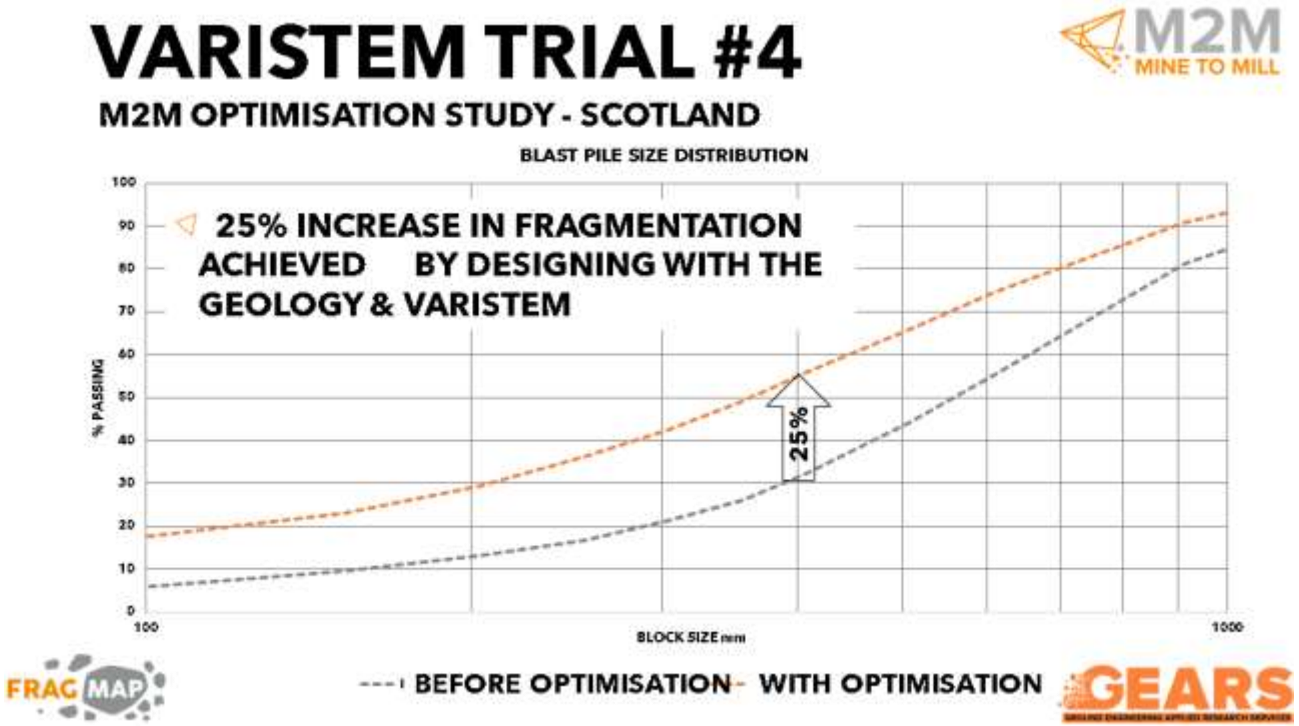


Trial Specifications:

• Hole diameter:	110mm
• Blast Ratio:	3.0-3.4
• Burden:	3.3m
• Spacing	3.8m
• Stemming height:	3.0m
• Number of rows:	3

UK CASE STUDY 3: Quartz-Dolerite Quarry

UK CASE STUDY 4: Greywacke Quarry



In this case study, the blast design was specifically done in consideration of the geological conditions of the block (i.e. fracture network, stress distributions).

Varistem stemming plugs allowed for a means to achieve specific charge designs to ensure optimal energy distribution relative to the geological conditions.

UK CASE STUDY 4: Greywacke Quarry

Research Findings

- **Varistem stemming plug trials yielded the following benefits:**
  - ✓ Improved blast confinement
  - ✓ Reduction in Noise and Airblast Overpressure
  - ✓ Effective mitigation of Flyrock
  - ✓ Improved fragmentation and particle size uniformity
  - ✓ Reduced total cost of mining

- **The use of ML and AI to measure and interpret mining/quarry data:**
  - ✓ Quicker fragmentation tracking
  - ✓ Improved fragmentation prediction models
  - ✓ Ability to track CO_2 impact related to improved blasting outcomes (measured using fragmentation and assumptions related to CO_2 impact of mining activities)

Conclusion

- Mounting pressure (financial and environmental metrics) render technological innovation a necessity for the quarrying, mining and civil industries.

- Employing effective M2M strategies have become more important than ever, especially improved management and interpretation of big and complex datasets. ML and AI allows for the practical achievement of this with a higher degree of speed and accuracy. (Example of CO2 tracking through continuous fragmentation analysis as proven by GEARS at Mountsorrel Quarry Project).

- Apart from the transformative power of AI – the most notable potential lies within its predictive analysis of data. These predictions can pave the way for intelligent decisions as to how to achieve an even more sustainable future in quarrying and mining industries (GEARS, 2024).

- The use of engineered products such as Varistem® Stemming Plugs make it practically possible to navigate complex blasting conditions and, thereby, greatly reduce environmental impacts of blasting whilst also ensuring a reduced overall cost of mining.

THANK YOU!