Outline

- Introduction
- Fragmentation Analysis
- Damage Analysis
- Implementation control
- Specific Case: Optimizing Ring Blast, Fragmentation and Damage
  Conclusion and Future Work
Simulation and Model Validation of Ring Blasting Designs

- **What?**
  - Explosive Energy Distribution and the real effects on Fragmentation and Damage

- **Why?**
  1. Model Validation is required to a proper use of blasting software
  2. Productivity increases, dilution control, ore loss and costs improvement by optimized blast design
  3. To take into account the relation between blast induced damage and stope stability
Introduction

Simulation and Model Calibration of Ring Blasting Designs

- How?
  1. Using software to simulate blast designs → JKSimBlast
  2. Measuring implementation/results on site → Split-Desktop, LaserScan, Measuring tape, etc...
  3. Comparing results to calibrate model and improve designs
Fragmentation Analysis for Blast Design Optimization

Fragmentation Digital Analysis and Energy Simulation
Damage Analysis for Blast Design Optimization

Factors involved in blast damage:
- Rock mass features
- Explosive characteristics and energy distribution
- Blast design and implementation control

Rock information
Explosive
Drill design
Blast design
Correct operation

Good fragmentation
High ore recovery
Minimum damage

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Damage Effects

Blast damage → Inestability
Damage Effects
Damage Effects

Excessive energy/rock quality

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Difference Theoretical and Real Hydraulic Radius (HR)

Must be considered that the support designed can be insufficient if the damage is excessive. The effect of the increase in HR depends the overbreak that have relation between energy levels of the blasts and characteristics of rock mass.
Critical Hydraulic Radius (HR)
Improved Results

Correct Geotechnical Evaluacion / Correct Design - Energy / Correct Implementation
Implementation Control

A model is not useful without correct implementation

Quality control of ring blasting and model parameters include:

- Collar Accuracy
- Hole length + deviation
- Explosive density control
- Loading accuracy (stemming)
Implementation Control

Hole length loaded
Design at 102mm

Energy distribution at 102 mm

Actually loaded (89mm)

Ring A

Ring B
Ring Blasting Spacing

Hole diameter control

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Implementation Control QA/QC

• Correct Timing Control

• Hole Collaring- Alignment
**RESUMEN DE RESULTADOS POR MATERIAL: MASIVO - STOCKWORK - POLIMETALICO**

**Diseño vs. Real**

- **Número de barrenos**: 89/102
- **Densidad lineal real**: 0.33 till 0.66
- **Perforación total real**: 2.0 till 5.0
- **Deviation from design (m)**
  - 0.33 till 0.66: -17%
  - 0.0 till 0.33: -24%

**Curva Granulométrica DIC15**

- **Mina Aguas T eñidas**
- **Energía factor (kJ/t)**
  - Stockwork: 472,9
  - Masivo: 266,6
  - Polimetálico: 229,67

**Comportamiento por materiales**

- **Diferencia de perforación teórica vs. real**
- **Diferencia de consumo específico**
- **Diferencia de densidad lineal**

**Explosive Linear density (kg/m)**

- **Densidad lineal teórica**
- **Densidad lineal real**

**Energy Factor (kJ/t)**

- **kJ/t teórico**
- **kJ/t real**
Specific Case:

Optimizing Ring Blast Design, Fragmentation and Damage
Specific Case: Optimizing of Fragmentation

Standard Ring Blast Design

- BLAST DESIGN OPTIMIZATION
  - Increasing around 15% energy level
  - Implementation Control

Optimized Ring Blast Design

- Improvement average of 55% in particle size distribution, getting up to 65% in fines material.
- Decreasing size below the P80 benchmarking of the mine

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Specific Case: Optimizing of Damage

Standard Ring Blast Design

Standard design, which reported an average of 4.6 m (181.1 inch) of damage and an important change in the HR

BLAST DESIGN OPTIMIZATION
-Increasing around 15% energy level
-Implementation Control

Optimized Ring Blast Design

No overbreak and HR changes, keeping the stope in its stability state

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Specific Case: Optimizing of Fragmentation and Damage
Ring Blast

Economical Improvement for a stope:
- Tonnage of 73,000 t
- Cut off: 3.49 Cu and 0.84 Zn
- NSR: 84.37 $/t

<table>
<thead>
<tr>
<th></th>
<th>Standard Blast Design</th>
<th>Optimized Blast Design</th>
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</thead>
<tbody>
<tr>
<td>% Ore Loss</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>Tonnage Ore Loss</td>
<td>9,490 t</td>
<td>3,650 t</td>
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<tr>
<td>$ Ore Loss Value</td>
<td>$ 800,671</td>
<td>$ 307,950</td>
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</table>

Profit Improvement per Stope: $492,720
Conclusion and Future Work

- Simulation and Calibration of models are useful to improve ring blast designs in Fragmentation and Damage for improvements in productivity, ore loss, costs and dilution control.

- Analysis, simulations and measurements are required to improve the accuracy of this prediction models (per material, zone of the stope, primary/secondary, etc)

- Economic value on average metal operations is around 7 MUSD/year
Thank you!