Technology transfer on minimising seismic risk in the platinum mines
20 September 2017, SAMIRA ’17
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MHSC
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3. Fatality Frequency Rate
4. Fall of Ground vs Transportation and Mining Fatalities
5. Frequency of Disaster Accident
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1. MHSC Mandate

MHSC is a national public entity established in terms of the MHSA, No 29 of 1996, Celebrating 20 years in May 2017.

- Advise the Minister on all occupational health and safety issues in the mining industry relating to legislation, research and promotion
- Review and develop legislation (regulations) for recommendation to the Minister
- Promote health and safety culture in the mining industry
- Oversee research in relation to health and safety in the mining industry
1. MHSC Mandate

- **Technology, Innovation & product development and commercialisation**
  - Research outcomes inform alternative use of existing technology or introduce new mining techniques, technology and personal protective equipment to mitigate or eliminate exposure to occupational health and safety risks and improve outcomes.

- **Training**
  - Research outcomes can be used to inform the design of occupational health and safety training interventions. Training interventions should also be developed to support the launch and promotion of new technology, innovation and products emerging from research activity.

- **Legislation, regulation and standards**
  - Research outcomes may be required to inform a review, update or amendment of existing occupational health and safety legislation, to drive the achievement of desired practices and outcomes within mining operations.

- **Promotion**
  - Research outcomes to be publicised and promoted and industry-wide (nationally, regionally and internationally) through journal publication, and through marketing and promotion efforts.
2. Percentage Fatalities by Classification

All Mines
Percentage Fatalities by classification (Provisional)
(01 Jan. - 11 Sep.) - 2017

- FOG (struck by object) 31%
- General (struck by rolling rock) 2%
- General (burning and scalding) 2%
- Transportation and Mining (RBE) 12%
- Machinery (TMM) 10%
- Transportation and Mining (RBE) 12%
- General (overcome by gas) 7%
- Machinery (Conveyors) 3%
- General (caught between) 3%
- Transportation and Mining (Winch) 3%
- Miscellaneous 5%
- General (fell in)...
- General (fell) 2%
- Explosives 2%
- Machinery (General) 2%
- General (inundated with ore) 2%
3. Fatality Frequency Rate

Fatality Frequency Rate
All Mines
2003 - 2016

Benchmark
Actual
4. Fall of Ground vs Transportation and Mining Fatalities

Fall of Ground; Transportation and Mining Fatalities
2003 - 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall of ground</th>
<th>Transportation and Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>131</td>
<td>50</td>
</tr>
<tr>
<td>2004</td>
<td>96</td>
<td>56</td>
</tr>
<tr>
<td>2005</td>
<td>83</td>
<td>50</td>
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<tr>
<td>2006</td>
<td>86</td>
<td>46</td>
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<tr>
<td>2007</td>
<td>76</td>
<td>48</td>
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<tr>
<td>2008</td>
<td>56</td>
<td>41</td>
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<tr>
<td>2009</td>
<td>62</td>
<td>47</td>
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<tr>
<td>2010</td>
<td>47</td>
<td>37</td>
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<tr>
<td>2011</td>
<td>40</td>
<td>38</td>
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<tr>
<td>2012</td>
<td>25</td>
<td>29</td>
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<td>2013</td>
<td>32</td>
<td>31</td>
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<tr>
<td>2014</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>2015</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>2016</td>
<td>24</td>
<td>24</td>
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</table>
5. Frequency of Disaster Accidents

Frequency of Disaster Accidents
2003-2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>3</td>
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<tr>
<td>2004</td>
<td>2</td>
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<td>2005</td>
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<td>2014</td>
<td>9</td>
</tr>
<tr>
<td>2015</td>
<td>3</td>
</tr>
<tr>
<td>2016</td>
<td>4</td>
</tr>
</tbody>
</table>
## MILESTONE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Project initiation (start-up presentation and report)</td>
<td></td>
</tr>
<tr>
<td>1. Learning materials for production personnel</td>
<td></td>
</tr>
<tr>
<td>2. Production personnel training roll-out</td>
<td></td>
</tr>
<tr>
<td>3. Learning materials for Rock Eng. personnel</td>
<td></td>
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<tr>
<td>4. Seismic system audit protocol</td>
<td></td>
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<tr>
<td>5. System audits</td>
<td></td>
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<tr>
<td>6. Audit results</td>
<td></td>
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<tr>
<td>Final report (approval)</td>
<td></td>
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</tbody>
</table>
8. How were the research outcomes achieved?

• Research outcome 1:
  • Animated learning training materials for production personnel
7. How were the research outcomes achieved?

• Research outcome 2:
  • *Roll-out of the production personnel training incl. train-the-trainer workshops on all mines with seismic hazard.*
8. How were the research outcomes achieved?

- Research outcome 3:
  - Training materials for rock engineering personnel

Manuals

Visuals

"Technology transfer on minimising seismic risk in platinum mines"

Output 4: Learning materials for rock engineering personnel in seismically active platinum mines

Visuals and links
8. How were the research outcomes achieved?

- **Research outcome 4:**
  - **Seismic system audit protocol in line with SIM100301 guidelines.**

  1. **Network planning**
  2. **Source quantification**
  3. **Analysis & reporting**

<table>
<thead>
<tr>
<th>Seismic system score card</th>
<th>Mine/shaft: Dishaba</th>
<th>Assessed by: WB and FE</th>
<th>Date: 15/3/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section No.</strong></td>
<td><strong>Criteria</strong></td>
<td><strong>Comments</strong></td>
<td><strong>Score</strong></td>
</tr>
<tr>
<td>1.</td>
<td>1. Monitoring objectives defined for different areas of the mine.</td>
<td>According to TSD, 5 standard MonObs declared (Jäger &amp; Ryder, 1999). Some cannot be met due to low seismic activity levels (2.6 events per day).</td>
<td>7/10*40% = 28%</td>
</tr>
<tr>
<td>1.</td>
<td>2. Network station configuration planned according to monitoring objectives.</td>
<td>Originally installed for MER mining.</td>
<td>✓</td>
</tr>
<tr>
<td>1.</td>
<td>6. Filter settings and sampling rate match relevant Magnitude range.</td>
<td>Yes (1.65 to 3.3kHz)</td>
<td>✓</td>
</tr>
<tr>
<td>1.</td>
<td>7. At least 80% of stations operational at all times.</td>
<td>80-90%, but slowly decreasing (see below); major faults with short repair times.</td>
<td>✓</td>
</tr>
<tr>
<td>1.</td>
<td>8. Sensor health checked and reported on, and always above 90%.</td>
<td>Checked and reported: usually above 80% (see below).</td>
<td>✓</td>
</tr>
<tr>
<td>1.</td>
<td>9. Sensor orientation and polarity checked (not required for smart sensors).</td>
<td>Not done for Dishaba and Tumela</td>
<td>✗</td>
</tr>
<tr>
<td>1.</td>
<td>10. Synchronisation of system clocks for regional events.</td>
<td>GPS time base; suitable for exchange with neighbouring networks.</td>
<td>✓</td>
</tr>
</tbody>
</table>

1. Principal sites receive priority with respect to repair and maintenance and are each equipped with a UFS.

*Bonus question:* Were Calibrations blasts used to calibrate source parameters, e.g., location accuracy? Use confirmed rockburst locations as master events.
10. Implementation of research outcomes

- Roll-out of the training for production personnel

- WBV alone: ~1 500 strata control personnel in need of training

- Train the trainer sessions in Northam, Rustenburg, Burgersfort, and Polokwane area

- 12 training centres

- 50 USB sticks with animated modules

- Flexible user interface

- Training materials for Rock Eng. professionals

- Presented at SANIRE meetings in W- and E-Bushveld

- 300 manual sets (incl. CDs)

- Mines arranged internal distribution

- Audit reports distributed, results presented to SANIRE
10. Implementation of research outcomes

- Research outcome 3:
  - Manual
  - Visuals

Stress field

In this middle, the extraction of more than one headway can result in stress field changes on the lashing mining face, leading to increased pillar loading and increased potential for uncontrolled pillar collapses. This combination of factors, where a pillar collapse in one area is below a fail-safe area on another headway, leads to mining instability. The potential for pillar collapse, as well as pillar-stripping of slightly larger sizes, increases substantially in this scenario.

Recommendation: Ensure the proper sequencing of multi-headway mining sequences.

Rocks and minerals

The confinement of rockfall material within and around a pillar can be increased by maintaining an intact rockfall or reduced when forming a deep strike gully close to a pillar (a so-called pillar necking). Conversely, confinement can be increased by leaving a pillar with a larger headway or by reducing the amount of rockfall available or by using shoring around the pillar. The influence of pillar necking, results from the small area of confinement, in order to prevent pillar collapse around a pillar.

Confinement conditions can have an adverse effect on the confinement: confinement is increased by an intact rockfall, whereas pillar necking decreases the confinement. A pillar with a gully can only be avoided by reducing the pillar size around the pillar.

4. Mining practice to reduce seismic damage potential

In addition to the potential for mining practices to reduce the probability of seismic events, some of these practices are also valuable in reducing the likelihood and severity of seismic damage when a seismic event does occur. Implementation of appropriate mining practices has also become a necessity that can mitigate the potential effects of seismic events and should always be considered for implementation on this basis.

Stable ground conditions

Stress fracture orientation and density are not only a function of the mining depth, but also of the gully layout (head and tail) and the surrounding area depth.

Stress fracturing could affect the local rock mass response to vibrations caused by a seismic event. It is critical to ensure stable ground conditions in and around gullies. This can be promoted by the following:

- Minimize headways in line with panel faces to areas where stress fracturing occurs.
- Sidesheds that are cut deep enough to ensure that the gully sidesheds do not negatively affect the pillar behaviour and that gullies do not reduce confinement of the footwall around the pillars.
- Selection of a suitable gully direction in relation to the roof strike direction to limit the damage to the hangingwall caused by gully development and by maintaining deep gullies.

Hangwall stability is an even greater concern where the exposed rock type is Norite. As mentioned earlier, reflector material often results in flat-dipping, high-density fracture fabric, a condition prone to instability during seismic events. The cutting of Norite into thin sheets with sharp edges is likely caused by the low lateral strength of this rock type.

Recommendations: Implement gully and sideling mining practices to prevent the creation of unstable fracturing. Prevent the exposure of the norite material.

Support practice

When approaching technologies, the risk of exposure of reflector material in the hangingwall increases and thereby the risk of seismic damage also increases. The planning of mining in and around reflectors, including the design and implementation of appropriate support practices, is critical to limiting this risk.

Using support to address specific mining conditions in an attempt to enhance stable mining conditions is a well-known practice. Not a simple exercise, the most common methodologies to design support that are appropriate and likely to reduce rockburst damage from seismic activity include methods that will:
- Ensure sufficient support resistance to the rock walls, whilst at the same time,
10. Implementation of research outcomes

- Research outcome 3:
  - *CD with sources and references*
11. Research Conclusions

• **Summary:**
  - *SIM140301: Technology Transfer project successfully completed*
  - *Three independent output streams reached the target stakeholder mines*
  - *Benefit of increased knowledge levels and awareness of rockburst risk in PGM mines*
  - *Set new standard in state-of-the-art training methodology at stakeholder training centres.*
Any Questions?
Thank you

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