MINE WASTE AS AN ECONOMIC PROSPECT?

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Talk Overview

1. Motivation for change: Risks in mining

2. Case study: Savage River mine: Old Tailings Dam (OTD)- Co

3. The Future: New opportunities in Tasmania and Queensland
Brumadinho Dam, Córrego do Feijão iron ore mine, Brazil, 25/01/19

12 million cubic meters of tailings released
237 people lost their lives, ~33 still missing
Over the past century, tailings dams and ash pond failures and the resulting fast-moving mudflows have led to a cumulative loss of almost 3,000 lives.
Risks in mining

The sector needs to redefine its image as a sustainable and responsible source of the world’s minerals

To do this, organizations need to:

- Take a whole of business approach to license to operate driven from the top down
- Commit and contribute to community, government, employees and environment needs beyond life of mine
- Walk the talk! Make it part of the company’s DNA

Risks in mining

**Imperial Metals Share Price:** Mt. Polley Failure

- CAN $37.3 Million loss

**BHP Share Price:** Samarco Failure

- Aug 2016: AUD $6.4 billion loss

**Vale Share Price:** Brumadinho Failure

- 7% drop within 24 hours; billions lost

**Vale Share Price:** Brumadinho Failure

- 28 Jan '19: 24% drop, US $19 Billion loss
Characterise materials, identify recommercialisation opportunities, reduce risk & liabilities (increase profits?)
Geometallurgical characterisation approach

## Composite head characteristics

<table>
<thead>
<tr>
<th>Zone</th>
<th>S</th>
<th>S²-</th>
<th>Fe</th>
<th>Cu</th>
<th>Co</th>
<th>Zn</th>
<th>Ni</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone A Head</td>
<td>0.72%</td>
<td>0.56%</td>
<td>9.38%</td>
<td>98 ppm</td>
<td>60 ppm</td>
<td>32 ppm</td>
<td>75 ppm</td>
<td>15 ppm</td>
</tr>
<tr>
<td>Zone B Head</td>
<td>15.9%</td>
<td>14.2%</td>
<td>18.1%</td>
<td>2120 ppm</td>
<td>580 ppm</td>
<td>88 ppm</td>
<td>595 ppm</td>
<td>25 ppm</td>
</tr>
<tr>
<td>Zone C Head</td>
<td>10.6%</td>
<td>9.54%</td>
<td>14.1%</td>
<td>1480 ppm</td>
<td>440 ppm</td>
<td>102 ppm</td>
<td>375 ppm</td>
<td>30 ppm</td>
</tr>
<tr>
<td>Zone D Head</td>
<td>9.54%</td>
<td>8.62%</td>
<td>13.6%</td>
<td>1640 ppm</td>
<td>380 ppm</td>
<td>76 ppm</td>
<td>305 ppm</td>
<td>35 ppm</td>
</tr>
<tr>
<td>Composite Head</td>
<td>9.16%</td>
<td>8.22%</td>
<td>14.0%</td>
<td>1400 ppm</td>
<td>360 ppm</td>
<td>74 ppm</td>
<td>325 ppm</td>
<td>30 ppm</td>
</tr>
</tbody>
</table>

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**Diagram:**

- Talc
- Pyrite
- Antigorite
- Chlorite
- Actinolite
- Epidote
- Sanidine
- Anorthite

**Graphs:**

- Co59
- Ni60
- Cu65

**Note:**

- n=143
Flotation results: Mineralogy

Collector: potassium amyl xanthate
84 µm, pH 5.3
Airflow: 40-60 L/min
3 stage rougher: 5 min, 3 min, 3 min

Frother: methyl isobutyl carbinol

New Tailings
Biox Feed
Composite Head

- Talc
- Pyrite
- Antigorite
- Chlorite
- Actinolite
- Epidote
- Sanidine
- Anorthite
## Flotation results: Chemistry

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Composite head</th>
<th>Biox feed</th>
<th>New Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>%</td>
<td>14</td>
<td>37</td>
<td>9.5</td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>1100</td>
<td>5910</td>
<td>452</td>
</tr>
<tr>
<td>Co</td>
<td>ppm</td>
<td>360</td>
<td>1840</td>
<td>70</td>
</tr>
<tr>
<td>Ni</td>
<td>ppm</td>
<td>350</td>
<td>1385</td>
<td>170</td>
</tr>
<tr>
<td>Pb</td>
<td>ppm</td>
<td>30</td>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>114</td>
<td>166</td>
<td>80</td>
</tr>
<tr>
<td>S</td>
<td>%</td>
<td>7.53</td>
<td>44.9</td>
<td>1.09</td>
</tr>
</tbody>
</table>

### Neutralising characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Composite head</th>
<th>Biox feed</th>
<th>New Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fizz Rating</td>
<td>-</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>ANC (Sobek)</td>
<td>Kg H₂SO₄/t</td>
<td>14</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>

### Acid generating characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Composite head</th>
<th>Biox feed</th>
<th>New Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPA</td>
<td>Kg H₂SO₄/t</td>
<td>230</td>
<td>1374</td>
<td>33</td>
</tr>
<tr>
<td>NAPP</td>
<td>Kg H₂SO₄/t</td>
<td>216</td>
<td>1374</td>
<td>11</td>
</tr>
<tr>
<td>NAG*</td>
<td>Kg H₂SO₄/t</td>
<td>45</td>
<td>115</td>
<td>15</td>
</tr>
<tr>
<td>NAGpH</td>
<td>-</td>
<td>2.3</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td>ARD Classification</td>
<td>PAF</td>
<td>PAF</td>
<td>PAF</td>
<td></td>
</tr>
</tbody>
</table>
pH: 40°C, 9K Medium

1.3 – 1.4
1.5 – 1.6
1.7 – 1.8
2.0 – 2.1

Temp: pH 1.5, 9K Medium

40°C
45°C
35°C

Medium Fe: pH 1.5, 40°C

4
9
12
16

Monitored daily, collected liquor and solids periodically collected.

Acidithiobacillus ferrooxidans
Acidithiobacillus thiooxidans
Leptospirillum ferrooxidans
Bioleaching results: Co leached

- **Fresh tailings in**: B3
- **1/3 pulp transferred**: B2
- **1/3 pulp transferred**: B1
- **Oxidised tailings removed**

7 days reaction, fresh con. added

- **Final exit solid**: < 5 ppm Co

Graphs showing time vs. concentration for Co, Fe, and S-sulf for B3, B2, and B1.

- **B3**: 53% Co leached
- **B2**: 96% Co leached
- **B1**: 99% Co leached
## Bioleaching results: Solid mineralogy

<table>
<thead>
<tr>
<th></th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>Talc (Mg₂Si₄O₁₀(OH)₂)</td>
<td>Pyrite (FeS₂)</td>
<td>Gypsum (CaSO₄)</td>
<td>Jarosite (KFe³⁺₉(OH)₆(SO₄)₂)</td>
</tr>
</tbody>
</table>

### Images:

- **B3** - final residue
  - Gyp
  - Py

- **B2** - final residue
  - Gyp
  - Py

- **B1** - final residue
  - Gyp
  - Jst
## Co precipitation tests

<table>
<thead>
<tr>
<th>Experiment</th>
<th>pH</th>
<th>Fe (mg/L)</th>
<th>Co (mg/L)</th>
<th>Cu (mg/L)</th>
<th>Ni (mg/L)</th>
<th>As (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test A</td>
<td>2.18</td>
<td>9730</td>
<td>135.5</td>
<td>275</td>
<td>96.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Test B</td>
<td>3</td>
<td>124</td>
<td>135.5</td>
<td>218</td>
<td>96.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Test C</td>
<td>3.8</td>
<td>93.6</td>
<td>126</td>
<td>38.2</td>
<td>86.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Test D</td>
<td>4.86</td>
<td>20.6</td>
<td>64.9</td>
<td>0.9</td>
<td>30</td>
<td>0.7</td>
</tr>
<tr>
<td>Test E</td>
<td>6.3</td>
<td>0.80</td>
<td>1</td>
<td>&lt;0.2</td>
<td>0.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Feed Liquor</td>
<td>19,950</td>
<td>127</td>
<td>267</td>
<td>90.8</td>
<td>6.8</td>
<td></td>
</tr>
</tbody>
</table>

1L + NaOCl (15% 5 ml) + NaOH (5% 8 ml) to pH 4.5

Intermediate saleable product

Co(OH)$_2$
A potential business case?

38 Mt tailings → 2.66 Mt pyrite → 2.660 t cobalt

LME Co = US $34,250/t → 90% recovery → Value = US $81 million

Why is cobalt important?

- 65% of the cobalt demand in 2020 is needed for the e-vehicle market

Why is cobalt potentially an issue?

- 55% of the world supply is coming from Democratic Republic of the Congo

Will cobalt demand exceed supply?

- The price per ton has escalated rapidly
- 48% of the EU imports are coming from Democratic Republic of the Congo

The gap between supply and demand is widening, while battery manufacturing capabilities are set to grow. This emphasizes the importance of frameworks such as the Raw Materials Initiative.
Future implications for the OTD

New 2019 geomet. program commissioned by SRRP and Grange

Optimise flotation by finer grind (< 33 µm) and introducing polysaccharides

Refine bioleaching by increasing O₂ into the tanks
Tasmania: Recommercialisation opportunities

- New cobalt resources
- Tin and gold from historic tailings
- Zinc from slag
- New indium resources?

Redrawn from MRT (2001)
Tasmania: Recommercialisation opportunities
Queensland: Recommercialisation opportunities

Source: [http://www.viewoftheworld.net/?p=5649](http://www.viewoftheworld.net/?p=5649)

- Ernest Henry - Fe recovery
- Mount Carbine, W recovery
- Mt Morgan, Au recovery
- Mary Kathleen, REE recovery
- New Century - Zn recovery
Mine waste as a resource: Research programs

Focused on improving metal recovery from (sulphidic) mine waste

Image source: CSIRO
Thank you for your attention...

Questions?