Wet Muck Operations at Underground DOZ Mine PT. Freeport Indonesia
Outline

1. DOZ Mine design and operations
2. Wet muck:
   • Definition and genesis
   • Classification and slide mechanism
3. Wet muck impacts
   • Safety
   • Productivity
4. Wet muck operations
   • Challenges and opportunities
Safety Talk

What can go wrong and what you should do?
Deep Ore Zone (DOZ) Mine

- Foot print  
  1,200mL x 600mW x 500mH
- Block cave mining
- Advanced undercutting
- Production start up at 2000
- Decreasing production target on 2021
Deep Ore Zone (DOZ) Mine

- Reserve 78.8 Mt (@ 0.57% Cu, 0.71 g/t Au)
- Payable metal:
  Cu: 1.9B lbs
  Au: 3.1M oz
- Designed peak production: 80,000 tpd.
- Adjusted peak production: 50,000 tpd.
Deep Ore Zone (DOZ) Mine

- Operation manpower: 700
- LHD Elp-1600 and 1700 series: 25
- Haul truck AD-55/60: 20
- Rock breaker: 22
- Utilities: 20
- Gyratory crusher: 2 @ 2,000 tph
Block Cave Mine
Mine Section
Production Activities – Extraction Level

Load-Haul-Dump
Secondary breaking
Production Activities – Extraction Level

Development repair

Construction repair
Production Activities – Haulage Level

Loading chute

Dumping to crusher
Earlier Stage of DOZ Mine

Dry muck

Boulders
DOZ Mine Today

Wet muck

Mud rush
What cause the muck get wet?

Infiltration from surface
(Run off)

Rock formation
(Aquifer)
What cause the muck get wet?

• Dynamic connection between underground (cave zone) and surface (subsidence zone)

• Complex groundwater and surface water connection

• Fines or clay generating dynamic muck pile (i.e. caved ore)

• We cannot see inside the cave
Wet Muck

Broken / caved ore in the drawbell with water content of >8.5% (moist to wet)

Material is composed of unsorted particles (muck including mud) and water in proportions that can potentially flow by gravity, if undermined or disturbed (e.g. liquefied) – Jarec Jakubec, Russel Clayton, and Alan Guest.
Drawpoint Classification

Based on **fragmentation size** and **water content**

- Evaluation and class changes
- Possibility degree of slide / spill
- Mucking strategy
- Securing treatment
- Other operation strategy related to wet muck
Drawpoint Classification

1. Alphabetic code for fragmentation size
   • **A** = content of >70% coarse muck (≥5cm)
   • **B** = content of coarse muck (≥ 5cm) which mixed with 30-70% of fine muck (<5cm)
   • **C** = content of >70% fine muck (<5cm)

2. Numerical code for water content
   • **1** = dry
   • **2** = moist
   • **3** = wet
## Drawpoint Classification

<table>
<thead>
<tr>
<th>Water Content</th>
<th>Fragmentation Size ≥ 5cm (M)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M &gt; 70% Dominated with coarse material</td>
<td>30% &lt; M ≤ 70% Mix between coarse and fine to medium material</td>
<td>M ≤ 30% Dominated with fine material</td>
<td></td>
</tr>
<tr>
<td>&lt; 8.5% Dry</td>
<td>A1</td>
<td>B1</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td>8.5 - 11% Moist</td>
<td>A2</td>
<td>B2</td>
<td>C2</td>
<td></td>
</tr>
<tr>
<td>≥ 11% Wet</td>
<td>A3</td>
<td>B3</td>
<td>C3</td>
<td></td>
</tr>
</tbody>
</table>
Class A Drawpoints

A1
Coarse dry

A2
Coarse moist

A3
Coarse wet
Class B Drawpoints

- **B1** Mix dry
- **B2** Mix moist
- **B3** Mix wet
Class C Drawpoints

C1
Fine dry

C2
Fine moist

C3
Fine wet
Mud Rush / Slide
Wet Muck Slide Mechanism

Sequence of Events:
1. A large rock arch occurs in the draw column.
2. A void is created as material below the arch is extracted.
3. Rock arch inhibits downward movement of draw column.
4. Under the head of the muck pile or drawing from adjacent drawpoint the rock arch collapses.
5. As the draw column compacts the mud pocket is discharged.
6. As mud is forced along the drift miner air is compressed, causing an air blast.

Muck pile head driving force
Wet Muck Impacts to Operation

Muck and/ or mud rush from drawpoint may cause:

• Serious severity to fatality to people
• Property damage
• Difficult to handle
• Production loss time due to recovery
Challenges of wet muck has started on 1989
Remote Control Era – End of 90’s

Intermediate Ore Zone (IOZ) Mine:
Small number of fleet, target, and footprint
Challenges to DOZ Mines Operation

• Larger foot print
• Frequency of wet muck slides
• Rapid drawpoint class changes
• Recovery of buried and trapped LHD
• Exposes hazard to other area other than Extraction Level
• Mine and infrastructure design
• Accessibility of production support activities in to production area
Current Foot Print

Total 887 drawpoints
- ▲ Closed permanent: 288 (32%)
- ▲ Wet: 406 (46%)
- ▲ Dry: 193 (22%)
Increasing Number of Wet Drawpoint
Muck and Mud Rush

Production panel and LHD recovery
Mine Infrastructures Design

Mine infrastructures are inflexible to handle wet material.
Balancing The Goals

- SAFETY
- PRODUCTION
- QUALITY
Hierarchy of Controls

A means of determining how to implement feasible and effective control solutions
Opportunities

- Autonomous LHD system
- Remote control machines for Secondary Breaking activities
- Remote control chute
- Dynamic safety procedure changes
- Controlled accesses and activities to hazardous area
- LHD recovery machines
- Drawpoint restrictor
Autonomous LHD System

CAT Minegem system commenced on 2011
Autonomous LHD System

Comfortable, safely, and productively operation of the machines from 6km outside of the mine
Autonomous LHD System

Autopilot – Co-Pilot – Teleremote
Remote Control Mobile RB

Harvest the ‘the low hanging-fruit”
Remote Water Cannon

Treat the medium hung-ups and re-packed drawpoints
Remote Chute

Eliminate wet muck rush exposure to operator
Standard Operating Procedure

- Developed based on the empirical data
- The most frequently revisited procedure in Freeport Indonesia’s underground mine
- Including entry protocol
- Covers all area affected by wet muck operations
Standard Operating Procedure

- 24 hours re-entry protocol
- Accountability of all parties involved in the wet muck operations
- Wet Muck Committee, Inspector, and Assessor
- Drawpoint classification
- Unsafe drawpoints criteria and how to correct the unsafe conditions
- Area exposed by wet muck slide
Controlled Activities

All activities in the production area must meet the entry protocol and production requirements.
Extractor

Pulling up to 120t to reduce the manual activities in the panel
Drawpoint restrictor

Reduce the slide volume
Challenges – now and onward

- Embracing a new mining mind-set
- Total remote controlled mine equipment
- Reduce the delays
- Increase the panel and drawpoint availability
- Production infrastructure standardization
- More ...
- And more ...
- And more ...
- And more ...
We Need You
End of Slides