Block Cave Underground Mine

October 2020
Open Pit to Underground Mine

End 2017 10-K Development Plan

Mill Throughput (tpd)

- GRSOP & Stockpile
- GBC
- DOZ
- BG
- DeepMLZ
- KL

Years: 2018 - 2048
<table>
<thead>
<tr>
<th>Mine Complex</th>
<th>Top Elv.</th>
<th>Lowest Elv.</th>
<th>Area</th>
<th>Production</th>
<th>Mining Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIG GOSSAN</td>
<td>3,268</td>
<td>2,400</td>
<td>0.14 km²</td>
<td>7,000 tpd</td>
<td>Stopping</td>
</tr>
<tr>
<td>KUCING LIAR</td>
<td>3,160</td>
<td>2,605</td>
<td>1 km²</td>
<td>80,000 tpd</td>
<td>Block Cave</td>
</tr>
<tr>
<td>GBC</td>
<td>3,502</td>
<td>2,814</td>
<td>0.8 km²</td>
<td>130,000 tpd</td>
<td>Block Cave</td>
</tr>
<tr>
<td>DMLZ</td>
<td>3,123</td>
<td>2,587</td>
<td>0.5 km²</td>
<td>80,000 tpd</td>
<td>Block Cave</td>
</tr>
<tr>
<td>DOZ</td>
<td>3,648</td>
<td>3,113</td>
<td>0.4 km²</td>
<td>20,000 tpd</td>
<td>Block Cave</td>
</tr>
</tbody>
</table>
What: Block (gravity) caving is a bulk underground mining method, which allows large low-grade deposits to be mined underground. This method involves undermining the orebody to make it collapse under its own weight into a series of chambers from which the ore extracted. It is a useful technique to extend the life of large deposits previously mined by open pits, and it is a method increasingly proposed for new mines around the world.

Why: Block caving has a high production rate, which means high capital costs at the start of the project but relatively low operating costs. This is why it is common at large copper porphyry deposits where other than open pitting, block caving is the most economical way to mine.
Block-caving, where applicable gives a lower mining cost than any other underground method. It is essentially for large scale work. In its different forms it is applicable to deposits of various shape and to ores of various strength, but has rigid requirements and limitations. In unsuitable deposits, or where carelessly conducted, the loss of ore may exceed that of any other method; systematic work careful supervision and good judgment are essential to success.
General conditions leading to use of caving methods

- Large scale work
  - Orebodies of large horizontal area... usually overlain by capping
  - Ore which is weak, or which if hard is thoroughly fractured
  - Deposits of cheap minerals or low grade ore in which loss of ore, or contamination with waste, is less serious than for high grade ore

Advantages of block-caving

- Safe
  - Cheap
  - Centralized Production

Disadvantages

- Prep of block requires time and considerable outlay
- Extraction is often low and there is constant danger of losing large amounts of ore
Predicting block cave performance is an uncertain process

This is due to a number of factors:

- Limited knowledge:
  - of orebody characteristics (grade, strength etc.), particularly up column
  - of the fragmentation and flow processes; particularly up column

- Mining method that has little direct control on what appears at the drawpoint (e.g. compared to more traditional mining methods where the ore that is blasted is the ore that is extracted)
The evolution of cave mining

1898
First Block Cave

Before 1980s

1980s to 2010

2010 -2020

Beyond 2020

Production rates increased steadily….then plateaued from 1970s….and now face a step-change

2-8 ktpd  10-20 ktpd  20-40 ktpd  80-160 ktpd

Grizzly and slusher systems
Weak rocks shallow depths

Mechanised systems
Strong rocks moderate depths

Deep Level & High Capacity Cave mining systems (super caves)

The NEXT Paradigm ?
**Terminology**

**RELATIONSHIP BETWEEN THE UNDERCUT LEVEL AND THE EXTRACTION LEVEL**

- **UNDERCUT X/CUTS (E-W)**
- **UNDERCUT RINGS**
- **UNDERCUT TUNNELS (N–S)**
- **STAGGERED DRAWPOINTS**
- **PRODUCTION PANELS (N–S)**
- **FRINGE DRIFT**

**ACTIVE DRAWPOINTS**

**MINOR APEX**

**MAJOR APEX**

13m 11m
Terminology

Yielded Zone

Zone of Stress Fracturing (seismogenic zone)

Pre-mining Conditions

Expansion Void (Air gap)

Caved Zone

Direction of Advancing Undercut

IF THE DRAW RATE EXCEEDS THE CAVING RATE, A GAP MAY OCCUR IN THE CAVE. THIS COULD ALLOW WASTE TO RUN DOWN THE MUCK PILE CAUSING DILUTION.

(Modified from Duplancic & Brady 1999)
Cave Performance
Dec 2014
Caving Basics
1. Develop undercut level
2. Develop production tunnels
3. Drill and blast undercut rings
4. Open troughs

Cave mining is based on the principle that, once a sufficiently large area of a block has been undercut by drilling and blasting, the overlying block of ore will start to cave under the influence of gravity.

The process will continue until caving propagates through the entire block to surface or to the level above; i.e. DOZ.
The process of undercutting creates instability at the base of the block being caved. Block cave mining is based on the principle that when a sufficiently large area of a block has been undercut by drilling and blasting, the overlying block of ore will start to cave under the influence of gravity.

At the start the cave will propagate vertically, while subsequent mining from the initial block will result in a lateral extension of the caved area. The Hydraulic radius recognize variation in geometry particularly with respect to minimum span and will give the highest HR for a circle.
The ideal shape of the drawbell is like a bell, so that ore can flow to the drawpoint. However, it is a compromise between strength and shape. The major and minor apexes must have sufficient strength to last out the life of the draw. It needs to be established how much influence the shape of the drawbell has on interaction.

The draw rate from the drawbells is an important factor in that it must provide space for caving; also it must not be too fast to create a large air gap and possible air-blasts.
Hauling - Truck
Hauling – Train

GBC Rail Haulage
- Autonomous rail system
- Remote Loading Chutes
- 40T Electric Locomotive
- Ore Wagon size - 20m³, +/- 38 ton
- 11 wagon for one locomotive
- 120 Chutes
- Three gyratory crushers
- Restricted Railway Access
Convergence Resulting in Costly Repairs and Production Delays
Other Technology Implementation

- MineGem
- Remote control room
- Autonomous Production Rail System
- Remote control chutes and rock breakers
- Dispatcher
- Geotech Integrated Monitoring Center
- MineStar draw control tracking
- Traffic control Management
- Personnel tracking
Thank You