Underground Mining of Metalliferous Deposits
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Lecture 54
Vertical Crater Retreat Method-II

VERTICAL CRATER RETREAT METHOD

The application of this new and revolutionary and mining method has been possible only after down-the–hole drills were introduced to underground mining operations. The method employs large diameter long holes of 152, 165 or 200 mm diameter and is based on the spherical charge technology (also known as crater-blast technology) which is used to produce a series of craters in a horizontal plane, as a result of blasting.

Applicability:

- The method works best where the orebody dips at angles >70°
- Where shrinkage stoping is feasible, but orebody is massive
- Competent host rock to avoid dilution
- Down-the-hole (DTH) drilling facility must be available
- Where Sublevel development may not be feasible
- Where Pillar recovery is questionable to improve recovery

Characteristics	Requirements
' 'Orebody Dimensions	▪ Steeply-dipping orebodies (>45°), with widths of no less than 12-15m, **OR** ▪ Very large both vertically and horizontally [2]
Ore and Rock Strength	▪ The strength of the waste rock must be competent in order to blast against it without having excessive amounts of dilution ▪ The ore deposit is to be of medium to competent strength [2]
Grade	▪ VCR is not a selective mining method, therefore the ore grade should be low to medium, and it should be relatively uniform throughout the entire orebody [2]
Depth	▪ VCR mining can occur at any depth. Work is carried out in reinforced, small drifts; and given the nature of the mining method, no personnel has to work directly within the drift. Therefore, safe execution of VCR mining can be carried out in deep mines [2]
Oxidizing Ores	▪ Given the small, localized stope size in VCR mining, ore can be recovered very soon after blasting occurs. Therefore, oxidizing and self-cementing ores such as pyrrhotite can be mined using this method [2]

Planning Steps

1. Evaluate are the size, dip and plunge of the orebody, which is important because the installations of draw points are essential to the gravity flow of the blasted ore for collection.
2. To assess is the shape and consistency of the orebody. Two horizontal drifts are required before mining can take place, which are to have a very large vertical separation. The distance between the two drifts depends on the consistency of the ore, the drilling accuracy, accessibility, and competency of the hanging wall. These drifts are cut inside the ore body in order to minimize developmental costs.
3. The next step is assessing the blasting characteristics of the rock, which will help to determine the drilling pattern and stope sizing of the mine. These tests can be done on similar ore blocks, or simply theoretically.
4. Early consideration of equipment selection can be done at this point, as they will be based on stope and block size, as well as production requirements, and most importantly availability

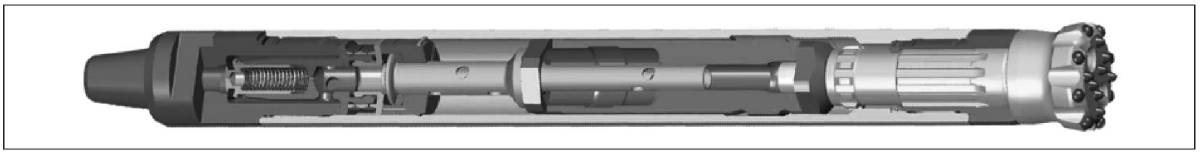
Stope Development

All working drifts are reinforced with the necessary ground support.

The pre-mining development for VCR mining includes:

- Haulage drift along the orebody, at the draw-point level
- Draw-point loading arrangement below the stope
- Undercut of the stope
- Overcut - as access for drilling and blast charging (Drill level)
- The development of the top sill consists of driving an access into the orebody, and then cutting out the ore in that region, along with any waste also inhabiting the zone.
- Once complete, ground support is implemented so that working crews can maneuver safely within.
- This is the platform from which drilling occurs, going down to the bottom sill.
- The main haulage way is driven along the strike of the orebody, with approximately 40 to 50 feet separating it from the bottom sill.
- Draw points are then driven into the sill every 30 to 50 feet along the strike, with the actual spacing dependent on the ground conditions.
- The smaller the spacing, the higher the potential extraction ratio (without the required use of remote controlled mucking).

- However, a higher extraction ratio means that smaller pillars are left behind, which raise potential stability issues.



Courtesy of Atlas Copco.
Figure 7.2-2 Cutaway view of a DTH hammer and bit

The Stoping Method:

The VCR method requires large dia holes, usually of 165 mm dia, to be drilled in a parallel pattern from a top drilling drive (called an over cut) down to an undercut on the level below. When the drill pattern has been completed over the whole stoping block, the bottom of each hole is blocked off and charged with 'spherical' slurry bags placed in the hole at an optimum depth of burial. Horizontal slices of ore up to about 5 m thick, are then blasted into the undercut. The 'swell' of broken ore is then drawn off (as in shrinkage stoping) from draw points by LHD equipment, prior to the next blast being taken. After each blast has been drawn off, the space between the top of the broken ore and the face of the stope is measured which forms the basis for determining the thickness of the next slice to be blasted. Repeating this loading and blasting procedure, mining of the stope or pillar retreats in the form of horizontal slices in a vertical upwards direction until the entire block is crater-blasted.

DRILLING & BLASTING

Drilling is done from the top sill all the way down to the bottom sill. The cross-sectional dimensions of the top sill must be 3.4m high and 4.5m wide in order for the drill mast to achieve clearance and maneuverability. The most common drill hole diameter used in VCR mining is 165mm, however 140mm diameter holes have been used as well as 205mm diameter holes, in some rare cases. Although some blast-holes in excess of 90m length have been used, experience suggests that a reduction in depth of 75m or even 60m can result in lower overall mining costs because the higher development costs are then offset by improved results arising from greater drilling accuracy.

Explosives:

The VCR method necessitates the use of aluminized slurry explosive having high densities, high detonation velocities and high bulk strengths. ANFO, because of its low density has not been used in VCR blasting, despite its attractive cost and safety characteristics.

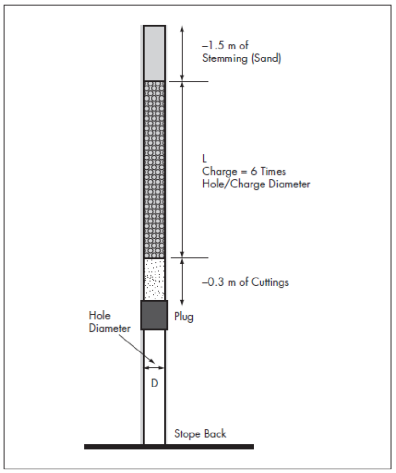


Figure 13.4-19 Typical cross section of a VCR-charged hole

Backfilling

Cemented paste backfill (CPB) is an engineered mixture of fine process tailings (75–85% solids by weight), a hydraulic binder (3–9% by total dry paste weight) and mixing water for a solid density of 70–80% by weight The addition of a binder is essential for the strength and stability of CPB. CPB has to contain sufficient water content to achieve the desired consistency for its transport from the paste plant to the underground openings. In general, a granular material must have at least 15 wt.% finer material than 20μm to retain sufficient colloidal water so as to form paste with the desired flow properties for its transport through a borehole or pipeline.

Advantages

- Higher tonnage per day and lower stoping cost.
- Lower development cost since it eliminates raise boring and slot-cutting.
- Increased safety of operations because drilling and blasting are carried out from above and there is no need for the miner to enter the actual stope.
- Improvement in fragmentation (the method yields lowest powder factor).
- Reduced labour requirements and drilling and charging time.
- Elimination of up-hole drilling and up-hole loading of explosives.

SAFETY

- VCR mining is very safe method because workers are only required inside two areas, the top and bottom sills; both of which get rock bolted immediately.

- There is therefore no need to install ground support immediately after a blast, which saves money and time.
- An overhand cut and fill operation would require that 13 to 16 lifts be rock bolted, which would be expensive and time consuming.
- The reduction in required ground support with VCR mining can be up to 88%, which means that workers are effectively protected at all times from overhead rock falls in VCR.
- Well designed VCR mines have good drainage, good visibility, stable ground, smooth corners and good ventilation.

Improved safety comes hand-in-hand with improved productivity.