Underground Mining of Metalliferous Deposits
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Lecture 57
Block Caving – I

BLOCK CAVING: AN OVERVIEW

- Block caving is a mass mining system that uses the action of gravity to fracture a block of unsupported ore, allowing it to be extracted through pre-constructed draw points.
- The block and sublevel caving systems have been widely used all over the world: the share of these systems is as high as at least 60% in foreign countries and above 70% in Russia.
- “Block” refers to the mining layout in which the ore body is divided into large sections of several thousand square meters.
- “Caving” of the rock mass is induced by undercutting a block.

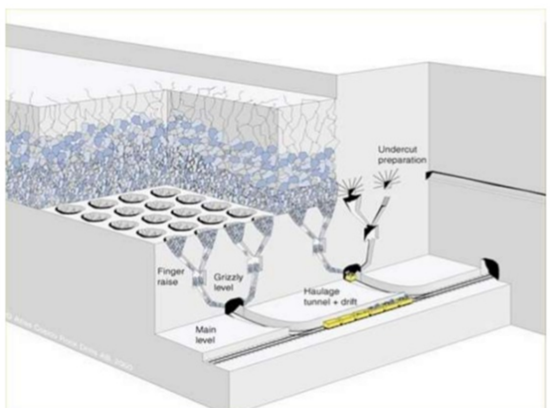

Fig 1: Block caving in a massive orebody.

- The rock slice directly beneath the block is fractured by blasting, which destroys its ability to support the overlying rock.
- Gravity forces on the order of millions of tons act on the block, causing the fractures to spread until the whole block is affected.
- Continued pressure breaks the rock into smaller pieces that pass through draw points where the ore is handled by LHDs.

Applicability

Conditions suitable for Block Caving:

- Massive ore bodies (Large vertical and horizontal dimensions)
- Prefer friable, fractured, or jointed rock that will break into pieces of manageable size
- Should cave freely under own weight when undercut; free running, not sticky if wet, not readily oxidized.
- A surface that is allowed to subside

Geotechnical parameters:

Ore strength: Weak to strong, must be fractured or jointed and cave freely (> 40 MPa UCS).

Host rock (Footwall and hang wall rocks): Weak-moderate, similar to ore in characteristics.

Geometry, disposition & orientation:

Deposit shape: massive or thick tabular, fairly regular

Deposit dip: steep (>60 degrees or vertical); can be fairly flat if sufficiently thick

Deposit size: Very Large areal extent; thickness > 100 ft (30m).

Ore grade: Low, Uniform and homogeneous.

Stope Development

First, access shafts and decline drive, must be drilled to a level below the ore.

1. **Haulage drifts in a regular pattern bellow the bottom of the ore block.**
2. Ore pass or finger raises up to a grizzly level, from such loading/haulage drifts.
3. A grizzly level for control of the ore and secondary blasting.
4. **Finger raises and cone up to the undercut.**
5. **Undercut.**

Trackless Mining: With haulage drift, the ore is loaded by LHD. This development can be simplified by excluding point 2 and 3.

Track : In this development, the ore is loaded through chute into mine cars.

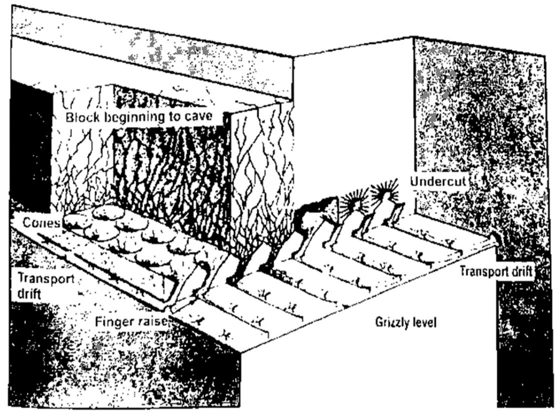

Figure 2. Isometric view of block caving in a massive orebody (Trackless mining).

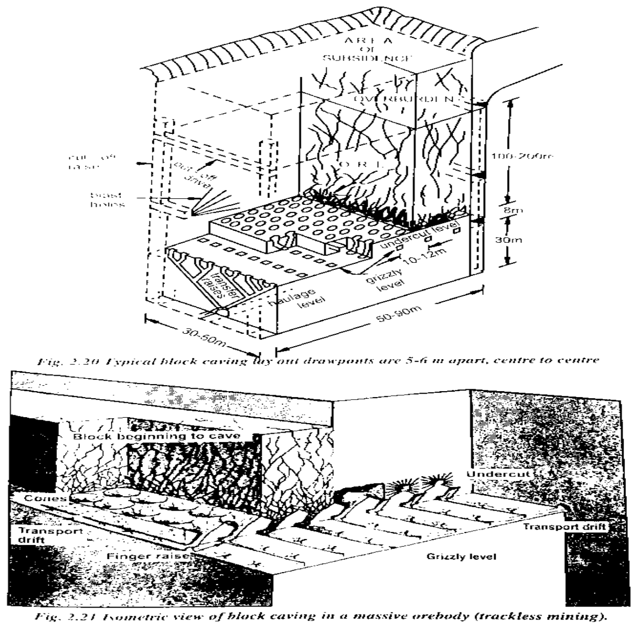

Figure 3. Typical Blocking caving layout drawpoints are 5-6m apart, centre to centre apart.

Ventilation: Main haulage ways are often paralleled by laterals, interconnected by crosscuts to ensure good ventilation.

Additional sublevels: One or more additional sublevels are required for grizzly or slusher operation.

Support : Supports commonly used are

i. cast concrete and steel beneath the cave;
ii. shotcrete and fully grouted bolts in the peripheral areas; and
iii. shotcrete and split sets outside the cave abutment areas.

CYCLE OF OPERATIONS

Drilling(Undercut): Pneumatic or hydraulic powered percussion Jumbos are used for undercut drilling; hole size 51 to 76 mm).

Blasting(Undercut): Explosives used are ANFO, Slurries; bulk charging by pneumatic loader or pump, firing electrically or by detonating fuse.

Secondary Blasting (in haulage drift): Boulders size are decreased by Impact hammer, dynamite bomb, drill and blast mud cap.

Loading (through draw bells or ore pass): Gravity flow to chutes; LHD, Front end Loader, slusher at draw points.

Haulage (on main level): Ores are transported by LHD, rail, truck, belt conveyor.

- Depending on the integrity of the rock, additional tunnels are dug higher in the rock at the "undercut" level to provide access for blasting to initiate the caving process.
- Blasting is used to form the "undercut", the extensive horizontal surface from which the ore collapses.
- Directly below the undercut, large rock funnels ("draw bells") are excavated by blasting upward from the raises.
- The mouths of these funnels abut one another, forming a continuous plane of funnel mouths where they contact the undercut.
- Once all the raises, funnels, and undercut are constructed, the main ore body is ready for blasting to shatter it into small pieces.
- Ore debris collapses from the undercut and pours through the funnels and into the raises, where special front-end loaders collect it.
- As the funnels are empty, the broken ore continues to drop away from the "roof" above the undercut. Unsupported, the ore roof collapses, feeding more material into the funnels. This process progresses until the ore body is exhausted.
- In practice, the ore body itself usually requires continued blasting to reduce it to manageable size pieces.
- Even with extensive blasting of the ore body, large blocks often fall from the ore roof, and lock the funnels or raises.
- Additional chambers, called "grizzlies", are incorporated into raises to trap these blocks and allow them to be broken up.

Typical Equipment

Drilling : Pneumatic or hydraulic powered percussion Jumbos.

Loading : LHD, Front end Loader, slusher at draw-points.

Haulage (on main level): LHD, rail, truck, belt conveyor.

Automation

Automation is employed to improve productivities and reduce exposure of operators to injury.

- Automated trucks (e.g., used at the Finsch mine in South Africa).
- Automated Rail haulage systems are managed from a remote control center (e.g., used at El Teniente mine).
- Automated LHD on the extraction level uses scanning lasers mounted fore and aft to scan and remember the tunnel profile on a single horizontal section (e.g., the DOZ and El Teniente mines).
- Buckets still require manual remote loading using cameras, as the muck type and size are too variable to allow automation of the bucket-loading process.

SUBSIDENCE

- Subsidence is discontinuous and affects large areas of the surface;
- The final geometry of the subsidence area due to block caving is quite varied, depending on
  - i. Resistance ore;
  - ii. Resistance overburden;
  - iii. Presence of significant structural features (e.g., dykes, faults);
  - iv. Depth of mining;
  - v. Natural slope of the surface.

ADVANTAGES

1. Mining cost is low and may be nearly as economic as in opencast method of mining.
2. After the caving starts, a high rate of production is possible.

3. The accident rate is fairly low.
4. Control of ventilation is less complex compared to other methods of mining.
5. High recovery.

DISADVANTAGES

1. The capital expense is large. Slow, extensive , costly development.
2. Secondary blast is required on a large scale as big chunks of ore come down during caving.
3. Caving of a block is difficult to control. Draw control is critical.
4. Maintenance of openings in production areas is substantial and costly if pillar load excessively.
5. No chance of selective mining of high and low grade ore. Dilution may be high (10 to 25%) and there is some loss of ore.
6. Mechanism is possible only to a limited extent.
7. There must be careful supervision of ore drawing.
8. Caving and Subsidence occur on a large scale.
9. As in all methods of caving, a large flow of surface water or groundwater finds its way through the caved area during monsoon to the underground workings and the mine must be equipped with adequate pumping capacity.

   At present, Block Caving is not adopted at any of the mines in India.