Underground Mining of Metalliferous Deposits
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Lecture 53
Vertical Crater Retreat Method – I

VERTICAL CRATER RETREAT (VCR) METHOD

One of the most recent methods to be adopted in underground metal mining is the vertical crater retreat (VCR) mining which is now being employed in over large and medium scale underground mines in different countries. 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.

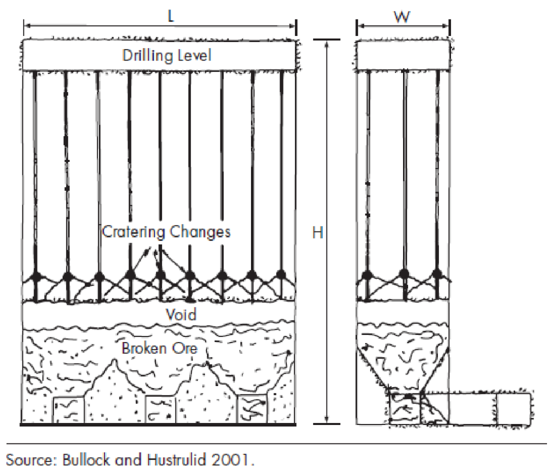

Figure 1. VCR method of mining

CRATER BLASTING

CRATER is a surface cavity in a material formed by the action of detonating an explosive charge within the material. This blasting concept was initially used as a tool to evaluate the capability of an explosive. It gained importance in surface blasting operations, and in the recent past, in underground blasting operations too.

STRAIN ENERGY EQUATION

A small charge may be blasted with no visible effect at the free face forming the surface of the confining medium. With increased weight of charge sane failure of the surface will ultimately be produced. Livingston (1956) terms the depth at which failure is first apparent as the "critical depth", and the weight of charge used at that depth is called the "critical weight".

The relationship between these two parameters is determined by the maximum possible rate of energy transfer between the explosive and the confining medium, defined by the Strain-Energy-Equation.

$N = E\ [W_c]^{1/3}$,

Where, N is the critical depth,

E is the strain energy factor,

W_c is the critical weight of charge

E is a constant for a given explosive and a given confining medium.

If the weight of the explosive charge is increased further until cratering of the confining medium is produced, the conditions then pass beyond Livingston's strain energy range, and enter what he calls the shock range, the upper limit of which is stated to coincide with the point of maximum efficiency of the utilization of explosives in blasting (*Sathianvongnusar*, 1985).

The weight of the explosives producing this maximum blast efficiency is the "optimum weight", and this is related to the upper limit of the shock range by the equation,

$d_o = \Delta . E.\ [W_o]^{1/3}$,

Where, d_o is the "optimum depth",

Δ is the "depth ratio",

and W_o is the "optimum weight" of charge.

The optimum weight of charge is defined as that weight of explosive, charged in a given shape, which produces the maximum quantitative separation of the confining medium from the parent mass.

The depth ratio *Δ*, is defined as: $\Delta = \frac{\text{depth of charge}}{\text{critical depth}}\ \Delta = \frac{\text{depth of charge}}{\text{critical depth}}$

Livingston has shown the importance of the shape of the charge in the breakage process. The effect of the charge shape was demonstrated by detonating two equal charges of the same explosive but of different shape in the same type of rock.

Table1 : Comparison of spherical and cylindrical charges

	Spherical charge	**Cylindrical charge**
Charge weight	4.5 kg	4.5 kg

Hole diameter	114 mm	67 mm
Diameter-to-length ratio	1:2.7	1:15
Volume of crater	$4.4m^3$	$1.1m^3$
Crater radius	1.7m	1.5m

- The method of VCR mining utilizes concentrated or spherical charges as opposed to conventional cylindrical charges.
- A charge is considered to be spherical if its length-to-diameter ratio does not exceed 6 to 1.
- Thus for a hole of 165 mm diameter, a slurry package of 165 mm diameter and 990 mm length would form a spherical charge.
- The geometrical configuration of a spherical charge limits its weight to approximately 35 kg in a 165 mm hole.